Heavy Photon Search Update

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On behalf of the Heavy Photon Search Collaboration

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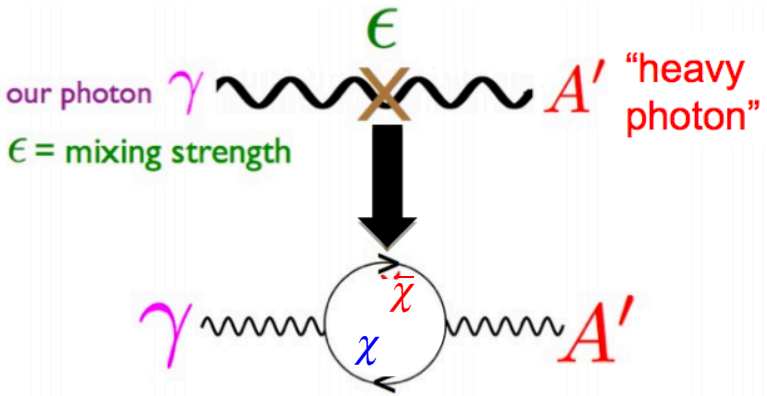
OLD DOMINION
UNIVERSITY

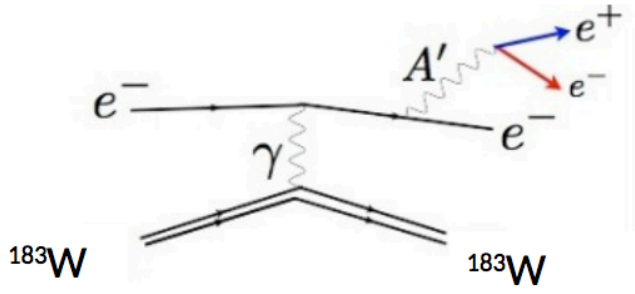
Motivation

Additional U(1) symmetry in nature
-> new gauge boson!



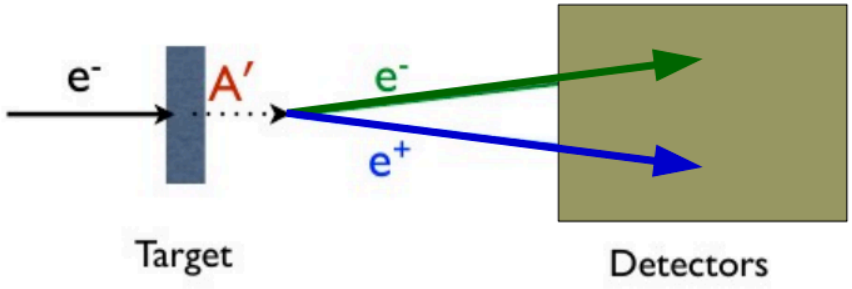
Kinetic mixing could be the leading interaction between the Standard Model and Dark Sector!

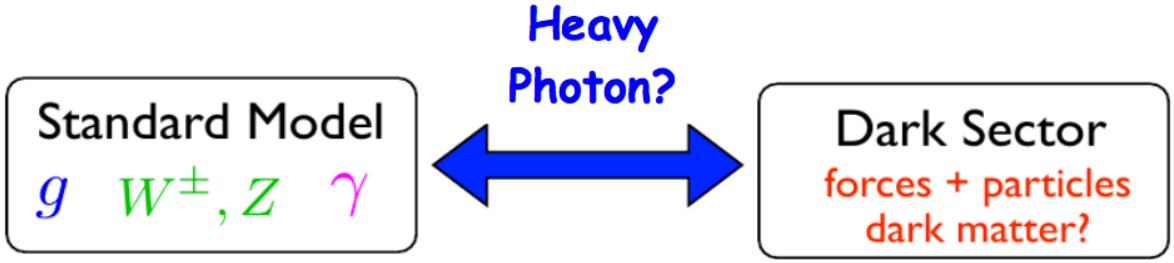
Experimental Signature



$e^- + {}^{183}W \rightarrow A' + X \rightarrow e^+ + e^- + X$

A' → Standard Model particles



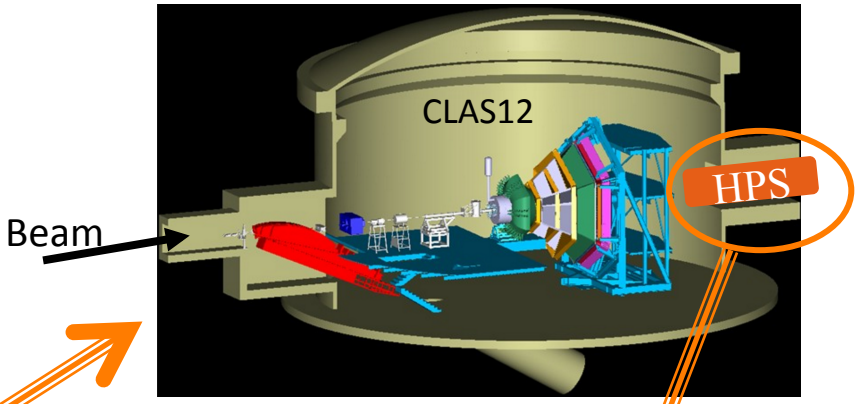


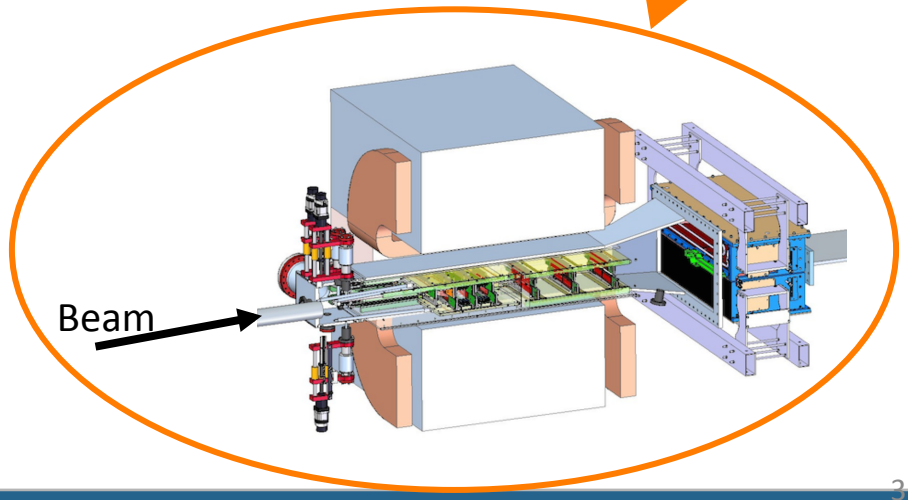
Experimental Setup

CEBAF max energy 2.2 GeV/pass (max 5 pass)
Simultaneously deliver beam to 4 halls

