PAC-48, Jeopardy and targets for future running

S. Stepanyan (JLAB)

HPS Collaboration meeting

JLAB, November 18-19, 2019

OFFICE OF SCIENCE

Jefferson Lab
Thomas Jefferson National Accelerator Facility

JSA

Outline

- Jeopardy process
- HPS update for PAC-48
  - Update on physics
  - Progress since the first proposal, analysis results and publications
  - Detector upgrade
  - Performance during the first production run
  - More detector upgrades and im
- Targets for future running
- Summary

Jeopardy in 12 GeV era

https://www.jlab.org/exp_prog/PACpage/PAC47/Jeopardy_2016_Final.pdf

In order to help manage the backlog of nuclear physics experiments at Jefferson Lab, we will implement a Jeopardy program similar to that used in the 6 GeV era of CEBAF. The basic principle is that experiments that remain approved on the books for extended periods of time need to be periodically reevaluated by the PAC. We currently have 70 approved experiments that will require 6-10 years of full operation of CEBAF to complete. By 2020 we may have

Review Process

PAC meetings after the start of the Jeopardy process will be considering both new proposals and resubmitted Jeopardy proposals. Resubmitted proposals in Jeopardy will be requested to submit updates to their original proposals and give a presentation before the PAC. The PAC will review the updated proposals and reconsider their approval status, grade and number of approved PAC days. The spokespersons of these experiments will be notified directly that their experiments will be reviewed under jeopardy along with specific instructions for resubmission.

PAC47 Jeopardy – 1st Phase, only Halls A/C experiments PAC-approved before 2010

Proposal	Hall	Title	Contact Person	PAC days	Rating	Scheduled?	Status after PAC47
E12-06-101 E12-07-105	C	Measurement of the Charged Pion Form Factor to High Q^2 Scaling Study of the L-T Separated Pion Electroproduction Cross Section	G. Huber* T. Horn*	52 36	A (HI) A-	No	Combined as E12-19-006, 88 PAC days, A (52 HI)
E12-06-104	C	Measurement of the Ratio $R=\sigma_L/\sigma_T$ in Semi-Inclusive Deep-Inelastic Scattering	R. Ent*	40	A-	No	40 PAC days, A
E12-06-105	C	Inclusive Scattering from Nuclei at x > 1 in the quasielastic and deeply inelastic regimes	D. Day*	32	A- (HI)	No	32 PAC days, A-
E12-06-107	C	The Search for Color Transparency at 12 GeV	D. Dutta*	26	B+	35% complete	17.5 PAC days, B+, prioritize Q^2
E12-06-114	A	Measurements of Electron-Helicity Dependent Cross Sections of Deeply Virtual Compton Scattering with CEBAF at 12 GeV	C. Hyde*	100	A (HI)	50% complete	35 PAC days, A, move to Hall C with NPS
E12-06-122	A	Measurement of neutron asymmetry A_1^n in the valence quark region using 8.8 GeV and 6.6 GeV beam energies and Bigbite spectrometer in Hall A	B. Wojtsekhowski*	23	A-	No	Withdrawn
E12-07-109	A	Large Acceptance Proton Form Factor Ratio Measurements up to 14.5 $(GeV/c)^2$ Using the Recoil Polarization Method	B. Wojtsekhowski*	45	A- (HI)	No	45 PAC days, A- (HI)

Summary: one experiment withdrawn, one experiment moved to another Hall (for less days), one experiment scientific rating increased

Jeopardy for Hall-B experiments – PAC-48

https://www.jlab.org/exp_prog/PACpage/PAC47/Jeopardy_2016_Final.pdf

In 2020, we propose that the Jeopardy process will be applied to the presently approved Hall B program. Run groups approved prior to 2017 that still have beamtime remaining on the books in 2020 will be considered in Jeopardy, unless they are on the then current schedule for running. We might expect this will include the current Run Groups A, B, C, D, E, G, H, I, K (note: includes HPS as run group I), but of course it depends on the actual run schedule in the next 5 years.

