Imperial College London

Measurements of the T9 and T10 low momentum fluxes

Yuri Shitov, Imperial
On behalf of UK HPTPC groups

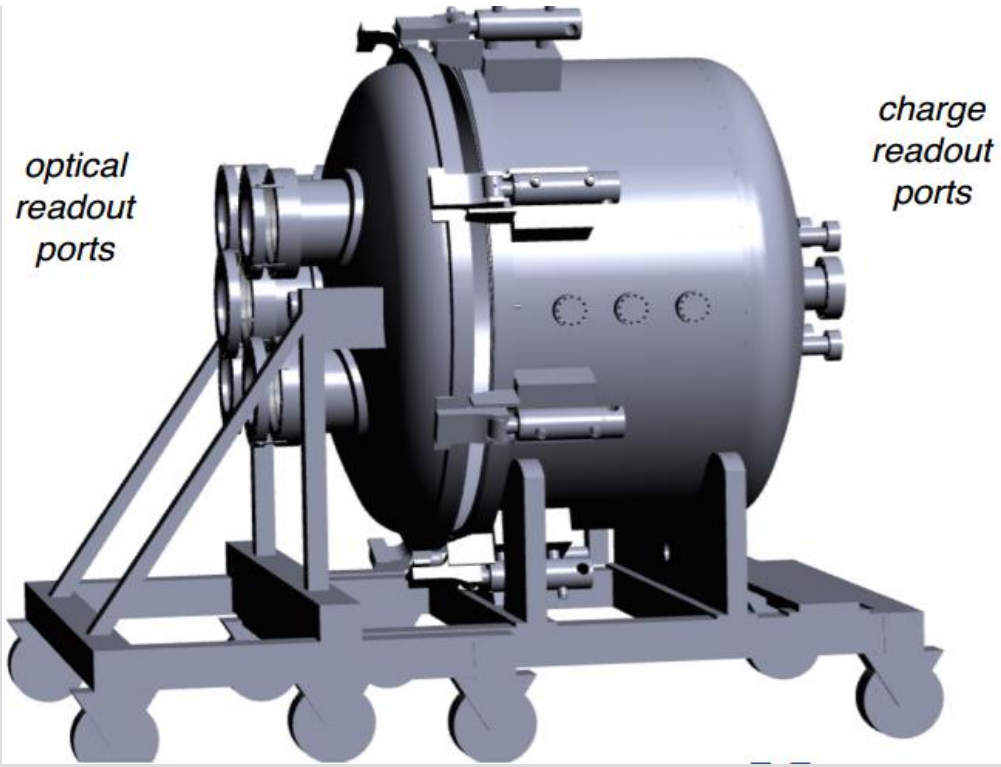
2nd Workshop on Neutrino Near Detectors based on gas TPCs, CERN March 20-21, 2017

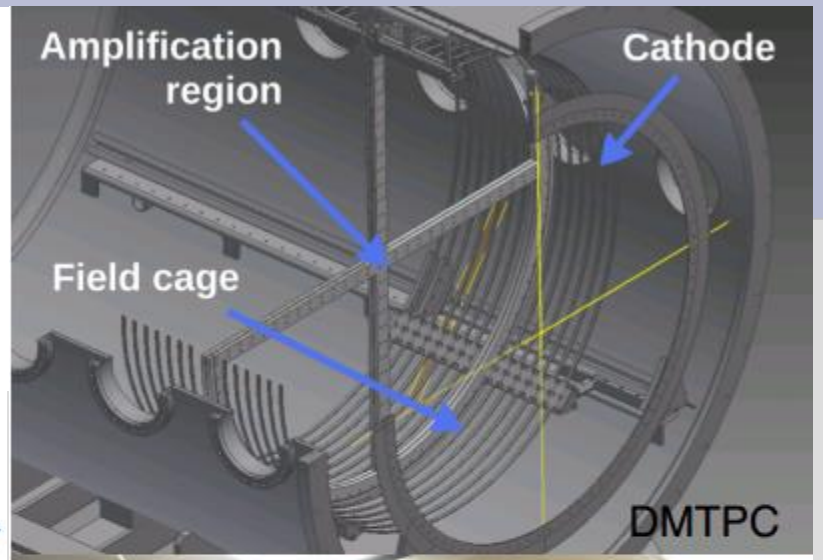
Outline

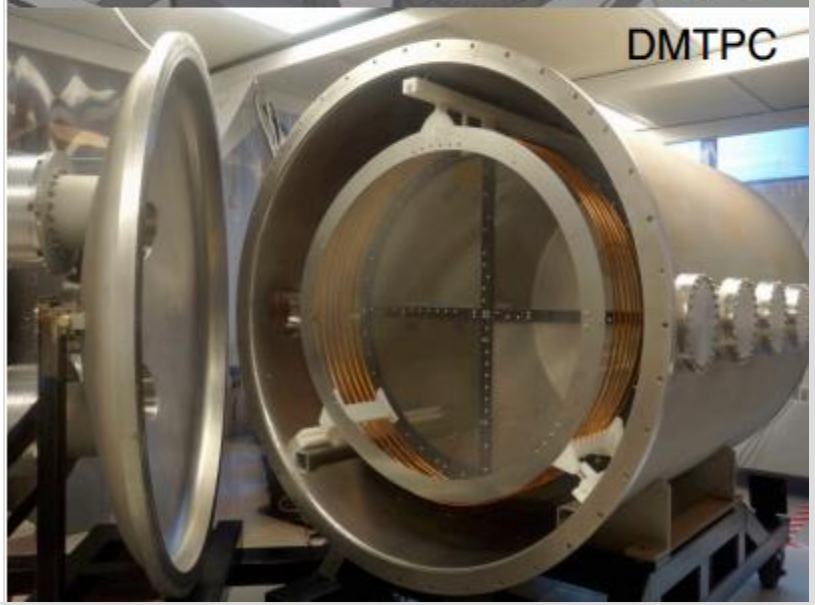
1. Motivation
2. CERN beams
3. Tests
4. Off-axis measurement
5. Conclusion

Creation of HP TPC Prototype: goal 1

- **We are building UK HPTPC prototype (fig. on bottom) with optical readout based on successful DM TPC experience (left fig.)**
- **Must be tested & calibrated on real data…**
- **and produce useful physics results.**

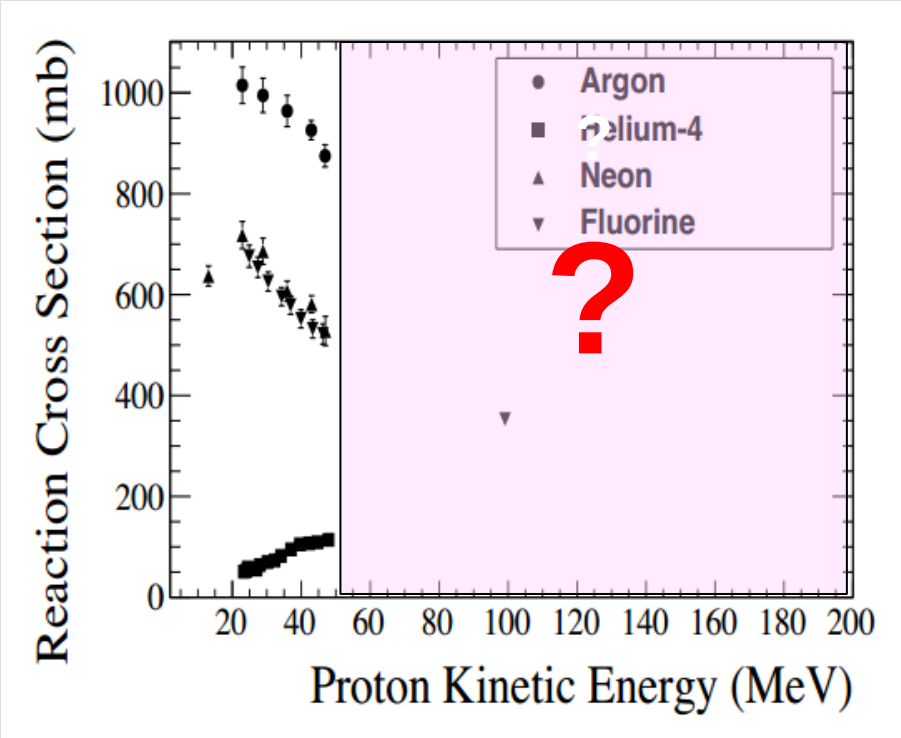


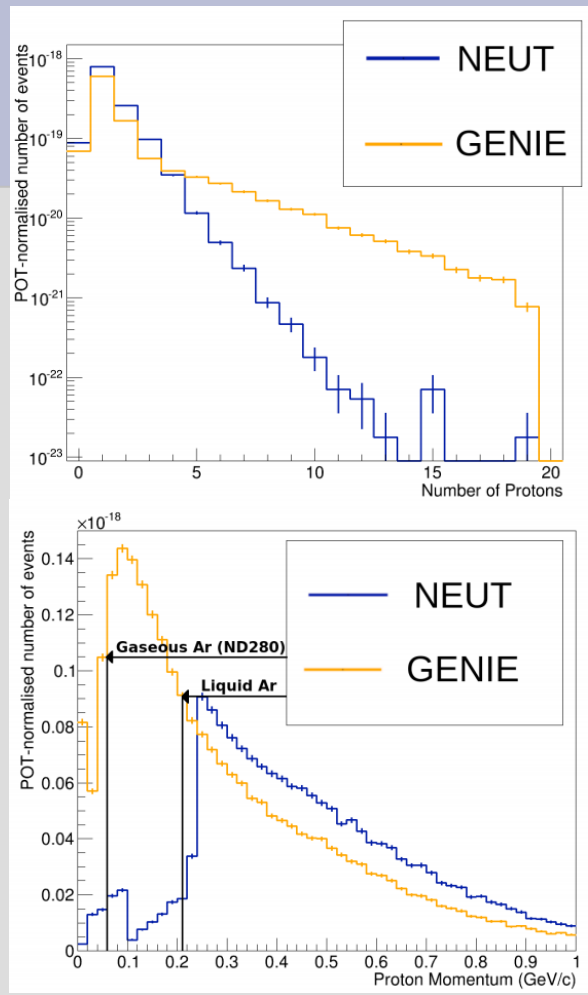




Proton cross-section status: goal 2

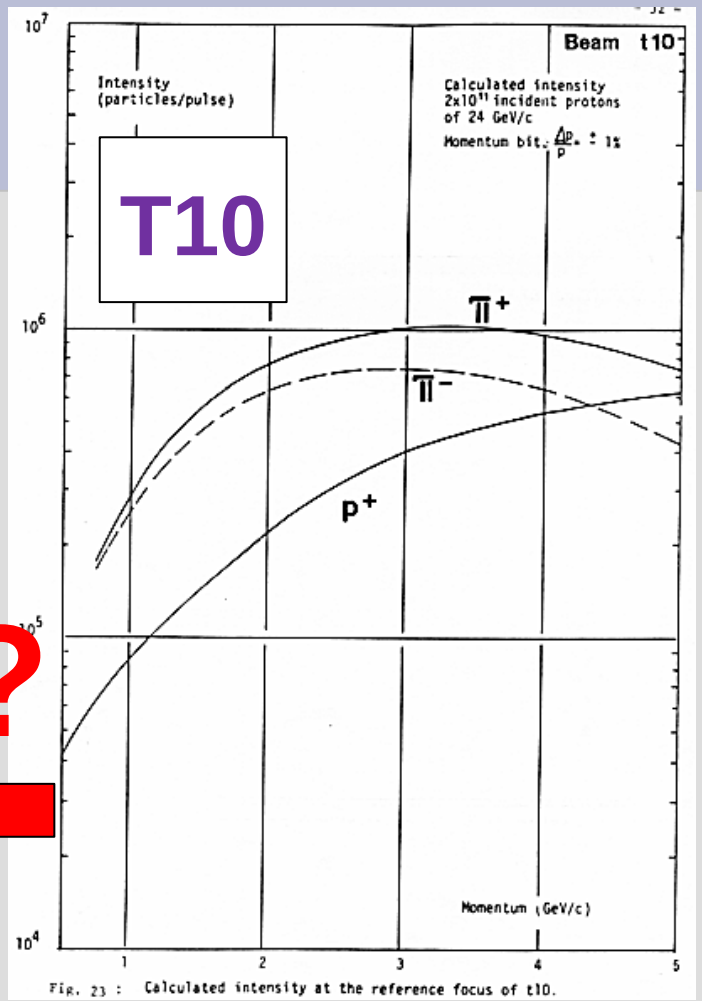
- **There is a lack of data for p xsec in [50-200] MeV area (see the figure below).**
- **There are essential discrepancies between neutrino generators (see the figures on the right)**
- **New experimental data would be useful here!**



