Hadronization from CLAS6 and CLAS12

Studies of Hadronization from CLAS6 and Readiness for CLAS12

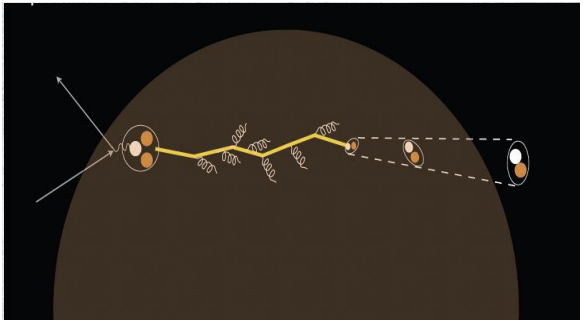
Latiful Kabir (MSU)
Lamiaa El Fassi (MSU)

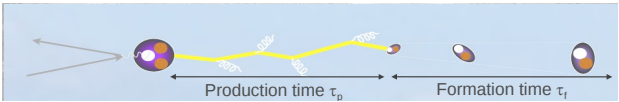
July 13, 2018

Outline

Hadronization Studies

- Evolution of a colored bare quark into a fully dressed hadrons – Hadronization.
- Hadronization timescales: Production time τ_p and Formation time τ_f
- A direct probe of QCD confinement.
- Use semi-inclusive deep inelastic scattering (SIDIS) to gain access to physics observables.





Hadronization Studies

- Multiplicity ratio:

$$R_{\mathrm{A}}^{h}\left(\nu, Q^{2}, z, p_{T}, \phi\right)=\frac{\left.\frac{N_{h}(\nu, Q^{2}, z, p_{T}, \phi)}{N_{e}(\nu, Q^{2})}\right|_{\mathrm{DIS}}|_{\mathrm{A}}}{\left.\frac{N_{h}(\nu, Q^{2}, z, p_{T}, \phi)}{N_{e}(\nu, Q^{2})}\right|_{\mathrm{DIS}}|_{\mathrm{D}}}$$

- Transverse momentum broadening: $\Delta P_T^2 = \langle P_T^2 \rangle_A - \langle P_T^2 \rangle_D$

DIS channels: *stable* hadrons, accessible with 11 GeV JLab experiment PR12-06-117

Actively underway with existing 5 GeV data

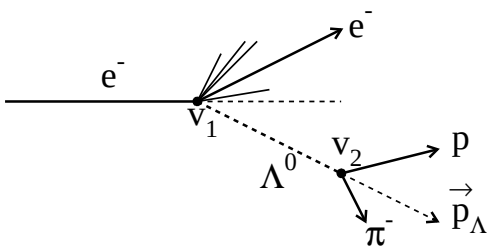
meson	cτ	mass	flavor content
π^0	25 nm	0.13	$u\bar{u}d\bar{d}$
π^+, π^-	7.8 m	0.14	$u\bar{d}$, $d\bar{u}$
η	170 pm	0.55	$u\bar{u}d\bar{d}s\bar{s}$
ω	23 fm	0.78	$u\bar{u}d\bar{d}s\bar{s}$
η'	0.98 pm	0.96	$u\bar{u}d\bar{d}s\bar{s}$
ϕ	44 fm	1.0	$u\bar{u}d\bar{d}s\bar{s}$
$f1$	8 fm	1.3	$u\bar{u}d\bar{d}s\bar{s}$
K^0	27 mm	0.50	$d\bar{s}$
K^+, K^-	3.7 m	0.49	$u\bar{s}$, $\bar{u}s$

baryon	cτ	mass	flavor content
p	stable	0.94	ud
$\bar{p}$	stable	0.94	$\bar{u}\bar{d}$
Λ	79 mm	1.1	uds
$\Lambda(1520)$	13 fm	1.5	uds
Σ^+	24 mm	1.2	us
Σ^-	44 mm	1.2	ds
Σ^0	22 pm	1.2	uds
Ξ^0	87 mm	1.3	us
Ξ^-	49 mm	1.3	ds

