BAB I
PENDAHULUAN

1.1 Latar Belakang

Dalam bidang kesehatan, komputer sangat berperan penting. Penggunaan komputer dalam bidang kesehatan tidak hanya akan dirasakan manfaatnya oleh para penggunanya, tetapi juga oleh organisasi tersebut, dalam hal ini misalnya rumah sakit, puskesmas, klinik, dan lain sebagainya. Perangkat ini secara tidak langsung dapat menolong jiwa manusia.

Komputer dapat digunakan mulai dari penyimpanan dan pengolahan data administrasi suatu rumah sakit atau klinik, hingga melakukan riset bidang kedokteran, mendiagnosis penyakit, menemukan obat yang tepat, serta menganalisis organ tubuh manusia bagian dalam yang sulit dilihat.

Peranan komputer dalam bidang kesehatan sangat banyak dan penting salah satunya adalah mensimulasikan pesawat *Linear Accelerator* atau LINAC dengan lapangan IMRT (*Intensity Modulated Radiation Therapy*). LINAC pertama digunakan pada tahun 1953 di rumah sakit di London, yakni Hammer Smith Hospital. Secara garis besar prinsip kerja LINAC adalah berdasarkan proses percepatan elektron menggunakan gelombang elektromagnetik berfrekuensi tinggi melalui struktur akselerator gelombang mikro. Berkas elektron energi tinggi itu sendiri dapat digunakan untuk pengobatan kelainan yang terletak dipermukaan kulit atau dapat memperoduksi sinar-X apabila ditumbukkan pada target. Sinar-X ini digunakan untuk mengobati kelainan yang terletak jauh di bawah permukaan kulit. (Susworo, 2007)

Pesawat LINAC modern telah dilengkapi dengan pilihan berkas terapi radiasi, yaitu: berkas elektron dan berkas foton (dual mode), dua berkas foton dan lima atau lebih berkas energi elektron. Dalam proses simulasi pesawat LINAC kita dapat menggunakan *software Monte Carlo BEAMnrc* dan

DOSXYZnrc kelebihan dari *software* ini adalah hasil yang ditampilkan memiliki tingkat akurasi yang tinggi serta algoritmanya yang relatif sederhana sehingga banyak digunakan diseluruh dunia. Dalam *software* tersebut kita juga dapat bebas menentukan medium apa yang digunakan untuk penelitian ini kita akan menggunakan medium a-Si EPID karena a-Si EPID memiliki beberapa kelebihan seperti dosis dan respon memilki hubungan yang linier, kalibrasi yang sederhana selain itu mudah disimpan. Dengan *software Monte Carlo BEAMnrc* kita dapat menghitung deposisi dosis radiasi pada a-Si EPID model dengan luas lapangan radiasi tertentu. Oleh karena itu akan dilakukan penelitian tentang simulasi serapan radiasi a-Si EPID Model pada *Linear Accelerator* (LINAC) .

1.2 Rumusan Masalah

Berdasarkan latar belakang tersebut, permasalahan yang akan dikaji dalam penelitian kali ini, bagaimanakah hasil simulasi dengan menggunakan software simulasi *BEAMnrc Monte Carlo* dan *DOSXYZnrc* terhadap penggunaan medium a-Si EPID dan bagaimana perbandingan simulasi a-Si EPID dengan air.

1.3 Batasan Masalah

Berdasarkan permasalahan yang telah disebutkan diatas, maka penelitian ini dibatasi oleh :

1. Pengukuran Deposisi Energi a-Si EPID dengan Air.
2. Perhitungan Deposisi Energi IMRT dengan Air..
3. Menghitung Deposisi Energi pada lapangan persegi 5x5 cm^2, 10x10 cm^2, 15x15 cm^2, dan 20x20 cm^2.

1.4 Tujuan Penelitian

Penelitian ini bertujuan untuk mensimulasikan dan menghitung deposisi dosis radiasi pemanfaatan a-Si EPID sebagai dosimeter untuk treatment IMRT.

1.5 Manfaat Penelitian

Data ini dapat digunakan sebagai referensi untuk rumah sakit dalam menentukan dosis radiasi yang aman dan efisien.

(halaman ini sengaja dikosongkan)

BAB II
TINJAUAN PUSTAKA

2.1 Simulasi *Monte Carlo BEAMnrc*

Metode *Monte Carlo* merupakan metode yang menggunakan random sampling dari distribusi probabilitas yang diketahui untuk menyelesaikan permasalahan dalam fisika atau matematika. Pada metode *Monte Carlo* random sampling dari distribusi probabilitas yang diketahui digunakan untuk mengetahui bagaimana keluaran dari suatu permasalahan. Metode *Monte Carlo* tidak menyelesaikan persamaan eksplisit melainkan dengan cara mensimulasikan atom/foton secara individu dan merekam beberapa aspek (perhitungan) dari sifat rata-rata atom/foton tersebut. Terdapat beberapa aplikasi untuk pemodelan perhitungan menggunakan *Monte Carlo* yaitu *MCPT* (hanya *photon-brachytherapy*), *MCNP* (Reaktor dan Neutron), dan *EGS/BEAMnrc* untuk pemodelan akselerator.

Simulasi *Monte Carlo BEAMnrc* dapat digunakan untuk membangun LINAC dan mensimulasikan untuk mengkalkulasi dosis. Pada proses simulasi terdapat skema langkah yang dilakukan untuk melakukan simulasi akselerator. Pada langkah menentukan dan membangun akselerator, pengguna menginstruksikan sistem bagaimana untuk bekerja sama antara kode sumber dan membuat sebuah modul pengeksekusi.

Pada tahap ini hanya bagian luar akselerator yang didefinisikan (misalkan *flattening filter* sesudah dan sebelum kolimator primer). Selama tahap pelaksanaan, program membaca dalam jumlah besar data terkait dengan data *cross sections* foton dan elektron untuk bahan tertentu dalam model akselerator ini. Data-data ini dihasilkan pada kode yang disebut *PEGS4* (yang disertakan dengan *EGSnrc* sistem. Yang terkandung dalam *$HEN HOUSE*/data subdirektori). Pengguna juga bisa membuat sebuah file masukan yang menentukan

semua rincian tentang akselerator tertentu (misalkan *scattering foil*, jarak ke *exit window*, bahan penyusun dan ketebalan bahan). Pengguna juga harus menentukan semua parameter yang mengendalikan radiasi, pemodelan transportasi dan juga harus memilih dan mengontrol pengurangan varian yang digunakan.

Pada tahap akhir dari simulasi adalah analisa keluaran *phase space files* (dalam ukuran puluhan atau ratusan *Megabytes*). (Berger, 1988)

Berikut ini adalah beberapa kelebihan metode *Monte Carlo*:

1. Algoritma mendekati kondisi real tranportasi radiasi, yaitu dengan cara mengikuti transportasi radiasi tahapan demi tahapan sampai energi radiasi sangat rendah.
2. Algoritma relatif simpel, sehingga dalam melakukan *coding* dan *debugging* dapat dilakukan relatif mudah.
3. Jika algoritma sudah sesuai, maka tingkat akurasinya ditentukan oleh akurasi data *cross section*, sehingga data *cross section* dapat di-*update* tanpa harus mengubah algoritma yang ada.
4. Metode simulasi *Monte Carlo* adalah metode "mikroskopik", sehingga geometri medium tidak mempengaruhi algoritma *Monte Carlo*. Karena itu simulasi *Monte Carlo* dapat digunakan untuk medium yang kompleks.

Sedangkan beberapa kelemahan metode *Monte Carlo* antara lain:

1. Simulasi *Monte Carlo* membutuhkan waktu yang sangat lama sehingga untuk keperluan klinis radioterapi belum digunakan.
2. Simulasi Monte Carlo untuk transportasi elektron masih menggunakan algortima "*condensed-*

history". Pada beberapa bagian masih menggunakan aproksimasi (*stopping power* untuk *low energy* dan menggunakan *multiple-scattering theory* untuk kejadian *small angle*) sehingga masih mengandung *systematic errors*.

(Keall, 2003)

2.2 a-Si EPID (*Electronic Portal Imaging Device*)

Silikon amorf (a-Si) adalah bentuk allotropic non-kristalin silikon. a-Si dapat disimpan dalam film tipis pada suhu rendah pada berbagai substrat. Silikon adalah atom terkoordinasi empat kali lipat yang biasanya tetrahedrally terikat empat atom silikon tetangga. Dalam silikon kristal (c-Si) struktur tetrahedral berlanjut atas berbagai macam ikatan sehingga membentuk kisi kristal tertata. (Akhadi, 2000)

Electronic Portal Imaging Device (EPID) memainkan peran penting dalam terapi radiasi portal pencitraan, verifikasi geometris dan dosimetri.Kualitas gambar yang konsisten dan respon radiasi yang stabil diperlukan untuk pemanfaatan yang tepat yang membutuhkan jaminan kualitas rutin (QA). Pada EPID QA terdapat sebuah *'Quality Control EPID'* phantom seberat 3,8 kg dengan dimensi $25 \times 25 \times 4{,}8\ cm^3$. Perangkat ini memiliki kemampuan dapat mengukur akurasi geometrik, *signal-to-noise ratio* (SNR), linearitas dosis, dan resolusi kontras tinggi yang dapat digunakan untuk QA. Dengan keunggulan a-Si EPID dalam dosis respon gambar pencitraan yang dihasilkan lebih stabil dan untuk perawatan a-Si EPID cenderung lebih mudah. (Vandyk, 2005)

2.3 *Intensity Modulated Radiation Therapy* (IMRT)

Intensity Modulated Radiation Therapy (IMRT) merupakan teknik modern dalam radioterapi yang menggunakan banyak lapangan radiasi dalam penyinaran dengan intensitas yang tidak seragam pada setiap arah lapangan radiasi untuk mendapatkan distribusi dosis yang optimum.

Perubahan intensitas radiasi pada pesawat LINAC diatur dengan membuat beberapa segmen pada setiap lapangan radiasi.

Pergerakan MLC pada teknik IMRT ada dua macam yaitu : *dynamic* MLC (*sliding window*) dan *static* MLC (*step and shoot*). *Dynamic* MLC merupakan teknik di mana MLC bergerak kontinu selama radiasi berlangsung pada setiap arah sudut gantri, mempunyai waktu yang lebih singkat dibandingkan metode *static* MLC. Metode *static* MLC merupakan metode dimana MLC bergerak membentuk segmen ketika radiasi berhenti dan MLC berhenti selama radiasi berlangsung untuk masing-masing sudut gantri dan MLC berhenti selama radiasi berlangsung begitu seterusnya untuk masing-masing gantri. (Budgell, 2001)

Pada teknik *3D Conformal* juga menggunakan MLC yang digunakan untuk mengkolimasi radiasi yang keluar sesuai bentuk target tumor, membutuhkan *filter wedge* untuk mengatenuasi radiasi pada daerah yang dibutuhkan. Pada IMRT MLC digunakan untuk mengkolimasi dan mengatenuasi radiasi yang keluar dari pesawat linear akselerator sesuai distribusi dosis yang dibutuhkan.

Komputer TPS (*Treatment Palnning System*) yang dapat melakukan perhitungan untuk beberapa lapangan radiasi yang tidak seragam intensitasnya dari masing-masing arah penyinaran, pesawat radiasi yang dapat memberikan radiasi dengan intensitas yang tidak seragam sesuai dengan apa yang direncanakan komputer. (Metcalfe, 2007)

2.4 Interaksi Materi

Ketika sebuah foton memasuki suatu medium, maka foton tersebut akan mengalami berbagai proses interaksi, diantaranya efek fotolistrik, hamburan Compton, produksi pasangan, dan hamburan Rayleigh. Kontribusi masing-masing proses tergantung pada probabilitas interaksi yang ditentukan oleh *cross-section* tiap-tiap interaksi. Efek

fotolistrik terjadi apabila sebuah foton yang berinteraksi dengan elektron yang terikat pada sebuah orbit atom medium. Pada proses ini energi foton $h\upsilon$ akan digunakan untuk membebaskan ikatan elektron pada atom dan digunakan untuk energy kinetik elektron yang keluar dari atom tersebut. Interaksi ini dominan untuk energi foton yang rendah.

Produksi pasangan dominan pada energi tinggi. Apabila energi foton lebih besar dari $2m_ec^2$, foton dapat berinteraksi dengan atom medium melalui proses produksi pasangan. Dalam proses ini foton berinteraksi kuat dengan medan inti, dan berubah menjadi pasangan partikel elektron dan positron. Atau bisa jadi foton (energinya lebih besar dari $4 m_ec^2$) berinteraksi dengan elektron atom, dan sebagai hasil interaksinya dihasilkan 2 elektron dan 1 positron. Mengingat positron memiliki waktu hidup pendek, maka setelah positron kehilangan energi, secepatnya akan bergabung dengan elektron dan membentuk 2 foton (proses annihilasi).

Pada hamburan Compton, foton berinteraksi dengan sebuah elektron yang berada dalam keadaan "bebas" (terikat sangat lemah). Energi ikat elektron tersebut lebih kecil dari energi yang dimiliki foton. Peluang foton untuk berinteraksi dengan sebuah elektron bebas, ditentukan dengan menggunakan rumus Klein-Nishina. Interaksi Compton ini dominan pada daerah antara efek foto listrik dan produksi pasangan. Bila proses Compton terjadi pada foton energi rendah, energi yang ditransfer pada elektron sangat rendah, sehingga sebagian energinya dihamburkan. Di lain pihak, bila energi foton datang tinggi, 10 – 100 MeV, sebagian besar energinya ditransfer kepada elektron, dan hanya sedikit yang dihamburkan. Interaksi lain yang juga terjadi adalah hamburan Rayleigh, hanya saja hamburan ini elastik, sehingga tidak ada energi yang ditransfer ke medium dengan interaksi ini. Peristiwa interaksi foton dengan medium adalah

peristiwa acak, hanya saja peristiwa ini mengikuti suatu distribusi dengan nilai probabilitas tertentu. Di bawah 20 keV, efek fotolistrik cukup dominan, di atas 30 MeV produksi pasangan cukup dominan, dan diantara keduanya efek Compton cukup dominan. Tetapi pada daerah tersebut probabilitas interaksi menjadi tumpang tindih (misalnya energi 20-30 KeV) efek fotolistrik dan hamburan Compton memiliki probablitas yang cukup besar. (Podgorsak, 2005)

2.5 Simulasi Interaksi Materi

Dalam proses simulasi, satu atau lebih foton memiliki posisi, arah dan energi. Yang tersimpan dalam *stack*. Transportasi foton dari satu posisi ke posisi berikutnya dinamakan tahapan. Setelah partikel mengalami satu tahapan, data partikel (posisi, arah partikel dan energi) diperbaharui. Untuk foton, dalam setiap tahapan terdapat beberapa hal yang diperhatikan:

1. Jarak yang ditempuh foton sampai mengalami interaksi (*distance to the next interaction*). Dalam setiap tahapan, foton ditranspotasikan menempuh jarak secara acak. Probabilitas jarak tempuh foton sampai mengalami interaksi, diberikan oleh persamaan;

   $$F(x) = \sigma_T(E)e^{\sigma T(E)x}$$

   Dengan $\sigma_T(E)$ merupakan *cross-section* total. Persamaan ini sering dinamakan dengan hukum atenuasi eksponensial (*exponential attenuation law*) atau dalam simulasi *Monte Carlo* dinamakan *probablity distribution functions* (pdf). Selanjutnya untuk mendapatkan x atau jarak yang ditempuh foton sampaimengalami interaksi, digunakan metode *direct sampling*.

2. Setelah satu tahapan ditempuh, kemudian dilakukan pemilihan tipe interaksi, apakah efek foto listrik, efek Compton, produksi pasangan atau hamburan Rayleigh.

Tipe interaksi ini juga dipilih secara *random*. Metode yang digunakan untuk memilih tipe interaksi ini adalah *rejection method*. Metode ini biasanya dipilih ketika inversi *cumulative distribution function* (cdf) sulit dilakukan (*impractical*).

3. Setelah tipe interaksi dipilih, selanjutnya adalah pemilihan sudut partikel dan energi baru yang dimiliki foton tersebut. Pemilihan sudut dan energi ini juga peristiwa *random*, yang probablitasnya dipengaruhi energi awal foton dan medium yang dilalui.

4. Sebagai hasil dari tiap interaksi, bisa jadi tercipta partikel baru. Ketika partikel baru tercipta, maka posisi, arah dan energi partikel yang tercipta ditambahkan kedalam *stack*. (Fippel, dkk, 2003)

2.6 Komponen Pada *Linear Accelerator* (LINAC)

Secara umum, kepala LINAC untuk model foton, terdiri atas komponen: target, kolimator primer, *flattening filter*, *monitor chamber*, cermin dan kolimator sekunder (*jaws*). Setiap manufaktur dalam mengatur komponen tersebut, bisa dengan urutan yang berbeda. Untuk tujuan klinis, juga sering ditambahkan komponen yang lain.

Target berfungsi untuk menghasilkan berkas foton setelah foton berenergi tinggi menumbuk dan berinteraksi dalam bahan target tersebut. Untuk foton, arah radiasi foton searah datangnya foton. Berkas foton yang dihasilkan memiliki profile yang tidak rata. Di bagian tengah yakni pada arah sumbu utama target memiliki intensitas yang lebih tinggi dibandingkan di bagian pinggir. Untuk itu foton yang terbentuk, dilewatkan *flattening filter* agar profile foton menjadi rata. Dengan digunakannya *flattening filter*, dosis relatif pada daerah sekitar sumbu utama menjadi

lebih rendah dibandingkan daerah pinggir profile berkas foton.

