ORANGE

An accurate dose algorithm in MCNP(X)

Steven van der Marck, MCNEG 2007
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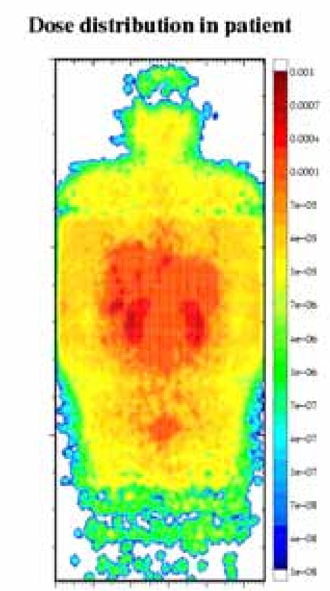
- MCNP(X): is there a problem?
- ORANGE ↔ MCNP
- Examples
  - ✓ 18 MV photon beam, 1.5×1.5 cm^2
  - ✓ High energy neutron beam
  - ✓ 65 MeV proton beam



The problem with MCNP(X) ?

- ☺ Particle transport is fast
- 😐 Electron transport is good enough for most purposes, (but not as accurate as EGS, Penelope)
- ☹ Dose algorithm is slow

  the more voxels, the slower the run

Example:

6 MV beam on a

(30 cm)^3 water phantom

#voxels	MCNP	'MeshTally'
3^3	1.1	0.7
10^3	60.7	0.9
30^3	5487.0	10.0
60^3	86731.1	65.5

(CPU minutes)

ORANGE

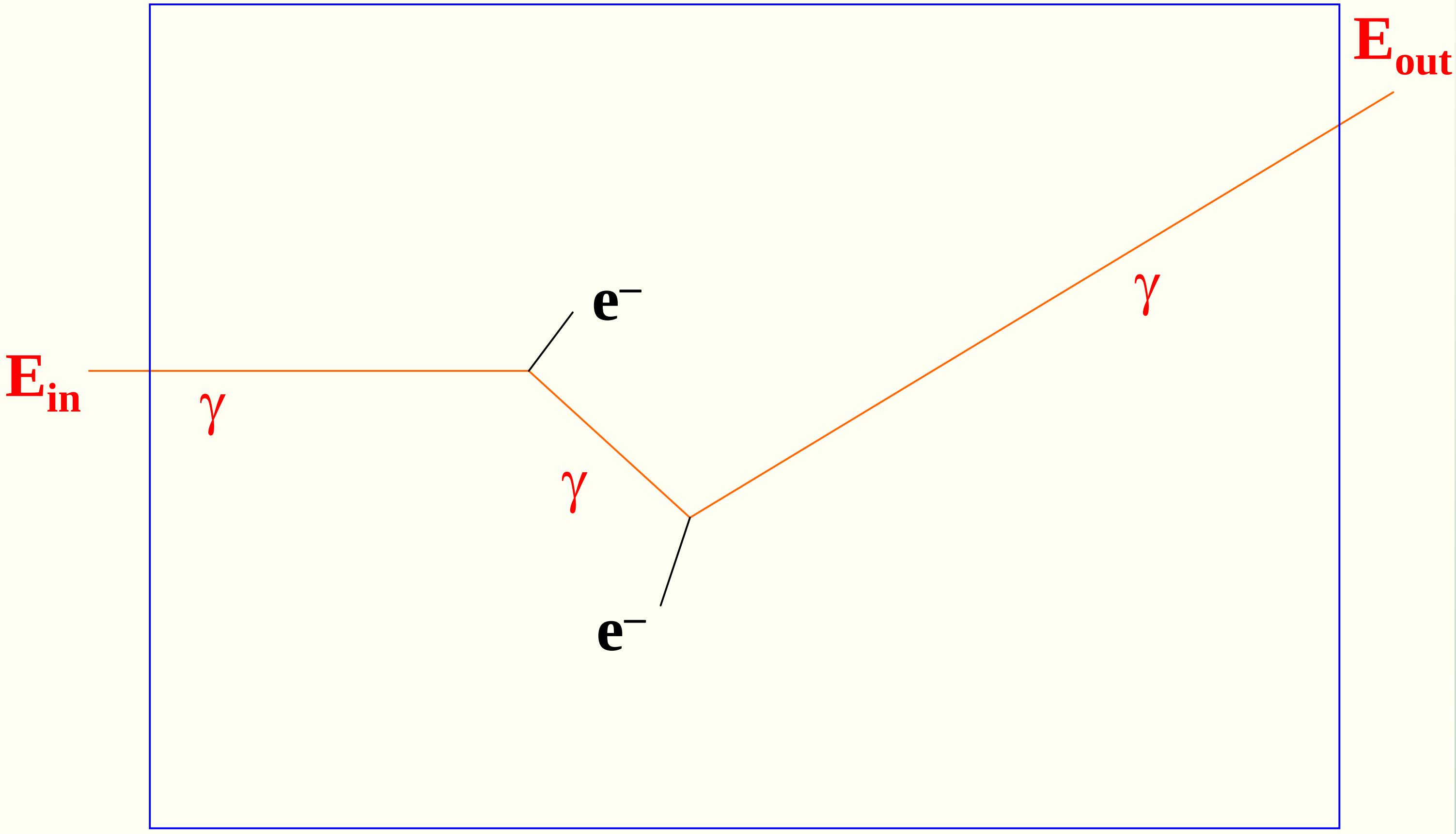
- Based on MCNP-4C3 and MCNP**X**-2.6.c
- No additional approximations
- Identical physics to MCNP(X)
- Retains all functionality of MCNP(X)

