e-LINAC Beam Facility Characterization For Its Use For Space Detectors Performance Studies

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7th Geant4 Space Users Workshop, 18-20 August, 2010

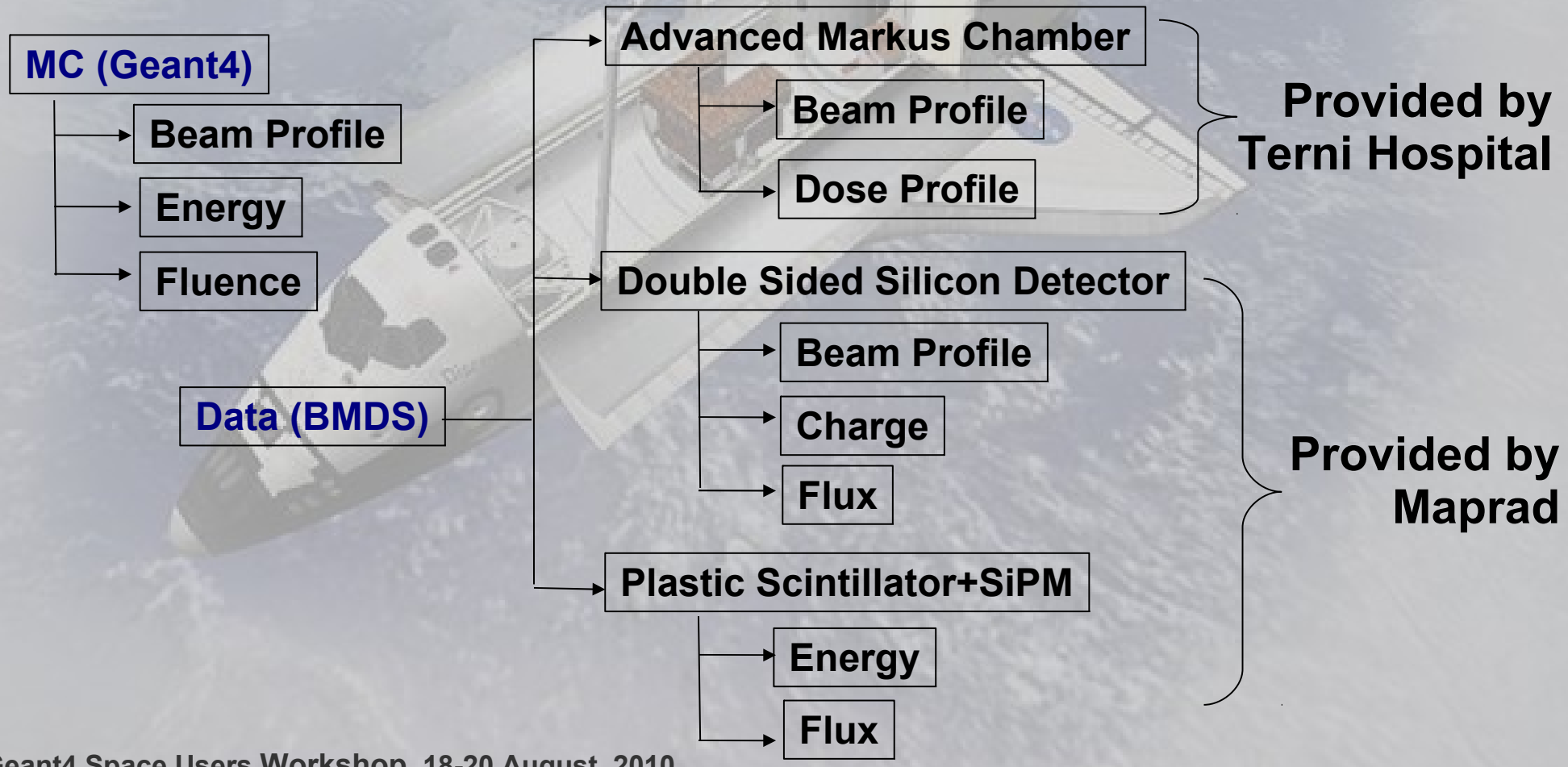
Outline

- Motivation
- Beam & Dose profiles
- Available energy & Flux @ detector surface
- Conclusions

Motivation

The goal is to use of AOT's e-Linac for Space Detectors' Performance testing

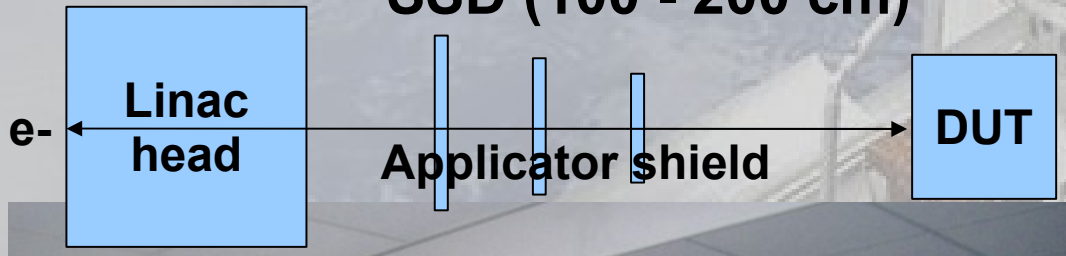
To do this we need full Monte Carlo (MC) description of irradiation system as well as a Beam Monitoring Detector system (BMDS)



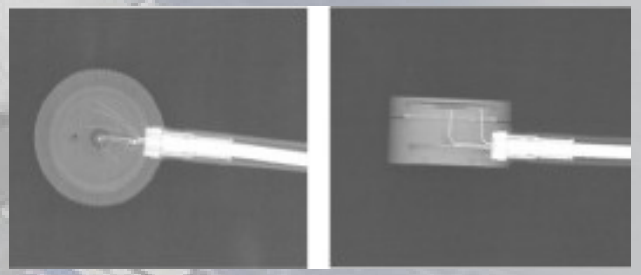
Terni Hospital e-Linac

Advanced Markus Chamber
PTW-34045

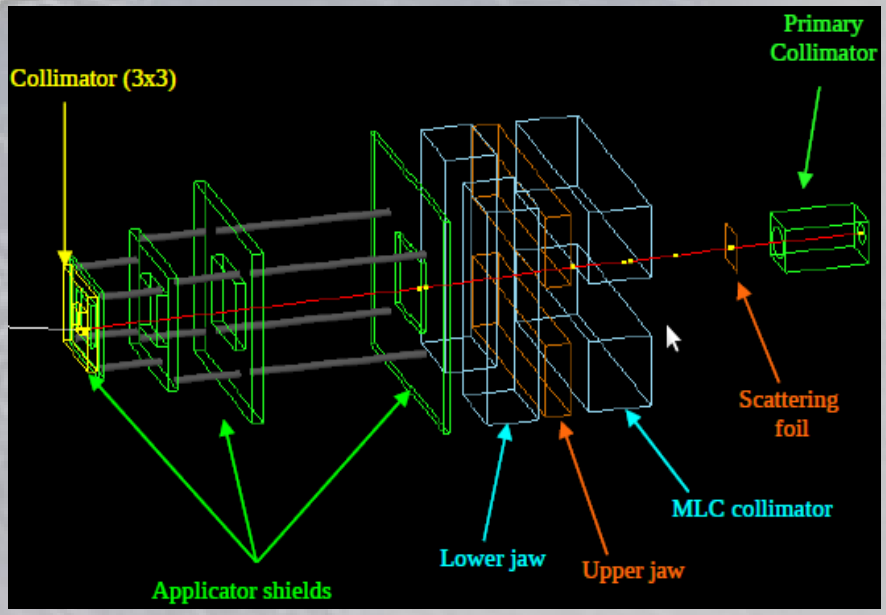
Source to Surface Distance
SSD (100 - 200 cm)



Entrance window thickness 0.03 mm
Sensitive volume 20 mm^3



Simulated Accelerator Head



Physics Lists & Applied Cuts

Two kinds of physics list classes are available;

G4VUserPhysicsList	for relatively simple physics lists
G4VModularPhysicsList	for detailed physics lists

Recommended Built-in Physics used

- G4EmStandardPhysics_option1
- G4EmStandardPhysics_option2
- G4EmStandardPhysics_option3
- G4EmPenelopePhysics
- G4EmLivermorePhysic

/process/eLoss/binsDEDX 480
/process/eLoss/binsLambda 480

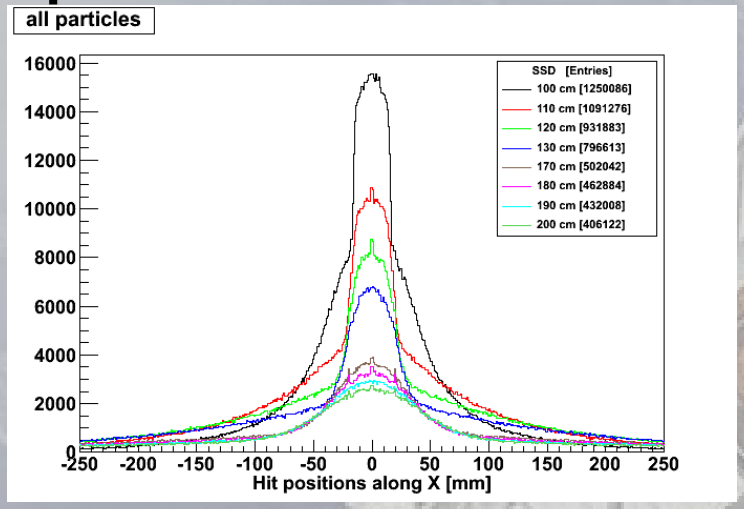
Particle production thresholds (Cuts) = 0.1 and 1 mm

