

Brief Update on Meson Structure Studies

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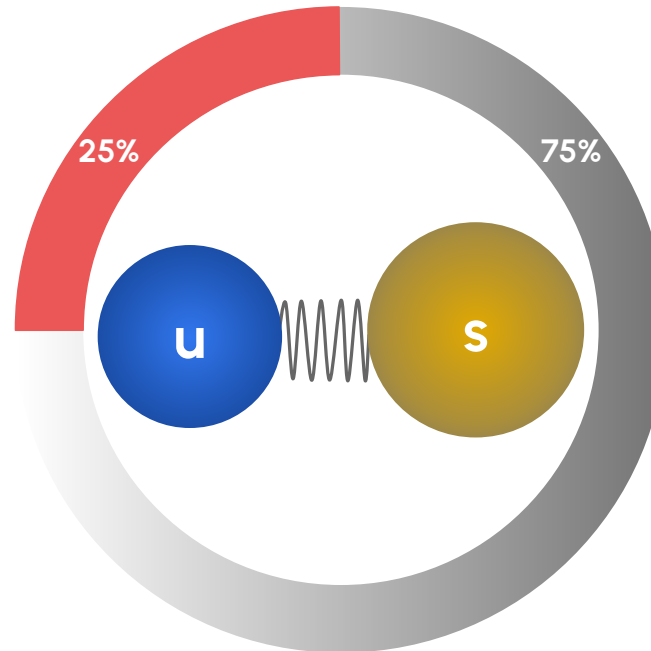


Science Background: Pions and Kaons are vital to understand Hadron Structure

Example: Kaon Structure Functions

Allow for understanding interplay of different mass generation mechanisms

Higgs mechanism
Quark masses

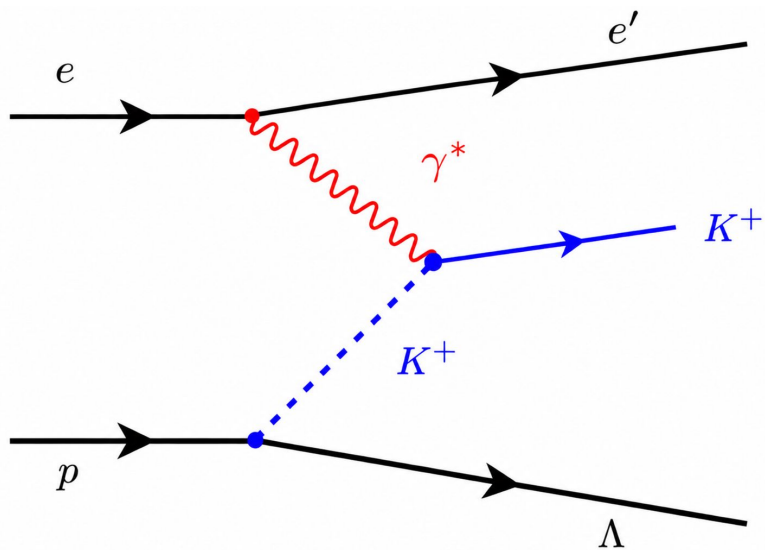


Emergent mass QCD
Quark motion, sea pairs

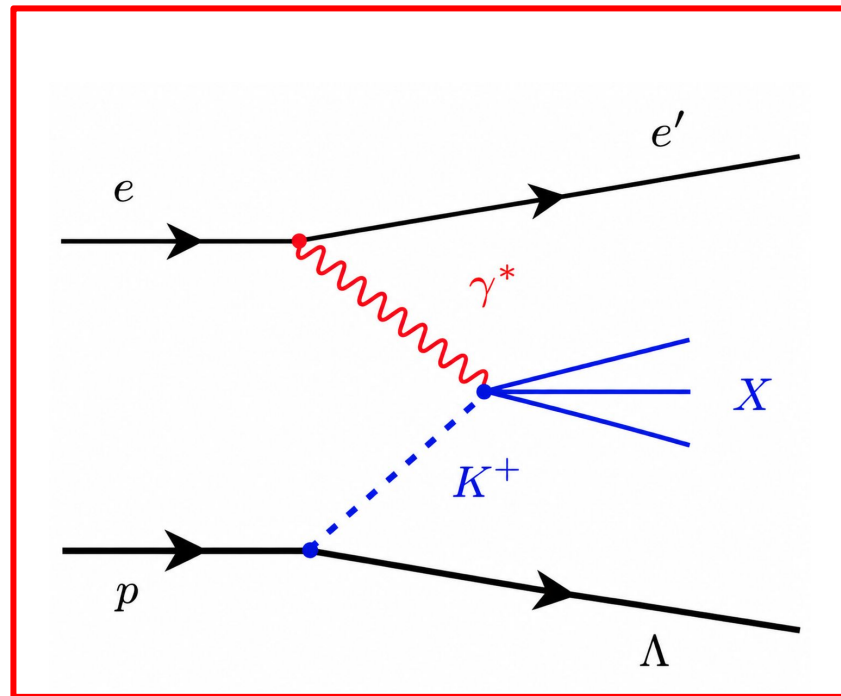
**Kaon is a Goldstone Boson
and also the simplest
system with s-quark**