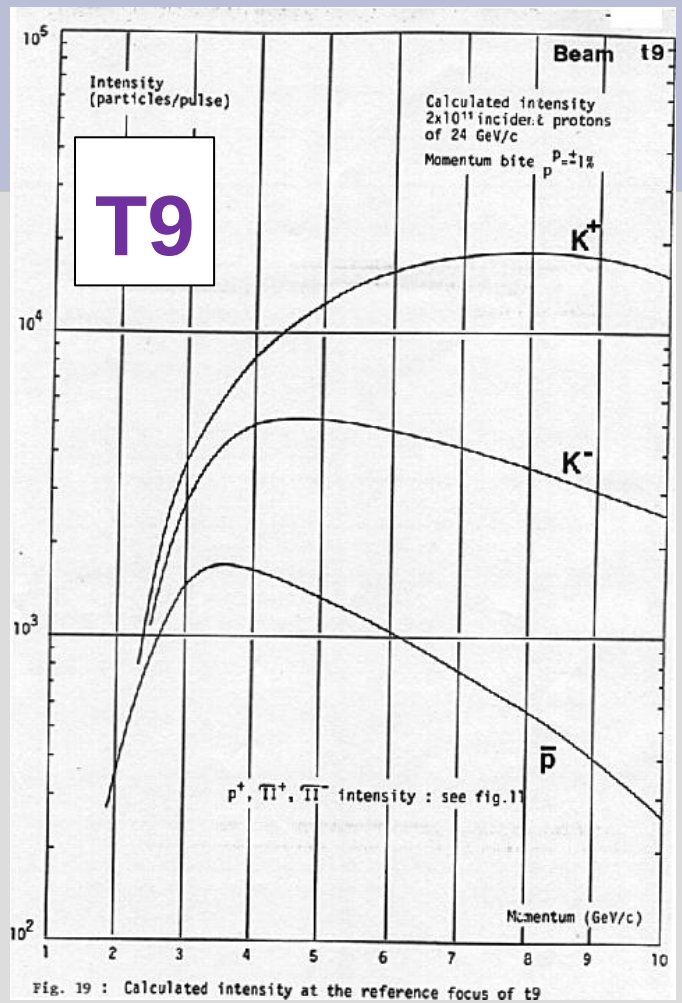


Proton multiplicity (Up) and momentum (Down) from νμCC on Argon (J-PARC OA beam)

Lack of low-E flux data on CERN T9/T10 beams



?



CERN beam tests have been performed in order to explore undocumented beam conditions at <= 1 GeV.

CERN beams: scheme

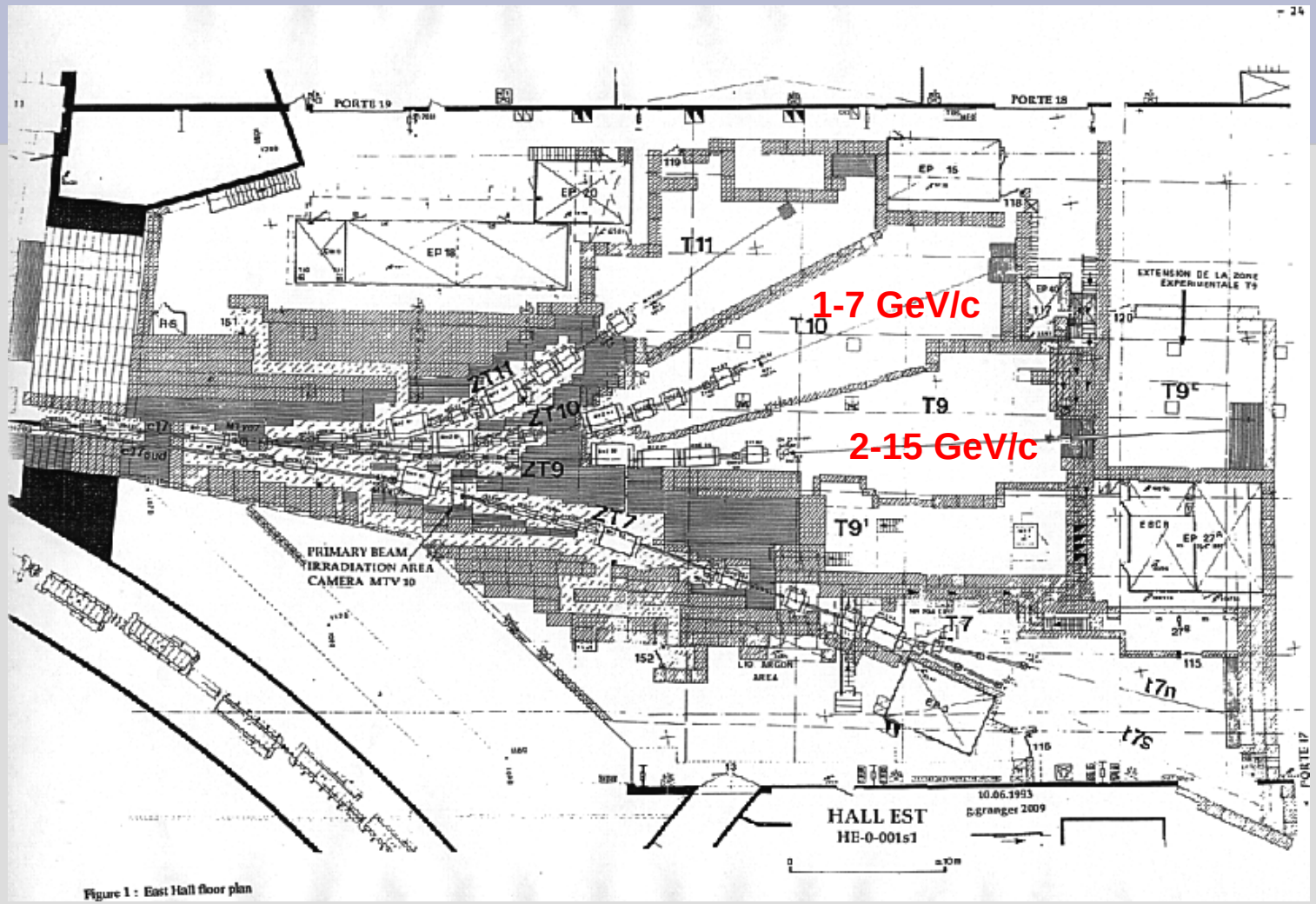


Figure 1 : East Hall floor plan

..

