A Probe of the Color Force

On Behalf of the E06014 Collaboration

Hall A Collaboration Meeting
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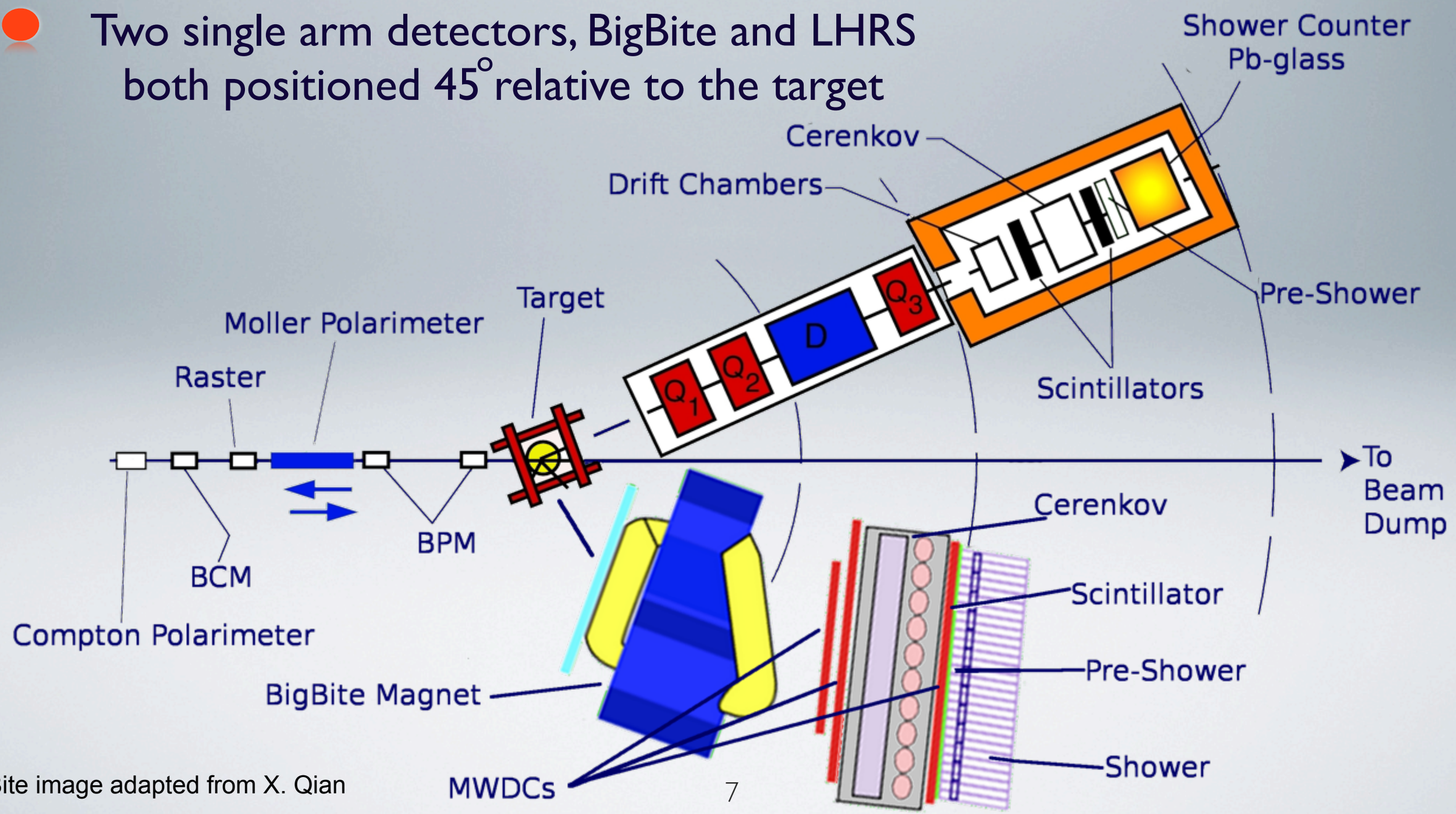
or ...

- d_2 is the average transverse color force on a quark just after interaction with a virtual photon (M. Burkardt)

Experimental Set-Up For E06014

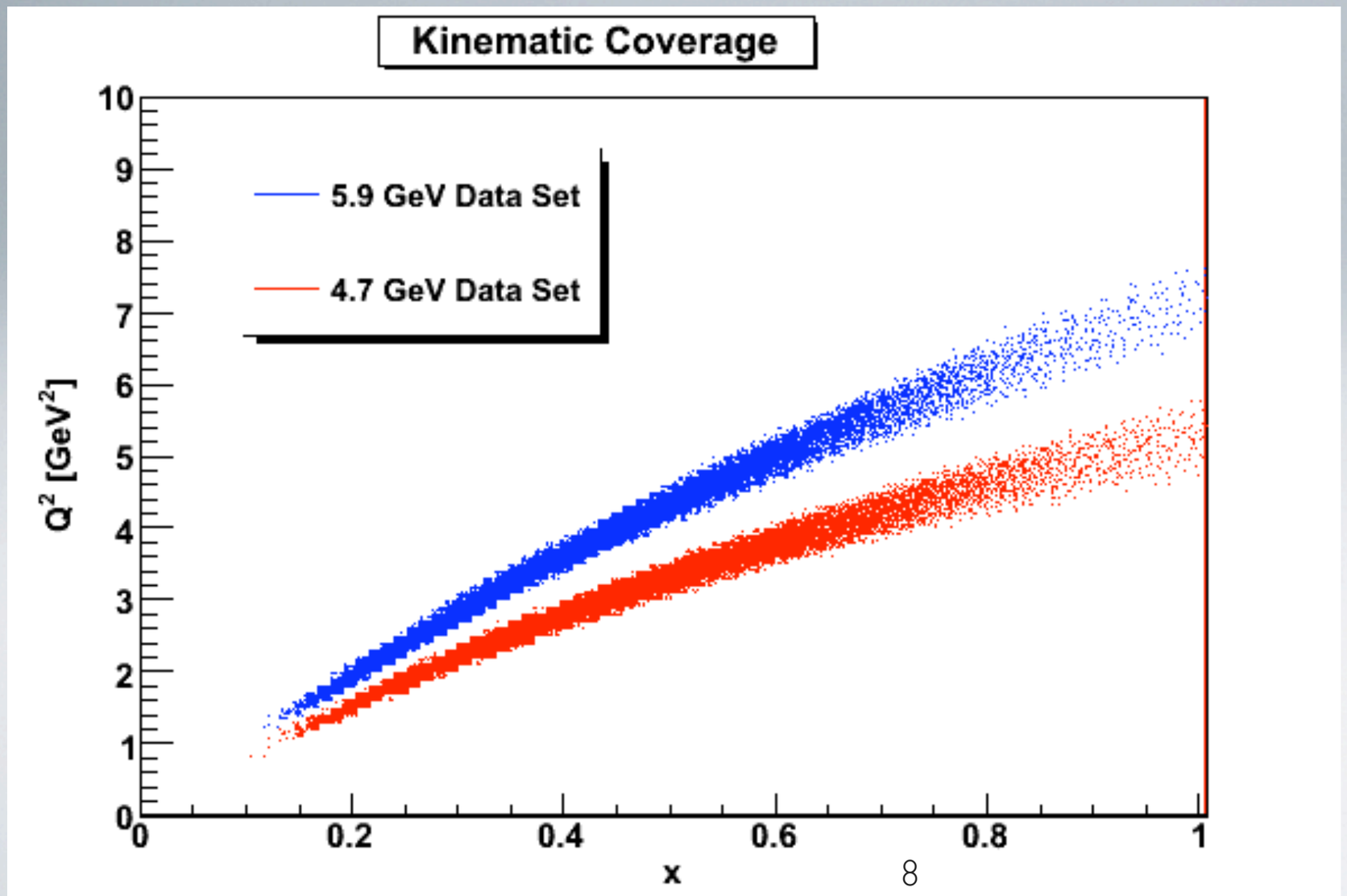
- Scatter longitudinally polarized electrons from a longitudinally and transversely polarized He^3 target
- Two single arm detectors, BigBite and LHRS both positioned 45° relative to the target



BigBite image adapted from X. Qian

Kinematic Coverage

- Data sets at two beam energies: 4.7 GeV and 5.9 GeV in DIS region
- 5.9 GeV primary data set (most of E06014 data)
- 4.7 GeV data set will be used in Q^2 evolution



Experimental Definitions

- $\sigma_0 = \left(\frac{Ne}{Q\rho LT\epsilon}\right)\left(\frac{1}{w\Delta E'\Delta\Omega\Delta Z}\right)$ (LHRS)
- $A_{\parallel} = \frac{\sigma^{\downarrow\Uparrow} - \sigma^{\uparrow\Uparrow}}{\sigma^{\downarrow\Uparrow} + \sigma^{\uparrow\Uparrow}}$ (BigBite)
- $A_{\perp} = \frac{\sigma^{\downarrow\Rightarrow} - \sigma^{\uparrow\Rightarrow}}{\sigma^{\downarrow\Rightarrow} + \sigma^{\uparrow\Rightarrow}}$
- $\Rightarrow$ = Target spin towards BigBite
- $\Leftarrow$ = Target spin towards LHRS

Combining BigBite and LHRS Data

- $$d_2 = \int_0^1 \frac{MQ^2}{4\alpha^2} \frac{x^2y^2}{(1-y)(2-y)} \sigma_0 \left[\left(3\frac{1+(1-y)cos(\theta)}{(1-y)sin(\theta)} + \frac{4}{y} tan(\frac{\theta}{2}) \right) A_\perp + \left(\frac{4}{y} - 3 \right) A_\parallel \right] dx$$

- Measured cross-sections and asymmetries allow us to evaluate d_2 exclusively from our data (no world data extractions needed)

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$\left[\left(3\frac{1+(1-y)cos(\theta)}{(1-y)sin(\theta)} + \frac{4}{y}tan(\frac{\theta}{2}) \right) A_\perp + \left(\frac{4}{y} - 3 \right) A_\parallel \right] dx$

- Measured cross-sections and asymmetries allow us to evaluate d_2 exclusively from our data (no world data extractions needed)

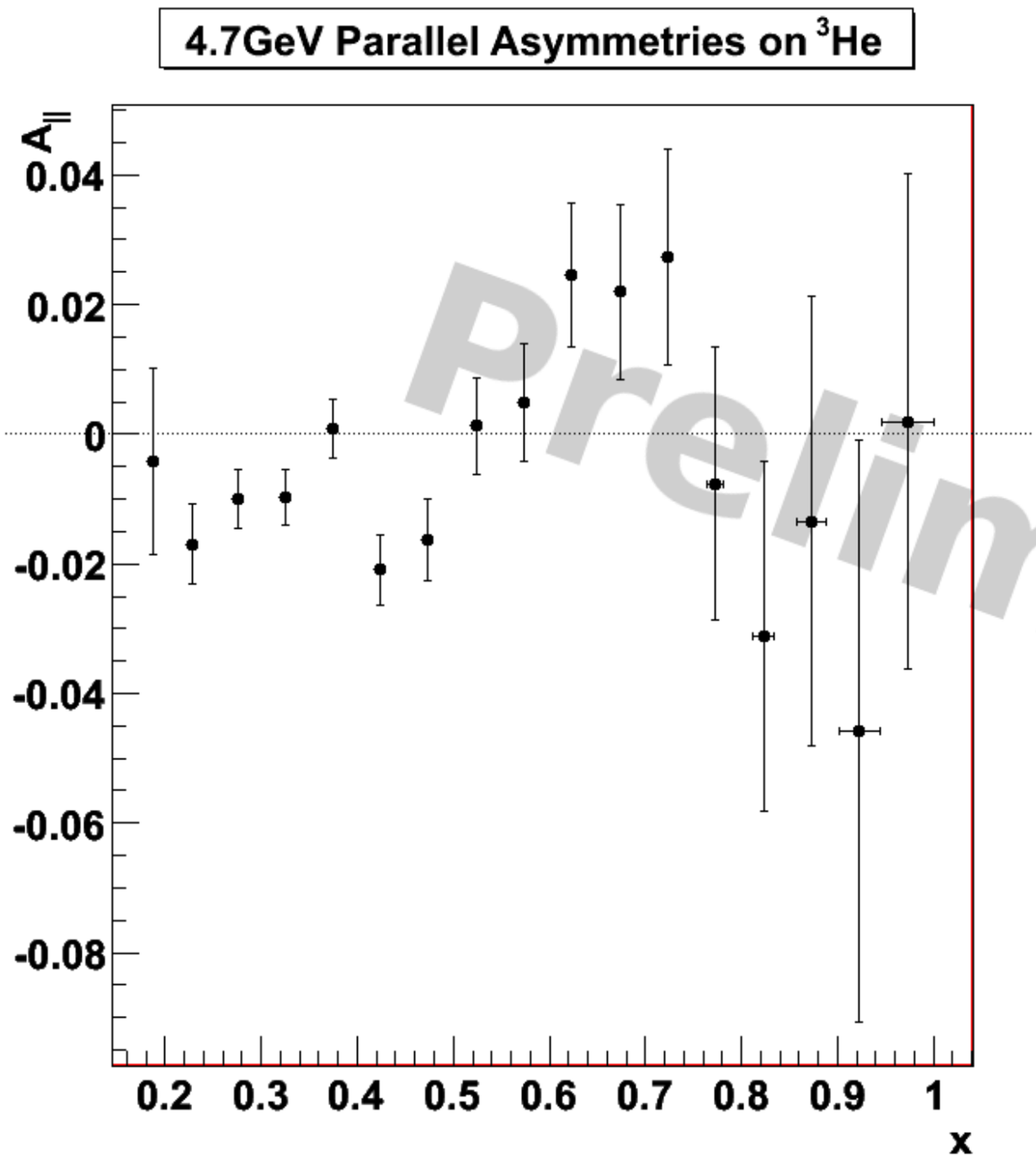
- We also pick up the spin structure functions:

