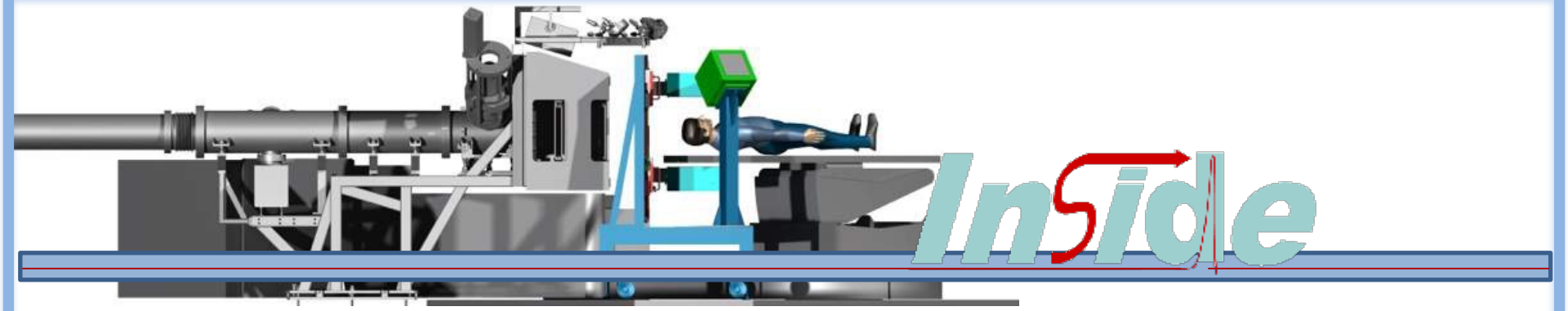
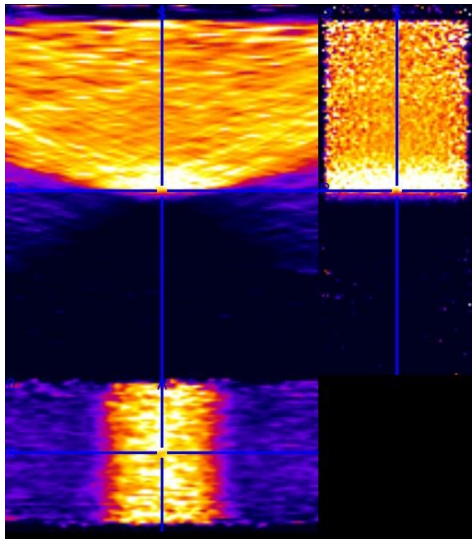


Activity Simulations and First Results on Phantom Positioning

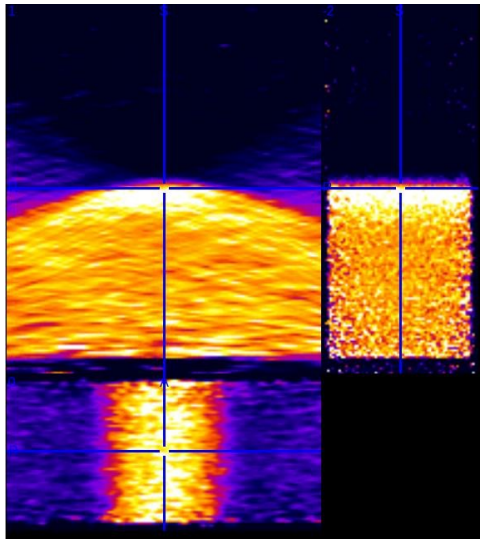
Veronica Ferrero, Elisa Fiorina, Francesco Pennazio

Homogeneous Activity Simulation

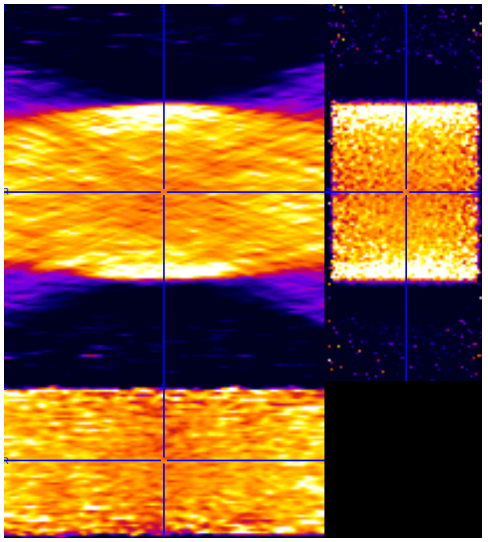
10x10x12 cm^3 water phantom at different positions along z (beam axis)
30 uCi activity
new reconstruction model (x=140, y=70, z=165 slices, 0.16 cm each)



