STATUS OF THE E06-007 EXPERIMENT
Impulse Approximation limitations to the (e,e'p) reaction on ^{208}Pb, ^{208}Bi and ^{12}C

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   - $^{12}C(e,e'p)$
   - $^{208}Pb(e,e'p)$
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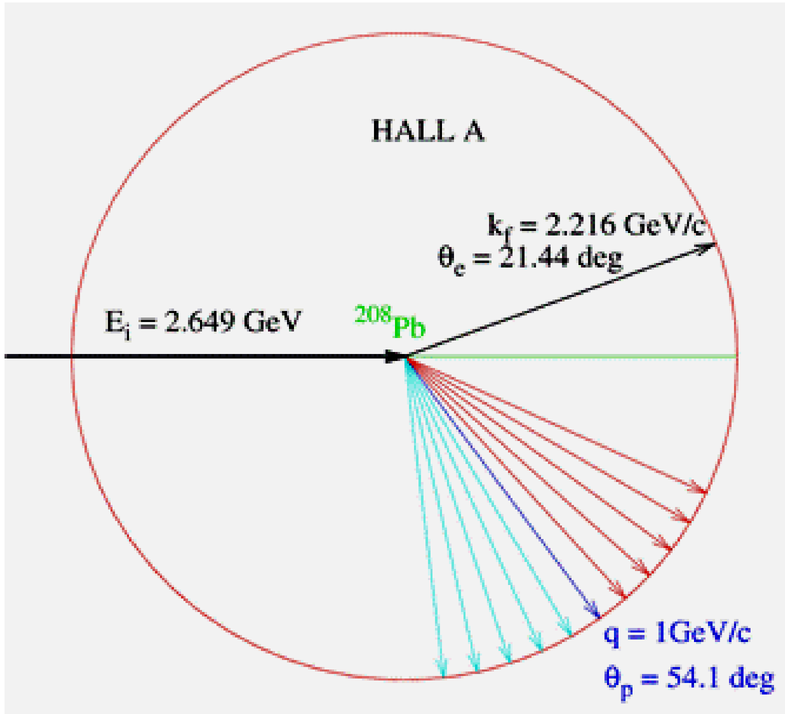
1. EXPERIMENT E06-007

- We measured ^{208}Pb(e,e'p)^{207}Tl cross sections at true quasielastic kinem. (x_B=1, q=1GeV/c, ω=0.433GeV/c) and at both sides of q.
- This has never been done before for A>16 nucleus
- Additionally we measured ^{209}Bi(e,e'p) and ^{12}C(e,e'p)



OBJECTIVES

1. **Determine momentum distributions**: 0< p_{miss}< 500MeV/c
2. **Determine A_{TL}** by measuring cross sections on either side of q
3. **Determine the spectroscopic factors dependence with Q^2 (0.81, 1.40, 1.97 GeV^2)**

1. EXPERIMENT E06-007

Data acquisition:

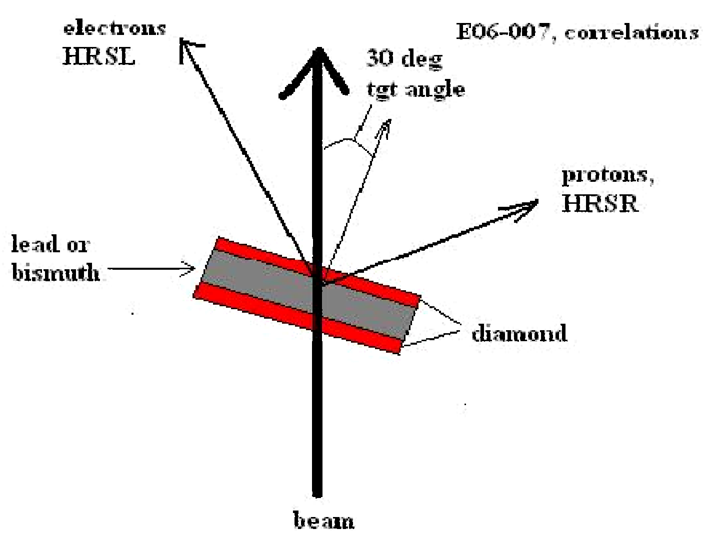
- RUN 1 – (March, 3-26, 2007)
- RUN 2 – (January 2008) Additional measurements in Lead in the high p_{miss} region. With thin and thick lead target.

Target:

- Diamond/Lead/Diamond sandwich cryogenic target 0.2mm Lead + 0.3mm Diamond (needed for high beam current).

Requirements:

- Good Energy Resolution
- Raster Correction
- Normalization Factors
- Use ^{12}C as a reference



2. THEORY AND SIMULATIONS

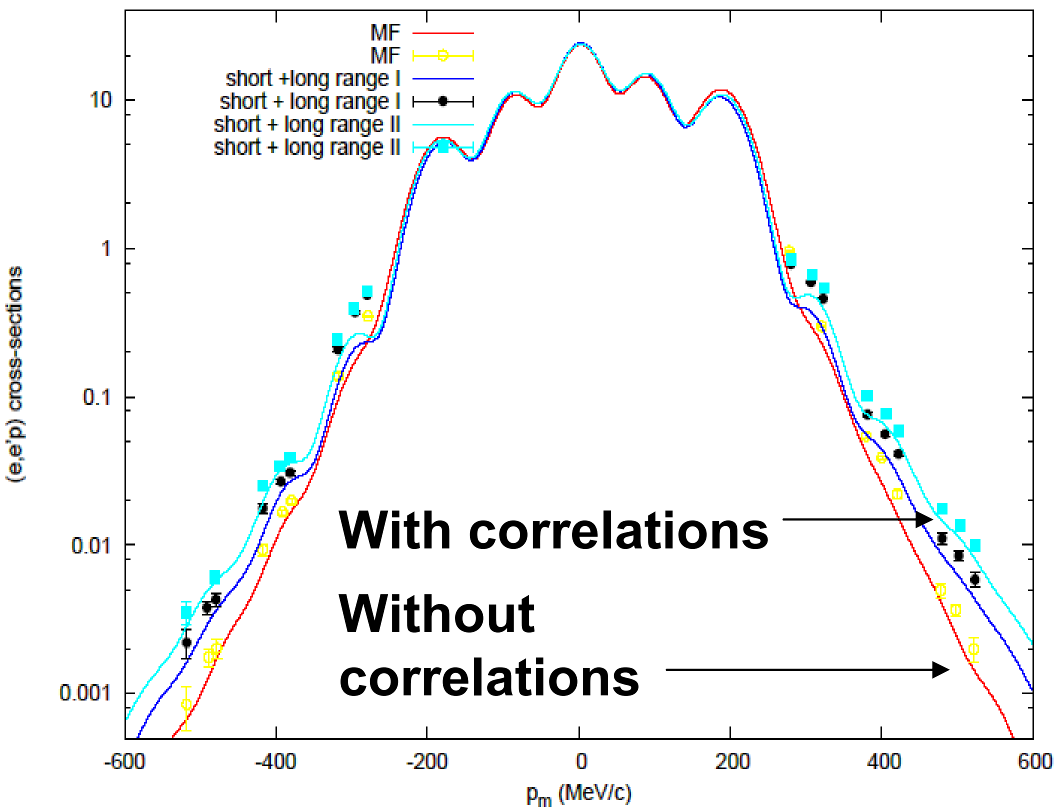
Previous experiment at NIKHEF (Bobeldijk, PRL 1994) found an excess of strength at high p_{miss} in ^{208}Pb(e,e'p). This was explained by two approaches:

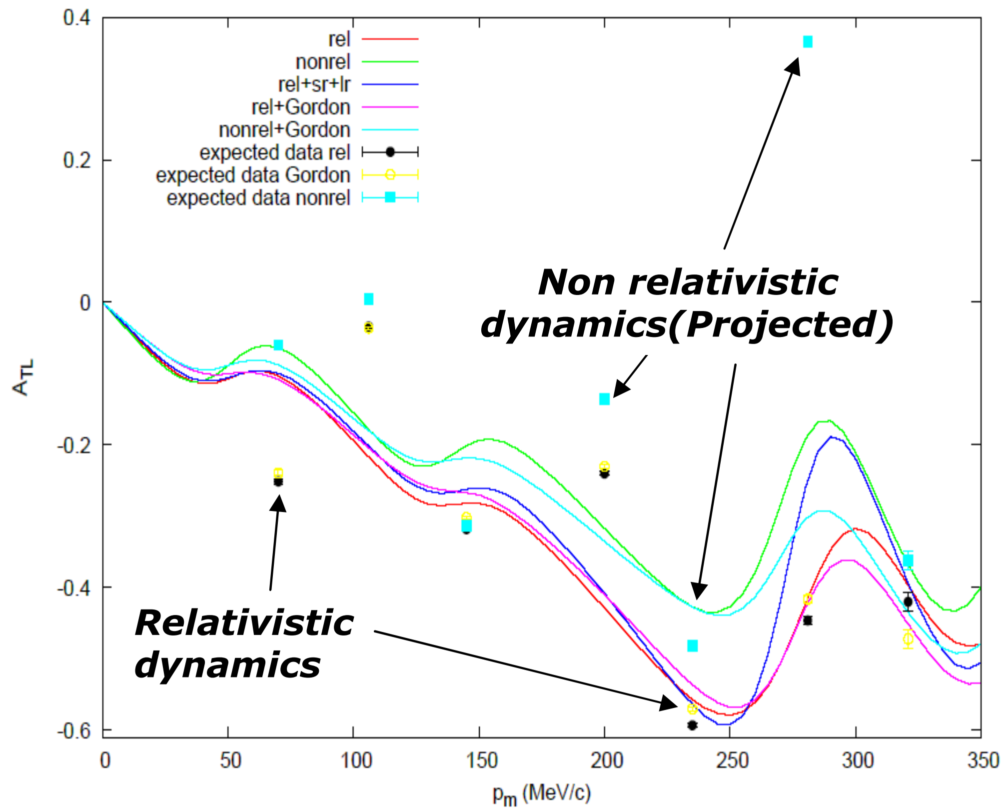
(1) Quasiparticle orbits plus non-relativistic DWIA.

(2) Relativistic DWIA using independent particle orbit solutions to Dirac equation.

The A_{TL} is an excellent observable to check both models.

Measuring the high p_{miss} region at the quasielastic peak with good statistics will reveal if long-range correlations are needed to describe the data.





2. THEORY AND SIMULATIONS

INPUT PARAMETER	OPTION
BOUND-NUCLEON WAVE FUNCTION	NLSH
OPTICAL MODEL	EDAI-C (^{12}C) & EDAD (^{208}Pb)
NUCLEAR SPINOR DISTORTION	**RELATIVISTIC** AND **PROJECTED (NON-RELATIVISTIC DYNAMICS)**
ELECTRON DISTORTION	NONE (yet)
KINEMATICS	RELATIVISTIC
CURRENT OPERATOR	CC2
NUCLEON FORM FACTORS	J.ARRINGTON (ROSENBLUTH DATA FIT)
GAUGE	COULOMB
RADIATION	SIMULATED BUT NOT UNFOLDED

3. DATA ANALYSIS – Calibration

- **The first part of the data analysis consisted in:**

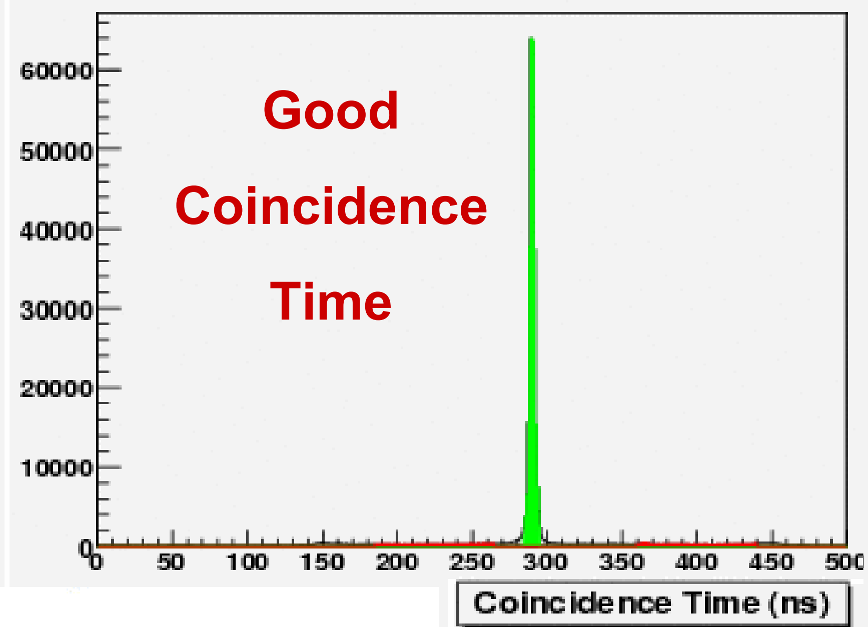
✓ Improving the Optics Database to get 1MeV resolution.

