



The Heavy Photon Search Experiment at Jefferson Lab

Sarah Gaiser (Stanford/SLAC),
on behalf of the HPS collaboration

Light Dark World 2023

Low Mass Freeze-Out Thermal Relics

SLAC



- Annihilation cross section from weak interaction: $\langle\sigma v\rangle \sim \frac{m_\chi^2}{M_Z^4}$
 - For $m_\chi \lesssim 2 \text{ GeV}$: $\langle\sigma v\rangle$ too small for thermal DM (**Lee-Weinberg bound**)

Low Mass Freeze-Out Thermal Relics

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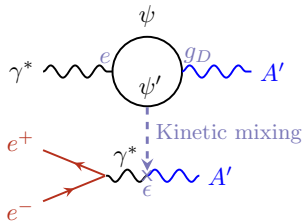


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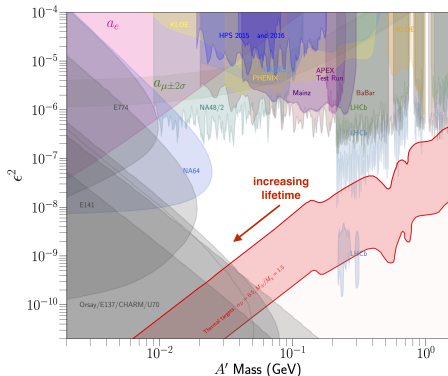
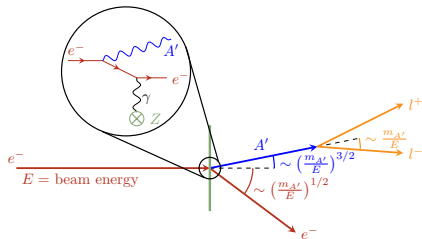


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- Dark Sector with lighter mediator increases cross section
- Minimal Dark Sector: new U(1)'
 - Natural extension to SM
 - Heavy/Dark Photon A'
 - Kinetic mixing with SM
 - small coupling: Dark Sector – SM
 - Can reproduce correct DM abundance



$$\mathcal{L} \supset -\frac{\epsilon}{2 \cos \theta_W} F'_{\mu\nu} F_Y^{\mu\nu}$$

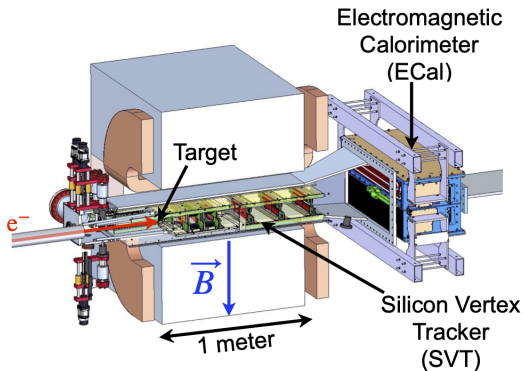
HPS Search Strategy

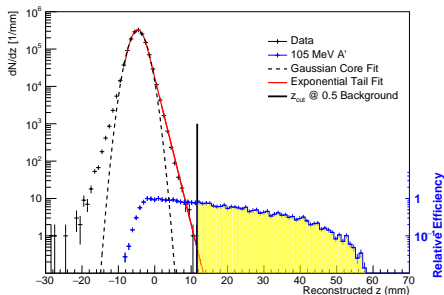


- e^- beam on W target; production of A' through Dark Bremsstrahlung
- Search for visibly decaying Dark Photons: $2m_e < m_{A'} < 2m_\chi$
 - Depending on coupling strength: prompt or displaced decay
 - Resonance and displaced vertex search

HPS experiment at JLab

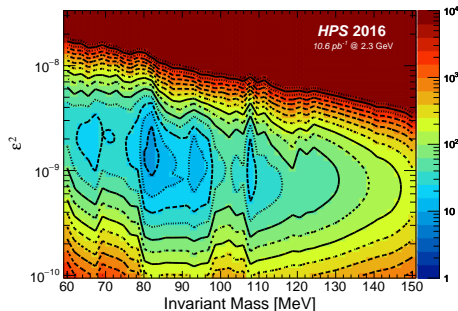
- HPS experiment in Hall B at JLab using electron beam from CEBAF
- ECal for trigger
- SVT: silicon strip tracker
 - ~ 25000 channels
 - Close to beam: 500 μm , 15 mrad acceptance
- Four datasets:
 - Two engineering runs: 2015 (1.05 GeV), 2016 (2.3 GeV)
 - Two physics runs: 2019 (4.55 GeV), 2021 (3.74 GeV)
- Recent results published on **2016 data**





