Gabriele Simi
Universitá di Padova and INFN

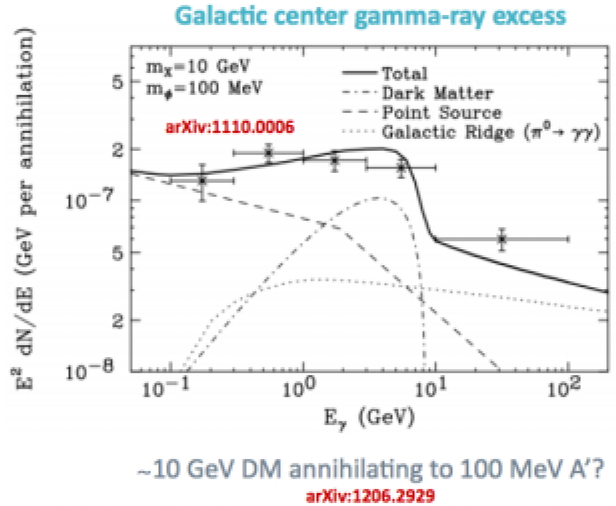
Consiglio di Sezione INFN
9 Luglio 2018

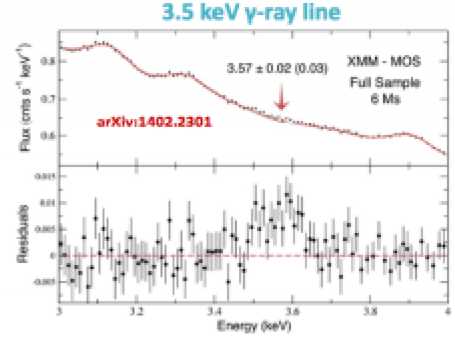
Outline

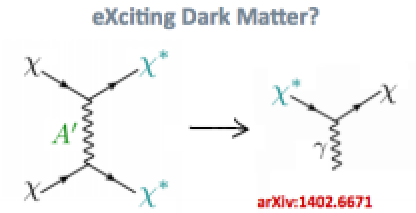
- Introduzione e motivazione
- Stato dell'esperimento
- Stato dell'analisi
- Piano futuri
- Anagrafica e richieste

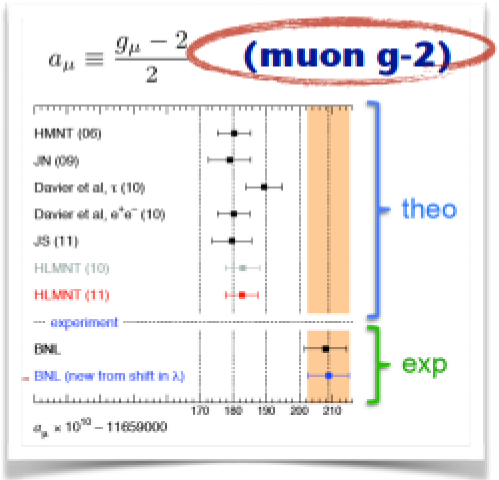
Motivation

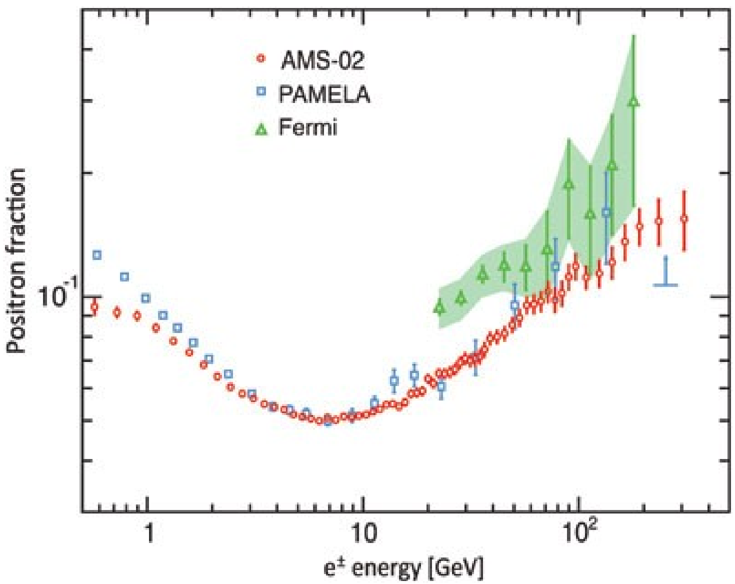
- Alcune anomalie astrofisiche potrebbero avere una spiegazione in termini di una dark matter carica sotto la nuova U(1)

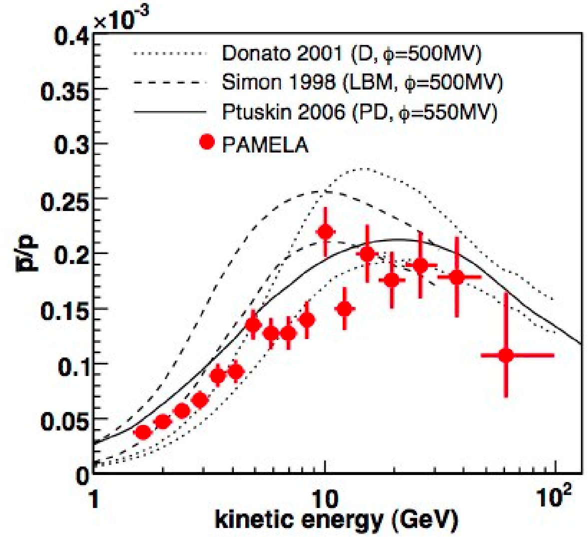






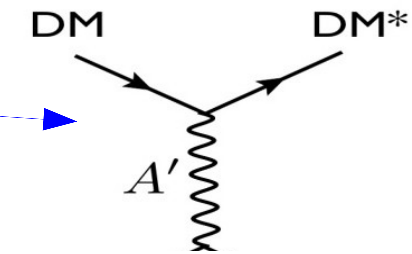




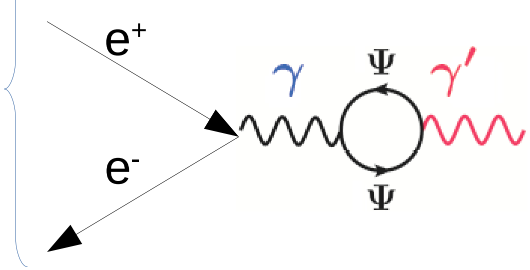


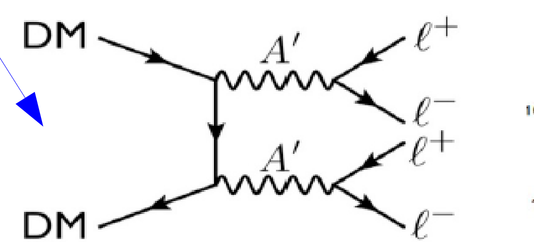
Portal to Hidden Sector

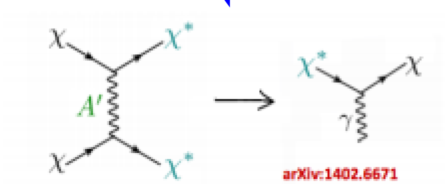
- New U(1)' gauge symmetry ⇒ A' gauge boson, force mediator for Dark Matter
  - Coupling to SM trough kinetic mixing $\varepsilon \sim 10^{-2}$-10^{-6}
  - [Holdom, Phys. Lett B166, 1986]
- Positron excess could be explained by DM annihilation into hidden sector photons
- g_μ-2 anomaly by a modification of the vertex diagram (PRD79,015014 PLB671,391)
- 3.5 KeV line explained by exiting dark matter doublet
- Absence of anomaly in anti-protons
  - $M_{A'}$<1GeV
- Beam dump searches
  - $M_{A'}$>20MeV
- Decay into leptons

