ECAL Trigger Rates and PVDIS FOM
with Full Background

Rakitha S. Beminiwattha

ECAL Trigger Analysis

- Backgrounds are generated using cross section weighted events from hall D generator

- Combined Pions : π^- , π^+, π^0 and EM background

  - Events are uniformly separated in time according to the background rates

- Tracks incident on the ECAL can then be separated to 30 ns time windows (trigger window is 30 ns)

- Each sector (12 deg) of ECAL is treated independently

- Total time in simulation is 35070 ns or 1169 background trigger windows

- Photon blocker included in the simulation

Trigger Rate Estimation with All Background

- Total time windows 1169

  – In each window there are 30 individual sectors → 1169*30

- Maximum trigger rate is 1/30 ns → 33.33 MHz

  – This is if all time windows are triggered

- Total background trigger rate is 4.85 MHz or 162 kHz per sector

  - Total time windows after applying the trigger 170

- Total trigger rate only from pion bkg. 4.612 MHz or 154 kHz per sector

Trigger Rate Sector wise summary			
Sector	Total Windows	Triggered Windows	Trig. Rate (kHz)
1	1169	9	256.6
2	1169	6	171.1
3	1169	1	28.5
4	1169	7	199.6
5	1169	7	199.6
6	1169	5	142.6
7	1169	2	57.0
8	1169	4	114.0
9	1169	5	142.6
10	1169	6	171.1
11	1169	4	114.0
12	1169	5	142.6
13	1169	9	256.6
14	1169	6	171.1
15	1169	3	85.5
16	1169	5	142.6
17	1169	5	142.6
18	1169	7	199.6
19	1169	7	199.6
20	1169	5	142.6
21	1169	5	142.6
22	1169	4	114.0
23	1169	8	228.1
24	1169	8	228.1
25	1169	6	171.1
26	1169	3	85.5
27	1169	10	285.1
28	1169	6	171.1
29	1169	6	171.1
30	1169	6	171.1
Total per Sector	35070	170	161.6

Trigger Rate Estimation in preCDR

region	full	high	low
	rate entering the EC (kHz)		
e^-	413	148	265
π^-	5.1×10^5	2.7×10^5	2.4×10^5
π^+	2.1×10^5	1.0×10^5	1.2×10^5
$\gamma(\pi^0)$	8.4×10^7	4.2×10^7	4.3×10^7
p	5.5×10^4	2.4×10^4	3.1×10^4
sum	8.5×10^7	4.2×10^7	4.3×10^7
	trigger rate for $p > 1$ GeV (kHz)		
e^-	321	80	231
π^-	4.8×10^3	3.4×10^3	1.4×10^3
π^+	0.28×10^3	0.11×10^3	0.17×10^3
$\gamma(\pi^0)$	4	4	0
p	0.18×10^3	0.10×10^3	0.08×10^3
sum	5.6×10^3	3.7×10^3	1.9×10^3
	trigger rate for $p < 1$ GeV (kHz)		
sum	$(3.1 \pm 0.7) \times 10^3$	$(1.6 \pm 0.4) \times 10^3$	$(1.5 \pm 0.4) \times 10^3$
	Total trigger rate (kHz)		
total	$(8.7 \pm 0.7) \times 10^3$	$(5.3 \pm 0.4) \times 10^3$	$(3.4 \pm 0.4) \times 10^3$

- Total trigger rate from Wiser + EM is 8.7 MHz
  - 290 kHz per sector

ECAL Trigger Response

- Using above full trigger analysis, trigger response curves are obtained for the ECAL

  - Improve the simulation speed by replacing full trigger analysis with trigger response curves

  - Trigger response curves are generated for electrons and pions

    - Without any background

    - With Hall D gen. hadrons (Pions : π^- , π^+, π^0) and EM background

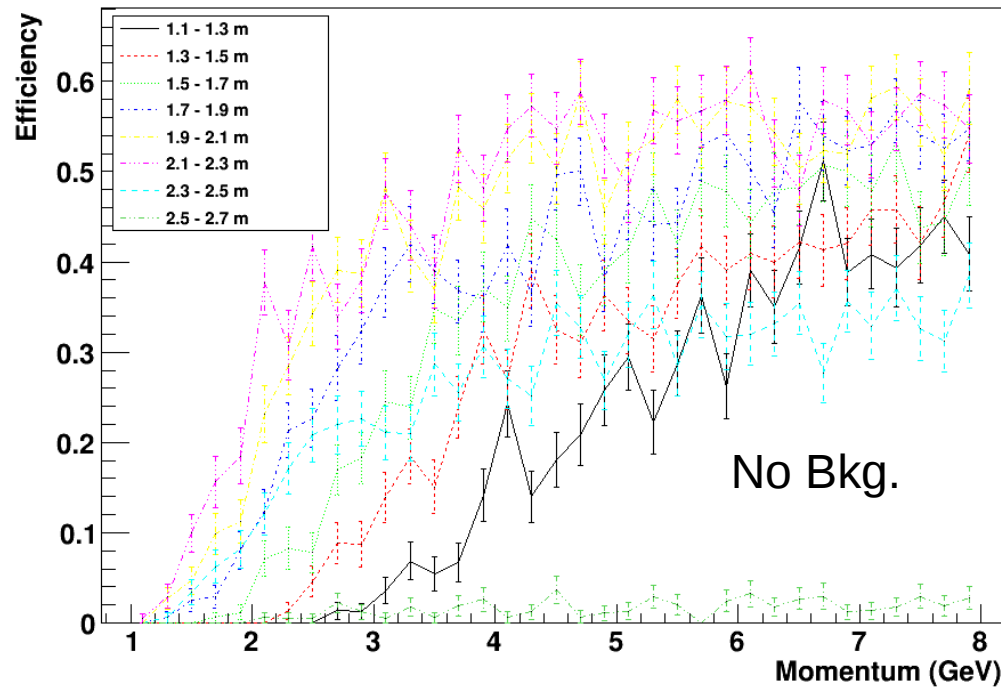# ECAL Trigger Response

Radial response functions for electrons

ECAL Trigger Response
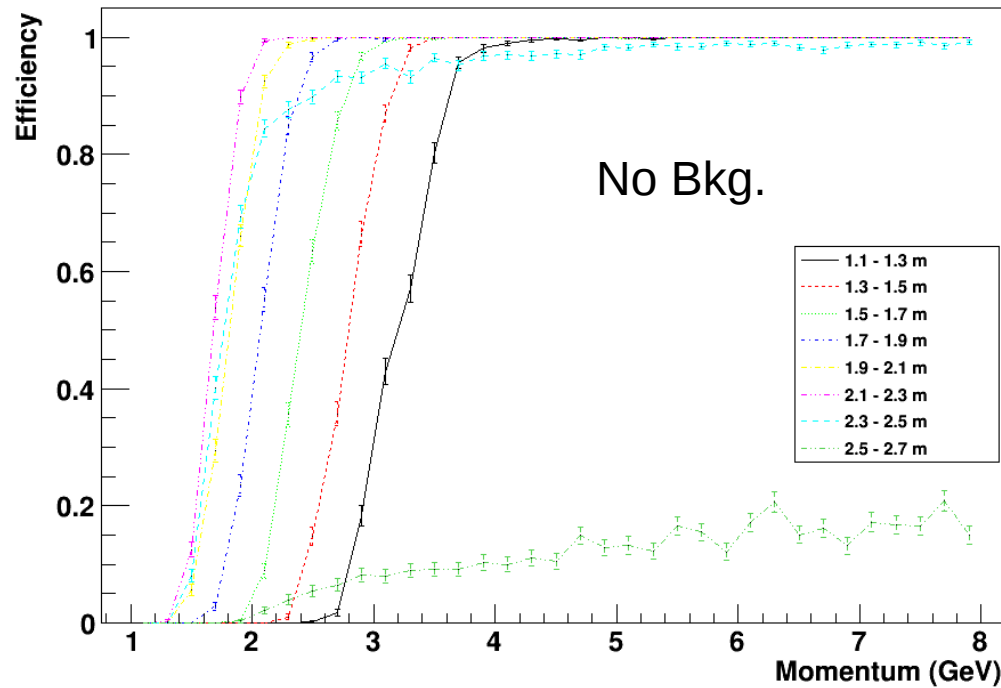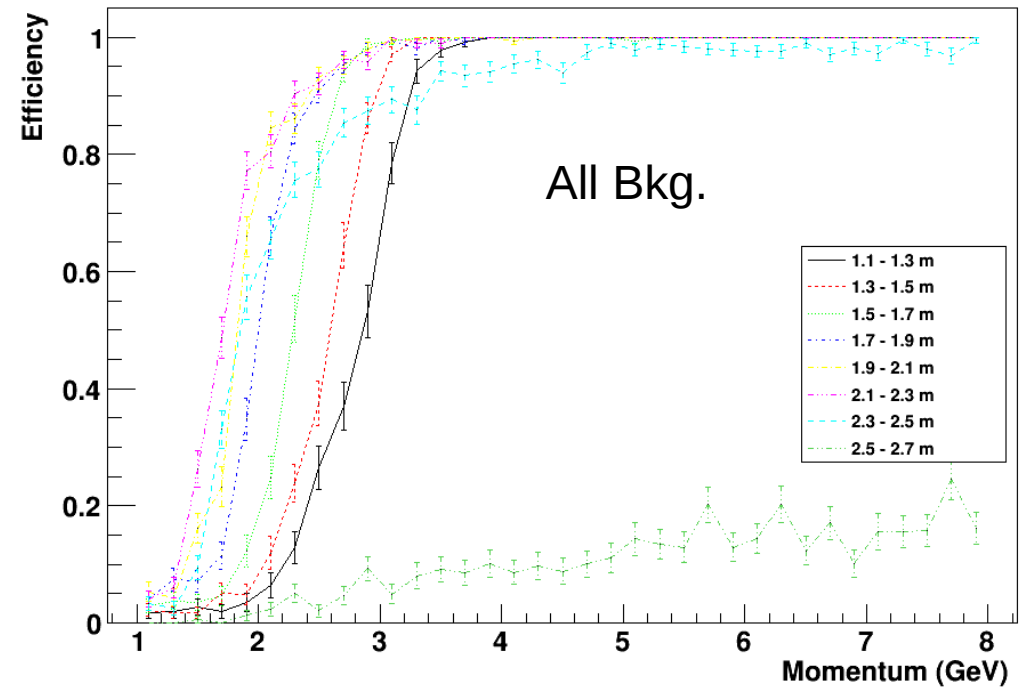
Radial response functions for pions
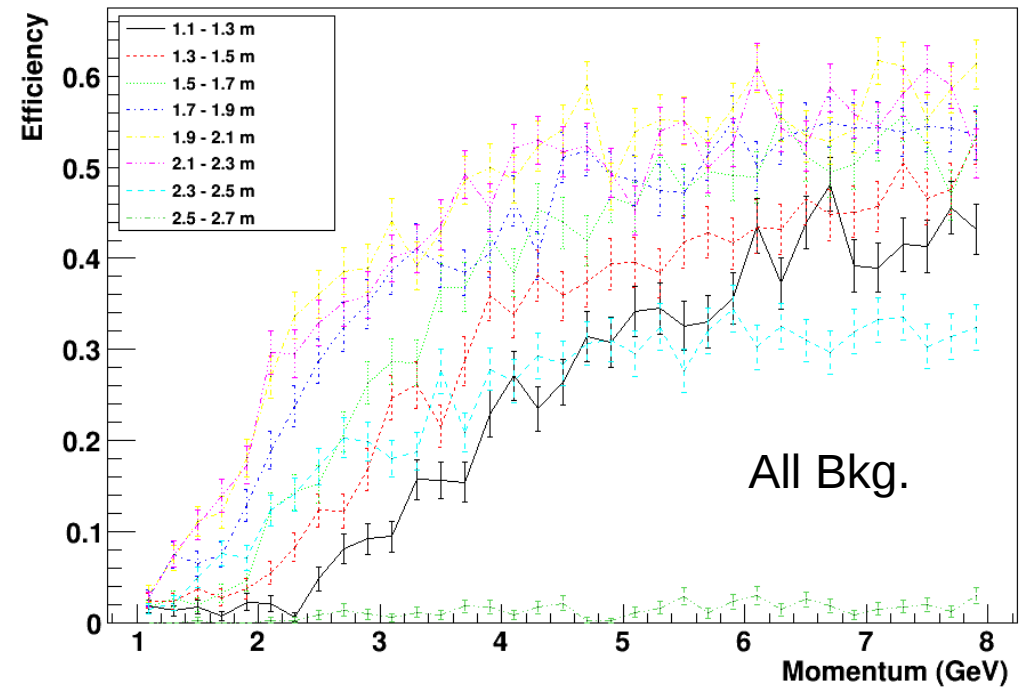
ECAL Trigger Response
Radial response functions from preCDR
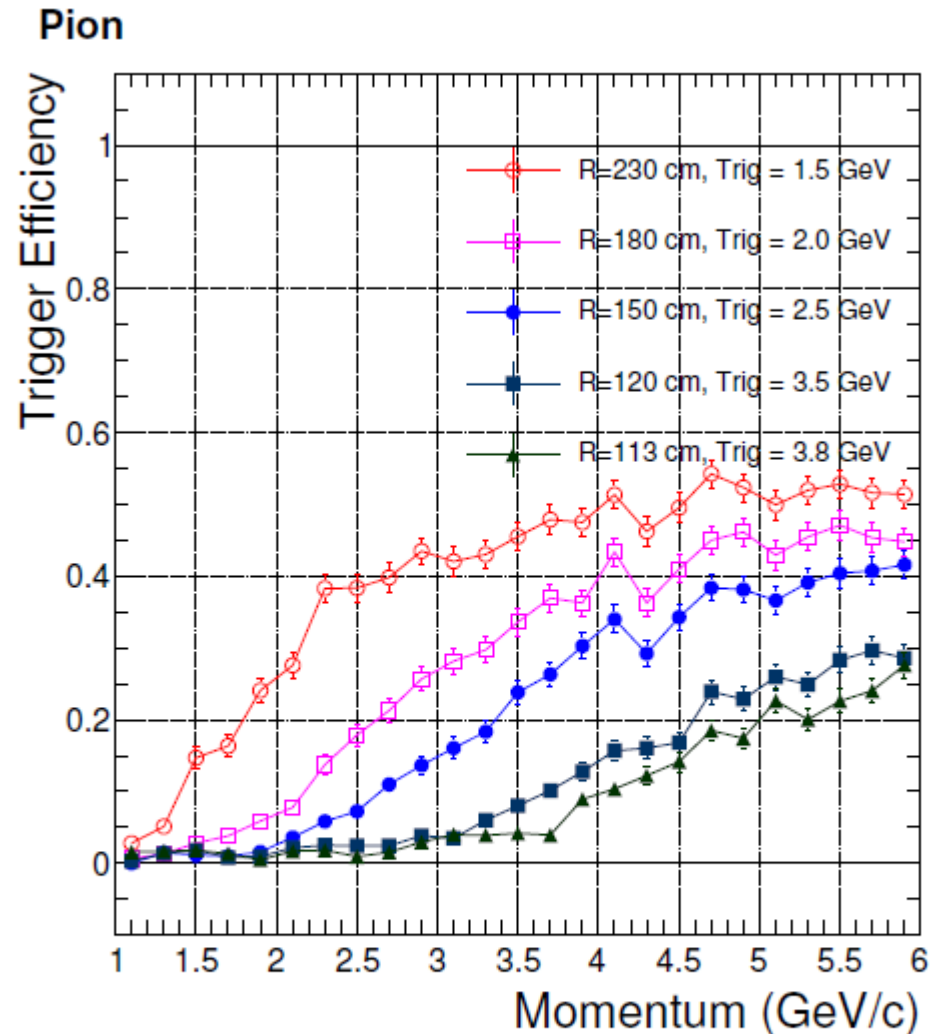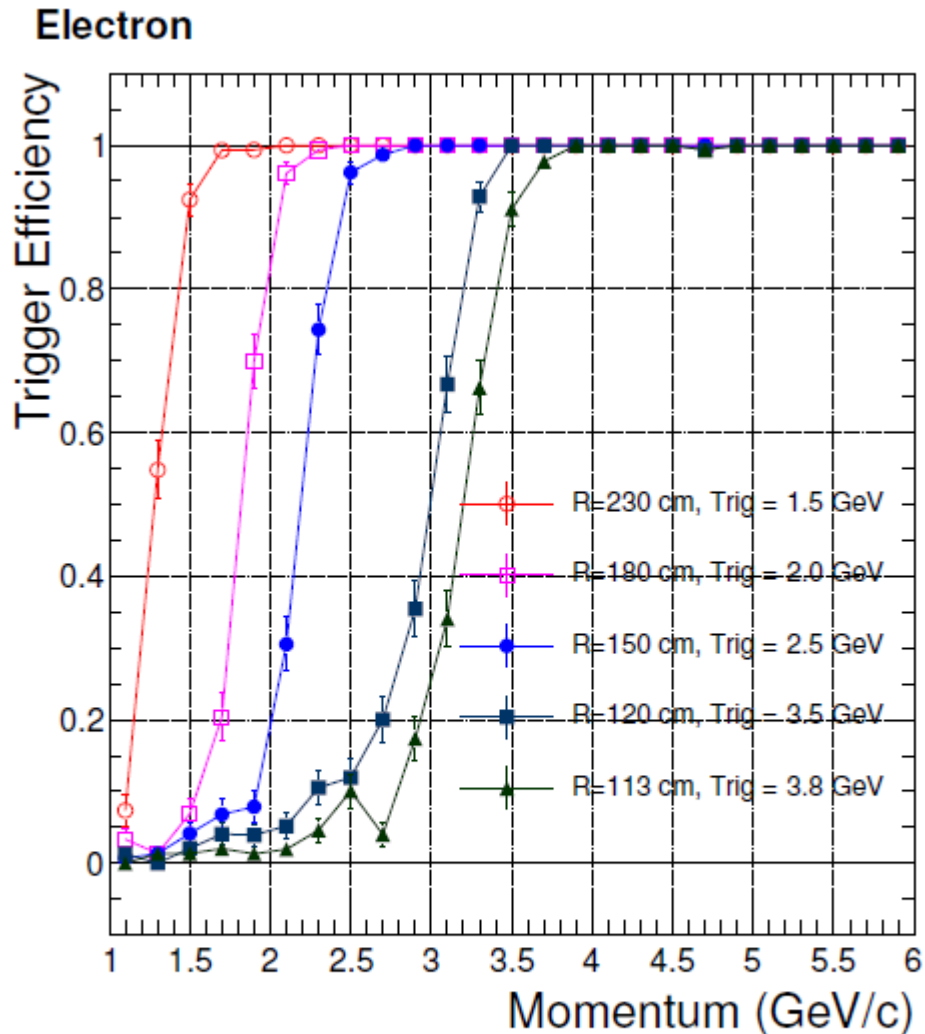
(a) Higher-radiation azimuthal region

