NA61/SHINE
SPS Heavy Ion and Neutrino Experiment

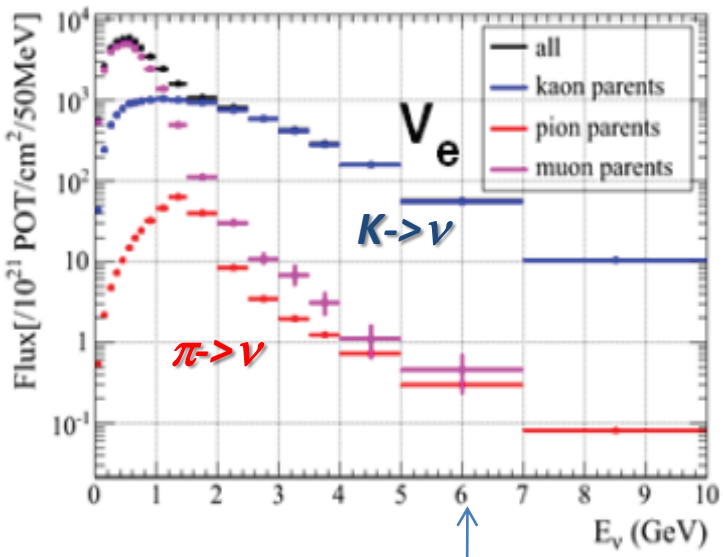
SHINE
NA61

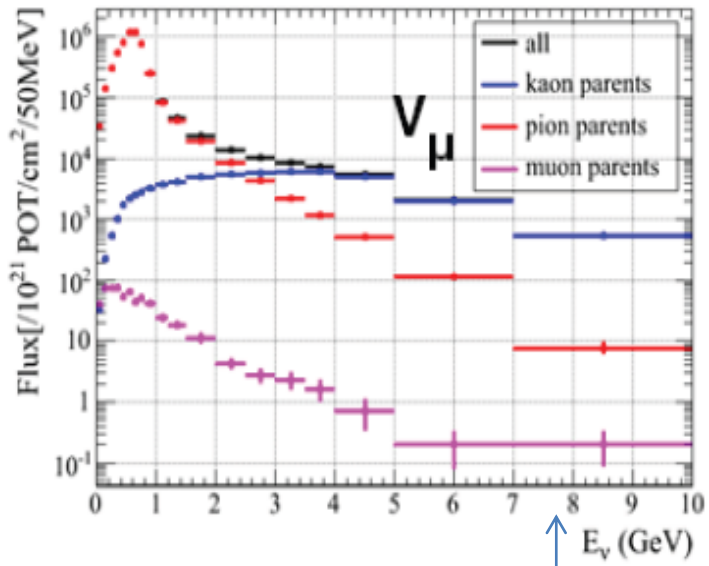
Strange Particle Measurements with the NA61 experiment

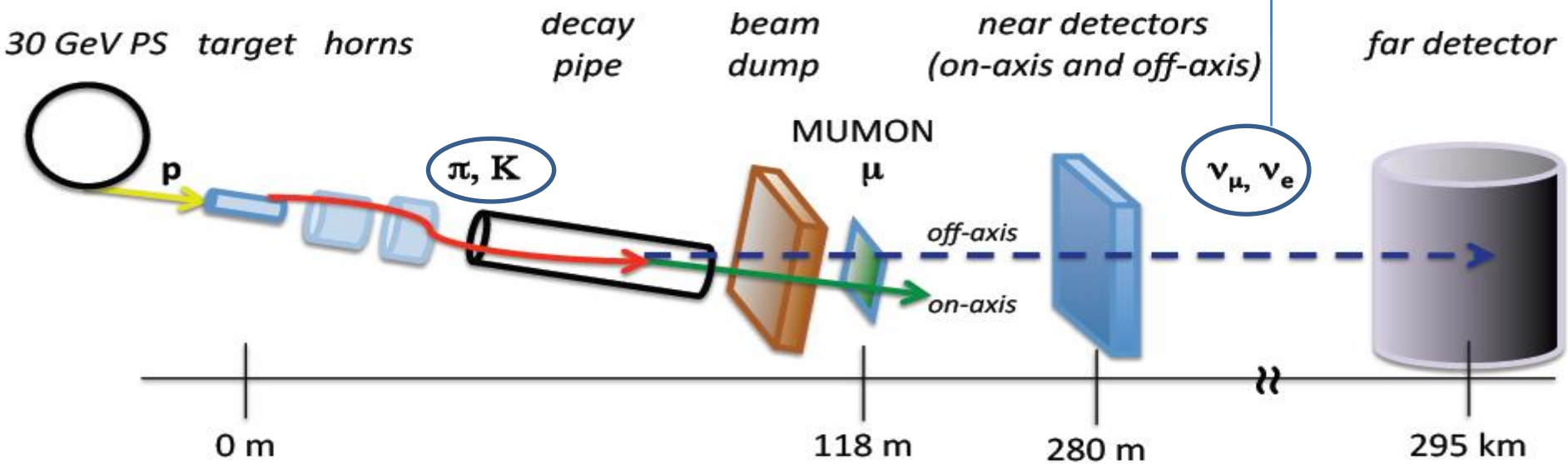
S. di Luise, ETHZ
On behalf of the NA61 collaboration

NUFACT, Université de Geneve & Cern , Aug 1-6 2011

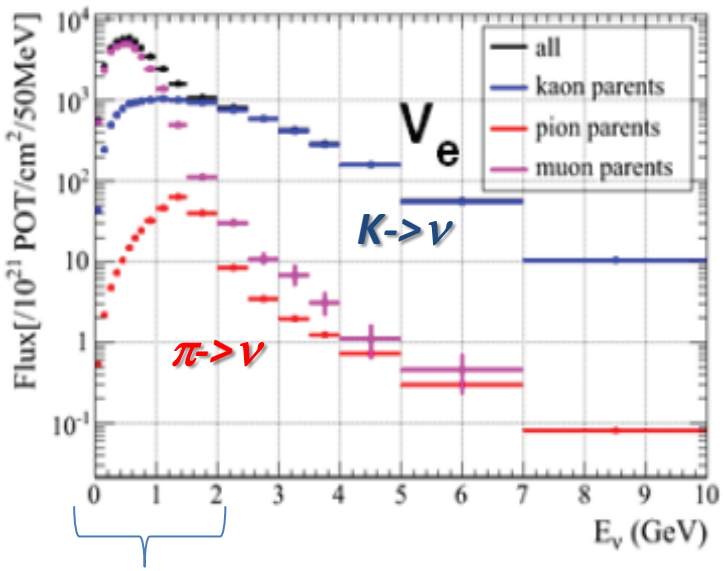
Importance of the Measurement: Kaon Contribution to the ν flux in T2K

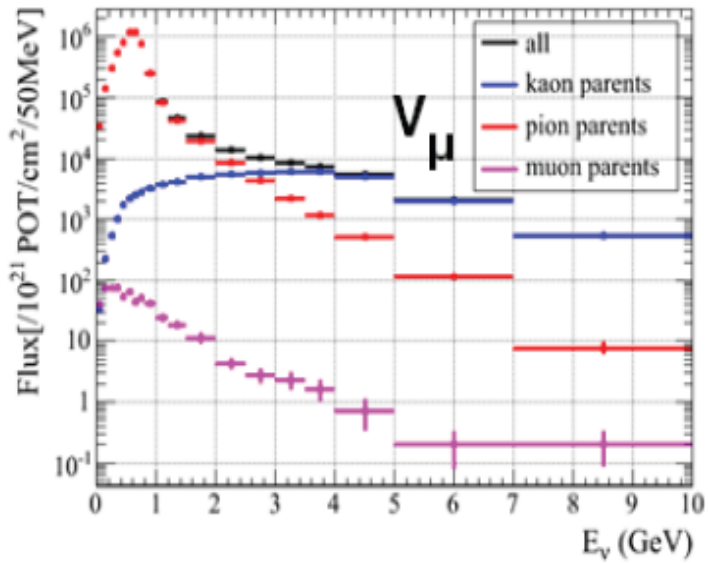


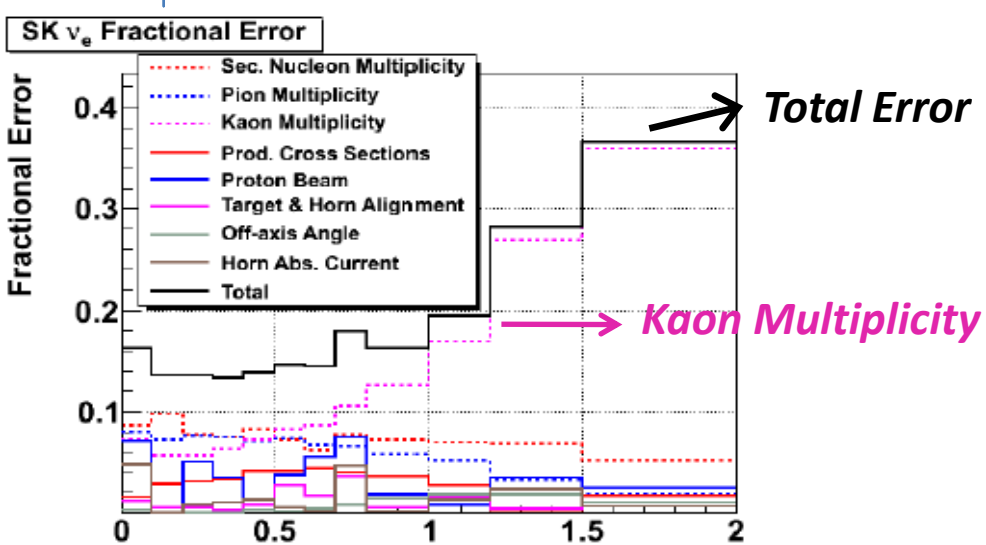


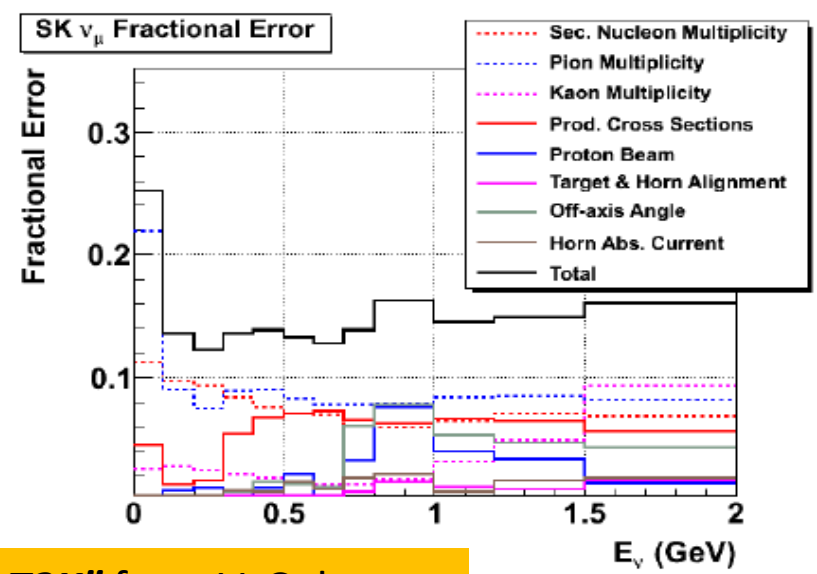


Importance of the Measurement: Kaon Contribution to the ν flux in T2K









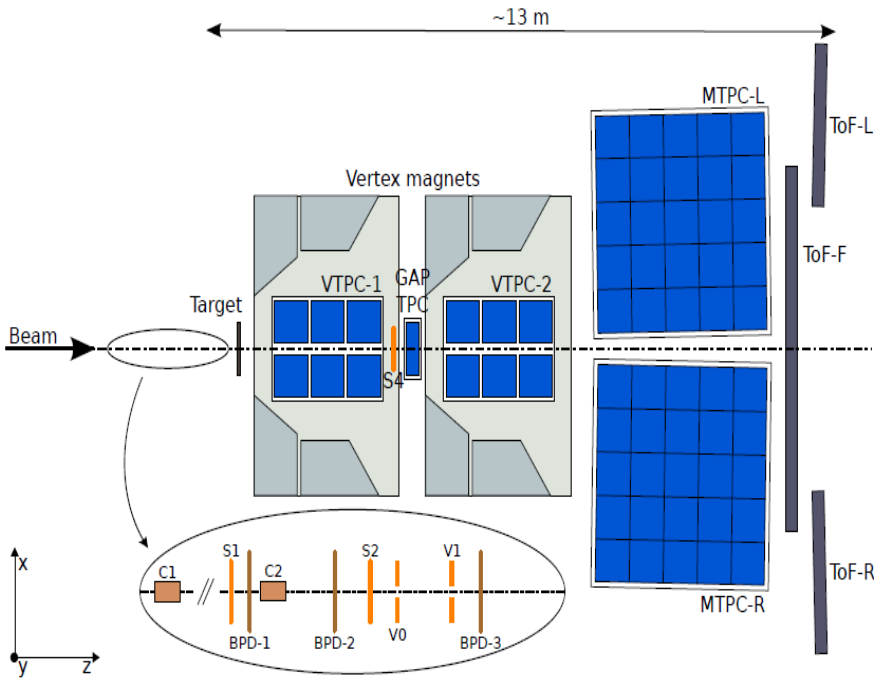
see following talk "***Predicting the Neutrino Flux at T2K***" from V. Galymov