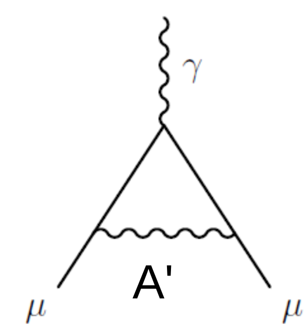


$$\Delta \mathscr{L} = \epsilon \, e \, A'_\mu J^\mu_{em}$$



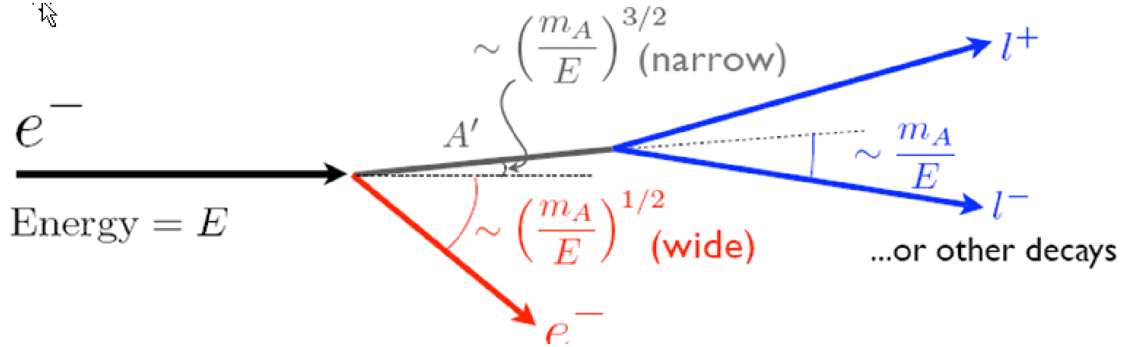






HPS Design

- A' kinematics ⇒ need good forward coverage down to ~ $\theta_{decay}/2$.
  This puts detectors close to the beam.



$E_{A'} \approx E_{beam}$
$\theta_{A'} \approx 0$
$\theta_{decay} = m_{A'}/E_{A'}$

HPS Design

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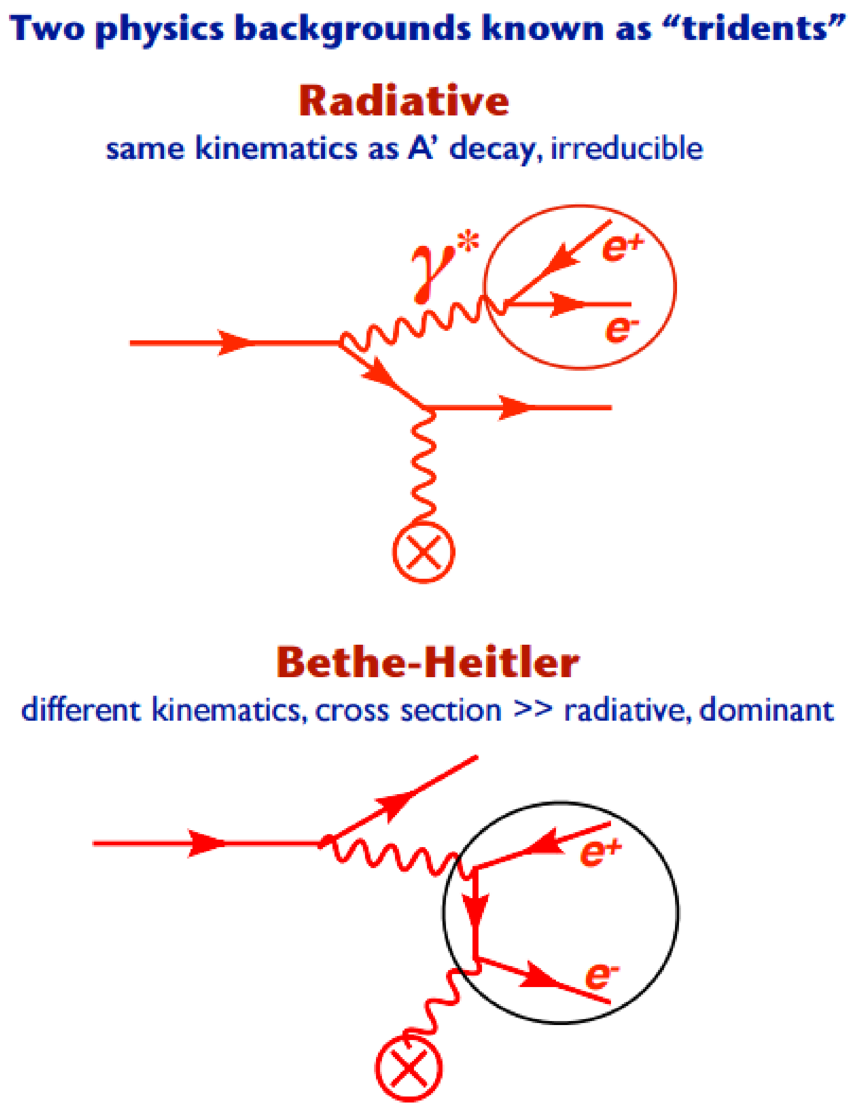
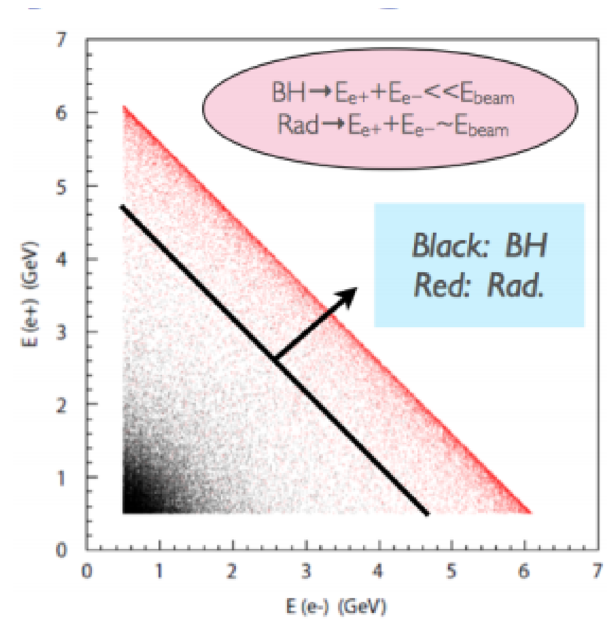
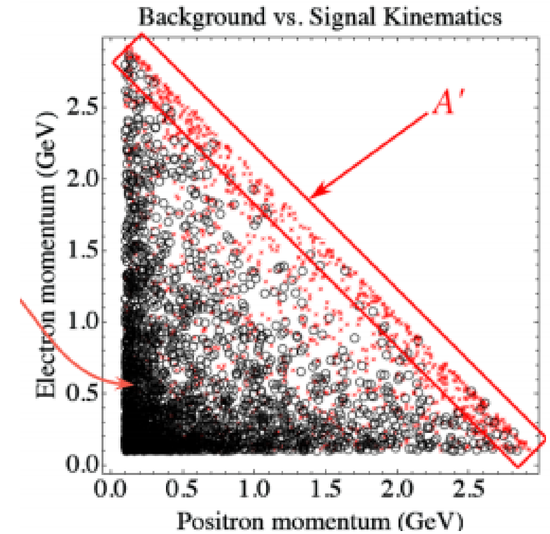




