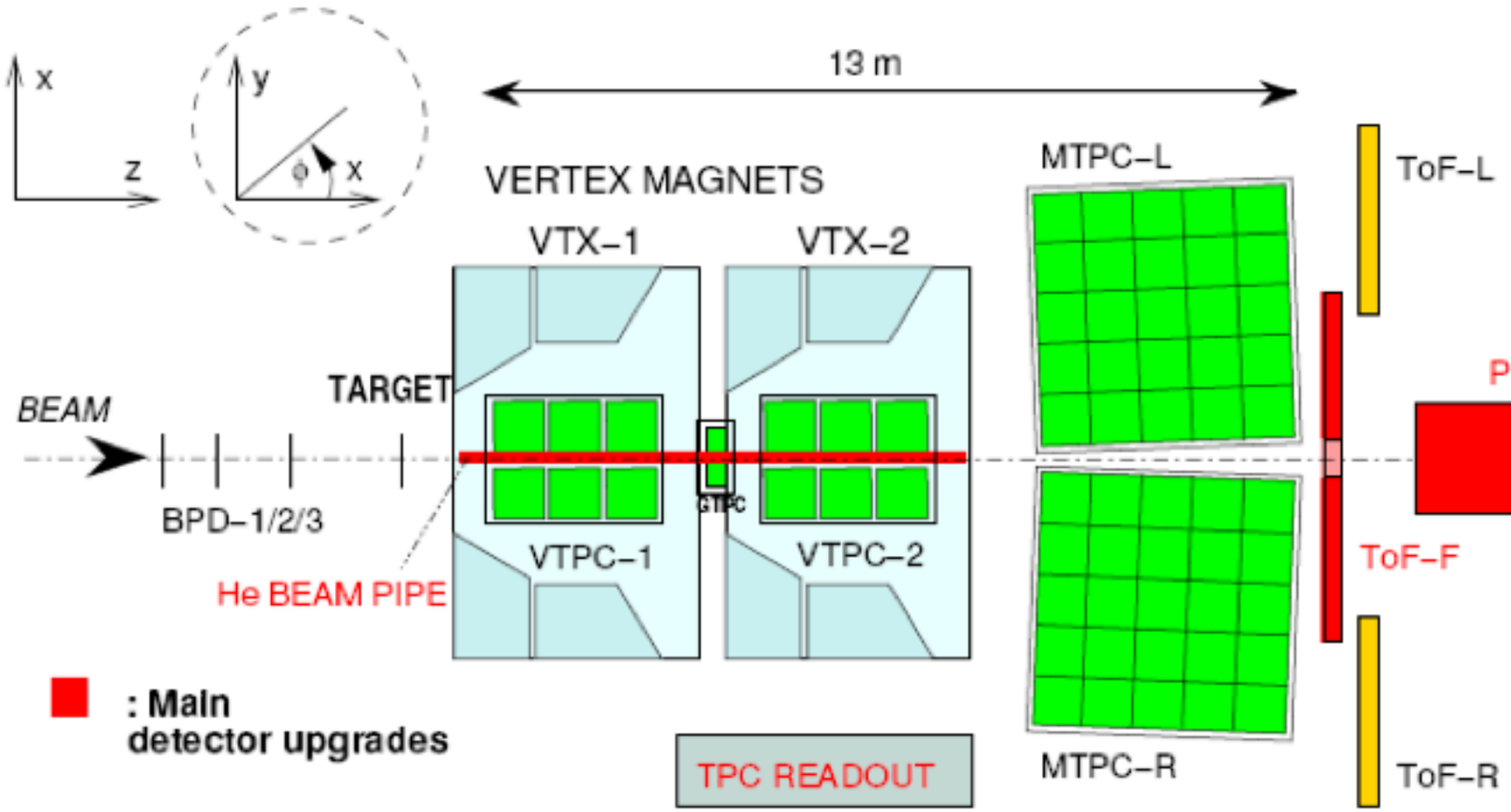
ToF PID in NA61

ToF and dE/dx Fit

NA61 detector overview



~~2007 run ~**1.5x10^6** triggers~~

pC @ 30 GeV

with different targets:

thin target: 2.5x2.5x2 cm^3

int. length ~ 0.04

long target: 90 cm

$\varnothing$ = 2.6 cm

int. length ~ 1.9

- **670k** triggers thin target
- **230k** triggers long target
- **80k** triggers empty target

ToF Resolutions:

