

Heavy Photon Search Run and Results Update

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On behalf of the Heavy Photon Search Collaboration

Old Dominion University, Department of Physics

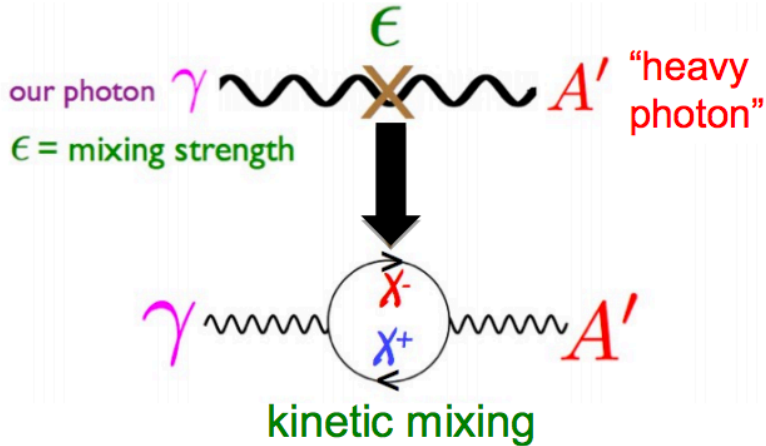
DNP Fall Meeting, 16 Oct 2016

Vancouver, BC



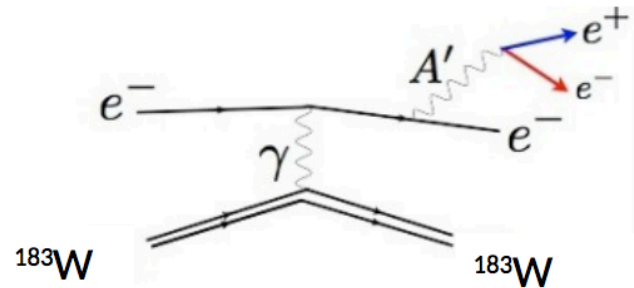
Motivation

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



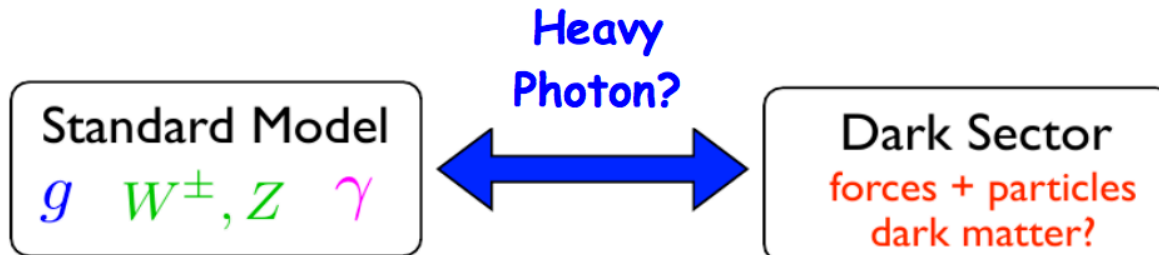
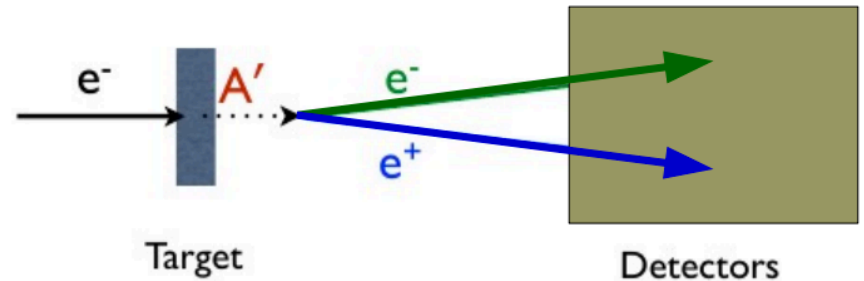
Kinetic mixing could be the leading interaction between the Standard Model and Dark Sector!

Experimental Signature



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

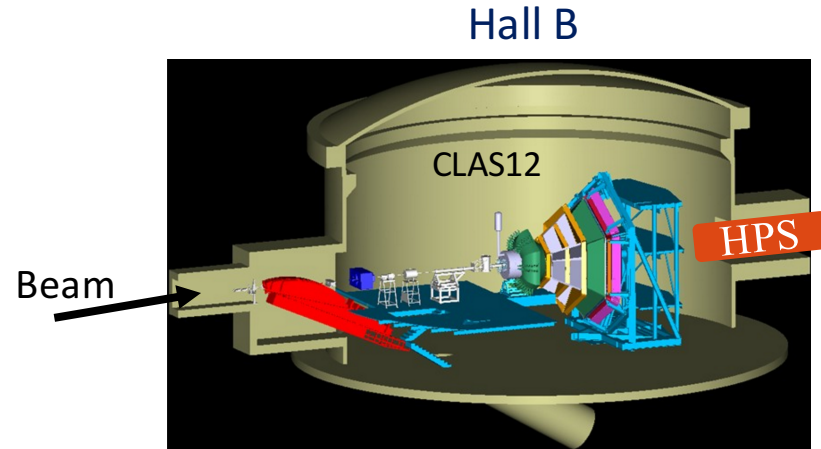
$A' \rightarrow$ Standard Model particles



