

DarkLight Experiment at TRIUMF/ARIEL

Search for New Physics in e^+e^- Final States
with an Invariant Mass between 10-20 MeV

Canada – UBC, Manitoba, St. Mary's, TRIUMF, Winnipeg

USA – Arizona, Hampton, JLab, MIT, StonyBrook

Europe -- Mainz

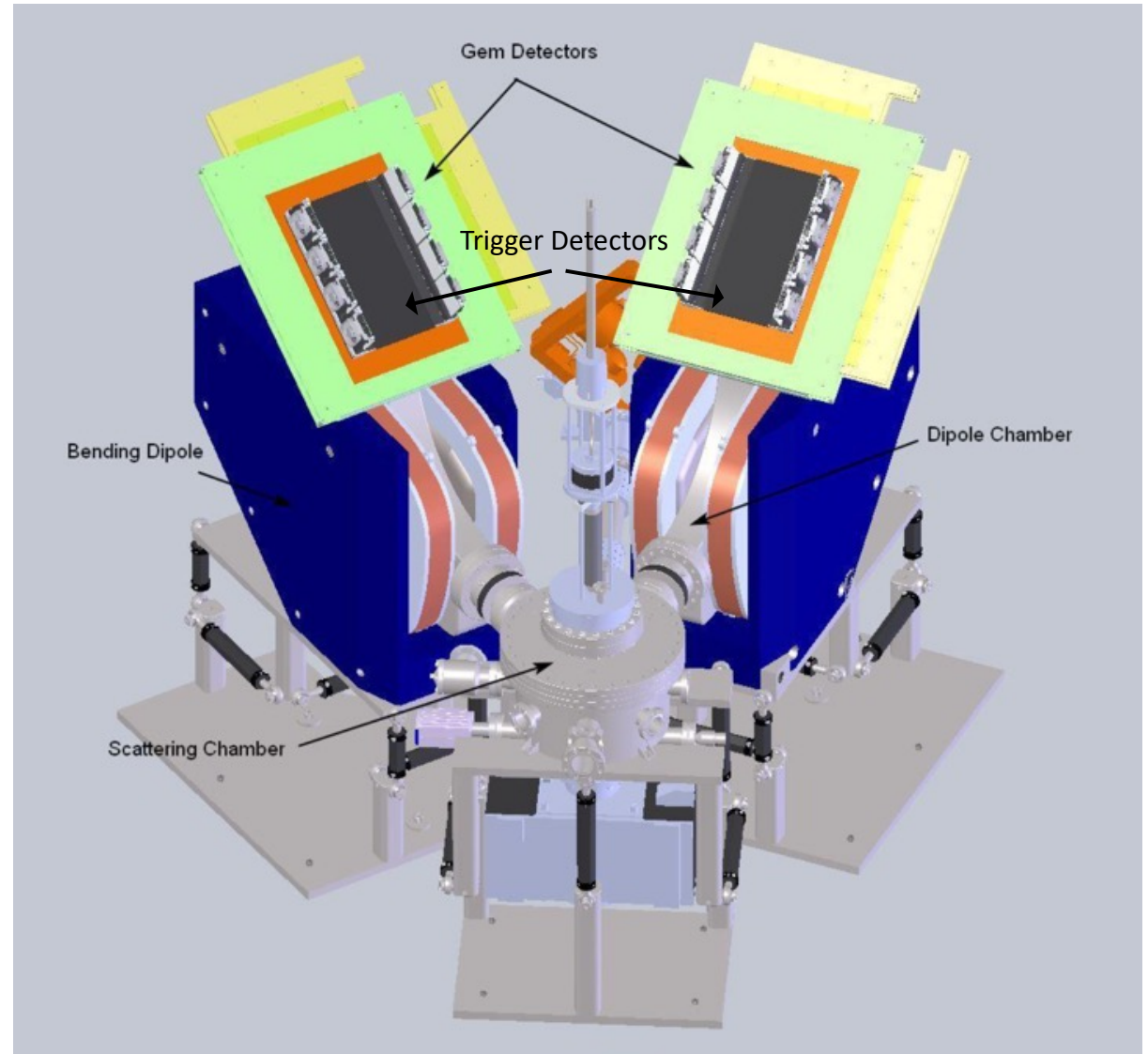
Group Responsibilities

Canada – Trigger Scintillators, DAQ

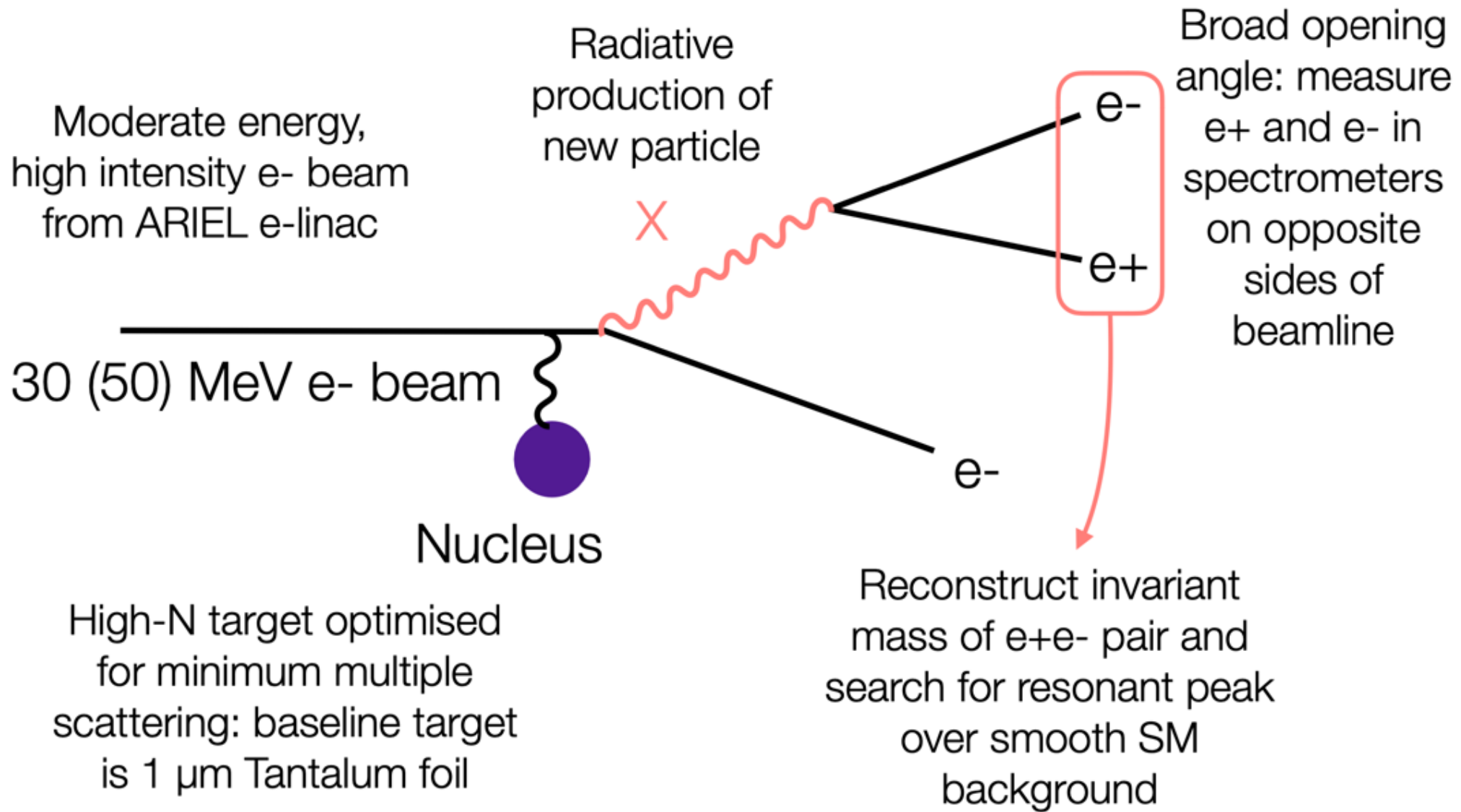
