NPWG Report

Fall CLAS Collaboration Meeting

November 15th, 2019

Lamiaa El-Fassi

Session Agenda

08:35 - 12:15 Nuclear Physics Working Group

https://bluejeans.com/811083791

Convener: Dr. Lamiaa El Fassi (Mississippi State U.)

08:35 **NPWG Business** *20'*
- Speaker: Dr. Lamiaa El Fassi (Mississippi State U.)
- Material: **Slides**

08:55 **An update on Omega Meson Hadronization Studies** *35'*
- Speaker: Mr. Andres Borquez (UTFSM)
- Material: **Slides**

09:30 **Updates on validation of neutrino energy estimation using electron scattering data** *35'*
- Speaker: Mariana Khachatryan (ODU)
- Material: **Slides**

10:00 - 10:30 Coffee break

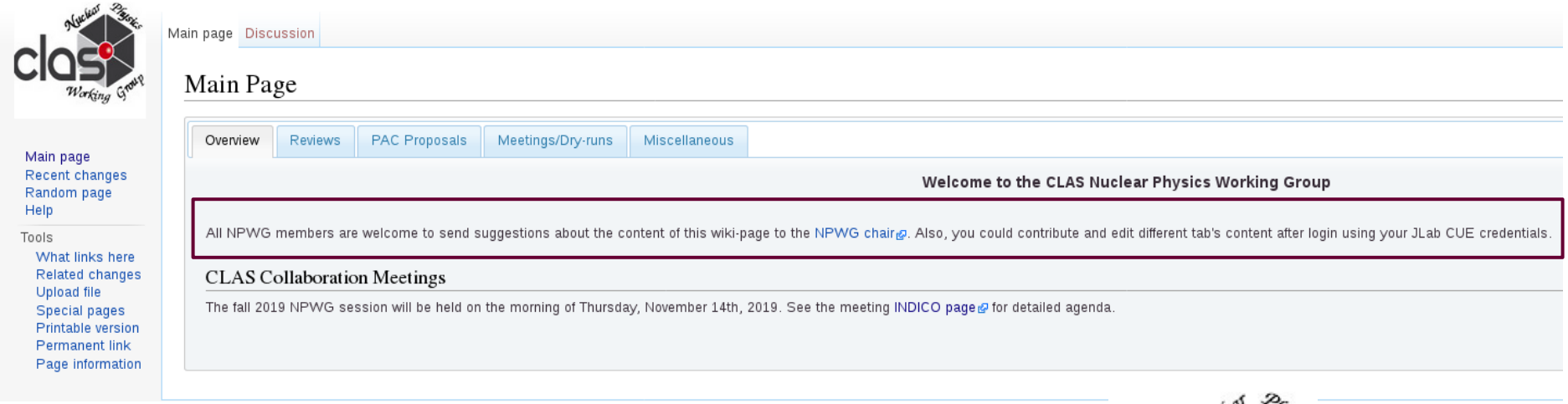
10:35 **Current status on color propagation analysis for pi+** *35'*

(Remote talk)
- Speaker: Mr. Sebastian Moran (UTFSM)
- Material: **Slides**

11:10 **Updates on the EG2 Λ-Hadronization Studies** *40'*
- Speaker: Dr. Taya Chetry (Mississippi State University)
- Material: **Slides**

WG Activities & Responsibilities

- Thanks to Nathan, the new wiki-page was created roughly a week ago,
  - ✔ It Resides at https://clasweb.jlab.org/Hall-B/npwg/index.php/Main_Page



- ◆ Proposed a kind of competition to redesign a WG logo:
  - ✔ Will award the winning design $100 Amazon gift card!

WG Activities & Responsibilities

- Reviews Tab:

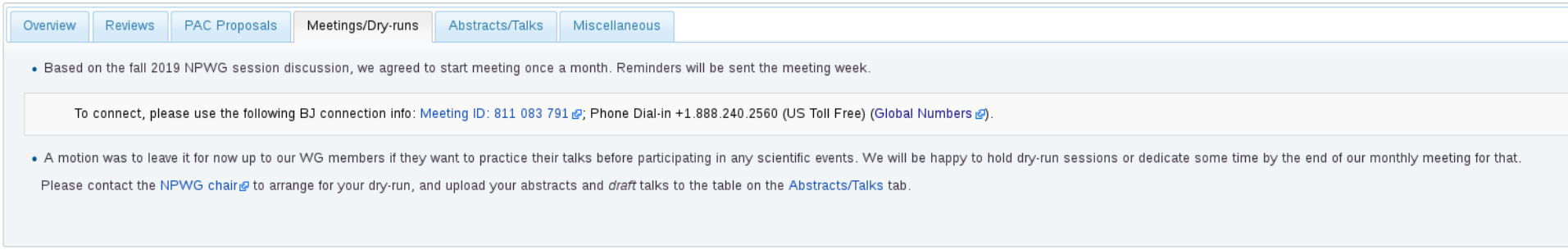
2019 Summary					
Analysis TOPIC	*Lead Authors*	*Review Committee*	*Status*	*Database/Shiftbot Link*	*Adhoc Status*
Probing 2N-SRC Using the C(e; e'pn) and C(e; e'p) Reactions	Axel Schmidt / Igor Korover *et al.*	H. Hakobyan (Chair), N. Zachariou, and S. Joosten	Back to authors after the 1st round review	Review #8487480	Not started yet!
Validation of neutrino energy estimation using electron scattering data	Mariana Khachatryan *et al.*	H. Egiyan (Chair), N. Dashyan, and M. Hattawy	**APPROVED; Congrats!**	Review #5423632	Waiting for authors plans
Pi0 Hadronization with CLAS6	Taisiya Mineeva *et al.*	L. Weinstein (Chair), Y. Ilieva, Sereres Johnston* (**Not a member anymore!*)	Back to authors after the 3rd round review in which S. Stepanyan was invited to settle a disagreement between the main two reviewers on how to take into account the systematic uncertainties related to "Photon ID" cuts .	Review #6510077	Not started yet!
Coherent and Incoherent DVpi0P with CLAS EG6	Frank Cao *et al.*	Chaden Djalali (Chair), Ahmed El Alaoui , Axel Schmidt	**APPROVED; Congrats!**	Review #3315727	Not started yet!
Differential Cross Sections for Reaction gamma d → π^{−} p p_{spec} in the Quasi–Free Region	Nikolai Pivnyuk *et al.*	Nathan Baltzell (Chair), M. Paolone, and Or Hen	*Stalled for 2 years. Contacted the authors for updates but no reply yet!*	Review #6236203	Not started yet!
Study of the hadronization of charged pions	Raphael Dupre *et al.*	M. Wood (Chair), A. Kim, and S. Manly	Back to authors after the 1st round review; Ongoing investigations between Orsay and UFTSM groups to resolve the discrepancy observed in the extracted charged pions results.	Review #5648485	Not started yet!
Measurements of the Fifth Structure Function of the Deuteron	Gerard Gilfoyle *et al.*	S. Kuhn (Chair), A. El Alaoui, K. Hafidi	*Closed upon the author's request due to lack of time with the start of CLAS12 RG-B program*	Review #4138354	None yet!

