

Bump Hunt Update

Early datasets with solenoid at 1200 A and mode 8 readout:

- ~14 M events with **FCAL trigger**: runs 1501-1525
- ~25 M events with **BCAL trigger**: runs 1547-1807
- ~200 M events with **FCAL-BCAL trigger**: runs 2140-2420
- Timing OK between downstream detectors (SC/BCAL/FCAL/TOF?)

Track Selection

- Use DTrackTimeBased tracks with only the pion mass hypothesis and require:
 - Tracking FOM $> 10^{-3}$ and # DOF > 7
 - POCA to beamline: $50 < Z < 80$ cm
 - Matched to SC hit (for timing with tagger)

Event Statistics

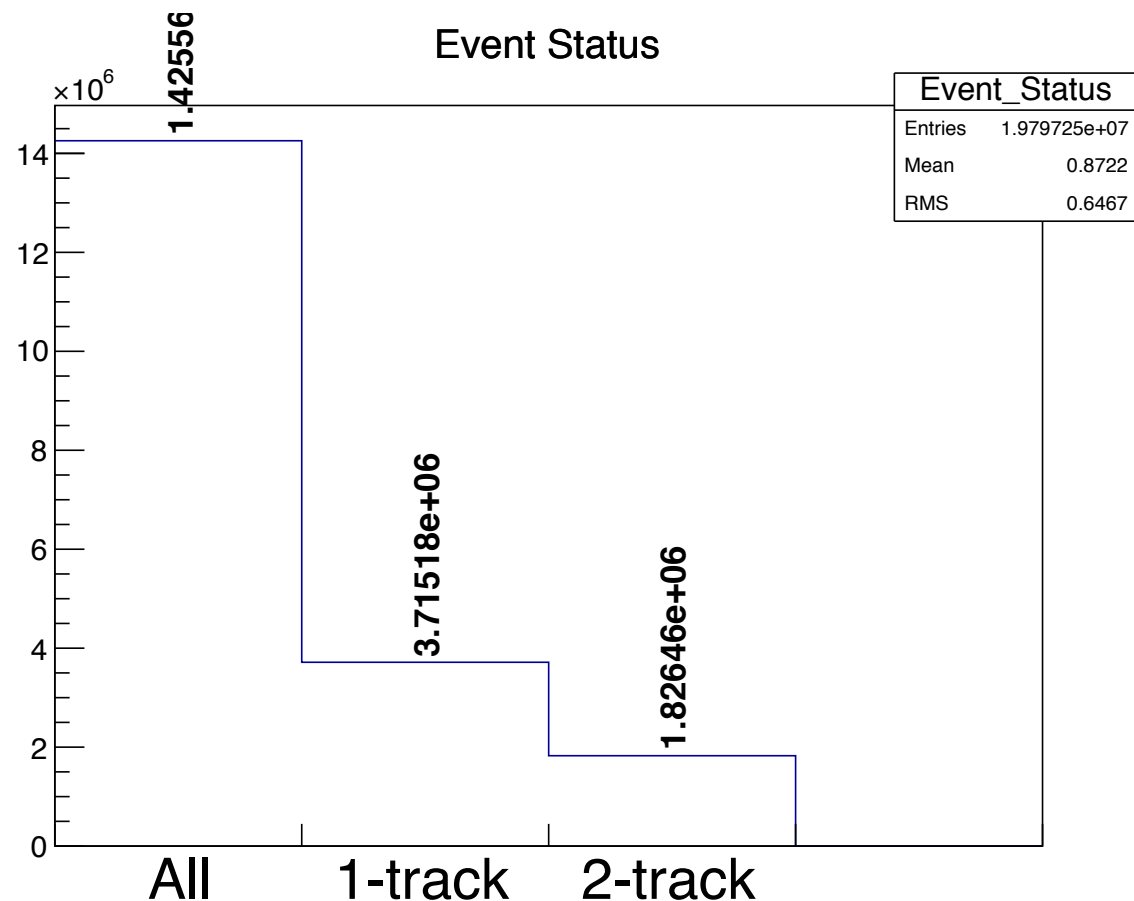
- Analyzed raw EVIO data (no skims) to better document event statistics
- Also calculate “Luminosity” = beam current x run time (nA*s) as a rough **relative** scale factor. **Note:** assumes same radiator and similar collimator throughput

FCAL trigger:

~14M events

~13% have 2 cand tracks

Lumi ~ 3M nA*s

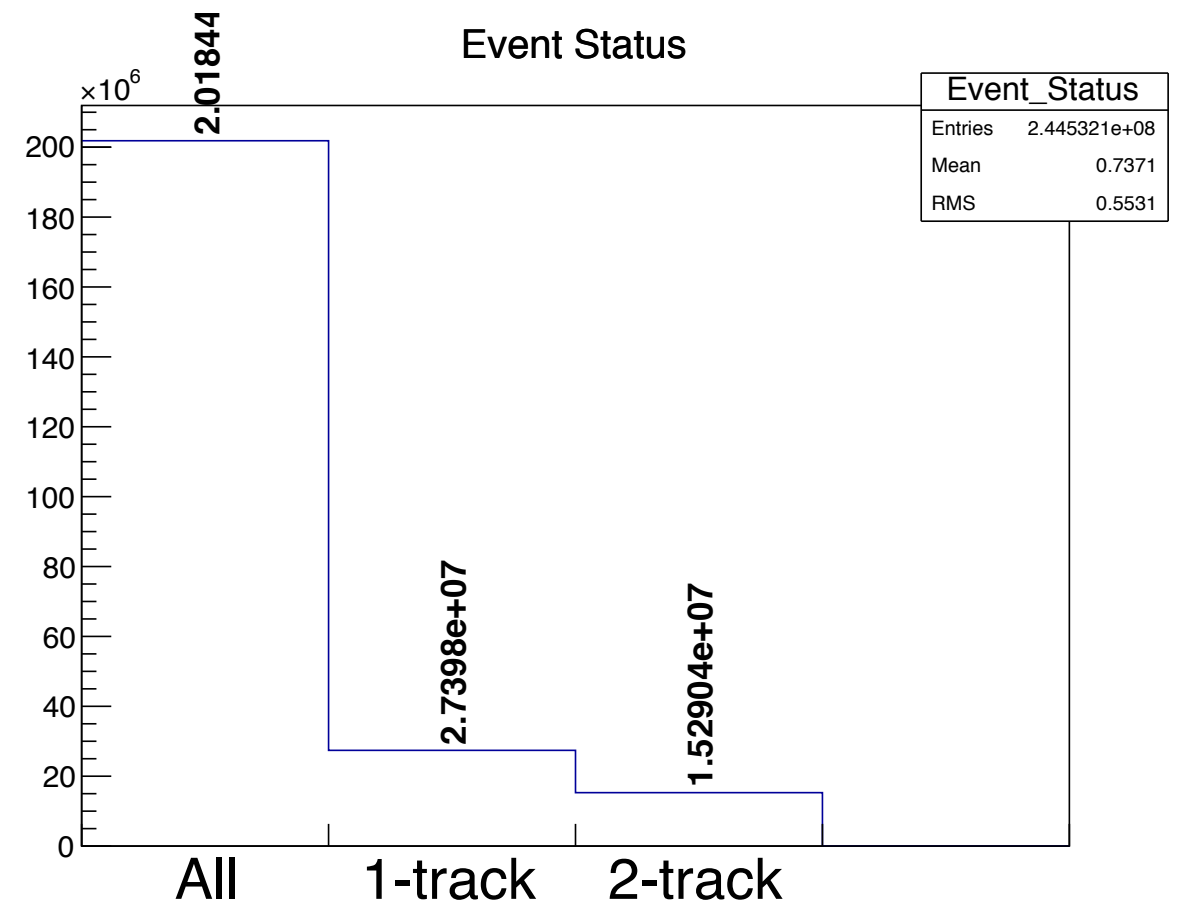


FCAL-BCAL trigger:

~200M events

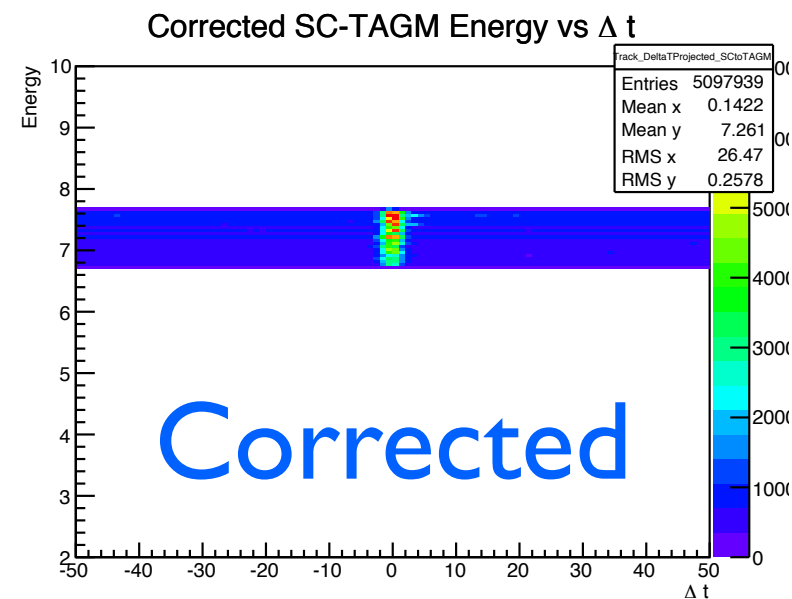
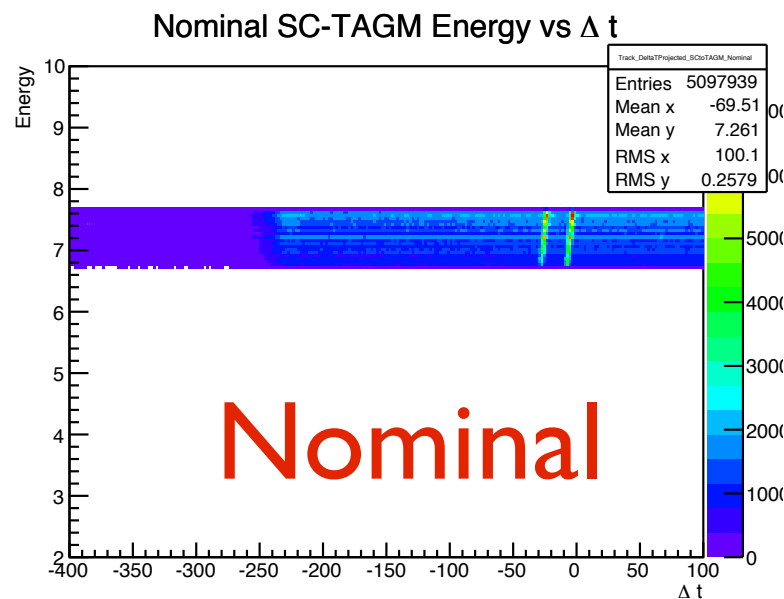
~7% have 2 cand tracks

Lumi ~ 10M nA*s

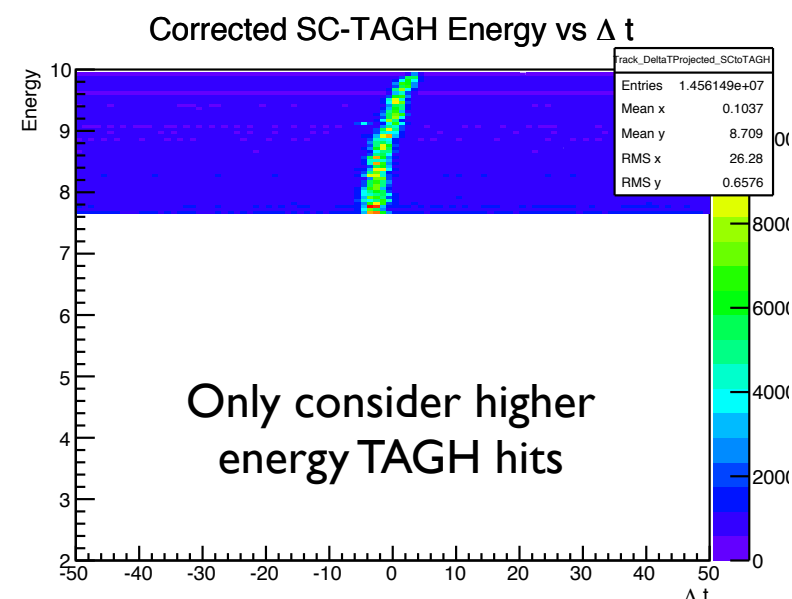
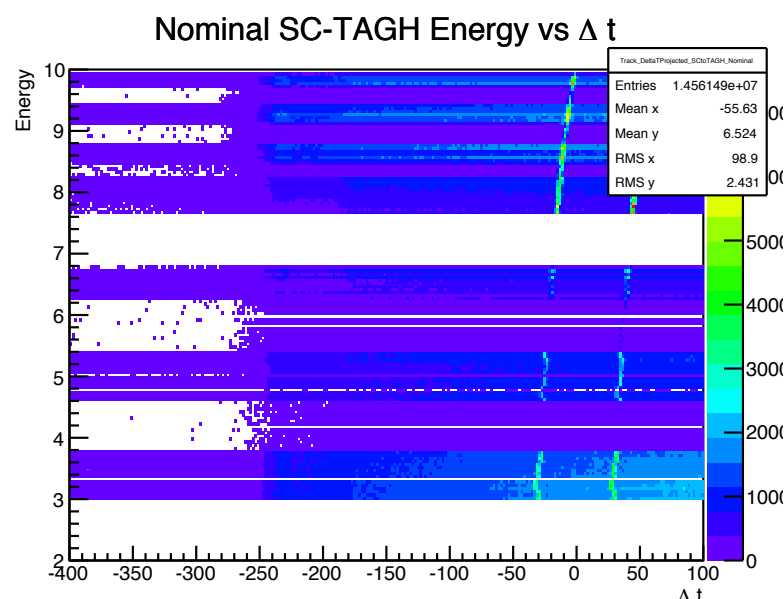


Time offset between SC and TAGM/H

- Require tracks have matched hit in SC
- Use pathlength to determine time of SC hit propagated to the target
- Calculate “Nominal” Δt (SC-TAGM/H) at target, and correct to center at 0



TAGM:
corrected
time nicely
centered at
 $\Delta t = 0$



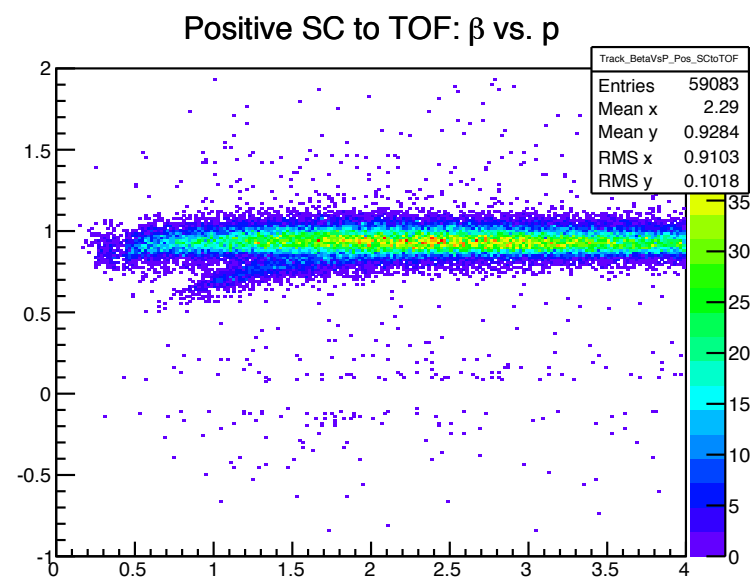
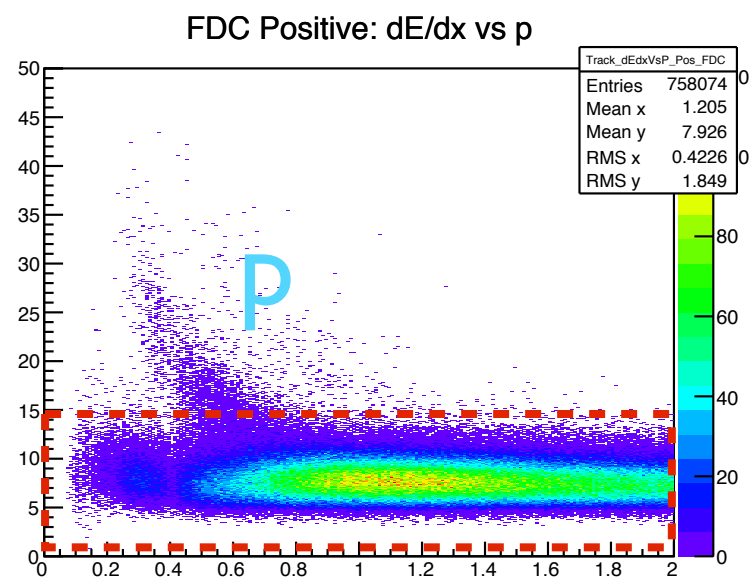
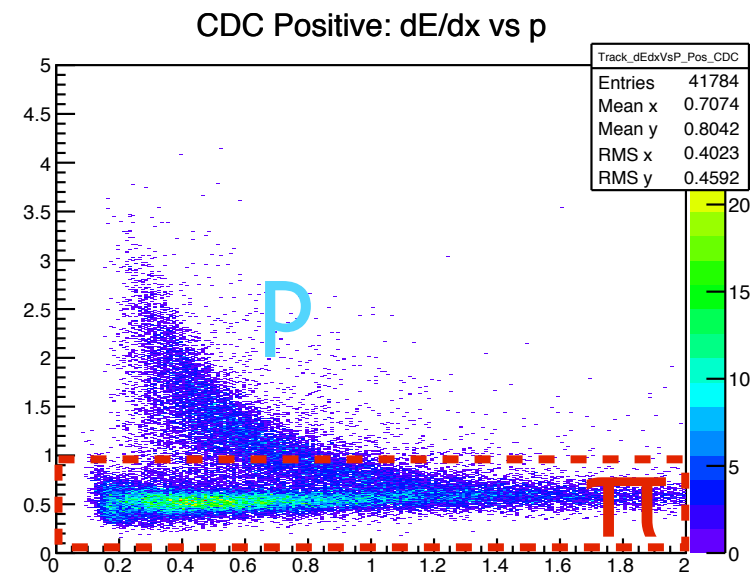
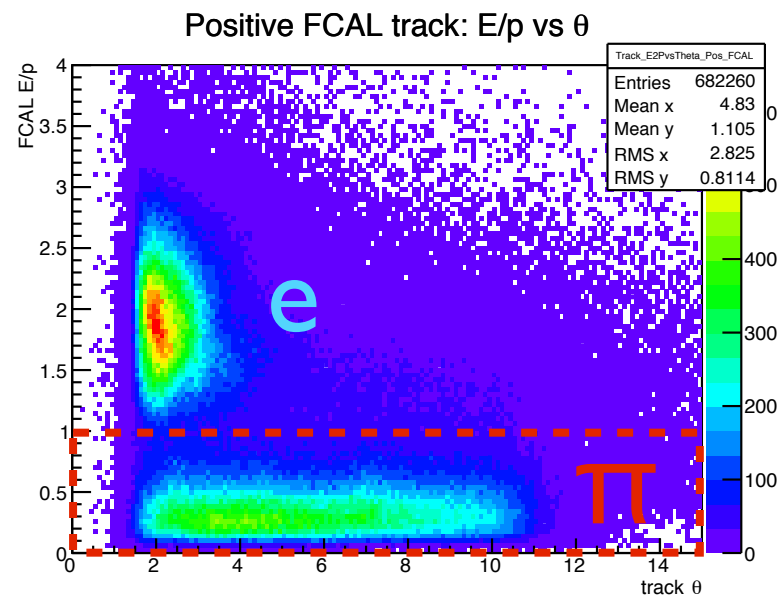
TAGH: some
“curvature”
with energy
(ie. counter
ID) but still
centered at
 $\Delta t = 0$

