



U.S. DEPARTMENT OF  
**ENERGY**



# Data Analysis Overview

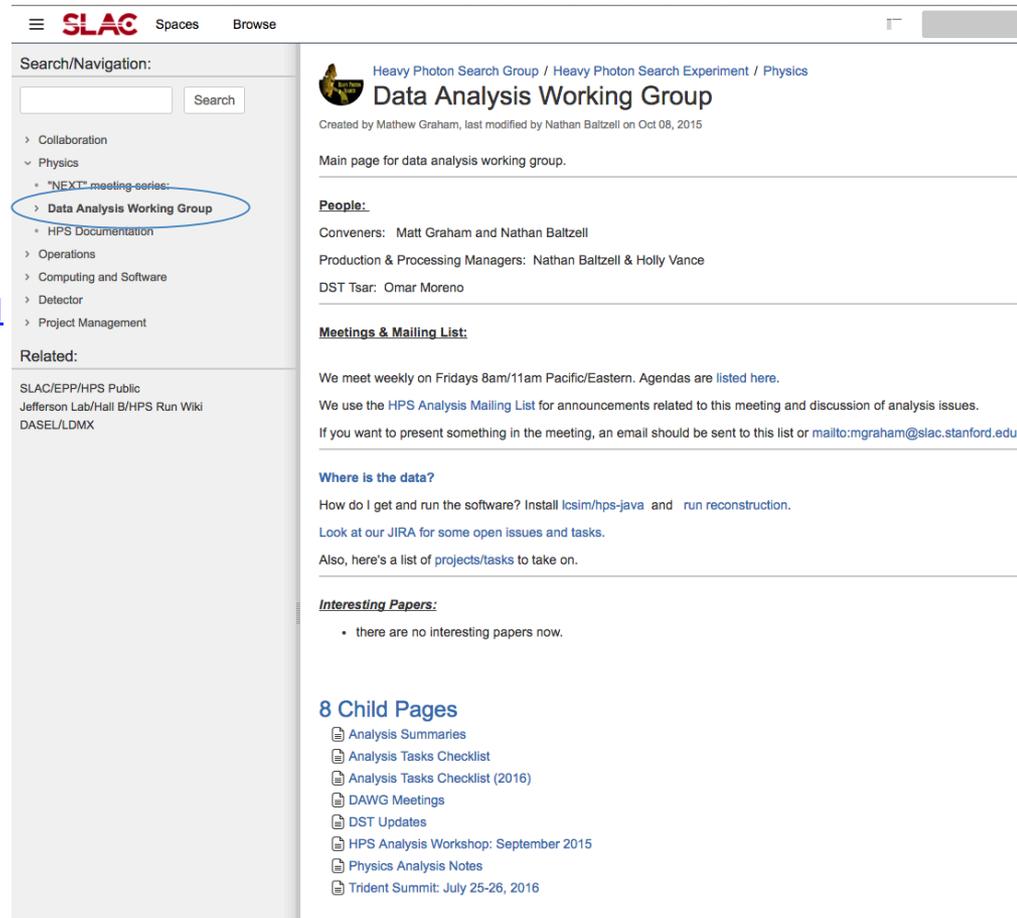
Nathan & Matt  
HPS Collaboration Meeting  
November 2016

# Organization

- HPS's Data Analysis Work Group (DAWG)
  - Leader / Deputy: Matt / Nathan
- Weekly Meetings: Friday @ 11:00 (JLab time)
  - Time change has been proposed recently
    - A doodle poll of “ideal” times was done a couple weeks ago
      - <http://doodle.com/poll/eiy5e2iuqpeugu6n>
      - Tuesday at 11:00 seems to have won that poll, but not unanimous
- Mailing list:
  - [hps-analysis@jlab.org](mailto:hps-analysis@jlab.org)
  - private, to request access:
    - <https://mailman.jlab.org/mailman/listinfo/hps-analysis>

# Documentation (0)

- Confluence pages with meeting agendas and links to all weekly talks and more
  - <https://confluence.slac.stanford.edu/display/hpsg/Data+Analysis+Working+Group>
  - Important to have all presentations accessible from the meeting pages
  - Push for more details in presentations, e.g. MC version, text/legends accompanying figures, conclusion slides, and better cataloging of presentations



