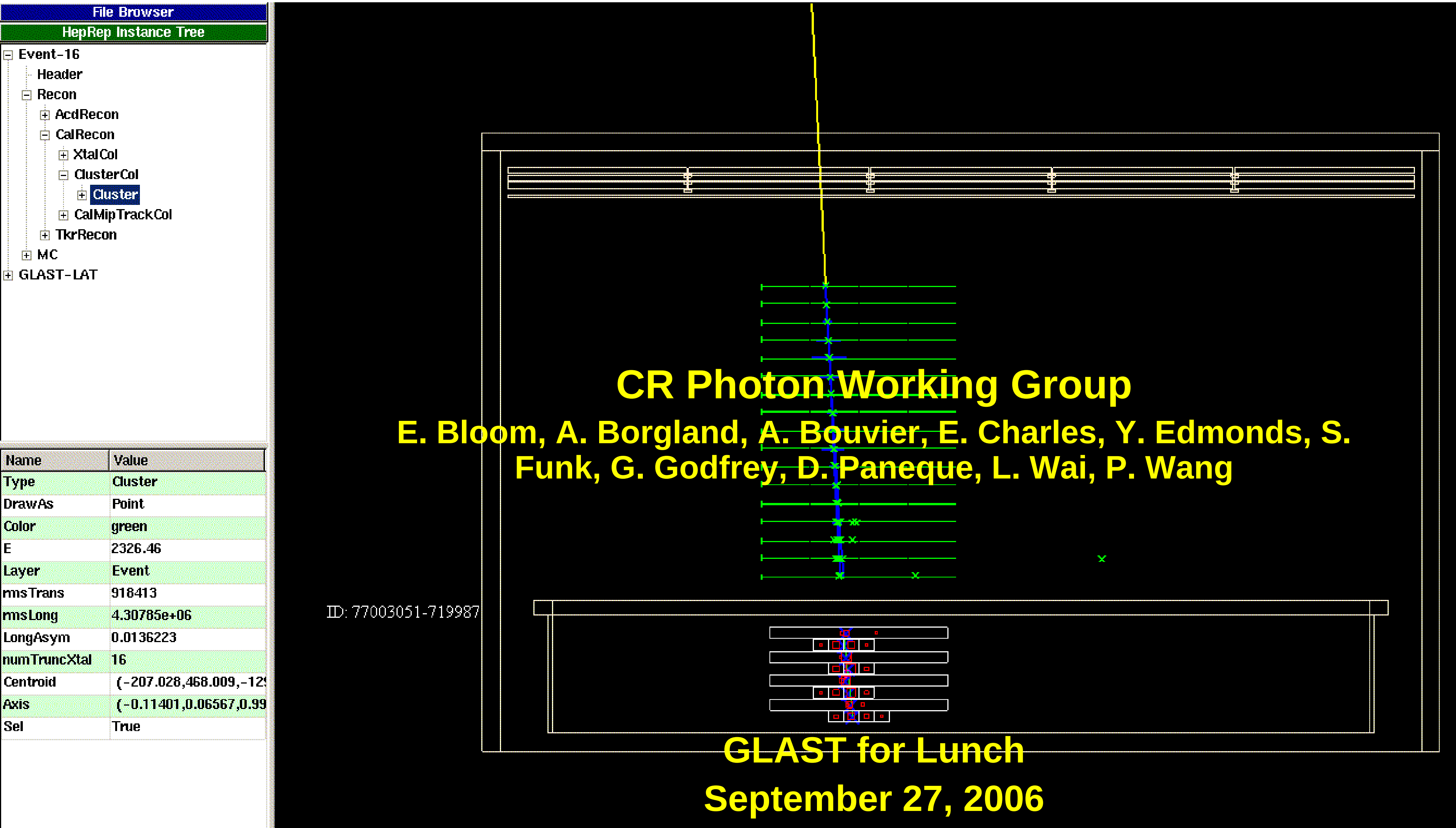
GLAST LAT

Comparison of Ground Cosmic Ray Photon Data in the LAT with GLEAM MC.

Preliminary results in an ongoing study.



CR Photon Working Group

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GLAST for Lunch

September 27, 2006

Overview

- **Goals:**

1. **Calibrate ACD and make ACD cuts at 0.25 MIPs in both the CR data and MC. Currently data has MIPS > 0.02 and MC > 0.1. Some ACD variables are calculated for MC and not for data. – Anders, Eric, Yvonne**
2. **Select Photon data from LAT Cosmic Ray (CR) data. This photon data is of high purity - Gary, Ping**
3. **Compare splash back in MC and real data – Larry**
4. **Bootstrap incoming photon spectrum by using MC efficiencies vs. energy applied to photon data. - Ping**
5. **Compare photon data to MC using rForest techniques - Aurelien, David, Stefan**

Method used to Select a CR Photon Beam

- **Photon Selection Method:**
  1. Obtain final photon data (Photons) from CR data, using cuts derived from all-gamma-MC, checking single event displays on real data to find additional cuts that clean up the sample.
  2. Check photon cuts on muon MC and show that the photon cuts remove essentially all muons (~ 10^{-6} rejection of muons).
  3. Define a CR beam well contained in the fiducial volume of the LAT using all gamma MC cuts. Check against MC truth and Photons.
  4. Estimate input photon energy spectrum for real data in the fiducial volume by using all-gamma-MC input/output ratio (efficiency vs. energy).
  5. Use this input spectrum and fiducial cuts with all-gamma-MC.
  6. Compare this new MC photon sample and Photons (both after final cuts), using rForest technique. Generally find good agreement with some exceptions.

Select pure photons …

- Fiducial Beam cuts
  - -500 < VtxX0, VtxY0 < 500 Include picture
  - VtxZDir < VtxZDir_critical

- Photon purity cuts (MC and Photon data study)
  - AcdTileCount = 0 (MIPs/tile < 0.25)
  - AcdRibbonCount = 0 (MIPs/Ribbon < 0.25)
  - AcdCornerDoca < -5 or AcdCornerDoca > 50
  - 30 < CalEnergyRaw < 20000 – MC range
  - 0 < CalEdgeEnergy < 20 – control leakage
  - 0 < CalTransRms < 35 - good shape for shower, reject multiple particles
  - 0 < CalTrackAngle < 0.8 – photon track lines up roughly in tracker and cal
  - -180 < CalZEcntr < -50 – photon energy centroid not too far back in cal
  - 0.5 < TkrNumTracks <3.5 - 1 or more tracks but not too many

Check photon cuts on muon MC

- EM-v6r070329p16/surface_muons_4M (May/06)
  - Totally 2141283 events
  - After cuts, 6 events left (3e-6 rejection)

Photon Energy Variable

- Use derived energy variable **EvtEnergyCorr_CalCfp**

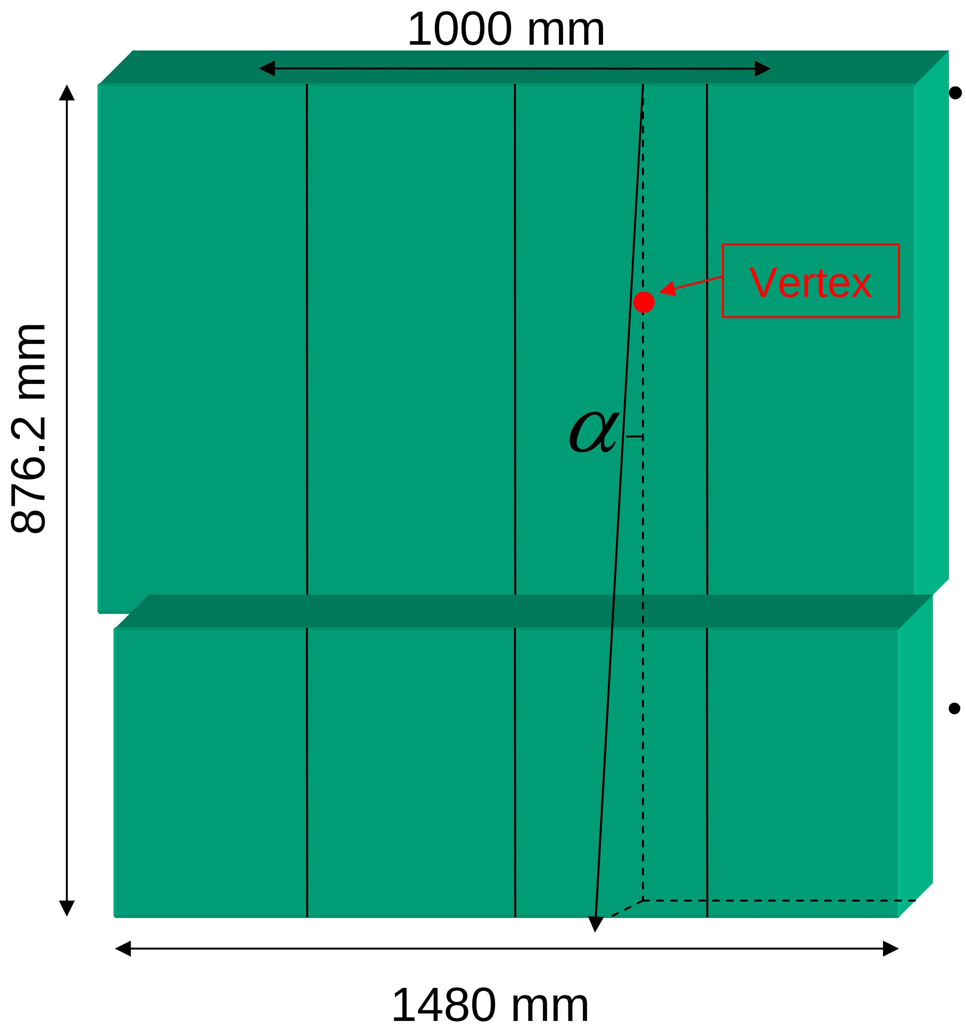
$$EvtEnergyCorr\_CalCfp = \begin{cases} EvtEnergyCorr & \text{for CalEnergyRaw < 1GeV} \\ CalCfpEnergy & \text{for CalEnergyRaw > 1 GeV and CalCfpEffRLn > 4} \\ -1 & \text{otherwise} \end{cases}$$

