HPS Overview

Tim Nelson - SLAC

HPS Collaboration Meeting

JLab - November 18, 2019

U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

State of the HPS collaboration

Completing 2016 analyses

Operation of 2019 Run

Preparing for 2019 analysis

Preparing for future operations

Collaboration for the 2019 Run (already obsolete!)

SLAC

The collaboration - somewhat smaller than in 2016 - really came together around operations!

Catholic University of America —	Kalicy
Glasgow —	McKinnon, Sokhan
INFN-Catania —	Bondi, De Napoli, Randazzo
INFN-Genova —	Celentano, Marsicano, Battaglieri, DeVita
INFN-Padova —	Simi
INFN-Roma —	D'Angelo
INFN-Sassari —	D'Urso, Carpinelli, Sipala
INFN-Torino —	Filippi
JLab —	Duer, Freyberger, Raydo, Wojsekhowski, Cuevas, Vance, Egiyan, Elouadrhiri, Ungaro, Baltzell, Boyarinov, Stepanyan, Kubarovsky, Burkart, Sharabian
ODU —	Bueltmann
Orsay —	Munoz, Charles, Guidal, Dupre, Niccolai
Stony Brook —	Essig
SLAC —	Reese, Bravo, Field, Jaros, Graham, Solt, Toro, Graf, Moreno, Schuster, Herbst, Maruyama, Nelson
Tel Aviv University —	Paul
UCSC —	Spellman, Johnson, Fadeyev
UNH —	Yale, McCarty, Holtrop, Paramuzyan
William and Mary —	Griffoen
Yerevan —	Voskanyan, Dashyan, Gevoryan

Changes in Membership

Some notable last-minute additions made a big difference during the run!

- TongTong Cao — UNH (postdoc)
- Dominique Marchand — Orsay
- Pierfrancesco Butti — SLAC (postdoc)

We need more effort on calibration, reconstruction and analysis than in the past, and we have lost or will soon lose some important students and postdocs.

Potential new members:

- Christina Gurney — UNH (student)
- Lauren Tompkins — Stanford faculty (+ postdoc and/or student) (discussing contributions to SVT repair and reconstruction/analysis)

We have a lot of work to do on our data, and a lot of physics potential, making this an ideal time to engage new students!

HPS Organization

Spokespeople:

Maurik Holtrop (UNH), Tim Nelson (SLAC), Stepan Stepanyan (JLab)

Executive Committee: (two seats to be elected at this meeting)

Nathan Baltzell (JLab), Marzio De Napoli (INFN Catania), Raphael Dupre (Orsay),
Matt Graham (SLAC), Maurik Holtrop (UNH), John Jaros (SLAC-ex officio),
Tim Nelson (SLAC), **Stepan Stepanyan (JLab - chair)**

Publications and Presentations Committee:

Gabriel Charles (Orsay), Andrea Celentano (INFN Genova - Chair),
Rouven Essig (Stony Brook), Norman Graf (SLAC), Rafayel Paremuzyan (UNH)

HPS Subgroups and Coordinators

SLAC

SVT/Tracking: *T. Nelson(SLAC), N. Graf(SLAC)*

- construction, commissioning, operations
- calibration and alignment
- track and vertex reconstruction

ECal: *R. Dupre(Orsay)*

- construction, commissioning, operations
- calibration and alignment
- ECal reconstruction

Beamline: *S. Stepanyan(JLab)*

- beam controls and diagnostics
- detector protection and interlocks

DAQ: *S. Boyarinov(JLab), R. Herbst(SLAC)*

- Integration of SVT DAQ/JLab TDAQ
- Event building and data handling

Trigger: *V. Kubarovsky(JLab)*

- study of trigger rates and efficiencies
- definition of trigger menu

Software: *M. Holtrop(UNH)*

- reconstruction framework and data processing
- simulation framework and MC production
- detector calibrations

Analysis: *M. Graham(SLAC), N. Baltzell(JLab)*

- data quality
- directing physics analysis
- planning publications and releases of new results
- define critical tasks for software and detector groups

Monte Carlo?

