



HEAVY PHOTON SEARCH

AT JEFFERSON LAB

DM

HPS Overview

Maurik Holtrop (UNH)
HPS Collaboration Meeting
May 29-31, 2019, Jefferson Lab

Outline

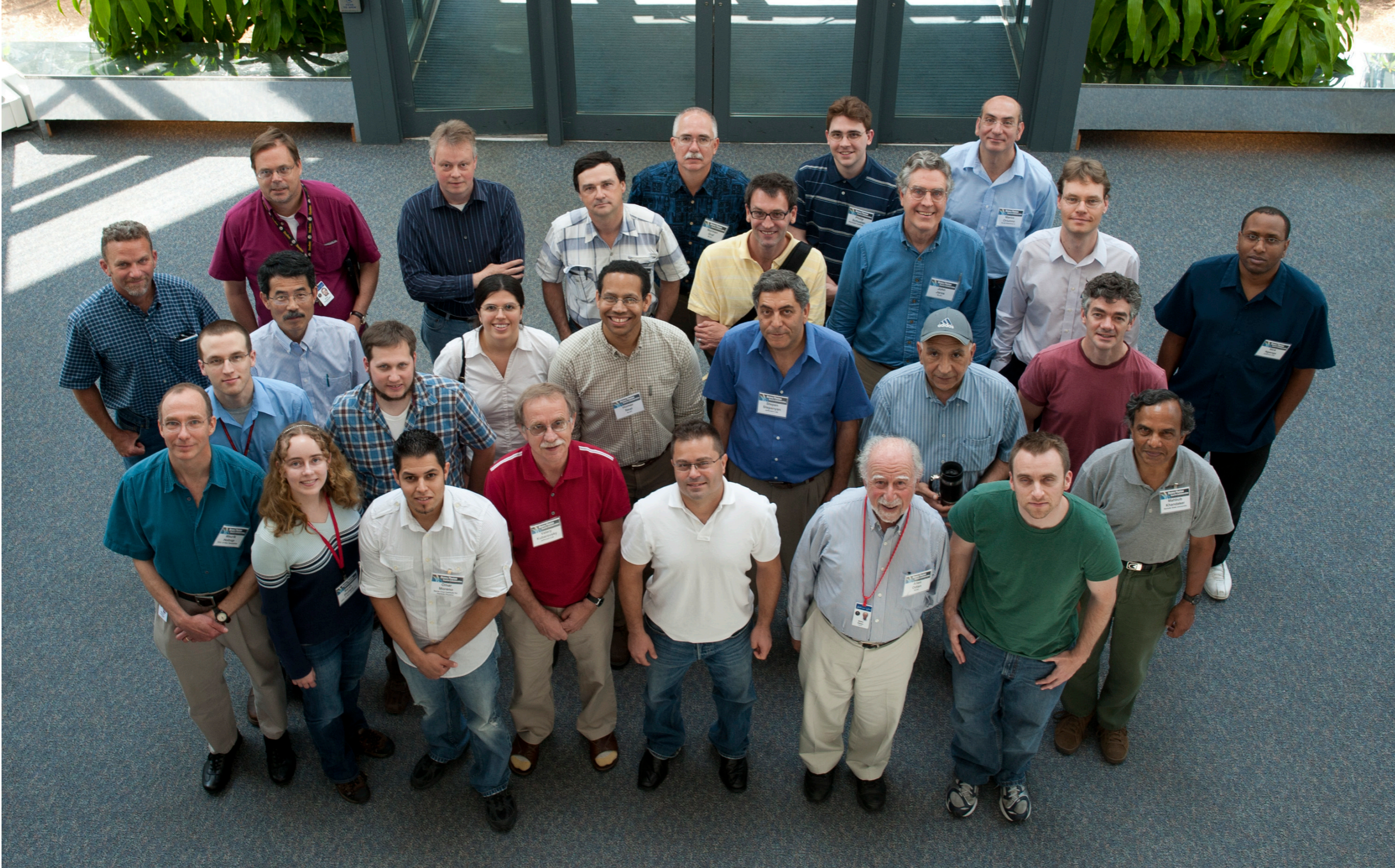
- The collaboration.
- The 2016 Engineering run data analysis.
- Status of the HPS detector.
- First production run, in 2 weeks.
- Look ahead: Analyzing the 2019 data.
-

HPS Collaboration

- At SLAC's **Dark Forces Workshop** (9/09), Takashi presented our first thoughts on the Heavy Photon Search. Active collaboration between Jlab and SLAC got started.
— John Jaros @ First collaboration meeting, May 2011



- HPS started almost 10 years ago, to do a quick experiment, with data before 2012 shutdown...