- One approved analysis by Mariana Khachatryan *et al.* since June 2019.
- Started a new review for a 2N SRC analysis by Igor Korover *et al.* in Sept. 2019.
- Two ongoing reviews for EG2 hadronization analyses of charged (R. Dupre *et al.*) and neutral (Taisiya Mineeva *et al.*) pions.
- One stalled review of the G10 analysis by Nikolai Pivnyuk *et al.!*
- One closed analysis due to lack of time and other project priorities. Will be reopend upon request!

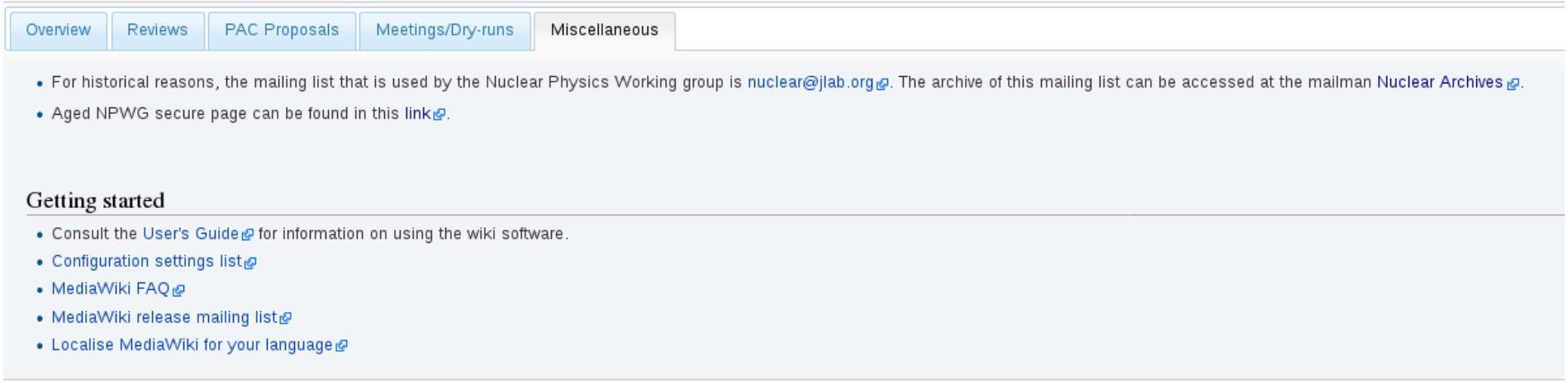
WG Activities & Responsibilities

- PAC Proposals Tab:

- Meetings/Dry-runs Tab:



- Miscellaneous Tab:



CLAS Speakers Committee

What do we do?

Our main role is to supervise and promote an accurate and broad dissemination of results to the scientific community by talks from members of the CLAS Collaboration.

What do **you** need to do?

- All Invited talks need to be Approved by the CSC committee
- CLAS Members need to Notify CSC for Contributed talks, for Invited seminars, or Posters
- For General talks in which 50% of the slides or less are CLAS related members need to Notify CSC
- All Proceedings need to be submitted to CSC for review and approval at least 1 week before the submission deadline

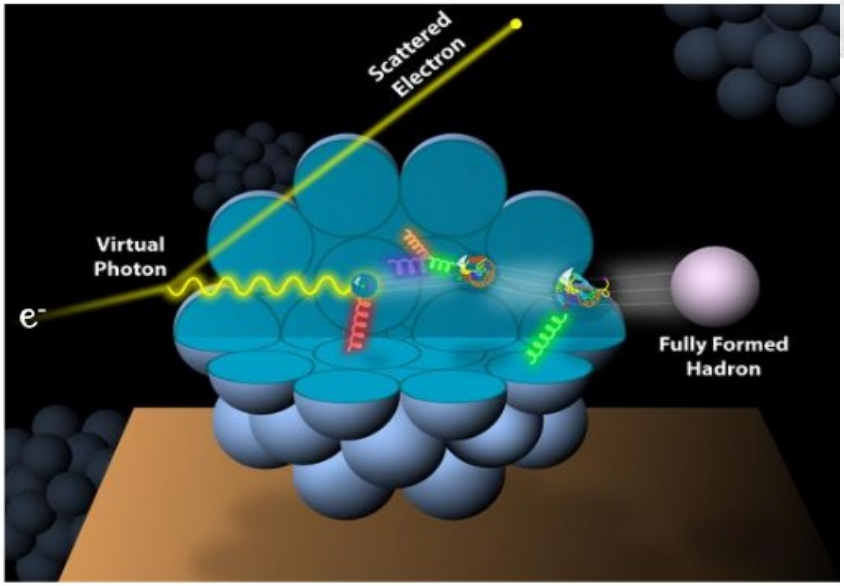
The notification and approval requests are done using the SHIFTBOT Interface

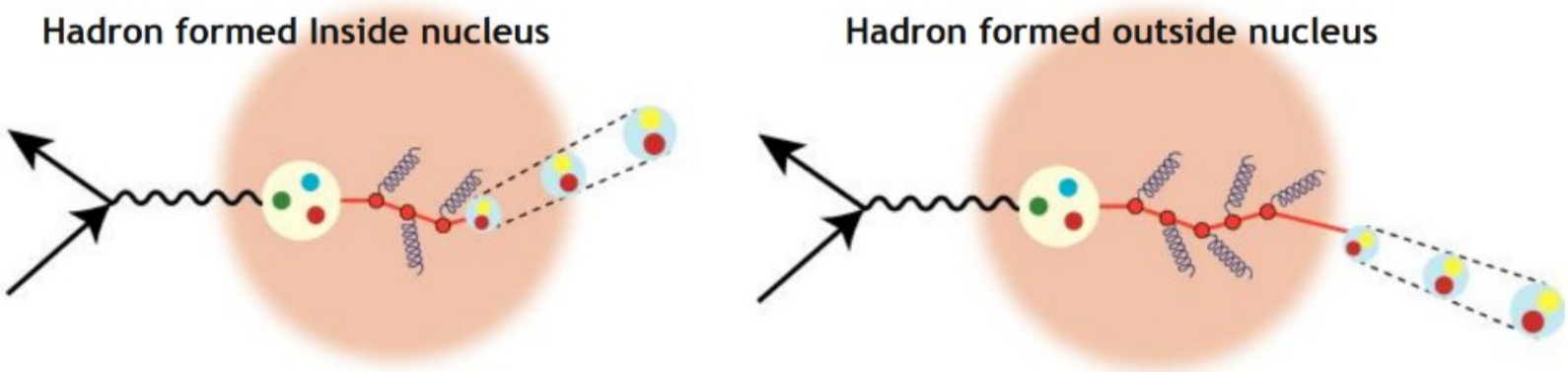
For any issues or clarifications you can contact CSC directly: csc@jlab.org