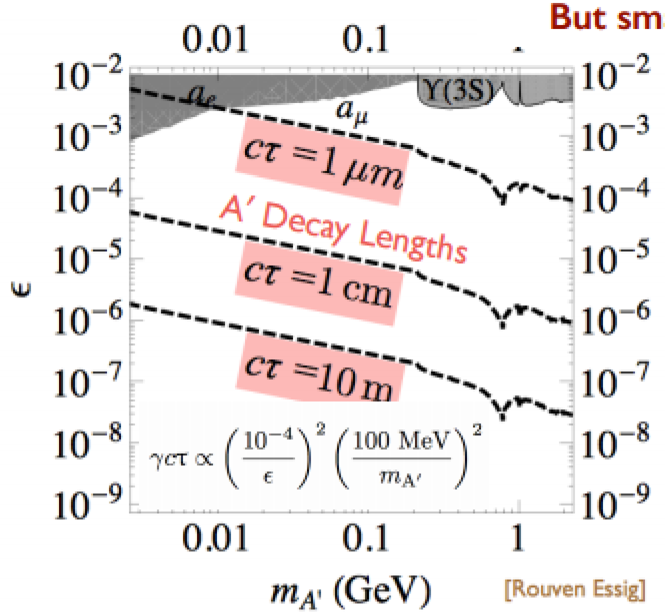


HPS Design

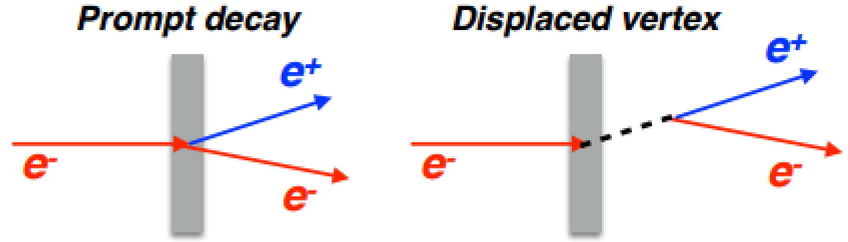
Problem: explore small couplings ($\epsilon < 10^{-4}$) and intermediate mass region

Small couplings mean very few events => Intense beam => lot of background

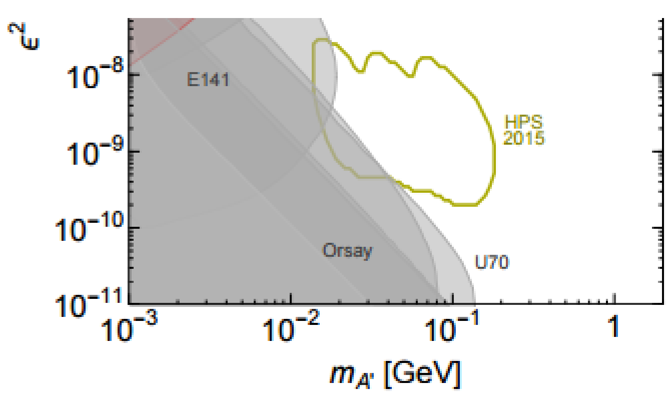
But small couplings also make A' long-lived !



It's all about rejecting the prompt background (~ 10^{-7} !)



Bump Hunting + Vertexing



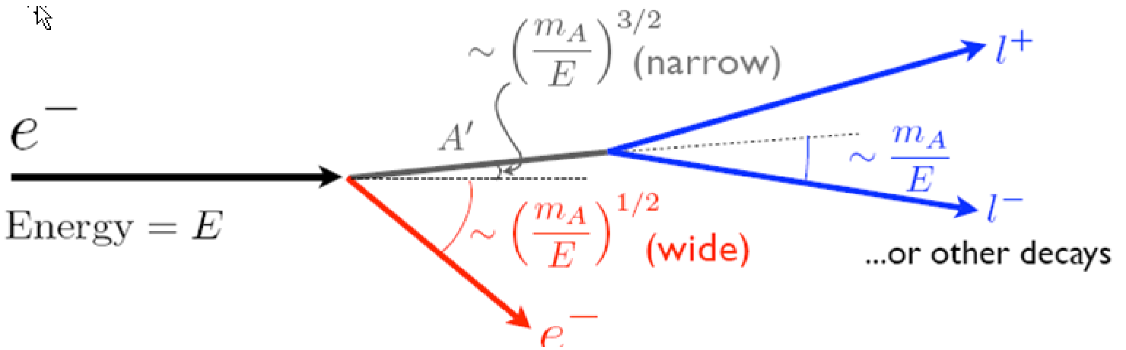
HPS solution: reconstruct A' decay vertex to beat down trident background

HPS needs

✓ Vertex reconstruction with good resolution
Δz ~ 1mm (detectors close to the target)

HPS Design

- A' kinematics ⇒ need good forward coverage down to ~ $\theta_{decay}/2$. This puts detectors close to the beam.

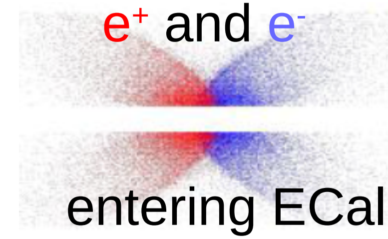


$E_{A'} \approx E_{beam}$
$\theta_{A'} \approx 0$
$\theta_{decay} = m_{A'}/E_{A'}$

- Vertexing A' decays requires detectors close to the target. Bump hunting needs good momentum/mass resolution. Both need tracking and a magnet.

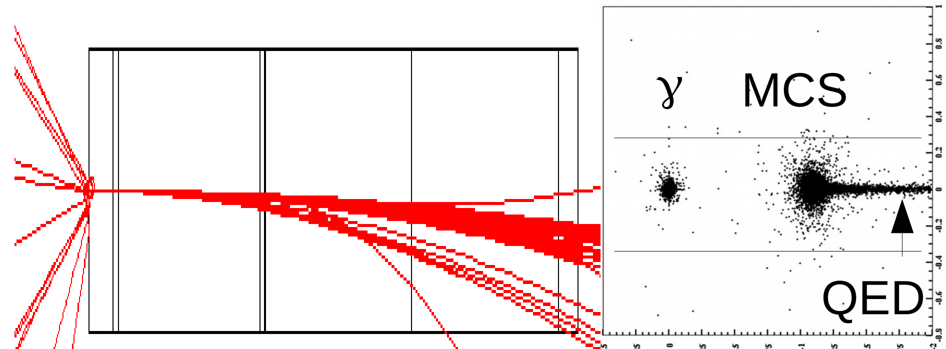
Want $\Delta m/m \sim 1\%$ for bump hunt
Want $\Delta z \sim 1mm$

