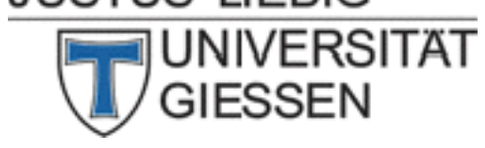
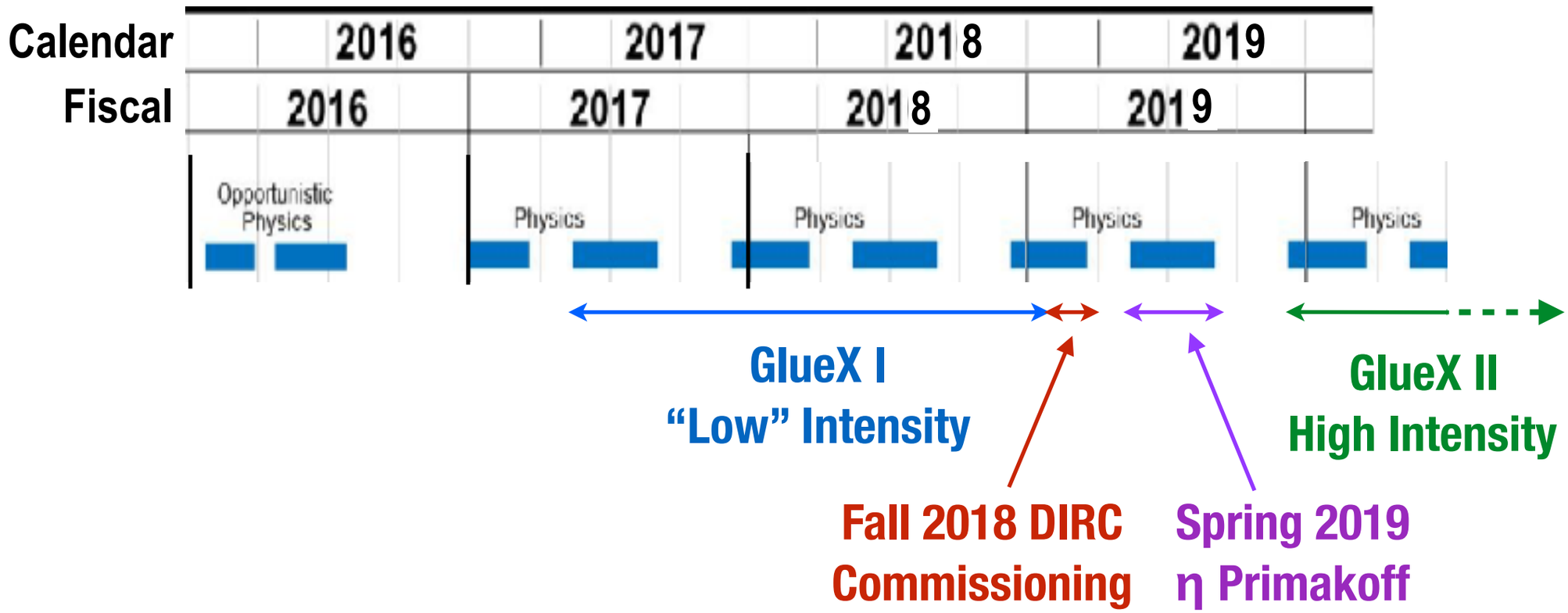
DIRC project: overview and status

GlueX DIRC Working Group
June 25, 2018

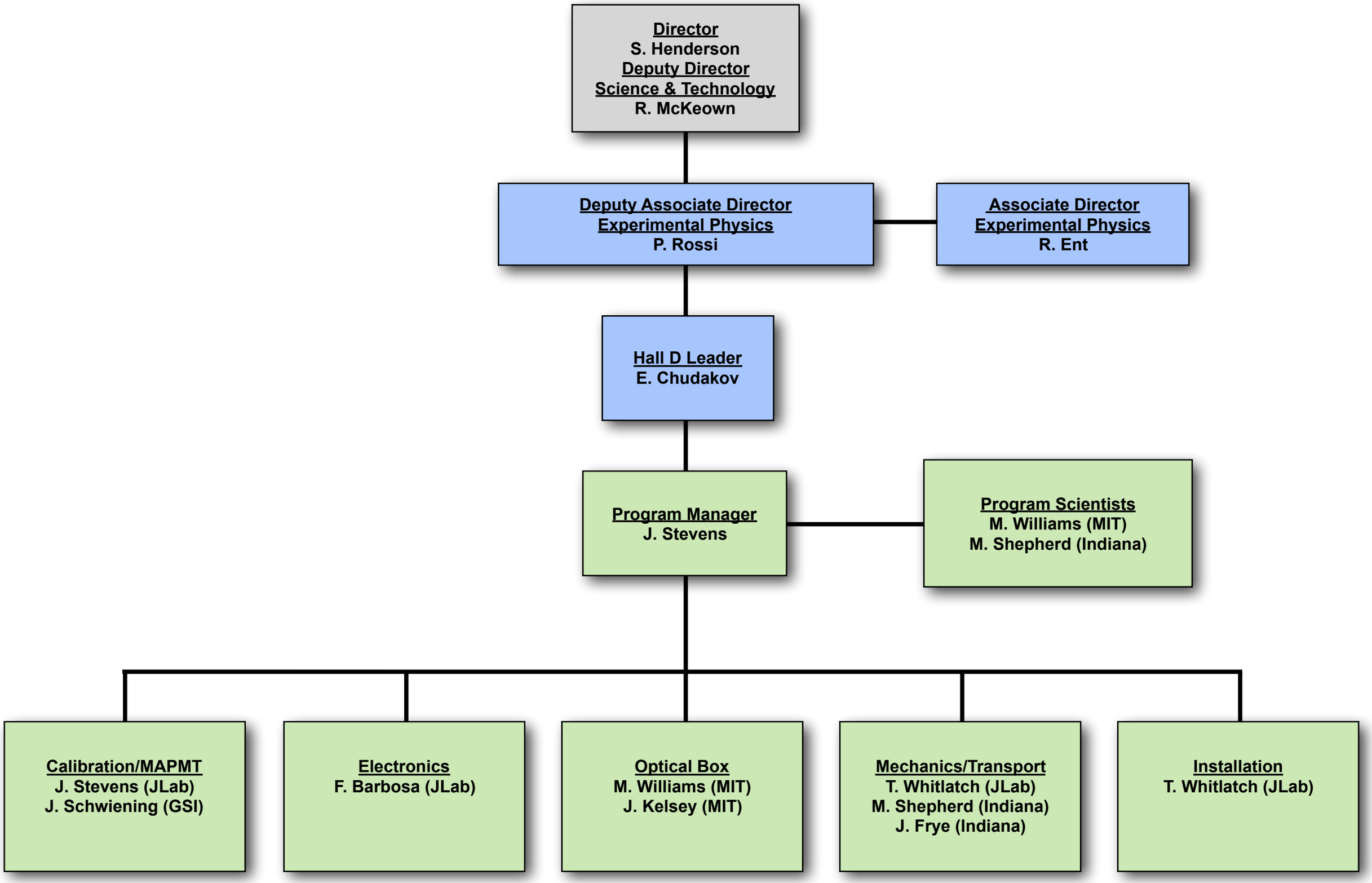


Hall D beam schedule



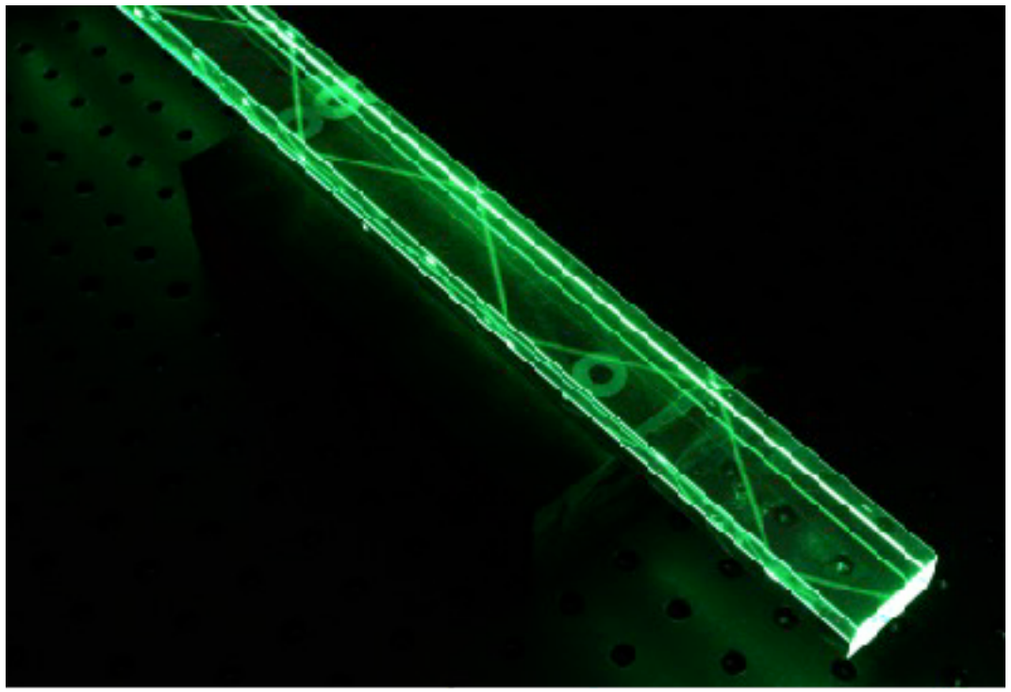
- Low intensity (GlueX I) will be completed by end of October 2018
- This readiness review aims to address:
  - Initial DIRC commissioning in Fall 2018 (3 weeks of beam)
  - High Intensity GlueX II in Fall 2019 including the DIRC

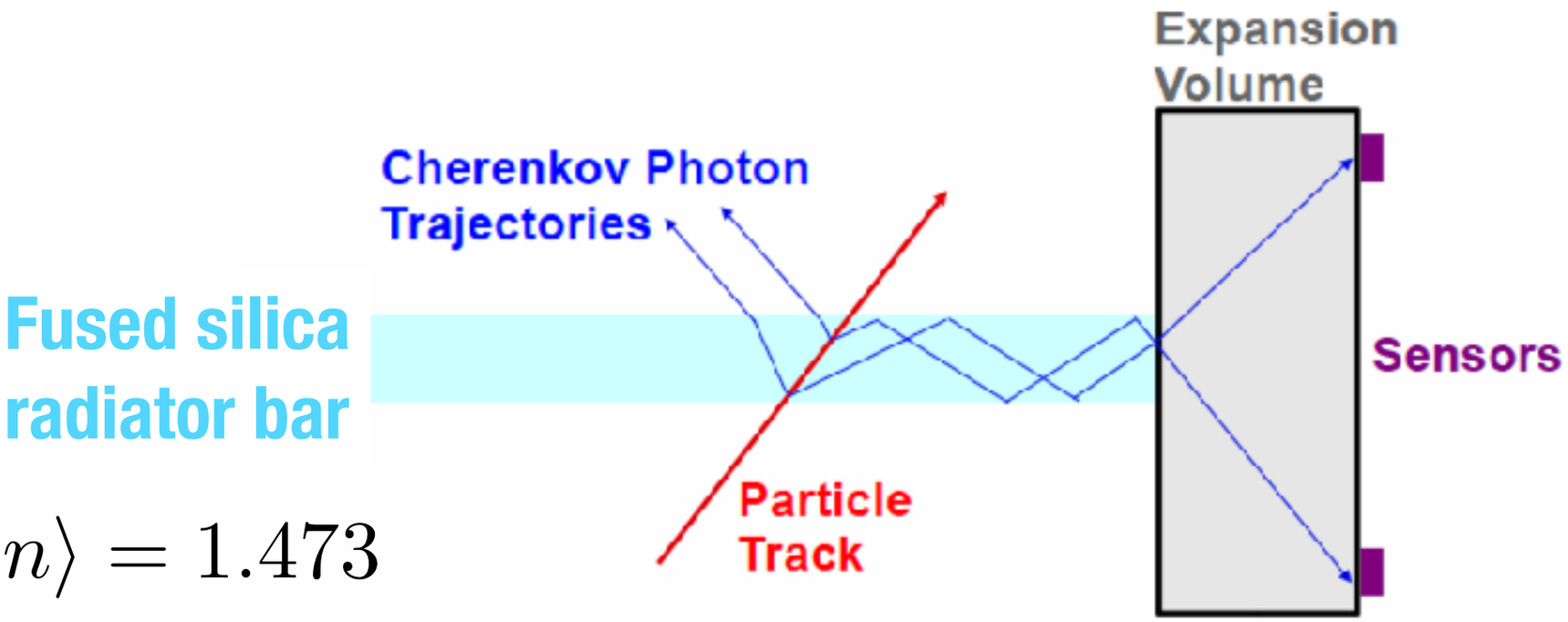
DIRC project organization



Particle Identification: DIRC

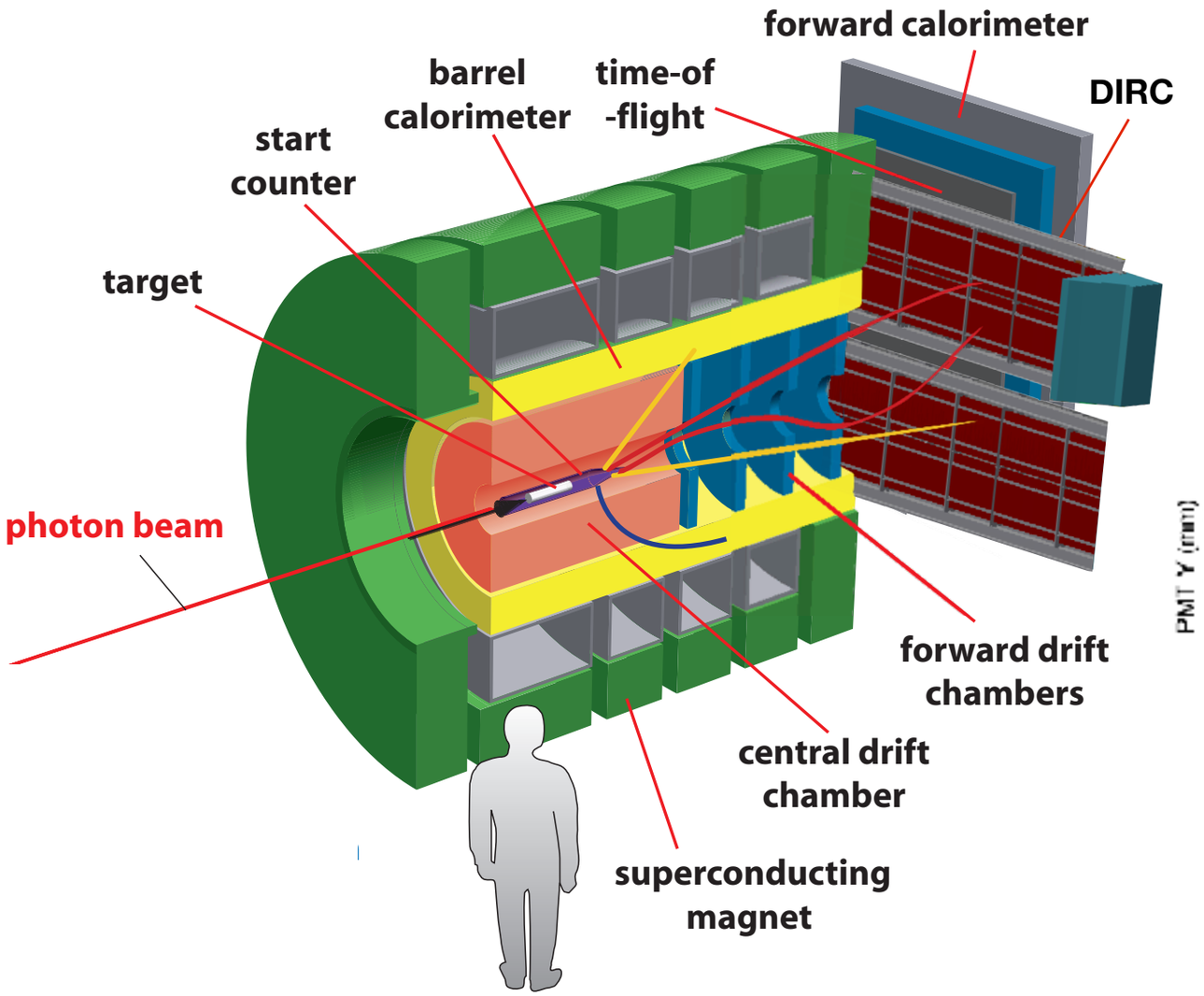
- **DIRC**: Detection of Internally Reflected Cherenkov Light
- Pioneered for BaBar detector at SLAC PEP-II
- Image photons to measure Cherenkov angle

