

KJ.00005:
The DarkLight experiment
at ARIEL (TRIUMF)*



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Abstract

**KJ.00005: Michael Kohl (Hampton University and Jefferson Laboratory)
The DarkLight experiment at ARIEL (TRIUMF)**

The DarkLight experiment was conceived to **search for a dark photon** produced in electron scattering, motivated by theory, astrophysical observations, and observed **anomalies in particle physics** such as the deviation of the muon anomalous magnetic moment from the Standard Model. Of particular interest is the mass window **below 20 MeV**, favored by an observed excess of dilepton production from nuclei known as the **Be-8 anomaly**, which has been explained with a fine-tuned boson representing a fifth force. The new DarkLight project has been proposed to use the **30-50 MeV electron beam** of the ARIEL facility at TRIUMF on a Tantalum target along with a high-resolution apparatus to detect the e^+e^- pair, to probe the continuous **e^+e^- invariant mass spectrum** from 10-20 MeV for **narrow structures** and to provide an independent test of the fifth-force postulation. The experiment design, sensitivity, implementation strategy, and current status will be reported.

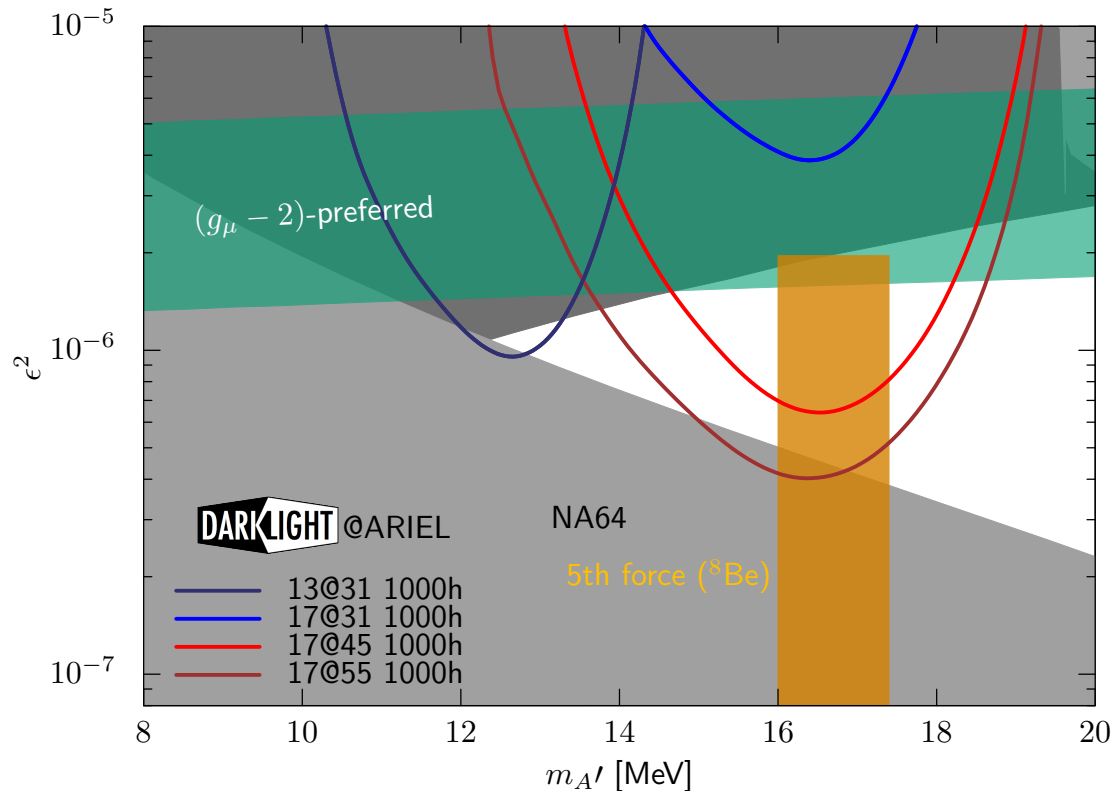
- 2011-2017: DarkLight at LERF: PAC37 (C2); approved (C1) by PAC39 (2013)
 - 2012 Demonstrated to pass ERL mA beam through narrow aperture
 - 2014 NSF/MRI funding, staging of DarkLight in Phase I (a,b,c), and II
 - 2016 Last LERF operation, test beam time with DarkLight solenoid
 - 2016 Atomki PRL claiming X17 (8-Be) [PRL 116, 042501 \(2016\)](#)