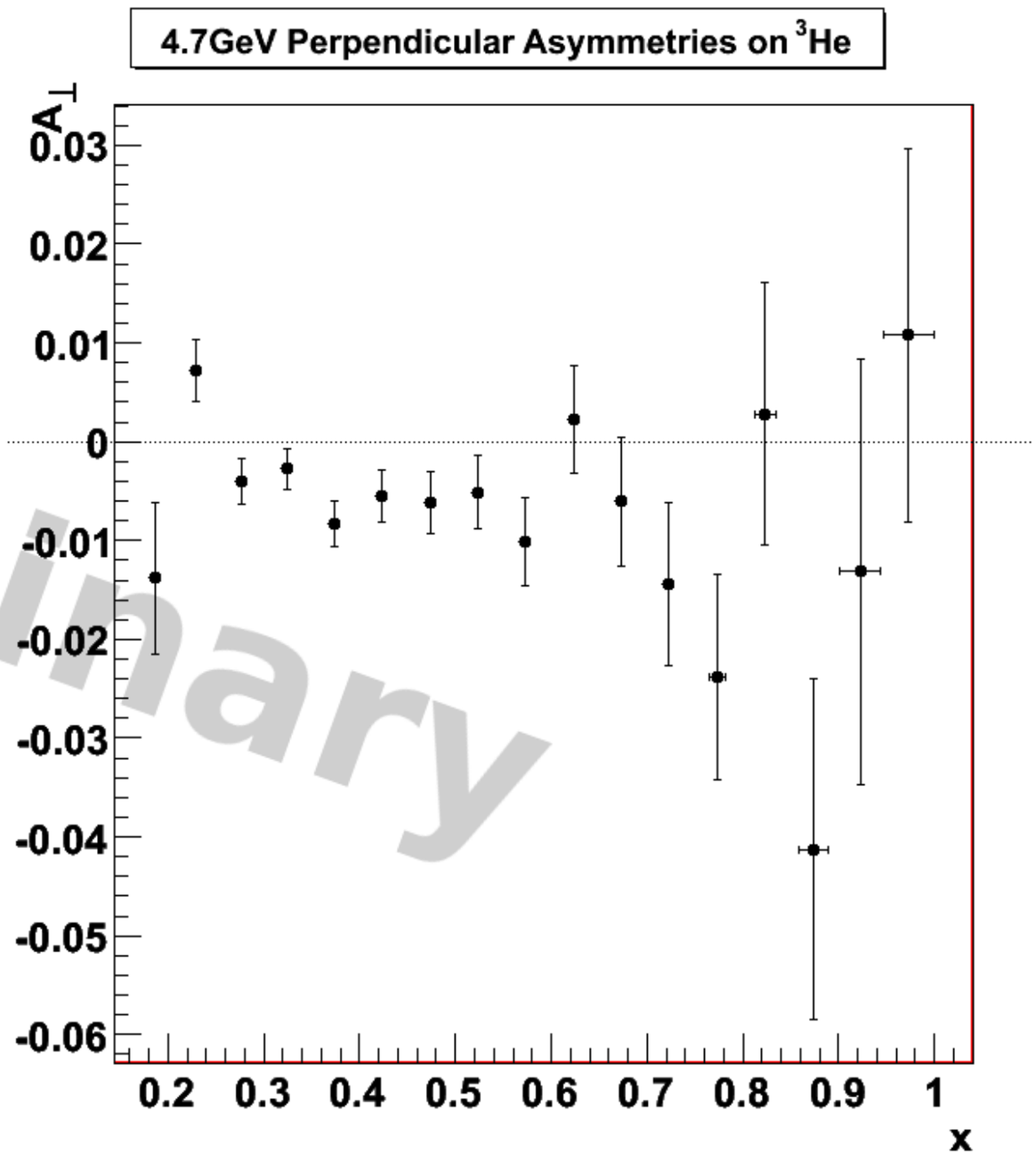
  - $g_1 = (2\sigma_0) \left(\frac{MQ^2}{4\alpha^2} \frac{y}{(1-y)(2-y)} \right) \left[A_\parallel + tan(\frac{\theta}{2}) A_\perp \right]$

  - $g_2 = (2\sigma_0) \left(\frac{MQ^2}{4\alpha^2} \frac{y^2}{2(1-y)(2-y)} \right) \left[-A_\parallel + \frac{1+(1-y)cos(\theta)}{(1-y)sin(\theta)} A_\perp \right]$

4.7 GeV ^{3}He Asymmetries

Asymmetry analysis done by
Diana Parno and Matt Posik





Note: Radiative and positron corrections are not applied

For more information see
http://hallaweb.jlab.org/experiment/E06-014/talks/DianaParno_PrintableDissertation.pdf

BigBite Positron Dilution Factor

- Data were taken with BigBite in
  positive polarity (focus on detecting positrons) and
  negative polarity (focus on detecting electrons)

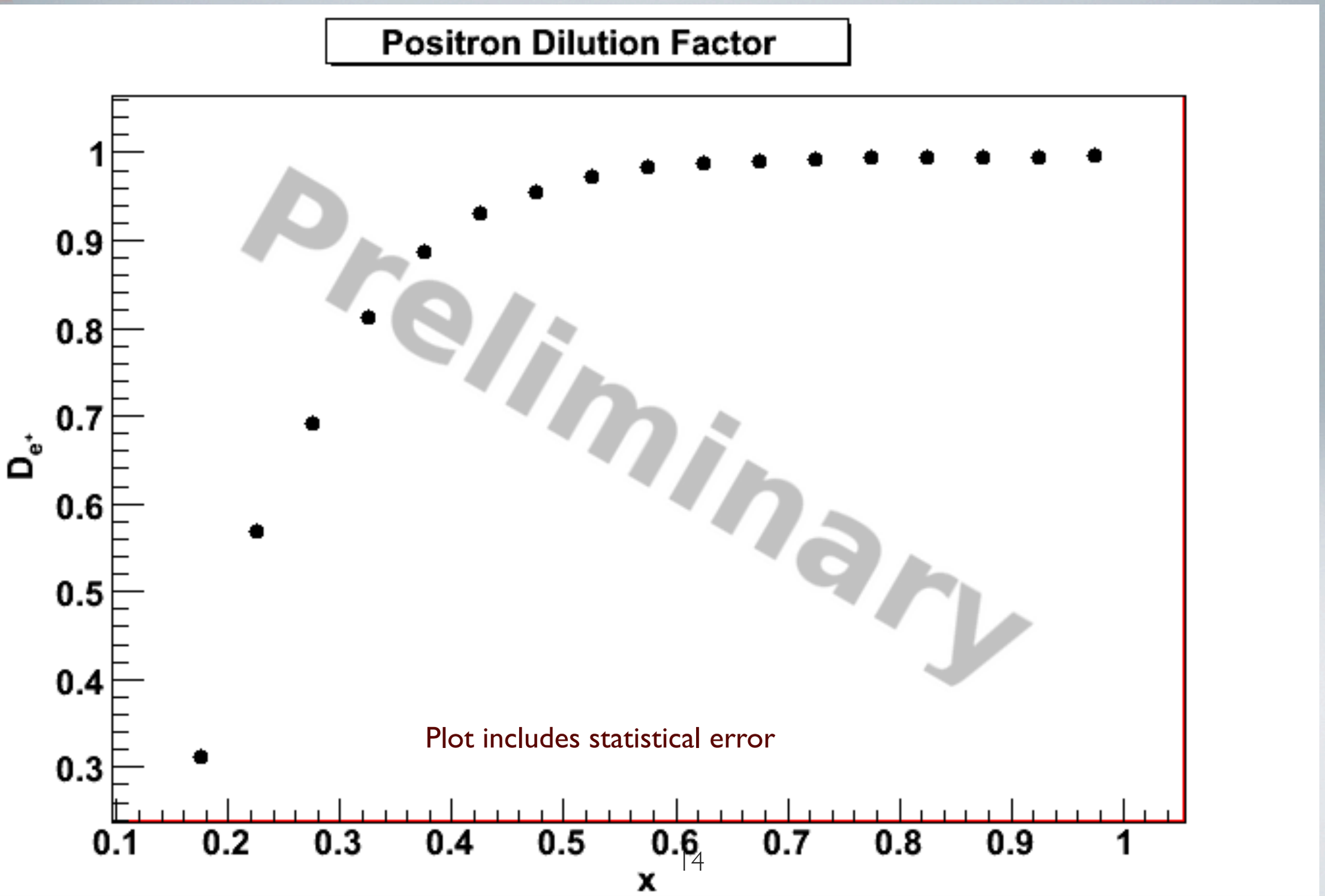
- Positron dilution factor:

