Short Range Correlations at x>2: E08-014 Analysis Update

Zhihong Ye

University of Virginia

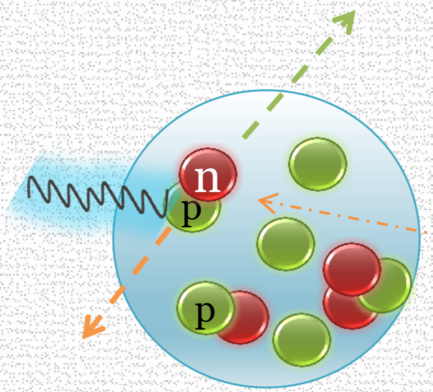
Hall-A Winter Meeting, Dec. 10th 2012

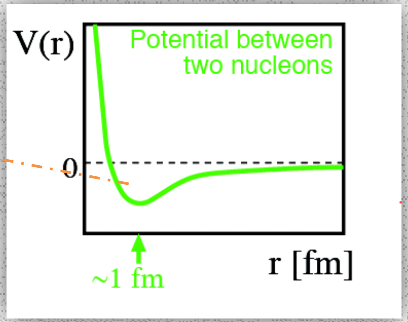
UNIVERSITY of VIRGINIA

Jefferson Lab

Probe SRCs using A(e, e')

Problem: Mean Field Effect only takes charge for nucleon at low momentum, and cause the missing strength (30-40%) at high momentum.

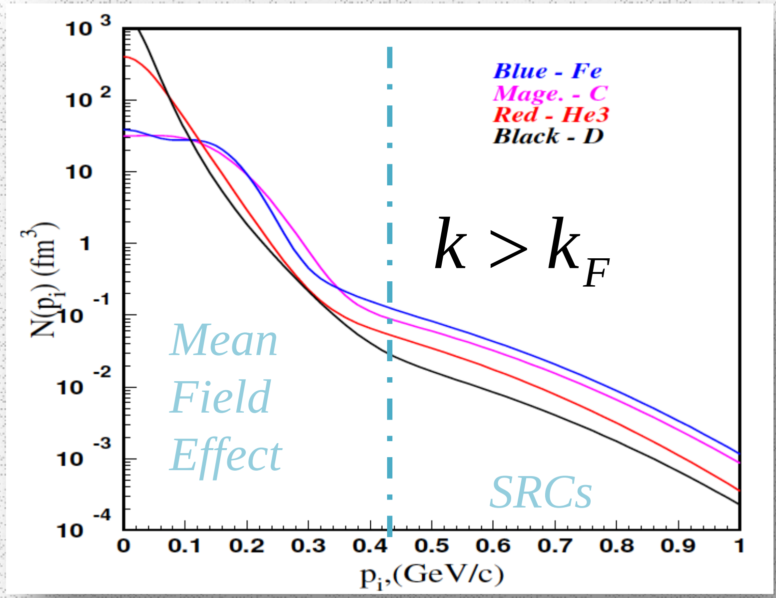




Fact: Nucleons generate high relative momenta, when they become too close.

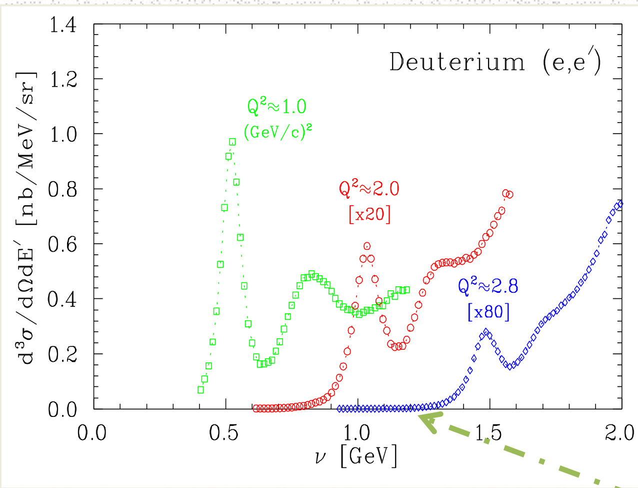
SRCs:

- Strong interaction of nucleon pairs or cluster with high relative momenta.
- Attribute to the missing strength.
- Dominate the high momentum tail.
- Similar shape for nuclei with varying A
- Isospin dependent?



Probe SRCs using A(e, e')

- **Inclusive Q-E Scattering Cross Section Measurement**



$$x_{bj} = \frac{Q^2}{2m_p \nu} \leq A, \quad \begin{cases} x_{bj} < 1 & \textit{Inelastic Region} \\ x_{bj} \approx 1 & \textit{Q-E Peak} \\ x_{bj} > 1 & \textit{High Momentum Tail} \end{cases}$$

Broad Q-E peak. At x_{bj} >1, SRCs dominate .

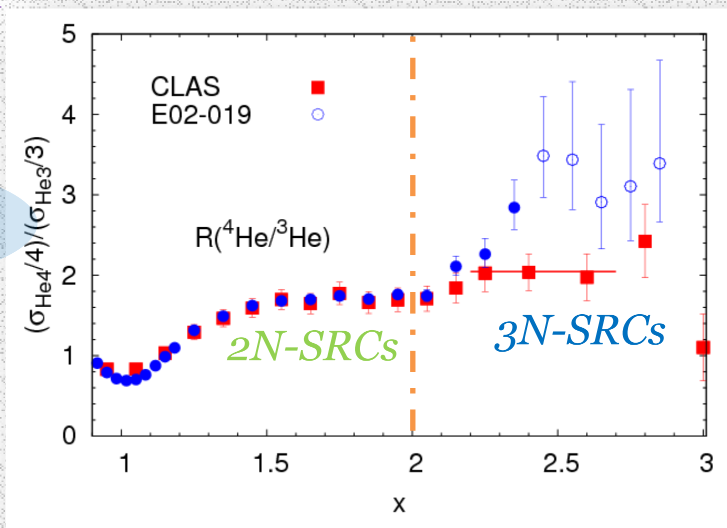
High Momentum Tail

The cross section for x_{bj} >1.3 is given by:

$$\sigma_A(x,Q^2) = \frac{A}{2} a_2(A)\sigma_2(x,Q^2) + \frac{A}{3} a_3(A)\sigma_3(x,Q^2) + \dots$$

2N-SRCs (x_{bj} >1) 3N-SRCs (x_{bj} >2)

$$r_2(A,D) = \frac{2}{A}\frac{\sigma_A(x,Q^2)}{\sigma_D(x,Q^2)}, r_3(A,{}^3He) = K_3(\sigma_n,\sigma_p)\cdot\frac{3\sigma_A}{A\sigma_{{}^3He}}$$



E08-014 In Hall-A

- **Standard Configurations:**

  VDC + S1 + S2m + GC + Calo. Two HRSs taking data. Simultaneously
- **Modified T1 & T3 Triggers:**

  S1 + S2m + GC, traditional T1&T3 are renamed as T6&T7
- **Mis-Tuning RQ3**

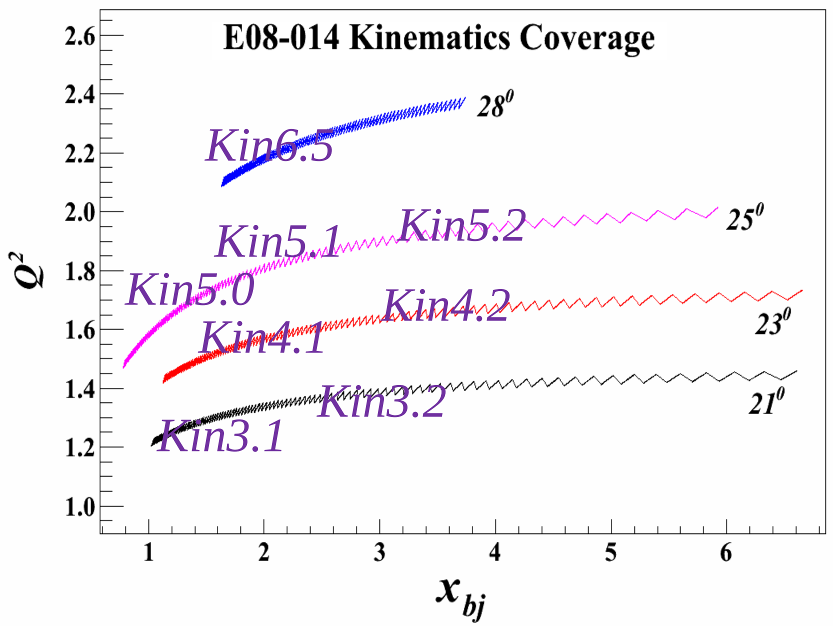
  Q3 on HRS-L scaled down to 87.72% due to a power supply issue.
- **Kinematics Coverage:**

  E0 = 3.356GeV
- **Targets:**

  D2, He3, He4, C12,

  Ca40, Ca48, *(Isospin in SRC)*

  and other calibration targets.

