

Testing the Limits of the Single Particle Model in $^{16}\text{O}(e,e'p)$

Status of E00102

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Old Dominion University

Hall A Collaboration Meeting
December 14, 2007

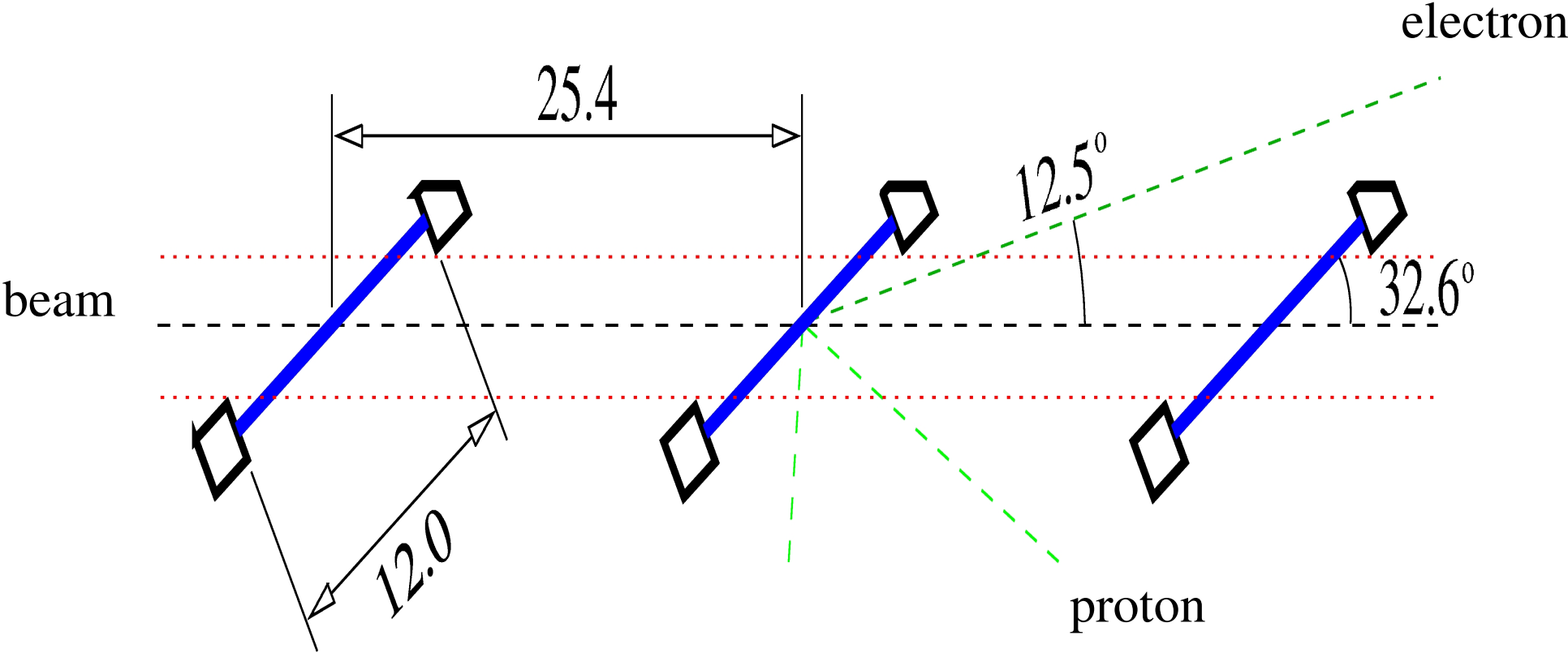
People Involved

- Spokespersons: L.Weinstein (ODU),
K.Fissum (Lund),
A.Saha (Jlab),
W.Bertozzi (MIT)
- Graduate Students: M.Andersson (Lund),
K.Foe (ODU),
J.Lopez (Madrid)
- Theory J.Udias (Madrid)
- Postdoc: J.Lachniet (ODU)

Goals of E00102

- Measurement of cross-section, R_{lt} and A_{lt} for the $^{16}\text{O}(e,e'p)$ reaction with higher precision and to higher missing momentum than in E89003.
- Determine the limits of validity of the single-particle model of valence proton knock-out.
- Determine effects of relativity and spinor distortion on valence proton knock-out using the diffractive character of the A_{lt} asymmetry.
- Determine bound-state wave function and spectroscopic factors for valence proton knockout.

E00102 Waterfall Target



E00102 Kinematic Settings

- $E_0 = 4.620 \text{ GeV}$
- $Q^2 = 0.902 \text{ (GeV/c)}^2$ {Electron angle fixed at 12.5° }
- $|\vec{q}| = 1.073 \text{ GeV/c}$
- $\omega = 0.499 \text{ GeV}$
- $E_{\text{miss}} = 0 \text{ to } 0.240 \text{ GeV}$ {Proton angle varied between 28.27° and 96.10° }
- $P_{\text{miss}} = -0.515 \text{ to } 0.755 \text{ GeV/c}$ {E89003 covered P_{miss} up to 0.345 GeV/c }