Try to adjust for
counter ID
dependent offset
(ie. slope in
Nominal plots)

FCAL-BCAL trigger: runs 2140-2420

π^\pm candidate selection

- Remove electrons with E/p cut in the FCAL
- Remove protons with dE/dx in CDC and FDC and β from SC-TOF coincidence
- All other tracks are π^\pm candidates

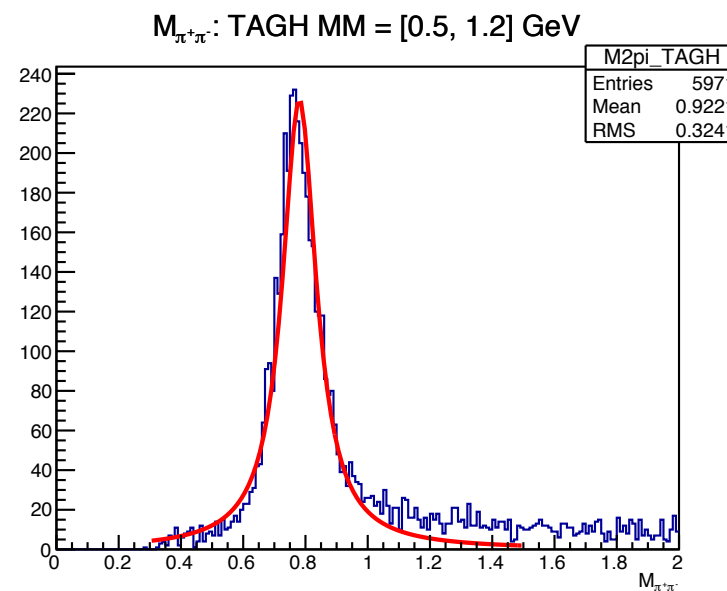
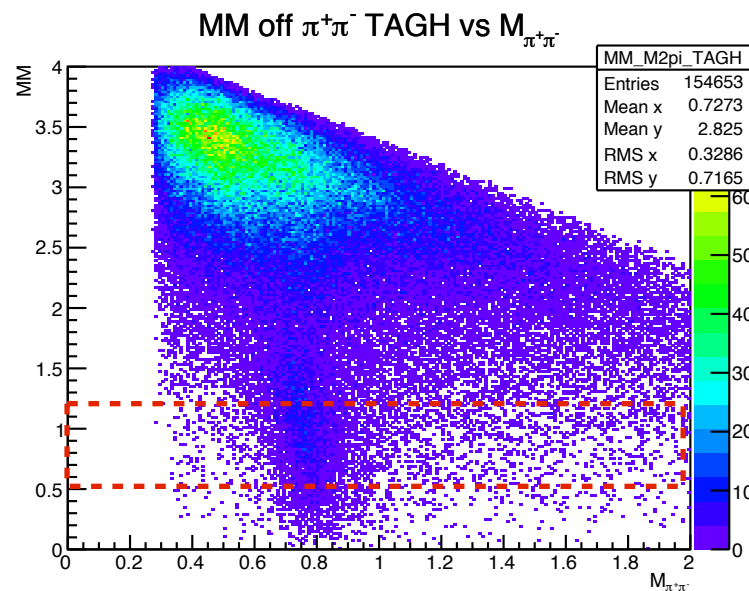
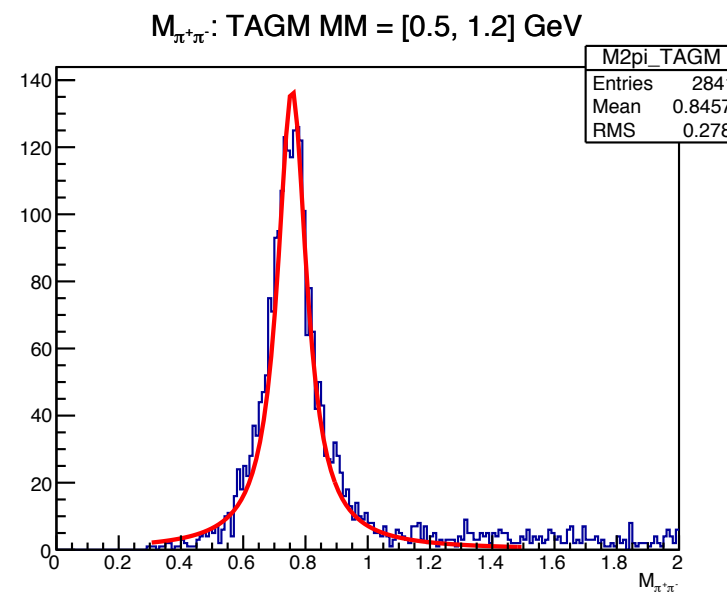
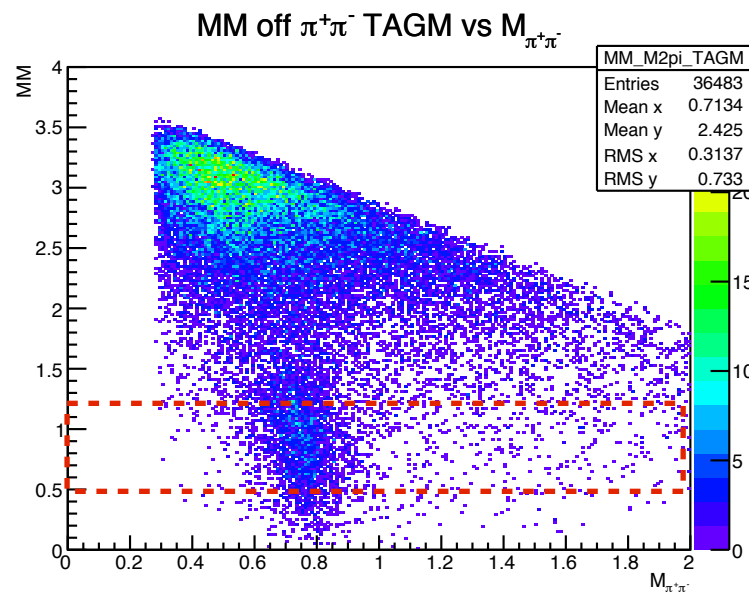


TOF not used
because timing
not synced for
some runs of
FCAL-BCAL
trigger

FCAL trigger: runs 1501-1525

Missing Mass vs $M_{\pi^+\pi^-}$

- Select $\pi^+\pi^-$ candidate pairs and calculate missing mass (MM) from TAGM/H photon (select time window using π^- SC hit)
- Select MM region for protons (0.5-1.2 GeV) to select exclusive $p\pi^+\pi^-$

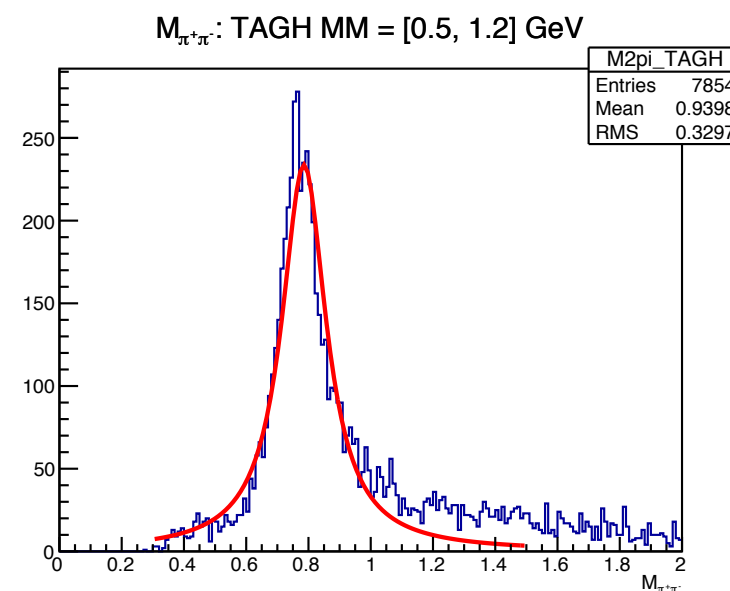
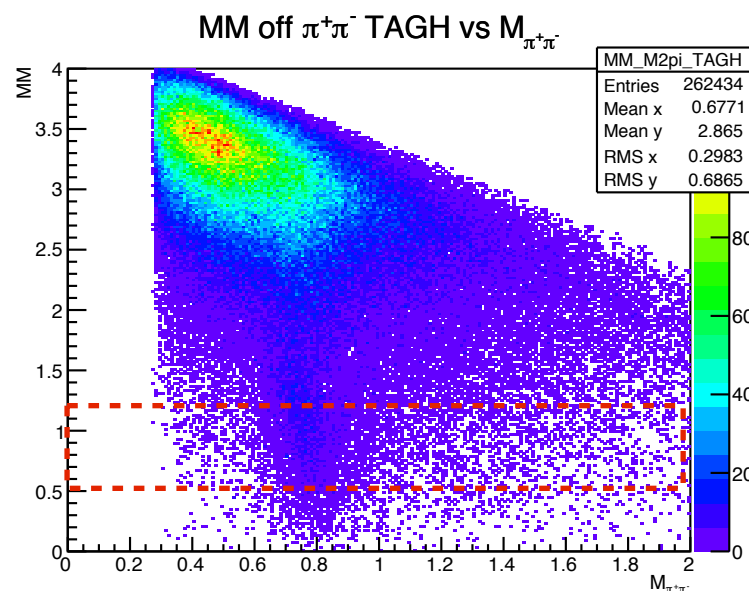
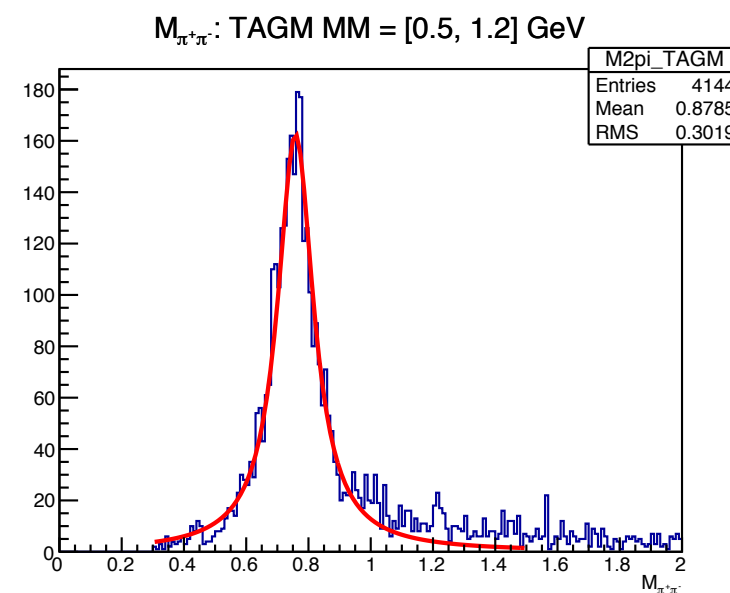
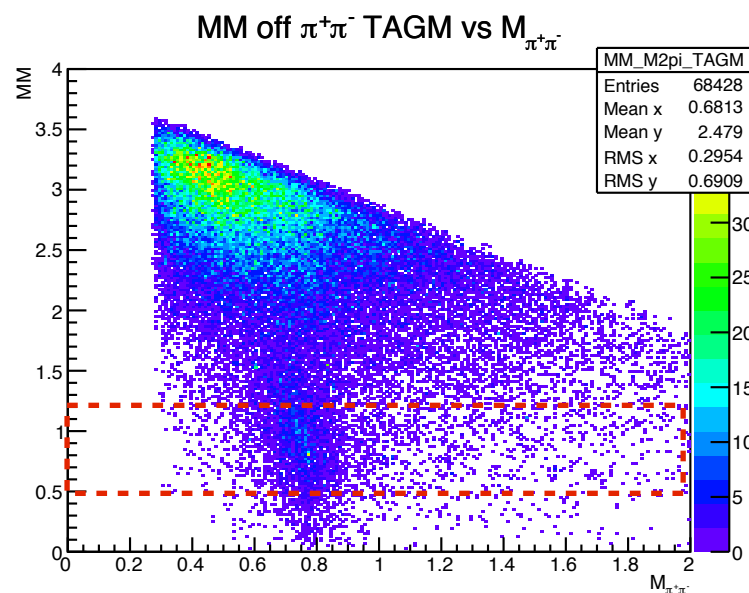


Fairly clean ρ peak in $\pi^+\pi^-$ mass distribution after select “missing proton”

FCAL trigger: runs 1501-1525

Missing Mass vs $M_{\pi^+\pi^-}$

- Select $\pi^+\pi^-$ candidate pairs and calculate missing mass (MM) from TAGM/H photon (select time window using π^- SC hit)
- Select MM region for protons (0.5-1.2 GeV) to select exclusive $p\pi^+\pi^-$



Fairly clean ρ peak in $\pi^+\pi^-$ mass distribution after select “missing proton”

FCAL-BCAL trigger: runs 2140-2420

ρ Candidate Event Displays:

$$0.5 < MM < 1.2 \text{ GeV}$$

$$0.7 < M_{\pi\pi} < 0.9 \text{ GeV}$$

Hall-D Event Viewer

Source: /lustre/expphy/volatile/halld/home/mstaib/fcal_bcal_m8/2trackskim/hd_rawdata_002152_002.2tracks.evio

View Controls

Transverse Coordinates
 x/y
 r/phi

Event Controls

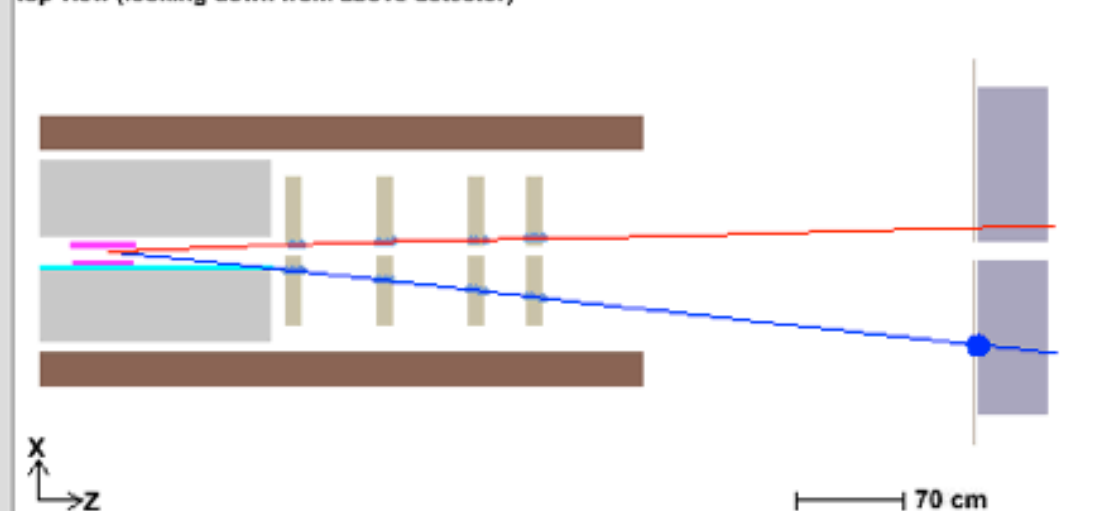
continuous
 delay:

Info

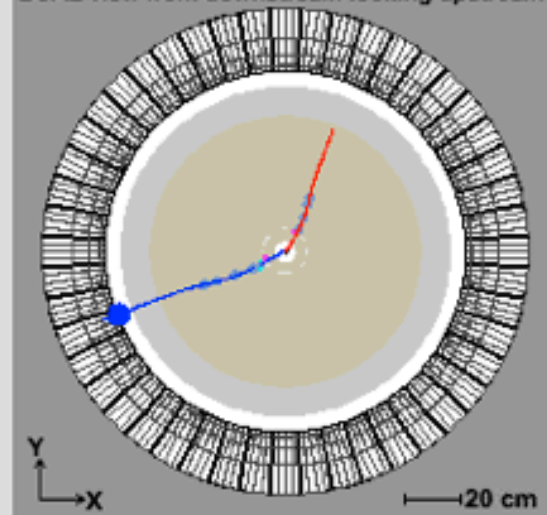
Run: -----
Event: 1369

Inspectors

top view (looking down from above detector)



BCAL view from downstream looking upstream



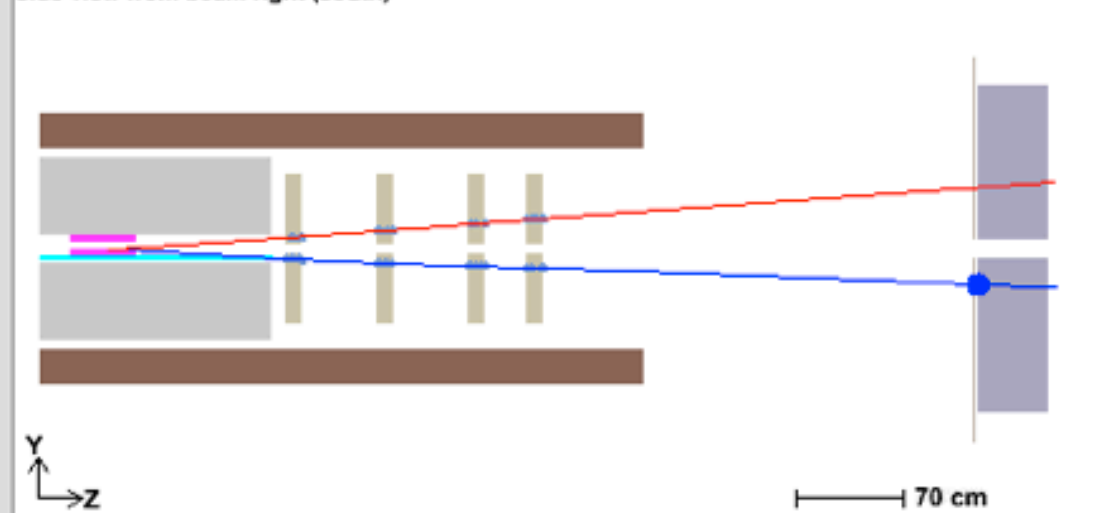
BCAL colors

- 10.00 GeV
- 3.16 GeV
- 1.00 GeV
- 316.2 MeV
- 100.0 MeV
- 31.6 MeV
- 10.0 MeV
- 3.2 MeV
- 1.0 MeV

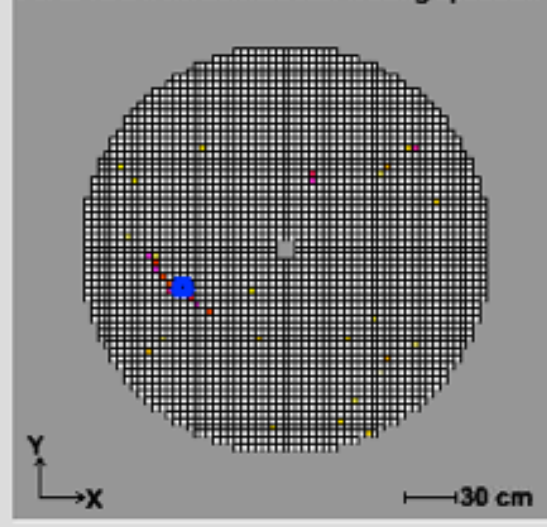
Track Draw Options

- DTrackCandidate: <default>
- DTrackWireBased: <default>
- DTrackTimeBased: <default>
- DChargedTrack: <default>
- DNeutralParticle
- DMCThrown
- DMCTrajectoryPoint

side view from beam right (south)



FCAL view from downstream looking upstream



FCAL colors

- 10.00 GeV
- 3.16 GeV
- 1.00 GeV
- 316.2 MeV
- 100.0 MeV
- 31.6 MeV
- 10.0 MeV
- 3.2 MeV
- 1.0 MeV

Hit Draw Options

- CDC
- CDC Drift Time
- CDCTruth
- FDC Wire
- FDC Pseudo
- FDCTruth
- TOF
- TOFTruth
- FCAL
- BCAL

