HPS Update

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CLAS Collaboration Meeting

June 16, 2016
Motivation

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

Our photon \( \gamma \)
\( \epsilon \) = mixing strength
\[ \gamma \rightarrow A' \quad \text{“heavy photon”} \]

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

Heavy Photon?

Standard Model
\( g \ W^\pm, Z, \gamma \)

Dark Sector
forces + particles
dark matter?
Experimental Setup

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

- Analyzing Magnet
- Electromagnetic Calorimeter (Ecal)
- Silicon Vertex Tracker (SVT)

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

Silicon Vertex Tracker
- Measures particle trajectories
- Momentum and vertex

SVT active area
0.5 mm from beam!

<table>
<thead>
<tr>
<th>Layer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>z position from target [cm]</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>50</td>
<td>70</td>
<td>90</td>
</tr>
<tr>
<td>Stereo angle [mrad]</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Non-bend plane resolution [μm]</td>
<td>≈ 6</td>
<td>≈ 6</td>
<td>≈ 6</td>
<td>≈ 6</td>
<td>≈ 6</td>
<td>≈ 6</td>
</tr>
<tr>
<td>Bend-plane resolution [μm]</td>
<td>≈ 60</td>
<td>≈ 60</td>
<td>≈ 60</td>
<td>≈ 120</td>
<td>≈ 120</td>
<td>≈ 120</td>
</tr>
</tbody>
</table>
HPS Proposed Reach

Runs status to date:

Spring 2015: Engineering Run
1.05 GeV, 50 nA
Achieved ~ 1.6 of 7 proposed days (SVT at 0.5 mm)
~ 1 of 7 proposed days (SVT at 1.5 mm)

Spring 2016: Physics Run
2.3 GeV, 200 nA
Achieved ~5 of 7 proposed days (SVT at 0.5 mm)
2015 Run Results

Goal: 30 mC
Achieved: 10 mC with SVT at +/-1.5 mm, 10 mC with SVT at +/-0.5 mm

Opportunistic running only Nights + Weekends
2016 Run Results

Goal: 120 mC
Achieved: 92.5 mC on target, $6.3 \times 10^9$ events (77% of proposed running)

SVT @ 0.5 mm

[Graph showing integrated current x lifetime (mC) per week from February to April, with annotations for opportunistic running only Weekends and CHL repair.]

[Graph showing millions of events per week from March to April, with a link to the userweb.jlab.org site for more statistics.]
2016 Run: Beam

- 2.3 GeV beam at 200 nA
- 4μm W target
2016 Run: Ecal Performance

Cosmics for initial gain calibration

Elastically-scattered beam energy electron calibration

Timing calibration and improvement in resolution (with higher energy)

Cluster_Energy [GeV]

Energy [GeV]

$\sigma_E/E (\%) = \frac{1.62}{E} + \frac{2.87}{\sqrt{E}} + 2.5$
2016 Run: SVT Performance

First look at track efficiency by SVT layer

E/P for Elastic Events
No Fiducial Cuts to Ecal
Invariant Mass

$e^+ e^- \text{ invariant mass}$

- **1.05 GeV beam**
- **2.3 GeV beam**

Radiative Cut

**PRELIMINARY**
2015 Analysis

A' Monte Carlo
Moller data
Moller Monte Carlo

Preliminary

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

cb α = 1.4746 ± 0.014
cb μ = 0.0332394 ± 0.0000046
cb σ = 0.0014028 ± 0.0000061
gauss μ = 0.000000 ± 0.00000065
gauss σ = 0.003528 ± 0.0000058
n = 2.454 ± 0.038
nbkg = 5879 ± 514
nsig = 204054 ± 681
2015 Run: 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

Plots from dissertation of Omar Moreno
2015 Run: Vertex search

- Search for long-lived A' with separated vertex

Plot from Sho Uemura
Summary

• Successful running at 2.3 GeV in the spring of 2016
• 1st PhD thesis complete, Omar Moreno of UCSC, 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
• This summer:
  • Fix cuts
  • Unblind data (100%)