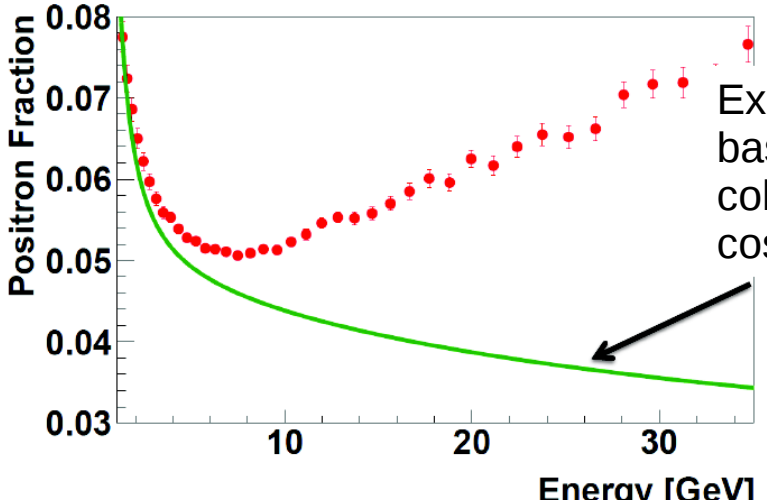
G.Simi

Riunione Preventivi INFN 2016

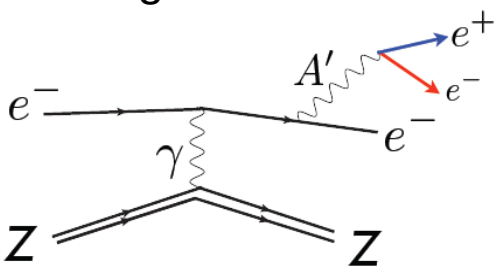
JLAB12: HPS experiment one slider

- There are new sources of positrons
- Search for a new hidden sector heavy photon A' in the mass range 0.01 to 1 GeV

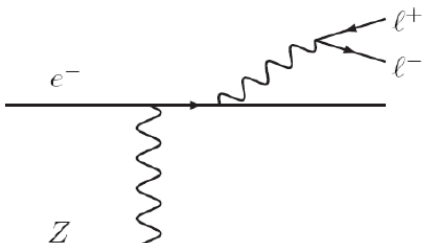


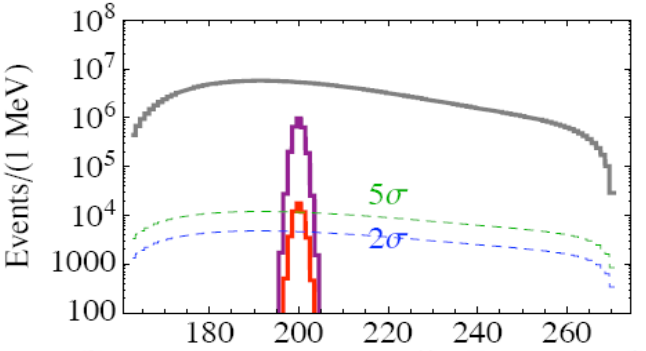
Expectation based on collision of cosmic rays

signal

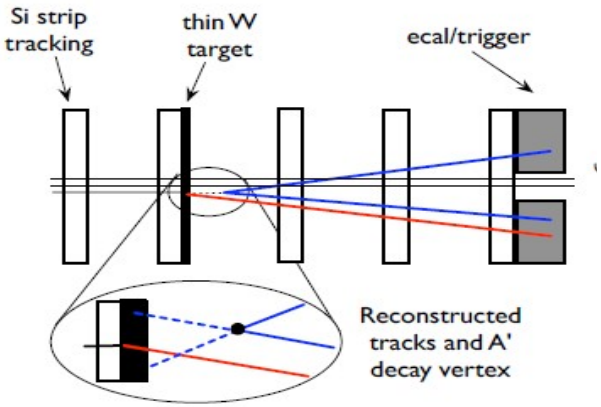


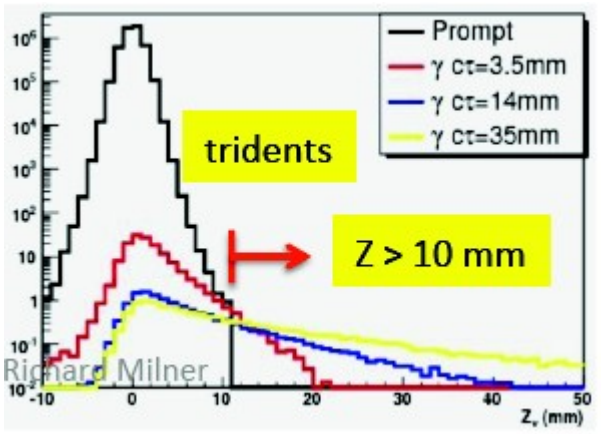
QED background





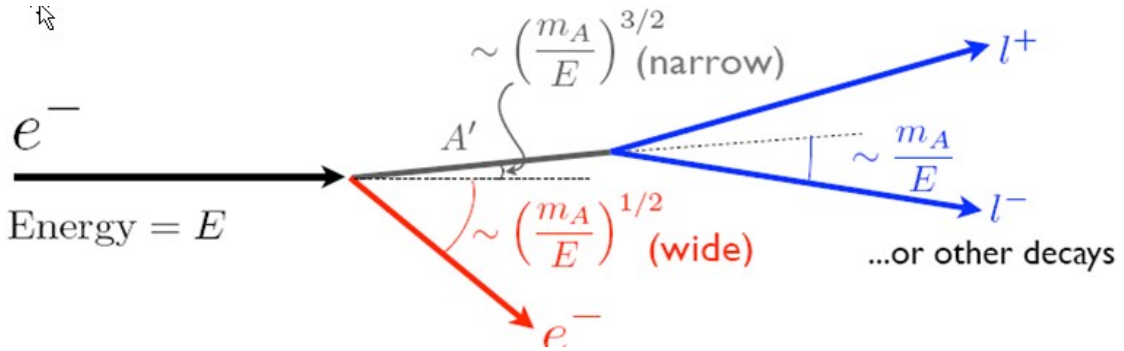
- Use vertex detector to reduce copious QED (tridents) background and search for rare long lived A'





HPS Design

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

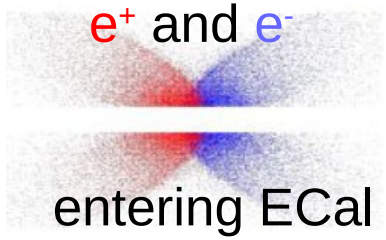


$E_{A'} \approx E_{beam}$
$\theta_{A'} \approx 0$
$\theta_{decay} = m_{A'}/E_{A'}$

- 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 $\Delta z \sim 1$mm

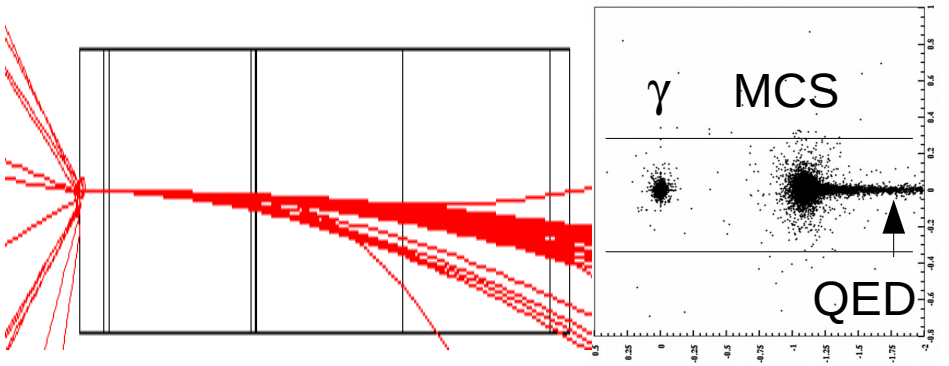
Beam's Eye View
e^+ and e^-



entering ECal

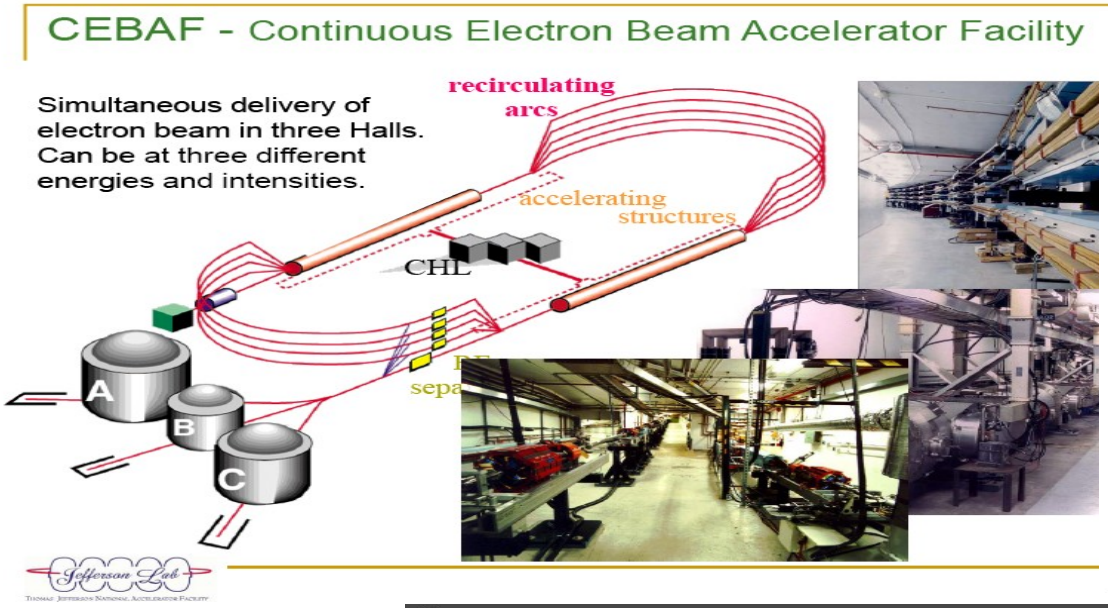
- Trigger with a high rate Electromagnetic Calorimeter downstream of the magnet to select e^+ and e^-.

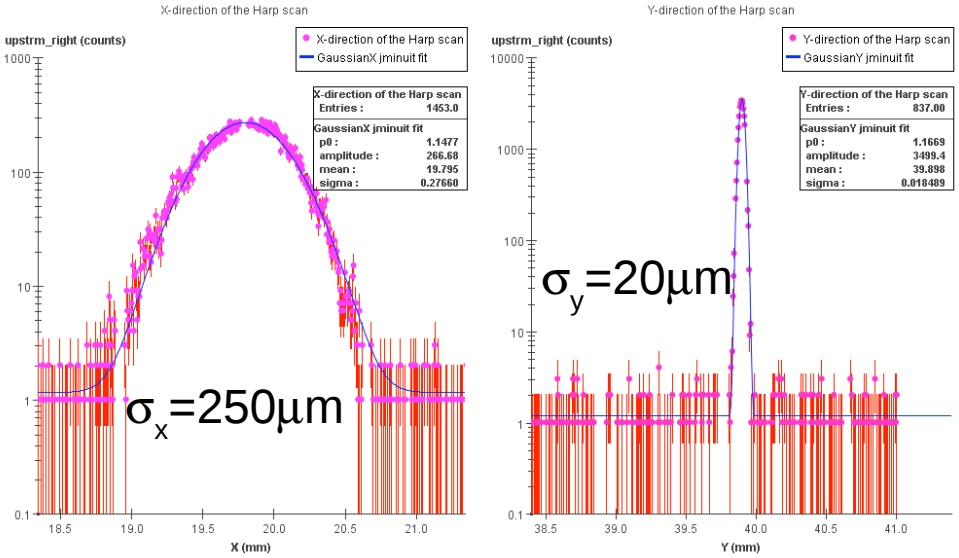
- Beam, QEDand Multiple Couplomb Scattering background in the bending plane => split detectectors



