US-NA61

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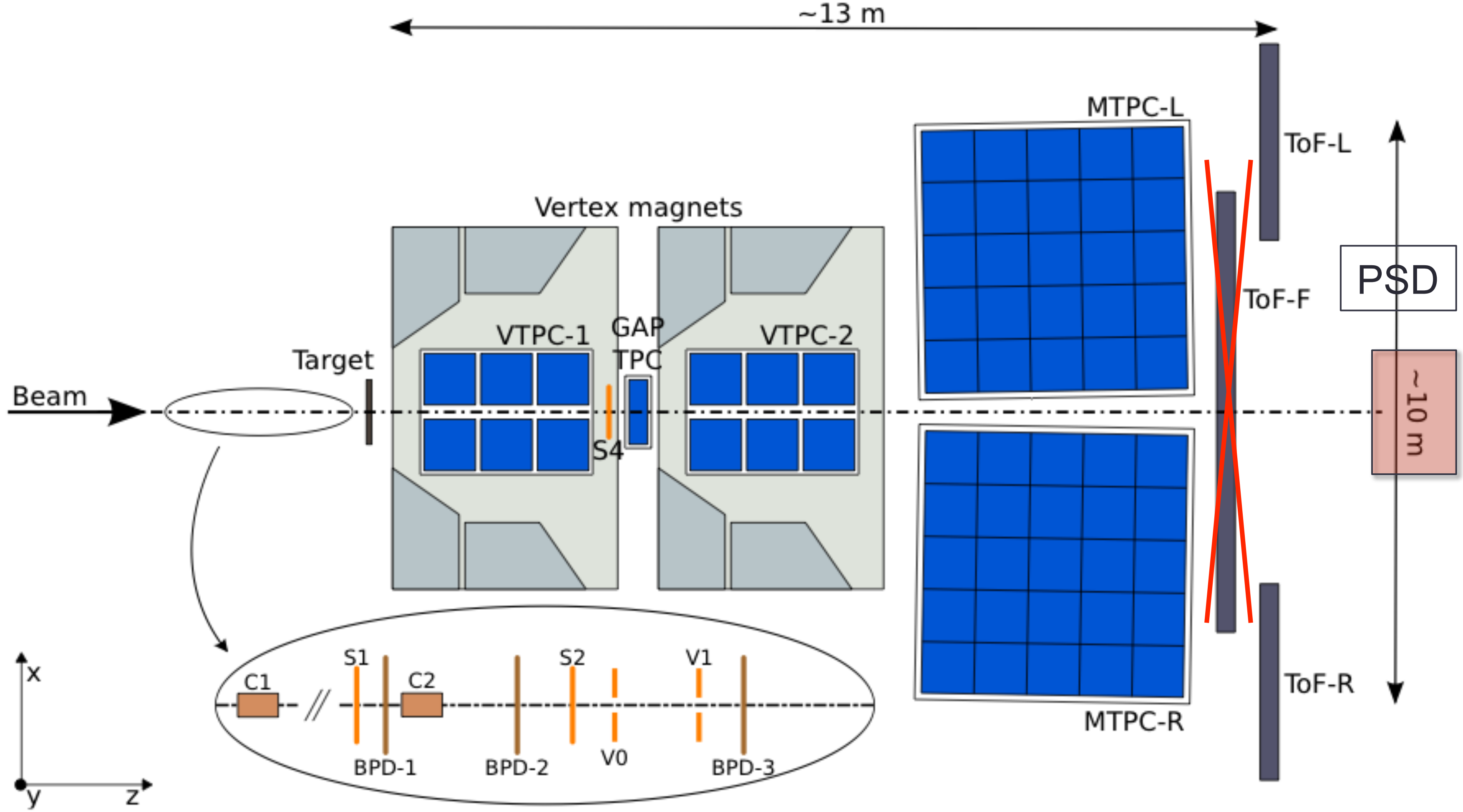
Motivations

- **NA61** is a large acceptance hadron spectrometer built at the North Area at CERN on the H2 beamline of the Super Proton Syncrotron accelerator.
- We started a **temporary** (4-5 years) **collaboration** (**US-NA61**) with the NA61 people in order to measure the secondary hadron production spectra in the kinematical region of interest to ongoing and future neutrino experiments at Fermilab.
- Precision **calculations of neutrino fluxes** in high energy accelerator beams are presently **limited by insufficiently detailed knowledge of hadron production** cross-sections in proton-nucleus collisions.

Goal and timeline

- The measurement campaign will provide **particle production yields that could be directly applied in beam simulations**.
- A **Letter Of Intent** has been written and sent to the DOE in May
- Two short **pilot runs** took place in June and July **2012**
- **No beam** is expected in **2013**
- Other runs with different targets will follow the first one

NA61 spectrometer



NA61 particle ID

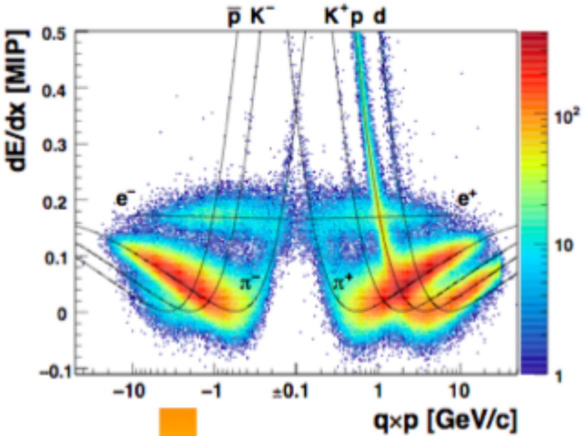
- How do we identify particles in NA61/SHINE ?