- 2018-2020: DarkLight at CEBAF: deferred by PAC46 (2018) and PAC48 (2020)
 - 2019 Second Atomki claim (4-He) [arxiv:1910.10459](#)

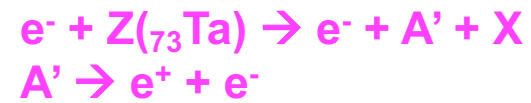
- Since 2020: DarkLight at ARIEL (TRIUMF) initiated
 - DND2020: Developing New Directions in Fundamental Physics
 - 2021: DarkLight proposal to TRIUMF, for 10-20 MeV search window
Phase 1 approved by TRIUMF EEC with high priority for 1,300 beam hours
 - 2022 Third Atomki claim (12-C) [arxiv:2209.10795](#)

DarkLight @ ARIEL/TRIUMF

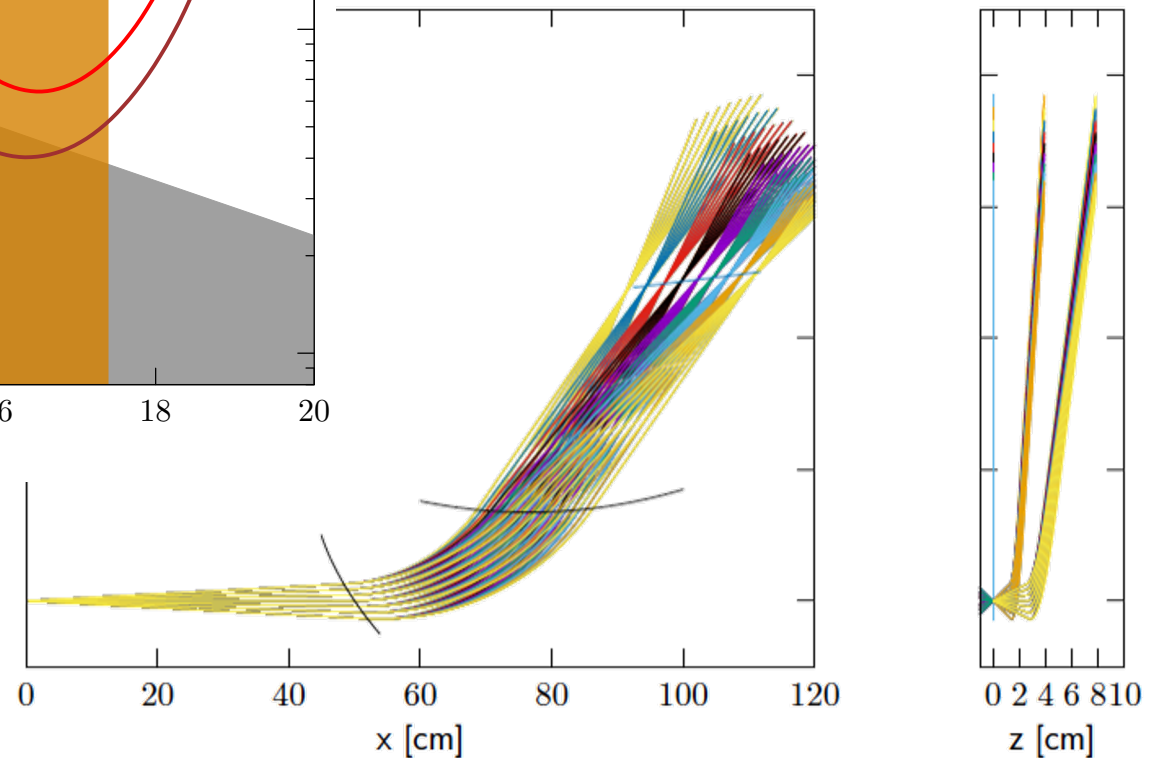
- Low-energy electroproduction of X17 (DP), LERF@JLab → ARIEL@TRIUMF