Dead zone

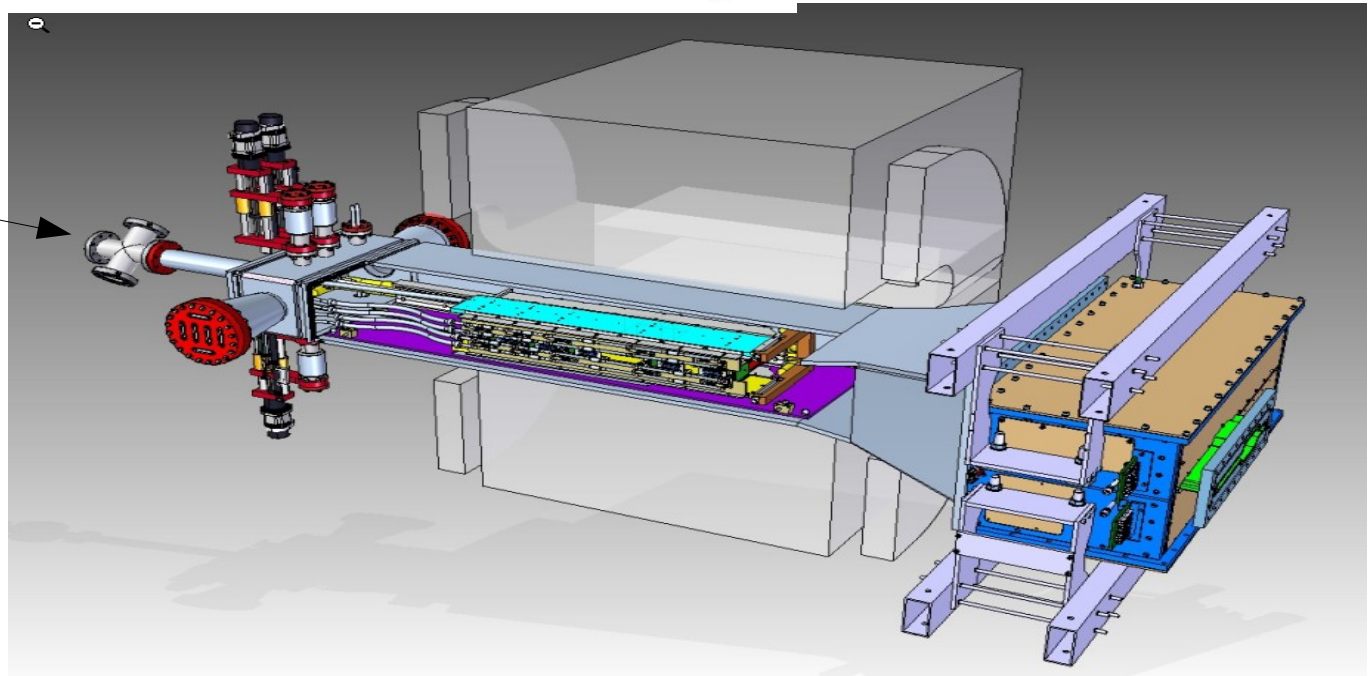
2012 Test Detector





Beam

γ beam on converter



Approval

HPS received JLAB approval for installation of HPS hardware after:

- Successful test measurement in 2012

- DOE HEP funding

- Progress in preparation of equipment

- Receive High Impact Status by JLAB advisor committee PAC41

Response to the Report from the DOE Review of the Heavy Photon Search Experiment on July 11, 2013
and
HPS Request for Formal JLab Approval

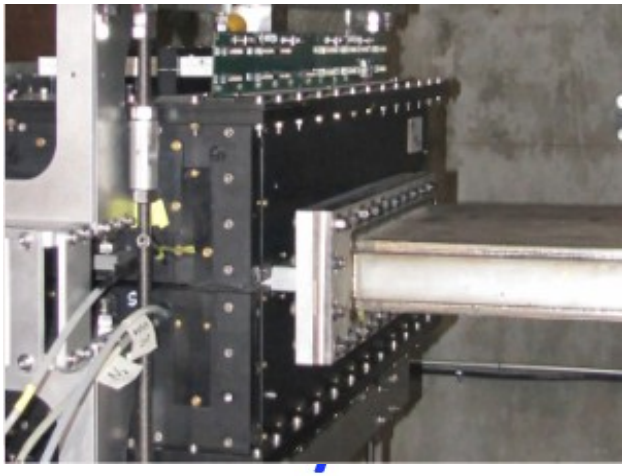
The Heavy Photon Search Test Detector

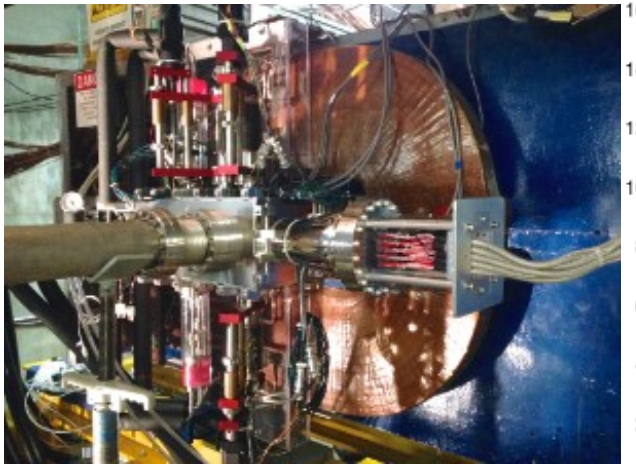
HPS Collaboration
March 14, 2014

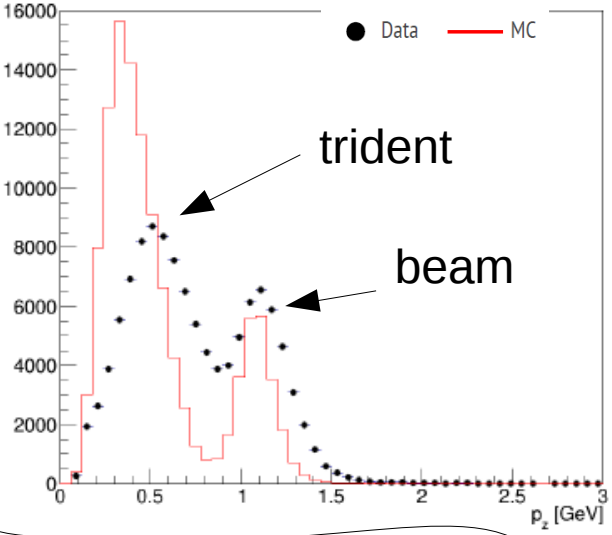
Page | 1

HPS Collaboration

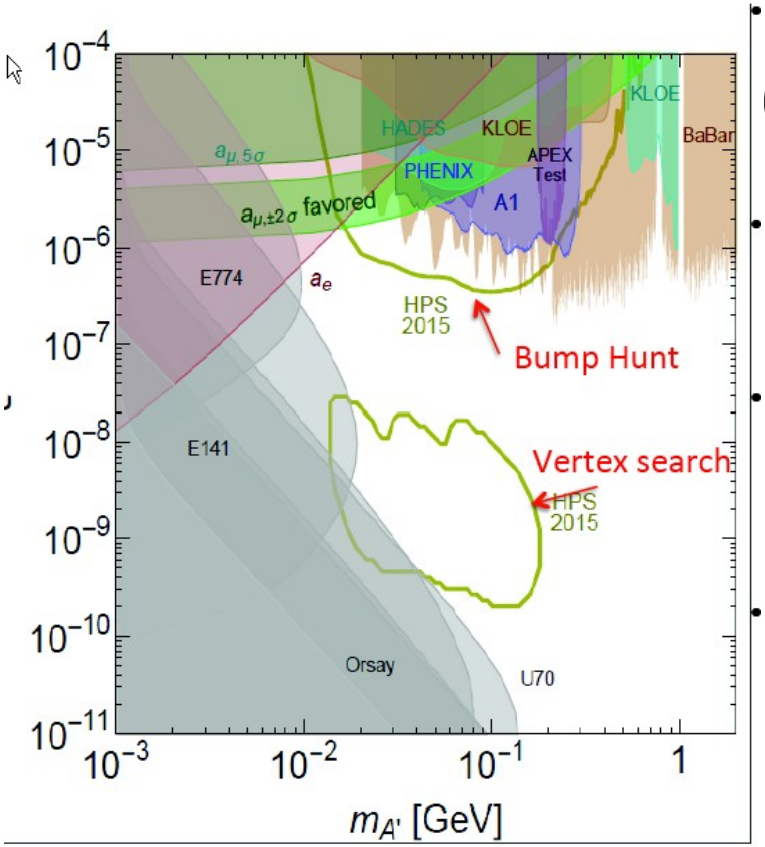
HPS Status one slider



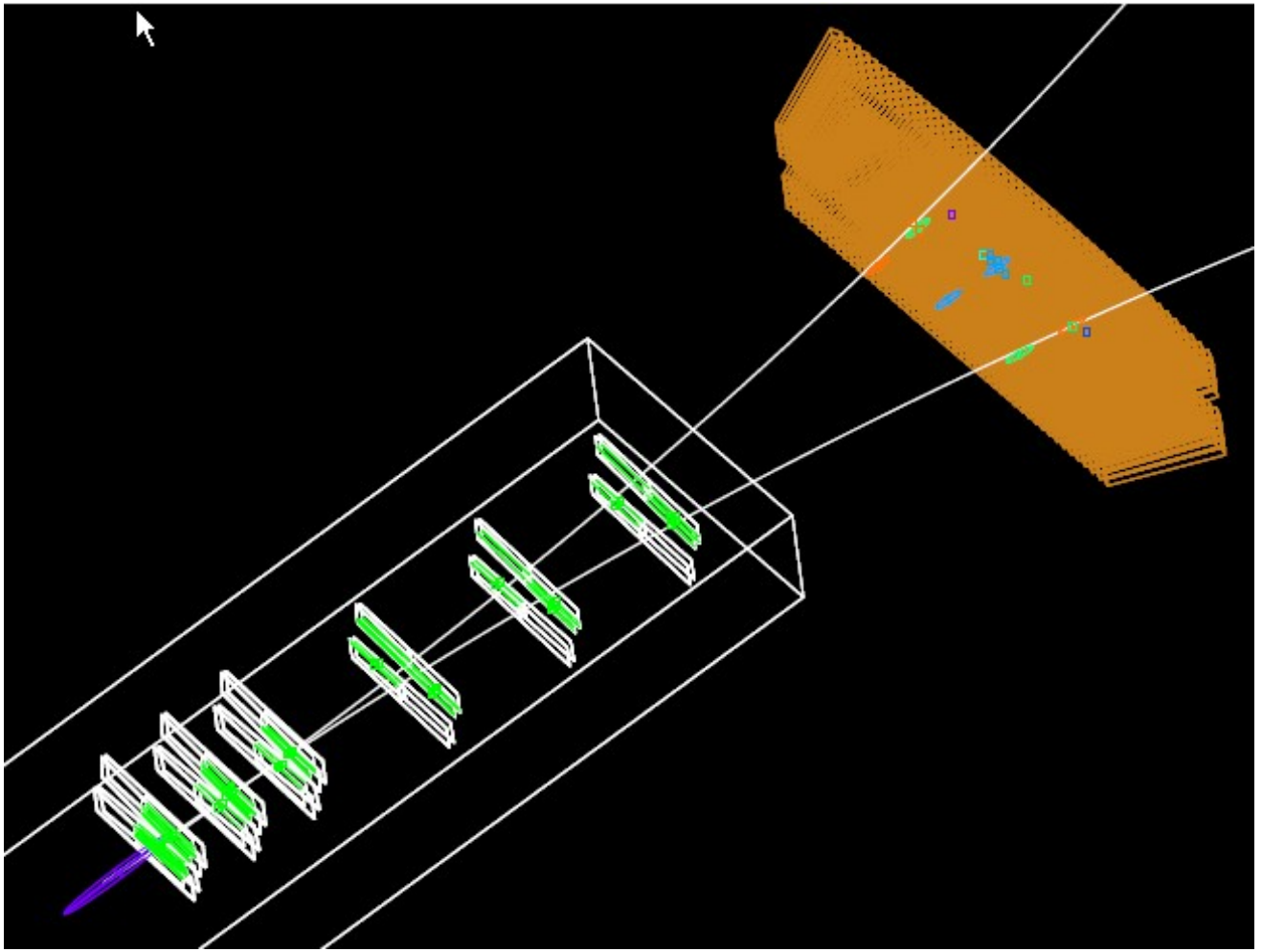




2015 HPS Reach and Existing Limits



- 2012 test run with prototype - DOE HEP funding - Installation in 2014 and run with calorimeter - Vertex detector installation in 2015 – Engineering run in spring 2015 (E_beam=1.06 GeV)
- Padva Joined HPS in 2014
- Participated to the engineering run in december 2014 and run in 2015
- Contributed to tracking and alignment of vertex detector
- Interest in search for heavy photons also in Frascati