HPS, May 2011, JLab

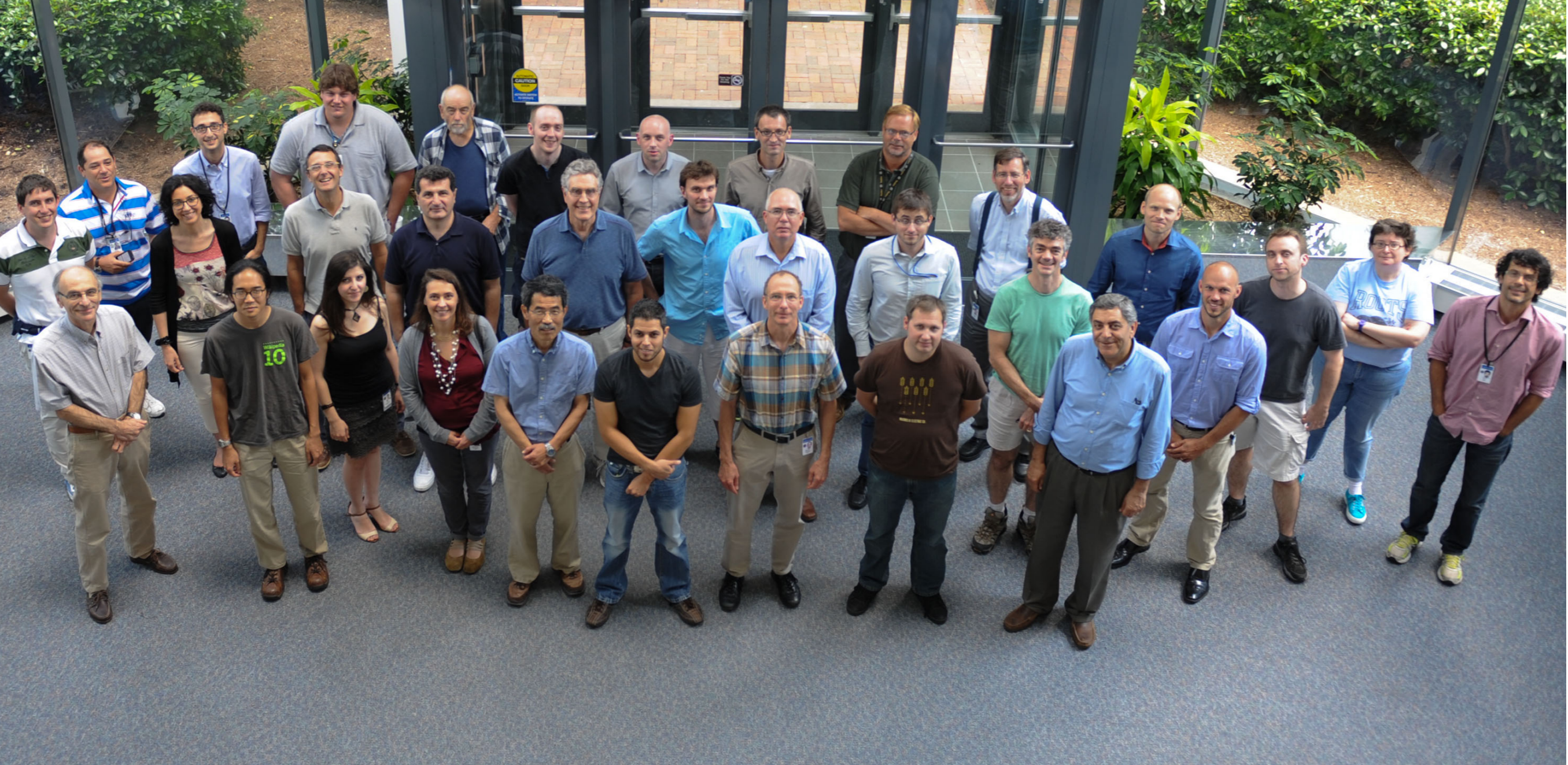


HPS, September 2012, SLAC



HPS Collaboration Meeting

June 4-6, 2013 • Jefferson Lab



HPS Collaboration Meeting

Thomas Jefferson National Accelerator Facility • Newport News, VA

June 16-18, 2014

The Heavy Photon Search (HPS)

July 1-3, 2015

Orsay - France

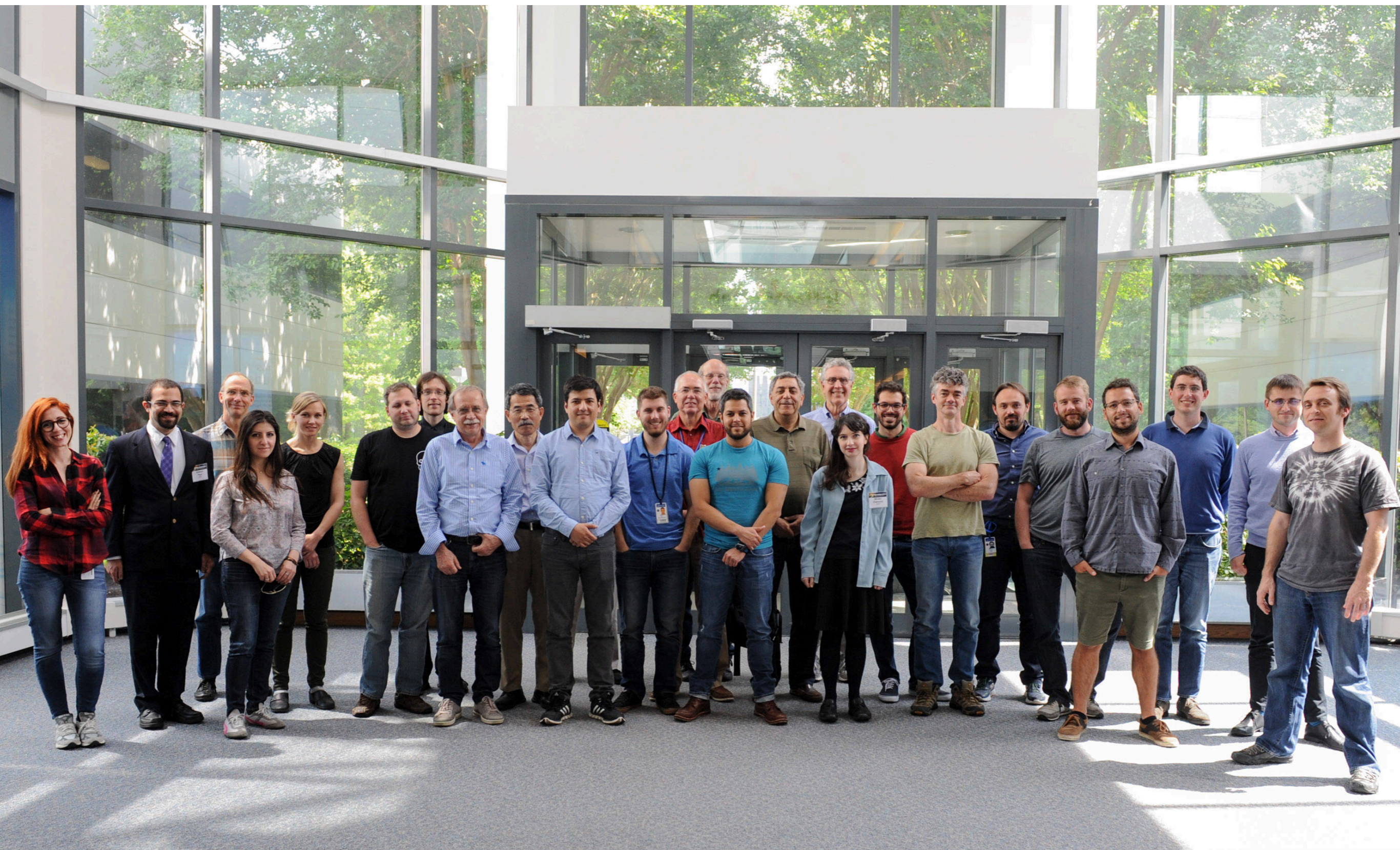


FRANCE-STANFORD CENTER
for Interdisciplinary Studies





HPS, November 2016



HPS, May 2017



HPS, May 2018

New Members

- Students:
 - Alic Spellman, UCSC
- Postdocs:
 - Cameron Bravo - postdoc @ SLAC (since Nov 18)
 - Tontong Cao - postdoc @ JLab with UNH (yesterday).
 - Pierfrancesco Butti - postdoc @ SLAC (starting soon!)
- New Full members to be voted on:
 - Dominique Marchand, Orsay.

The 2016 run data analysis

- At the last meeting we thought to complete the 2016 data analysis before the summer run, and work towards a combined (resonance and vertex search) publication.
- Where are we?
 - ✓ Pass2 processing completed, but it took much longer than hoped.
 - ✓ Additionally, reprocessed the V0 skim LCIO files. (Norman)
 - ✓ Large sample MC is generated (Bradley).
 - ★ High-z events still not fully understood. (Matt S. and Holly working on this.)
 - ✓ Analysis methods are now established, but we are still making improvements.
 - ✓ Need to finish systematic studies:
 - ✓ Mass resolution (Rafo)
 - ✓ Radiative trident fraction (Bradly has update)
- The main people to do the analysis also needed to build the hodoscope, the new SVT layers, work on the trigger studies.

2016 Data Analysis



Heavy Photon Search Group / ... / Data Analysis Working Group

2016 Resonance Search Task list

Edit Watch Share ...