ECAL Trigger Response
Radial response functions from preCDR
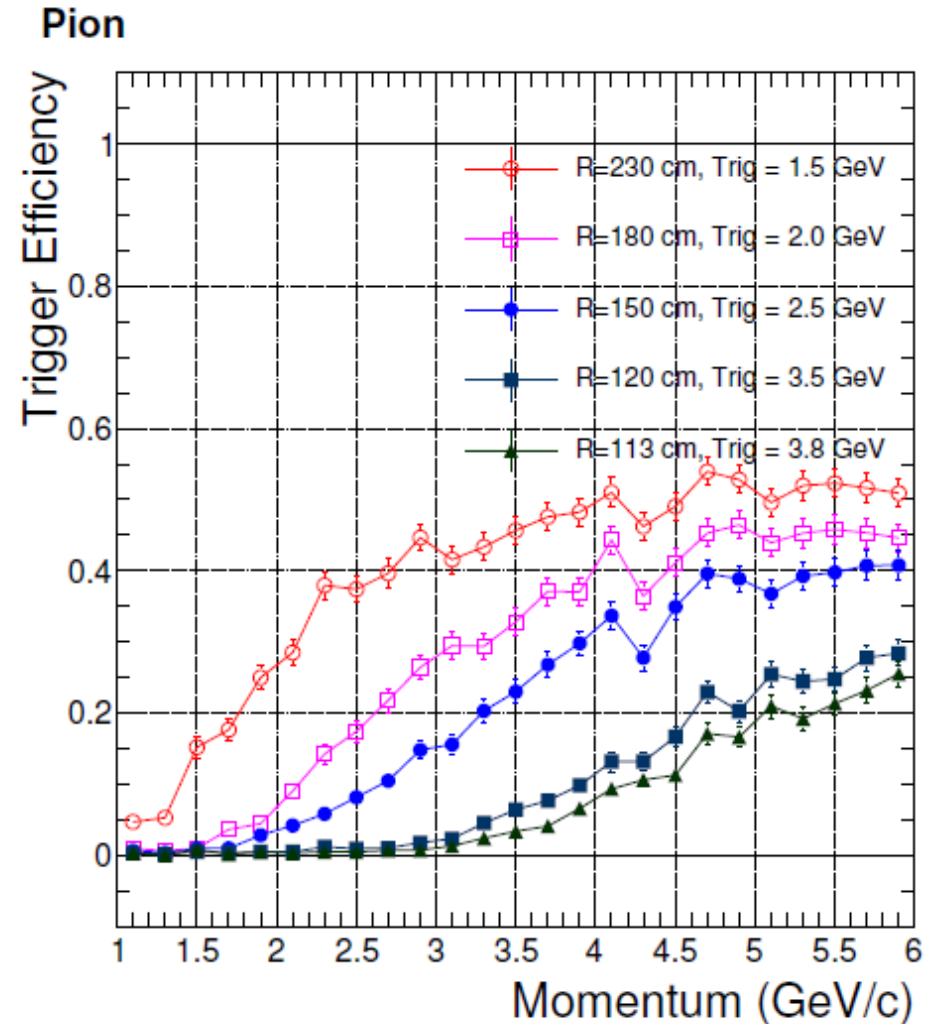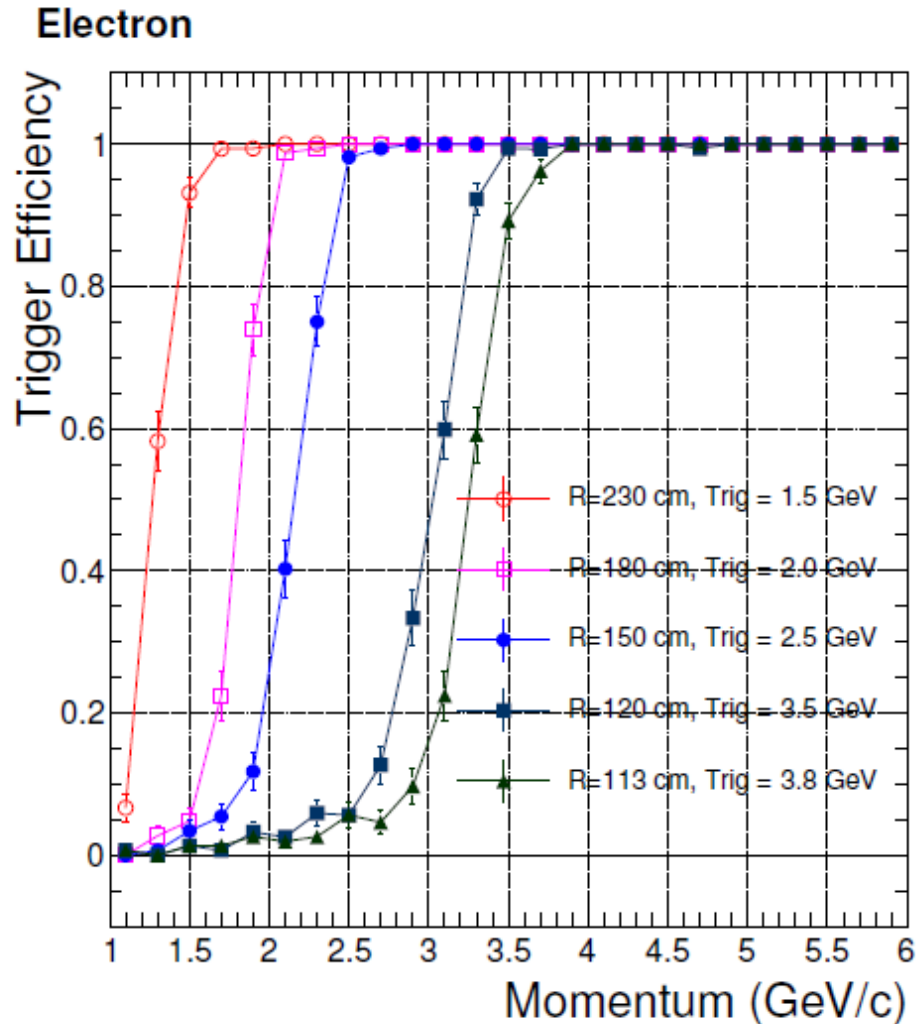
(b) Lower-radiation azimuthal region

ECAL Trigger Rates using Response Functions

- Only 1 GeV or larger momentum tracks can initiate a trigger
  - Low energy (less than 1 GeV) tracks contribute to trigger as pile up to high momentum tracks by increasing energy deposit in trigger windows
- Total (background+DIS) trigger rate is 5.13 MHz
  - 171 kHz per sector

PID	P > 1 GeV	
	Total Rate (MHz)	Trigger Rate (MHz)
Pi-	85.971	4.539
Pi+	11.377	0.328
DIS	0.437	0.26
Total ECAL Trigger		5.127

Trigger Rate Estimation in preCDR

region	full	high	low
rate entering the EC (kHz)			
e^-	413	148	265
π^-	5.1×10^5	2.7×10^5	2.4×10^5
π^+	2.1×10^5	1.0×10^5	1.2×10^5
$\gamma(\pi^0)$	8.4×10^7	4.2×10^7	4.3×10^7
p	5.5×10^4	2.4×10^4	3.1×10^4
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$\gamma(\pi^0)$	4	4	0
p	0.18×10^3	0.10×10^3	0.08×10^3
sum	5.6×10^3	3.7×10^3	1.9×10^3
trigger rate for $p < 1$ GeV (kHz)			
sum	$(3.1 \pm 0.7) \times 10^3$	$(1.6 \pm 0.4) \times 10^3$	$(1.5 \pm 0.4) \times 10^3$
Total trigger rate (kHz)			
total	$(8.7 \pm 0.7) \times 10^3$	$(5.3 \pm 0.4) \times 10^3$	$(3.4 \pm 0.4) \times 10^3$

