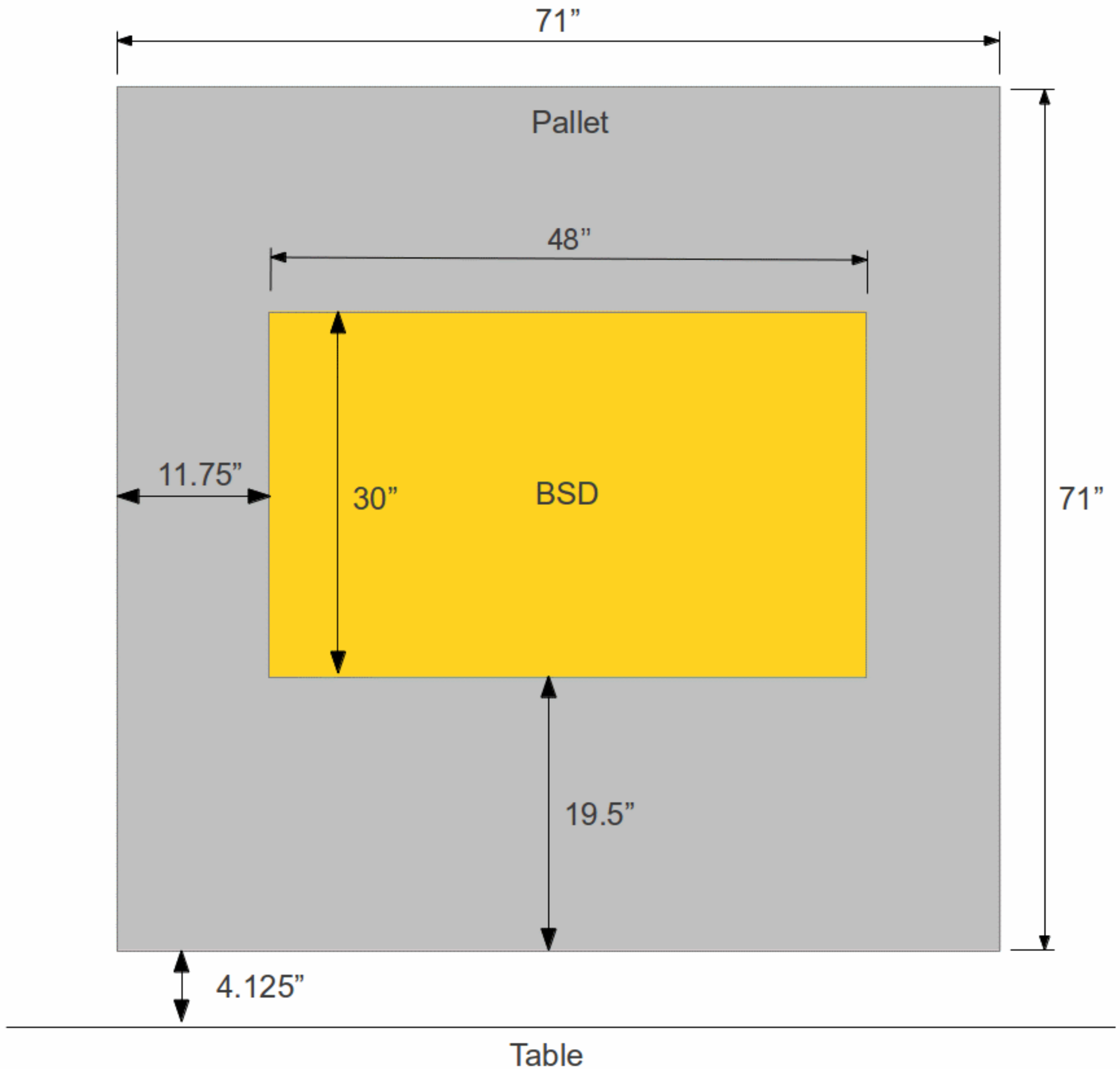
CERN 2012 BSD Analysis Update

Tyler Anderson

January 9, 2013

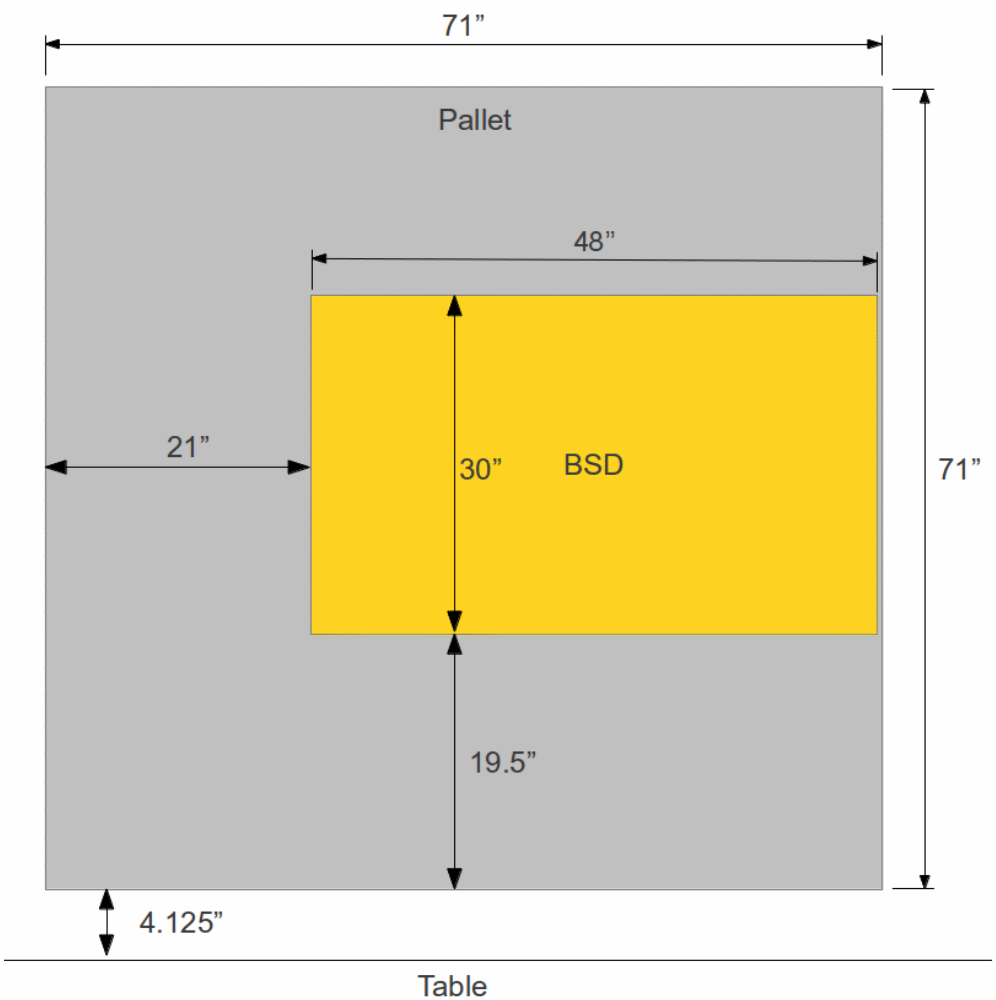
BSD Group Meeting

Configuration A

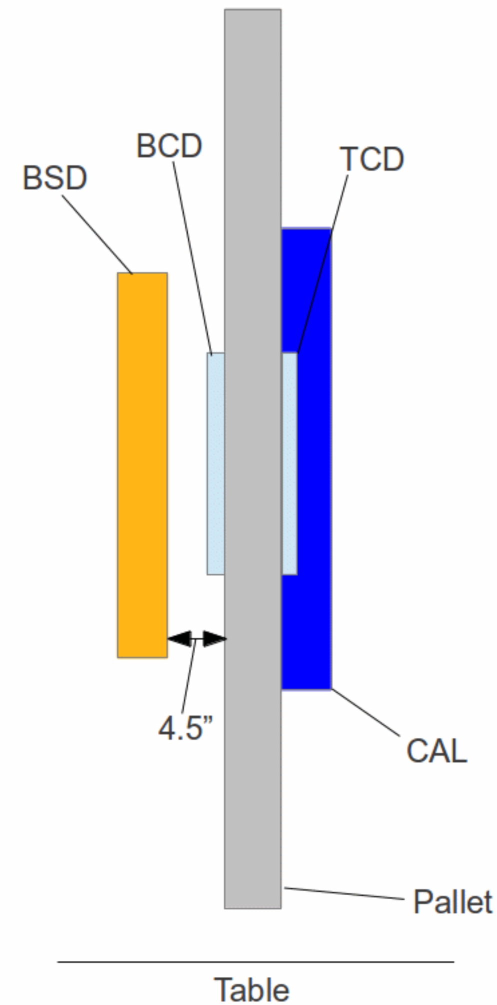


- Looking upstream
- No BCD or TCD
- Upstream side of BSD is 5.5" from downstream surface of pallet