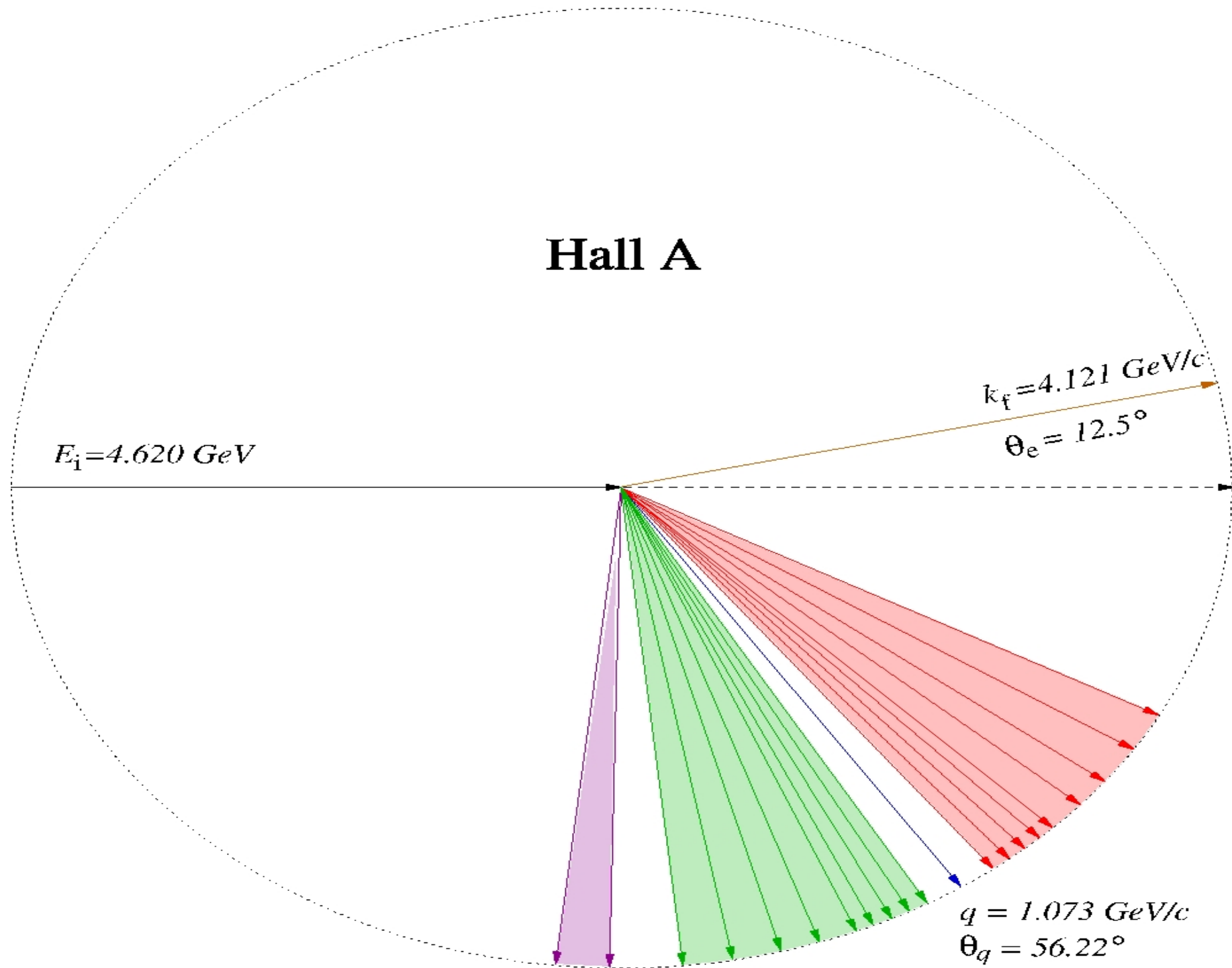
Hall A

$E_i = 4.620 \text{ GeV}$

$k_f = 4.121 \text{ GeV}/c$

$\theta_e = 12.5^\circ$

$q = 1.073 \text{ GeV}/c$
 $\theta_q = 56.22^\circ$

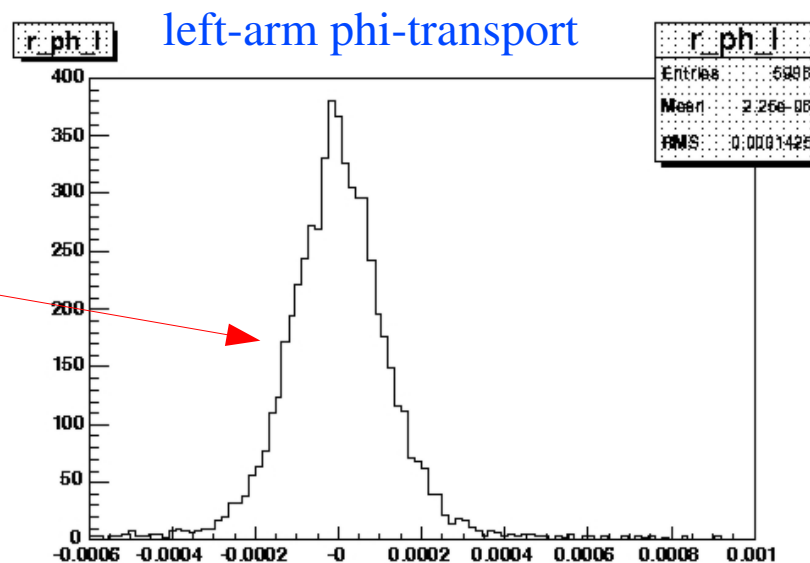
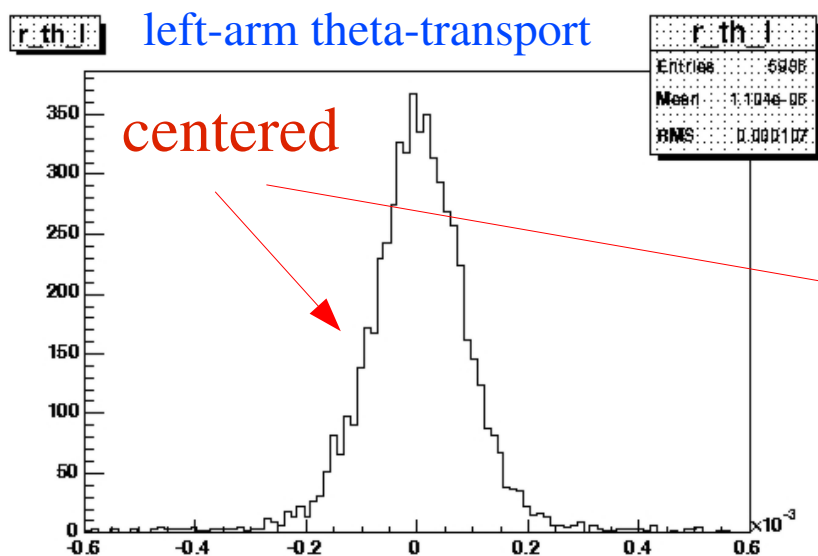
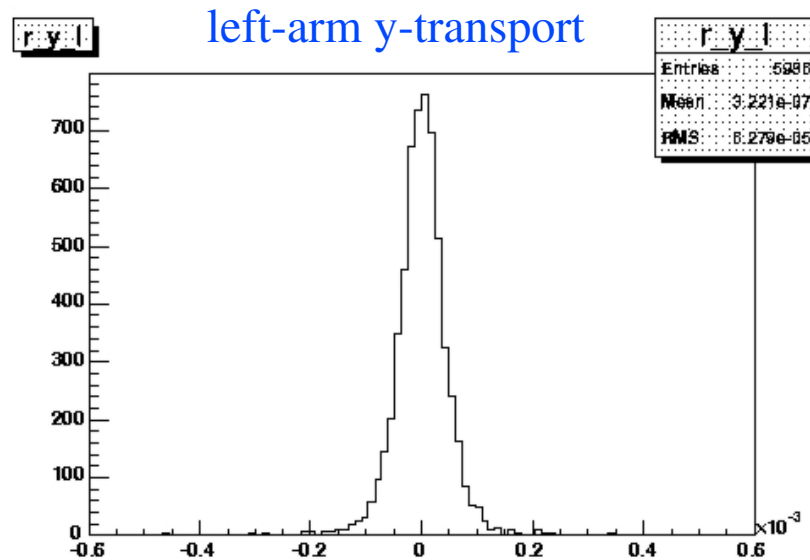
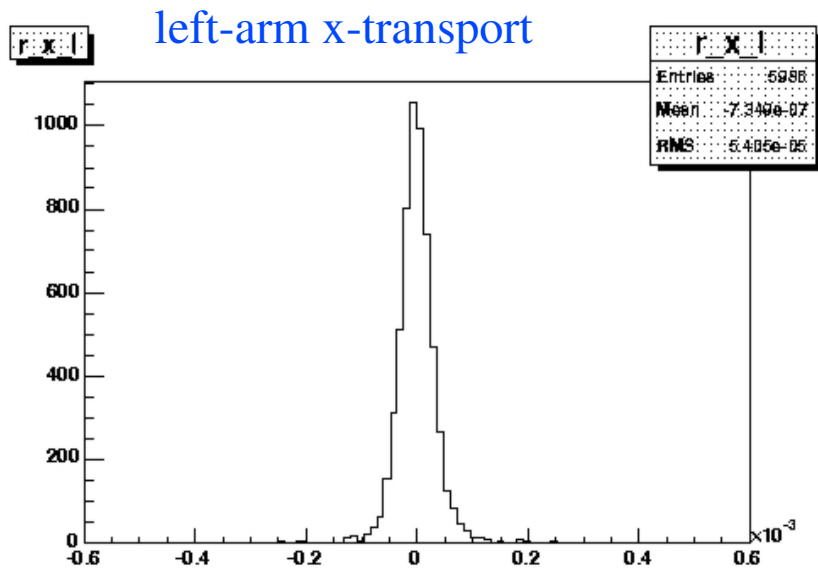


Tasks Completed

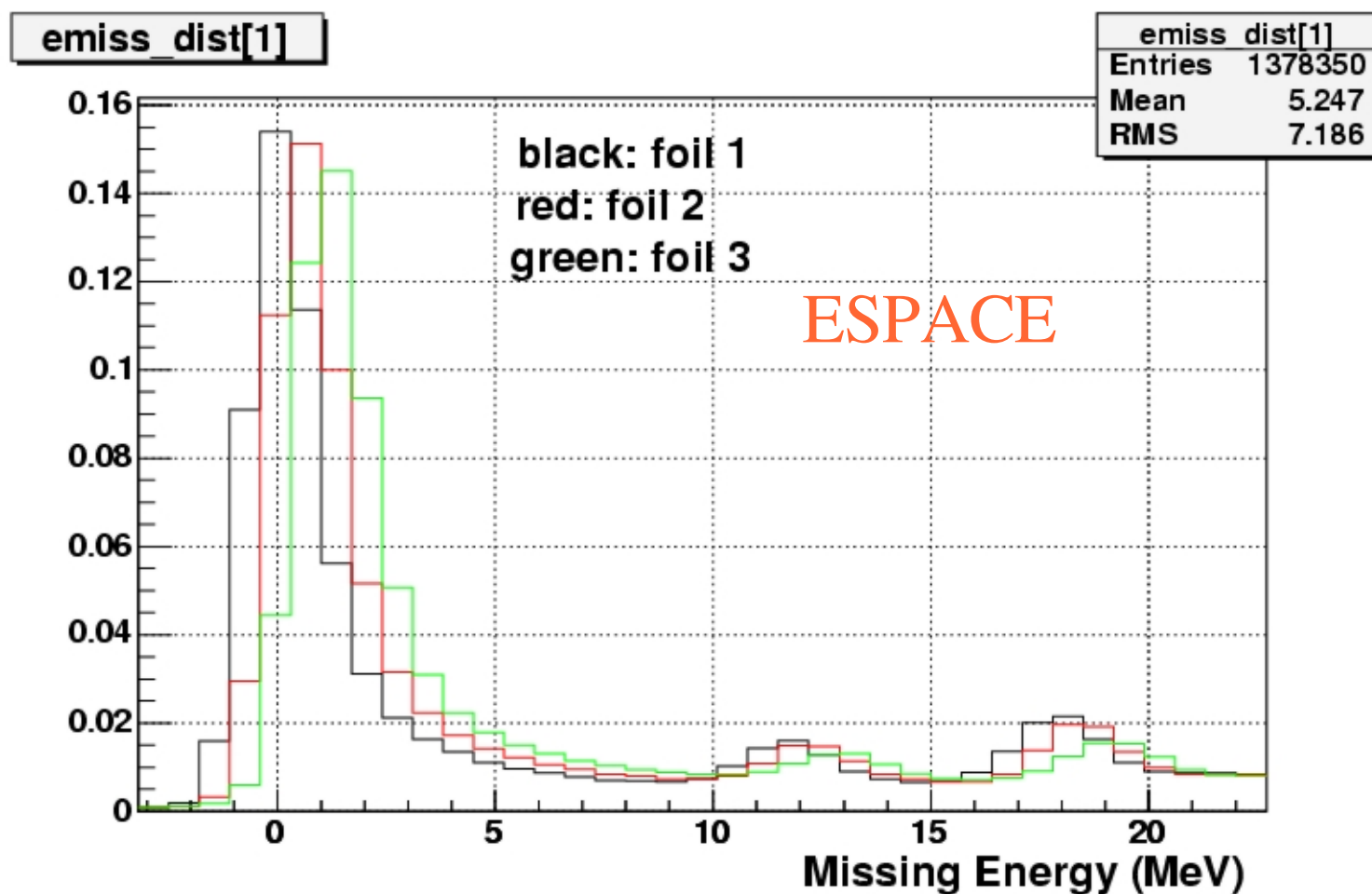
- Beam position/Beam energy calibrations.
- Optics calibration and spectrometer mispointing.
- First pass replay using ESPACE.
- Water-foil thickness measurement from $^{16}\text{O}(e,e'p)$ to BeO (e,e'p) yield comparison.
- Converted end-of-run-file information to MySQL database
- Determination of $1p_{1/2}$ cross section relative to H(e,e')
- Conversion from ESPACE to analyzer
- Waterfall target model added to analyzer
- R-function calculation added to analyzer
- Coincidence timing added to analyzer, and CT calibration
- Luminosity/deadtime monitoring with elastic scattering
- ◆ Udias/Madrid model incorporated into MCEEP

Optics problems with ESPACE to analyzer conversion have been fixed

analyzer – ESPACE difference, transport coordinates (left-arm)