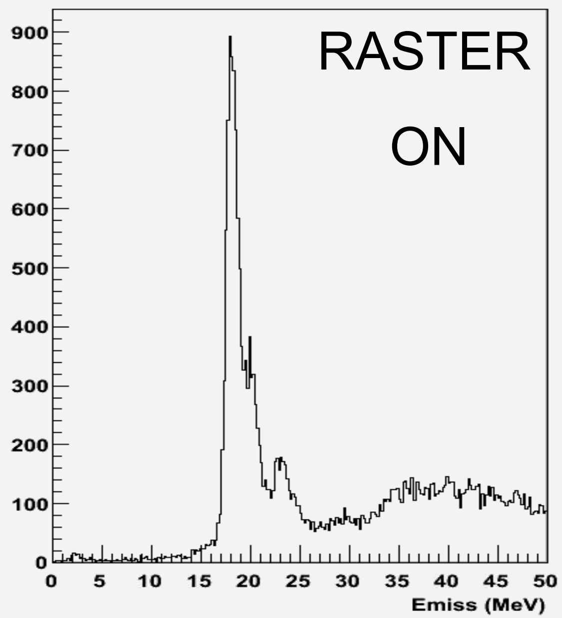
✓ Improving the Coincidence Time (resolution ~2.5ns).

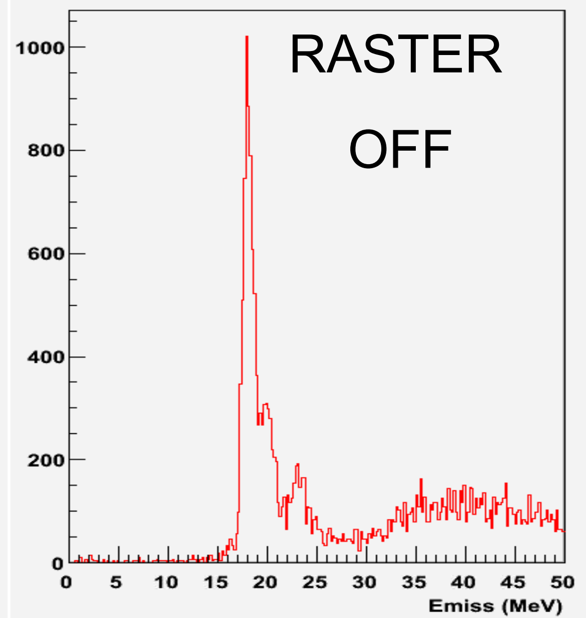
✓ Establishing the Raster Correction (we used a large raster)

✓ Normalization factors (Dead-time,Multitracks correction)

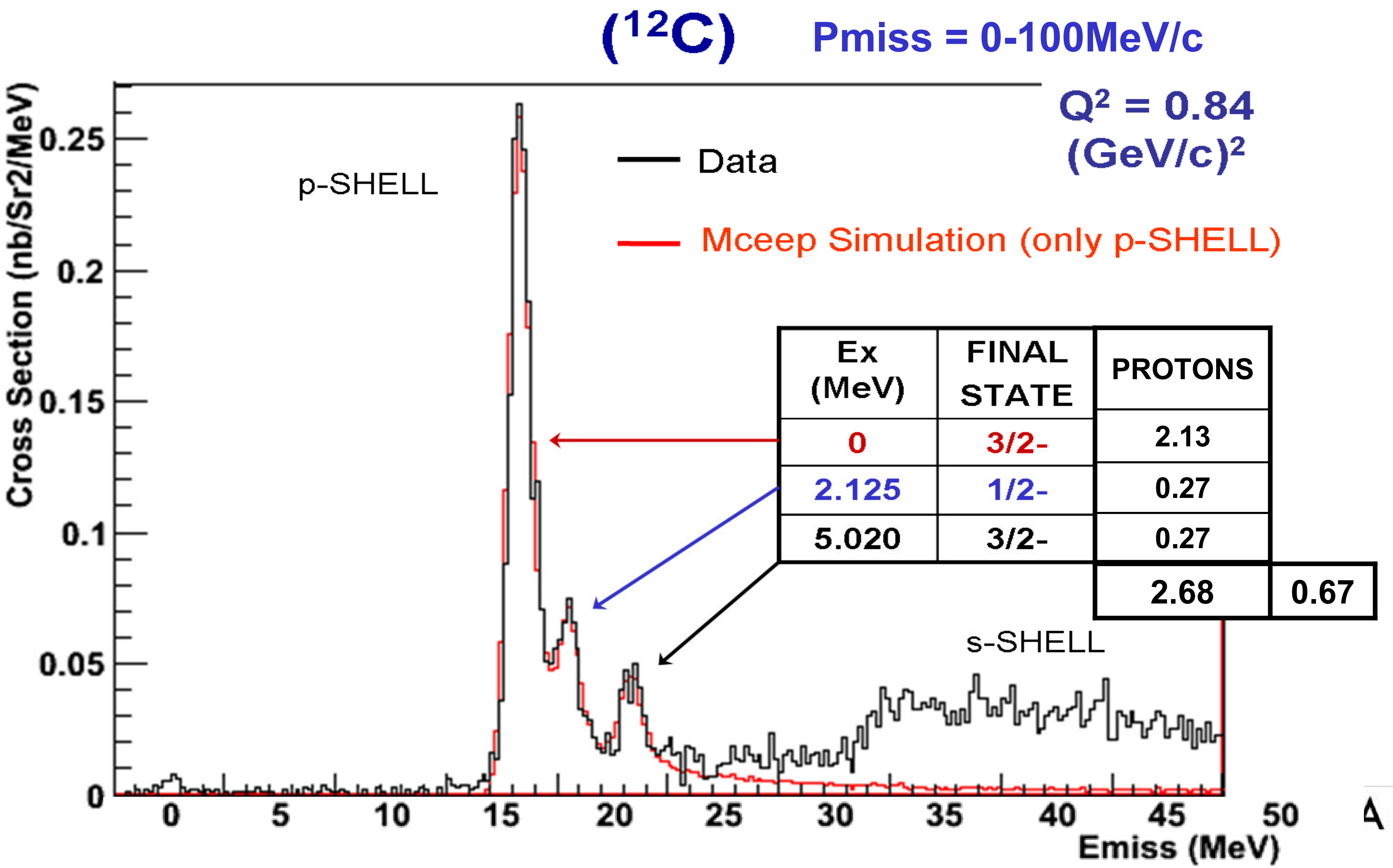
- **This part of the analysis is almost finished and we obtain reasonable good results:**







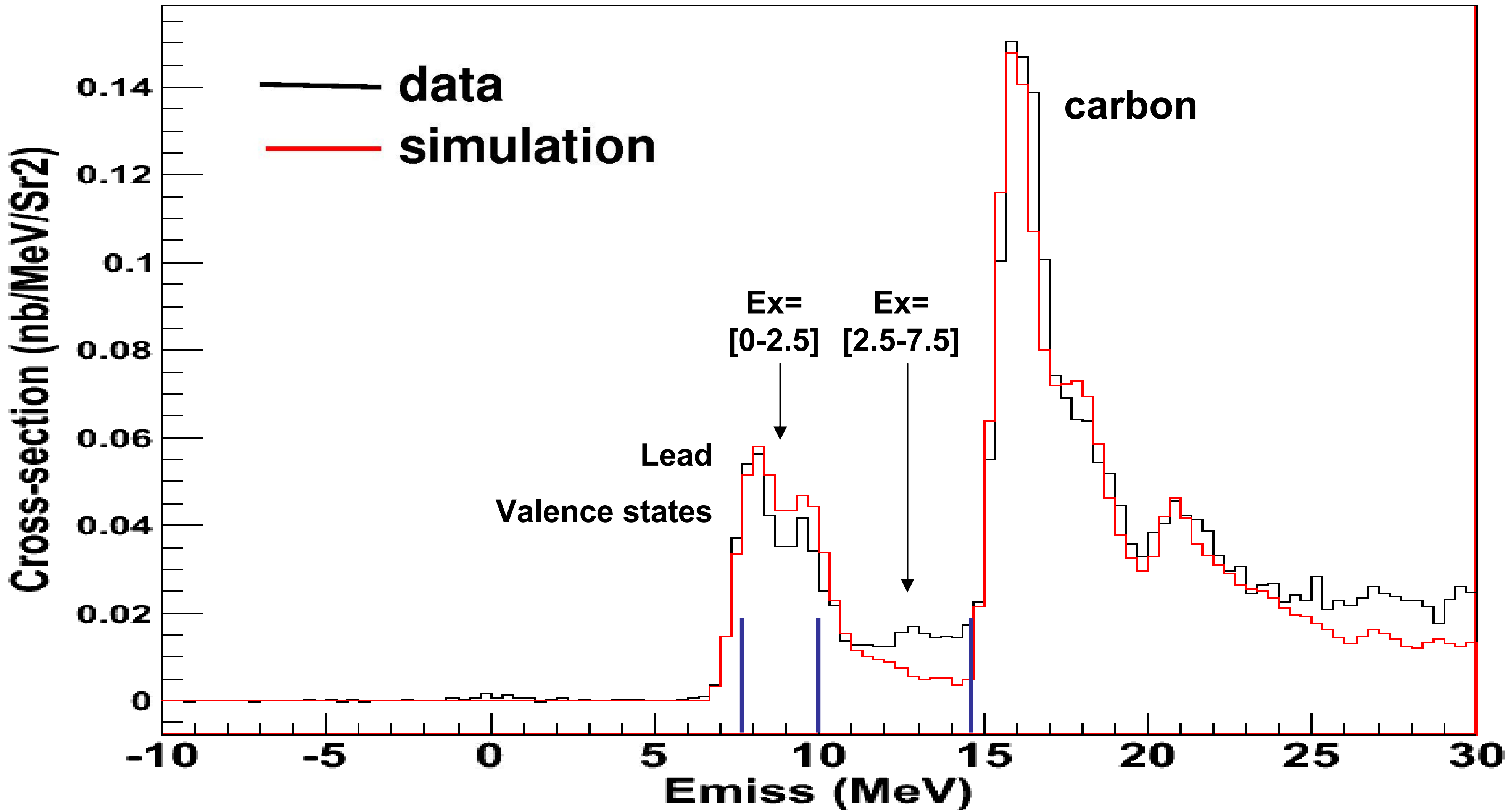
3. DATA ANALYSIS: Emiss Resolution



Ex (MeV)	FINAL STATE	PROTONS	
0	3/2-	2.13	
2.125	1/2-	0.27	
5.020	3/2-	0.27	
		2.68	0.67

3. DATA ANALYSIS: Emiss Resolution

-Two peaks can be separated in this ^{208}Pb Emiss spectrum (Pmiss=0). Both of them are composed of two peaks.



