PET Imaging from Proton Activation with Contrasts and Correlation with Dose

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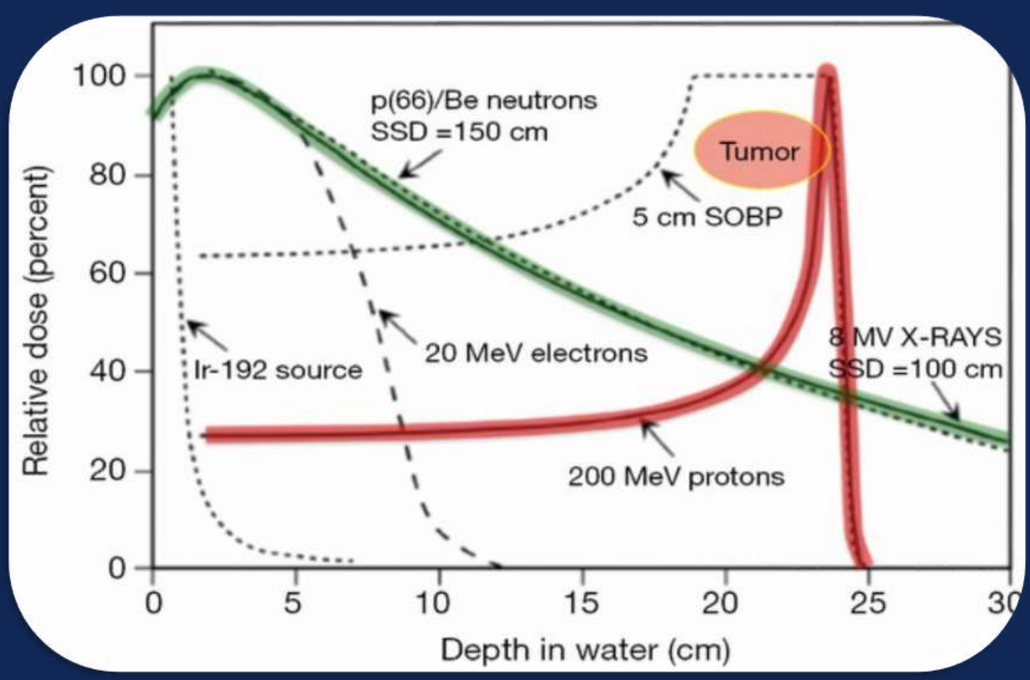
1. INTRODUCTION

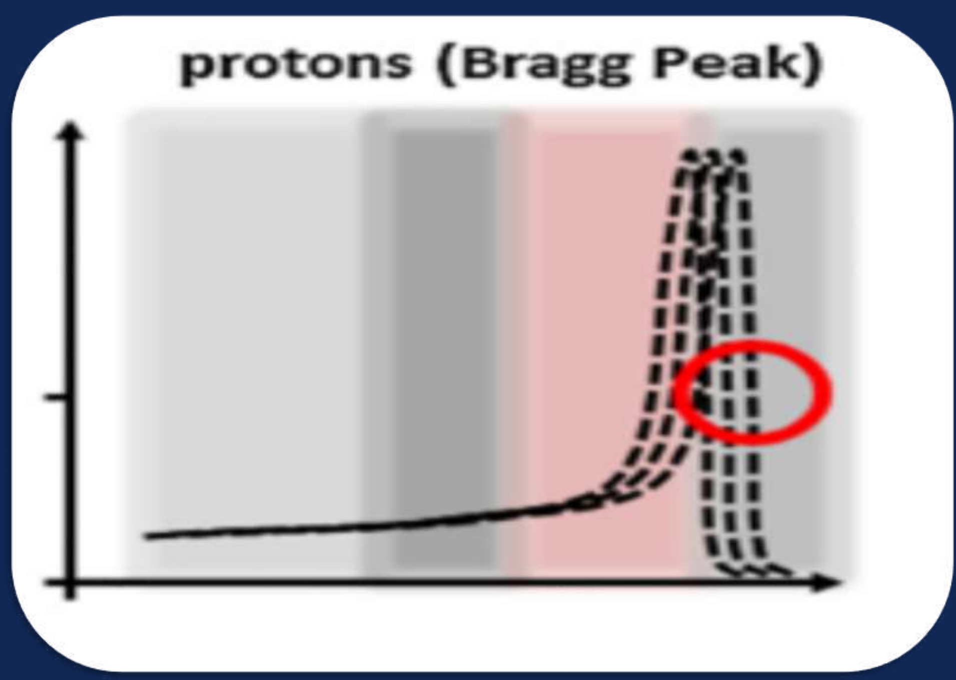
Proton radiotherapy provides physical advantages which permit a better conformal dose distribution than photon / electron radiotherapy because of the Bragg Peak.

