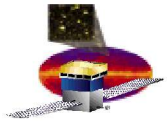

Analysis of TowerA Van de Graff Data

Instrument Analysis Workshop 6

SLAC February 27-28, 2006

Does the GLAST Monte Carlo successfully model real low energy photon data?

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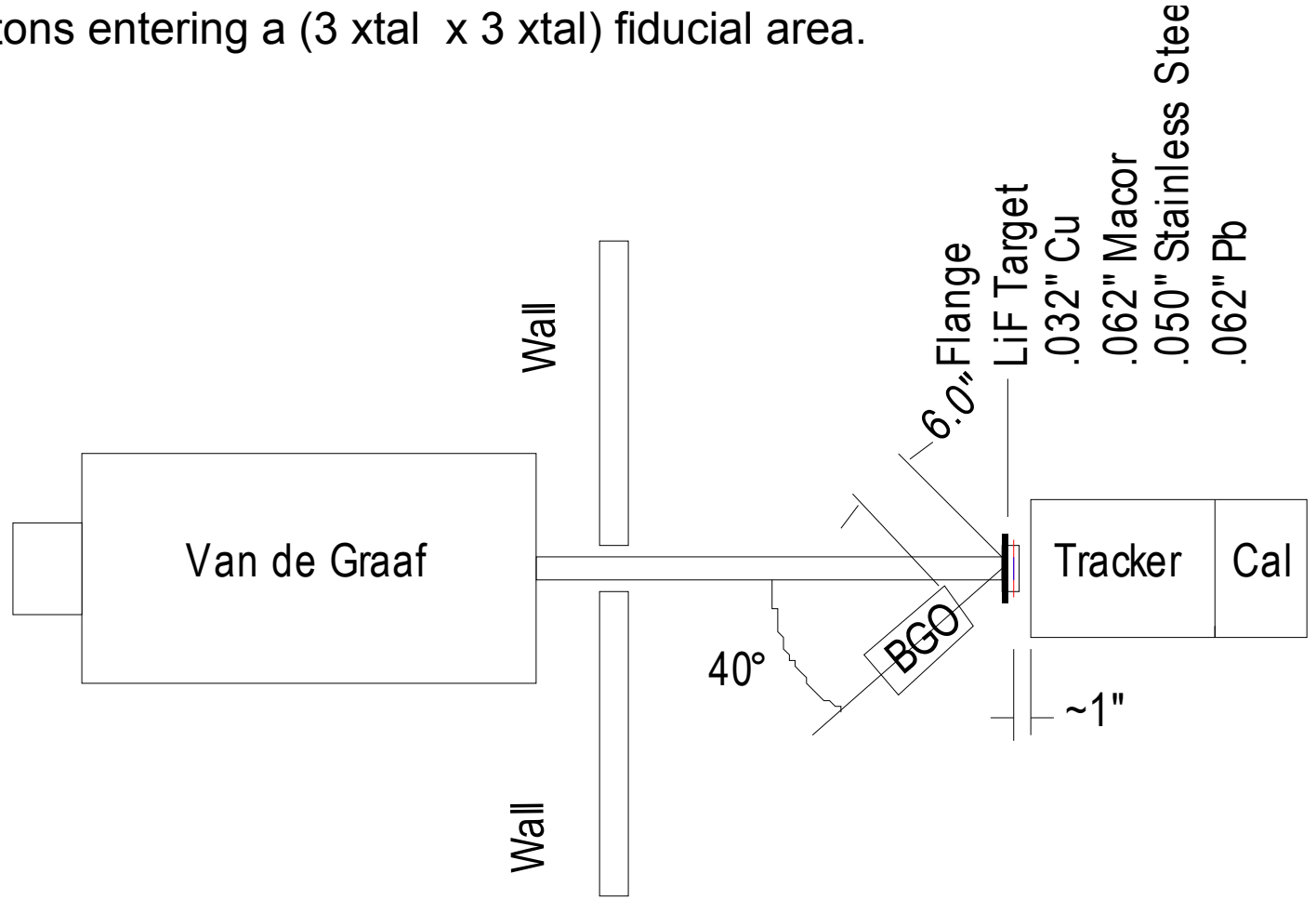
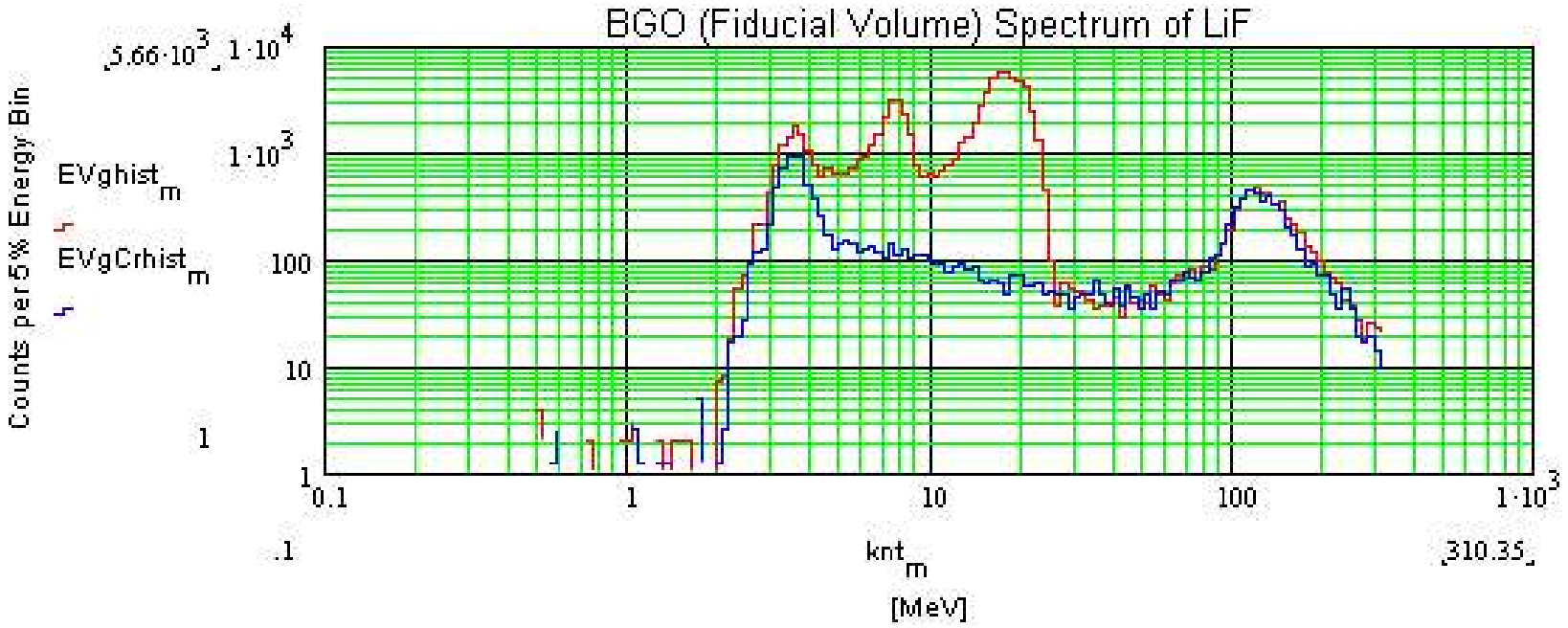
Introduction

1) VG proton beam hits a LiF target.
2) Produces F(6.1), Li(14.6, 17.6) Mev photons (intensities.58 : .50 : 1.00)
3) Isotropic flux
4) Segmented (7 xtal x7 xtal) BGO calorimeter counts the number of photons entering a (3 xtal x 3 xtal) fiducial area.



