



# An Overview of the Heavy Photon Search Collaboration

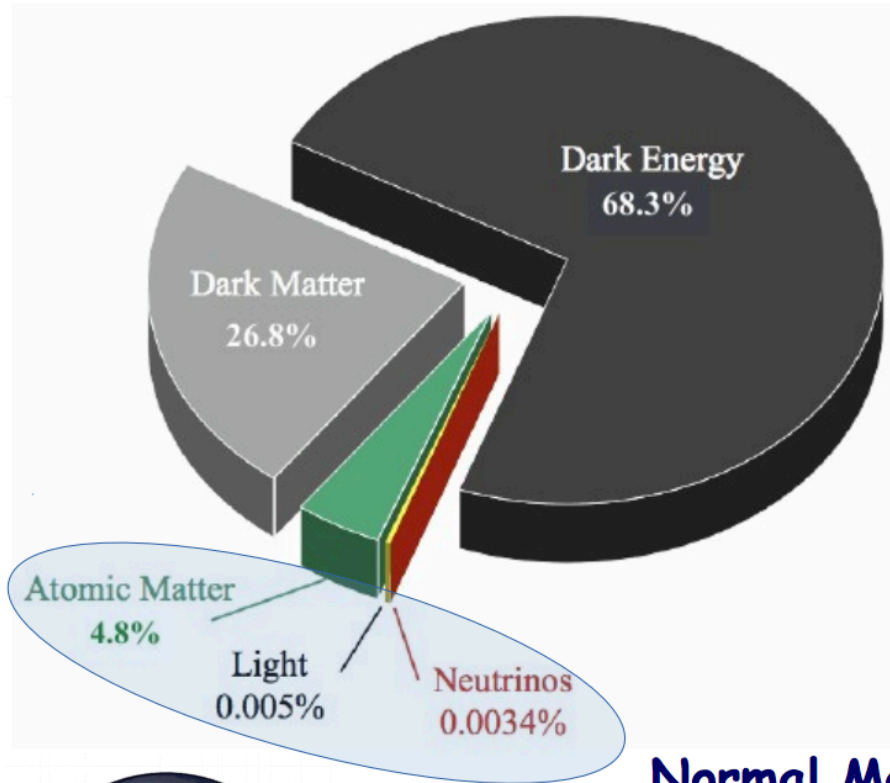
Holly Szumila-Vance

HUGS

June 2016



# Motivation



You are here

Dark Sector:

Dark Matter + Dark Energy



- Gravity
- Other interactions?

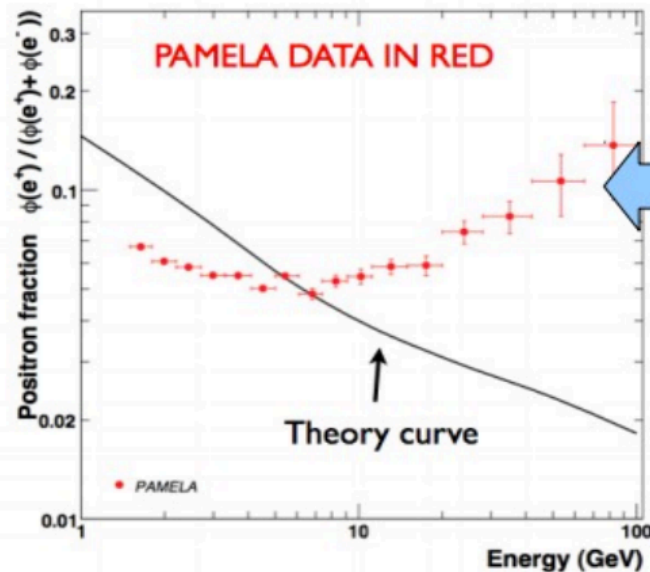
Normal Matter:

- Electromagnetic
- Strong
- Weak
- Gravity

# Motivation

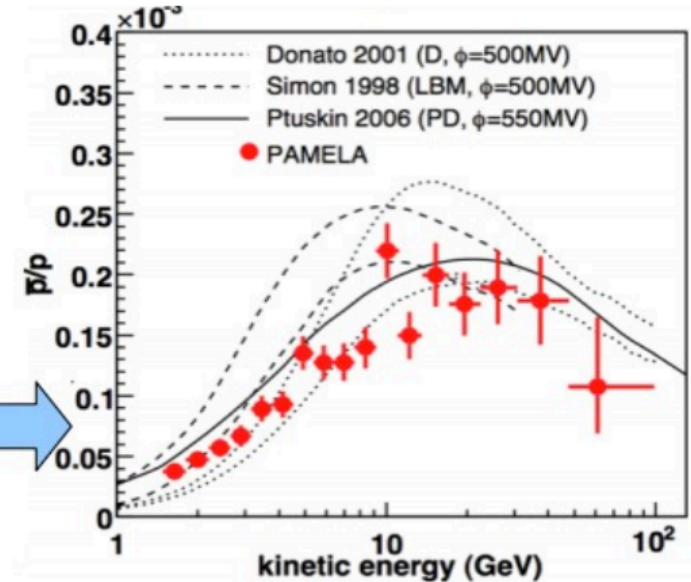
Hints from dark matter?

High energy cosmic ray satellite measurements



Excess in  $e^+/e^-$  ratio

But not in the  $\bar{p}/p$  ratio

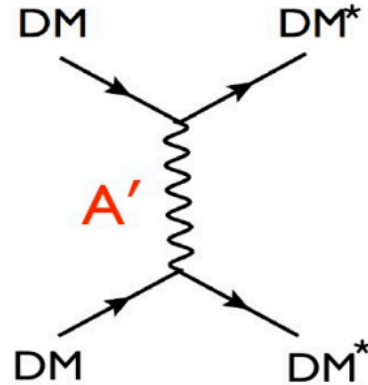


Dark matter particle decaying to  $e^+e^-$  but not  $\bar{p}p$ ?

Link between the Dark Sector and normal matter?