Hampton – GEM Tracking Detectors

MIT – Dipoles, Scatt/Vacuum Chamber, Exp Design

SBU – Slow Controls, DAQ

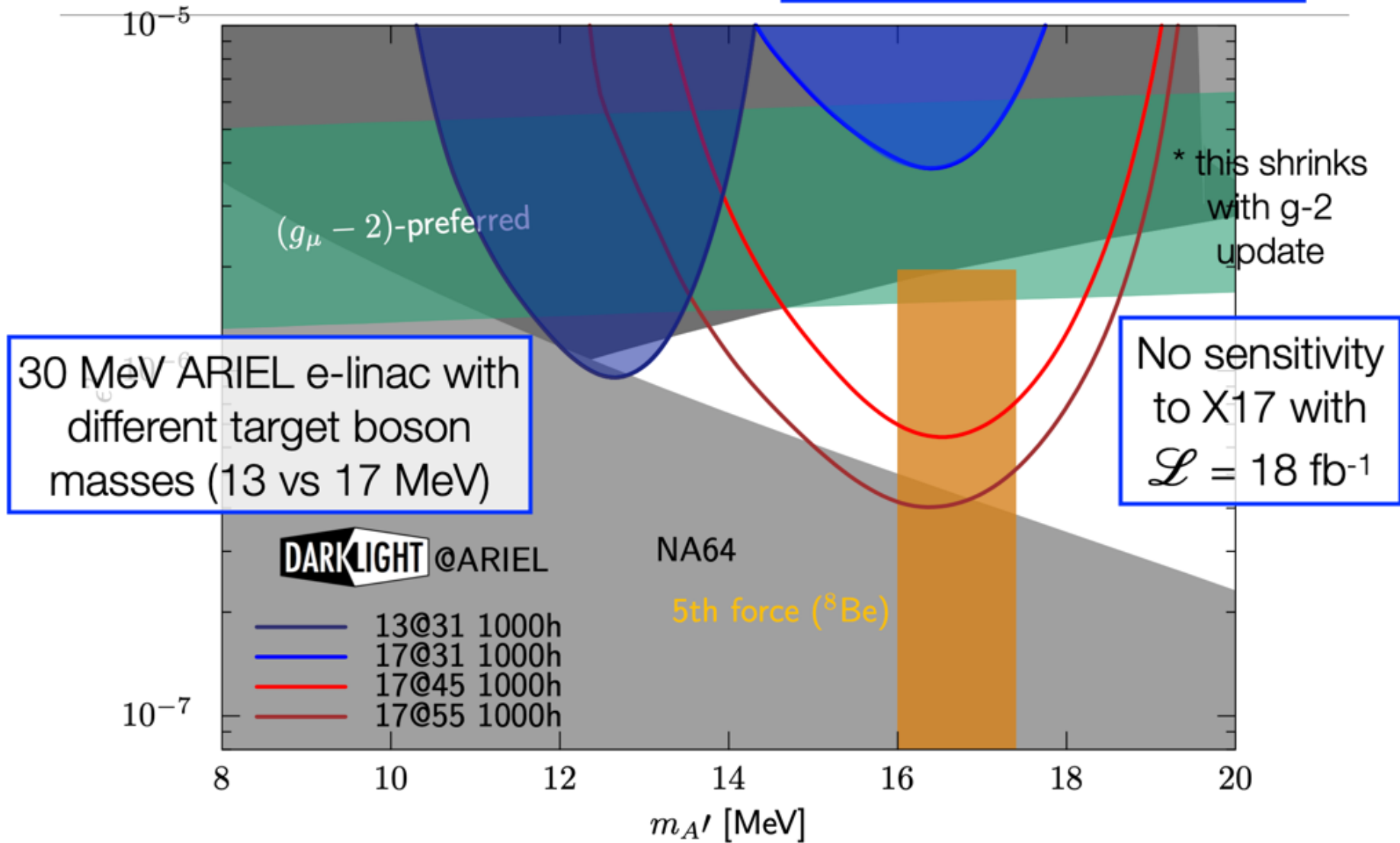


DarkLight Experiment at TRIUMF/ARIEL

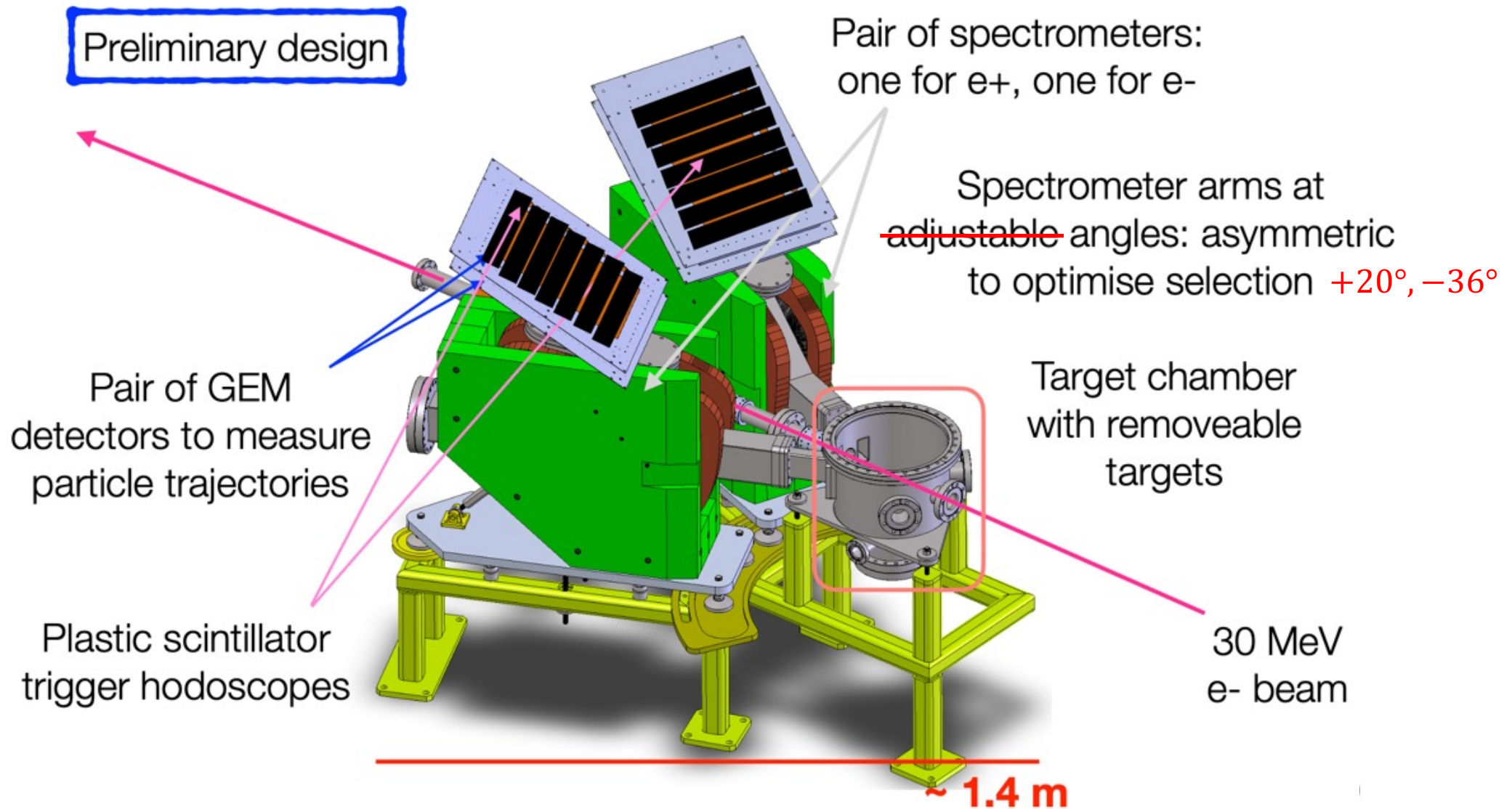


Sensitivity at 30 and 50 MeV accelerators

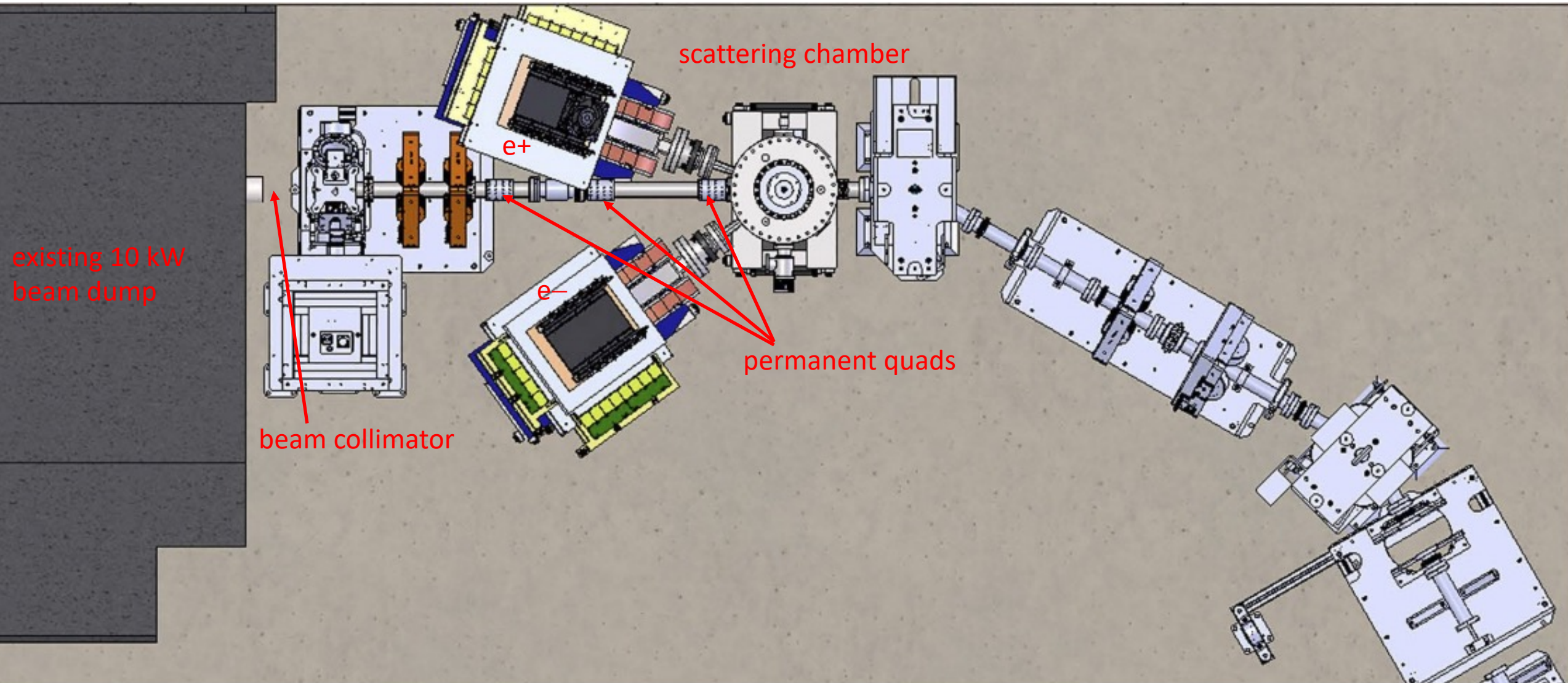
Overlap with g-2 favoured region is only in already-excluded areas