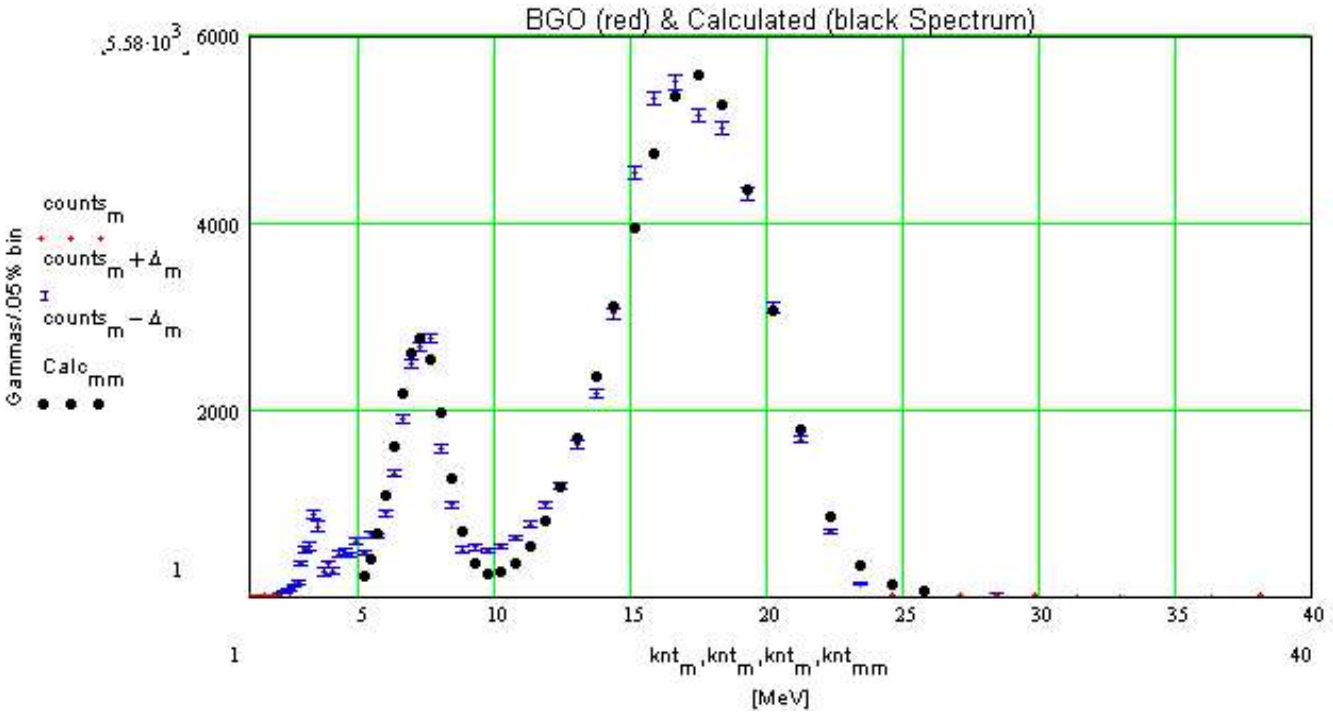
BGO Monitoring

BGO 3 x 3 fiducial volume spectrum for run VG112. Red= VG on. Blue= VG off for an equal amount of time. Cosmic peak ~120 MeV.



BGO Monitoring

The blue points with error bars are the cosmic subtracted BGO 3 x 3 fiducial volume spectrum for run VG112. The black dots are a convolution of Gaussians and Lorentzians for the 3 lines using energies (7.1, 14.6, 17.6 Mev), intrinsic widths (.001, .01, 1.5 Mev), relative intensities (.58, .497, 1.00) , and a BGO energy σ_E/E = 13% at all energies.



BGO Monitoring

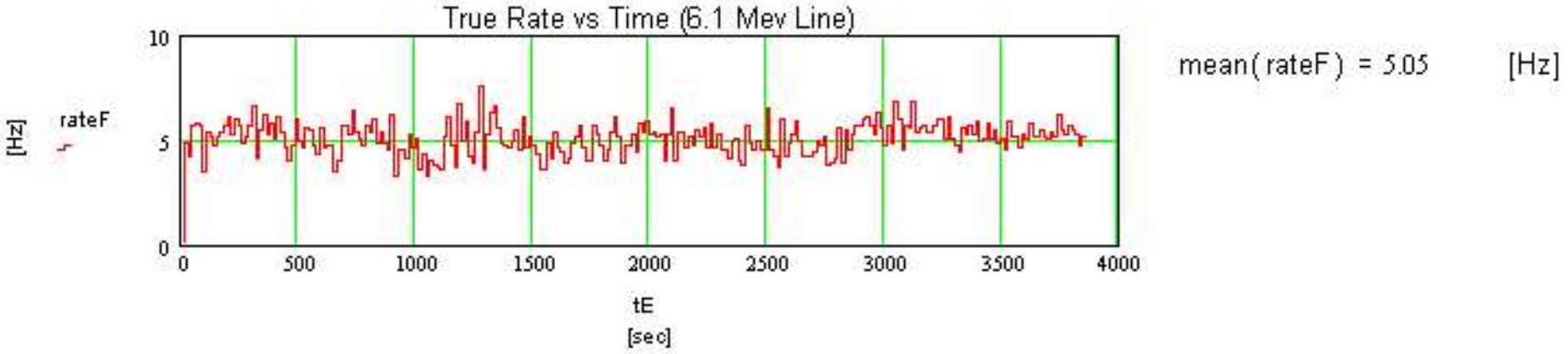
1) Simultaneously with a Tower A run, take a VGxxx run to measure the rate of F and Li [photons/sec] versus time in the BGO fiducial area.

4) # of photons produced / sterad = $\frac{\text{(Avrg rate in BGO) x (Sec of TowerA run)}}{\text{MC Solid angle of BGO fiducial area}}$

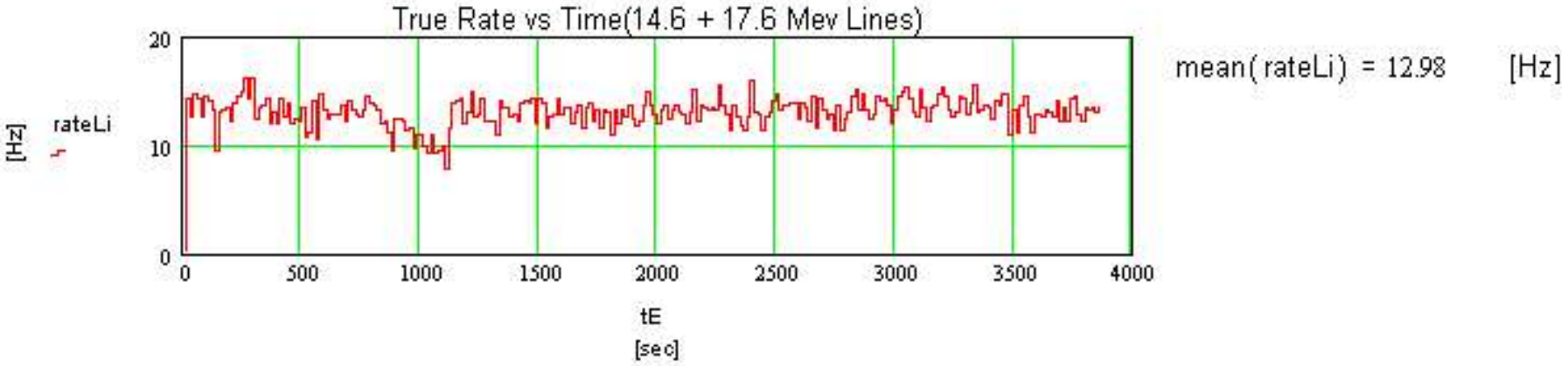
3) MC Solid angle of BGO fiducial area = .102 $\pm$ .08 str

BGO Monitoring

Cosmic subtracted, deadtime corrected F line rate (5-10 MeV summed) versus time for run VG112.



Cosmic subtracted, deadtime corrected Li line rate (10-25 MeV summed) versus time for run VG112.