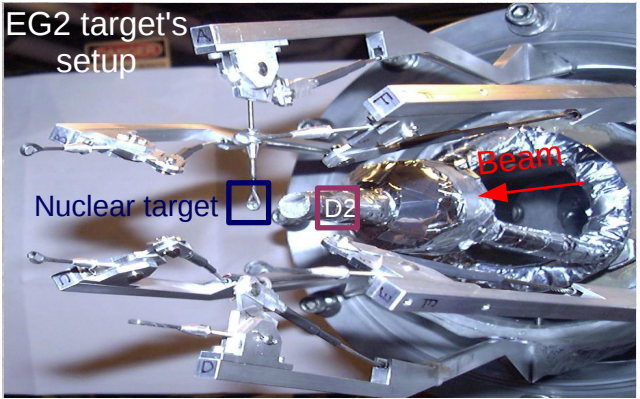
Lambda Hadronization From EG2

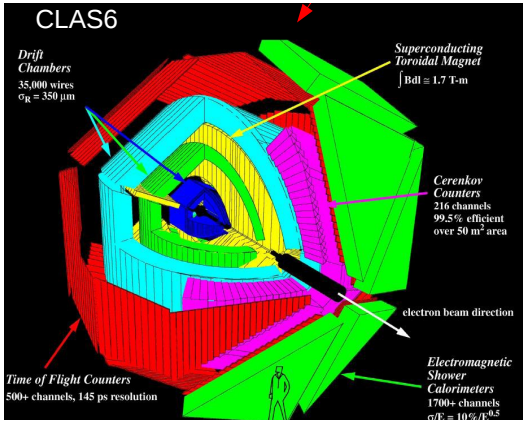
$$e + A \rightarrow e' + \Lambda + X$$

- PID: e-, π^-, proton
- Vertex correction
- Data Quality: Normalized Yield
- SIDIS Cut
- Lambda Identification
- Background subtracted Lambda
- Correction for detector efficiencies and background