- **Total trigger rate from Wiser + EM is 8.7 MHz**
  - **290 kHz per sector**

PVDIS FOM

- PVDIS FOM revisited with new ECAL trigger response function

    – Assumed Cerenkov will pass all DIS electrons

    – We don't have the Cerenkov trigger analysis done yet

- Compared PVDIS FOM before and after the ECAL trigger

DIS Acceptance before Trigger

θ vs. Momentum (Rate Weighted)
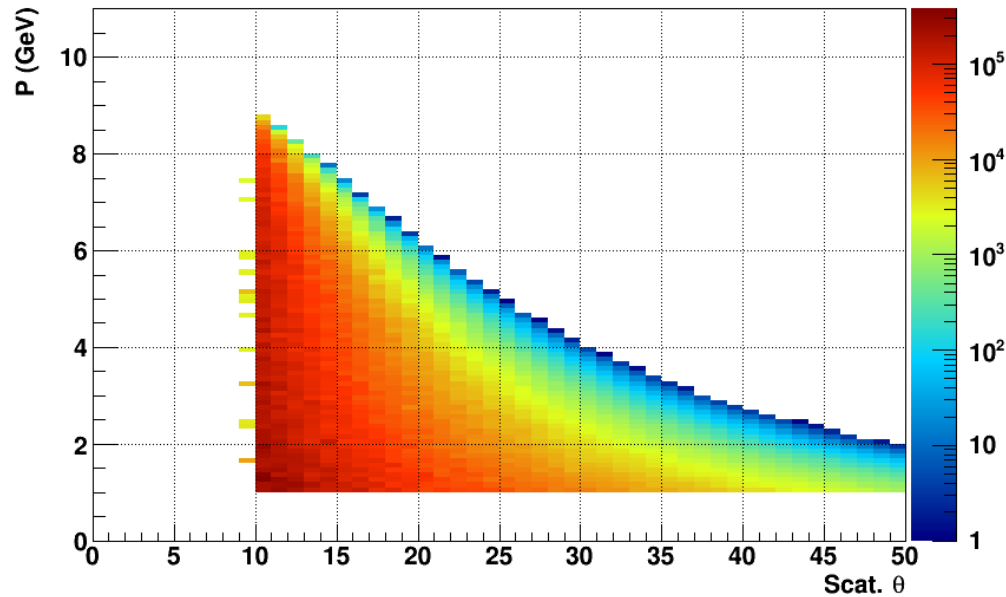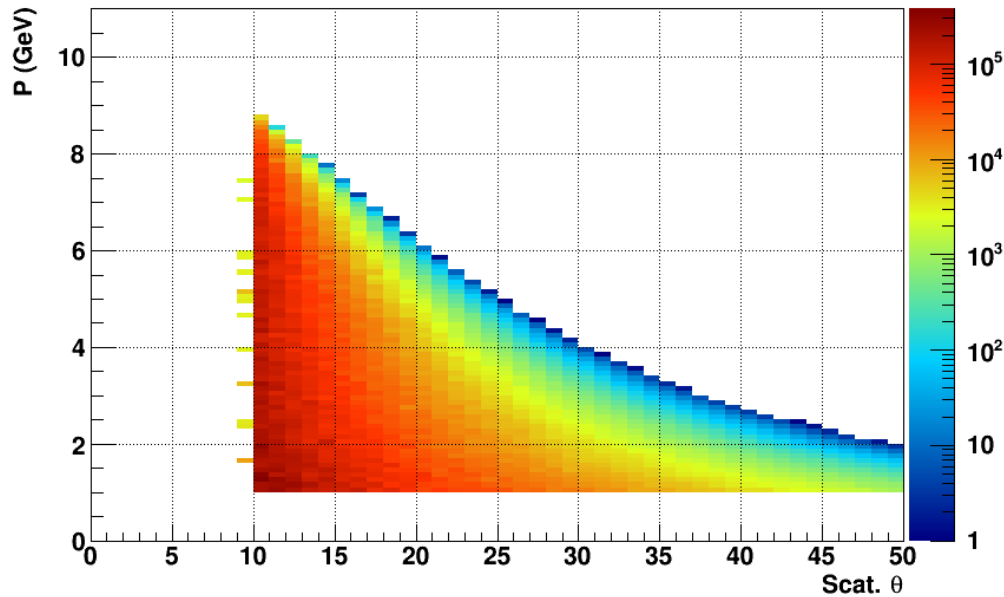
θ Angle vs. Momentum (Rate+Acceptance Weighted)

DIS Acceptance after Trigger
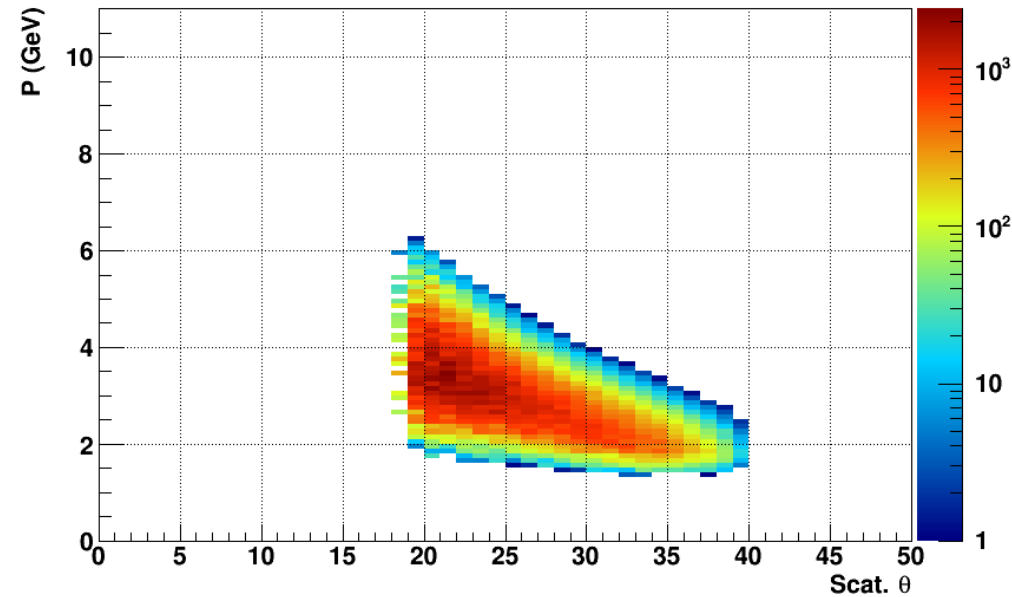
PVDIS FOM before Trigger

Asymmetry Uncertainty (%) with 120 days of 85% polarized 50uA electron beam on 40 cm LD2 target
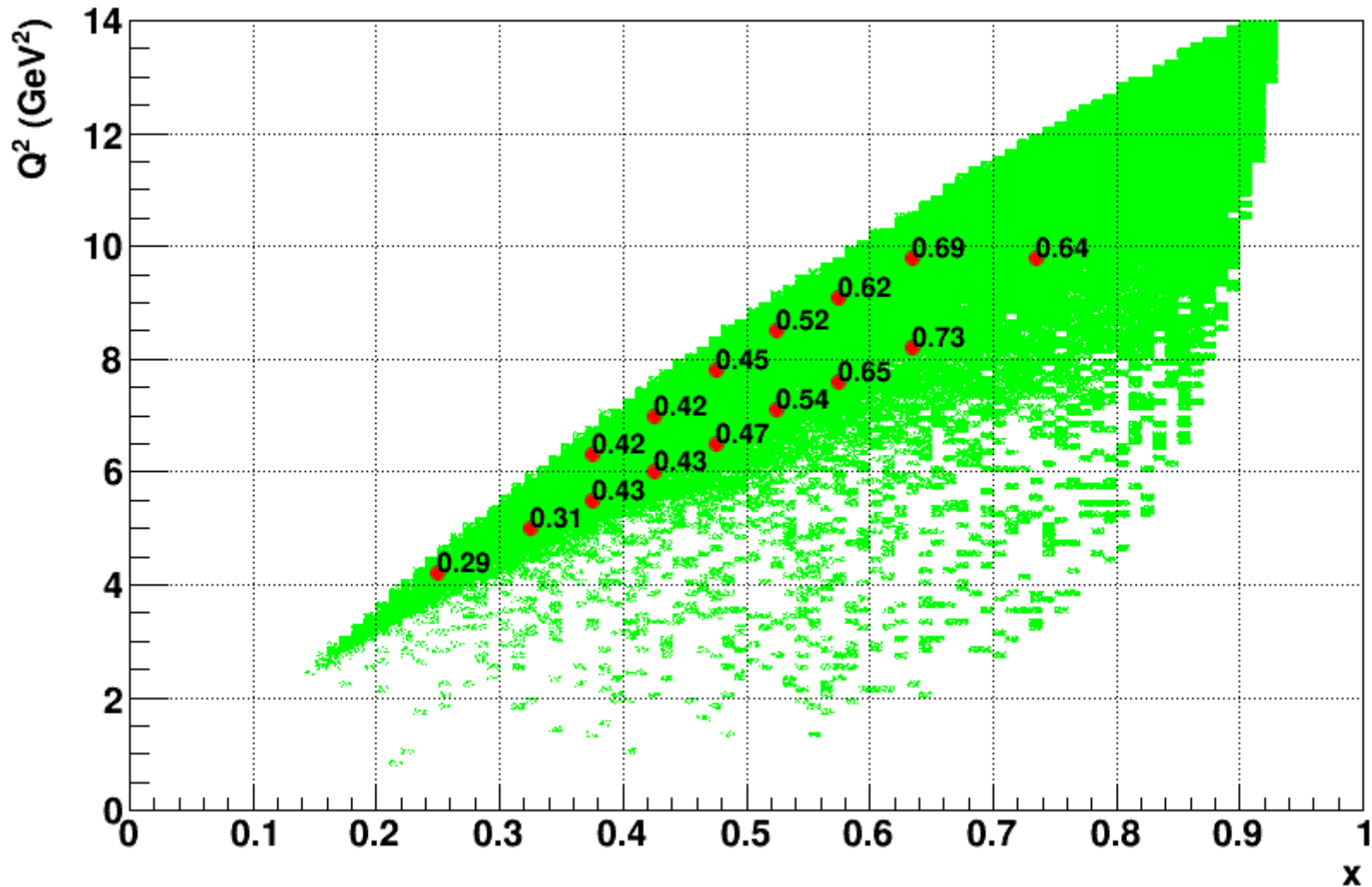
PVDIS FOM after Trigger

Asymmetry Uncertainty (%) with 120 days of 85% polarized 50uA electron beam on 40 cm LD2 target

