

# Throttle Studies - Part II

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# Recap from last time

- 2 throttle types
  - "Throttle 1" is active when a triggered tower is shadowed by a hit ACD tile
    - May disengage throttle when there is a Cal-Hi trigger. Calling this the "Cal-Hi switch"
  - "Throttle 2" is active when the front or first two rows of the ACD are hit
    - May disengage throttle when there is a Cal-Lo trigger. Calling this the "Cal-Lo switch"

# Executive Summary

- Results following will show that:
  - regardless of throttle type, it is necessary to use a Cal switch to disengage throttle
  - T2 w/ Cal-Lo switch eliminates slightly more background than T1 w/ Cal-Hi switch
  - T1 w/ Cal-Hi switch eliminates slightly fewer gammas than T2 w/ Cal-Lo switch
  - Other combinations of throttles and switches (T1 w/ Lo, T2 w/ Hi) perform well/poorly with gammas, and poorly/well with background, so better balance is found with the other 2 combinations

# Best Throttle/Switch Combos

Percentage of events eliminated

**Gammas**

**TKR triggers**

**TKR & >5 MeV**

**After DC1 Cuts**

Energy	T1 w/ Cal-Hi	T2 w/ Cal-Lo	T1 or vetoed w/ Cal-Hi	T2 or vetoed w/ Cal-Lo	T1 w/ Cal-Hi	T2 w/ Cal-Lo	T1 or vetoed w/ Cal-Hi	T2 or vetoed w/ Cal-Lo	T1 w/ Cal-Hi	T2 w/ Cal-Lo	T1 or vetoed w/ Cal-Hi	T2 or vetoed w/ Cal-Lo
100 MeV	12.8	16.6	29.3	30.2	4.8	6.6	6.9	7.7	0	0	0	0
1 GeV	18.9	22.4	39.6	43.4	10.7	9.5	16.1	14.2	3.5	2.6	7.3	5.8
10 GeV	22.5	20.9	38.9	63.6	12.2	9.4	20.2	18.6	2	0	5.7	4
100 GeV	18	17.3	30.3	88	10.3	8.1	14.7	14.5	0.1	0	1	1

Background Elimination	Backgndavgpdr rate: 3370 Hz		Backgndmaxpdr rate: 10830 Hz		albedo_gamma_upward rate: 256 Hz	
	%	Hz	%	Hz	%	Hz
Onboard Filter Veto	90.4	320	90.6	1020	50	127
<b>T1 w/ Cal-Hi switch</b>	<b>76.8</b>	<b>780</b>	<b>78.9</b>	<b>2290</b>	<b>32</b>	<b>176</b>
Vetoed or T1 w/ Cal-Hi switch	93.1	230	94.1	640	53	124
<b>T2 w/ Cal-Lo switch</b>	<b>75.6</b>	<b>820</b>	<b>75.9</b>	<b>2620</b>	<b>37</b>	<b>163</b>
Vetoed or T2 w/ Cal-Lo switch	91	310	90.9	990	53	120

% eliminated
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Rate after elimination
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Next few slides have details on each of the 4 throttle/switch combinations

# Impact on gammas - TKR triggers

Using  
Cal-Lo  
switch

Percent of TKR triggers vetoed by OnboardFilter and/or eliminated by a Throttle

Energy	T1	T1 w/ switch	T2	T2 w/ switch	Onboard- Filter Veto	T1 or Vetoed	Incremental Throttle Damage (ITD) relative to Onboard- Filter Damage	Vetoed OR (T1 w/ switch)	ITD	T2 or Vetoed	ITD	Vetoed OR (T2 w/ switch)	ITD
100 MeV	12.8	12.8	16.6	16.6	28.5	29.3	0.8	29.3	0.8	30.2	1.7	30.2	1.7
1 GeV	18.9	18	28.6	22.4	36.3	39.6	3.3	37.6	1.3	43.4	71	38.3	2
10 GeV	37.7	19.8	51.8	20.9	36.9	51.2	14.3	37.4	0.5	63.6	26.7	37.7	0.8
100 GeV	67.9	16.6	79.3	17.3	29.5	77.6	48.1	30	0.5	88	58.5	30.2	0.7

