DarkLight@ARIEL

Win Lin • Stony Brook University

LEEPP@JLAB • 03/27/2026

Center for Frontiers in Nuclear Science

Stony Brook University

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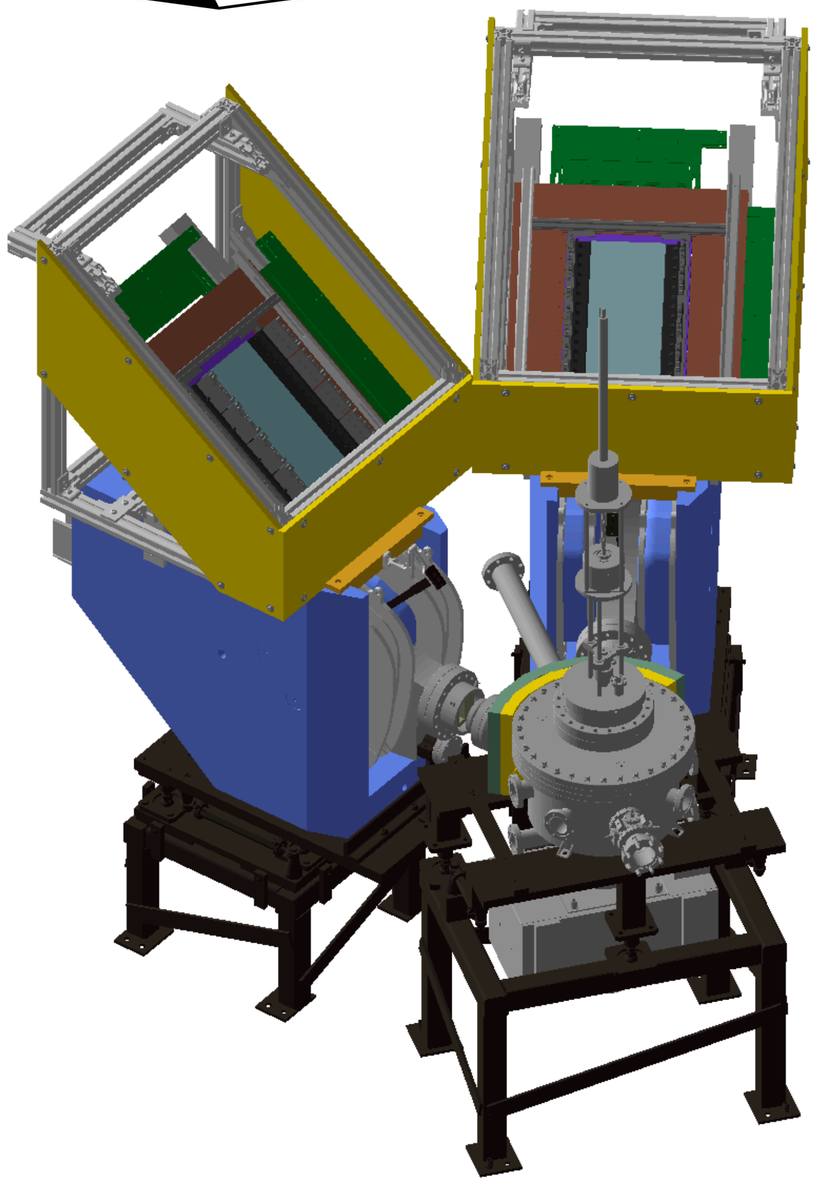


The Standard model only describes a small fraction of the universe

Dark Matter

26%

Visible Matter 5%

Dark Energy

69%

Dark Matter

Visible Matter

One way to search for BSM physics:

Sweep the phase space and check for simple models

Dark Matter

Visible Matter

One way to search for BSM physics:

Sweep the phase space and check for simple models

Another way:

Look at anomalies for complex models

Dark Matter

Visible Matter

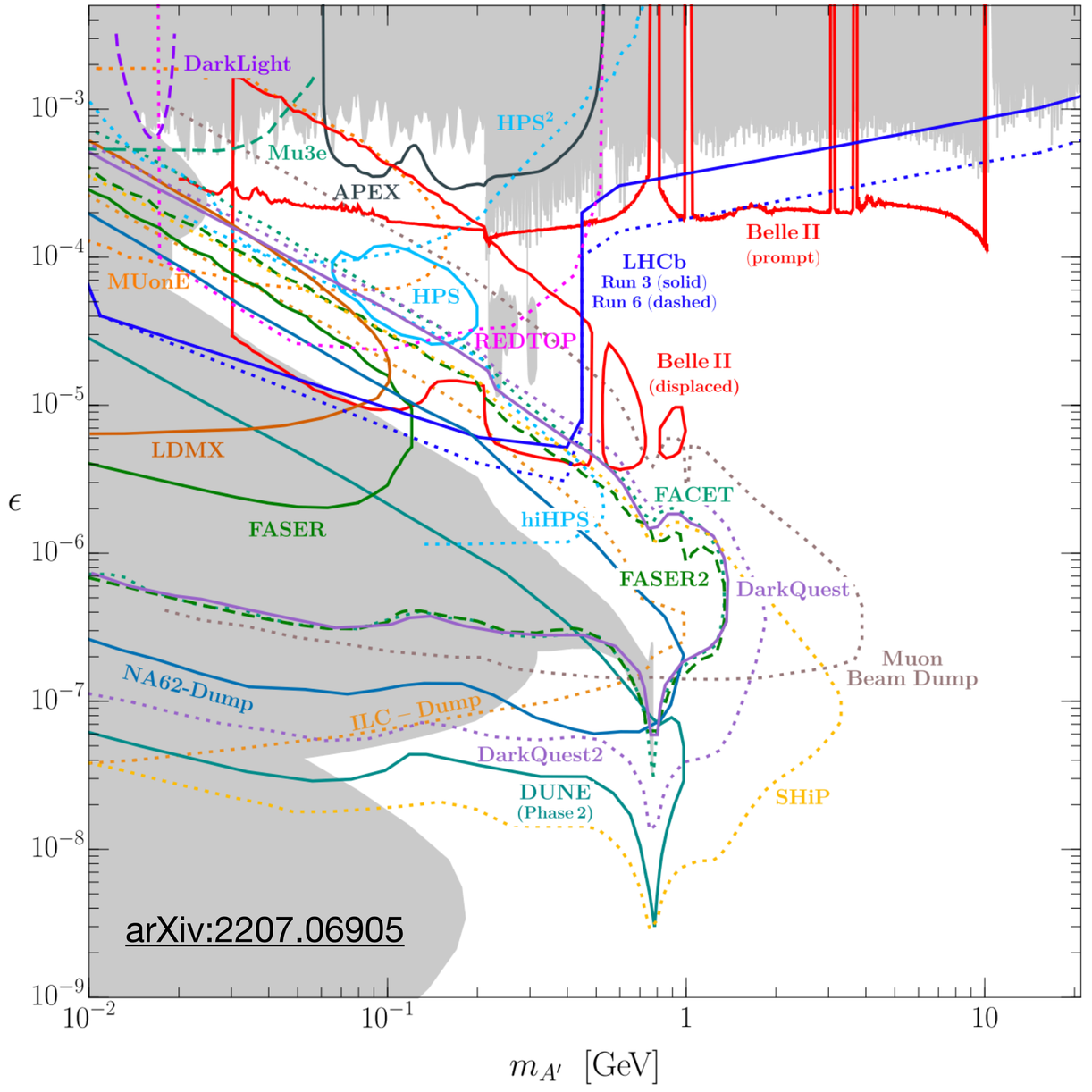
One way to search for BSM physics:

Sweep the phase space and check for simple models

Another way:

Look at anomalies for complex models

Dark Matter

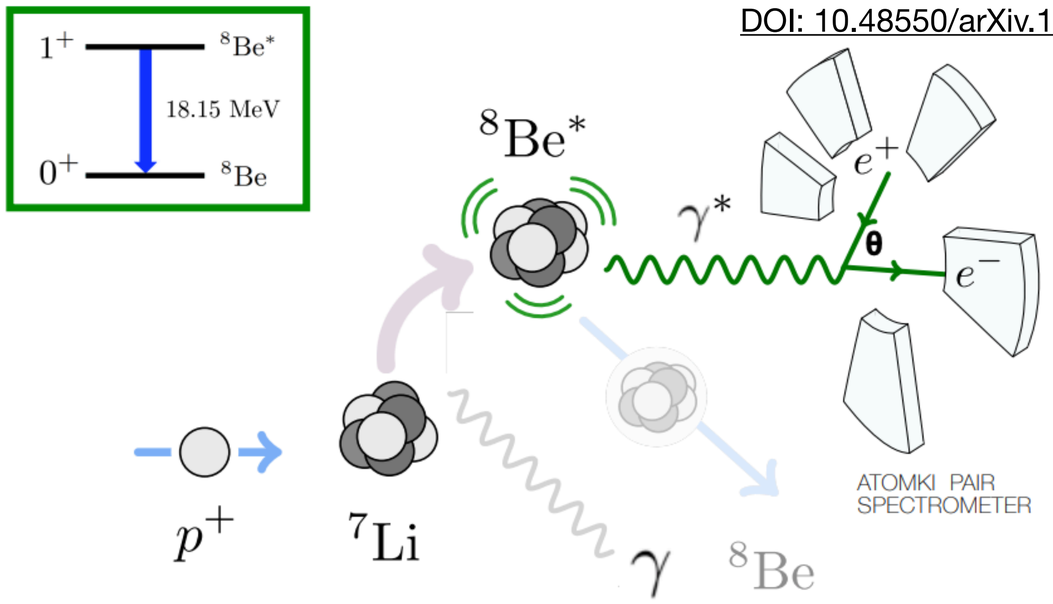


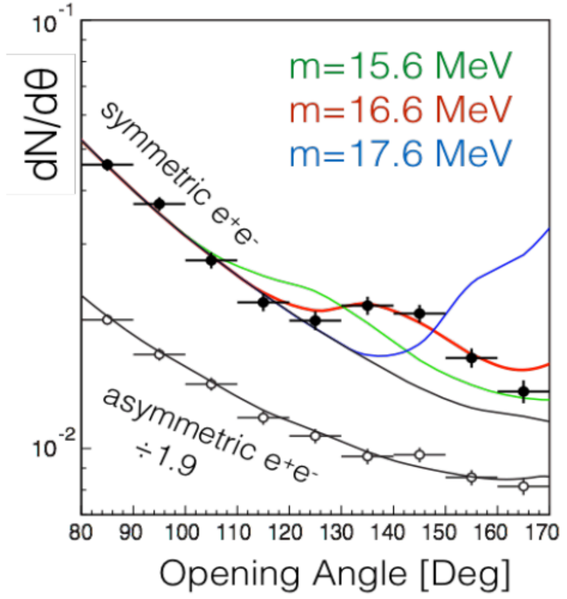
Visible Matter

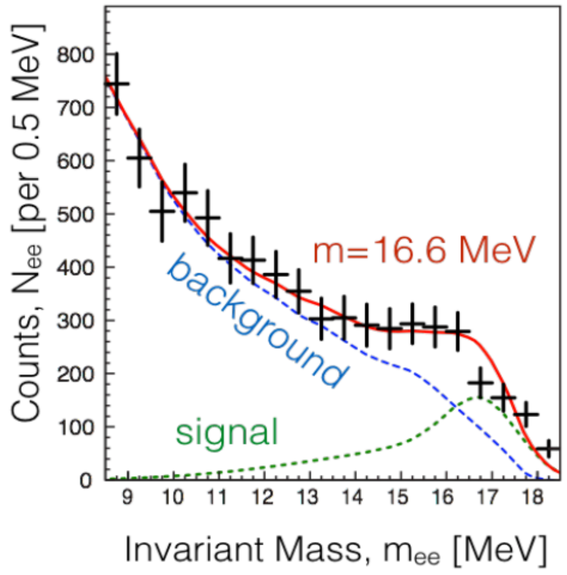
X17:
The ATOMKI Experiment

- New boson with mass 17 MeV?
- Protophobic

DOI: 10.1103/PhysRevLett.116.042501
DOI: 10.48550/arXiv.1707.09749







X17:
The ATOMKI Experiment

- New boson with mass 17 MeV?
- Protophobic
- Similar observations in ^{4}He, ^{12}C decays with independent apparatus:

