PHITS simulations of the Matroshka experiment

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Introduction

- The radiation environment in space is harmful
- Radiation exposure estimations are necessary
- Benchmarking PHITS with experimental data from Matroshka at ISS
- The goal is to develop a tool able to estimate the radiation exposure for future space missions

Simulations

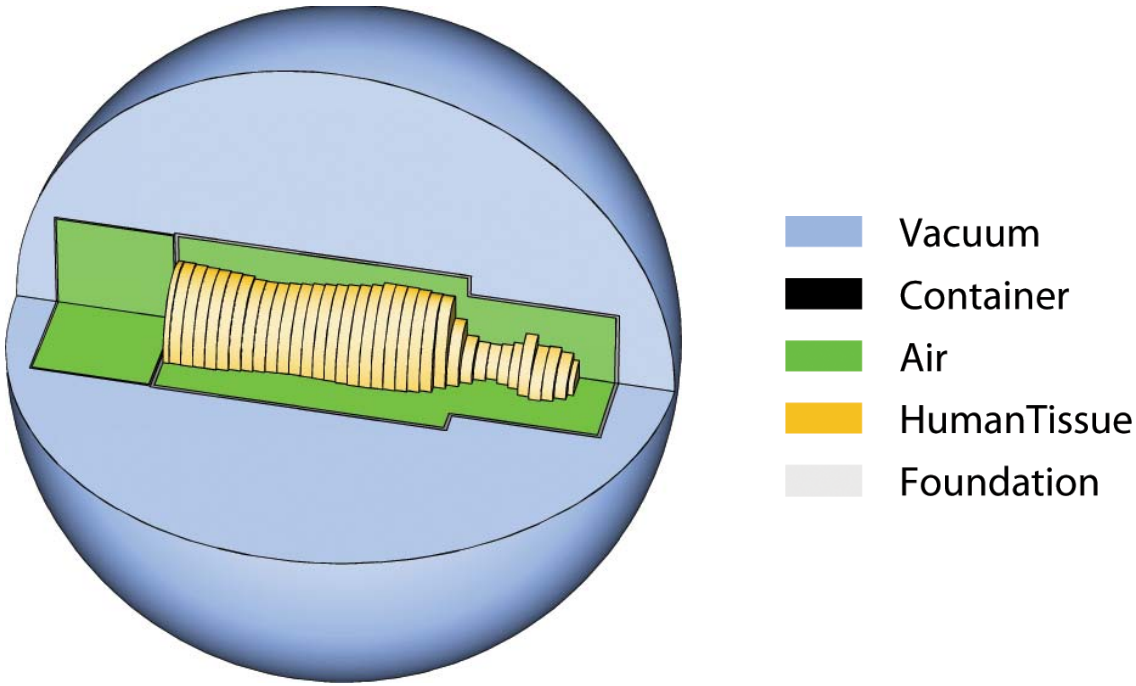
PHITS

- PHITS - the Particle and Heavy-Ion Transport code System
- Cooperation between RIST, JAEA, KEK, Japan and Chalmers, Sweden
- 3-dimensional Monte Carlo code
- Applications
  - Shielding at accelerator facilities
  - Radiation shielding in space
  - Radiotherapy: heavy ions and BNCT
  - Transmutation