Track Info

Thrown

trk:	type:	p:	theta:	phi:	z:
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Reconstructed

trk:	type:	p:	theta:	phi:	z:	chisq/Ndof:	Ndof:	FOM:	cand:	<input type="button" value="DTrackTimeBased:"/>
1	pi+	3.808	6.652	-146.2	64.92	1.215	17	0.242039	1	
2	pi-	3.208	4.505	53.13	61.81	0.1826	13	0.999412	2	
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BCAL view from downstream looking upstream

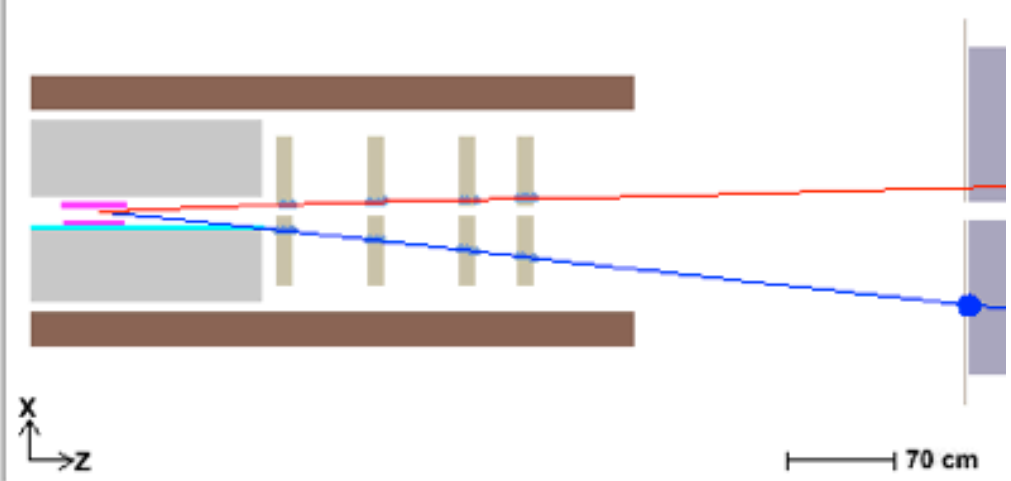
Source: /lustre/expphy/volatile/halld/home/mstaib/fcal_bcal_m8/2trackskim/hd_

View Controls

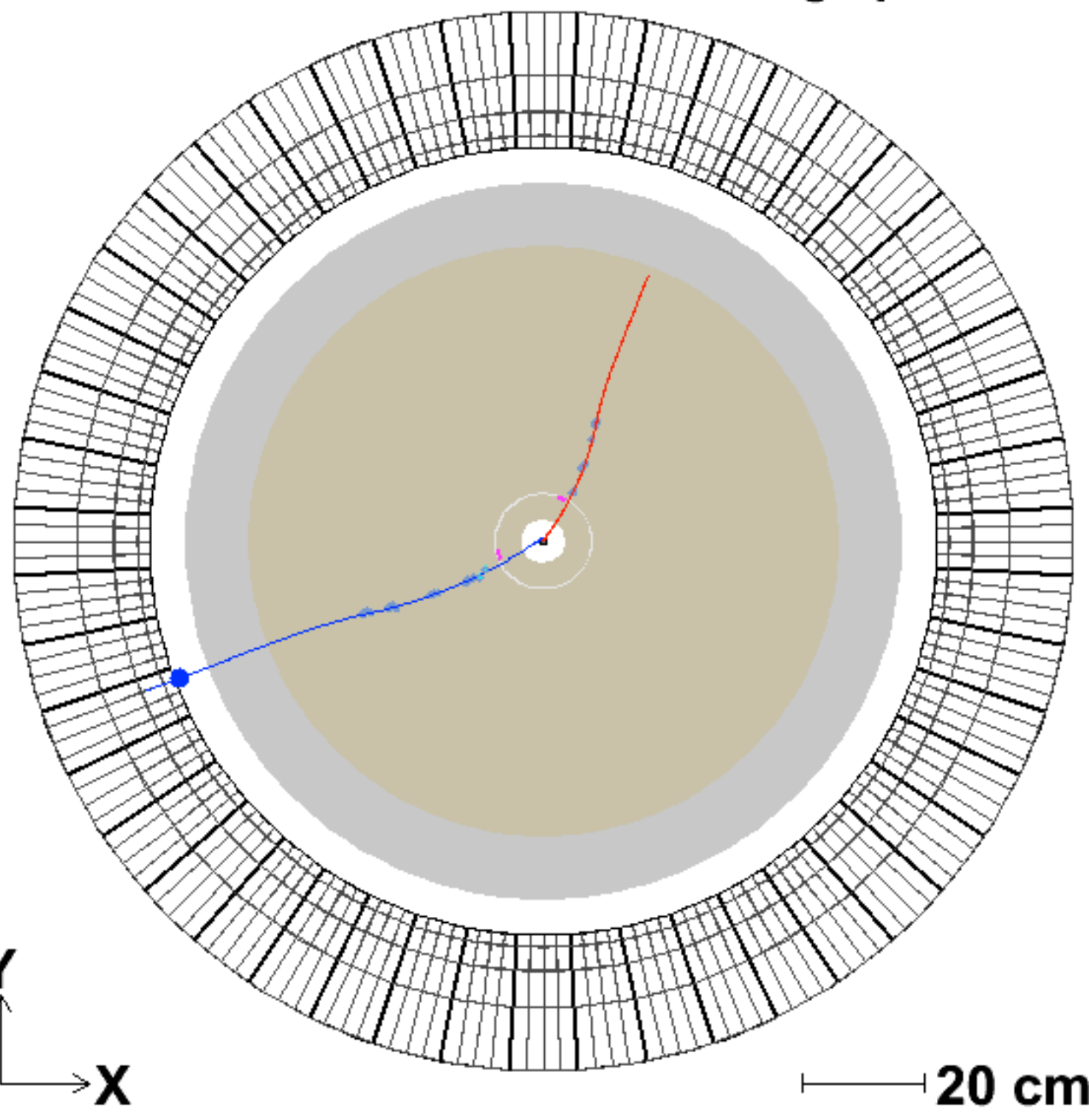
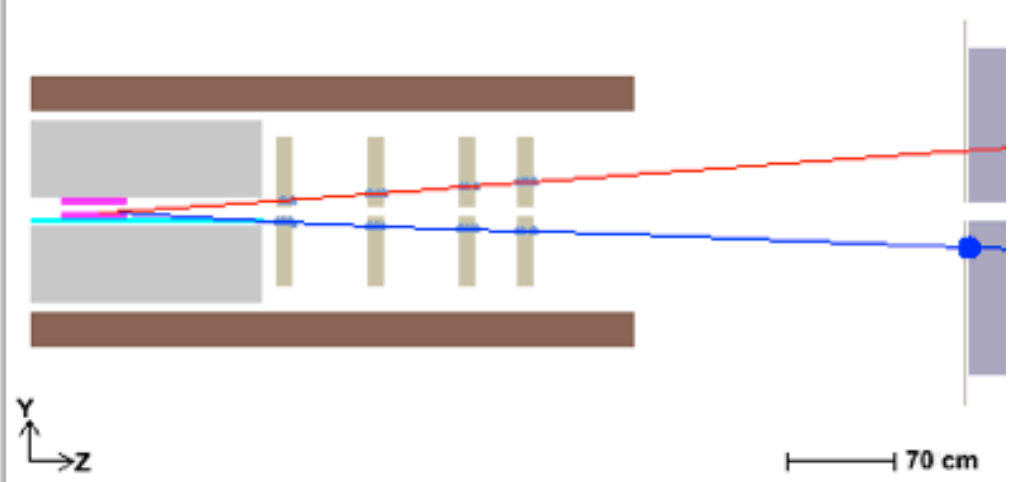
-X X+ ZOOM - + Transverse Coordinates
 -Y Y+ x/y
 -Z Z+ r/phi
 Reset

Event Control
 <-- Prev

top view (looking down from above detector)



side view from beam right (south)



Track Info

Thrown					
trk:	type:	p:	theta:	phi:	z:
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Reconstructed										
trk:	type:	p:	theta:	phi:	z:	chisq/Ndof:	Ndof:	FOM:	cand:	DTrackTimeBased:
1	pi+	3.808	6.652	-146.2	64.92	1.215	17	0.242039	1	
2	pi-	3.208	4.505	53.13	61.81	0.1826	13	0.999412	2	
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Hall-D Event Viewer

Source: /lustre/expphy/volatile/halld/home/mstaib/fcal_bcal_m8/2trackskim/hd_rawdata_002152_002.2tracks.evio

View Controls

x/y r/phi

Event Controls

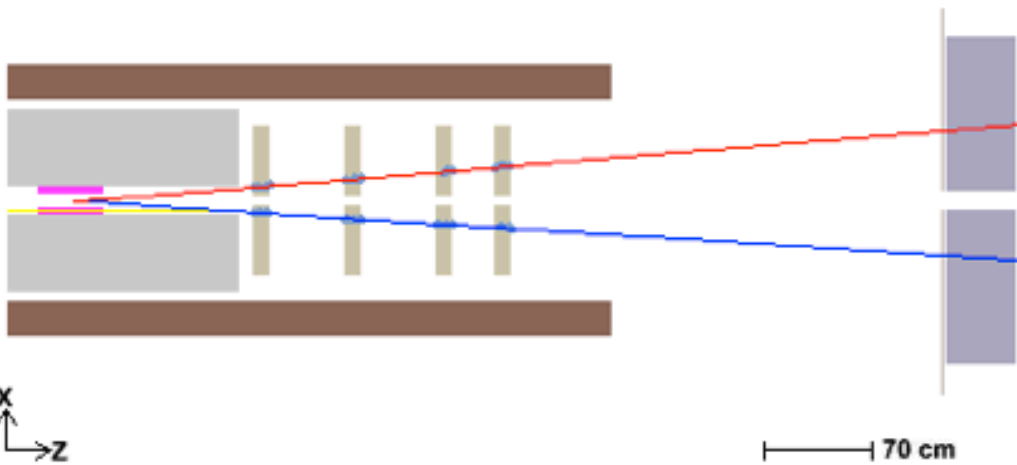
continuous
 delay:

Info

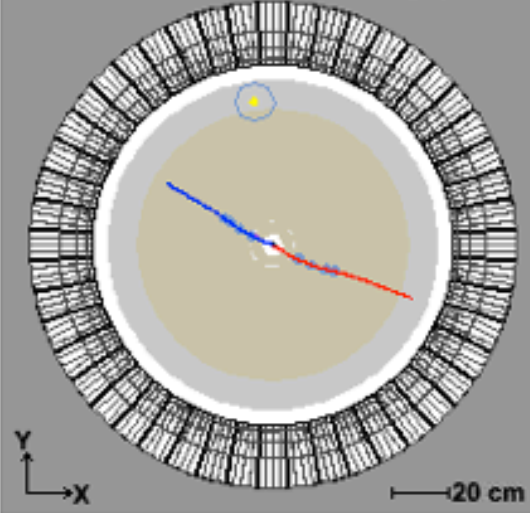
Run: -----
Event: 1530

Inspectors

top view (looking down from above detector)



BCAL view from downstream looking upstream



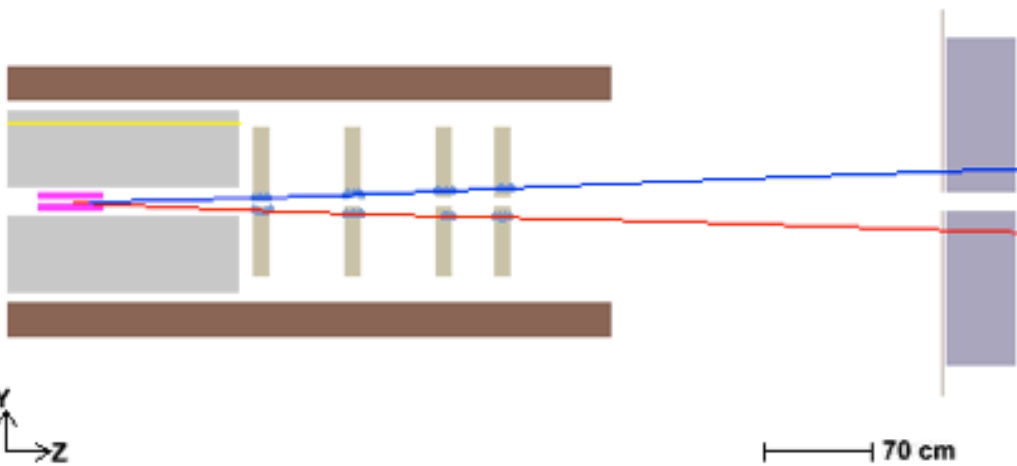
BCAL colors

- 10.00 GeV
- 3.16 GeV
- 1.00 GeV
- 316.2 MeV
- 100.0 MeV
- 31.6 MeV
- 10.0 MeV
- 3.2 MeV
- 1.0 MeV

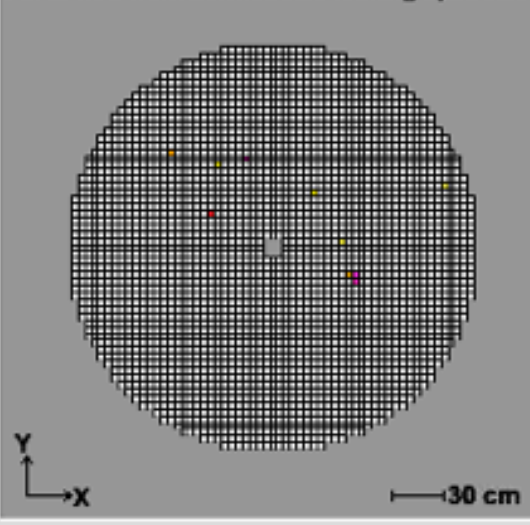
Track Draw Options

- DTrackCandidate: <default>
- DTrackWireBased: <default>
- DTrackTimeBased: <default>
- DChargedTrack: <default>
- DNeutralParticle
- DMCThrown
- DMCTrajectoryPoint

side view from beam right (south)



FCAL view from downstream looking upstream



FCAL colors

- 10.00 GeV
- 3.16 GeV
- 1.00 GeV
- 316.2 MeV
- 100.0 MeV
- 31.6 MeV
- 10.0 MeV
- 3.2 MeV
- 1.0 MeV

Hit Draw Options

- CDC
- CDC Drift Time
- CDCTruth
- FDC Wire
- FDC Pseudo
- FDCTruth
- TOF
- TOFTruth
- FCAL
- BCAL

Track Info

Thrown

trk:	type:	p:	theta:	phi:	z:
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Reconstructed

trk:	type:	p:	theta:	phi:	z:	chisq/Ndof:	Ndof:	FOM:	cand:
1	pi-	4	5.038	-33.23	59.17	0.3141	13	0.990275	1
2	pi+	4.556	4.207	160.7	69.49	0.2787	13	0.994576	2
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cand:

Hall-D Event Viewer

Source: /lustre/expphy/volatile/halld/home/mstaib/fcal_bcal_m8/2trackskim/hd_rawdata_002152_002.2tracks.evio

View Controls

x/y r/phi

Event Controls

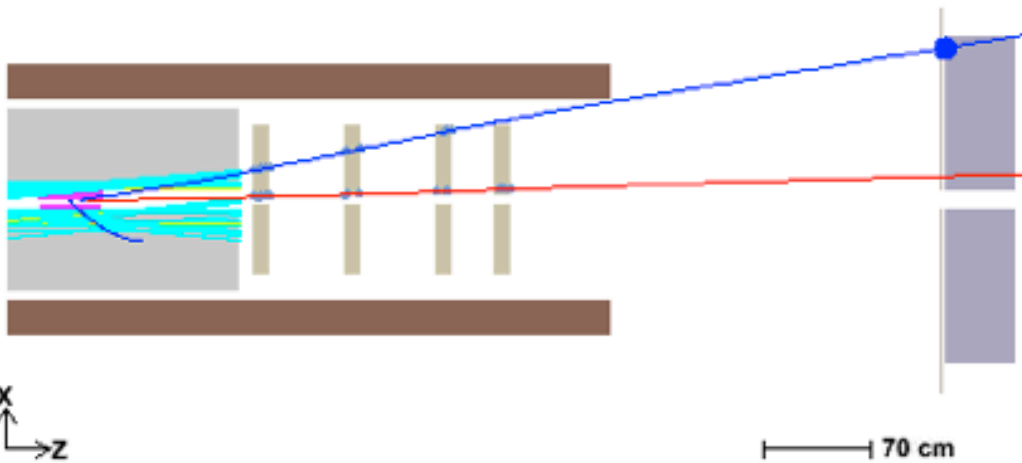
continuous
 delay:

Info

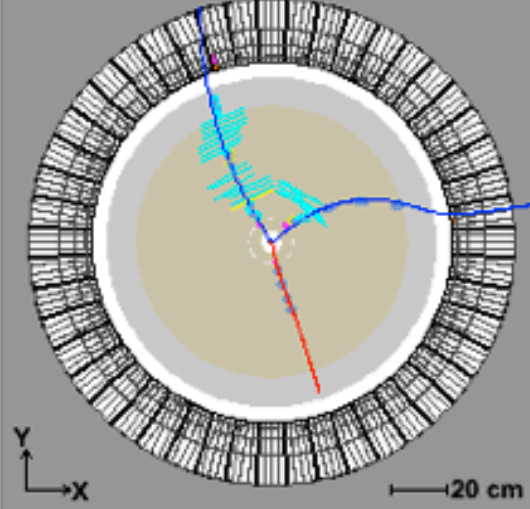
Run: -----
Event: 2072

Inspectors

top view (looking down from above detector)



BCAL view from downstream looking upstream



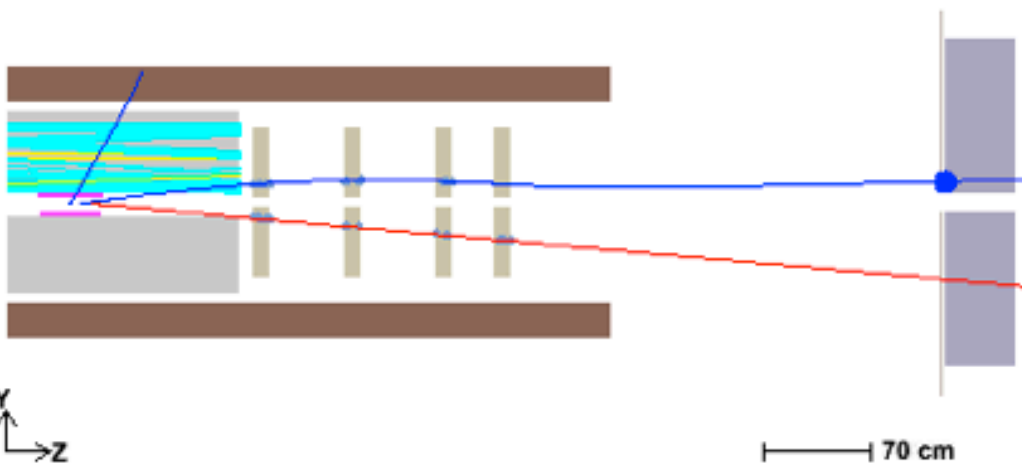
BCAL colors

- 10.00 GeV
- 3.16 GeV
- 1.00 GeV
- 316.2 MeV
- 100.0 MeV
- 31.6 MeV
- 10.0 MeV
- 3.2 MeV
- 1.0 MeV

