Update on RG-D Alignment and CT Analysis

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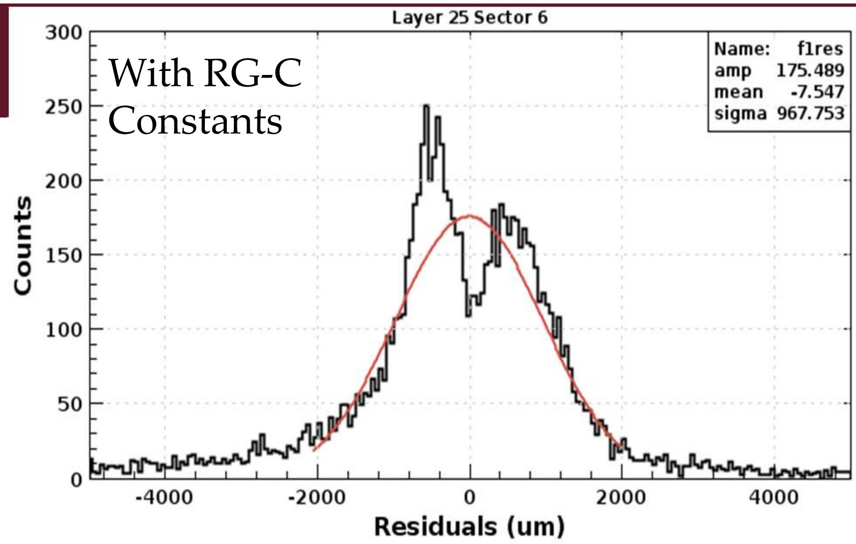
CLAS Collaboration Meeting
June 26th, 2024

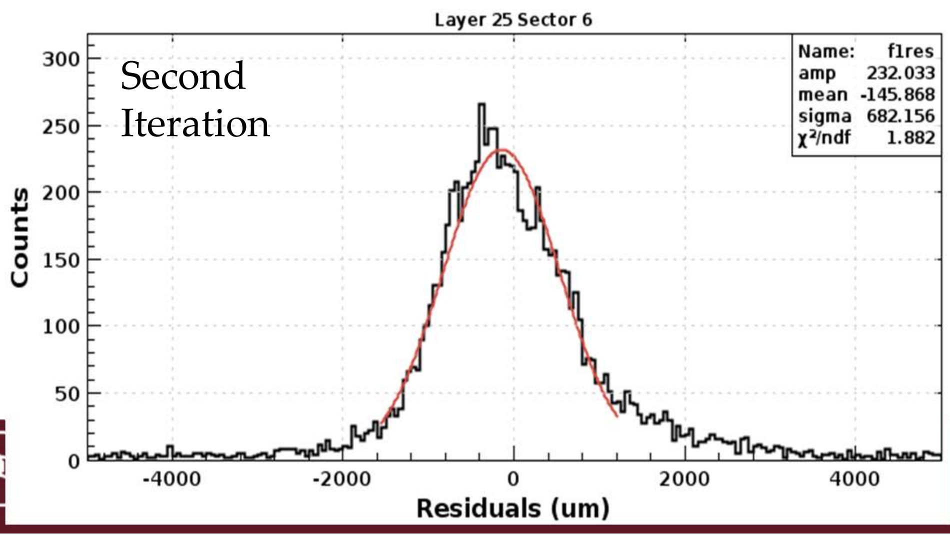
Outline

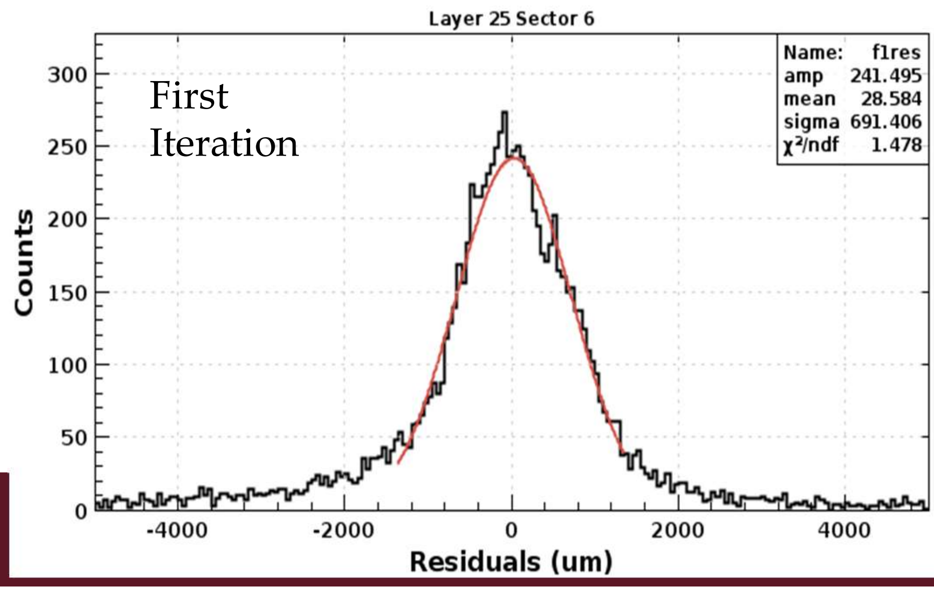
- RG-D Alignment
  - Fall 2023 alignment
  - May 2024 alignment
- Preliminary RG-D CT Analysis
  - Kinematics and cuts
  - $\pi^+\pi^-$ Invariant Mass
  - Carbon Nuclear Transparency Results
- Summary & Outlook

Online Fall 2023 Alignment

- ❖ The first alignment of RG-D was completed using a zero-filed run, 18316
- ❖ After the first alignment attempt, the calibration pre-sets had to be adjusted
- ❖ The DC calibration led to good results of the first alignment iteration
- ❖ Only one more iteration was completed to obtain the fall 2023 alignment constants

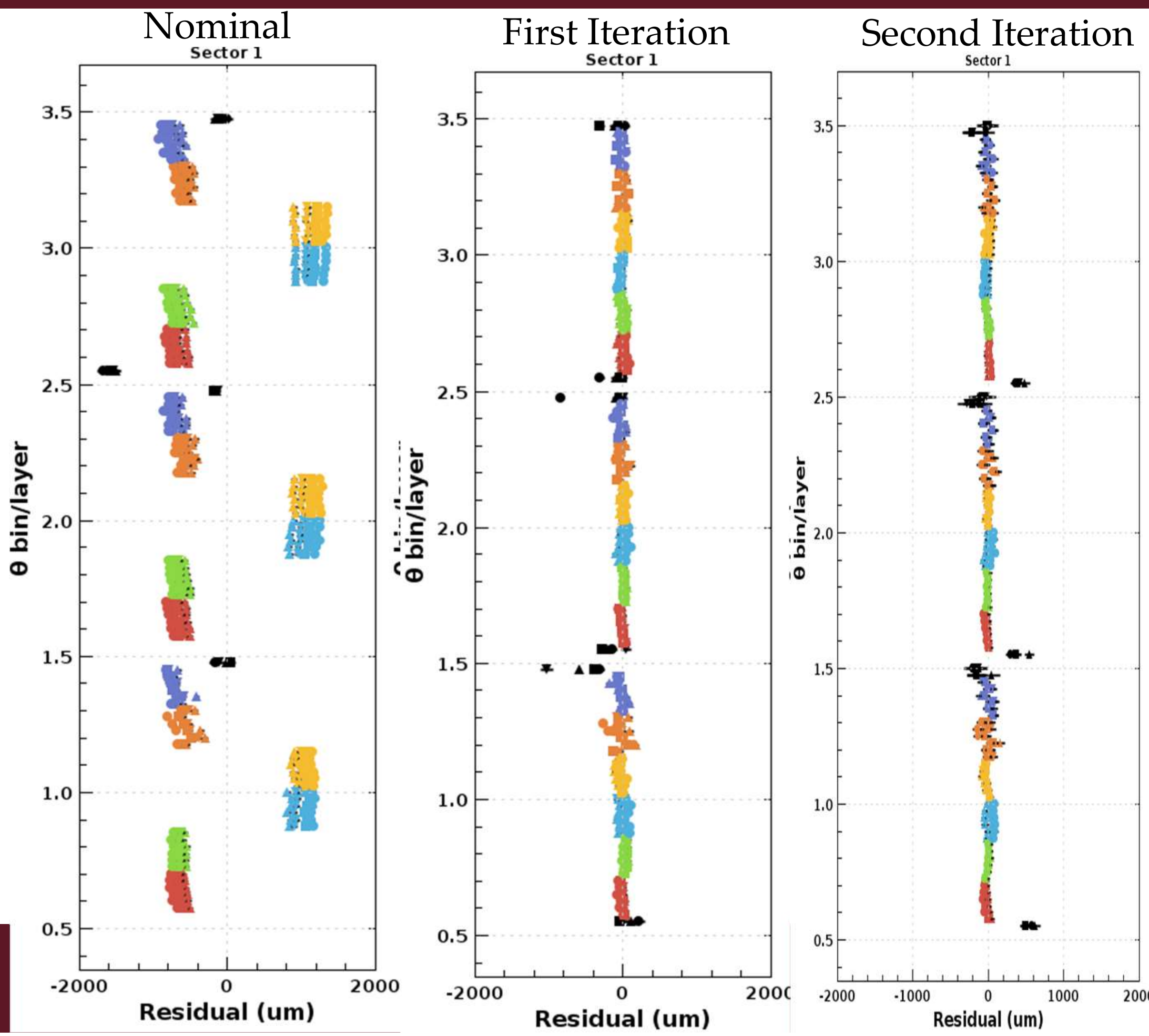






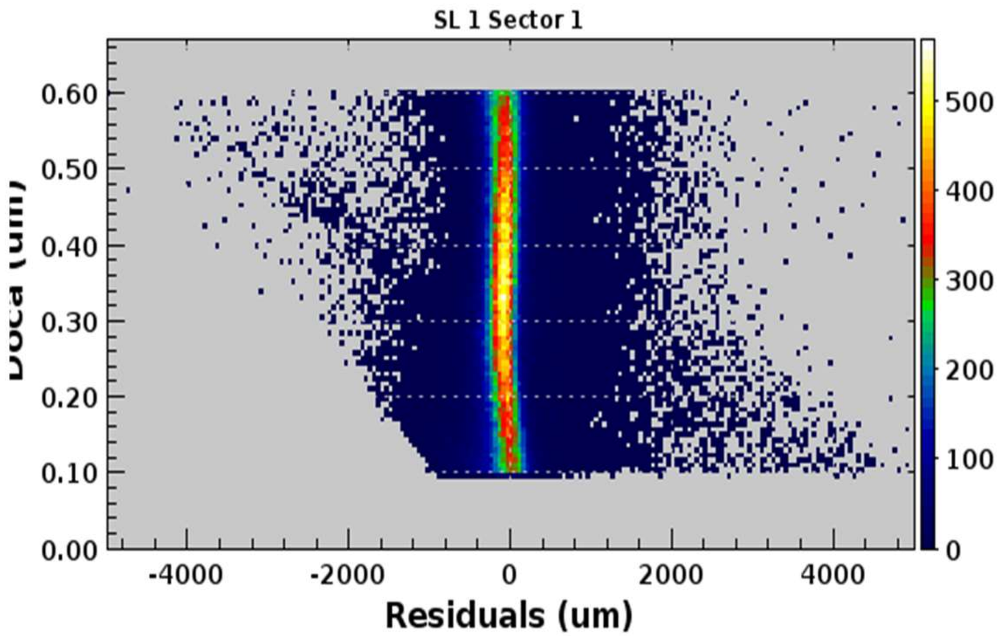
Residuals Results

- The colorful dots on each line represent the polar angle bins and the line on the bottom shows the vertex shifts in tens of microns
  - Different symbols shows the θ bins
  - Shift is with regard to known target position