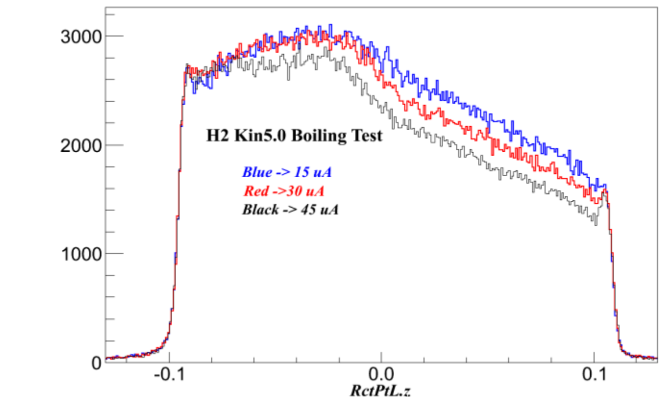


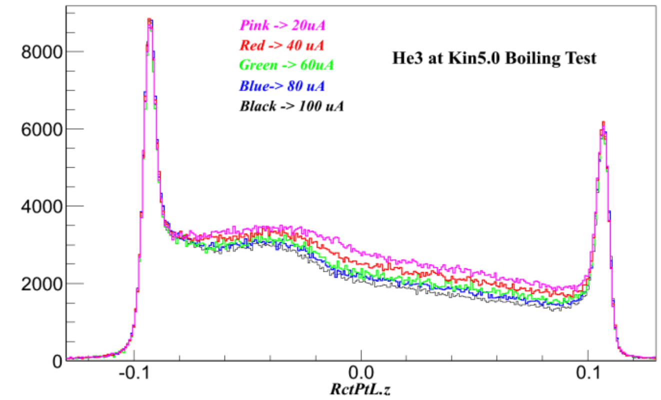
General Analysis Status

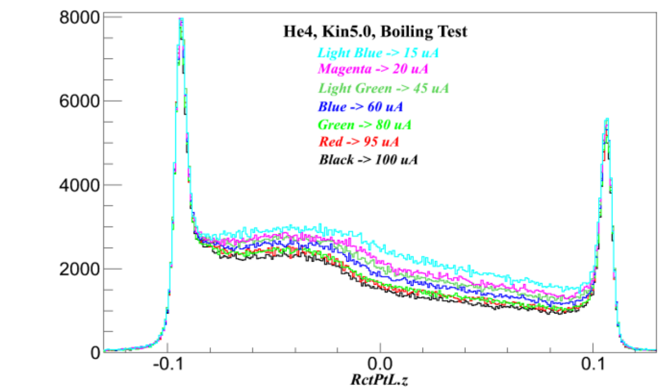
- **Finished:**
  - Optics, Beam, Target, Detectors
  - PID Cut, Efficiencies, Dead-Time.
- **On-going: (talked in rest of slides)**
  - Cross Section Model
  - Radiation Correction (RC)
  - Monte Carlo Simulation (MC)
  - Acceptance Study
  - Extracting Cross Section
  - Errors Analysis

Cryo-Target Density Uniformity

- **Problems:** The cooling system on the *20 cm* long cells causes non-uniform target density. The upstream part is *cooler* than the downstream part.
- **Bumps** raise on D2, He3 and He4 targets. The effect become significant when beam current goes higher.
- **Issues:** Complicate boiling effect correction; Real target luminosity; Radiation corrections.



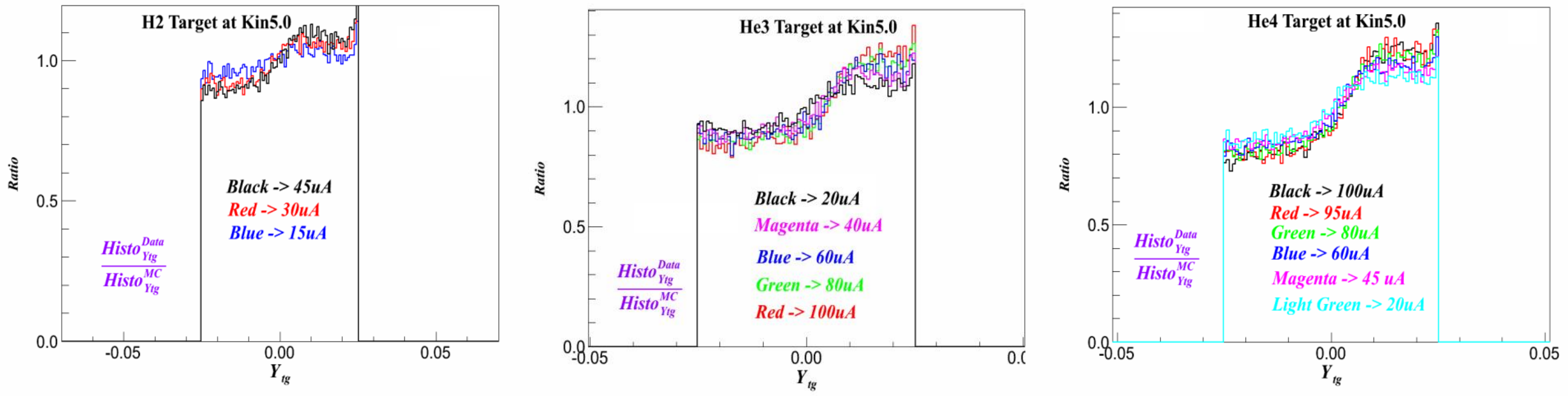




Cryo-Target Density Uniformity

- **Extract the density distribution:**

Z_{react} (Vertex Z) distribution in data includes the density distribution as well as the acceptance effects. Divided the distribution by the histograms of simulation data with uniform density distributions:

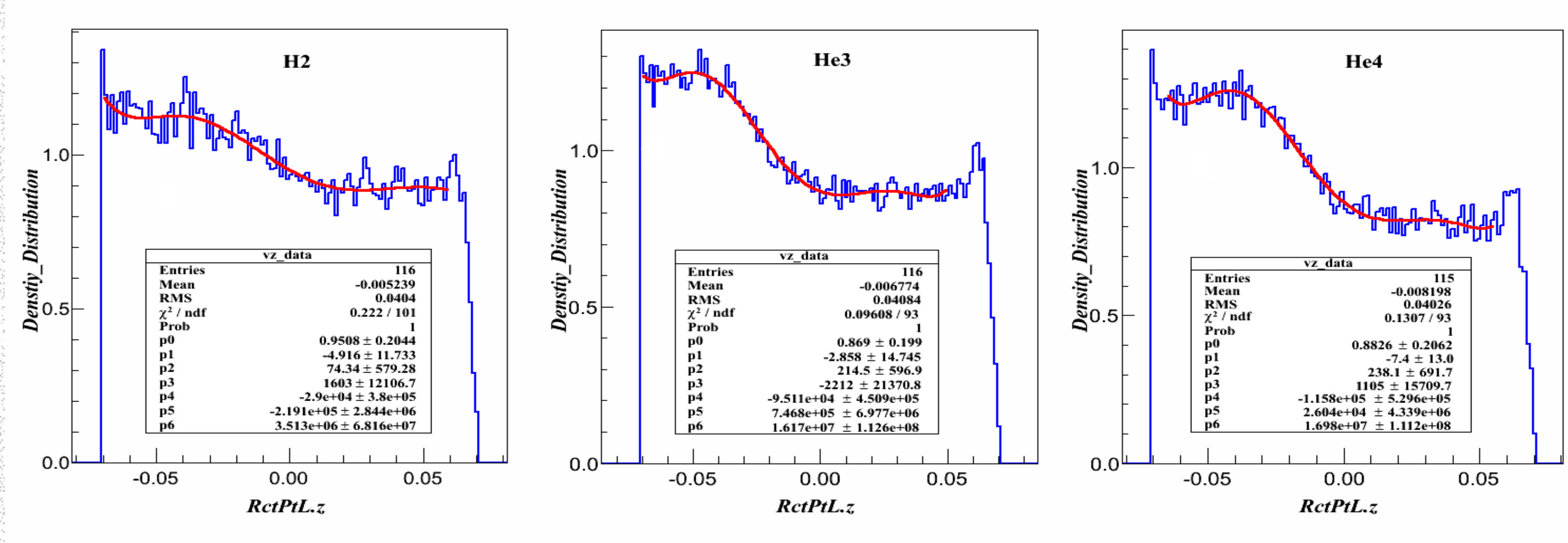


Absolute density values at the entrance or exit of cells can be calculated from sensor readings of pressure and temperature

Cryo-Target Density Uniformity

- **Extract the density distribution:**

Z_{react} (Vertex Z) distribution in data includes the density distribution as well as the acceptance effects. Divided the distribution by the histograms of simulation data with uniform density distributions:



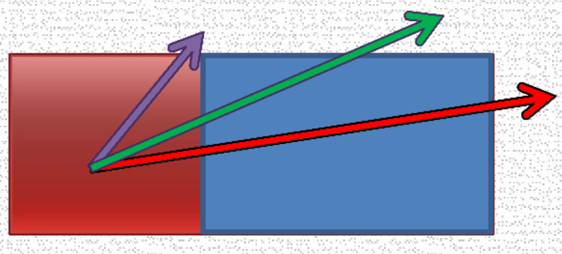
Absolute density values at the entrance or exit of cells can be calculated from sensor readings of pressure and temperature

