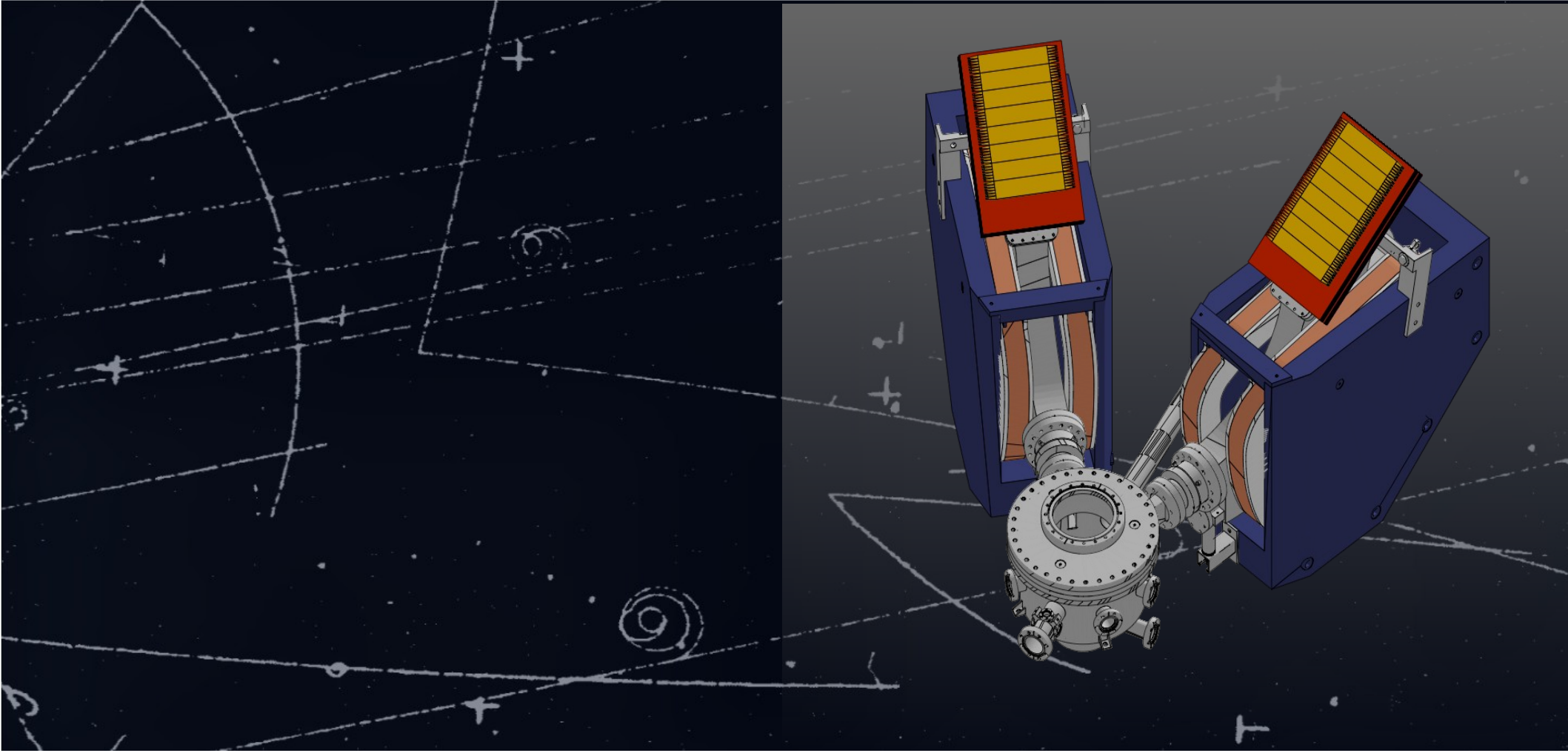


DarkLight@ARIEL Experiment
Simulation Study

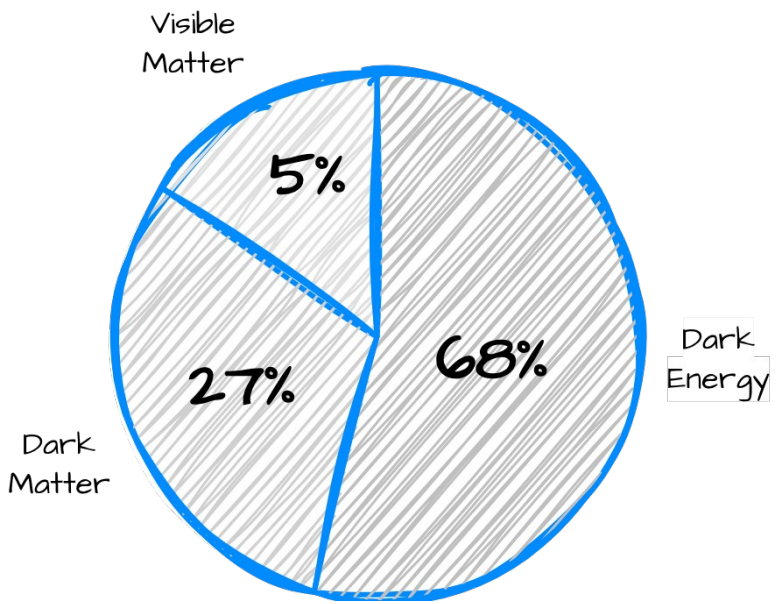
Siddhartha Gupte
Stony Brook University

Stony Brook University

DARKLIGHT

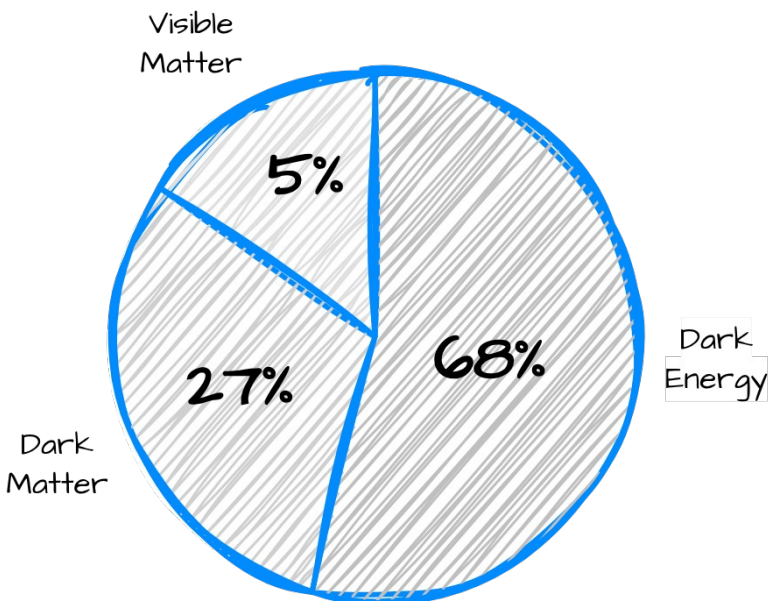
DarkLight and the Search for Hidden-Sector Physics

- Standard Model explains only ~5% of the universe
- What lies beyond the Standard Model?
- Precision searches for the low-mass, weakly coupled particles



DarkLight and the Search for Hidden-Sector Physics

- Standard Model explains only ~5% of the universe
- What lies beyond the Standard Model?
- Precision searches for the low-mass, weakly coupled particles
- **DarkLight**: Designed to explore the hidden sector via electron-nucleus interactions in a fixed-target setup



The X17 Anomaly: A Window into the Dark Sector?

