

# HPS Overview

Tim Nelson - **SLAC**

*HPS Collaboration Meeting*

*November 18, 2020*

**HPS collaboration news**

**Completing 2016 analyses**

**Launching 2019 analyses**

**Preparing for 2021 operations**

**HPS beyond 2021**

# HPS Membership News

*Lauren Tompkins (Stanford) has formally applied for membership, up for approval at this meeting: (Don't forget to vote!)*

- SIMPs (Stany Sevova and Jess Fry)
- FEB diagnostics and redesign (Marcelo Vicente)

*A new Ph.D. to celebrate:*

- Dr. Matthew Solt 🎉 — UVA postdoc (LDMX)

*With the availability of 2019 data, and more coming in 2021, we now have more physics (and thesis topics) than students!*

*This is a great time to engage new students on HPS: we have a significant dataset, operations next year to triple our data, and multiple postdocs who are now top analysis experts ready to guide new students!*

## *Spokespeople:*

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

## *Executive Committee:*

Marzio De Napoli (INFN Catania), Norman Graf (SLAC), Maurik Holtrop (UNH), John Jaros (SLAC - emeritus), Omar Moreno (SLAC), Tim Nelson (SLAC), Rafayel Paramuzyan (JLab), **Stepan Stepanyan (JLab - chair)**

## *Publications and Presentations Committee:* (two seats to be elected at this meeting)

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

*Don't forget to vote!*

# HPS Management Plan

*The complexion of the collaboration and the challenges it faces have changed since the collaboration was established during construction. The spokespeople and EC have developed a new organization aimed at meeting our challenges over the next ~year.*

- Proposed working groups and coordinators
  - Preparing for 2021 run:
    - DAQ, Sergey and Ryan
    - Trigger, Valery
    - Slow controls, Nathan and Omar
    - Monitoring, Matt G.
    - SVT, Tim
    - ECal/hodoscope, Rafo
    - Beamline, Stepan
  - 2019 analysis:
    - Analysis, Matt G. and Cameron
    - Calibration and recon., Norman and PF
    - MC, Tongtong
    - Software, Norman
- EC oversight
  - slow controls, Rafo
  - ECal/hodo, beamline, DAQ/trigger, Marzio
  - MC and Software, Maurik
  - analysis, Tim
  - monitoring, Norman
  - calibration/recon, Omar
  - SVT, Stepan

The EC has drafted a management plan to clarify these roles.

<https://www.overleaf.com/read/yfpkppnmsrmz>

# HPS Code of Conduct

*The HPS Charter and Bylaws is increasingly outdated with respect to current best practices for diversity and inclusion.*

An important first step is a code of conduct for the collaboration.

The EC is beginning to review a draft code of conduct for inclusion in our governing documents.

We will have a presentation of this from Omar on Friday with time for discussion afterwards.

*There is much more to do in this area, and I would like to encourage broader participation among the collaboration in these efforts.*

*The review of HPS by PAC 48 was a major milestone for this year.*

*Success rested on three pillars:*

- Analysis results from 2016 data
- Progress with calibration and reconstruction for 2019 data
- A run plan for 2021 and beyond with updated reach estimates

*These continue to define many of our activities.*

PAC 48 SUMMARY OF JEOPARDY RECOMMENDATIONS								
Number	Contact Person	Title	Hall	Days Req'd	Days Awarded	Scientific Rating	PAC Decision	Topic
<a href="#">E12-12-002 (GlueX-II)</a>	M. Shepherd	An update on the GlueX II and Jefferson Lab Eta Factory experiments	D	220		A	Remain Active	1
<a href="#">E12-13-008 (Pion polarizability)</a>	R. Miskimen	Measuring the Charged Pion Polarizability in the gamma gamma -> pi+ pi- Reaction	D	25		A-	Remain Active	2
<a href="#">RG-A</a>	L. Elouadrhiri	CLAS12 Run Group A (RG-A)	B	200		A	Remain Active	4
<a href="#">RG-B</a>	S. Nicolai	CLAS12 Run-Group B: Electroproduction on deuterium with CLAS12	B	56		A	Remain Active	3
<a href="#">RG-C</a>	S. Kuhn	CLAS12 Run Group C	B	200	120	A	Remain Active	4
<a href="#">RG-D</a>	L. El Fassi	Study of Color Transparency in Exclusive Vector Meson Electroproduction off Nuclei	B	60	30	B+	Remain Active	5
<a href="#">RG-E</a>	W. Brooks	Quark Propagation and Hadron Formation	B	60		A-	Remain Active	5
<a href="#">RG-G</a>	W. Brooks	The EMC Effect in Spin Structure Functions (CLAS Run Group G)	B	55		B+	Upgrade Rating A-	4
<a href="#">RG-H</a>	M. Contalbrigo	Run Group H Jeopardy Update Document. CLAS12 Experiments with a Transversely Polarized Target	B	110		A	Remain Active	4
<a href="#">RG-I</a>	T. Nelson	Search for Massive Photons at Jefferson Laboratory (HPS)	B	180		A	Remain Active	6
<a href="#">RG-K</a>	A. D'Angelo	RG-K Quark-Gluon Confinement & Strong QCD	B	100		A-	Remain Active	5

**3) Should the remaining beam time allocation and experiment grade be reconsidered?**

The collaboration proposes that future physics operations include 10 PAC weeks at  $\approx 4$  GeV and 6 PAC weeks at  $\approx 2$  GeV. The PAC endorses this scenario and recommends maintaining the remaining time allocation (135 days) as well as the experiment grade A.

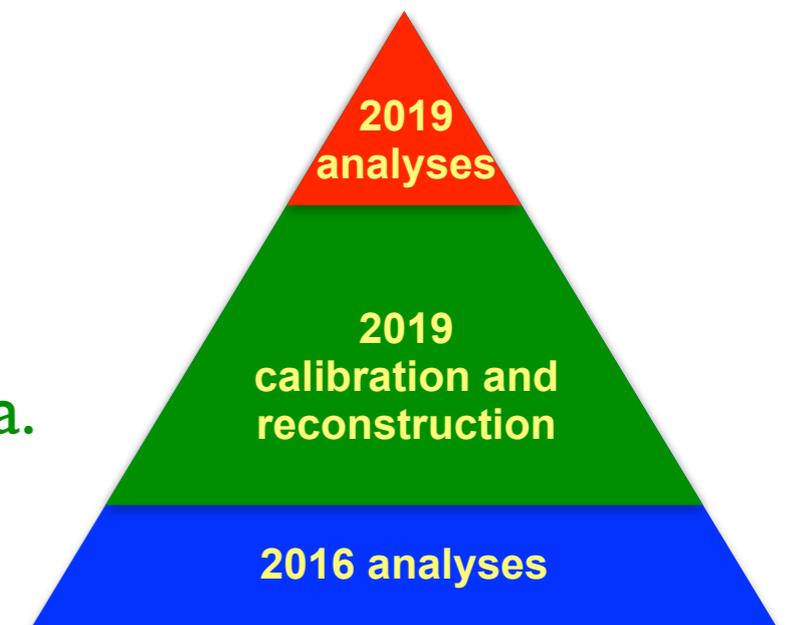
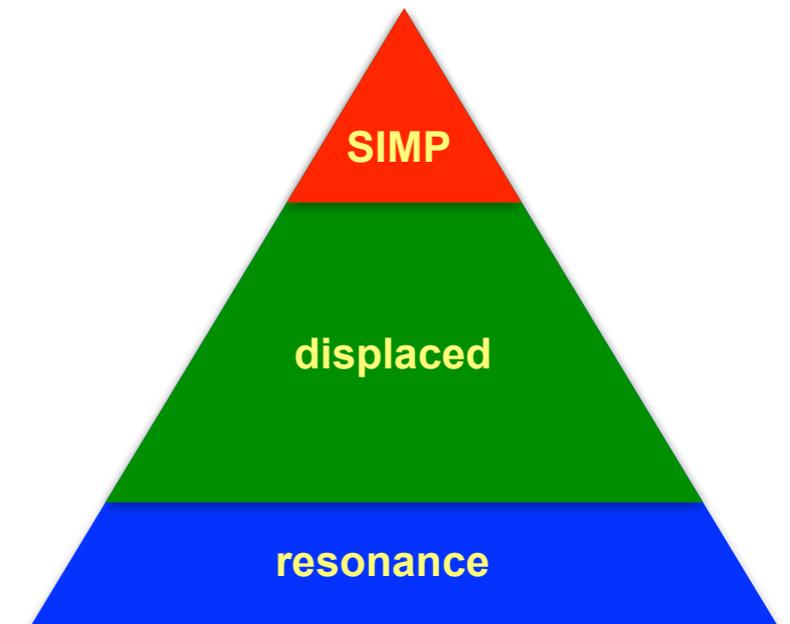
**Summary:** The PAC recommends the approval of 135 PAC days of beam time for running with beam energies from  $\approx 2$  GeV to  $\approx 4$  GeV.