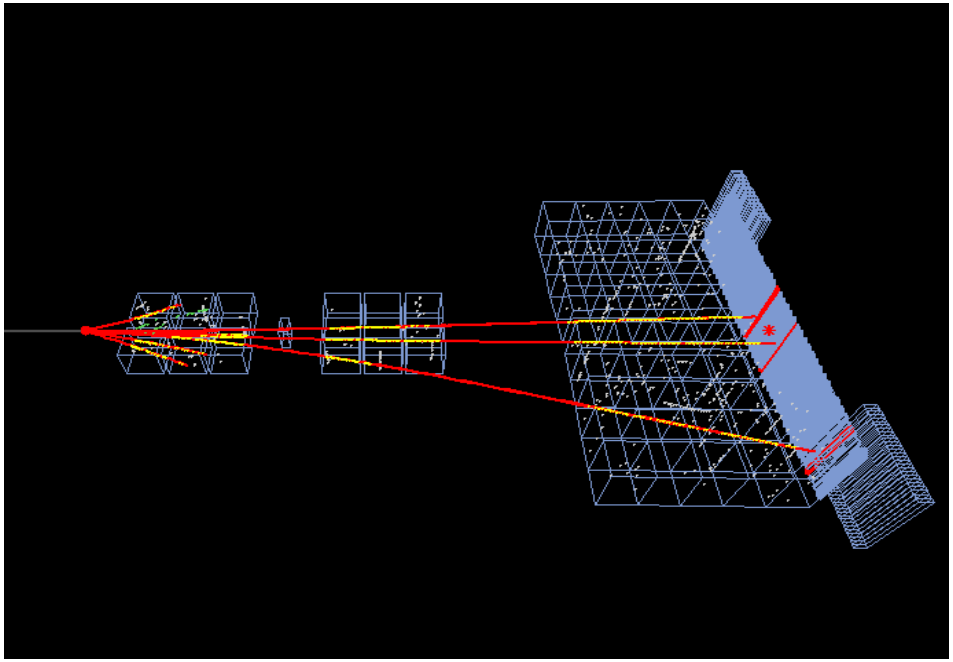
Outlook of the Analysis

- K+ Cross Section for 2007 Thin Target data -

- Goal
  - Cover most of the p-θ phase space relevant for T2K
  - Perform Cross Section measurements with Stat+Syst error below 20%

- Critical Points
  - Limited Statistics
  - Kaon Decay in Flight
  - PID at higher momentum

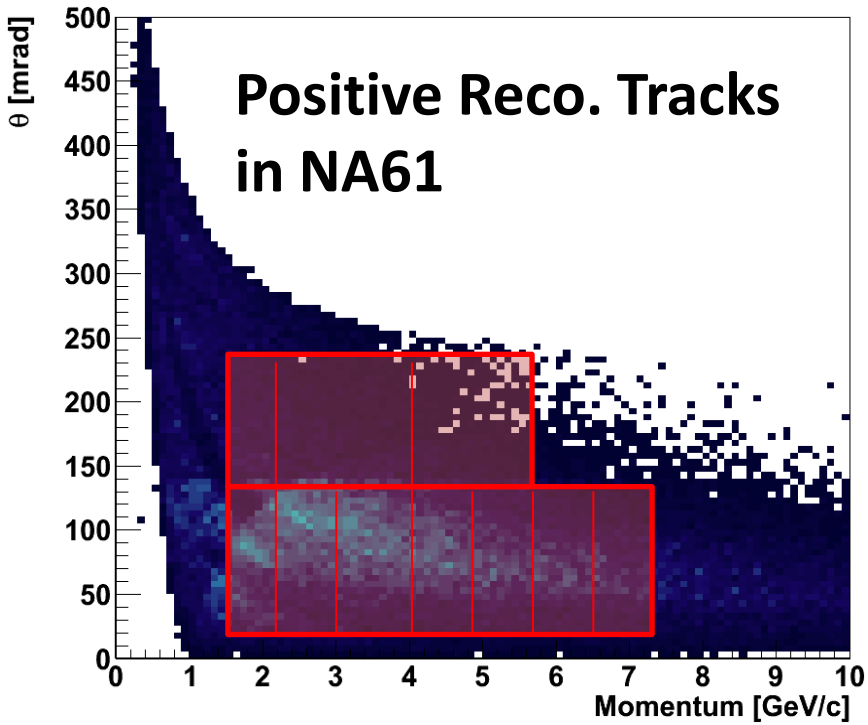


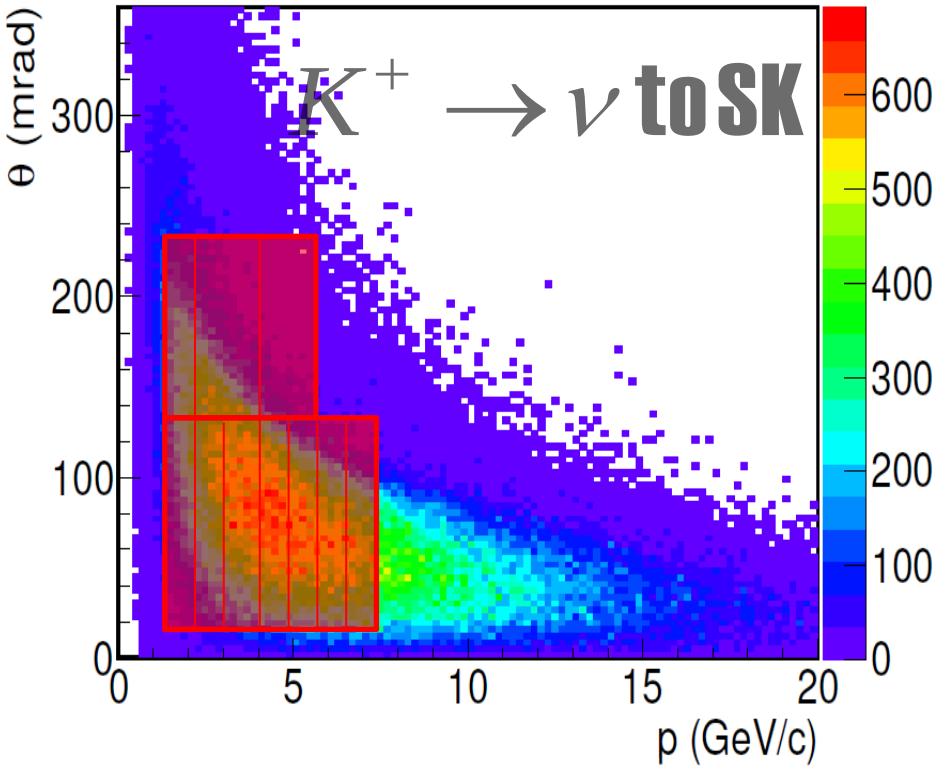


Coverage of the T2K Phase Space

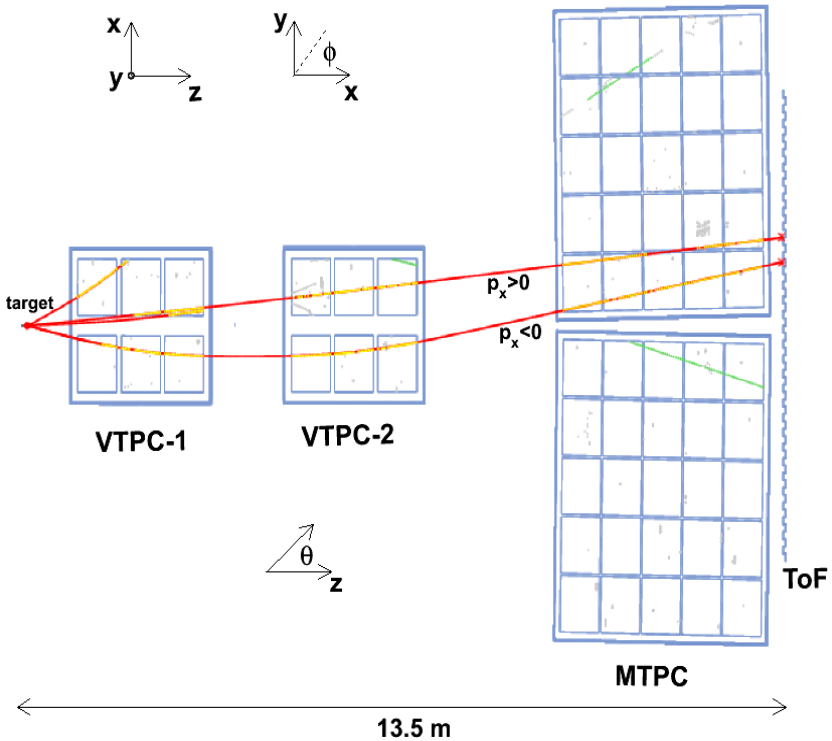
ϑ: [20,140] mrad
7 bins 0.8 GeV/c wide in the range [1.6,7.2] GeV/c

ϑ: [140,240] mrad
3 bins: 1.6,2.4,4.0,5.6 GeV/c

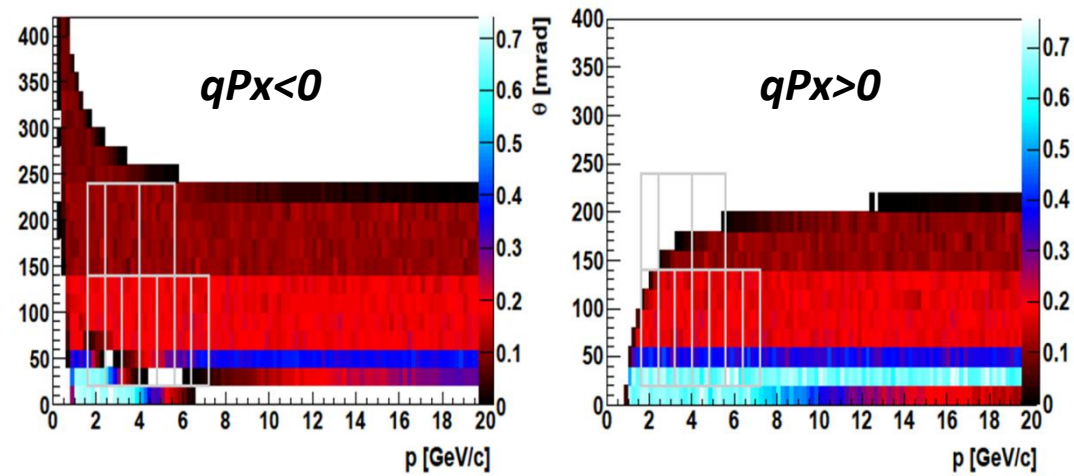




Track Selections: quality cuts

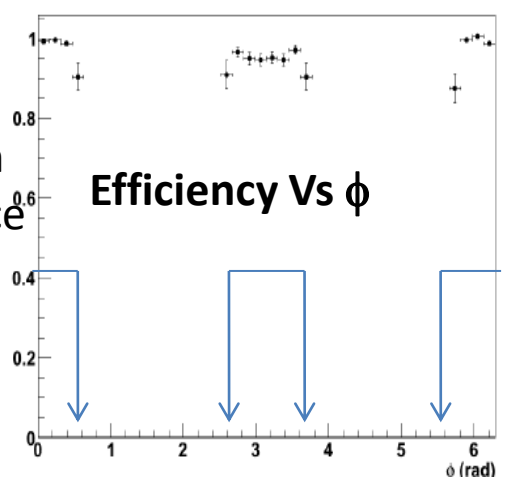


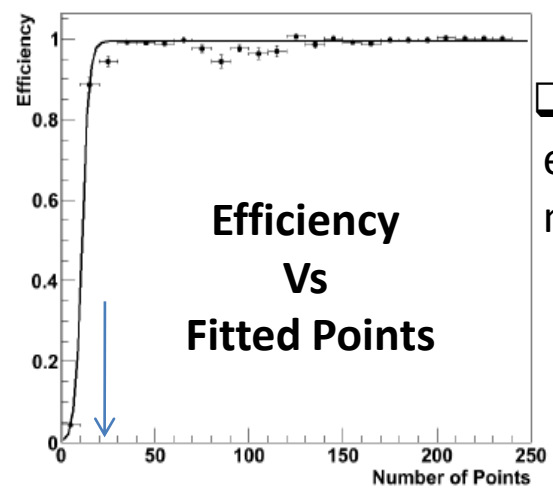
- On the p-θ phase space acceptance is very sensitive to topology