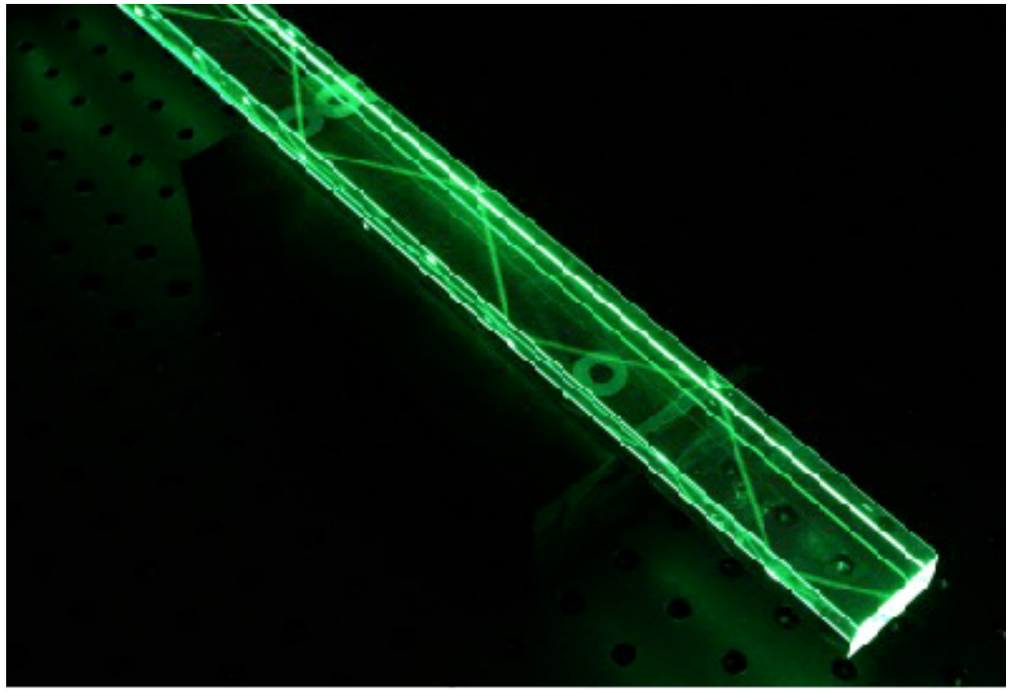


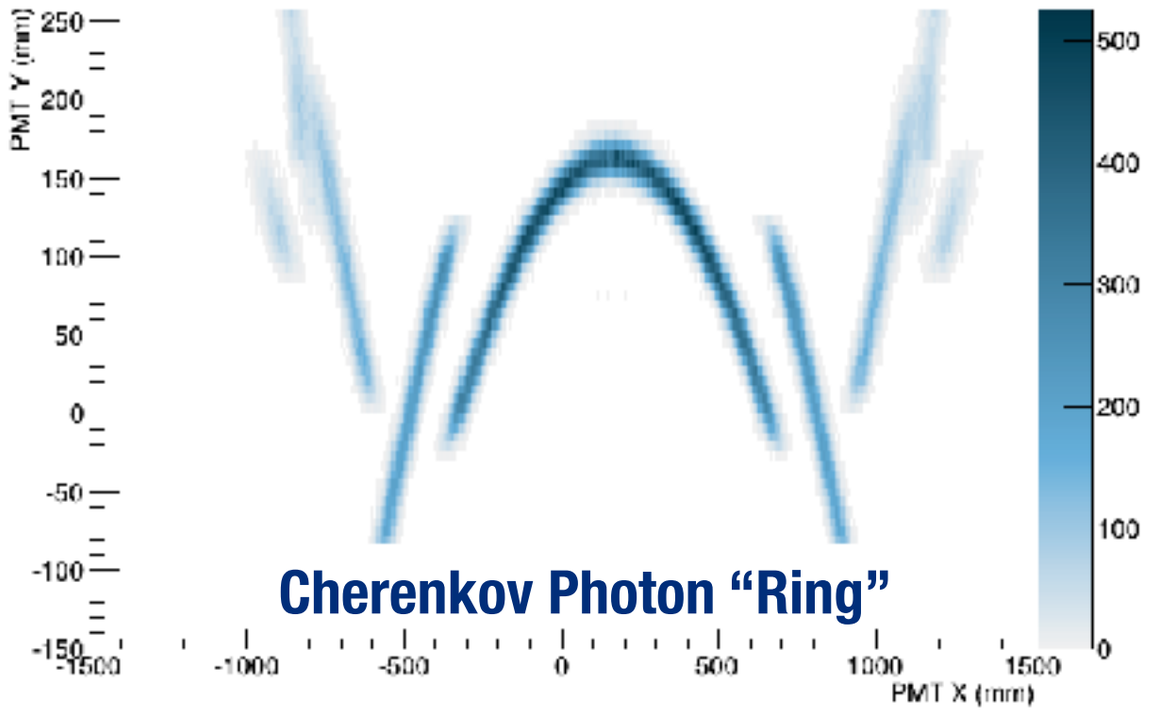


$$\langle n \rangle = 1.473$$

GlueX DIRC

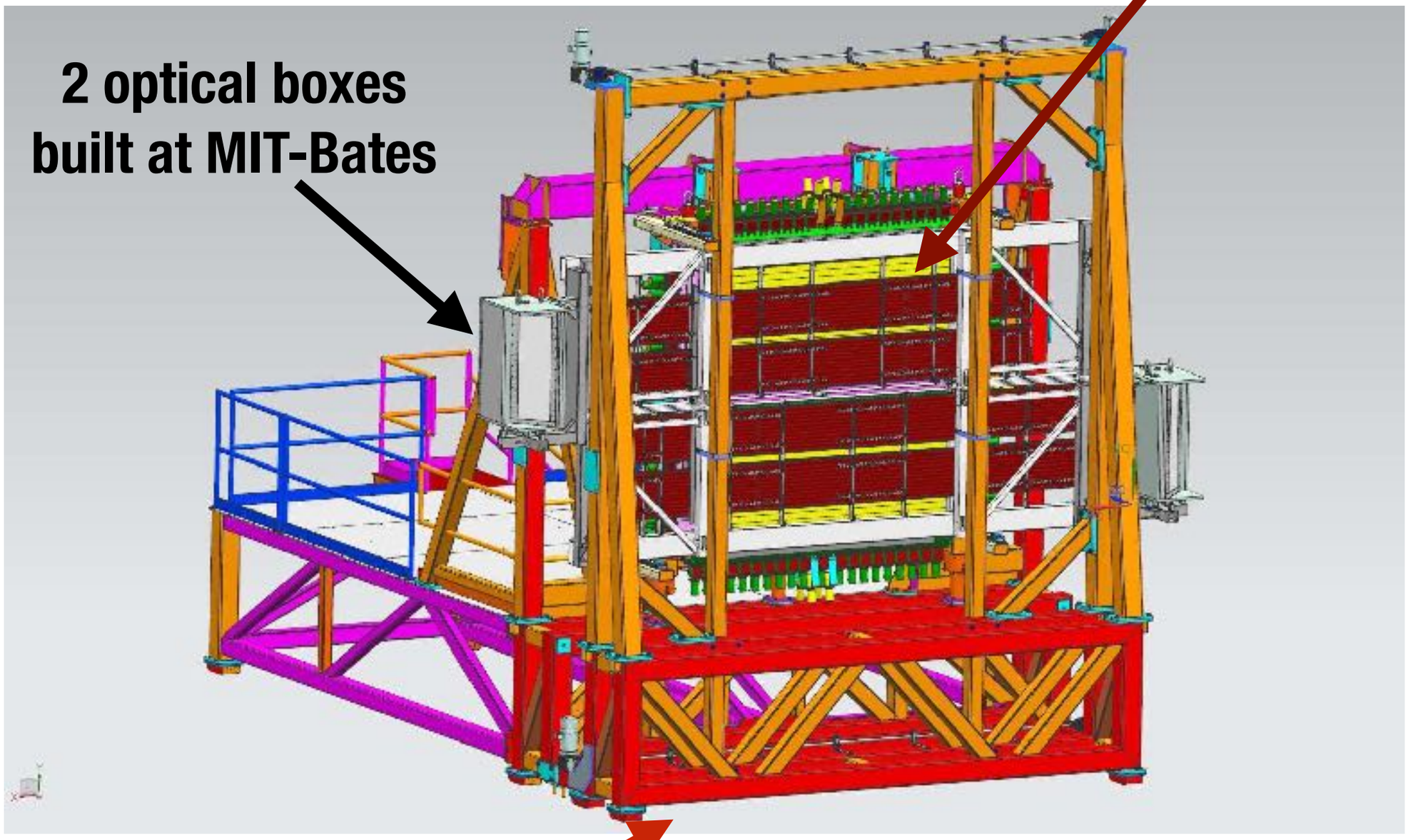






Cherenkov Photon "Ring"

