

# **NPWG Report**

**Fall CLAS Collaboration Meeting**  
November 15<sup>th</sup>, 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** 

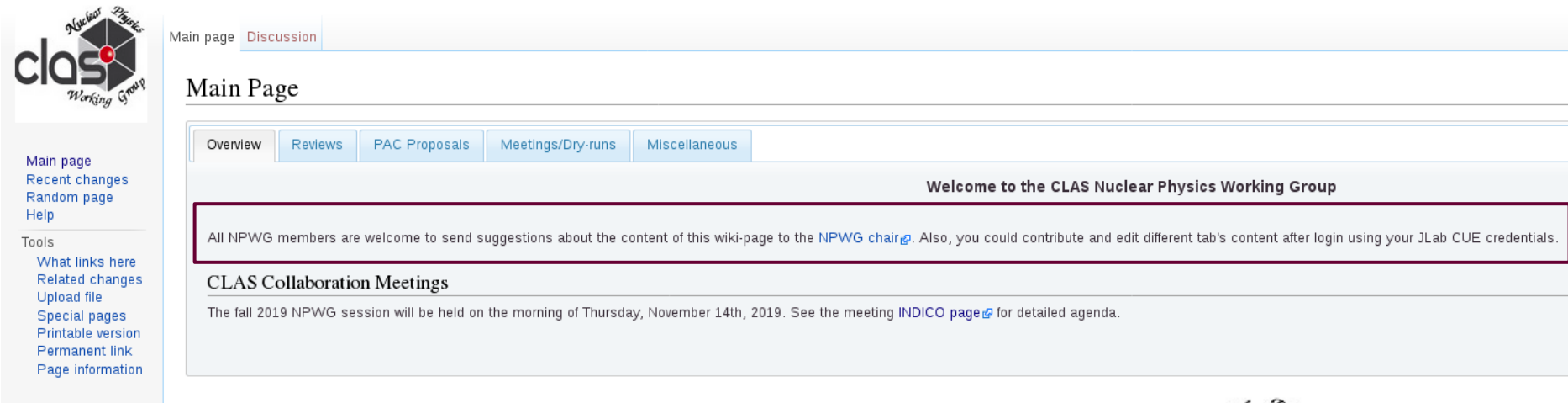
11:10 **Updates on the EG2  $\Lambda$ -Hadronization Studies 40'**

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](https://clasweb.jlab.org/Hall-B/npwg/index.php/Main_Page)



The screenshot shows the 'Main Page' of the CLAS Nuclear Physics Working Group wiki. The page has a light blue header with 'Main page' and 'Discussion' tabs. Below the header, there's a navigation bar with tabs: 'Overview', 'Reviews', 'PAC Proposals', 'Meetings/Dry-runs', and 'Miscellaneous'. The main content area features a welcome message: 'Welcome to the CLAS Nuclear Physics Working Group'. Below this, a red-bordered box contains a message: 'All NPWG members are welcome to send suggestions about the content of this wiki-page to the NPWG chair. Also, you could contribute and edit different tab's content after login using your JLab CUE credentials.' Further down, there's a section titled 'CLAS Collaboration Meetings' with the text: 'The fall 2019 NPWG session will be held on the morning of Thursday, November 14th, 2019. See the meeting INDICO page for detailed agenda.' On the left side, there's a sidebar with a logo and a list of links: 'Main page', 'Recent changes', 'Random page', 'Help', 'Tools', 'What links here', 'Related changes', 'Upload file', 'Special pages', 'Printable version', 'Permanent link', and 'Page information'.

- ◆ 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 <i>et al.</i>	H. Hakobyan (Chair), N. Zachariou, and S. Joosten	Back to authors after the 1st round review	<a href="#">Review #8487480</a>	Not started yet!
Validation of neutrino energy estimation using electron scattering data	Mariana Khachatryan <i>et al.</i>	H. Egiyan (Chair), N. Dashyan, and M. Hattawy	<b>APPROVED; Congrats!</b>	<a href="#">Review #5423632</a>	Waiting for authors plans
Pi0 Hadronization with CLAS6	Taisiya Mineeva <i>et al.</i>	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 .	<a href="#">Review #6510077</a>	Not started yet!
Coherent and Incoherent DVpi0P with CLAS EG6	Frank Cao <i>et al.</i>	Chaden Djalali (Chair), Ahmed El Alaoui , Axel Schmidt	<b>APPROVED; Congrats!</b>	<a href="#">Review #3315727</a>	Not started yet!
Differential Cross Sections for Reaction $\gamma d \rightarrow \pi^0(-) p$ p_{spec} in the Quasi-Free Region	Nikolai Pivnyuk <i>et al.</i>	Nathan Baltzell (Chair), M. Paolone, and Or Hen	Stalled for 2 years. Contacted the authors for updates but no reply yet!	<a href="#">Review #6236203</a>	Not started yet!
Study of the hadronization of charged pions	Raphael Dupre <i>et al.</i>	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.	<a href="#">Review #5648485</a>	Not started yet!
Measurements of the Fifth Structure Function of the Deuteron	Gerard Gilfoyle <i>et al.</i>	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	<a href="#">Review #4138354</a>	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:

Overview	Reviews	PAC Proposals	Meetings/Dry-runs	Miscellaneous	[edit]
2020 Summary					
Proposal TOPIC	Contact Person	Review Committee	PAC Decision	Database/Shiftbot Link	

## ■ Meetings/Dry-runs Tab:

Overview	Reviews	PAC Proposals	Meetings/Dry-runs	Abstracts/Talks	Miscellaneous
<ul style="list-style-type: none"><li>Based on the fall 2019 NPWG session discussion, we agreed to start meeting once a month. Reminders will be sent the meeting week.</li></ul> <p>To connect, please use the following BJ connection info: <a href="#">Meeting ID: 811 083 791</a>; Phone Dial-in +1.888.240.2560 (US Toll Free) (<a href="#">Global Numbers</a>).</p> <ul style="list-style-type: none"><li>A motion was to leave it for now up to our WG members if they want to practice their talks before participating in any scientific events. We will be happy to hold dry-run sessions or dedicate some time by the end of our monthly meeting for that. Please contact the <a href="#">NPWG chair</a> to arrange for your dry-run, and upload your abstracts and <i>draft</i> talks to the table on the <a href="#">Abstracts/Talks</a> tab.</li></ul>					