Exit point in FOV



Entrance point in FOV

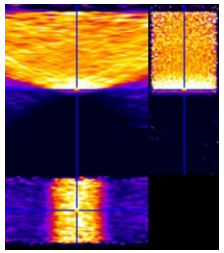


Central point in FOV

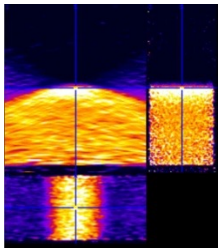
Homogeneous Activity Simulation

10x10x12 cm^3 water phantom at different positions along z (beam axis)

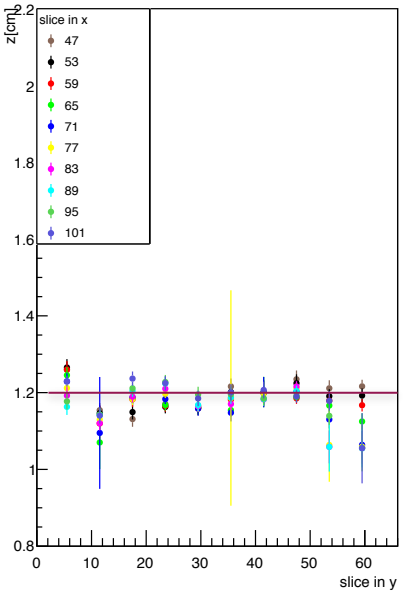
Exit point in FOV



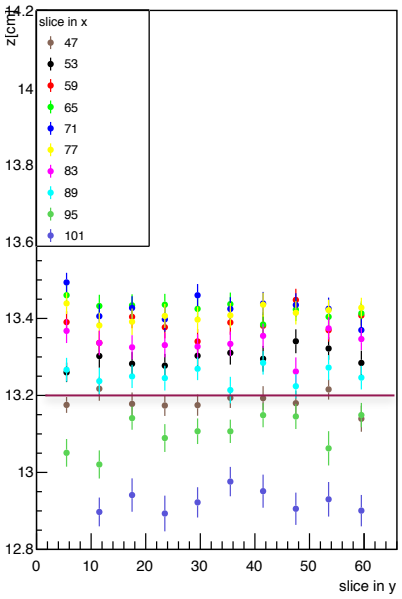
Entrance point in FOV



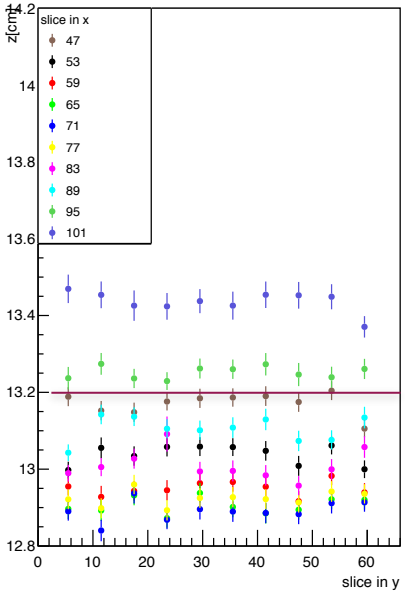
Entrance inflection point



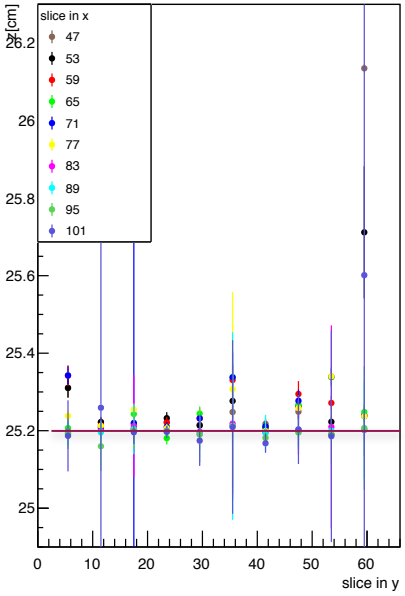
Exit inflection point



Entrance inflection point



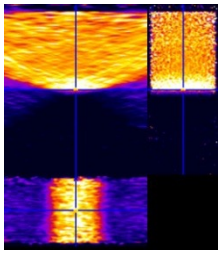
Exit inflection point



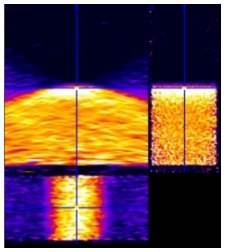
Homogeneous Activity Simulation

10x10x12 cm^3 water phantom at different positions along z (beam axis)