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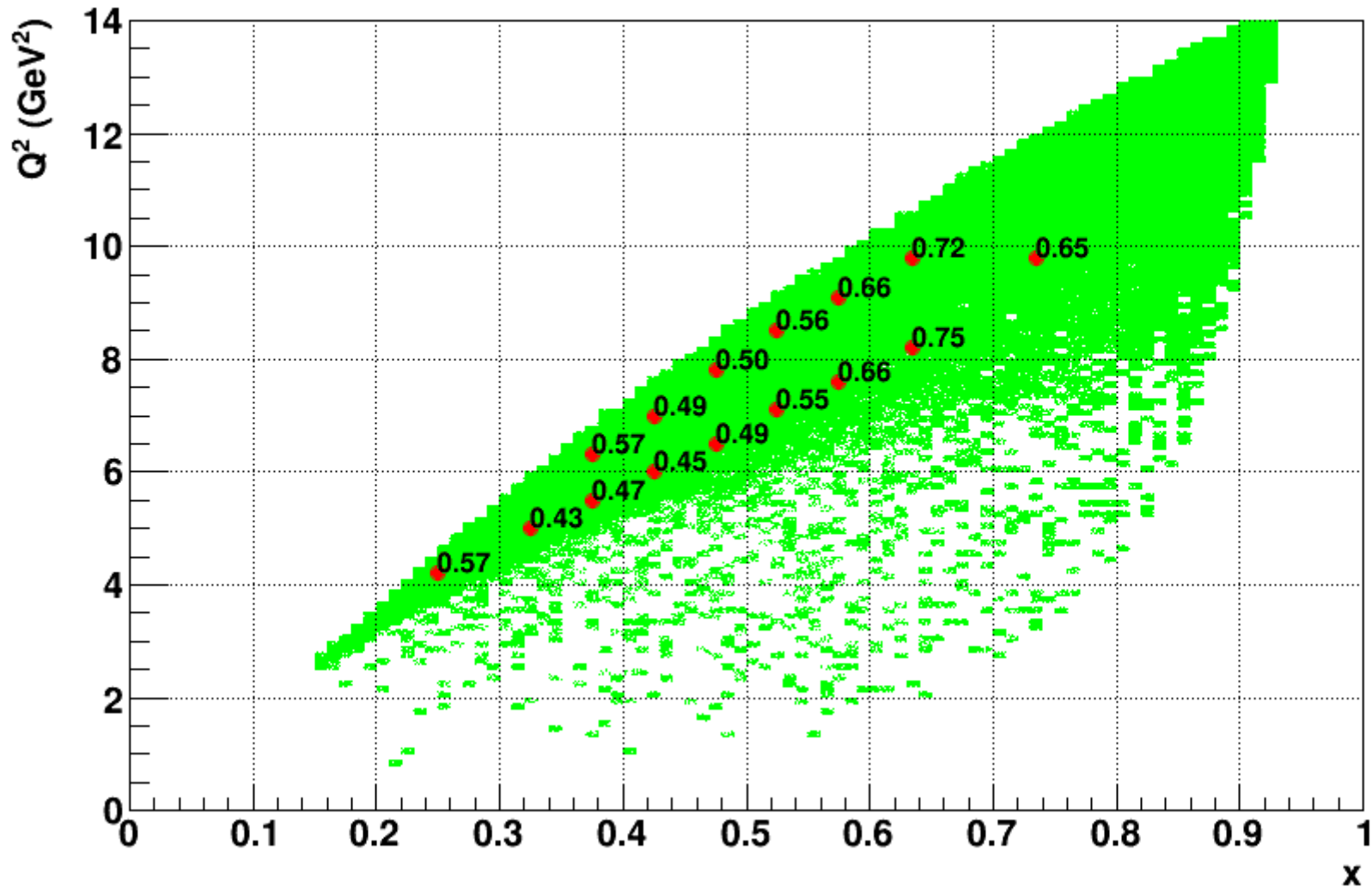
PVDIS FOM From Wiki
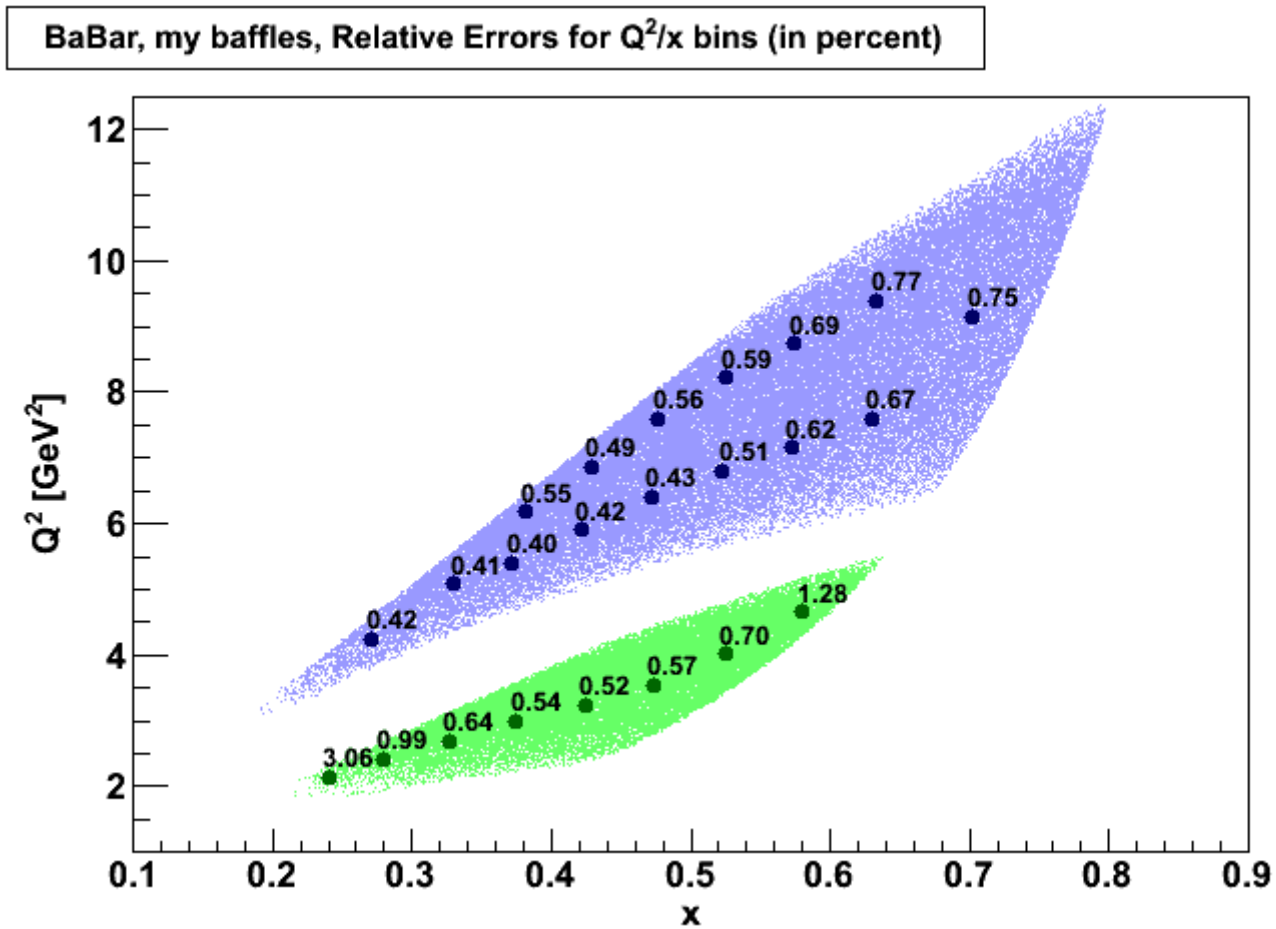
https://hallaweb.jlab.org/wiki/index.php/Solid_design_FOM

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PVDIS FOM

xbj	Q2	Abeam_ave	AbeamErr	Rate
	GeV)2	(ppb)	(%)	(Hz)
0.25	4.20	365214.25	0.57	30579
0.33	5.00	436394.23	0.43	37127
0.38	5.50	466107.21	0.47	27375
0.38	6.30	555876.32	0.57	13098
0.42	6.00	509720.15	0.45	25223
0.42	7.00	615986.47	0.49	14717
0.47	6.50	535749.88	0.49	19432
0.47	7.80	677128.99	0.50	11575
0.53	7.10	579095.91	0.55	13213
0.53	8.50	736003.66	0.56	7863
0.57	7.60	594356.10	0.66	8759
0.57	9.10	791141.17	0.66	4925
0.64	8.20	645045.42	0.75	5709
0.64	9.80	853324.71	0.72	3584
0.73	9.80	776222.89	0.65	5188

PVDIS Rate Map before Trigger

Rate Map: xbj vs. Q2 (Rate + Acceptance Weighted)
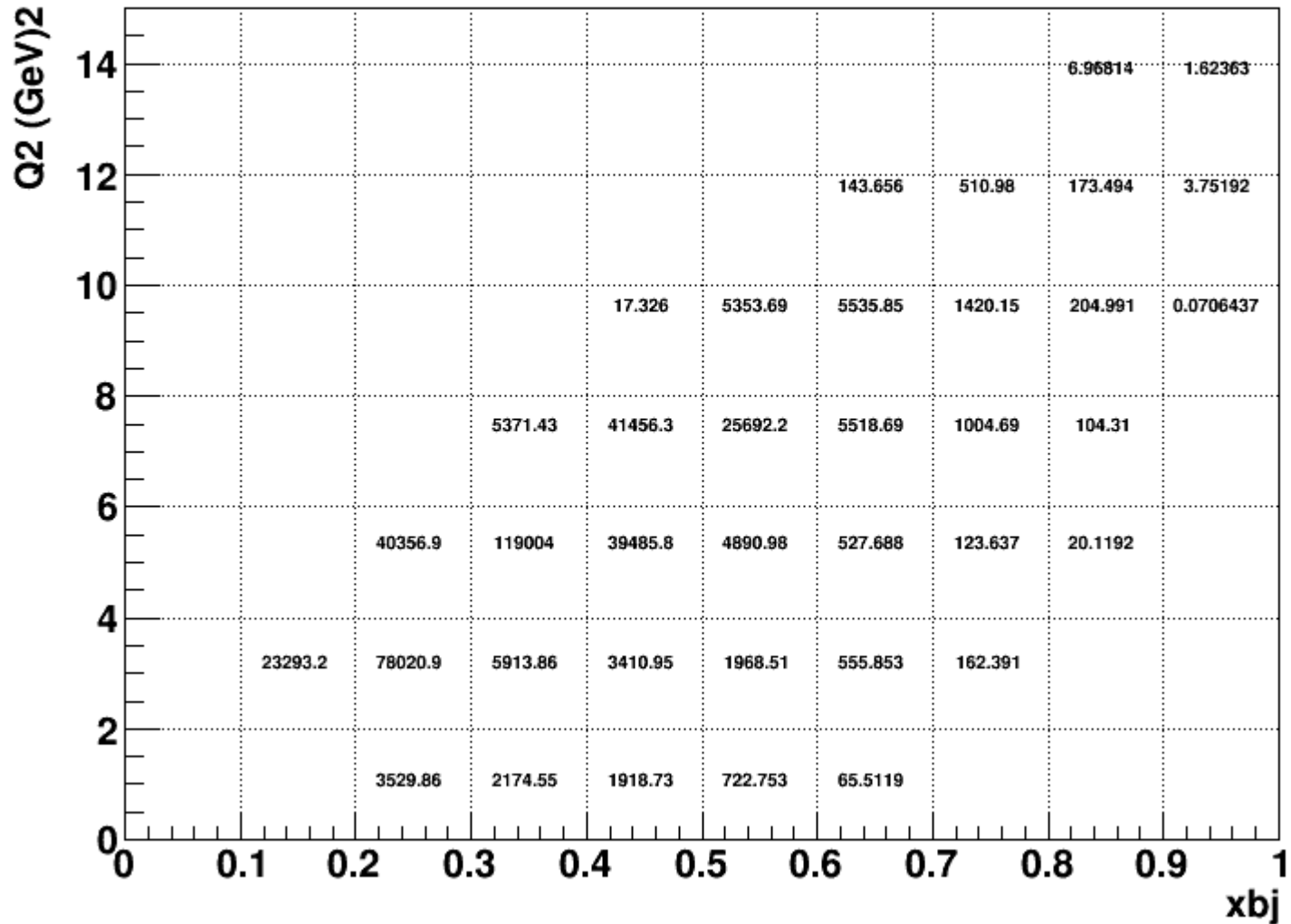
PVDIS Rate Map after Trigger

Rate Map: xbj vs. Q2 (Rate + Acceptance Weighted)

Supplementary

Rakitha Beminiwattha
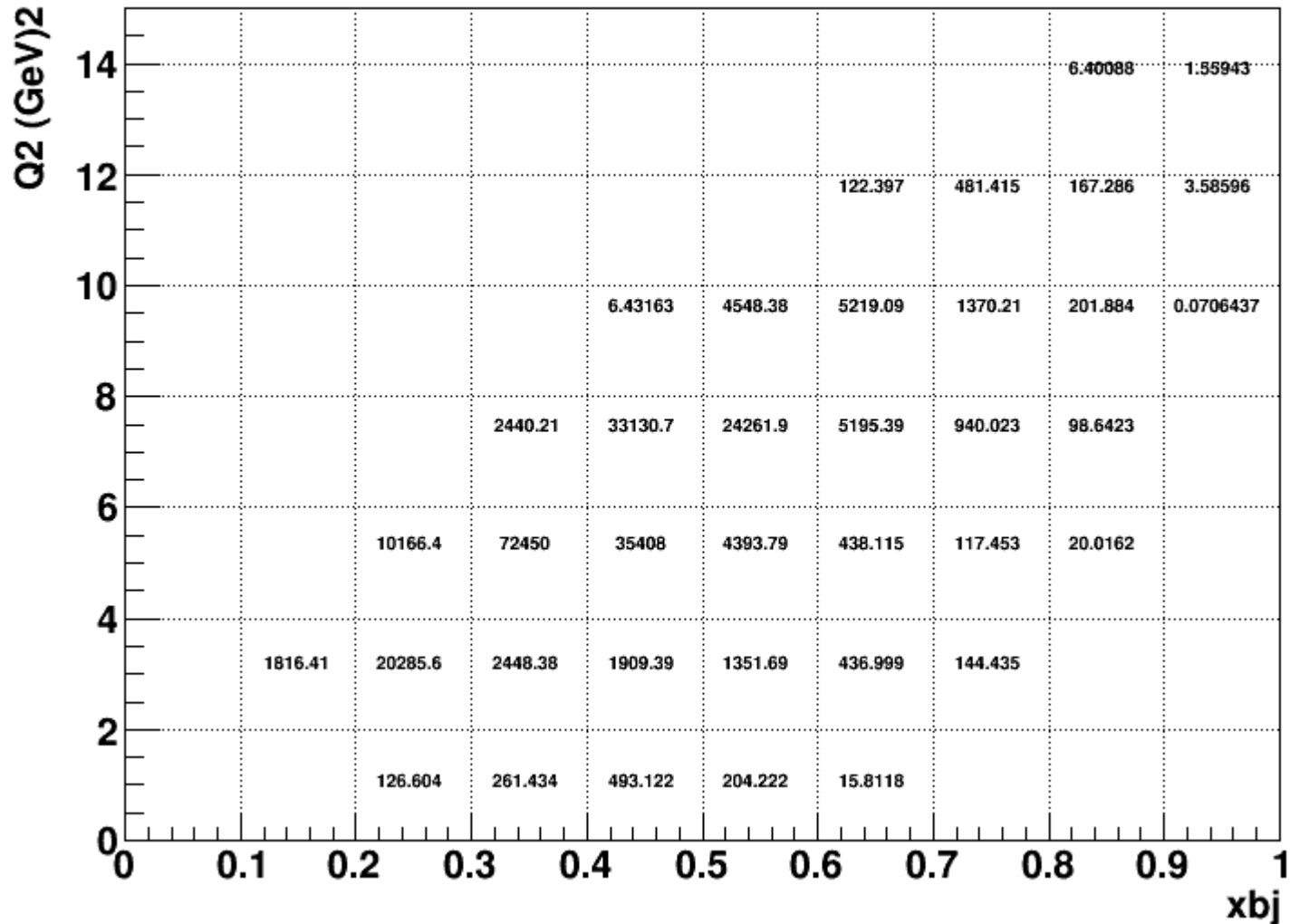
Cluster vs Track Radius