The screenshot shows a Confluence page titled "Data Analysis Working Group" under the "Heavy Photon Search Group / Heavy Photon Search Experiment / Physics" hierarchy. The page is created by Mathew Graham and last modified by Nathan Baltzell on Oct 08, 2015. It serves as the main page for the data analysis working group. Key sections include:

- People:** Conveners: Matt Graham and Nathan Baltzell; Production & Processing Managers: Nathan Baltzell & Holly Vance; DST Tsar: Omar Moreno.
- Meetings & Mailing List:** Meetings occur weekly on Fridays 8am/11am Pacific/Eastern. Agendas are listed here. The group uses the HPS Analysis Mailing List for announcements. Presentations should be emailed to <mailto:mgraham@slac.stanford.edu>.
- Where is the data?:** Instructions on software installation (Icsim/hps-java) and reconstruction. Links to JIRA for open issues and a list of projects/tasks.
- Interesting Papers:** Currently, there are no interesting papers listed.
- 8 Child Pages:** A list of related pages including Analysis Summaries, Analysis Tasks Checklist, DAWG Meetings, DST Updates, HPS Analysis Workshop: September 2015, Physics Analysis Notes, and Trident Summit: July 25-26, 2016.

The left sidebar shows a navigation menu with "Data Analysis Working Group" highlighted. The "Related" section lists "SLAC/EPP/HPS Public", "Jefferson Lab/Hall B/HPS Run Wiki", and "DASEL/LDMX".

# Documentation (1)

- We have github repositories
  - first entries were shift operations manuals and official JLab docs
  - over past year many calibration documents added
  - physics analysis documents growing
  - For write access
    - first, get a github account
    - then ask any HPS member that already has write access
      - or just request by emailing an hps mailing list
  - World readable:
    - <https://github.com/jeffersonlab/hps-notes>
  - Restricted read access:
    - <https://github.com/jeffersonlab/hps-analysis-notes>
    - <https://github.com/jeffersonlab/hps-pubs>
- And a JLab pdf archive for final “published” pdfs, with note numbers
  - Again, one is public for calibrations etc:
    - [https://misportal.jlab.org/mis/physics/hps\\_notes/](https://misportal.jlab.org/mis/physics/hps_notes/)
  - And one is private for more sensitive physics topics (is it working?):
    - [https://misportal.jlab.org/mis/physics/hps\\_analysis\\_notes](https://misportal.jlab.org/mis/physics/hps_analysis_notes)

JeffersonLab / HPS-NOTES

Unwatch 22 Star 0 Fork 4

Code Issues 0 Pull requests 0 Projects 0 Pulse Graphs Settings

Branch: master HPS-NOTES / ANALYSIS /

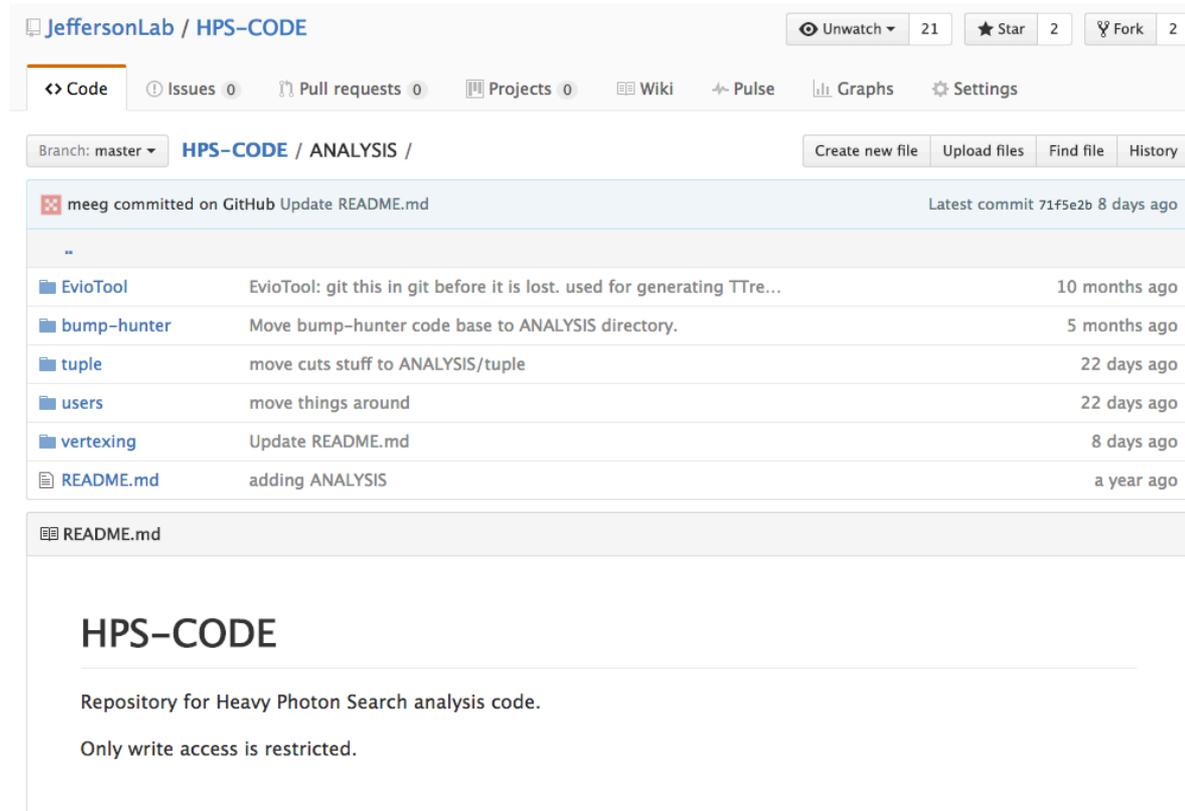
Create new file Upload files Find file History

