

MPEXS benchmark results

- phase space data -

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Aim

- To validate results of **MPEXS** with **phase space data** by comparing with **Geant4** results
 - Depth dose and lateral dose distributions are evaluated for the validation.
- To compare the **calculation speeds** of the simulations between MPEXS and Geant4 with **phase space data**

Contents of Phase Space Data

- header
 - **the total number of particles**, the total number of photons, the max. kinetic energy of the particles, the min. kinetic energy of the particles, etc.
- particle information of *the total number of particles*
 - **LATCH**: the particle's history, **the particle charge**
 - **E**: **the particle total energy**
 - **X**: **the particle X-position** [cm], **Y**: **the particle Y-position** [cm] on a scoring plane
 - **U**: **the X-direction cosine**, **V**: **the Y-direction cosine** at the particle position
 - **WT**: the particle's weight: **the sign of the Z-direction cosine**,
W: $= \text{SQRT}(1-(U^2+V^2))$

Dataset of Phase Space Data

- SIEMENS Primus electrons or X-rays

- (a) total energy, (b) total number of source particles, (c) number of files, and (d) total file sizes
- electron source

(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
6 MeV	43,976,682	8	1.1 GB	15 MeV	91,321,327	8	2.4 GB
9 MeV	61,634,988	8	1.6 GB	18 MeV	114,334,660	7	3.0 GB
12 MeV	89,084,463	8	2.3 GB	21 MeV	167,747,990	8	4.4 GB

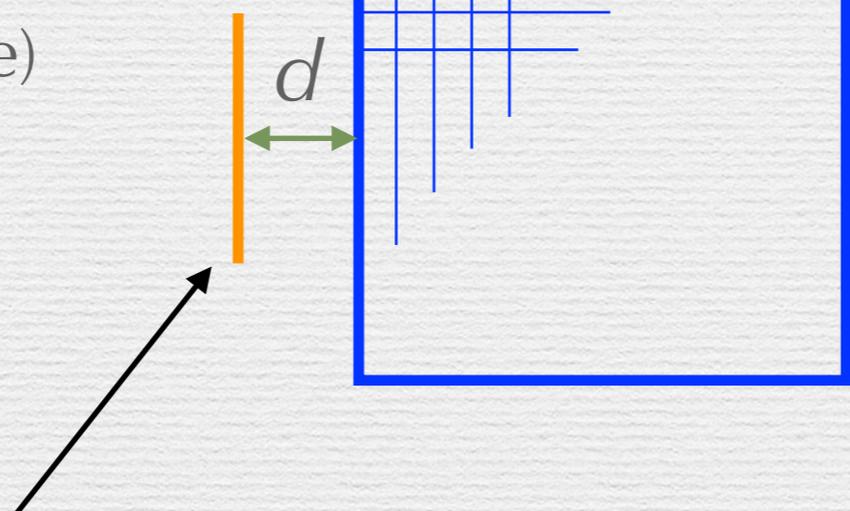
- X-rays source

(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
6 MeV	83,171,454	8	2.2 GB	18 MeV	60,284,412	8	1.6 GB

Geometry Configuration of Simulation

water phantom

SSD: 100 cm
(source surface distance)



size: 20 cm x 20 cm x 20 cm
of voxels: 100 x 100 x 100

phase space plane

size: 10 cm x 10 cm

distance to surface (d): electron phase space source: $d = 1$ cm
X-ray phase space source: $d = 50$ cm

Geant4 simulation

- version: [10.2 p2](#)
 - Physics processes:
 - for electrons and positrons
 - G4eMultipleScattering, G4eIonisation, G4eBremsstrahlung, G4eplusAnnihilation
 - for X-rays
 - G4PhotoElectricEffect, G4ComptonScattering, G4GammaConversion
- range cut value: 1 mm (default)

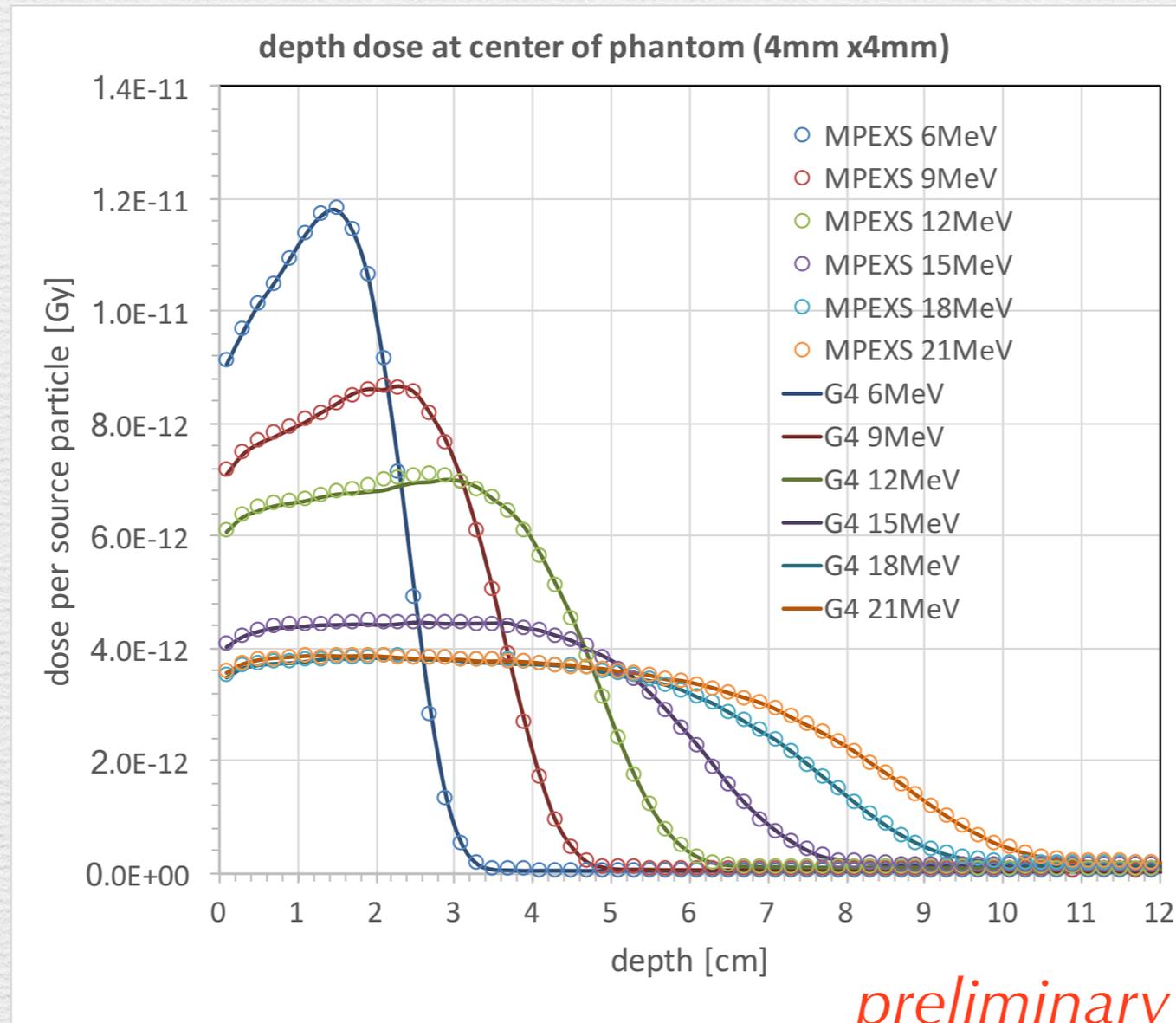
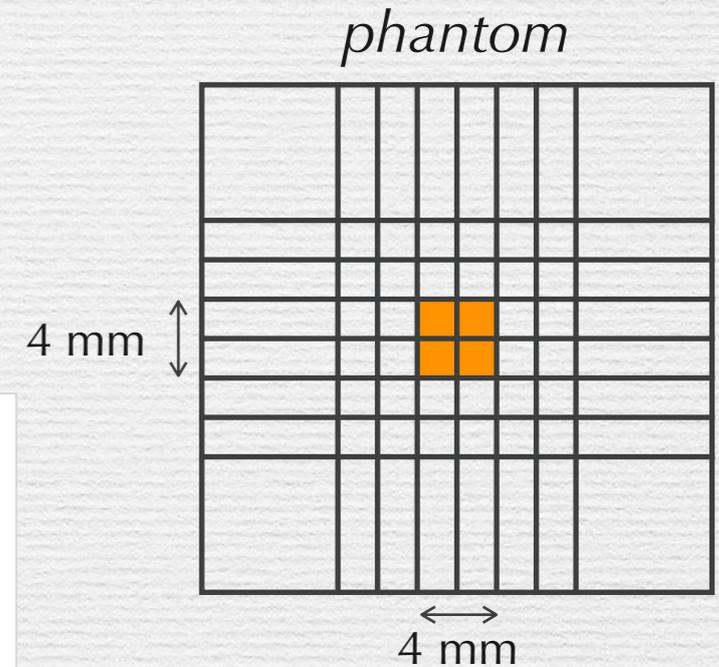
MPEXS

