Update sulle simulazione MC di rivelazione di protoni nel profiler

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MC FLUKA reliability

Test at Heidelberg Ion-Beam Therapy Center (HIT) Feb. 2014

FLUKA

	HIT 90deg	Full Sim.
Oxy300	6.20×10^{-3} <p>	
Oxy260	2.88×10^{-3}	
Oxy210	1.65×10^{-3}	
C220 (*GSI)	1.83×10^{-3} <p> 0.78×10^{-3} <d> 0.12×10^{-3} <t>	
C220 <r12-14>	2.31×10^{-3} <p>	1.73×10^{-3} <p>
C181	1.06×10^{-3} <p>	0.85×10^{-3} <p>
C160	0.67×10^{-3} <p>	0.56×10^{-3} <p>
C120	0.22×10^{-3} <p>	0.20×10^{-3} <p>
C80 (*Catania)	0.021×10^{-3} <p>	
He145	0.79×10^{-3} <p>	0.66×10^{-3} <p>
He125	0.43×10^{-3} <p>	0.44×10^{-3} <p>

Protons / sr Primary

Monitoring of hadrontherapy treatments by means of charged particle detection

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L Piersanti et al.
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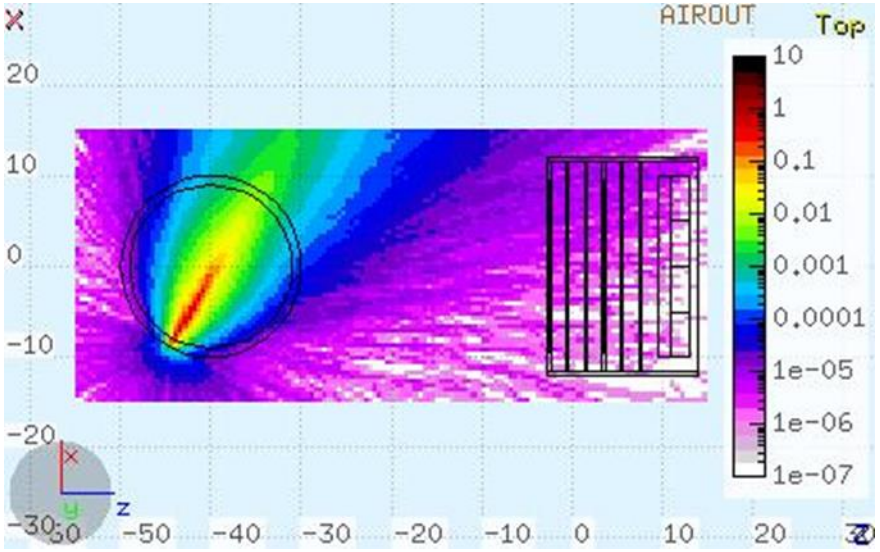
GSI DATA
^{12}C @ 220 MeV/u