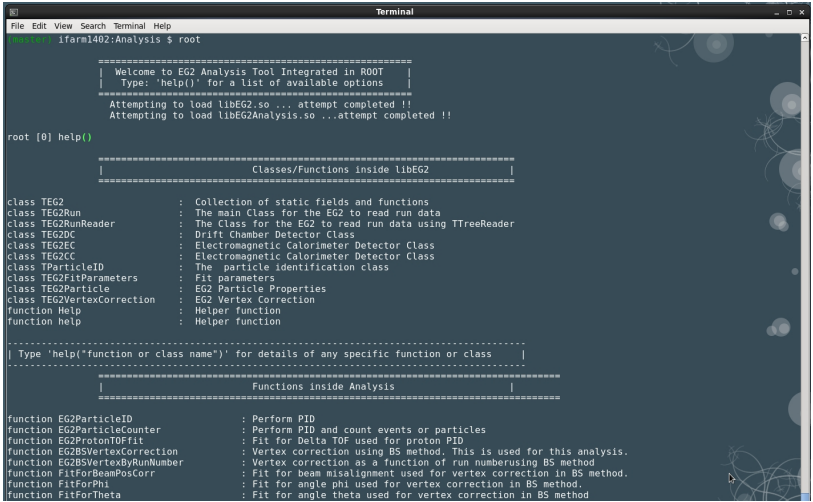


Experimental Setup

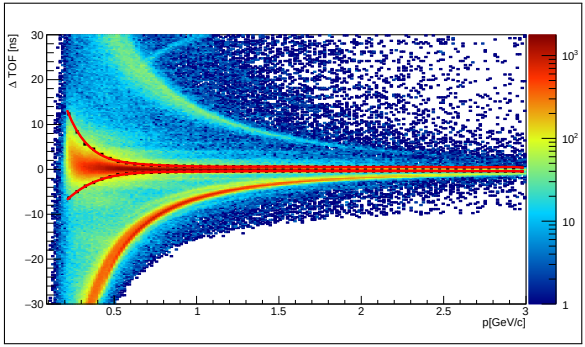


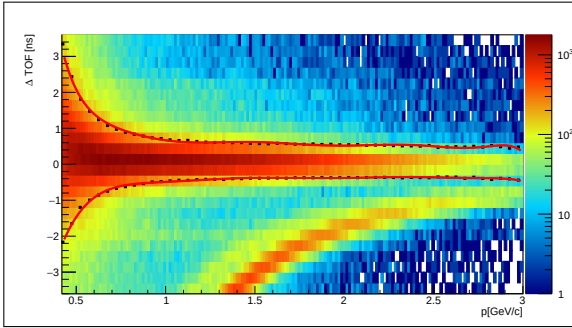


Setup for Analysis

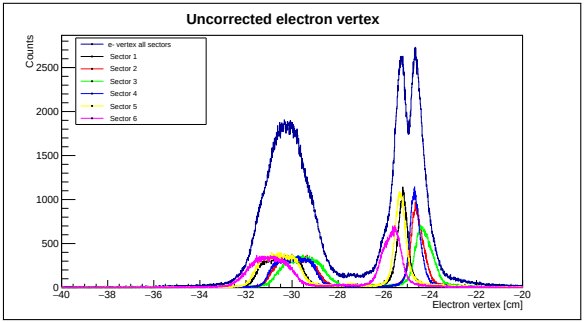


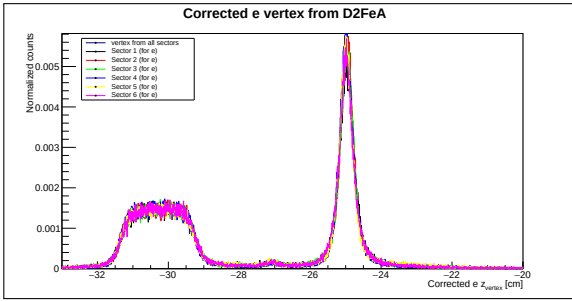
Proton Identification



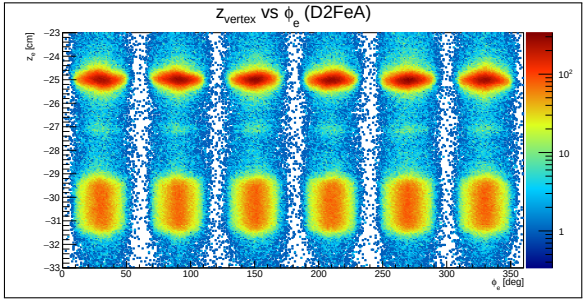


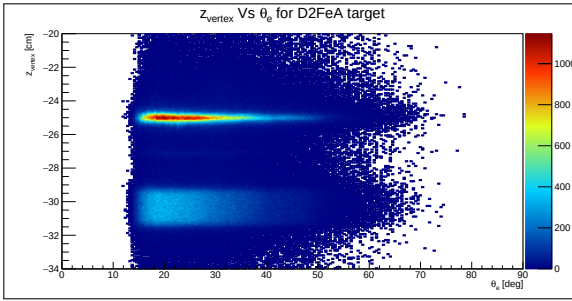
Vertex Correction



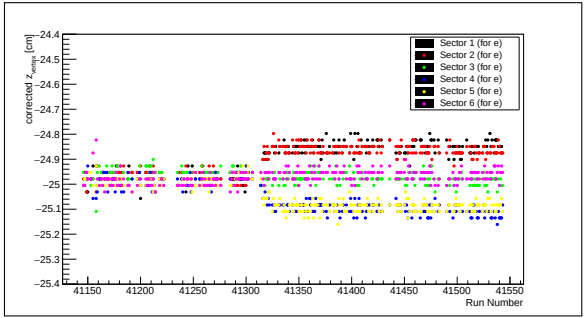


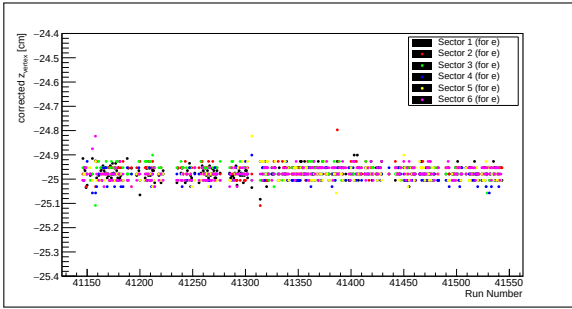
Vertex Correction





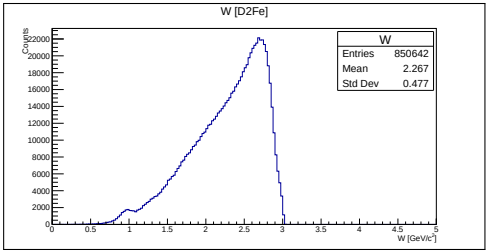
Vertex Correction

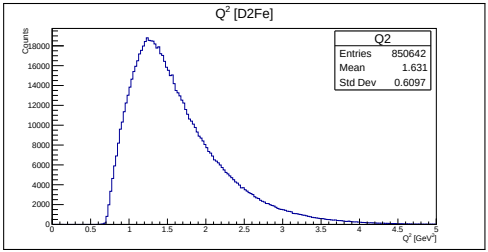




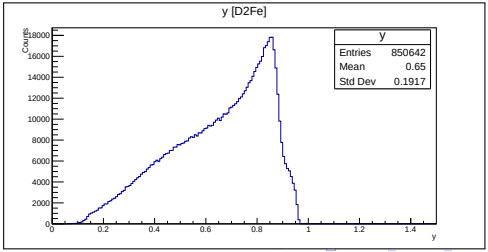
- First observed by Sereres Johnston (ANL)

