Probing 2N-SRC via (e,e'N) reactions off ^{3,4}He and ^{12}C targets

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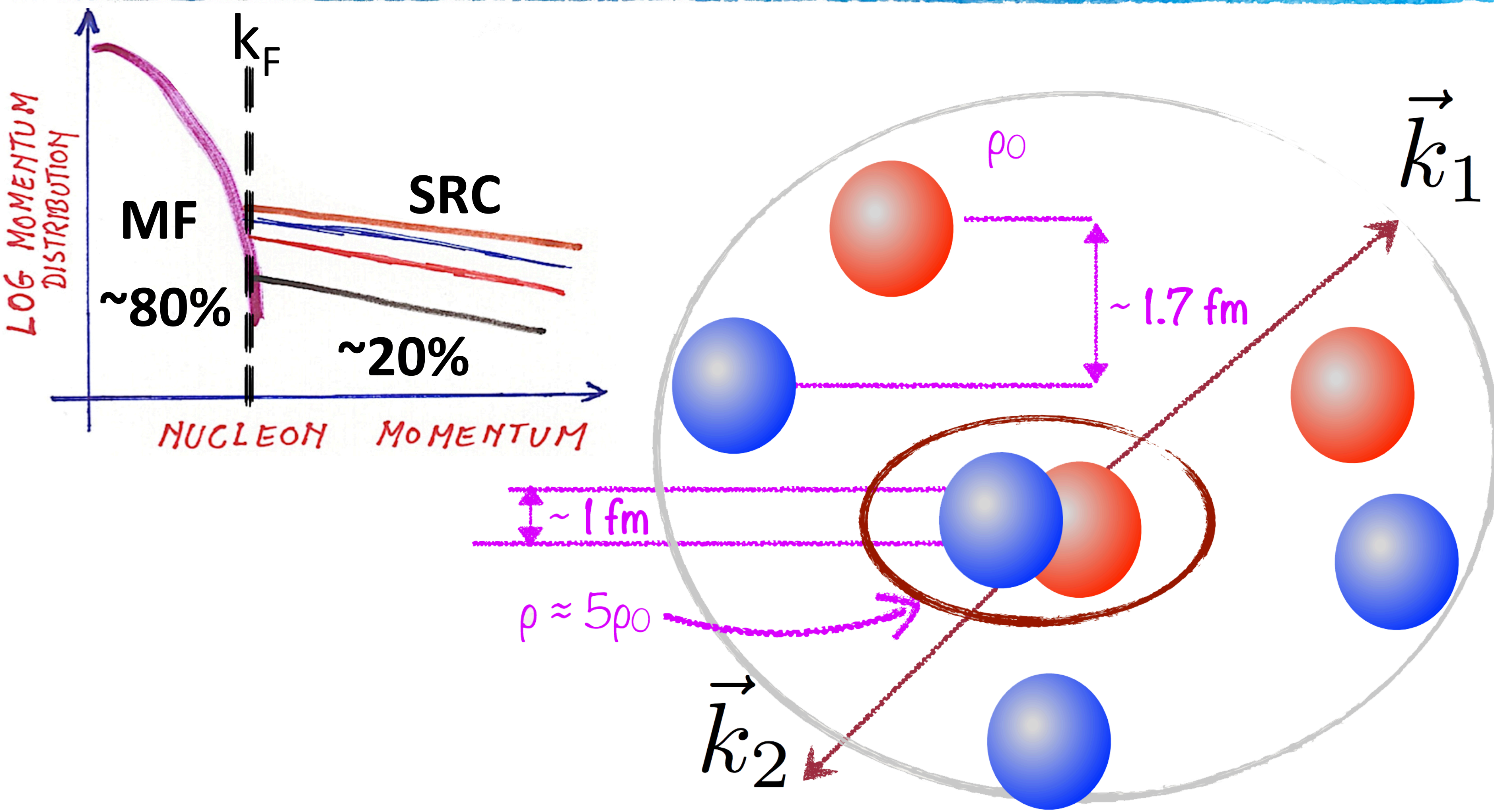
June 5, 2018

SRC-101

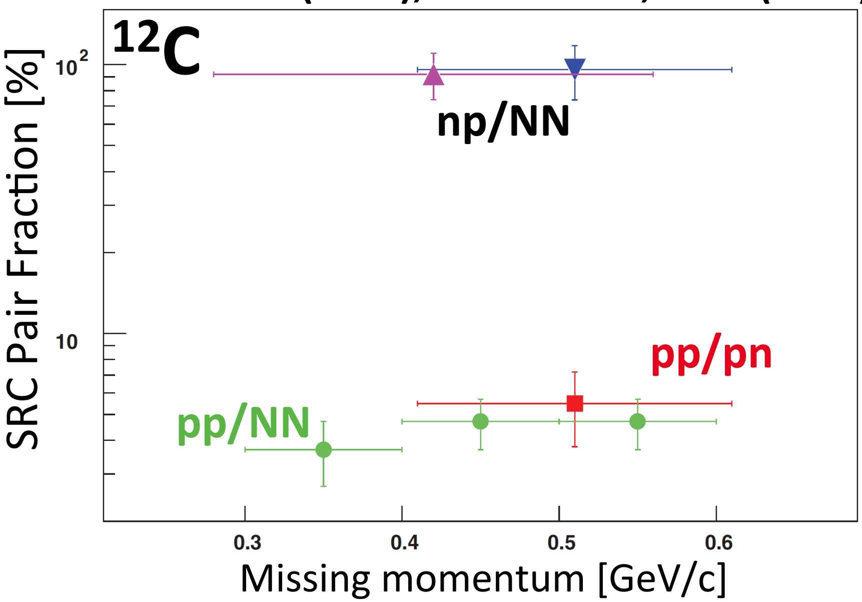


Majority = most abundant nucleon species in an asymmetric nucleus

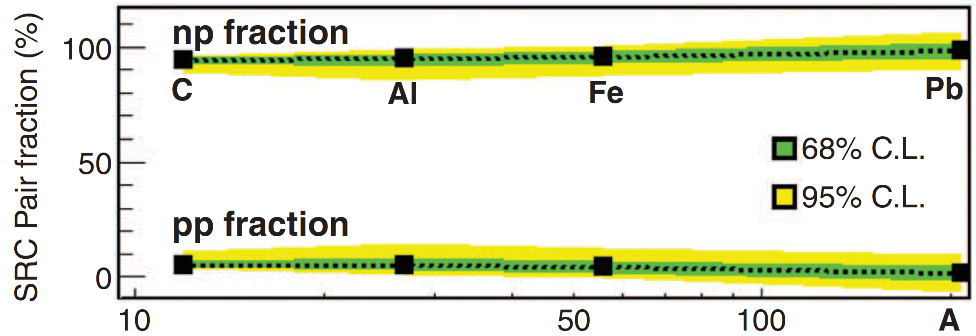
Minority = least abundant nucleon species in an asymmetric nucleus

np-dominance and asymmetric nuclei

PRL 162504 (2006); Science 320, 1476 (2008)

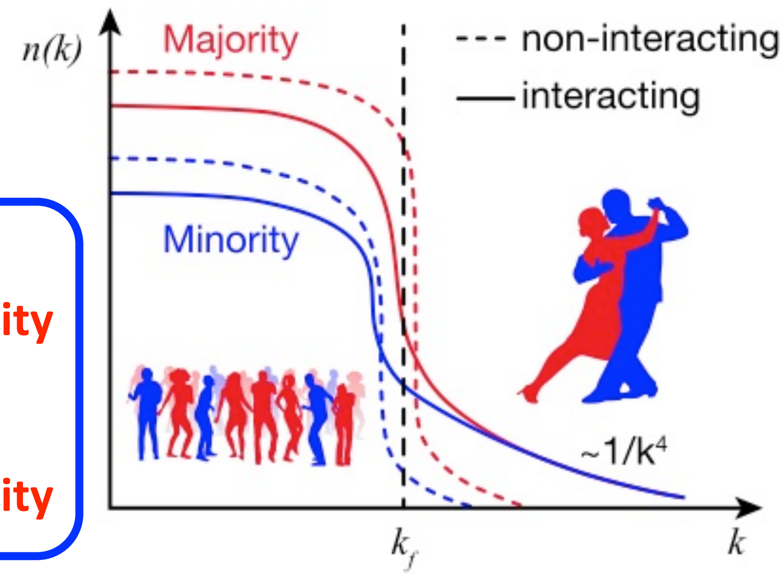


Hen et al., Science 346 (2014)



Pauli principle: $\langle T \rangle_{Minority} < \langle T \rangle_{Majority}$

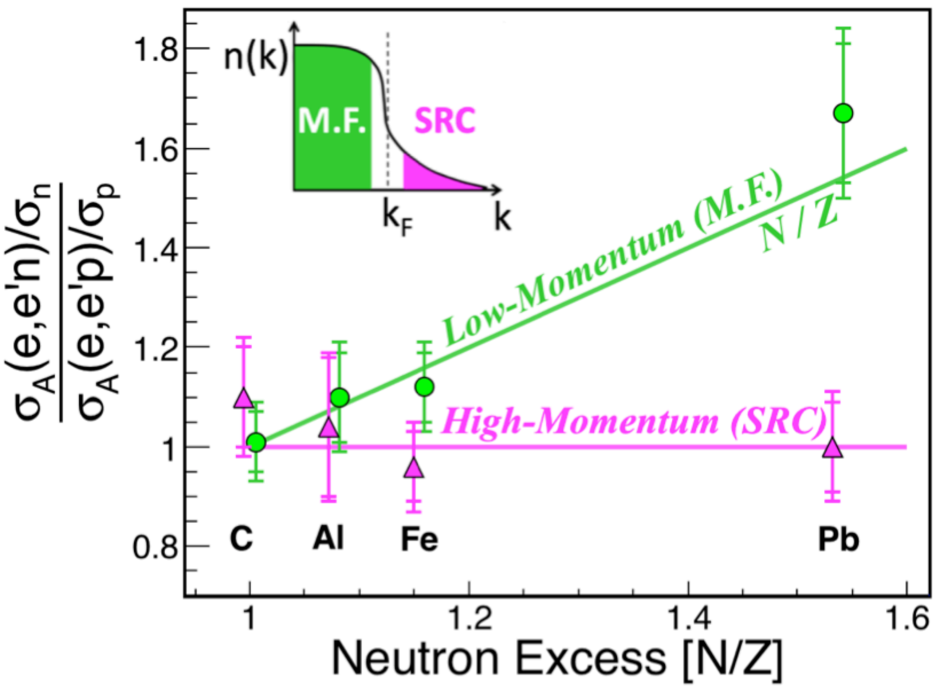
np correlations: $\langle T \rangle_{Minority}$? $\langle T \rangle_{Majority}$

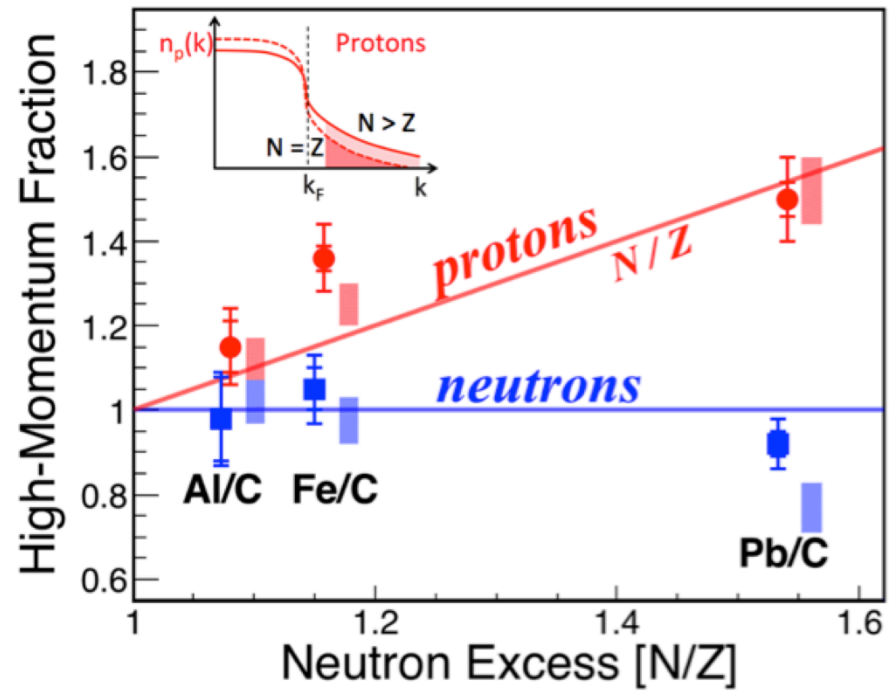


Possible inversion of the momentum sharing

Results in heavy nuclei

Analysis by Meytal (EG2 data)





Minority moves faster than majority in heavy nuclei!

Same goal for this analysis, this time on ^{3,4}He and ^{12}C, E_{beam} = 4.4 GeV (*i.e.* e2a data)

EG2 vs. e2a

e2a (This analysis):

Nuclear targets:
^{3}He, ^{4}He, ^{12}C

Ebeam:
4.461 GeV

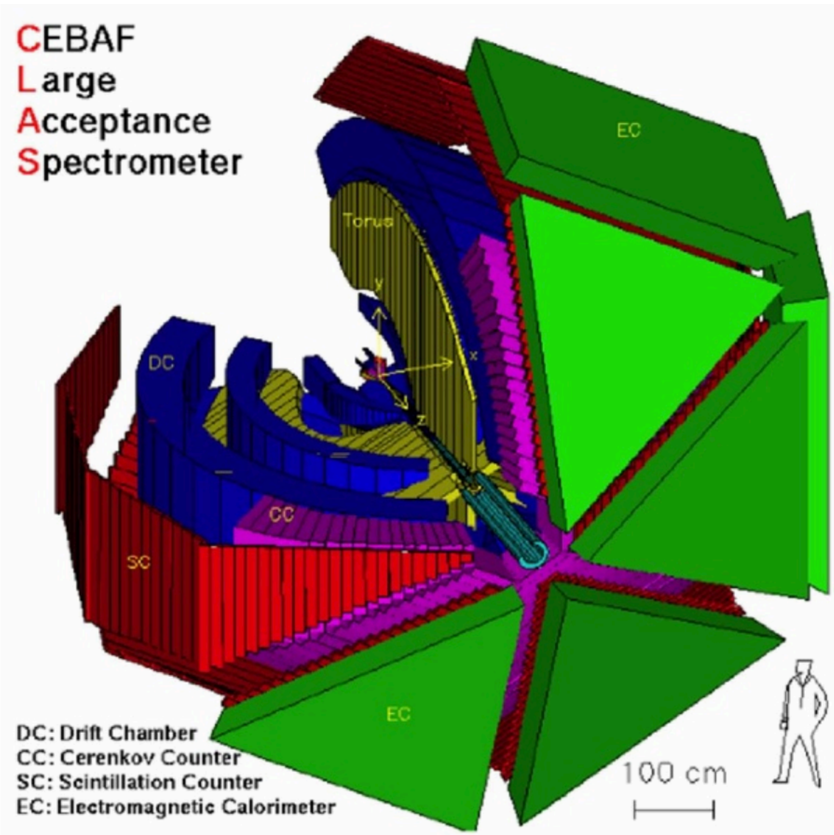
EG2 (Meytal's analysis):

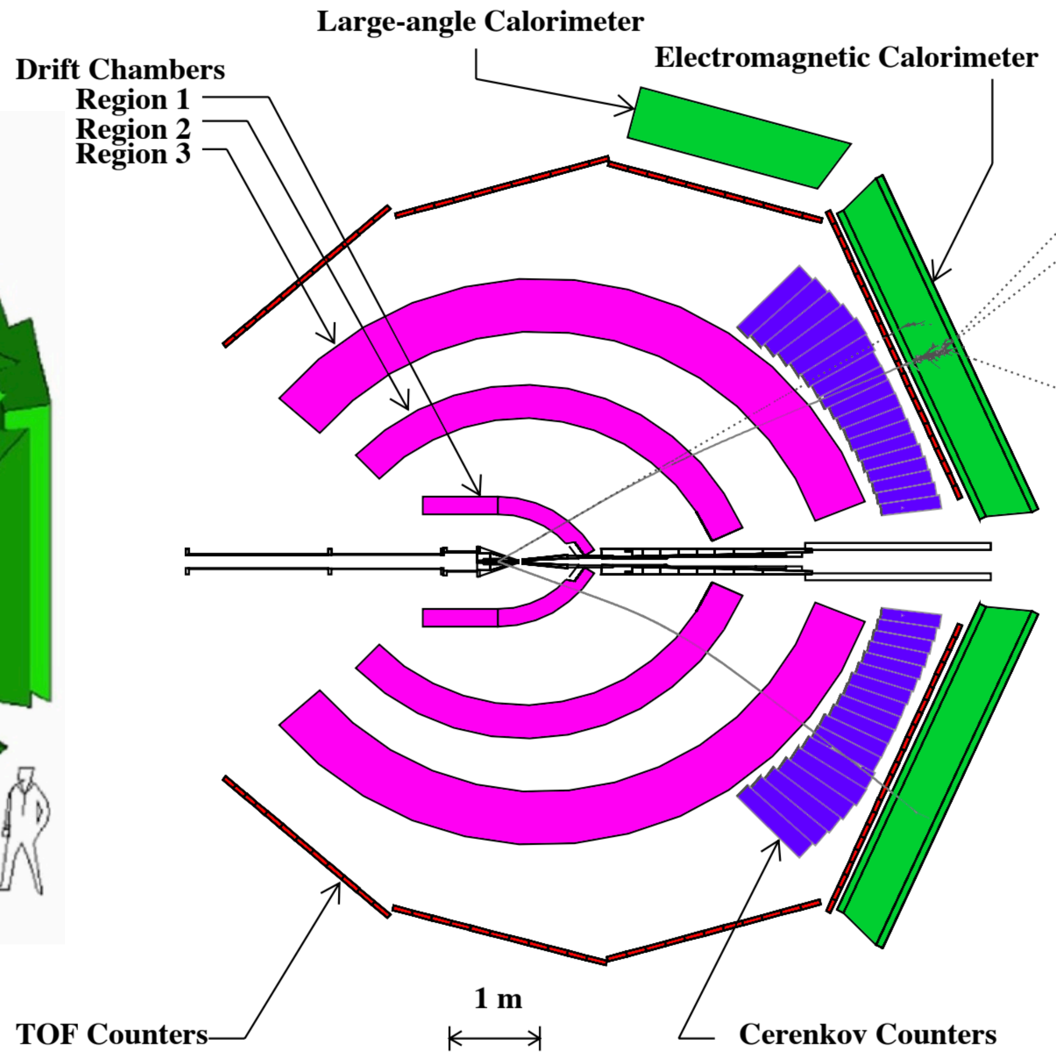
Nuclear targets:
^{12}C, ^{27}Al, ^{56}Fe, ^{208}Pb

