Monte Carlo Status

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Spring 2017 Collaboration Meeting

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MC Status Summary

- MadGraph5 is now used for all tridents

- A more efficient background (“tritrig-wab-beam”) is available for acceptance/reach studies, made by artificially raising the trident rate

- Tuples for FEE, Mollers, and tridents are now being generated at recon, along with the output slcio/DST files

- The most recent Monte Carlo (all detectors) is in “production/rotationFix”, named for a tweak in the event processing before SLIC

- Scripts and software needed to run Monte Carlo are now in a git repository

MC Generator types

Monte Carlo events come from several different generators:

- Egs5 (scattered beam, Mollers)
  - Events are generated only using egs5
  - HPS target parameters are set (thickness, current)

- MadGraph (tri, tritrig, wab, ap, TM)
  - Events are generated with MadGraph
  - Scattering within the HPS target is then handled using egs5
  - MadGraph cross sections used to mix events with egs5 beam events

- Geant4 (hadrons)
  - A macro is set up and run using an xml script: /u/group/hps/production/mc/EngRun2015Scripts/stdhep/hadrons.xml

MC Components from egs5
(egs5 generation -> .stdhep output)

- Scattered Beam (egs5, beam_v5)
  - Saves all events passing the following cuts:
    - Photon theta_y > 4 mrad
    - Electron energy > Ebeam*0.005
    - Electron energy < Ebeam*0.6 and Electron theta > 15 mrad

- Mollers (egs5, moller_v3)
  - Saves after-target events from Moller subroutine if:
    - Electron energy > 10 MeV
    - Electron theta > 5 mrad
    - May also save photons/positrons from the event

2 versions of MadGraph

- MadGraph5 (all tridents)
  - Tritrig (full diagram. Unbiased tridents without sum cut is unstable)
    - ESum cut > ~Ebeam/2
  - RAD (radiative only, no exchange term)
  - BH (Bethe-Heitler only, no exchange term)

- MadGraph4
  - wab (wide-angle bremsstrahlung)
  - A’ signal (and anything else made using this generator)

MC Production Chain

- After generation and any further processing with egs5, the remaining simulation steps are:
  - SLIC
    - The background mixing using MadGraph cross sections, and the 30.5 mrad beam offset happens **BEFORE** this step
    - This is also when most .lhe events get converted to .stdhep (via egs5)
    - Scattering of lhe events is simulated within a target volume by egs5 before offsets are applied
      - Scripts that perform the things in this step are in hps-mc/mc_scripts/slic/
  - Readout
    - Non-XS-mixed pure signals (tritrig, A') are spaced out by 250 blank events to avoid pileup before this step (org.hps.users.meeg.FilterMCBunches)
    - Standard Clustering + Triggering procedures are then applied via HPS-java
      - Scripts that perform this step are in hps-mc/mc_scripts/readout/
  - Recon
    - Standard track Finding + Fitting + Vertexing in HPS-java
      - Scripts that perform this step are in hps-mc/mc_scripts/recon/

Mixing Procedure before SLIC (wab-beam-tri)

- All .lhe (MadGraph) events are
  - Processed through egs5 (.lhe -> .stdhep)
  - Target thickness and beam current are set, as it is for scattered beam generation
  - After this, any tridents without a parent are given a 622 ('stdhep/add_mother')

- "Rotated" about y, and moved in z by -5mm (stdhep/beam_coords)

$$vtx\_x' = vtx\_x * cos(\theta) + vtx\_z * sin(\theta) \qquad px' = px * cos(\theta) + pz * sin(\theta)$$
$$vtx\_z' = vtx\_z * cos(\theta) - vtx\_x * sin(\theta) \qquad pz' = pz * cos(\theta) - px * sin(\theta)$$