Sebouh Paul update Latest commit 8103c87 on Sep 15

..		
MollersEngRun2015	Moller 2015 note	5 months ago
clusterTrackMatching	ignore complied files	2 months ago
definitions	negative first draft	a year ago
ecalCalibration2015	Moller 2015 note	5 months ago
ecalPedestals2014	cleanup	2 months ago
ecalPulseFitting	update ref, remove note #	a year ago
ecalTimingCalib	Moller 2015 note	5 months ago
goldenRunSelection2016	added golden run selection 2016 to git	2 months ago
randomPdfs	move pdf without source code into subdir	2 months ago
timeDependentEcalGains	update	2 months ago
tridentsEngRun2015	Moller 2015 note	5 months ago
README.md	Create README.md	a year ago

# Documentation (2)

- And a github repository for software
  - calibrations, analysis, etc.
- Already being used for sharing physics analyses, repeatability



JeffersonLab / HPS-CODE

Unwatch 21 Star 2 Fork 2

Code Issues 0 Pull requests 0 Projects 0 Wiki Pulse Graphs Settings

Branch: master HPS-CODE / ANALYSIS / Create new file Upload files Find file History

meeg committed on GitHub Update README.md Latest commit 71f5e2b 8 days ago

Commit	Description	Time
..		
EvioTool	EvioTool: git this in git before it is lost. used for generating TTre...	10 months ago
bump-hunter	Move bump-hunter code base to ANALYSIS directory.	5 months ago
tuple	move cuts stuff to ANALYSIS/tuple	22 days ago
users	move things around	22 days ago
vertexing	Update README.md	8 days ago
README.md	adding ANALYSIS	a year ago

README.md

## HPS-CODE

Repository for Heavy Photon Search analysis code.

Only write access is restricted.