More information can be found on our wiki page

Probing QCD Dynamics

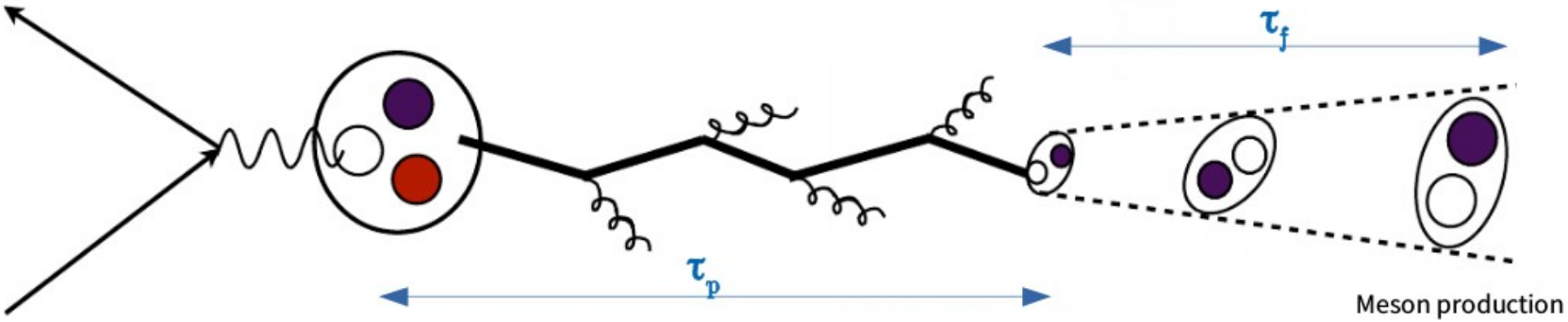
- **Hadronization process:**
  - Evolution of a colored bare quark into a fully dressed hadron.
  - A direct probe of the QCD confinement dynamics: quark propagation and fragmentation.





Depending on the size of nucleus and the energy of the probe, hadron formation can take place inside or outside the nucleus.

- Hadronization Timescales:
  - Production time, τ_p: Time spent by a deconfined quark to neutralize its color charge.
  - Formation time, τ_f: Time required to form a regular hadron.



- Hadronization studies:
  - Provide information on the dynamical scales of the process.
  - Constrain existing models that provide predictions of its time-characteristics.

Experimental Observables

- **Multiplicity ratio:**

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

  - Normalization with the electron DIS events that permits cancellation of the initial state effects.

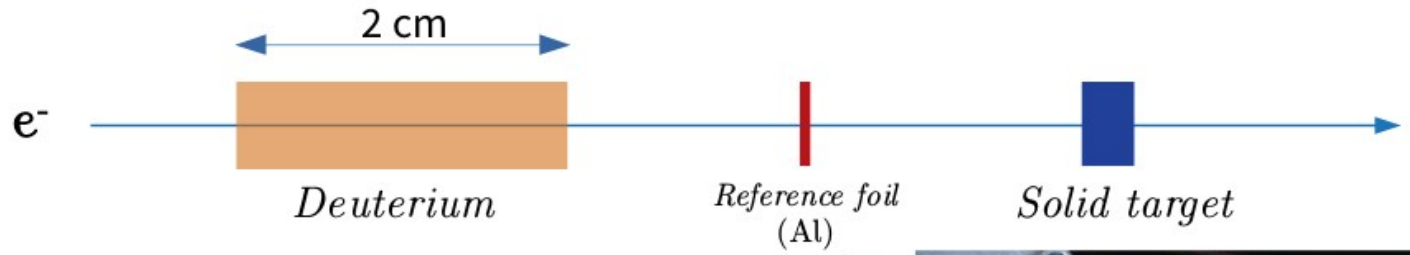
- **Transverse momentum broadening:**

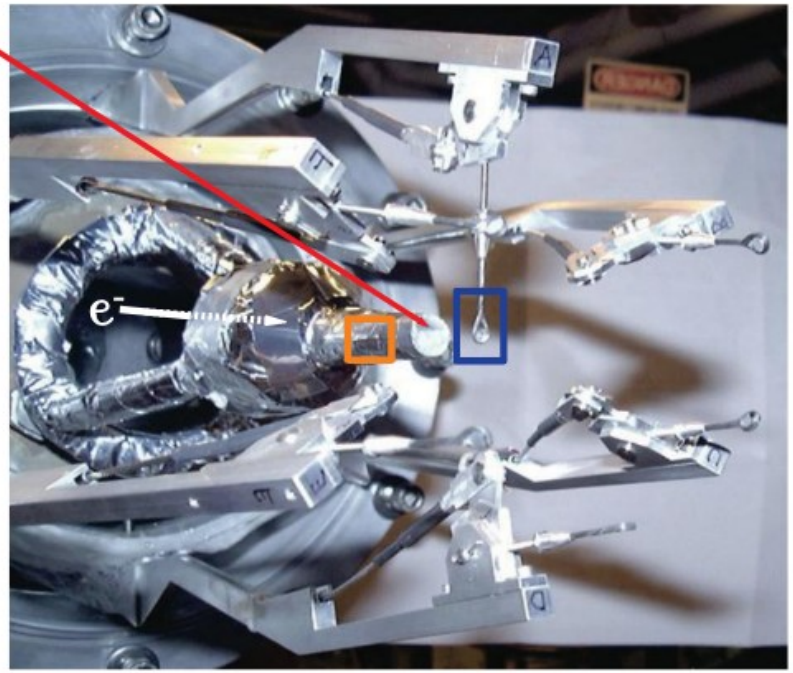
$$\Delta P_T^2 = \langle P_T^2 \rangle_A - \langle P_T^2 \rangle_D$$

D = loosely bound nuclei
A = Heavy Nuclei

- **These observables provide insights about**
  - The hadronization timescales, i.e., production and formation times.
  - Parton energy loss (related to the p_T broadening).
  - Hadron attenuation (related to R_A^h).