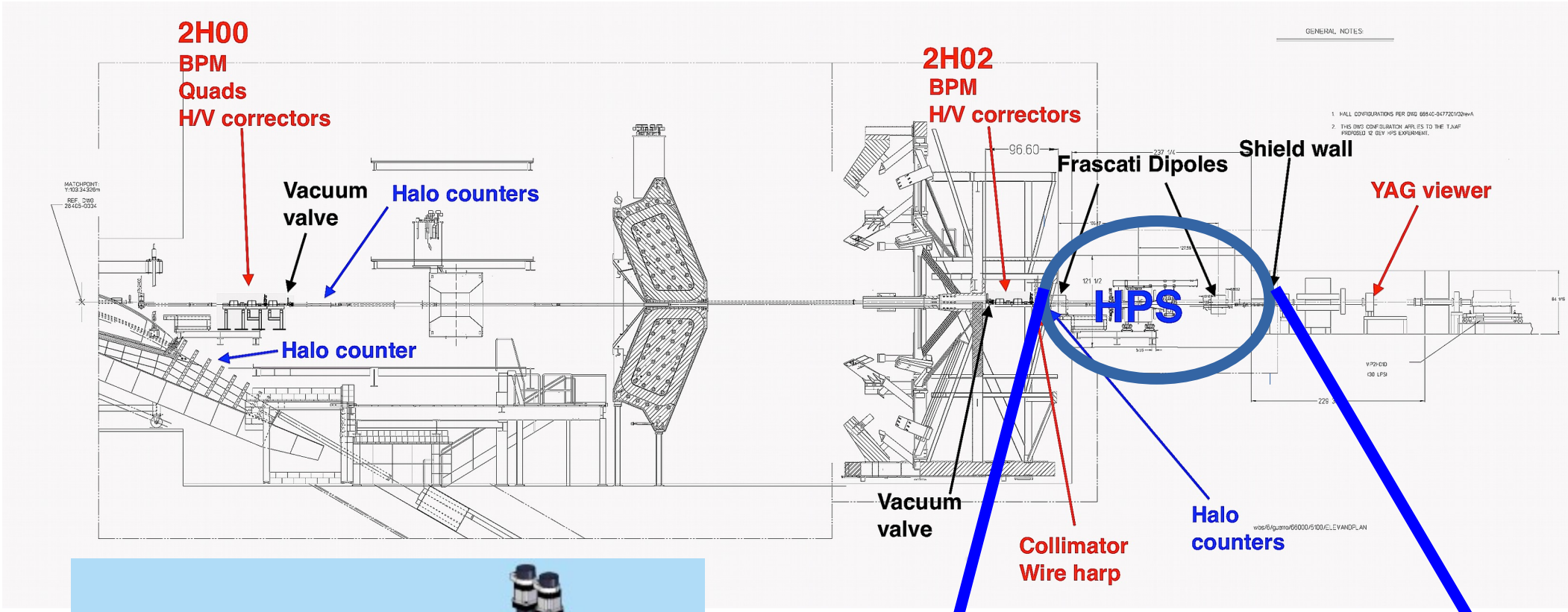


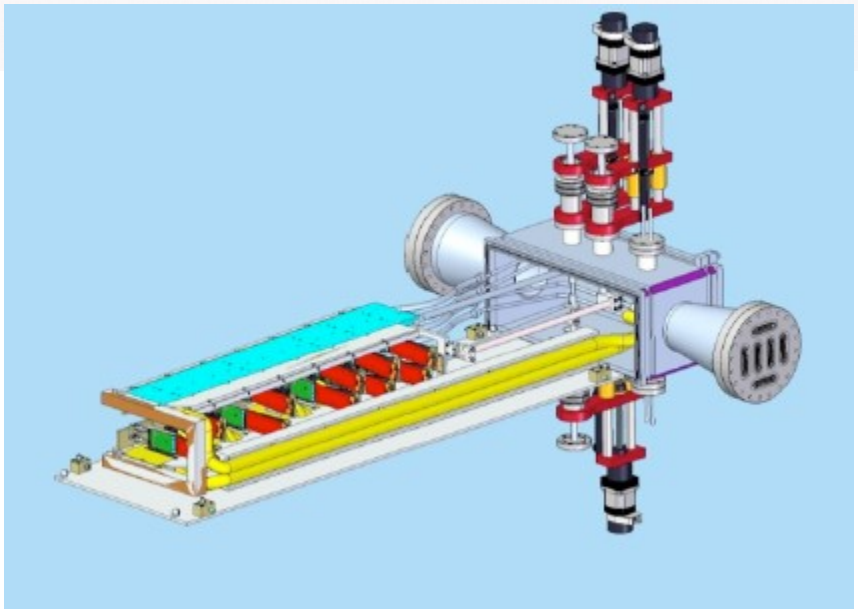
Run 5623
Event 62
N. Graf

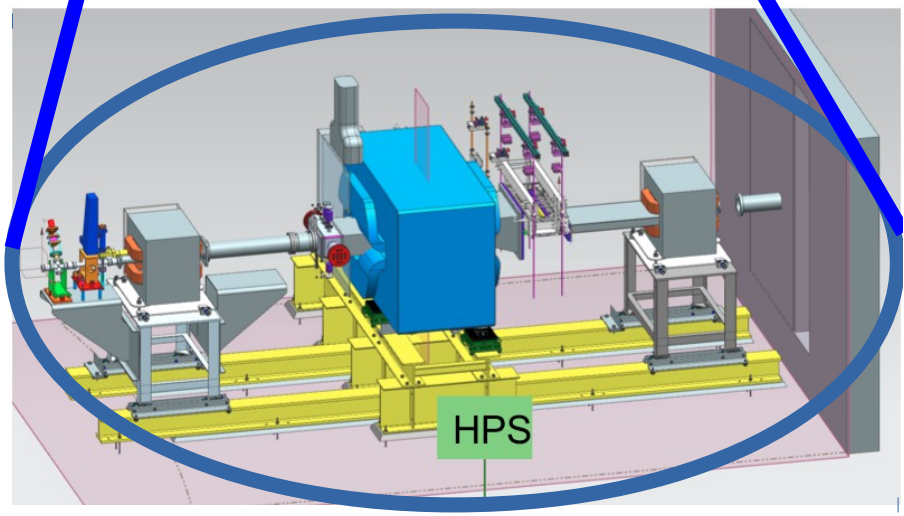
HPS Engineering Run Update

May 19, 2015

Beam Line & Detector Design



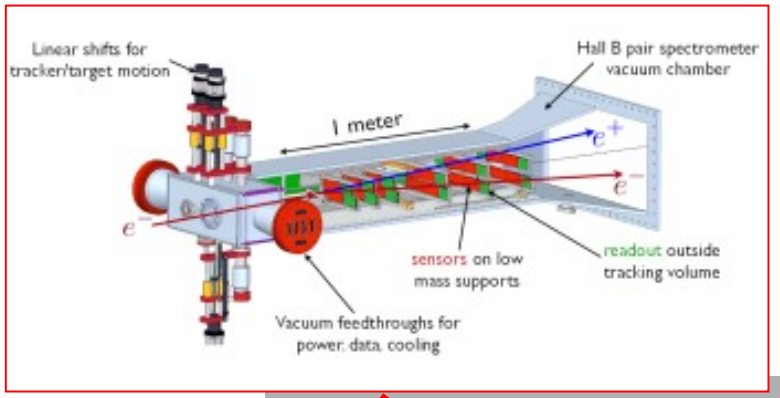


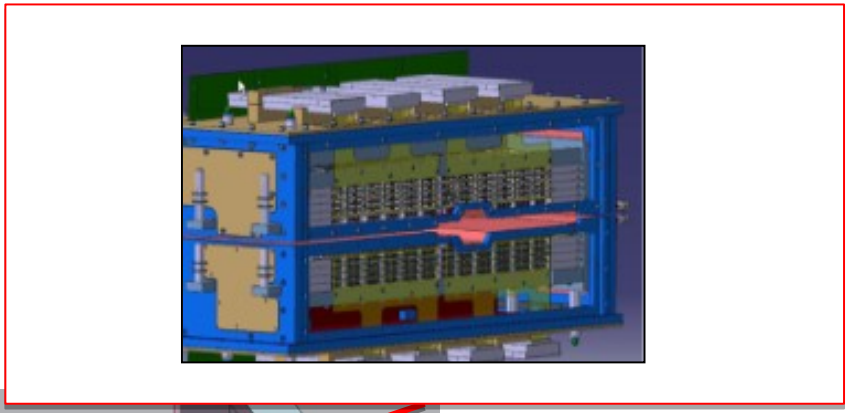


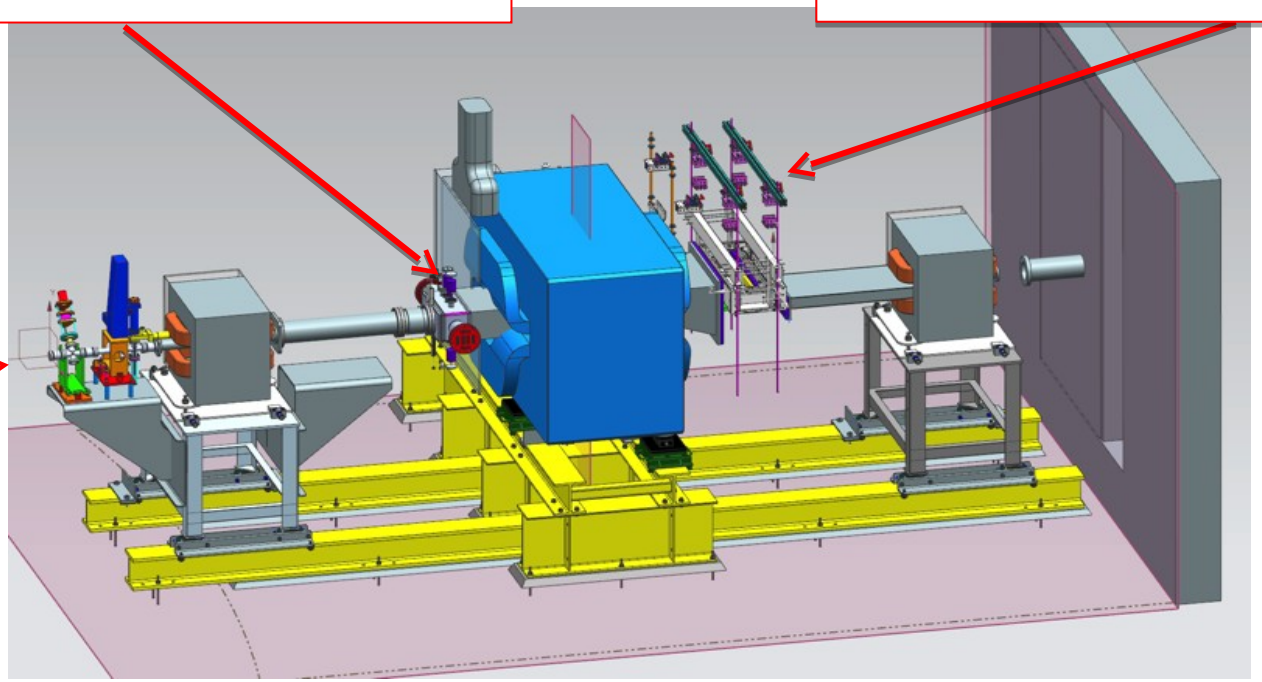
HPS Setup in Hall B Alcove

Si Vertex Tracker Installed Feb 23, 2015

$PbWO_4$ Ecal Installed September, 2014





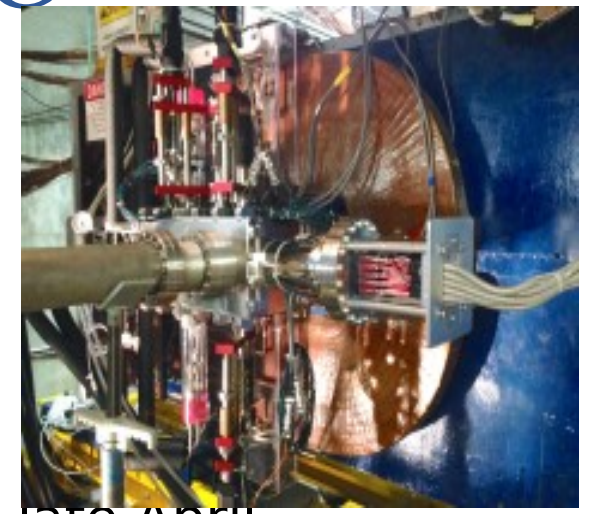


A magnet chicane directs the CEBAF 12 electron beam onto a W foil, producing heavy photons. They decay to e^+e^- pairs, which are measured by the Si vertex tracker inside an analyzing magnet. A $PbWO_4$ ECal provides a fast trigger.