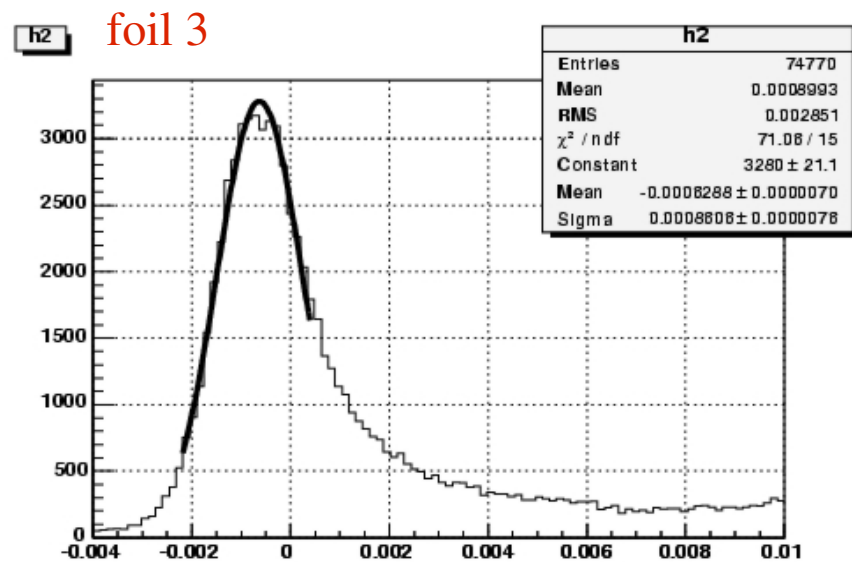
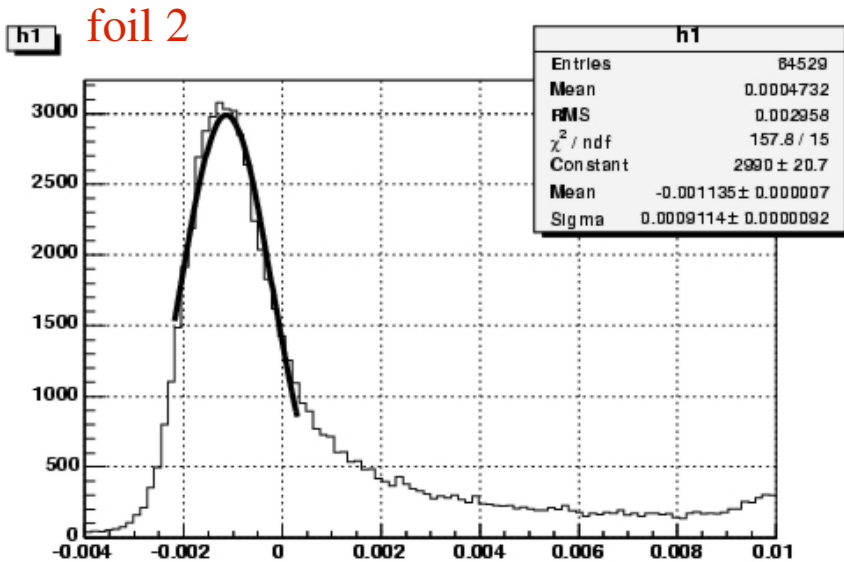
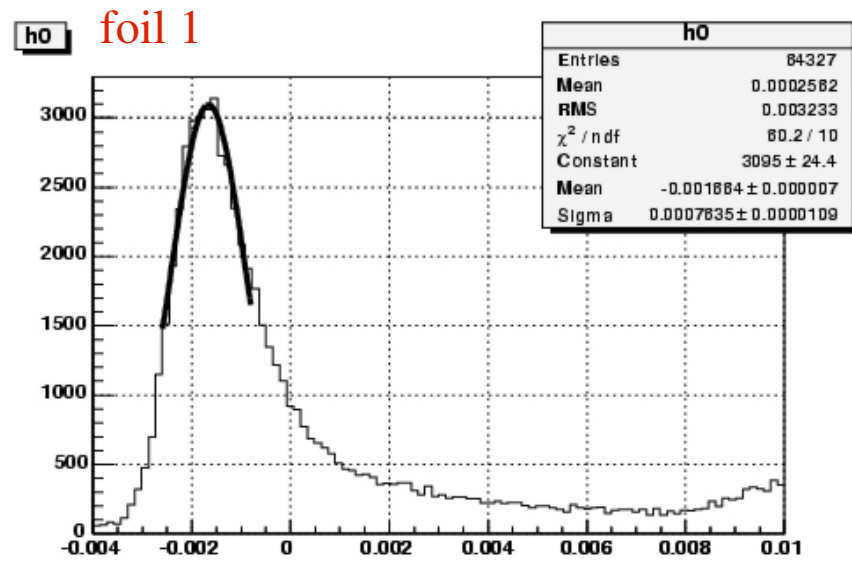
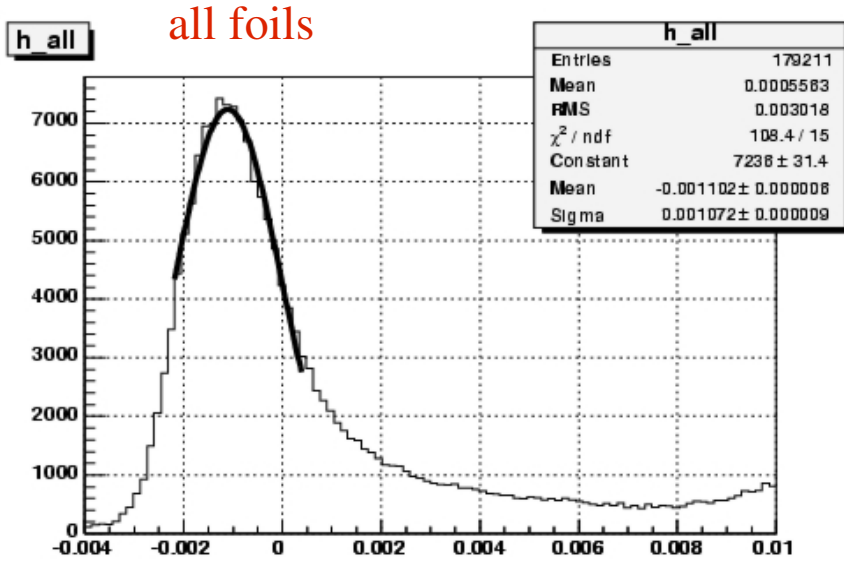


The ESPACE results for the missing energy distribution were not satisfactory. Shown below are the missing energy distributions for the three target foils, taken from parallel kinematics data. Note that there is a separation in the elastic peak positions of ~ 1.1 MeV.



Analyzer output, BEFORE Eloss corrections

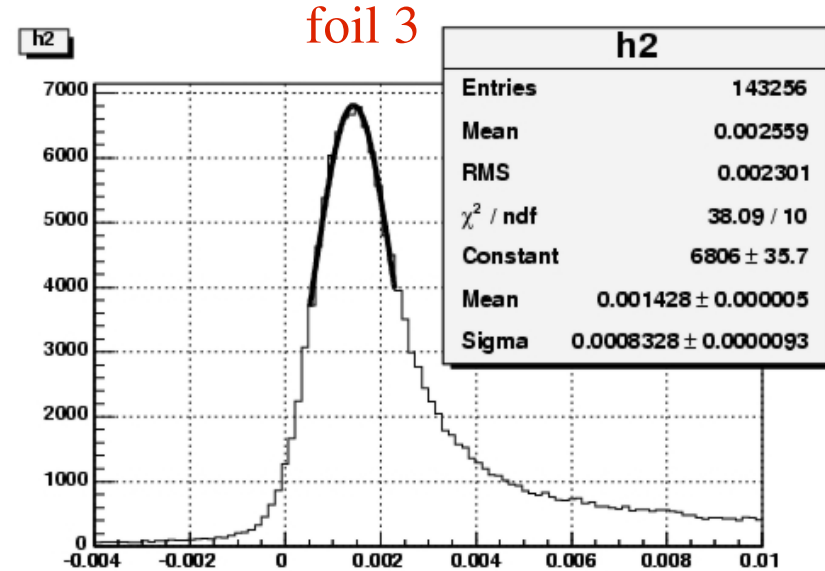
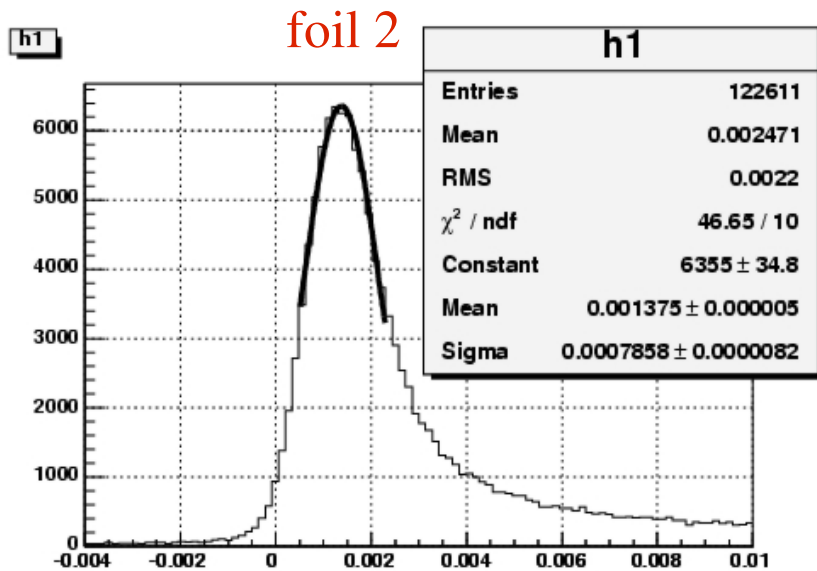
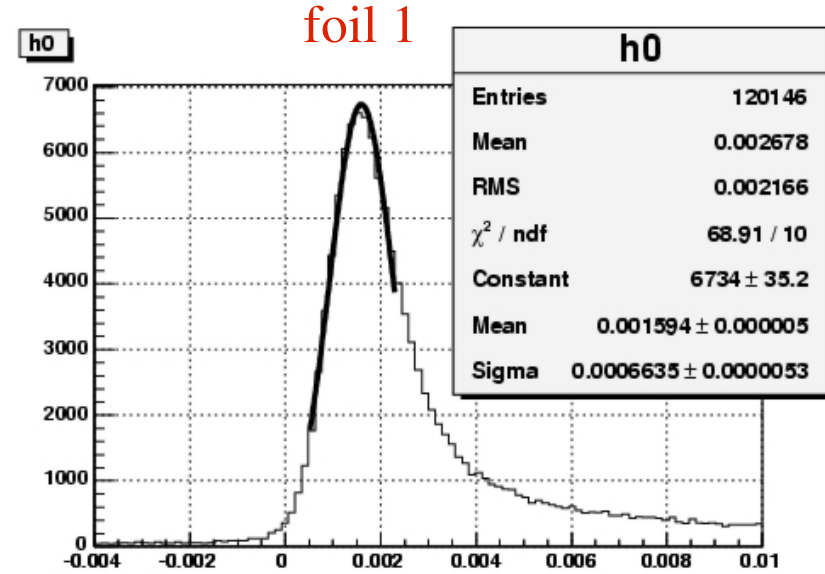
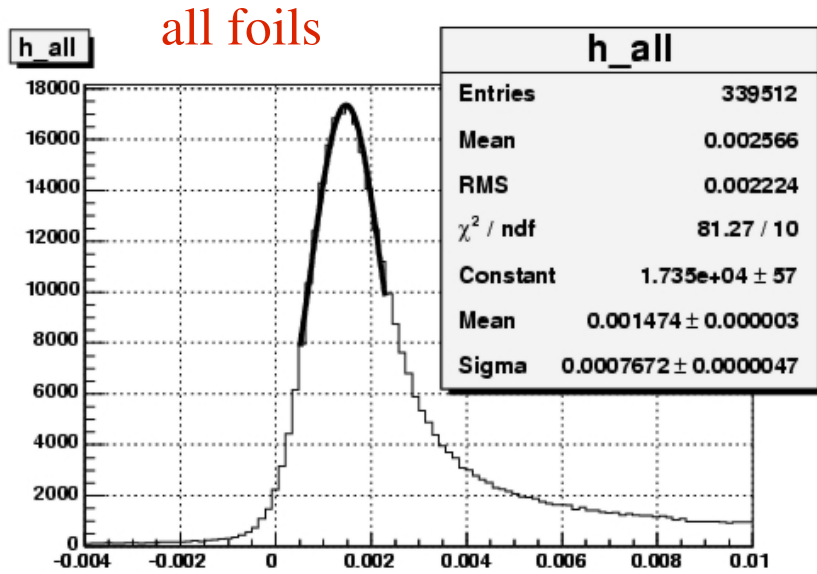
foil-by-foil fits to elastic peak position, run 2086