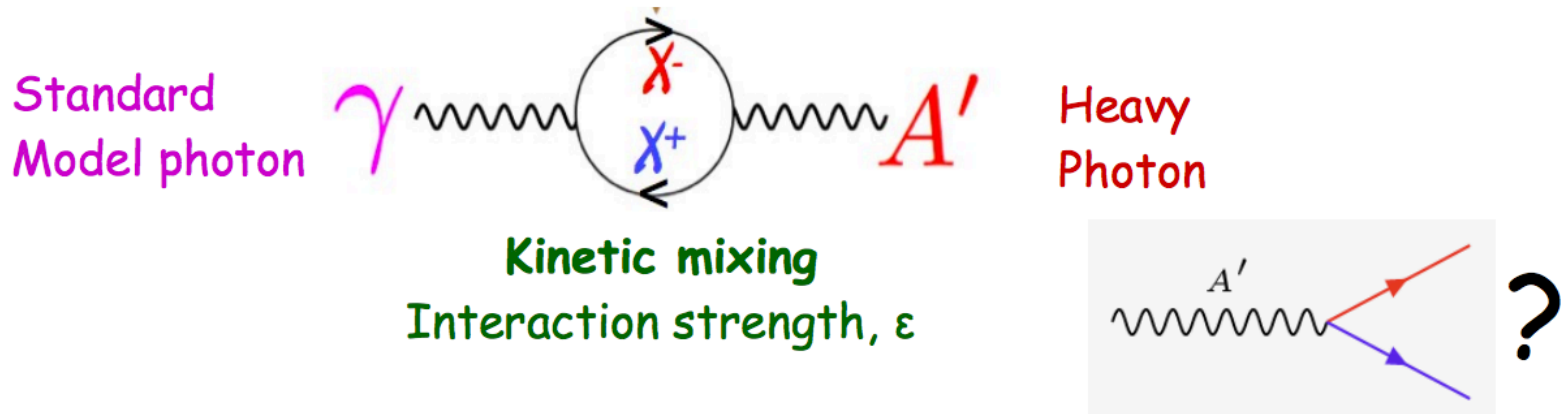
# One possible theory...

Dark Matter could scatter via Heavy Photon:



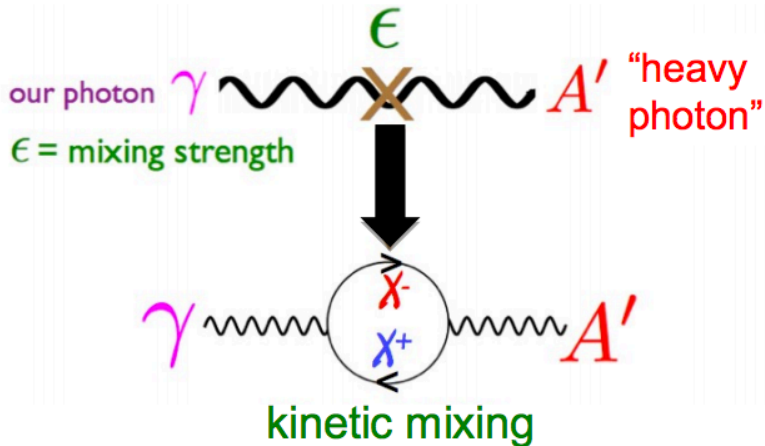
→ Mediator for a Dark Electromagnetic Force

If Heavy Photon interacts (mixes) with our photon,



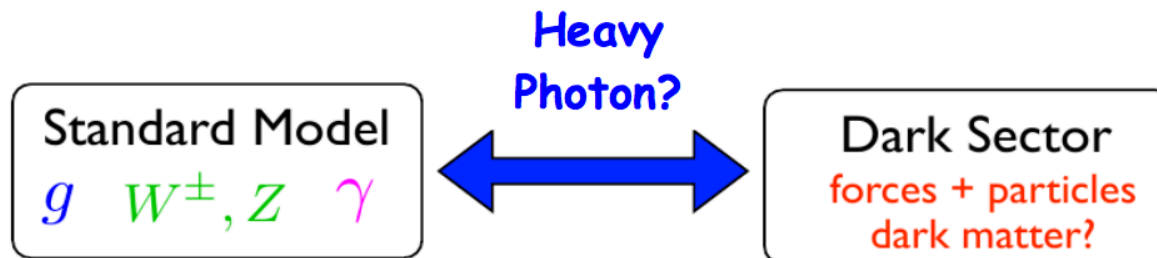
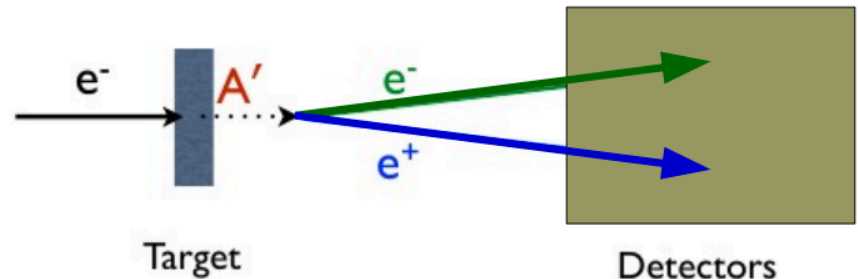
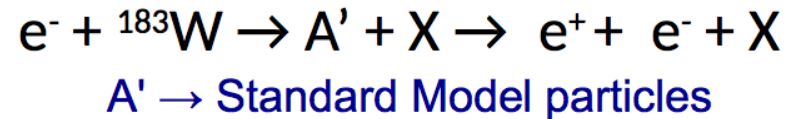
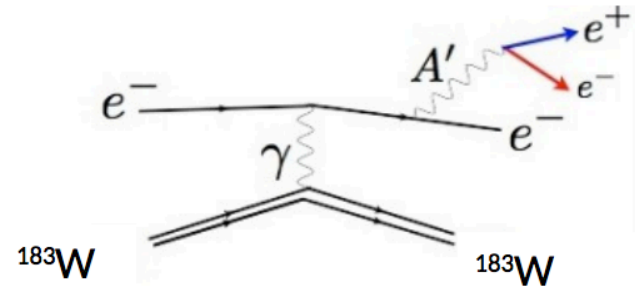
# One possible theory...

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



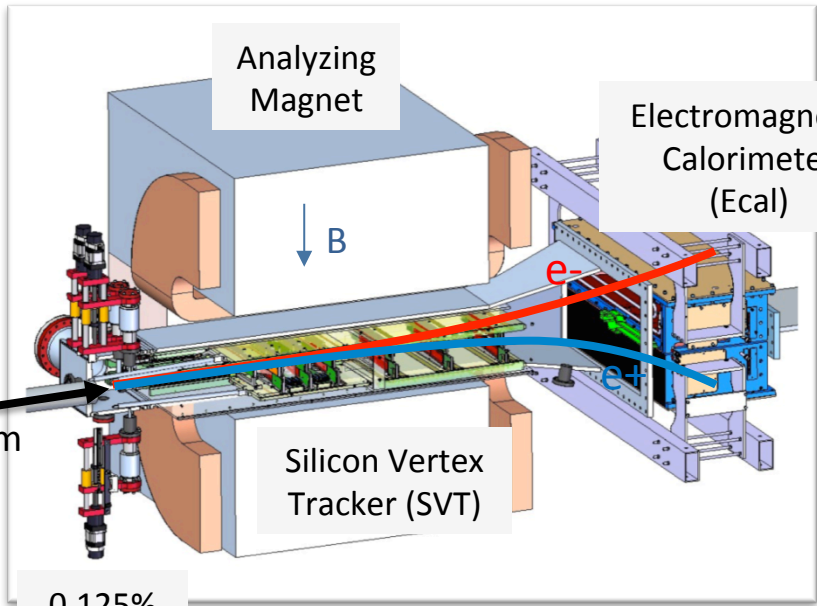
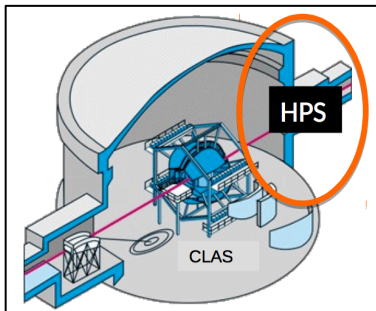
Kinetic mixing could be the leading interaction between the Standard Model and Dark Sector!