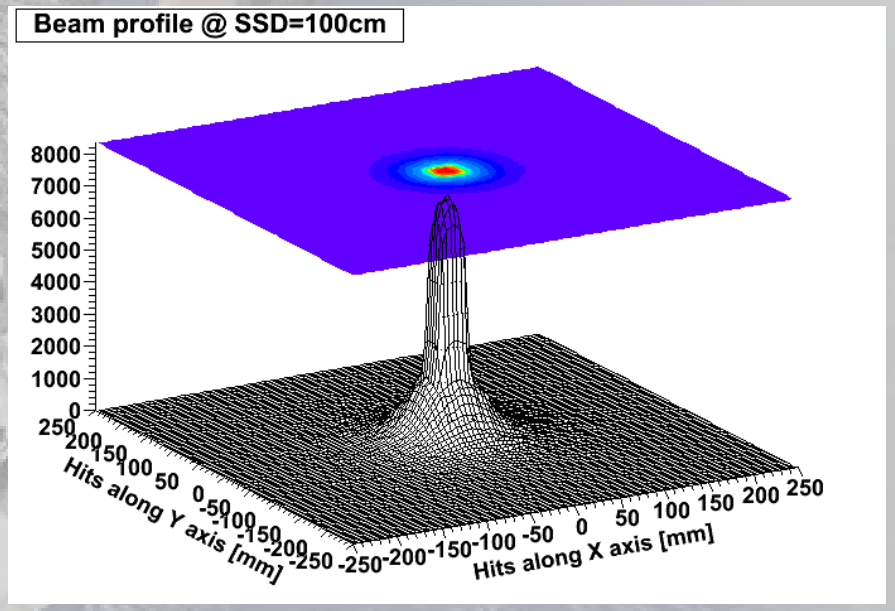
StepSize (Steps) = 1 and 100 mm

Generated primaries → mono-energetic electrons
with no beam divergency (energy range 4-20 MeV)

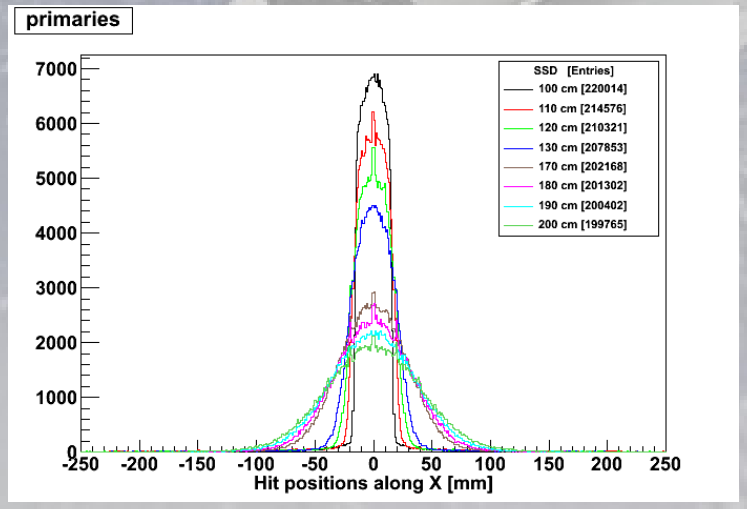
Beam Profiles

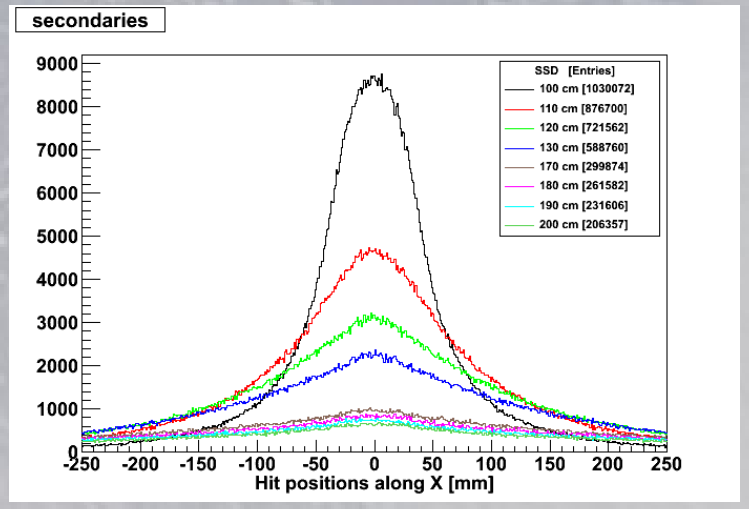
Beam profile width from FWHM



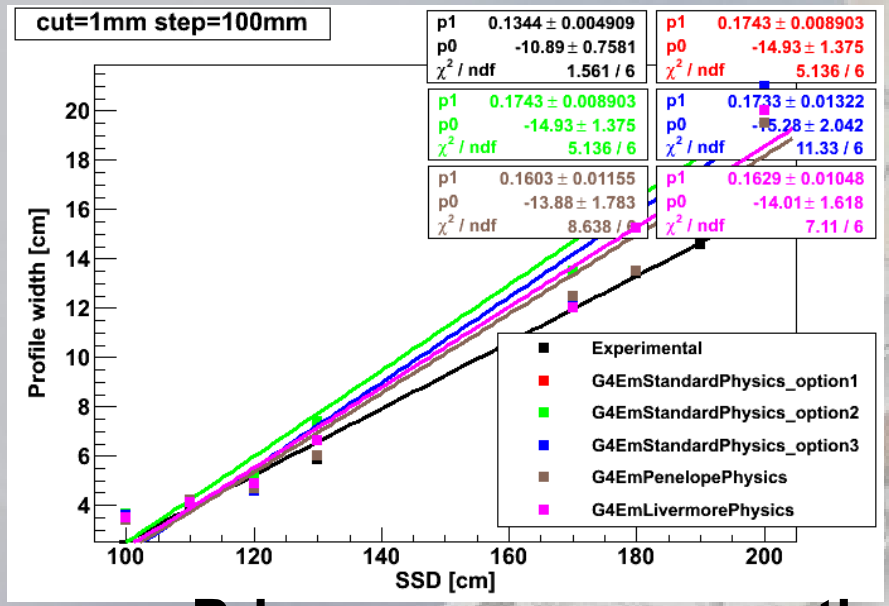


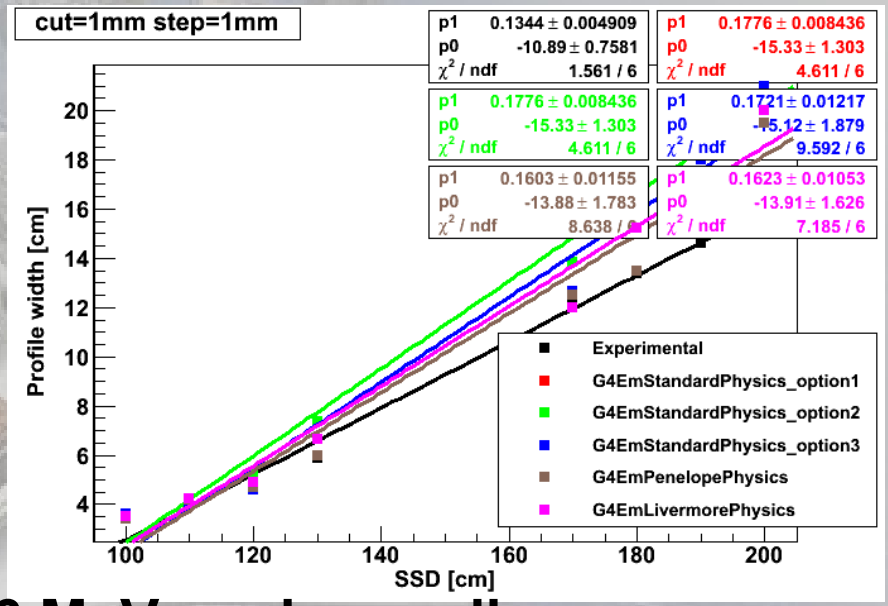
Sample plots @ 100 cm with option3
15 MeV (mono-choromatic, no beam divergence)