90 deg
1.83×10^{-3} p/sr pr

60 deg
2.35×10^{-3} p/sr pr

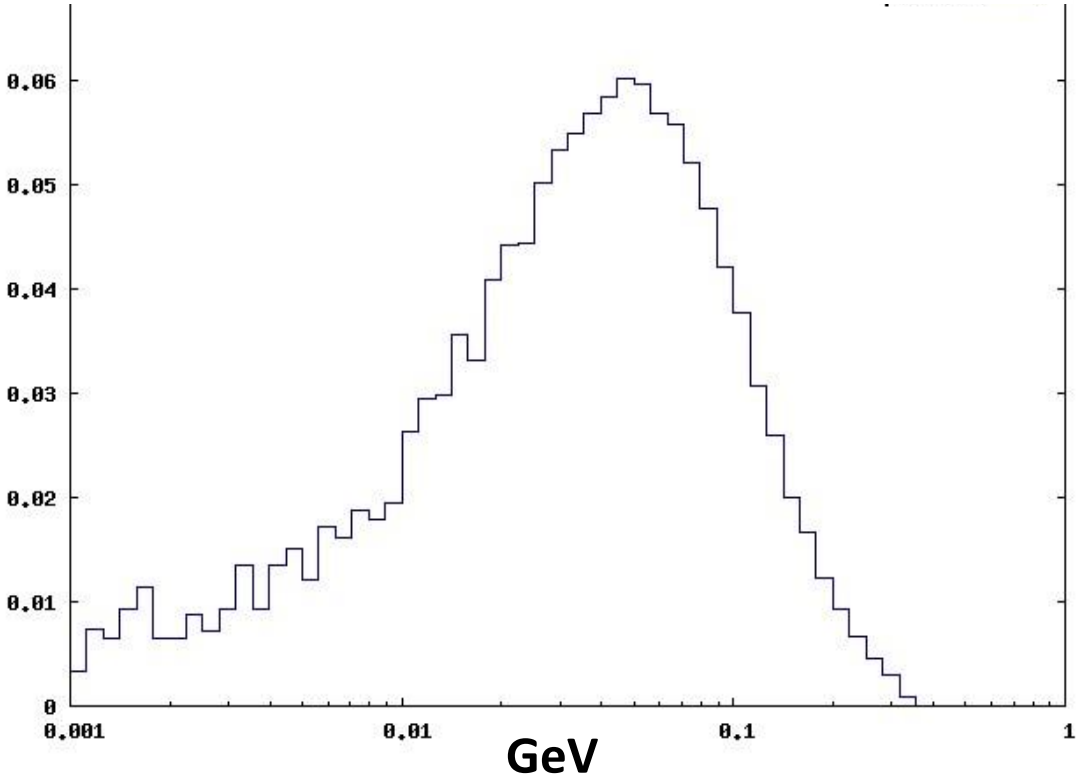
FLUKA full simulation

^{12}C beam: 220 MeV/u
60°



Proton energy distribution entering the Profiler

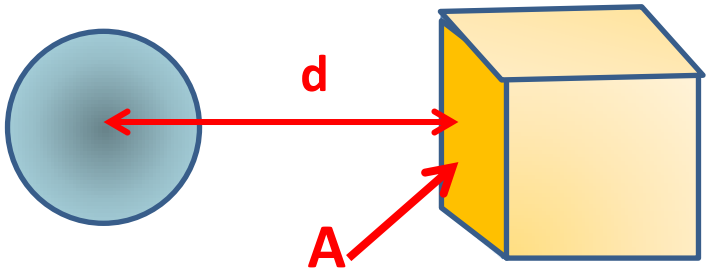
$\frac{dNp}{Nc}$ (Profiler) =
1.44×10^{-3} Protons/^{12}C primary



From HIT data:

Protons/ $^{12}C_{primary}$ x sr

$$\frac{dNp}{Nc\ d\Omega}(60^o) = (8.78 \pm 0.07_{stat} \pm 0.64_{sys}) \times 10^{-3}\ sr^{-1}$$



$$\Delta\Omega_{Profiler} = \frac{A}{d^2} = 0.27\ sr$$

$$\frac{dNp}{Nc}(\text{Profiler}) = \mathbf{2.36 \times 10^{-3}}\ \text{Protons}/^{12}C_{primary}$$

What next:

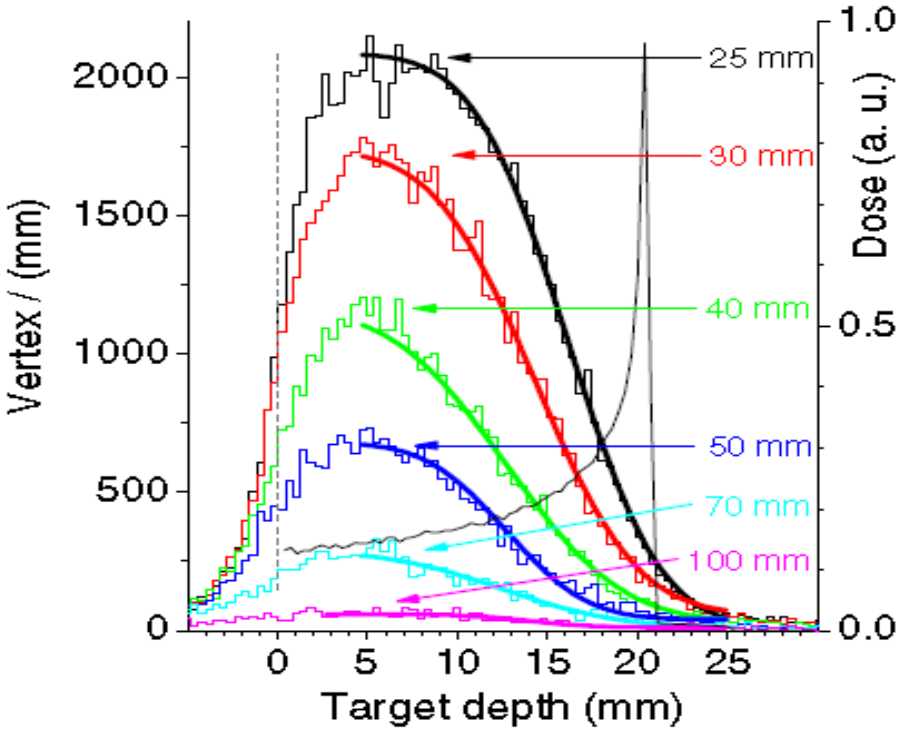
Evaluation of the proton emission distribution shape @ different target thickness