The foil-to-foil variation in elastic peak position is 1.04 MeV

Analyzer output, AFTER Eloss corrections

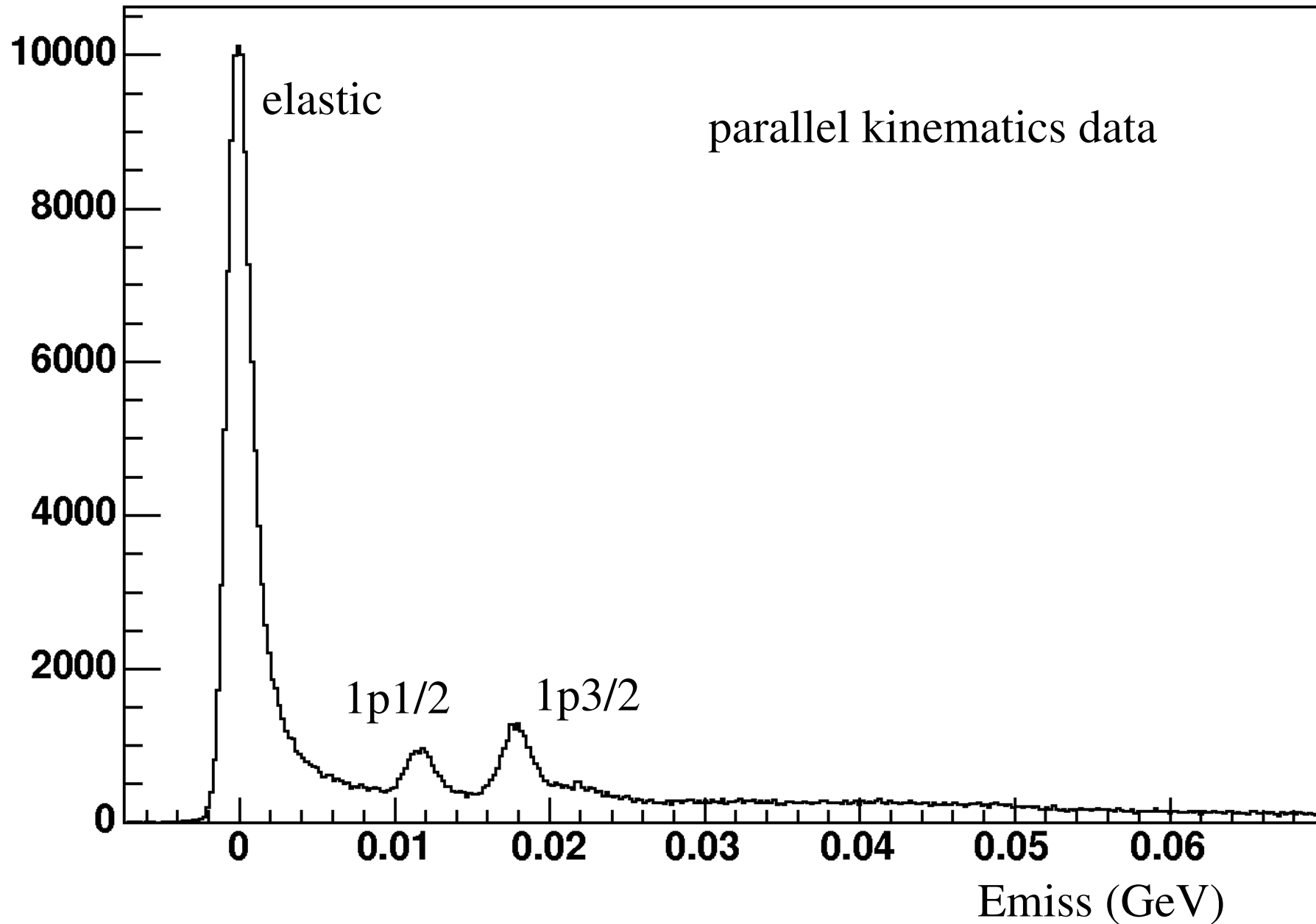
foil-by-foil fits to elastic peak position, run 2086



The foil-to-foil variation in elastic peak position is 0.219 MeV

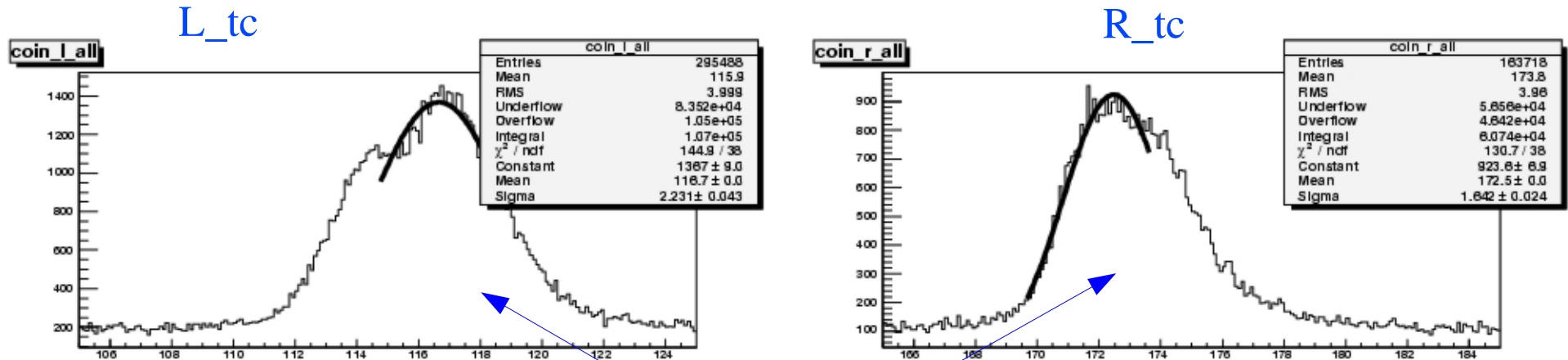
Kinematic adjustments:

Small corrections to Θ_{left} and E_0 to center Emiss and ΔE distributions

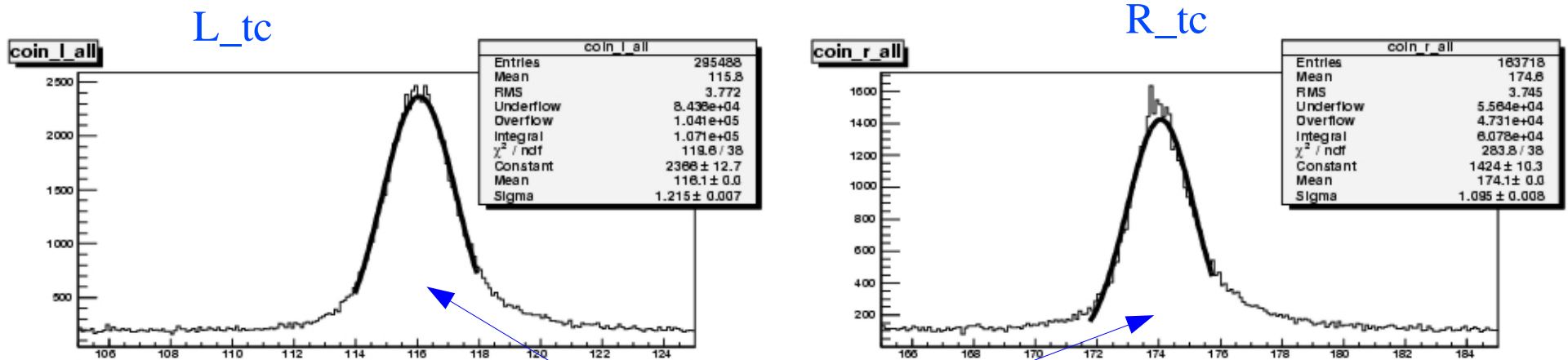


Coincidence timing with analyzer has been fixed

Data from run 1548 (BB- kinematics)