# Trident Summit

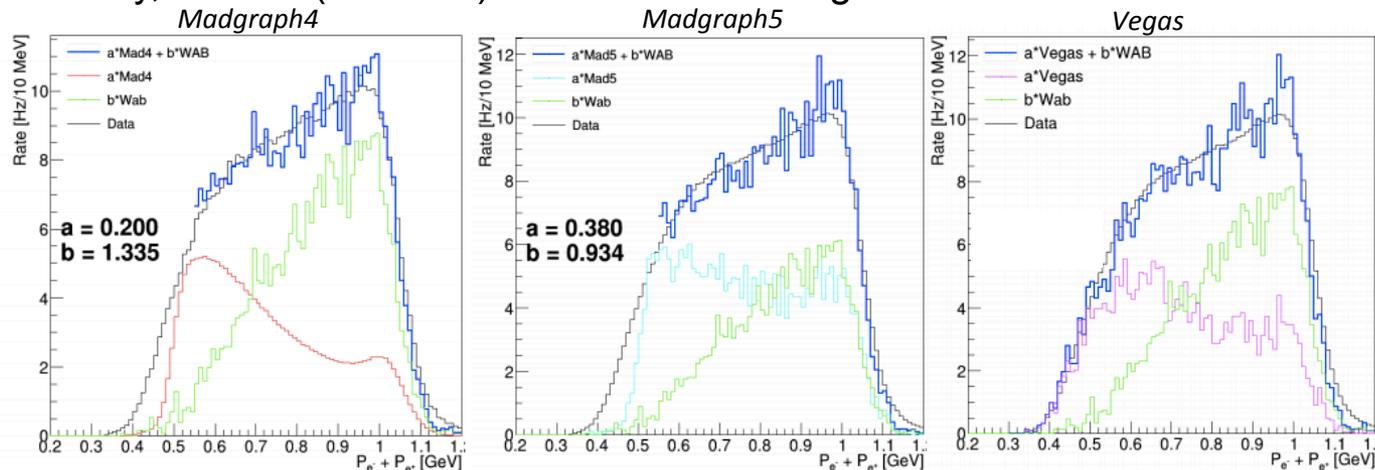
- By early summer, a large MC/Data discrepancy in  $e^+e^-$  energy sum had been confirmed by many analyses
  - was good agreement at large energy, >2x discrepancy at low
- Trident Summit was organized to identify all possible sources, study them, rule them out, find the cause
  - <https://confluence.slac.stanford.edu/display/hpsg/Trident+Summit%3A++July+25-26%2C+2016>
  - <https://confluence.slac.stanford.edu/display/hpsg/Trident+Summit+Followup+Summary>
  - Inefficiencies in data, problems in MC generators, insufficient detector/trigger modelling in MC, etc ...
- No single smoking gun was found at the time (and still not)
- A couple warranted MC improvements were identified
- Various new homeworks, crosschecks generated
  - group been going through punch list since
- Learned the importance of wide angle Bremstrahlung (WAB) background
  - had been underestimated by EGS5 (due to wrong electron kinematics)
  - it became a new (big) background that was previously unaccounted for in proposal

# Summit Followup: Overview

- Trident / WAB rates
  - 3-prong topology ratios (Holly, Rafo)
  - 2-prong shapes (Holly, Matt, Rafo)
  - MC Generators (Annie, Brad, Rafo, Luca, Sebouh, Takashi)
- Tracking Efficiency (Holly, Matts, Sho)
- Calorimeter / Trigger Efficiency (Kyle)
- Current dependence (Holly, Sho)
- MC Chain (Brad, Kyle)
- Moller, FEE, WAB Cross Sections (Brad, MattS, Sebouh, Rafo)

# Summit Followup: MC (1)

- After more realistic SVT geometry, remove double counting of WABs, some MC iterations ...
- Then a first properly normalized comparison of 3 trident event generators
  - Madgraph4, Madgraph5, Luca/Vegas
  - Revealed significant differences between MG4 and MG5 at low energy
    - MG5 matches data much better
  - Saw that HPS's MG4 trident generator matches APEX's
    - But APEX phasespace is small and where MG4/MG5 agree ...
- And more recently,
  - Luca's (Beranek) generator now normalized and agrees much better with MG5 than MG4
  - Yesterday, Annie's (Beranek) calculations also agrees better with MG5 than MG4!