(1) The Cal-Lo switch is necessary

(2) Concerning TKR triggers, Throttle 1 performs better than Throttle 2

(3) OnboardFilter does more damage than either throttle

(4) Adding either throttle does little additional damage to the efficiency, meaning that almost all throttled events would be killed later by OnboardFilter

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# Impact on gammas - TKR triggers

Using Cal-Hi switch

Percent of TKR triggers vetoed by OnboardFilter and/or eliminated by a Throttle

Energy	T1	T1 w/ switch	T2	T2 w/ switch	Onboard-Filter Veto	T1 or Vetoed	Incremental Throttle Damage (ITD) relative to Onboard-Filter Damage	Vetoed OR (T1 w/ switch)	ITD	T2 or Vetoed	ITD	Vetoed OR (T2 w/ switch)	ITD
100 MeV	12.8	12.8	16.6	16.6	28.5	29.3	0.8	29.3	0.8	30.2	1.7	30.2	1.7
1 GeV	18.9	18.9	28.6	28.6	36.3	39.6	3.3	39.6	3.3	43.4	7.1	43.4	7.1
10 GeV	37.7	22.5	51.8	25	36.9	51.2	14.3	38.9	2	63.6	26.7	40.3	3.4
100 GeV	67.9	18	79.3	19.7	29.5	77.6	48.1	30.3	0.8	88	58.5	30.6	1.1

The Cal-Hi switch is necessary

Concerning TKR triggers, Throttle 1 performs better than Throttle 2

0.8
1.3
0.5
0.5

Incremental damage larger using Cal-Hi as opposed to Cal-Lo

# Impact on gammas - TKR and $> 5$ MeV

Using  
Cal-Lo  
switch

Percent of events eliminated that have a  
TKR trigger and  $> 5$  MeV in the cal

Energy	T1	T1 w/ switch	T2	T2 w/ switch	Onboard- Filter Veto	T1 or Vetoe d	Incrementa l Throttle Damage (ITD) relative to Onboard- Filter Damage	Vetoed OR (T1 w/ switch)	ITD	T2 or Vetoed	ITD	Vetoed OR (T2 w/ switch)	ITD
100 MeV	4.8	4.8	6.6	6.6	6.2	6.9	0.7	6.9	0.7	7.7	1.5	7.7	1.5
1 GeV	10.7	6.3	18.2	9.5	11.4	16.1	4.7	13	1.6	21.4	10	14.2	2.8
10 GeV	32.2	8.6	50	9.4	17.6	36.6	19	18.4	0.8	52.7	35.1	18.6	1
100 GeV	70.6	7.6	84. 3	8.1	13.7	72.8	59.1	14.3	0.6	85.6	71.9	14.5	0.8

Damage is  
less than it  
was for TKR  
triggers only

12.8
18
19.8
16.6

Throttle 1 still better  
than Throttle 2

Incremental damage is still  
small

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# Impact on gammas - TKR and $> 5 \text{ MeV}$

Using  
Cal-Hi  
switch

Percent of events eliminated that have a  
TKR trigger and  $> 5 \text{ MeV}$  in the cal

Energy	T1	T1 w/ switch	T2	T2 w/ switch	Onboard- Filter Veto	T1 or Vetoe d	Incrementa l Throttle Damage (ITD) relative to Onboard- Filter Damage	Vetoed OR (T1 w/ switch)	ITD	T2 or Vetoed	ITD	Vetoed OR (T2 w/ switch)	ITD
100 MeV	4.8	4.8	6.6	6.6	6.2	6.9	0.7	6.9	0.7	7.7	1.5	7.7	1.5
1 GeV	10.7	10.7	18.2	18.2	11.4	16.1	4.7	16.1	4.7	21.4	10	21.4	10
10 GeV	32.2	12.2	50	14.7	17.6	36.6	19	20.2	2.6	52.7	35.1	30.7	13.1
100 GeV	70.6	10.3	84. 3	11	13.7	72.8	59.1	14.7	1	85.6	71.9	15	1.3