❖ Better algorithm for ‘dose per voxel’

❖ Dose based on energy deposition per interaction

⇨ Faster general purpose Monte Carlo

MCNP dose algorithm

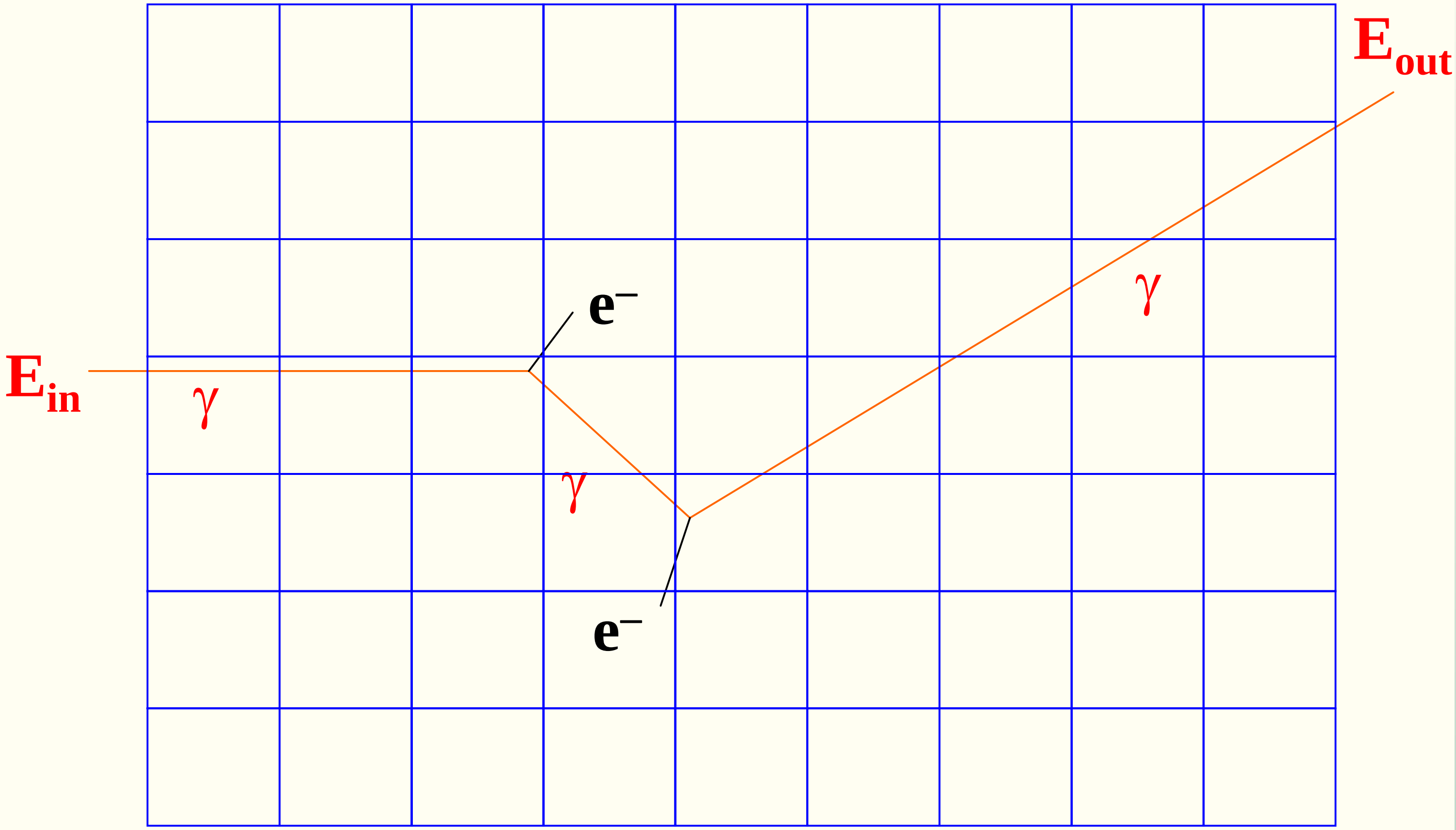


voxel

Dose = (E_{in} – E_{out})/m