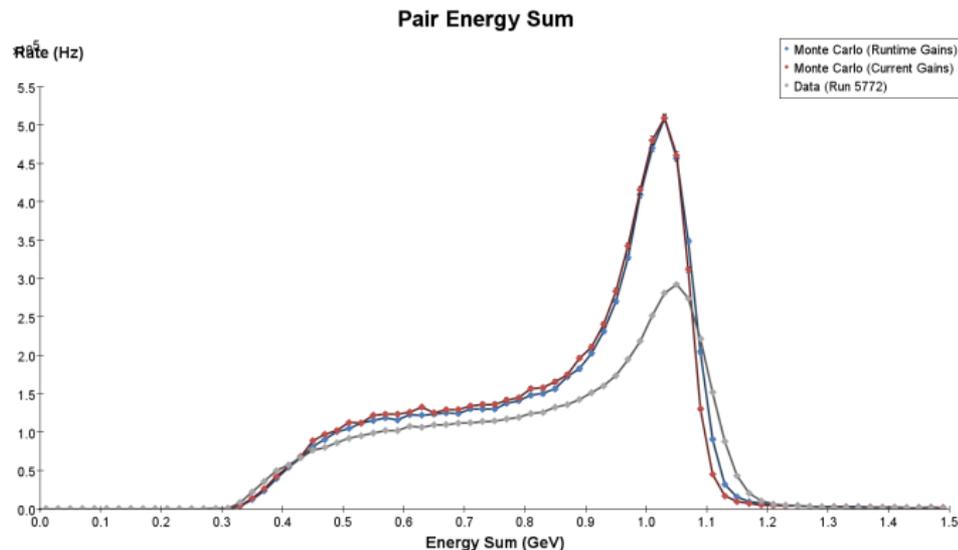


# Summit Followup: MC (2)

- WABs are a critical background at high  $\epsilon_{\text{sum}}$  where our  $A'$  search lives
  - needs firm understanding even with efforts to reject it event-by-event
  - learned APEX kinematics don't have significant WAB contribution
- Problems found in HPS's WAB usage of Madgraph4 (Sebouh)
  - We use MG4 for wide-angle Brems, since easier than fixing EGS5
  - But it had incorrect diagrams (spin states of real photon)
    - inherited from MG4 use as a massive  $A'$  photon generator
    - A factor of 15% overestimate of WABs
    - Officially resolved?

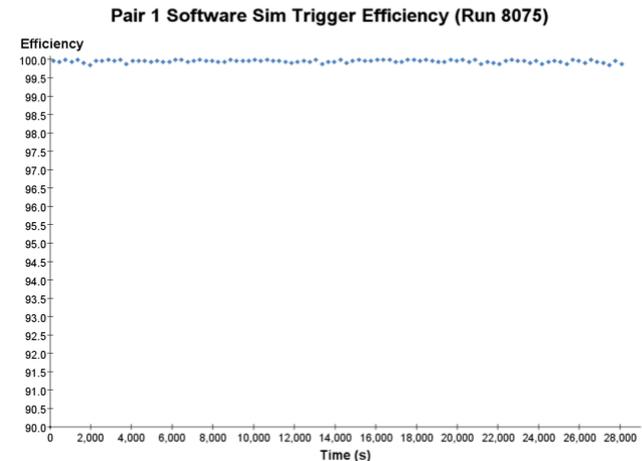
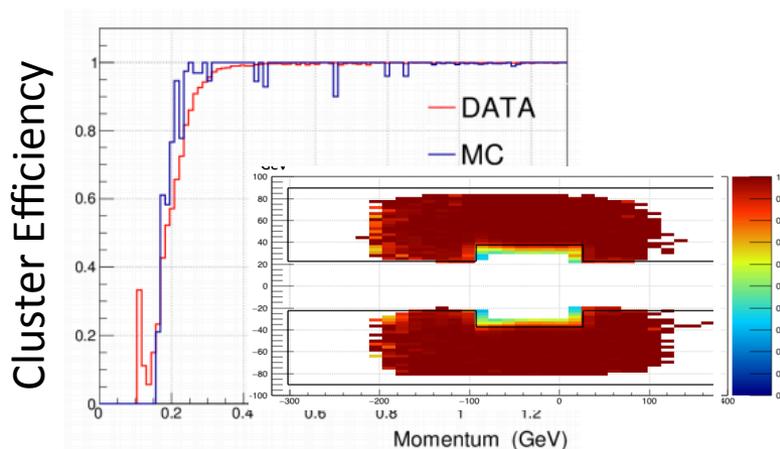
# Summit Followup: MC (3)

- Cosmic gains used in the real trigger were off by as much as 10%
  - relative to best gains measured with FEE and checked with WAB/Moller
  - Kyle showed the effect is small via proper simulation
    - Best gains in readout (GeV $\rightarrow$ ADC)
    - Online cosmic gains in trigger decision (ADC $\rightarrow$ GeV)