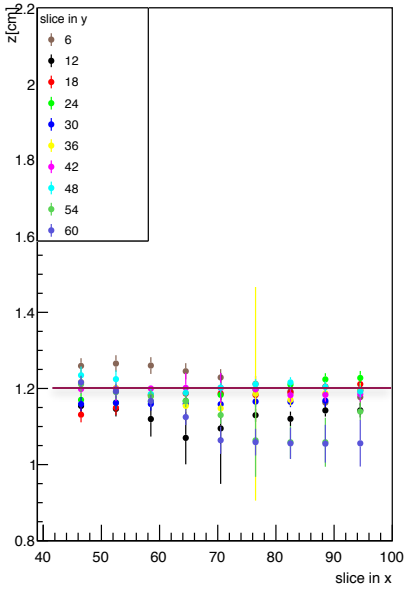
Exit point in FOV



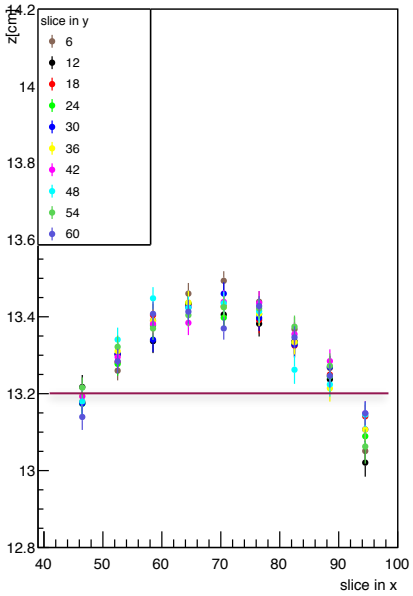
Entrance point in FOV



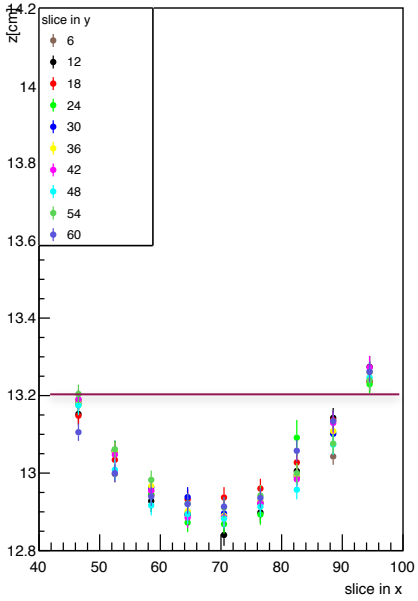
Entrance inflection point



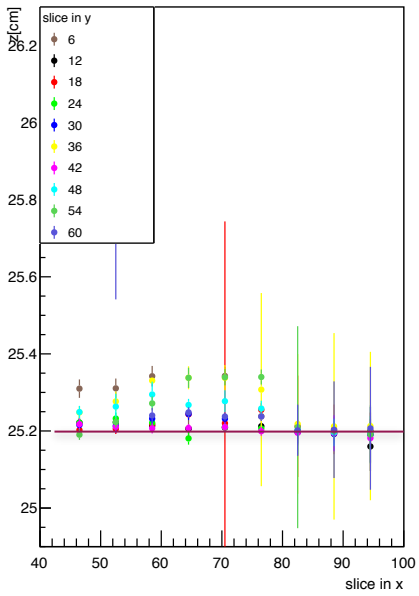
Exit inflection point



Entrance inflection point



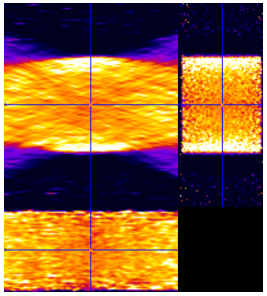
Exit inflection point



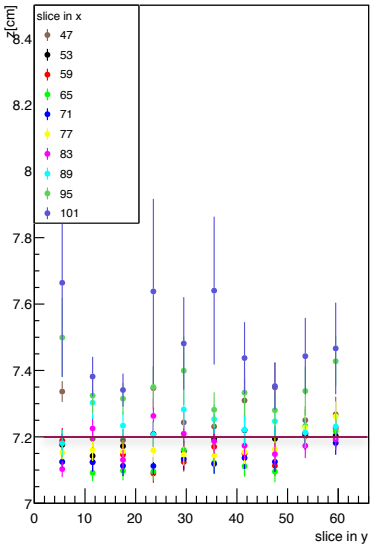
Homogeneous Activity Simulation

10x10x12 cm^3 water phantom at different positions along z (beam axis)