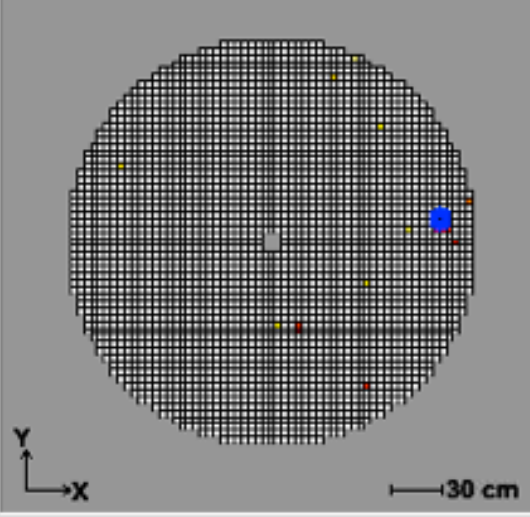
Track Draw Options

- DTrackCandidate: <default>
- DTrackWireBased: <default>
- DTrackTimeBased: <default>
- DChargedTrack: <default>
- DNeutralParticle
- DMCThrown
- DMCTrajectoryPoint

side view from beam right (south)



FCAL view from downstream looking upstream



FCAL colors

- 10.00 GeV
- 3.16 GeV
- 1.00 GeV
- 316.2 MeV
- 100.0 MeV
- 31.6 MeV
- 10.0 MeV
- 3.2 MeV
- 1.0 MeV

Hit Draw Options

- CDC
- CDC Drift Time
- CDCTruth
- FDC Wire
- FDC Pseudo
- FDCTruth
- TOF
- TOFTruth
- FCAL
- BCAL

Track Info

Thrown

trk:	type:	p:	theta:	phi:	z:
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Reconstructed

trk:	type:	p:	theta:	phi:	z:	chisq/Ndof:	Ndof:	FOM:	cand:	<input type="button" value="DTrackTimeBased:"/>
1	pi+	0.8211	62.44	123.1	57.25	3.936	2	0.0195291	2	
2	pi-	6.578	5.365	-79.87	68.3	0.4781	11	0.917956	3	
3	pi+	1.308	11.57	45.9	63.82	1.323	13	0.190542	4	
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BCAL view from downstream looking upstream

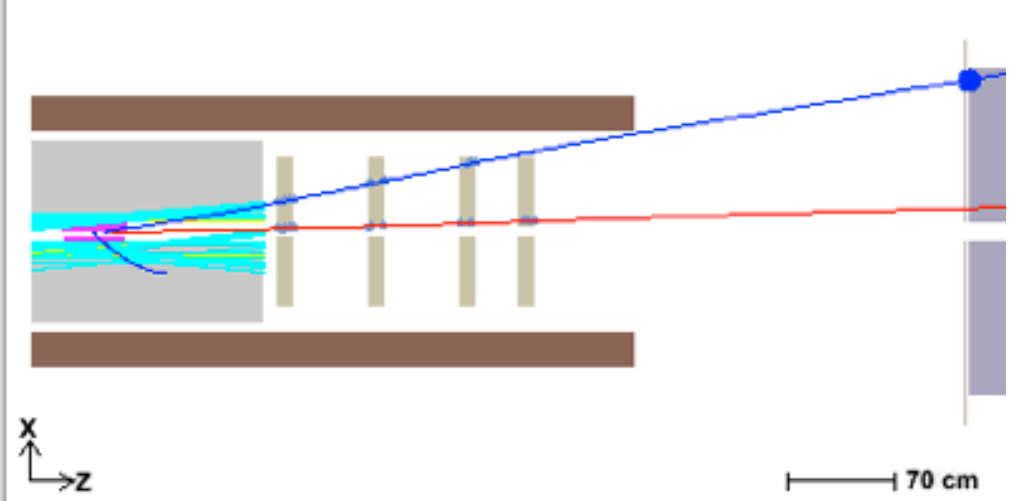
Source: /lustre/expphy/volatile/halld/home/mstaib/fcal_bcal_m8/2trackskim/hd_

View Controls

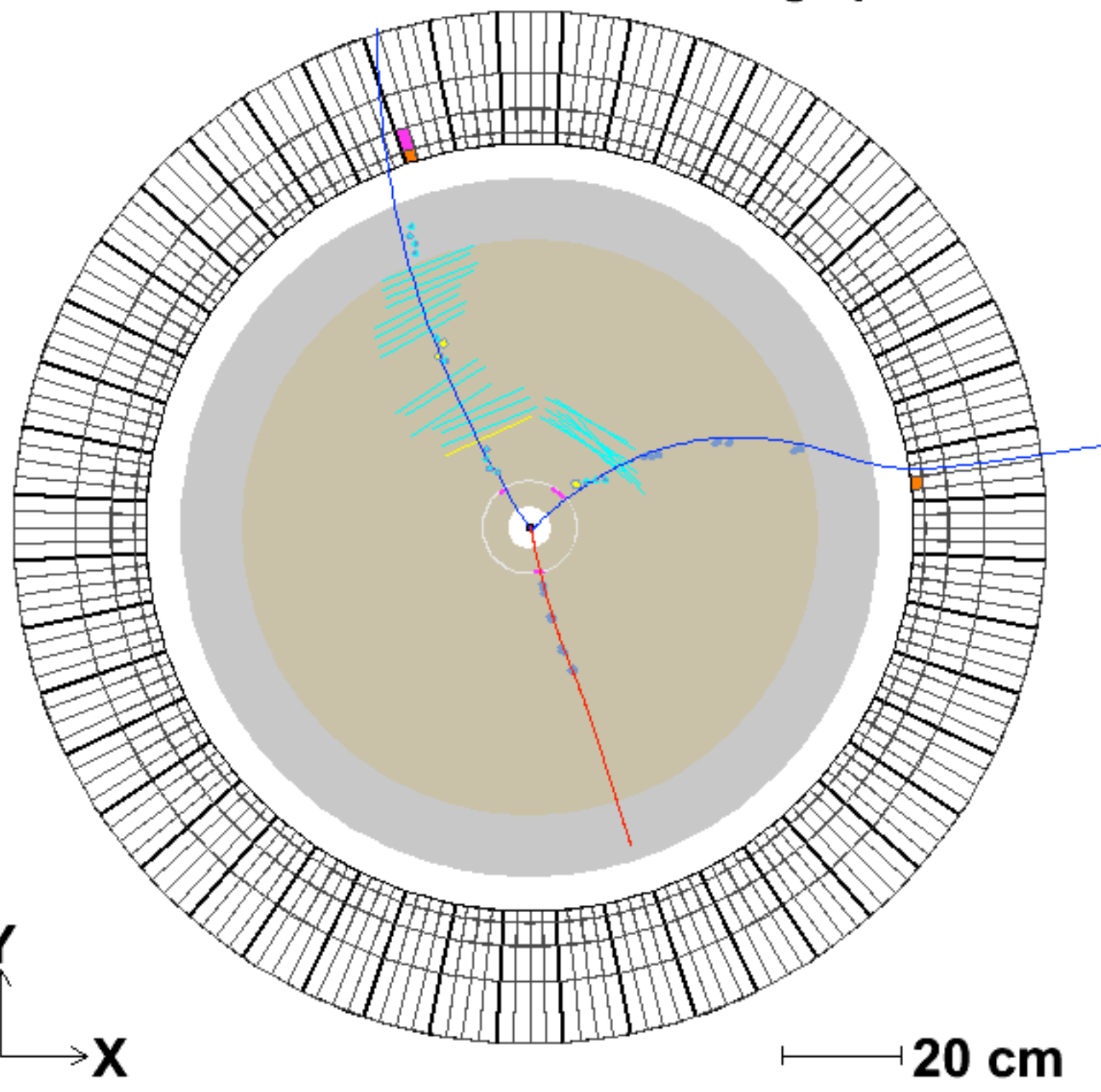
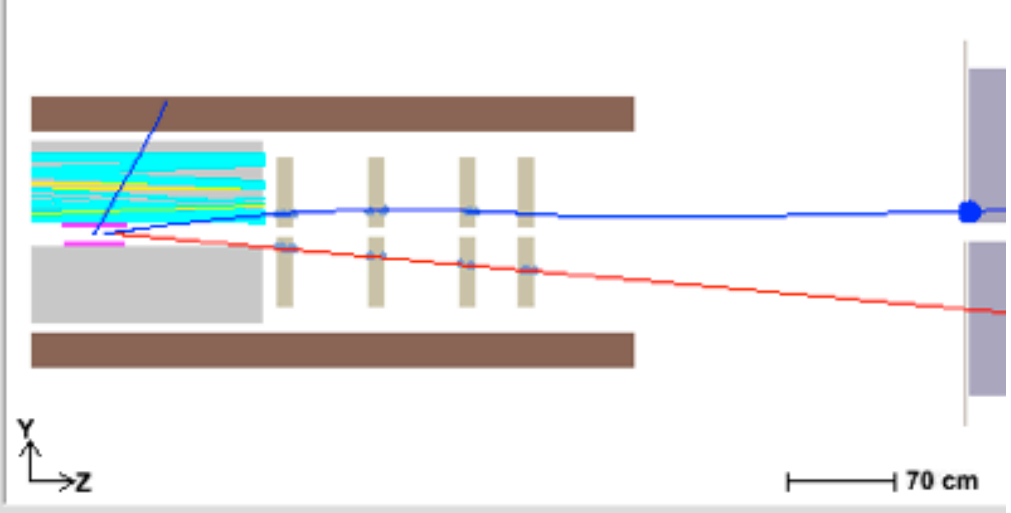
-X X+ ZOOM - + Transverse Coordinates
 -Y Y+ x/y
 -Z Z+ r/phi
 Reset

Event Control
 <-- Prev

top view (looking down from above detector)



side view from beam right (south)



Track Info

Thrown

trk:	type:	p:	theta:	phi:	z:
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Reconstructed

trk:	type:	p:	theta:	phi:	z:	chisq/Ndof:	Ndof:	FOM:	cand:	DTrackTimeBased:
1	pi+	0.8211	62.44	123.1	57.25	3.936	2	0.0195291	2	
2	pi-	6.578	5.365	-79.87	68.3	0.4781	11	0.917956	3	
3	pi+	1.308	11.57	45.9	63.82	1.323	13	0.190542	4	
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Hall-D Event Viewer

Source: /lustre/expphy/volatile/halld/home/mstaib/fcal_bcal_m8/2trackskim/hd_rawdata_002152_002.2tracks.evio

View Controls

x/y r/phi

Event Controls

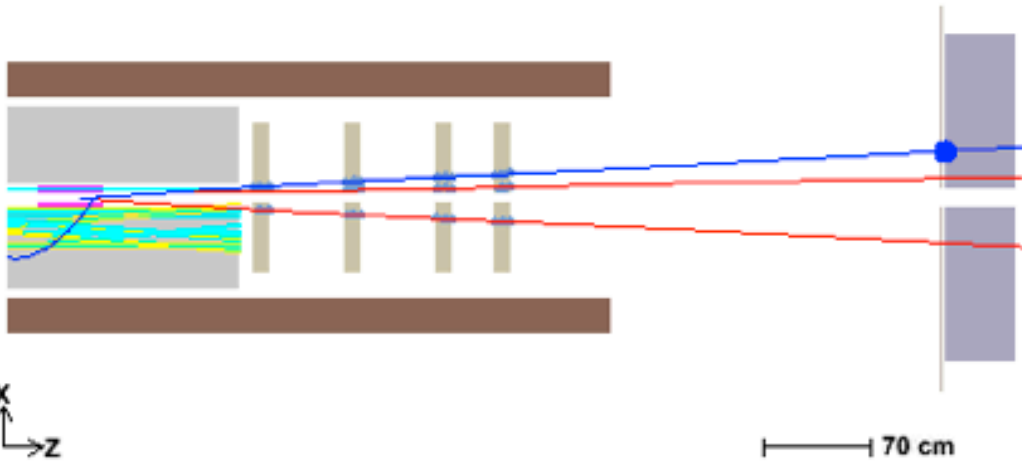
continuous
 delay:

Info

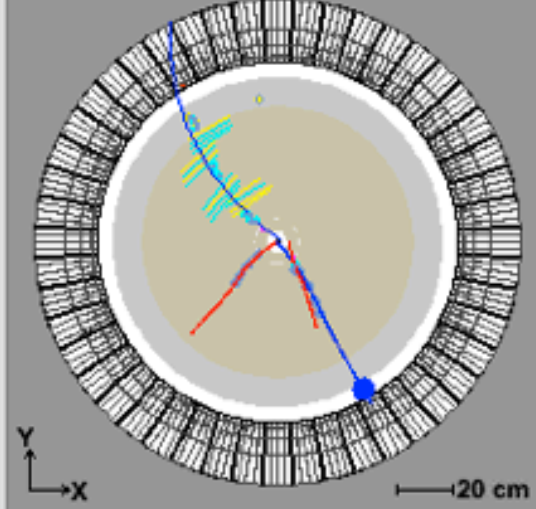
Run: -----
Event: 454

Inspectors

top view (looking down from above detector)



BCAL view from downstream looking upstream



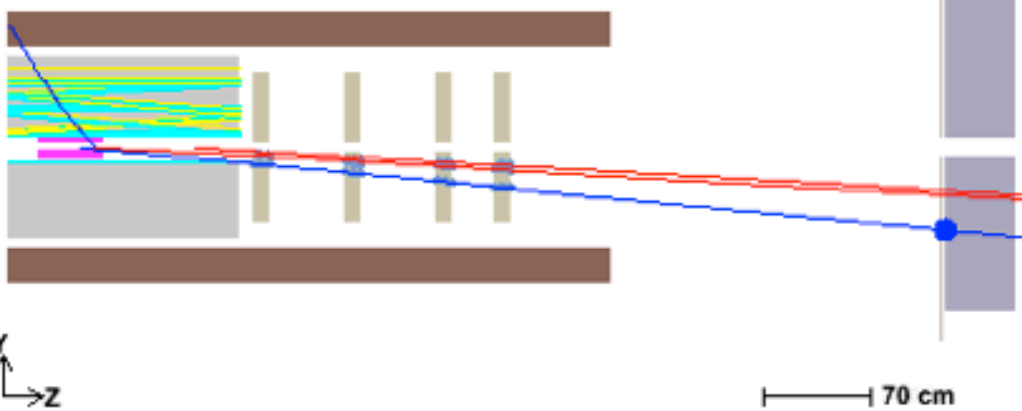
BCAL colors

- 10.00 GeV
- 3.16 GeV
- 1.00 GeV
- 316.2 MeV
- 100.0 MeV
- 31.6 MeV
- 10.0 MeV
- 3.2 MeV
- 1.0 MeV

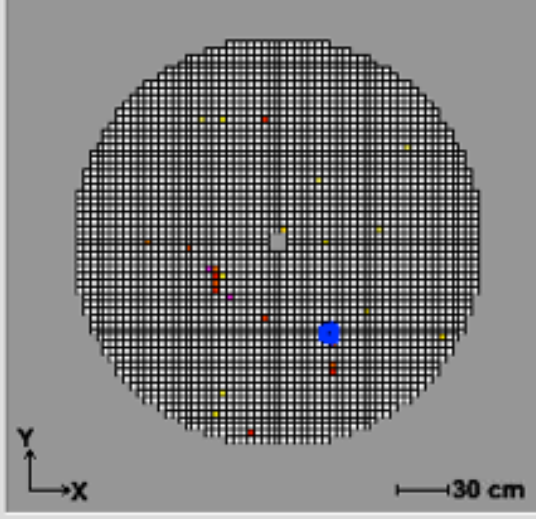
Track Draw Options

- DTrackCandidate: <default>
- DTrackWireBased: <default>
- DTrackTimeBased: <default>
- DChargedTrack: <default>
- DNeutralParticle
- DMCThrown
- DMCTrajectoryPoint

side view from beam right (south)



FCAL view from downstream looking upstream



FCAL colors

- 10.00 GeV
- 3.16 GeV
- 1.00 GeV
- 316.2 MeV
- 100.0 MeV
- 31.6 MeV
- 10.0 MeV
- 3.2 MeV
- 1.0 MeV

Hit Draw Options

- CDC
- CDC Drift Time
- CDCTruth
- FDC Wire
- FDC Pseudo
- FDCTruth
- TOF
- TOFTruth
- FCAL
- BCAL

Track Info

Thrown

trk:	type:	p:	theta:	phi:	z:
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Reconstructed

trk:	type:	p:	theta:	phi:	z:	chisq/Ndof:	Ndof:	FOM:	cand:	<input type="button" value="DTrackTimeBased:"/>
1	pi+	0.4368	120.8	146.6	73.5	3.825	3	0.00942228	1	
2	pi-	2.995	4.387	-149.3	66.81	1.691	13	0.0555837	2	
3	pi+	5.422	6.307	-50.88	63.51	0.2833	16	0.997633	3	
4	pi-	2.446	3.389	-87.75	137.8	2.813	2	0.0600218	4	
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

BCAL view from downstream looking upstream

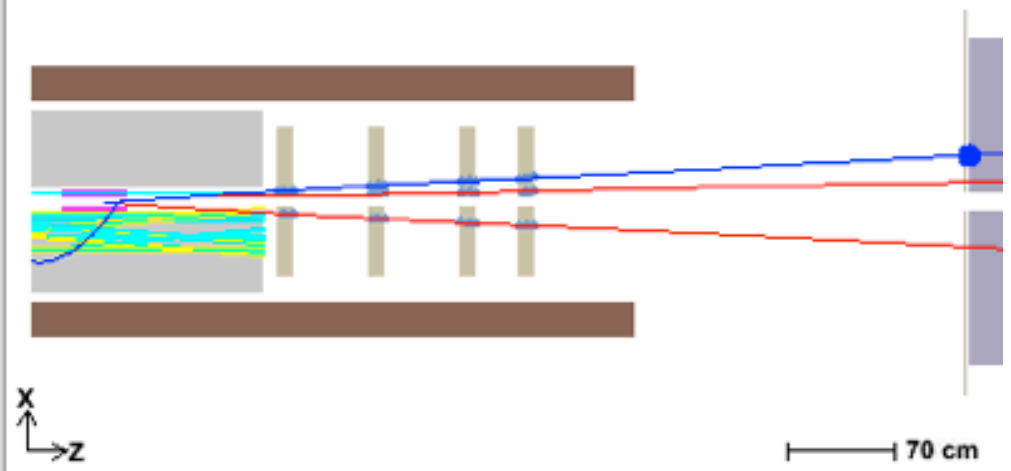
Source: /lustre/expphy/volatile/halld/home/mstaib/fcal_bcal_m8/2trackskim/hd_