## ■ Miscellaneous Tab:

Overview	Reviews	PAC Proposals	Meetings/Dry-runs	Miscellaneous
<ul style="list-style-type: none"><li>For historical reasons, the mailing list that is used by the Nuclear Physics Working group is <a href="mailto:nuclear@jlab.org">nuclear@jlab.org</a>. The archive of this mailing list can be accessed at the mailman <a href="#">Nuclear Archives</a>.</li><li>Aged NPWG secure page can be found in this <a href="#">link</a>.</li></ul> <h3>Getting started</h3> <ul style="list-style-type: none"><li>Consult the <a href="#">User's Guide</a> for information on using the wiki software.</li><li><a href="#">Configuration settings list</a></li><li><a href="#">MediaWiki FAQ</a></li><li><a href="#">MediaWiki release mailing list</a></li><li><a href="#">Localise MediaWiki for your language</a></li></ul>				

# 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

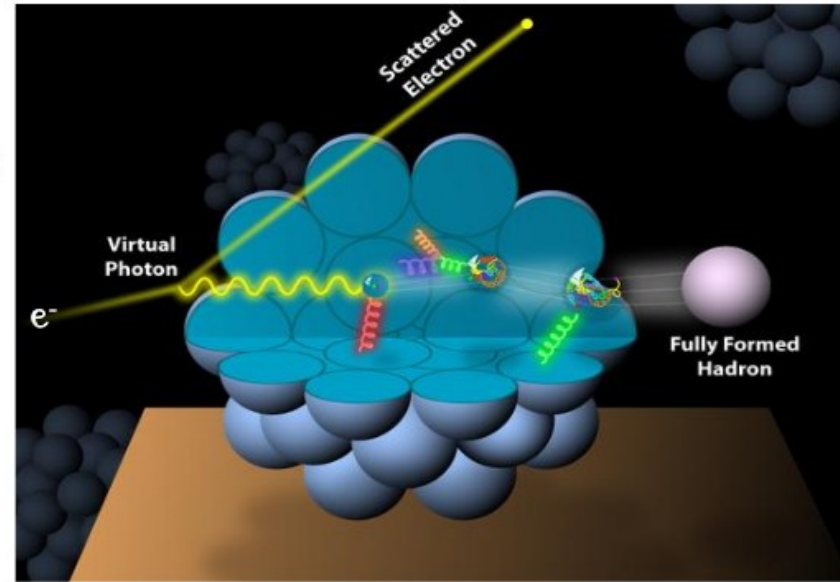
The notification and approval requests are done using the **[SHIFTBOT](#)** Interface

For any issues or clarifications you can contact CSC directly: **[csc@jlab.org](mailto:csc@jlab.org)**

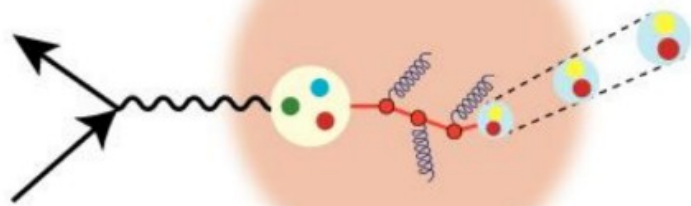
More information can be found on our **[wiki page](#)**

- **Hadronization process:**

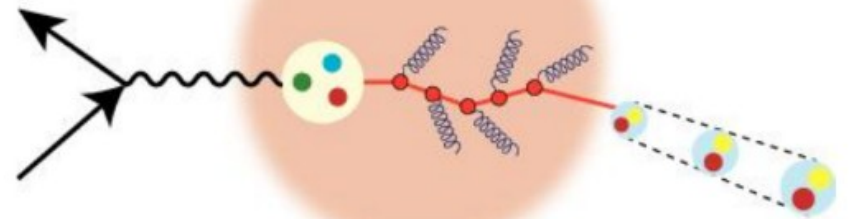
- Evolution of a colored bare quark into a fully dressed hadron.
- A direct probe of the QCD confinement dynamics: quark propagation and fragmentation.



Hadron formed Inside nucleus



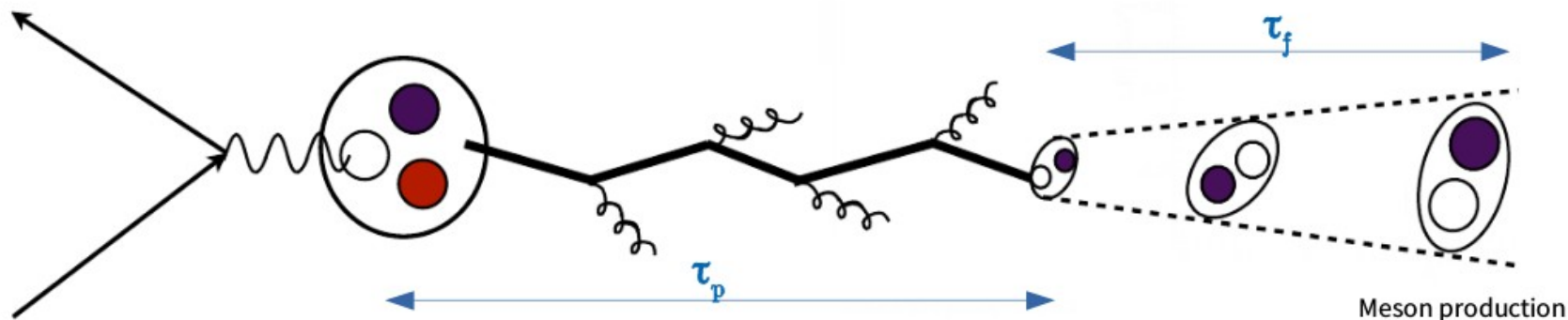
Hadron formed outside nucleus



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,  $\tau_p$ : Time spent by a deconfined quark to neutralize its color charge.
- Formation time,  $\tau_f$ : 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.