$$D_{e+} = 1 - \frac{N^+ Q^-}{N^- Q^+}$$

- Positron contamination in BigBite is
  still being studied

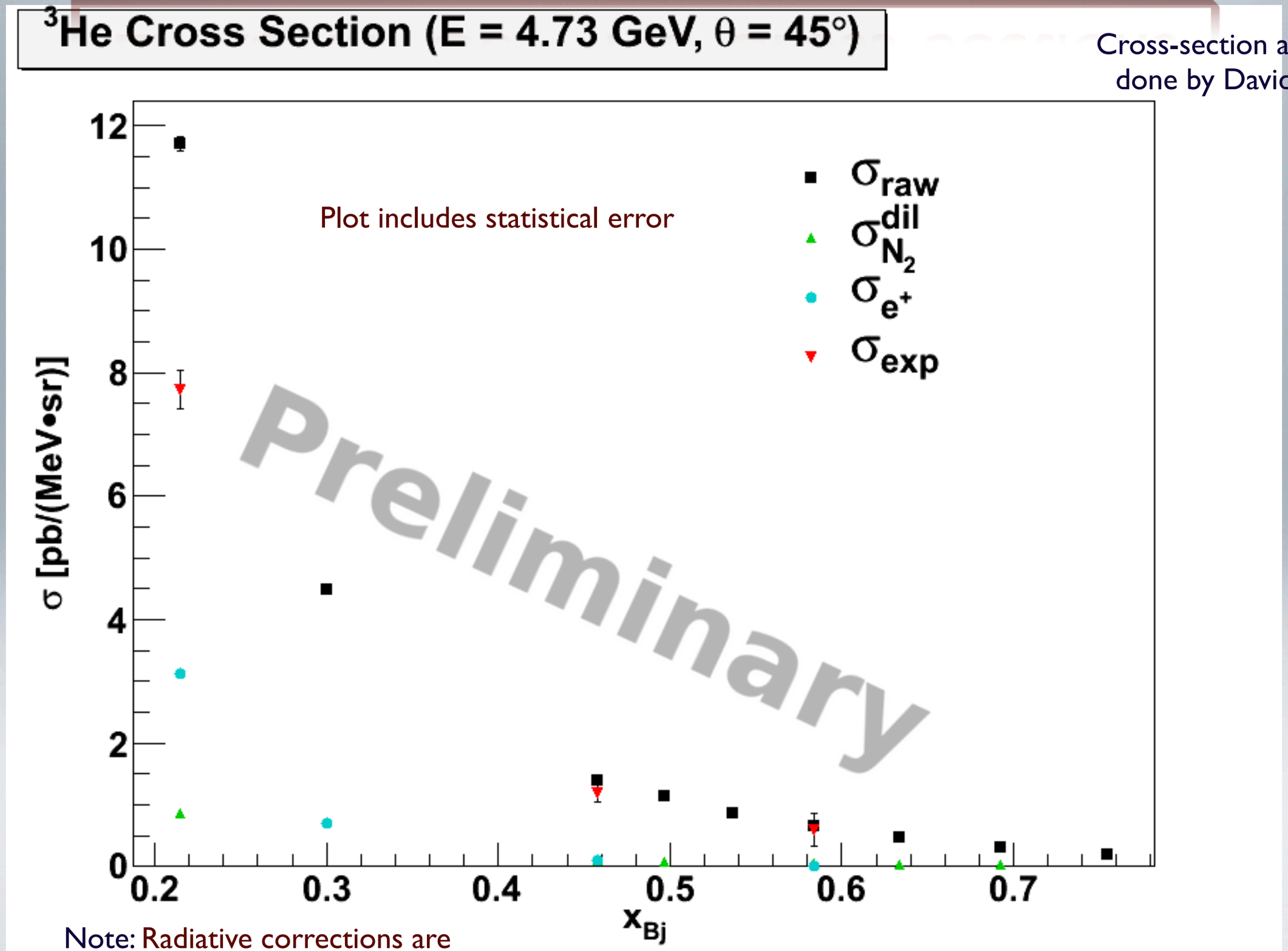
BigBite Positron Dilution Factor

- Positron dilution factor at 4.7 GeV



LHRS 4.7 GeV ^{3}He Cross-Sections

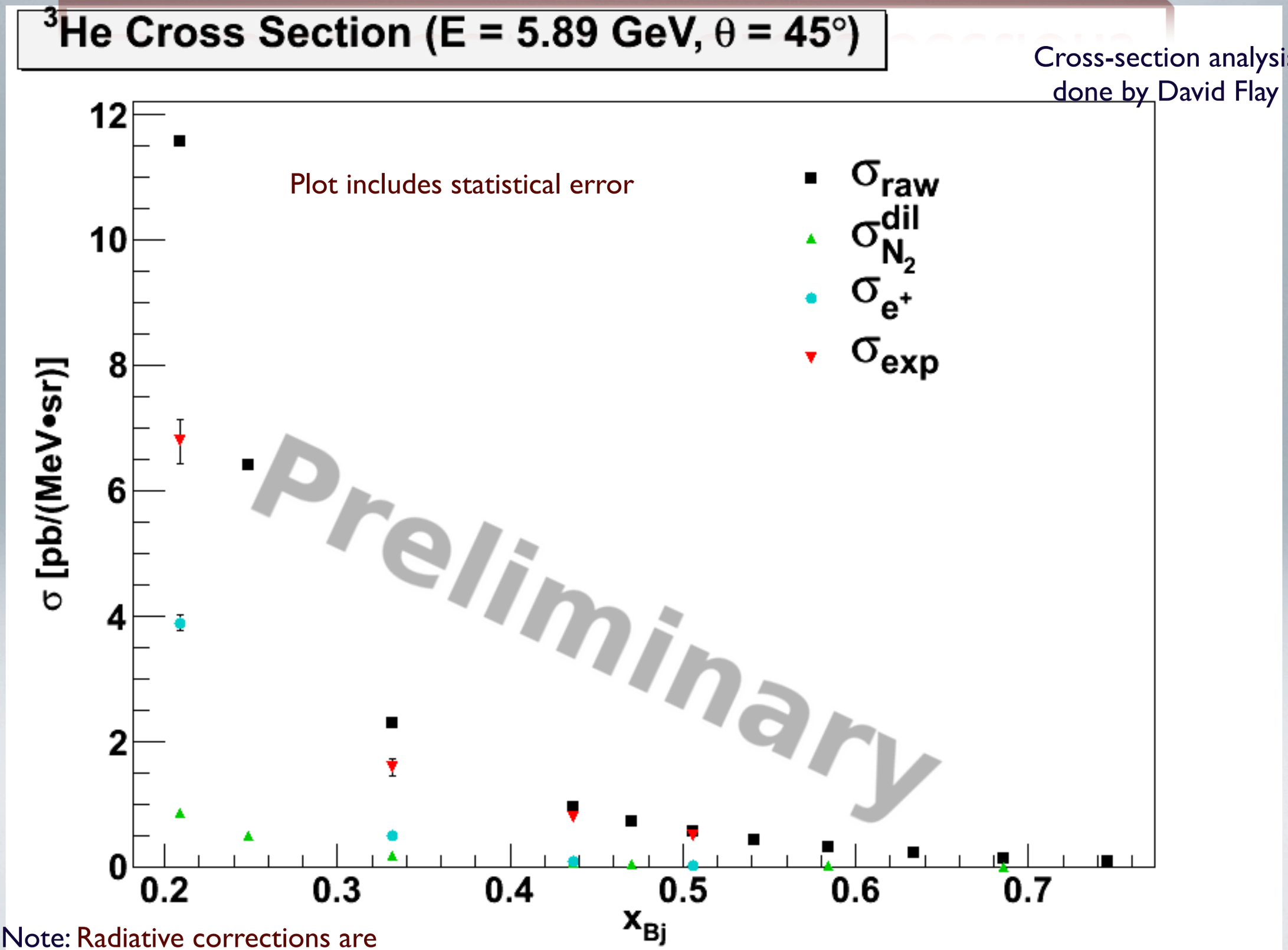
Cross-section analysis done by David Flay



Note: Radiative corrections are not applied

LHRS 5.9 GeV ^{3}He Cross-Sections

Cross-section analysis done by David Flay



Note: Radiative corrections are not applied

What's Next

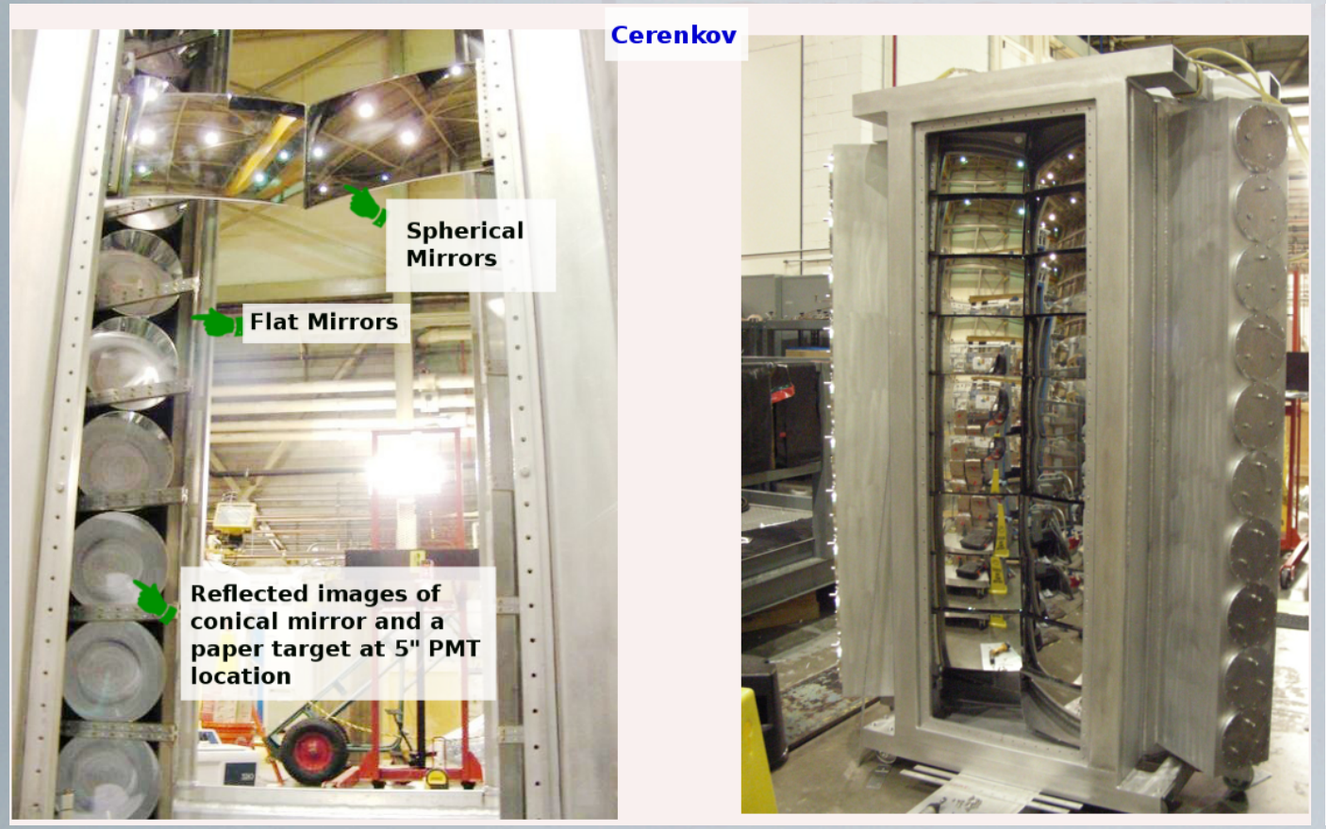
- Continue pair-production contamination studies
- Combine cross-section and asymmetries to form:
  - g_1 and g_2 spin structure functions
  - d_2

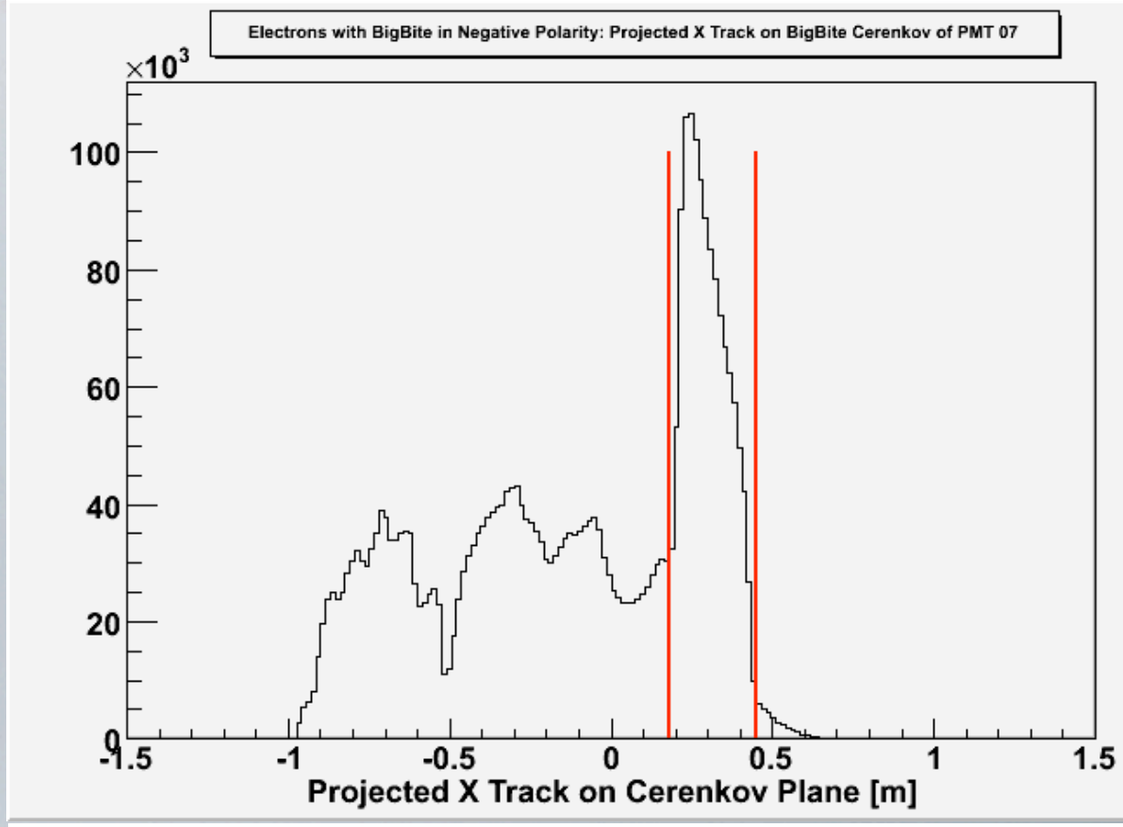
- Radiative corrections to asymmetries and cross-sections
- Form 5.9 GeV data set asymmetries
- Apply nuclear corrections