Beam's Eye View

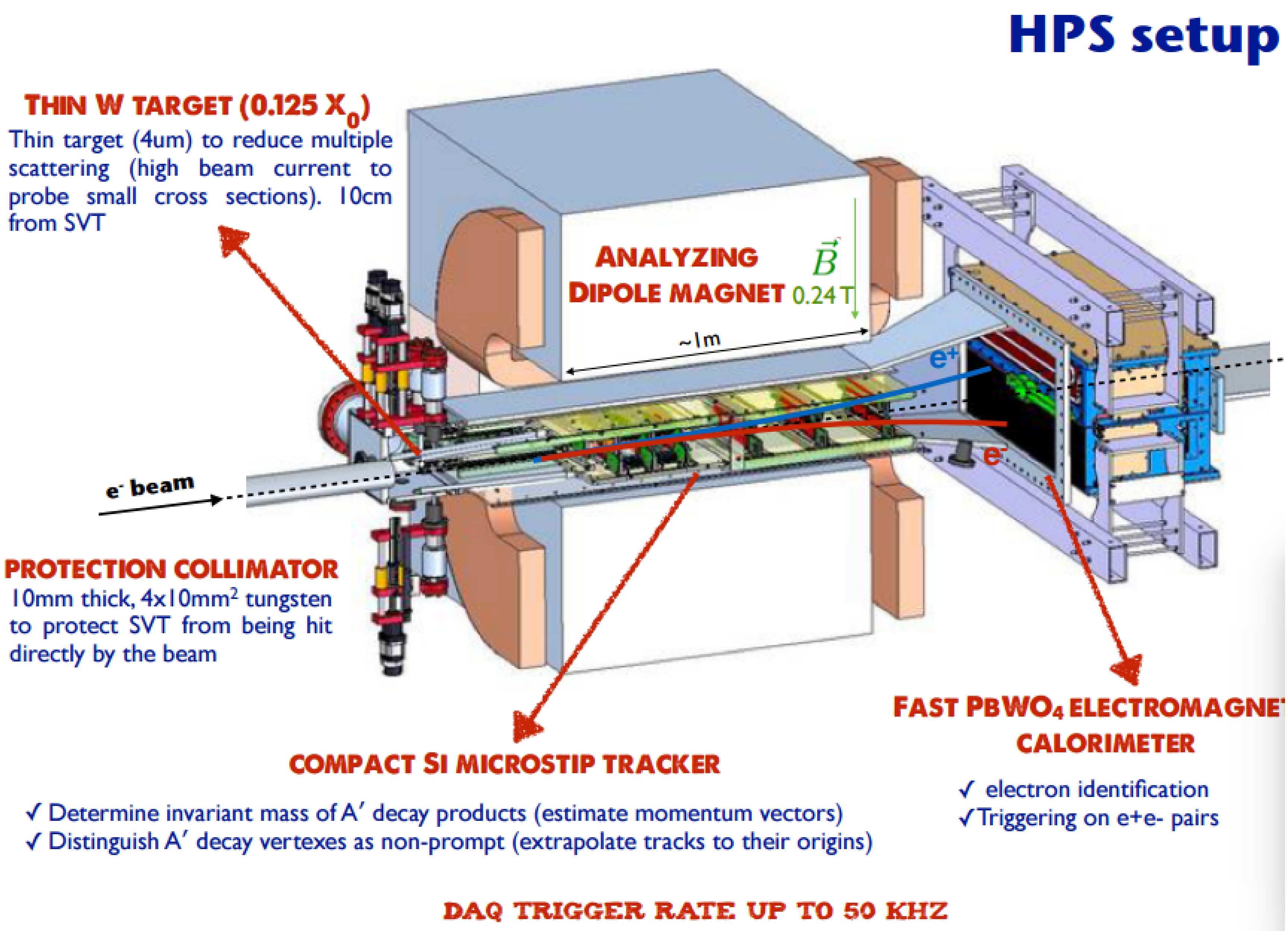


- Trigger with a high rate Electromagnetic Calorimeter downstream of the magnet to select e^+ and e^-.

- Beam, QEDand Multiple Couplomb Scattering background in the bending plane => split detectectors



Dead zone

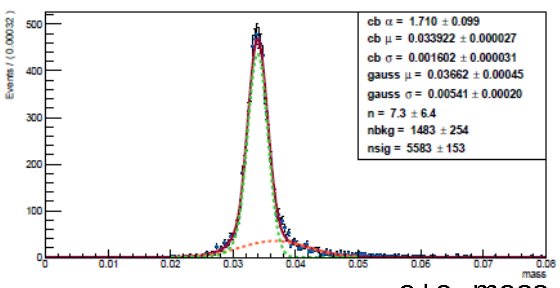

HPS setup
THIN W TARGET (0.125 X0)
Thin target (4um) to reduce multiple scattering (high beam current to probe small cross sections). 10cm from SVT
ANALYZING DIPOLE MAGNET 0.24 T
B
~1m
e+
e-
e- beam
PROTECTION COLLIMATOR
10mm thick, 4x10mm2 tungsten to protect SVT from being hit directly by the beam
COMPACT SI MICROSTIP TRACKER
✓ Determine invariant mass of A′ decay products (estimate momentum vectors)
✓ Distinguish A′ decay vertexes as non-prompt (extrapolate tracks to their origins)
FAST PBWO4 ELECTROMAGNE
CALORIMETER
✓ electron identification
✓Triggering on e+e- pairs
DAQ TRIGGER RATE UP TO 50 KHZ

Bump Hunt Analysis of 2015 data: Ready for pub

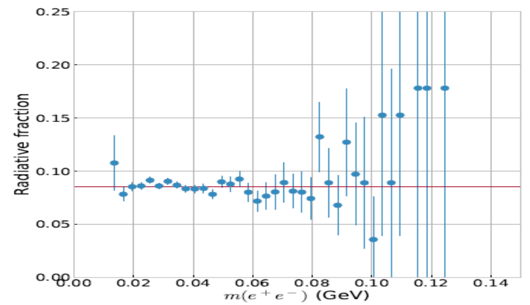
- HPS 2015 engineering run@1GeV/c^2
- Rerunning analysis with TwPass6
  - Corrections due to z_{target}=-5mm
  - A' radiative tail
- Evaluating Systematic
  - Difference in mass resolution between data and MC
  - Radiative fraction
  - Fit bias
- Completing the Paper draft

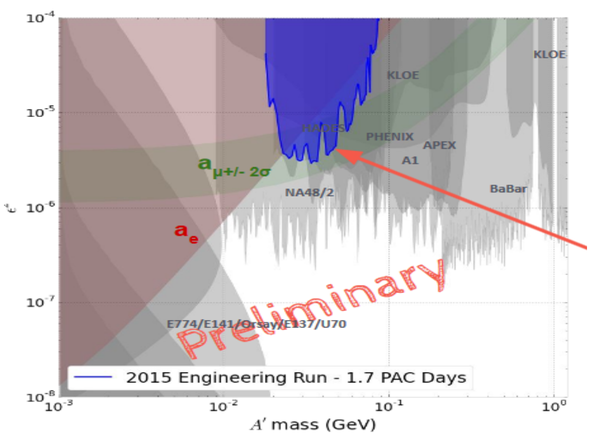
Systematic Description	Value
Radiative Fraction	
e^+e^- Composition	7%
Mass Resolution	
Fit to Møller mass spectrum	2.6%
Target position	1.5%
Fits	
Fit systematic < 70 MeV	9%
Fit systematic >= 70 MeV	6%