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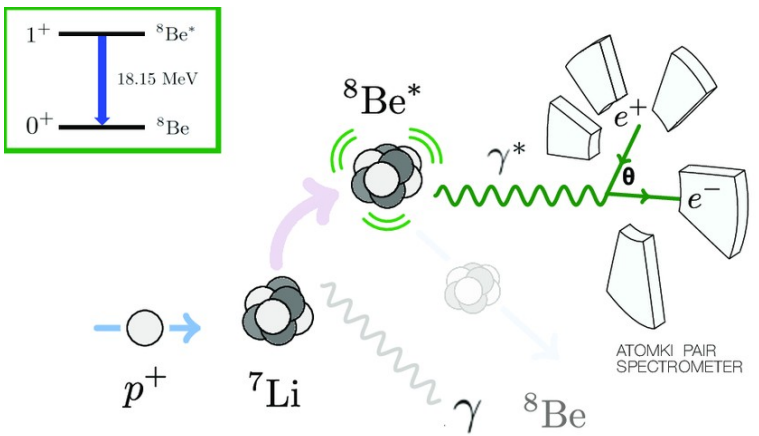

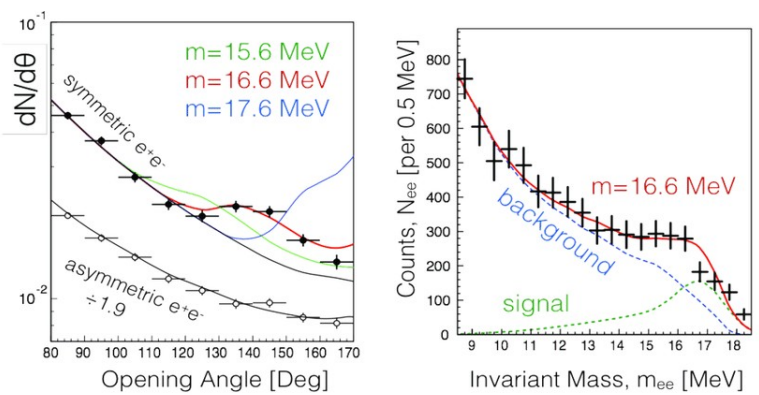

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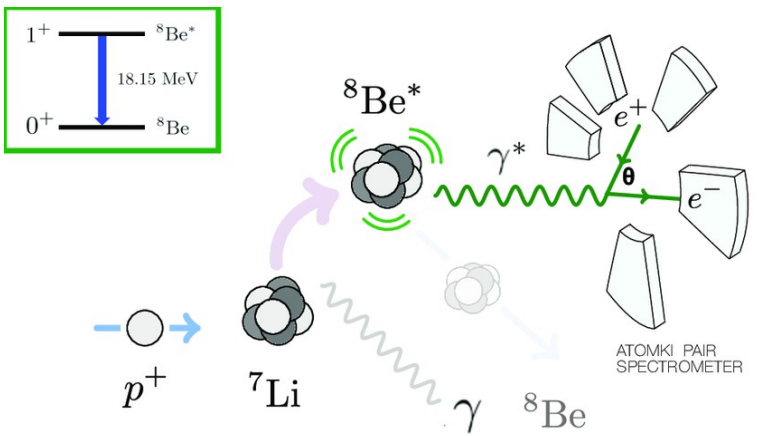

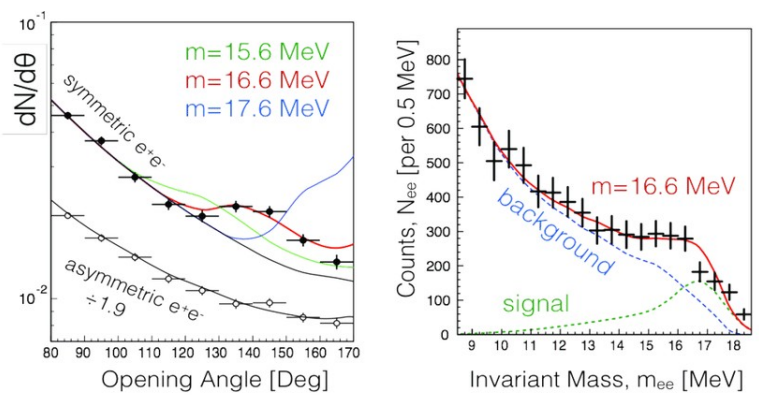

The X17 Anomaly: A Window into the Dark Sector?

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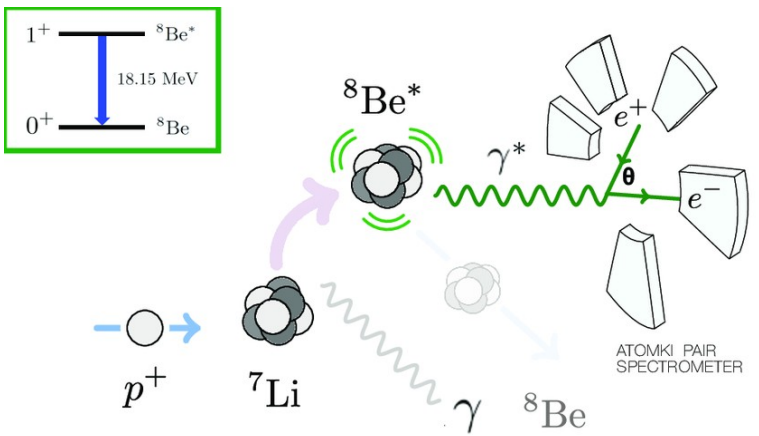
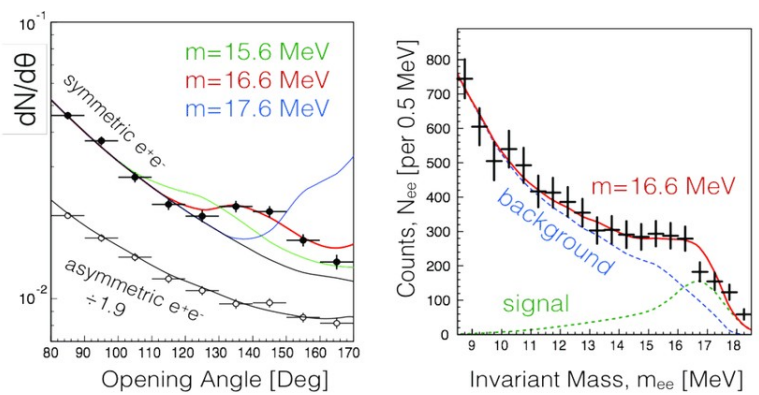
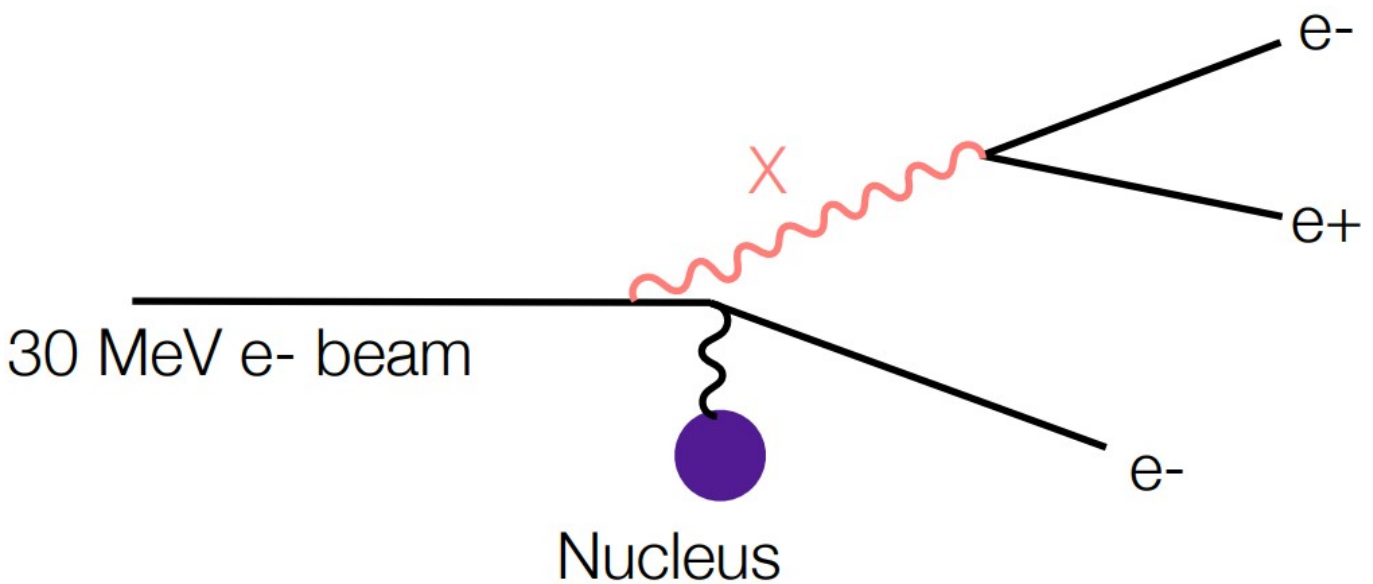
- Interpreted as possible new boson: mass $\approx$ 17 MeV (X17)





