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

Status of E00102

Jeff Lachniet
Old Dominion University

Hall A Collaboration Meeting
June 22, 2007

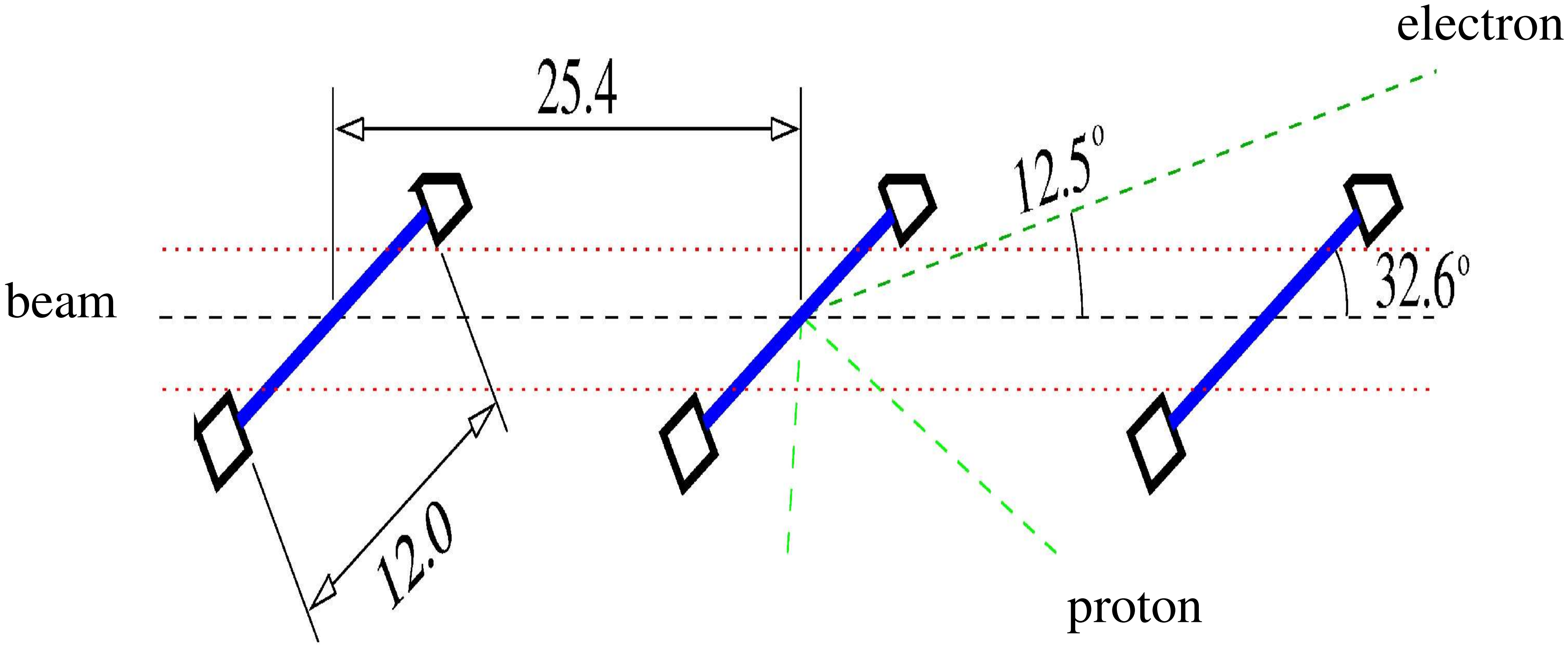
People Involved

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

Goals of E00102

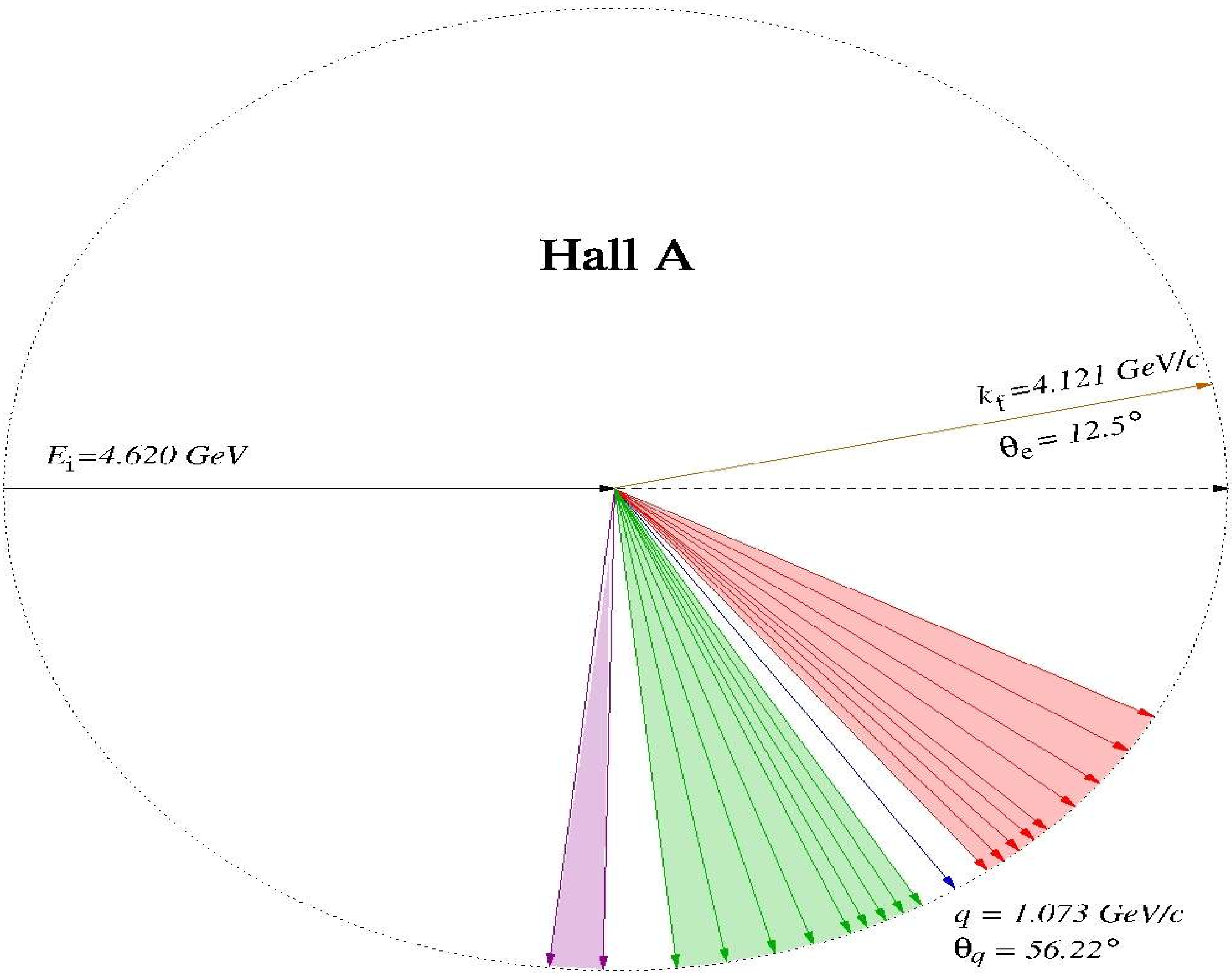
- Measurement of cross-section, R_{lt} and A_{lt} for the $^{16}O(e,e'p)$ reaction with higher precision and to higher missing momentum than in E89003.
- Determine the limits of validity of the single-particle model of valence proton knock-out.
- Determine effects of relativity and spinor distortion 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 GeV
- Q^2 = 0.902 $(GeV/c)^2$ {Electron angle fixed at 12.5^o }
- $|\vec{q}| = 1.073\, GeV/c$
- ω = 0.499 GeV
- Emiss = 0 to 0.240 GeV {Proton angle varied between 28.27^o and 96.10^o}
- Pmiss = -0.515 to 0.755 GeV/c {E89003 covered Pmiss up to 0.345 GeV/c}