DIRC detector overview



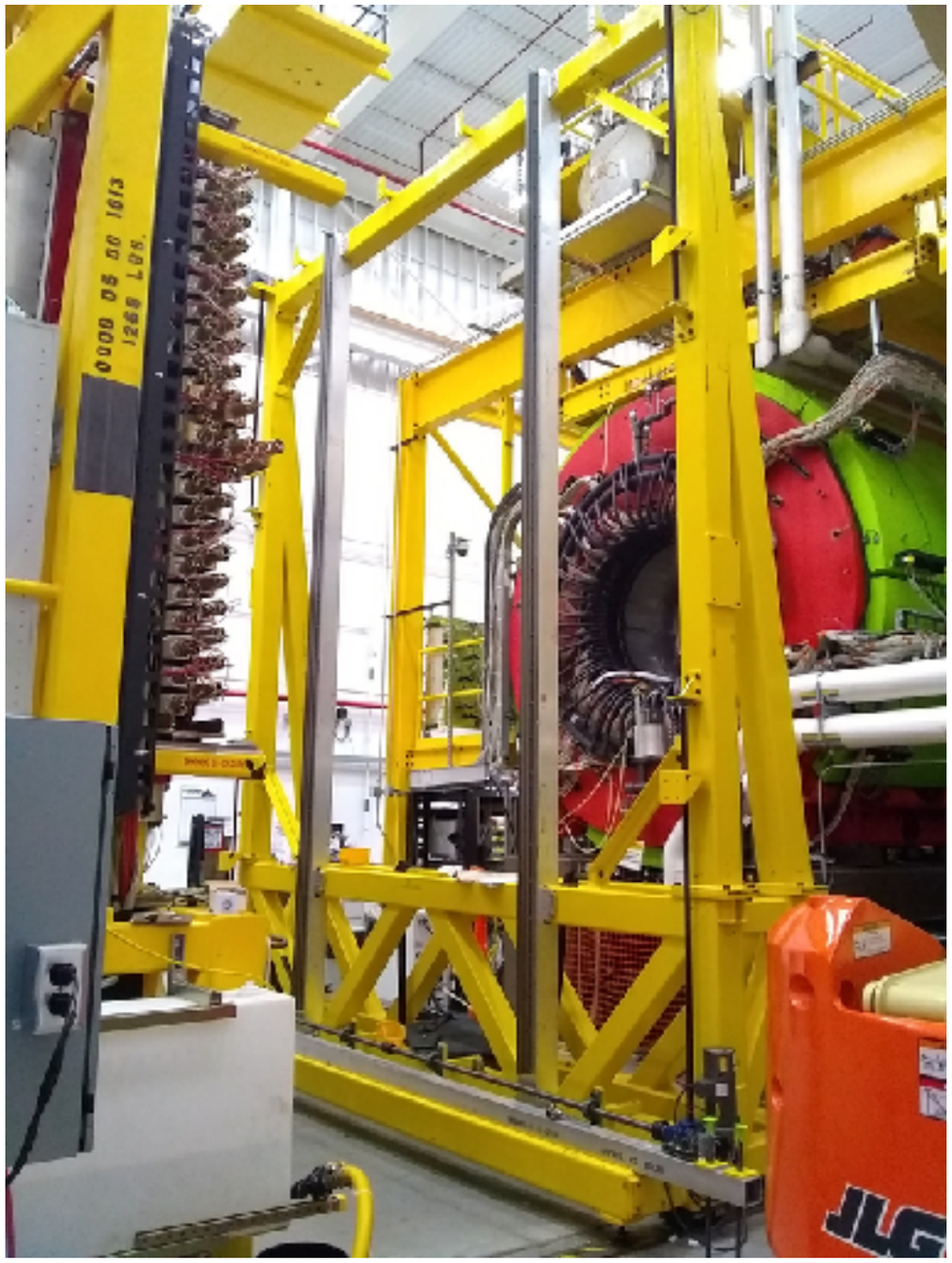
Mechanics: Support structure

INDIANA UNIVERSITY

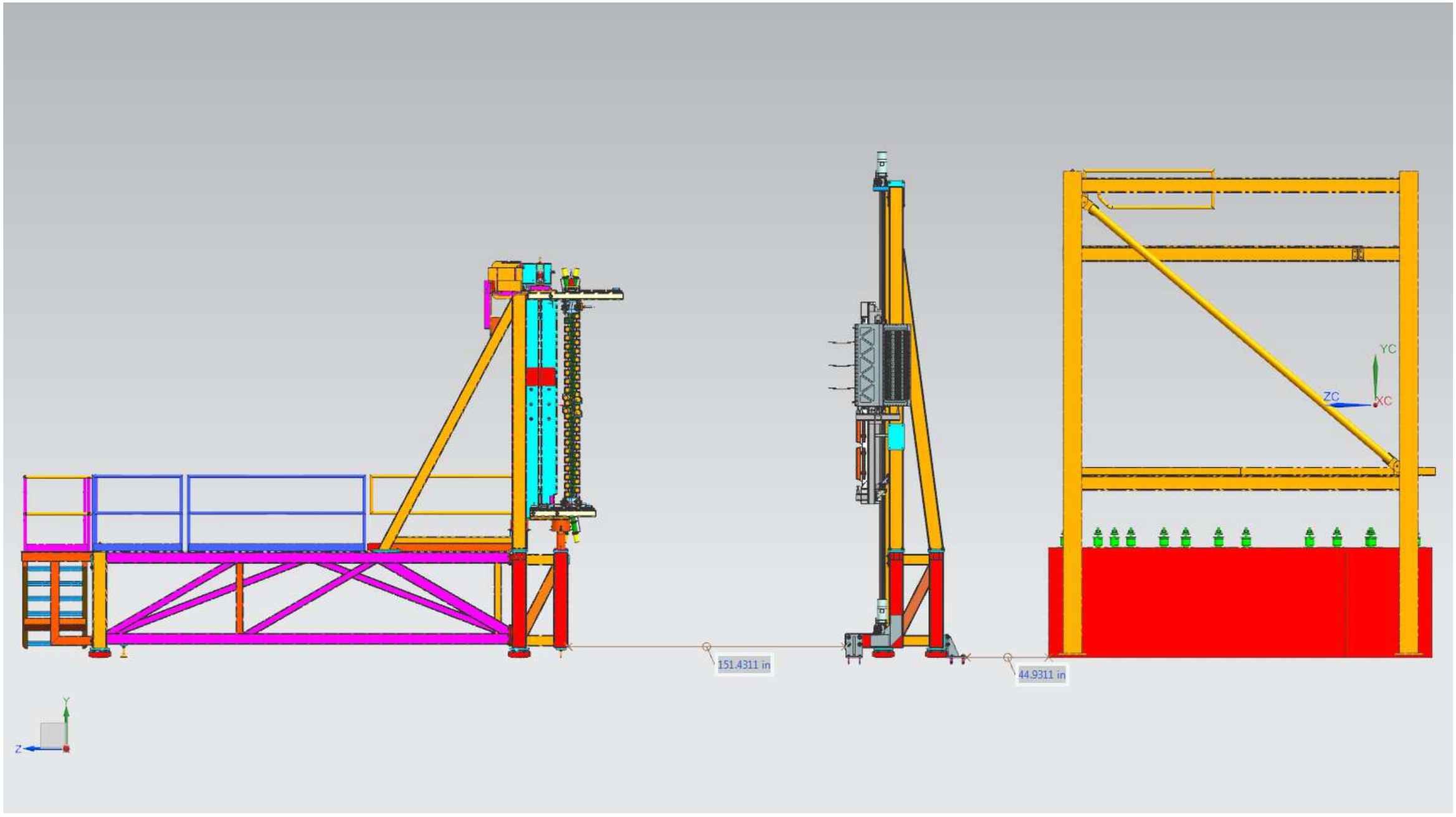
Jefferson Lab

Support structure

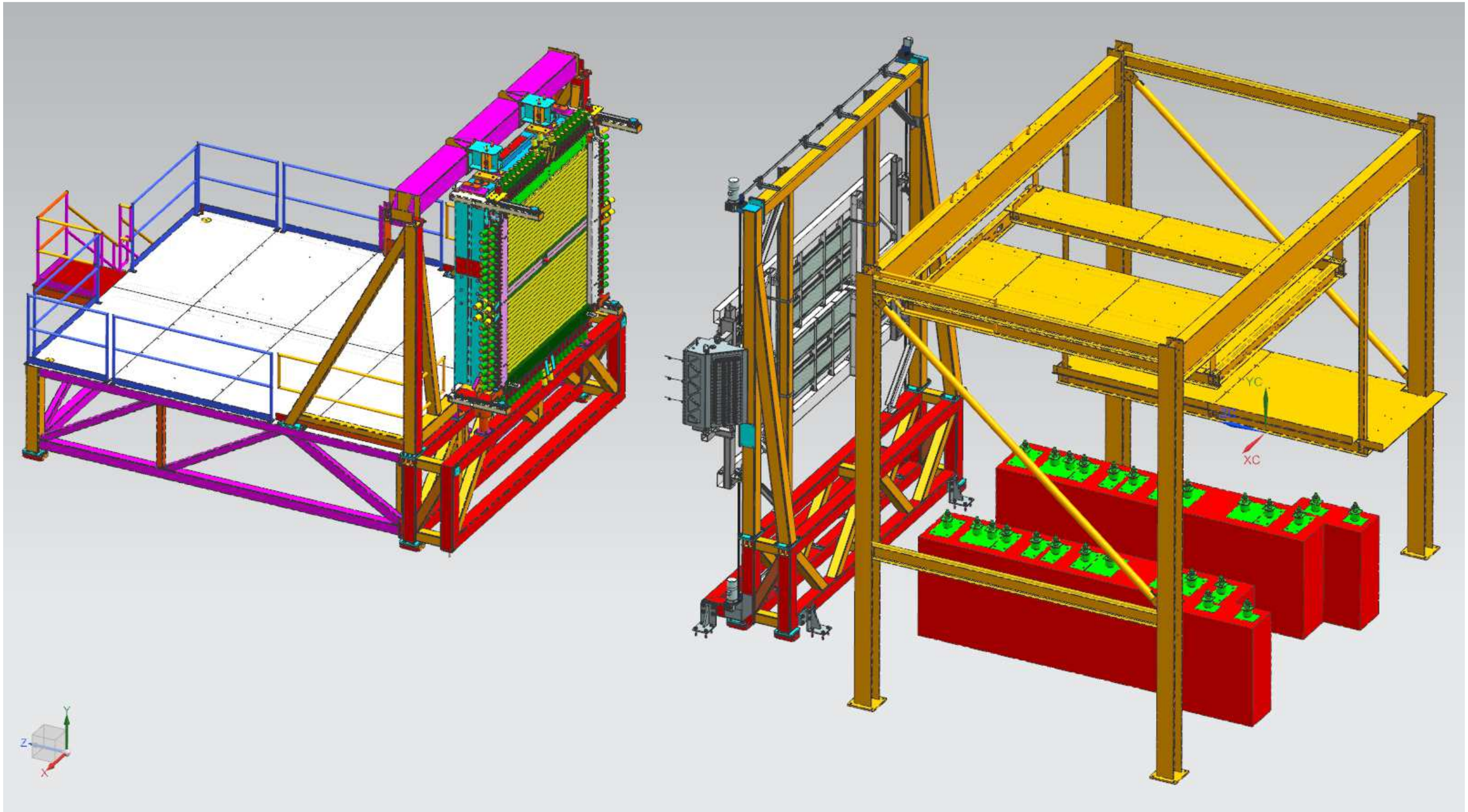
- Follow similar structure for supporting bar boxes from BaBar
- **Requirements:**
  - Minimized material in active area in front of FCAL calorimeter
  - Ability to remove detector elements from active area for other experiments, eg. PrimeX
- Delivered in July 2017 and **installation completed!**



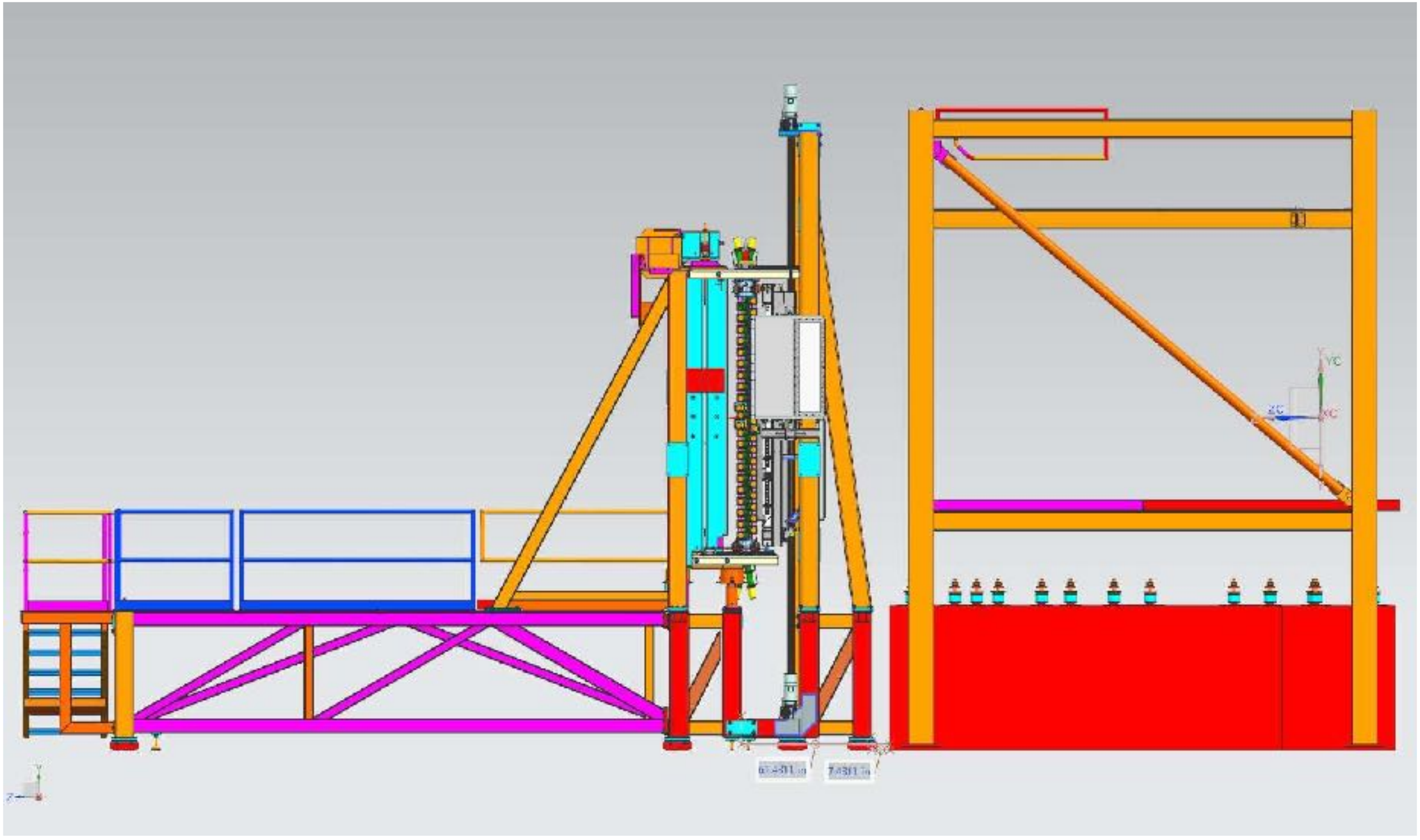
Hall D installation views



Hall D installation views



Hall D installation views



Transportation

Massachusetts Institute of Technology

INDIANA UNIVERSITY

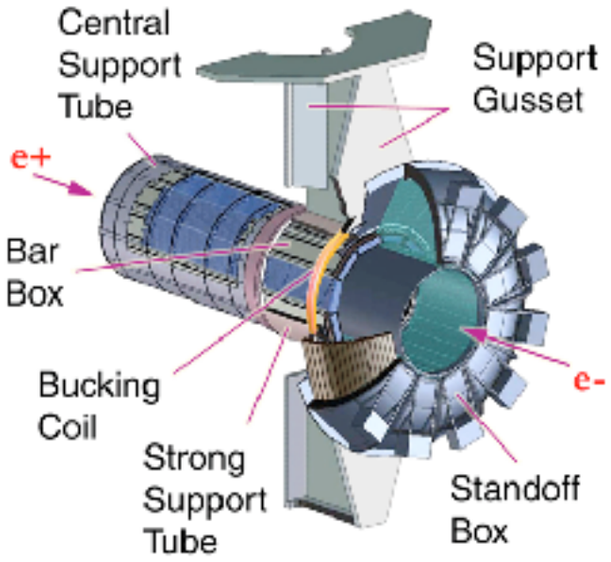
Jefferson Lab

The Catholic University of America

GlueX DIRC

RECYCLE

Final shipment from SLAC 3 weeks ago!



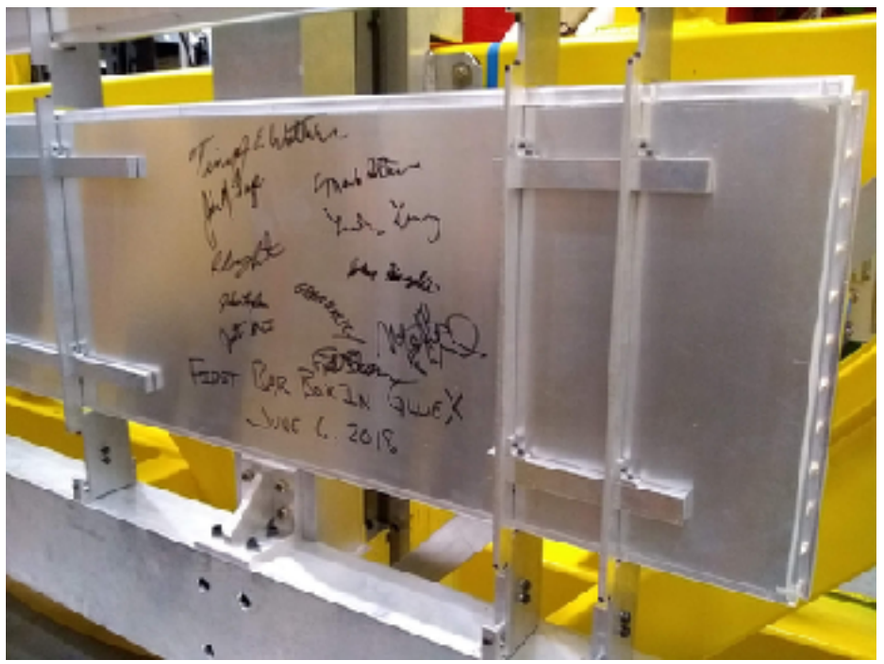
Follow the trip: twitter @GlueX_DIRC

Transportation strategy

- Transport 4 bar boxes from SLAC to JLab in two separate shipments
- First bar box shipment in November 2017, second shipment of three after demonstrating initial trip
- System required to monitor bar boxes in transit
  - Camera system developed and extensively tested with boxes at SLAC before transport
  - Full system developed (cameras, N_2 sensors, accelerometers, etc.) for real time monitoring
  - Central computer on truck broadcasts wireless to trail car, over the entire trip

Transportation **complete!**

- 4 bar boxes transported from SLAC to JLab with no visible issues mechanically or optically
- 2 bar boxes successfully installed for Fall 2018 commissioning; remaining 2 stored safely in Hall D
- Planning to write document on procedure for future possible shipments (*not in GlueX project scope*)