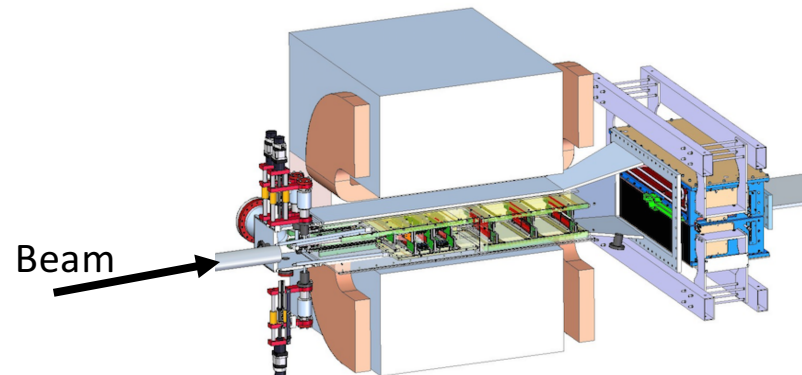
Experimental Setup

Jefferson Lab, CEBAF

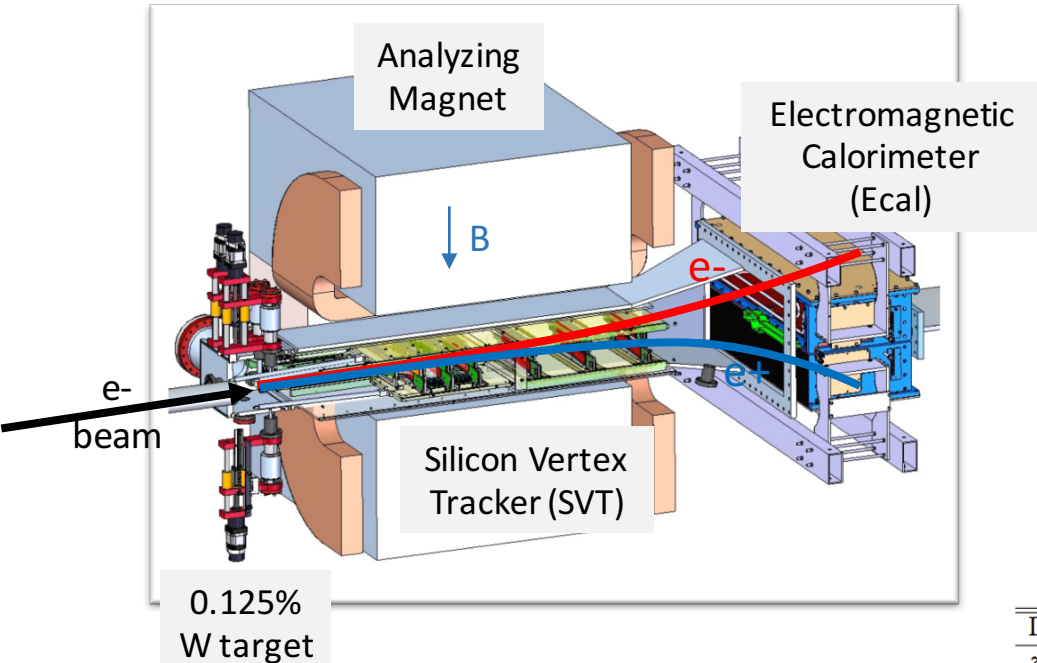
CEBAF max energy 2.2 GeV/pass (max 5 pass)
Simultaneously deliver beam to 4 halls



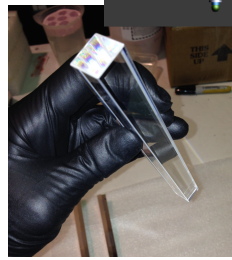
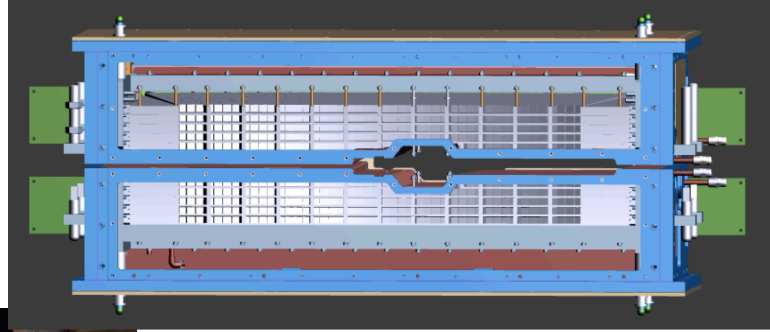
HPS is in the alcove of Hall B



Experimental Setup



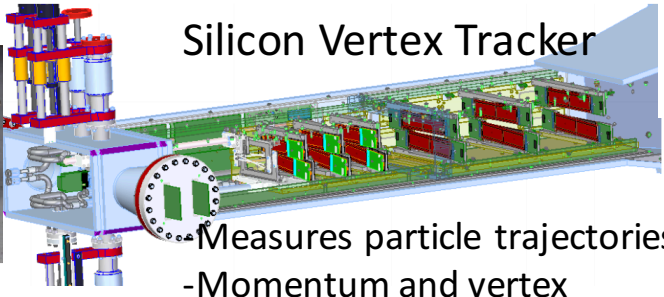
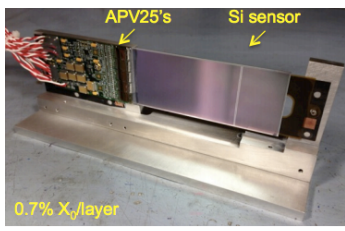
Electromagnetic Calorimeter



- Triggers events
- Measures particle energy
- Resolution: $4\%/\sqrt{E}$

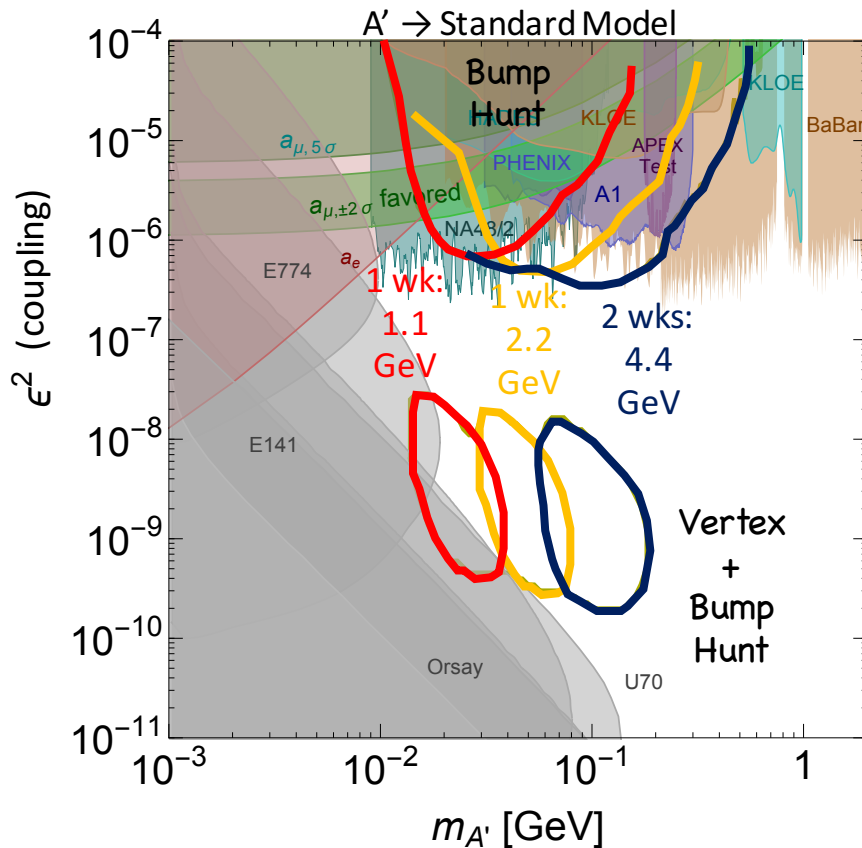
SVT active area
0.5 mm from beam!