- Physics configuration is the same as one of Geant4:
 - Physics processes:
 - for electrons and positrons
 - multiple scattering, ionization, Bremsstrahlung, positron annihilation
 - for X-rays
 - photoelectric effect, Compton scattering, gamma conversion
- range cut value: 1 mm (default)

Depth Dose at Center of Phantom (Primus electrons)

MPEXS (circles) vs Geant4 (lines)

- central axis voxel of 4 mm x 4 mm x 2 mm thick
- electrons: 6, 9, 12, 18 and 21 MeV

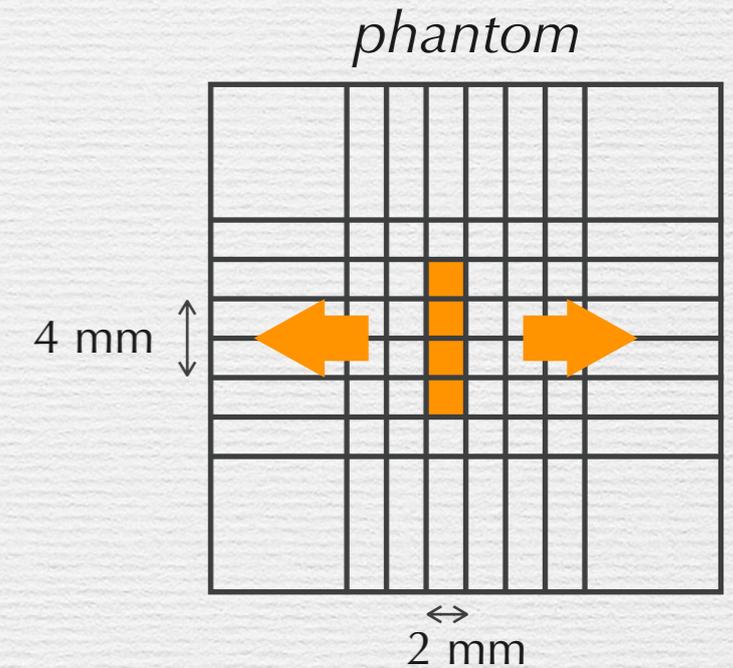


preliminary result

X-axis Profiles (Primus electrons at 1.5 cm depth)

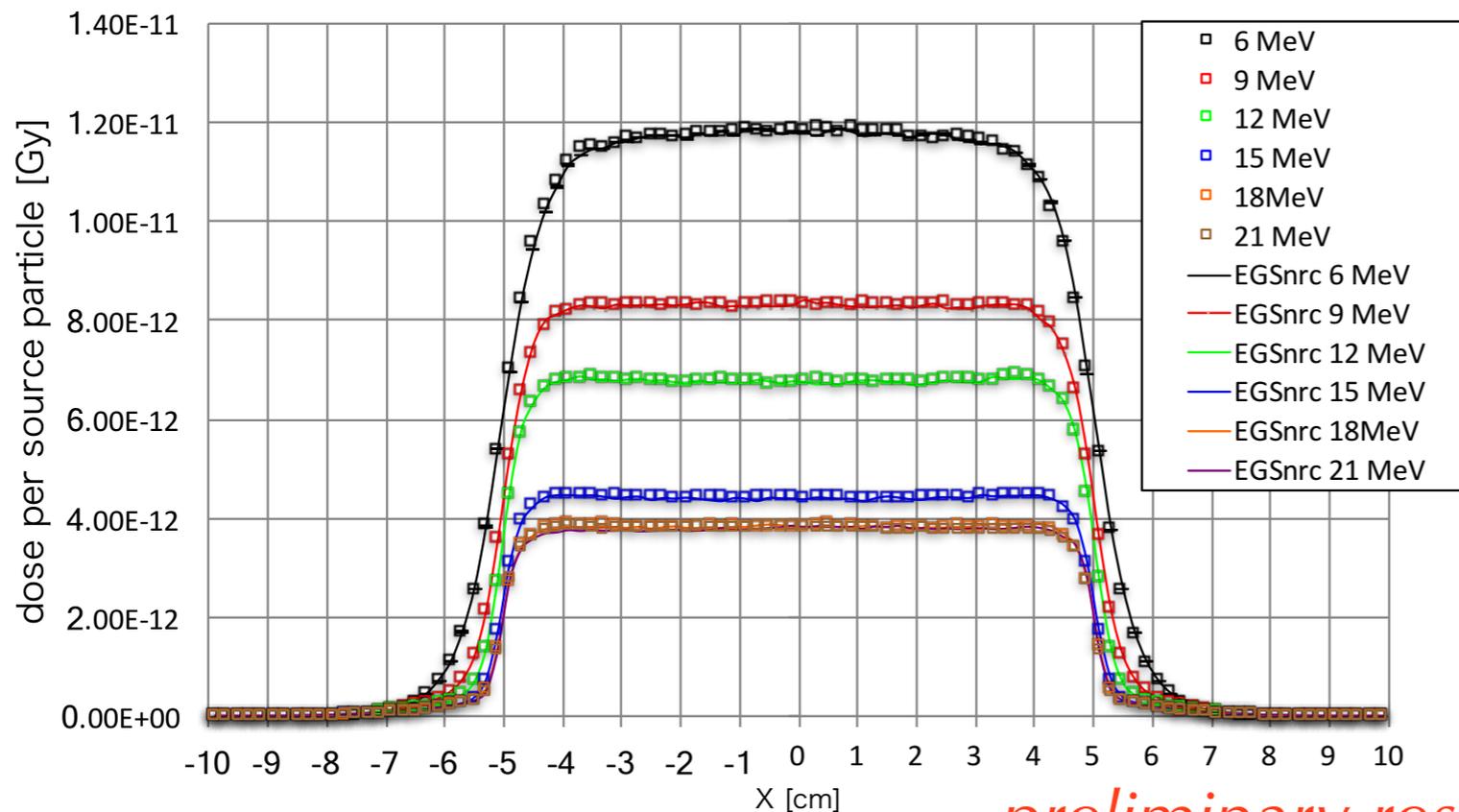
MPEXS (circles) vs Geant4 (lines)