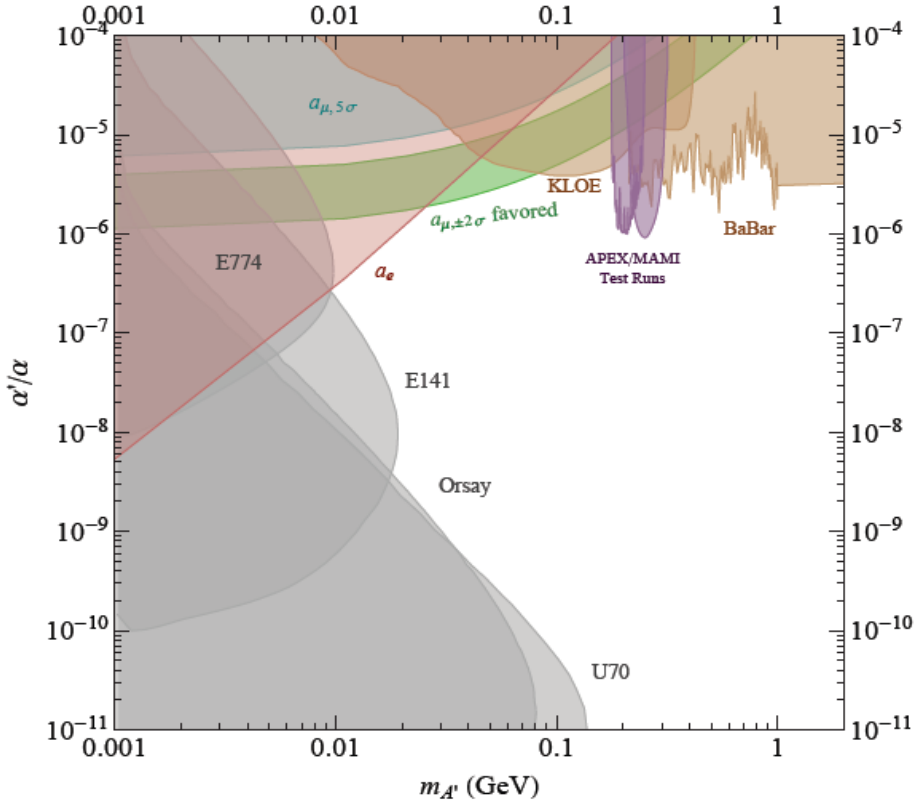
- Each experiment under the jeopardy from Halls A and C submitted about 10 page long updates to PAC-47 and had 20 minutes at the meeting to make the case
- HPS (RG-I) and all other Hall-B run groups will do the same. There will be one document and one presentation from each RG
- Typically, deadline for submission of updates/proposals is about 1.5 month before the PAC meeting