- **Multiplicity ratio:**

$$R_A^h(\nu, Q^2, z, p_T, \phi) = \frac{\left. \frac{N_h(\nu, Q^2, z, p_T, \phi)}{N_e(\nu, Q^2)|_{\text{DIS}}} \right|_A}{\left. \frac{N_h(\nu, Q^2, z, p_T, \phi)}{N_e(\nu, Q^2)|_{\text{DIS}}} \right|_D}$$

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

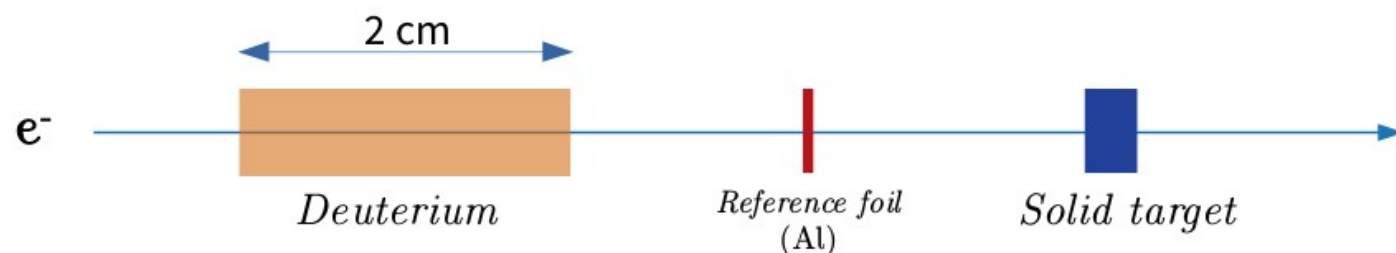
- **Transverse momentum broadening:**

D = loosely bound nuclei  
A = Heavy Nuclei

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

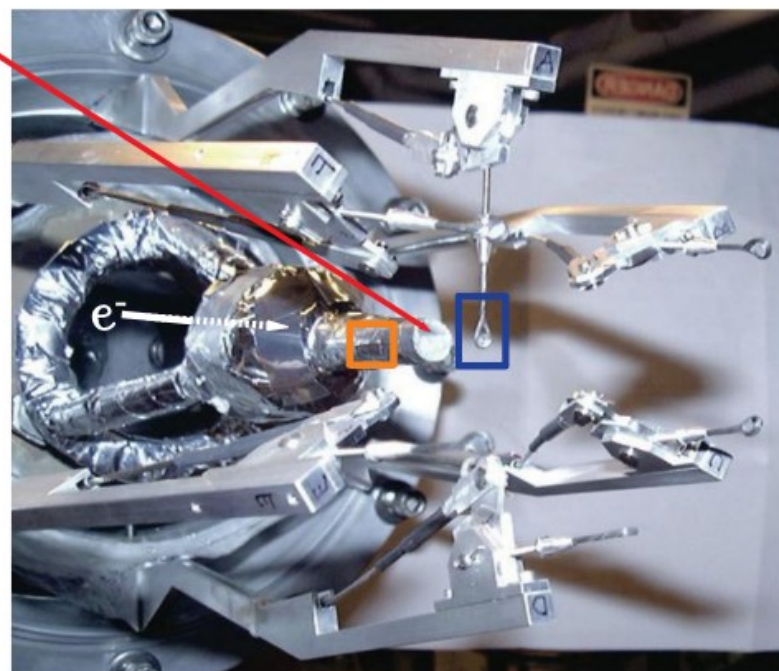
- **These observables provide insights about**
  - The hadronization timescales, i.e., production and formation times.
  - Parton energy loss (related to the  $p_T$  broadening).
  - Hadron attenuation (related to  $R_A^h$ ).

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



- Luminosity  $\sim 10^{34} \text{ s}^{-1} \text{ cm}^{-2}$
- Beam energy: 5 GeV
- Target separation  $\sim 4 \text{ cm}$
- 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)