https://confluence.slac.stanford.edu/display/hpsg/Heavy+Photon+Search+Experiment

Beam's Eye View of SVT

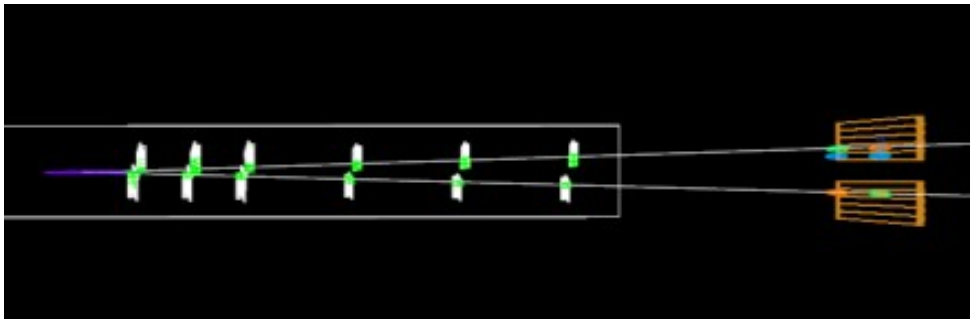
Spring Engineering Run



- Installed SVT end of February
- Commissioned Hall B beamline March-April
  * Calibrated bpms & established orbit locks
  * Set up SVT Protection Collimator
  * Checked beam position stability
- CEBAF down after power outage
- Commissioned Trigger and Integrated SVT DAQ late April
- Explored SVT backgrounds as moved SVT closer to beam
- Production running at 1.5 mm started May 1
- Production running at 0.5 mm started May 12

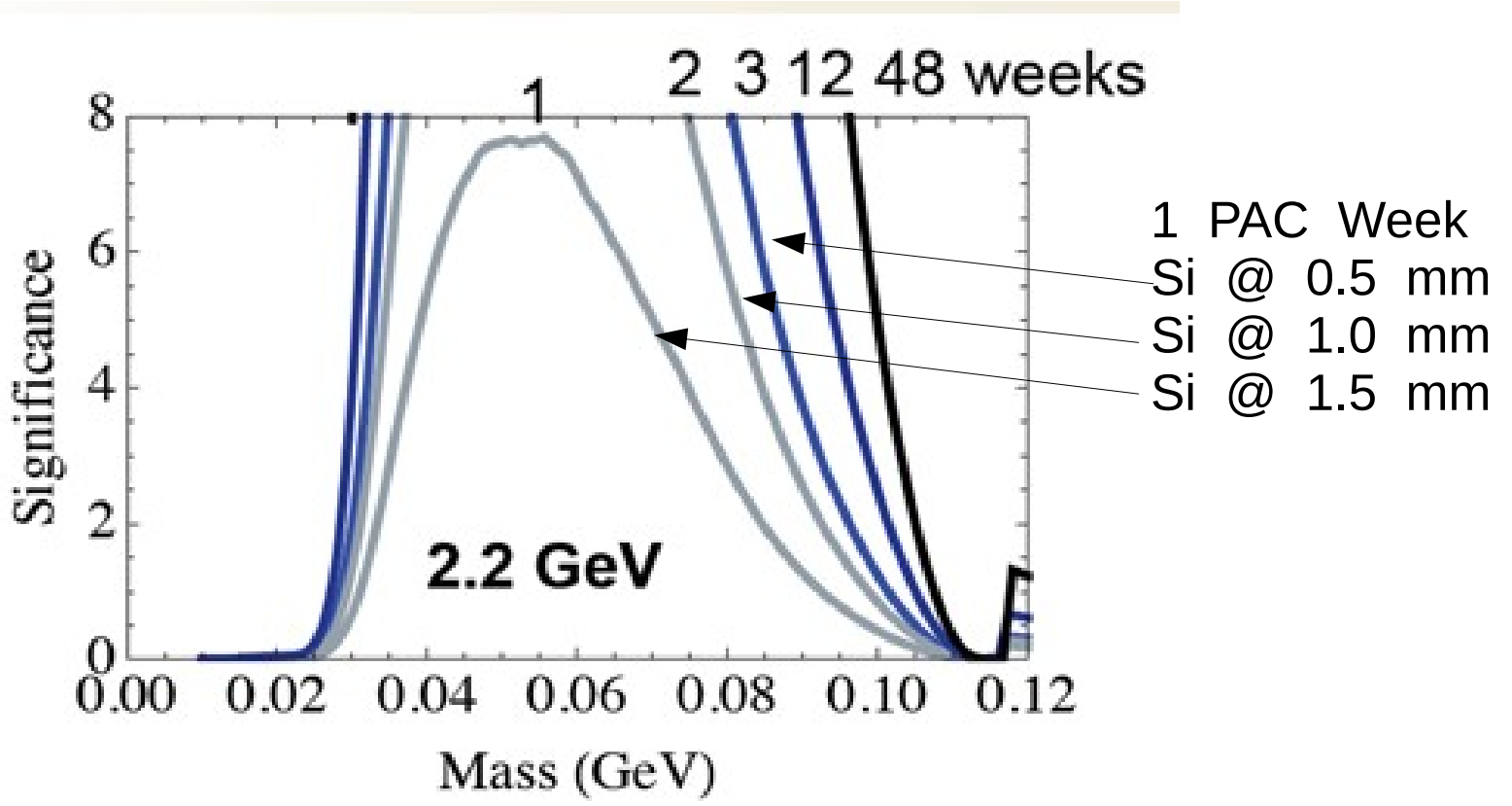
Run 5623
Event 62
N. Graf

Layer 1 silicon sensors are just 0.5 mm above and below beam. Min opening angle is θ_y= 15 mrad.



Why SVT @ 0.5 mm?

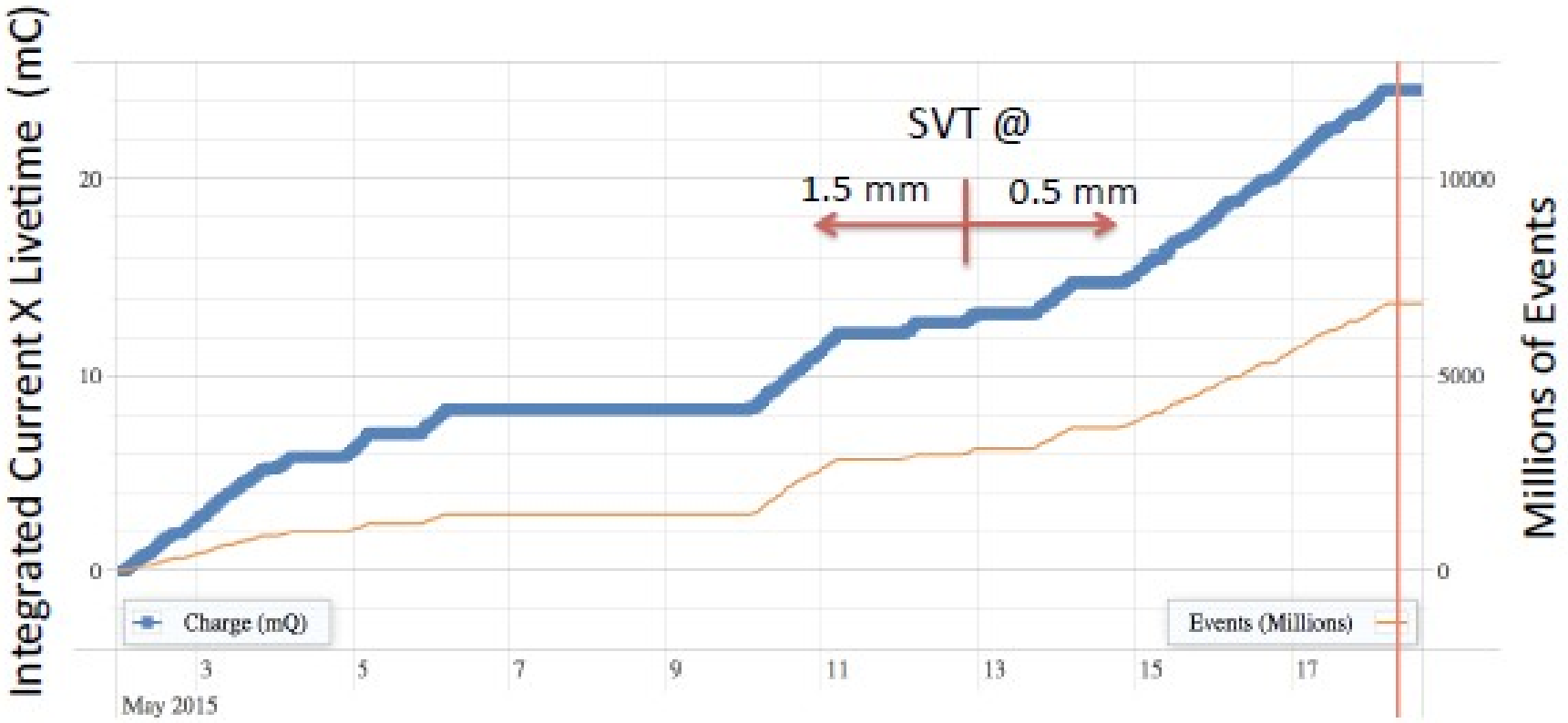
HPS's reach is very sensitive to SVT position below 60 MeV A' mass.



Plot is for 2.2 GeV, but same effect at 1 GeV.

1 GeV Run, Final

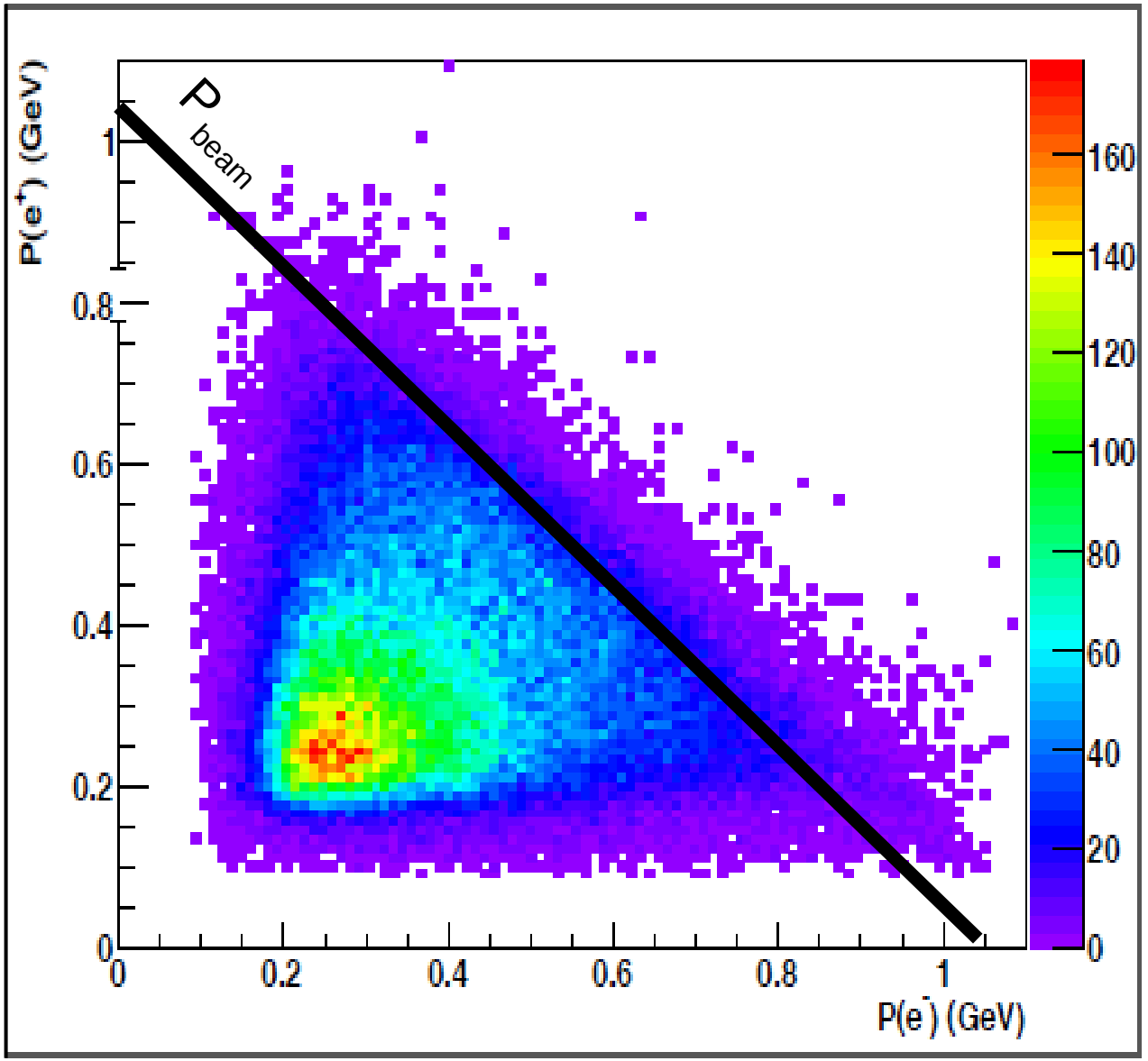
- Proposal: 1 Full week of 50 nA beam on target, 30 mC
- Achieved: ~10 mC with SVT @ 1.5 mm, 10 mC @ 0.5 mm