  etc

Geometry setup

- An approximate Matroshka phantom is used



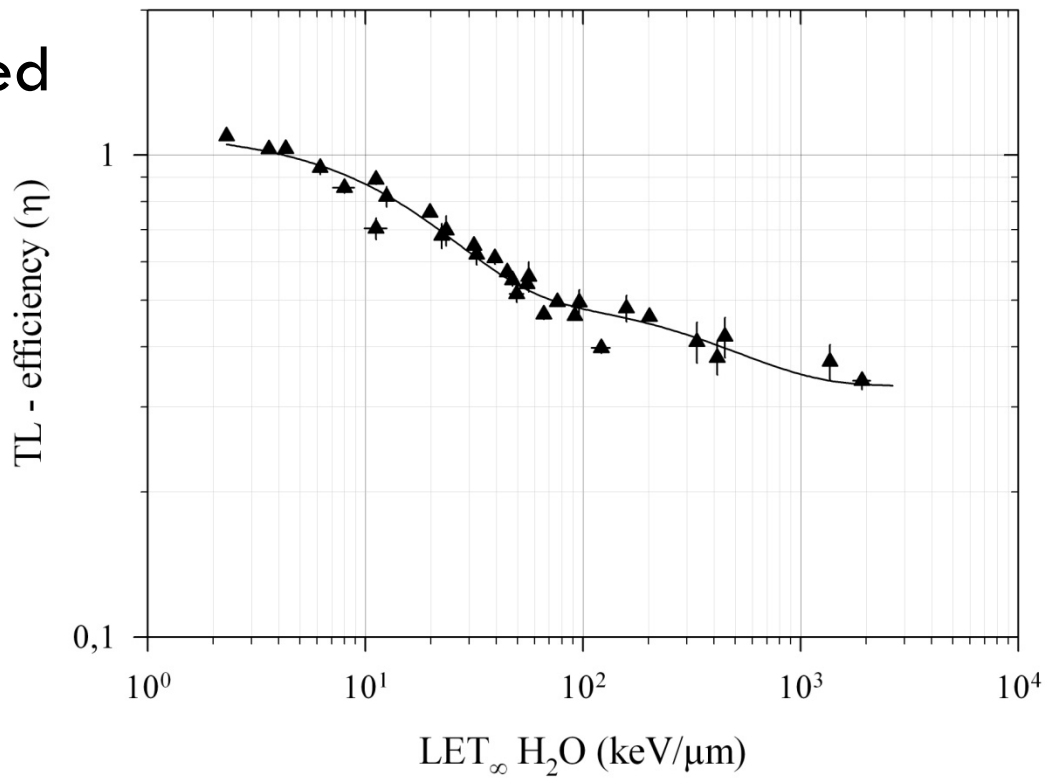
- No shielding from the ISS included yet

Source

- 26th of February 2004 to 18th of August 2005
  => **539 days**
- More solar minimum than solar maximum
- Altitude from 1st of December 2004
  => **364 km / 347 km** (apogee and perigee)
- CREME96 is used to estimate the radiation environment before interacting with the Matroshka geometry

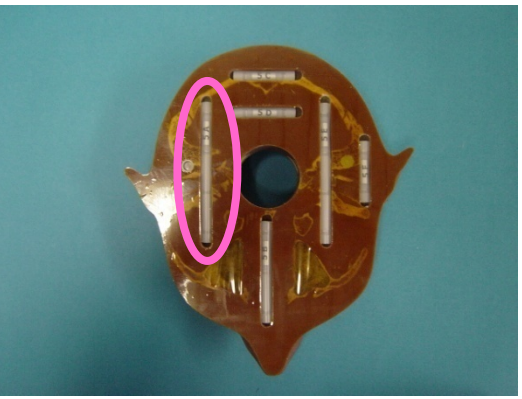
Detector setup

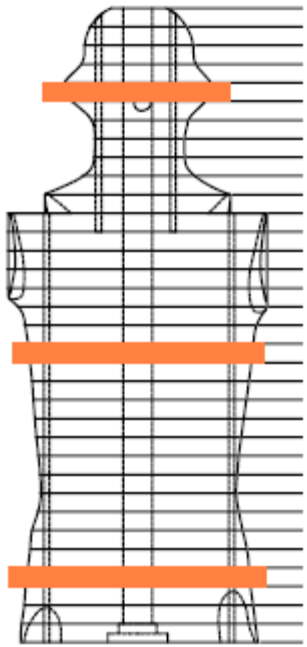
- xyz- grid with a 1 cm^3 volume
- DLR experimental data: 7LiF:Mg,Ti (TLD 700)
- Absorbed dose estimations
  - all by PHITS estimated
  - efficiency corrected
  - efficiency corrected with cut off