- Targets: Deuterium, Carbon, Iron, Lead, Tin, Aluminum.
- Deuterium and solid target in beam simultaneously for reduced run-time systematics:





- Luminosity ~ 10^{34} s^{-1} cm^{-2}
- Beam energy: 5 GeV
- Target separation ~ 4 cm
- Solid Targets:

Targets	Fe	C	Al	Al	Pb	Sn
Radius (mm)	1.5	1.5	1.5	1.5	1.5	1.5
Thickness (mm)	0.4	1.72	0.58	1.5 E-03	0.14	0.3

An update on Omega Meson Hadronization Studies

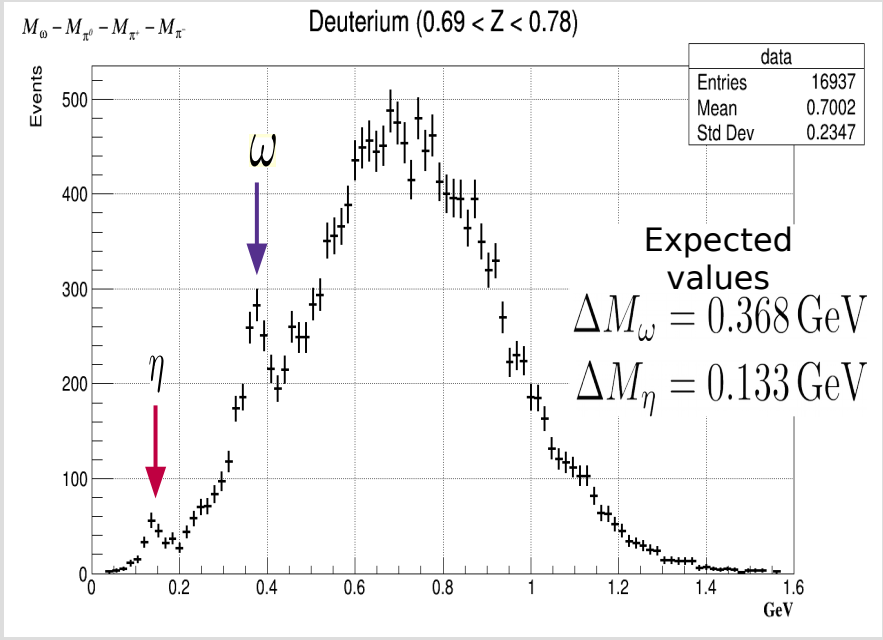
Andrés Bórquez (UTFSM, Chile)

First measurement of ω Multiplicity Ratios.

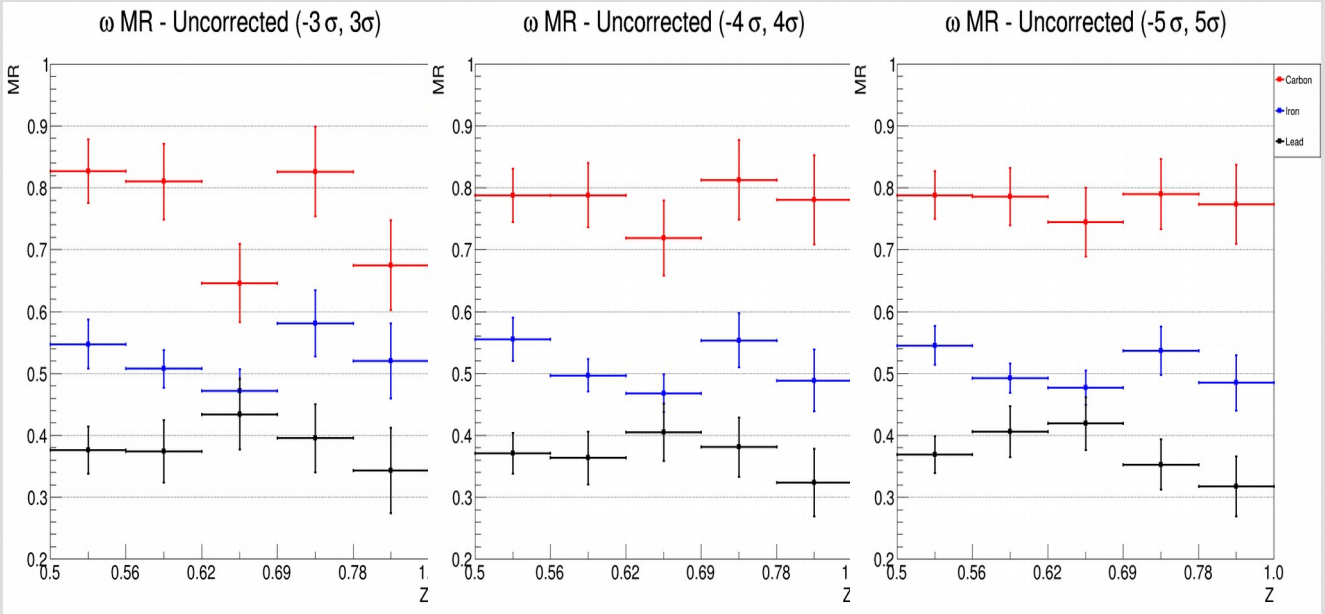
Main channel: $\omega \rightarrow \pi^+\pi^-\pi^0 \rightarrow \pi^+\pi^-\gamma\gamma$

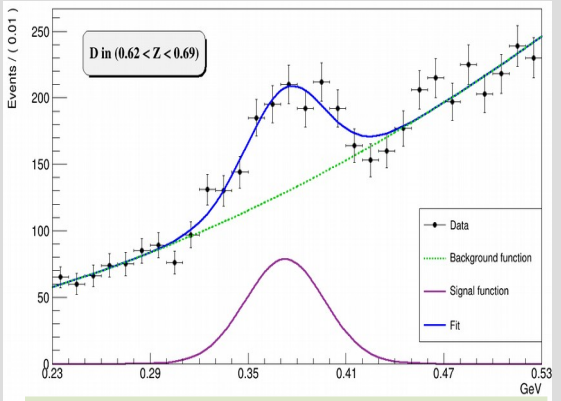
$$\mathrm{MR} \equiv \frac{\left(\frac{\mathrm{N}_{\omega}^{\mathrm{DIS}}}{\mathrm{N}_{e}^{\mathrm{DIS}}}\right)_A}{\left(\frac{\mathrm{N}_{\omega}^{\mathrm{DIS}}}{\mathrm{N}_{e}^{\mathrm{DIS}}}\right)_D}$$

Data sample

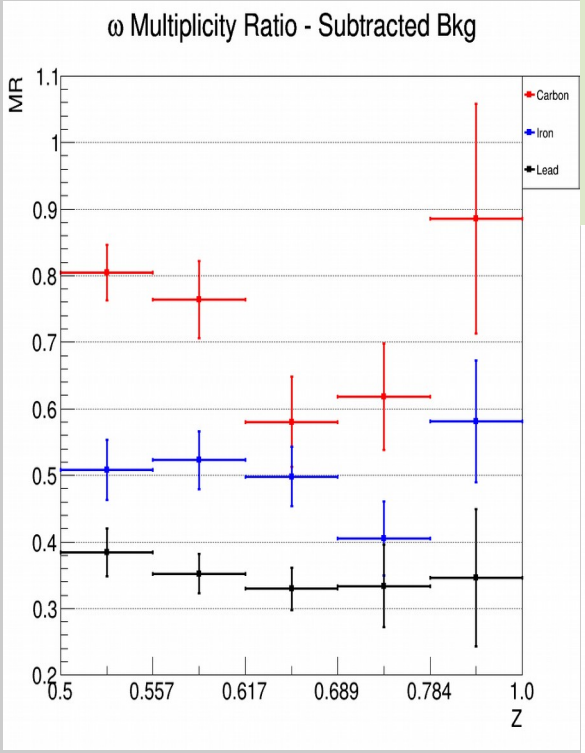


Uncorrected MR: No acceptance correction nor background subtraction involved.