Use EvtEnergyCorr_CalCfp as the best estimate of photon energy.

We will throw away some events during the spectrum reconstruction, but it's only a small fraction.

(Ref.: http://polywww.in2p3.fr/~bruel/CalFullProfile.ps)

What is VtxZDir_critical?



- VtxZDir_critical = $-\cos\alpha$

  If abs(VtxX0) > abs(VtxY0),

  $$\tan\alpha = \frac{740 - abs(VtxX0)}{876.2}$$

  If abs(VtxX0) < abs(VtxY0),

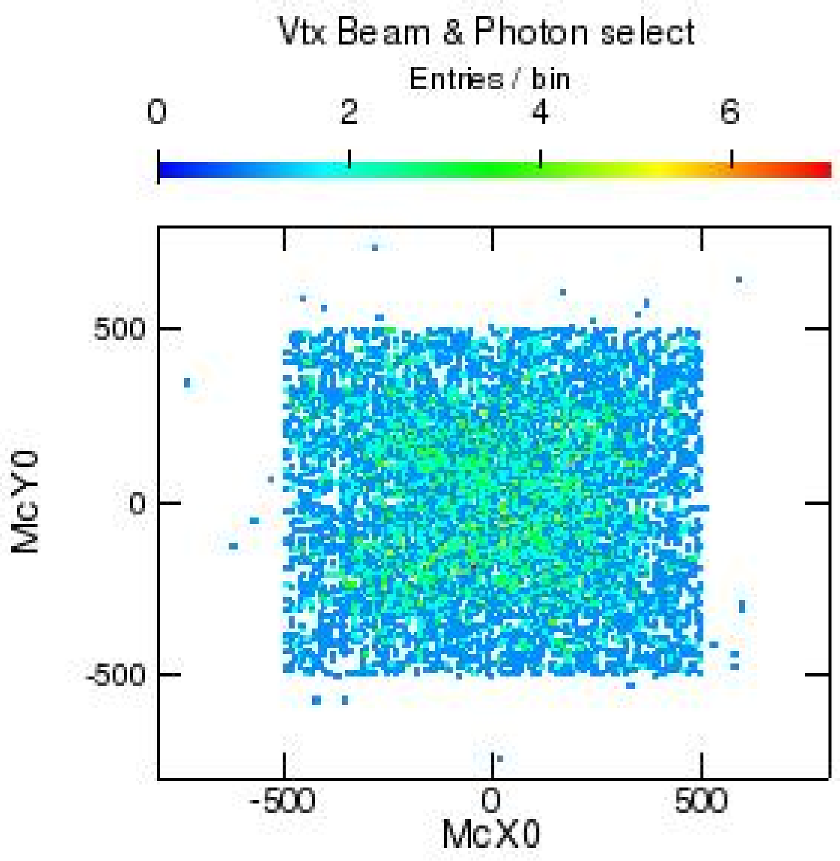
  $$\tan\alpha = \frac{740 - abs(VtxY0)}{876.2}$$

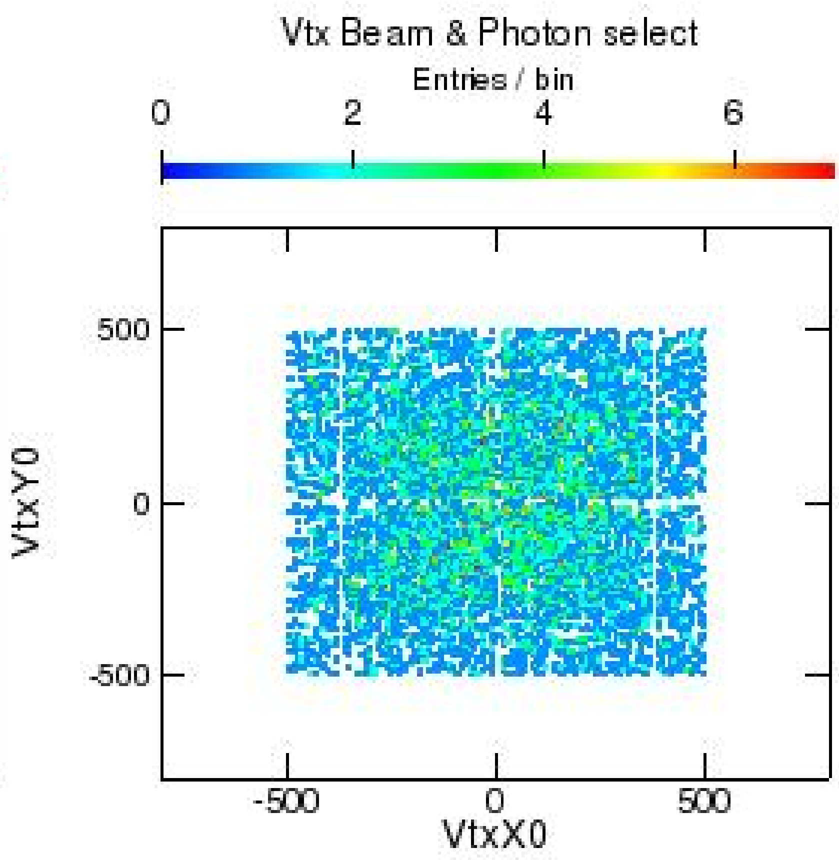
- Make sure all the photons go through the whole CAL. Conservative fiducial cut.

The spatial fiducial volume distribution after cuts (I)