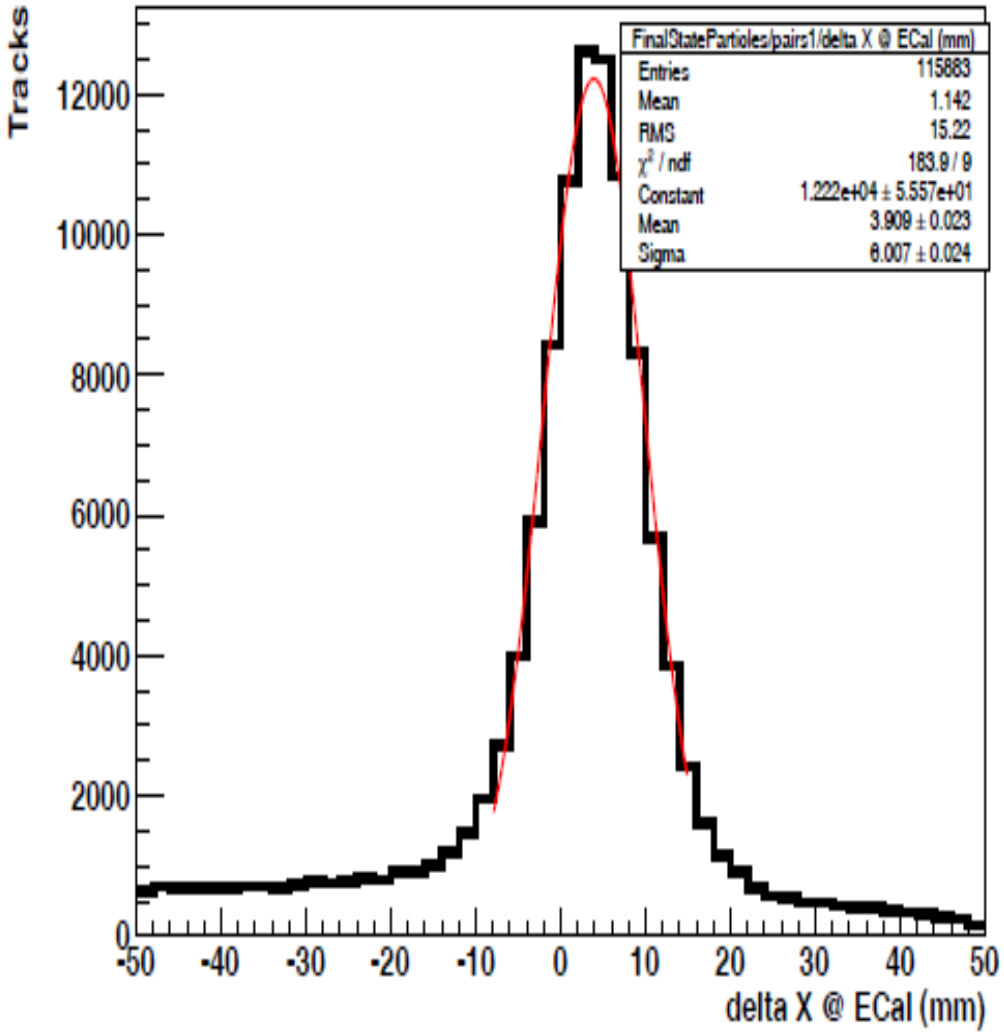
Tracked Pairs at 1.5 mm

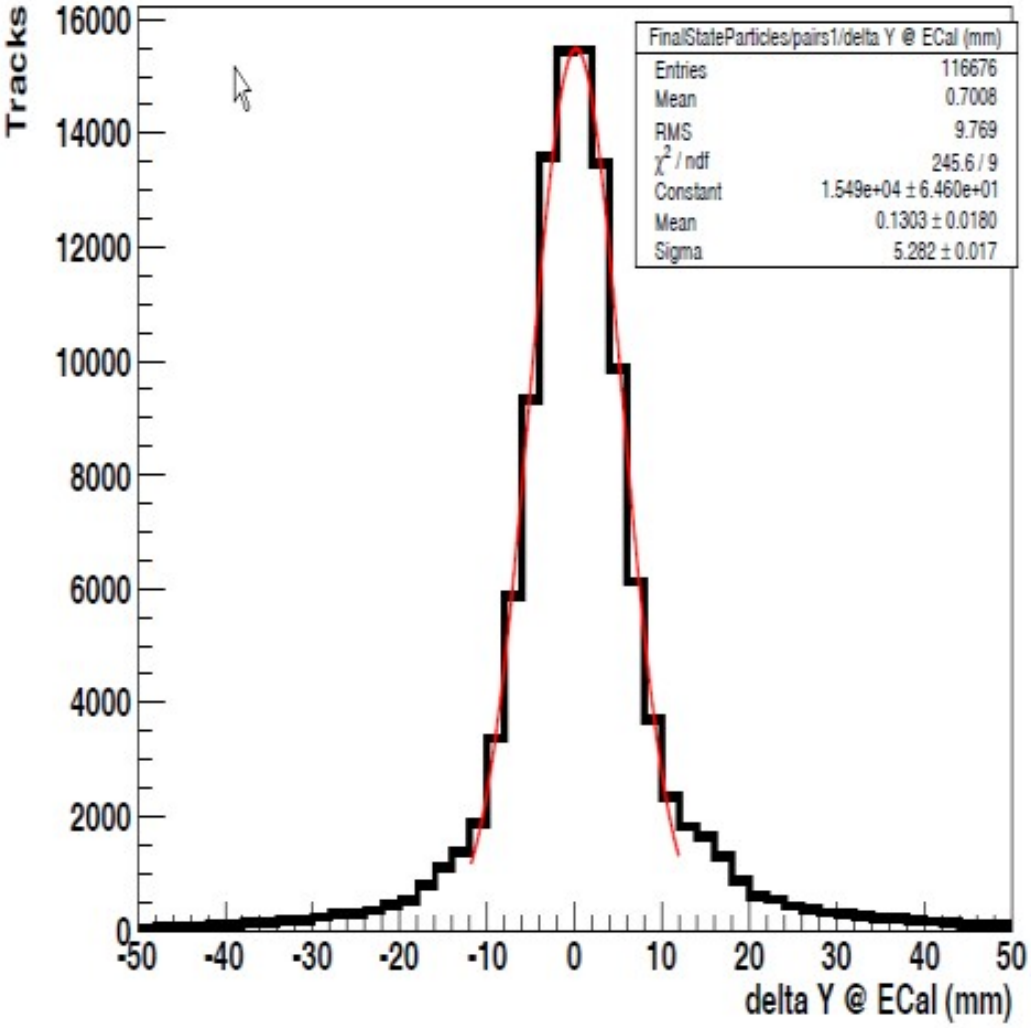
Plots from M. Graham

A′ candidates have $P_{e+} + P_{e-} \approx P_{beam} = 1.05$ GeV



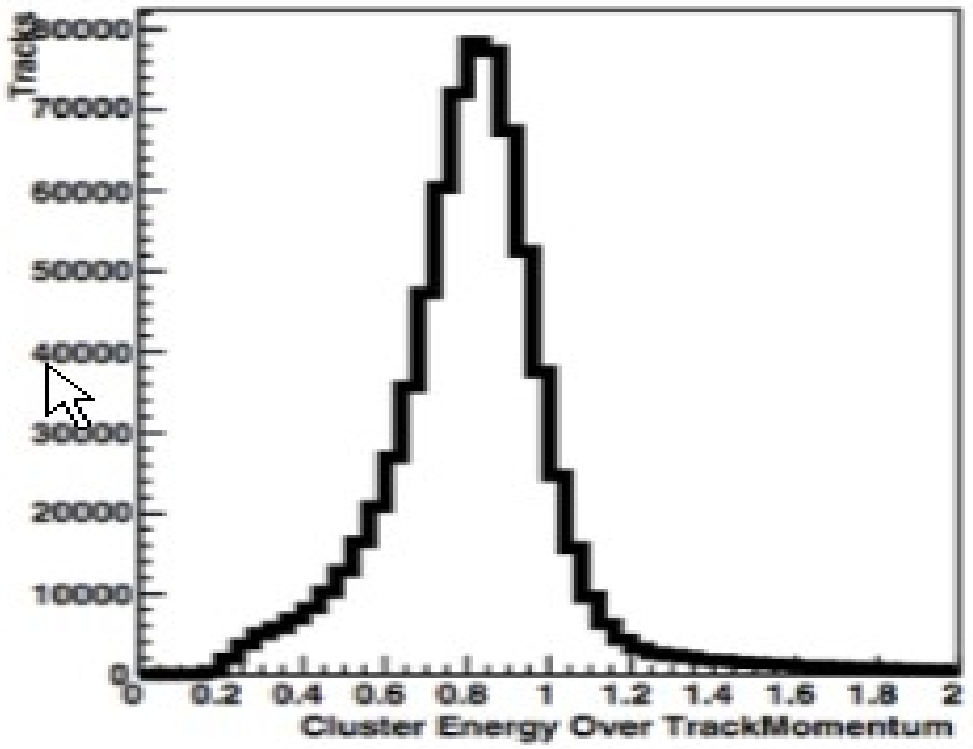
Track Matching at Ecal





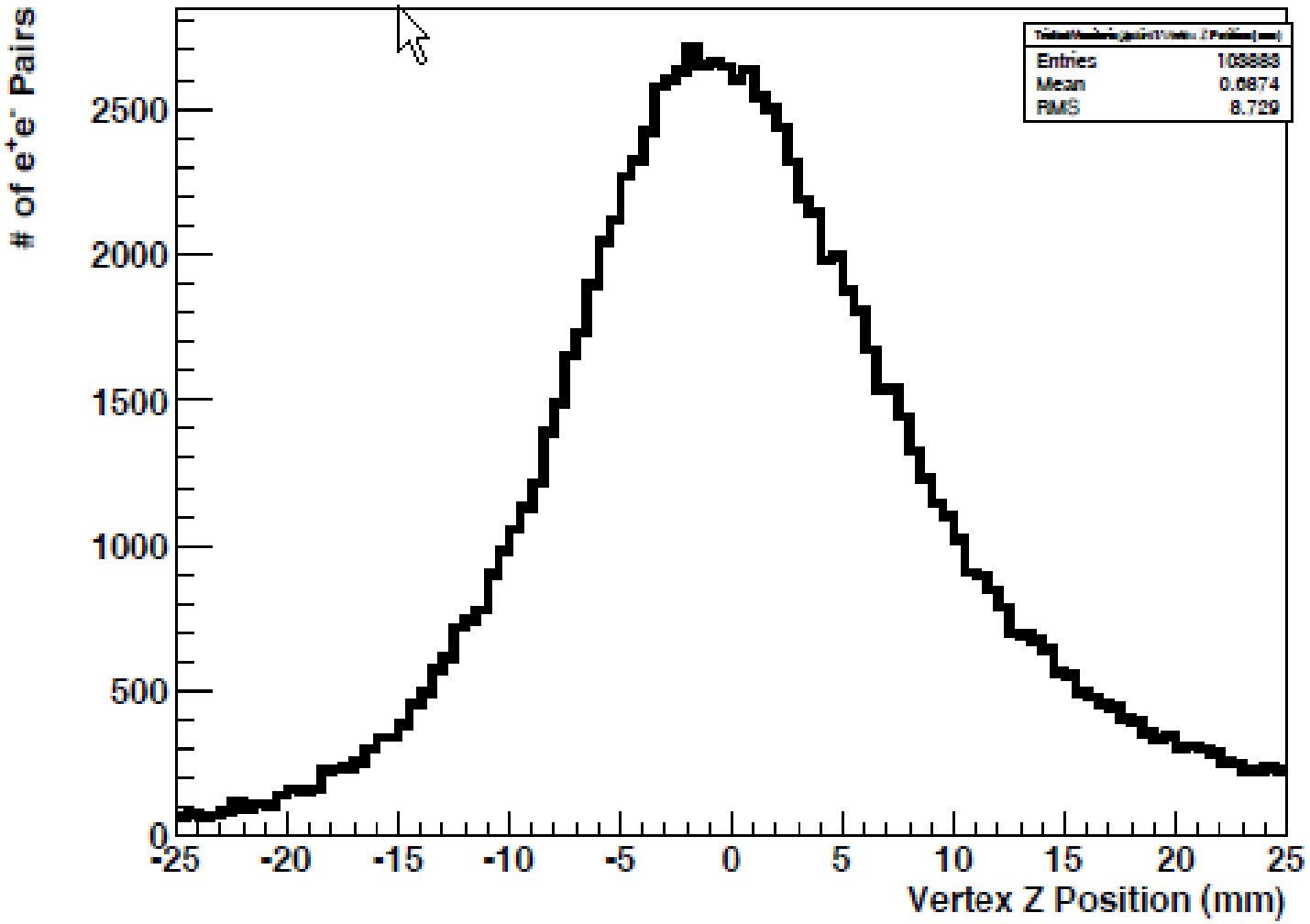
Alignment fine tuning needed, but close

SVT Momentum/ ECal Energy Match

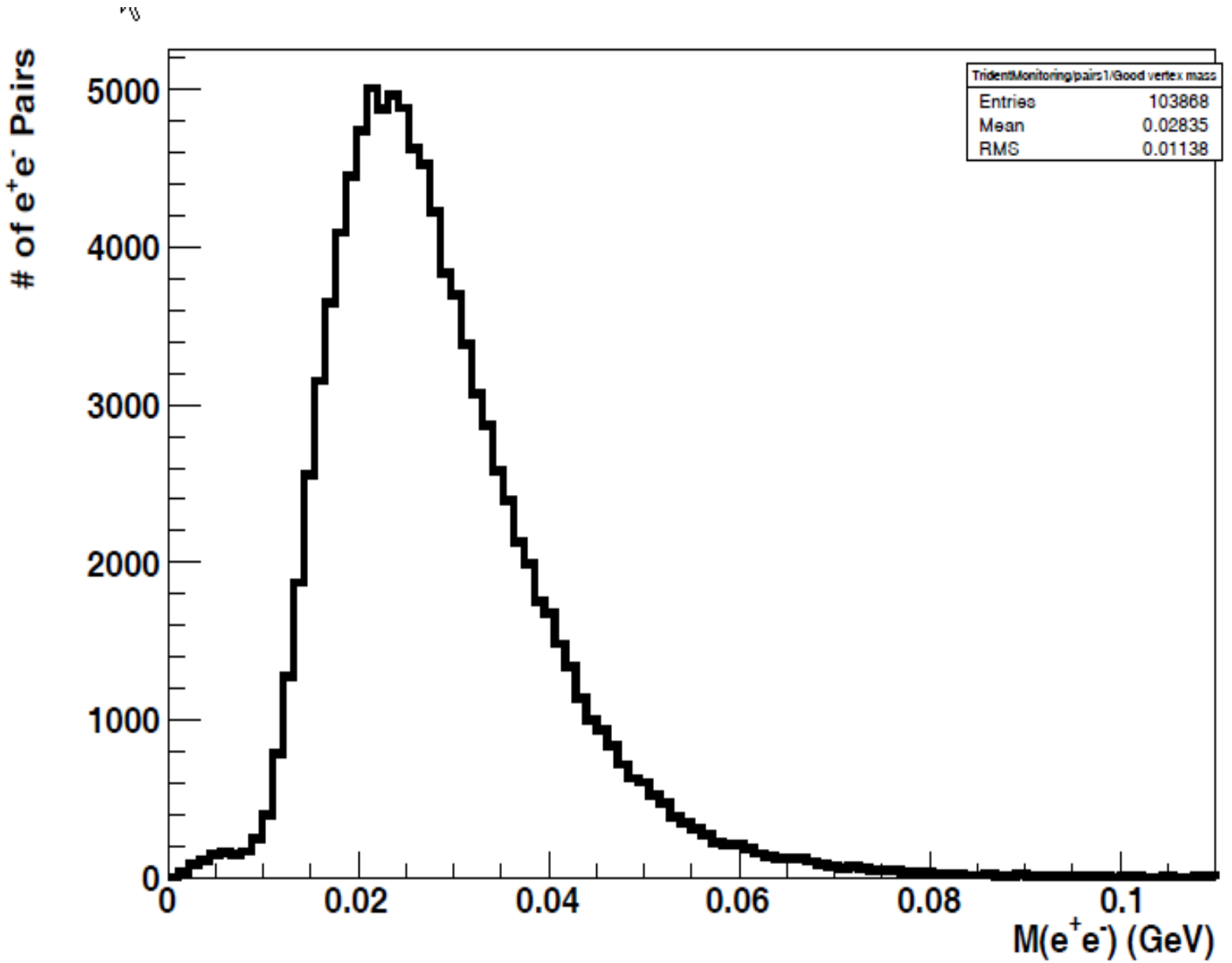


Further Ecal Calibration/Tracker Alignment Needed

Pairs Vertex at the Target



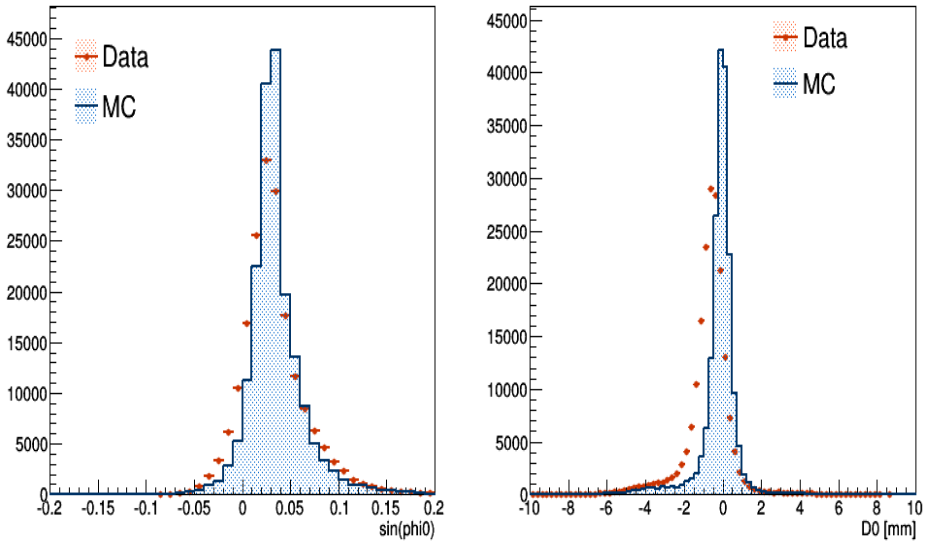
Pairs Mass Distribution



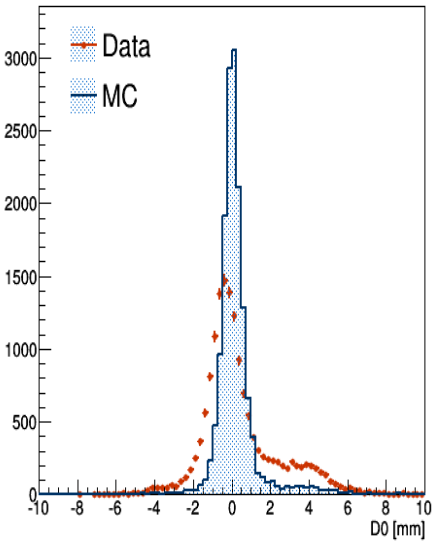
Tracking tails

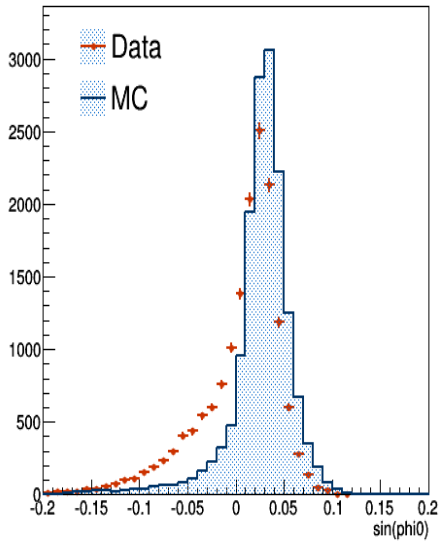