Kolimator pada modern LINAC ada 2 buah, yaitu kolimator primer dan kolimator sekunder. Kolimator primer ukurannya tetap, sementara kolimator sekunder, ukurannya bisa diubah-ubah sesuai kebutuhan (*adjustable*). Kolimator sekunder sering dinamakan *jaws*, yang fungsi utamanya untuk membentuk lapangan radiasi (*field size*).

Monitor chamber berguna untuk mengukur dosis radiasi yang dihasilkan LINAC. Monitor chamber dapat menampilkan nilai monitor unit (MU), dapat memonitor *dose rate*, *beam flatness*, dan *beam energy*; dan digunakan sebagai metode untuk mematikan sistem LINAC. *Monitor chamber* terdiri atas *primary ionization chamber* dan *secondary ionization chamber*. (Butdee, 2008)

BAB III
METODOLOGI PENELITIAN

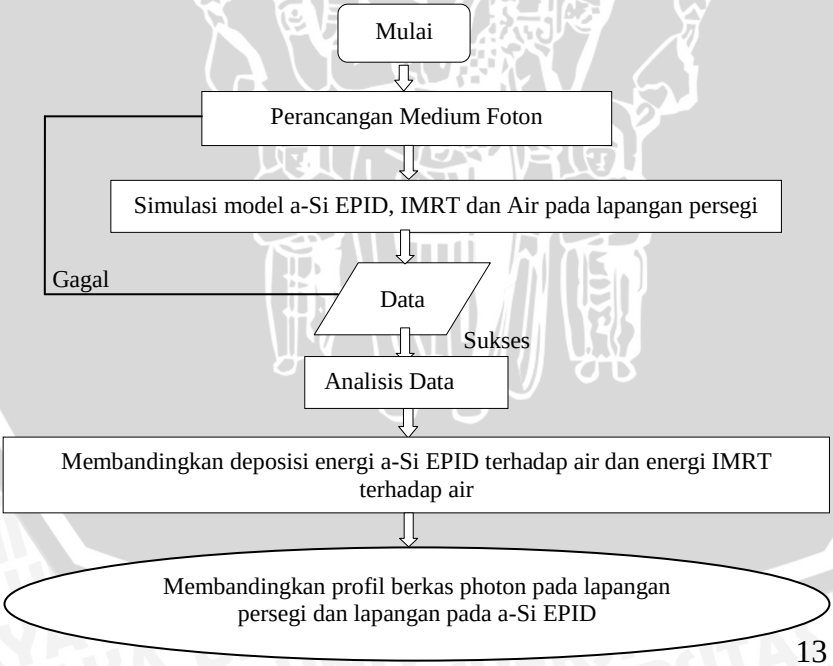
3.1 Waktu dan Tempat Penelitian

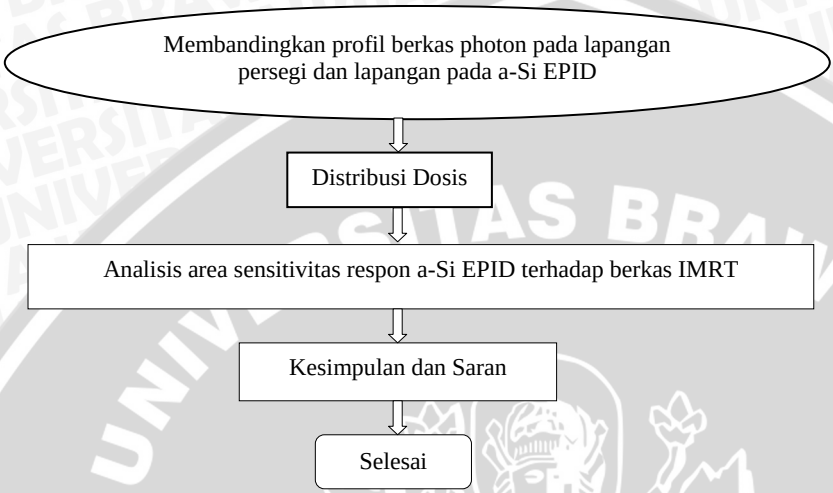
Perancangan dan proses simulasi dilakukan pada bulan September 2012 sampai bulan Mei 2013, simulasi dan perancangan dilakukan di Ruangan TPSDP Jurusan Fisika Universitas Brawijaya.

3.2 Alat dan Bahan Penelitian

Dalam penelitian ini digunakan satu set perangkat PC (*Personal Computer*) dengan software *BEAMnrc Monte Carlo* dan *DOXYZnrc*, serta *Microsoft Office Excel* untuk menggambarkan grafiknya.

3.3 Tahapan Penelitian





Gambar 3.1 Diagram Alir Tahap Penelitian.

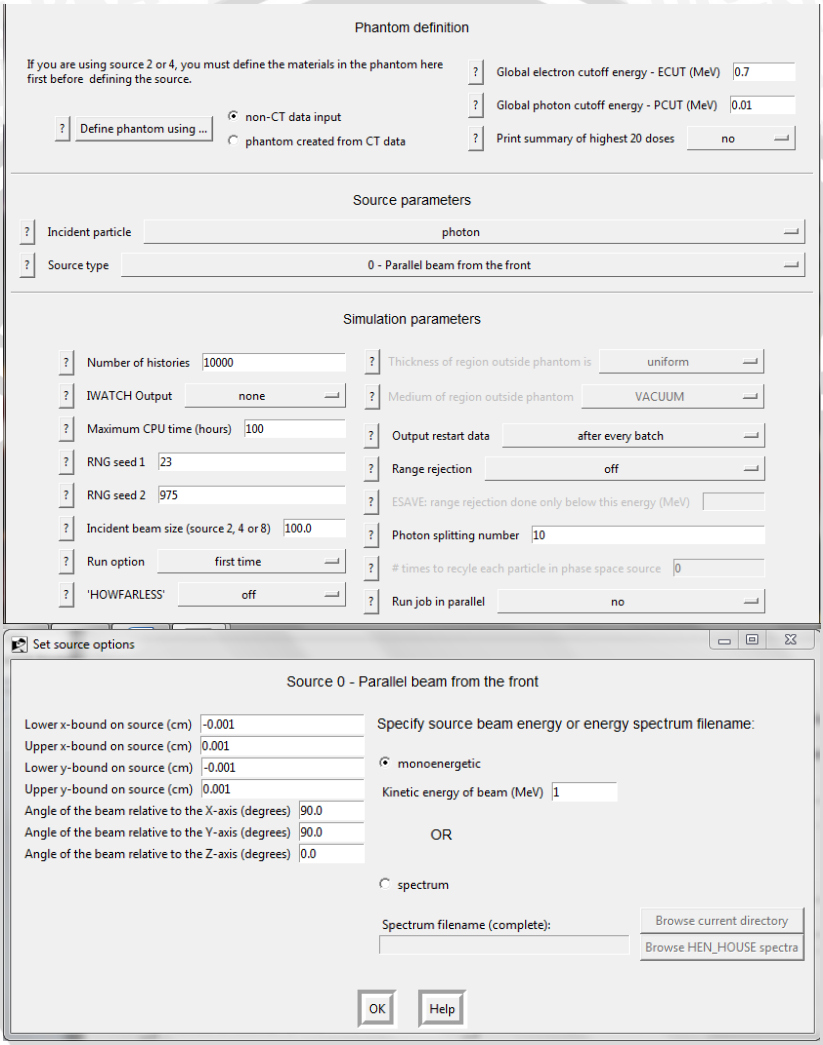
3.4 Langkah-langkah Penelitian

3.4.1 Perancangan Medium Foton

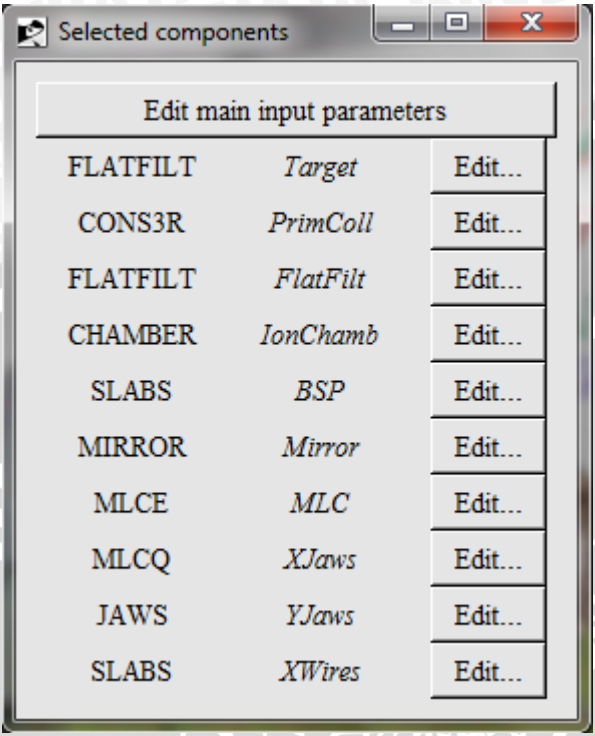
Dengan menggunakan software *BEAMnrc*, kita dapat merancang medium foton dan simulasi LINAC. Komponen kepala LINAC *Elekta* adalah target sinar-x, blok target, kolimator primer, *monitor chamber*, cermin dan *jaws* (kolimator sekunder). Pada penelitian ini untuk mendapatkan sinar-X tanpa perata filter perata dilepaskan dari kepala *Linac*. Data lengkap yang berisi geometri dan urutan diambil dari *SL*.

Series LINAC *Physics Manual* dalam *BEAMnrc*, komponen-komponen tersebut dapat dibuat dengan modul-modul tertentu yang sudah tersedia dalam paket *BEAMnrc*. Komponen kepala LINAC dan Modul yang digunakan dalam

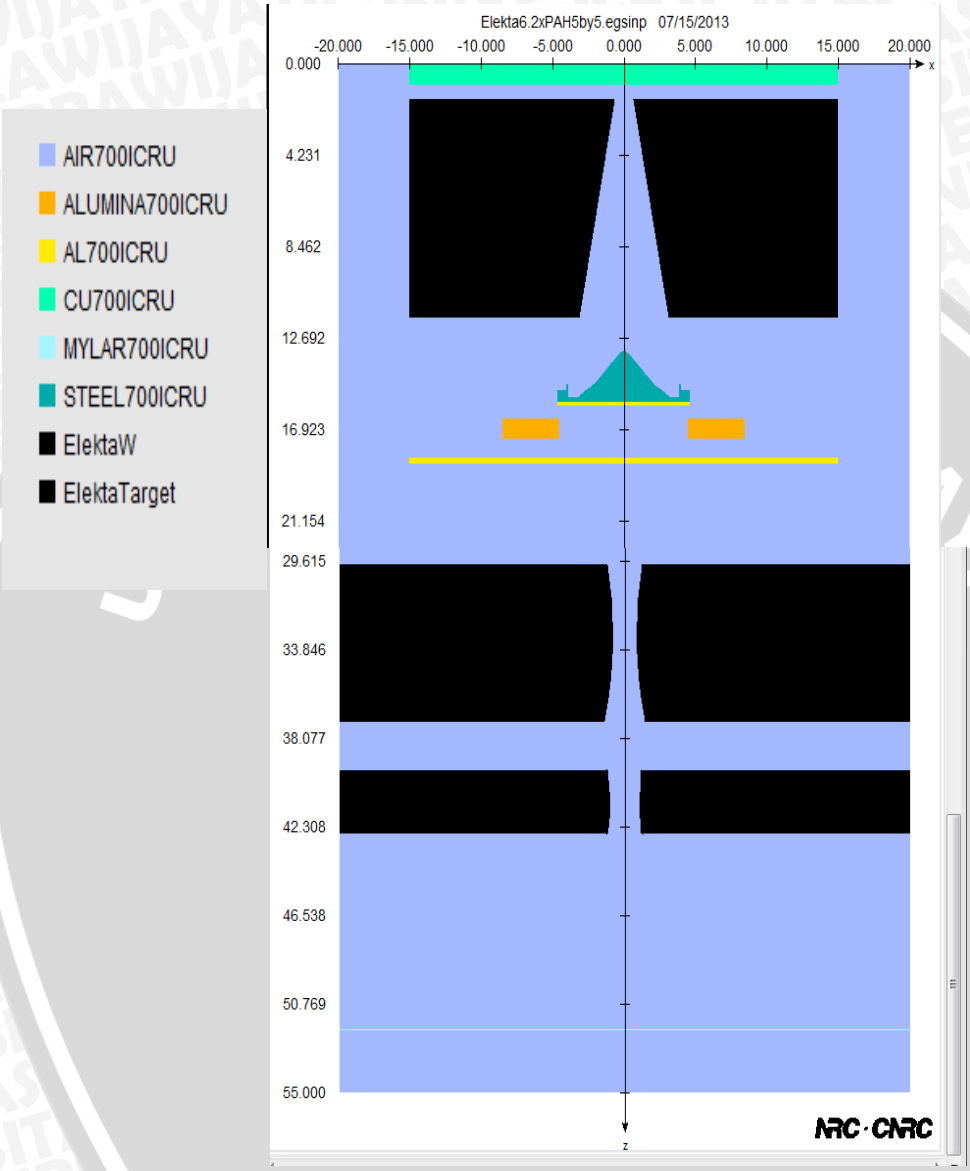
BEAMnrc ditunjukan pada gambar 3.3. dan simulasinya dapat ditunjukkan pada gambar 3.4.



Gambar 3.2 Model *Input* Data



Gambar 3.3 Model Komponen LINAC



Gambar 3.4 Tampilan desain pesawat LINAC pada simulasi *Monte Carlo*

3.4.2 Simulasi Model a-Si EPID, IMRT dan Air pada Lapangan Persegi

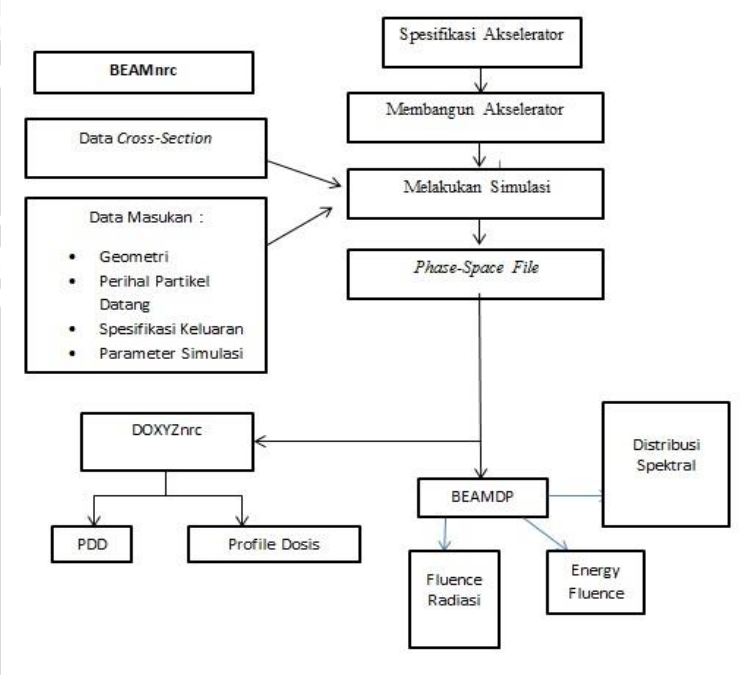
EGSnrc merupakan program untuk mensimulasikan transportasi elektron danfoton dengan metode *Monte Carlo*. *EGSnrc* merupakan pengembangan dari *EGS4* oleh *National Research Council of Canada* (NRCC) yang dapat digunakan untukmensimulasikan foton dari energi 1 KeV hingga ratusan GeV.

Kode program *EGSnrc* terdiri atas *user code* dan *egs code*. Pada *user code* terdapat program utama (*MAIN*) yaitu tempat untuk menginisialisasi simulasi dengan menentukan karakteristik foton berupa posisi awal foton (sumber), jenis materi, jenis medium, transport radiasi (elektron atau foton) hingga energi awal. Selain *MAIN* terdapat subroutine *HOWFAR* dan *AUSGAB* pada *user code* masing-masing memiliki fungsi untuk menentukan geometri, dan untuk mengeluarkan hasil program.

Setelah memasukan data simulasi pada *user code* maka data akan diproses pada *egs code*, baik untuk elektron atau foton. Pada elektron dalam *egs code* terjadi peristiwa annihilasi, interaksi Moller, interaksi Babha, interaksi bremsstrahlung, *single scattering* dan *multiple scattering*. Sedangkan untuk foton terjadi peristiwa efek Compton, efek foto listrik, produksi pasangan dan hamburan Rayleigh. Terdapat beberapa program *Monte Carlo general-purpose* yang dibuat menggunakan *EGSnrc*. Diantaranya *BEAMnrc*, *DOSXYZnrc* dan *BEAMDP*.

BEAMnrc merupakan program yang sudah dibuat dengan modul-modul tertentu, sehingga pengguna tidak perlu mendesain geometri dari awal. *BEAMnrc* ini sangat berguna untuk mendesain kepala akselerator. *DOSXYZnrc* adalah program untuk menentukan dosis yang dideposisi pada medium dengan voxel (volume element) berbentuk rectilinier. Sementara *BEAMDP* adalah program untuk analisis *phasespace file* yang dihasilkan oleh *BEAMnrc*, misalnya

untuk menentukan *fluence*, *energi fluence*, *energy spektral*, distribusi angular dan lain-lain.

