Meson structure studies at EIC using the Sullivan Process

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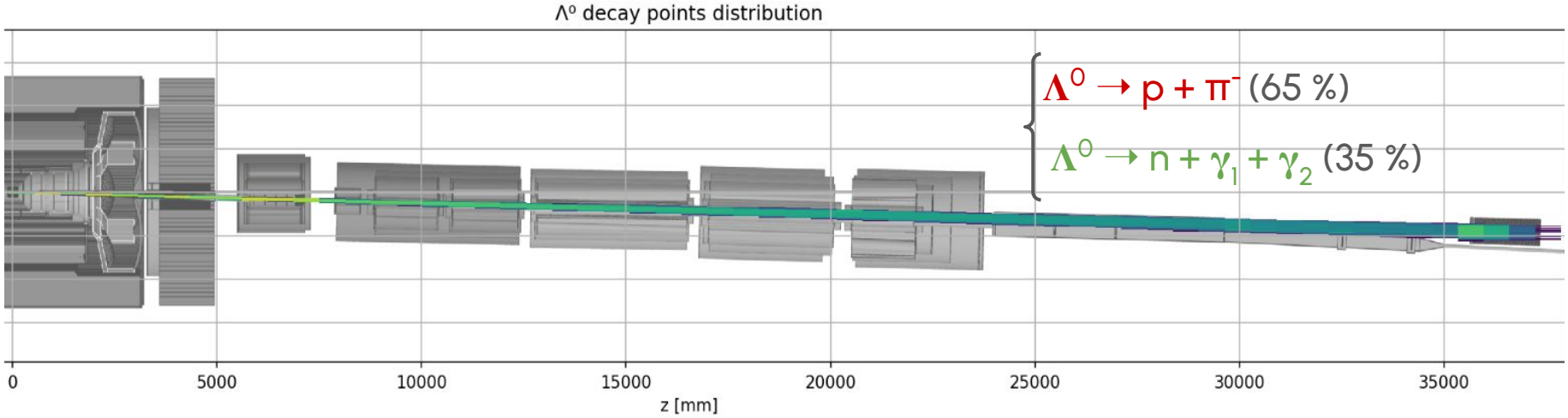
Background and motivations

- Meson Structure Function Group : https://jeffersonlab.github.io/meson-structure/
  - Goal : readiness for Kaon structure function measurements (see Yellow Report)
- Motivation : only one measurement of the Kaon structure in the 80's [2]
  - Method : Drell-Yan process
  - Modern data evaluation / theory validation : need for - sparse and + precise inputs
- Readiness of future measurements with EIC/ePIC using e+p collision :
  - Small-t meson-exchange pole dominates over background + far-forward tagging [2]
  - Broad energy ranges from 5 x 41 GeV to 18 x 275 GeV
  - Method : semi-inclusive measurement of Sullivan process $e + p \rightarrow e' + \Lambda^0 (+ K^+)$
  - Theoretical backing: virtual K^+ is a reliable target if Mandelstam-t small enough [3]

*[1] J. Badier et al., PLB **93**, 1064 (1980),* [2] McKenney, Sato, Melnitchouk, PRD **93** 054011 (2016), [3] *S.-X. Sue et al. PRC 97, 015203 (2018)*

The challenging measurement of Λs

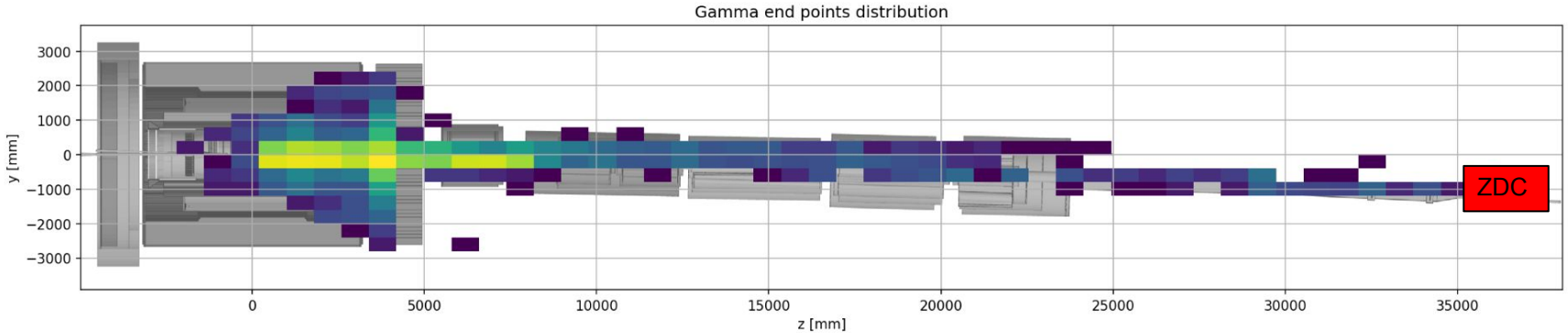
- The Kaon structure is inferred from the measurement of Λ's momenta
- The Λ's observables are challenging to measure: unstable with 2 decay channels