View Controls

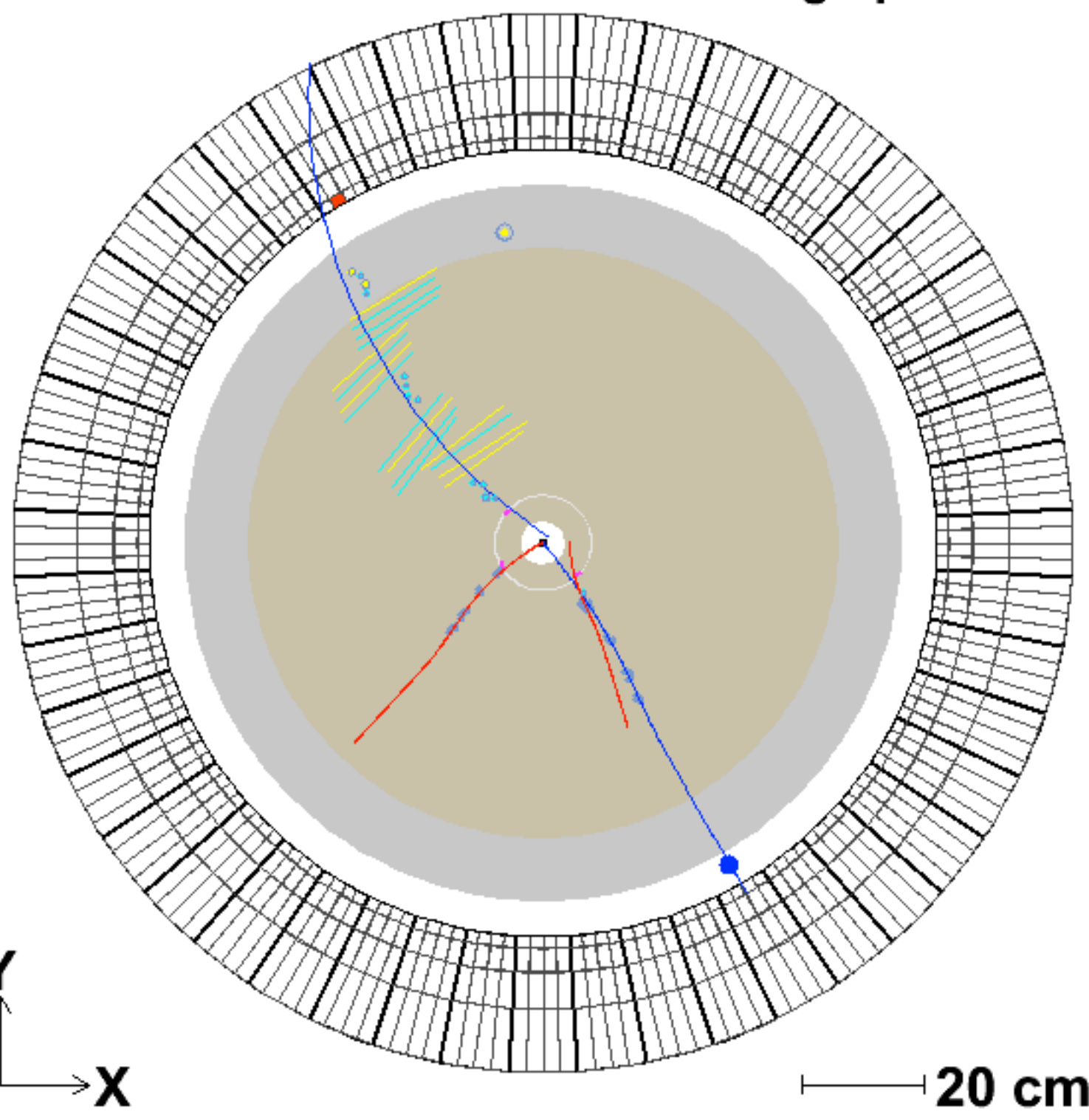
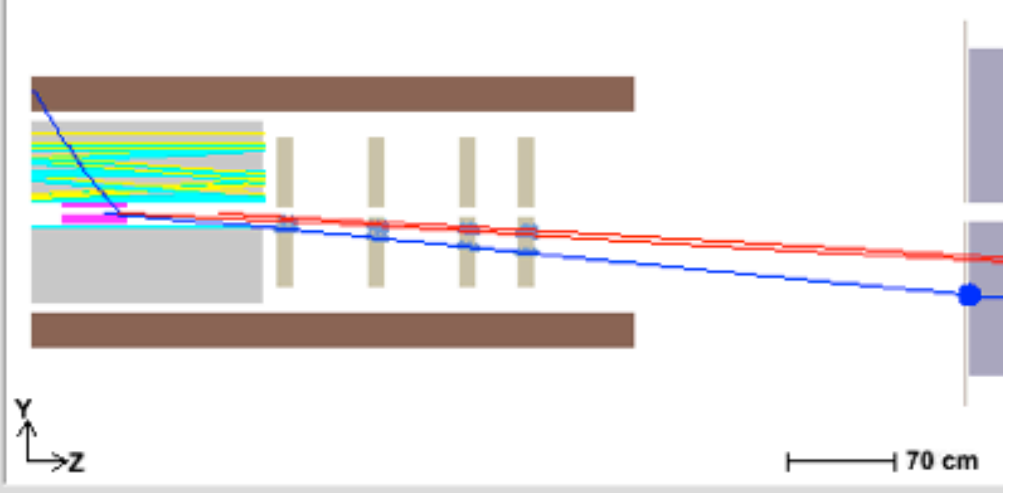
-X X+ ZOOM - + Transverse Coordinates
 -Y Y+ x/y
 -Z Z+ r/phi
 Reset

Event Control
 <-- Prev

top view (looking down from above detector)



side view from beam right (south)



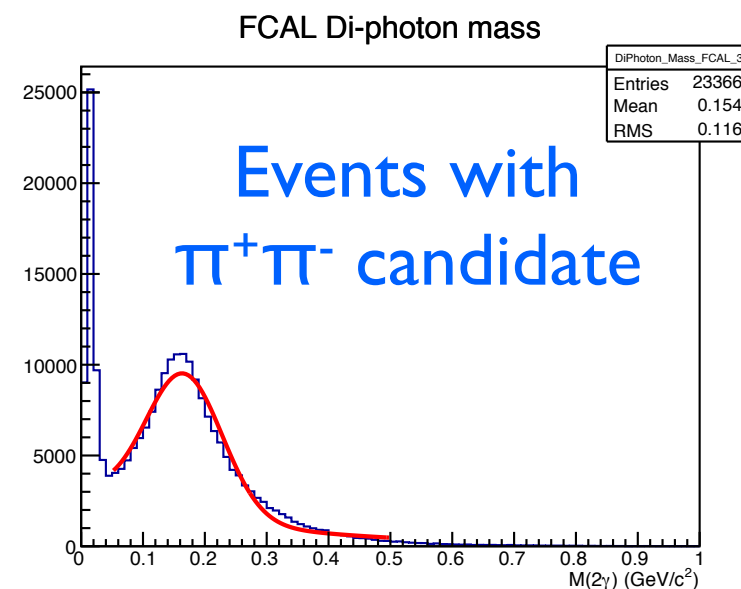
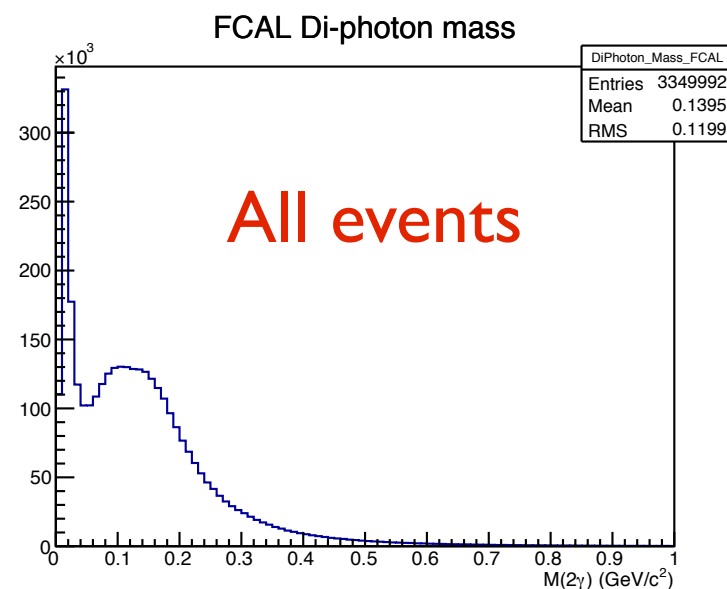
Track Info

Thrown					
trk:	type:	p:	theta:	phi:	z:
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----
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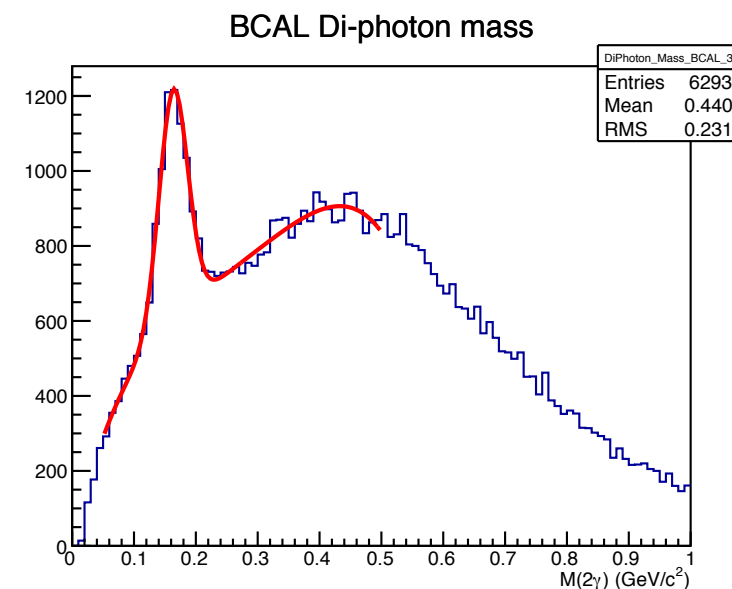
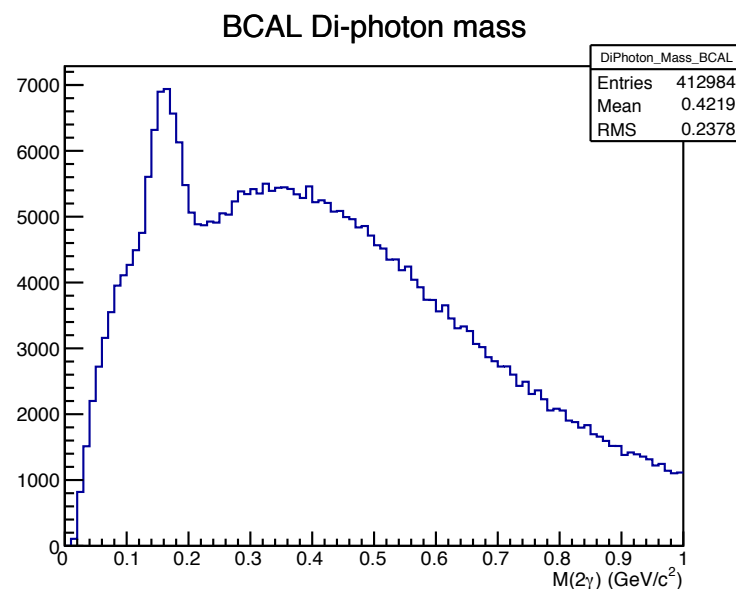
Reconstructed										
trk:	type:	p:	theta:	phi:	z:	chisq/Ndof:	Ndof:	FOM:	cand:	DTrackTimeBased:
1	pi+	0.4368	120.8	146.6	73.5	3.825	3	0.00942228	1	
2	pi-	2.995	4.387	-149.3	66.81	1.691	13	0.0555837	2	
3	pi+	5.422	6.307	-50.88	63.51	0.2833	16	0.997633	3	
4	pi-	2.446	3.389	-87.75	137.8	2.813	2	0.0600218	4	
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	

π^0 candidate selection

- Standard FCAL (Matt) and BCAL (Will) cuts used in other talks/studies from all events
- Will pair these with $\pi^+\pi^-$ candidate so only consider those events and use mass cut of $M(2\gamma) = [0.1, 0.25]$ GeV



Background under π^0 peak smaller for FCAL

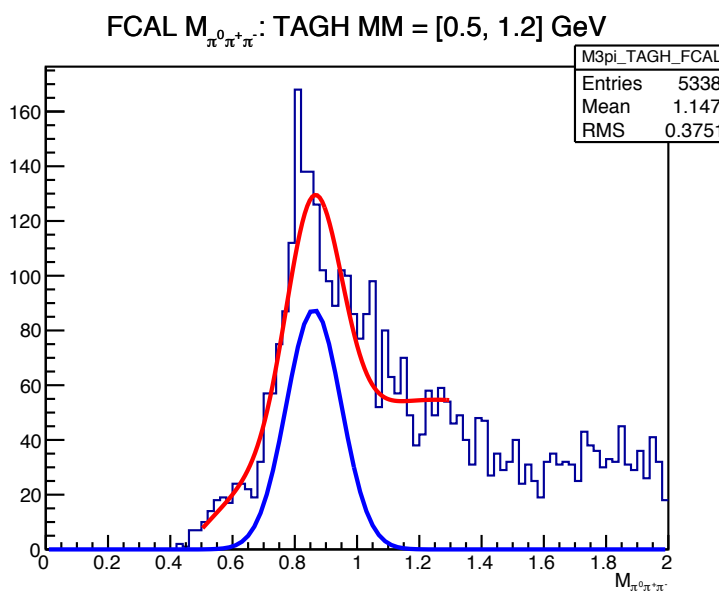
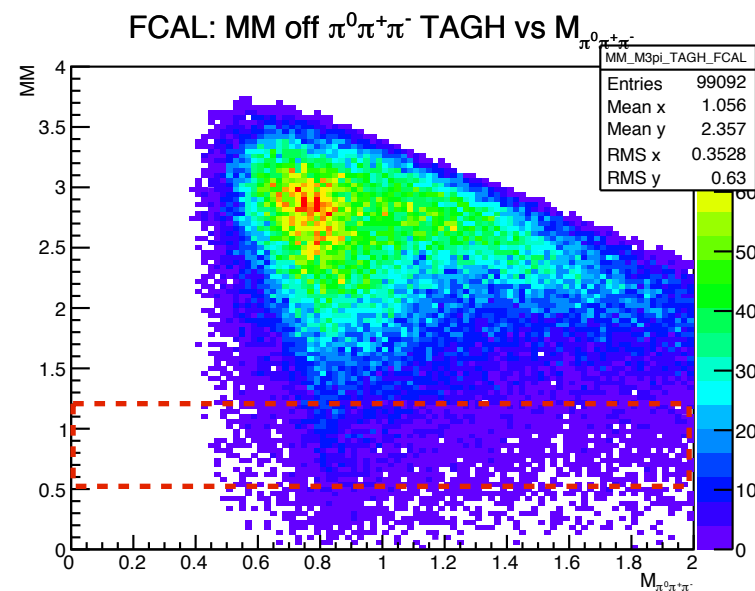
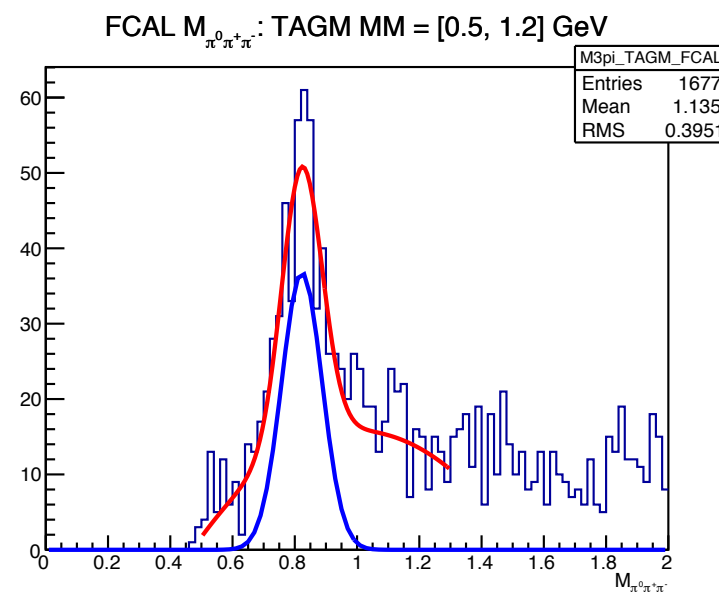
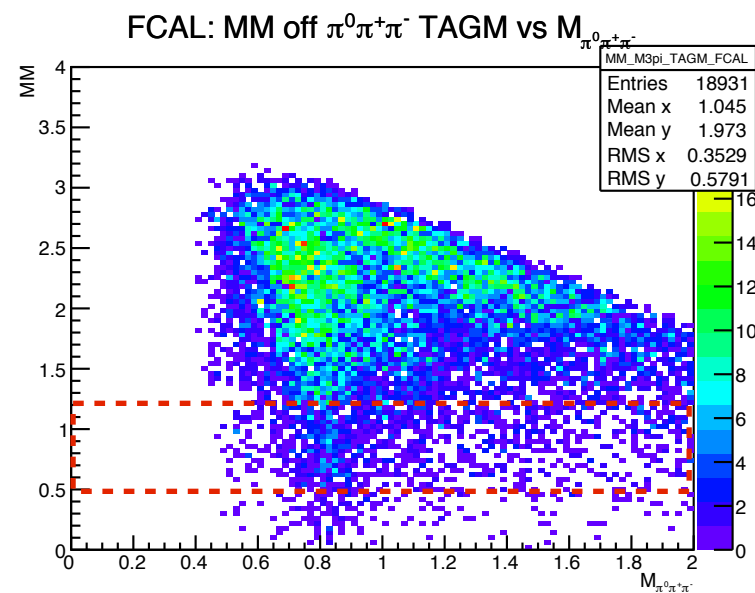


π^0 mass resolution better for BCAL?

FCAL trigger: runs 1501-1525

Missing Mass vs $M_{\pi^0\pi^+\pi^-}$ (FCAL π^0)

- Select $\pi^0\pi^+\pi^-$ candidates (π^0 from FCAL) and calculate missing mass (MM) from TAGM/H photon (select time window using π^- SC hit)
- Select MM region for protons (0.5-1.2 GeV) to select exclusive $p\pi^0\pi^+\pi^-$

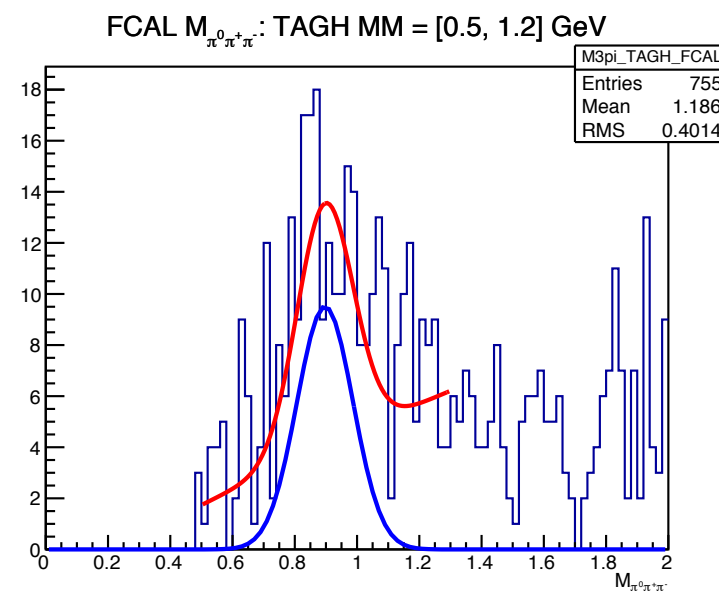
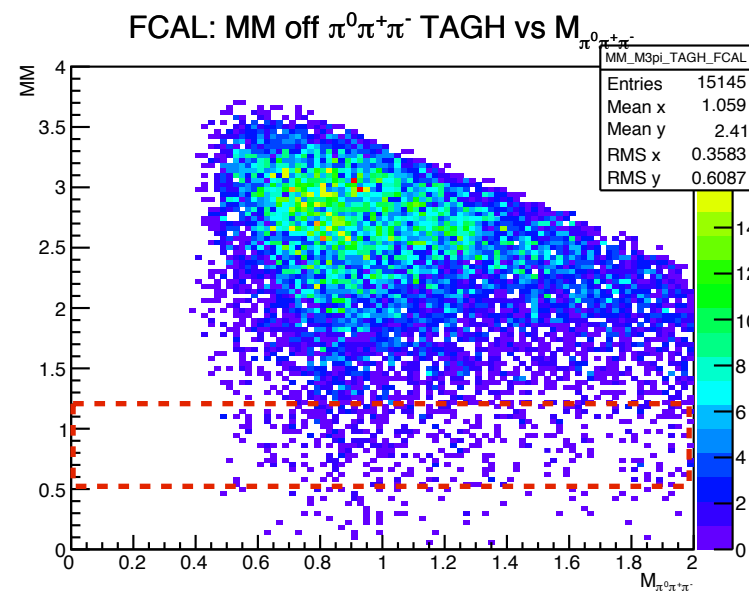
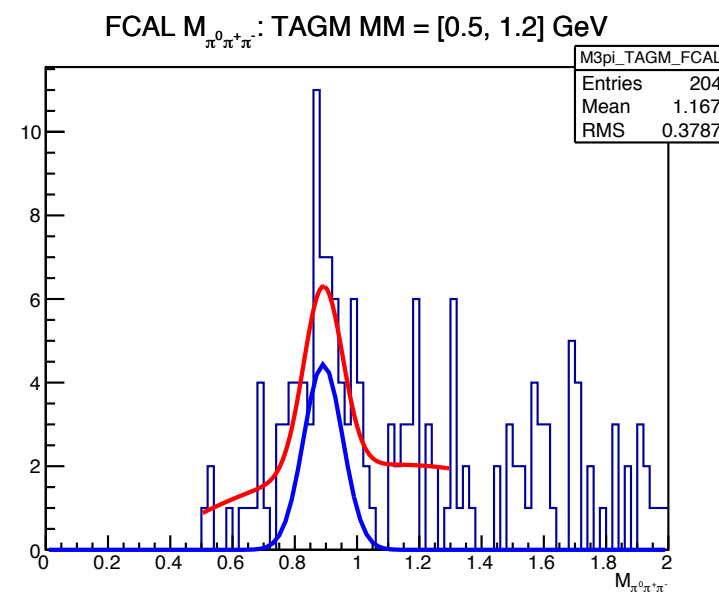
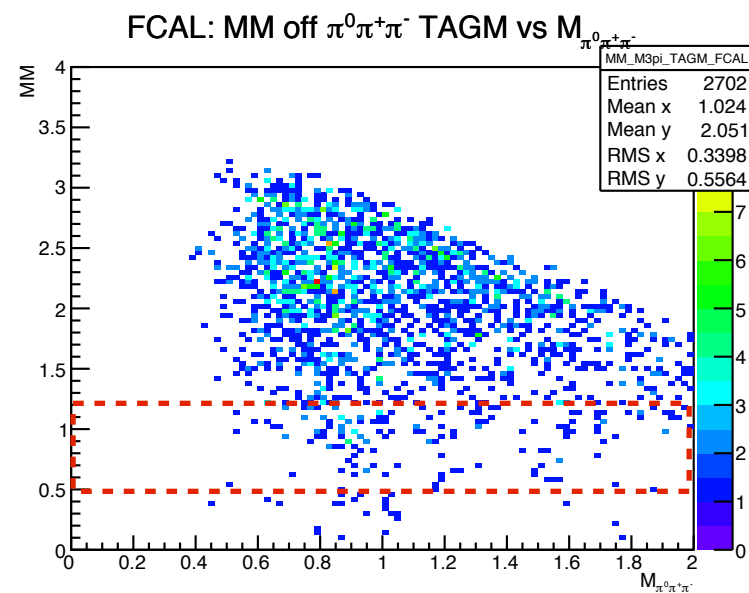