Thank You

- To the Hall A collaboration
- All those who took shifts on E06014
- Primary analysis team: Brad Sawatzky, Diana Parno, David Flay, Yawei Zhang, Gregg Franklin, Zein-Eddine Meziani
- P. H. Solvignon, V. Sulkosky, S. Riordan, Yi Qiang, L. El Fassi
- X. Qian, J. Huang, K. Allada, C. Dutta

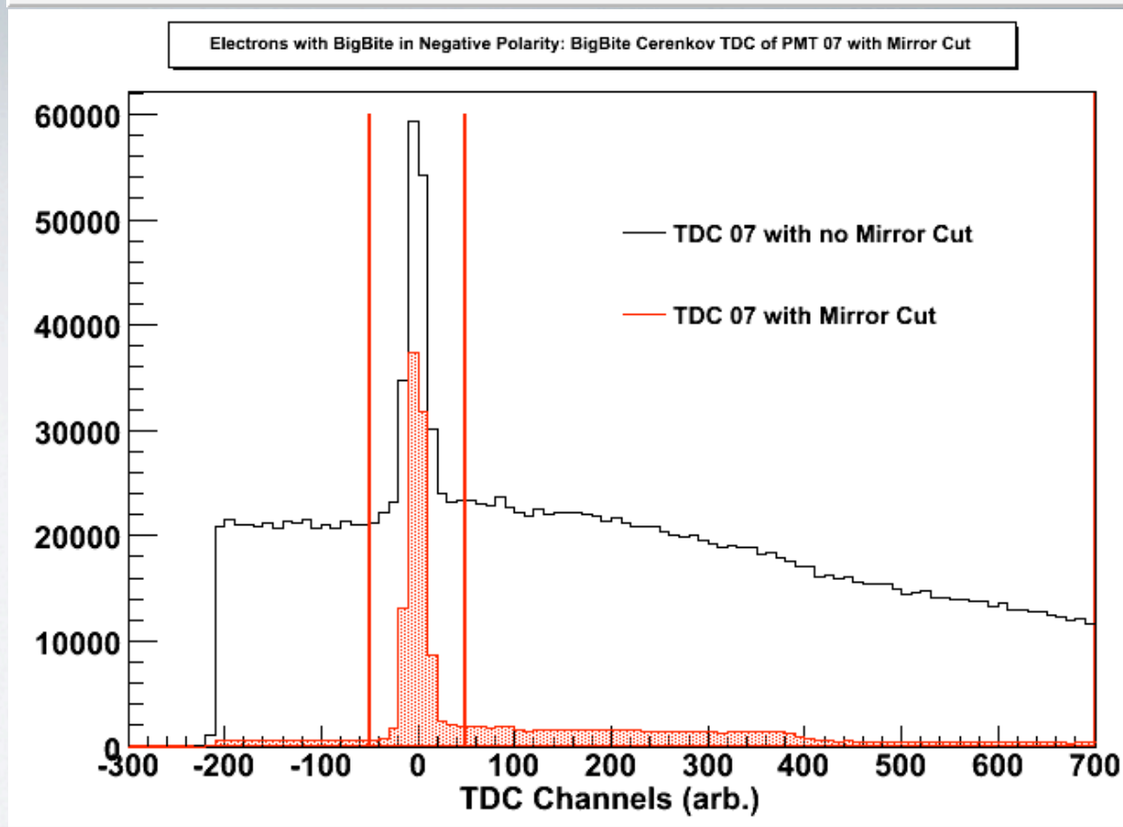
Cherenkov Cuts



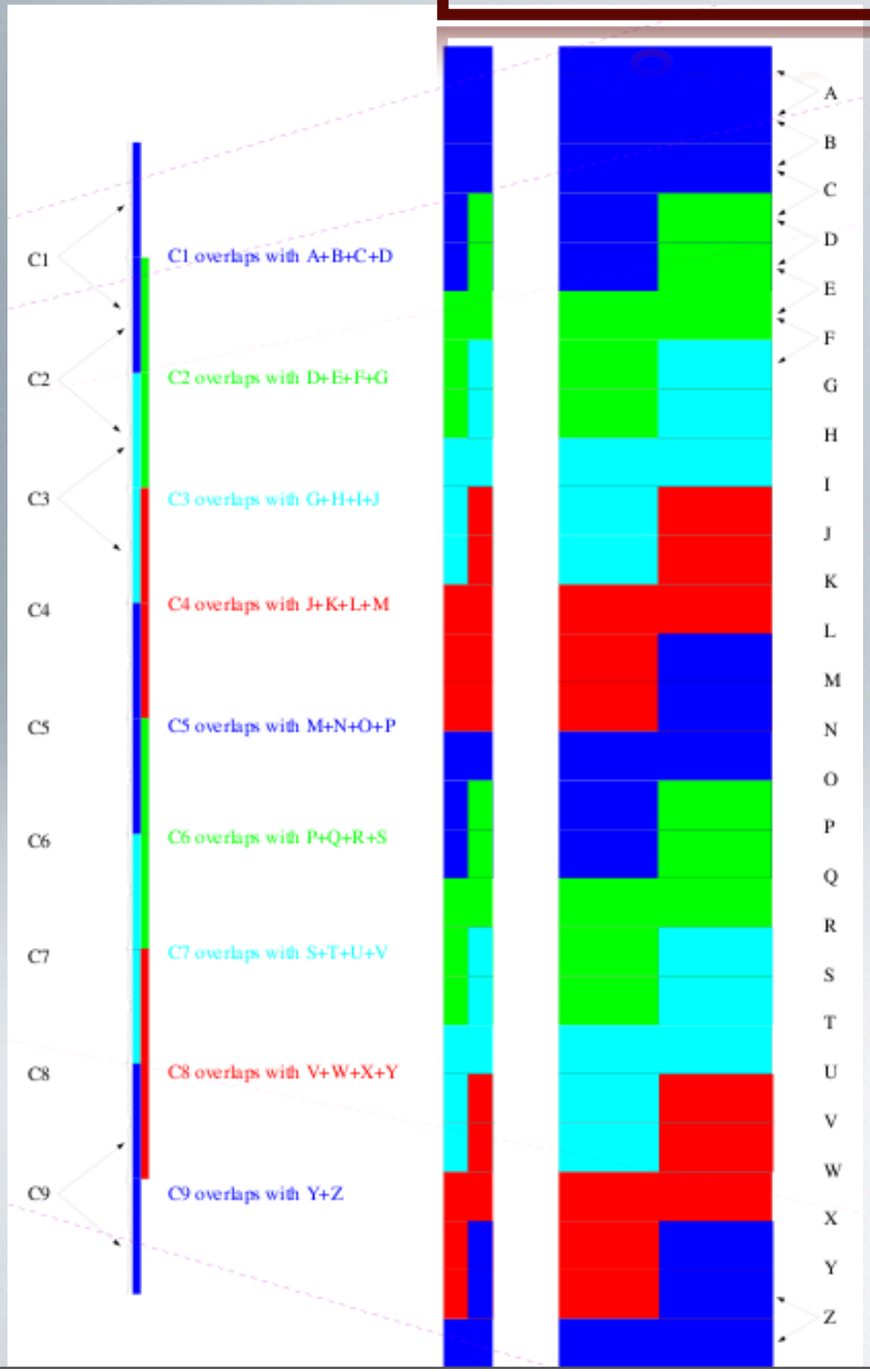


- Trajectory cut requires particle to pass through Cherenkov mirror location

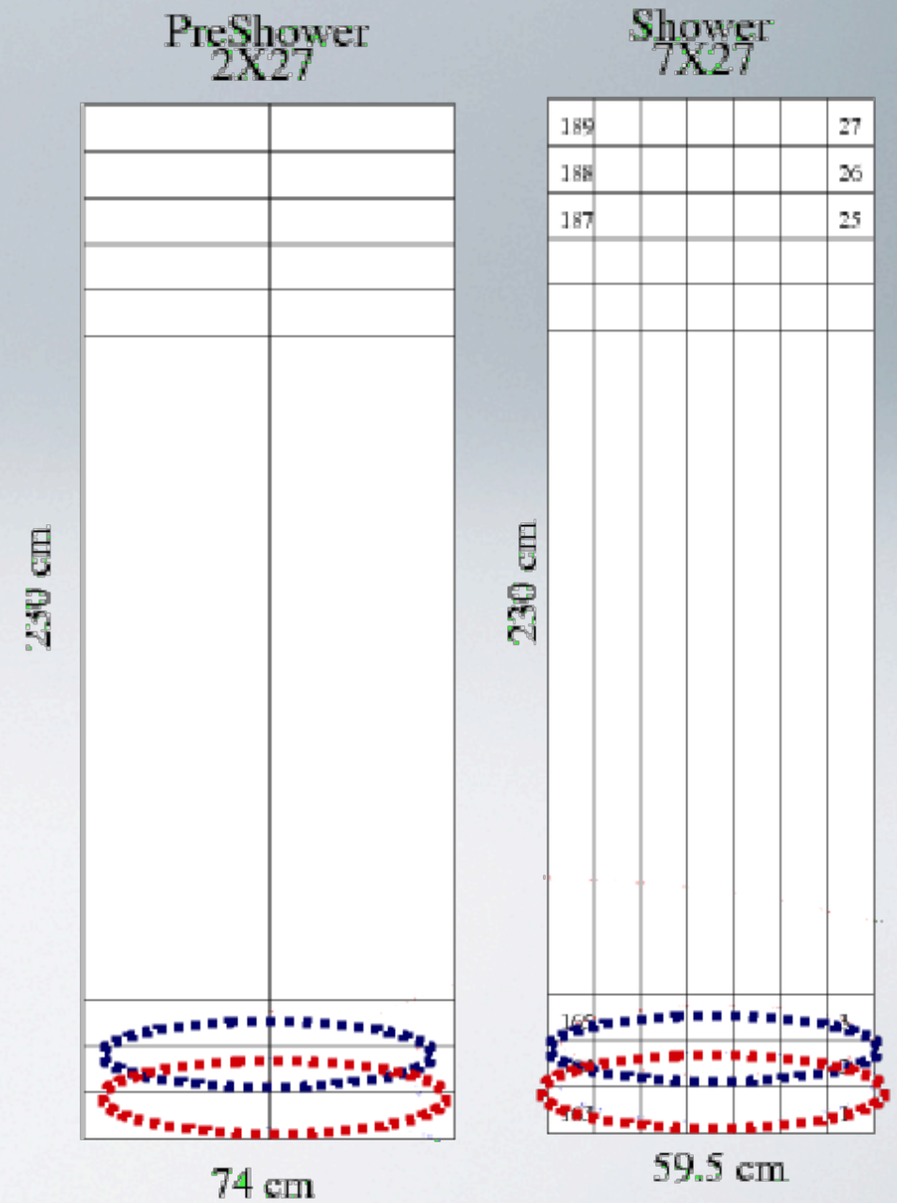
- Trajectory cut also cleans up TDC spectrum