DarkLight Experimental Overview



DarkLight @ ARIEL – Phase 0 @ 30 MeV



ARIEL re-circulation ring --- Energy upgrade to 50 MeV

- Phase 0:

- Single user mode @31 MeV
- minor changes to optics, existing beam dump

received Apr'24

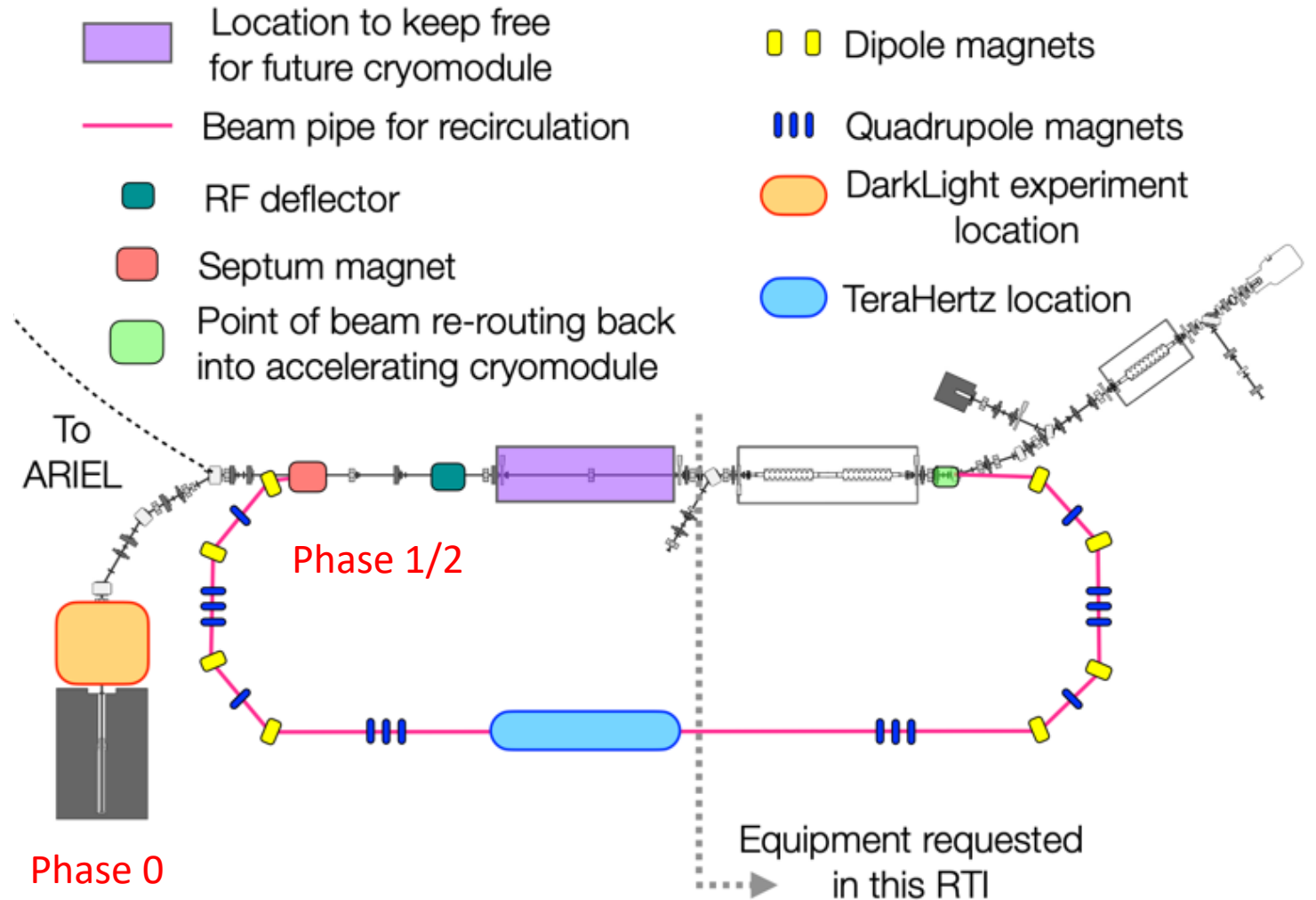
- 450k CAD NSERC for half of recirculating ring upgrade

- Phase 1:

- Single user mode ~50 MeV

- Phase 2: (~2027+)