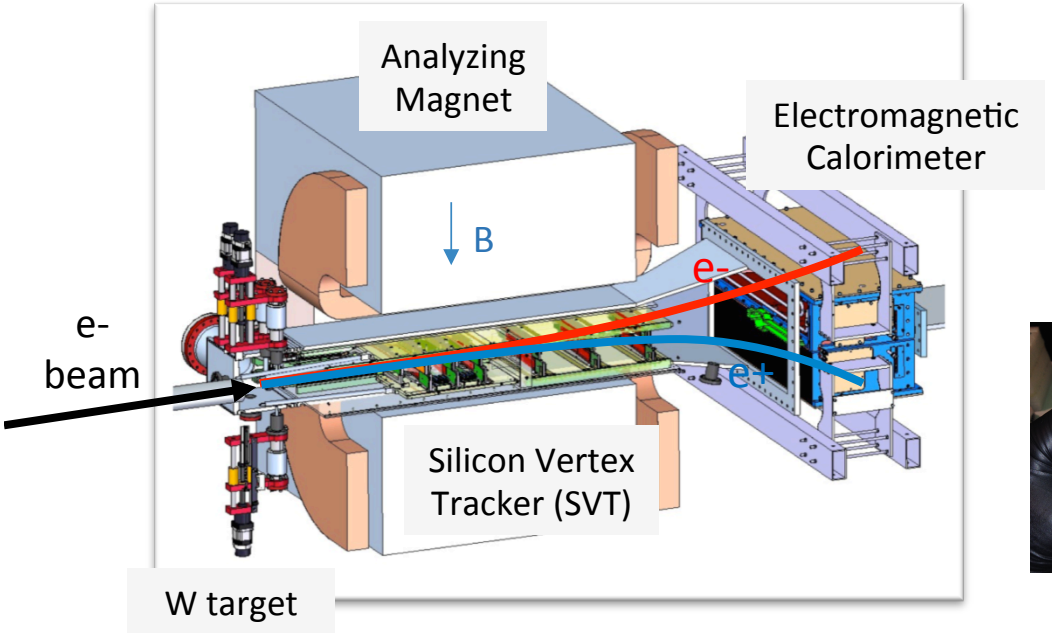
Jefferson Lab, CEBAF

Hall B

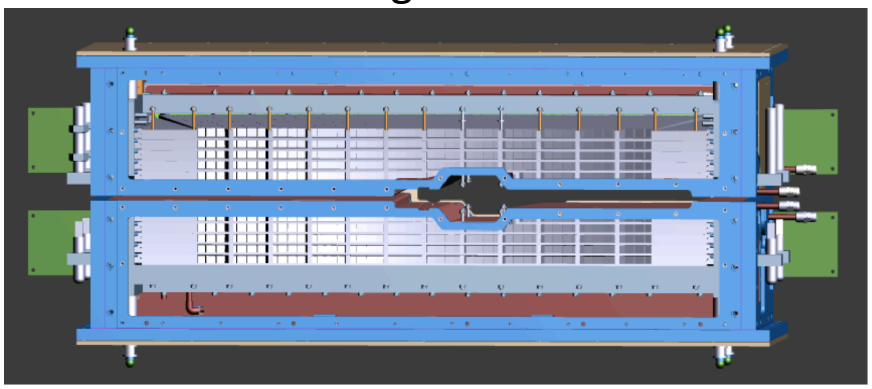




Experimental Setup

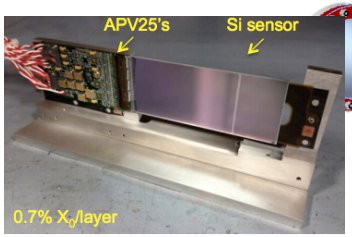


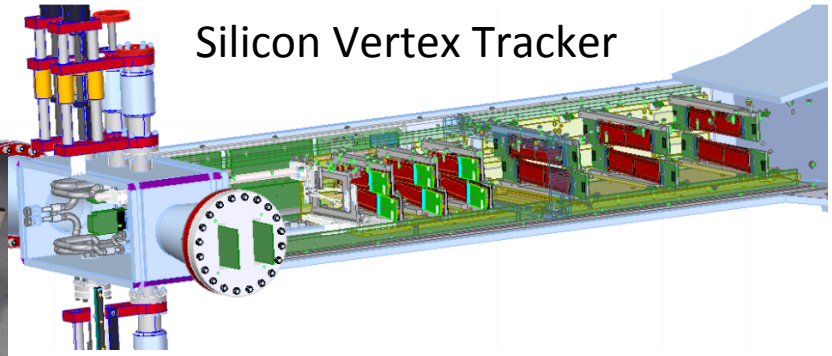
Electromagnetic Calorimeter



442 $PbWO_2$ crystals
Middle gap for sheet of flame
-Triggers events
-Measures particle energy