Damage is  
less than it  
was for TKR  
triggers only,  
but still  
larger than  
when using  
Cal-Lo switch

12.8
18.9
22.5
18

Throttle 1 still better  
than Throttle 2

Again, incremental damage  
when using Cal-Hi is larger

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Using  
Cal-Lo  
switch

# Impact on gammas - after DC1 cuts

Percent of events eliminated that passed all DC1 cuts (pruning, background, and goodEvent)

Energy	T1	T1 w/ switch	T2	T2 w/ switch	Onboard- Filter Veto	T1 or Vetoed	Incremental Throttle Damage (ITD) relative to Onboard- Filter Damage	Vetoed OR (T1 w/ switch)	ITD	T2 or Vetoed	ITD	Vetoed OR (T2 w/ switch)	ITD
100 MeV	0	0	0	0	0	0	0	0	0	0	0	0	0
1 GeV	3.5	0.9	10	2.6	4.4	7.3	2.9	4.9	0.5	12.7	8.3	5.8	1.4
10 GeV	19.2	0	42.2	0	4	22	18	4	0	43.7	39.7	4	0
100 GeV	65	0	88.3	0	1	65.5	64.5	1	0	88.3	87.3	1	0

Very little damage with either throttle

Incremental damage is very small

Using  
Cal-Hi  
switch

# Impact on gammas - after DC1 cuts

Percent of events eliminated that passed all DC1 cuts (pruning, background, and goodEvent)

Energy	T1	T1 w/ switch	T2	T2 w/ switch	Onboard- Filter Veto	T1 or Vetoed	Incremental Throttle Damage (ITD) relative to Onboard- Filter Damage	Vetoed OR (T1 w/ switch)	ITD	T2 or Vetoed	ITD	Vetoed OR (T2 w/ switch)	ITD
100 MeV	0	0	0	0	0	0	0	0	0	0	0	0	0
1 GeV	3.5	3.49	10	10	4.4	7.3	2.9	7.3	2.9	12.7	8.4	12.7	8.4
10 GeV	19.2	2	42.2	3.9	4	22	18	5.7	1.7	43.7	39.7	7.5	3.5
100 GeV	65	0.1	88.3	0.1	1	65.5	64.5	1	0	88.3	87.3	1	0

Little damage with either throttle

Incremental damage is larger when using Cal-Hi switch

# Comparing all variations

TKR Triggers

TKR & >5 MeV

After DC1 cuts

Energy	T1 w/ Cal-Lo Cal-Hi	T2 w/ Cal-Lo Cal-Hi	T1 or vetoed w/ Cal-Lo Cal-Hi	T2 or vetoed w/ Cal-Lo Cal-Hi	T1 w/ Cal-Lo Cal-Hi	T2 w/ Cal-Lo Cal-Hi	T1 or vetoed w/ Cal-Lo Cal-Hi	T2 or vetoed w/ Cal-Lo Cal-Hi	T1 w/ Cal-Lo Cal-Hi	T2 w/ Cal-Lo Cal-Hi	T1 or vetoed w/ Cal-Lo Cal-Hi	T2 or vetoed w/ Cal-Lo Cal-Hi
100 MeV	12.8 12.8	16.6 16.6	29.3 29.3	30.2 30.2	4.8 4.8	6.6 6.6	6.9 6.9	7.7 7.7	0 0	0 0	0 0	0 0
1 GeV	18 18.9	22.4 28.6	37.6 39.6	43.4 43.4	6.3 10.7	9.5 18.2	13 16.1	14.2 21.4	0.9 3.5	2.6 10	4.9 7.3	5.8 12.7
10 GeV	19.8 22.5	20.9 25	37.4 38.9	63.6 63.6	8.6 12.2	9.4 14.7	18.4 20.2	18.6 30.7	0 2	0 3.9	4 5.7	4 7.5
100 GeV	16.6 18	17.3 19.7	30 30.3	88 88	7.6 10.3	8.1 11	14.3 14.7	14.5 15	0 0.1	0 0.1	1 1	1 1