Configuration B



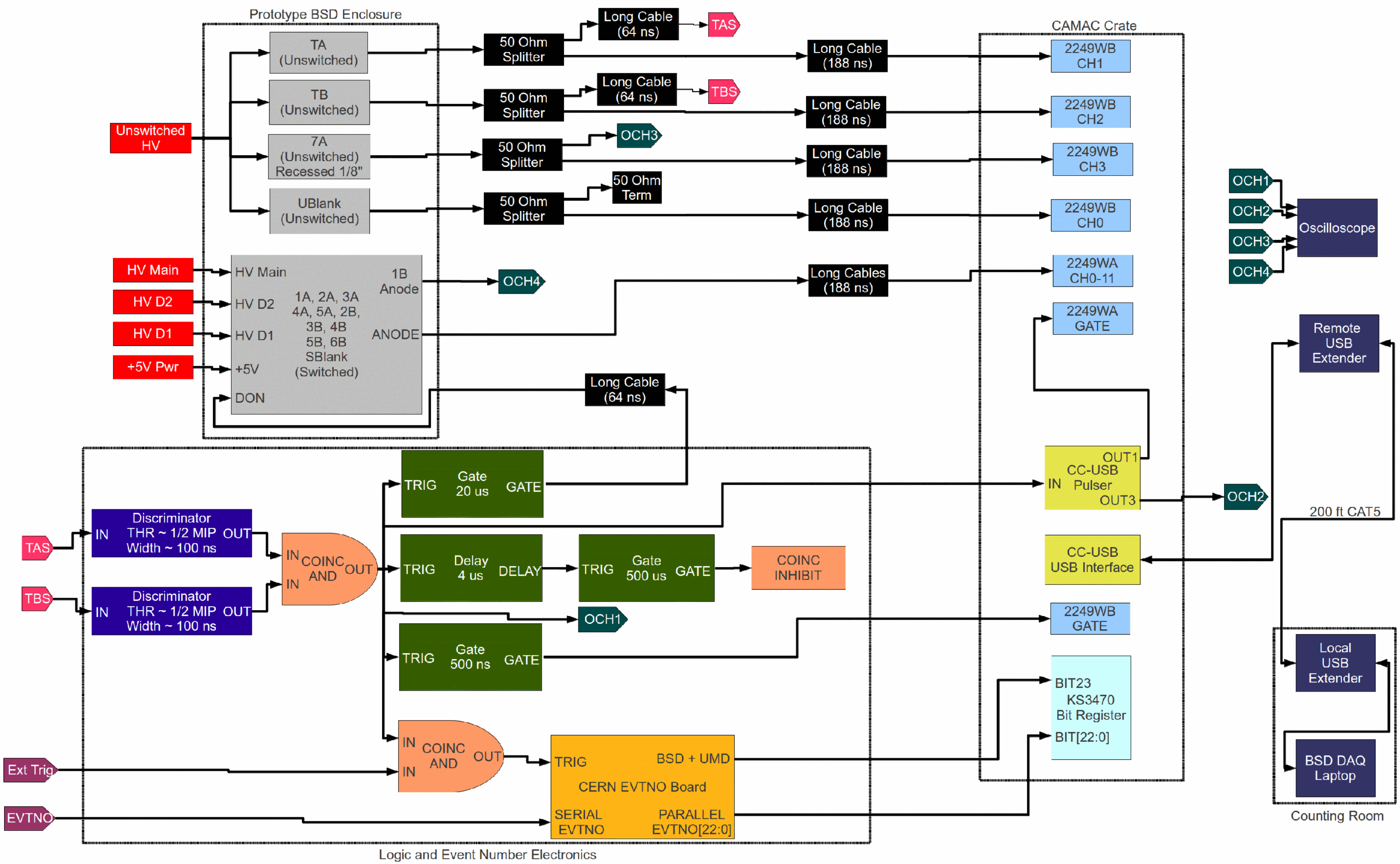
Looking upstream



Looking sideways

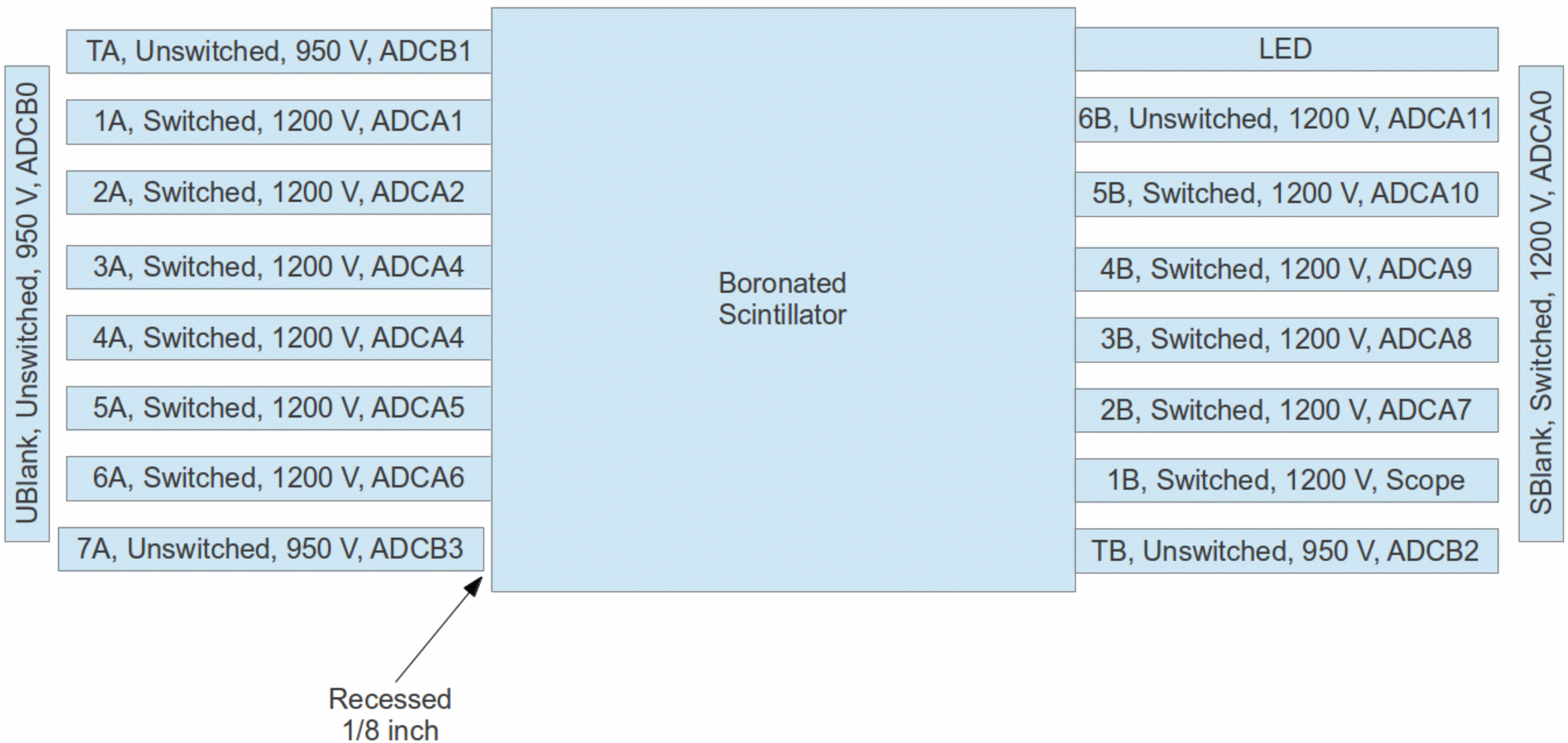
BCD and TCD in place

Equipment Setup

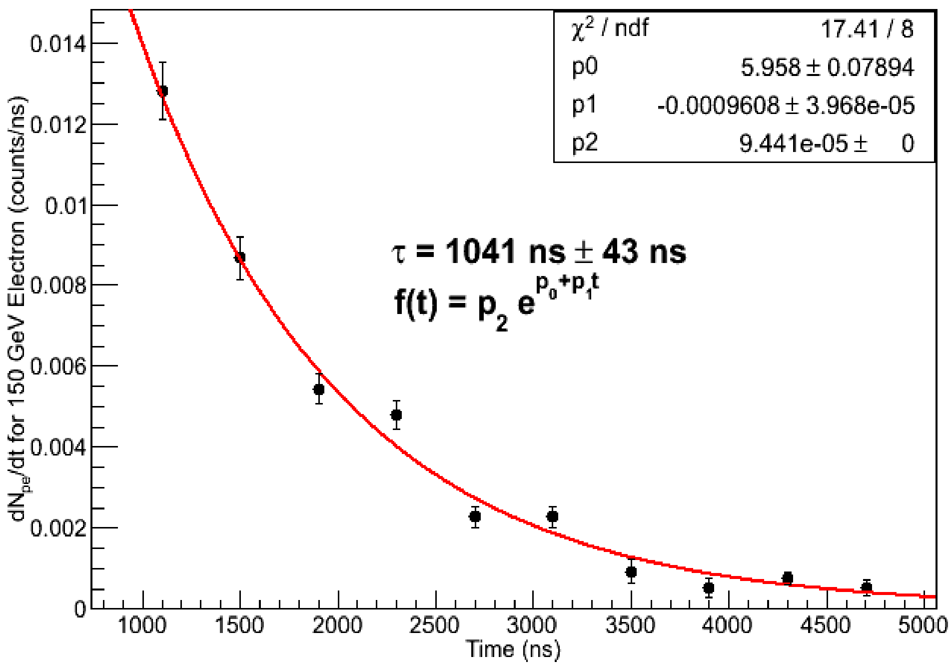


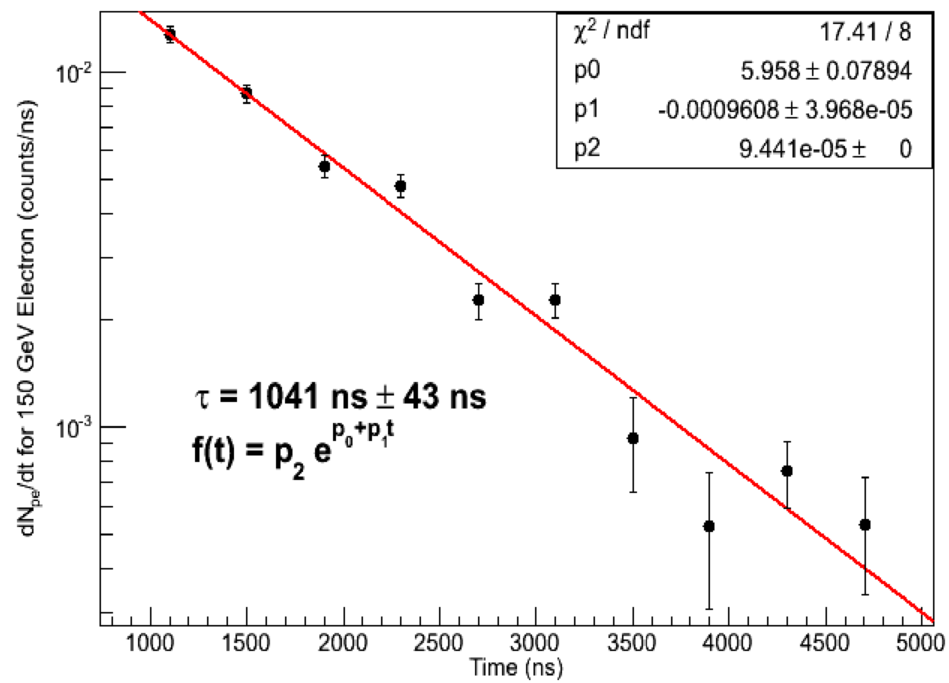
- 2249WA integrates switched tubes between 917 ns to 4517 ns from early shower
- 2249WB integrates unswitched tubes between -83 ns to 417 ns from early shower

CERN BSD Tube Layout



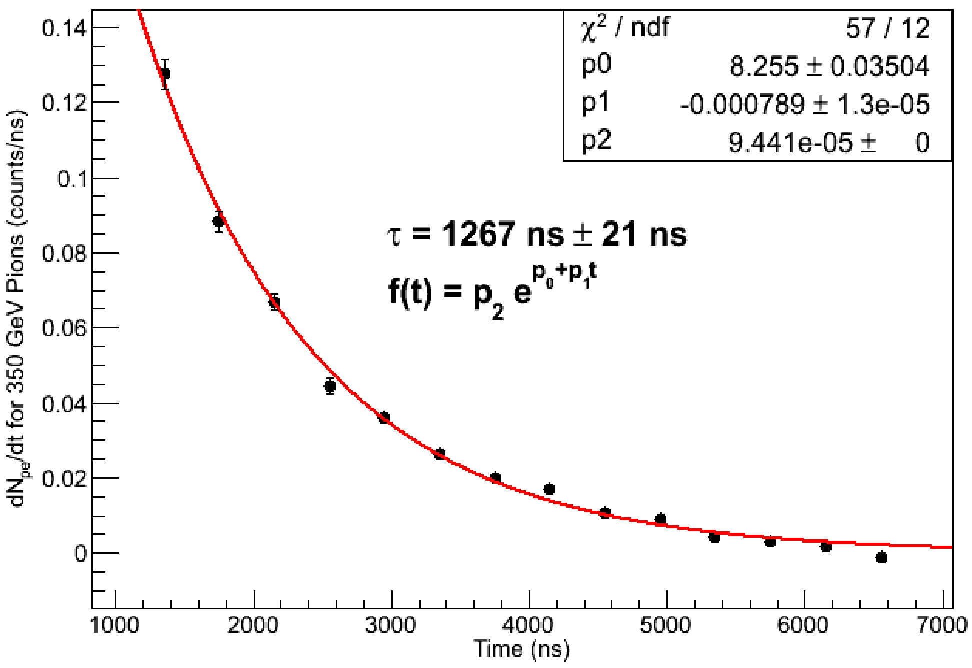
Scope Electron Data

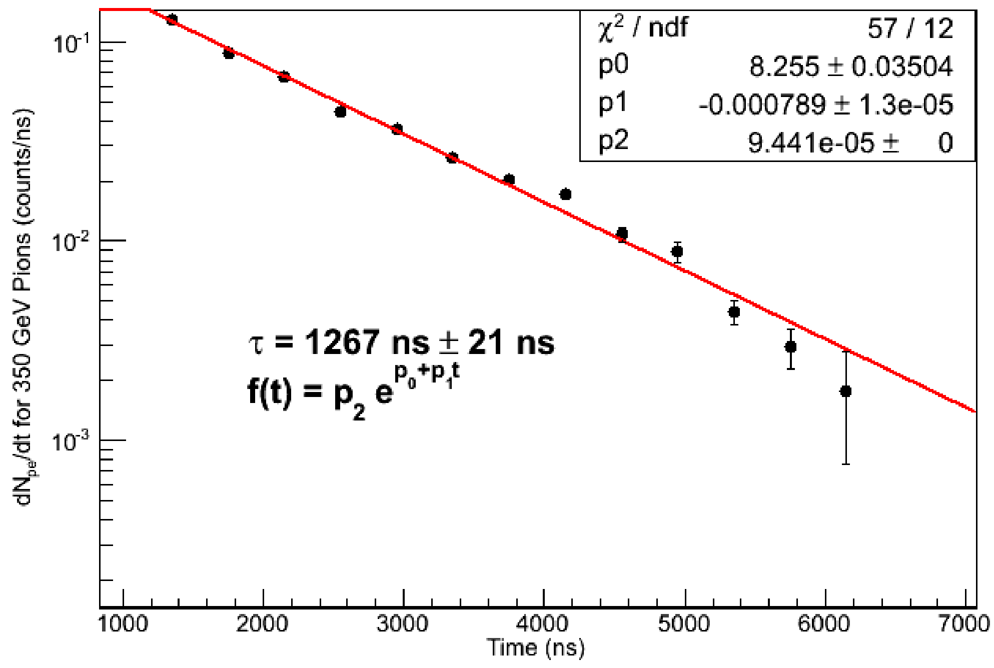




- Using PMT 1B, 150 GeV electron data from oscilloscope area measurements
- Using ~1k events per data point
- Error bars calculated as quadrature sum from three contributions:
  - Error in center point approximation for derivative
  - Standard error of mean in peak determination
  - Standard error of mean in pedestal determination (small)
- Parameter p2 is “fixed” (i.e. not allowed to vary with fit) as part of conversion from ADC channel count to PE count.
- 15 PE between 900 ns to 4500 ns (Note: Lead was in place for this run, but not for typical configuration B.)

Scope Pion Data





- Using PMT 1B, 350 GeV pion data from oscilloscope area measurements
- Using ~1k events per data point
- Error bars calculated as quadrature sum from two contributions:
  - Error in center point approximation for derivative
  - Standard error of mean in peak determination
- Parameter p2 is “fixed” (i.e. not allowed to vary with fit) as part of conversion from ADC channel count to PE count.
- 213 PE between 900 ns to 4500 ns

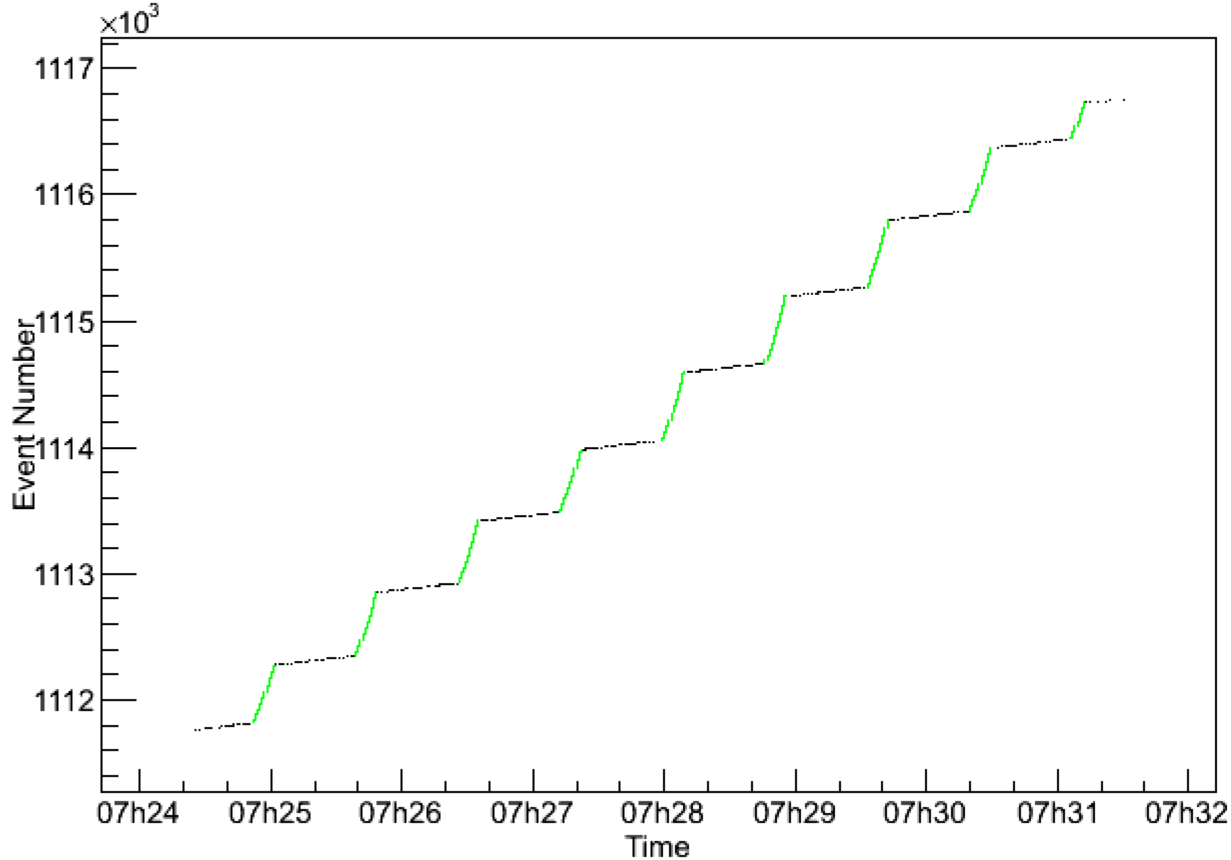
2249W Mean PE Count by Tube
917 ns to 4517 ns (Configuration B)