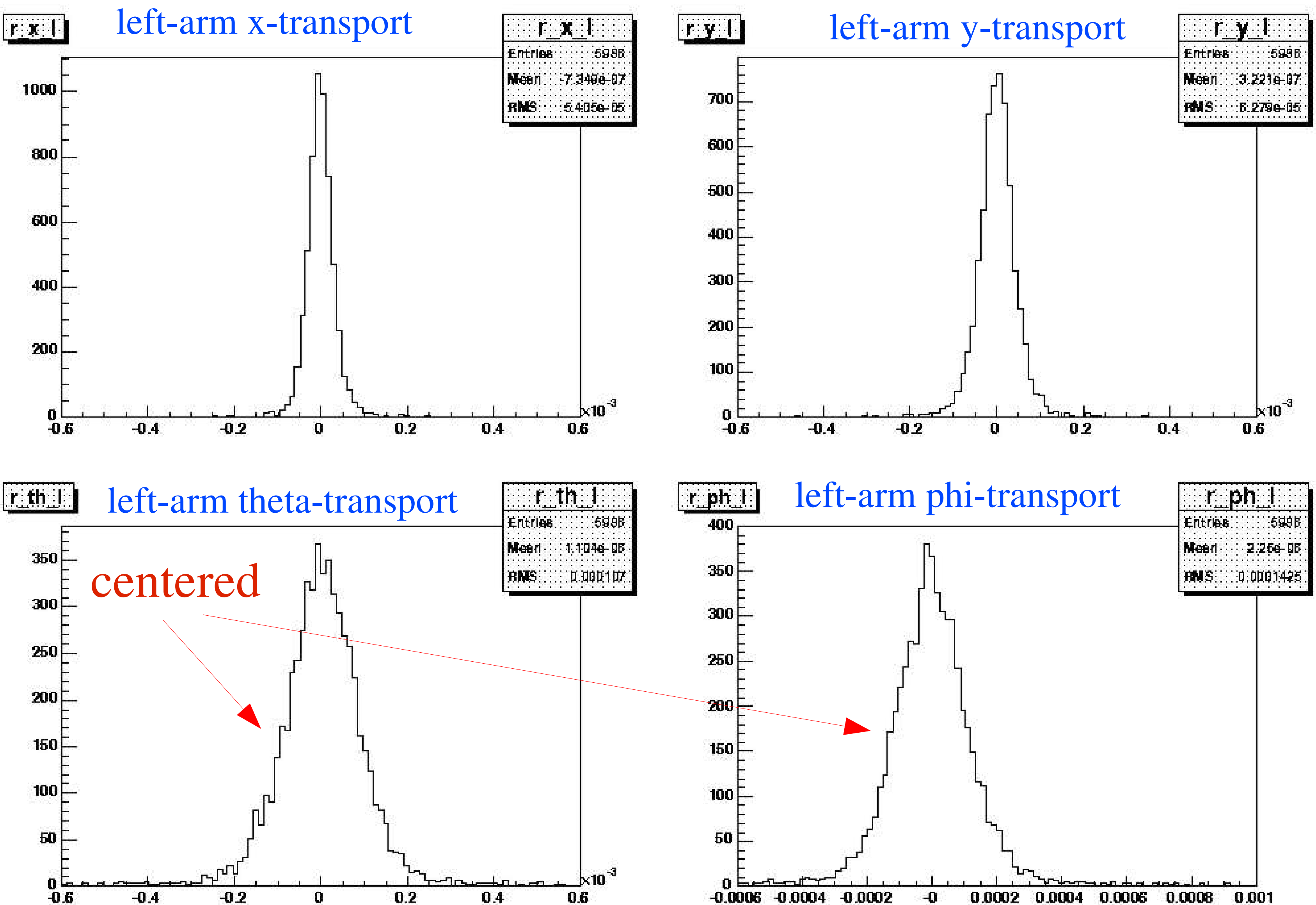
Hall A
k_f=4.121 GeV/c
θ_e = 12.5°
E_i=4.620 GeV
q = 1.073 GeV/c
θ_q = 56.22°

Tasks Completed

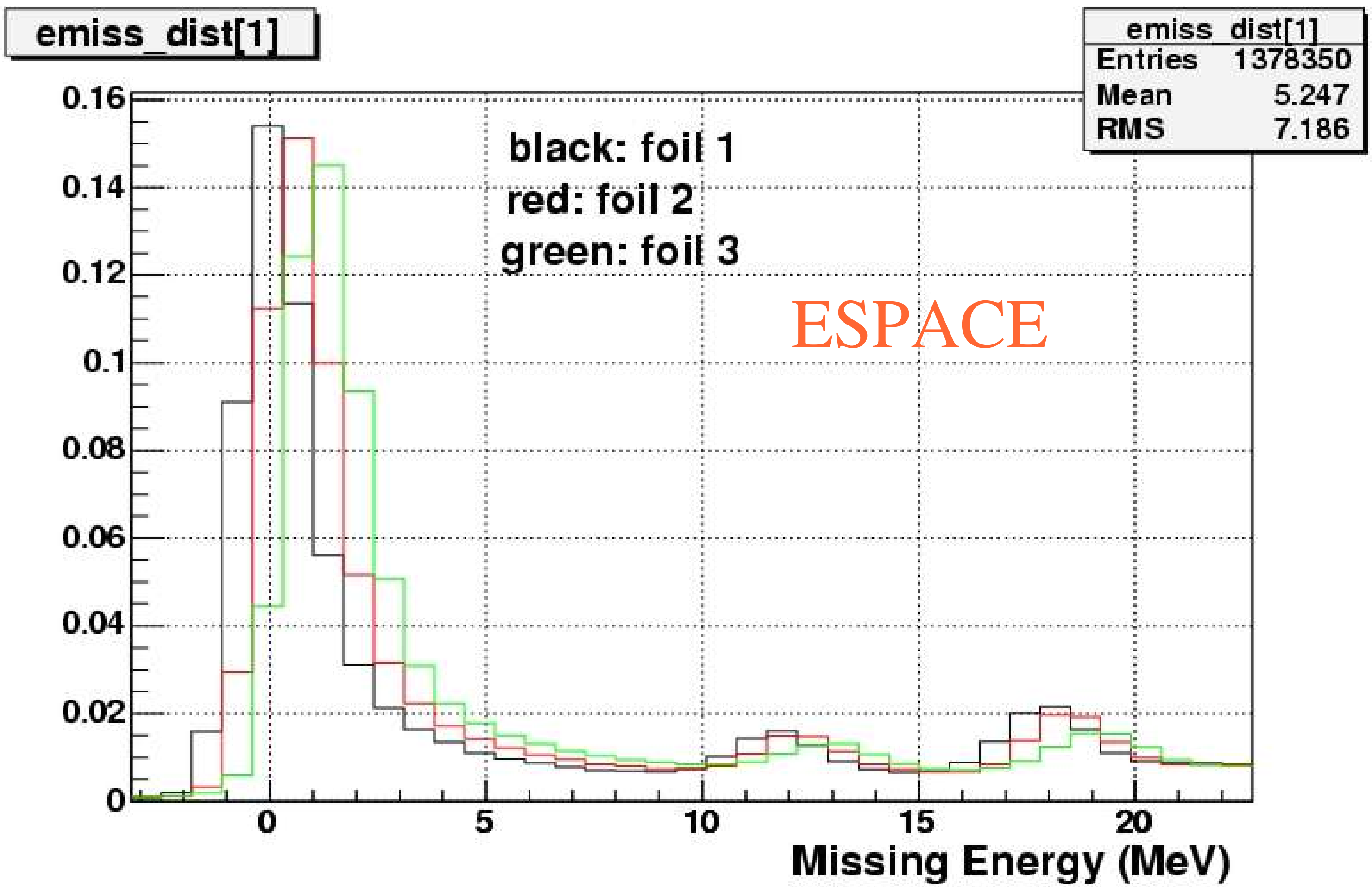
- Beam position/Beam energy calibrations.
- Optics calibration and spectrometer mispointing.
- First pass replay using ESPACE.
- Water-foil thickness measurement from ^{16}O(e,e'p) to BeO (e,e'p) yield comparison.
- Converted end-of-run-file information to MySQL database
- Determination of $1p_{1/2}$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