- In data, the distributions of some of the track parameters of electron and positron tracks showed tails that were not present in MC

Electrons



Positrons



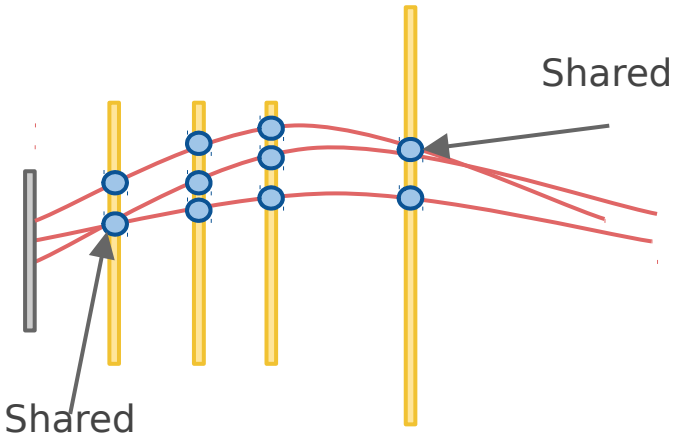


- Residuals of the tracks on these tails are terrible → Likely not real tracks
- Looking at tracks matched to clusters, the distribution gets cleaned up quite a bit. Those that aren't matched to a cluster look the same as above

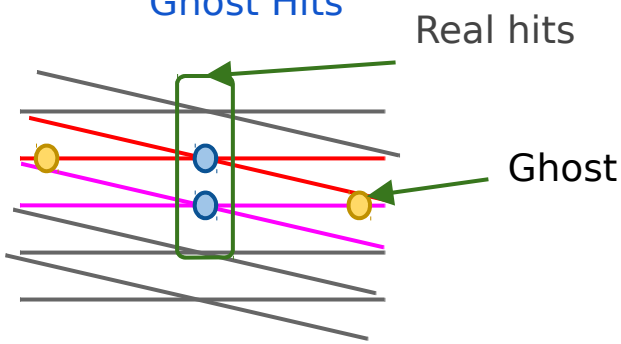
Where are they Coming From?

- Several things can lead to “large D0” tracks including

Shared hits leading to fake tracks



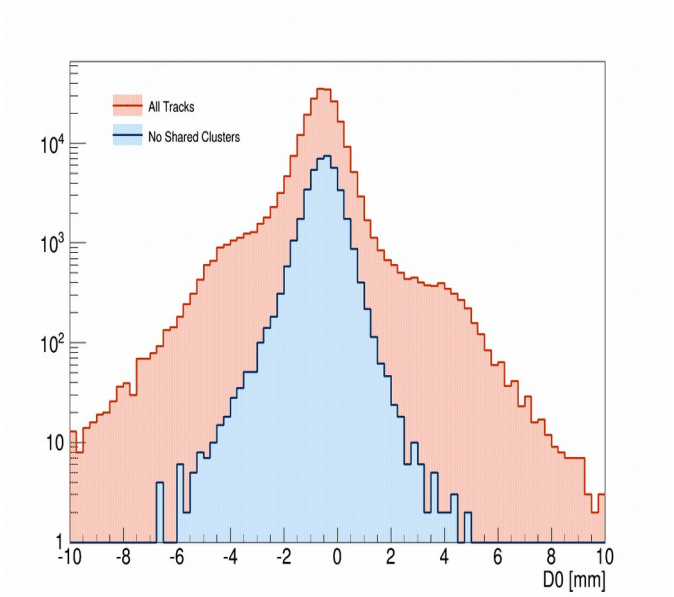
Ghost Hits

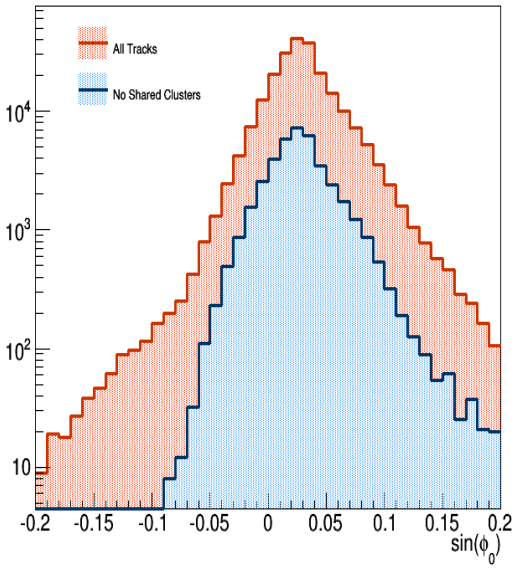


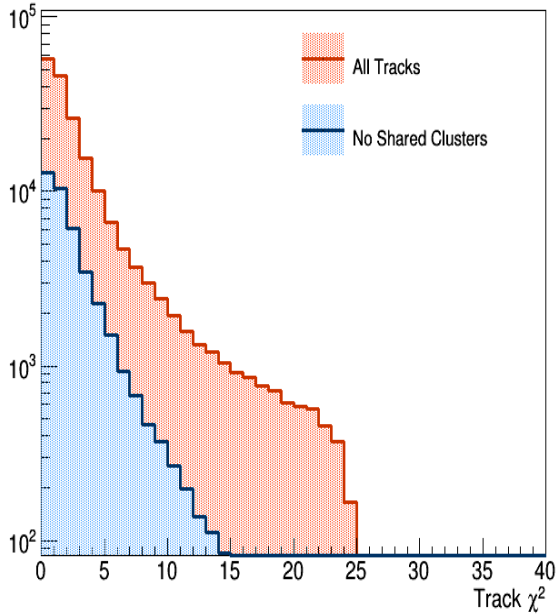
Background coming from upstream?