3. DATA ANALYSIS: Cross-Section (e,e'p)

- For each kinematics, the cross-section is obtained as:

$$\frac{d^5\sigma}{d\Omega_e d\Omega_p d\omega} = \frac{Number\_of\_counts\_corrected}{\Delta\Omega_e \cdot \Delta\Omega_p \cdot \Delta\omega \cdot L}$$

Live time and Multitrack corrections (→ corrected counts)

Solid angles ($\Delta\Omega_e \cdot \Delta\Omega_p$) — Electron Energy Range ($\Delta\omega$) — Luminosity (L)

- Using MCEEP we can simulate the Phase-space population and bin the acquired data in (p_{miss},q,ω,ϕ)
- Reduced cross-section was obtained as:

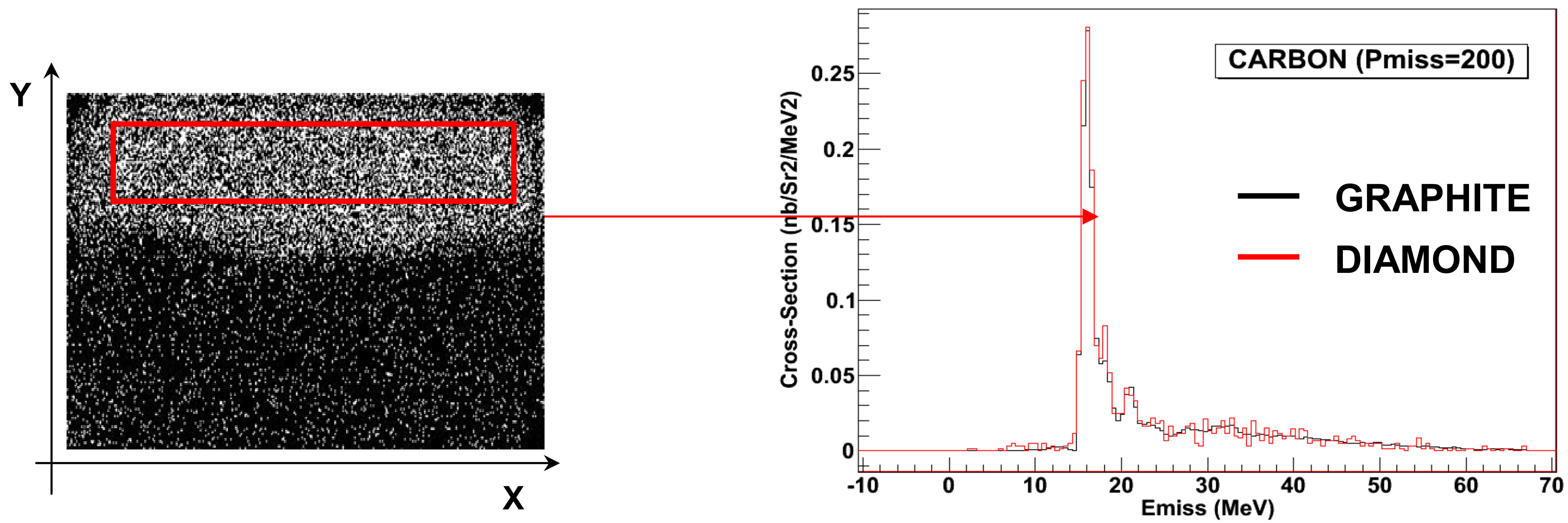
$$\frac{d^5\sigma_{red}}{d\Omega_e d\Omega_p d\omega} = \frac{1}{E_p P_p \sigma_{CC1}} \cdot \frac{d^5\sigma}{d\Omega_e d\Omega_p d\omega}$$

σ_{CC1} - Prescription of De Forest Form Factors from J. Arrington fit of Rosenbluth data. PRC 69, 022201 (2004).

3. DATA ANALYSIS: Checks

1) Numerical evaluation of the Luminosity, Acceptances, Number of counts in the Emiss region with background subtraction and corrections were performed independently in Los Angeles and in Madrid in several kinematics. This confirmed that there were not mistakes at this part.

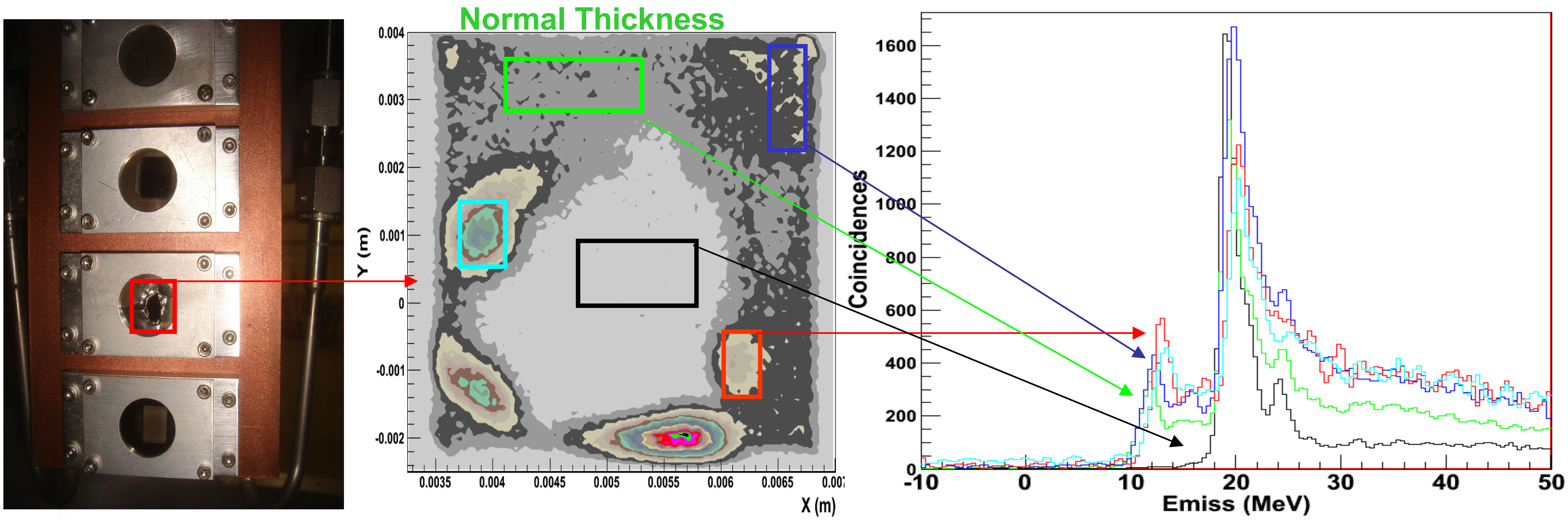
2) C+Bi+C target had a problem and Bismuth only covered one-half of the target. We compared the measured cross-section from the other half (with only C+C foils) against the graphite target. Agreement is better than 3%.



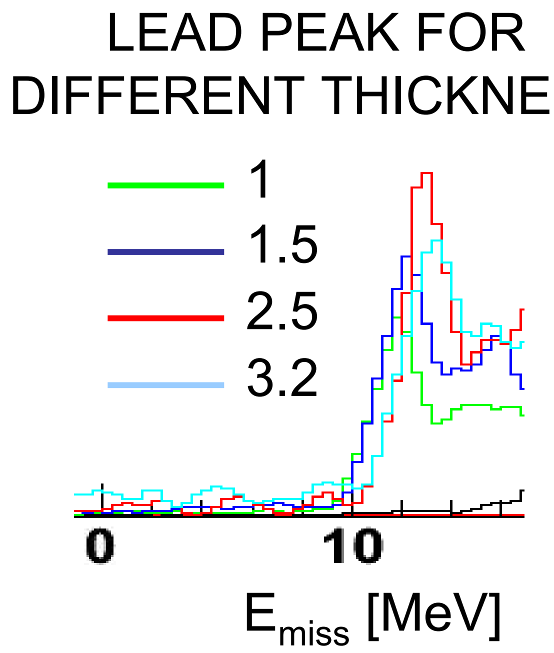
3. DATA ANALYSIS: Radiative Correction

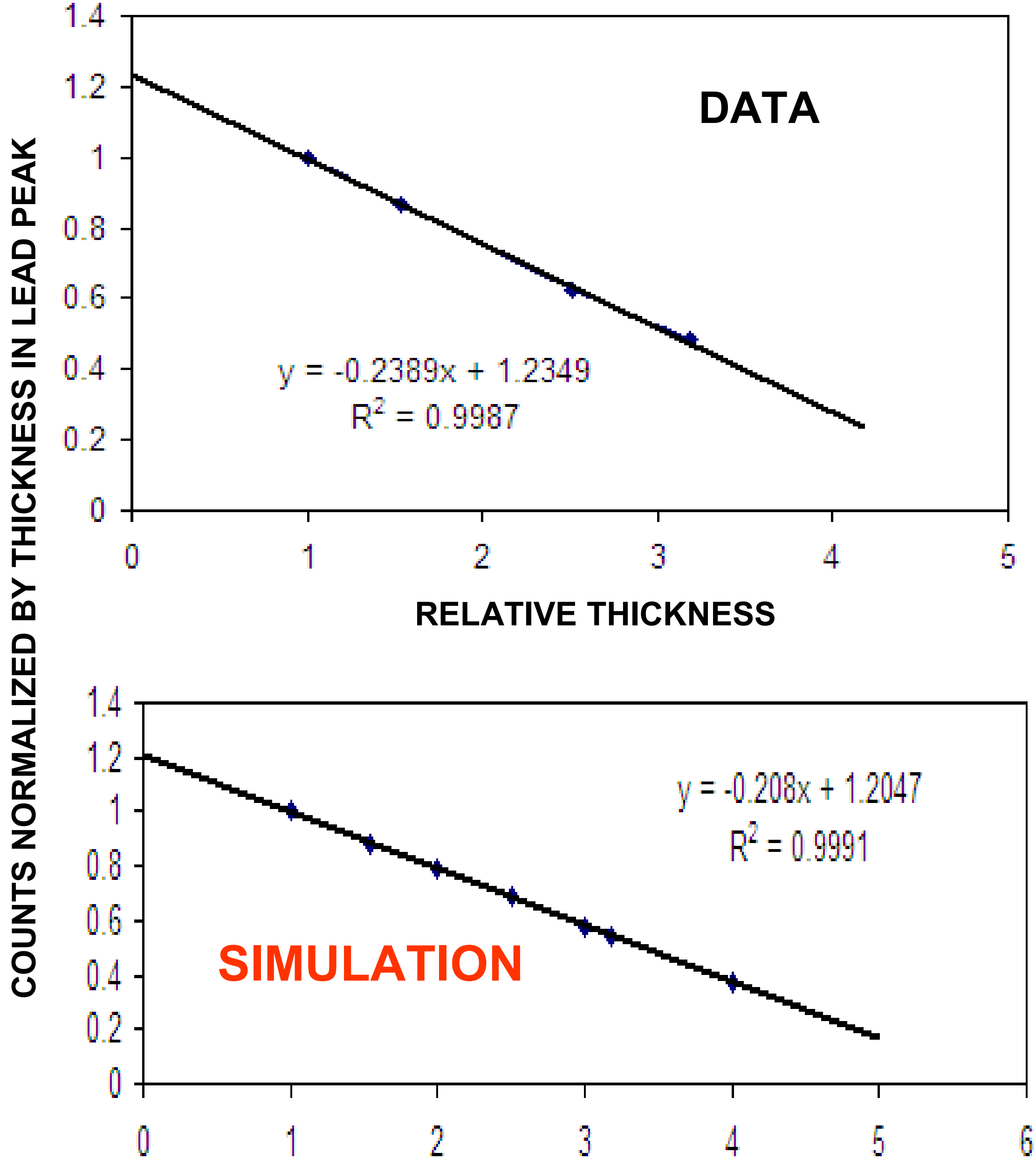
3) During the experiment one of our C+Pb+C targets was damaged. <u>This allows checking radiative corrections with different target thickness.</u>

Each region in the damaged target has a different amount of Lead and the same amount of Diamond. Lead Thickness can be estimated both from the additional Energy Loss and from the additional random coincidences. The agreement between both methods is quite good (below 10%).



3. DATA ANALYSIS: Radiative Correction



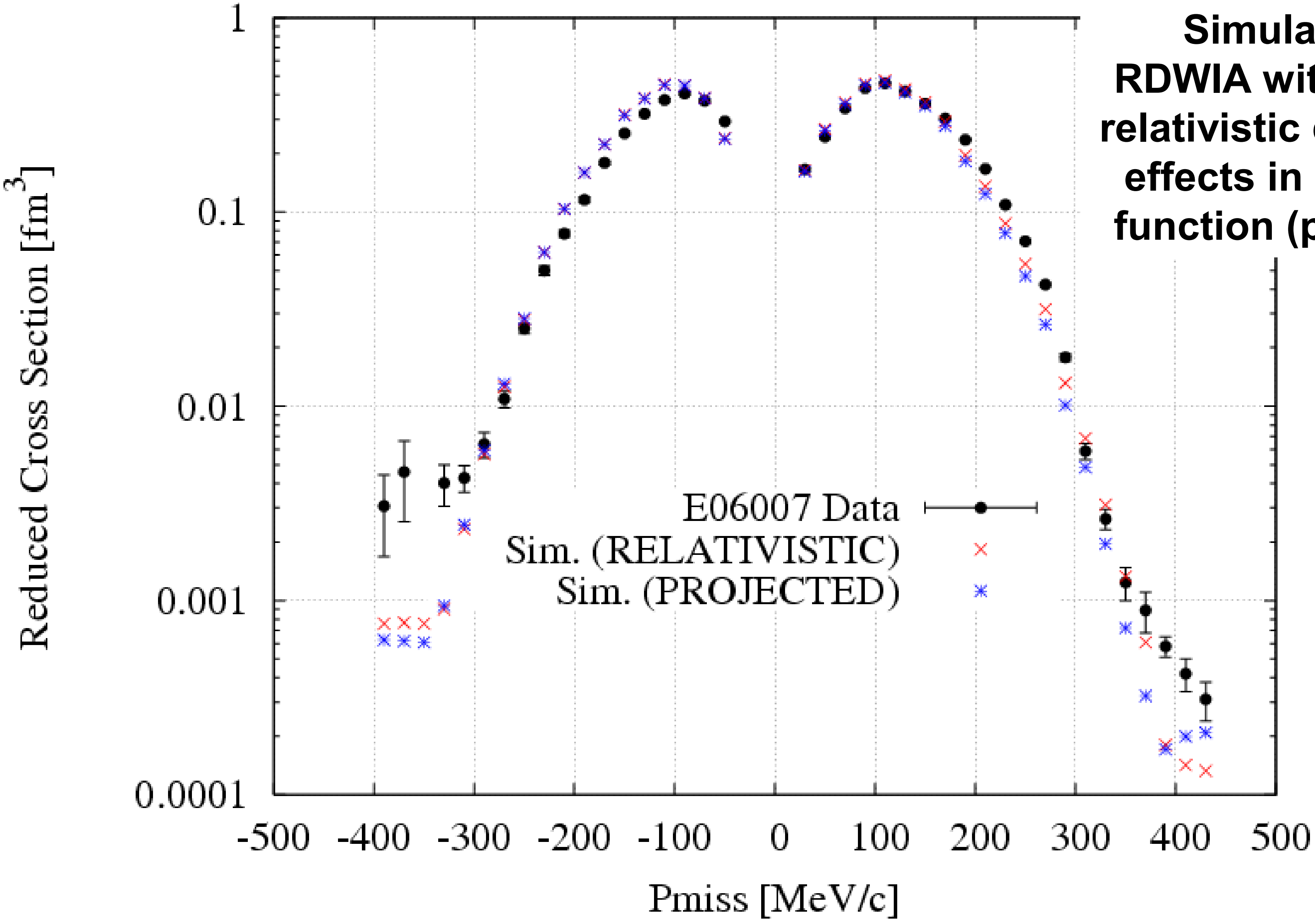


- The number of counts in the lead peak normalized by the target thickness decreases with the thickness due to external radiation.