Created by Rafayel Paremuzyan, last modified by Omar Moreno on Feb 10, 2019

Task	Subtask	Comment	Document	
MC and Data agreement	<input type="checkbox"/> Check the tracking efficiency (Matt, Omar) <input type="checkbox"/> Check single hit efficiency? (Matt, Omar) <input checked="" type="checkbox"/> MG5 cross section converges? (Bradley) <input type="checkbox"/> Any significant discrepancy between MC and data selection cut? (Matt)	Unlike to 2015 data, we see that the Normalized data is about 30% higher than the normalized MC		
Event Selection	<input type="checkbox"/> Optimize event selection cuts (Rafo) <input type="checkbox"/> Optimize energy/momentum sum cut (Rafo? Omar?) <input type="checkbox"/> Generate final e+e- invariant mass spectrum (Rafo)			
Determine mass resolution with the pass4 data	<input type="checkbox"/> Generate A'-beam MC at several different masses along with Moller-beam MC (Bradley). <input type="checkbox"/> Check data-MC agreement for Moller data (Matt? Omar?) <input type="checkbox"/> Develop a cutflow to isolate Moller peak and fit using a Crystal Ball function to extract the mass resolution (Rafo? Omar?) <input type="checkbox"/> Isolate A' invariant mass peaks and fit each using a Crystal Ball function to extract mass resolution (Rafo) <input type="checkbox"/> Fit A' mass resolution as a function of A' mass to obtain mass parametrization. (Rafo) <input type="checkbox"/> Determine mass scale correction (Kyle)	<p>There is still a lot to be done, and we should do this!</p> <p>Talks on Thursday.</p> <p>Task List: https://confluence.slac.stanford.edu/display/hpsg/2016+Resonance+Search+Task+list </p>		
Bump Hunting	<input type="checkbox"/> Run the BumpHunter (Kyle) <input type="checkbox"/> Use Crystal-Ball instead of the Gauss for the signal shape (Omar) <input type="checkbox"/> Add CLs limit calculation <input type="checkbox"/> Import mass resolution parametrization (Kyle) <input type="checkbox"/> Optimize fitting function and window size. Requires knowledge of the mass resolution (Kyle) <input type="checkbox"/> Incorporate mass resolution and scale systematic. <input type="checkbox"/> Add "Pulls to exclusion limits" conversion in the BumpHunter?			
Systematics	<input type="checkbox"/> fRad (Matt) <input type="checkbox"/> Mass resolution (Moeller mass fit, different target positions) (Rafo) <input type="checkbox"/> fits (Kyle)			

There is still a lot to be done, and we should do this!

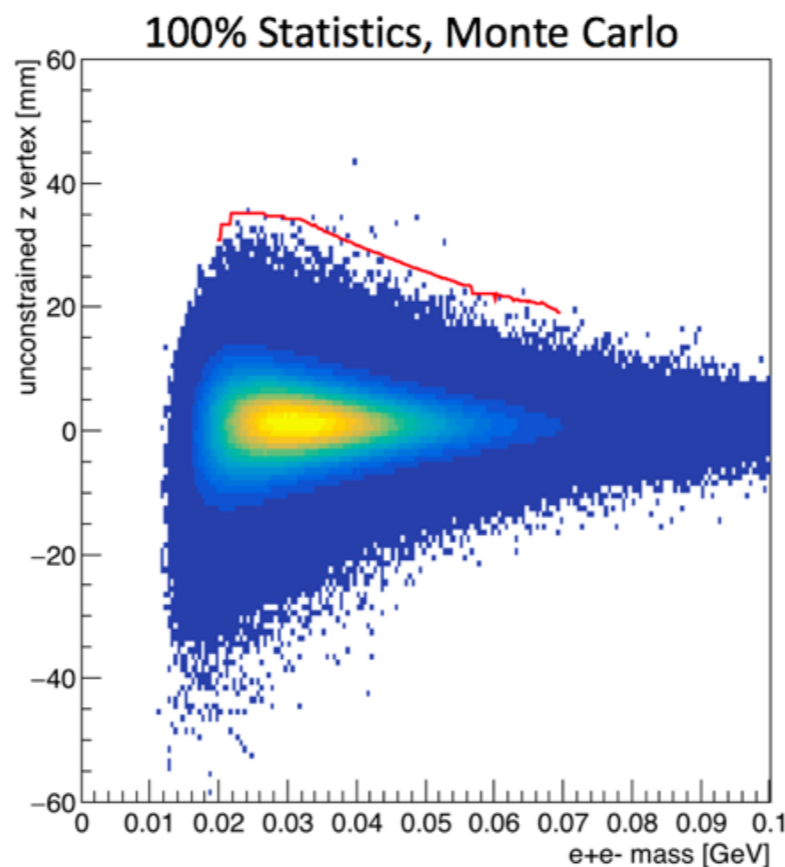
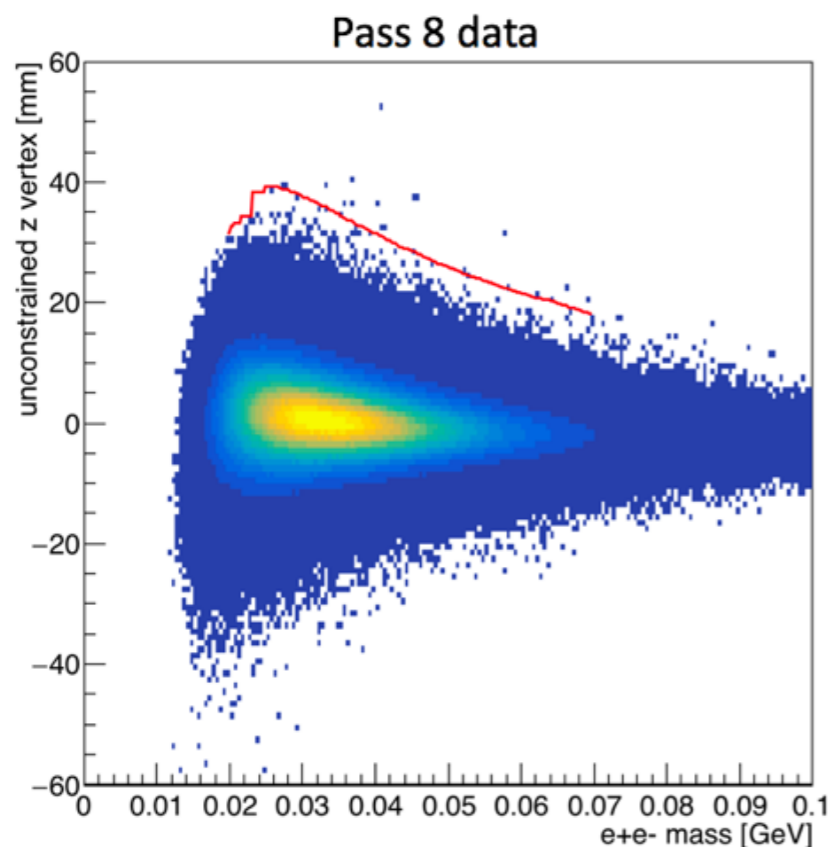
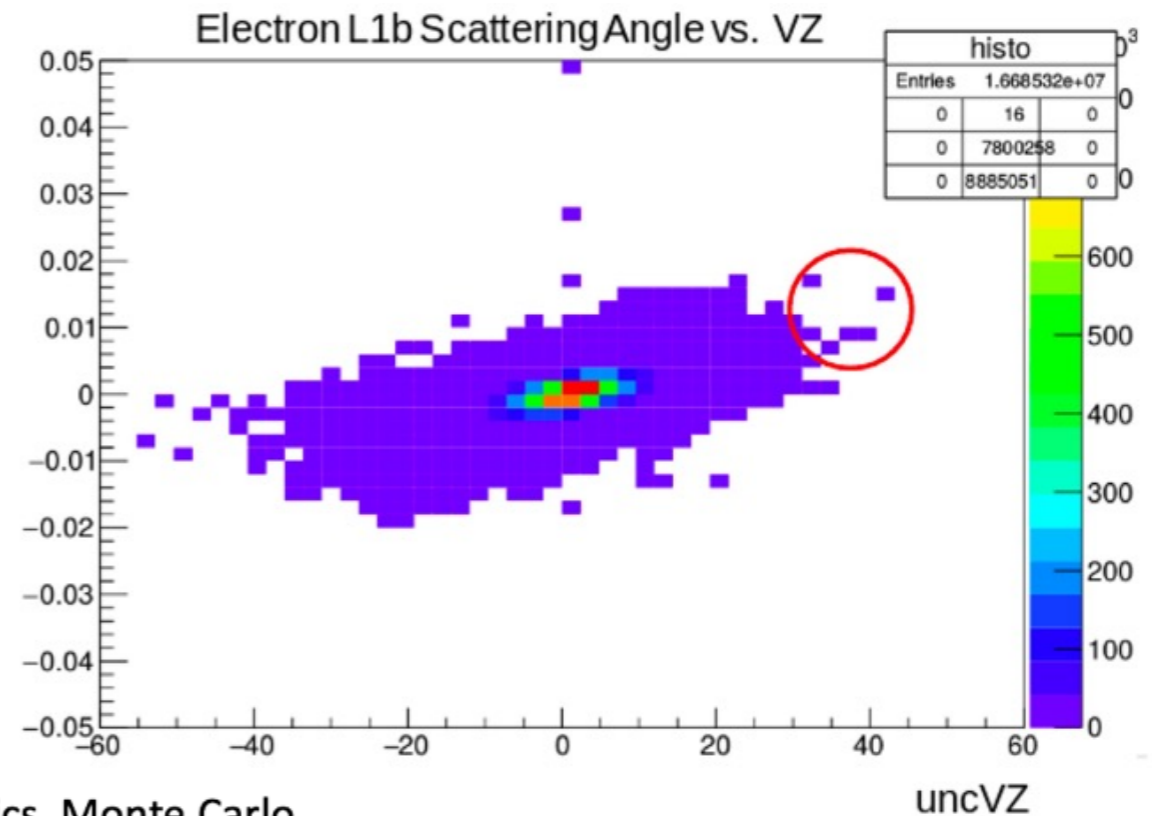
Talks on Thursday.