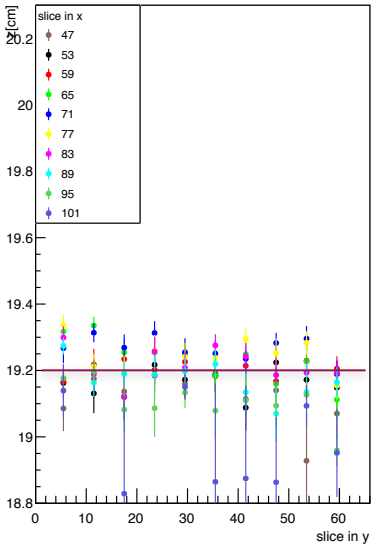
Central point in FOV



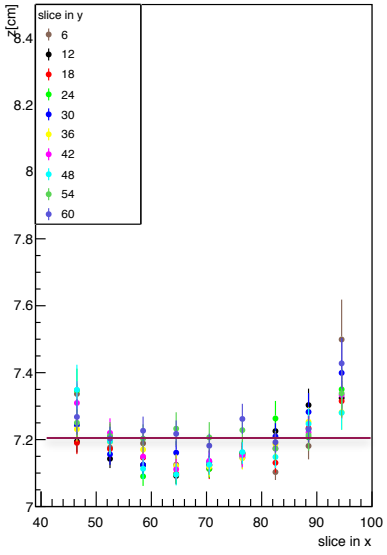
Entrance inflection point



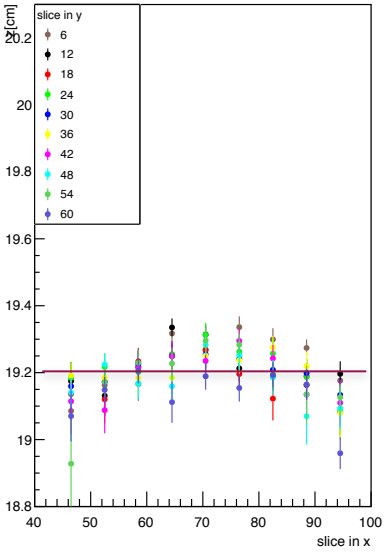
Exit inflection point



Entrance inflection point

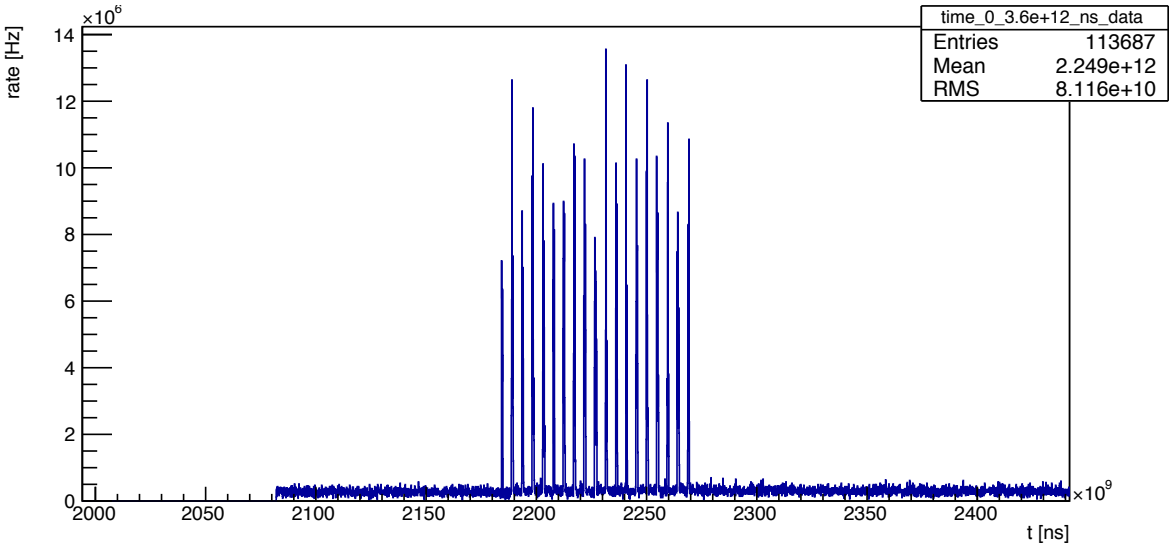


Exit inflection point



Experimental Set Up

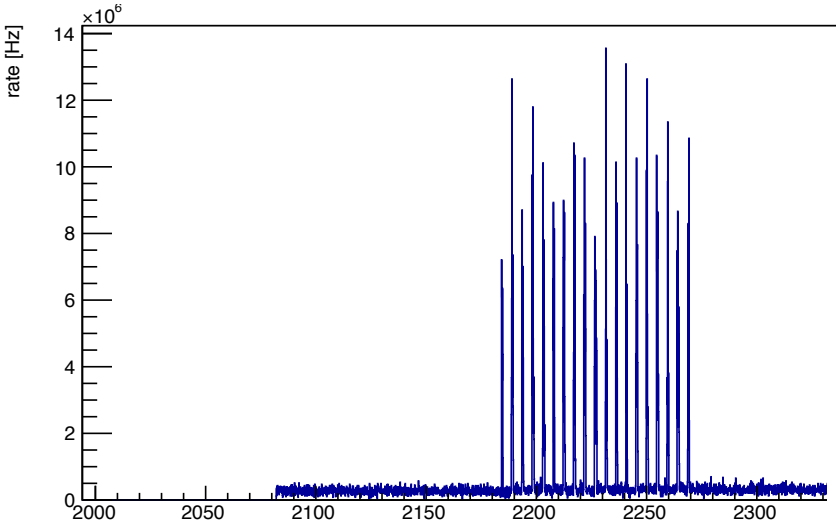
Monocromatic proton beam (50mm in water, 81 MeV/u circa)
15x15x20 cm^3 PMMA homogeneous phantoms (4x)
repeated acquisitions with phantoms at different positions in z