- There is an offset between the 6+1 max. energy cluster radius and the radius of the incident track at the front face of the ECAL

  - R_Track < R_Cluster
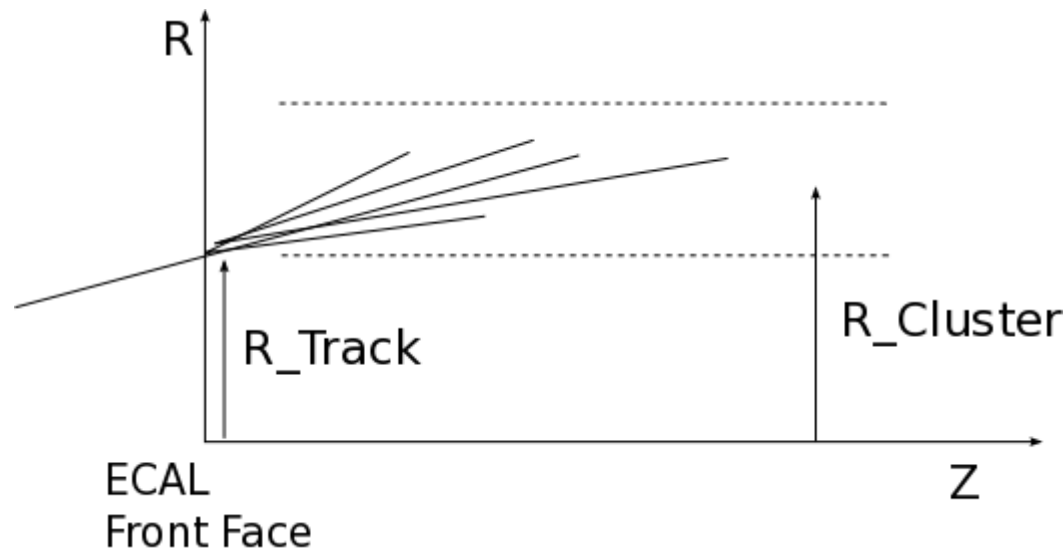
Cluster vs Track Radius : Electrons
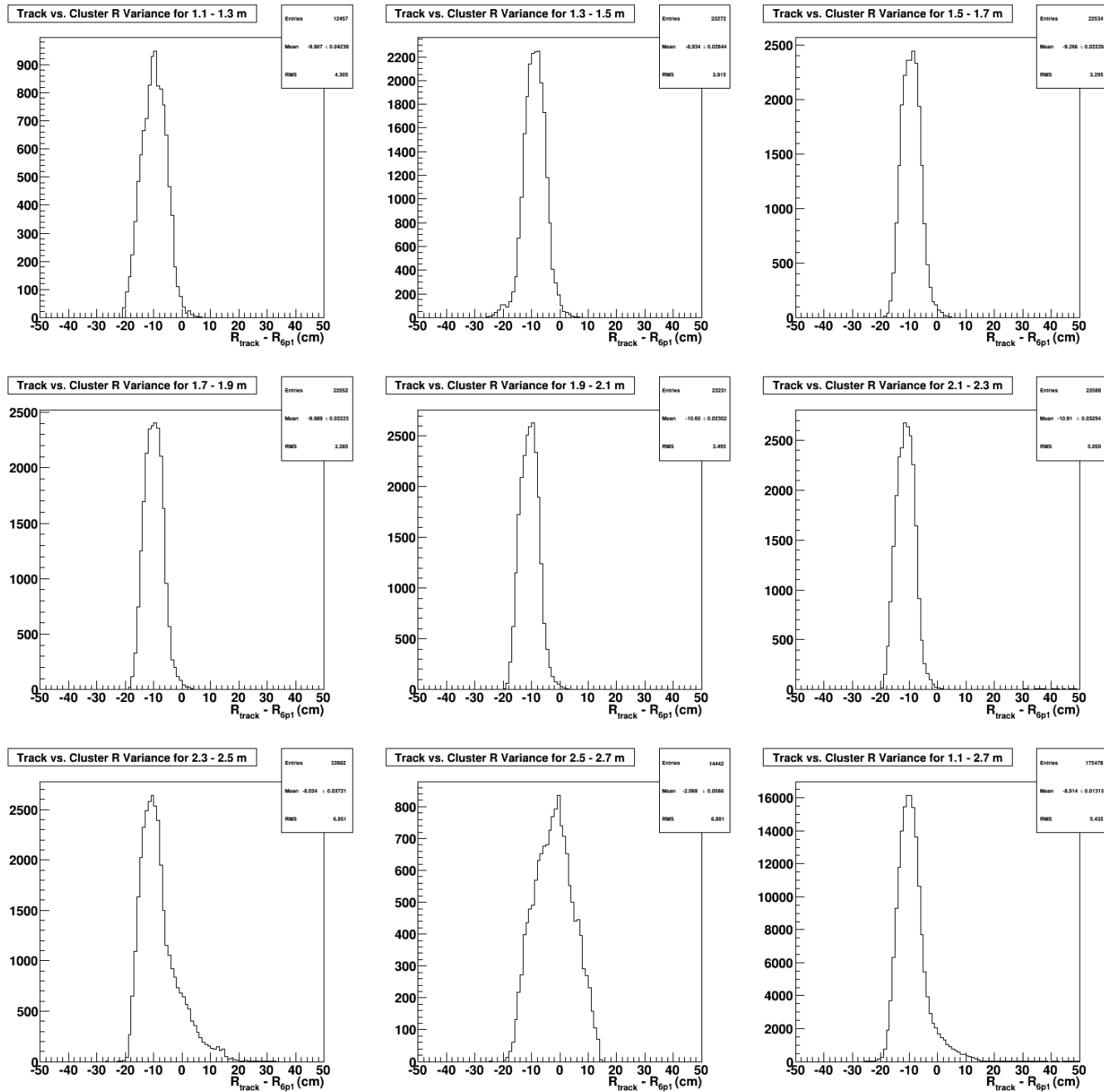
Cluster vs Track Radius : Pions
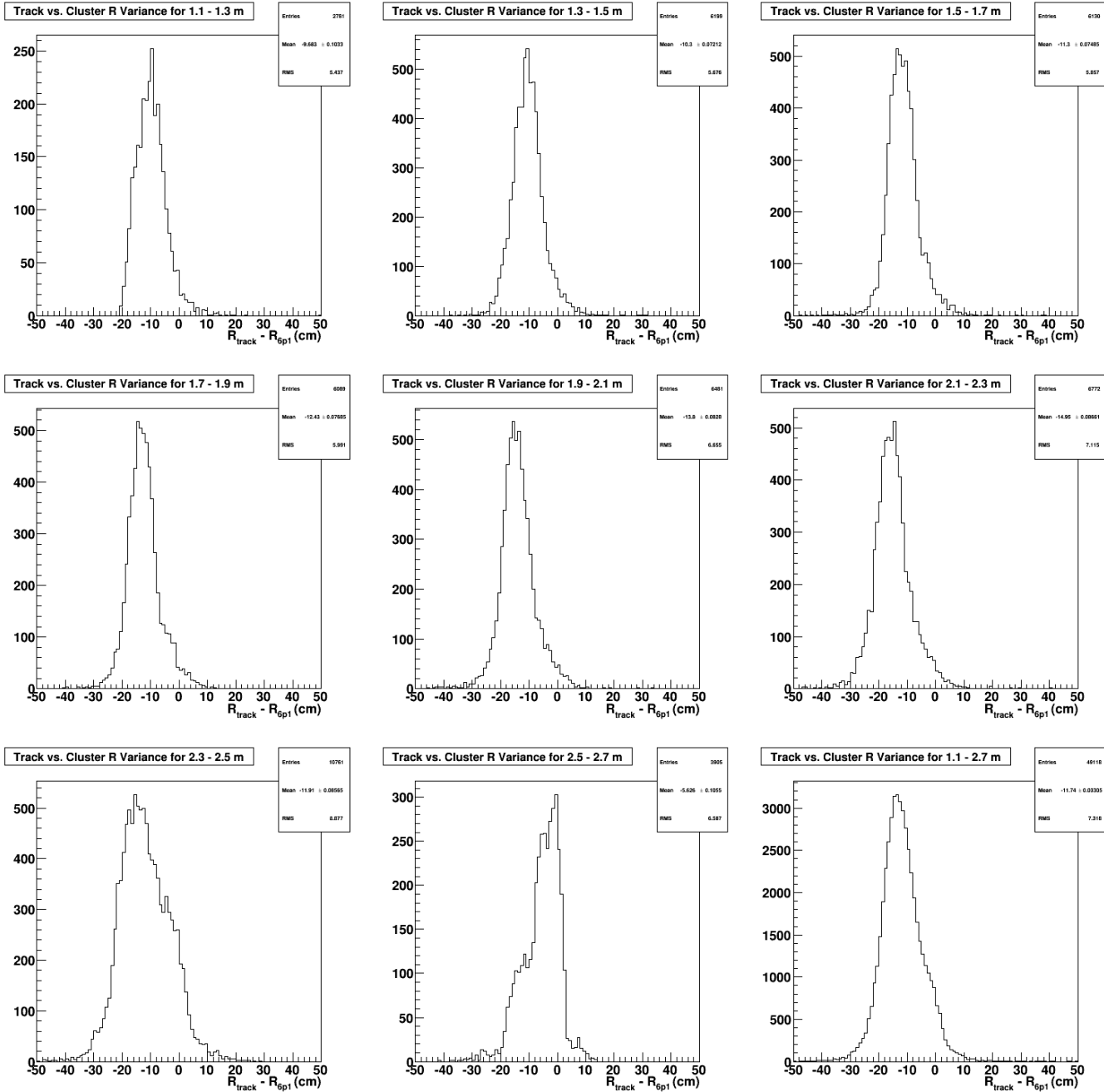
Trigger Thresholds from DIS Gen.

- Cluster thresholds generated from electron signals (DIS weighted generator)

- The trigger threshold is the DIS threshold in the shower.

  - Radius bins: {110 -130 ,130 - 150 ,150 – 170, 170 – 190, 190 - 210 ,210 – 230, 230 - 250 ,250 - 270}

  - Shower 6+1 Thresholds : {617.9 ,531.0 ,460.0 ,389.8 , 331.0 ,287.6 ,271.9 ,272.0} MeV

  - Shower 2+1 Thresholds : {501.5 ,471.9 ,412.8 ,340.5 , 291.9 ,255.3 ,243.7 ,244.0} MeV

- No threshold is applied to Pre-Shower clusters

ECAL Analysis with Trigger Windows

- Backgrounds are generated using cross section weighted events from hall D generator

- Combined Pions : π^- , π^+, π^0 and EM background

    - Events are uniformly separated in time according to the background rates

- Tracks incident on the ECAL can then be separated to 30 ns time windows (trigger window is 30 ns)