Ebeam:
5.014 GeV

CLAS detector

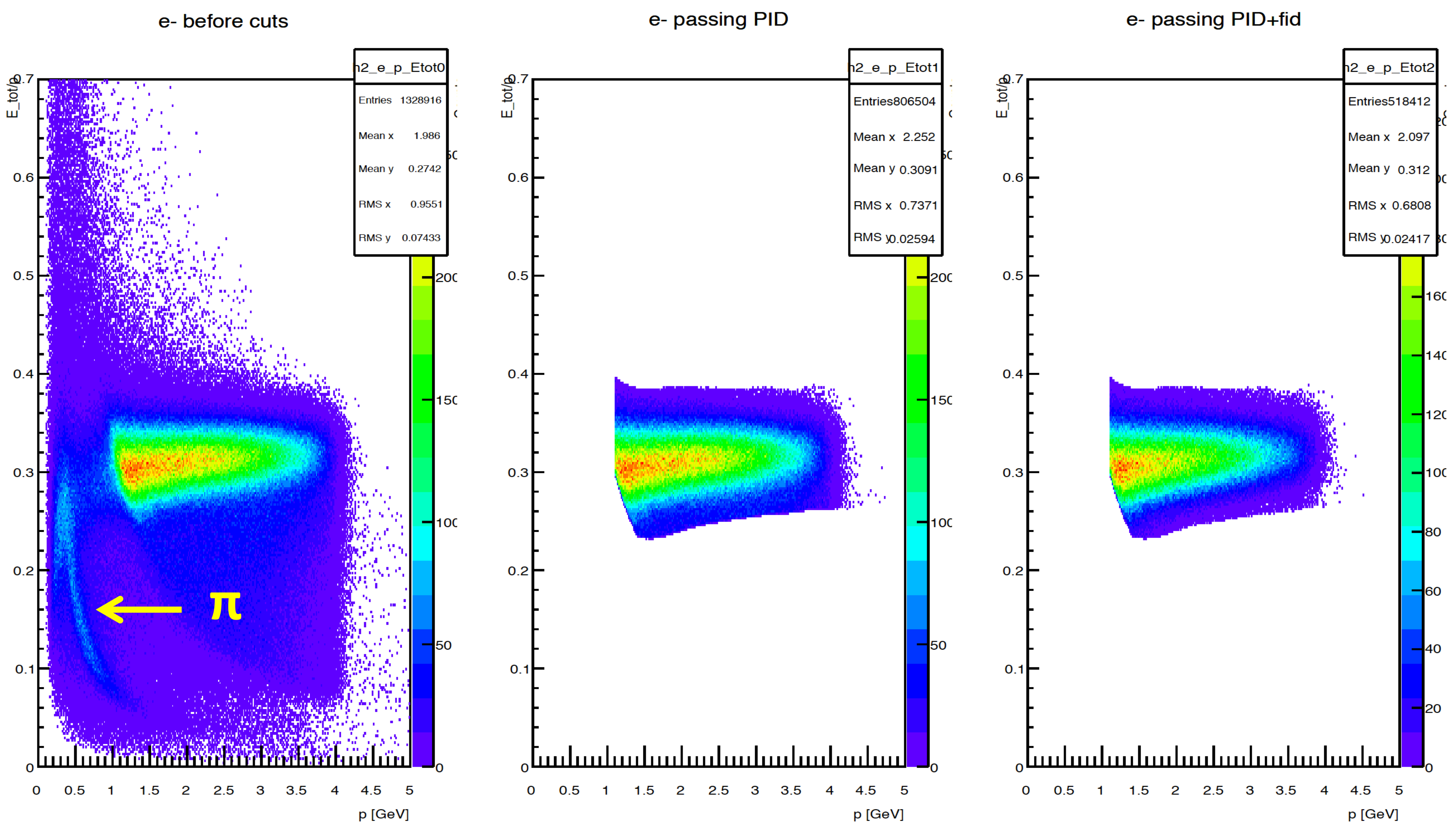
6 sectors





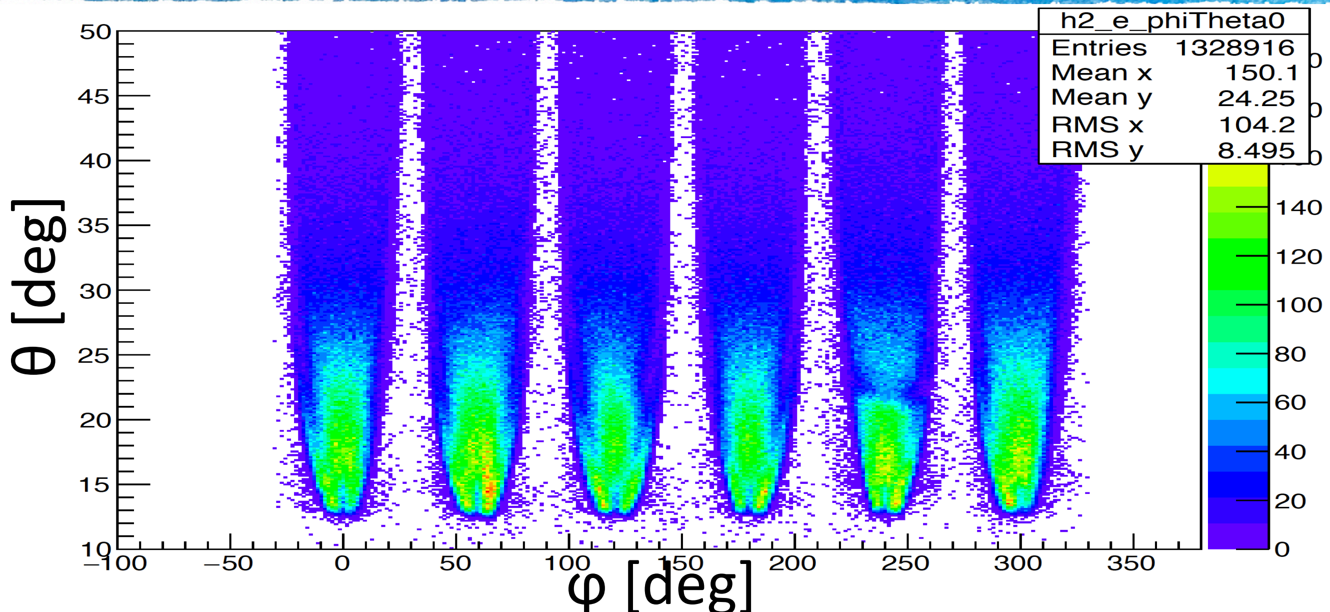
e2a corrections and cuts

Electron PID and fiducial cuts (Run 17908)

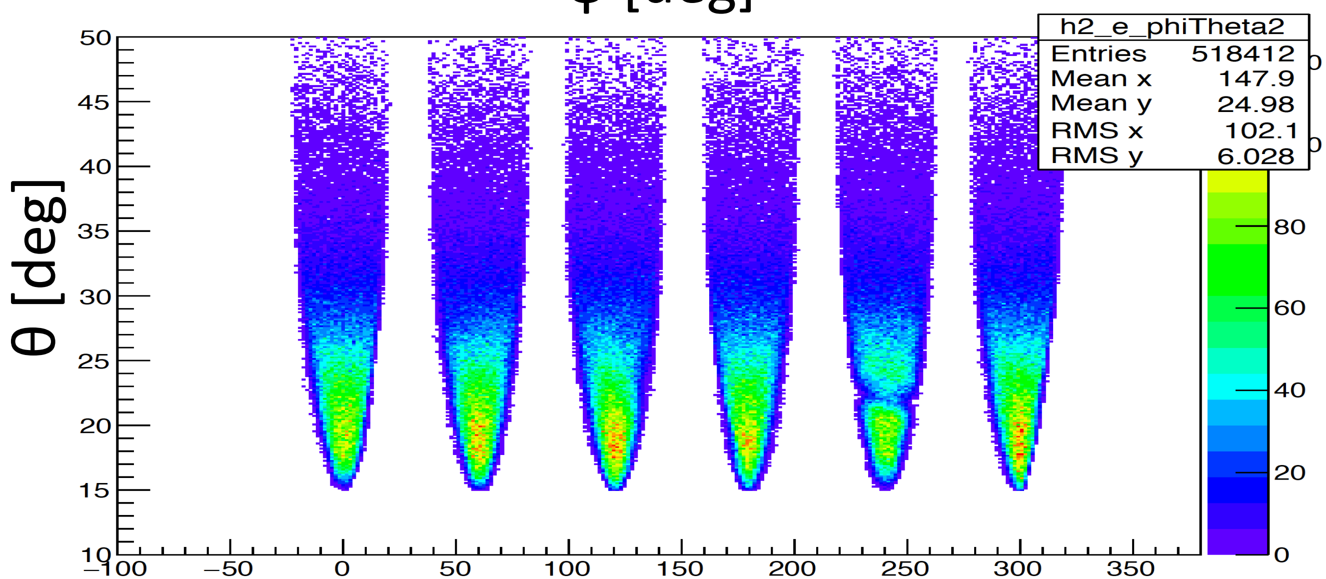


Electron PID and fiducial cuts (Run 17908)

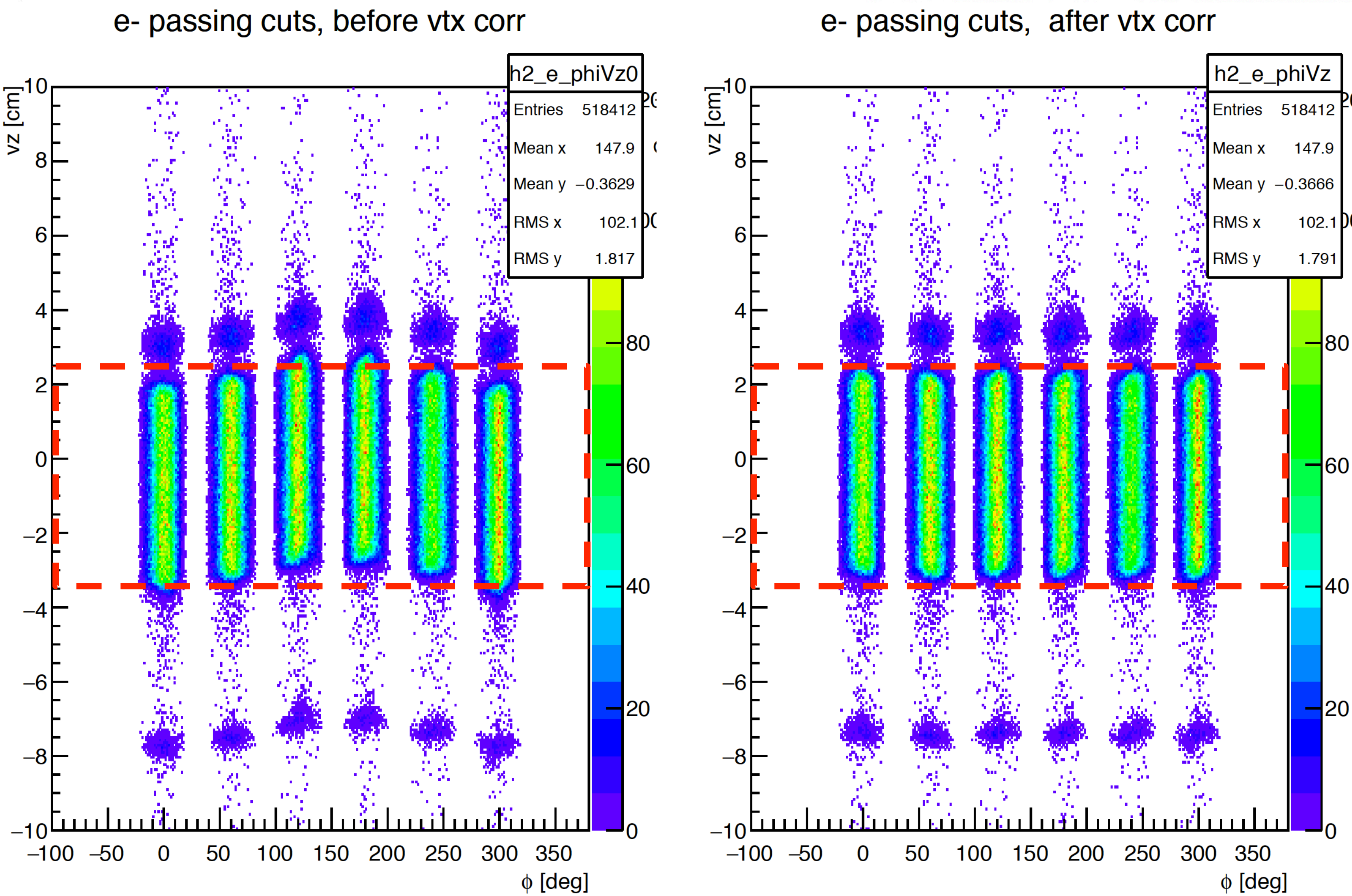
All candidate electrons



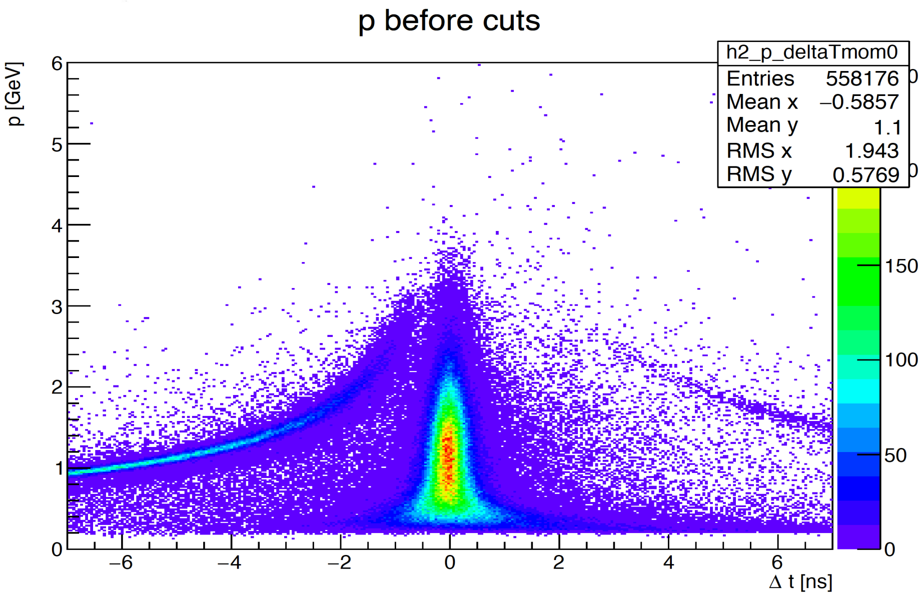
electrons passing pid and fiducial cuts

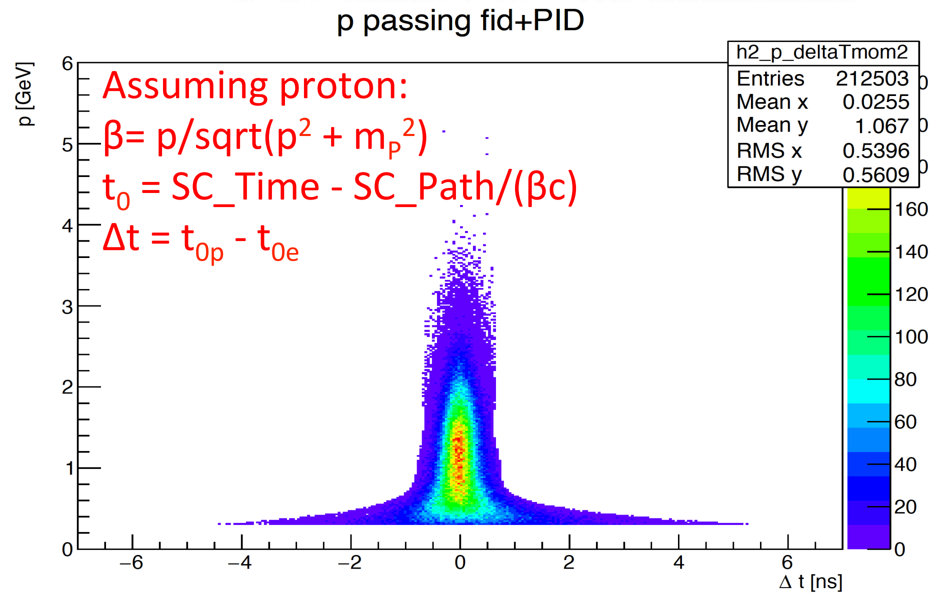


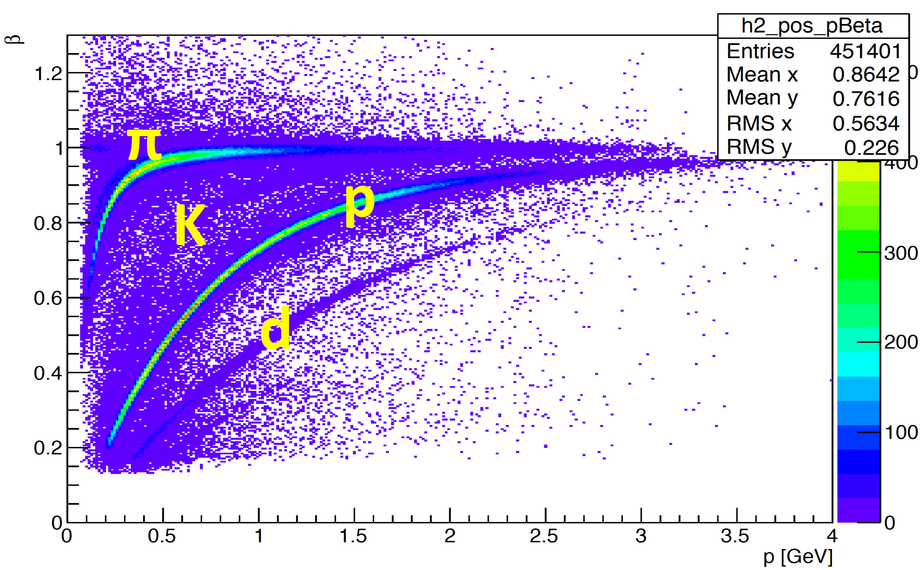
v_z corrections (Run 17908)

