Nuclear data for medical applications:

PENH + nuclear data

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I Jornada CEIDEN de usuarios de bases de datos nucleares utilizadas en cálculos para aplicaciones nucleares energéticas y no-energéticas

- The description of nuclear reactions based on (any) ENDF formated data files has been implemented in PENH code, which is the extension for protons of the well established PENELOPE code in the radiotherapy domain for MC simulation of the transportation of e+, e- and photons.

- In the previous PENH version (PENH-2013):

  - EM transportation of protons is performed with the same class-II mixed algorithm than for electrons, prositrons and photons.

  - Elastic scattering of protons includes consistently EM and nuclear contributions .

- The main goal was to provide a realistic calculation of the dose along the beam axis, which is underestimated in absence of nuclear reactions → PENH-2018.

- Products of nuclear reactions (multiplicity, energy-angle distributions) are sampled from ENDF files (MF=3,6 & MT=2,5).

- Light fragments (A<5) are transported as “heavy” protons, with their energies scaled to produce the right range.

- Recoils (A>4) deposit their energy locally.

1) Deph-Dose Profile (preliminary results)

Simulaciones y discusión de resultados: Agua

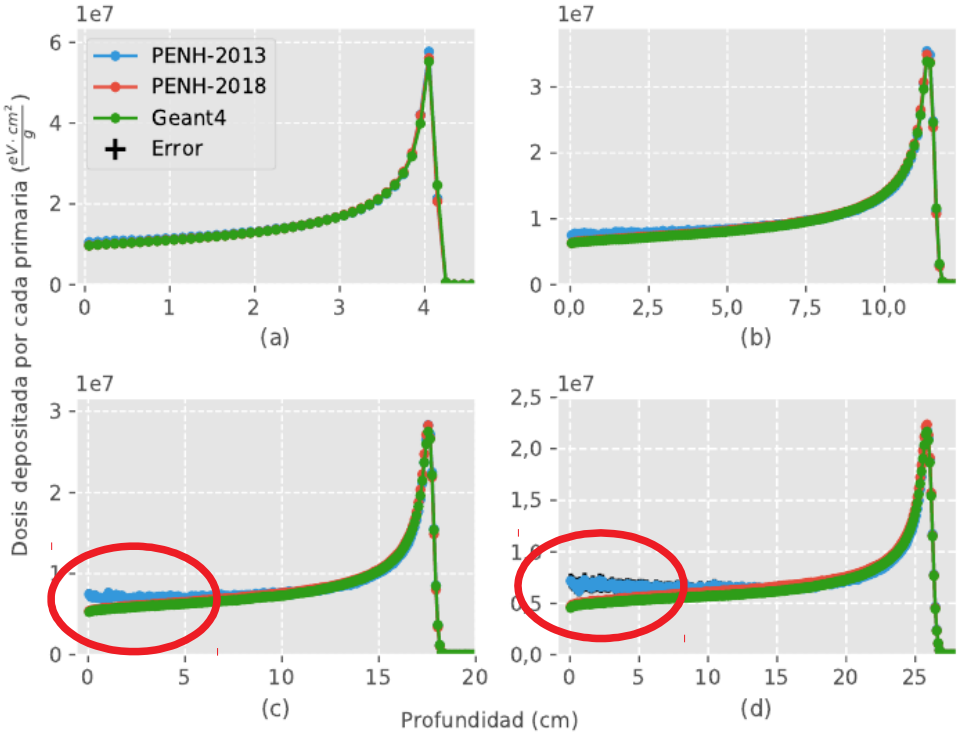
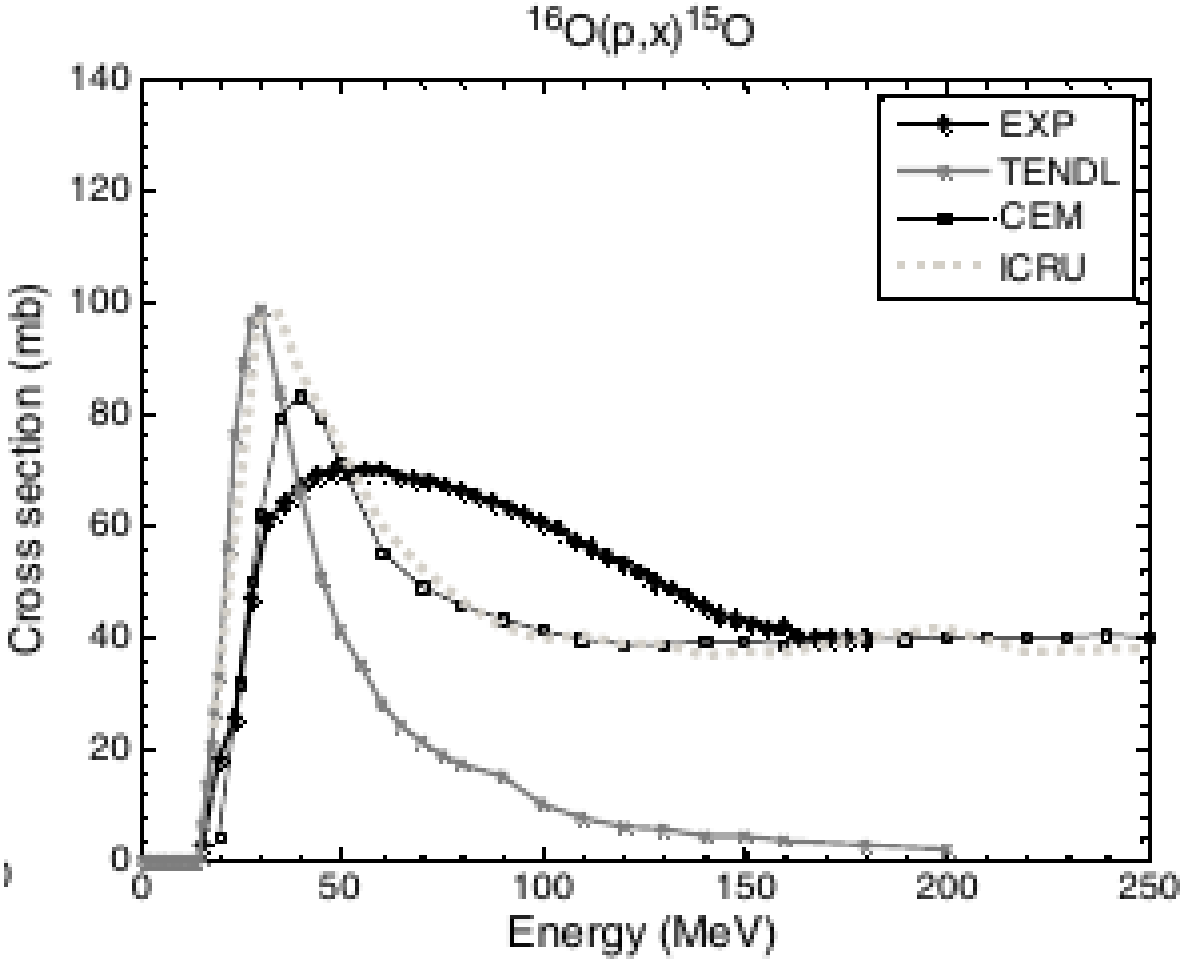


Figura 7: Valores de dosis depositada por cada primaria en agua ($\frac{eV \cdot cm^2}{g}$) frente a la profundidad (cm) para los diferentes códigos, a unas energías del haz de (a) E=70MeV, (b) E=125MeV, (c) E=160MeV y (d) E=200MeV.

2) PET isotopes production.