Before paddle timing offsets

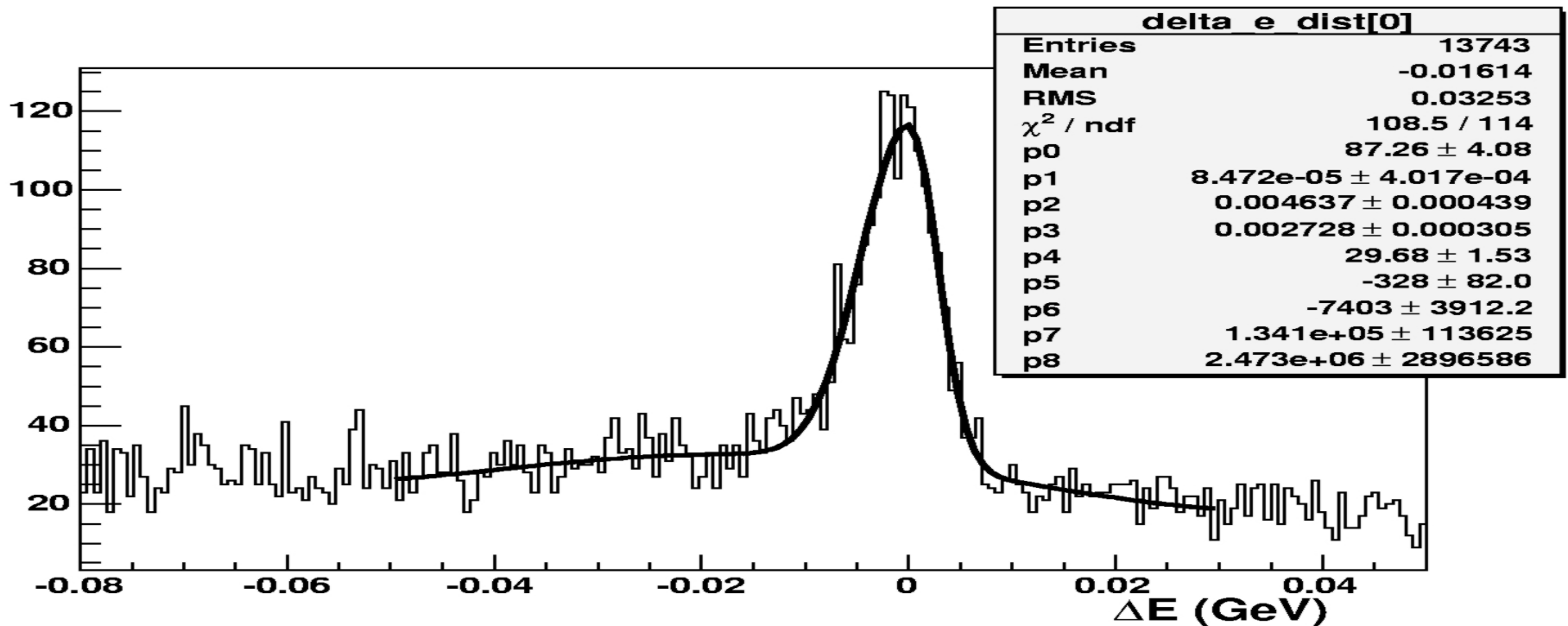


After paddle timing offsets

Luminosity monitoring:

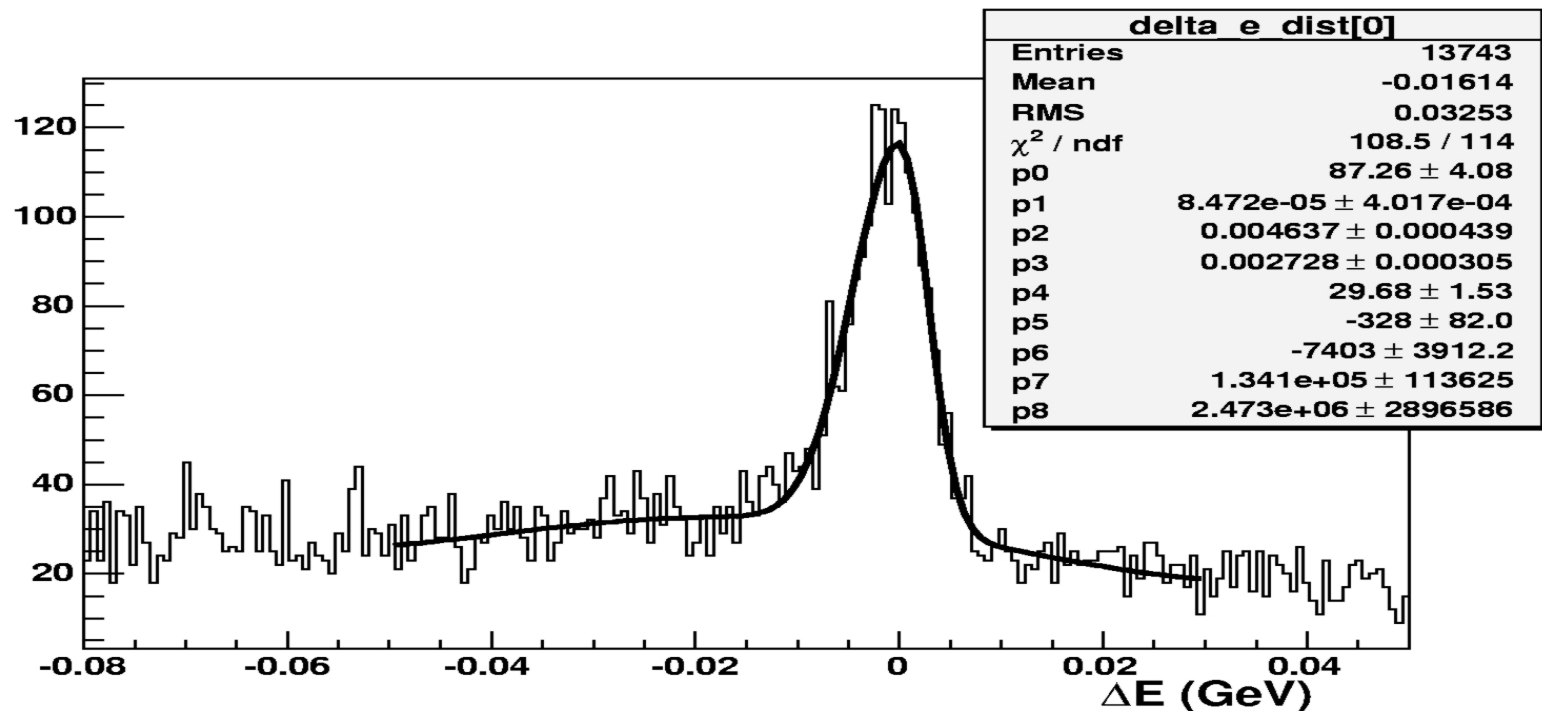
- Left arm fixed (same angle, same momentum) for all kinematics.
- Continuously monitors H(e,e'p) elastic scattering

$$\begin{aligned}\Delta E &= E' - E(\Theta) \\ &= E' - \frac{E_0}{1 + \frac{E_0}{M_P}(1 - \cos \Theta)}\end{aligned}$$



Luminosity monitoring:

- Left arm fixed (same angle, same momentum) for all kinematics.
- Continuously monitors H(e,e'p) elastic scattering
- Provides continuous measurement of target foil thicknesses and (left-arm) electronic deadtime.
- Provides convenient normalization for ^{16}O cross sections.



Integration of Udias RDWIA model with MCCEP

- The cross section of each simulated event can be expressed as a function of the variables $(E_{\text{miss}}, p_{\text{miss}}, q, \omega)$.
- If we consider only those cases where the ejected protons belong to a given shell, then only three variables are needed: $(p_{\text{miss}}, q, \omega)$.
- Using the RDWIA code of Udias et al, we can obtain the response functions $(R_L, R_T, R_{LT}, R_{TT})$ as a function of $(p_{\text{miss}}, q, \omega)$.
- The response functions are calculated on a three dimensional grid, interpolation of which is used to weight events in MCEEP.

