Enhancing gamma production for online dose verification in proton therapy

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106° Congresso Nazionale Società Italiana di Fisica

14-18 settembre 2020

Trento Institute for
Fundamental Physics
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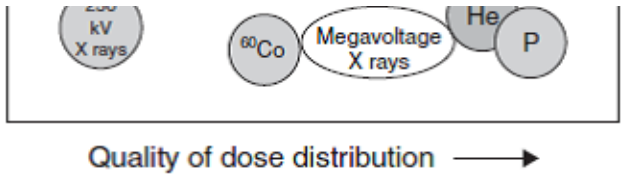
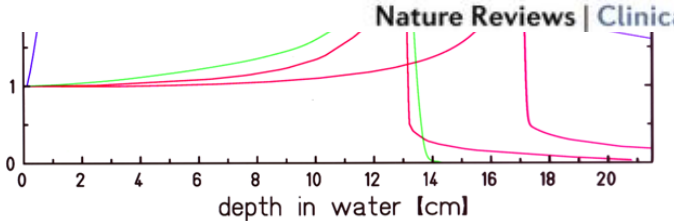
CANCER RADIOTHERAPY





SOME PHYSICS CHALLENGES IN ION THERAPY

Treatment Plan Optimization:

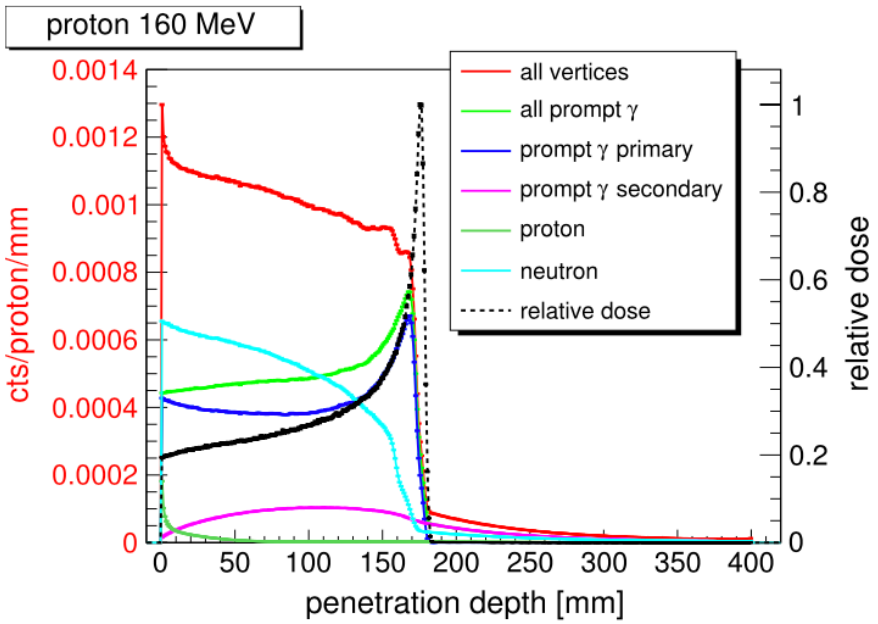
- Beam delivery technologies (including 4D/5D optimization)
- Broaden the type of diseases (cancer and non cancer) treated with particles
- New ions ^{4}He (paediatrics) or ^{16}O (hypoxic tumors)
- Monte Carlo based TPS

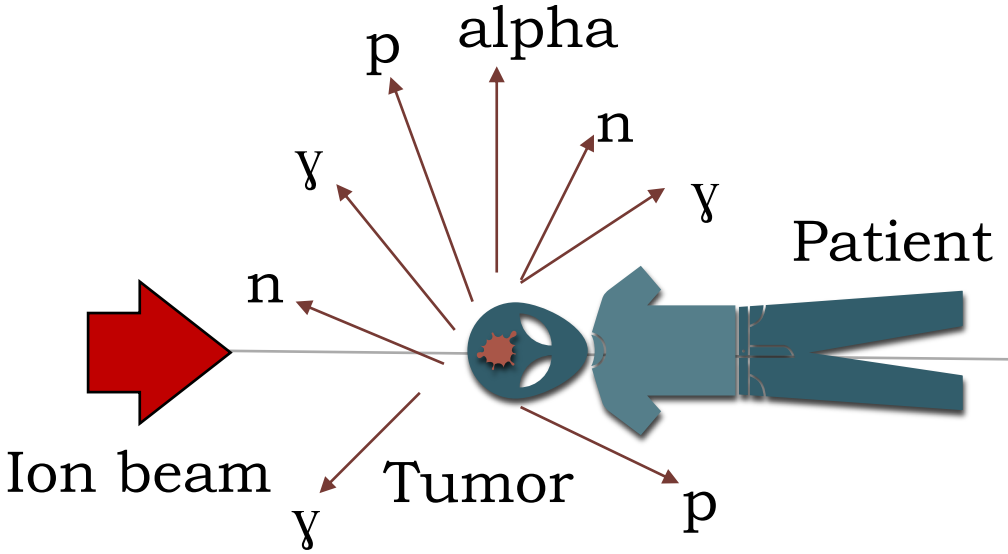
Treatment Plan Verification:

- Particle range
- Real-time dosimetry

CORRELATION BETWEEN SECONDARIES EMISSION AND PENETRATION DEPTH

Krimmer et al, 2018



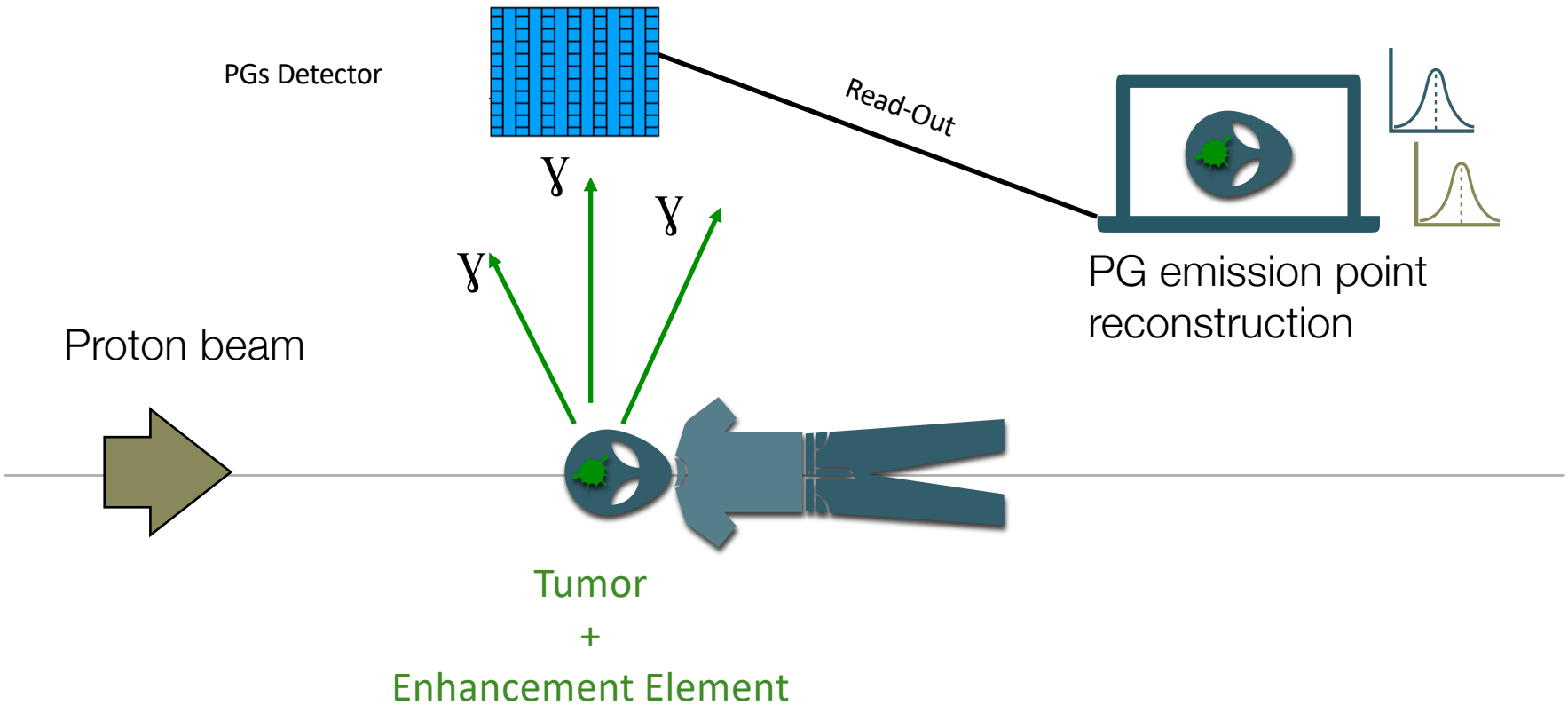


The interaction probability increases with:

- Depth, highest at Bragg peak
- Decreasing energy of the primary

A DIFFERENT APPROACH

What if the tumor could be loaded with a “enhancement element” that can not only enhance the production of PG but also emit a signature spectrum?