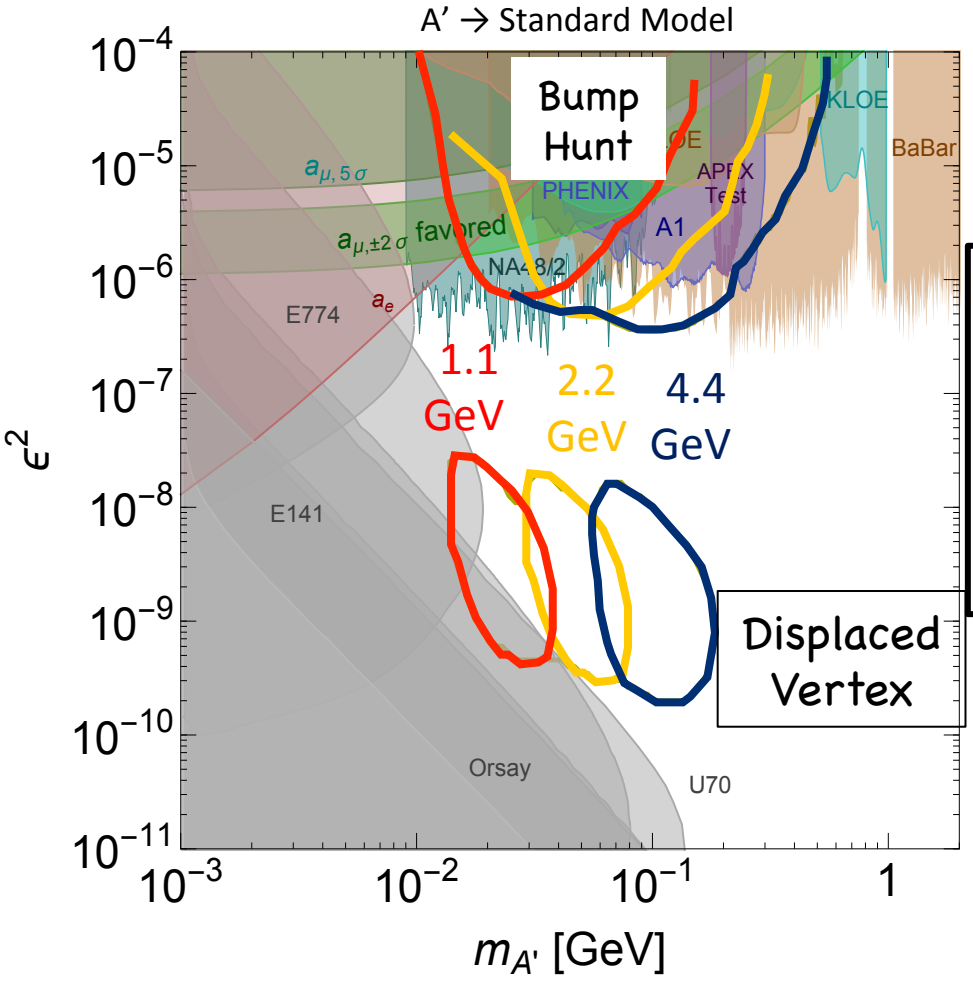
Silicon Vertex Tracker



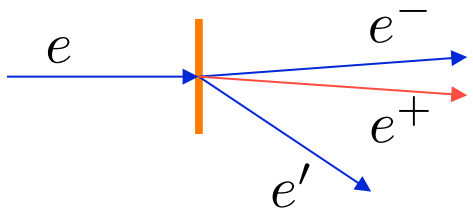


active area 0.5 mm from beam!
-6 layers, segmented top/bottom
-Measures particle trajectories
-Momentum and vertex

HPS Proposal Reach



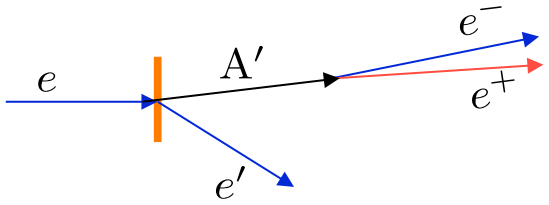
Large ϵ coupling ➔ prompt decay



Invariant mass peak on large background

HPS approved for 180 beam days
Spring 2015: Engineering Run
1.1 GeV, 50 nA, 1.7 days
Spring 2016 Run: (weekends only)
2.3 GeV, 200 nA, 5.2 days
Need more time to achieve the reach shown

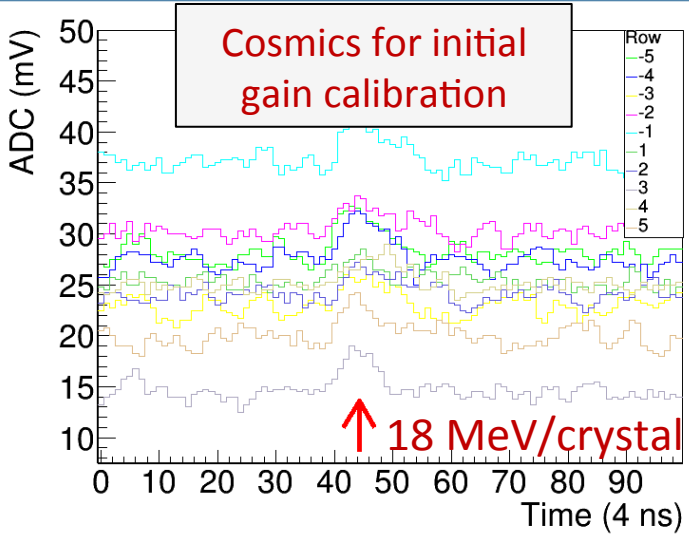
Small ϵ coupling ➔ A' long-lived



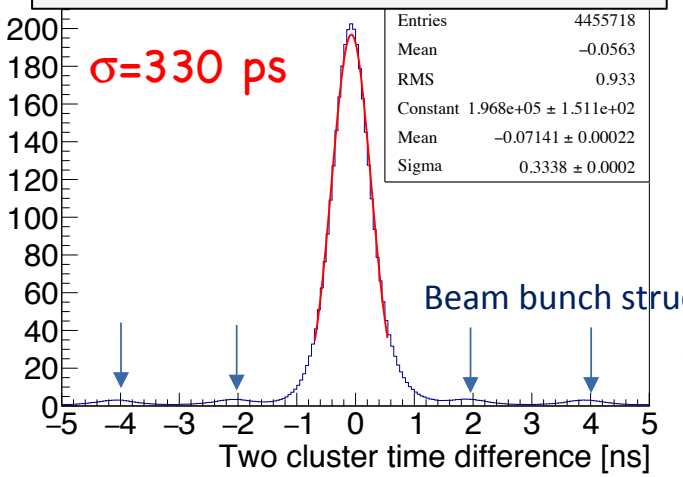
displaced decay vertex ➔
few events, no background,