Gamma performance from best to worst: T1 w/ Cal-Lo

T2 w/ Cal-Lo

T1 w/ Cal-Hi

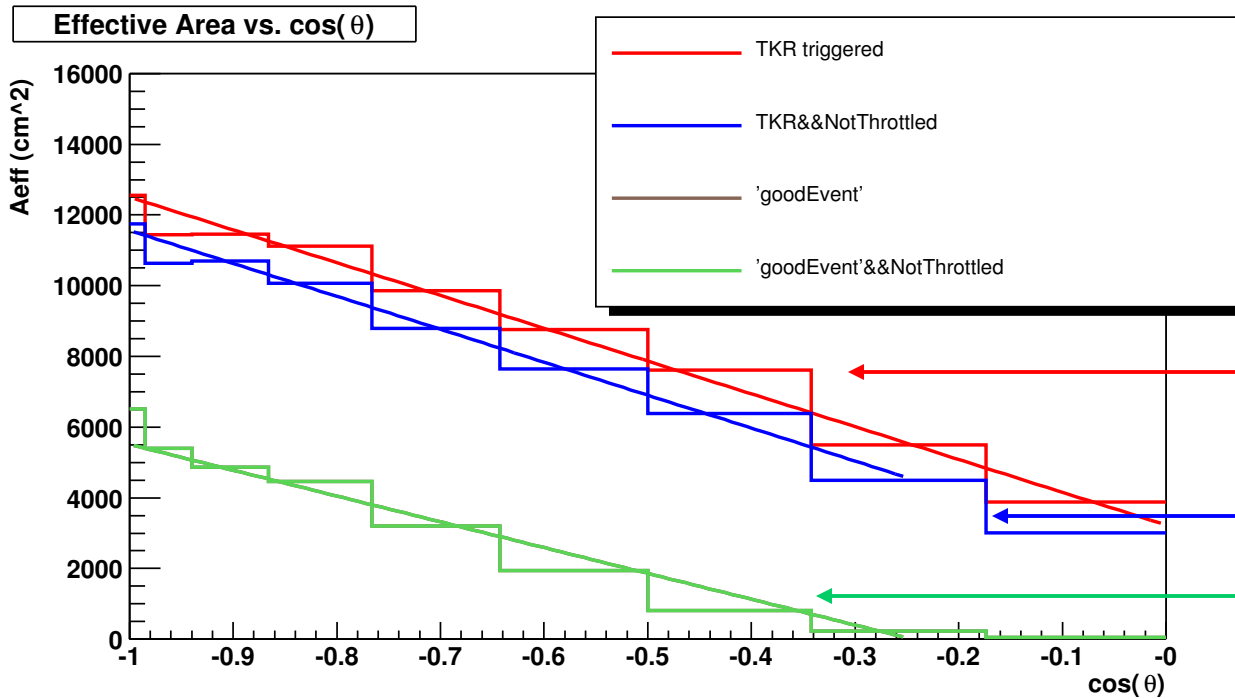
T2 w/ Cal-Hi

This is regardless of whether we consider OnboardFilter.