Use MC data 1 to compare measured values with true MC values

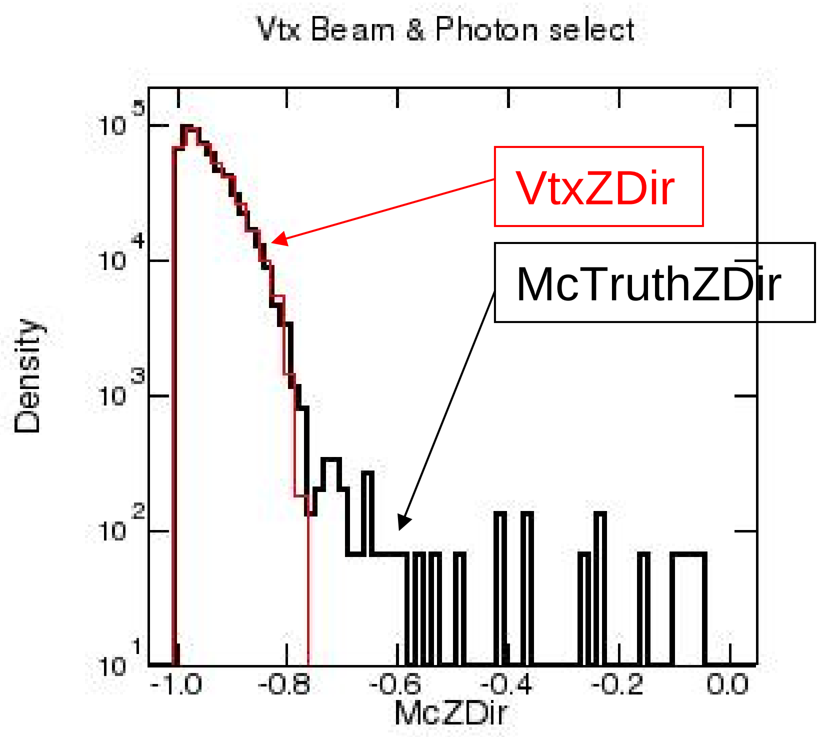
- **(McX0, McY0) Vs. (VtxX0, VtxY0)**





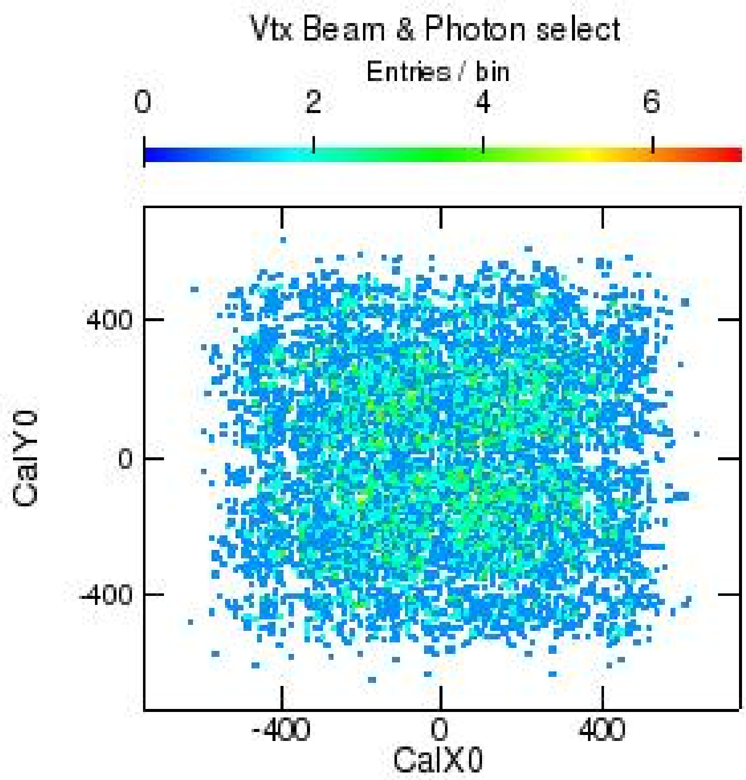
The spatial fiducial volume distribution after cuts (II)

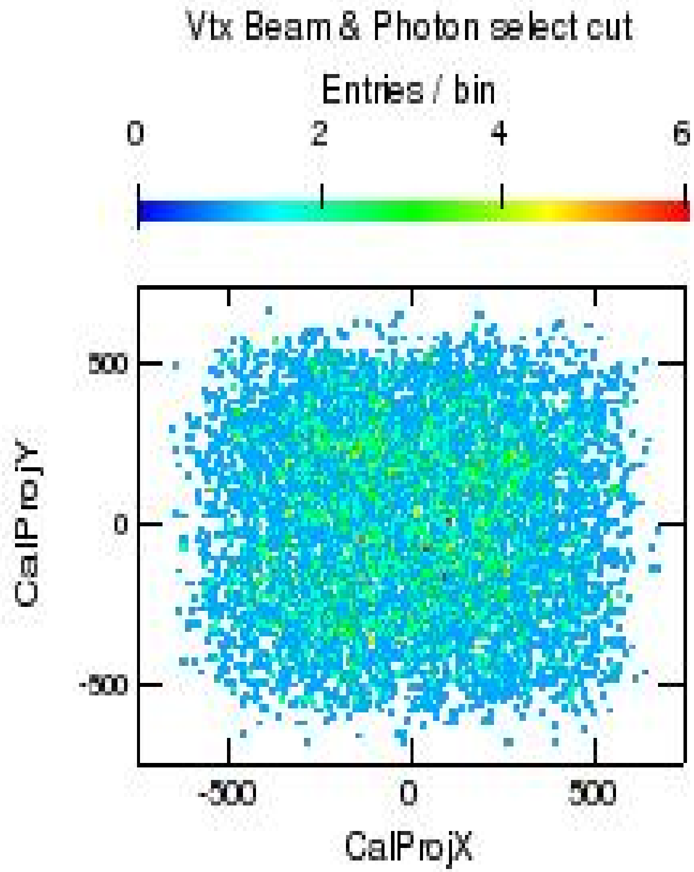
- McTruthZDir Vs. VtxZDir



The spatial fiducial volume distribution after cuts (III)

- (CalX0, CalY0): position of CAL "track" measured at the energy centroid
- (CalProjX, CalProjY): projection position of TKR “track” to the bottom of CAL





Input energy spectrum iteration

1. **Use Ander's all gamma MC data (MC-A input spectrum) to obtain the selection efficiency**

$$\mathbf{Efficiency = Output_{MC}(E_\gamma)/Input_{MC}(E_\gamma)}$$

1. **"Real" Photon Input spectrum processed through purity cuts**

$$\equiv Output_D(E_\gamma)$$

2. **Obtain MC-Bootstrap input CR photon spectrum using**

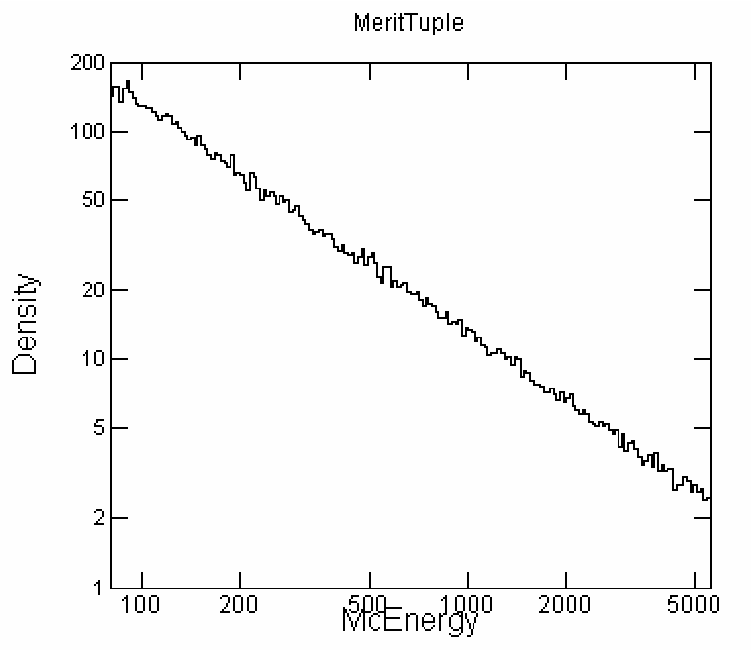
$$= Output_D(E_\gamma) / Efficiency$$

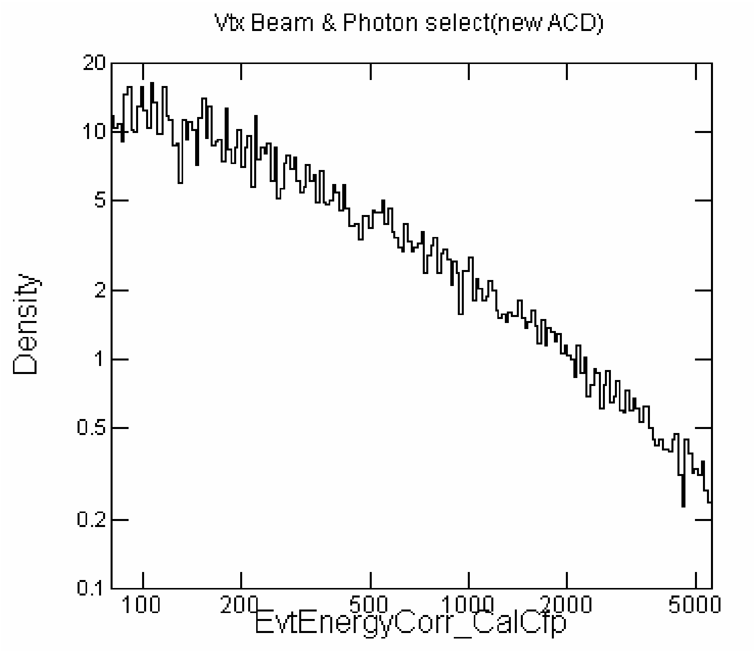
The Final Input spectrum for Photon data in Bldg 33 (I)

- Because of the potential backsplash effect, fit the after-cut spectrum up to 5 GeV. (We use the range from 80 MeV to 5 GeV)