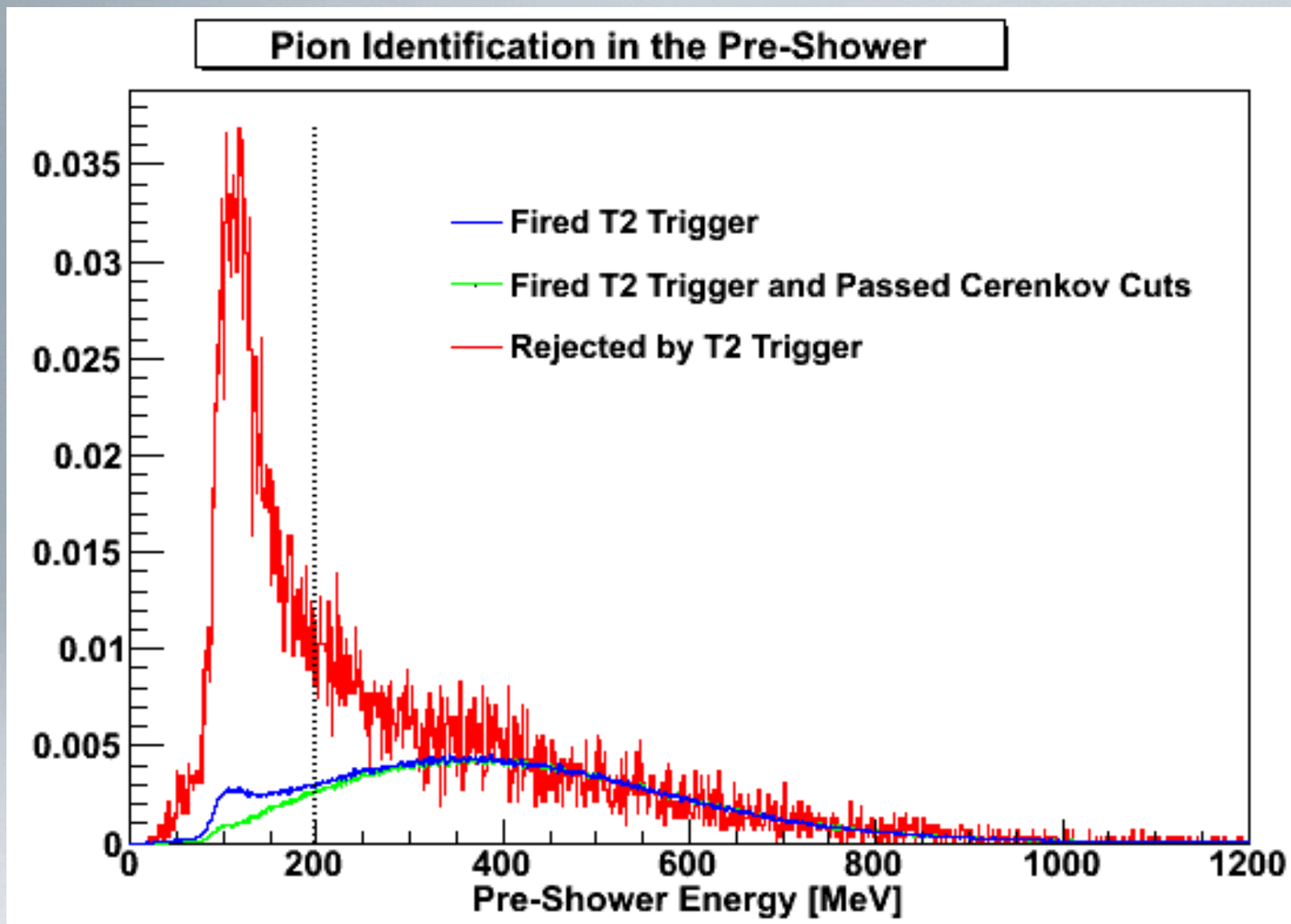
BigBite T2 Trigger



- Main electron trigger
- Formed by geometrical overlap of shower/pre-shower + Cherenkov

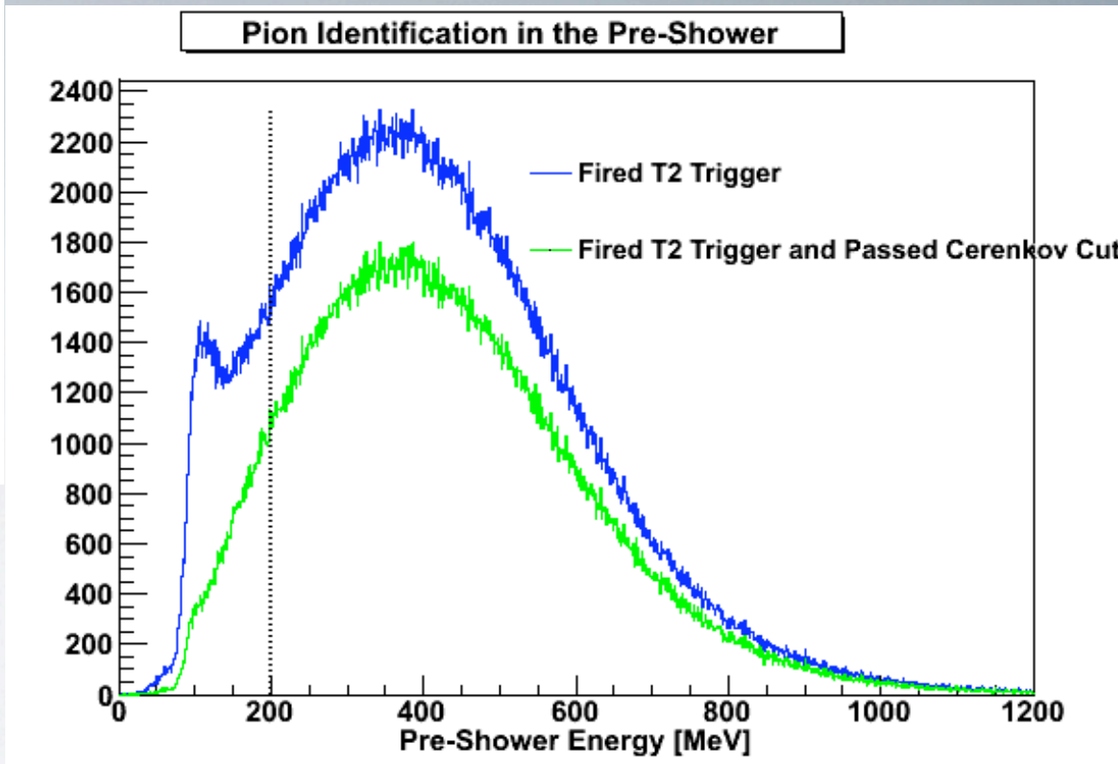


T2 Trigger Effect on Pions



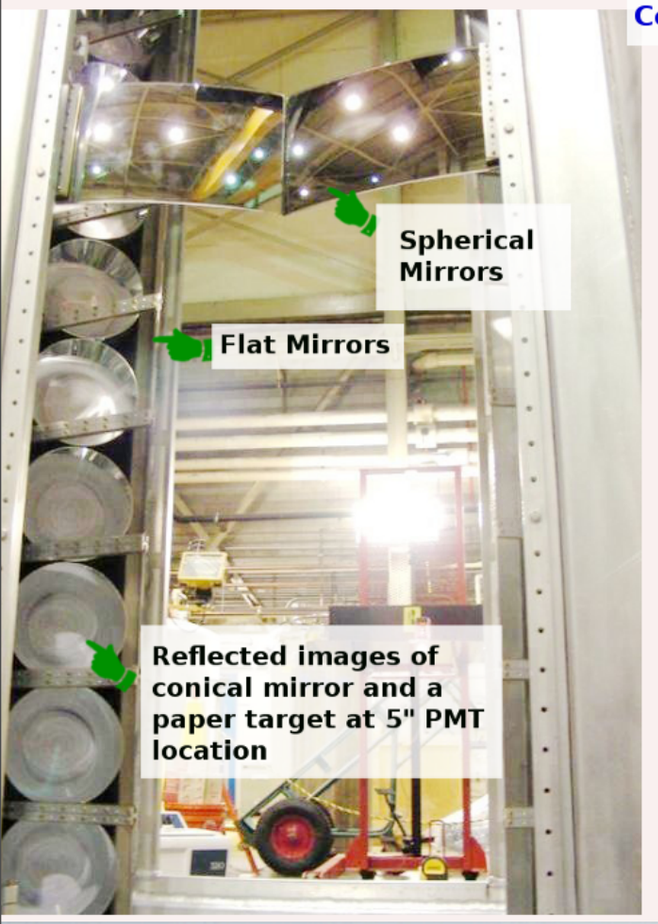
scaled

- Histograms to left are normalized to energy range 400-2000 MeV
- Pion peak E = 100MeV greatly suppressed by T2 trigger