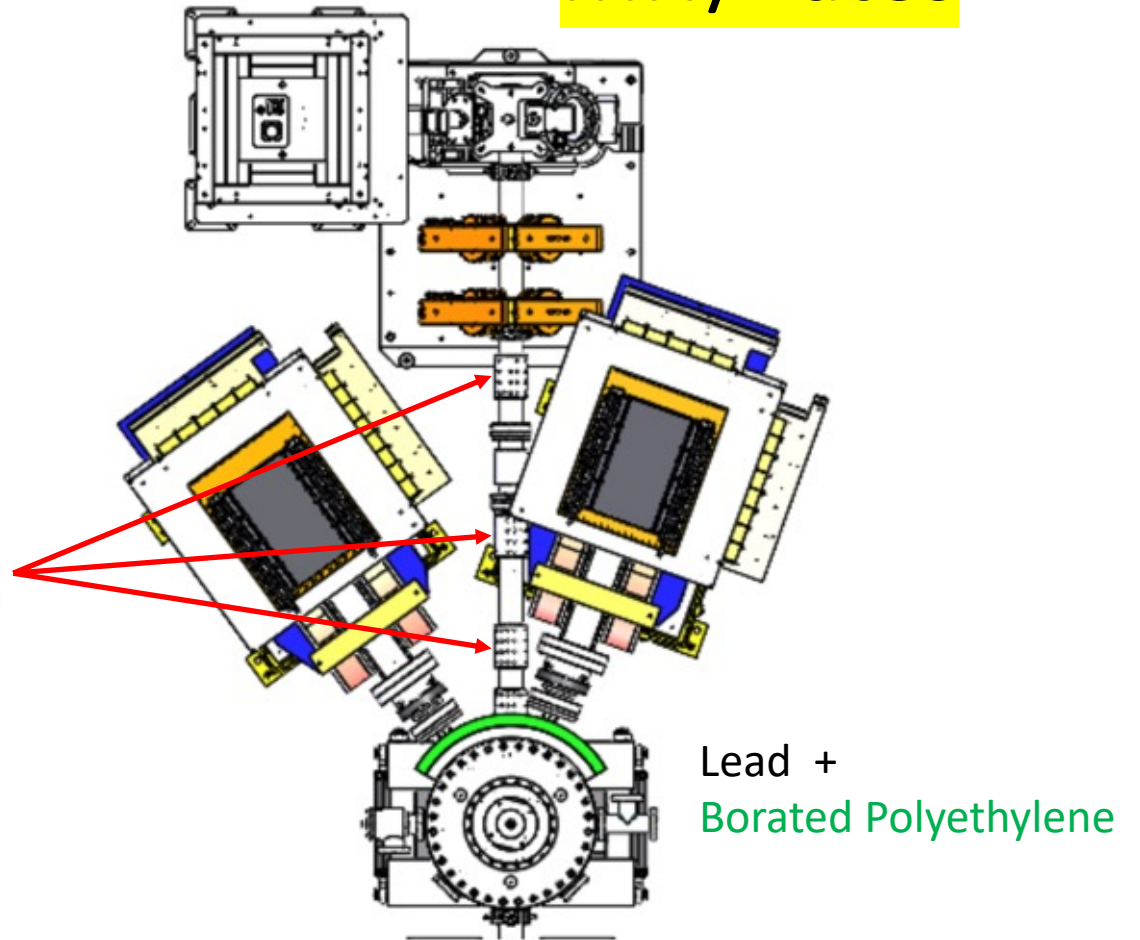
- Multi-user mode ~50 MeV



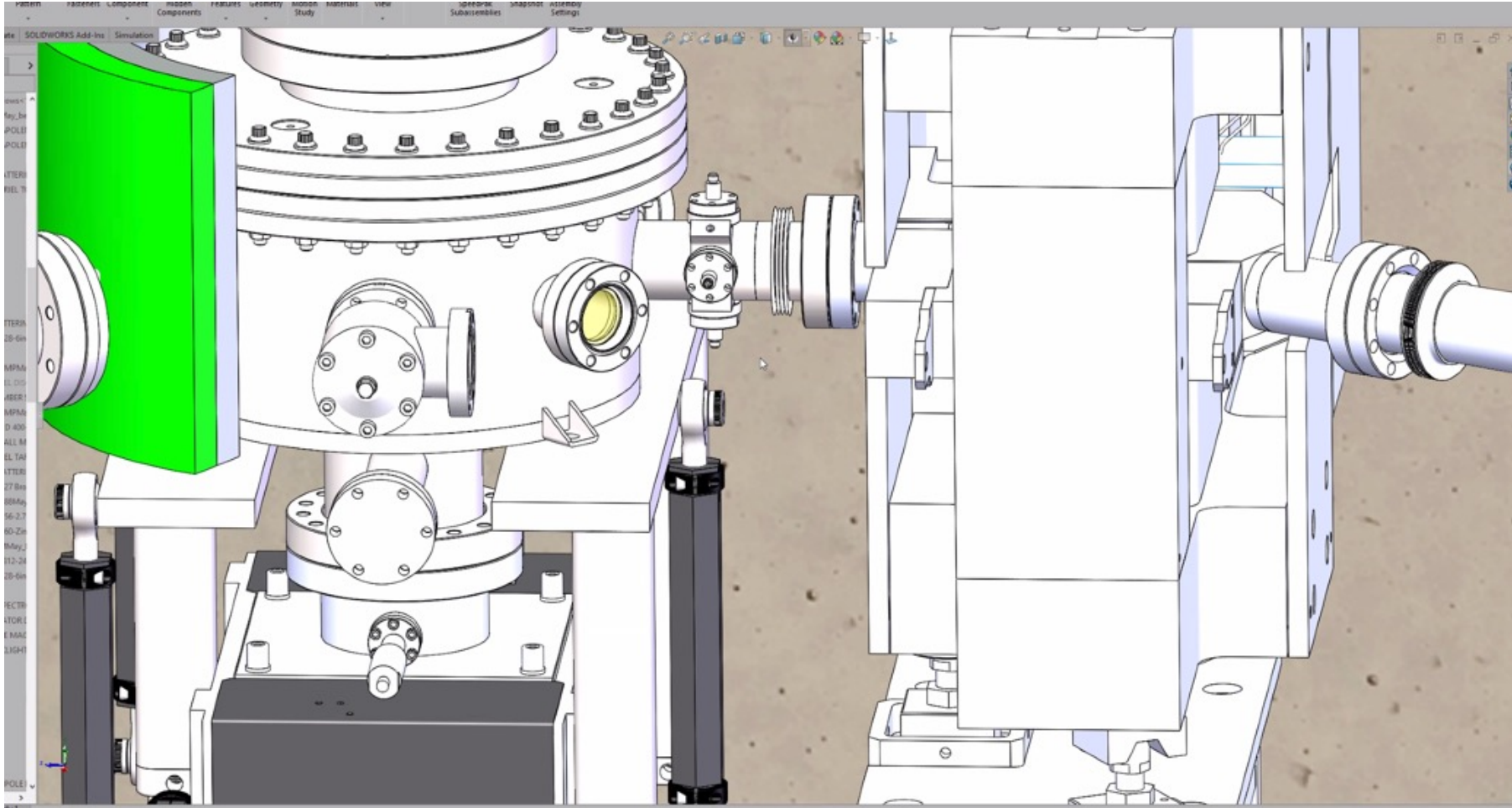
Scattering Chamber and Spectrometers

MIT/Bates

- Target ladder: 10,5,1,0.5 μm
Ta foil + empty
- 8W heating from 300 μA
beam @ 30 MeV
- Permanent beam quadrupole magnets downstream allow spectrometer arm at small angle