DOCA

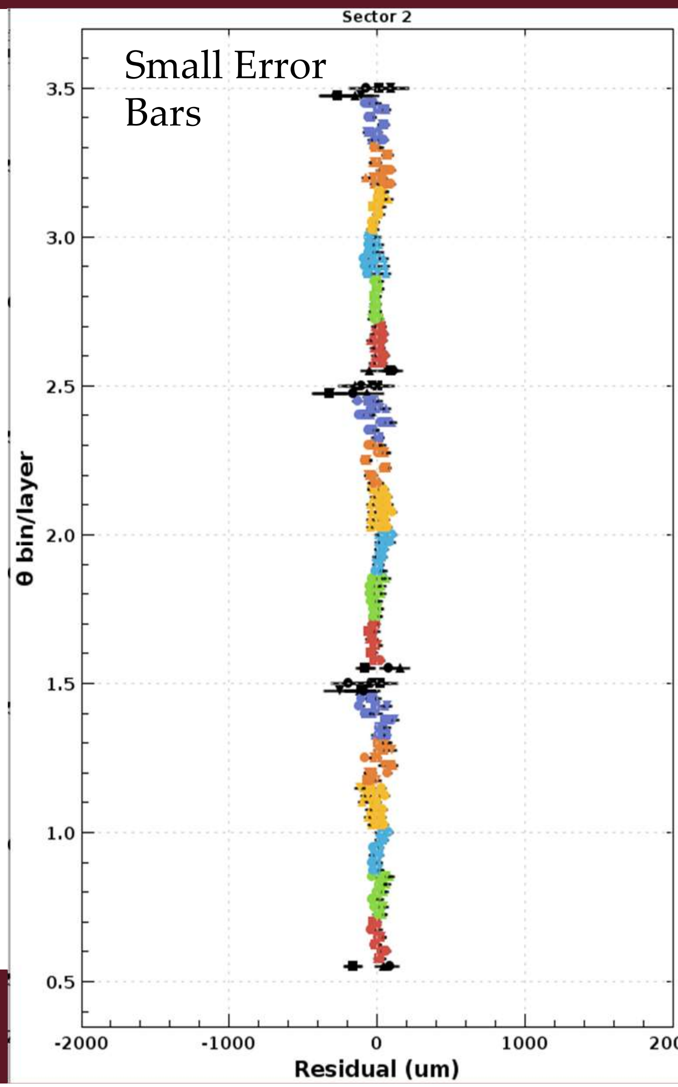
- The iteration of the alignment preformed in May 24 was done after the improvement of the DC calibration procedure and suite for zero-field runs
- The improved DC calibration led to a nicely centered Distance Of Closest Approach in all superlayers, regions, and sectors

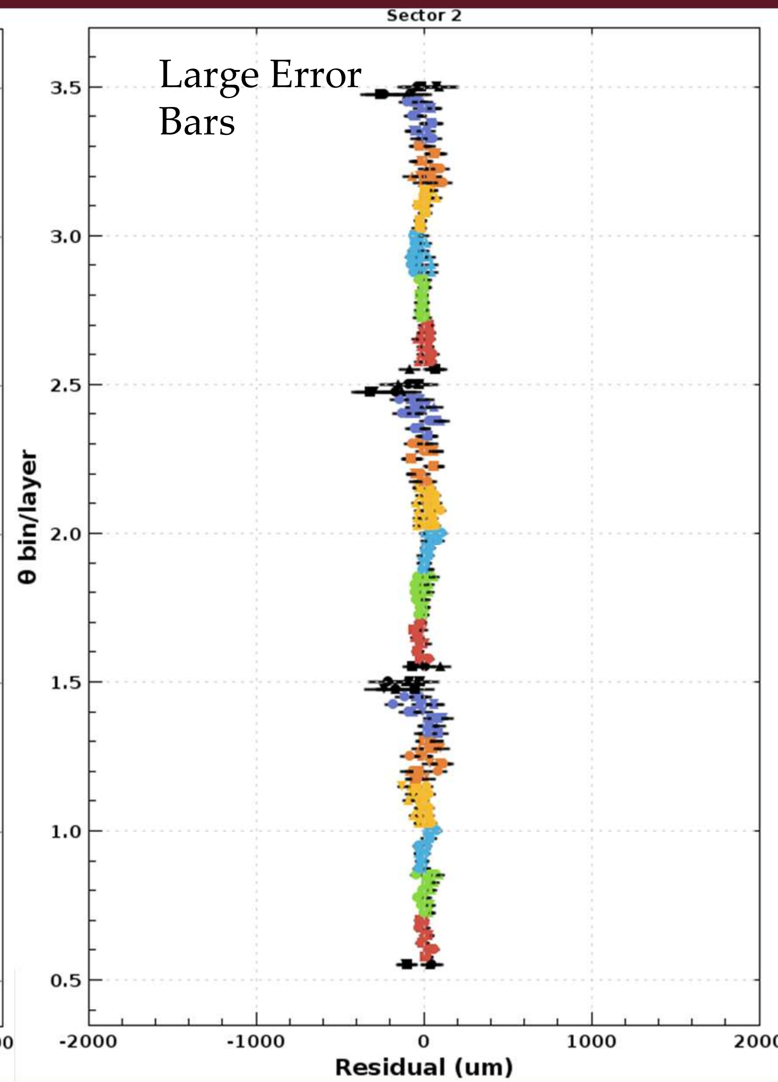


Look to Raffaella De Vita's presentation:
"Offline software: ongoing projects status"
And Daniel Carman's presentation:
"Calcom Update"

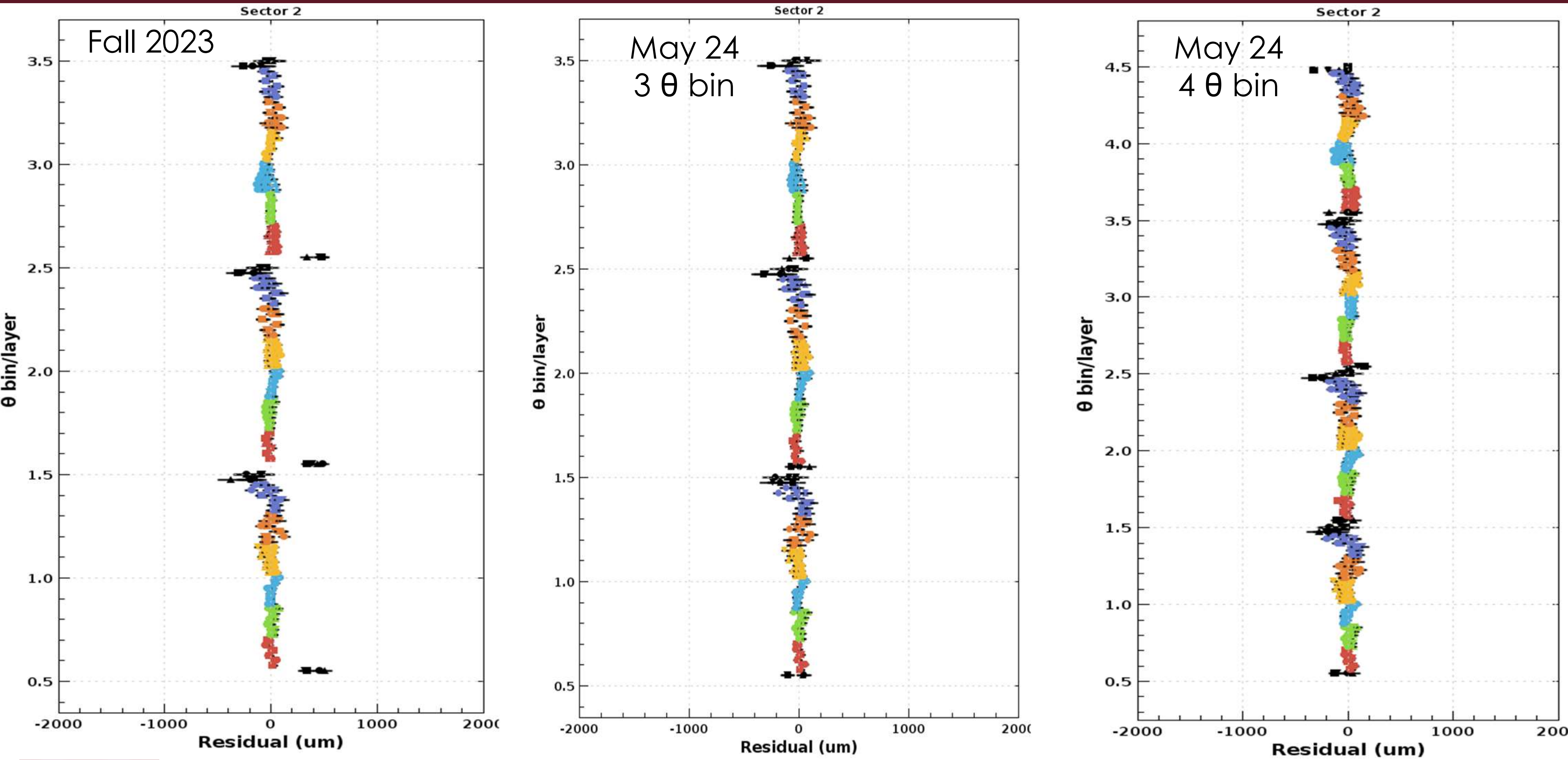
Effect of Uncertainty Changes

- The increase of error bars prevent the yet to be understood region 3 (R3) pattern from biasing the alignment results