- Each sector (12 deg) of ECAL is treated independently

- Total time in simulation is 35070 ns or 1169 background trigger windows

- Photon blocker included in the simulation

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Trigger Definition

- Select 6+1 max energy cluster for each window in each sector

- If above the threshold, trigger the sector

- Trigger condition applied based on radial dependence cluster thresholds

Tracks Incident on ECAL
no EM Background
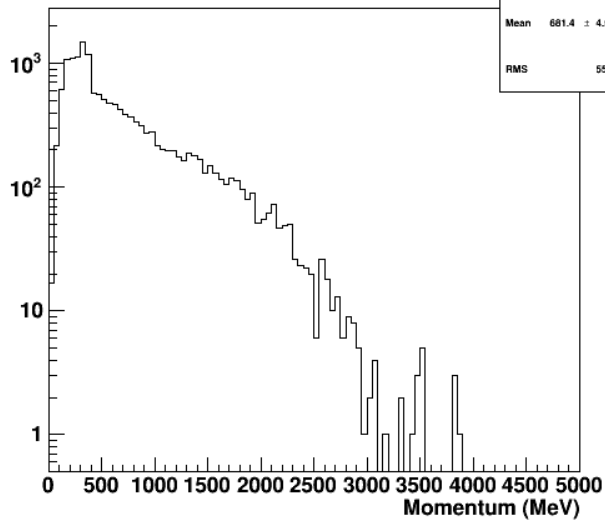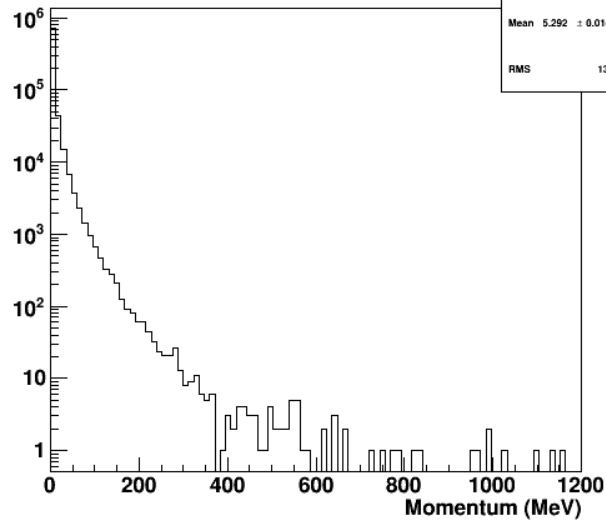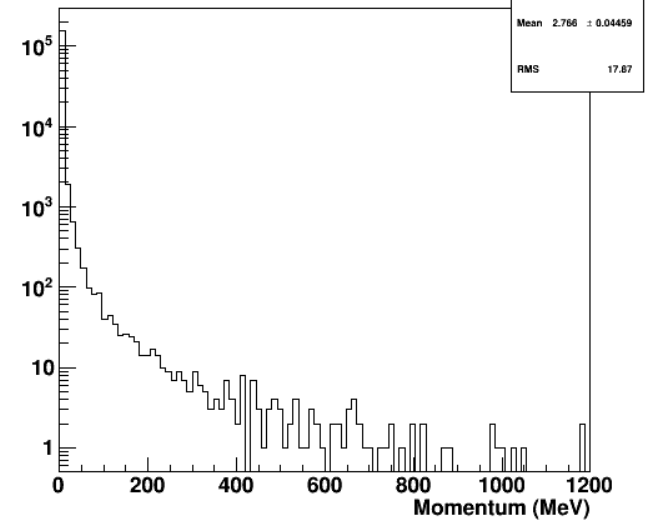
Total no.of tracks incident on the ECAL sector are categorized in to,
- Pions (+/-)
- Pi0 Photons
- All other photons

Tracks Incident on ECAL
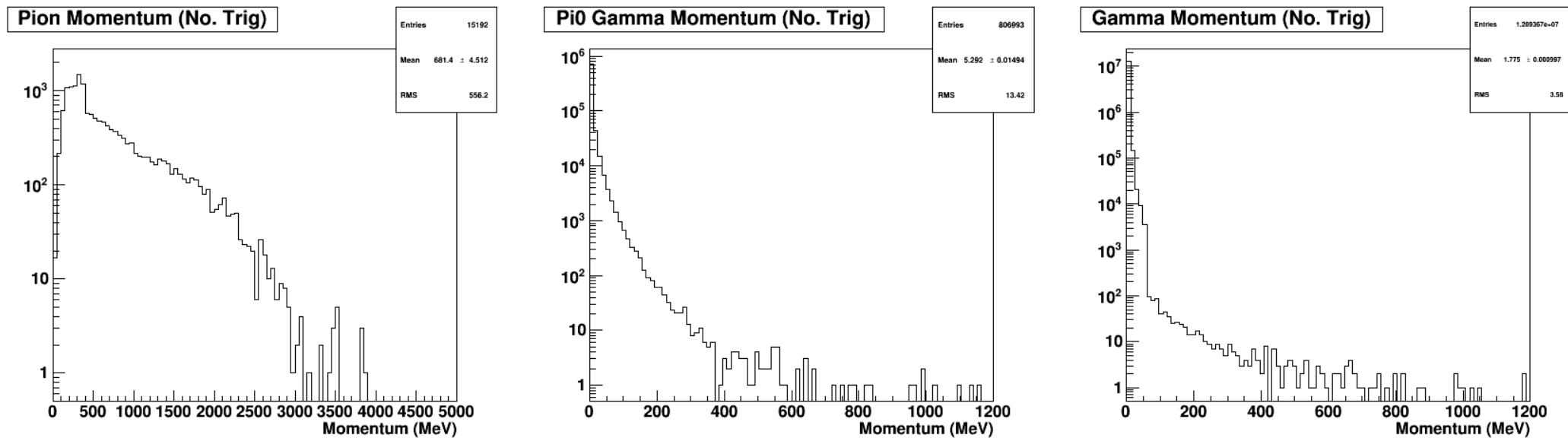
Total no.of tracks incident on the ECAL sector are categorized in to,
- Pions (+/-)
- Pi0 Photons
- All other photons

Tracks Incident on ECAL After 6+1 Trigger
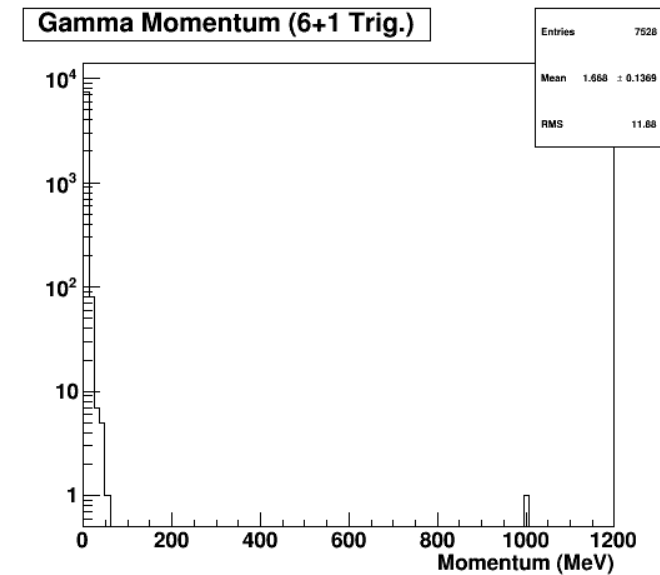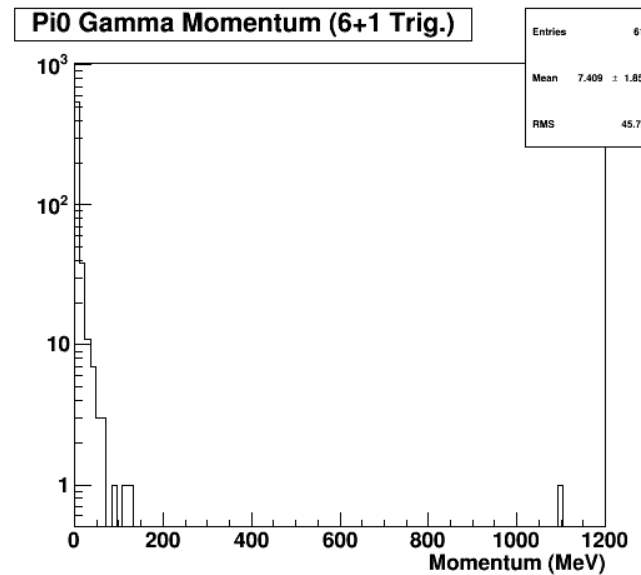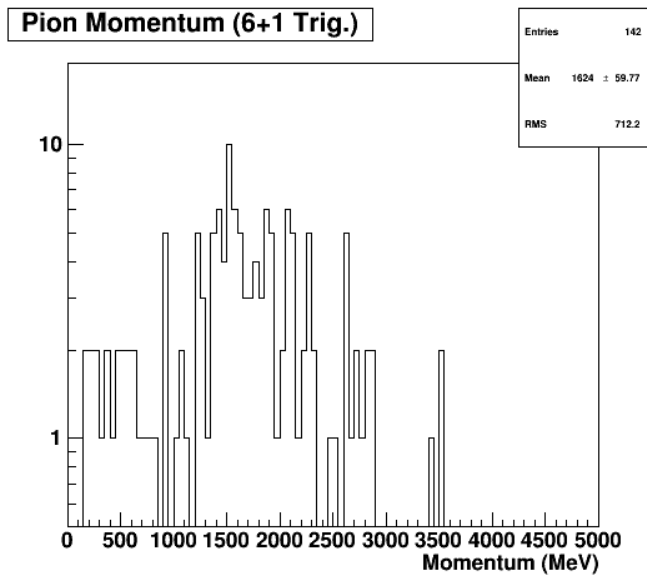
Total no.of tracks incident on the ECAL sector are categorized in to,
- Pions (+/-)
- Pi0 Photons
- All other photons

ECAL : Wiser Background Rate

- Total background rates before and after applying the trigger
- With the photon blocker
- Photons are separated into two groups
  - From Pi0 and all other secondary photons
  - No high energy gammas after photon blocker
  - Photon rate is mostly dominated by very low energy tracks

All Mom.		Before Trigger (MHz)	After 6+1 Trigger (MHz)	After 2+1 Trigger (MHz)
	Bkg. e±	1308.2	0.9	0.4
	π±	842.5	5.3	2.0
	γ(π0)	55346.5	49.9	14.3
	all other γ	9104.3	11.4	3.7
P > 1 GeV				
	Bkg. e±	0.0	0.0	0.0
	π±	140.1	4.3	1.0
	γ(π0)	0.3	0.0	0.0
	all other γ	0.0	0.0	0.0
P < 1 GeV				
	Bkg. e±	1308.2	0.9	0.4
	π±	702.4	1.0	1.0
	γ(π0)	55346.2	49.9	14.3
	all other γ	9104.3	11.4	3.7

ECAL : Hall D Gen. Background Rate no EM Background

- Total background rates before and after applying the trigger

- With the photon blocker

- Photons are separated into two groups

  – From Pi0 and all other secondary photons

  – No high energy gammas after photon blocker

  – Photon rate is mostly dominated by very low energy tracks

All Mom.		Before Trigger	After 6+1 Trigger	After 2+1 Trigger
		(MHz)	(MHz)	(MHz)
	Bkg. e±	396.9	0.3	0.0
	π±	433.2	3.8	0.5
	γ(π0)	23010.9	14.2	2.5
	all other γ	4581.4	3.0	0.7
P > 1 GeV				
	Bkg. e±	0.1	0.0	0.0
	π±	97.3	3.1	0.5
	γ(π0)	0.2	0.03	0.0
	all other γ	0.2	0.0	0.0
P < 1 GeV				
	Bkg. e±	396.7	0.3	0.0
	π±	335.8	0.7	0.1
	γ(π0)	23010.7	14.1	2.5
	all other γ	4581.2	3.0	0.7

ECAL : Hall D Gen. Background Rate

- Total background rates before and after applying the trigger

- With the photon blocker

- Photons are separated into two groups

  - From Pi0 and all other secondary photons

  - No high energy gammas after photon blocker

  - Photon rate is mostly dominated by very low energy tracks

All Mom.		Before Trigger (MHz)	After 6+1 Trigger (MHz)	After 2+1 Trigger (MHz)
	Bkg. e±	3907.4	2.1	0.2
	π±	433.2	4.0	0.6
	γ(π0)	23010.9	17.4	2.9
	all other γ	367655.3	214.7	48.2
P > 1 GeV				
	Bkg. e±	0.1	0.0	0.0
	π±	97.3	3.3	0.5
	γ(π0)	0.2	0.03	0.0
	all other γ	0.2	0.0	0.0
P < 1 GeV				
	Bkg. e±	3907.2	2.1	0.2
	π±	335.8	0.8	0.1
	γ(π0)	23010.7	17.4	2.9
	all other γ	367655.1	214.6	48.2