Shared Strips Cut

- Currently, there is no isolation cut being applied to any of the hits being used to make tracks
- This will lead to ghost hits being used on tracks, but are these the main cause of the “large d0” tails?
- Do something quick and easy (Sho style) … drop ALL 3D stereo hits that share a cluster with another stereo hit



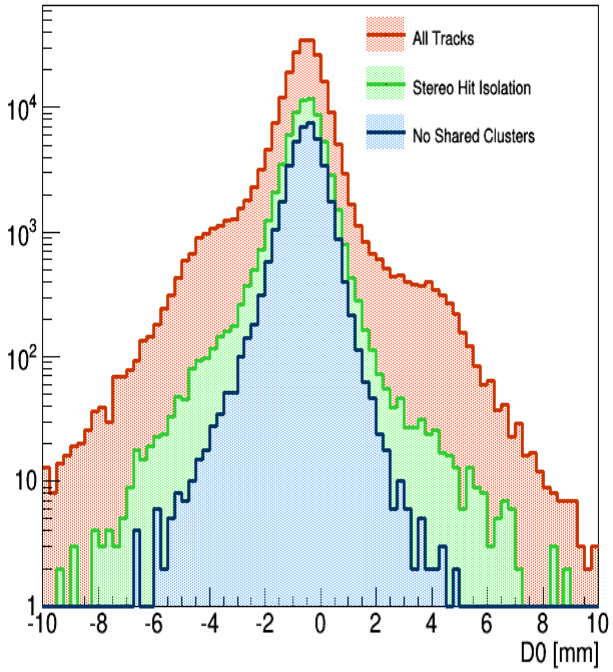


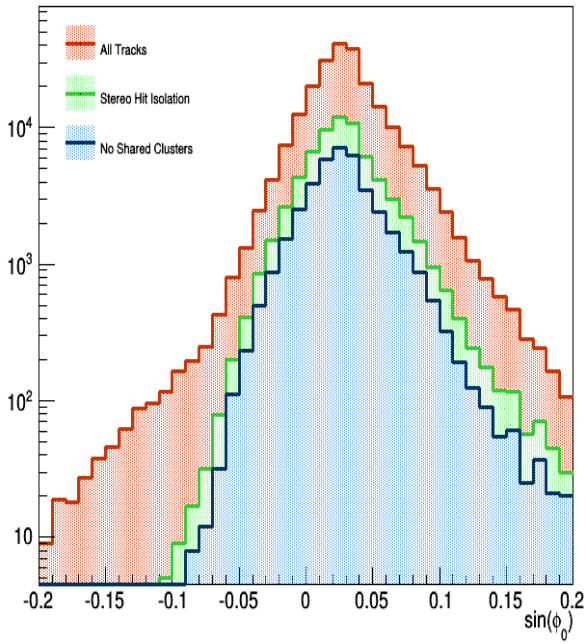


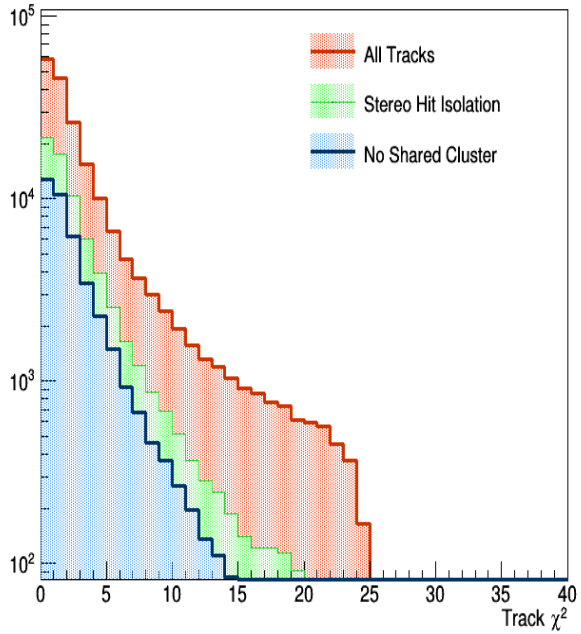
Works … but very inefficient (only getting about 20% of tracks). Need an isolation cut on either the stereo hits or/and clusters.

Stereo Hit Isolation

- Loop through all tracks and check that all stereo hits on a track are some minimum distances (delta x and delta y) away from the stereo hits on the same sensor
- If any two of the cuts fail, drop the track … Ideally, we just want to choose the best and drop the rest
- For this study, delta x = 1 mm, delta y = 10 um. No real reason to choose these cuts ….





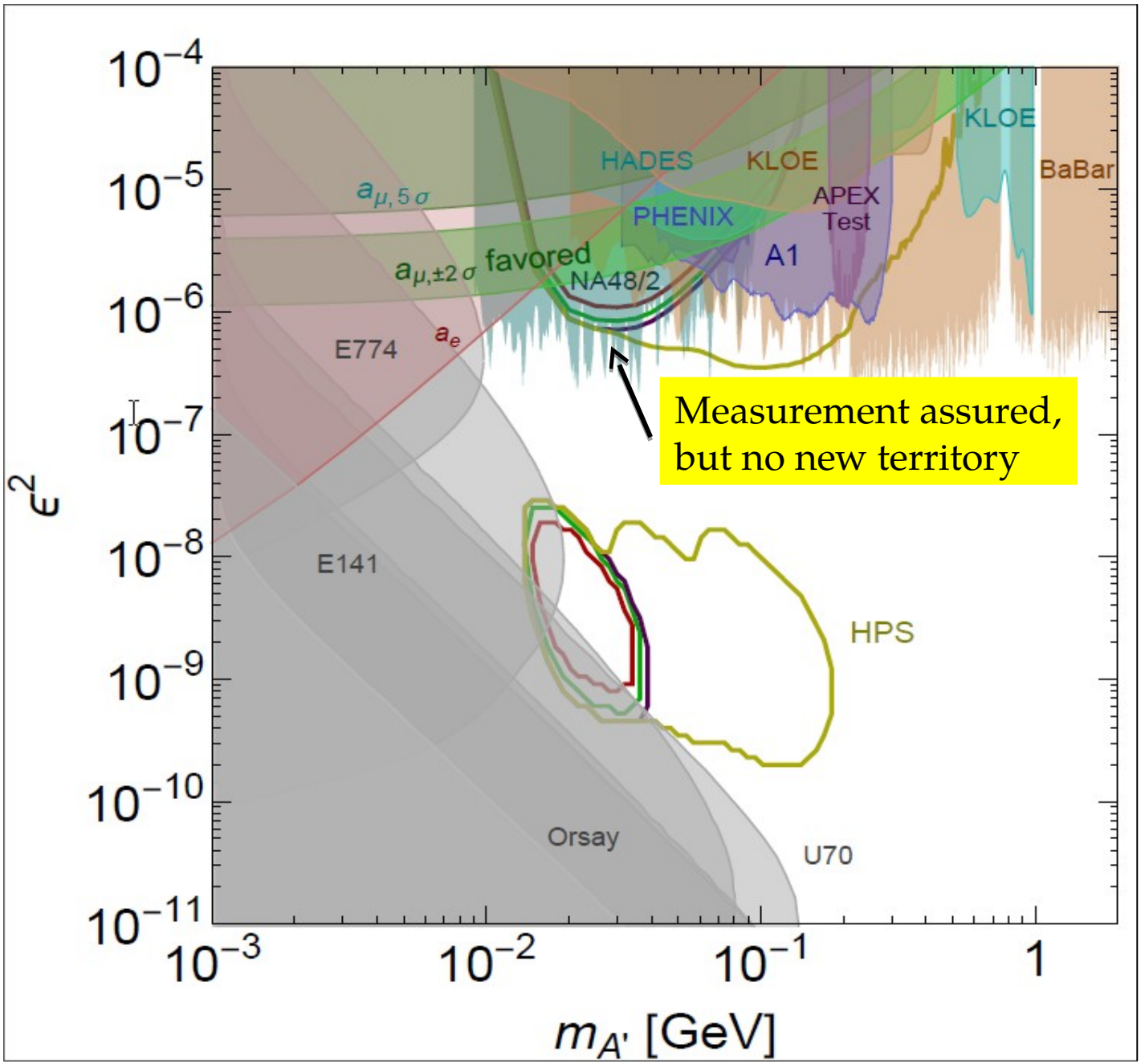


- Also cuts out much of the tail with slightly improved efficiency but it's clear additional cuts will be needed

Physics Measurement?

- **We have roughly 1/3 PAC week with Si at 0.5 mm** (15 mrad acceptance)
- **Beamline, Ecal, Trigger and SVT all worked well**
- **Lots of Work to Do…**
  Check Trident Yield in the data
  Ecal energy calibration and alignment
  SVT alignment
  Understand the Vertex Tails
- **But a physics result may be in reach**

Reach vs Runtime



Assumes coverage to 15 mrad

1 GeV Contours:

1 PAC week

5/7 PAC week

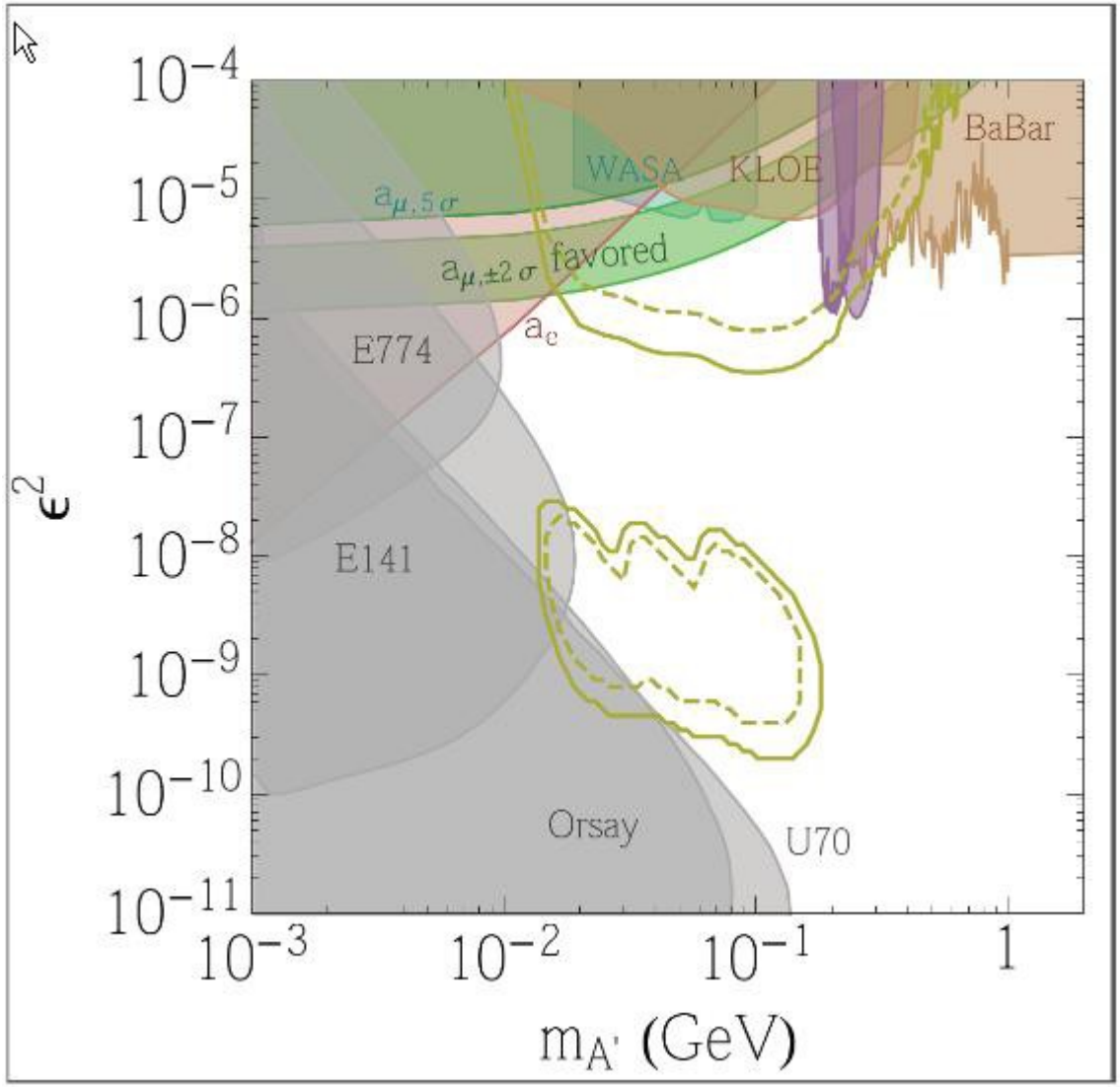
3/7 PAC week

People/Requests

- G.Simi 30%
- Interests from other researchers
- Travel fundings
  - meeting di collaborazione 3kE
  - Shifts presa dati: ??