Dedicated search for the
17-MeV fifth-force carrier



**Two-spectrometer solution
to detect e^+e^- pair**



Responsibilities

Task	Lead institutions
Magnetic spectrometers	MIT, Mainz
Target and scattering chamber	MIT
GEM detectors	Hampton University
Data acquisition	Stony Brook & TRIUMF
Trigger hodoscopes	TRIUMF, UBC, UM, UW, and SMU
Software & simulation	Stony Brook, TRIUMF, MIT
Integration with ARIEL	TRIUMF & UM

Milestones

- **Proposal submitted** **March 2021**
- **Proposal approved** **April 2021**
- **Canadian groups funded** **April 2022**
- **Technical design of experiment completed** **Sep. 2022**
- **Technical review by TRIUMF** **Oct. 2022**
- **US groups funded** **Oct. 2022**
- **Construction of experiment** **Oct. 2022 – Oct. 2023**
- **Experiment installed** **Nov. 2023**
- **Commissioning of experiment** **Nov. 2023 – March 2024**
- **Data taking begins** **April 2024**
- **Data taking completed** **Sep. 2024**

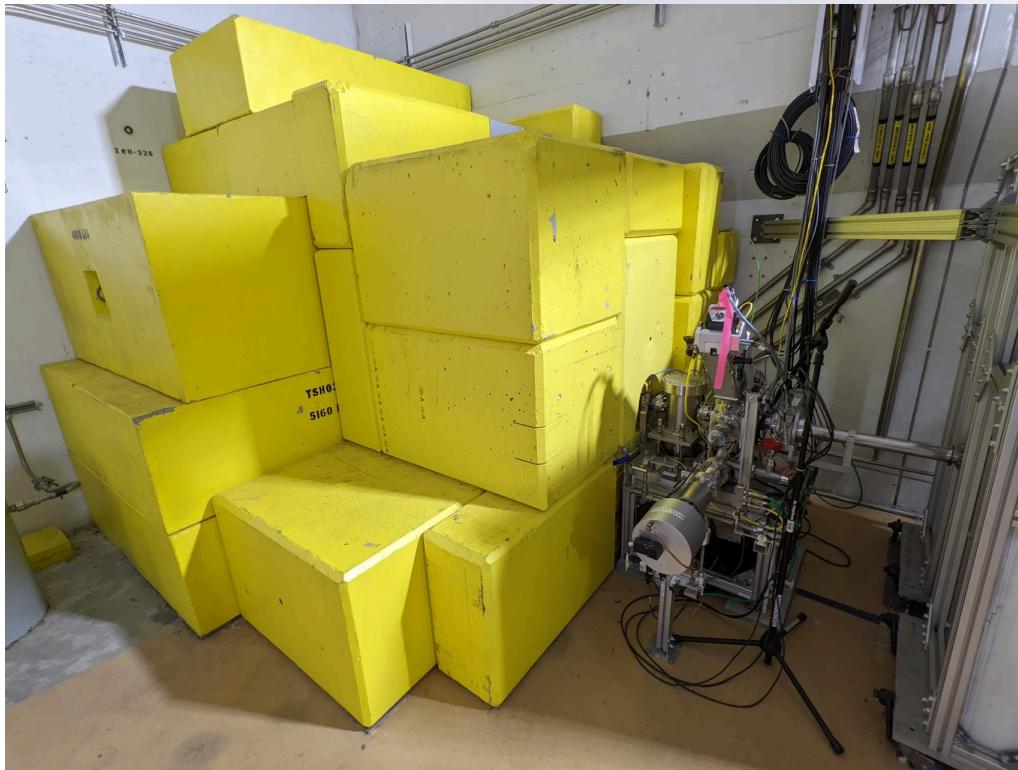
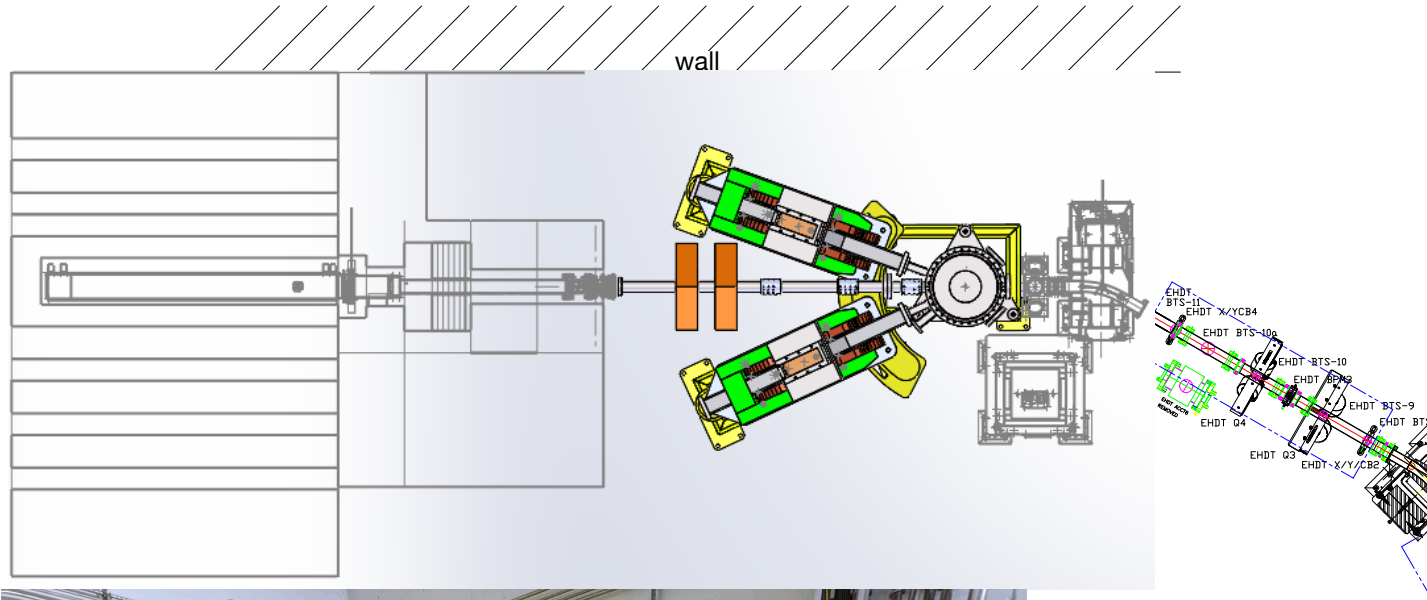
A lot of space at ARIEL (May 2022)