Layer	1	2	3	4	5	6
z position from target [cm]	10	20	30	50	70	90
Stereo angle [mrad]	100	100	100	50	50	50
Non-bend plane resolution [μm]	≈ 6	≈ 6	≈ 6	≈ 6	≈ 6	≈ 6
Bend-plane resolution [μm]	≈ 60	≈ 60	≈ 60	≈ 120	≈ 120	≈ 120

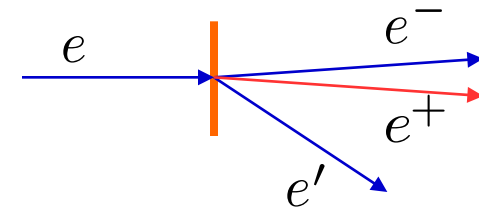


- Measures particle trajectories
- Momentum and vertex

HPS Proposed Reach



Large ϵ coupling, prompt decay



Peak on large background

Runs status to date:

Spring 2015: Engineering Run

1.05 GeV, 50 nA

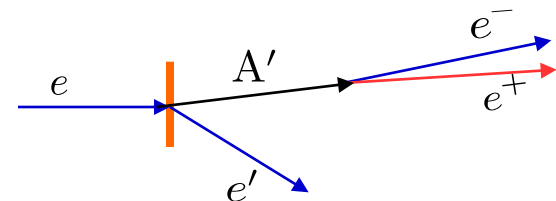
Achieved 30% of proposed production data

Spring 2016: Physics Run

2.3 GeV, 200 nA

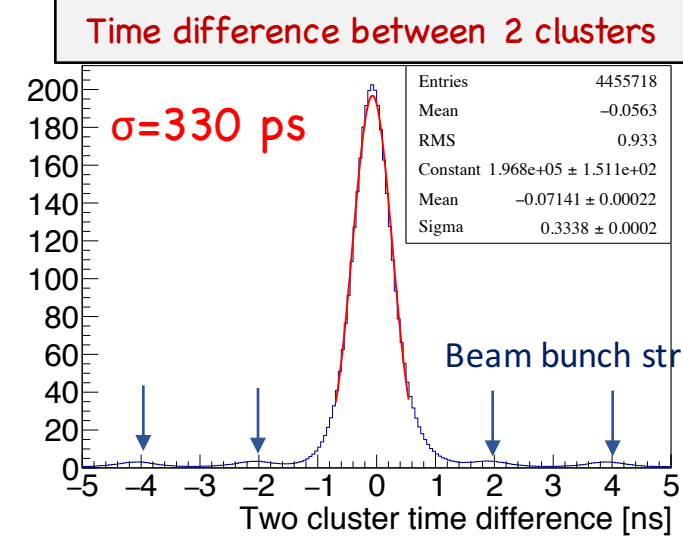
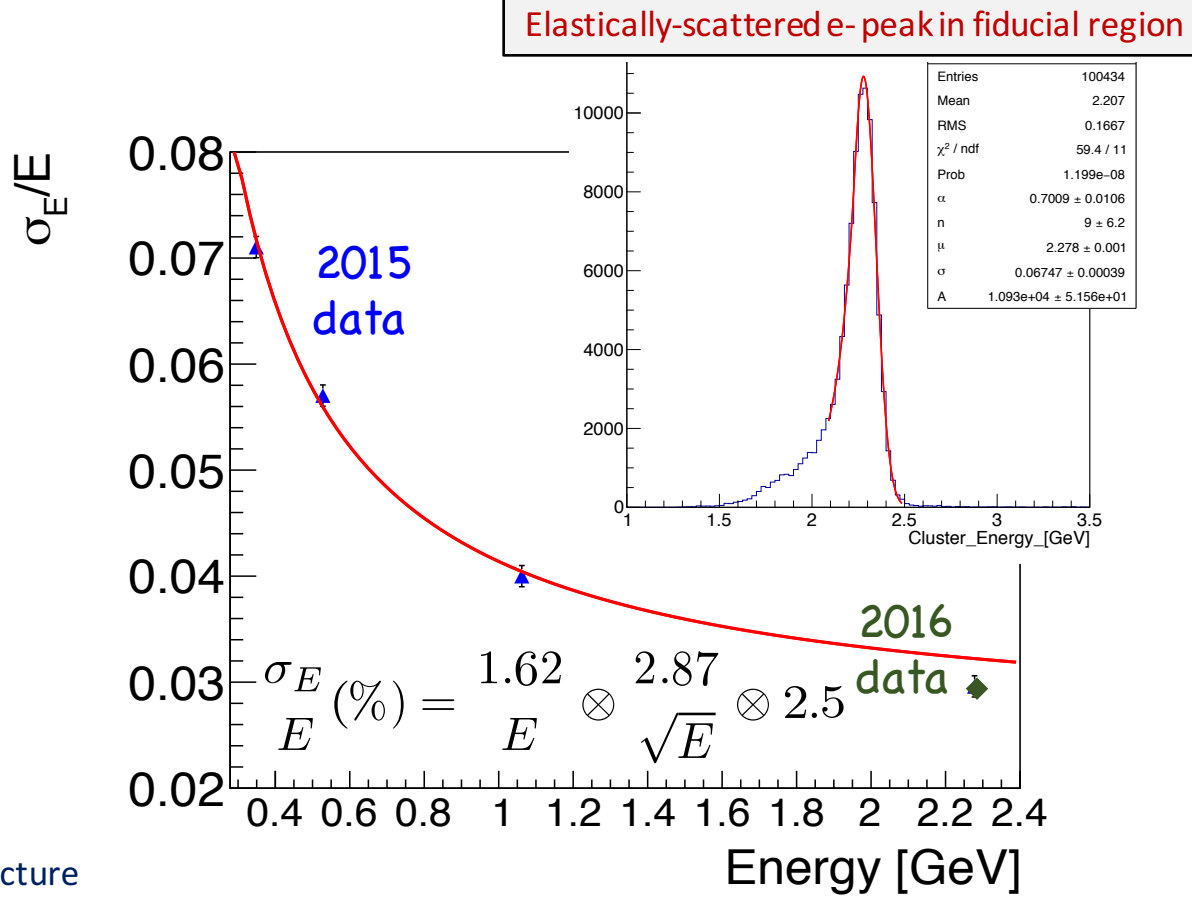
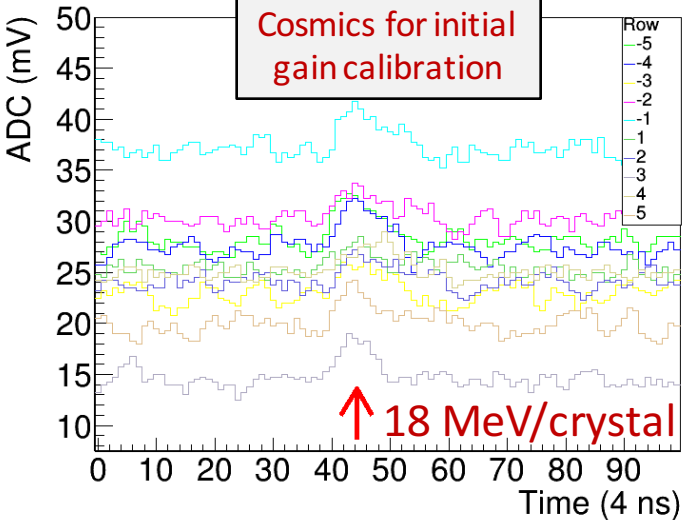
Achieved 77% of proposed production data