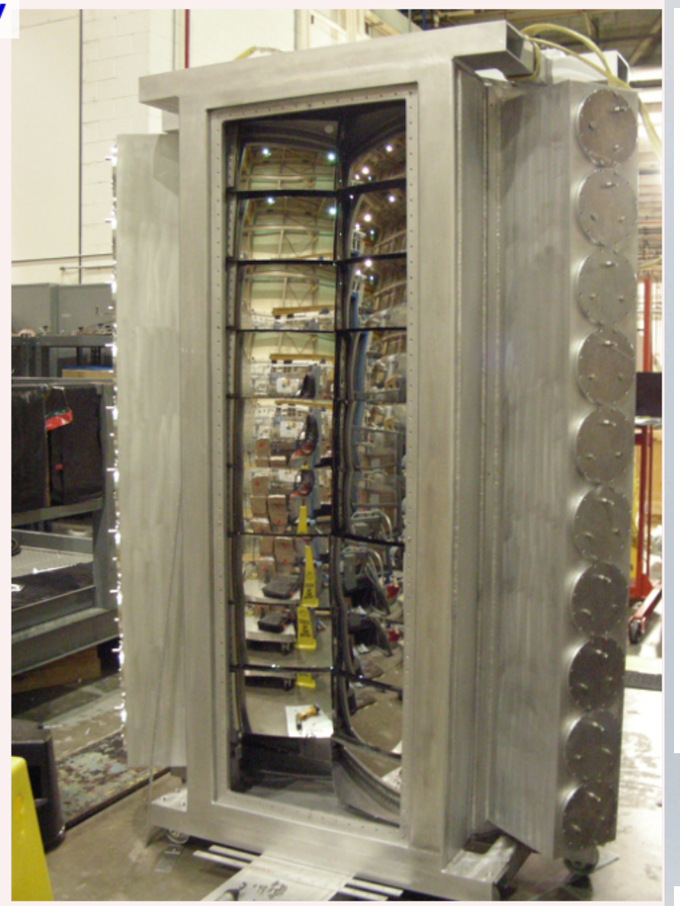


not scaled

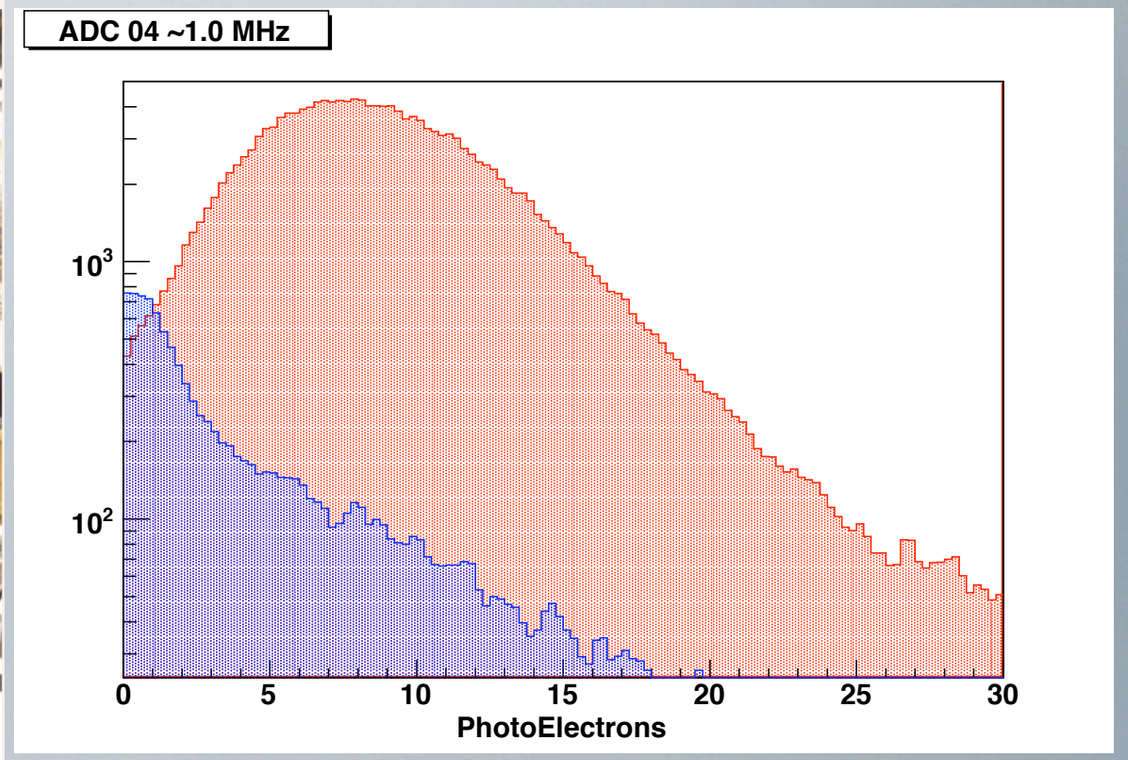
BigBite Cherenkov



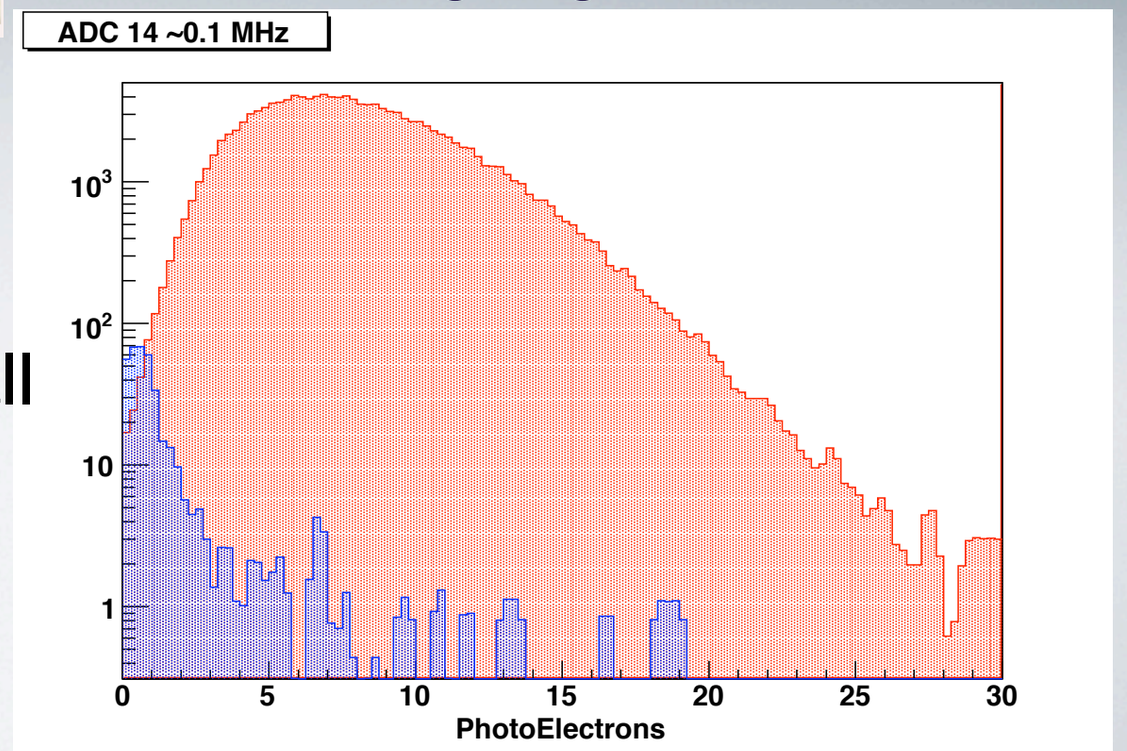
Cerenkov



small angle side

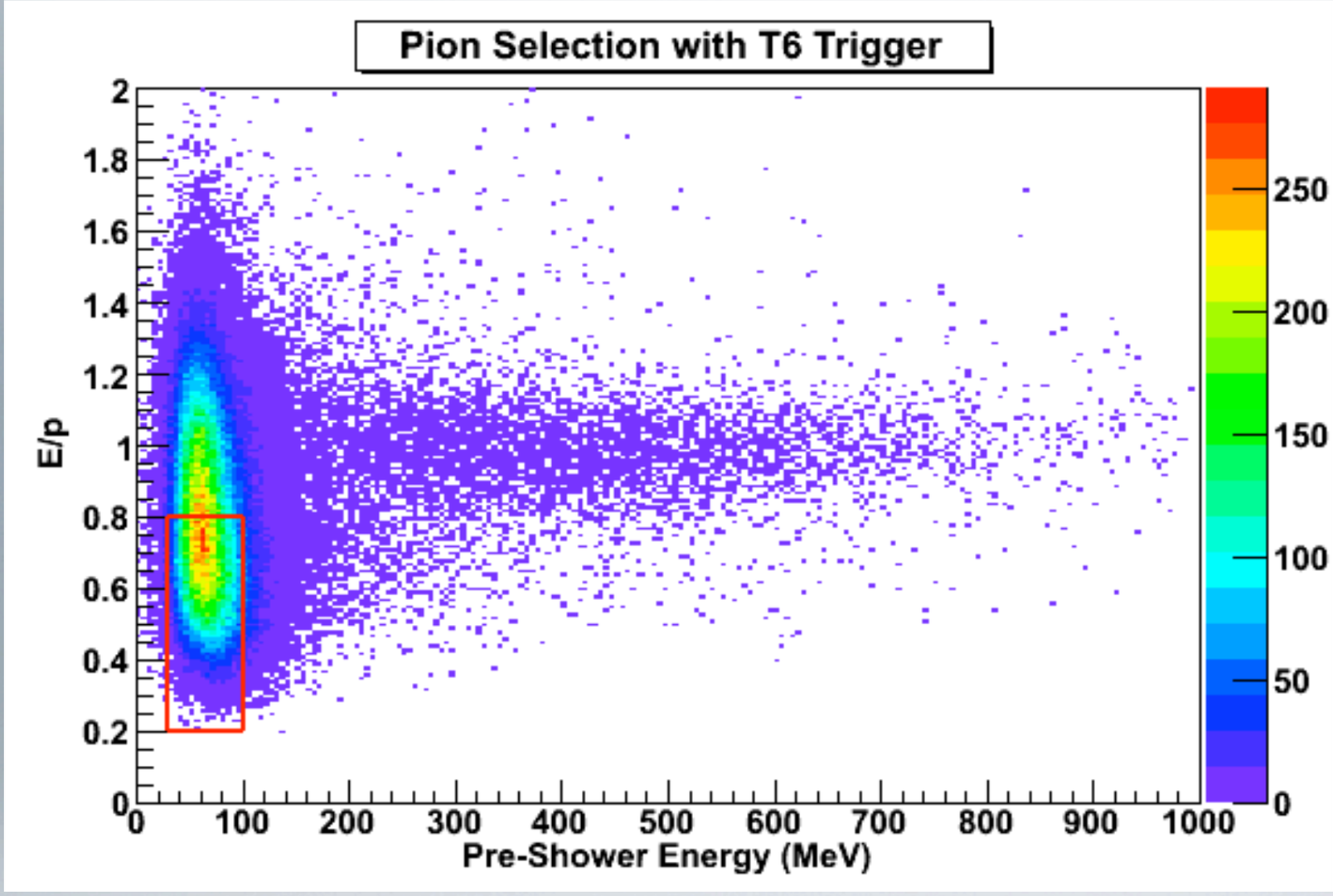


large angle side



- Rate ~10 times larger on small angle side
- Resulted in larger background on small angle side