# 2016 Analyses

*We went all-in on the effort to complete the 2016 A' analyses with several goals in mind:*

- show the PAC what HPS can do with its data
- develop and document improved tools and techniques as foundation for **future generations of the A' analyses.**
- create a foundation with the resonance and displaced searches – where no new sensitivity was expected – on which to **build the first SIMPs result.** (*Jess Fry's talk*)
- develop expertise in these analyses among new collaborators who will **carry them forward with 2019 data.**

*So far, this has been a relatively successful strategy, but more work is needed to capitalize on it.*



# Analyzing 2019 Data

*Accordingly, attention has turned increasingly to work required to enable 2019 analysis, which defines the offline Working Groups:*

## *Calibration and Reconstruction:*

- ECal calibration (*Andrea's Talk*)
- SVT alignment and calibration (*PF's talk*)
- Track reconstruction improvements (*PF/Robert/Alic's talk*)
- Development of new calibration techniques and samples (*Norman's talk*)

## *Monte Carlo:*

- Development of data samples required for calibration and analysis (*TongTong's talk*)
- Development of tools for generating much larger background samples (*Omar's talk*)

## *Software and Computing:*

- Management of software and computing resources for data processing (*Norman's talk*)

## *Analysis*

- Further development of the analysis framework for 2019 data (*Cameron's talk*)

*Significant advances have been made in all of these areas, but there is much left to do, and these groups would all benefit from broader participation.*

# Preparing for 2021 Operations

*On top of everything else, we've got quite a lot to do to get ready to run next year under less-than-optimal circumstances.*

Beamline changes and improvements (*Stepan's Talk*)

SVT maintenance and repair (*Tim and Marcelo's Talks*)

ECal and Hodoscope maintenance and repair (*Rafo's talk*)

DAQ updates (*Sergey's Talk*)

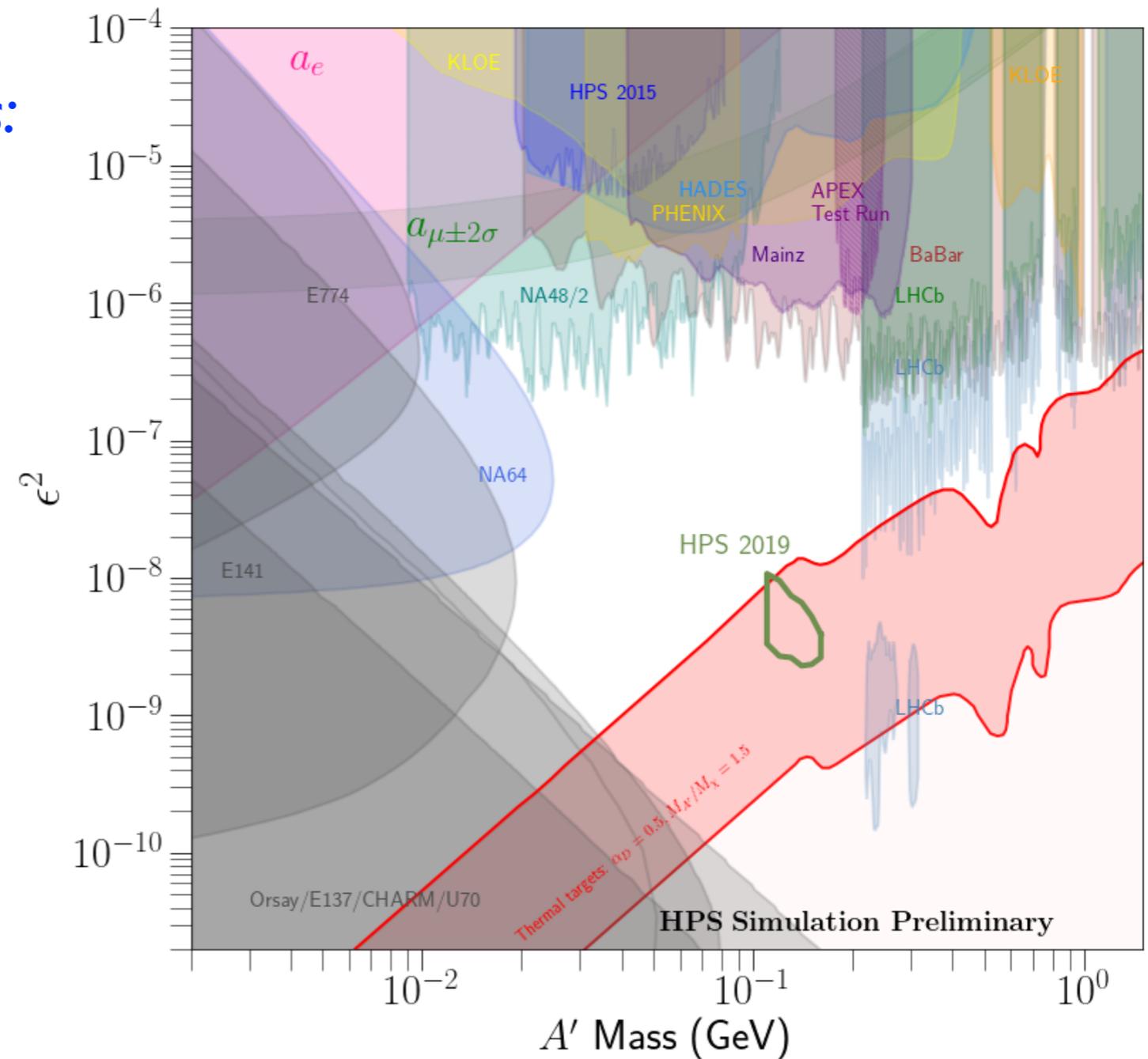
*Monthly meetings of Run Group / Task Force provide an important forum to track progress, discuss problems, and plan solutions.*

*It is difficult to make specific plans in the presence of COVID uncertainties, but we need to make a baseline schedule and update it as conditions evolve.*

# Reach Projections (from PAC presentation) *See Cameron's talk*

*Updated reach projections based on experience with 2016 analyses:*

2019 data @ 4.55 GeV opens up window of sensitivity



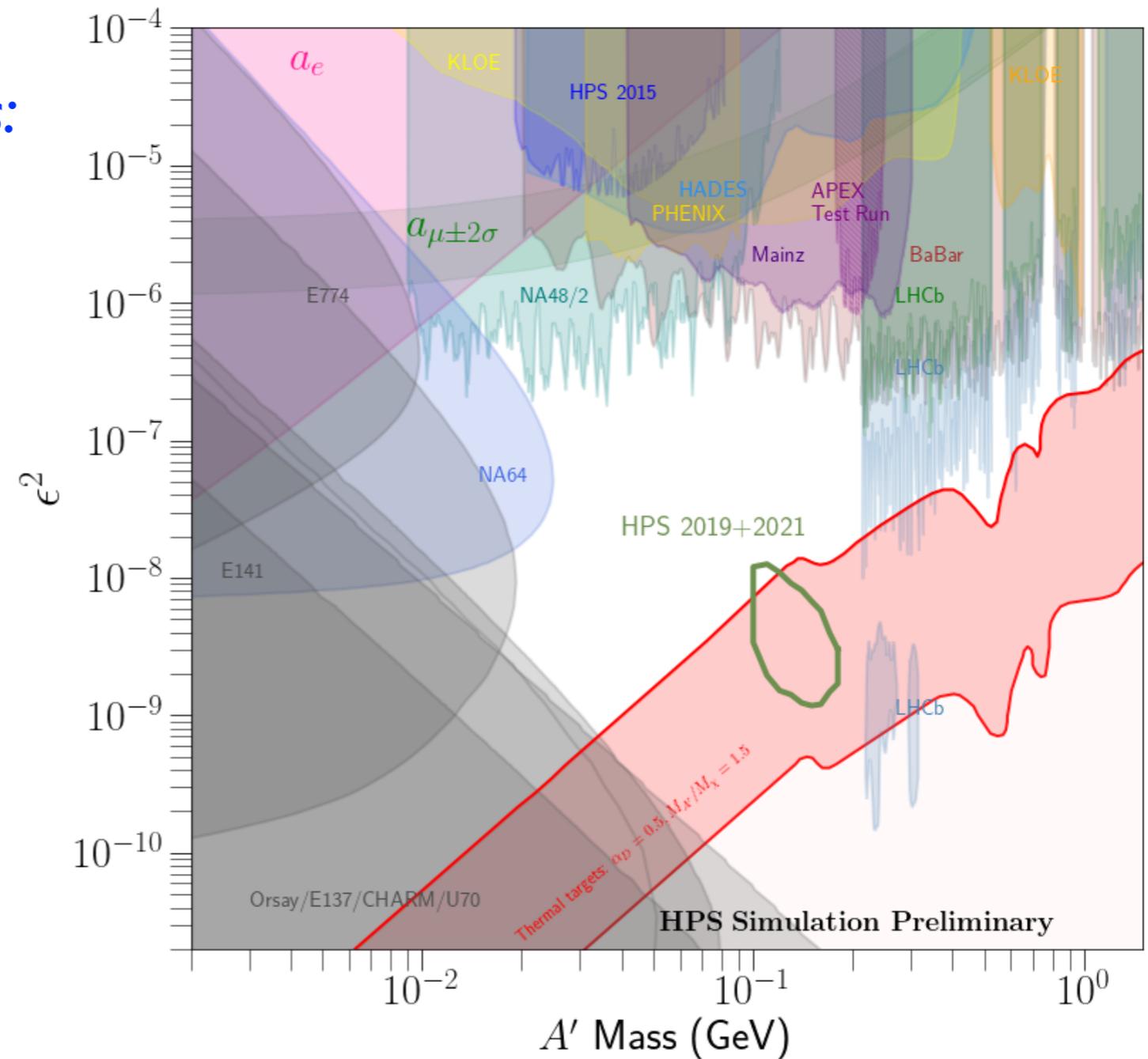
*Run plan optimization is ongoing and depends on availability of specific energies.*