Experimental Signature

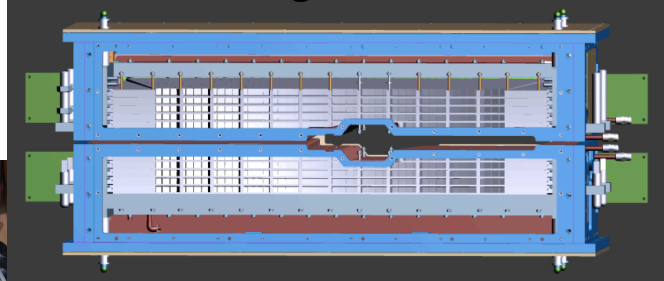


# Experimental Setup

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



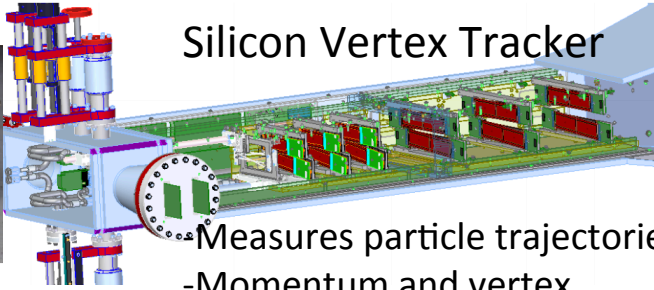
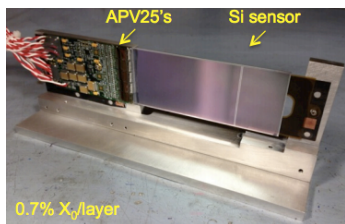
Electromagnetic Calorimeter



- Triggers events
- Measures particle energy
- Resolution: 4%/VE

SVT active area  
0.5 mm from beam!

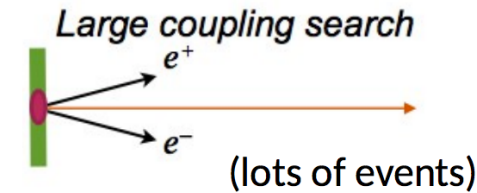
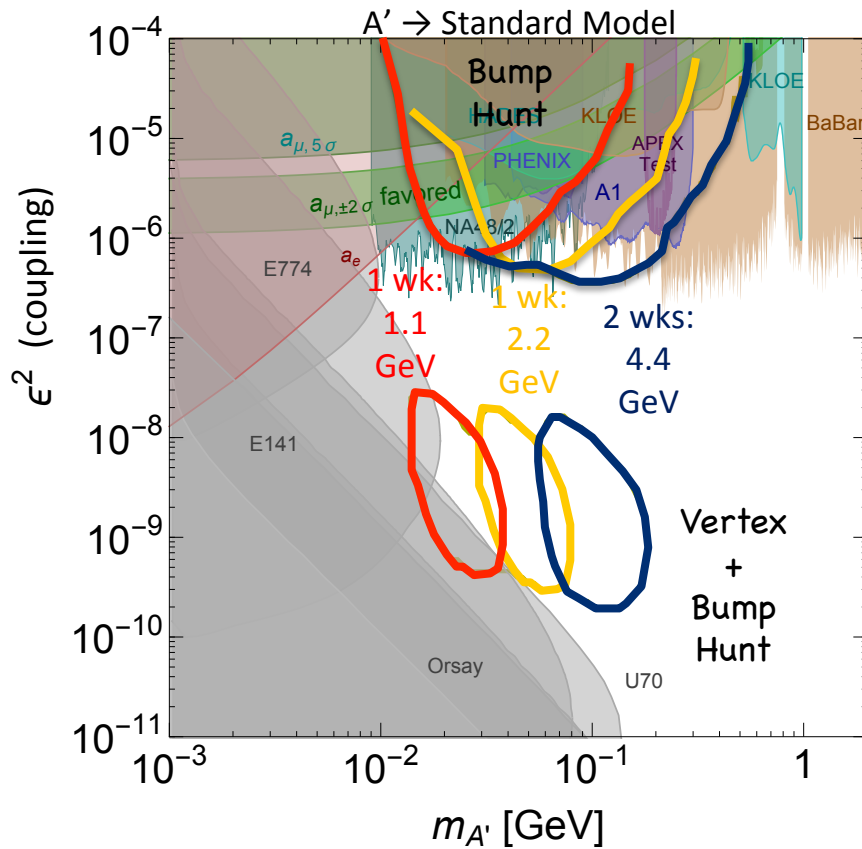
Layer	1	2	3	4	5	6
$z$ position from target [cm]	10	20	30	50	70	90
Stereo angle [mrad]	100	100	100	50	50	50
Non-bend plane resolution [ $\mu\text{m}$ ]	$\approx 6$	$\approx 6$	$\approx 6$	$\approx 6$	$\approx 6$	$\approx 6$
Bend-plane resolution [ $\mu\text{m}$ ]	$\approx 60$	$\approx 60$	$\approx 60$	$\approx 120$	$\approx 120$	$\approx 120$



Measures particle trajectories  
-Momentum and vertex

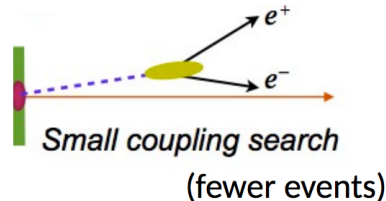


# HPS Proposed Reach



Runs status to date:

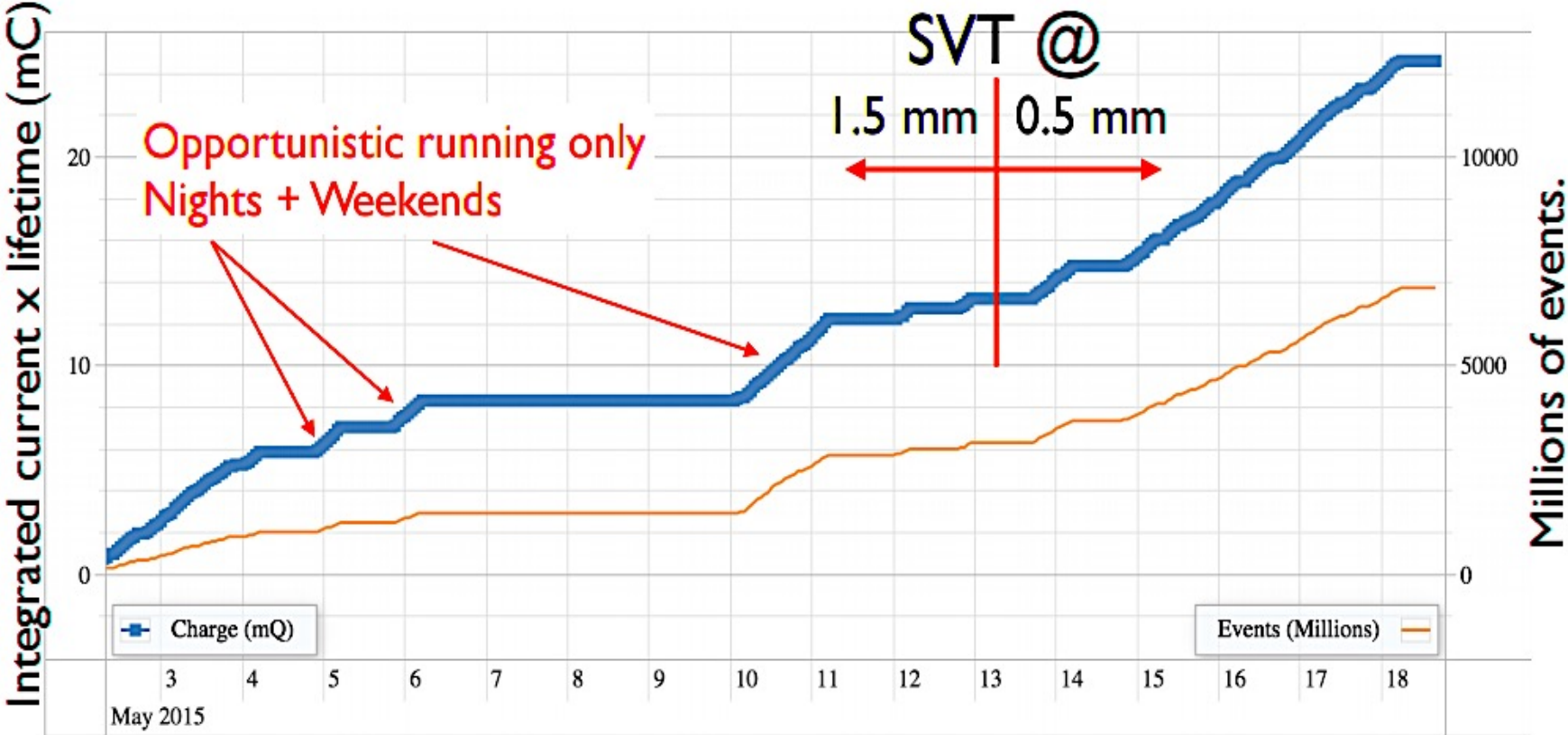
- Spring 2015: Engineering Run  
1.05 GeV, 50 nA  
Achieved 2 of 7 proposed days
- Spring 2016: Physics Run  
2.3 GeV, 200 nA  
Achieved 5 of 7 proposed days