TPCs: energy loss measurement

TOFs: time of flight → m^2

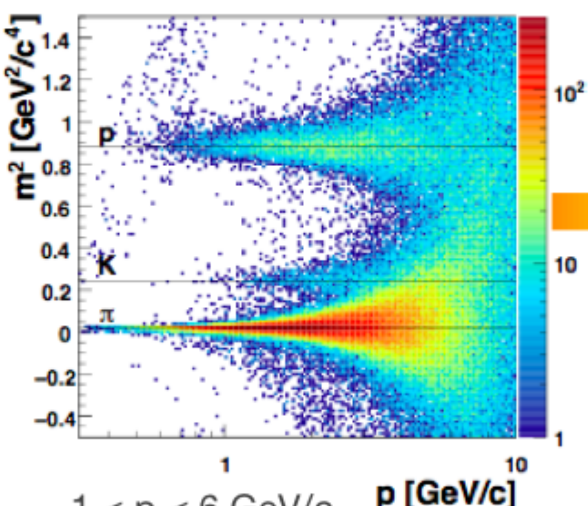
Combined measurement of ToF & dEdx

powerful PID over large momentum range

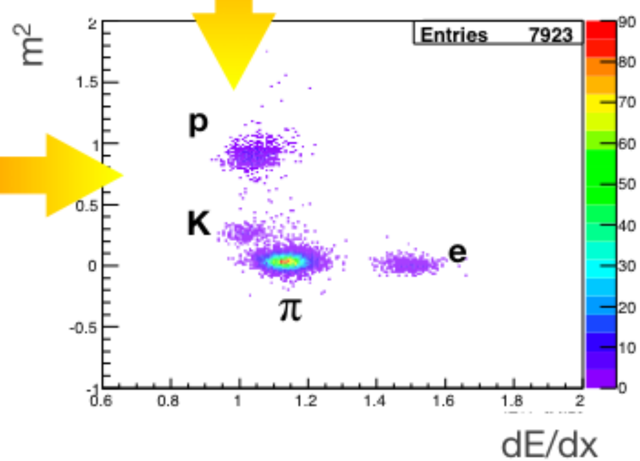


$p < 1$ GeV/c

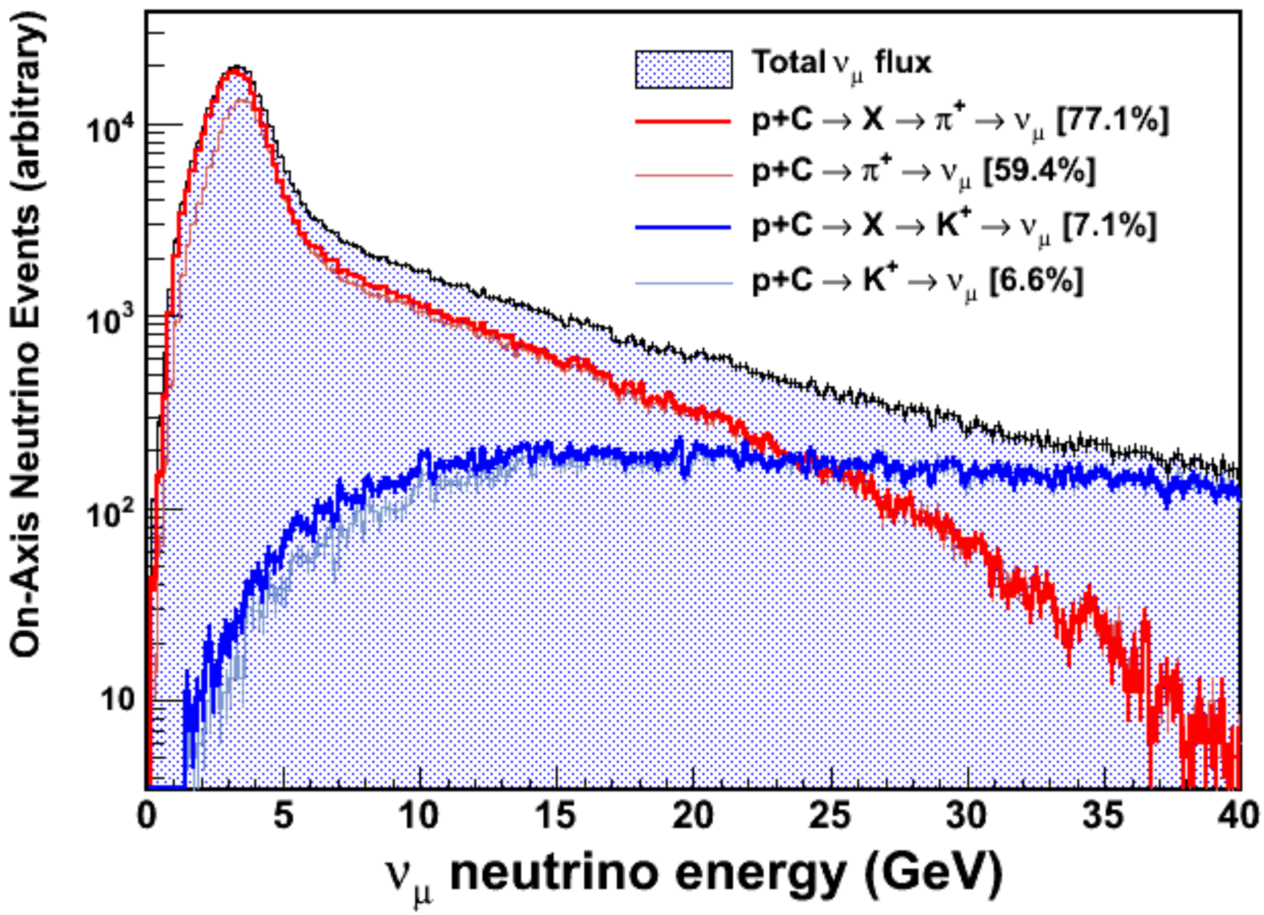
$p > 3$ GeV/c



1 < p < 6 GeV/c



What particles are we interested in?