Particle:	Electron	Electron	Electron	Electron	Electron	Pion	Pion	Pion
Energy:	75 GeV	100 GeV	125 GeV	150 GeV	175 GeV	250 GeV	300 GeV	350 GeV
1A	23 PE	35 PE	47 PE	60 PE	74 PE	230 PE	266 PE	299 PE
2A	22 PE	34 PE	46 PE	58 PE	72 PE	250 PE	289 PE	327 PE
3A	29 PE	47 PE	64 PE	78 PE	104 PE	330 PE	377 PE	417 PE
4A	29 PE	47 PE	64 PE	81 PE	100 PE	305 PE	340 PE	372 PE
5A	20 PE	31 PE	43 PE	54 PE	67 PE	234 PE	265 PE	297 PE
6A	22 PE	33 PE	44 PE	58 PE	72 PE	245 PE	283 PE	318 PE
2B	21 PE	32 PE	43 PE	55 PE	68 PE	217 PE	247 PE	274 PE
3B	25 PE	38 PE	52 PE	67 PE	84 PE	282 PE	326 PE	363 PE
4B	41 PE	66 PE	90 PE	115 PE	143 PE	411 PE	466 PE	510 PE
5B	34 PE	53 PE	72 PE	91 PE	113 PE	354 PE	402 PE	445 PE
Mean	27 PE	42 PE	56 PE	80 PE	90 PE	286 PE	326 PE	362 PE

Data Quality Cuts and Correction

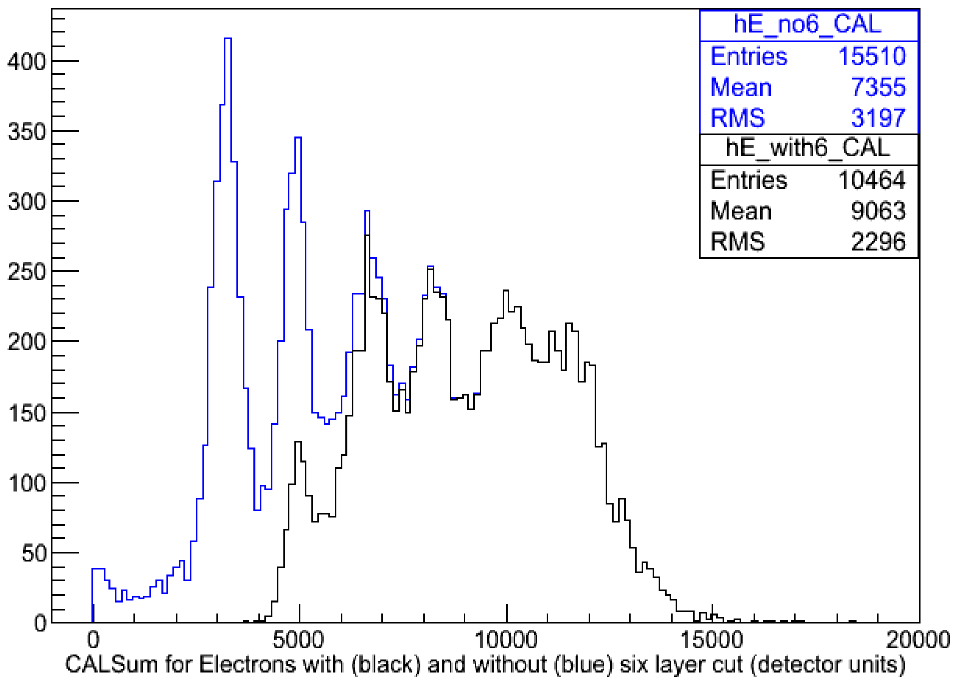
- Note: Using data from configuration B, since that's where energy scans were performed
- “IsWithCal” Cut
  - Requires that both BSD and CAL saw event (matched by event number)
  - CDAQ has much more dead time (~20 ms) than BSD's CAMAC readout (~300 us), so this cuts a lot of data
- Require >40 MeV in 6 consecutive CAL layers (flight CAL trigger)
  - Use approximate conversion 9 chan = 1 MeV (from S. Nutter) as rough conversion.
  - Note: This analysis should be redone when CAL is gain calibrated
- Saturation Correction
  - Set any fCHA[n] < 0 (2249W saturated) for n = 1 to 10 (switched tubes) to 2048 channels. Use “myBSDLatePE” variable as gain converted PE sum of these.

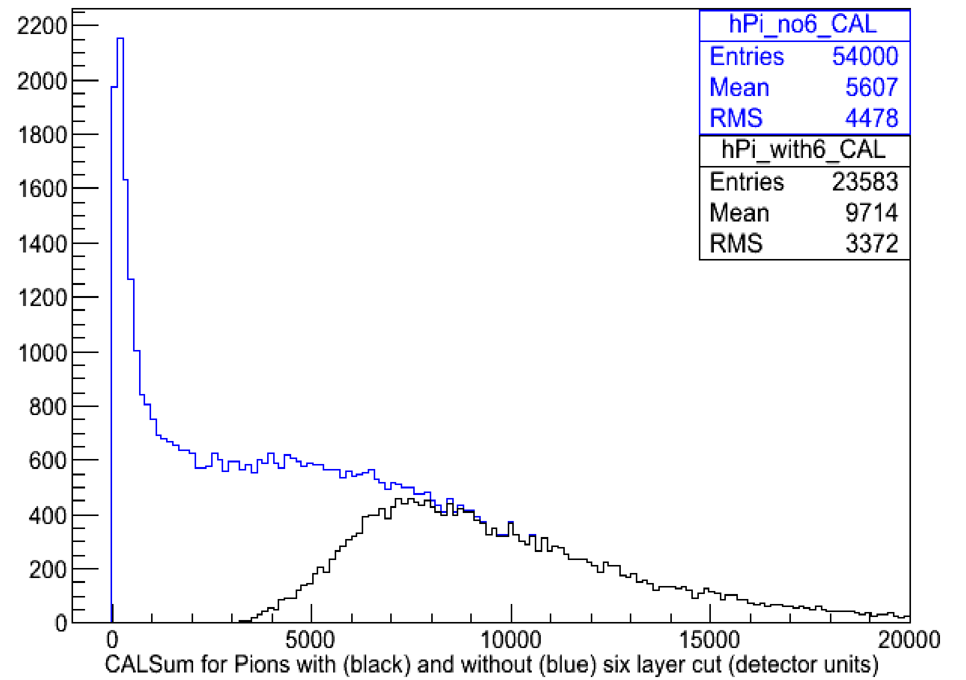
IsWithCal For In Spill Events



- Choosing “IsWithCal” is a good proxy for in spill events.
- Example plot for 150 GeV electron run BSDCALCombined_11-27-2012-13-24-15.root
  - Black: All events in run
  - Green: Events with “IsWithCal” flag
- Makes sense since this is the time window when the BSD and upstream scintillator counter triggers are well correlated.

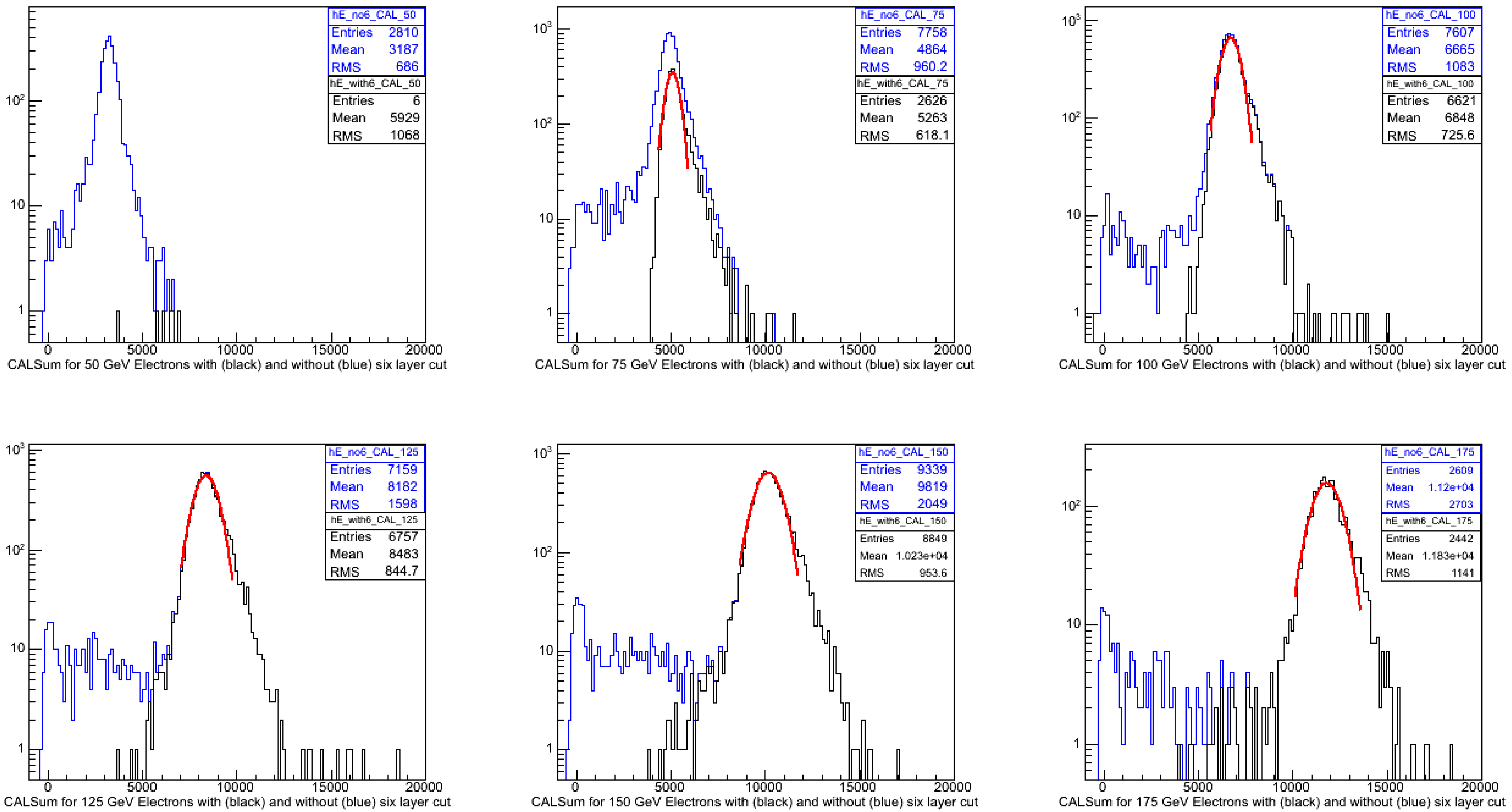
Effect of Six Layer Cut (i.e. "flight cut") on CALSum





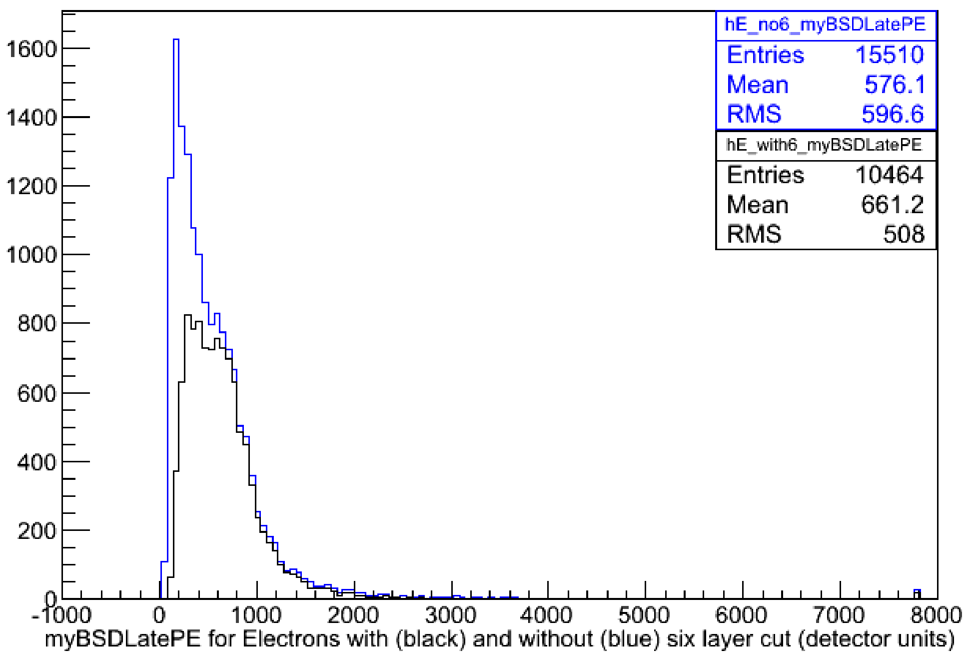
- Left histogram: Black is CALSum with equal numbers of events from electron runs at 50 GeV, 75 GeV, 100 GeV, 125 GeV, 150 GeV, and 175 GeV. Blue is remaining histogram after requiring CAL to have 6 consecutive layers with >40 MeV on this dataset.
- Right histogram: Black is CALSum with equal numbers of events from pion runs at 250 GeV, 300 GeV, and 350 GeV. Blue is remaining histogram after requiring CAL to have 6 consecutive layers with >40 MeV on this dataset.
- Note that the 6 layer cut removes many more low energy events than high energy events
- For analysis, must weight with equal amounts of all energies ***<u>AFTER</u>*** 6 layer cut.