Ecal Performance

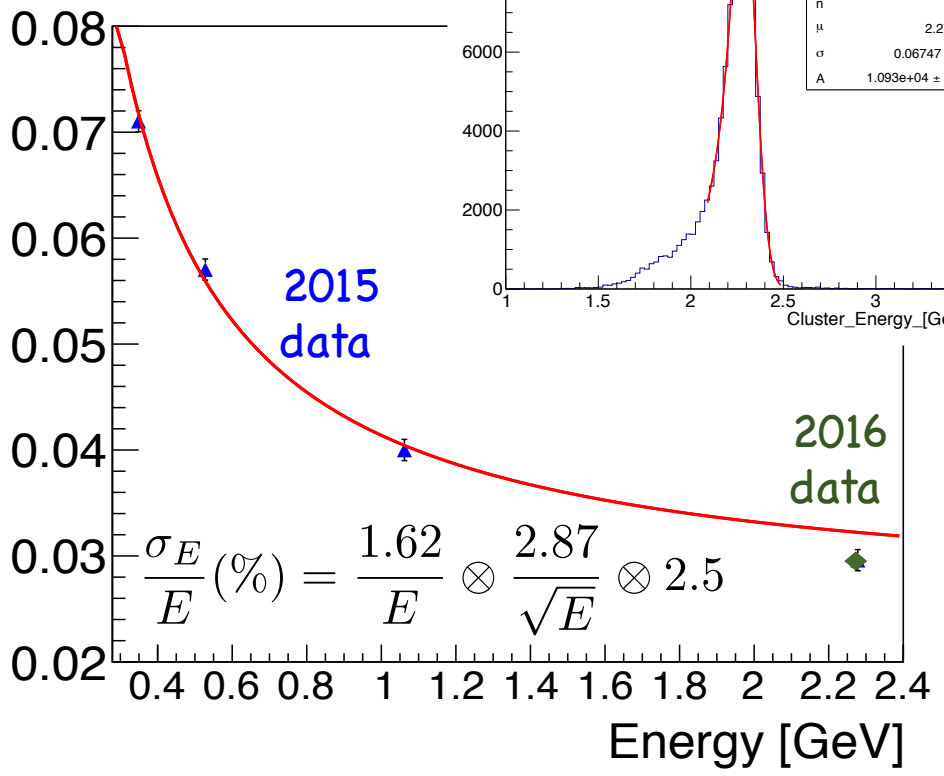
Cosmics for initial gain calibration



Time Resolution



Energy resolution: elastic scattering

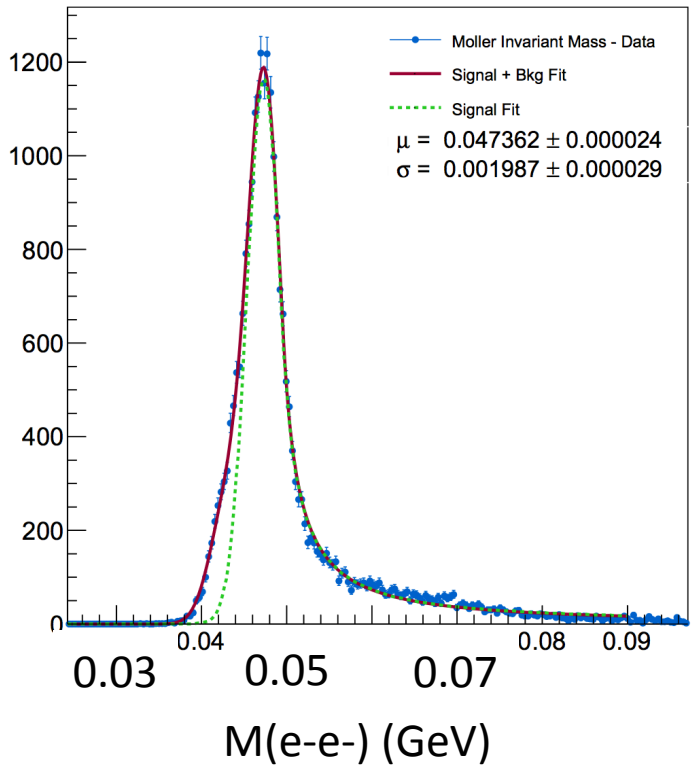


Timing offsets were calibrated using RF time from accelerator

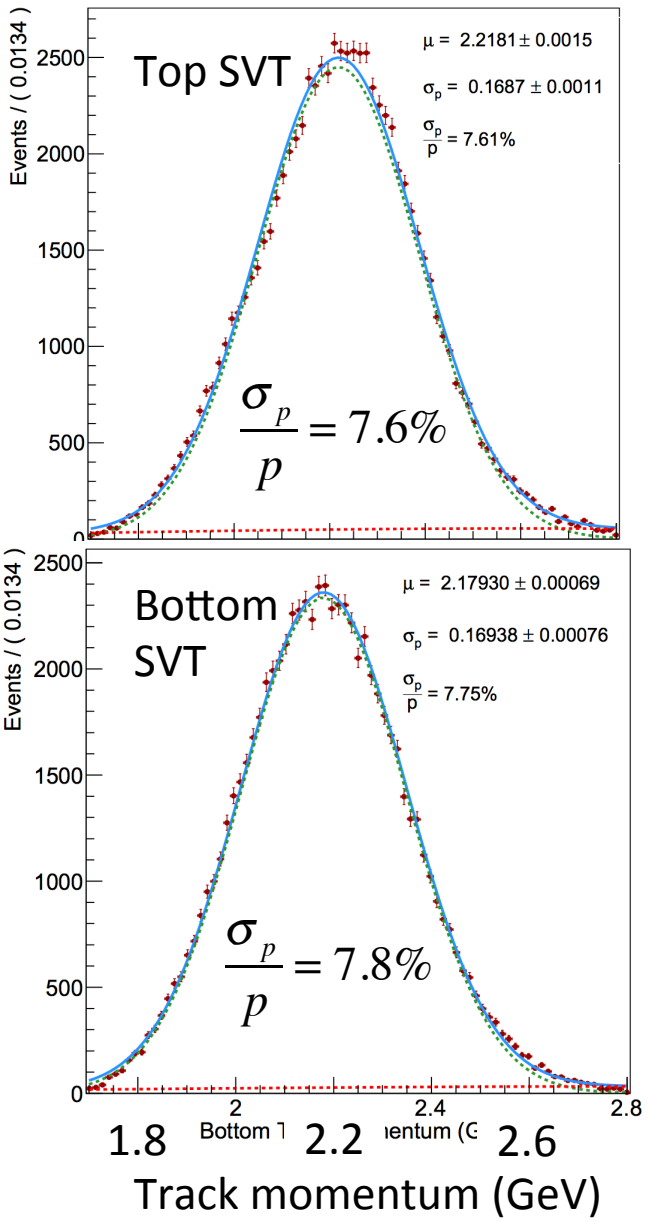
SVT Performance

- 2015 1.1 GeV data calibrated
- 2016 2.3 GeV calibration in progress
  - Precalibration results already excellent