**Crucial need for
structure function data**
There are only 8 data
points worldwide

Experimental approach : Sullivan Process



Form Factors
(exclusive limit)



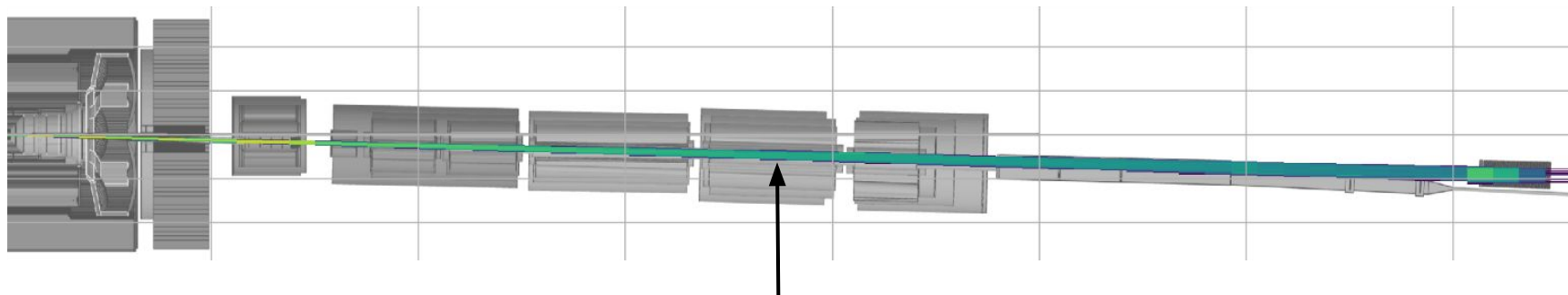
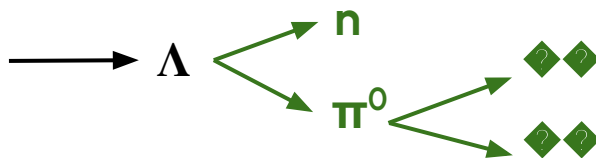
Structure Functions
(Tagged DIS)

Experimental Considerations

Recoil Λ^0 is neutral:
looks like a
neutron, but it
decays

Two decay channels
Charged: $p + \pi^-$ (65 %)
Neutral: $n + \gamma + \gamma$ (35 %)

Charged channel studies
ongoing, but in this
update we **focus on
neutral channel**



Λ decay points along ePIC setup at 18x275 GeV (tens of meters!)

Meson SF Software Development Timeline Overview

Recent software efforts by the group in 2026

- January - March : Λ reconstruction algorithm implementation (complete)
- February : Campaign + Λ reconstruction algorithm local tests (complete)
- March - May : DD4hep issue (<https://github.com/eic/epic/issues/1069>) and solution
 - Note: all global campaigns in that period did not generate useful Meson SF data
- April - June : EICrecon Pull Request (<https://github.com/eic/EICrecon/pull/2622>) (complete)

Note: April global campaign had Meson SF data, but **with old software (still not useful for anal.)**

- July : **New Issue: missing pions in ZDC**

More detail on software and analysis on the Meson SF Github page:

Campaigns: <https://jeffersonlab.github.io/meson-structure/campaigns.html>

Background: <https://jeffersonlab.github.io/meson-structure/background.html>

Review: the issue with Λ reconstruction and ZDC only

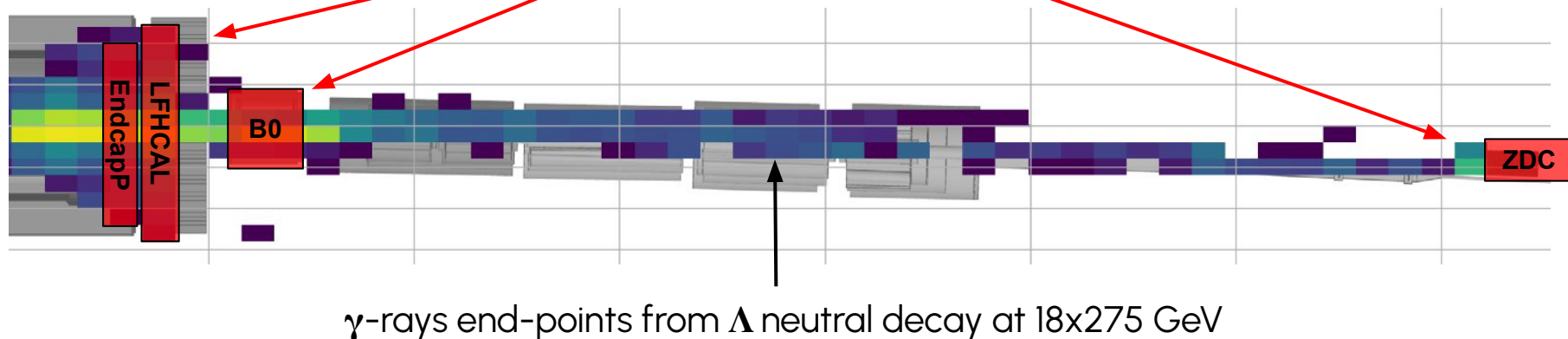
- Previously : Λ reconstruction algo. using ZDC alone ($n + \gamma + \gamma$)
- Our analysis showed an efficiency for realistic generated Λ : near 0
 - Reasons : angle acceptance, clustering of γ from boosted pion
- Strategy for improving the reconstruction algorithm :
 - (1) improve the acceptance by including other calorimeters
 - (2) enhance purity by checking invariant mass reconstruction

Overview: the new EICrecon algorithm for Λ reconstruction

Implemented algorithm
multi-detector seeking
for a pool of n and γ cl.

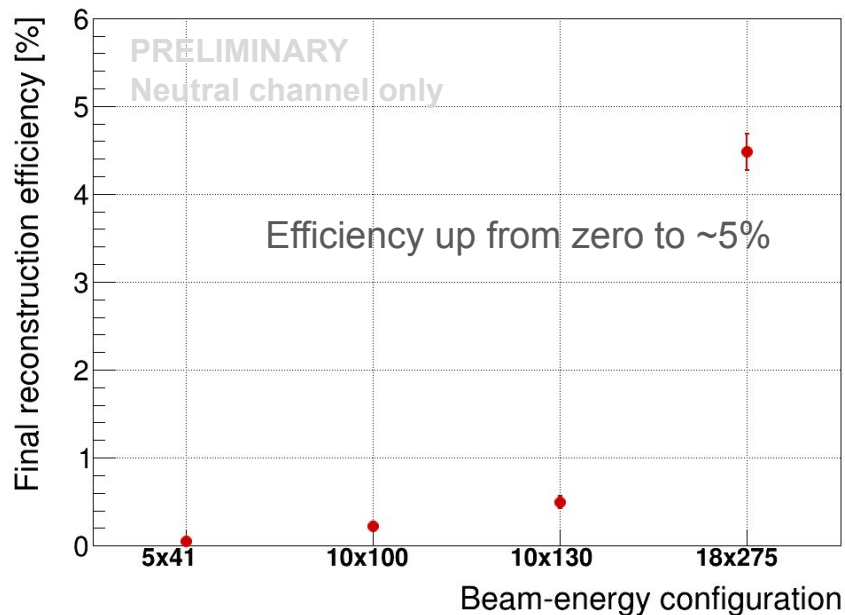
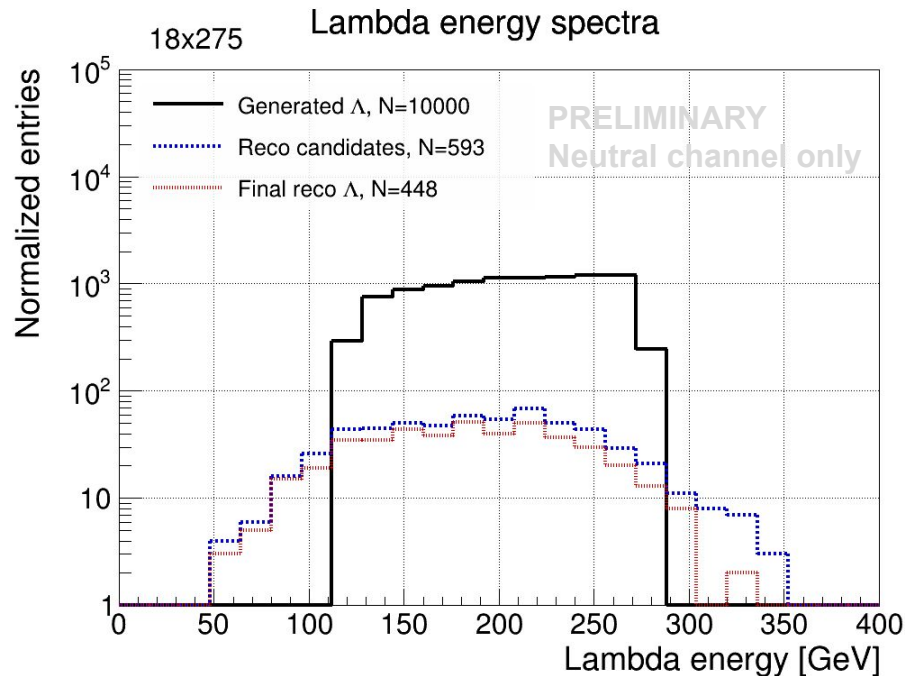
Involved detectors
EndcapP-Ecal, LFHCAL,
B0-Ecal, ZDC-Hcal