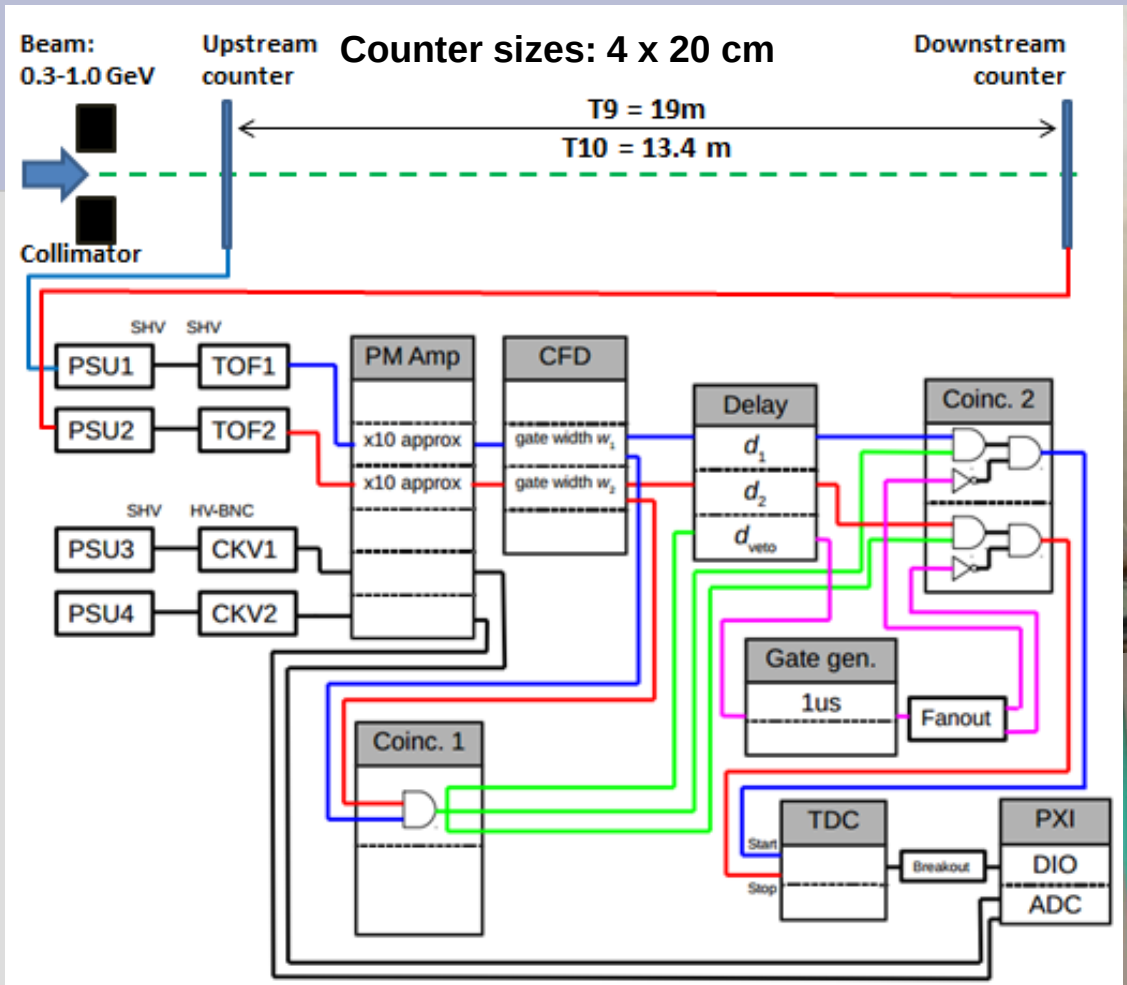
CERN beams: photos

T10

T9

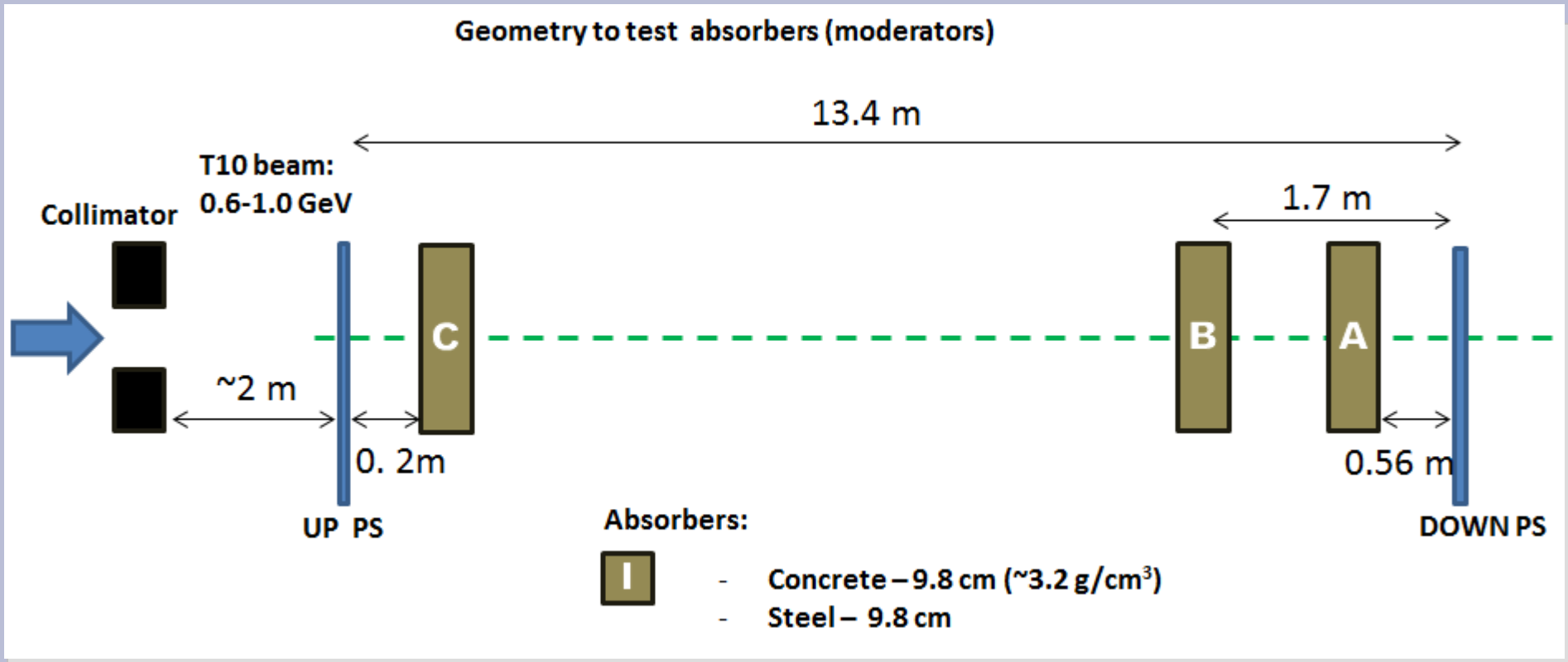
..

Experimental setup



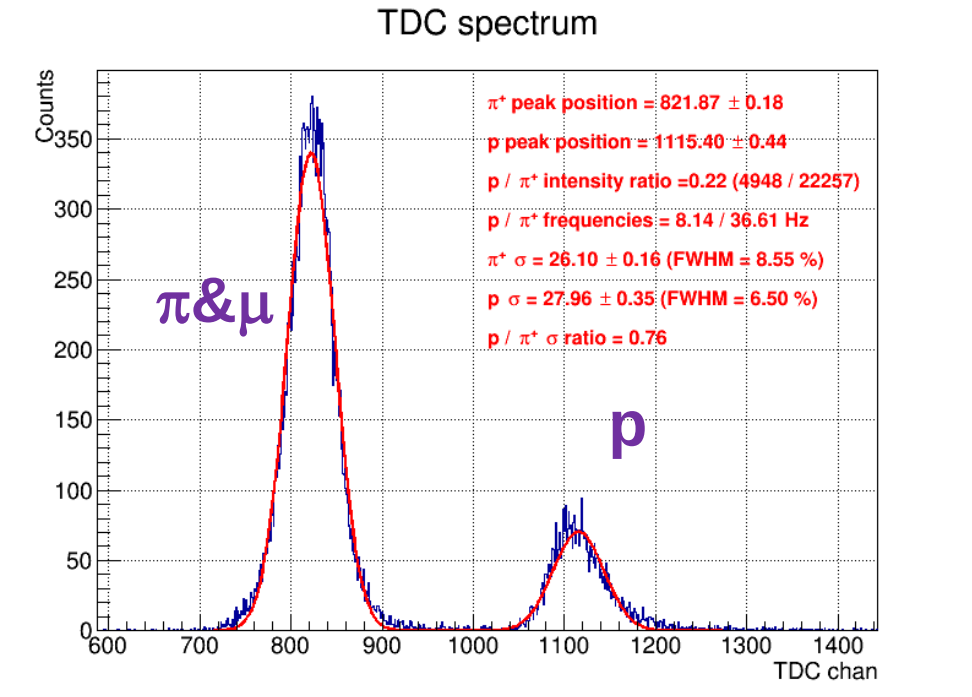
- **Tests have been done in Sep-Oct 2016**
- **~ 100 hours of data have been collected.**

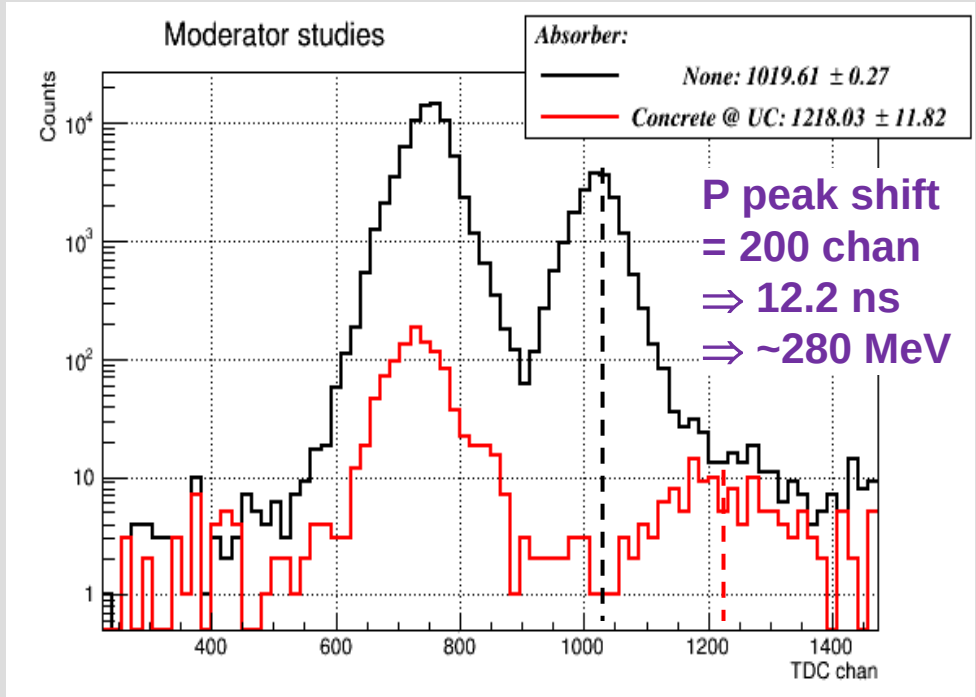
Setup for absorber studies



Several measurements have been done with absorder (moderator): concrete and steel blocks (thickness ~10 cm) placed in beam line.

Examples of experimental data

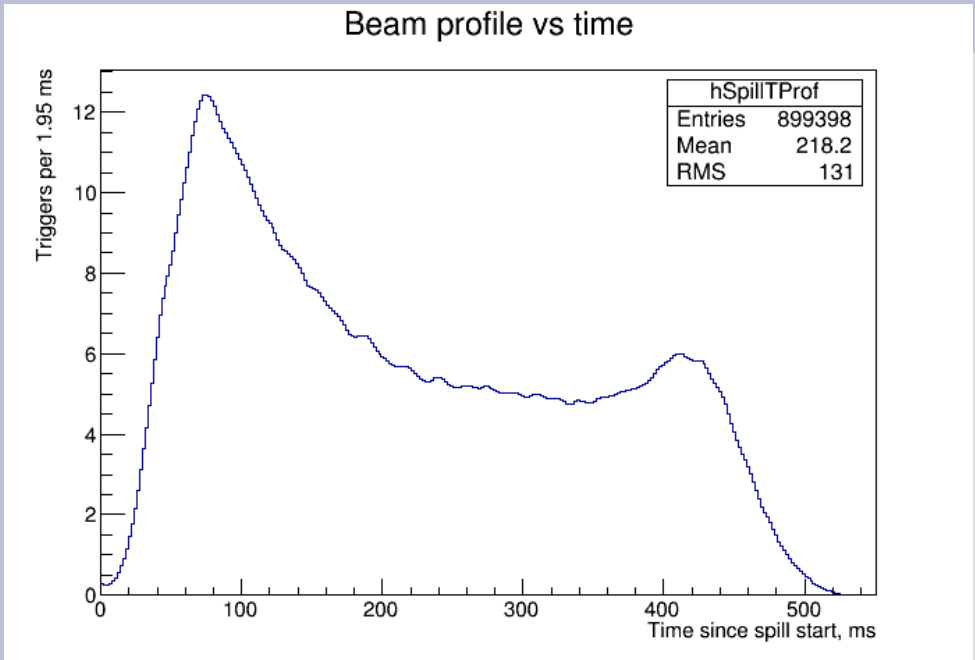


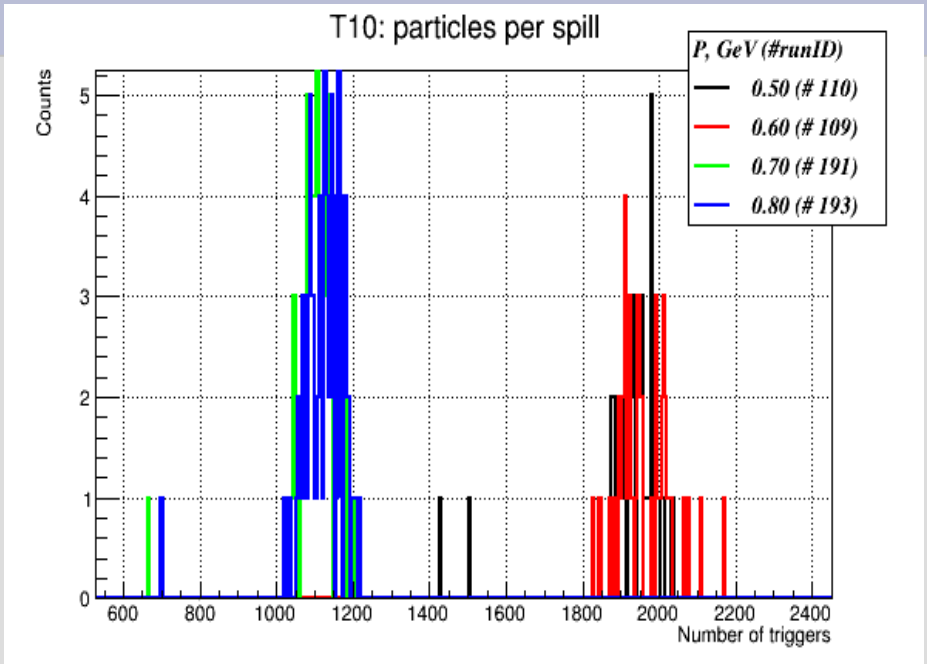


Main spectrum is shown on left figure with clearly separate peaks of proton and rest particles (mostly pions). Right picture: comparison of spectra measured without and with steel absorber.