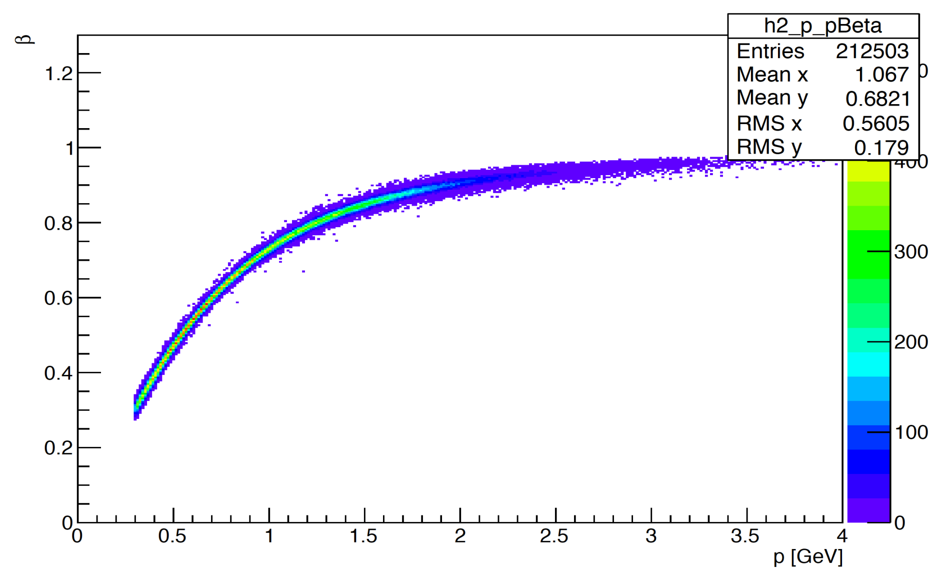


Proton PID and fiducial cuts (Run 17908)



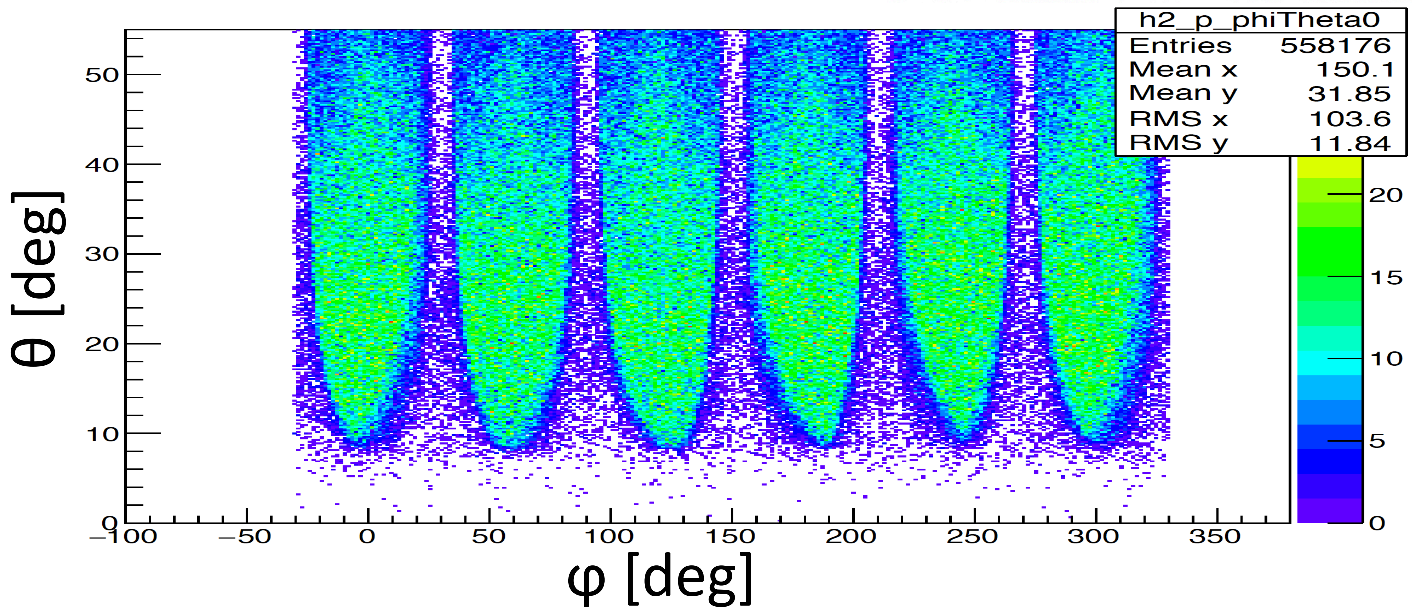




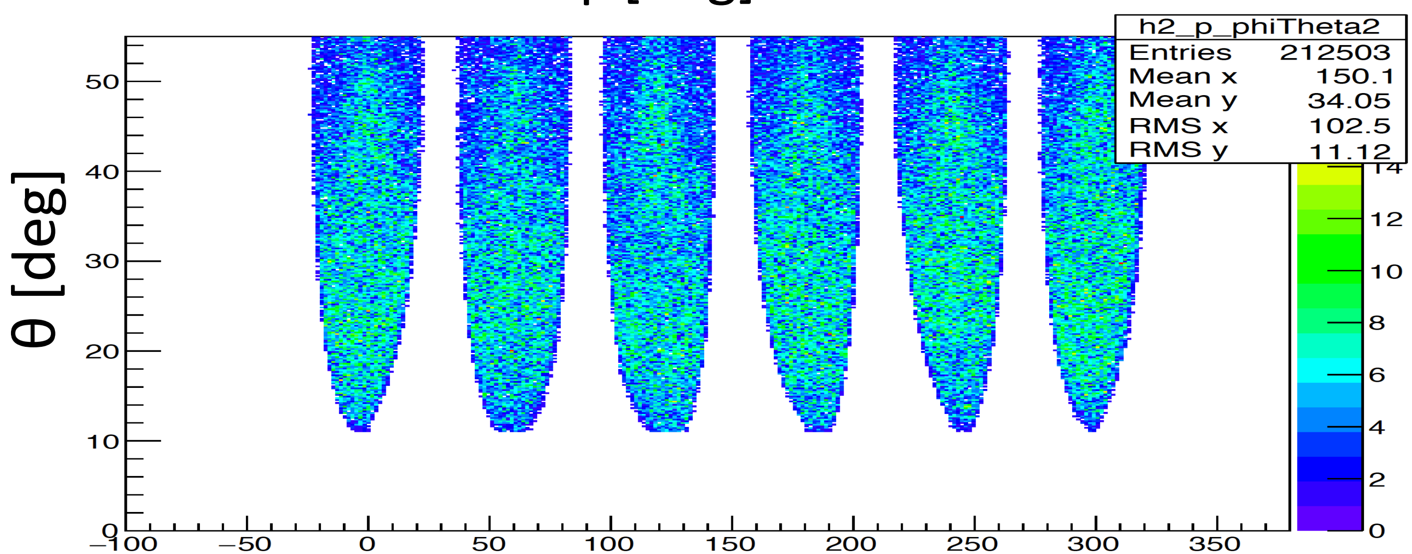


Proton PID and fiducial cuts (Run 17908)

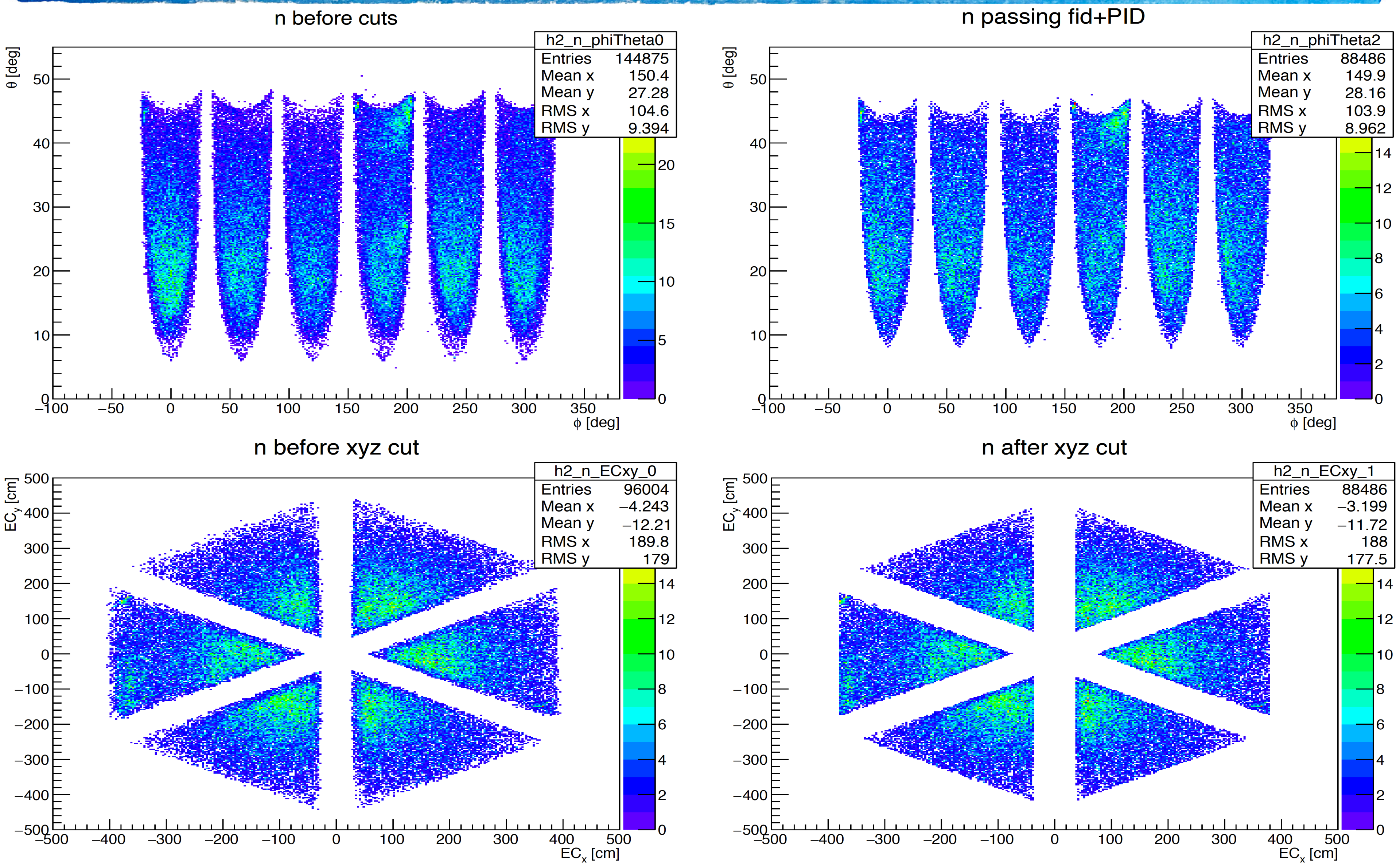
All candidate protons



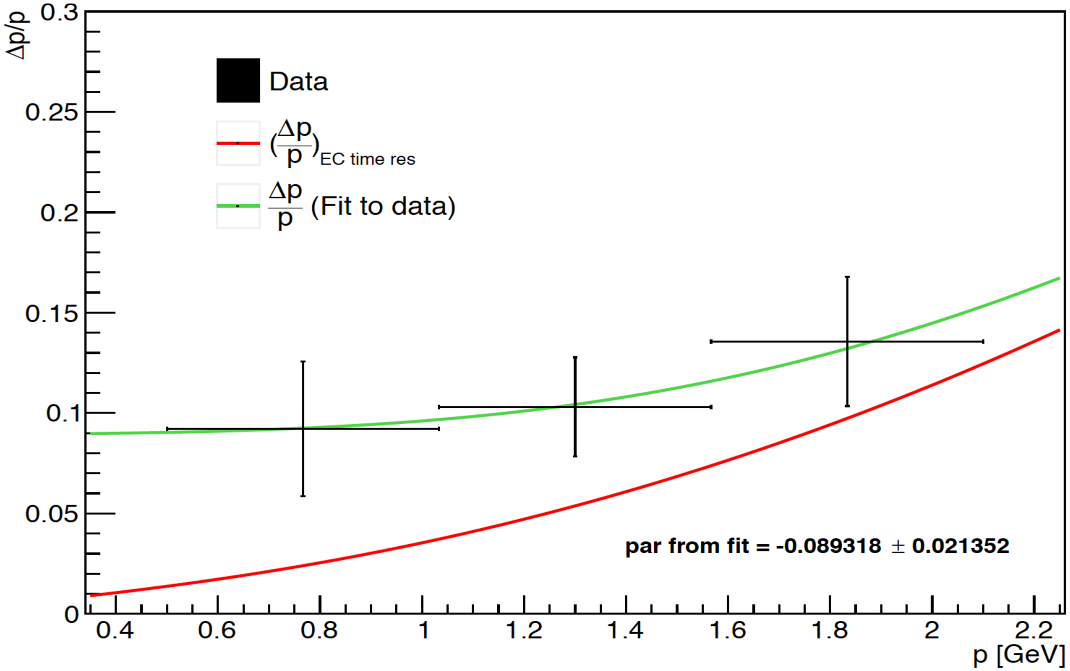
protons passing pid and fiducial cuts



Neutron fiducial cuts (Run 17908)



Smearing proton momentum



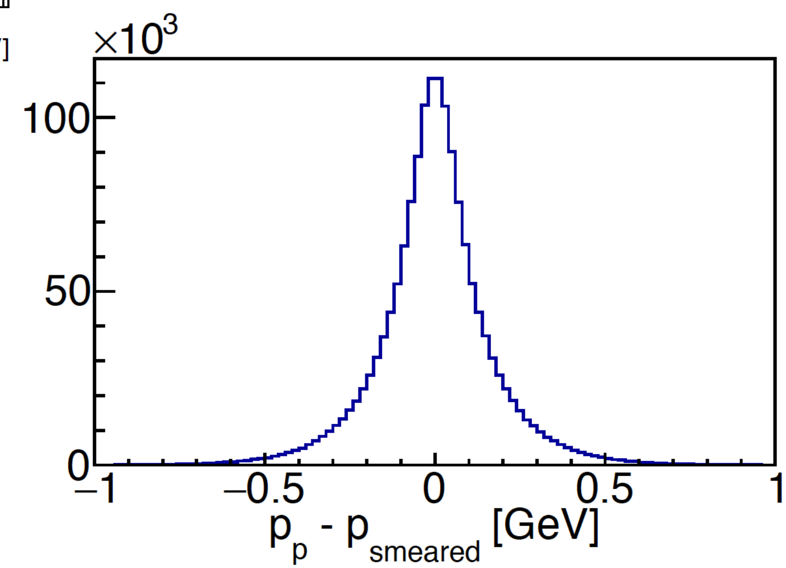
$$\left(\frac{\Delta p}{p}\right)_{EC\ time\ res} = \frac{p}{m_n^2}\sqrt{m_n^2+p^2}\,\frac{\delta t}{x}$$

$$\frac{\Delta p}{p} = \sqrt{\left(\frac{\Delta p}{p}\right)^2_{EC\ time\ res} + (par)^2}$$

