Status Report of PQ analysis

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Comments received at the group presentation

- Λ_C^+ mass plot
- Cross section limit with motivated Gaussian widths.
    - 6.1 MeV (in the draft) is the measured width in HERA-I: so we like to keep this version.
    - 12.2 MeV is simply twice of the measured. But, H1 used mass resolution is 4.8-11.3 MeV. (discuss in page 9)
    - Limit with the detector resolution (which varies as a function of pK_S^0 mass), is an option: in this talk.
    - 8 Mev quoted in the previous paper is the Breit-Wigner width. - We would like to keep Gaussian searches only.
    - explain why the limit is worse at smaller masses.
    - Why event-by-event weight ? Better with the global correction?

- Proton/Pion efficiency: Why 1/13 of the previous analysis in event number per luminosity.
    - Proton PID efficiency is experimentally estimated by a Λ sample (Note + this slides)
    - (New) Pion efficiency (or rejection factor) is measured with pions from K_S^0 sample.

- Make a statement on the agreement between the private and common ntuple before the proton id
- pK_S^0 mass plot with HERA-I like cut?
- dE/dx plots (Fig 2): with looser cut?
- Plot HERA-1 results (H1 limit, ZEUS cross sections)

Λ_c^+(anti-Λ_c^+) Mass

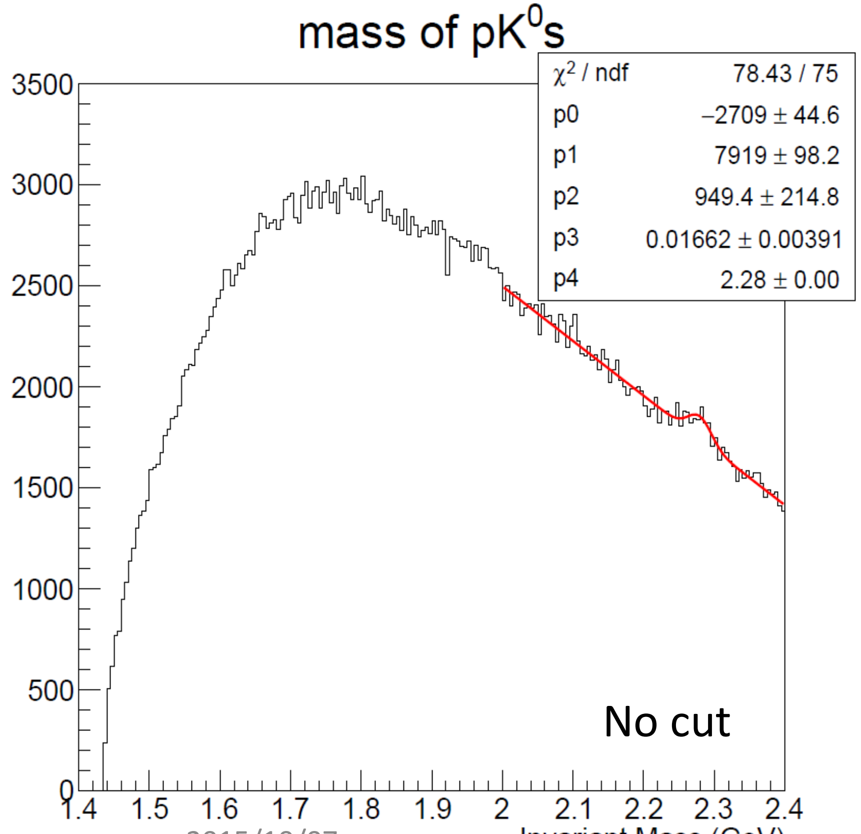
- In the note, we show the mass plots with DATA (including PHP)
  - With $\frac{p_T}{E_{Tcone10}}$ cut to enhance charmed jet event.
  - Fit Λ_c^+ by Gaussian (signal) and the resolutions are compared with the MC.

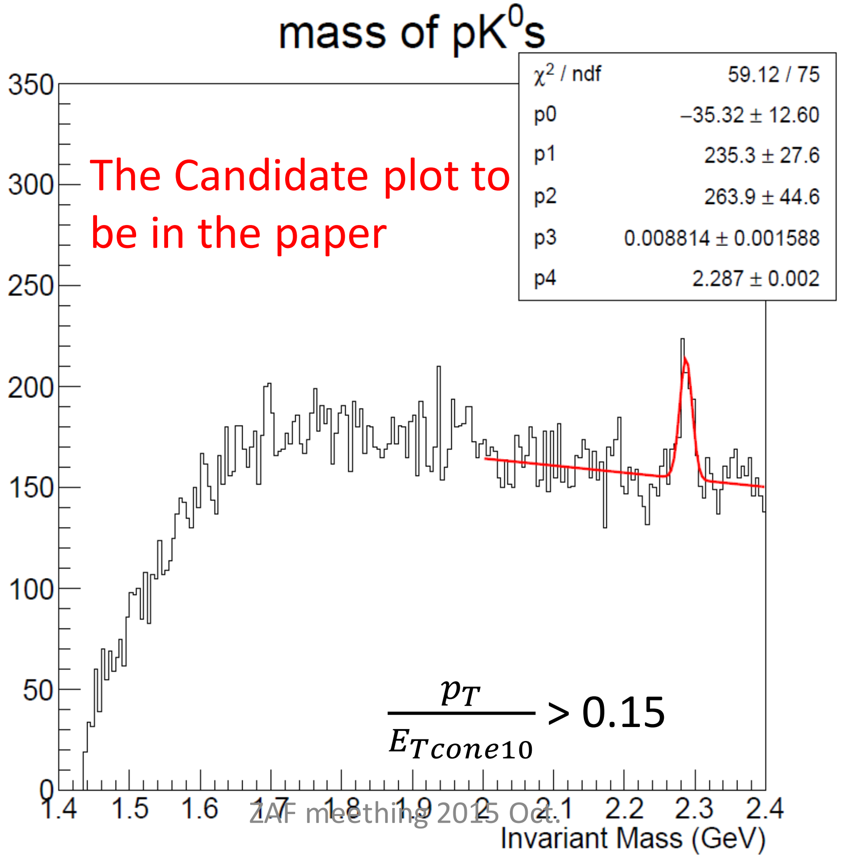
- (New) for the final sample, the mass plot is extended to the high-mass side. Using the width from the above, there may be a signal but not convincing.

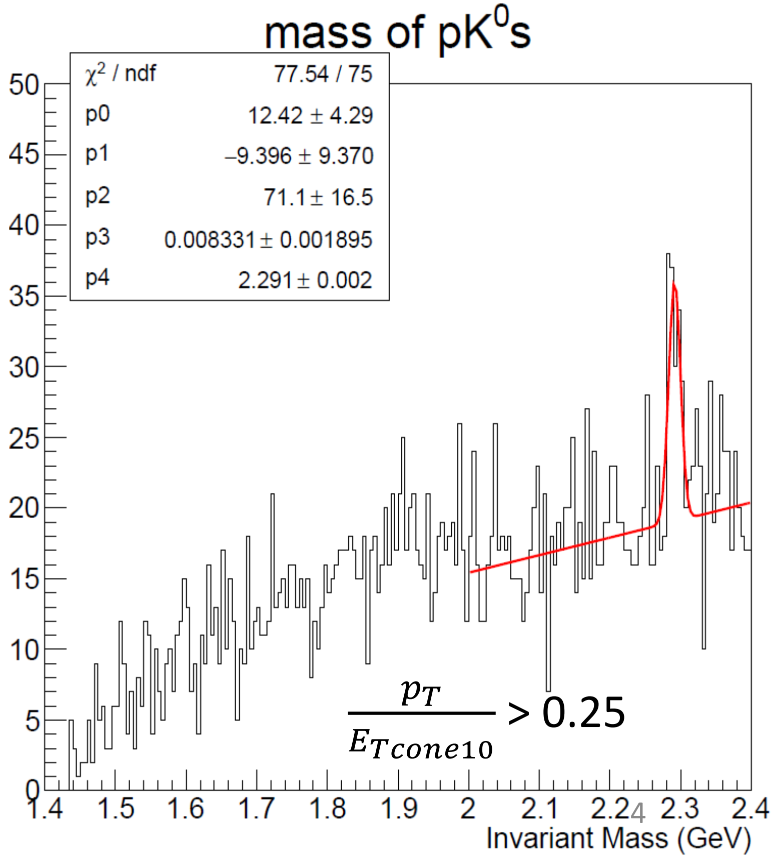
-> Proposal: Include Photo production mass plots in the paper (with very brief event selection description)

Λ_c^+ Mass distribution

- DATA (including PHP)
  - With $\frac{p_T}{E_{Tcone10}}$ cut to enhance charmed jet event.
  - Fit Λ_c^+ by Gaussian (signal) and constant (B.G.)

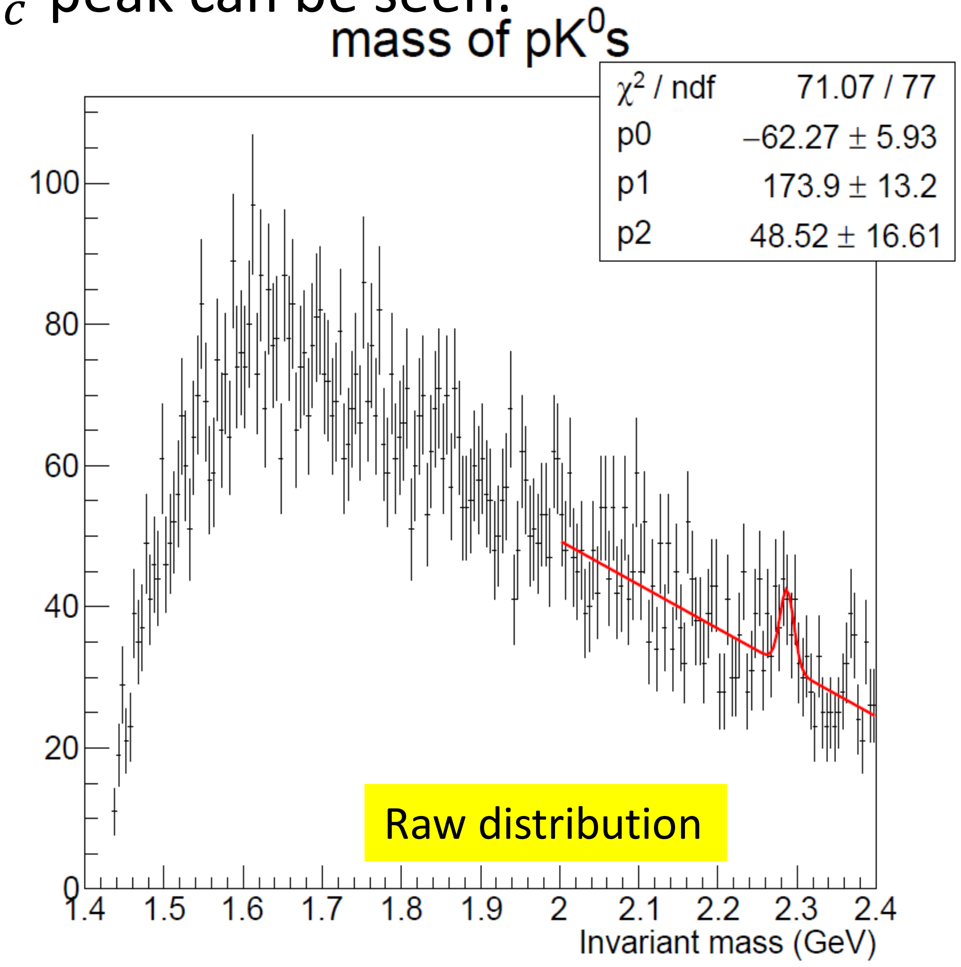


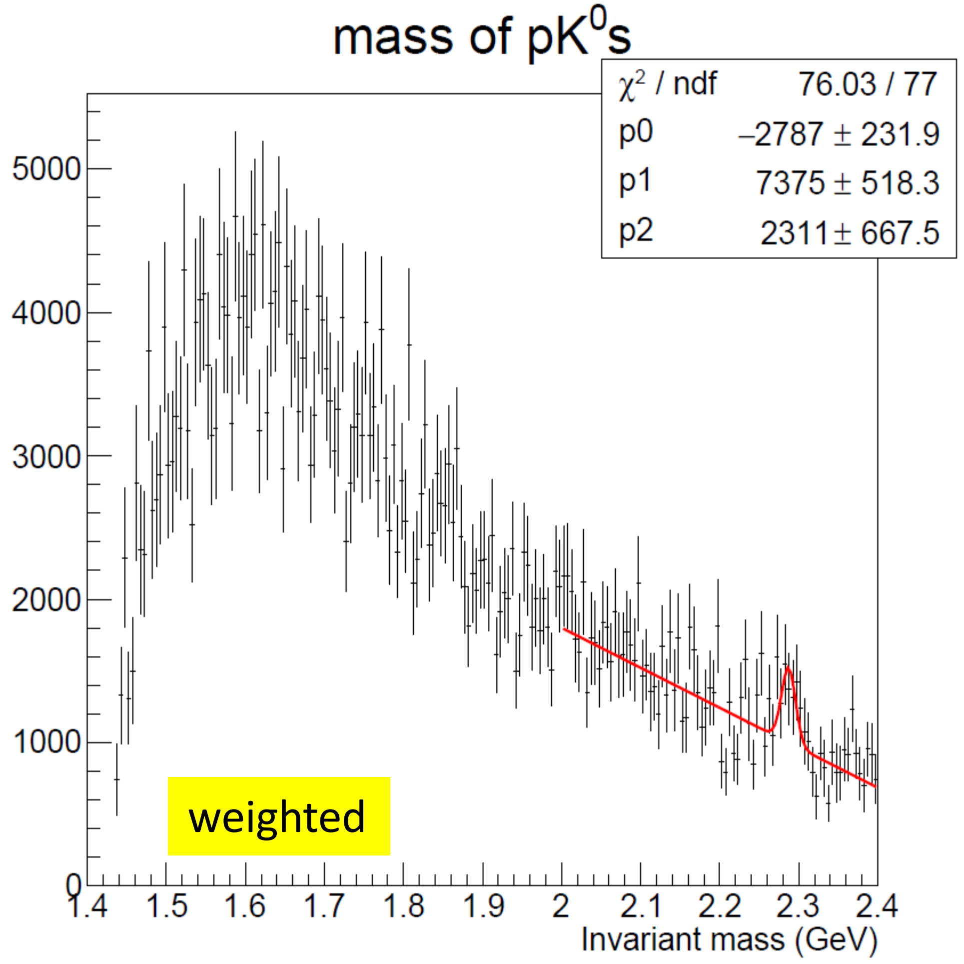




(New) Check Λ_c^+ Mass distribution (DIS PQ search final sample)

- Fitted by Gaussian + linear function (fixed σ and mean to PHP result)
- Λ_c^+ peak can be seen.





Cross section limit with motivated Gaussian widths

- 6.1 MeV (in the draft) is the measured width: so we like to keep this version (No change)
- Limit with the detector resolution (which varies as a function of pK_S^0 mass), is an option.
  - Mass resolution is estimated with MC (note)
  - In the measured mass range the resolution is parametrized with a linear function of pK_S^0 mass. (page 7).
  - Limit with this mass resolution is shown (page 8).
- 8 MeV quoted in the previous paper is the Breit-Wigner width.
  - We would like to keep Gaussian searches only.
- Explain why the limit is worse at smaller masses
  - At low mass the Gaussian area below pK_S^0 mass threshold was included. If we put a sharp cut at the Gaussian at threshold, it looks better.

Proposal: Limits are shown only above M(PQ) > 1.45 GeV.

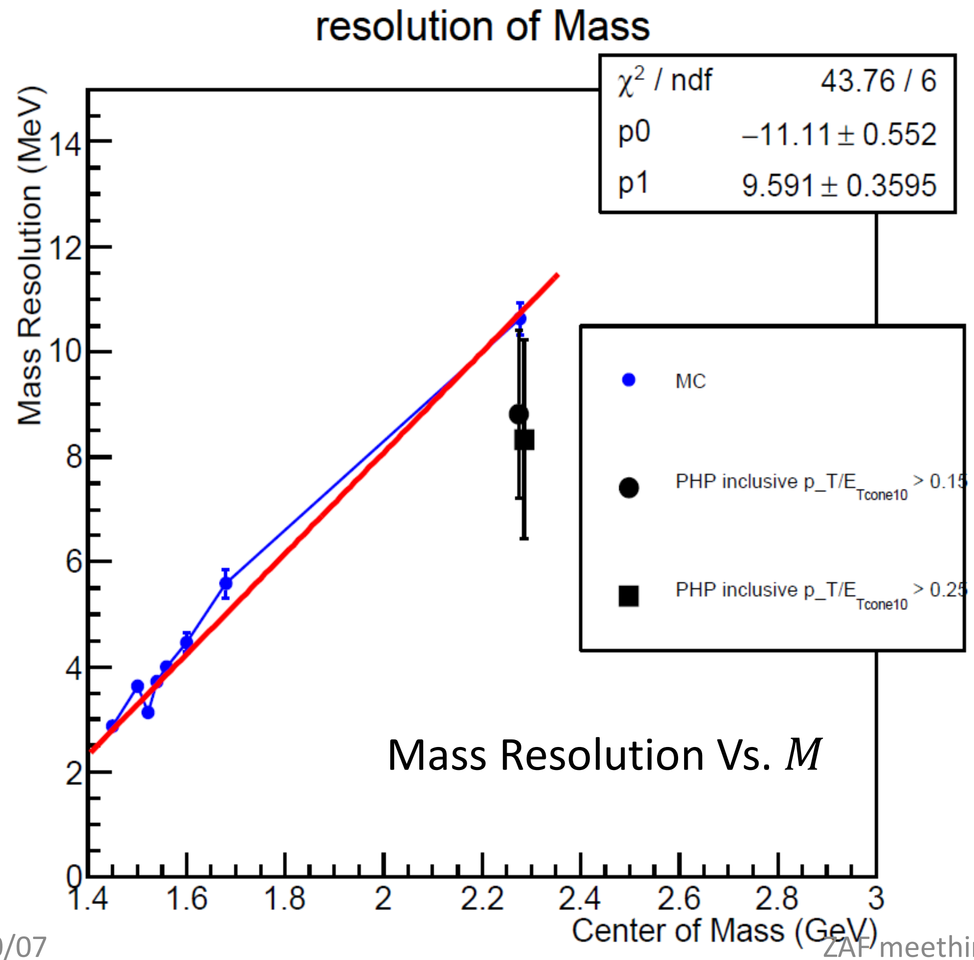
- Why event-by-event weight ? Better with the global correction? (Robert Klanner)

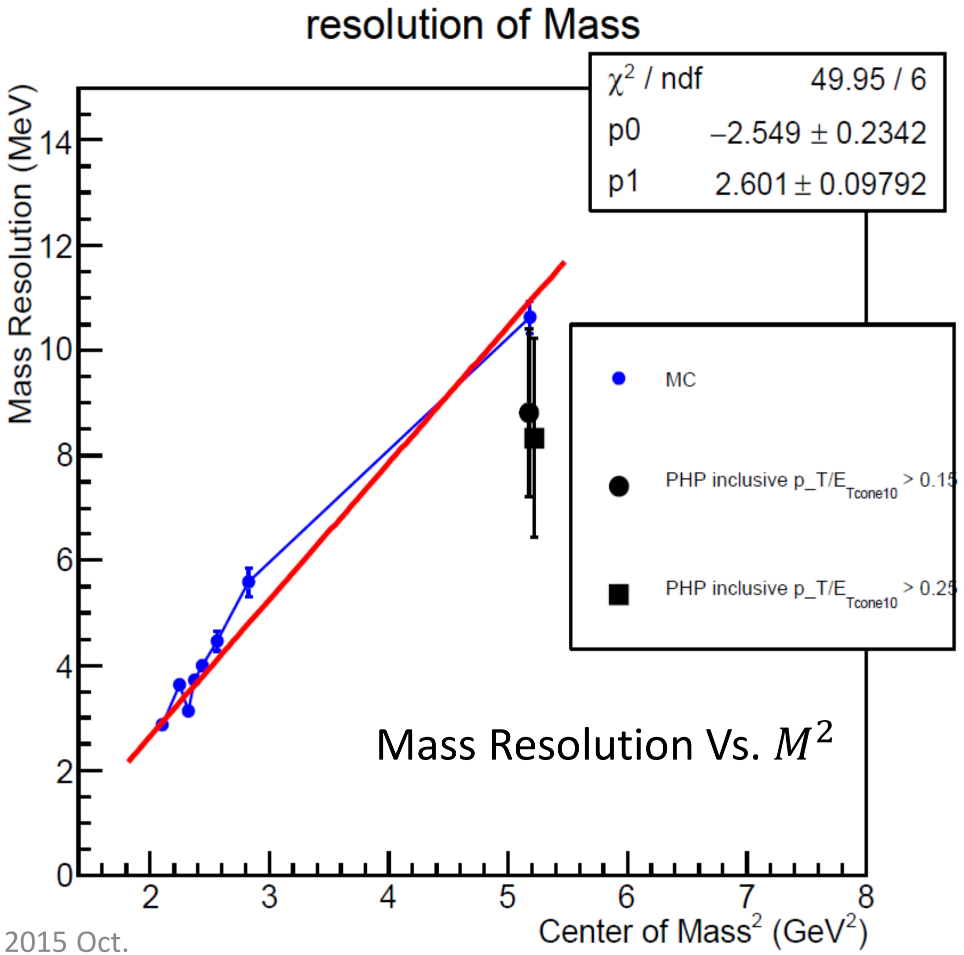
We used event-by-event correction because we have 2 different correction (PID and eta-pt acceptance) for each events. For the main analysis we decided to choose a global correction to the p_T $-\eta$, now proton PID efficiency is the only event-by-event weight. In this situation, it is also thinkable to have the global correction for proton PID as well.