# Effective Area and FOV

	Energy: 100 MeV		Energy: 1 GeV		Energy: 10 GeV		Energy: 100 GeV*	
	Aeff at normal incidence (cm <sup>2</sup> )	FOV (sr)	Aeff at normal incidence (cm <sup>2</sup> )	FOV (sr)	Aeff at normal incidence (cm <sup>2</sup> )	FOV (sr)	Aeff at normal incidence (cm <sup>2</sup> )	FOV (sr)
Cut and Throttle used								
TKR after T1 (Cal-Lo switch)	11550	3.5	14330	3.6	14820	3.7	15650	4.3
DC1 after T1 (Cal-Lo switch)	5510	2.3	10310	2.5	10300	2.5	9530	2.3
<b>TKR after T2 (Cal-Lo switch)</b>	<b>11560</b>	<b>3.8</b>	<b>14340</b>	<b>3.4</b>	<b>14830</b>	<b>3.7</b>	<b>15610</b>	<b>4.3</b>
<b>DC1 after T2 (Cal-Lo switch)</b>	<b>5510</b>	<b>2.3</b>	<b>10250</b>	<b>2.5</b>	<b>10300</b>	<b>2.5</b>	<b>9530</b>	<b>2.3</b>
<b>TKR after T1 (Cal-Hi switch)</b>	<b>11560</b>	<b>3.8</b>	<b>13590</b>	<b>3.7</b>	<b>14450</b>	<b>3.7</b>	<b>15690</b>	<b>4.2</b>
<b>DC1 after T1 (Cal-Hi switch)</b>	<b>5510</b>	<b>2.3</b>	<b>10030</b>	<b>2.5</b>	<b>10090</b>	<b>2.5</b>	<b>9575</b>	<b>2.3</b>
TKR after T2 (Cal-Hi switch)	11550	3.6	13180	3.4	14190	3.7	15630	4.2
DC1 after T2 (Cal-Hi switch)	5510	2.3	9590	2.5	9980	2.5	9530	2.3

Statistics are low, so take these numbers with a grain of salt (Aeff may be underestimated, FOV overestimated). See next 2 slides for some sample plots of the fits.



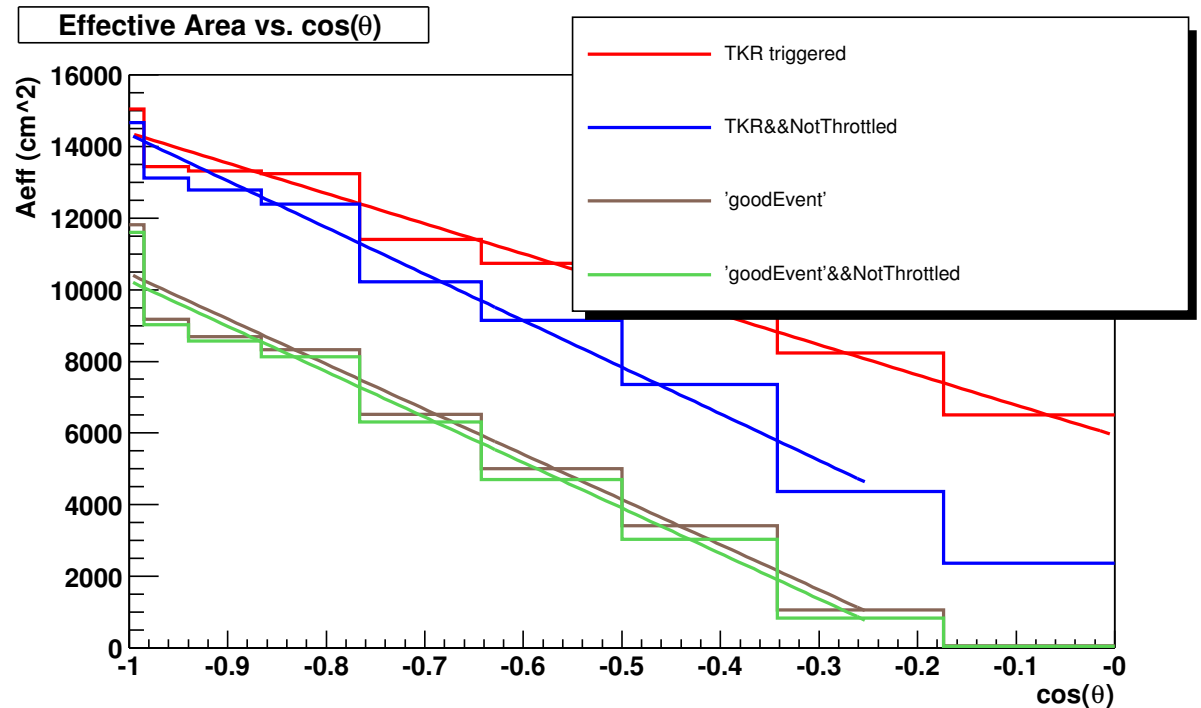
100 MeV gammas,  
Throttle 1 w/ Cal  
-Lo switch