  DOI: 10.1103/PhysRevC.104.044003

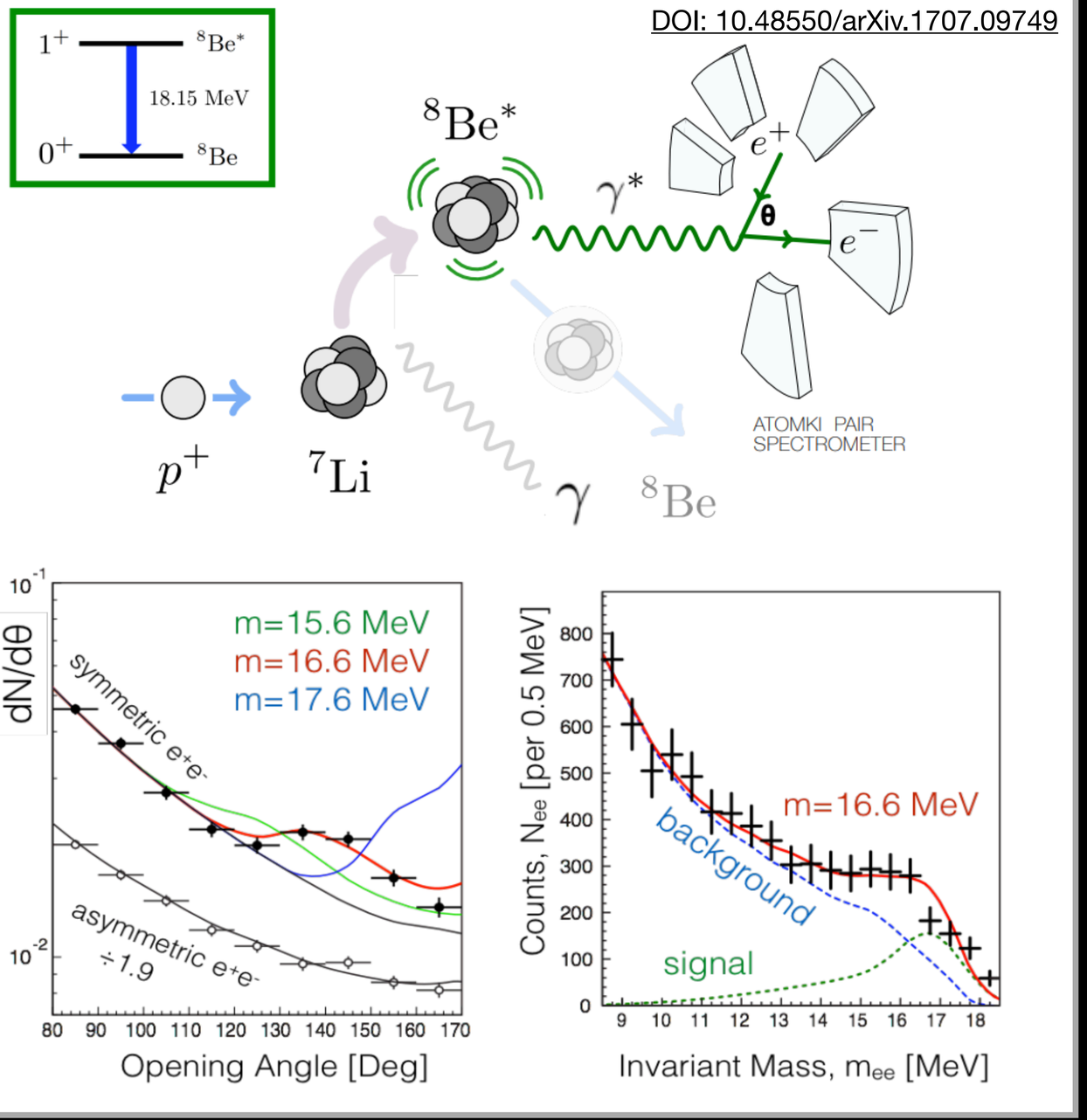
  DOI: 10.1103/PhysRevC.106.L061601

  and in pC, dC, dCu interactions:

  DOI: 10.48550/arXiv.2311.18632

DOI: 10.1103/PhysRevLett.116.042501

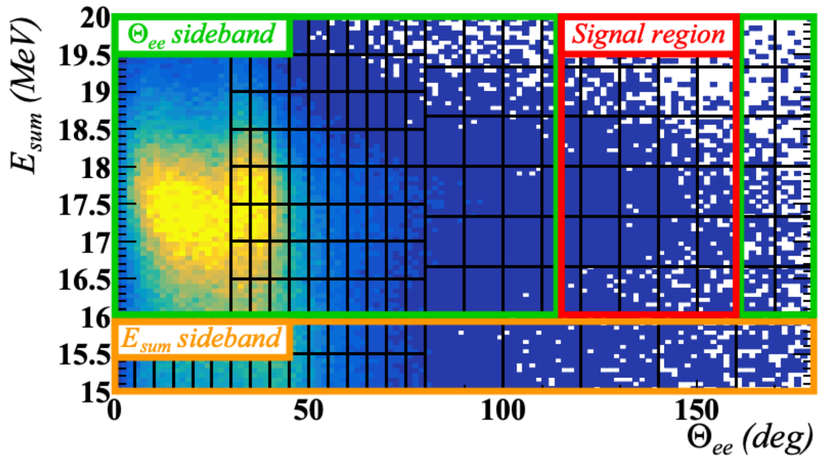
DOI: 10.48550/arXiv.1707.09749

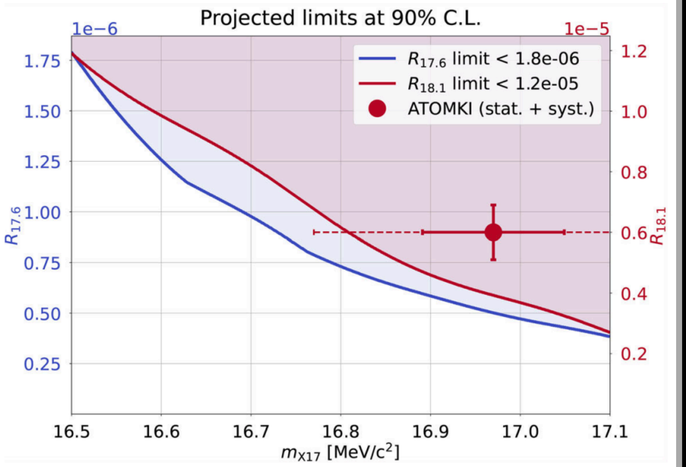


X17:
Recent measurements

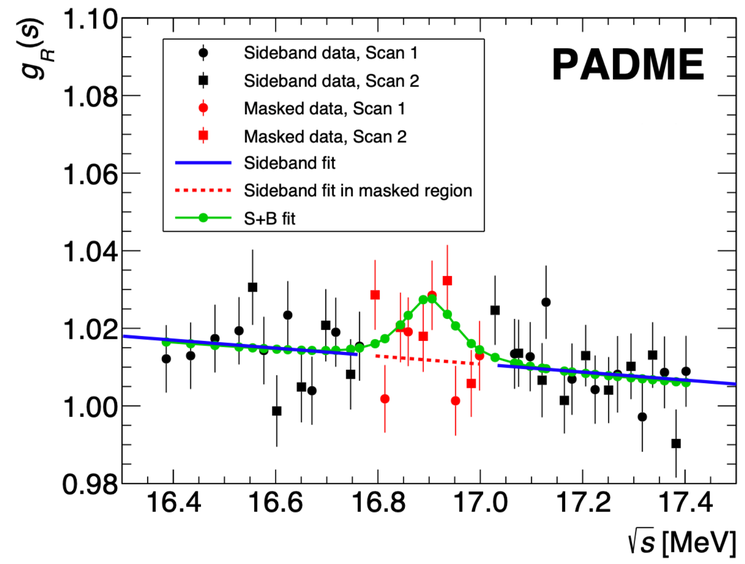
- MEGII @ PSI
  - $^{7}\mathrm{Li}(\mathrm{p}, \mathrm{e}^{+}\mathrm{e}^{-})^{8}\mathrm{Be}$
  - No observation of X17
  - Signal range is at the edge of acceptance
- PADME @ INFN-LNF
  - $e^{+}e^{-} \rightarrow \gamma A$
  - 1.6σ excess

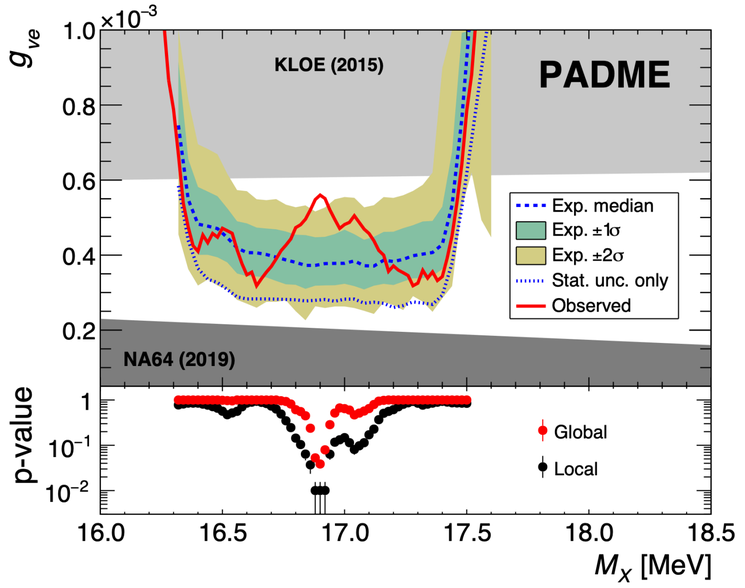
https://doi.org/10.1140/epjc/s10052-025-14345-0





