

Plans for HPS *2014 and beyond*

July 31, 2012



**HEAVY PHOTON
SEARCH**

DM

Hidden Sector Excitement

- Evidence for excess HE electrons and positrons in the cosmic rays has been confirmed with new measurements. AMS results soon!
- Dark Matter annihilations into heavy photons remain a viable explanation for this excess. More general motivations for heavy photons are also alive and well.
- Continued excitement in heavy photon phenomenology. Two recent examples:
 - “Muon anomaly and Dark Parity Violation”, Davoudiasl, Lee, and Marciano, **PRL 109**, 031802 (2012)
 - “Radiatively decaying scalar dark matter through U(1) mixings and the Fermi 130 GeV line”, J-C Park and S. C. Park, arXiv:1207.4981v1 (2012)
- Competition: New Results are coming from BaBar and Mainz

HPS Goal: Physics ASAP

- **6 Week Commissioning Run late 2014 using Test Run apparatus.**
Apparatus requires minor repairs. DAQ needs minor upgrades.
This run provides HPS experience with electron beams and searches the $g-2$ region. It will deliver physics and theses.
- **HPS physics runs in 2016 and beyond with Full HPS apparatus.**
Improved acceptance and mass resolution and addition of muon ID extend reach and improve beam time efficiency significantly.

HPS will explore much of the parameter space for Heavy Photons and other hidden sector particles, discover True Muonium, and measure its properties.

What HPS needs from JLAB

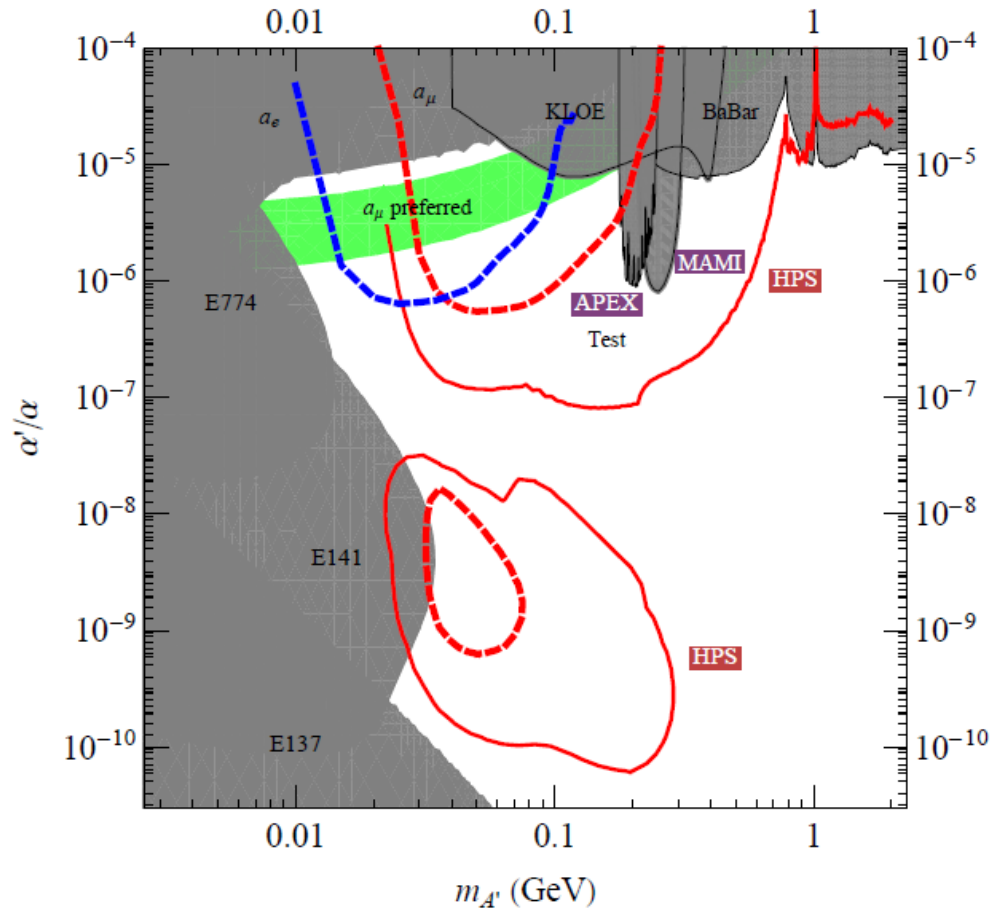
- **ASAP: Commitment to 2014 commissioning run with Test Run Apparatus**
Need this to submit revised FWPs to DOE for repairs & upgrades.
- **SOON: Review of the HPS test run results as a step towards approval of Full HPS.**
- **CONTINUING: HPS Support at JLAB**
 - * Commitment to run time in 2014
 - * Beamline engineering, diagnostics, interlocks for 2014 Run
 - * Access to DAQ and electronics engineering
 - * Installation and setup