- Data and simulations show a similar behavior.

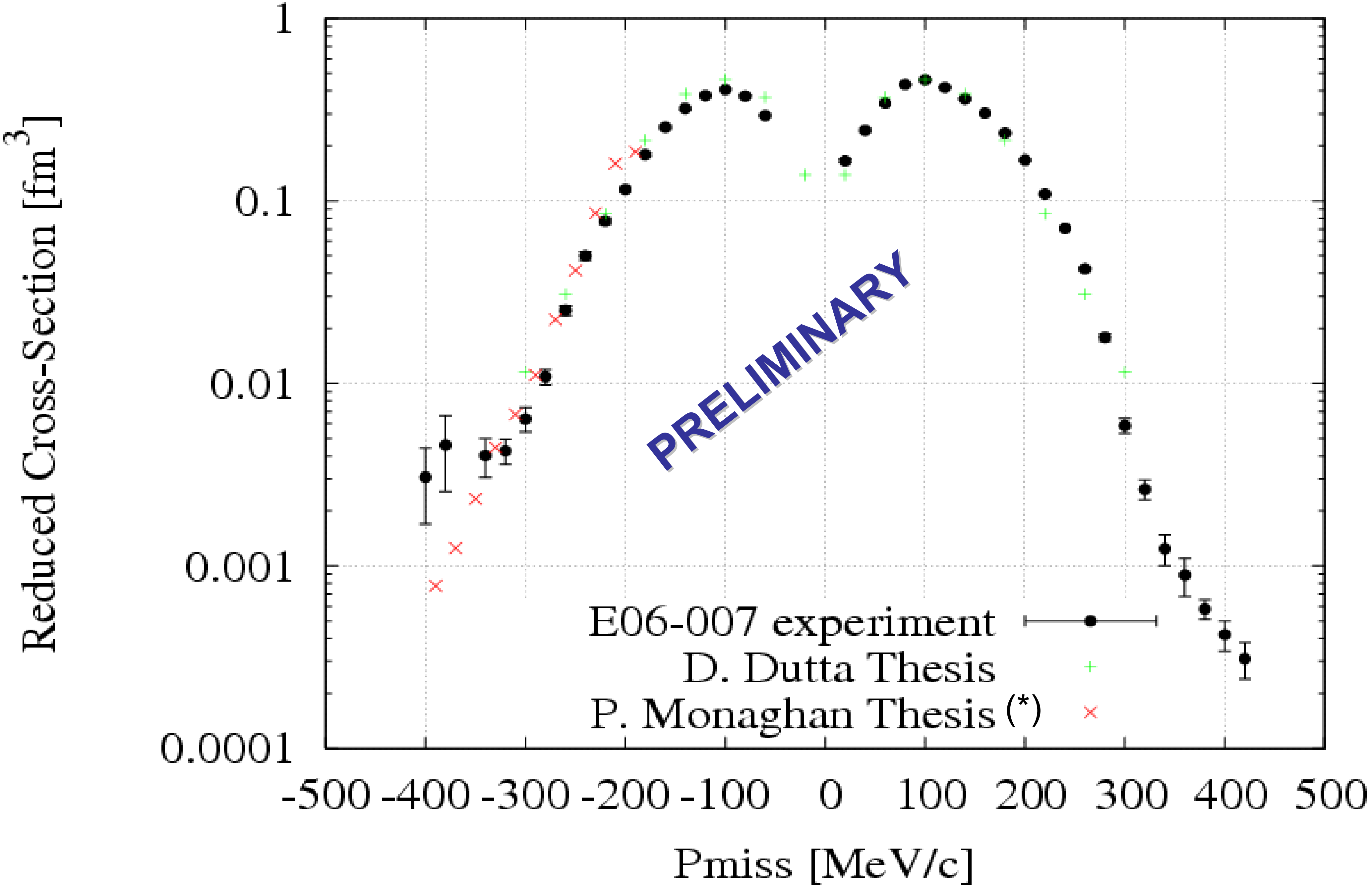
RESULTS

4. RESULTS: $^{12}C(e,e'p)$ REDUCED CROSS-SECTION

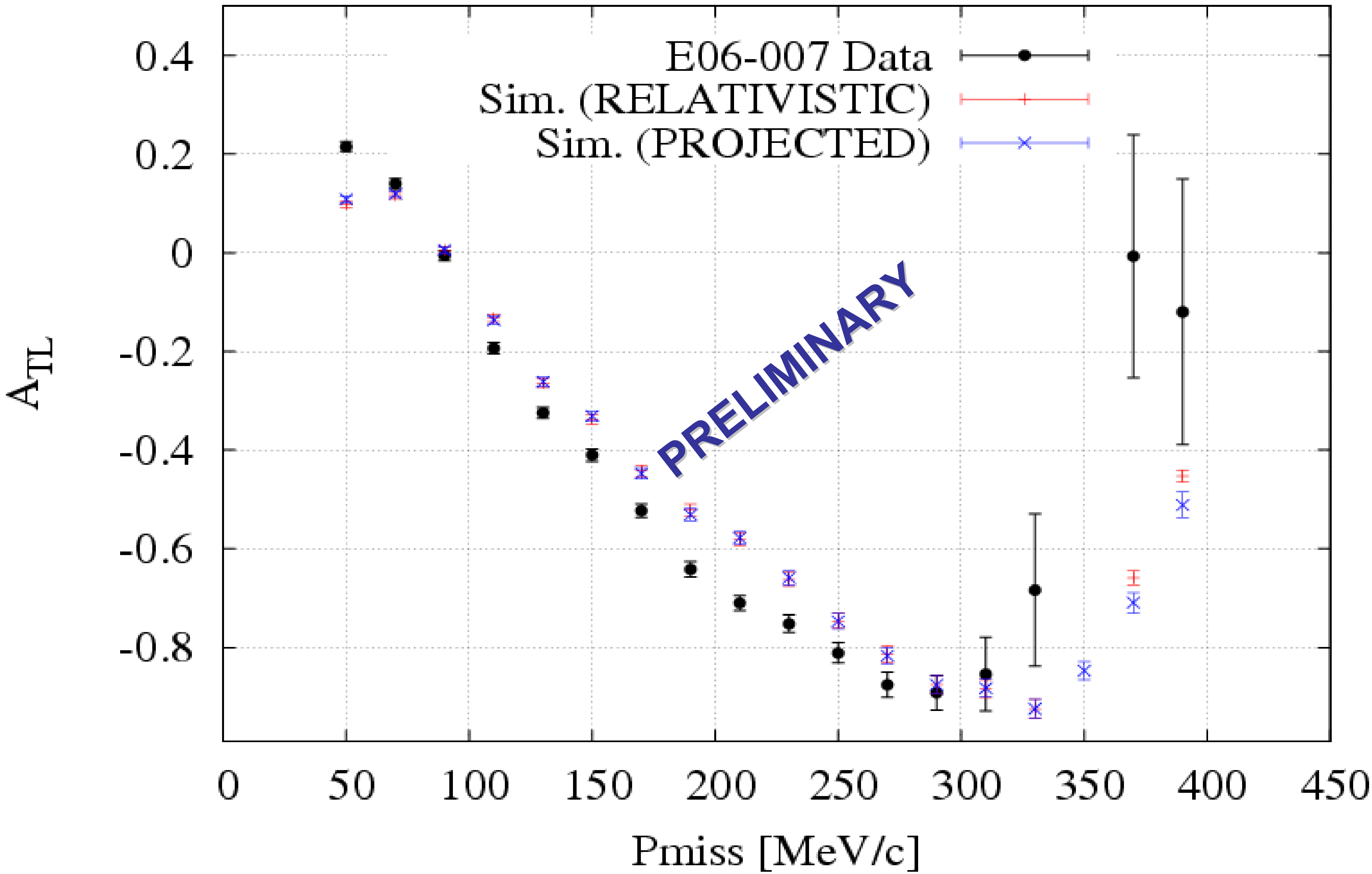


Simulations:
RDWIA with and w/o relativistic dynamical effects in the wave function (projected)

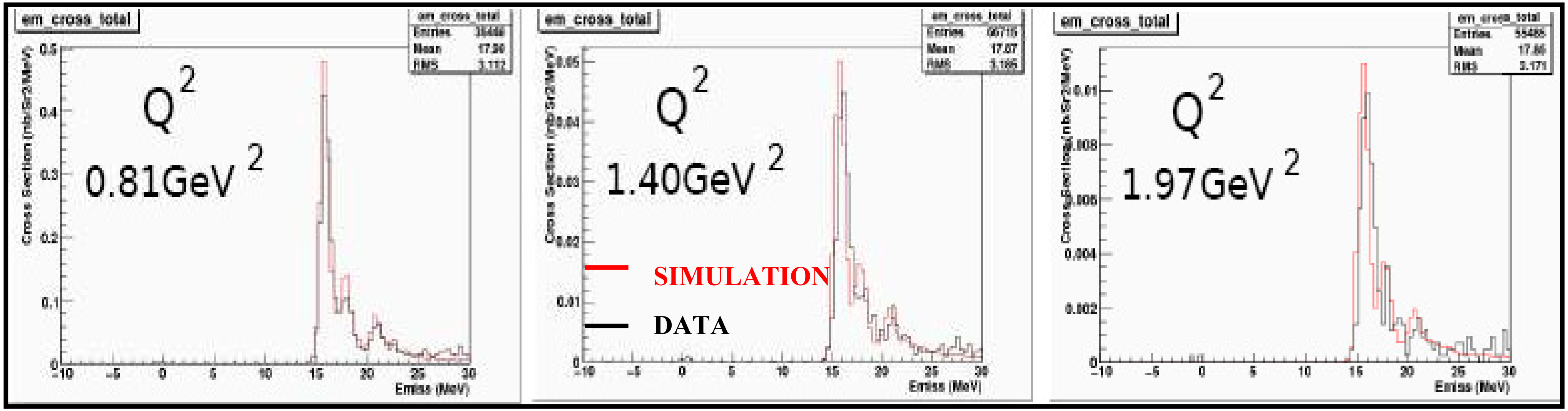
4. RESULTS: $^{12}C(e,e'p)$ REDUCED CROSS-SECTION COMPARATIVE WITH PREVIOUS EXPERIMENTS