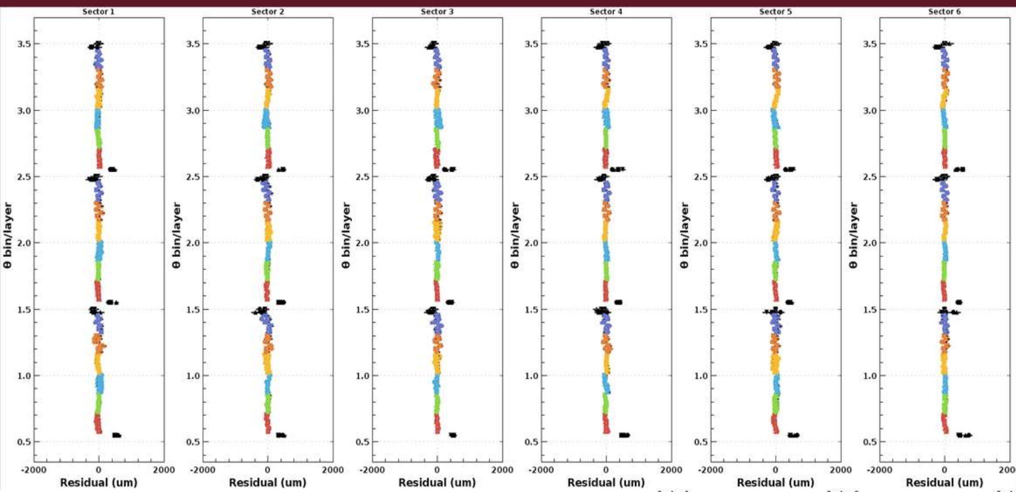




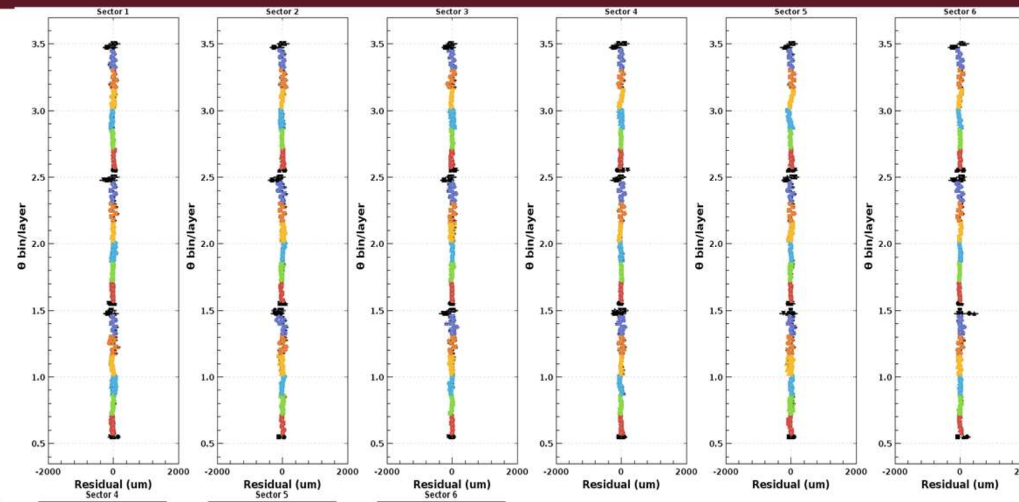
Comparison of various Alignment Iterations



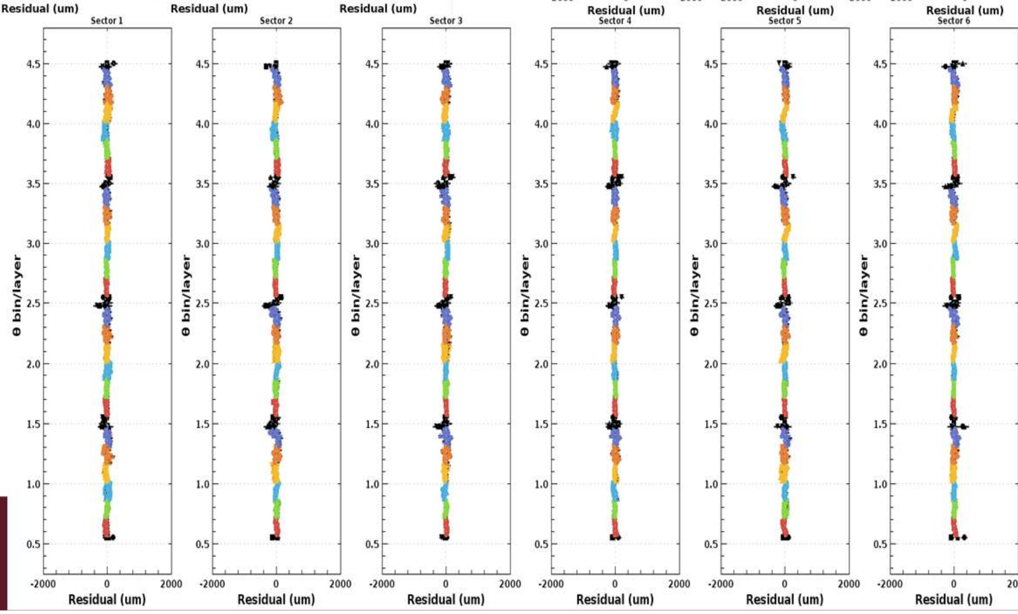
Comparison of various Alignment Iterations



Fall 2023



May 24 w/ 3 θ bins



May 24 w/ 4 θ bins

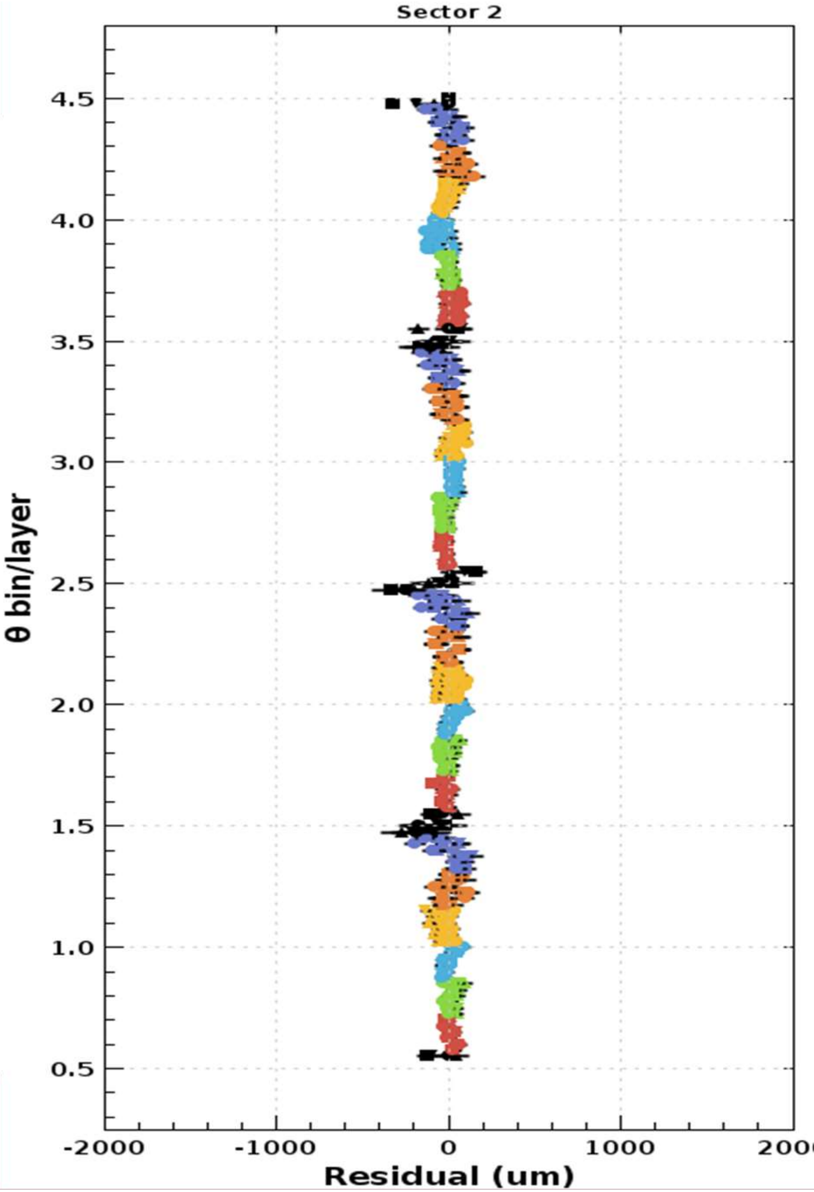
Ongoing Geometry Debugging

❖ The third DC region suffers from a wiggly pattern due to the mis-programmed wires shift:

➢ The shift of the reference wire was not included in the alignment code

➢ Shifts due to the shape of wire feed-through holes were also not included

Look to yesterday's Raffaella De Vita presentation: "Offline software: ongoing projects status"



Offline Beam Offset Calibration

- Tentative list of runs for the offline beam offset calibration, considering:
  - shifts in the vertical position (y-direction) based on downstream beam position monitor
  - Changes in beam current for various studies such as luminosity scans, etc.
- Preparing for the full calibration review once previous steps are done and Pass0v4 timeline is produced