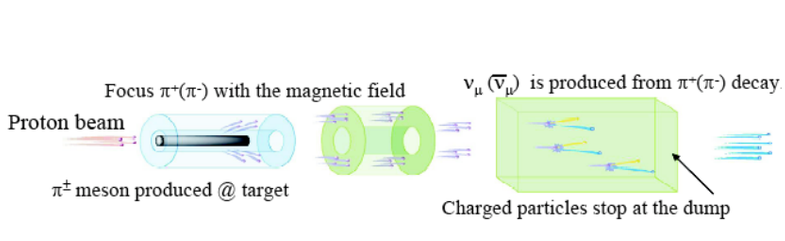
ToF-F: ~120 ps

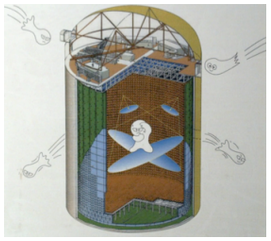
ToF-L,R: ~100ps

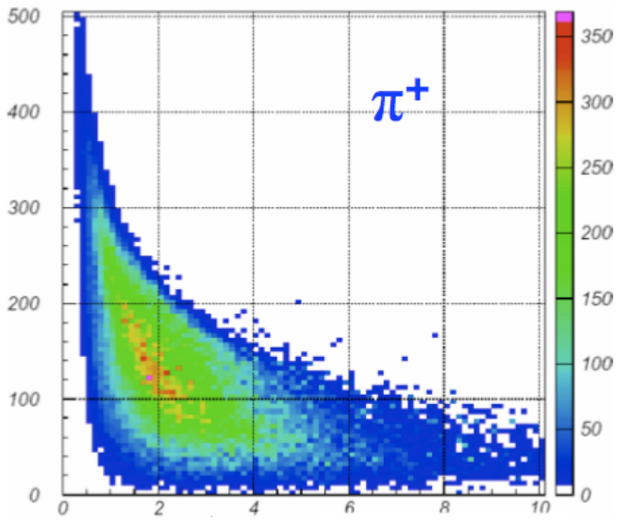
NA61 Acceptance for T2K

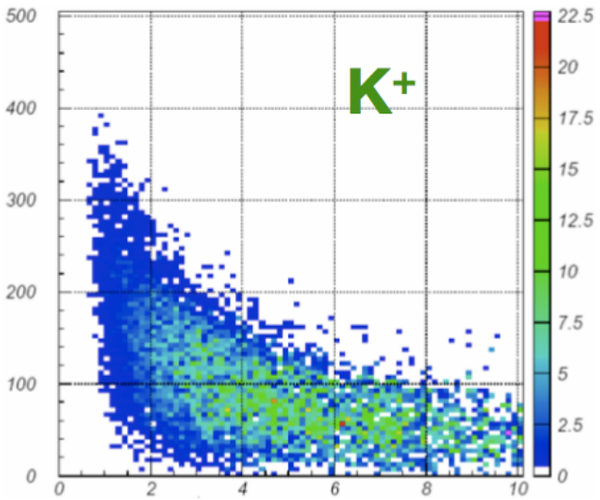
identifies pi/K in the T2K phase space

T2K phase space

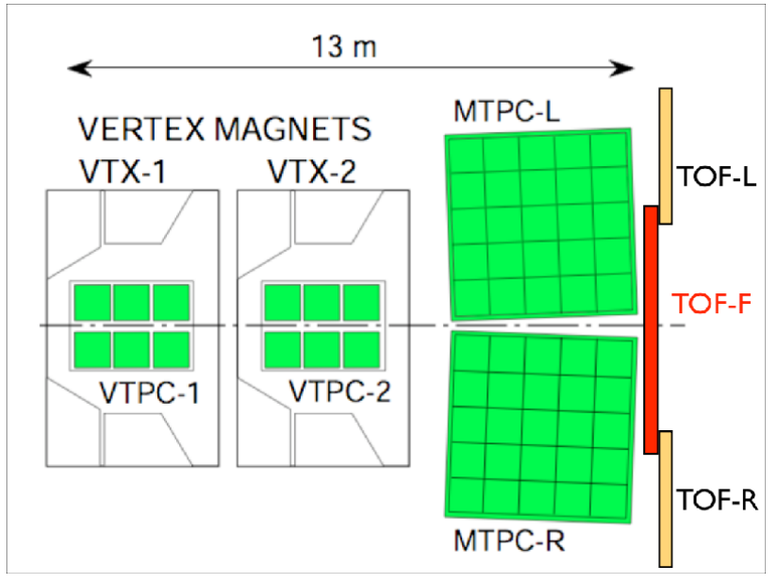






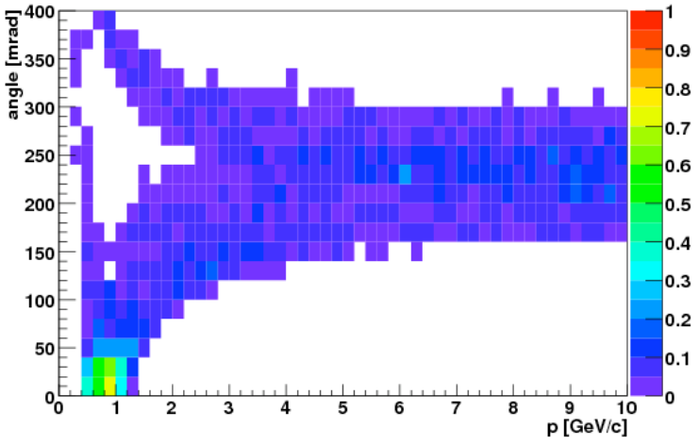


NA61 acceptance

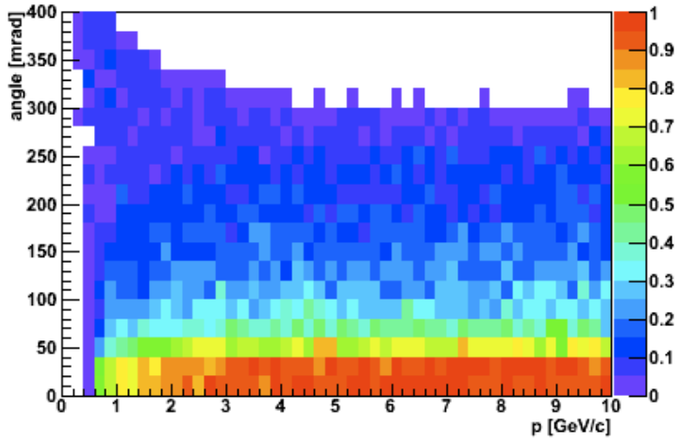


TPC+ ToF acceptance

NA61 with ToF-L,R only



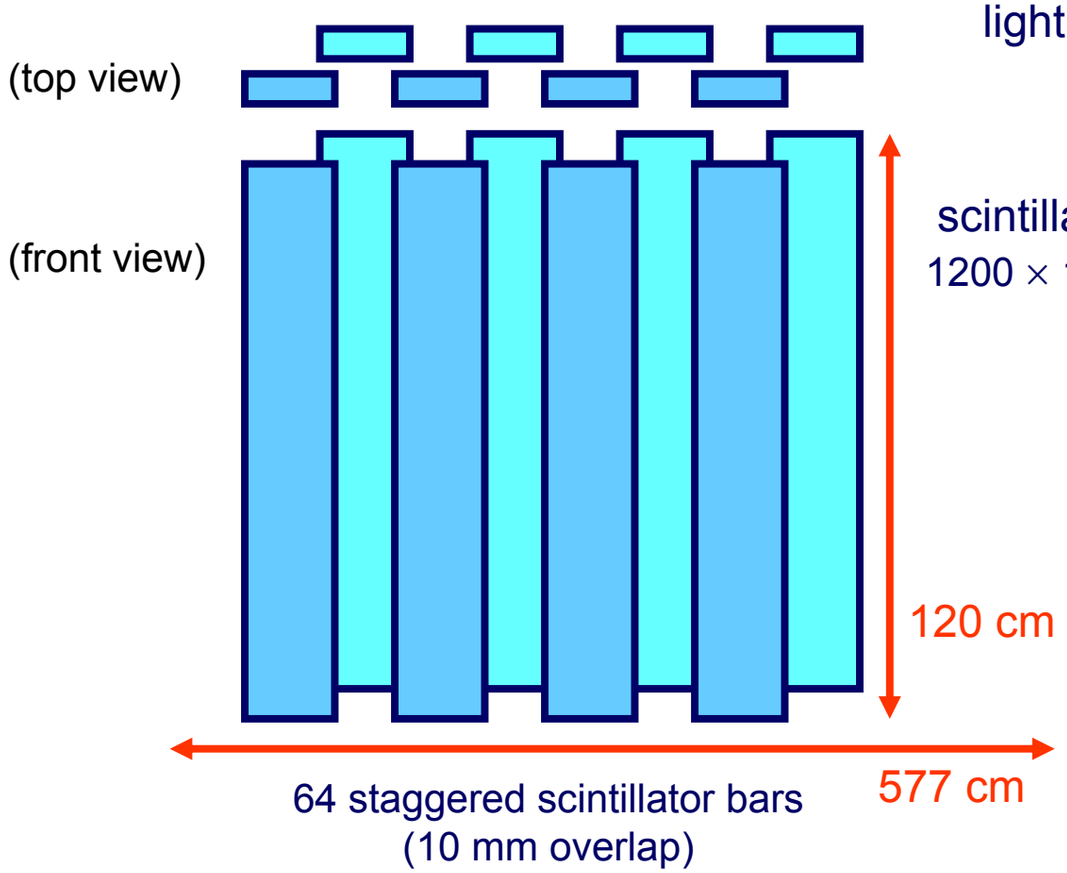
NA61 with the new ToF-F

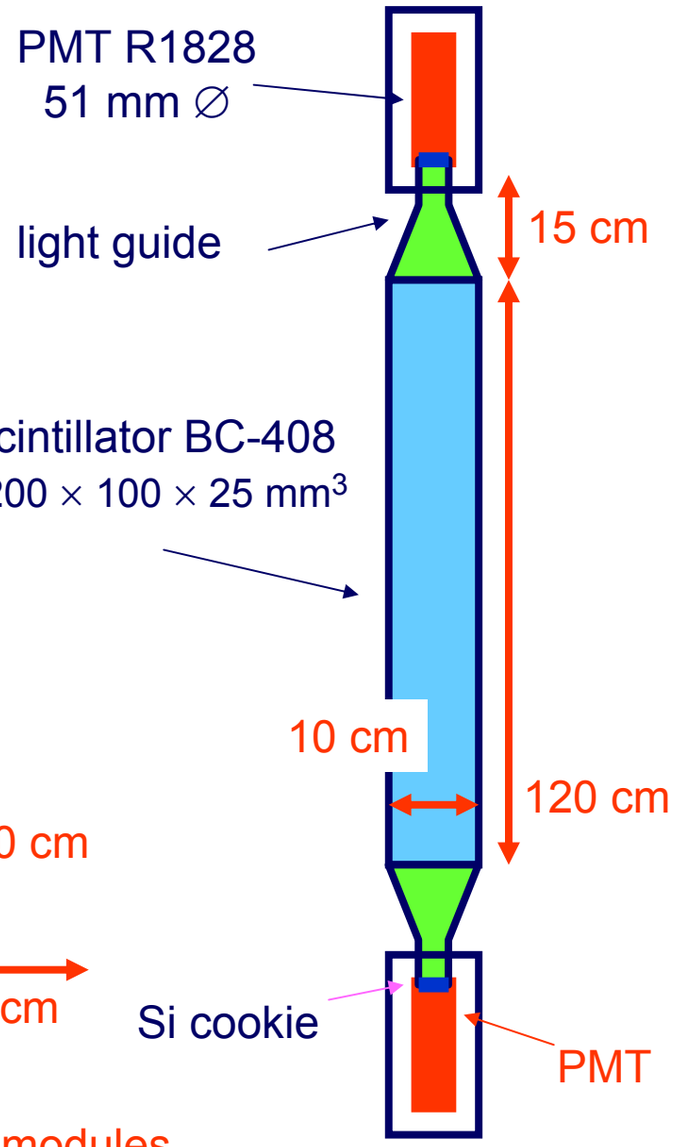


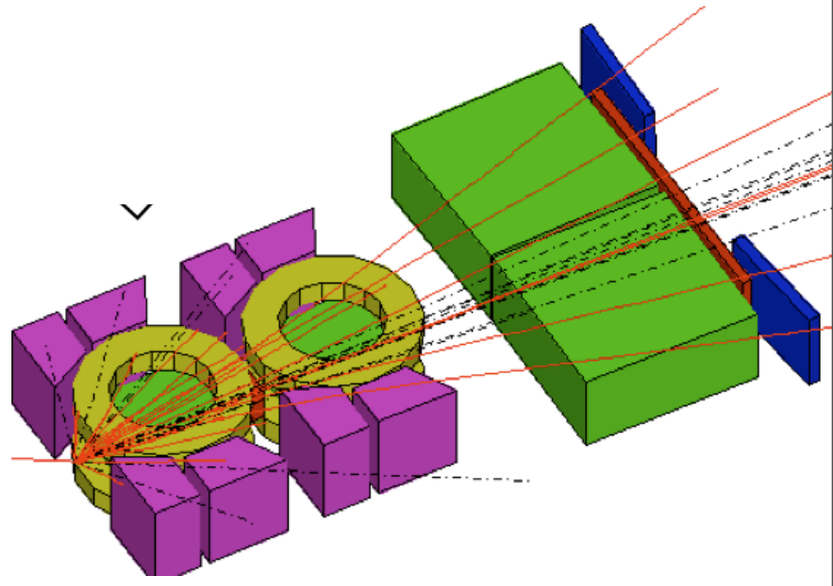
ToF-F description

total area 577 × 120 cm^2

64 scintillator bars readout on both sides
128 readout channels





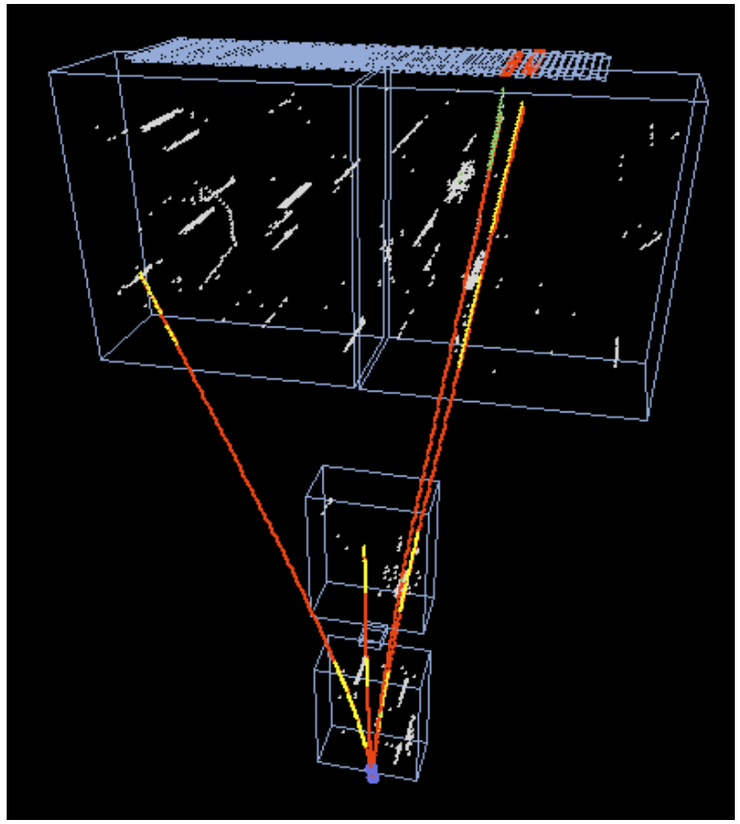


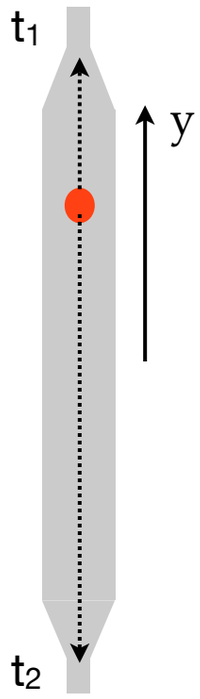
8 scintillators mounted on a single frame → 8 ToF modules

ToF-F Calibration

$$m^2 = p^2 \left[\frac{c^2 t^2}{l^2} - 1 \right]$$

particle momentum (p) and track length (l) are precisely measured in the TPCs
tracks are then extrapolated to the ToF and associated to a scintillator which gives a value for t.
(the hit in a scintillator provides a stop signal. the start signal is given by a counter placed upstream of the target)



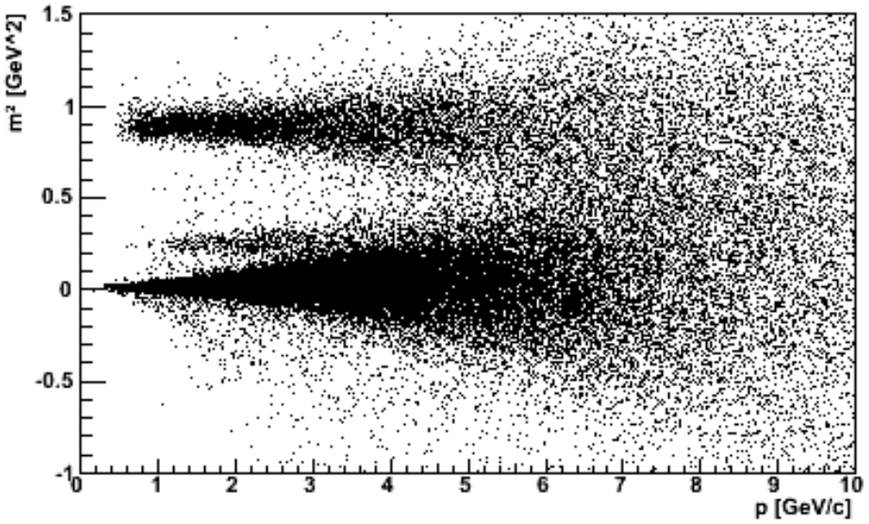


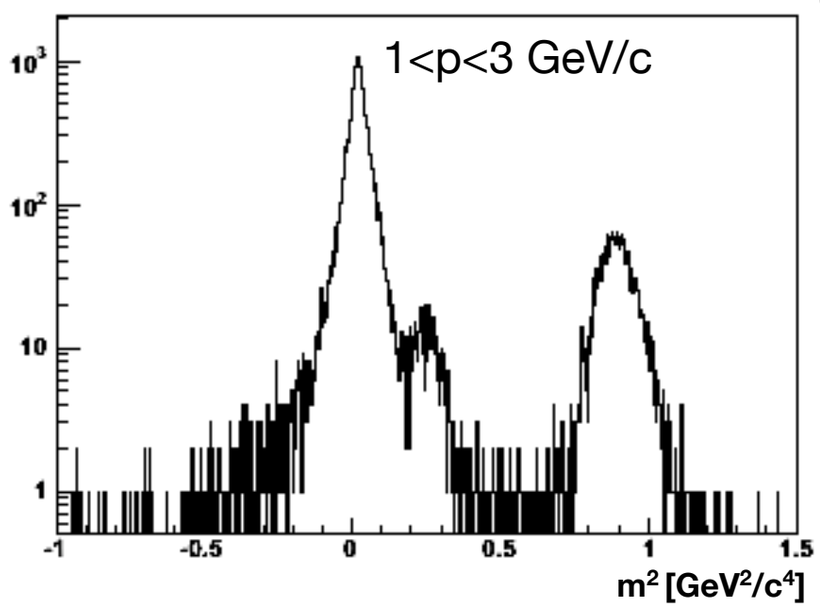
the mean time between the two tdc values is measured:

$$t = \frac{tdc1 + tdc2}{2} + T_0$$

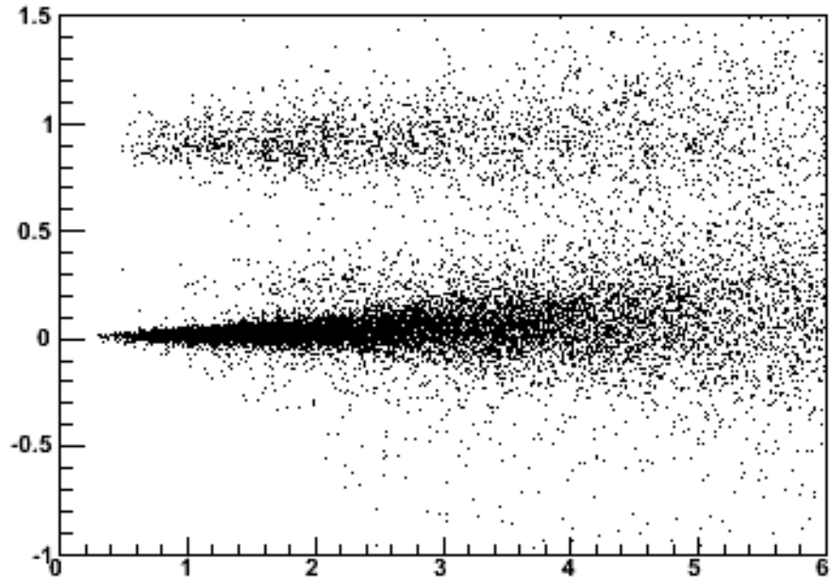
Latest mass squared distributions from ToF