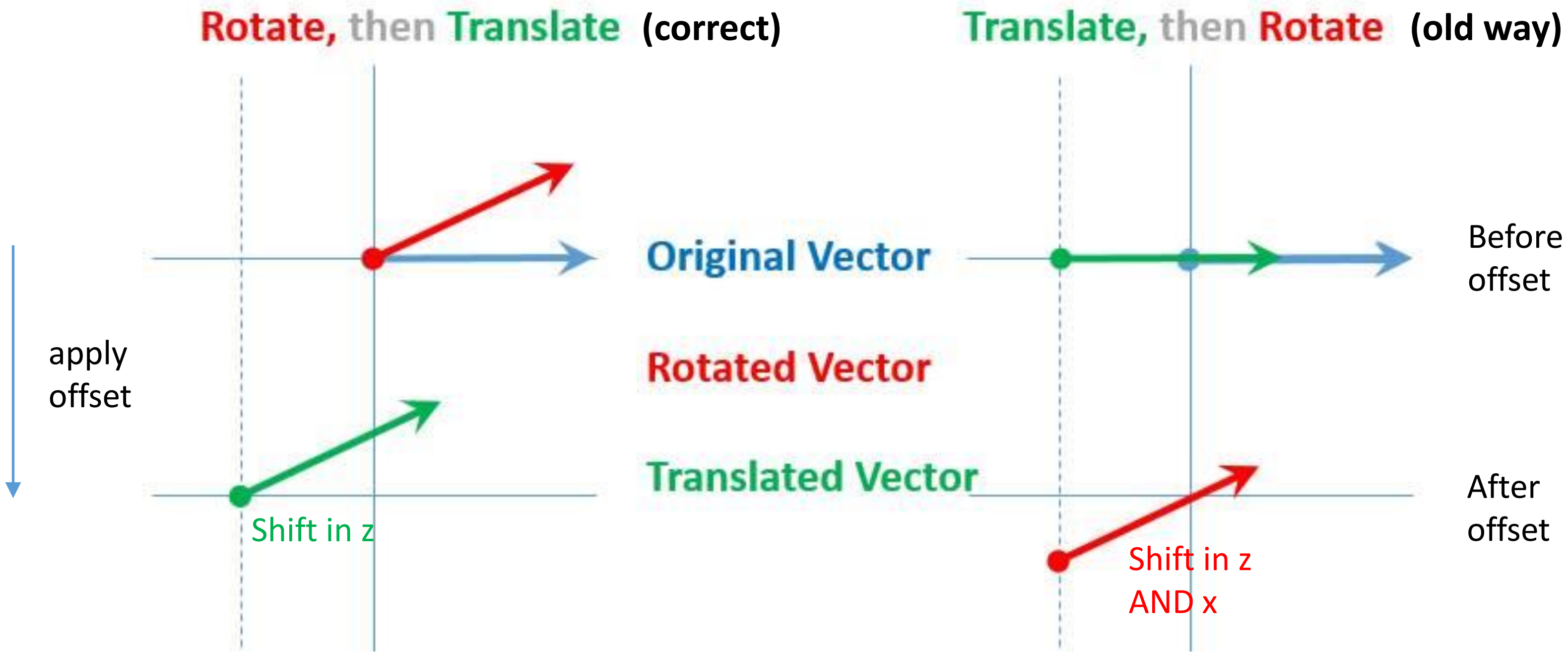
30.5 mrad

  - Vertex positions are then sampled within a beamspot of user-defined Gaussian widths: $\sigma_x = 0.3\ mm \ \ \sigma_y = 0.03\ mm$

- "Poissonized" (stdhep/merge_poisson)
  - Events sampled from a Poisson distribution, based on MadGraph integrated cross section (must be correct!)

Recent MC Change: “rotationFix”

- Recent change in Pre-SLIC rotation/translation order



- Will avoid a slight beamspot shift in –x

Mixing Procedure before SLIC (wab-beam-tri)

- Poisson Sampling procedure
  - Takes an input stdhep file, and writes a random # of events into a new stdhep file, sampled from a Poisson distribution. These events get merged with beam events
  - This Poisson distribution is weighted according to the MadGraph integrated cross section and calculated luminosity

$$\#\ \boldsymbol{of\ sampled\ events = gsl\_ran\_poisson(r, \mu)} \xrightarrow[\text{distribution}]{\text{probability}} \frac{\mu^{r} e^{-\mu}}{r!}$$

$$\mu = mean\ \#events\ \ per\ sampled\ event$$
$$= luminosity * \sigma$$
$$= density * thickness * bunchsize * \sigma$$

$density$
$= 6.306 * 10^{-2}\ \ atoms/(cm * barns)$

$thickness = 0.0004062\ cm$

$bunchsize(I) = 625\ (50nA), 2500\ (200nA)$

- 1 bunch = 2ns of beamtime
- 500k bunches per background file => 1ms per file
- Typical wab-beam-tri sample (10k SLIC files): **5 Billion bunches = 10 sec.**

Mixing Procedure before SLIC (wab-beam-tri)