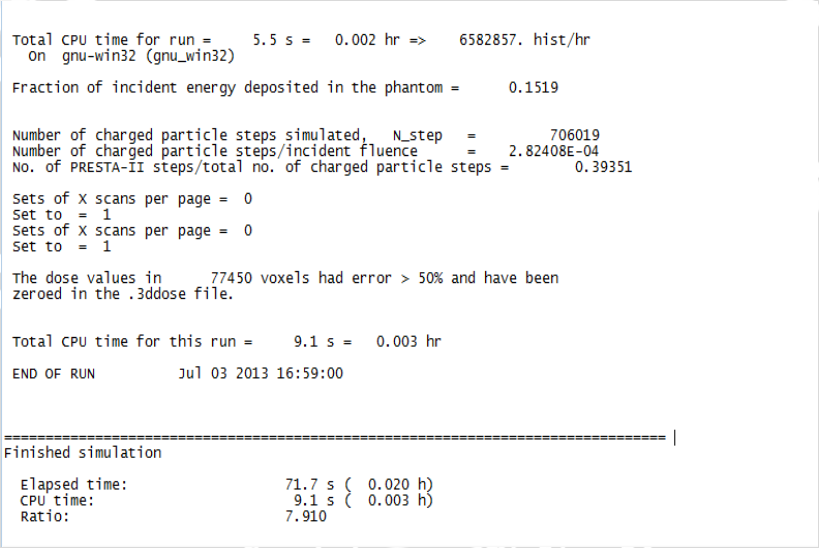


Gambar 3.5 Diagram Urutan Simulasi Besaran Dosimetri. Pemodelan Kepala LINAC dengan *BEAMnrc*, Analisis *phase-space file* dengan *BEAMDP* dan Penentuan Dosis dengan *DOSXYZnrc*

3.5 Analisa Data

3.5.1 Analisis Dosis Serap Energi

Besarnya dosis serap yang diterima pada bahan baik a-Si EPID maupun air dapat diketahui dengan mengalikan fraksi energi dengan insident energi, hasil fraksi energi dapat diperoleh dari keluaran hasil simulasi dari *DOSXYZnrc*



```
 Total CPU time for run =     5.5 s =   0.002 hr =>    6582857. hist/hr
   On  gnu-win32 (gnu_win32)

 Fraction of incident energy deposited in the phantom =      0.1519


 Number of charged particle steps simulated,   N_step   =         706019
 Number of charged particle steps/incident fluence      =    2.82408E-04
 No. of PRESTA-II steps/total no. of charged particle steps =        0.39351

 Sets of X scans per page =  0
 Set to  =  1
 Sets of X scans per page =  0
 Set to  =  1

 The dose values in      77450 voxels had error > 50% and have been
 zeroed in the .3ddose file.


 Total CPU time for this run =     9.1 s =   0.003 hr

 END OF RUN          Jul 03 2013 16:59:00



================================================================================ |
Finished simulation

  Elapsed time:                  71.7 s (  0.020 h)
  CPU time:                       9.1 s (  0.003 h)
  Ratio:                         7.910
```

Gambar 3.6 Contoh Hasil Keluaran Simulasi *DOSXYZnrc*

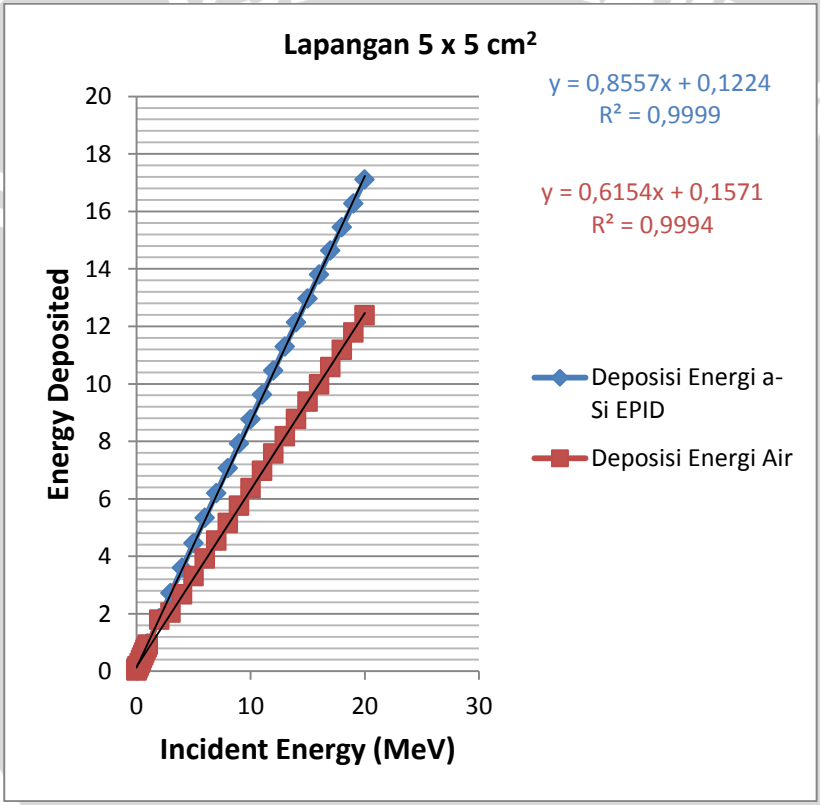
3.5.2.Analisis Ratio Deposisi Dosis Serap.

Rasio deposisi dapat diperoleh dari perbandingan hasil dosis serap antara a-Si EPID dengan air dari perbandingan ini nanti kita dapat melihat hasil rasio pada tiap luasan lapangan.

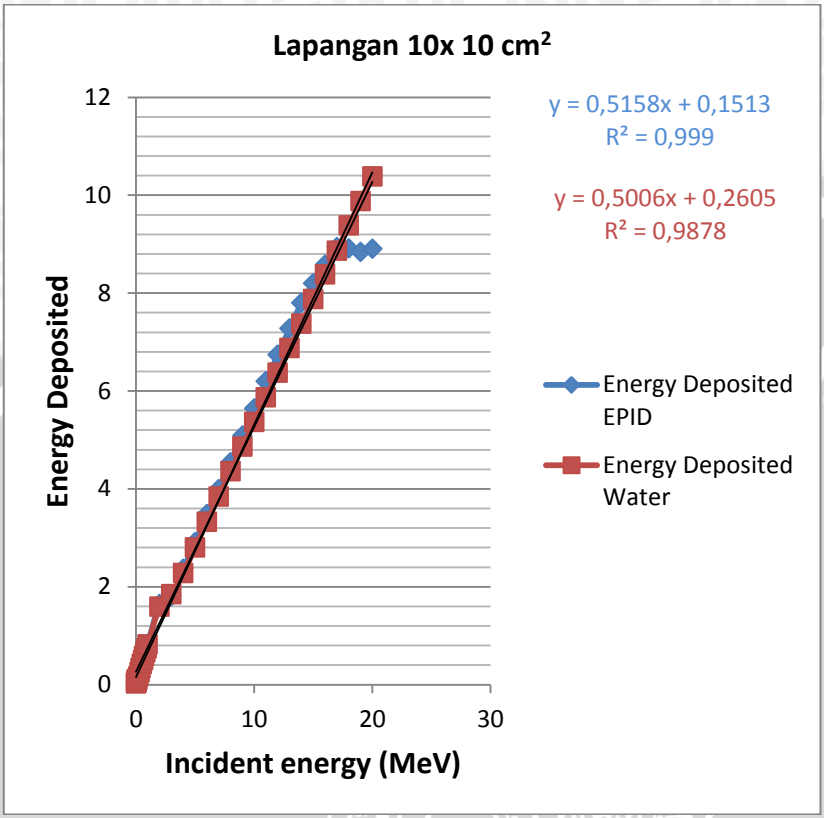
BAB IV

HASIL DAN PEMBAHASAN

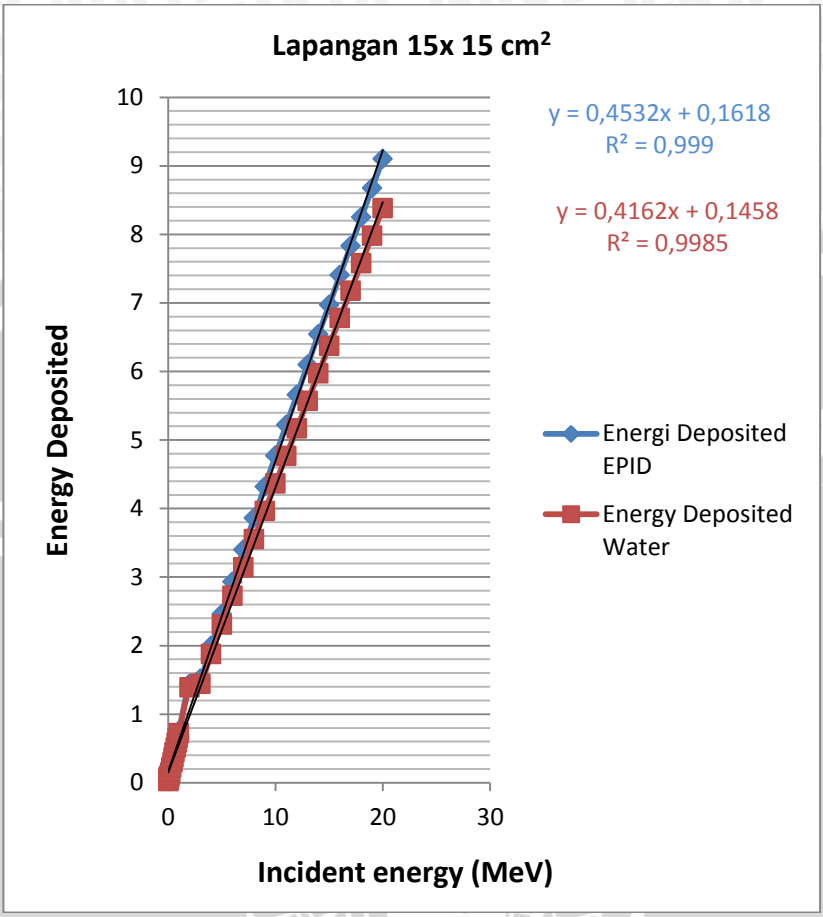
Dari hasil simulasi ini didapatkan grafik hasil dosis serap a-Si EPID dan air pada luasan tiap lapangan. Luas lapangan yang digunakan adalah 5x5 cm^2, 10x10 cm^2, 15x15 cm^2, 20 x 20 cm^2 dan 40 x 40 cm^2.



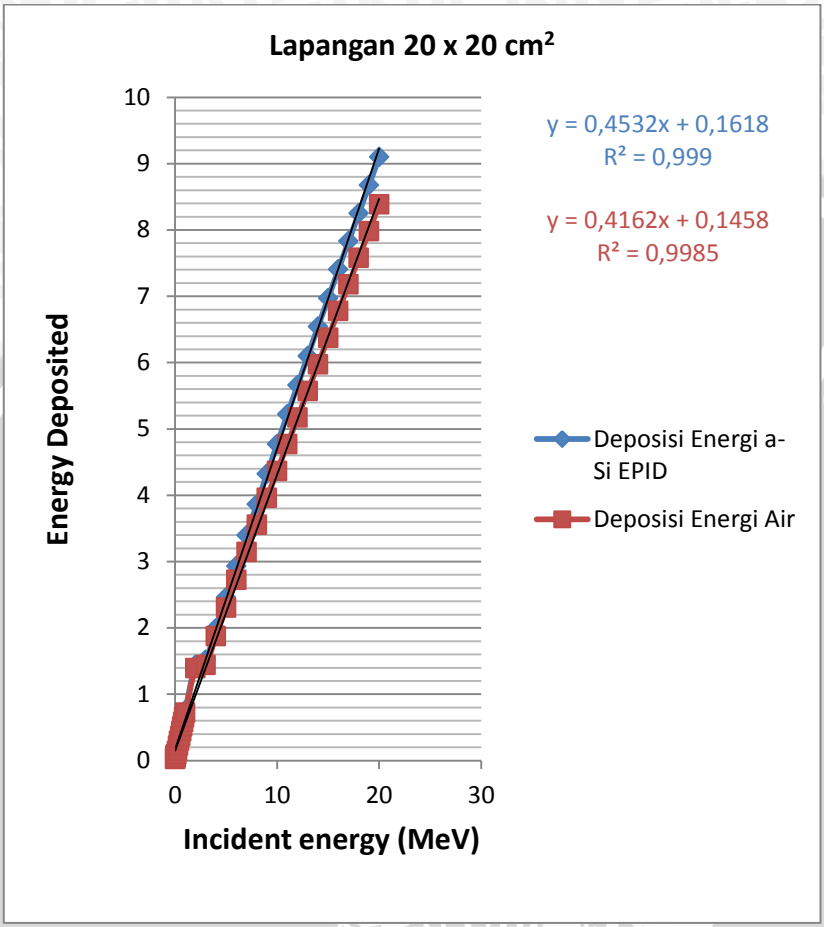
Gambar 4.1 Grafik Hubungan Energi Serap dengan *Incident Energy* pada Luas Lapangan 5 x 5 cm^2



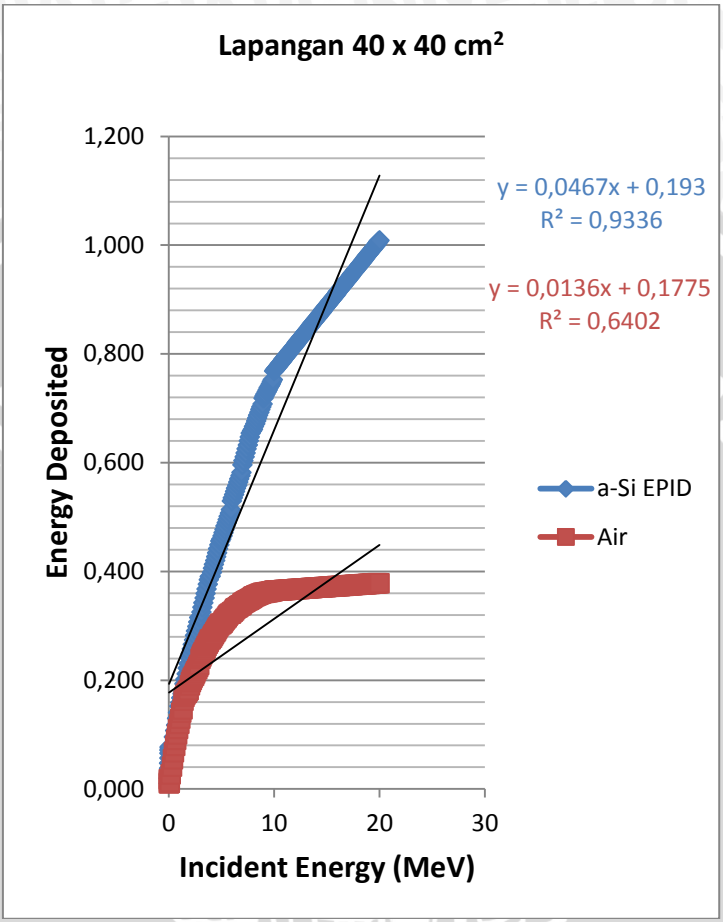
Gambar 4.2 Grafik Hubungan Energi Serap dengan *Incident Energy* pada Luas Lapangan 10 x 10 cm^2



Gambar 4.3 Grafik Hubungan Energi Serap dengan *Incident Energy* pada Luas Lapangan 15 x 15 cm^2



Gambar 4.4 Grafik Hubungan Energi Serap dengan *Incident Energy* pada Luas Lapangan 20 x 20 cm^2



Gambar 4.5 Grafik Hubungan Energi Serap dengan *Incident Energy* pada Luas Lapangan 40 x 40 cm^2

Bahan a-Si EPID memiliki keunggulan dengan penyimpanannya mudah, dapat disimpan dalam bentuk film tipis pada suhu rendah pada berbagai subtrat. Selain itu a-Si EPID juga dapat menghasilkan kualitas gambar yang konsisten dan respon radiasi yang stabil.

Air digunakan sebagai pembanding efektifitas yang diperoleh dari a-Si EPID karena mayoritas tubuh kita terdiri dari air dan darah pada tubuh memiliki kekentalan yang setara dengan kekentalan air.

Pada gambar 4.1 hingga gambar 4.4 untuk *energy deposited* pada a-Si EPID dan air terdapat dua garis linear pada *incident energy* 0,01 - 1 MeV dan 4 - 20 MeV. Pengecualian untuk gambar 4.2 untuk *energy deposited* air garis linear hanya terdapat pada *incident energy* 0,01 - 1 MeV dan 4 - 18 MeV. Pada gambar 4.5 garis linear pada *energy deposited* pada a-Si EPID dan air terdapat beberapa garis linear pada *incident energy* 0,01 - 1,6 MeV, pada 2,7 - 8,4 MeV, pada 9,8 – 13 MeV, pada 13,8 - 15 MeV, pada 16,7 – 20 MeV. Pada gambar 4.5 *incident energy* yang digunakan memiliki selisih 0,1 Me MeV , hal ini berbeda dengan gambar 4.1 hingga gambar 4.4 yang memiliki selisih *incident energy* 1 MeV.

Dari gambar 4.1 hingga 4.5 dapat dilihat hubungan antara energi serap dengan medium a-Si EPID dan air. Didapatkan bahwa semakin besar luas lapangan maka kurva energi serap antara a-Si EPID dan air akan semakin menjauh, hal ini disebabkan oleh dengan semakin luasnya lapangan target maka berkas foton pada target akan semakin tersebar. Dengan adanya perbedaan proses interaksi foton antara penggunaan a-Si EPID dan air meskipun dengan besaran *incident energy* yang sama akan menghasilkan energi serap yang berbeda.

Energi serap yang dihasilkan melalui a-Si EPID cenderung lebih besar dibandingkan dengan air. Dengan bentuk ikatan a-Si EPID yang lebih menjuntai dibandingkan dengan air sehingga ketika foton melewati a-Si EPID maka energi yang hilang atau terhamburkan akan sedikit. Luas lapangan juga sangat berpengaruh terhadap besaran energi serap, semakin luas suatu lapangan radiasi maka energi serapnya akan semakin kecil.