	A	B	C	D	E	F	G
1	Position (2H01)	Run #	duration	# of Events	Current (nA)	Torus State	comments
2	**LD2 target**						
3	x-pos = -1.4 mm y-pos = 1.0 mm	18309	2:12:11	70,064,834	35	-1	https://logbooks.jlab.org/files/2023/10/4192656/clonpc16_20231004_185028.gif
4	x-pos = -1.4 mm y-pos = 1.0 mm	18318	1:14:24	6,966,837	5	-1	https://logbooks.jlab.org/files/2023/10/4193812/clonpc16_20231006_084639.gif
5	x-pos = -1.4 mm y-pos = 1.0 mm	18319	0:30:29	10,002,718	20	-1	https://logbooks.jlab.org/files/2023/10/4193909/clonpc16_20231006_105922.gif
6	x-pos = -1.4 mm y-pos = 1.0 mm	18321	1:03:04	25,005,322	35	-1	https://logbooks.jlab.org/files/2023/10/4193944/clonpc16_20231006_120352.gif
7	x-pos = -1.4 mm y-pos = 1.0 mm	18324	0:34:14	25,005,092	50	-1	https://logbooks.jlab.org/files/2023/10/4194047/clonpc16_20231006_135922.gif
8	x-pos = -1.4 mm y-pos = 1.0 mm	18325	0:50:33	51,857,208	75	-1	https://logbooks.jlab.org/files/2023/10/4194108/clonpc16_20231006_150907.gif
9	x-pos = -1.4 mm y-pos = 1.0 mm	18326	0:58:44	50,548,605	100	-1	https://logbooks.jlab.org/files/2023/10/4194239/clonpc16_20231006_183641.gif
10	**CxC target**						
11	x-pos = -1.4 mm y-pos = 1.0 mm	18339	0:36:43	5,069,529	10	-1	https://logbooks.jlab.org/files/2023/10/4194704/clonsl1_20231007_091454.gif
12	x-pos = -1.4 mm y-pos = 1.0 mm	18340	0:29:34	10,242,961	20-45	-1	https://logbooks.jlab.org/files/2023/10/4194760/clonsl1_20231007_101731.gif
13	x-pos = -1.4 mm y-pos = 1.0 mm	18341	0:22:53	14,653,064	45	-1	https://logbooks.jlab.org/files/2023/10/4194768/clonsl1_20231007_103056.gif
14	x-pos = -1.4 mm y-pos = 1.0 mm	18342	0:50:14	34,622,003	50	-1	https://logbooks.jlab.org/files/2023/10/4194790/clonsl1_20231007_105725.gif
15	x-pos = -1.4 mm y-pos = 1.0 mm	18343	0:23:30	15,626,379	50-90	-1	https://logbooks.jlab.org/files/2023/10/4194865/clonsl1_20231007_121425.gif
16	x-pos = -1.4 mm y-pos = 1.0 mm	18344	0:27:41	26,532,001	75	-1	https://logbooks.jlab.org/files/2023/10/4194871/clonsl1_20231007_122124.gif
17	x-pos = -1.4 mm y-pos = 0.5 mm	18346	0:38:50	23,748,447	50	-1	https://logbooks.jlab.org/entry/4194659 & https://logbooks.jlab.org/files/2023/10/4194950/clonsl1_20231007_144323.gif
18	**CuSn target**						
19	x-pos = -1.4 mm y-pos = 0.5 mm	18347	0:13:13	6,015,270	100	-1	https://logbooks.jlab.org/files/2023/10/4194991/clonpc16_20231007_154447.gif
20	x-pos = -1.4 mm y-pos = 0.0 mm	18348	0:29:03	10,148,936	100	-1	https://logbooks.jlab.org/entry/4194659 & https://logbooks.jlab.org/files/2023/10/4194995/clonpc16_20231007_155625.gif
21	x-pos = -1.4 mm y-pos = 0.0 mm	18349	0:23:28	13,828,468	110-130	-1	https://logbooks.jlab.org/entry/4195006
22	x-pos = -1.4 mm y-pos = 0.0 mm	18350	0:55:33	20,693,001	150-200	-1	https://logbooks.jlab.org/entry/4195006
23	x-pos = -1.4 mm y-pos = 0.0 mm	18352	0:48:08	22,855,033	130	-1	https://logbooks.jlab.org/files/2023/10/4195096/clonpc16_20231007_182354.gif
24	x-pos = -1.4 mm y-pos = 0.0 mm	18372	0:26:00	25,117,366	150	-1	https://logbooks.jlab.org/files/2023/10/4196134/clonsl1_20231009_125103.gif
25	x-pos = -1.4 mm y-pos = 0.0 mm	18373	0:35:25	26,278,056	175	-1	https://logbooks.jlab.org/files/2023/10/4196160/clonsl1_20231009_132250.gif
26	x-pos = -1.4 mm y-pos = 0.0 mm	18375	0:18:50	3,984,894	130	-1	https://logbooks.jlab.org/files/2023/10/4196180/clonsl1_20231009_140556.gif
27	x-pos = -1.4 mm y-pos = 0.0 mm	18377	1:13:19	36,773,378	150	-1	https://logbooks.jlab.org/files/2023/10/4196282/clonpc16_20231009_174509.gif
28	x-pos = -1.4 mm y-pos = 0.0 mm	18386	0:27:12	13,857,299	150	-1	https://logbooks.jlab.org/files/2023/10/4196524/clonsl1_20231010_074929.gif

RG-D Experiments

E12-06-106: Study of Color Transparency (CT) in Exclusive Vector Meson Electroproduction off Nuclei

Spokespeople: W. Armstrong[1], L. El Fassi[3], K. Hafidi[1], M. Holtrop[4], and B. Mustapha[1]

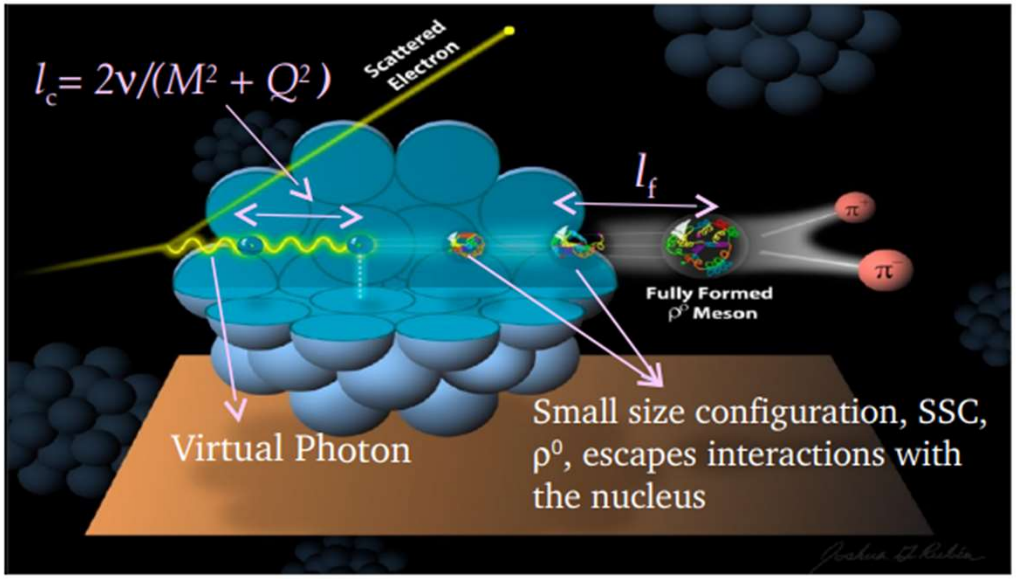
E12-06-106A (endorsed by *PAC-48*): Nuclear TMDs in CLAS12

Spokespeople: R. Dupré[2], L. El Fassi[3], Zein-Eddine Meziani[1], and Holly Szumila-Vance[5]

See Daniel Matamaros' talk

[1]: Argonne National Lab (ANL)
[2]: IJCLAB, Orsay, France
[3]: Mississippi State U. (MSSate)
[4]: University of New-Hampshire (UNH)
[5]: Jefferson Lab

Color Transparency Phenomenon

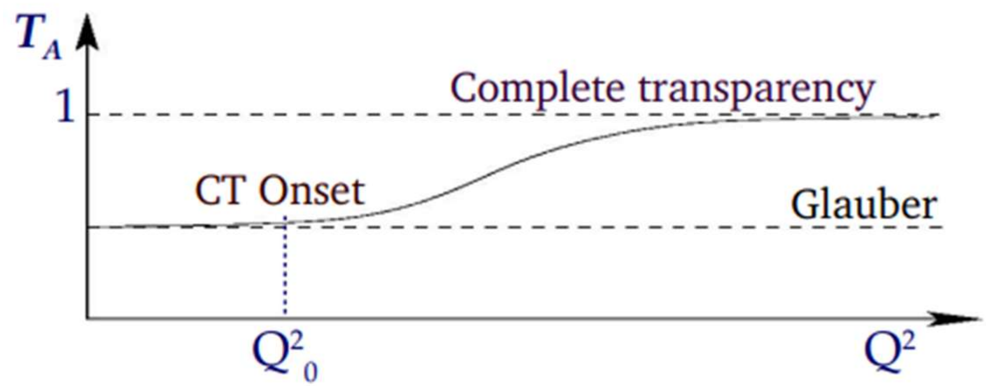


The CT signature is the increase of the medium "nuclear" transparency, T_A, as a function of the four-momentum transfer squared, Q^2.