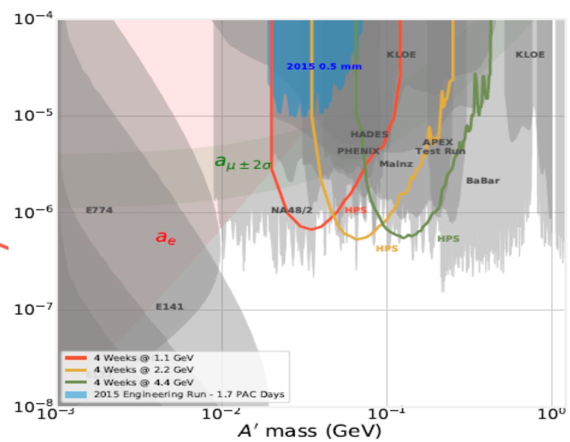
Mollers Scale Mass Resolution

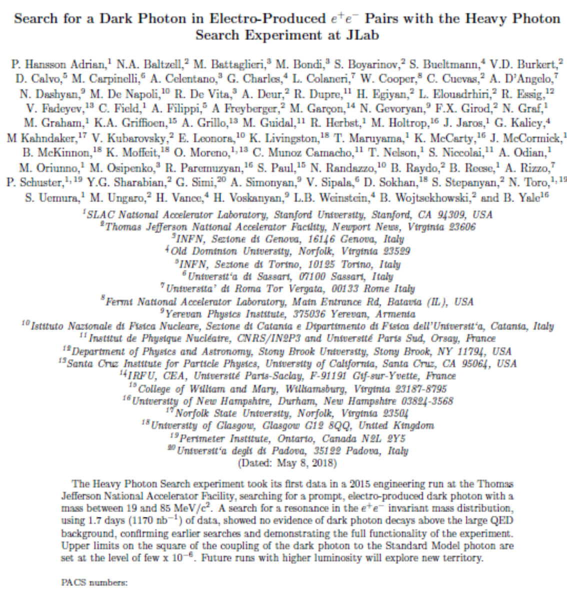


e+e- mass









Search for a Dark Photon in Electro-Produced e^+e^- Pairs with the Heavy Photon Search Experiment at JLab

P. Hansson Adrian,[1] N.A. Baltzell,[2] M. Battaglieri,[3] M. Bondi,[3] S. Boyarinov,[2] S. Bueltmann,[4] V.D. Burkert,[2] D. Calvo,[5] M. Carpinelli,[6] A. Celentano,[3] G. Charles,[4] L. Colaneri,[7] W. Cooper,[8] C. Cuevas,[2] A. D'Angelo,[7] N. Dashyan,[9] M. De Napoli,[10] R. De Vita,[3] A. Deur,[2] R. Dupre,[11] H. Egiyan,[2] L. Elouadrhiri,[2] R. Essig,[12] V. Fadeyev,[13] C. Field,[1] A. Filippi,[5] A Freyberger,[2] M. Garçon,[14] N. Gevoryan,[9] F.X. Girod,[2] N. Graf,[1] M. Graham,[1] K.A. Griffioen,[15] A. Grillo,[13] M. Guidal,[11] R. Herbst,[1] M. Holtrop,[16] J. Jaros,[1] G. Kalicy,[4] M Kahndaker,[17] V. Kubarovsky,[2] E. Leonora,[10] K. Livingston,[18] T. Maruyama,[1] K. McCarty,[16] J. McCormick,[1] B. McKinnon,[18] K. Moffeit,[18] O. Moreno,[1,13] C. Munoz Camacho,[11] T. Nelson,[1] S. Niccolai,[11] A. Odian,[1] M. Oriunno,[1] M. Osipenko,[3] R. Paremuzyan,[16] S. Paul,[15] N. Randazzo,[10] B. Raydo,[2] B. Reese,[1] A. Rizzo,[7] P. Schuster,[1,19] Y.G. Sharabian,[2] G. Simi,[20] A. Simonyan,[9] V. Sipala,[6] D. Sokhan,[18] S. Stepanyan,[2] N. Toro,[1,19] S. Uemura,[1] M. Ungaro,[2] H. Vance,[4] H. Voskanyan,[9] L.B. Weinstein,[4] B. Wojtsekhowski,[2] and B. Yale[16]

[1]SLAC National Accelerator Laboratory, Stanford University, Stanford, CA 94309, USA
[2]Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606
[3]INFN, Sezione di Genova, 16146 Genova, Italy
[4]Old Dominion University, Norfolk, Virginia 23529
[5]INFN, Sezione di Torino, 10125 Torino, Italy
[6]Universit'a di Sassari, 07100 Sassari, Italy
[7]Universita' di Roma Tor Vergata, 00133 Rome Italy
[8]Fermi National Accelerator Laboratory, Main Entrance Rd, Batavia (IL), USA
[9]Yerevan Physics Institute, 375036 Yerevan, Armenia
[10]Istituto Nazionale di Fisica Nucleare, Sezione di Catania e Dipartimento di Fisica dell'Universit'a, Catania, Italy
[11]Institut de Physique Nucléaire, CNRS/IN2P3 and Université Paris Sud, Orsay, France
[12]Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY 11794, USA
[13]Santa Cruz Institute for Particle Physics, University of California, Santa Cruz, CA 95064, USA
[14]IRFU, CEA, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France
[15]College of William and Mary, Williamsburg, Virginia 23187-8795
[16]University of New Hampshire, Durham, New Hampshire 03824-3568
[17]Norfolk State University, Norfolk, Virginia 23504
[18]University of Glasgow, Glasgow G12 8QQ, United Kingdom
[19]Perimeter Institute, Ontario, Canada N2L 2Y5
[20]Universit'a degli di Padova, 35122 Padova, Italy

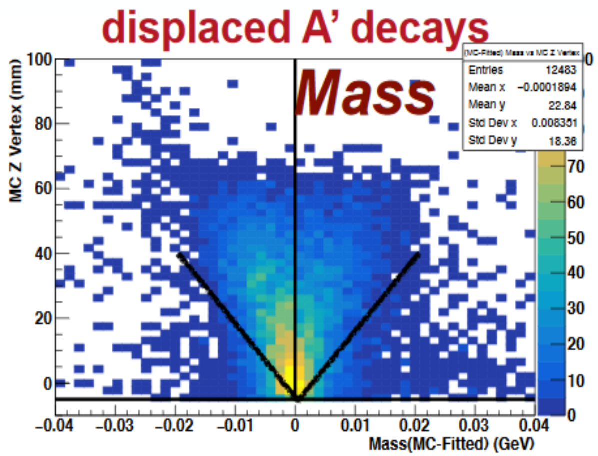
(Dated: May 8, 2018)

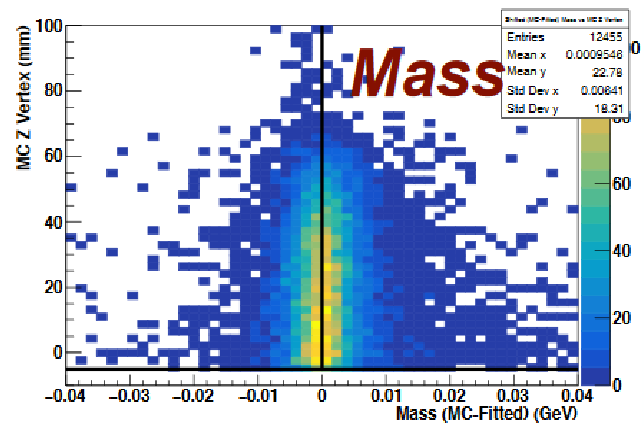
The Heavy Photon Search experiment took its first data in a 2015 engineering run at the Thomas Jefferson National Accelerator Facility, searching for a prompt, electro-produced dark photon with a mass between 19 and 85 MeV/c^2. A search for a resonance in the e^+e^- invariant mass distribution, using 1.7 days (1170 nb^{-1}) of data, showed no evidence of dark photon decays above the large QED background, confirming earlier searches and demonstrating the full functionality of the experiment. Upper limits on the square of the coupling of the dark photon to the Standard Model photon are set at the level of few x 10^{-6}. Future runs with higher luminosity will explore new territory.

