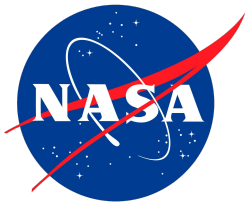
Gamma-Ray and AntiMatter Survey (GRAMS)

Sept. 23, 2026 @ NASA Physics of the Cosmos Early Career Workshop

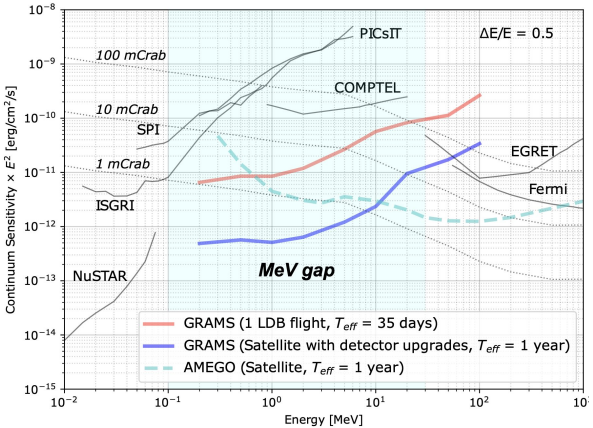
Yinrui Liu
Columbia University



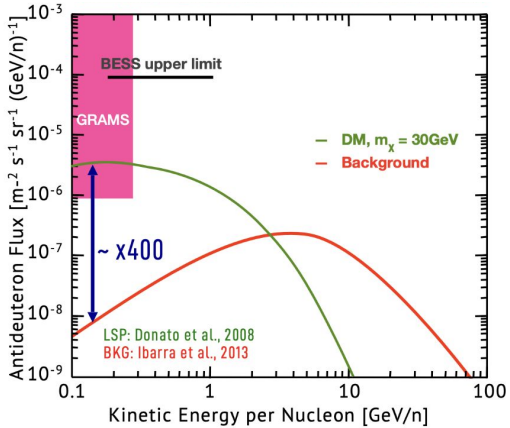
The GRAMS project

Astropart.Phys. 114 (2020) 107-114

- GRAMS is one of the NASA *Physics of the Cosmos* suborbital missions.
- Leveraging the Liquid Argon Time Projection Chamber (LArTPC) technology, GRAMS targets both **MeV gamma-ray observations** and **indirect dark matter search** with extensively improved sensitivities.