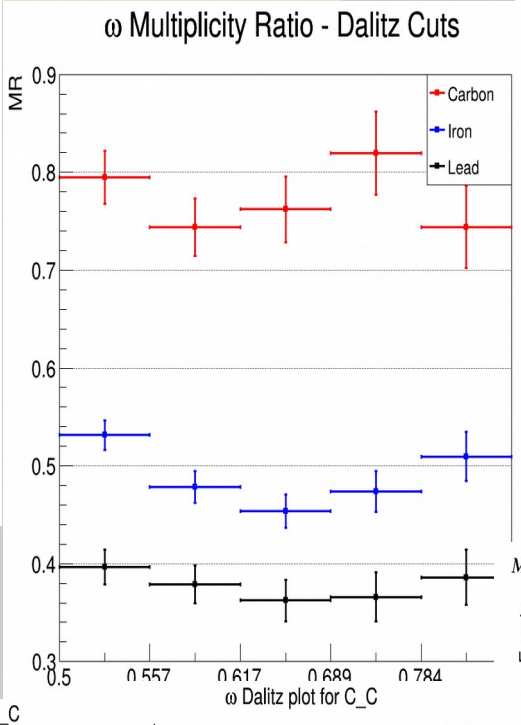


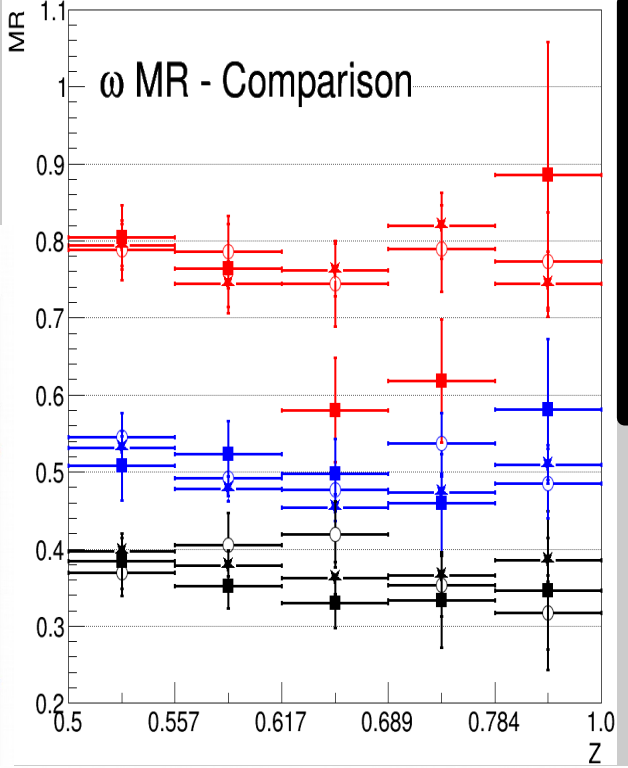


Background subtraction

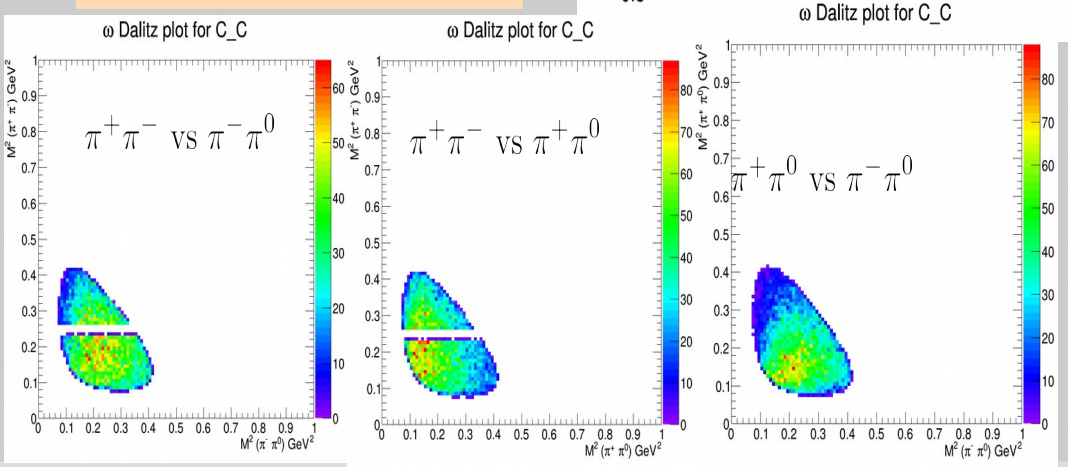


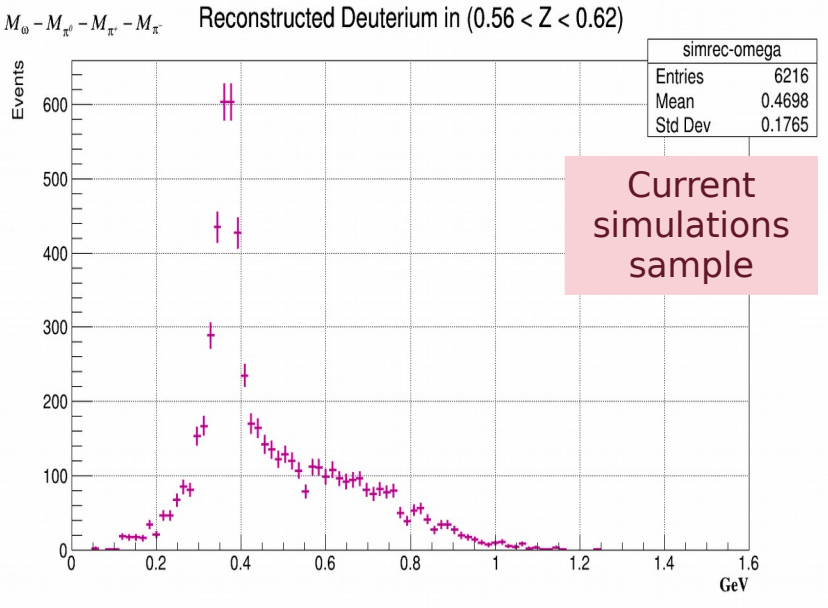
Background subtracted MR





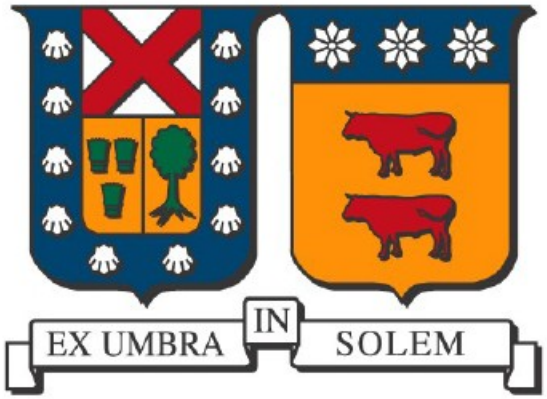
Dalitz Plots studies





Current simulations sample

Updates in Color Propagation Analysis for Positive Pions



Summary

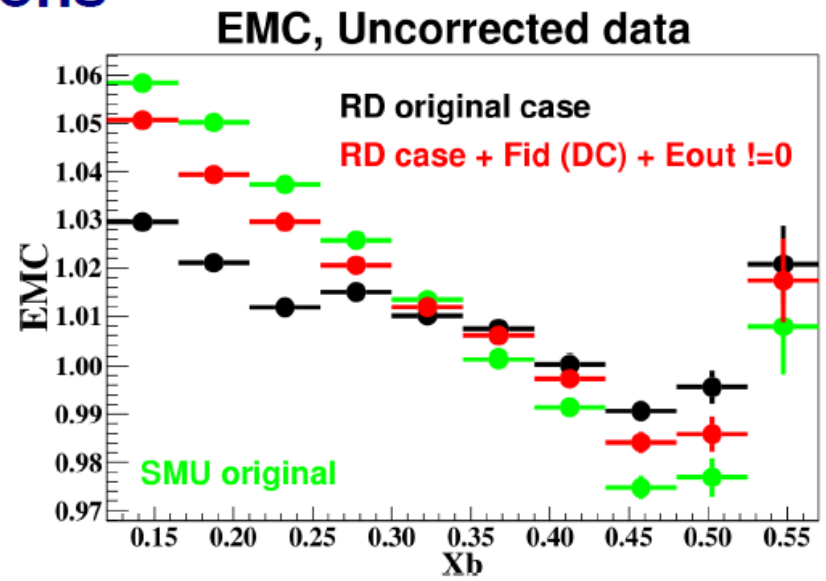
Universidad Técnica Federico Santa María
Physics Department
Casa Central, Valparaíso, Chile

Sebastián Morán Vásquez

November, 2019