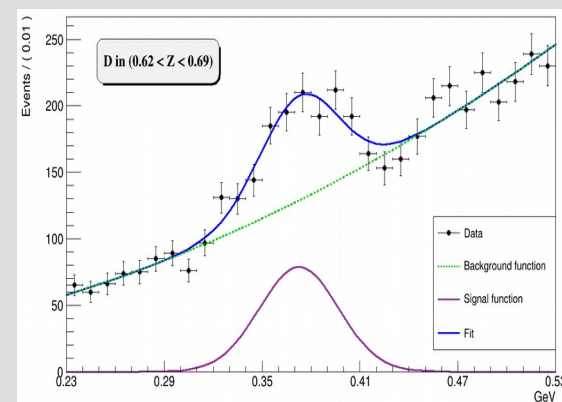
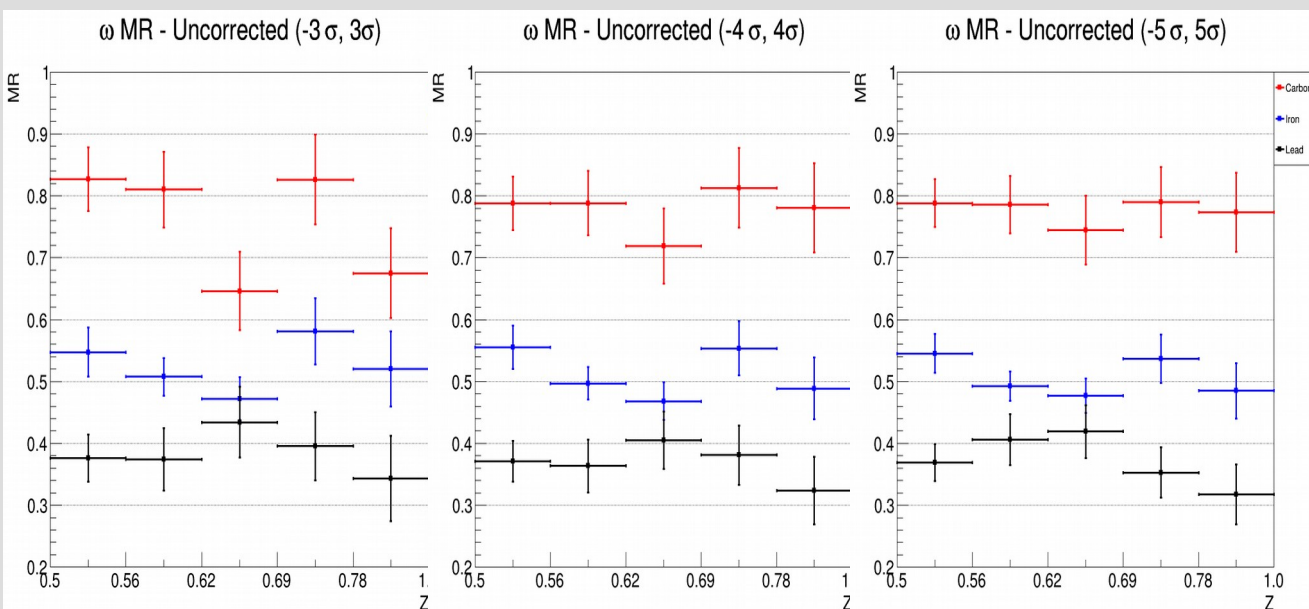
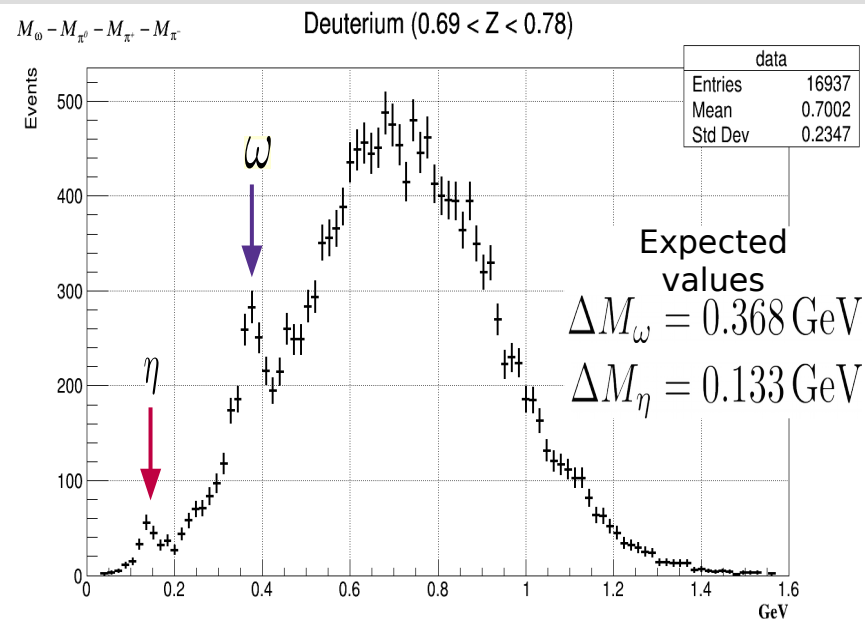
First measurement of  $\omega$  Multiplicity Ratios.

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

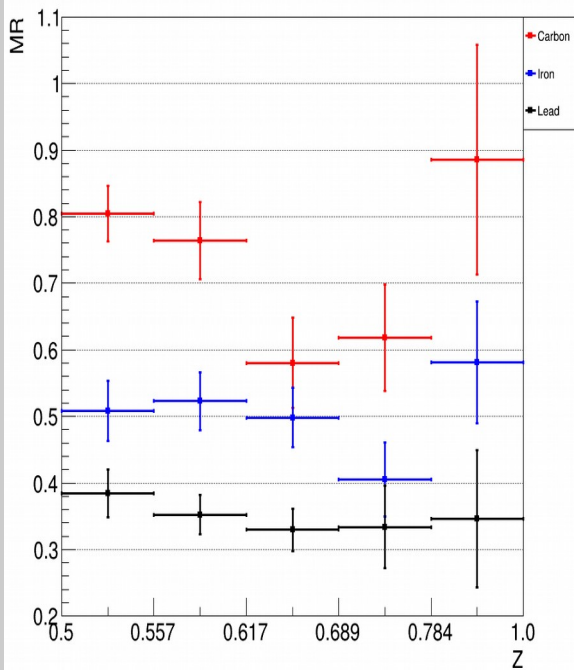
$$\text{MR} \equiv \frac{\left( \frac{N_{\omega}^{\text{DIS}}}{N_e^{\text{DIS}}} \right)_A}{\left( \frac{N_{\omega}^{\text{DIS}}}{N_e^{\text{DIS}}} \right)_D}$$

Uncorrected MR: No acceptance correction nor background subtraction involved.