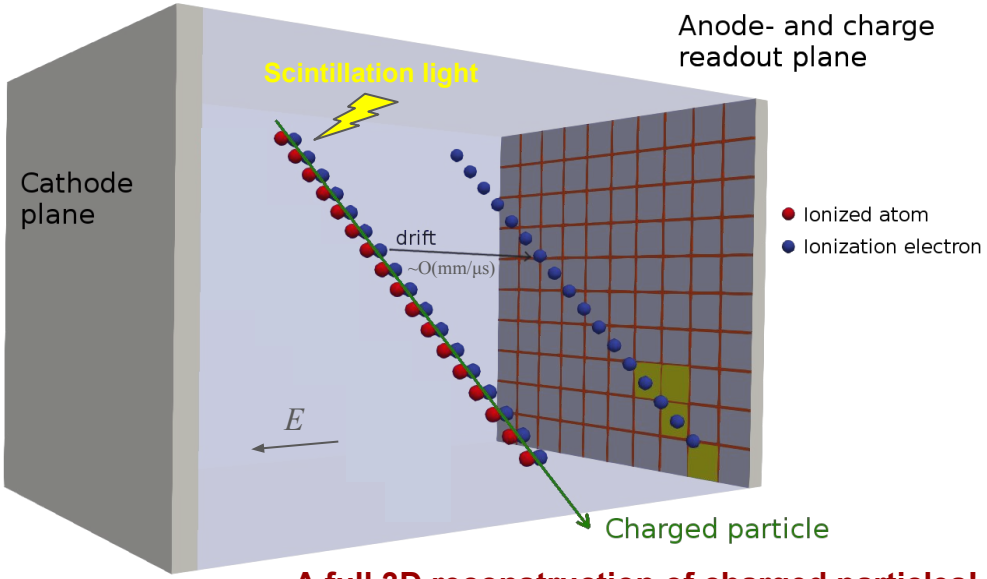
Gamma-ray observations



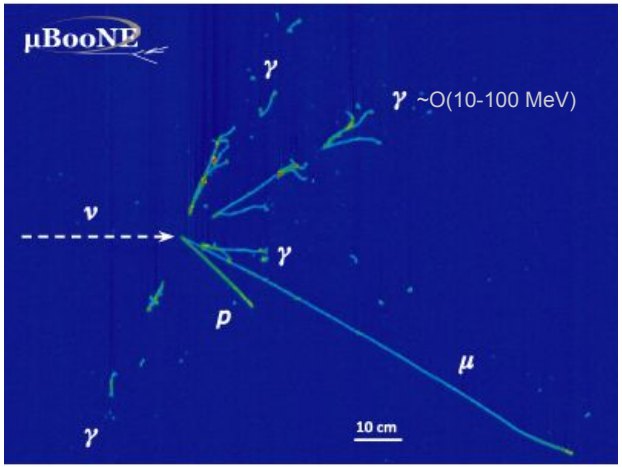
Indirect dark matter search

Liquid Argon Time Projection Chamber (LArTPC)

- Widely used in ground-based neutrino experiments, the LArTPC technology is scalable, cost-effective, and provides high-precision particle imaging.



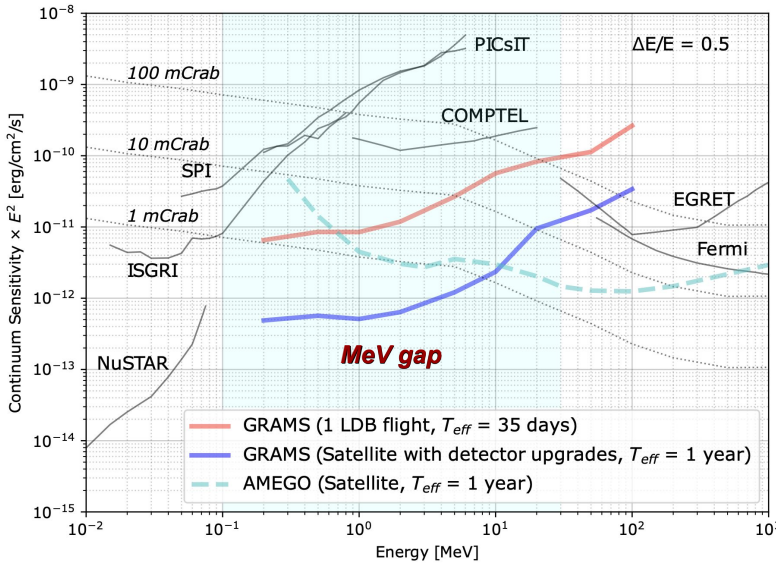
A full 3D reconstruction of charged particles!

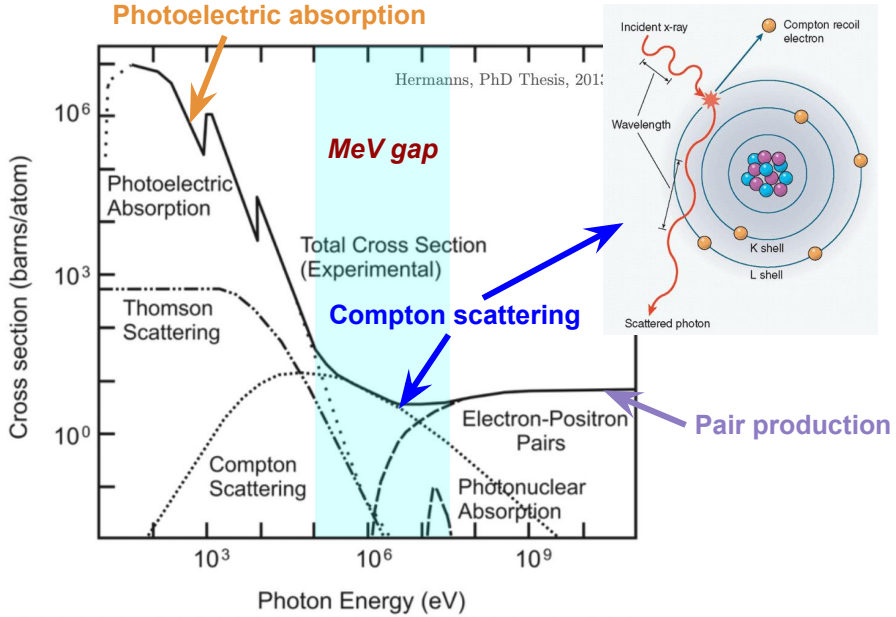


An example LArTPC event display
(from MicroBooNE experiment at Fermilab)