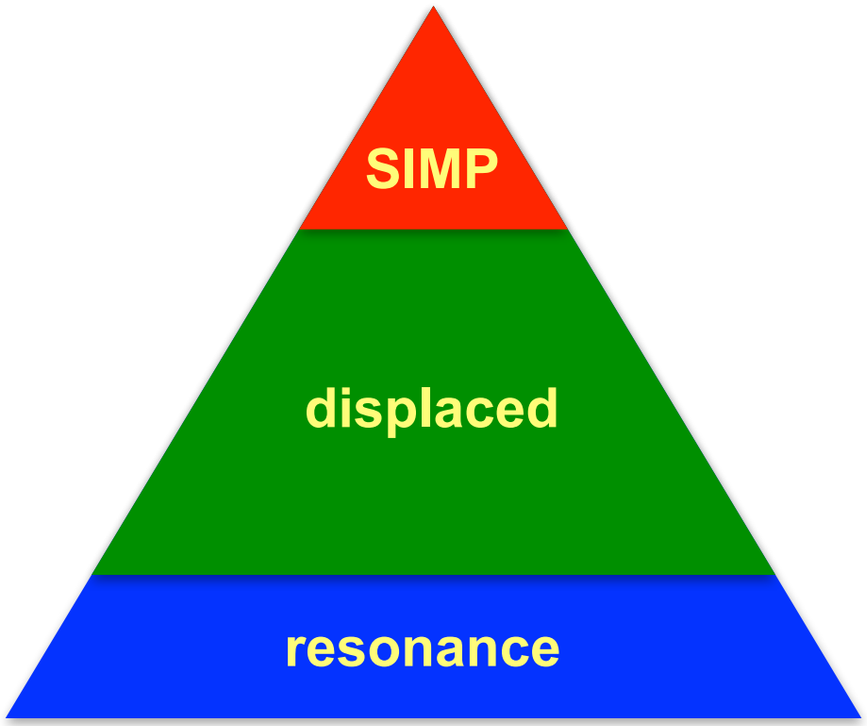
Other additions/changes?

Completing 2016 Analyses

Goal was to have these completed by now, and we must decide without delay how to pursue them.

- Resonance and displaced searches for dark photons have marginal access to new physics

- SIMP search — an extension of displaced search — very likely accesses new physics



Given major investment in this data, dropping these entirely is unacceptable.

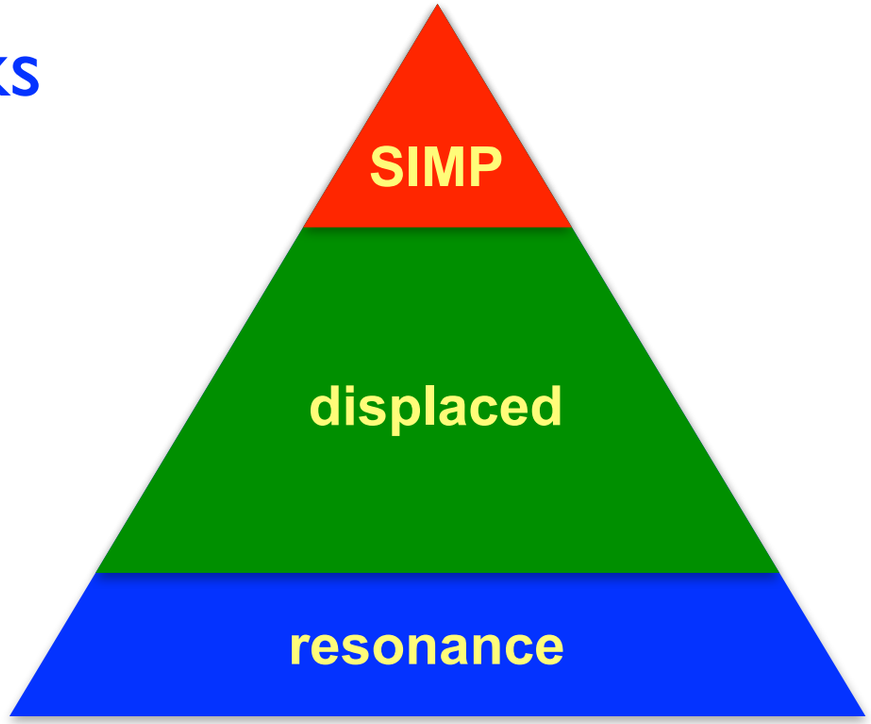
Work required to get the most impactful physics - the SIMPs - out of the data is considerable.

My opinion: we should go all-in to complete these, and figure out how to leverage the work required in the furtherance of 2019 analyses.

Completing 2016 Analyses

These analyses have come a long way, but more work is required to bring them to completion.

- Validation and tuning of MC kinematics and efficiencies
- Selection optimization for events and tracks
- mass scale, resolution
- vertex position, resolution
- vertexing cut validation and optimization
- SIMP MC validation
- … and systematics on all



A framework is needed: analysis notes that compile all of this as progress is made, and editorial boards to evaluate and advise.