Dengan melihat hasil gambar 4.1 hingga 4.5 maka dapat diperoleh rasio deposisi dosis a-Si EPID model terhadap air, ini dapat dilihat pada tabel 4.1

Tabel 4.1 Hasil Rasio Deposisi Dosis a-Si EPID Model Terhadap Air

Luas Lapangan (cm^2)	Ratio
5 x 5	0,78
10 x 10	0,903
15 x 15	0,86
20 x 20	0,86
40 x 40	0,52

Dari hasil tabel 4.1 dapat dilihat bahwa deposisi dosis dengan penggunaan a-Si EPID model lebih baik dibandingkan dengan menggunakan air.

(halaman ini sengaja dikosongkan)

BAB V
KESIMPULAN

5.1 Kesimpulan

Dari hasil penelitian ini didapatkan bahwa rasio deposisi dosis a-Si EPID model terhadap air untuk lapangan 40 x 40 cm^2 diperoleh 0,52, pada lapangan 20 x 20 cm^2 dan 15 x 15 cm^2 memiliki rasio yang sama yaitu 0,86, pada lapangan 10 x 10 cm^2 hasil rasionya 0,903 dan pada lapangan 5 x 5 cm^2 nilai rasionya turun menjadi 0,78 . Dari hasil pengukuran diperoleh semakin luas lapangan radiasi rasionya semakin besar dan nilai energi serapnya akan semakin kecil.

5.2 Saran

Untuk menghindari hasil output yang tidak sesuai ada baiknya pada saat perancangan simulator dilakukan dengan teliti.

(halaman ini sengaja dikosongkan)

DAFTAR PUSTAKA

Ahnesjo A. and Aspradakis M. M. (1999). *Dose Calculations for External Photon Beams in Rradiotherapy*, Phys. Med. Biol.44

Akhadi M. (2000). *Dasar-dasar Proteksi Radiasi*, Jakarta: Rineka Cipta

Berger M. J. and Wang R. (1988). *Multiple-scattering Angular Deflections and Loss Straggling*, in *Monte Carlo Transport of Electrons and Photons*, edited by T. M.

Butdee C. (Januari 2008), *Modeling of 10 MV Photon Beam From Medical Linear Accelerator Using Monte Carlo Simulation*, Mahidol University Thesis.

Choirul A. (2010). *Simulasi Monte Carlo untuk Kontaminasi Elektron pada Berkas Sinar X 6 MV Produksi Pesawat Linac Elekta SL-15*, Universitas Indonesia, Tesis.

Cunningham, J.R and Johns, H.E. (1983). *The Physics of Radiology*. Charles Thomas Publisher, Springfield, Illinois, U.S.A, Fourth Edition.

Fippel M., Haryanto F., Dohm O., Nusslin F. and Kriesen S. (2003). *A Virtual Photon Energy Fluence Model for Monte Carlo Dose Calculation* Med. Phys. 30301–11

Keall P. J., Siebers J. V., Libby B., Mohan R. (2003). *Determining the Incident Electron Fluence for Monte Carlo-Based Photon Treatment Planning Using a Standart Measured Data Set*, Med Phys 30: 574-82.

Khan, F.M. (2003). *Physics of Radiation Therapy*. Lippincott William and Wilkins. Third Edition.

Metcalfe P., Kron T., Hoban P. (2007). *The Physics of Radiotheraphy Xrays and Electrons*. Madison, Wisconsin: Medical Physics Publishing.

Podgorsak E. B. (2005). *Treatment Machines for External Beam Radiotherapy*, in *Radiation Oncology Physics: A Handbook for Teachers and Students*, edited by Podgorsak E. B., pages 161-217.Vienna, Austia:Publishing Section IAEA.

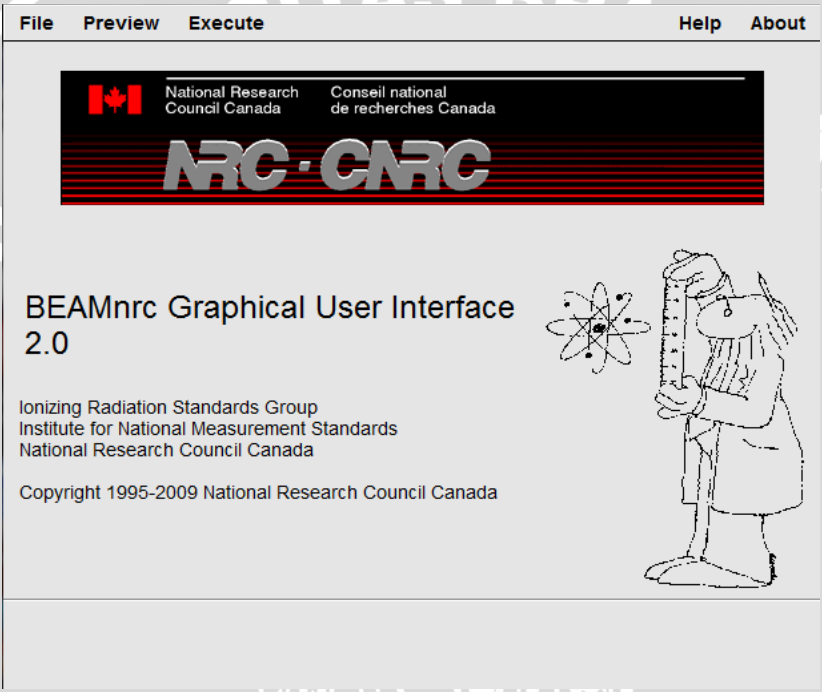
Saw, C. B. (2004). *Foundation of Radiological Physics*. Nebraska: C.B Saw Publishing.

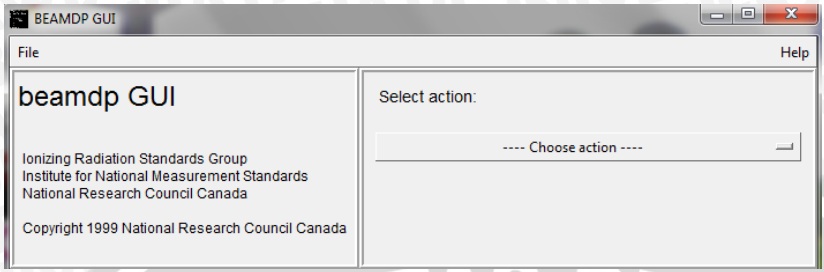
Susworo, R. (2007). *Radioterapi: Dasar-dasar Radioterapi, Tata Laksana Radioterapi penyakit kanker*. Jakarta: UI-Press.

VanDyk J. (2005). "Radiation Oncology Overview." *The Modern Technology of Radiation Oncologi: A Compendium for Medical Physicists and Radiation Oncologist*. Ed. Van Dyk J. Wisconsin: Medical Physics, 1-18.

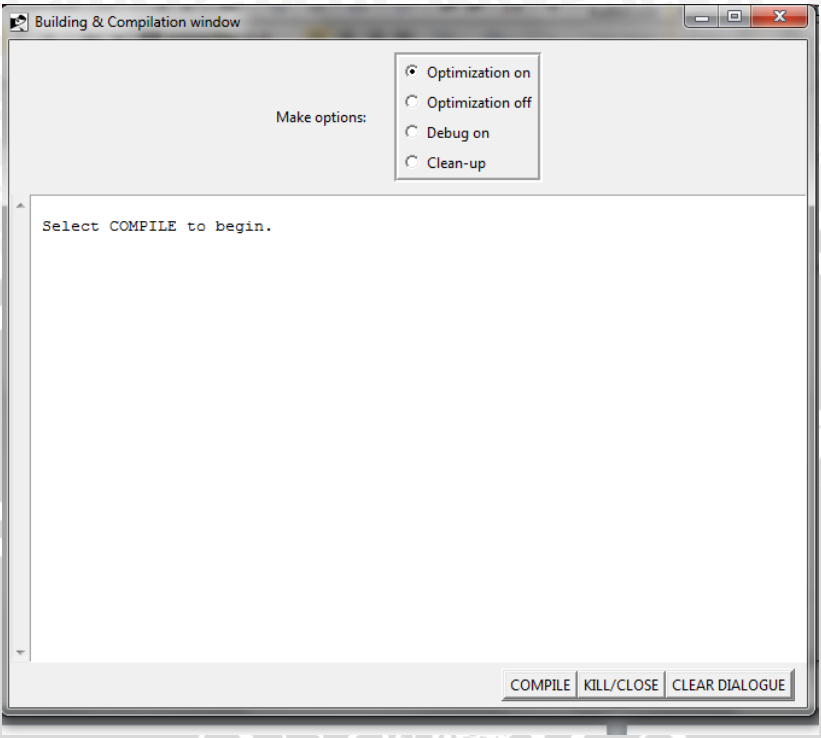
LAMPIRAN

Lampiran I : Tampilan *software BEAMnrc Monte Carlo*




BEAMDP GUI
File
Help
beamdp GUI
Ionizing Radiation Standards Group
Institute for National Measurement Standards
National Research Council Canada
Copyright 1999 National Research Council Canada
Select action:
---- Choose action ----


DOSXYZnrc GUI
File
Run
Help
About
Start a new input file
Load a previous input file
Edit parameters
Save input parameters
Save input parameters as...
Change PEGS4 file
Exit
Conseil national
de recherches Canada
CNRC
DOSXYZnrc Graphical User Interface 1.1
Ionizing Radiation Standards Group
Institute for National Measurement Standards
National Research Council Canada
Copyright 2001 National Research Council Canada


Building & Compilation window
Make options:
Optimization on
Optimization off
Debug on
Clean-up
Select COMPILE to begin.
COMPILE
KILL/CLOSE
CLEAR DIALOGUE

Lampiran II : *Output software BEAMnrc Monte Carlo*

```
Make sure you've saved any changes to the input file before starting!
Select EXECUTE to begin.


================================================================
=============
EGSnrc version 4 for gnu-win32                  Wed Jul 03 16:57:51 2013
================================================================
=============
configuration.....................gnu_win32
user code.....................dosxyznrc
pegs file.....................700icru_a_new2 on HEN_HOUSE
using host.....................WS-05
input file.....................lat_1
output file(s).....................lat_1
================================================================
=============

 Begin execution with large arrays being zeroed
 Thisis only needed for Linux g77 compiler - comment
 this code near the top of dosxyznrc.mortran if you are
 not using a linux g77 compiler


*****************************************************************************
***
 NRCC/UW EGSnrc user-code DOSXYZnrc ($Revision: 1.45 $ last edited $Date: 2009/10/21
21:20:24 $)
 ON gnu-win32 (gnu_win32)                  16:57:52 Jul 03 2013

*****************************************************************************
***
 **                                          **
 **                    DOSXYZnrc                    **
 **                  Z pronounced zed               **
 **                                          **
 **    Code developed at the NationalResearch Council of Canada and      **
 **       University of Wisconsin as part of the OMEGA project        **
 **                                          **
 **       This is $Revision: 1.45 $ last edited $Date: 2009/10/21 21:20:24**
 **                                          **

*****************************************************************************
***

    The following parameters may be adjusted in dosxyz_user_macros.mortran
$MXMED:    Max number of media: 14
$MXSTACK:  Max stack size:     15000
$IMAX,etc: Max dose scoring regions in x,y,z directions:  256  256  756
```

$MAXDOSE: Max dose scoring regions consistent with above:*******
$DOSEZERO(=1) 1=> all doses with uncert > 50% are zeroed in .3ddose file

The following parameters may be adjusted in srcxyz.macros
$INVDIM: number of elements in inverse CPD for input energy spectra = 1000
$NENSRC: number of bins in input energy spectrum = 200

==========

Title: latihan3

==========

Number of media (min = 1, max = 14, 0 => CT data): 8
Medium 1: AIR700ICRU
Medium 2: PMMA700ICRU
Medium 3: CU700ICRU
Medium 4: AL700ICRU
Medium 5: 170C700ICRU
Medium 6: POLYSTY700ICRU
Medium 7: Gadox
Medium 8: amSi

ECUTIN,PCUTIN,(ESTEPE,SMAX--DUMMY INPUTS):
0.700 0.010 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000

regions in x (max= 256),y (max= 256),z (max= 756) directions
(if<0,implies # groups of reg), IPHANT (1 to output a .egsphant
file for dosxyz_show, 0[default] to not output this file)
: -1 -1 -20 0

Input boundaries in the x-direction

Initial boundary: -20.500
Width in this group, number of regions in group: 0.160 256
Boundaries
-20.500 -20.340 -20.180 -20.020 -19.859 -19.699
-19.539 -19.379 -19.219 -19.059 -18.898 -18.738
-18.578 -18.418 -18.258 -18.098 -17.938 -17.777
-17.617 -17.457 -17.297 -17.137 -16.977 -16.816
-16.656 -16.496 -16.336 -16.176 -16.016 -15.855
-15.695 -15.535 -15.375 -15.215 -15.055 -14.895
-14.734 -14.574 -14.414 -14.254 -14.094 -13.934
-13.773 -13.613 -13.453 -13.293 -13.133 -12.973
-12.813 -12.652 -12.492 -12.332 -12.172 -12.012

-11.852 -11.691 -11.531 -11.371 -11.211 -11.051
-10.891 -10.730 -10.570 -10.410 -10.250 -10.090
-9.930 -9.770 -9.609 -9.449 -9.289 -9.129
-8.969 -8.809 -8.648 -8.488 -8.328 -8.168
-8.008 -7.848 -7.688 -7.527 -7.367 -7.207
-7.047 -6.887 -6.727 -6.566 -6.406 -6.246
-6.086 -5.926 -5.766 -5.605 -5.445 -5.285
-5.125 -4.965 -4.805 -4.645 -4.484 -4.324
-4.164 -4.004 -3.844 -3.684 -3.523 -3.363
-3.203 -3.043 -2.883 -2.723 -2.563 -2.402
-2.242 -2.082 -1.922 -1.762 -1.602 -1.441
-1.281 -1.121 -0.961 -0.801 -0.641 -0.480
-0.320 -0.160 0.000 0.160 0.320 0.480
0.641 0.801 0.961 1.121 1.281 1.441
1.602 1.762 1.922 2.082 2.242 2.402
2.563 2.723 2.883 3.043 3.203 3.363
3.523 3.684 3.844 4.004 4.164 4.324
4.484 4.645 4.805 4.965 5.125 5.285
5.445 5.605 5.766 5.926 6.086 6.246
6.406 6.566 6.727 6.887 7.047 7.207
7.367 7.527 7.688 7.848 8.008 8.168
8.328 8.488 8.648 8.809 8.969 9.129
9.289 9.449 9.609 9.770 9.930 10.090
10.250 10.410 10.570 10.730 10.891 11.051
11.211 11.371 11.531 11.691 11.852 12.012
12.172 12.332 12.492 12.652 12.813 12.973
13.133 13.293 13.453 13.613 13.773 13.934
14.094 14.254 14.414 14.574 14.734 14.895
15.055 15.215 15.375 15.535 15.695 15.855
16.016 16.176 16.336 16.496 16.656 16.816
16.977 17.137 17.297 17.457 17.617 17.777
17.938 18.098 18.258 18.418 18.578 18.738
18.898 19.059 19.219 19.379 19.539 19.699
19.859 20.020 20.180 20.340 20.500

Input boundaries in the y-direction

Initial boundary: -20.500
Width in this group, number of regions in group: 0.160 256
Boundaries
-20.500 -20.340 -20.180 -20.020 -19.859 -19.699
-19.539 -19.379 -19.219 -19.059 -18.898 -18.738
-18.578 -18.418 -18.258 -18.098 -17.938 -17.777
-17.617 -17.457 -17.297 -17.137 -16.977 -16.816
-16.656 -16.496 -16.336 -16.176 -16.016 -15.855
-15.695 -15.535 -15.375 -15.215 -15.055 -14.895
-14.734 -14.574 -14.414 -14.254 -14.094 -13.934
-13.773 -13.613 -13.453 -13.293 -13.133 -12.973
-12.813 -12.652 -12.492 -12.332 -12.172 -12.012
-11.852 -11.691 -11.531 -11.371 -11.211 -11.051
-10.891 -10.730 -10.570 -10.410 -10.250 -10.090
-9.930 -9.770 -9.609 -9.449 -9.289 -9.129
-8.969 -8.809 -8.648 -8.488 -8.328 -8.168

-8.008	-7.848	-7.688	-7.527	-7.367	-7.207
-7.047	-6.887	-6.727	-6.566	-6.406	-6.246
-6.086	-5.926	-5.766	-5.605	-5.445	-5.285
-5.125	-4.965	-4.805	-4.645	-4.484	-4.324
-4.164	-4.004	-3.844	-3.684	-3.523	-3.363
-3.203	-3.043	-2.883	-2.723	-2.563	-2.402
-2.242	-2.082	-1.922	-1.762	-1.602	-1.441
-1.281	-1.121	-0.961	-0.801	-0.641	-0.480
-0.320	-0.160	0.000	0.160	0.320	0.480
0.641	0.801	0.961	1.121	1.281	1.441
1.602	1.762	1.922	2.082	2.242	2.402
2.563	2.723	2.883	3.043	3.203	3.363
3.523	3.684	3.844	4.004	4.164	4.324
4.484	4.645	4.805	4.965	5.125	5.285
5.445	5.605	5.766	5.926	6.086	6.246
6.406	6.566	6.727	6.887	7.047	7.207
7.367	7.527	7.688	7.848	8.008	8.168
8.328	8.488	8.648	8.809	8.969	9.129
9.289	9.449	9.609	9.770	9.930	10.090
10.250	10.410	10.570	10.730	10.891	11.051
11.211	11.371	11.531	11.691	11.852	12.012
12.172	12.332	12.492	12.652	12.813	12.973
13.133	13.293	13.453	13.613	13.773	13.934
14.094	14.254	14.414	14.574	14.734	14.895
15.055	15.215	15.375	15.535	15.695	15.855
16.016	16.176	16.336	16.496	16.656	16.816
16.977	17.137	17.297	17.457	17.617	17.777
17.938	18.098	18.258	18.418	18.578	18.738
18.898	19.059	19.219	19.379	19.539	19.699
19.859	20.020	20.180	20.340	20.500	