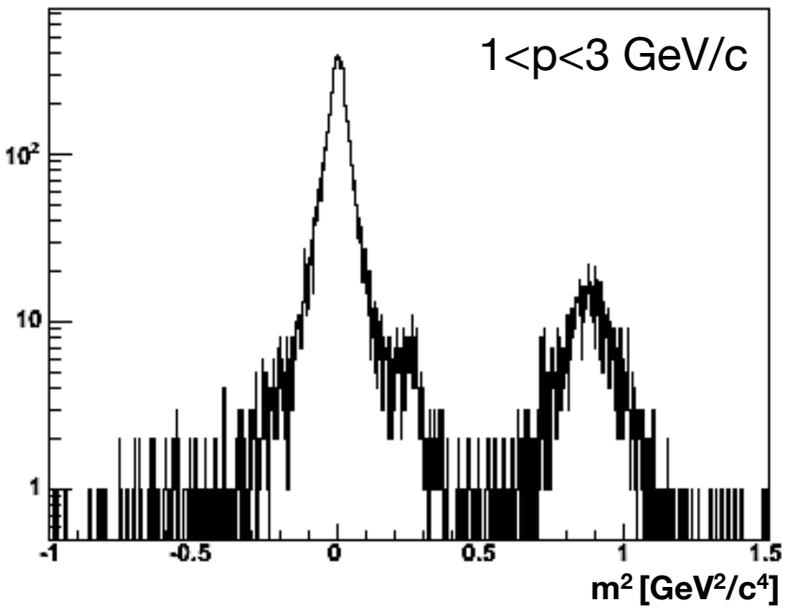
thin target data





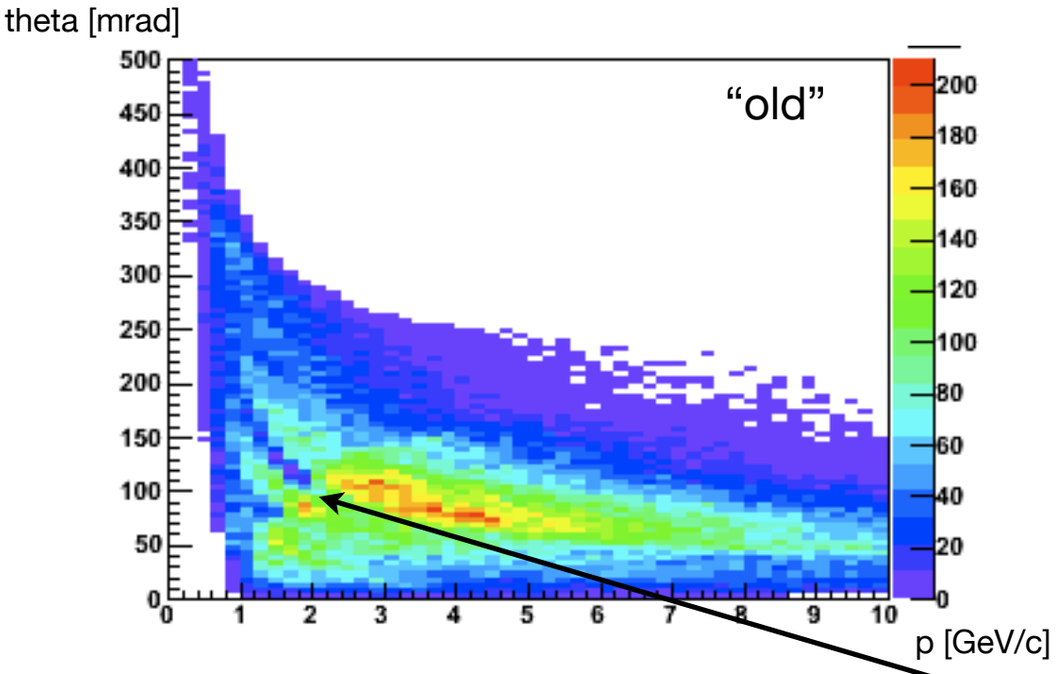
long target data

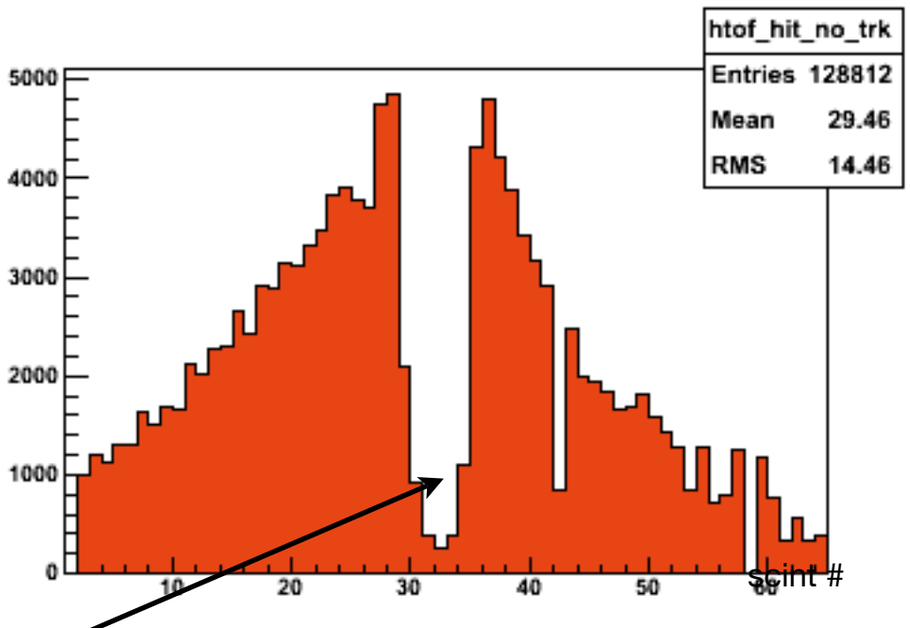




long target ToF resolution is not as good because of poor track length calculation this comes from a bad vertex fit of the z coordinate (due to secondary interactions in the target).
=>fit has to be optimized for long target (work in progress)

Improvement in acceptance coverage

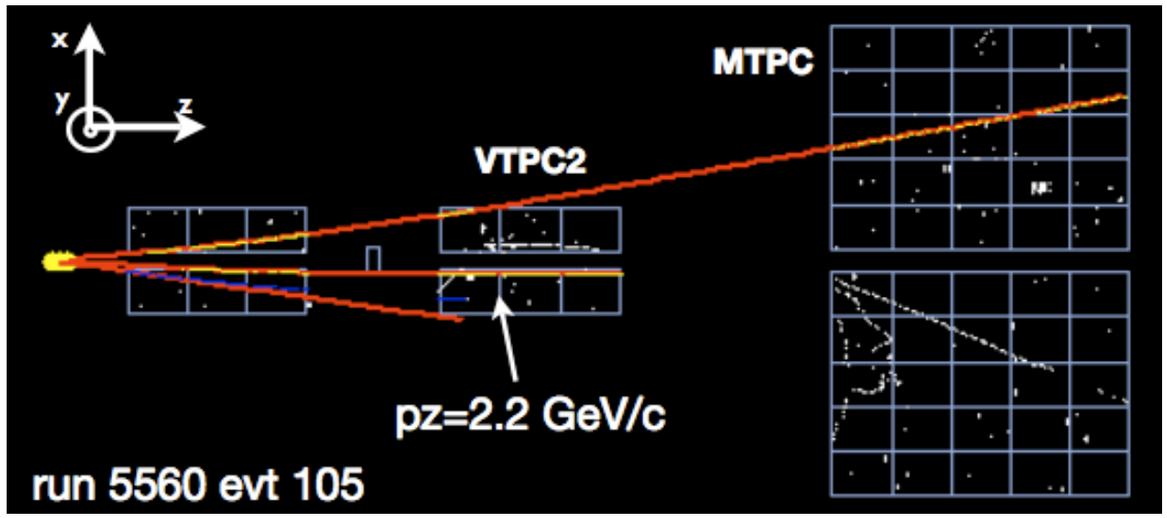




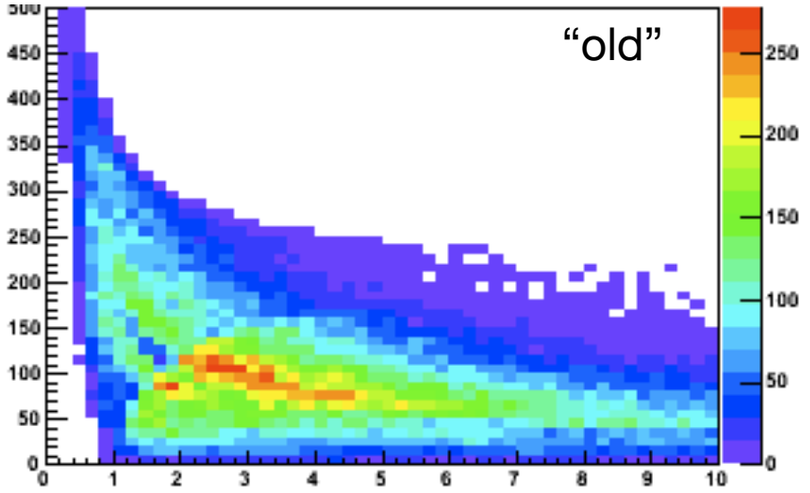
where are these tracks?

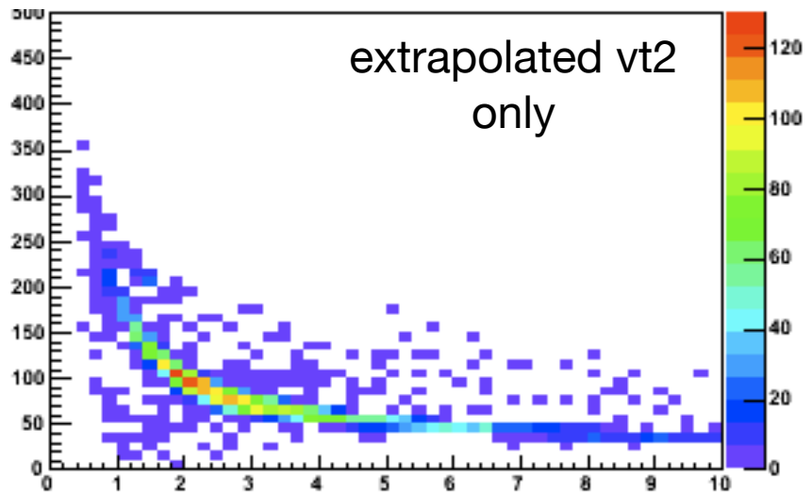
these are mainly tracks
that hit vtpc2 but not mtpc.

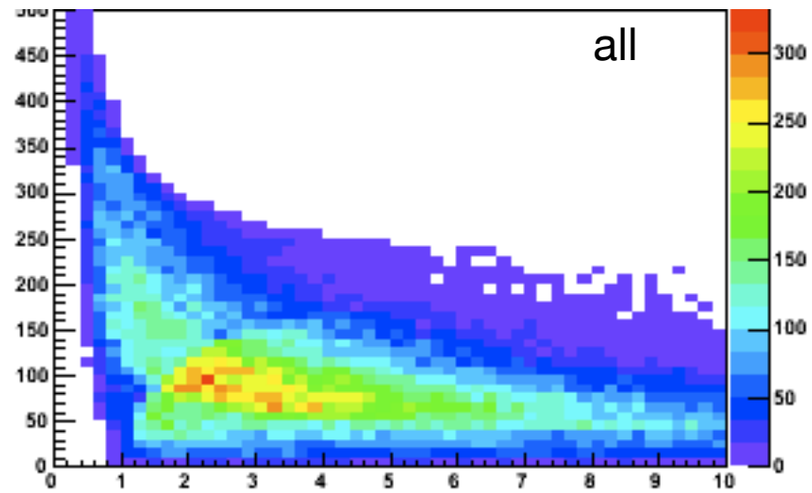
The extrapolation of tracks to the ToF was done from MTPCs..
to populate the hole extrapolate them from the end of vtpc2 to the ToF

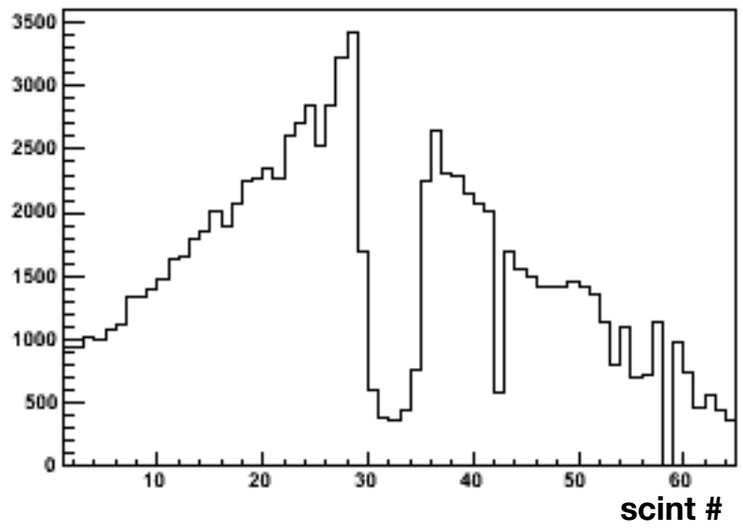


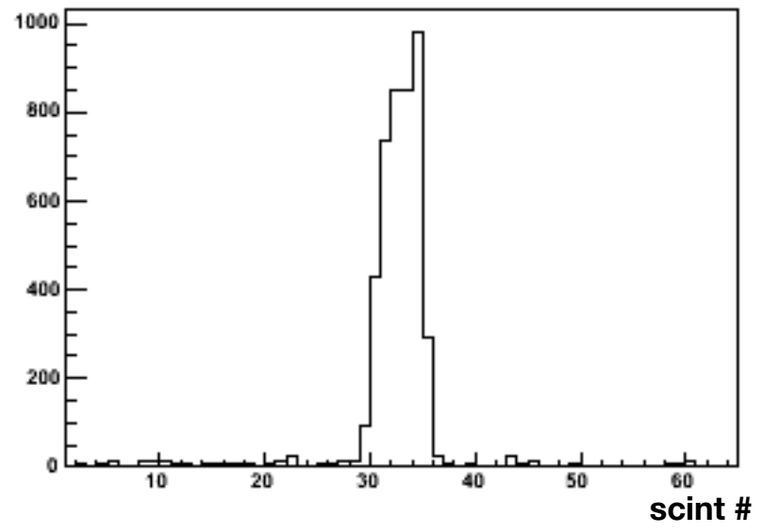
Hole in acceptance

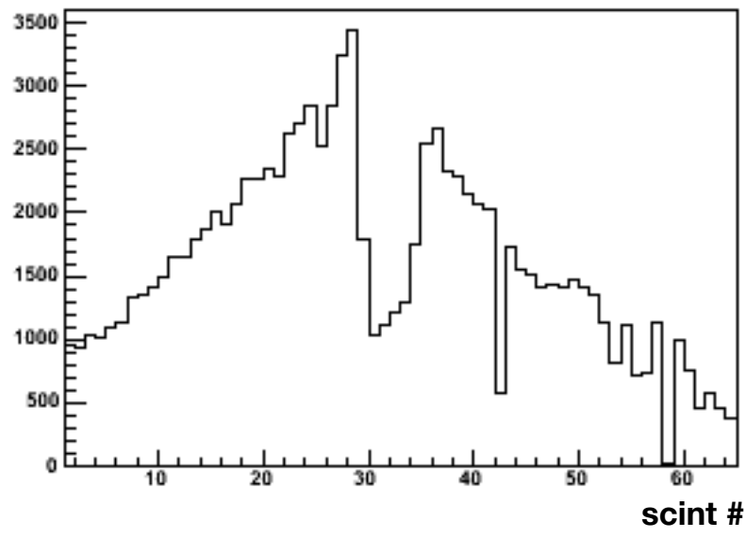












Still doesn't fill the hole enough.

MC shows that the remaining gap is due to tracks that don't hit any sensitive volumes (i.e go trough the all the gaps in the TPCs).. but they will obviously hit the Gap-TPC..