DarkLight@ARIEL Experiment



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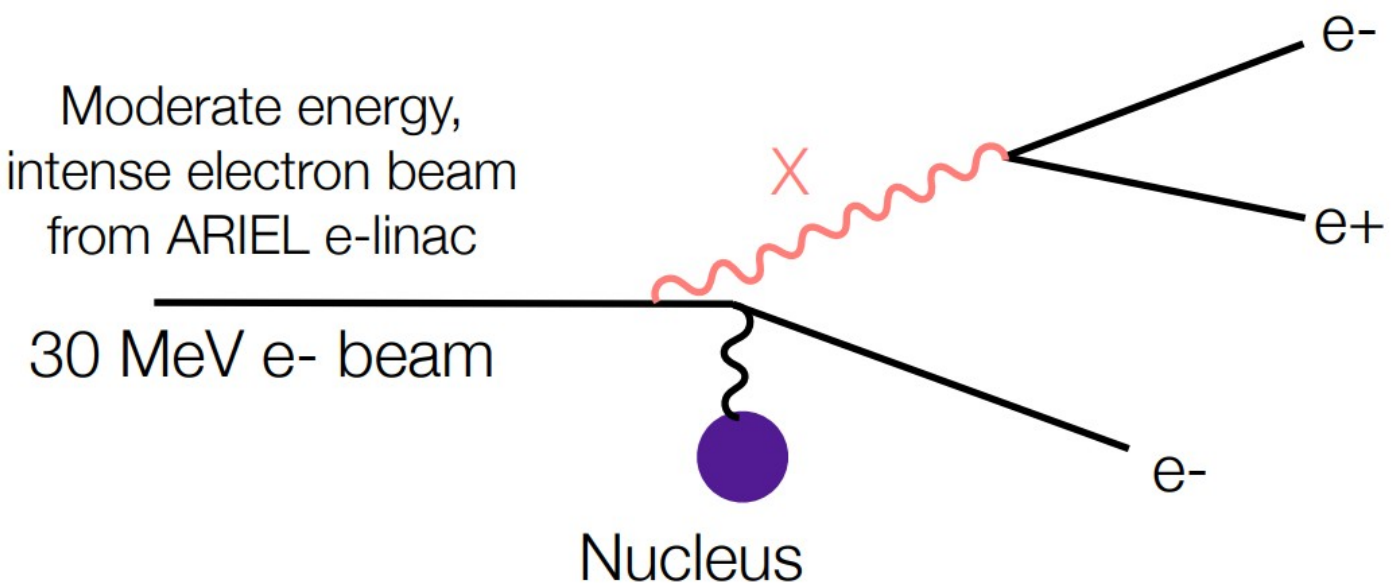

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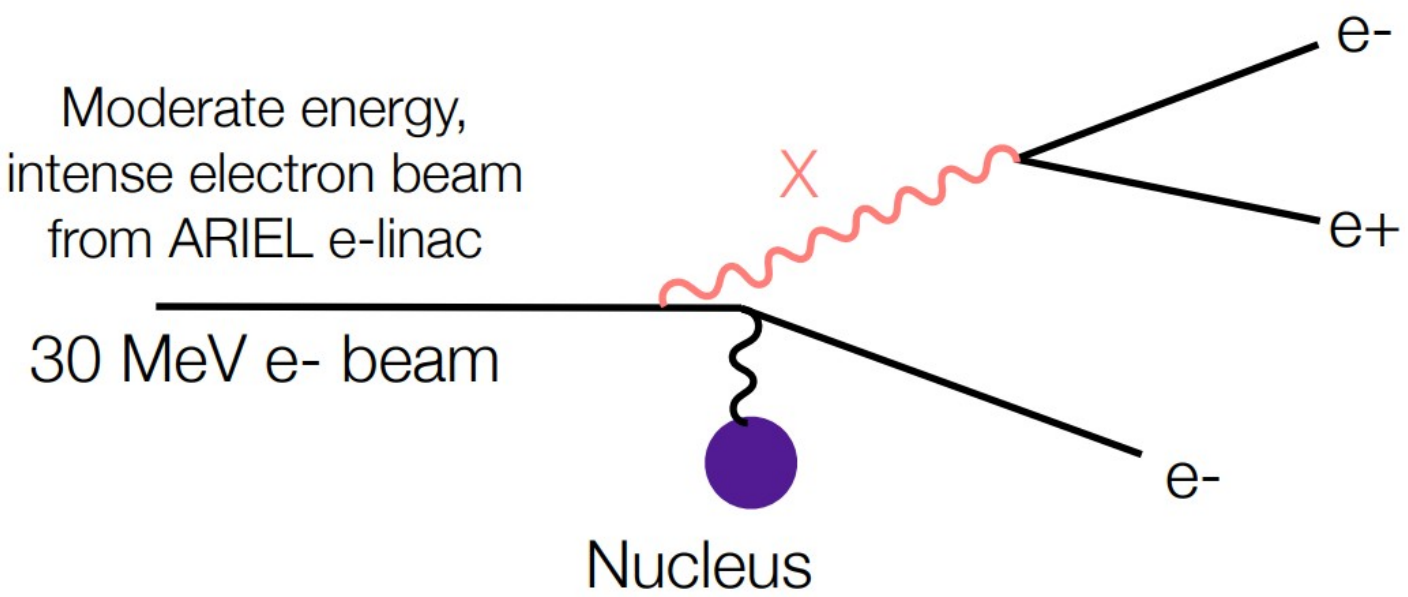
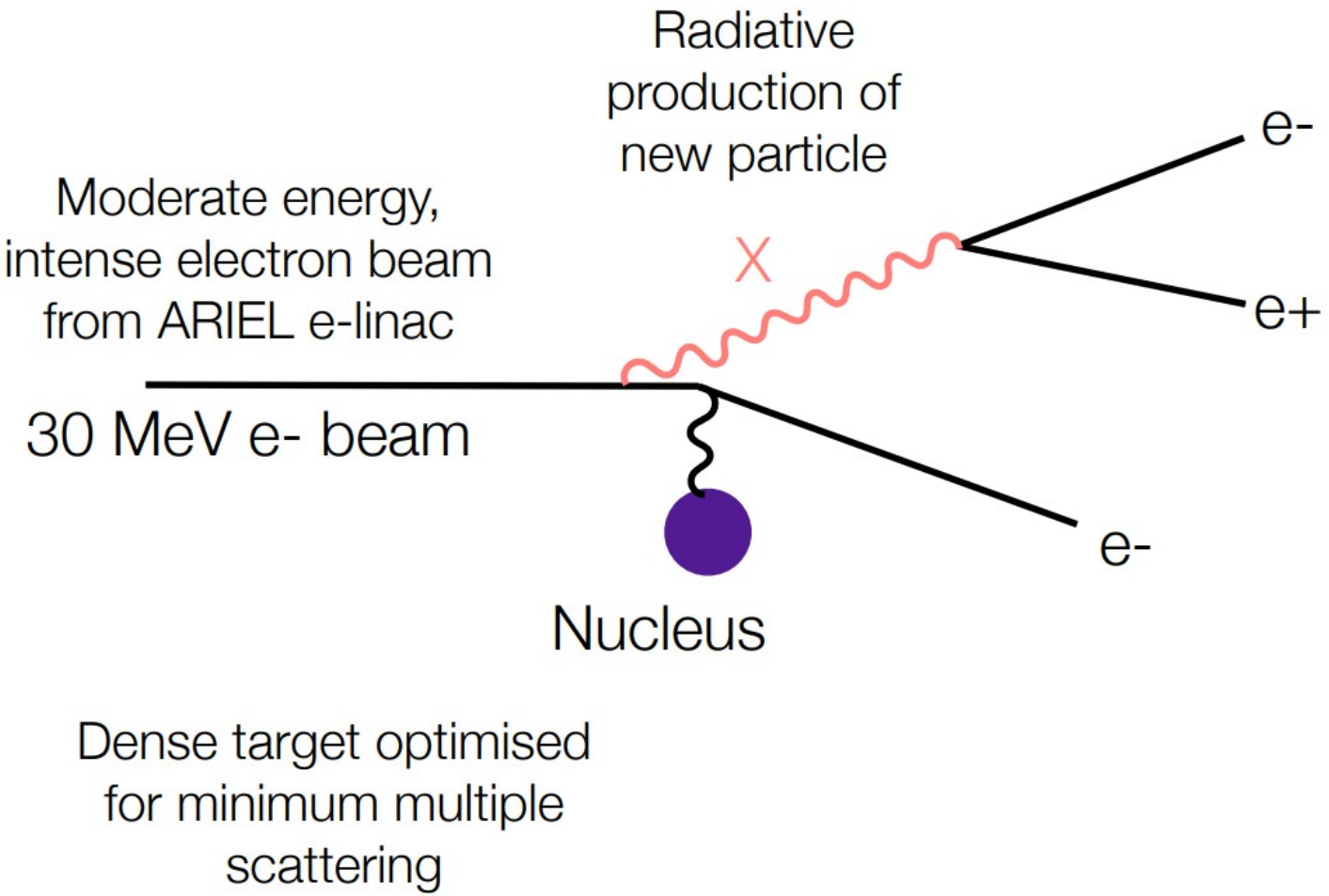