Cryo-Target Density Uniformity

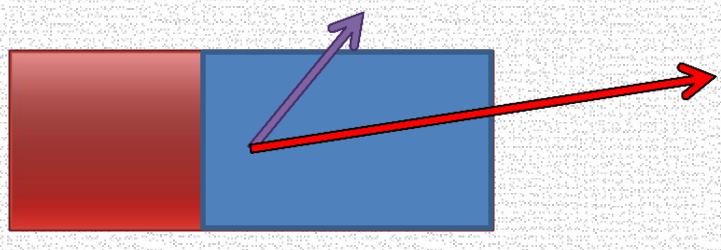
- **Other Corrections:**

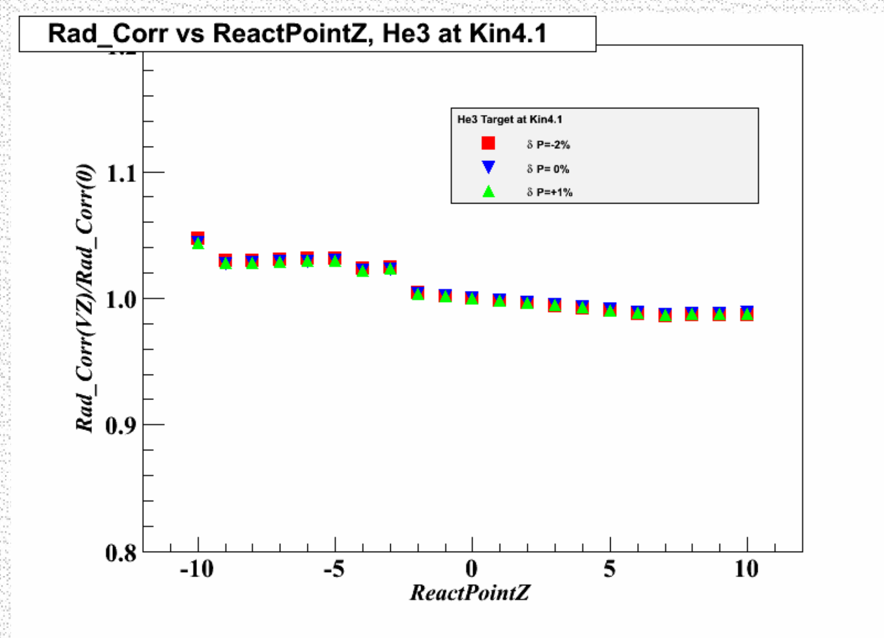
1, Put the extract distributions in MC (simplified step functions)

2, Evaluate Radiation Corrections (RC):



Final RC value is statistically weighted by RC distribution along the Cryo-Target cell.





RC depends on the location of reactions.

XEMC – Cross Section Calculation Package

- **In C++, stand-alone package maintained by Z. Ye**

  Born Cross Section Models + Radiation Correction.

- **Born Cross Section Model:** $\sigma_{born} = \sigma_{born}^{QE} + \sigma_{born}^{DIS}$

σ_{born}^{QE} : Quasi-Elastic Term, available:

(1), XEM - F(y) fitting, see N. Fomin's thesis

(2), QFS - From Temple group

(3), F1F2QE09 - P. Bosted and V. Mamyan (*arXiv:1203.2262v2*)

σ_{born}^{DIS} : Inelastic Term:

(a), XEM - F1F206 + special corrections in different regions

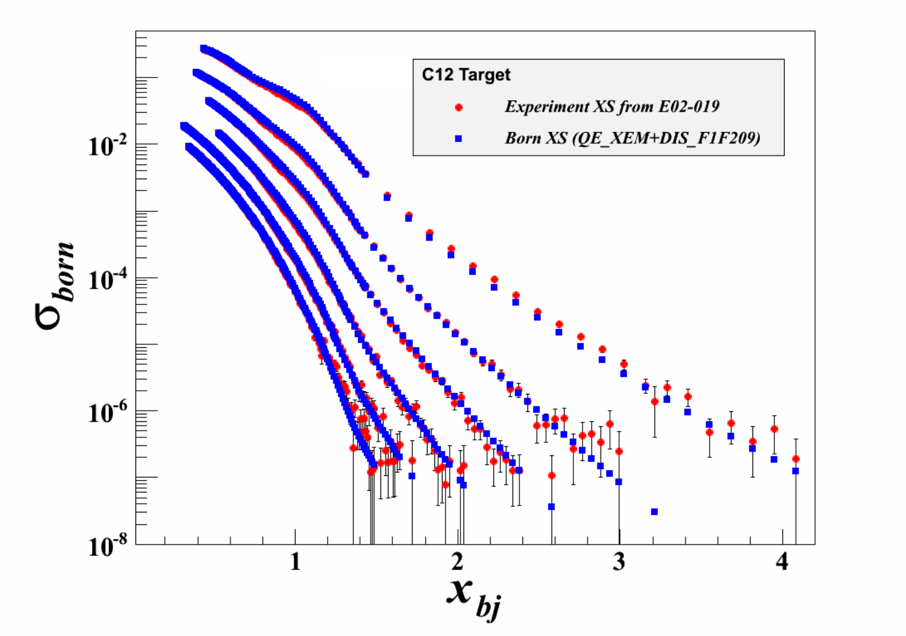
(b), QFS - DIS + Delta + Resonances + DIP

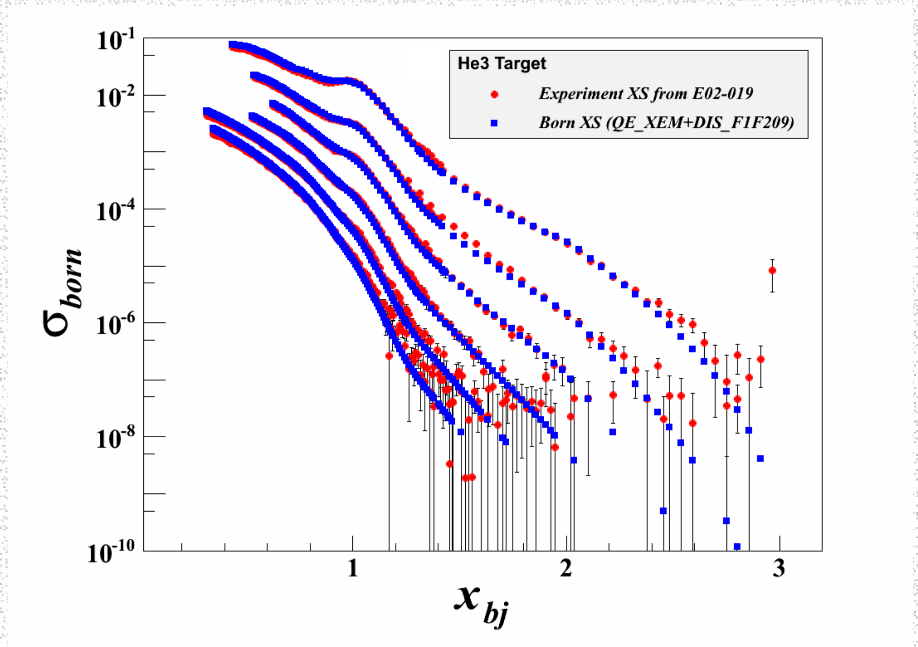
(c), F1F2IN09 - P. Bosted and V. Mamyan

All available in the code, but in term of agreement and speed, (1) + (c) works the best in our kinematics

XEMC – Born Cross Section

- Comparing with E02-019 Data:





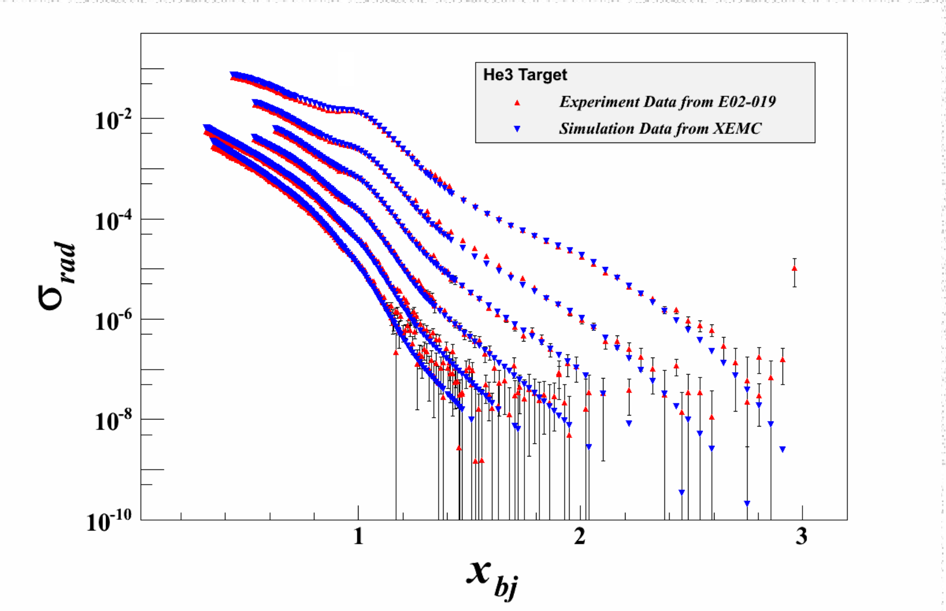
XEMC – Radiation Correction

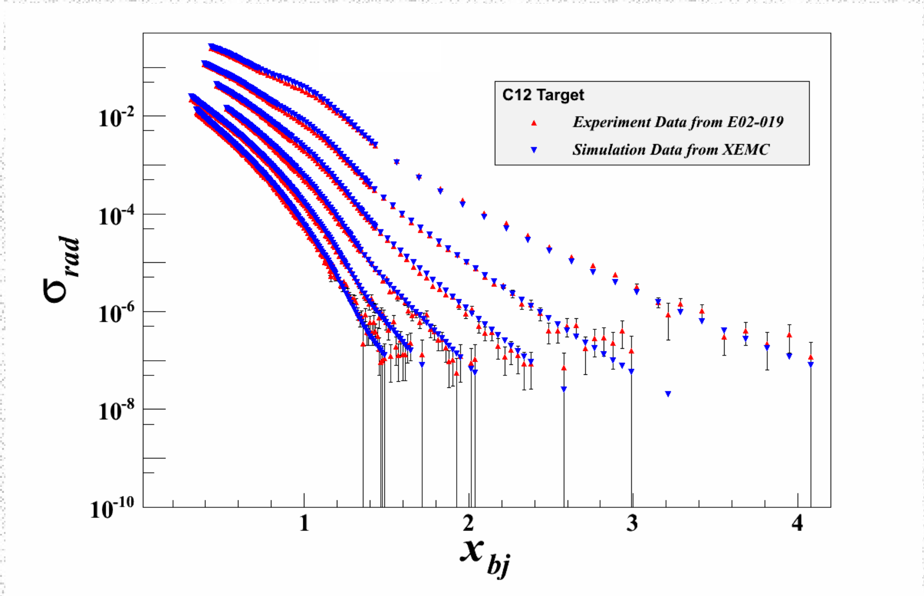
- **Subroutines from RadCor package** (developed by Temple group and coded by H. Yao etc.).
- **Basic Idea:** *S. Stein et al, Phy. Rev. D 12 1884*

  Simplified 1-D individual integrals of E_0 and E' for QE tail.
- **Better Radiation Correction code with 2-D integrals is available in XEM, but in FORTRAN, and run slow.**

XEMC – Radiation Correction

- Comparing with E02-019 Data:





Monte Carlo Simulation

- **SAMC – C++ version developed by H. Yao**

  Standard HRS configurations.

  QFS & XEMC embedded.

- **Updated HRS-R Transportation Functions**

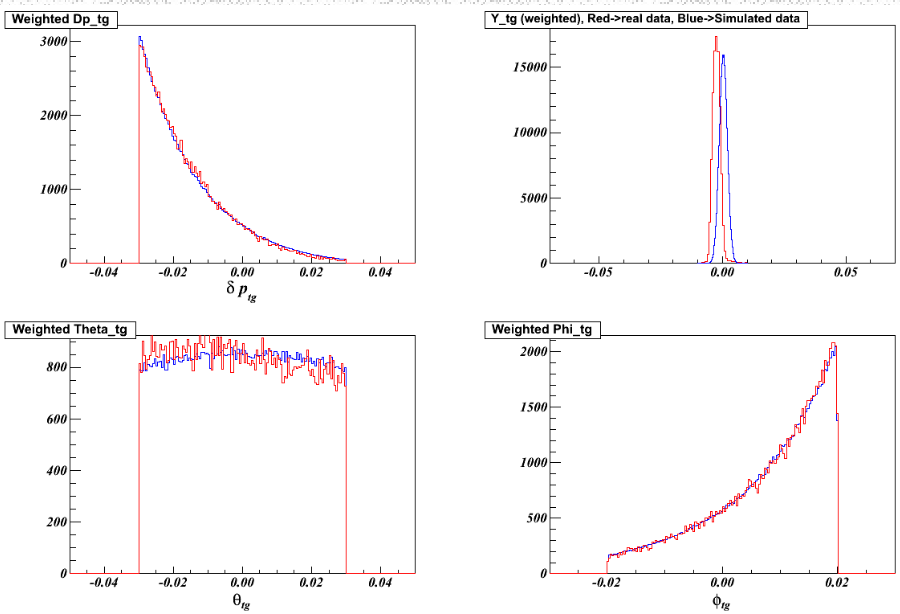
  For RQ3 with mistuning field (J. LeRose)

- **Special Correction on Cryo-Target Bumps**

  For non-uniform target density distributions, a simplified step function is used to generate events along $Z_{react.}$

Monte Carlo Simulation

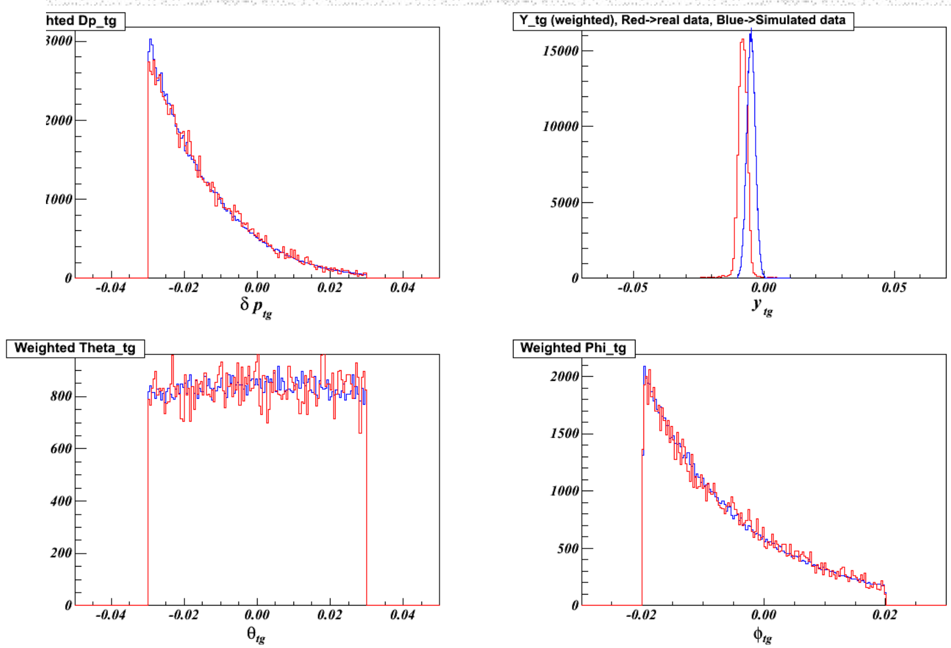
- **C12 Target Plane Quantities :**



HRS-L

Blue -> Simulation Data
Red -> E08-014 Data

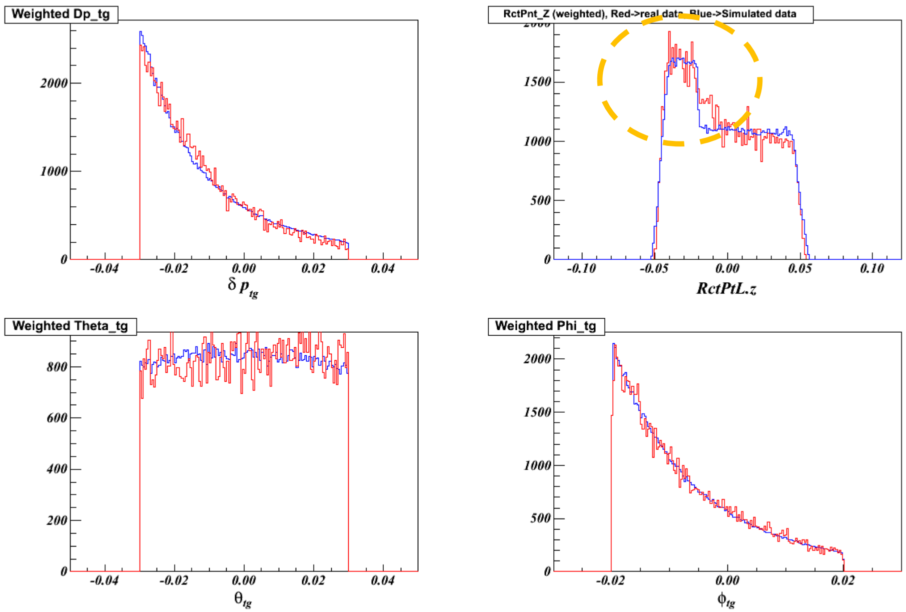
HRS-R



Histograms are weighted by Cross Sections from XEMC

Monte Carlo Simulation

- **He3 Target Plane Quantities :**

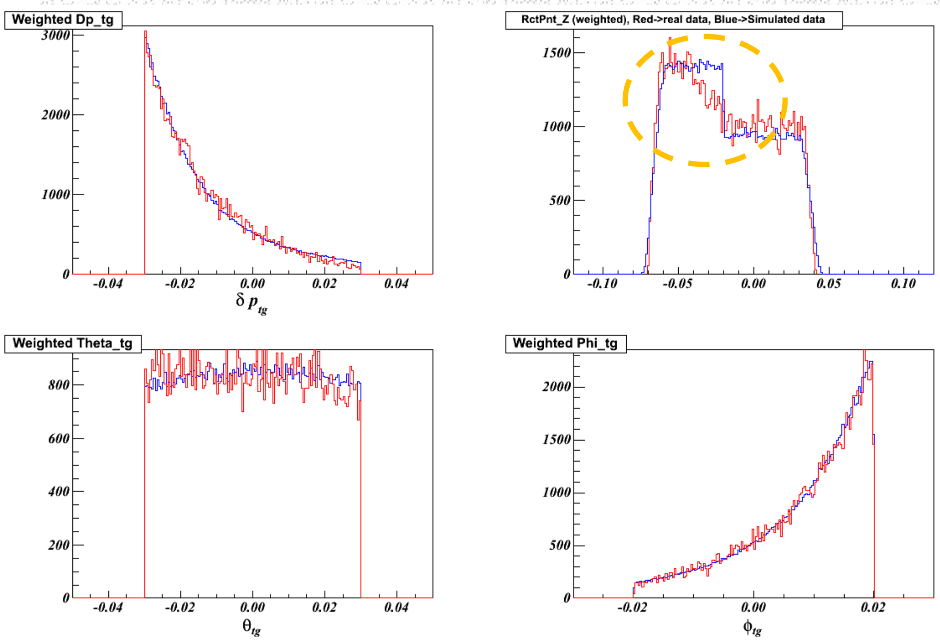


HRS-L

Blue -> Simulation Data

Red -> E08-014 Data

HRS-R



The "Bump" is simulated!