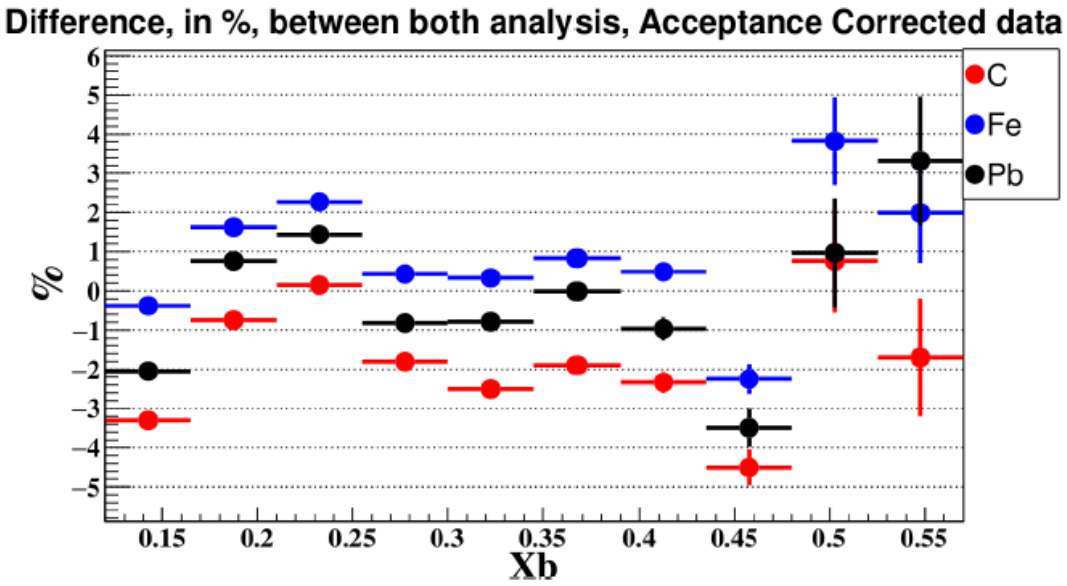
Two independent analysis for pi plus was done in our group, different results, the goal of the presentation is try to understand where is the source of the discrepancy.

Electrons



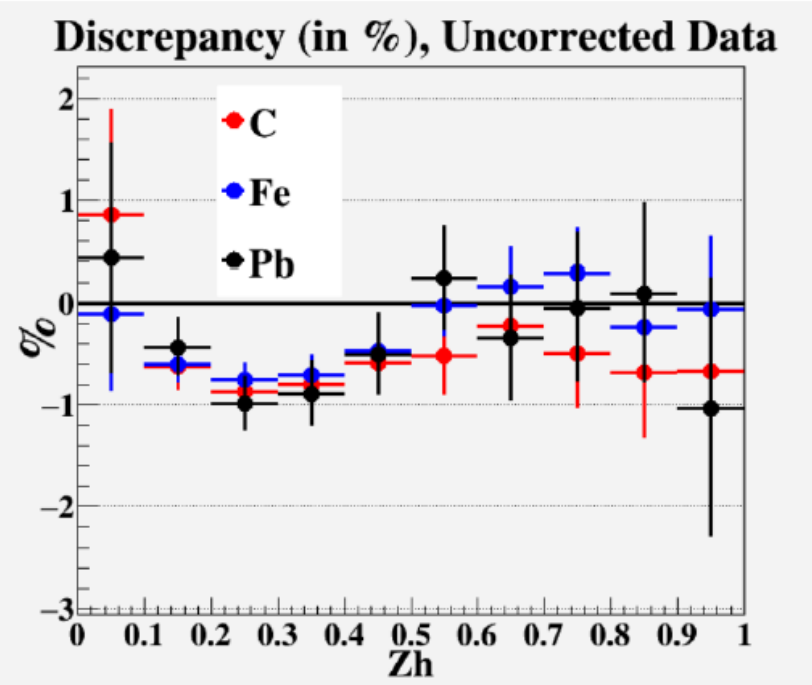
Fully understand the discrepancy between both analysis at uncorrected data level

$$\mathrm{EMC} \equiv \frac{\left(\mathrm{N}_{el^-}^{\mathrm{DIS}}\right)_A}{\left(\mathrm{N}_{el^-}^{\mathrm{DIS}}\right)_D}$$



At acceptance corrected level the discrepancy remains, is of order of ~2% with some extreme cases of ~4%