Dense target optimised
for minimum multiple
scattering

DarkLight@ARIEL Experiment



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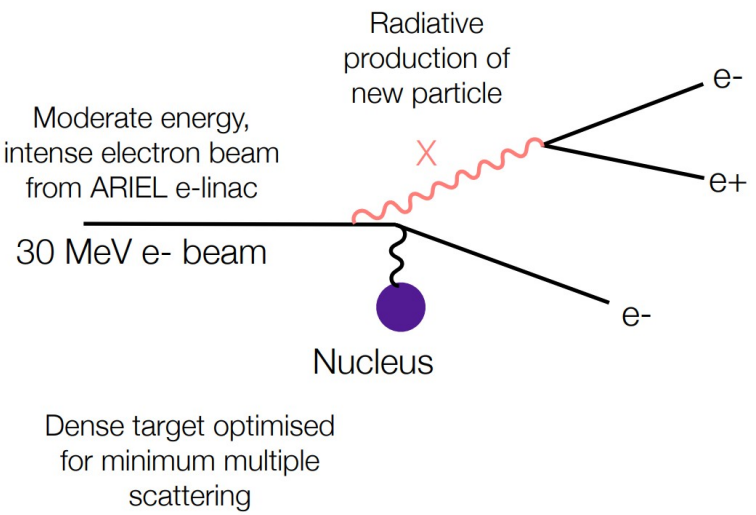
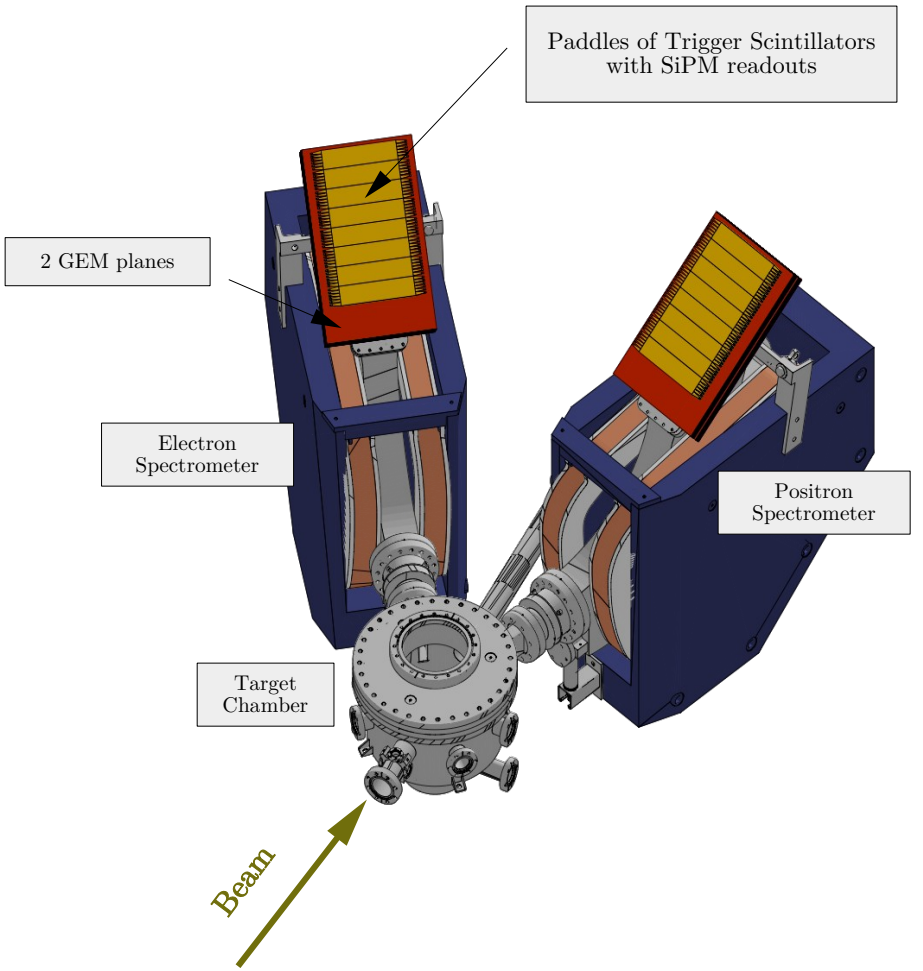
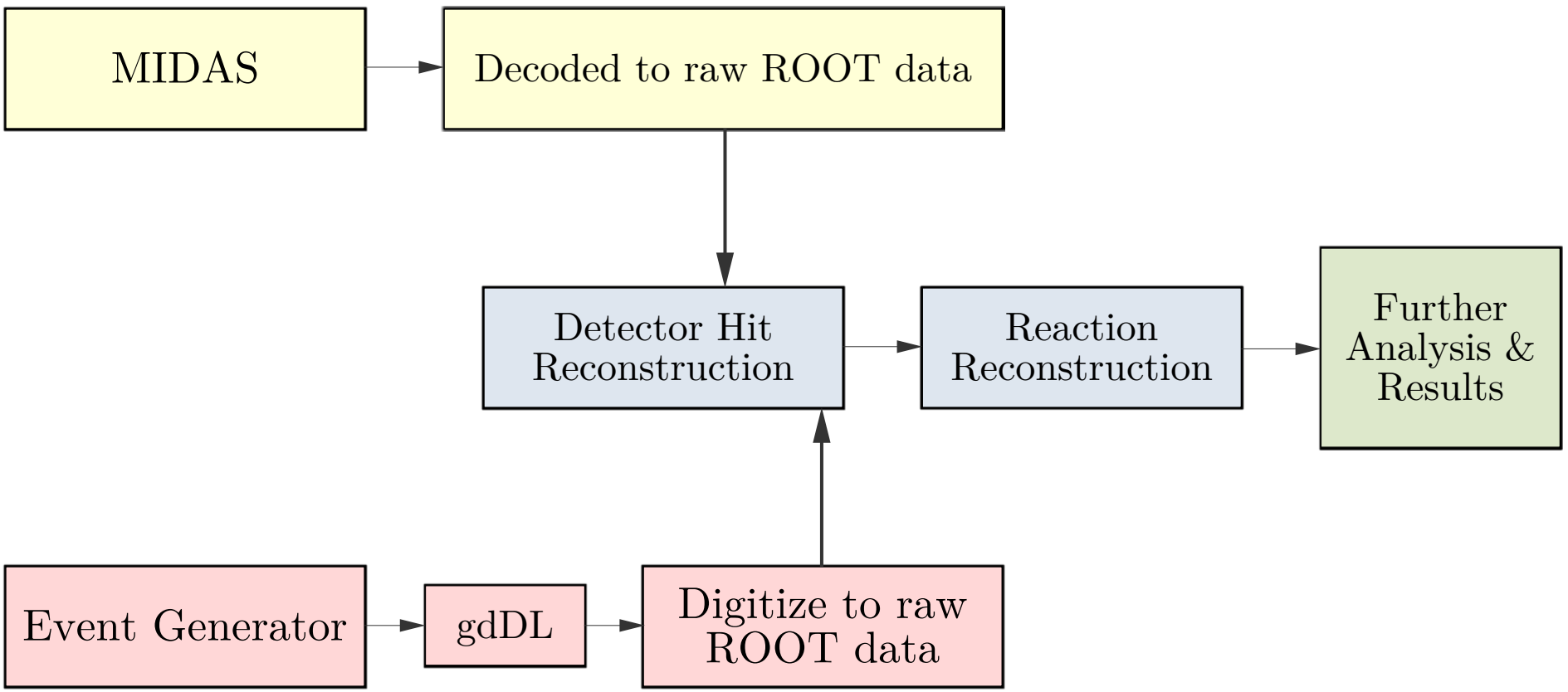