Immediate Goal: HPS Commissioning Run 2014

- Test setup was built around the Hall-B PS dipole and scattering chamber. It is already partly installed (SVT)
- The most cost/effort efficient option is to run in the present location, upstream of CLAS12 using the Hall-B PS and TPE chicane
 - everything exists (magnets, PSs, vacuum chambers, stands ...)
 - beam line supports beam currents 5 nA to 400 nA needed for HPS test
 - will need an option to terminate beam upstream of the detector for beam tuning purposes – can use tagger magnet and tagger dump
- Will need one month for installation and alignment
- Will need 3 weeks continuous occupancy of the Hall, 2 of which with ~ 2 GeV physics quality beam
- Physics data taking for 2 weeks on the floor for 1 GeV running, and 2 weeks for 2 GeV running. This will cover the muon “g-2” region.

Commissioning Run Reach

HPS can deliver Hall B/JLAB physics in 2014-15



1.1 GeV

2 weeks on the floor

200 nA/ .25% X0

2.2 GeV

2 weeks on the floor

200 nA/ .25% X0

Needed Improvements/Repair for 2014 Run

- Beamline

- Restore beamline controls and diagnostics (harps, halo counters, BPMs, viewer on FC, beam blocker, tagger magnet ...)
- Complete and test Ecal vac chamber

- ECal

- Replace bottom-left motherboard
- Repair shorted HV channels on top-left mother board
- Order more preamplifier boards
- Replace LV power supply with remotely controlled one
- Change mounting system