Mission I: filling the MeV gap in gamma-ray astronomy

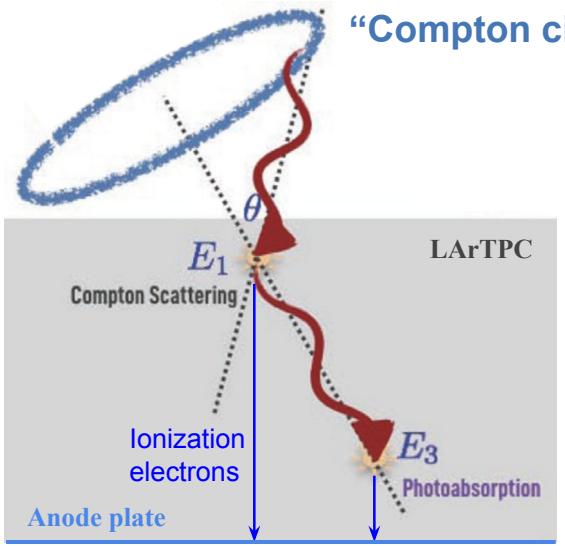
- The **“MeV gap”**: underexplored region where Compton scattering dominates.
  - Crucial for particle acceleration transitions, nucleosynthesis, and multi-messenger astronomy

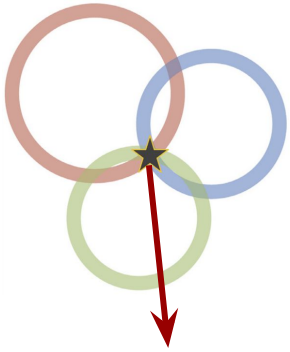


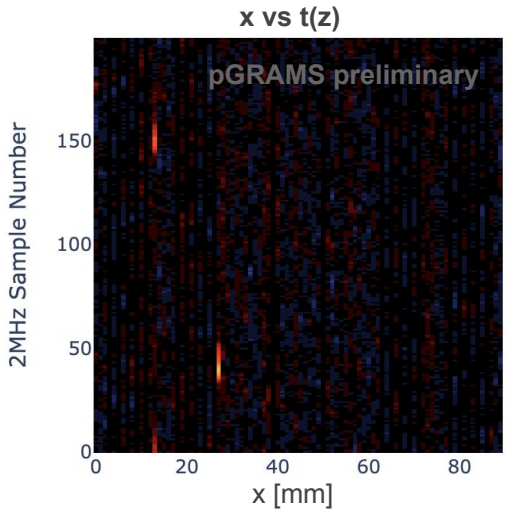


Mission I: filling the MeV gap in gamma-ray astronomy

- The “MeV gap”: underexplored region where Compton scattering dominates.
  - Crucial for particle acceleration transitions, nucleosynthesis, and multi-messenger astronomy
- The GRAMS LArTPC acts as an advanced **Compton camera**.