- Follow the input energy spectrum iteration

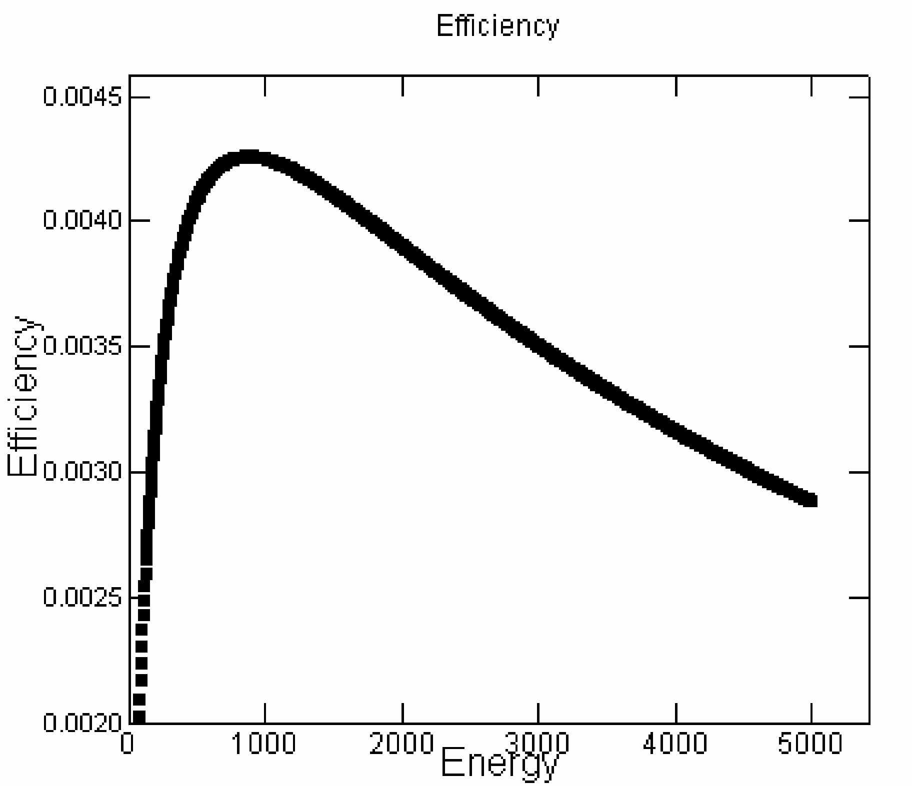
1. The input and output MC spectrum (MC data 1)



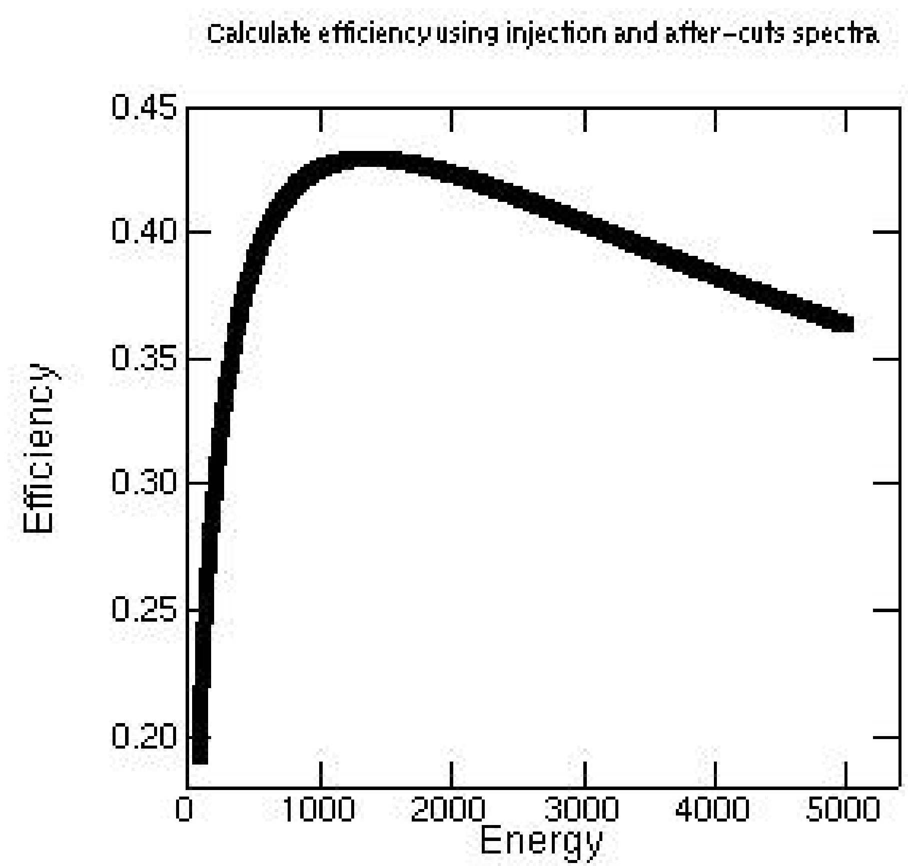


The Final Input spectrum for Photon data in Bldg 33 (II)

2. **Selection efficiency**

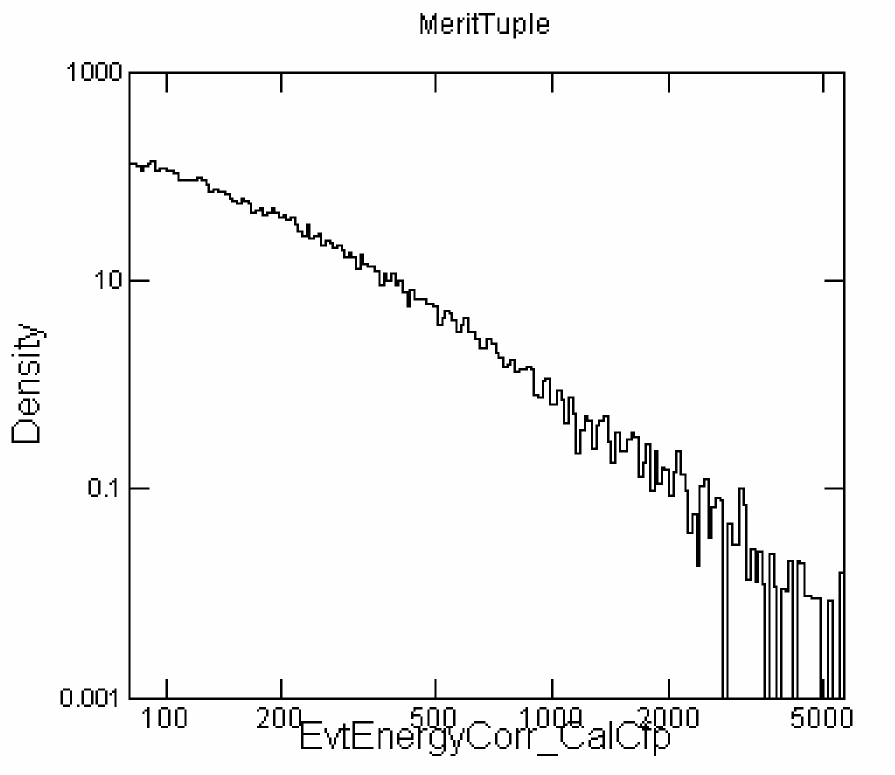


Efficiency into fiducial volume



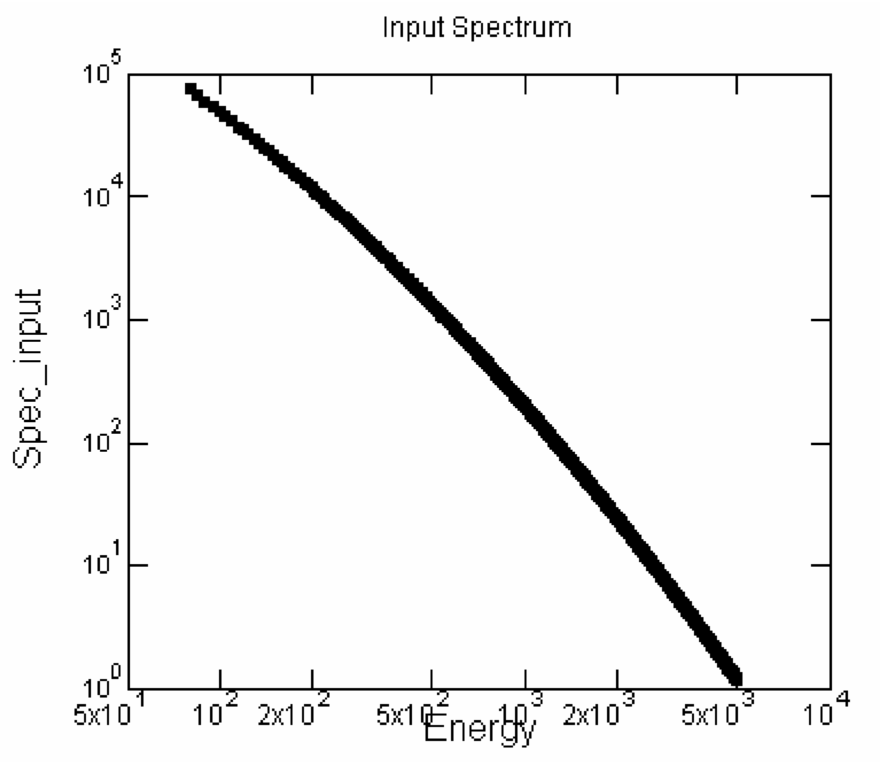
The Final Input spectrum for Photon data in Bldg 33 (III)