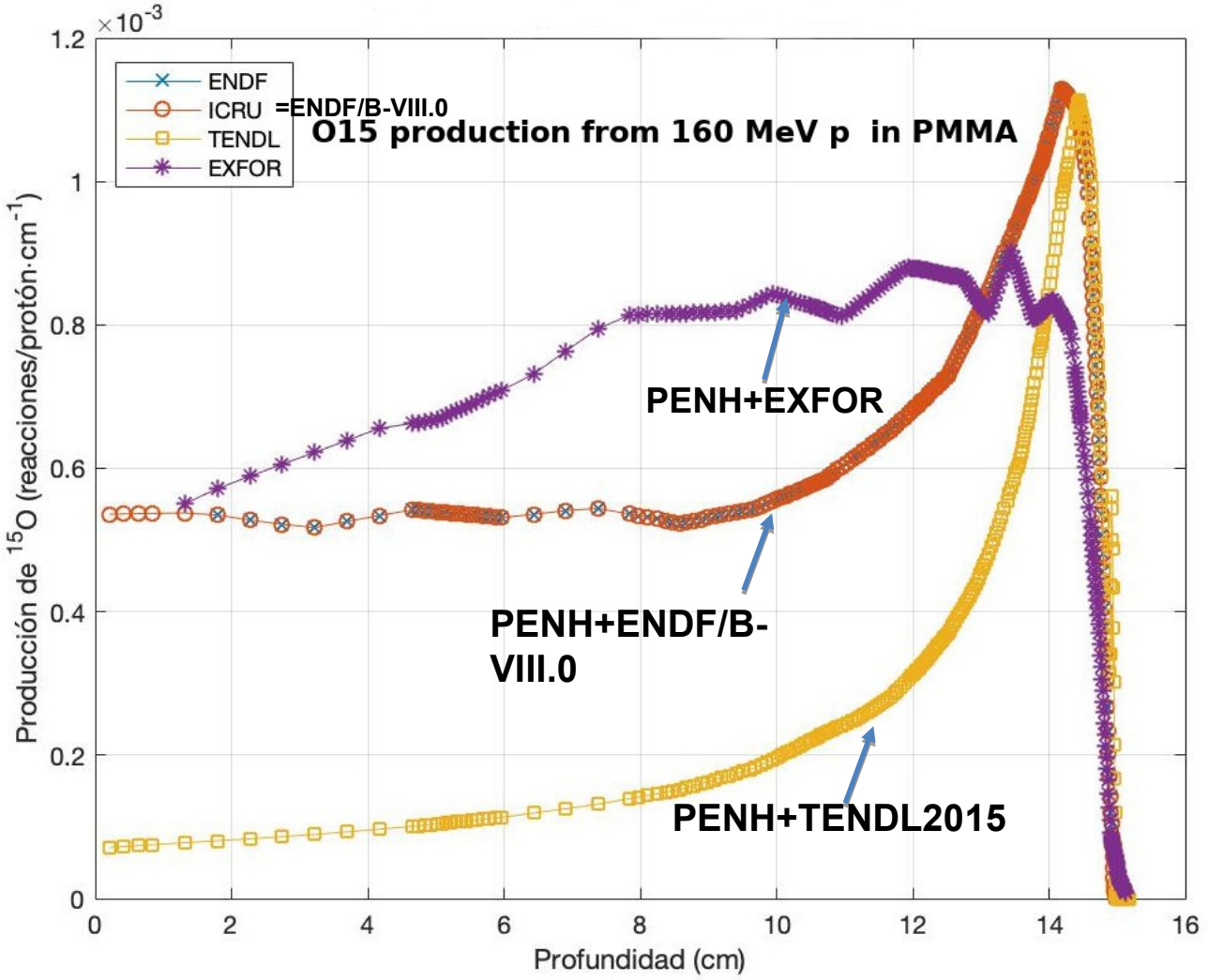


Seravalli et al, Phys. “Monte Carlo calculations of positron emitter yields in proton radiotherapy”. Med. Phys. Biol. 57 (2012) 1659–1673

PROBLEM:

Big discrepancies in production cross sections

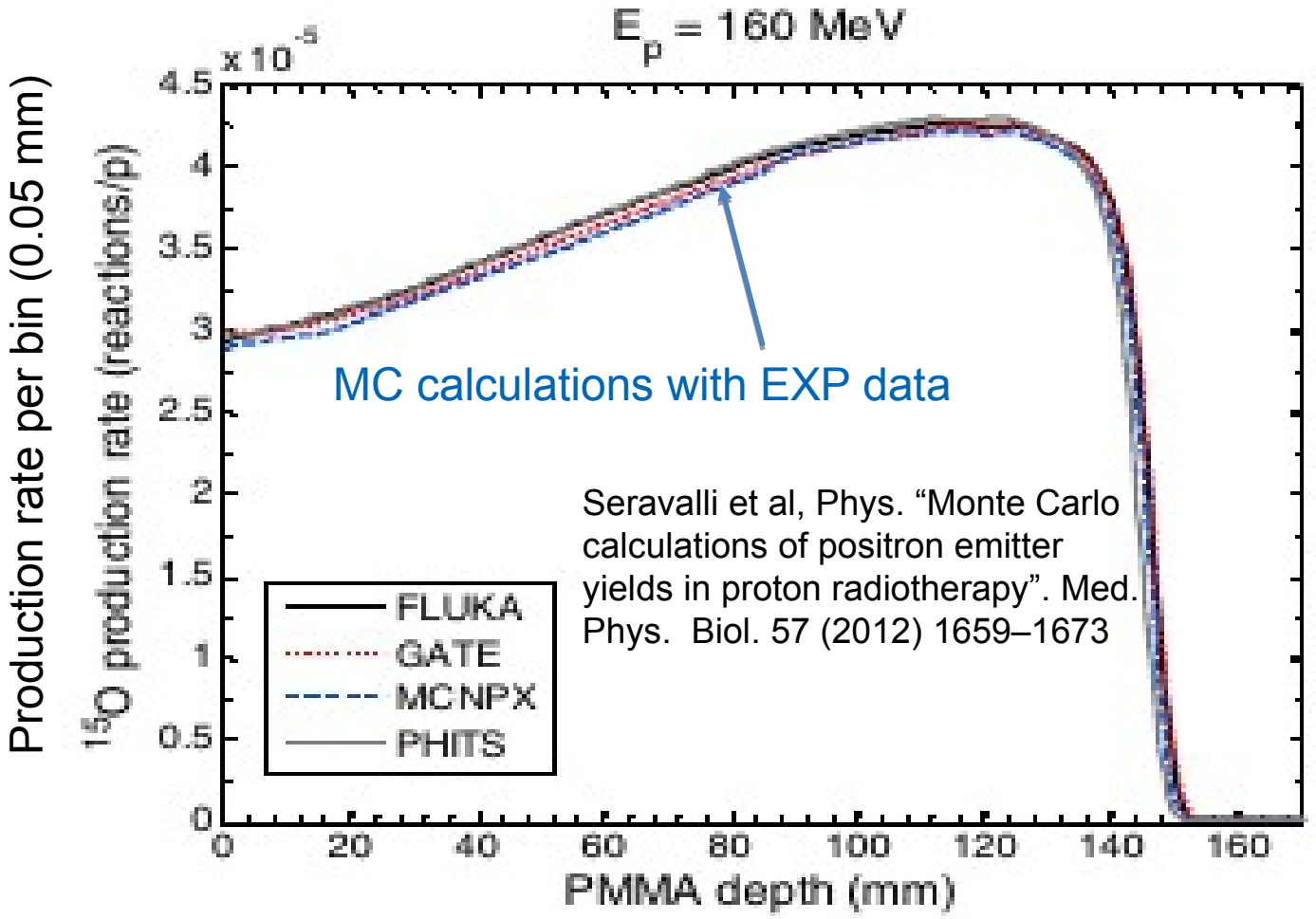
Calculation of PET isotopes production with PENH-2019 (preliminary)



Production cross section:

- From ENDF file
- Experimental (EXFOR)