Task List:

<https://confluence.slac.stanford.edu/display/hpsg/2016+Resonance+Search+Task+list>

Vertexing analysis with large MC sample

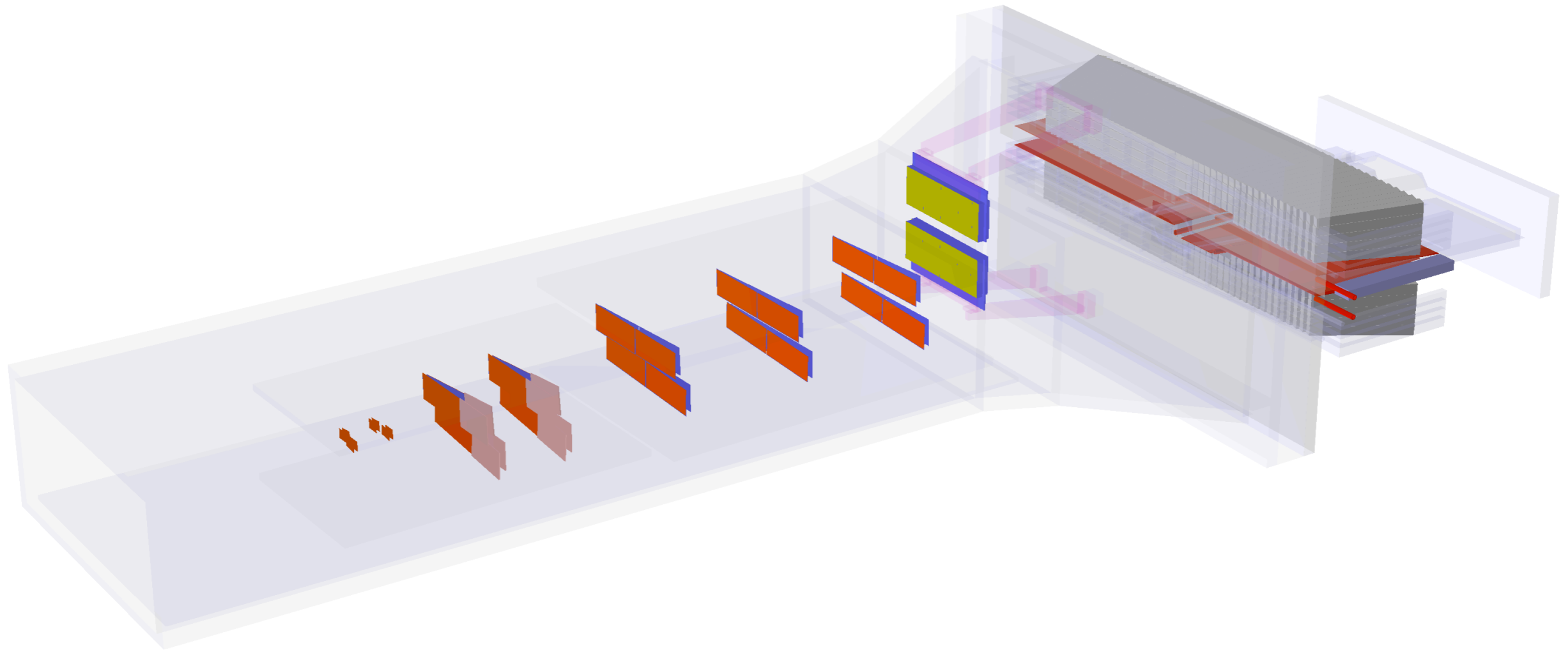
- Compare 100% *tritrig-wab-beam*, 100% *tritrig*, and 10x *tritrig* have been simulated
- Full simulation has similar z vs. mass distribution with high-z pairs
- High z backgrounds in all categories (L1L1, L1L2, L2L2) are due to large scatters in tri-trig



Looking into new analysis methods, Multilayer Perceptron (MLP)

Update in Matt Solt's talk on Thursday

Status of the HPS Detector



View of the detector model in Monte Carlo.