Input boundaries in the z-direction

Initial boundary: 55.000

Width in this group, number of regions in group:	43.100	1
Width in this group, number of regions in group:	3.800	1
Width in this group, number of regions in group:	55.200	1
Width in this group, number of regions in group:	0.300	1
Width in this group, number of regions in group:	1.600	1
Width in this group, number of regions in group:	0.075	1
Width in this group, number of regions in group:	0.570	1
Width in this group, number of regions in group:	0.100	1
Width in this group, number of regions in group:	0.084	1
Width in this group, number of regions in group:	0.052	1
Width in this group, number of regions in group:	0.054	1
Width in this group, number of regions in group:	0.110	1
Width in this group, number of regions in group:	0.300	1
Width in this group, number of regions in group:	0.200	1
Width in this group, number of regions in group:	1.520	1
Width in this group, number of regions in group:	0.380	1
Width in this group, number of regions in group:	0.650	1
Width in this group, number of regions in group:	0.300	1
Width in this group, number of regions in group:	3.400	1

```
Width in this group, number of regions in group:       0.200    1
Boundaries
    55.000     98.100    101.900    157.100    157.400    159.000
   159.075    159.645    159.745    159.829    159.881    159.935
   160.045    160.345    160.545    162.065    162.445    163.095
   163.395    166.795    166.995

Total # regions including exterior =   1310721

Input groups of regions for which density and medium are not defaults
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)(  1   1)  1    0.001
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)(  2   2)  1    0.001
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)(  3   3)  1    0.001
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)(  4   4)  6    1.030
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)(  5   5)  1    0.001
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)(  6   6)  4    2.700
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)(  7   7)  1    0.001
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)(  8   8)  3    8.960
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)(  9   9)  1    0.001
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 10  10)  5    2.050
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 11  11)  7    3.670
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 12  12)  8    2.540
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 13  13)  5    1.600
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 14  14)  4    2.700
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 15  15)  1    0.001
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 16  16)  3    3.950
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 17  17)  1    0.001
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 18  18)  4    2.700
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 19  19)  1    0.001
Lower,upper i, j, k,  MEDIUM, DENSITY (  1 256)(  1 256)( 20  20)  6    1.030
Lower,upper i, j, k,  MEDIUM, DENSITY
  Found blank line => end of this input


Input groups of regions for which ECUT and PCUT are not defaults
NB This option is disabled, just input 8 zeros.
Dummy values of lower,upper i, j, k,  ECUT, PCUT
  Found blank line => end of this input


Enter 8 numbers on one line
 3 pairs defininglower,upper x,y,z indicies of dose regions
          for which results are to be output
 IZSCAN:      non-zero for z-scan/page
 MAX20:       if any one = 1, output summary of max 20 doses.
 end signaled by first pair both zero
 forno dose printed, MAX20 is still read from first line

     1 168    84  84    12  12    0    0
     1 168    83  83    12  12    0    0
     1 168    85  85    12  12    1    0
 Found blank line => end of this input
```

Source configuration

(0) Parallel, rectangular beam incident from the front
Requires 9 inputs:
charge (-1,0,1),
0 (mandatory, to identify source type),
lower x-coordinate of the beam (cm),
upper x-coordinate of the beam (cm),
lower y-coordinate of the beam (cm),
upper y-coordinate of the beam (cm),
angle of beam with respect to the positive x-axis (degrees),
angle of beam with respect to the positive y-axis (degrees),
angle of beam with respect to the negative z-axis (degrees)
(angles default to 90,90,0--incident on front of phantom)

or (1) Parallel, rectangular beam incident from any direction
Requires 10 inputs:
charge (-1,0,1),
1 (mandatory, to identify source type),
x-coordinate of the isocenter (cm),
y-coordinate of the isocenter (cm),
z-coordinate of the isocenter (cm),
angle between +z direction and the line joining the
center of the beam (collimator) to the isocenter
--called the polar angle(degrees),
angle between +x direction and the projection of the
line joining the center of the beam (collimator)
to the isocenter on the xy plane--called the azimuthal
angle (degrees),
total x-widthof the beam in the plane perpendicular
to the beam direction (cm),
total y-width of the beam in the plane perpendicular
to the beam direction (cm),
angle by which the collimator is rotated in the
collimator plane perpendicular to the beam
direction (degrees),
(+ve rotation is counterclockwise looking along
the beam direction

or (2) Full phase-space of each particle
Requires 9 inputs plus data stored in units 43 and 44:
charge (-1 electron,0 photon,1 positron, 2 all),
2 (mandatory, to identify source type),
x-coordinateof the isocenter (cm),
y-coordinate of the isocenter (cm),
z-coordinate of the isocenter (cm),
angle between +z direction and the line joining the
origin in the phase space plane to the isocenter
--called the polar angle(degrees),
angle between +x direction and the projection of the
line joining the origin in the phase space plane
tothe isocenter on the xy plane--called the azimuthal

angle (degrees),
absolute distance from the isocenter to the origin
in the phase space plane
angle by which the source is rotated in the
phase space plane perpendicular to the beam
direction (degrees),
(+ve rotation is counterclockwise looking down
from the origin in the phase space plane),
i_dbs--set to 1 if DBS was used in BEAM simulation used
to generate the phsp source and you want to reject fat
photons, 0 otherwise,
DBS splitting radius (cm),
SSD at which splitting radius defined (cm),
Z at which phsp source collected (cm),
No. of times to split charged particles.

or (3) Point, rectangular beam incident from the front
Requires 7 inputs:
charge (-1,0,1),
3 (mandatory, to identify source type),
lower x-coordinate of the beam (cm),
upper x-coordinate of the beam (cm),
lower y-coordinate of the beam (cm),
upper y-coordinate of the beam (cm),
distance to the plane (cm),

or (6) Uniform isotropically radiating parallelepiped within
the phantom
Requires 8 inputs:
charge (-1,0,1),
6 (mandatory, to identify source type),
lower x-coordinate of active volume (cm)
upper x-coordinate of active volume (cm),
lower y-coordinate of active volume (cm)
upper y-coordinate of active volume (cm),
lower z-coordinate of active volume (cm)
upper z-coordinate of active volume (cm)

or (7) Parallel beam incident from multiple, user-selected angles
Requires 9 inputs on this line:
charge (-1,0,1),
7 (mandatory, to identify source type),
x-coordinate of the isocenter (cm),
y-coordinate of the isocenter (cm),
z-coordinate of the isocenter (cm),
number of incident theta-phi pairs or -ve number of
groups of incident theta-phi pairs where, within a group
only theta or phi can vary, the varying angles are
evenly distributed and have equal probability,
total x-width of the beam in the plane perpendicular
to the beamdirection (cm),
total y-width of the beam in the plane perpendicular
to the beam direction (cm),

angle by which the collimator is rotated in the
collimator plane perpendicular to the beam
direction (degrees),
(+ve rotation is counterclockwise looking along
thebeam direction

or (8) Full phase-space incident from multiple angles
Requires 8 inputs on this line and data stored in units 43,44:
charge (-1 electron,0 photon,1 positron, 2all),
2 (mandatory, to identify source type),
x-coordinate of the isocenter (cm),
y-coordinate of the isocenter (cm),
z-coordinate of the isocenter (cm),
number of incident theta-phi pairs or -ve number of
groups of incident theta-phi pairs where, within a group
only theta or phi can vary, the varying angles are
evenly distributed and have equal probability,
absolute distance from the isocenter to the origin
in the phase space plane
angle by which the source is rotated in the
phase space plane perpendicular to the beam
direction (degrees),
(+ve rotation is counterclockwise looking down
from the origin in the phase space plane),
i_dbs--set to 1 if DBS was used in BEAM simulation used
to generate the phsp source and you want to reject fat
photons, 0 otherwise,
DBS splitting radius (cm),
SSD at which splitting radius defined(cm),
Z at which phsp source collected (cm)
No. of times to split charged particles.

or (9) BEAM simulation of treatment head
Requires 11 inputs plus name of accelerator simulation,
input file used in accelerator simulation, and pegs4
data used in accelerator simulation:
charge (-1 electron,0 photon,1 positron, 2 all),
9 (mandatory, to identify source type),
x-coordinate of the isocenter (cm),
y-coordinate of the isocenter (cm),
z-coordinate of the isocenter (cm),
angle between beam central axis and +z axis in DOSXYZ
geometry--called the polar angle(degrees),
angle between +x direction in DOSXYZ geometry and
beam central axis projected on the DOSXYZ xy plane
--called the azimuthal angle (degrees),
absolute distance from the isocenter to centre of
scoring plane in BEAM simulation,
angle to rotate BEAM simulation about its central
axis (degrees) (+ve rotation is counterclockwise
looking down the axis),
i_dbs--set to 1 if DBS is being used in BEAM simulation
and you want to reject fat photons, 0 otherwise,

No. of times to split charged particles.

or (10) BEAM simulation source incident from multiple angles
Requires 10 inputs plus name of accelerator simulation,
input file used in accelerator simulation,and pegs4
data used in accelerator simulation:
charge (-1 electron,0 photon,1 positron, 2 all),
9 (mandatory, to identify source type),
x-coordinate of the isocenter (cm),
y-coordinate of the isocenter (cm),
z-coordinate of the isocenter (cm),
number of incident theta-phi pairs or -ve number of
groups of incident theta-phi pairs where, within a group
only theta or phi can vary, the varying angles are
evenly distributed and have equal probability,
absolute distance from the isocenter to centre of
scoring plane in BEAM simulation,
angle to rotate BEAM simulation about its central
axis (degrees) (+ve rotation is counterclockwise
looking down the axis),
i_dbs--set to 1 if DBS is being used in BEAM simulation
and you want to reject fat photons, 0 otherwise,
No. of times to splitcharged particles.

All inputs on one line:
Parallel beam incident from the front(+ve z-axis)
Electric charge of the source: 0
x-boundaries: -0.0010 cm -- 0.0010 cm
y-boundaries: -0.0010cm -- 0.0010 cm
Angle relative to +x: 90.0000
Anglerelative to +y: 90.0000
Angle relative to -z: 0.0000

Enflag(0=mono-E,1=spectr,2=phsp or full BEAM sim.,3=dosecomp,4=beam model),
Mode(0,2), medsur(0 = vacuum), dsurround(1), dflag(0=1 dsurround,
1=4 dsurrounds), dsurround(2), dsurround(3), dsurround(4)
: 0 0 0 0.000 0
Beam Energy (K.E. in MeV): 1.000

NCASE,IWATCH,TIMMAX,INSEED1,INSEED2,BEAM_SIZE,ISMOOTH,IRESTART,IDA
T,
IREJECT,ESAVE_GLOBAL,NRCYCL,IPARALLEL,PARNUM,n_split,ihowfarless
:
10000 0 100.00 23 975 100.00 0 0 0 0 0.00 0 0 0 10 0

Index ranges of beam field

```
   -0.001     0.001   i index ranges over i=128 to 129
   -0.001     0.001   j index ranges over j=128 to 129

 Angle of beam to
  axes(in deg, 90,90,0 is normal):       90.00     90.00      0.00 deg

 Starting a new calculation

 Store intermediate files for each batch

********************************************************************************
***

       Summary of source parameters (srcxyznrc $Revision: 1.25 $)

********************************************************************************
***

              Parallel beam incident from the front(+ve z-axis)

                 Electric charge of the source:        0
                 x-boundaries:       -0.0010 cm-    0.0010 cm
                 y-boundaries:       -0.0010 cm-    0.0010 cm
                 Angle relative to +x:            90.0000 degrees
                 Angle relative to +y:            90.0000 degrees
                 Angle relative to -z:            0.0000 degrees


****************** Warning:
File C:\egsnrc_mp\dosxyznrc\egsrun_992_lat_1_WS-05\lat_1.errors
 is already opened and connected to unit  15
 Will not try to re-open this file, assuming it has been opened
 by specifying it in the .io file.



 Bound Compton start region
  Setting all to  0
 Rayleigh start region
  Setting all to  0
 Relaxations start region
  Setting all to  0
 PE sampling start region
  Setting all to  0


 Call hatch
 ----------

 Found medium with gas pressure
 Rayleigh data available for medium  7 in PEGS4 data set.
```

```
 Rayleigh data available for medium  8 in PEGS4 data set.


(Re)-initializing photon cross section data
Using data files from the series si

Photon cross sections: si Compton cross sections: default
Working on medium   1 ... OK
Working on medium   2 ... OK
Working on medium   3 ... OK
Working on medium   4 ... OK
Working on medium   5 ... OK
Working on medium   6 ... OK
Working on medium   7 ... OK
Working on medium   8 ... OK
  old PRESTA calculates default min. step-size for BCA:
     minimum ECUT found:   0.7
     default BLCMIN is:   4.16161154
     this corresponds to   64.1748594 elastic MFPs
  Reading screened Rutherford MS data ..... done


Reading spin data base from C:\HEN_HOUSE\data\spinms.data
EGSnrc spin data, version 2.0
Data generated on a machine with 1234 endianess
The endianess of this CPU is 1234
Ranges:      1.00   100.00  0.30054  1.00000


  medium    1 ..... done
  medium    2 ..... done
  medium    3 ..... done
  medium    4 ..... done
  medium    5 ..... done
  medium    6 ..... done
  medium    7 ..... done
  medium    8 ..... done

  Medium  1 sige =   0.358165483  0.353042079 monotone =  F T
  Medium  2 sige =   0.424200577  0.417696255 monotone =  T T
  Medium  3 sige =   0.967714609  0.960653957 monotone =  T T
  Medium  4 sige =   0.590715662  0.584002525 monotone =  T T
  Medium  5 sige =   0.434137554  0.427544508 monotone =  T T
  Medium  6 sige =   0.410003831  0.40353657 monotone =  T T
  Medium  7 sige =   1.39184498  1.38497619 monotone =  T T
  Medium  8 sige =   7.19754811  6.93248838 monotone =  F F

  Initializing tmxs for estepe =   0.25 and ximax =   0.5

Output from subroutine EDGSET:
==============================
Atomic relaxations not requested!
```

Bound Compton scattering not requested!

EGSnrc SUCCESSFULLY 'HATCHED' FOR 8 MEDIA.

==========

Electron/Photon transport parameter

==========

Photon cross sections	si
Compton cross sections	default
Photon transport cutoff(MeV)	0.1000E-01
Pair angular sampling	SIM
Pair cross sections	BH
Triplet production	Off
Bound Compton scattering	OFF
Radiative Compton corrections	Off
Rayleigh scattering	OFF
Atomic relaxations	OFF
Photoelectron angular sampling	OFF
Electron transport cutoff(MeV)	0.7000
Bremsstrahlung cross sections	BH
Bremsstrahlung angular sampling	SIM
Spin effects	On
Electron Impact Ionization	OFF
Maxium electron step in cm (SMAX)	5.000
Maximum fractional energy loss/step (ESTEPE)	0.2500
Maximum 1st elastic moment/step (XIMAX)	0.5000
Boundary crossing algorithm	PRESTA-I
Skin-depth for boundary crossing (MFP)	64.17
Electron-step algorithm	PRESTA-II

==========

Medium	AE	AP
AIR700ICRU	0.700	0.010
PMMA700ICRU	0.700	0.010
CU700ICRU	0.700	0.010
AL700ICRU	0.700	0.010
170C700ICRU	0.700	0.010
POLYSTY700ICRU	0.700	0.010
Gadox	0.700	0.010
amSi	0.521	0.010

No range rejection.

Photons will be split 10 times

```
************************************************************

 Histories to be simulated for this run        10000

 Histories to be analyzed after this run       10000

************************************************************
 Elapsed wall clock time to this point=      28.890 s

 CPU time so far for this run =      1.672 s

BATCH #  TIME-ELAPSED  TOTAL CPUTIME  RATIO  TIME OF DAY  RNG pointers

   1        0.0          0.0      0.00   16:58:20   ixx jxx =   97  33
   2        1.1          0.5      2.48   16:58:21   ixx jxx =   92  28
   3        1.7          1.0      1.73   16:58:22   ixx jxx =   27  60
   4        2.3          1.5      1.51   16:58:22   ixx jxx =   50  83
   5        2.9          2.1      1.39   16:58:23   ixx jxx =   93  29
   6        3.5          2.7      1.31   16:58:24   ixx jxx =   91  27
   7        4.2          3.3      1.26   16:58:24   ixx jxx =   30  63
   8        5.1          4.0      1.28   16:58:25   ixx jxx =   42  75
   9        6.0          4.6      1.29   16:58:26   ixx jxx =   39  72
  10        6.7          5.4      1.25   16:58:27   ixx jxx =   53
86C:\egsnrc_mp\dosxyznrc\egsrun_992_lat_1_WS-05\egsrun_992_lat_1_WS-05_junk
C:\egsnrc_mp\dosxyznrc\egsrun_992_lat_1_WS-05\lat_1.3ddose
C:\egsnrc_mp\dosxyznrc\egsrun_992_lat_1_WS-05\lat_1.egsdat
C:\egsnrc_mp\dosxyznrc\egsrun_992_lat_1_WS-05\lat_1.egslst
C:\egsnrc_mp\dosxyznrc\egsrun_992_lat_1_WS-05\lat_1.errors


 Total CPU time for run =      5.5 s =   0.002 hr =>    6582857. hist/hr
  On  gnu-win32 (gnu_win32)

 Fraction of incident energy deposited in the phantom =      0.1519


 Number of charged particle steps simulated,  N_step  =        706019
 Number of charged particle steps/incident fluence     =    2.82408E-04
 No. of PRESTA-II steps/total no. of charged particle steps =        0.39351

 Sets of X scans per page =  0
 Set to  =  1
 Sets of X scans per page =  0
 Set to  =  1

 The dose values in      77450 voxels had error > 50% and have been
 zeroed in the .3ddose file.
```

Total CPU time for this run = 9.1 s = 0.003 hr

END OF RUN Jul 03 2013 16:59:00

==========
Finished simulation

Elapsed time: 71.7 s (0.020 h)
CPU time: 9.1 s (0.003 h)
Ratio: 7.910

End of run Wed Jul 03 16:59:00 2013
==========

Fraction of incident energy deposited in the phantom = 0.0285

Number of charged particle steps simulated, N_step = 55320735
Number of charged particle steps/incident fluence = 2.21283E-01
No. of PRESTA-II steps/total no. of charged particle steps = 0.51886

Sets of X scans per page = 0
Set to = 1
Sets of X scans per page = 0
Set to = 1

The dose values in 70242 voxels had error > 50% and have been zeroed in the .3ddose file.