Small ϵ coupling, A' long-lived



Few events, no background, displaced decay vertex

2016 Run: Ecal Performance

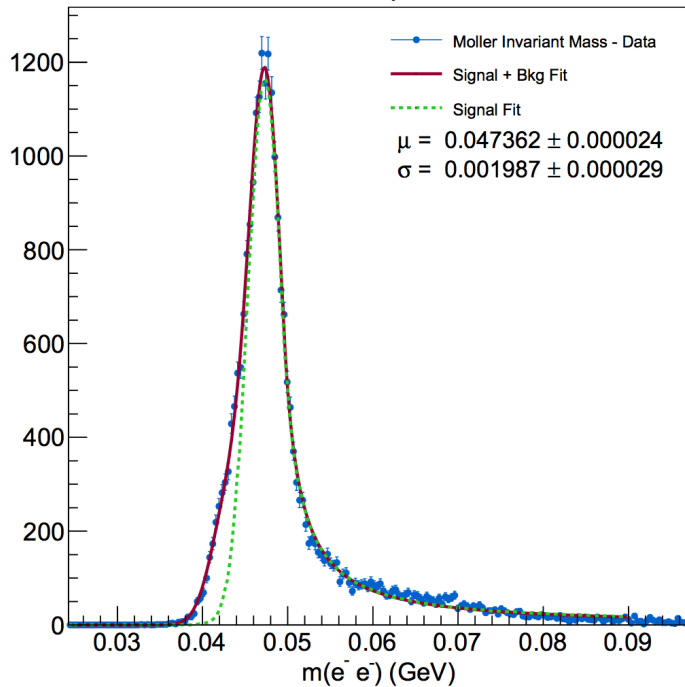


Timing offsets were calibrated using RF time from accelerator

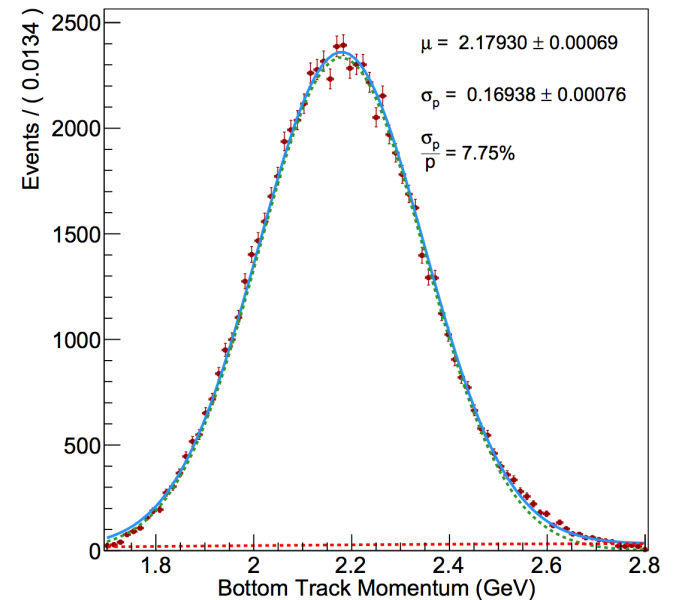
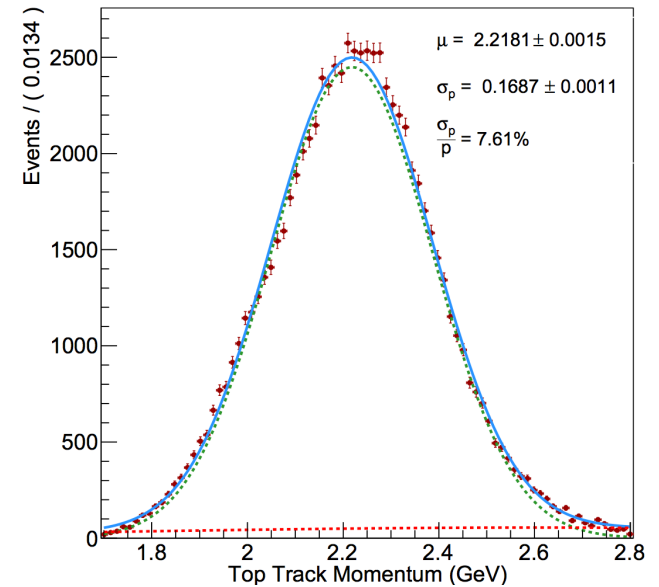
2016 Run: SVT Performance