1. Dose concentrate at the tumor.
2. No dose beyond the distal edge.
3. Lower dose in healthy tissue



One of the main issues in proton therapy is the proton range. Because of the sharp peak of the dose we must know very well the position on BP, in other words, the proton range.

Current uncertainties ~3 % of proton range, limiting dose conformity in tumor.



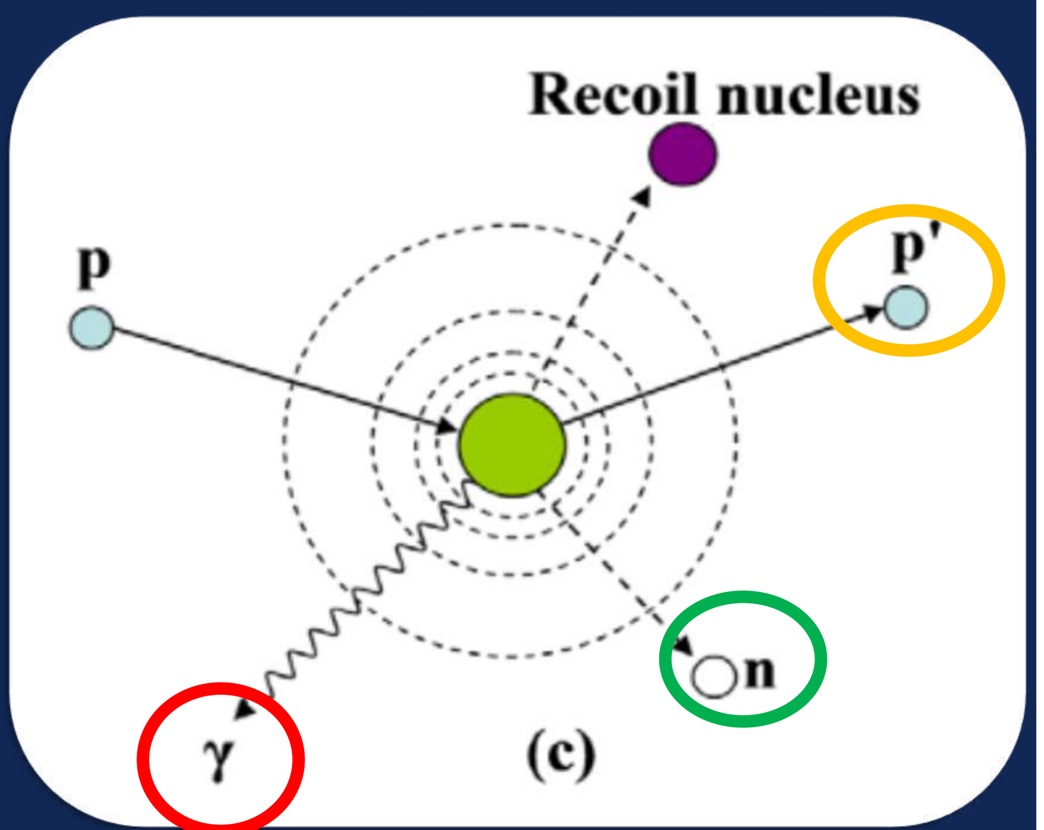
2. PROTON RANGE VERIFICATION TECHNIQUES

In-vivo techniques use secondary radiation produced after nuclear interactions in order to obtain the dose distribution.