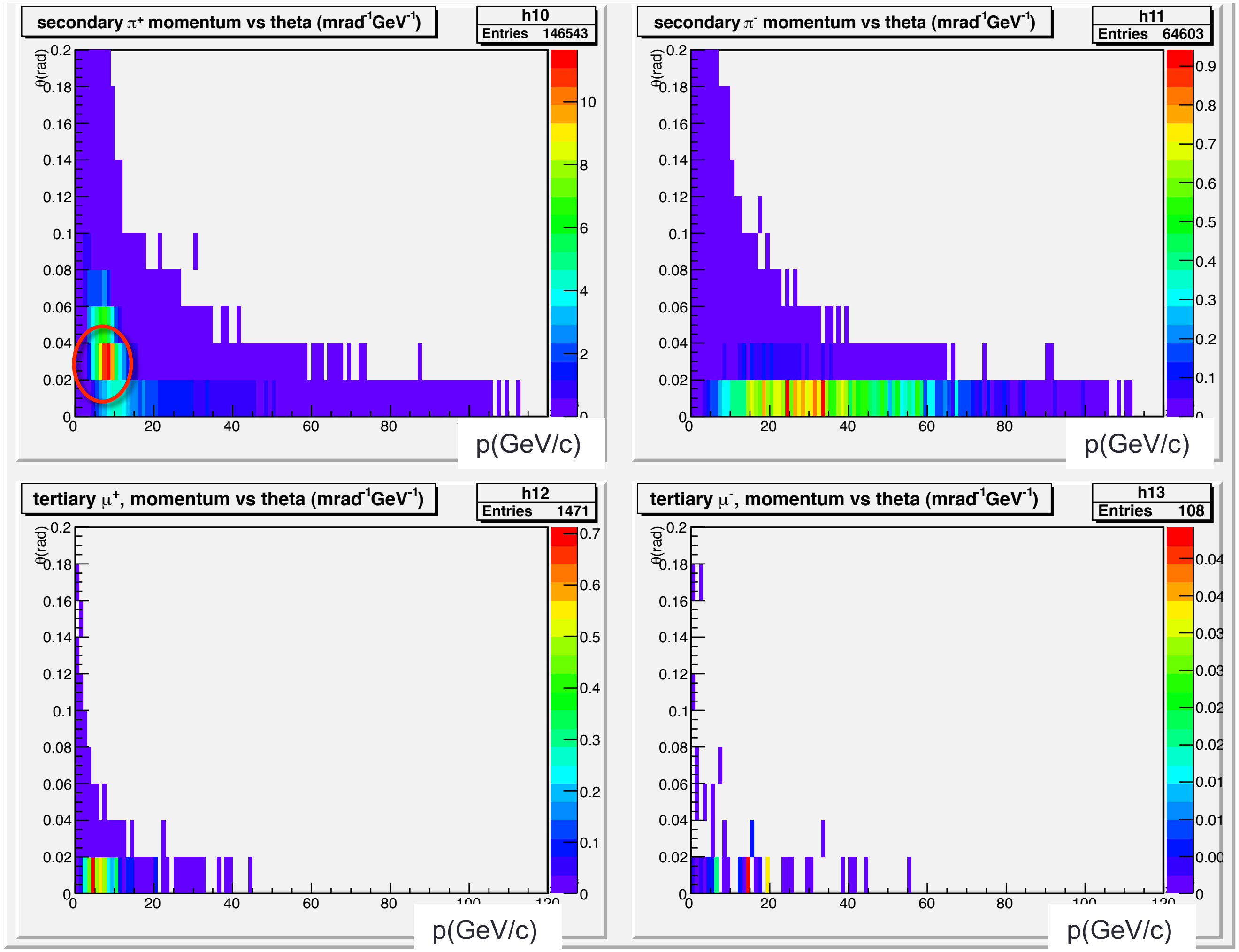


NuMI flux

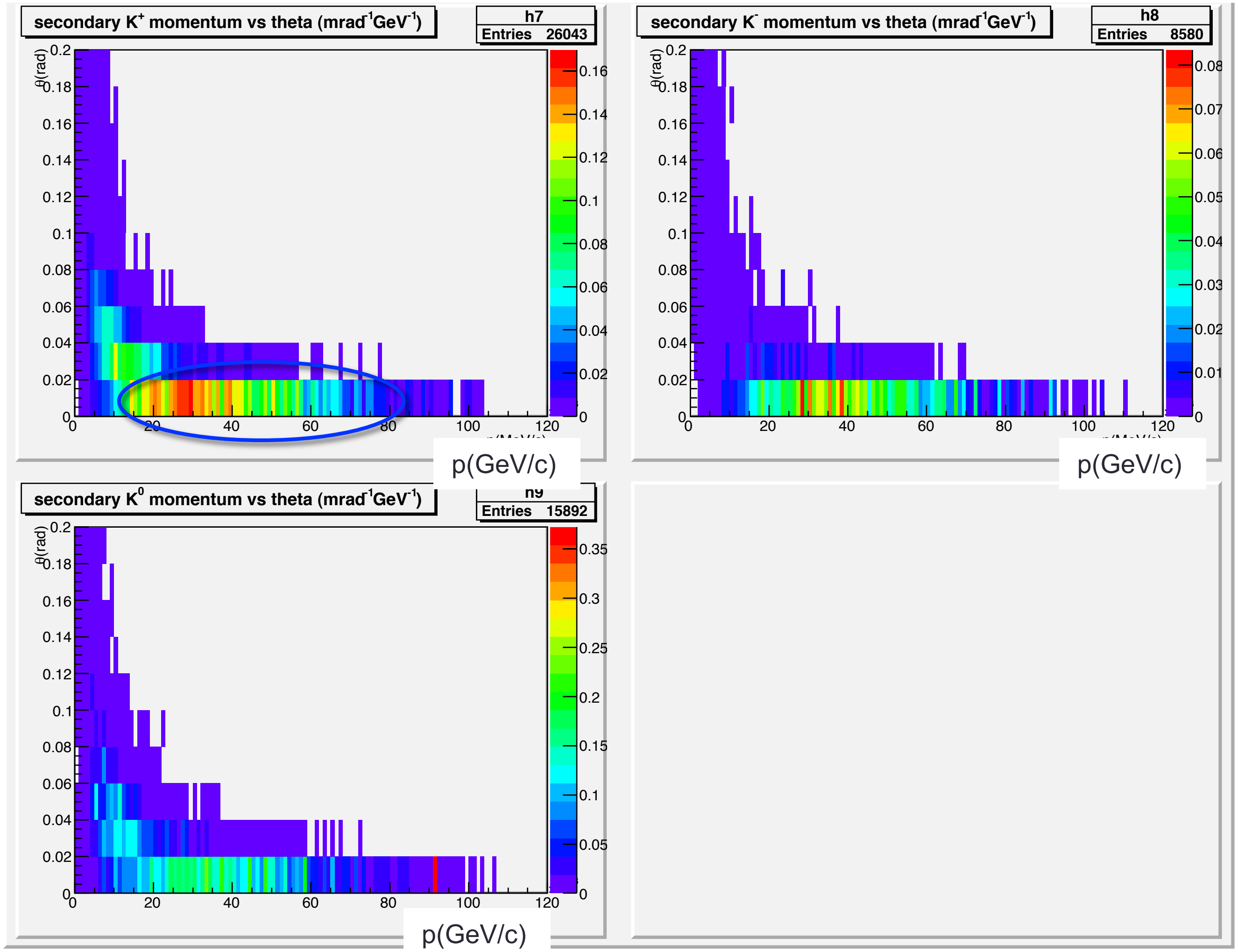
What is the interesting phase space?

- In a thin (4% nuclear interaction length) target at NA61 we will only measure secondary particles (i.e. produced in the interactions of primary protons in the target)
  - What is the phase space of the secondary particles at NuMI responsible for generating neutrinos in our detectors?
  - This is what we'll need to focus on in our measurement
  - I used Minerva beam ntuples to answer this question