- SVT DAQ

Add DTM to COB for direct data transfer to JLAB DAQ

Replace 1 Ghz data links with 10 Ghz links

Develop APV buffer to boost pipeline data rate

Exercise/debug data acquisition

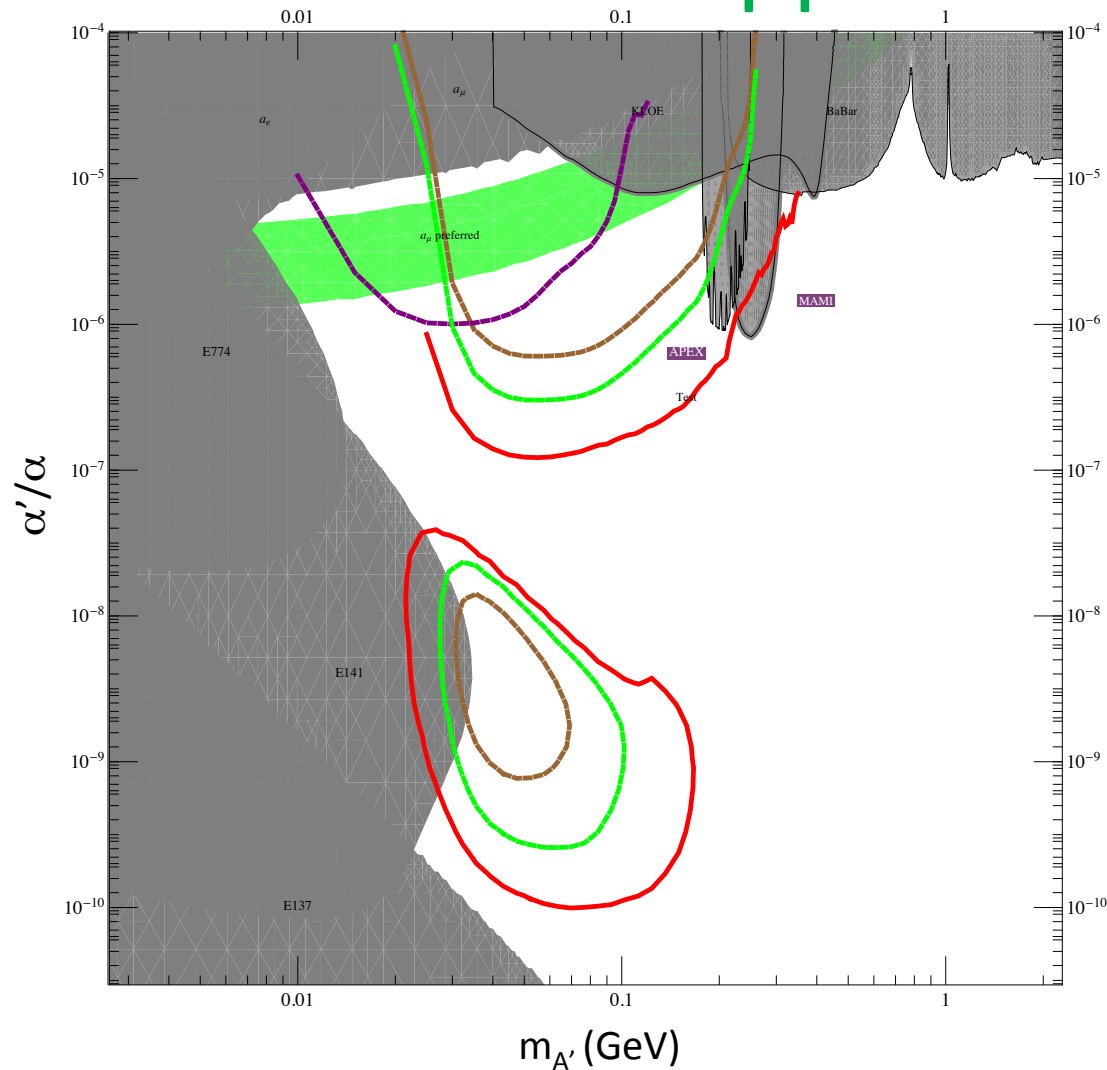
Needed Improvements/Repair for 2014 Run

- Online Software
 - Add EPICS information into data record
 - Add full Event header information (trigger bits, run type, event time ...)
 - Develop One-Event displays
 - Develop online monitoring and start up procedures
 - Develop online timing and data quality checks
- Trigger
 - New CTP (GTP) and firmware
 - New SSP firmware with more diagnostics
- Slow controls
 - Restore all controls from parasitic run
 - Add beam interlocks for SVT safety
 - Add motor control for SVT and target movers

What if time appears in 2015?

- If Hall B is available, HPS Test apparatus can do physics in 2015.
- Maintaining the commissioning setup in Hall B PS location is most efficient option.
- An extended run will require extra cooling for sensor modules to handle expected radiation dose.
 - Either* Replace Si modules with modified modules after the commissioning run
 - Or (better)* Modify Si modules before commissioning run, and use same setup for both runs.
 - Note* Both options require ~1 year lead time to modify modules
- An extended run would benefit from replacing Ecal APDs and preamps. Also requires substantial lead time.
- Tentative Run Plan: Explore 6 GeV Running with 2 months on the floor. First look at higher mass A' parameter space
6 GeV running needed for TM search

2015 Physics Run Reach with Test Run Apparatus



True Muonium in 2015?