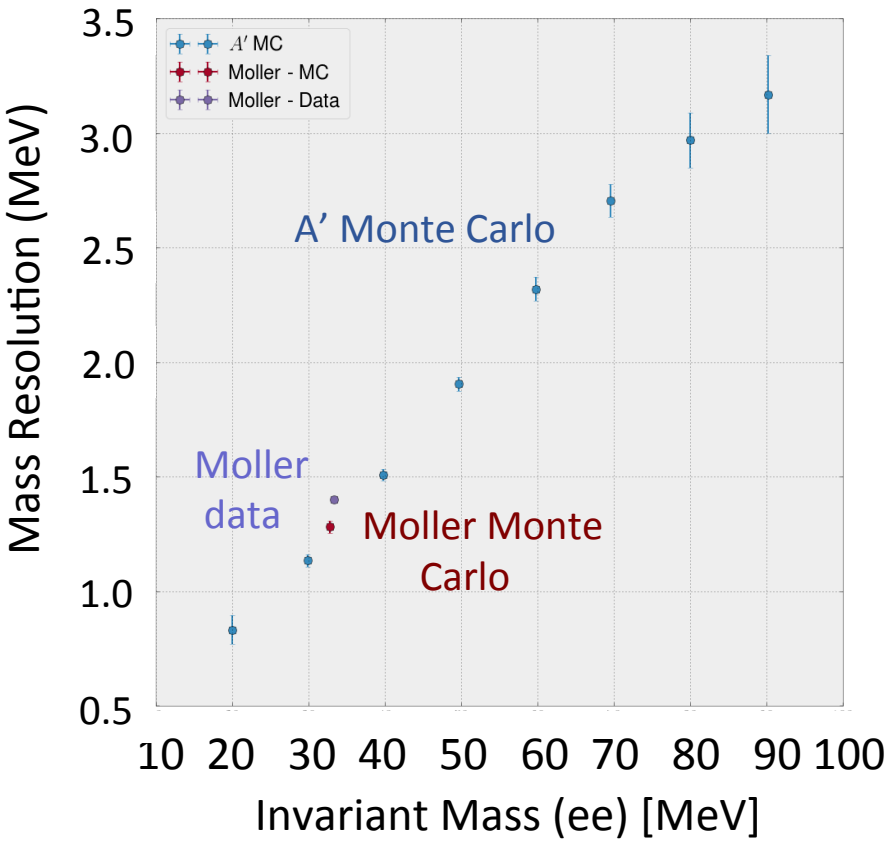
Moller Mass, initial data



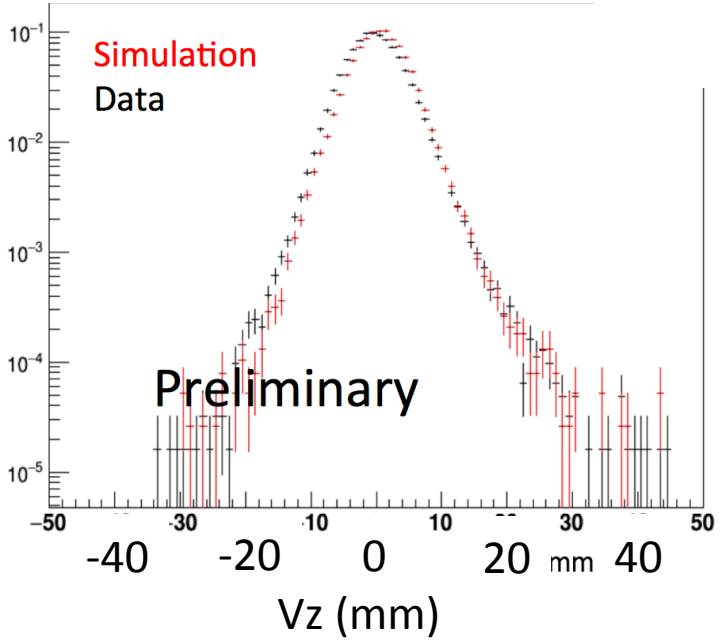
Elastic scattering, initial data



1.1 GeV Analysis



e+e- vertex displacement (M = 0.04 GeV)