Secondary particle phase space



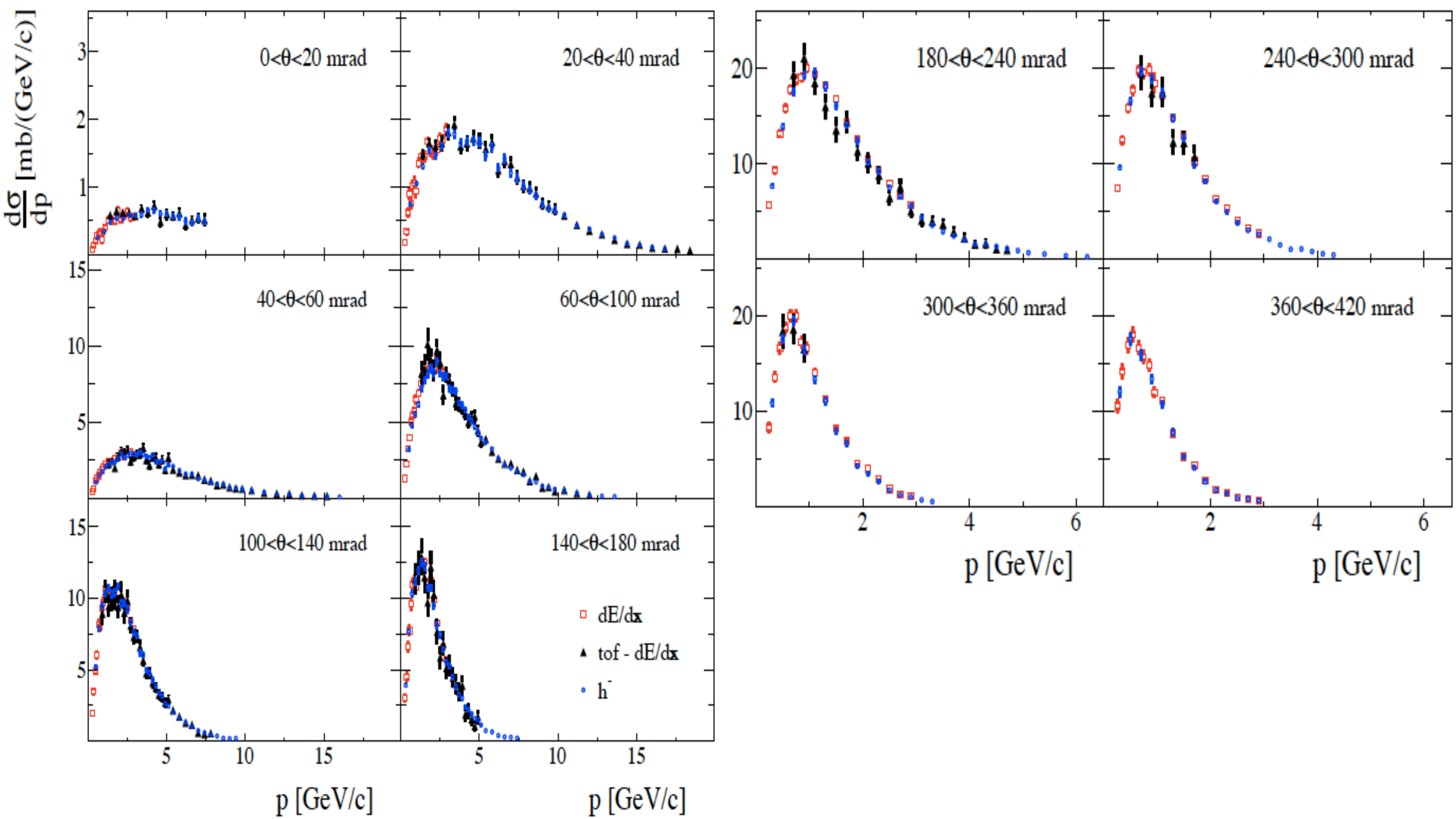
Secondary particle phase space



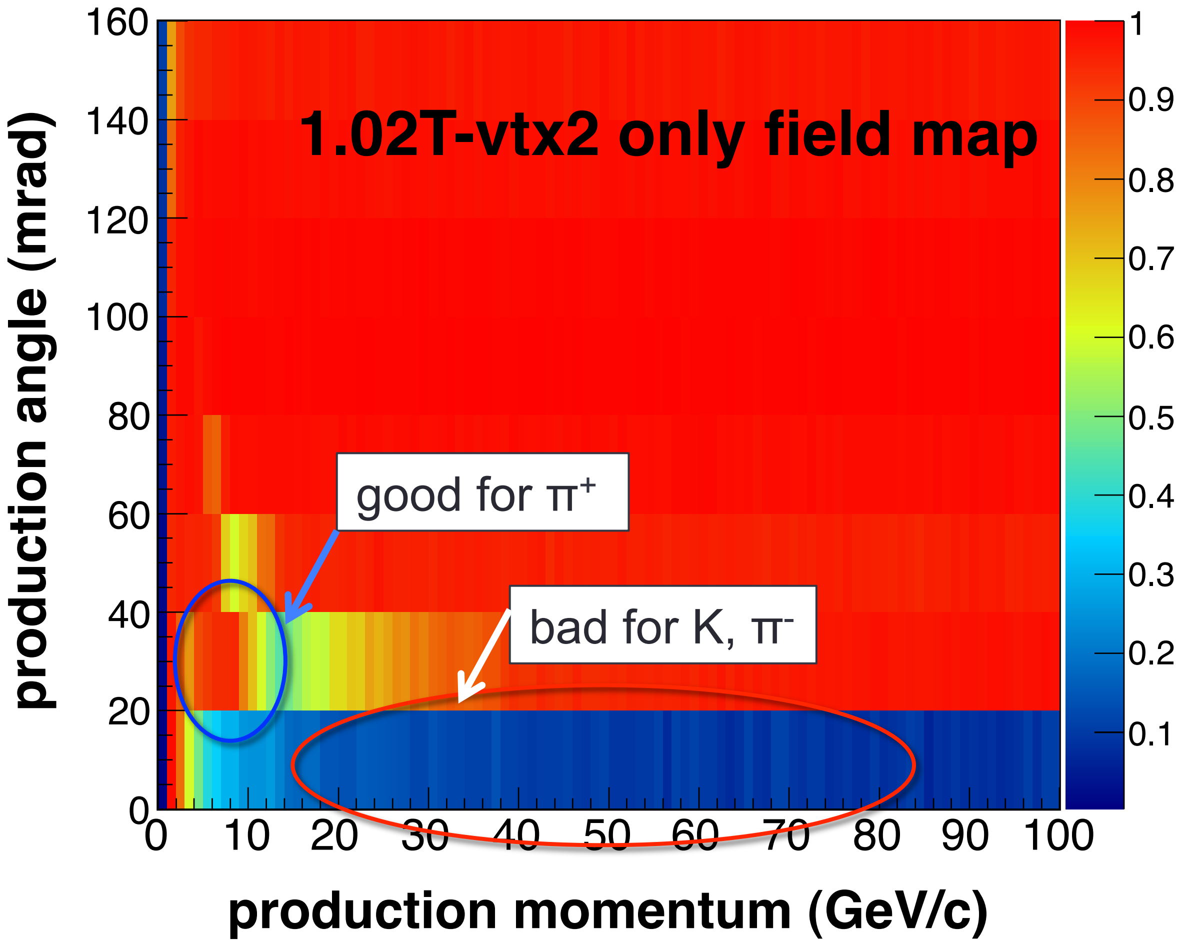
June/July pilot runs: p-C @ 120 GeV

- Thin C target (4% λ), p @ 120 GeV
- **<u>June Run</u>**
  - Detector configuration:
    - no forward ToF (expected)
    - No magnetic field (unexpected, due to unforeseen problems with the magnets cooling system during the startup of the detector after ~ 1 year of inactivity)
    - collected ~435000 triggers
- **<u>July Run</u>**
    - A problem occurred with the vtx1 magnet after which it needed to be shut down
    - We took 4 days of data with only 1 magnet at a reduced magnetic field
    - Collected ~3.5 M triggers with a reduced magnetic field

NA61 31 GeV π^- data



What is the acceptance for that magnetic field configuration?



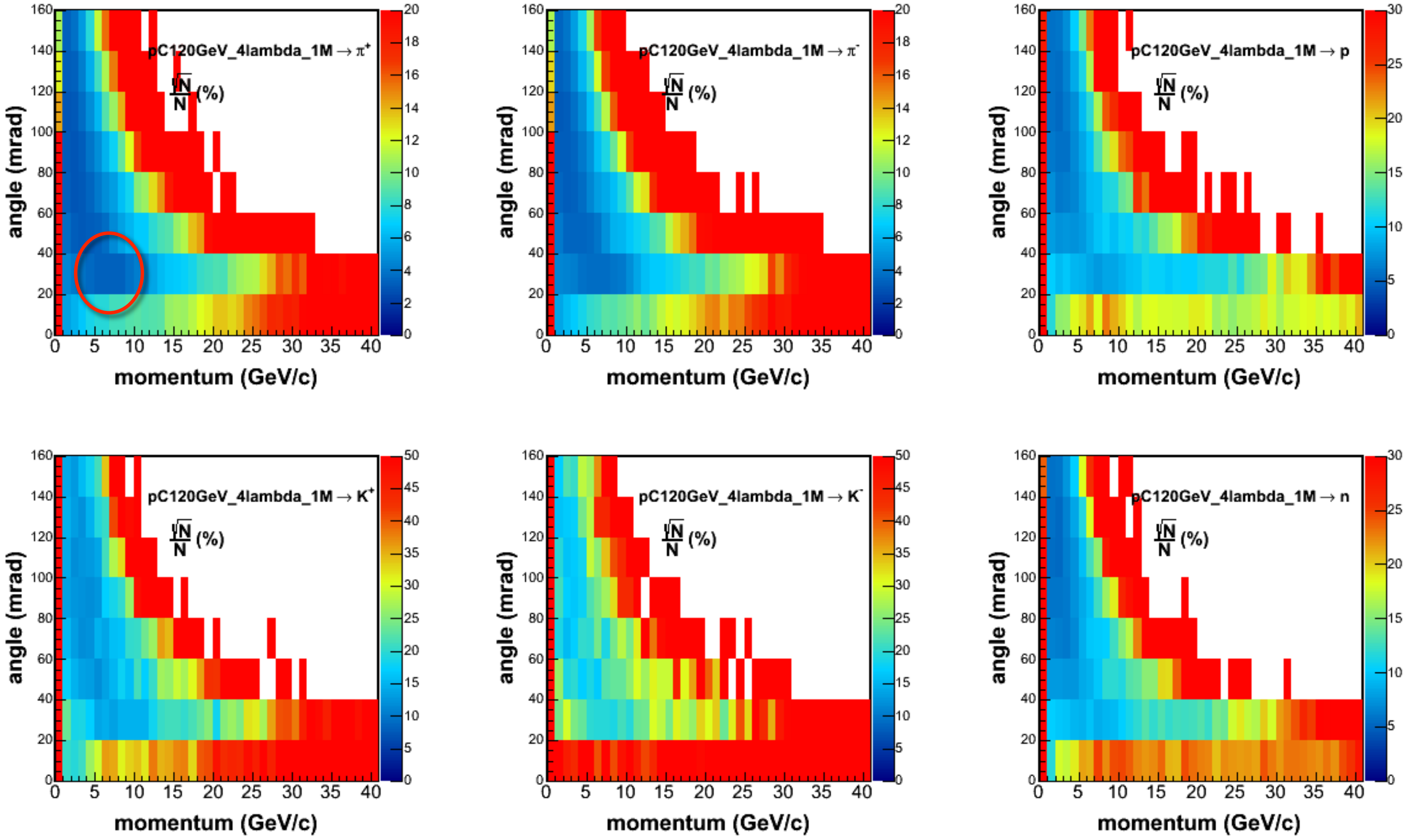
What is the statistical power of our data?