-- We tried this option. (page 21)

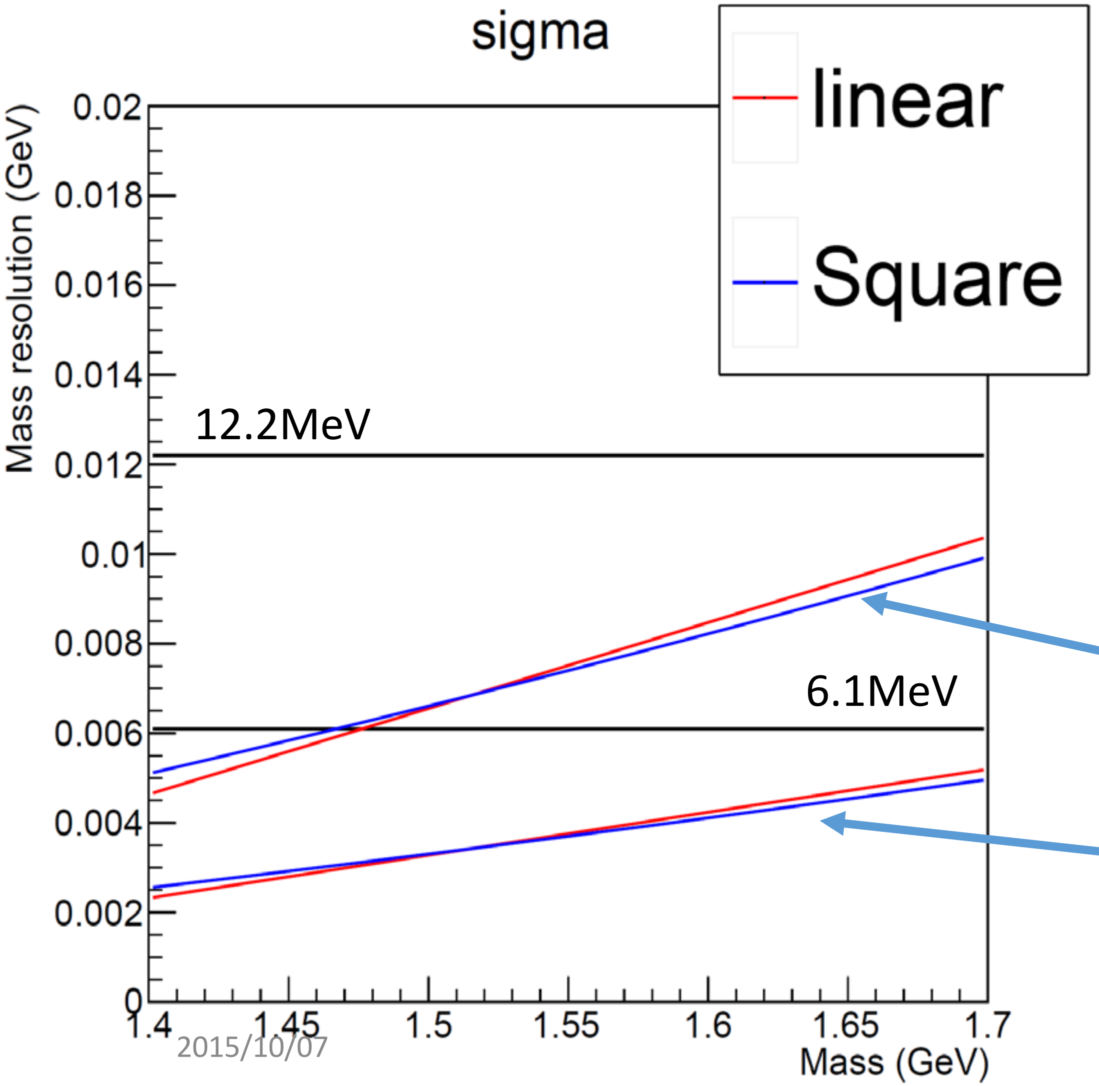
Fit mass resolution with MC event.

- Mass dependency of mass resolution is fitted by linear function (red).
- Black points are come from data (circle; $\frac{p_T}{E_{Tcone10}} > 0.15$, square; $\frac{p_T}{E_{Tcone10}} > 0.25$)





Mass dependence comparison with constant



- Linear: $0.009591M$ - 0.01111 GeV
- Square: $0.002601M^2$ - 0.002529 GeV
- The difference is very small

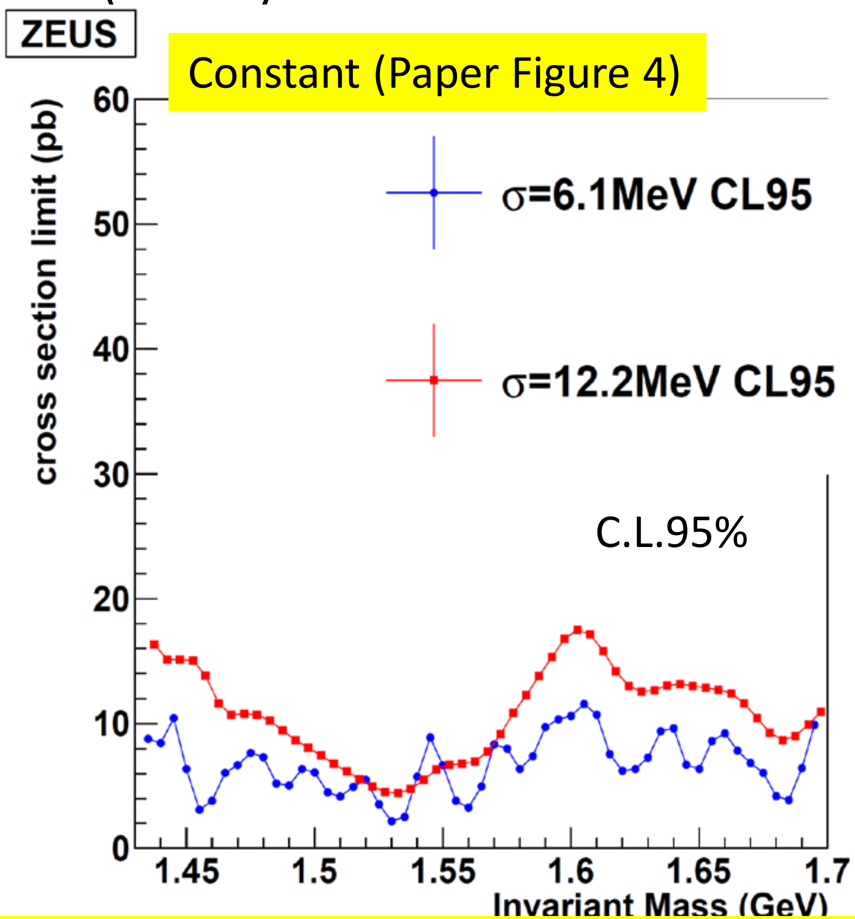
-> the Linear function (red) is used.

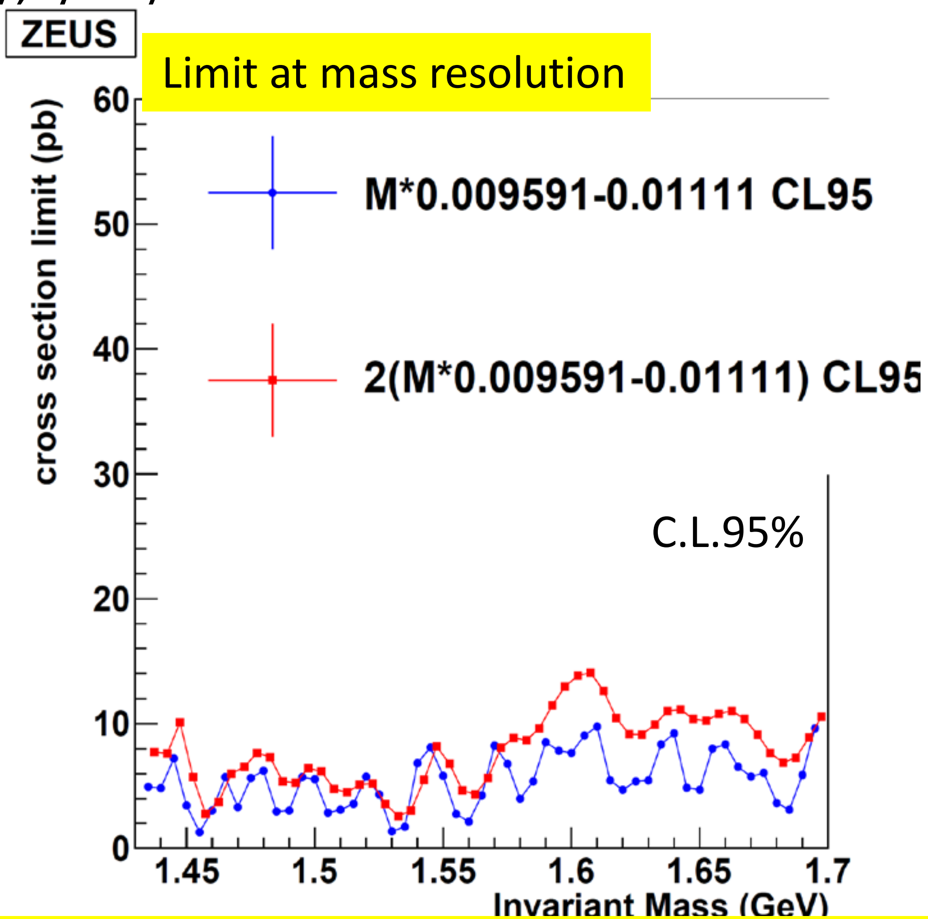
(Mass resolution)x2 :
No physical motivation, but for information

(Mass resolution)

Cross section comparison

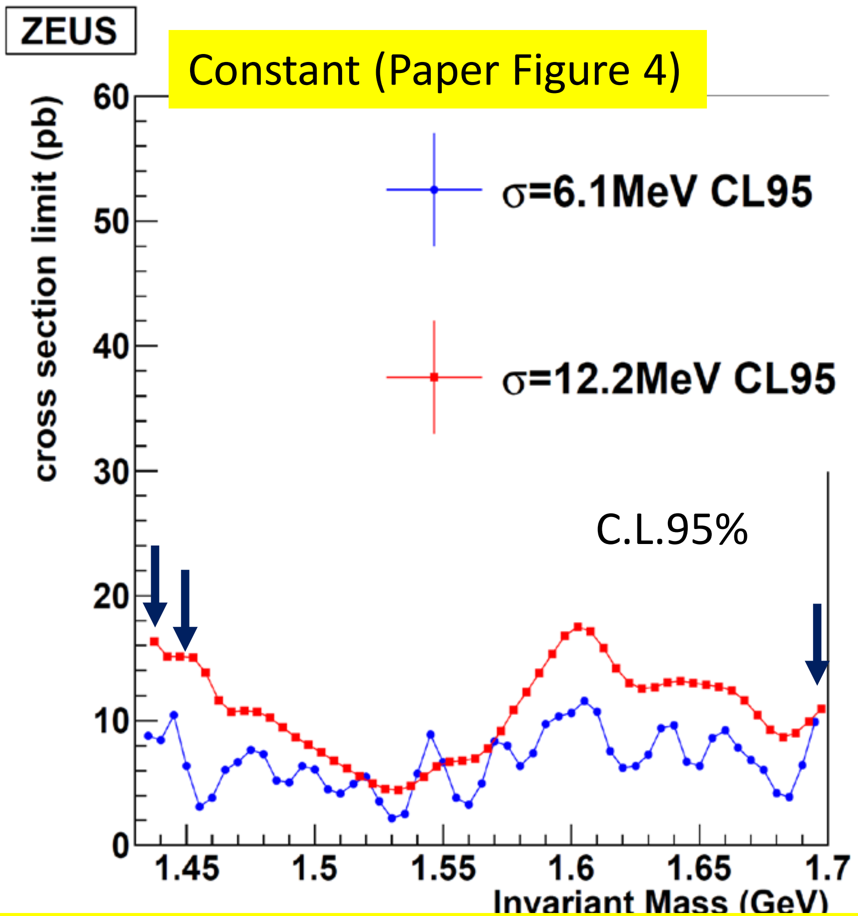
(No systematical error study, yet)





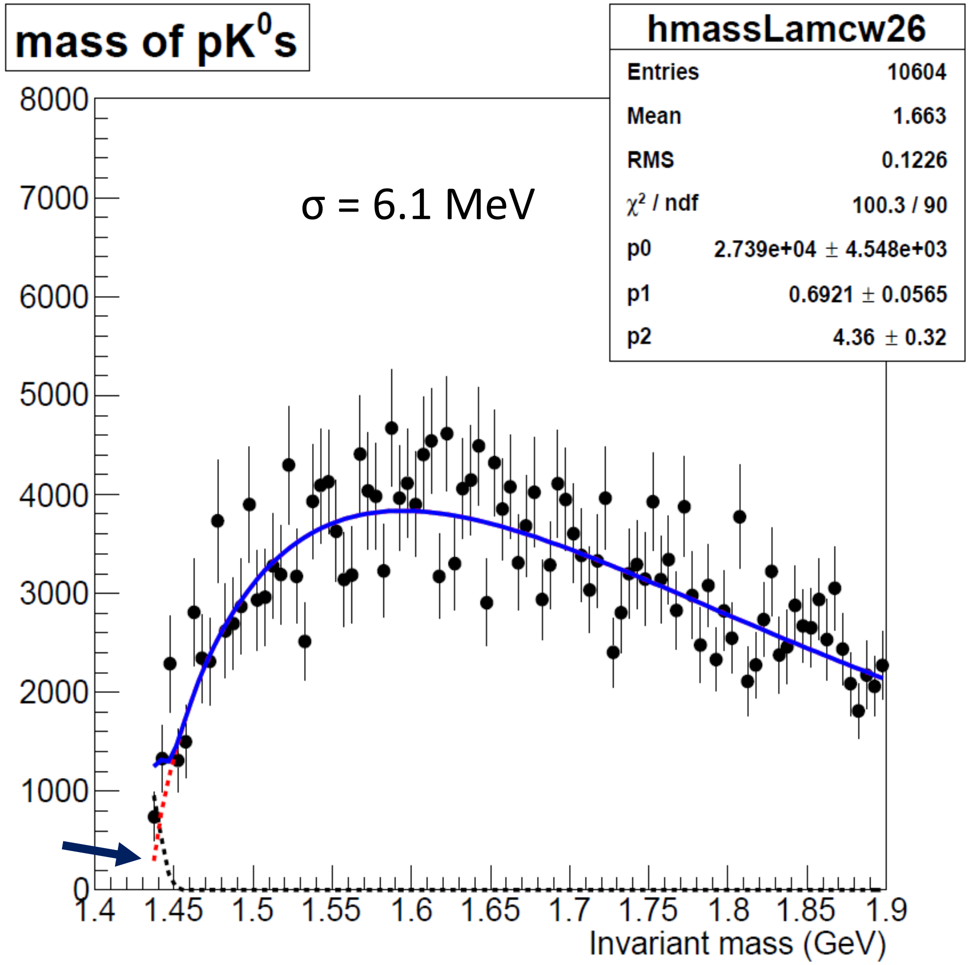
- Fit range 1.435 < M < 1.900 GeV
- Conclusion: No strong opinions but for example: Fig4.a) As it is (6.1 MeV) Fig 4.b) resolution limit (blue points in right figure) + 12.2 MeV (current fig4.b) + H1-HERA-I (4.8-11.3 MeV variable width) with the center values only? (We will discuss this again at the end)

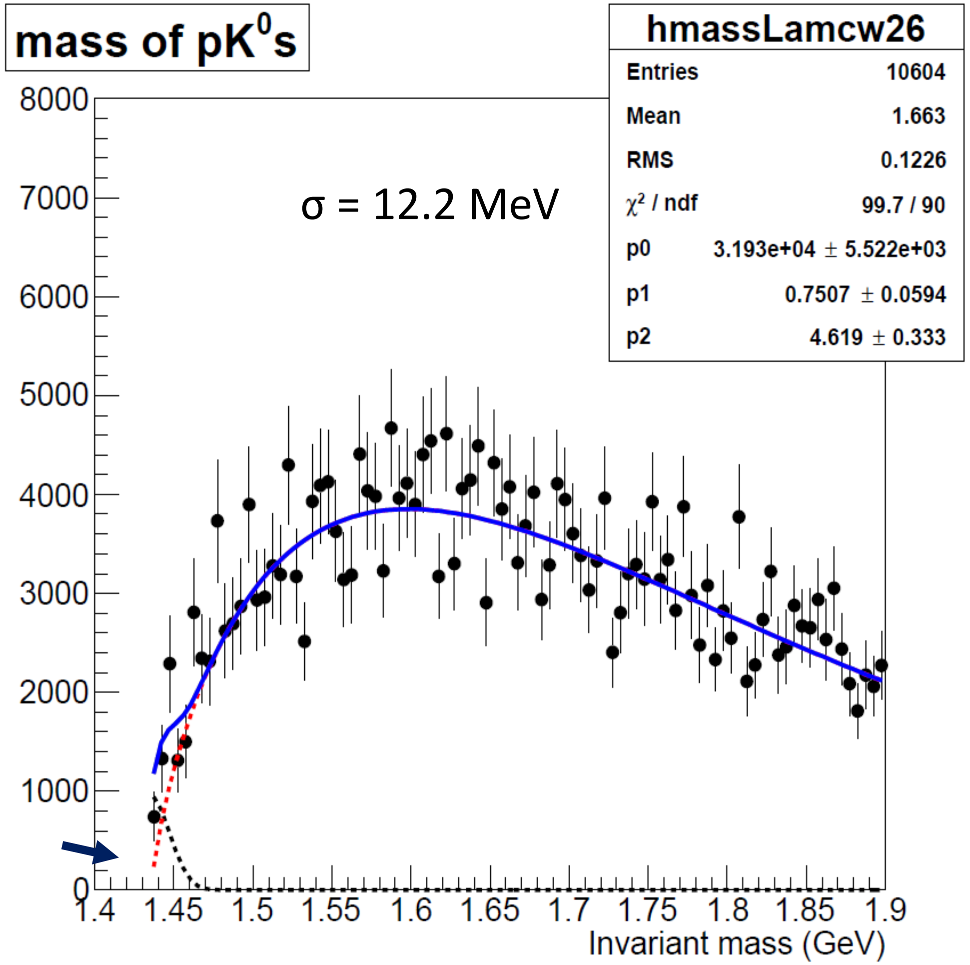
Worse limit at low mass:



- Fit range is 1.435 < M < 1.900 GeV. I.e. for the higher mass, we use the data above 1.7 GeV in the fit. For the low mass side, no data below pK_S^0 mass threshold but the cross sections were calculate with the full Gaussian (including the area below the threshold)