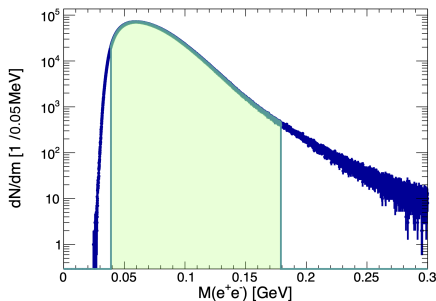
Plot from HPS Collaboration, PRD108, 012015 (2023)

- Displaced vertex search
 - No sensitivity to minimal A' model yet
 - Strongest exclusion at $m_{A'} = 82 \text{ MeV}$,
 $\epsilon^2 = 1.7 \times 10^{-9}$
 $\rightarrow 7.9 \times \sigma_{A'}^{\text{exp}}$
 - Sensitive to unique phase space given higher luminosity



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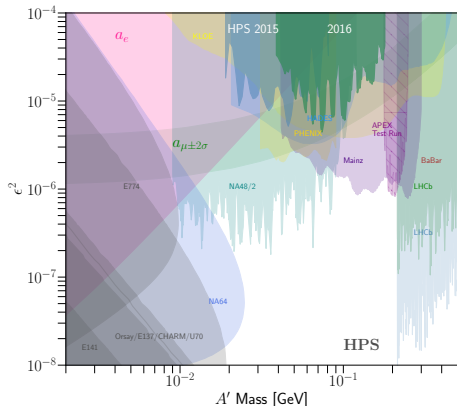
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- Resonance search
 - Using 95 % CL_s limit
 - Trying to get better sensitivity by improving background model for future analyses

Results of the 2016 Engineering Run

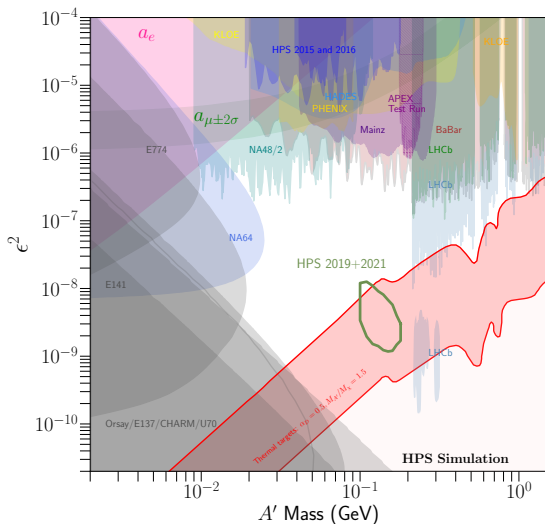


Exclusion plot combining 2015 (HPS Collaboration, PRD98, 091101 (2018)) and 2016 (HPS Collaboration, PRD108, 012015 (2023)) results

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Current Status and Plans

- Looking into other DM models that HPS is sensitive to
- Analysis of 2019 and 2021 datasets is currently in progress, results expected soon
- Requesting running in 2025 with JLab

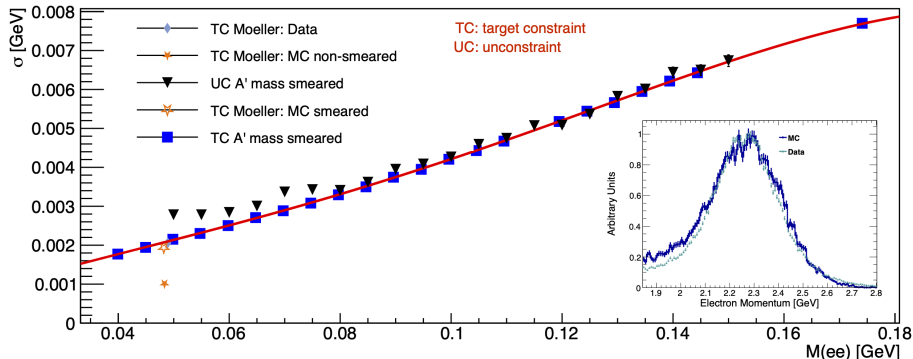


Thank you!

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Questions?