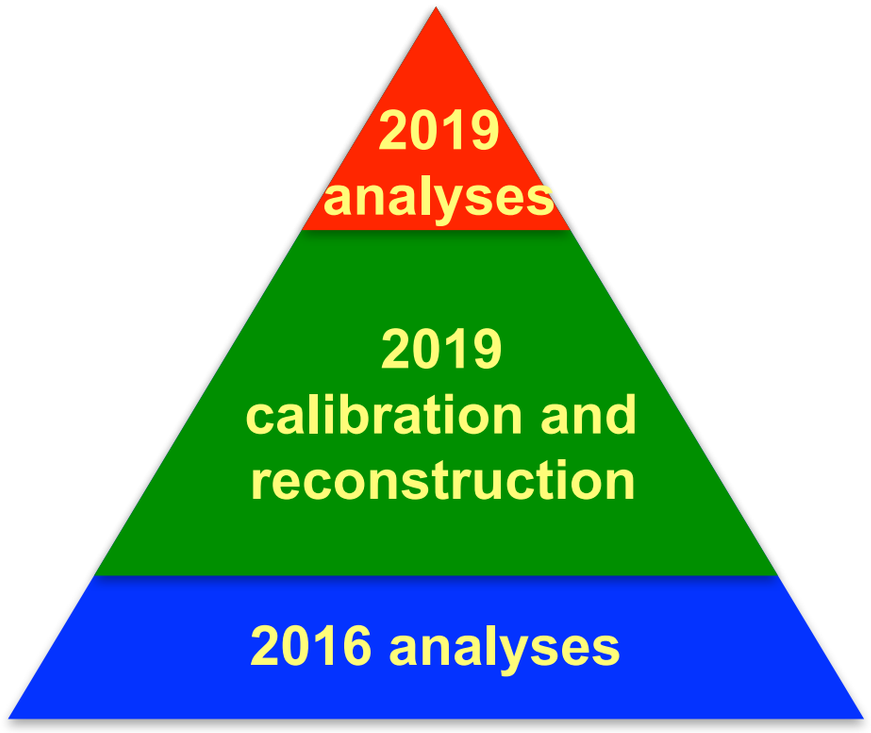
More detail in Matt Graham's talk

Completing 2016 Analyses

This work must pay maximum dividends beyond the results themselves.

If we can complete 2016 analyses with:

- Well founded and carefully tested analysis techniques
- Careful and complete documentation of the work at every stage
- Involvement of those who will be responsible for duplicating the analyses with 2019 data.



…then completing the 2016 analysis can put us in a better position for the future.