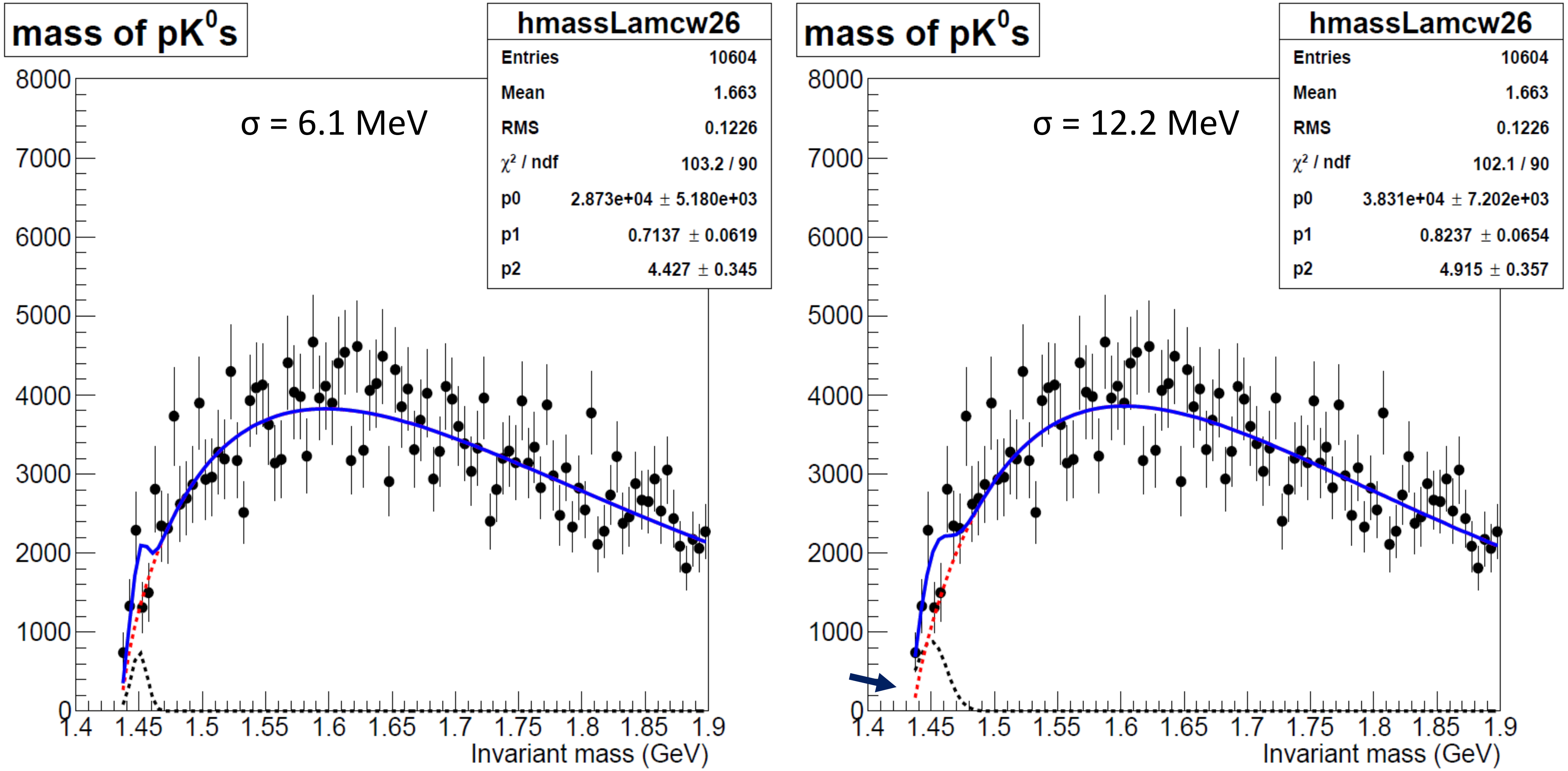
Fit figure. (M=1.435GeV)





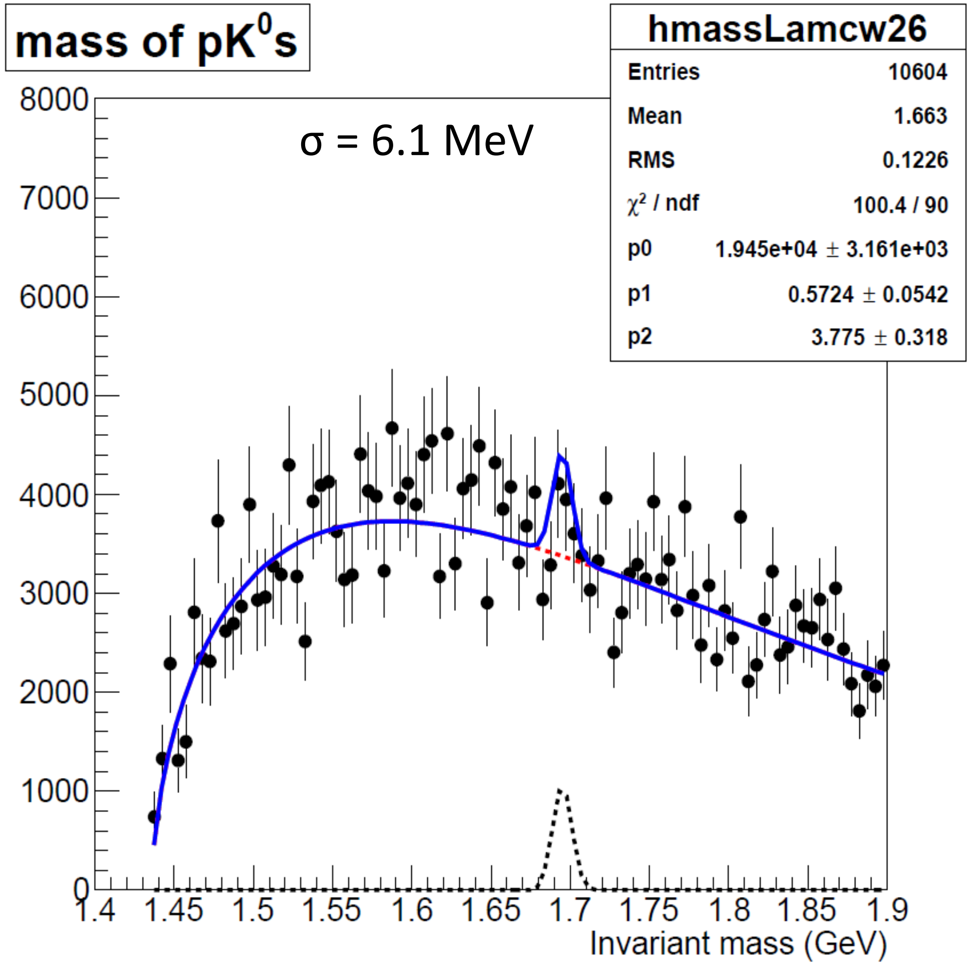
- Cross section is overestimated because of the edge of fitting Gaussian is out of fit range.

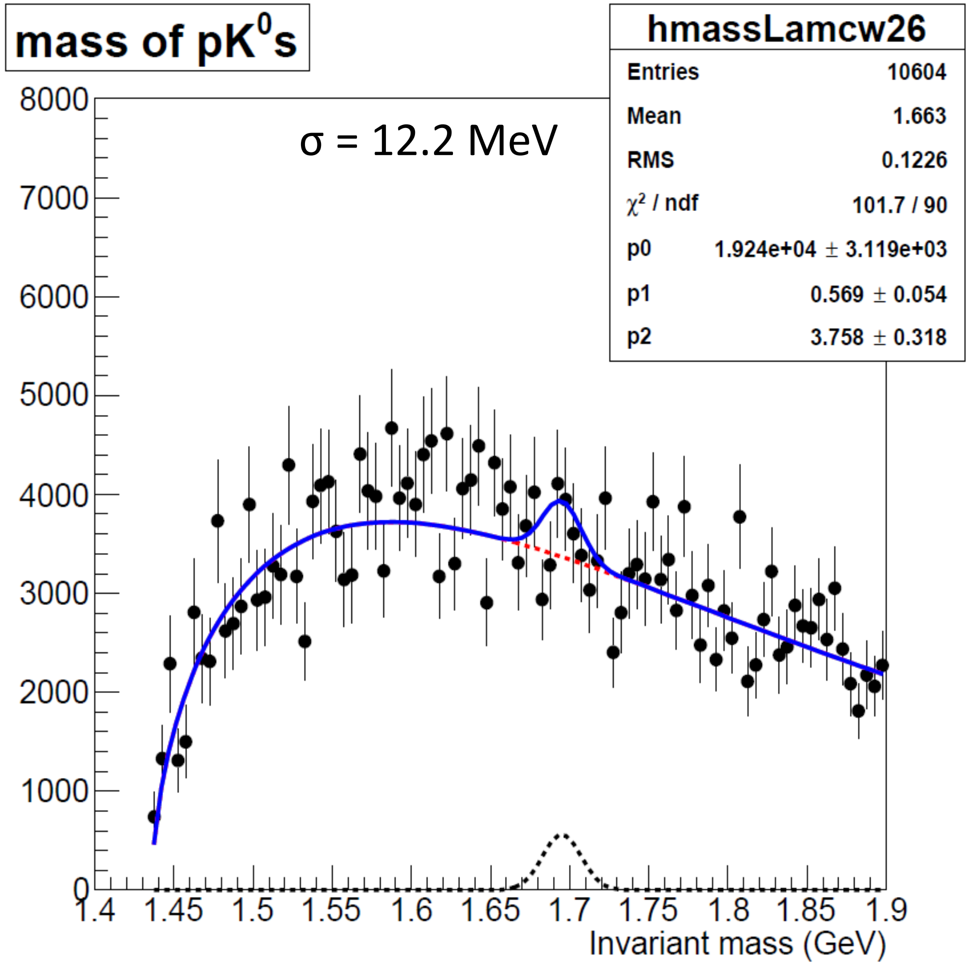
Fit figure. (M=1.450GeV)



- Fitting Gaussian of larger σ shape also out of the range.

Fit figure. (M=1.695GeV)





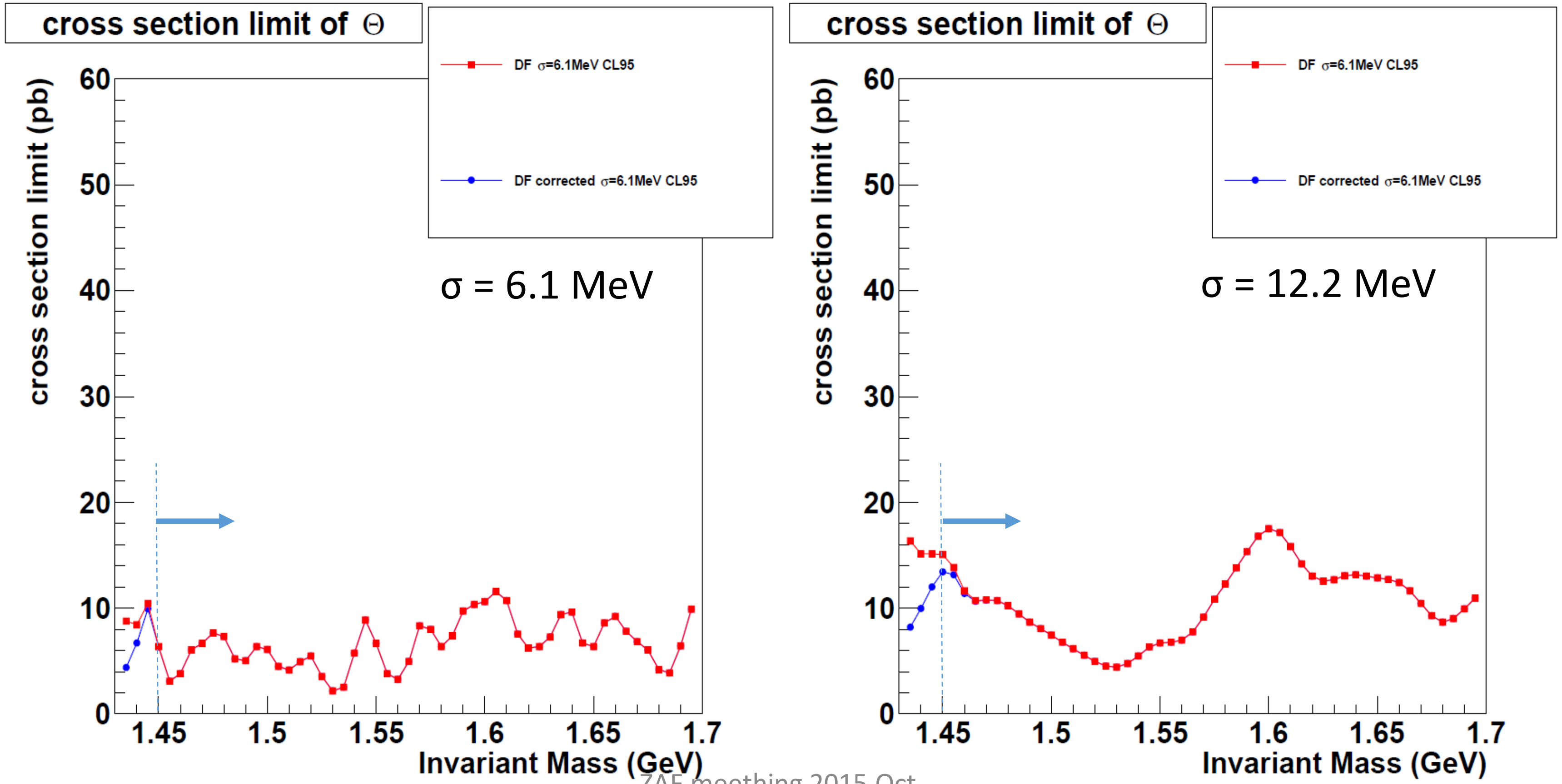
- Since mass range is enough to fit, there is no problem.

Gaussian correction

- Simple Test to correct an effect of signal Gaussian（after correction：blue）.
  - Exclude the Gaussian area below pK_S^0 mass kinematic limit:

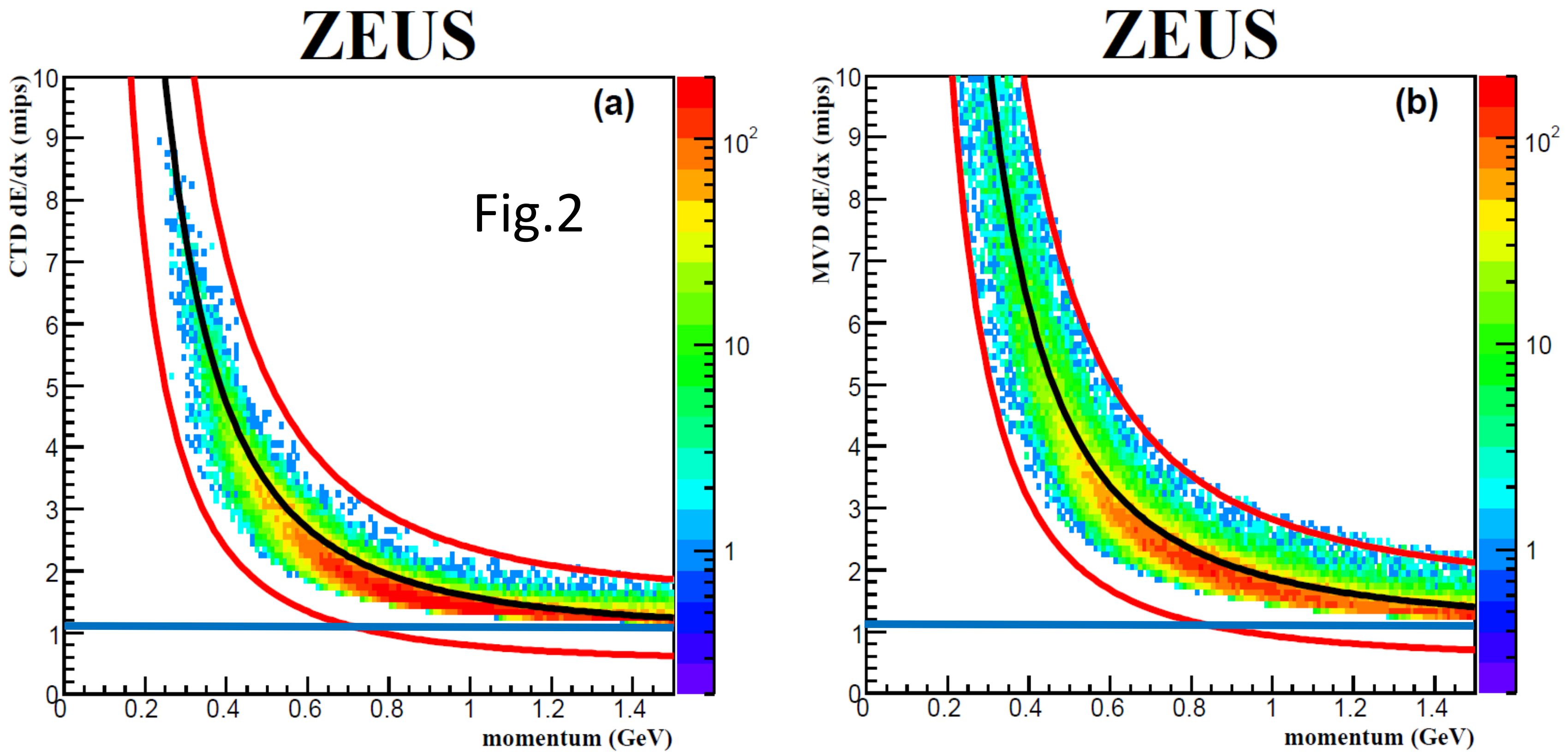
    We don’t like to consider the more complicated threshold effect

    → Proposal： show the limits above 1.45 GeV



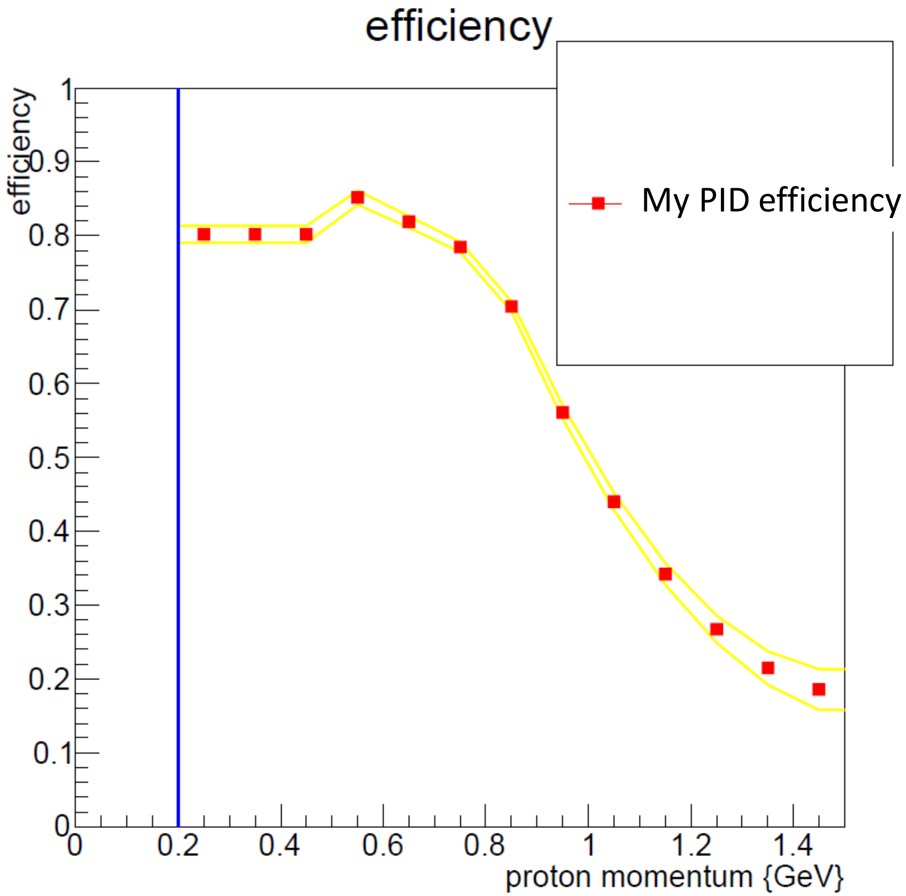
Event-by-event PID weighting factor?
Or
Global correction.