- Each beam file is randomly sampled into 100 files using 100 different seeds

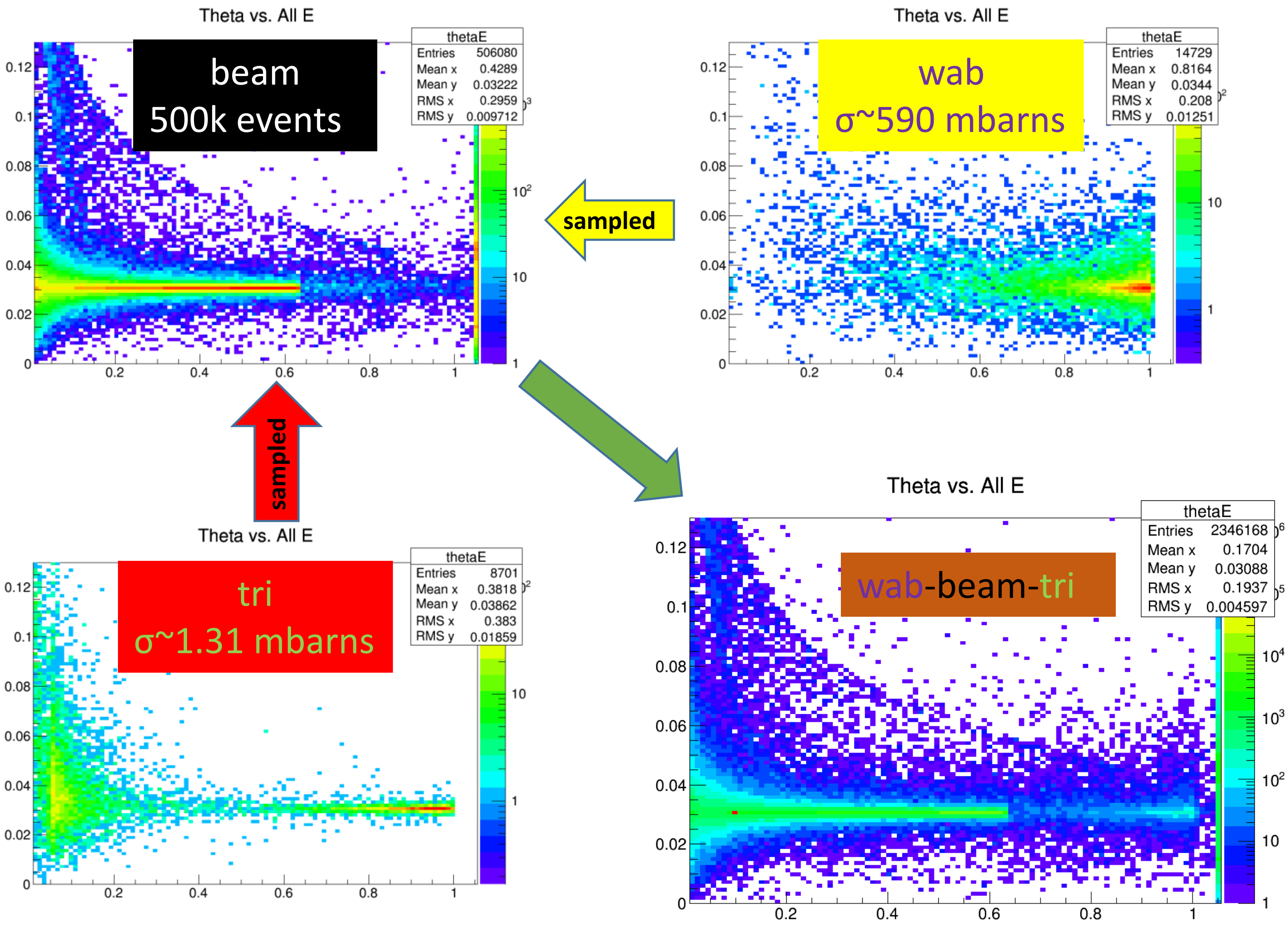
  …/hps_soft/stdhep/src/random_sample.cc

  - For the beam's Poisson distribution, $\mu = \frac{\#\ of\ generated\ events}{500k} \sim 1.4$
  - After sampling, each beam file contains 500k events

- Each signal file is also sampled into 100 files (according to cross section), and each of these 100 files are merged with sampled beam files 1-to-1
  - hps-mc/stdhep/src/merge_files.cc
  - Each mixed file contains 500k events to be run through SLIC