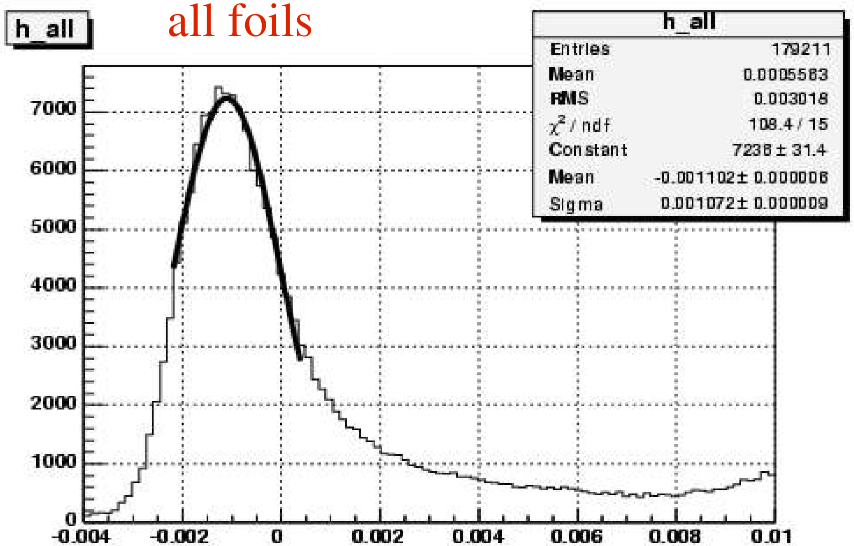
The ESPACE results for the missing energy distribution were not satisfactory. Shown below are the missing energy distributions for the three target foils, taken from parallel kinematics data. Note that there is a separation in the elastic peak positions of ~1.1 MeV.



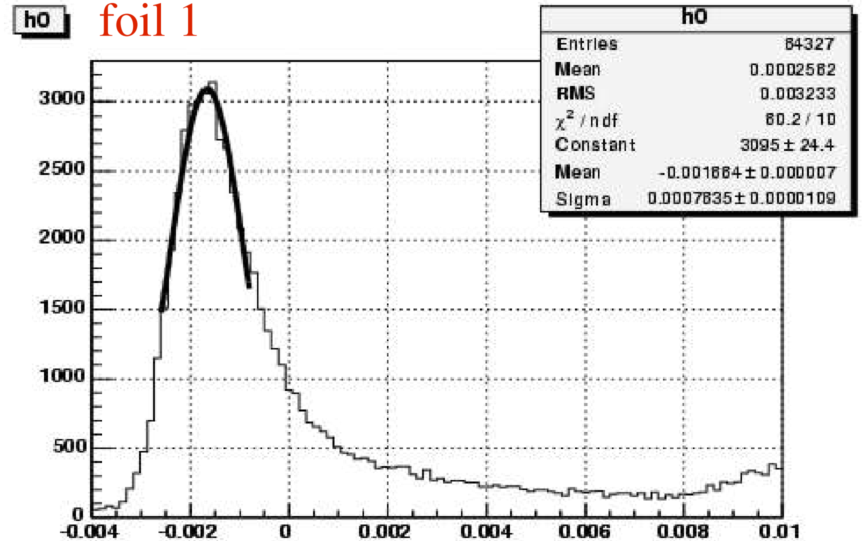
Analyzer output, BEFORE Eloss corrections