<http://nuclear.unh.edu/HPS/Detector/>

SVT Installation

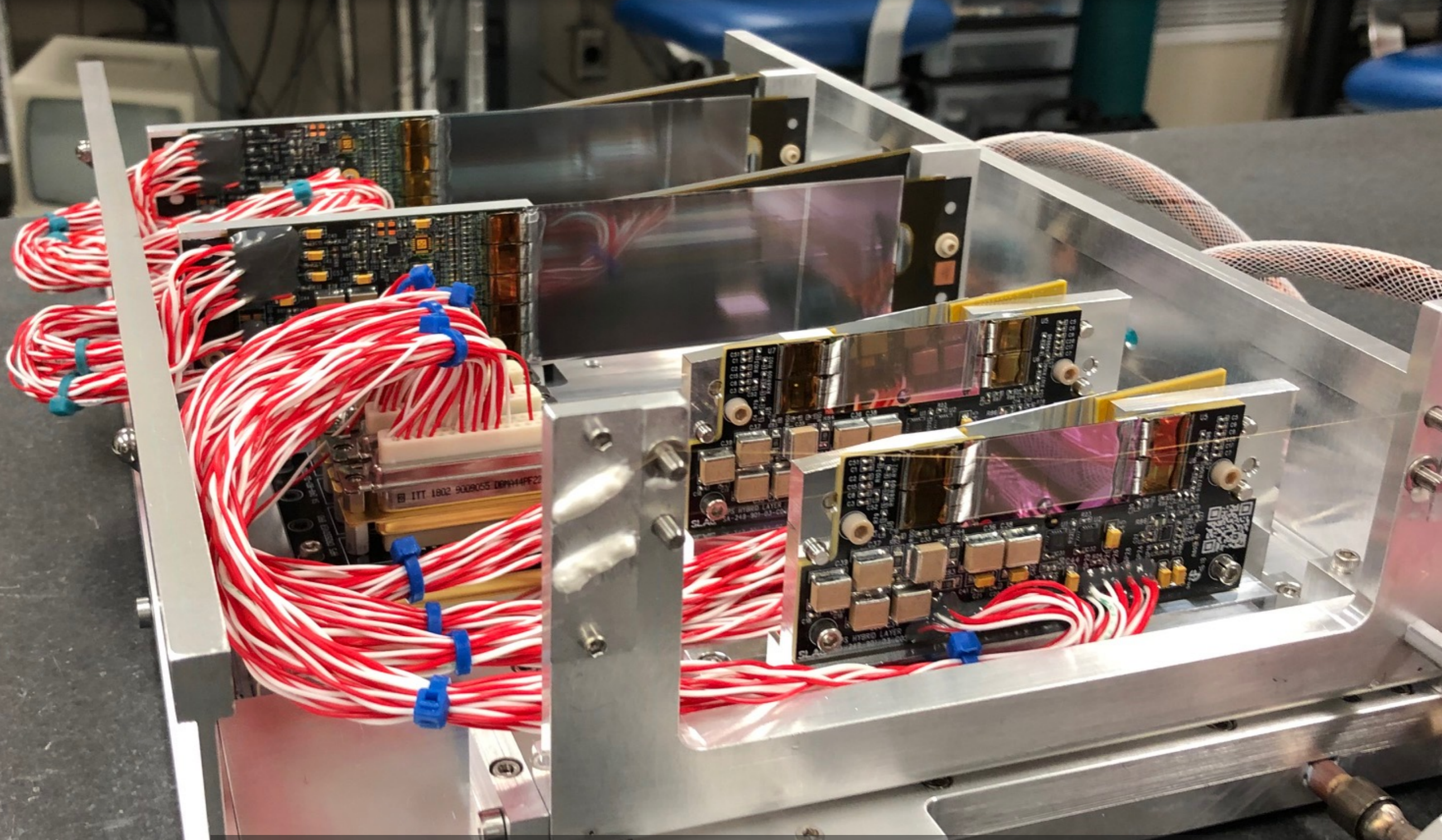


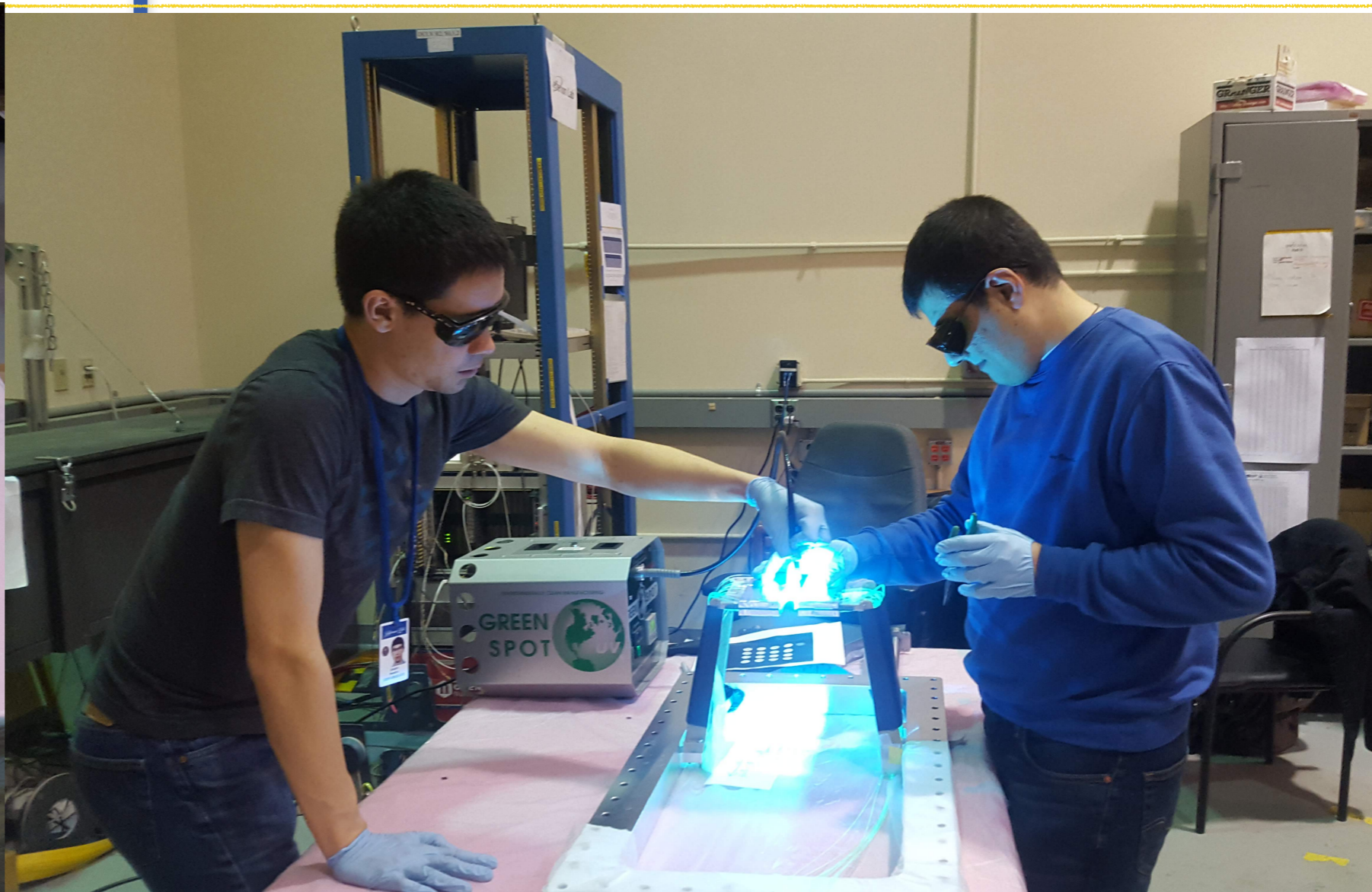
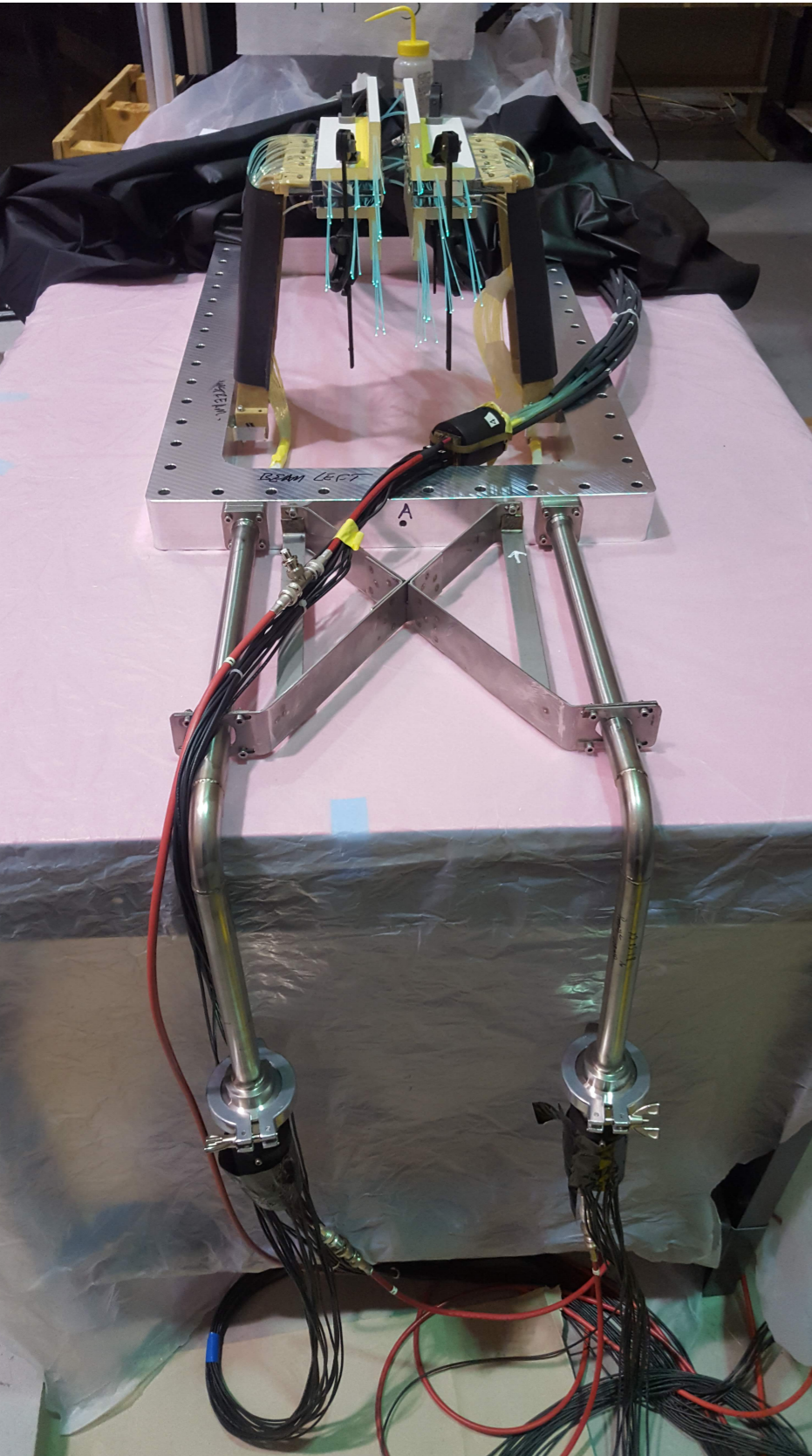
Photo from Tim, 4/29/2019. See SVT Talk