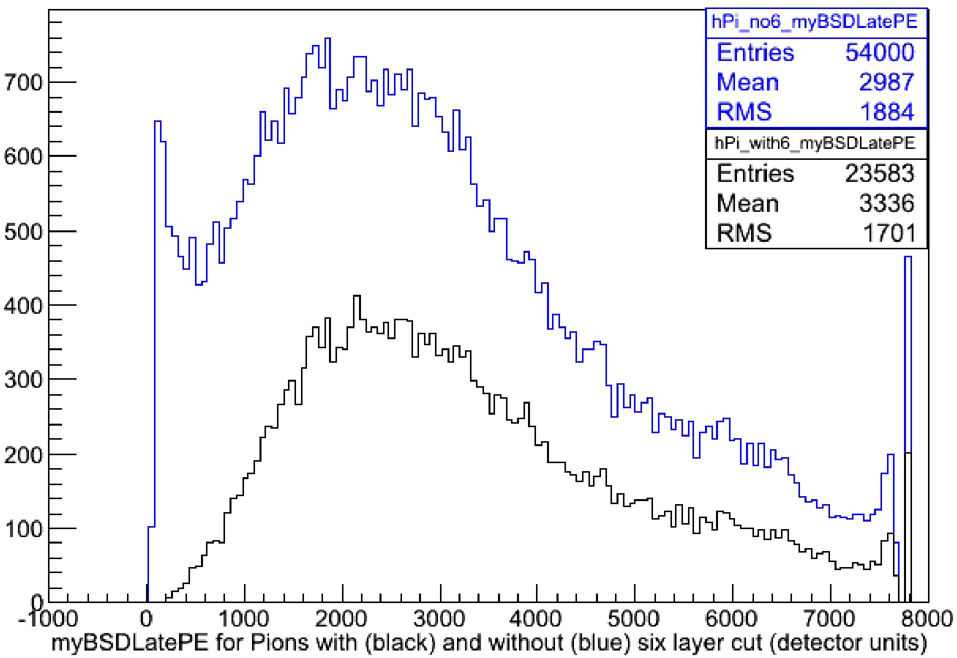
Another Effect of 6 Layer Cut



- Electron beam is only ~75% pure, but this cut removes most of the impurities. (Pion beam is ~95% pure.)
- Only 6 events from the 50 GeV electron runs survive the 6 layer cut, so they will not be used in the remaining analysis.

Effect of 6 Layer Cut on myBSDLatePE



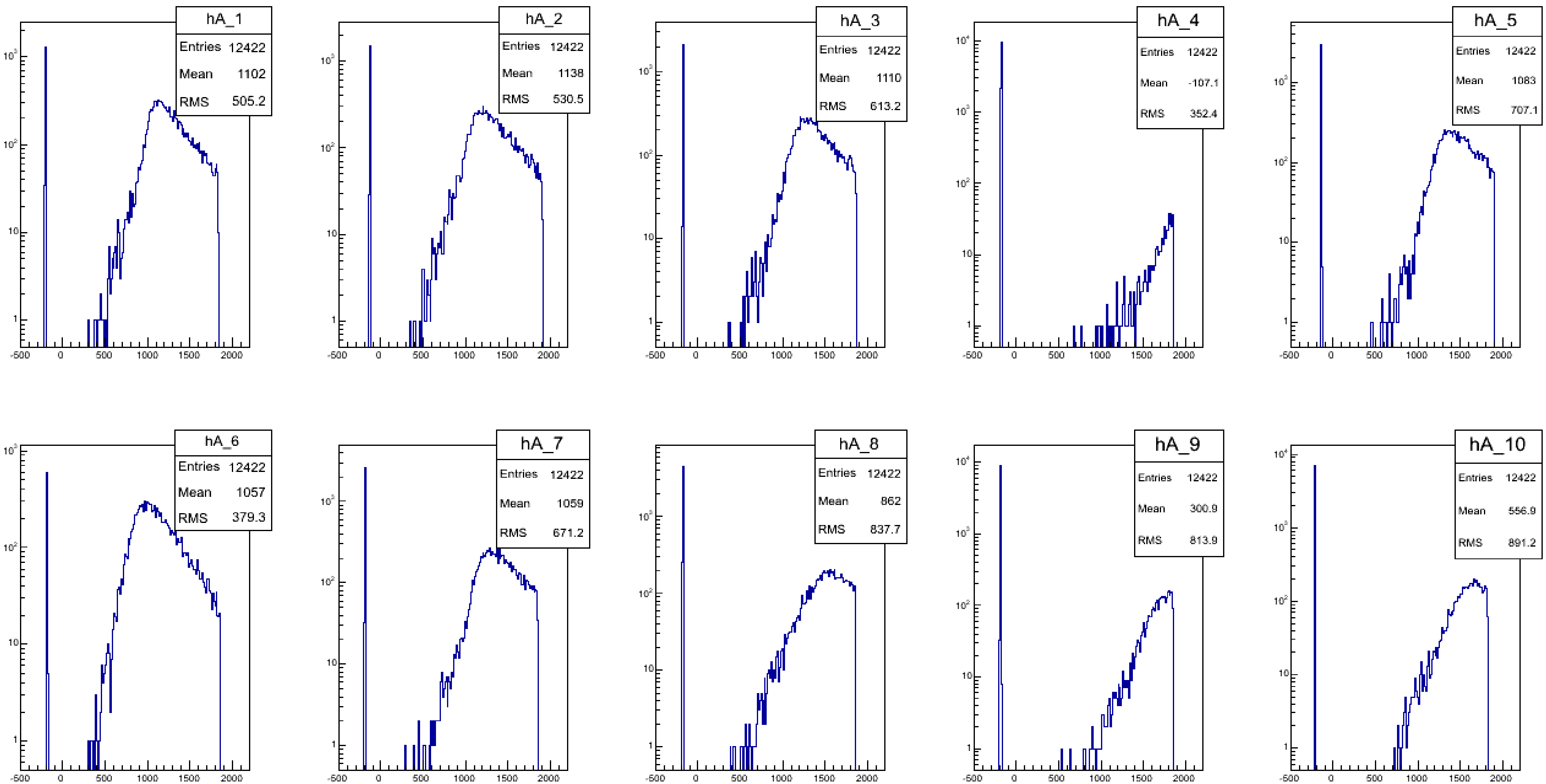


- Left histogram: Black is myBSDLatePE with equal numbers of events from electron runs at 50 GeV, 75 GeV, 100 GeV, 125 GeV, 150 GeV, and 175 GeV. Blue is remaining histogram after requiring CAL to have 6 consecutive layers with >40 MeV on this dataset.
- Right histogram: Black is BSDLatePE with equal numbers of events from pion runs at 250 GeV, 300 GeV, and 350 GeV. Blue is remaining histogram after requiring CAL to have 6 consecutive layers with >40 MeV on this dataset.
- For analysis, must weight with equal amounts of all energies ***AFTER*** 6 layer cut

Saturated Event Correction

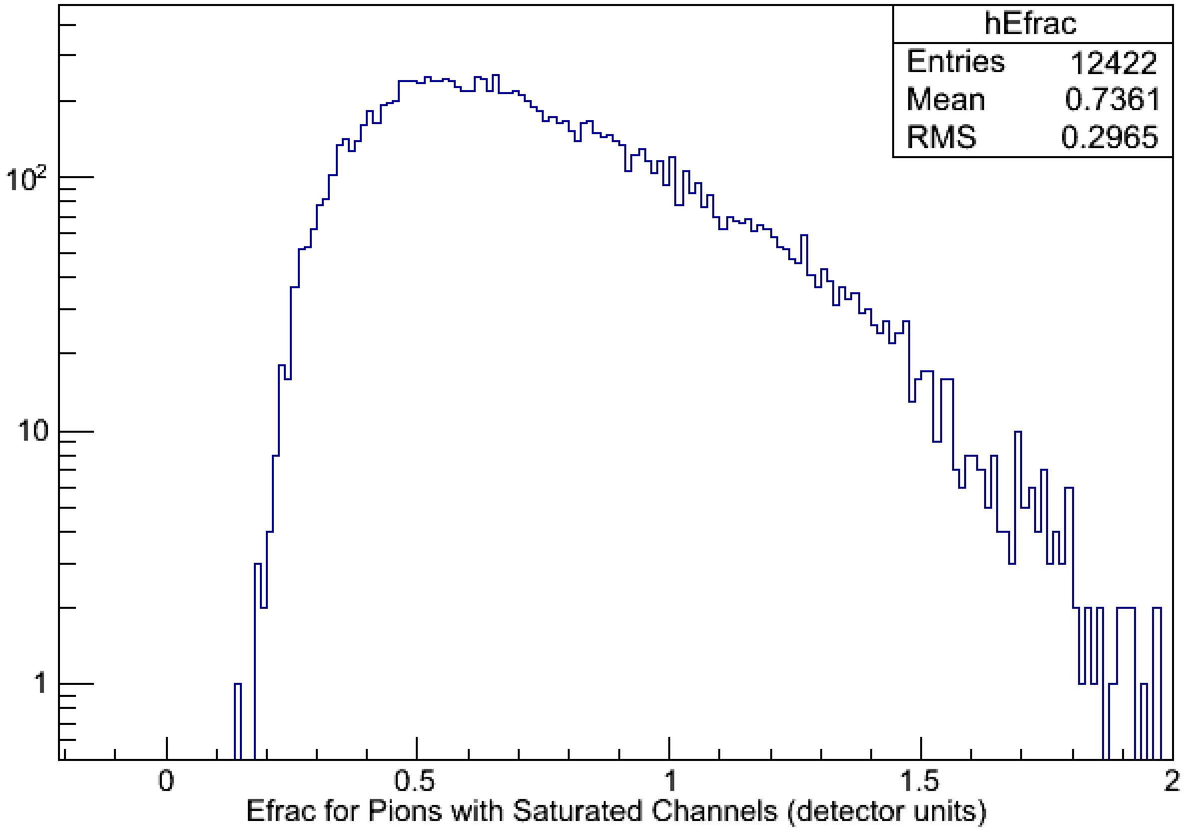
- The 2249W puts out a number much less than pedestal (typically “1”) when it saturates
- The fCHA branch is already pedestal subtracted, so these saturated values will show up as a large negative spike in channel histograms
- These saturated events are significant (especially for pions) because:
  - They represent large PE signals
  - They are much more common for pions (because of larger BSD late signal) than for electrons
- Hence, missing these events will throw off Efrac significantly

Looking at fCHA[n] < 0 Events



- Clearly, these are saturated events
- 96.3% have fCHA[4] saturated.
- 99.1% have either fCHA[4] or fCHA[9] saturated.

Saturated Event Solution



- Solution: If a channel is saturated, give it max value, 2048 channels. This is a good approximation, though it under estimates the signal sum a little bit. Call this variable “myBSDLatePE”.
- All events with saturation (histogram above) then end up outside the electron Efrac range (Efrac < 0.1 in detector units). Thus, the slightly under estimated signal sum only influences the total histogram counts (a small effect), but not the counts for events in range of electron Efrac (a larger effect).

Data Cuts and Conditioning Summary

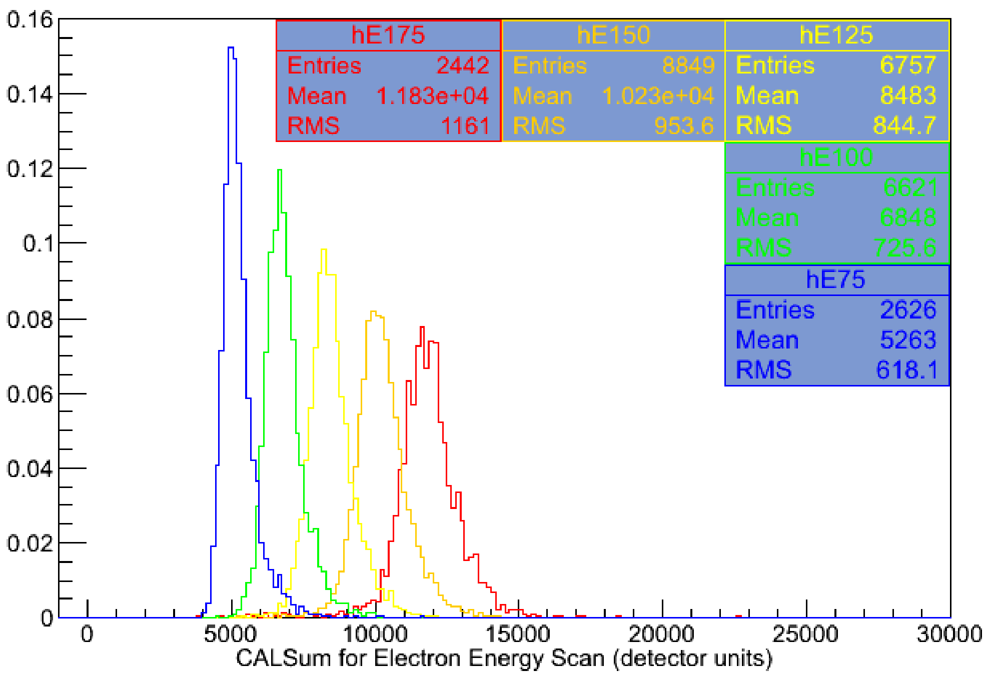
Electron Energy (GeV):	***50***	***75***	***100***	***125***	***150***	***175***	***Total***
Starting Count	**37685**	**42175**	**37262**	**33997**	**30504**	**9942**	**191565**
"IsWithCAL" (% cut of starting count)	92.5%	81.6%	79.6%	78.9%	69.4%	73.8%	80.5%
"6 Layer Cut" (% cut of remaining)	99.8%	66.2%	13.0%	5.6%	5.2%	6.4%	26.8%
Final Count	**6**	**2626**	**6621**	**6757**	**8849**	**2442**	**27301**
Corrected For Saturation (% conditioned of remaining)	0.0%	0.5%	0.4%	0.3%	0.1%	0.2%	0.3%