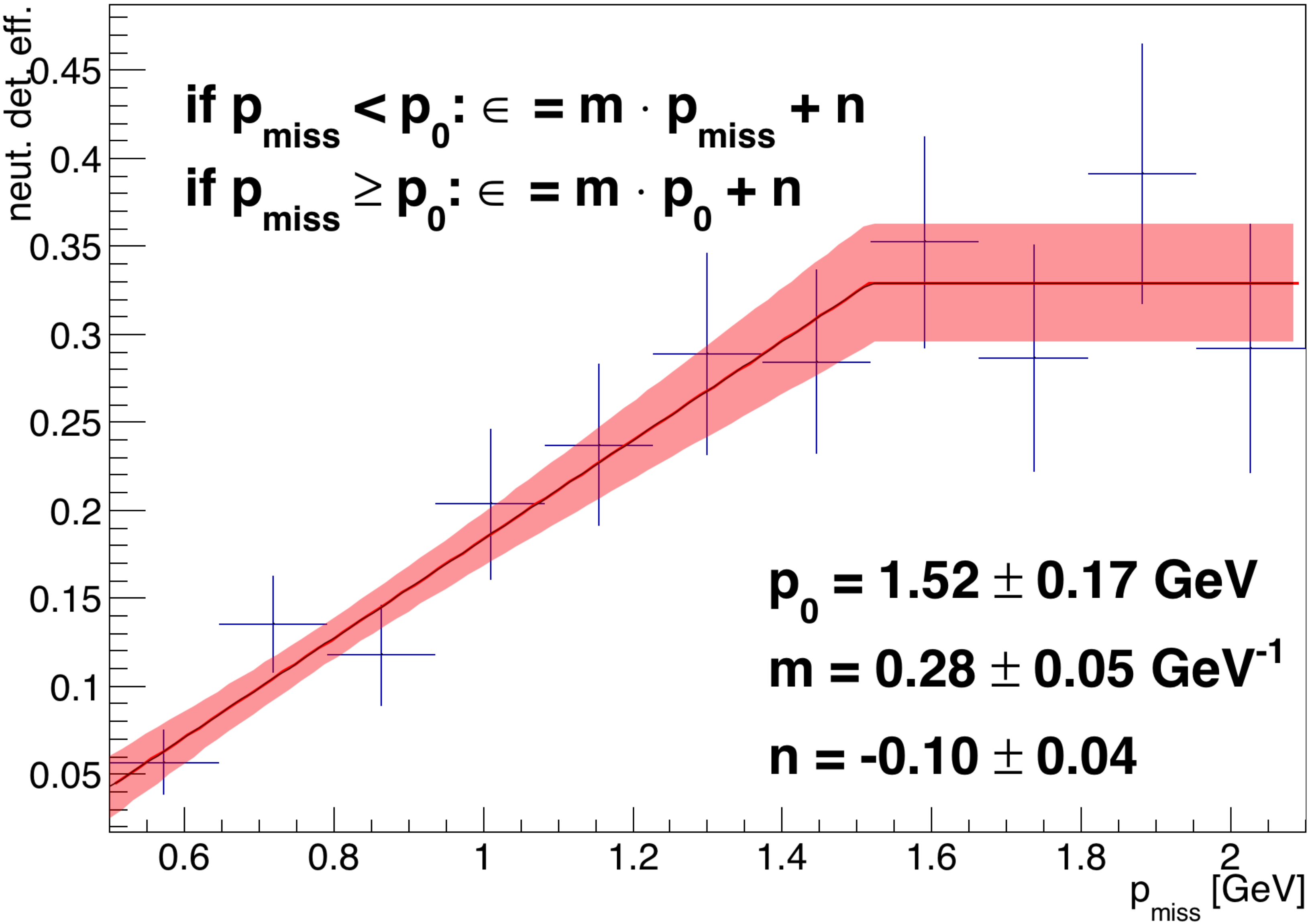
$\delta t =$ 0.392 ns

$$P_p \rightarrow P_{smeared} = \sum Gauss(P_p, \sigma)$$

Use smeared protons to:
* Define and test the cuts
* Study bin migration

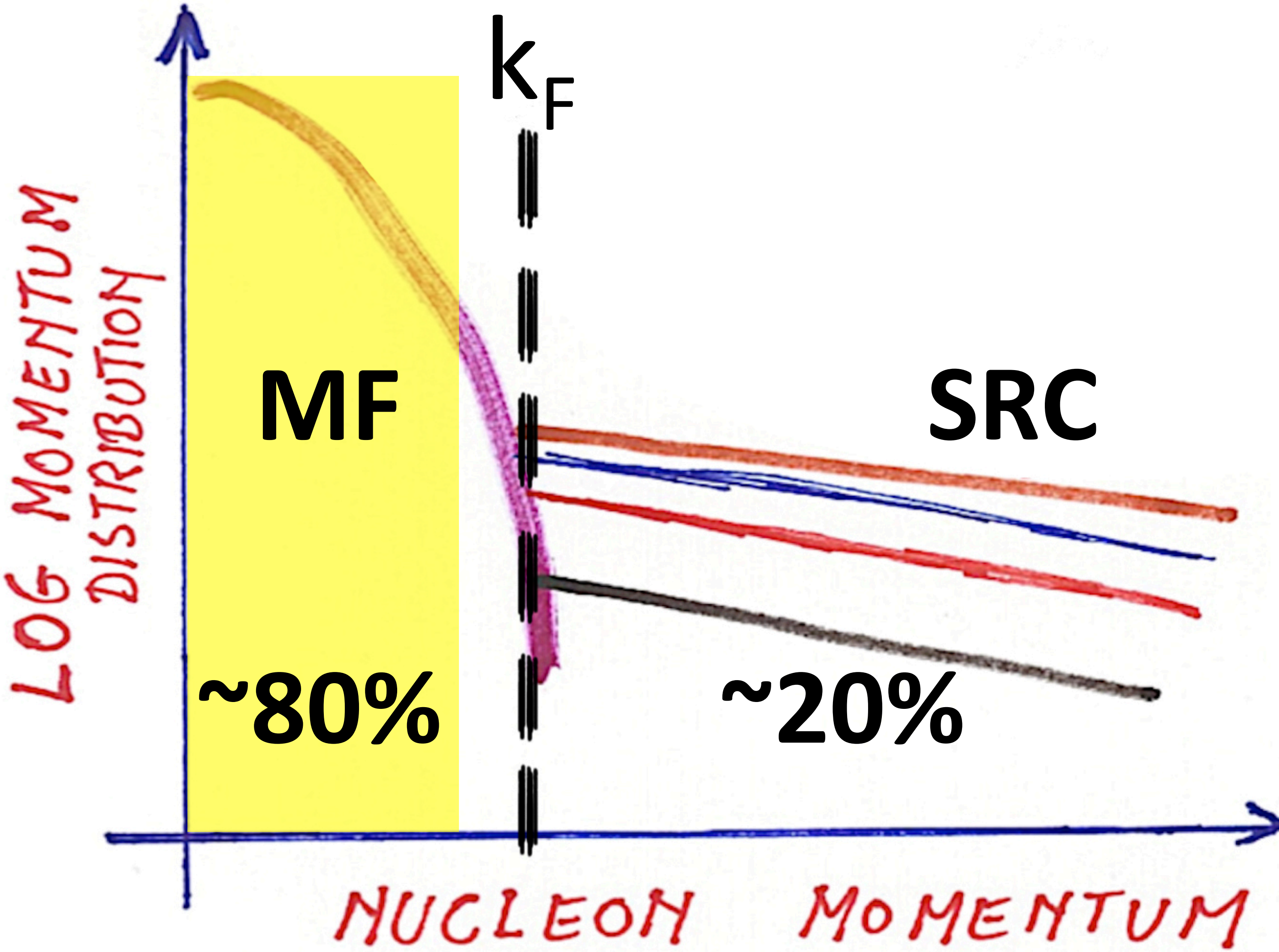


Neutron detection efficiency



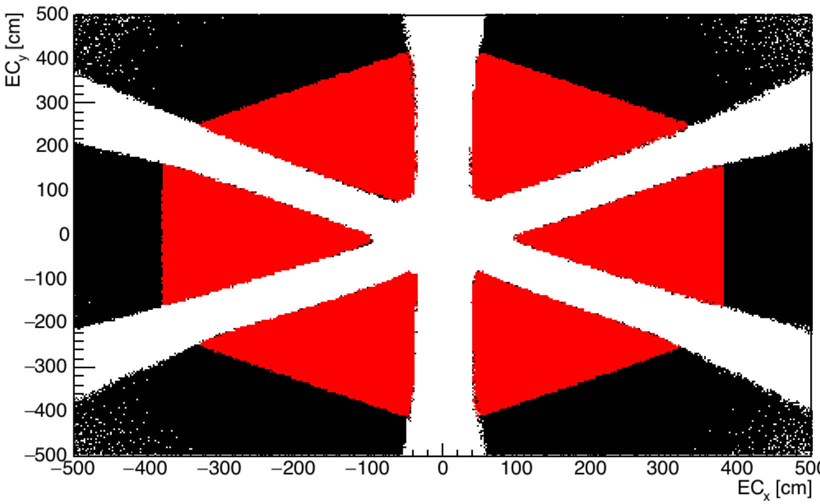
analysis begins here

Identifying M.F. QE events

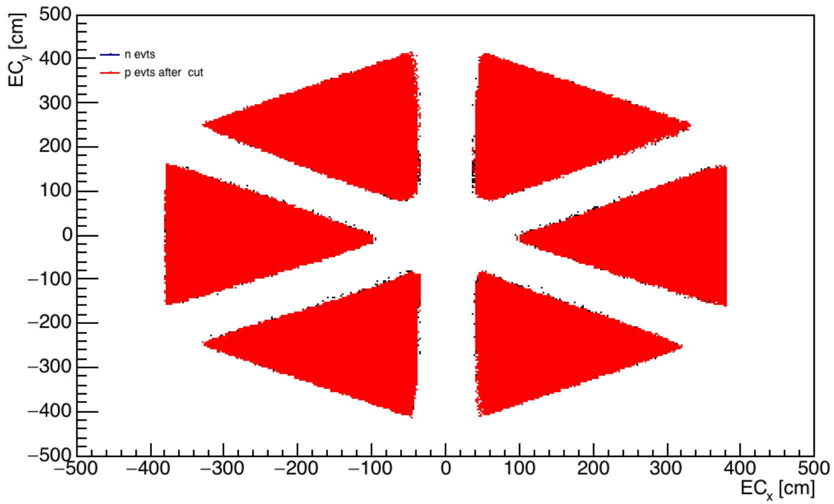


Matching proton and neutron acceptances

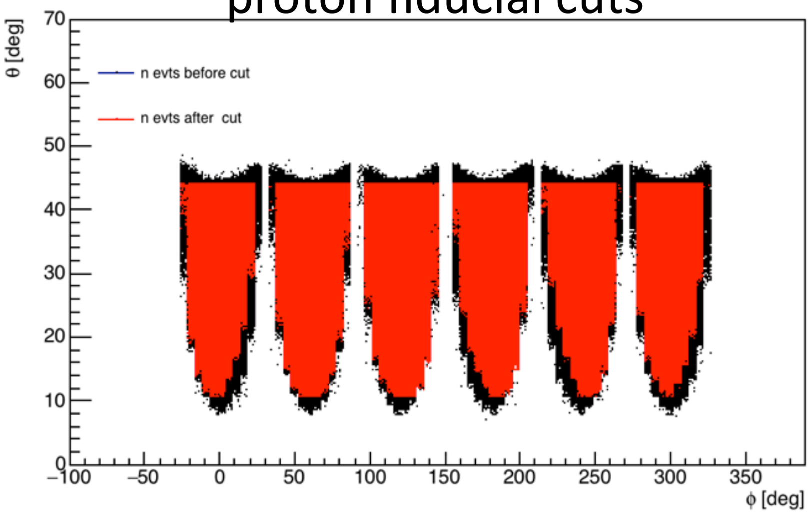
Protons **before** and **after** 10cm EC cut



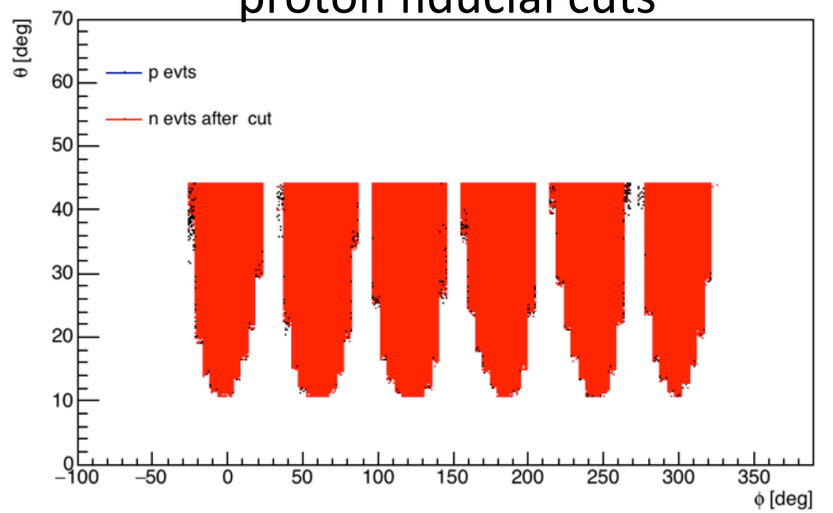
Protons and **neutrons** after 10cm EC cut



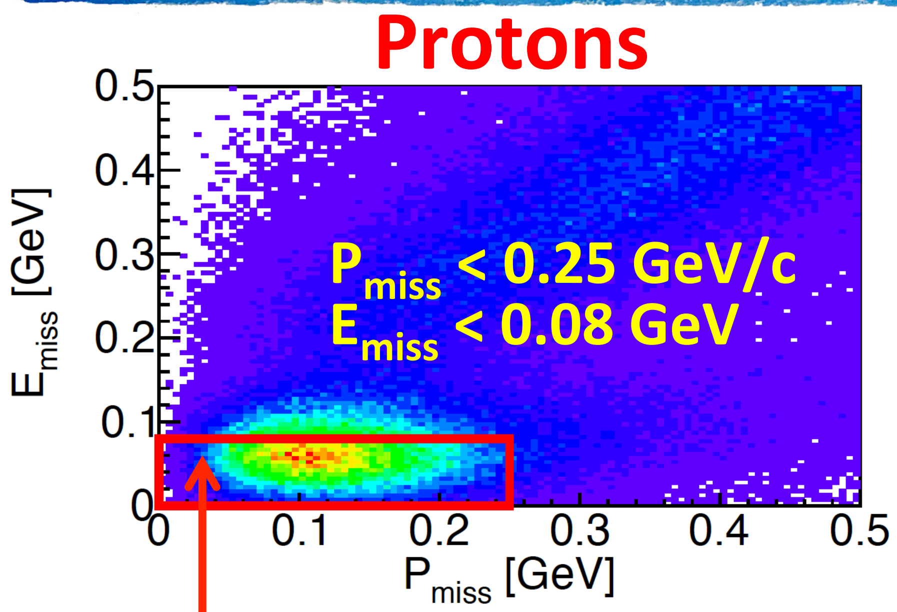
Neutrons **before** and **after** proton fiducial cuts

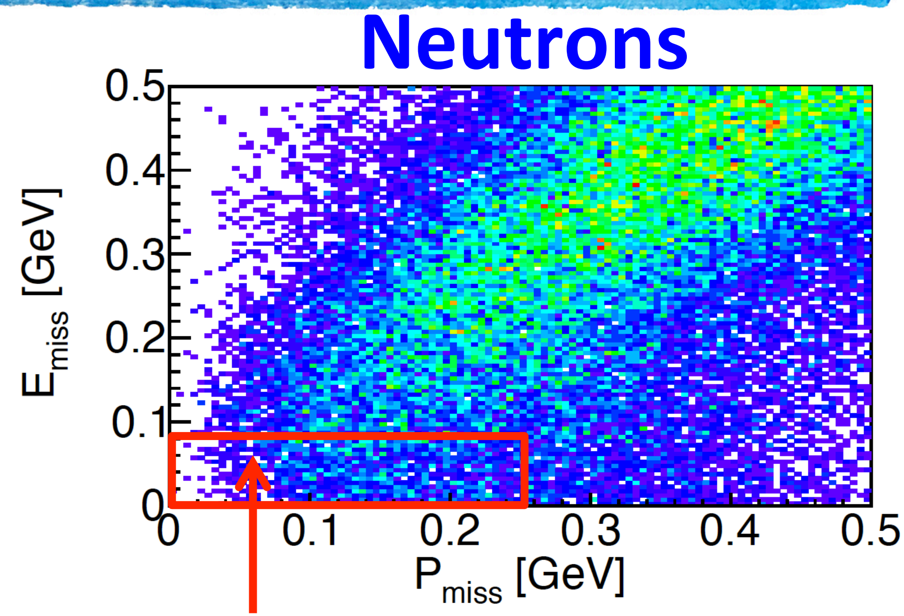


Neutrons and **protons** after proton fiducial cuts



Identifying M.F. QE events





Quasi-Elastic (QE) peak

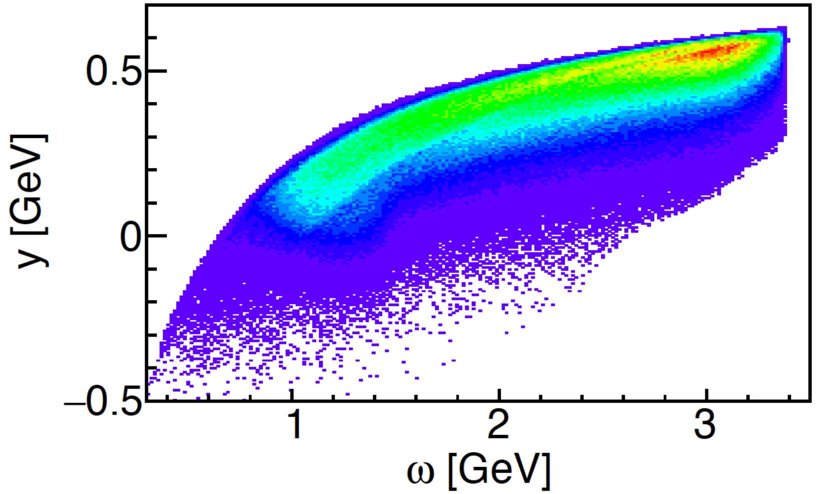
Problem: QE peak washed out by poor EC momentum resolution.

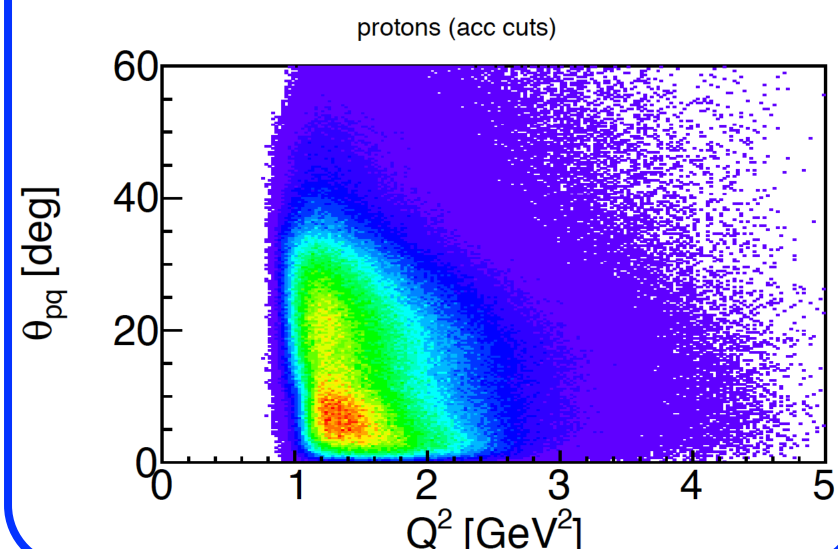
Solution:

- Apply cuts more suitable for the identification of QE events.
- Smear proton momentum with the EC momentum resolution.
- Use information about un-smeared and smeared protons as an equivalent to knocked-out and reconstructed neutrons respectively

Identifying M.F. QE events

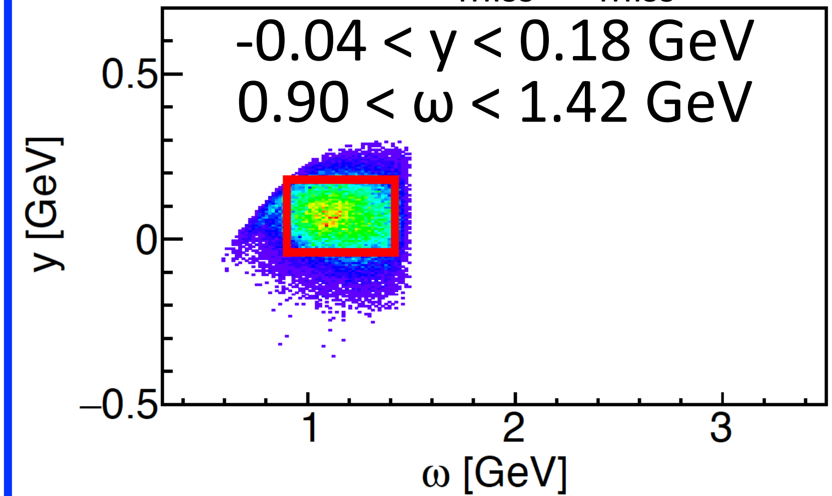
Protons before E_{miss}, P_{miss} cuts

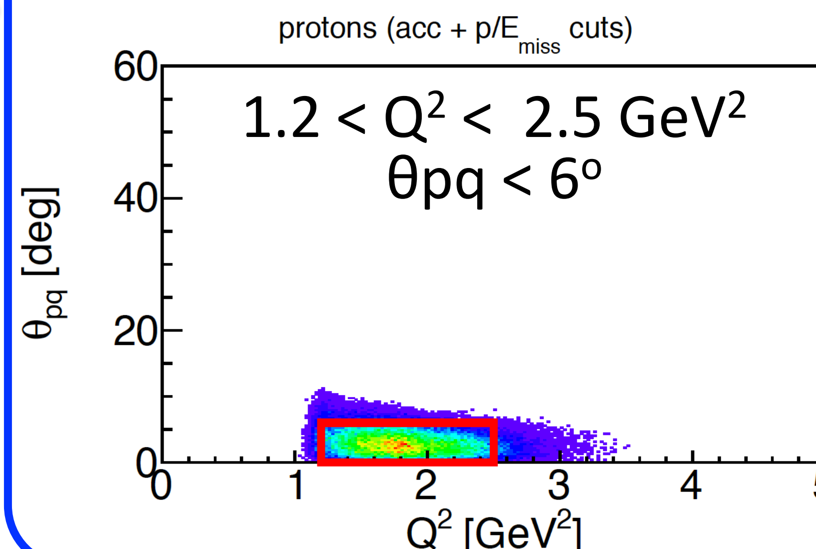




E_{miss}, P_{miss} cuts

Protons after E_{miss}, P_{miss} cuts





Identifying M.F. QE events

P_{miss}, E_{miss} distributions with cuts:

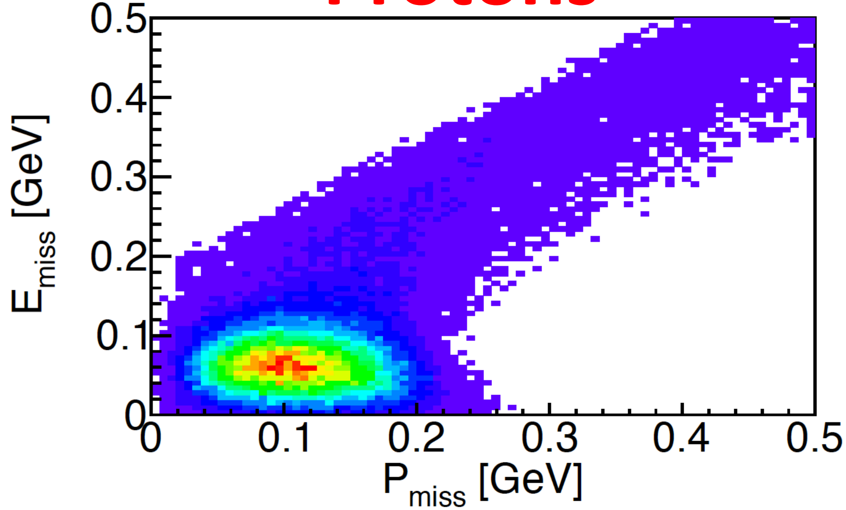
$-0.04 < y < 0.18$ GeV

$0.90 < \omega < 1.42$ GeV

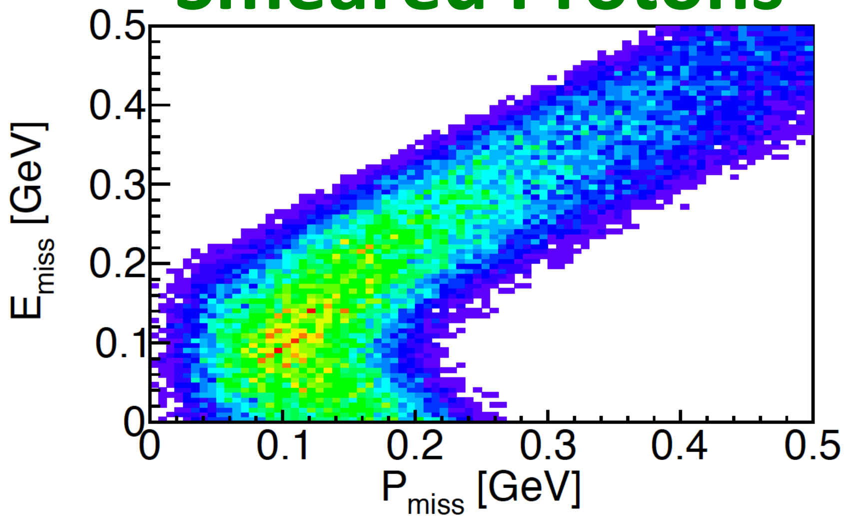
$1.2 < Q^2 < 2.5$ GeV^2

$\theta pq < 6^o$

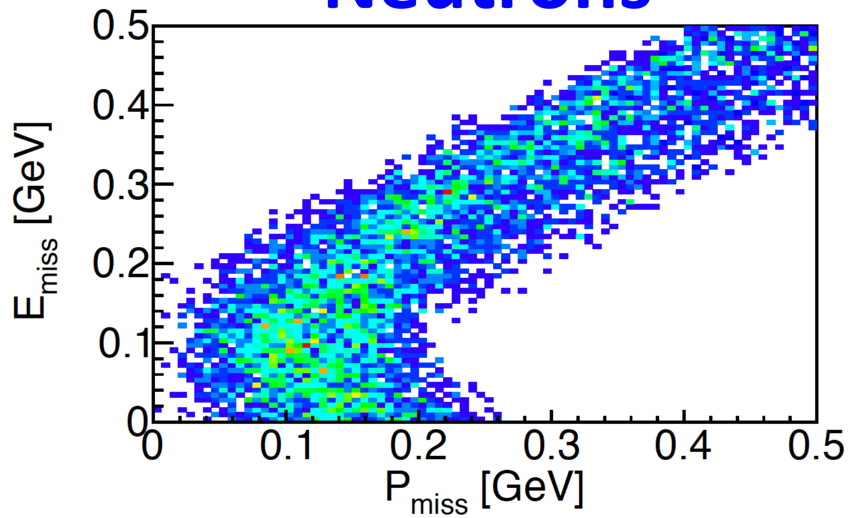
Protons



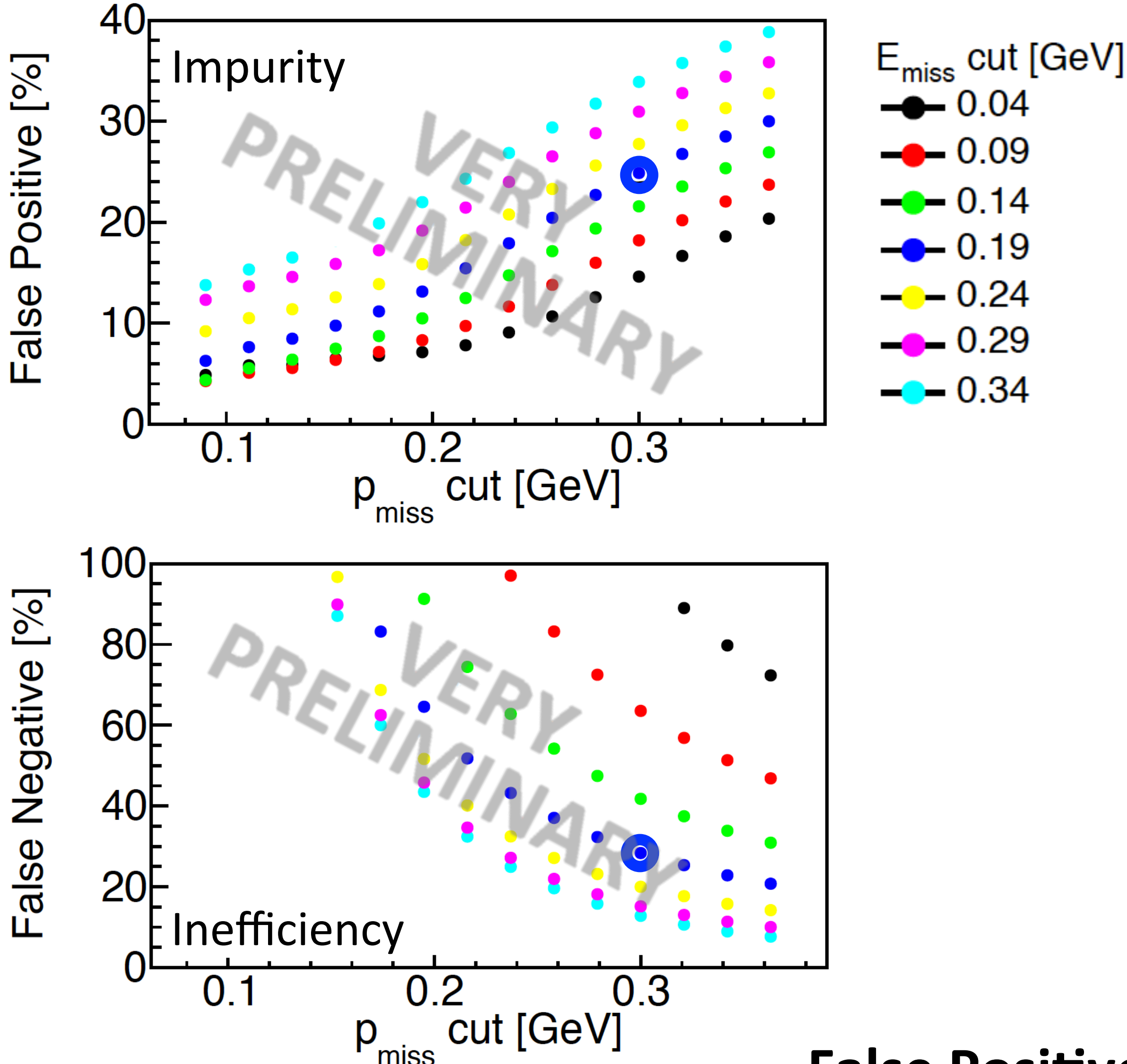
Smeared Protons



Neutrons



Identifying M.F. QE events

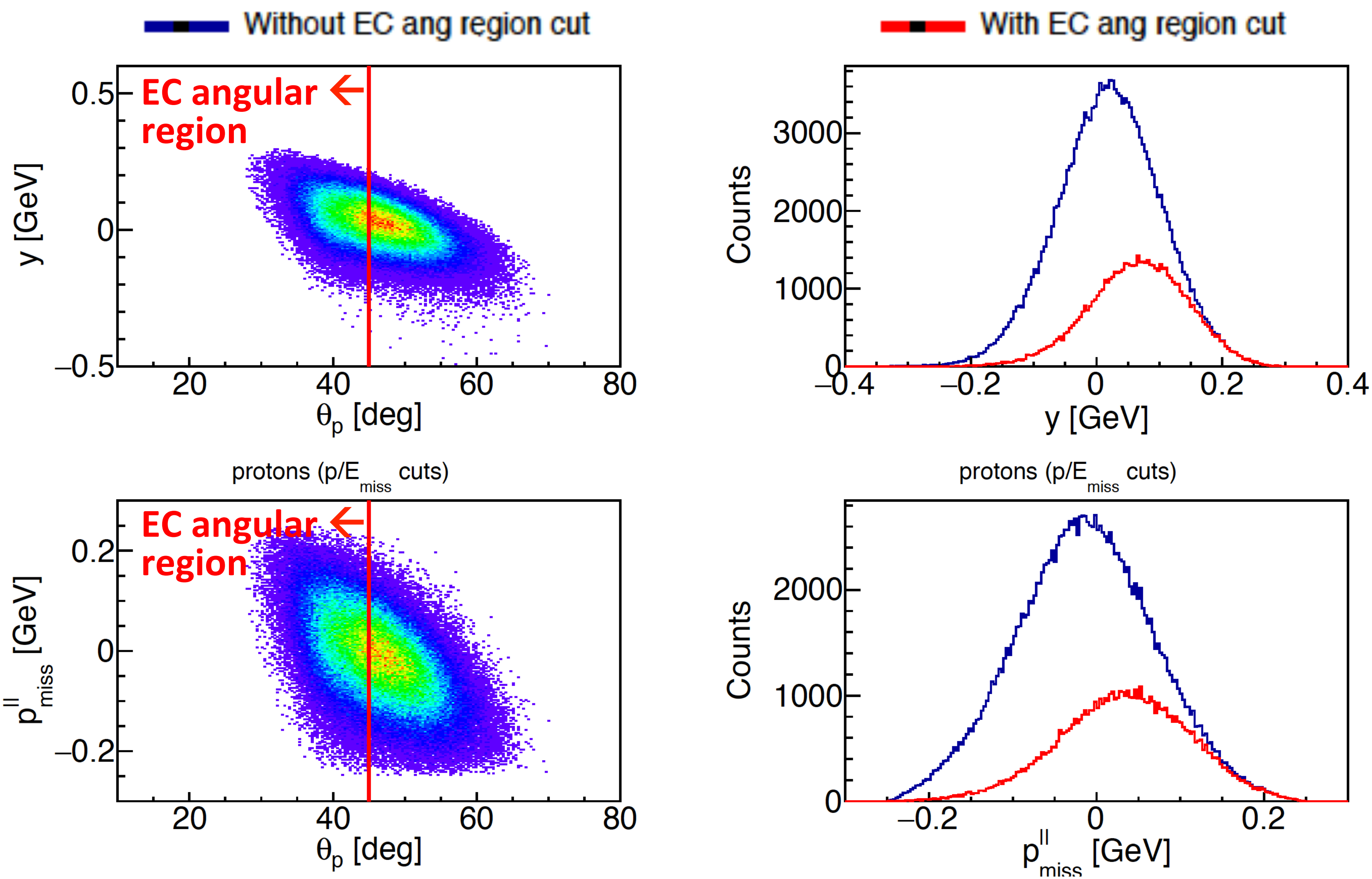


smeared p/n cuts:
P_{miss} < 0.3 GeV/c
E_{miss} < 0.19 GeV

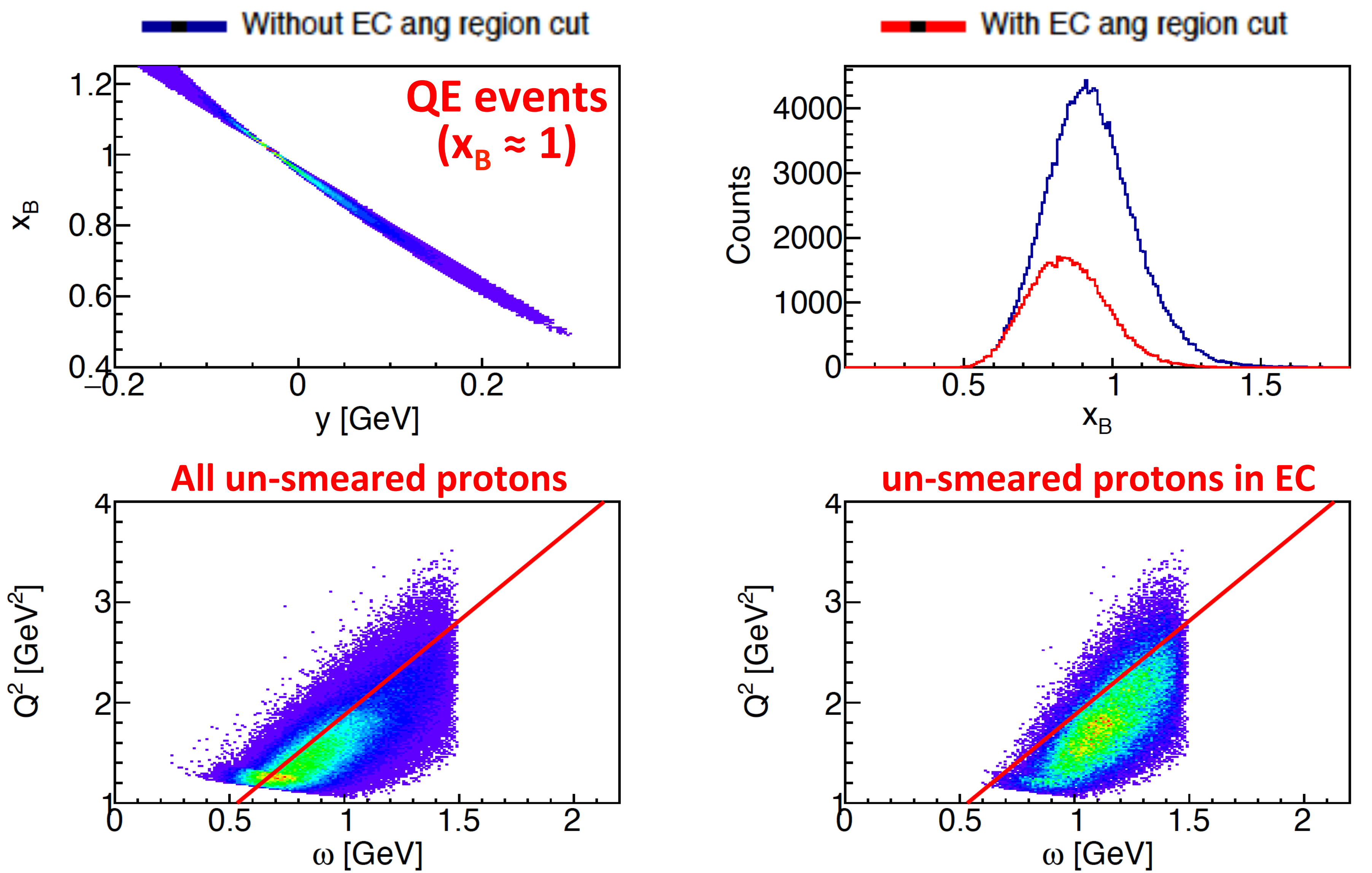
un-smeared p cuts:
P_{miss} < 0.25 GeV/c
E_{miss} < 0.08 GeV

False Positive ≈ False Negative ≈ 25%

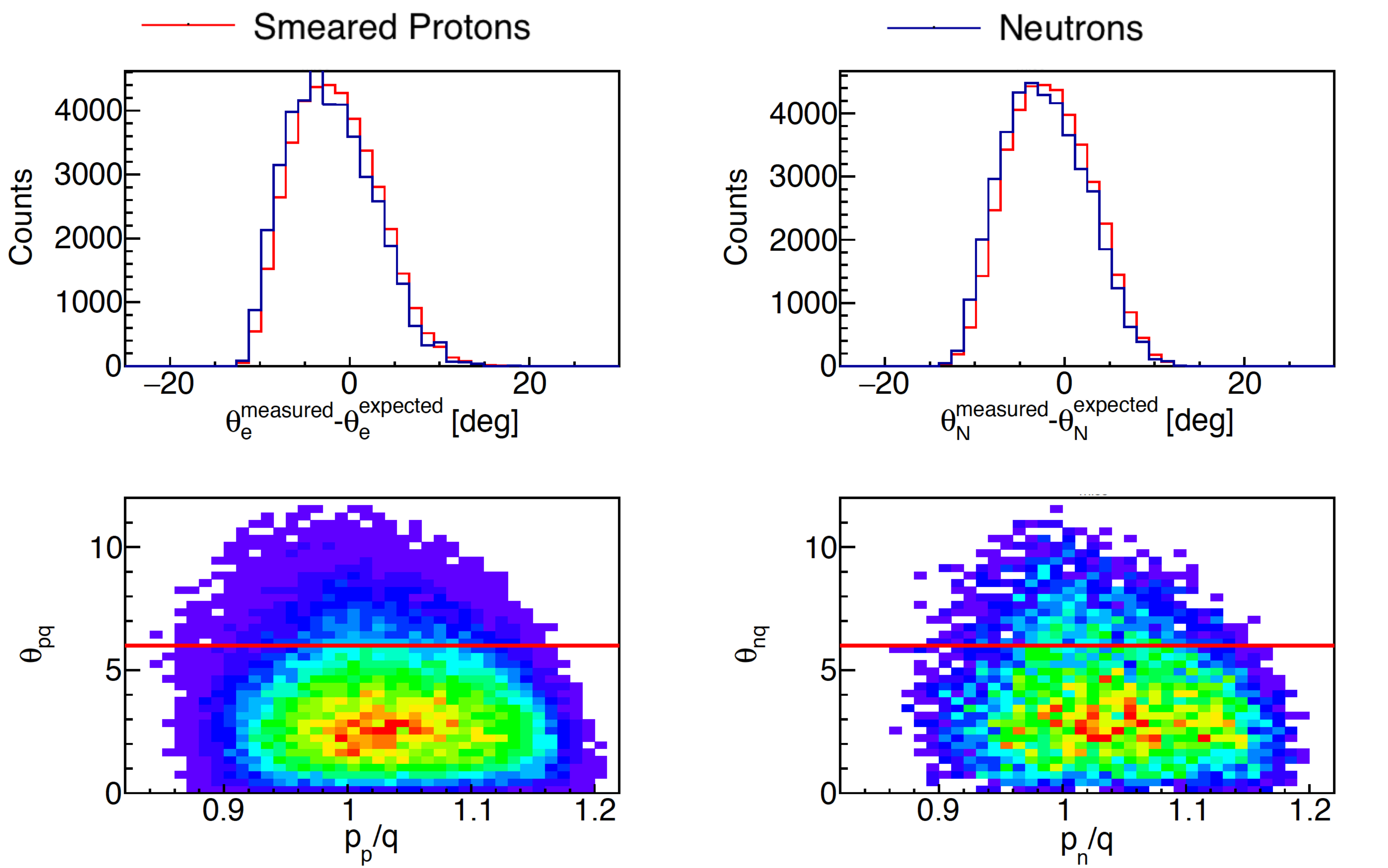
Effect of cutting on the EC angular region (MF)