SVT Installation



Photo from Tim, 5/15/2019. See SVT Talk

Hodoscope Installation



Hodoscope assembly in lab.

Hodoscope Installation

See Hodoscope
Talk

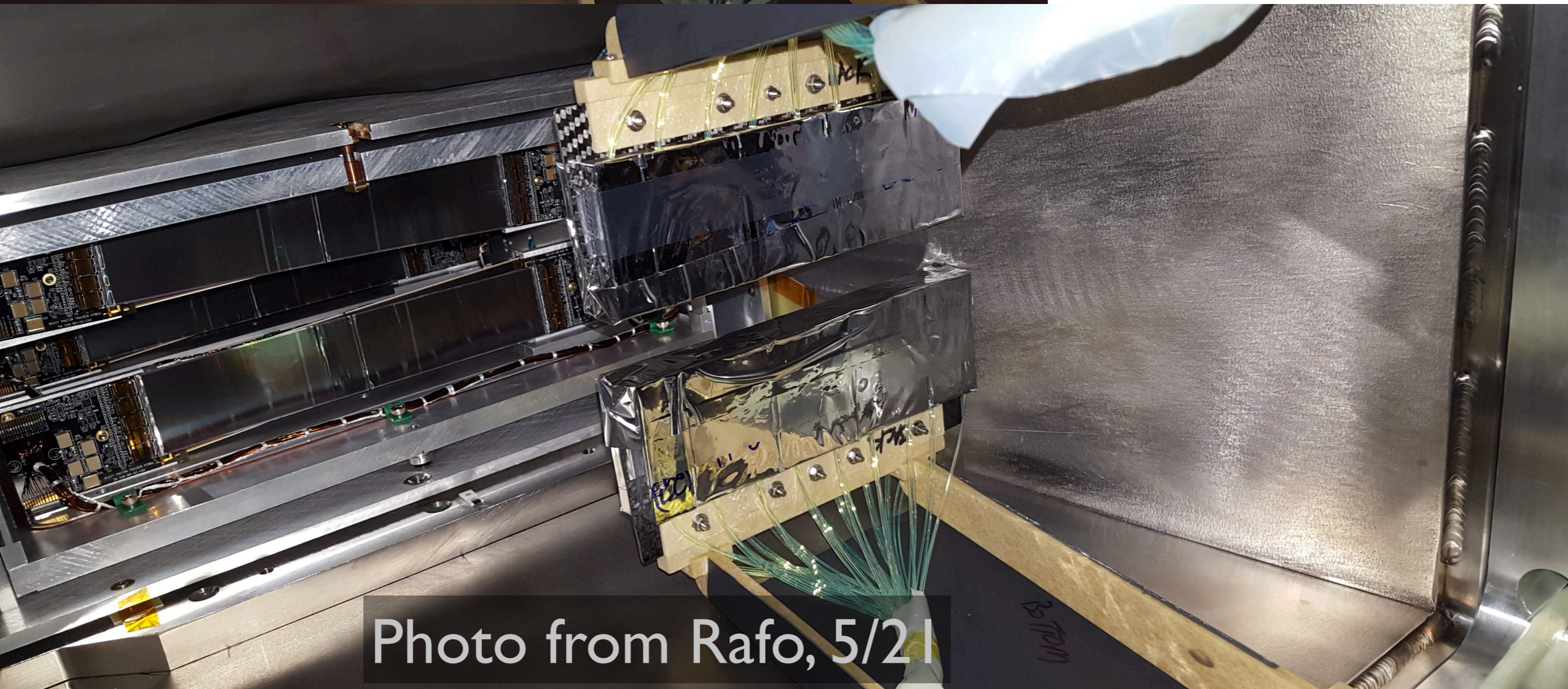


Photo from Rafo, 5/21

2019 Data Run

- Start in less than 3 weeks (19 days)!
- We will be 9 weeks “on the floor”, and hope to get at least 32 “PAC days” of data.
- Higher efficiency of the upgraded detector trigger (2x) should translate to at least 10 ~ 12 times the amount of useful data compared to 2016 run.
- SVT upgrade will make this data ~3x more efficient for vertex searches, so vertex searches we see 30 times the useful data.
- **This will be a lot of data!!**

2019 Run - Trigger

- Upgraded detector with Hodoscope will have a “positron” trigger: single e^+ cluster + hodoscope hit.
- Will improve acceptance and reduce WAB background.
- Trigger firmware also upgraded — See Ben’s talk.
- Will also keep pre-scaled Pairs I, Pair0, Single I, Single0 and pulser.
- We will need to study the trigger in detail!
 - MC studies, ongoing, see Kyle’s talk.
 - Trigger Commissioning, see Valerie’s talk.