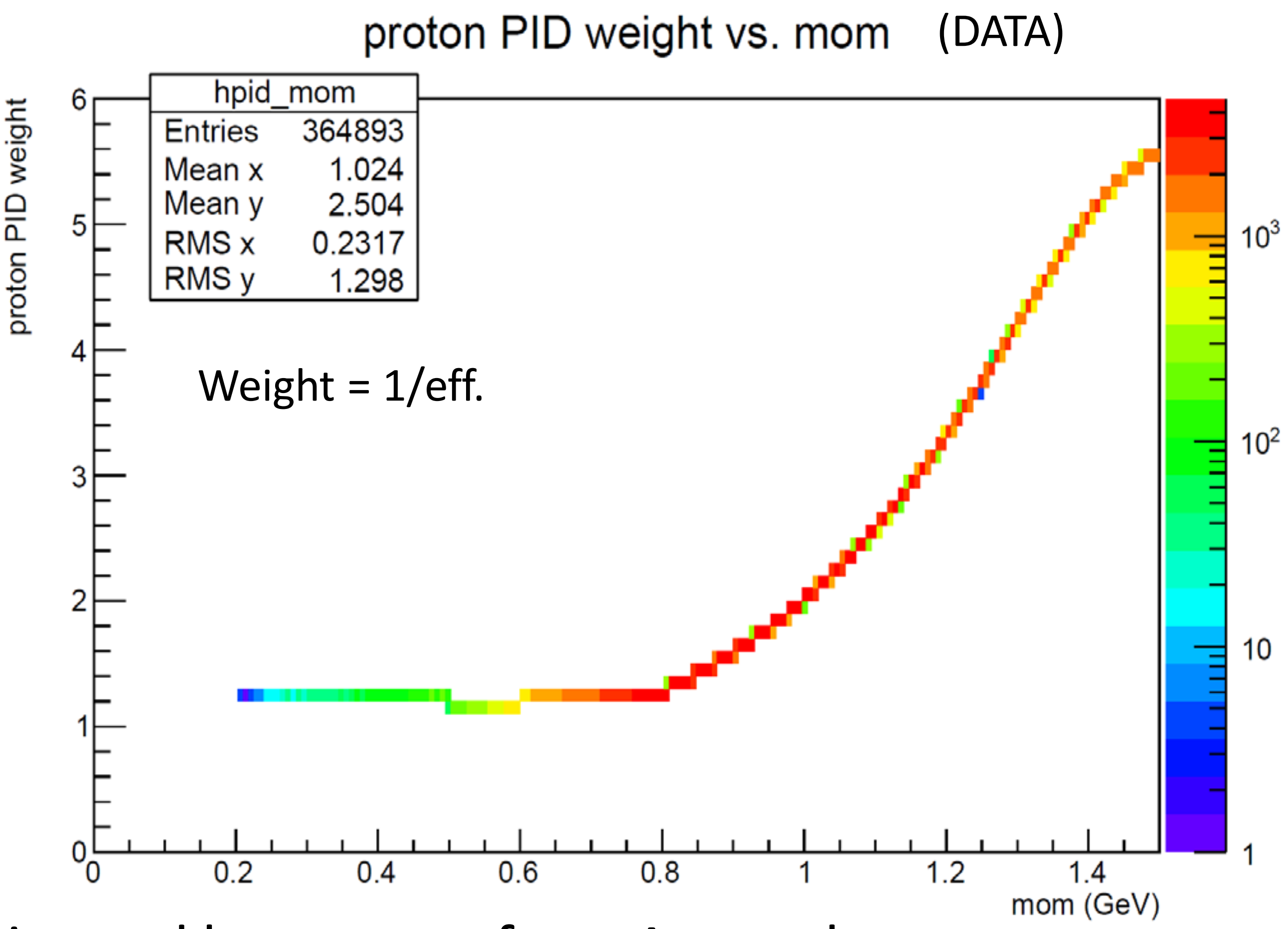
dE/dx by my PID (Fig 2)



- My dE/dx likelihood selection cuts the low dE/dx events at high momentum.
- dE/dx mips cut (> 1.15) line (blue) will add to Fig.2.

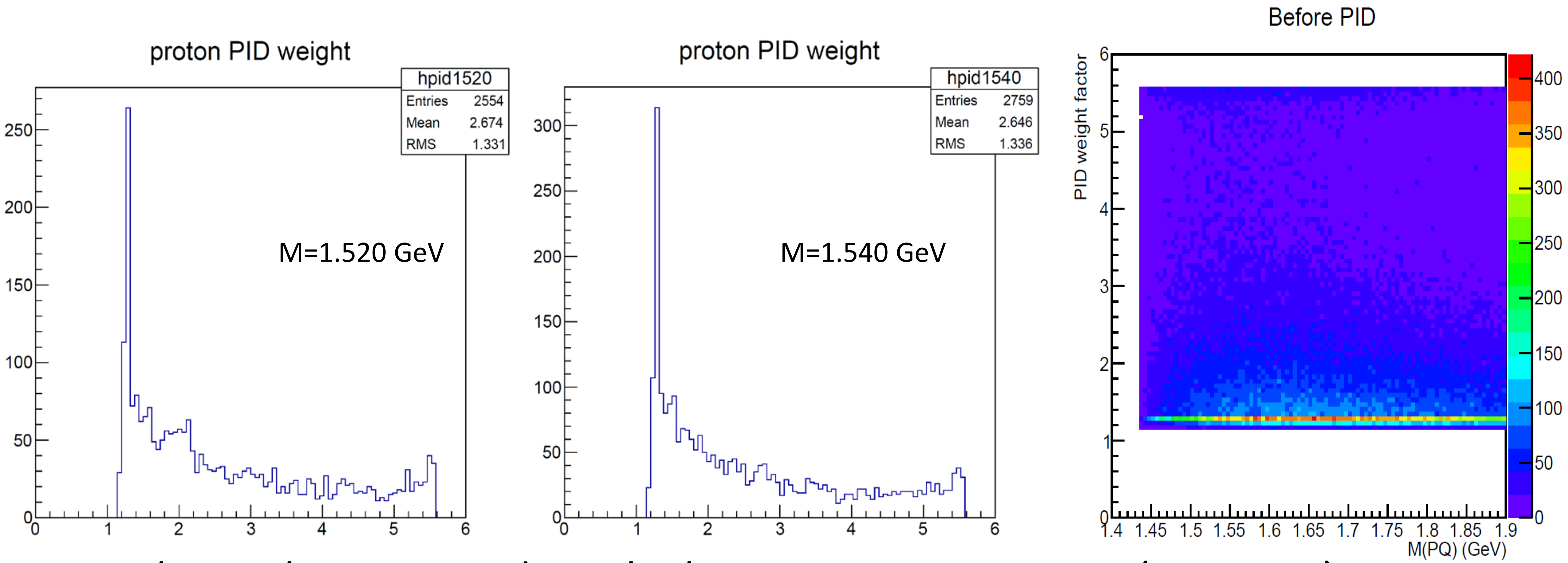
Test PID efficiency





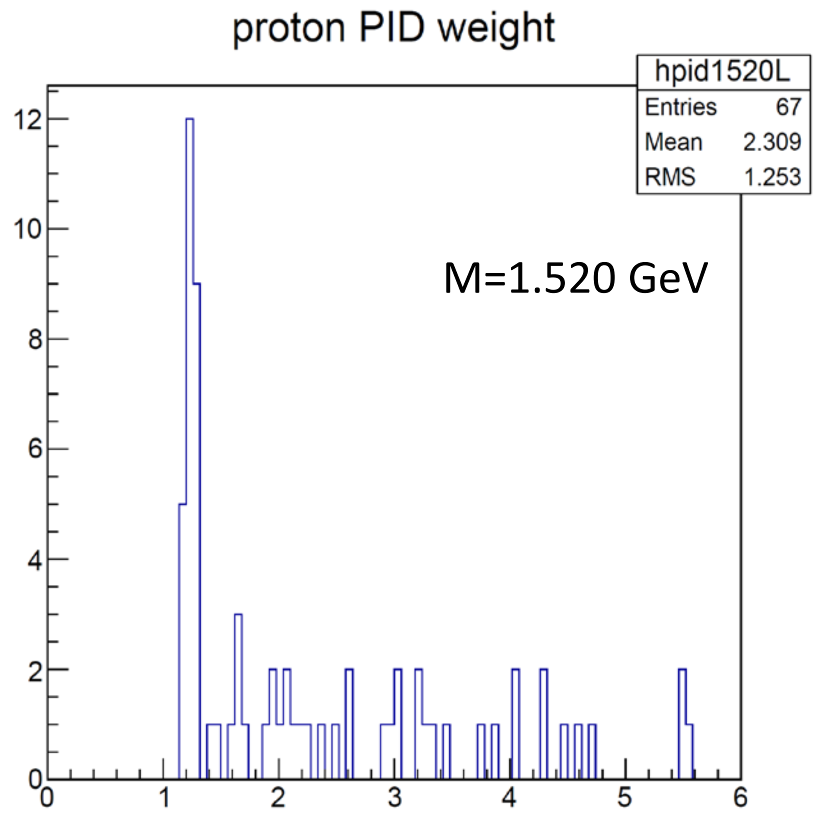
- PID efficiency weighting factor is estimated by protons from Λ sample.
  - Almost constant for p(p) < 0.8 GeV and low efficiency at the higher momentum to reduce the pion’s background

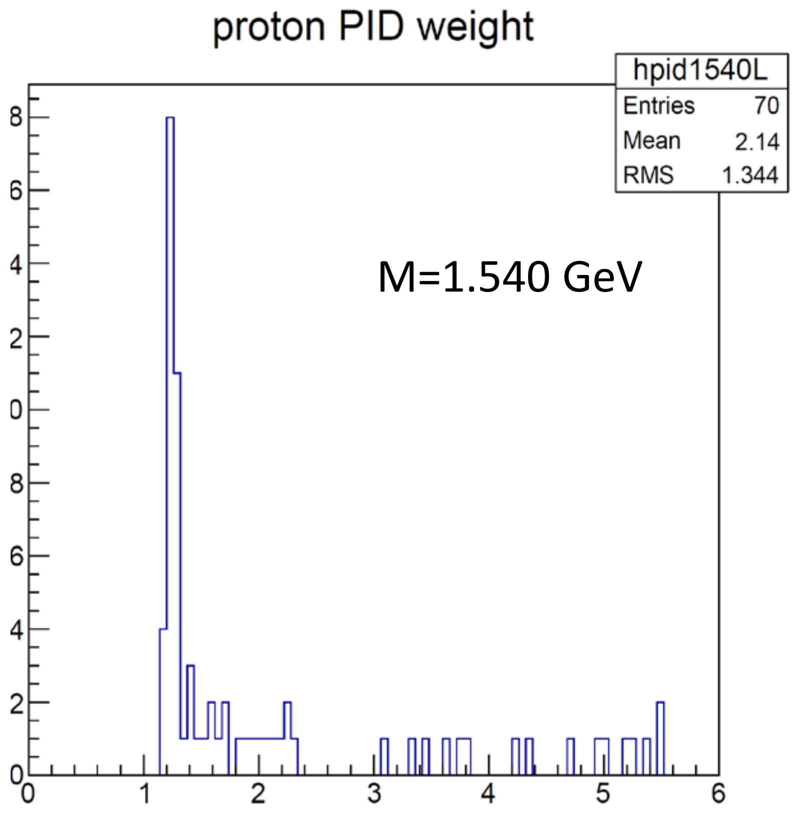
Event-by-event PID weight distributions for each pK_S^0 mass (before PID selection)

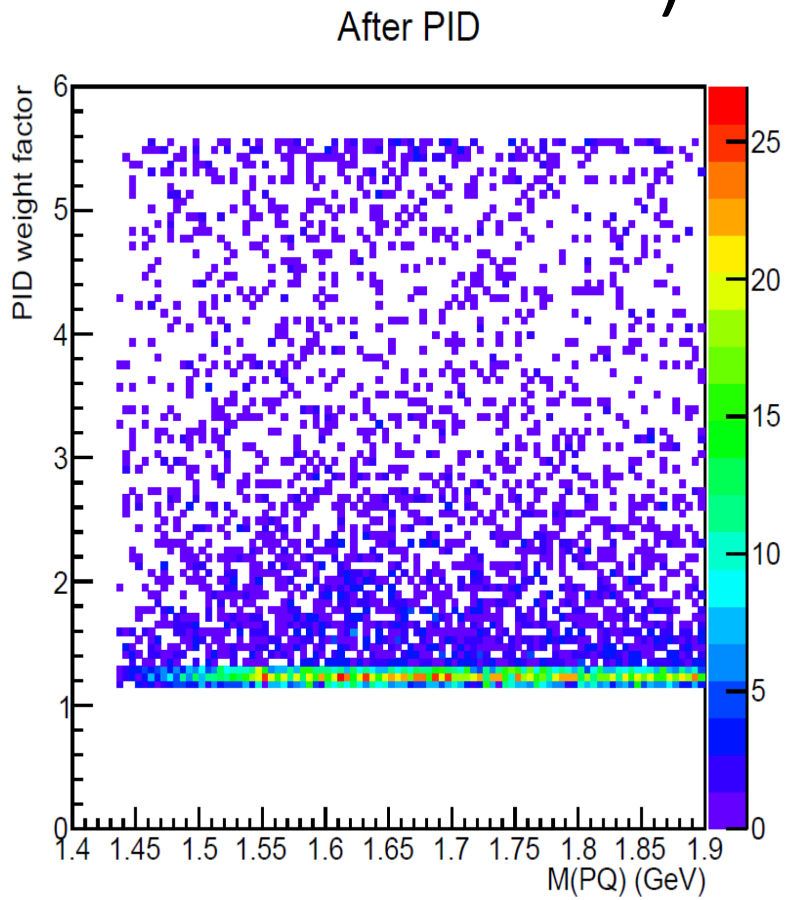


- The peak corresponds to the low momentum proton (<0.8 GeV).

PID weight distributions (after the PID selection)



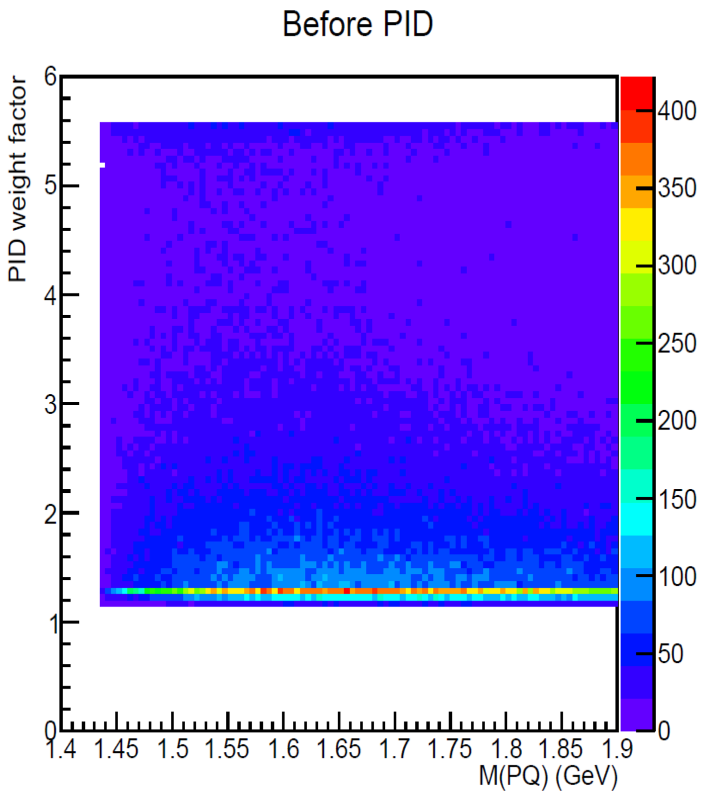


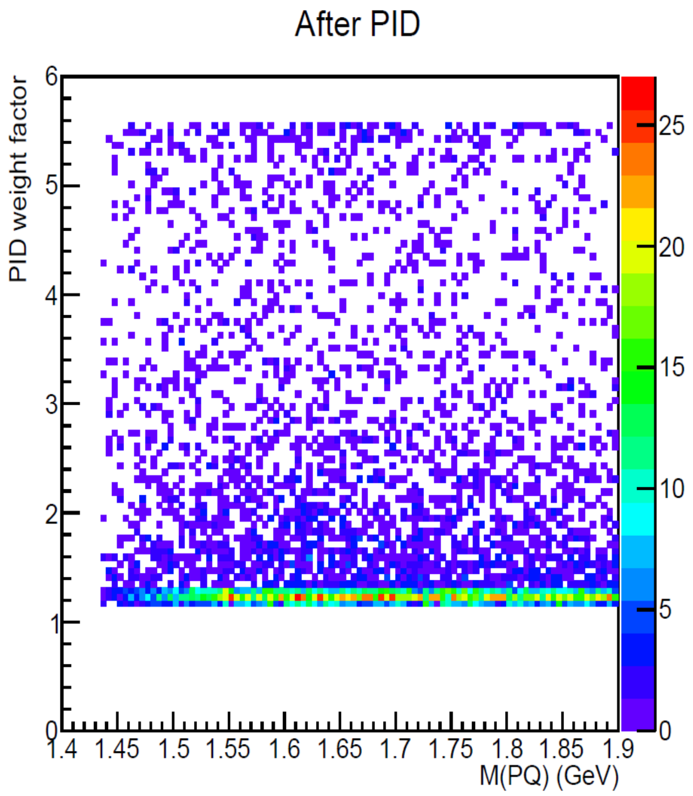


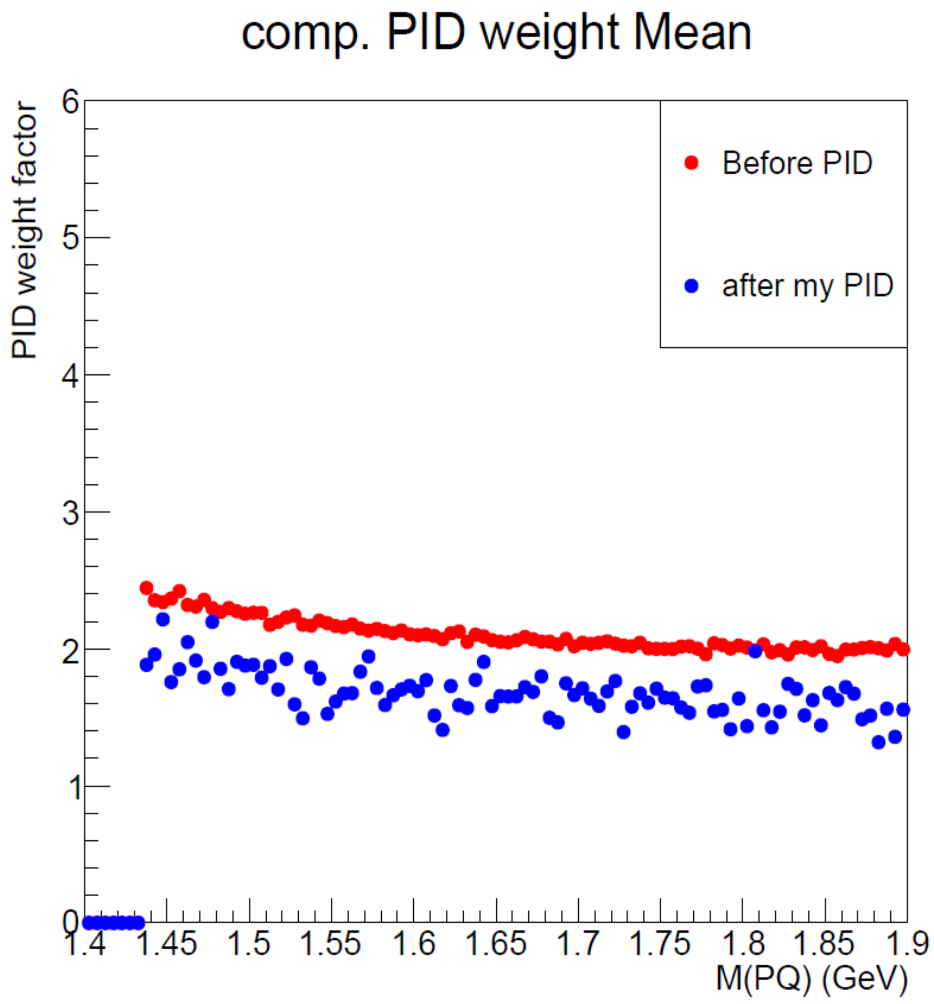
- After PID selection, low statistics -> weight fluctuations become large.