Histograms are weighted by Cross Sections from XEMC

Experimental Cross Section

- **Yield Ratio Method:** *binning on x_{bj}*

$$\frac{d\sigma_{born}^{EX}}{dE'd\Omega}(E_0, E'_i, \theta_0) = \frac{Y_{EX}^i}{Y_{MC}^i} \times \sigma_{born}^{MC}(E_0, E'_i, \theta_0),$$

Where, **Experimental Yield:**

$$Y_{EX}^i = N_{EX}^i \Big/ N_e \cdot \varepsilon_{eff},$$

N_{EX}^i -- *Total events in ith bin*

N_e -- *Total electron charge*

ε_{eff} -- *Total efficiencies*

And **Monte Carlo Yield**:

$$Y_{MC}^i = N_{tg} \cdot \sum_{j \in i} \sigma_{rad}^{MC}(E'_j, \theta_j) \cdot \frac{\Delta\Omega_{MC} \Delta E'_{MC}}{N_{MC}^{gen}}$$

N_{tg} -- *Total target luminosity*

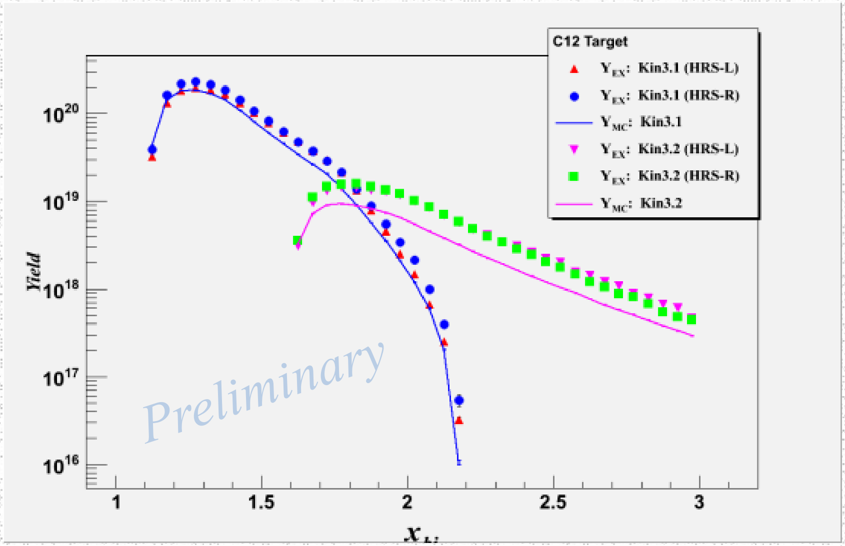
N_{MC}^{gen} -- *Total generated MC events*

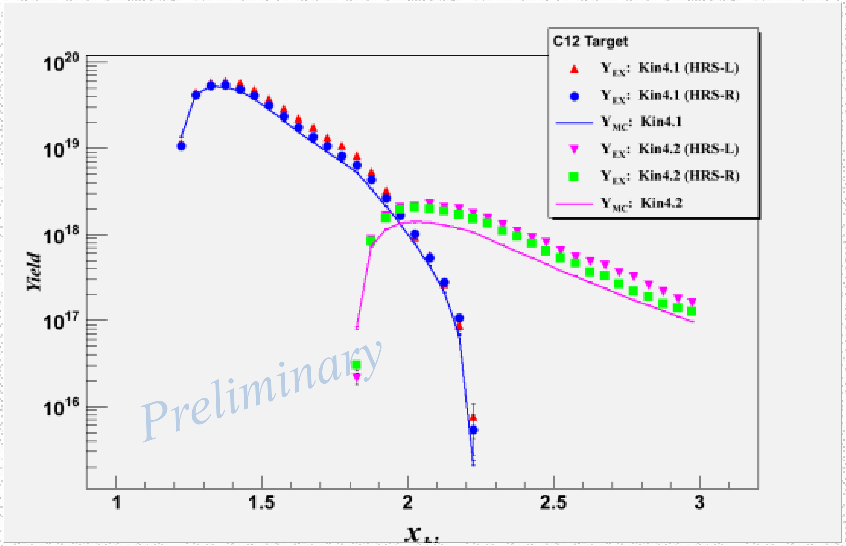
$\Delta\Omega_{MC}, \Delta E'_{MC}$ - *Entire phase space in MC (slight larger than real HRS acceptance)*

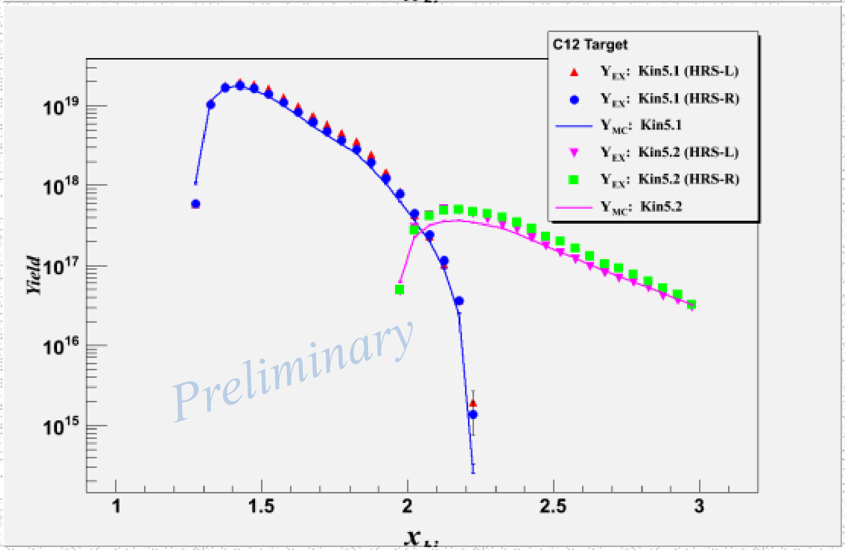
$\sum_{j \in i} \sigma_{rad}^{MC}(E'_j, \theta_j)$ - *Radiated Cross Section Sum of all events in ith bin*