PACS numbers:

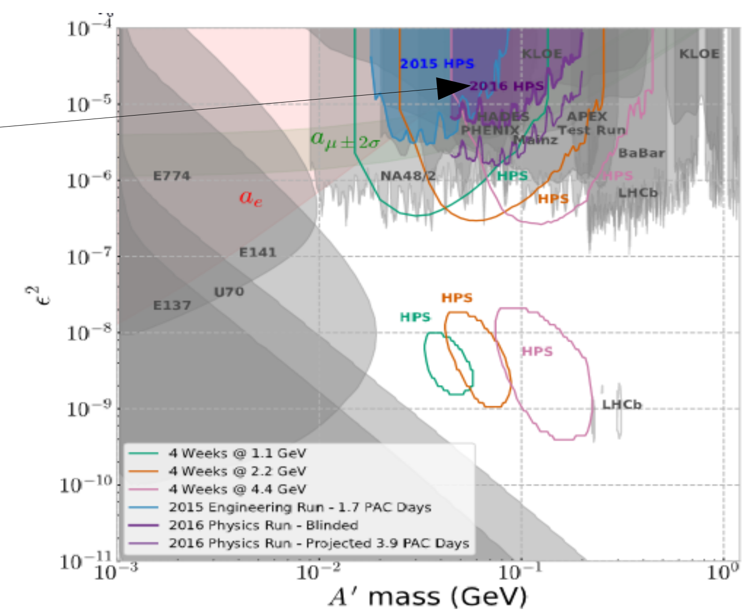
Vertex search with 2015 and 2016 data analysis ongoing

- Vertex search with 2015 data
  - Improving on vertex covariance matrix



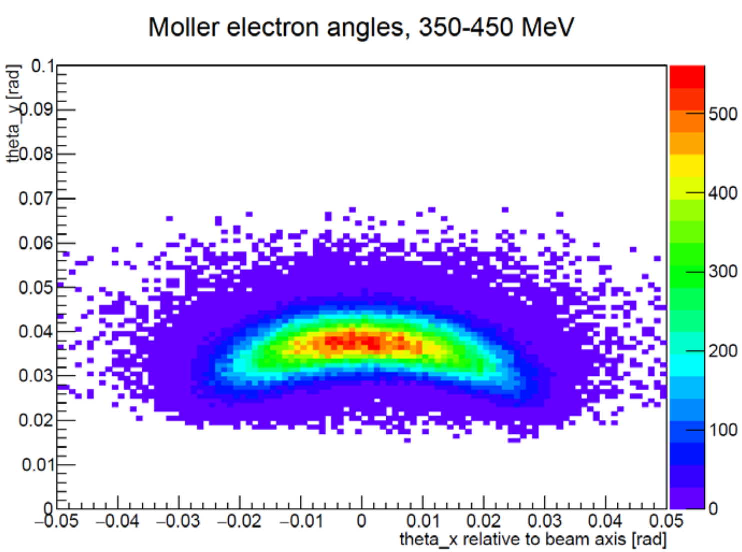


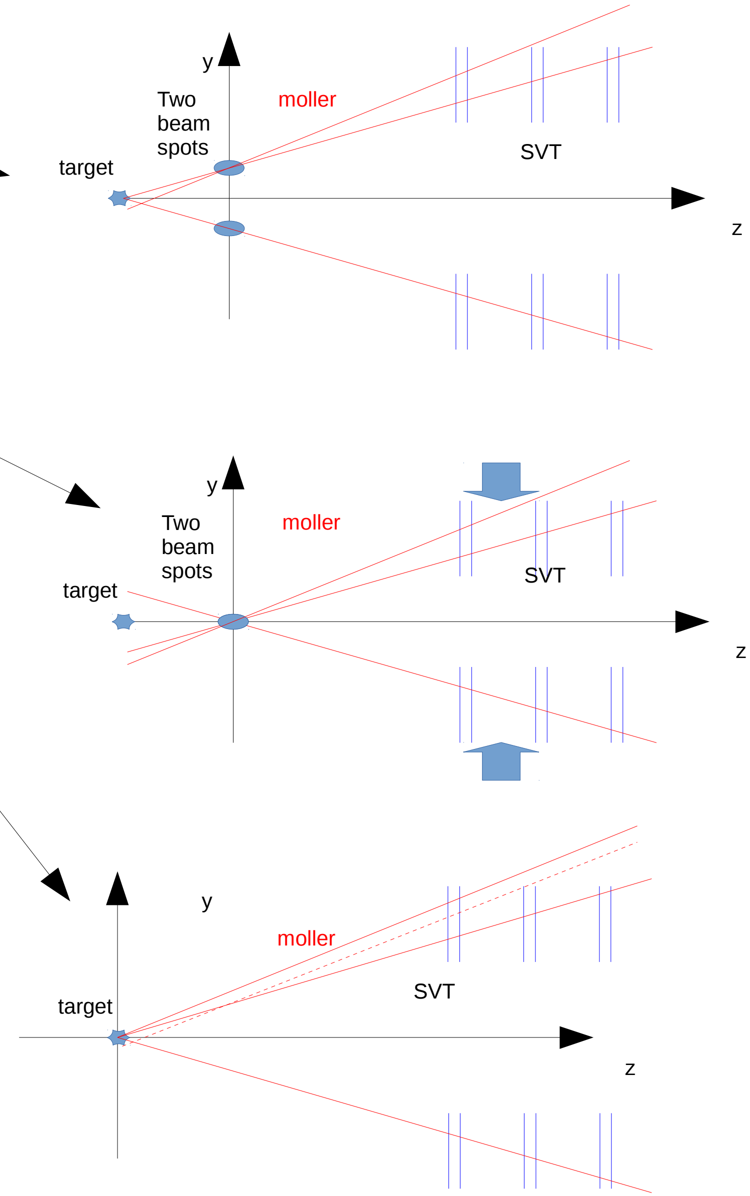
- Analysis of 2016 data
  - 10% of 2016 data analyzed
  - Performance similar to 2015



Alignment of 2015-2016 data

- Large shift in z vertex position (target) after internal SVT alignment understood
  - Constrained to zero for global alignment
  - Target moved to origin and iterate alignment
- Ongoing: include some kinematic constraints such as theta_y vs theta_y for a given momentum slice





Prospettive Miglioramenti Allineamento

- Allineamento
  - Include beam spot (and ECal?) into alignment
  - procedure using single-track
  - Include vertex constraint for multiple track events
  - Include vertex and mass constraint for Møller events
  - Ties SVT coordinate system to HPS lab system
  - Robustify, streamline and automate(?) procedures