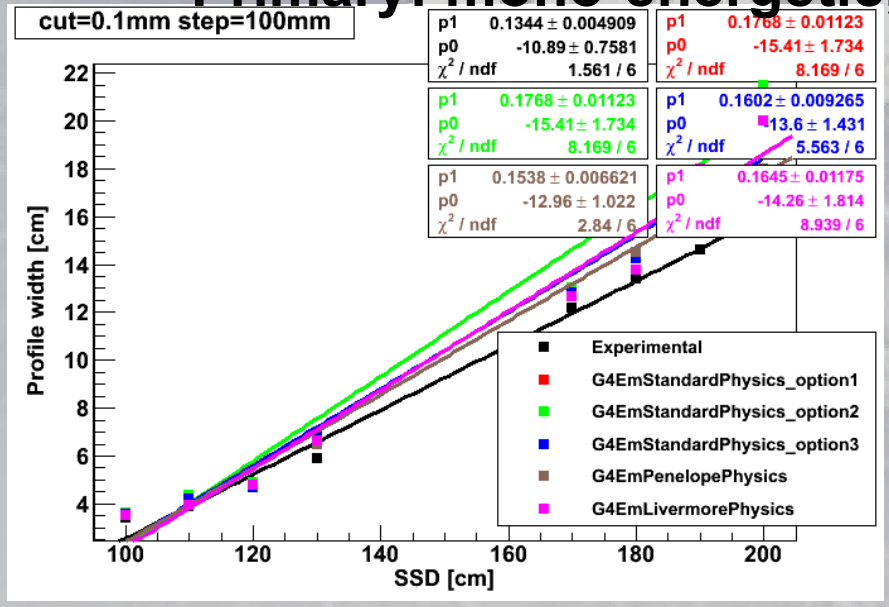


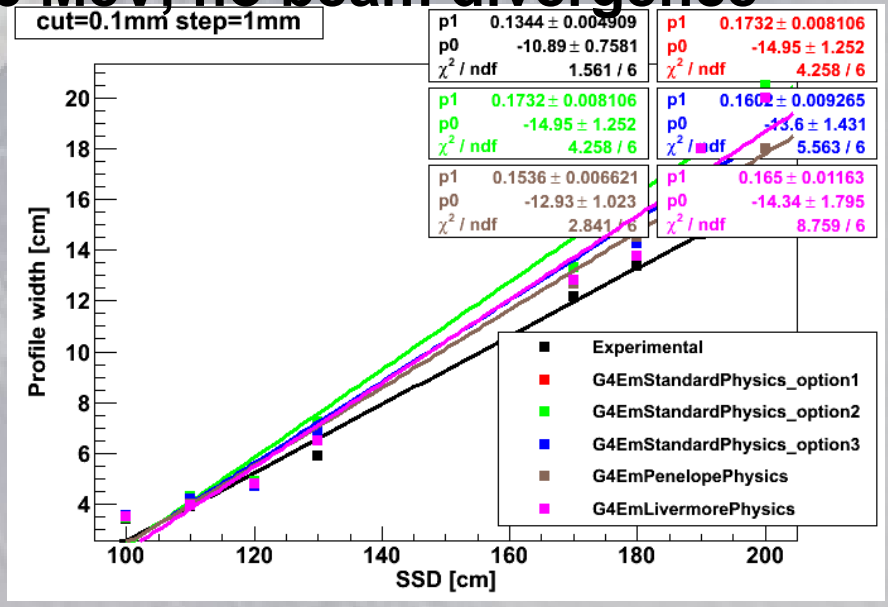
Beam Profile Widths



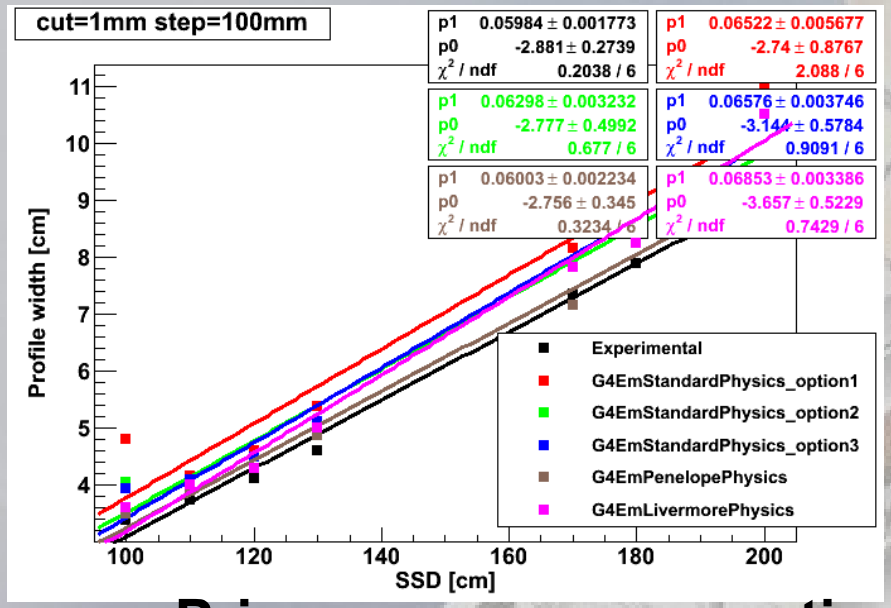


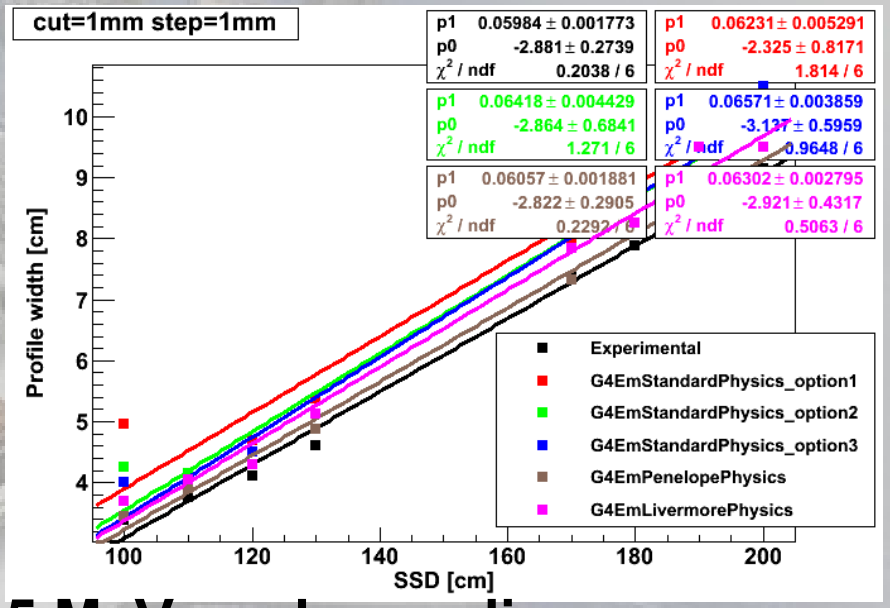
Primary: mono-energetic, 6 MeV, no beam divergence



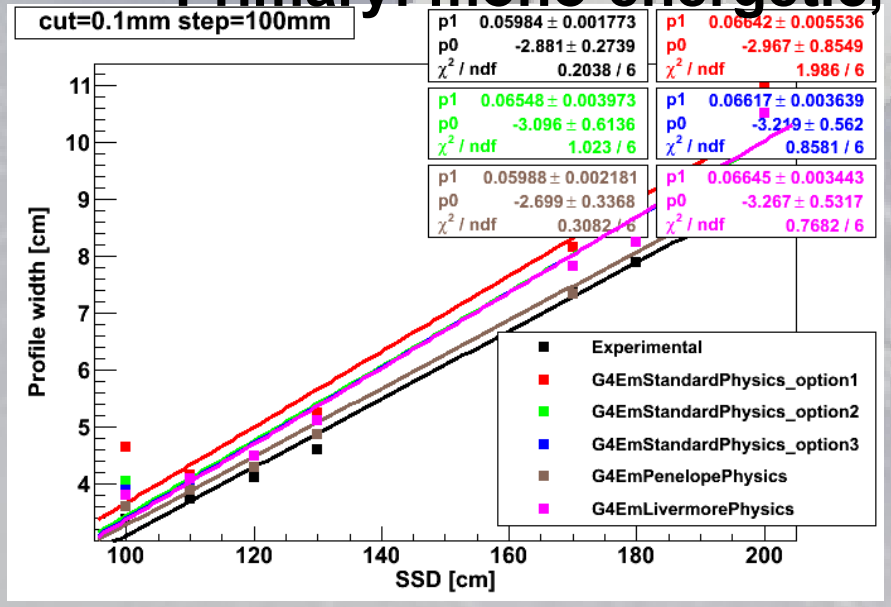


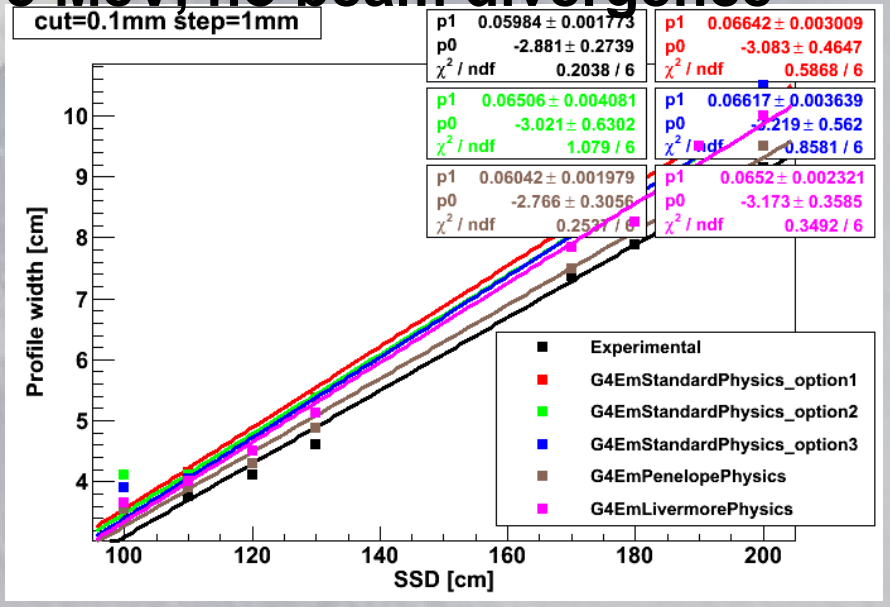
Beam Profile Widths





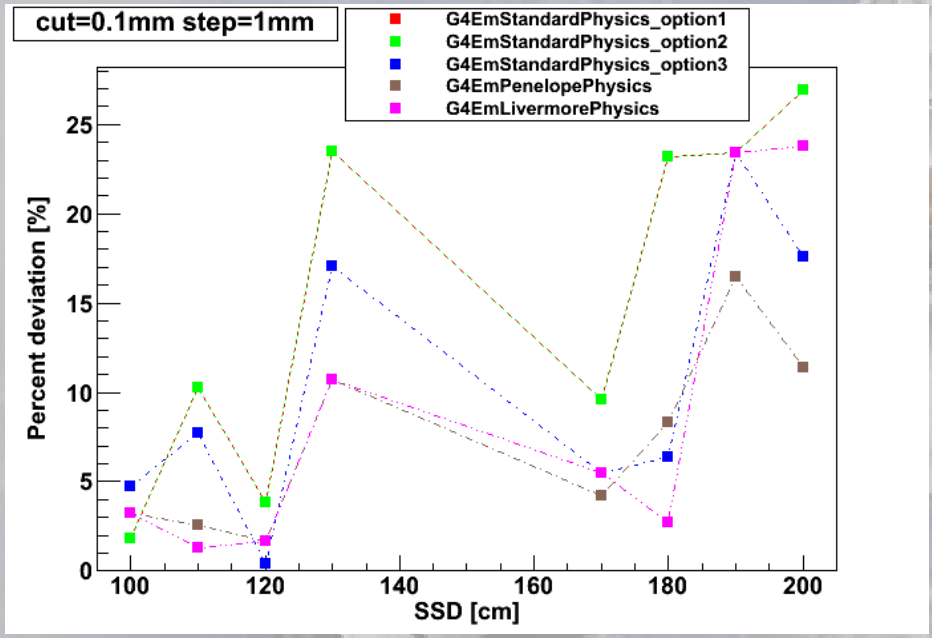
Primary: mono-energetic, 15 MeV, no beam divergence