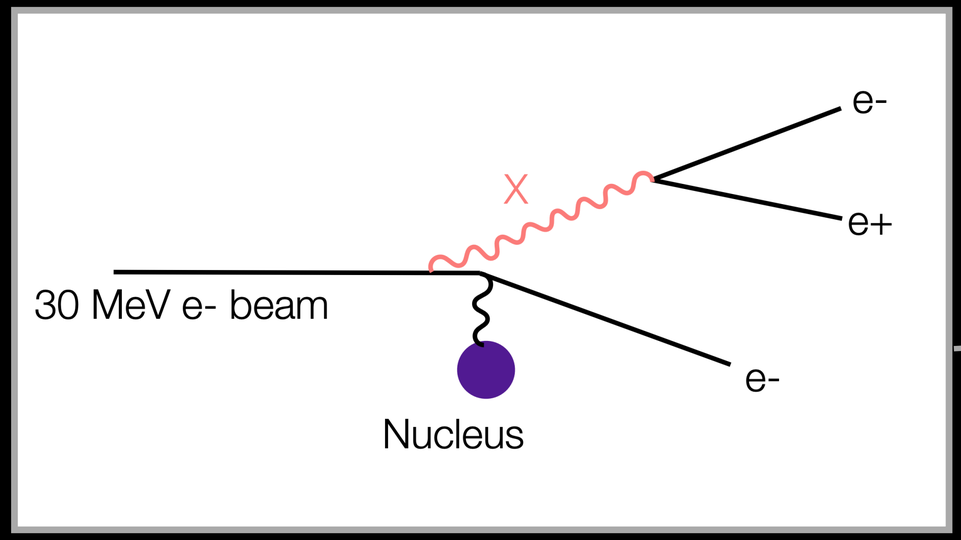
https://arxiv.org/pdf/2505.24797

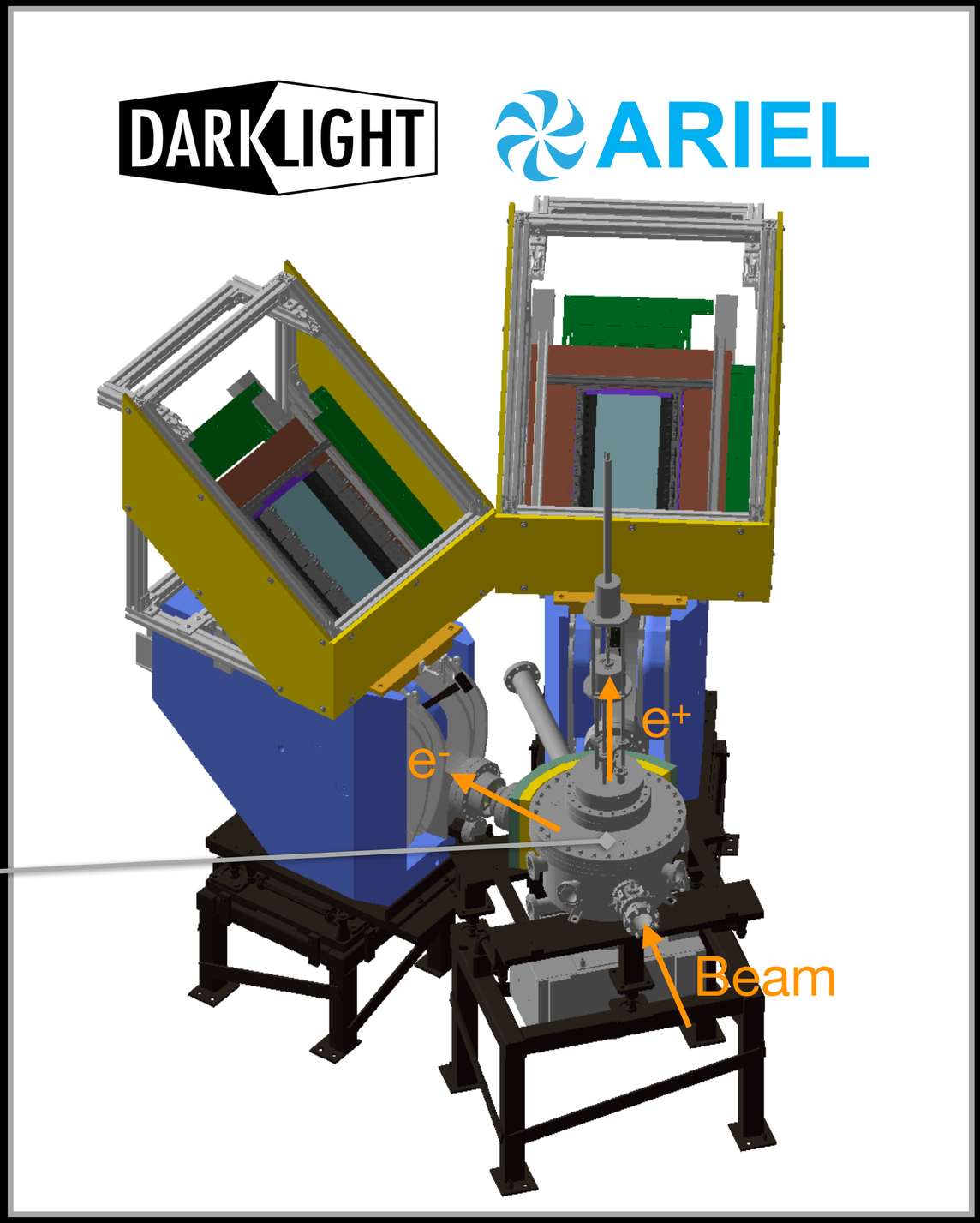




DarkLight Experiment

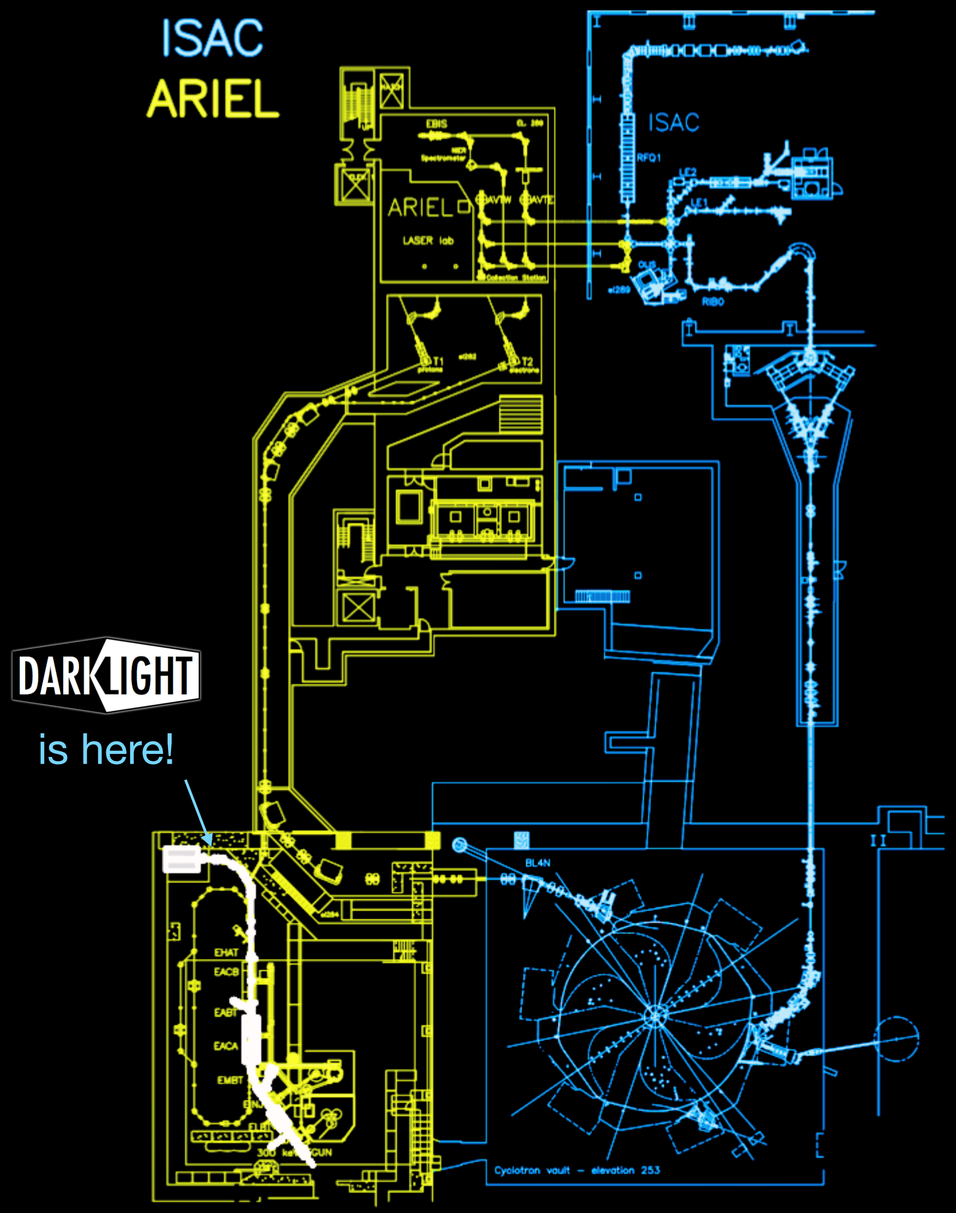
- Two-spectrometer setup
- Tantalum foil target





Beamline:

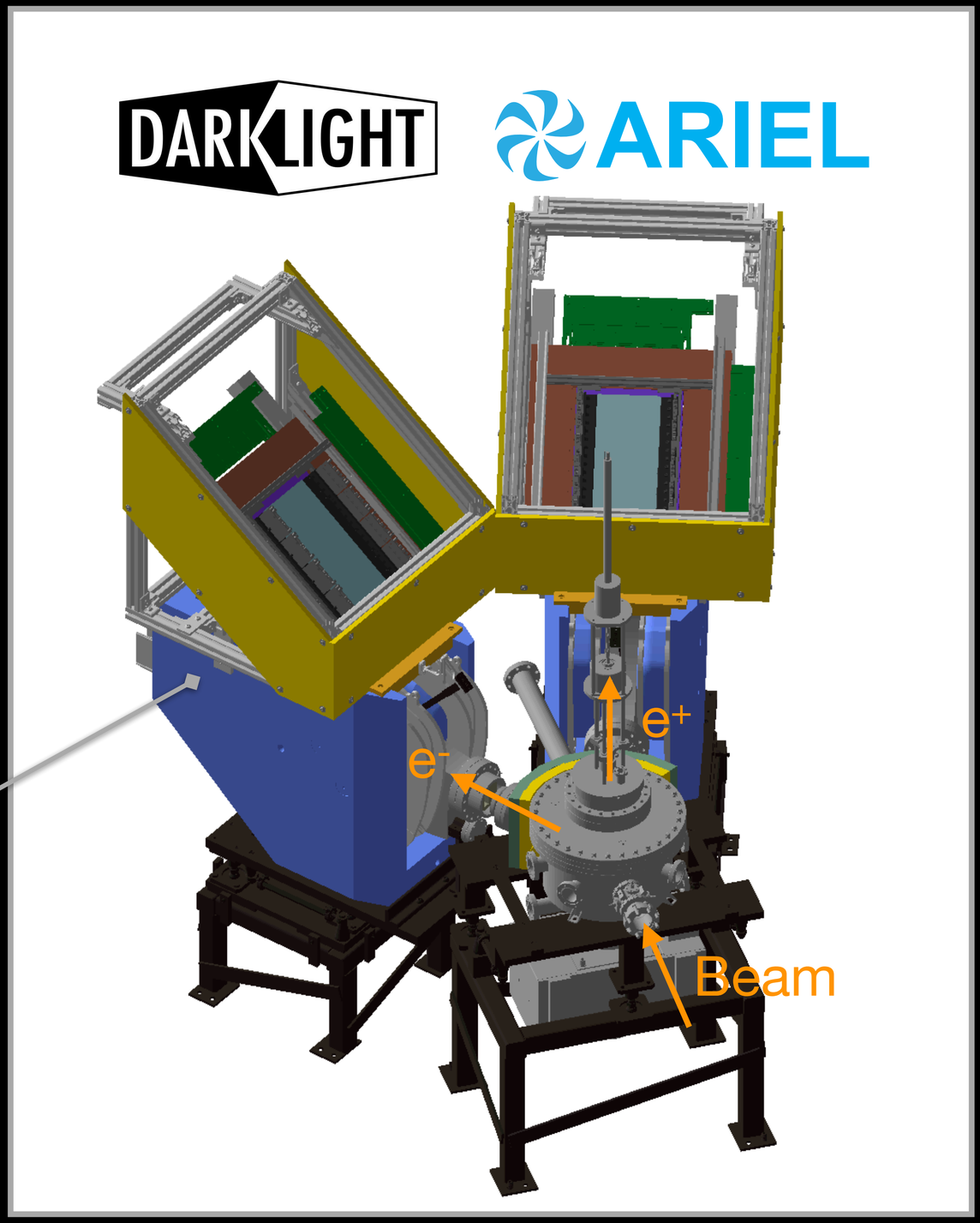
TRIUMF ARIEL
ADVANCED RARE ISOTOPE LABORATORY



Detector setup:

- **Magnetic spectrometers**

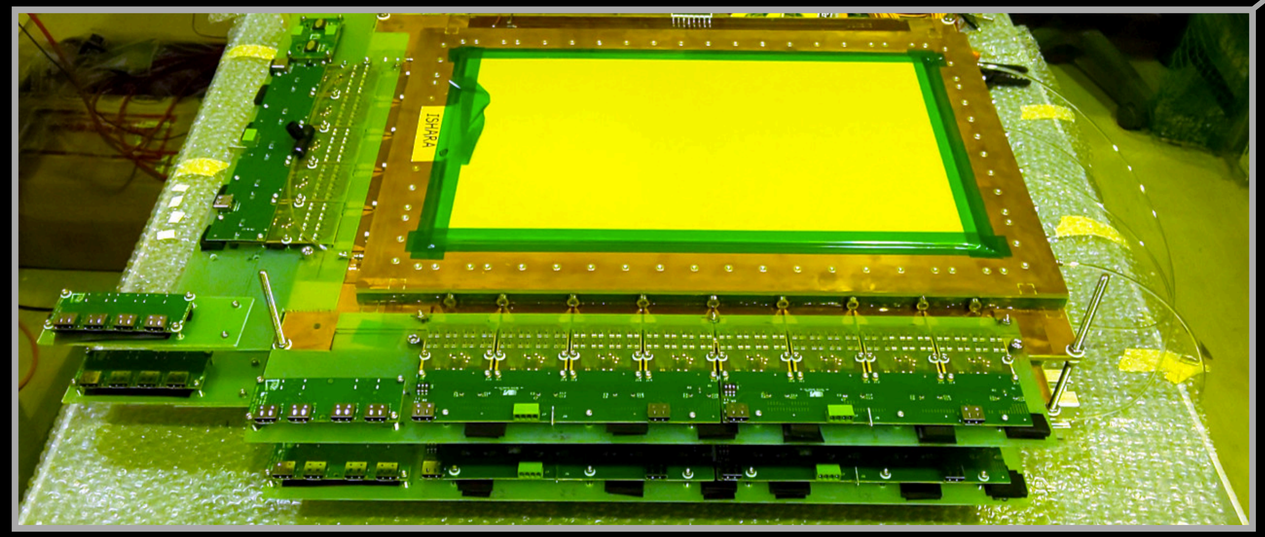
- $\pm 1.35^{\circ}$ in-plane, $\pm 5^{\circ}$ out-of-plane angle
- $\pm 20\,\%$ momentum

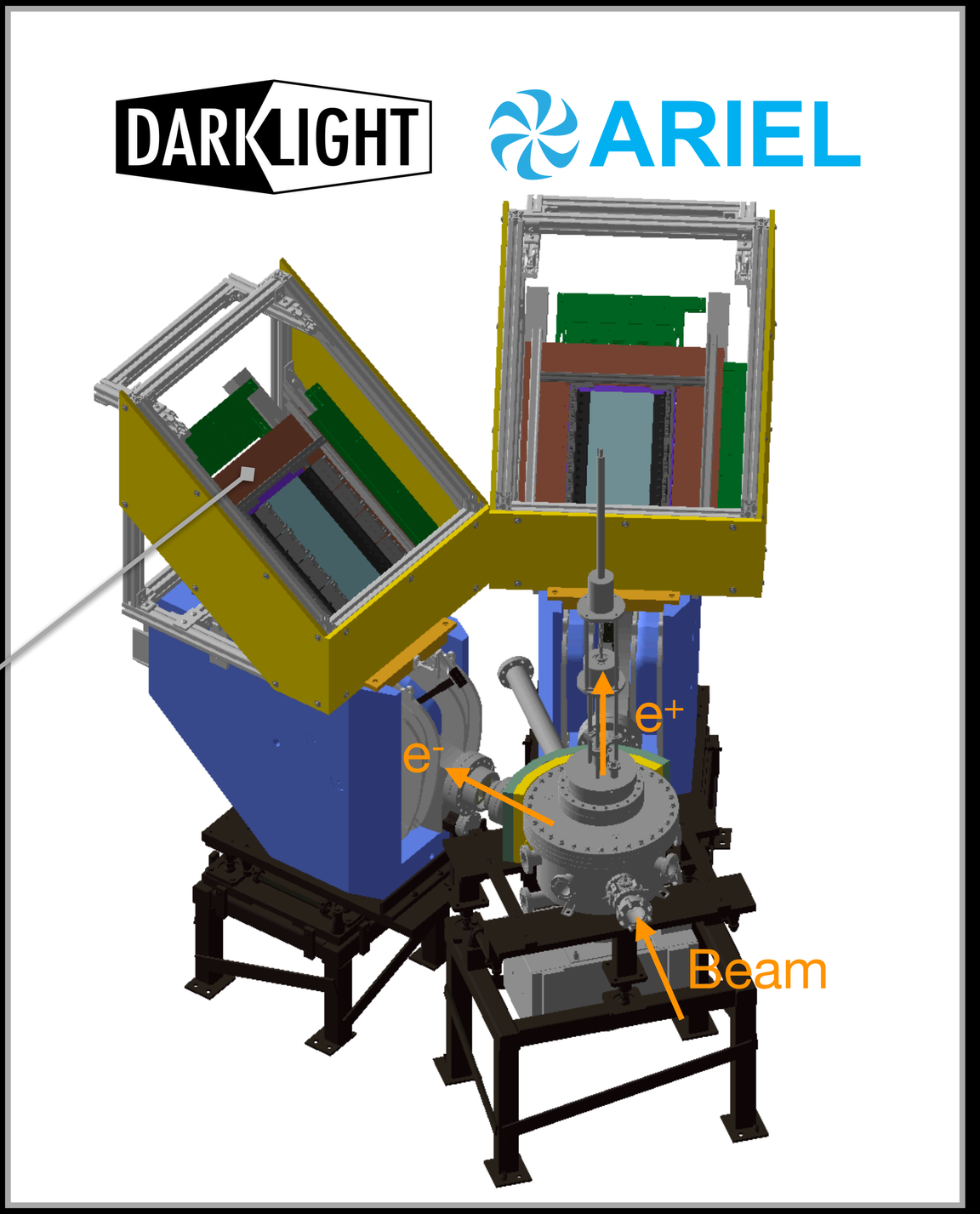


Detector setup:

- **GEM trackers**

- 25 x 40 cm triple layer GEMs
- 2 planes per spectrometer arm
- APV + MPD4 readout

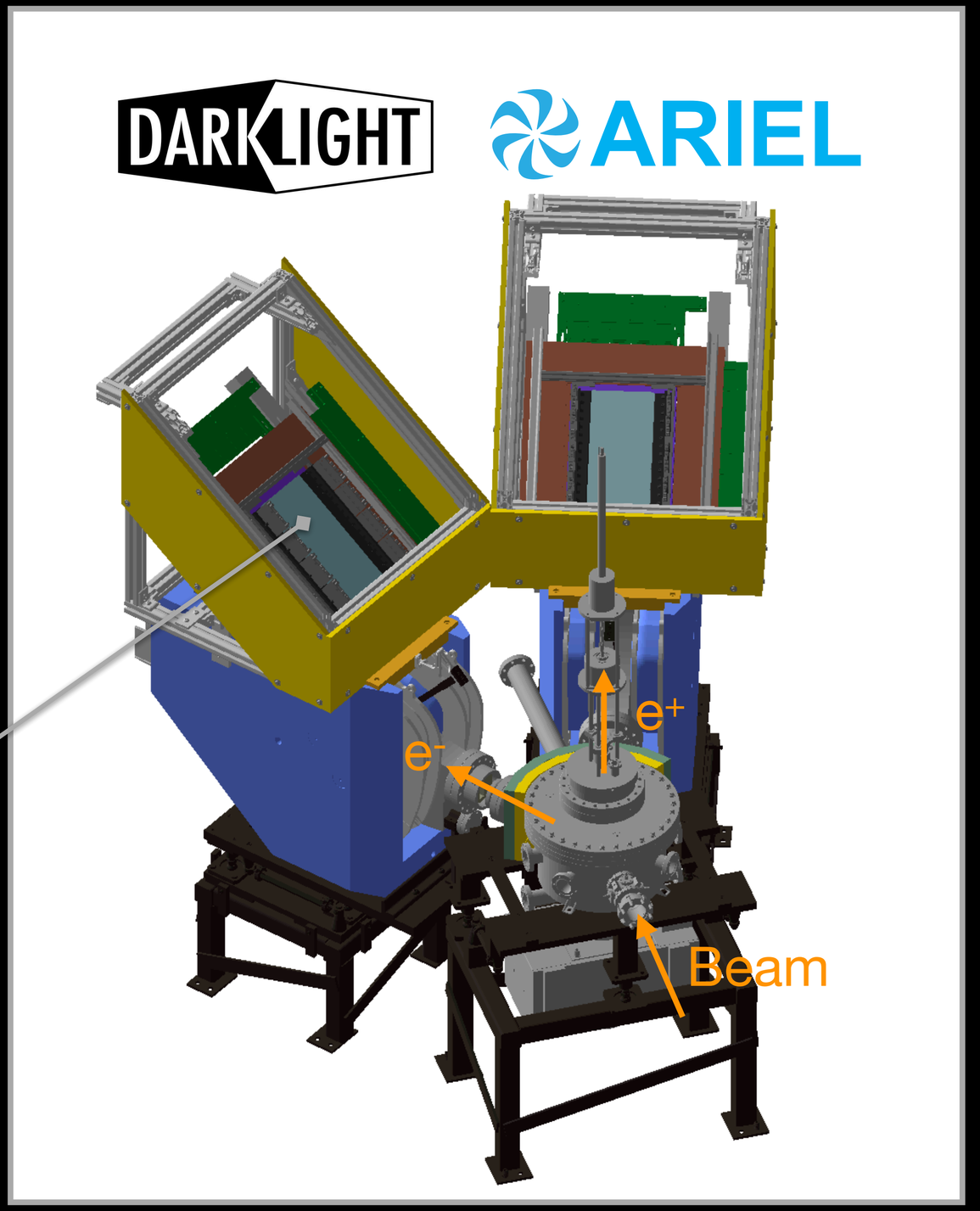




Detector setup:

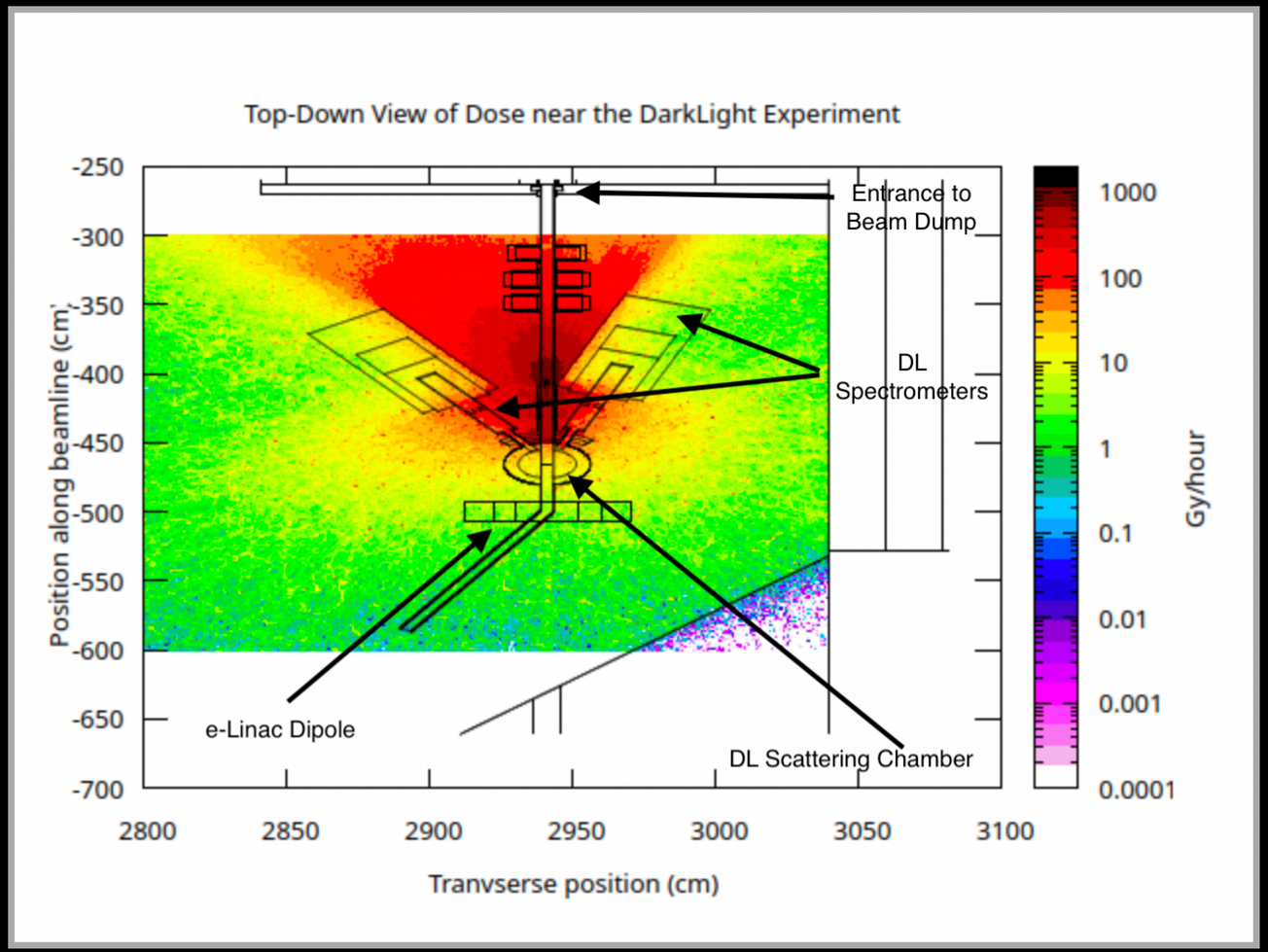
- **Scintillator triggers**

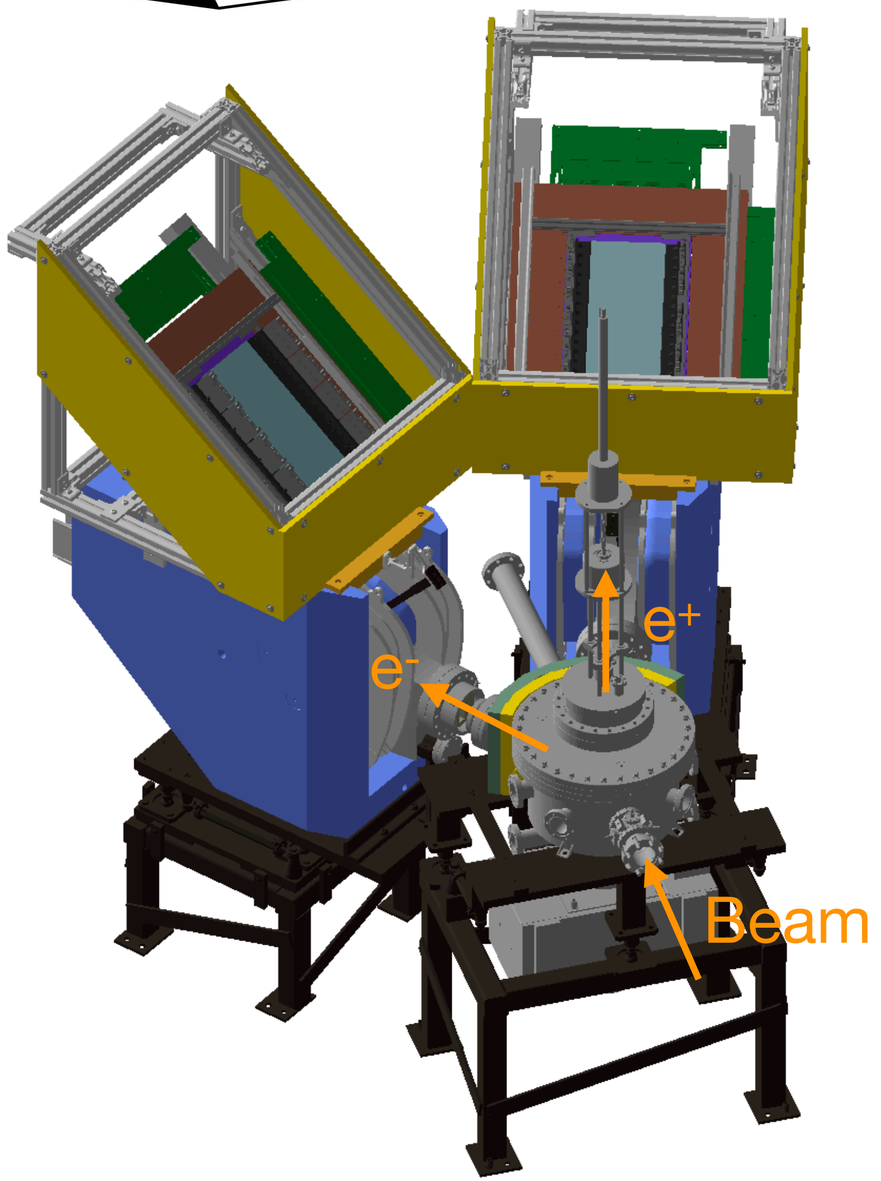
- 8 paddles per spectrometer
- Plastic scintillators, SiPM readouts



Detector setup:

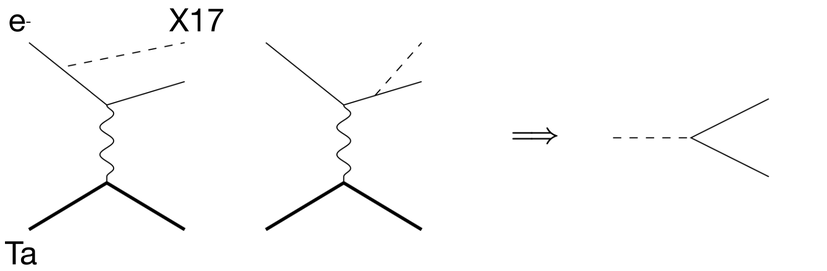
- Shielding for γ and n



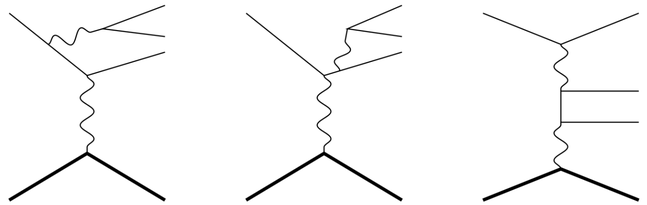


Detector setup:

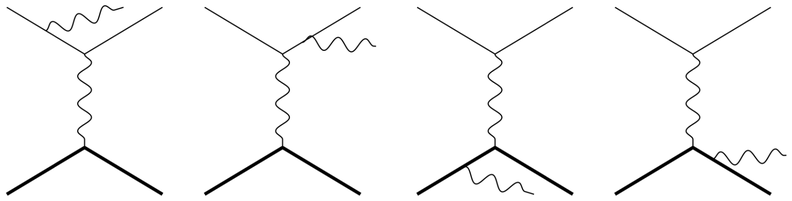
- **Asymmetric spectrometers**



Signal

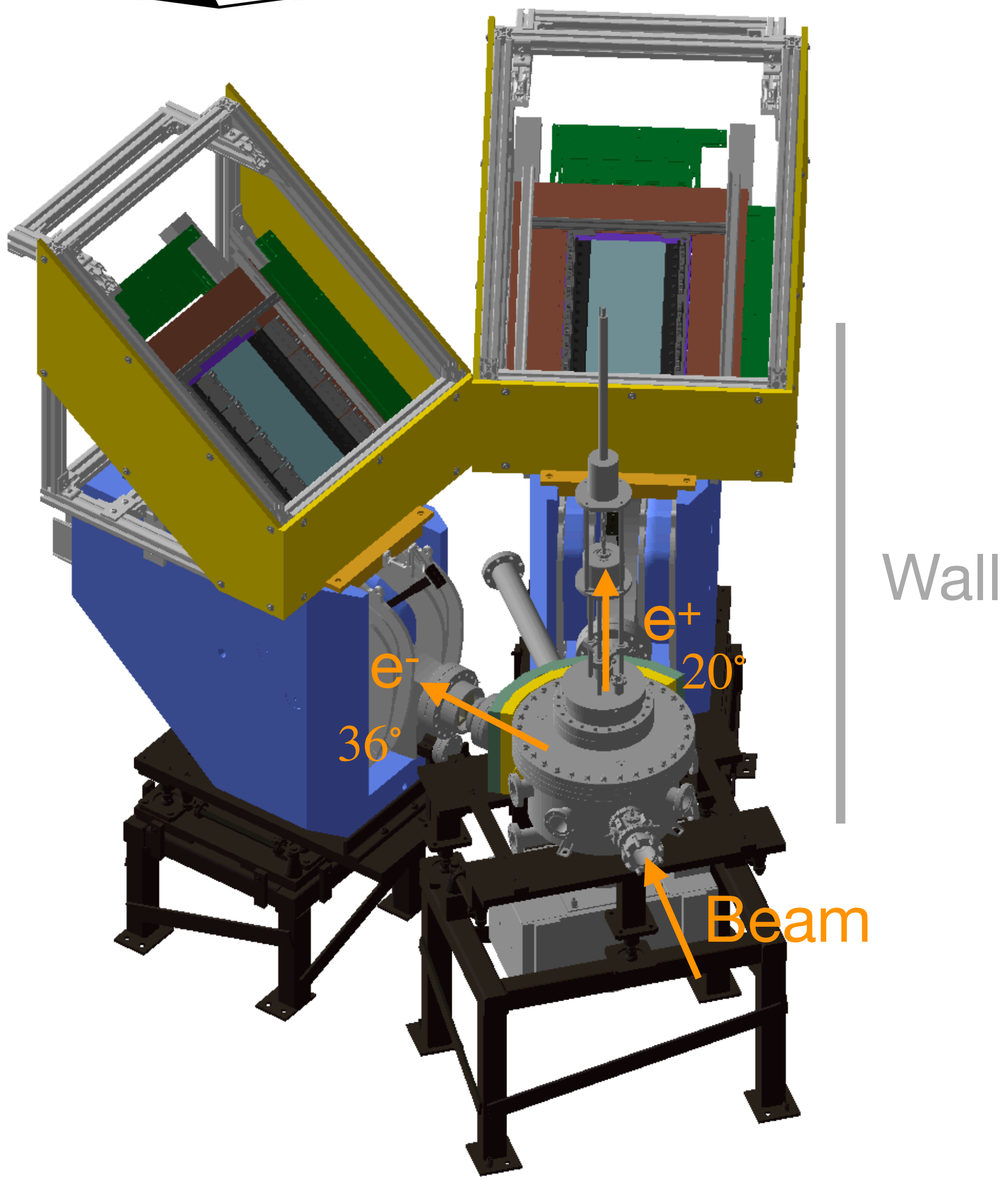


Irreducible background



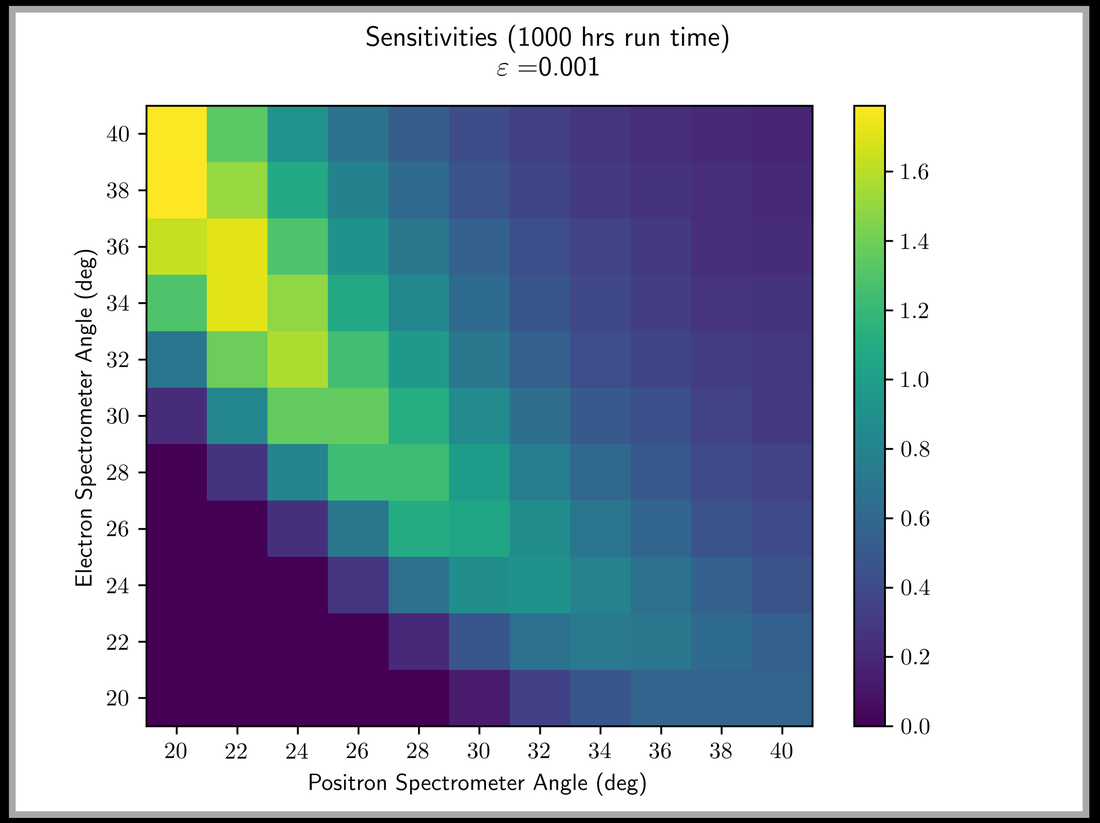
Combinatorial background

Physics processes in production runs



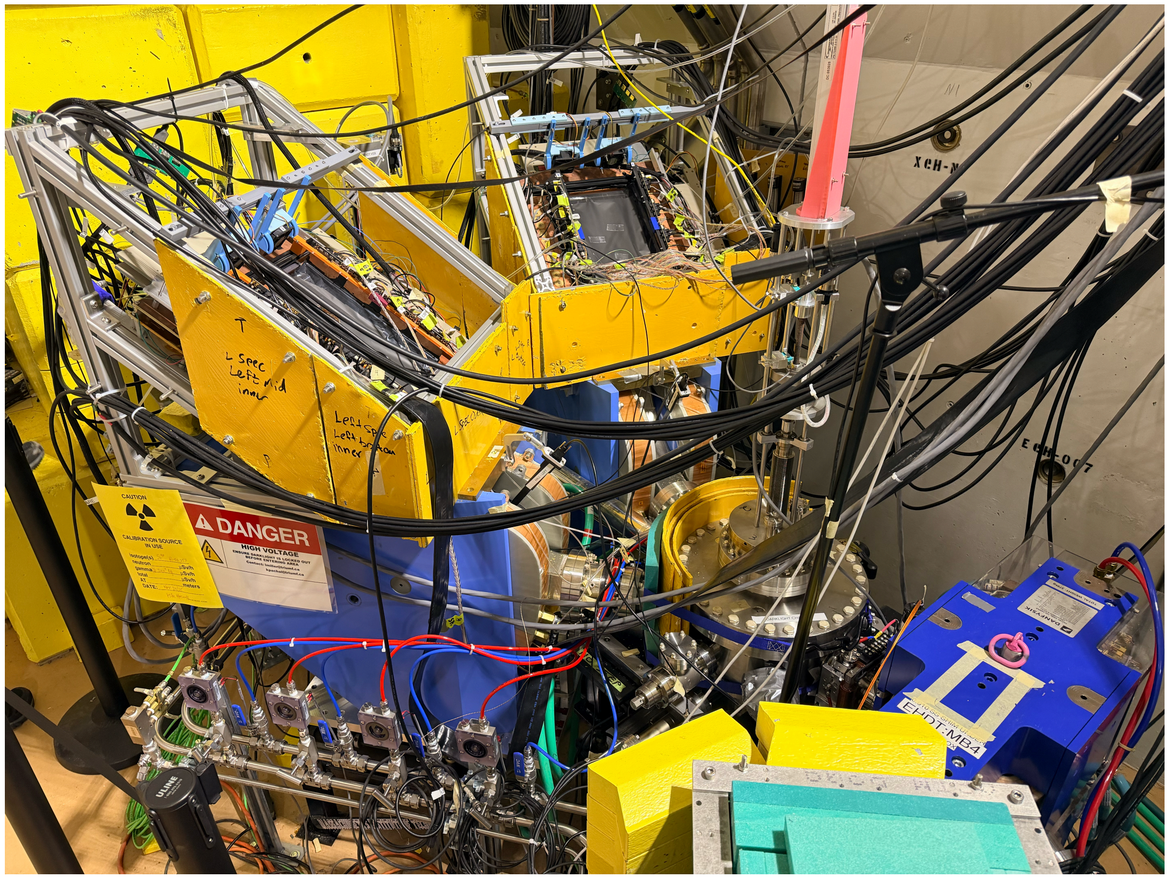
Detector setup:

- **Asymmetric spectrometers**



Full setup:

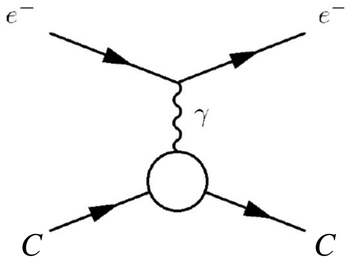
- Installation in Fall 2025



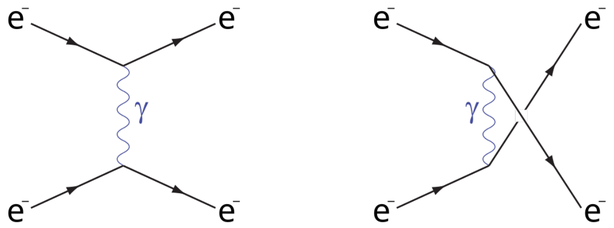
Commissioning:

- Installation in Fall 2025
- Fall 2025 - Jan 2026
  Commissioning with
  10 to 30 MeV beam

Physics processes for commissioning data



eC scattering



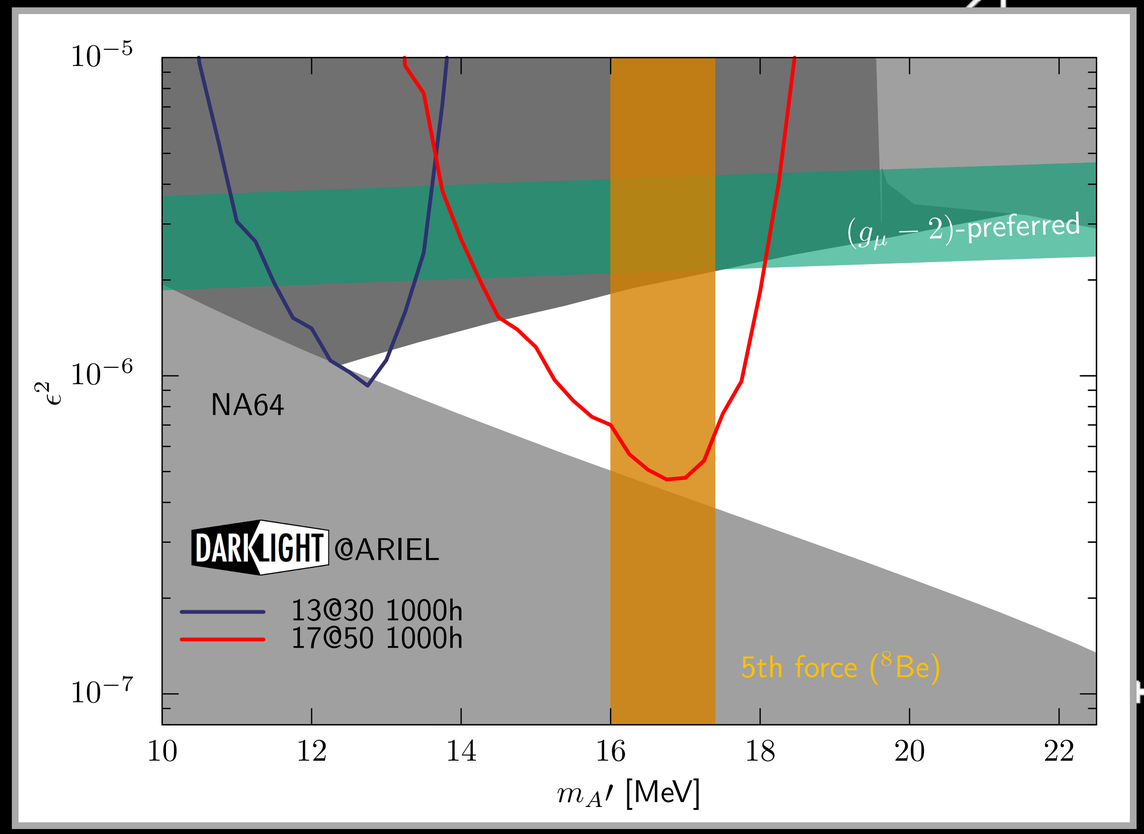
Møller scattering

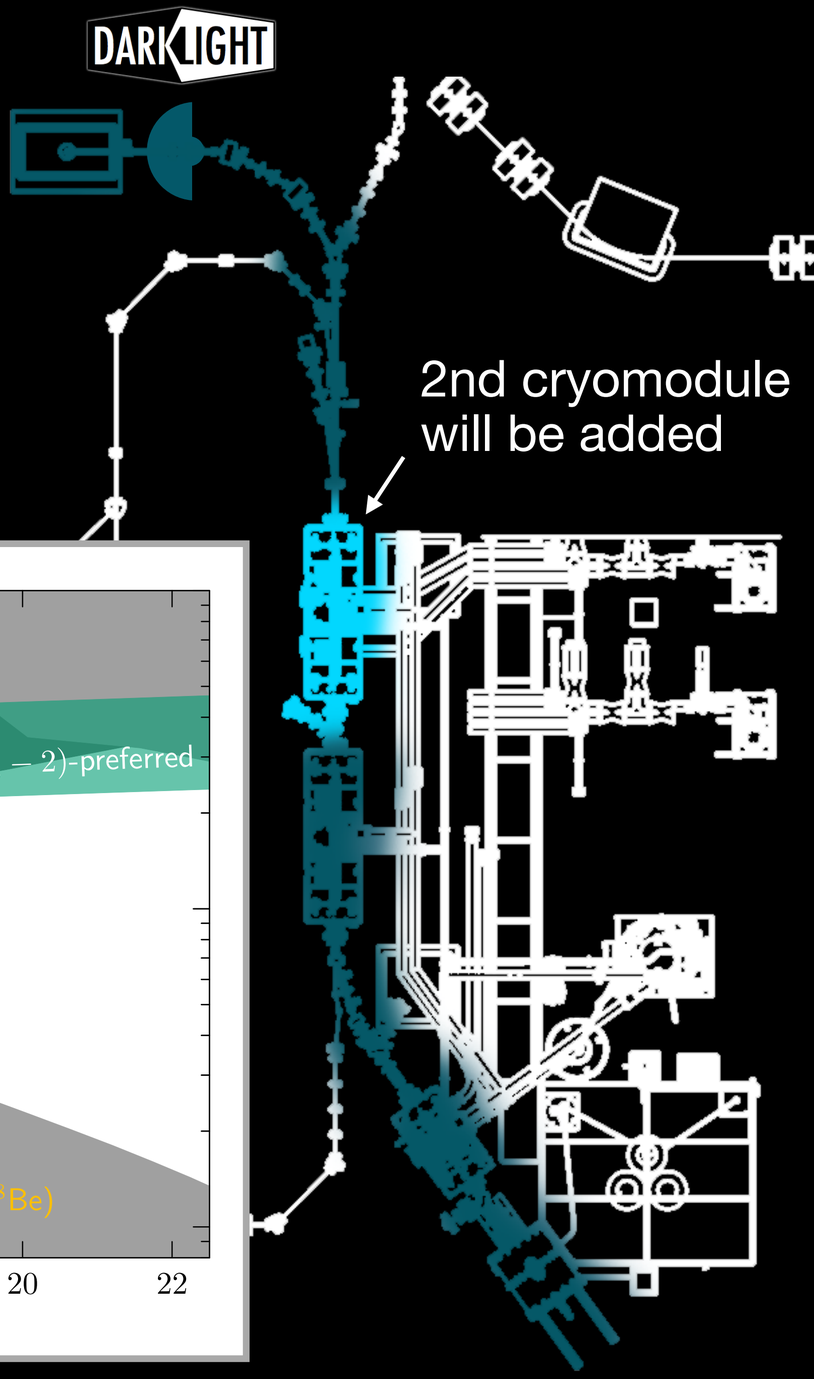
Plan for production data

- Installation in Fall 2025
- Fall 2025 - Jan 2026
- Commissioning with
- 10 to 30 MeV beam