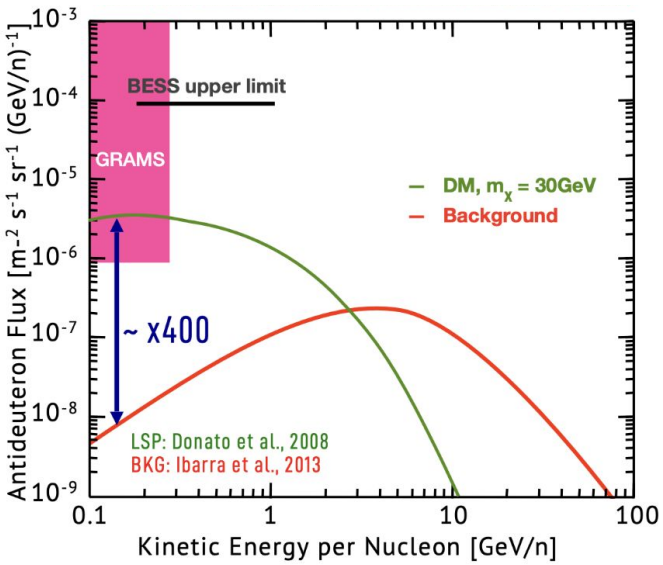


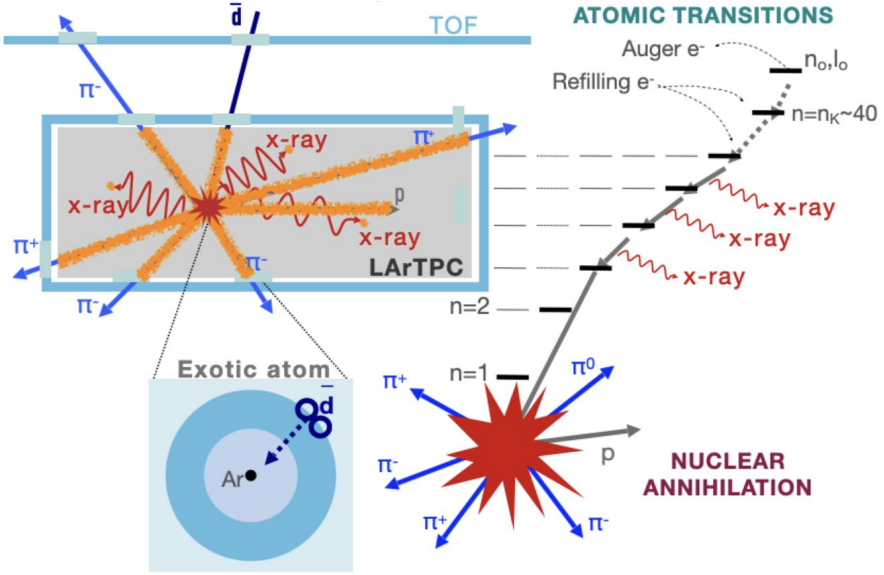


Candidate compton scatter blips from a Cs source run

Mission II: indirect search for dark matter

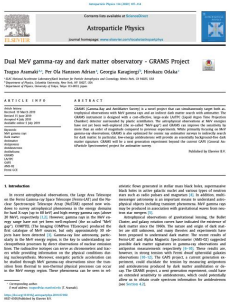
- GRAMS can detect cosmic antideuterons ($\bar{d}$) produced from DM candidates.
  - Near-zero astrophysical background
  - Capture into Ar exotic atoms; characteristic atomic X-ray and particle signals





Timeline

Jan 2020
Concept paper published & initial R&D



Astroparticle Physics

Dual MeV gamma-ray and dark matter observatory – GRAMS Project

Concept paper

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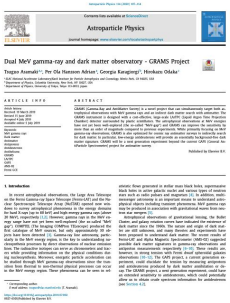
Astroparticle Physics

Dual MeV gamma-ray and dark matter observatory – GRAMS Project

Tsuguo Aramaki, Per Ola Hansson Adrian, Georgia Karagiorgi, Henkaus Odaka

Concept paper

Spring 2023
Prototype flight funded by NASA APRA

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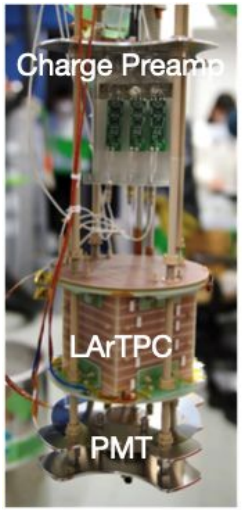
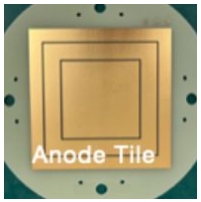
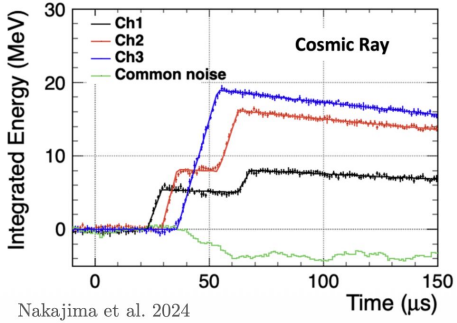


First LArTPC operated in the stratosphere!





Nakajima et al. 2024

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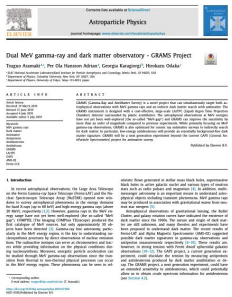
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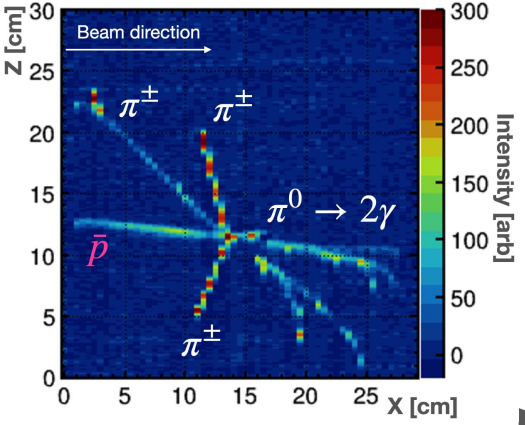