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

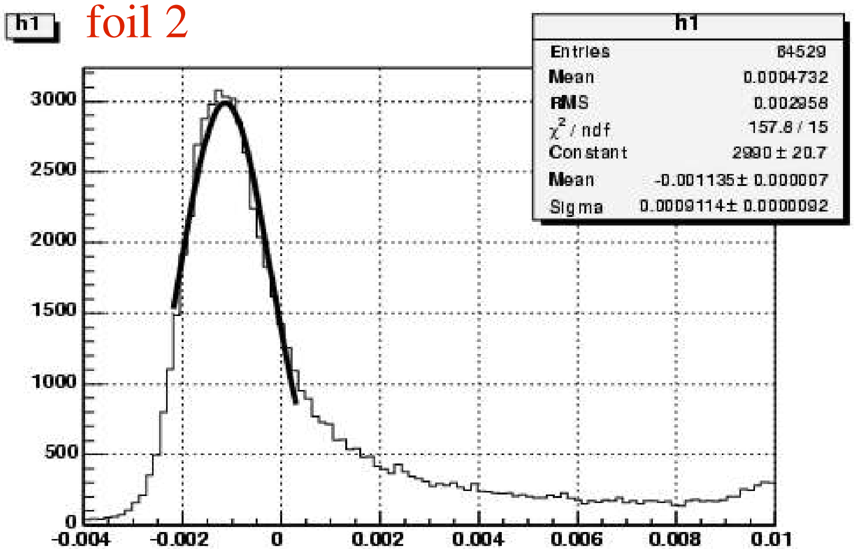
all foils



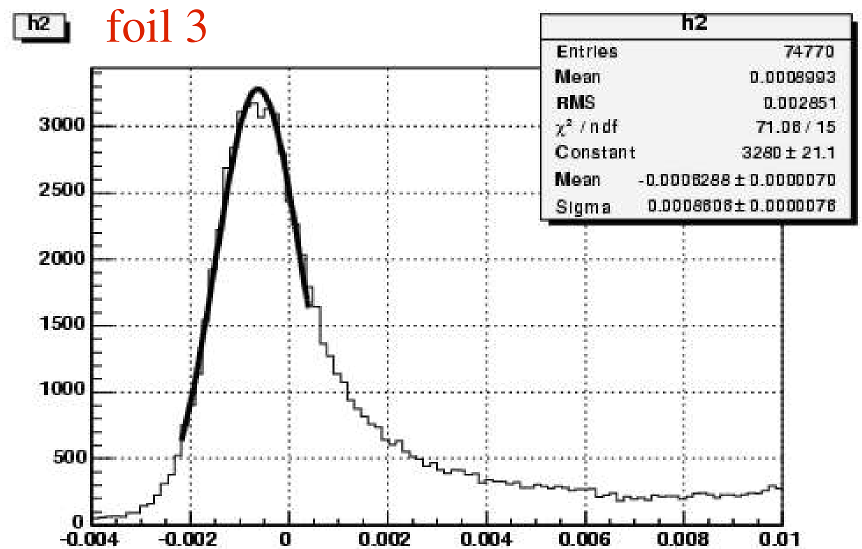
foil 1



foil 2



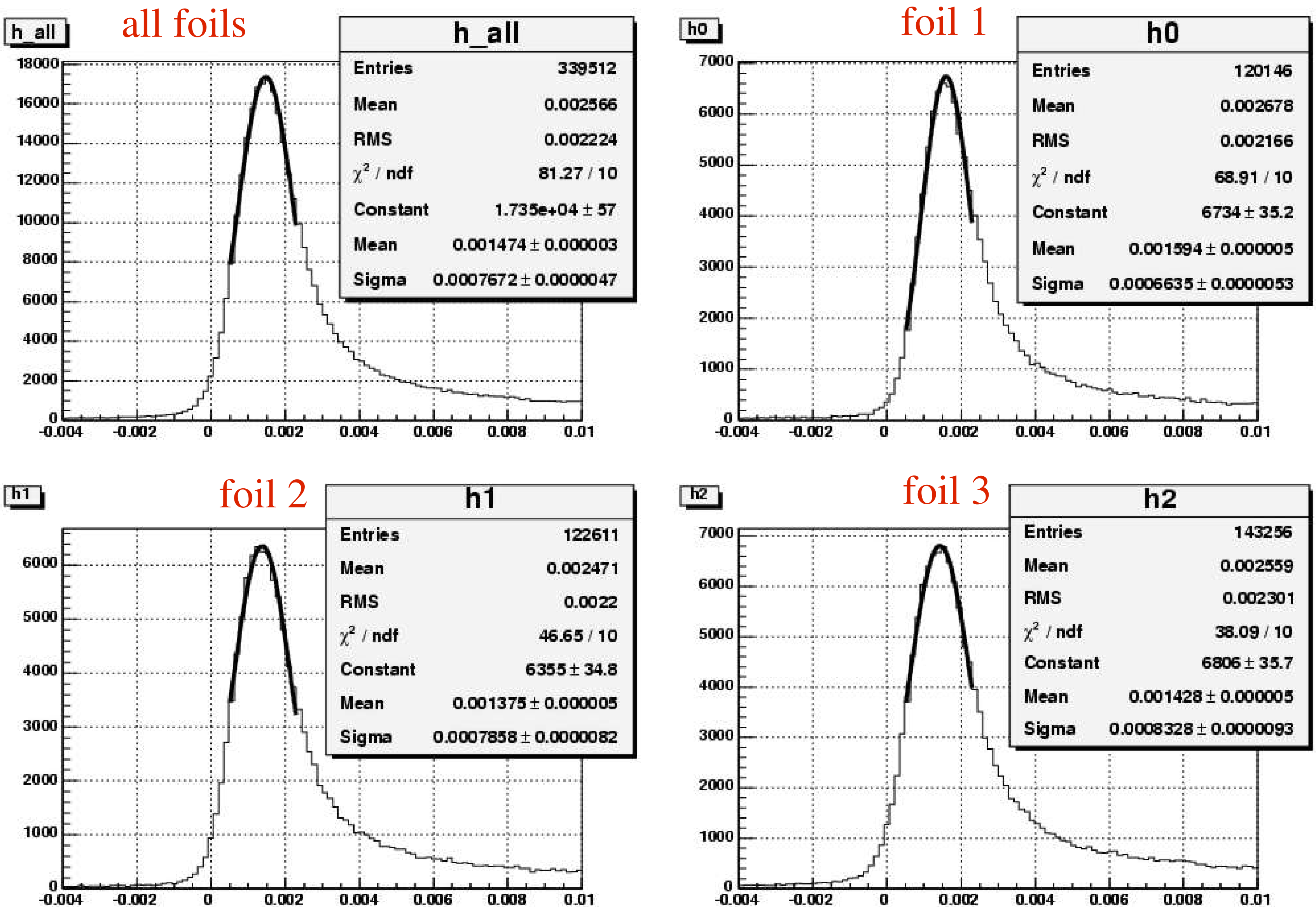
foil 3



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

Analyzer output, AFTER Eloss corrections

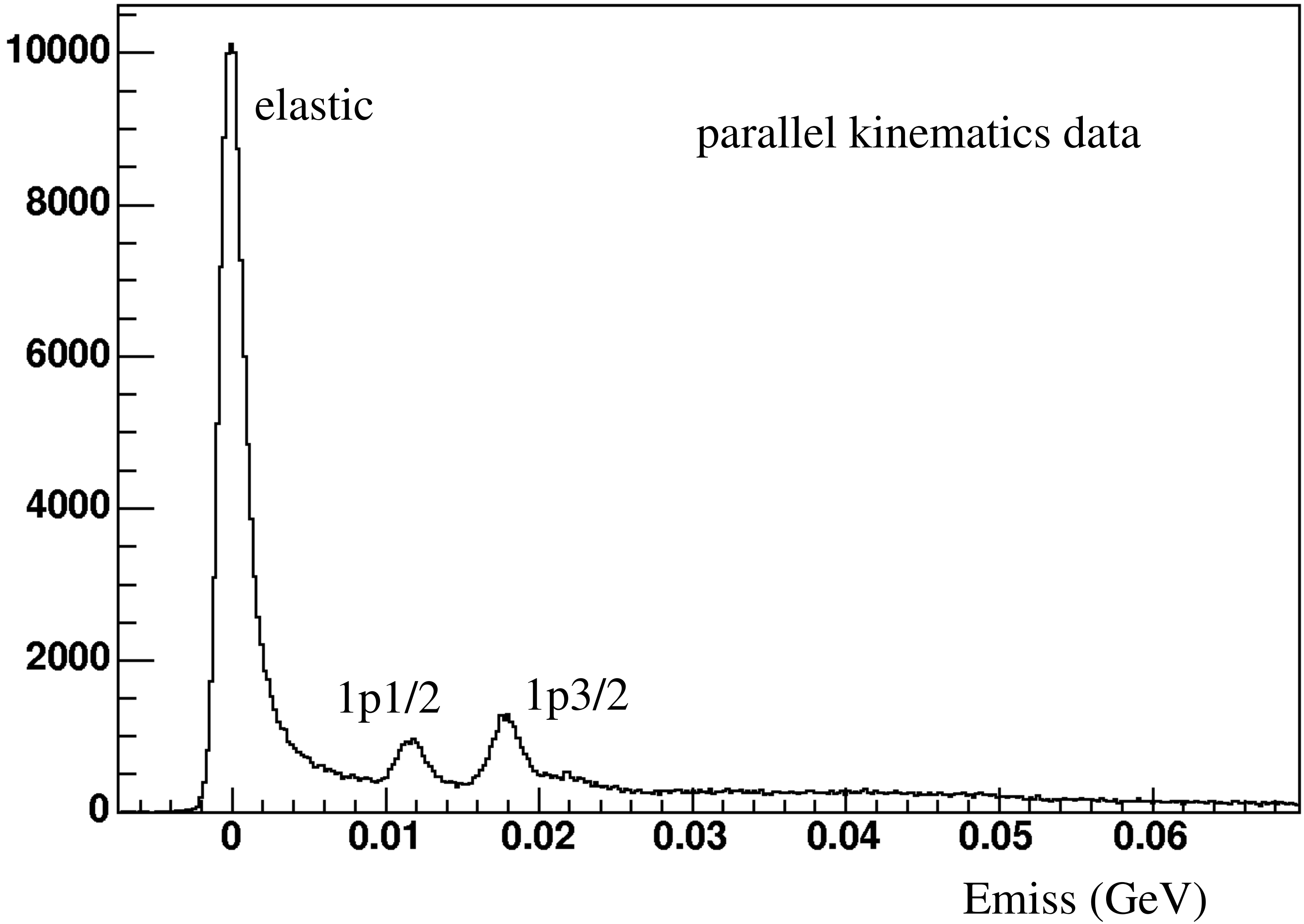
foil-by-foil fits to elastic peak position, run 2086



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

Kinematic adjustments:

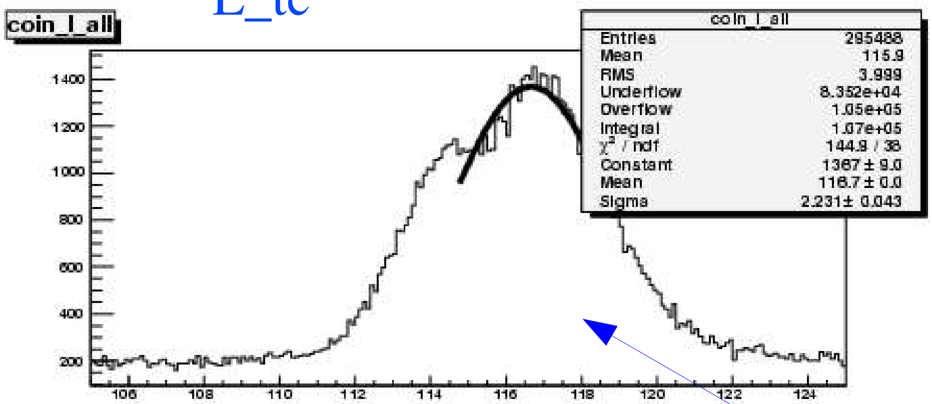
Small corrections to Θ_{left} and E_0 to center Emiss and ΔE distributions