Kinematic Cuts to Select SIDIS Events

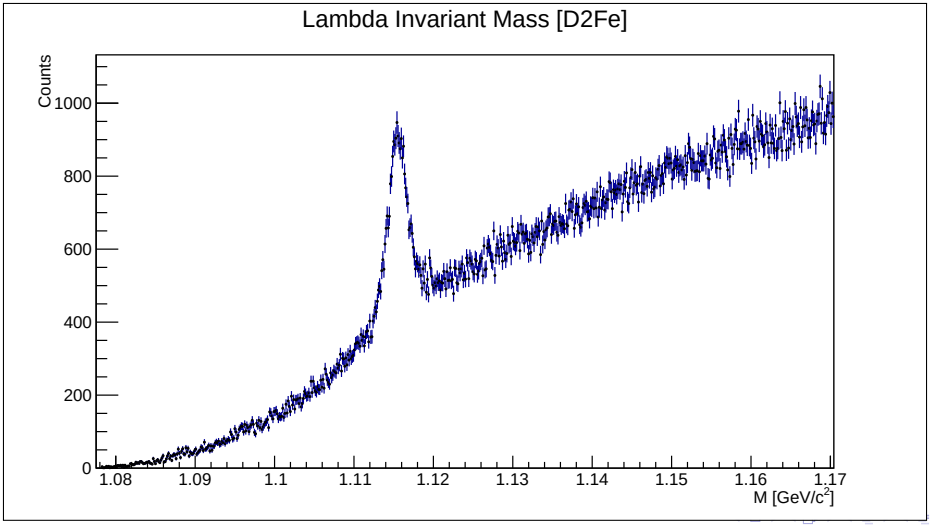




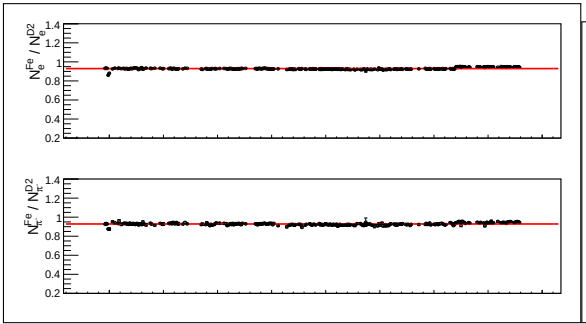
- $Q^2 > 1$ (4-momentum transfer)
- W > 2 (Hadronic mass)
- y < 0.85 (Struck Quark Energy Fraction)