➢ the two subsamples treated separately

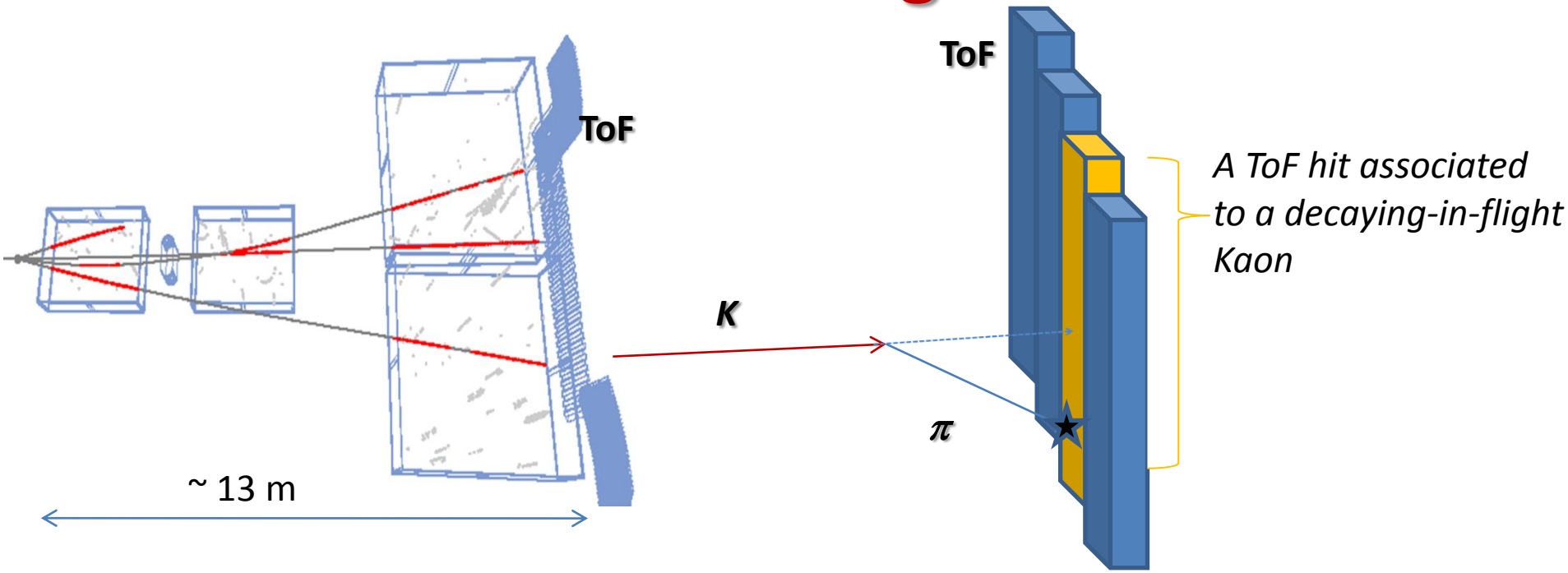
- On the transverse plane reconstruction limited by acceptance





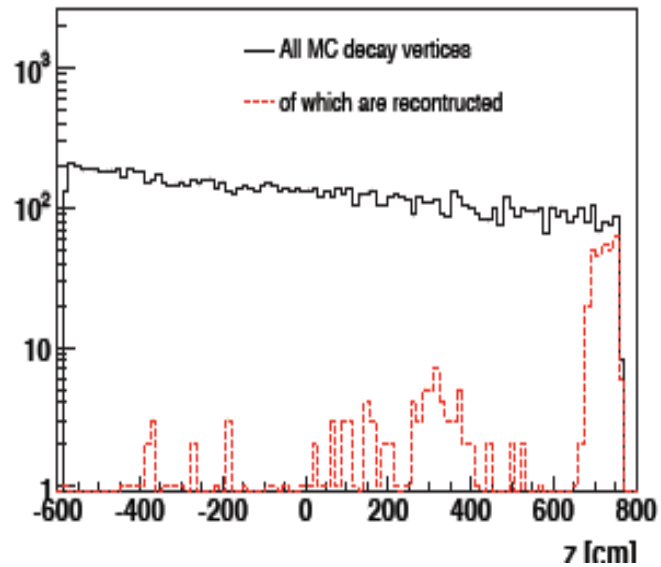
- High Reconstruction efficiency Vs number of points

Track Selections: dealing with Kaon DiF

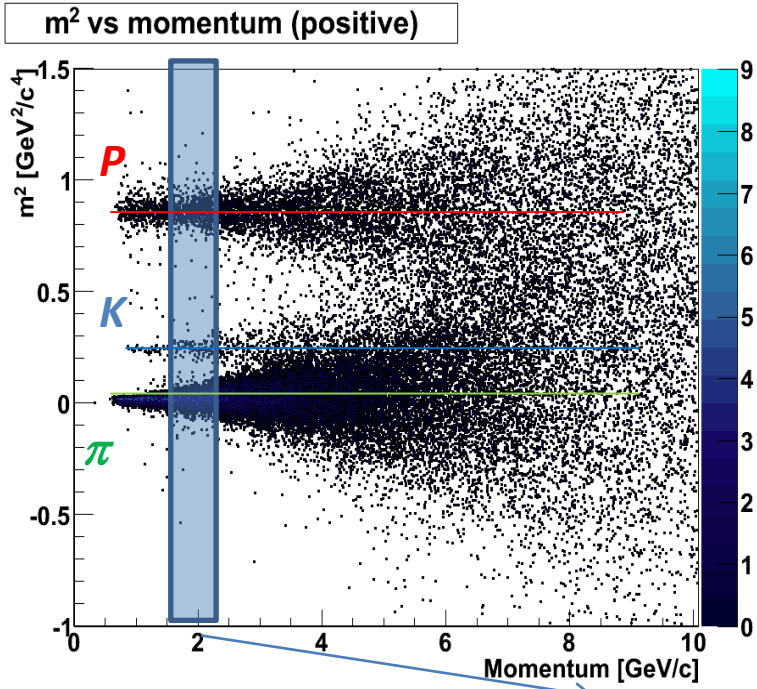


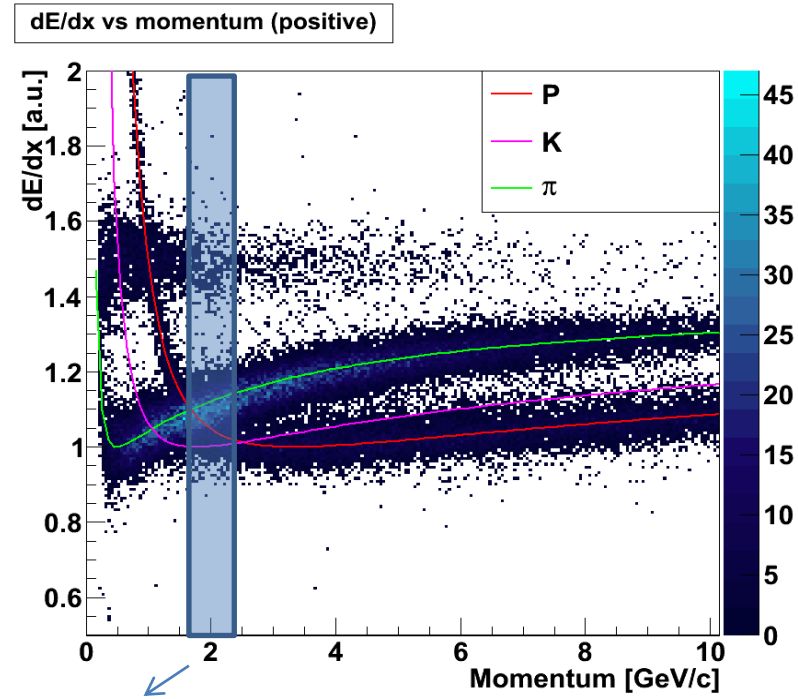
- Decay in Flight of Kaons into π's,μ's
  - ToF and/or dE/dx biased

- Suitable cut: selection of "**long tracks**"
  - High rejection of DiF Kaons
    - Less statistics
    - High purity
    - Analytical correction can be applied
    - Systematics under control

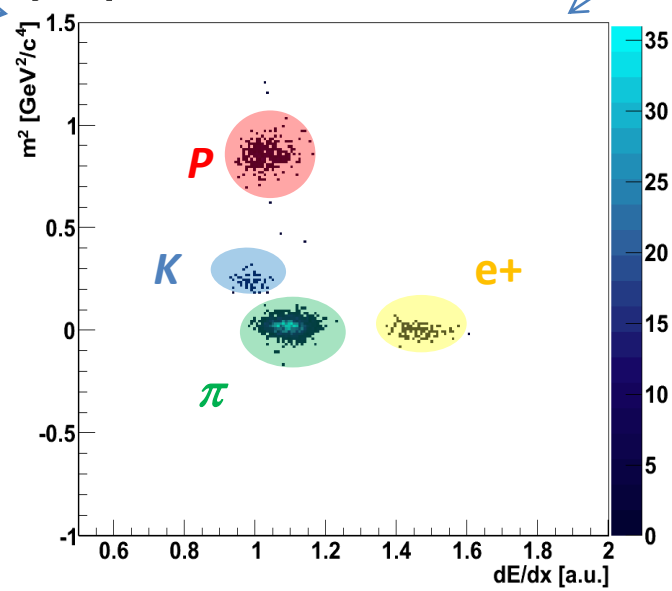


Particle Identification



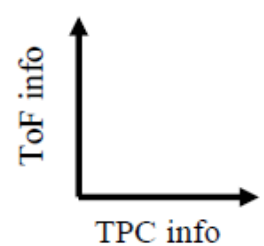


Combined *ToF* and *dE/dx* Information needed for *Particle Identification* in the analysed momentum range