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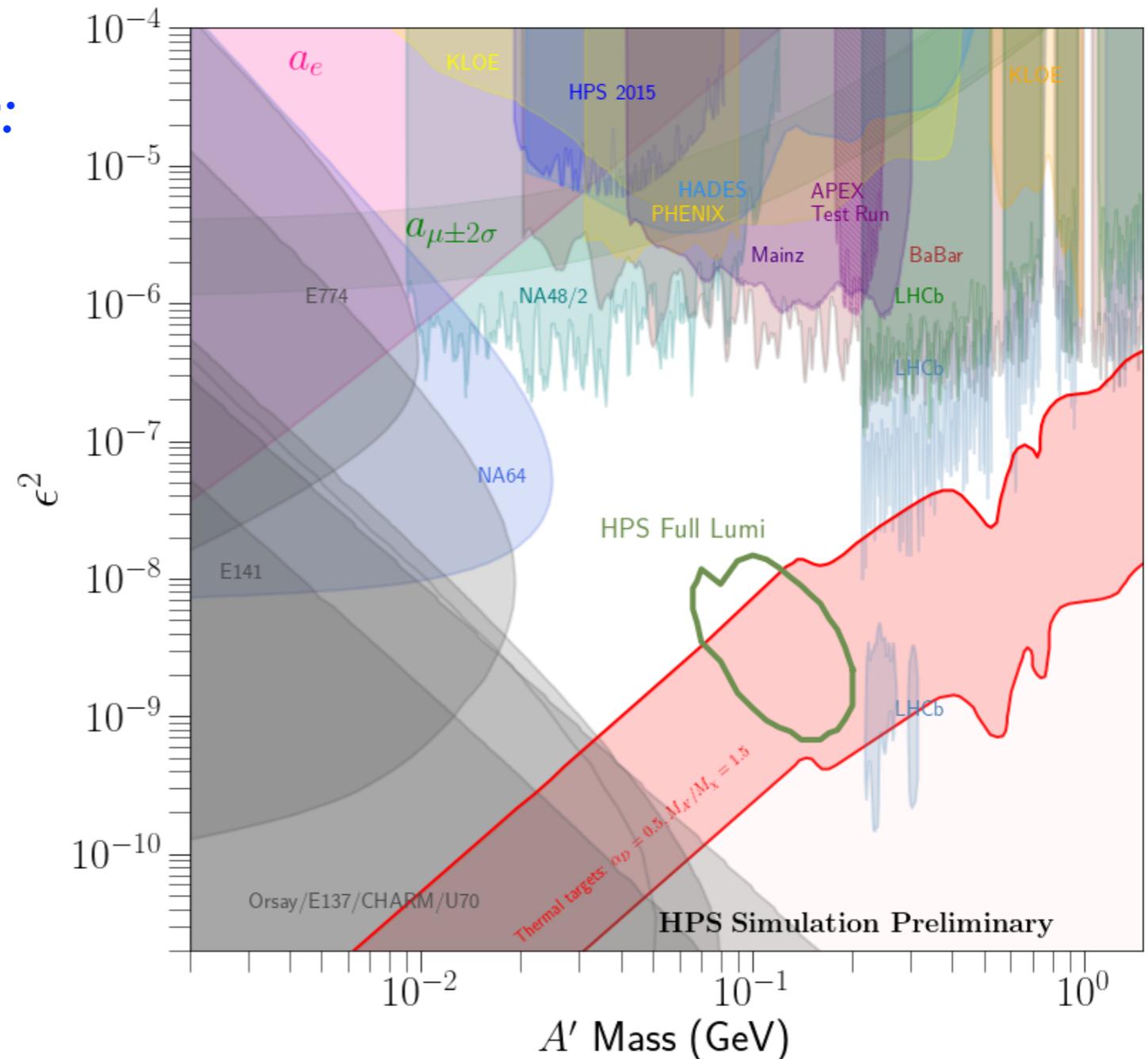
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Full Run Plan (2021 + 107 days) more than doubles this again.



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# LHCb – Run 2 (completed) and Run 3 (2021-2023)

Potential for reach in two mass ranges.

[arXiv:1603.08926](https://arxiv.org/abs/1603.08926) [hep-ph]

Run 2 and Run 3 above dimuon threshold

$$A' \rightarrow \mu^+ \mu^-$$

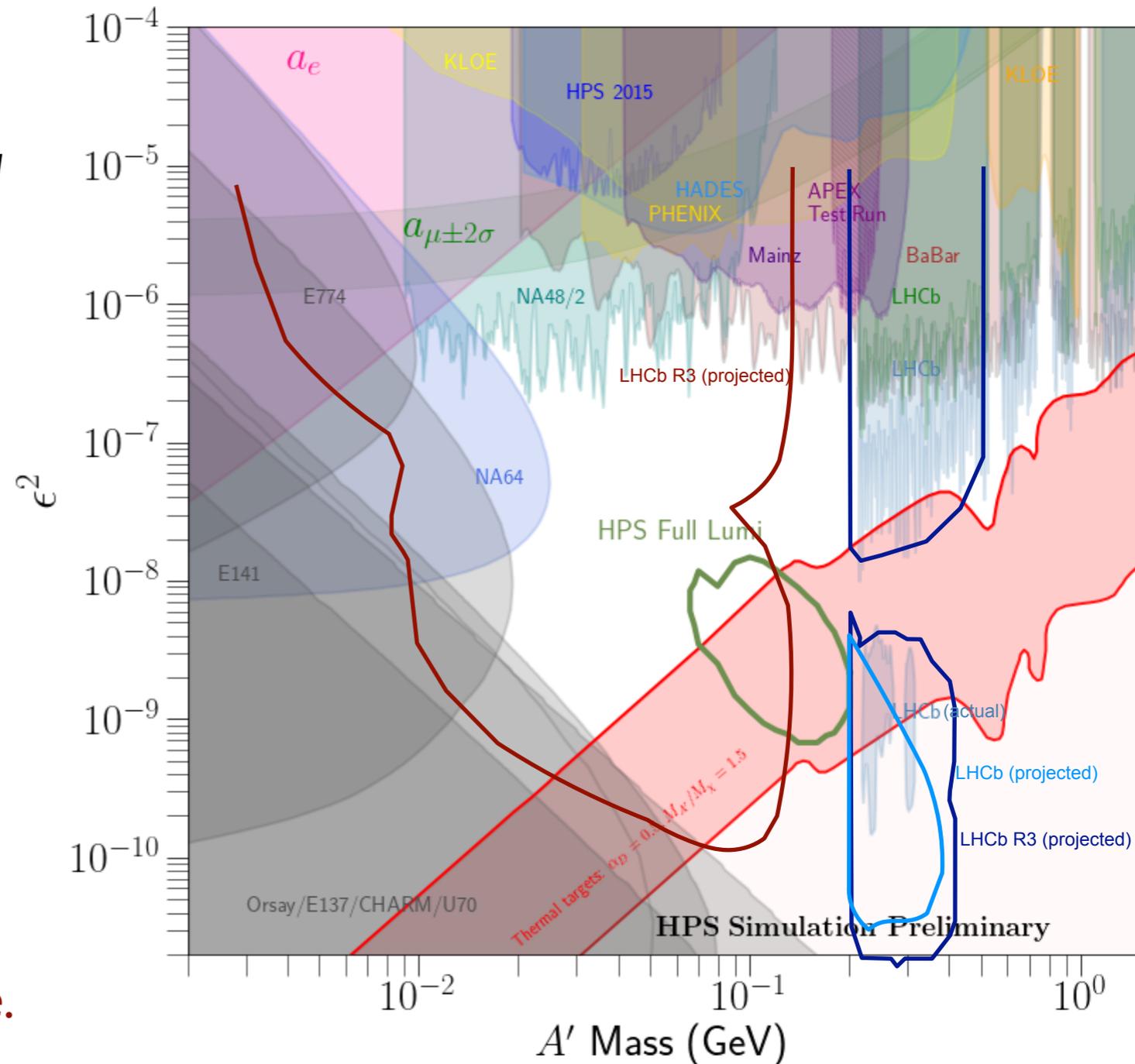
Unexpected long-lived backgrounds impacted expected reach.