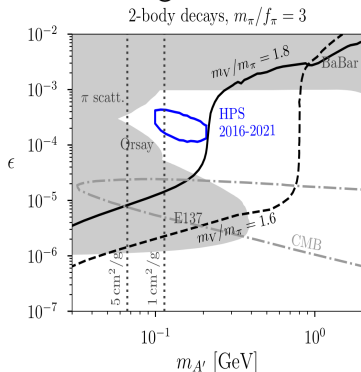
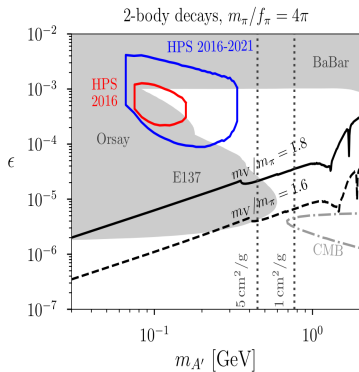
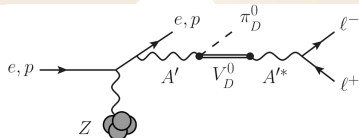
Results of the 2016 Engineering Run



- 2016 mass resolution:
 - Elastically scattered electrons have $E \sim E_{\text{beam}}$
 - Smear MC momenta to match data resolution
 - Compare Møller pairs in data and smeared MC

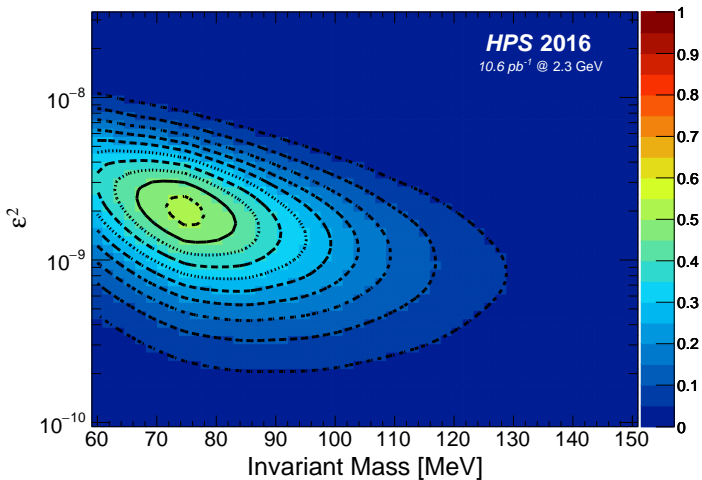
HPS SIMP Reach Estimates

- Dark Sector might have SU(3) gauge symmetry

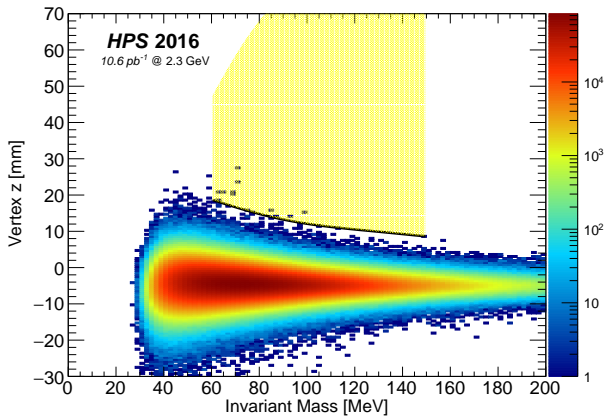


- Start looking at 10% data sample soon

Expected Yield



Z_{vtx} vs $M_{A'}$ – L1L1



L1L1

Target

A'

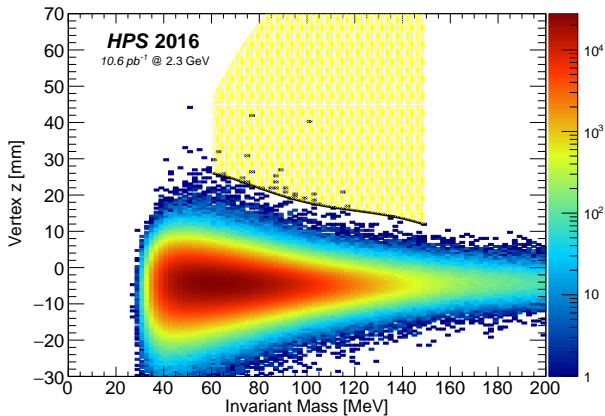
L1

L2

e^-

e^+

Z_{vtx} vs $M_{A'}$ – L1L2



L1L2

Target

A'

L1

L2

e^-

e^+