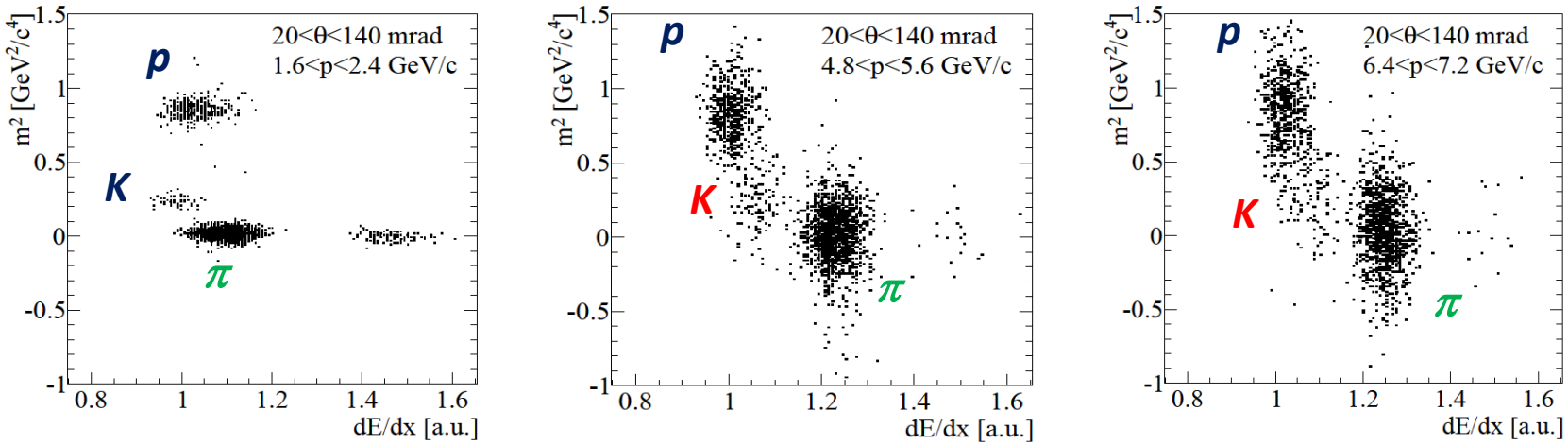
$$\sigma\left(\frac{dE}{dx}\right)/\left\langle\frac{dE}{dx}\right\rangle \approx 3\%$$

$$\sigma(ToF) \approx 120\ ps$$

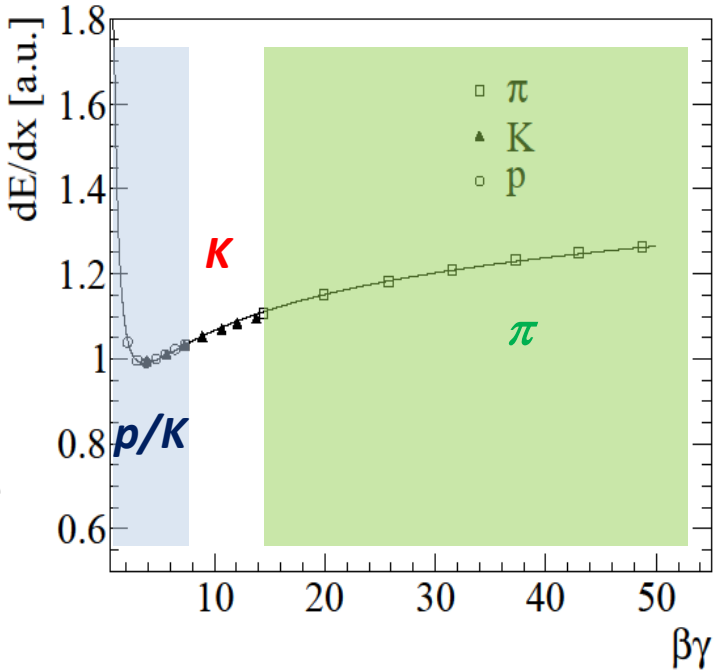


dE/dx Parametrization From Data

Kaon Yield extraction stability critically depends on the constraint on the dE/dx peak position



- ***Low βγ***: ***p/K*** of low-mid momentum
- ***Intermediate βγ***: ***K*** of high momentum
- ***High βγ***: ***π*** whole momemtum range



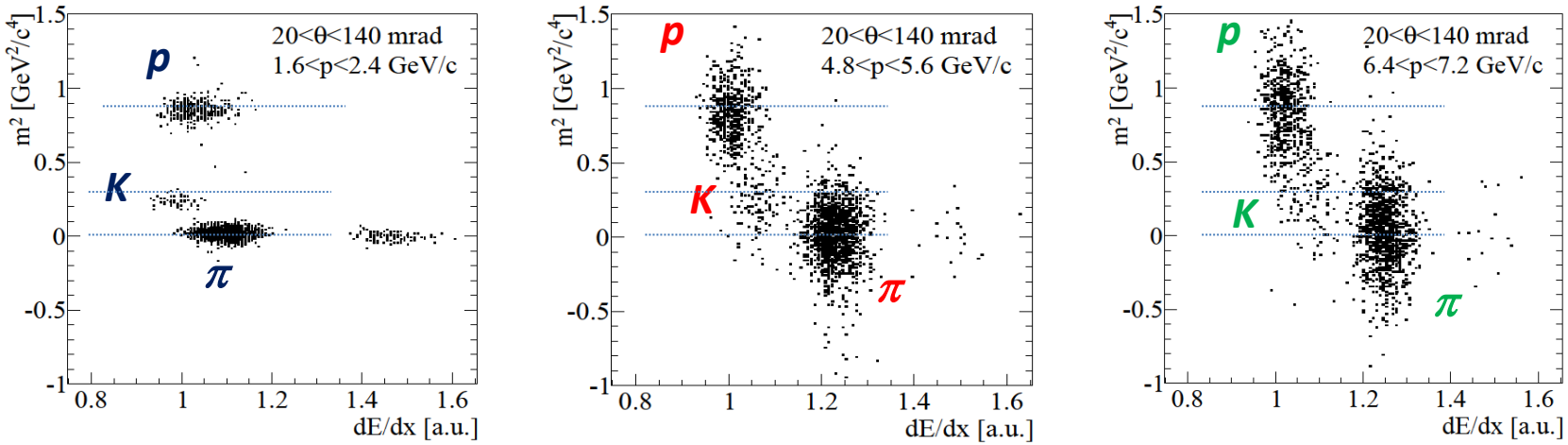
Bethe-Bloch fit to dE/dx measurements in βγ regions where peak separation power is maximal

Precision dE/dx prediction in βγ region where peaks overlap

m^2 Parametrization From Data

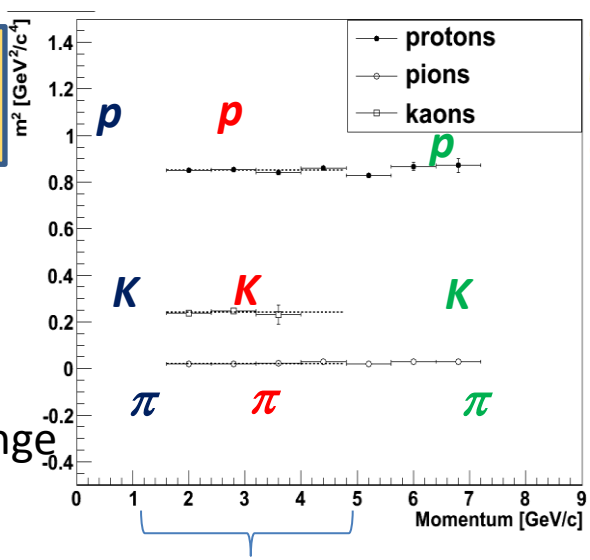
Kaon Yield extraction stability critically depends on the constraints on the m^2 distributions

m^2 resolution ~ p^2 → high separation power at low momenta

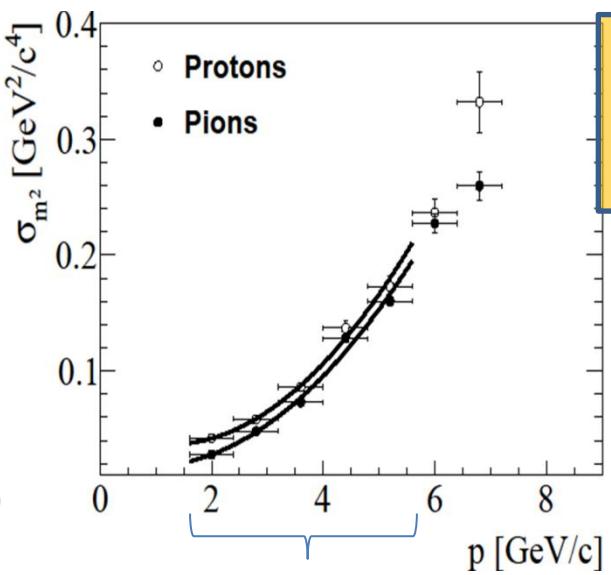


m^2 central value is stable vs mom

Peak Positions fixed over the whole mom. range



Fit



Fit

Resolution function extracted from the data

Peak Widths extrapolated at higher momenta

Kaon Yield Extraction

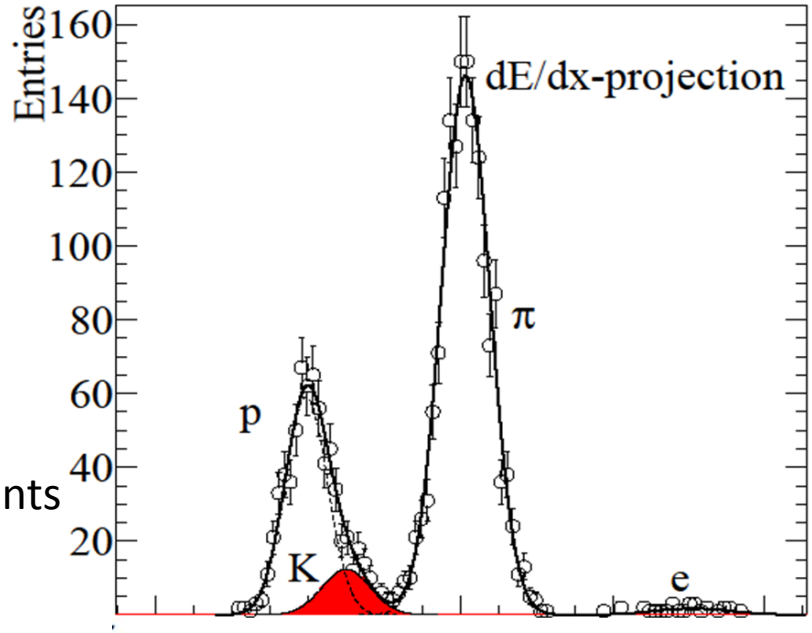
- Model: Superpostion of 4 2D Gaussians

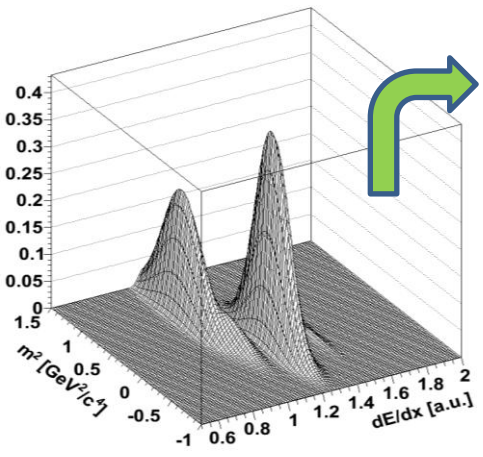
dE/dx

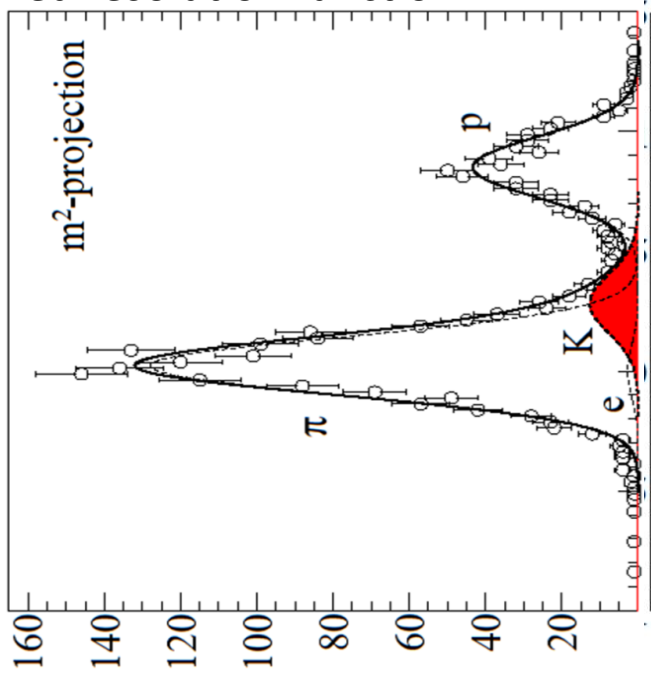
- Peak Positions: <dE/dx> calculated from the measured Bethe-Bloch parametrization
- Peak Width: σ(dE/dx) same for all the hadrons set as a free fit parameter
  - smearing due to bin size taken into account