TKR triggers

TKR triggers after  
throttle applied

DC1 after throttle

1 GeV gammas,  
Throttle 2 w/  
Cal-Lo switch

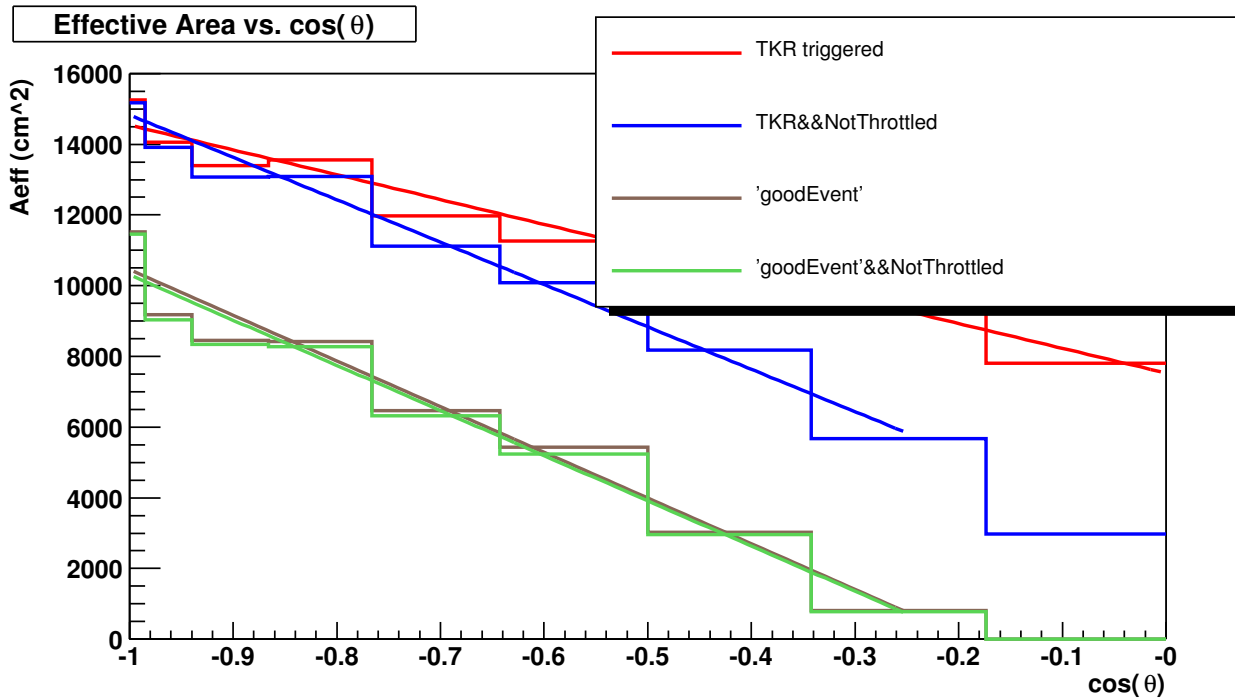


TKR triggers

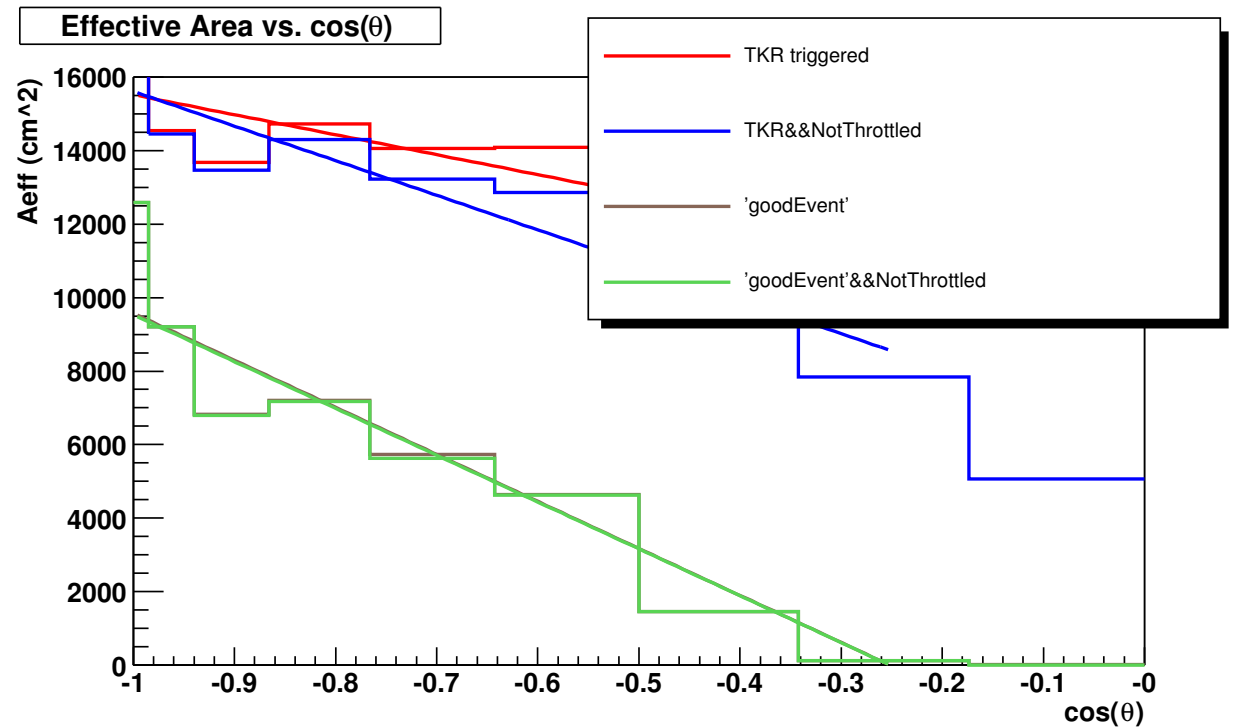
TKR triggers after  
throttle applied

DC1 events ( passed cuts)

DC1 after throttle



100 GeV gammas,  
Throttle 1 w/ Cal-  
Lo switch



TKR triggers

TKR triggers after  
throttle applied

DC1 events ( passed cuts)

DC1 after throttle

# Background

**T1 w/ Cal-Lo:**  
Throttle with best gamma performance also does worst at background elimination →

**T2 w /Cal-Hi:**  
Throttle with worst gamma performance does best at background elimination →

	Backgndavgpdr	TKR Rate: 3370 Hz	Backgndmaxpdr	TKR Rate: 10830 Hz
	% eliminated	Rate (Hz)	% eliminated	Rate (Hz)
Onboard Filter Veto	90.4	320	90.6	1020
T1 w/ Cal-Lo switch	64.7	1190	64.6	3830
<b>T1 w/ Cal-Hi switch</b>	<b>76.8</b>	<b>780</b>	<b>78.9</b>	<b>2290</b>
Vetoed or T1 w/ Cal-Lo switch	90.8	310	90.8	990
Vetoed or T1 w/ Cal-Hi switch	93.1	230	94.1	640
<b>T2 w/ Cal-Lo switch</b>	<b>75.6</b>	<b>820</b>	<b>75.9</b>	<b>2620</b>
T2 w/ Cal-Hi switch	88.7	380	91.9	877
Vetoed or T2 w/ Cal-Lo switch	91	310	90.9	990
Vetoed or T2 w/ Cal-Hi switch	94	200	95.1	530

After OnboardFilter, there is little difference between T1 and T2



# Results Summary

- Of 2 throttles tested, "Throttle 1" does slightly less damage to gammas
  - More complex method than Throttle 2
- Either throttle must use a Cal switch to disengage, or gamma damage is high
  - Cal-Lo hurts gammas less, but Cal-Hi kills more background
- Both methods, on their own, do significantly less damage to gammas than OnboardFilter
- The best balance between background rejection and gamma efficiency can be found in either **T1 w/ Cal-Hi** switch, or **T2 w/ Cal-Lo** switch

To investigate: Using a throttle as a pre-filter. How does the OnboardFilter logic look now?