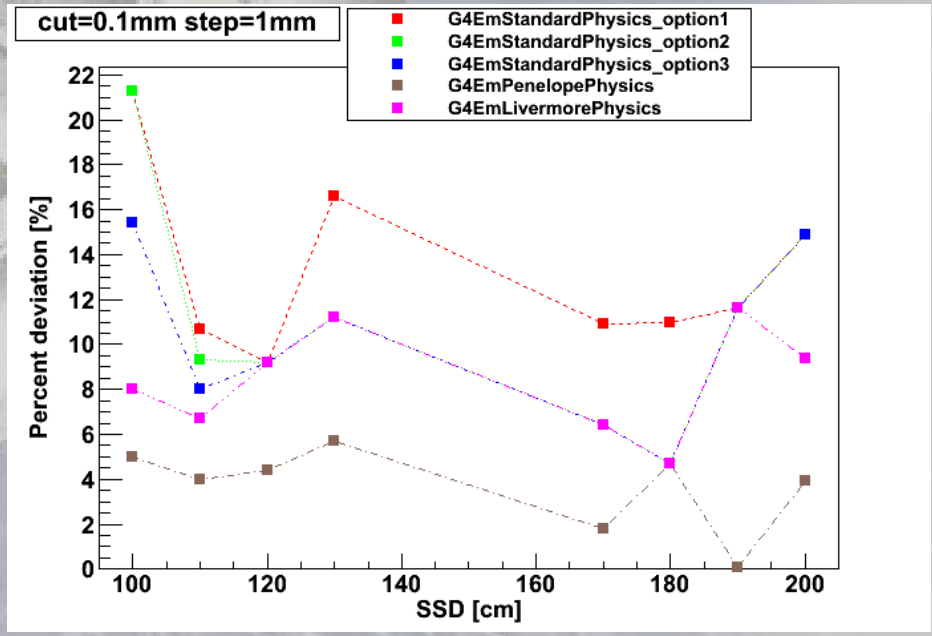




Beam Profile Widths

Beam Profile Width Percent Deviation = ((MC-Data)/Data)x100

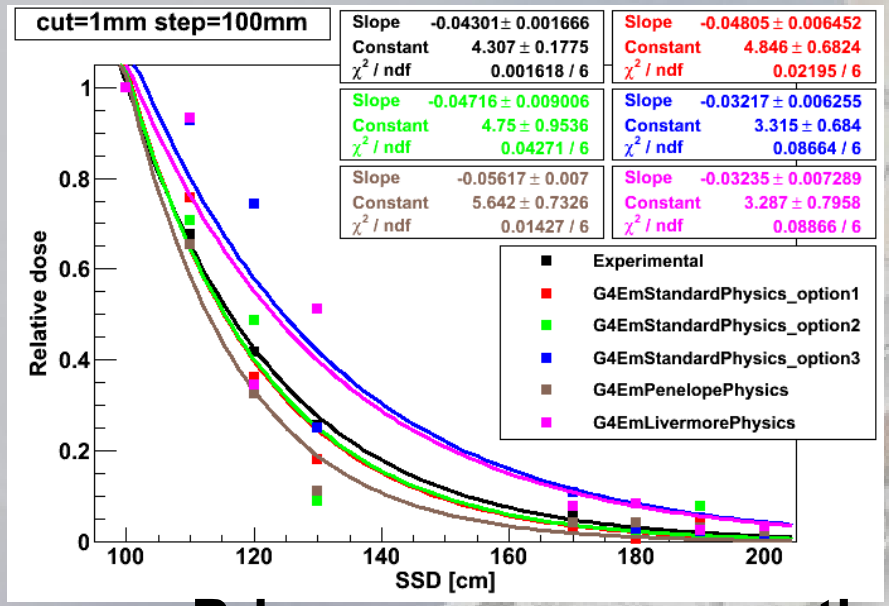


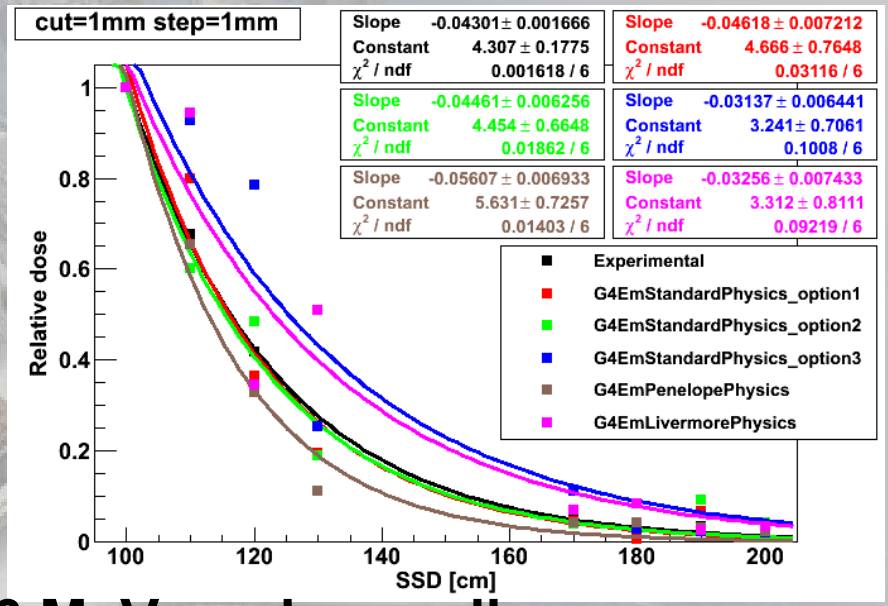


@ 6 MeV e-Beam
Deviation starts after 130 cm for all Physics lists

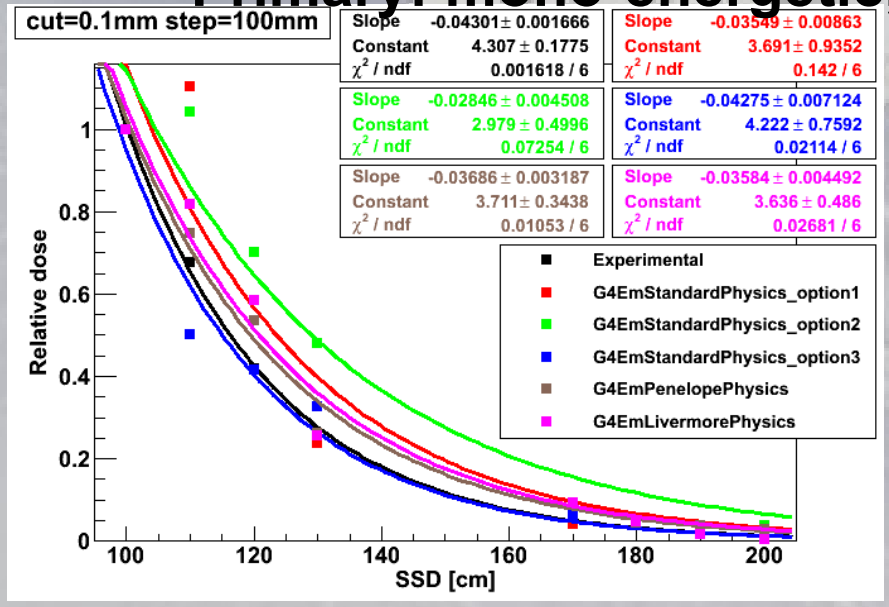
@ 15 MeV e-Beam
G4EmPenelope better agreement

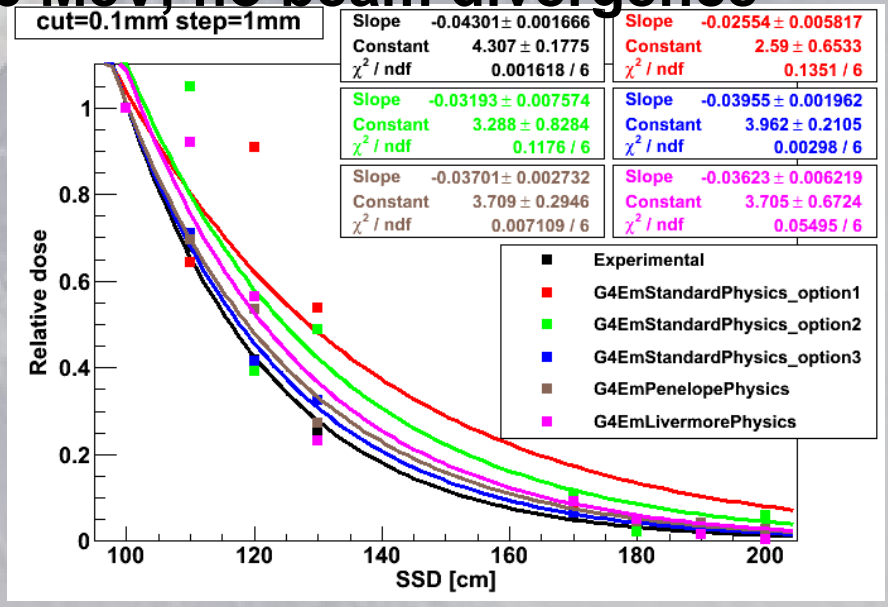
Dose & Energy



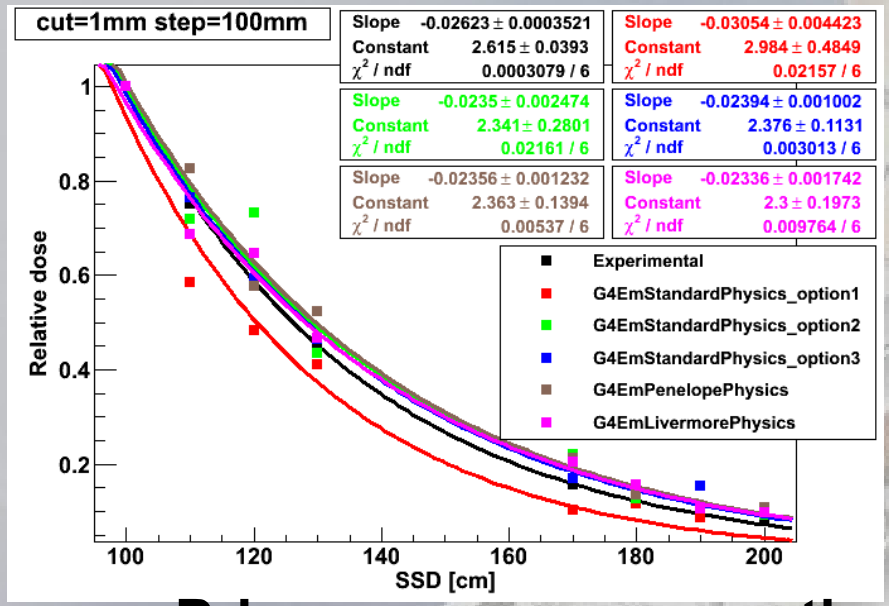


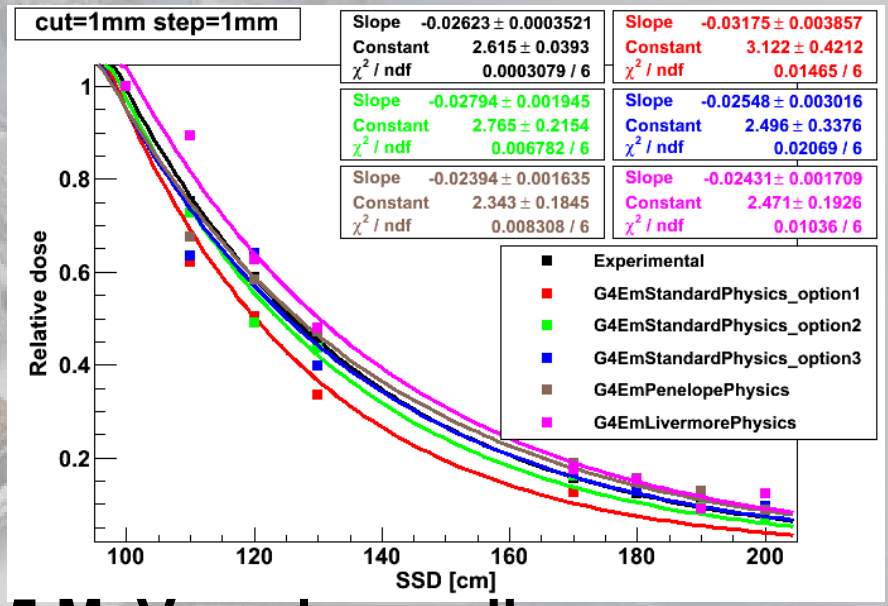
Primary: mono-energetic, 6 MeV, no beam divergence