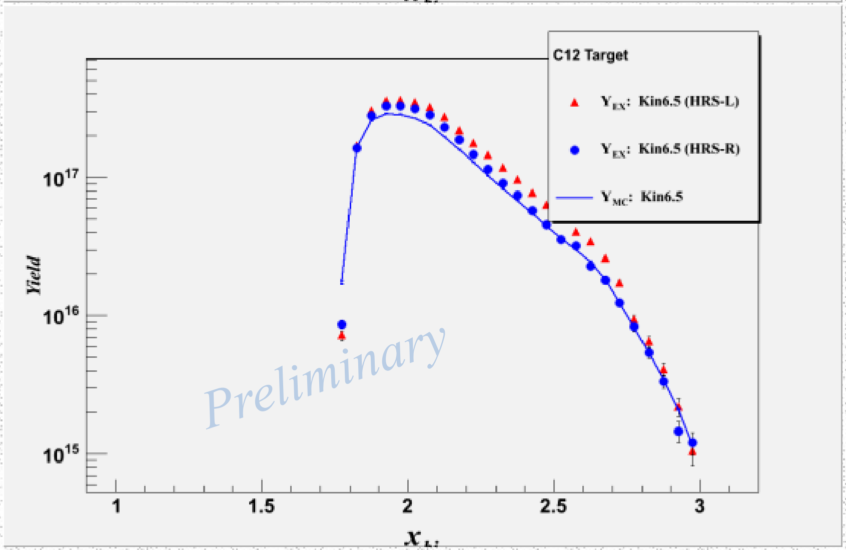
Experimental Cross Section – C12 Yield

Yield in Xbj Bining: ***Dots -> Experiment, Lines -> MC***



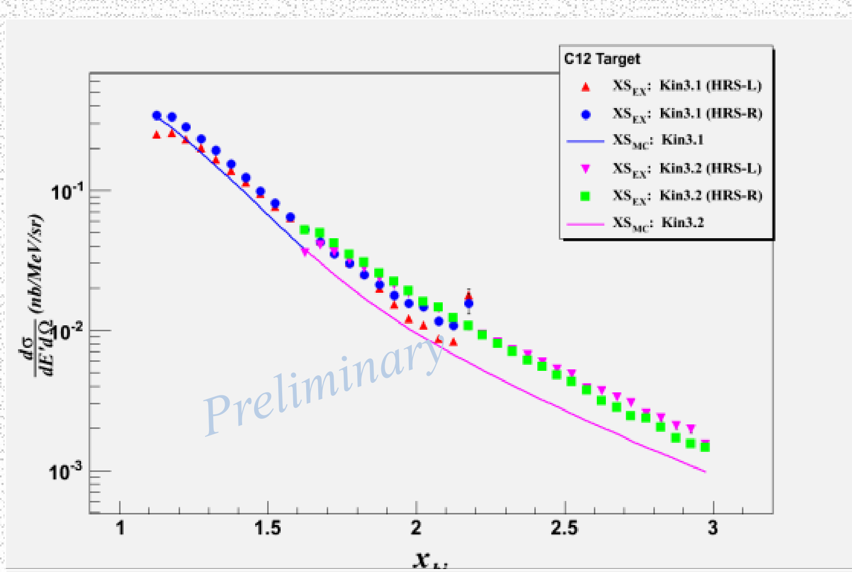


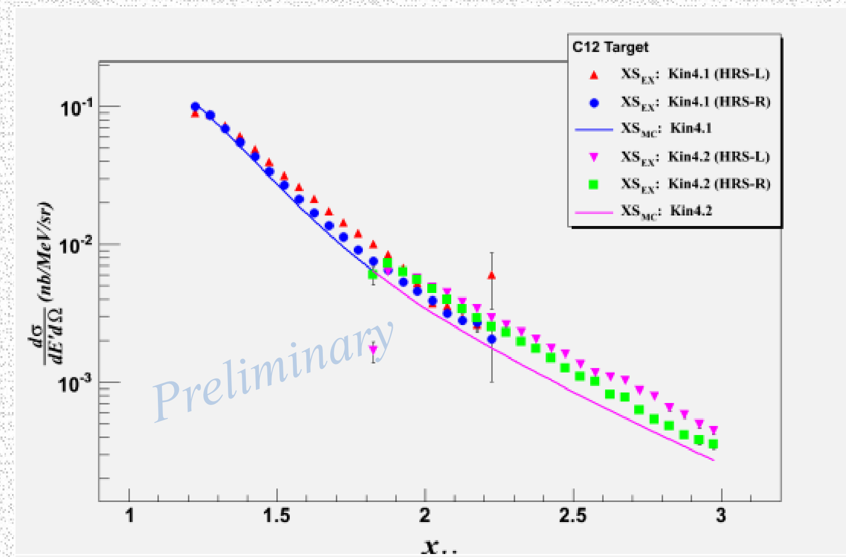


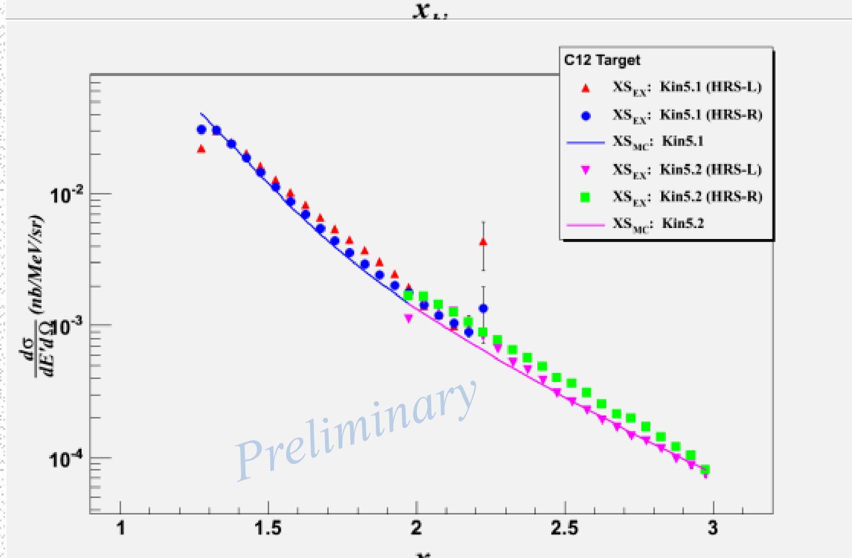


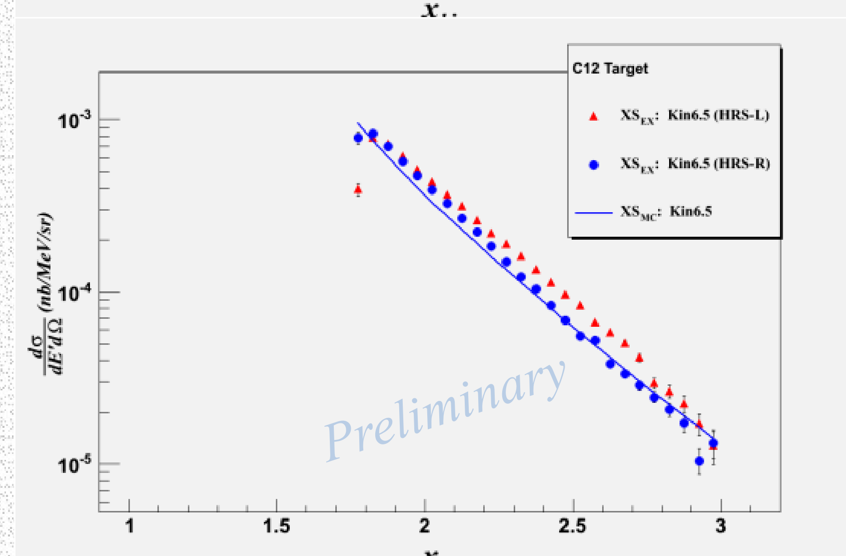
Experimental Cross Section – C12 XS

Cross Section in Xbj Bining : ***Dots -> Experiment, Lines -> MC***



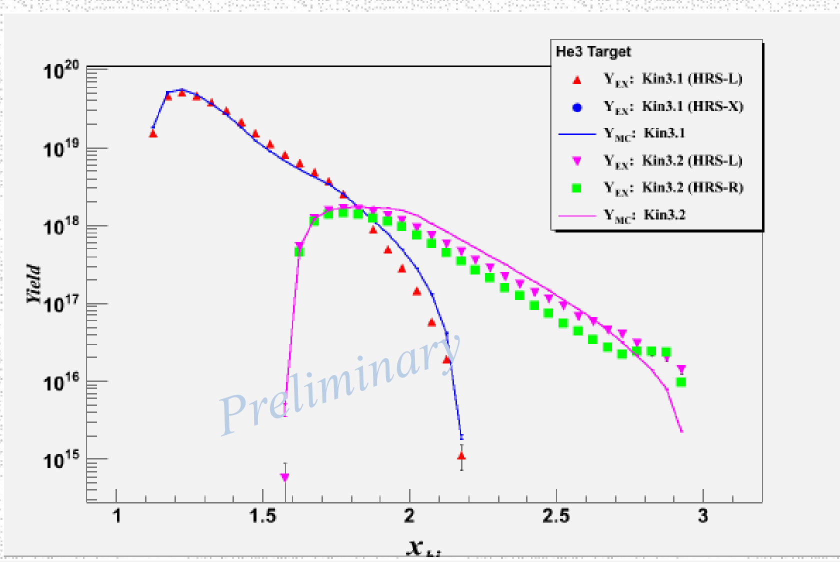


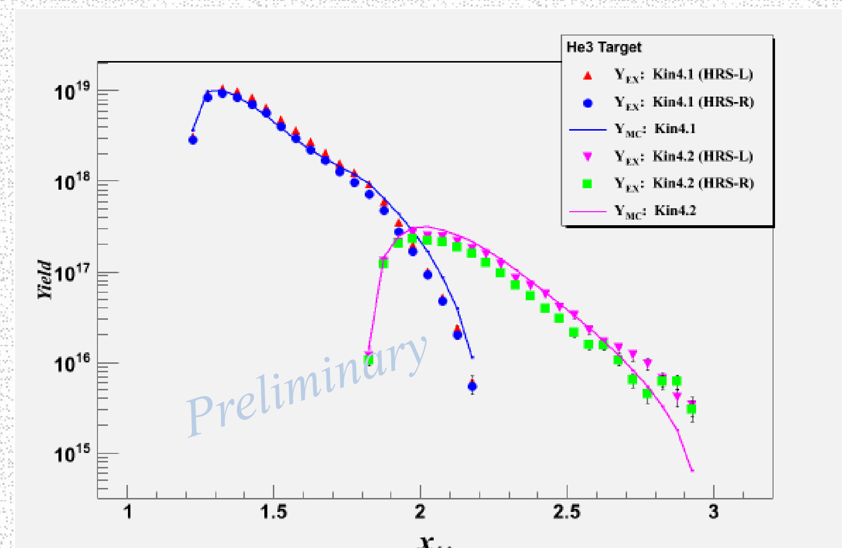


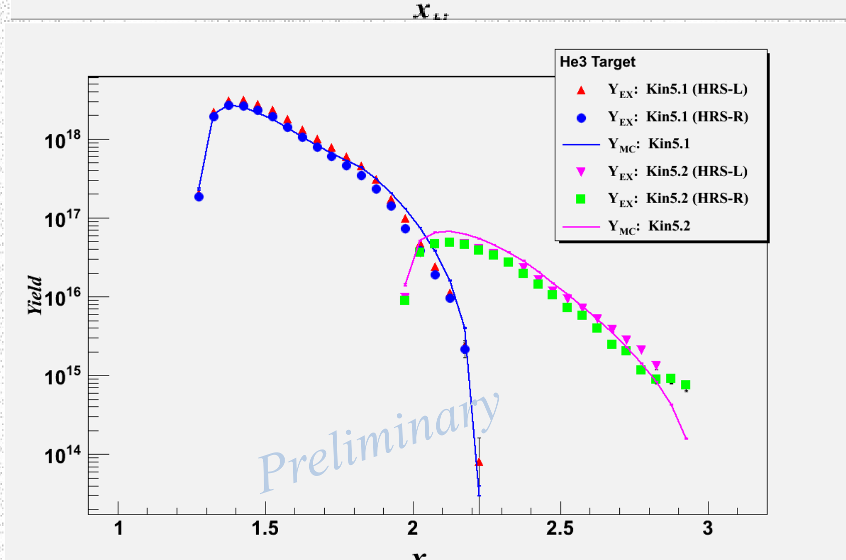


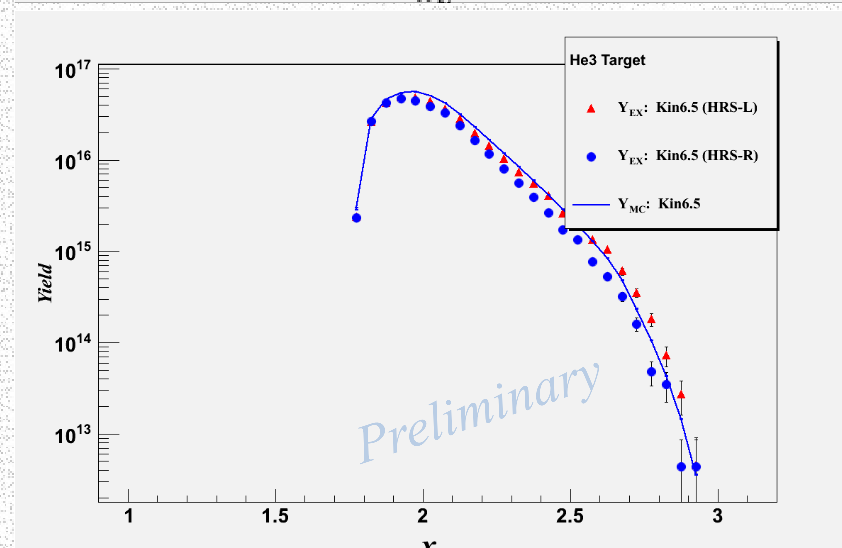