$$T_A = \frac{\sigma_A}{A\,\sigma_N}$$

σ_A is the nuclear cross section

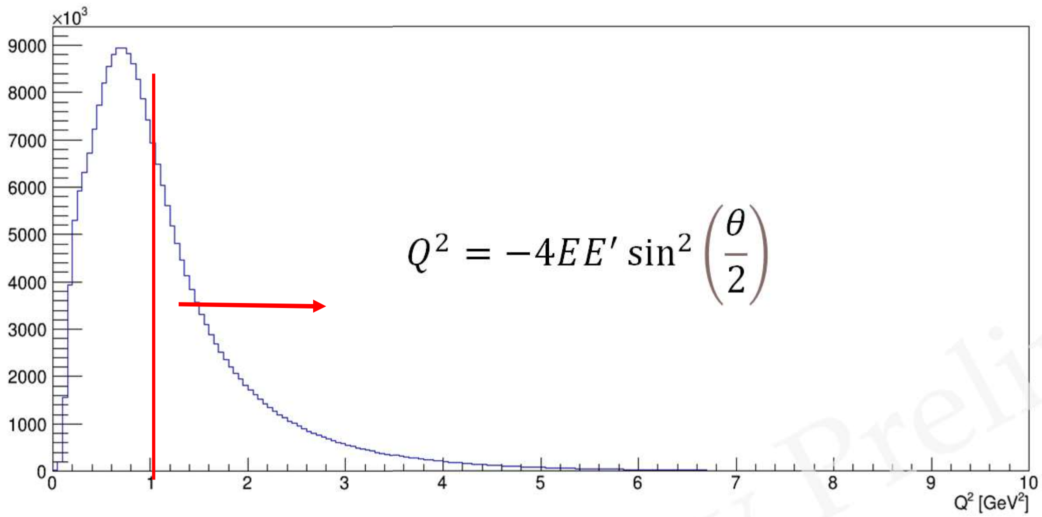
σ_N is the free (nucleon) cross section

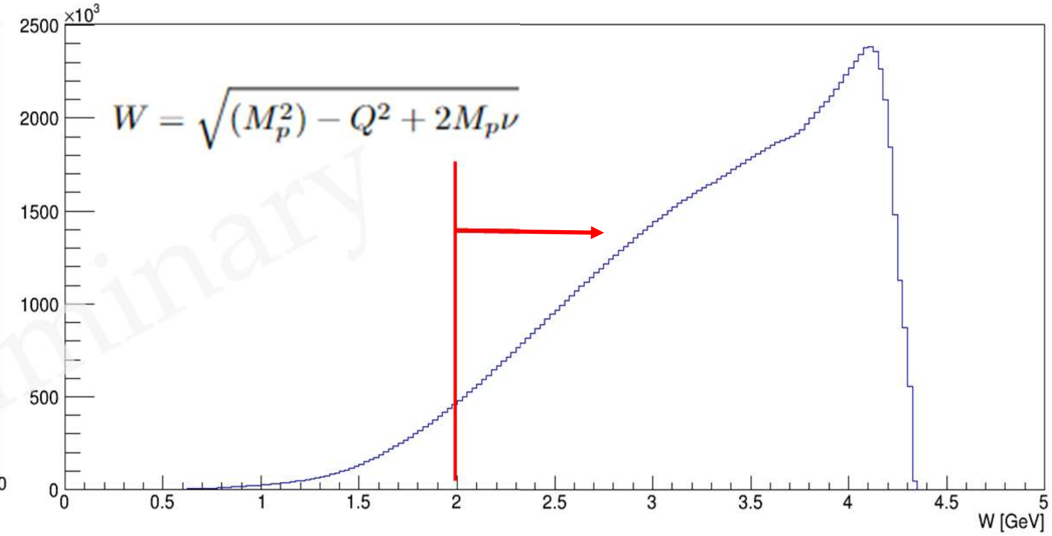


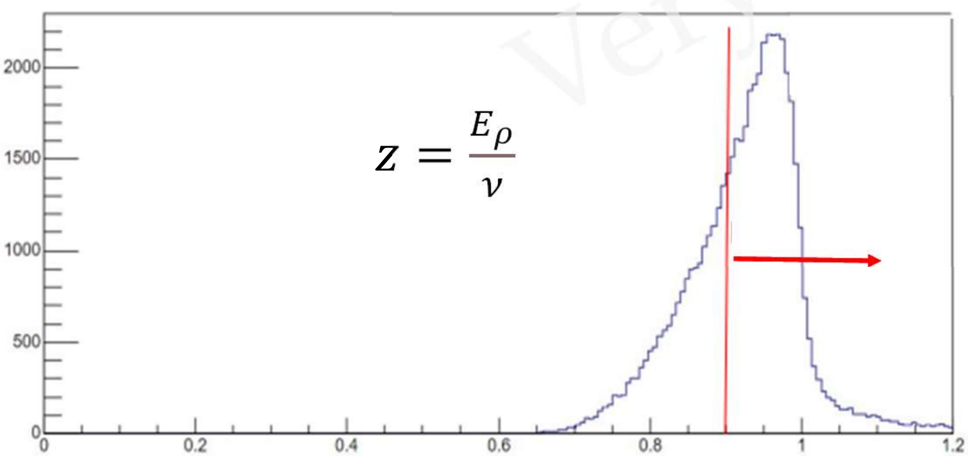
- Coherence length, l_c: the lifetime of the qq-bar pair.
- Formation time, l_f: the time evolution of SSC to an on-shell ρ^0 meson.

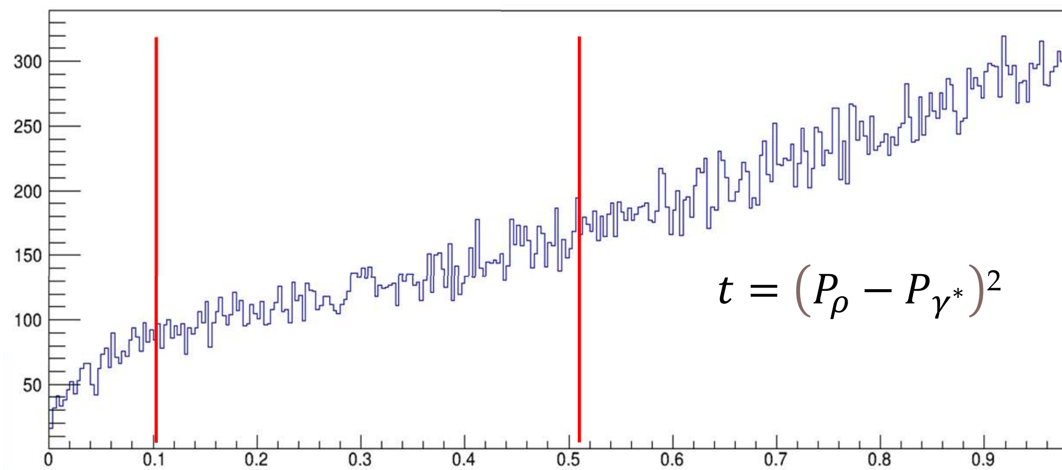
Preliminary CT Analysis: Kinematic and cuts

- Study of exclusive, diffractive and incoherent ρ^0 electroproduction off nuclei