- 3.5 M triggers recorded in a 1.02 T magnetic field
- We will need to apply some cuts to (partially) get rid of out of target interactions
  - For 31 GeV protons on target this cut reduced the data sample by a factor of ~ 0.78
- We will then need to apply other cuts to select good particle tracks
  - For 31 GeV protons on target this cuts reduced the data sample by another 87 %
- We can calculate the number of events (θ,p) we expect to survive the cuts
- $N(\theta,p) = N_{rawpC}(\theta,p)$ x NA61acceptance x selection cuts

MC   NA61 MC   previous analysis

- We then can calculate the (binning dependent) statistical error (θ,p) as $N(\theta,p)/\sqrt{N(\theta,p)}$

Statistical error for 3.5 M triggers



Calibration and reconstruction – ongoing efforts

- The calibration and reconstruction of the raw data is performed by the NA61 collaboration
  - it is in general an iterative process which takes 2-3 years to complete
- Our data were taken in a new magnetic field configuration for which there is no B field map available (the existing field maps were measured when the TPCs hadn't been built yet)

➢ In order to start processing our data we need the correct field map

  - G. Mills, W. Sondheim and J. Bossevain are working on this at LANL

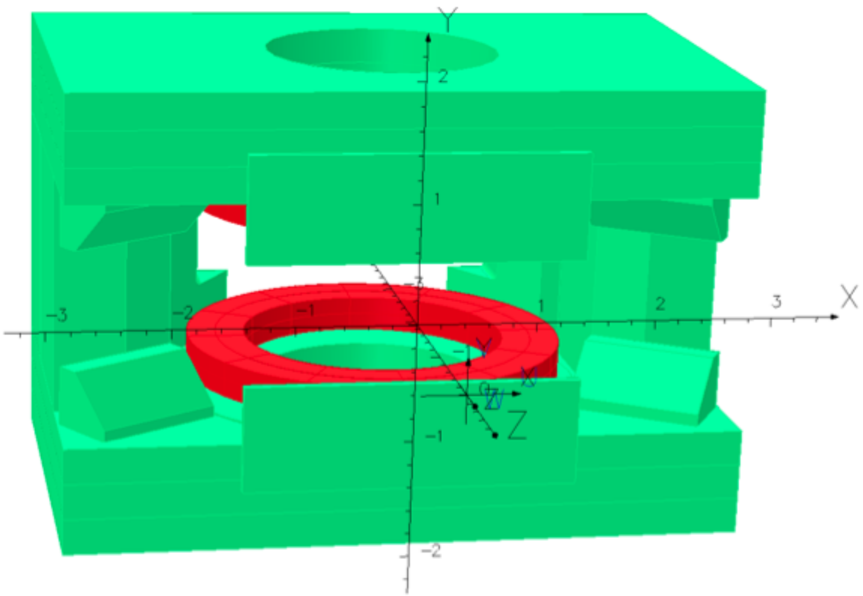
K. Yarritu, S. Johnson and myself are working to speed up the calibration process

B field map calculation (Geoff, Jan, Walt)

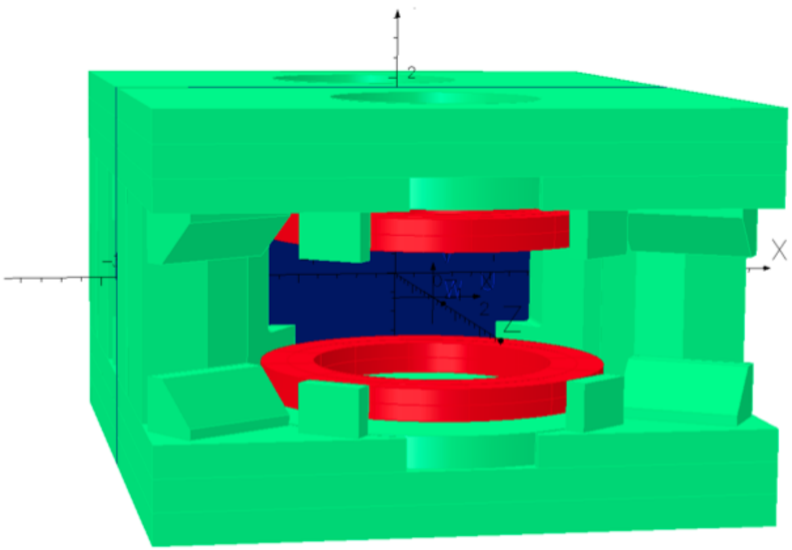
- Generate 3D model of magnet
  - Gather old drawings and photos
  - Jan Bossevain constructed the various components in UniGraphics CAD software
- Input model to Opera front end software
  - Add UG model (W. Sondheim)
  - Use B vs H curves from original calculation files
  - Estimate current density in coil from total current and conductor cross sectional area
- Run TOSCA on resulting model

Magnetic field map

VTX1 with plates;

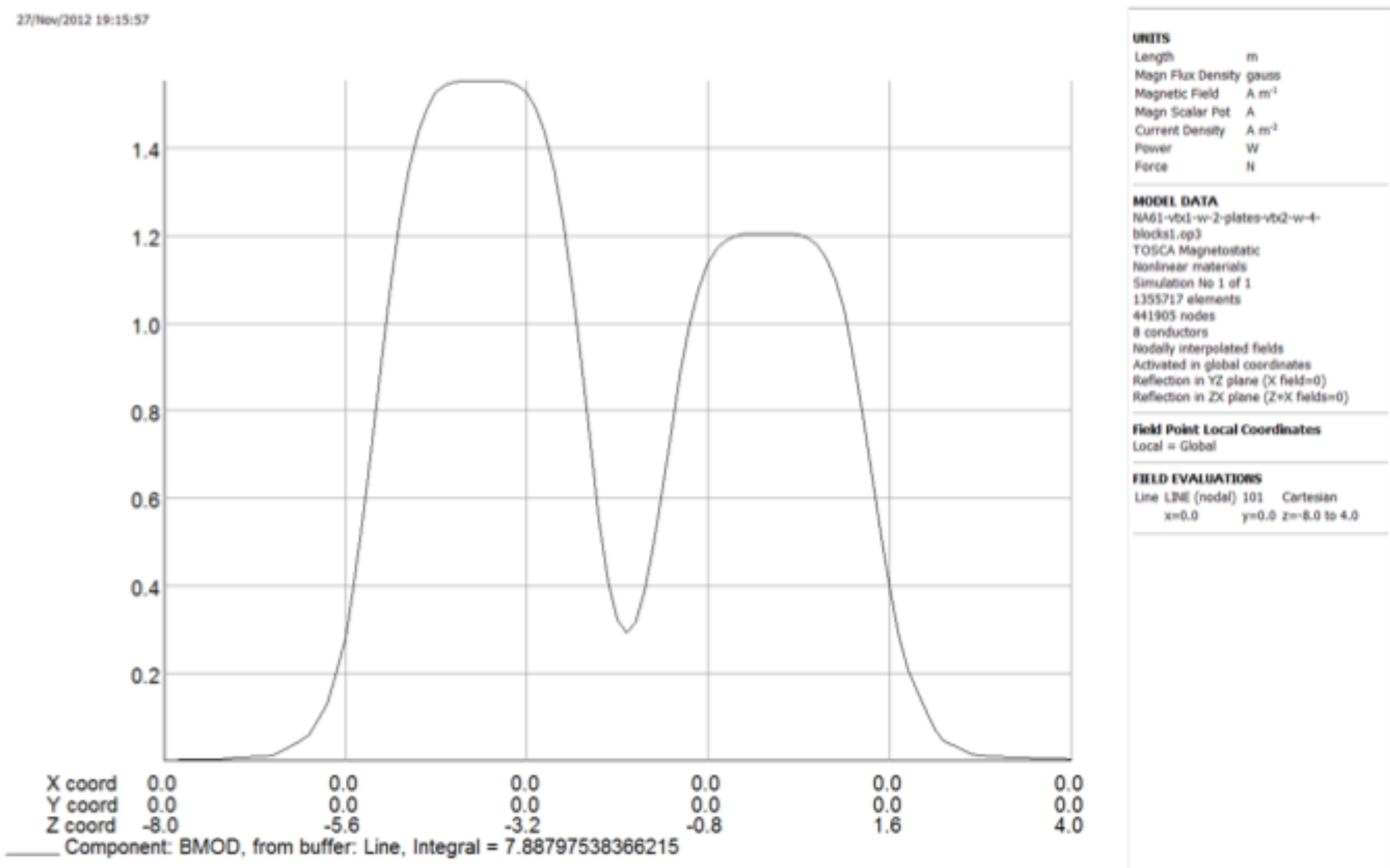


VTX2 with blocks;