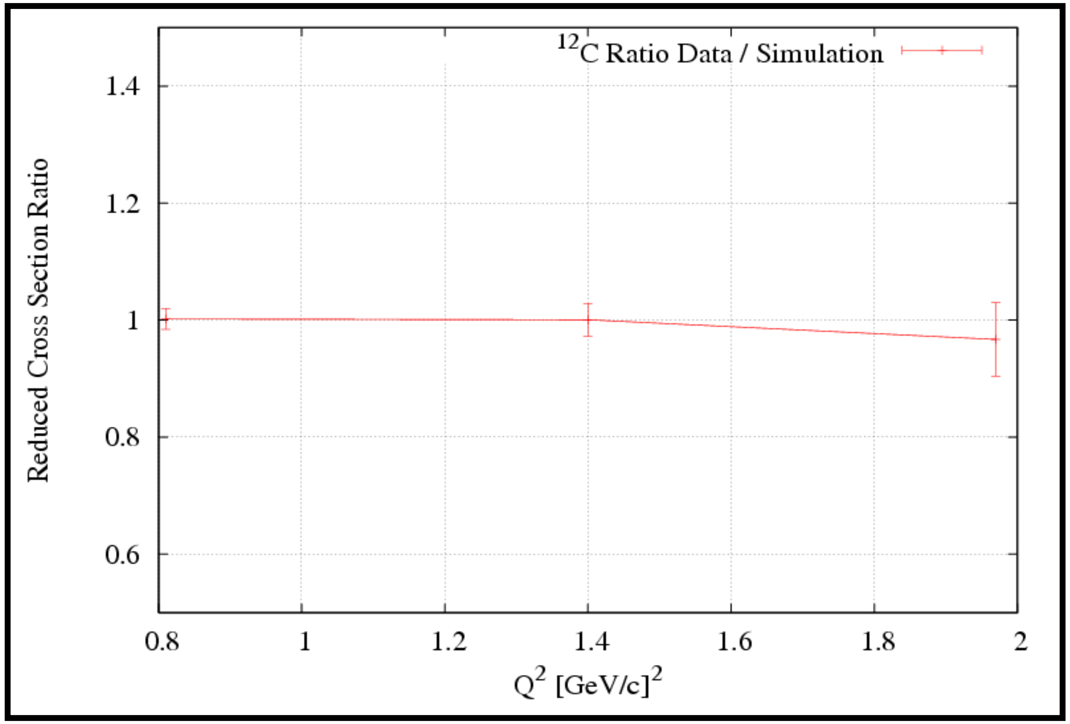


4. RESULTS: $^{12}C(e,e'p)$ A_{TL}



4. RESULTS: Study of dependence with Q^2 in ^{12}C

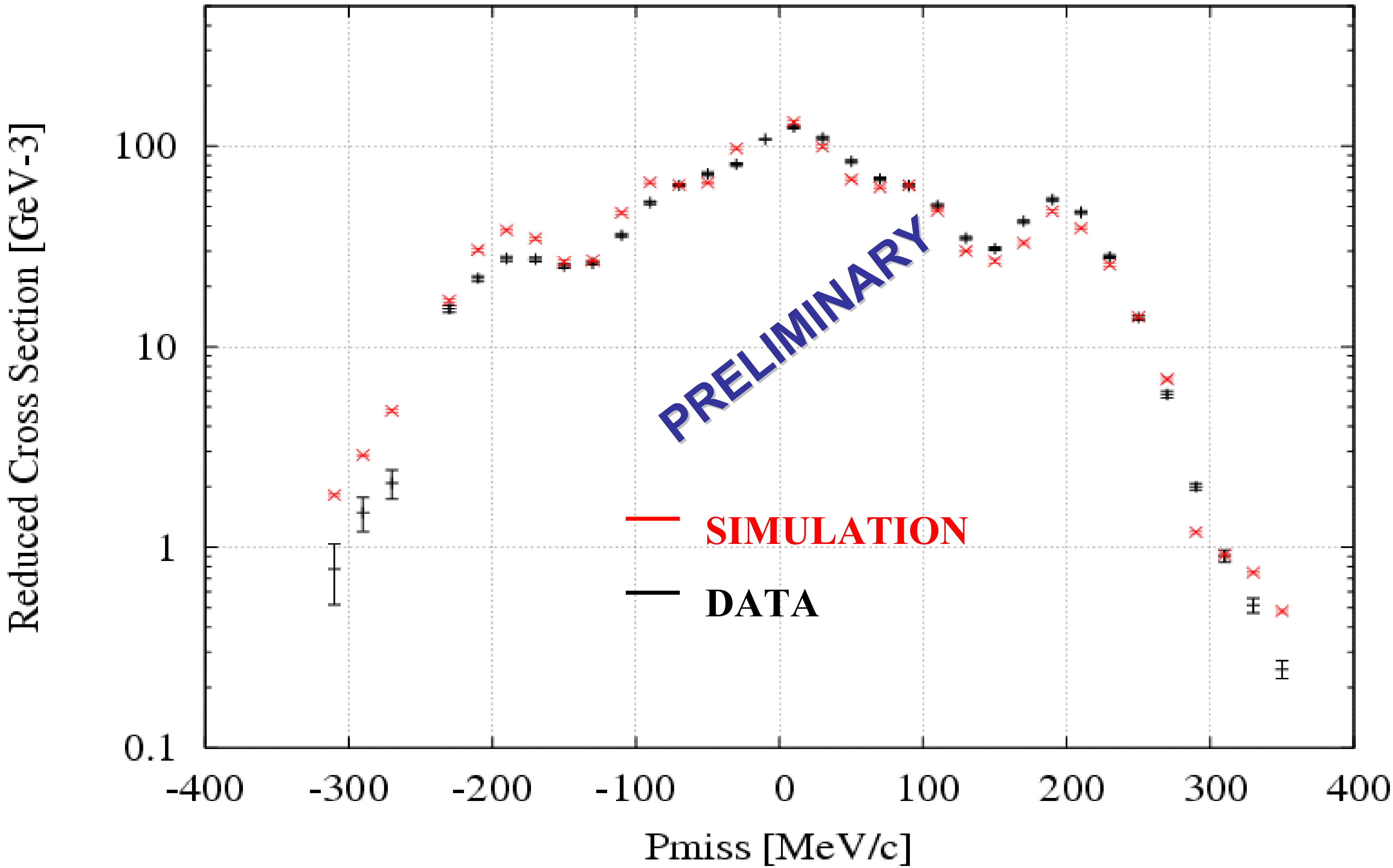




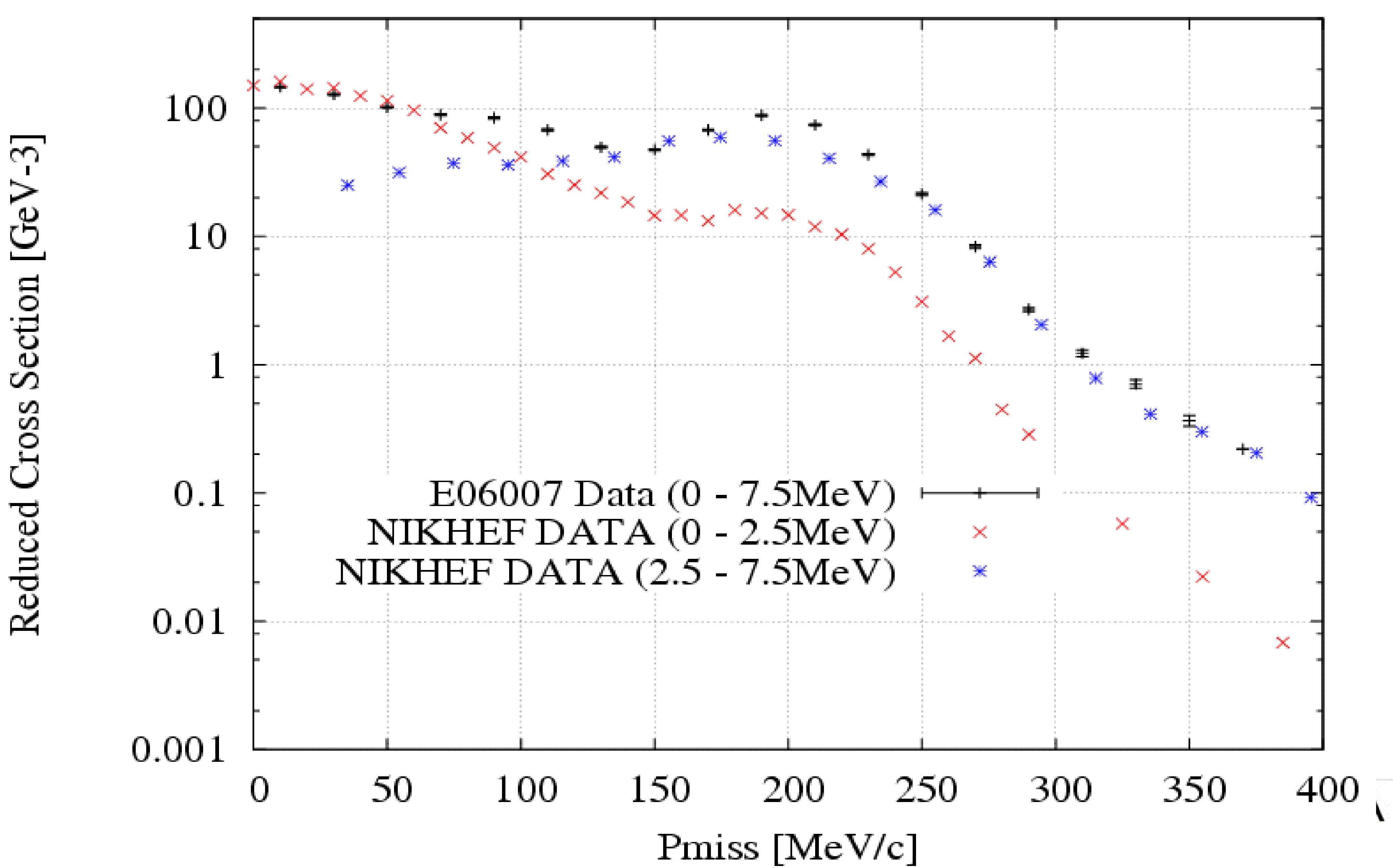
Reduced cross-section for the $1p_{32}$ shell (Emiss=[14-23] MeV) in $^{12}C(e,e'p)$ are independent of Q^2

No need to adjust simulation for the experiments at different Q^2 within error bars (5%)

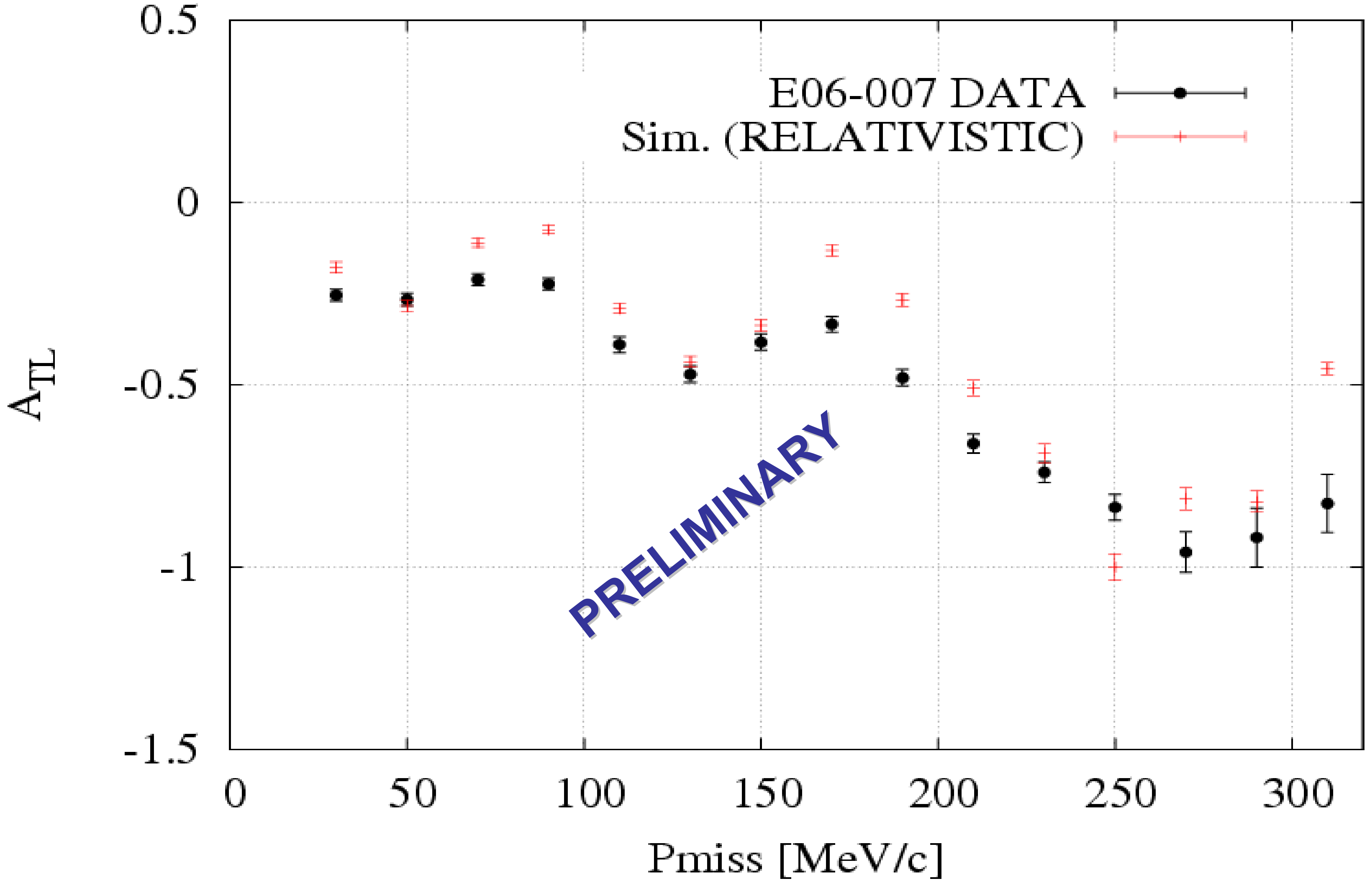
4. RESULTS: $^{208}Pb(e,e'p)$ RED. CROSS-SECTION (Emiss region –Ex=0..7.5MeV-)