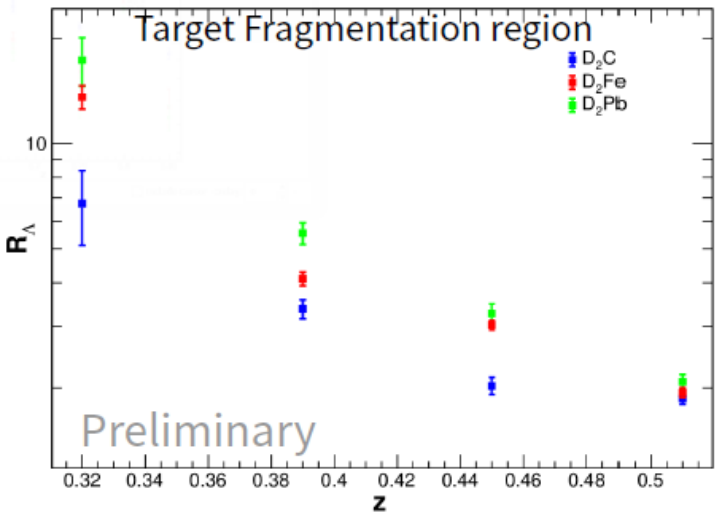
Pi Plus



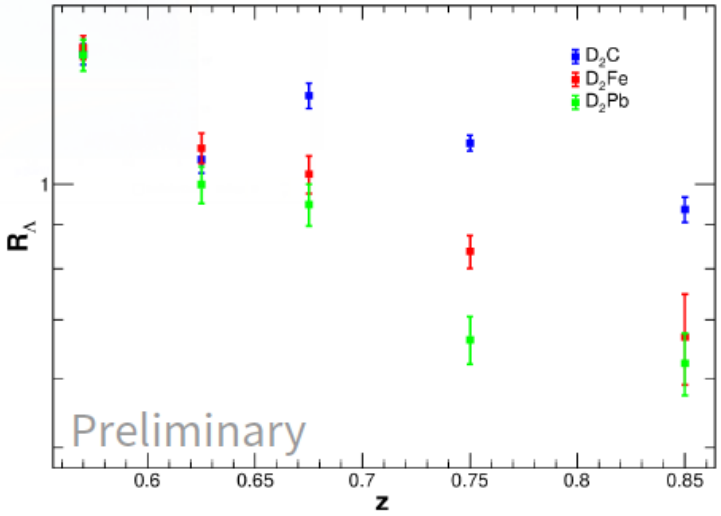
After some modifications in one analysis, both analysis agreed within ~1% difference, at an uncorrected level

For the **acceptance** corrected case the **difference remains**, all the cuts in PID was analyzed in detail, none of them explain the difference, the source of the discrepancy comes from the simulation set itself.

Currently running a third set of simulations to be able to get new insights about this problem. Final results are going to be given in the next collaboration meeting.

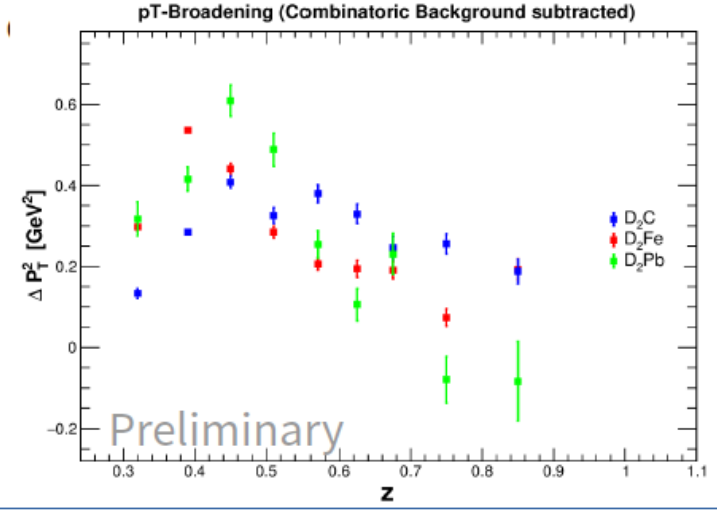


$$R_A^h(z) = \frac{\frac{N_h(z)}{N_e|_{DIS}}\Big|_A}{\frac{N_h(z)}{N_e|_{DIS}}\Big|_D}$$

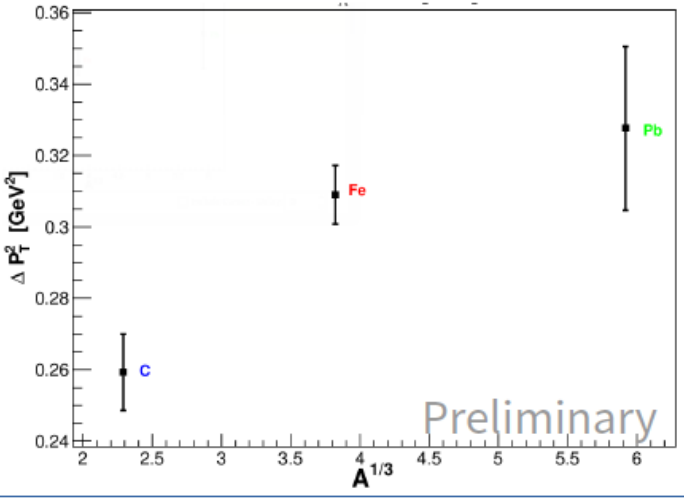


First ever study of the hadronization process of Λ hyperon which probes the forward (current) and backward (target) fragmentation regions.

pT-broadening as a function of z and nuclear size.