3. **Photon data (Real data)**



The Final Input spectrum for Photon data in Bldg 33 (III)

4. **Final Bootstrapped Input spectrum for Photon input flux (Real data)**



$$\frac{dN_{input}}{dE} = norm \times E^{-(\alpha + \beta \log E)}$$

$$norm = 4.2216 \times 10^6$$

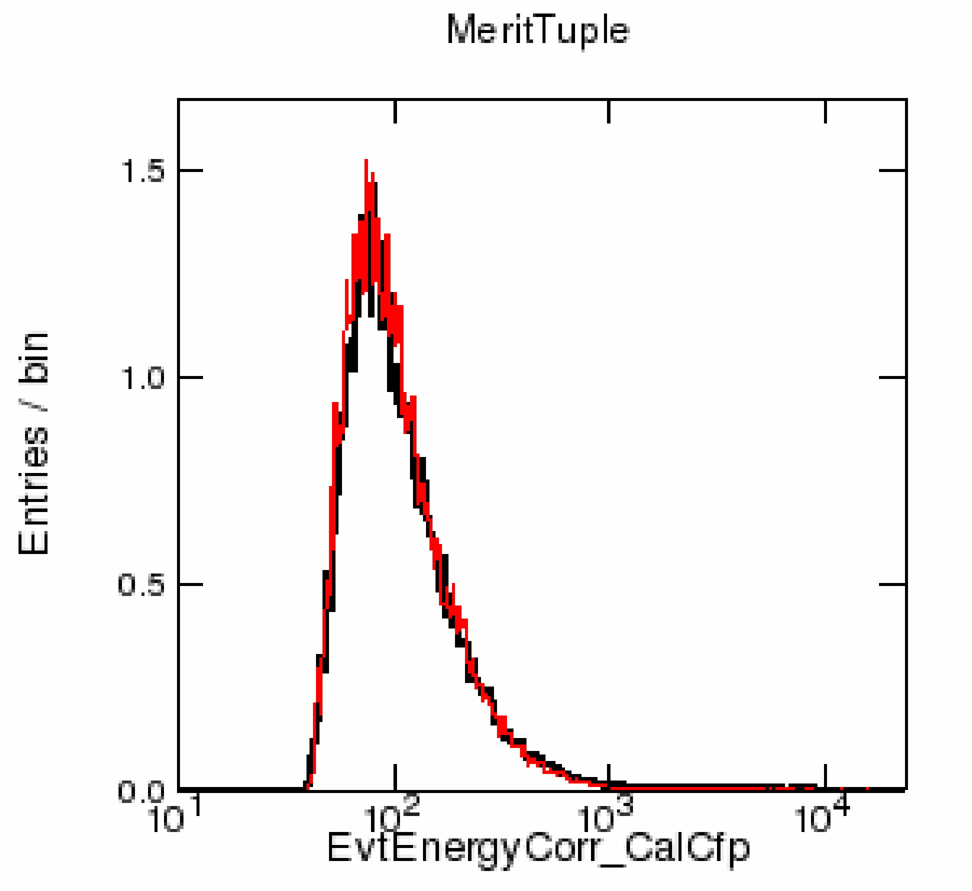
$$\alpha = 0.01389$$

$$\beta = 0.206494$$

E in MeV

5.Obtain final MC sample, using this bootstrapped Photon spectrum

MC photon spectrum VS real one (both are after cuts)



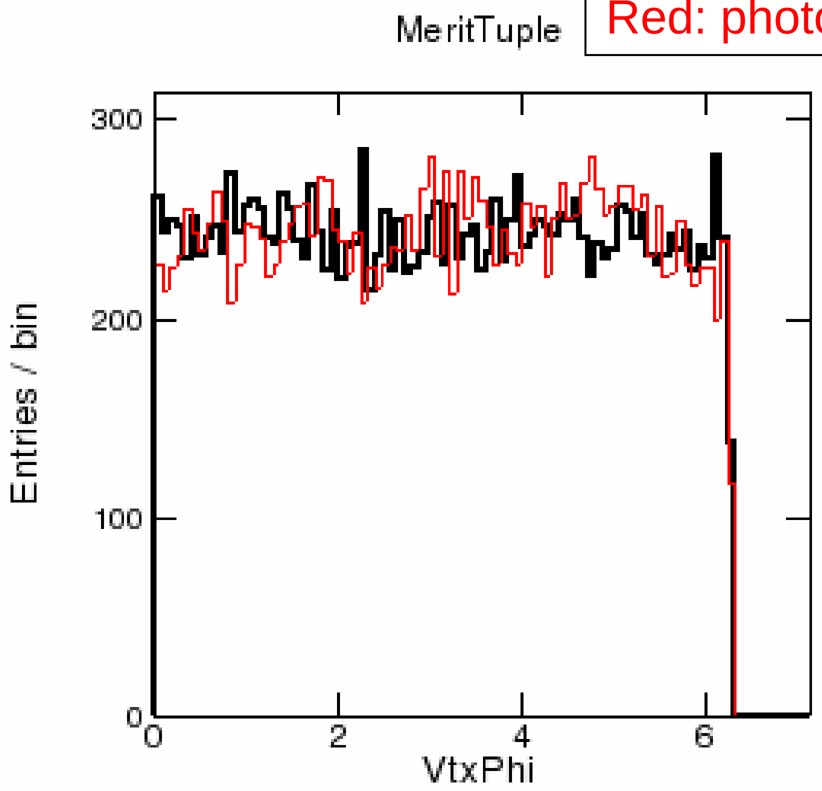
Black: photons from MC data 2

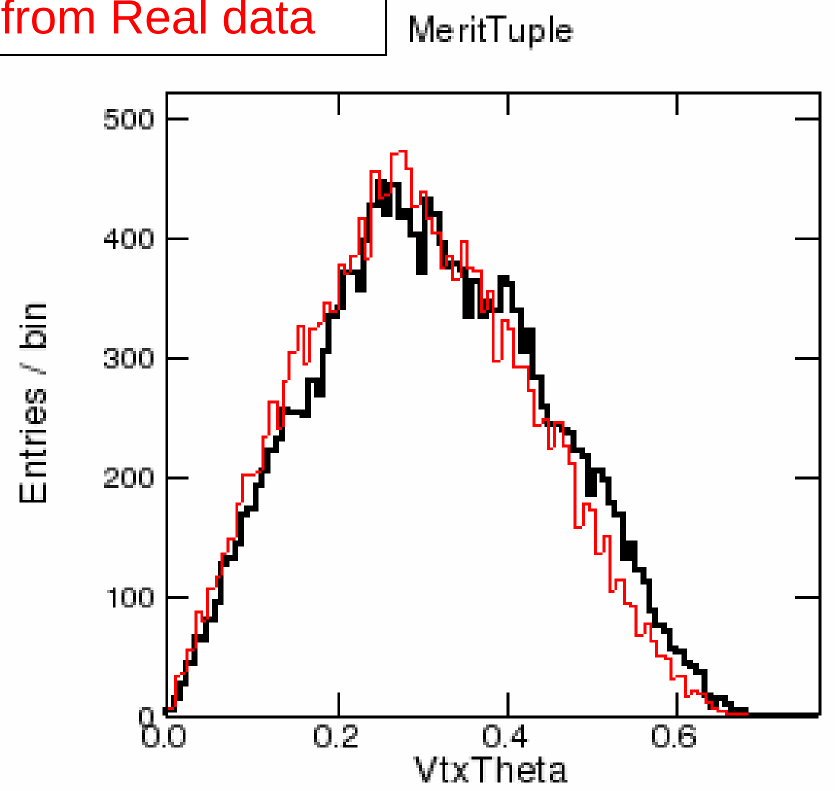
Red: photons from Real data

MC photon direction VS real one (both are after cuts)