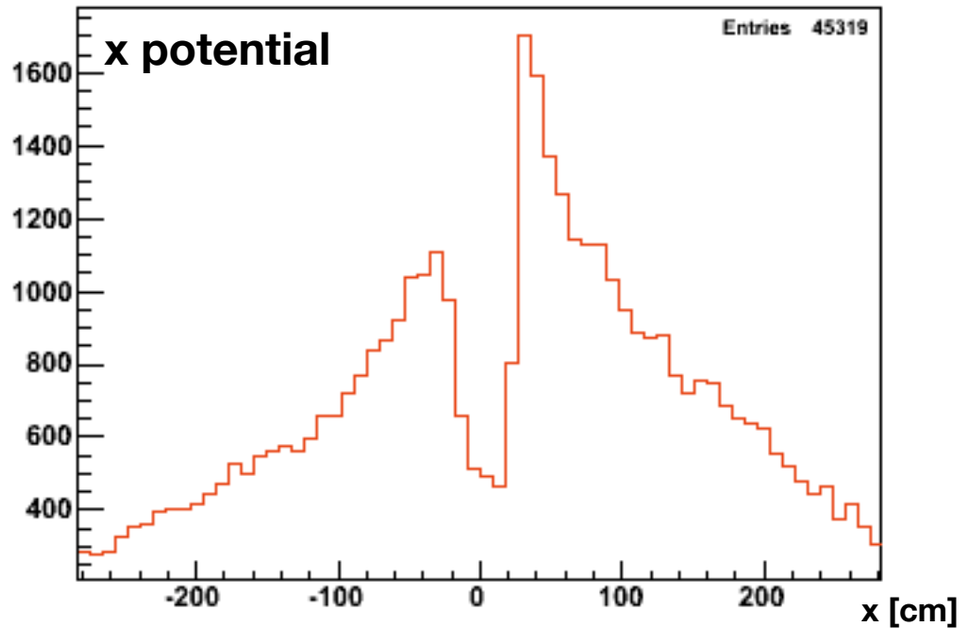
=>**We now have (since last week) a new data production which includes Gap-TPC reconstruction**

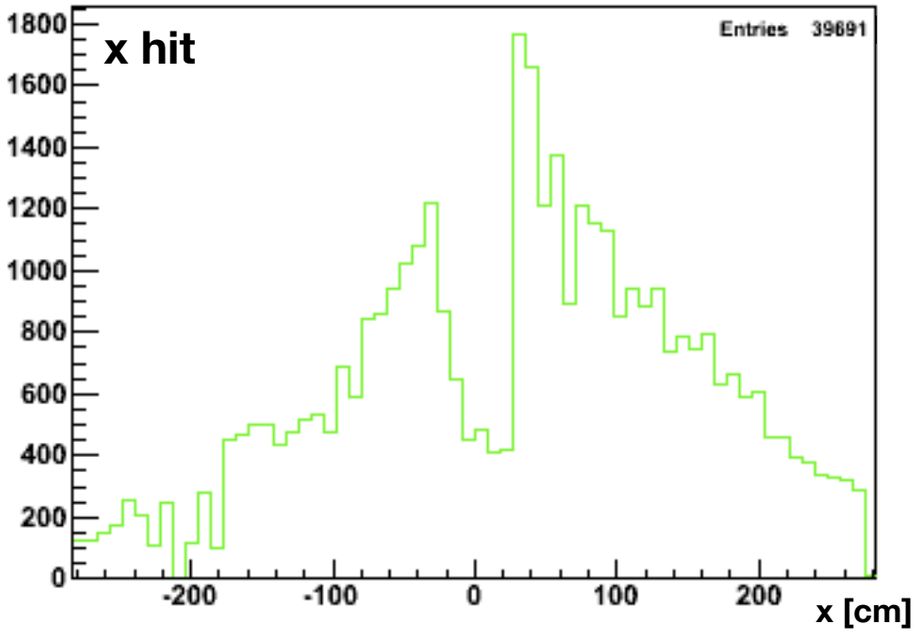
ToF efficiency

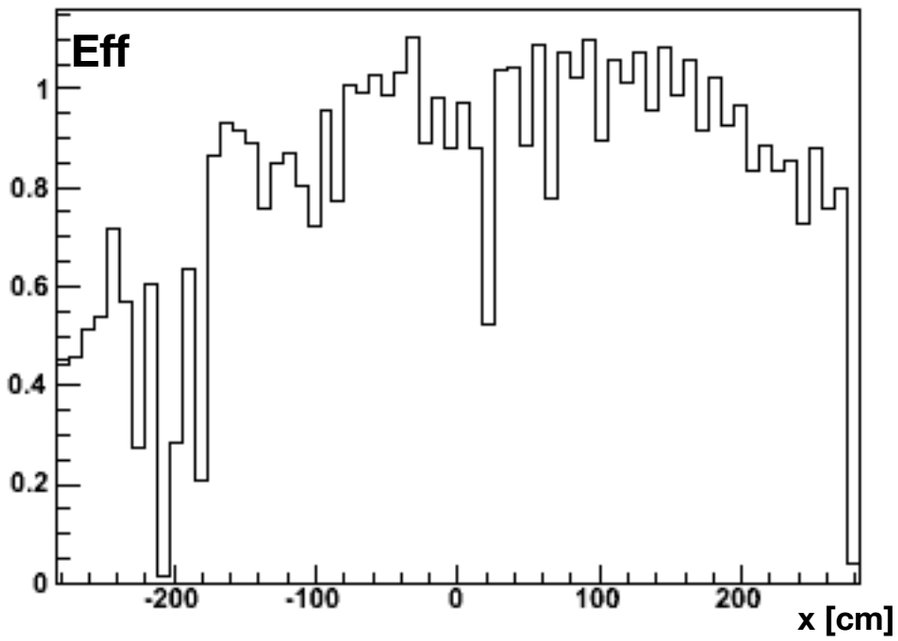
will have to correct the spectrums for ToF detection efficiency.

I look for potential x coordinate of tracks extrapolated to the ToF (x_pot) and which of these actually produce a hit (x_hit).

The efficiency is then given by $\mathbf{Eff} = \frac{\mathbf{x_{hit}}}{\mathbf{x_{pot}}}$



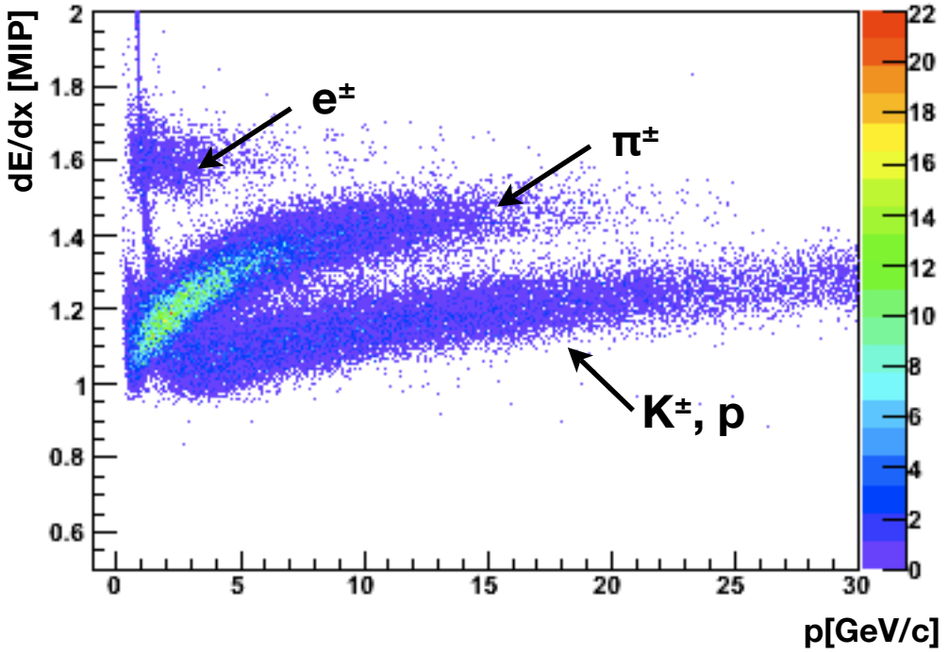


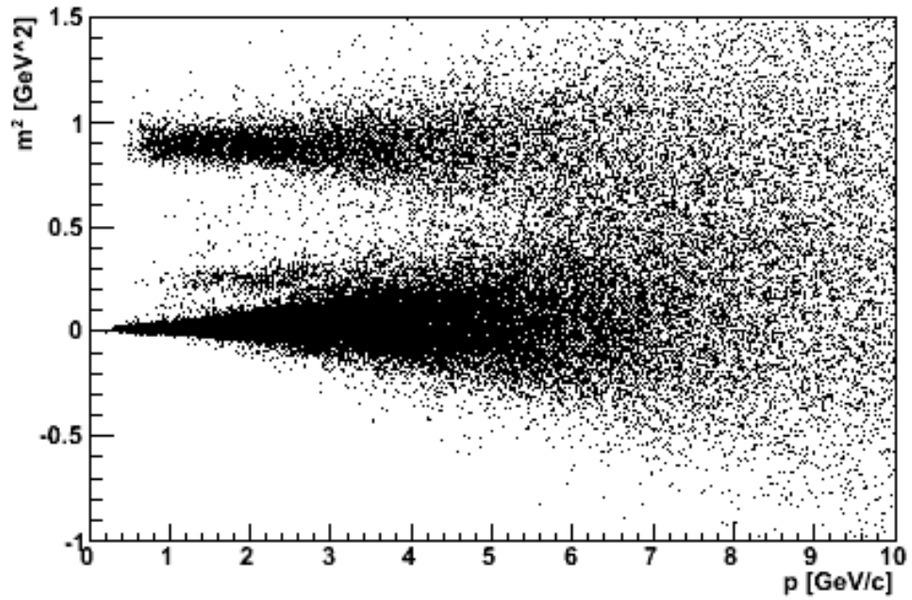


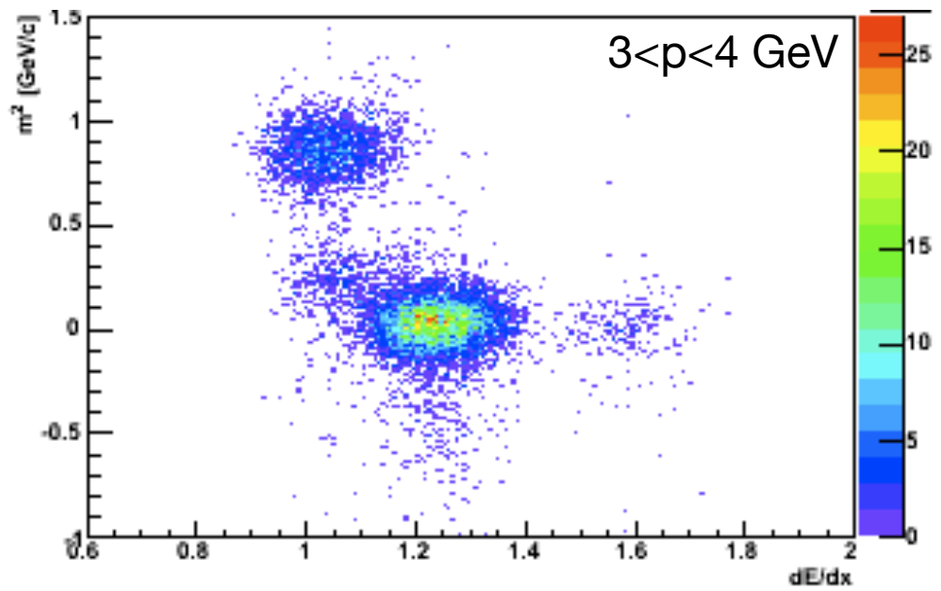
- estimation of global efficiency by dividing the number of entries : Eff ≈ 40/45 ≈ 88%
- Efficiency is really reduced on Salève side because of a few faulty channels (but this we already know)
- Very efficient scintillators have Eff>1 (~1.07) this is due to overlapping hits..
- Will input this scintillator-efficiency in MC as part of the steps in getting corrected spectrums

Particle identification in NA61

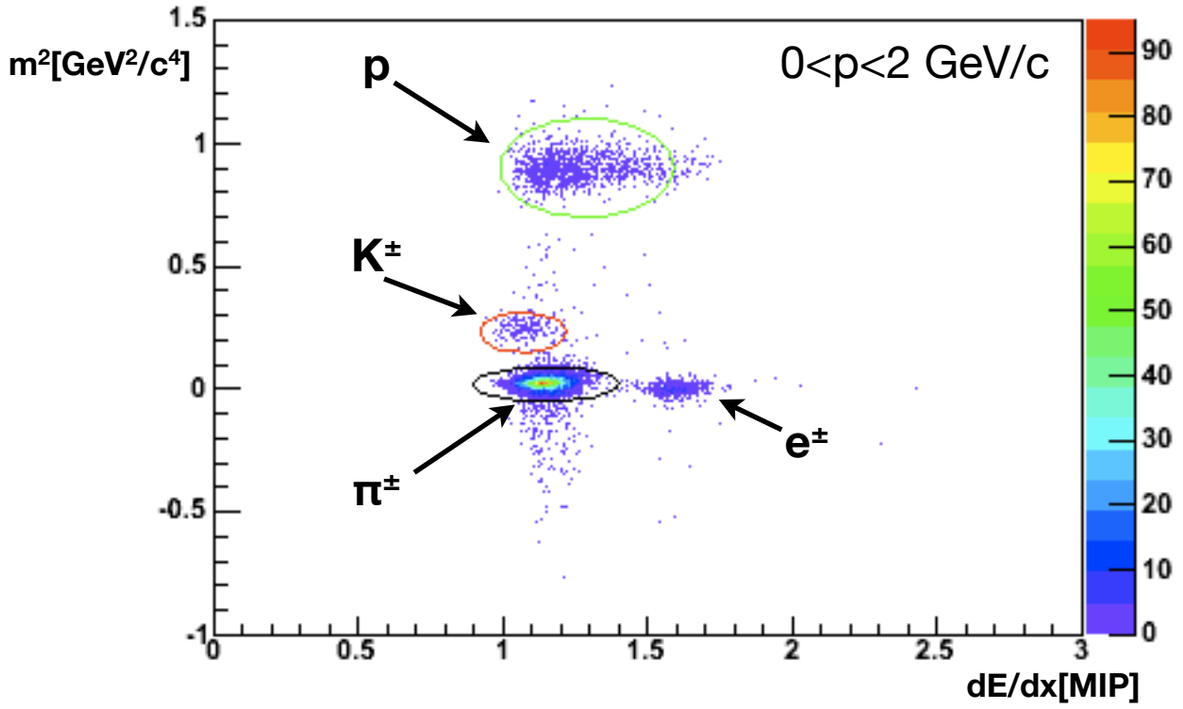
a high quality PID is performed by combining ToF and dE/dx measurements:
Typically below 4 GeV/c momenta, PID is mainly performed by ToF
4<p<10 GeV/c pi/p separation is still ToF but dE/dX is needed for pi/K discrimination
dE/dX can also identify electrons