- voxel of 8 mm out of plane and 2 mm x 2mm thick
- electrons: 6, 9, 12, 18 and 21 MeV



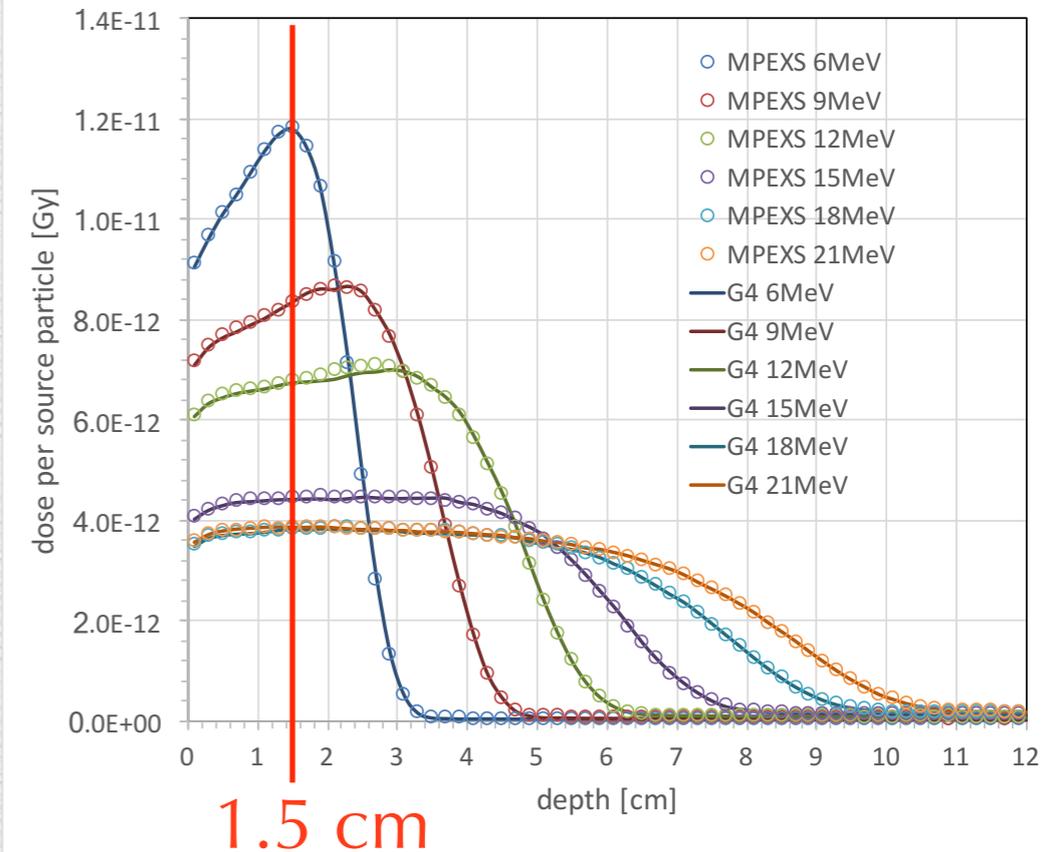
X-axis

Profiles of Primus electrons at 1.5 cm depth



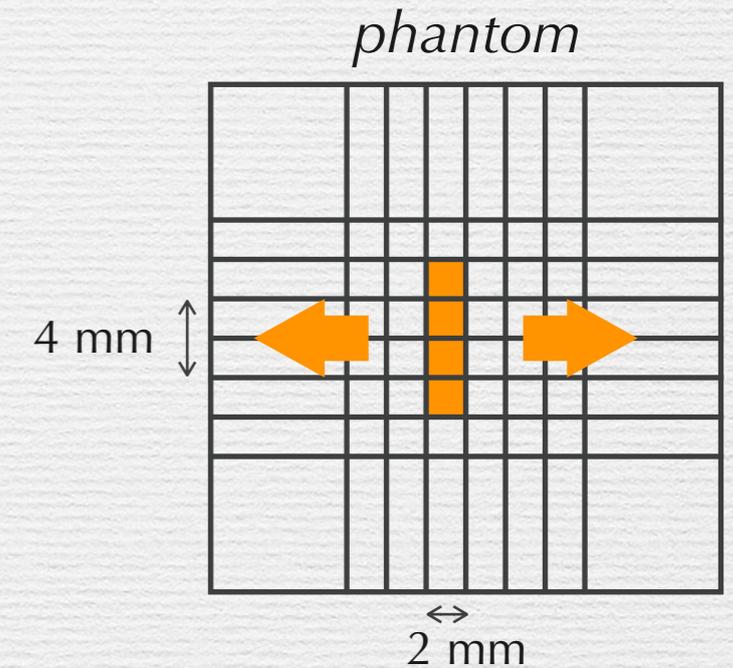
preliminary result

depth dose at center of phantom (4mm x4mm)