Optical box: design and fabrication

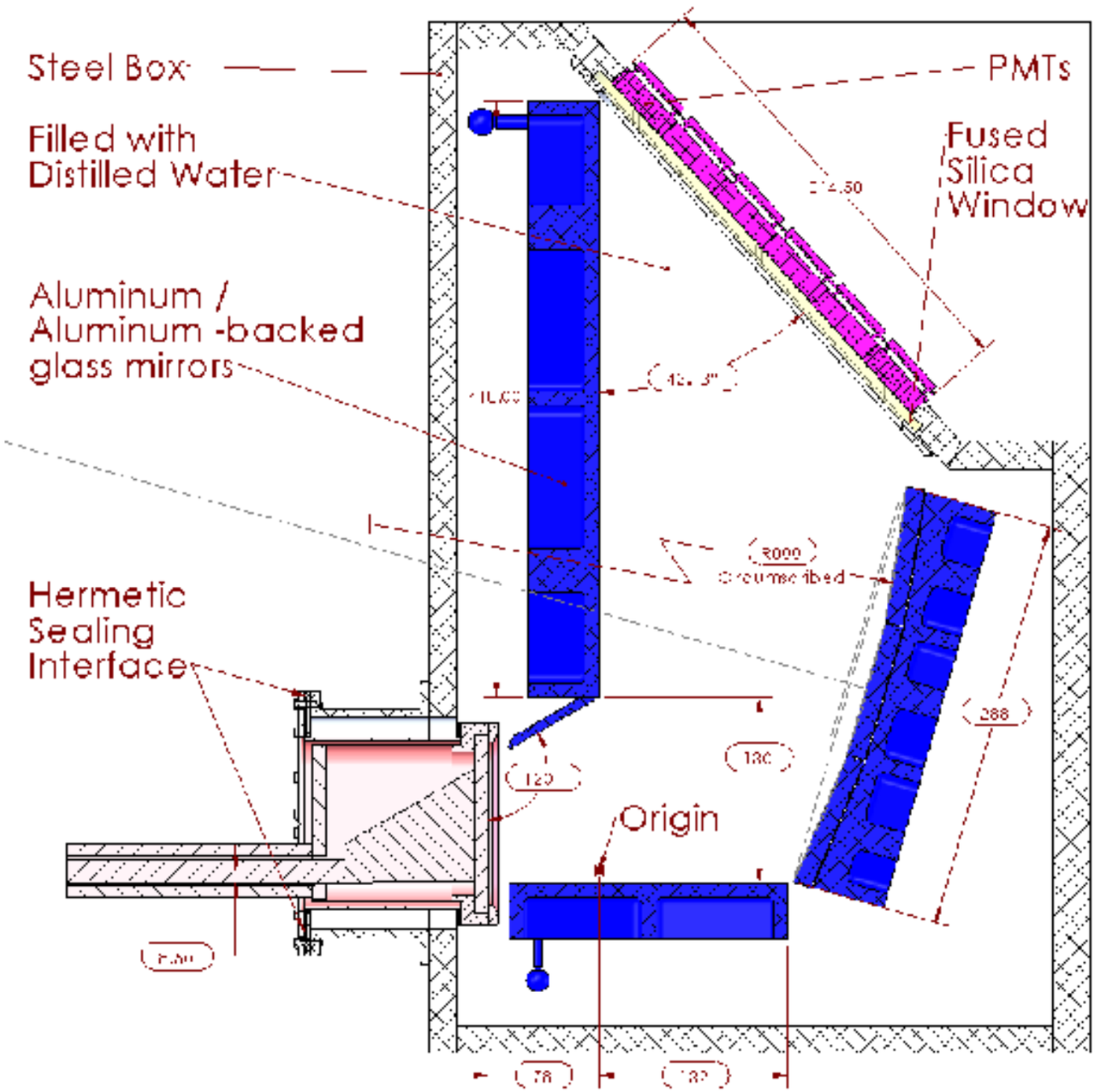
Massachusetts Institute of Technology

Jefferson Lab

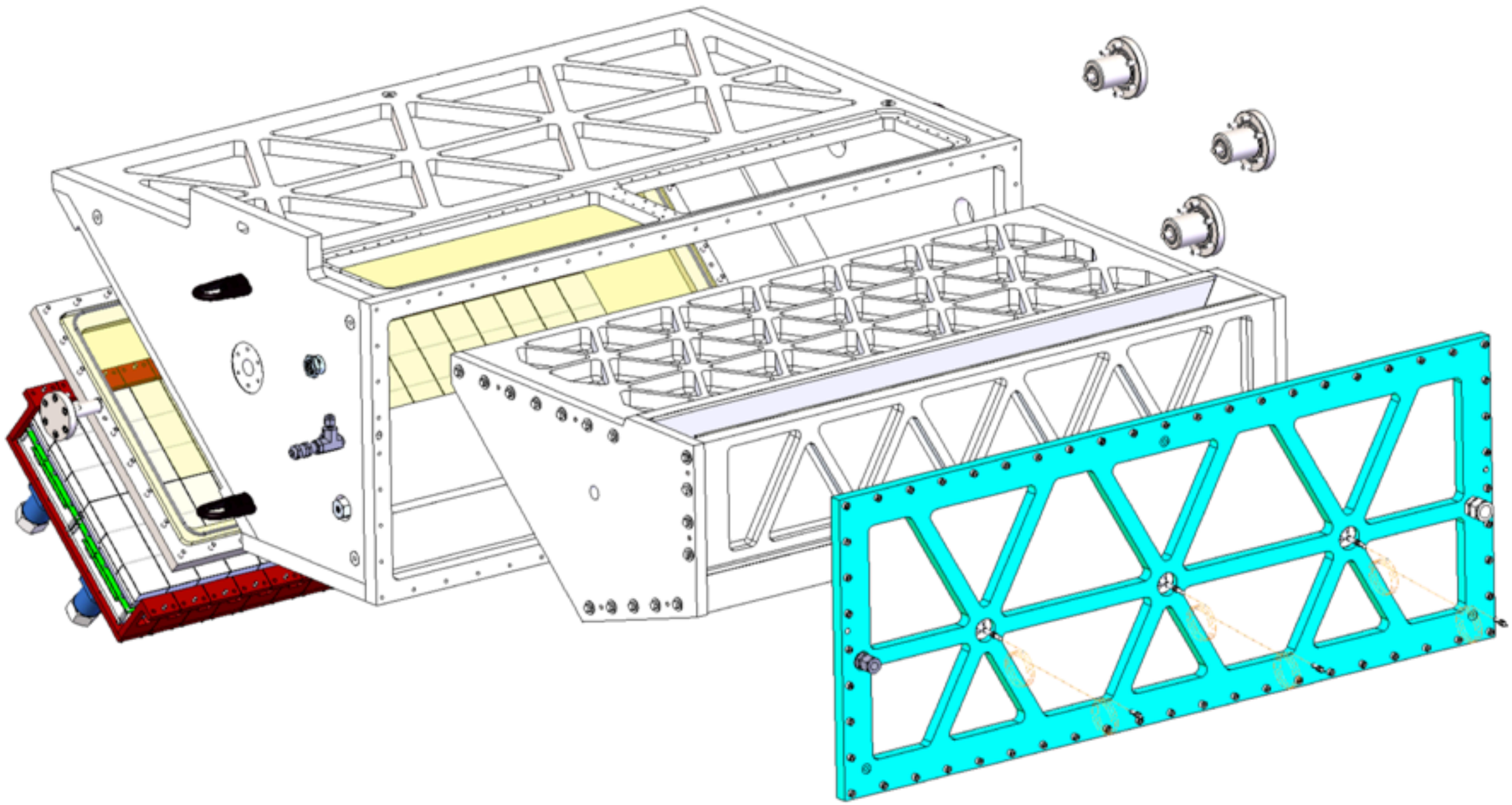
Optical box design

- Improved coupling of bar box and optical box
- Calibration light sources added
- Optical cookies for PMT coupling
- Thicker quartz window required

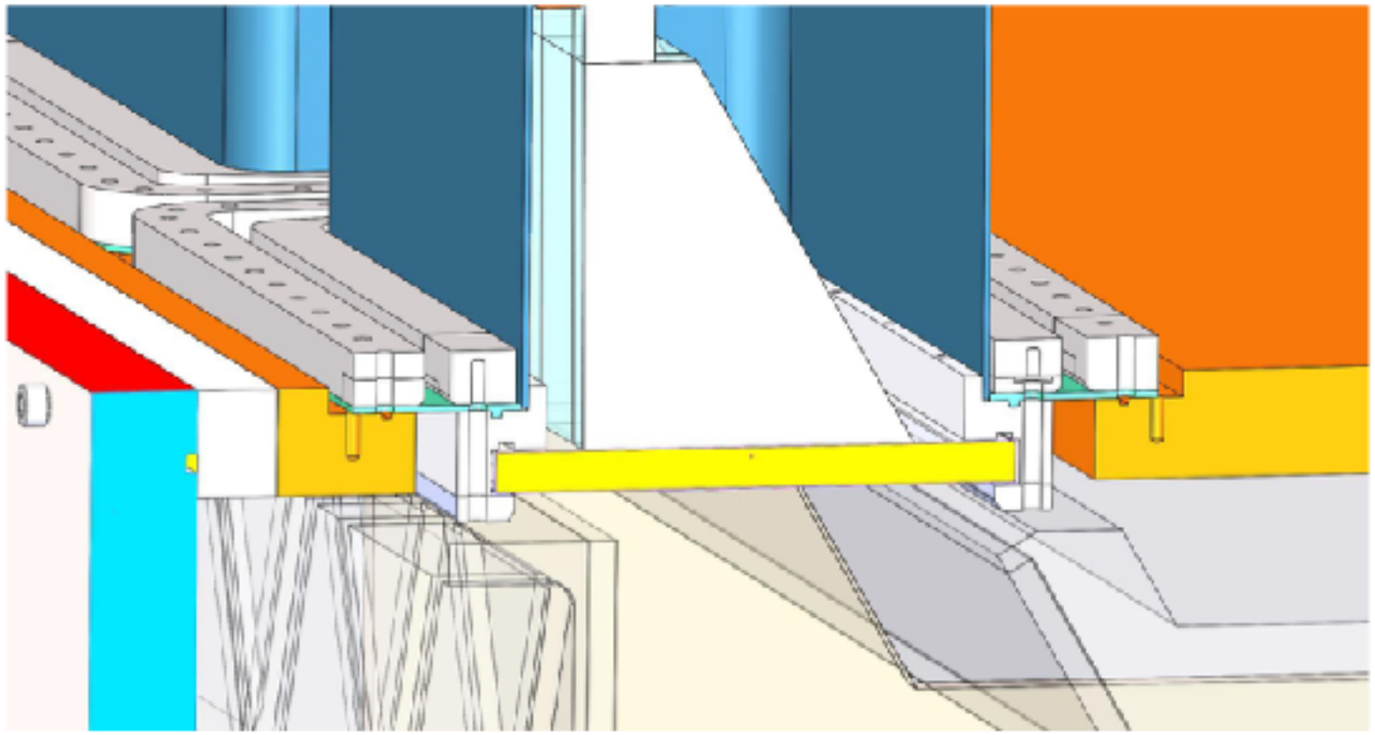
Design from 2015 review

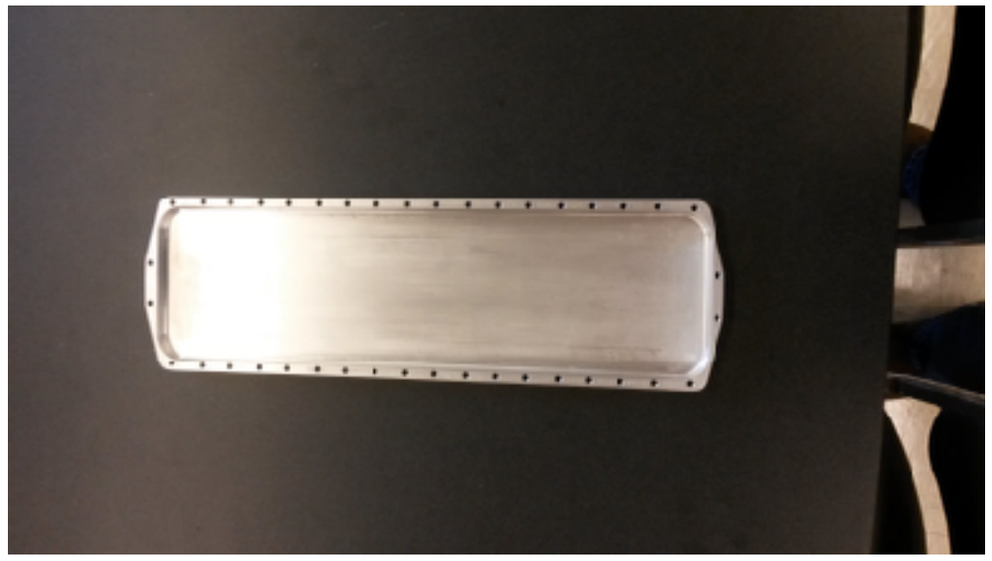


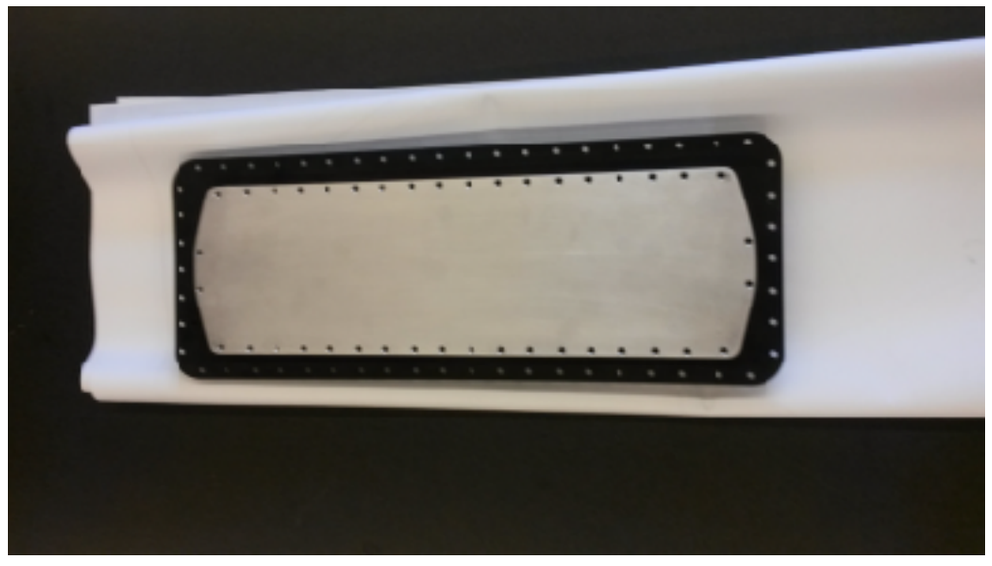
Optical box design



Bar box coupling

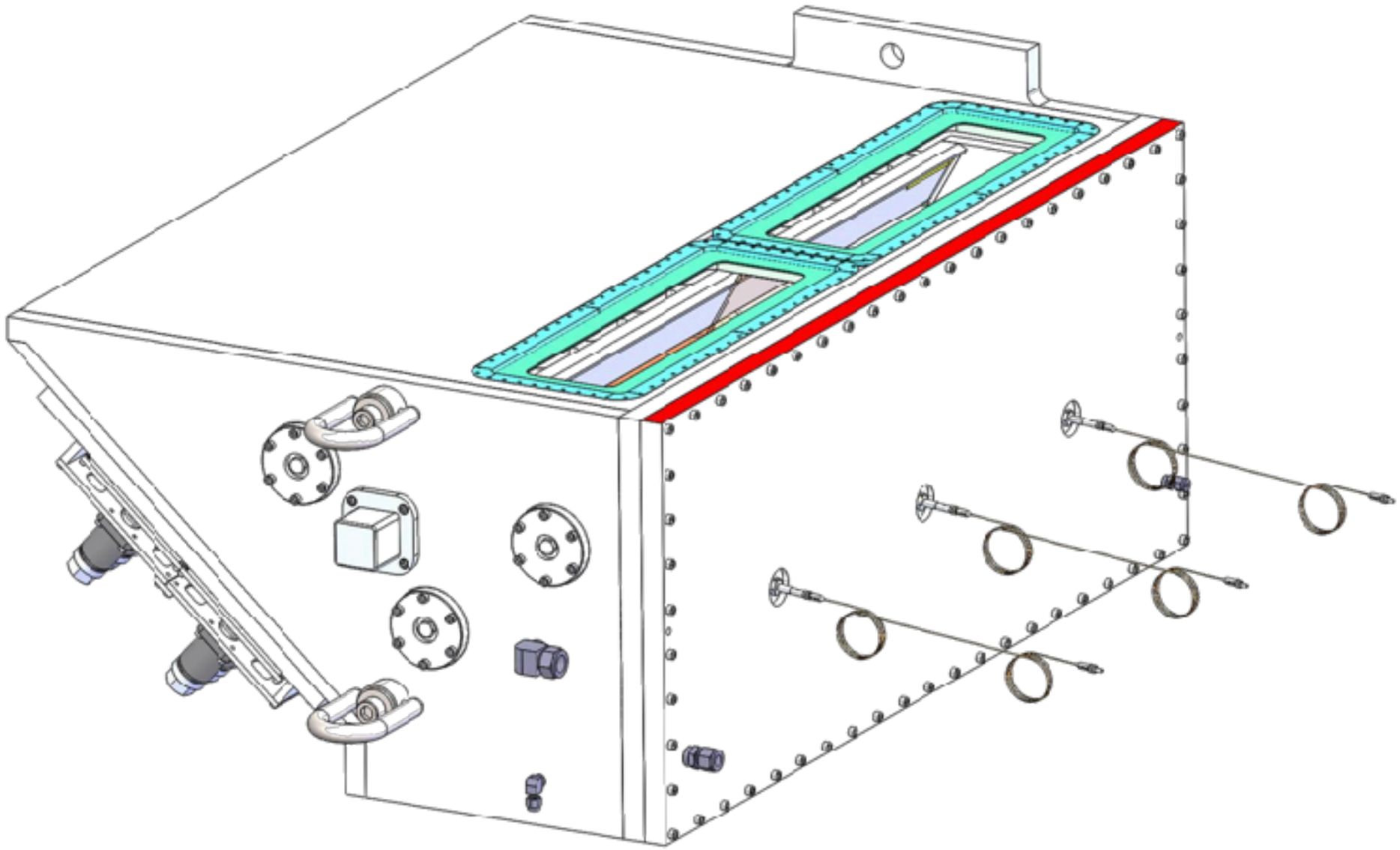






- New gasket designed and procured at MIT
- Will be used in optical box leak tests at MIT and in installation of bar boxes JLab

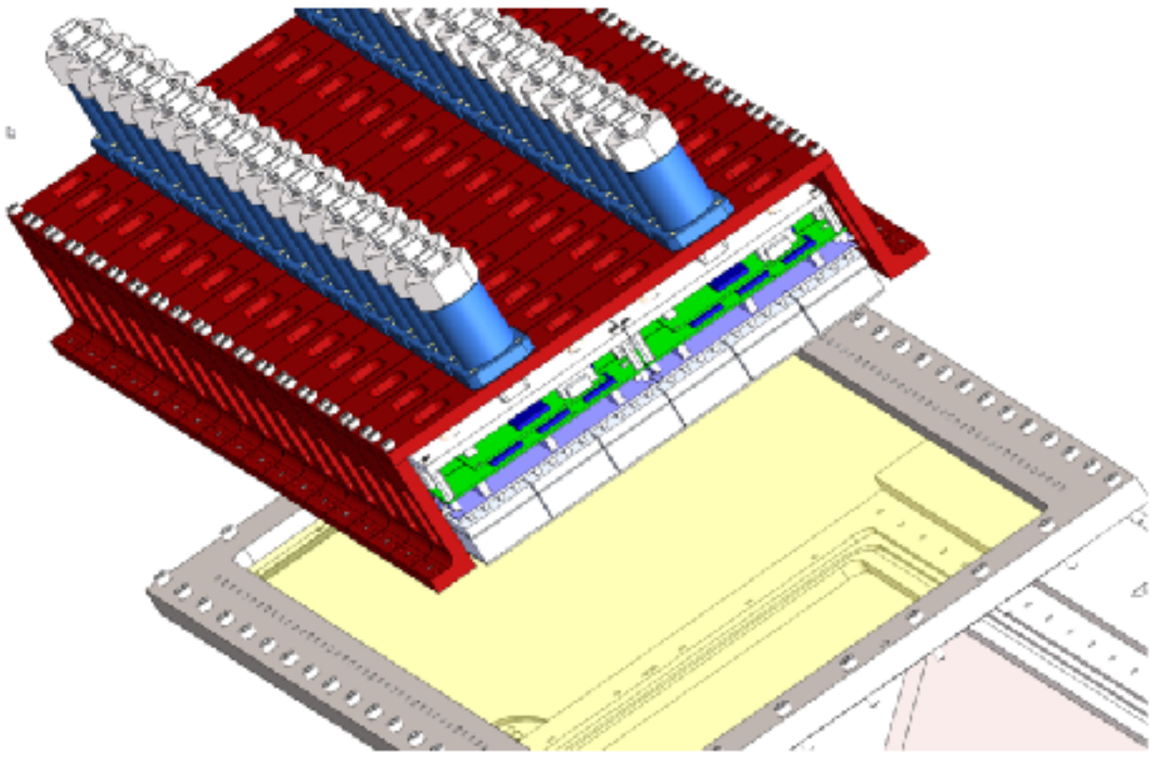
Optical box design

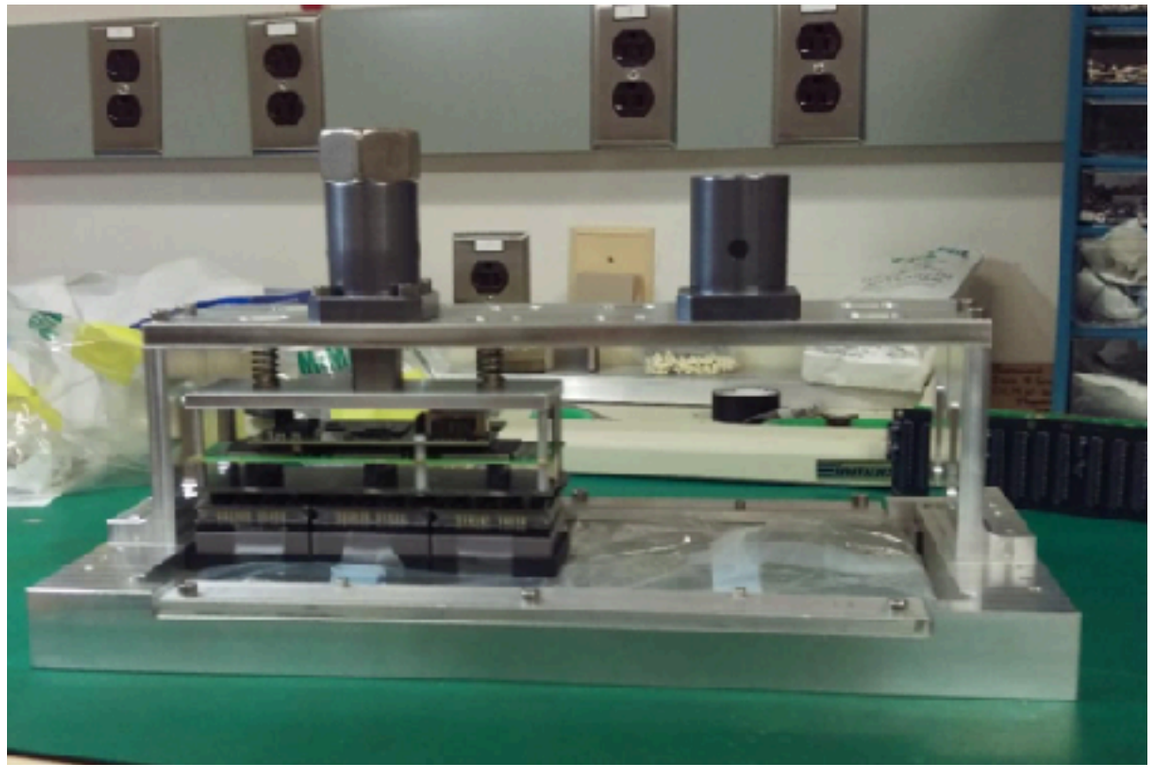


- Interface with support structure and water system
- Optical fiber ports for calibration light source