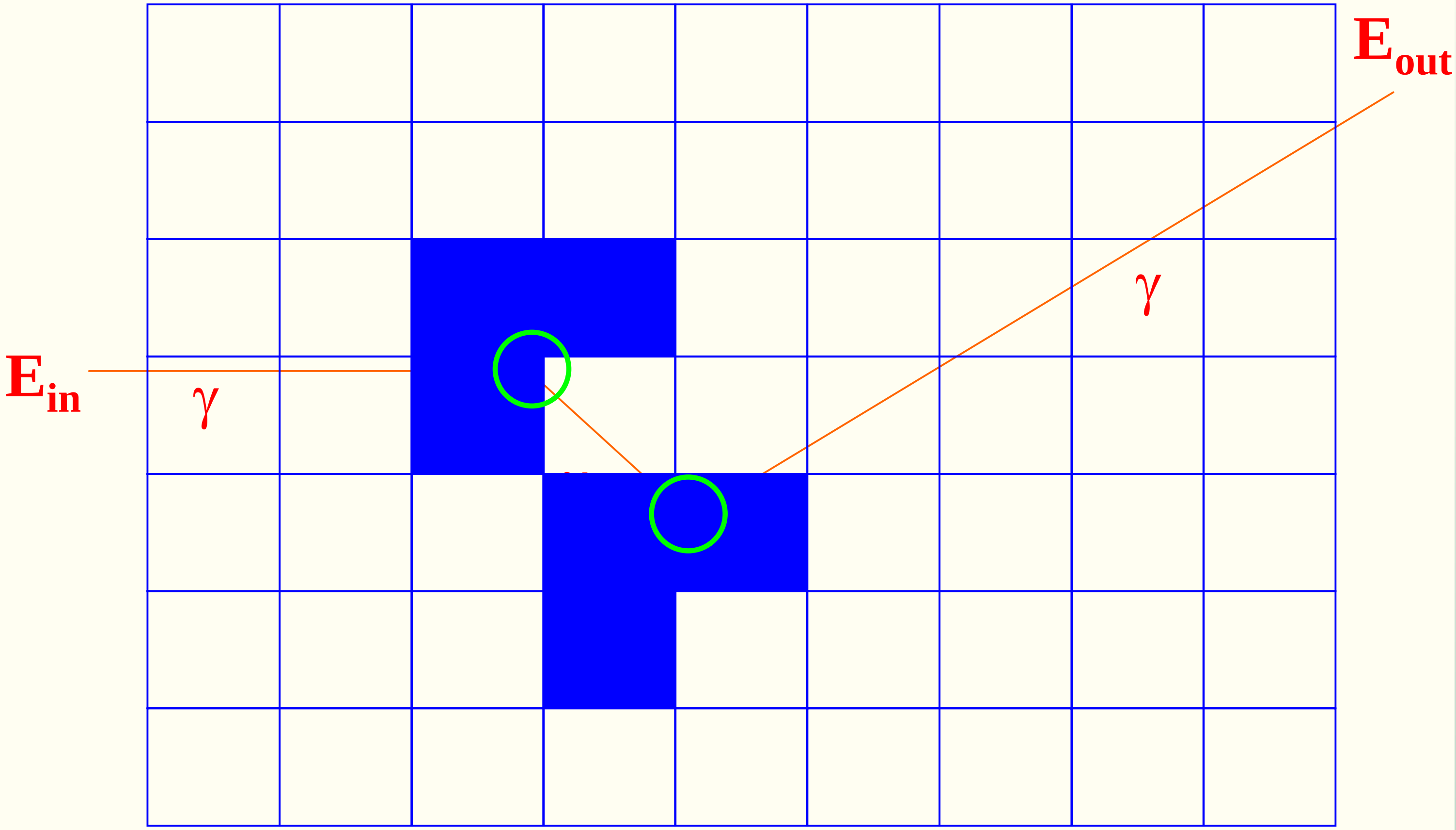
m=mass in voxel

MCNP dose algorithm



Dose = (E_{in} – E_{out})/m   for all voxels!

ORANGE dose algorithm



Dose = (E_{in} – E_{out})/m per *interaction*

(for just a few voxels!)

Speed of Orange