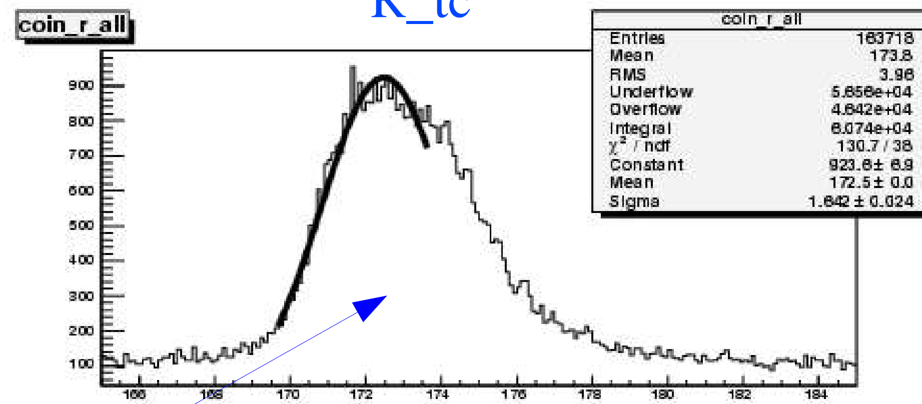
Coincidence timing with analyzer has been fixed

Data from run 1548 (BB- kinematics)

L_tc

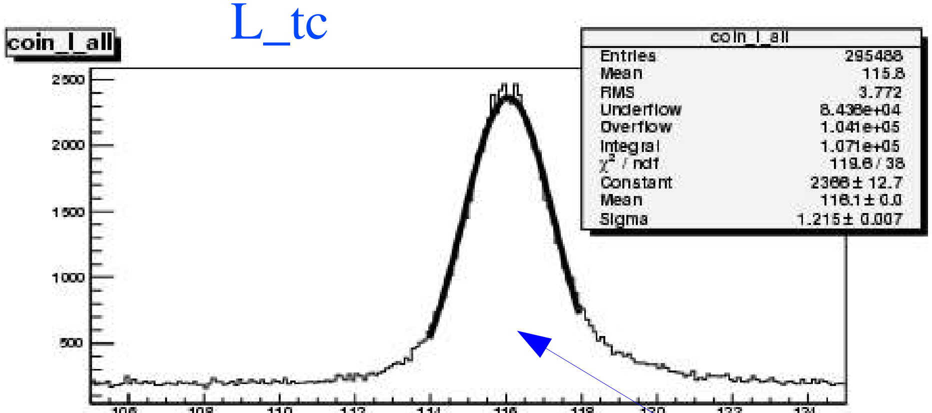


R_tc

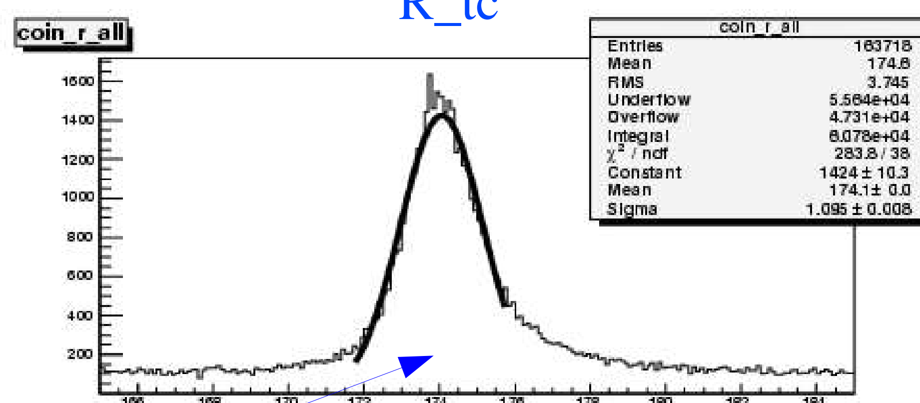


Before paddle timing offsets

L_tc



R_tc

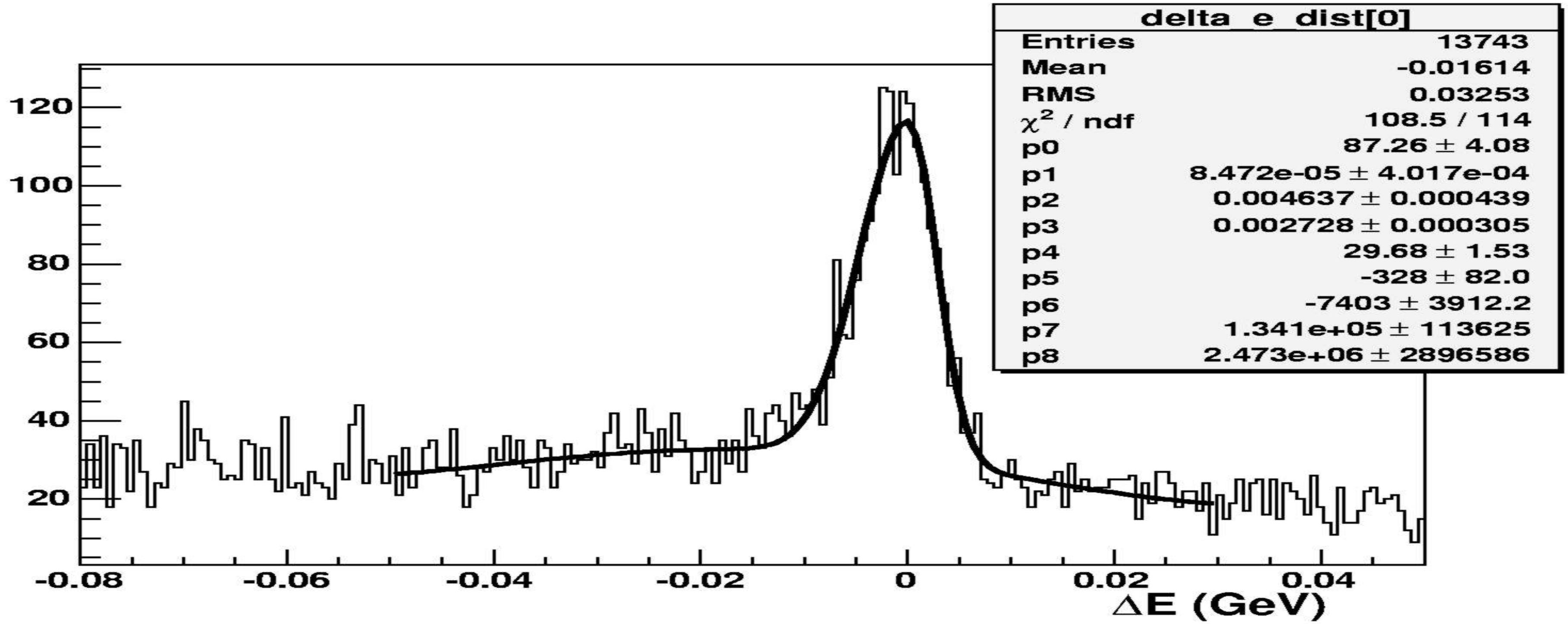


After paddle timing offsets

Luminosity monitoring:

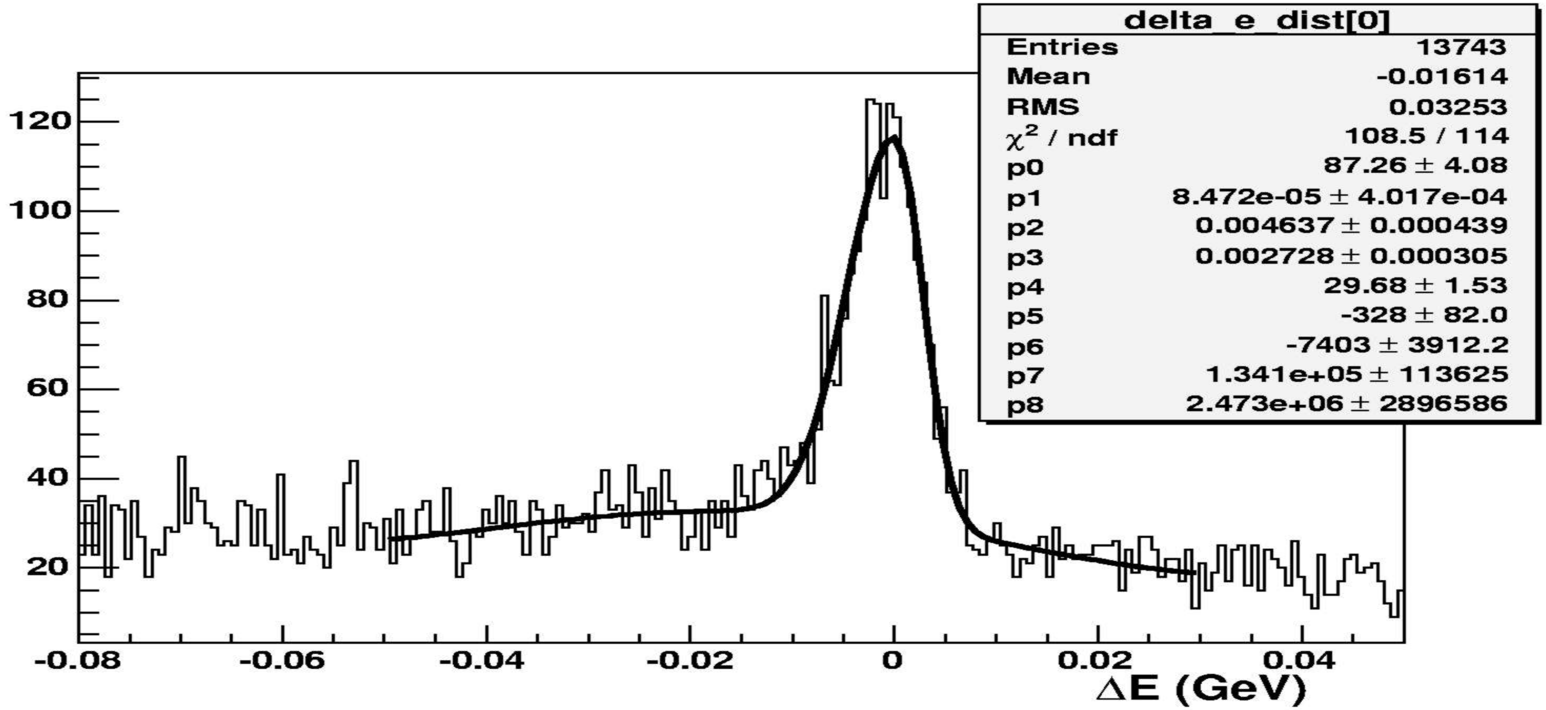
- Left arm fixed (same angle, same momentum) for all kinematics.
- Continuously monitors H(e,e'p) elastic scattering

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



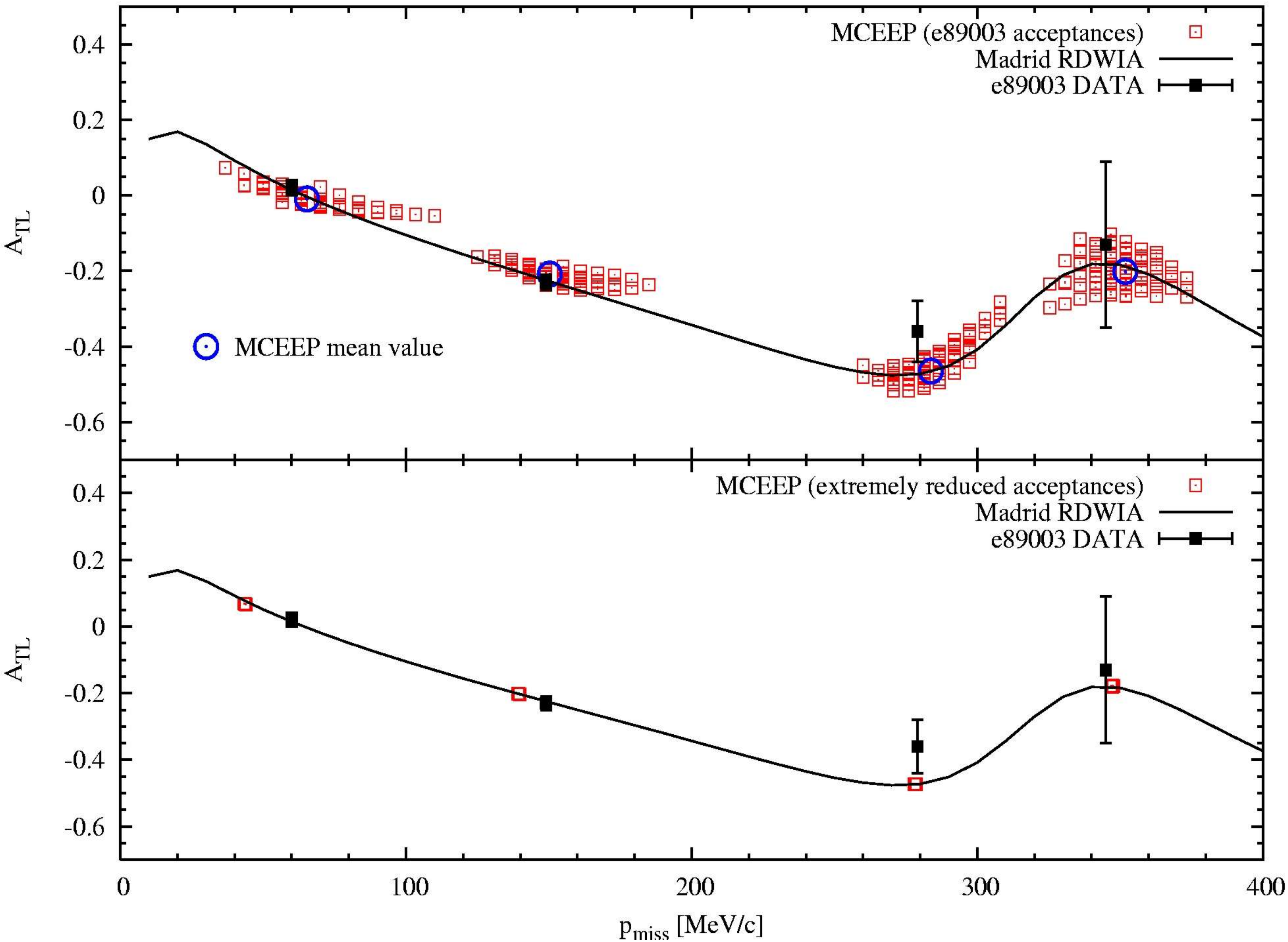
Luminosity monitoring:

- 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 ($E_{miss,}$ p_{miss}, q, ω).
- If we consider only those cases where the ejected protons belong to a given shell, then only three variables are needed: (p_{miss}, q, ω).
- 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_{miss}, q, ω).
- The response functions are calculated on a three dimensional grid, interpolation of which is used to weight events in MCEEP.