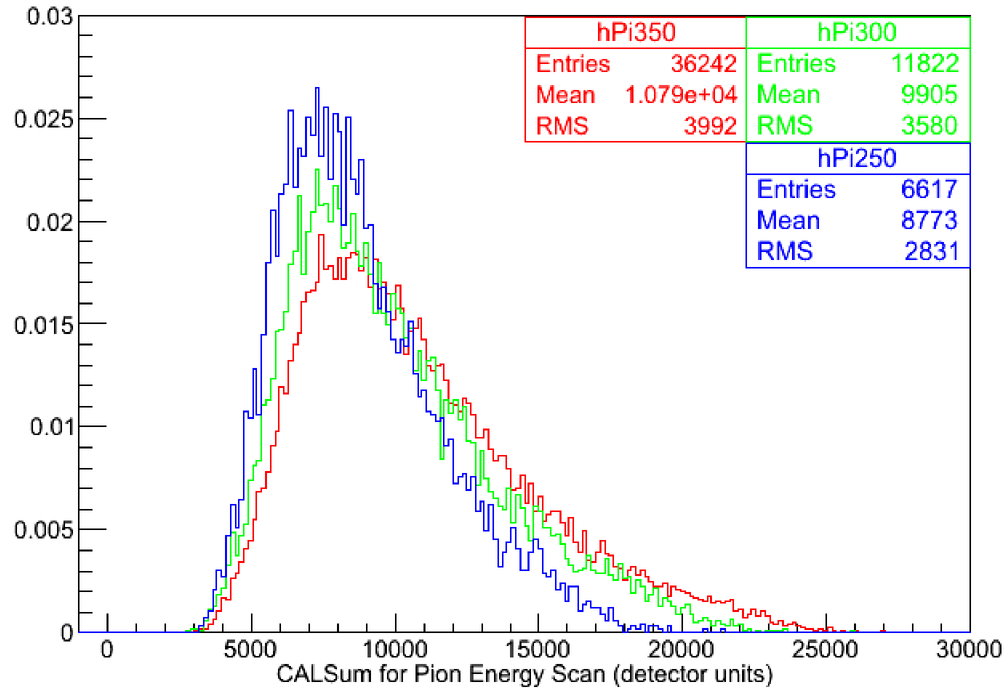
Pion Energy (GeV):	***250***	***300***	***350***	***Total***
Starting Count	**243938**	**85405**	**204650**	**533993**
"IsWithCAL" (% cut of starting count)	91.8%	68.1%	61.1%	76.2%
"6 Layer Cut" (% cut of remaining)	66.9%	56.6%	54.5%	56.9%
Final Count	**6617**	**11822**	**36242**	**54681**
Corrected For Saturation (% conditioned of remaining)	14.6%	18.9%	25.5%	22.7%

Now what?

- Cuts and data conditioning measures have been outlined/verified
- Would like to make plots which are:
  - 1.) physically meaningful
  - 2.) can be compared with MC simulation data
- Choose to do analysis of CALSum, myBSDLatePE, Efrac, and rejection power vs. electron acceptance for 75 GeV-175 GeV electron energies and 250 GeV-350 GeV pion energies.
- Not all energy runs have the same amount of data, so we "mix" for equal fractions of all energies ***AFTER*** cuts and conditioning!

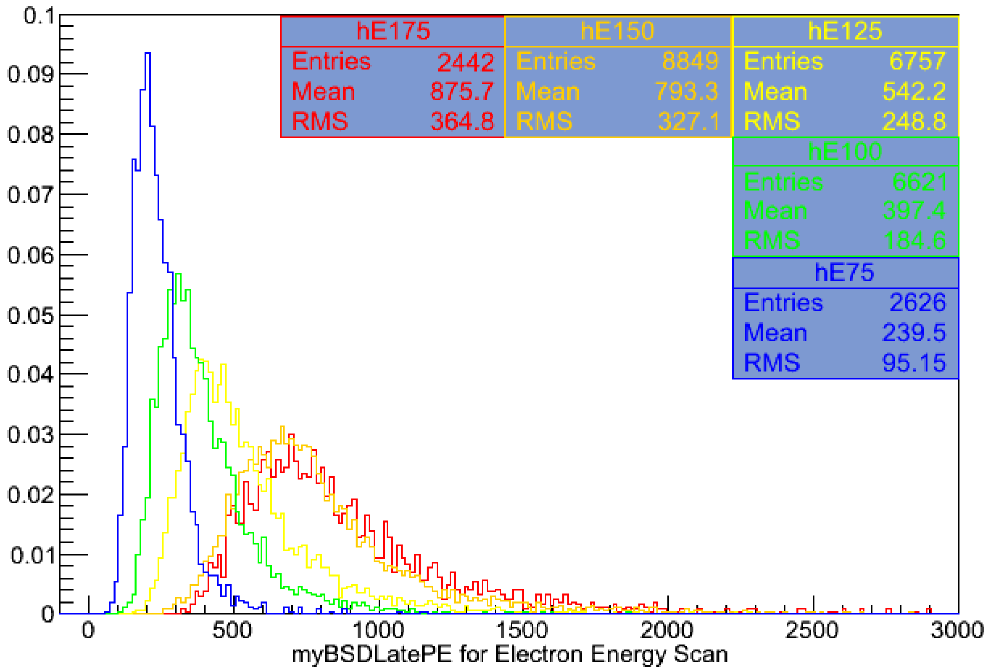
CAL Response With Particle Energy

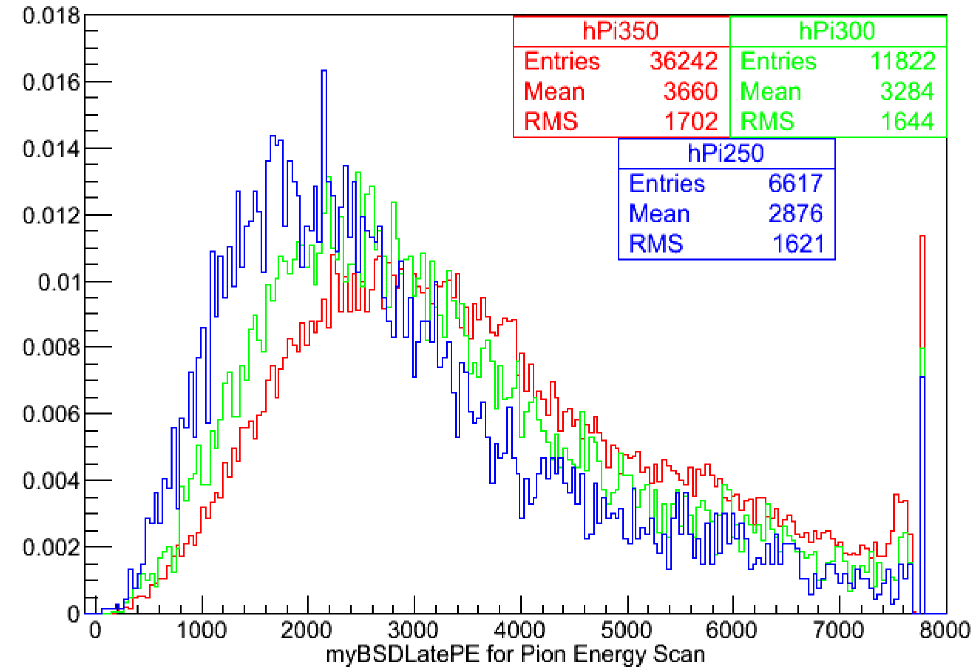




- Histograms are scaled to equal areas by total number of events and normalized such that total area is 1
- Note: 50 GeV electrons don't shower enough to meet the software “>40 MeV in 6 consecutive layers” cut. So they aren't included in these plots even though we have data for them.

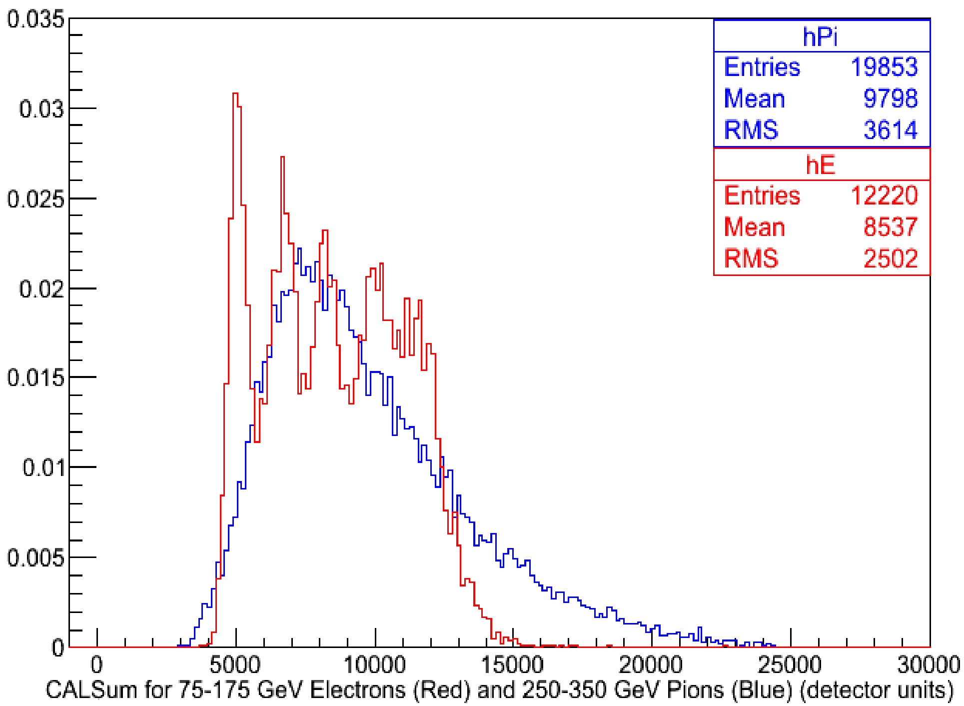
BSDLatePE Response With Particle Energy

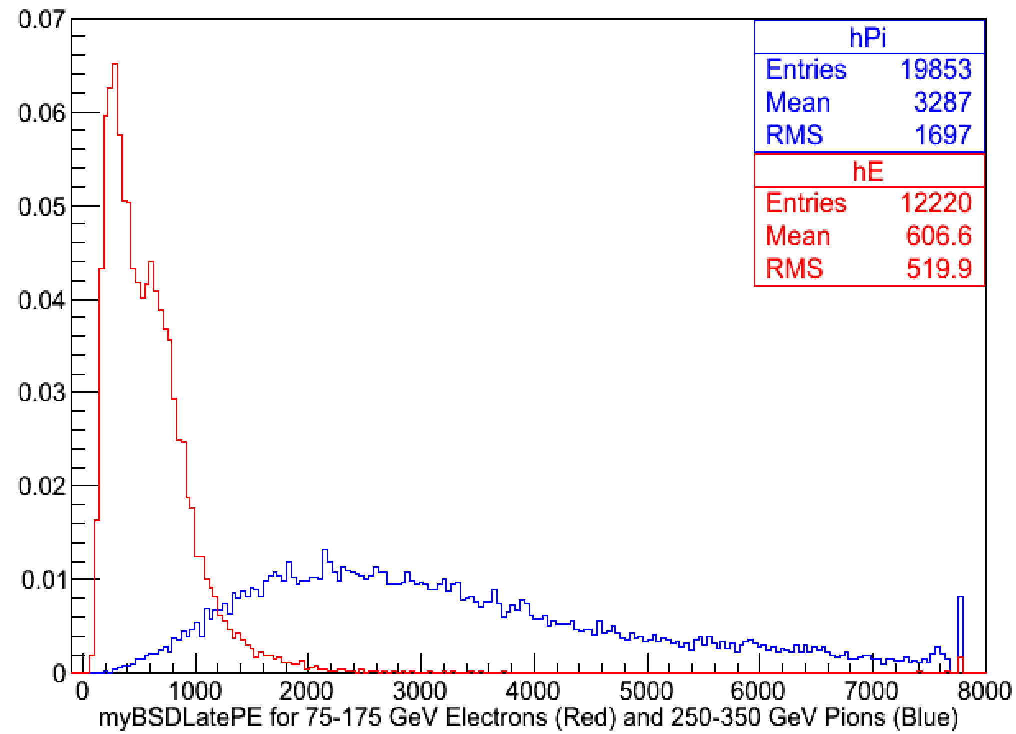




- Histograms are scaled to equal areas by total number of entries and normalized such that total area is 1
- Note:150 and 175 GeV electrons are quite similar