- Option 1 : measure the charged decay channel (2 particles, magnets-dependent)
- Option 2 : measure the neutral decay channel (3 particles, magnets-independent)

Λ-reconstruction algorithm : current status

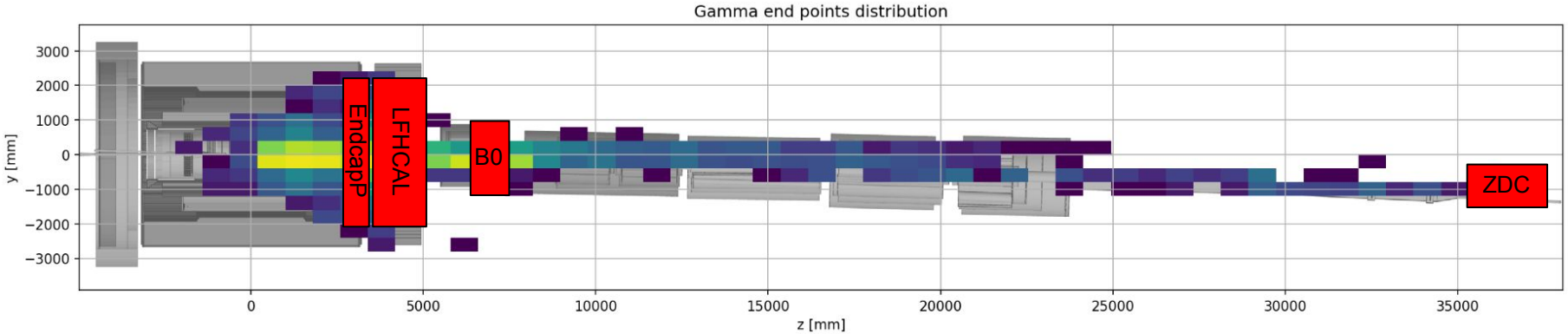
- Algorithm available in EICrecon from S. Paul [1] tested with mono-energetic Λ-gun
- Strategy: triple-coincidences (n + γ_1 + γ_2) in ZDC-Hcal
- Event generator for "realistic" Λ : *github.com/JeffersonLab/eic_mesonsf_generator*
- Acceptance simulations with "realistic" Λs from the event generator [2]
    - ~0.0 % reconstructed @ 5 x 41 GeV
    - ~0.4 % reconstructed @ 18 x 275 GeV



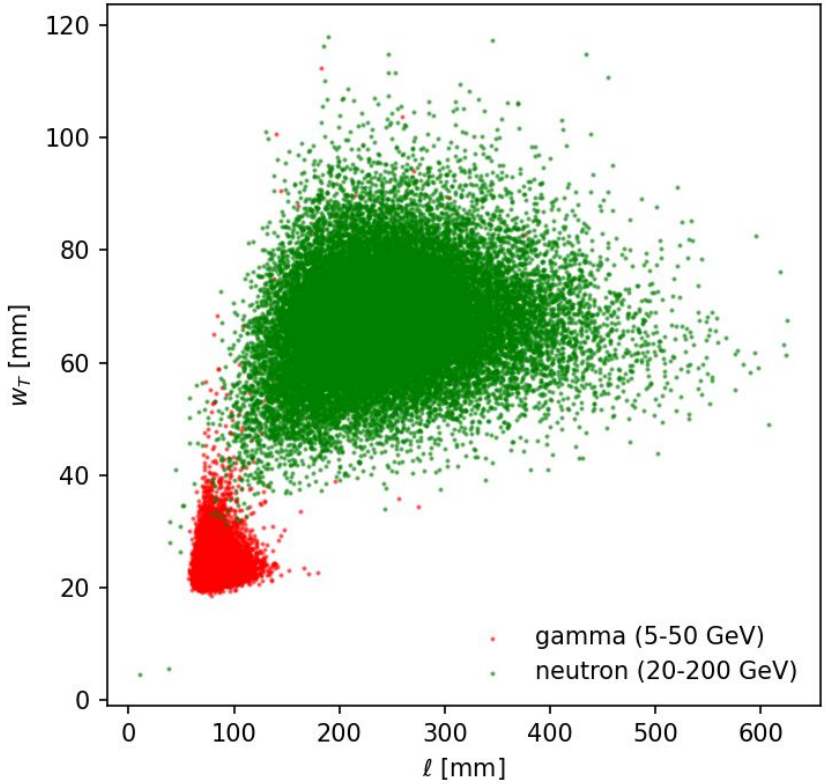
[1] S. J. Paul et al., Phys. Rev. B (2025) [2] ePIC: nightly_2023-03-12 , Event Generator: 0.1, 2025-07 simulation campaign