DarkLight to be installed near beam dump

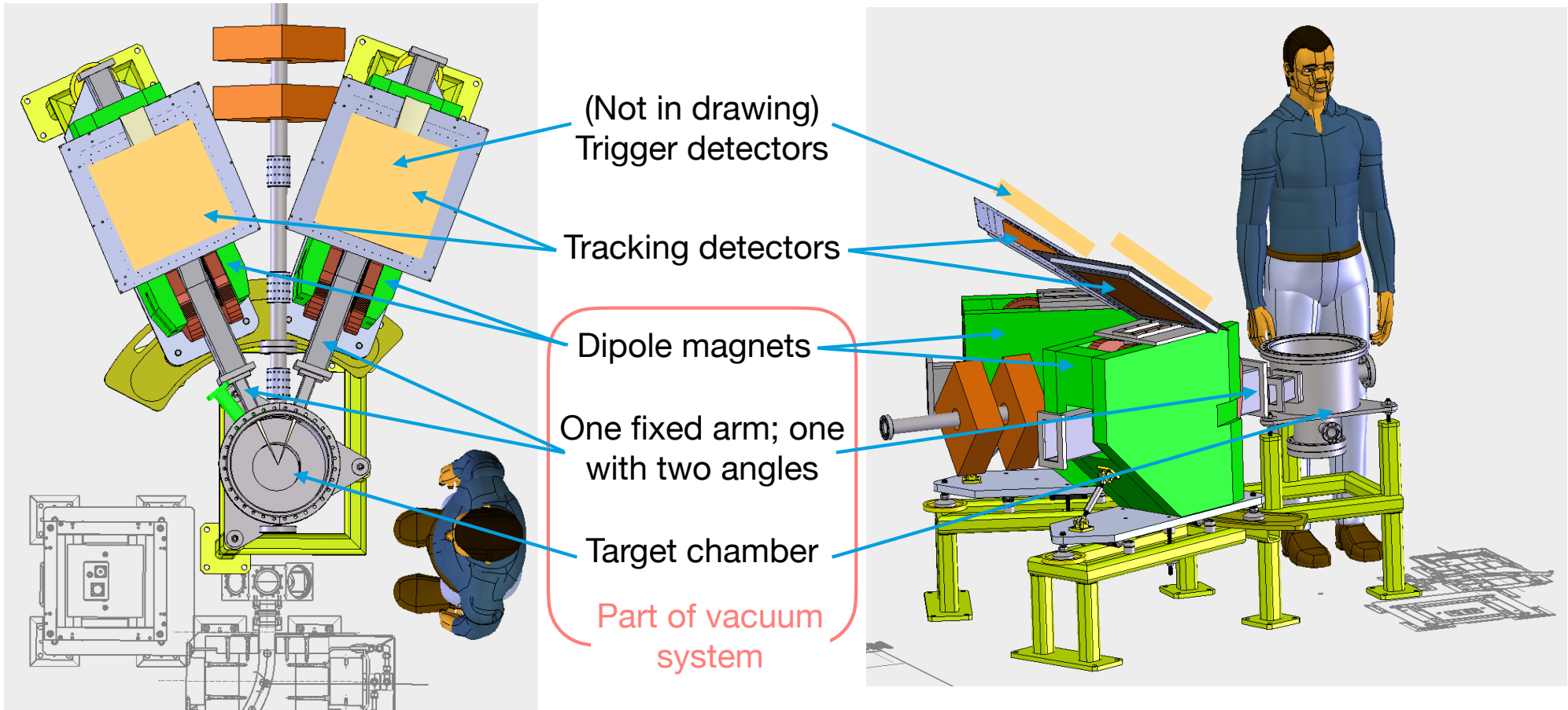


DarkLight to be installed near beam dump



3D Solid Model

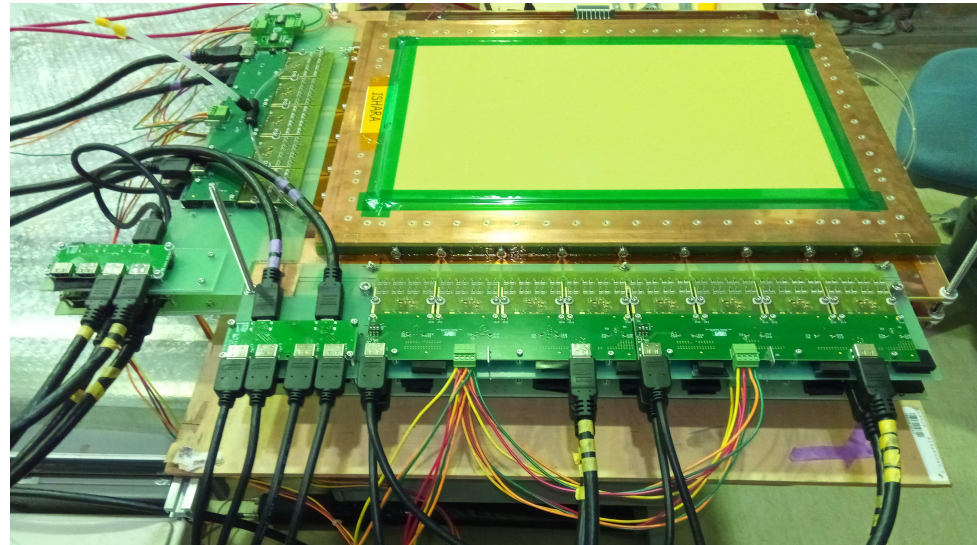
- Includes scattering chamber, exit quads, spectrometer magnets and GEM