MCEEP (e89003 acceptances)
Madrid RDWIA
e89003 DATA
MCEEP mean value
MCEEP (extremely reduced acceptances)
Madrid RDWIA
e89003 DATA
A_TL
p_miss [MeV/c]
0.4
0.2
0
-0.2
-0.4
-0.6
0
100
200
300
400

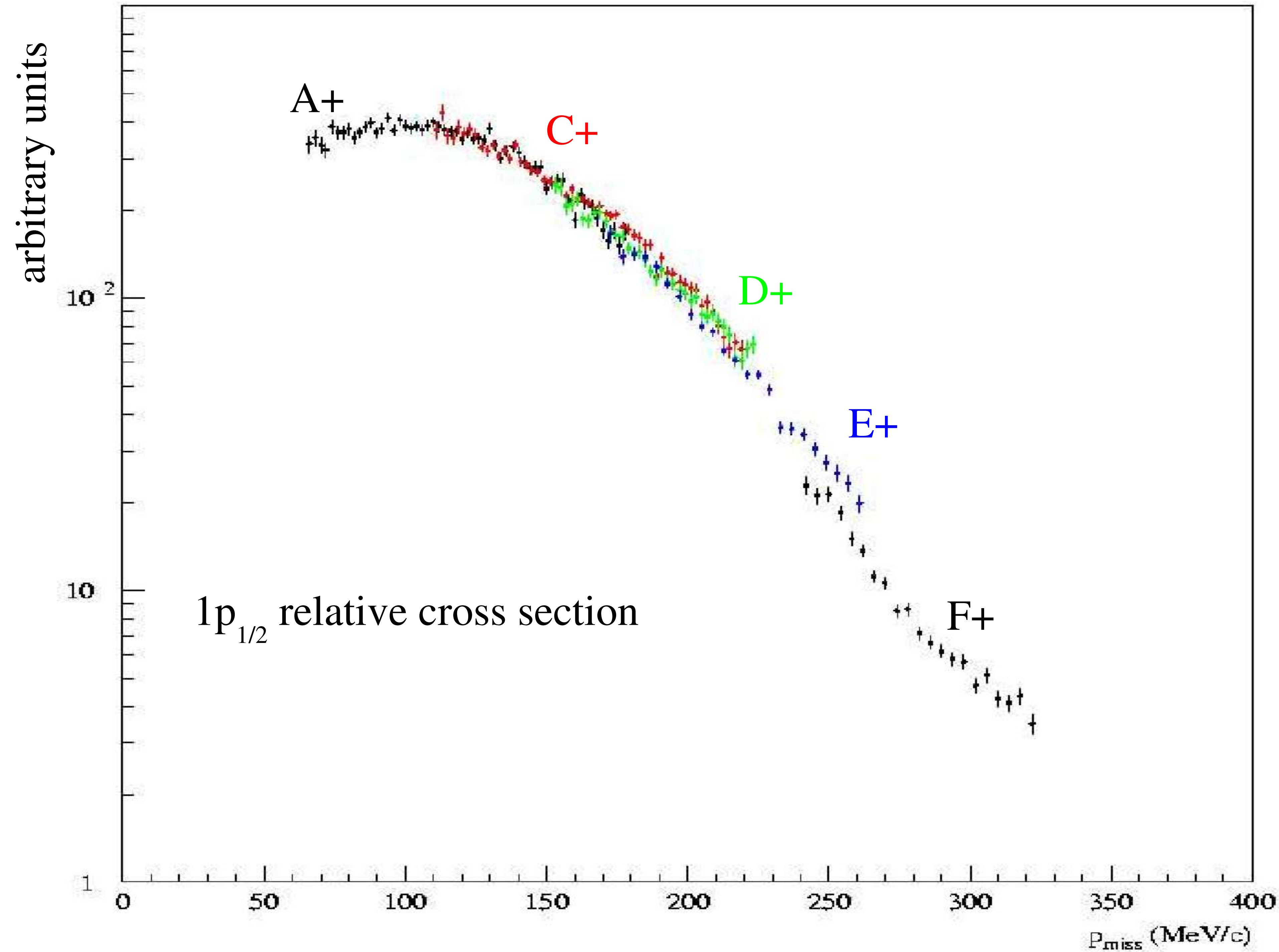
$1p_{1/2}$ relative cross section (M.Andersson)

- Determination of $1p_{1/2}$ cross section relative to H(e,e')
- Uses data in the range:

$$0 < Pmiss < 350 \text{ MeV/c}$$

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

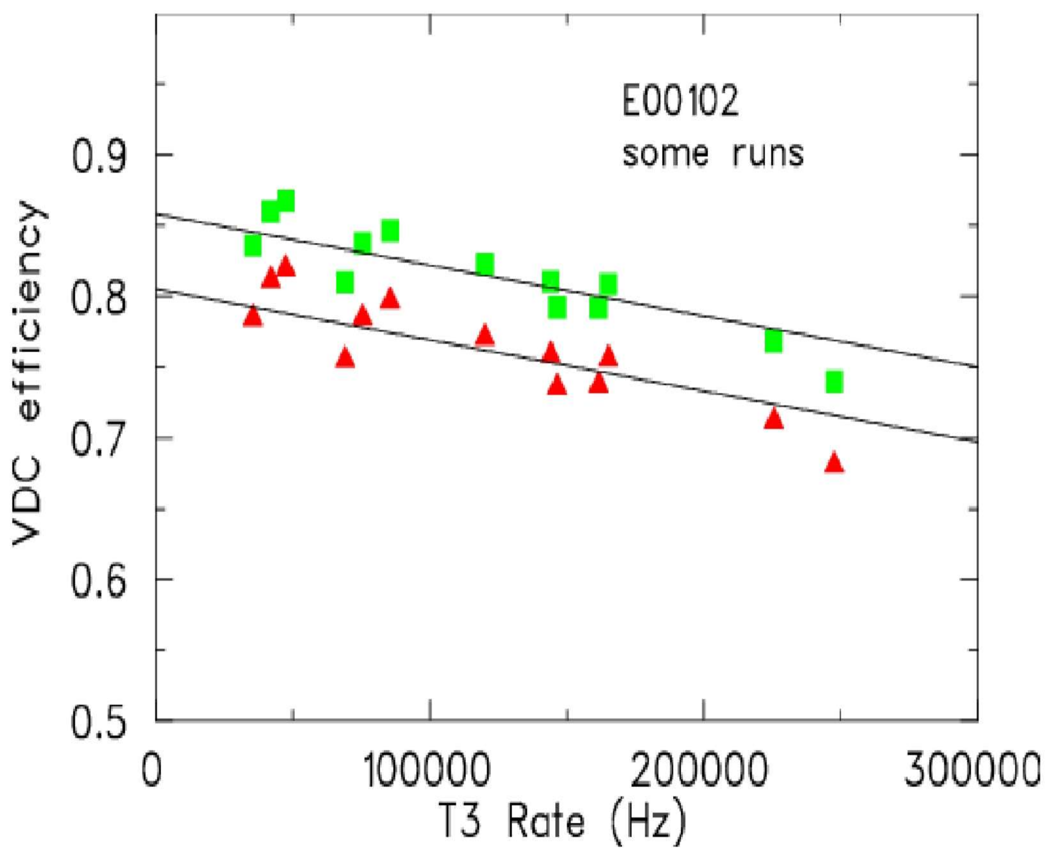
- Pmiss bins are 2 MeV/c for A+ through D+, 4 MeV/c for E+,F+
- Only central foil was used.
- Acceptance cuts: ±50 mr in θ and ϕ, ±3.5% in δp
- Statistical uncertainty is 7% or less. Systematic uncertainty estimated at ≈5%.



arbitrary units
A+
C+
D+
E+
F+
1p1/2 relative cross section
10 2
10
1
0
50
100
150
200
250
300
350
400
pmiss (MeV/c)