TowerA Trigger Rates

1) There were 12 – one hour front face E2E and SVAC runs, various configurations, VG ON. For each run:

   a) Calculate the deadtime corrected trigger rate.
   b) Subtract the cosmic ray rate of Run 135000954.
   c) Measure the F and Li photon rates using the BGO.
   d) Predicted trigger rate=

$$\left(\frac{\text{MC Effic}\Omega\text{tower}}{\text{MC }\Omega\text{bgo}} \times \text{BGO rate}\right)_F + \left(\frac{\text{MC Effic}\Omega\text{tower}}{\text{MC }\Omega\text{bgo}} \times \text{BGO rate}\right)_{Li}$$

   h) The Tower is much less efficient for triggering on F than Li photons.

   MC EfficΩtower(F)= .028 str MC EfficΩtower(Li)=.348 str

   l) Calculate Ratio= Measured Trig Rate / Predicted Trig Rate

   n) The average Ratio was 1.10 $\pm$ .05 statistical varience of 12 runs
   $\pm$ .08 systematic BGO distance error

Run 135000949

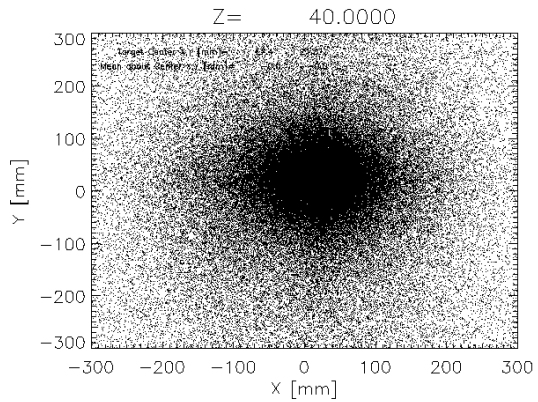
1) Horizonal LAT 1” in front of VG target. LAT z axis parallel to VG pipe.

3) VG is ON. BGO run VG112. Tower run 135000949.

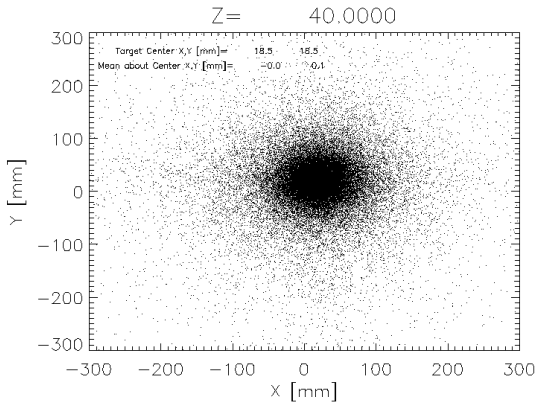
5) Events are used in the following plots if GoodTrk= .True.

GoodTrk =	[Vtx1NumTkrs ≥ 1]	At least 1 track
and	[Tkr1NumHits ≥ 4]	Looser than 6 hit hardware trigger
and	[abs(VtxX0+560.) ≤ 250.]	Vertex in loose Tower volume
and	[abs(VtxY0+560.) ≤ 250.]	
and	[0. < VtxZ0 < 610.]	

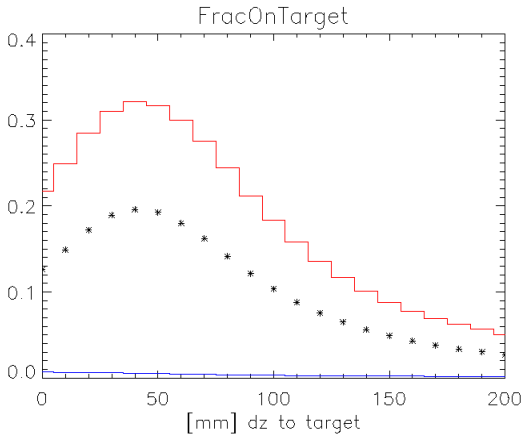
Run 135000949



VG data tracks extrapolated to a plane 40 mm in front of the top silicon layer.



MC data tracks extrapolated to a plane 40 mm in front of the top silicon layer.

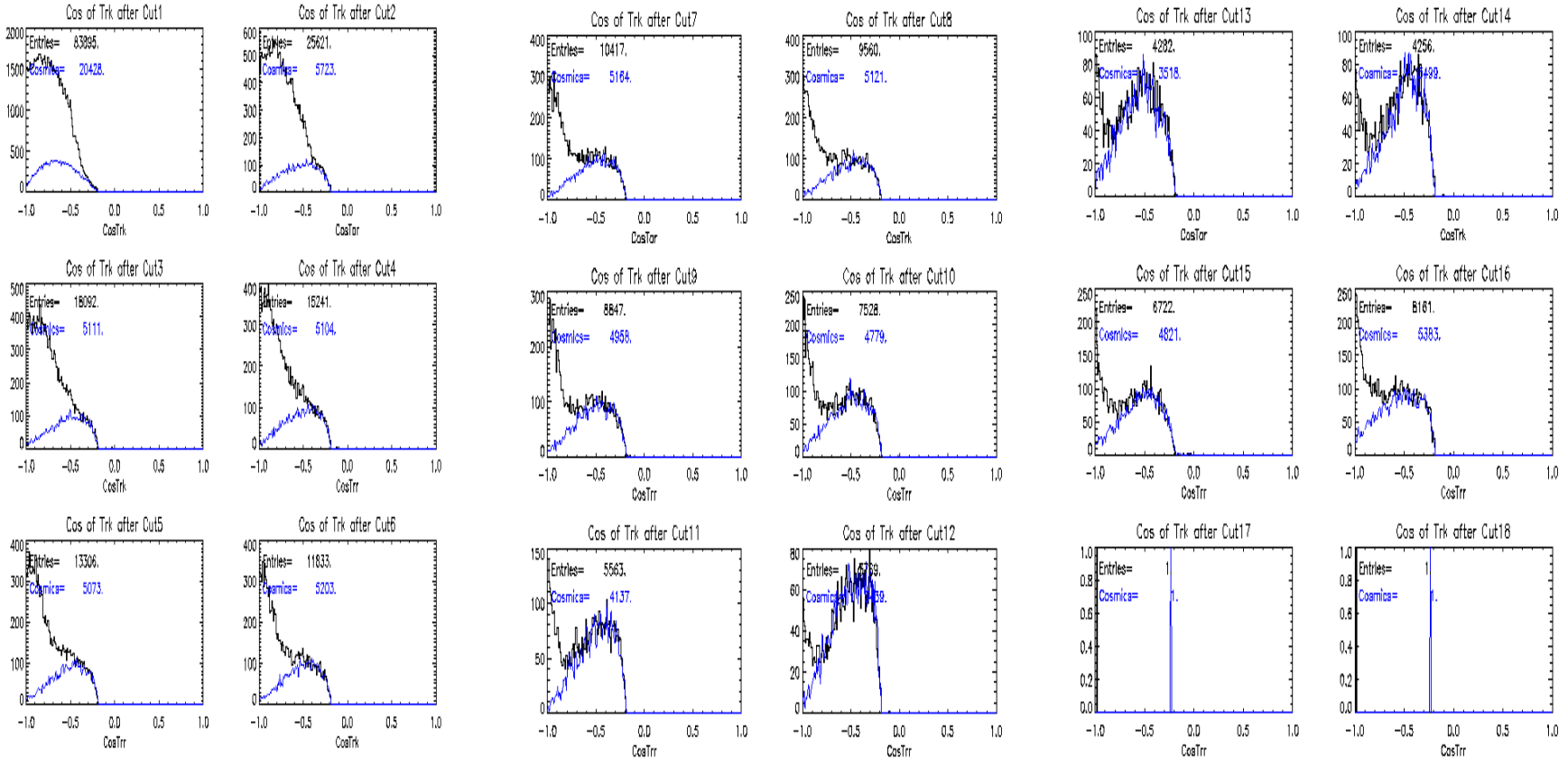


Fraction of hits in a 60 mm diameter circle centered on the spot versus the distance of the extrapolation plane from the top silicon. MC (red histogram), VG (black points), and Cosmics (blue histogram)