Black: photons from MC data 2

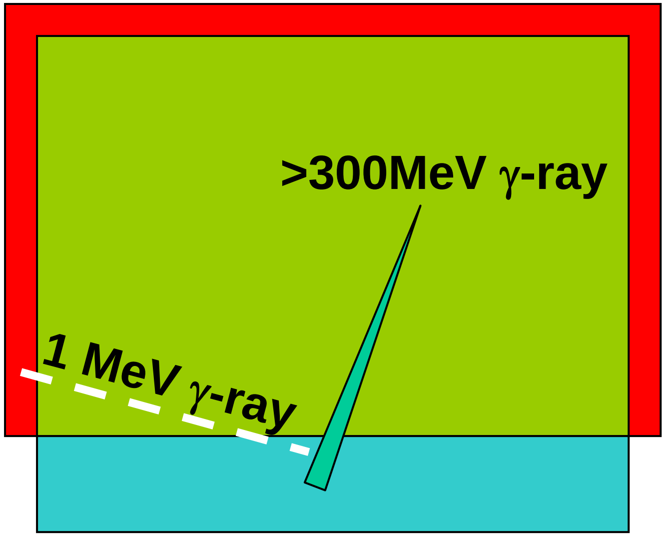
Red: photons from Real data





Gamma Shower Backsplash Study

- Select single gamma ray events from LAT ground data
- Use ACD to reject charged cosmic rays; however, still allow some ACD hits to look at backsplash
- Compare ACD energy in data & Monte Carlo (per gamma energy range)



Data sets

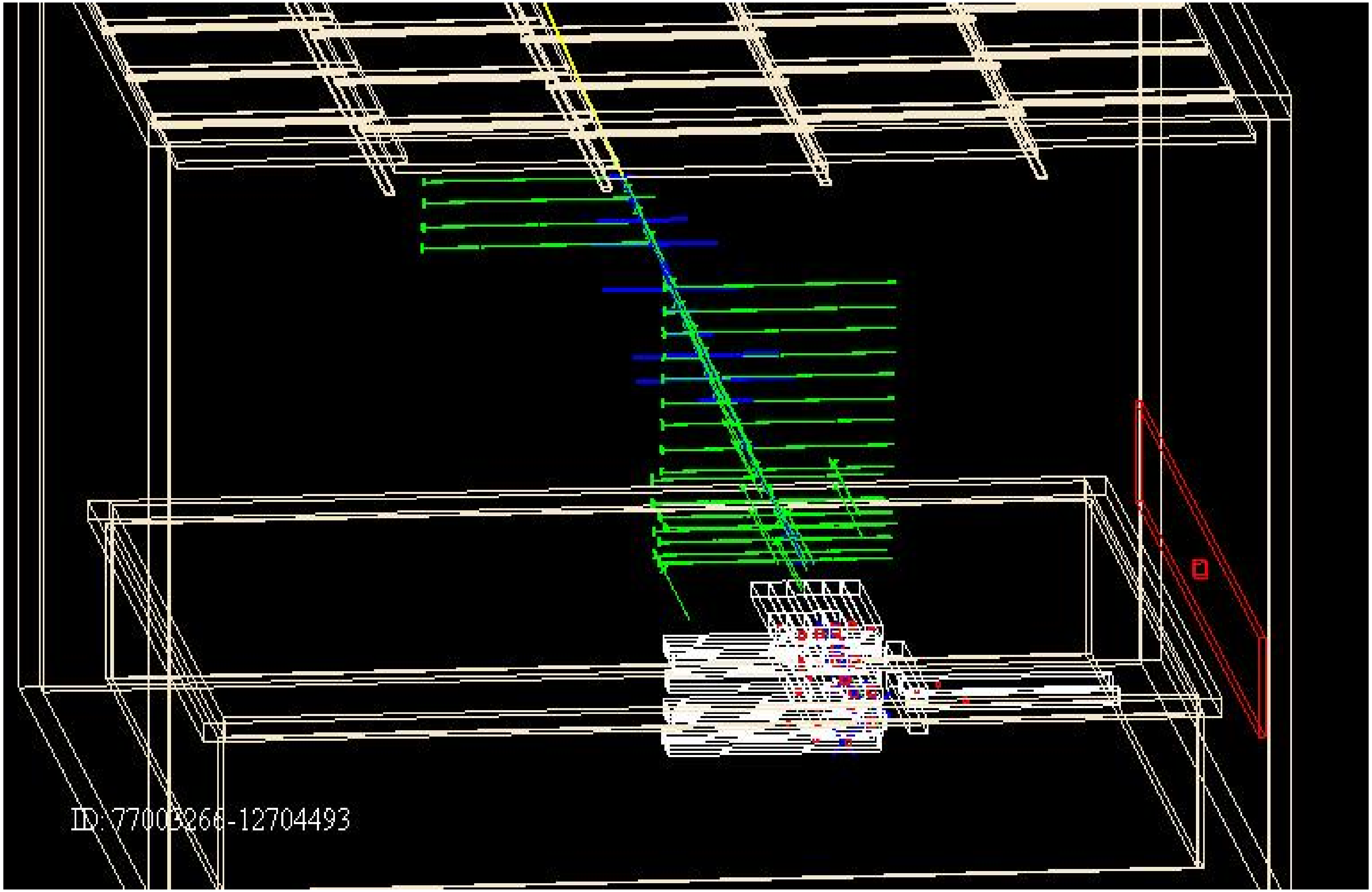
- SLAC building 33, LAT axis vertical
- “70x” (nominal settings, no OBF), run #s 077003051-077003475 (30min each); 36.5hrs of ground data
- Monte Carlo gammas generated by Ping
  - Input spectrum tuned to match data after stringent single gamma selection cuts

Different Single gamma data reduction (allows hits in some tiles in the ACD)

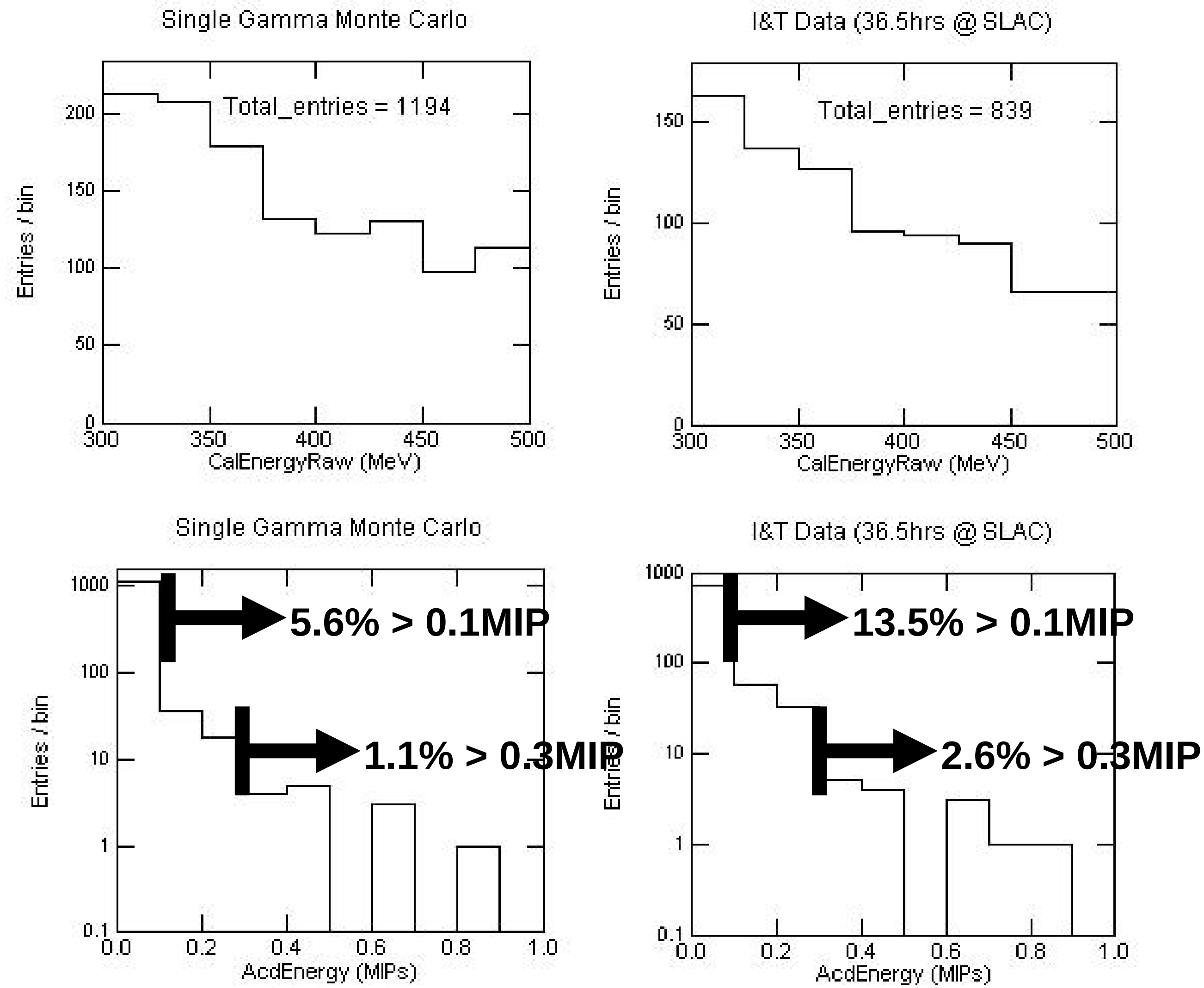
1. *Analysis threshold*
   - CalEnergyRaw>300MeV
2. *Muon rejection*
   - no ACD hits (>0.25MIP) in upper half, i.e. no hits in 0xx, x0x, x1x. Allow hits in x2x, x30
   - at least 6 hits in upper half of TKR
   - CAL cluster direction within 45 degrees of LAT axis
3. *Multiple gamma rejection*
   - CalTransRms<35mm
   - Less than 3 hits in upper half of outer TKR towers
4. *Fiducial cut*
   - -300mm<CalXEcntr<300mm
   - -300mm<CalYEcntr<300mm