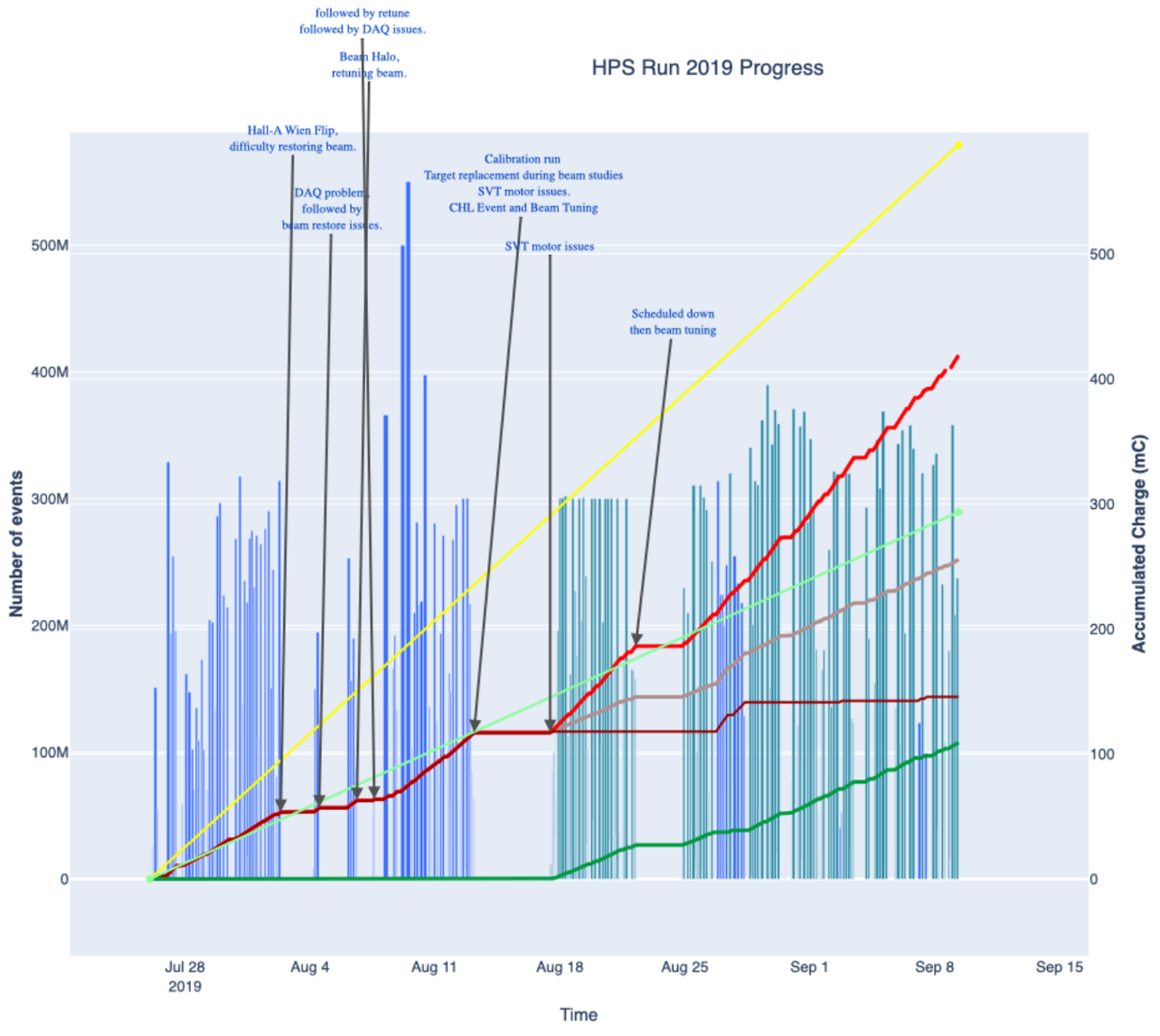
More detail in Matt Graham's talk

Operation of the 2019 Run

It was an uphill battle all the way

- CEBAF issues cut running time, created data quality issues, and damaged detector
- Environmental issues in the alcove - radiation, temperature - also caused significant downtime
- SVT suffered the most
- ECal had mostly minor issues.

We took a lot of data, but need to identify solutions to the problems.



More in Maurik's talk, as well as subsystem talks

Preparing for 2019 Analysis

Data Quality and Calibration

SVT:

- status (position, bias)
- per-channel calibrations (incl. "bad" status)
- alignment

} relatively complicated
- multiple people over several months

ECal:

- per-channel calibrations (incl. "bad" status)
- alignment

} relatively simple
- 1-2 people over a few months

Hodoscope

- alignment
- per-channel calibrations
- crosstalk

} relatively simple but a *new task*
- 1-2 people over a few months?

Some key experts now gone.

More details in subsystem talks

Preparing for 2019 Analysis

Reconstruction Techniques

SVT:

- improved SVT hit reconstruction (position & time reconstruction and errors)
- improved track finding/fitting (Kalman filter / GBL revalidation / 4-d fitting)
- improved track cleaning and selections

Some of these are necessary given holes in the SVT in 2019 data.

More from Norman, Robert, and PF

ECal and Hodoscope:

- improved position and energy reconstruction
- improved ECal/Hodoscope position/energy reconstruction. Particle ID (esp. μ)

Some creative work needed to take advantage of the hodoscope.

More from Nathan and Rafo

Preparing for 2019 Analysis

SLAC

Monte Carlo — new tools are needed to deal with higher statistics

- biasing for background samples
- better infrastructure for distribution of large jobs
- overlay of random trigger data to model beam backgrounds

Takashi leaves big shoes to fill here. Cameron has been investigating how to approach simulation in the future. More from Cameron and TongTong.

Data Analysis — need functional and easily maintainable tools

- The flat NTuple is bloated and has no good framework to support analysis
- A root-based "DST" filled with reconstructed objects is the preferred solution
- Grassroots effort has developed around HPSTR — successor to the old DST — developed with the goal of better supporting complex analysis chains.

Regardless of what is chosen, work is needed to prepare these tools to handle the full range of tasks for 2019 analysis. See Maurik's software talk.

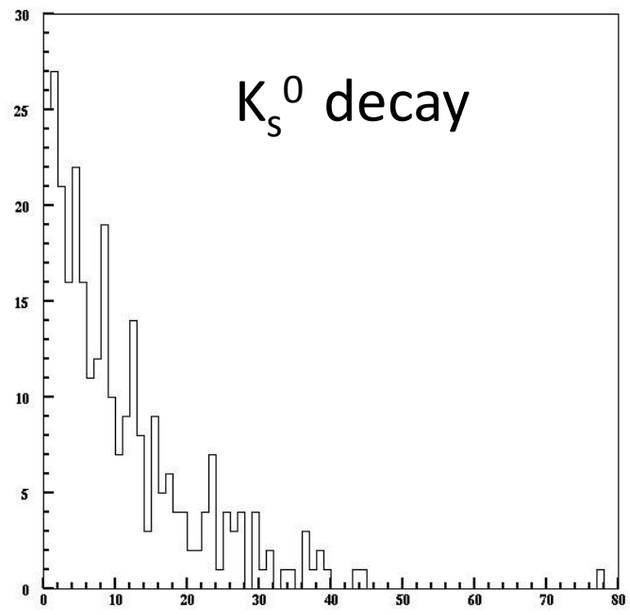
Life Without Møllers

From Takashi's talk last fall:

https://www.jlab.org/indico/event/288/session/3/contribution/26/material/slides/0.pdf

	$\sigma(\gamma p) \cdot BR$	σ(e-W) FLUKA	HPS Acceptance	Trigger Eff. HPS-MC	Rate @ 300 nA
ρ	20 μb	13 mb			
$\omega \rightarrow \pi+\pi-$	5μb · 1.5×10^{-3}	~2 mb	0.7 %	14%	0.3 Hz
$\omega \rightarrow$ e+e-	5μb · 7×10^{-5}	~2 mb	0.7 %	100%	0.1
$\phi \rightarrow$ K+K-	0.4μb · 0.49	0.13 mb	46 %	14%	420
$\phi \rightarrow$ KsKl	0.4μb · 0.34	0.13 mb	1.2 %	14%	8

Learning how to calibrate our mass scale and resolution will be a major project. (Consider how much time was spent mastering Møllers!)