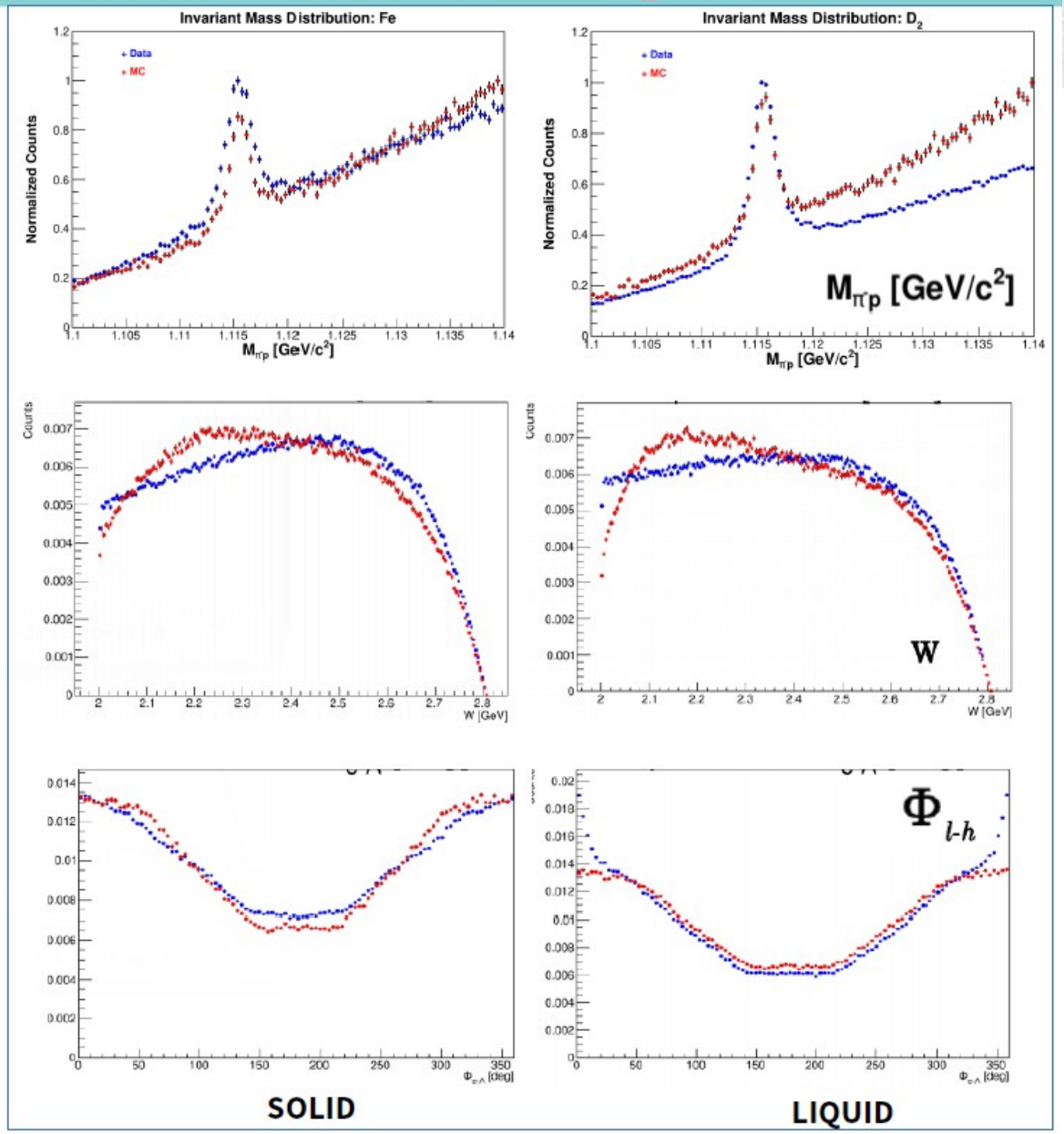
$$\Delta P_T^2 = \langle P_T^2 \rangle_A - \langle P_T^2 \rangle_D$$



Λ Hadronization Studies (CLAS EG2 Data)

Ongoing and Future Efforts

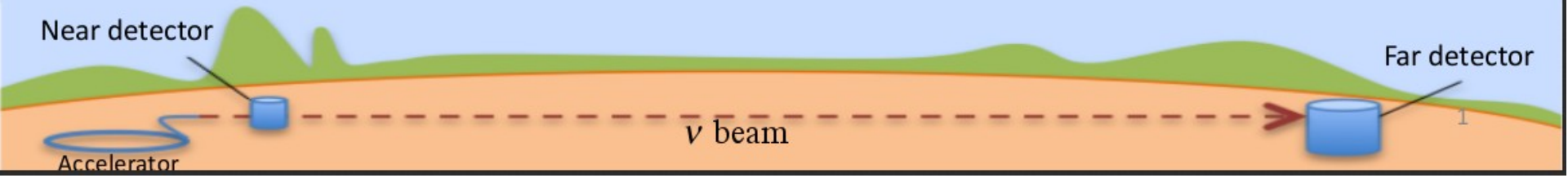
- We are actively involved in the **optimization of the PYTHIA generator** to improve the comparison between the real data and simulation.
- **A first look** shows **promising agreement** between experimental data and simulation.
- **Next steps** involve extraction and application of acceptance and radiative corrections and study of systematics.



OLD DOMINION UNIVERSITY

Update: Validation of neutrino energy estimation using electron scattering data

Mariana Khachatryan - ODU



Summary

1. The first use of electron data to test neutrino energy reconstruction algorithms:
   - select zero-pion events to enhance quasi-elastic signal
     - ✧ Subtract for undetected π and extra p.
   - just using scattered lepton (E_{QE})
     - ✧ used in Cherenkov-type neutrino detectors
   - total energy of electron plus proton (E_{Cal})
     - ✧ used in calorimetric neutrino detectors
2. Only 0.16-0.55 of events reconstruct to within 5% of the beam energy:
   - better for lighter nuclei and lower energies
   - improved by a transverse momentum cut
   - agreement between two methods does not imply accurate energy reconstruction.
3. There is a discrepancy between energy reconstruction from e-Genie and data.
4. Probable significant impact on oscillation analysis of proposed $1.5B DUNE experiment.
5. Inspired upcoming "Electrons for Neutrinos" experiment .
6. CLAS analysis review complete.
7. Paper submission soon.

Targets in E2a:

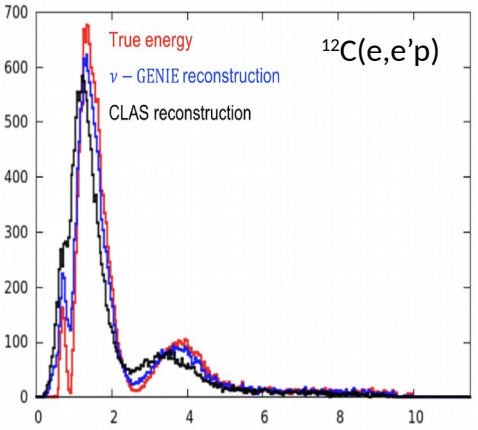
- ^{3}He
- ^{4}He
- ^{12}C
- ^{56}Fe

Beam energies E2a:

- 1.161 GeV
- 2.261 GeV
- 4.461 GeV

Targets in neutrino experiments:

T2K: CH, H_2O
Minerva: ^{3}He, ^{4}He, C, Fe, H_2O
Microboone: Ar
Miniboone: mineral oil (C, H, O)
Nova: $C_6H_3(CH_3)_3$
DUNE: Ar



e4ν

Florian Hauenstein (ODU)

Afroditi Papadopoulou (MIT@FNAL)

Adi Ashkenazi (MIT@FNAL)

Energy Reconstruction for QE reactions

(1) Cherenkov detectors:
- Detect: leptons & pions
- Miss: protons and neutrons

(2) Tracking detectors:
- Detect: Charged particles + π^0
- Miss: Neutrons and charged particles below threshold

Use lepton kinematics assuming QE interaction

$$E_{QE} = \frac{2M\varepsilon + 2ME_l - m_l^2}{2\left(M - E_l + |k_l|cos(\theta_l)\right)}$$

Use final-state calorimetry assuming low residual excitations

$$E_{Cal} = E_l + T_p + \varepsilon$$

$\varepsilon = E_{\text{bind}} = \text{Binding energy}$