6 MV beam on a $(30\text{ cm})^3$ water phantom

#voxels	MCNP	SpeedTally	Orange
3^3	1.1	0.6	**0.6**
10^3	60.7	1.0	**0.7**
30^3	5487.0	4.8	**1.7**
60^3	86731.1	73.8	**3.0**

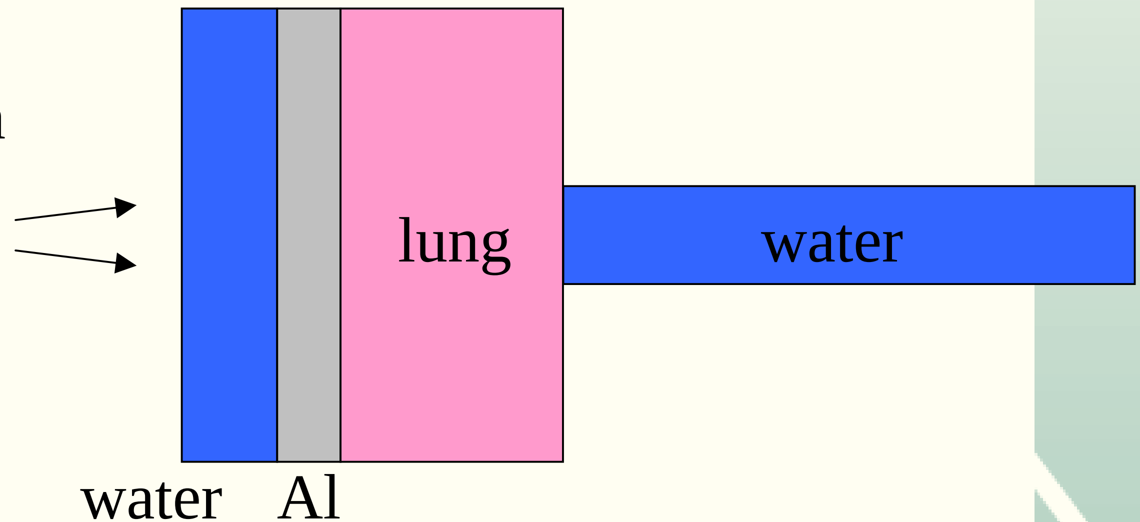
(CPU minutes)

