

# Requirements for Medical Physics Applications

Joseph Perl  
Geant4 Collaboration Workshop  
Sevilla, 23 September 2013

External  
Beam Therapy

Brachy-  
therapy

Interventional  
Nucl Medicine

Medical  
Imaging

External  
Beam Therapy

Brachy-  
therapy

Interventional  
Nucl Medicine

Medical  
Imaging

Linac

Co

Cyc/  
Synch

LDR

HDR

elec-  
tronic

Cs,Co,Ir,I...

Radiopharma-  
ceuticals

pCT

CT

PET

OPET  
SPECT  
etc.

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e-

$\gamma$

p

C

$\gamma$

e-

$\gamma$

e-

$\gamma$

p

e+

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$\gamma$  e-

$\gamma$  p e+

1-25MeV 50-230MeV

20keV-3MeV

few keV

few 100s of keV

100MeV 50-400MeV/n

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# Interventional Nucl Medicine

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equipment design

dose calculation

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dose  
calculation

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dose  
calculation

equipment  
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m to mm

cm to mm

micro to nano

m to mm

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m to mm

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micro to nano

m to mm

to nano hence  
Geant4-DNA

to nano hence  
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to nano hence  
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to nano hence  
Geant4-DNA



# Why Geant4?

- Competition from EGSnrc, MCNPX, FLUKA.  
Especially EGSnrc: while our EM is considered good enough for clinical work, EGSnrc is considered to have slightly more accurate electron scattering and Bremsstrahlung, and EGSnrc claims much better speed than Geant4.
- We have huge numbers of users.
- Advantages of Geant4:
  - All particle
  - Complex geometry
  - Fields
  - 4D
  - Modern Language
  - Free

# Requested Input From:

- Geant4 Medical Applications Forum
- Geant4 North American Medical Users Org  
(170 email addresses, mostly in north america, but some elsewhere)

# List I Wrote Myself

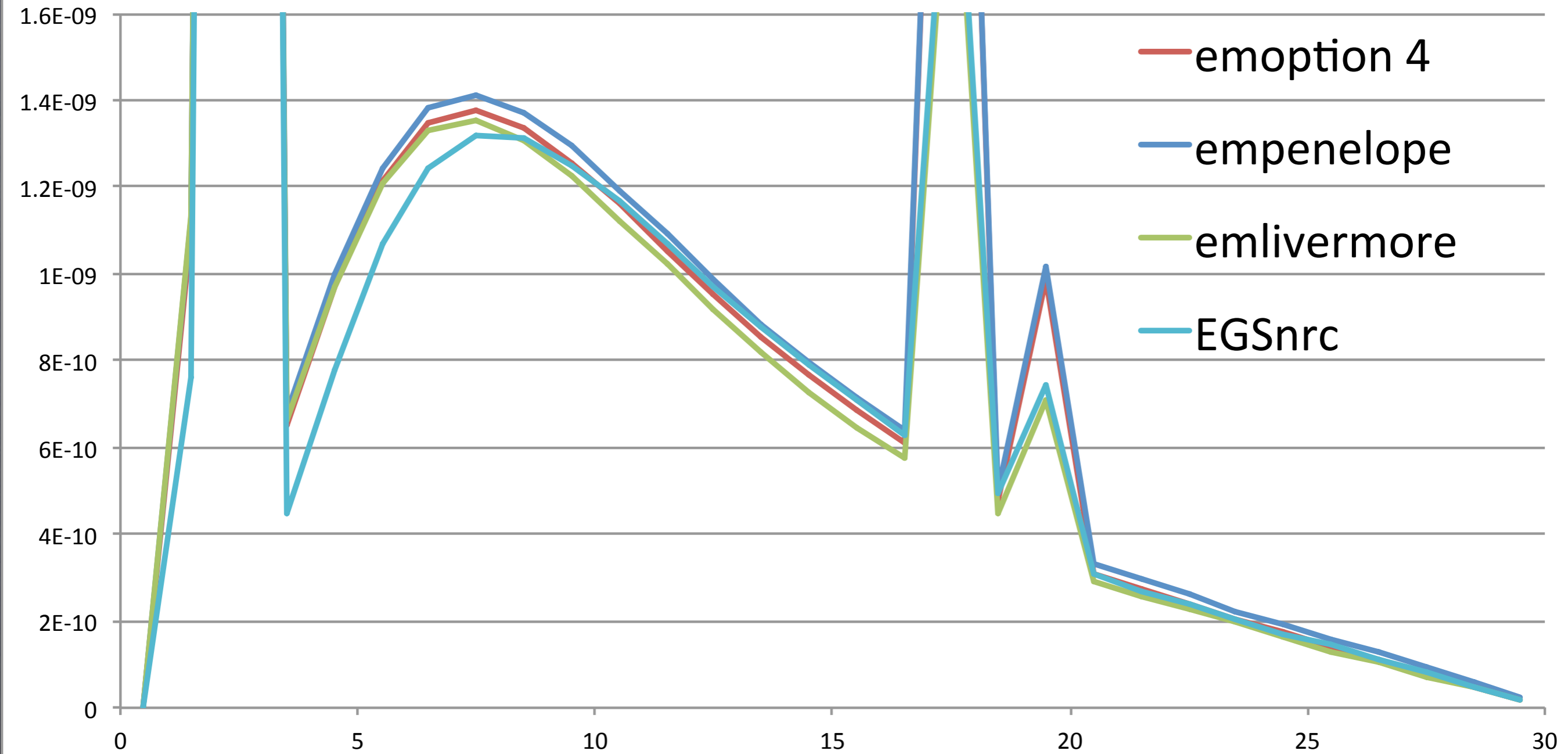
- Better ways to import CAD designs and to handle DICOM I/O.
- Increased accuracy in clinical x-ray and electrons (to close the small but measurable accuracy gap between Geant4 and EGS in Bremsstrahlung and large angle electron scattering).
- Increased speed in all of our computations.
- Better physics in prompt gamma emission for proton therapy.
- Geant4-DNA is of interest to all medical users, but I defer to Sebastien's to discuss these issues