# 2015 Run Results

Goal: 30 mC

Achieved: 10 mC with SVT at +/-1.5 mm, 10 mC with SVT at +/-0.5 mm

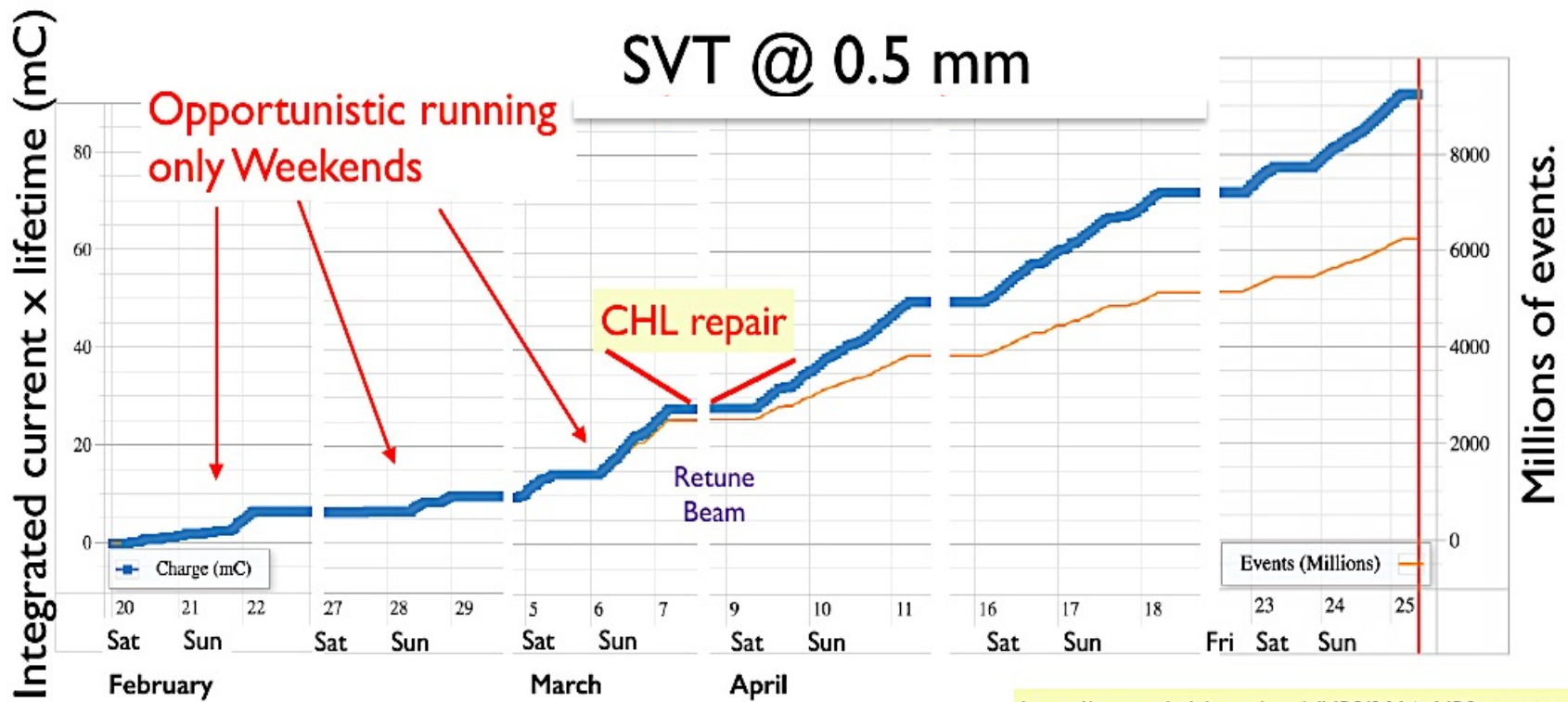




# 2016 Run Results

Goal: 120 mC

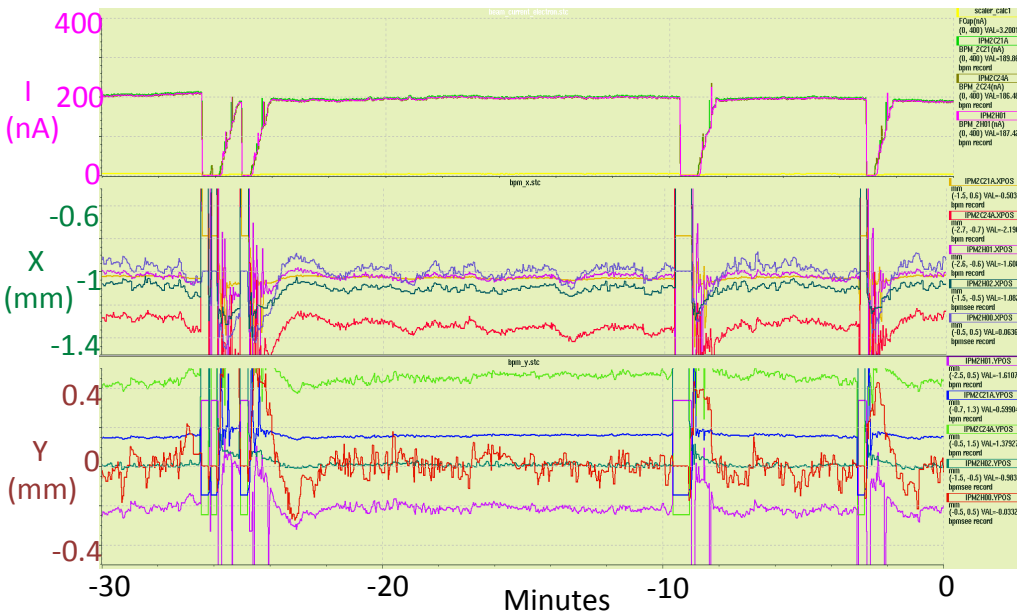
Achieved: 92.5 mC on target,  $6.3 \times 10^9$  events (77% of proposed running)



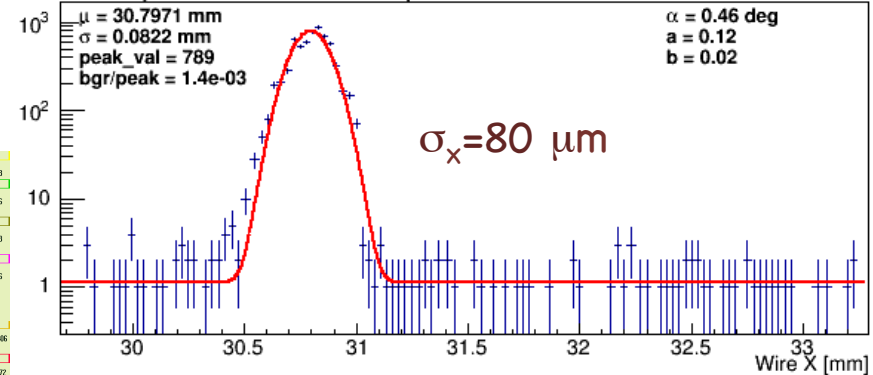
[https://userweb.jlab.org/~vpk/HPS/2016\\_HPS\\_statistics](https://userweb.jlab.org/~vpk/HPS/2016_HPS_statistics)

# 2016 Run: Beam

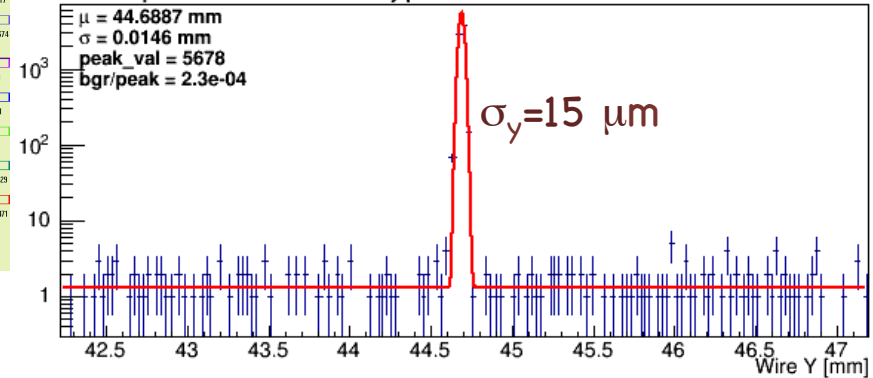
- 2.3 GeV beam at 200 nA
- 4 $\mu$ m W target