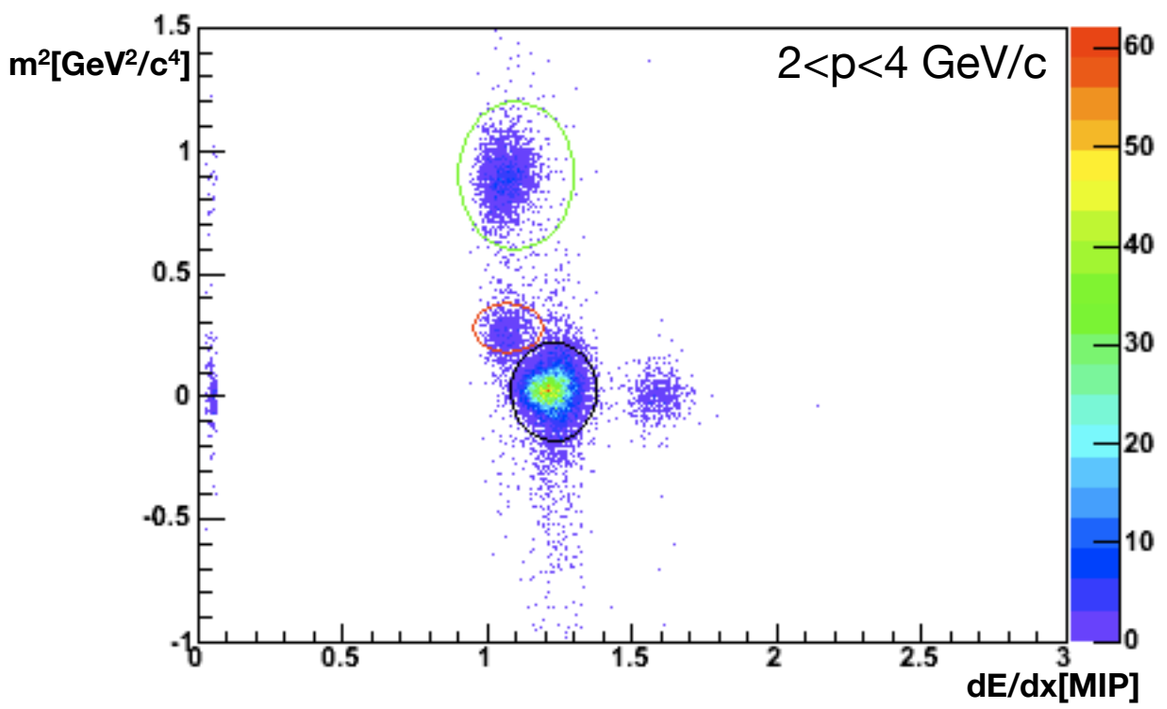


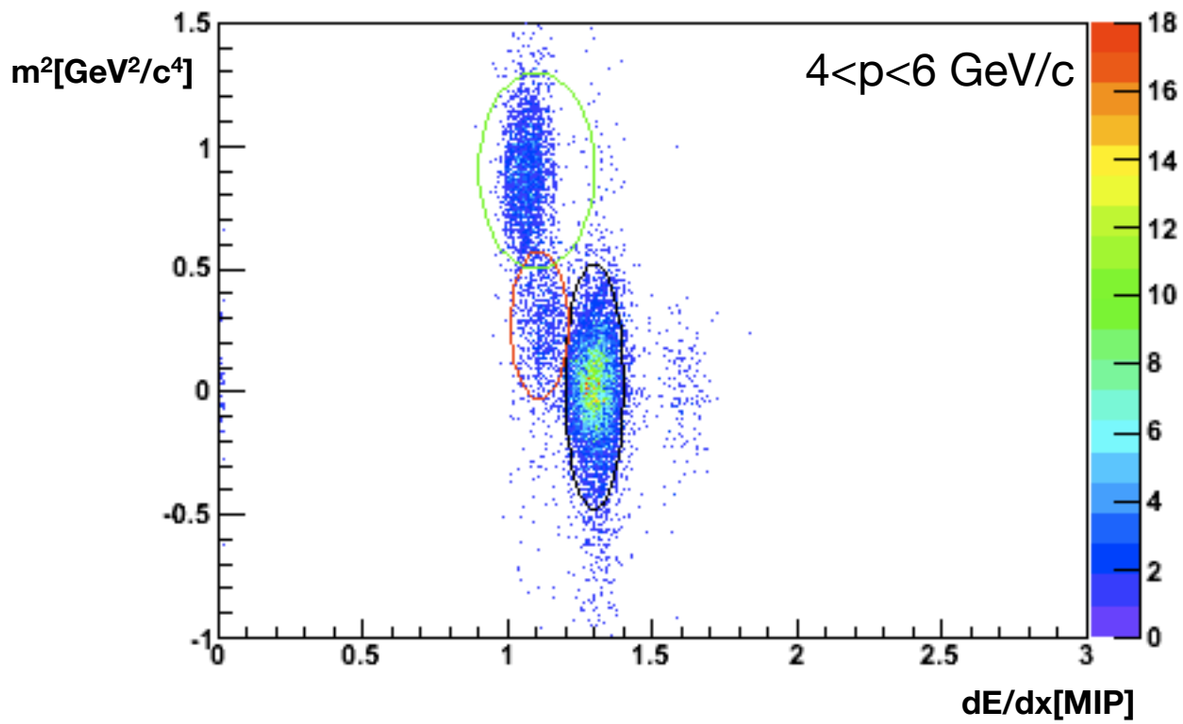


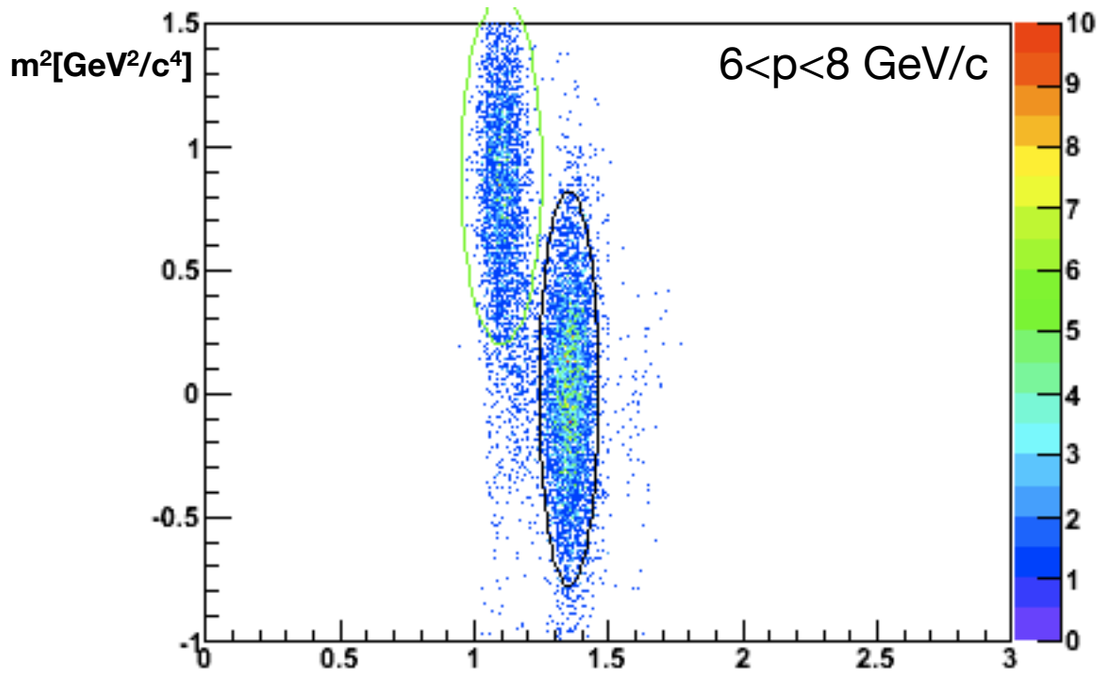


preliminary pid



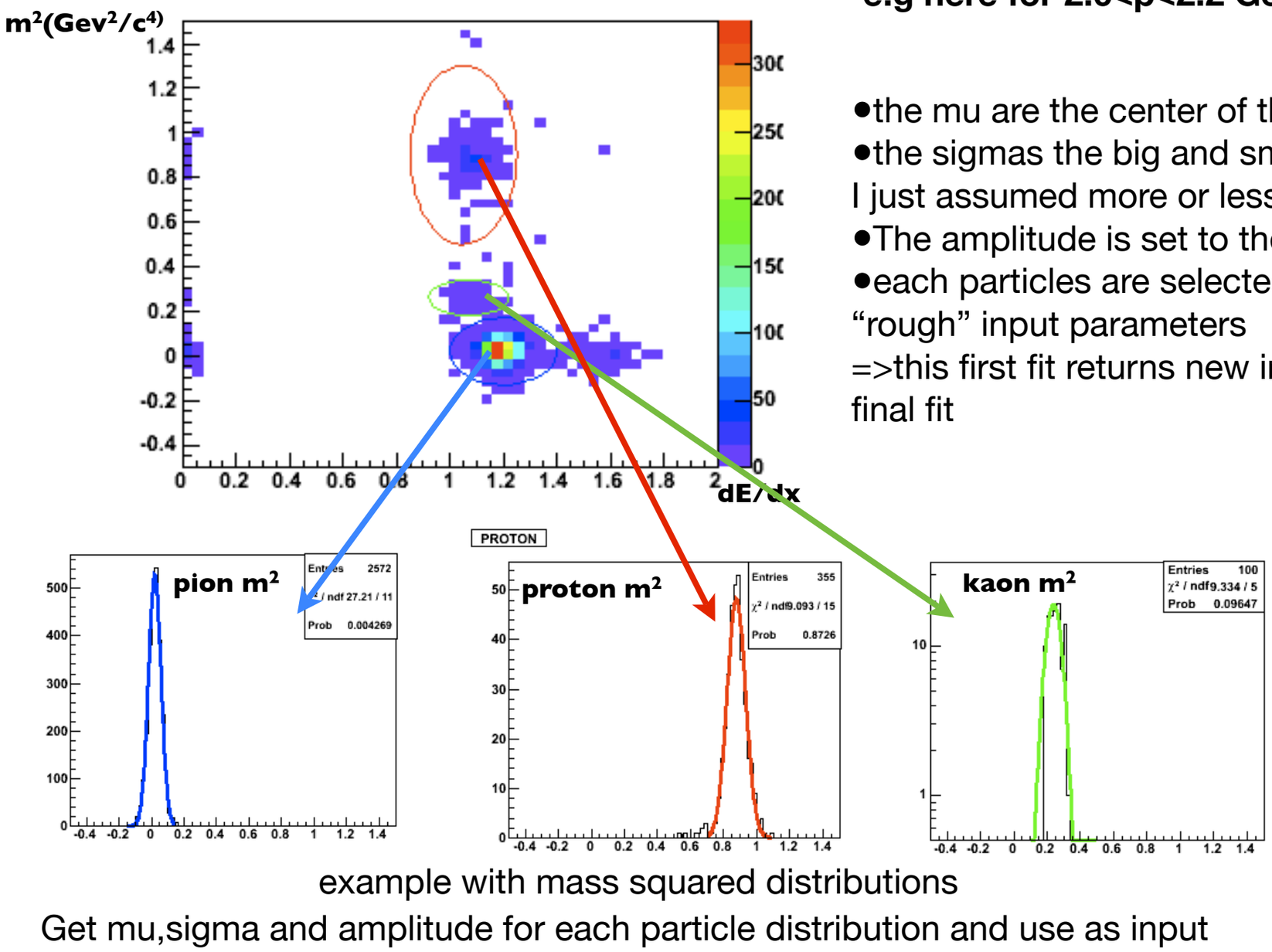






Parameters for 2D Fit

- The “official” binning for T2K is: 50 bins of 200 MeV/c between 0-10 GeV/c momentum and 20 bins in polar angle 0<theta<500 mrad
- Divide only in momentum: for each bins of 200 MeV/c plot mass squared versus dE/dx and the particles are selected with an ellipse.
- The input parameters for the fits are selected from these ellipses



example with mass squared distributions

e.g here for 2.0<p<2.2 GeV/c

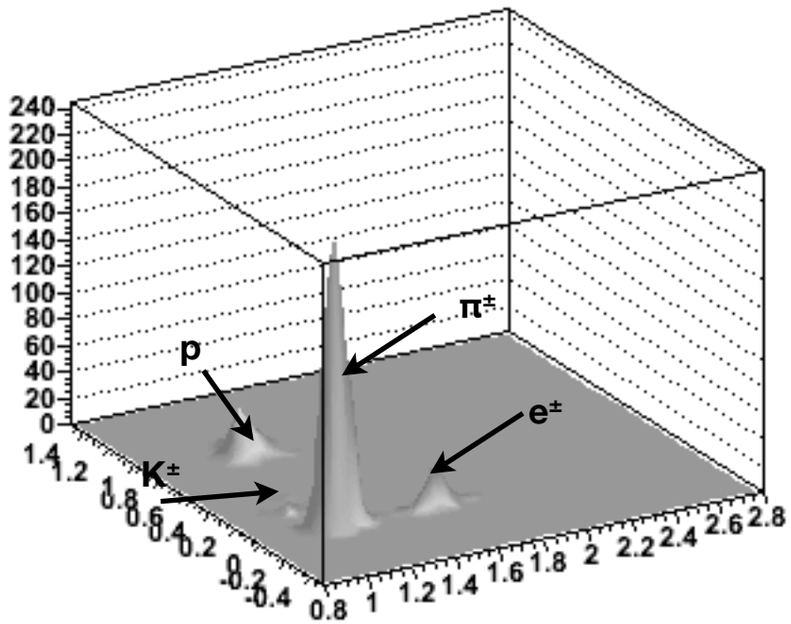
- the mu are the center of the ellipses
- the sigmas the big and small radius divided by 10 (this is arbitrary, I just assumed more or less the ellipses were surrounding ~10σ)
- The amplitude is set to the maximum bin content in each ellipse
- each particles are selected and fitted individually with these “rough” input parameters