BigBite Cherenkov: Pion Rejection

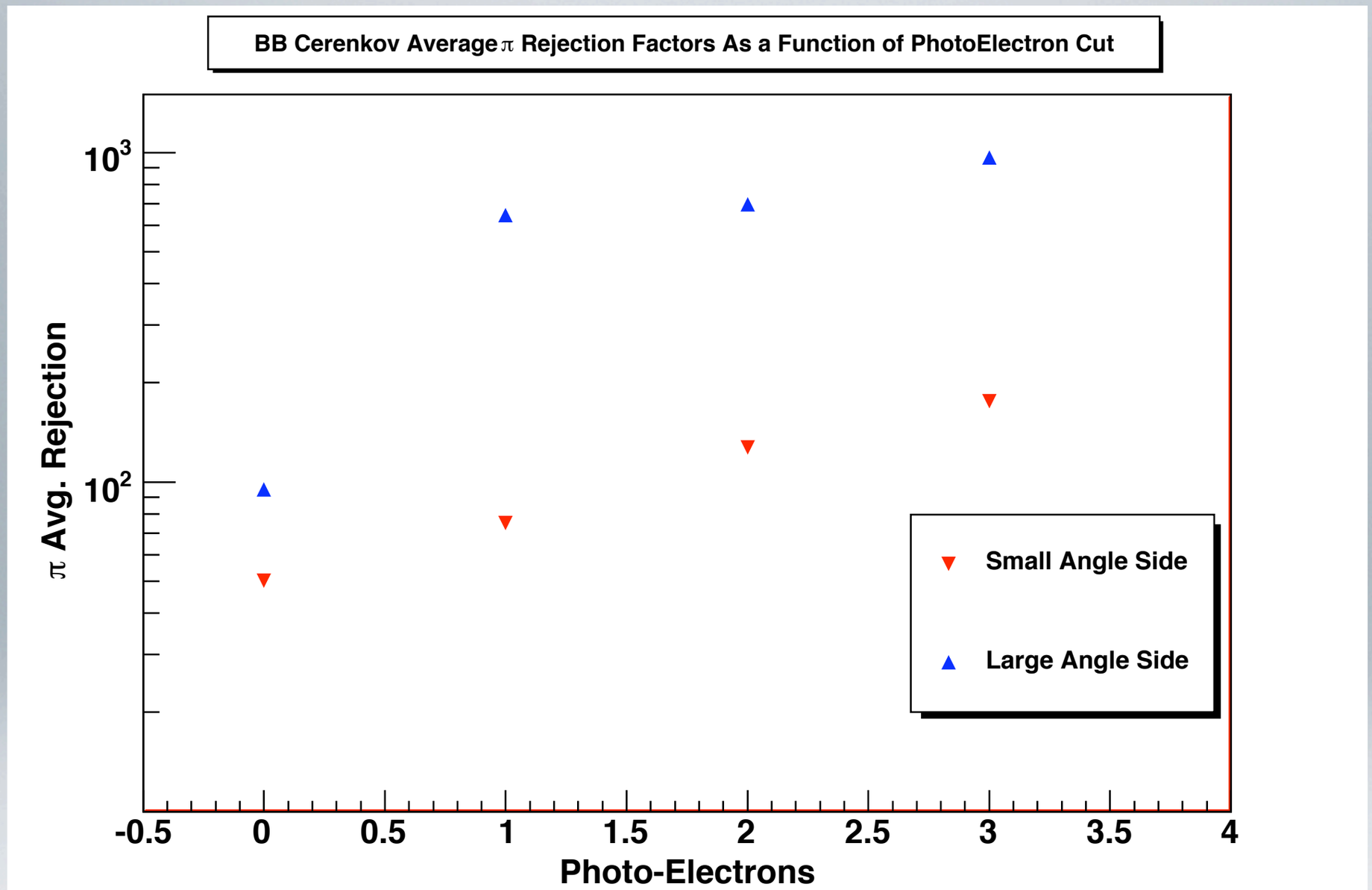


- $\epsilon_\pi = \dfrac{N_\pi}{N_{cer}}$

- N_{cer} = Number of pions left after Cherenkov cut

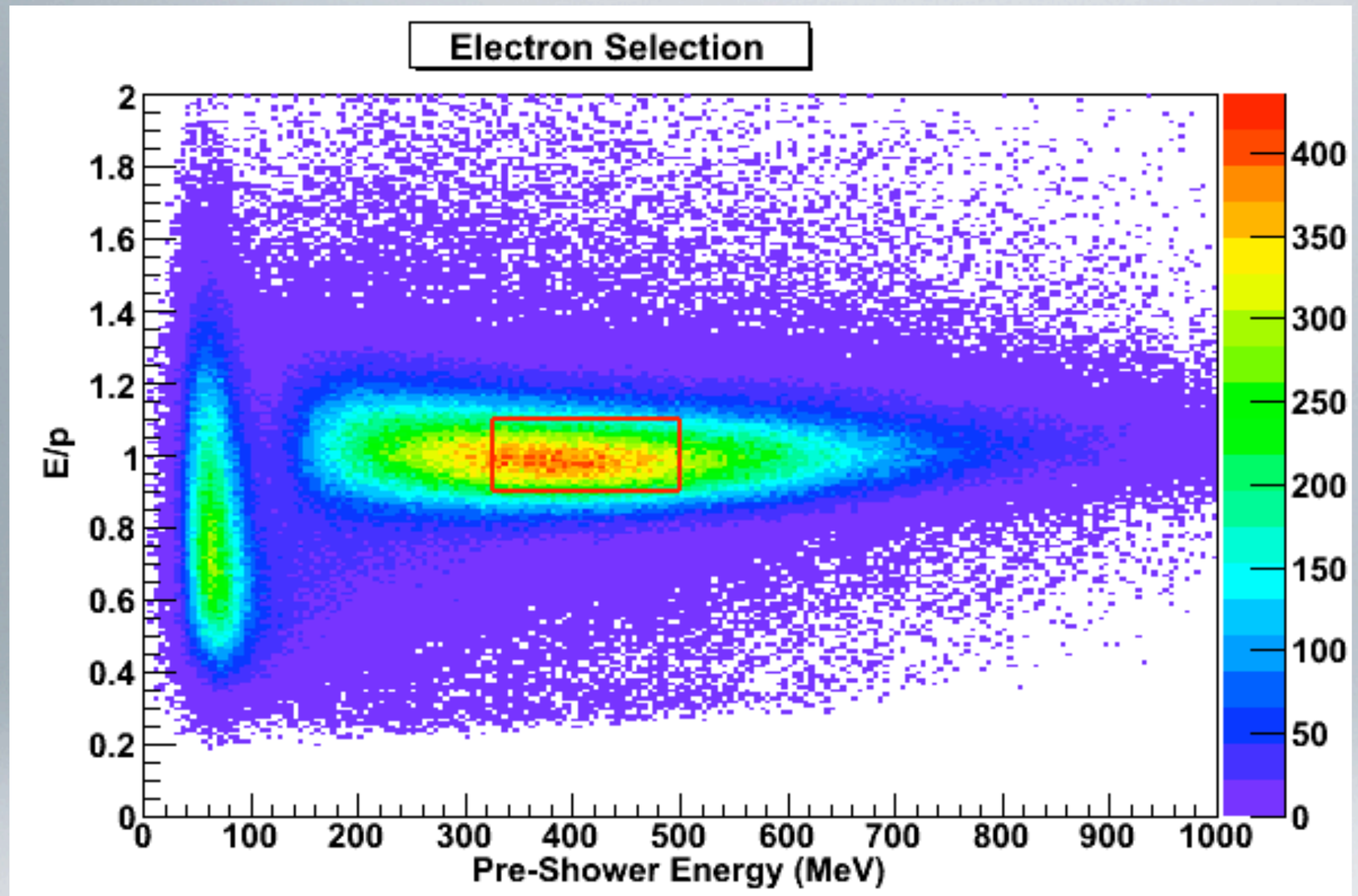
- N_π = Number of events in pion sample

BigBite Cherenkov: Pion Rejection



- Small angle side pion rejection factor at 3 photo-electron cut ~200
- Large angle side pion rejection factor at 3 photo-electron cut ~900

BigBite Cherenkov: Electron Efficiency

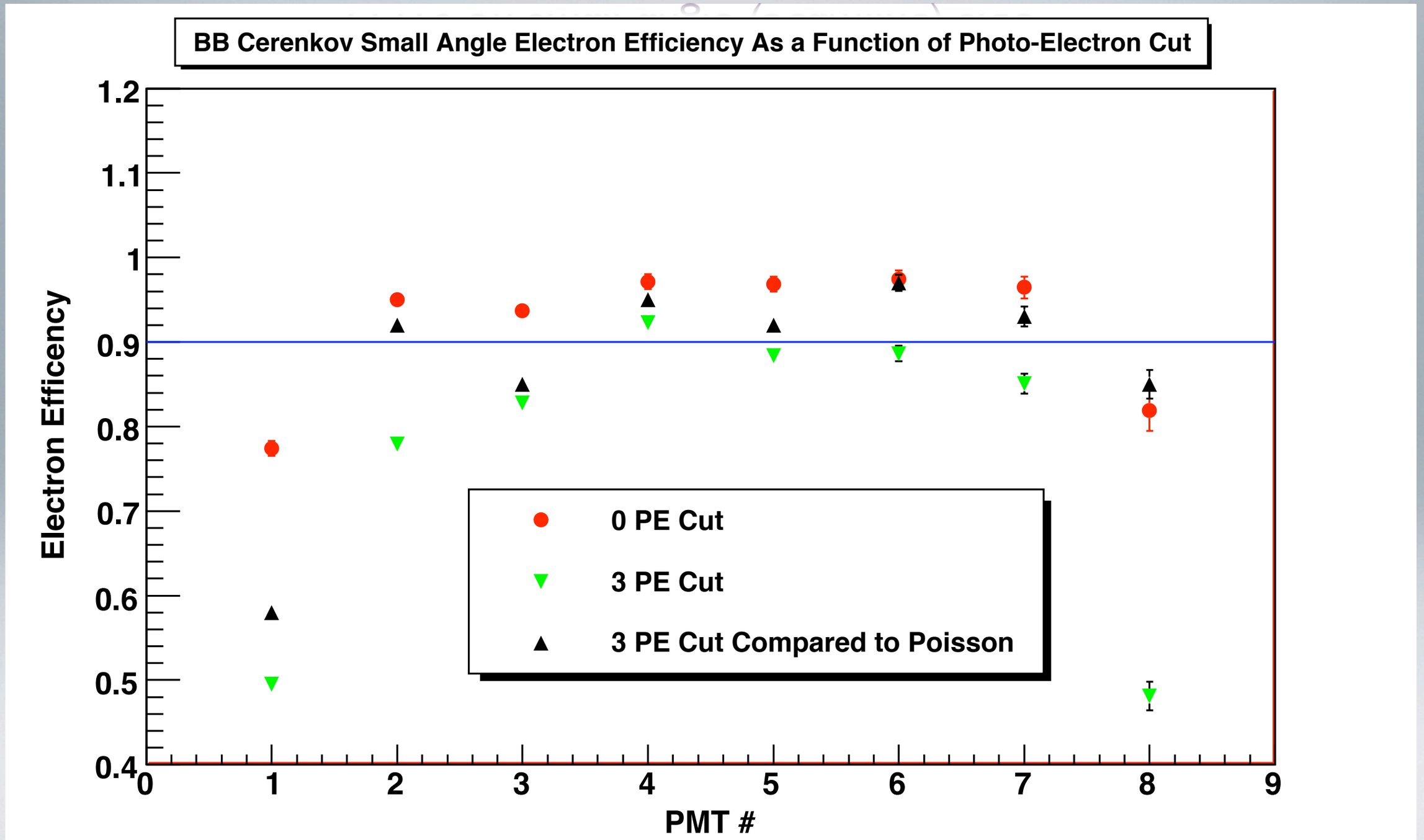


- $\epsilon_e = \dfrac{N_{cer}}{N_e}$

- N_e = number of events in electron sample
- N_{cer} = number of events in electron sample after Cherenkov cut