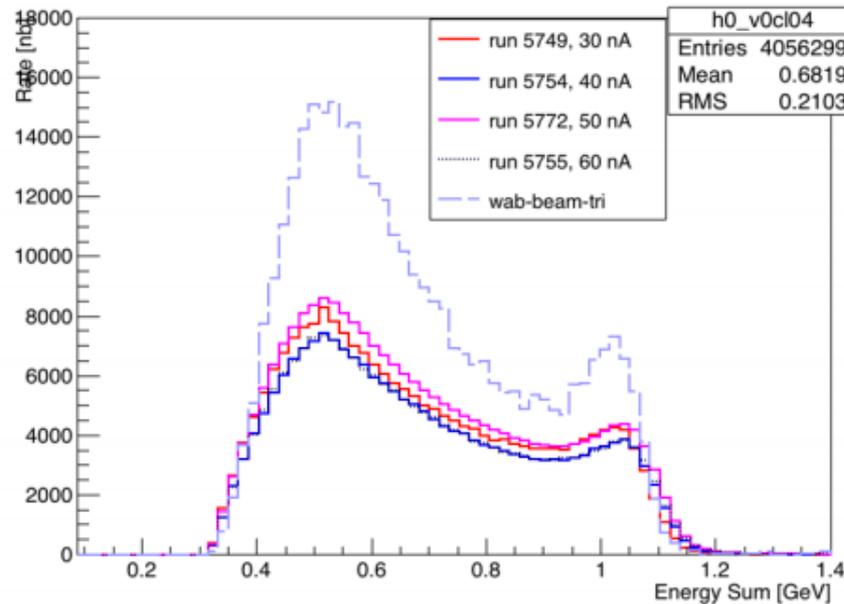
# Summit Followup: ECAL/Trigger Checks

- Cluster Efficiency
  - based on pulser triggers and good tracks pointing to calorimeter
    - very good agreement with MC across full energy range
- Trigger Efficiency
  - Rigorous simulation of trigger hardware/software
    - given clusters that were readout and recorded trigger information, efficiency ~100% (Kyle)
- Overall Efficiency
  - based on pulser triggers and tracks that look like they should have created a pair-1 trigger
    - using  $\frac{3}{4}$  of full 2015 data, suggests effective pair-1 efficiency of at least 95%