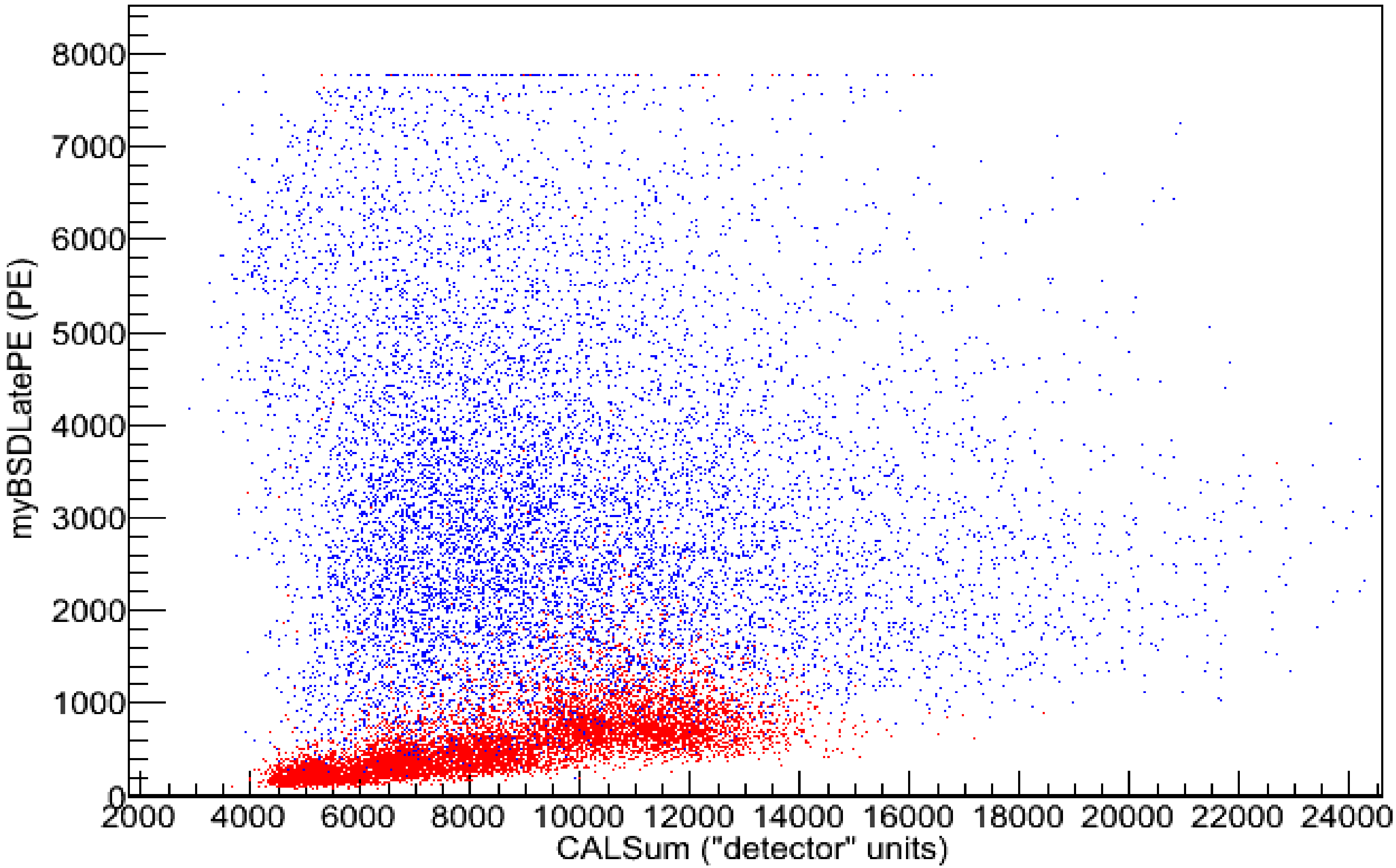
CALSum and BSDLatePE for 75-175 GeV Electron and 250-350 GeV Pions





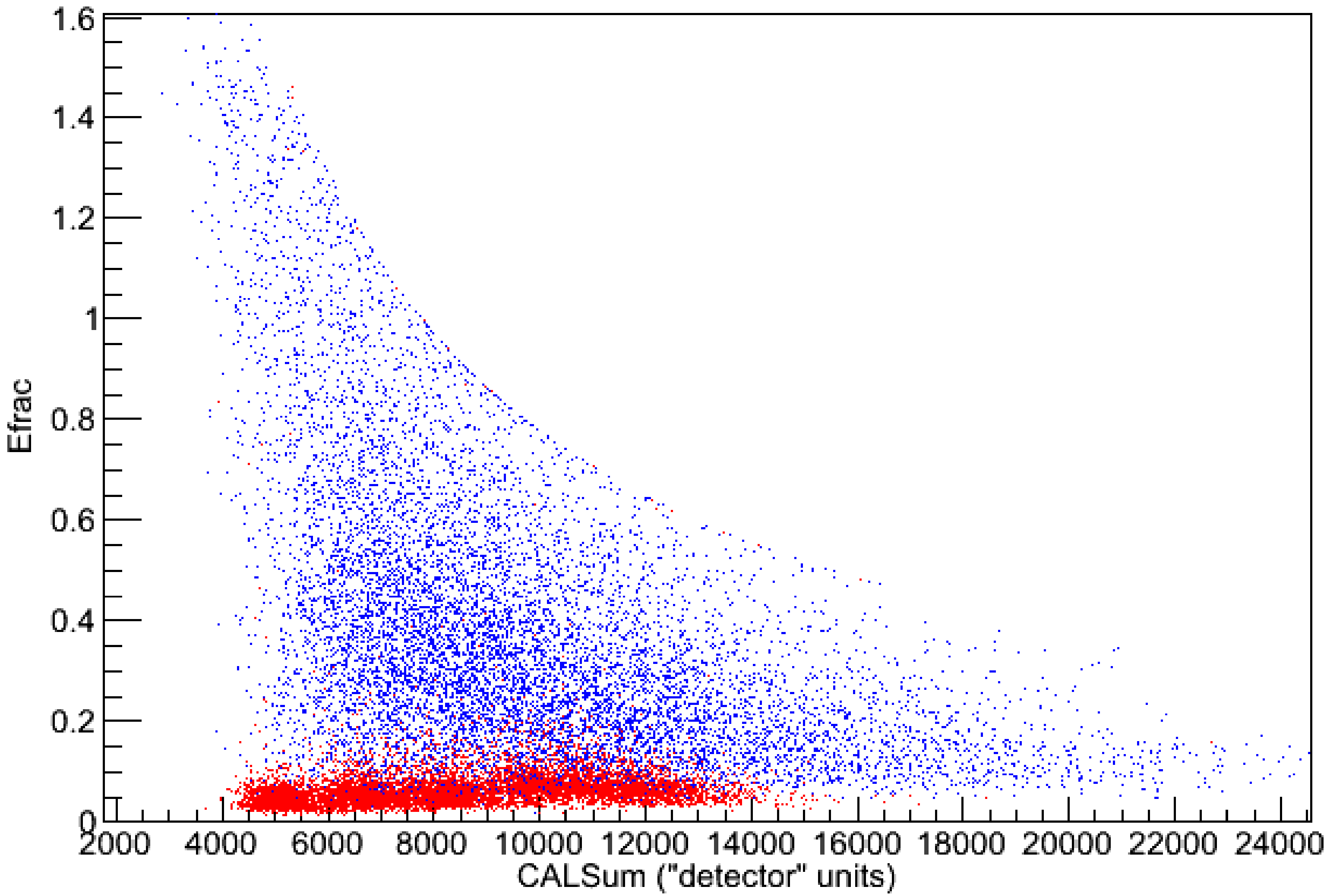
- Events have been selected from energy runs such that all energies are weighted equally
- Histograms scaled to equal areas by total number of entries and normalized such that total area is 1

BSD Late vs. CAL



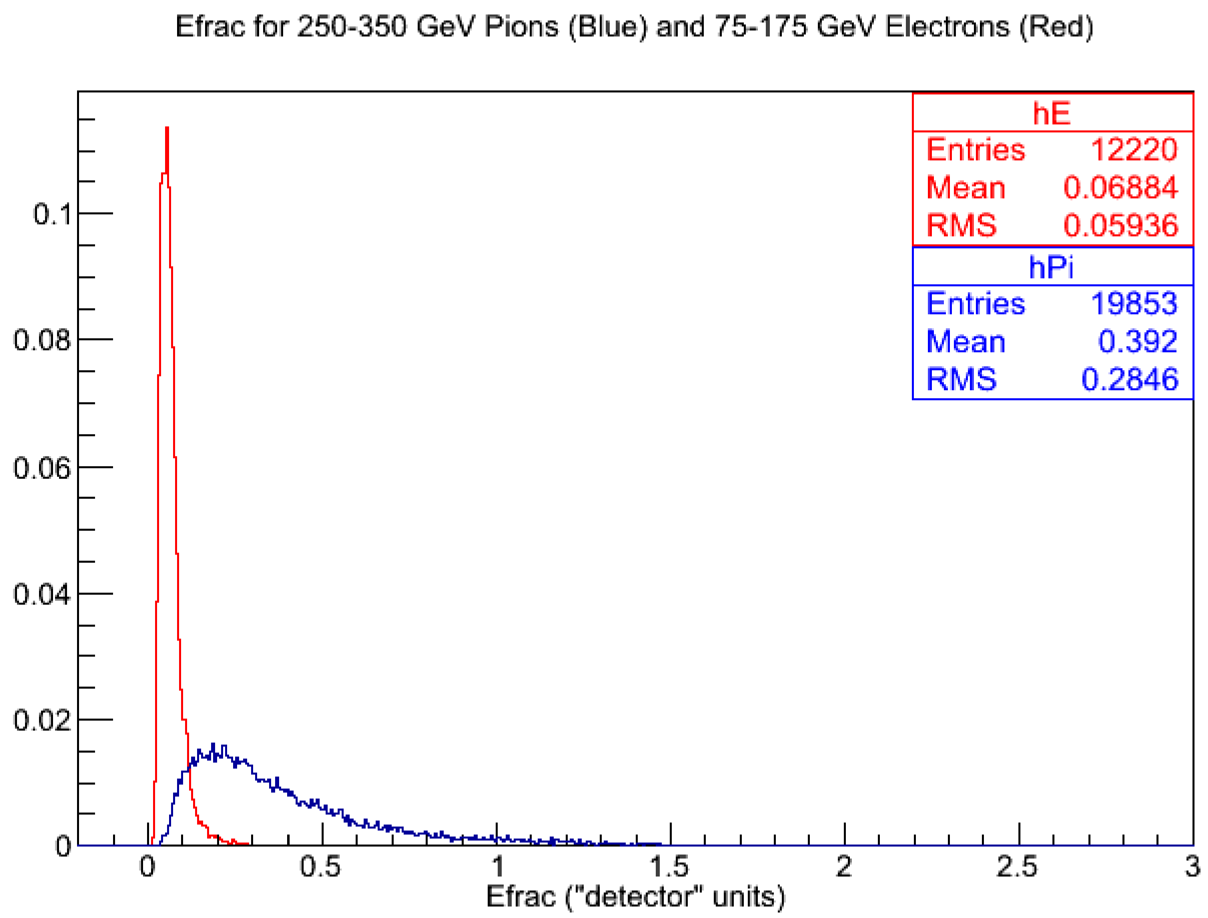
- 75-175 GeV electrons (red) and 250-350 GeV pions (blue)

Efrac vs. CALSum



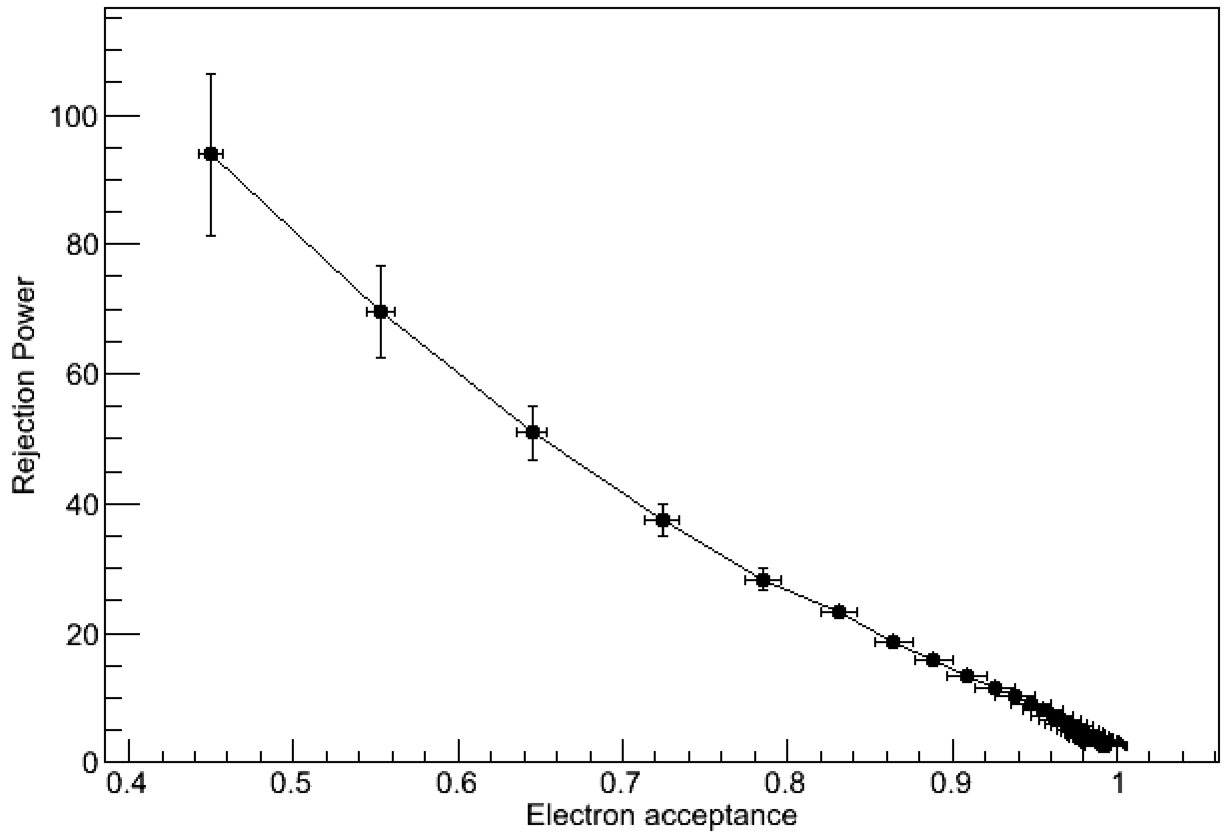
- 75-175 GeV electrons (red) and 250-350 GeV pions (blue)