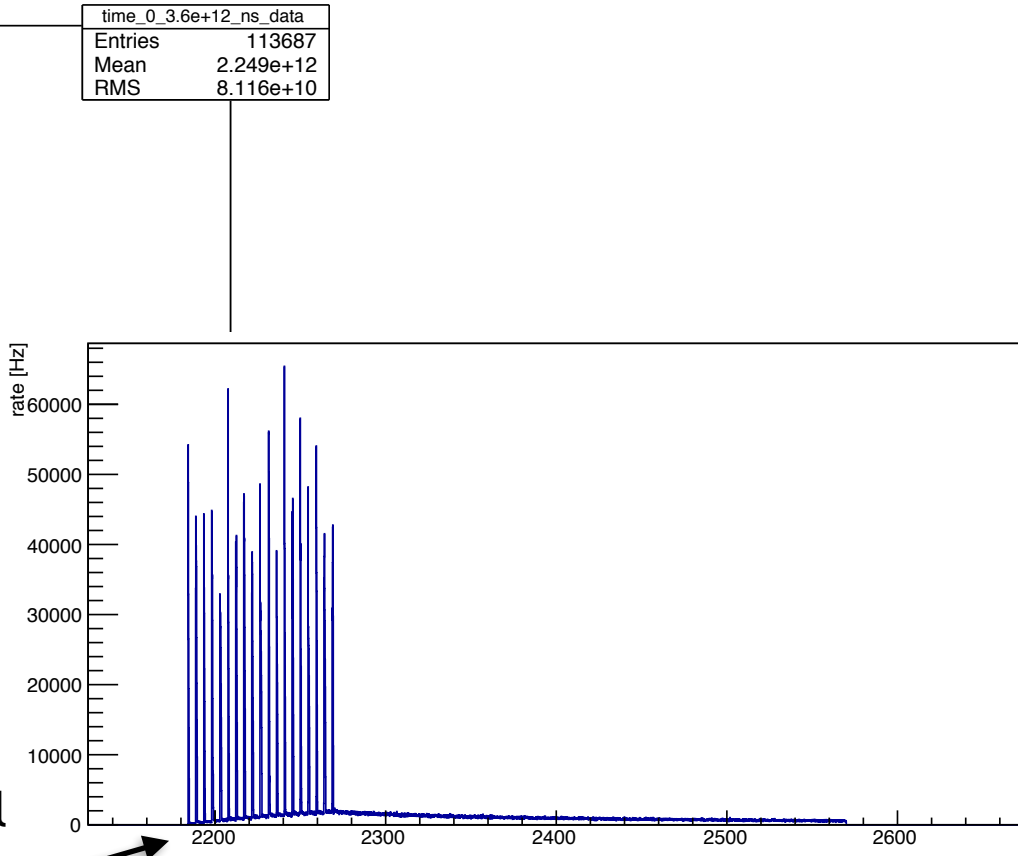


bkg + spill + aftertreatment

Experimental Set Up

Monocromatic proton beam (50mm in water, 81 MeV/u circa)
15x15x20 cm^3 PMMA homogeneous phantoms (4x)
repeated acquisitions with phantoms at different positions in z





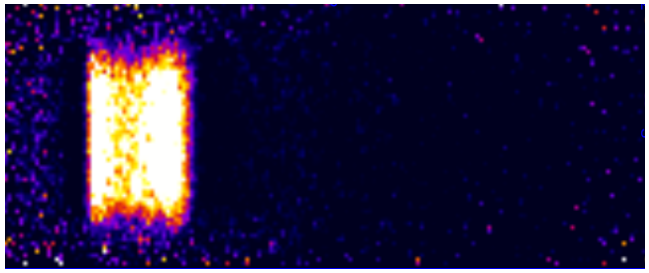