- After SLIC, each of these 100 files are readout at the same time
  - where the "100to1" tag comes from

Mixing Procedure before SLIC (wab-beam-tri)



beam
500k events

wab
σ~590 mbarns

sampled

sampled

tri
σ~1.31 mbarns

wab-beam-tri

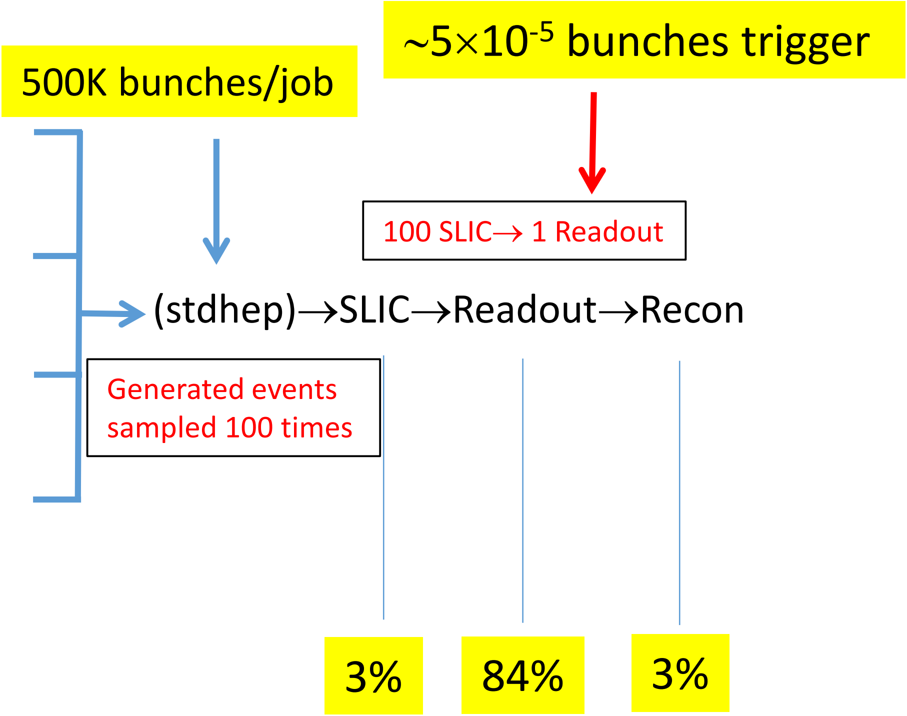
After SLIC

- Files are readout, either 10-to-1 or 100-to-1 (explicitly labelled)
  - /org/hps/steering/readout/EngineeringRun2015TrigPairs1_Pass2.lcsim
  - /org/hps/steering/readout/EngineeringRun2015TrigSingles1_Pass2.lcsim
- Then reconstructed
  - /org/hps/steering/recon/EngineeringRun2015FullReconMC.lcsim
  - The latest MC (output from every step + DSTs + tuples) is in /mss/hallb/hps/production/rotationFix

MC chain for wab-beam-tri (flowchart)

- Beam background (one record per bunch)
  - EGS5 →(stdhep)→(rotate)
- Trident
  - MG5 → (lhe) → EGS5 →(stdhep)→(rotate)
- WAB
  - MG4 → (lhe) → EGS5 →(stdhep)→(rotate)
- Hadrons
  - Geant 4 → (stdhep)→(rotate)

Saved permanently



$\sim 5\times10^{-5}$ bunches trigger

500K bunches/job

100 SLIC→ 1 Readout

(stdhep)→SLIC→Readout→Recon

Generated events sampled 100 times

CPU Time: 10% 3% 84% 3%

~few days / 10 sec long beam time (5 billion bunches) + overhead for job failures

Disk space: ~5 TB / (10sec beam time) dominated in the SLIC-Readout step

10× more statistics is doable, but 100× is the “effective limit” (months of production).