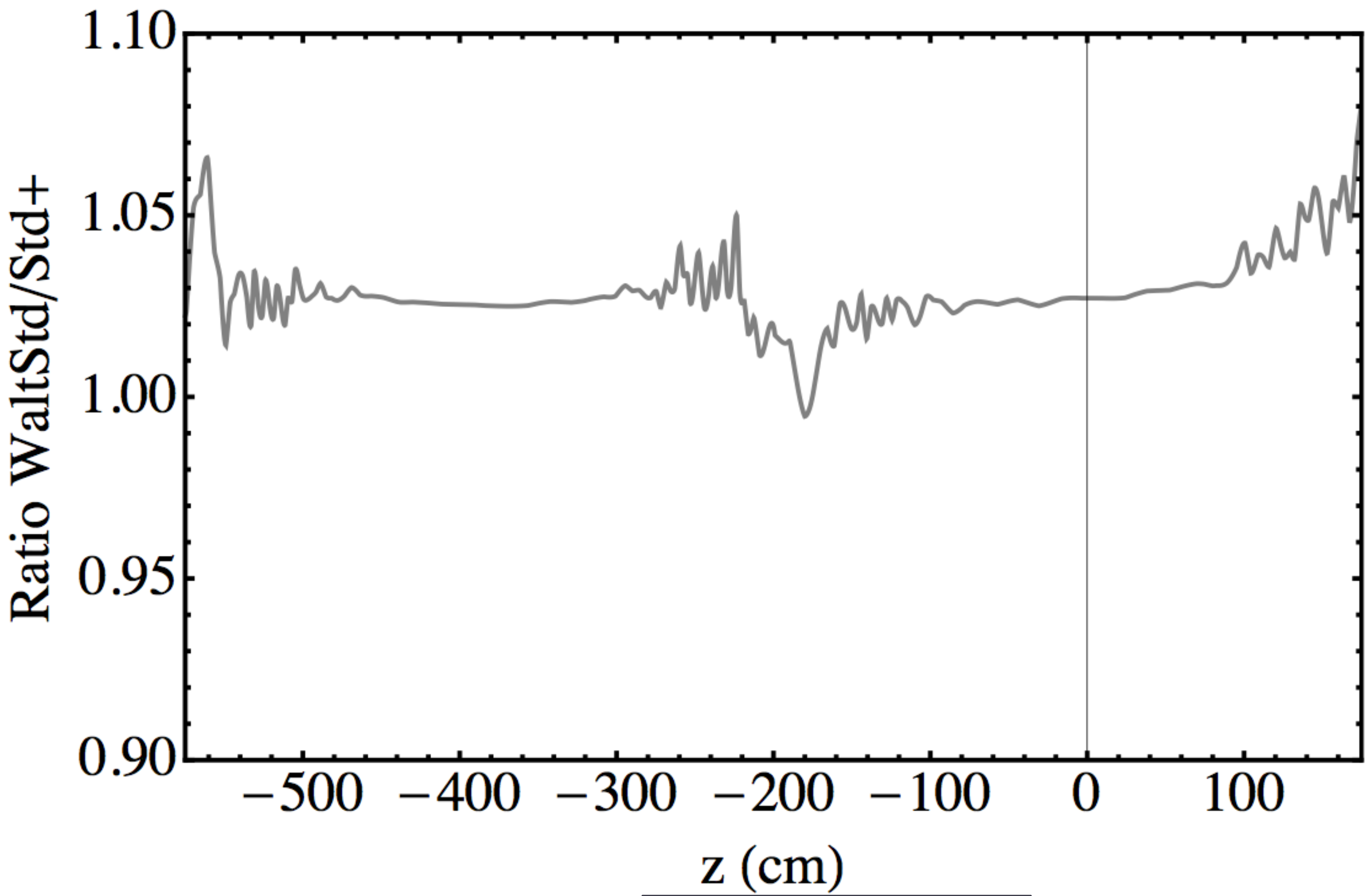


Opera

Magnetic field map

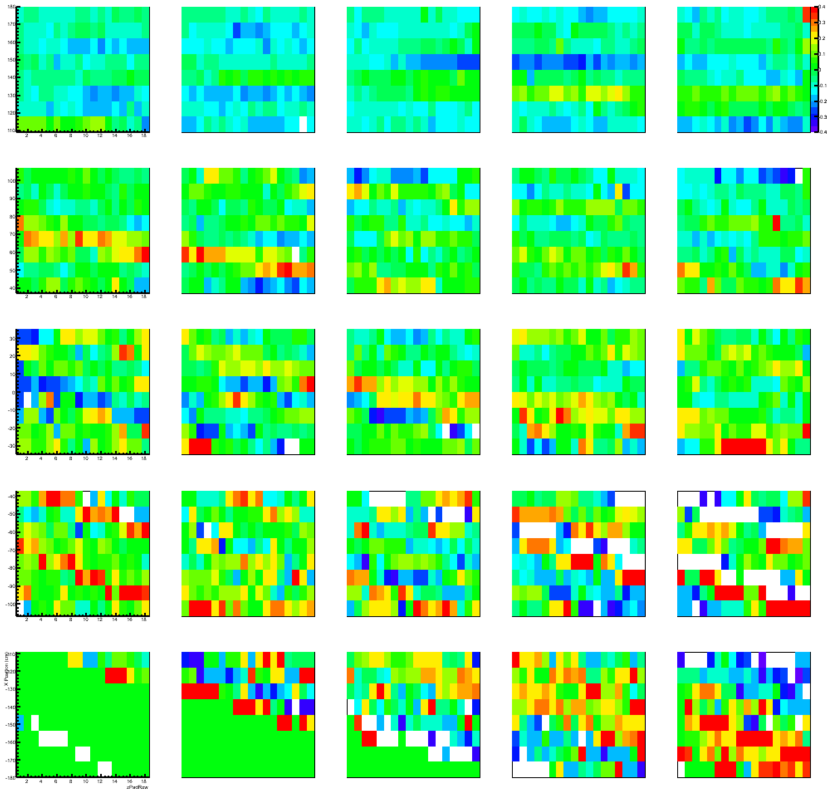


Comparison of the previous results in a standard configuration



~ 3% discrepancy

Quality monitoring: TPC

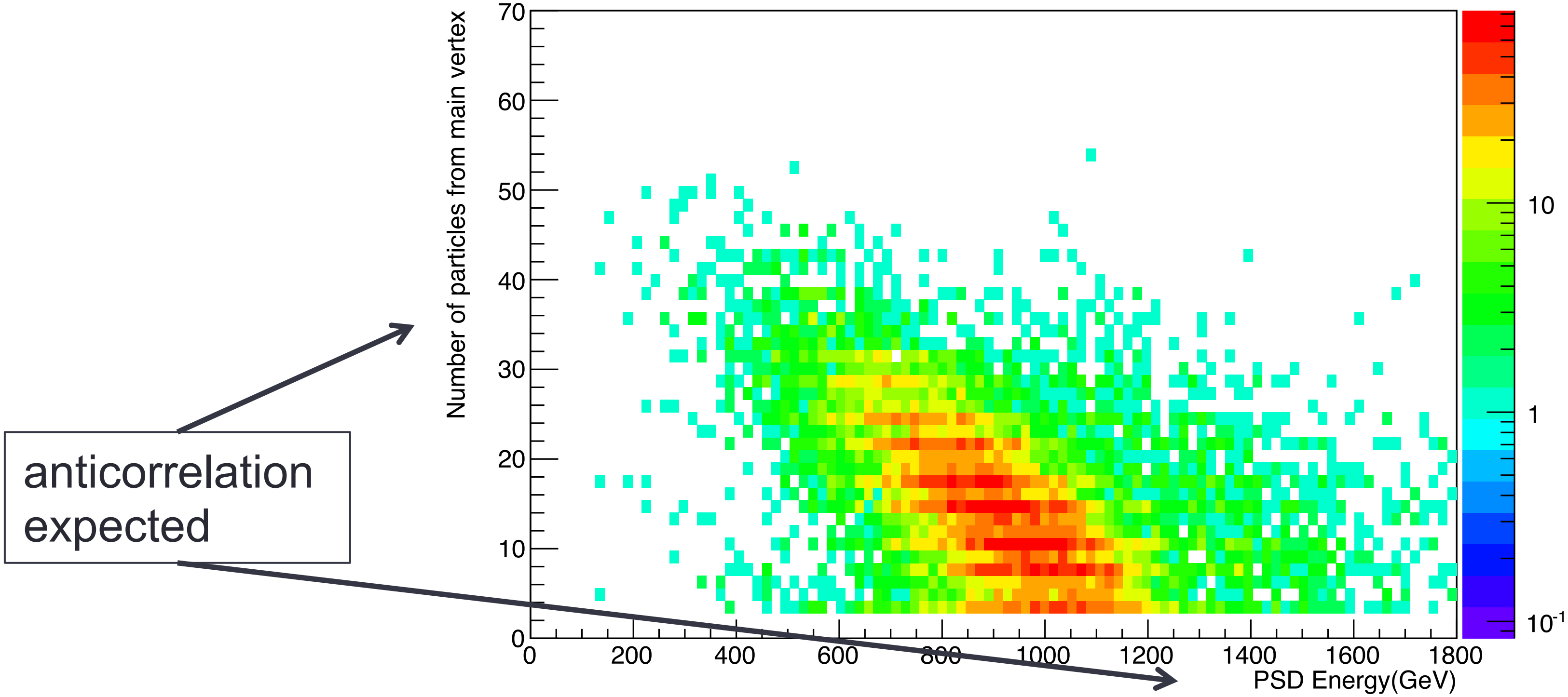


Main TPC Right