4. RESULTS: ^{208}Pb(e,e'p) RED. CROSS-SECTION COMPARATIVE WITH PREVIOUS EXPERIMENTS



4. RESULTS: ^{208}Pb(e,e'p) A_{TL}

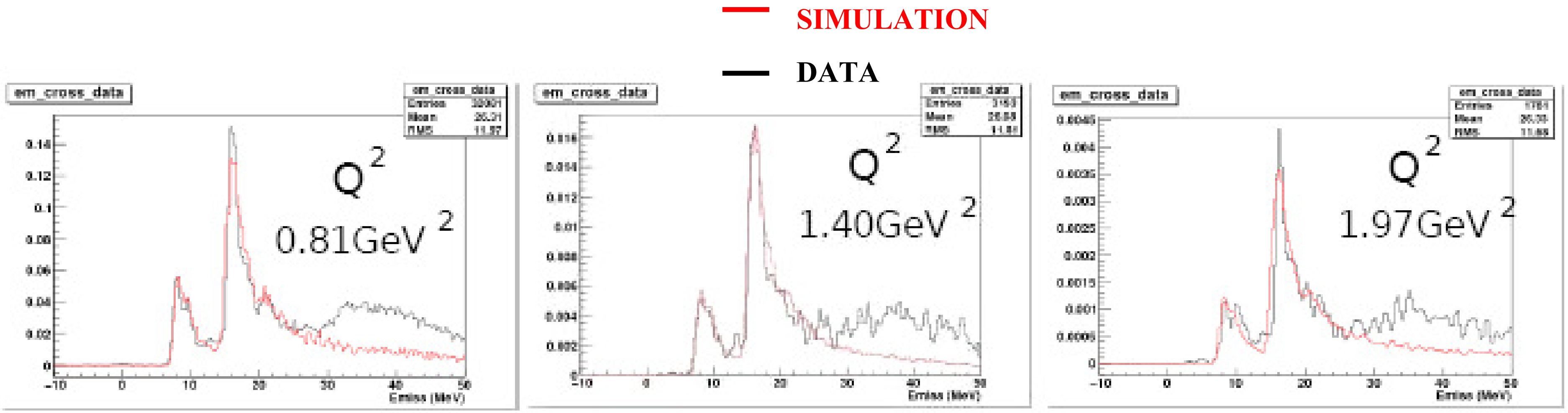


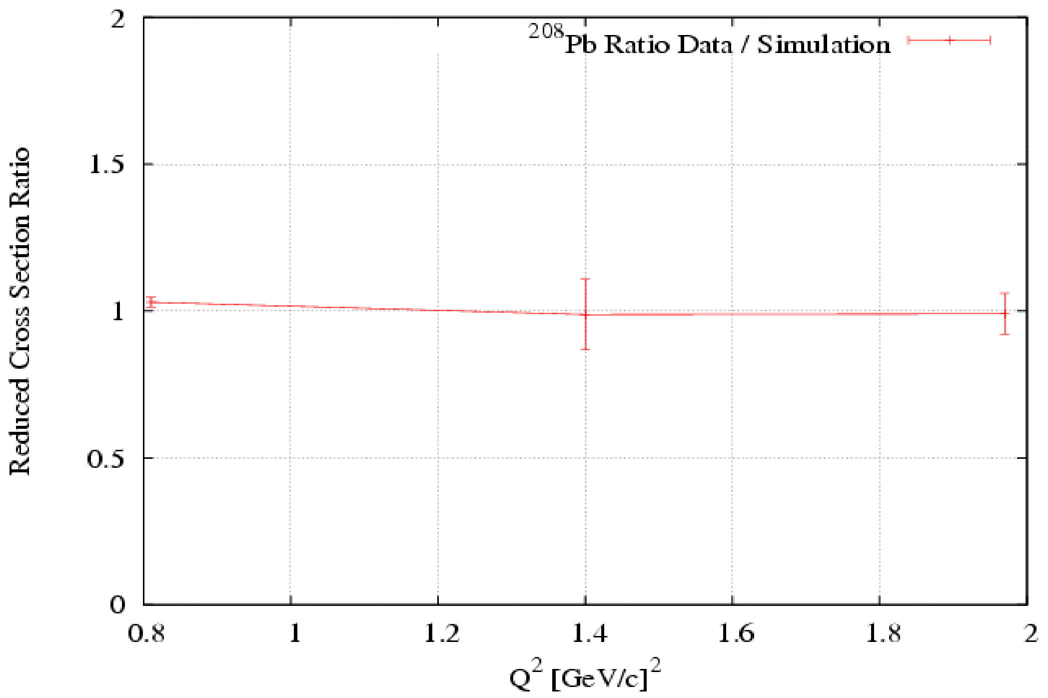
4. RESULTS: ^{208}Pb(e,e'p)

Study of dependence with Q^2 in 208Pb

pmiss = 0 MeV/c

LEAD





Reduced cross-section for the valence states in ^{208}Pb(e,e'p) are also independent of Q^2

5. CONCLUSIONS

☑ Most of the data analysis of E06-007 experiment has already been done and preliminary results have been obtained.

☑ These preliminary results are in good agreement with both previous experiments and Monte Carlo simulations based on RDWIA calculations.

CARBON:

☑ These results shows that there is no significant dependence of spectroscopic factors with Q^2.

☑ The A_{TL} in ^{12}C has the expected shape.

LEAD:

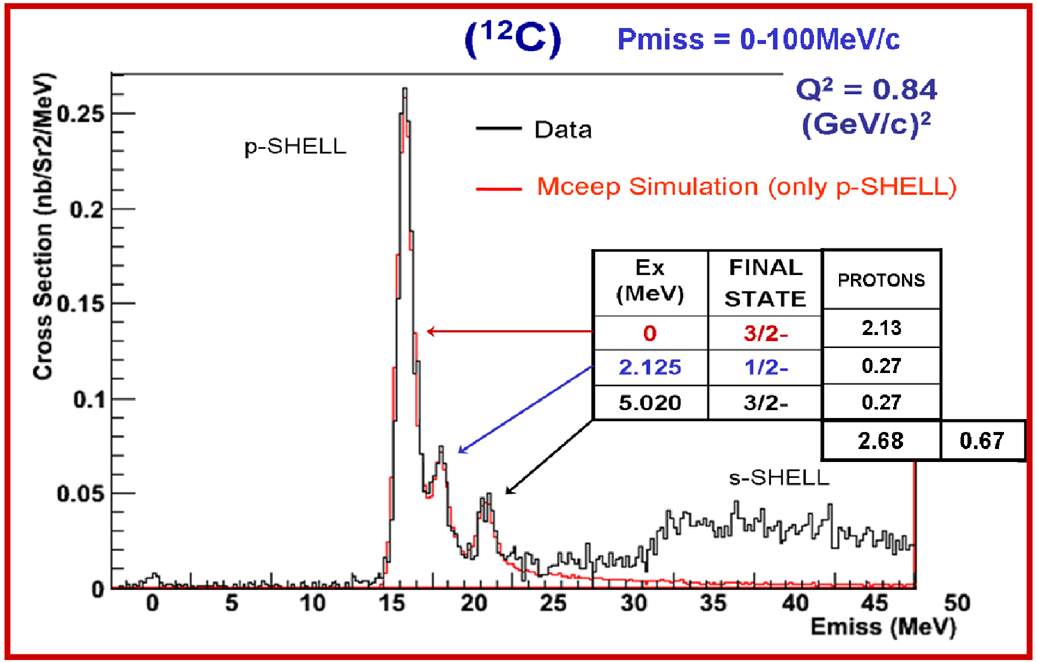
☑ Lead data also shows that there is no significant dependence of spectroscopic factors with Q^2.

☑ Simulations obtained from just relativistic mean field calculations (without long-range correlations included) seem to compare fairly well with data at both low and high missing momentum.

☑ These results will be checked in more detail in the following months. Specially the radiative corrections and different theoretical models will be studied.

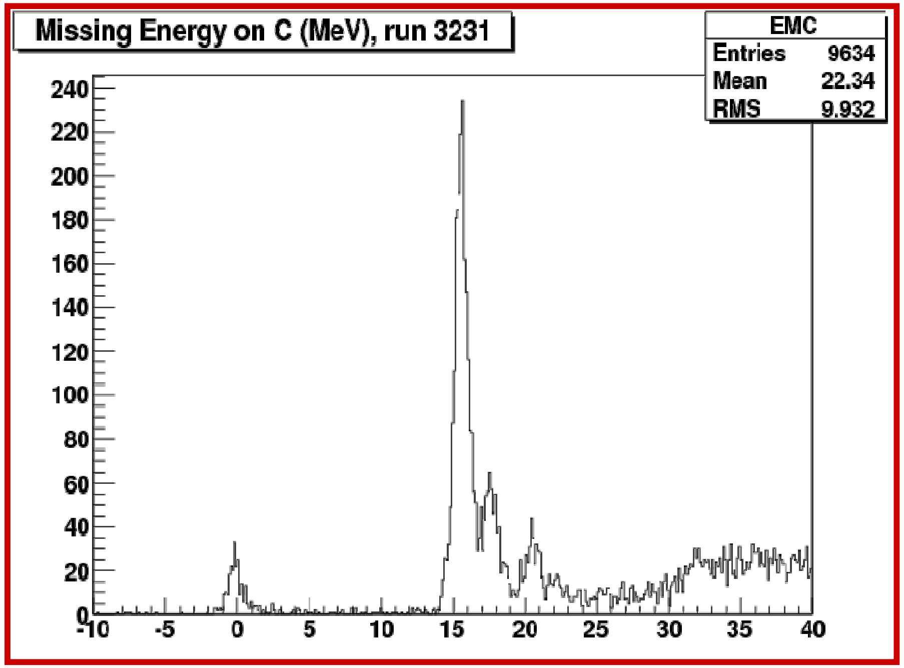
THANK YOU!