PID weight distributions (Mean)

- After PID, the mean of weight factor looks like scattering than the one before PID.
  -> This gives the fluctuation in the mass plots after the correction.
- => global proton PID correction with PQ MC is tried.





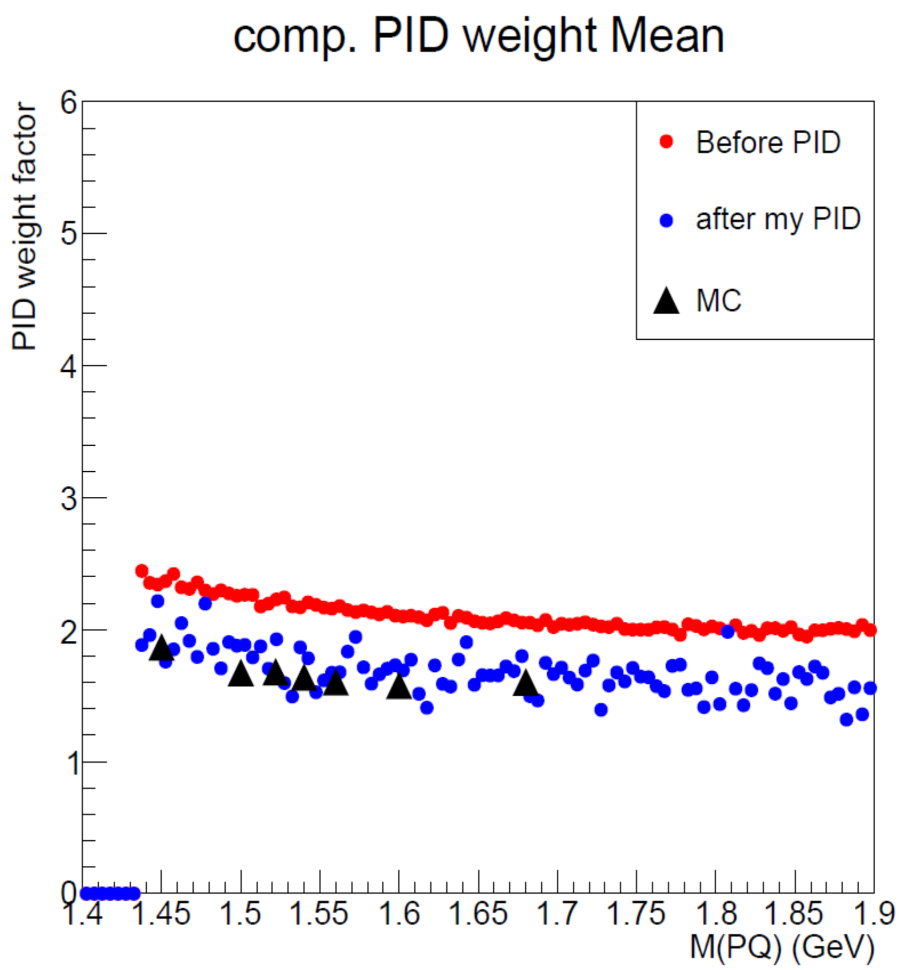


Global PID efficiency correction

Global PID efficiency correction.

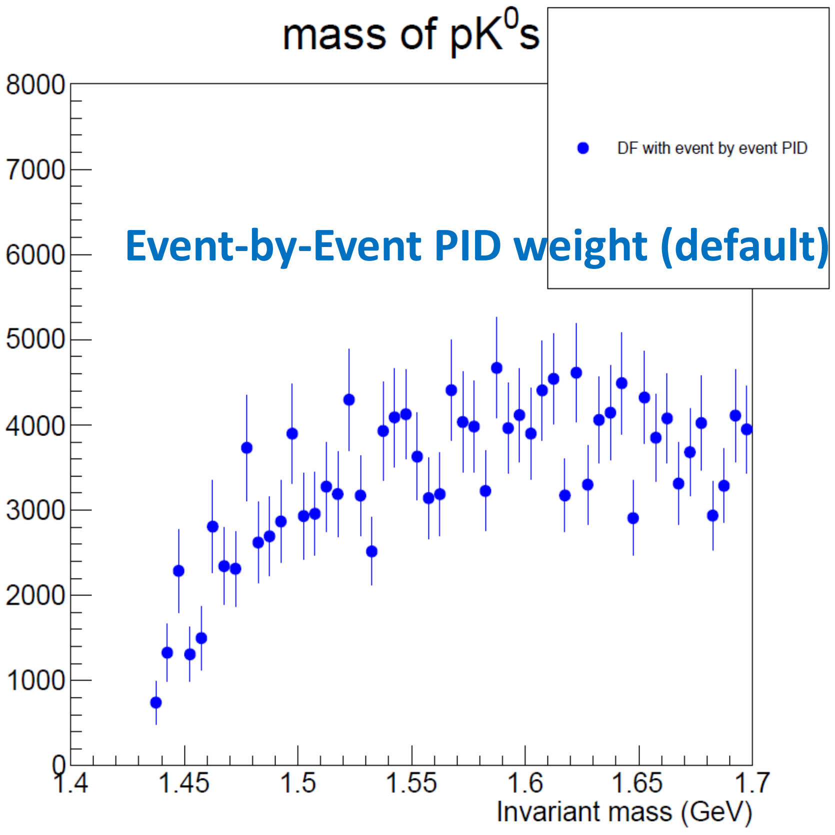
- Test an alternative method of proton PID efficiency correction.
  - Weight factor is calculated from PQ MC samples.
  - Include PID efficiency weight into acceptance correction.

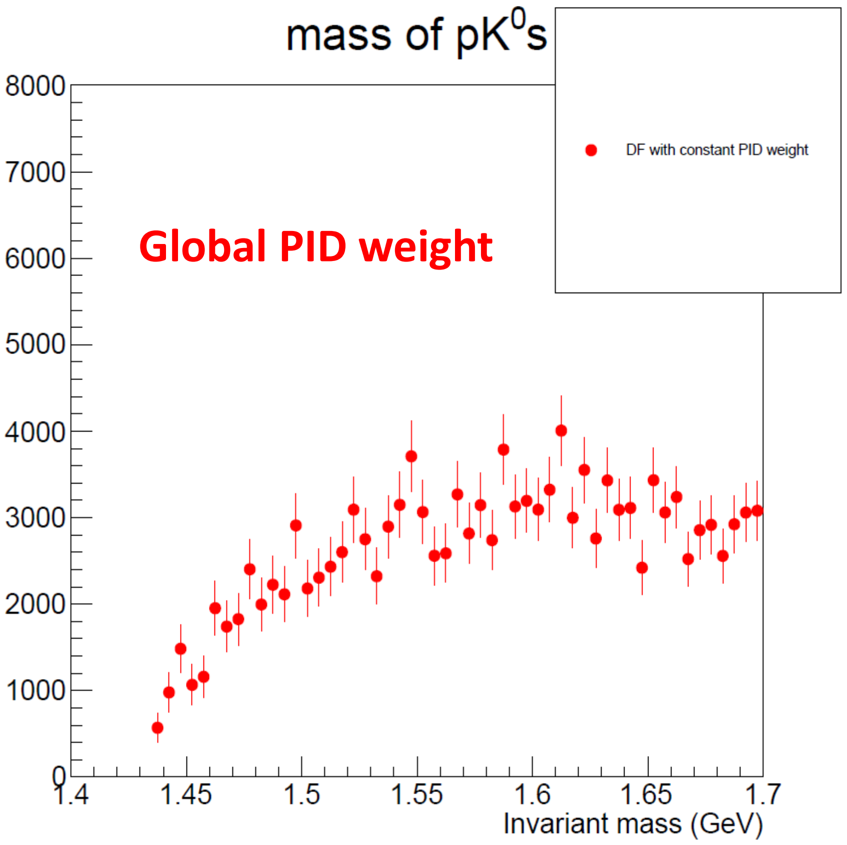
PID efficiency comparison (DATA and MC)

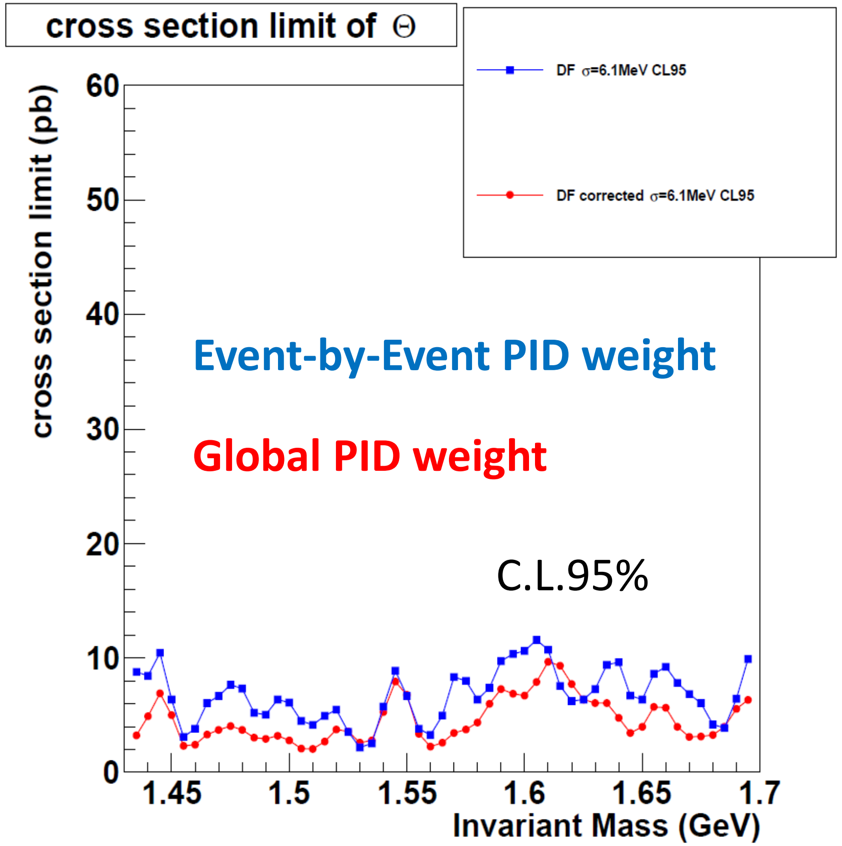


- The correction factor determined by the PQ MC follows the average event-by-event factor from the data (but less fluctuation)

Comparison



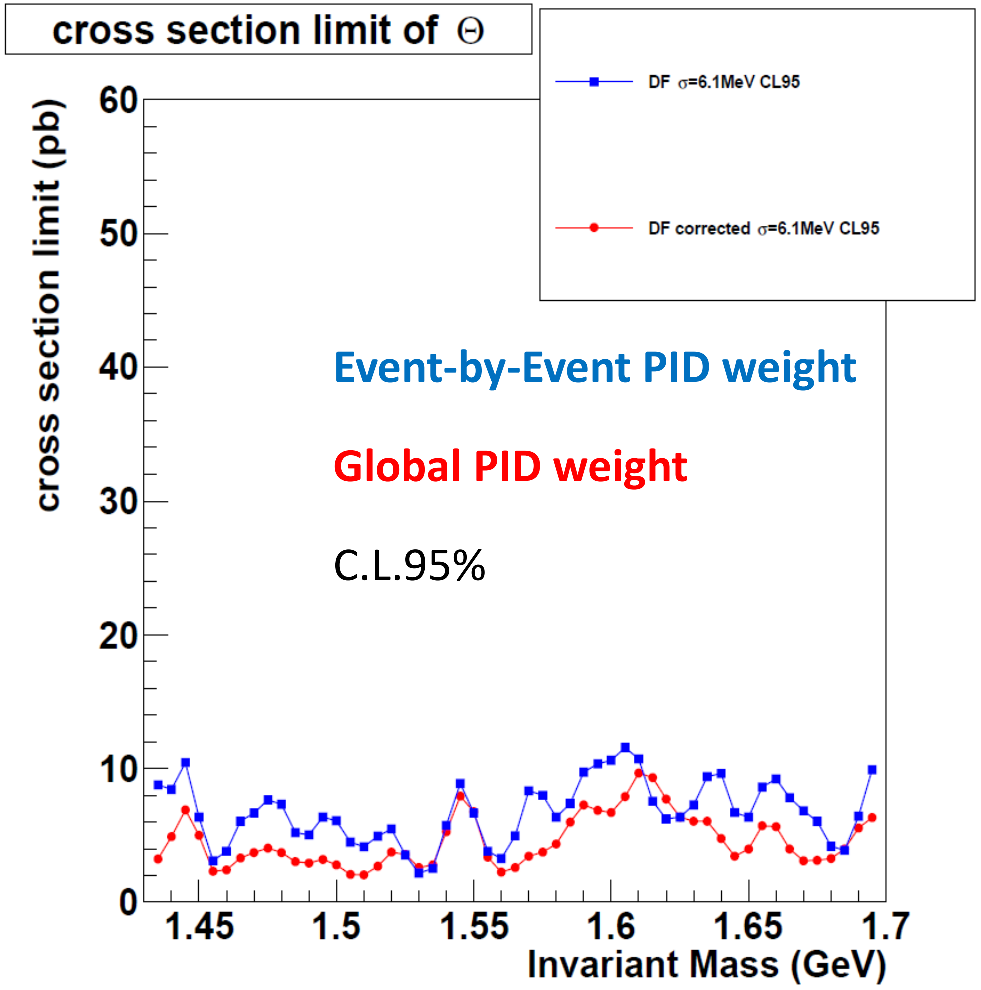


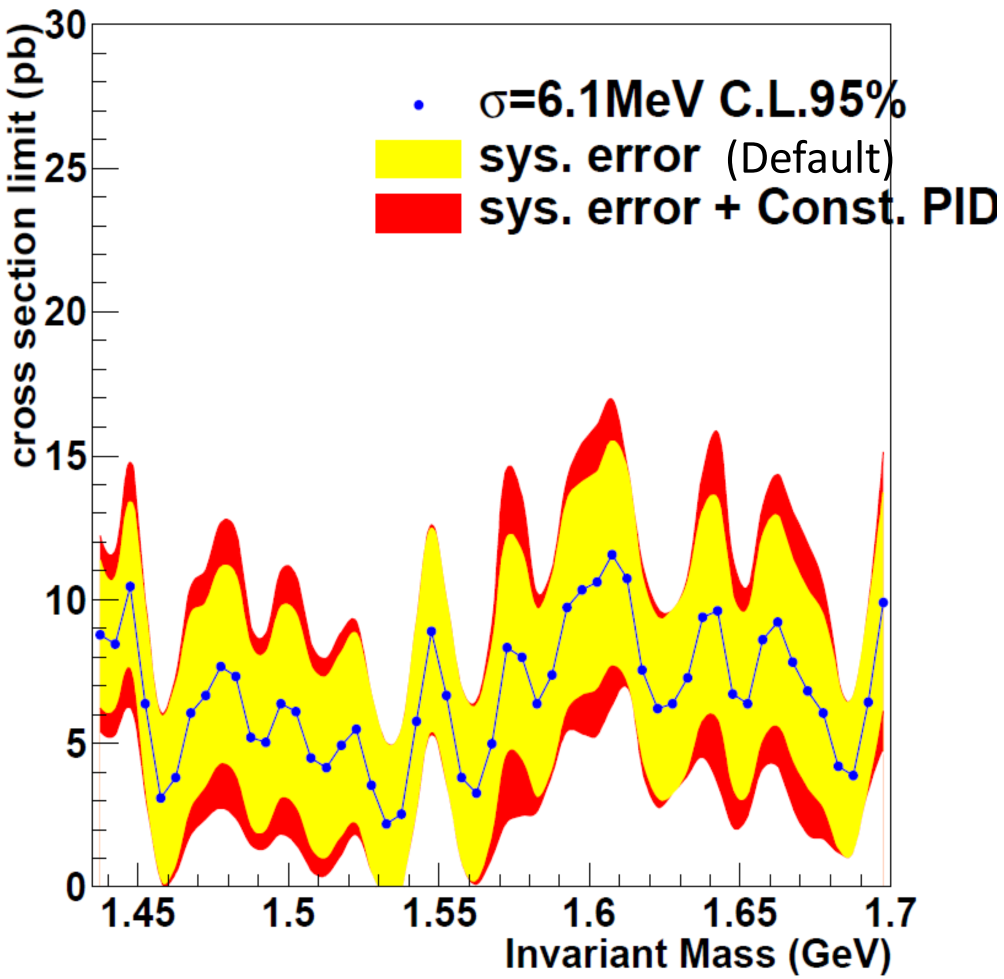


- Lower fluctuation with the global correction.
- The cross section limit is ~20% smaller.

Systematic error?

- Better limit with the global correction.
- But, it is not so large difference.
  - -> try to include it to default systematic errors (yellow).
  - -> The red includes it to systematic error.



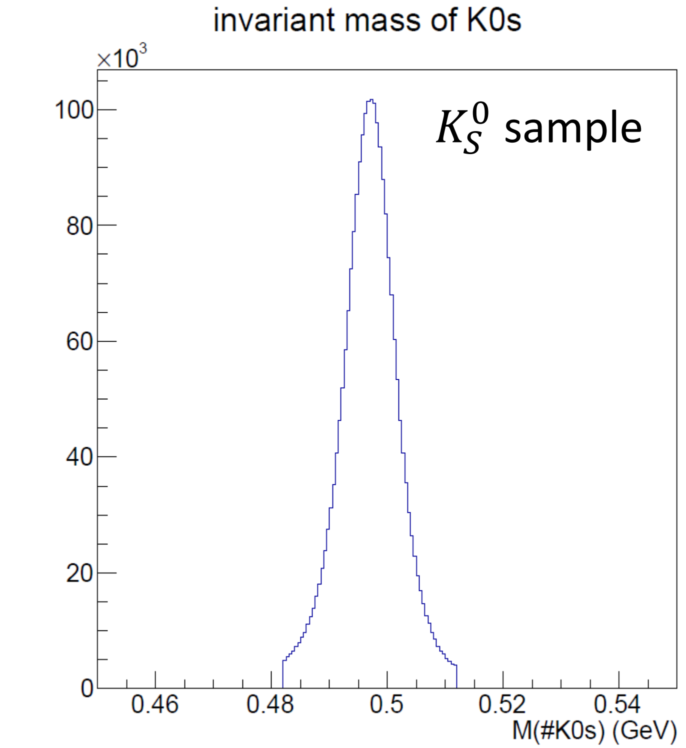


PID Quality:
How better the new PID is?

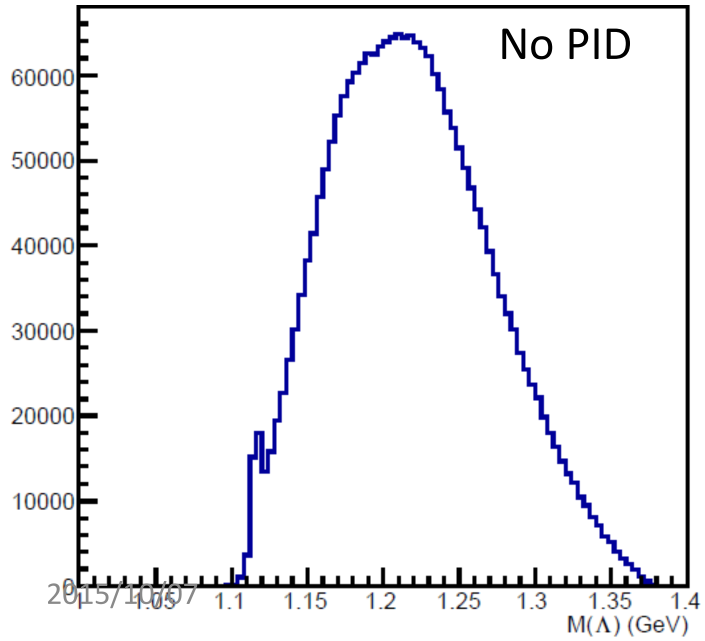
Pions from K_S^0 are used for efficiency to the pion.