Estimates from Philip Schuster

- Assume 6 GeV, 450 nA, 0.1% X_0 target
- 1 month run
- Raw yield (1S): 180 events for $x > 0.8$ and $\lambda > 1.5$ cm
- Estimated Acceptance = 20%
(detailed simulation is in the works)

⇒ 25 events with very little background

= Discovery!

Full HPS in 2016 and beyond

- **The bulk of heavy photon parameter space will be unexplored in 2016.**
Extended HPS runs at 2 GeV, 6 GeV, and 10 GeV are needed.
Running at 6 GeV and above will allow discovery and study of TM.
- **Optimizing the full HPS design will maximize HPS reach, minimize run time.**
It is cost effective to replace the Test Run apparatus with Full HPS.
- **We need a review of the HPS test run results as a step towards approval of Full HPS.**

Why the need for a review?

- **New information from the test run makes the case for approval**
 - Early HPS Test Run in Spring '12 demonstrated much of the technical readiness & performance
 - Final Results from Test Run on Tracking and Triggering coming Fall 2012
- **Approval is needed so the Collaboration can seek funding from DOE to proceed with Full HPS**
- **Delaying full approval seriously delays HPS, or worse**

If delay until the completion of the 2014 run, full HPS pushed back to 2018/19 .

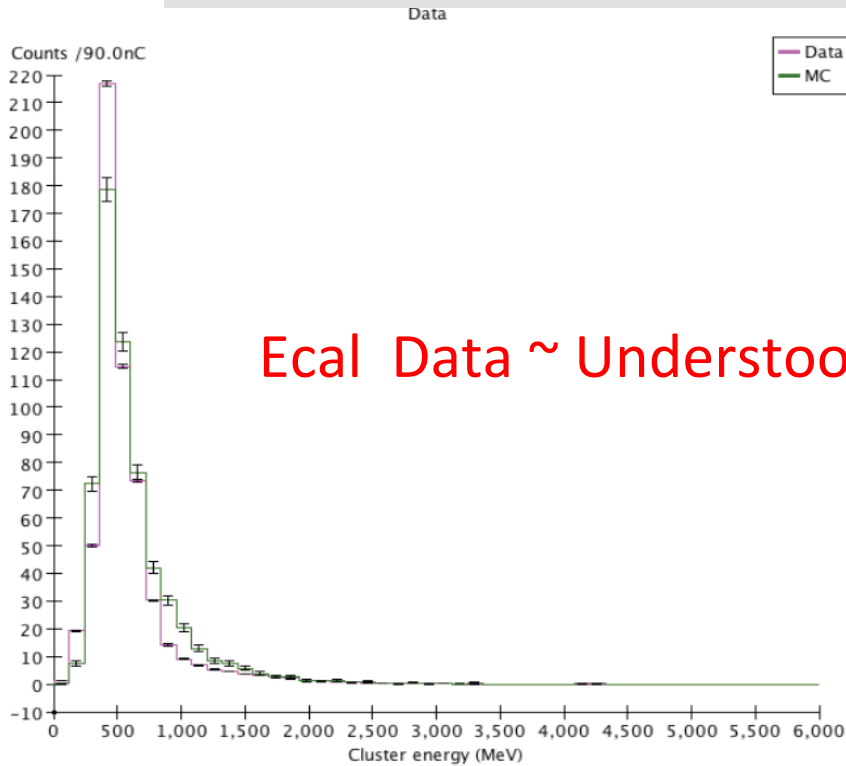
 - the earliest to run the HPS test is in FY15 (Oct-Dec of 2014)
 - assume full approval by February-March 2015
 - apply and get funding for full HPS in FY16
 - build and install full HPS, 2+ years