- **PET**
- **Prompt-Gamma**

- **Neutron Range Verification [1]**

- **pCT [2]**



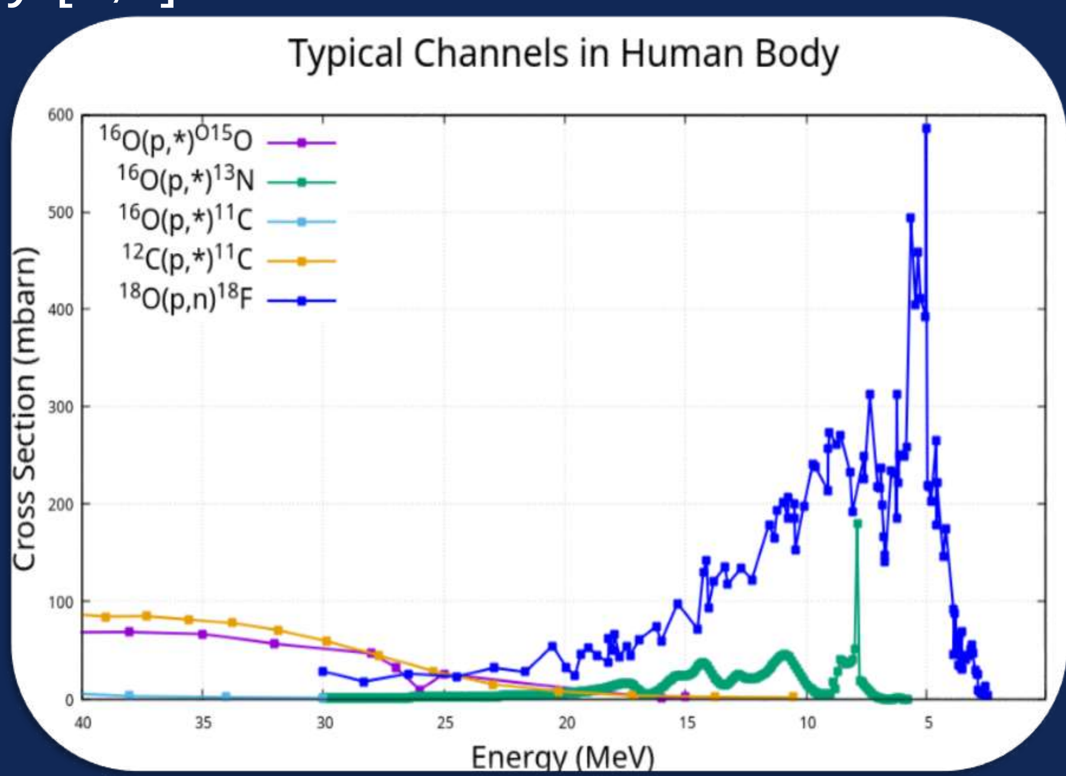
3. CONTRAST AGENTS

We propose the use of contrast agents in proton. We are looking for **(p,X) reaction channels** which produce β+isotopes very close to the BP in order to solve the problem of the distal fall-off position of the natural PET activity in the human body [3,4].

1) The reaction Energy Threshold must be low.

2) The cross section should peak at sufficiently low energies.

3) The half-life of the produced isotope must be short enough.

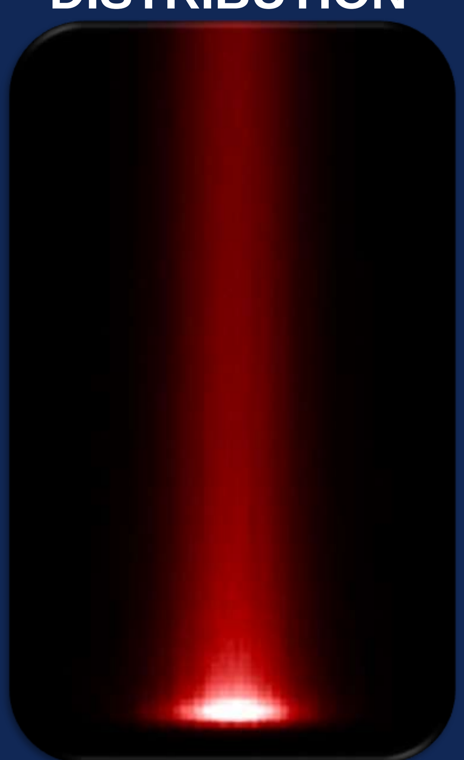


4. RESULTS

- We propose as contrast Water-18 which is a mix of normal water and $H_2{}^{18}O$. ^{18}F is produced in a $^{18}O(p,n)$ reaction and it is a β^+ isotope with a 109.7 min half-life. The concentration of $H^2{}_{18}O$ is a 50% in the simulation and a 10% in the experiment.