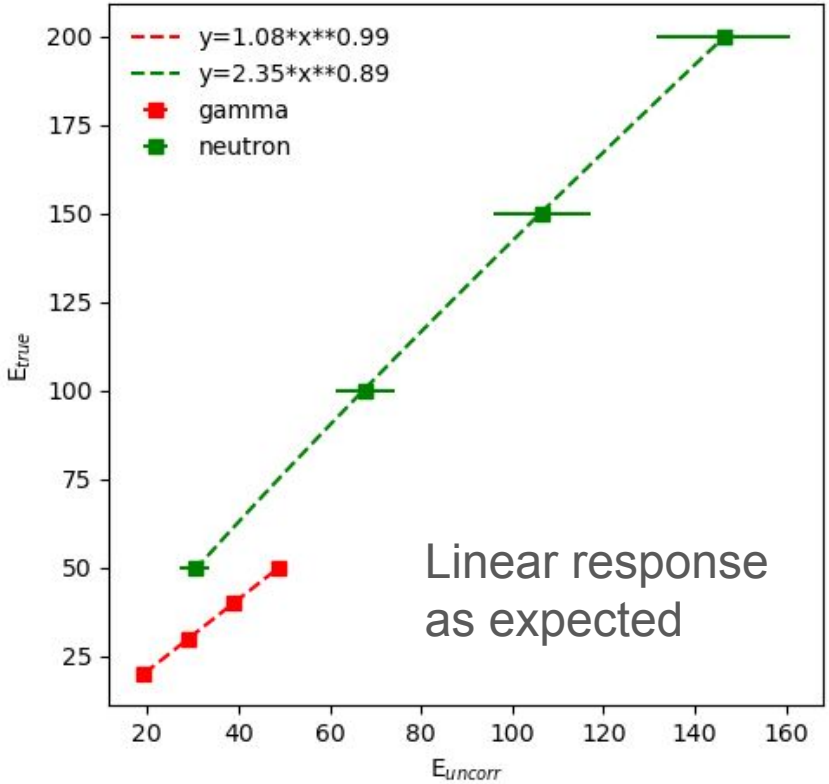
Λ-reconstruction algorithm : upgrade

- New strategy : search of triple-coincidences (n + γ_1 + γ_2) with several calorimeters
  - Including **ZDC-Hcal** and **B0-Ecal** in the Far-Forward region
  - Including **EndCapP-Ecal** and **LFHCAL** in the 'central'-forward region
- Goal :
  - Increase the acceptance of high-energy Λ with Far-Forward calorimeters
  - Increase the acceptance of low-energy Λ with 'Central'-Forward calorimeters