- Calibration in progress
- Initial data, prior to alignment, already consistent with proposal

Moller Mass, initial data



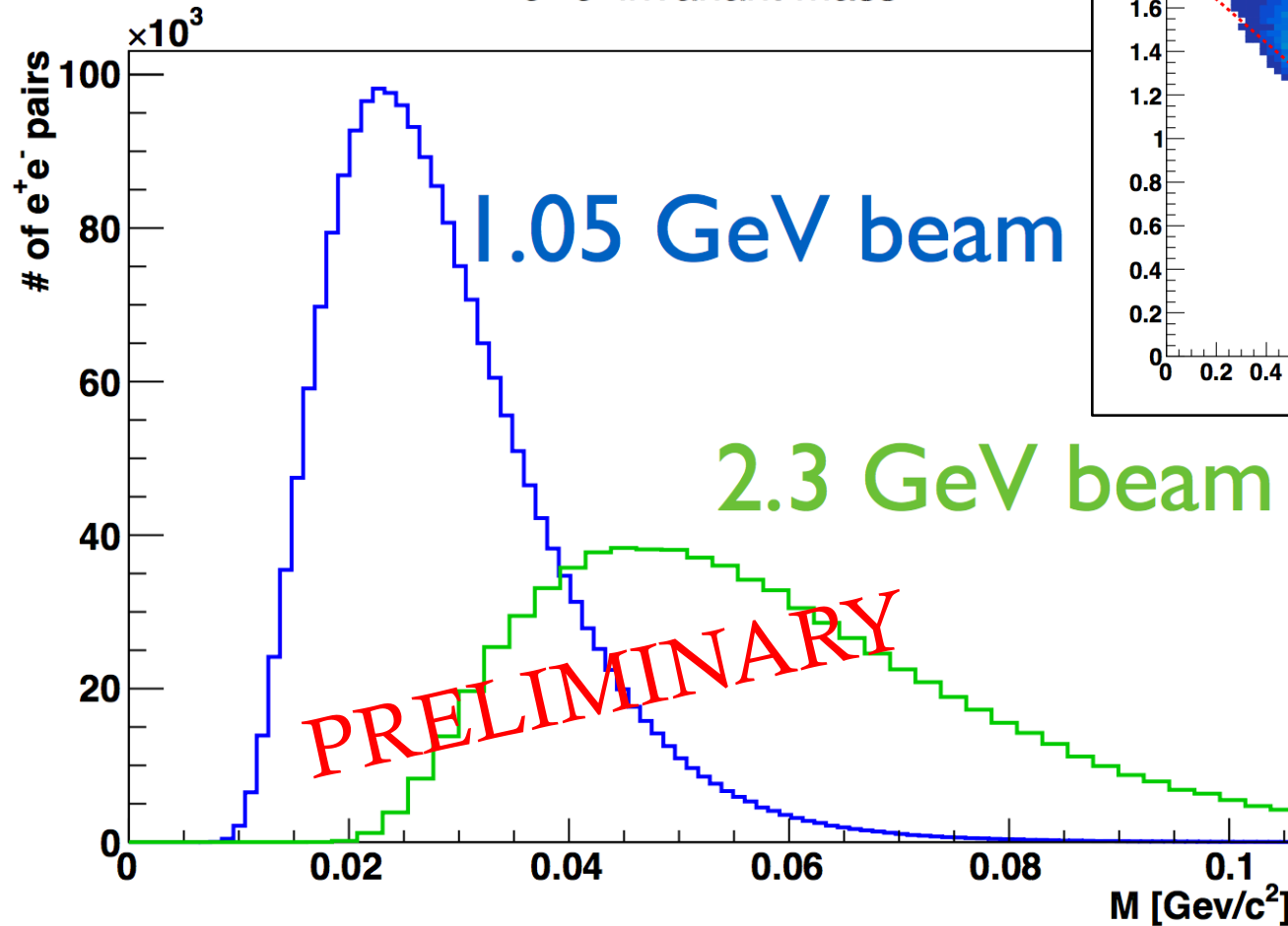
Elastically scattered e-, initial data



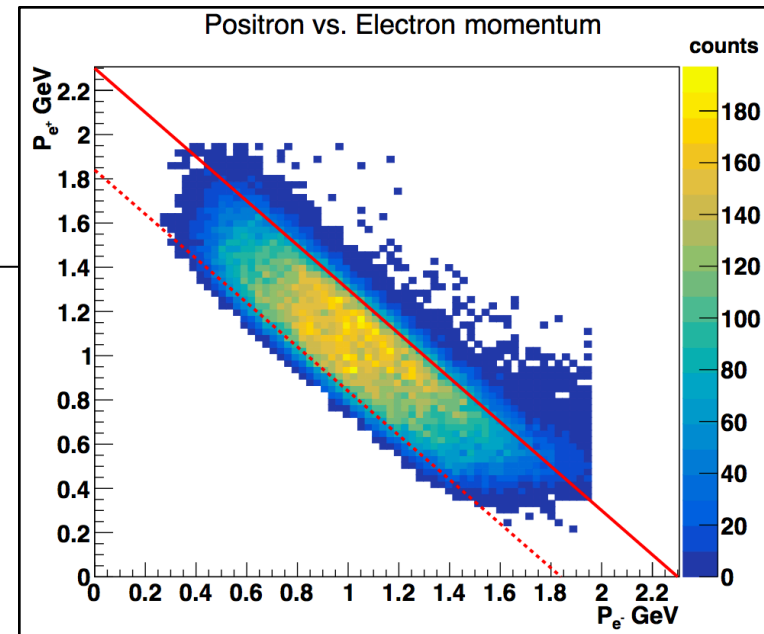
Invariant Mass

Searching for the Heavy Photon using a blinded analysis (10% of the data)