Efrac For All Energies



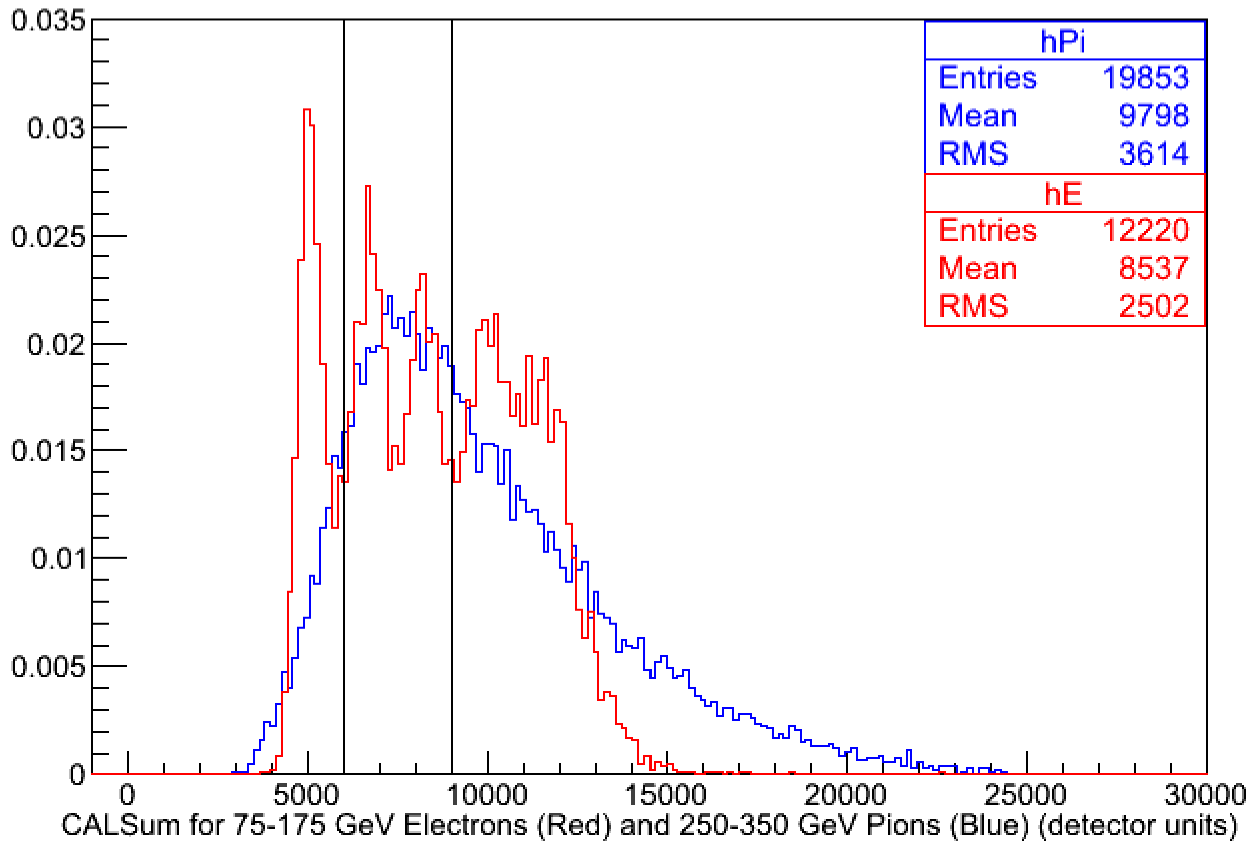
- Electron and pion histograms scaled to equal area by total number of entries and normalized such that total area is 1

Rejection Power vs. Electron Acceptance



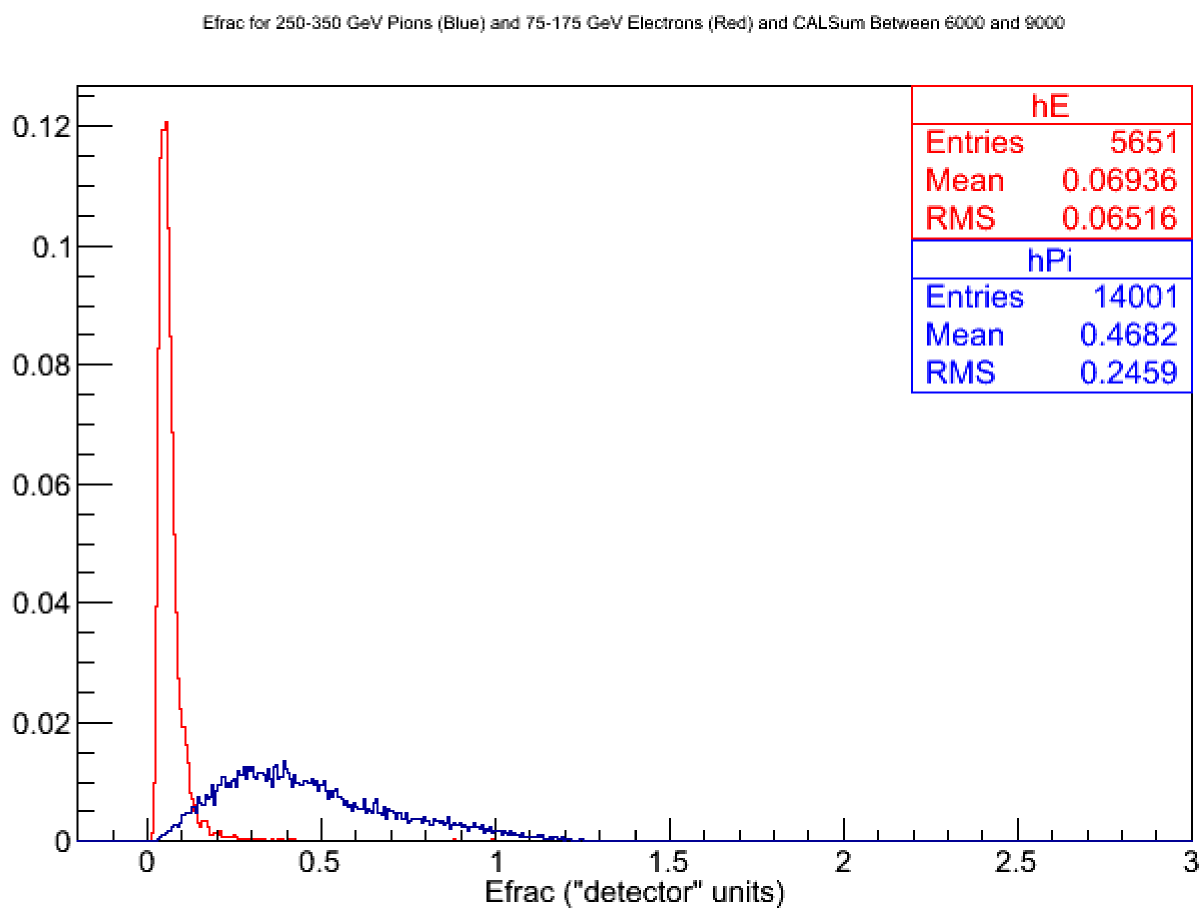
- Error bars propagated from statistics of Efrac histogram

New Analysis: Cut on CALSum



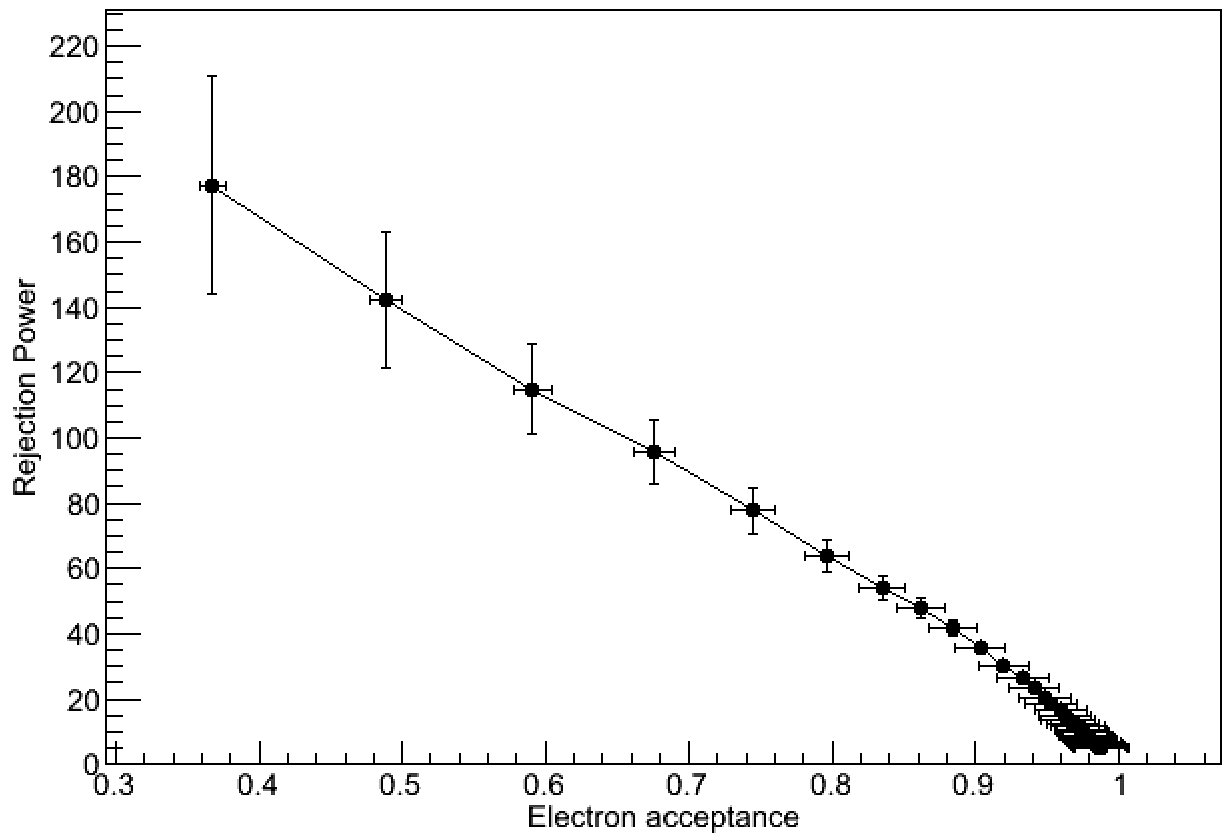
- Calculate Efrac, rejection ratio, and electron acceptance for CALSum between 6000 and 9000
- This is mostly 100 to 125 GeV electrons and 250 to 350 GeV pions

New Efrac



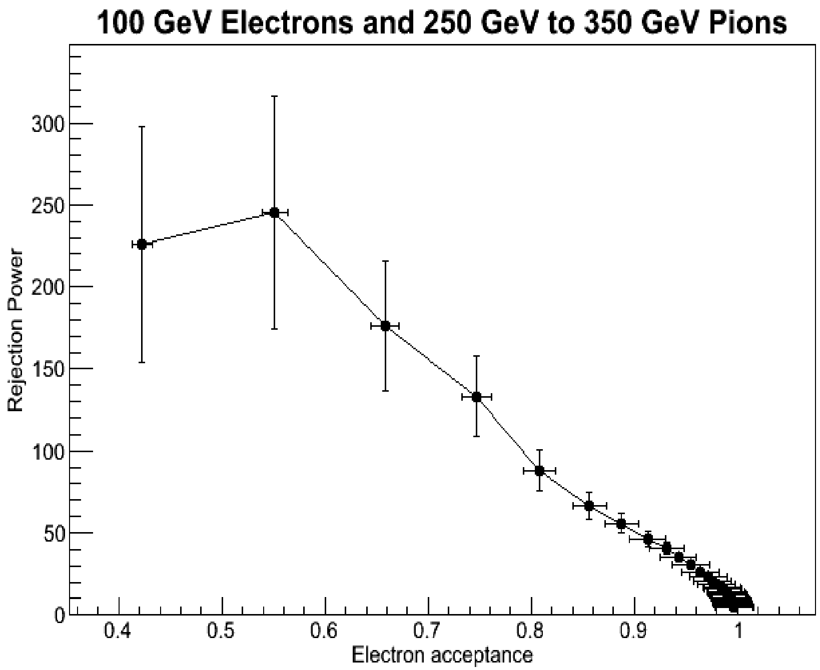
- Efrac for CALSum between 6000 to 9000

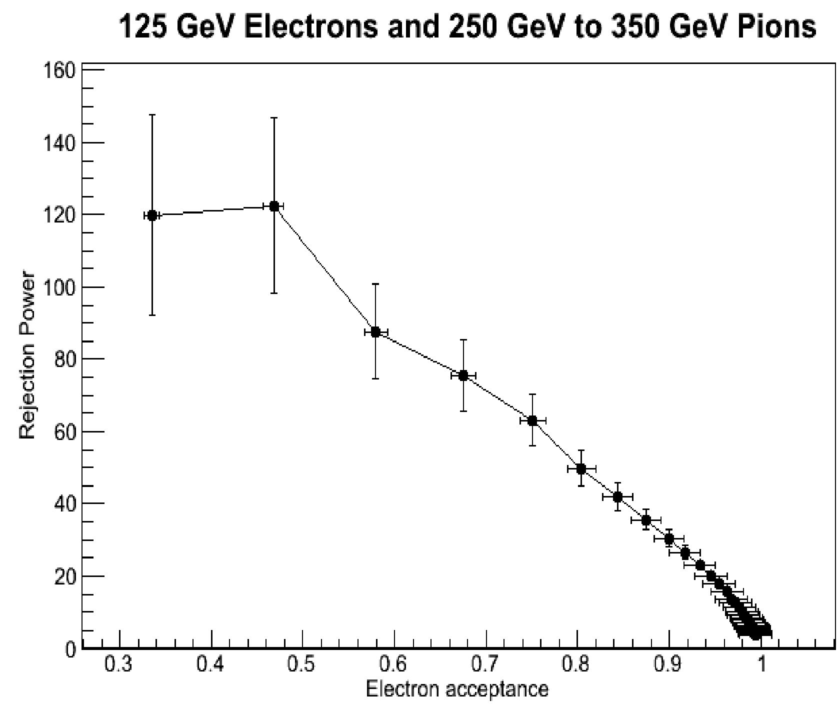
Rejection Power vs. Electron Acceptance



- Rejection Power vs. Electron Acceptance for CALSum between 6000 and 9000
- Somewhat better than using all CALSum range