Run 3 below the  $D^{*0}$ - $D^0$  mass difference

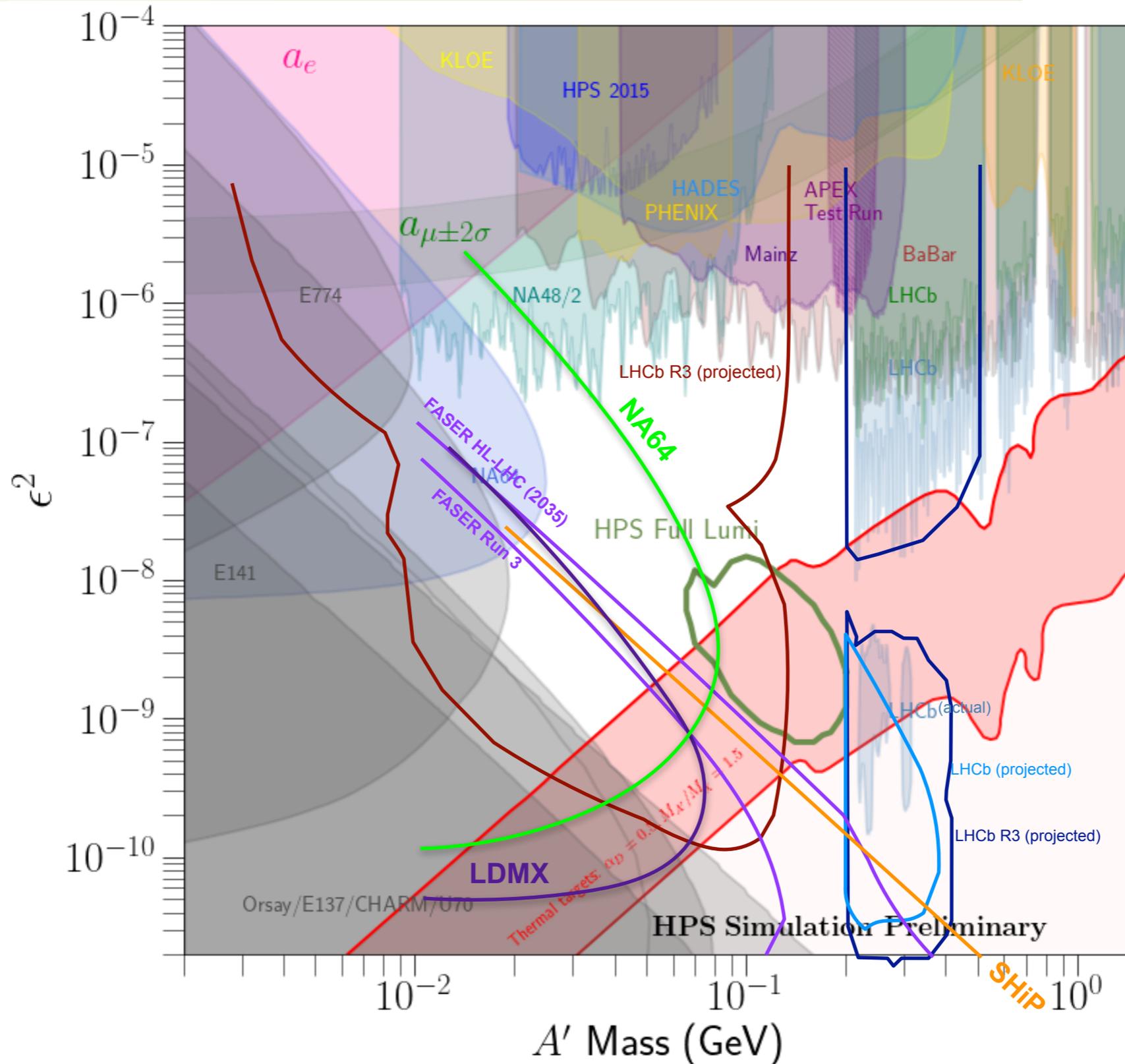
$$D^{*0} \rightarrow D^0 A'$$

$$A' \rightarrow e^+ e^-$$

Requires upgraded vertex detector and triggerless readout = full recon in real time. backgrounds still unknown.