However, in an effort to help increase statistics…

New MC type: tritrig-wab-beam

- A MG5 updated version of “tritrig-beam-tri”

- Mixing tridents by cross section before SLIC (WBT) is very inefficient
    - ~270,000 triggered events per 5,000,000,000 bunches

- Instead, mix tridents into “wab-beam” after SLIC, but before readout
    - Space tridents by 250 bunches (~4 trigger windows) and insert into beam
    - Each readout event is approximately a trident event
    - ~8.7 million triggered events per 5,000,000,000 bunches (32x increase!)
    - A much more efficient way to increase statistics
    - However, the trigger rate is artificially increased to ~2 MHz
        - Please be aware of this when normalizing

- “wabtrig-beam-tri” can be made the same way to study wab backgrounds

New MC type: tritrig-wab-beam

- Full MadGraph5 tridents are only “tritrig” (tridents with an ESum cut)
- Unbiased (uncut) MG5 tridents below ESum~Ebeam/2 give an unstable cross section across files
- Since there is a trident event inserted in each trigger window, unbiased ones are left out from pre-SLIC mixing for now. MG4 “tri” would need to be used for this (but probably shouldn’t).
- Tridents are inserted at 2 MHz (20k events per 10 ms of beam), so this may be difficult to normalize. More of a hack to get events with background.

New MC repository to house framework

- https://github.com/JeffersonLab/hps-mc.git

- Contains everything needed to run the MC chain:
  - EGS5 + HPS-specific configs
  - Madraph4 + Madgraph5 generators
  - Stdhep programs needed for pre-SLIC processing
  - Scripts to submit MC jobs to a batch farm

- Jeremy has been tweaking the layout and creating wrappers to build everything more easily

For more information on how to run MC or what the files contain,

- https://confluence.slac.stanford.edu/display/hpsg/MC+Production

How to run:

- 2015 MC Production using a Command Line
- 2015 MC Production Using Scripts

Normalizations:

- https://confluence.slac.stanford.edu/display/hpsg/MC+Generated+Cross+Sections

- If you need something, or run into issues, please email Takashi and me

MC Tasklist (discussion)

- At least 100 sec. of Nominal/L0 tritrig-wab-beam (all energies)
- 2.3 GeV everything
- “Wabtrig-beam-tri”
- More 1.056 GeV A’
- 1.5mm
- Rough Priority? (Publications/upgrade -> who’s graduating next?)

Backup

Les Houches Events (.lhe->.stdhep)
MadGraph generation + Egs5 Scattering

- Unbiased Tridents (“tri”, e- N+ > e- N+ e+ e-)
  - MadGraph cuts:
    - 50 MeV< e+ energy < 100 GeV
    - 10 mrad < e+ theta_y < 100 rad
    - No additional cuts in egs5 (lhe_v1)

- Preselected Tridents (“tritrig”, same diagram)
  - MadGraph cuts:
    - 50 MeV < e+, e- energy < 100 GeV
    - 10 mrad < e+, e- theta_y < 100 rad
    - 10 MeV < invariant mass < 100 GeV
    - ESum > 500 MeV (for 1.056 GeV beam)
    - No additional cuts in egs5 (lhe_v1)

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    - No additional cuts in egs5 (lhe_v1)

    - e- N+ > e- N+ f+ f-   @3 (RAD)
    - e- N+ > e- N+ f+ f-   @2 (BH)

“RAD” and “BH” can also be generated separately, and have distinguishable electrons

Les Houches Events (.lhe->.stdhep)
MadGraph generation + Egs5 Scattering

- WAB (“wab”, f- N+ > f- N+ x)
  - MadGraph cuts (similar for unbiased tridents)
    - 50 MeV< e+, e- energy < 100 GeV
    - 10 mrad < e+, e- theta_y < 100 rad
    - No additional cuts in egs5 (lhe_v1)

- A’ (“ap”, e- N+ > e- N+ (x > f+ f-))
  - MadGraph cuts (virtually none)
    - e+, e- energy < 100 GeV
    - e+, e- theta_x,y < 100 rad
    - Invariant mass < 100 GeV
    - No additional cuts in egs5 (lhe_v1)

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No egs5 scattering for A’s

Decay length is applied
during stdhep conversion
(“stdhep/lhe_tridents”)

MadGraph Generator Scripts

- Scripts that run MadGraph:

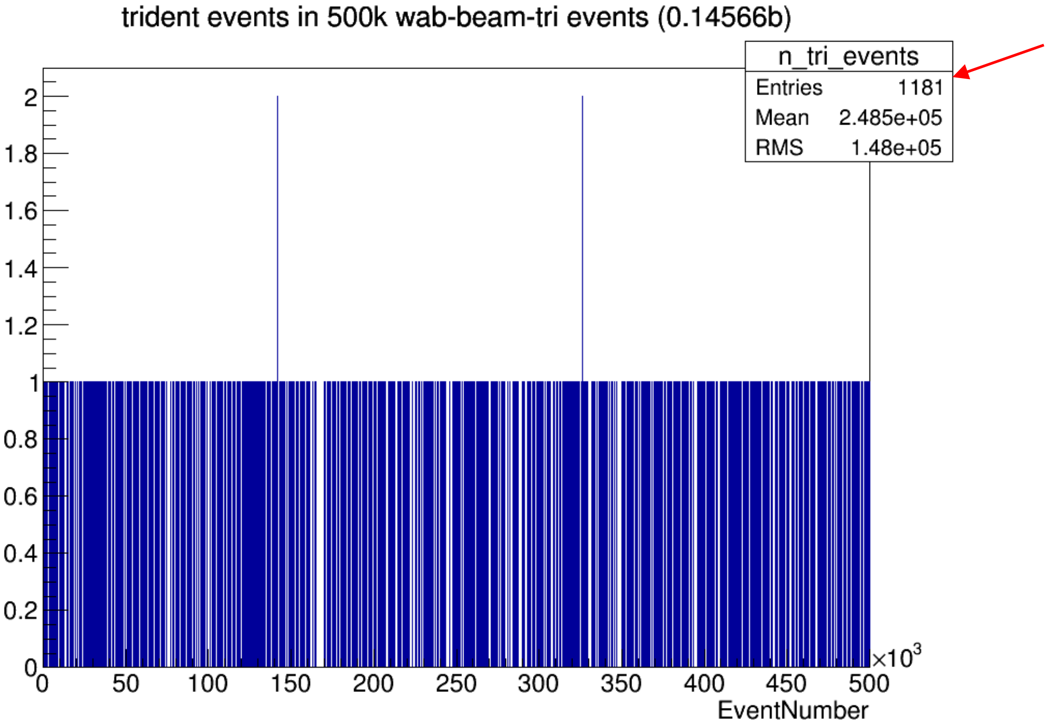
/u/group/hps/production/mc/EngRun2015Scripts/lhe/

- The generators and run cards can be found here:

/u/group/hps/production/mc/MadGraph/

To Calculate Expected Tridents in a WBT File

# of trident events per 500k bunches =
(0.14566 barns)*(6.306*^-2 nuclei/barn-cm)*(0.0004062 cm)
(625 electrons/bunch)(500000 bunches)
= **1166**



MC directory naming (/mss/hallb/hps/production/***/...)

postTriSummitFixes :

Incorporates the following fixes/improvements that took effect after the Trident Summit:

- WAB events are now unweighted (labelled '**wabv2**')
- The WAB process is now suppressed in egs5, since it was not being handled correctly (the electron was not being scattered). This also prevents double-counting the MadGraph WABs. (files labelled '**egsv5'**)
- Updated target thickness (now 4.062 um from 4.375 um). Calculated from Clive's Note
- MC events are shifted 5mm along the z-axis to account for a discrepancy in target position
- New detector geometry that removes extraneous material (EngRun2015-Nominal-v5-0-fieldmap)
  - The carbon fiber volume in the L1-3 half-modules was previously too large, obstructing the beam.
  - 1.5mm SVT version is also available
- GEANT4/SLIC has been updated to 10.01.p03/REL, from 10.01.p02/HEAD.
- Additional 'wab-beam-tri' tags within the 'postTriSummitFixes' directory:
  - **500kBunches:** Enough WABs were guaranteed to be generated in order to make 500k bunches (1ms) of mixed background per SLIC file, 10ms per recon file. Corrects the overall normalization of wab-beam-tri in analysis.
  - **zipFix:** 500kBunches + fixes another small error which potentially prevented photons from being handled correctly
  - **T0Offset:** Recon used the same steering file as for data recon, which sets 'correctT0Shift' and 'correctChanT0' flags to 'true' in RawTrackerHitFitterDriver (determined to not be the correct way to process MC)
- **The "most correct" 2015 wab-beam-tri files are currently labelled 'zipFix' (NOT T0Offset!)**

Other 2015 MC directories (/mss/hallb/hps/production/***/...)

Pass #

- Uses a jar (also tagged in the file name) that matches an 'official' data pass of the same number

DBGainsPass

- Database runtime gains used for readout

LucaTri

- Luca’s various Vegas trident generator tests (labeled by date)

Layer0Studies (older L0 studies, “rotationFix” is updated)

- A pass using the new Layer-0 detectors will go here