VG & Cosmics: Cosθ Distributions by Layer

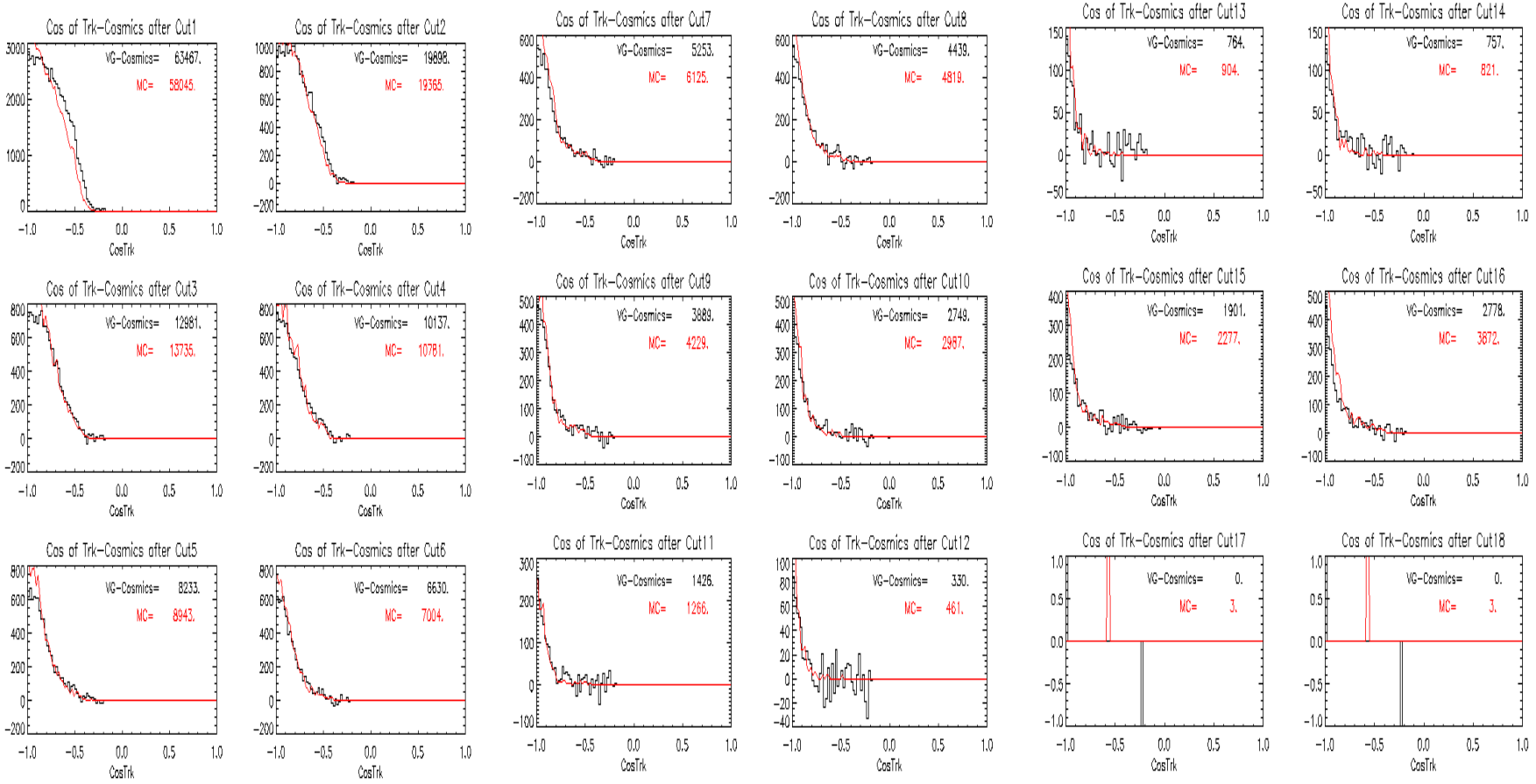
The black histograms are VG cosθ (between the track and the z axis of the tower) distributions. The blue curves are cosmic data. Each plot is for tracks with their vertex in a particular layer.

Cut1=Top most gap of tower. Cut18=Bottom most gap of tower.



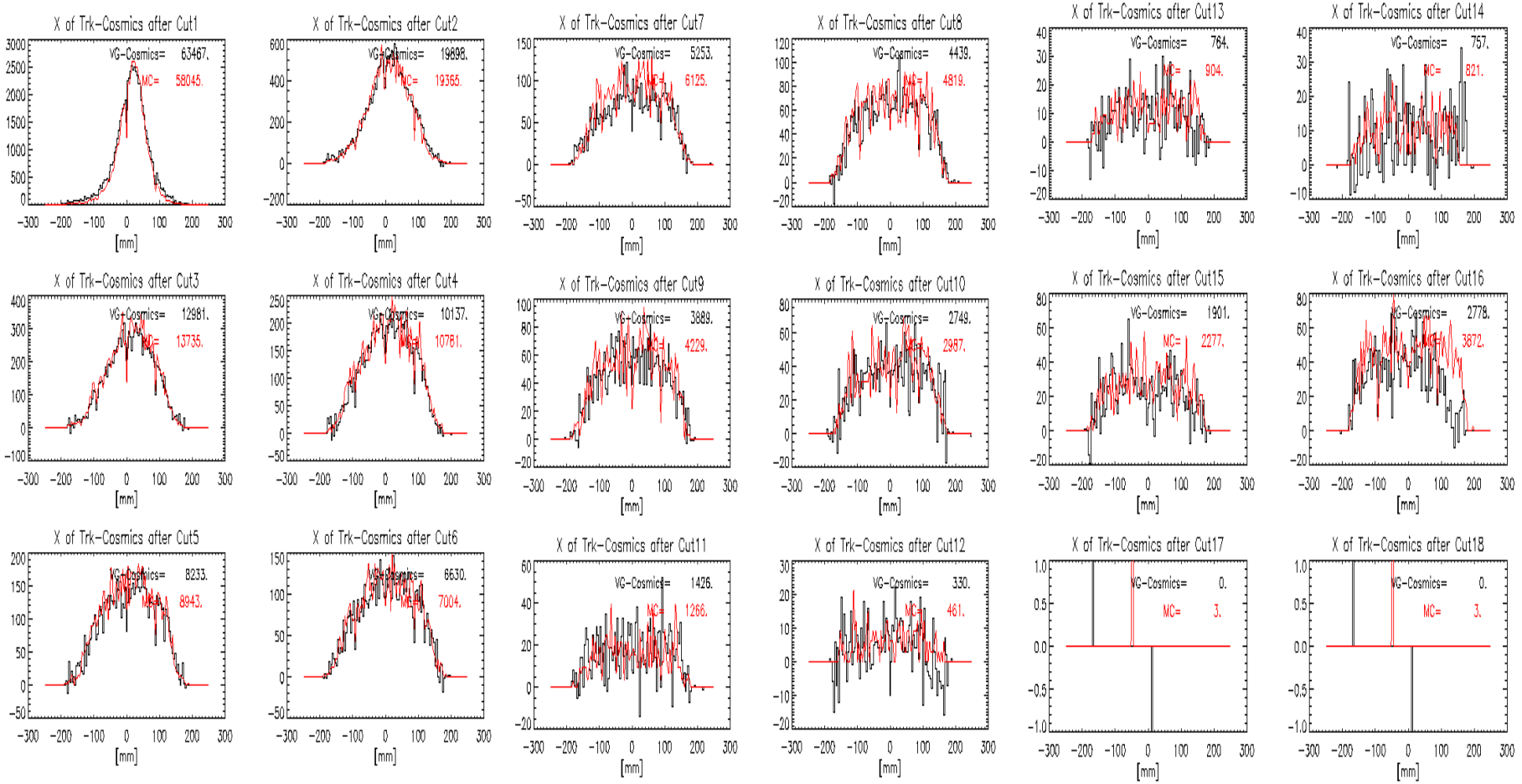
VG & MC: Cosθ Distributions by Layer

The black histograms are VG-cosmics cosθ (between the track and the z axis of the tower) distributions. The red histograms are the MC.
Cut1=Top most gap of tower. Cut18=Bottom most gap of tower.