# AAPM TG-195

- Comparing accuracy of various MC codes for medical imaging
- Task Group leader, Ioannis Sechopoulos, is doing the Geant4 studies, in close communication with Geant4 EM group.
- "I second the need for increased accuracy of Bremsstrahlung"

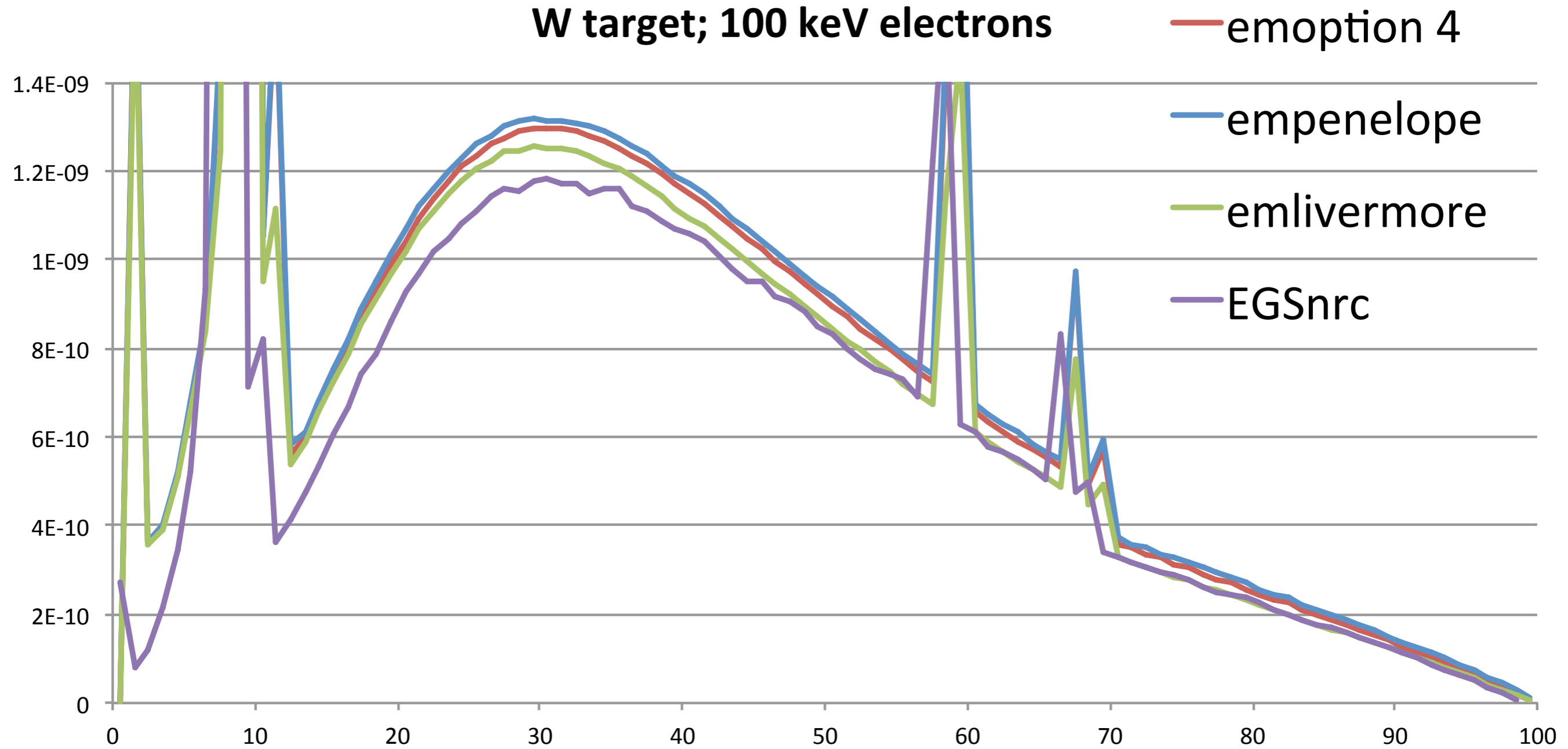
# AAPM TG-195

Mo target; 30 keV electrons



# AAPM TG-195

W target; 100 keV electrons



# SPEED

- Boundless appetite for speed in imaging and dose calculation.
- Increased resolution of imaging drives the field towards reduced treatment margins, hence more fine-grained dose calculation
- MPI
- MT
- GPU

# Nano Scale

- Susanna Guatelli reminds us that there is work to do to perfect some parts of the toolkit for the nano scale
  - energy loss is averaged over the micron level
  - some physics models not adapted yet to this scale



# Variance Reduction

- Appetite for any VR techniques we can build in.
  - Directional Bremsstrahlung Splitting

# Geant4's Message Back to the Medical User Community

- Explain to them how we are funded and how this then affects what we can focus on
- Encourage them to "step up to the plate"

# Geant4 2013 International User Conference at the frontier between Physics, Medicine and Biology



**October 7 – 11, 2013**

**Mercure Château Chartrons hotel, Bordeaux, France**

- ⑥ 62 Talks from around the globe
- ⑥ 104 participants
- ⑥ By far most impressive Geant4 Medical gathering ever