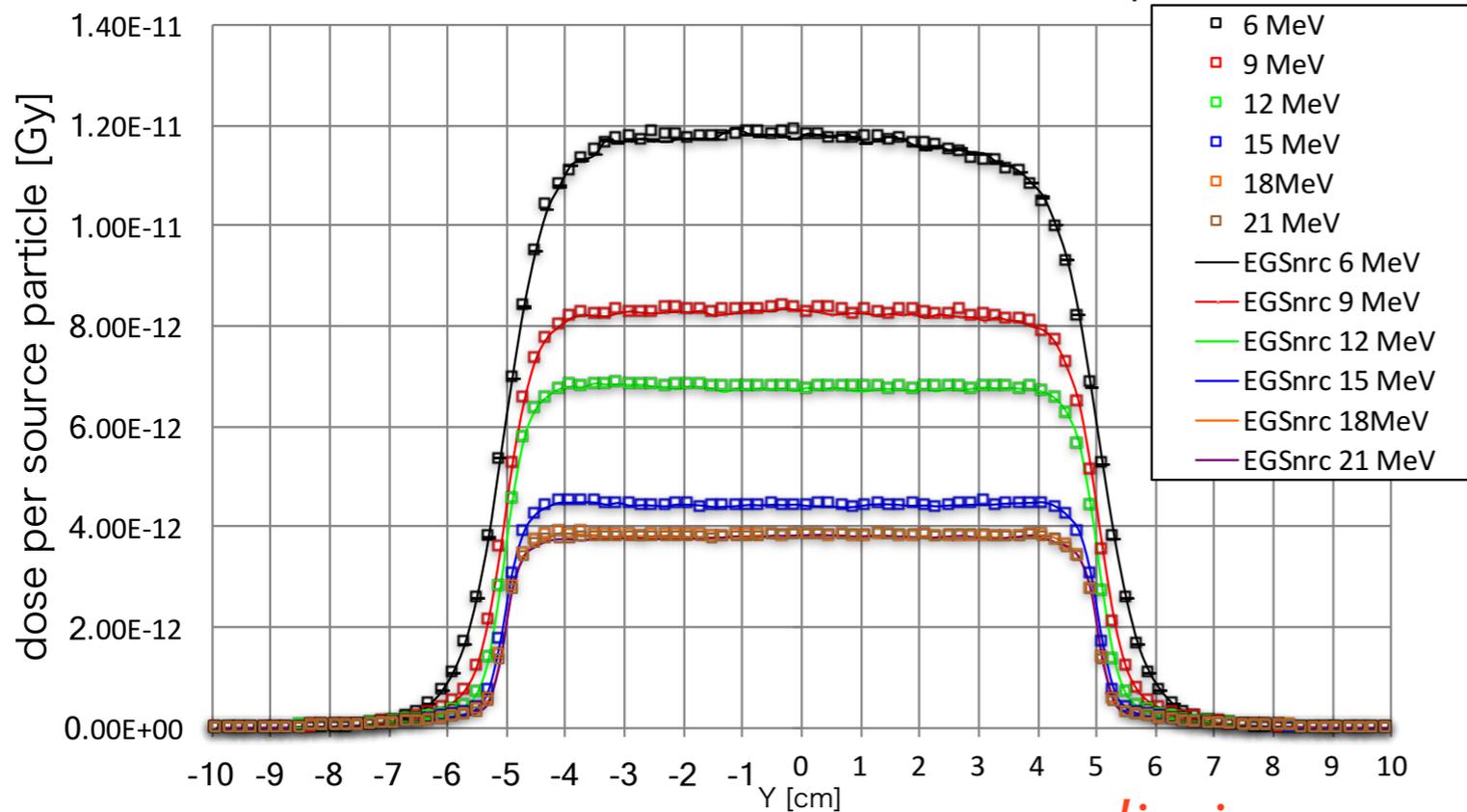
Y-axis Profiles (Primus electrons at 1.5 cm depth)

- MPEXS (circles) vs Geant4 (lines)
 - voxel of 8 mm out of plane and 2 mm x 2mm thick
 - electrons: 6, 9, 12, 18 and 21 MeV