DarkLight Scattering Chamber MIT/Bates



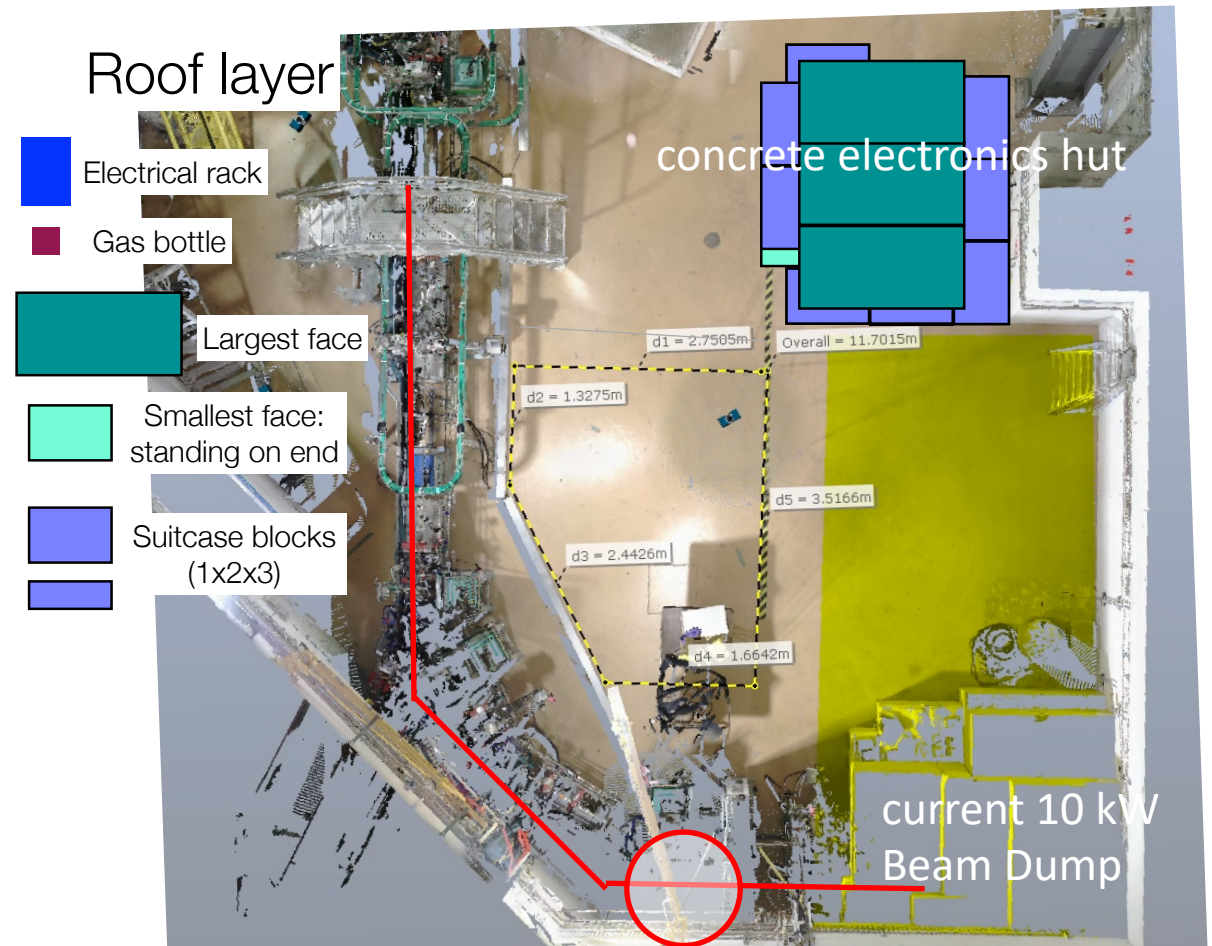
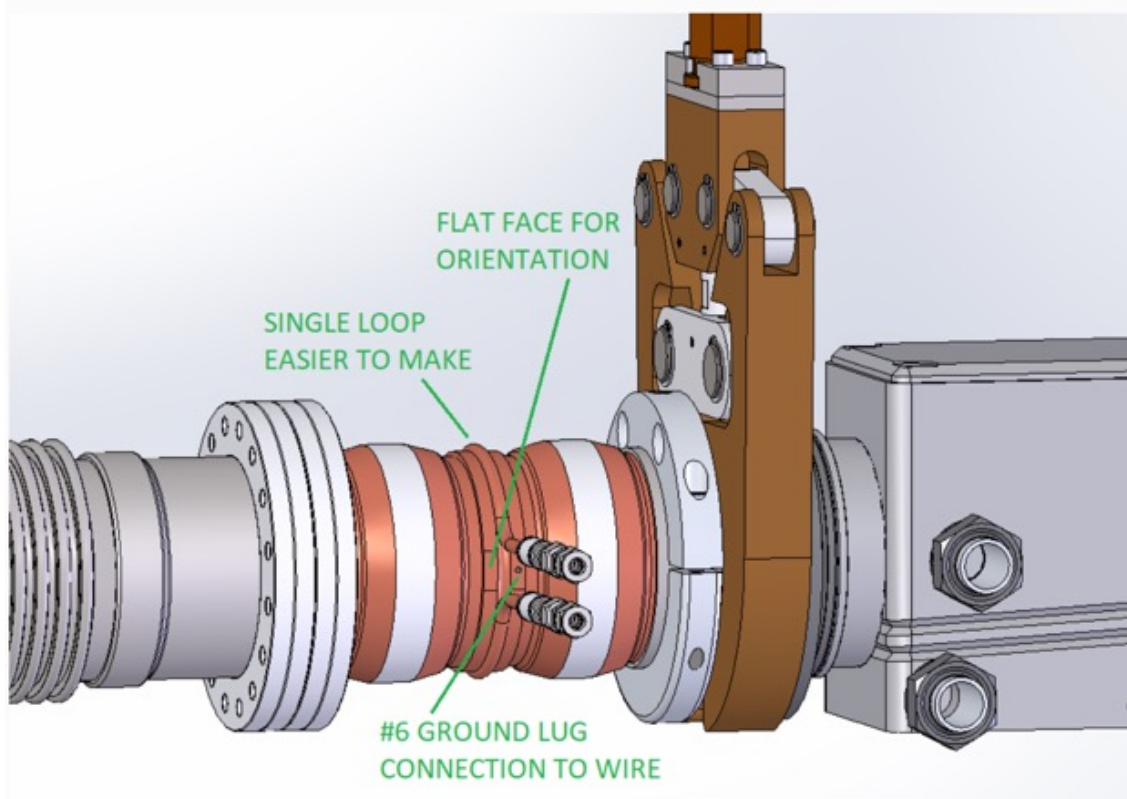
Required eLinac Beamline Modifications -- 1

- May – 2024 MIT/Bates
 - scattering chamber now at MIT/Bates
 - clean scatt chamber, weld US bellows, test vacuum
- June
 - receive vacuum chambers
 - machine PEEK absorber & mount inside vacuum chambers
 - test large vacuum chamber exit windows
- July
 - mount new PMQ magnets on DS beampipe
- Aug
 - ship scattering chamber to TRIUMF w mag ports blanked off
- Oct/Nov
 - receive spectrometers from Buckley (NZ)
 - mount Hall probe, vacuum chambers in magnet
 - machine various attachment points on magnet yoke
- Nov/Dec
 - ship magnets to TRIUMF for field mapping (TR)

Required eLinac Beamline Modifications -- 2

- May – 2024 **MIT/Bates**
 - scattering chamber now at MIT/Bates
 - clean scatt chamber, weld US bellows, test vacuum
- June
 - receive vacuum chambers
 - machine PEEK absorber & mount inside vac chambers
 - test large vacuum chamber exit windows
- July
 - mount new PMQ magnets on DS beampipe
- Aug
 - ship scattering chamber to TRIUMF w mag ports blanked off
- Oct/Nov
 - receive spectrometers from Buckley (NZ)
 - mount Hall probe, vacuum chambers in magnet machine various attachment points on magnet yoke
- Nov/Dec
 - ship magnets to TRIUMF for field mapping (TR)
- May – 2024 **TRIUMF**
 - finalize new optics design (AM, TP), prepare Exp Safety Report
 - order new high strength permanent quadrupole magnets
- June/July
 - update commissioning plans for CNSC, Gate 2/3 review
 - prepare new water cooled DS beam collimator
- Sept
 - Gate 4a, mount scattering chamber on eLinac beamline
- Oct
 - test beam transport, measure background rates
 - build electronics hut in e-Hall
 - install gas lines & cable tray for GEM/Trigger readout cables
- Jan -- 2025
 - mount GEMs and trigger scintillators onto the magnet yoke
 - attach magnets to scattering chamber in e-Hall
- Feb/Mar
 - start commissioning runs (300 hrs)
- Apr → Dec
 - complete data taking runs (1000 hrs in 3 separate periods)