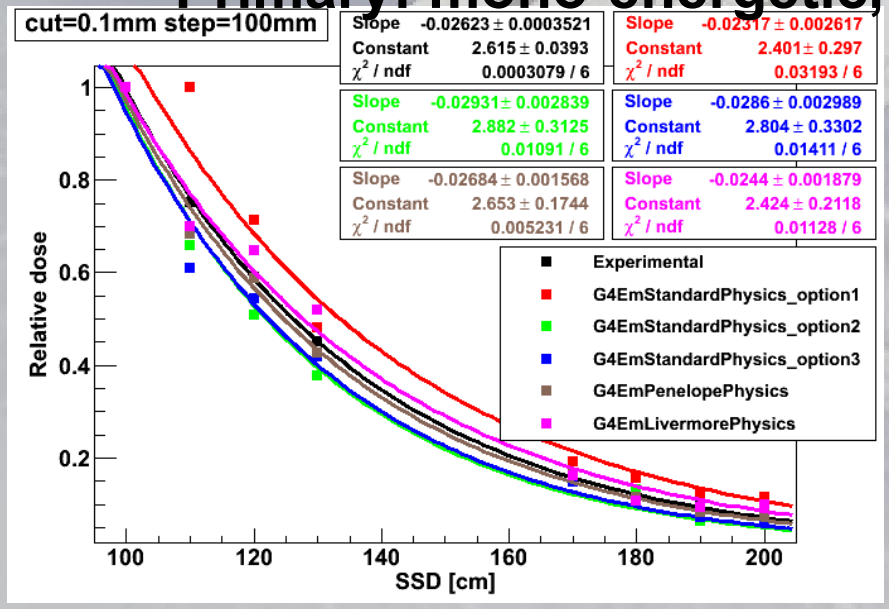


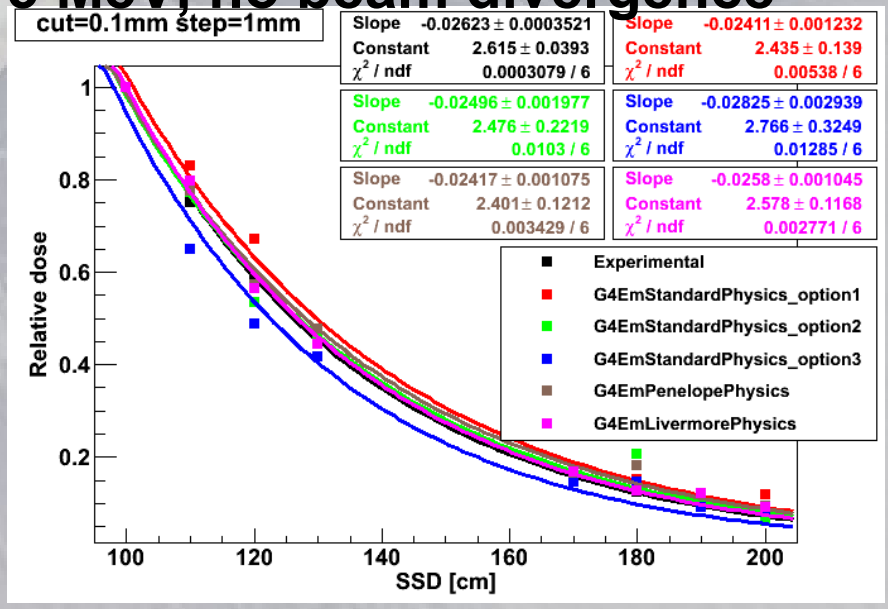
Dose & Energy



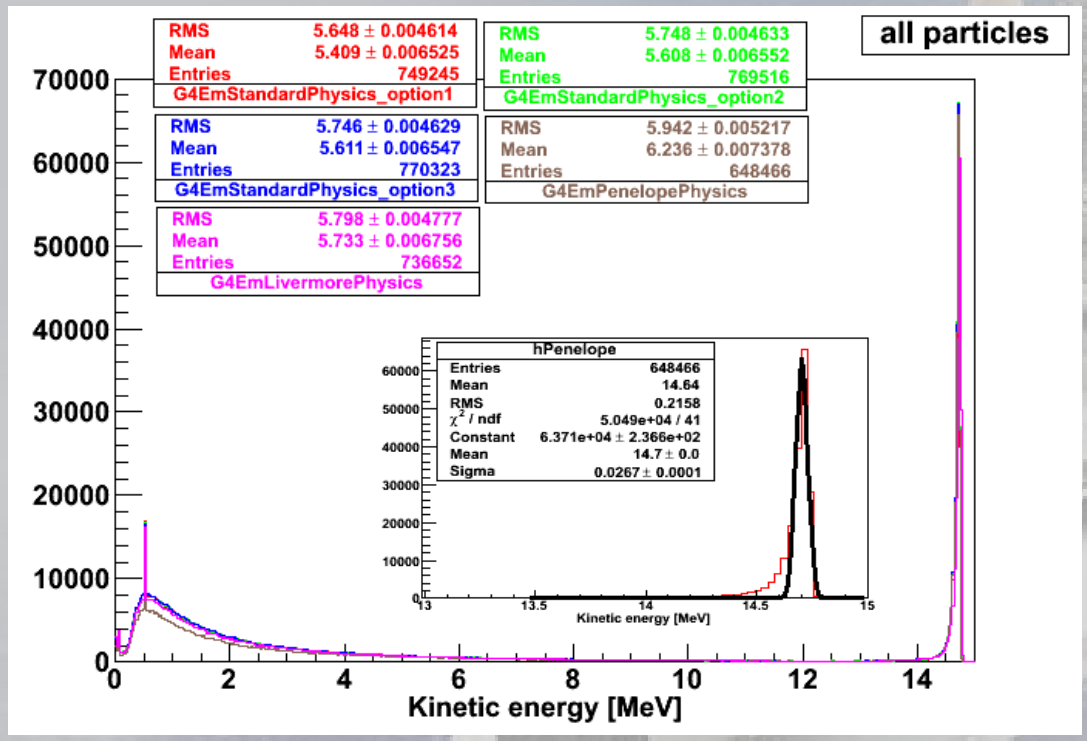


Primary: mono-energetic, 15 MeV, no beam divergence





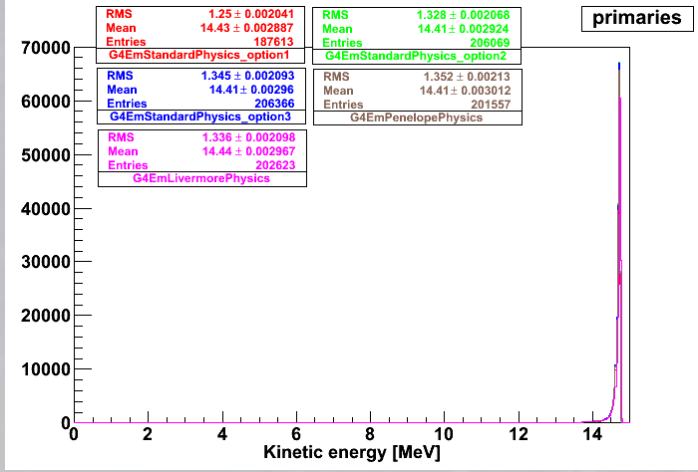
Available Energy @ Detector Surface

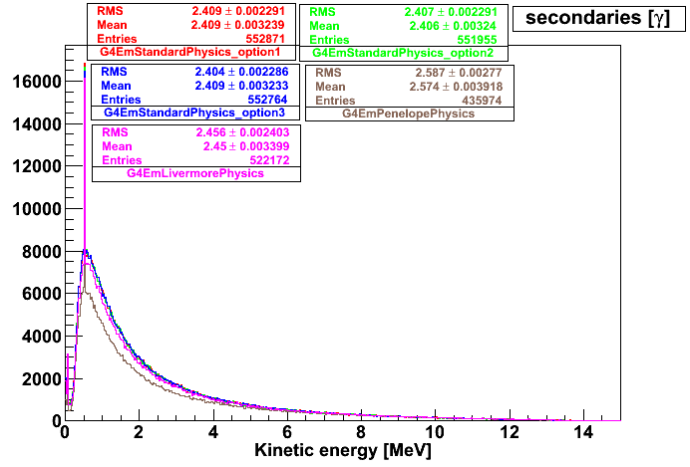


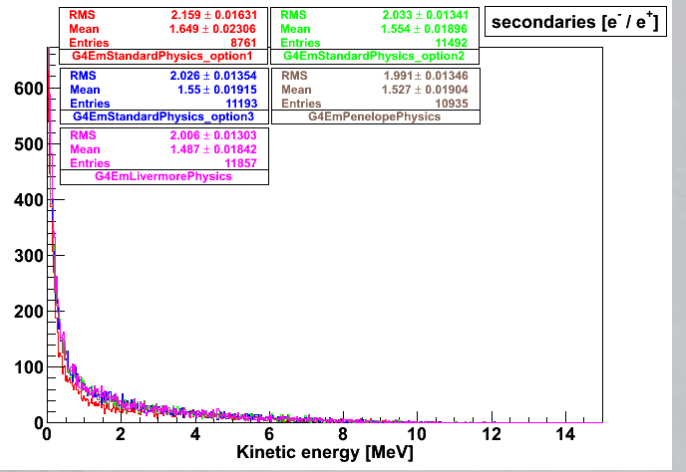
Kinetic energy @ SSD=130cm