Speed of Orange

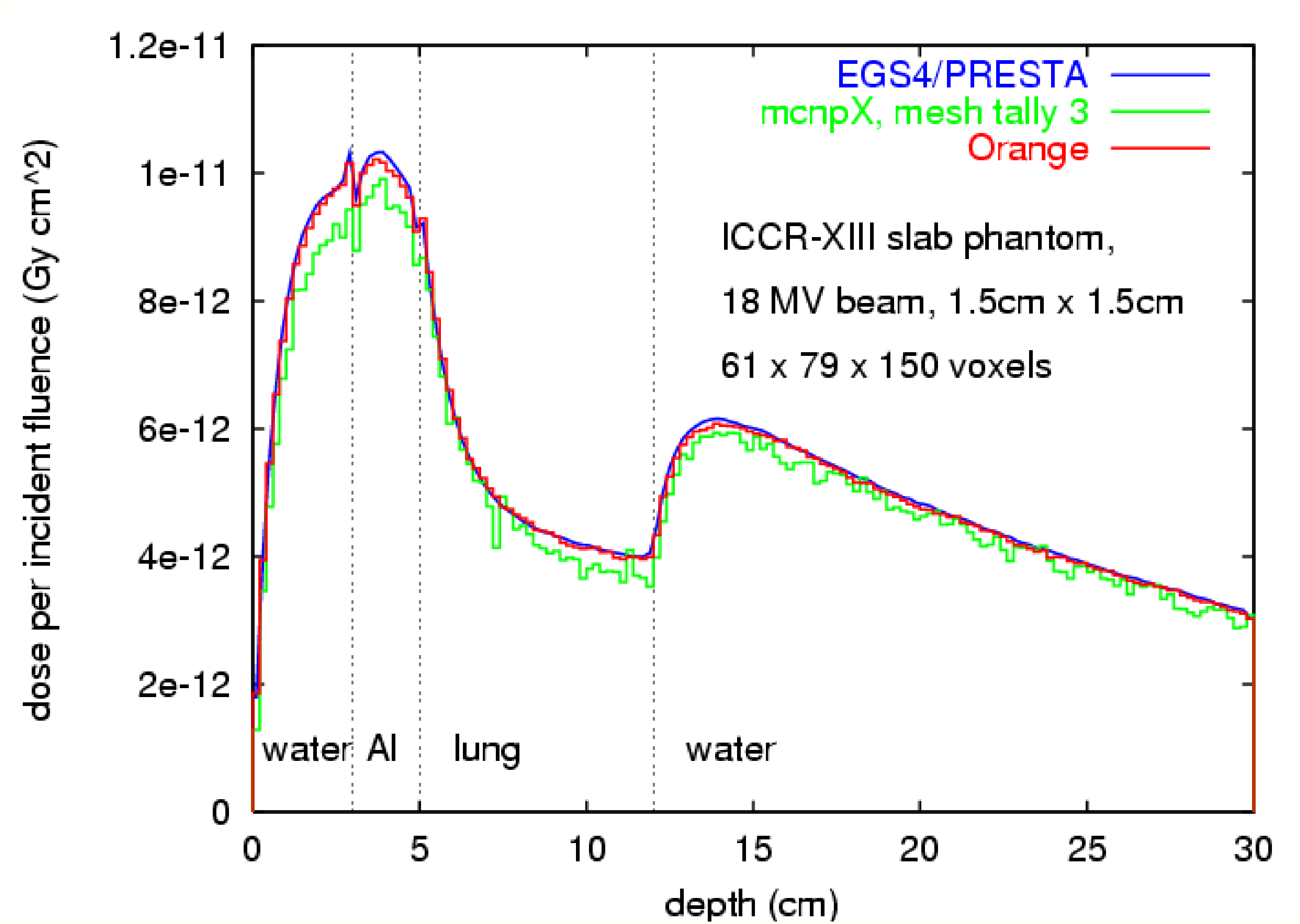
#voxels	MCNP	Mesh Tally 3	Orange
3^3	1.1	0.7	**0.6**
10^3	60.7	0.9	**0.7**
30^3	5487.0	10.0	**1.7**
60^3	86731.1	65.5	**3.0**

Calculational benchmark (ICCR)

- Uniform 18 MV beam, 1.5×1.5 cm^2
- Voxel size $0.5 \times 0.5 \times 0.2$ cm^3
- Phantom:
  - 3 cm water
  - 2 cm Aluminium
  - 7 cm lung
  - 18 cm water
- Comparison:
  Orange *vs* EGS