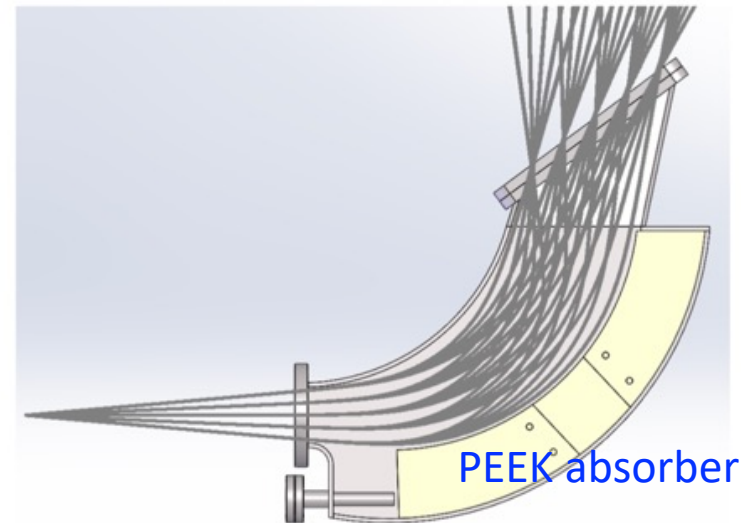
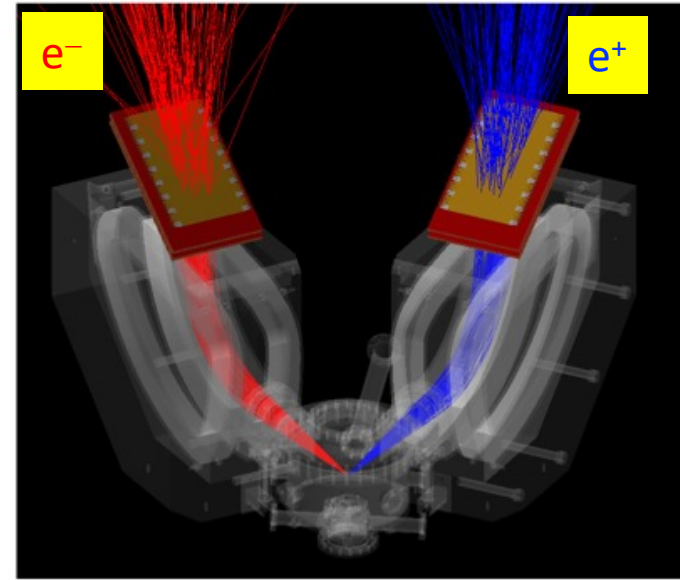
New water cooled DS beam collimator
 -- all components now @ TRIUMF
 -- welding in TRIUMF WS by end of July



Spectrometers

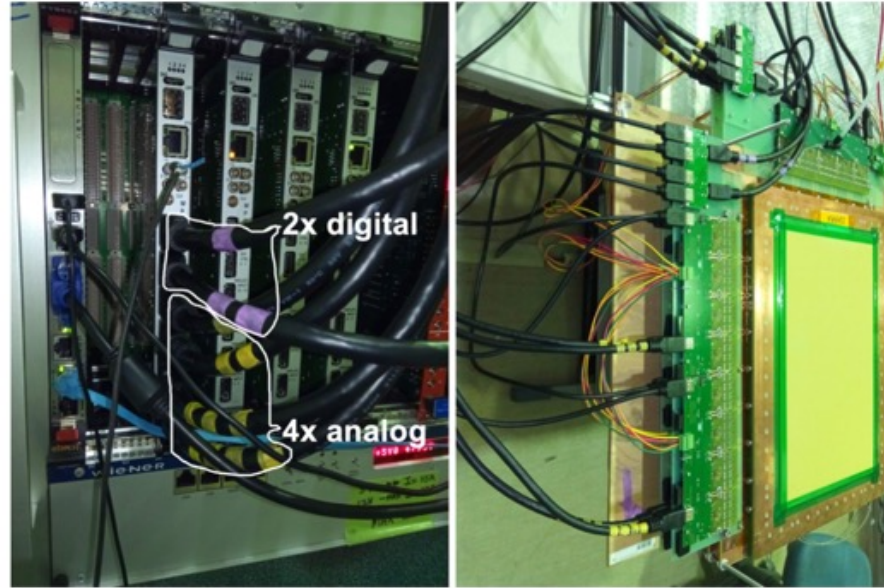
MIT/Bates

- Engineering model integrated into simulation chain allows detailed optimization
 - PEEK inserts added inside vacuum to reduce elastic e^- background
- Chamber and magnets on order, will be assembled at MIT Bates
- Assembly schedule limited by long leadtime on magnets



Detectors

- 25x40cm² triple-GEM focal plane detectors built by Hampton
- APV+MPD4 readout
- 2 at TRIUMF, 2 at JLab for commissioning



Hampton Univ.

- Segmented scintillator hodoscope triggers
- SiPM readout, resolution < 200ps
- Under construction at TRIUMF



TRIUMF/UBC

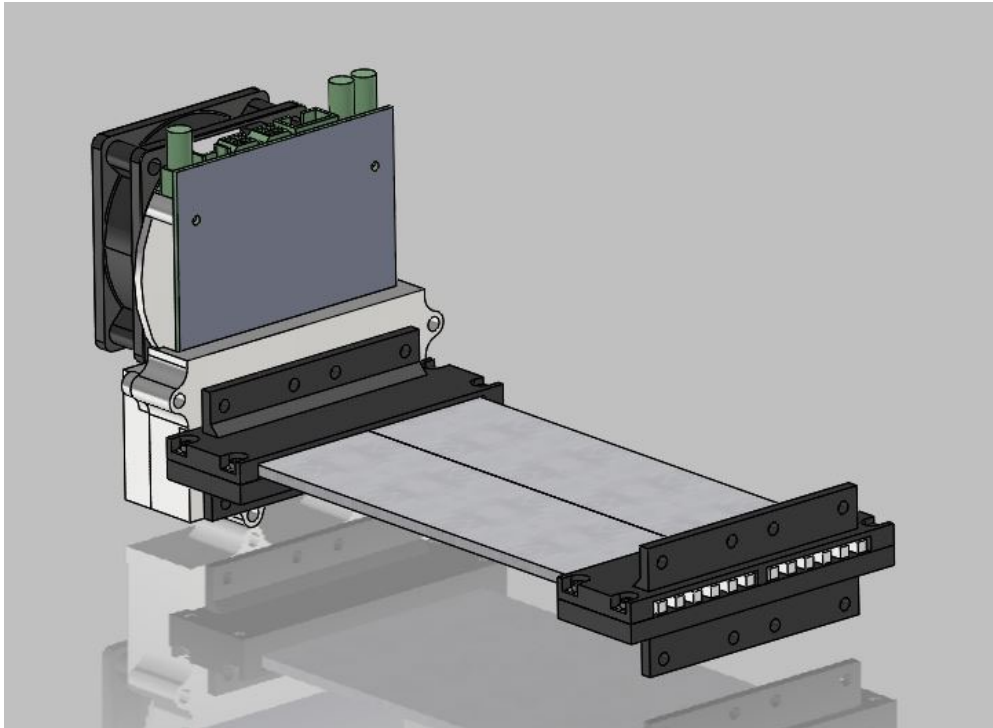
PSD personnel--
PeterM, NicolasM
PhilipL, KonstantinO
ClaytonH, TristanS