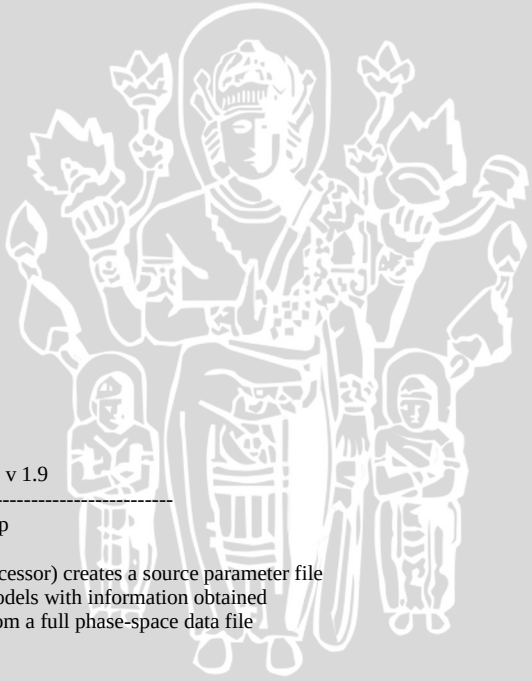
Total CPU time for this run = 47.8 s = 0.013 hr

END OF RUN Jul 05 2013 02:39:30

```
============================================================
============
Finished simulation

 Elapsed time:          48.2 s (  0.013 h)
 CPU time:              47.8 s (  0.013 h)
 Ratio:                1.008

End of run                          Fri Jul 05 02:39:30 2013
============================================================
============
```



```
 Running beamdp...


 Running BEAMDP, Version v 1.9
 ------------------------------------------------------------
 Type ? at any prompt for help

 BEAMDP (BEAM Data Processor) creates a source parameter file
 for beam characterization models with information obtained
 from the user and derived from a full phase-space data file
 created by BEAM

 This programme can be used to derive planar fluence, spectrum,
 mean energy and angle distribution, etc., from a phase-space
 file created by BEAM.

 Ifyou are not familiar with this programme, you can get an
 explanation before any input request. Otherwise, the prompts
 will be terse.
```

```
However, you can get help by typing a ? to any prompt.

Do you wish more detailed information about the file created
by the program?  (y/n[Default])=>
Input a number for the operation required:
***********************************************

(0) - Process data for beam characterization models
(1) - Derive fluence vs position from ph-sp data
(2) - Derive energy fluence vs position from ph-sp data
(3) - Derive spectral distribution from ph-sp data
(4) - Derive energy fluence distribution from ph-sp data
(5) - Derive mean energy distribution from ph-sp data
(6) - Derive angular distribution from ph-sp data
(7) - Derive ZLAST distribution from ph-sp data
(8) - Derive distribution of particle weights from ph-spdata
(9) - Derive X-Y scatter plot of particles from ph-sp data
(10) - Combine two ph-sp files into one
(11) - List parameters for a number of ph-sp particles
(12) - Quit

Number(default=100), IQ(-1,0,1,2,3) =?

IQ = 0 (only for photons)

Name of file containing phase space data (with ext., < A100):
 File name input
is:C:/egsnrc_mp/BEAM_Elekta6X_PAH/PAH_IMRT_987999_6X_f1b7p9.egsphsp1

First, try to open it as a MODE0 file

        TOTAL NUMBER OF PARTICLES IN FILE:          33
             TOTAL NUMBER OF PHOTONS:          33
THE REST ARE ELECTRONS/POSITRONS.

    MAXIMUM KINETIC ENERGY OF THE PARTICLES:       5.218 MeV
    MINIMUM KINETIC ENERGY OF THE ELECTRONS:       0.000 MeV
 # OF INCIDENT PARTICLES FROM ORIGINAL SOURCE:        100.0

 ENERGY  IQ    X      Y      U      V      W    WEIGHT      LATCH (set=1, not set=0)

  4.526   0  -3.493   0.508 -0.062  0.007  0.998 1.000E-03  01101 10000000001010111111110111
  0.938   0  -0.469   1.187 -0.007  0.019  1.000 1.000E-03  01101 10000000001010111111110111
  0.323   0   0.016   1.156  0.001  0.021  1.000 1.000E-03  01101 10000000001010111111110111
  0.747   0  -1.052   0.827 -0.019  0.015  1.000 1.000E-03  01101 10000000001010111111110111
  2.044   0   1.622   1.680  0.030  0.031  0.999 1.000E-03  01101 10000000001010111111110111
  0.837   0  -0.543  -1.215 -0.010 -0.022  1.000 1.000E-03  01101
10000000001010111111110111
  2.372   0   0.914   1.468  0.017  0.027  0.999 1.000E-03  01101 10000000001010111111110111
  1.470   0  -0.566   1.358 -0.010  0.025  1.000 1.000E-03  01101 10000000001010111111110111
  1.314   0  -1.324  -0.536 -0.024 -0.009  1.000 1.000E-03  01101
10000000001010111111110111
  2.130   0  -1.485   0.534 -0.027  0.010  1.000 1.000E-03  01101 10000000001010111111110111
```

```
 2.374   0  -0.324   0.690 -0.006  0.013  1.000 1.000E-03  01101 10000000001010111111110111
 0.922   0  -0.471  -1.092 -0.008 -0.019  1.000 1.000E-03  01101
10000000001010111111110111
 0.541   0  -0.670   1.168 -0.013  0.021  1.000 1.000E-03  01101 10000000001010111111110111
 0.439   0  -0.632   0.905 -0.012  0.016  1.000 1.000E-03  01101 10000000001010111111110111
 5.218   0  -1.227   0.213 -0.023  0.003  1.000 1.000E-03  01101 10000000001010111111110111
 1.327   0   0.174  -1.622  0.003 -0.030  1.000 1.000E-03  01101 10000000001010111111110111
 0.962   0  -1.002  -1.313 -0.019 -0.025  1.000 1.000E-03  01101
10000000001010111111110111
 0.714   0  -0.086   1.357 -0.002  0.024  1.000 1.000E-03  01101 10000000001010111111110111
 2.093   0   0.882   1.520  0.016  0.028  0.999 1.000E-03  01101 10000000001010111111110111
 2.814   0  -0.341  -1.310 -0.007 -0.023  1.000 1.000E-03  01101
10000000001010111111110111

 ENERGY  IQ     X      Y     U      V      W    WEIGHT       LATCH (set=1, not set=0)

 2.080   0  -0.712  -1.583 -0.014 -0.029  0.999 1.000E-03  01101
10000000001010111111110111
 5.040   0  -1.282  -0.834 -0.024 -0.015  1.000 1.000E-03  01101
10000000001010111111110111
 2.385   0  -1.482  -0.027 -0.027  0.000  1.000 1.000E-03  01101 10000000001010111111110111
 5.037   0  -1.325  -0.493 -0.024 -0.008  1.000 1.000E-03  01101
10000000001010111111110111
 0.333   0  -0.269   1.613 -0.005  0.030  1.000 1.000E-03  01101 10000000001010111111110111
 2.594   0  -0.705   1.325 -0.013  0.025  1.000 1.000E-03  01101 10000000001010111111110111
 1.314   0  -0.283  -0.891 -0.005 -0.017  1.000 1.000E-03  01101
10000000001010111111110111
 3.918   0   1.726   1.533  0.032  0.027  0.999 1.000E-03  01101 10000000001010111111110111
 1.343   0   2.010   1.627  0.037  0.029  0.999 1.000E-03  01101 10000000001010111111110111
 0.500   0  -0.505  -1.293 -0.009 -0.024  1.000 1.000E-03  01101
10000000001010111111110111
 1.583   0   0.025  -0.936  0.001 -0.018  1.000 1.000E-03  01101 10000000001010111111110111
 5.197   0  -0.724  -1.598 -0.013 -0.030  0.999 1.000E-03  01101
10000000001010111111110111
 4.604   0  -3.199  -0.537 -0.058 -0.011  0.998 1.000E-03  01101
10000000001010111111110111

 BYE!
```

==========

```
EGSnrc version 4 for gnu-win32                Wed Jul 03 11:37:36 2013
================================================================================
configuration.....................gnu_win32
user code.....................BEAM_Elekta6X_PAH
pegs file.....................700icru_a_new2 on HEN_HOUSE
using host.....................DHIEKNET06-PC
input file.....................PAH_IMRT_987999_6X_f1b7p9
output file(s).....................PAH_IMRT_987999_6X_f1b7p9
================================================================================


 BEAMnrc  Vnrc(Rev 1.78 of 2004-01-12 11:44:06-05),(USER_MACROS Rev 1.5)
 ON gnu-win32 (gnu_win32) WITH EGSnrc.                11:37:36 Jul 03 2013


 The following internal parameters are set:
 Max number of CMs: 20                Max number of media  12
 Max number of regions: 250           Max stack:     10000
 Max bremsstrahlung split:      2000   Max number dose zones:  50
 Max number of scoring planes:  3      Max number of scoring zones:   5
 Max number dose components: 12        Minimum air gap:      0.0100 cm
   All of above can be adjusted in beamnrc_user_macros.mortran


****************** Warning:
File
C:\egsnrc_mp\BEAM_Elekta6X_PAH\egsrun_5428_PAH_IMRT_987999_6X_f1b7p9_DHIE
KNET06-PC\PAH_IMRT_987999_6X_f1b7p9.egslst
 is already opened and connected to unit   1
 Will not try to re-open this file, assuming it has been opened
 by specifying it in the .io file.


 TITLE: PA3_JJT, 6.0MV: 03CSPINE24; 16   RAO310; meterset is 22.999999


 Reading in EGSnrc transport parameters:
 ---------------------------------------

****************** Warning:
File
C:\egsnrc_mp\BEAM_Elekta6X_PAH\egsrun_5428_PAH_IMRT_987999_6X_f1b7p9_DHIE
KNET06-PC\PAH_IMRT_987999_6X_f1b7p9.errors
 is already opened and connected to unit  15
 Will not try to re-open this file, assuming it has been opened
 by specifying it in the .io file.


 Bound Compton start region
  Setting all to  0
```

```
Rayleigh start region
 Setting all to  0
Relaxations start region
 Setting all to  0
PE sampling start region
 Setting all to  0


Finished reading EGSnrc transport parameters.


MEDIUM of nominal AIR (exactly as in pegs4dat) (left justify):  AIR700ICRU


IWATCH(-N-4), ISTOR(0,+-1), IRESTART(0-3), IO_OPT(0-4),
IDAT(0-1), LATCH_OPTION (1-3), IZLAST(0-2):          0        0       0       0       0
2         0

Do not track(0) or track(>0) every interaction or trackNth
history only(-N):                                    0
Store random # for a batch(0),a history(1) or read random #(-1):    0
First run(0),restarted(1),make(2),analyze(3):                0
Output to PH-SP(0),not(1),BEAM-MODEL(2),PH-SP&MODEL(3),
    output to PH-SP in IAEA format(4):               0
Store data(0) or not(1):                             0
LATCH OPTION,do not inherit(1),inherit+record origin(2,3):          2
Do not score ZLAST(0), score ZLAST(1), output file for graphics(2):  0

#HISTORIES, RN SEED #1, RN SEED #2, TIMMAX,  IBRSPL(0,1,2,29),
      NBRSPL, IRRLTT(0,1,2), ICM_SPLIT
:
       100.          1       2450    100.0000        2      1000        0       0

# of histories:                                      100
1st initial random number seed(>0,<31329):                1
2nd initial random number seed(>0,<30081):             2450
maximum cpu time allowed:                        100.00 hrs
bremsstrahlung angular sampling is always switched on
bremsstrahlung splitting off(0),uniform(1),directional(2),
selective(29):                                     2
each brem split into:                             1000
Russian roulette off(0),on(1),on+annihilation split(2):          0


Inputs for DBS:
---------------
Field radiusat SSD (cm), SSD (cm), CM no. for electron splitting
(0 for no splitting), Plane no. within CM for electron splitting,
IRAD_DBS (set to 1 for radially-symmetric splitting), Z position
of russian roulette plane (cm).
:
     7.982     100.000          3          9          1      15.700
```

Electrons will be split 1000 times:
CM no. for splitting = 3
Splitting plane no. = 9
Z of russian roulette plain = 15.70000 cm

Split electrons will be redistributed with radial
symmetry about the beam axis.

CHARGE OF THE INCIDENT BEAM(-1,0,1),
SOURCE CONFIGURATION
(0) Parallel beam incident from the front:(0),radius(cm),
incident direction cosines (U,V,W)

or (1) Point source on axis incident from the front,
DISTZ,distance of source to VERY front of first CM.
RBEAM,beam radius (cm) or flag indicating rectangular(<0),
GAMMA,1/2 angle(degrees) of source if RBEAM=0.0,
XINL,XINU,YINL,YINU, dimensions of rectangular beam if
RBEAM<0.

or (3) Uniform isotropically radiating source incidentwithin CMs
Source is a vertical ring centred on the Z-axis if input #4
is >= 0 or a horizontal cylinder centred || to X-axis if
input #4 is < 0:
(3),inner radius of vertical ring or Z of centre
of horizontal cylinder (cm), outer radius of
vertical ring (if >= 0) or radius of horizontal
cylinder (if < 0) (cm), minimum Z or minimum X
(cm), maximum Z or maximum X (cm)

or (5) NRC swept beam, cone 1/2 angle (in degrees)
radius of beam spot (in cm)

or (6) Parallel rectangular beam incident along Z-axis:(6),
centred at (Xo,Yo), half-widths: Xh, Yh (cm)
(0, 6, Xo, Yo, Xh, Yh)

or (7) Scanning beam, scanning field size to 100 cm
ratio of the frequencies in Y/X directions
spot size at the initial point.

or (8) Scanning point source for MM50--uniform field coverage:
(8), SSD (defaults to 100 cm), radius of
field at SSD (defaults to RMAX_CM(1)), radius
of beam spot at Z=0 (defaults to 0).
Note that this option assumes the point
source is at Z=0

or (9) Scanning point source for MM50--discrete field coverage:
(9), SSD (defaults to 100 cm), # of
discrete points at SSD.

```
    Note that this option assumes the point
  source is at Z=0

or (10) Parallel circular beam incident on an x-ray target:
            (10), radius(cm), direction cosines (U,V)
            default to (-1,0), (W is set to 0)

or (13) Parallel rectangular beam incident on an x-ray target:
            (13), half-width(cm), half-height (cm)
            direction cosines (U,V,W), default to (-1,0,0)

or (15) NRC swept beam with radial divergence and intensity distribution:
            (15),cone 1/2 angle (in degrees), Z of apex of cone (cm),
            radius at which beam divergence angle is defined (cm),
beam divergence angle (degrees)

or (19) Parallel elliptical beam with gaussian in X andY:
          (19),sigma of gaussian distribution in X (if > 0) or
          -FWHM of gaussian distribution in X (if < 0) in cm,
          incident direction cosines (U,V,W),
          mean angular spread (degrees, none if <=0,
          if set >0 then overrides U,V,W inputs),
        sigma (if > 0) or -FWHM (if < 0) of gaussian
      distribution in Y in cm (if = 0 then defaults to
        value in X-direction)

or (21) Full phase-space of each particle read from unit 42
            component module #
    (particles incident on the front of this CM),
      no. of times to recycle each particle
    (calculated automatically if set to 0),
  no. of parallel jobs (if using pprocess script),
       job no. (if using pprocess),
            ISRC_DBS (1 if source generated using DBS),
            RSRC_DBS,SSDSRC_DBS (splitting radius, SSD used
  to generate this source--only if ISRC_DBS=1),
     ZSRC_DBS (Z where the source was generated--
        only if ISRC_DBS=1)
            (0, 21, INIT_ICM, 0,0,0,0,0,0,0)

or (23) Full BEAM simulation source incident from user-defined angle
            component module #
          (particles incident on the front of this CM),
            ISRC_DBS (1 if source using DBS),
       angle of rotation about X axis (ALPHA24),
      angle of rotation about Y axis (BETA24),
    distance of point of rotation above INIT_ICM (DIST24)
          (0, 23, INIT_ICM, ISRC_DBS,ALPHA24,BETA24,DIST24)

or (24) Full phase-space incident from user-defined angle
       Input line 1:
            component module #
             (particles incident on the front of this CM),
```

no. of times to recycle each particle
(calculated automatically if set to 0),
no. of parallel jobs (if using pprocess script),
job no. (if using pprocess),
ISRC_DBS (1 if source generated using DBS),
RSRC_DBS,SSDSRC_DBS (splitting radius, SSD used
to generate this source--only if ISRC_DBS=1),
ZSRC_DBS (Z where the source was generated--
only if ISRC_DBS=1)
(0, 24, INIT_ICM, 0,0,0,0,0,0,0)
Inputline 2:
angle of rotation about X axis (ALPHA24),
angle of rotation about Y axis (BETA24),
distance of point of rotation above INIT_ICM (DIST24)

or (31) Beam characterization model, component module #
(particles incident on the front of this CM)
(0, 31, CMSOU,0.,0.,0.)