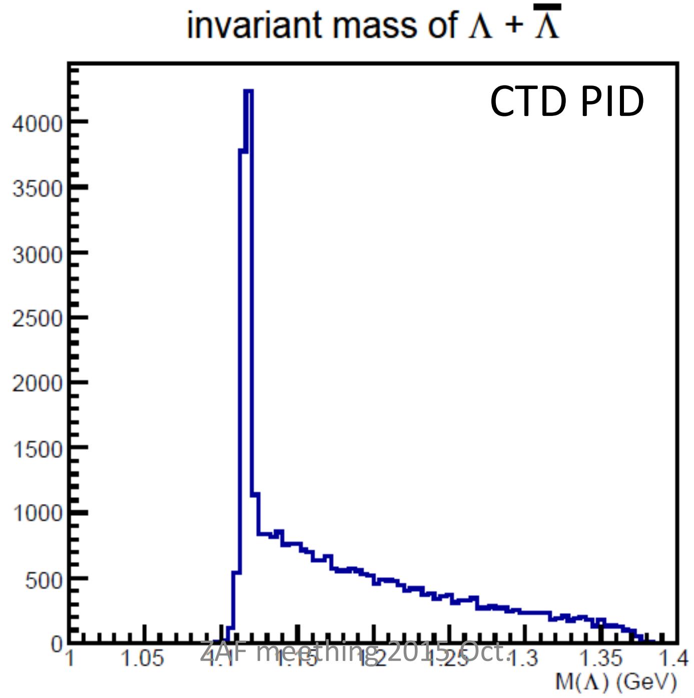
- K_S^0 sample
  - Selected by std. K_S^0 selections (without Λ rejection, to see the proton efficiency, at the same time).
  - Pions of K_S^0 are used as proton candidates.
- PID
  - CTD PID; band and CTD dE/dx > 1.15 mips
  - My PID; CTD and MVD, band, dE/dx > 1.15 mips and dE/dx likelihood
- Check PID effect

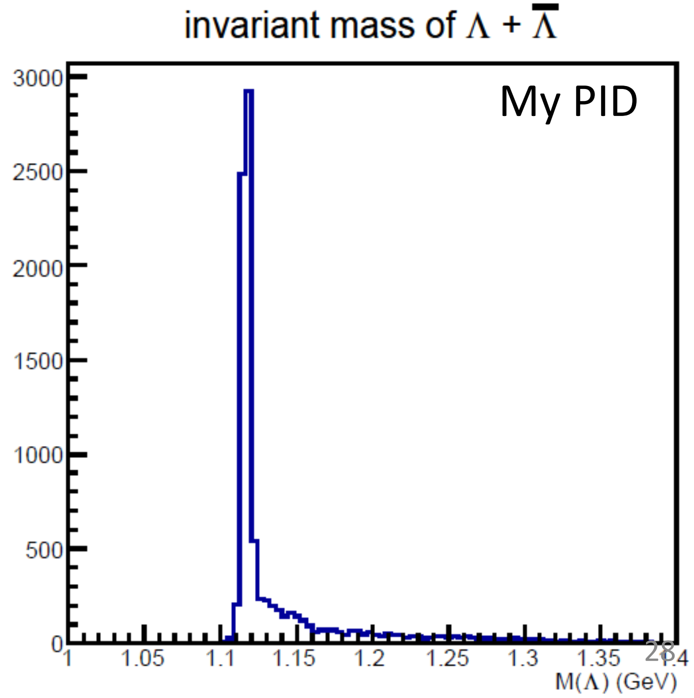
Mass distribution M(pπ) by K_S^0 sample



- K_S^0: HERA-II all sample (left plot)
- Check the contamination on (pπ) mass spectrum: Λ peak is clearly seen in the all samples. Efficiency to the Λ is almost same but pions are strongly reduced with the new PID.

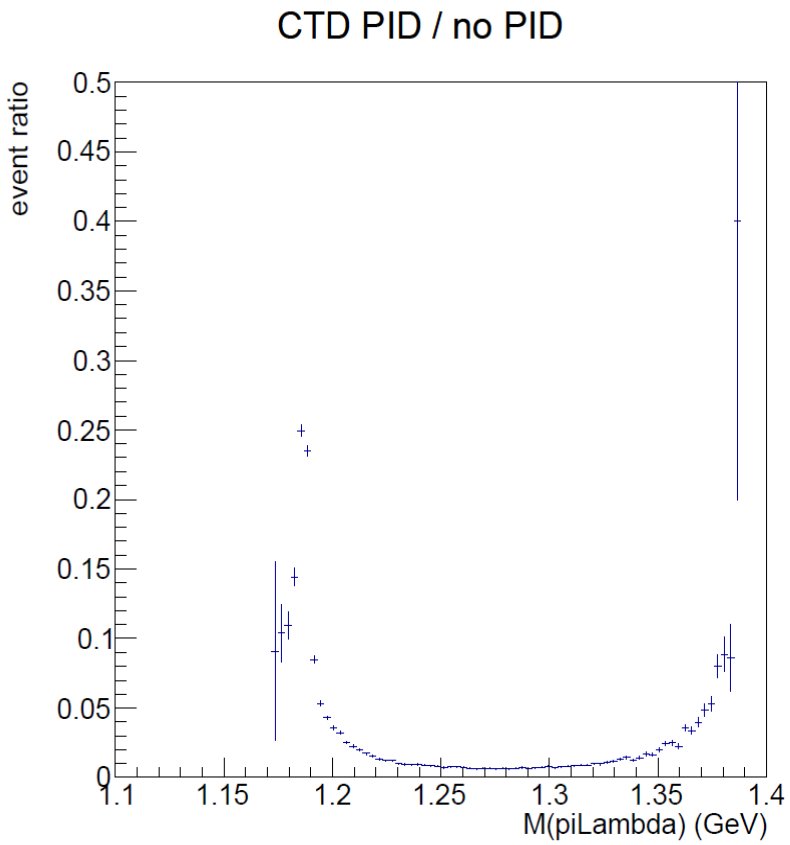


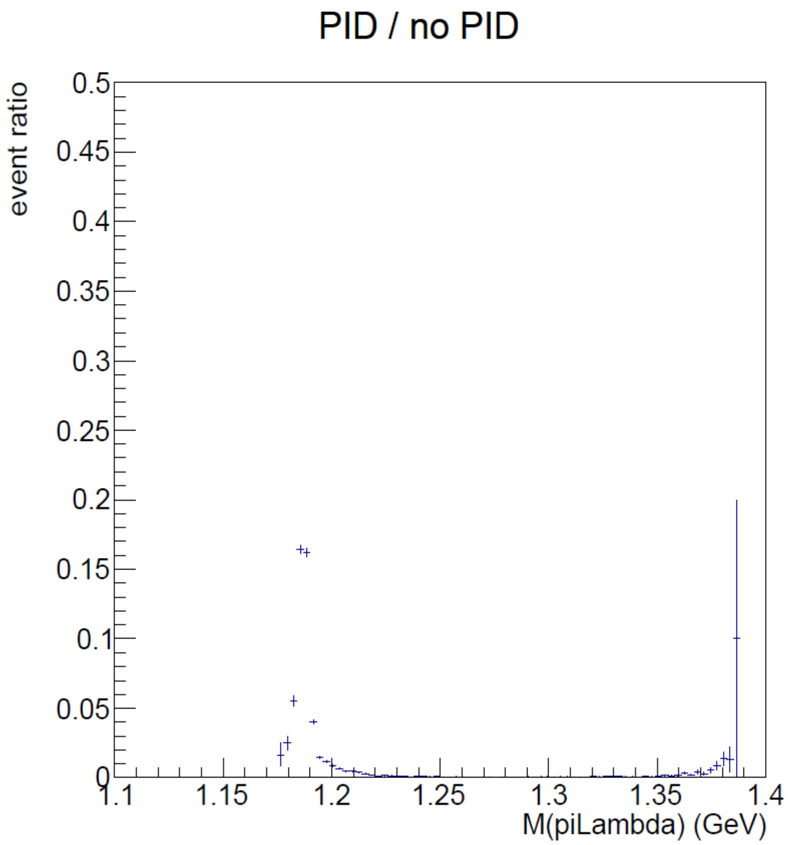


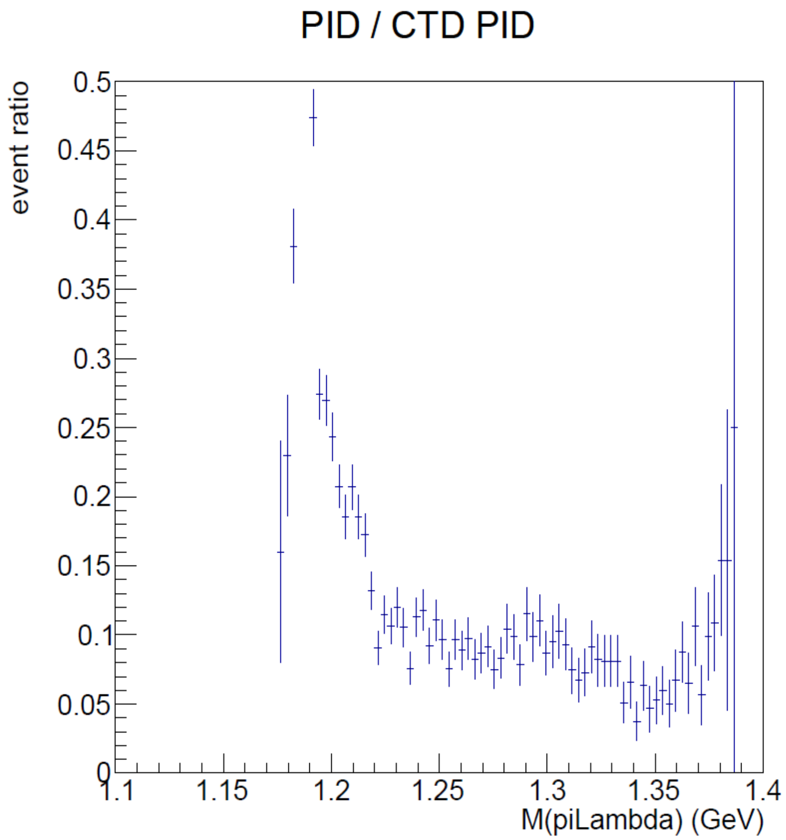


Ratio of event number (linear plot)

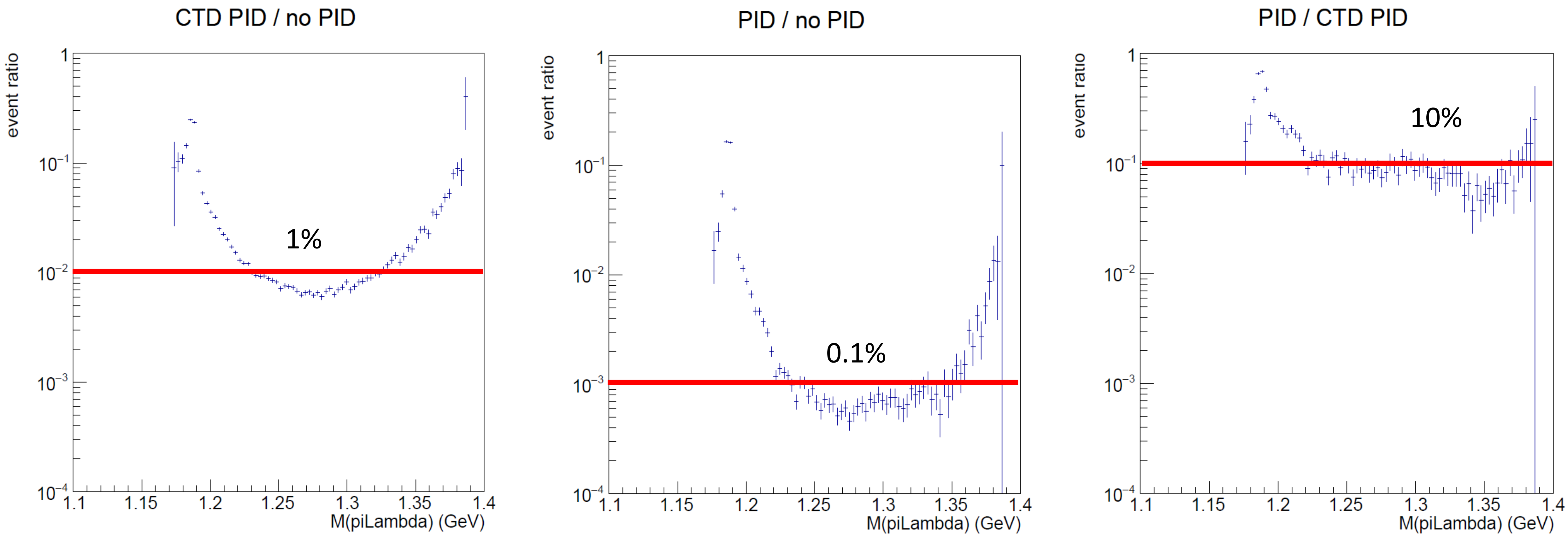
- Event number ratio comparison between no PID, CTD only PID and my PID (uses CTD & MVD).
- Log scale plots -> next page.







Ratio of event number (log plot)



- My PID can exclude π contamination 10 times stronger than CTD only PID.
- This is the base on the statement in paper "The reason of this large reduction is mainly attributed to the tighter PID selection for the proton candidates."

Comparison between the private Nuple and CN

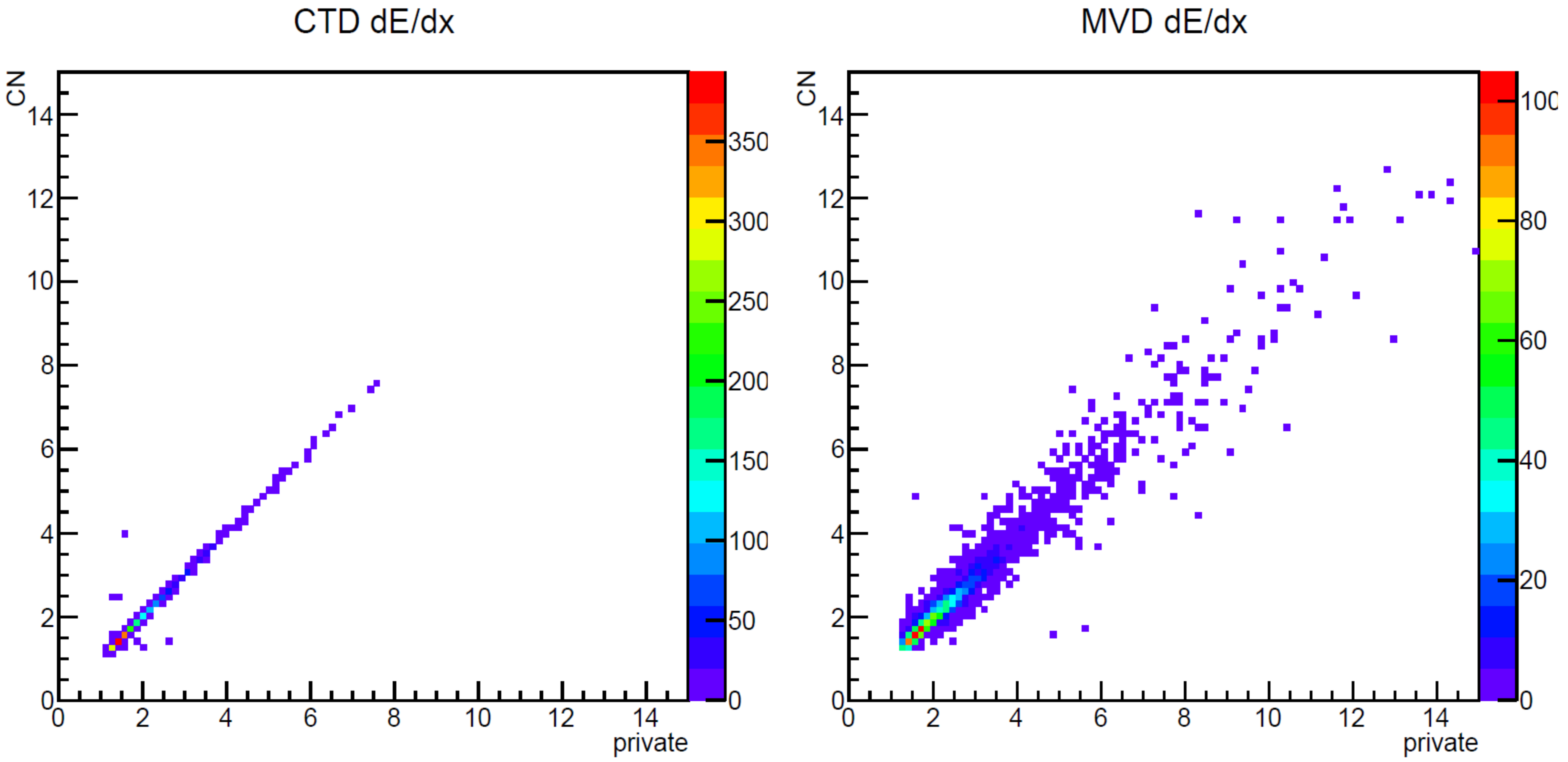
Comparison with CN and my private ntuple (DF)

- In summer 2014, I reported there are no big overlap in the events selected by my nutple and common ntuple. After some differences (in track selections) are corrected, the agreement is better and the main difference is in the PID selection.
- Comparison of numbers of events between after CTD PID and my PID are shown below tables.
  - events in CN are ~10% more than my ntuple but now 80% of events are common after CTD-PID selection
  - Difference become larger after the CTD&MVD PID but this is because the calibration of MVD PID is better in my ntuple.