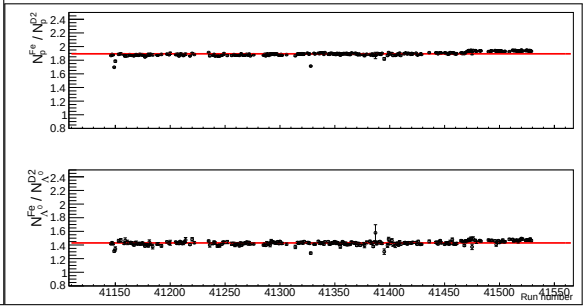


Lambda Identification

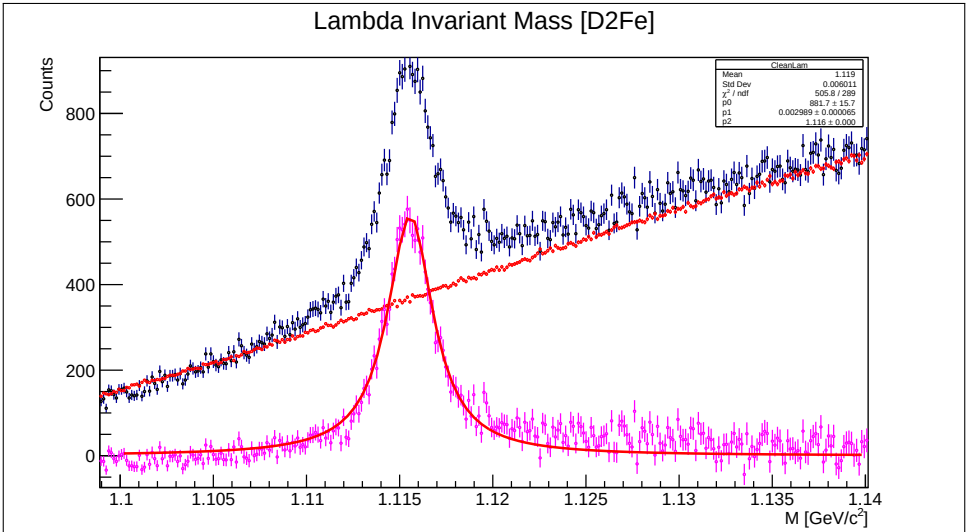


Data Quality





Background Subtraction

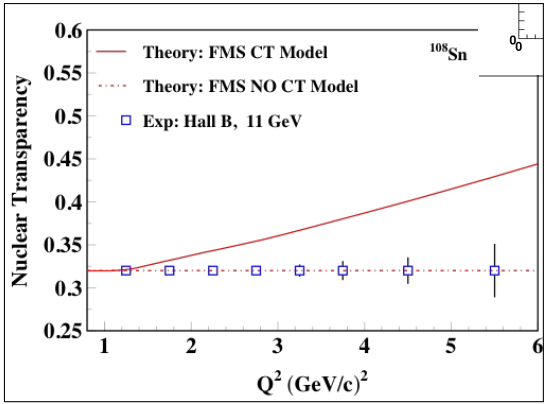


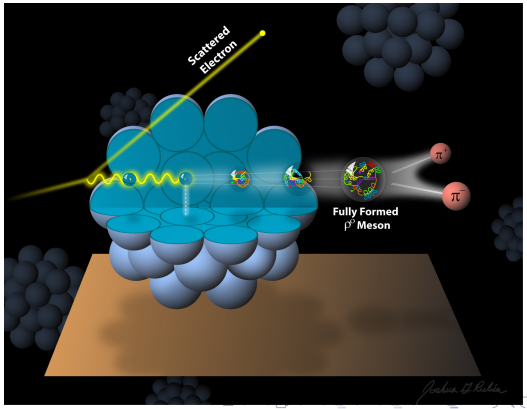
Ongoing Work

- Calculate multiplicity ratios for each data-set.
- Correct for radiative effects
- Correct for detector acceptance
- Finish systematic error budget

Readiness for CLAS12

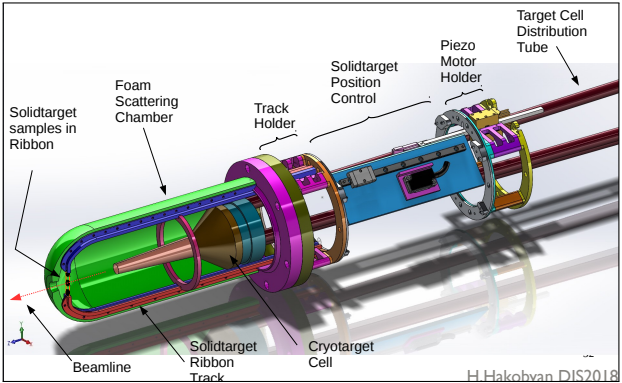
- In addition to hadronization, we are also interested in CT in 12 GeV



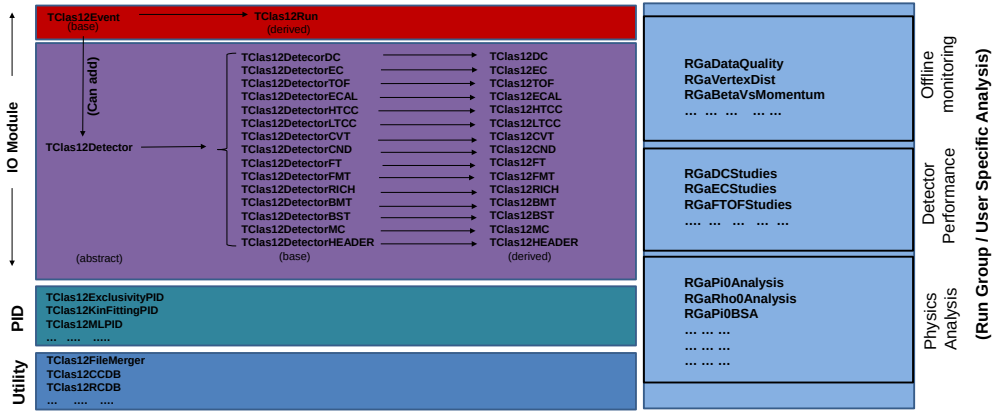


Target Status

- Dual nuclear target for CLAS12 under construction in Chile
- Target types: C, Cu, Sn, Pb and others
- 5T Magnetic field
- Cryotarget at 30 ^{0}K
- Radiation hardness