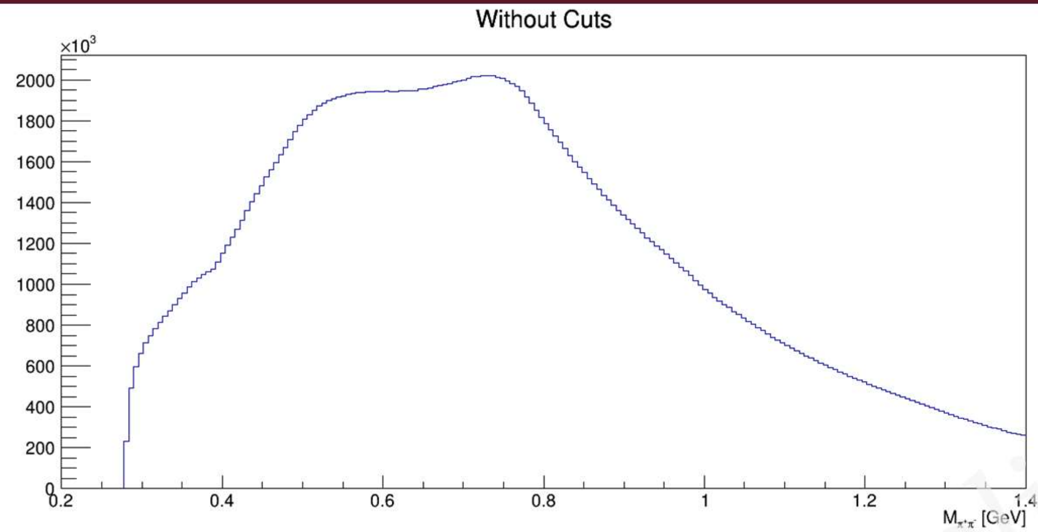


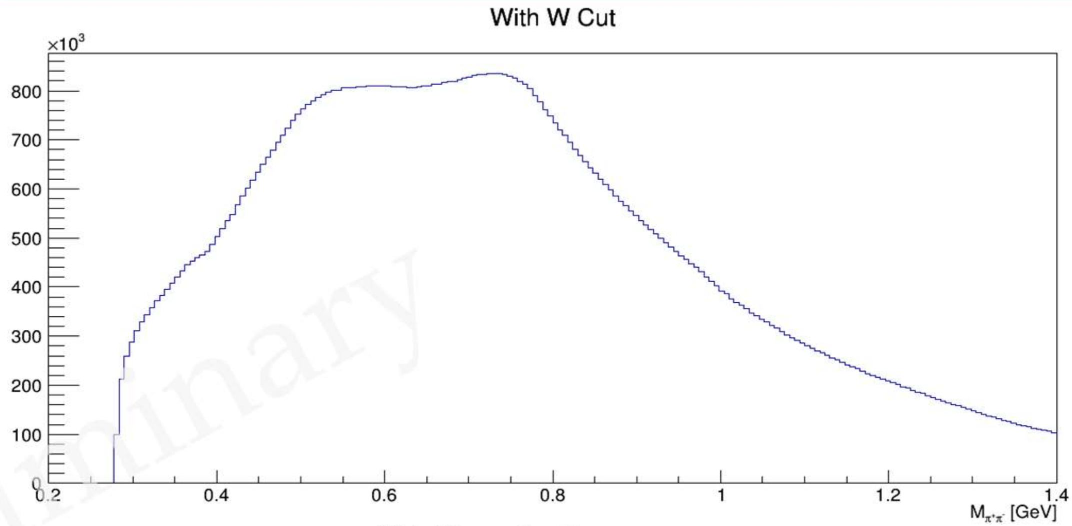


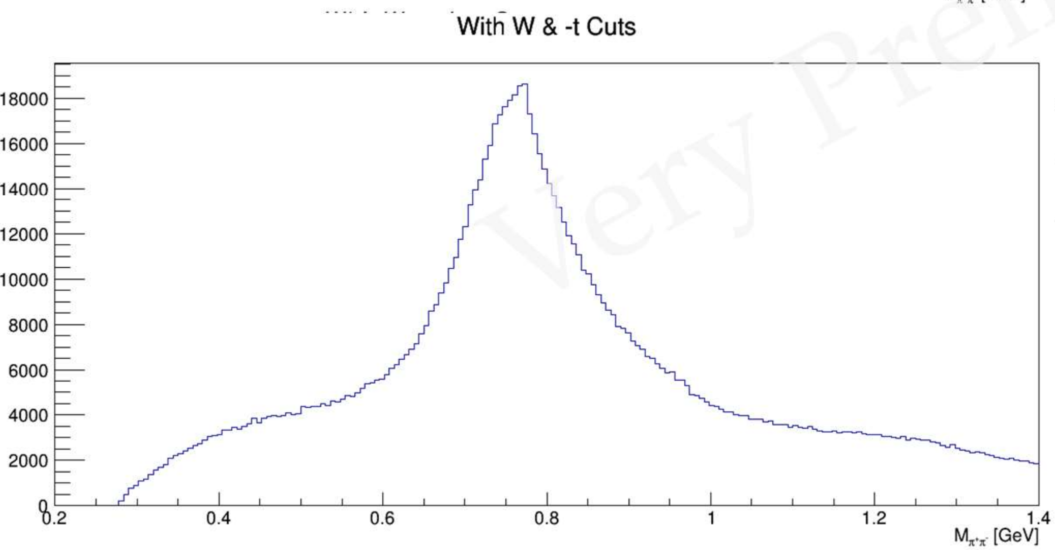


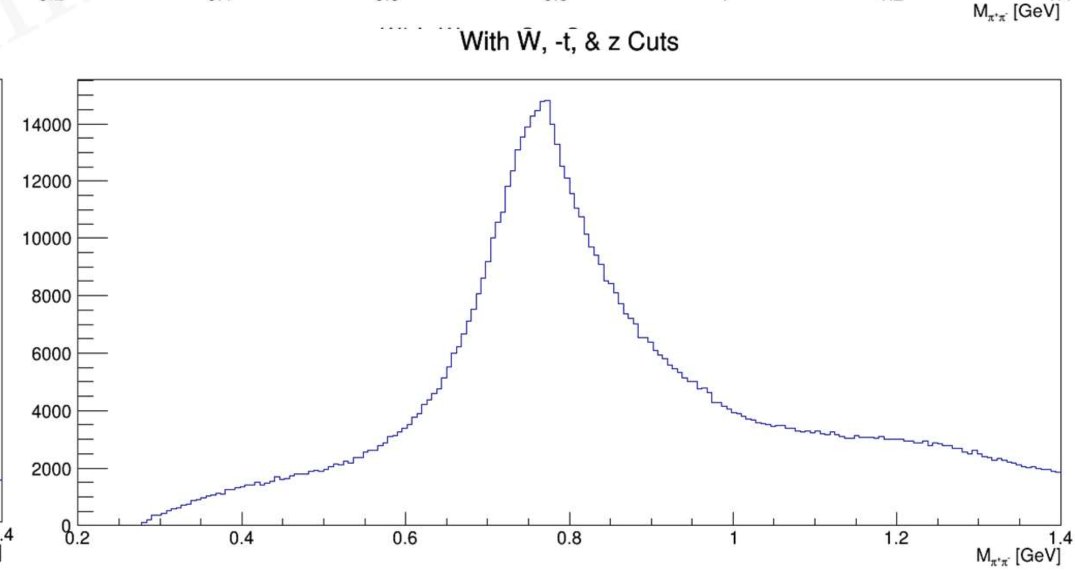


$\pi^+\pi^-$ Invariant Mass

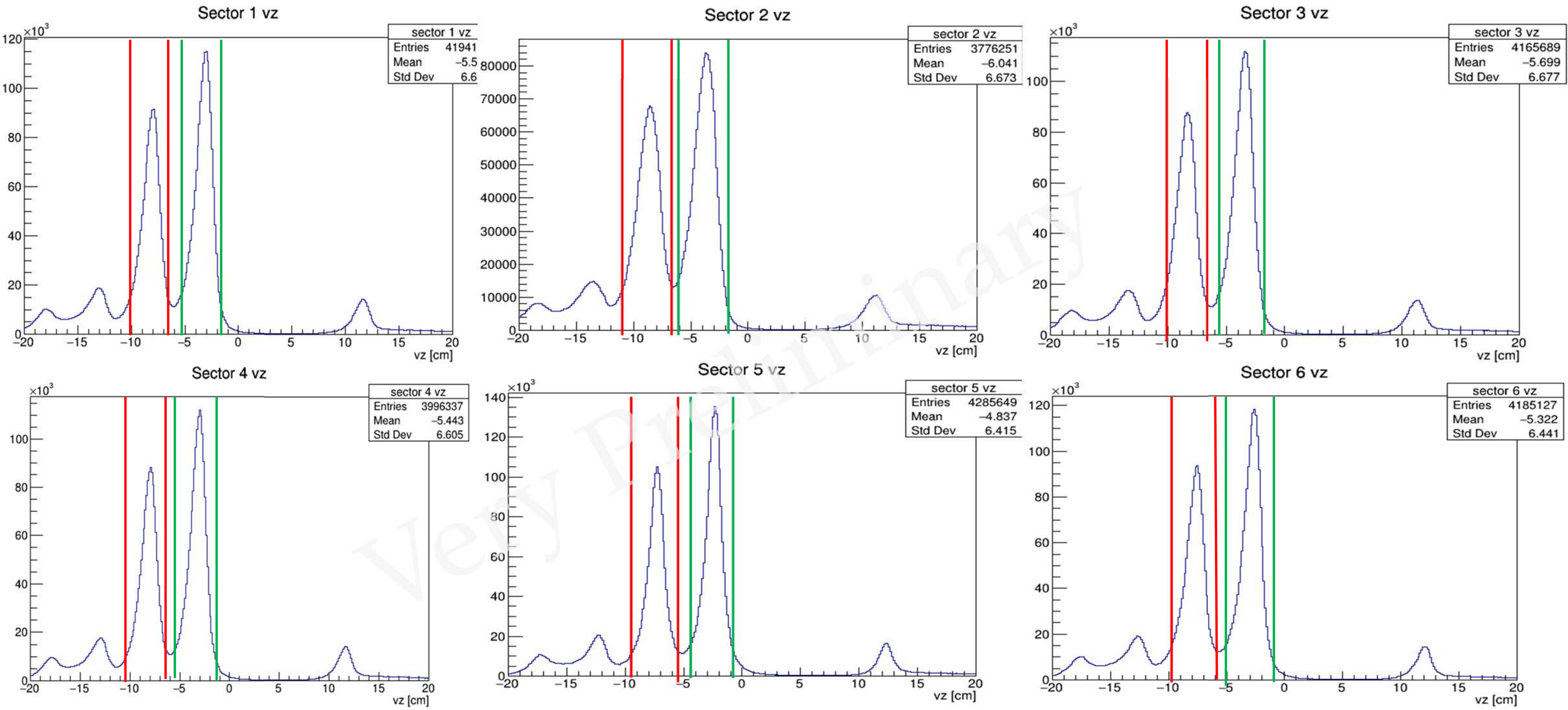