time selection from first spill
and TOT selection
(INSIDEWriteLORfile)

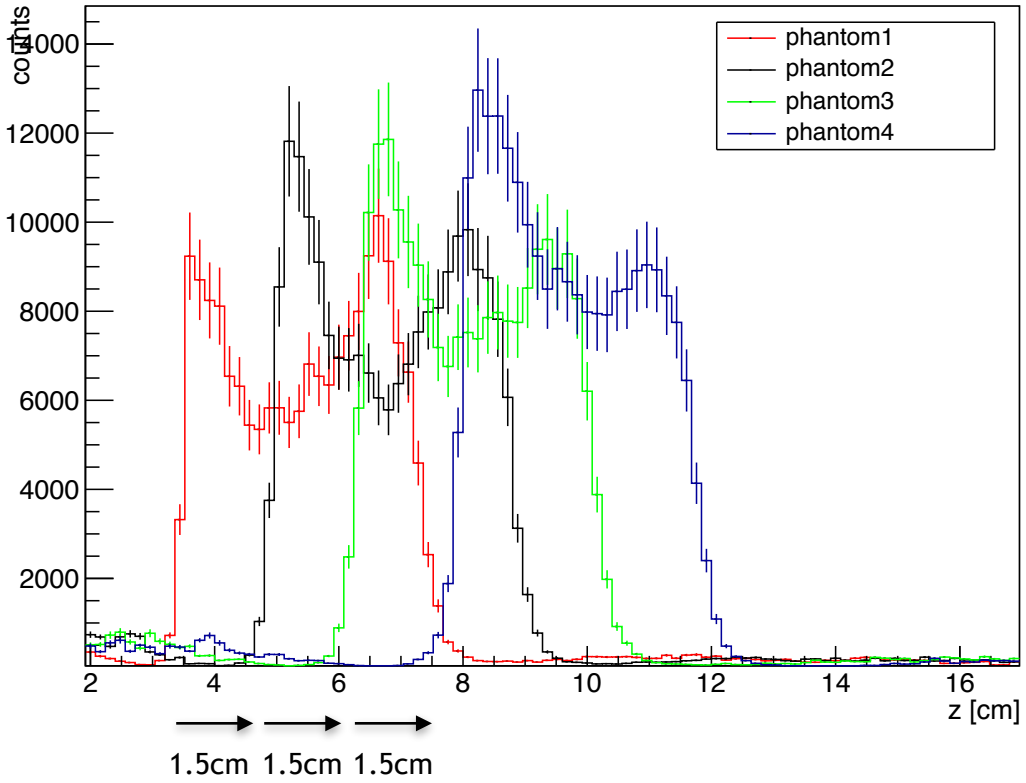
86 s spill + 300 s aftertreatment

Phantom Positioning

Monocromatic proton beam (50mm in water, 81 MeV/u circa)
15x15x20 cm^3 PMMA homogeneous phantoms (4x)
repeated acquisitions with phantoms at different positions in z