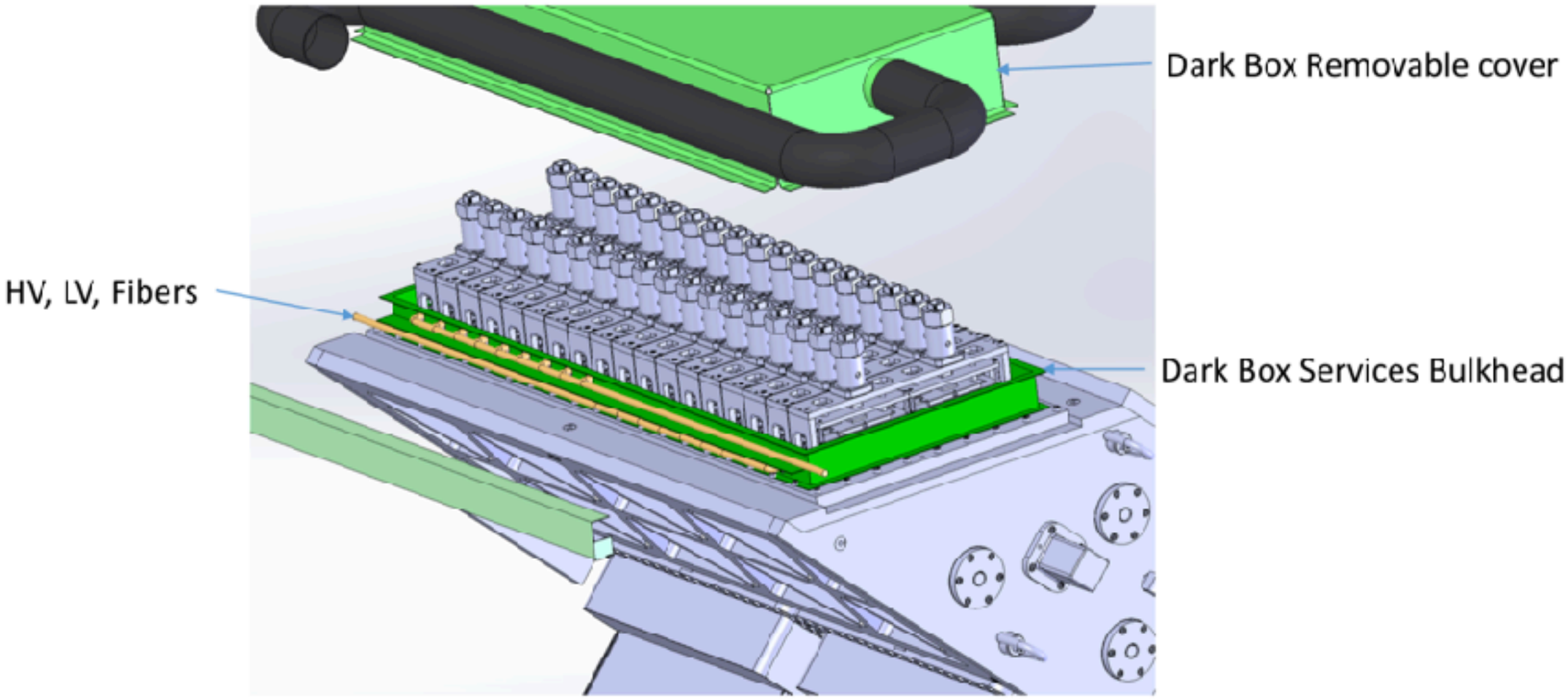
MAPMT installation

- 18 rows (2 modules each) are mounted to each optical box through an assembled bracket
- Prototype bracket at MIT-bates: testing coupling with optical cookies to dummy window
- Production of components for all brackets underway



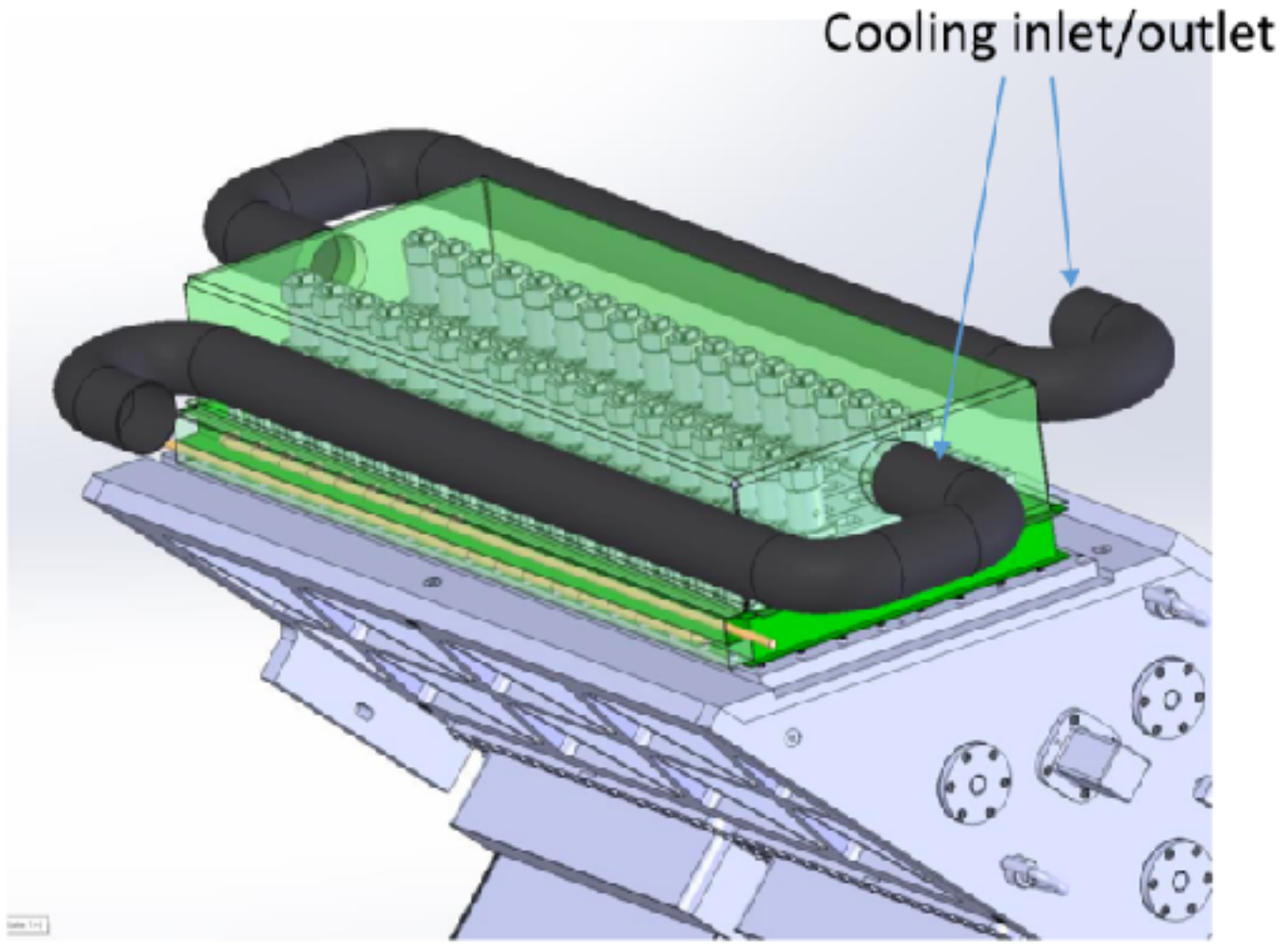


Dark box



- Provides light tight environment for PMTs and cooling for electronics in the enclosed environment
- Interlock HV with proximity sensor and temperature sensors to protect PMTs and electronics

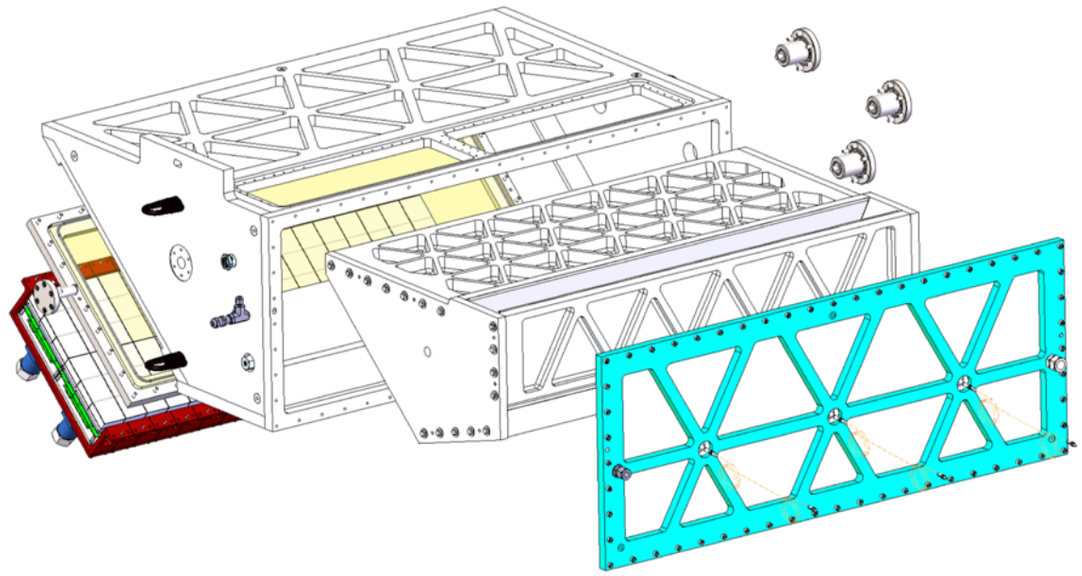
Dark box



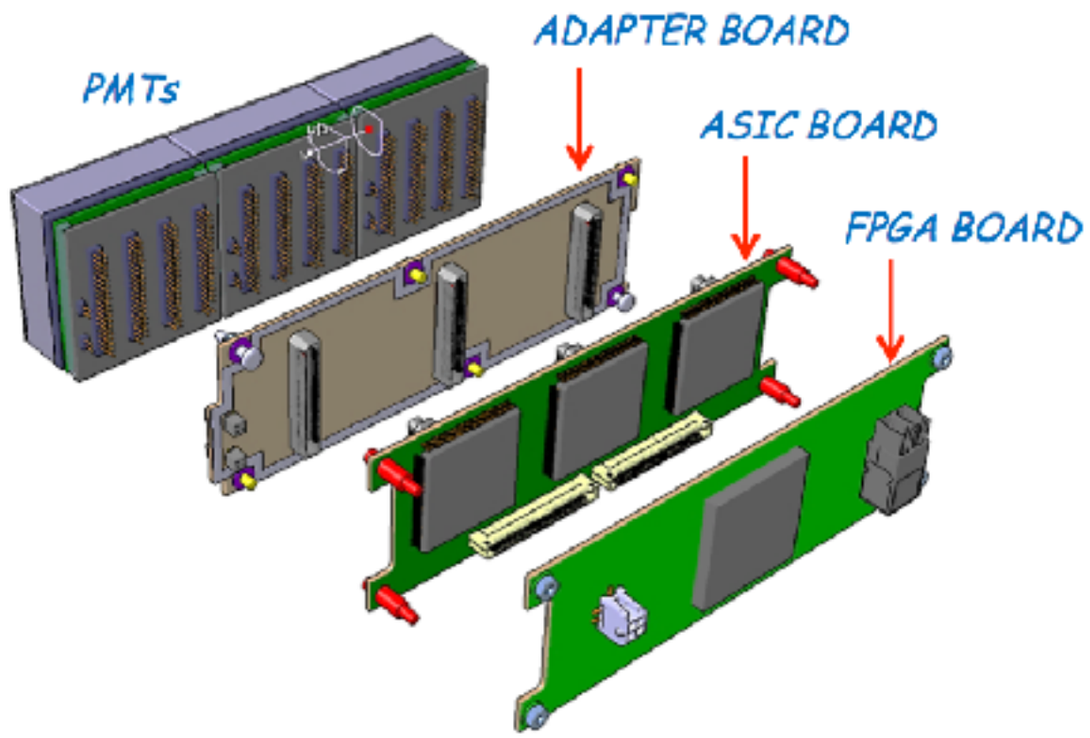
- Provides light tight environment for PMTs and cooling for electronics in the enclosed environment
- Interlock HV with proximity sensor and temperature sensors to protect PMTs and electronics

Optical box fabrication schedule

- Water system at JLab ready for optical box install



- Outer box being fabricated at vendor and delivery to Bates is expected July 1
- Mirror strongbacks fabricated and delivered to Bates
- Delivery of completed optical box expect July 14
- Expect quartz window delivered to JLab by July 24



Electronics and MAPMTs

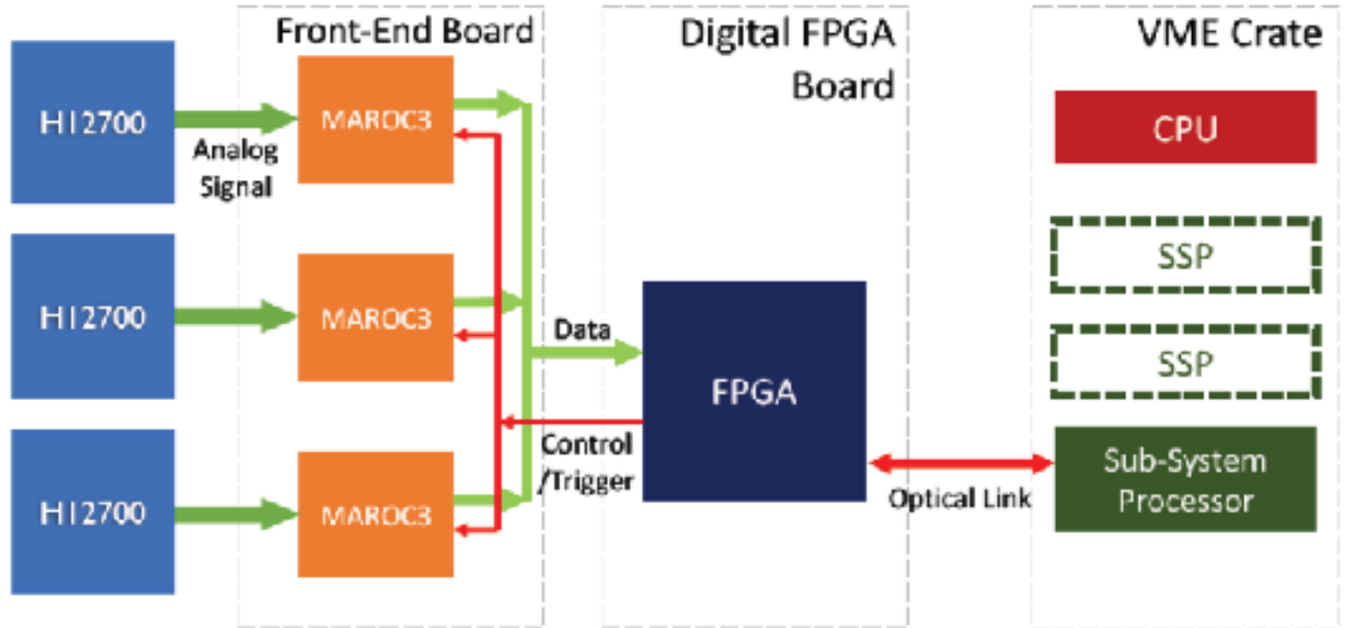
WILLIAM & MARY
CHARTERED 1693

Jefferson Lab

MAPMTs

- Full order for 210 H12700 MAPMTs placed in November 2017: (180 required + 30 spares)
- Production/delivery faster than initially expected:
  - 170 MAPMTs delivered so far (~40/month), so order should be complete by August