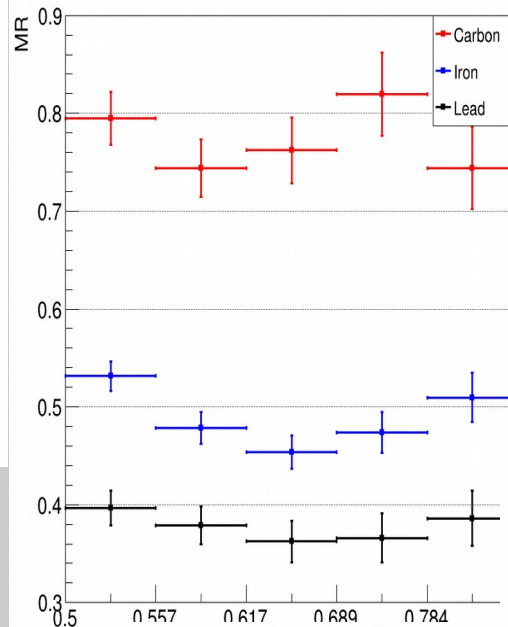
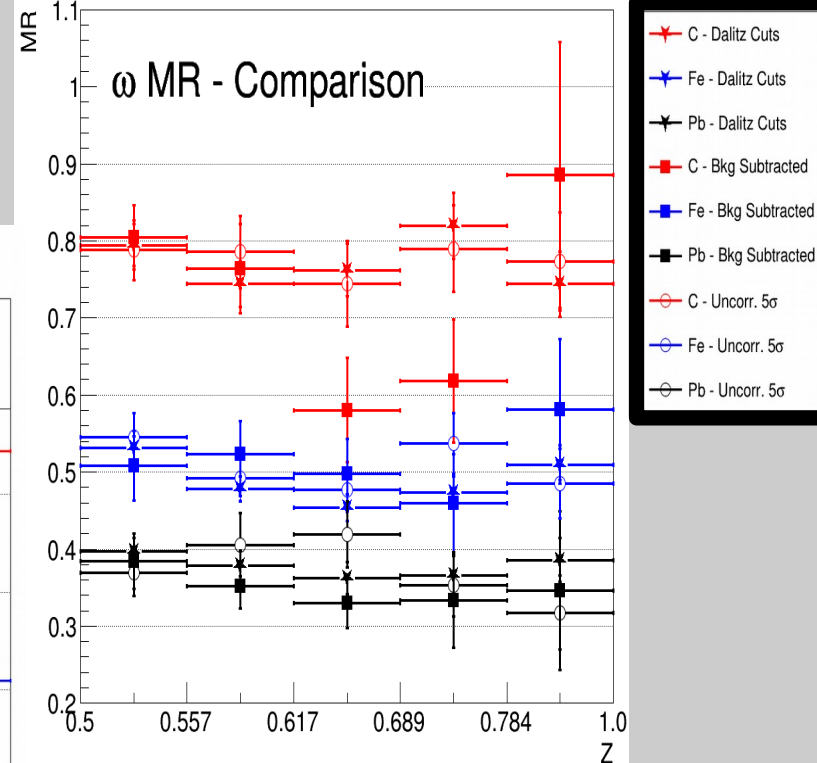
Data sample



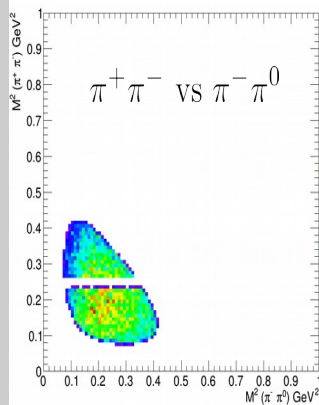
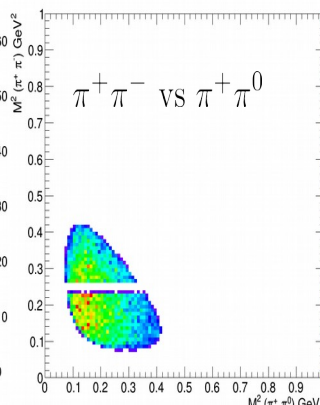
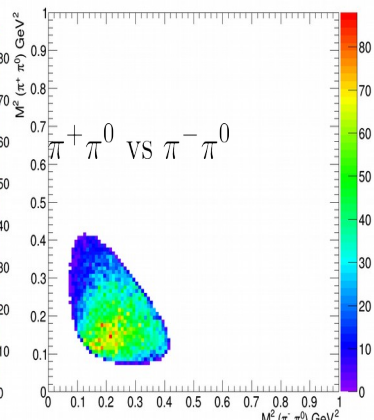
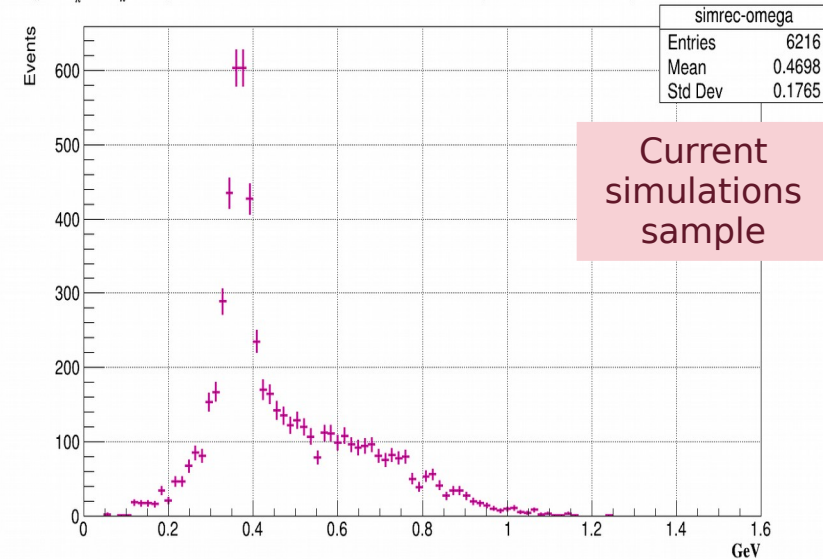
Background subtraction

$\omega$  Multiplicity Ratio - Subtracted Bkg

Background  
subtracted MR

 $\omega$  Multiplicity Ratio - Dalitz Cuts $\omega$  MR - Comparison

Dalitz Plots studies

 $\omega$  Dalitz plot for C\_C $\omega$  Dalitz plot for C\_C $\omega$  Dalitz plot for C\_C $M_{\omega} - M_{\pi^+} - M_{\pi^-} - M_{\pi^0}$  Reconstructed Deuterium in  $(0.56 < Z < 0.62)$ 