Looking to the Future

The JLab jeopardy process is a key milestone, and we must understand what we can show on that timeframe.

- near complete 2016 analyses
- significant progress on 2019 analyses

Is this enough? More from Stepan tomorrow.

In preparing to run again, repairing the SVT is the big item

- FEBs
- Layer 0/1 modules

In addition, being several years old, some things simply need service:

- SVT chiller
- SVT motors
- ECal?

In addition, we need to consider beamline/monitoring changes required for safer running. More in beamline talk?

HPS in the Bigger Picture

The competition is coming…

- LHCb recently released $A' \longrightarrow \mu\mu$ results for full RunII dataset.

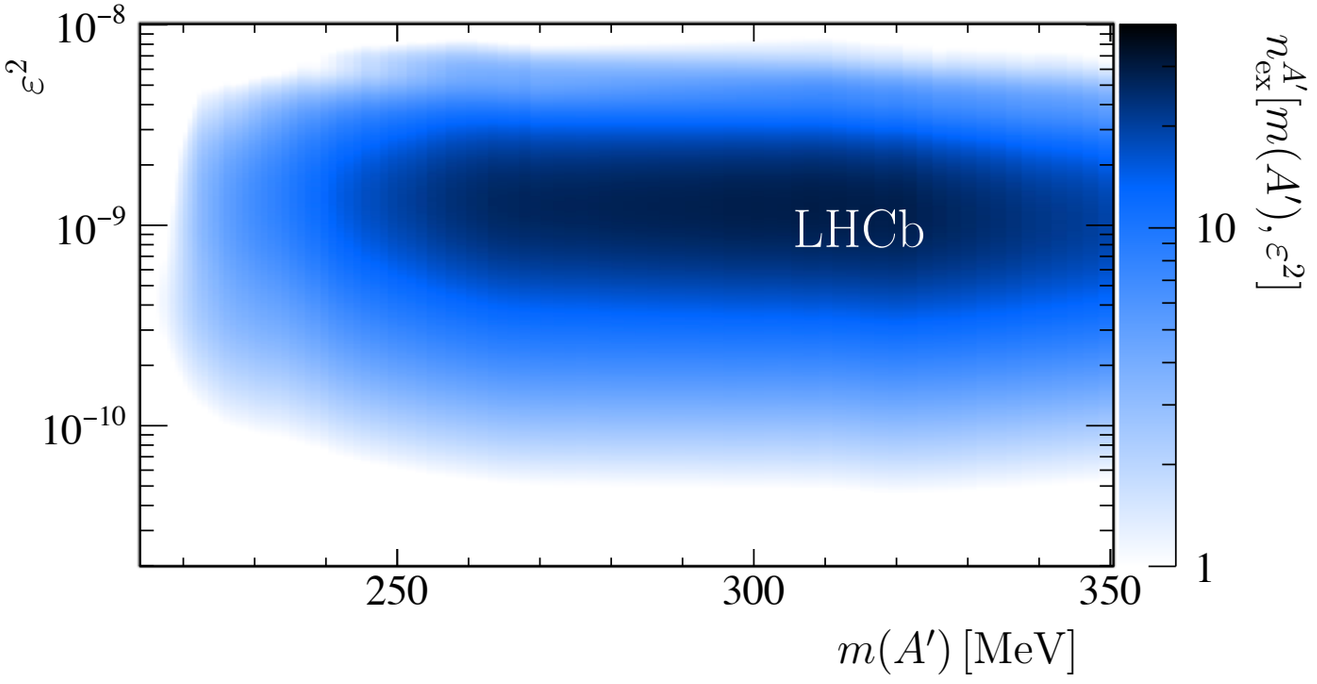
$\Longrightarrow$ actual reach much less than projected

— getting to zero background is hard!

- Seaquest running, hoping to add ECal

$\Longrightarrow$ actual $\mu\mu$ reach appears likely much less than projected (trigger efficiency)

$\Longrightarrow$ DarkQuest proposal (including ECal) for DMNI funding declined



… but still room for HPS to have a big impact with future runs!