IQIN,ISOURC, up to 8 reals: -1 19 -0.1000 0.0000 0.0000 1.0000 0.0000 0.0000 0.0000 0.0000
SOURCE CHARGE is -1
ISOURC = 19
PARALLEL ELLIPTICAL BEAM INCIDENT FROM FRONT WITH GAUSSIAN DISTRIBUTION
IN X AND Y:
X-SIGMA OF BEAM AT THE FRONT FACE OF THE TARGET: 0.0425 cm
Y-SIGMA OF BEAM AT THE FRONT FACE OF THE TARGET: 0.0425 cm
X-POSITION OF MIDPOINT OF ELLIPTICAL SPOT: 0.0000 cm
Y-POSITION OF MIDPOINT OF ELLIPTICAL SPOT: 0.0000 cm
X-AXIS DIRECTION COSINE: 0.0000
Y-AXIS DIRECTION COSINE: 0.0000
Z-AXIS DIRECTION COSINE: 1.0000

Source energy --Monoenergetic(0) or spectrum (1): 0
Monoenergetic source
Kinetic energy of incident beam (MeV): 6.2000

(ESTEPIN,SMAX--DUMMY INPUTS),ECUTIN,PCUTIN,(IDORAY--DUMMY INPUT)
IREJCT_GLOBAL(-2...2),ESAVE_GLOBAL,(IFLUOR--DUMMY INPUT)
: 0.000 0.0000E+00 0.7000 0.0100 0 2 1.0000 0
Global esave cutoff value for range rejection: 1.0000 MeV
RANGE REJECTION below ESAVE with RANGE and DNEAR

Photon forcing: next five numbers on one line
Forcephoton interactions in the target?(0)=>no,(1)=>yes,
min/max photon interaction #/history to do forcing for,
min/max CM # in which to do forcing
: 0 0 0 0 0

No photon interaction forcing in effect

Information about scoring planes

There will be phase space files generated at each plane
Number of scoring planes(NSC_PLANES) & list of CMs (score at back of each)
: 1 10
Number of planes for fluence scoring or phase space output: 1
Fluence will be scored at the back of component module(s): 10,

Inputs for scoring plane 1

Number of scoring zones(5) & zone type (0-annular;1-square;2-grid): 1 1
Half-width of scoring zones, in increasing order(10/line)
: 20.00000

Total dose only(0) or total dose & dose components(1): 0

Z dist from ref plane(Z=0) to CM front (include any airgap): 0.00000

Finished general beamnrc input, now input re component modules

==========
 Input blank line to signify start of component module

==========
Outer boundary of CM 1: 15.00000

Next component is a set of conical slabs
TITLE: Photon Target
Z at which FLATFILT (excluding air gap) starts (cm) -0.35000

***WARNING IN CM 1 (FLATFILT):
Z_min_CM(1) > Z of first layer
Z_min_CM(1) reset to -0.35000 cm from 0.00000 cm

Number of layers (MINIMUM 1, MAXIMUM80): 3

For layer 1 :

Number of coaxial cones in layer 1 (Min 1, Max80)
and thickness of this layer: 1 0.26100

input top radii of cones in layer 1
(on one line in order of increasing radius)
: 0.27000

input bottom radii of cones in layer 1
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 0.27000

For layer 2 :

Number of coaxial cones in layer 2 (Min 1, Max80)
and thickness of this layer: 1 0.08900

input top radii of cones in layer 2
(on one line in order of increasing radius)
: 0.27000

input bottom radii of cones in layer 2
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 0.27000

For layer 3 :

Number of coaxial cones in layer 3 (Min 1, Max80)
and thickness of this layer: 1 1.00000

input top radii of cones in layer 3
(on one line in order of increasing radius)
: 1.75000

input bottom radii of cones in layer 3
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 1.75000

Inputs for ECUT, PCUT, dose zones, media ...

For layer 1 :

For cone 1 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
2.00000 0.01000 0 1
material MEDIUM (left justify): AIR700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
2.00000 0.01000 0 14
material MEDIUM (left justify): CU700ICRU

```
For layer    2 :

For cone    1 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
      2.00000       0.01000    0   13
material  MEDIUM (left justify):  ElektaTarget

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
      2.00000       0.01000    0   14
material  MEDIUM (left justify):  CU700ICRU


For layer    3 :

For cone    1 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
      0.70000       0.01000    0    0
material  MEDIUM (left justify):  CU700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
      0.70000       0.01000    0    0
material  MEDIUM (left justify):  CU700ICRU


================================================================
============
 Input blank line to signify start of component module

================================================================
============
 Outer boundary of CM  2:   15.00000

 PrimColl (CONS3R: Rev 1.10)

 This component is a set of stacked cones with 3 regions
   Outer boundary is a cylinder of radius      15.000 cm
 This CM starts at back of previous CM at      1.00000 cm
 TITLE:  Primary Collimator
 Air gap/front of this  CM starts at:    1.0000 cm
 Distance from front of cones(not air gap) to z = 0.0 plane:        1.66000
 CONS3R total thickness (in cm, excluding front air):       10.10000
 INPUT THE # OF NODES (VERTICES) DEFINING THE CONES
(1 < # NODES <   16):    2
 INPUT THE  COORDINATES PAIRS (Z, R) FOR     2 NODES, ONE PAIR/LINE
 RECALL THAT Z(i+1) >= Z(i)
 INPUT COORDINATES OF NODE  1 AS Z, R:        1.66000       0.64500
 INPUT COORDINATES OF NODE  2 AS Z, R:       11.76000       3.14500

 For this CM, the inner region is 1, the outer 2
 For region  1
```

ECUT, PCUT(MeV), DOSE ZONE (0=> NO DOSE), IREGION_TO_BIT, IREJCT(0=> 2 -
1=>0)
: 0.70000 0.01000 0 2 0
material of region 1 MEDIUM (left justify): AIR700ICRU
For region 2
ECUT, PCUT(MeV), DOSE ZONE (0=> NO DOSE), IREGION_TO_BIT, IREJCT(0=> 2 -
1=>0)
: 0.70000 0.01000 0 3 0
material of region 2 MEDIUM (left justify): ElektaW

==========
Input blank line to signify start of component module

==========
Outer boundary of CM 3: 15.00000

Next component is a set of conical slabs
TITLE: flatfilt
Z at which FLATFILT (excluding air gap) starts (cm) 13.25000
Number of layers (MINIMUM 1, MAXIMUM80): 9

For layer 1 :

Number of coaxial cones in layer 1 (Min 1, Max80)
and thickness of this layer: 1 0.11000

input top radii of cones in layer 1
(on one line in order of increasing radius)
: 0.00000

input bottom radii of cones in layer 1
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 0.26000

For layer 2 :

Number of coaxial cones in layer 2 (Min 1, Max80)
and thickness of this layer: 1 0.49000

input top radii of cones in layer 2
(on one line in order of increasing radius)
: 0.26000

input bottom radii of cones in layer 2
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 0.90000

For layer 3 :

Number of coaxial cones in layer 3 (Min 1, Max80)
and thickness of this layer: 1 0.49000

input top radii of cones in layer 3
(on one line in order of increasing radius)
: 0.90000

input bottom radii of cones in layer 3
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 1.45000

For layer 4 :

Number of coaxial cones in layer 4 (Min 1, Max80)
and thickness of this layer: 1 0.51000

input top radii of cones in layer 4
(on one line in order of increasing radius)
: 1.45000

input bottom radii of cones in layer 4
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 2.19200

For layer 5 :

Number of coaxial cones in layer 5 (Min 1, Max80)
and thickness of this layer: 3 0.04000

input top radii of cones in layer 5
(on one line in order of increasing radius)
: 2.19200 3.85000 3.99900

input bottom radii of cones in layer 5
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 2.25000 3.85000 3.99900

For layer 6 :

Number of coaxial cones in layer 6 (Min 1, Max80)
and thickness of this layer: 3 0.21000

input top radii of cones in layer 6

(on one line in order of increasing radius)
: 2.25000 3.85000 3.99900

input bottom radii of cones in layer 6
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 2.67600 3.85000 3.99900

For layer 7 :

Number of coaxial cones in layer 7 (Min 1, Max80)
and thickness of this layer: 3 0.35000

input top radii of cones in layer 7
(on one line in order of increasing radius)
: 2.67600 3.85000 4.65000

input bottom radii of cones in layer 7
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 3.25000 3.85000 4.65000

For layer 8 :

Number of coaxial cones in layer 8 (Min 1, Max80)
and thickness of this layer: 1 0.20000

input top radii of cones in layer 8
(on one line in order of increasing radius)
: 4.65000

input bottom radii of cones in layer 8
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 4.65000

For layer 9 :

Number of coaxial cones in layer 9 (Min 1, Max80)
and thickness of this layer: 1 0.20000

input top radii of cones in layer 9
(on one line in order of increasing radius)
: 4.65000

input bottom radii of cones in layer 9
(on one line in order of increasing radius--Note that
cones in one layer cannot cross)
: 4.65000

Inputs for ECUT, PCUT, dose zones, media ...

For layer 1 :

For cone 1 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
2.00000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For layer 2 :

For cone 1 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
2.00000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For layer 3 :

For cone 1 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
2.00000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For layer 4 :

For cone 1 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
2.00000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:

0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For layer 5 :

For cone 1 :
(innermost cone)
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
2.00000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For cone 2 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For cone 3 :
(outermost cone)
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For layer 6 :

For cone 1 :
(innermost cone)
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
2.00000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For cone 2 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For cone 3 :
(outermost cone)
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For layer 7 :

For cone 1 :
(innermost cone)
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For cone 2 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For cone 3 :
(outermost cone)
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

For layer 8 :

For cone 1 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 4
material MEDIUM (left justify): STEEL700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 4
material MEDIUM (left justify): AIR700ICRU

For layer 9 :

For cone 1 :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 4
material MEDIUM (left justify): AL700ICRU

For region between outermost cone and RMAX_CM :
ECUT, PCUT (MeV), DOSE ZONE (0=DO NOT SCORE DOSE), IREGION_TO_BIT:
0.70000 0.01000 0 0
material MEDIUM (left justify): AIR700ICRU

DBS in FlatFilt:
Electron splitting no. = 1000

```
 Electron splitting plane no.  =           9
 Z position of splitting plane =   15.65000 cm

Split electrons will be distributed with radial symmetry about
the beam axis in this plane.


 Reminder: Z position of russian roulette plane =   15.70000 cm


============================================================
============
 Input blank line to signify start of component module

============================================================
============
Outer boundary of CM  4:   15.00000

IonChamb  (CHAMBER Rev 1.8)

This component is an ion chamber or for scoring dose components
     Outer boundary is a cylinder of radius   15.0000cm

TITLE:  Ion Chamber
This CM, including air gap, starts at end of previous CM at  15.85000 cm

Distance from front of IonChamb(not air gap) to ref plane(z=0):   16.44000

This module consists of 3 partS:
  1 --- top part,
  2 --- main part: the chamber/phantom central part,
3 --- bottom part.

Input the number of layers for each part:
N-TOP (>=0), N-CHAM (>0 to input chamber layers individually or <0 to
input -N-CHAM groups of layers), N-BOT (>=0) (N-TOP + total numberof
chamber layers + N-BOT <=  199) on one line
:        0      13       0

       INPUTS FOR THE Central CHAMBER PART

INPUT THE INNER RADIUS OF THE CHAMBER WALL (R_INNER),
THE OUTER RADIUS OF THE CHAMBER WALL (R_WALL), AND THE OUTER
RADIUS,
 OF THE GAP BETWEEN THE CHAMBER WALL AND CONTAINER WALL
(R_OUTER),
ALL ON ONE LINE.
:      4.50000      8.50000     10.00000

Note that R_OUTER also defines the inner radius of the container.
The outer radius of the container is defined by RMAX_CM.
```

INPUT THICKNESS FOR EACH LAYER WITHIN THE CHAMBER
FOR LAYERS OF EQUAL THICKNESS (ZTHICK) AND MEDIUM,
INPUT ZTHICK,N-CHAM (in one line)
OTHERWISE, INPUT ZTHICK FOR EACH LAYER STARTING FROM 1ST LAYER
: 0.10000 0

THE 13 LAYERS HAVE DIFFERENT ZTHICK AND/OR MEDIA.

FOR LAYER 1 IN THE CHAMBER:

ZTHICK = 0.10000
ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
: 0.7000 0.0100 1 5
For this layer :
MEDIUM (left justify): AIR700ICRU

FOR LAYER 2 IN THE CHAMBER:

ZTHICK: 0.00120
ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
: 0.7000 0.0100 0 5
For this layer : MEDIUM (left justify): MYLAR700ICRU

FOR LAYER 3 IN THE CHAMBER:

ZTHICK: 0.10000
ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
: 0.7000 0.0100 0 5
For this layer : MEDIUM (left justify): AIR700ICRU

FOR LAYER 4 IN THE CHAMBER:

ZTHICK: 0.00120
ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
: 0.7000 0.0100 0 5
For this layer : MEDIUM (left justify): MYLAR700ICRU

FOR LAYER 5 IN THE CHAMBER:

ZTHICK: 0.10000
ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
: 0.7000 0.0100 0 5
For this layer : MEDIUM (left justify): AIR700ICRU

FOR LAYER 6 IN THE CHAMBER:

ZTHICK: 0.00120
ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
: 0.7000 0.0100 0 5
For this layer : MEDIUM (left justify): MYLAR700ICRU

FOR LAYER 7 IN THE CHAMBER:

```
 ZTHICK:       0.10000
 ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:   0.7000    0.0100    0           5
 For this layer : MEDIUM (left justify):  AIR700ICRU

 FOR LAYER   8 IN THE CHAMBER:

 ZTHICK:       0.00120
 ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:   0.7000    0.0100    0           5
 For this layer : MEDIUM (left justify):  MYLAR700ICRU

 FOR LAYER   9 IN THE CHAMBER:

 ZTHICK:       0.10000
 ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:   0.7000    0.0100    0           5
 For this layer : MEDIUM (left justify):  AIR700ICRU

 FOR LAYER  10 IN THE CHAMBER:

 ZTHICK:       0.00120
 ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:   0.7000    0.0100    0           5
 For this layer : MEDIUM (left justify):  MYLAR700ICRU

 FOR LAYER  11 IN THE CHAMBER:

 ZTHICK:       0.22000
 ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:   0.7000    0.0100    0           5
 For this layer : MEDIUM (left justify):  AIR700ICRU

 FOR LAYER  12 IN THE CHAMBER:

 ZTHICK:       0.00120
 ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:   0.7000    0.0100    0           5
 For this layer : MEDIUM (left justify):  MYLAR700ICRU

 FOR LAYER  13 IN THE CHAMBER:

 ZTHICK:       0.20000
 ECUT,PCUT,DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:   0.7000    0.0100    2           5
 For this layer : MEDIUM (left justify):  AIR700ICRU

 FOR THE CHAMBER WALL:

 ECUT,PCUT, DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:    0.7000    0.0100    0           5
 For this region:  MEDIUM (left justify):  ALUMINA700ICRU
```

```
 FOR THE GAP BETWEEN THE CHAMBER WALL AND THE
CONTAINER WALL:

 ECUT,PCUT, DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:    0.7000    0.0100    0            5
For this region:  MEDIUM (left justify):  AIR700ICRU

 FOR THE CONTAINER WALL:

 ECUT,PCUT, DOSE ZONE(0=>do not score dose),IREGION_TO_BIT
:    0.7000    0.0100    0            5
For this region:  MEDIUM (left justify):  AIR700ICRU

 THERE WILL BE AN AIR GAP SET UP BETWEEN Z= 15.8500 AND Z= 16.4400


 MRNGE: ENTER 1 to estimate thickness of IonChamb for ECUTRR
 calculations in automated range rejection; otherwise, do
 not calculate ECUTRR    0



============================================================
============
 Input blank line to signify start of component module

============================================================
============
 Outer boundary of CM  5:   15.00000

 BSP (SLABS: Rev 1.6)
 This component is a set of planar slabs
     Outer boundary is a square with |x| & |y| <      15.00 cm
 Previous CM ends at:    17.36720 cm
 TITLE:  Backscatter plate
 NUMBER OF SLABS (MINIMUM 1, MAXIMUM 30):     1
 DISTANCE FROM FRONT OF SLABS (excluding air gap) TO REF PLANE (z=0):
18.25000


 Inputs for slab #     1
 SLAB THICKNESS(cm), ECUT, PCUT, DOSE ZONE(0=>DONT SCORE),
IREGION_TO_BIT,ESAVE
:    0.29000    0.70000    0.01000        0                0    1.00000
 SLAB  MEDIUM (left justify):  AL700ICRU
 Front air gap      Z_min_thick( 5, 2)=     0.883  MED_min_thick( 5, 2)=    1


============================================================
============
 Input blank line to signify start of component module
```

```
================================================================
============
Outer boundary of CM  6:   15.00000

Mirror (MIRROR Rev 1.5)

Next component is a flat inclined mirror
     Outerboundary is a square with |x| & |y| <      15.00 cm
Previous CM ends at:    18.54000 cm
TITLE:  Mirror
Z position at which mirror (excluding air gap) starts
and thickness of mirror in Z direction (on one line)
:       18.54000       9.60000
XFMIN (X position that front face crosses front of CM) and
XBMIN (X position that front face crosses back of CM):     4.00000   -6.00000
Number of layers of the mirror, minimum 1, maximum  10
Number of layers in this mirror is   2
Thickness of layer  1(in cm):         0.00120
Thickness of layer  2(in cm):         0.00003

For layer  1 of mirror:
ECUT, PCUT(MeV), DOSE ZONE(0=DO NOT SCORE DOSE), IREGION_TO_BIT
:   0.700    0.010             0              6
Material of layer   1  MEDIUM (left justify):  MYLAR700ICRU

For layer  2 of mirror:
ECUT, PCUT(MeV), DOSE ZONE(0=DO NOT SCORE DOSE), IREGION_TO_BIT
:   0.700    0.010             0              6
Material of layer   2  MEDIUM (left justify):  AL700ICRU

For region behind mirror:
ECUT, PCUT(MeV), DOSE ZONE(0=DO NOT SCORE DOSE), IREGION_TO_BIT
:   0.700    0.010             0              0
Material of region behind mirror  MEDIUM (left justify):  AIR700ICRU

For region in front of mirror:
ECUT, PCUT(MeV), DOSE ZONE(0=DO NOT SCORE DOSE), IREGION_TO_BIT
:   0.700    0.010             0              0
Material of region in front of mirror  MEDIUM (left justify):  AIR700ICRU


================================================================
============
 Input blank line to signify start of component module

================================================================
============
Outer boundary of CM  7:   30.00000

Next component is an MLCE type MLC
Title:  MLC
The leaves can be arranged as:
```