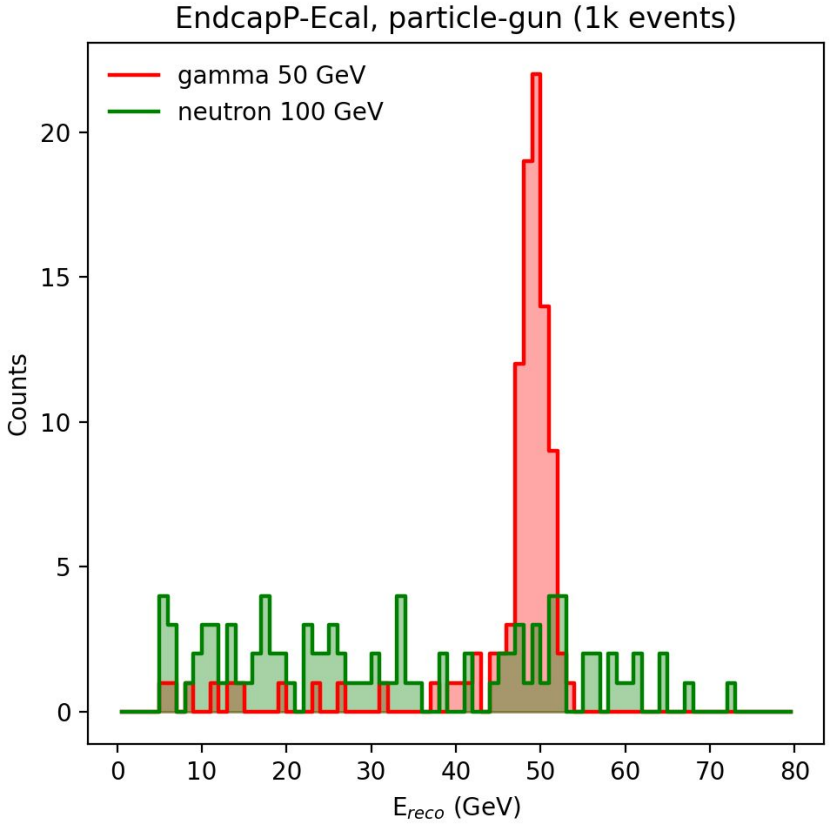


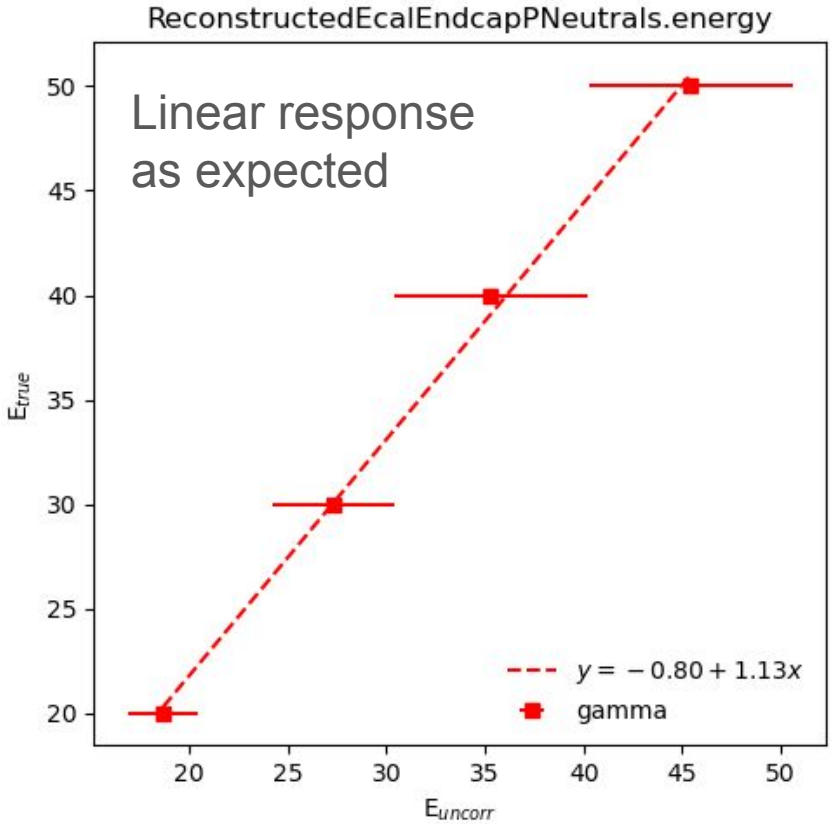
ZDC-Hcal response to neutrons and gamma-rays