2018/2019 is dangerously late to have an impact

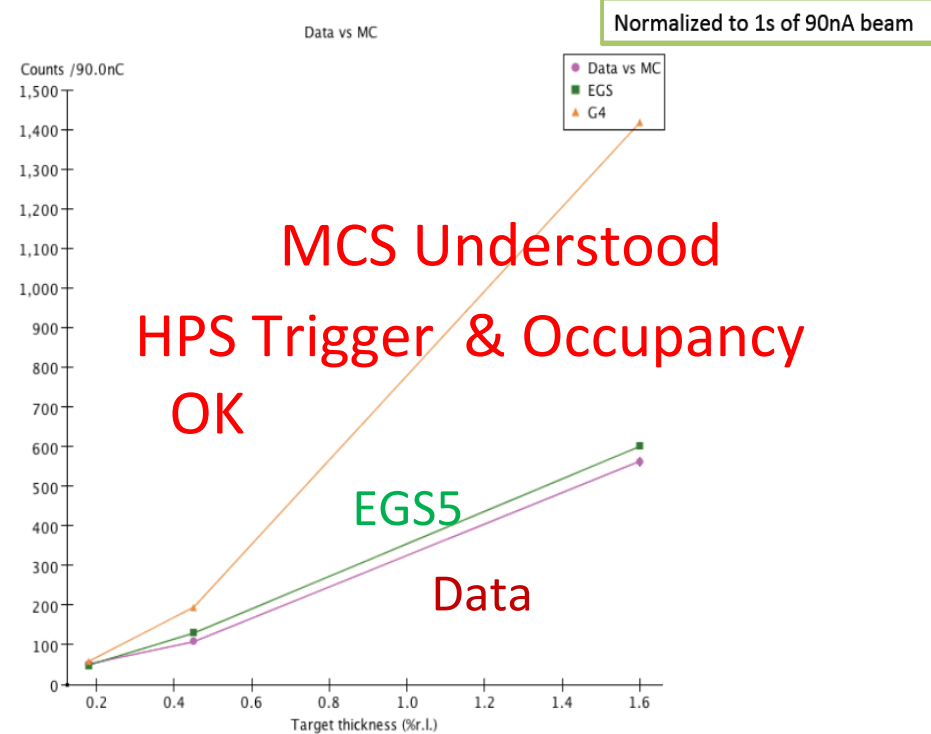
Ecal Performance Updates

- Ecal and Ecal readout fully simulated. Dead channels accounted for.
- Trigger efficiency >90% from offline cross-checks

Cluster Energy Data/MC



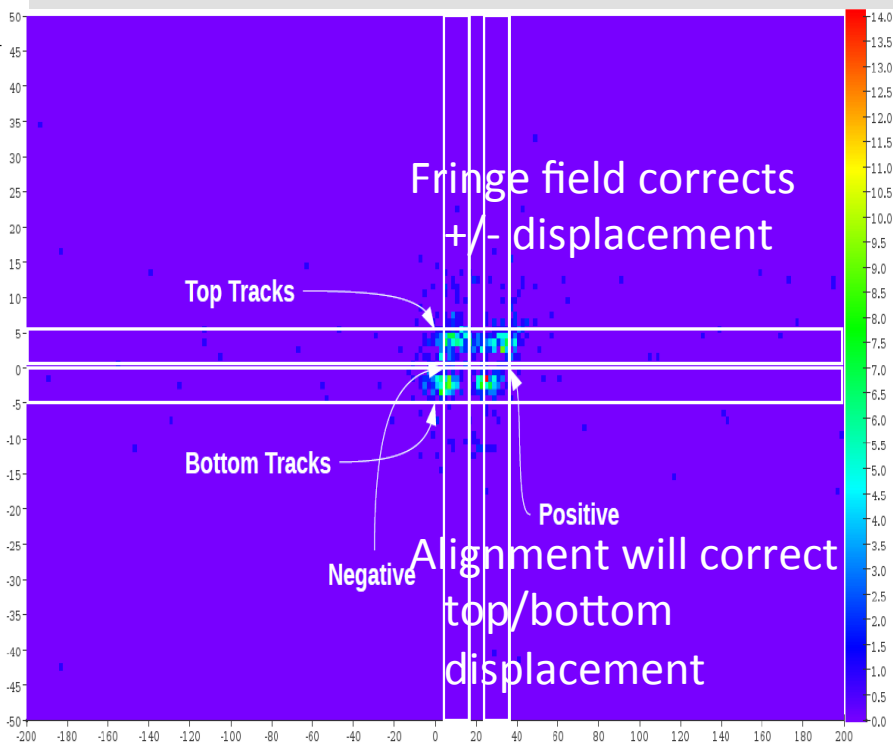
Trigger Rate vs Thickness Data confirms EGS5