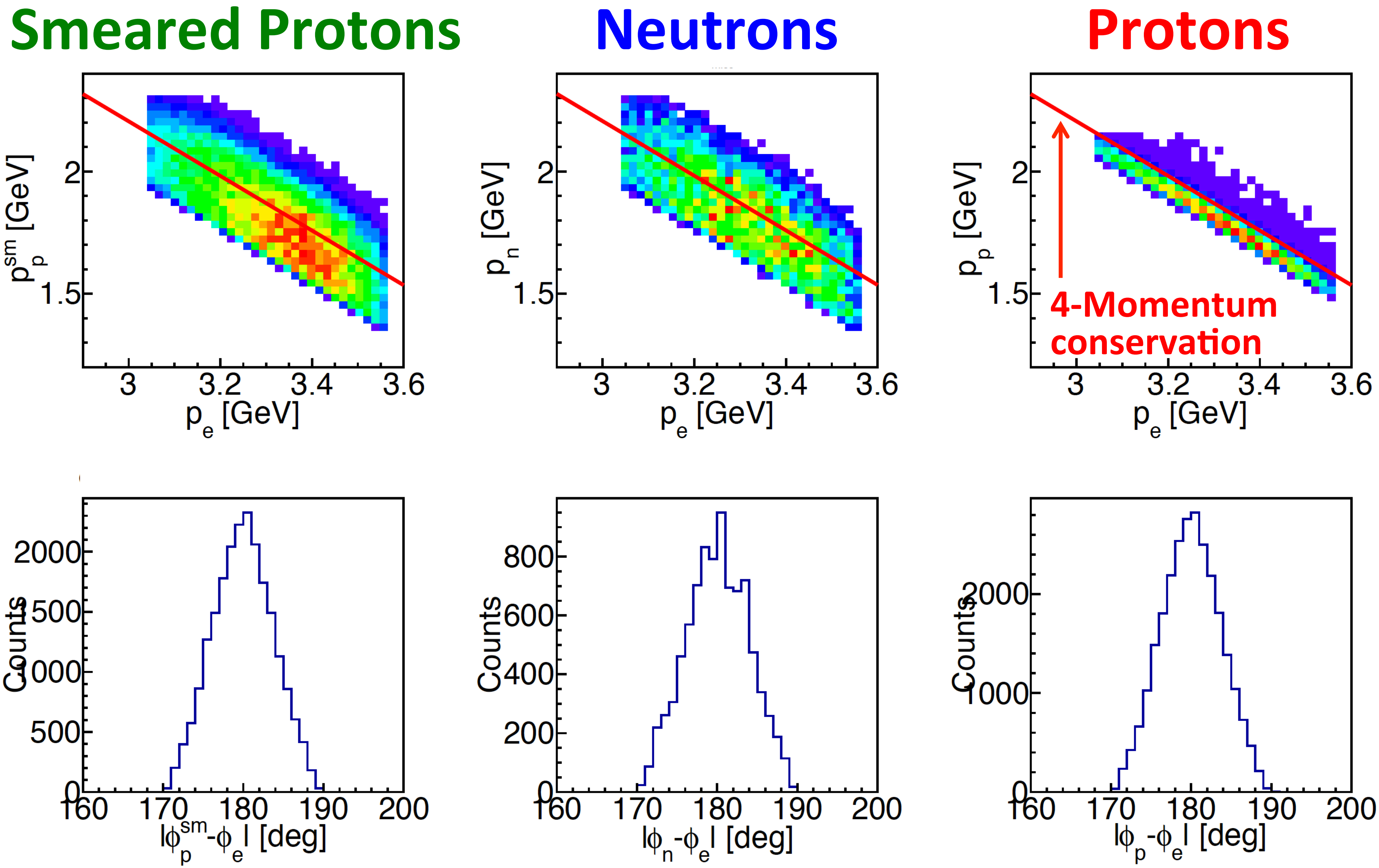
Effect of cutting on the EC angular region (MF)



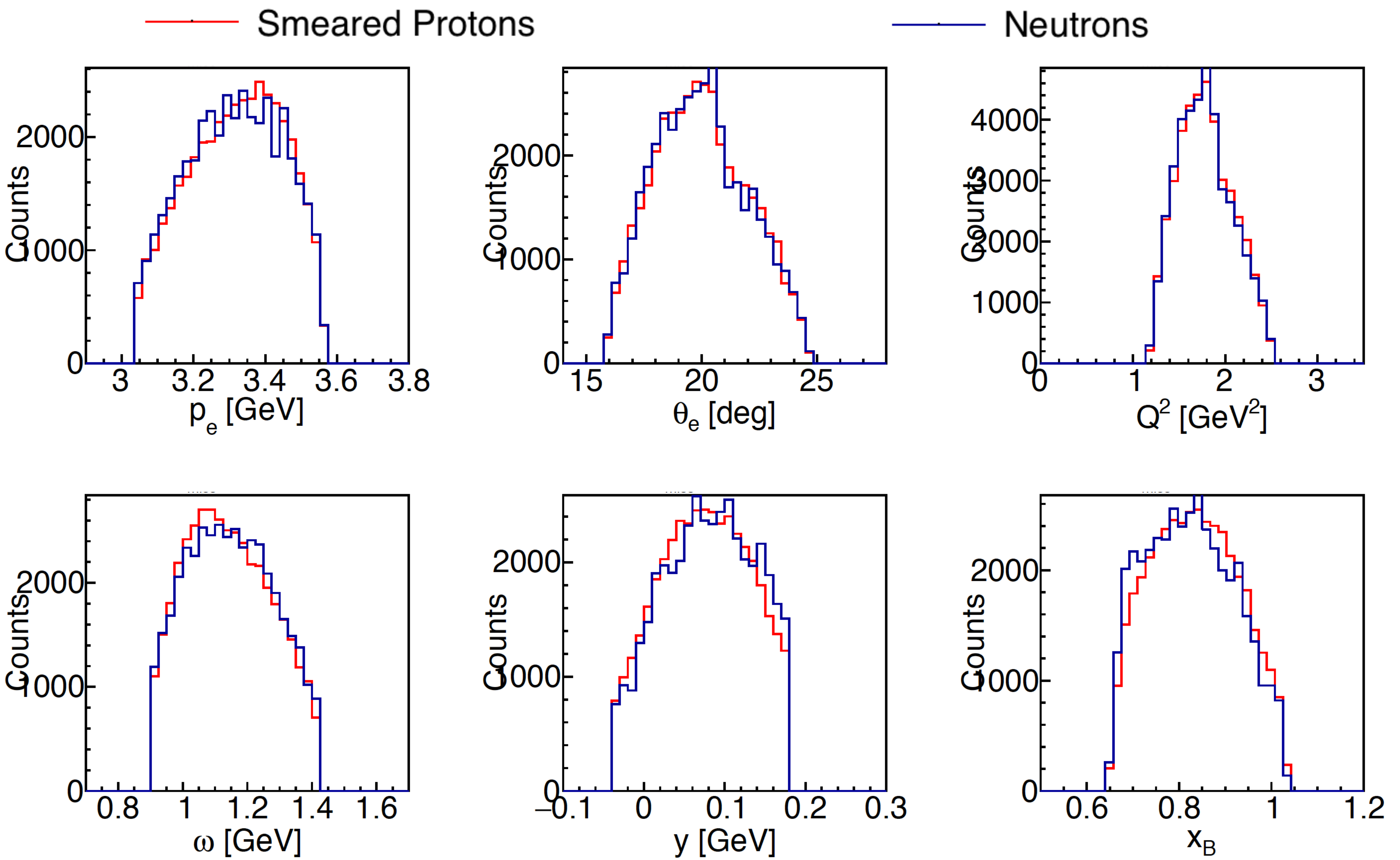
Comparing smeared protons and neutrons (MF)



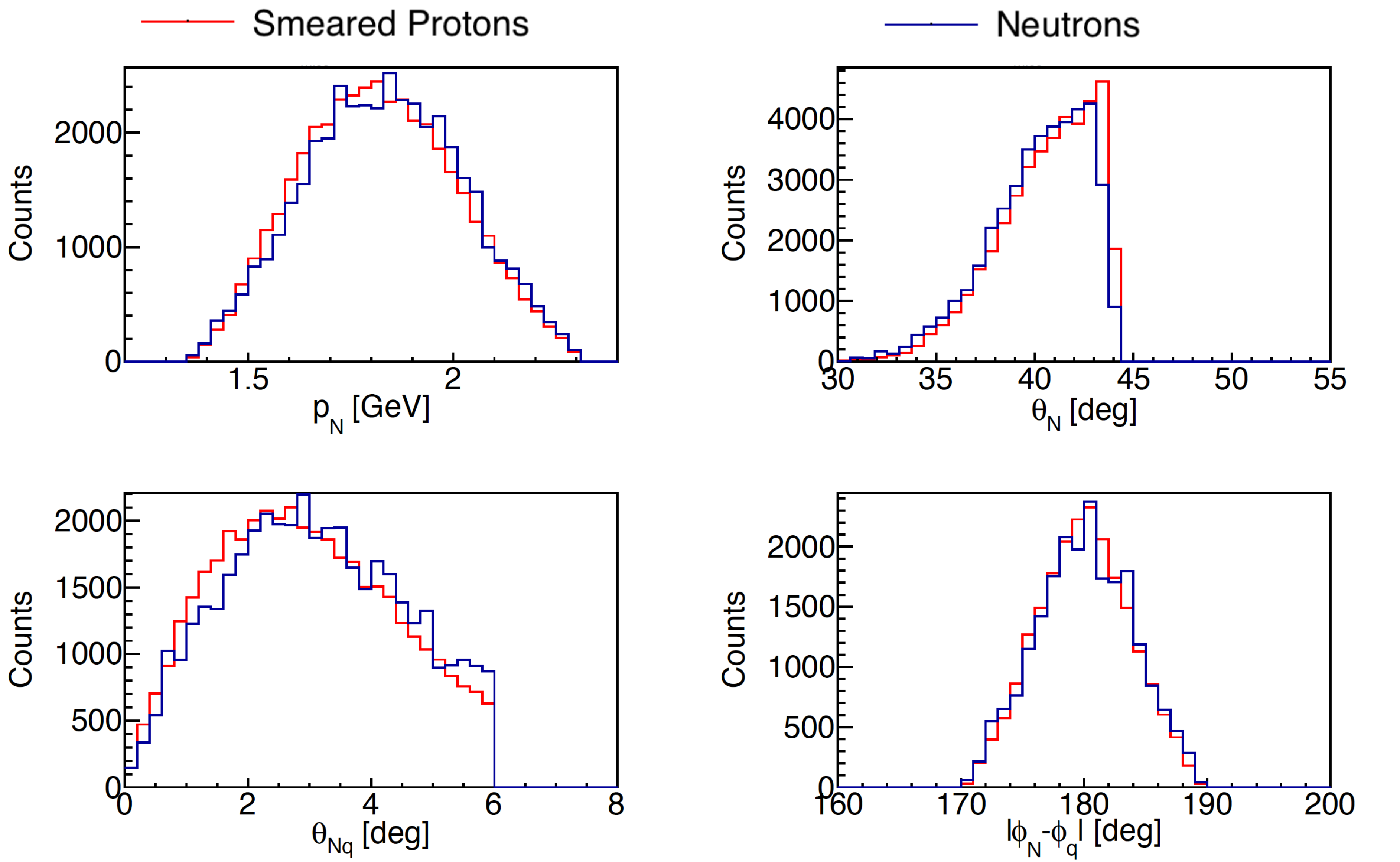
Comparing smeared protons and neutrons (MF)



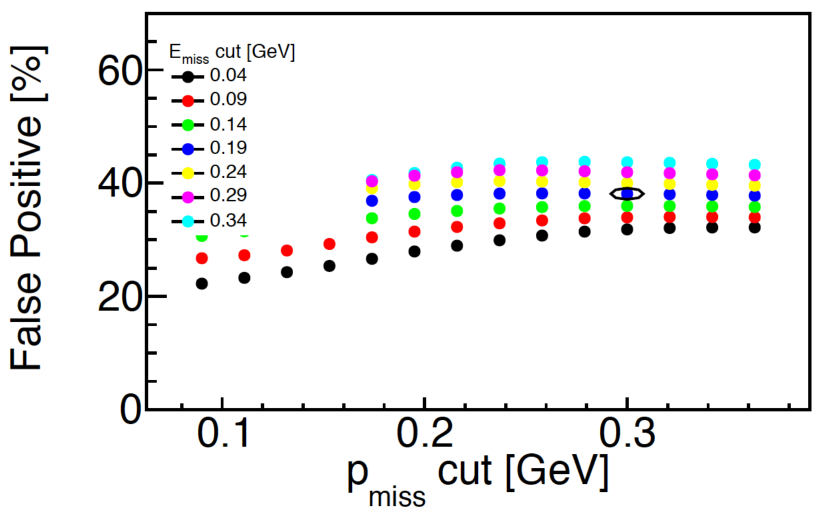
Comparing smeared protons and neutrons (MF)

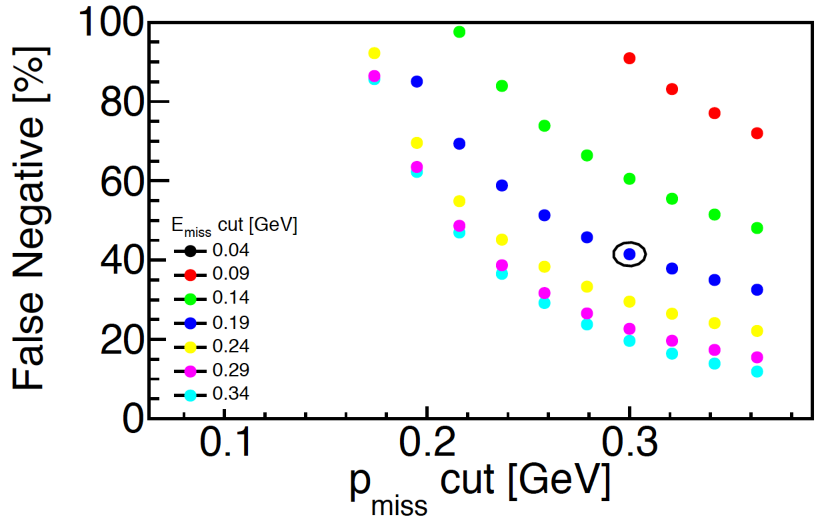


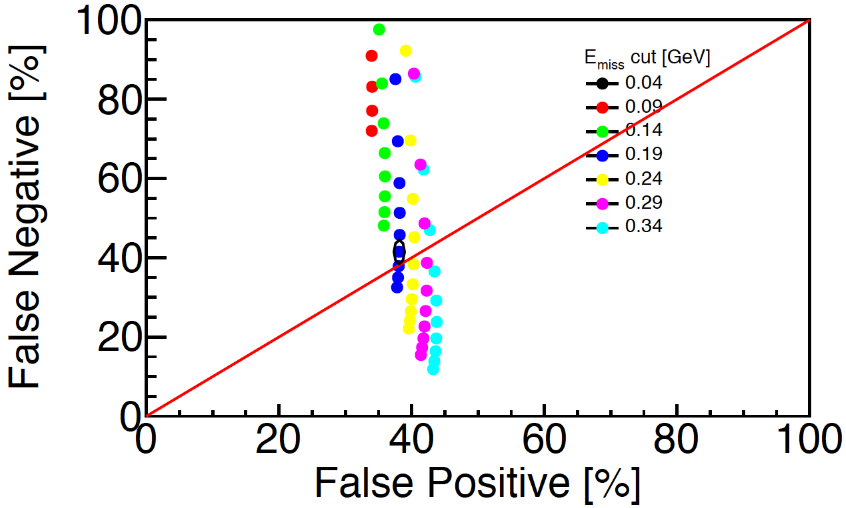
Comparing smeared protons and neutrons (MF)