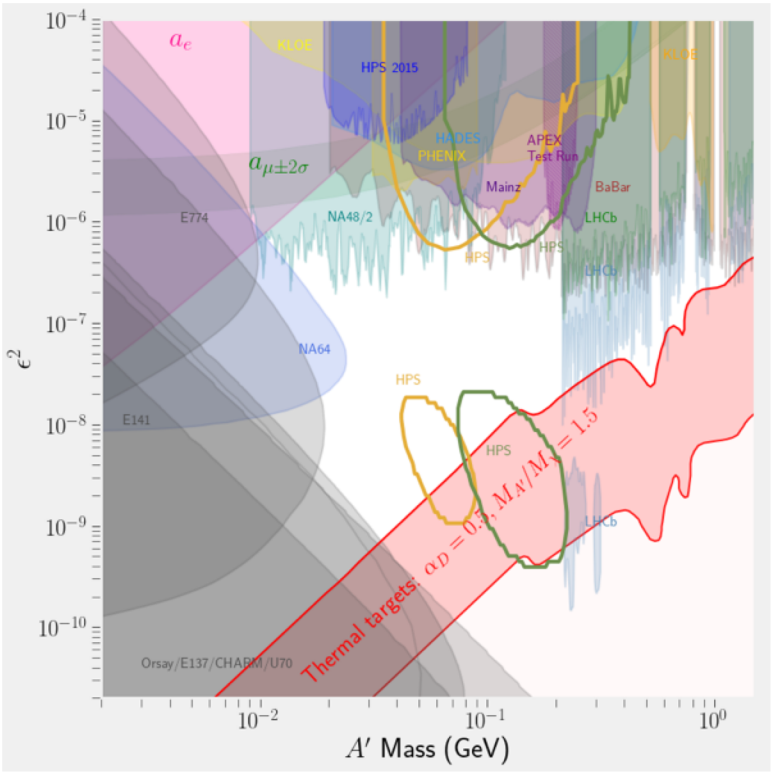
HPS update for PAC-48

- Physics case
- Accomplishments from the engineering runs
  - publications, including technical papers
  - physics results, final results from 2016 resonance search and displaced vertex analysis
- Detector upgrades, motivation, the upgraded detector and its performance during the first physics run
  - vertex resolution, addition of the L0
  - increase of the acceptance for long lived decays, V0's without L0
  - reconstruction of single cluster (e+) V0 events
- Expectations from the first physics run – realistic reach based on the accumulated charge for "golden" runs and near to complete analysis of unblinded data sample
- Detector rework before the next run – must have
- Plans/strategy for future running, E < 5 GeV

Update on physics case

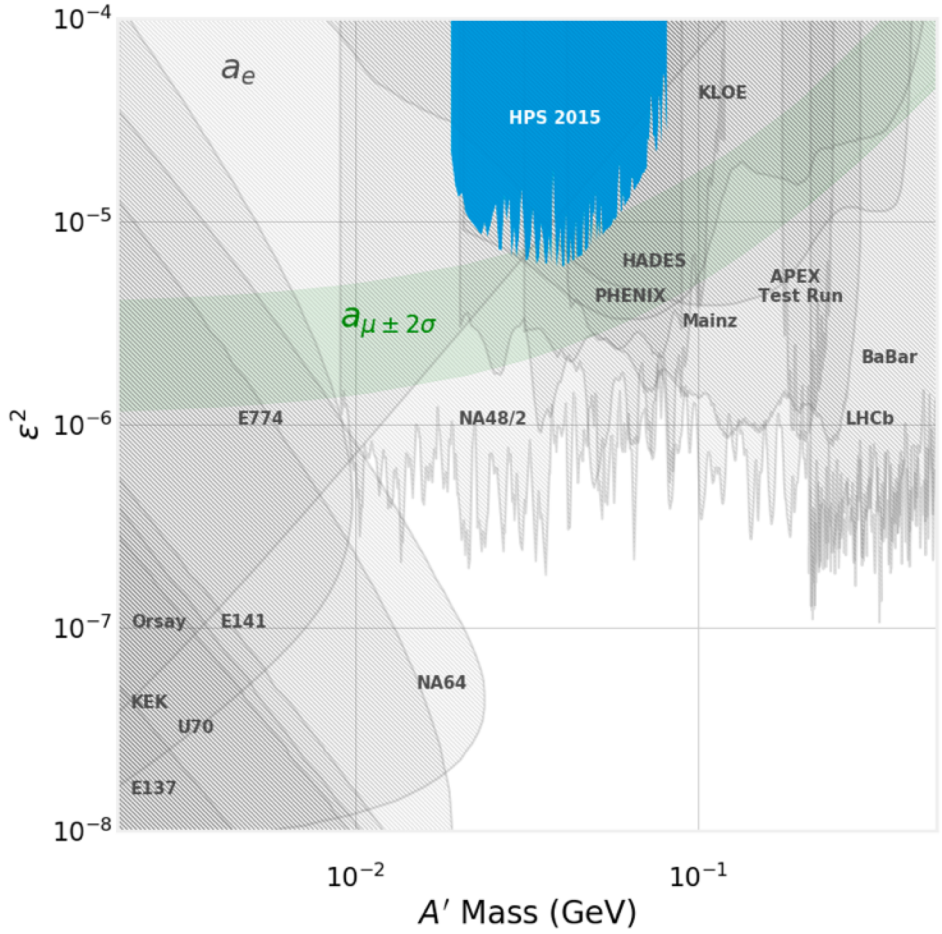
- Since the first proposal, available parameter space for A' searches has changed significantly. Resonance search region reachable for HPS is excluded, $\varepsilon^2>10^{-6}$ and 1 MeV < m < 1000 MeV.
- **HPS is unique in searching for long lived states, $\varepsilon^2<10^{-7}$, with masses m < 200 MeV**
- **Physics case should focus on a Light Dark Matter and Strongly Interacting Dark Matter**