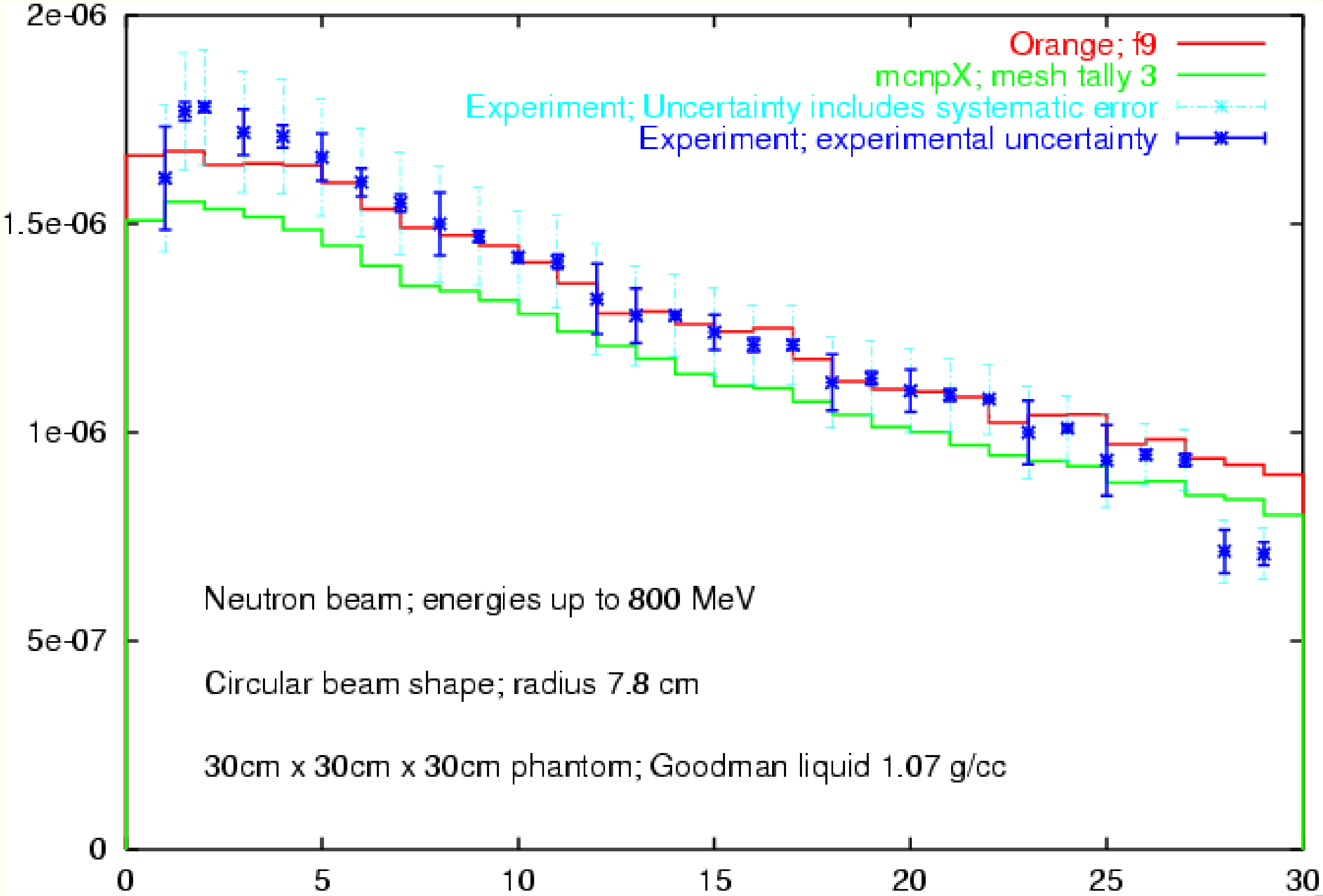
Results for ICCR benchmark



Sutton experiment at LANL

- M.R. Sutton, 'High energy neutron dosimetry'
  PhD thesis, Georgia Inst. Techn. (2001)
- Neutron beam, $E < 800$ MeV, peak around 300 MeV
- Circular beam shape, radius 7.8 cm
- $(30\ \text{cm})^3$ phantom, Goodman liquid, 1.07 g/cc
- 5 beams (1 unfiltered + 4 filtered with Pb or CH_2)
- PDDs and profiles at several depths