Yuri Shitov, y.shitov@ic.ac.uk,

Some beam properties

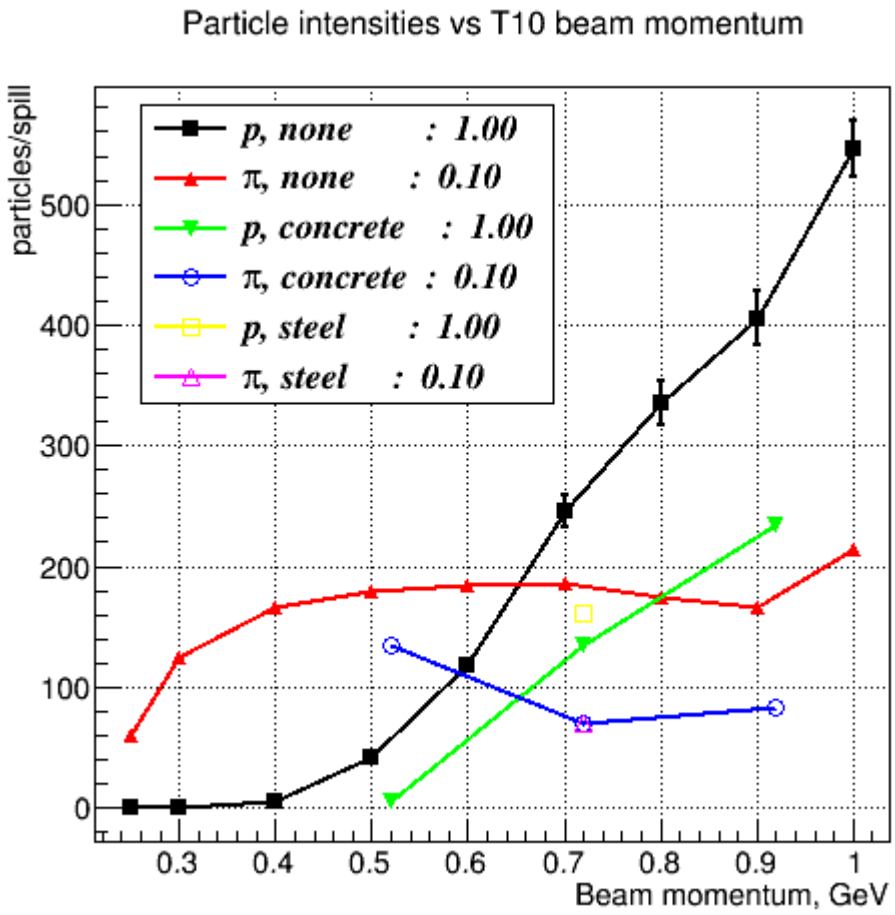


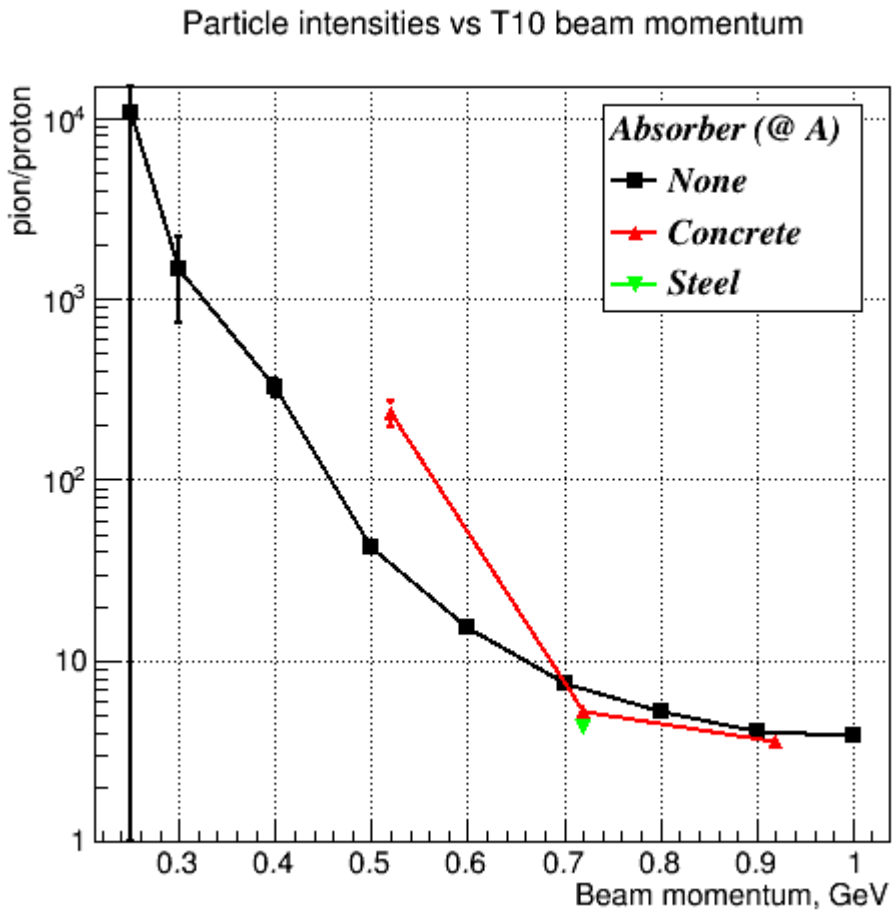


Profile of beam spill: number of particles (Y-axis) delivered vs spill time ~ 0.5 sec (X-axis).

Number of particles per spill vs different runs in time. Factor of 2 has been observed.
It's difficult to give absolute values in "particles per spill" unit.

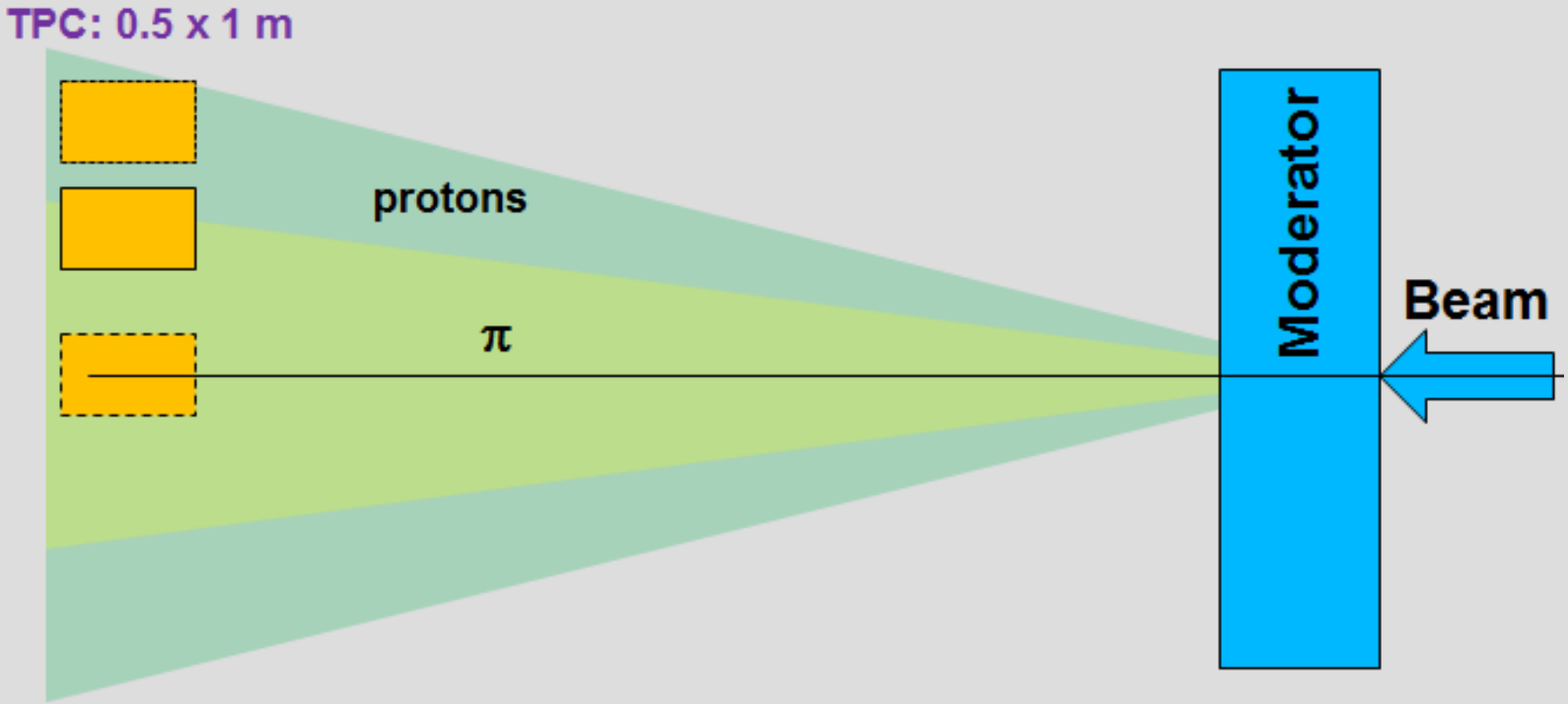
Main Results for ON axis measurement





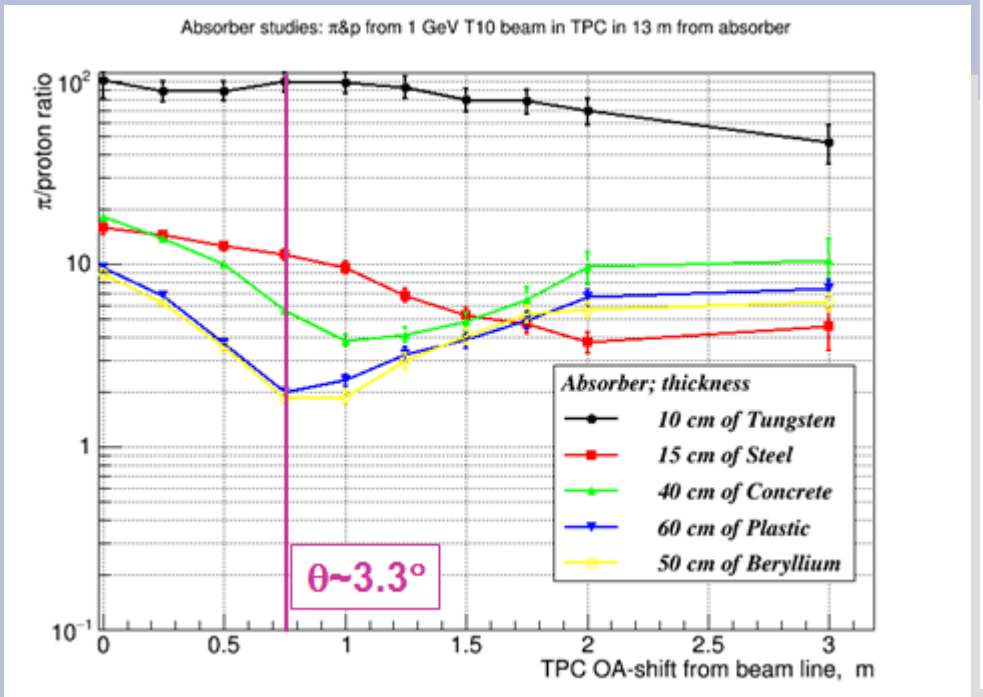
1) **No protons for T10 beam <= 0.4 GeV**
2) **Huge background from pions&muons**
3) **Attempt to use moderator (get smaller energies from higher beam) is not working here.**