Accomplishments: Physics results and publications

- One physics paper, Phys.Rev. D**98**, 091101(R), 2016=5 resonance search and a conference proceedings (ICHEP) arXiv:1812.02169 [hep-ex]
- Three technical papers:
  - *"The Heavy Photon Search test detector"*, NIM **A777** (2015) – based on the 2012 test run with photon beam
  - "*The HPS Electromagnetic Calorimeter*", NIM **A854** (2017) – based on the engineering runs
  - "*The Heavy Photon Search beamline and its performance*", NIM **A859** (2017) – based on the engineering runs
- **By PAC-48 must have 2016 resonance and displaced vertex search results out if not submitted already for publication**



Motivations for the detector upgrade

These were the main points:

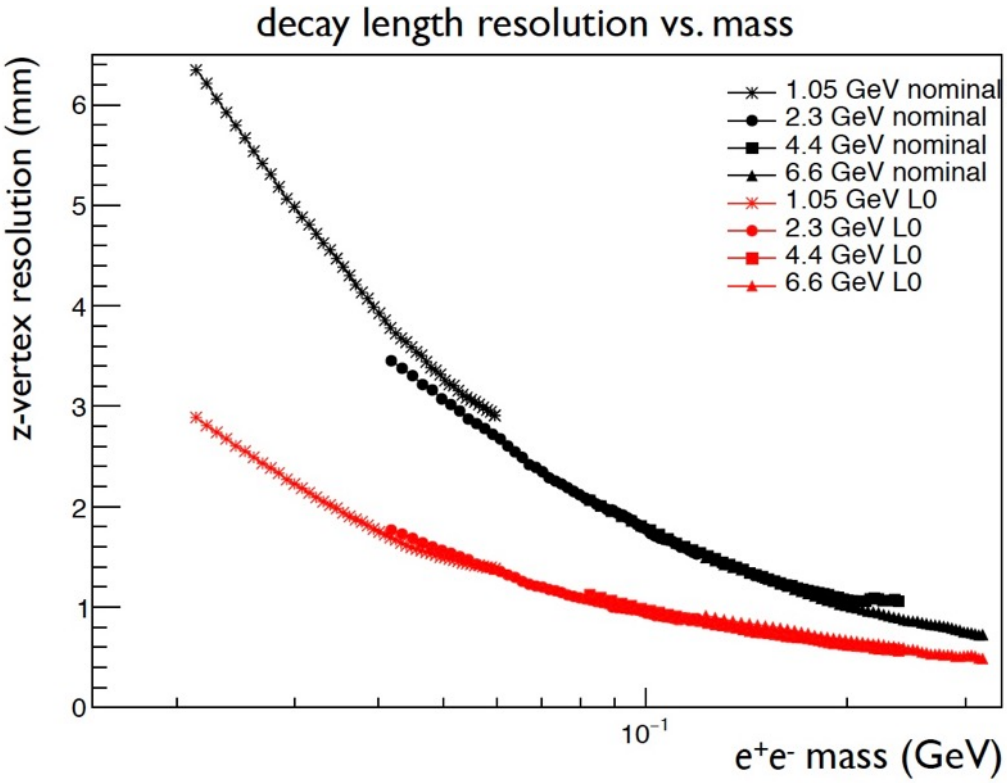
1. With 2-cluster trigger we were loosing ~50% V0's because of electron hole in ECal and large fraction of recorded triggers were from WABs
2. Because of 15 mr opening from the target, acceptance for long decay length diminishes quickly, ,especially for low mass A's
3. Non-Gaussian tails of the Z-vertex distribution forced the z-cut to much higher values, z-vertex resolution improvements will have significant impact on z-cut

SVT and the trigger upgrades to restore the original reach:

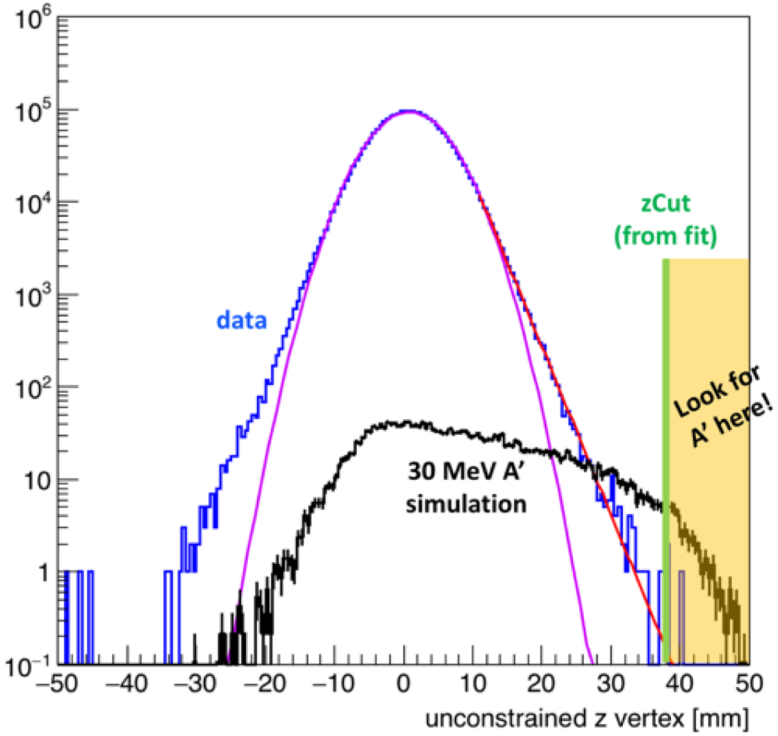
1. A single-arm positron trigger will eliminate losses due to ECal electron hole. Scintillation hodoscope was built and installed in front of the ECal to tag positrons and veto bremsstrahlung photons that scatter to the positron side of the calorimeter.
2. The SVT Upgrade:
   - One more layer of sensors 5 cm downstream of the target was added, L0, expected to improve the vertex resolution by about **x2**
   - Moved L1, L2 and L3 closer to beam to boost acceptance for long-lived A'

Detector performance: SVT

- We expected that the new silicon layer, Layer 0, thinner and closer to the target will improve vertex resolution ~2x
- **For PAC-48 vertex distributions from 2019 data showing $\sigma \approx 1mm$ will be critical**

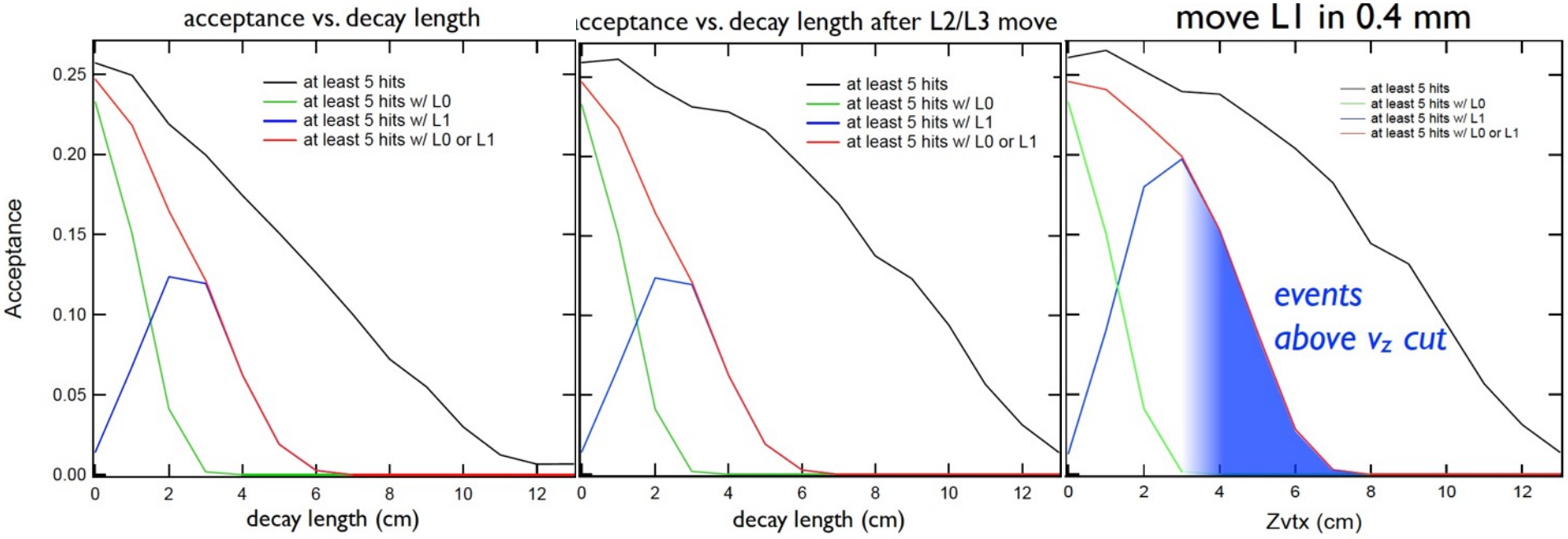


Data must be from the 2019 run



Detector performance: SVT (cont.)