Data Quality

- Online data monitor like previous runs.
- Data Quality Monitoring — Matt Graham.
 - Fully analyze ~ 1% of the data as it comes in.
 - Analysis jobs will launch automatically.
 - But will still need oversight.
 - Produce a standard set of plots. Compare with reference.
 - Web based interface to check plots.
 - DQM shifts can be done offsite.
 - Do we need to organize DQM “shifts”?
 - All this will need a lot of tweaking, and continuous development.

2019 Run - Calibrations

- Cosmic calibration runs already started.
- We should start calibrations on data immediately.
 - Use the 1% DQM jobs?
- Improve calibrations throughout the run.
- Improved alignment procedures.
 - We learned a lot from 2015 & 2016 data sets.
 - Are special runs needed for alignment?
 - Do the alignment procedures need updating for the L0 layer?
- See Nathan's talk Friday on calibrations.

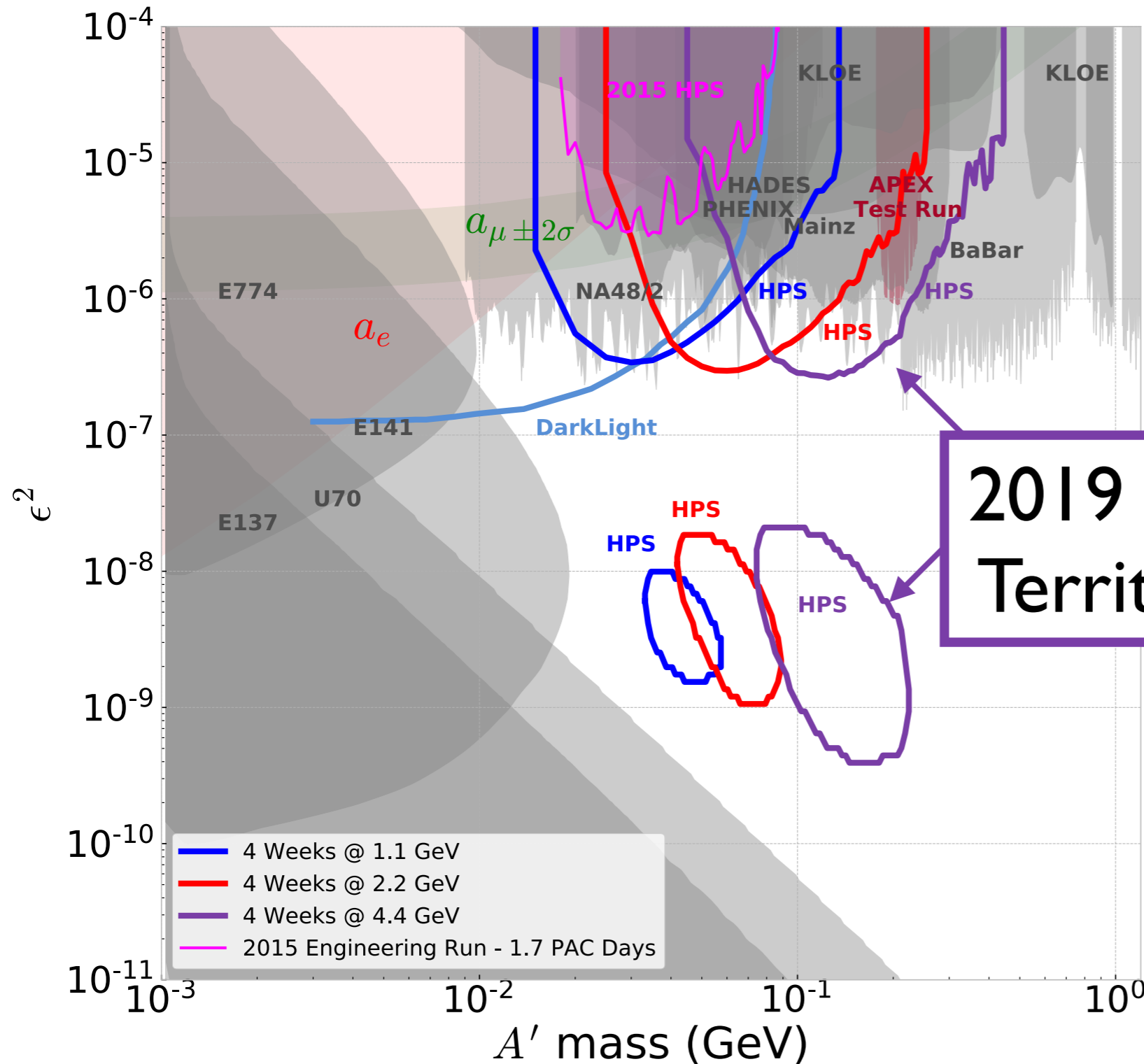
2019 Data Processing

- We need to improve our data processing strategies and organization.
- DQM: Immediately process 1% of data to check quality.
- We will not be able to do multiple passes!
- Early processing: 1% instead of 10%?
 - We cannot afford more than one full pass, but we can afford multiple 1% passes, and perhaps more than one 10% pass.
- Output:
 - LCIO files for “hpstr”.
 - LCIO files should be slimmed to take less space.
 - hpstr runs over the LCIO files instead of the “tuples”.
 - ROOT DSTs.

2019 Monte Carlo

- Monte Carlo sample will need to increase as well.
- Switch from “slic” to “hps-sim”:
 - Can use event biassing.
 - Simplify the MC production chain.
 - Still needs more validation and some more development.
- Need to get pulser data for beam background to work.
 - This requires new code, and verification. Not a small task.
- Move MC Production to Open Science Grid.
- Fewer variations, we need one large set of MC data.
 - Easier to organize.
- **Need new MC Tzar and MC Production Manager**