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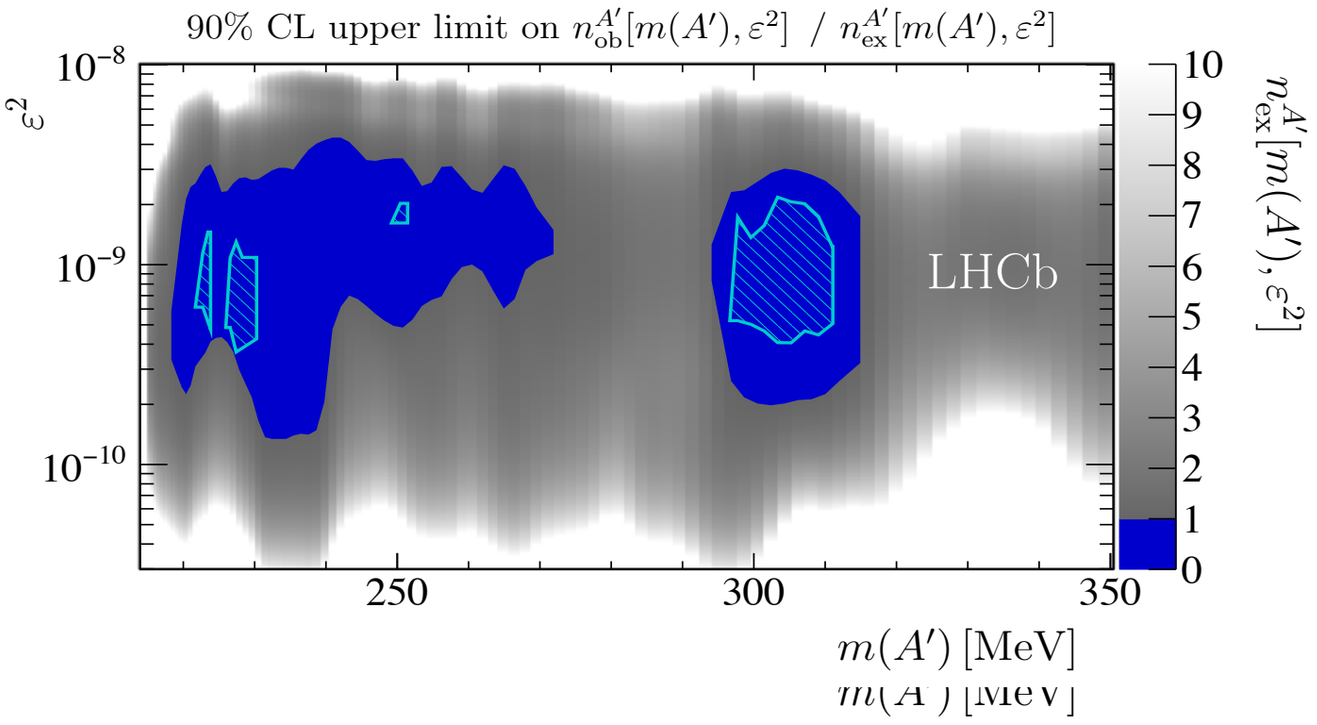

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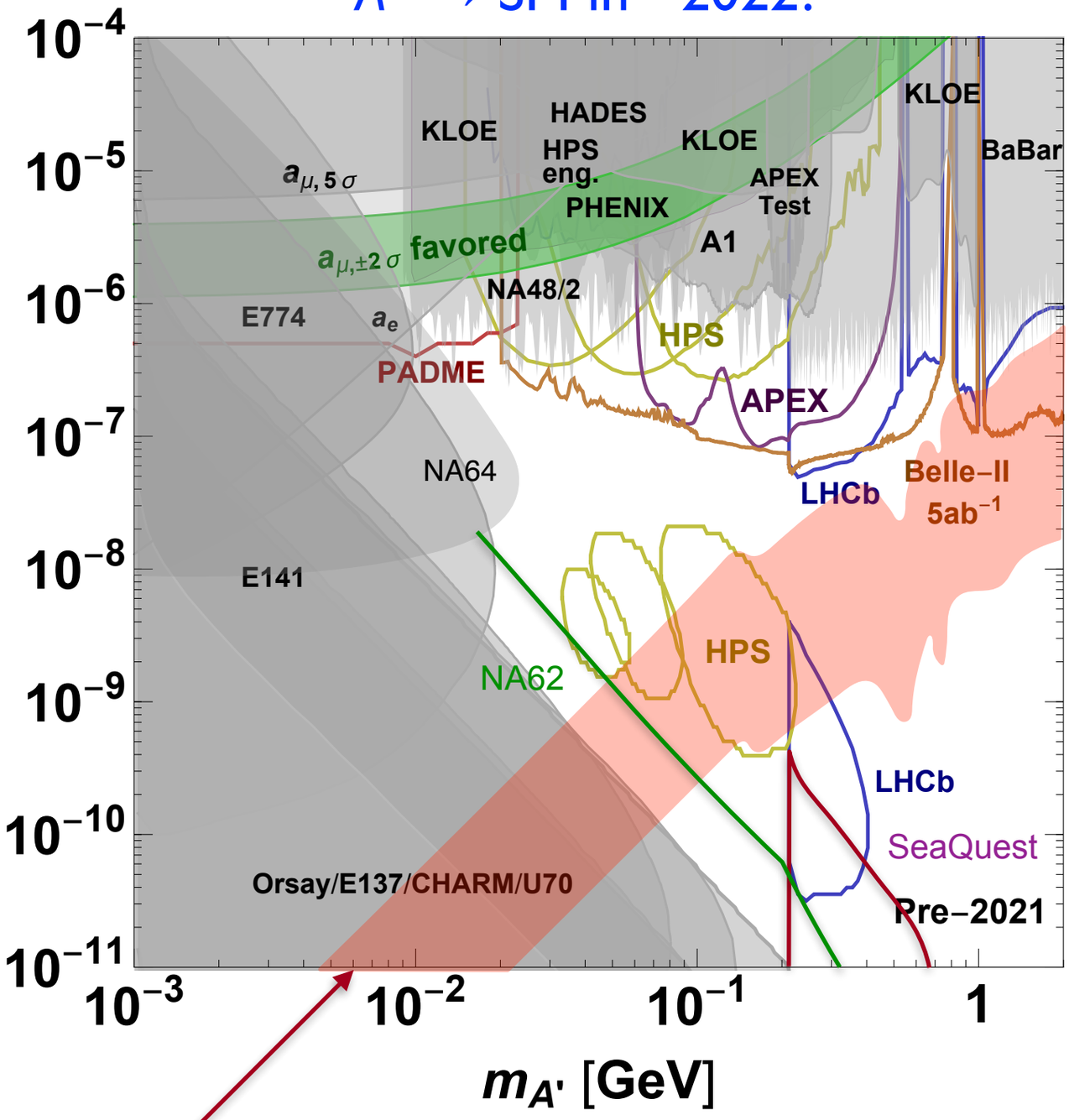
$A' \longrightarrow$ SM in ~2022?