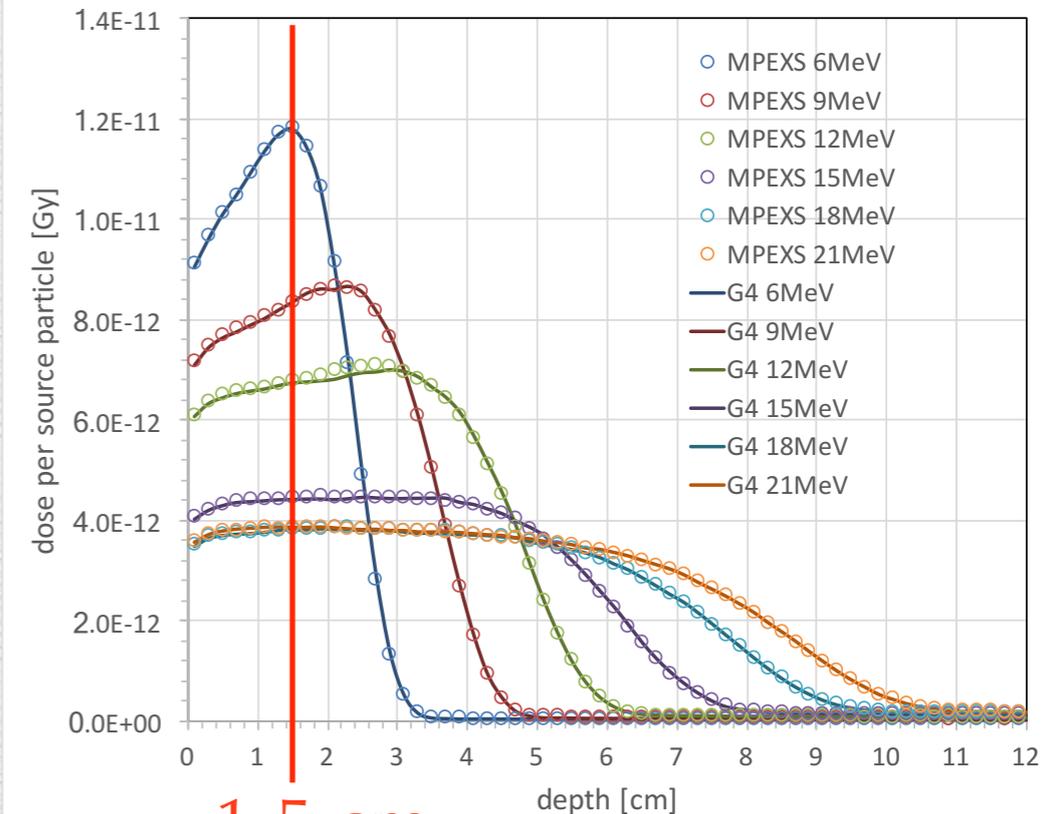
Y-axis

Profiles of Primus electrons at 1.5 cm depth



preliminary result

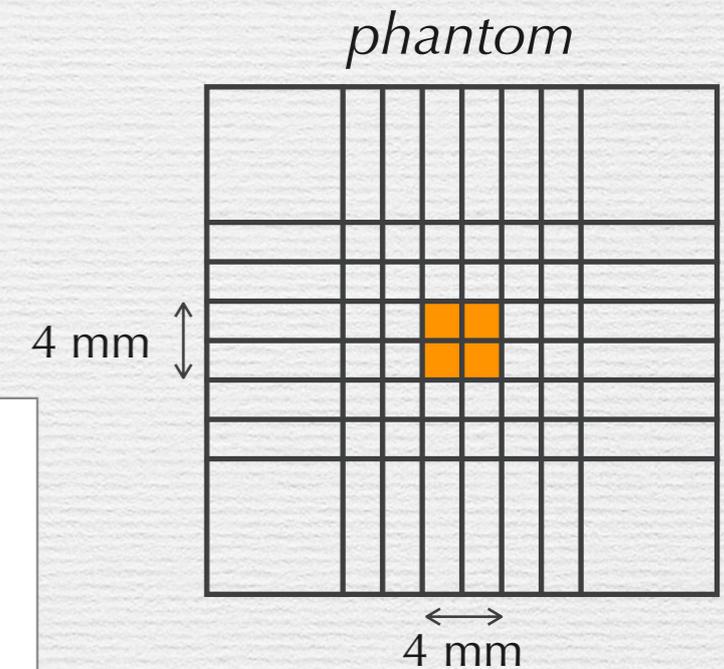
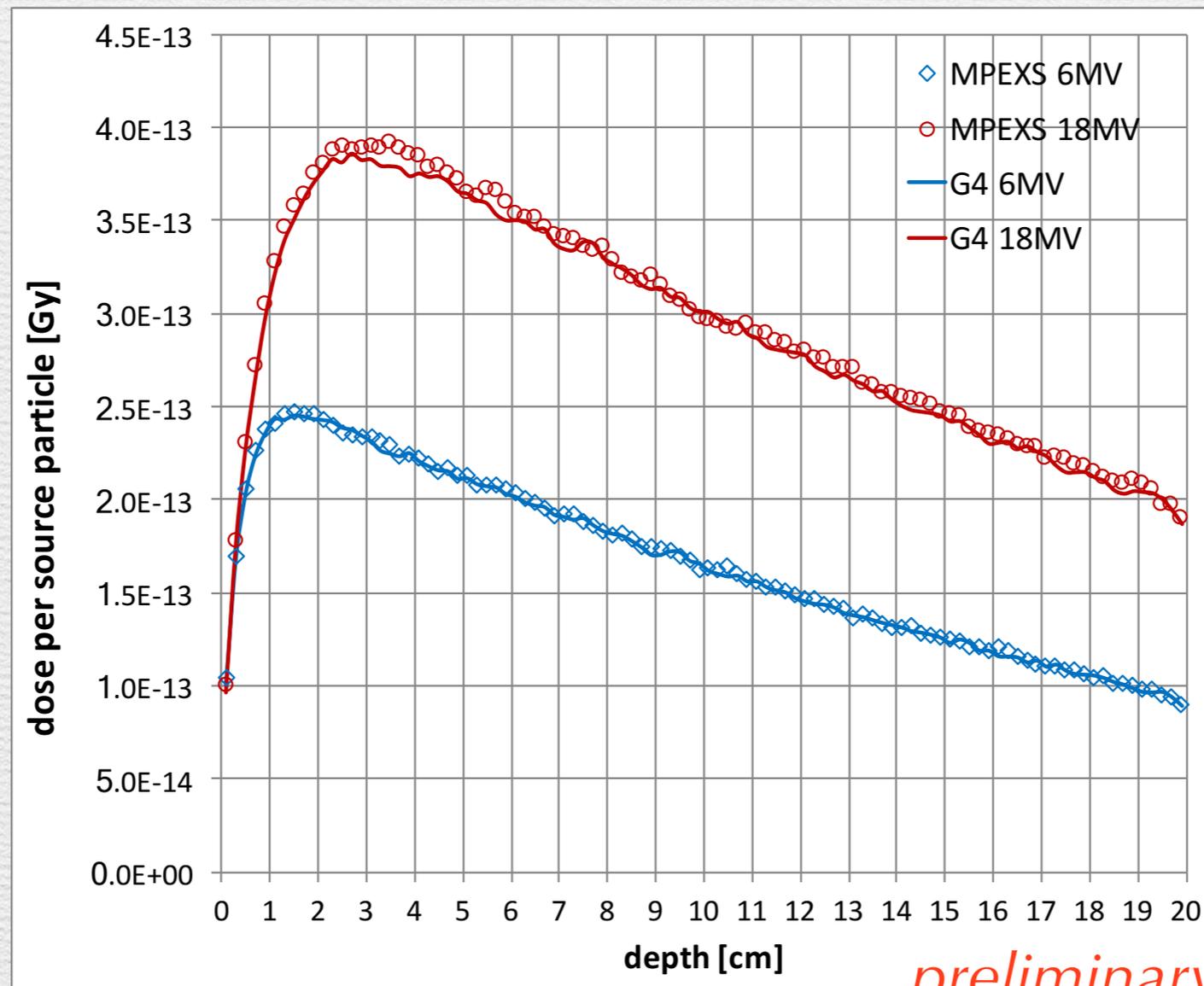
depth dose at center of phantom (4mm x4mm)



1.5 cm

Depth Dose at Center of Phantom (Primus X-rays)