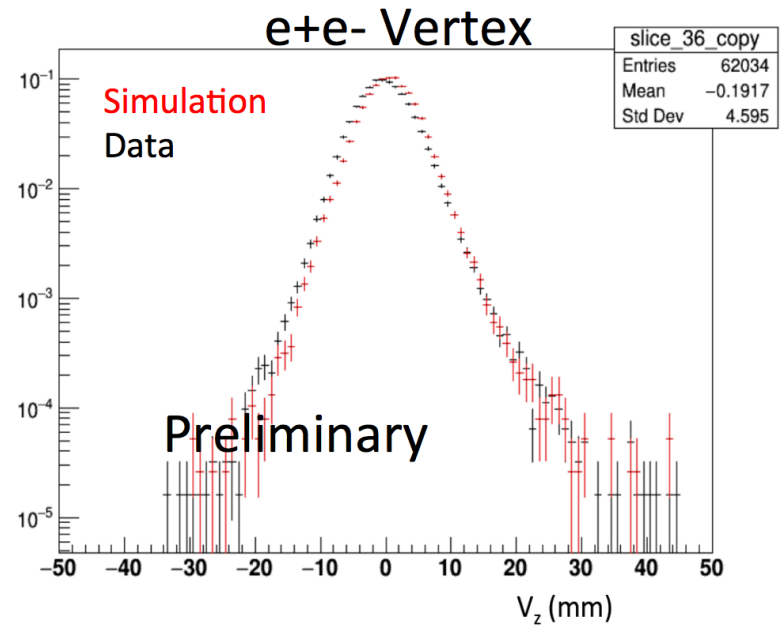
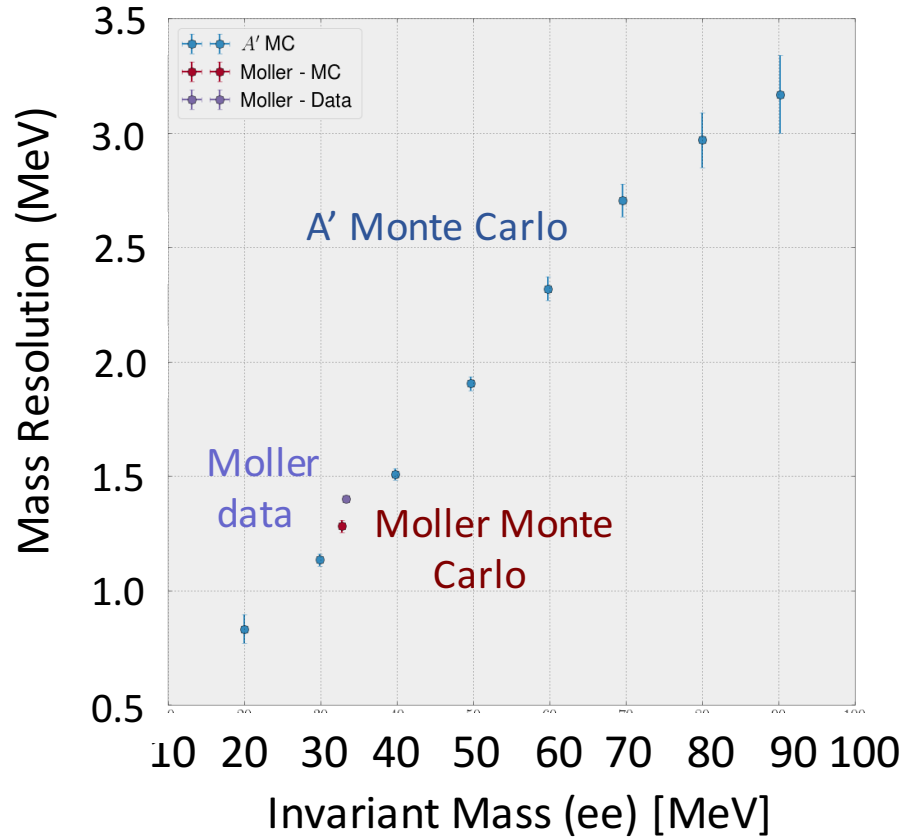
$e^+ e^-$ invariant mass