2019 Run - Reach Plot



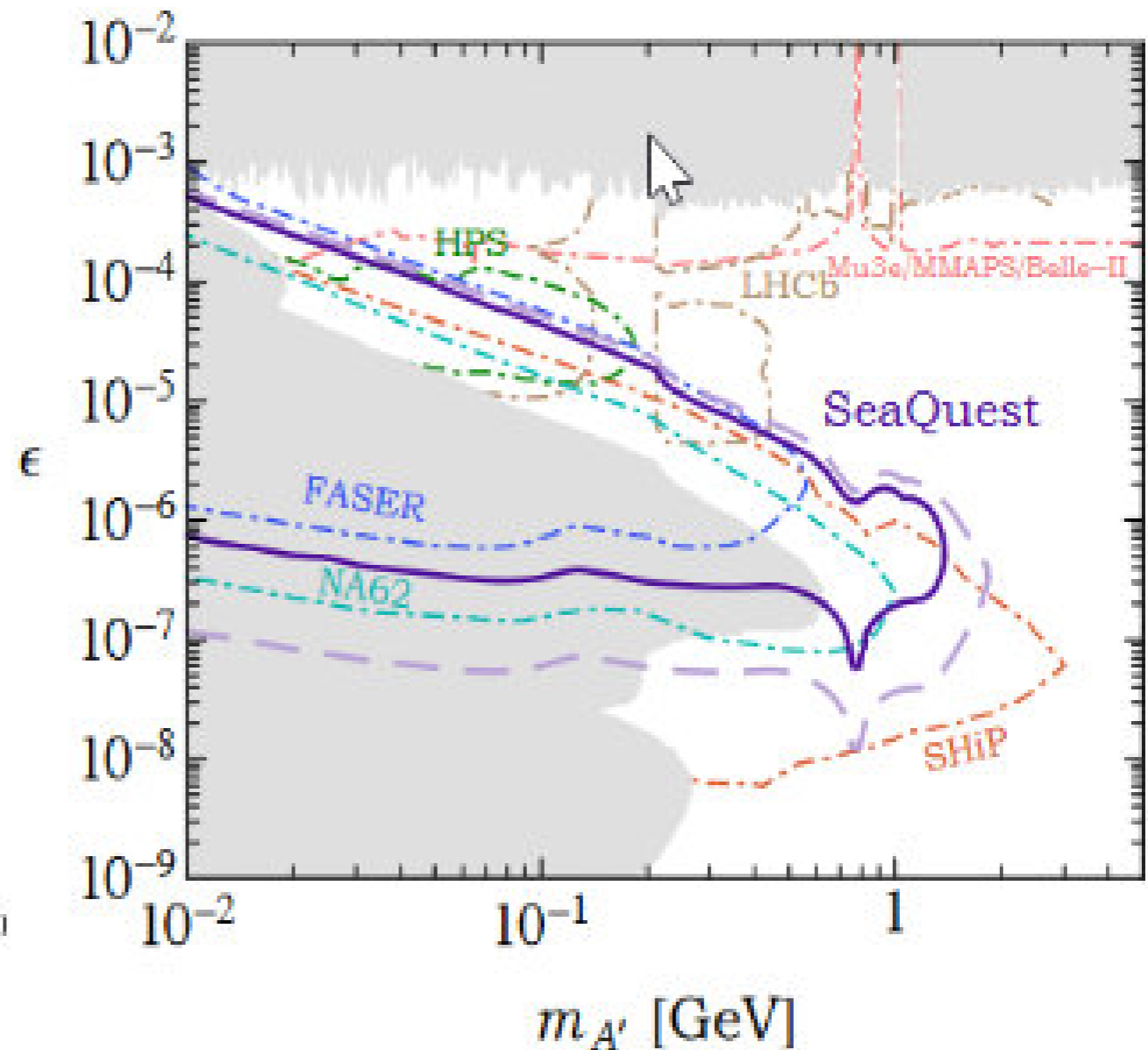
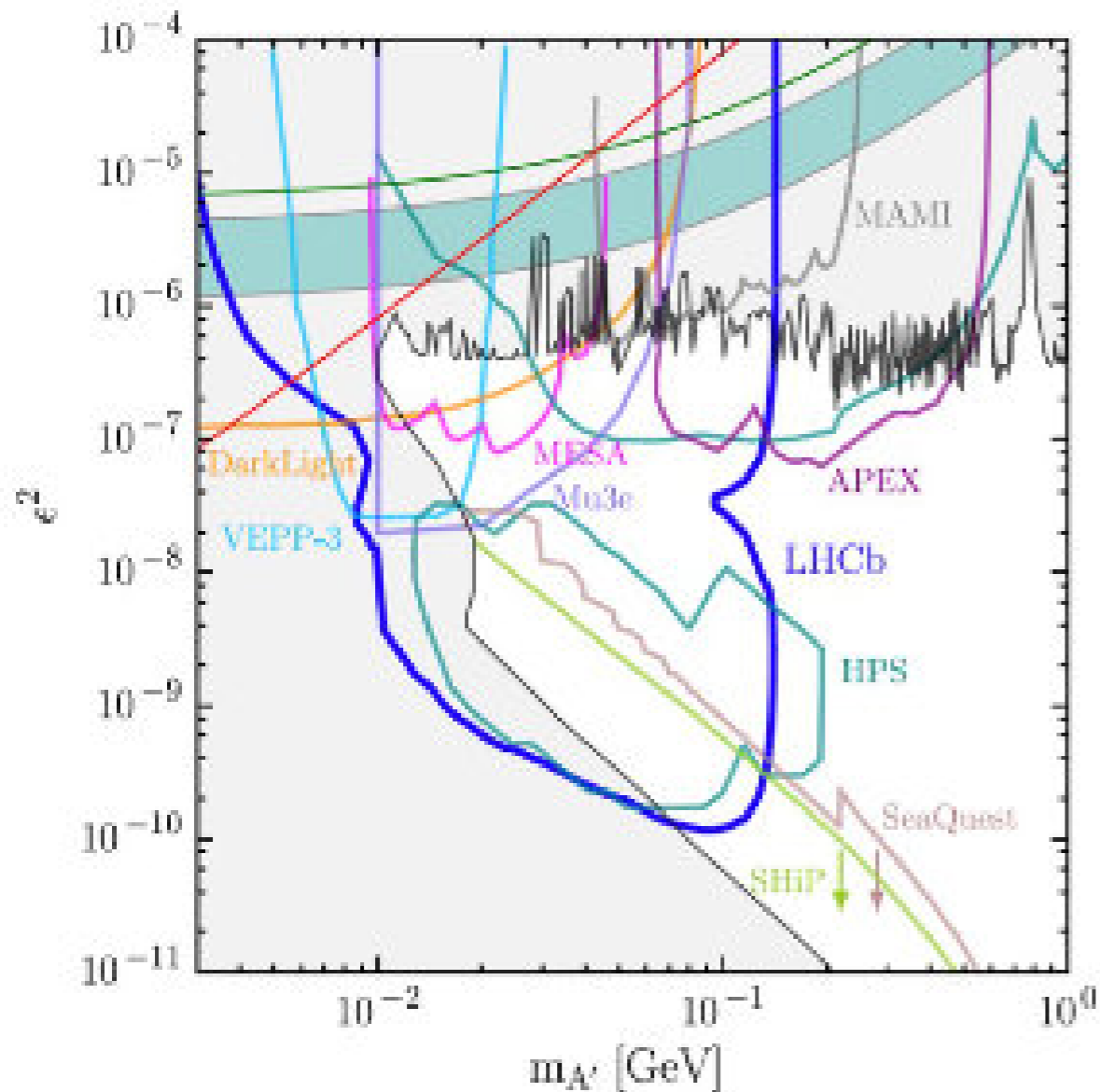
This hasn't changed since last meeting.

2019 Run Territory

Competition

Neither has this changed since last meeting.

- LHCb, with trigger less readout selecting e^+e^- pairs covers most of HPS reach. (Run III, 2021-2023)
- SeaQuest with proposed ECal trigger covers part of HPS reach (runs soon?)
- Future experiment SHiP, NA62, and FASER at CERN all cover part of HPS reach.



Conclusions

- The 2019 run will provide a great opportunity for HPS to explore new territory in the ε^2 vs M_A space.
- There is real competition, we cannot take our time.
- We have a lot of work ahead of us to make this run a success, and to analyze the data we will gather.
- We also have a lot of good people on HPS to make this happen. (*and we can use some more students.*)
- We cannot forget our 2016 data set, we should publish this soon.