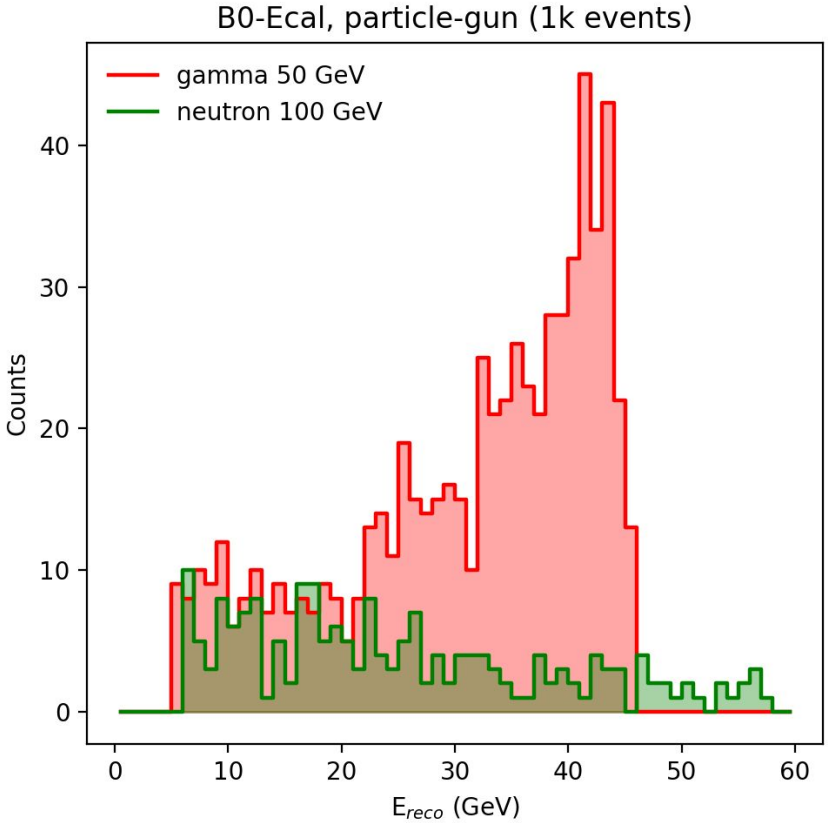


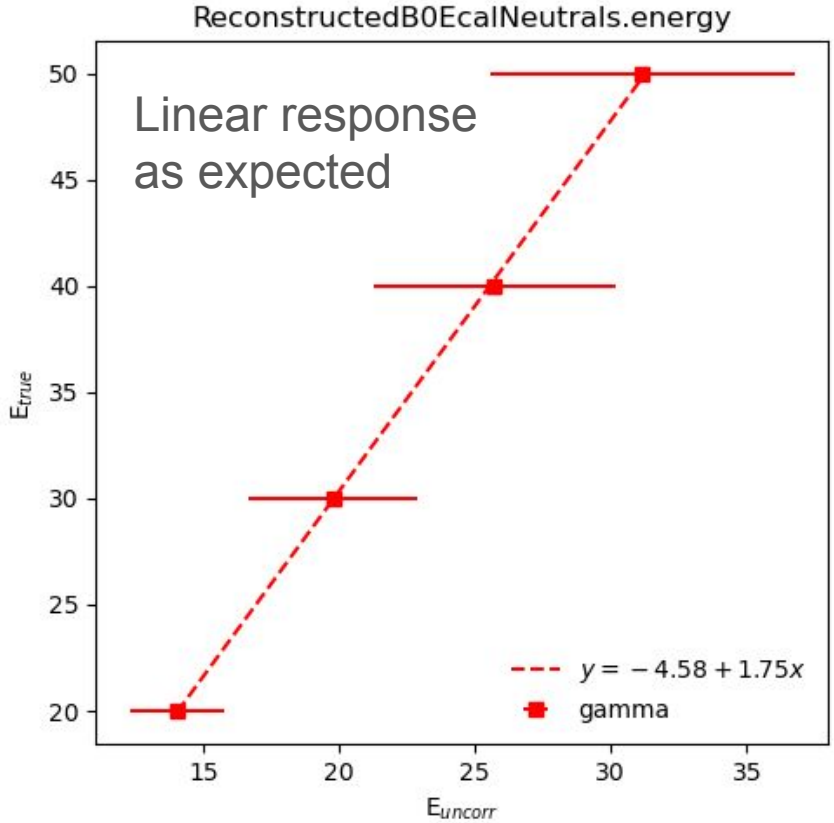
EndcapP-Ecal response to neutrons and gamma-rays