beam





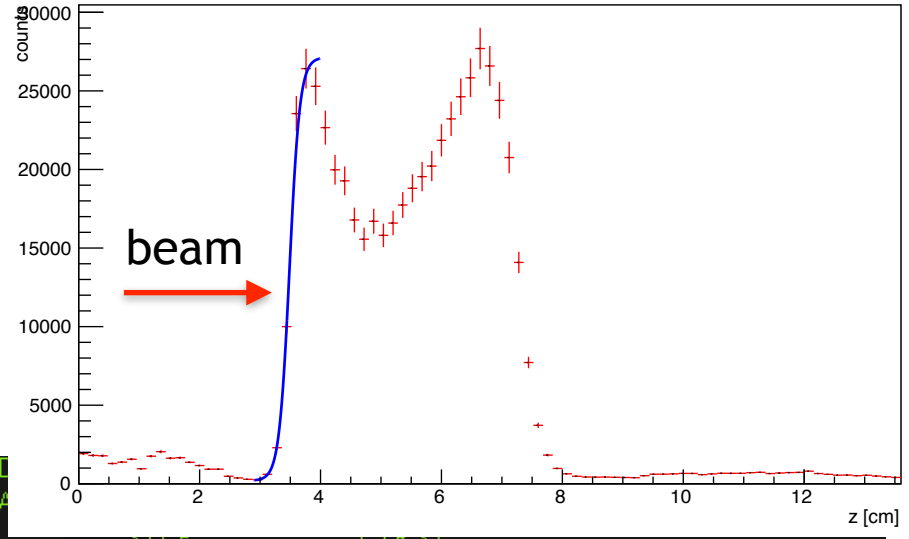
Experimental Set Up

How precisely can we determine the position?

"test" phantom to measure the beam entrance point with respect to the start of the FOV

image reconstruction as soon as LORs are available

sigmoidal fit

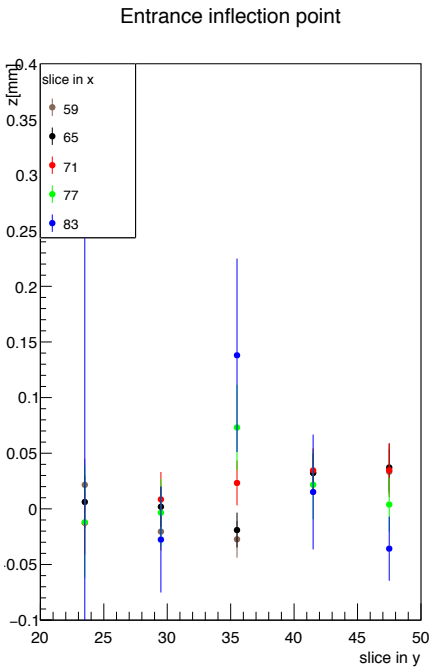



```
FCN=8.55971 FROM MIGRAD    STATUS=CONVERGED
                  EDM=9.15867e-08    STRA
 EXT PARAMETER                                          STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1   p0           2.71319e+04   8.85908e+02  -2.75586e+00  -6.67009e-07
  2   p1           1.98177e+02   1.60181e+01  -2.45141e-02  -3.37804e-05
  3   p2           1.16554e+01   3.93933e-01   3.88415e-04   1.75872e-03
  4   p3           3.48690e+00   8.60129e-03  -1.49275e-05   1.20731e-01
FCN=0.283124 FROM MIGRAD    STATUS=CONVERGED     263 CALLS         264 TOTAL
                  EDM=1.22027e-09    STRATEGY= 1      ERROR MATRIX ACCURATE
```

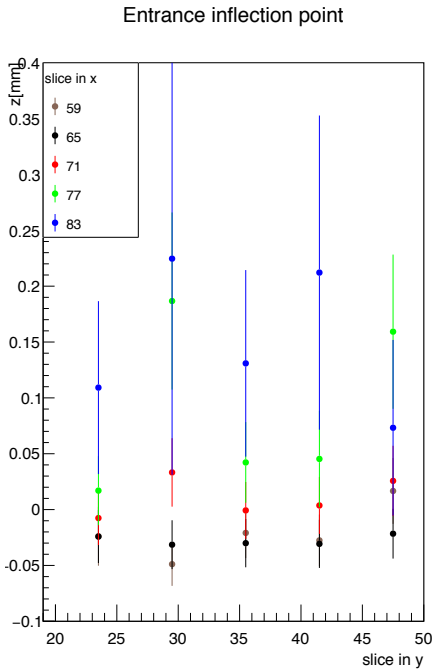
we are at (3.487±0.008) cm from the start of the FOV