Work in progress

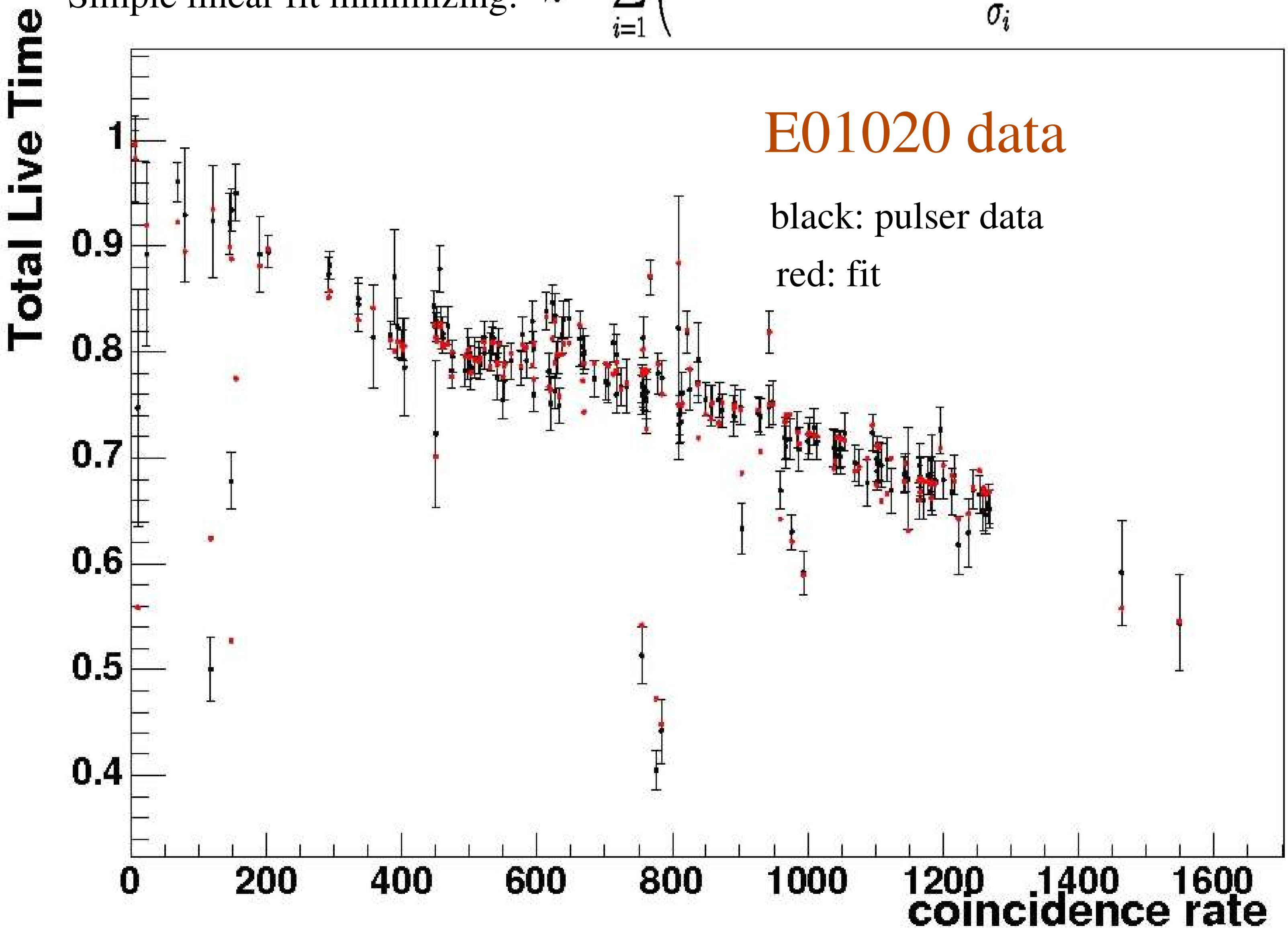
In conjunction with the E01020 analysis...



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



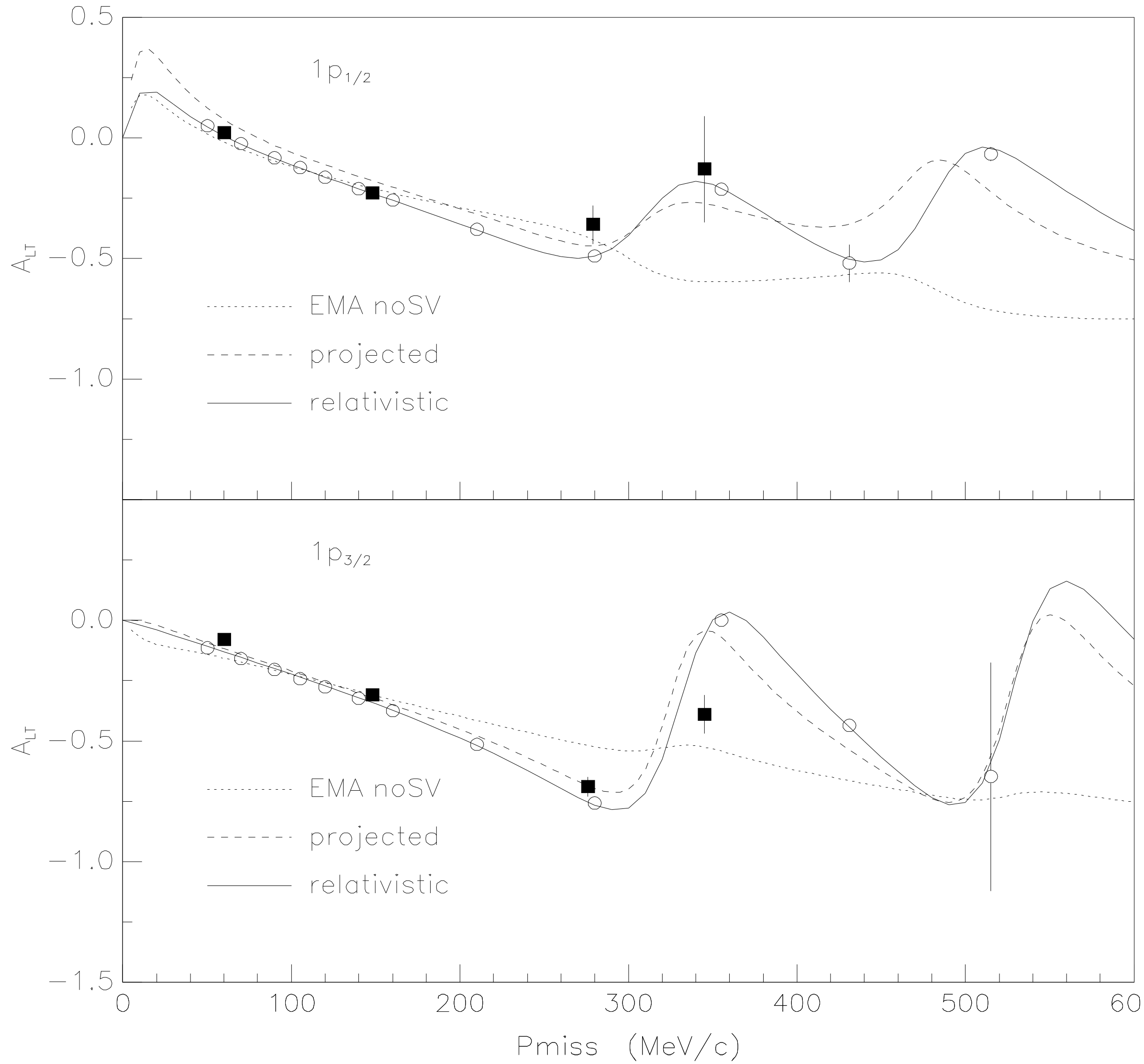
d1 = 595 ns

d3 = 726 ns

Work in progress

- Development of T0-based estimate of 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 and 1p3/2 cross section

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



- o Anticipated data points from E00-102
- ■ Data obtained from E89003

Compared to calculations by Udias *et al.*