DL Scintillator Support Systems -- Status Nov 2023

Philip Lu, Nicolas Massacret, Gabby Gelinias, Ben Scully

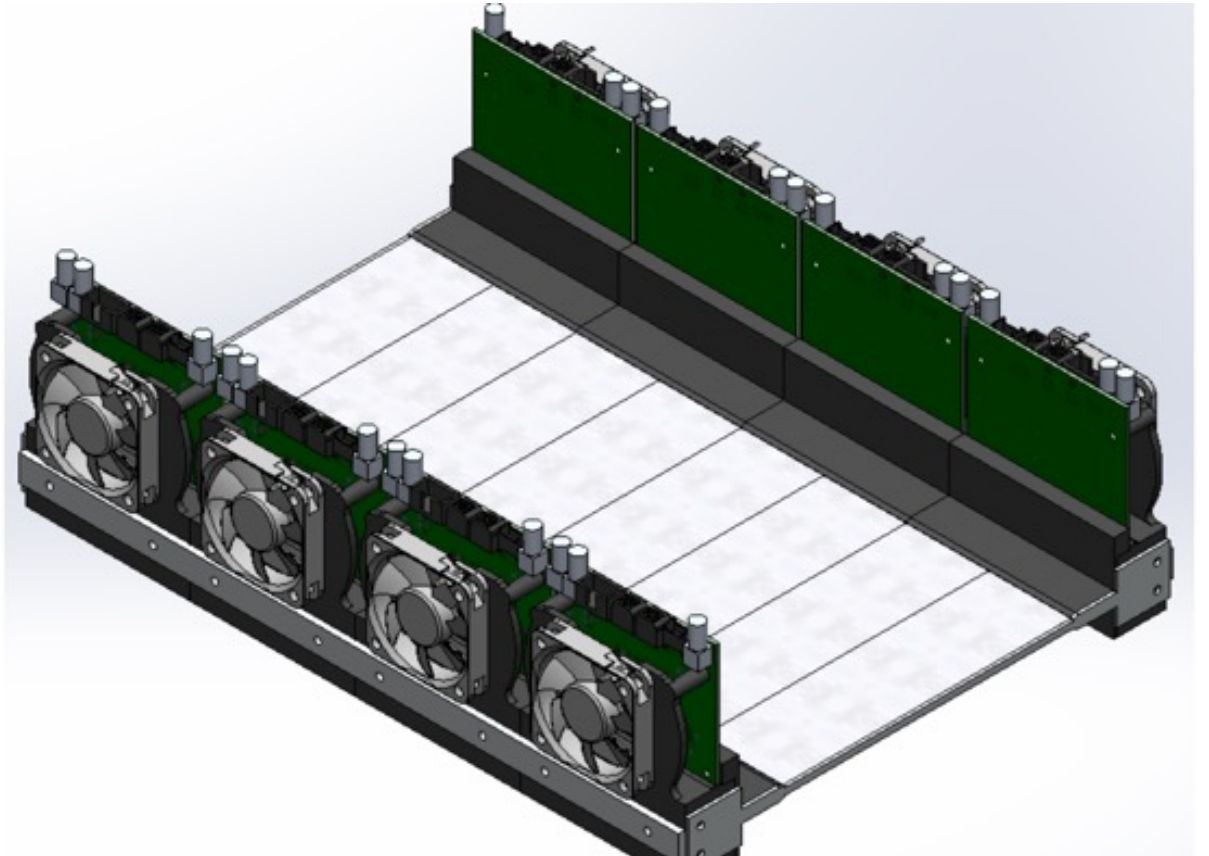
Prototype Board Supports – (3D printed)

- 1 support TDC board for each end of 2 scintillators
- need 2 sets (4 scintillators) for coincidence tests



e^- / e^+ arm Readout Board Supports --

- need 20 support frames for TDC cards-- 3D printed
- need 2 support holders for 8 scintillators * 2 (e^- & e^+ arms)



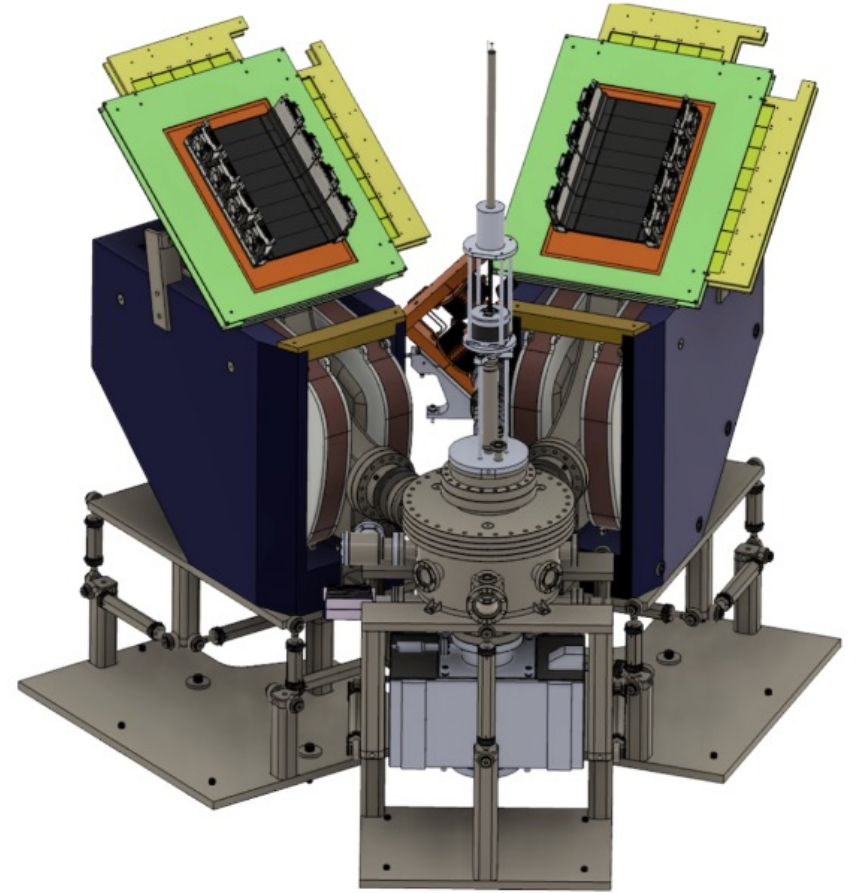
Detector Status & Timeline

GEM Tracking Detectors --

- One pair setup @ TRIUMF in Aug'23
- 2nd pair being commissioned @ JLab – will arrive @ TRIUMF in Oct'24 for assembly and DAQ bench testing with trigger scintillators
- Install GEMs & spectrometer magnets in e-Hall in Jan'25
- 4 spare GEM chambers under repair until Mar'25
- Fast optical GEM readout (VXS/VTP) will be available in Summer'25

Fast Trigger Scintillators --

- 20 scintillators paddles completed (require 8 + 8 + 4 (testing))
- all electronic boards tested
- FPGA timing system (~250 ps achieved)
- timing/efficiency tests currently underway
- will test one arm (8 paddles) with GEM in summer/fall