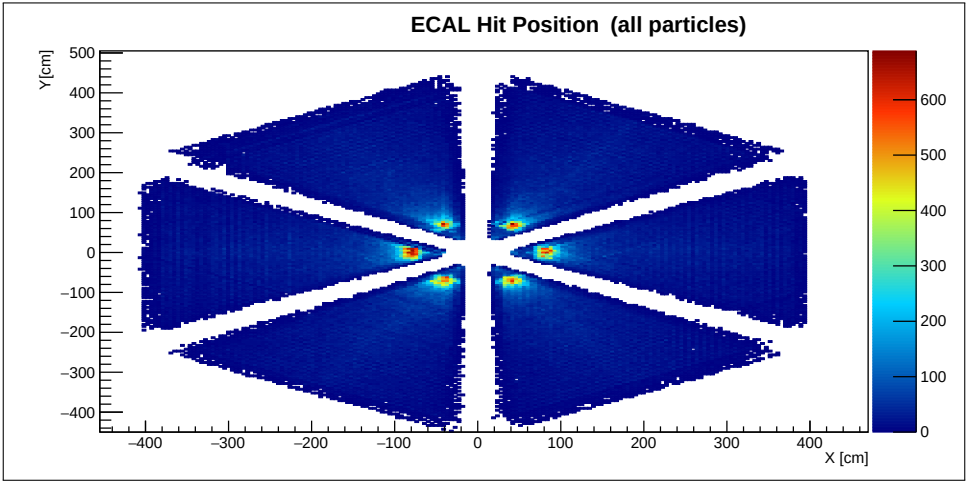


Dedicated Analysis Tool: The Architecture

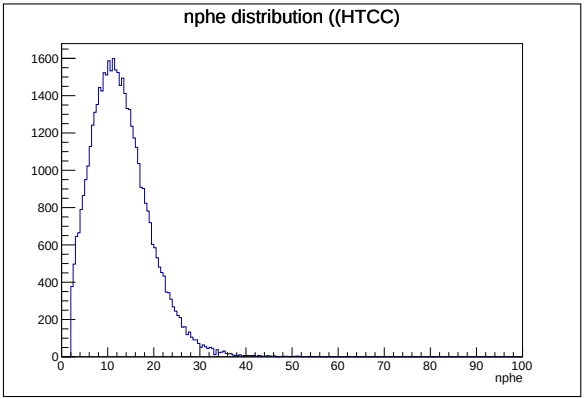


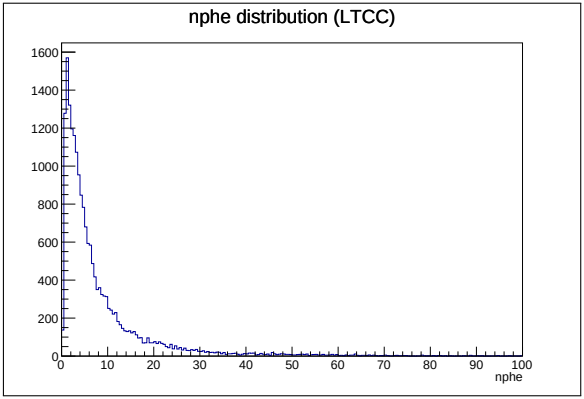
- ROOT based analysis tool on top of HIPO without requiring to convert to root files.
- Tailored to take full advantage of the batch farm resources.
- Data quality check, detector performance etc are intrinsic in the tool.