SIMULATION

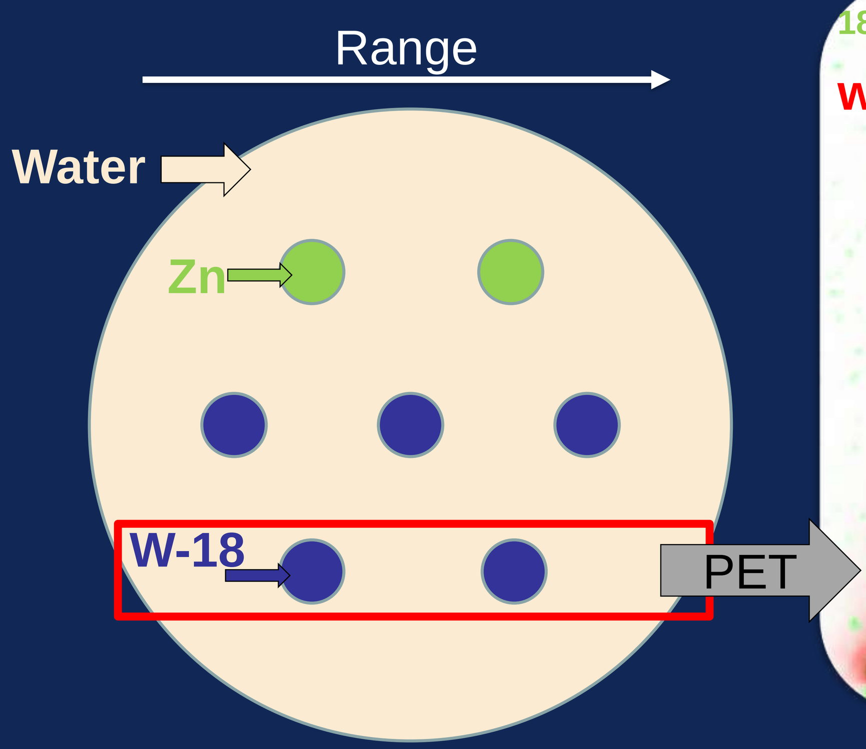
DOSE DISTRIBUTION



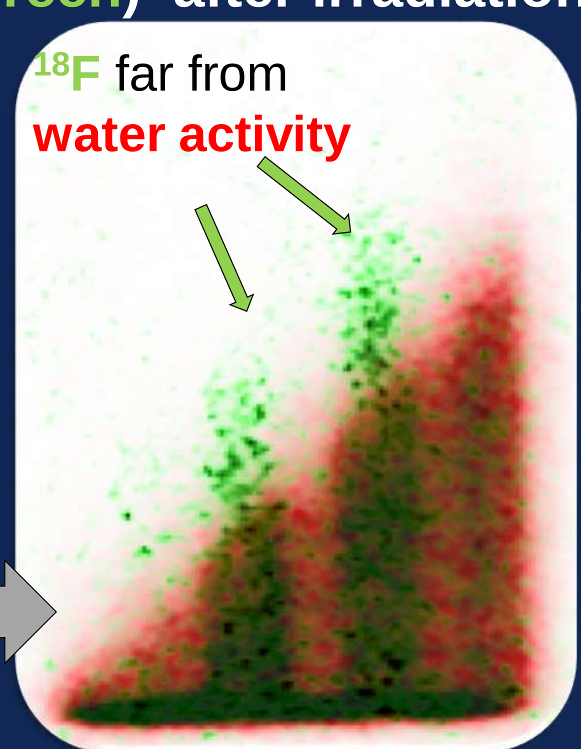
β^+ EMISSION DISTRIBUTION

EXPERIMENT

Irradiated Phantom



1 hour (red) & 3 hour (green) after irradiation



5. CONCLUSIONS

•**Contrasts improve activation distributions** and they can be used to calculate the proton range with better.

•**Contrasts with a short half-life may be used to produce in-vivo image**. Contrast with long half life (such as ^{18}F) could be used to verify Monte Carlo simulations or even for proton beam and beam transport quality assurance.

•We have obtained **experimental results that prove the viability of the use of ^{18}O as a contrast agent** in proton therapy.

•For the future we will try to **obtain real in-vivo PET images with short half-life contrasts agents.**

6. REFERENCE

[1] Kristian Smelandaet al. 2018 *Sci. Rep* **9 2011**
[2] Hanson, Kenneth M *IEE T-NS* **26 1979**
[3] Antje-Christin Knopf and Antony Lomax 2013 *Phys. Med. Biol.* **58**R131
[4] S. España et al 2011 Phys. Med. Biol. 56 2687.

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