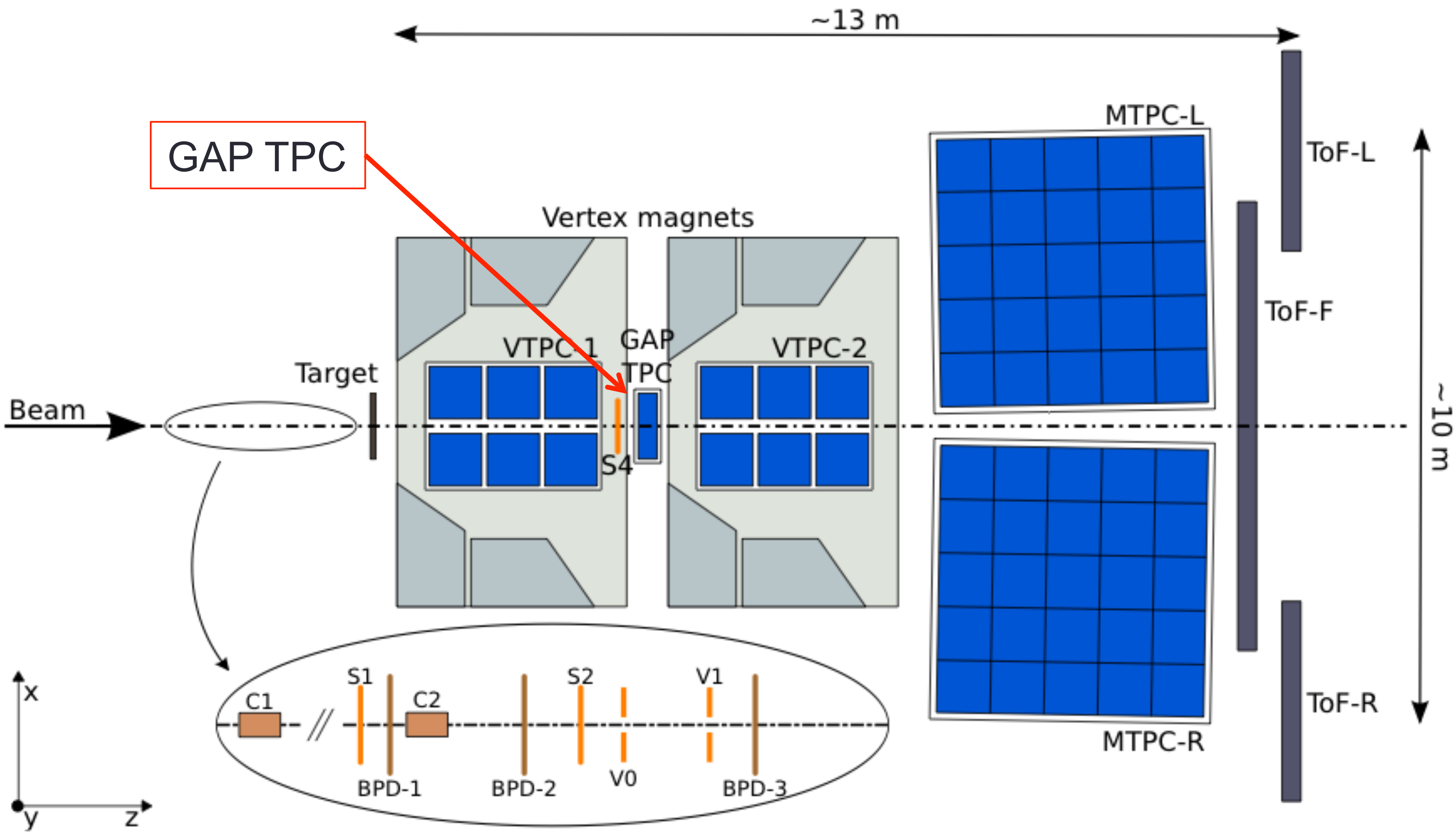
Differences between the reconstructed track and their clusters are a symptom of an incorrect calibration

Quality monitoring: PSD

- Merge the PSD data with those from the other detectors
- Check that the PSD data themselves are good (the PSD was installed only recently)