Experimental Cross Section – He3 Yield

Yield in Xbj Bining: ***Dots -> Experiment, Lines -> MC***



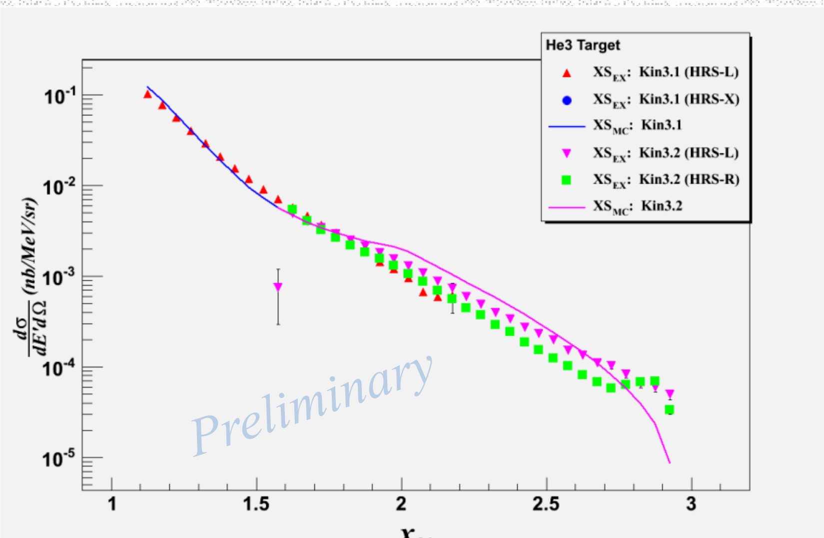


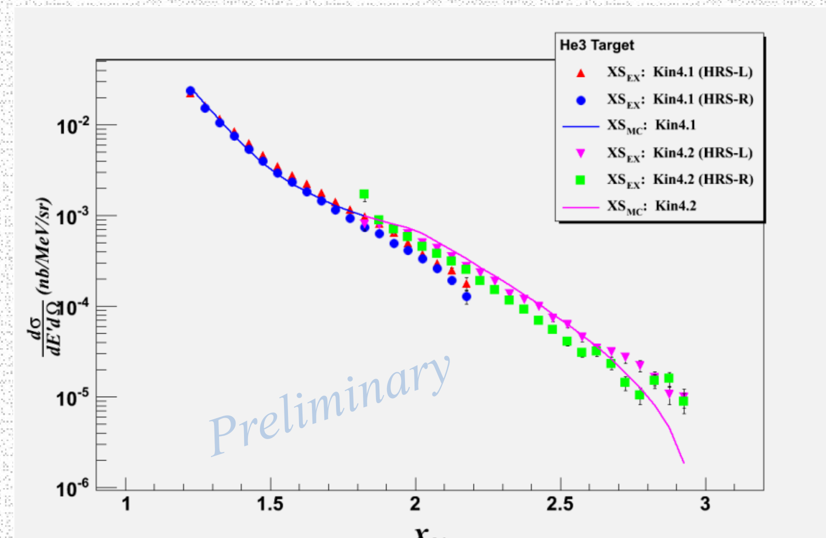


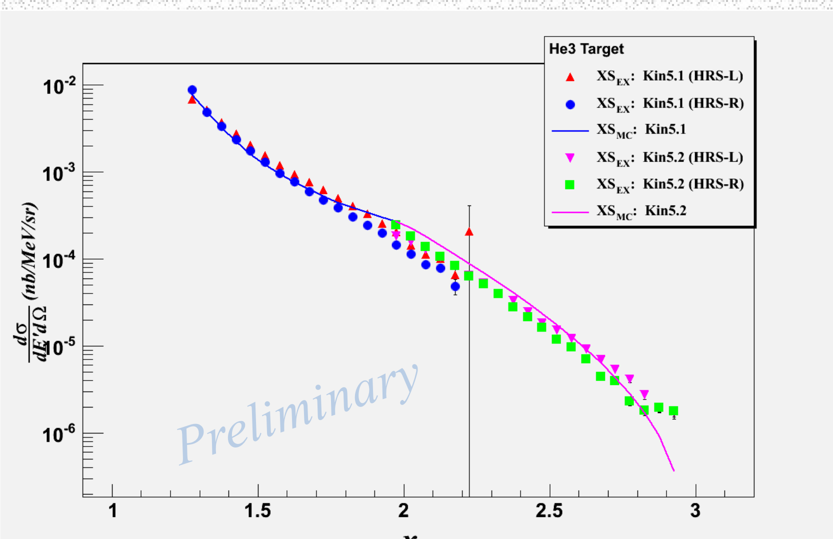


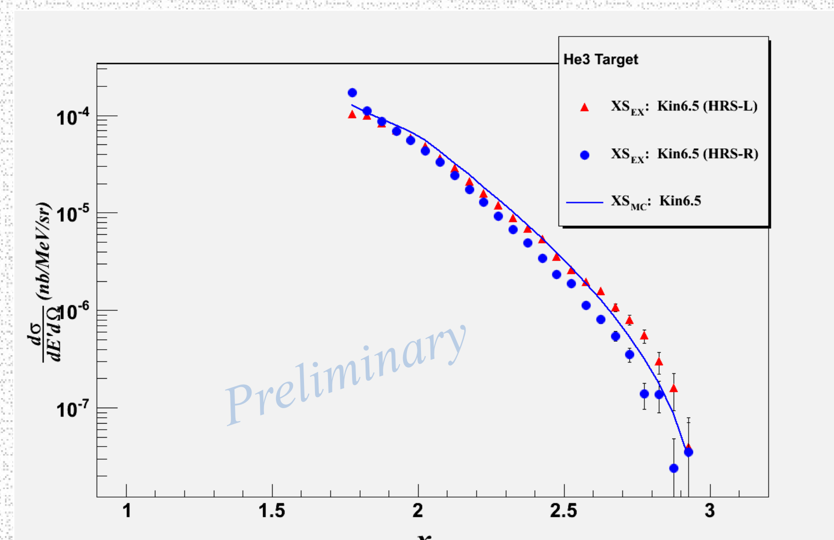
Experimental Cross Section – He3 XS

XS in Xbj Bining: *Dots -> Experiment, Lines -> MC*









Summary:

- On the last stage of data analysis
- Target issues have been resolved
- Nice cross section model (XEMC)and simulation tool (SAMC)
- Preliminary cross section results look nice but needed more works.