ARIEL shutdown

- (Jan 2027: 30 MeV production data)
- Beamline upgrade
- 2027/2028: 50 MeV production data





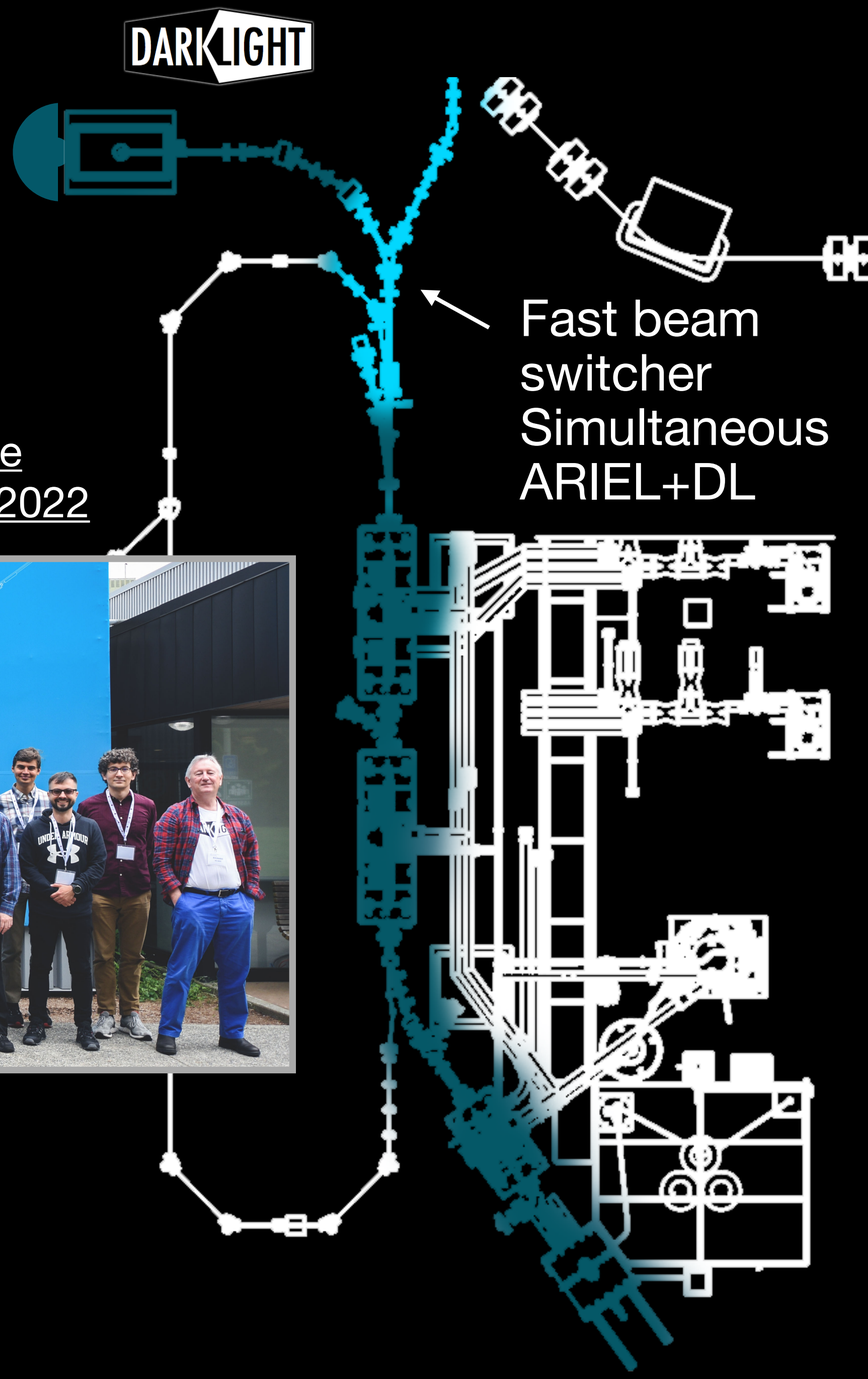
Additional physics

- Radiative Møller scattering
- $^{16}\mathrm{O}(\mathrm{e}, \mathrm{e}'\alpha)^{12}\mathrm{C}$
- Radii of nuclei
- Axial form factor

…

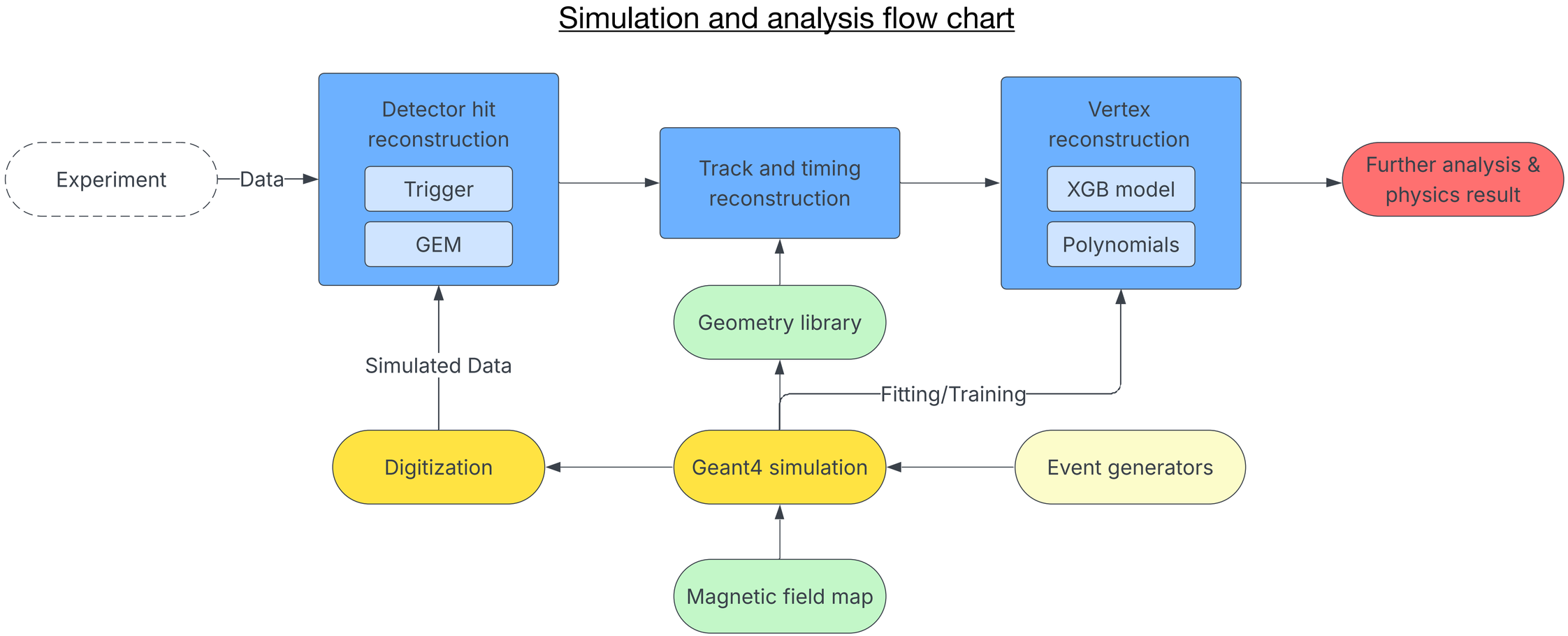
New Scientific Opportunities with the TRIUMF ARIEL e-linac, May 25-27, 2022

DOI: 10.1088/1742-6596/2391/1/012001



DarkLight analysis

- **Framework overview - COOKER**



DarkLight analysis

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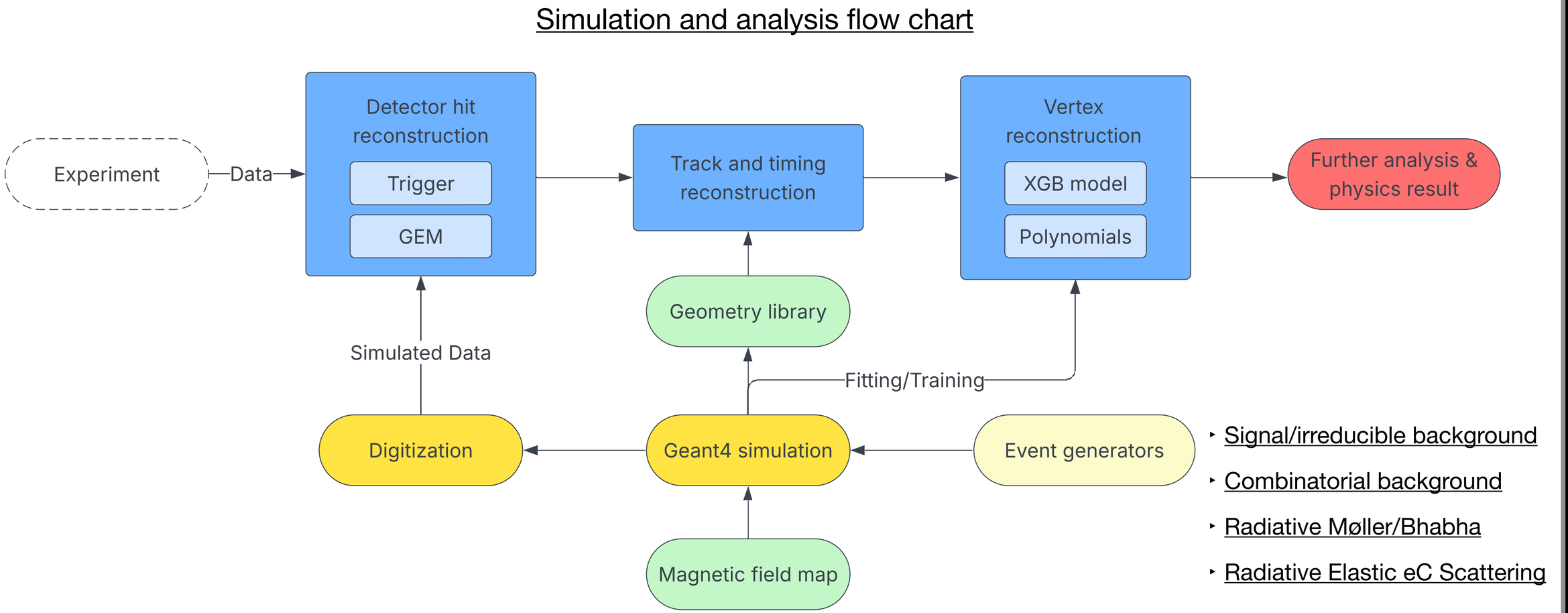
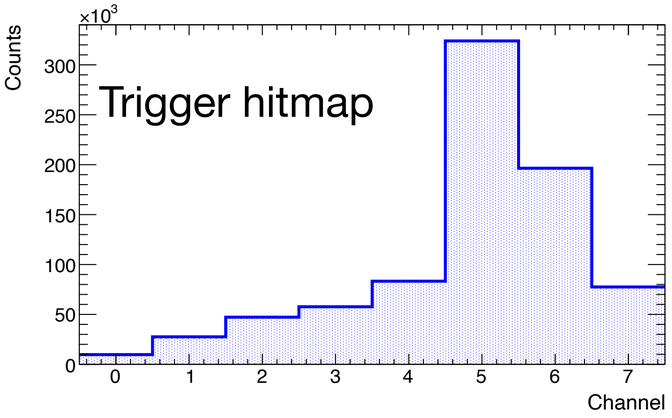
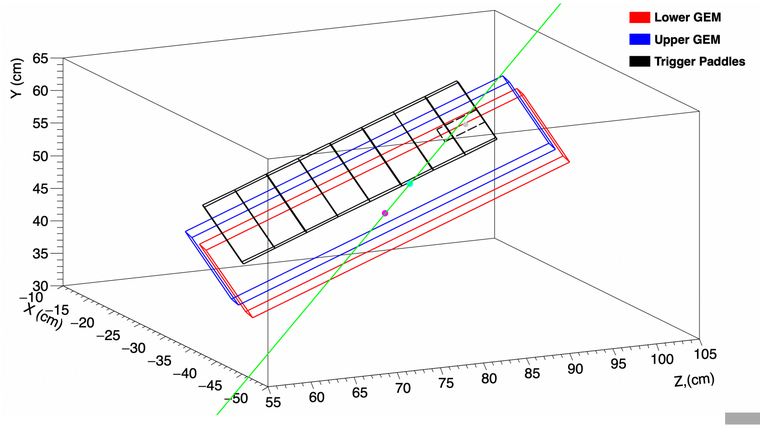