Data Quality

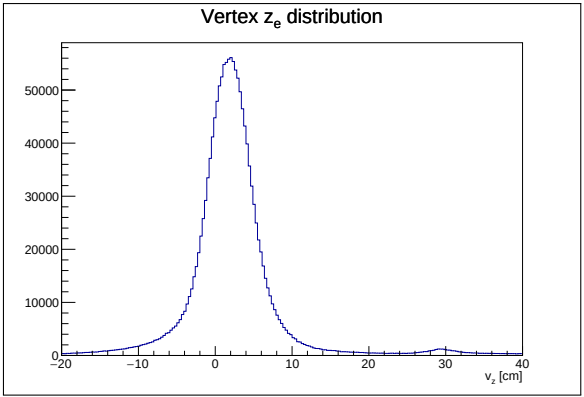


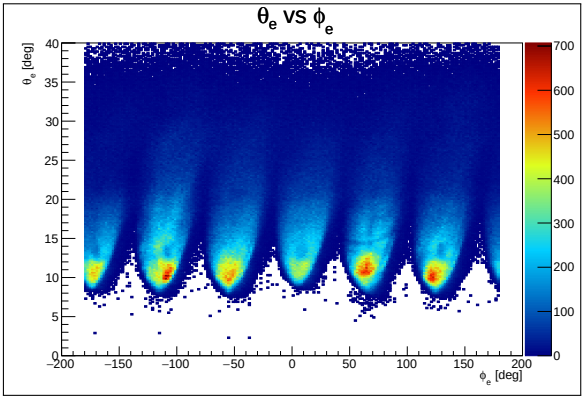
Data Quality



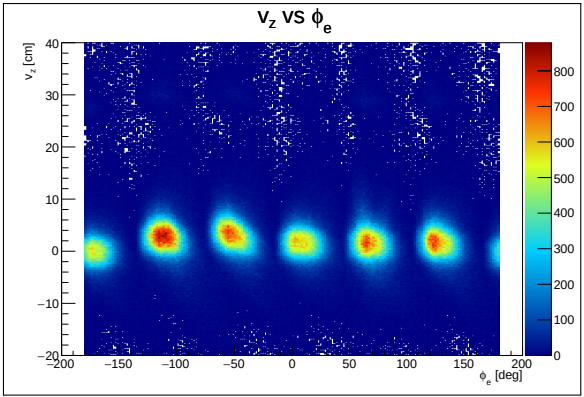


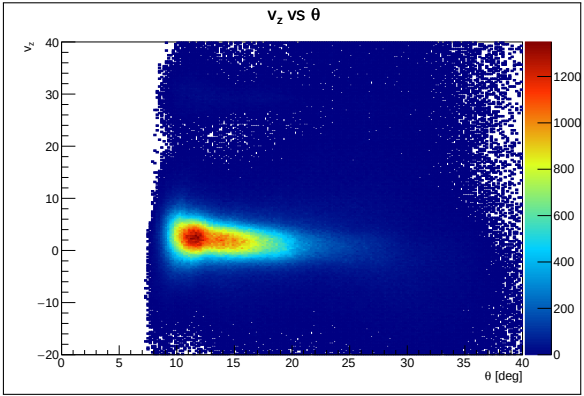
Data Quality



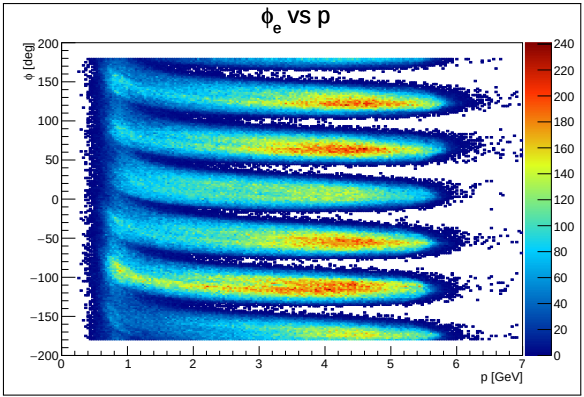


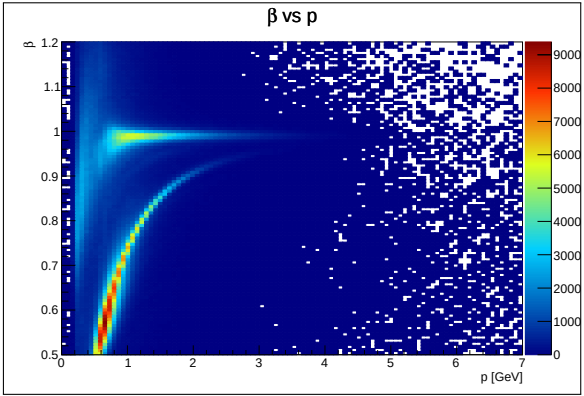
Data Quality





Data Quality

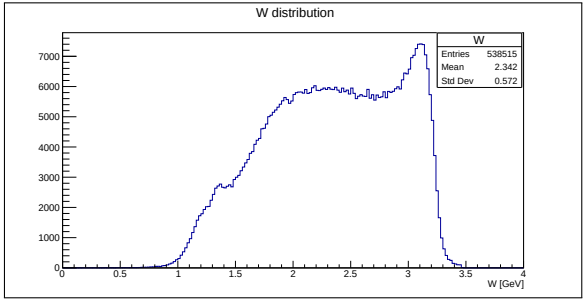


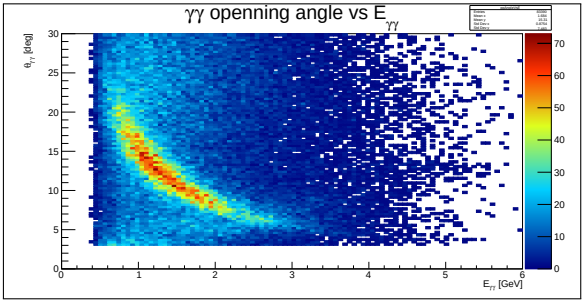


Let's Look At Some Reaction Channels

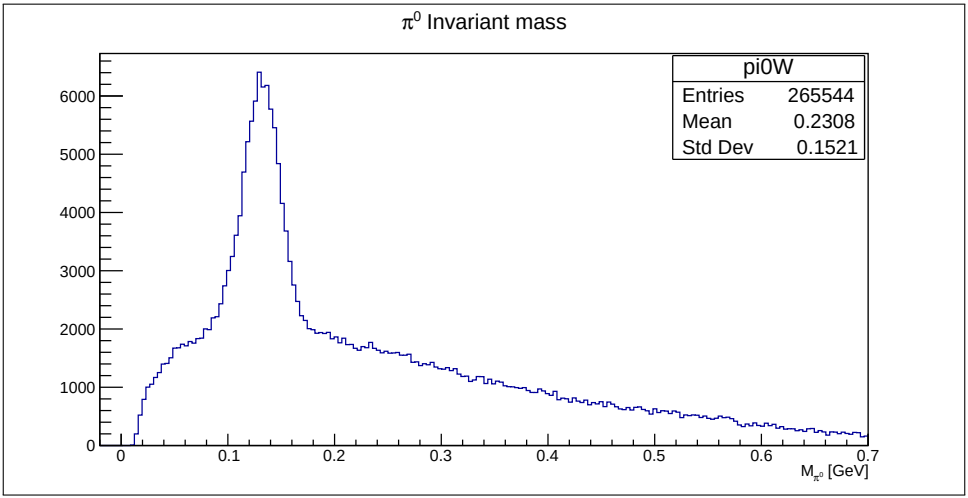
- $e + p \rightarrow e' + \pi^0 + X$
- $e + p \rightarrow e' + \rho^0 + X$
- $e + p \rightarrow e' + \Lambda + X$