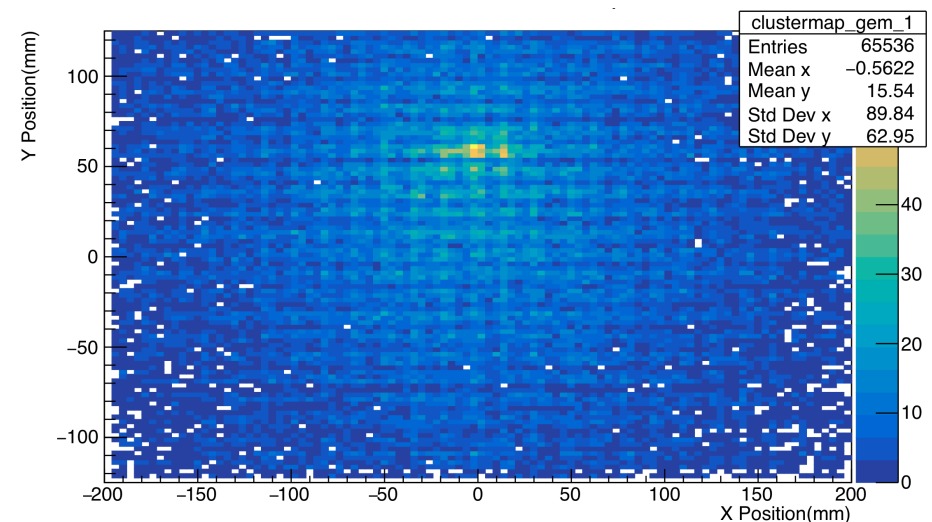
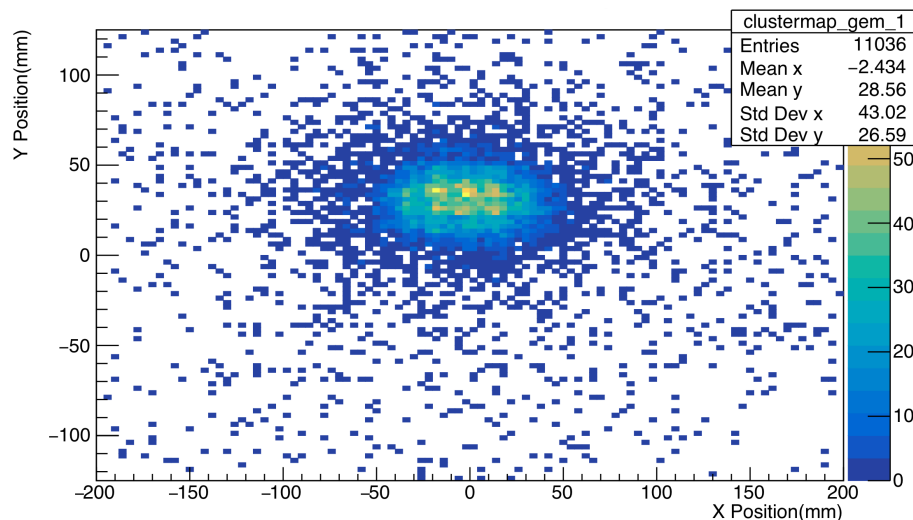
Gas Electron Multipliers (GEM)

GEMs (Hampton U.):

- NSF/MRI 2014-2018
- Constructed 2019
- Initial commissioning at ELPH (Tohoku U.)
- Covid delay 2020-22