Radiative Cut

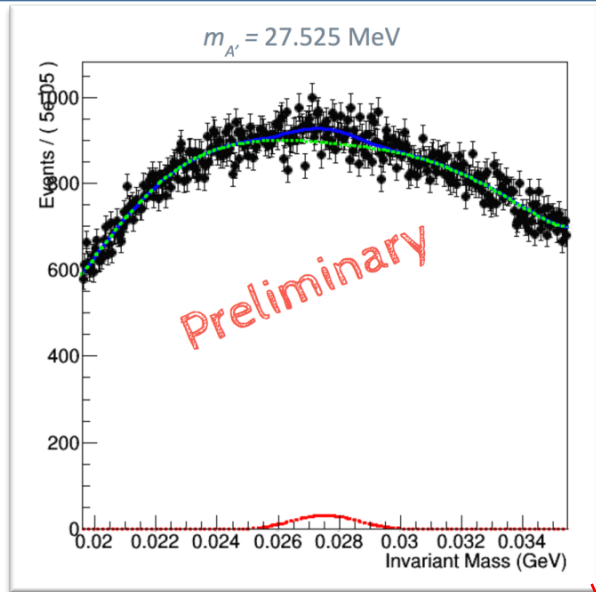


1 GeV Analysis

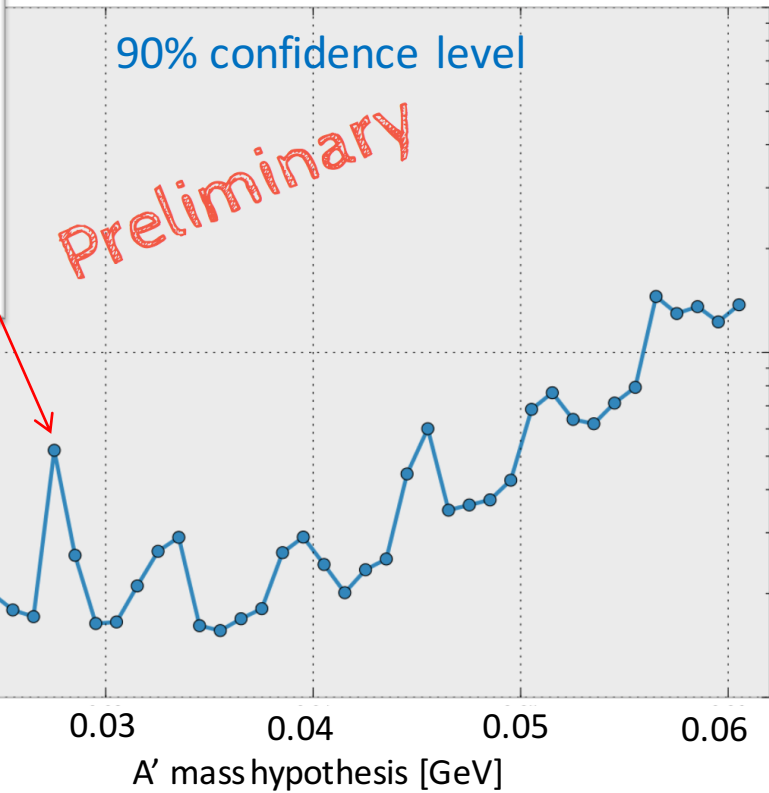


Parameter	Proposal value	Measured value
Beam current	50 nA	50 nA
SVT occupancy	<1%	1%
DAQ/trigg. rate	18 kHz	19 kHz
Pair mass res. @ 33 MeV/c ²	1.4 MeV	1.4 MeV
Pair vertex res. @ 40 MeV/c ²	4.4 mm	4.6 mm

1 GeV Analysis: Bump Hunt



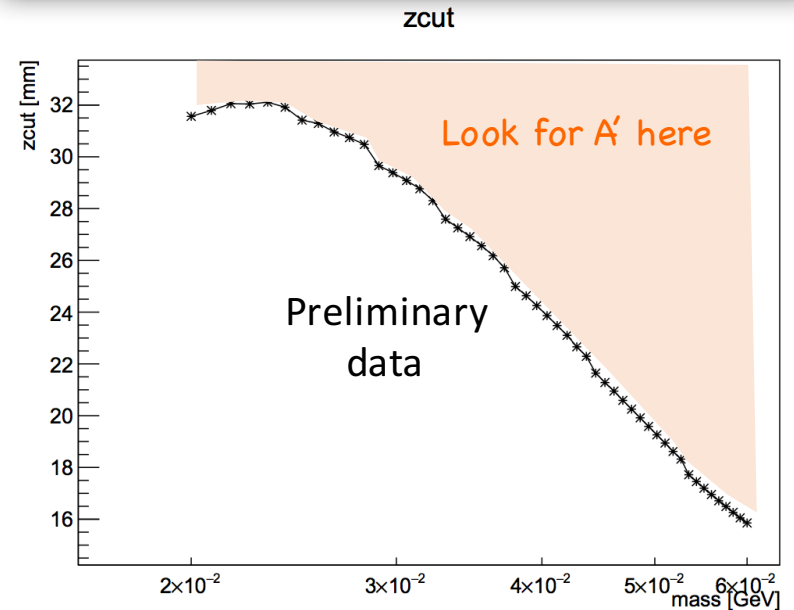
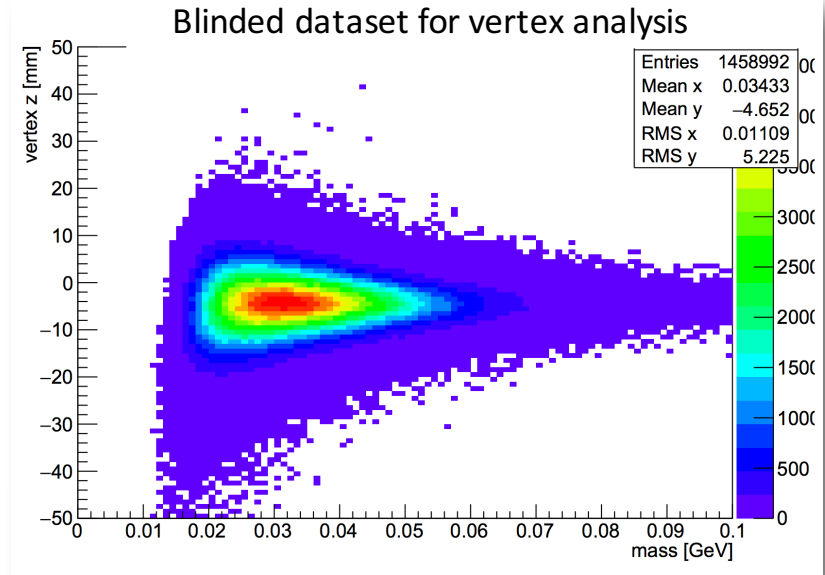
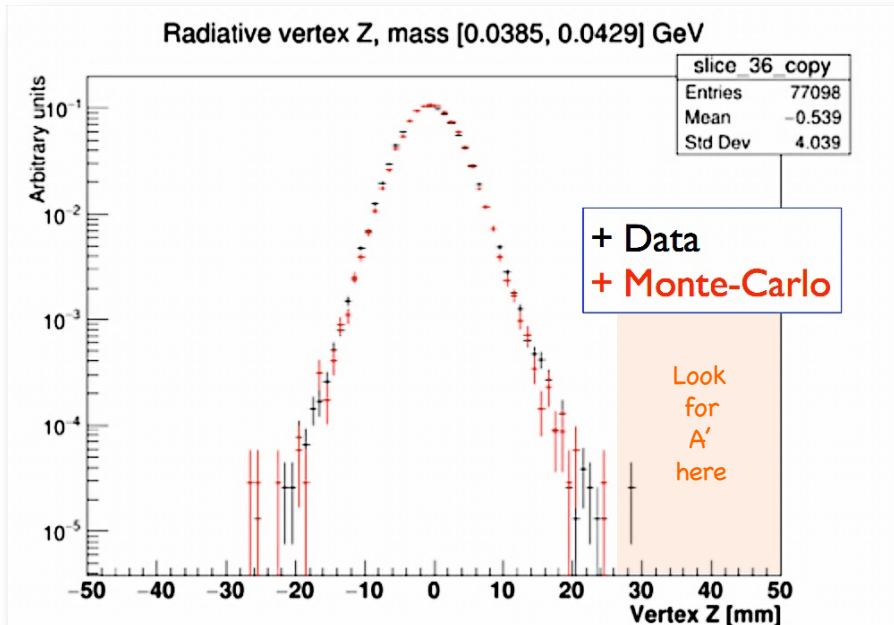
- 10% of 2015 data, SVT at 0.5 mm
- Conservative cuts
- Fits 7th order polynomial background + A' peak