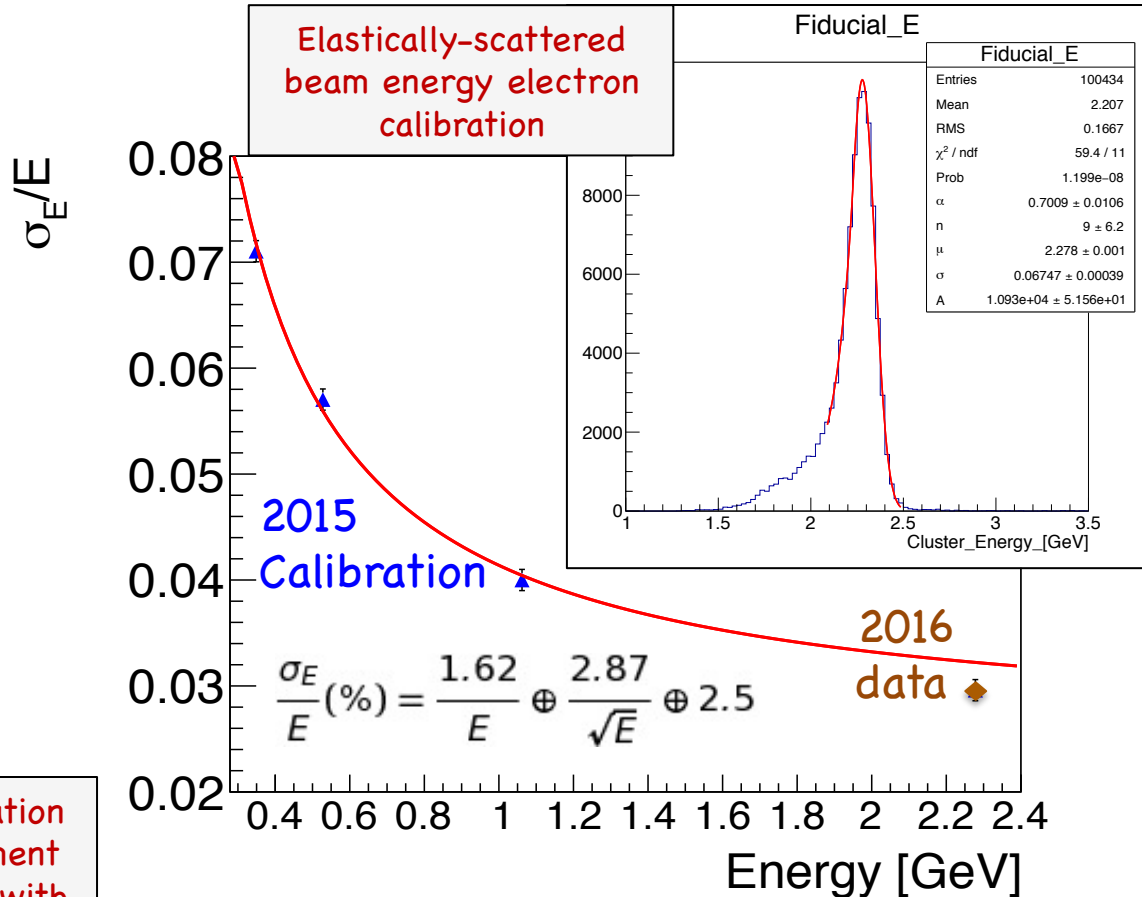
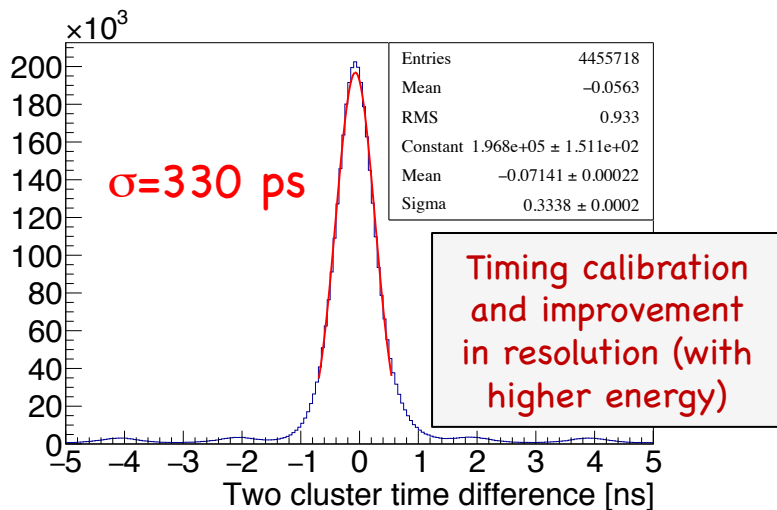
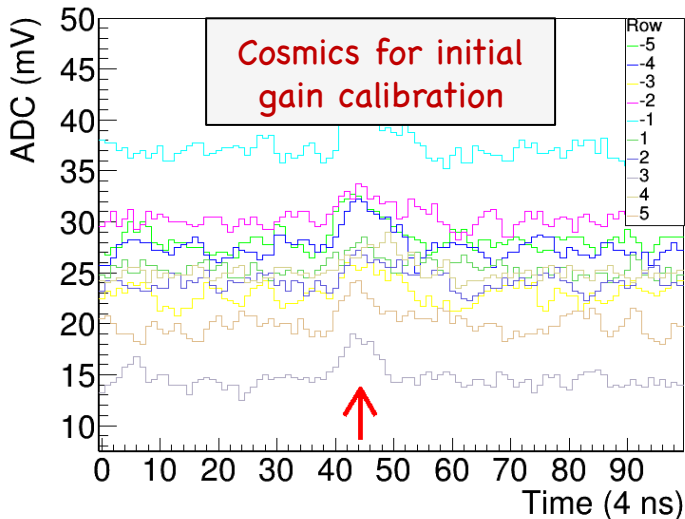
/home/epics/DATA/HARP\_SCANS/harp\_2H02A/harp\_2H02A\_04-23-16\_20:02:43.txt  
Harp: 2H02A Counter: HPS T x profile