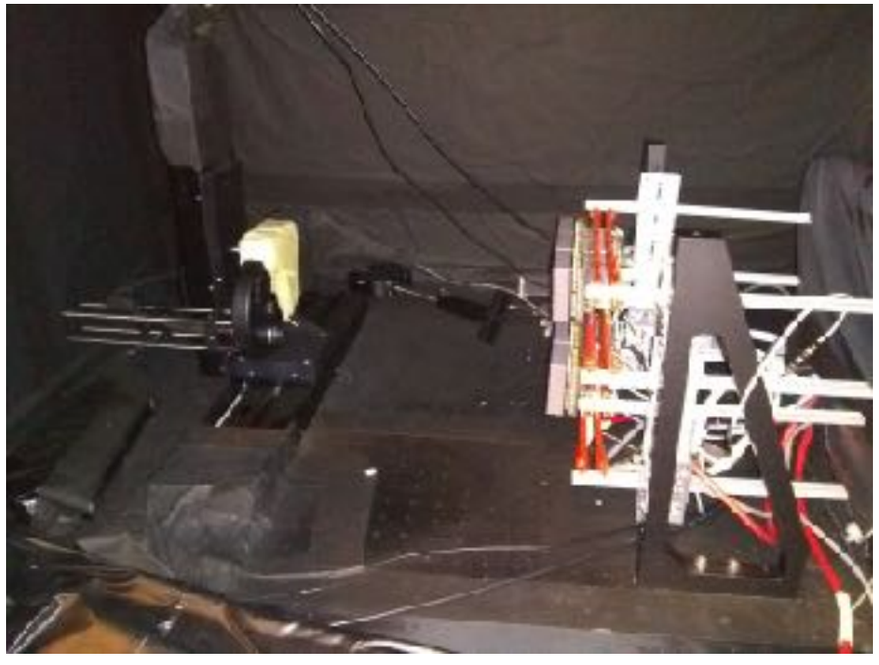
Readout electronics and cables

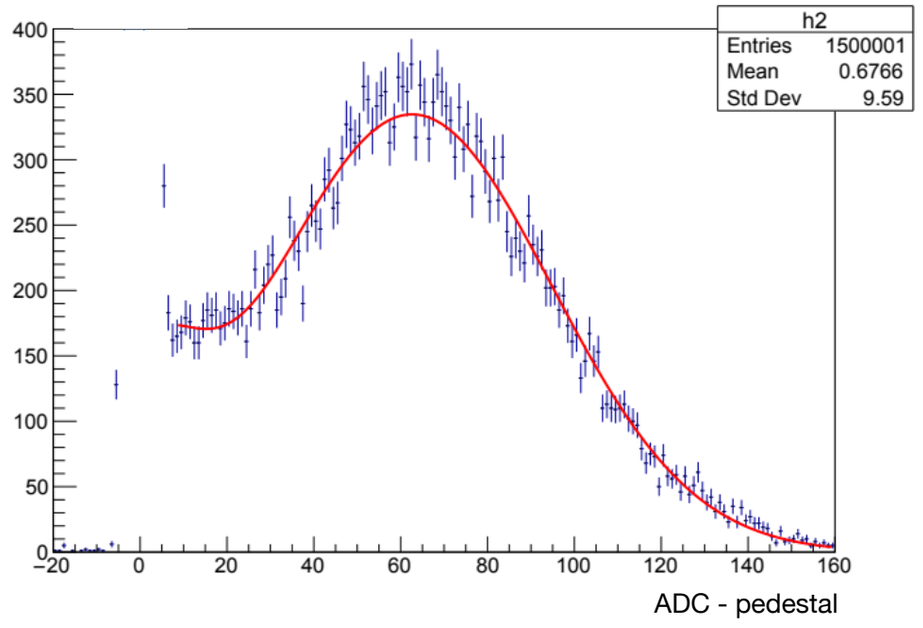


- All readout components for Fall 2018 installation are in hand at JLab or will arrive before August installation
- All ASIC, Adapter, FPGA boards at JLab and undergoing testing with MAPMT modules as they arrive
- Some remaining components (HV, LV, etc.) needed for January 2019 will be purchased later this year

PMT testing and calibration data

- Continuous testing in laser setup provided by Valery K. (Hall B RICH) since February 2018
  - Integrated test of PMTs, ASIC, and boards
  - Few minor failures with FPGA boards identified
- Determining timing resolution, gain, and efficiency for each pixel to be used in reconstruction





Cabling

MTP-LC Fiber

LV Distribution Chassis

Readout Tile

PMT

Window on Focusing Box

1

2

18

HV Distribution Chassis

Hall D GND Grid

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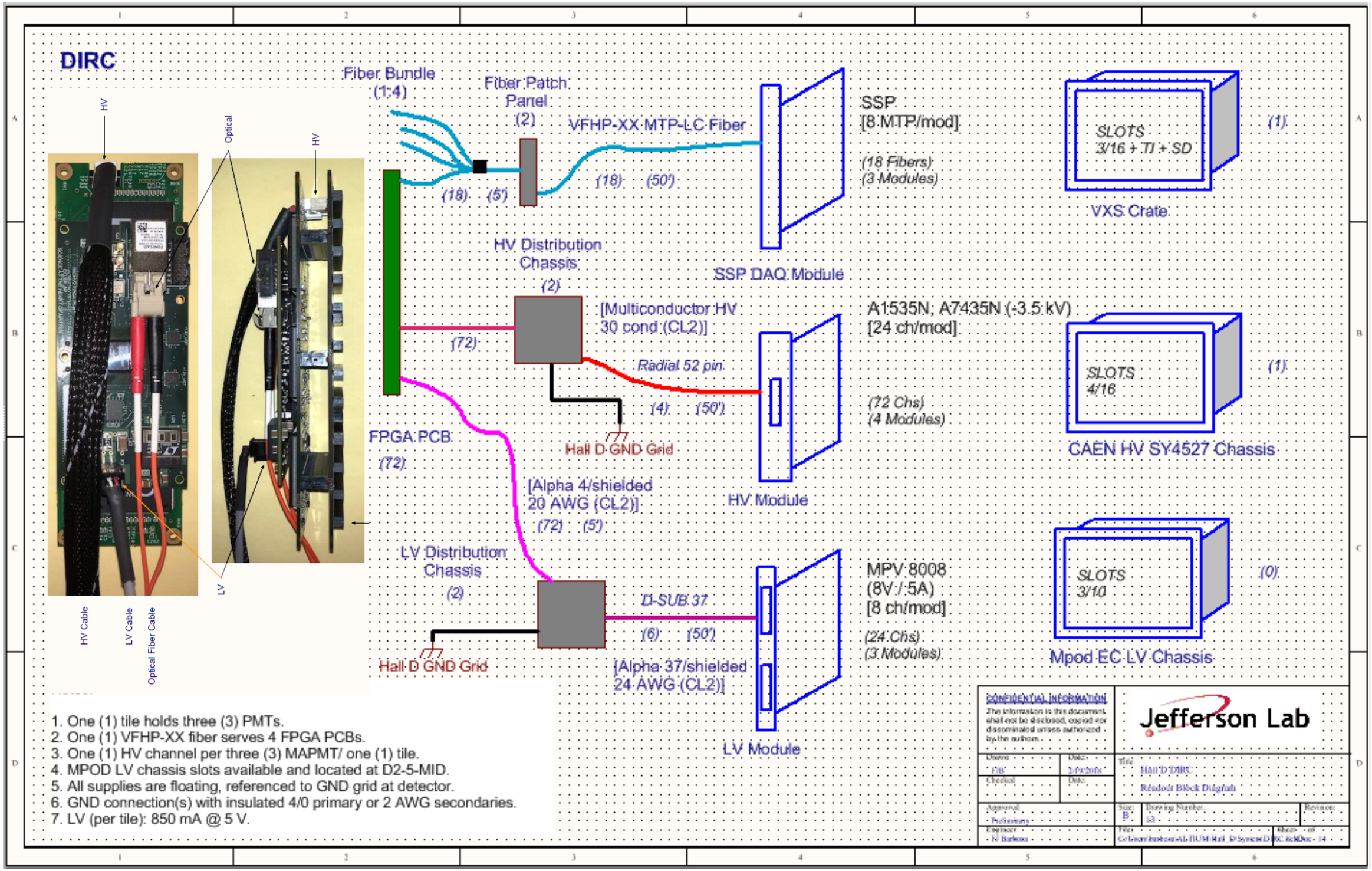
Jefferson Lab

Drawn: DB Date: 10/10/05
Checked: Date:
Approved: Preliminary
Engineer: DJ Barbosa
Size: B
Drawing Number:
Revision:
Title: DIRC Readout Tile Arrangement
File: C:\Users\barbosa\ALTIUM\DIRC\DIRC Block Diagram\DIRC Readout T...
Sheet 1 of 1

Cabling and DAQ



Hazards and Mitigations

Hazards	Mitigation/Controls
Exposure to high voltage or damage to MAPMTs	Dark box enclosure interlock turns off HV and LV through proximity sensor
Elevated temperature in dark box enclosure	Air cooling to remove excess heat, interlock system to turn off HV and LV if system is off or temparaure exceeds threshold
Nitrogen purge system: pressure and ODH	Very low flow (< 5 L/hr), ODH alarms in the hall
Water system: pressurized fluid	Maximum pressure of pump is 35 psi, very low stored energy

Calibration and commissioning

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CHARTERED 1693

Jefferson Lab

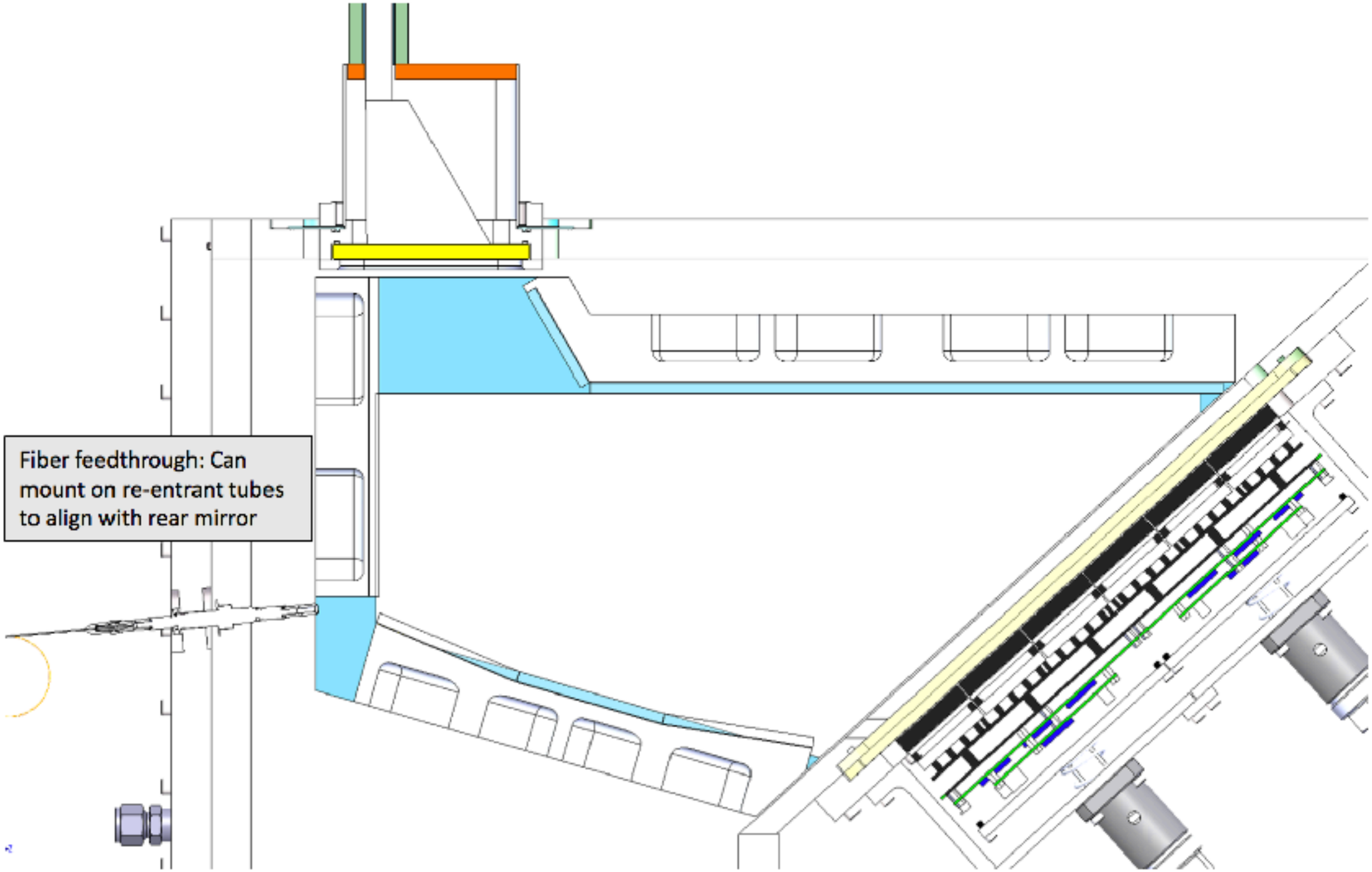
Massachusetts
Institute of
Technology

GSI

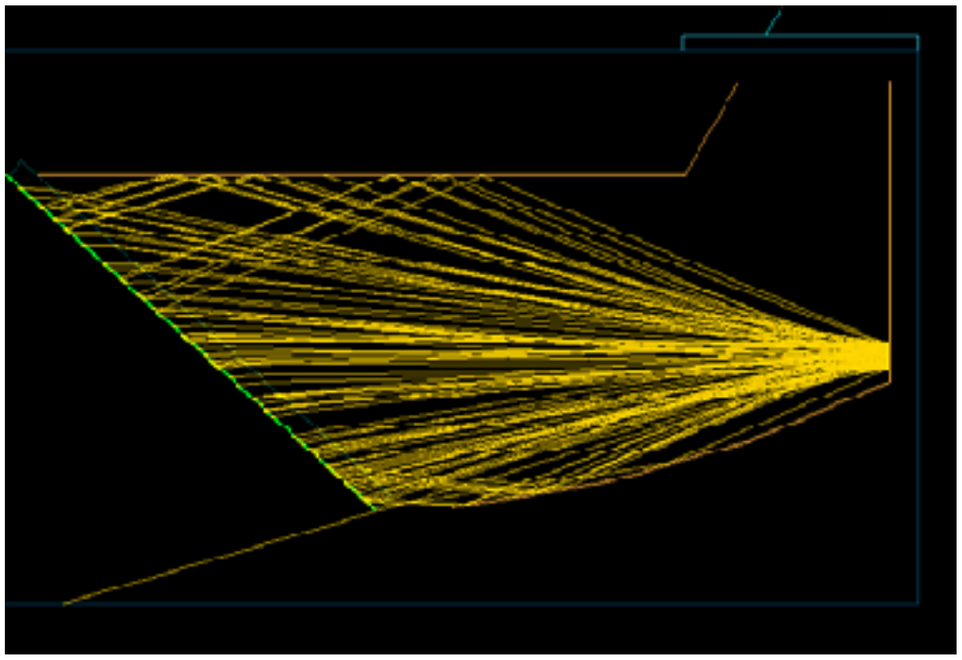
Calibration goals

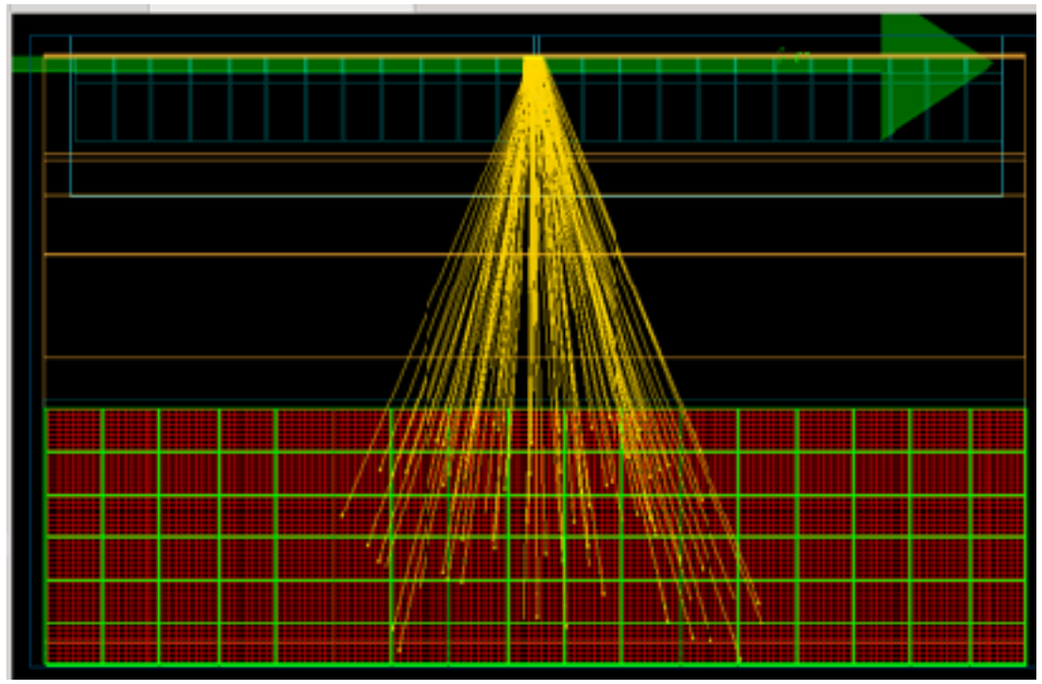
- MAPMT characterization prior to installation with the Hall B RICH laser setup (described previously)
- In-situ monitoring of gain and timing calibrations during the experiment
- Determination of final geometric alignment of optical components, utilizing pure samples of different particle types collected during the commissioning period