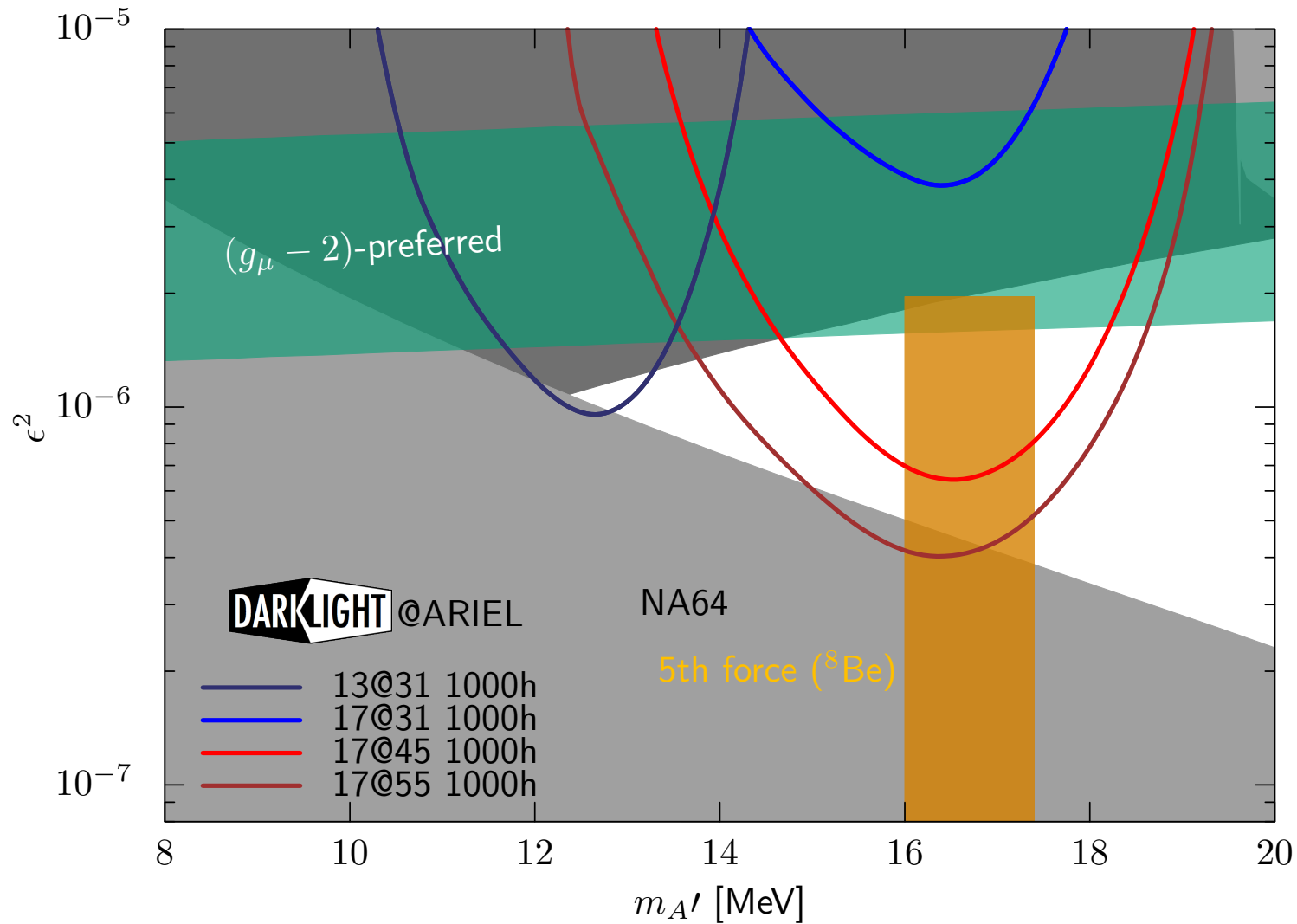


Fall 2019



Cluster map with focused and defocused ELPH test beam (0.7 GeV, ~10 kHz e^+)

1 GEM at ELPH, commissioning of 7 GEMs continued at JLab (Covid-delayed)



- Phase 1 (31 MeV) – 1000 hours running + 300 hours commissioning
- Phase 2 (45-55 MeV) required to probe allowed 17-MeV region

Summary

- DarkLight: **out of the dark, into the light** again at ARIEL (TRIUMF)
- Approved and funded, design well underway
- Construction, installation, commissioning in 2023
- Initial running at 31 MeV to probe near $m_{A'}$ \sim 13 MeV (Phase 1) in 2024
- Accelerator upgrade for Phase 2 (45-55 MeV) to fully probe X17 in 2025

The DarkLight@ARIEL Collaboration

Arizona State University, Tempe, AZ, USA

University of British Columbia, Canada

Hampton University, Hampton, VA, USA

TJNAF, Newport News, VA, USA

Massachusetts Institute of Technology, Cambridge, MA, USA

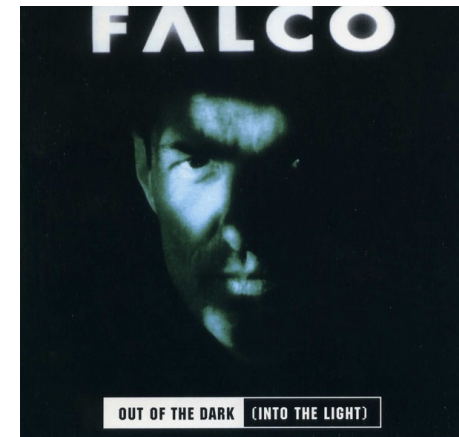
St. Mary's University, Halifax, Nova Scotia, Canada

Stony Brook University, NY, USA

TRIUMF, Vancouver, British Columbia, Canada

University of Manitoba, Canada

University of Winnipeg, Manitoba, Canada



- Please see the following talk (**KJ.00006 by Chenxi Ma**)
 “The simulation of DarkLight experiment at ARIEL (TRIUMF)”