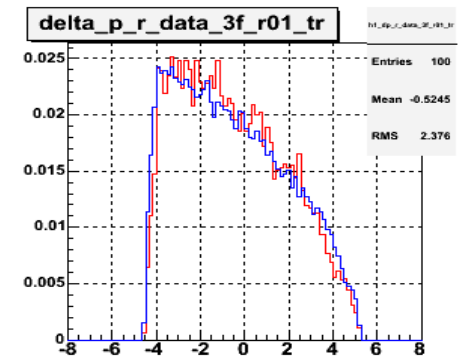
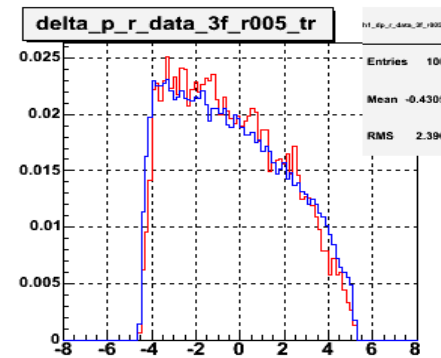
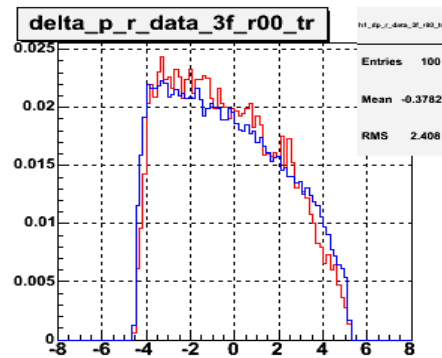
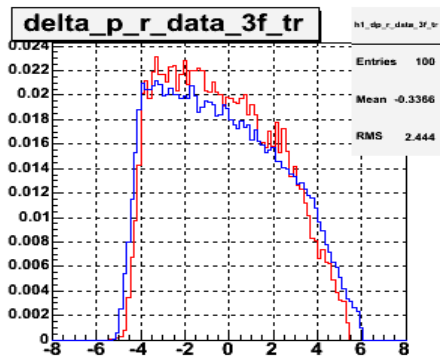
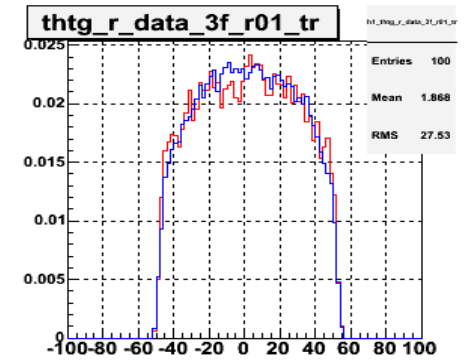
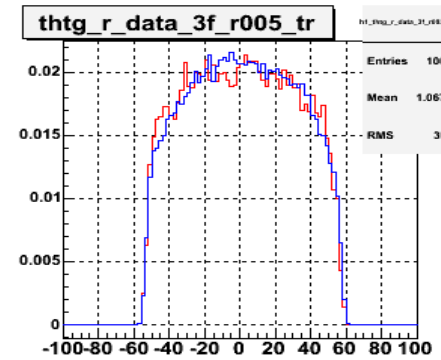
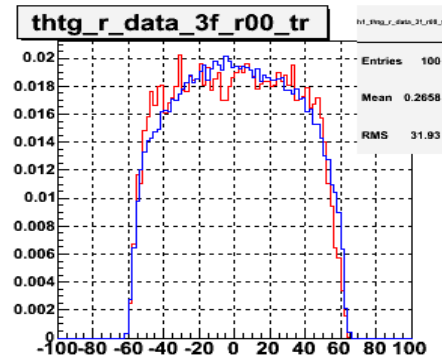
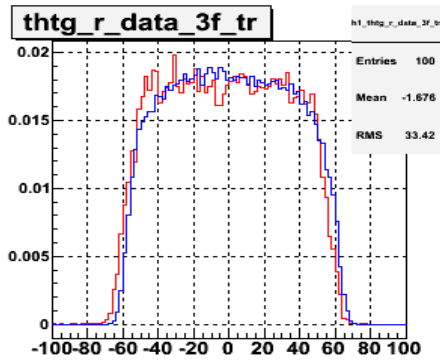
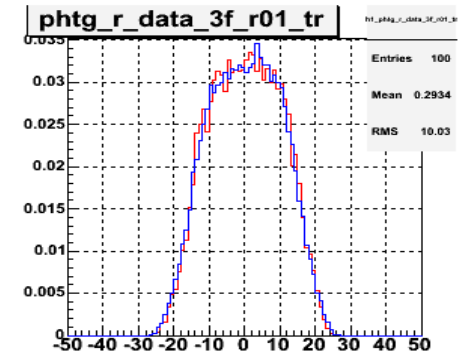
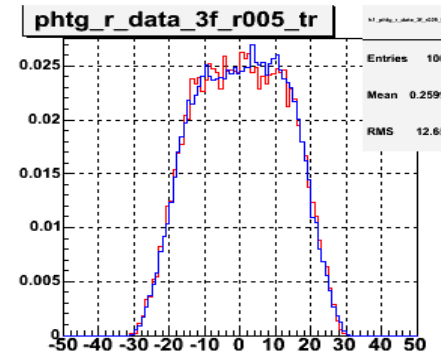
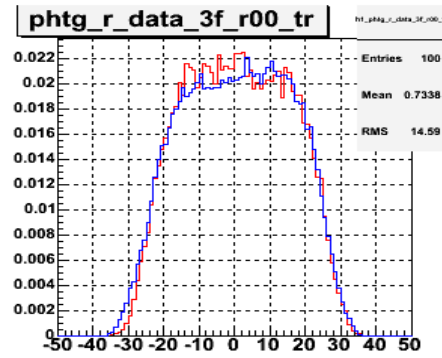
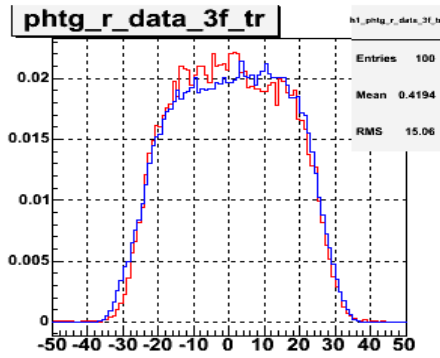
R-Arm Acceptance with 3-foils : Kin AA+

No cut

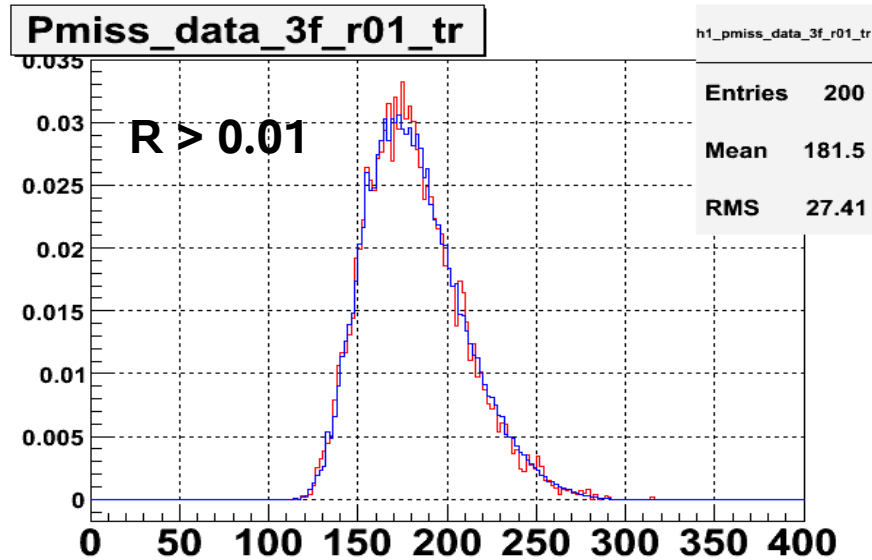
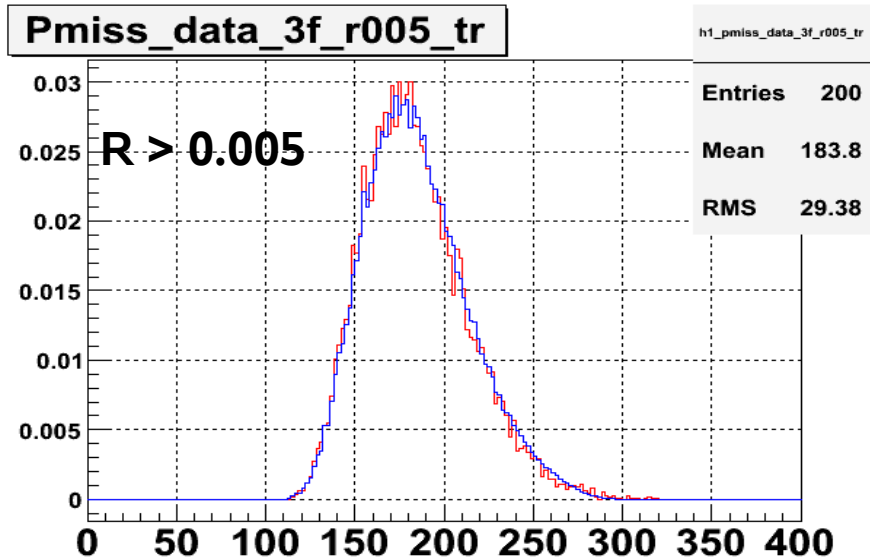
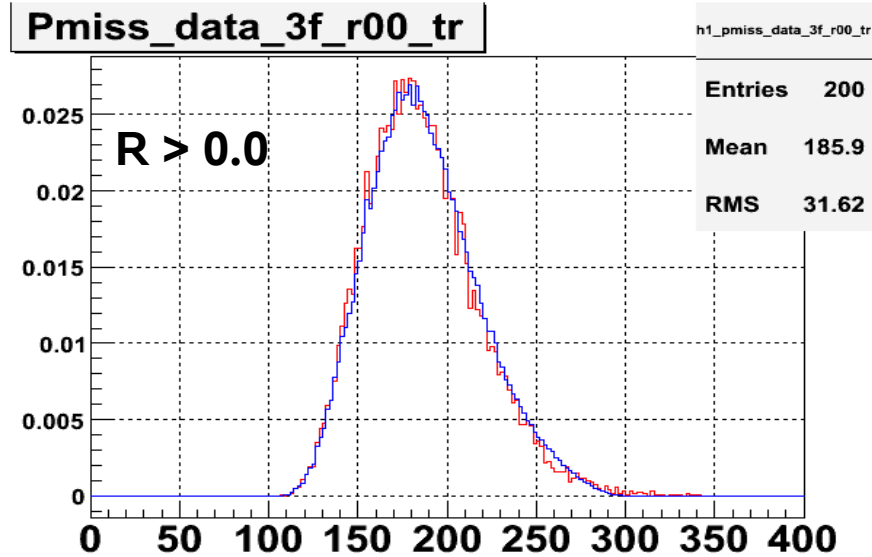
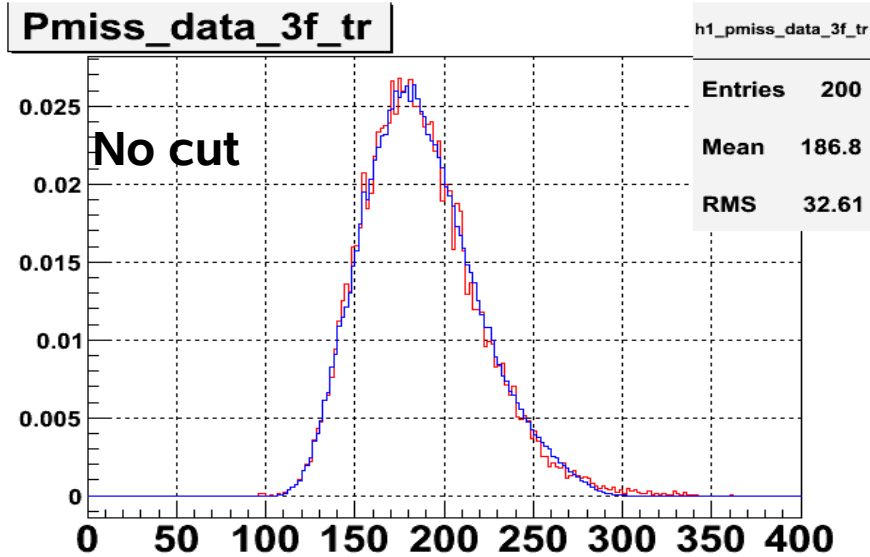
$R > 0.0$