Prospettiva Miglioramenti Pattern recognition

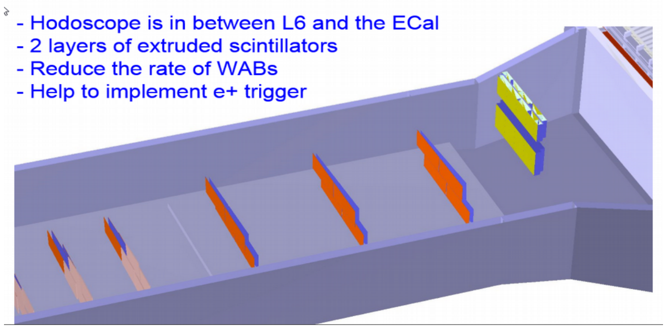
- Possible improvements:
  - Improved axial/stereo matching (L4-L6)
  - Improved and/or more strategies using 3D points
    - Needed for L0 anyway
  - Cluster-seeded tracking
    - ECal cluster position and energy define a trajectory which originates from the beam-spot (HPS Note 2015-006).
    - Find tracks consistent with that hypothesis.
  - Implement pattern recognition based on 1D strip hits.
    - No “ghost” hits, or parallax issues
    - Could see increased efficiency by not requiring hits in both

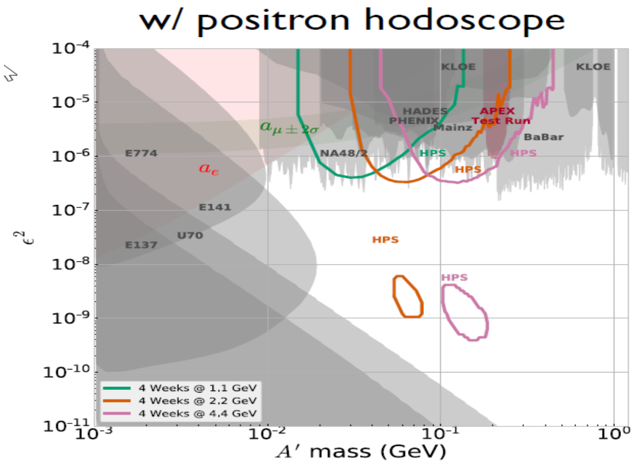
2019 Run and HPS Upgrade

HPS Physics run **APPROVED :**
Start June 10, 2019 - Continue until August 04, 2019 (8 weeks) @ 4.55 GeV

The Upgrades are needed to secure HPS Vertex Reach in 2019

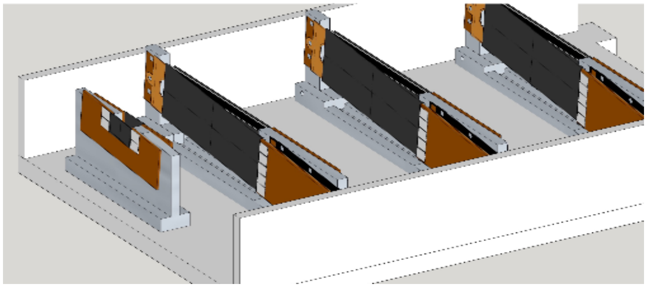
- **Positron Trigger Upgrade: Hodoscope**
- * Boosts acceptance
- * Reduces WAB rate
- * Improves trident yield

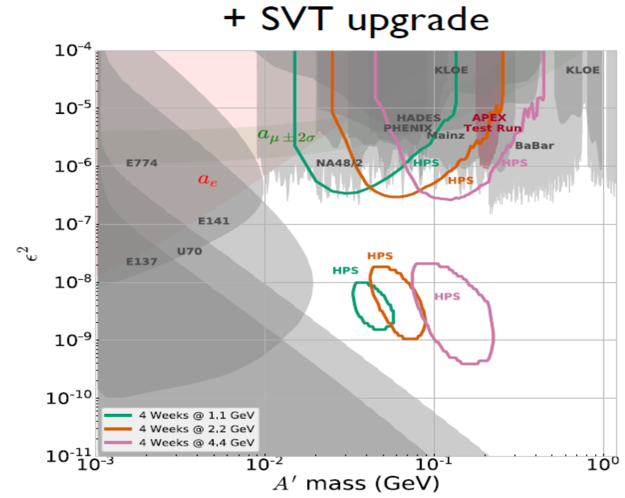




SVT Upgrade: L0

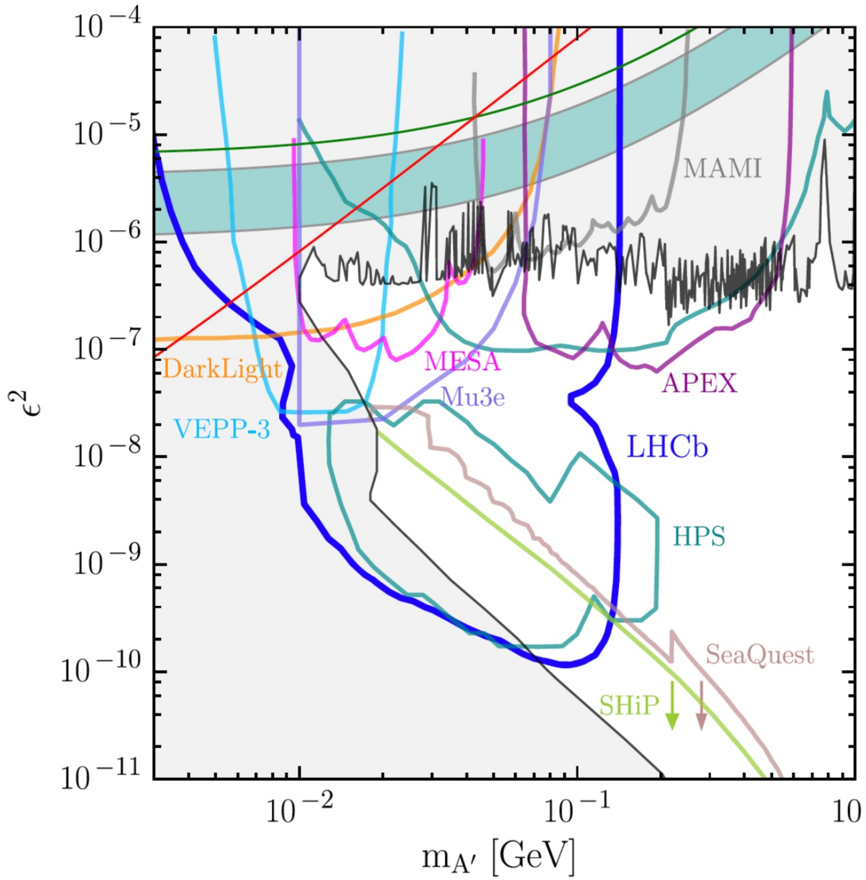
* Doubles z resolution
* Boosts acceptance in z
- * Huge impact on reach