High purity from
invariant mass cuts :
on π^0 and Λ



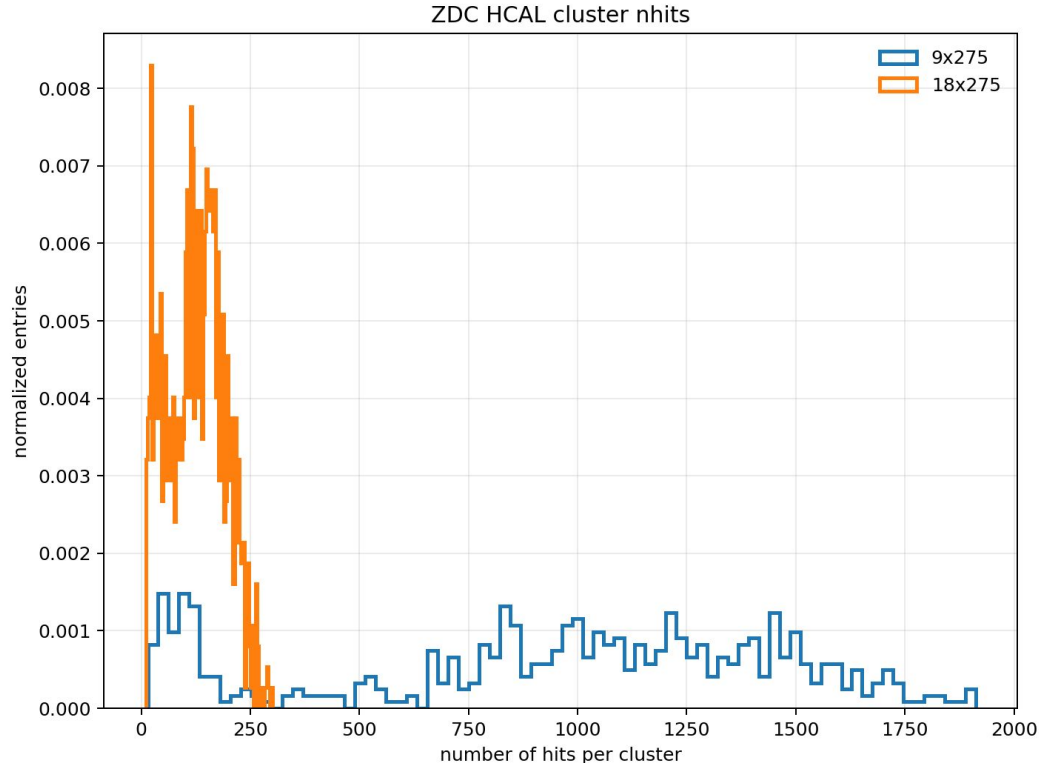
Results Λ reconstruction with new algorithm