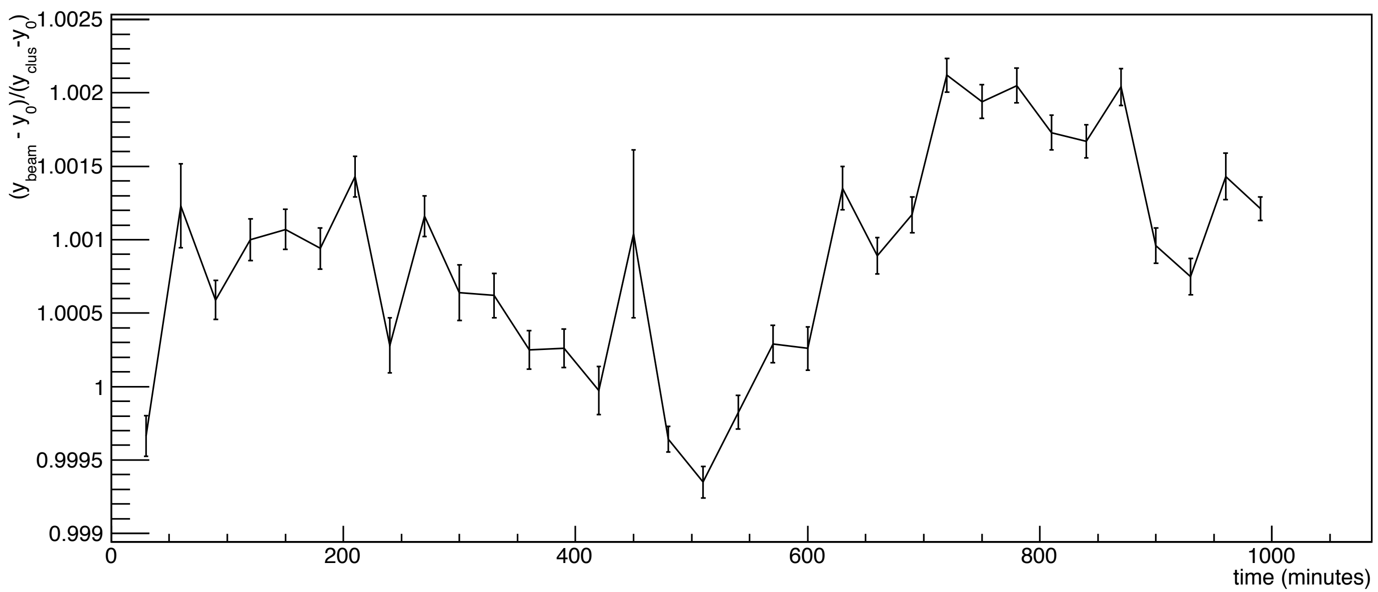
GAP TPC Calibration



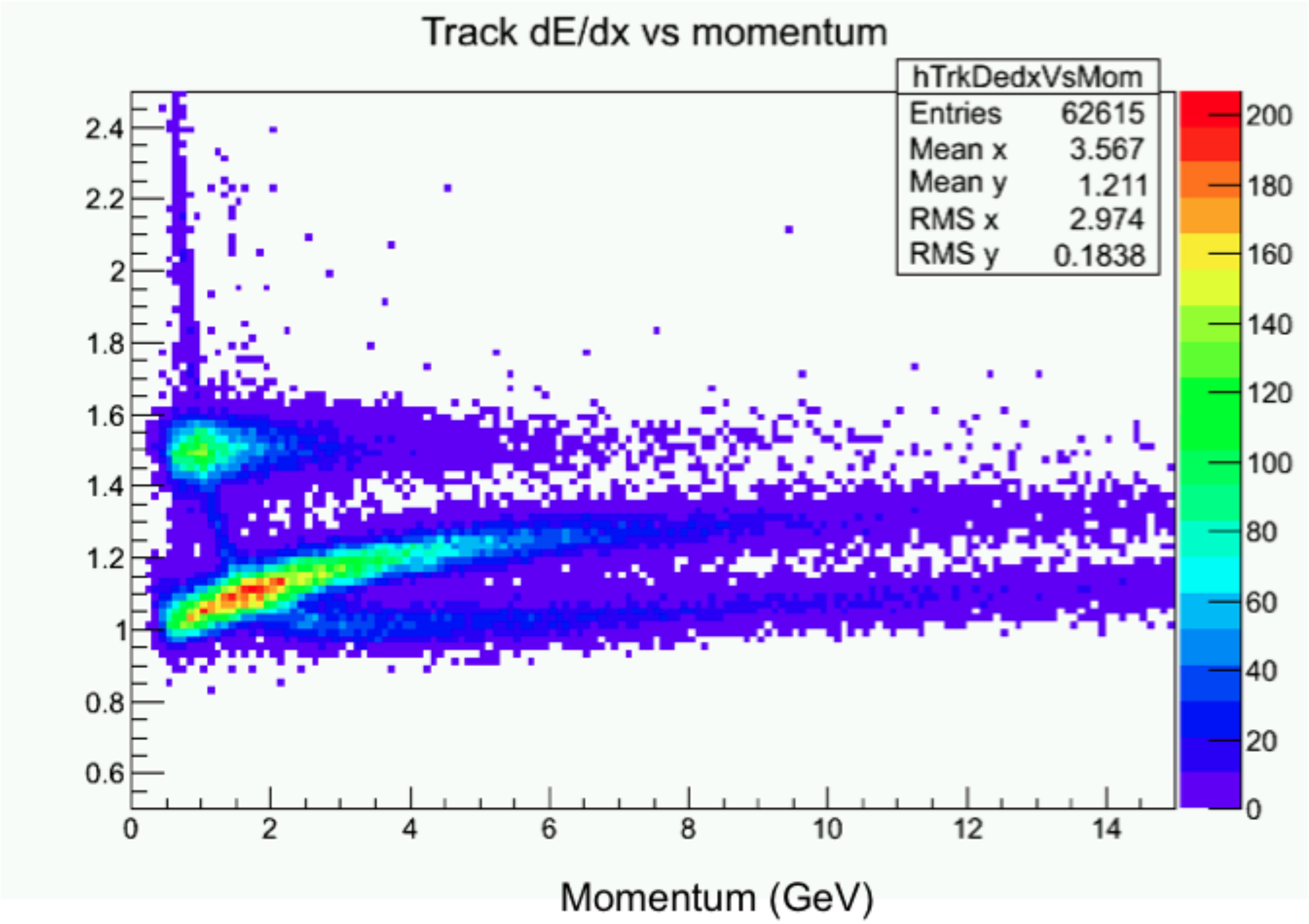
GAP TPC calibration

- Purpose: determine the correction factor c for the drift velocity without relying on the information from the remaining TPCs
- $v_{drift}' = v_{drift} * c$

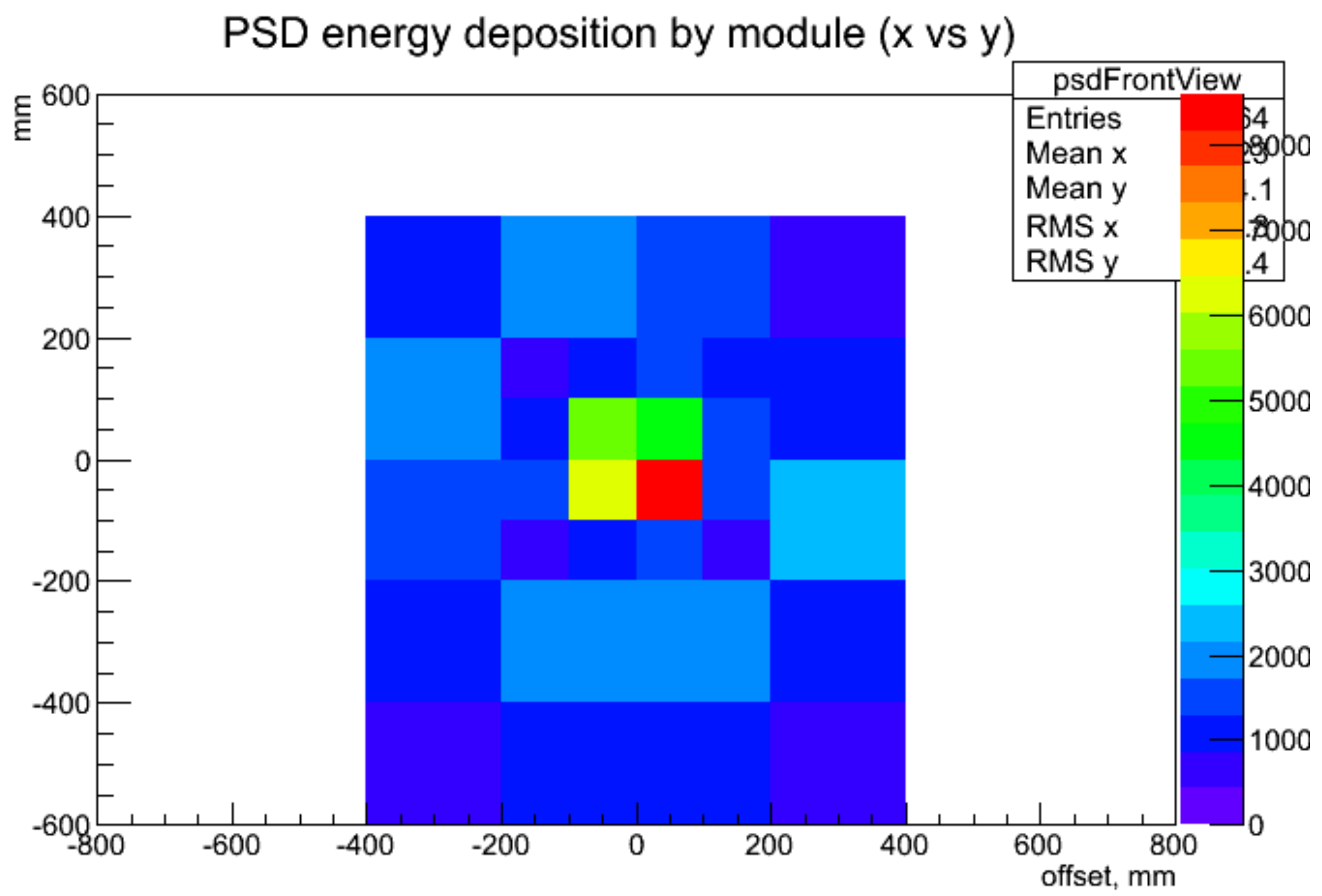
correction factor for runs 9451-9459



Analysis of T2K p(31 GeV) LH data



Online QA plots



Conclusions

- Binning the data as shown above (1 GeV in p, 20 mrad in θ) the statistical significance we can obtain from the data collected is sufficient to obtain a 5% measurement of positive pions in the region of interest for neutrino beamlines
- We are currently working to calibrate the data so that we can extract the Physics as soon as possible
  - results in the next years
- More data will be taken starting in 2014