COOKER Framework



Plugin 1: GEMTrack

- Reconstructs the particle trajectories using GEM detector hits data
- Converts the 2D hit positions into 3D tracks

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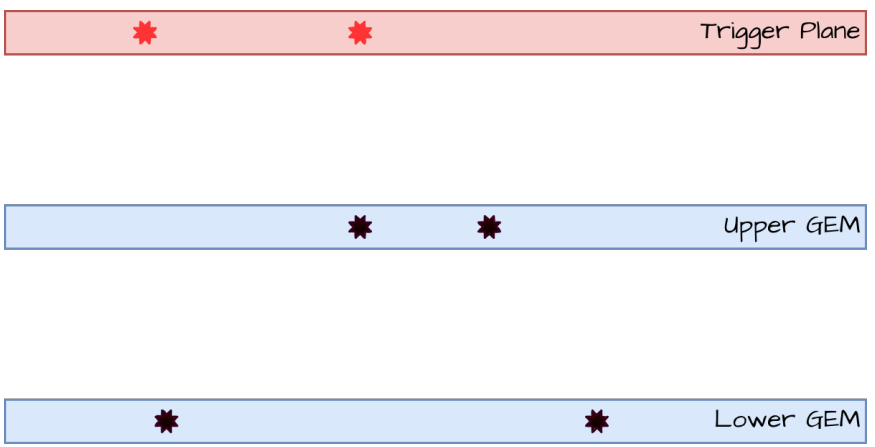
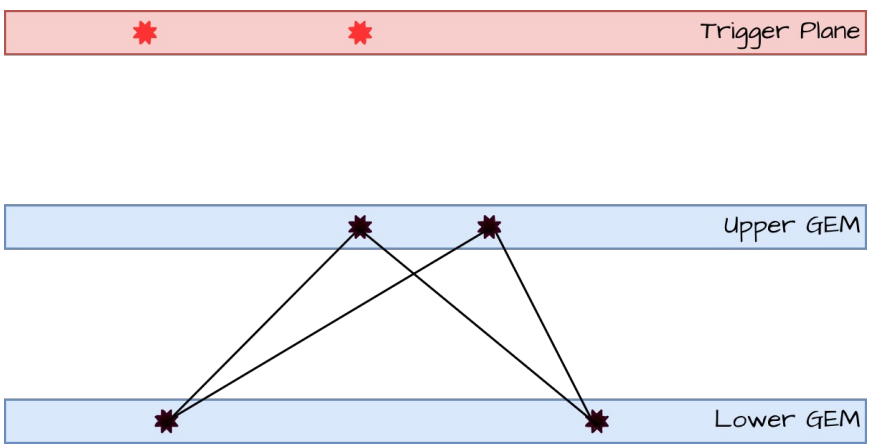
- Converts the 2D hit positions into 3D tracks
- Each event provides hit positions on the **Lower GEM**, **Upper GEM**, and the **Trigger Plane**.
- Initially, all hits are **unlabeled** and **not associated** with any track.
- **Goal**: Build candidate tracks by combining GEM hits and checking for consistency with Trigger hits



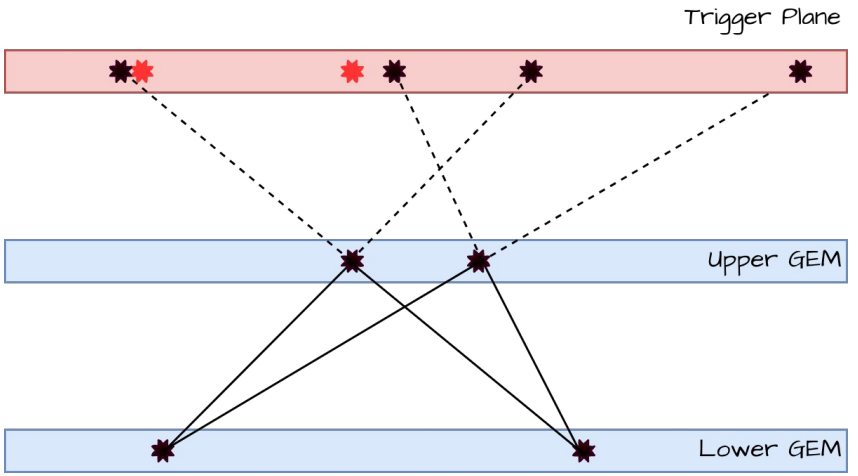
Plugin 1: GEMTrack

- Form all possible **GEM hit pairs** between Upper and Lower GEM planes.
- Each pair defines a **candidate track**.