=>this first fit returns new input parameters which are used for the final fit

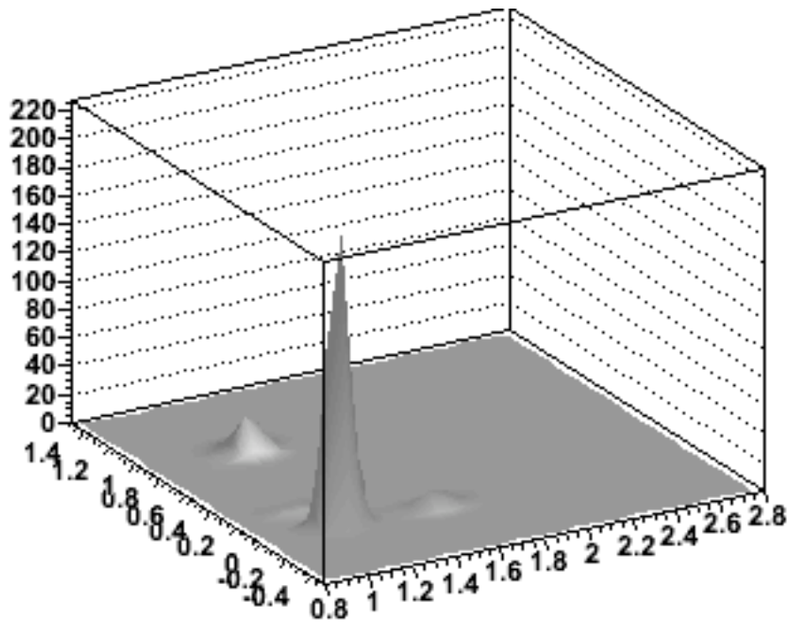
Get mu,sigma and amplitude for each particle distribution and use as input parameter for the 2 dimensional fit