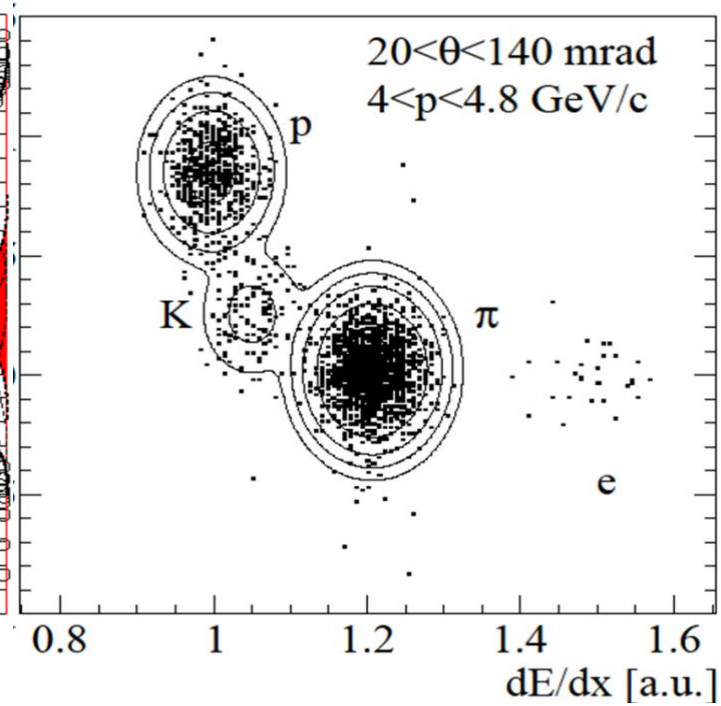
ToF

- Peak Positions: $\langle m^2 \rangle$ extrap. from measured points
- Peak Widths: $\sigma(m^2)$ calculated from the measured resolution function







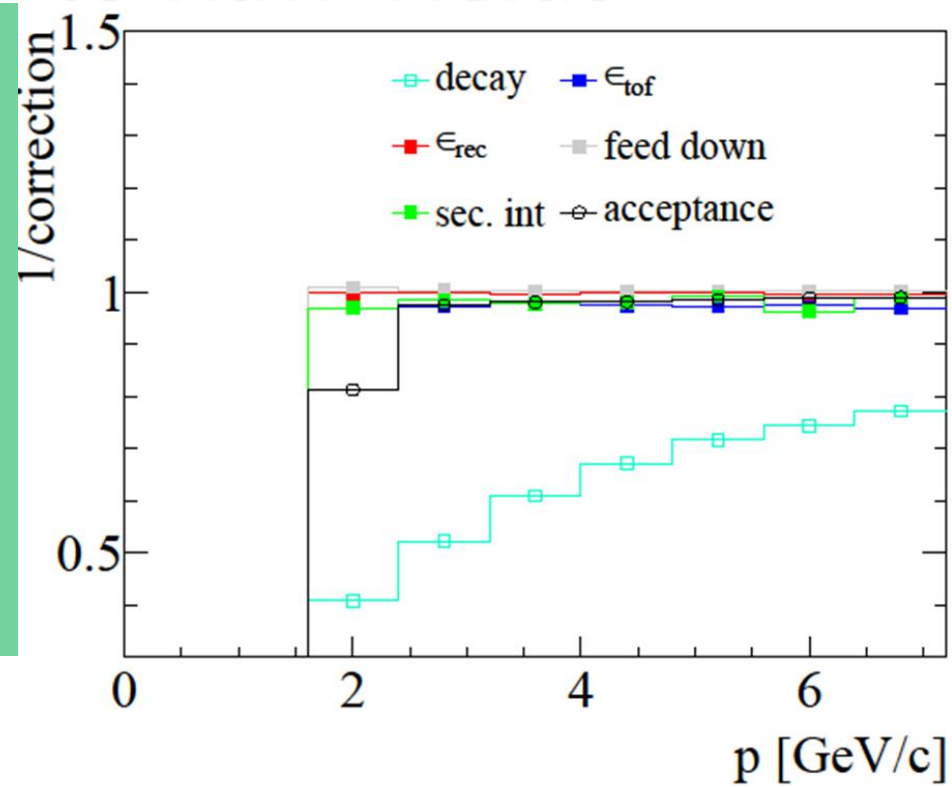


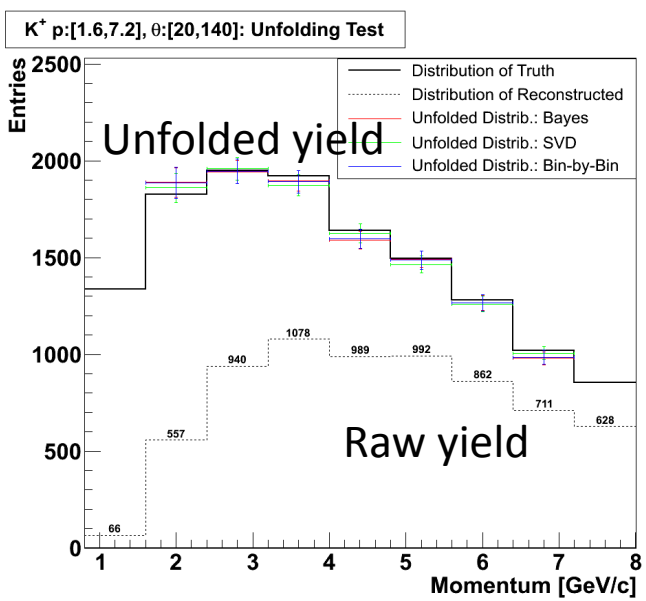
MC Correction to Raw Yields

- Major Contribution:
  Correction for the
  Decay in Flight of the Kaons

Others correction: below 10%

- Reconstruction Efficiency maximized
  at track selection level
- Feed Down
  (contamination of K's from e.g. Weak decays)
  →negligible
- Acceptance below 90% only in the first bin:
  optimized with track topology selection

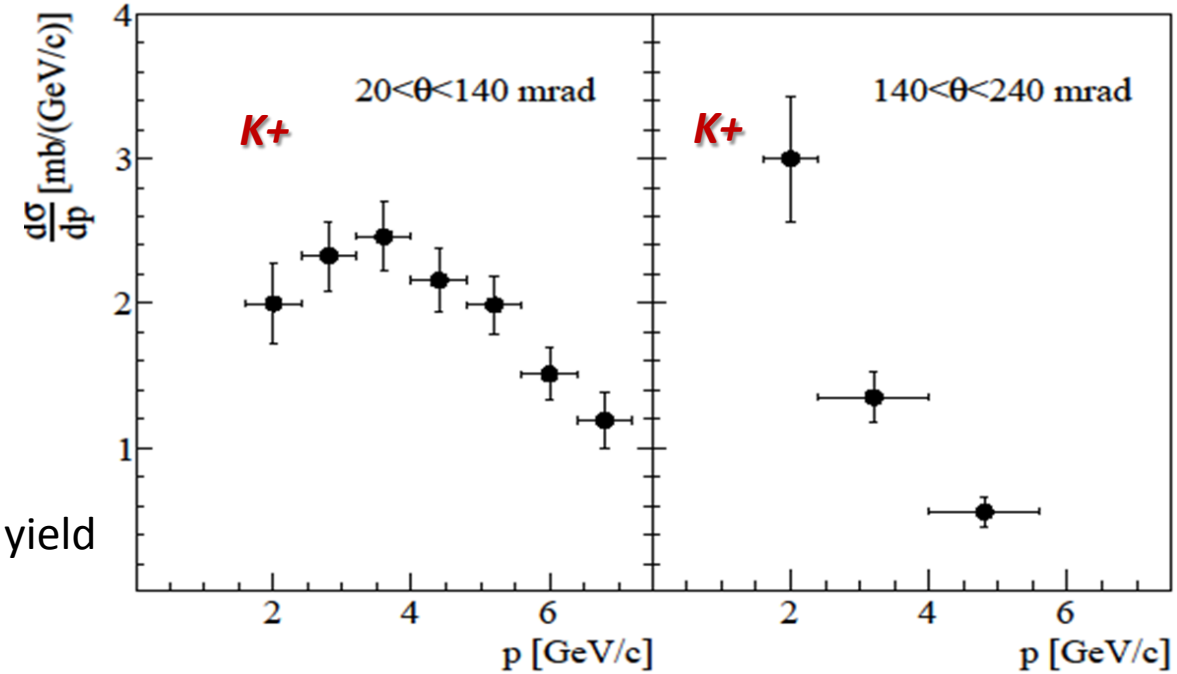




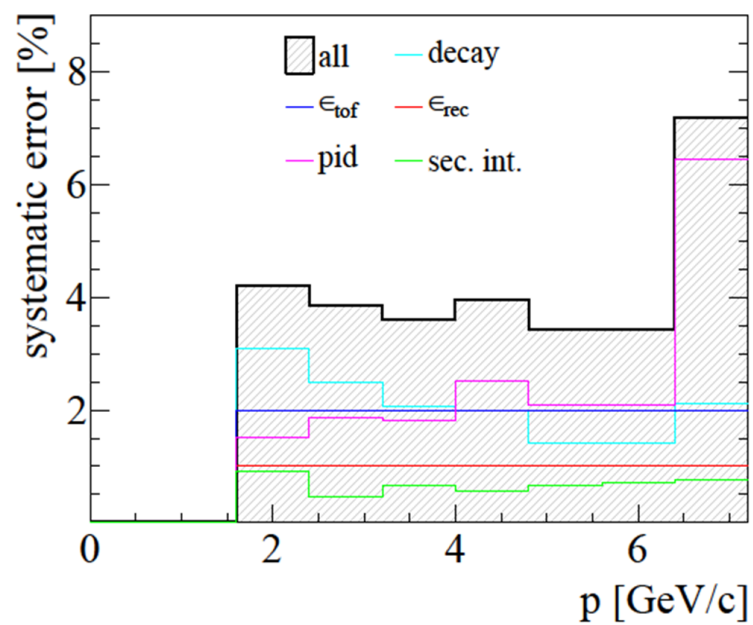
- Several Unfolding Algorithm Compared:
  Bin-by-Bin, Bayes, SVD. -> different results are consistent:
  bin-bin migration effect is under control
- Unfolding predictions tested on independent MC samples:
  -> no evidence for biases

Kaon Cross Section end Errors

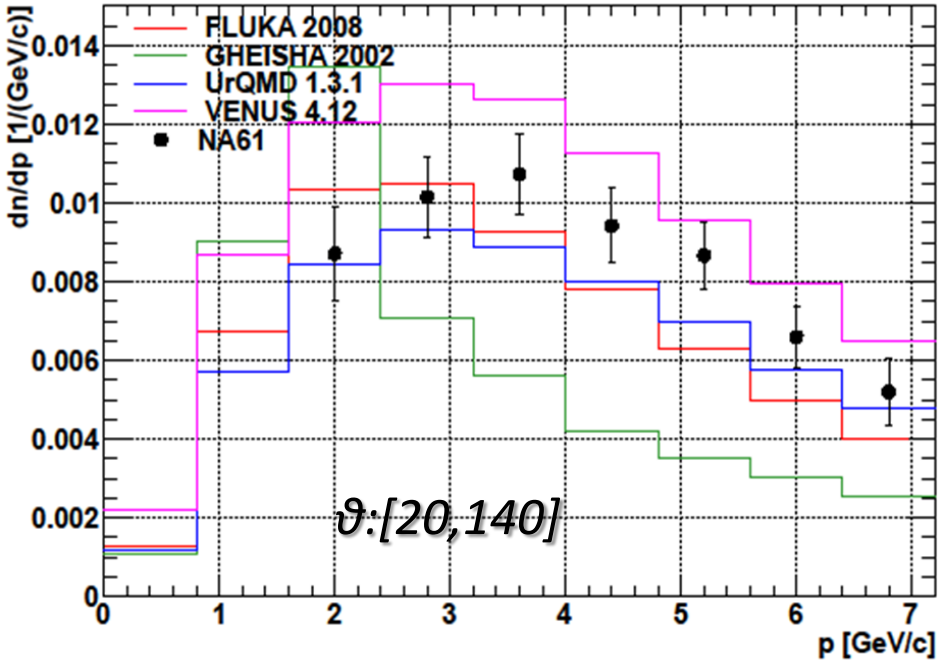
- Total Error: below 20%
- Limited Statistics: 1-3x10^3 tracks per bin.
  - Statistical Error ~ 12 %
- Systematics: 3-7 % dominated by
  - PID: bias on the fit to particle yield
  - Correction for Decay in Flight