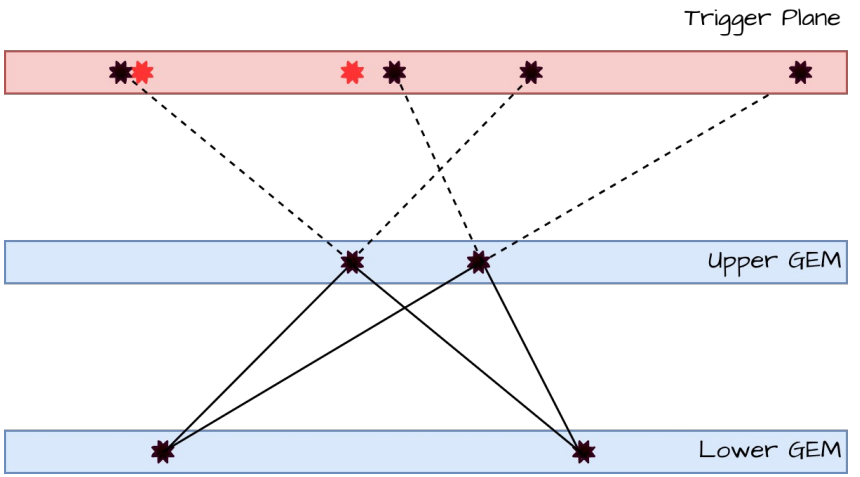
Plugin 1: GEMTrack

- Form all possible **GEM hit pairs** between Upper and Lower planes
- Each pair defines a **candidate track**
- Project each track onto the **Trigger plane**
- Compare **projected hits** with **actual Trigger hits**



Plugin 1: GEMTrack

- Filtering the tracks?
- Currently using **distance-based filtering**.
- Accept tracks only if the distance is below a threshold.
- **Future improvements**: Evaluating additional filtering strategies like χ^2 fit quality, Kalman filtering



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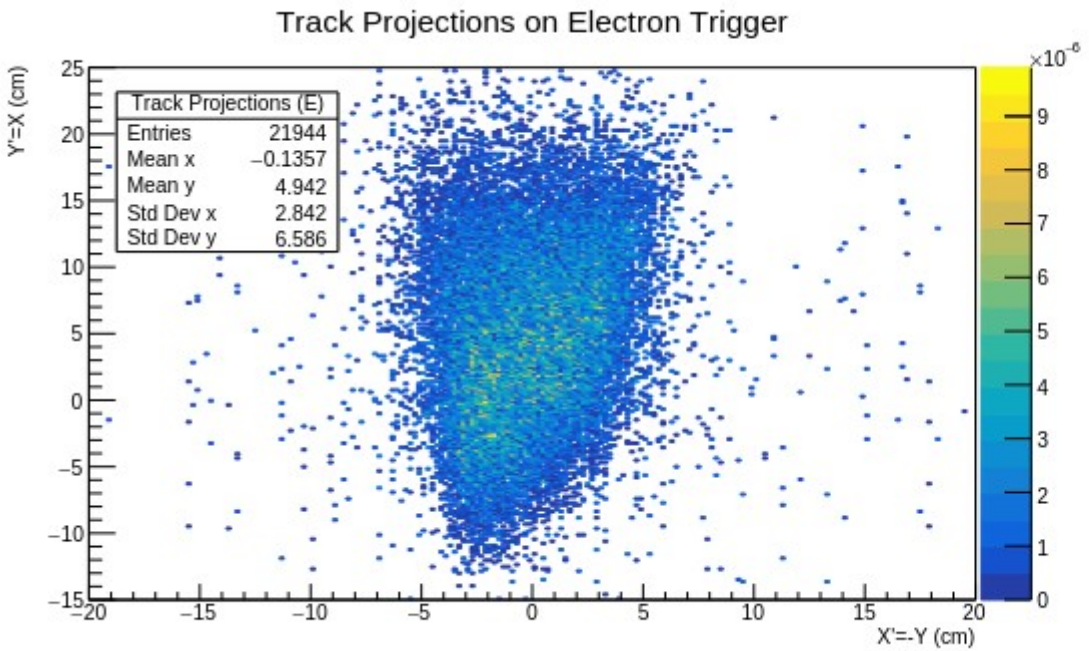

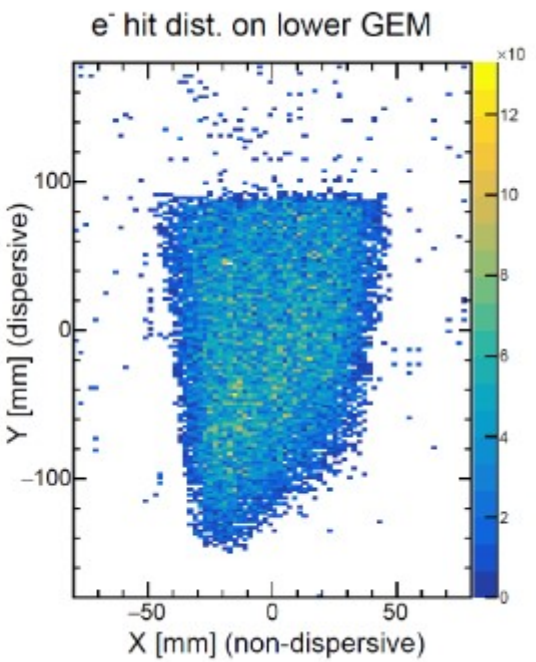

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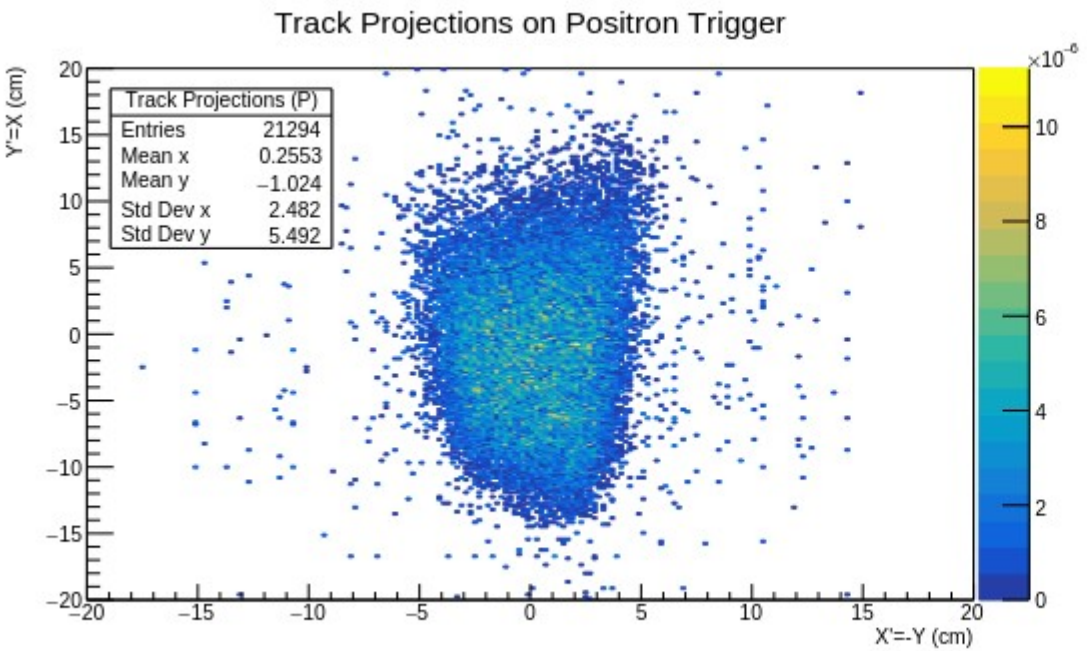
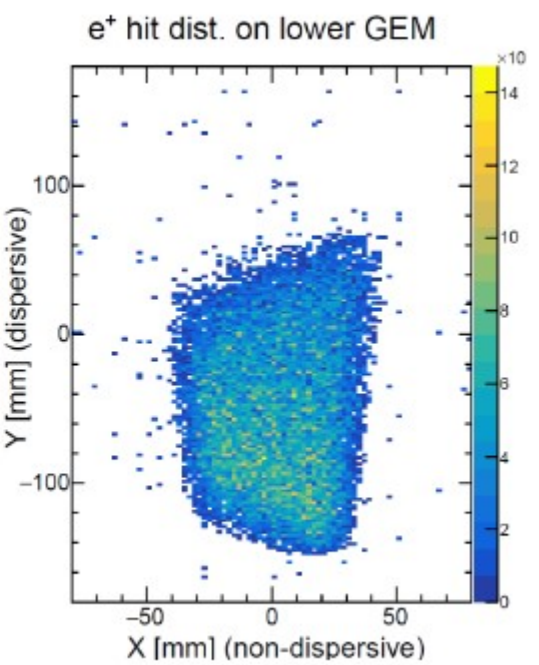
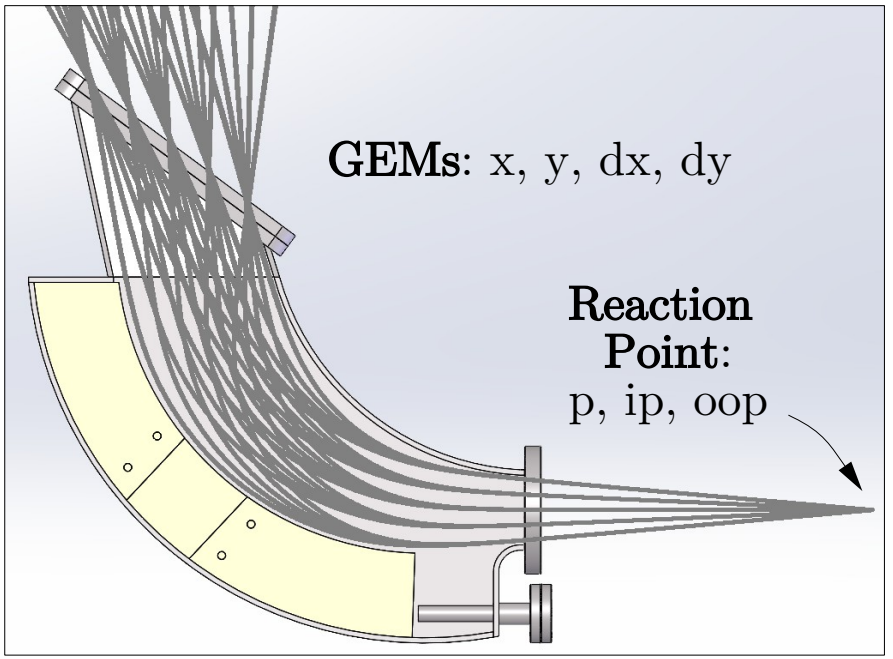




