Impulse Approximation limitations to the (e,e'p) reaction on ^{208}Pb Identifying correlations and relativistic effects in the nuclear medium : Analysis Report

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Physics Goals

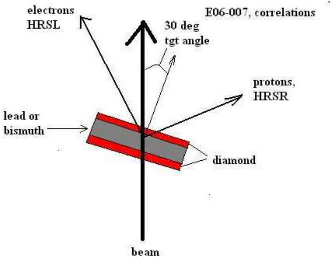
1. Long Range Correlations search and spectroscopic factors
    - Measure spectroscopic factors for states near the Fermi level. Spectroscopic factors depend on short range correlations (SRC) and long range correlations (LRC).
    - Measure cross sections for these low lying states to 500 MeV/c in P_{miss}. Excess strength here is theoretically identified as due to LRC.
    - Search for Q^2 dependence of spectroscopic factors
2. Identify dynamical relativistic effects in nuclear structure. Measure cross section asymmetry A_{TL} around the three momentum transfer. Relativistic mean field theory predicts an A_{TL} dependence on $P_{miss} < 300(MeV/c)$ due to dynamical enhancement of the lower component of the nucleon wave function. Calculations which do not include the enhancement of the lower component predict a substantially different A_{TL} behavior.

The Experiment

- Used doubly magic ^{208}Pb target
- Also had ^{209}Bi and ^{12}C targets.
- Measure the $^{208}\mathrm{Pb}(e,e'p)^{207}\mathrm{Tl}$ cross sections
- Collected data at both sides of q: $0 \leq P_{miss} \leq 500(MeV/c)$
- Had true quasi-elastic Kinematics with $X_B \approx 1, q = 1(GeV/c), \omega = 0.433(GeV)$
- Studies of Q^2 dependence on spectroscopic factors for $P_{miss} = 0$ were performed at three Q^2 points
- Had two separate runs, Run 1 on March 2007 and Run 2 on January 2008
- Run 2 had a thick and thin lead target

Challenges to Experiment

- Lead and Bismuth melt under intense beam.
- Required high beam current for luminosity
- To prevent melting, Lead and Bismuth were sandwiched by two diamond foils.
- As a result Carbon was present in all Lead and Bismuth spectra



Challenges to Experiment: Requirements

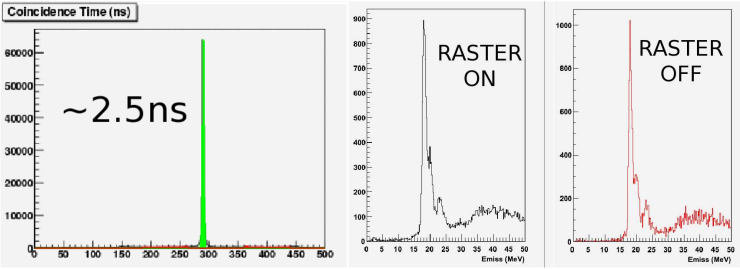
- Good energy resolution
  GEANT simulations show resolutions for a perfect spectrometer to be 1 (MeV) at FWHM.
  (to separate individual states)
- Good raster correction
  (^{208}Pb and ^{209}Bi required large raster)
- Good knowledge of $^{12}\mathrm{C}(e,e'p)^{11}\mathrm{B}$ cross sections
  (diamond foil in ^{208}Pb and ^{209}Bi targets)
- Good knowledge of luminosity
  (no hydrogen in targets to monitor luminosity)
- Good coincidence time
  (to get rid of random coincidences in high P_{miss} kinematics)

Achieved Goals: Run 1

A great expenditure of effort has been made in:

- ✓ Establish the raster correction
- ✓ Improving the coincidence time (~ 2.5ns)
- ✓ Improving the optics database

This part of the analysis is almost finished and we obtain reasonable good resolution.