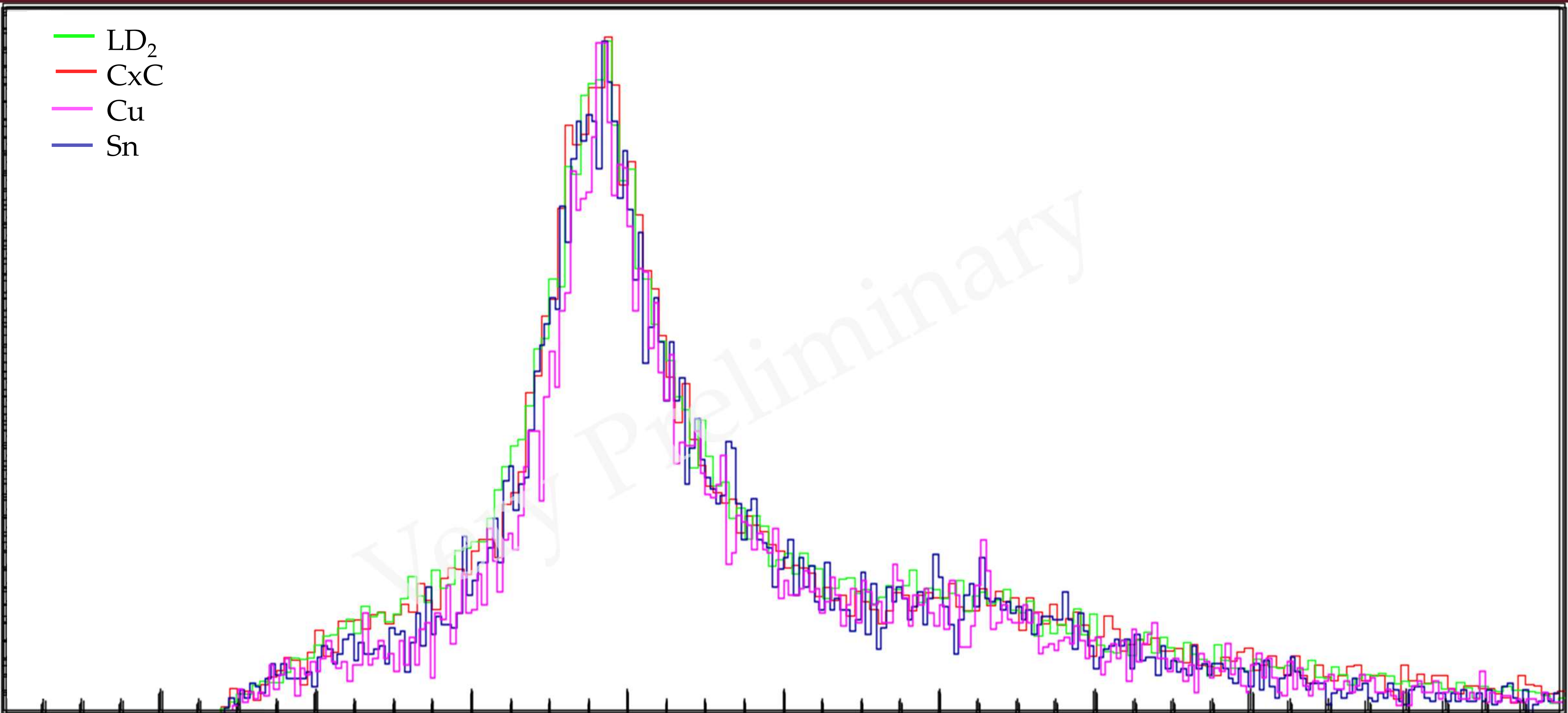




z-Vertex Distributions for CuSn Target Configuration

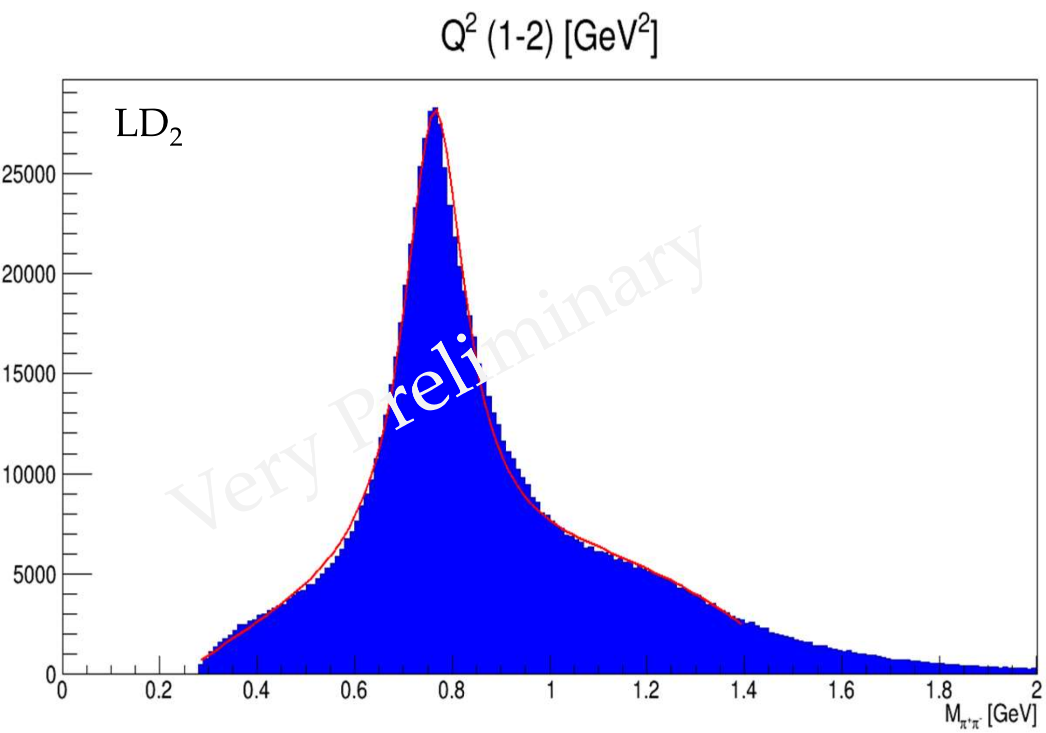


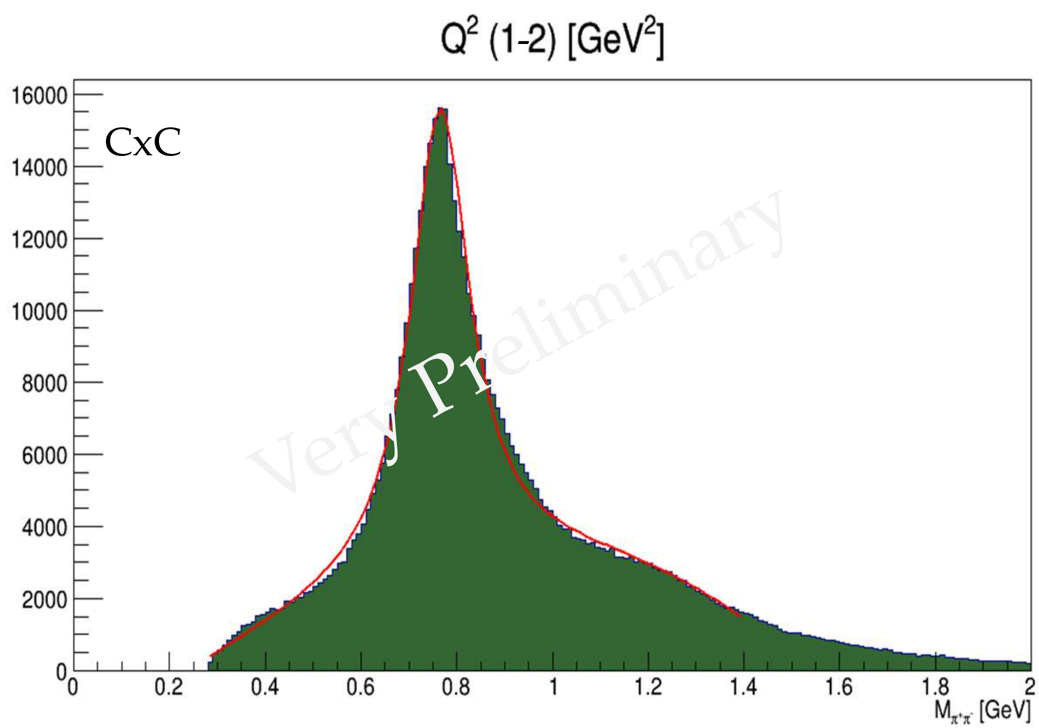
LD_2 , CxC, Cu, & Sn $\pi^+\pi^-$ Invariant Mass Comparison