Trigger Rate Estimation
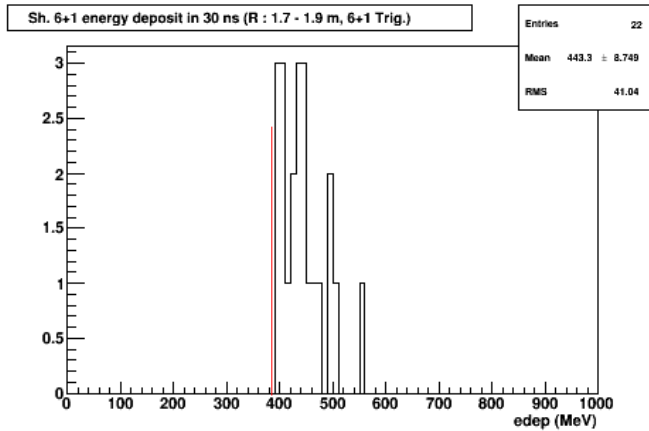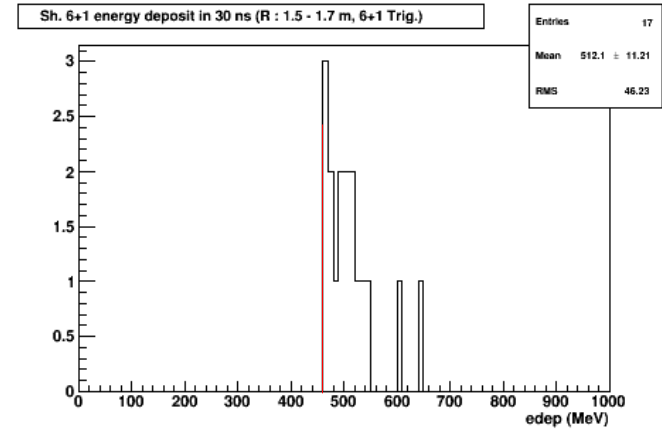
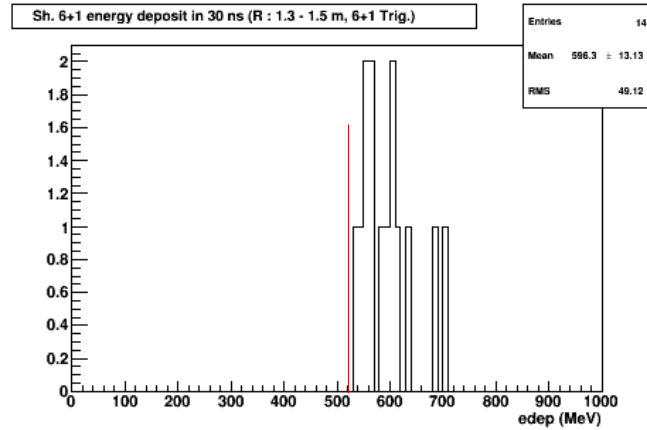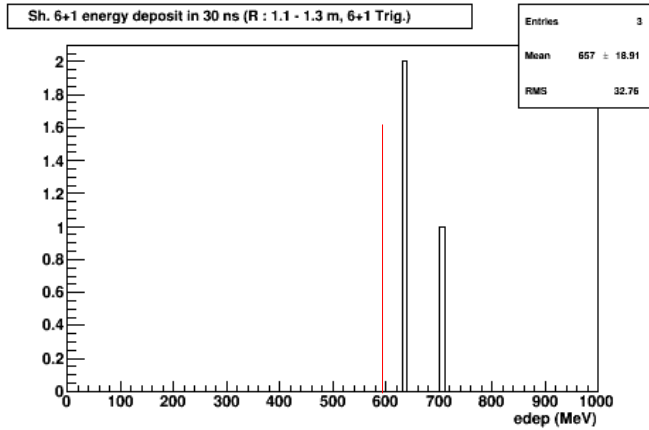# ECAL Shower Energy Deposit No EM
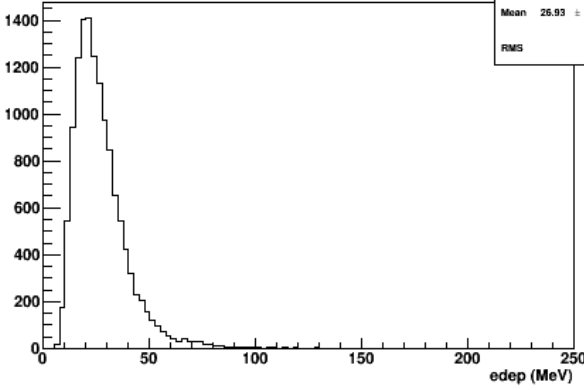
Trigger threshold ———
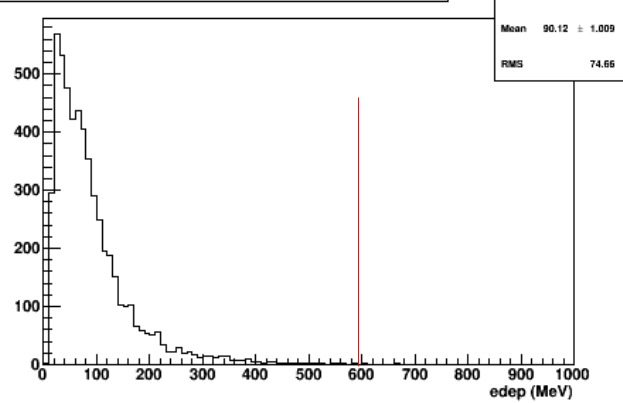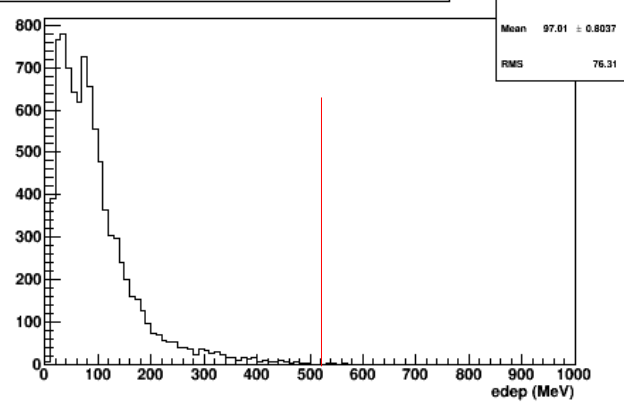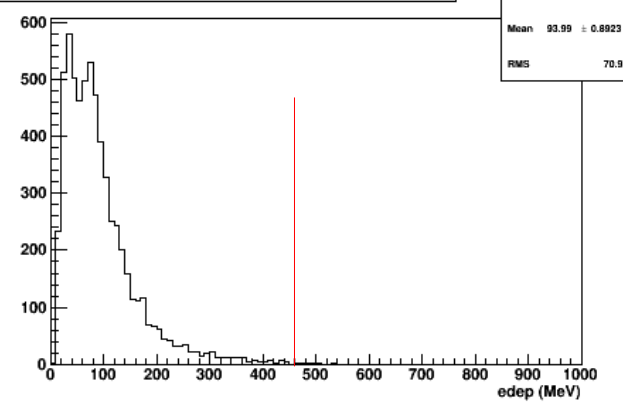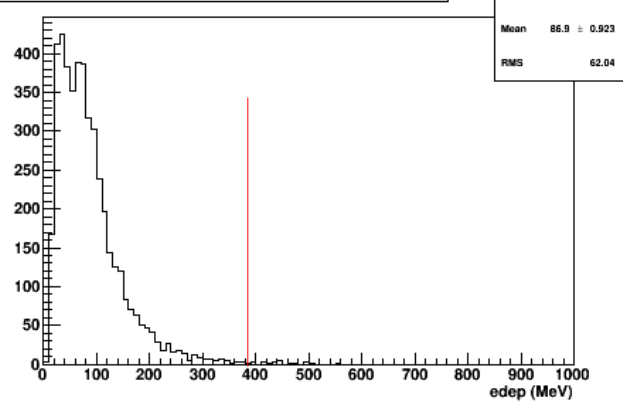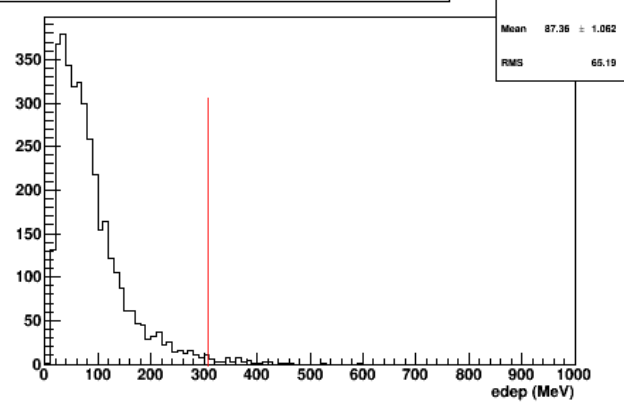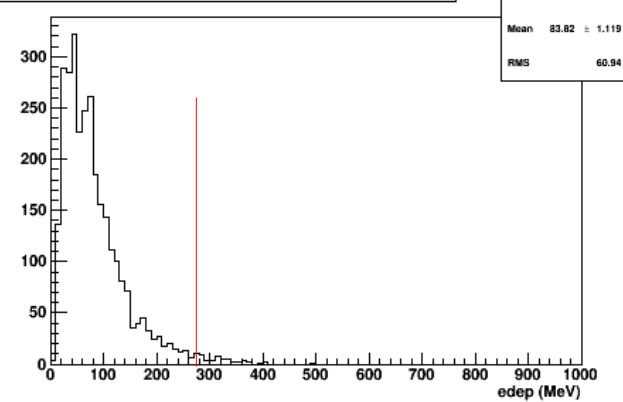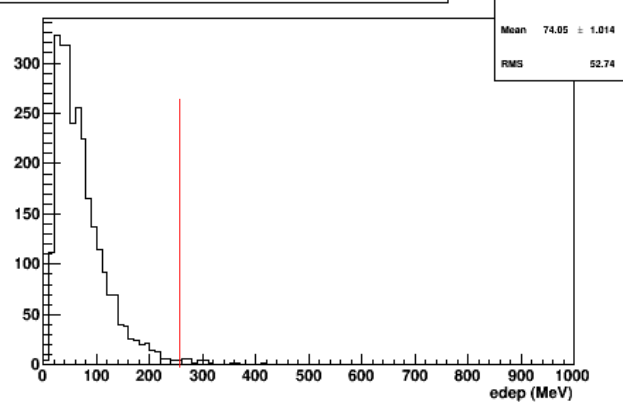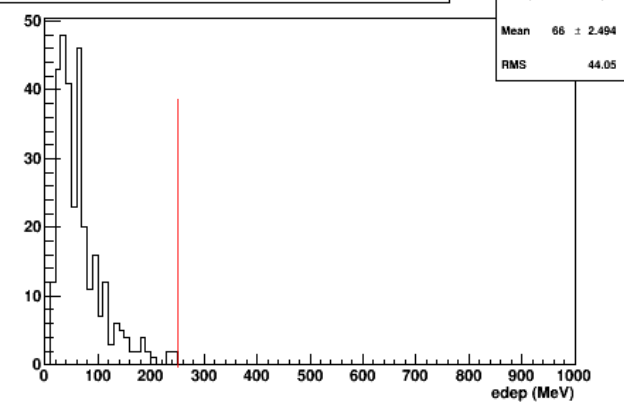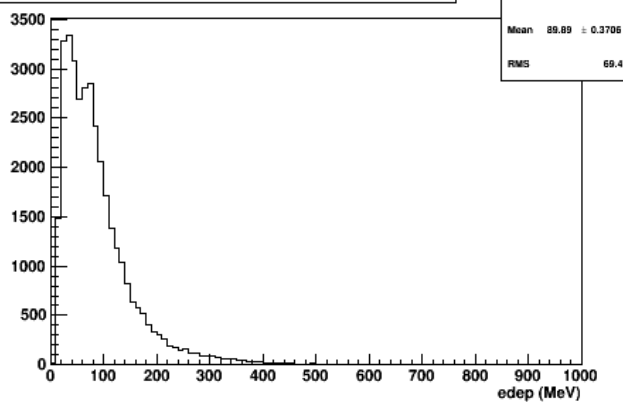
ECAL Shower Energy Deposit