Reaction Channel: π^0 $(e + p \rightarrow e' + \pi^0 + X)$ 6.4 GeV Run, Old Cooking

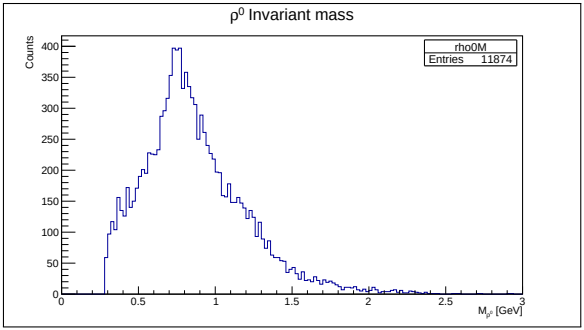




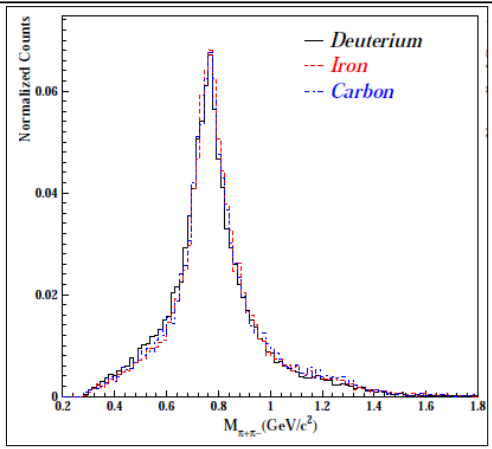
Reaction Channel: π^0 $(e + p \rightarrow e' + \pi^0 + X)$ 6.4 GeV Run, Old Cooking



Reaction Channel: ρ^0 $(e + p \rightarrow e' + \rho^0 + X)$ 10.6 GeV Run (3971), Old Cooking

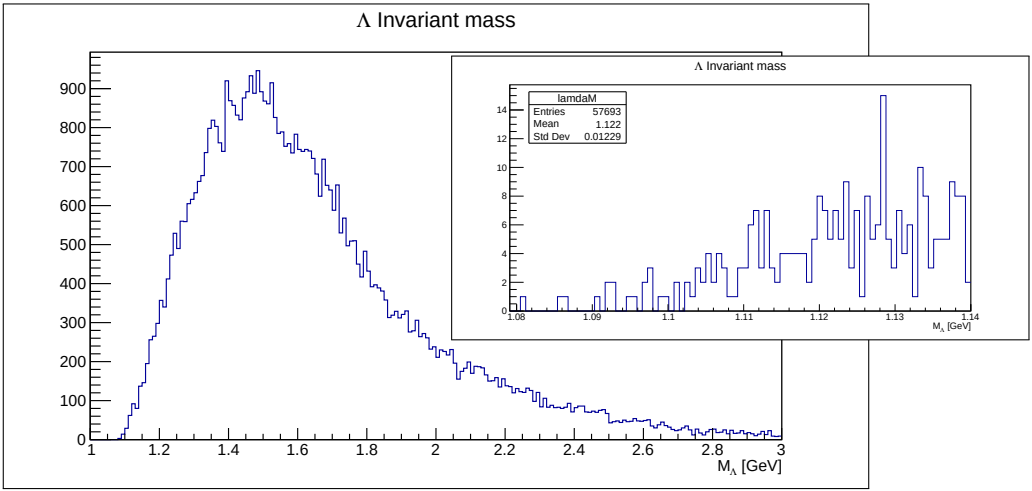


CLAS12 Data at 10.6 GeV



CLAS EG2 Data (CT Analysis Note) at 5 GeV

Reaction Channel: Λ ($e + p \rightarrow e' + \Lambda + X$) 10.6 GeV Run (3971), Old Cooking



Summary

- Lambda hadronization analysis from EG2 data is in advanced stage.
- 6 GeV hadronization and color transparency physics programs are on track to be extended to 12 GeV as well.
- Dedicated analysis tools and manpower are in place to extract the physics.