HYDROGEN



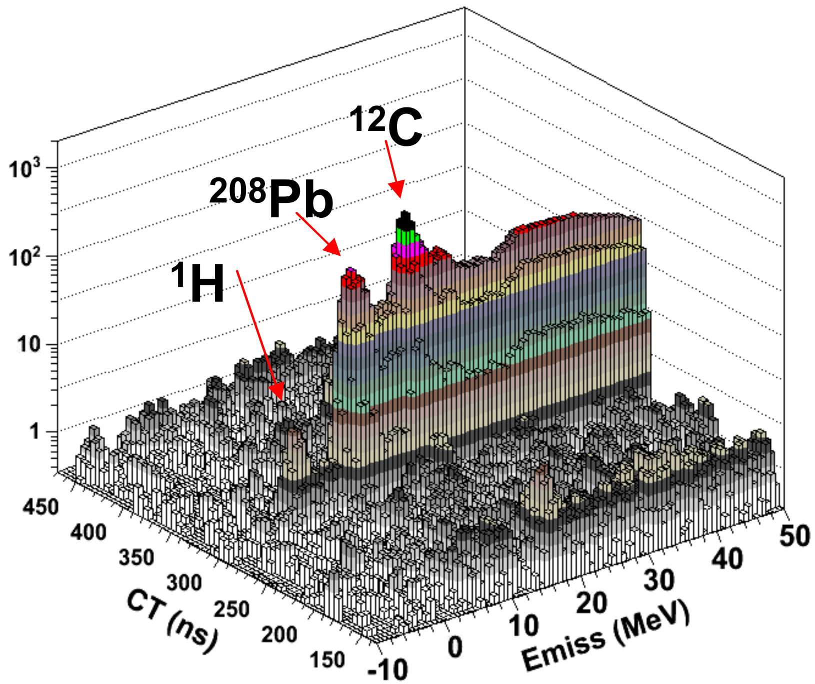
Ex (MeV)	FINAL STATE	PROTONS	
0	3/2-	2.13	
2.125	1/2-	0.27	
5.020	3/2-	0.27	
		2.68	0.67

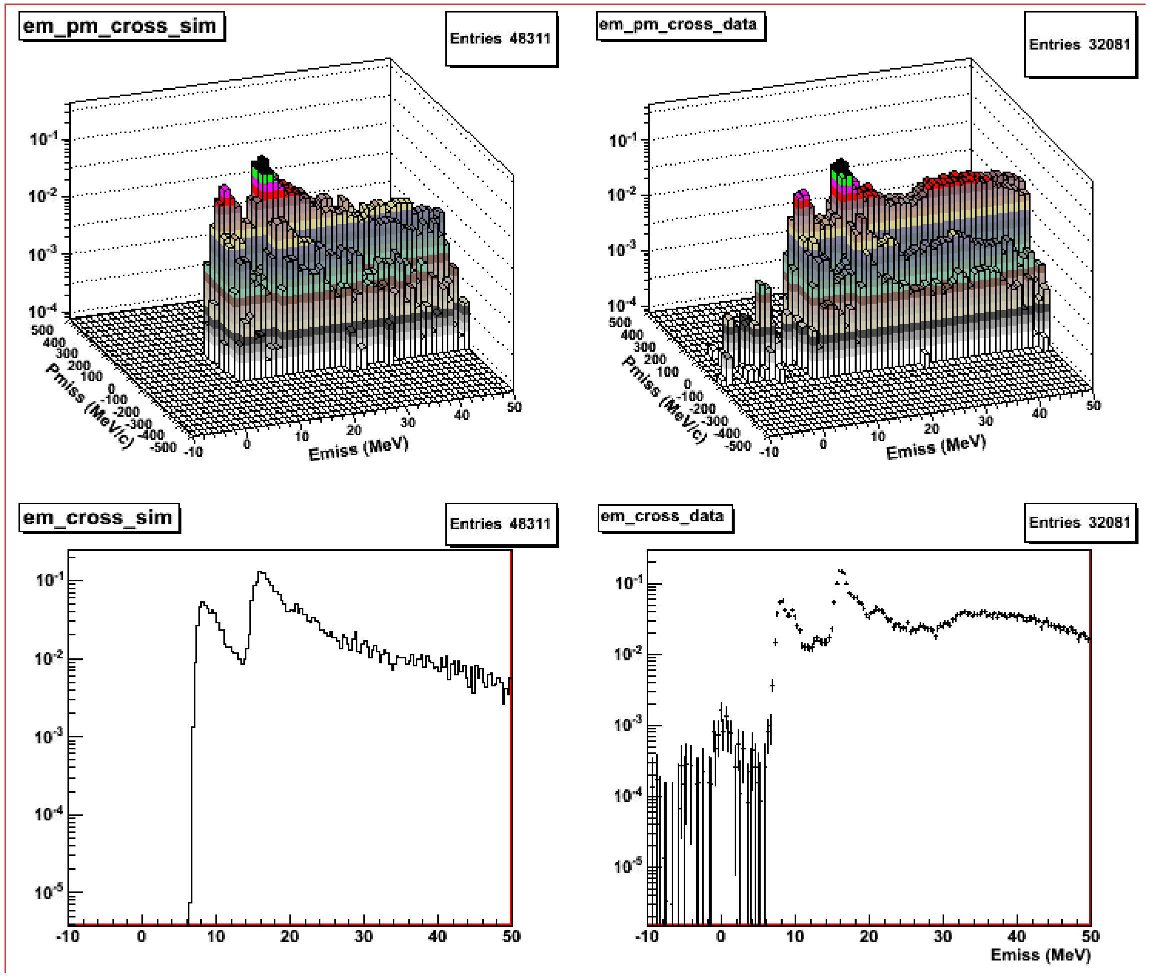
HYDROGEN IN
GRAPHITE TARGET
RUN 1 (MARCH 07')



HYDROGEN IN
GRAPHITE TARGET
RUN 2 (JAN08')

HYDROGEN IN THE EXPERIMENT





HOW MUCH HYDROGEN IS THERE?

- **LEAD TARGET:**

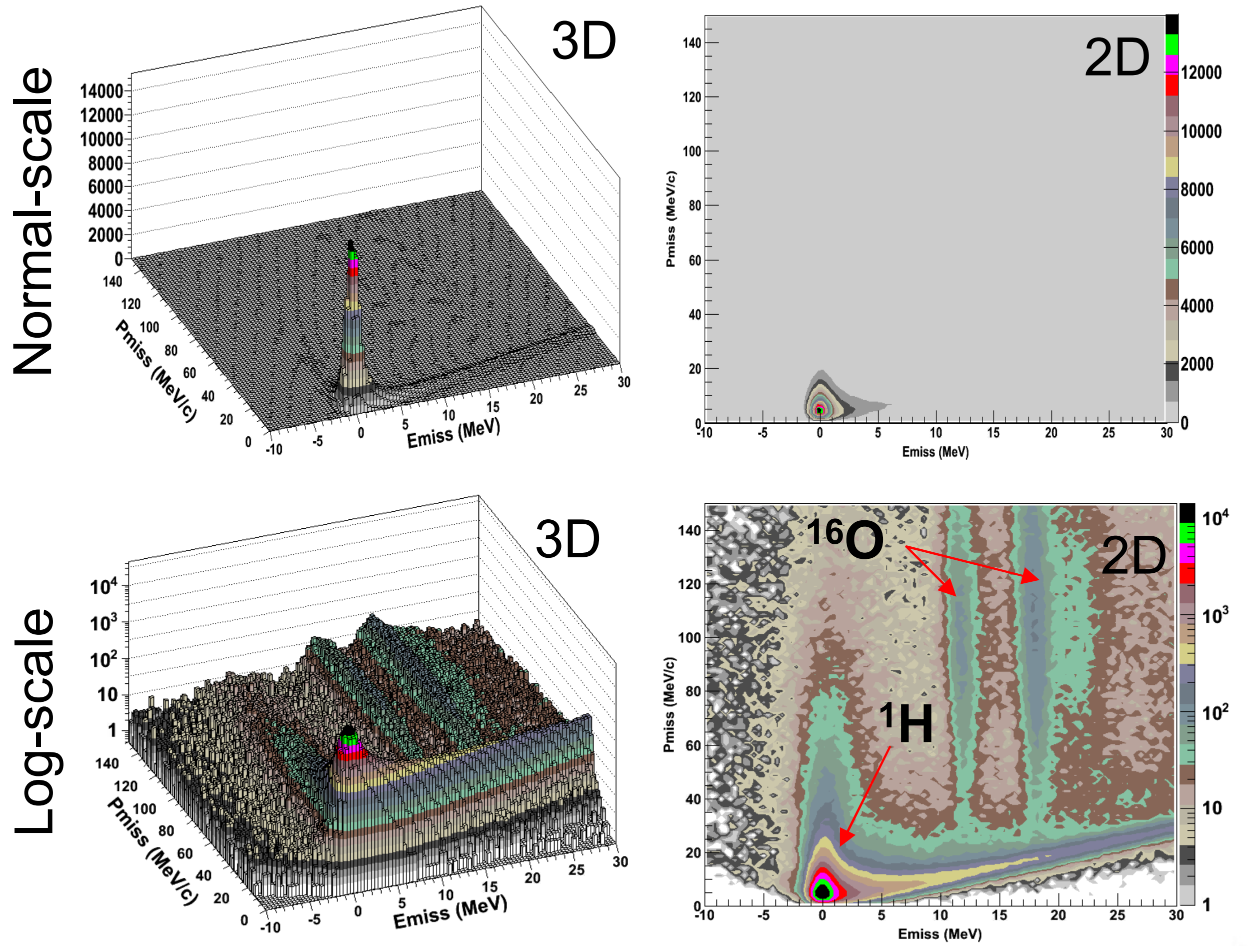
  $Nuclei_H$ ~0.12% $Nuclei_{Pb}$ →
  $(\rho.t)_H$~5.8E-6 $(\rho.t)_{Pb}$ = 1.13E-6 g/cm^2
  t_H ~ 1E-8m

- **GRAPHITE TARGET (RUN 1):**

  $Nuclei_H$ ~0.016% $Nuclei_C$ →
  $(\rho.t)_H$~2.2E-5 $(\rho.t)_C$ = 1.9E-6g/cm^2
  t_H ~ 2E-8m

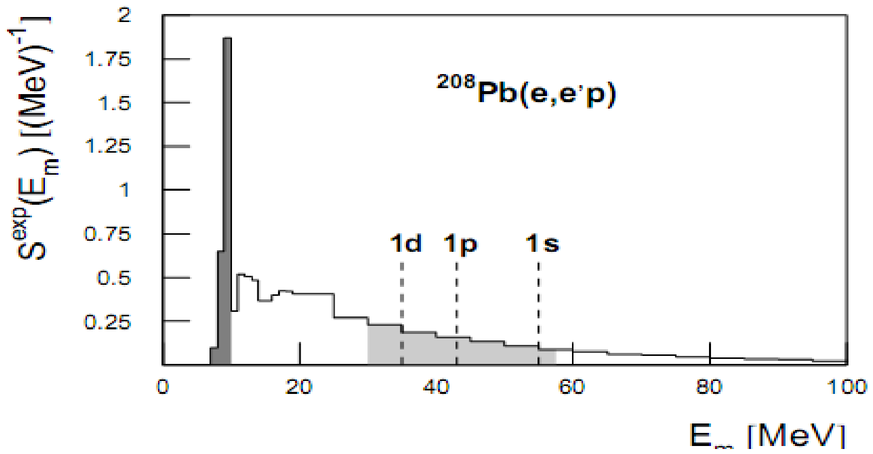
HYDROGEN AND OXYGEN IN E00-102 EXPERIMENT

EM,PM SPECTRUM FROM E00-102 EXPER.