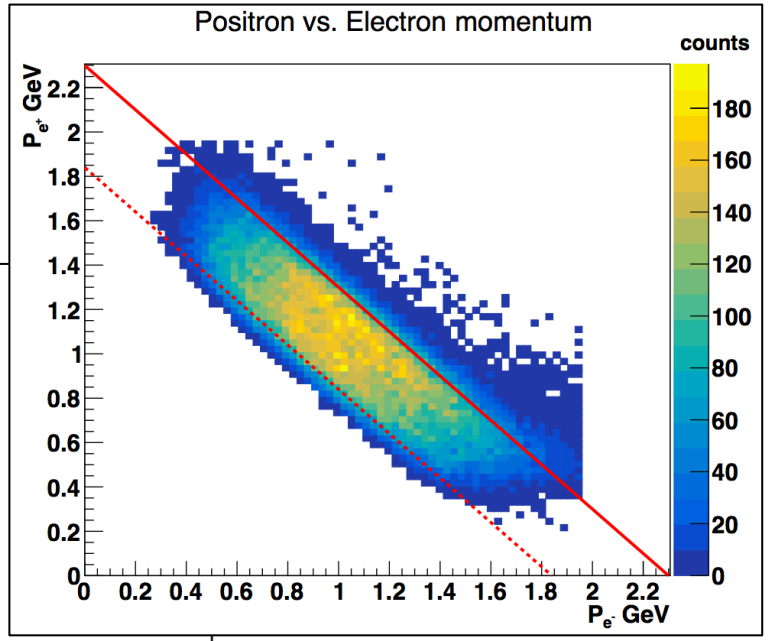


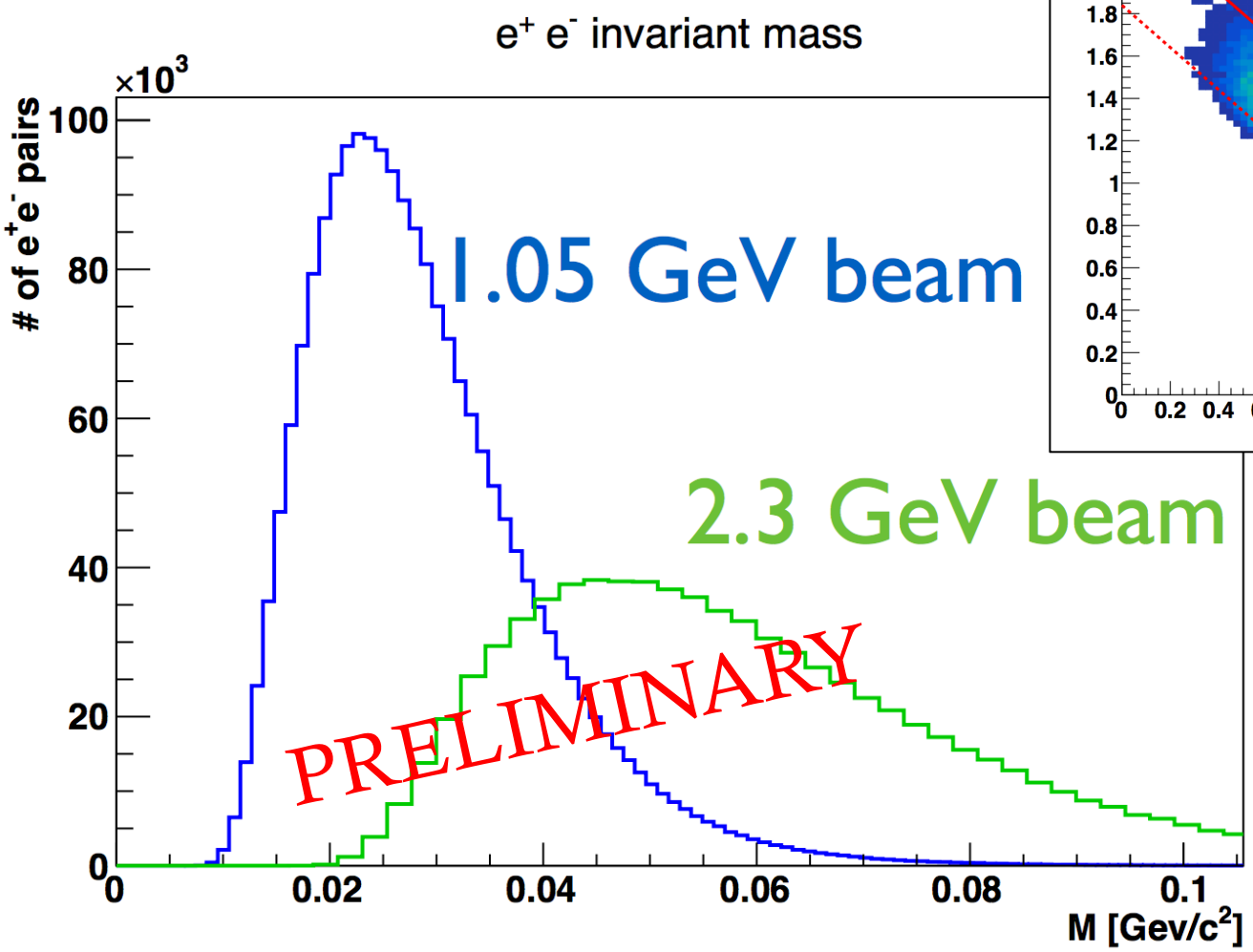
Parameter	Proposal value	Measured value
Beam current	50 nA	50 nA
SVT occupancy	<1%	1%
DAQ/trigg. rate	18 kHz	19 kHz
Pair mass res. @ 33 MeV/c^2	1.4 MeV	1.4 MeV
Pair vertex res. @ 40 MeV/c^2	4.4 mm	4.6 mm

Invariant Mass

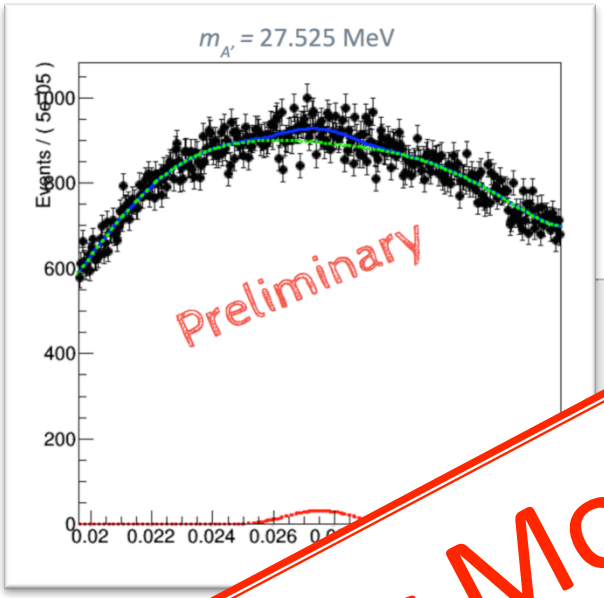
Analyze 10% of the data, fix cuts, then unblind

Radiative Cut



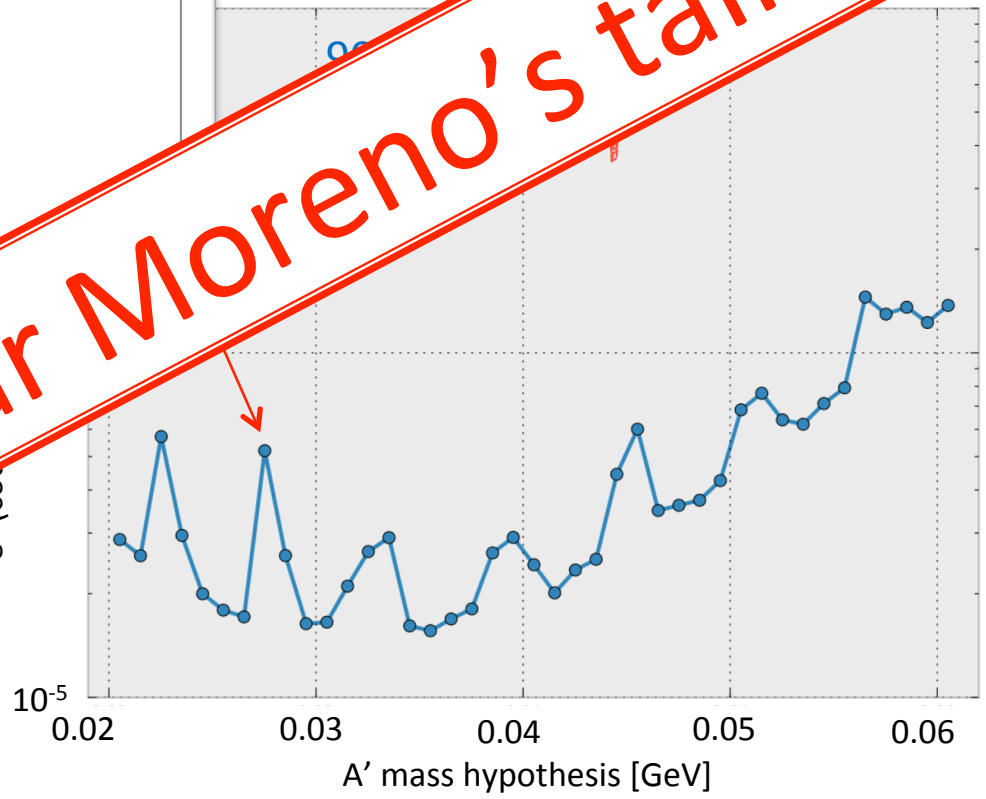


1.1 GeV: Bump Hunt



- 10% of 2015 data, SVT at 0.5
- Conservative cuts
- Fits 7th order pol
- A' peak