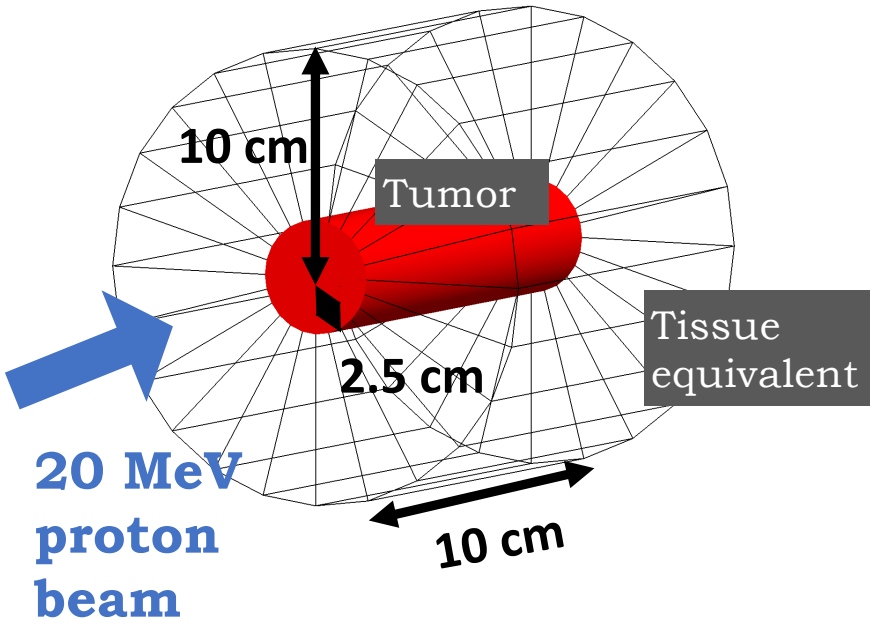


The region where signature PG yield is the highest identifies the tumour position

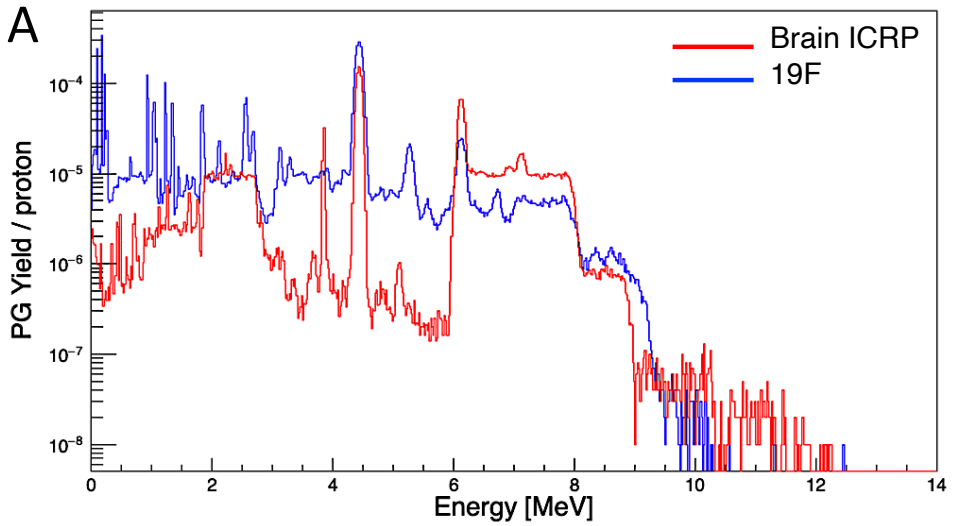
MONTE CARLO SIMULATIONS

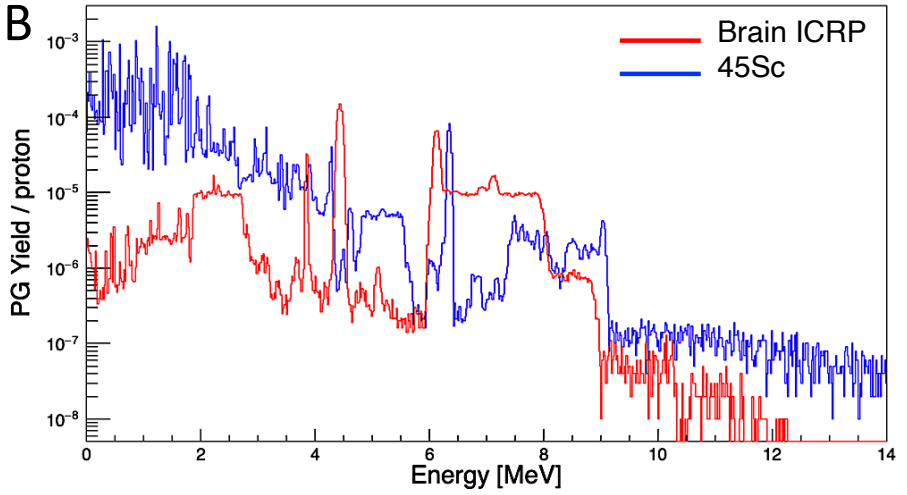
Geant4 (10.5) simulations changing the tumor material.