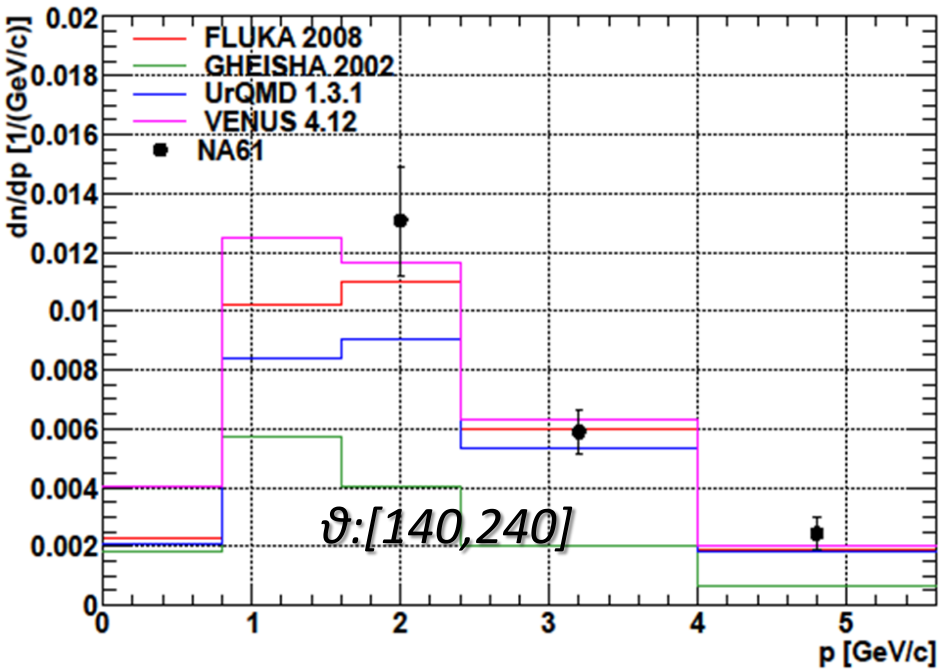


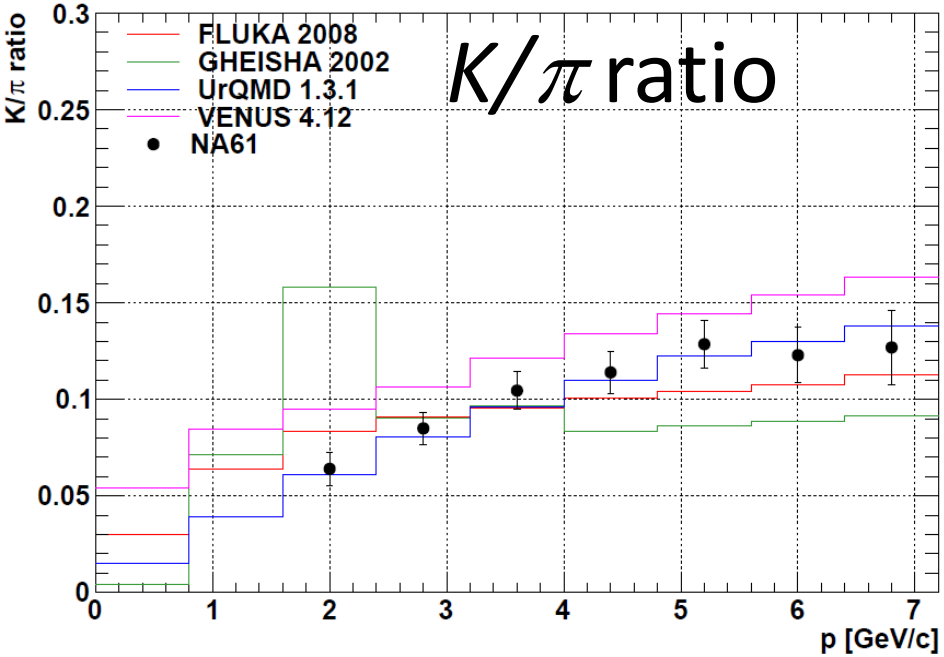
- Estimation of Systematics
  - PID: fit systematics calculated from the sensitivity to the input dE/dx and m² parameter setting
  - Decay:
    - Effect of mis-reconstructed kink topologies.
    - Effect of model dependent momentum distribution

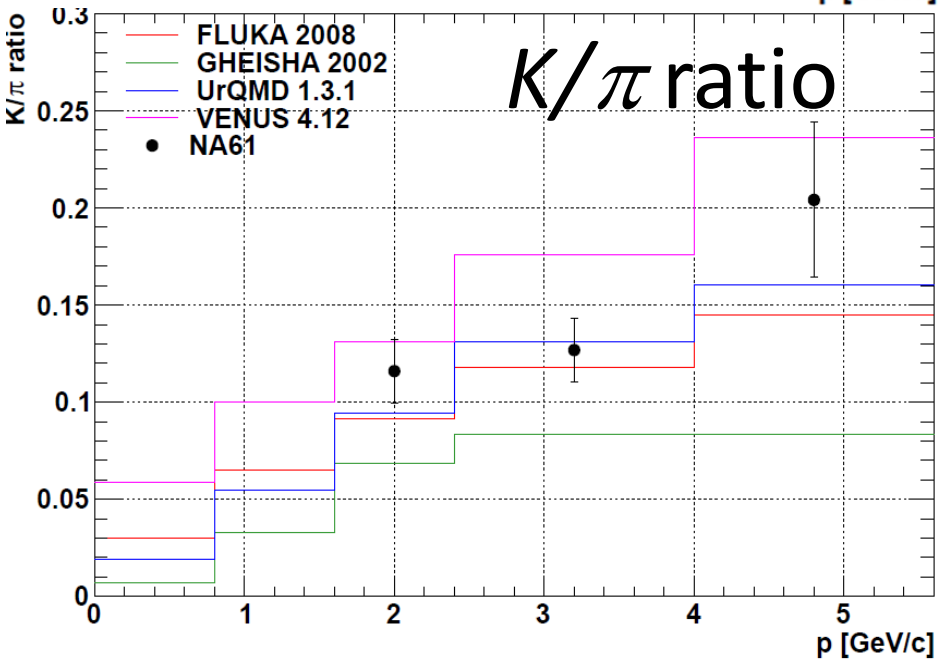


Comparison to MC Predictions



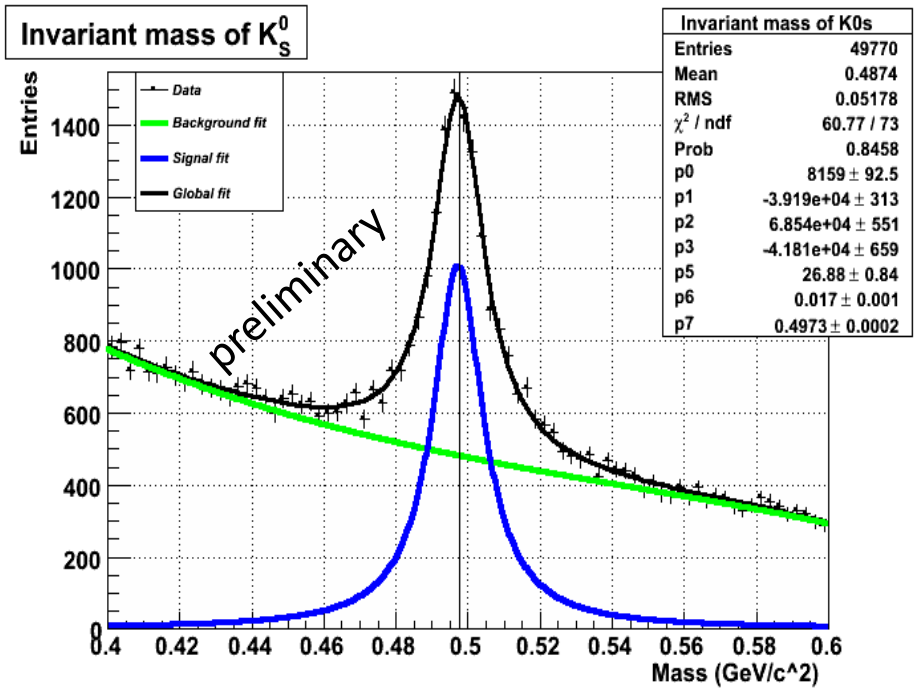


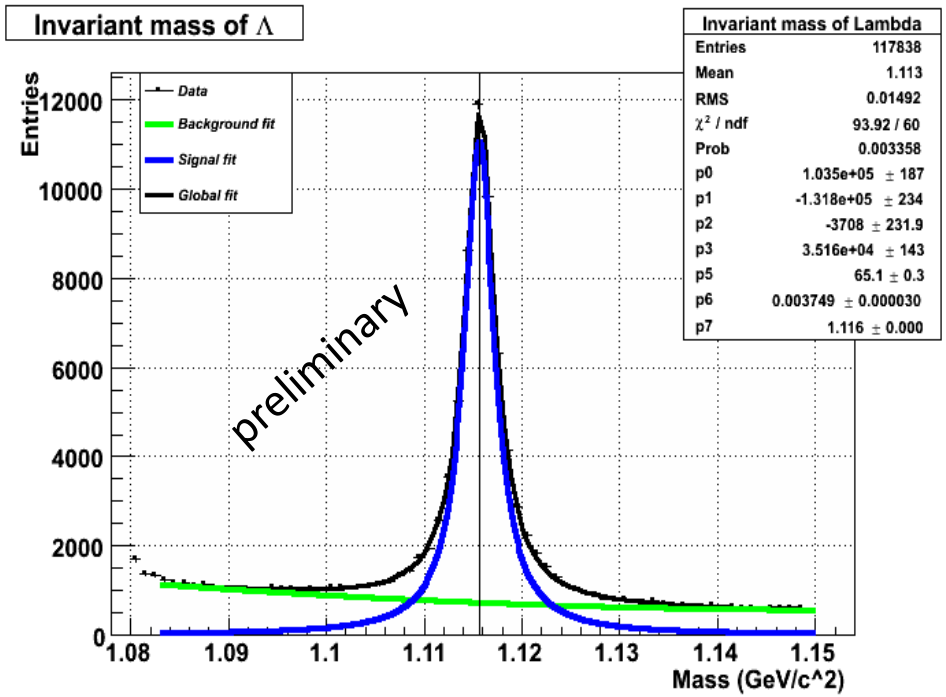




K^0s' and Lambda's with 2009 data

- The 4.5 M events of the 2009 (Thin Target) dataset have been processed.
  - K^0s and Λ signals extracted with a *B-W + Polynomial* fit to invariant mass distributions.
    No PID.