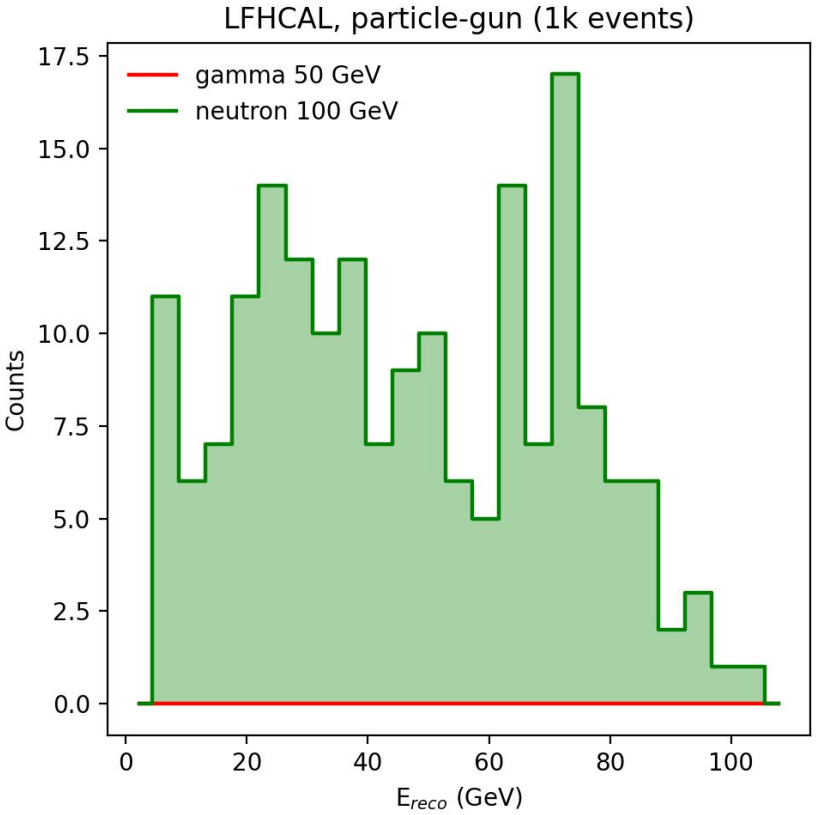


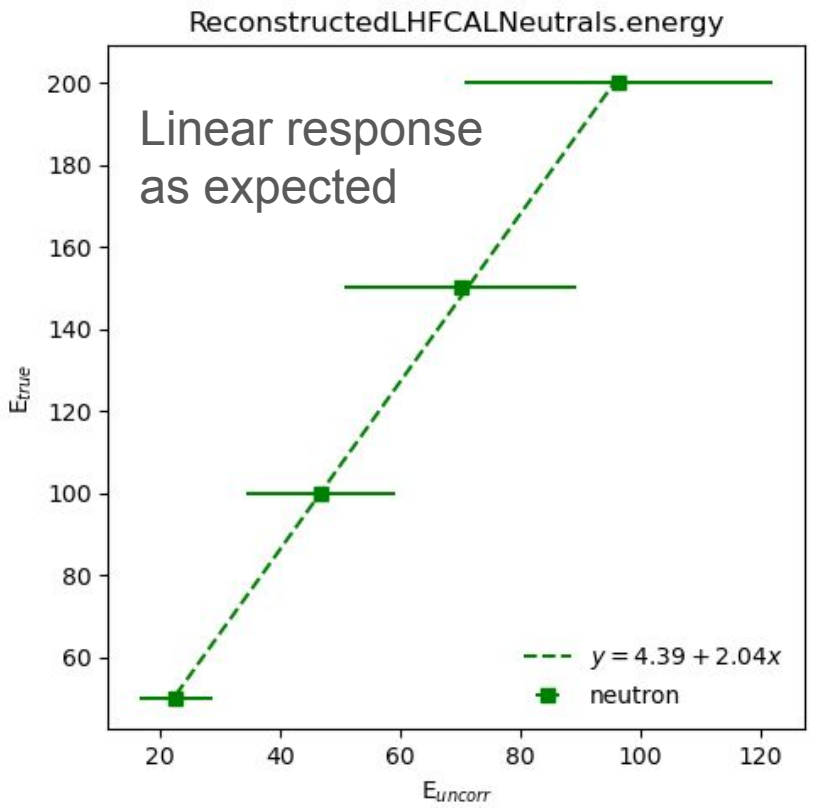
B0-Ecal response to neutrons and gamma-rays





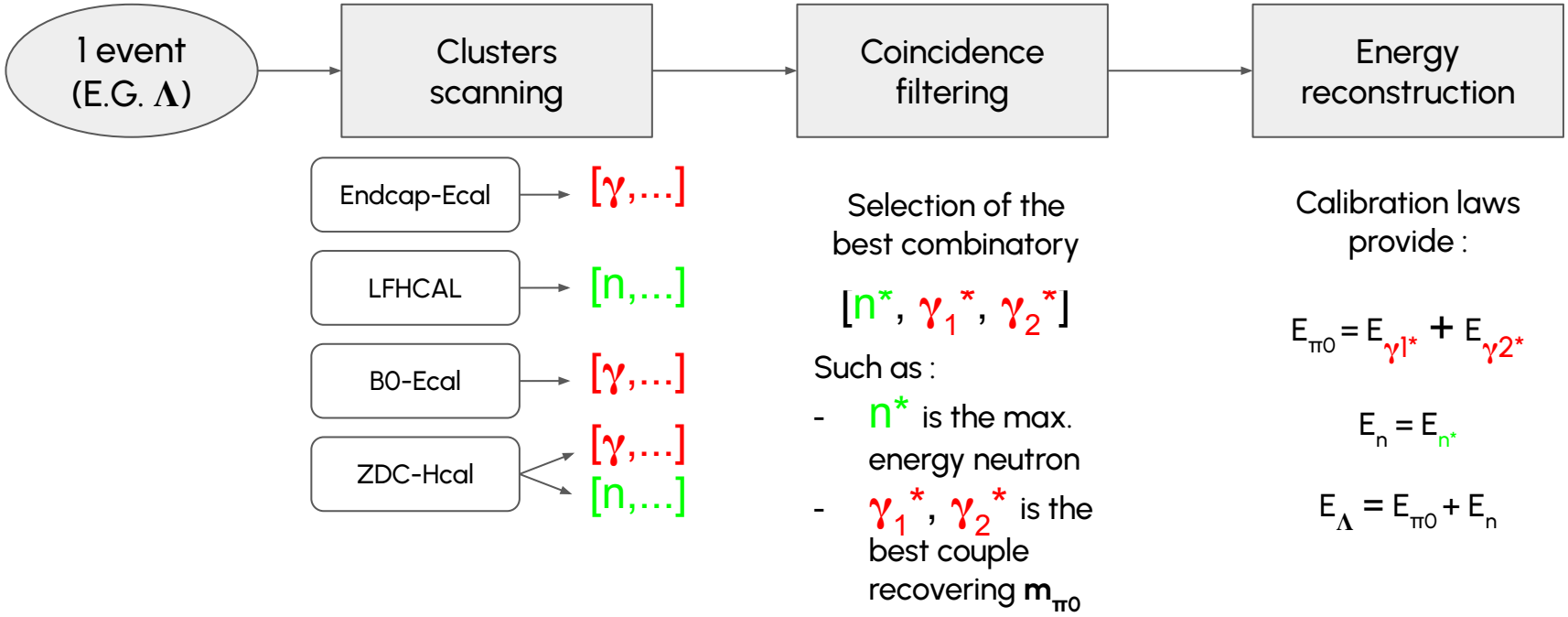
LFHCAL response to neutrons and gamma-rays