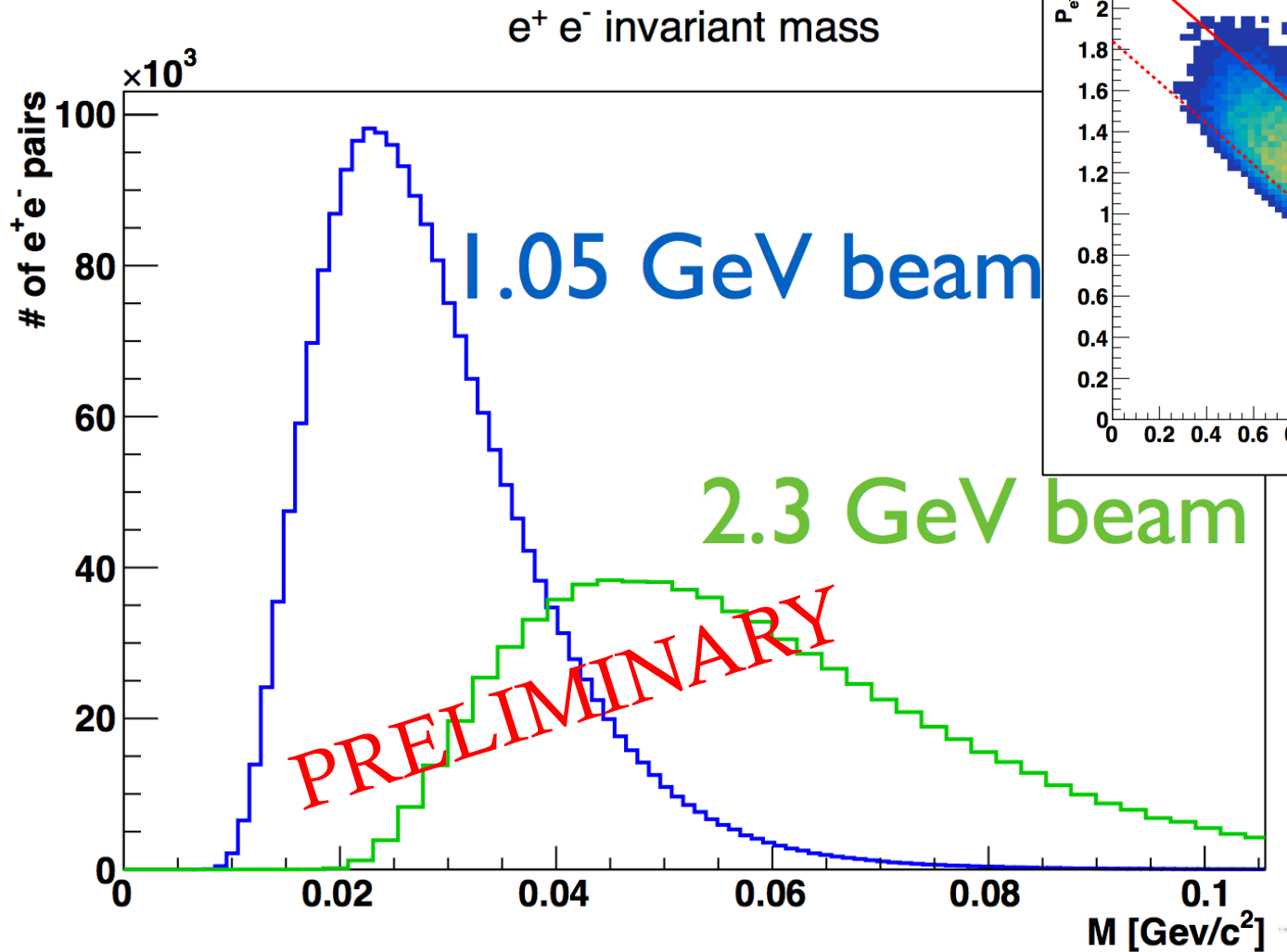
Harp: 2H02A Counter: HPS T y profile



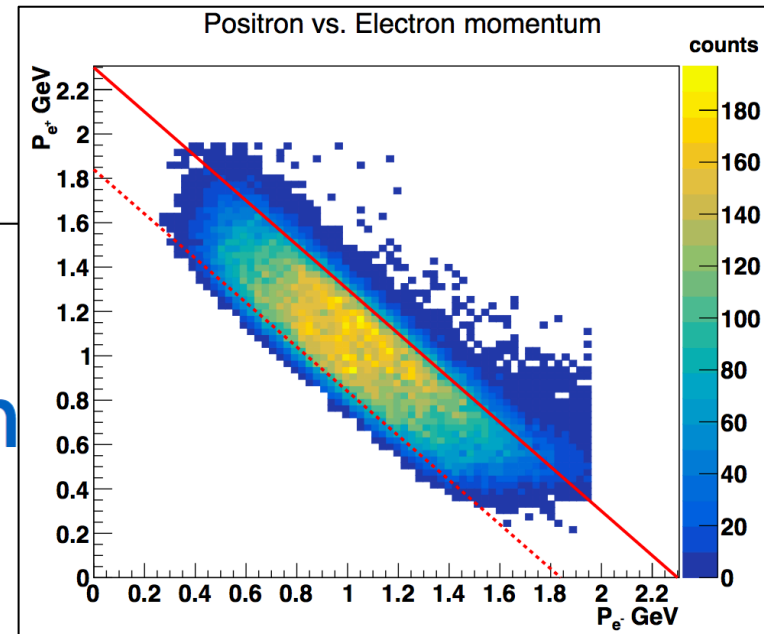
# 2016 Run: Ecal Performance



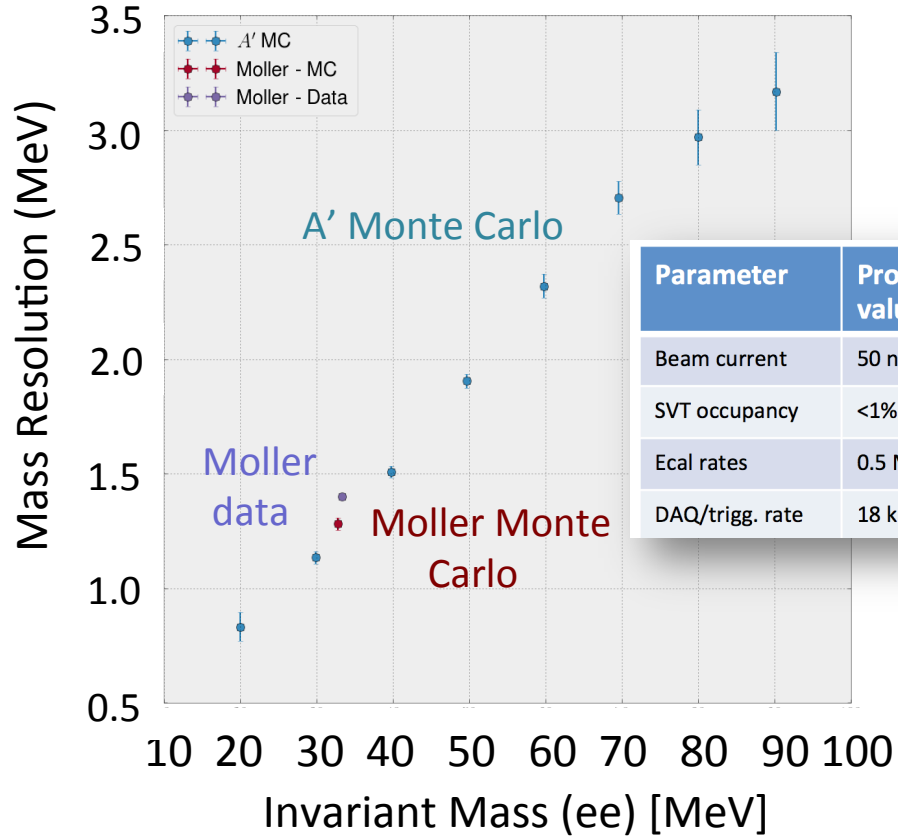
# Invariant Mass



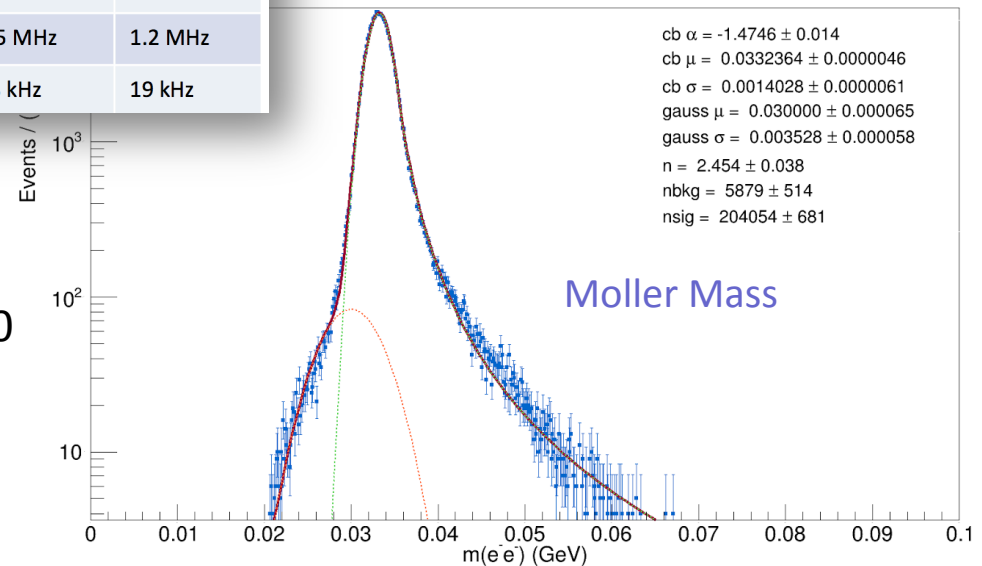
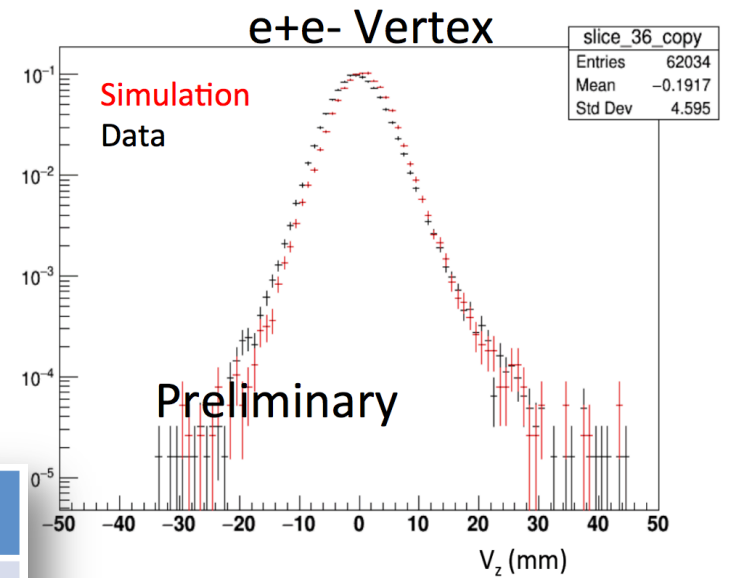
## Radiative Cut



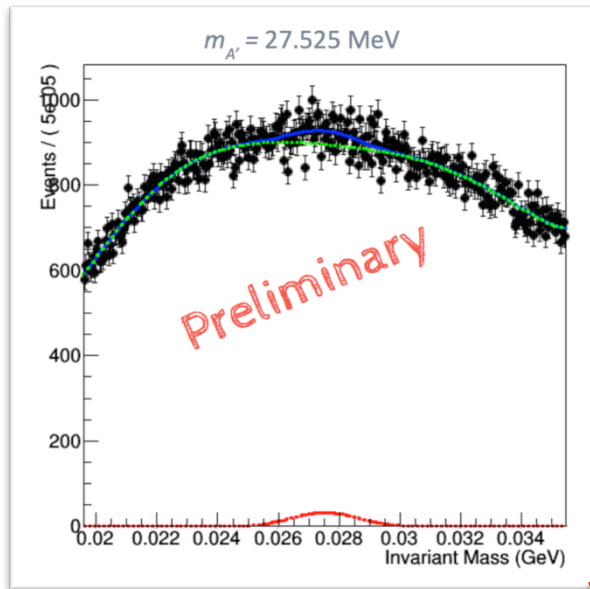
# 2015 Analysis



Parameter	Proposal value	Measured value
Beam current	50 nA	50 nA
SVT occupancy	<1%	1%
Ecal rates	0.5 MHz	1.2 MHz
DAQ/trigg. rate	18 kHz	19 kHz

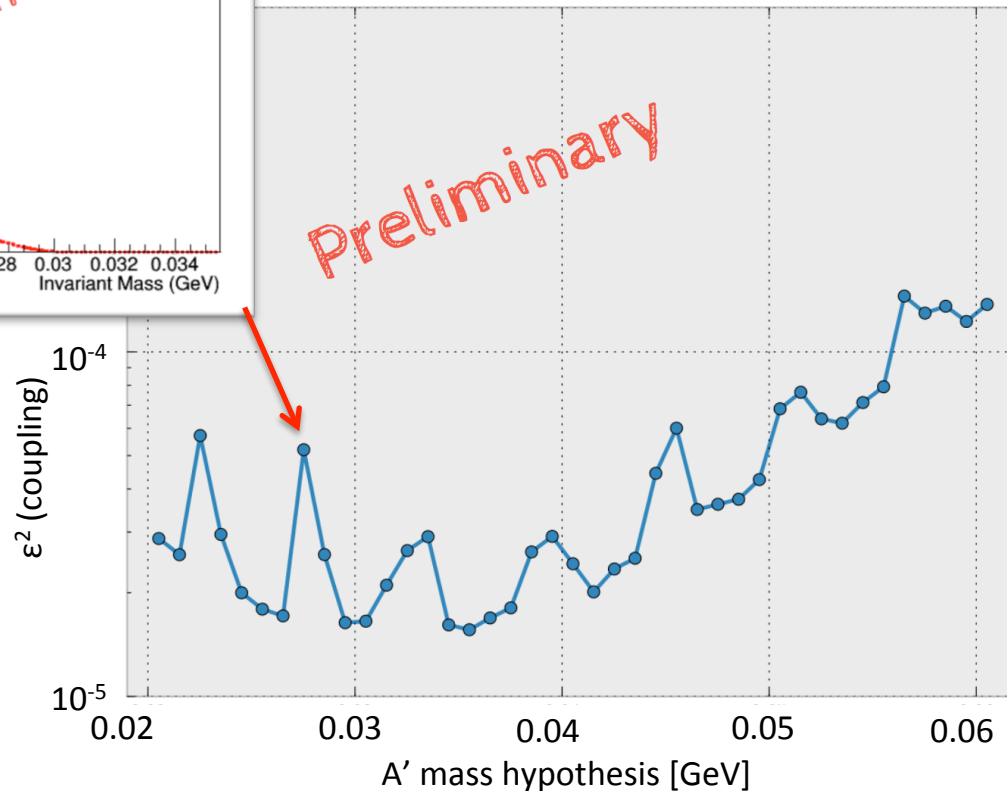


# 2015 Run: Bump Hunt



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

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





# Summary

- Successful running
  - 1.05 GeV, Spring 2015
  - 2.3 GeV, Spring 2016
- 1<sup>st</sup> PhD thesis complete on the bump hunt limits (10%)
  - 4 more theses on 2015 data
  - 3 theses on 2016 data
- NIM papers underway
- Blind data analysis using 10% of 2015 data
  - Bump hunt analysis nearly complete
  - Vertex cut analysis well advanced
  - Data un-blinding expected this summer