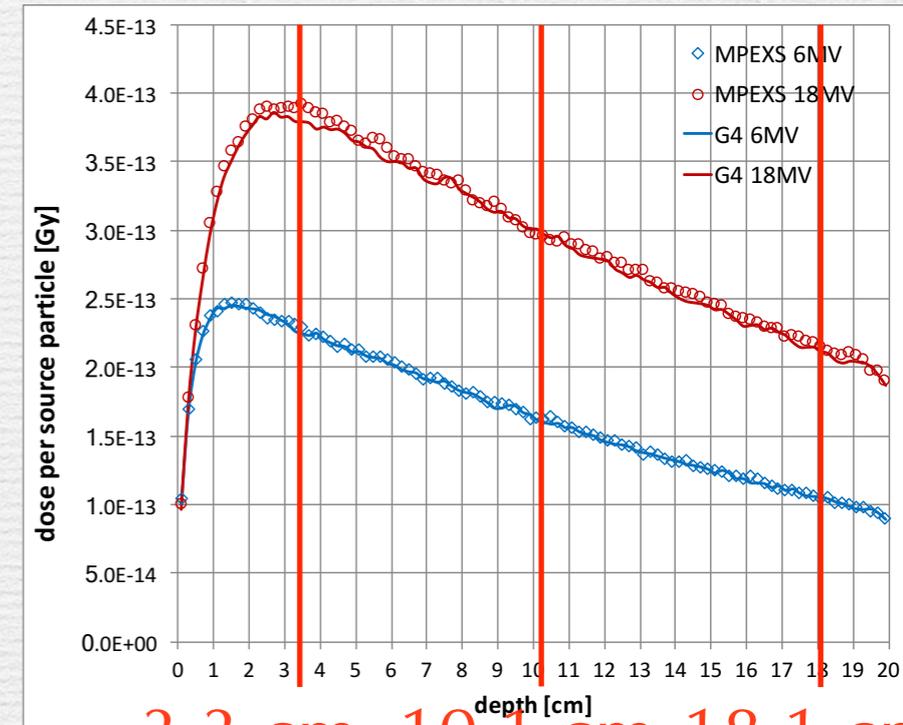
- MPEXS (circles) vs Geant4 (lines)
 - central axis voxel of 4 mm x 4 mm x 2 mm thick
 - X-rays: 6 and 18 MeV



X-axis profiles (Primus X-rays)

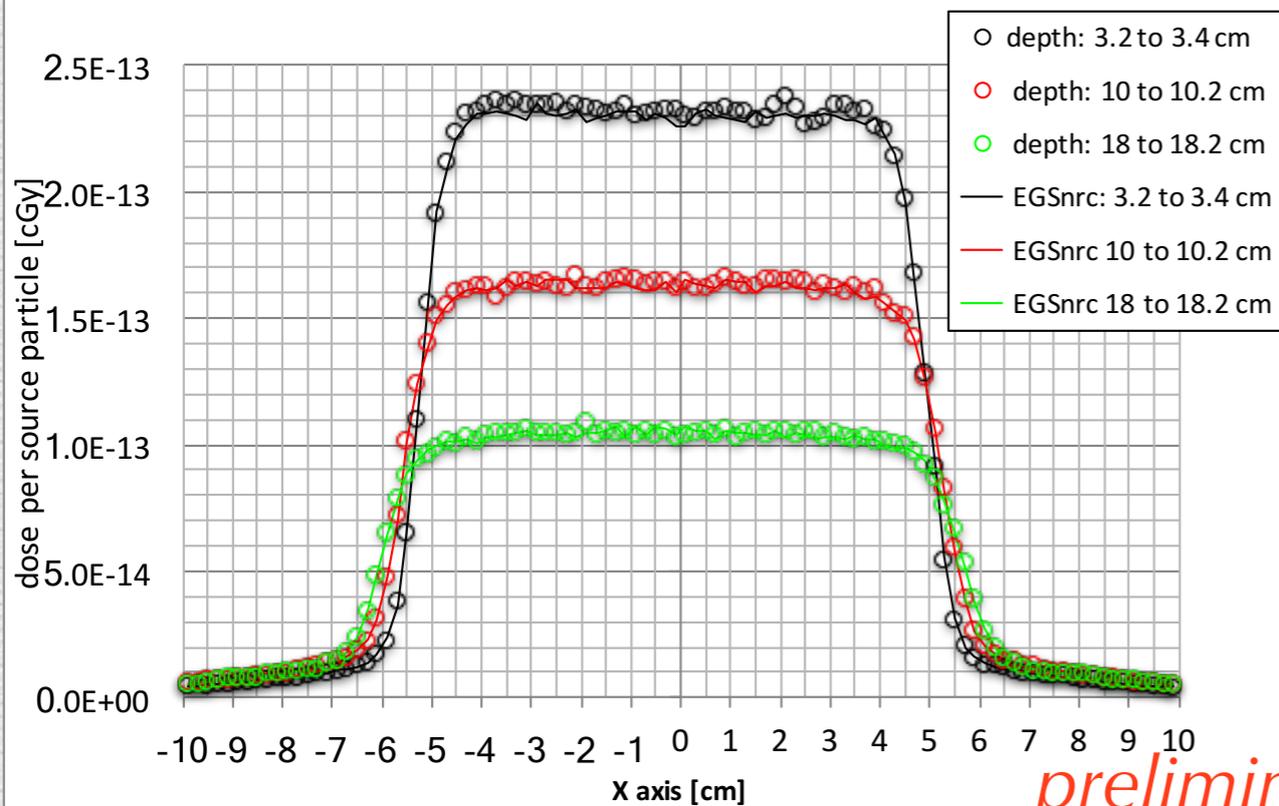
- MPEXS (circles) vs Geant4 (lines)

- voxel of 8 mm out of plane and 2 mm x 2mm thick at 3.3 cm, 10.1 cm, or 18.1 cm depths
- X-rays: 6 and 18 MeV