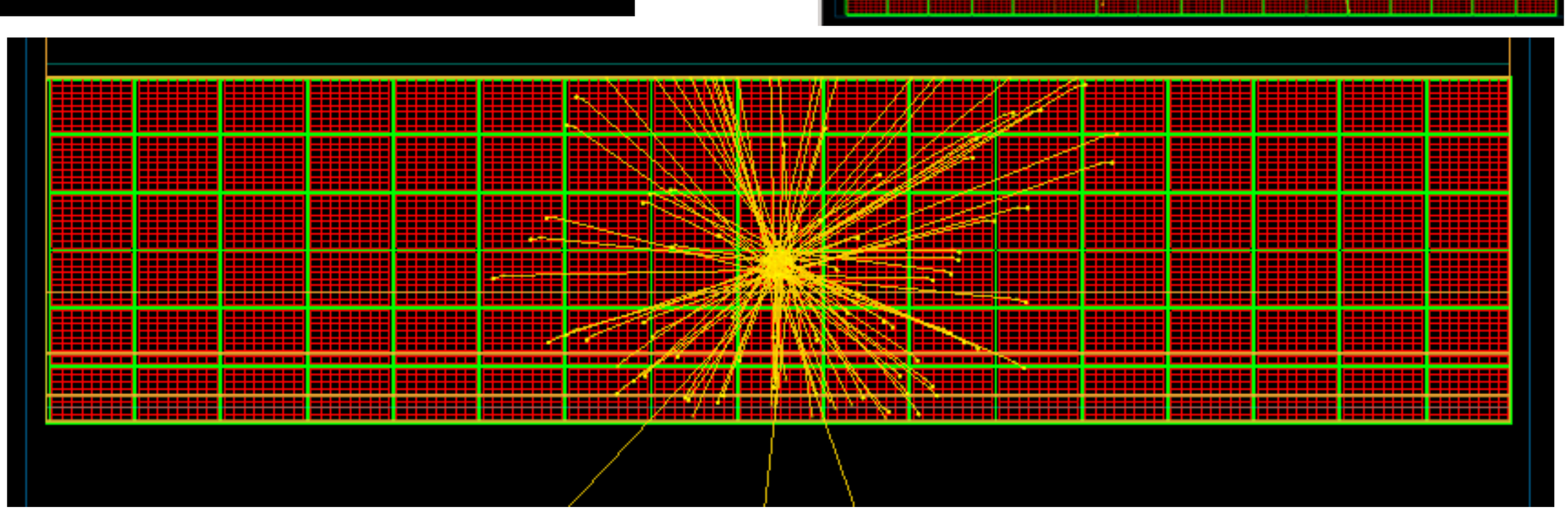
Calibration light source



Calibration source optimization

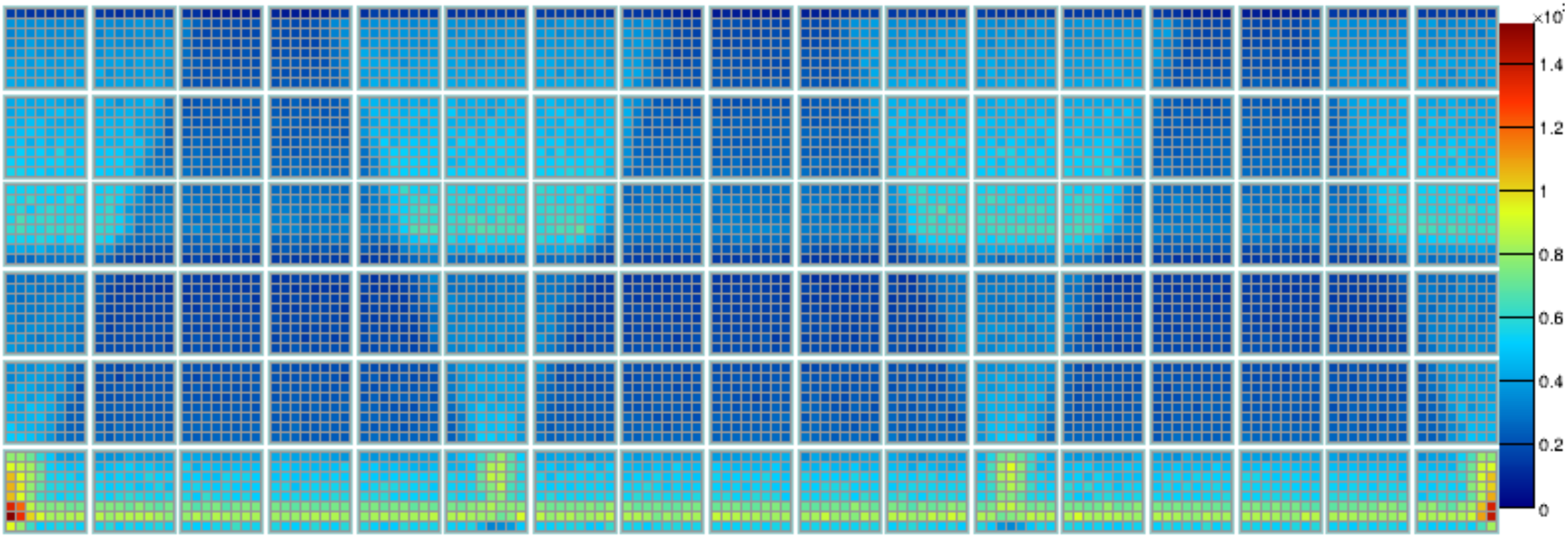






- Optimize opening angle, # fibers, etc… studies @ GSI

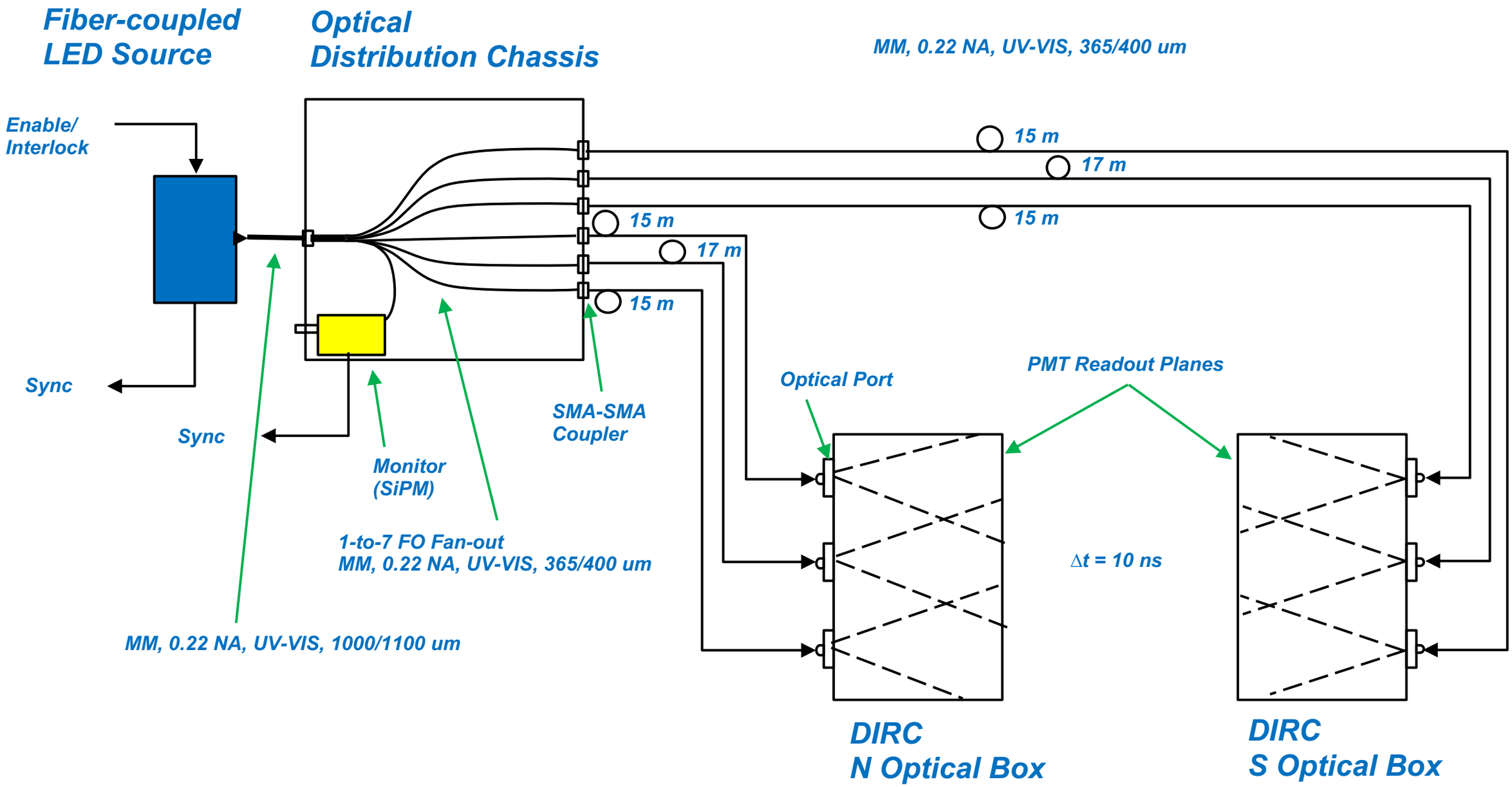
Calibration source optimization



- 3 fibers with a lens or square diffuser provides full illumination of the MAPMT plane
- Timing characteristics of LED light source provides sufficient measurement of each pixel's t_0

Calibration system

DIRC Calibration System



Fernando Barbosa

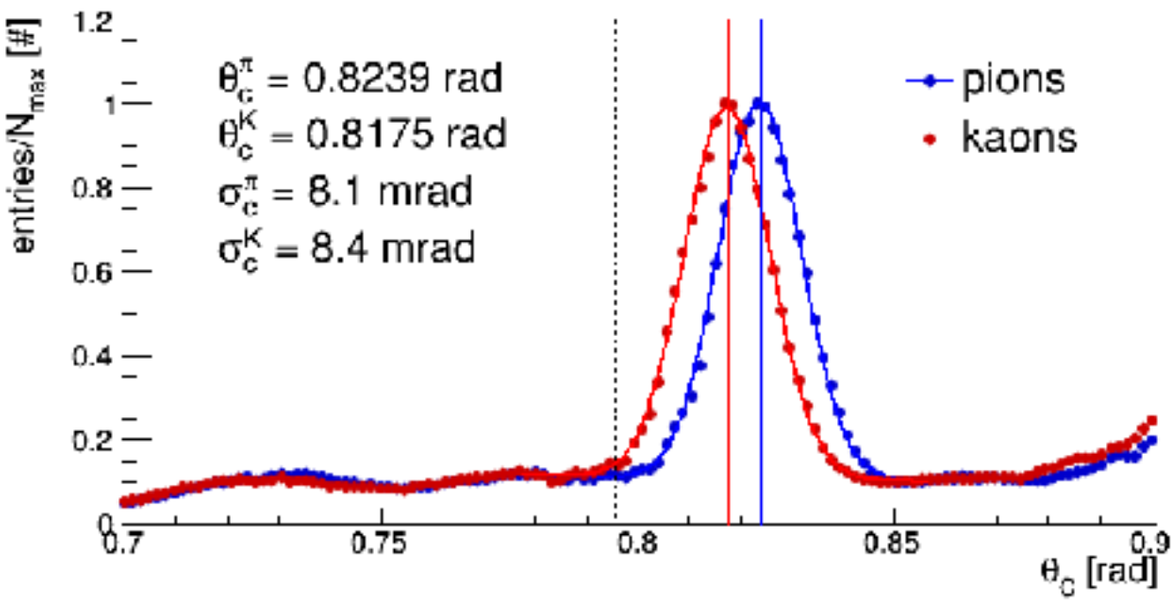
Commissioning program

- **Initial commissioning without beam:**
  - Calibrate timing provided by LED system
  - Integrate readout electronics into DAQ
- **Commissioning with beam:**
  - Collect samples of cleanly identified events with well measured tracks: e.g. $K_s \rightarrow \pi^+\pi^-$, $\phi \rightarrow K^+K^-$
  - Implement reconstruction algorithm and compare with simulation: # detected photons, θ_C resolution
  - Determine geometric alignment parameters using pure samples of known particle ID

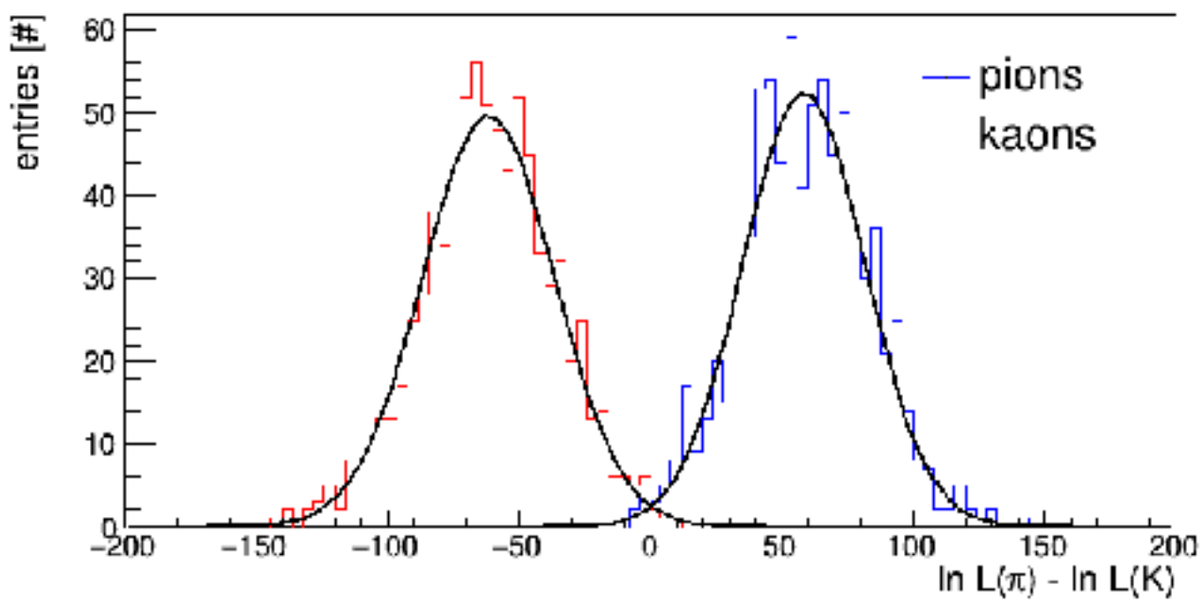
Reconstruction status

- For commissioning, plan to utilize Look Up Table (LUT) algorithm similar to that developed at SLAC
  - Fully implemented in GlueX reconstruction software: studies of commissioning simulation planned
- Future improvements with “time-based” imaging, to include time in 3D PDF expected