2D Fit examples

1.4<p<1.6 GeV/c

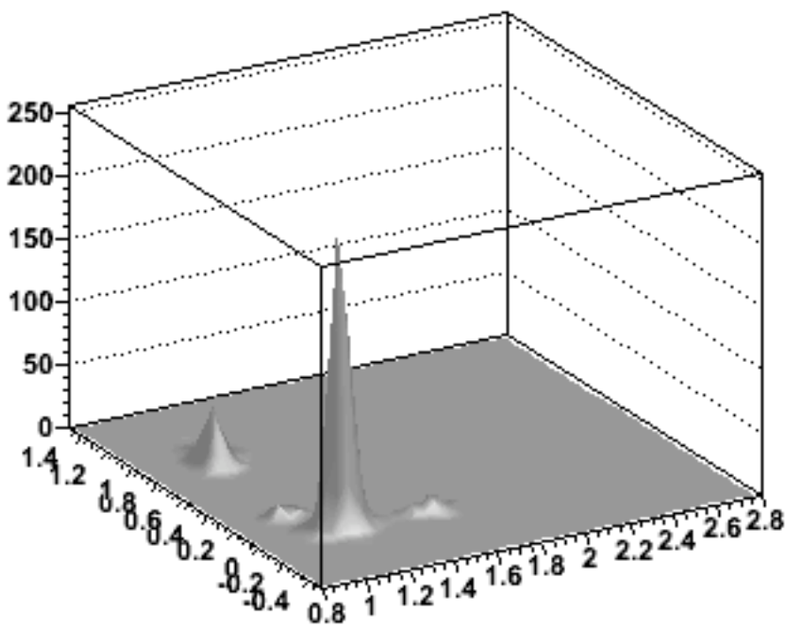


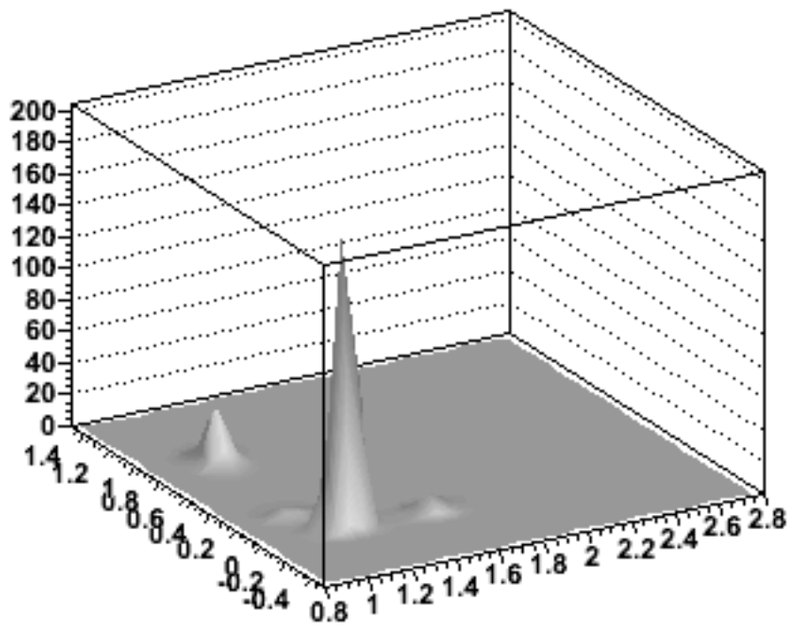
data



fit function

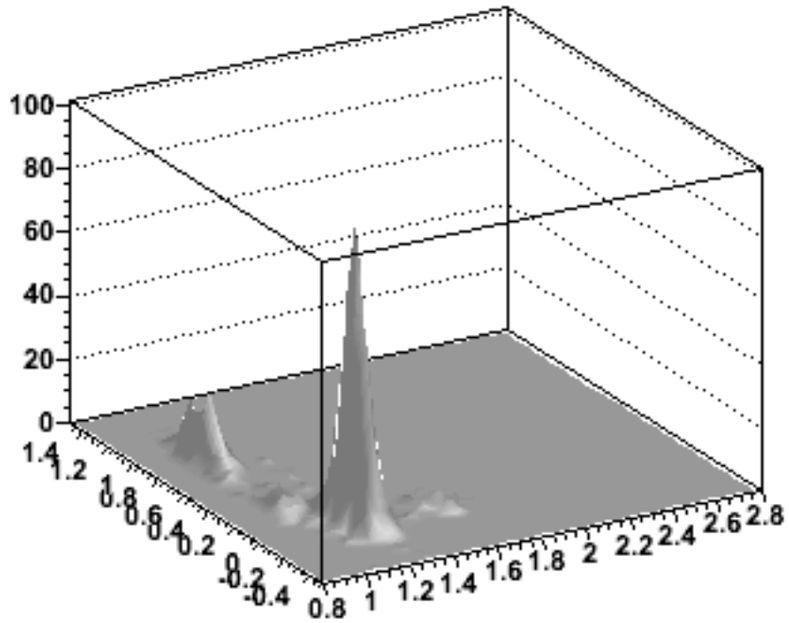
2.0<p<2.2 GeV/c



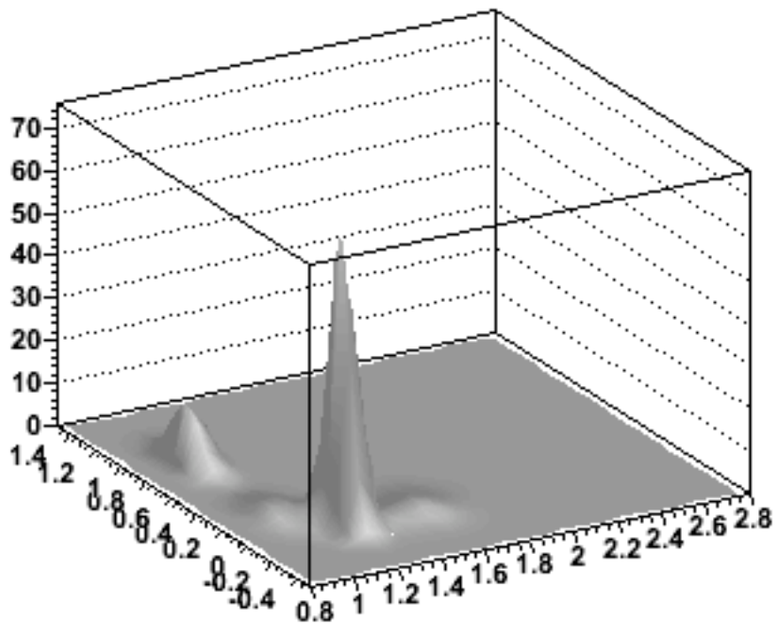


2D Fit

3.4<p<3.6 GeV/c

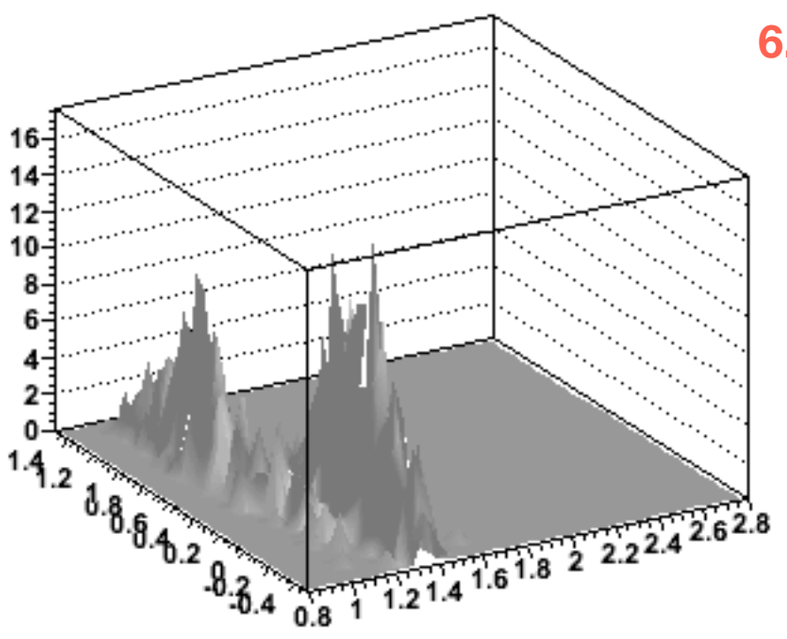


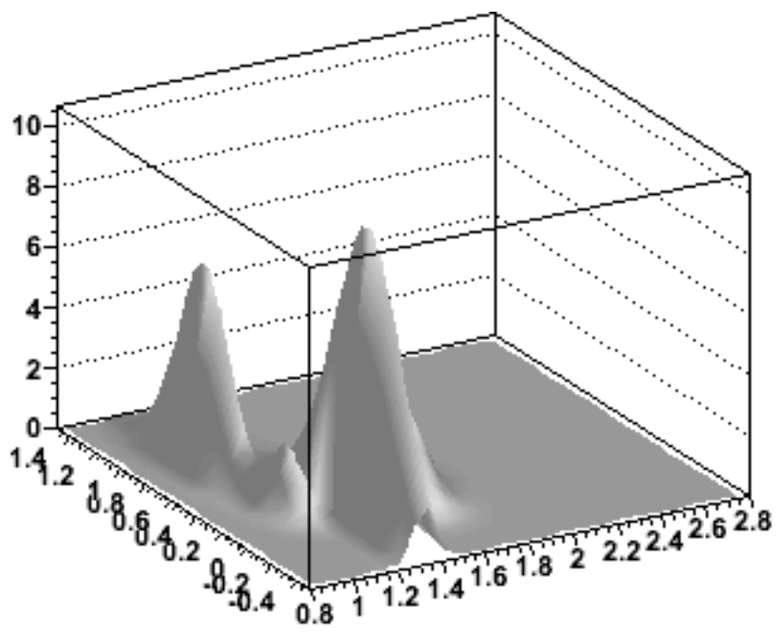
data



fit function

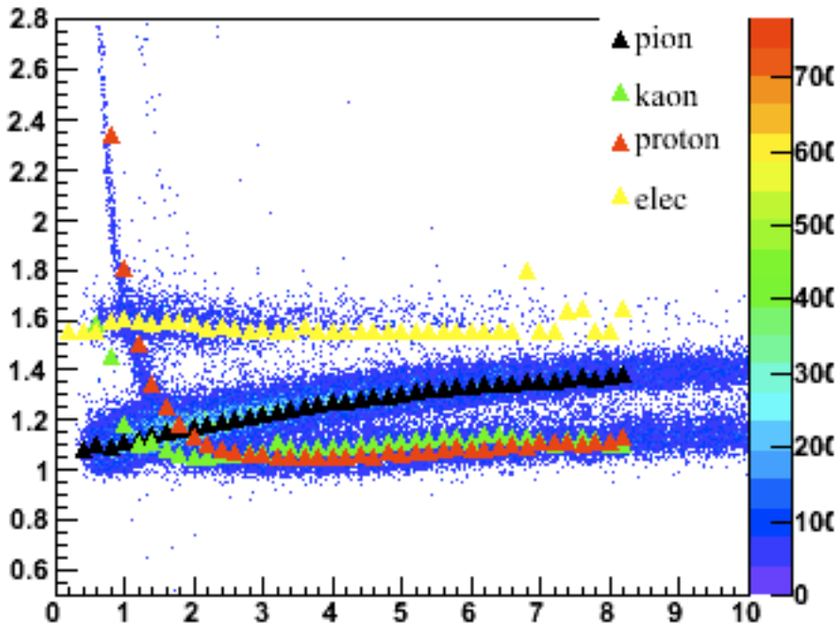
6.0<p<6.2 GeV/c



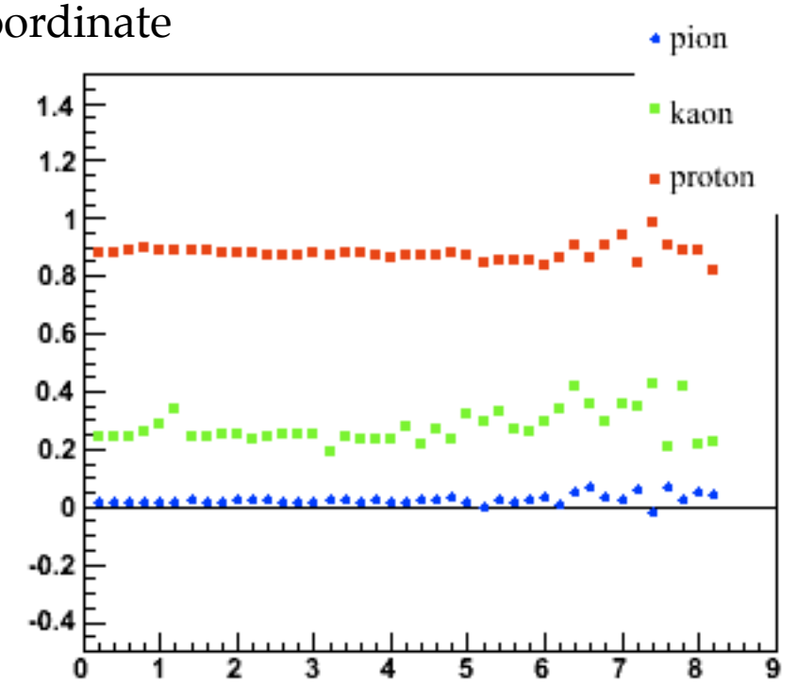


Quality of 2D Fit

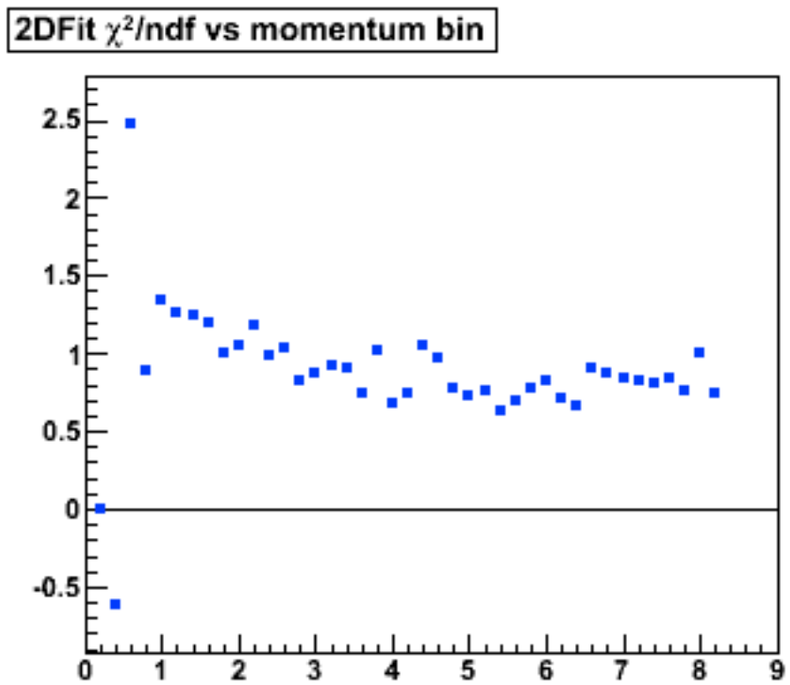
for each fit: retrieve the mean value of each gaussian function in ToF and dE/dx coordinate



mean value of gaussian in dE/dx coordinate super-imposed on real data.
Accurately reproduces the Bethe-Bloch curve



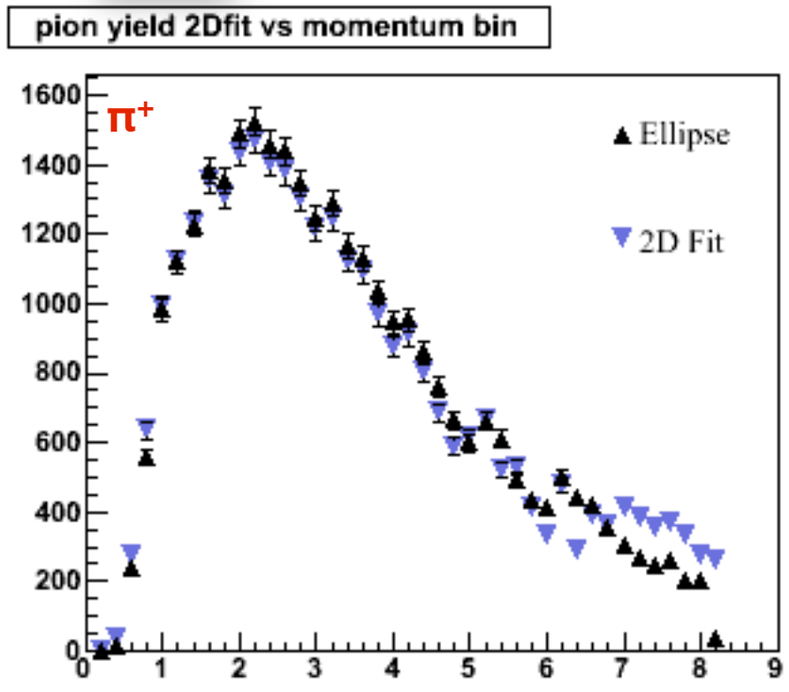
mean value of gaussian in ToF coordinate.
Stays constant at the mass squared value of each particle (as it should)



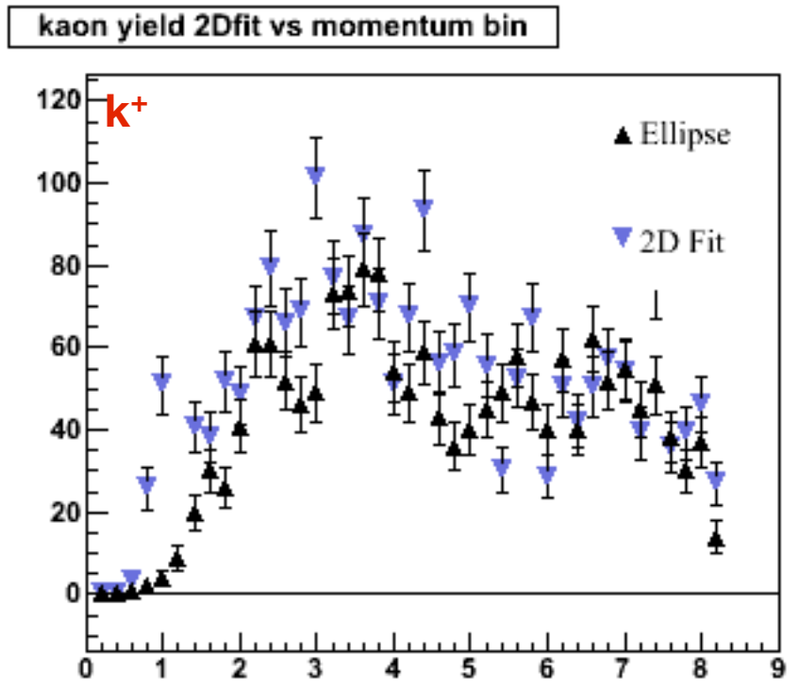
particle yields

particle yields given by fit and ellipses in each momentum bin.

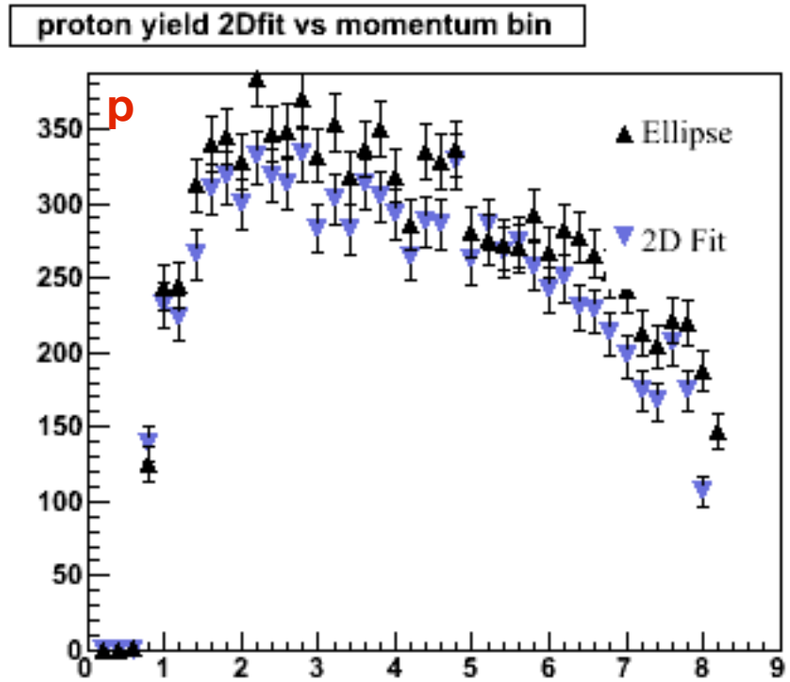
Positive tracks only



total number π^+ (0<p<8 GeV/c)
Ellipse method: 30,617
2D Fit: 30,427

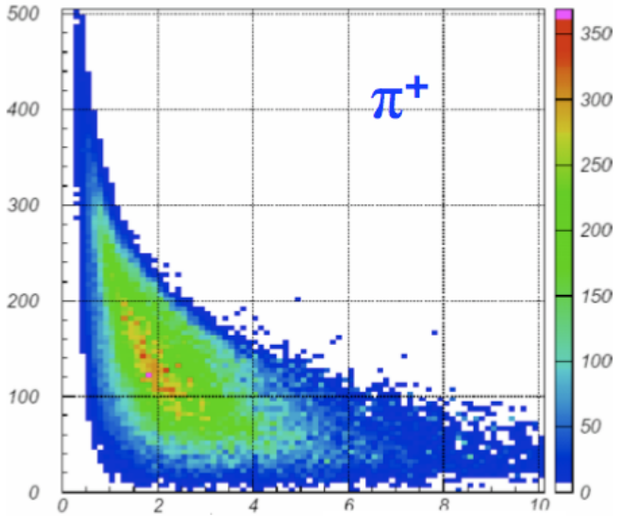


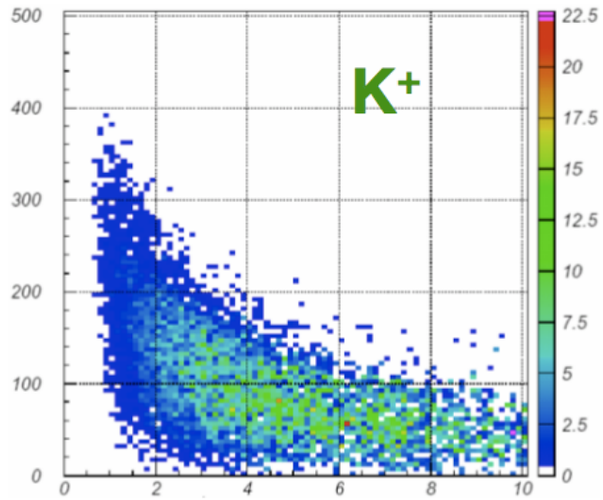
total number k^+ (0<p<8 GeV/c)
Ellipse method: 1,703
2D Fit: 2,289



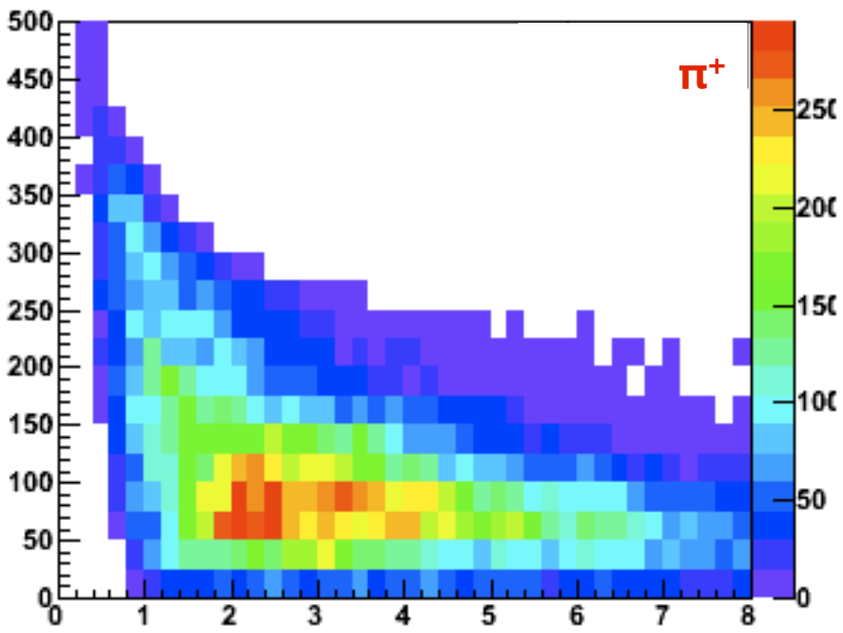
total number **p** (0<p<8 GeV/c)
Ellipse method: 10,786
2D Fit: 9,822