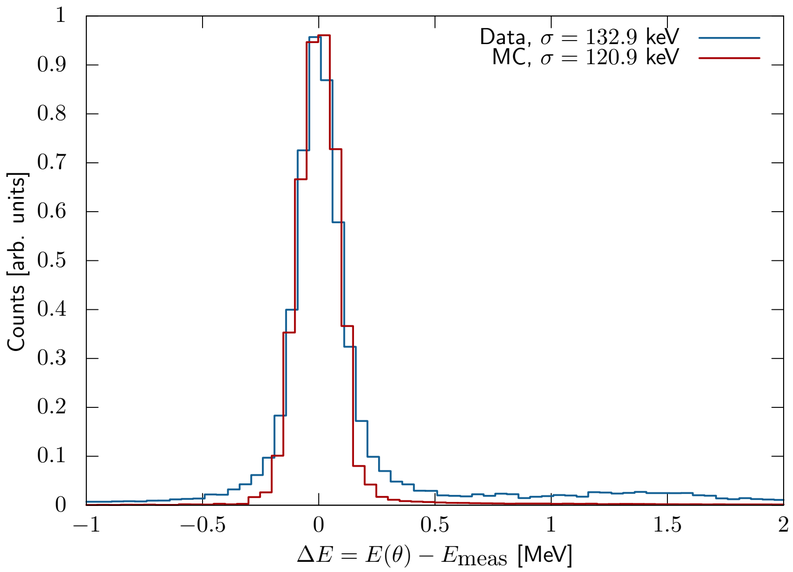
DarkLight analysis

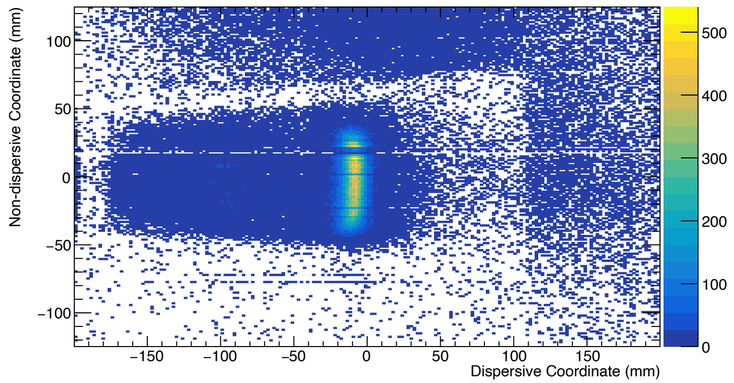
- **Event reconstruction**

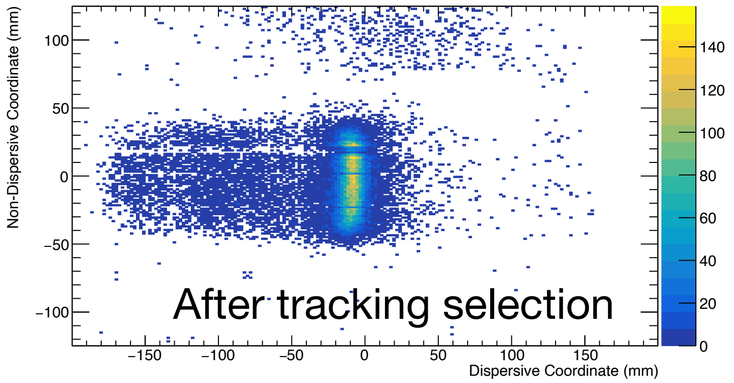
Example online analysis for 10 MeV eC scattering





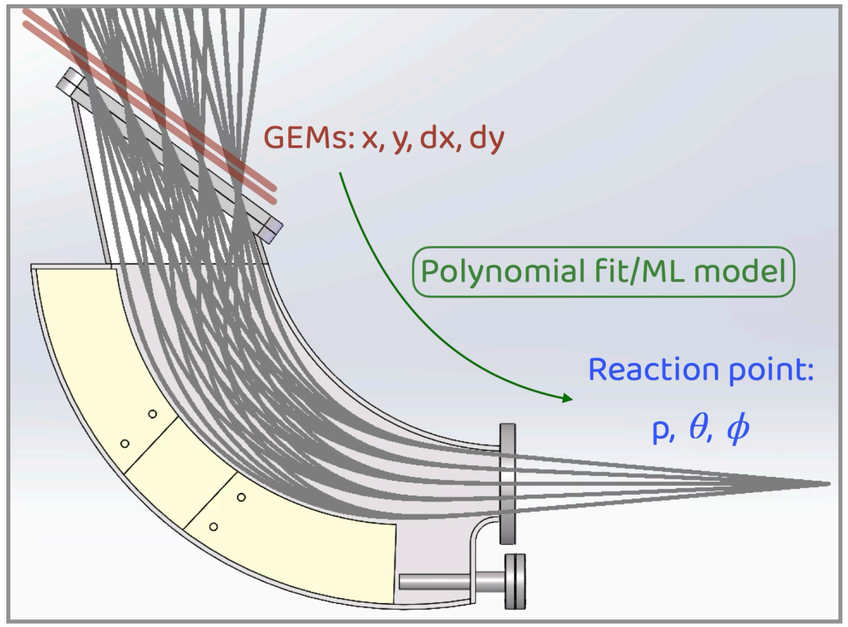




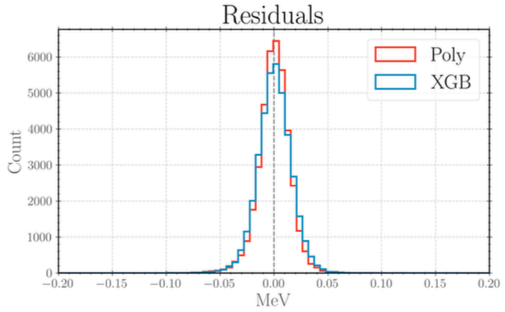


DarkLight analysis

- **Vertex reconstruction and machine learning study**

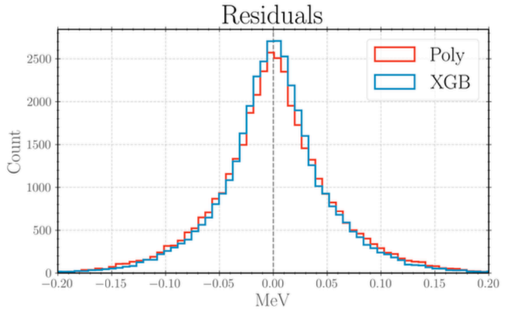


Model	MSE
Polynomial	0.00196
XGB	0.00178



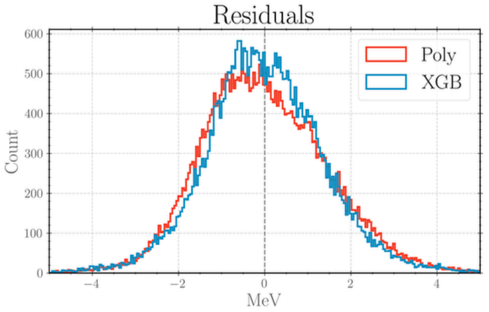
Momentum

Model	MSE
Polynomial	0.00574
XGB	0.00459



In-Plane Angle

Model	MSE
Polynomial	2.299
XGB	1.928

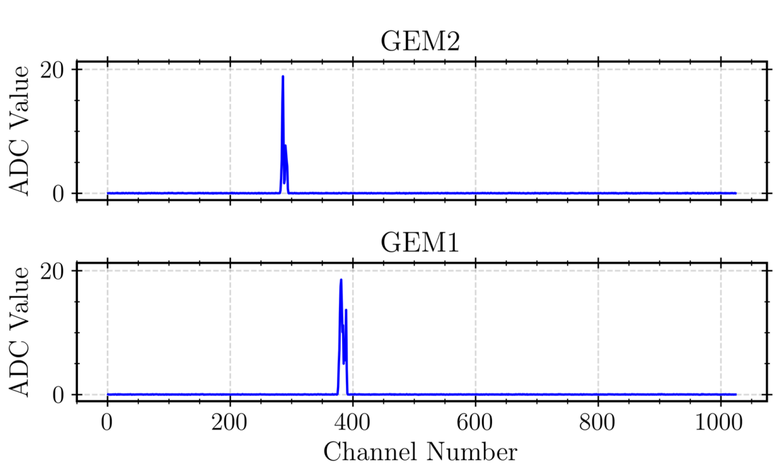


Out-of-Plane Angle

DarkLight analysis

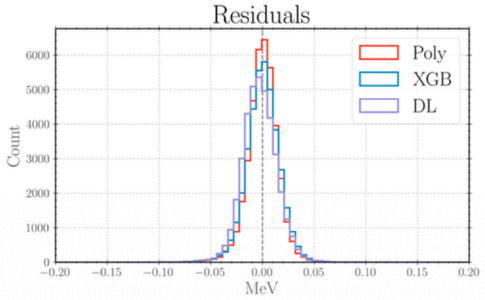
- **Vertex reconstruction and machine learning study**

Event display of a simulated large angle track



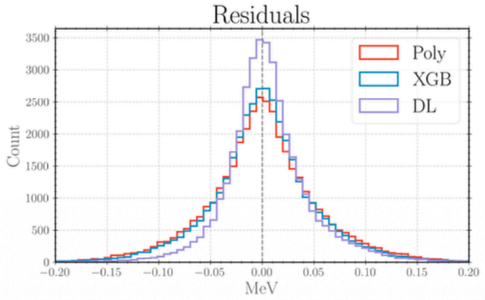
ADC ⟶ Kinematics

Model	MSE
Polynomial	0.00196
XGB	0.00178
DL	0.00192



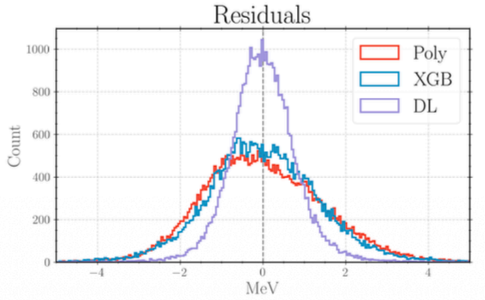
Momentum

Model	MSE
Polynomial	0.00574
XGB	0.00459
DL	0.00377



In-Plane Angle

Model	MSE
Polynomial	2.299
XGB	1.928
DL	0.714



Out-of-Plane Angle

Summary:

- DarkLight is searching for X17
- Installed and commissioned
- Processing commissioning data
- 50 MeV production data will come after beamline upgrade
- Exploring other physics opportunities

Timelapse video of installation: link