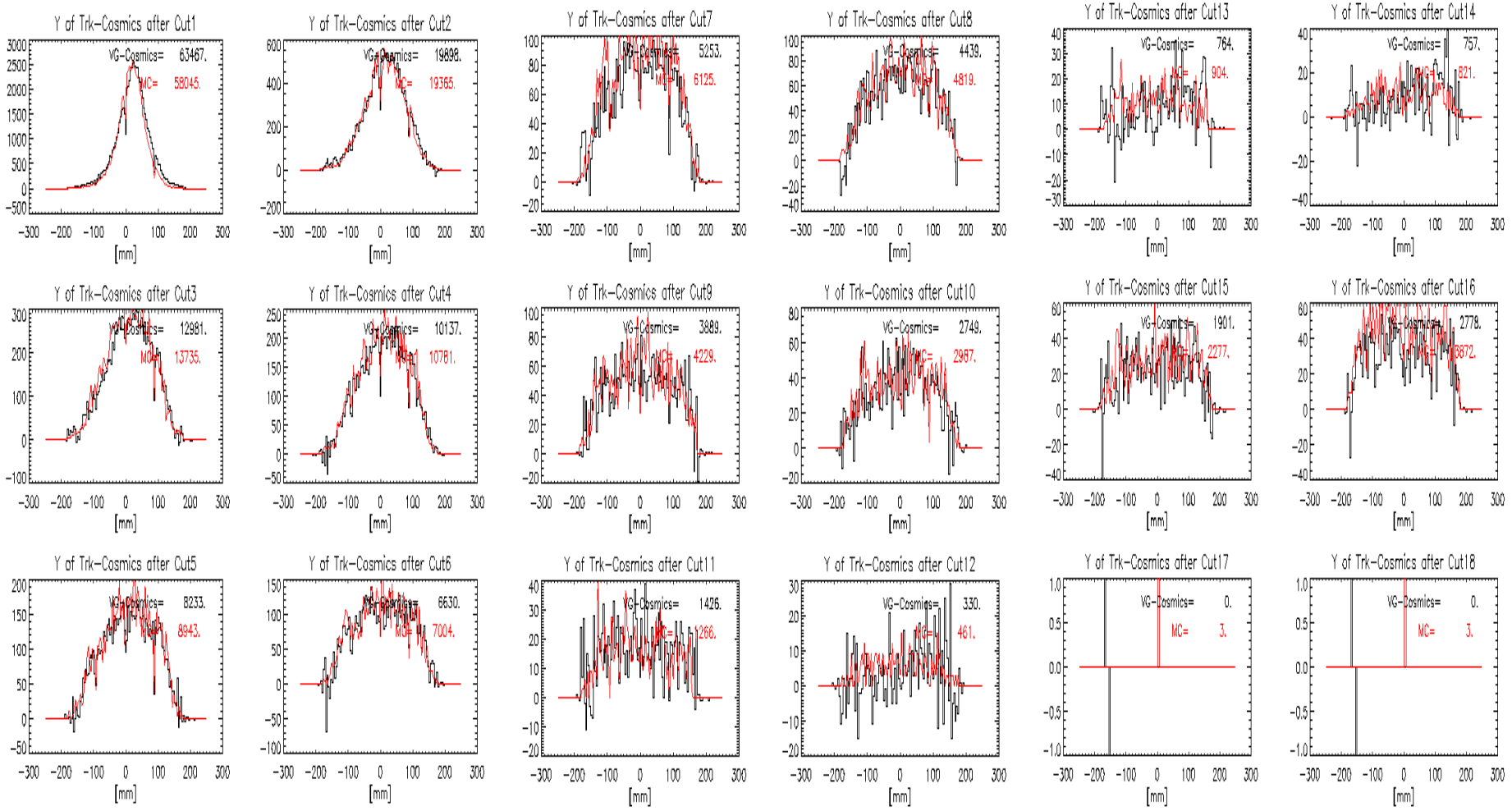
(VG-Cosmics) & MC : Track Vertex Distribution in X by Layer

Number of track origins versus transverse position x. The black histograms are VG-Cosmics and the red histograms are MC.



(VG-Cosmics) & MC : Track Vertex Distribution in Y by Layer

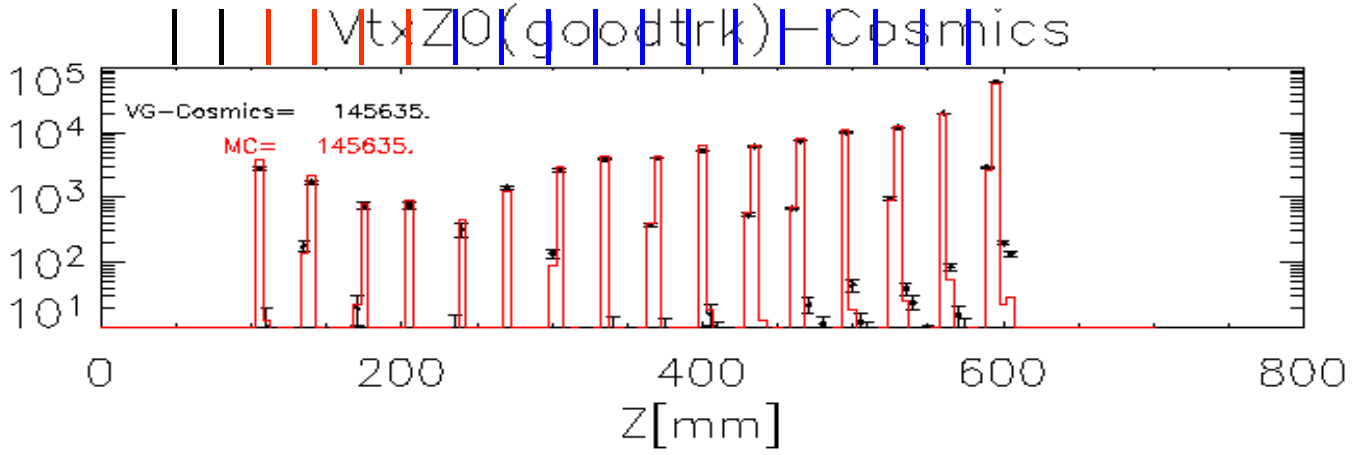
Number of track origins versus transverse position y. The black histograms are VG-Cosmics and the red histograms are MC.