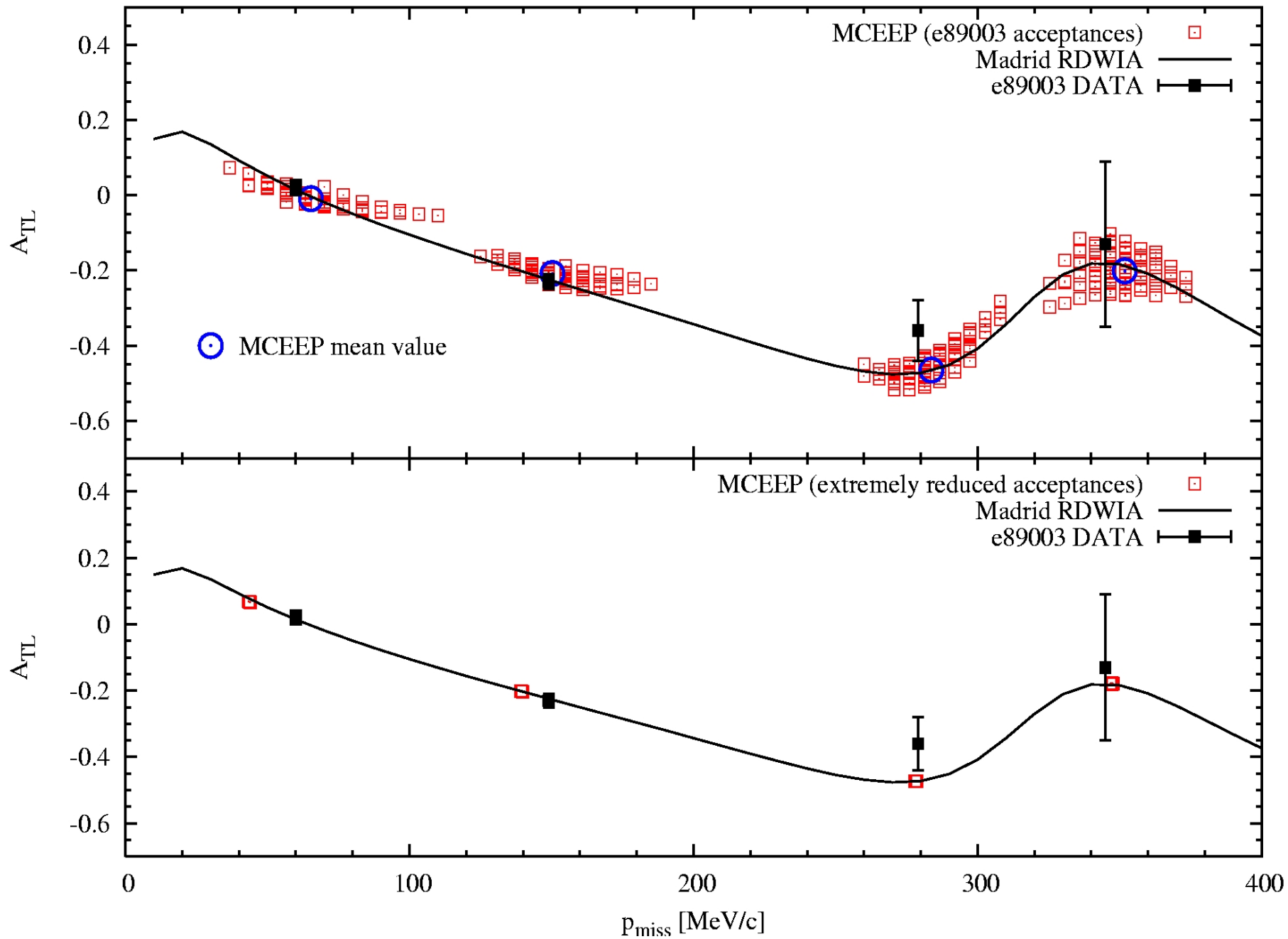
$R > 0.005$

$R > 0.01$



Missing Momentum : Kin DD+ (1497)





$1p_{1/2}$ relative cross section (M.Andersson)

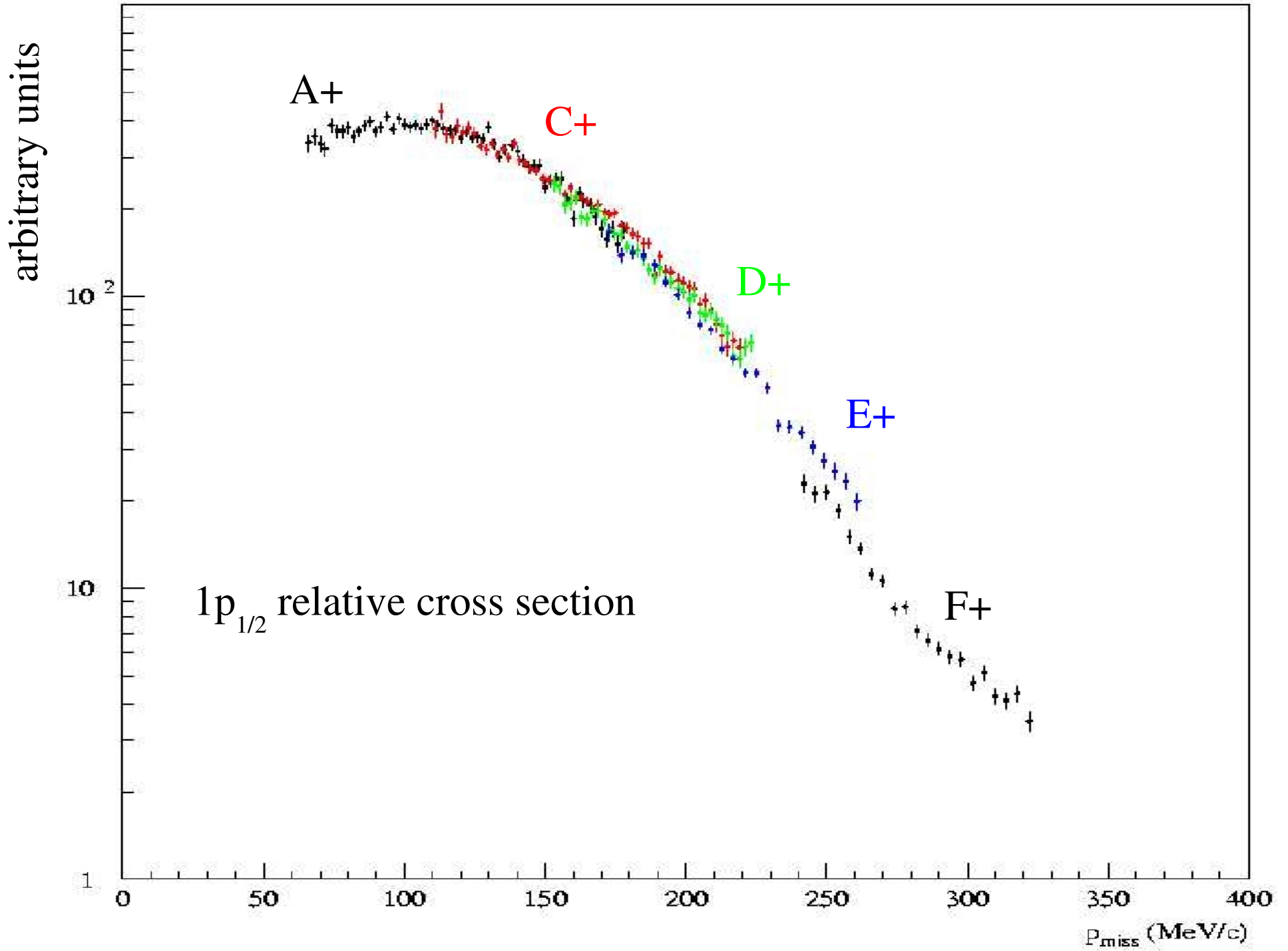
- Determination of $1p_{1/2}$ cross section relative to $H(e,e')$

- Uses data in the range:

$$0 < P_{\text{miss}} < 350 \text{ MeV}/c$$

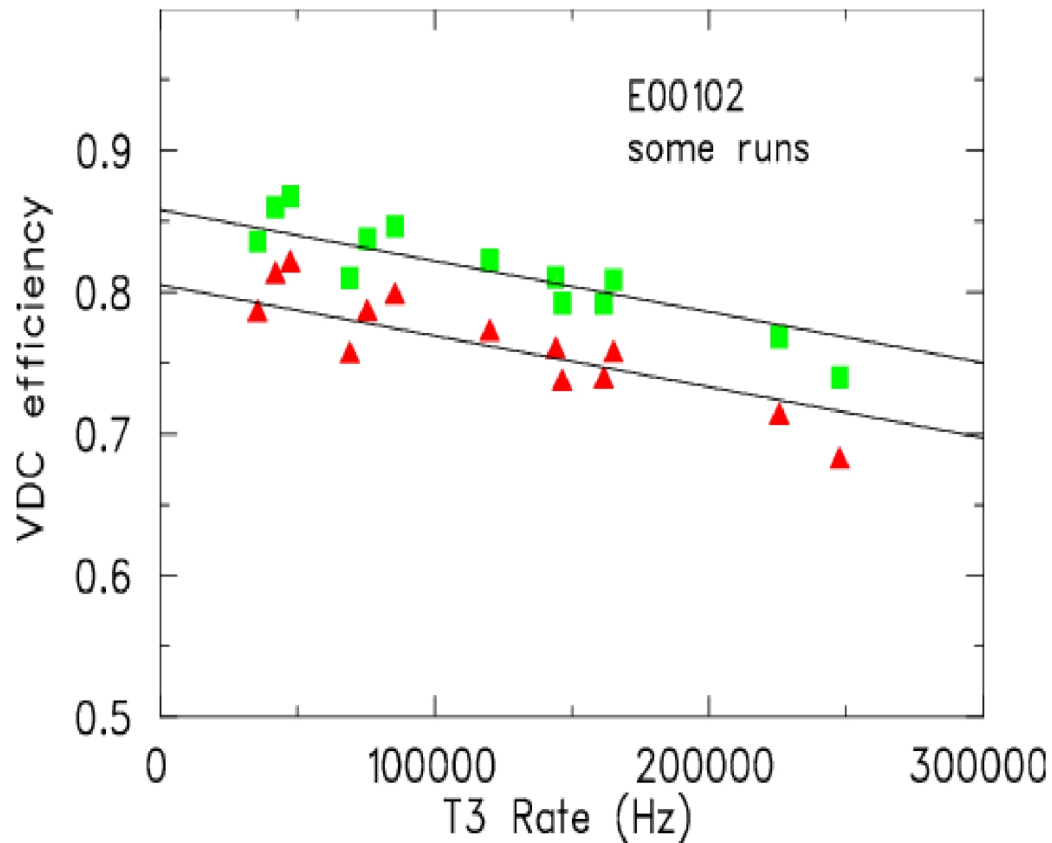
corresponding to kinematic settings A+,C+,D+,E+,F+

- P_{miss} bins are 2 MeV/c for A+ through D+, 4 MeV/c for E+,F+
- Only central foil was used.
- Acceptance cuts: ± 50 mr in θ and ϕ , $\pm 3.5\%$ in δp
- Statistical uncertainty is 7% or less. Systematic uncertainty estimated at $\approx 5\%$.