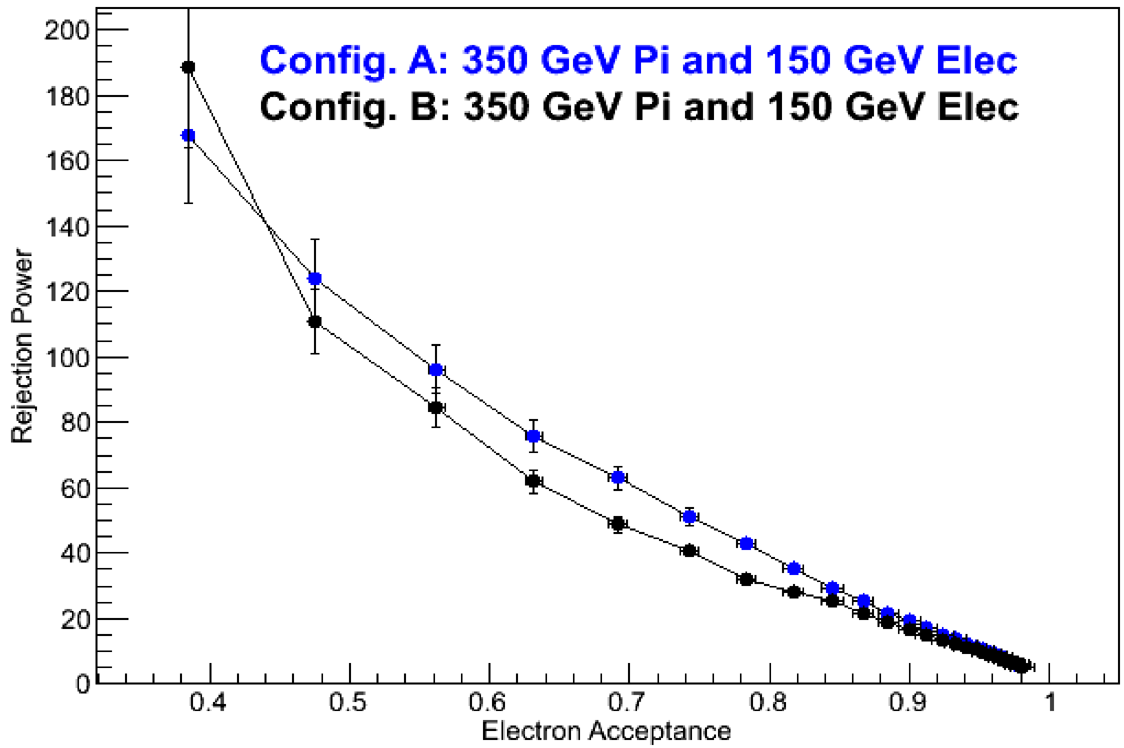
Different Approach to the Analysis





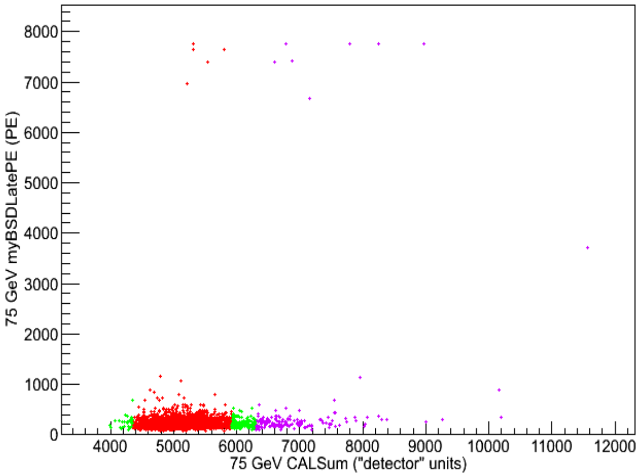
- Restrict analysis to CALSum within 2σ of electron's CALSum peak. Analyze electron energies individually.
- Make plots of rejection power vs. electron acceptance
- Note: As the electron energy you're looking at gets farther away from the center of the pion peak, this analysis becomes less meaningful, so only did 100 GeV and 125 GeV electrons.

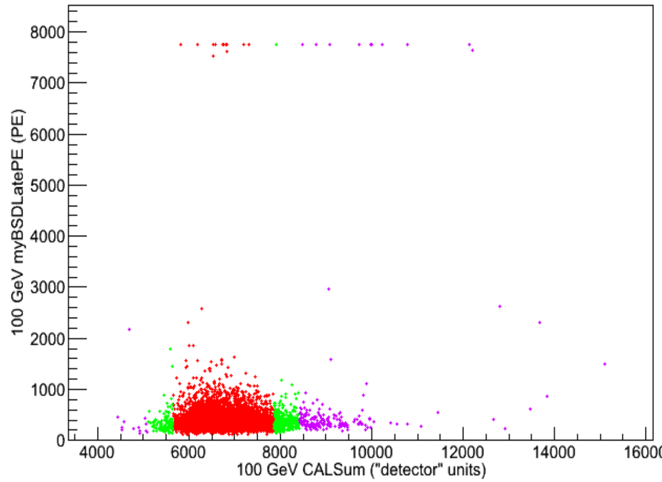
Rejection Power vs. Electron Acceptance

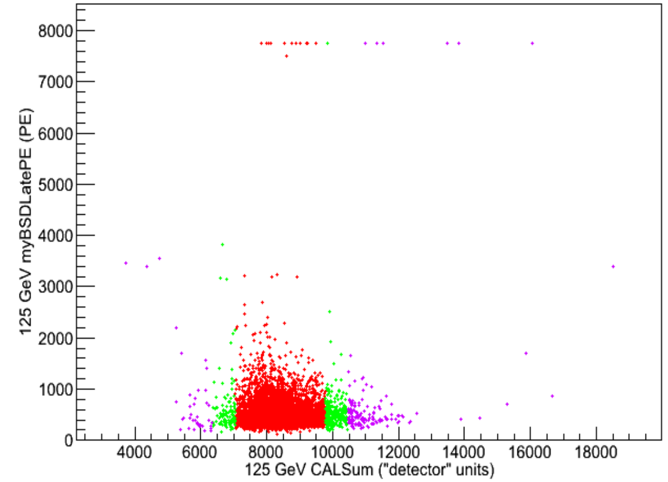


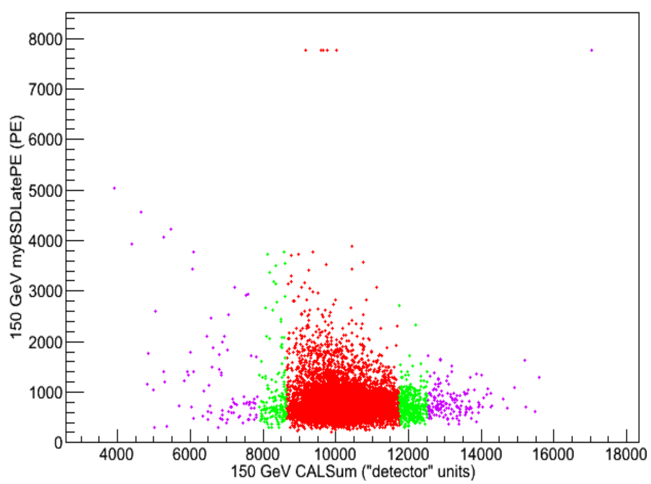
- 150 GeV electrons and 350 GeV pions
- Data from two different configurations:
  - Configuration A: BSD centered directly on center of CAL, no BCD/TCD
  - Configuration B: Beam roughly centered on BSD, offset ~14 cm from CAL center. BCD/TCD in place.
- Why the difference?
  - Different configuration. Maybe geometry makes a difference?

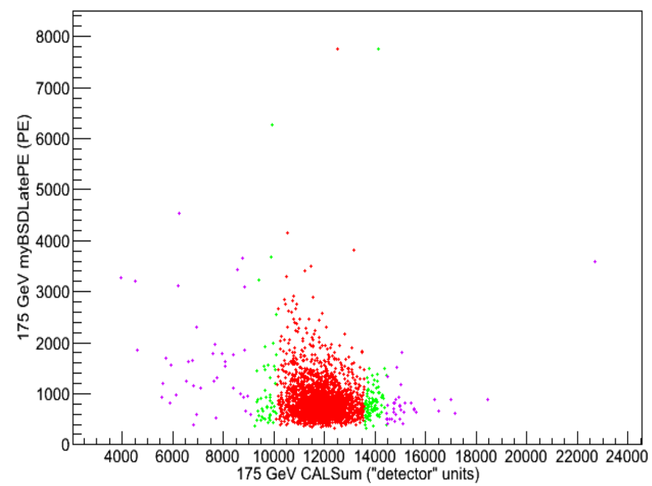
BSD Late vs. CALSum





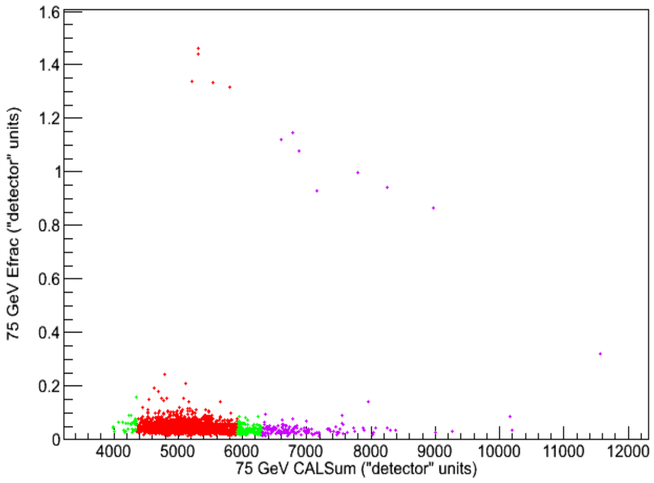


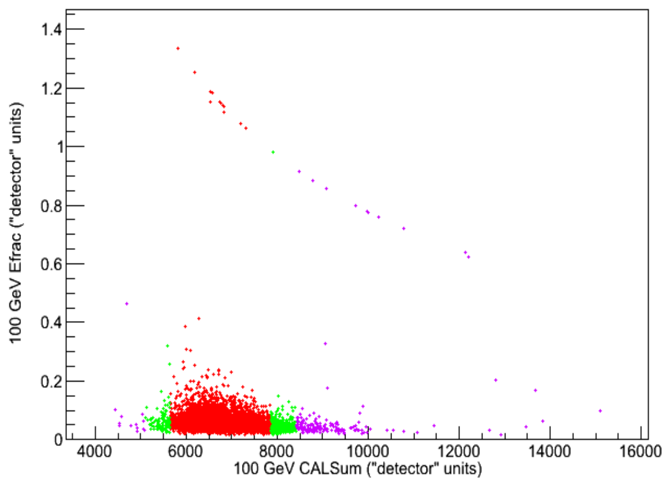


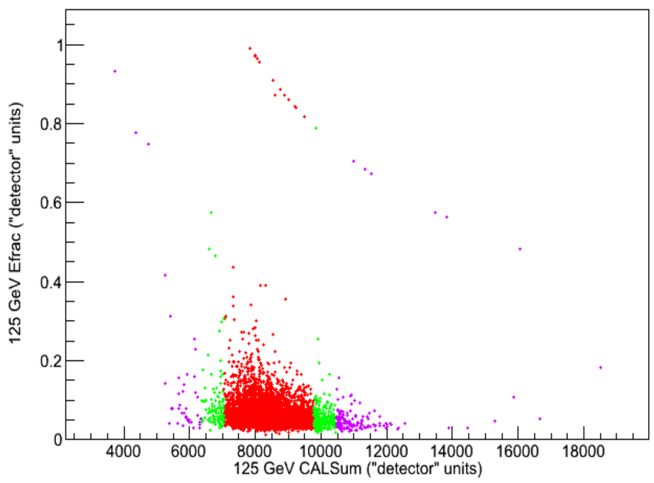


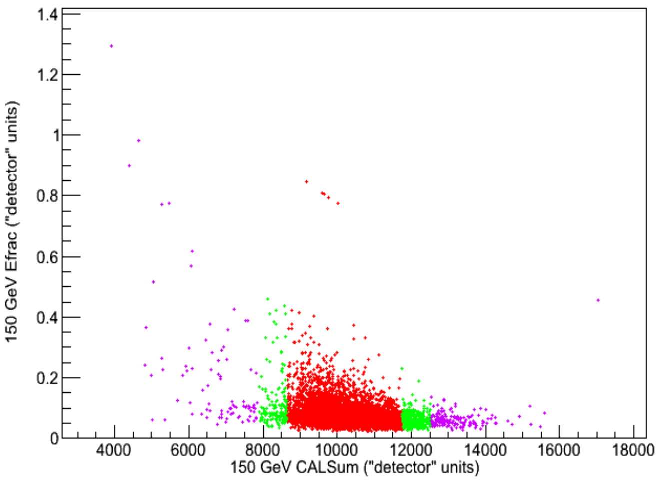
- Red: < 2 sigma
- Green: 2-3 sigma
- Violet: > 3 sigma

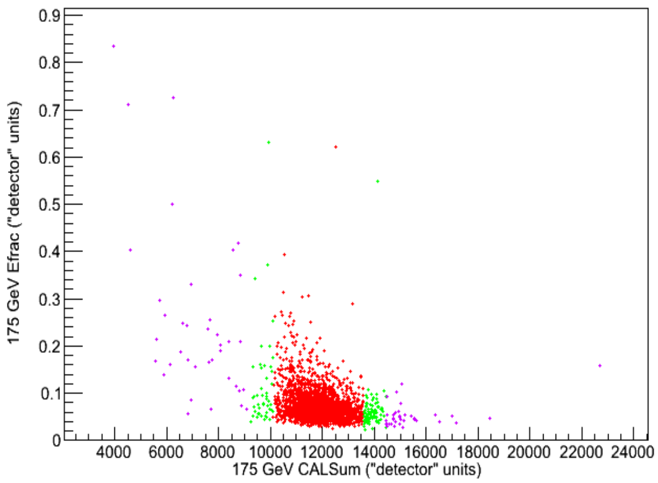
Efrac vs. CALSum











- Red: < 2 sigma
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- Violet: > 3 sigma