Calculation of PET isotopes production with general purpose MC codes



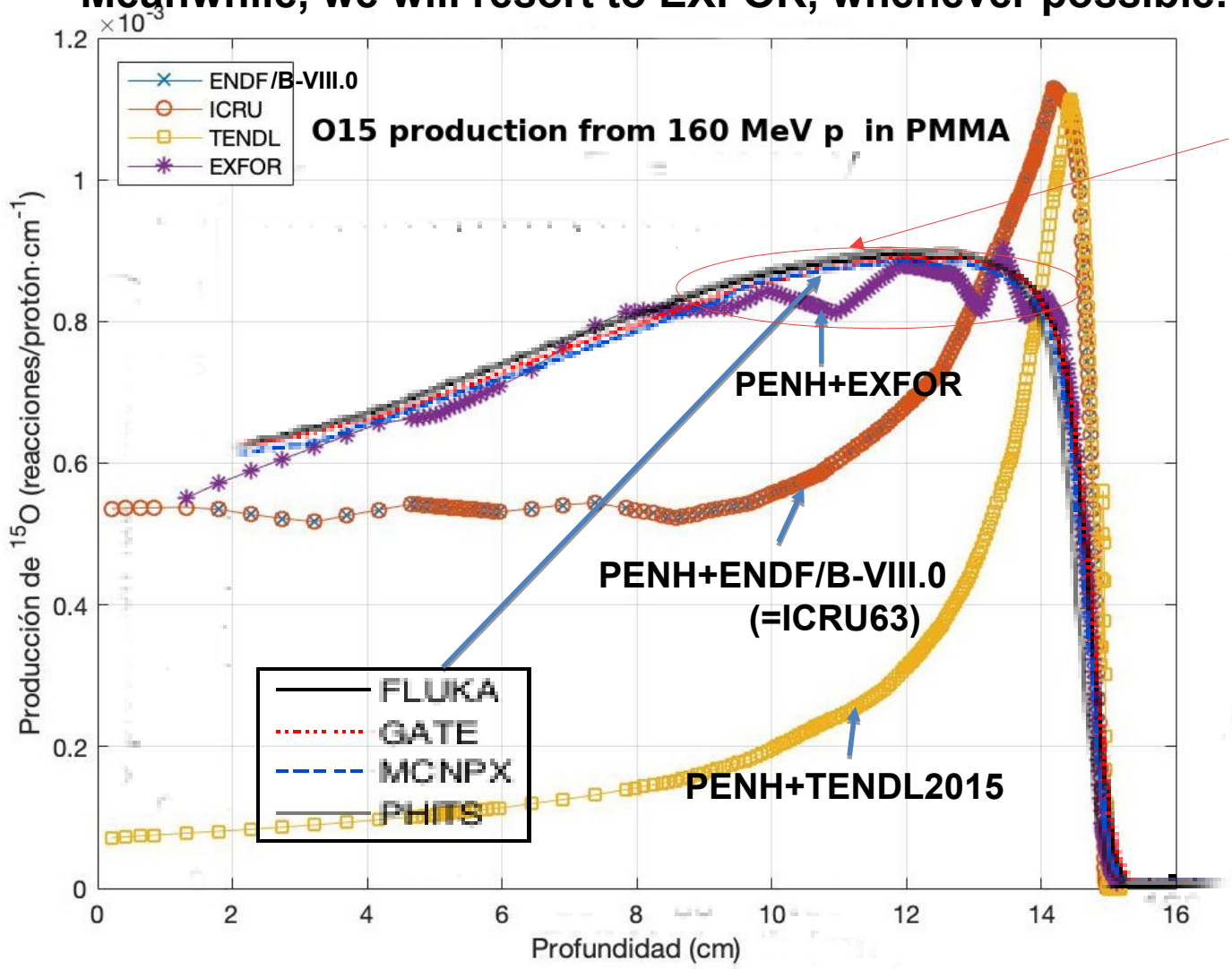
$$N_\gamma = \int \frac{d\Phi(E)}{dE} \frac{f_X \rho N_0}{A_X} \sigma_{X\to\gamma}(E) \Delta V dE$$

Spectral fluence (track lenght density)

Production cross section (either evaluated or experimental)

Need of more realistic Evaluated Nuclear Data.

Meanwhile, we will resort to EXFOR, whenever possible.



Oscillations are due to the non weighted averaged EXFOR data in PENH simulations (peliminary results)

IAEA is doing a great effort of collection and dissemination of ND

IAEA Medical Portal:
https://www-nds.iaea.org/medportal/

IAEA charged-particle monitor reactions (reference cross sections):
https://www-nds.iaea.org/medical/monitor_reactions.html

IAEA evaluated cross sections for production of positron emitters (diagnostic):
https://www-nds.iaea.org/medical/positron_emitters.html

IAEA evaluated cross sections for production of gamma emitters (diagnostic):
https://www-nds.iaea.org/medical/gamma_emitters.html

IAEA evaluated cross sections for production of therapeutic radionuclides:
https://www-nds.iaea.org/medical/therapeutic_2019.html

Technical Meeting on Nuclear Data for Medical Applications
IAEA Headquarters 10-13 Dec. 2018 (report INDC(NDS)-0776 on preparation)