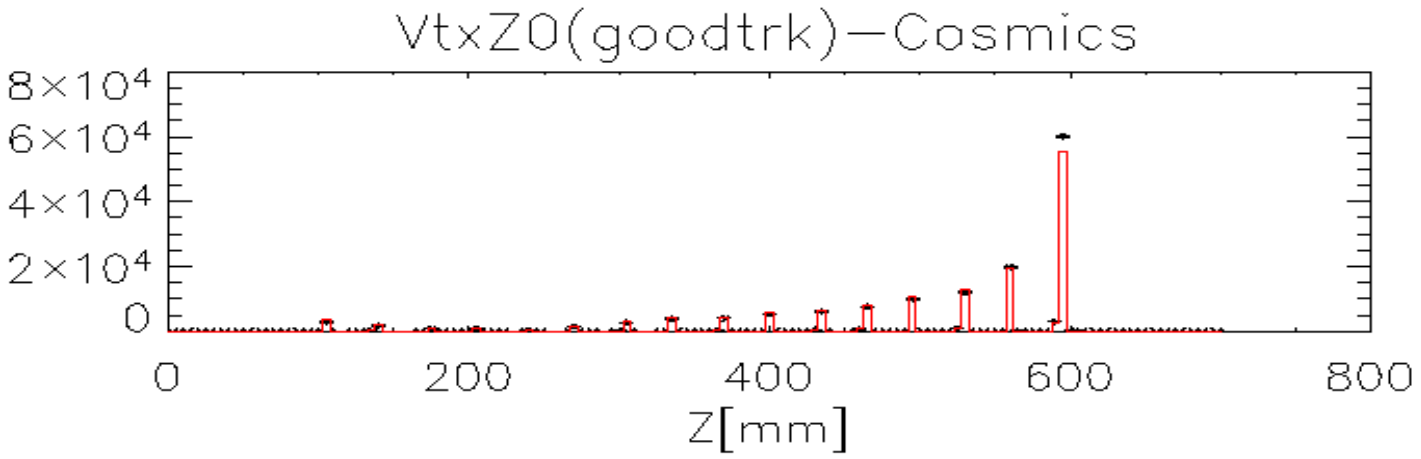


Distribution of Track Vertices in Z

The number of track origins as a function of z. (Log scale and Linear scale). The black points with statistical error bars are the VG data. The red is the MC.
VG/MC= .83 (bottom layers) =.92 (middle layers =1.06 (top layers)

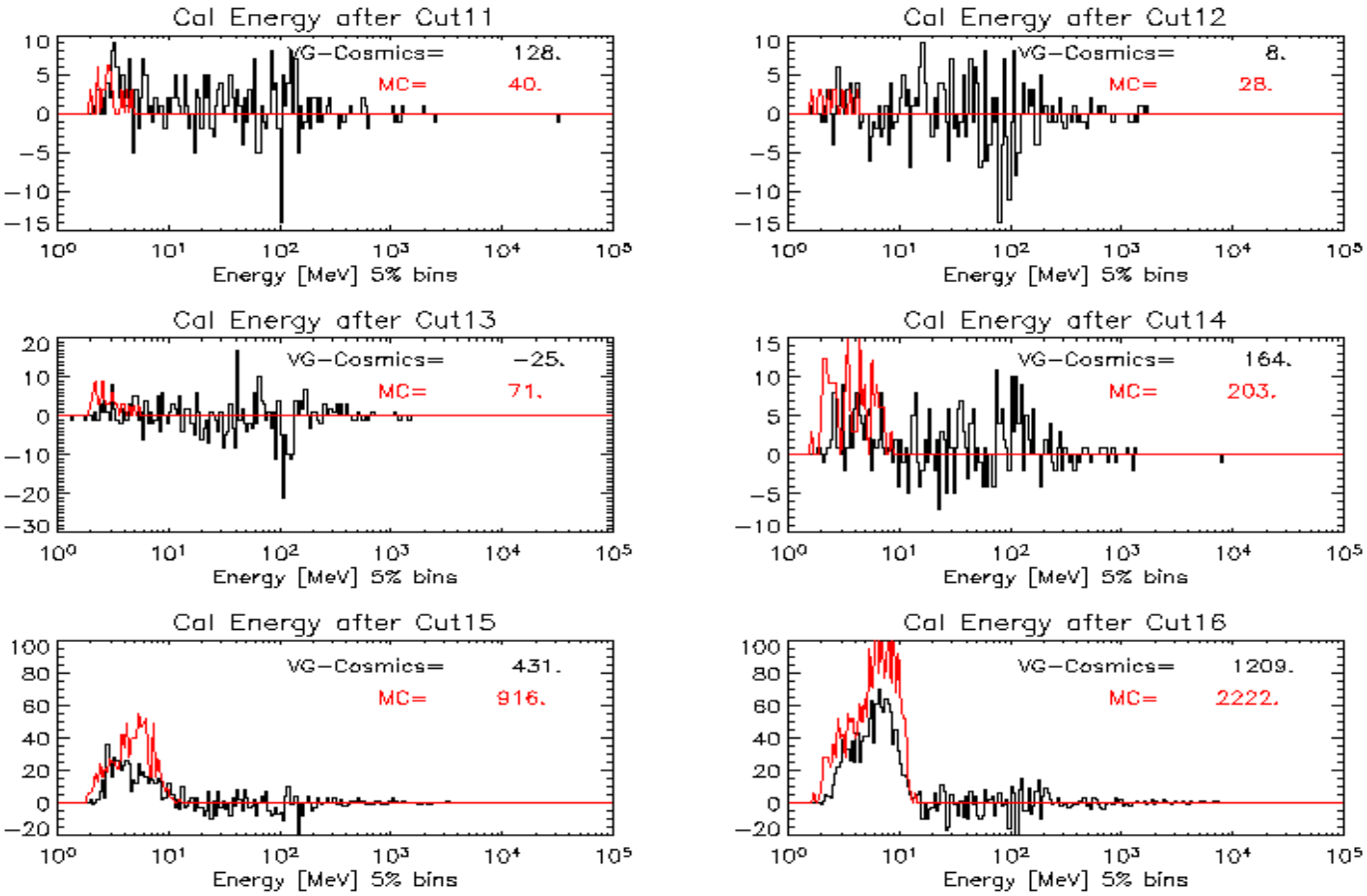
0% 18% 3% Tungsten radiators





Energy Deposited in Cal vs Vertex Layer

Energy deposition in the calorimeter for tracks originating in different layer. The black histogram is VG-cosmics and the red histogram is MC. Cut16 is the pair of silicon layers with the bottom most super GLAST radiator.