False positive/negative revisited







Begin with a sample that passes e-kinematics cuts

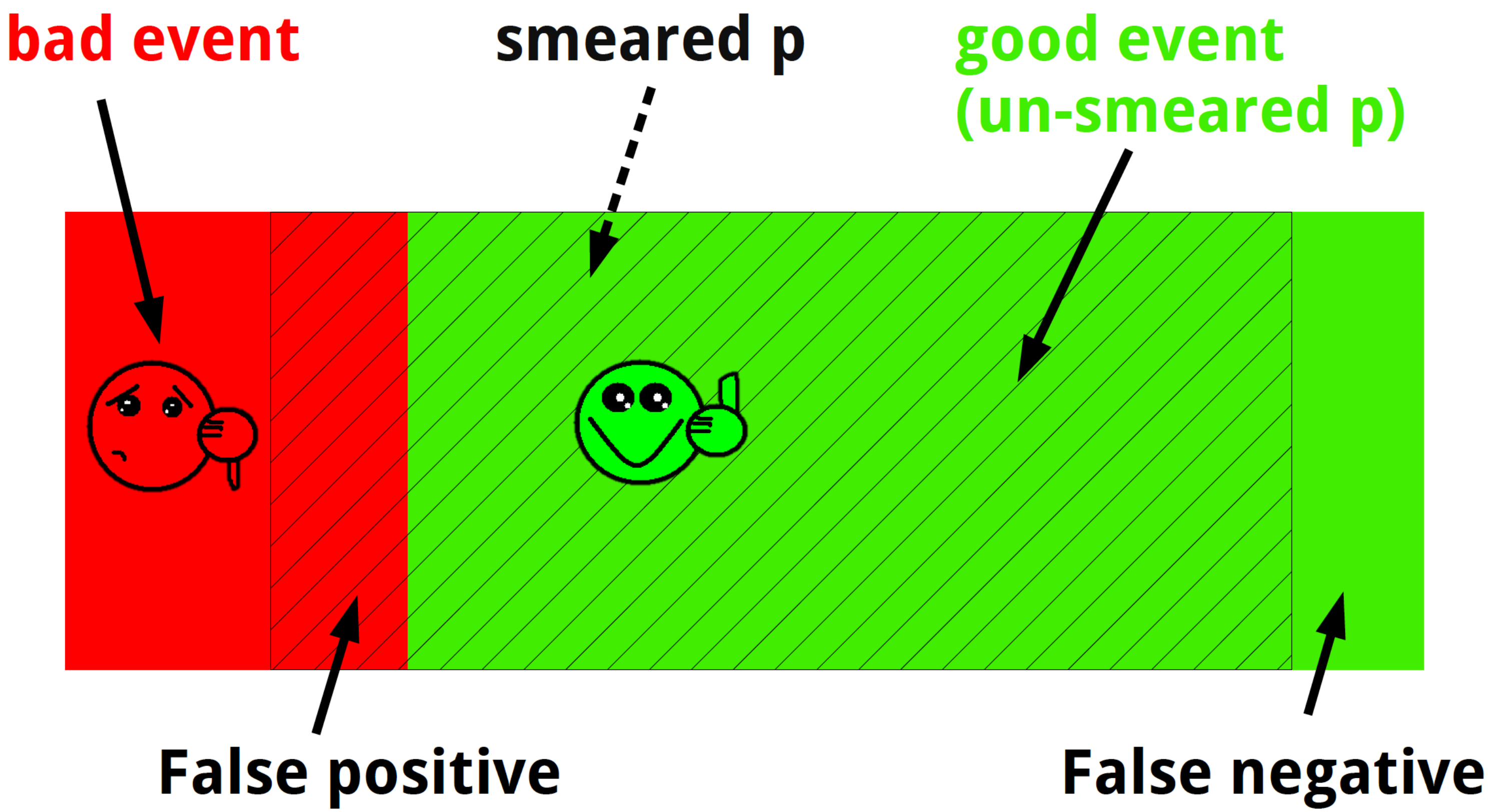
Denominator:
smeared protons pass test P_{miss}, E_{miss} cuts

False positive numerator:
Smeared protons pass test P_{miss}, E_{miss} cuts, and un-smeared fail P_{miss}, E_{miss} fixed

False negative numerator:
Un-smeared protons pass fixed P_{miss}, E_{miss} and smeared fail P_{miss}, E_{miss} cuts

False positive/negative revisited

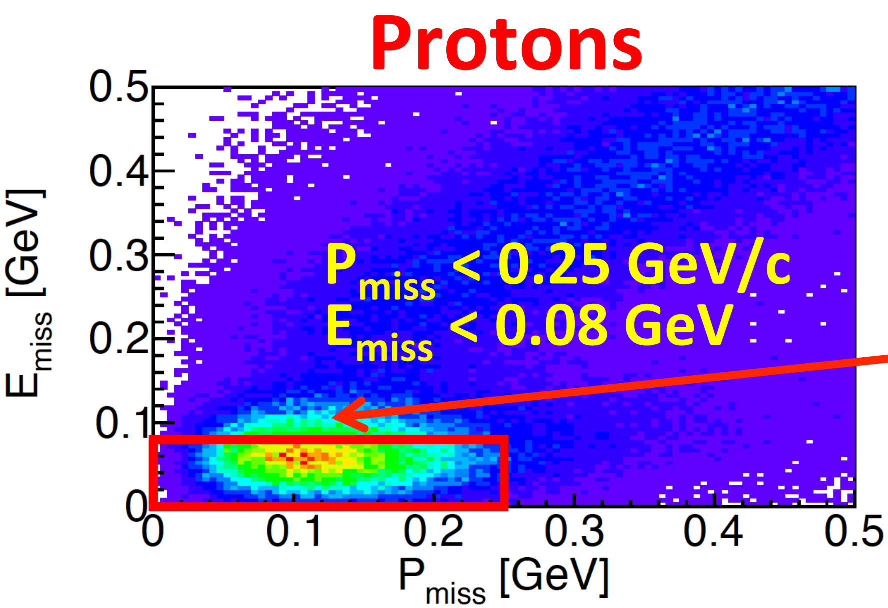
False Positive & Negative probabilities



Goal: Find cuts that minimize
false positive & negative

From Meytal's slides

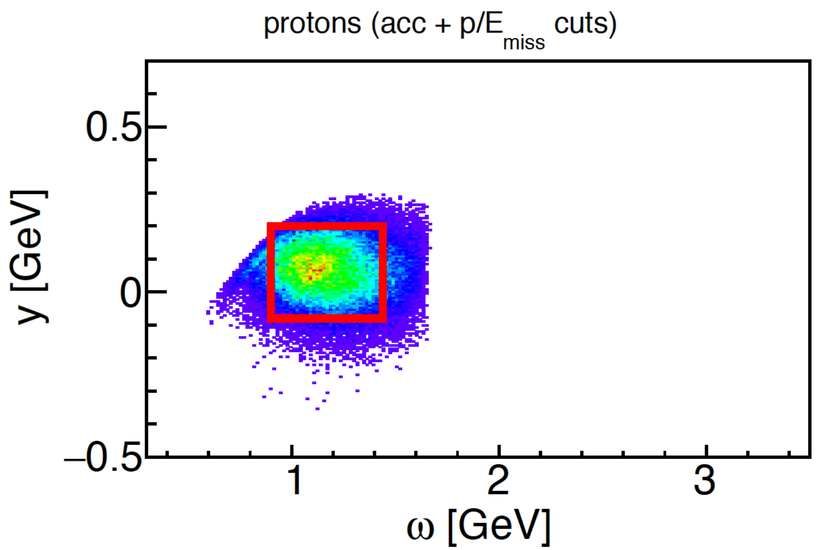
Identifying M.F. QE events

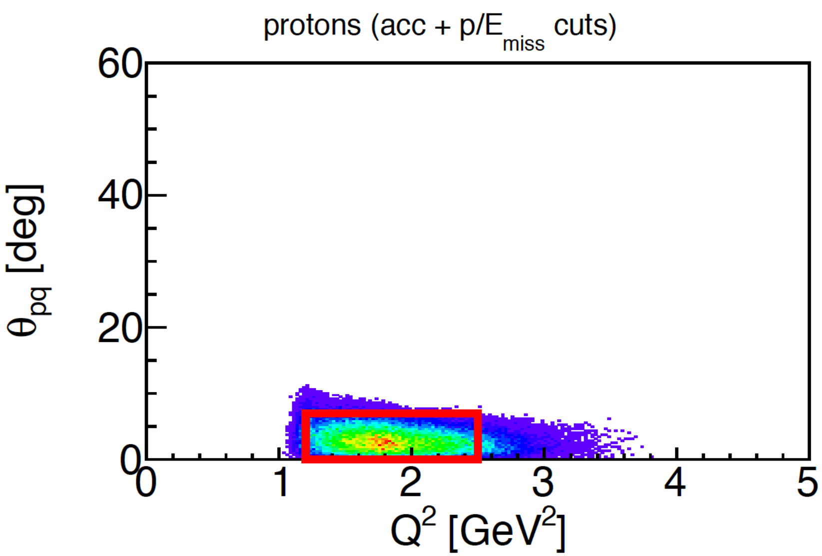


These events seem to be causing the problem.
Try to see if the electron kinematical cuts can be modified to exclude these events from the sample.

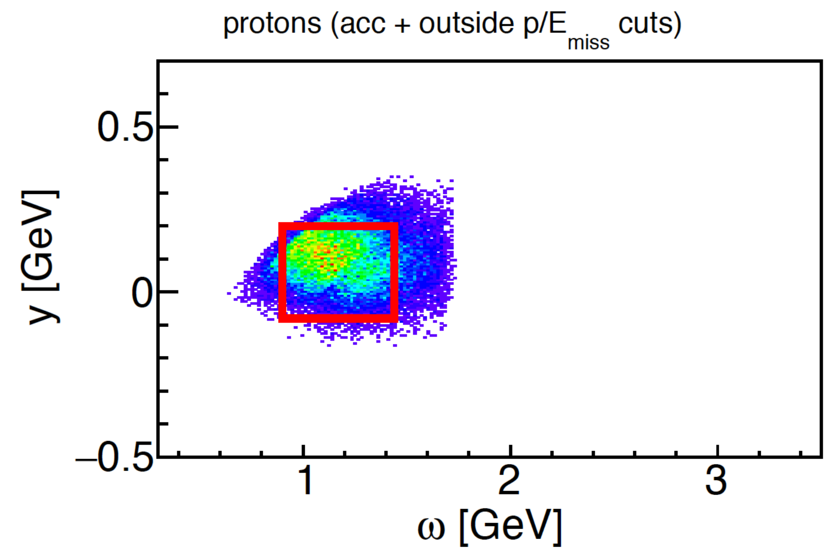
Events in and out of the QE box

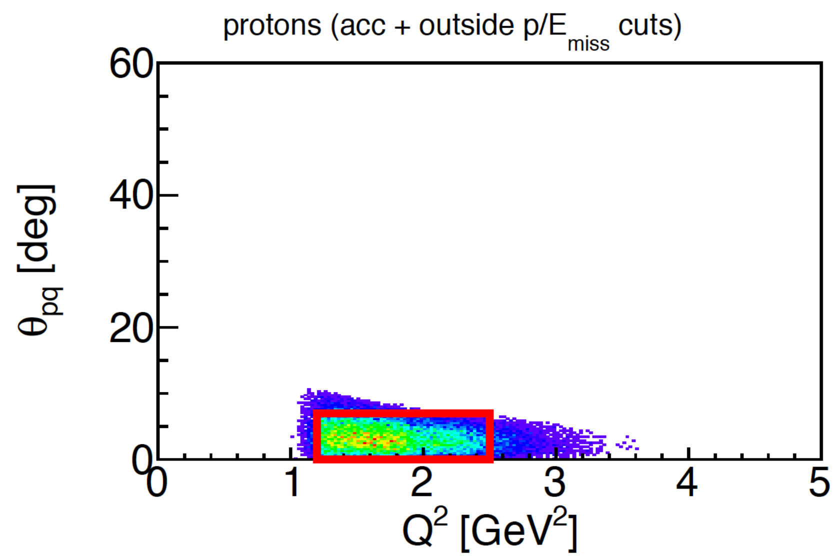
Events inside QE box





Events right above Em > 0.08 GeV





Data Files and Code Status

Data files and codes can be found here:
https://www.dropbox.com/sh/n16qjffa76wsu53/AAA9bDdbcXkDebYyxJFnAPata?dl=0

- Code.cxx ← Code (Mean field part of the analysis)
- data ← ^{12}C root data files
- infiles ← text files that are passed to the code as input
- Makefile ← Makefile
- parameters ← Parameters that the code uses
- Results ← Directory where the code puts its output

To run the code:
1) Make the code: make
2) Run the code: ./MeanField infiles/full_list_C12

Data File Structure

nRun	Run number
nParticles	number of particles in the event
nProtons	number of protons in the event
nNeutrons	number of neutrons in the event
Nu	transfer energy
Q2	transfer momentum squared
mom_x	momentum x-component
mom_y	momentum y-component
mom_z	momentum z-component
Part_type	particle type (geant nomenclature)
vtx_z_cor	vertex z position
ec_x	x coordinate of hit in the EC
ec_y	y coordinate of hit in the EC

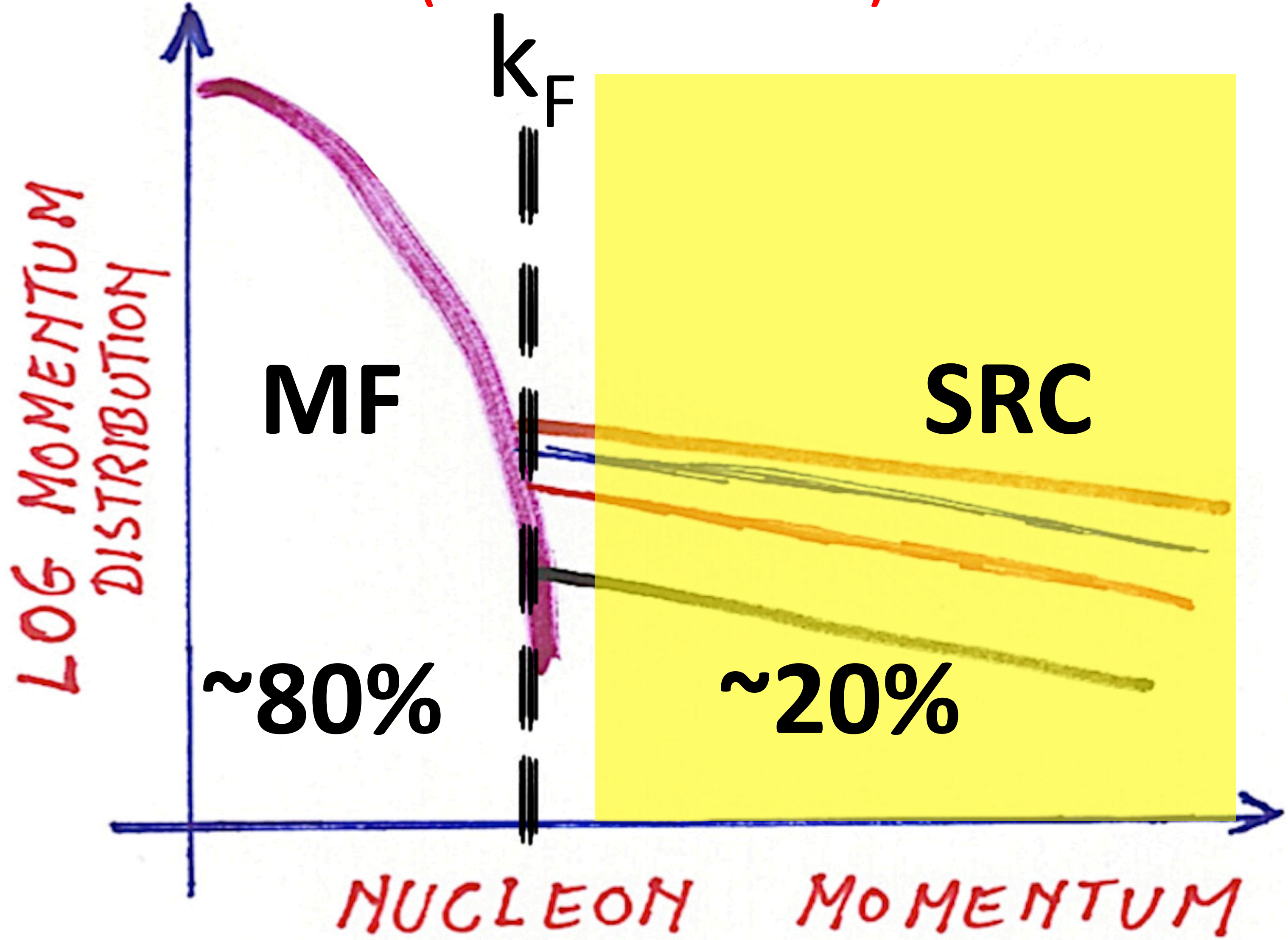
* These variables are arrays. The first element of the array corresponds to an electron, the second one to a proton, and the third one to a neutron

Thank you

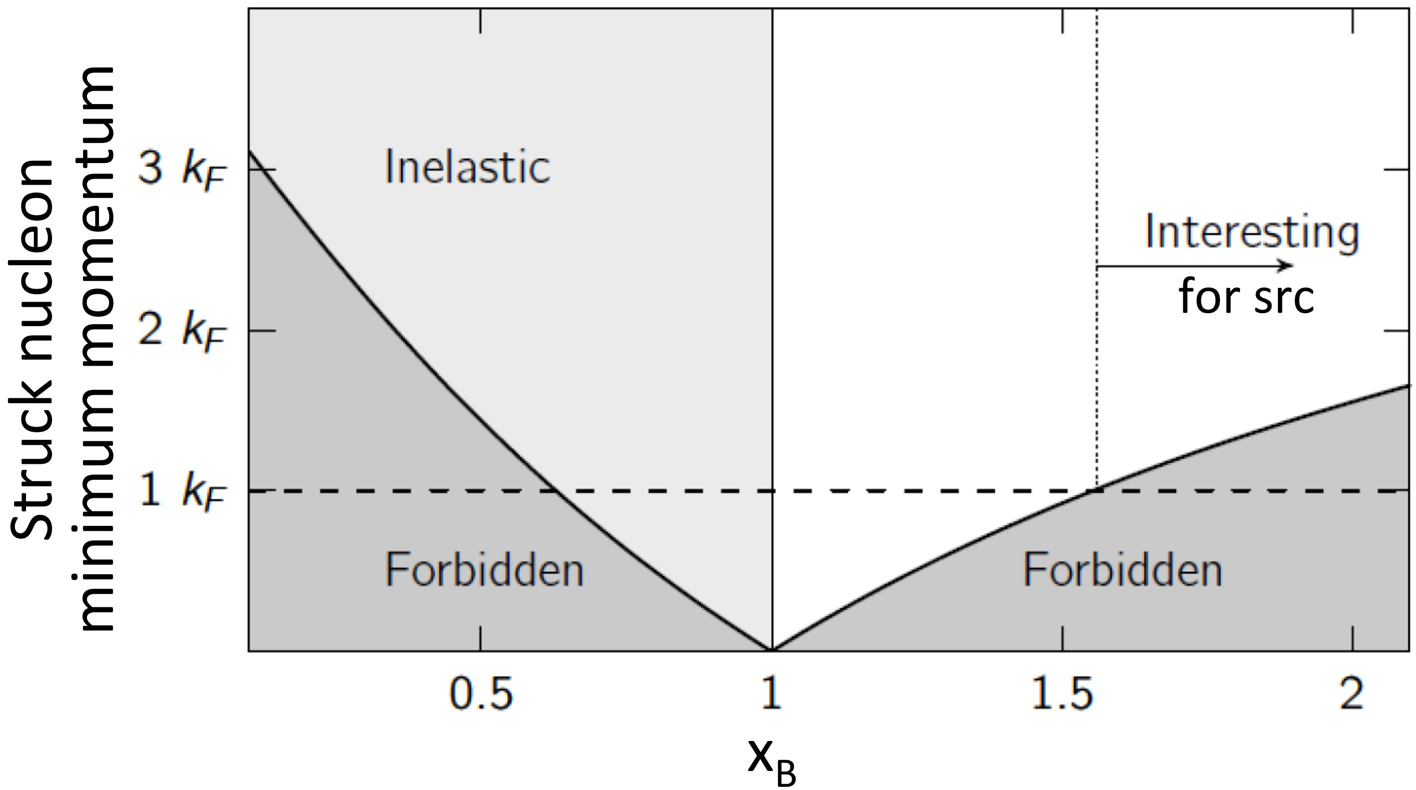
Backup slides

Identifying SRC QE events

(Same idea as in MF)