Work in progress

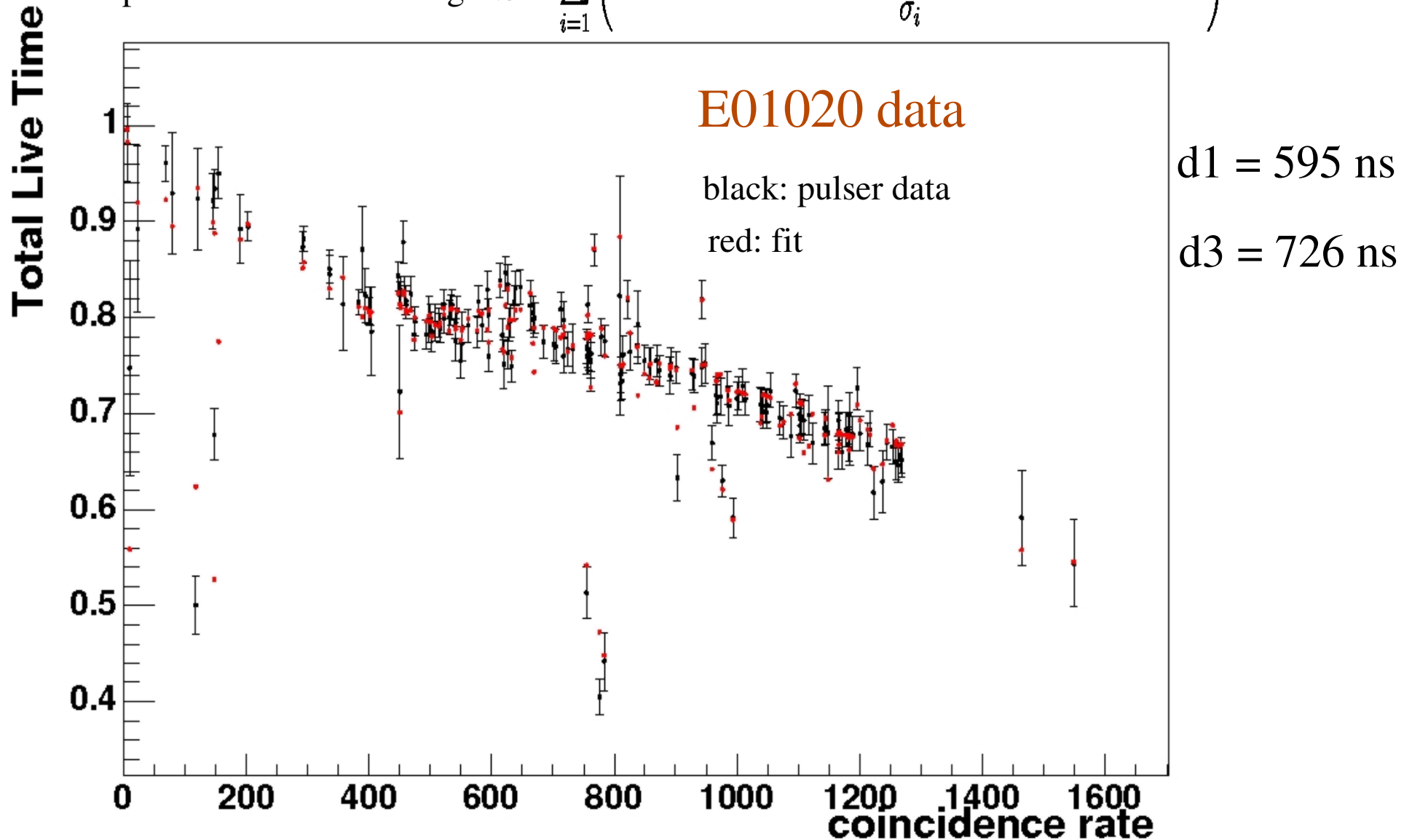
In conjunction with the E01020 analysis...



- VDC tracking/firing efficiency
- Trigger efficiency
- Determination of electronic deadtime from pulser data

Larger than expected electronic deadtimes are seen in both E01020 and E00102 data sets.

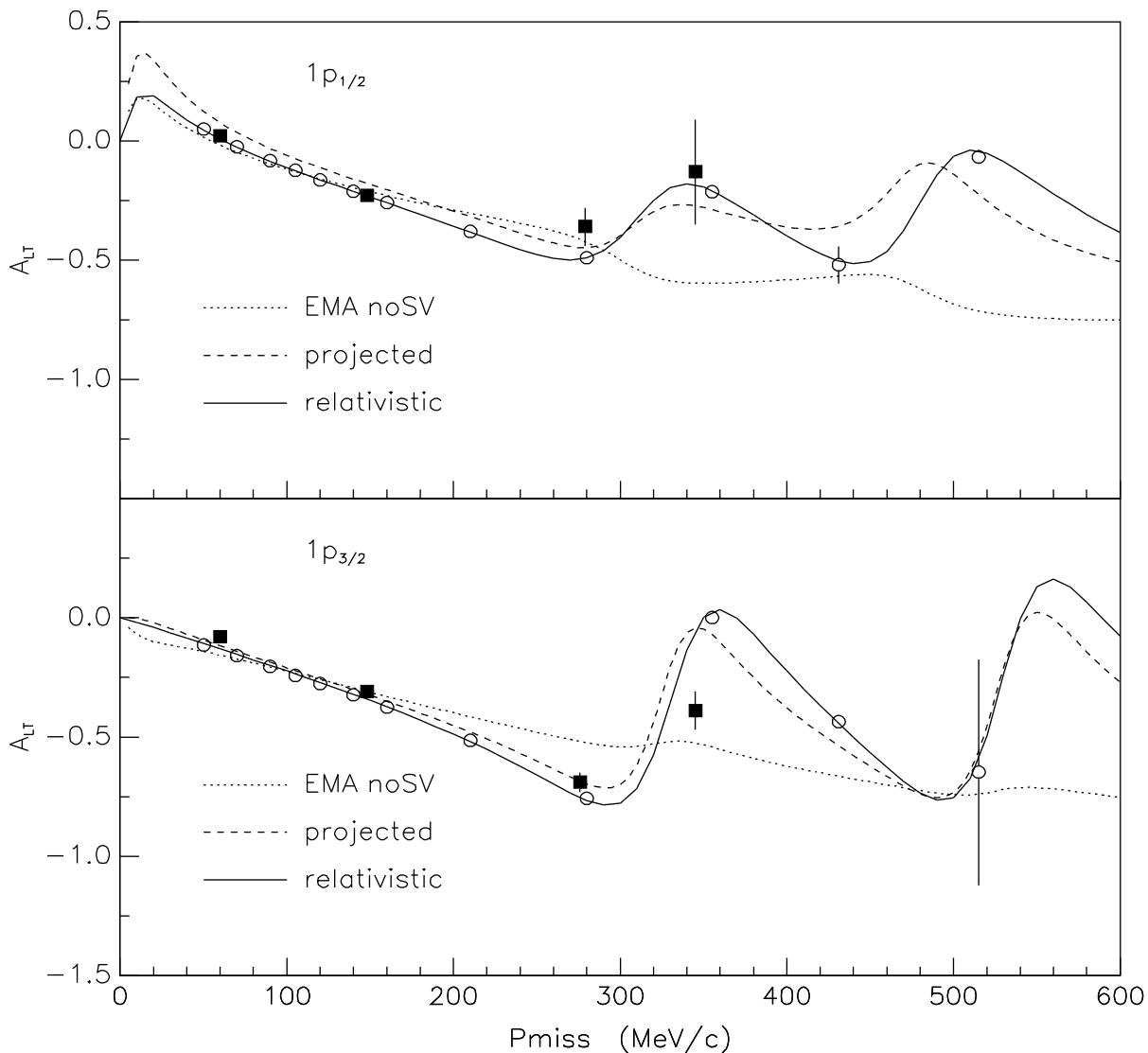
Simple linear fit minimizing:
$$\chi^2 = \sum_{i=1}^N \left(\frac{TLT_i - (1 - CDT_i) * (1 - d_1 * R1_i) * (1 - d_3 * R3_i)}{\sigma_i} \right)^2$$



Work in progress

- Development of alternate method of estimating electronic deadtime.
- ROOT-based replay of complete data set.
- Focal plane relative efficiency.
- Comparison of $H(e,e'p)$ cross-section measurement to world data, and foil-thickness monitoring by $H(e,e'p)$ yield comparison.
- $1p1/2$ relative cross section and A_{LT} extraction (coming soon...)

Projected A_{LT} for Proton Knockout from $1p_{1/2}$ and $1p_{3/2}$ -states of ^{16}O



○ Anticipated data points
from E00-102

■ Data obtained from
E89003

Compared to calculations
by Udias *et al.*