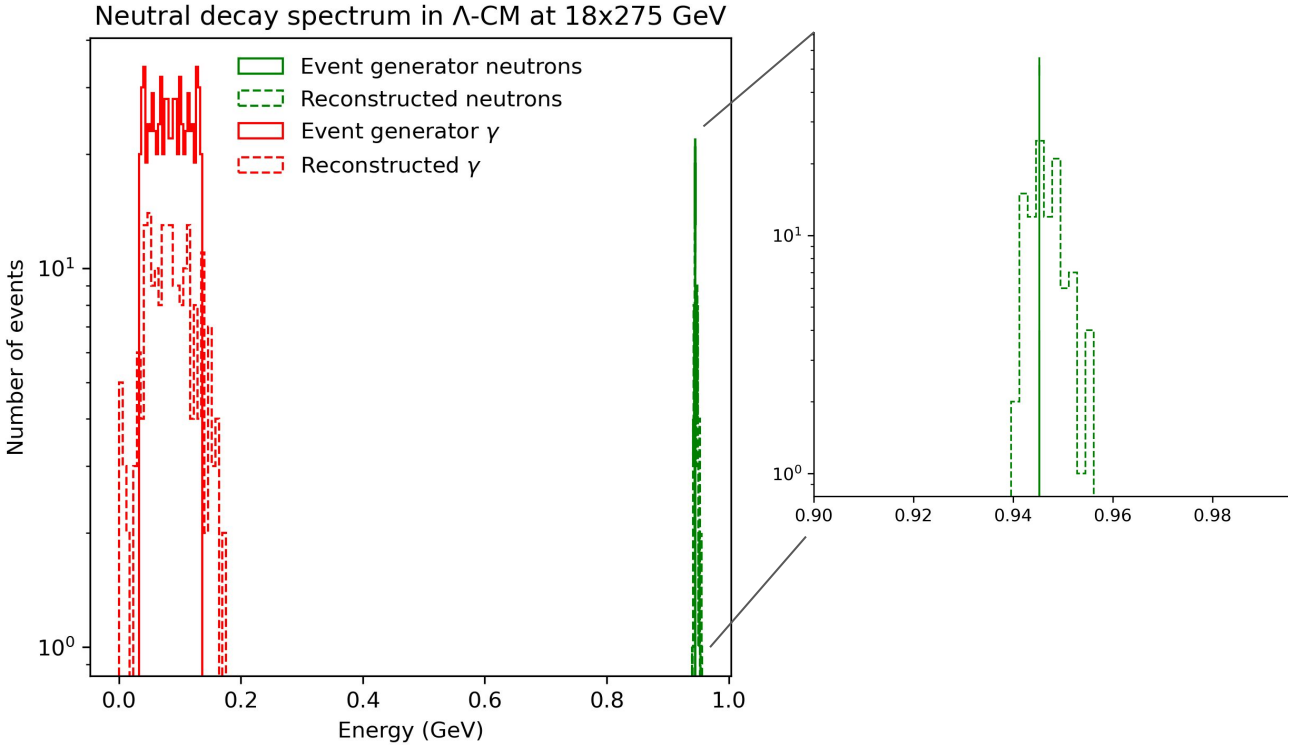


Λ-reconstruction algorithm: cross-detector triple coincidence

- New reconstruction algorithm in EICrecon

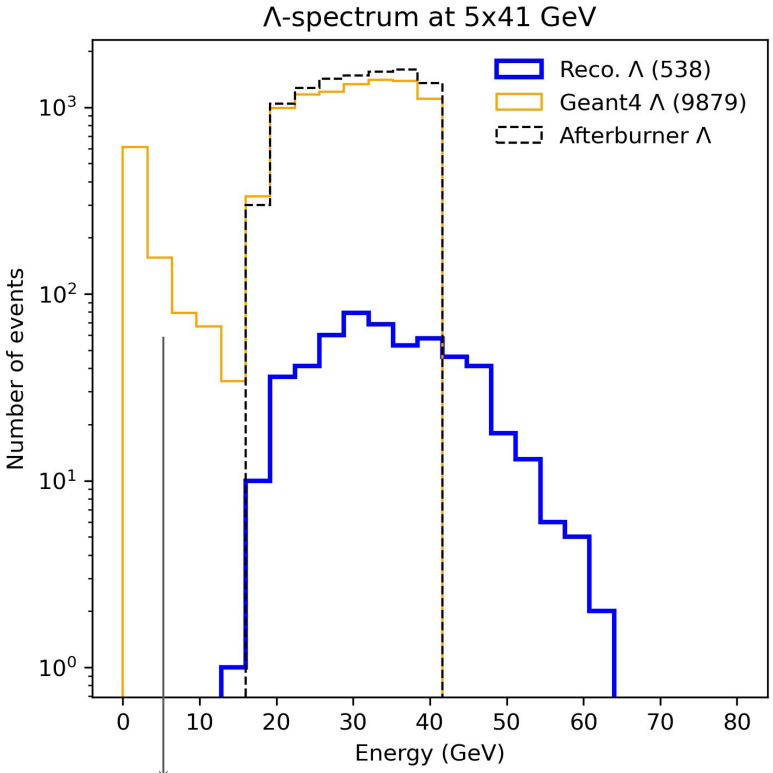


Λ-reconstruction : neutron-gamma identification

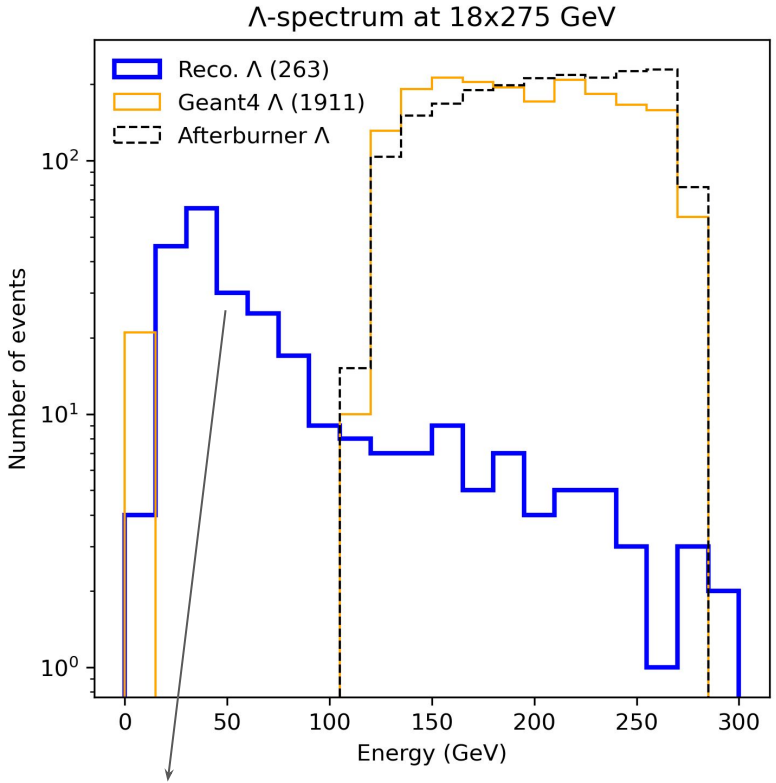


Conclusion: No neutron/γ mix up but resolution loss due to calorimeters stdev.

Λ-reconstruction : preliminary spectra



Indirect showered Λ
created by Geant4



Low-energy tail : bad [γ_1^*, γ_2^*]
selection due to π^0 boost ?

Conclusion and outlooks

- **Improvement of EICrecon** for Lambda reconstruction leveraging on forward calorimeters : **EndcapP-Ecal**, **LFHCAL**, **B0-Ecal**, **ZDC-Hcal**
- **Significant increase of the Λ acceptance (~5%)** through neutral decay
- **Accurate neutron-gamma identification** by the algorithm
- **Outlooks : Λ spectrum correction**
    - "Smearing" caused by calorimeters resolution
    - "Distortion" caused by the acceptance of the system
    - Bias from calorimeters calibration
    - In parallel : **charged decay channel** and **background study**

Thank you !

Backup 1 : hits