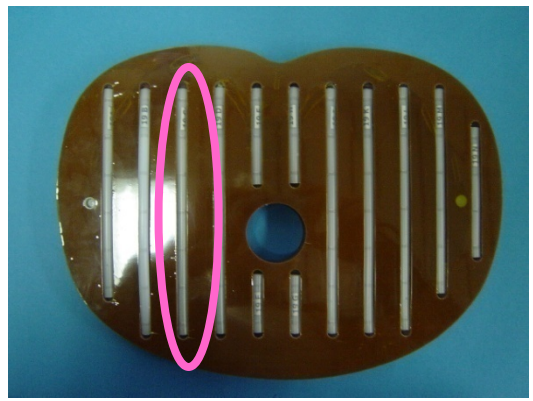


Results

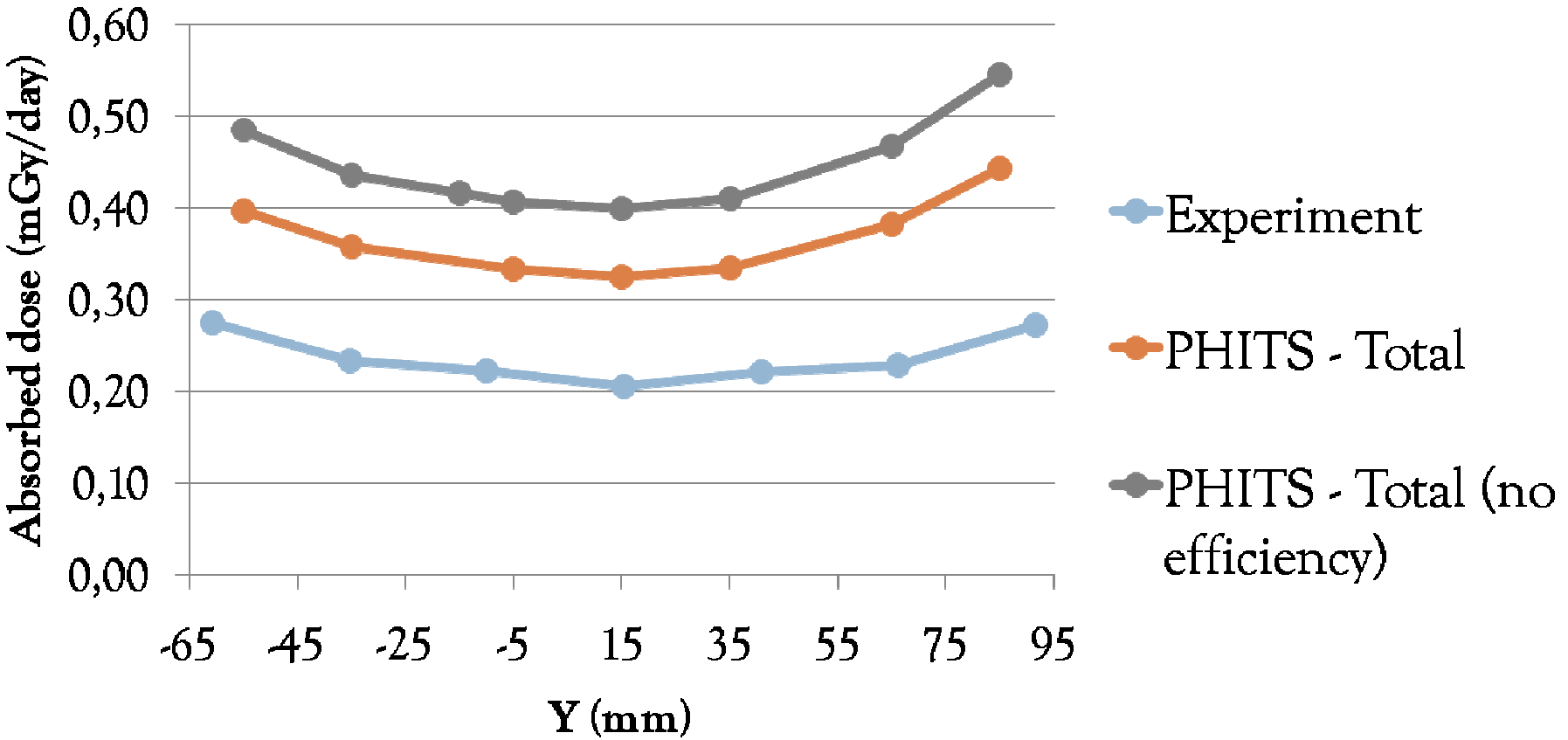
Slice of interest



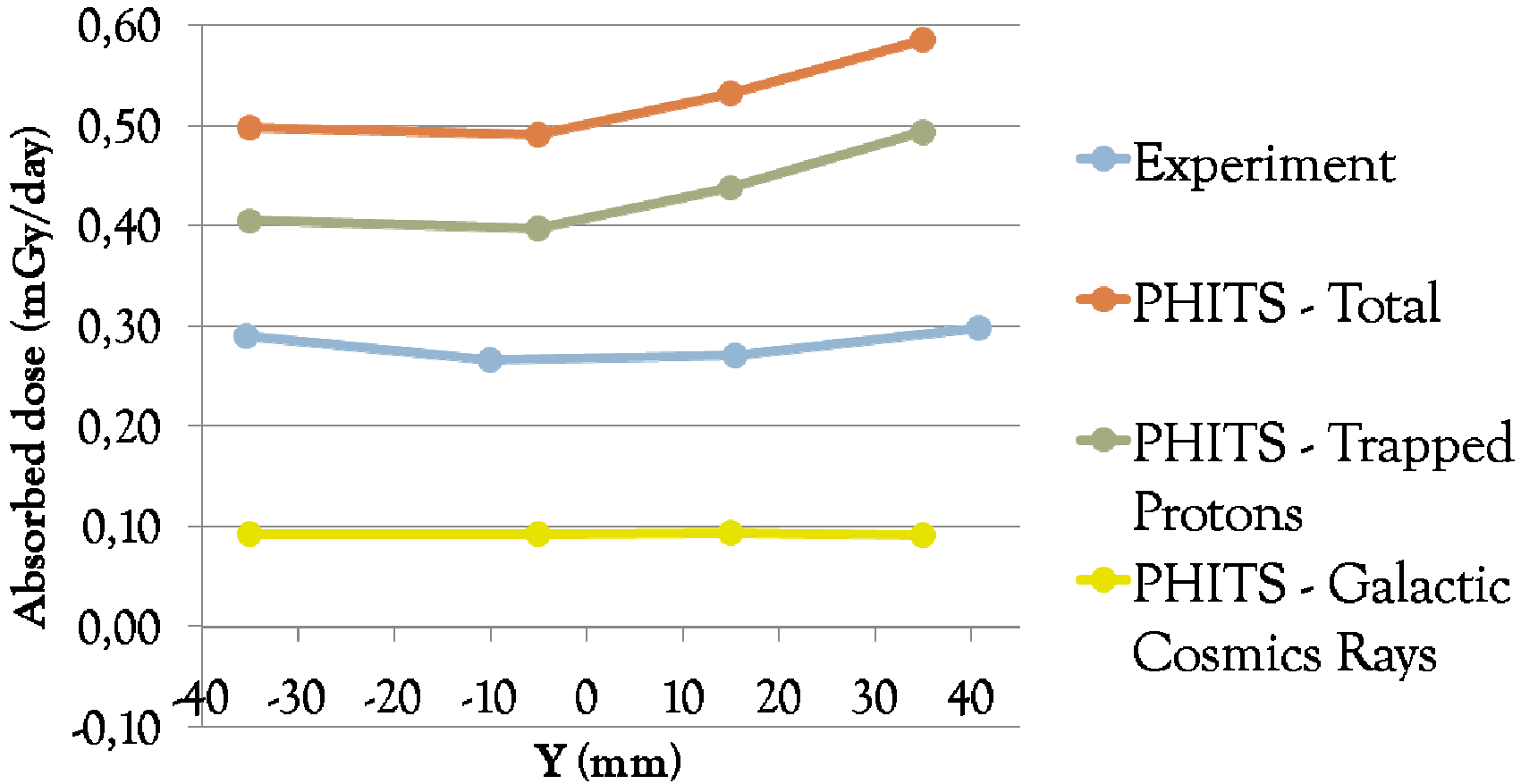




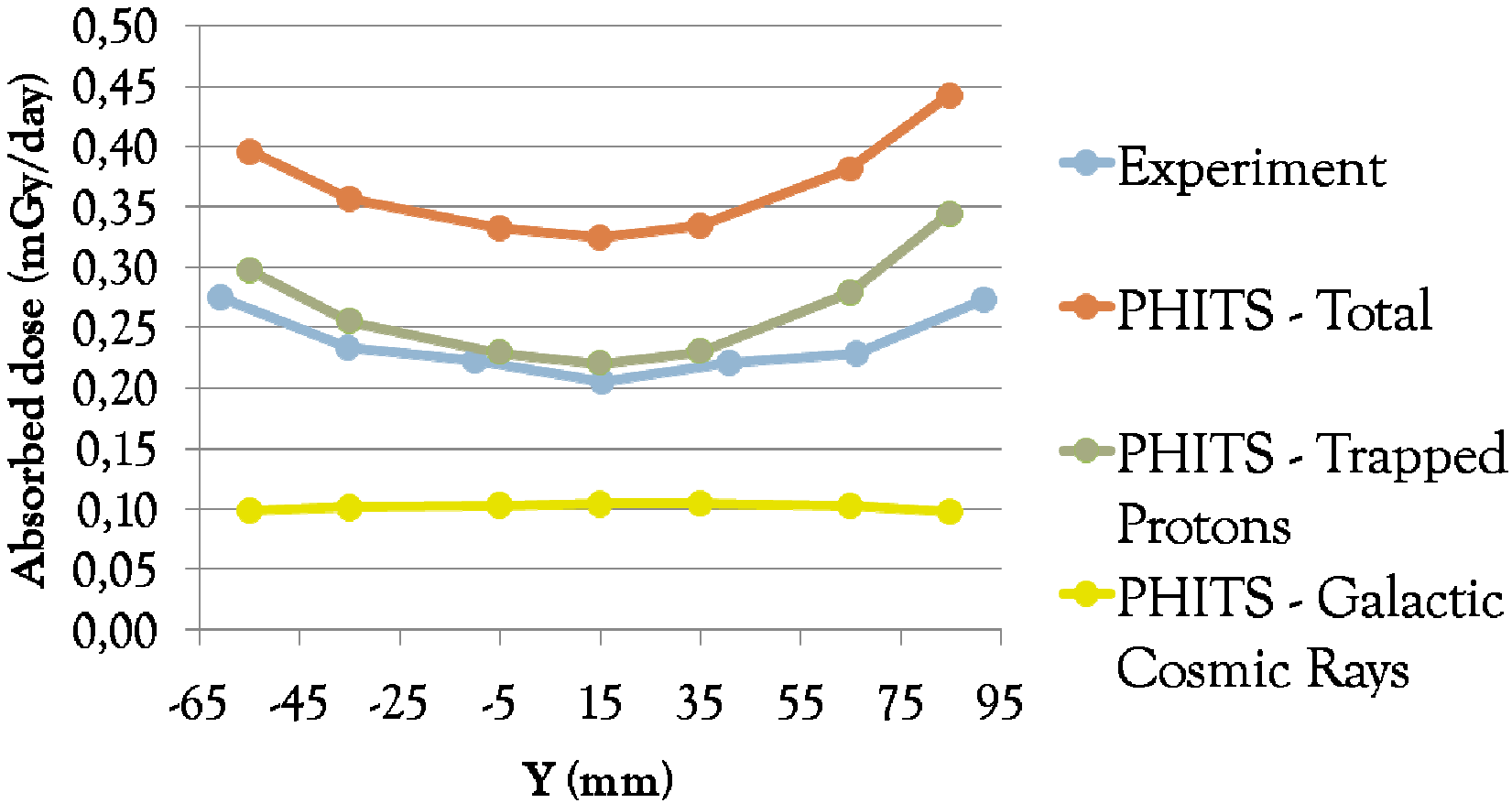
Slice 19 (Z=465mm) and X=63.5mm