- Further improvement in efficiency for displaced vertex analysis will be achieved by moving Layers 1, 2 and 3 closer to the beam plane.
- **For PAC-48 new simulations with realistic detector positions and performance will be needed to asses acceptances for long decay lengths**

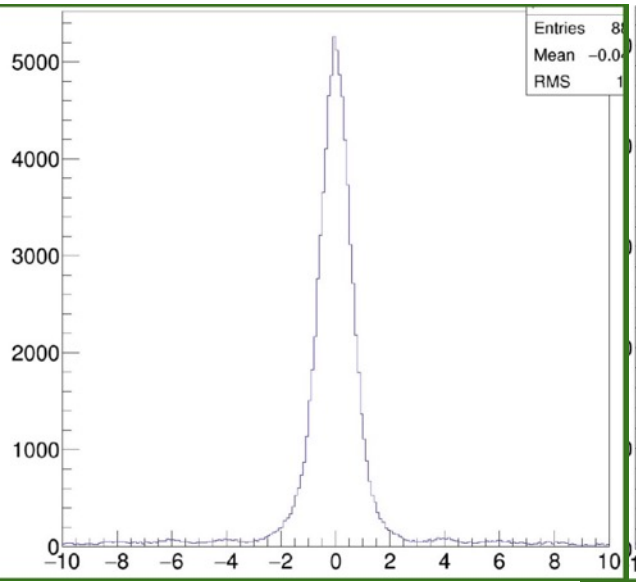


Upgraded detector performance: trigger/hodo

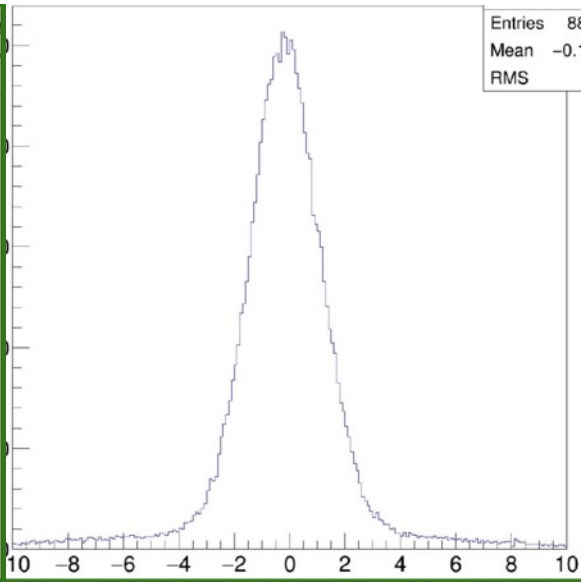
- A single-arm positron trigger to recover pairs with electron in the ECal beam electron hole.
- **Single arm trigger performance, rates and efficiency**
- **V0's with and without matched electron cluster, time difference, E_{sum} and the invariant mass distributions**

From 2019 data:

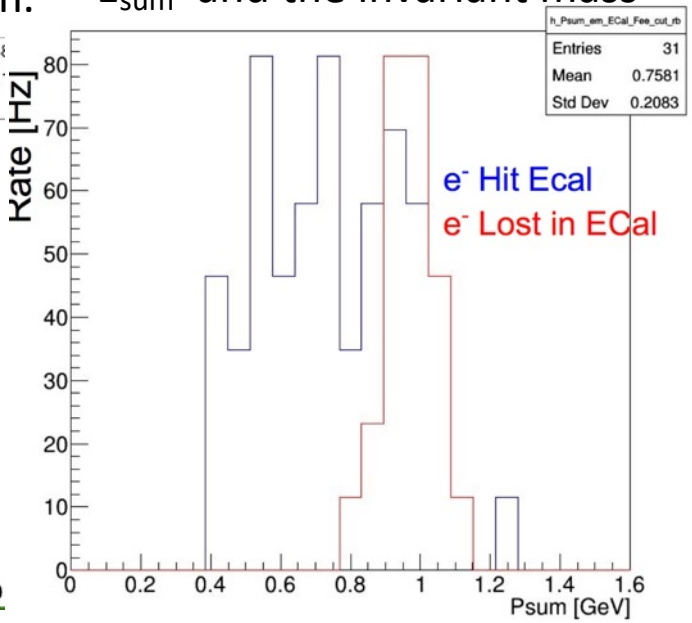
Two cluster time diff.



e^+ cluster and e^- track time diff.