Current  
simulations  
sample



# Updates in Color Propagation Analysis for Positive Pions



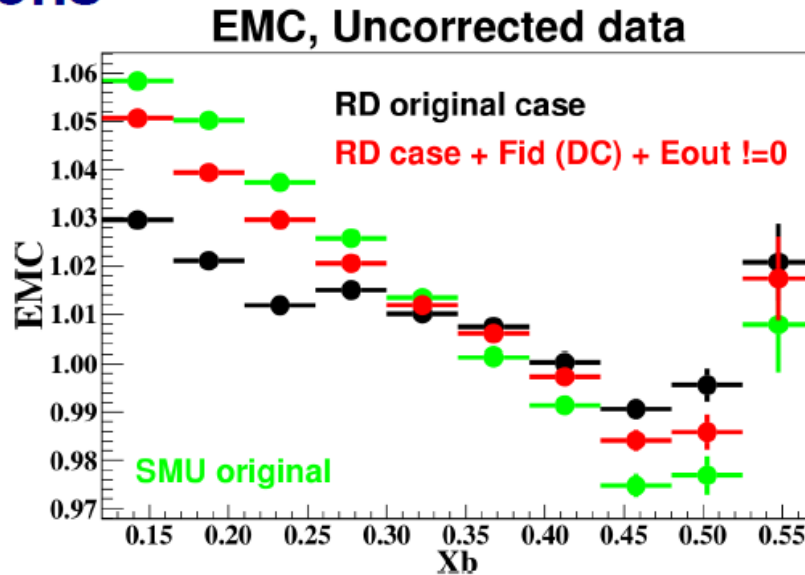
## Summary

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

Sebastián Morán Vásquez

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.

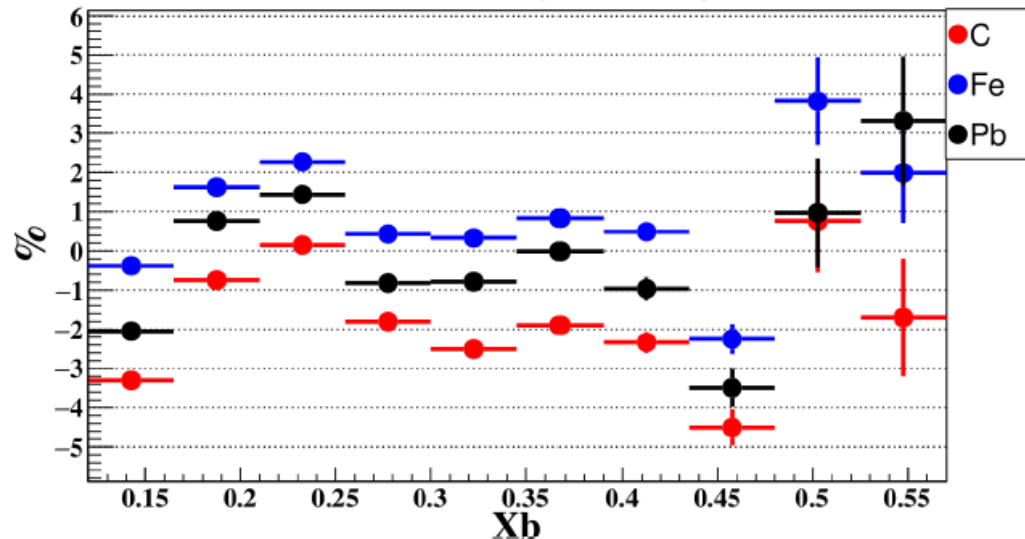
## Electrons



Fully understand the discrepancy between both analysis at uncorrected data level

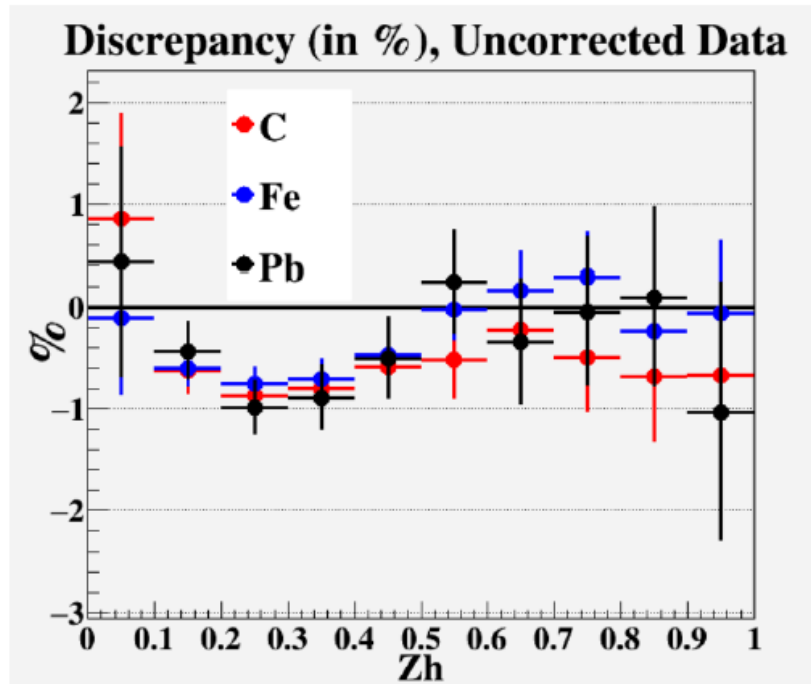
$$EMC \equiv \frac{(N_{el^-}^{DIS})_A}{(N_{el^-}^{DIS})_D}$$