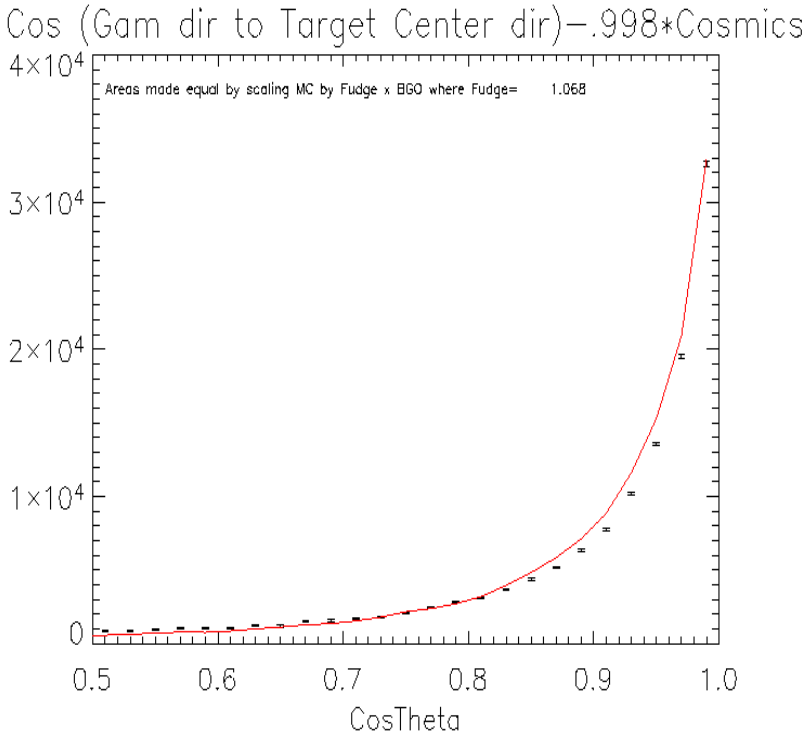


Tower PSF for VG Photons

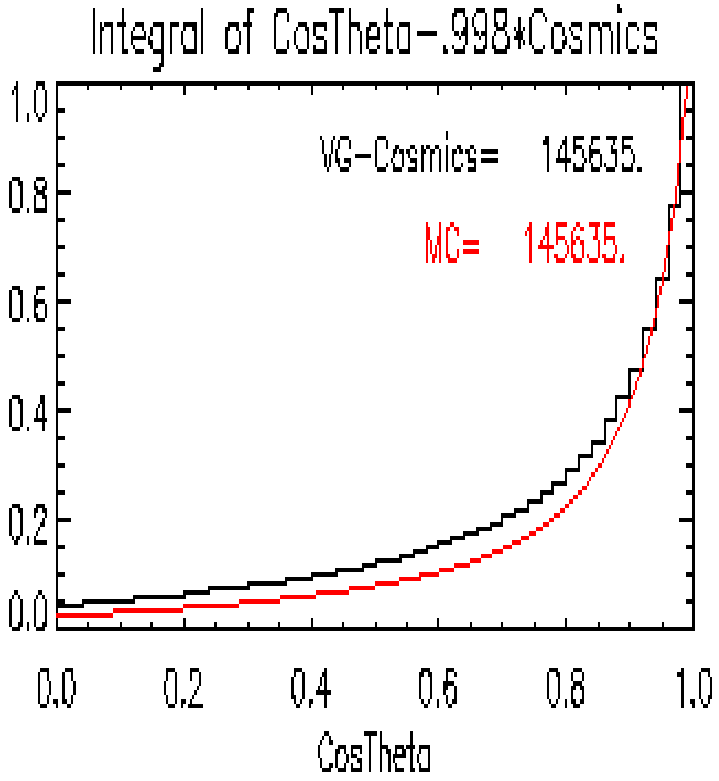
a) The cosθ distribution between the track unit vector and a line drawn from the vertex to the target center. The black histogram is the VG-cosmic data and the red curve is the MC.

b) The integral of the cosθ distributions are shown in (a). From plot (b) one reads off $\cos(\theta_{68})$=.83 and .86 for VG data and MC.

(a)



(b)



LAT VG Run

1) Goal: Compare the low energy γ acceptance of the final LAT to the MC with only a few percent normalization error.

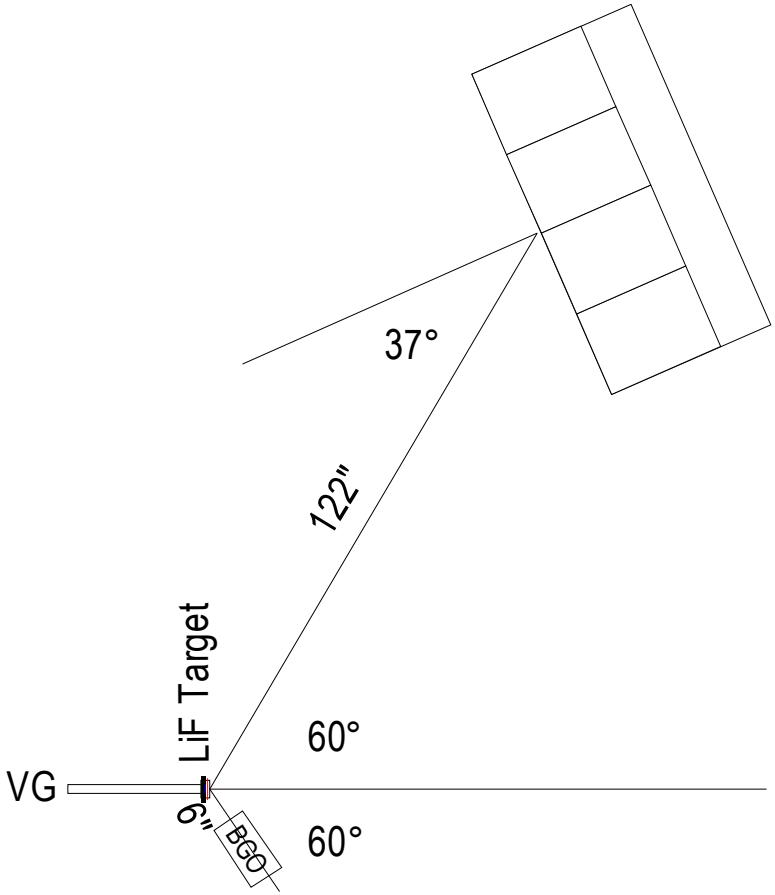
3) Parasitic to SVAC Horiz LAT Cosmic data taking.

5) VG on during ~5 hrs of the ~15 hrs of Horiz LAT Cosmic Run.

7) Adds ~5 Hz to the ~250 Hz LAT trig rate.

9) Systematic error on normalization will be smaller, since absorption of target window and Pb will be the same for BGO and LAT.

11) Target will appear to the LAT as an "AGN" point source that must be separated from the ~50 times larger bkgnd of charged cosmics (and ~5 times larger bkgnd of cosmic shower photons).



Summary

Known numbers of F(6.1) + Li(14.6+17.6) Mev photons generated by a Van de Graaff accelerator and by a Monte Carlo were put into Tower A.

3) Measured trigger rates for 12 runs were 1.10 times that expected from MC. This is consistent with an estimated .08 systematic error from the BGO monitoring used to scale the MC.

5) For the one run compared in detail to the MC, the number of “GoodTrk” VG events was 1.07 times that expected from the MC. (Approx the same 1.10 factor seen in the trigger rates).

7) After removing the 1.07 normalization factor:

   a) The distribution of track vertices in $\cos\theta$, x, y, and z show agreement between VG data and MC.

   a) For vertices in the bottom two super Glast layers, the energy reaching the cal shows agreement in shape between the VG data and MC. However, the number of cal events for the VG data is low by ~2 compared to the MC.

Summary

a) There is reasonable agreement between the real data and MC PSF for the VG energy photons. The MC is slightly broader than the data at small angles, and has a slightly lower tail than the data at big angles. This results in $\cos(\theta_{68})$=.83 (θ_{68}=34°) and .86 (θ_{68}=31°) for VG data and MC. The target half width is σ_{target} ~ (.75”/2.0”) x (180/π) = 21°, which must be subtracted in quadrature from θ_{68} to obtain the actual tower PSF.

c) The next comparisons between calibrated sources of photons and the GLAST MC will be:

   a) VG photons into the full LAT (target ~10 feet from LAT at ~37°)

   c) Brems photons into the 2-Tower Calibration Unit at CERN

Extra Slides

Table 1: VG Runs March 2005

E2Etest	Run ID	Events to tape	RunTime [sec]	Rate to tape [Hz]	True Particle Rate [Hz]	Frac of Pulser Written to Tape	Ext trig Typed GUI [Hz]	Rate from DT slope [Hz]	Trig Word Type	Blue=Meas Red=Meas Weird Busy Width DT Plot [sec]	Calc Dead Time Frac	VG File	TkrTrg ineff for these F gams [Hz]	Li gams [Hz]	Tower Meas/Predict Trig	Sys Error from BGO distance (6.0 ± 1/4")
9-1 (1")	135000945	142867	1564	91.35	91.57	1.0000	0		T	0.000027	0.002	VG111	0	16.1	1.15	0.08
9-1 (1")	135000946	143170	1393.75	102.72	103.00	1.0000	0		T	0.000027	0.003	VG111	0	18.95	1.15	0.08
9-2 (1")	**135000949**	**284100**	**3600.03**	**78.92**	**79.08**	**1.0000**	**0**	**76.4**	**TZ**	**0.000027**	**0.002**	**VG112**	**5.05**	**12.98**	**1.11**	**0.08**
9-5 (1")	135000951	298603	3600.03	82.94	85.59	0.0000	1118	1217	TZ	0.000027	0.031	VG113	5.37	14.43	1.11	0.08
B-11 (VG off)	135000954	101573	3600.17	28.21	28.27	1.0000	0		TZ4	0.000066	0.002					
9-6 (1")	135000956	288953	3600.07	80.26	104.26	0.0000	11180	11080	TZ	0.000027	0.230	VG114	7.6	19.41	0.99	0.08
B-16 (1")	135000958	316384	3027.28	104.51	104.80	1.0000	0		TZ	0.000027	0.003	VG115	7.4	19.94	1.09	0.08
B-16 (1")	135000959	316850	3058.49	103.60	103.88	1.0000	0		TZ	0.000027	0.003	VG115	7.4	19.94	1.08	0.08
B-16 (1")	135000960	314930	3065.48	102.73	103.01	1.0000	0		TZ	0.000027	0.003	VG116	6.86	19.13	1.11	0.08
B-16 (1")	135000961	311027	3180.02	97.81	98.06	1.0000	0		TZ	0.000027	0.003	VG117	6.23	17.35	1.14	0.08
B-16 (1")	135000962	190878	2068.82	92.26	92.49	1.0000	0		TZ	0.000027	0.002	VG118	5.73	16.12	1.13	0.08
9-3 (2")	135000965	291875	3600.02	81.08	81.25	1.0000	0		TZ	0.000027	0.002	VG119	5.44	15.65	1.11	0.08
9-4 (4")	135000968	234146	3600.01	65.04	65.15	1.0000	0		TZ	0.000027	0.002	VG120	5.41	15.38	1.07	0.08
9-7 (side)	135000971	138953	3600.14	38.60	38.64	1.0000	0		TZ	0.000027	0.001	VG122	5.47	15.34		
9-8 (side)	135000975	170160	3600.01	47.27	47.33	1.0000	0		TZ	0.000027	0.001	VG123	5.81	16.83		