Bump at ω mass in $\pi^0\pi^+\pi^-$ mass distribution after selecting missing proton region

FCAL trigger: runs 1501-1525

Missing Mass vs $M_{\pi^0\pi^+\pi^-}$ (FCAL π^0)

- Select $\pi^0\pi^+\pi^-$ candidates (π^0 from FCAL) and calculate missing mass (MM) from TAGM/H photon (select time window using π^- SC hit)
- Select MM region for protons (0.5-1.2 GeV) to select exclusive $p\pi^0\pi^+\pi^-$

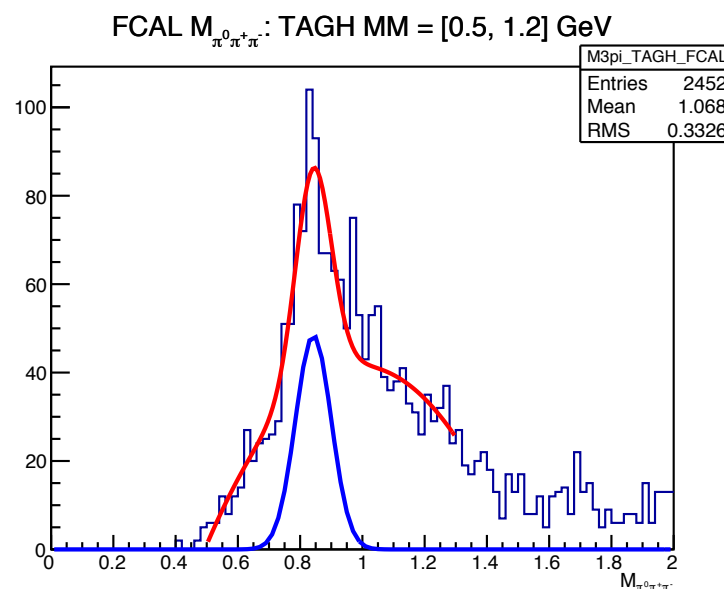
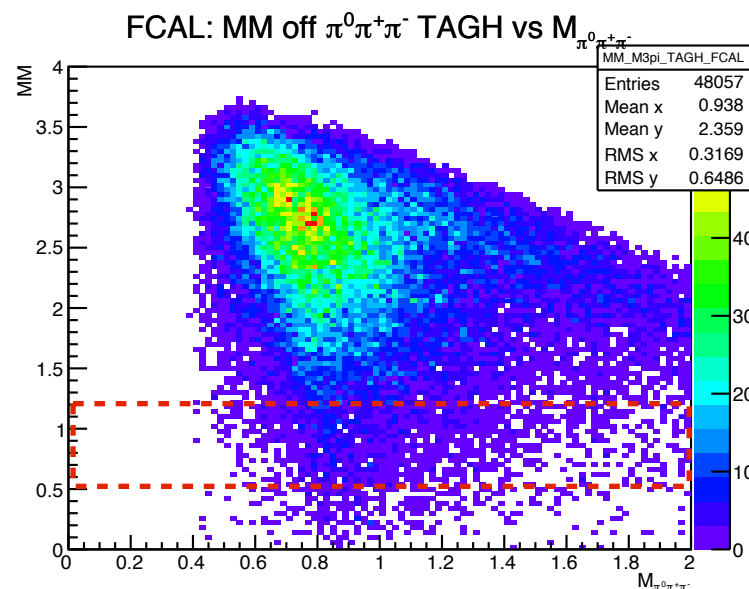
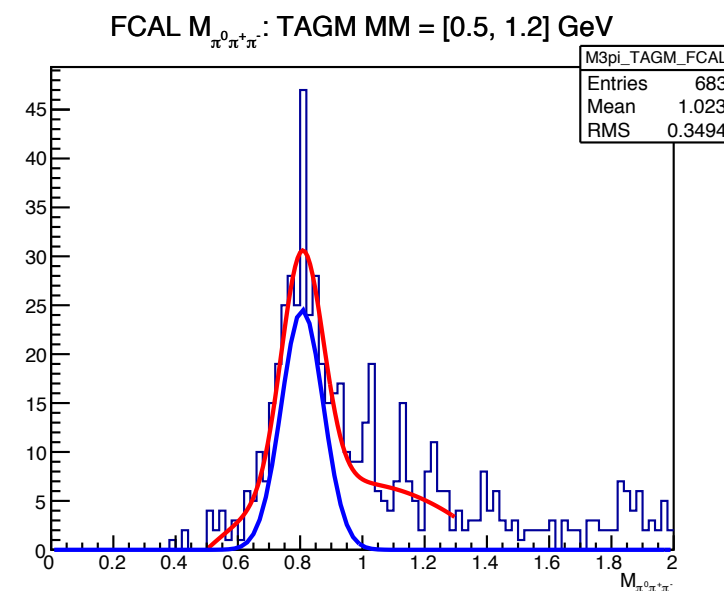
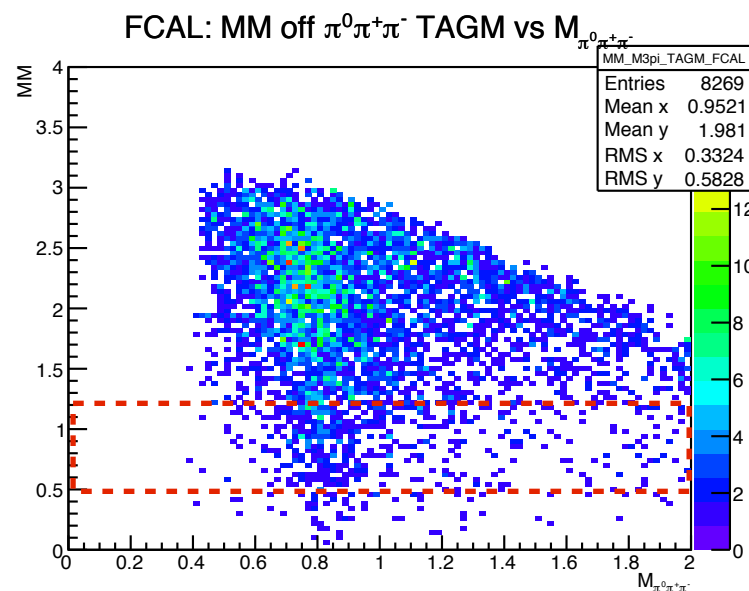


Weak bump at ω mass in $\pi^0\pi^+\pi^-$ mass distribution after selecting missing proton region

BCAL trigger: runs 1547-1807

Missing Mass vs $M_{\pi^0\pi^+\pi^-}$ (FCAL π^0)

- Select $\pi^0\pi^+\pi^-$ candidates (π^0 from FCAL) and calculate missing mass (MM) from TAGM/H photon (select time window using π^- SC hit)
- Select MM region for protons (0.5-1.2 GeV) to select exclusive $p\pi^0\pi^+\pi^-$

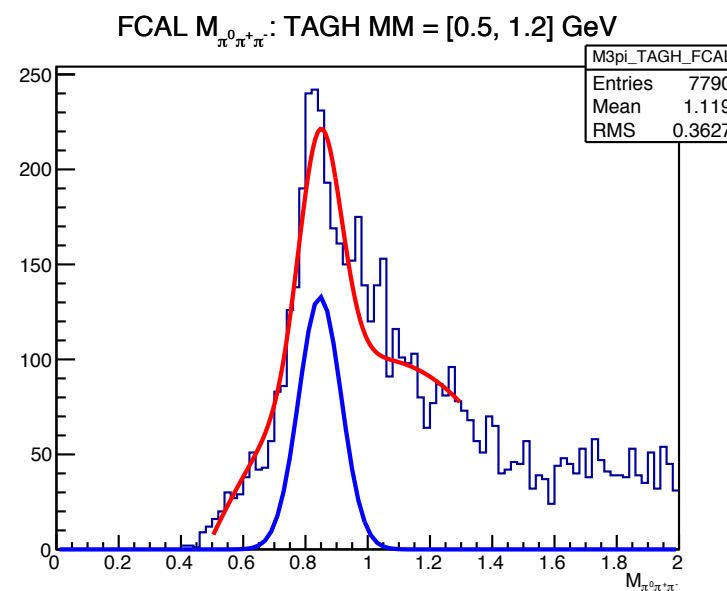
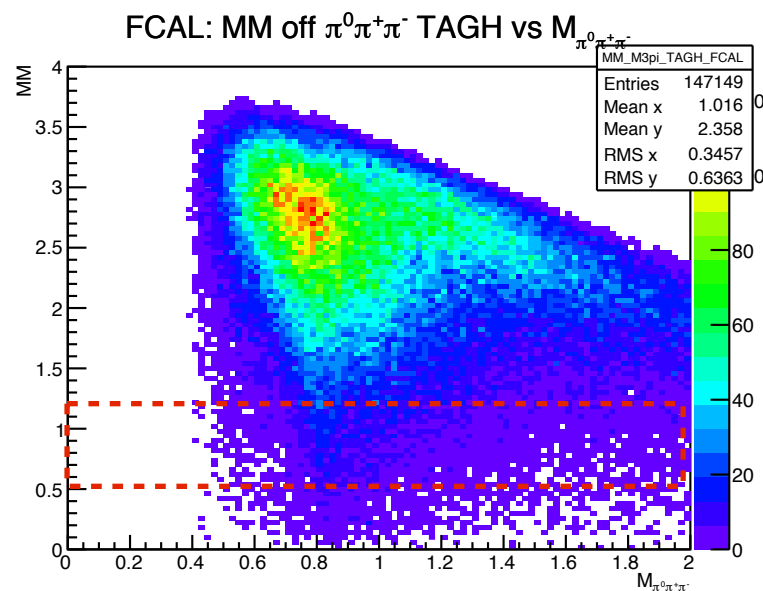
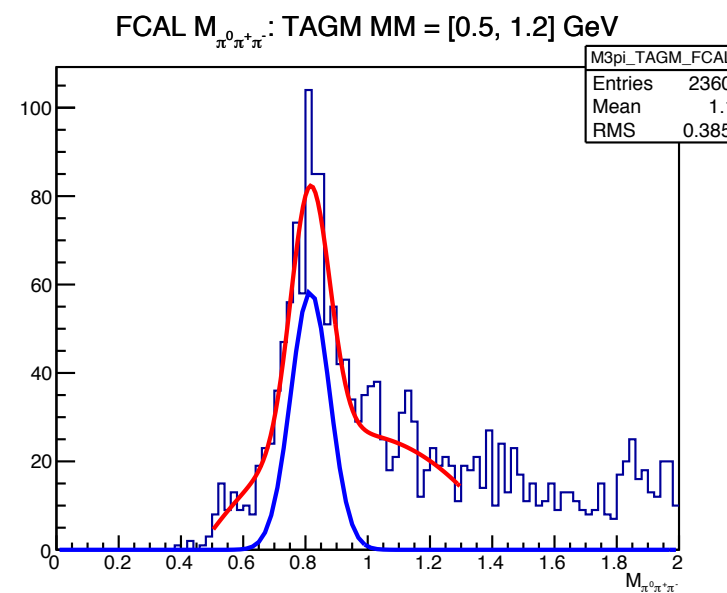
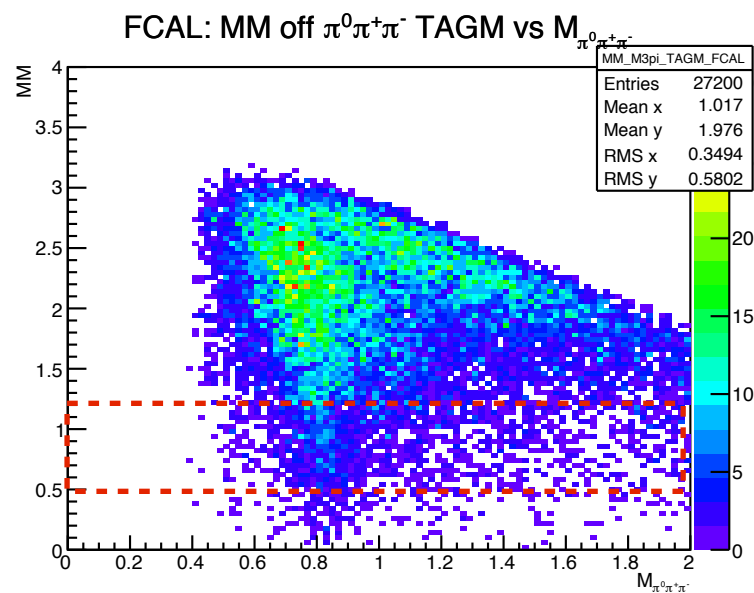


Bump at ω mass in $\pi^0\pi^+\pi^-$ mass distribution after selecting missing proton region

FCAL-BCAL trigger: runs 2140-2420

Missing Mass vs $M_{\pi^0\pi^+\pi^-}$ (FCAL π^0)

- Select $\pi^0\pi^+\pi^-$ candidates (π^0 from FCAL) and calculate missing mass (MM) from TAGM/H photon (select time window using π^- SC hit)
- Select MM region for protons (0.5-1.2 GeV) to select exclusive $p\pi^0\pi^+\pi^-$



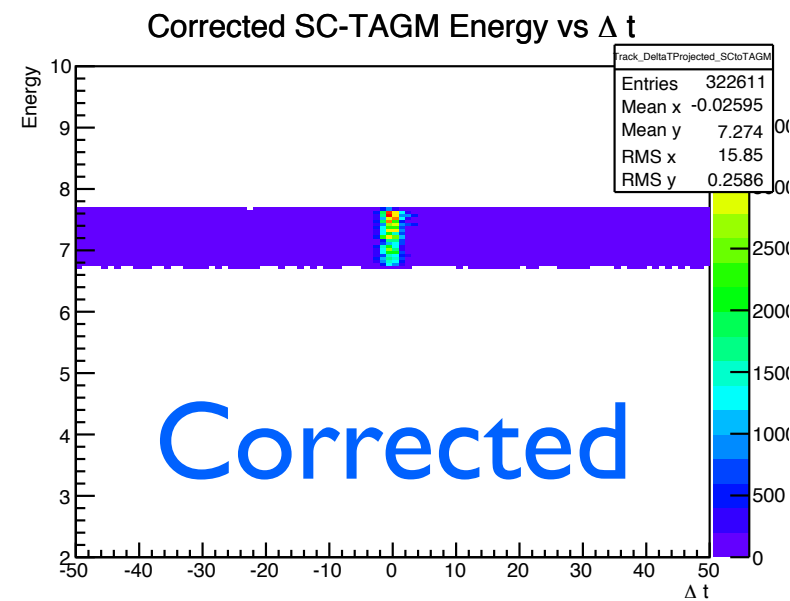
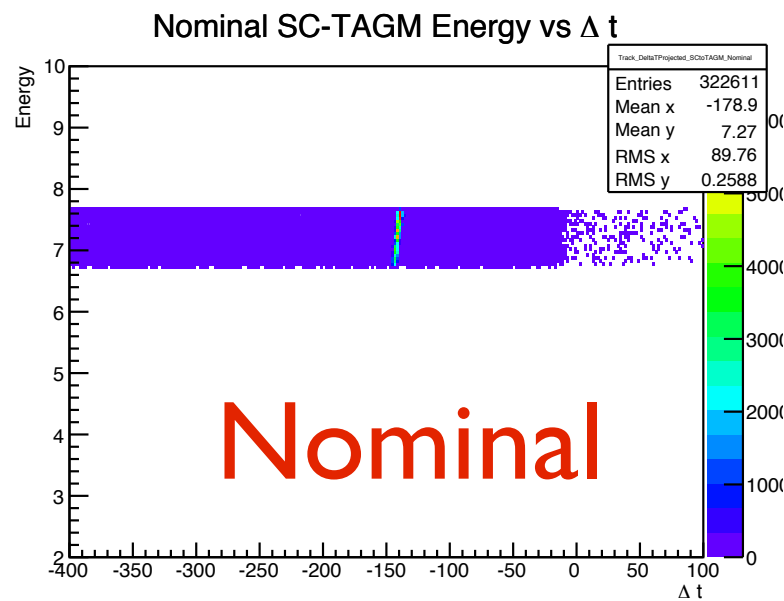
Bump at ω mass in $\pi^0\pi^+\pi^-$ mass distribution after selecting missing proton region