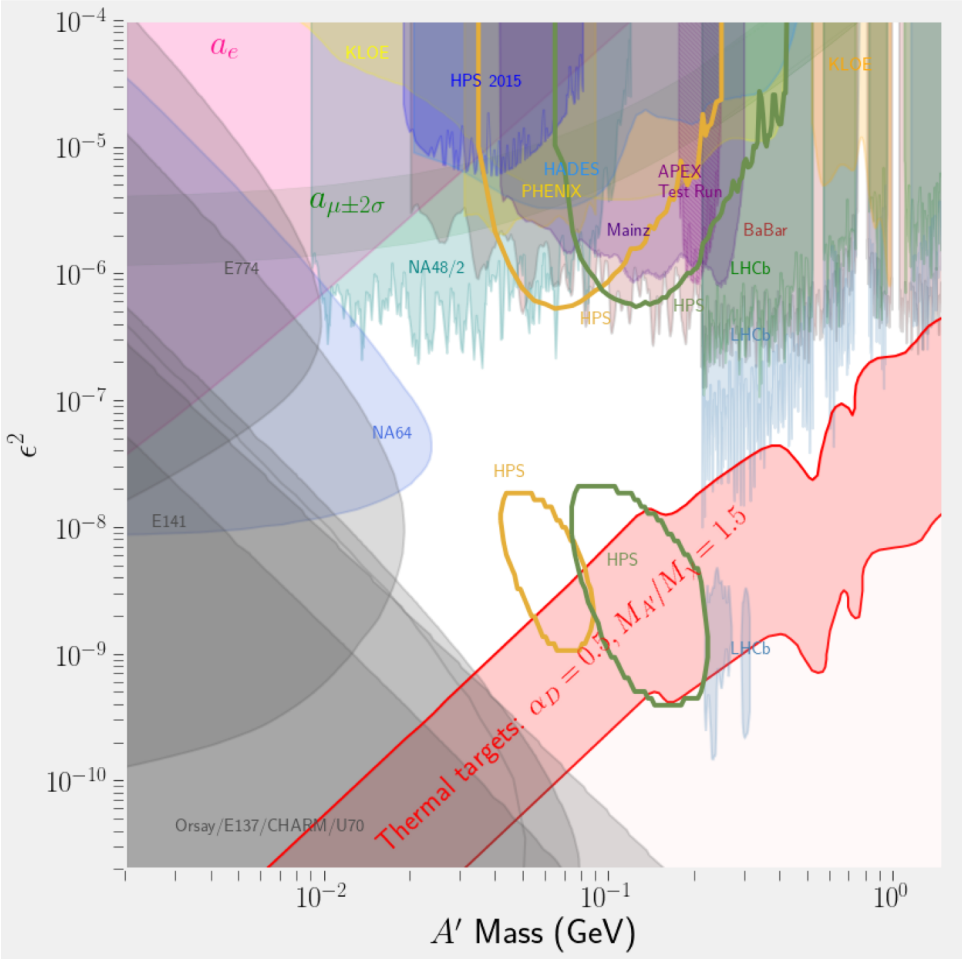
E_{sum} and the invariant mass



Expected reach from 2019 run

- Unblinded sample fully calibrated and processed
- Fully validated 2019 simulations
- Completed analysis of unblinded sample for both resonance and displaced vertex searches
- An accurate account of accumulated charge for “golden” runs

For PAC-48: Projected realistic reach in both, displaced vertex and resonance searches, is a must