For cuts=0.1mm and step=1mm

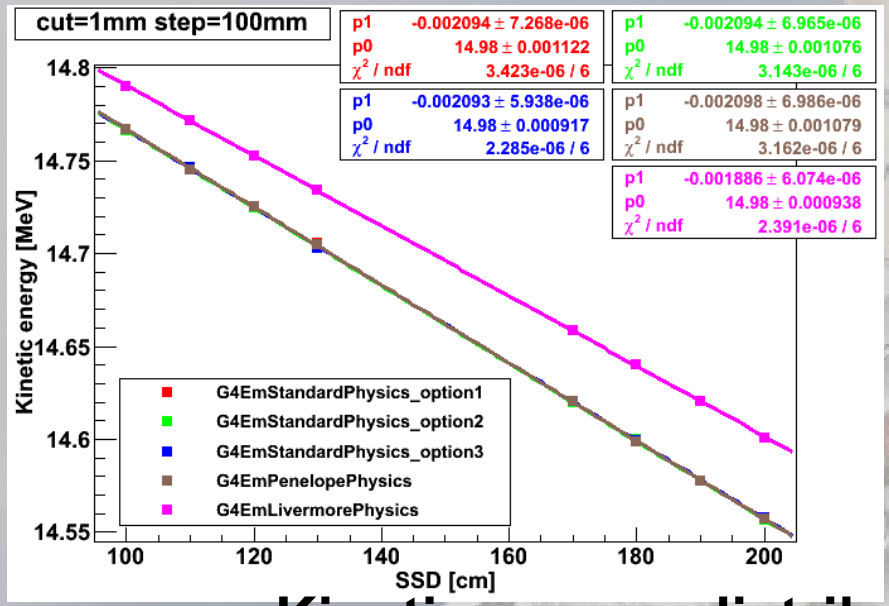
For primaries;
Fit Gauss & Sigma

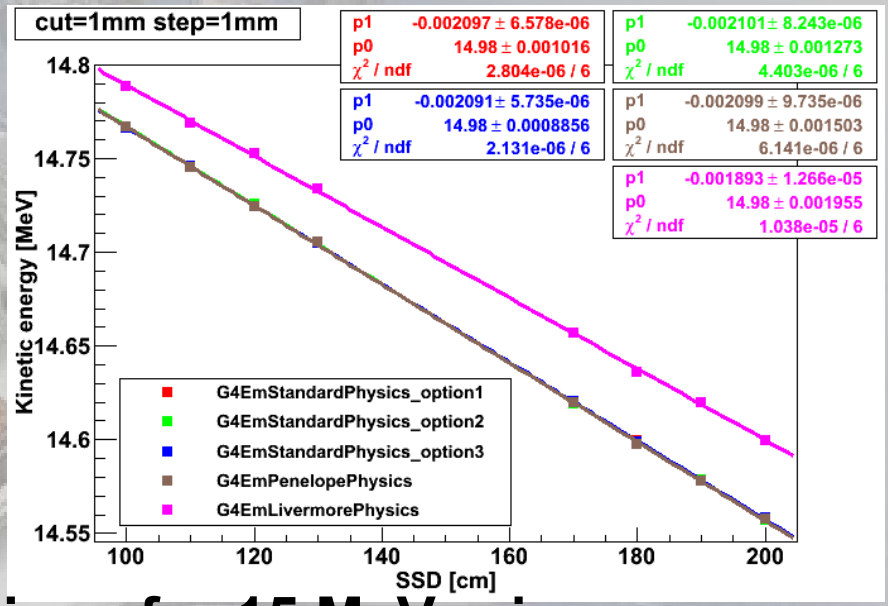




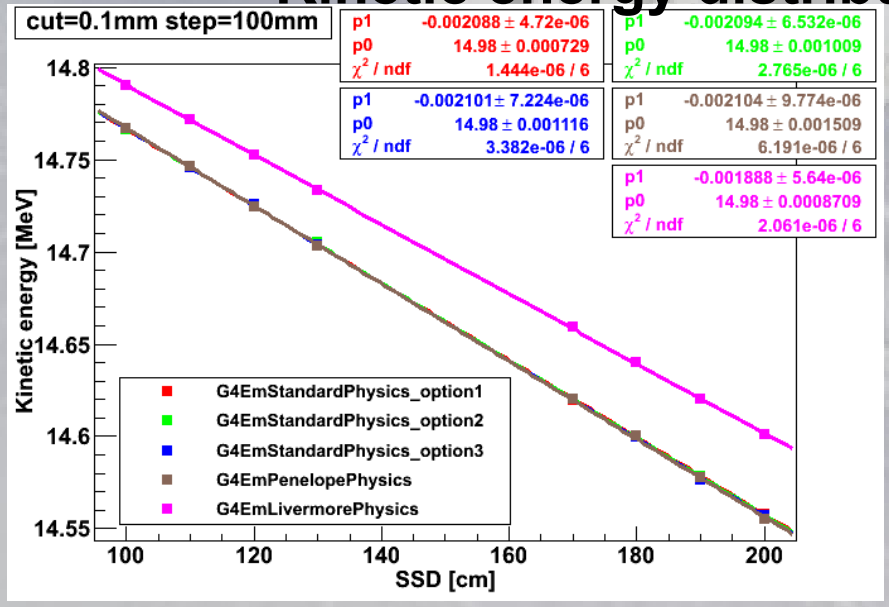


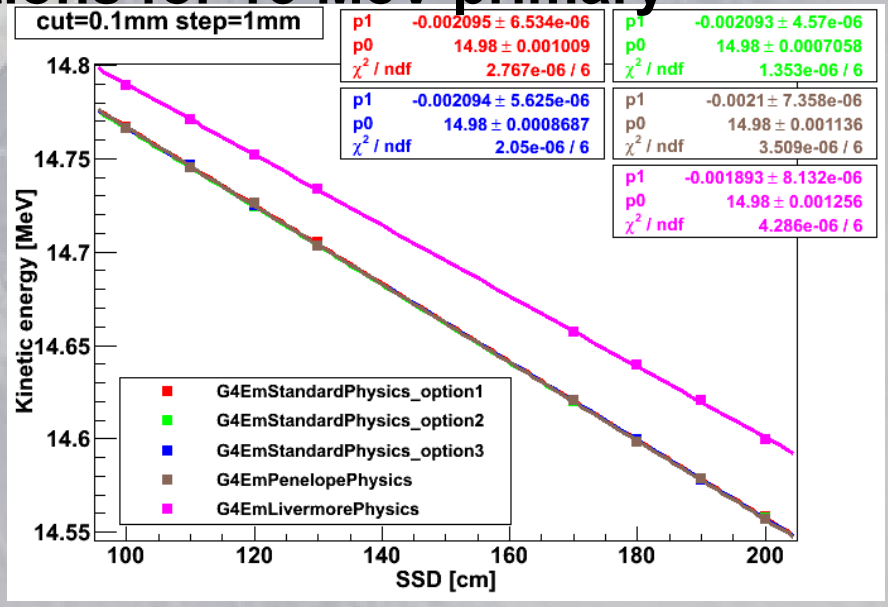
Available Energy @ Detector Surface



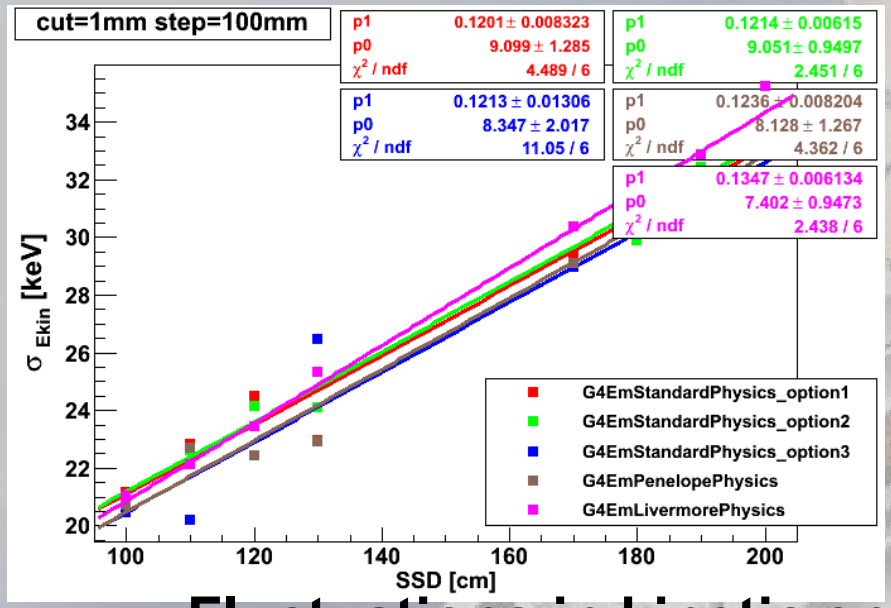


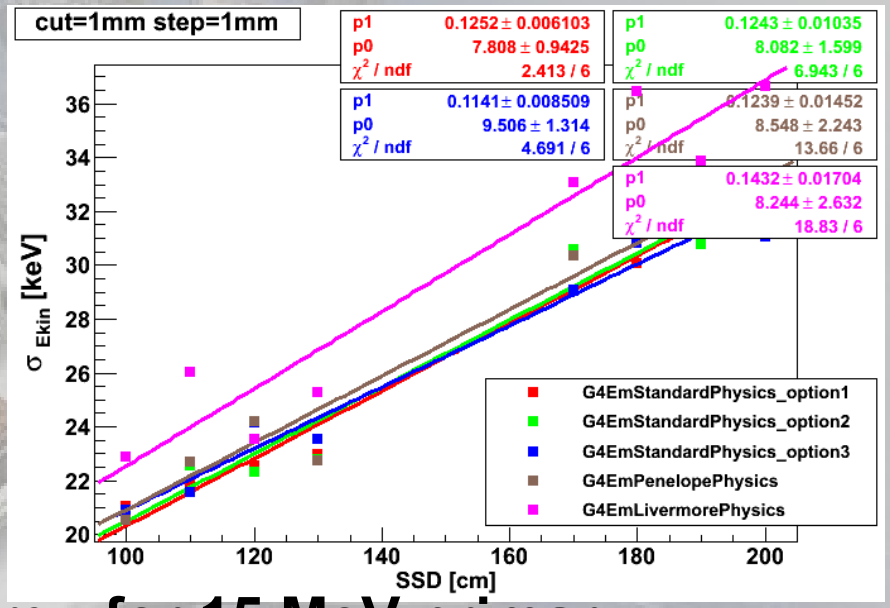
Kinetic energy distributions for 15 MeV primary