Now that we have calibrated ACD thresholds and consistent set of variables in MC and Photon data, we will use a standard set of cuts across analyses in the future

Typical scanned event
(>0.25MIP hit backsplash in ACD)



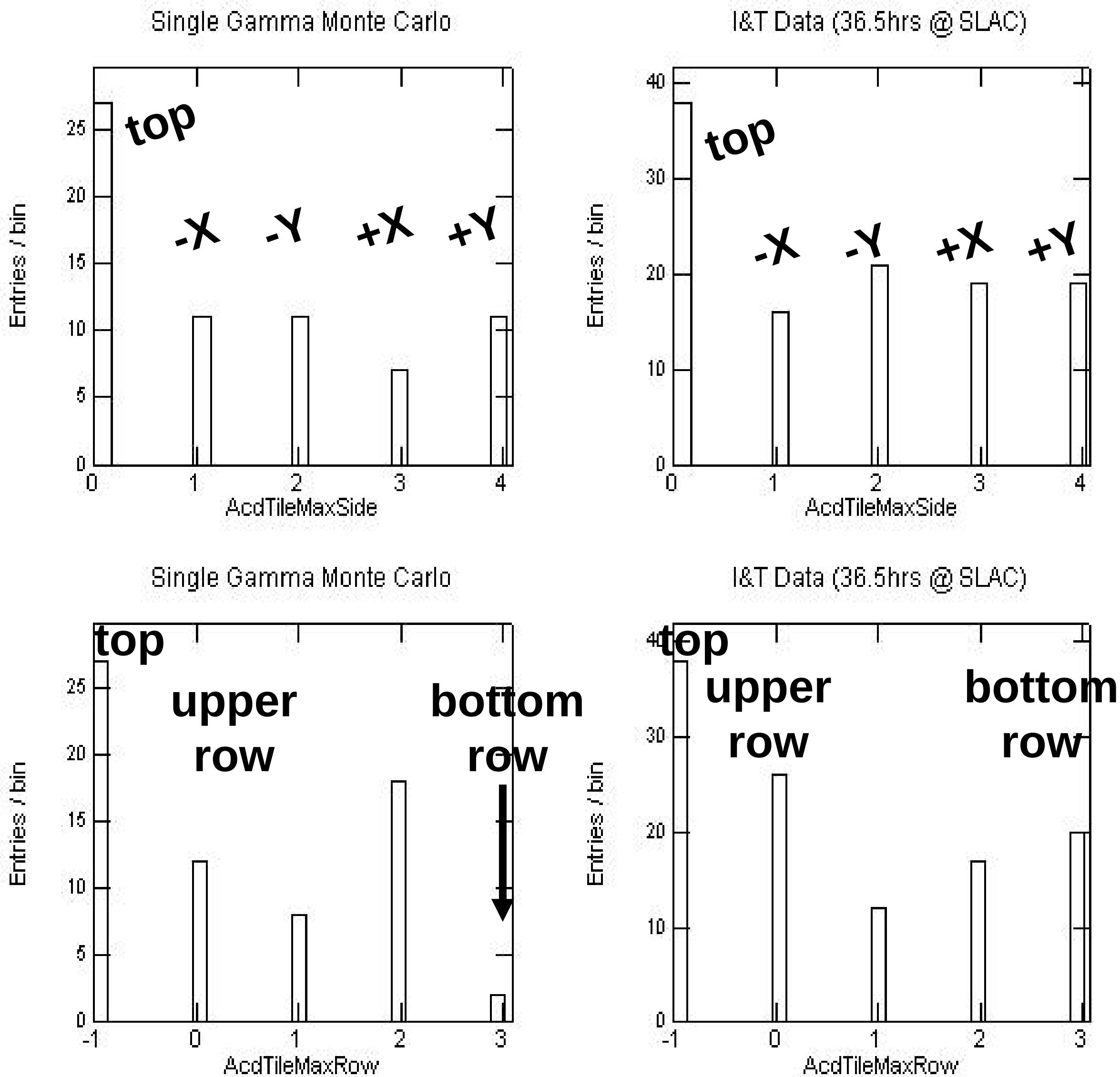
ACD energy distributions
(300MeV<CAL Energy<500MeV)



Photon data has factor of ~2.5 greater fraction of events w/ energy in ACD than MC

Max. Energy Tile distributions

(300MeV<CAL Energy<500MeV, AcdEnergy>0.1MIPs)



Fraction of events w/ max energy tile on top is ~35% for both I&T data and single gamma MC; i.e. ***no indication of contamination from showers*** *(would expect an excess on top).*

Significantly more events w/ max energy tile in bottom row in I&T data vs single gamma MC; i.e. ***some fraction of backsplash is not currently predicted by the simulation.***

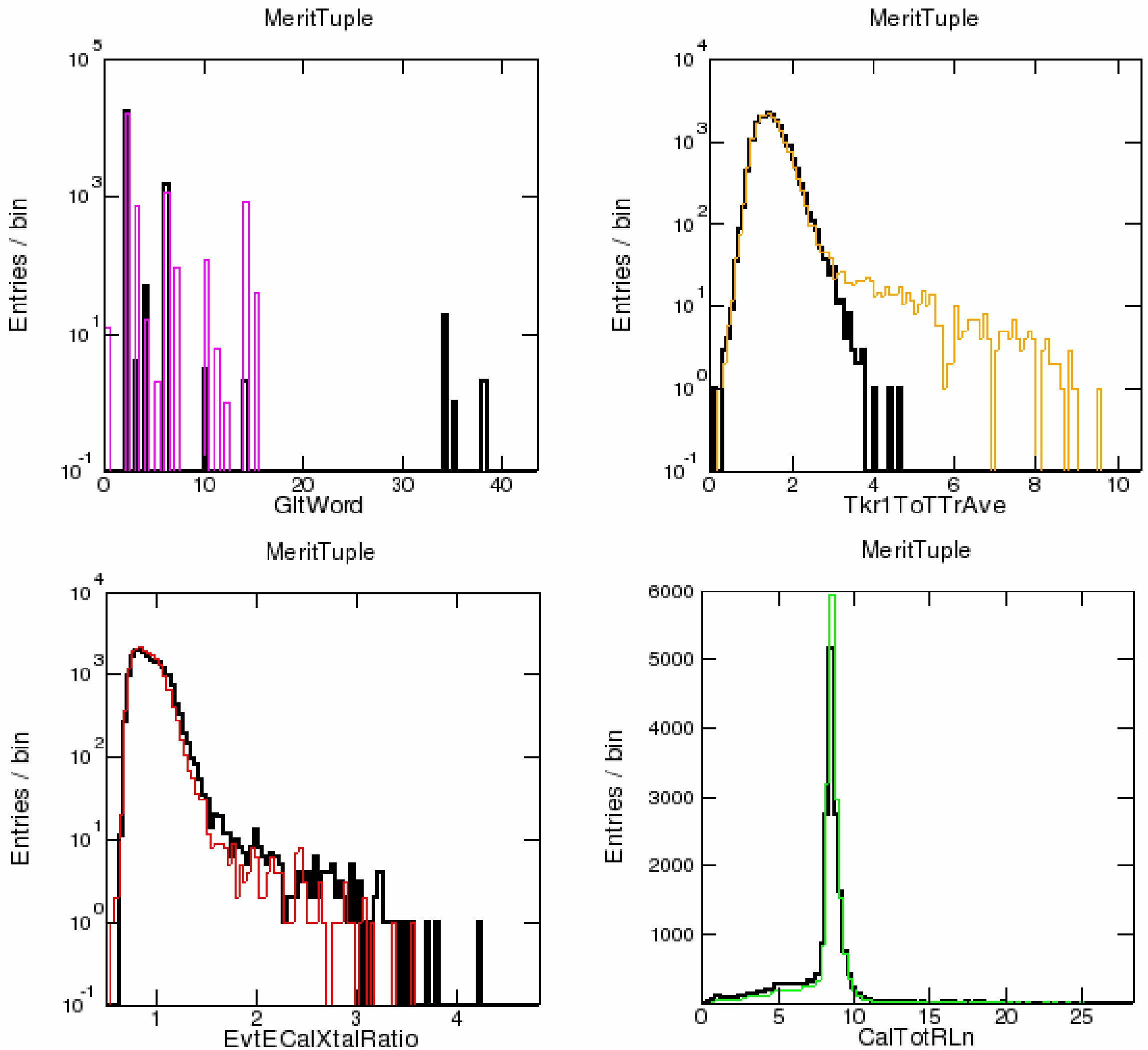
Compare two independent MC photon sets using rForest …