- Fix A' “peak” width, moving “peak” across spectrum to determine upper limits

1 GeV Analysis: Vertex search

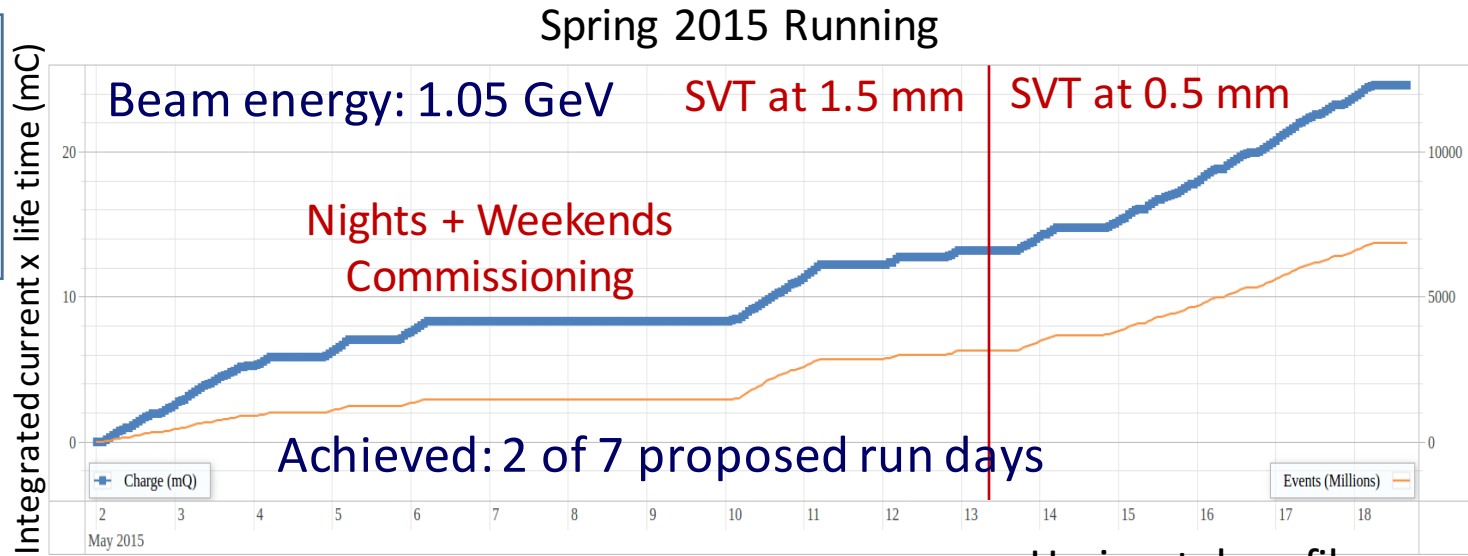
- Search for long-lived A' with separated vertex



Summary

- Successful very short runs in 2015 and 2016 with data taken for both bump hunt and vertex search for Heavy Photons
- 165 days still remain: We expect next physics runs in 2018 and later
- Instrumentation papers are in preparation for the beamline, SVT. Ecal NIM submitted this past week
- Finalizing analysis and expecting results in early 2017

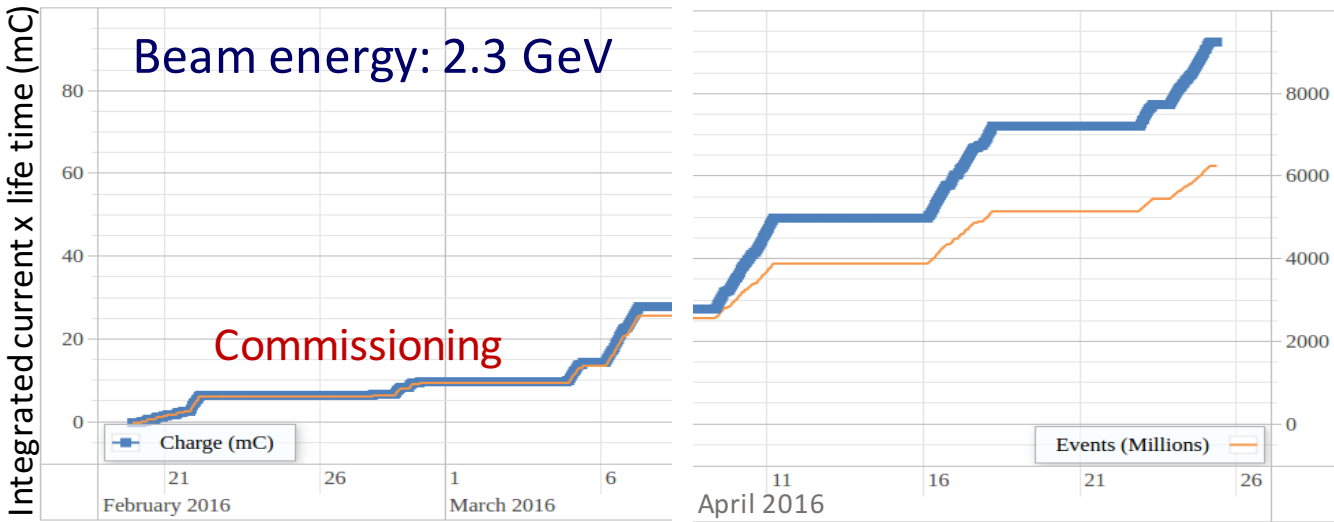
HPS Running



Spring 2016 Running

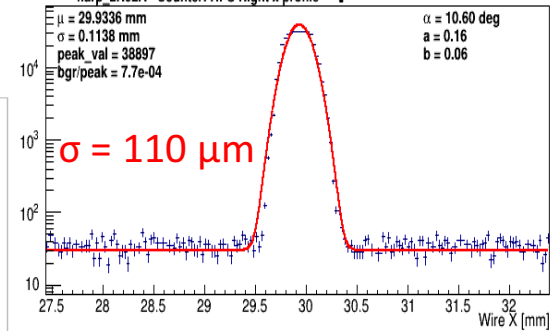
Beam energy: 2.3 GeV

Commissioning



Achieved: 5 of 7 proposed run days

Horizontal profile



Vertical profile