Sum of **FCAL** and **FCAL-BCAL** trigger runs

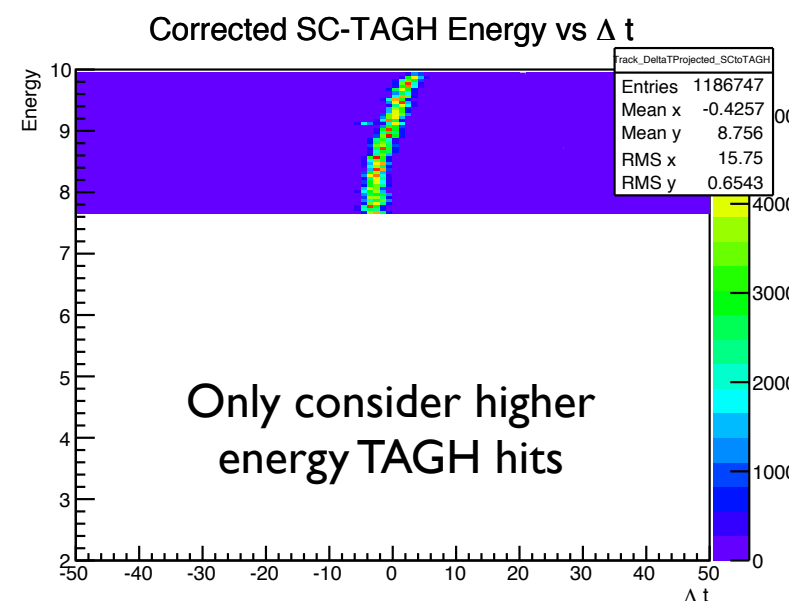
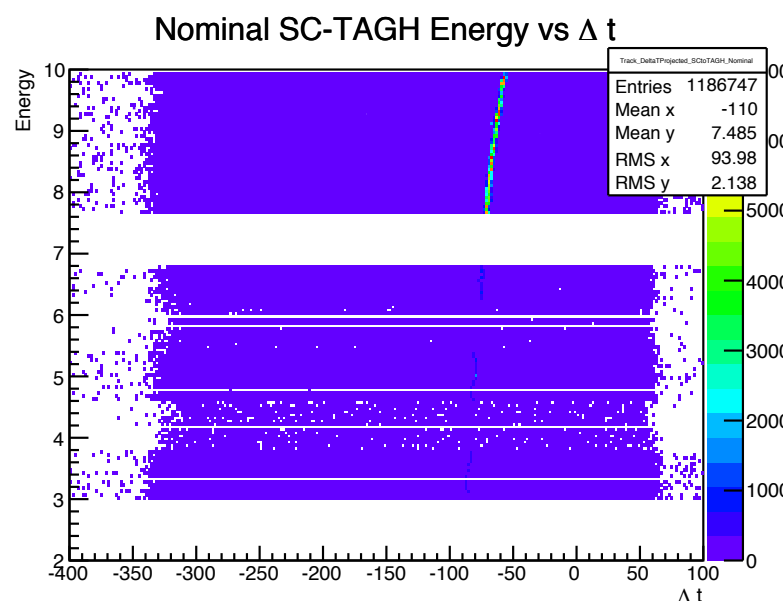
Backup

Time offset between SC and TAGM/H

- Require tracks have matched hit in SC
- Use pathlength to determine time of SC hit propagated to the target
- Calculate “Nominal” Δt (SC-TAGM/H) at target, and correct to center at 0



TAGM:
corrected
time nicely
centered at
 $\Delta t = 0$



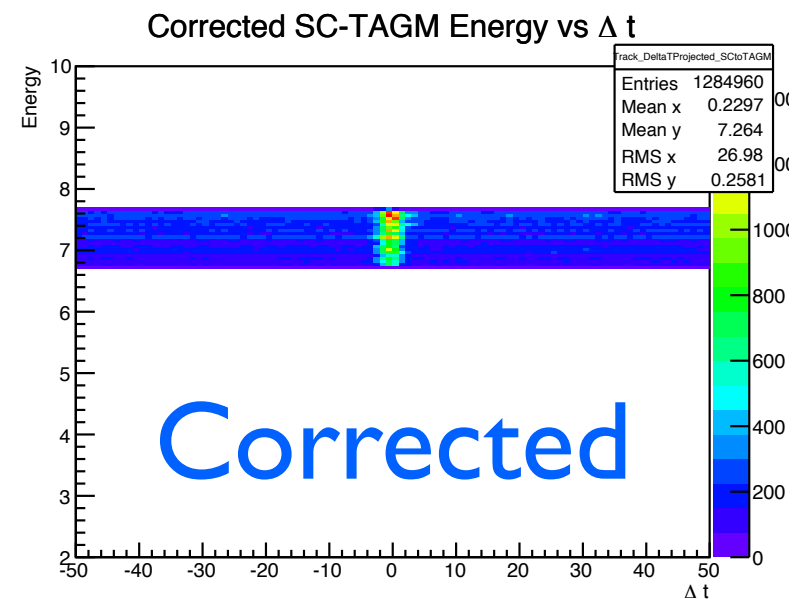
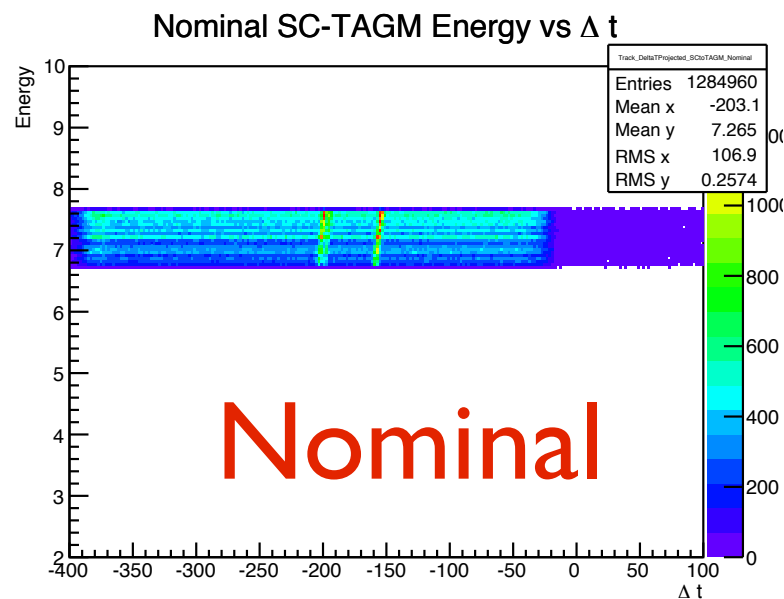
TAGH: some
“curvature”
with energy
(ie. counter
ID) but still
centered at
 $\Delta t = 0$

Try to adjust for
counter ID
dependent offset
(ie. slope in
Nominal plots)

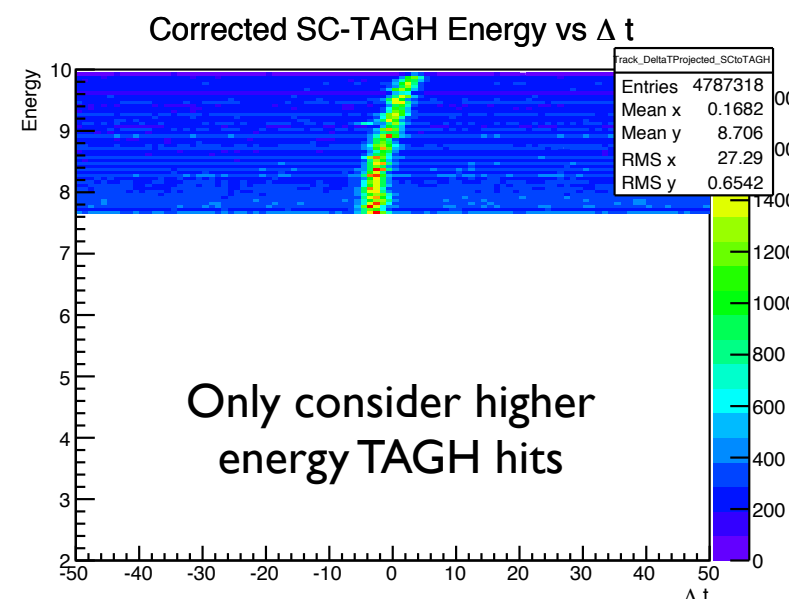
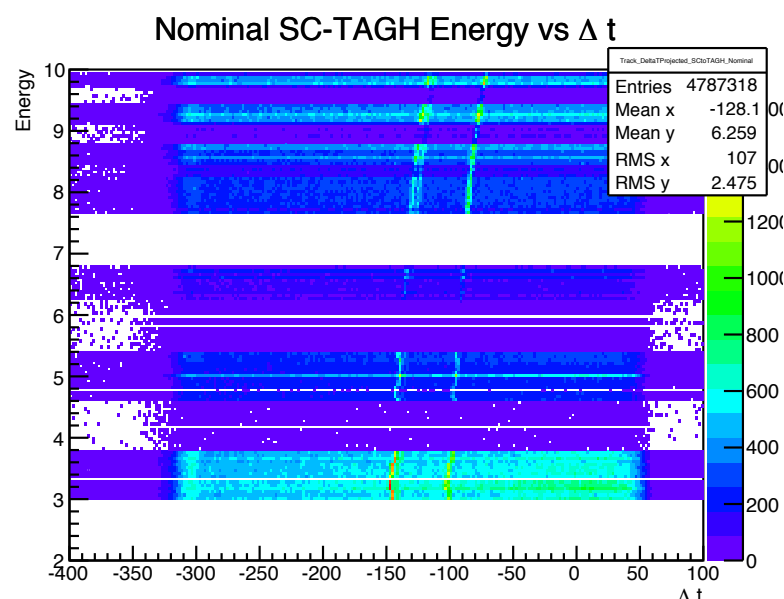
FCAL trigger: runs 1501-1525

Time offset between SC and TAGM/H

- Require tracks have matched hit in SC
- Use pathlength to determine time of SC hit propagated to the target
- Calculate “Nominal” Δt (SC-TAGM/H) at target, and correct to center at 0



TAGM:
corrected
time nicely
centered at
 $\Delta t = 0$



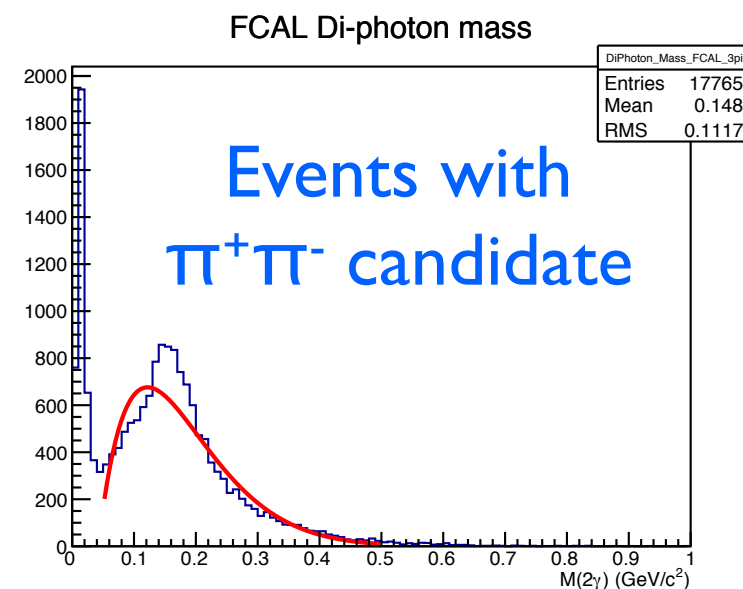
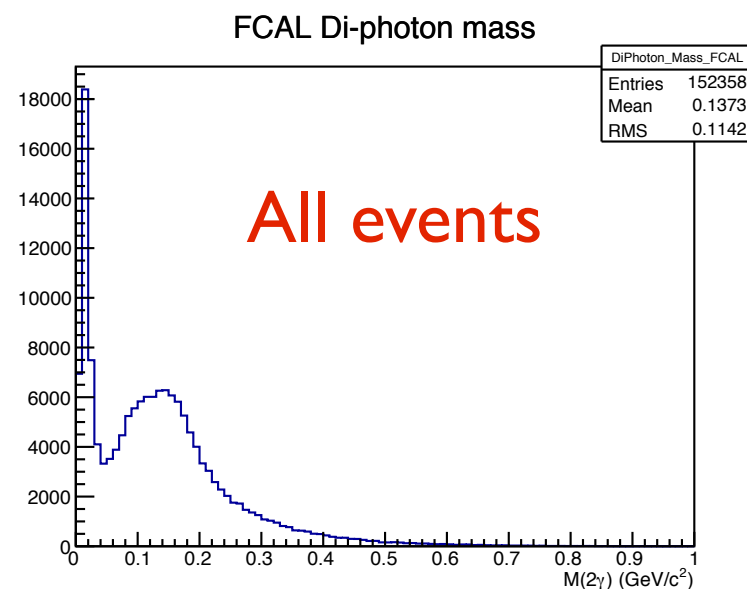
TAGH: some
“curvature”
with energy
(ie. counter
ID) but still
centered at
 $\Delta t = 0$

Try to adjust for
counter ID
dependent offset
(ie. slope in
Nominal plots)

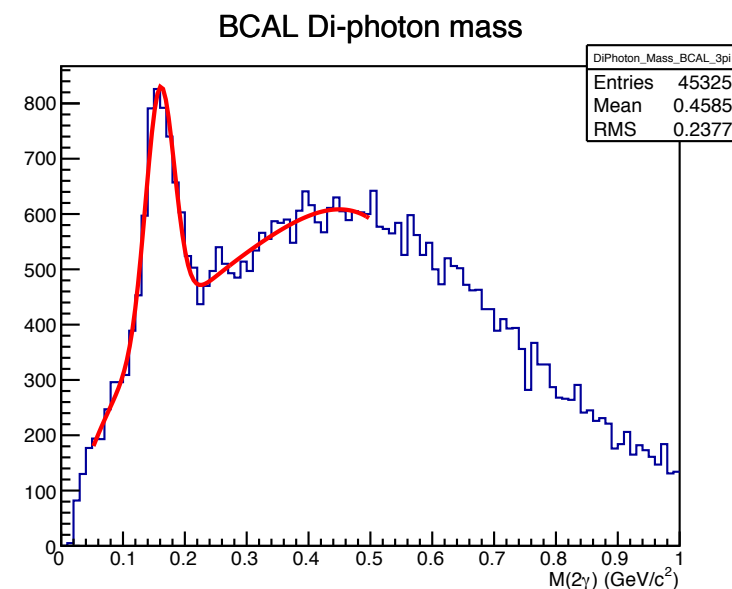
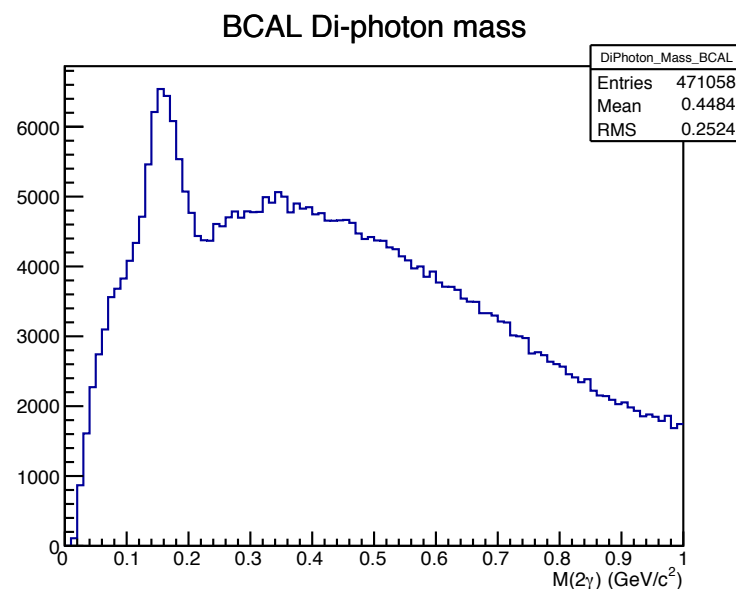
BCAL trigger: runs 1547-1807

π^0 candidate selection

- Standard FCAL (Matt) and BCAL (Will) cuts used in other talks/studies from all events
- Will pair these with $\pi^+\pi^-$ candidate so only consider those events and use mass cut of $M(2\gamma) = [0.1, 0.25]$ GeV



Background under π^0 peak smaller for FCAL

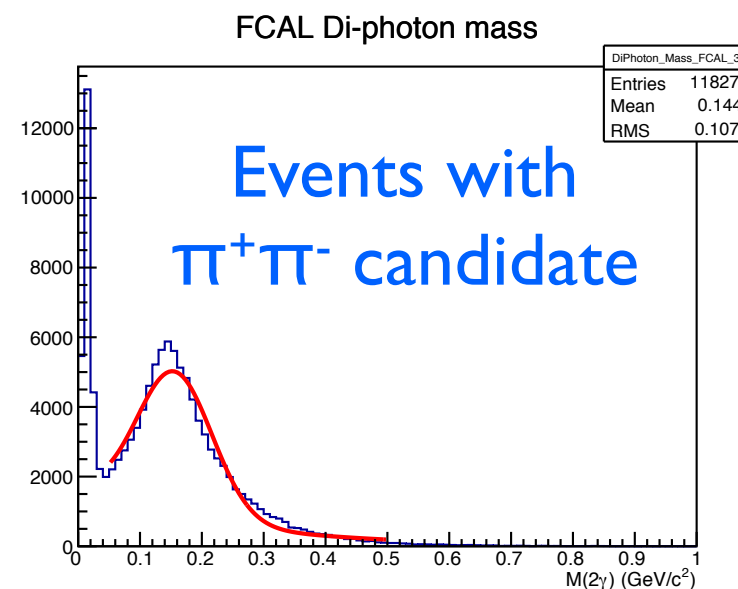
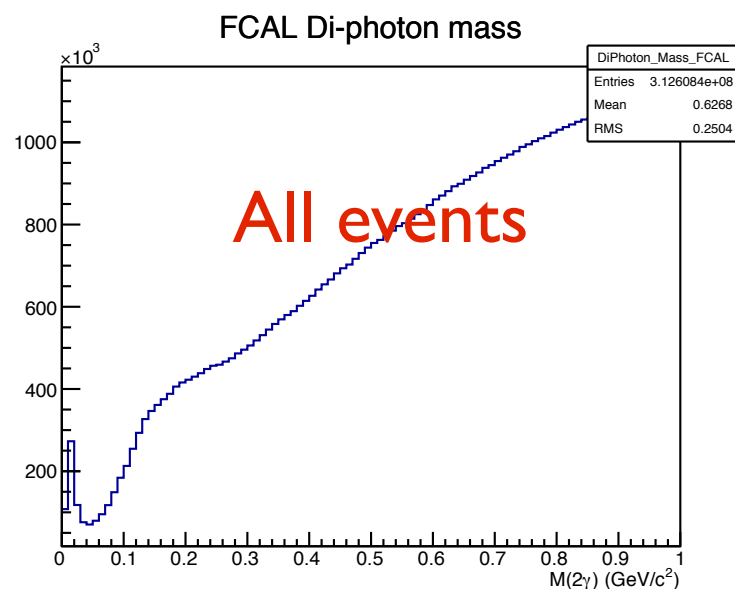


π^0 mass resolution better for BCAL?