General Selections

- Event Quality Cut -> Good Fitted Primary Vertex
- Acceptance and Efficiency -> Cut on Decay Angle
- Presence of a displaced V0 vertex -> cut on vertex longitudinal position

Conclusions

NA61/SHINE
SPS Heavy Ion and Neutrino Experiment

- ❑ Measurement of the Charged Kaon Differential Cross Section
  - important for the determination of the high energy tail of the neutrino flux in the Long Baseline Neutrino Exp. T2K

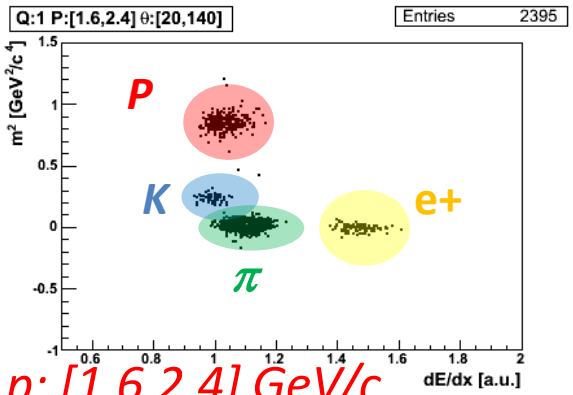
    (→ talk "***Predicting the Neutrino Flux at T2K***" from V. Galymov)

- ❑ Kaons from Low Statistics Pilot-Run
  - K+ production Cross Section results released
  - Coarse p-θ binning
  - Statistical error below 15%.
  - Systematic error below 10%, dominated by PID
  - Paper in preparation

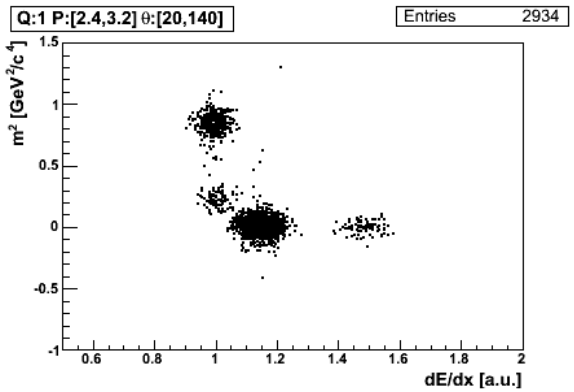
- ❑ Ongoing Analysis on the High Statistics (x10) Dataset
  - Calibration almost finalized
  - Whole dataset (~5M events) processed
  - First K^0s and Λ mass spectra very promising
  - Perform K+ Cross Section Analysis with
    - Refined Binning
    - Improved Errors