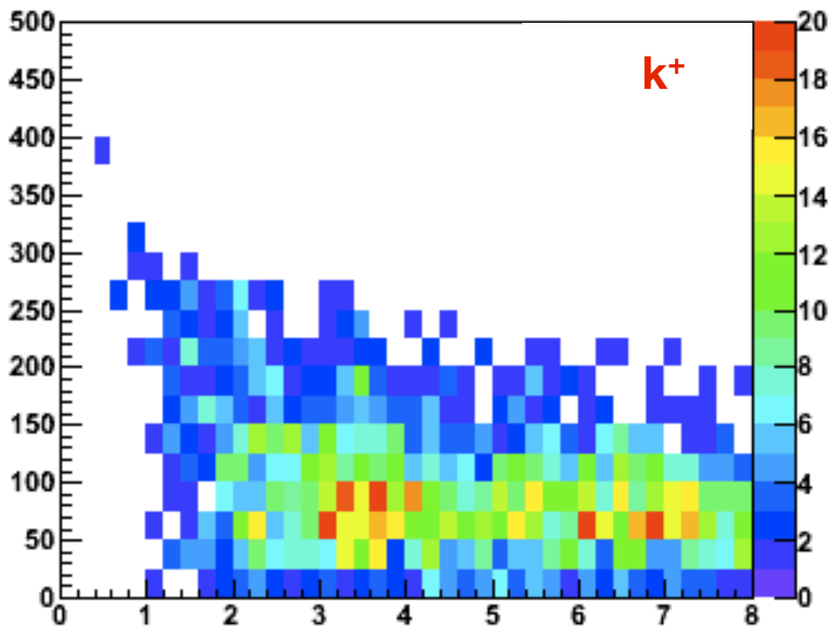
p-theta distributions with T2K binning

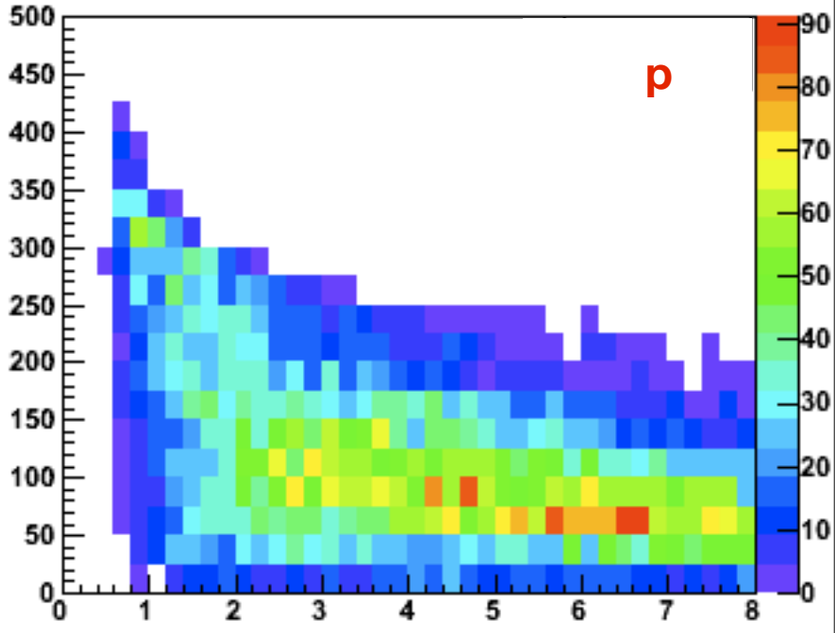




T2K Monte Carlo



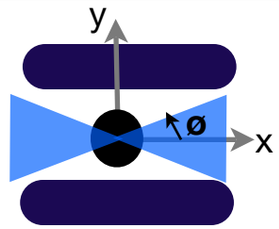


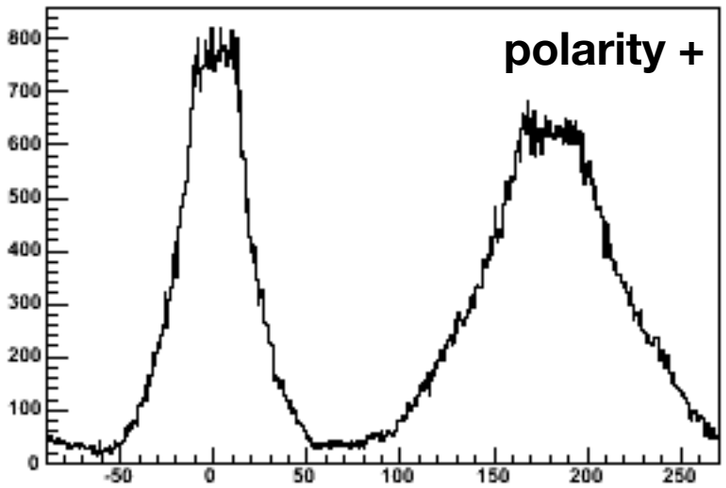


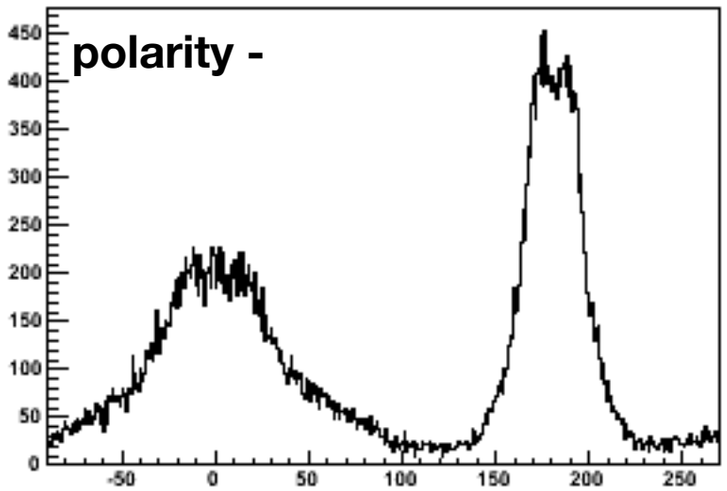
Particles identified with the 2D fit

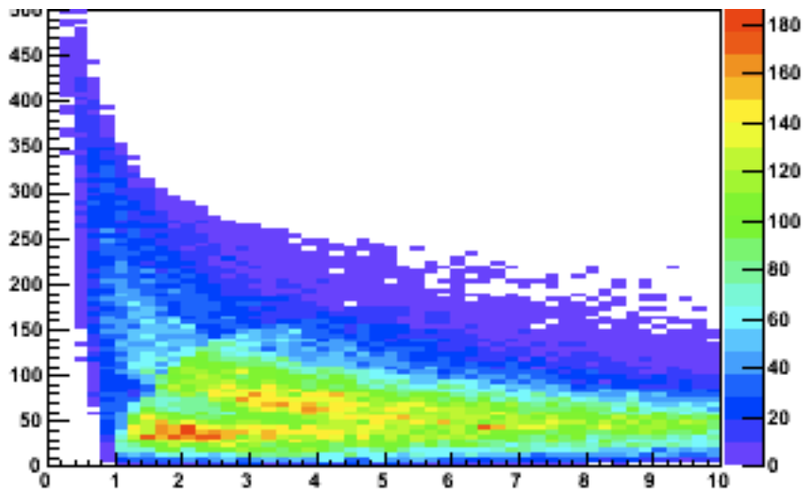
T2K requirements for 2-3 % error on F/N ratio are: at least 100 pions per bin in the T2K phase-space region..

azimuthal angle (ø) distributions

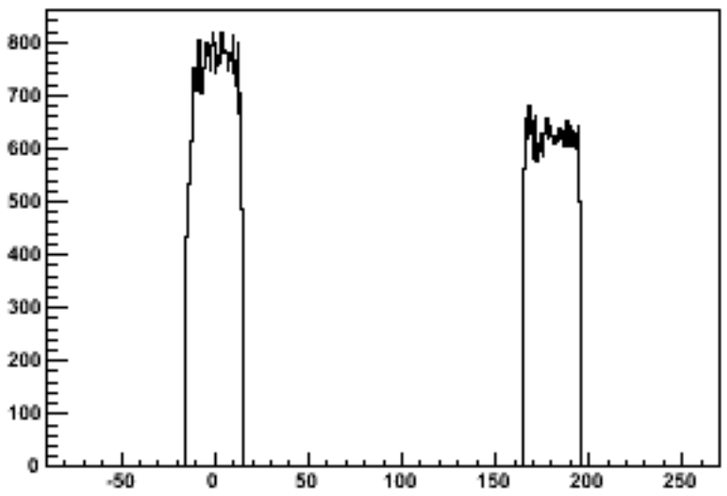


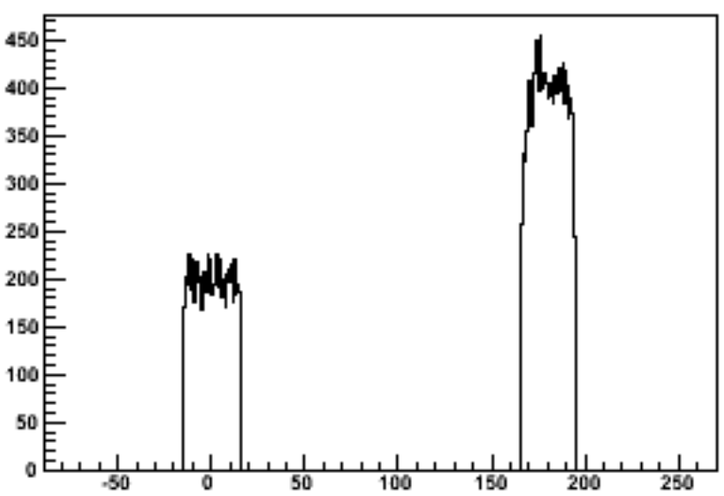


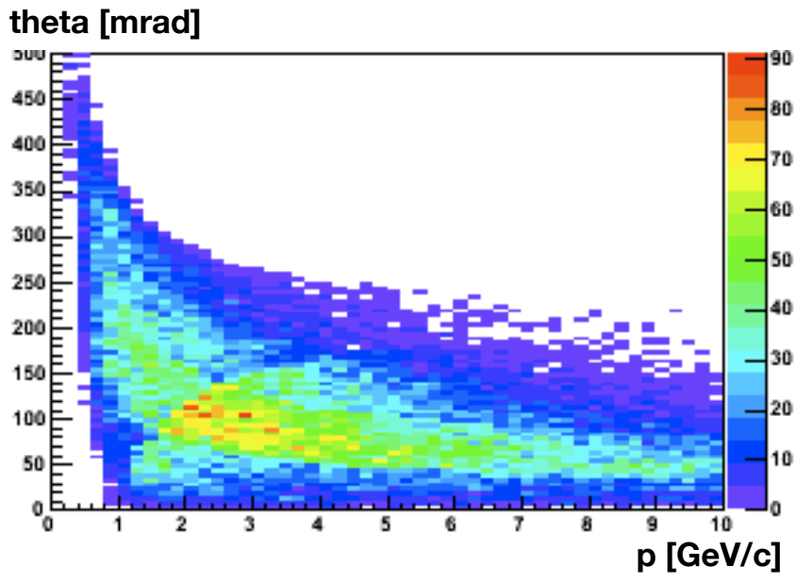




cut on ø±15° yields a (close to) 100% acceptance in each p-theta bin







the impact on statistics is high (loose approx 40%) but MC corrections are minimal in this zone

Summary and outlook

- High quality PID in NA61 using combined ToF-dE/dx measurements. We just have a new data-production with a much better dE/dx calibration=> this will further improve the PID

- The next step is to get corrected spectrums:

  -input ToF Efficiency in the MC

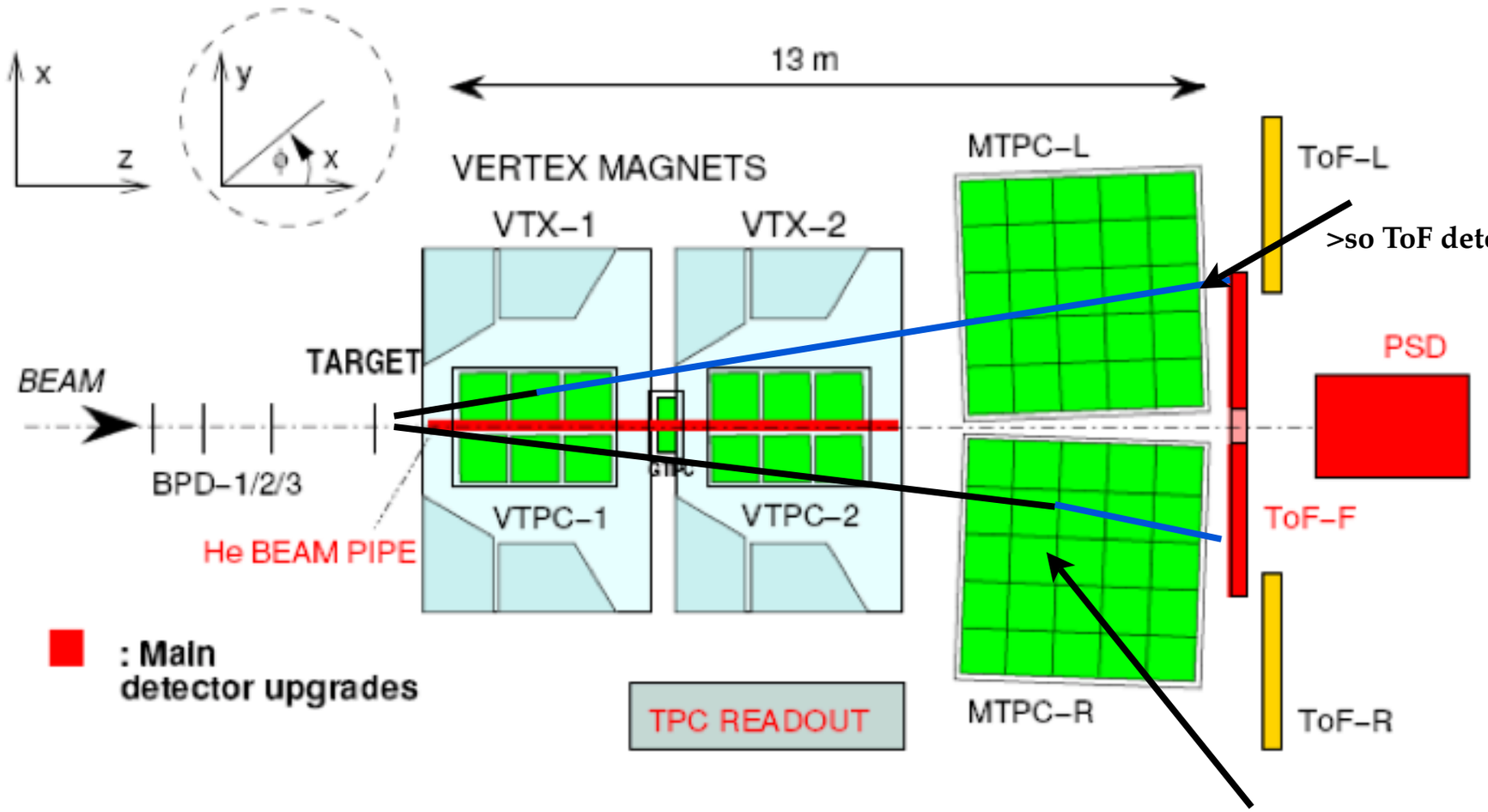
  -Reconstruction efficiency

  -Acceptance:in first approximation we can simply multiply the yields by 360/60 in each p-theta bins because acceptance is around 100% in the selected ø region. but of course MC geometrical correction will be needed for more precision.

  -Correct also for kaon decay (at 1 GeV/c 80% of kaons decay before reaching the ToF) - critical for T2K because its kaons that are responsible for the nu_e contamination in the beam

- expect corrected thin target cross-section results in spring.

at first we can think e.g at 1 GeV/c
to simply multiply the kaon yield by 5 (because only
20% reach the ToF
But it's more complicated than that!



flies as muon most of the time->so ToF detects it as muon (multiply k yield by 5 is ok)

flies as kaon most of the time->so ToF detects it as kaon (we will over-evaluate if the multiply by 5)