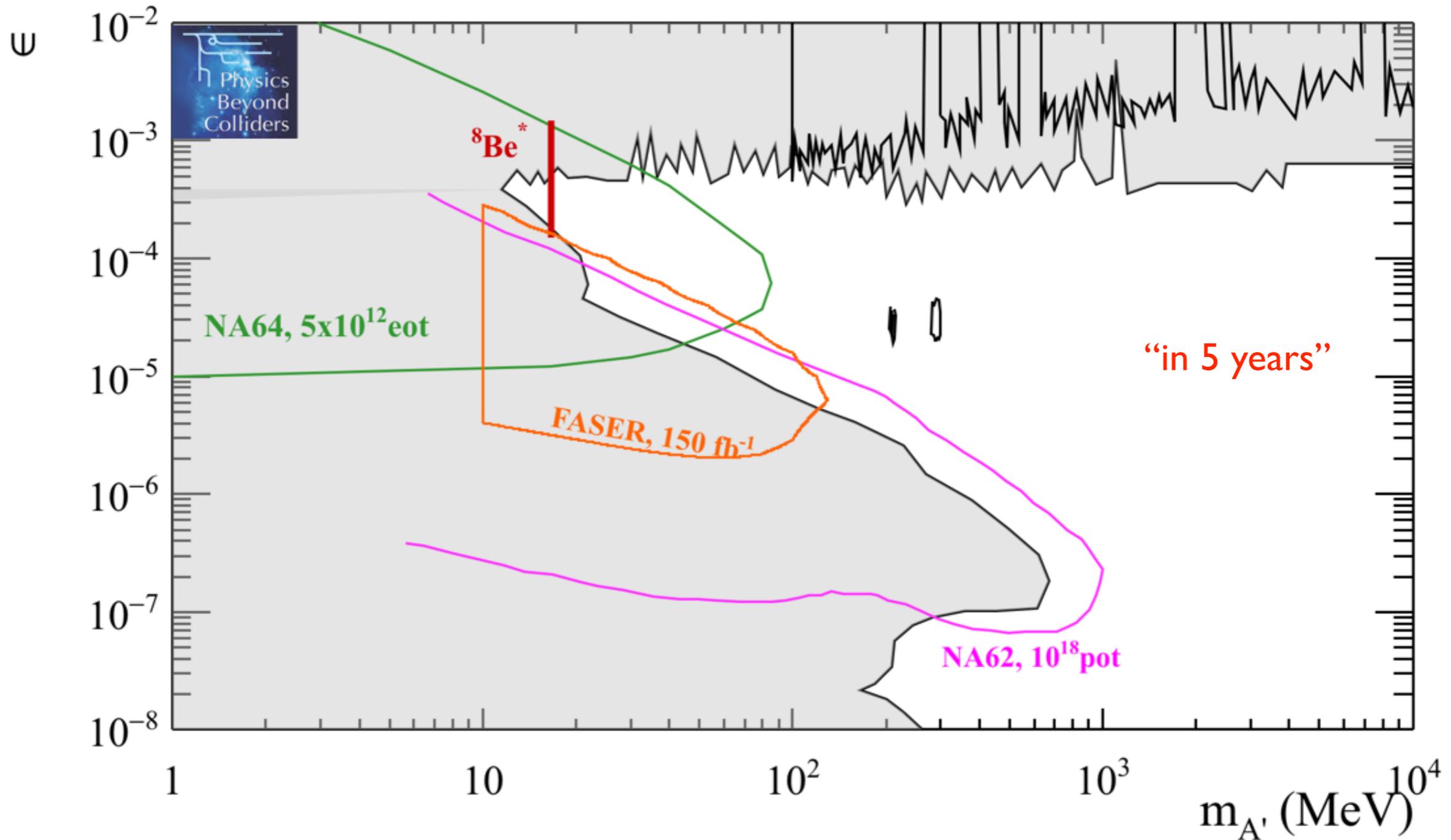


# And Other Planned/Proposed Experiments (from European Strategy Update – arXiv:1910.11775)



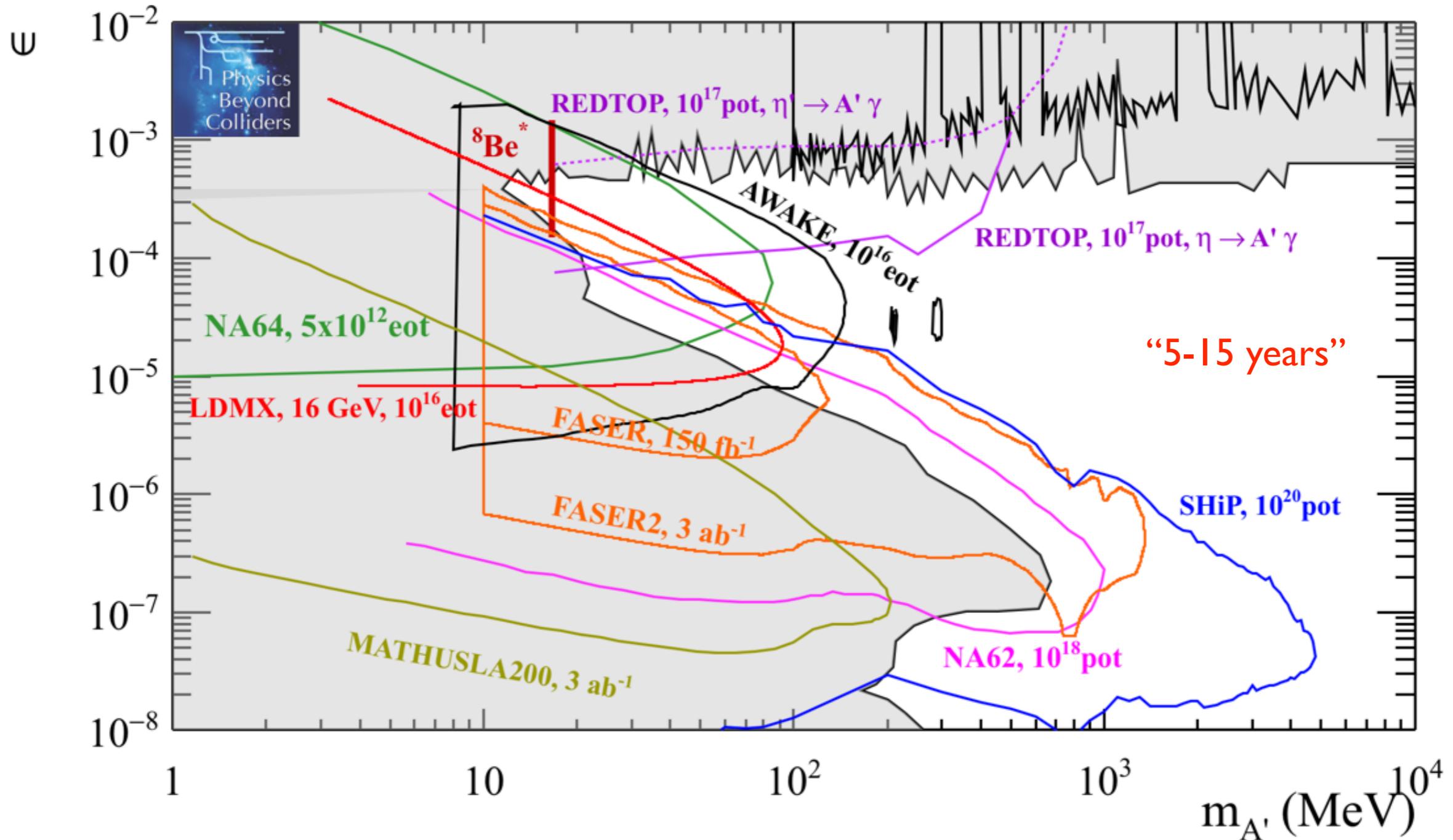
# CERN Vector Portal Outlook (from CERN PBC report)

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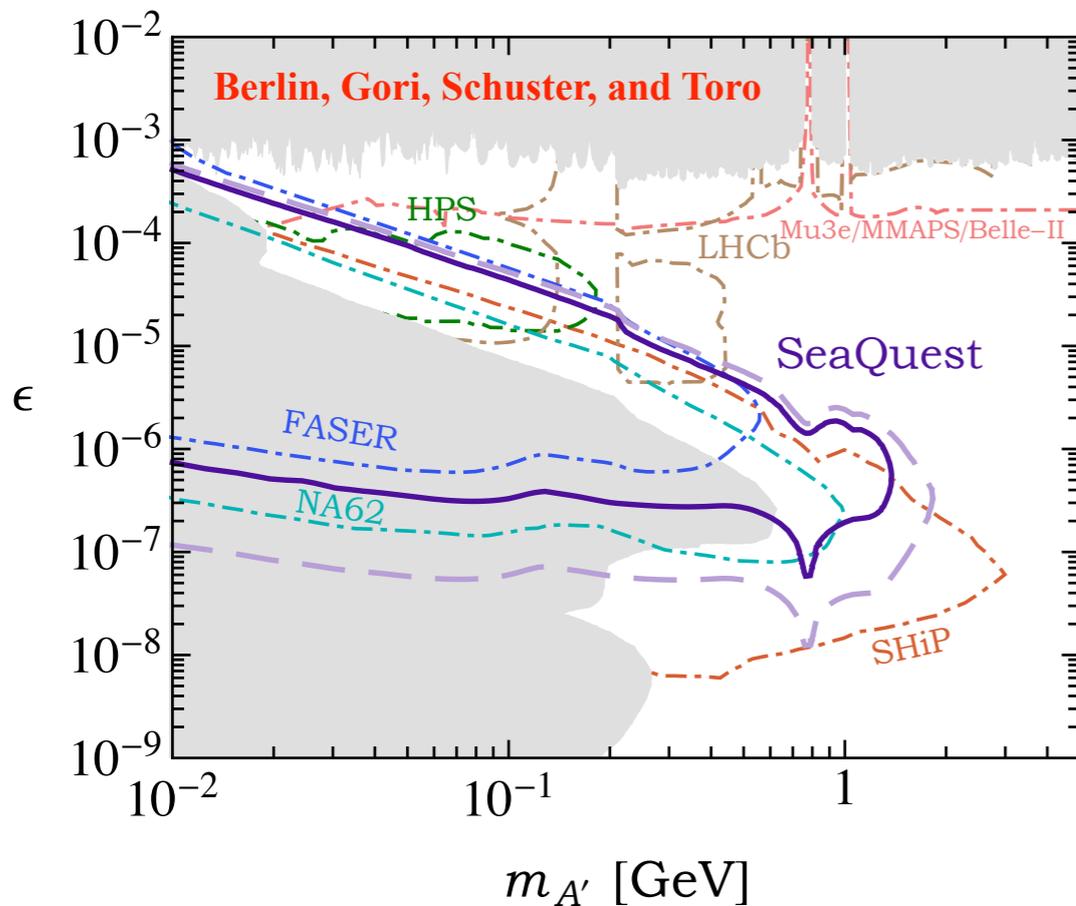
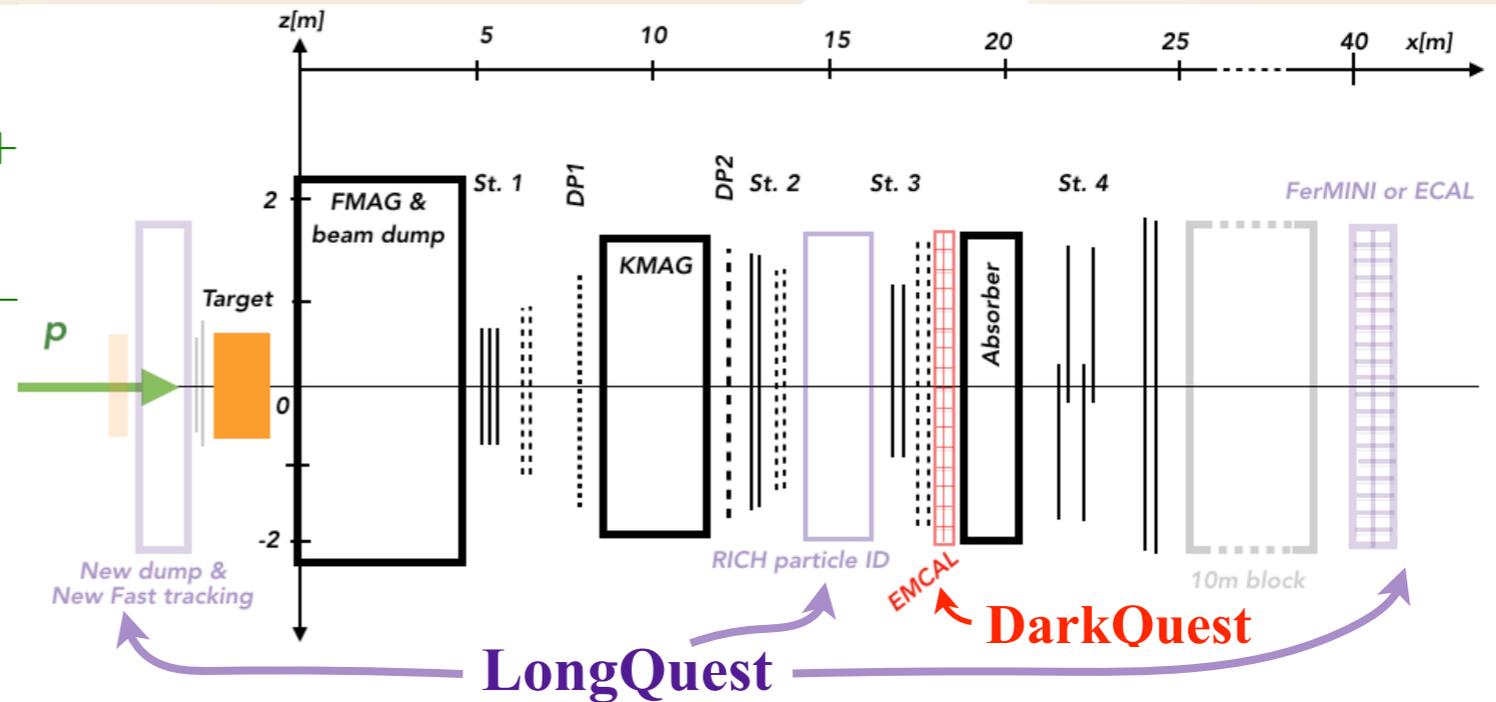
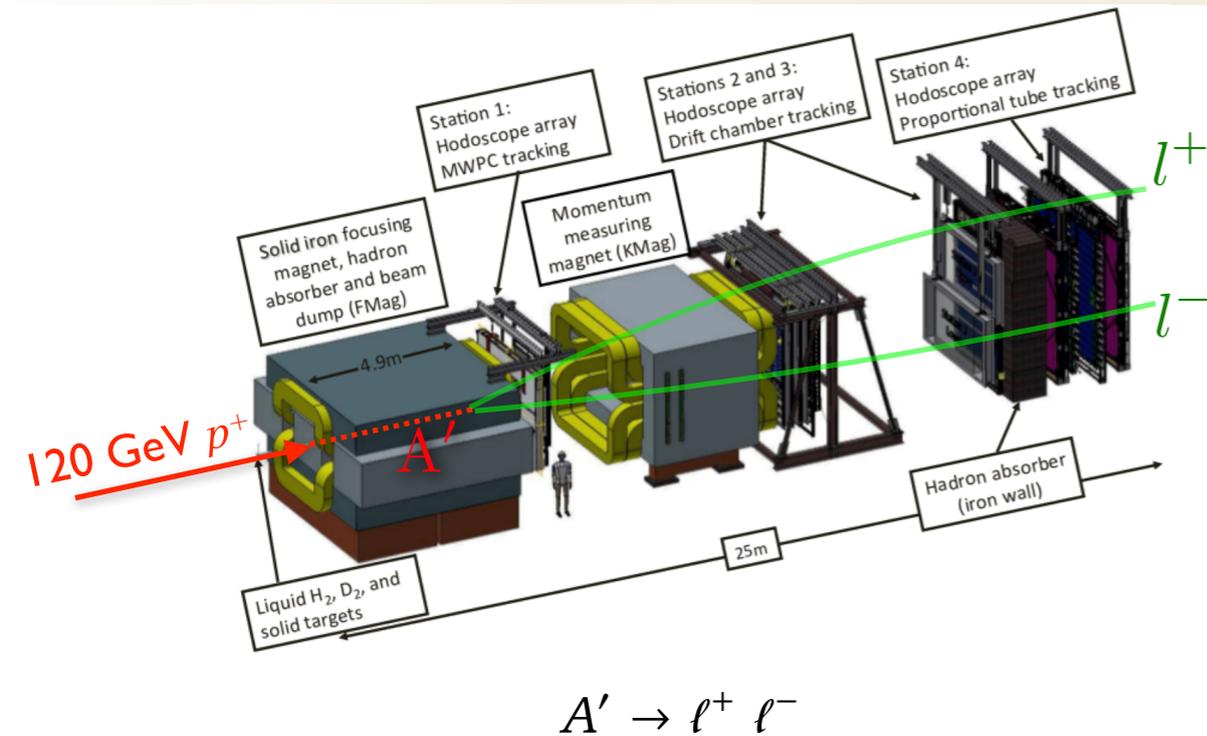
# CERN Status and Timelines