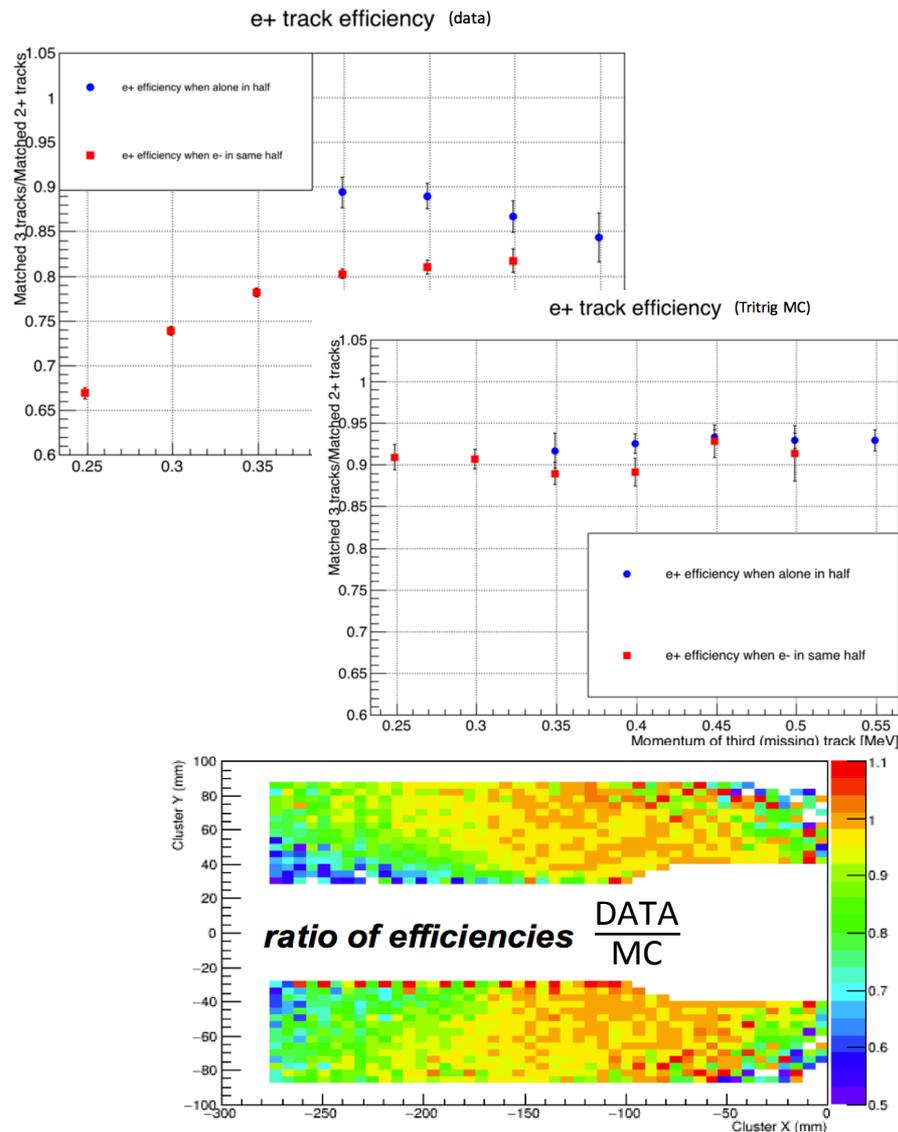
# Summit Followup: Current Dependence

- ECal-only normalized rates show small current-dependence (Holly)
  - FEE, and trident-like selection
- Tracking efficiency also a current-dependence not fully reproduced in MC, but not large



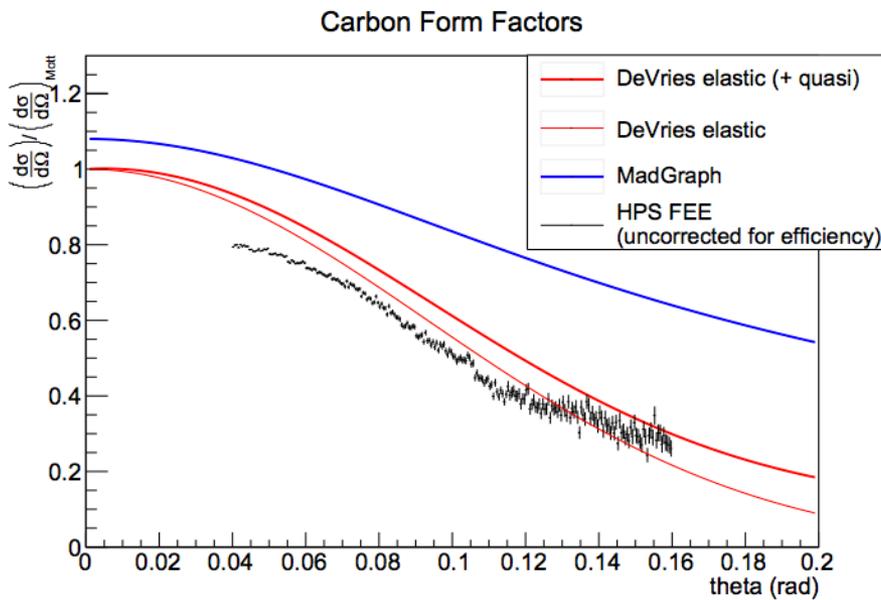
# Summit Followup: Tracking Efficiency

- Two different measures
  - 2- and 3-prong tridents
  - in rough agreement with each other
- Definitely some momentum-dependent discrepancy with MC
  - not huge, but needs to be finalized and included in physics analysis

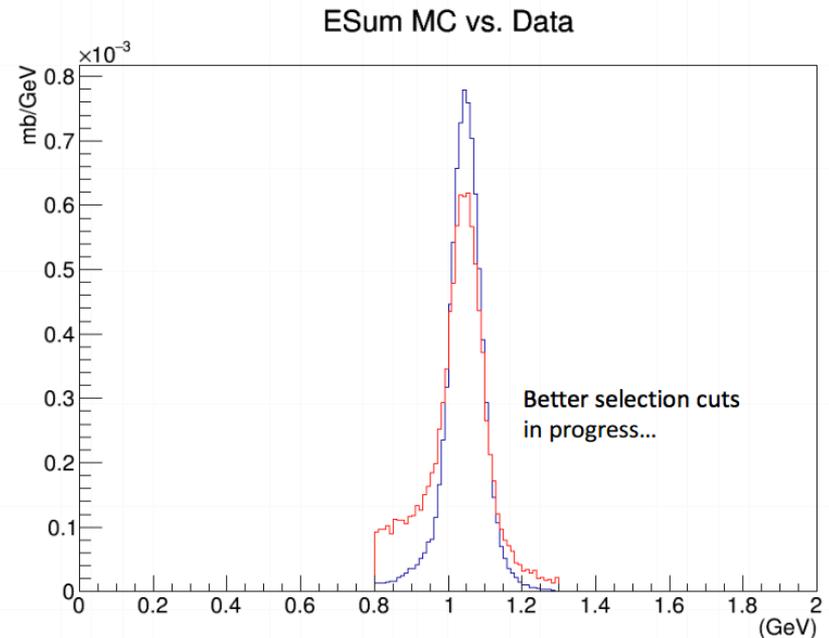


# FEE/Moller Rates

- Shown to be within ~20% of expected based on full MC



## Moller



# Trident Summit Followup Summary

[https://  
confluence.slac.stanford.edu/  
display/hpsg/Trident+Summit  
+Followup+Summary](https://confluence.slac.stanford.edu/display/hpsg/Trident+Summit+Followup+Summary)