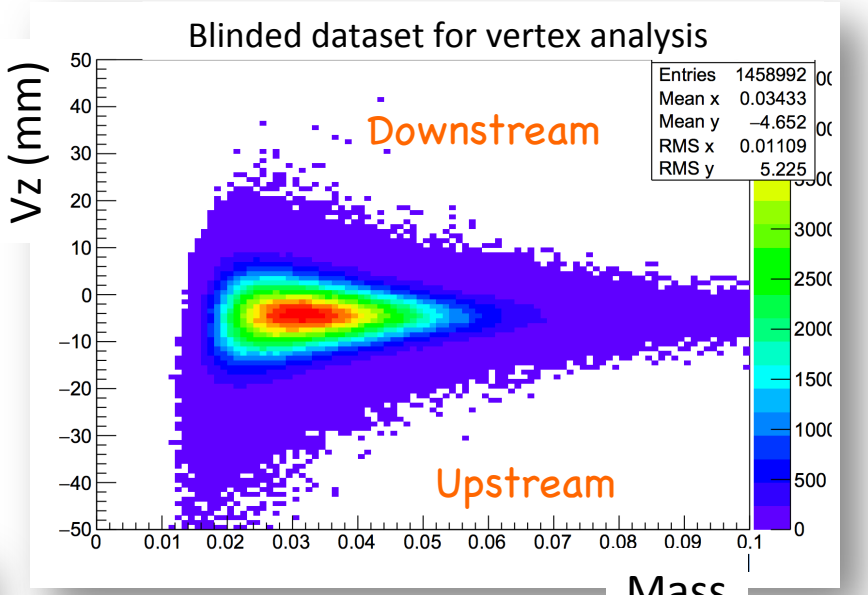
- Fix A' "peak
- movi
- d
- lim



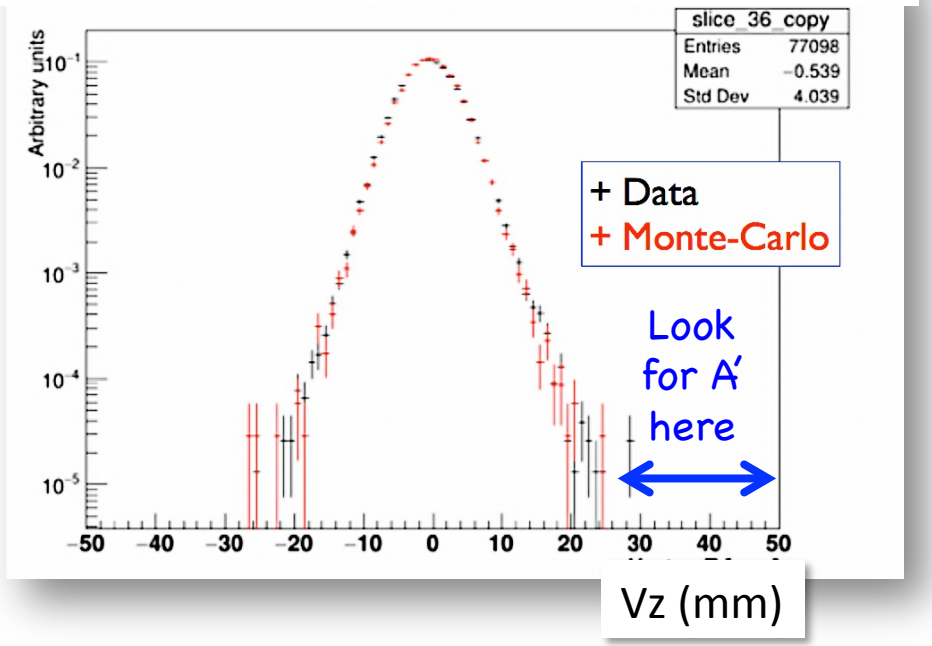
See Omar Moreno's talk next!