A very nice talk by Mike Lamont for Snowmass outlines the planned and potential facilities at CERN for these experiments:

<https://indico.fnal.gov/event/44819/contributions/193721/attachments/132920/163635/DS-facilities-RF6-kickoff.pdf>

			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	SPS		LS2						LS3					
	LHC		LS2		Run 3				LS3			Run 4		
North Area	NA64-electron	Operational	LS2		Data Taking									
	NA64-mu	< 1 MCHF	Studies		Test	Pilot	Phase 1							
	NA61/Shine	< 2 MCHF	Detector upgrade		Data Taking						Data Taking			
	MUonE	< 2 MCHF	Preparation		Pilot	Run 1	Data Taking							
	NA62-beamdump	< 1 MCHF	Studies		1e18 PoT in Run 3									
	KLEVER	~40 MCHF	Eol/proposal		R&D/Construction				Installation	Data Taking				
	COMPASS++	~10 MCHF	Studies/proposal		Phase1 Data Taking/Studies/R&D				Installation	Data Taking				
LHC	ALICE fixed target	<5 MCHF		Design/tests				Preparation/Construction			Data Taking			
	LHCb fixed target	<5 MCHF		Design	Construction and testing			Data	LS3			Data Taking		
	LHC Spin	~5 MCHF	Study		R&D				Production/Installation			Data Taking		
	FASER	~5 MCHF	Installation		Data Taking				Upgrade - phase 2			Data Taking		
	MATHUSLA	<100 MCHF	Funding to test design				Construction				Data Taking			
	CODEX-b	<5 MCHF	Eol		Beta		Beta data taking		Production/Installation			Data Taking		
	MilliQan	<5 MCHF	Demonstrator		Funding/Construction				Upgrade			Data Taking		
SPS	LDMX/eSPS	<10 MCHF			Studies		Production/Installation			Data Taking				
	SHiP	~70 MCHF	CDR	TDR/Prototypes				Production/construction			Installation	Data Taking		
	TauFV	tbc	Design		CDR	TDR/Prototypes		Production/construction			Installation	Data Taking		
TECH	BabylAXO (DE)	<5 MCHF	Production/construction			Commission	Data Taking							
	IAXO	~60 MCHF							Design, prototyping, construction, integration and commissioning (start tbc)					
	VMB	<5 MCHF	Lol	Studies										
	AION-100	tbc	Studies											
FACILITY	AWAKE	~15 MCHF	Prep/construction		AWAKE Run 2				LS3	AWAKE++?				
	eSPS	~80 MCHF	CDR		TDR		Preparation/Construction			Data Taking				
	Beam Dump Facility	~160 MCHF	CDR	TDR		Construction/Installation						Operation		
	Gamma Factory	~2 MCHF		CDR	SPS Proof of Principle/TDR				Preparation			LHC demo		
	nuSTORM	>160 MCHF	Study	CDR		TDR/Prototyping					Approval			
	CPEDM prototype (DE)	~20 MCHF	Study	CDR		TDR		Construction		Data Taking				

# SeaQuest/SpinQuest/... @ FNAL



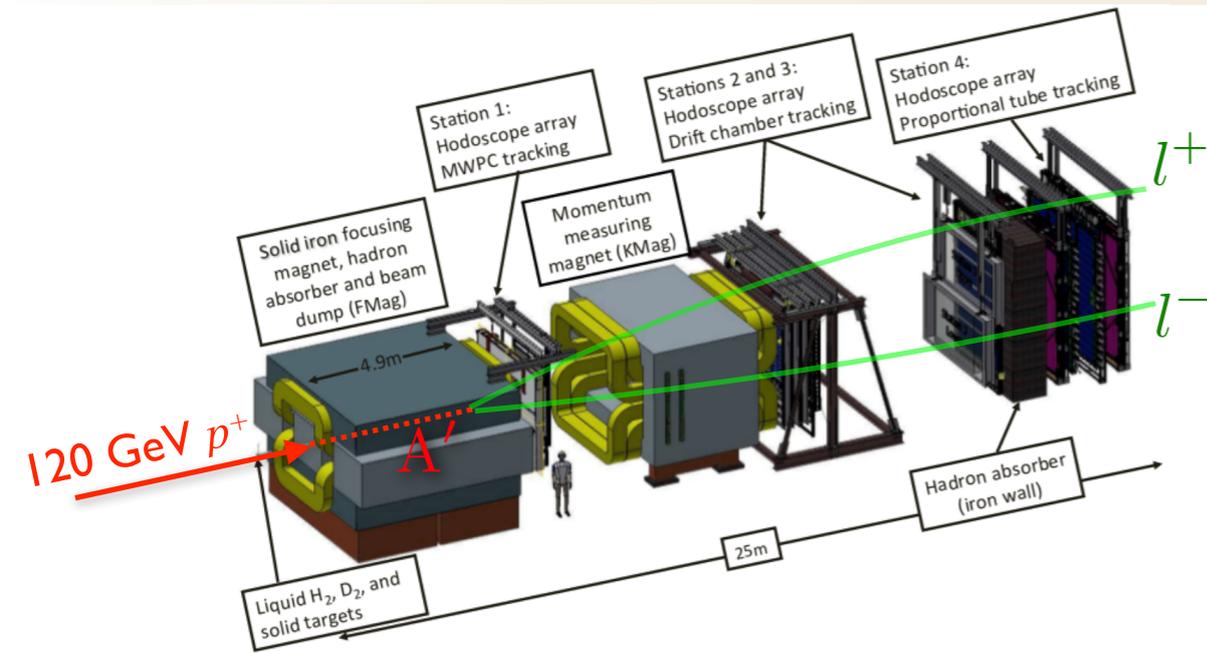
DarkQuest proposal to DMNI FOA was declined: funding for ECAL addition and DAQ/Trigger upgrade required for operation to  $1.4E18$  (DarkQuest I) and  $1E20$  (DarkQuest 2)