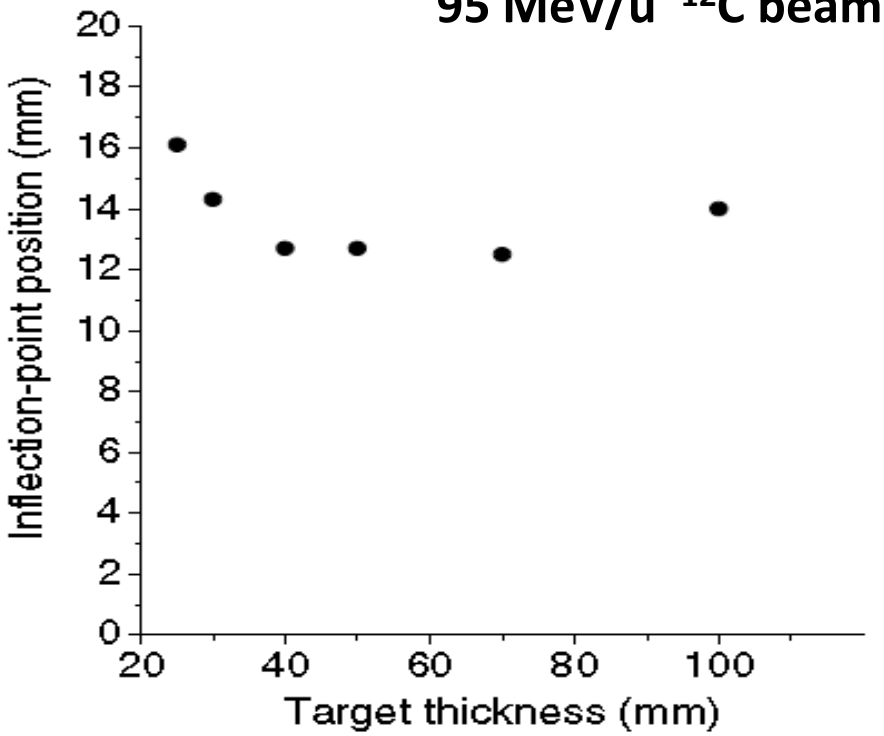
With growing target thickness, the proton emission shape changes.

E. Testa et al.
Phys. Med. Biol. 57 4655

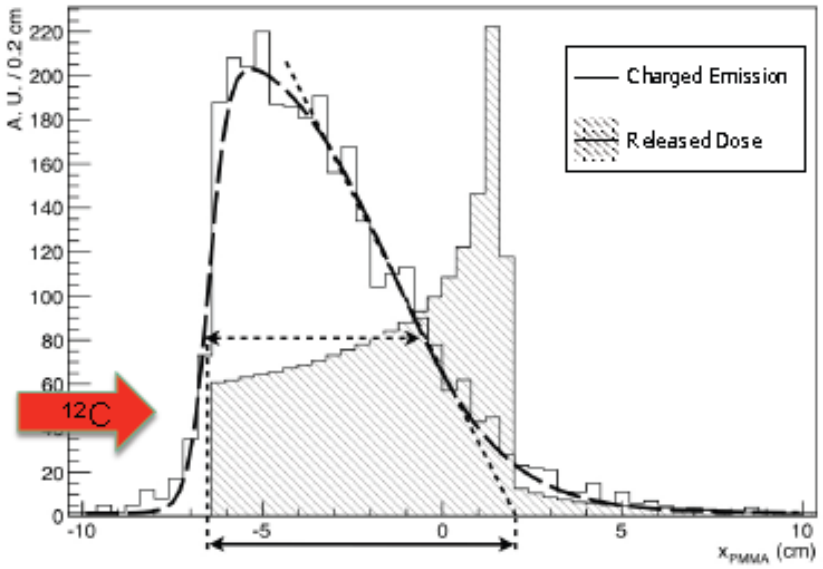
Protons detected outside different PMMA thickness at 20° with respect to the beam direction.

95 MeV/u ^{12}C beam





How to manage it:



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Create a parameter "map":

- Simulation with the parametric proton generator
- Cylindrical PMMA target with different thicknesses
- Fit of the proton emission curve with the function:

$$f(x) = p_0 \frac{1}{1+\exp\left(\frac{x-p_1}{p_2}\right)} \frac{1}{1+\exp\left(-\frac{x-p_3}{p_4}\right)} + p_5$$

⇨ Parameter VS thickness relation

NOTE: We will have to consider also the **proton range variation** due to the **material/density discontinuity** into the patient CT

Conclusions

- FLUKA reliability related to the integral secondary proton flux at large angle seems noticeable, notwithstanding the known issues related to the transition region between two different N-N interaction models. Maximum error within ~50%

- We have shown the need to investigate the relationship between the proton emission shape and the crossed material thickness (for NON-homogeneous materials as well!)