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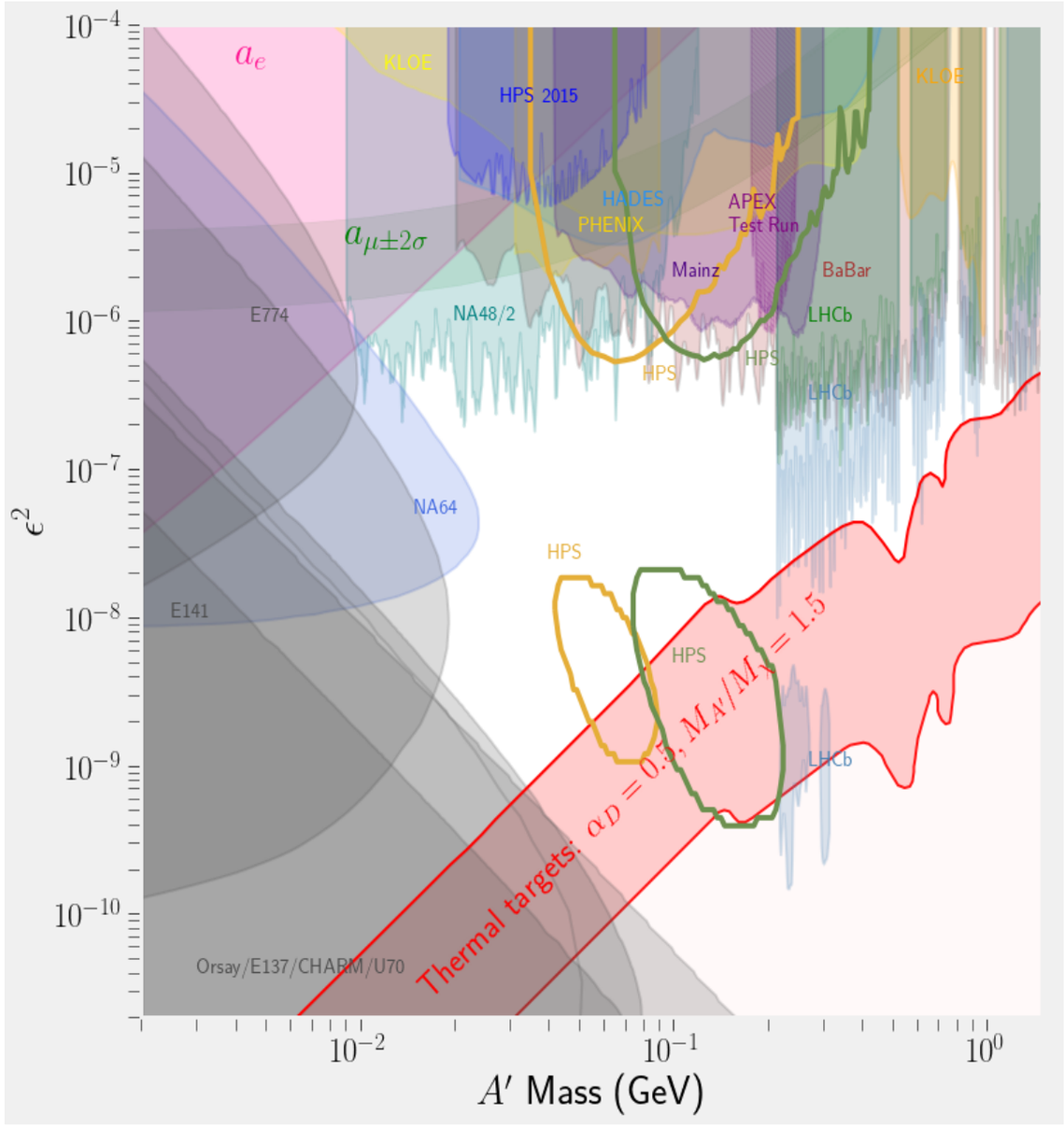