**Difference, in %, between both analysis, Acceptance Corrected data**



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

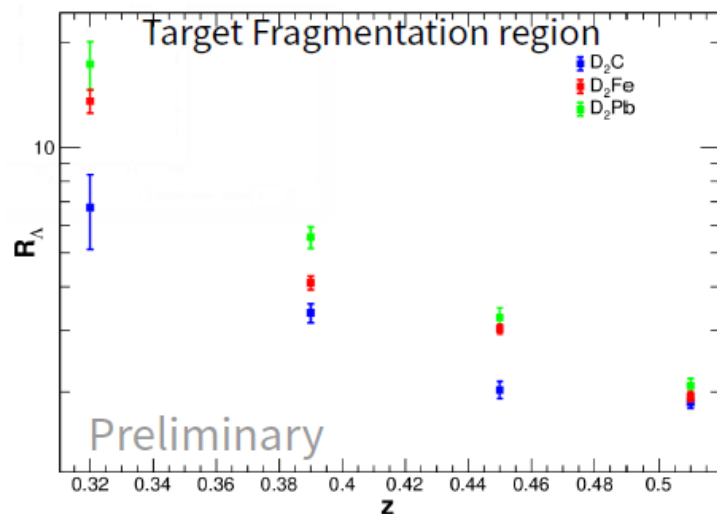
# Pi Plus



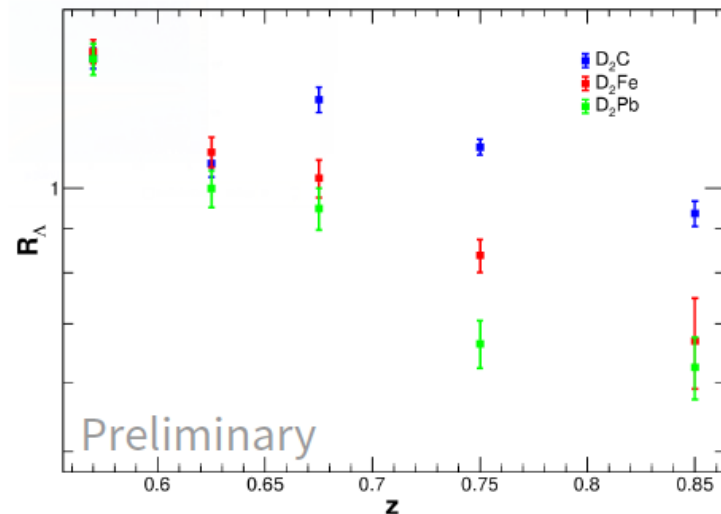
After some modifications in one analysis, both analysis agreed within  $\sim 1\%$  difference, at an uncorrected level

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.

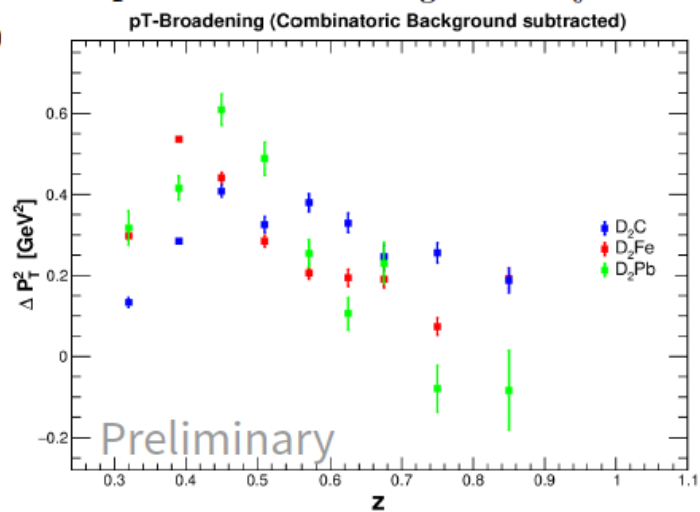


$$R_A^h(z) = \frac{\left. \frac{N_h(z)}{N_e|_{DIS}} \right|_A}{\left. \frac{N_h(z)}{N_e|_{DIS}} \right|_D}$$

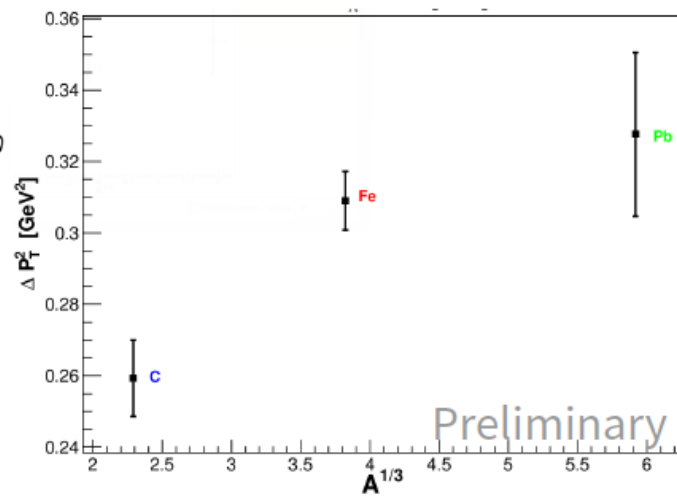


First ever study of the hadronization process of  $\Lambda$  hyperon which probes the forward (current) and backward (target) fragmentation regions.