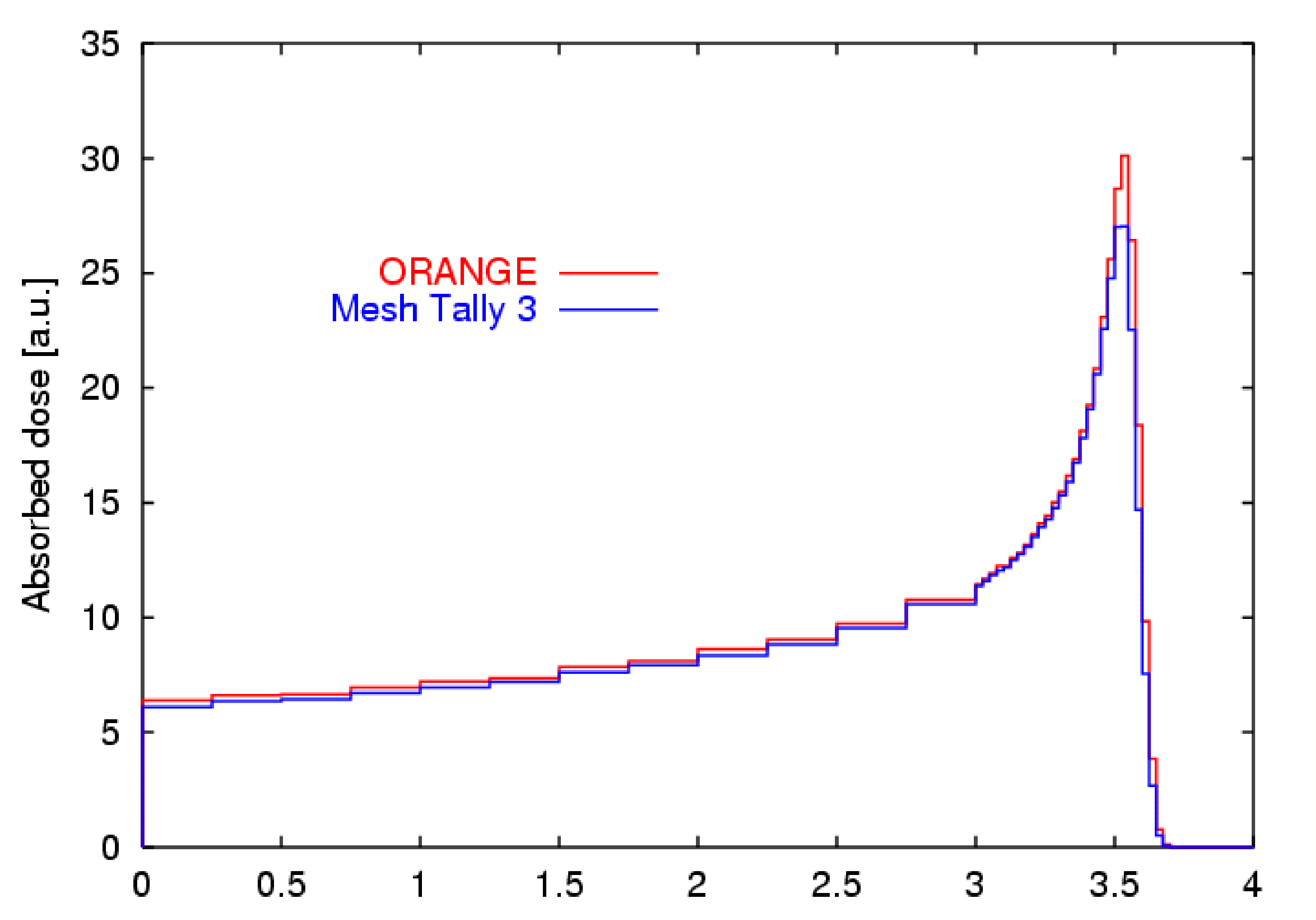
Results for Sutton experiment



Proton dose

- Orange version based on MCNPX: can also handle protons, deuterium, α, $\pi^{\pm}$, π^0, …
- Example
  - Water phantom
  - 65 MeV proton beam
  - Compare with "Mesh tally 3" from MCNPX

Results for proton beam



Conclusions

- Transport algorithms in MCNP(X) are good
  Dose algorithms: not the same quality
- Orange is *general purpose* Monte Carlo
- For a general purpose code, it is *fast*
- At small scale it is not as accurate as EGS, Penelope
- It can handle 'all' particles (e^-, γ, n, p, …)