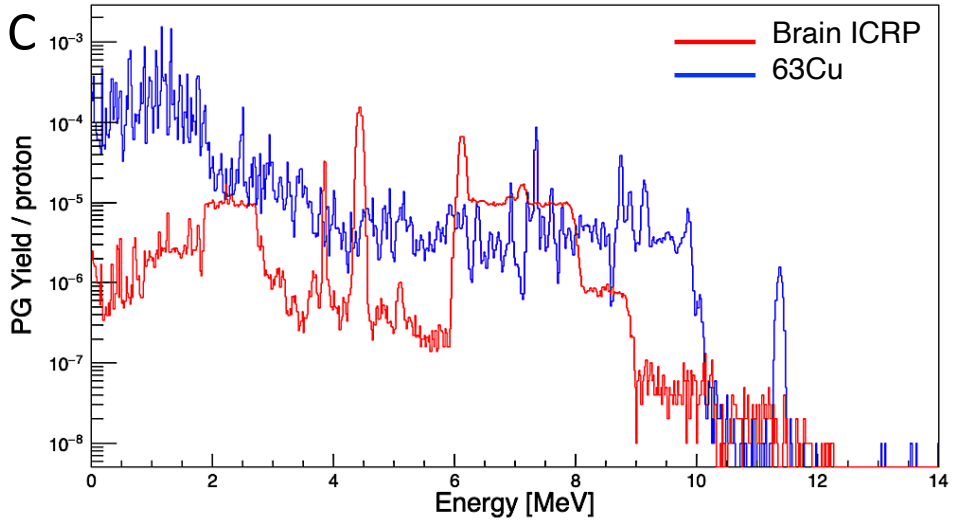
Tumor material	Link to clinic
1) Brain tissue	Background
2) 19F	18FDG
3) 45Sc	Under investigation
4) 63Cu	Cu-ATSM
5) 89Y	90Y-monoclonal antibody

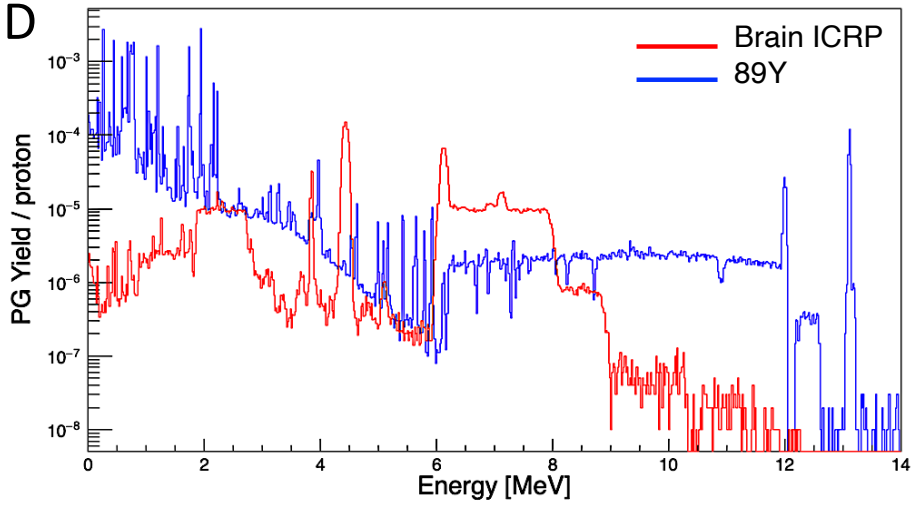


GAMMA ENERGY SPECTRA



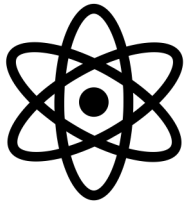






FROM EXPERIMENT TO CLINICAL APPLICATION

Enhancement element **requirements**:



- Production of high energetic PGs (to increase detection probability)
- Production of a signature spectrum (different from the background spectrum)

- Non toxic
- High selectivity
- Maximum **concentration** achievable

Conclusions and future perspective:

- Prompt gamma enhancement in the tumor is possible
- 63Cu and 89Y are promising candidates as tumor label elements
- Experimental measurements are necessary to quantify the enhancement and validate MC simulations
- Simulate and measure the PG enhancement with realistic element concentration


THANK YOU