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

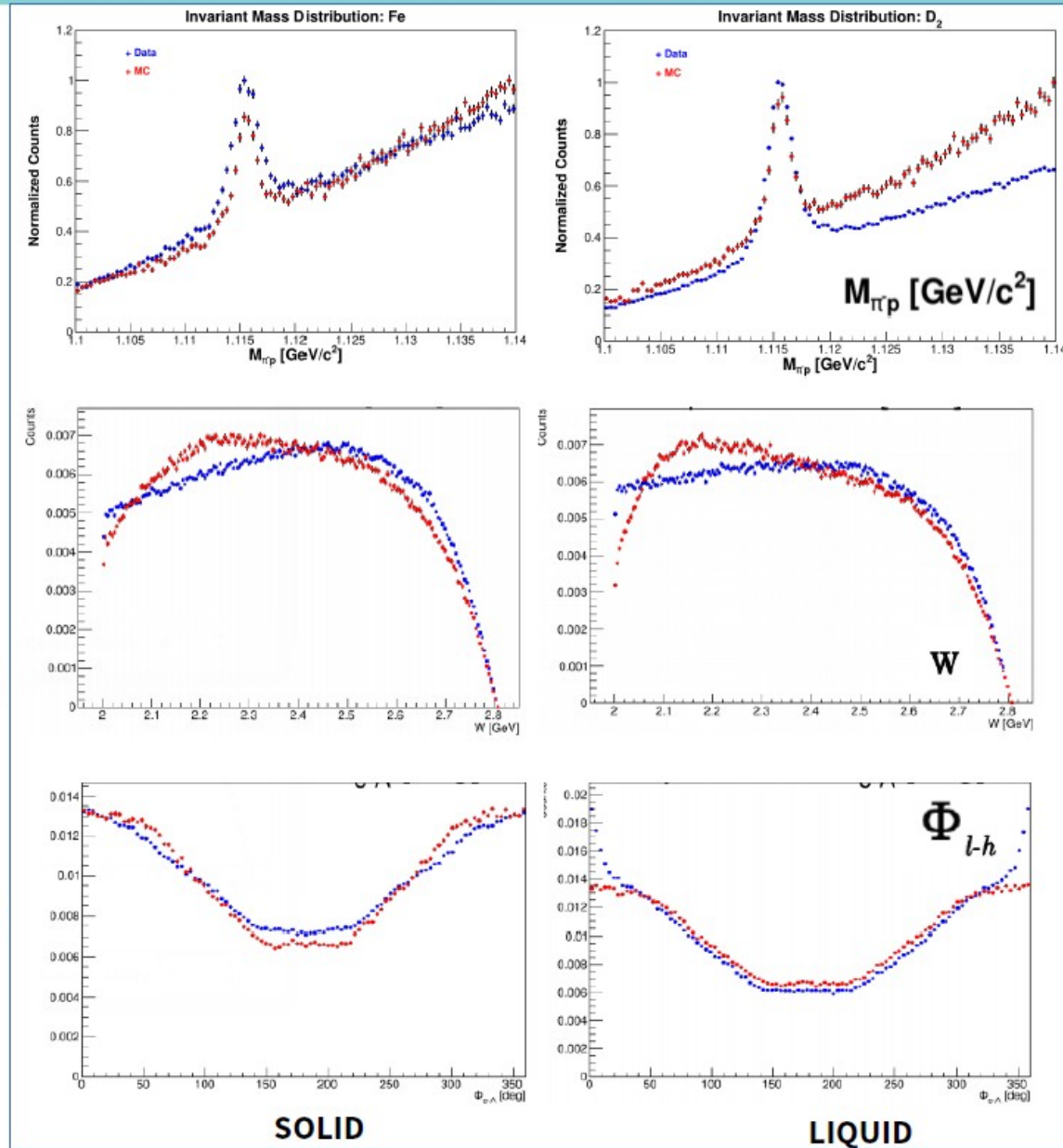


$$\Delta P_T^2 = \langle P_T^2 \rangle_A - \langle P_T^2 \rangle_D$$



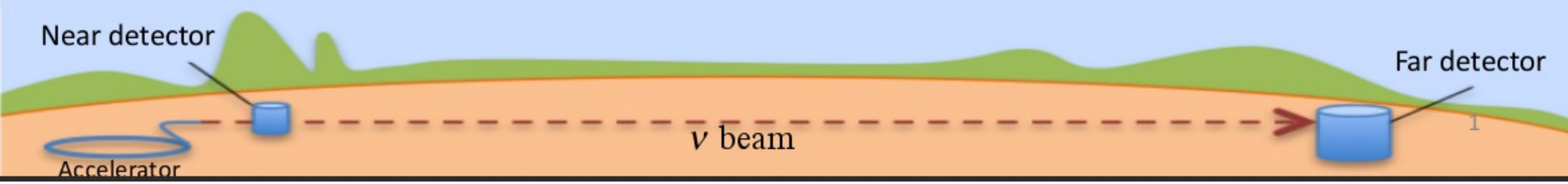


- We are actively involved in the **optimization of the PYTHIA generator** to improve the comparison between the real data and simulation.
- A first look shows **promising agreement** between experimental data and simulation.
- **Next steps** involve extraction and application of acceptance and radiative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



# 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  $\pi$  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.



**Florian  
Hauenstein  
(ODU)**



**Afroditi  
Papadopoulou  
(MIT@FNAL)**



**Adi Ashkenazi  
(MIT@FNAL)**

Targets in E2a:	Beam energies E2a:
• $^3\text{He}$	• 1.161 GeV
• $^4\text{He}$	• 2.261 GeV
• $^{12}\text{C}$	• 4.461 GeV
• $^{56}\text{Fe}$	

## Targets in neutrino experiments:

T2K: CH, H<sub>2</sub>O

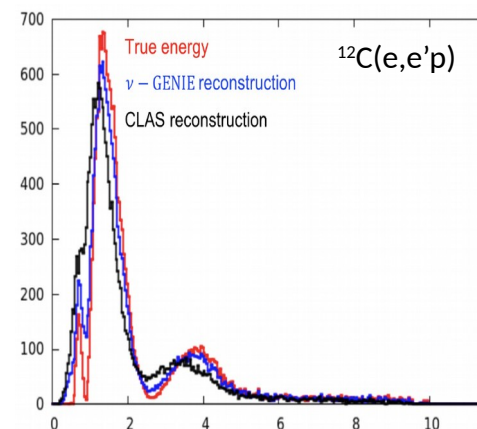
Minerva:  $^3\text{He}$ ,  $^4\text{He}$ , C, Fe, H<sub>2</sub>O

Microboone: Ar

Miniboone: mineral oil (C, H, O)

Nova: C<sub>6</sub>H<sub>3</sub>(CH<sub>3</sub>)<sub>3</sub>

DUNE: Ar



# Energy Reconstruction for QE reactions

## (1) Cherenkov detectors:

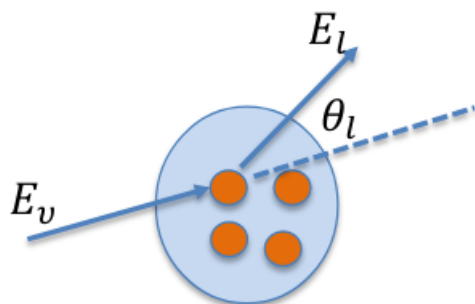
- Detect: leptons & pions
- Miss: protons and neutrons

## (2) Tracking detectors:

- Detect: Charged particles +  $\pi^0$
- Miss: Neutrons and charged particles below threshold

Use lepton kinematics  
assuming QE interaction

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



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

Use final-state calorimetry assuming  
low residual excitations

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