DL Readout Electronics -- Status Nov 2023

Peter Margetak, Konstantin Olchanski

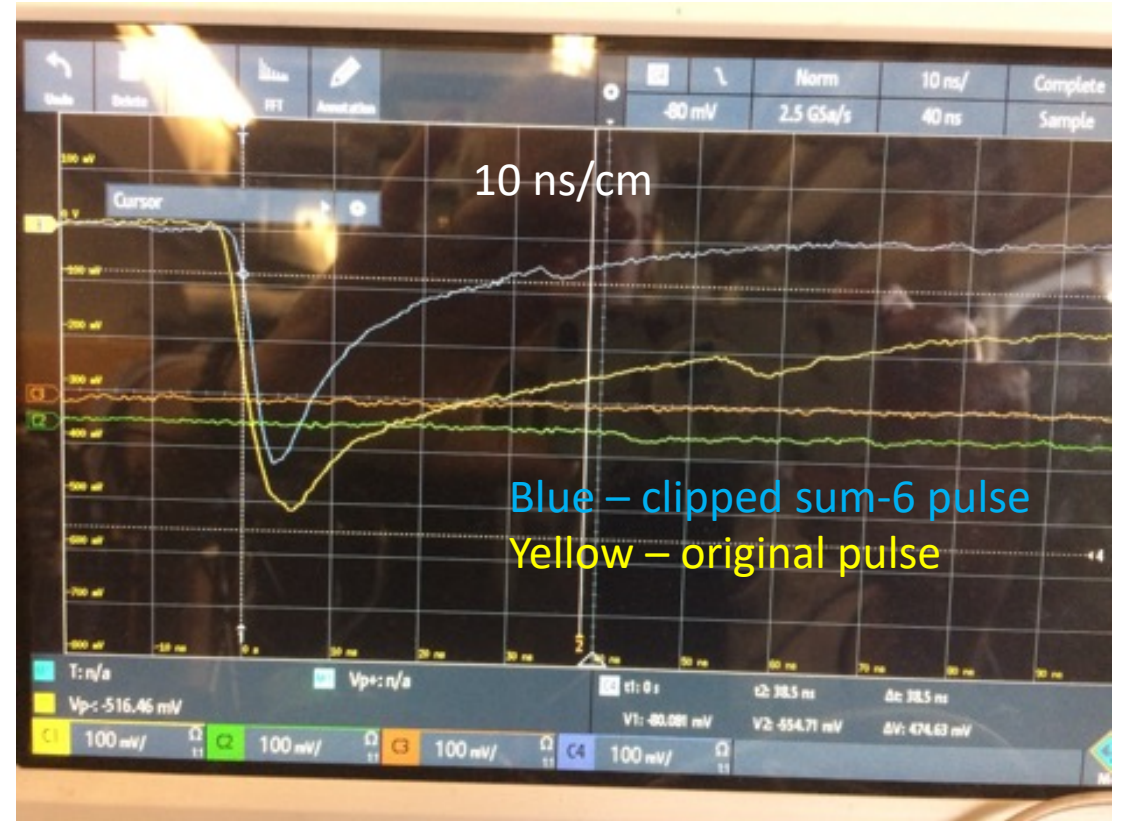
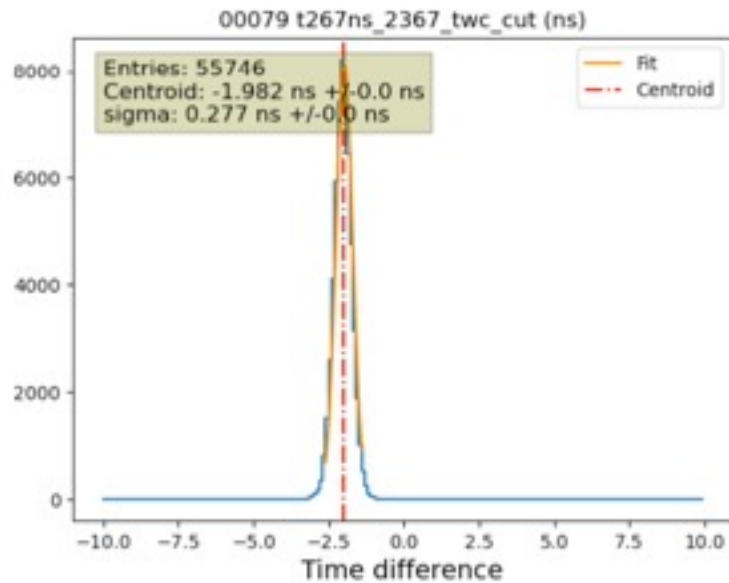
➤ TDC Readout Boards → FPGA (t_{LE} , t_{TE})

v1 – L Edge – received ~Mar'23, tested in Jul'23

v2 – Bittele – with RC signal clipping of each SiPM pulse
-- all boards received/tested in Jan'24

➤ Voltage Distribution Board

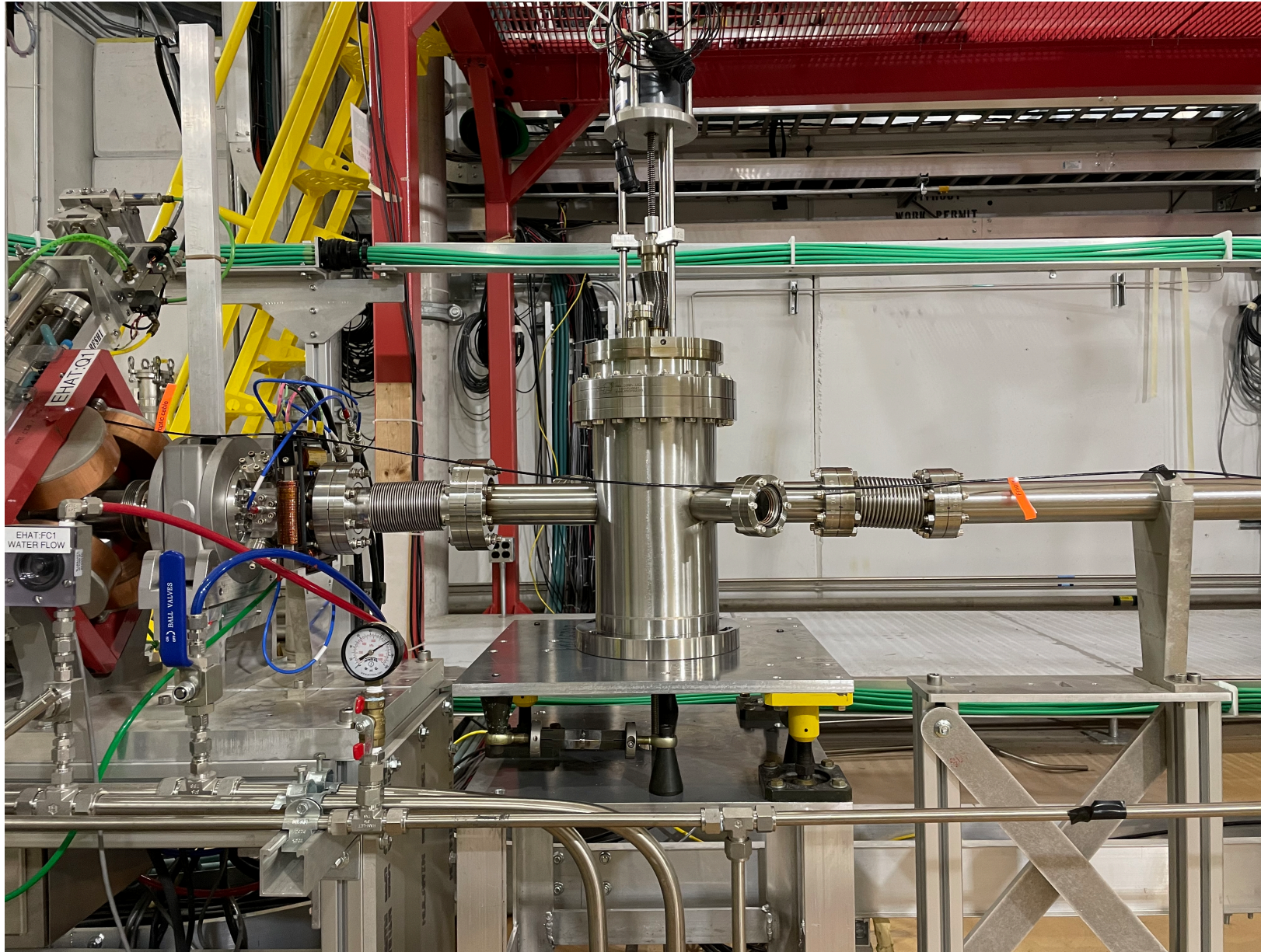
-- received Dec'23



Other experiments

- Resonance in Nuclear Decays:
 - COPE - not clear
 - **MEGII - 8Be ran in 2023, blinded**
 - Melbourne TPC - no timeline yet
 - **Montreal/Project X17 - 8Be run in 2023+, blinded**
 - New JEDI - not clear
 - *et al.*
- General-Purpose Accelerator:
 - Belle II - stats in 2025 or later
 - **FASER - first prelim results now, closes from below.**
 - LHCb - stats in 2026 or so
- Dark-Photon Specific:
 - APEX - probably can't reach
 - HPS - possible redesign to reach
 - LDMX - begins 2024+, closes from below. data hungry
 - MAGIX - begins 2025+
 - Mu3e - begins 2025+
 - NA64 - can modify in 2024 if other results encourage
 - **PADME - ran in 2022. blinded.**
 - PRad - modified to close the gap, approved in 2023
 - *et al.*

Test Scattering chamber – installed in June 2022



Thanks for your Attention

Questions ??

Backup Slides

DL DAQ – Status & Tasks Nov 2023 Konstantin

- ✓ FPGA TDC Readout for 4 scint bars (L/R → 8 TDC channels)
- ✓ Using Xilinx cyclone-5 in Chronobox -- LCELL delay chain fine time bins currently ~ 200 psec (L-R dT~400psec)
- Test Low Voltage distribution board and temp readout
- Move to MOB Lab space in December to trigger GEMs
- Setup dldaq17 with Network booting for FPGA and GEM controller, create MIDAS DAQ module
- Readout full 8 scintillator electron arm, positron arm
- Switch to faster FPGA and CARRY delay line to get fine time bins < 50 psec (based on DS20K work)