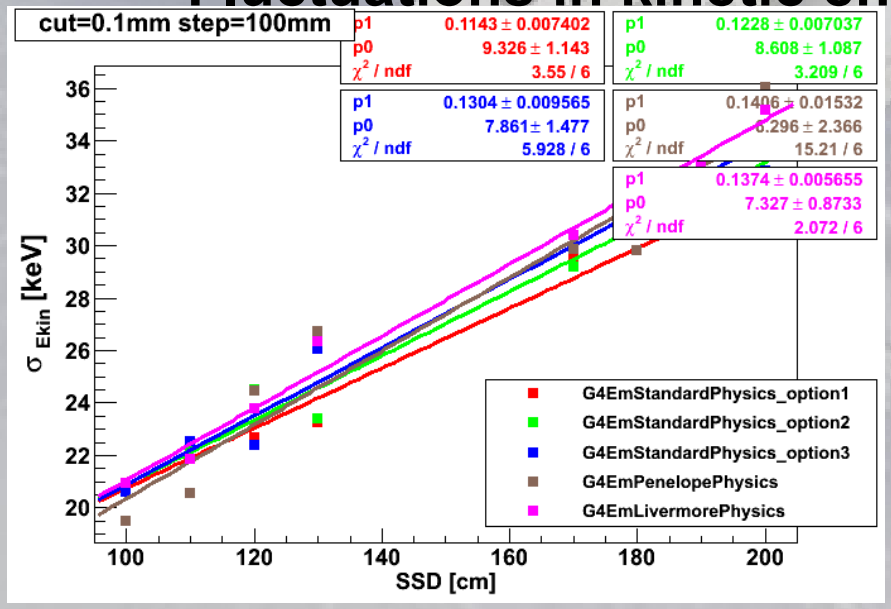


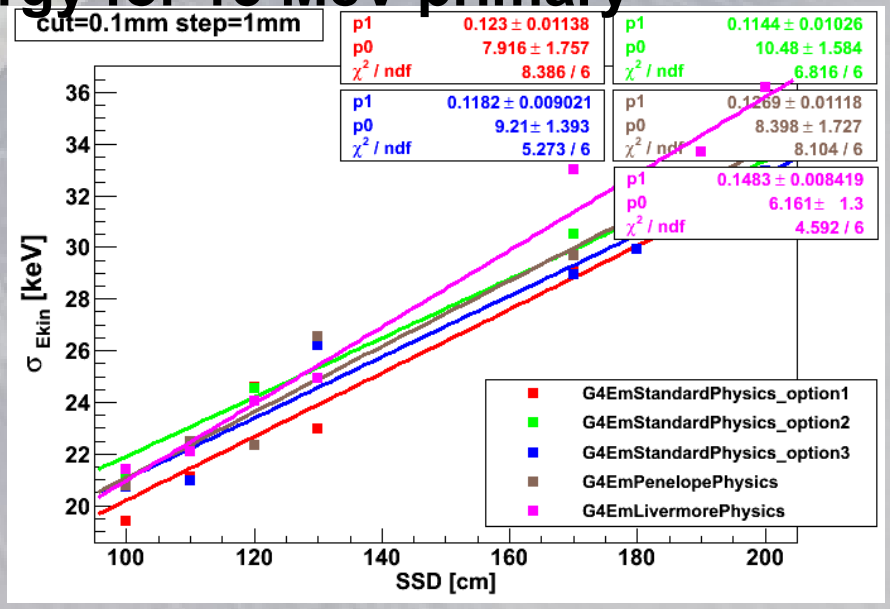
Available Energy @ Detector Surface





Fluctuations in kinetic energy for 15 MeV primary





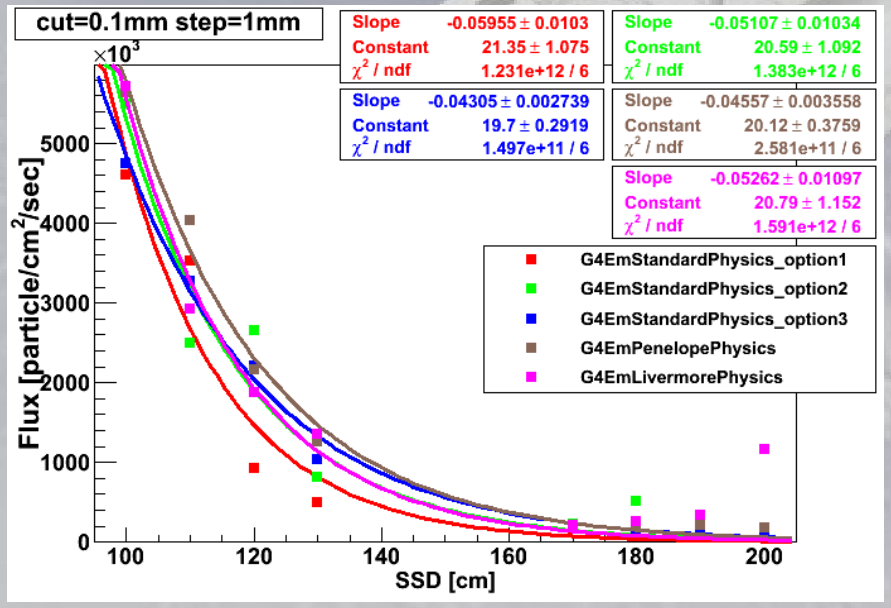
Flux @ Detector Surface

Steps to obtain flux

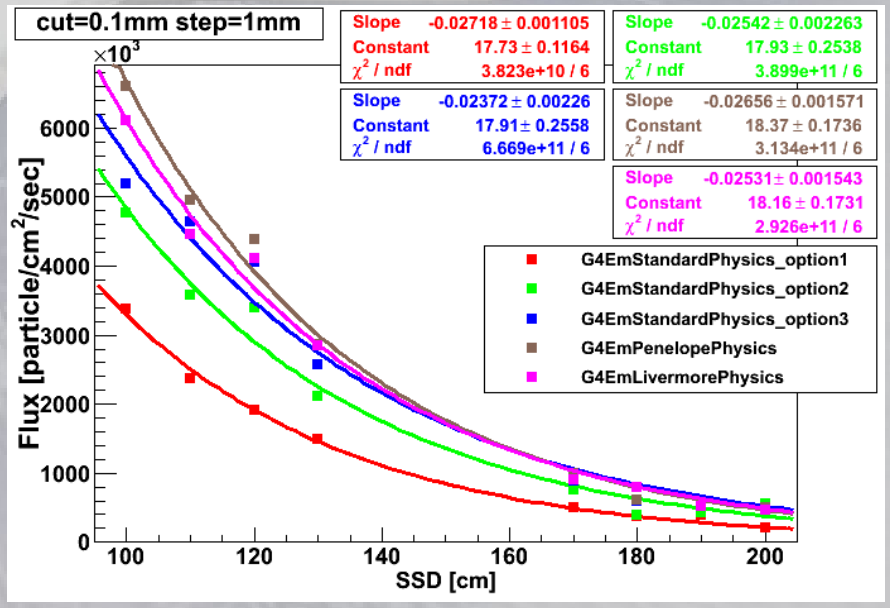
- Convert Energy [MeV] to Dose [Gy]
- Conversion factor [CF] = DoseGeant4 / DoseExperimental
- Flux = CF x DetectorSurfaceHits / DetectorSurface / Time

[particles] / [cm^2] / [second]