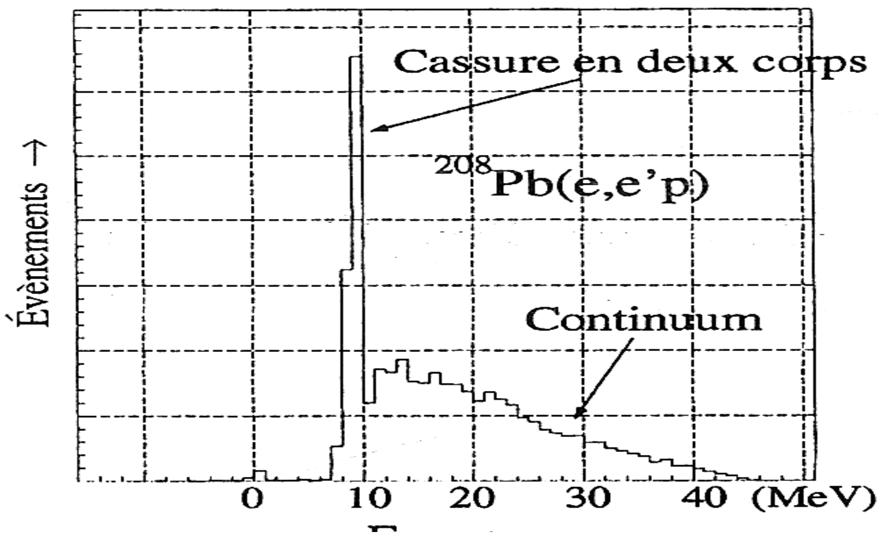


3. DATA ANALYSIS: Review

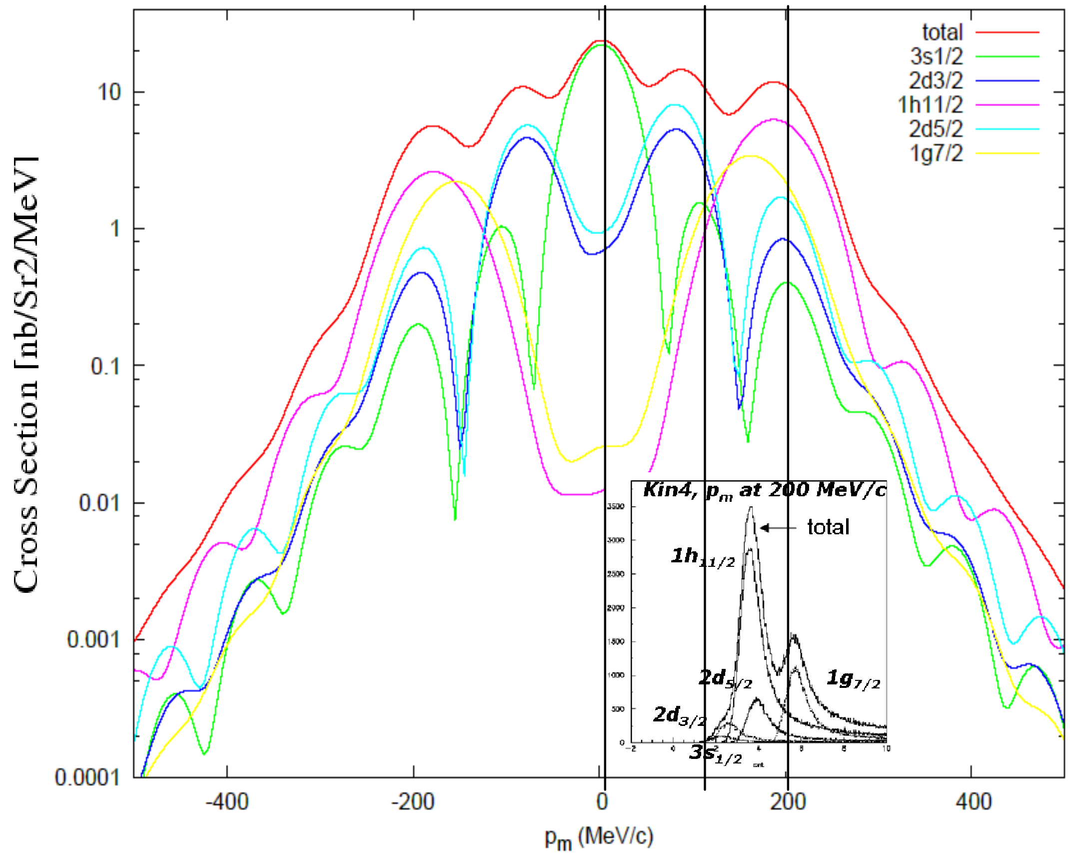
- Coincidence time Resolution: 5ns (FWHM)
- Energy Resolution (With and W/O raster): 1.05MeV – 1.1MeV (FWHM)
- Days of experiments: 20
- Number of runs / good runs (^{12}C, ^{208}Pb, ^{209}Bi): 230
- Acceptances used in the analysis: 1.024e-5 Sr^2
- Live-time (typical): 93%



Marcel van Batenburg (Thesis) - NIKHEF



Rosella Medaglia (Thesis) - SACLAY



3. DATA ANALYSIS: Radiative Correction

3) During the experiment one of our C+Pb+C targets was damaged. This allows checking rad. corrections using different target thickness.

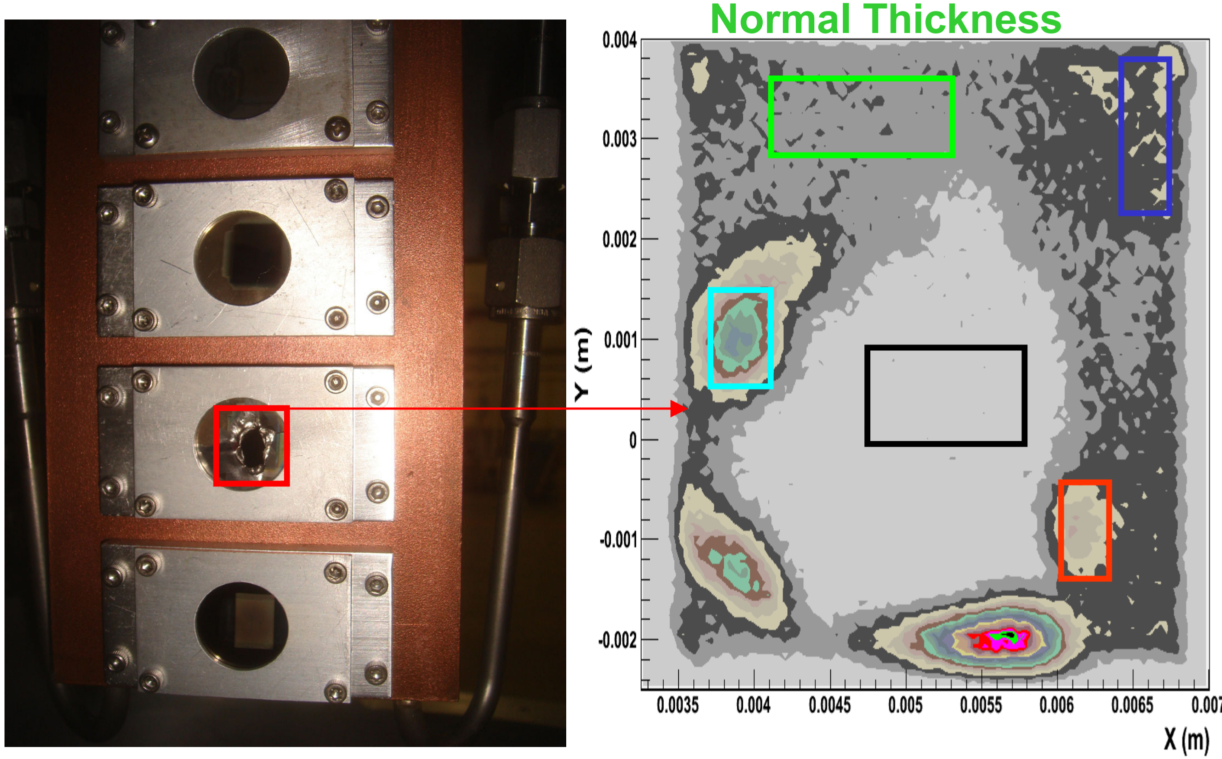
We chose several regions in the damaged target. Each of them had different amount of Lead but the same amount of Carbon.

- Lead Thickness can be obtained from the additional Energy Loss and from the random coincidences.

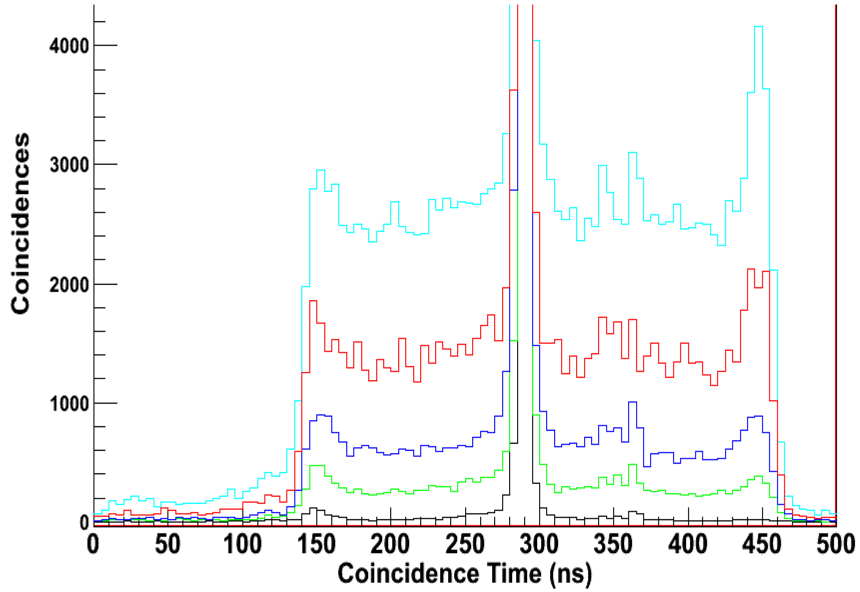
R_{Pb} = Randoms from damaged Pb

R_{Pb} = Randoms from diamond foils

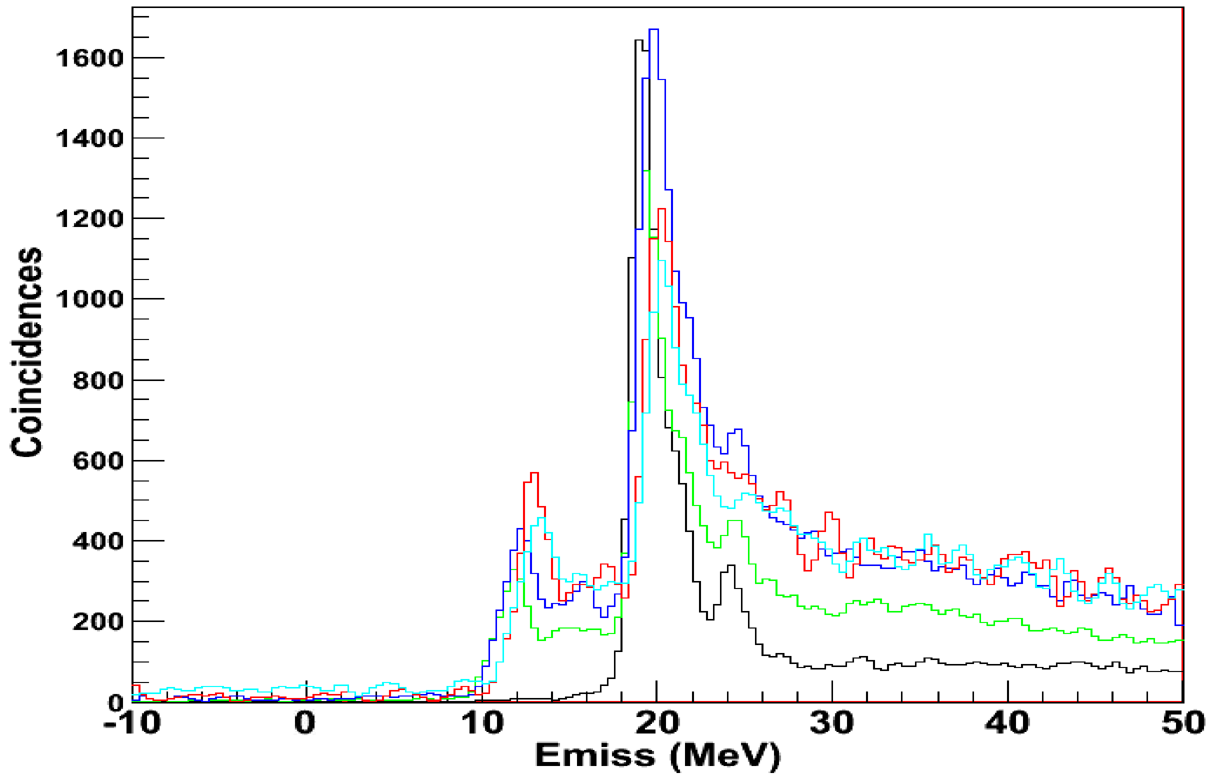
R_{Pb0} = Randoms from normal Pb



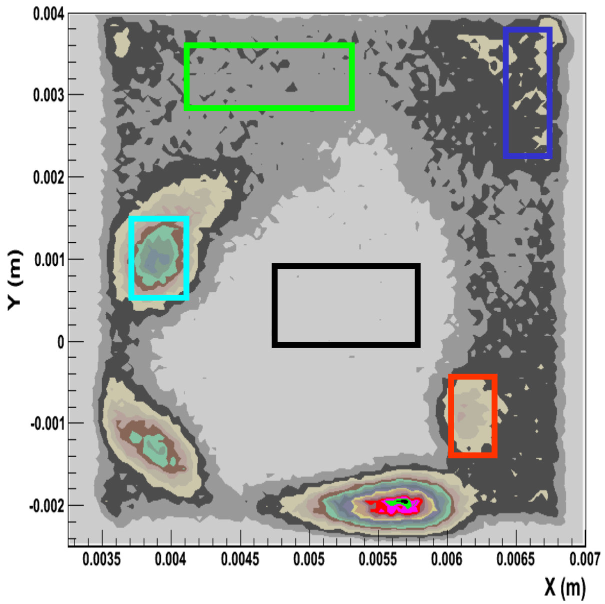
$$Thick\_Factor = \left[\frac{R_{Pb} - R_C}{R_{Pb0} - R_C} \right]^{1/2}$$



3. DATA ANALYSIS: Radiative Correction



- Simulations are being done for different thickness of Lead → Radiative corrections based on these simulations will be more reliable.



REGION	Additional Eloss (MeV)	Thickness Factor from Eloss	Thickness Factor from Randoms	Factor Thickness	Pb Thickness (g/cm^2)
1	0	1	1	1	0.1937 (measured)
2	0.358	1.56	1.52	1.54±0.02	0.2983
3	1.096	2.72	2.31	2.51±0.2	0.4862
4	1.401	3.20	3.15	3.18±0.03	0.6160