Old Run Plan (to be updated after Collab. Meeting)

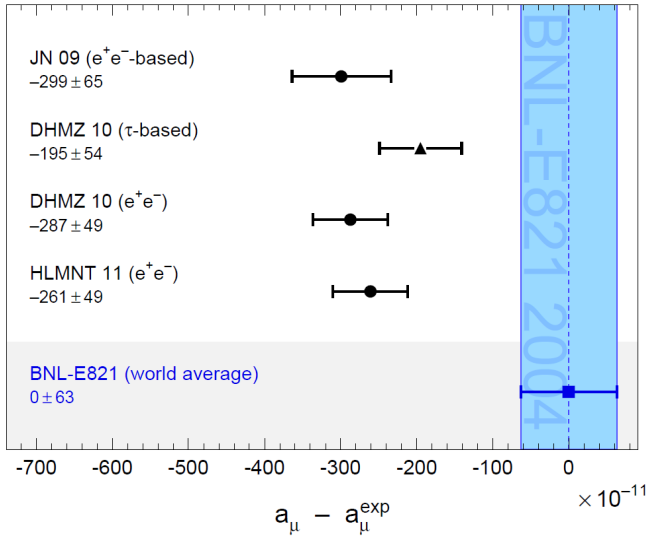
- 25 PAC days of engineering run approved
- 15 PAC days @ 4.4 GeV approved
  - A total of 13 weeks of shifts to be covered running nights and weekends
  - "Approval for future running beyond this engineering run will be contingent on successful demonstrated performance of the HPS apparatus during the engineering run."
- P5 will fund hidden sector particle searches in the "small projects portfolio" in the next 10 years"

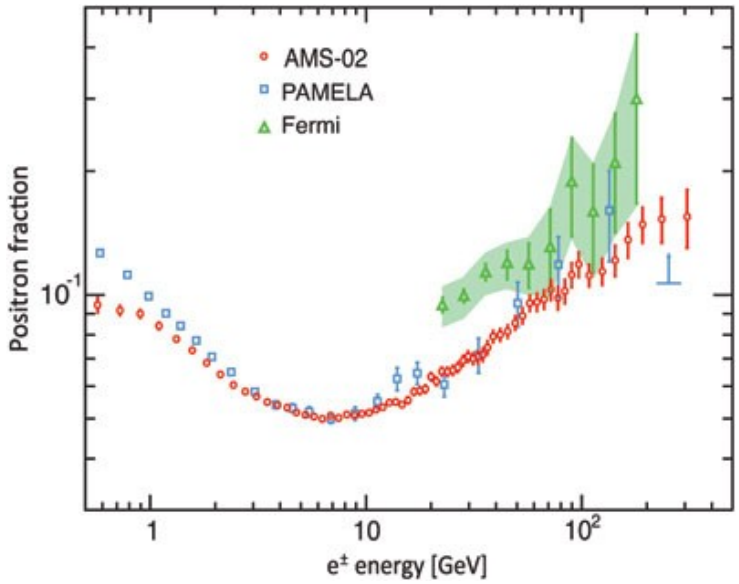


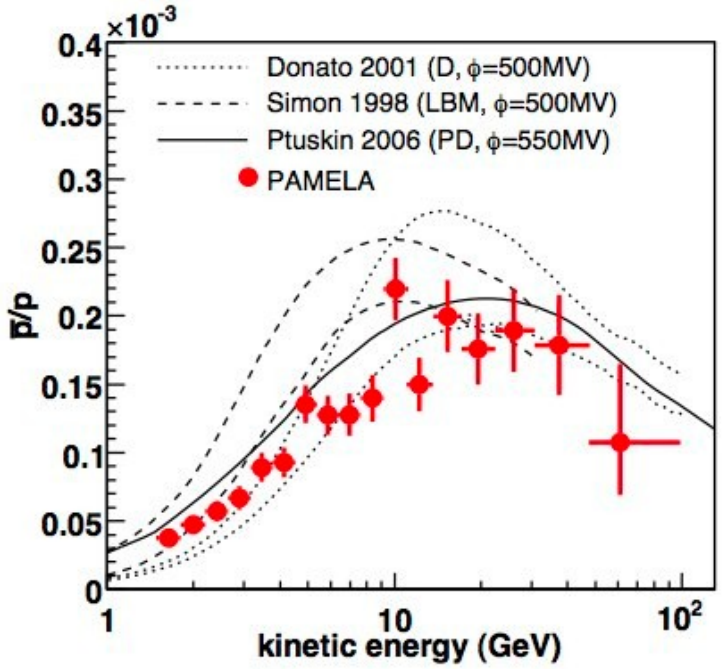
Backup

Motivation

- Positron excess in PAMELA/AMS data
  - Difficult to explain by thermal DM annihilation
- g_μ-2 anomaly
- DAMA/LIBRA modulation
- 511 KeV line from galactic center

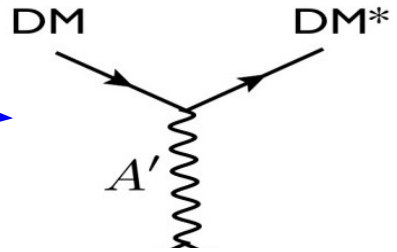




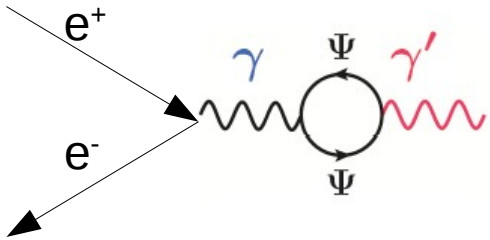


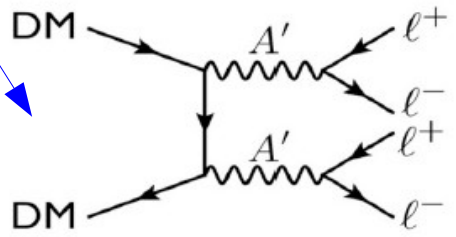
Hidden sector

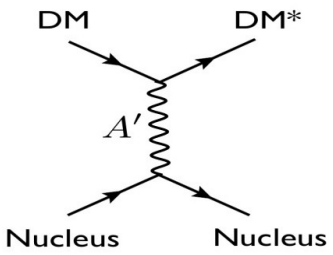
- New U(1)' gauge symmetry ⇒ A' gauge boson, force mediator for Dark Matter
  - Coupling to SM trough kinetic mixing $\varepsilon \sim 10^{-2}$–10^{-6}
  - [Holdom, Phys. Lett B166, 1986]
- Positron excess could be explained by DM annihilation into hidden sector photons
- g_μ-2 anomaly by a modification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

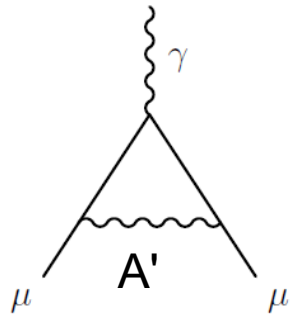


$$\Delta \mathscr{L} = \epsilon\, e\, A'_{\mu}\, J^{\mu}_{em}$$





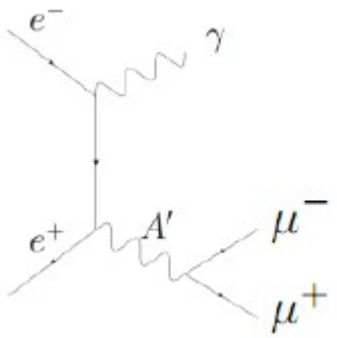




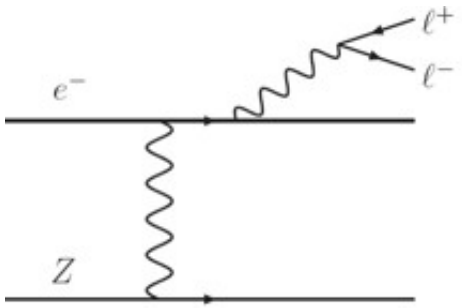
How to search for heavy photons

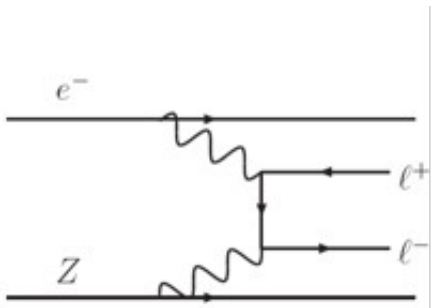
- in e^+e^- annihilations: Babar, Belle ($\Upsilon(2S,3S) \rightarrow \gamma A'$, $A' \rightarrow \mu^+\mu^-$),

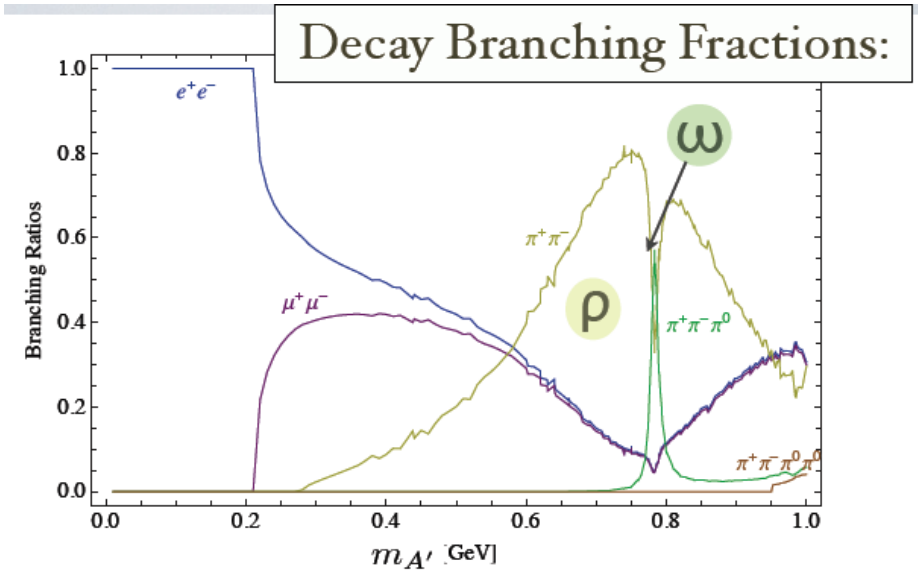
  KLOE, NA48 ($\pi^0 \rightarrow \gamma e^+e^-$)



- Electro-production in fixed target experiments
  - Without vertex detector
  - Using a vertex detector as proposed by D.Bjorken et. al. Phys. Rev. D80, 2009,075018
  - Signatures depend of A' mass

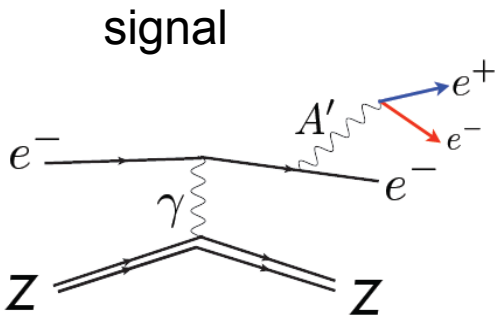


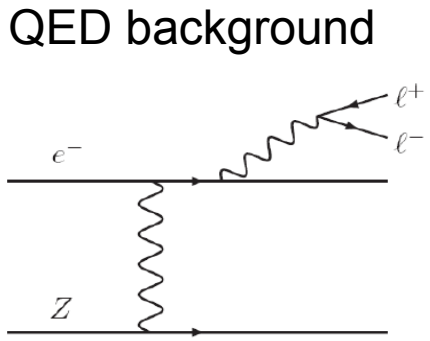


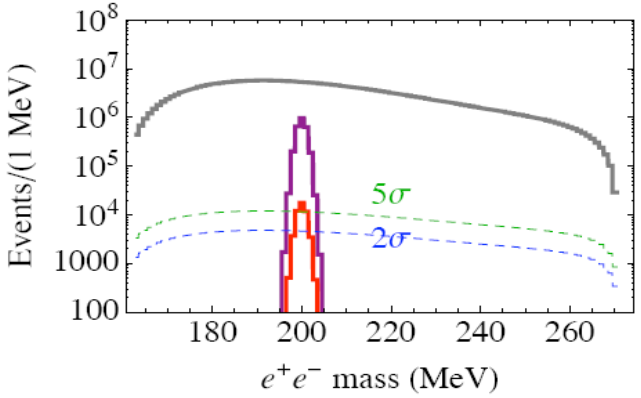


Signatures

- Invariant mass peak over a copious QED background







- Detached

  decay vertex