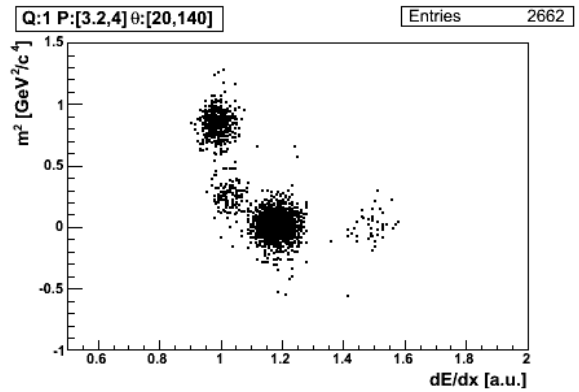
backup

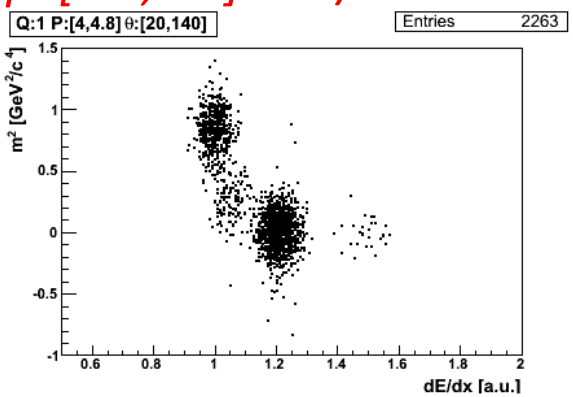
dE/dx-m² correlation in Raw Data

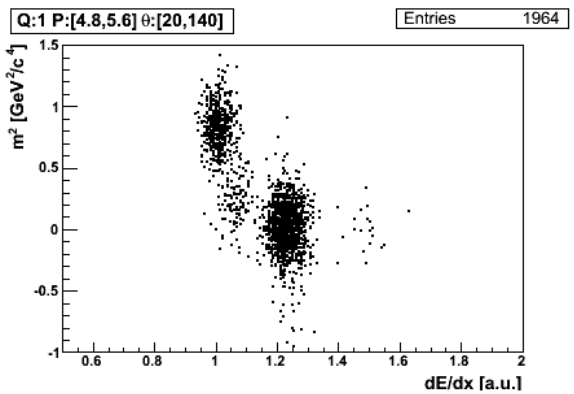


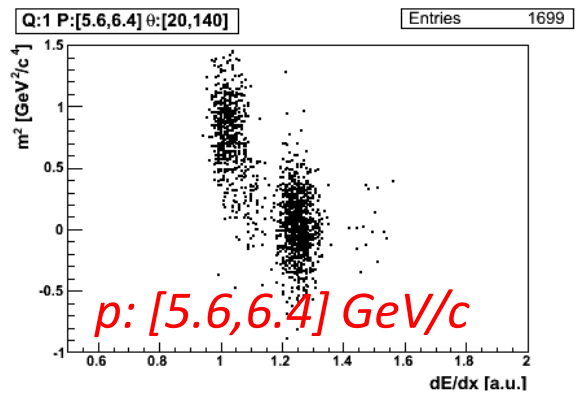
p: [1.6,2.4] GeV/c



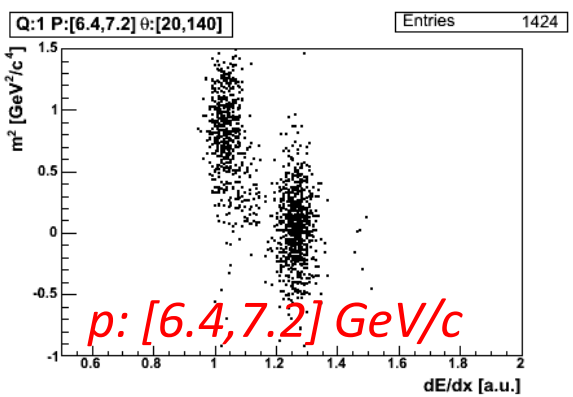








p: [5.6,6.4] GeV/c

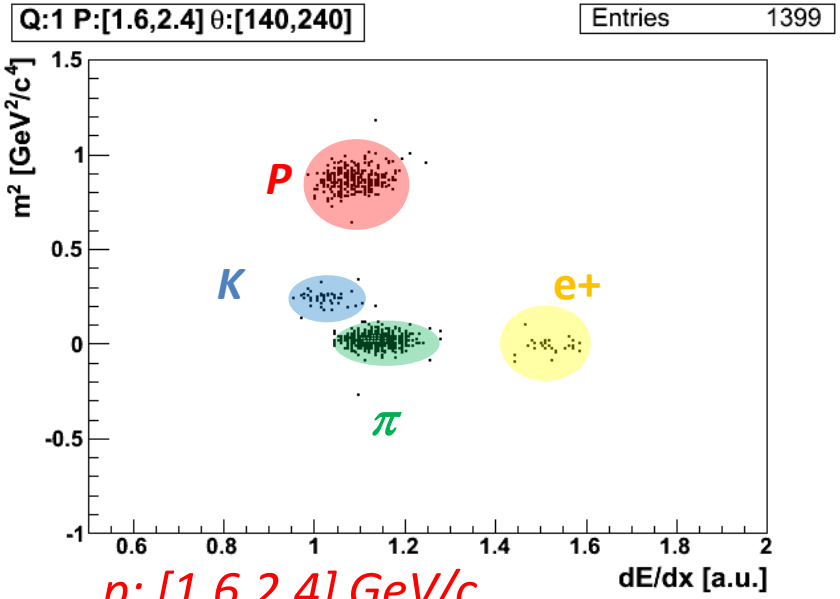


p: [6.4,7.2] GeV/c

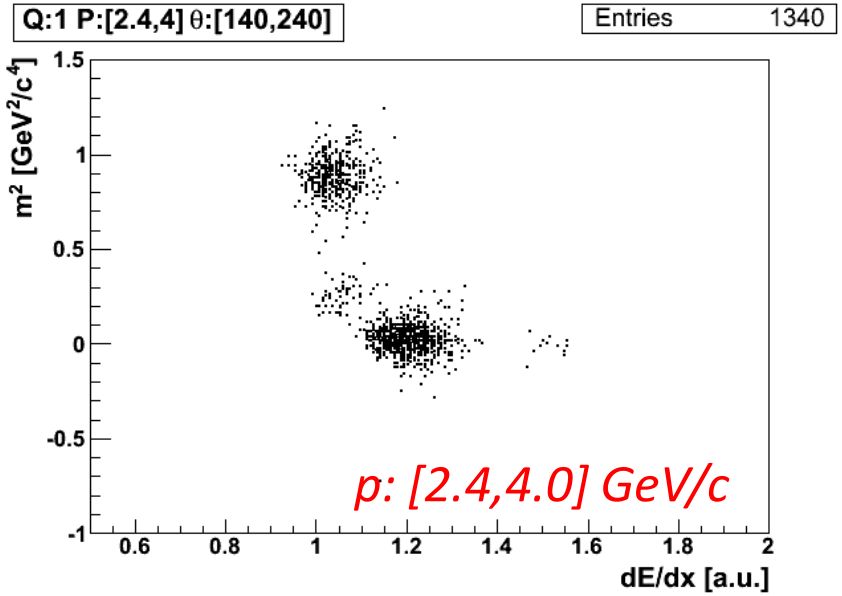
First Angular Bin

ϑ: [20,140] mrad

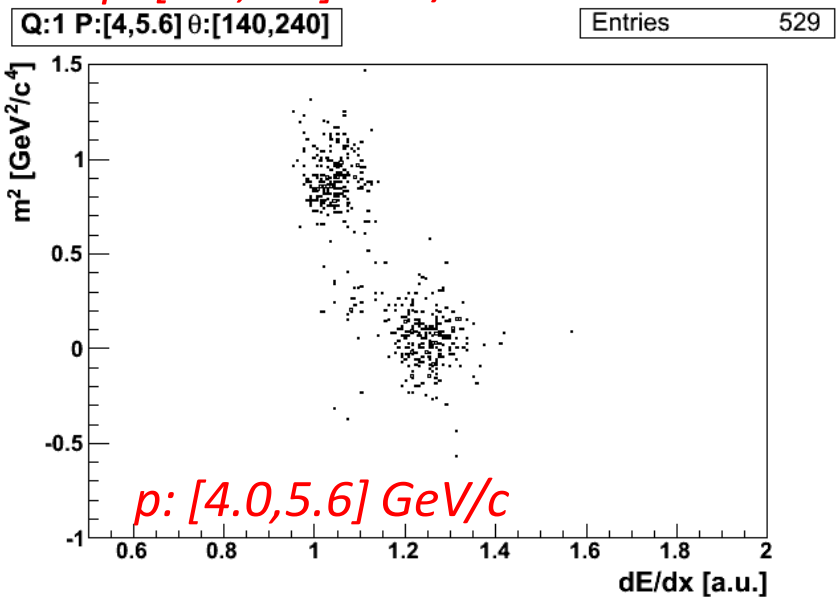
dE/dx-m² correlation in Raw Data



p: [1.6,2.4] GeV/c



p: [2.4,4.0] GeV/c

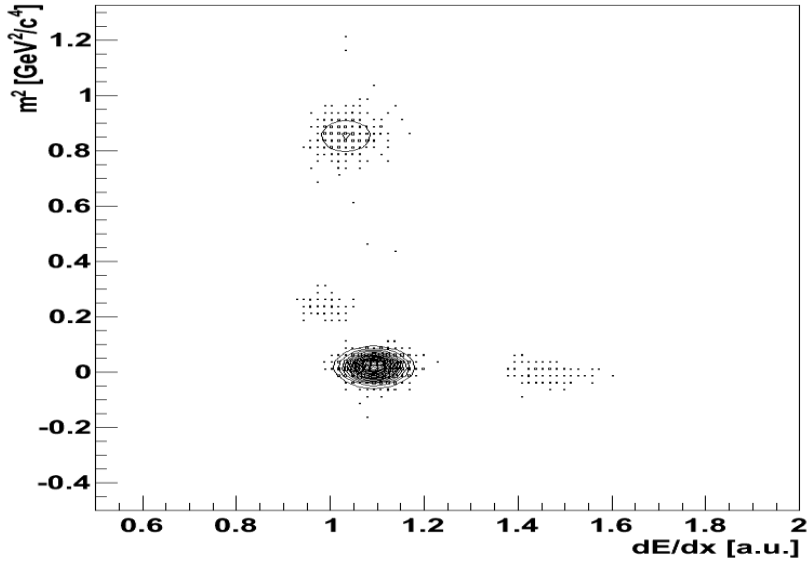


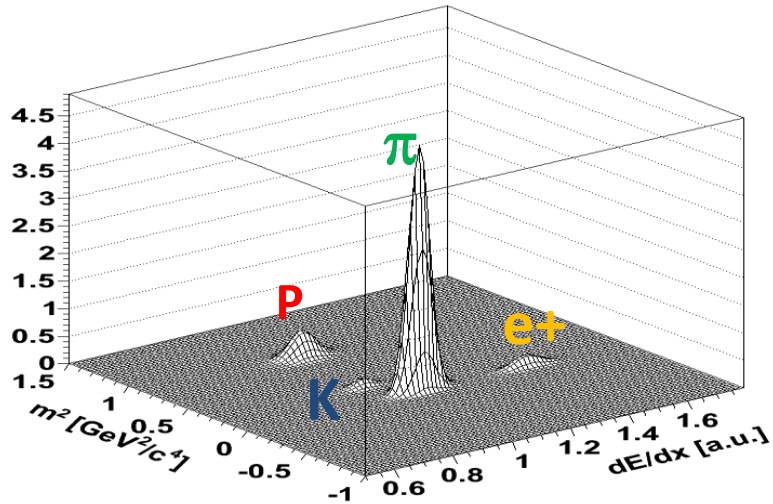
p: [4.0,5.6] GeV/c

Second Angular Bin
ϑ: [140,240] mrad

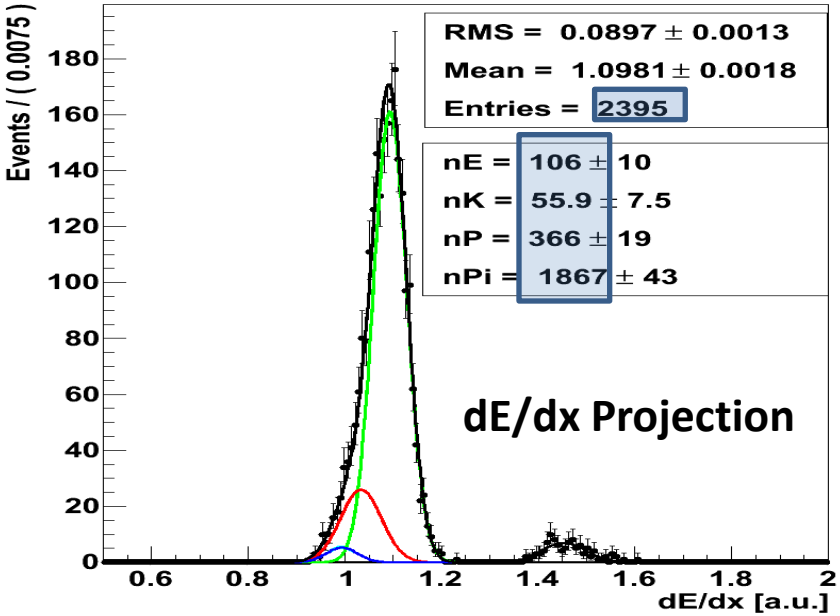
PID: Extraction of the Signal Yield

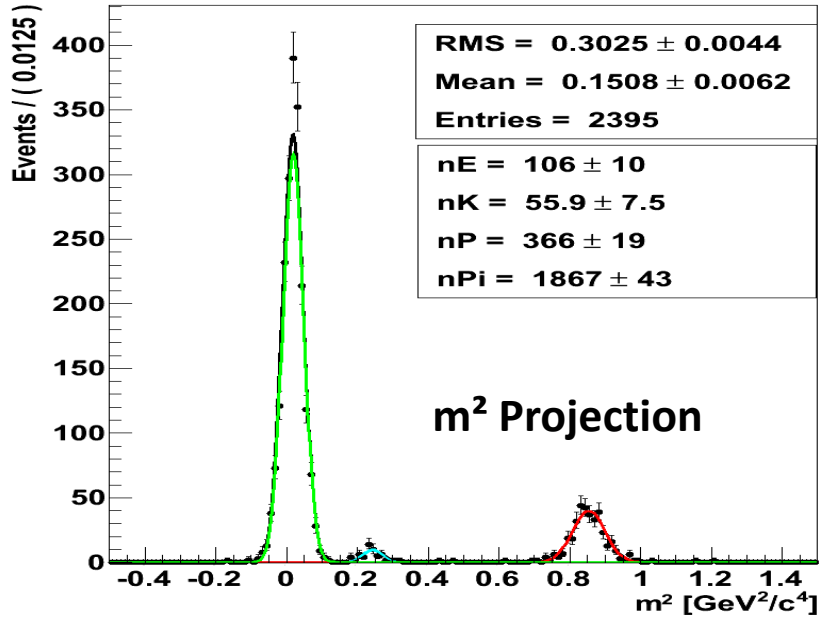
- Bidimensional dE/dx-m² fit: superposition of 4 2D Gaussians



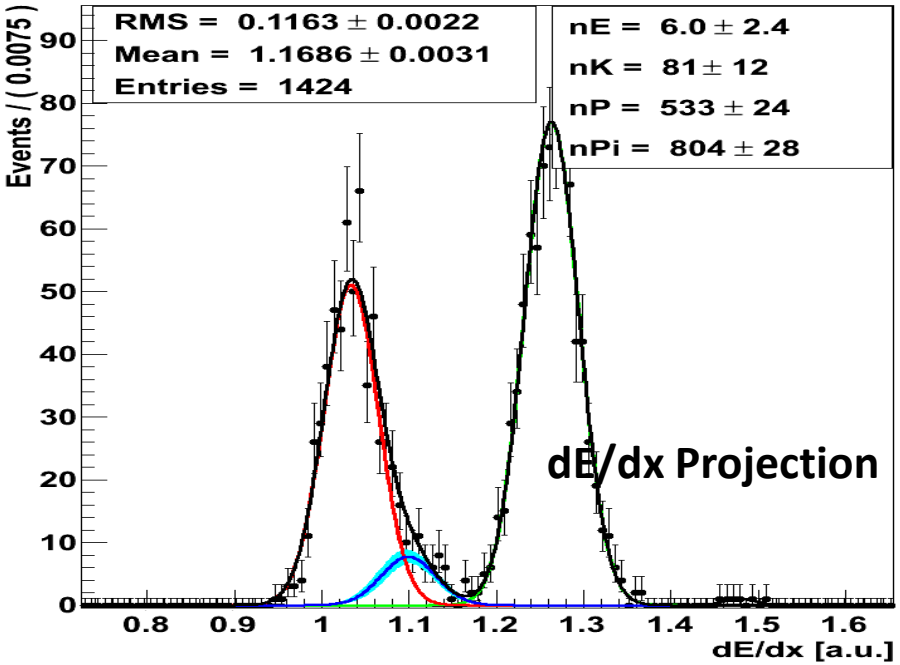


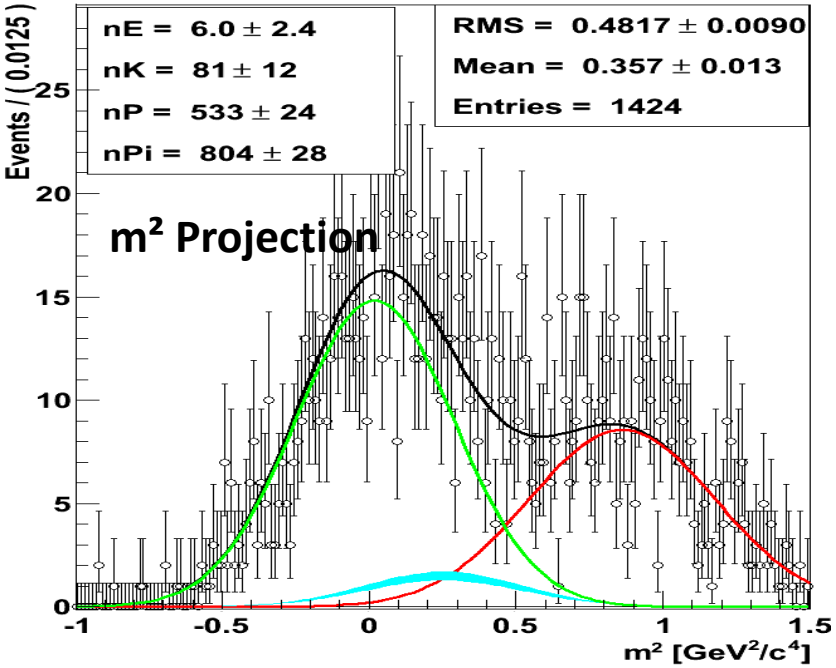
Fit p:[1.6,2.4] θ:[20,140]

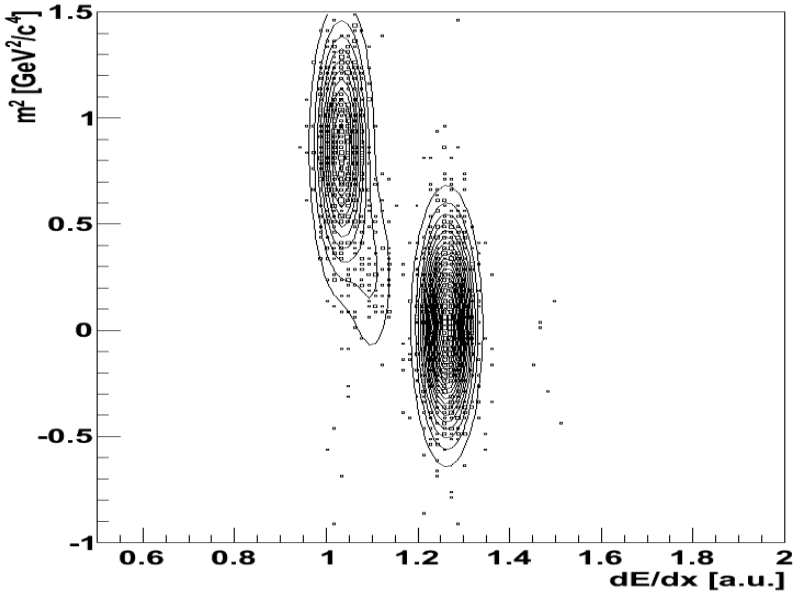


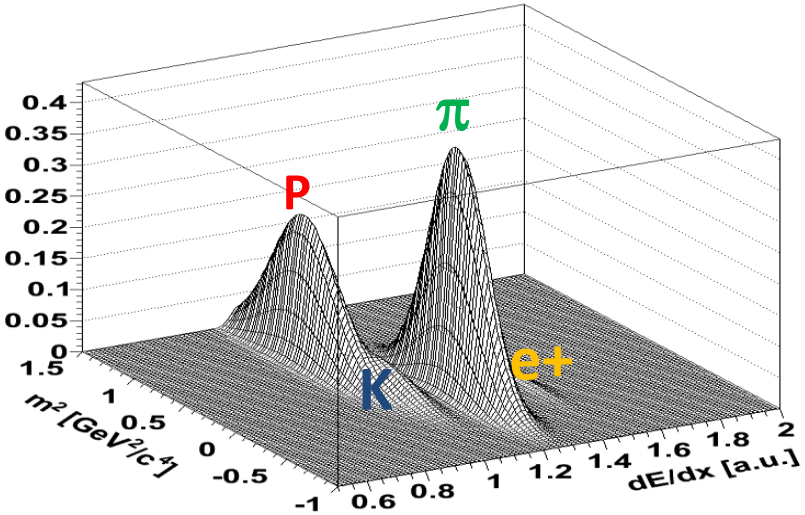


Fit p:[6.4,7.2] θ:[20,140]









Systematics: detector response uniformity

- Selection of tracks laying in the upper or lower side of the TPC = selection of tracks with short or long drift distance hits
  - consistent Kaons Yield -> detector response is uniform along the whole drift distance