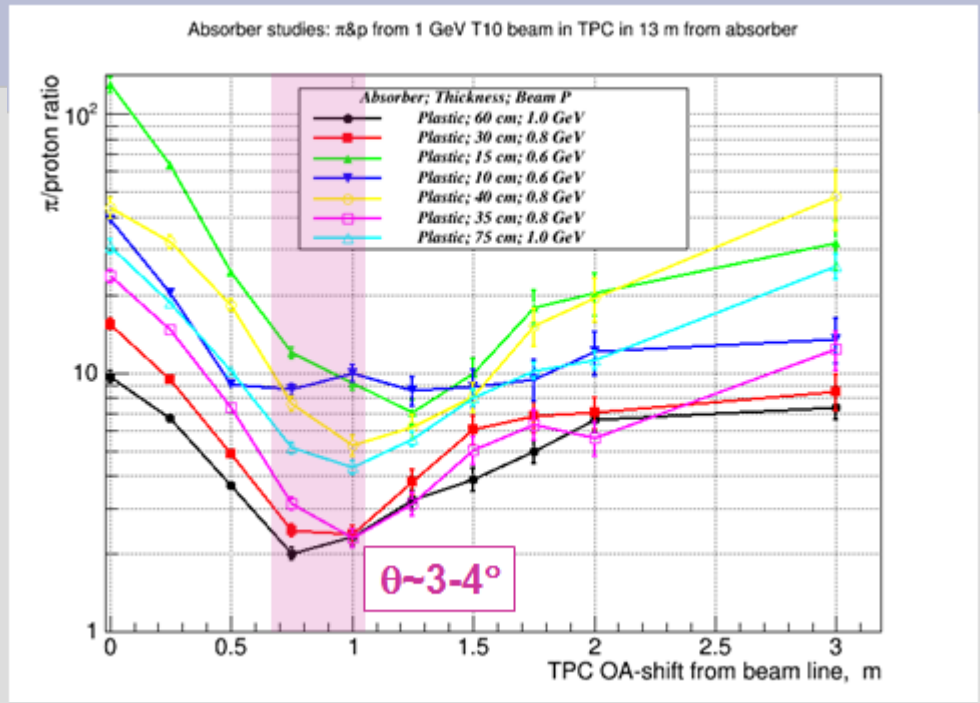
Idea for OFF-AXIS measurement



1) **Once protons are scattering harder on absorber one can try to move TPC off-axis in order to reduce pion background flux.**
2) **G4 simulations have been done in order to check this idea.**

Pions/protons ratios vs OFF-axis shift

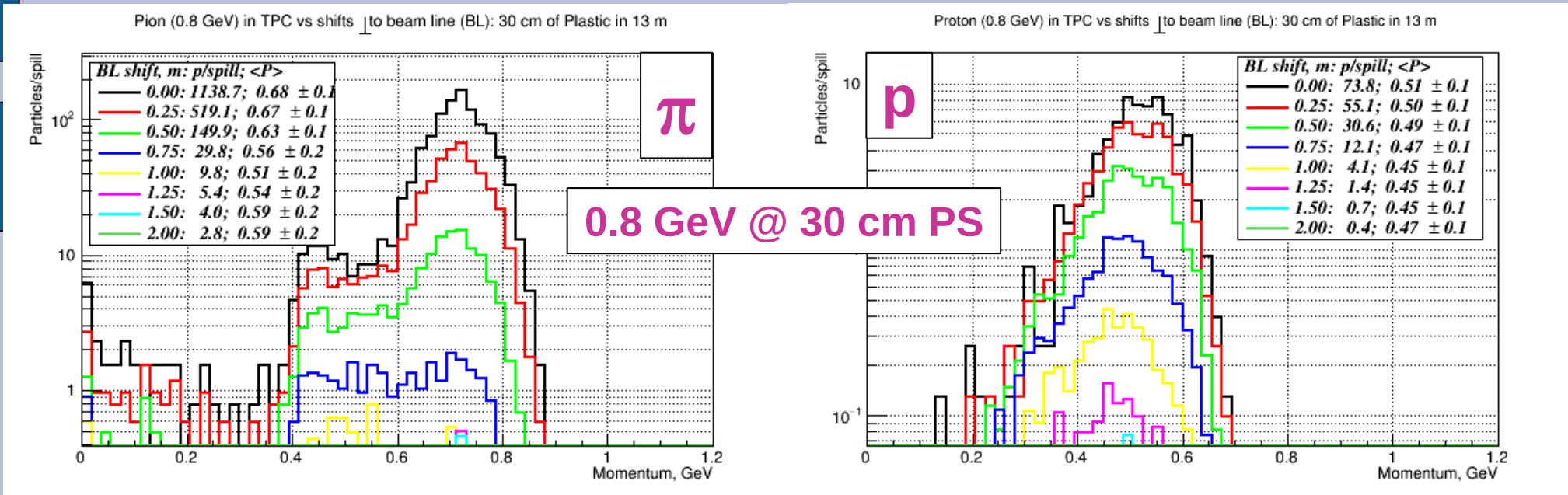




And it works! We really have optimal band at OA ~ 3-4°.
Left figure: comparison of different absorbers at 1 GeV beam
Right figure: different beam energies for plastic absorber.

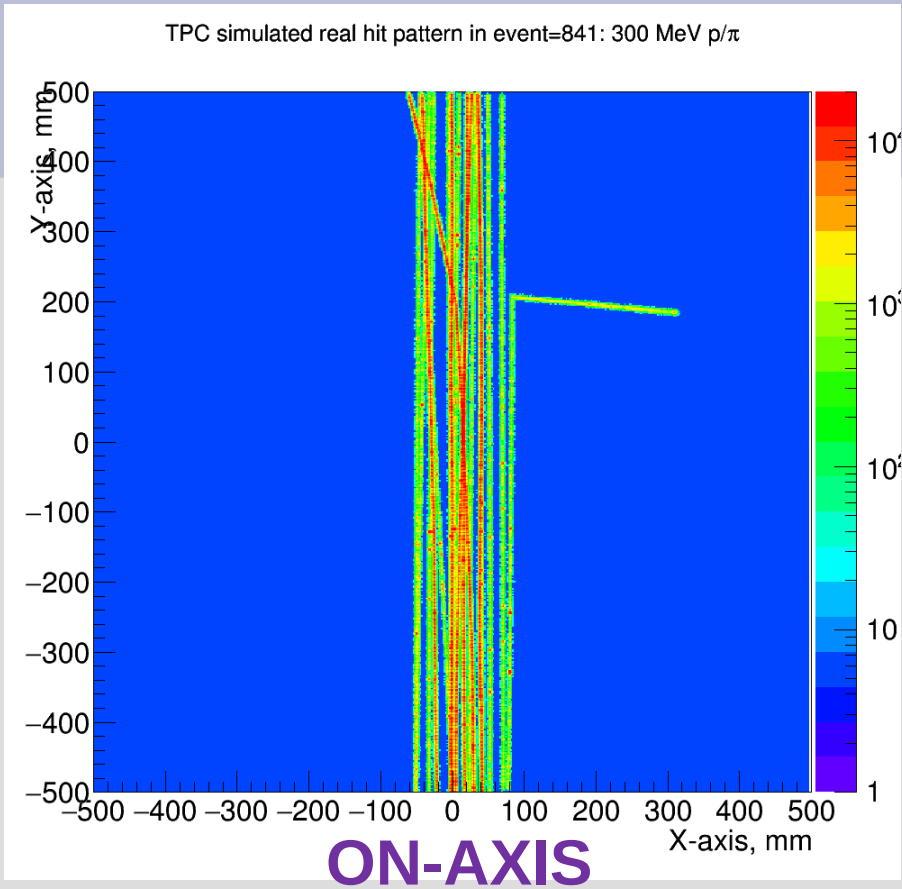
Optimal solution is ~ 35 cm of plastics for 0.8 GeV T10 beam.

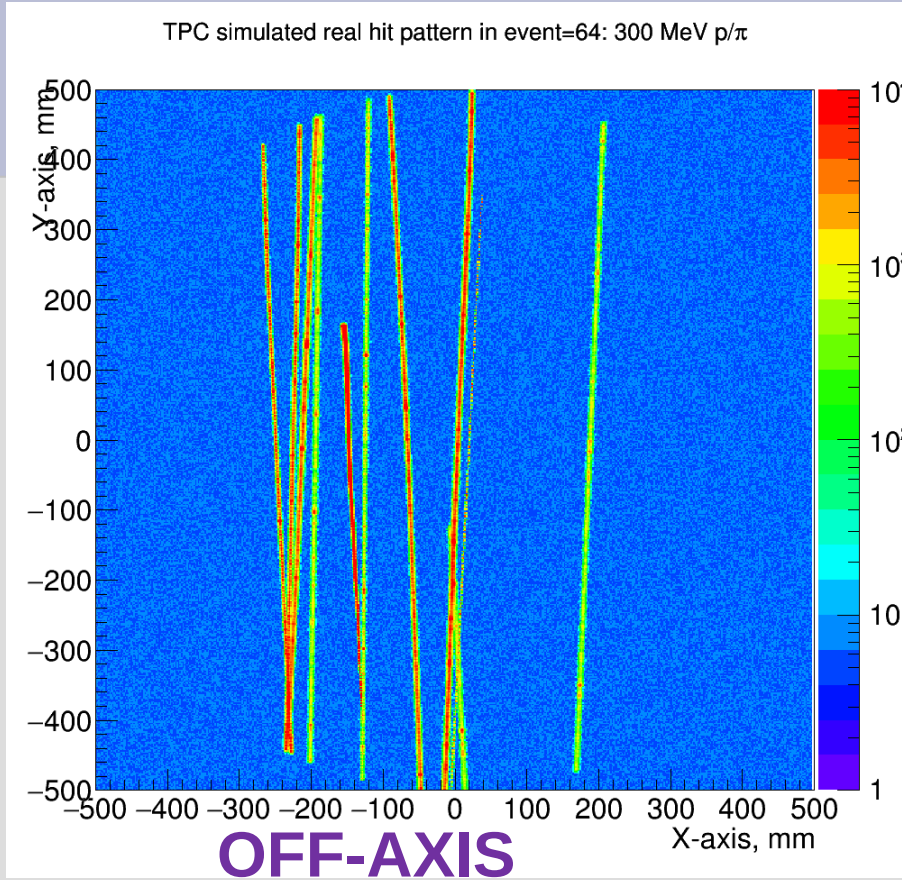
OFF-axis: pions & protons after plastic absorber



Momentum spectra of particles expected in the HP TPC prototype for optimal configuration: T10 0.8 GeV beam + 30 cm of plastic absorber.
Optimal OFF-axis position ~ 3 – yellow line on the figure.