Single photon θ_c resolution



π/K separation power



The DIRC team and responsibilities

System	Names	Institution
MAPMT	Justin Stevens Wenliang Li	William & Mary
Electronics/Cabling	Fernando Barbosa Electronics Group	Jefferson Lab
Controls	Nick Sandoval Hovanes Egiyan	Jefferson Lab
Mechanical	Tim Whitlatch Mark Stevens	Jefferson Lab
Calibration/Analysis	DIRC analysis group	MIT, W&M, CUA, GSI

Upcoming schedule

- **July/August 2018:** 1st optical box delivered and installed before Fall 2018 run
- **November/December 2018:** Initial commissioning with ~half of detector installed
- **January 2019:** Complete installation with 2 more bar boxes and 2nd optical box before PrimeX run
- **Spring/Summer 2019:** Analysis of commissioning data and final checkout of full detector
- **Fall 2019:** Begin GlueX-II running with DIRC

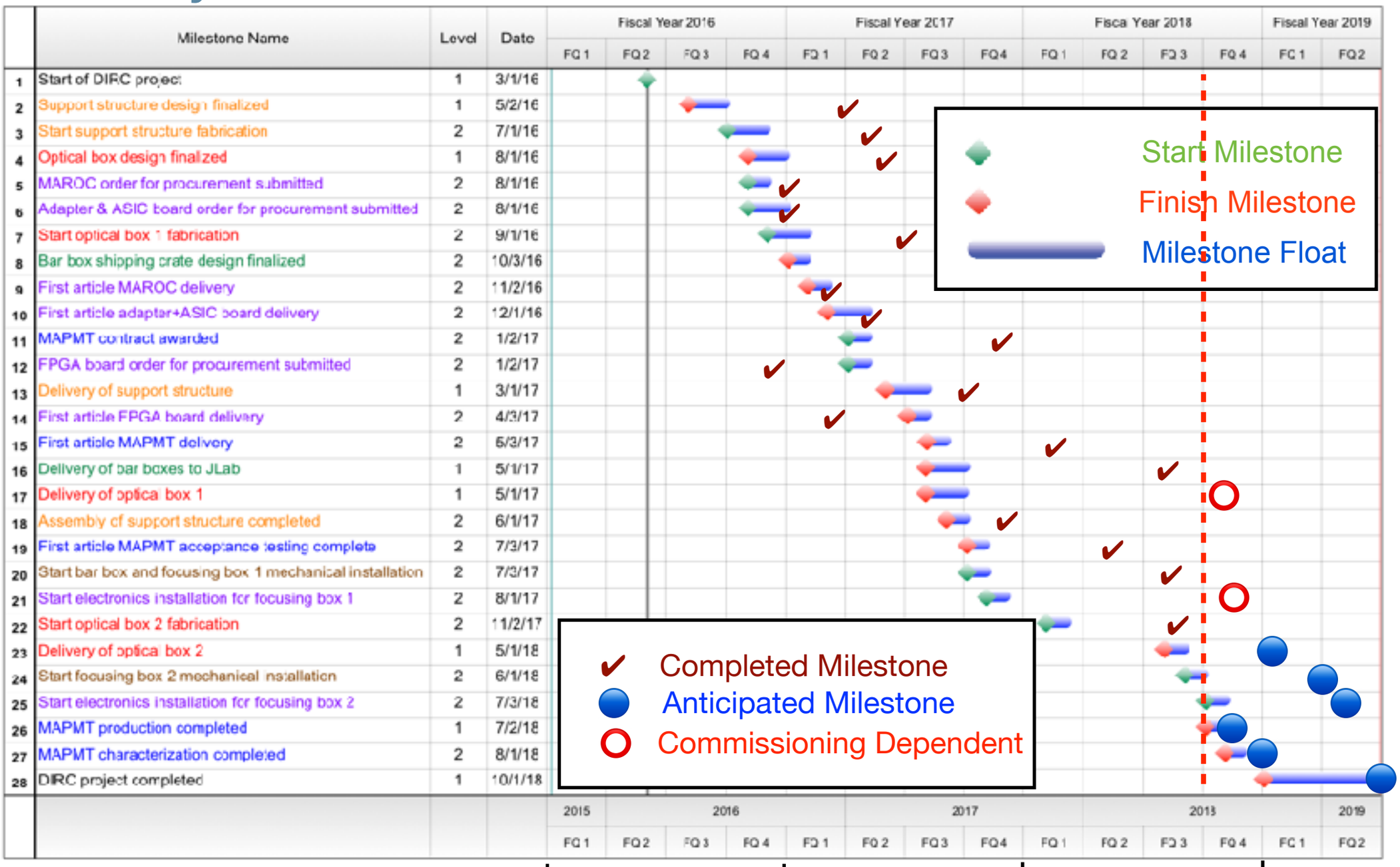
Summary

- BaBar bar boxes successfully transported from SLAC to JLab and installed on the support structure
- All PMTs and electronics required for the commissioning setup are acquired and tested
- Fabrication of the 1st optical box is ongoing at Bates and installation is contingent on this completion
- Installation of 1/2 of detector is expected to be completed in Fall 2018
- Commissioning of 1/2 of the detector will begin in November 2018, and full installation before GlueX-II physics running begins in Fall 2019

Backup

Project Schedule

	Milestone Name	Level	Date
1	Start of DIRC project	1	3/1/16
2	Support structure design finalized	1	5/2/16
3	Start support structure fabrication	2	7/1/16
4	Optical box design finalized	1	8/1/16
5	MAROC order for procurement submitted	2	8/1/16
6	Adapter & ASIC board order for procurement submitted	2	8/1/16
7	Start optical box 1 fabrication	2	9/1/16
8	Bar box shipping crate design finalized	2	10/3/16
9	First article MAROC delivery	2	11/2/16
10	First article adapter+ASIC board delivery	2	12/1/16
11	MAPMT contract awarded	2	1/2/17
12	FPGA board order for procurement submitted	2	1/2/17
13	Delivery of support structure	1	3/1/17
14	First article FPGA board delivery	2	4/3/17
15	First article MAPMT delivery	2	5/3/17
16	Delivery of bar boxes to JLab	1	5/1/17
17	Delivery of optical box 1	1	5/1/17
18	Assembly of support structure completed	2	6/1/17
19	First article MAPMT acceptance testing complete	2	7/3/17
20	Start bar box and focusing box 1 mechanical installation	2	7/3/17
21	Start electronics installation for focusing box 1	2	8/1/17
22	Start optical box 2 fabrication	2	11/2/17
23	Delivery of optical box 2	1	5/1/18
24	Start focusing box 2 mechanical installation	2	6/1/18
25	Start electronics installation for focusing box 2	2	7/3/18
26	MAPMT production completed	1	7/2/18
27	MAPMT characterization completed	2	8/1/18
28	DIRC project completed	1	10/1/18



Hall D Timeline

GlueX

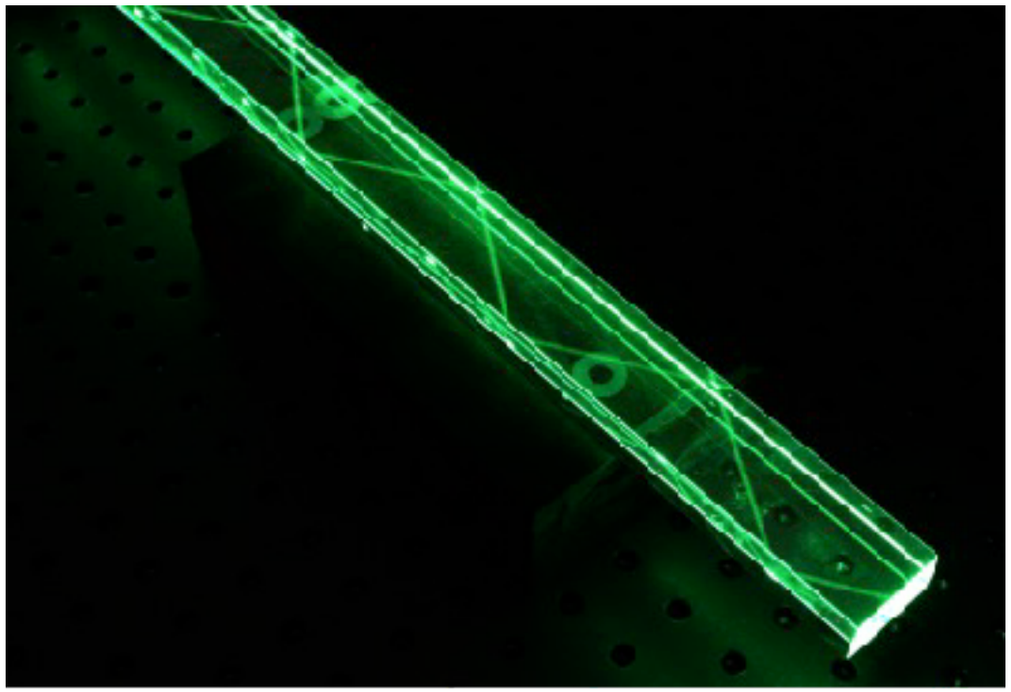
10^7 γ/s

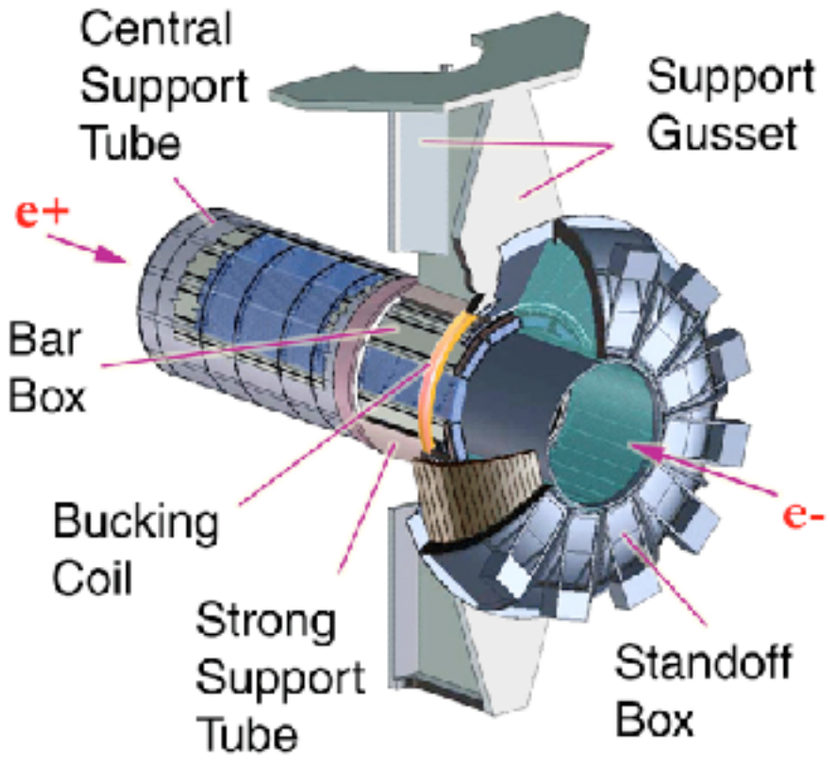
Spring 2019
η Primakoff

Fall 2018 DIRC Commissioning

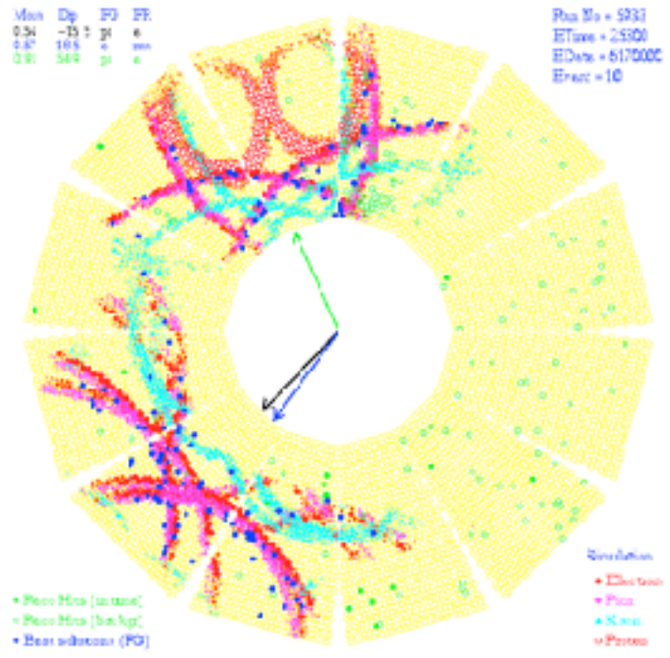
Particle Identification: DIRC

- **DIRC**: Detection of Internally Reflected Cherenkov Light
- Pioneered for BaBar detector at SLAC PEP-II
- Image photons to measure Cherenkov angle



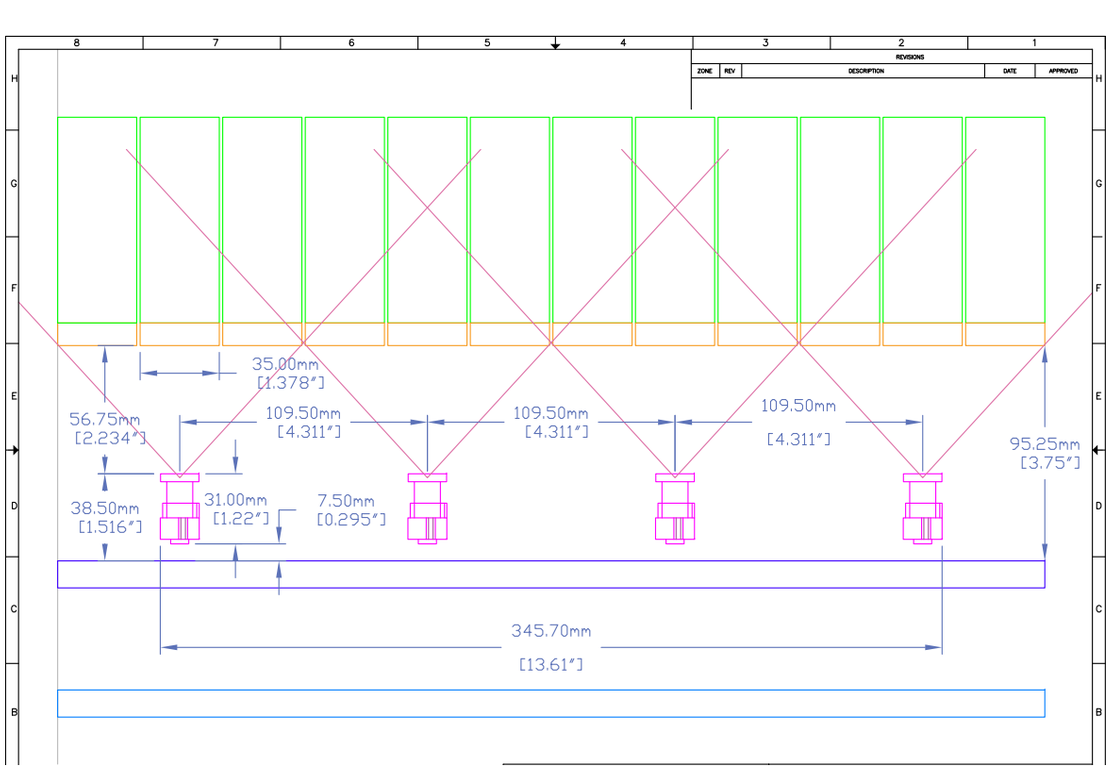


BaBar DIRC Event Display



Real time monitoring

- Distinct kaleidoscope patter when viewing bar from window which can be monitored in ~real time
- Accelerometer data in real time to assess any shocks which exceeded safety limits



Manpower considerations

- Electronics & cabling installation: Hall D electronics group
- Optical box fabrication: Bates
- Optical box installation: Bates and Hall D mechanical
  - PMT module installation: Bates, MIT, W&M, CUA
- **Commissioning tasks**
  - MAPMT laser test data analysis (underway): W&M
  - Timing calibrations: GSI and W&M
  - Reconstruction implementation: GSI, MIT and W&M
  - Detector alignment: MIT and W&M

Commissioning datasets

- Establish monitoring of rates/pixel
- HV and threshold scans
  - Characterize performance similar to laser test setup
- Intensity dependence of backgrounds
  - Vary from 1e7 (GlueX I) to 5e7 (GlueX II)