BigBite Cherenkov: Electron Efficiency

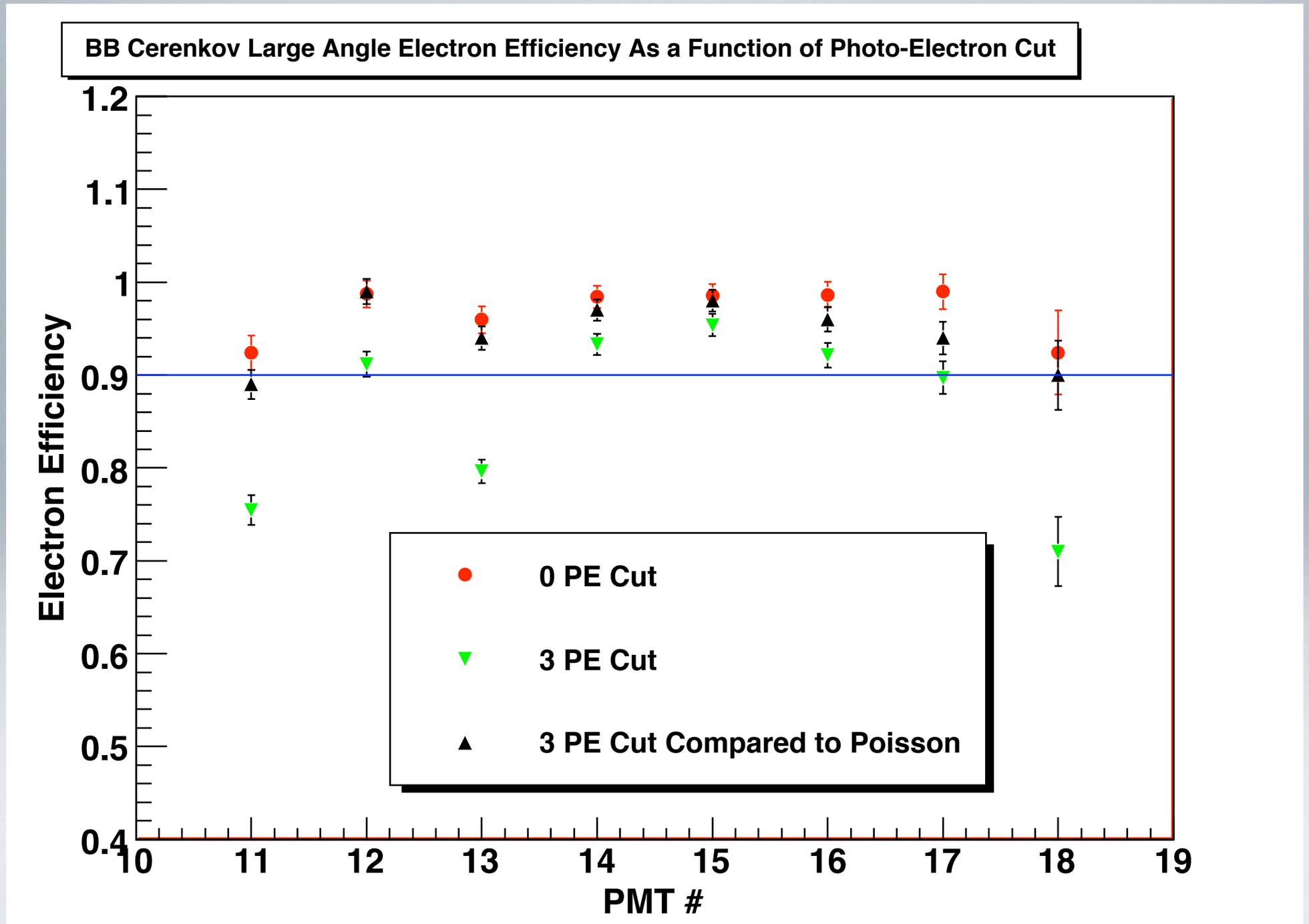
PMTs on small-angle (beamline) side



- Small angle average electron detection efficiency >85%

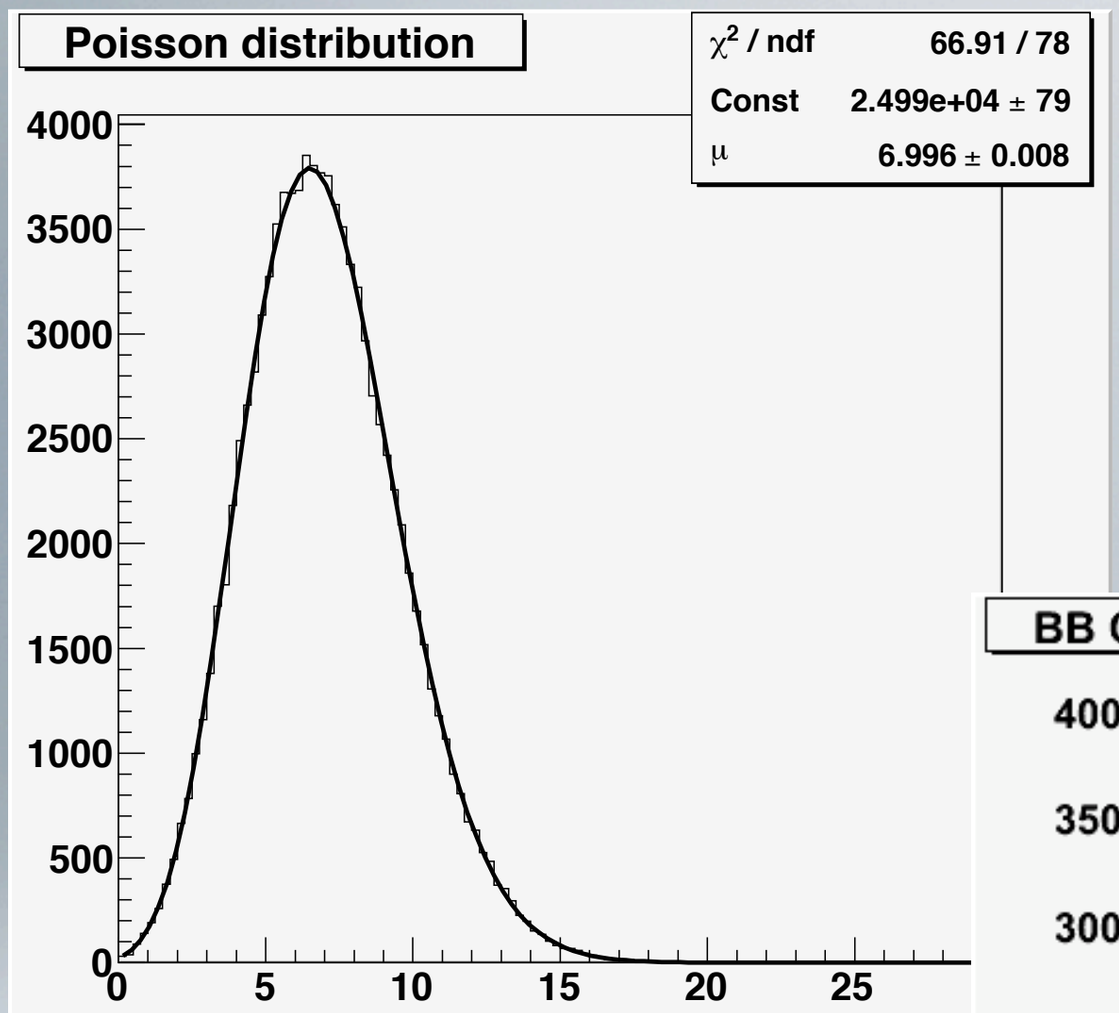
BigBite Cherenkov: Electron Efficiency

PMTs on the large-angle (RHRS) side



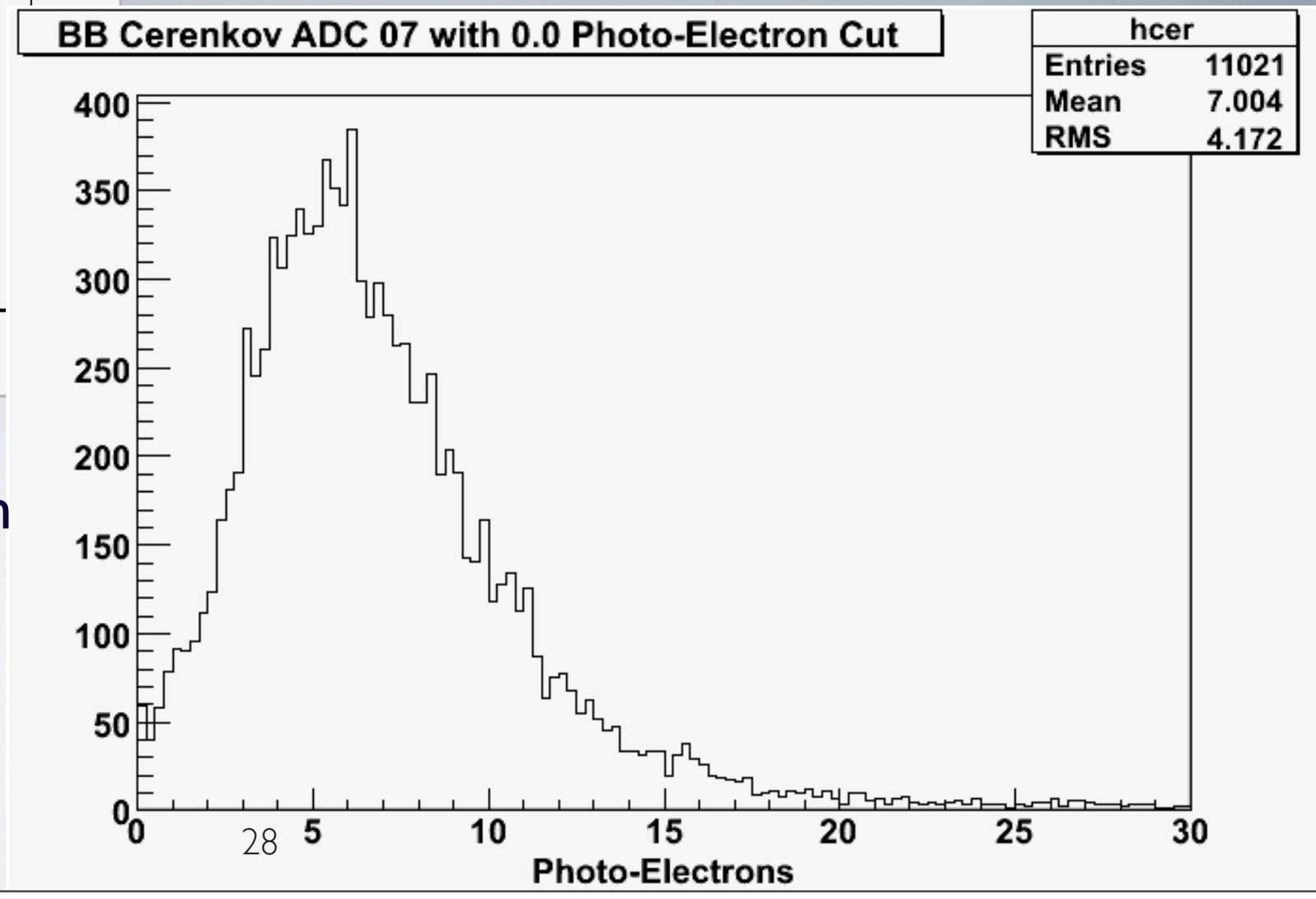
- Large angle average electron detection efficiency >90%

BigBite Cherenkov: Electron Efficiency

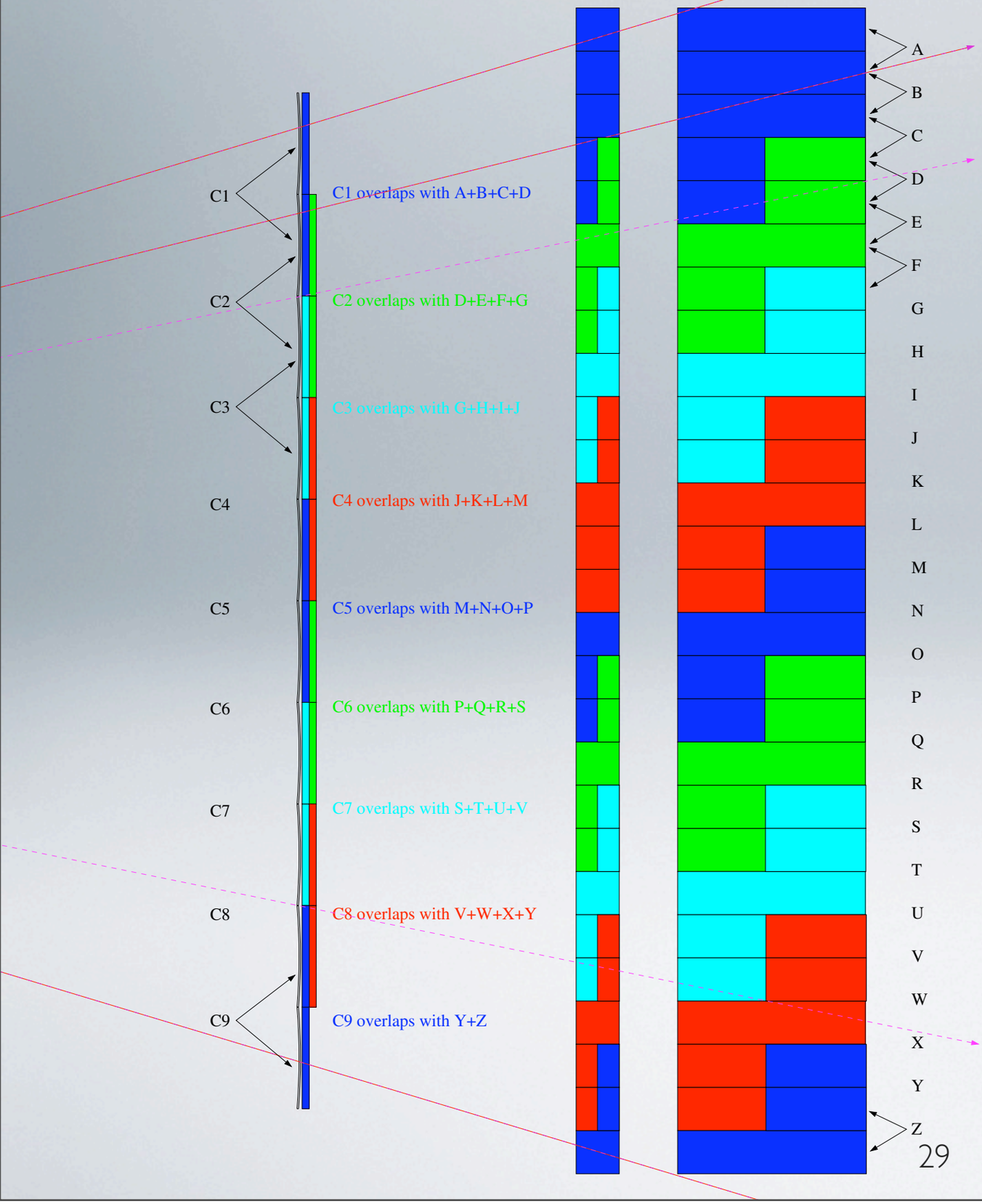


- Plot electrons in Cerenkov
- Find the mean photo-electrons
- Compare to Predicted distribution with same mean

- Predicted 3 photo-electron cut probability ~91%
- Empirical 3 photo-electron cut efficiency ~85%



T2 Trigger



Sh/PSh Sum#	Short patch cable	Long patch cable
26	N4–24L	20
25	N2–24L	24
24	N3–21L	52
23	N6–36L	–
22	N3–22L	6
21	N4–21L	17
20	N4–23L	–
19	N1–21L	S6–1NAU
18	N1–22L	23
17	N3–24L	–
16	N2–21L	2
15	N2–22L	14
14	N1–24L	–
13	N4–22L	51
12	N2–23L	11
11	N3–23L	–
10	N7–32L	1
9	N5–32L	9
8	N1–23L	–
7	N6–33L	53
6	N6–31L	5
5	N5–36L	–
4	N7–33L	3
3	N6–32L	21
2	N6–35L	–
1	N5–31L	50

29