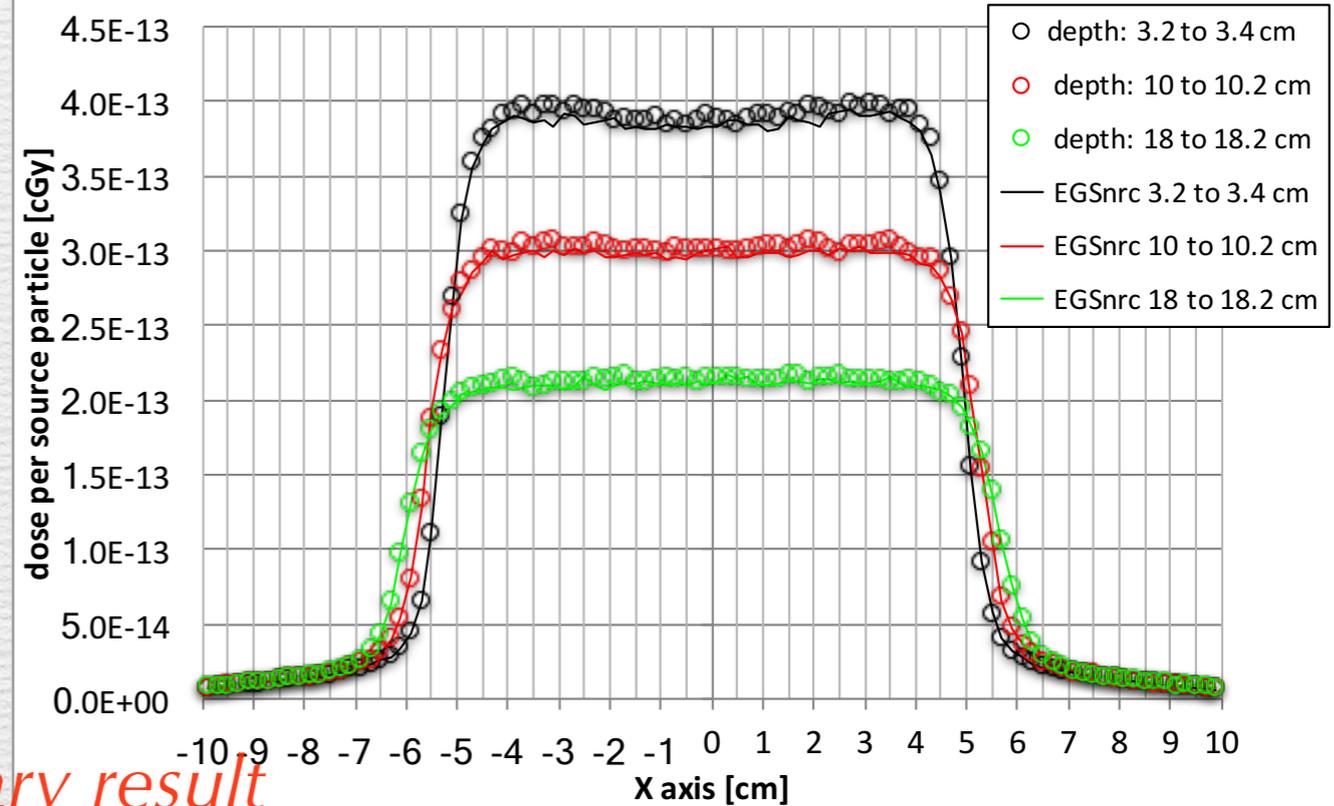


3.3 cm 10.1 cm 18.1 cm

X-axis profiles (siemens primus 6 MV X-ray)



X-axis profiles (siemens primus 18 MV X-ray)

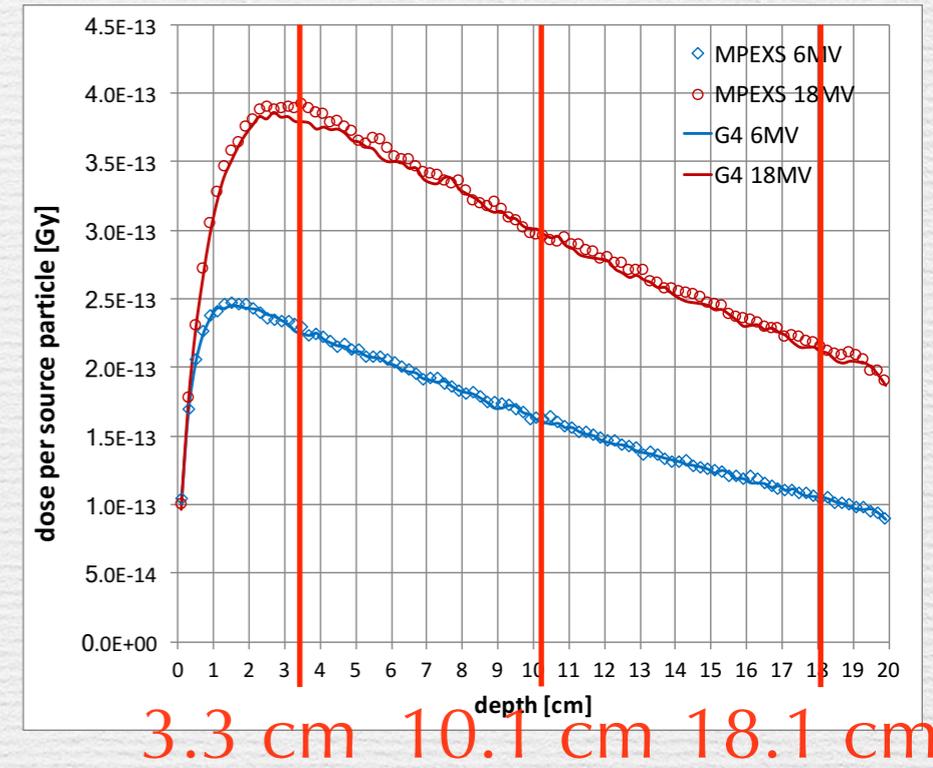


preliminary result

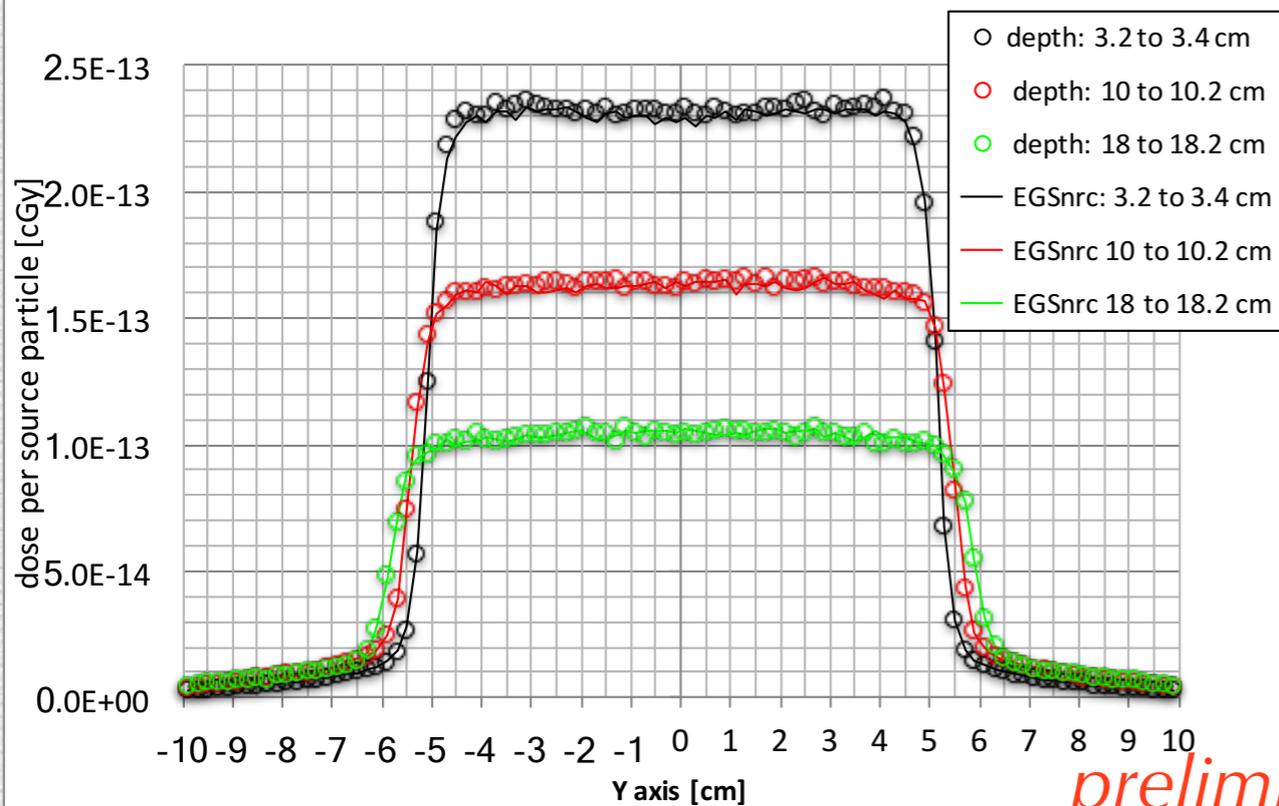
Y-axis profiles (Primus X-rays)