Phantom Positioning

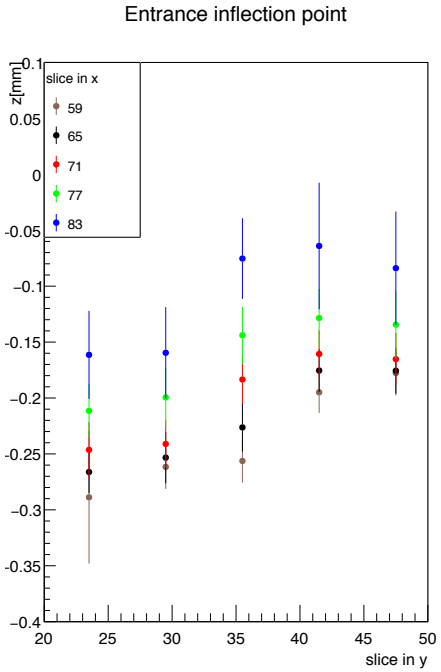
Monocromatic proton beam (50mm in water, 81 MeV/u circa)
15x15x20 cm^3 PMMA homogeneous phantoms (4x)
repeated acquisitions with phantoms at different positions in z



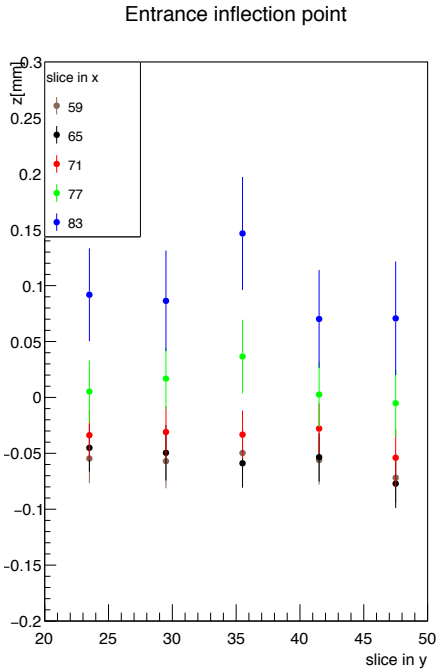
phantom1,
3.5 cm from
start of FOV



phantom2,
5 cm from start
of FOV



phantom3,
6.5 cm from
start of FOV



phantom4,
8 cm from start
of FOV

How precisely can we determine the position?

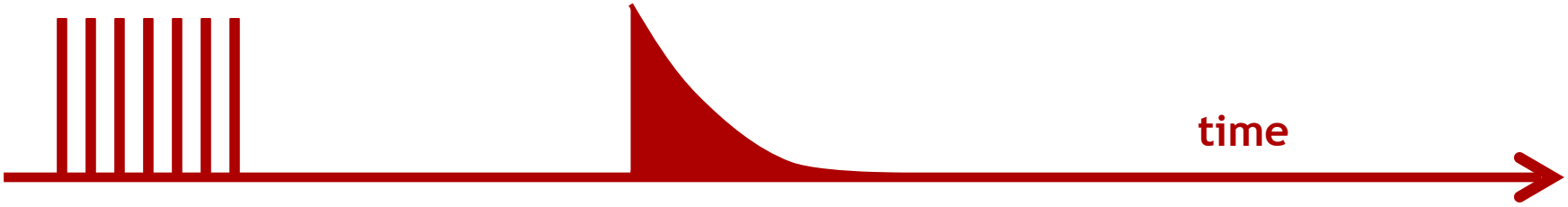
⟶ discrepancy in positioning lesser than *0.3 mm*

Backup slide: In-Beam Simulations

Isotopes production is a poor signal → all the statistics must be simulated.

STEP 1: Beam simulation	Time-tagged activity scoring	**STEP 2:** PET simulation	Data analysis & image reconstruction
About 1/100 of primary hadrons	❑ Annihilation time and position ❑ Isotope production map: ^{11}C ($t_{1/2}$=1220.04s) ^{15}O ($t_{1/2}$=122.4s) ^{10}C ($t_{1/2}$=19.290s) …	All positrons are simulated. Detector simulation.	Same as real data: ❑ Line Of Response (LOR) list extraction ❑ Image reconstruction (MLEM algorithm, 5 iterations)

100x



The temporal structure of the beam delivery is simulated.

Isotope decays are simulated.

The 4D reconstructed image depends on the acquisition time.