0 ---- parallel to y direction
1 ---- parallel to x direction (default).
Input your choice: Default to
1

Input the # of leaf pairs (less than 120)
This must be an even no. (usually 40): 40

Z position of top MLC, Z Position of bottom MLC = 29.74000 37.24000

Z position of left step central leaf,
Z Position of right step central leaf: 34.00000 33.80000

Width of step (TGW) : 0.05950

Upper (X3) and lower (X4) right coordinates of central leaf ignoring step
: 0.16375 0.20125

Distance between leaf centres in X direction (SPACE),
distance from Z=0 where SPACE is defined : 1.00000 100.00000

Leaf bank rotation angle = 0.00000

Input the type of leaf end desired :
0 --- Rounded leaf end or
1 --- Focused leaf end
Input your choice : 0

Input the radius of the leaf ends (>3.75 cm),
Z at which this radius is defined : 15.00000 33.08000

Due to leaf rotations, ZMIN in MLC changed from 29.74000000 cm
to 29.70865906 cm.

Due to leaf rotations, ZMAX in MLC changed from 37.24000000 cm
to 37.24268703 cm. Be aware of this when specifying downstream CM.

Input for MLC A and B leaf tips

Input min. X, max. X of origin of cylindrical leaf ends,
# of adjacent leaves with these coordinates:
For leaf 1 : -15.00000 15.00000 1
For leaf 2 : -15.00000 15.00000 1
For leaf 3 : -15.00000 15.00000 1
For leaf 4 : -15.00000 15.00000 1
For leaf 5 : -15.00000 15.00000 1
For leaf 6 : -15.00000 15.00000 1
For leaf 7 : -15.00000 15.00000 1
For leaf 8 : -15.00000 15.00000 1
For leaf 9 : -15.00000 15.00000 1

```
 For leaf  10 :     -15.00000      15.00000    1
 For leaf  11 :     -15.00000      15.00000    1
 For leaf  12 :     -15.00000      15.00000    1
 For leaf  13 :     -15.00000      15.00000    1
 For leaf  14 :     -15.00000      15.00000    1
 For leaf  15 :     -15.00000      15.00000    1
 For leaf  16 :     -15.00000      15.00000    1
 For leaf  17 :     -15.98775      15.16526    1
 For leaf  18 :     -15.96294      15.15199    1
 For leaf  19 :     -16.10014      15.08871    1
 For leaf  20 :     -16.20194      14.26703    1
 For leaf  21 :     -16.07631      14.33583    1
 For leaf  22 :     -15.88390      14.79915    1
 For leaf  23 :     -15.40137      16.13574    1
 For leaf  24 :     -14.32665      15.99848    1
 For leaf  25 :     -15.00000      15.00000    1
 For leaf  26 :     -15.00000      15.00000    1
 For leaf  27 :     -15.00000      15.00000    1
 For leaf  28 :     -15.00000      15.00000    1
 For leaf  29 :     -15.00000      15.00000    1
 For leaf  30 :     -15.00000      15.00000    1
 For leaf  31 :     -15.00000      15.00000    1
 For leaf  32 :     -15.00000      15.00000    1
 For leaf  33 :     -15.00000      15.00000    1
 For leaf  34 :     -15.00000      15.00000    1
 For leaf  35 :     -15.00000      15.00000    1
 For leaf  36 :     -15.00000      15.00000    1
 For leaf  37 :     -15.00000      15.00000    1
 For leaf  38 :     -15.00000      15.00000    1
 For leaf  39 :     -15.00000      15.00000    1
 For leaf  40 :     -15.00000      15.00000    1

Region   1 (MLC opening):
ECUT, PCUT (MeV), DOSE ZONE (0=NO DOSE SCORED), IREGION_TO_BIT
:       0.70000       0.01000    0    7
material of region   1  MEDIUM (left justify):  AIR700ICRU

Region   2 (MLC leaves):
ECUT, PCUT (MeV), DOSE ZONE (0=NO DOSE SCORED), IREGION_TO_BIT
:       0.70000       0.01000    0    8
material of region   2  MEDIUM (left justify):  ElektaW


============================================================
============
 Input blank line to signify start of component module

============================================================
============
Outer boundary of CM  8:   30.00000

Next component is a multileaf collimator
Title:  X-Jaws
```

The module can be arranged as:
0----leaf directionparallel to y direction(default),
1----leaf direction parallel to x direction.
Input your choice: 1

Z position of top of collimator: 39.60000

Collimator thickness (cm): 3.00000

Input the # of leaves(<120 must be even) and total width of leaves
at the top of the collimator: 2 40.00000

Input the Z focus point of the leaf sides: 0.00000

Input radius of leaf ends (cm) and Z where radius originates on one line
: 7.00000 41.20000

Input for collimator leaves

Input X origin of radius of leaf ends for -ve portion of leaves,
+ve portion of leaves, # of leaves with these endradius origins:
 For leaf 1 : -8.61212 8.52919 2

Region 1 (collimator opening):
ECUT, PCUT (MeV), DOSE ZONE (0=NO DOSE SCORED), IREGION_TO_BIT
: 0.70000 0.01000 0 8
material of region 1 MEDIUM (left justify): AIR700ICRU

Region 2 (collimator leaves):
ECUT, PCUT (MeV), DOSE ZONE (0=NO DOSE SCORED), IREGION_TO_BIT
: 0.70000 0.01000 0 8
material of region 2 MEDIUM (left justify): ElektaW

==========
 Input blank line to signify start of component module

==========
Outer boundary of CM 9: 30.00000
This component is sets of paired bars or jaws
  Outer boundary is a square with |x| & |y| < 30.00 cm
TITLE: Y-Jaws
Previous CM ends at: 42.60000 cm
NUMBER OF paired bars/jaws (minimum 1, maximum 12): 1

Paired bar/jaw set no: 1
Are bars/jaws perpendicular to x or y axis
i.e. is separation measured on x or y axis
(Input "y" or "Y" for Y jaws, any other character for X jaws): Y
Input ZMIN, ZMAX & jaw coordinates: YFP, YBP, YFN, YBN(cm) all on one line
(leave at least min. airgap = 0.01000 before 1st jaws)

```
:   43.10000   50.90000    1.33610    1.57790   -1.29300   -1.52700

 Now input data re ECUT and PCUT for each region

For central region which is assumed to be air
ECUT,       PCUT,  DOSE ZONE OF AIR,   REGION TO BIT
:    0.70000    0.01000    0    9

Paired bars/jaws no:  1
ECUT,        PCUT,  DOSE ZONE,    IREGION_TO_BIT
:    0.70000    0.01000    0   10
Medium in this region MEDIUM (left justify):  ElektaW


============================================================================
============
 Input blank line to signify start of component module

============================================================================
============
Outer boundary of CM 10:   30.00000

 XWires (SLABS: Rev 1.6)
 This component is a set of planar slabs
     Outer boundary is a square with |x| & |y| <      30.00 cm
 Previous CM ends at:     50.90000 cm
 TITLE:  Crosswires
 NUMBER OF SLABS (MINIMUM 1, MAXIMUM 30):     2
 DISTANCE FROM FRONT OF SLABS (excluding air gap) TO REF PLANE (z=0):
52.00000


 Inputs for slab #     1
 SLAB THICKNESS(cm), ECUT, PCUT, DOSE ZONE(0=>DONT SCORE),
IREGION_TO_BIT,ESAVE
:    0.01750    0.70000    0.01000       0              11    1.00000
 SLAB  MEDIUM (left justify):  MYLAR700ICRU


 Inputs for slab #     2
 SLAB THICKNESS(cm), ECUT, PCUT, DOSE ZONE(0=>DONT SCORE),
IREGION_TO_BIT,ESAVE
:    2.98250    0.70000    0.01000       0              11    1.00000
 SLAB  MEDIUM (left justify):  AIR700ICRU
 Front air gap      Z_min_thick(10, 3)=     1.100  MED_min_thick(10, 3)=    1
 Input blank line to signify end of component module

 Back in main of beamnrc.mortran after inputs from CMs


There are  8 different media:
        Medium(  1) is: AIR700ICRU
        Medium(  2) is: CU700ICRU
```

```
Medium(  3) is: ElektaTarget
Medium(  4) is: ElektaW
Medium(  5) is: STEEL700ICRU
Medium(  6) is: AL700ICRU
Medium(  7) is: MYLAR700ICRU
Medium(  8) is: ALUMINA700ICRU

CALL TO HATCH AT  11:37:37
Found medium with gas pressure
Rayleigh data available for medium  8 in PEGS4 data set.

Rayleigh data available for medium  4 in PEGS4 data set.

Rayleigh data available for medium  3 in PEGS4 data set.


(Re)-initializing photon cross section data
Using data files from the series si

Photon cross sections: si Compton cross sections: default
Working on medium   1 ... OK
Working on medium   2 ... OK
Working on medium   3 ... OK
Working on medium   4 ... OK
Working on medium   5 ... OK
Working on medium   6 ... OK
Working on medium   7 ... OK
Working on medium   8 ... OK
  old PRESTA calculates default min. step-size for BCA:
     minimum ECUT found:   0.7
     default BLCMIN is:   3.90687631
     this corresponds to   49.7433264 elastic MFPs
  Reading screened Rutherford MS data .....  done


Reading spin data base from C:\HEN_HOUSE\data\spinms.data
EGSnrc spin data, version 2.0
Data generated on a machine with 1234 endianess
The endianess of this CPU is 1234
Ranges:      1.00   100.00  0.30054  1.00000


  medium    1 .....  done
  medium    2 .....  done
  medium    3 .....  done
  medium    4 .....  done
  medium    5 .....  done
  medium    6 .....  done
  medium    7 .....  done
  medium    8 .....  done

  Medium  1 sige =   0.358165483  0.353042079 monotone =  F T
  Medium  2 sige =   0.967714609  0.960653957 monotone =  T T
```

```
 Medium  3 sige =   1.80306244  1.79610464 monotone =  T T
 Medium  4 sige =   1.47950203  1.47242818 monotone =  T T
 Medium  5 sige =   0.896836884  0.889788646 monotone =  T T
 Medium  6 sige =   0.590715662  0.584002525 monotone =  T T
 Medium  7 sige =   0.434437931  0.427908969 monotone =  T T
 Medium  8 sige =   0.551991286  0.545135076 monotone =  T T

 Initializing tmxs for estepe =   0.25 and ximax =   0.5

Output from subroutine EDGSET:
==============================
Atomic relaxations not requested!

Bound Compton scattering not requested!

 EGSnrc SUCCESSFULLY 'HATCHED' FOR     8 MEDIA.


************ Cross section enhancement will not be used



*** No rejection plane will be used with DBS ***
*** Correlated-particle warning ***



*** Brem. cross section enhancement WILL NOT be used ***


 HATCH COMPLETED AT 11:37:37

================================================================
=============

              Electron/Photon transport parameter

================================================================
=============

 Photon cross sections                    si
 Compton cross sections                    default
 Photon transport cutoff(MeV)                    0.1000E-01
 Pair angular sampling                   SIM
 Pair cross sections                    BH
 Triplet production                     Off
 Bound Compton scattering                      OFF
 Radiative Compton corrections                  Off
 Rayleigh scattering                     OFF
 Atomic relaxations                      OFF
```

```
Photoelectron angular sampling                    OFF

Electron transport cutoff(MeV)                  0.7000
Bremsstrahlung cross sections                   BH
Bremsstrahlung angular sampling                 SIM
Spin effects                                    On
Electron Impact Ionization                      OFF
Maxium electron step in cm (SMAX)               5.000
Maximum fractional energy loss/step (ESTEPE)    0.2500
Maximum 1st elastic moment/step (XIMAX)         0.5000
Boundary crossing algorithm                     PRESTA-I
Skin-depth for boundary crossing (MFP)          49.74
Electron-step algorithm                         PRESTA-II

================================================================
=============

 There are  1 scoring planes -see below

*********************************************************************
***
            EXECUTION INFORMATION AND WARNING MESSAGES

*********************************************************************
***

********** NEW INPUT FILE **********

 ************ Returned from beam_init: ircode =  0
 ************ jcase =  10

 BATCH #  TIME-ELAPSED  TOTAL CPUTIME  RATIO  TIME OF DAY  RNG pointers

    1        0.0          0.0      0.00    11:37:37   ixx jxx =   97  33
    # of histories run:        10      # of particles in ph-sp file:         0

    2        0.0          0.0      1.#J    11:37:37   ixx jxx =   86  22
    # of histories run:        20      # of particles in ph-sp file:         2

    3        0.0          0.0      1.#J    11:37:37   ixx jxx =   60  93
    # of histories run:        30      # of particles in ph-sp file:         2

    4        0.0          0.0      0.51    11:37:37   ixx jxx =   39  72
    # of histories run:        40      # of particles in ph-sp file:        14

    5        0.1          0.1      1.00    11:37:37   ixx jxx =   40  73
    # of histories run:        50      # of particles in ph-sp file:        19

    6        0.1          0.1      1.06    11:37:37   ixx jxx =   47  80
    # of histories run:        60      # of particles in ph-sp file:        19

    7        0.1          0.1      0.91    11:37:37   ixx jxx =   82  18
```

```
 # of histories run:       70     # of particles in ph-sp file:       20

 8       0.1          0.1     0.94    11:37:37   ixx jxx =   52  85
 # of histories run:       80     # of particles in ph-sp file:       22

 9       0.1          0.1     0.99    11:37:37   ixx jxx =   76  12
 # of histories run:       90     # of particles in ph-sp file:       22

10       0.1          0.1     1.01    11:37:37   ixx jxx =   59  92
 # of histories run:      100     # of particles in ph-sp file:       33


*** FINAL RANDOM NUMBER POINTERS:  ixx jxx =   25
58C:\egsnrc_mp\BEAM_Elekta6X_PAH\egsrun_5428_PAH_IMRT_987999_6X_f1b7p9_DH
IEKNET06-PC\egsrun_5428_PAH_IMRT_987999_6X_f1b7p9_DHIEKNET06-PC_junk
C:\egsnrc_mp\BEAM_Elekta6X_PAH\egsrun_5428_PAH_IMRT_987999_6X_f1b7p9_DHIE
KNET06-PC\PAH_IMRT_987999_6X_f1b7p9.egsdat
C:\egsnrc_mp\BEAM_Elekta6X_PAH\egsrun_5428_PAH_IMRT_987999_6X_f1b7p9_DHIE
KNET06-PC\PAH_IMRT_987999_6X_f1b7p9.egslst
C:\egsnrc_mp\BEAM_Elekta6X_PAH\egsrun_5428_PAH_IMRT_987999_6X_f1b7p9_DHIE
KNET06-PC\PAH_IMRT_987999_6X_f1b7p9.egsplot
C:\egsnrc_mp\BEAM_Elekta6X_PAH\egsrun_5428_PAH_IMRT_987999_6X_f1b7p9_DHIE
KNET06-PC\PAH_IMRT_987999_6X_f1b7p9.egstmpa
C:\egsnrc_mp\BEAM_Elekta6X_PAH\egsrun_5428_PAH_IMRT_987999_6X_f1b7p9_DHIE
KNET06-PC\PAH_IMRT_987999_6X_f1b7p9.errors
       6 file(s) moved.

 FOR THIS RUN:
 ------------
 ELAPSED& CPU TIMEs, RATIO =       0.1       0.2s (=   0.00HR)   0.95
 CPUTIME per history =   0.00156 sec. Number of historiesper hour =    2307678.
   On gnu-win32 (gnu_win32)

 MIN PARTICLE WEIGHT FOR ALL SCORING ZONES =    0.0010000
 MAX PARTICLE WEIGHT FOR ALL SCORING ZONES =    0.0010000

 END OF RUN         Jul 03 2013 11:37:37

================================================================
=============
Finished simulation

  Elapsed time:                 1.6 s (  0.000 h)
  CPU time:                     0.7 s (  0.000 h)
  Ratio:                    2.312


End of run                              Wed Jul 03 11:37:37 2013
================================================================
=============
```