2004-5CTD	**Total**	**Common**	**Ryuma Only**	**CN only**
Ryuma	7459	6720	739	
CN	8207	6720		1487

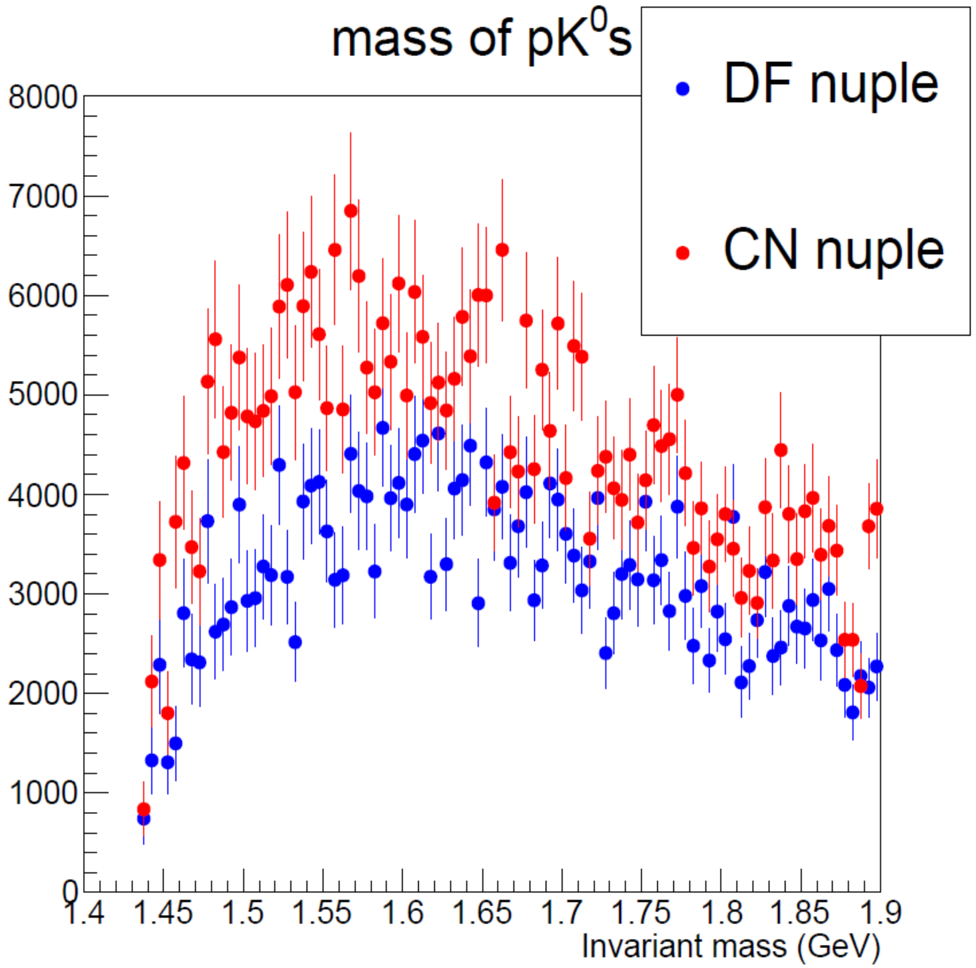
2005myPID	**Total**	**Common**	**Ryuma Only**	**CN only**
Ryuma	2866	2458	408	
CN	3476	2458		1017

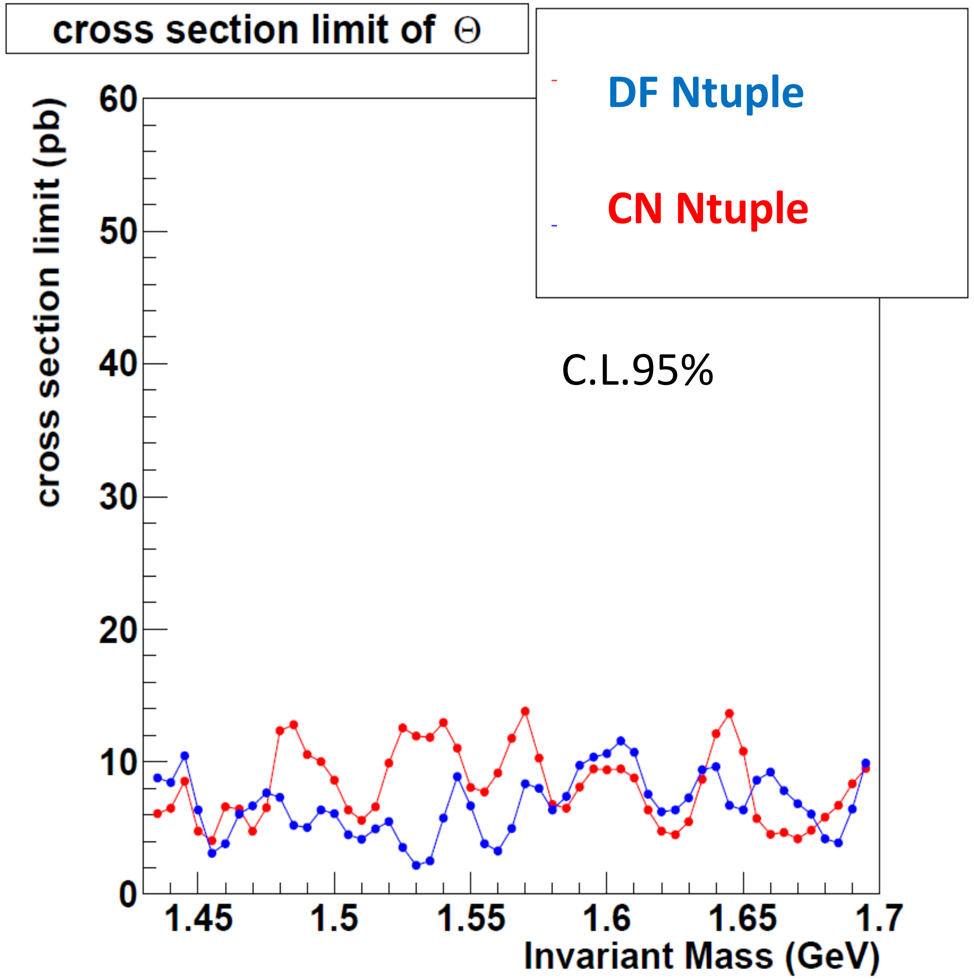
data dE/dx comparison in 2004-5 data



- MVD dE/dx is spread broader than CTD dE/dx.

Comparison weighted mass distribution and cross section limit





- CN ntuple is higher than DF. But the differences between cross section limits are not so large.

HERA-I cross section on the Figure3?
CTD-only PID plot?

Event number estimation from PQ results at ICHEP2004

6 Results

The cross section for the Θ^+ baryons and their antiparticles measured in the kinematic region given by $Q^2 \geq 20\,\mathrm{GeV}^2$, $0.04 < y < 0.95$, $p_T > 0.5\,\mathrm{GeV}$ and $|\eta| < 1.5$ was:

$$\sigma(e^{\pm}p \to e^{\pm}\,\Theta^+\,X \to e^{\pm}\,K^0 p\,X) = 125 \pm 27(\mathrm{stat.})^{+36}_{-28}(\mathrm{syst.})\ \mathrm{pb}.$$

Figure 2 shows the cross section integrated above Q^2_{min}. Figure 3 shows the ratio of this cross section to that of the Λ cross section integrated above Q^2_{min}, where the ratio, defined in the same kinematic region as above, is

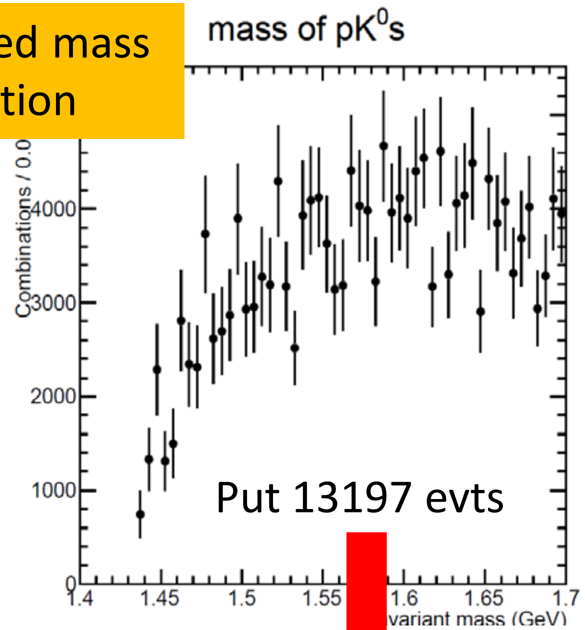
$$\mathrm{ratio} = \frac{\sigma(e^{\pm}p \to e^{\pm}\,\Theta^+\,X \to e^{\pm}\,K^0 p\,X)}{\sigma(e^{\pm}p \to e^{\pm}\Lambda X)}.$$

This ratio, for $Q^2_{\mathrm{min}} = 20\ \mathrm{GeV}^2$, is $4.2 \pm 0.9(\mathrm{stat.})^{+1.2}_{-0.9}(\mathrm{syst.})\%$ and, in the current data, shows no significant dependence on Q^2_{min}. Since the Θ^+ has other decay channels in addition to $\Theta^+ \to K^0 p$, this ratio sets a lower limit on the production rate of the Θ^+ to that of the Λ-baryon.

- Integrate luminosity;
  - (121 pb^{-1}; HERA-I)
  - 358 pb^{-1}; HERA-II
- Same kinematical Range (y , p_T and η)
- Θ production cross section (125 pb)
- Changing factors to event number.
  - BR($K^0 pX$-> $K^0 p$); ~ 1
  - K^0 branch to K_S^0; 0.5
  - K_S^0→$\pi^0\pi^0$ decay branch correction; 0.69
  - Q^2-range change from Q^2>20 to 20-100 GeV^2 (estimated by MC); 0.85
  - Etc. ?
- Estimation of number of events
  - (HERA-II luminosity)*(cross section) = 44866.9 evts.
  - (HERA-II luminosity)*(cross section)*(factors) = 13197.5 evts
- An artificial peak puts on invariant mass distributions in next page.

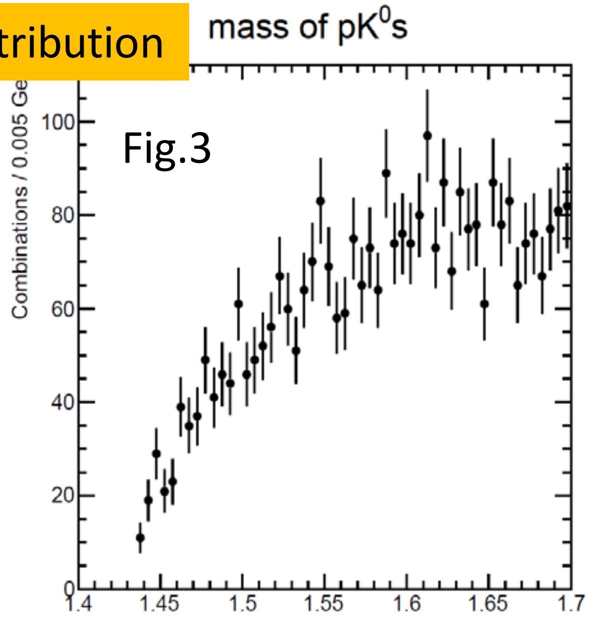
Hera-I Artificial peak on HERA-II

Weighted mass distribution



Put 13197 evts

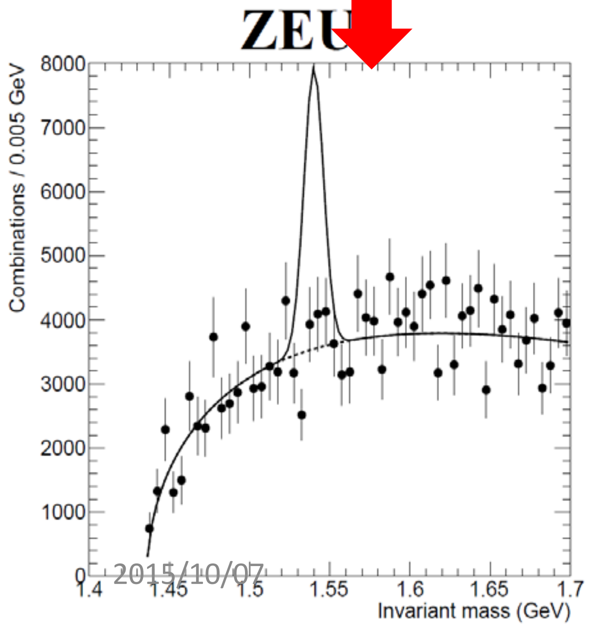
Raw distribution



Efficiency weighted dist. @1.54 GeV = 3930 evts.

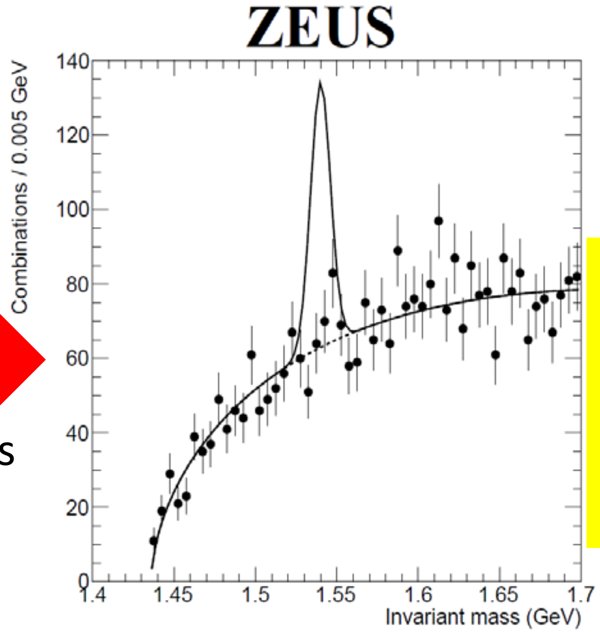
Raw distribution @1.54 GeV = 64 evts.

Weight factor = 64/3930



Convert by factor

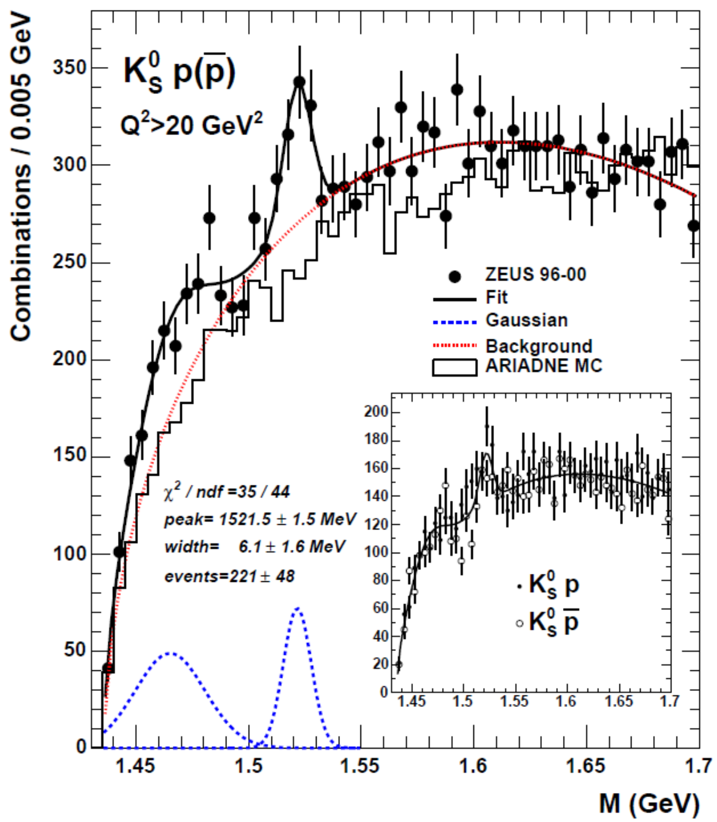
13197 evts -> 264 evts



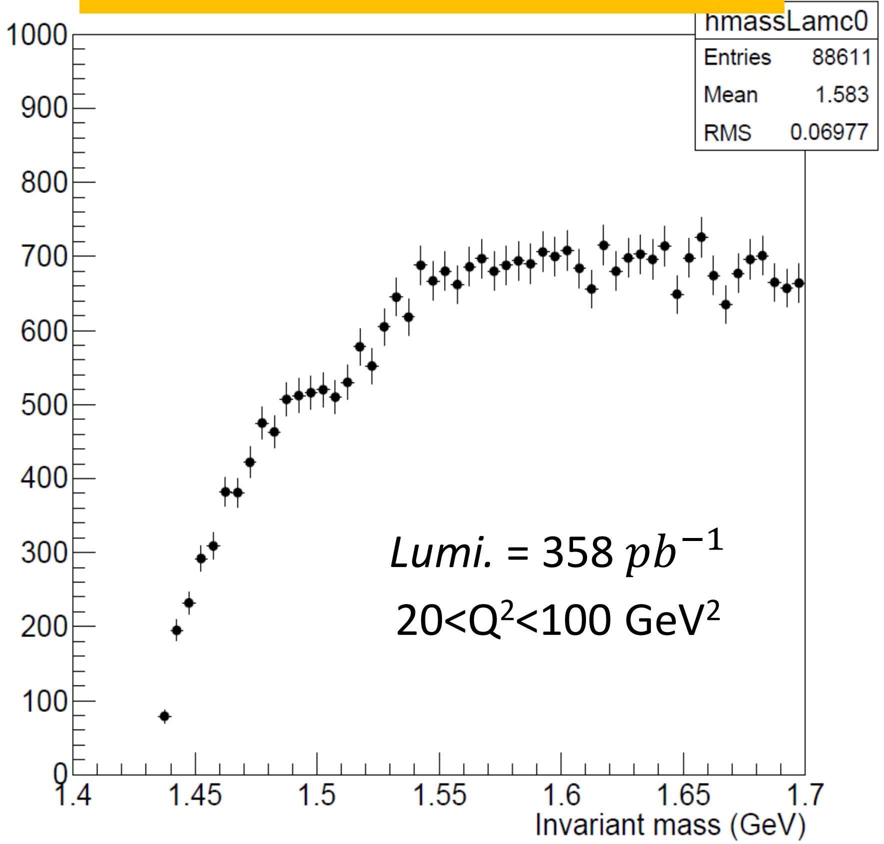
If this is acceptable, I will put this peak on Figure 3 (with a dotted line)

pK_S^0 mass plot with CTD-only PID?

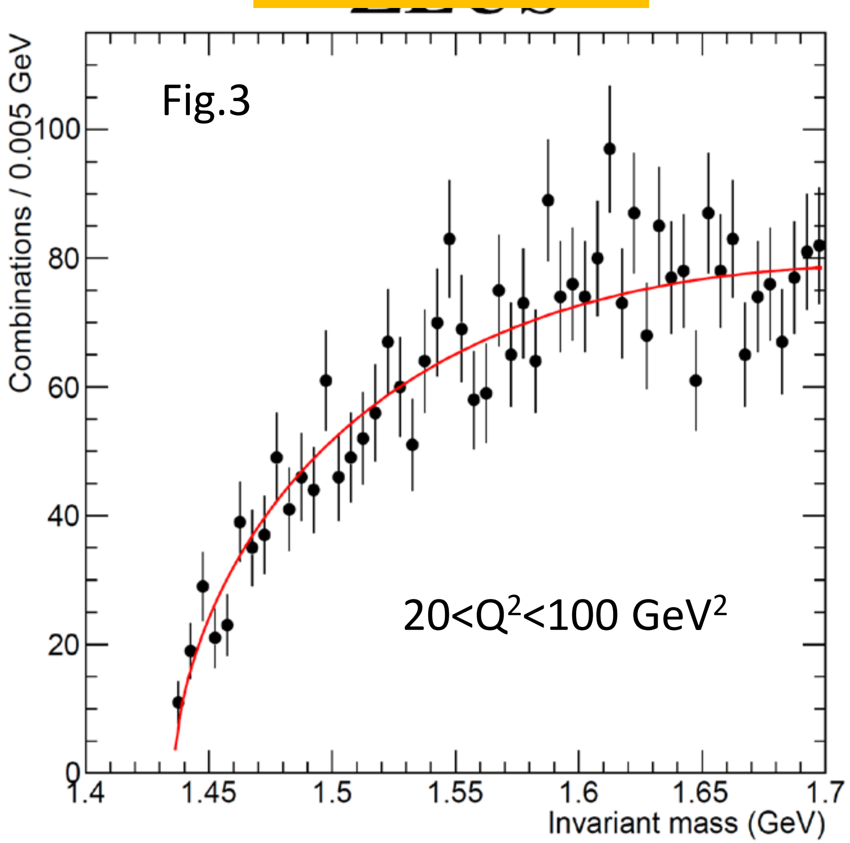
ZEUS $Lumi. = 121\ pb^{-1}$



CTD PID selections to HERA-I logic

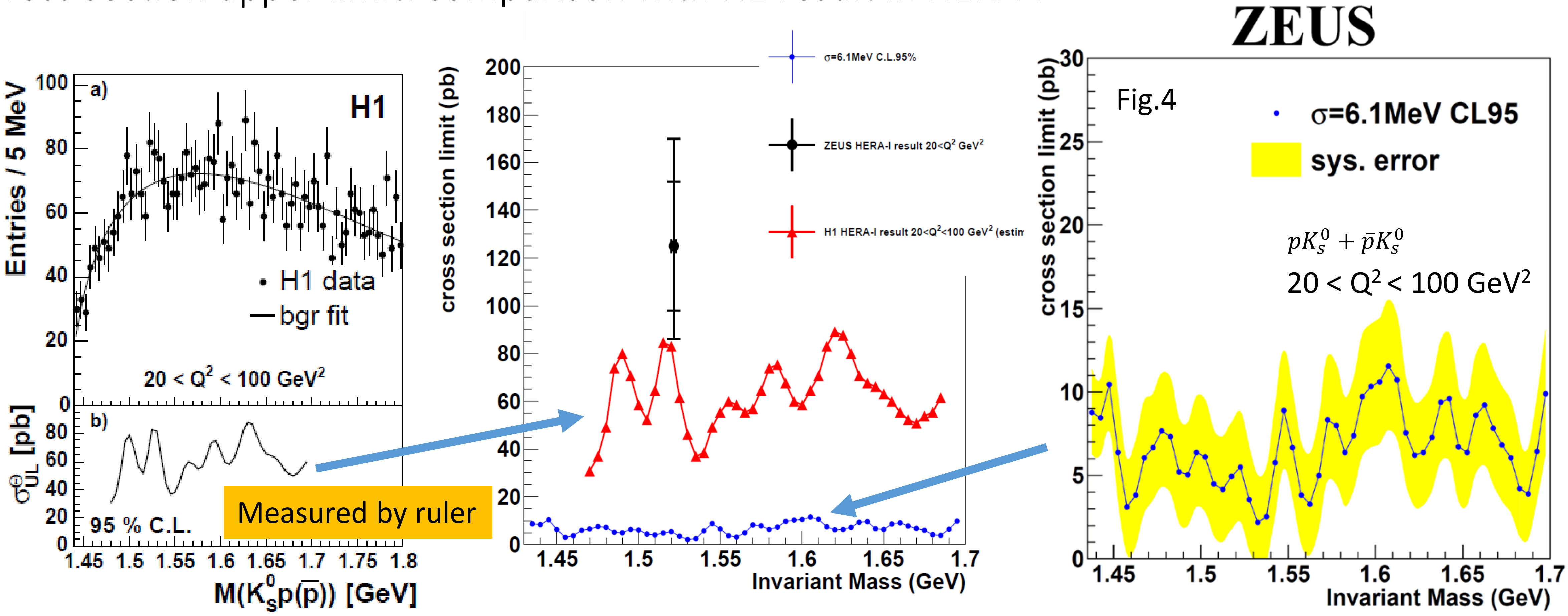


my PID selections



- If we use only CTD PID as same selections in HERA-I analysis as possible, the number of event per luminosity increases back to ~75% of HERA-I yield.