- MPEXS (circles) vs Geant4 (lines)

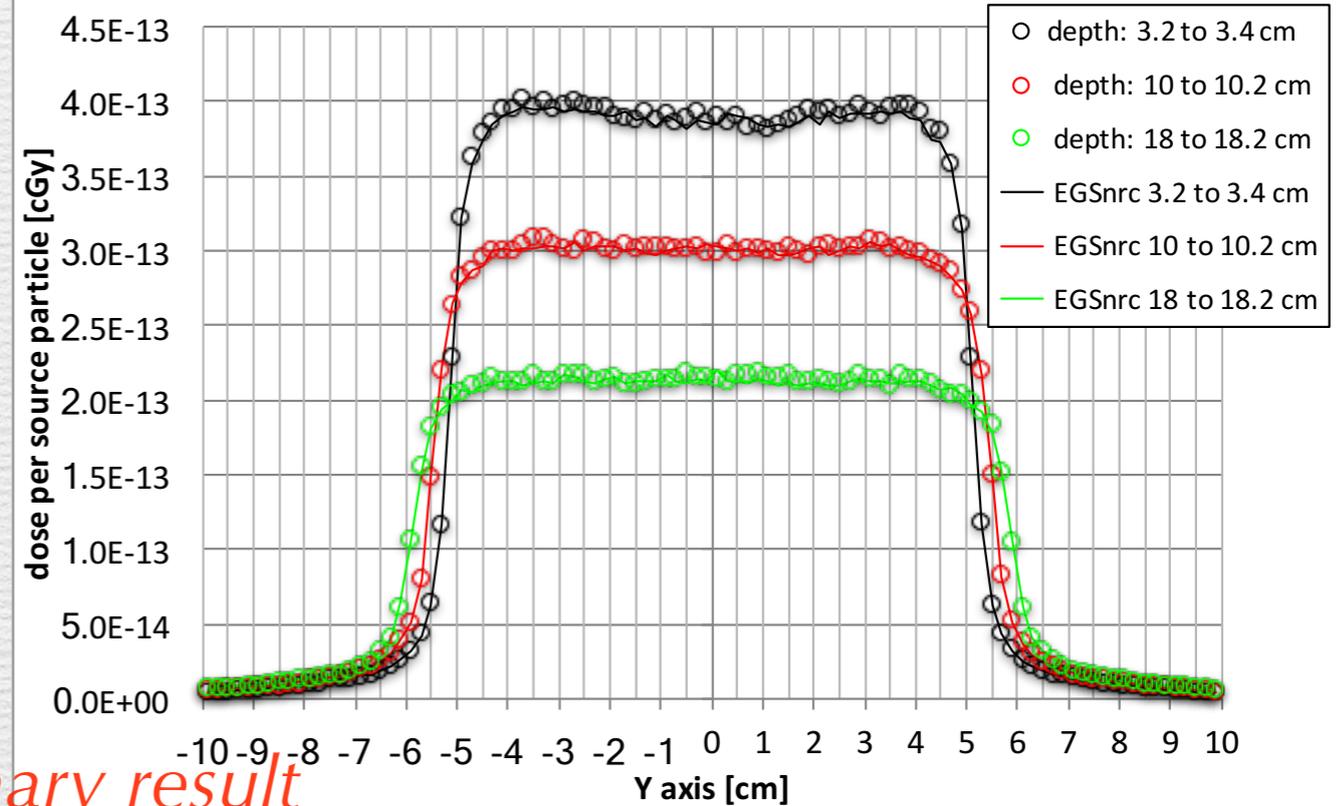
- voxel of 8 mm out of plane and 2 mm x 2mm thick at 3.3 cm, 10.1 cm, or 18.1 cm depths
- X-rays: 6 and 18 MeV



Y-axis profiles (siemens primus 6 MV X-ray)



Y-axis profiles (siemens primus 18 MV X-ray)



preliminary result

Calculation Speeds

- **MPEXS**

- GPU: **NVIDIA GTX1080**
- no. of processes: # threads: 256, # blocks: 256
- OS: CentOS 7, CUDA: 8.0

- **Geant4 10.2p2**

- CPU: **intel Core i7-6700 3.4GHz**
- no. of processes: single thread
- OS: CentOS 7

- **Phase space data 1:**

- source particles: Primus x-rays
- total energy: 6MV
- # of source particles: 10,394,741

	user time	system time	total time
MPEXS	17.98 sec.	7.64 sec.	25.62 sec.
Geant4	1272.17 sec.	0.12 sec.	1274.30 sec.

x 49.7
speed up

- **Phase space data 2:**

- source particles: Primus electron
- total energy: 6MeV
- # of source particles: 5,498,221

	user time	system time	total time
MPEXS	10.75 sec.	3.76 sec.	14.61 sec.
Geant4	692.63 sec.	0.07 sec.	692.63 sec.

x 47.4
speed up

Plans

- to measure the calculation speed of MPEXS with phase space data on the in2p3 machine, cca.in2p3.fr
 - I have submitted a job as following command, but the job has been kept in the queue and has never run.
 - `$ qsub -l os=cl7,GPU=1 -q mc_gpu_medium -pe multicores 1 exe`
 - 1 GPU (Tesla K80), 1 CPU core
 - batch queue: mc_gpu_medium
 - exe: the script to run MPEXS
- to optimize the code of MPEXS with phase space files to speed up

Summary

- The preliminary results show the valid results between MPEXS and Geant4 with the phase space data of SIMENS Primus electrons or X-rays.
- Calculation speeds of MPEXS with the phase space data is about 50 times faster than Geant4.
 - MPEXS: NVIDIA GTX1080
 - Geant4: single thread of intel Core i7-6700 3.4GHz

Another Work

- **MPEXSapp**: a desktop application software of MPEXS
 - GUI: Qt 5.7.0