Track multiplicity in the HP TPC





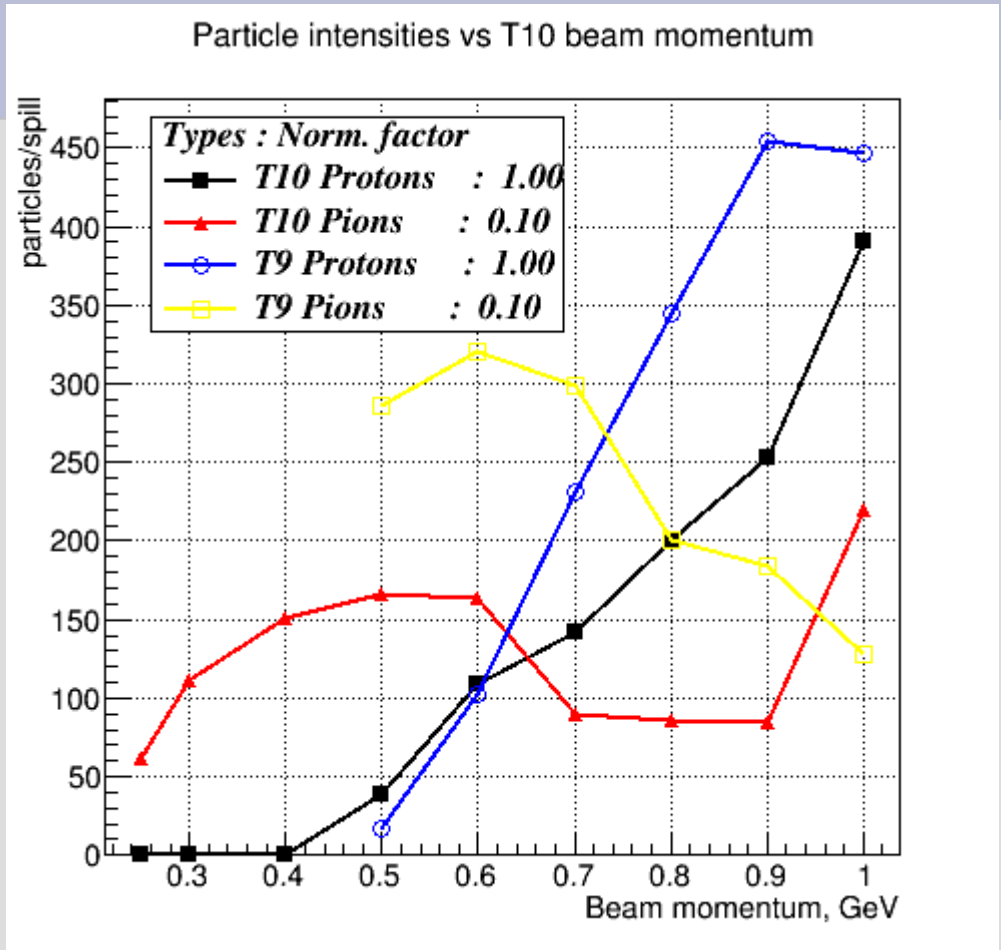
1) **In addition to better pi/p ratio OFF-AXIS tracks (figure on the right) have better spatial spread across the chamber, which is better for track reconstruction.**
2) **The concept of beam entrance window is not working for the OFF-AXIS measurement.**

Conclusion

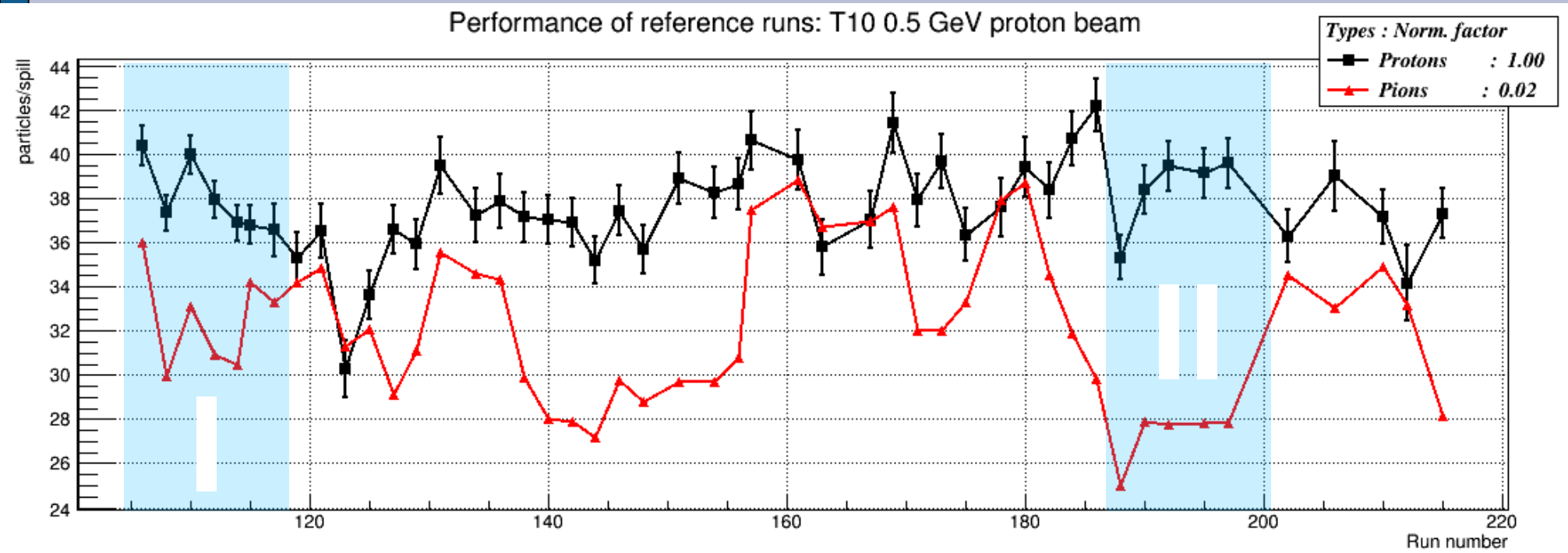
- **CERN beam tests of low proton fluxes have been done.**
- **For on-axis measurements no protons @ beam <= 0.4 GeV and huge (>= 10 pions/p) background.**
- **Off-axis measurement allows to reduce background dramatically by factor of 5 and makes it possible to perform proton xsec measurement in [0.2-0.4] GeV range.**
- **Paper preparation is in progress.**

BACKUP SLIDES

CERN beam tests

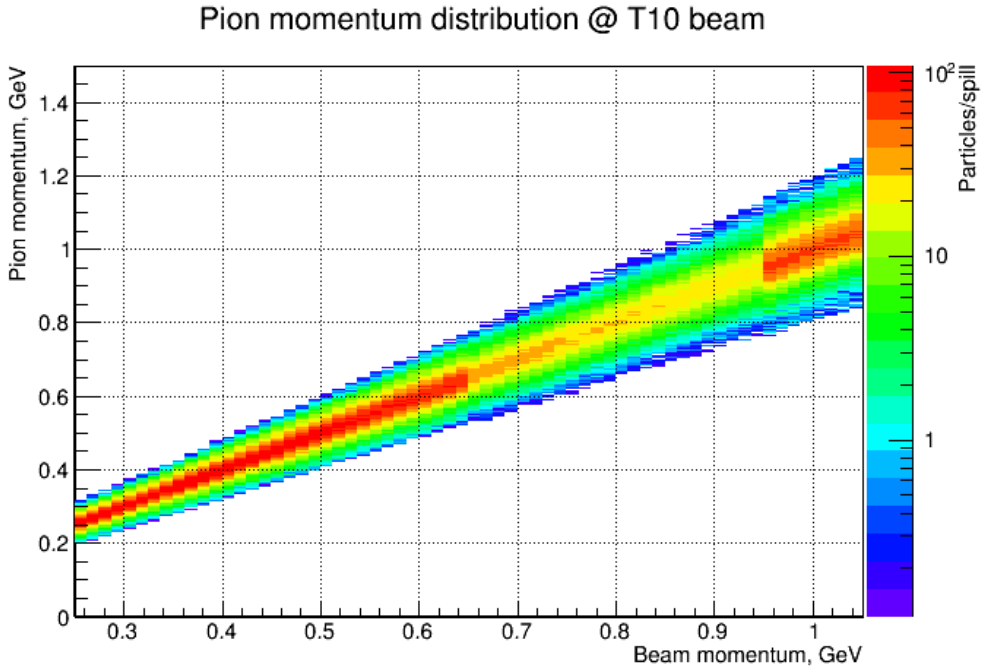


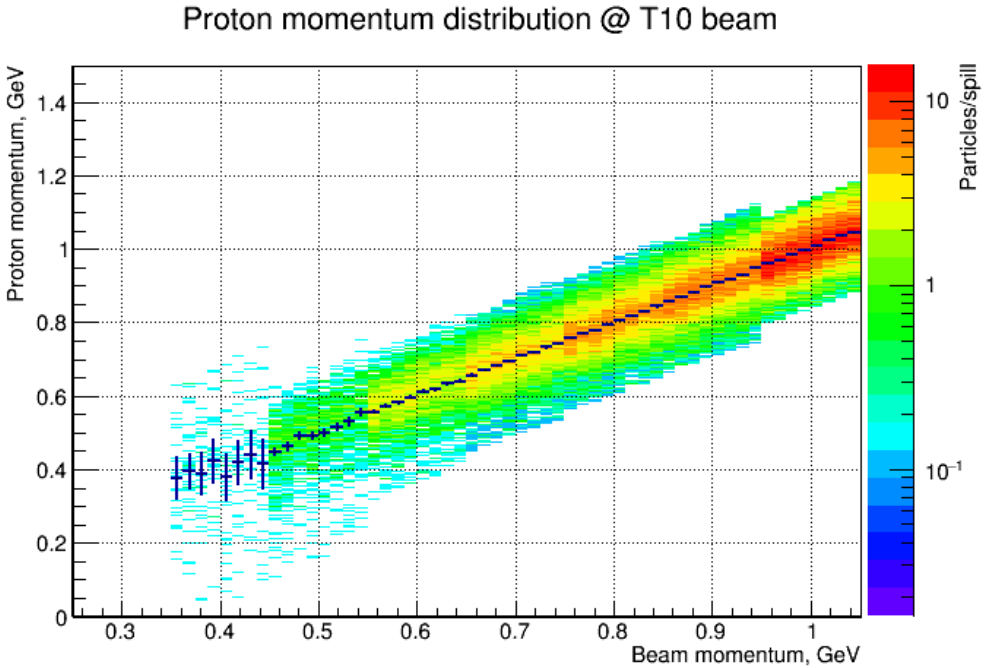
Reference runs: peak intensities



Reference 0.5 GeV runs have been taken before or after each data measurement. They have been used to correct results.