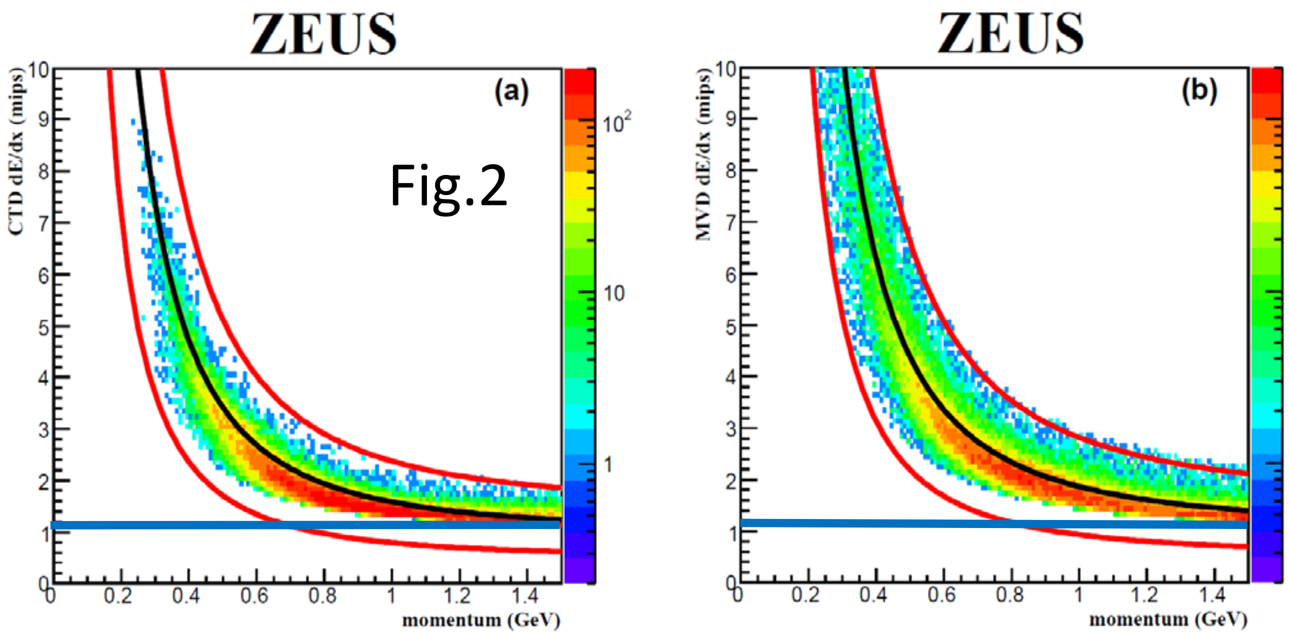
Cross section upper limit: comparison with H1 result in HERA-I



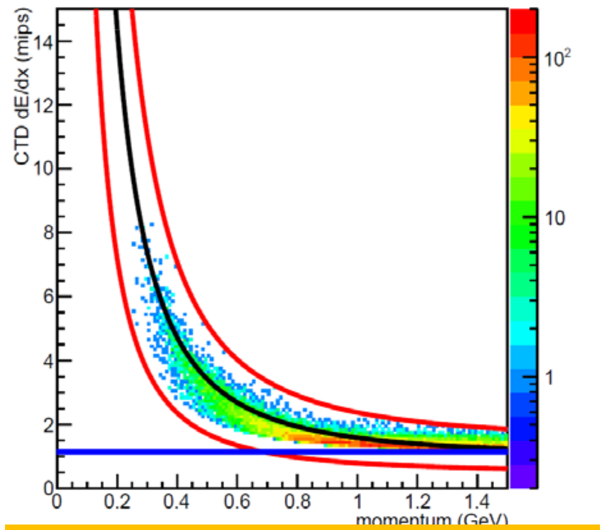
- HERA-I ZEUS result of production cross section is 125±27(stat.)$^{+36}_{-28}$ (sys.)pb^{-1} Cf. the ICHEP conference paper in Beijing(2004), mass resolution σ=6.1 MeV
- H1 reported the C.S. limit (used σ = 4.8-11.3 MeV).
- The obtained HERA-II ZEUS upper limit is significantly lower than HERA-I results.
- I try to compare with H1 HERA-I result measured by ruler. (Achim's request, but I don't access to H1 accurate values.)

Better dE/dx plots? (Figure 2)

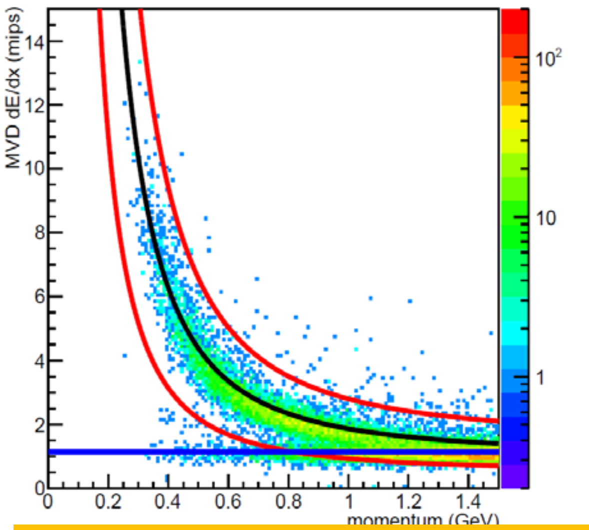
Alternative dE/dx Plots? (figure 2)



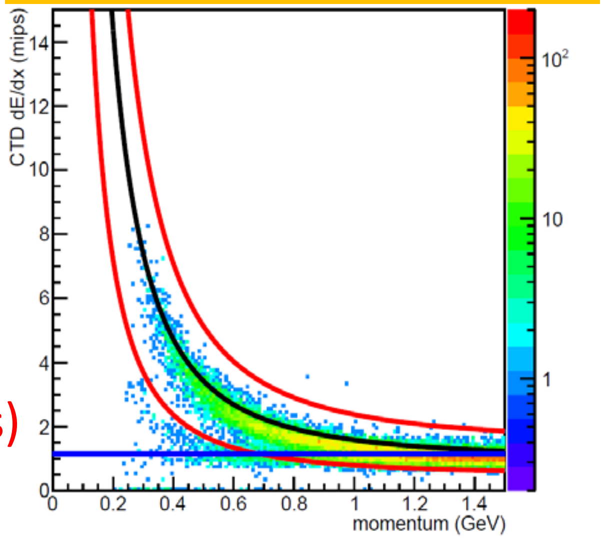
CTD dE/dx; selected by CTD



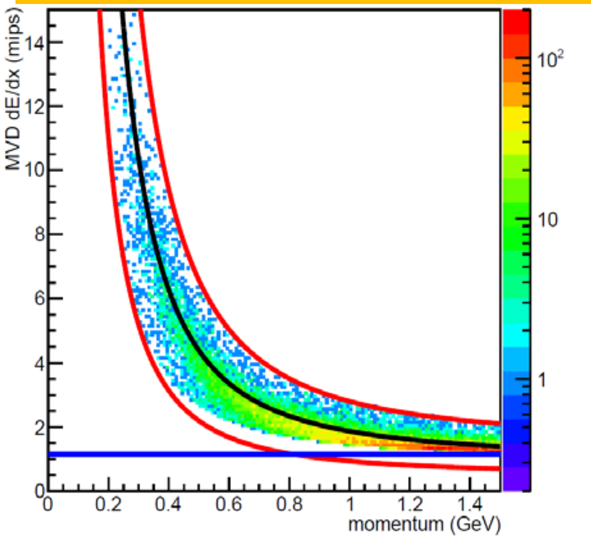
MVD dE/dx; selected by CTD



CTD dE/dx; selected by MVD



MVD dE/dx; selected by MVD



- Needs to explain about PID selections by dE/dx plots.
- These right 4 plots tell how our dE/dx measurements are good but they does not show how tightly we cut out the π. Proposal: Keep fig 2 as it is or show both plots (i.e. 6 figures)

Summary and Discussions

- Λ_C^+ plot: If acceptable, we will show the mass peak from the photoproduction sample, as an extra figure in the paper
- Cross section limit: Proposal:

  Figure 4a: σ = 6.1 MeV

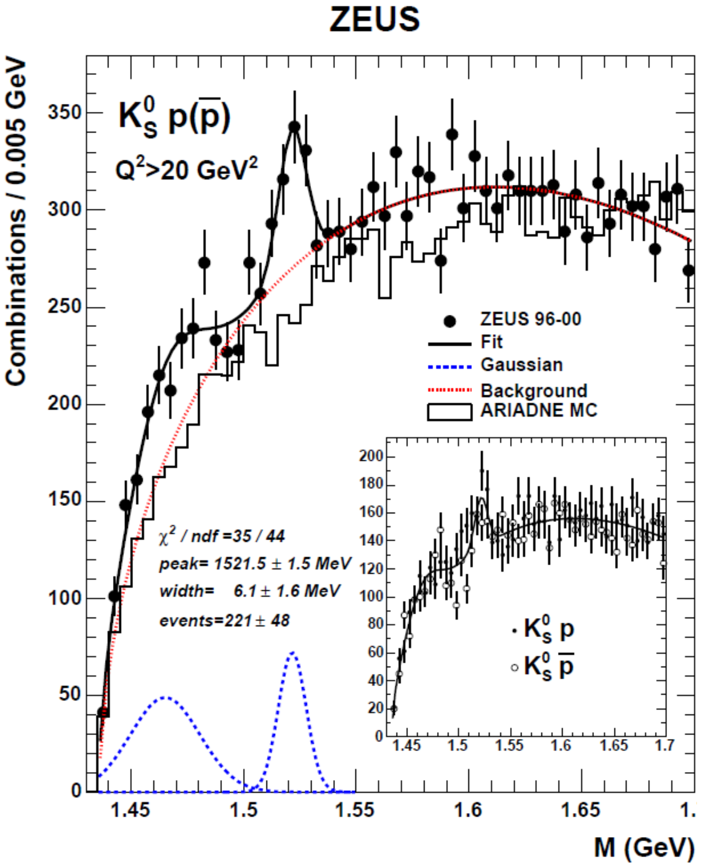
  Figure 4b: σ = 12.2 MeV + Resolution limit(page9) + H1 HERA-1

  (center values only: Systematics in note)

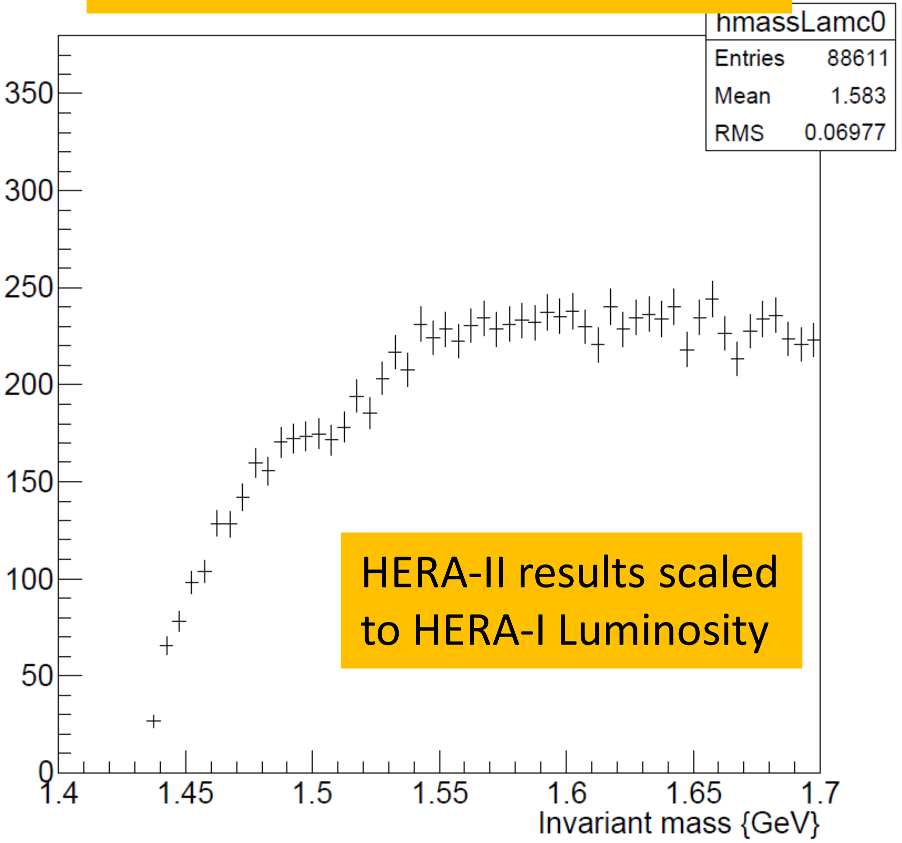
  Keep event-by-event weight as the default. But if board prefers the global PID weight, we will recalculate all (~one week work)
- Mass plot with CTD-dE/dx only? We don't see a merit, as the PID is not exactly same as HERA-I. But if strong recommendation, we will follow.
- dE/dx plot: alternative plot?

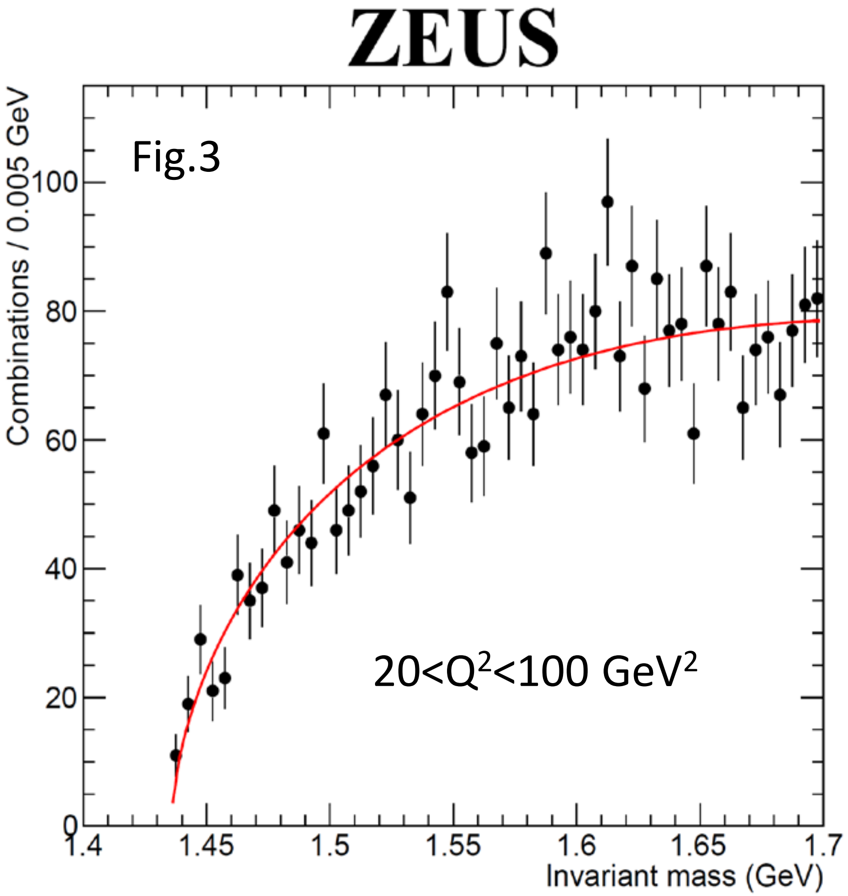
Backups

pK_S^0 mass plot with CTD-only PID and luminosity normalize



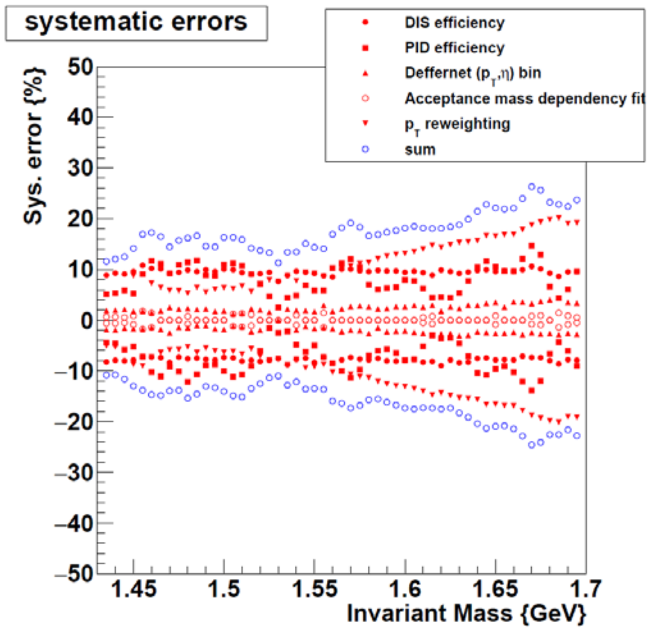
CTD PID selections to HERA-I logic

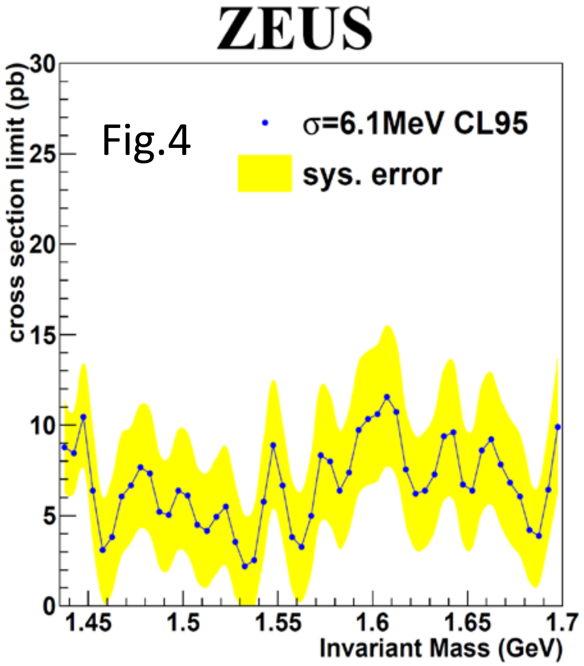


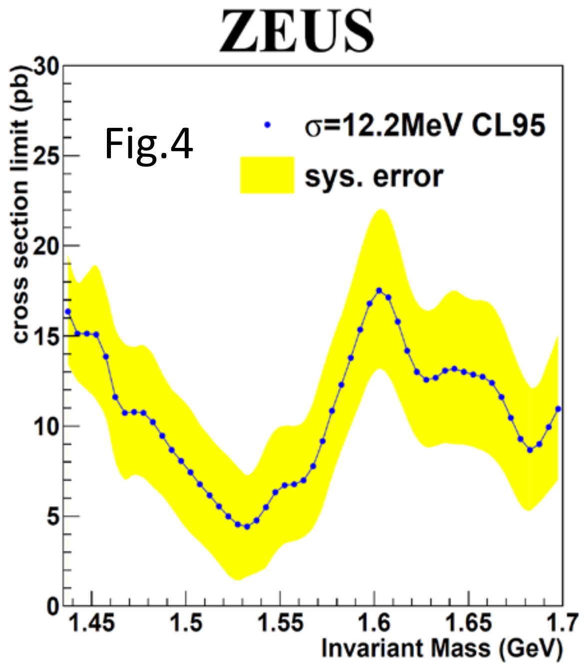


- If we use only CTD PID as same selections in HERA-I analysis as possible, the number of event increases back to ~75% of HERA-I yield.

Final result with systematic errors







Systematic errors (more detail)
- DIS
- PID
- accept. different (p_T, η) bin
- accept. mass dependency
- p_T re-weighting