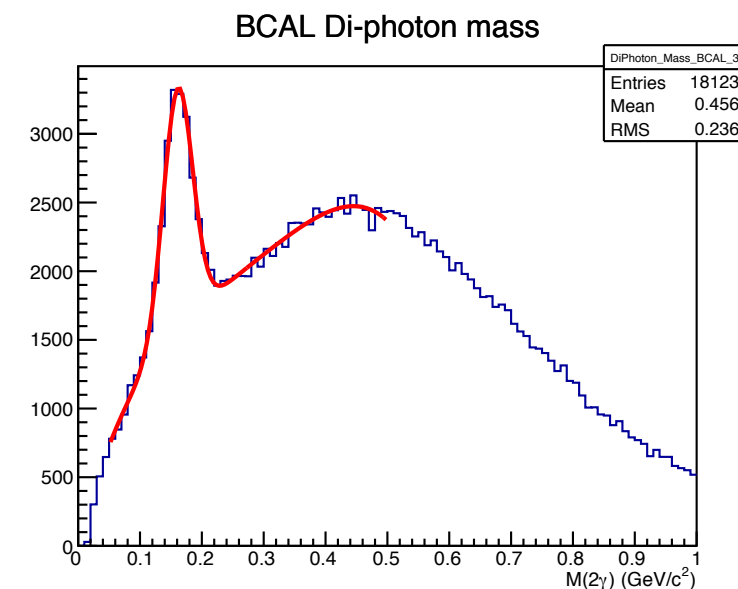
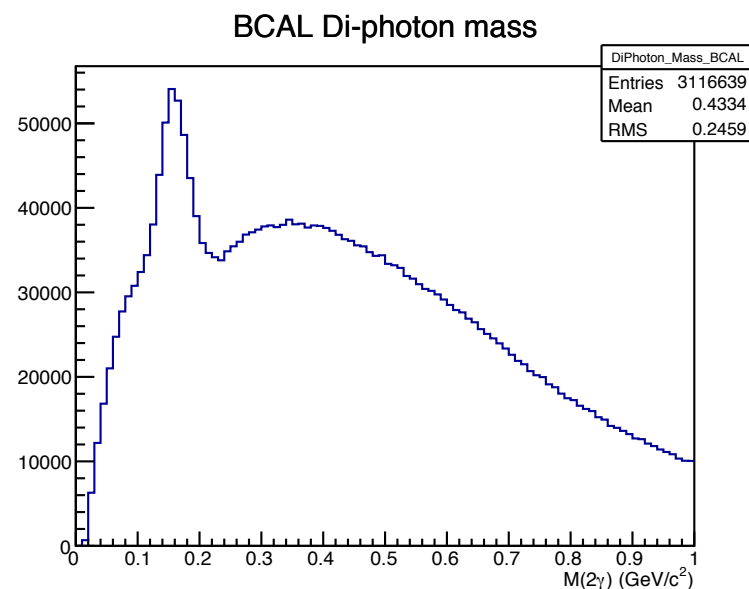
BCAL trigger: runs 1547-1807

π^0 candidate selection

- Standard FCAL (Matt) and BCAL (Will) cuts used in other talks/studies from all events
- Will pair these with $\pi^+\pi^-$ candidate so only consider those events and use mass cut of $M(2\gamma) = [0.1, 0.25]$ GeV



Background under π^0 peak smaller for FCAL

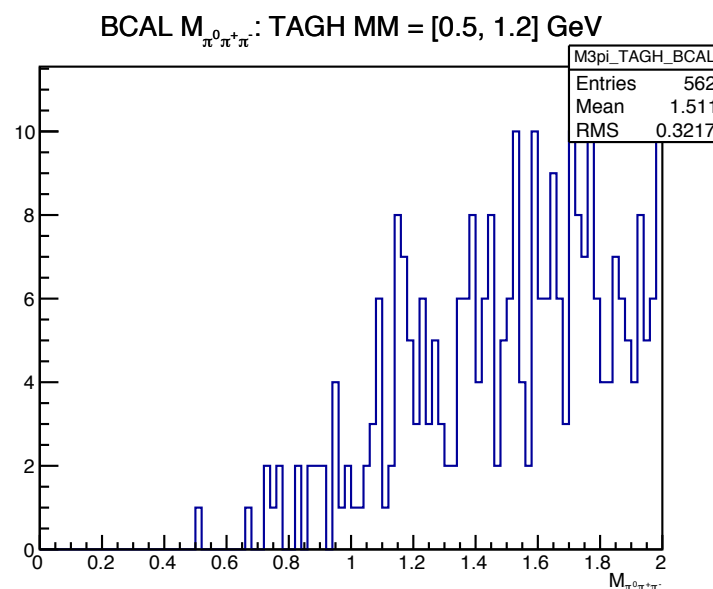
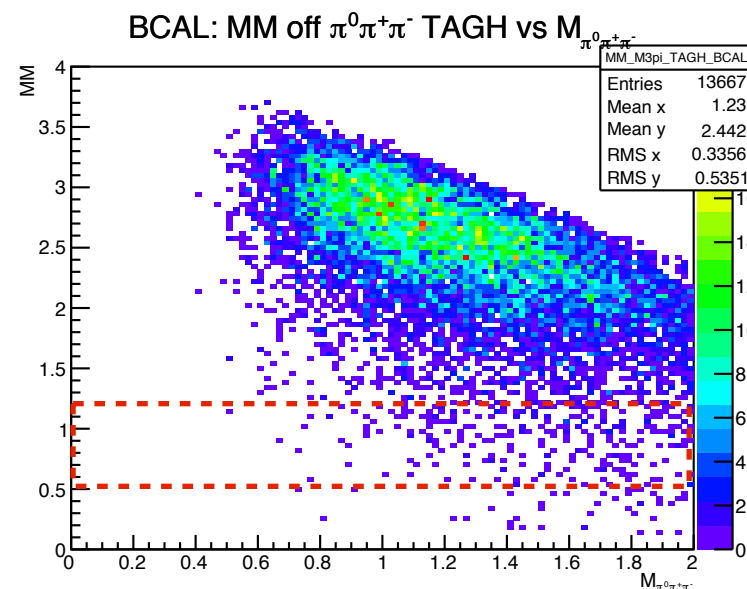
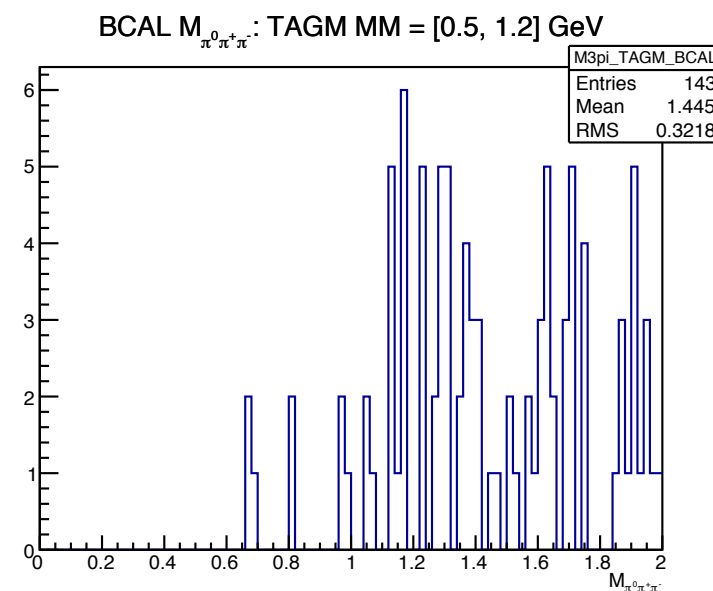
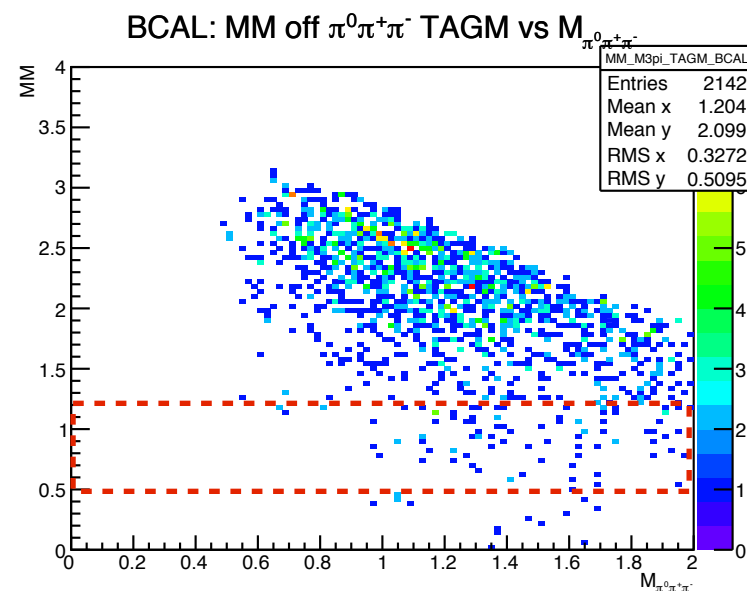


π^0 mass resolution better for BCAL?

FCAL-BCAL trigger: runs 2140-2420

Missing Mass vs $M_{\pi^0\pi^+\pi^-}$ (BCAL π^0)

- Select $\pi^0\pi^+\pi^-$ candidates (π^0 from BCAL) and calculate missing mass (MM) from TAGM/H photon (select time window using π^- SC hit)
- Select MM region for protons (0.5-1.2 GeV) to select exclusive $p\pi^0\pi^+\pi^-$

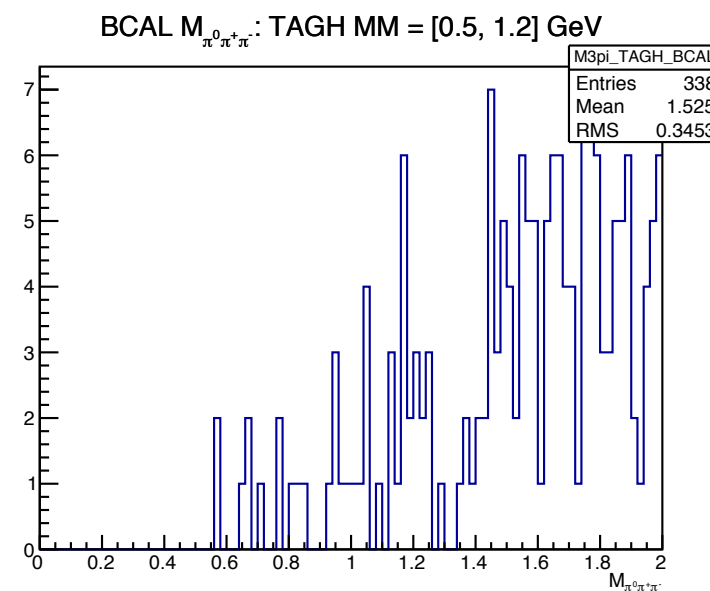
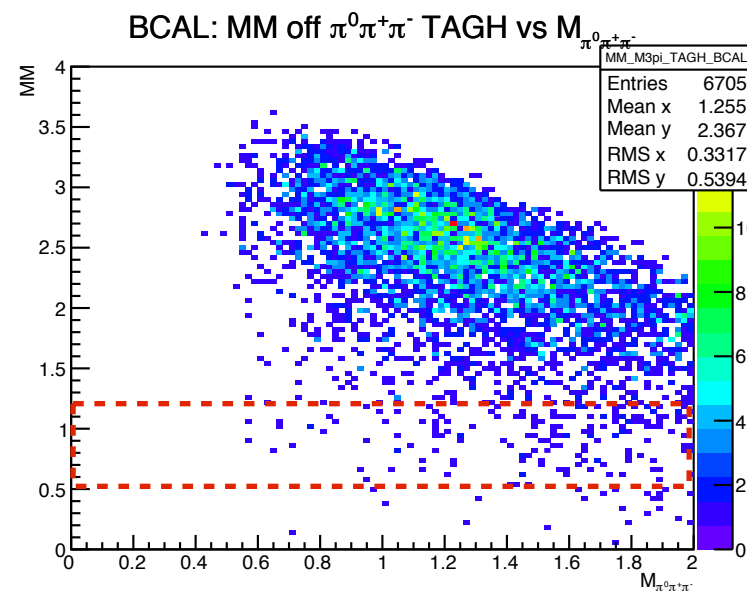
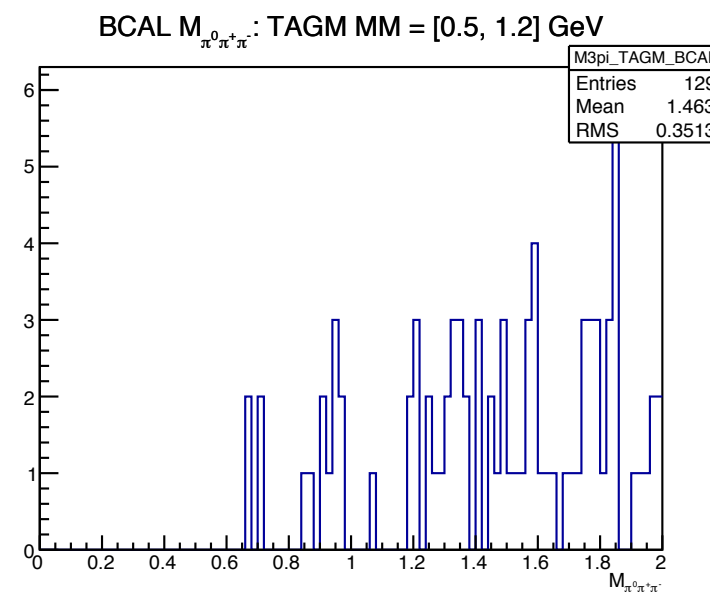
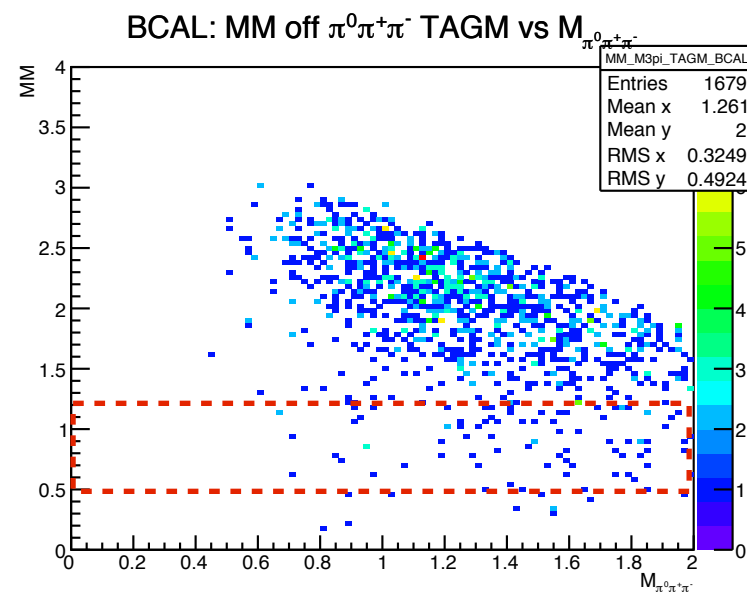


No peak at ω mass... no BCAL π^0 from exclusive $p\omega$?

FCAL trigger: runs 1501-1525

Missing Mass vs $M_{\pi^0\pi^+\pi^-}$ (BCAL π^0)

- Select $\pi^0\pi^+\pi^-$ candidates (π^0 from BCAL) and calculate missing mass (MM) from TAGM/H photon (select time window using π^- SC hit)
- Select MM region for protons (0.5-1.2 GeV) to select exclusive $p\pi^0\pi^+\pi^-$

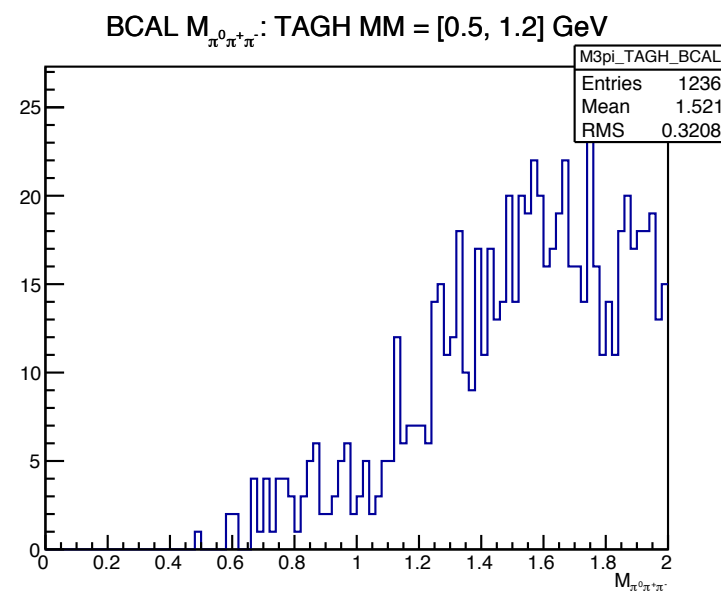
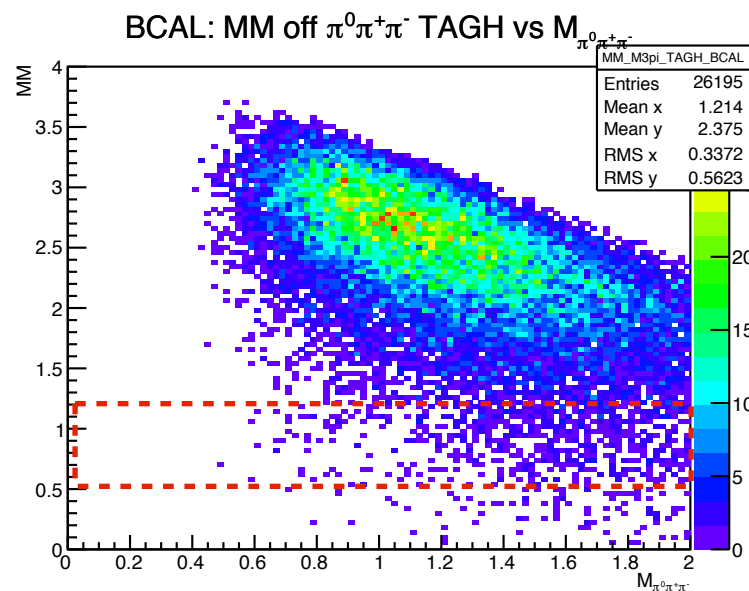
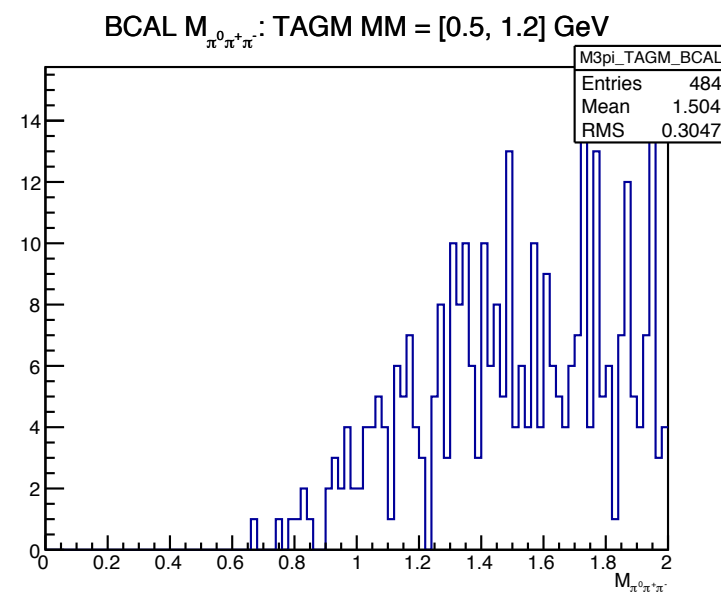
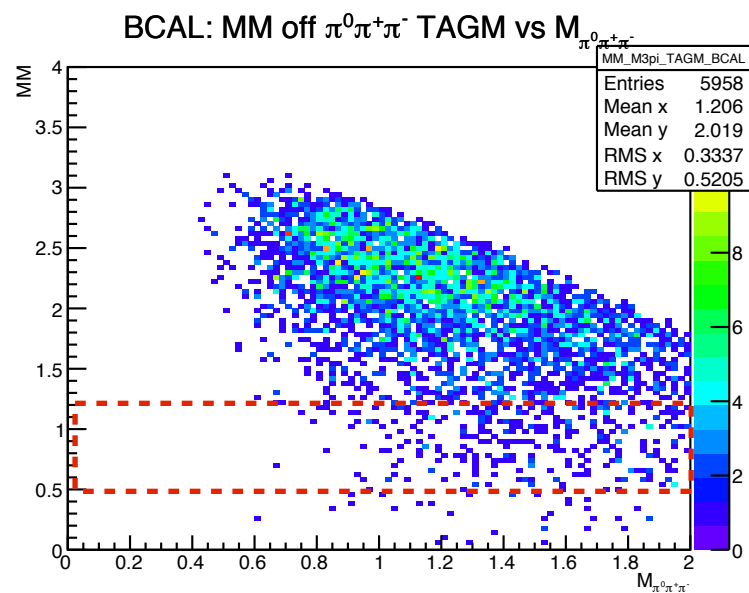


No peak at ω mass... no BCAL π^0 from exclusive $p\omega$?

BCAL trigger: runs 1547-1807

Missing Mass vs $M_{\pi^0\pi^+\pi^-}$ (BCAL π^0)

- Select $\pi^0\pi^+\pi^-$ candidates (π^0 from BCAL) and calculate missing mass (MM) from TAGM/H photon (select time window using π^- SC hit)
- Select MM region for protons (0.5-1.2 GeV) to select exclusive $p\pi^0\pi^+\pi^-$



No peak at ω mass... no BCAL π^0 from exclusive $p\omega$?

FCAL-BCAL trigger: runs 2140-2420