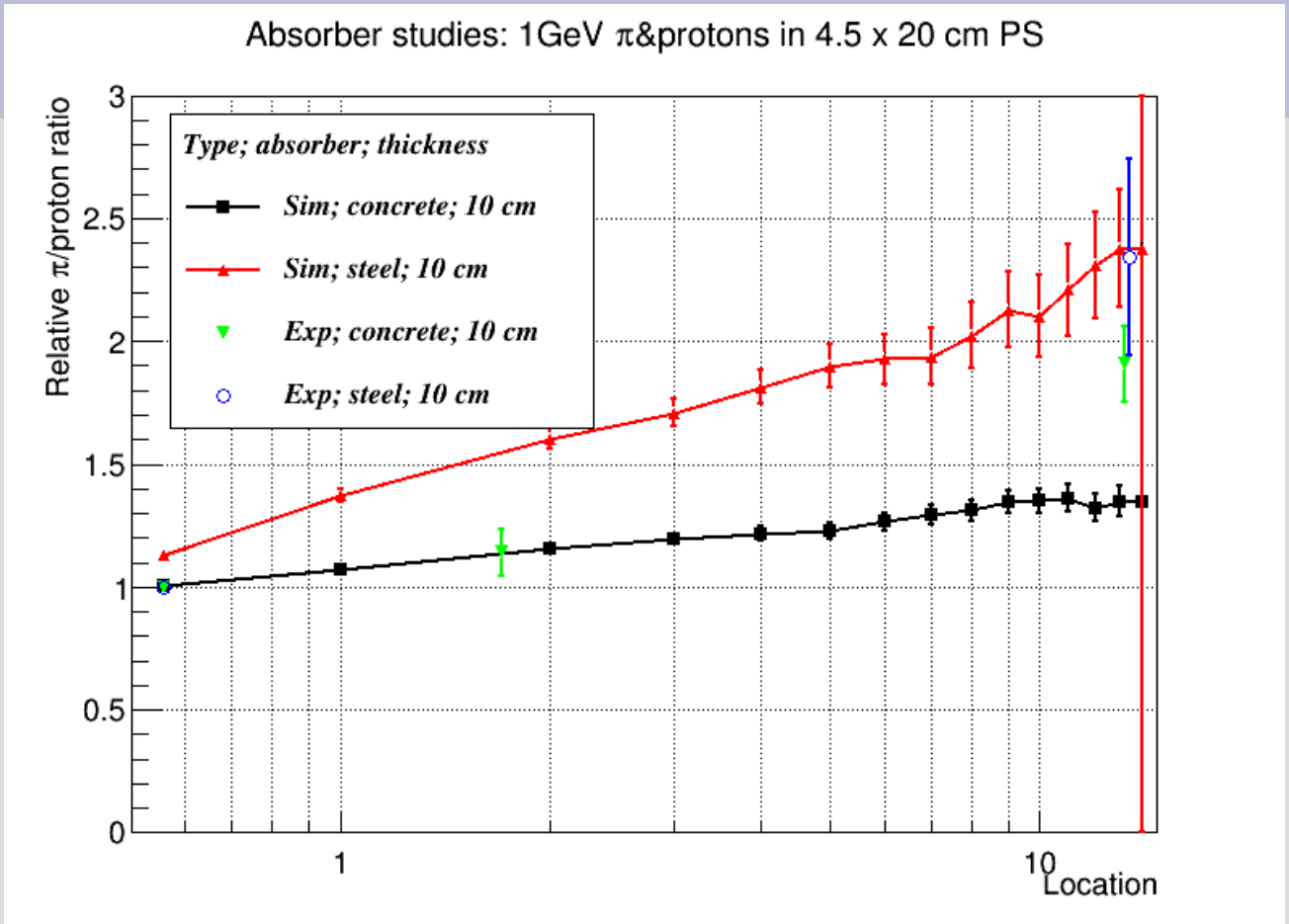
2D momentum distros





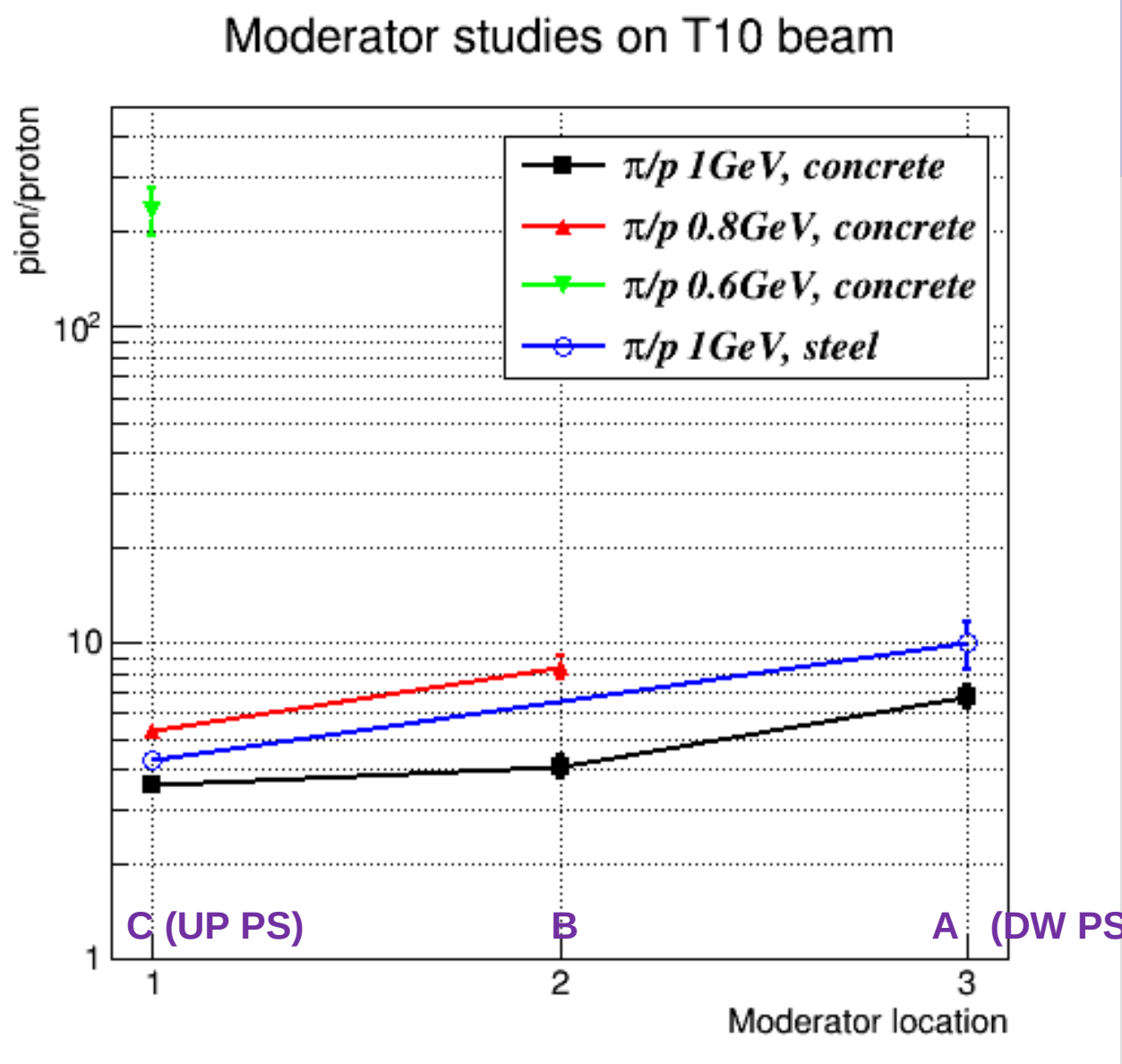
Pion (on the left figure) and proton profiles in momentum vs T10 beam momentum.

Pion/protons after absorbers (10 cm) vs. distance



ON-Axis measurements with absorbers: pi/p ratios vs distance.

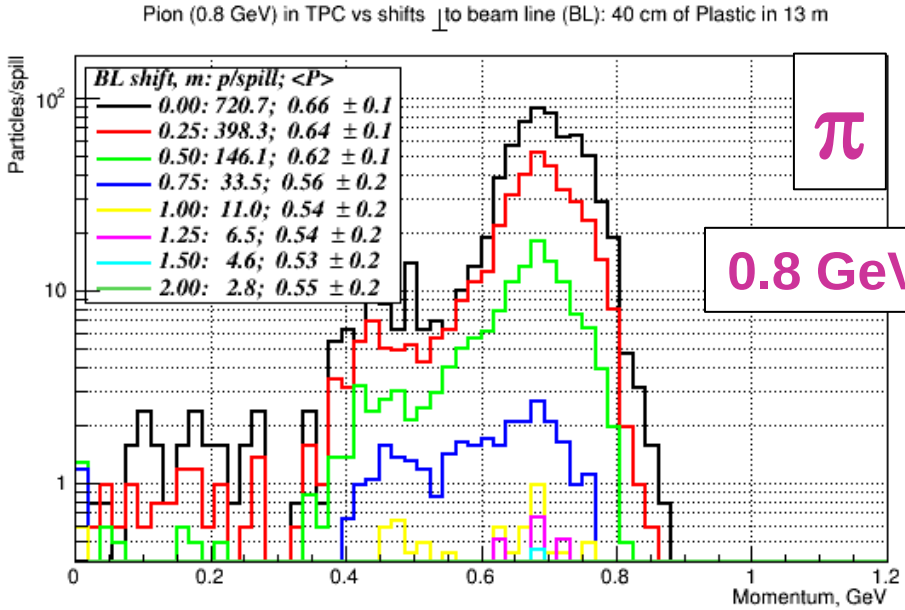
Moderator studies: π/p ratios

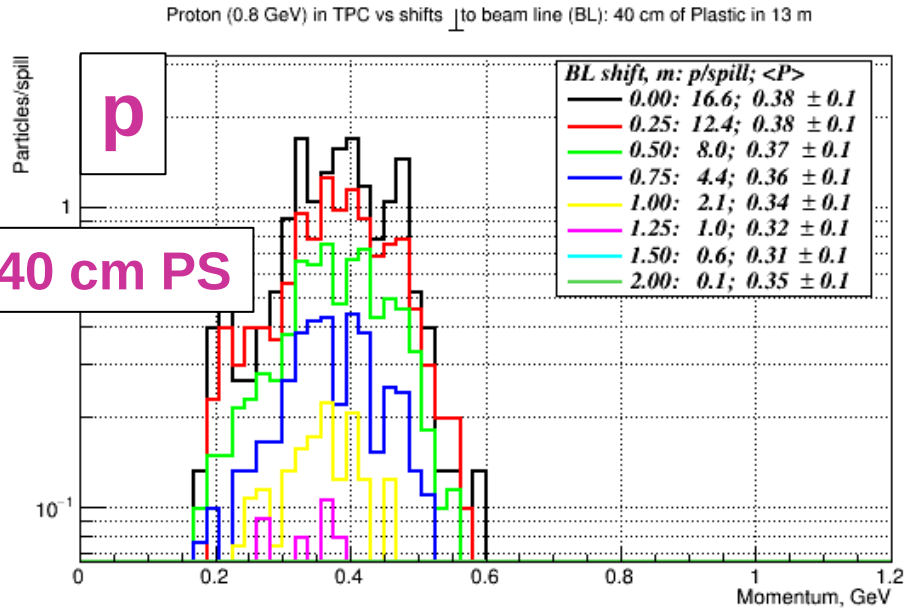


From π/p ratio plot it is clear that

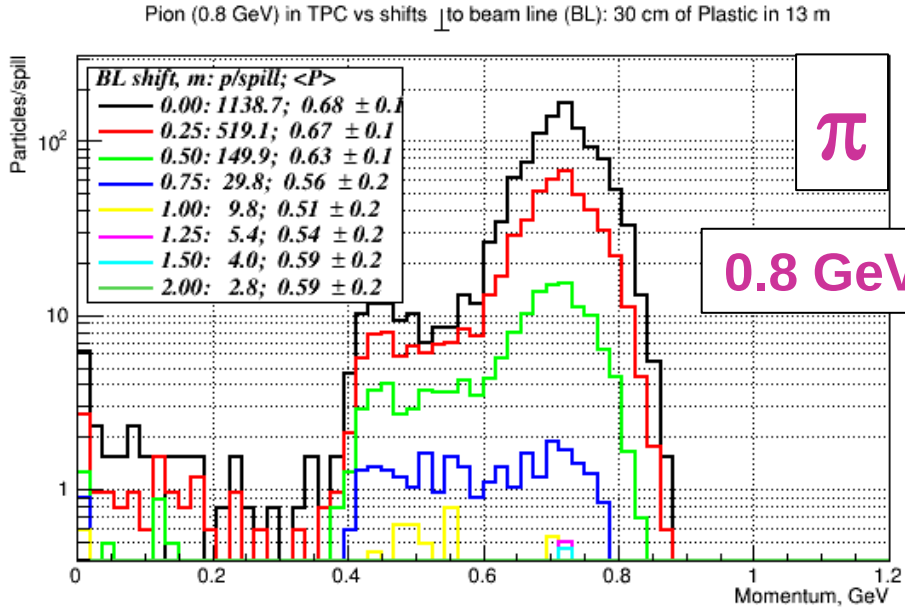
The scattering cone of pions is smaller than the proton's one: the π/p ratio falls down while moderator moves from the target - downstream PS here.