Plugin 2: `VertexXGB`

- Uses candidate tracks from `GEMTrack` from both spectrometer arms.
- Reconstructs the reaction point (vertex) of the event
- Critical for identifying e^+e^- pairs from possible new particles
- Current implementation uses two methods: **Polynomial fit**, **ML-Based Fit (XGBoost)**



Schematic of the cut-away view of spectrometer and particle trajectories

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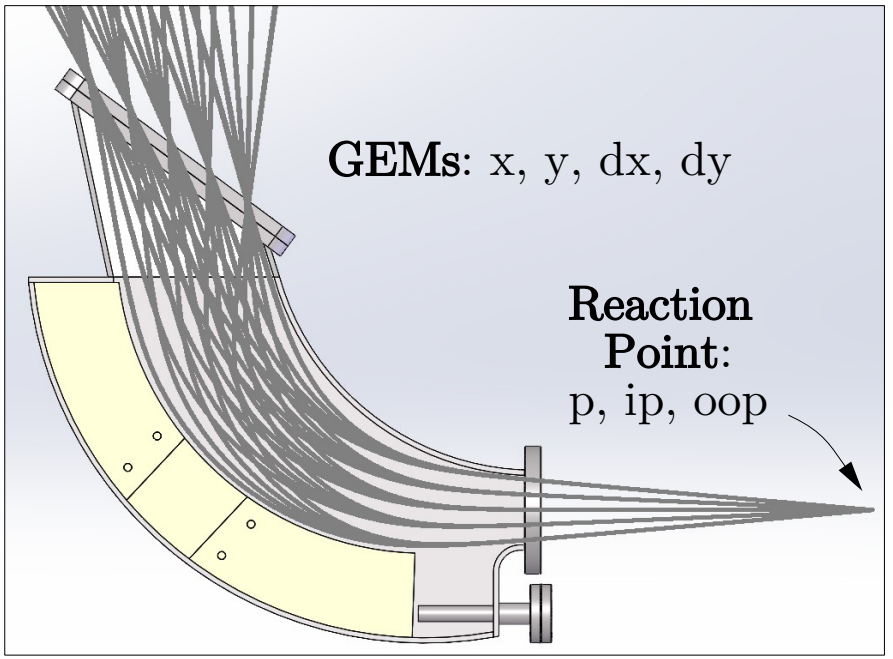

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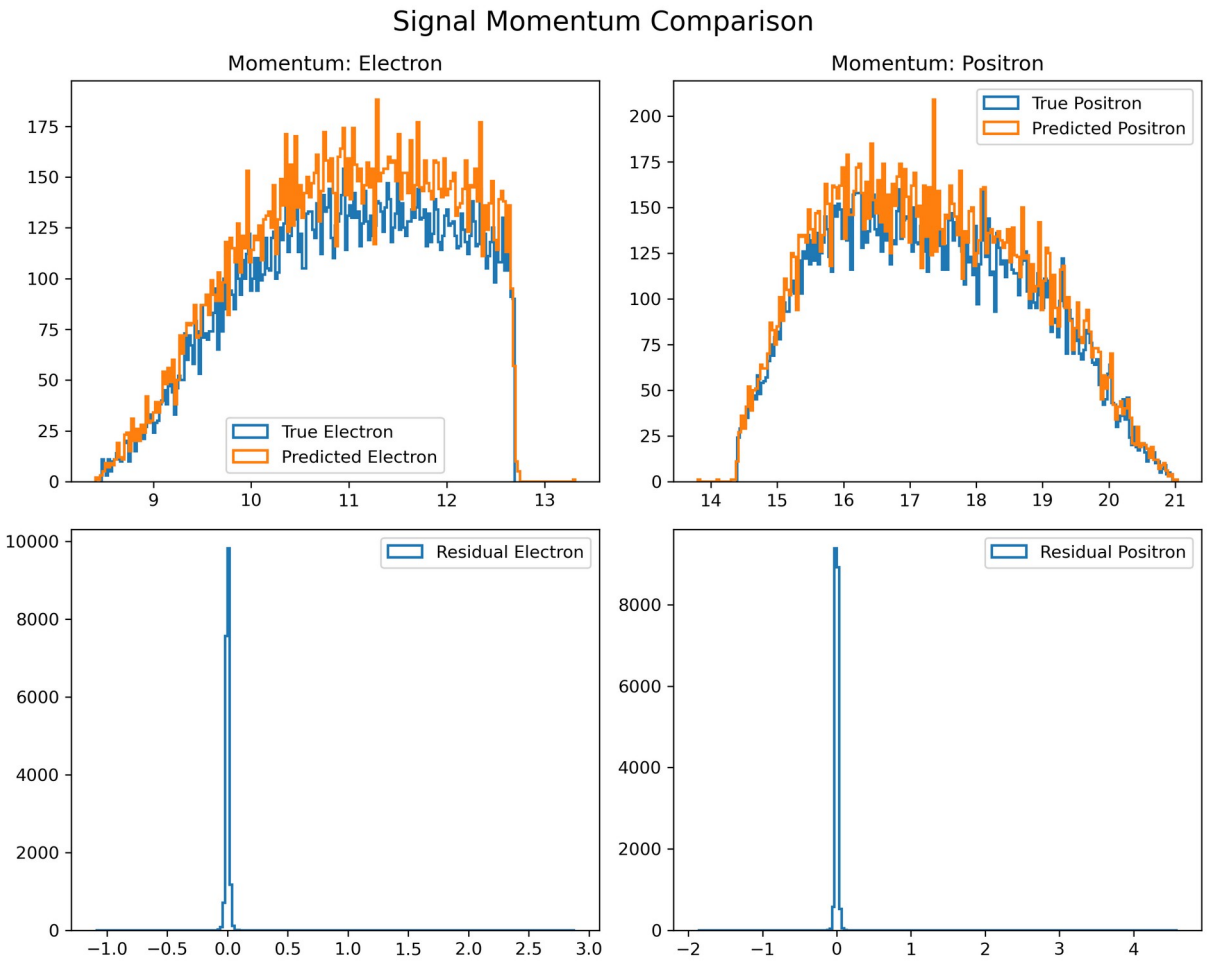