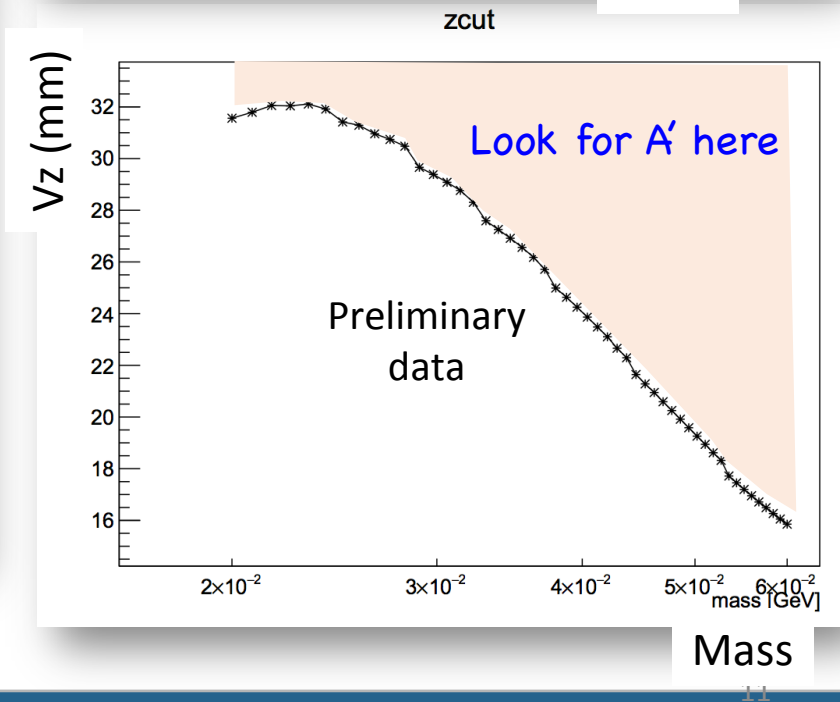
1.1 GeV: Vertex search

Search for long-lived A' with displaced e^+e^- vertex



e+e- vertex displacement: M(e+e-)=0.04 GeV



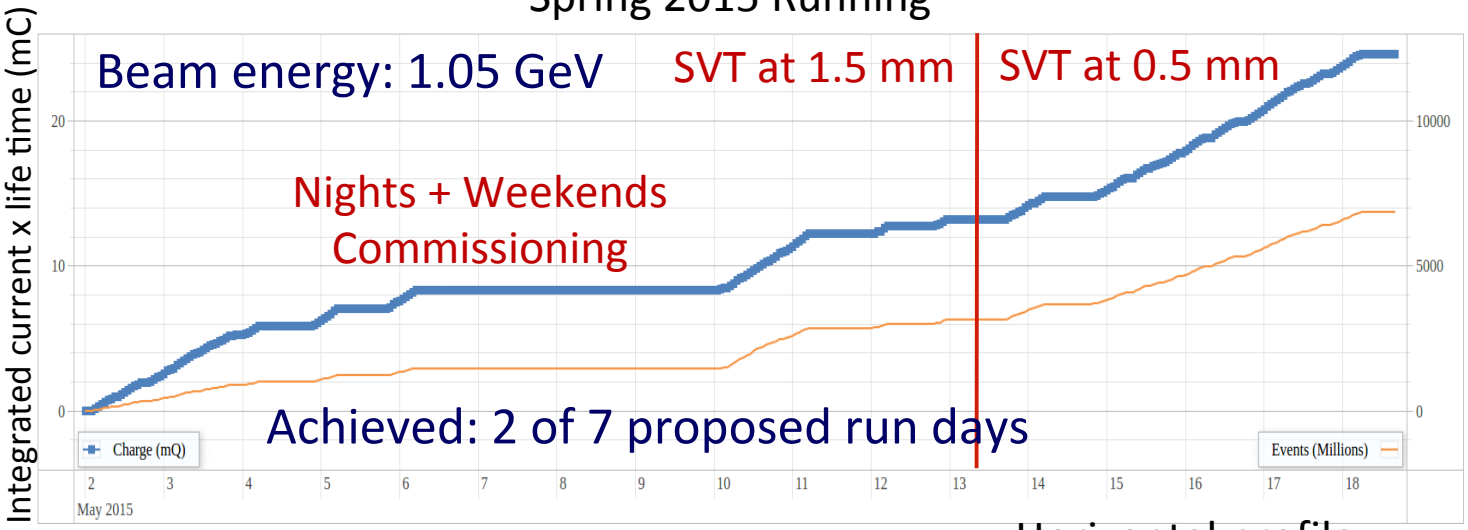


Heavy Photon Search: Summary

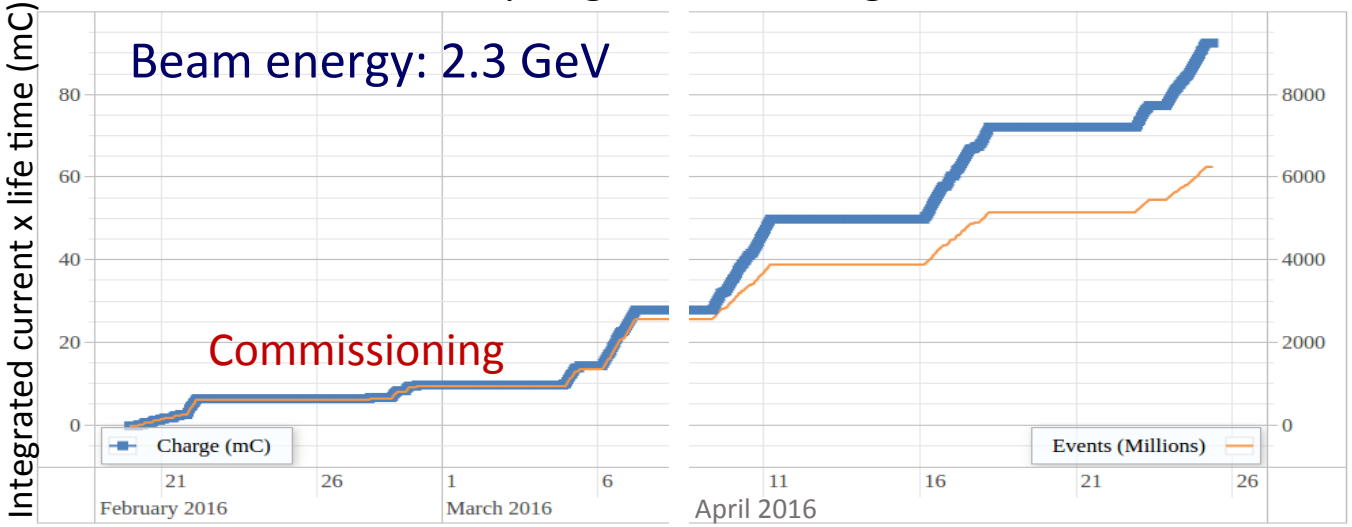
- Successful short runs in 2015 (1.1 GeV, 1.7 days) and 2016 (2.3 GeV, 5 days)
  - Bump hunt
  - Displaced e^+e^- vertex
- 165 days left: Next run 2018?
- Instrumentation papers:
  - Beam line and Ecal NIM papers submitted.
  - SVT paper in preparation
- Calibrating 2.3 GeV data
- Finalizing 1.1 GeV analysis. Unblinding 90% data in early 2017.

HPS Running

Spring 2015 Running

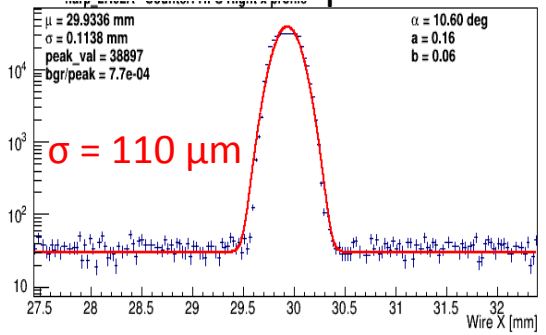


Spring 2016 Running



Achieved: 5 of 7 proposed run days

Horizontal profile



Vertical profile