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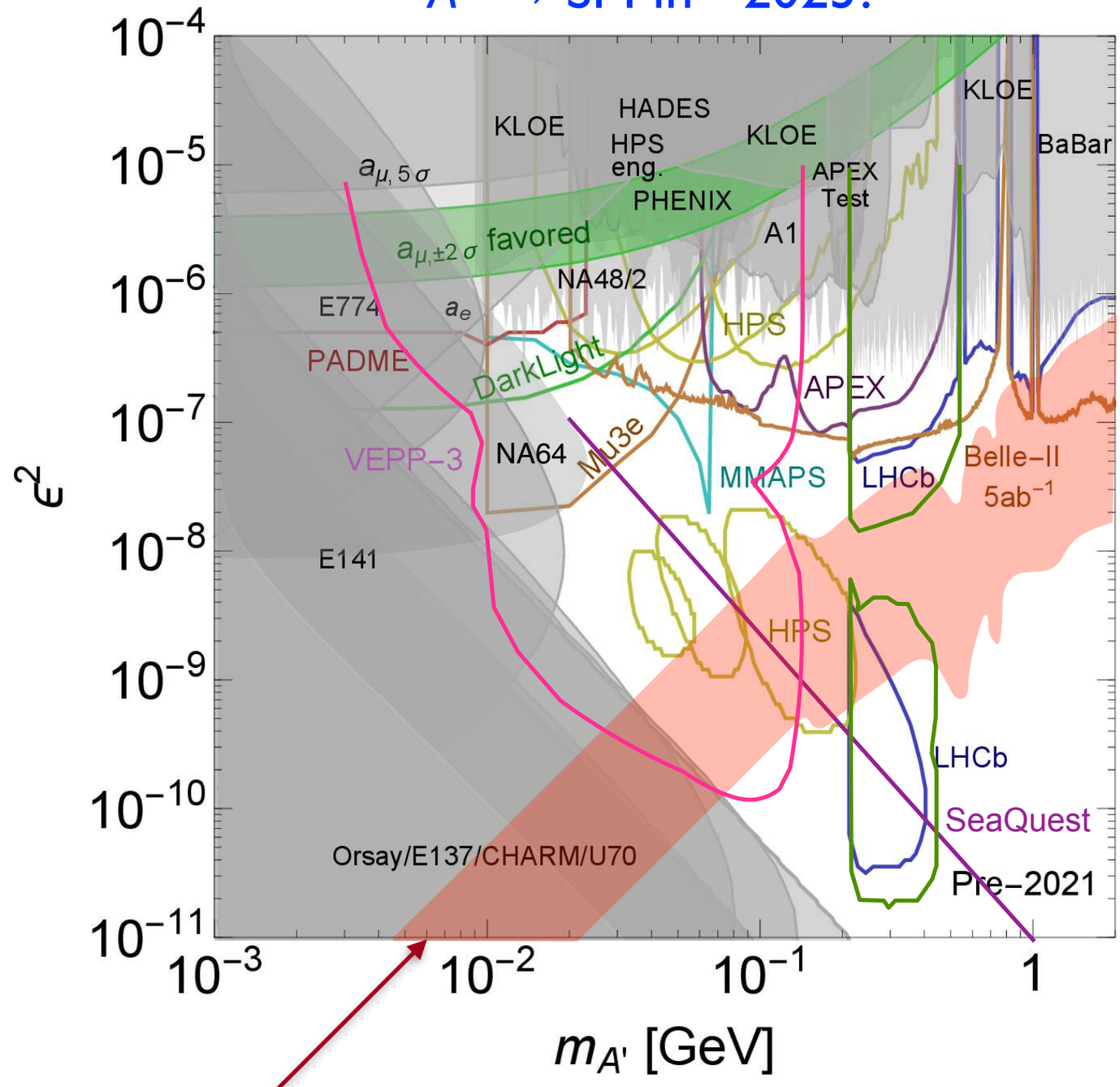

thermal targets

$\alpha_D = 0.5, M_{A'}/M_\chi = 1.5$

Summary

It is a very exciting time for the experiment

We succeeded with our first long run despite major headwinds

2019 dataset has a great deal of physics potential

Also have some real physics potential in the 2016 data

Serious work is required to convert these datasets into results

Similarly, there is a lot of work to do to get the detector into shape again. However, HPS is in a great position to do more physics over the coming years.