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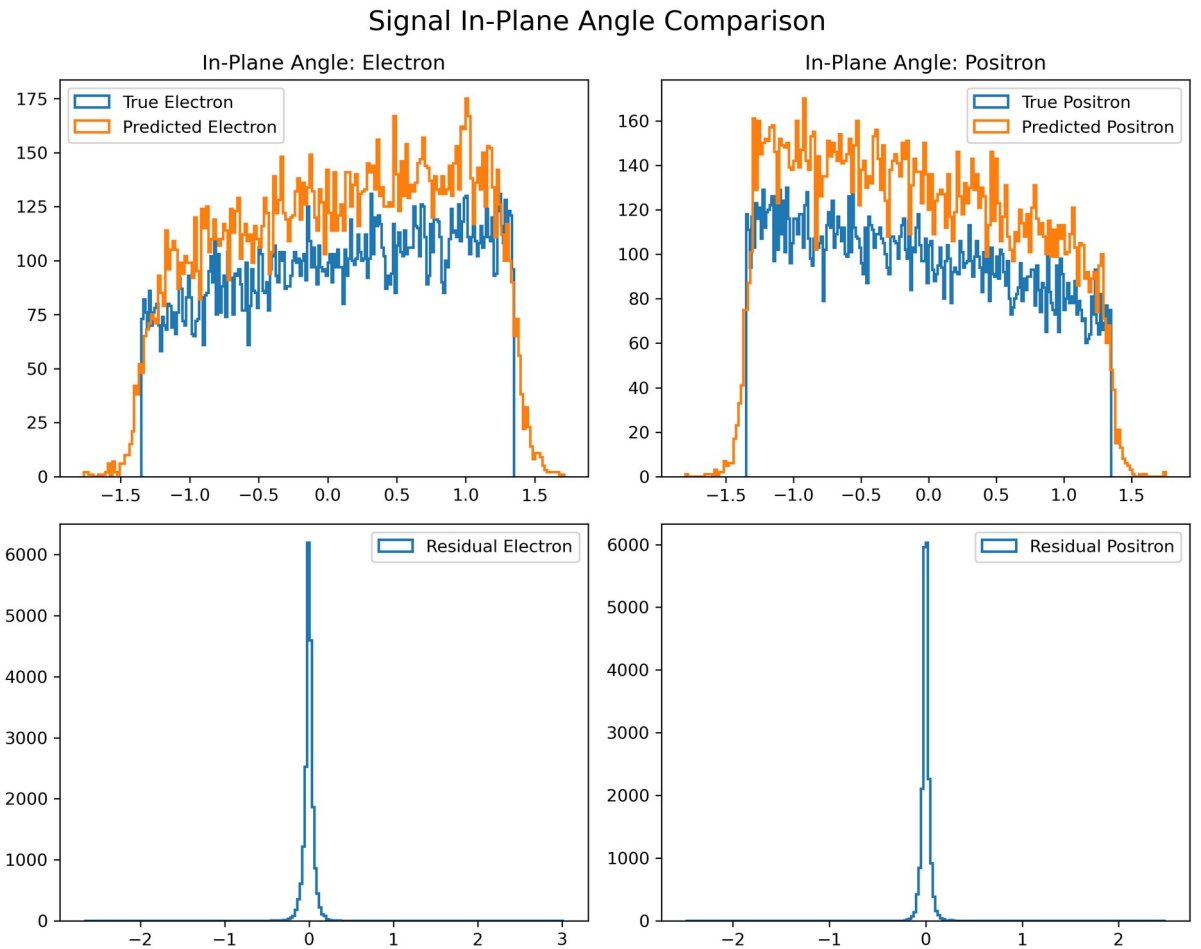

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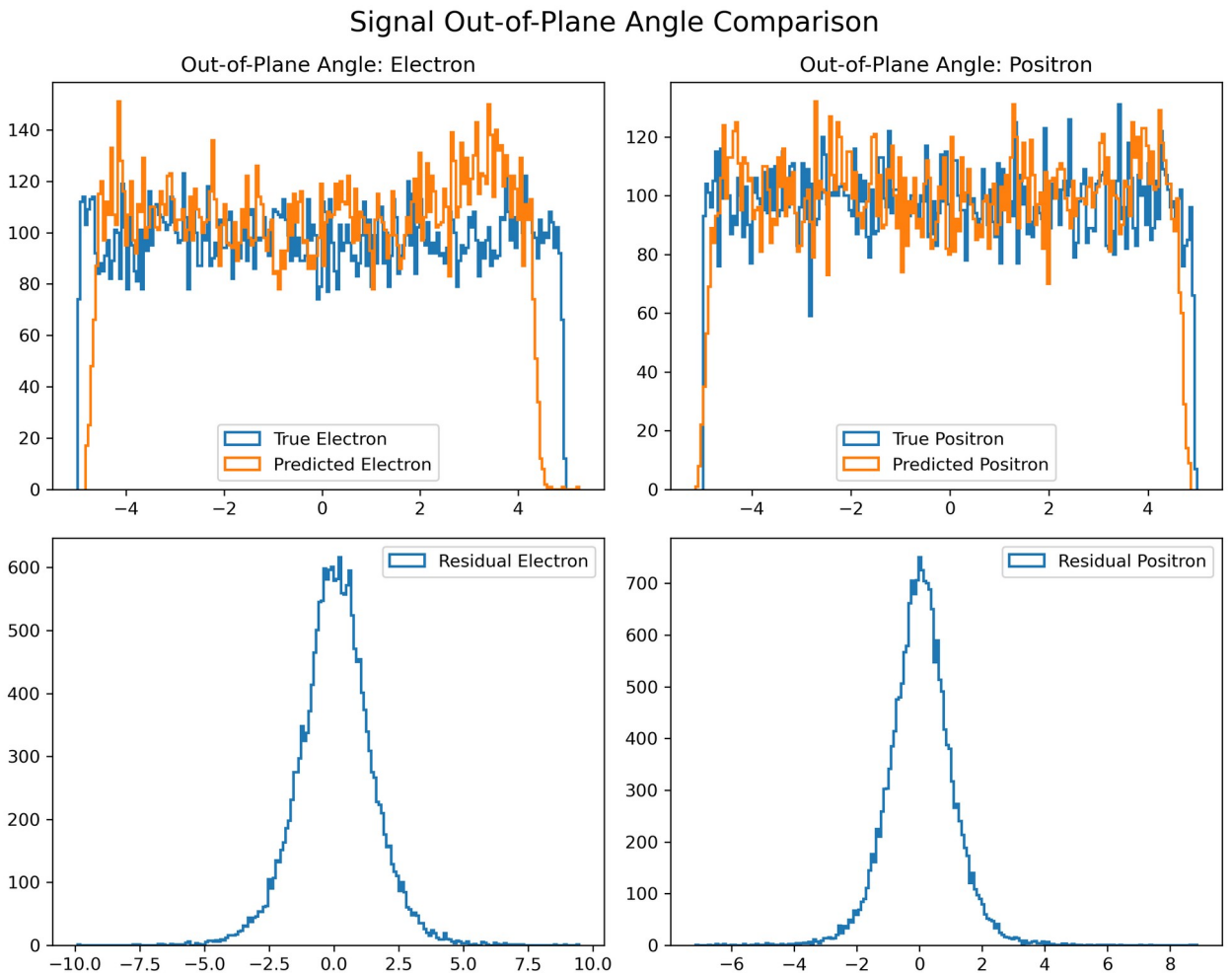

Plugin 3: MassRecon