Detector rework before the next run

Not much to say here

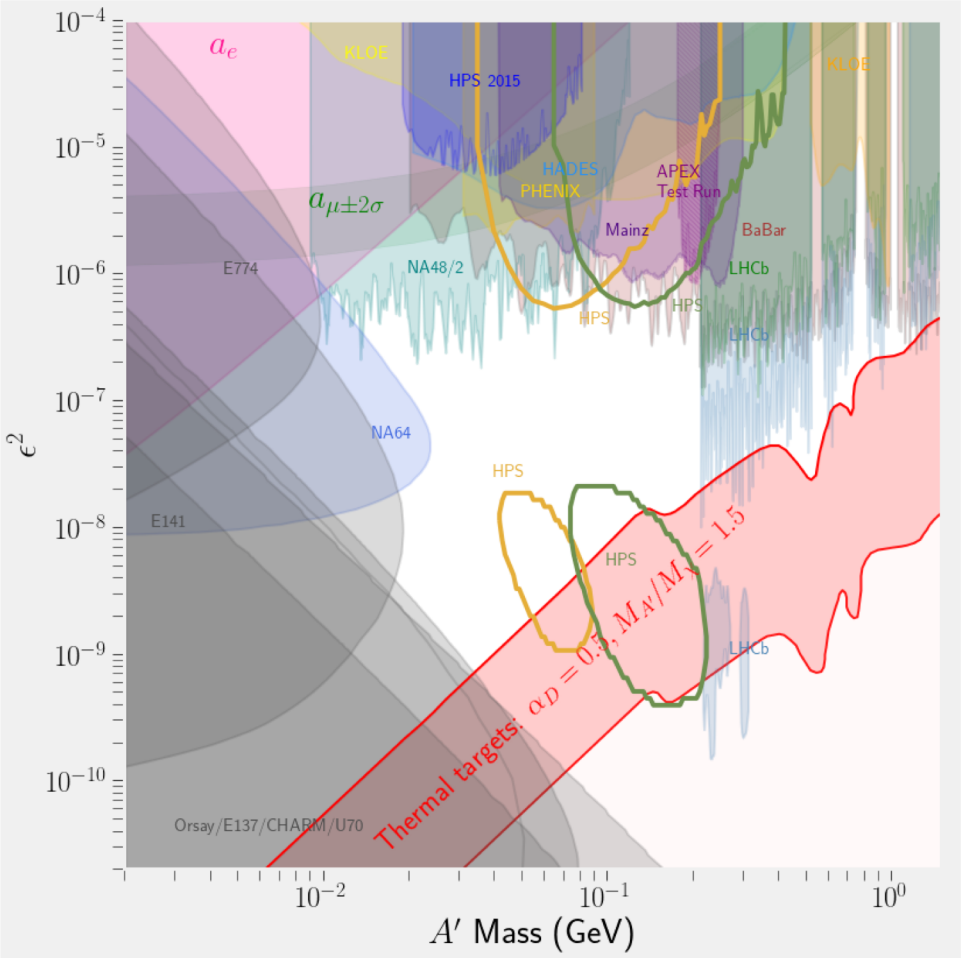
By the time of PAC-48 the list must be defined, resources identified

- Some of the items are known (e.g. a new protection collimator), rest will surface over time
- The main question is – do we need major upgrades to the detector or just repairs

Future HPS runs

- The original proposal asked for the beam energies 2.2 GeV and 6.6 GeV. Later we added 1.1 GeV. The latest results from LHCb left very little for HPS for the mass region above di-mon mass.
- How competitive is HPS with energies >5 GeV ($m_{ee} \geq 2m_{\mu}$)?
- Should HPS focus on running with energies between 2 GeV and 5 GeV?
- HPS has a unique reach in the uncharted region of A' masses from 20 MeV to 200 MeV and the couplings between few x10^{-8} to few x10^{-10} using the **displaced vertex search**

O. Moreno



To conclude

- Jeopardy process at the next PAC meeting will include Hall-B RGs. RG-I, HPS experiment, is in the list
- HPS will need to write an update (about 10 pages) and prepare a presentation for PAC-48. The deadline for the submission of the update (as for proposals) will be most likely end of May beginning of June
- **To succeed with the jeopardy we must have:**
  - **final results from engineering runs (ready to be submitted or be submitted for publication),**
  - **preliminary results of 2019 data analysis showing the z-vertex resolution**
  - **validated simulations showing acceptance for long decay states, and**
  - **a realistic estimation of HPS reach from 2019 data**
- The timeline for the update proposal:
  - outline and assignments – beginning of March
  - first draft for review – beginning of April
  - semi-final draft for review – beginning of May
  - final version ready for submission – week before the deadline