February 2026 campaign



Also have results for lower electron energy (early science),
but small impact as efficiency driven by hadron boost

July 2026: Missing pion in ZDC



- Effect in the simu pipeline :
most $\pi^0 \rightarrow \gamma\gamma$ merge into single cluster, so the Δ reconstruction fails ($n+\gamma+\gamma$)
- **ZDC Hcal tiles** changed from hexagonal to squared in **epic** ≥ 26.05 [PR#1070]
- zdc_pi0: allow_fail
https://github.com/eic/detector_benchmarks/pull/276
- Stuck for early science results

Outlooks

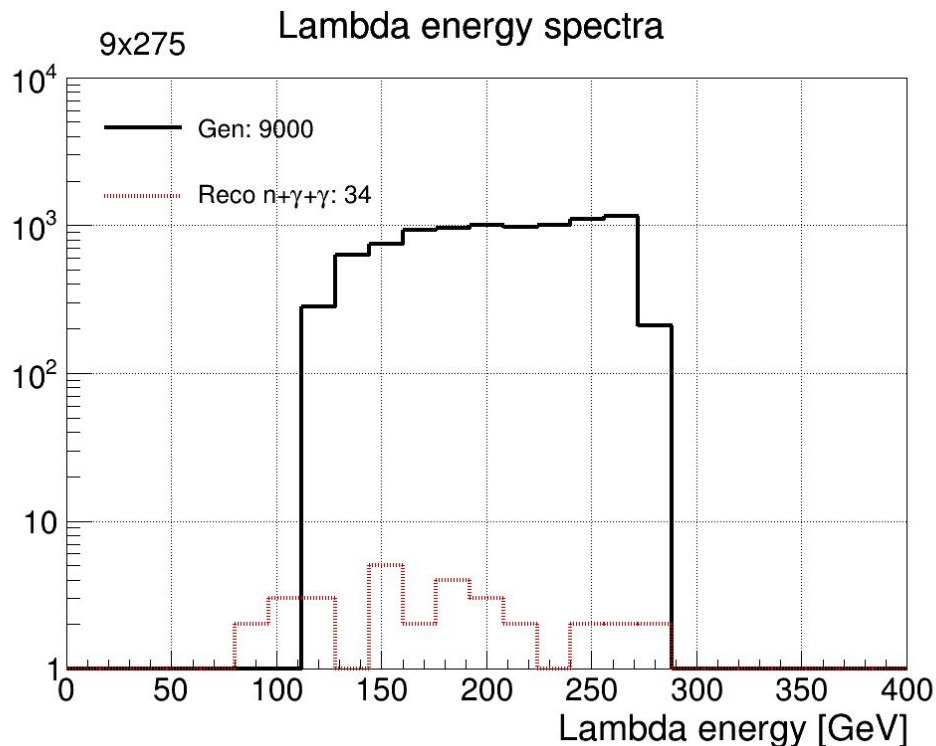
- Promising results of the Λ analysis (neutral channel) with the new reconstruction algorithm
- **Urgent:** the issue with the missing pions in ZDC needs to be resolved
- **Urgent (initial request was made in Sept 2025):** need to have meson SF + background data for the next analysis steps:
 - Identify and quantify sources of uncertainty for Λ -reconstruction efficiency
 - Physics background (very preliminary studies with DIS NC seems to indicate low contamination due to the unique pattern of Λ from Sullivan process)
 - Machine background (Λ from target fragmentation) to be studied
- Also ongoing: Include charged decay channel

Backups



Results Λ reconstruction with new algorithm

July 2026 campaign (new early science energies)



18x275 (26.02) vs. 9x275 (26.07)

- Similar generated events
- Similar neutral clusters in
 - B0, Endcap, LFHCAL
- ZDC clusters dropped
 - 18x275 : 1.55/evt
 - 9x275 : 0.510/evt
- ZDC hits / clusters increased
 - 18x275 : 127 hits/cl
 - 9x275 : 1023 hits/cl (!)
- ZDC clusters energy increased
 - 18x275 : 31 GeV
 - 9x275 : 126 GeV (!)

Current limited data on kaon structure