LongQuest concept adds fast tracking and particle ID, and extends apparatus to longer baseline to increase sensitivity

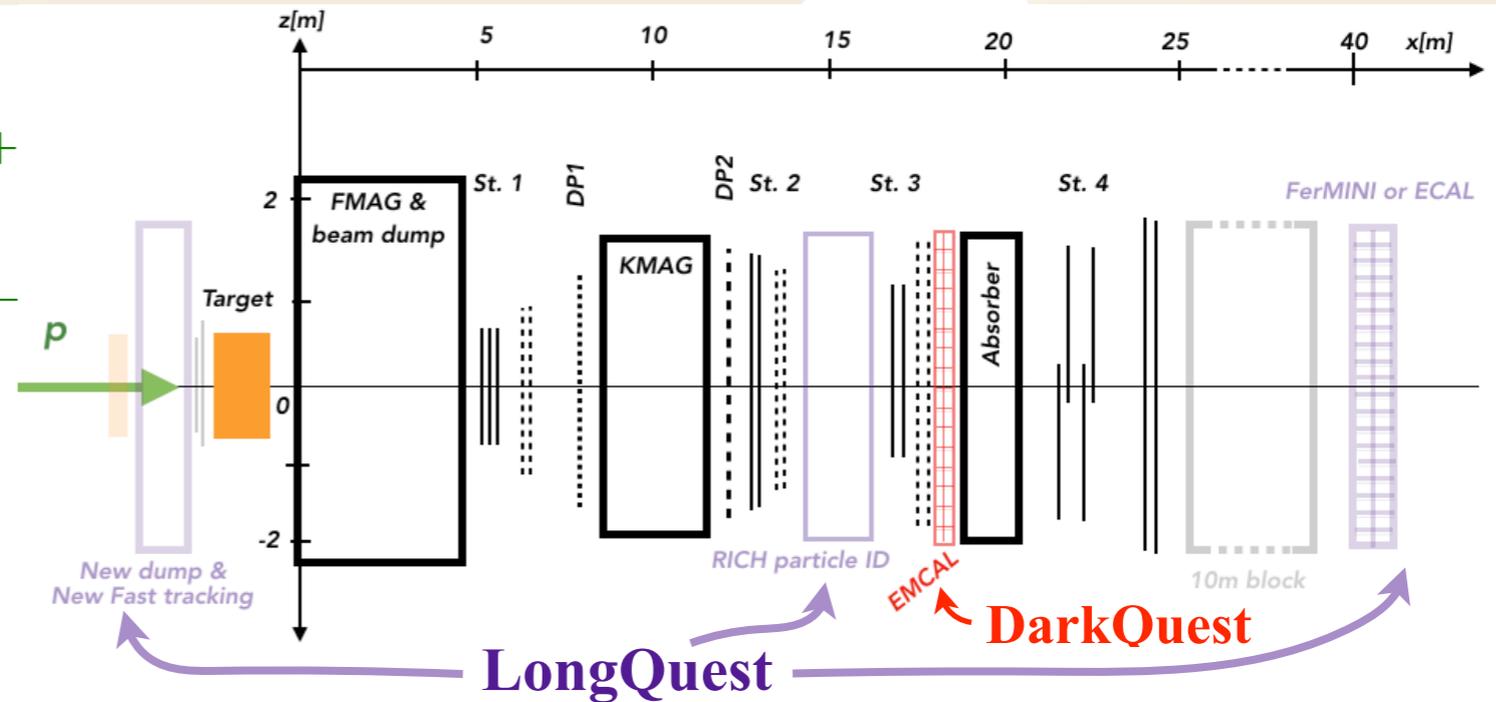
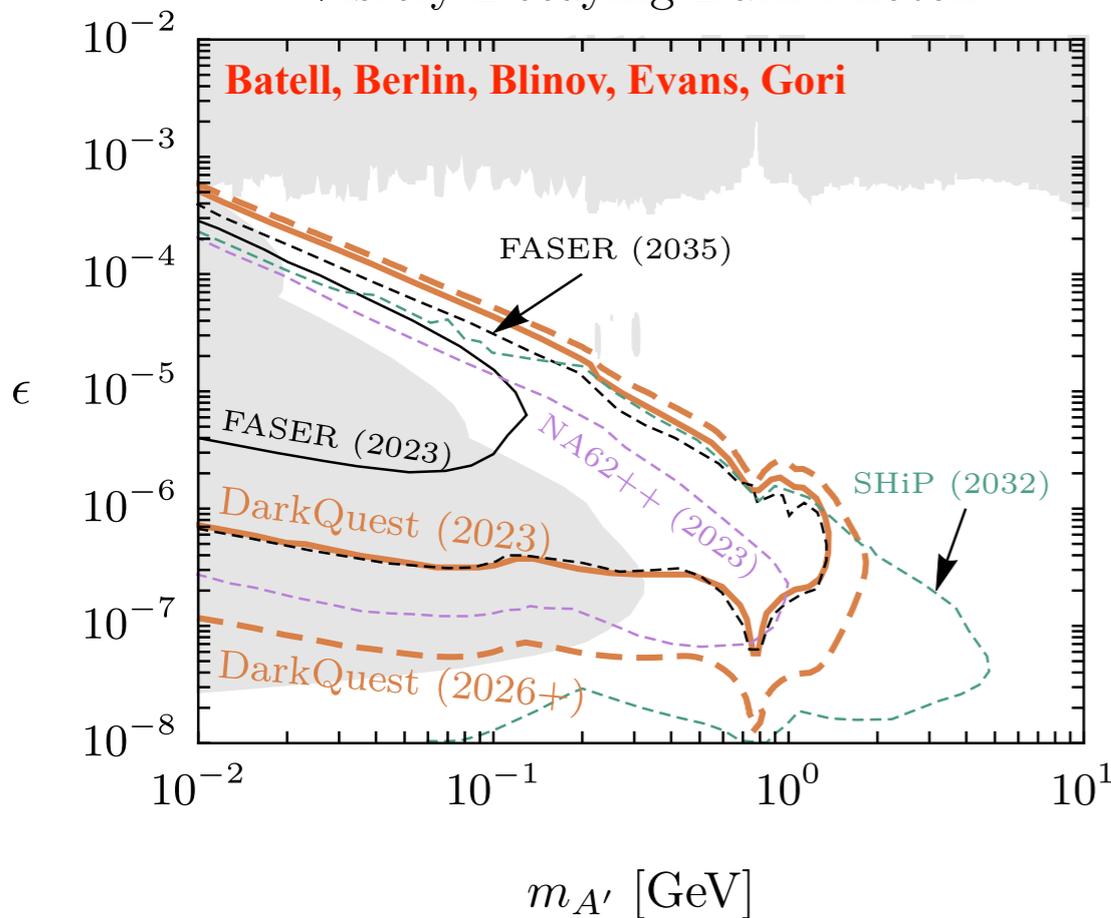
These “concepts” are little more than ideas, founded on recognition that there is a highly valuable apparatus sitting on an ideal beamline with a lot of potential as a dark sector experiment.

A FNAL-led group is still actively pursuing this, where the first steps still look like continued cooperation with NP program.