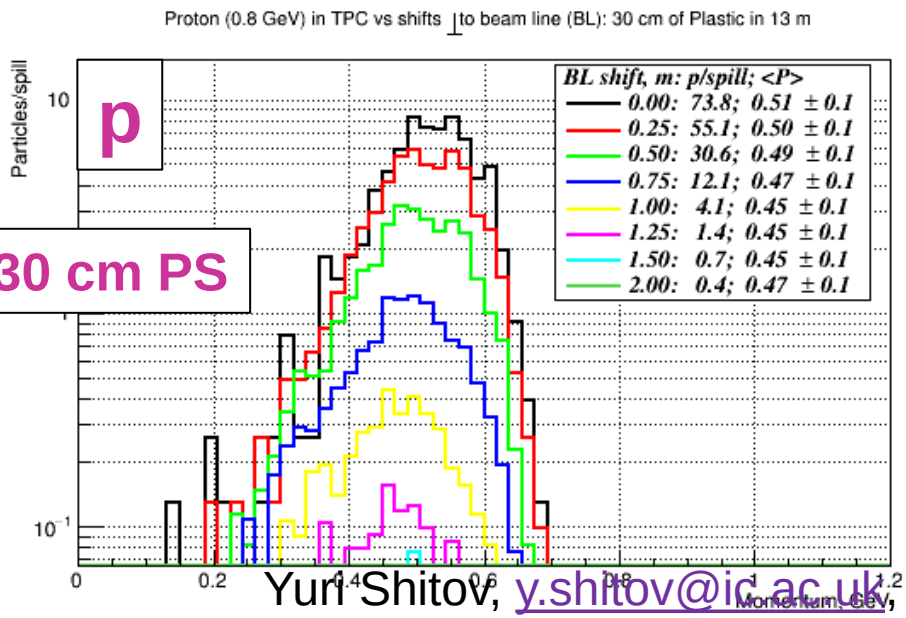
Proton & pions after plastic (PS)





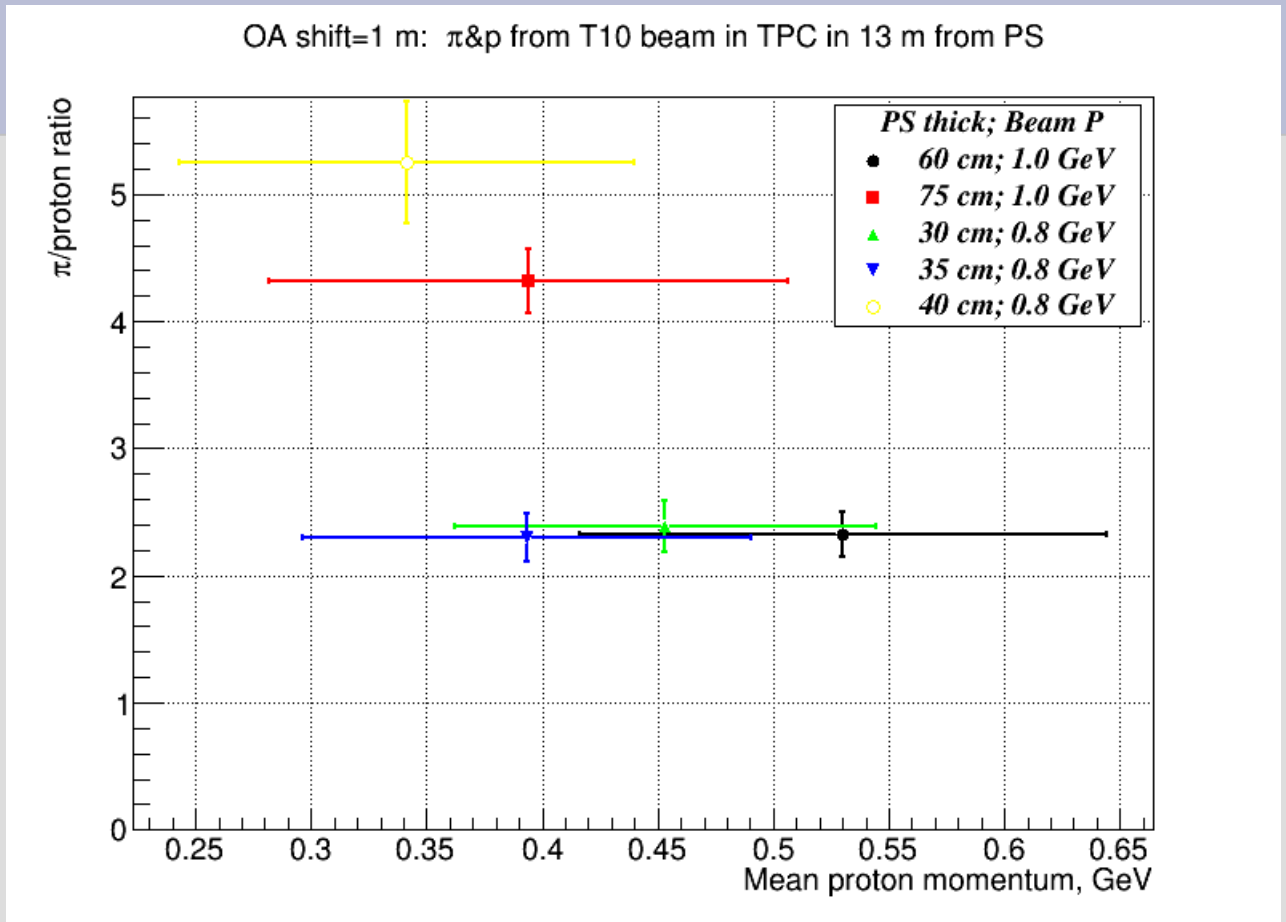
0.8 GeV @ 40 cm PS





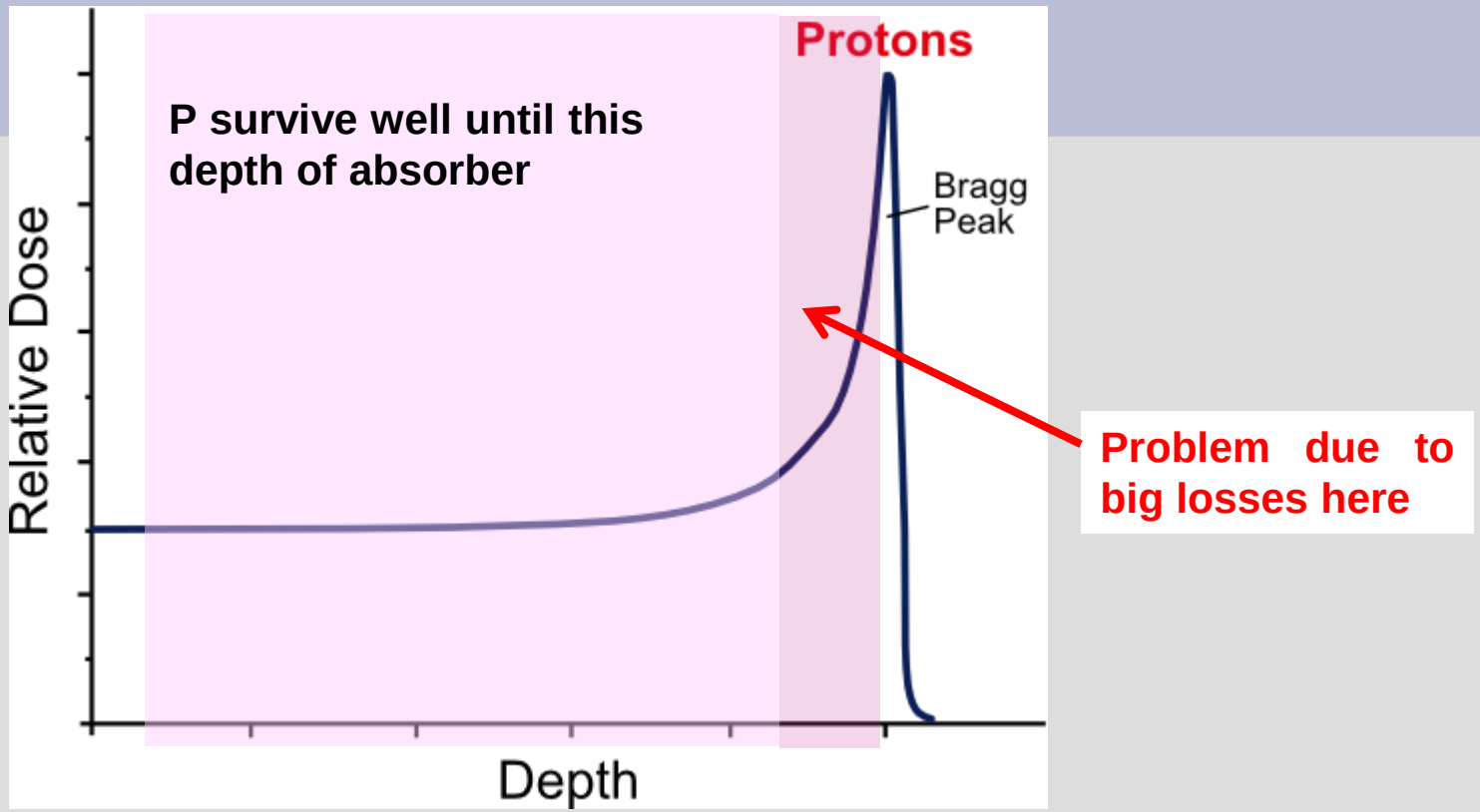
0.8 GeV @ 30 cm PS

Pi/p ratio after PS



This gap is more visible here – small increase in absorber thickness gives essential drop of proton flux

Proton Bragg peak effect



Effect observed is related to proton Bragg peak. Protons are surviving well until certain distance and once reaching Bragg peak area they stop quickly. At this boundary even small increase of absorber leads to big losses. This is why proton therapy works!