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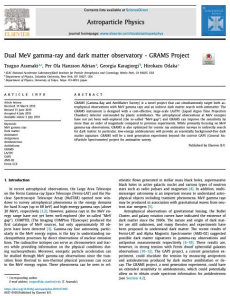
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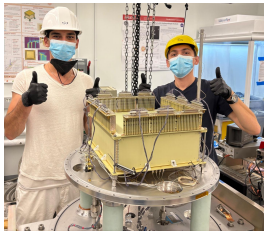

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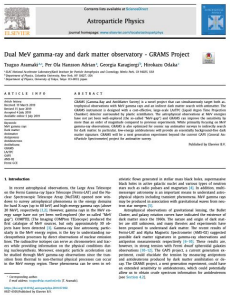
Fall 2026
Prototype balloon flight scheduled in Tucson, AZ

Late 2030s
Proposed satellite mission



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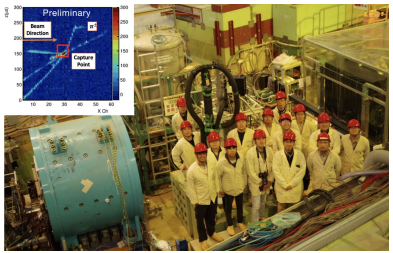
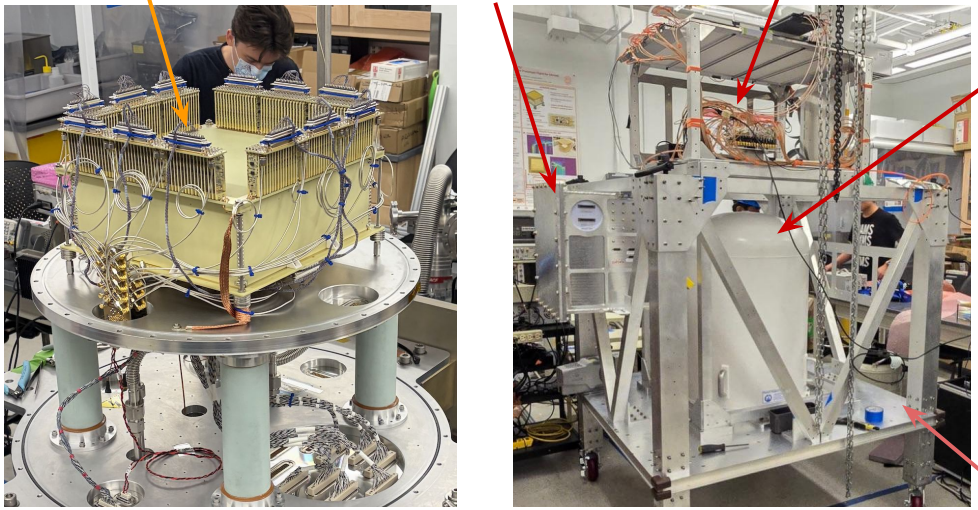


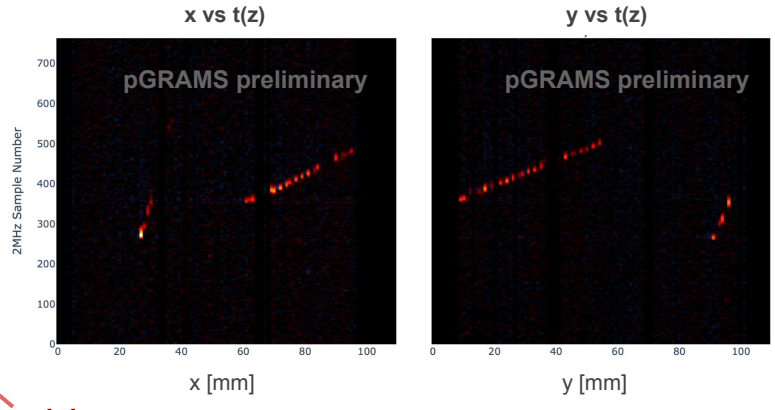
Late 2020s – Mid-2030s
Multiple LDB and ULDB (ultra-long duration balloon) science flights

Upcoming prototype flight (pGRAMS)

- ≥8-hour flight with a prototype detector scheduled to launch from Tucson, AZ, in Fall 2026 to validate detector performance in flight.
  - 30×30×10 cm³ LArTPC; 180 charge channels + 36 light channels, and SiPM ToF modules



Event display of cosmic rays during a LAr test run at Northeastern University



Thanks for your attention! Questions?

pGRAMS integration tests at Northeastern University
August 2026

Back-ups