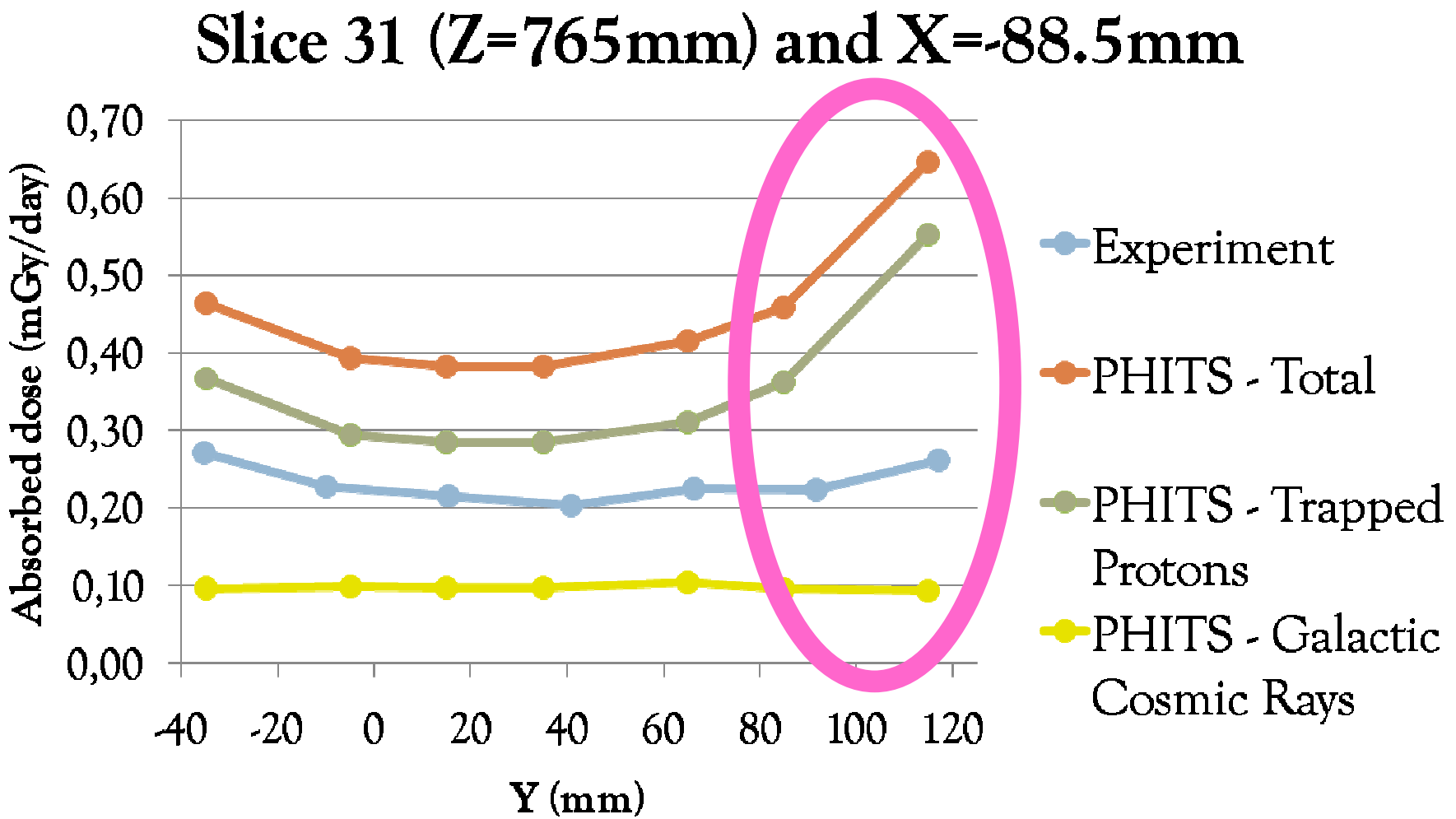


Slice 5 (Z=115mm) and X=38.1mm



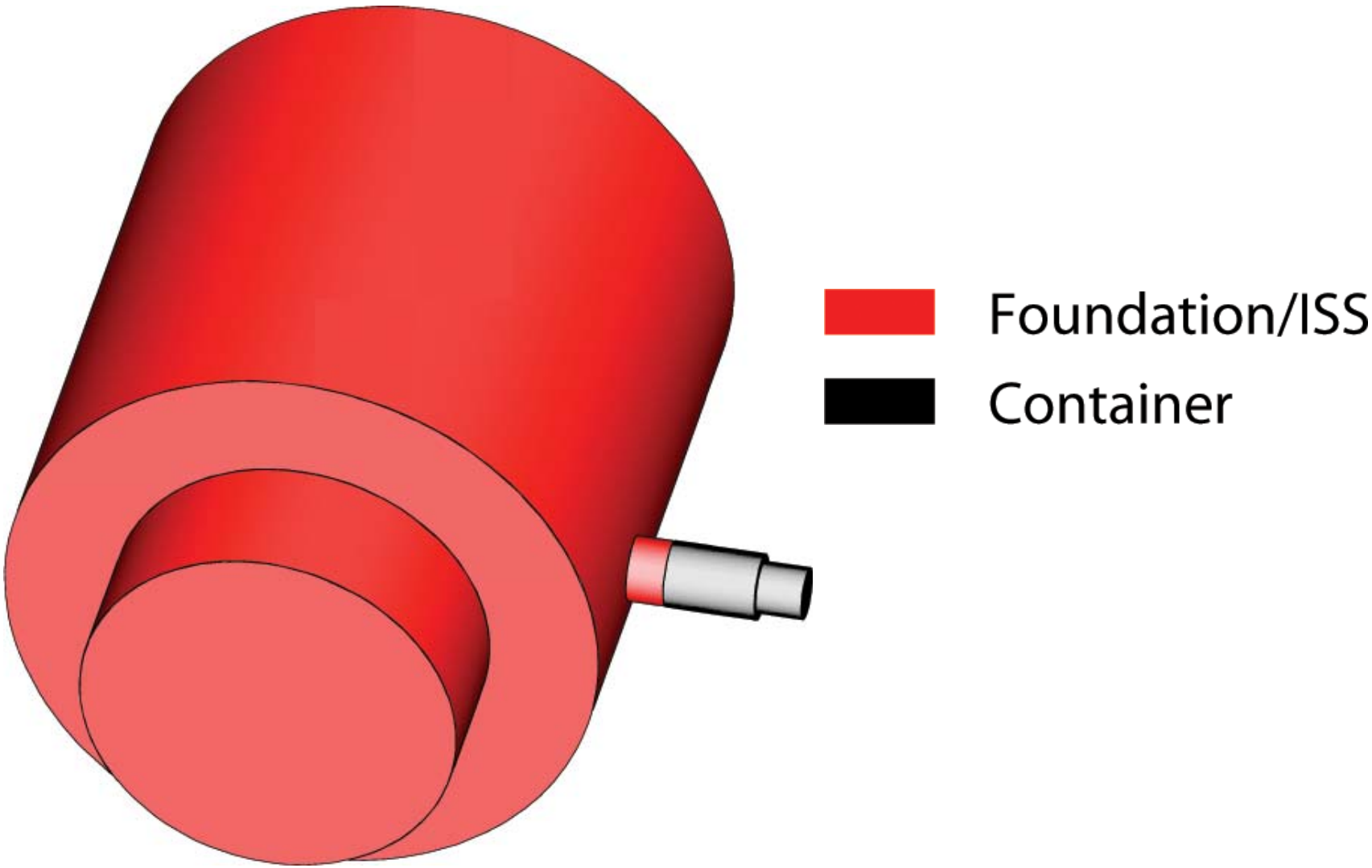
Slice 19 (Z=465mm) and X=63.5mm




Slice 31 (Z=765mm) and X=-88.5mm
Absorbed dose (mGy/day)
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
-40
-20
0
20
40
60
80
100
120
Y (mm)
Experiment
PHITS - Total
PHITS - Trapped Protons
PHITS - Galactic Cosmic Rays

Bonus

Including ISS shielding



Results

80% of the earlier value

Conclusions and future work

Conclusions

- Dose distribution shape agree but deviate a factor, approx. 1.9
- The deviation is depending on several parameters:
  - input flux,
  - lack of shielding,
  - geometry,
  - detection,
  - efficiency,
  - analysis etc.

Future work

- Advanced torso model by using voxel data based on CT scan
- Advanced ISS geometry
- More detailed simulations of real experimental conditions
- Continue benchmarking against different detector sets

Thank you for your attention!