Identifying SRC QE events

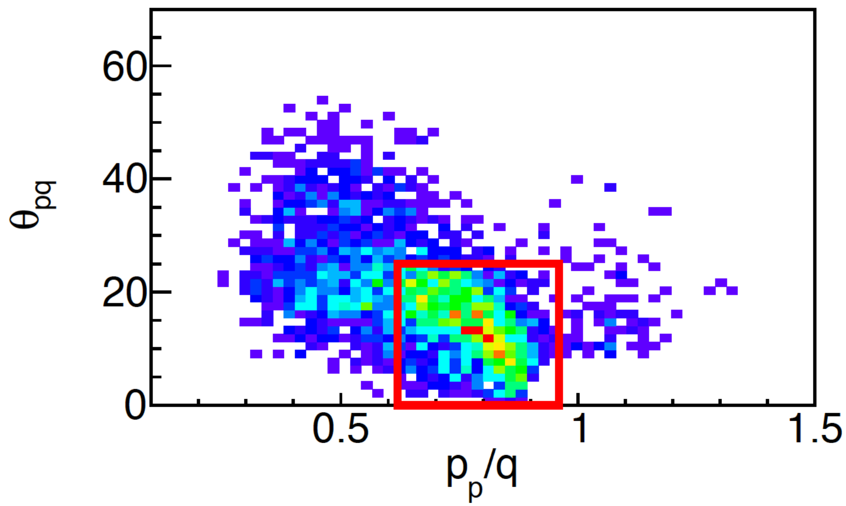


Un-smeared protons:
$x_B > 1.2$

Smeared protons/neutrons:
$x_B > 1.1$

Identifying SRC QE events

Protons



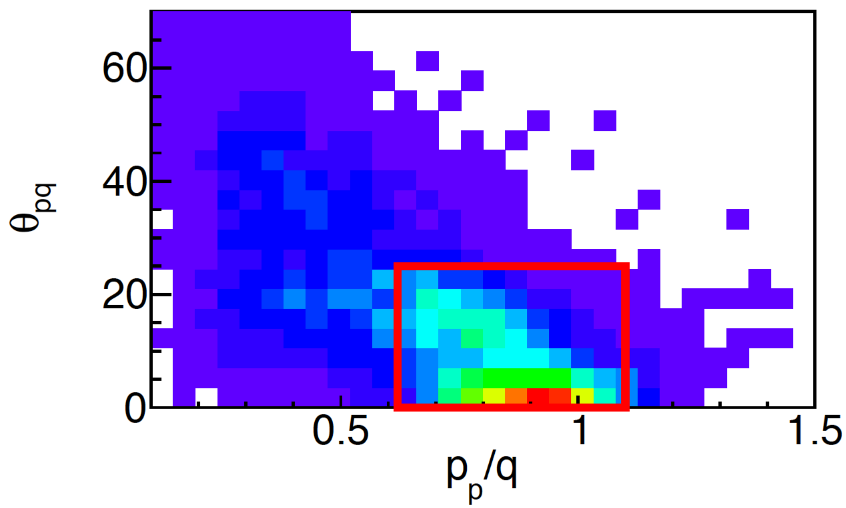
Leading hadron cuts:

$\theta_{Nq} < 25^o$

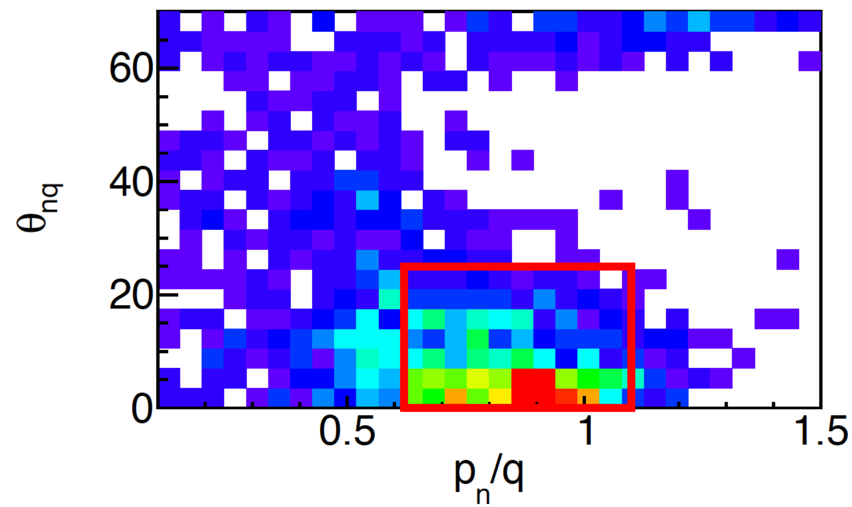
Un-smeared protons:
0.62 < p/q < 0.96 GeV

Smeared protons/neutrons:
0.62< p/q < 1.10 GeV

Smeared Protons

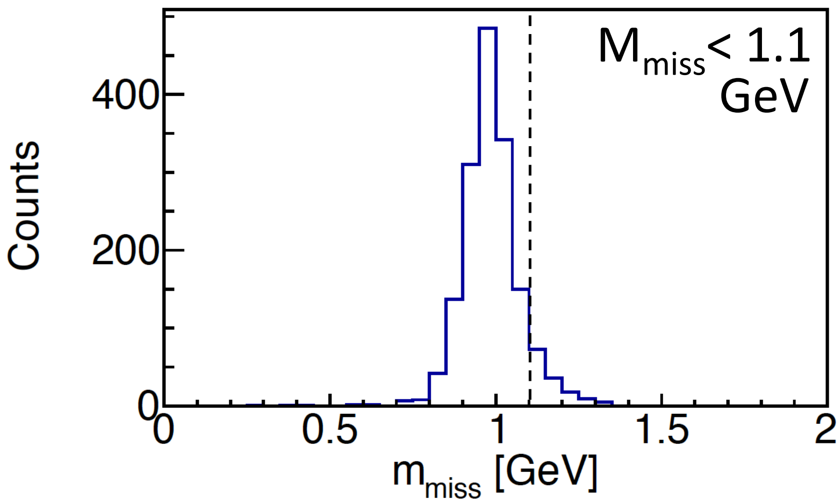


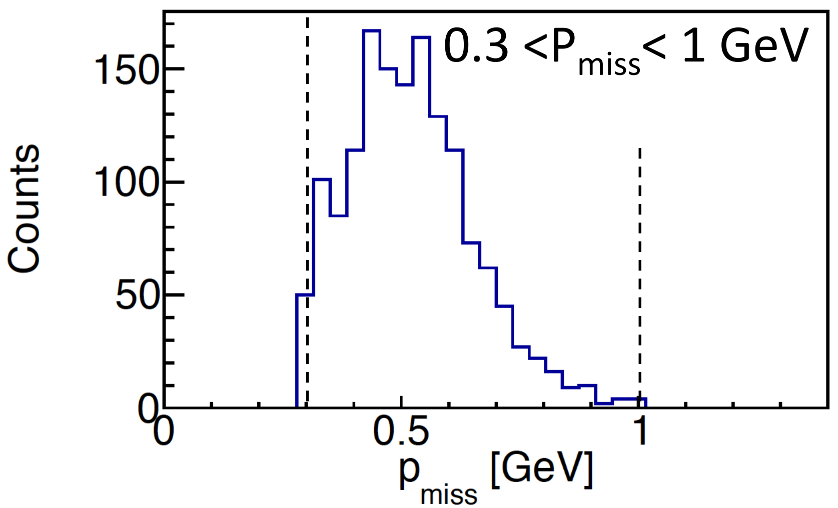
Neutrons



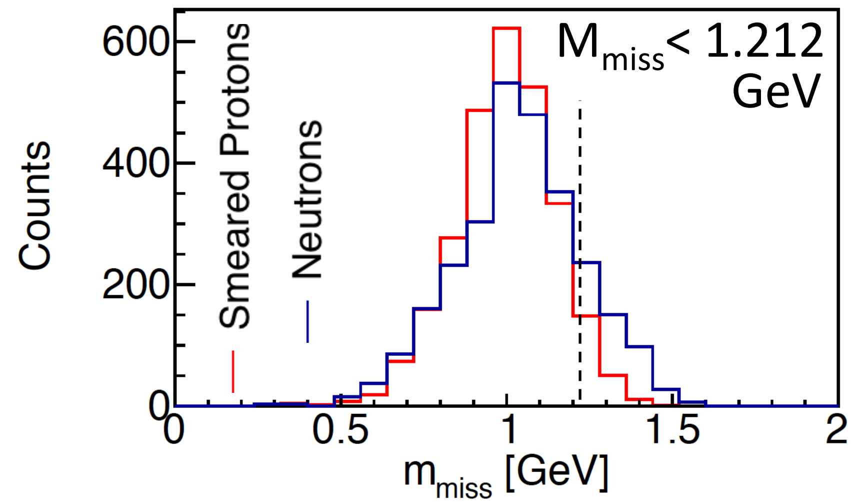
Identifying SRC QE events

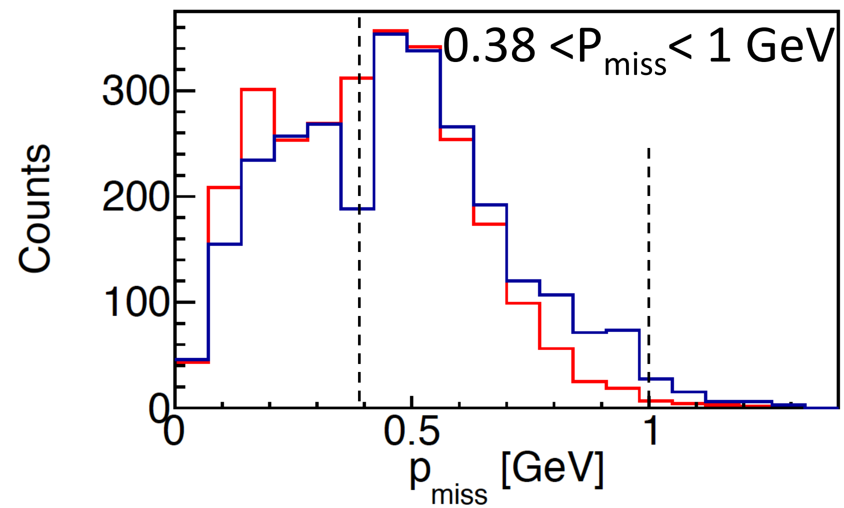
Protons



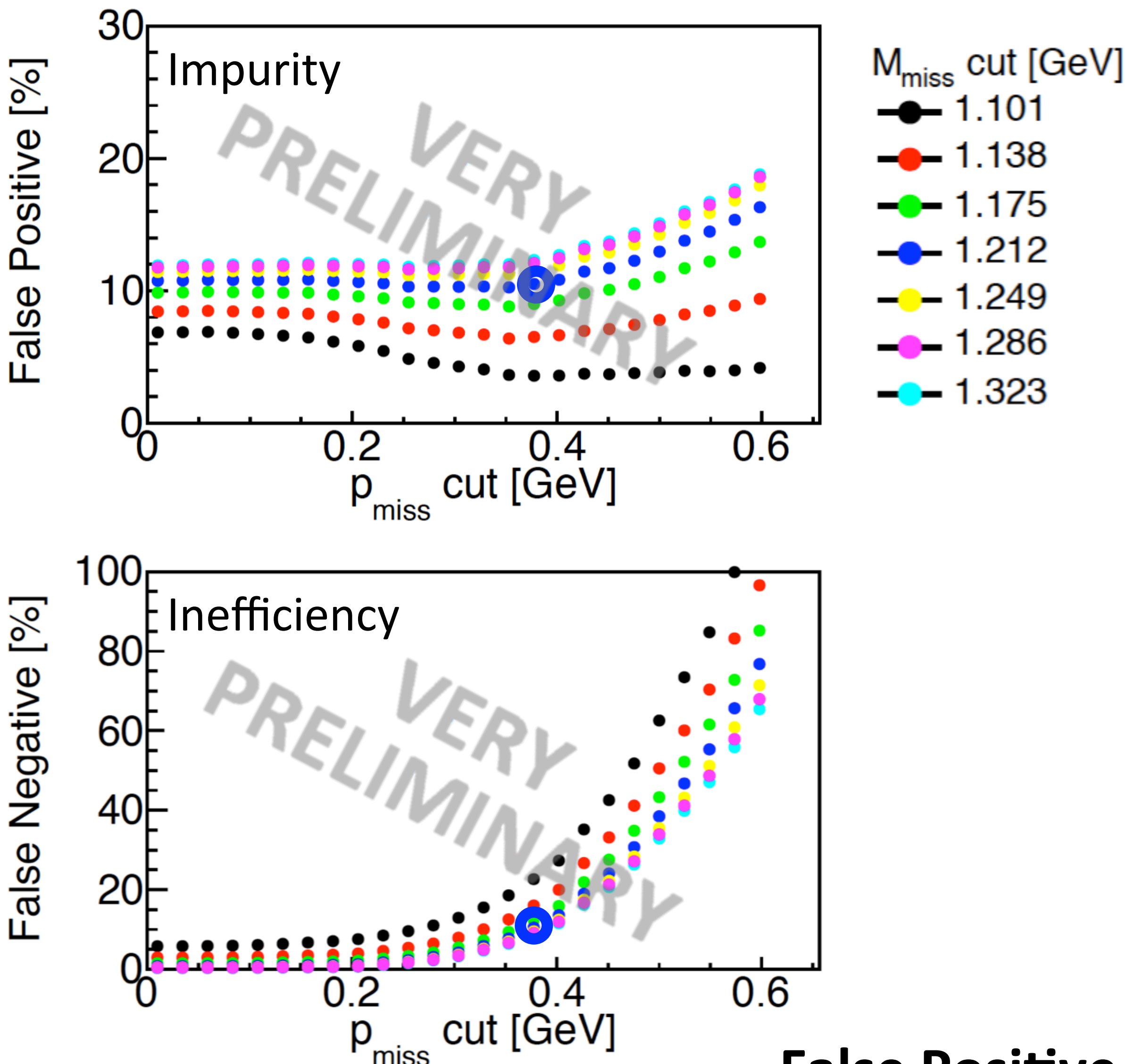


Smeared protons/neutrons





Identifying SRC QE events

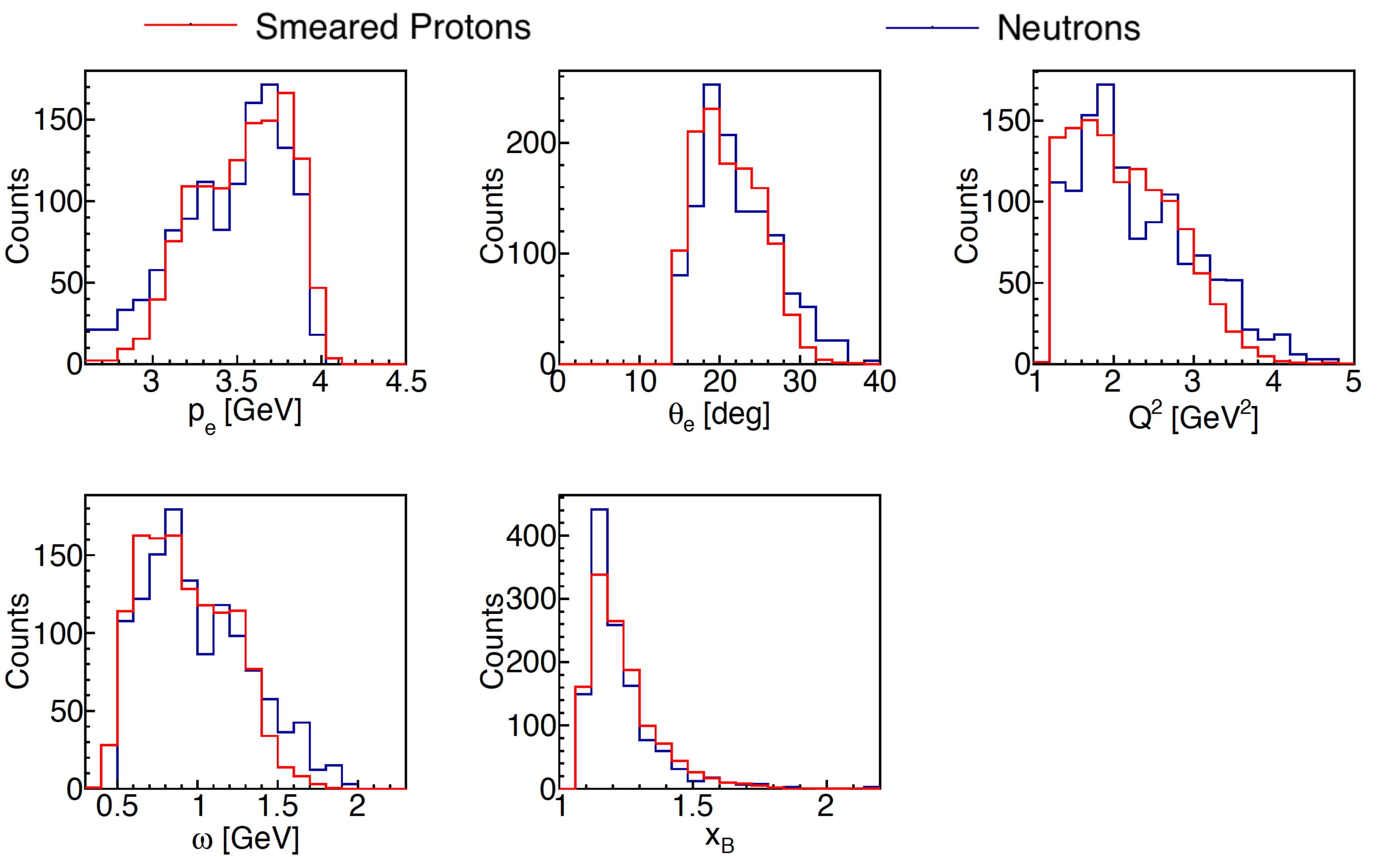


smeared p/n cuts:
$P_{miss} > 0.3775$ GeV/c
$M_{miss} < 1.212$ GeV

un-smeared p cuts:
$P_{miss} > 0.3$ GeV/c
$M_{miss} < 1.1$ GeV

False Positive ≈ False Negative ≈ 10.5%

Comparing smeared protons and neutrons (SRC)



Comparing smeared protons and neutrons (SRC)