## Tridents/WABs

- Trident/WAB ratios in MC and Data
  - 3-prong yield ratios of ( $e^+e^-e^+$ ) and ( $e^+e^+e^-$ )
    - Rafo (Sep 25)
  - 2-prong  $e^+e^-$  kinematic shapes (esp. Esum)
    - Rafo (July 25)
    - Sho (Aug 12) 1, 2, 3, 4, 5
    - Sho's Defense Slides (pages 23 and 24)
    - Matt (Oct 7 New MC)
  - Ecal-Only 2-prong Esum
    - Rafo (Oct 7 New MC)
    - Holly (Aug 24), (Oct 7 New MC)
- Trident Event Generator Comparisons
  - Luca (relative shapes, Sep 28)
  - Rafo (absolute normalization, Oct 14)
  - Takashi (absolute normalization with fast-mc)
- WAB Identification/Rejection
  - Norman (Aug 5, Aug 10)
  - Sho's Defense Slides (page 28)
- APEX WABs in Madgraph
  - Takashi (Aug 19, Aug 24, Aug 31)

## Møllers/FEE

- Møller MC/Data Cross Section
  - 2015, 1 GeV (Brad Oct 21)
- FEE MC/Data Cross Section
  - 2015, 1 GeV (Sebouh/Matt)

## Tracking Efficiency

- From 2-prong tridents
  - Matt (There was one with comparison with MC, can't find it. Is there one with top/bottom separately?)
  - Luminosity-dependence, Matt (2 GeV data: 200 nA, 300 nA)
- From 3-prong tridents
  - Holly (1 GeV data: Sep 21, Sep 30, Oct 7, Oct 11)

## ECAL/Trigger Efficiency

- Ecal Cluster Efficiency Based on tracks and clusters from pulser triggers
  - Nathan (Aug 5)
- Trigger Efficiency
  - Based on "Pair-1" tracks and TI bits from pulser triggers
    - Nathan (Sep 14)
  - Based on Pair-1 clusters and TI bits from pulser triggers
    - Kyle (Sep 9)
- Effect of Using (ln)Correct Gains in MC Trigger
  - Kyle (Oct 14)

## Rate dependence

- Ecal-Only Esum shape
  - Holly (Aug 24)
- With SVT
  - Sho

## "Missing" Tracks

- Matt (Sep 9, Sep 16)

## Z-Dependence of Tracking Acceptance

- Sho (Aug 12)



# Next Steps

1. Need decision, consensus on WAB and trident event generators, expert approval
2. Full MC production of correct wab-(beam)-tri
3. Finalize data/mc ratio of tracking efficiency (at least momentum dependence)
4. And WAB/Tri normalization for radiative fraction, needed by any HPS A' search

# Path to 1<sup>st</sup> Publications

- General scheme hasn't changed significantly since previous collaboration meeting
  - *Overall timeline delay ~6 months, as last few months of focus spent on addressing critical normalization issues*
  - 1.05 GeV bump hunt will be first
    - Omar now actively optimizing/finalizing cuts (on 10%)
    - conference release now expected in January
    - time to form a review committee (?)
    - will publication include 1.5 mm data?
  - Followed by 1.05 GeV vertexing
    - Holly finalizing analysis (on 10%)

# Summary

- Large efforts since ~June on understanding the “trident problem”, a discrepancy between MC/data pair rates
  - Much progress, no single cause but a few contributors that are being accounted for
    - WAB background becoming well understood, Madgraph5 agrees much better with data than MG4, some momentum-dependent inefficiencies
- Nearly ready to get back on track to finalize physics results and publish
  - Unblinding requirement discussion at end of today (Stepan)
- Updated reach estimates with what has been learned since the proposal (see Matt’s talk)