Optics Optimization

- Elastic ^{12}C$(e, e'p)$ data was used for the optics calibration
- Instead of using optimize++, a genetic algorithm, developed by Udias et al.[1], was applied.
- This way all the database coefficients of a variable could be obtained at the same time.
- Genetic algorithms are more powerful than just gradient minimization alone.
- The code, written in Fortran, is, as of yet, not well documented to be shared, but hopefully will be in the future.

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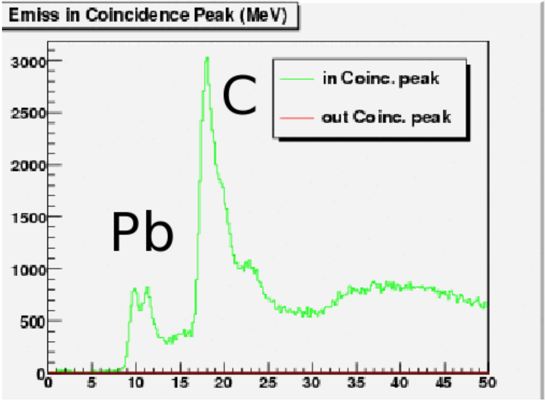
[1] C. Fernández-Ramírez, E. Moya de Guerra, A. Udías, and J. M. Udías. Phys. Rev. C **77**, 065212 (2008)

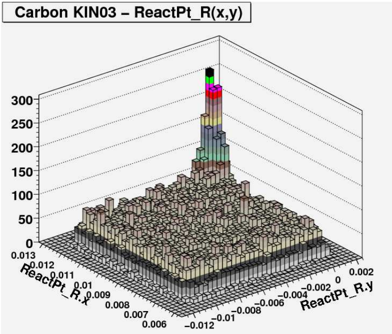
Optics Optimization

- With the optimized database and with the appropriate raster correction, good resolution has been achieved.
- Though, it is finite, so we are only able to see two peaks



Charge Normalization

- In this experiment, no Hydrogen was present to monitor the charge, so we have to be confident of the beam current incident on the target.
- Large raster hit on the target frame on some runs, and required us to compute the effective charge after cuts were applied to remove these regions.



Simulations

- Due to the finite experimental acceptances, the data cannot be compared directly with theory, which is obtained from central kinematical parameters)
- As such, we used monte carlo simulations to compare the data with the theory averaged through the experimental acceptances.
- Simulations were performed with:
  - GEANT: Cross sections from factorized calculation with spectral function from Udías et al.
  - MCEEP: Cross sections using RDWIA response functions from Udías et al.

Cross Sections for $(e, e'p)$

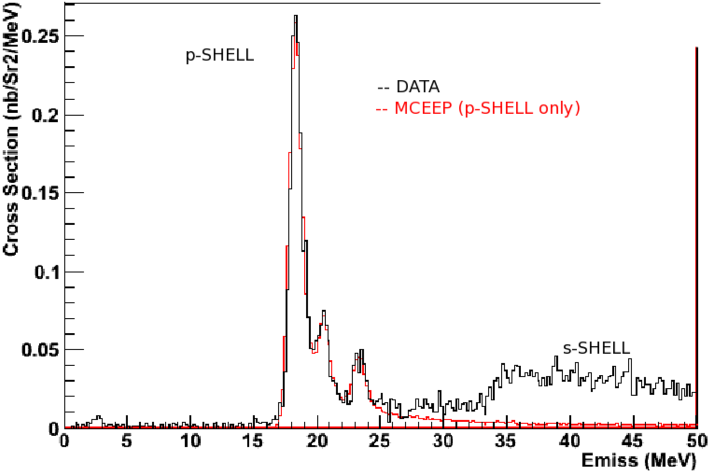
- At the moment only a single bin in $(\omega, q, P_{miss}, \phi)$ has been used for each kinematics.
- This will be improved on in the near future, with the goal of binning the data (and the simulation) in physical variables $(\omega, q, P_{miss}, \phi)$.

$$\frac{d^5\sigma}{d\Omega_e d\Omega_p dE_f} = \frac{N_s f_s}{\Delta\Omega_e \Delta\Omega_p \Delta E_f L}$$

where f_s is the correction to the number of counts, so far being only N5/T5. This will be improved in the future. L is our luminosity which takes into account the effective charge, and Δ_e is the electro energy range.