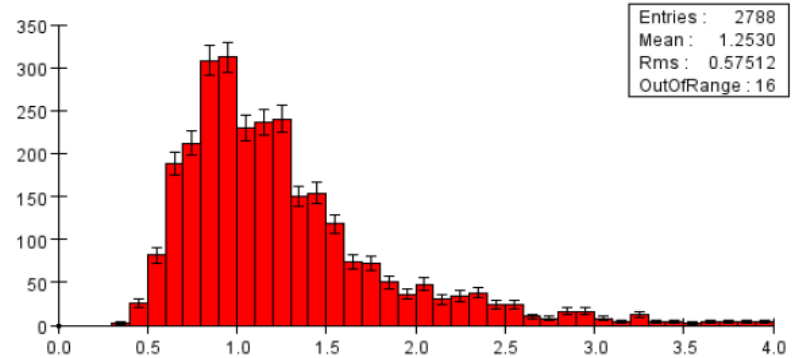
Tracking Performance Update

- Data Quality Checks: Identifying and eliminating noisy SVT channels
- Adding fringe fields and improving alignment
- Track Reconstruction Efficiency $\sim 90\%$
- Studies of e^+e^- pairs shown below:

Extrapolated Track Positions at Target
Accurate to few mm

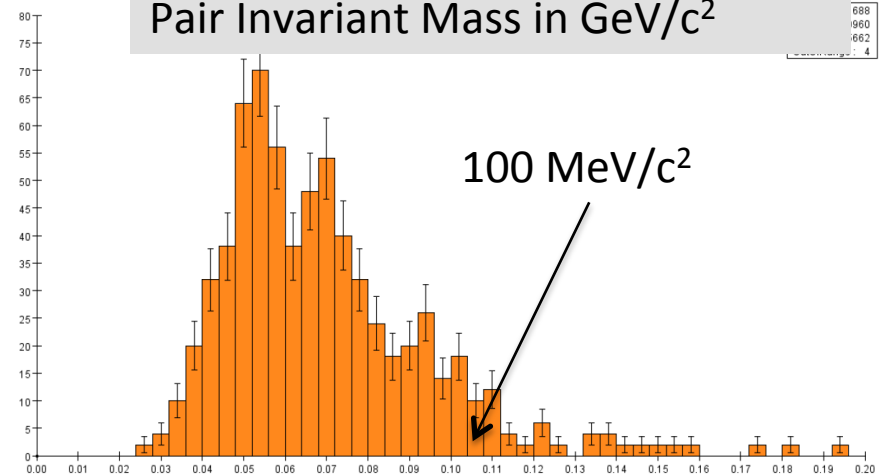


Track Momentum in GeV/c



Invariant Mass

Pair Invariant Mass in GeV/c^2



Conclusions

- HPS is ready to prepare for a commissioning run in 2014 and for Full HPS in 2016 and beyond.
- HPS can deliver physics beginning in 2014
- We need JLAB commitment and support for the commissioning run ASAP
- We need JLAB review of the HPS test run results in the next few months
- Without JLAB's strong commitments and support we cannot seek funding from DOE for the Full HPS