Summary of Track Origins vs Layer

	VG_9-2	Vdg_1M_641_2.3_Pb_1.59 (1M event 6.1 Mev MC run added with correct fract				
	135000949	(1/16" Pb)				
Increase BGO count by= (to make # VG GoodTrks = # MC GoodTrks)	1.068	ScaleMC=	3.073	Data/MC	Group Avrg	Group ±Stdev
	Data	MC	MC scaled			
Gammas into 4pi from VG target	8538037	2778120	8538037	1.00		
Triggers (less cosmics)	182531	57135	175594	1.04		
After Cut (less cosmics): Cut=GoodTrk= Vtx1NumTkrs GE 1 + Tkr1NumHits GE 4 ABS(GamX0) LE 250. + ABS(GamY0) LE 250. GamZ0 GE 0. + GamZ0 LT 610.	145635	47387	145635	1.00		
Cut 's effect	0.80	0.83				
Cut1 (less cosmics) Top 3% + Cut	63467	18887	58046	1.09		
Cut2 (less cosmics) 3% + Cut	19898	6301	19365	1.03	1.06	0.05
Cut3 (less cosmics) 3% + Cut	12981	4469	13735	0.95		
Cut4 (less cosmics) 3% + Cut	10137	3508	10781	0.94		
Cut5 (less cosmics) 3% + Cut	8233	2910	8943	0.92		
Cut6 (less cosmics) 3% + Cut	6630	2279	7004	0.95		
Cut7 (less cosmics) 3% + Cut	5253	1993	6125	0.86		
Cut8 (less cosmics) 3% + Cut	4439	1568	4819	0.92		
Cut9 (less cosmics) 3% + Cut	3889	1376	4229	0.92		
Cut10 (less cosmics) 3% + Cut	2749	972	2987	0.92	0.92	0.03
Cut11 (less cosmics) 3% + Cut	1426	412	1266	1.13		
Cut12 (less cosmics) 3% + Cut	330	150	461	0.72	0.92	0.29
Cut13 (less cosmics) 18% + Cut	764	294	904	0.85		
Cut14 (less cosmics) 18% + Cut	757	267	821	0.92		
Cut15 (less cosmics) 18% + Cut	1901	741	2277	0.83		
Cut16 (less cosmics) 18% + Cut	2778	1260	3872	0.72	0.83	0.08
Cut17 (less cosmics) 0% + Cut	0	0				
Cut18 (less cosmics) Bot 0% + Cut	0	0				

Tower PSF for VG Photons

1) The VG target is only 1” from the front face of the tower.

3) Therefore, the cosθ (between the track and the z axis of the tower) distribution is very broad (eg: tracks which point at the target for a vertex at the edge of the tray have very different cosθ than a vertex in the center of the tray).

5) So, attempt to measure the Tower PSF by plotting the cosθ distribution between the track unit vector and a line drawn from the track vertex to the target center.

7) This width of this distribution will be a convolution of the true Tower PSF and the VG LiF target size. The target half width is θ_{target} ~ (.75”/2.0”) x (180/π) = 21°, which must be subtracted in quadrature from the measured θ_{68} to obtain the actual tower PSF.

9) The plot on the next transparency shows: $\cos(\theta_{68})=.83$

θ_{68} =34°

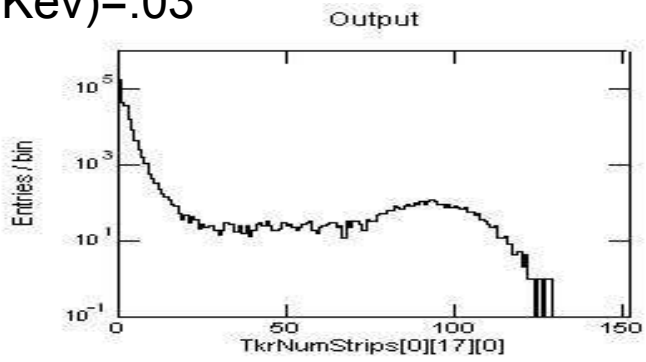
PSF =sqrt(34^2-21^2)=26°

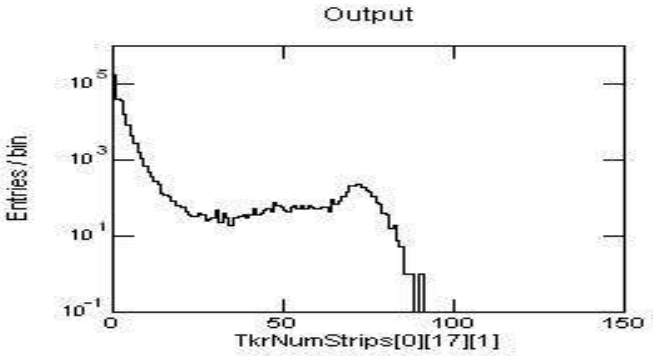
VG Xray Bursts (135000949 1/8” Pb)

Number of Events vs. Number of strips

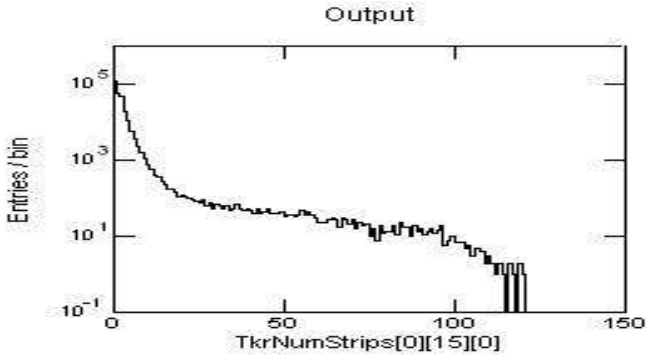
Trans(1/8” Pb, 200 Kev)=.03

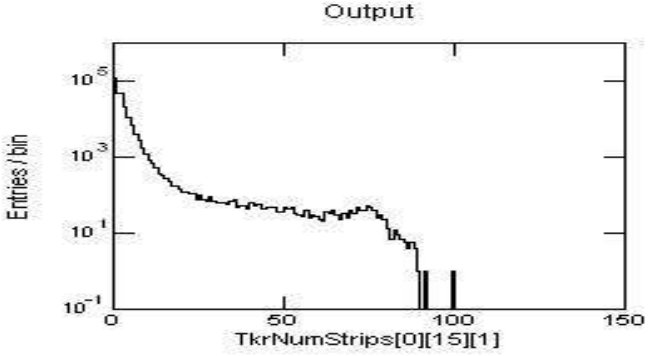
Layer 18 x,y





Layer 16 x,y





Layer 14 x,y