PRELIMINARY Results for ^{12}C, $P_{miss} = 0$

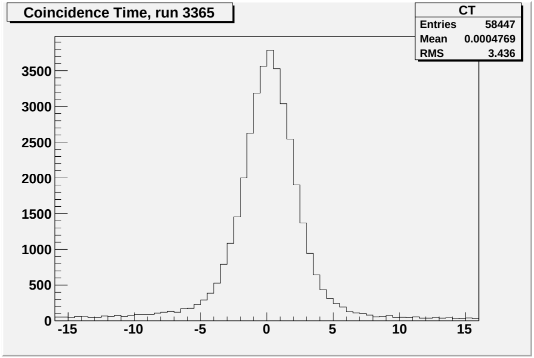
$Q = 0.84(Gev/c)$, showing MCEEP with ($E_x(MeV)$,final state) = $(0,3/2^-)$, $(2.125,1/2^-)$, $(5.020, 3/2^-)$



Achieved Goals: Run 2

PRELIMINARY

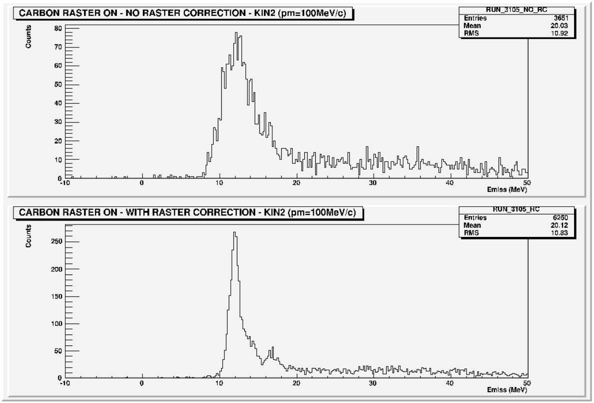
- ✓ Improved coincidence time down to 4ns at FWHM. Expecting improvements



Achieved Goals: Run 2

PRELIMINARY

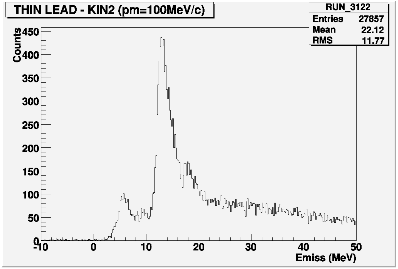
- ✓ Improved coincidence time down to 4ns at FWHM. Expecting improvements
- ✓ Promising initial raster corrections



Run 2 Beginnings

PRELIMINARY ONLINE SPECTRA

- Thin Lead seems a little decent since the start

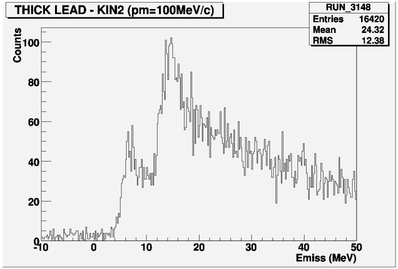


PRELIMINARY

Run 2 Beginnings

PRELIMINARY ONLINE SPECTRA

- Thin Lead seems a little decent since the start
- Thick lead will need more work



PRELIMINARY

Run 2 Beginnings

PRELIMINARY ONLINE SPECTRA

- Thin Lead seems a little decent since the start
- Thick lead will need more work
- Things should look better in the future

What's next?

- Complete analysis of Run 2 data
- Theory simulations must be tuned to simulate as much as possible the experimental conditions.
- Radiation in the simulation has to be checked.
- Recheck efficiency corrections of the data to establish final systematic errors
- Compare results from single carbon foil to diamond foil in data
- Explore options to extract carbon spectra from ^{208}Pb and ^{209}Bi data