# SeaQuest/SpinQuest/... @ FNAL



Visibly Decaying Dark Photon



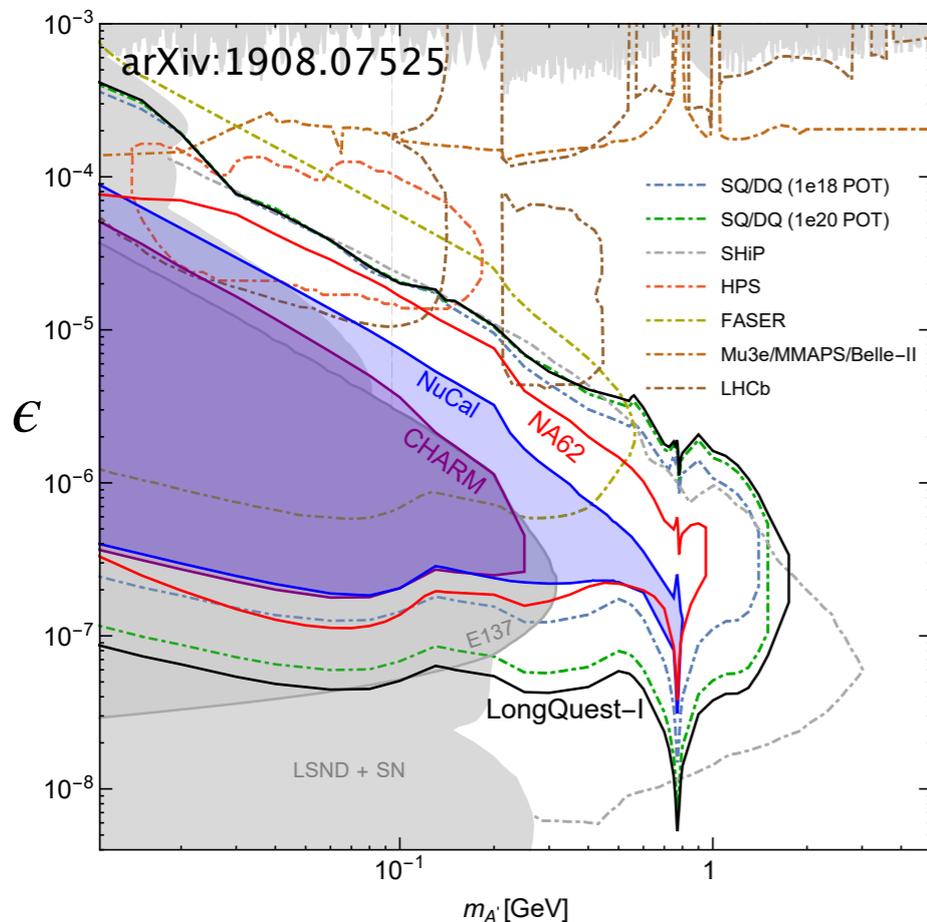
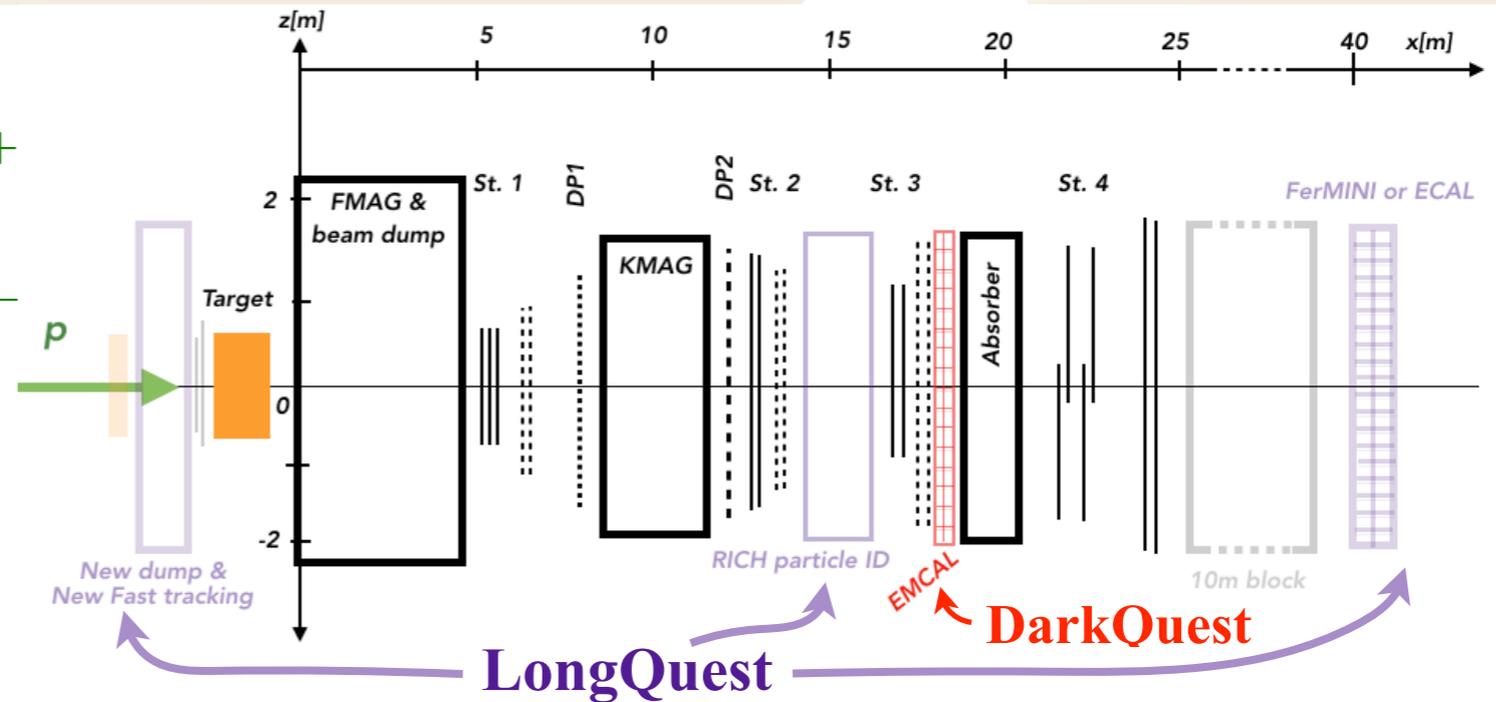
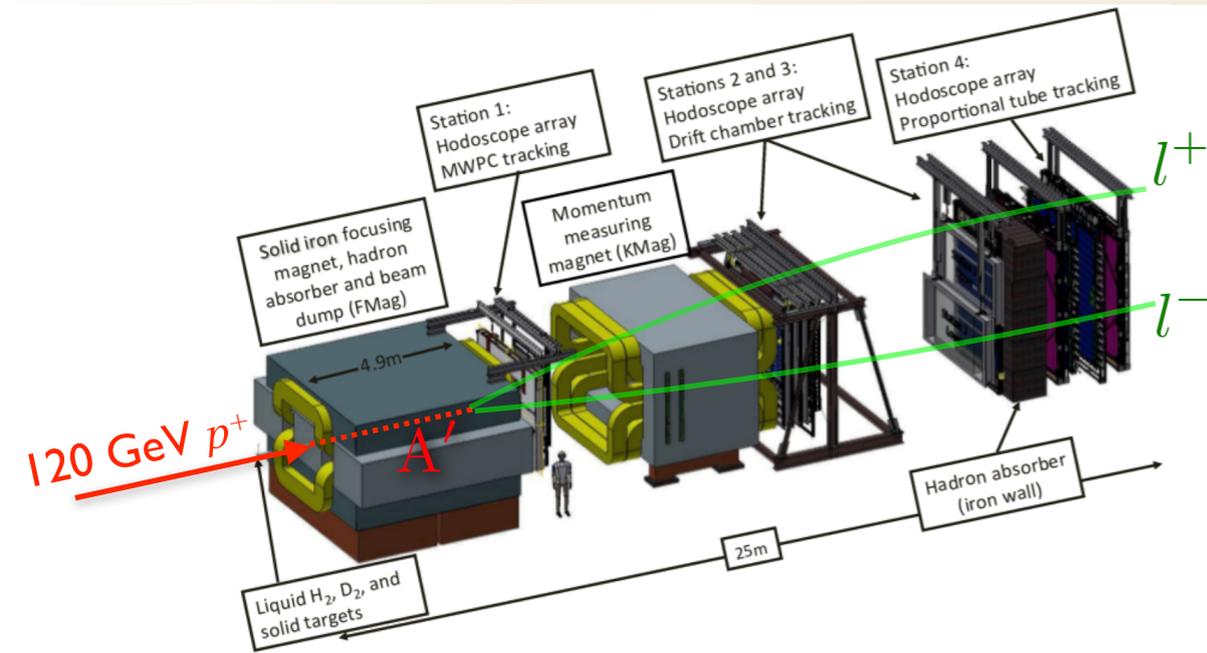
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# My Take on These Other Efforts



## *On the real axis*

- LHCb - operating, backgrounds for displaced search are unknown
- NA62 - already operating, few caveats
- NA64 - already operating, few caveats
- FASER Run 3 - funded and under construction, no obvious caveats for  $A'$  search



## *Likely to become real*

- FASER HL-LHC - requires larger apparatus
- LDMX - on track but not yet approved,  $A'$  reach based on pheno studies.



## *Future Unclear*

- SeaQuest/DarkQuest - powerful, inexpensive, lacking clear path for support
- REDTOP - Promising concept, expensive (<https://arxiv.org/abs/1910.08505>)



## *Likely to remain imaginary*

- AWAKE - operational scenarios presented have not been realistic
- SHiP - appears to be cost prohibitive

*Some others not mentioned, Darklight, VEPP-3, Mu3e, PADME, Belle-II, have little potential overlap with HPS*

# Summary and Outlook

*We passed a major milestone in the PAC review, and used the exercise as a vehicle to advance key goals of the experiment.*

*Having cleared that hurdle, there is a lot of work required to reach some exciting goals ahead, achievable in the coming year with sufficient effort:*

- analyzing the 2019 dataset to search for  $A'$  in highly motivated part of the parameter space.
- expanding HPS physics case to include SIMPs, with the potential for discovery already with 2016 data
- preparing to operate the experiment again next year to collect a more significant dataset still

*It's a great time to get more involved, especially for any new students.*

*One more thing: Snowmass creates a unique opportunity to explore expanding the physics case further, beyond minimal  $A'$  and SIMPs.*