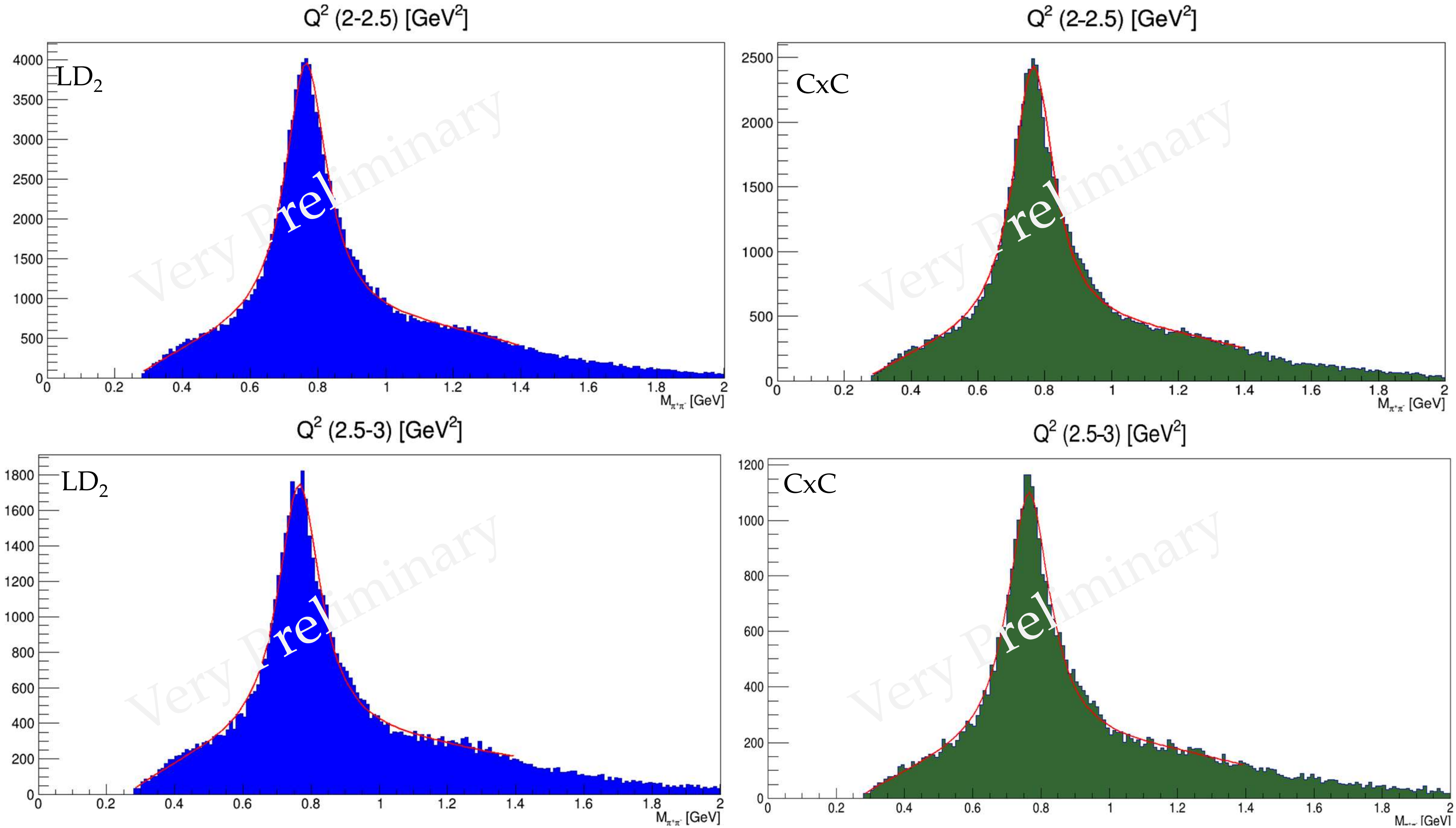


$\pi^+\pi^-$ Invariant Mass

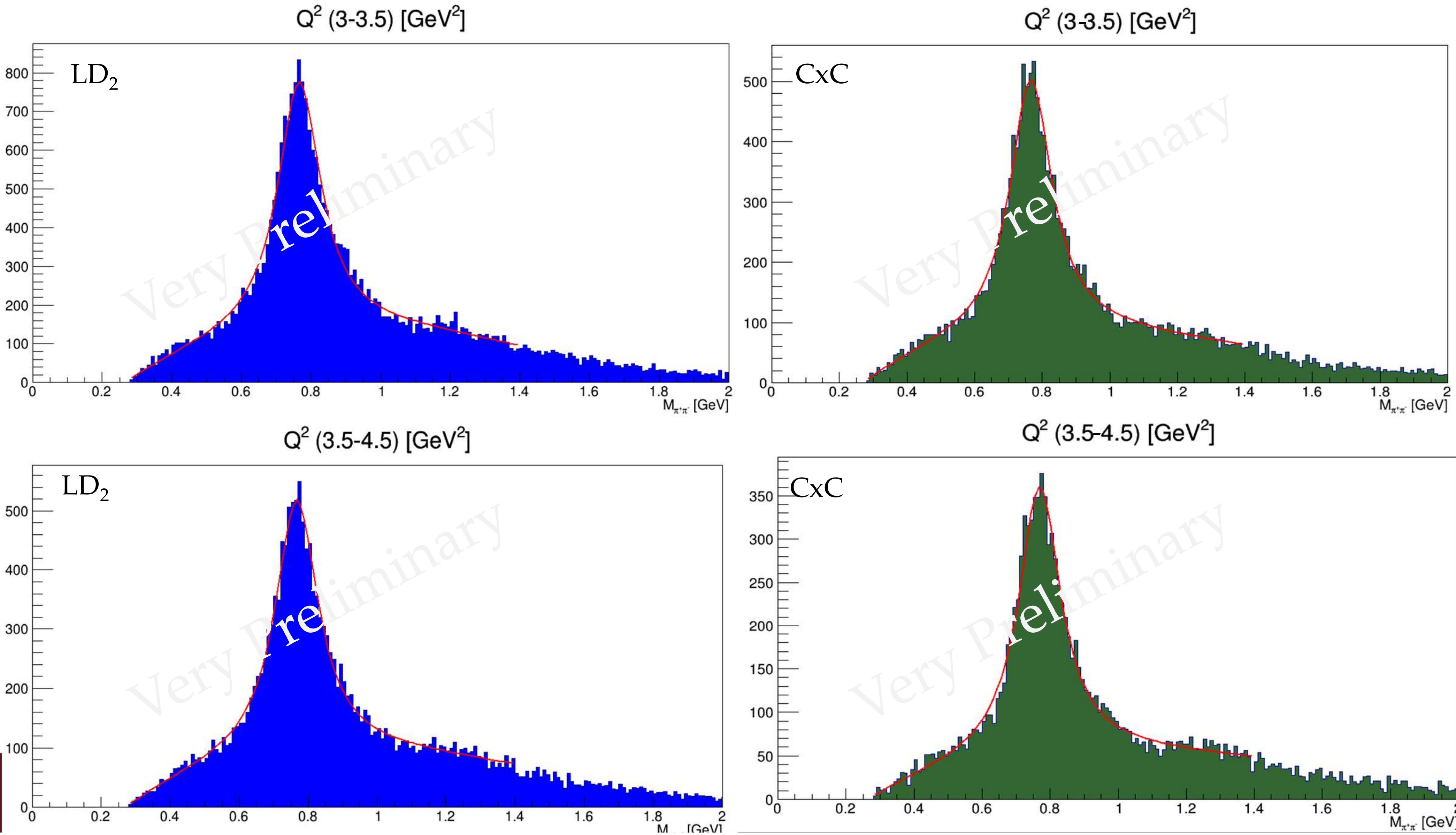
- $\pi^+\pi^-$ mass distributions for various Q^2 bins, and l_c <= 1 fm
- A very preliminary fit using a simple Breit Wigner and 3-D polynomial function



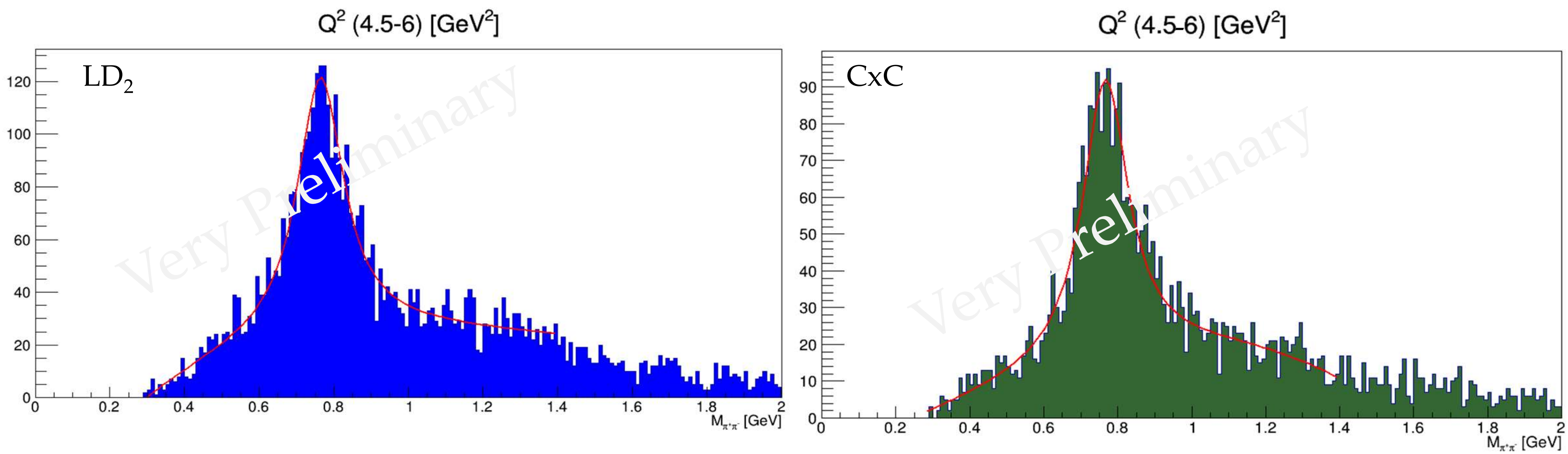




Q² (2-2.5) [GeV²]
LD₂
CxC
Q² (2.5-3) [GeV²]
M_{π⁺π⁻} [GeV]
Very Preliminary


Q^2 (3-3.5) [GeV^2]
LD2
Very Preliminary
M_{π+π-} [GeV]
Q^2 (3-3.5) [GeV^2]
CxC
Very Preliminary
M_{π+π-} [GeV]
Q^2 (3.5-4.5) [GeV^2]
LD2
Very Preliminary
Q^2 (3.5-4.5) [GeV^2]
CxC
Very Preliminary
M_{π+π-} [GeV]

$\pi^+\pi^-$ Invariant Mass



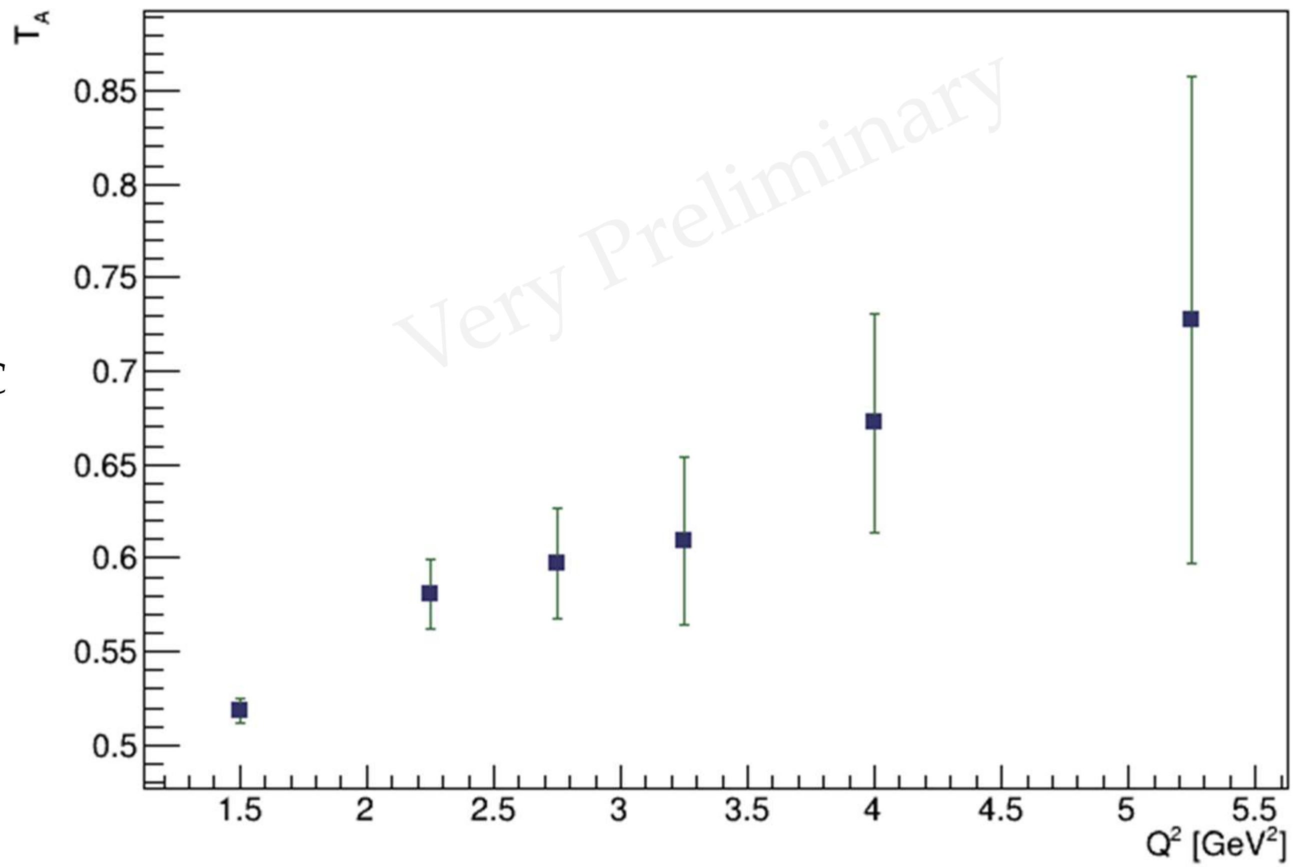
Carbon Nuclear Transparency Result

❖ Nuclear transparency is extracted as

$$T_A = \frac{N_C^{\rho}}{N_D^{\rho}}\left(\frac{t_D \text{ x } \rho_D}{t_C \text{ x } \rho_C}\right)$$

where,

- N_C is the rho yield from target CxC
- N_D is the rho yield from target LD_2
- t_D = 5 cm is LD_2 thickness
- t_C = 0.4 cm is CxC thickness
- ρ_D is the LD_2 density
- ρ_C is the C density



Summary & Outlook

- Finalize the detector alignment and calibration for the whole RG-D data sets
- Perform background subtraction using our ρ^0 event generator and the CLAS12 GEANT-4 simulation package
- Extract the nuclear transparency results for the three nuclei, C, Cu, and Sn, after applying various cuts and corrections
- Identify various sources of systematic uncertainties related to our nuclear transparency results

This work is supported in part by the US DOE award #: DE-FG02-07ER41528