6 MeV



15 MeV

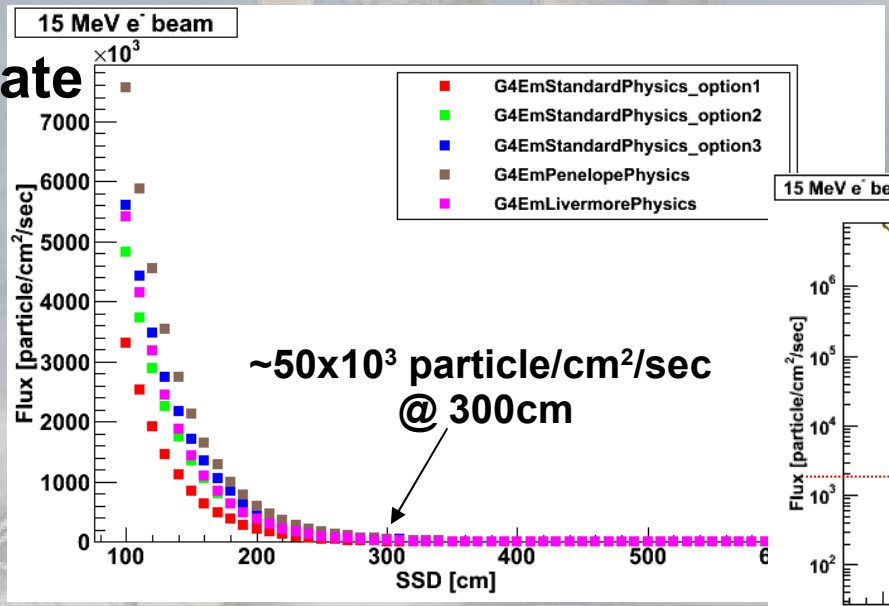


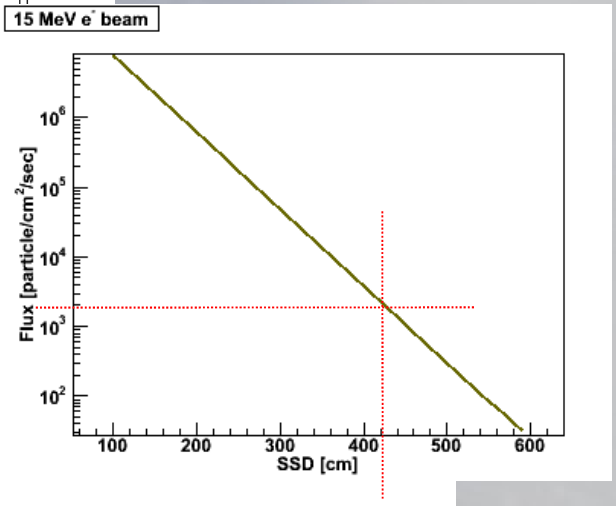
Flux @ Detector Surface

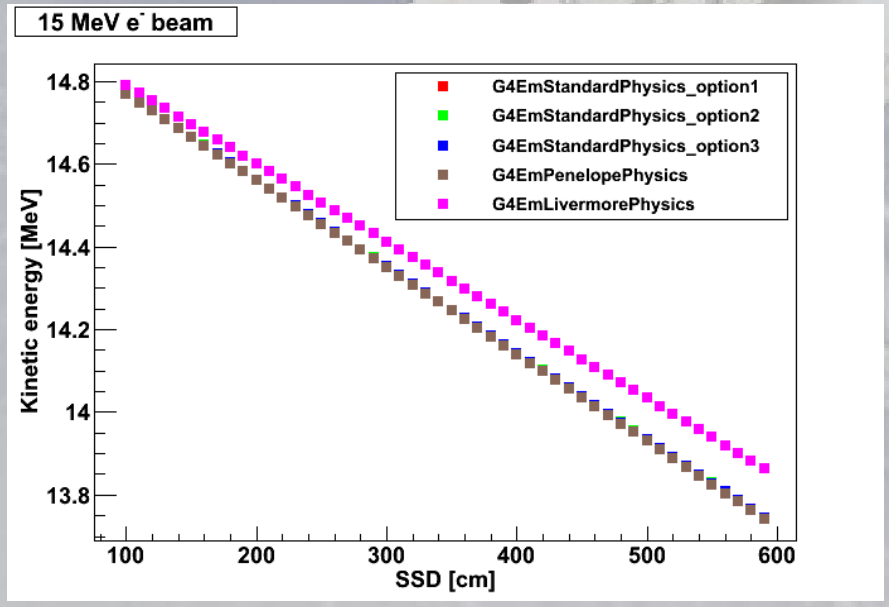
From fits one can estimate @ a given distance;

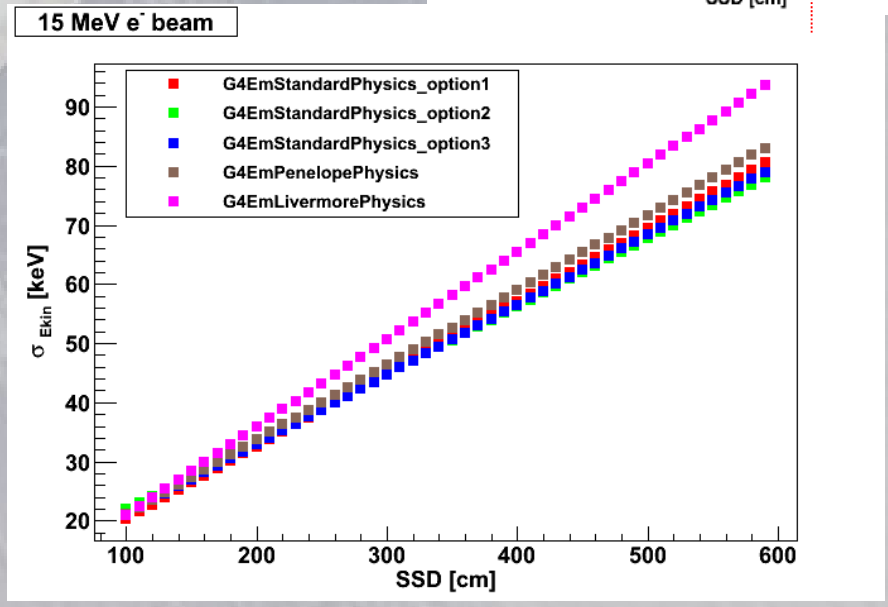
- **Flux**
- **Kinetic energy**
- **σ in Kinetic energy**

cuts=0.1mm step=1mm





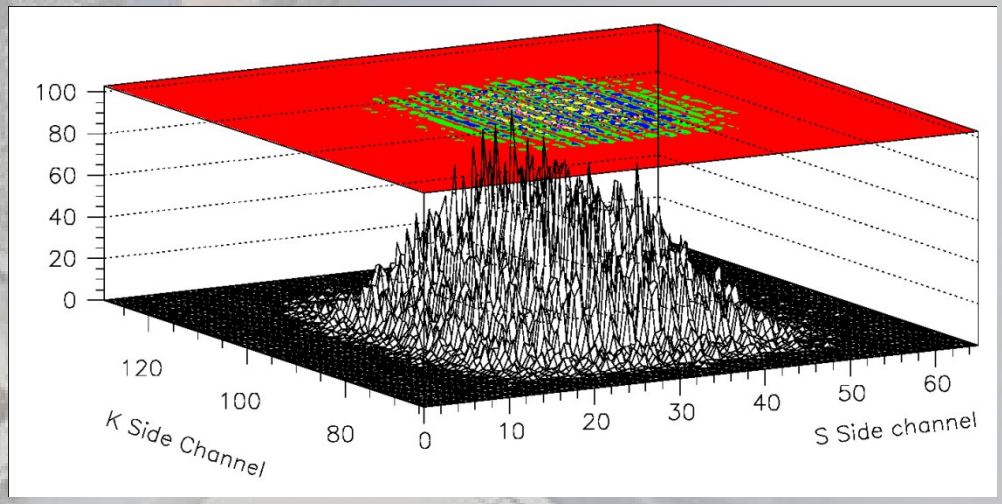


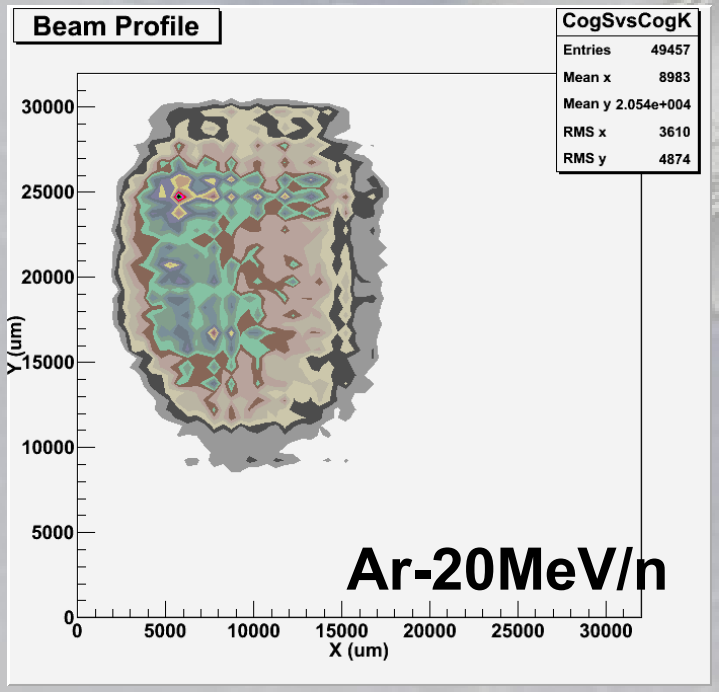


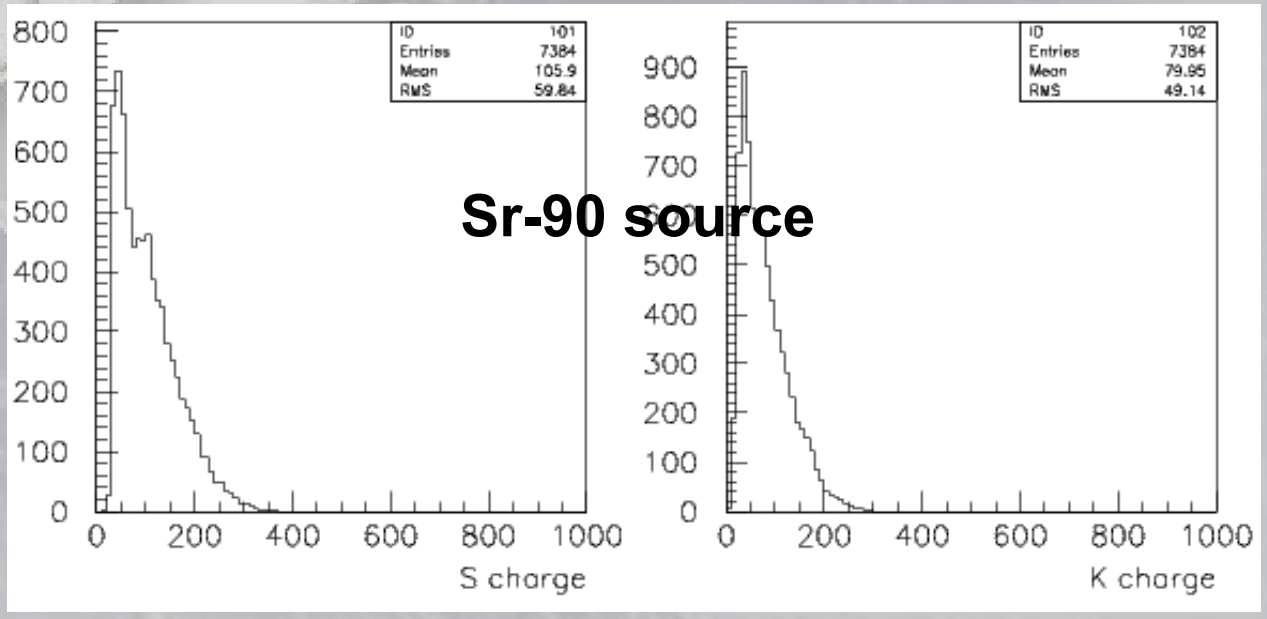
Double Sided Silicon Detector (DSSD)

Double sided silicon detector

- **35x35 mm² and 1.5 mm thick**
- **64 channel on p and n sides with readout pitch of 500 μm**







Conclusions 1/2

- Beam & Dose profiles from Advanced Markus Chamber used in AOT e-Linac is compared with full Geant4 simulations
- Measured Beam & Dose profiles are in better agreement with MC by using cuts=0.1 and step=1mm with G4EmPenelopePhysics
- To reach the same number of simulated events longer computation time is required for G4EmPenelopePhysics and G4EmLivermorePhysics
- In e-Linac facility we can obtain uniform energy distributions at almost all distances and deliver to DUT surface electron fluxes (from few particles/cm^2/sec at about 550 cm up to 10^6 particles/cm^2/sec at 100 cm)

Conclusions 2/2

- The distances larger than 200 cm requires to turn e-Linac head for horizontal irradiation
  (horizontally max available working distance is about 700 cm)

- In addition to instrumentation available at AOT we plan to develop The DSSD and Plastic Scintillator+SiPM detector developments for further comparison and validation studies

- e-Linac at Terni Hospital is a promising site for detector performance testing with electrons of energies ranging from 4-to-20 MeV