Remaining Works:

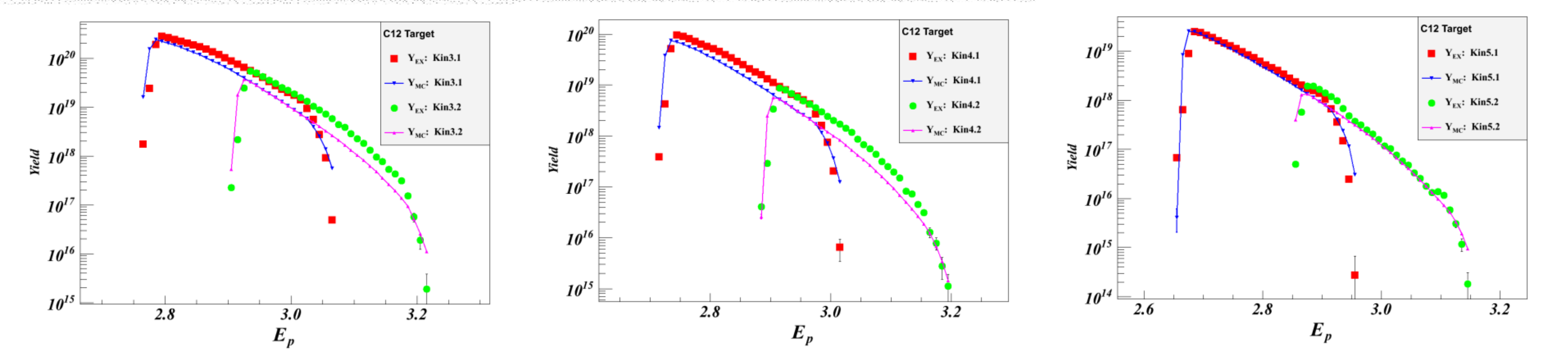
- Absolute Densities of Cryo-Target. Ca40 and Ca48 Thickness.
- Scattering Angle Checking through pointing study.
- Acceptance Study.
- Iterate Cross Section Model to fit our kinematic regions.
- Errors Analysis
- Taking Ratio!

Getting close to the final results and I am looking for a post-doc job!

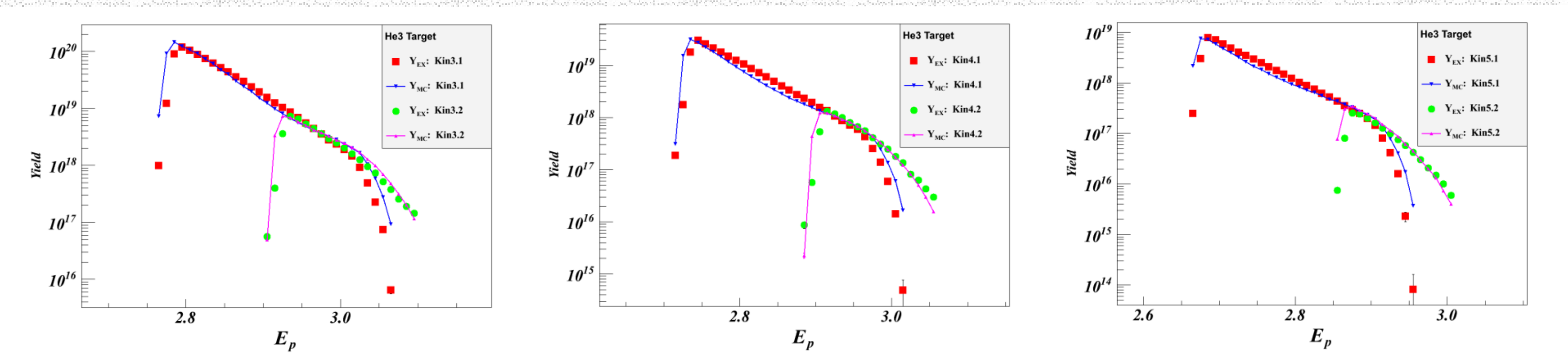
Backup Slides

Experimental Cross Section – Yield in E’

Yield in E’ Bining: Study the Acceptance of E’ (as an example, data on HRS-L)

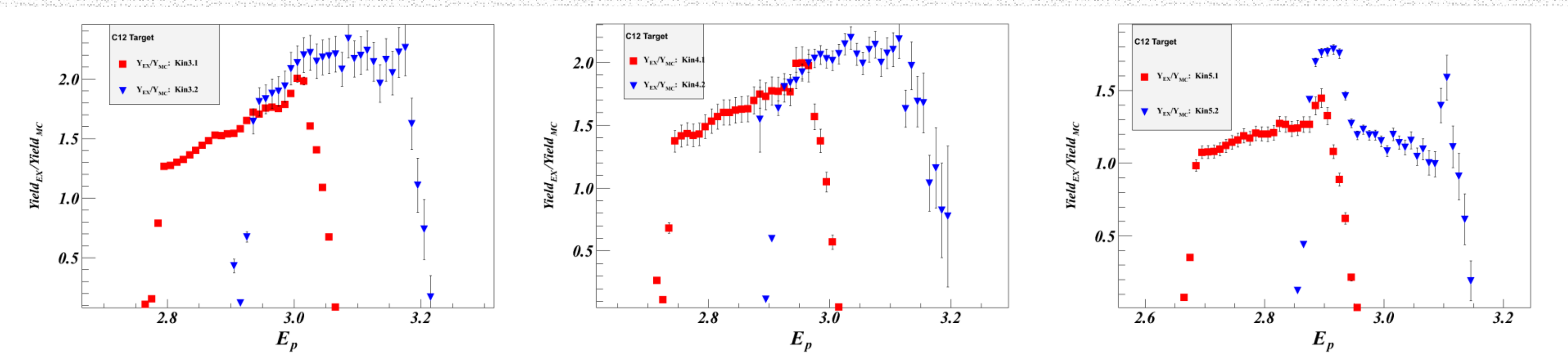


21^0 23^0 25^0

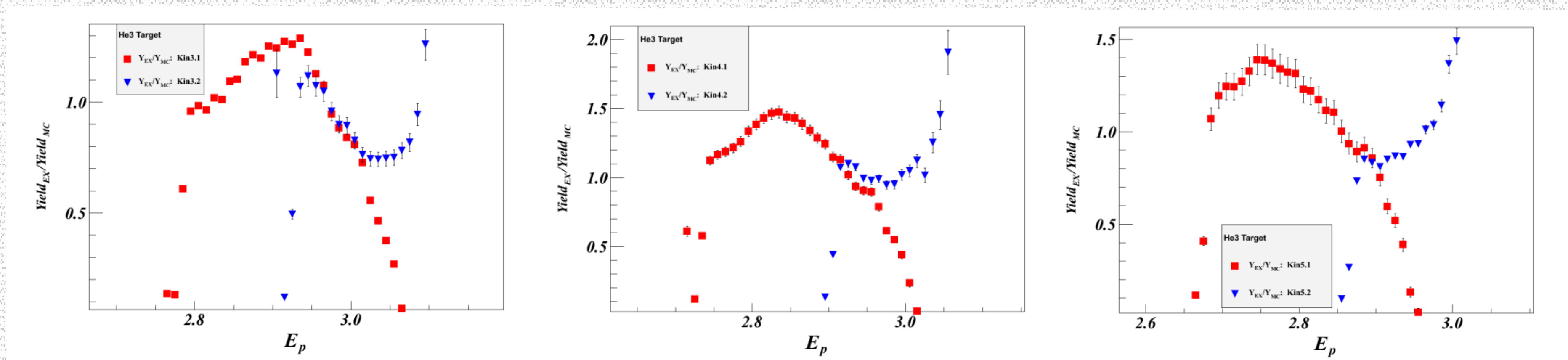


Experimental Cross Section – Yield in E’

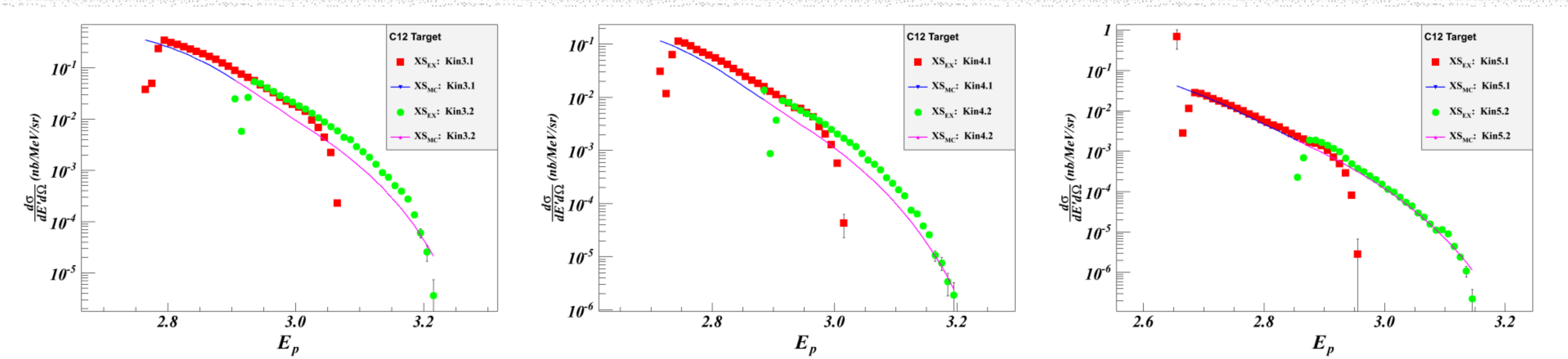
Yield Ratio in E’ Bining: Study the Acceptance of E’ (as an example, data on HRS-L)



21^0 23^0 25^0



Experimental Cross Section – XS in E’



21⁰ 23⁰ 25⁰