rForest result:			Sigma	Prob of agreement
15	TkrEnergyCorr	0.0804604	3.44079	0.000290012
112	VtxS2	0.0096729	2.97544	0.00146287
26	TkrUpstreamHC	0.0108485	2.73885	0.00308277
156	CalZEcntr	0.0498681	2.61028	0.00452343
69	Tkr1CoreHC	0.0319121	2.55805	0.00526298
240	CTBBestEnergy	0.0387257	2.51172	0.00600716
88	Tkr2YDir	0.0250437	2.4636	0.00687755
95	Tkr2TkrAngle	0.0315088	2.35771	0.00919393
107	VtxHeadSep	0.0254301	2.34628	0.00948086
216	EvtECalTransRms	0.0395763	2.14147	0.0161181
152	CalMIPDiff	0.036709	2.02905	0.0212265
46	Tkr1ConEne	0.0302296	1.84495	0.0325227
221	EvtEVtxDoca	0.0176093	1.77942	0.0375853
166	CalLllEneErr	0.0222568	1.76071	0.0391435
125	CalTPred	0.036923	1.75137	0.0399412
7	GltLayer	0.0315906	1.73057	0.0417644
207	EvtPSFModel	0.0248052	1.68224	0.046261
194	AcdTkrHitsCountTop	0.00120965	1.67733	0.0467386
203	EvtVtxKin	0.022095	1.66419	0.0480374
32	Tkr1LastLayer	0.0180763	1.64328	0.0501628
71	Tkr2FirstChisq	0.0322881	1.61732	0.0529044
5	GltXTower	0.0102628	1.58028	0.0570214
10	GltType	0.0063633	1.5157	0.064798
255	CTBTkrSHRCalAngle	0.0231398	1.42259	0.077427
120	CalTotRLn	0.0314224	1.40819	0.0795372

Compare MC photons and real photons using rForest …

rForest result:			Sigma	Prob of agreement
169	AcdTotalEnergy	1.46759	13.1433	9.30087e-40
65	Tkr1ToTTrAve	0.300316	7.949	9.40124e-16
212	EvtECalXtalRatio	0.876486	6.9006	2.58909e-12
120	CalTotRLn	0.1028	5.86633	2.22771e-09
153	CalMIPRatio	0.218158	5.71679	5.42774e-09
128	CalTwrEdgeCntr	0.413068	5.63263	8.87386e-09
245	CTBCalFrontBackRatio	0.10352	5.0421	2.30222e-07
129	CalTwrEdge	0.306968	5.02186	2.55871e-07
173	AcdDoca	3.86997	4.9903	3.01423e-07
246	CTBCalMaxXtalRatio	0.0836702	4.91779	4.37628e-07
213	EvtECalXtalTrunc	0.155422	4.89812	4.83796e-07
250	CTBParamProb	0.129972	4.82108	7.13906e-07
152	CalMIPDiff	0.242197	4.75776	9.78751e-07
216	EvtECalTransRms	0.271286	4.70014	1.29995e-06
57	Tkr1PhiErr	0.136283	4.63933	1.74774e-06
100	VtxPhi	0.0443337	4.47652	3.79346e-06
16	TkrHDCount	0.126023	4.42254	4.87743e-06
21	TkrRadLength	0.120598	4.39471	5.54605e-06
132	CalTrackDoca	0.0811545	4.26004	1.02195e-05
260	EvtEnergyCorr_CalCfp	0.216362	4.08741	2.18106e-05
90	Tkr2Phi	0.0330069	4.06955	2.35516e-05
139	CalELayer4	0.0792142	4.02427	2.85762e-05

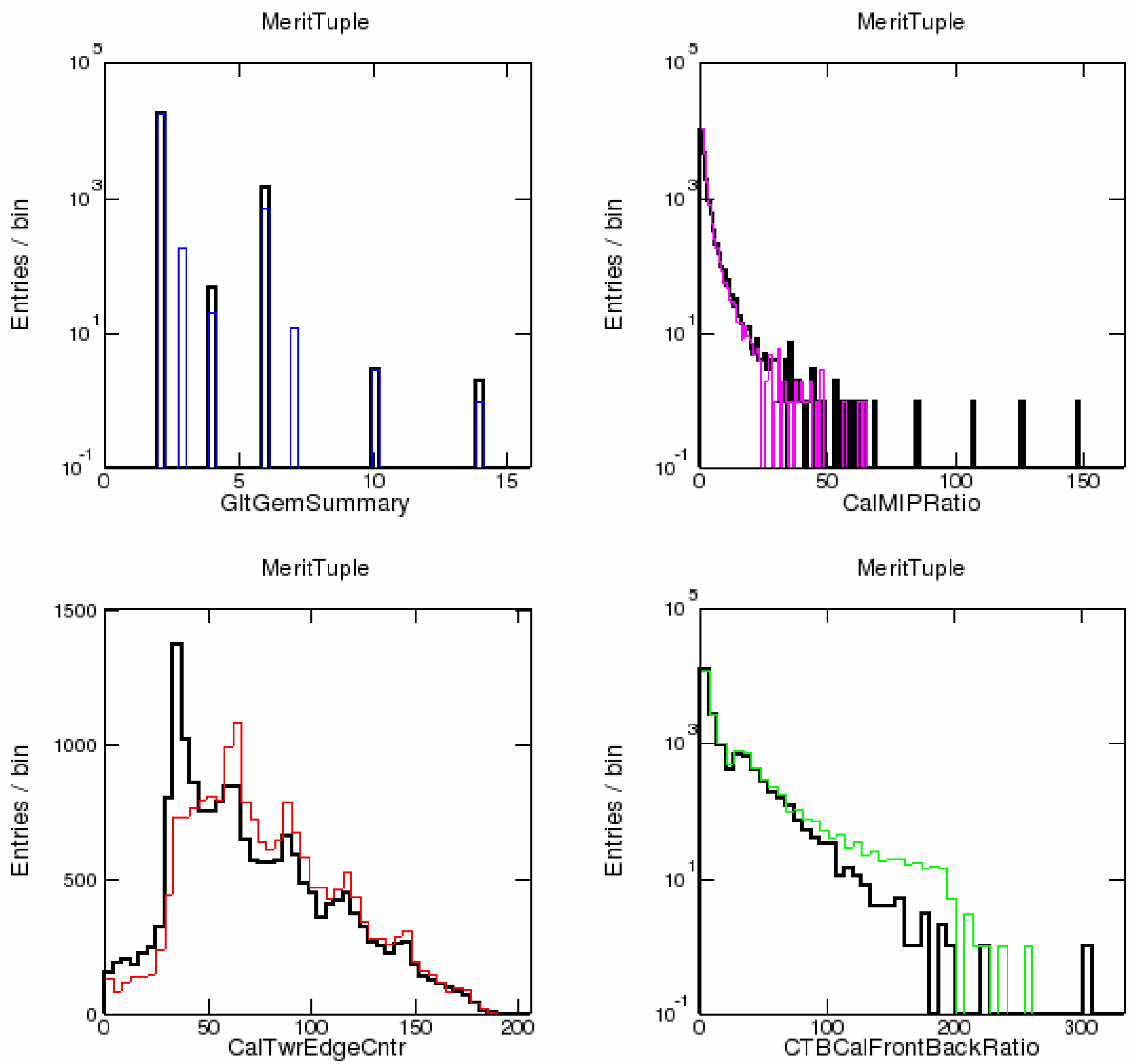
rForest The first 4 important variables



Black: MC data

Color: real data

The second 4 important variables



Black: MC data

Color: real data

Summary

- We have used some relatively simple cuts to select a pure sample of CR photons in the LAT
- Produced the CR photon spectrum in bldg 33 using a bootstrap method
- Compared the MC and real photons, and find that the two data sets generally agree with interesting exceptions
- We use rForest, which is a powerful tool, to do this comparison.
- Our to-do list:
  - We need to do much more work to understand the source of differences.
  - We need to examine of axis fiducial regions in the LAT
  - Include information from beam test analysis to check and augment our results.