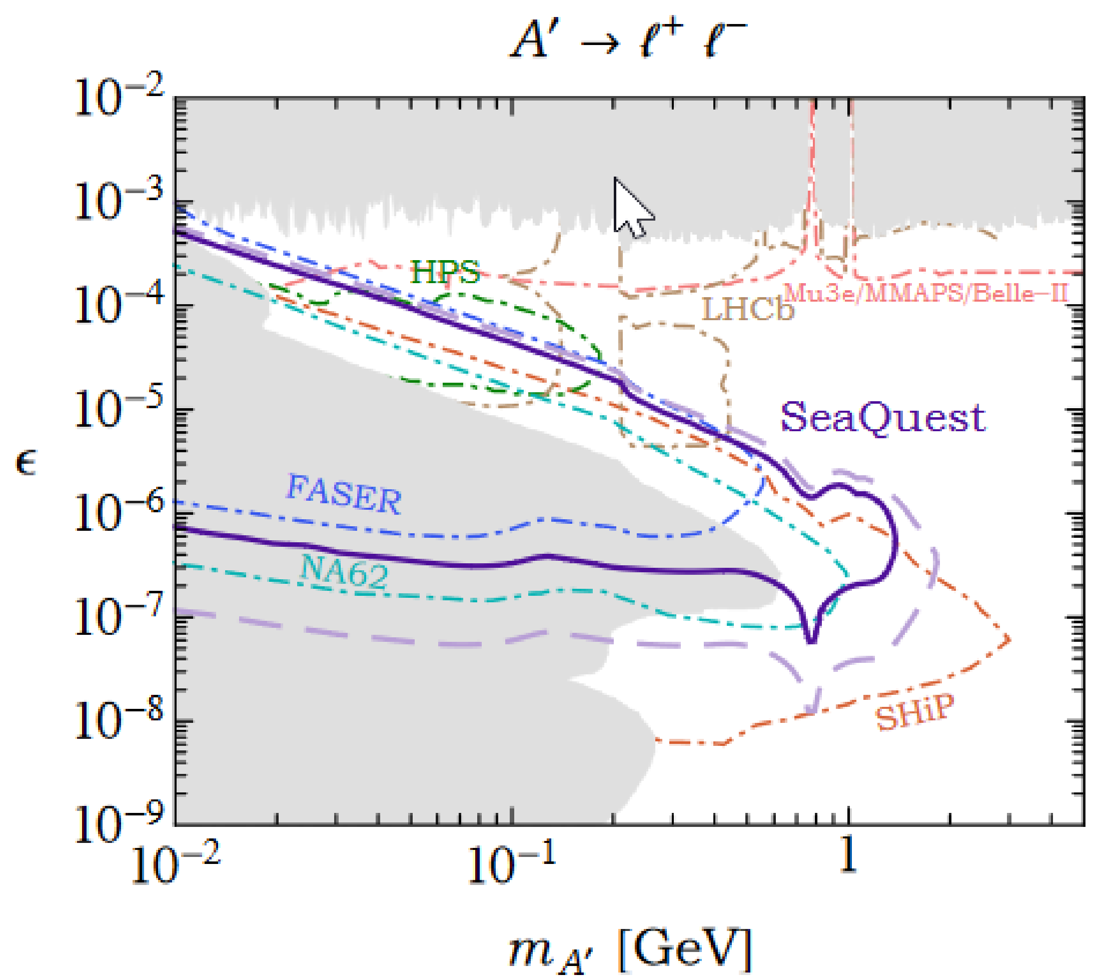




Prospettive HPS Dopo il 2019

- Necessario pubblicare almeno l'analisi dei run 2015-2016 per avere credibilita' e richiedere tempo fascio a JLAB
- Necessario prendere in seria considerazione competitori
  - data taking SeaQuest-now; NA62, LHCb-2021; Ship-2026; FASER-?





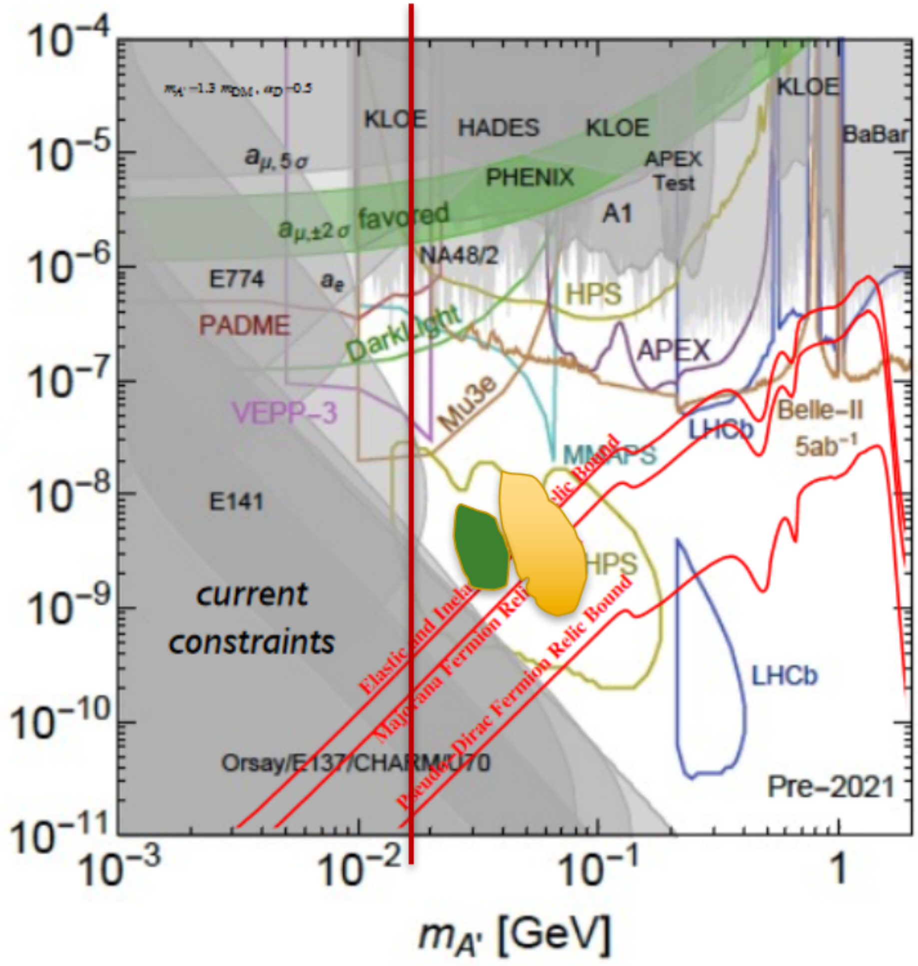
New targets, territory for future runs

Stepan Stephanyan
JLAB

- 137 PAC days in disposal, in chunks of ~30 PAC days (4 runs, if year a part – program for ~8+ years)
- Targeting specific regions in (m_A, ε) with optimized configuration is probably our best way to move forward, e.g.

Can we made a dent in the region of ^{9}Be 17 MeV anomaly by running at ~0.8 GeV

Can we move low energy vertexing towards higher ε



HPS: anagrafica/richieste 2018/2019

- G. Simi 30%
- Attivita' 2018/2019
  - Contributo a studi di performance del tracking
  - Contributo ad analisi dati x vertexig search analysis
- Richieste 2019
  - Travel fundings
    - 1 turno di presa dati a JLAB: 0.13kE x 7gg + 1kE = **2kE**
    - 1 meeting di collaborazione e collaborazione su tracking/allineamento: 0.13kE x 7gg + 1kE = **2 kE**
  - Consumi
    - Disco = **0.5kE**