Trigger threshold
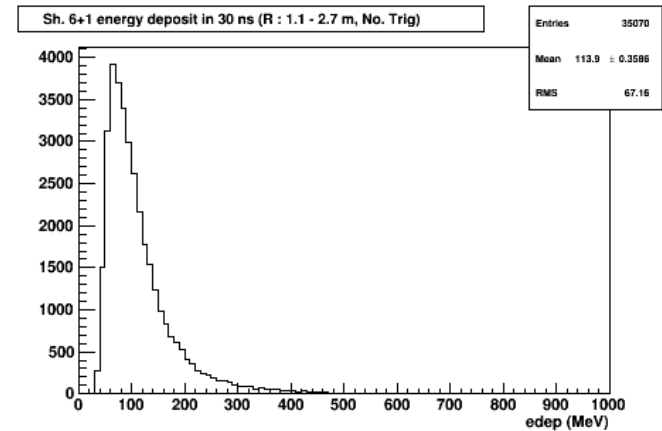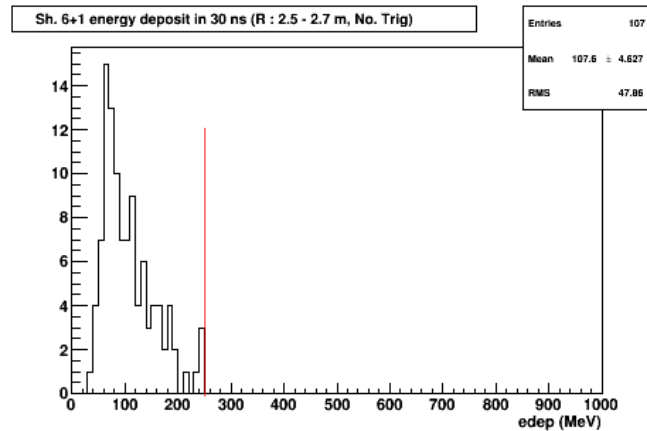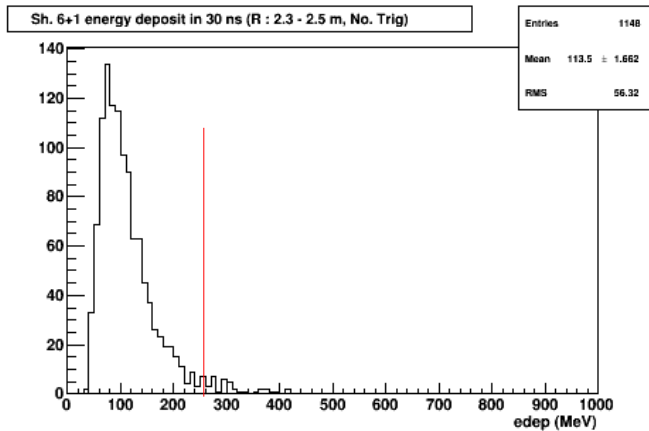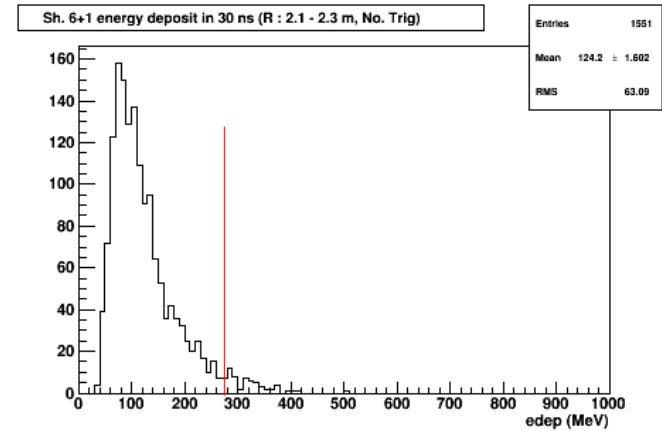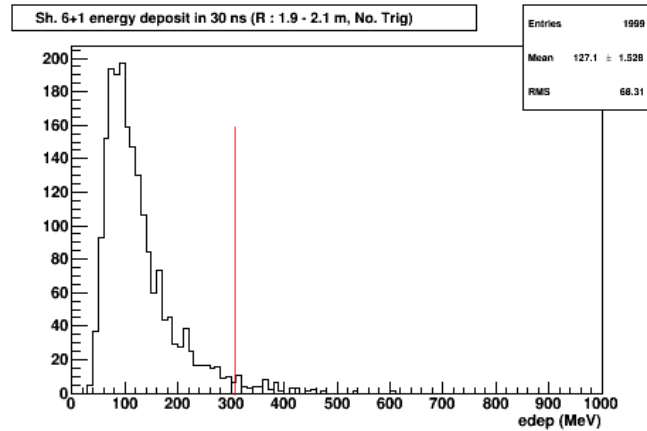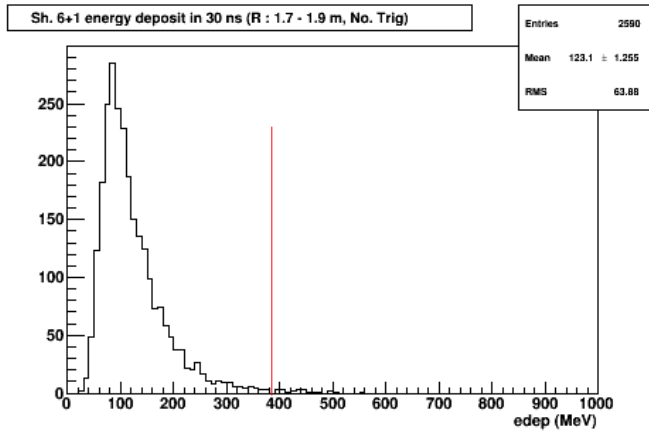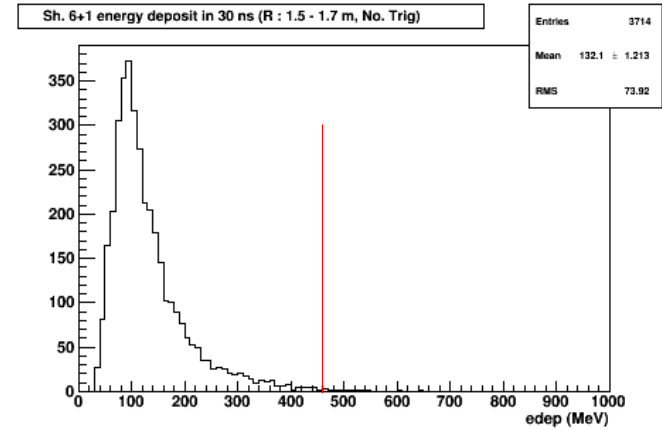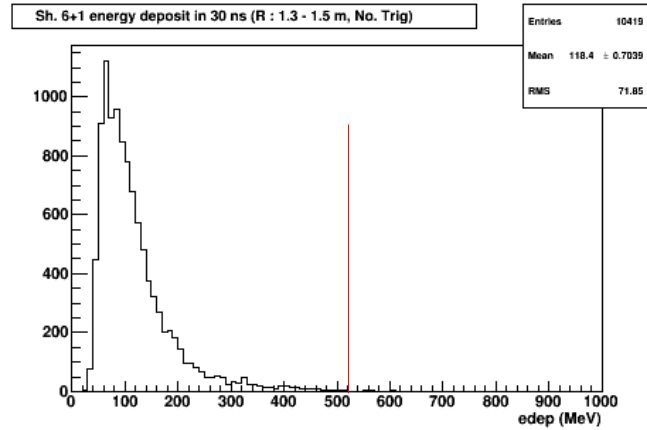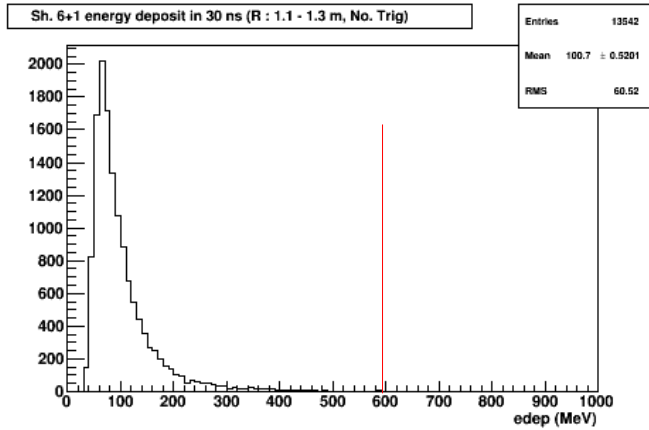
ECAL Shower Energy Deposit after Trigger

Trigger threshold ———
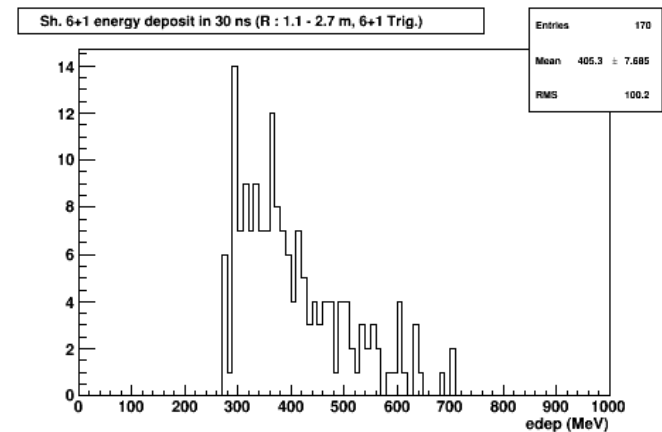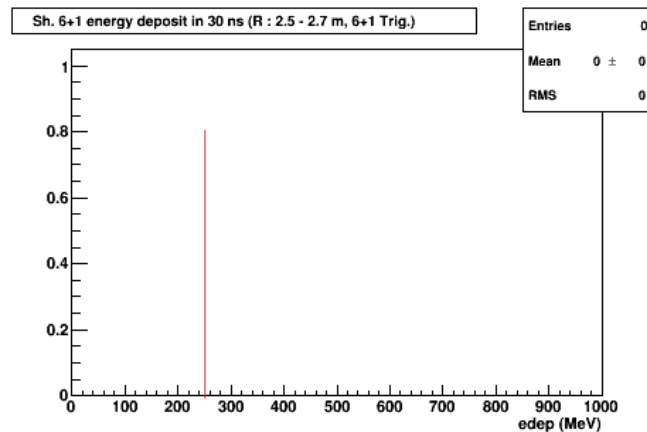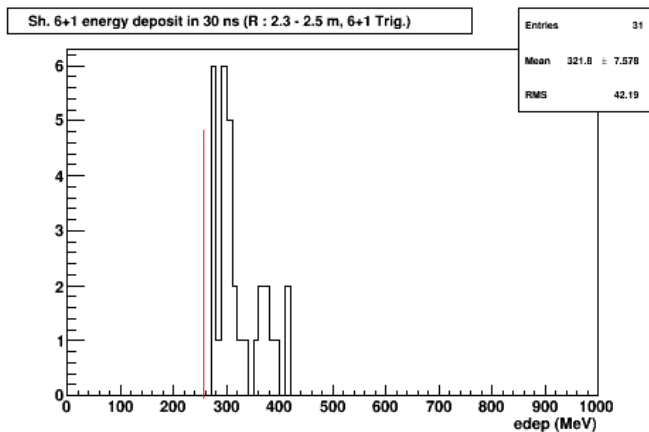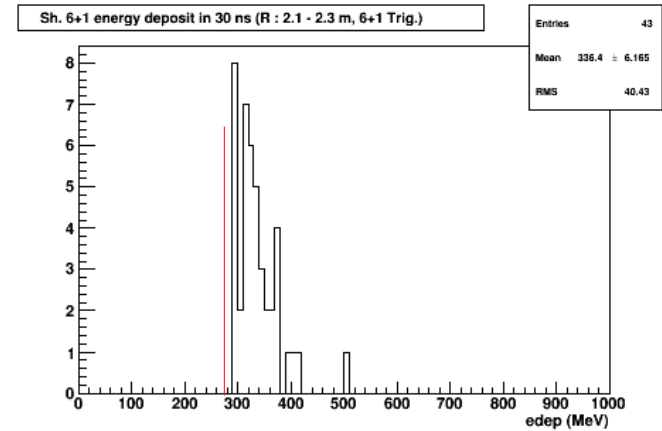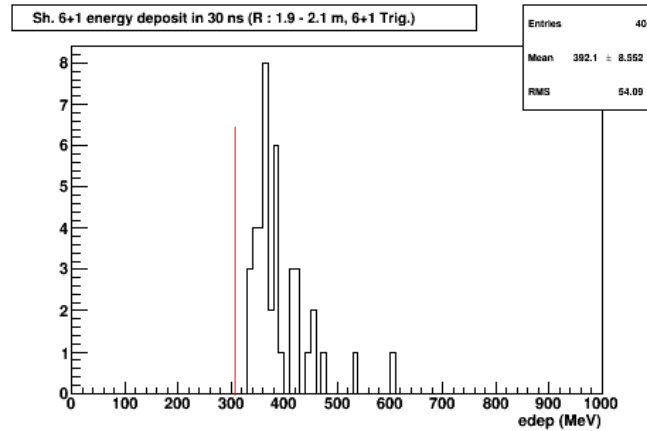
ECAL Pre-Shower Energy Deposit

Trigger Rate Estimation with EM Background

- Total time windows 1169
  - In each window there are 30 individual sectors → 1169*30

- Maximum trigger rate is 1/30 ns → 33.33 MHz
  - This is when all time windows are triggered

- Total trigger rate is 4.85 MHz or 162 kHz per sector
    - Total time windows after applying the trigger 170

- Total trigger rate only from pion bkg. 4.612 MHz or 154 kHz per sector

Sector	Total Windows	Triggered Windows	Trig. Rate (kHz)
Trigger Rate Sector wise summary			
1	1169	9	256.6
2	1169	6	171.1
3	1169	1	28.5
4	1169	7	199.6
5	1169	7	199.6
6	1169	5	142.6
7	1169	2	57.0
8	1169	4	114.0
9	1169	5	142.6
10	1169	6	171.1
11	1169	4	114.0
12	1169	5	142.6
13	1169	9	256.6
14	1169	6	171.1
15	1169	3	85.5
16	1169	5	142.6
17	1169	5	142.6
18	1169	7	199.6
19	1169	7	199.6
20	1169	5	142.6
21	1169	5	142.6
22	1169	4	114.0
23	1169	8	228.1
24	1169	8	228.1
25	1169	6	171.1
26	1169	3	85.5
27	1169	10	285.1
28	1169	6	171.1
29	1169	6	171.1
30	1169	6	171.1
Total per Sector	35070	170	161.6

Trigger Rate Estimation in preCDR

region	full	high	low
rate entering the EC (kHz)			
e^-	413	148	265
π^-	5.1×10^5	2.7×10^5	2.4×10^5
π^+	2.1×10^5	1.0×10^5	1.2×10^5
$\gamma(\pi^0)$	8.4×10^7	4.2×10^7	4.3×10^7
p	5.5×10^4	2.4×10^4	3.1×10^4
sum	8.5×10^7	4.2×10^7	4.3×10^7
trigger rate for $p > 1$ GeV (kHz)			
e^-	321	80	231
π^-	4.8×10^3	3.4×10^3	1.4×10^3
π^+	0.28×10^3	0.11×10^3	0.17×10^3
$\gamma(\pi^0)$	4	4	0
p	0.18×10^3	0.10×10^3	0.08×10^3
sum	5.6×10^3	3.7×10^3	1.9×10^3
trigger rate for $p < 1$ GeV (kHz)			
sum	$(3.1 \pm 0.7) \times 10^3$	$(1.6 \pm 0.4) \times 10^3$	$(1.5 \pm 0.4) \times 10^3$
Total trigger rate (kHz)			
total	$(8.7 \pm 0.7) \times 10^3$	$(5.3 \pm 0.4) \times 10^3$	$(3.4 \pm 0.4) \times 10^3$

- **Total trigger rate from Wiser + EM is 8.7 MHz**
  - **290 kHz per sector**