Muon monitoring in CallioLab (CUPP) and LSC

MuonMonitor Workshop
09.08.2016, LSC, Canfranc

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Angular distribution analysis:

→ At CUPP

=> EMMA experiment

=> Map of rock overburden

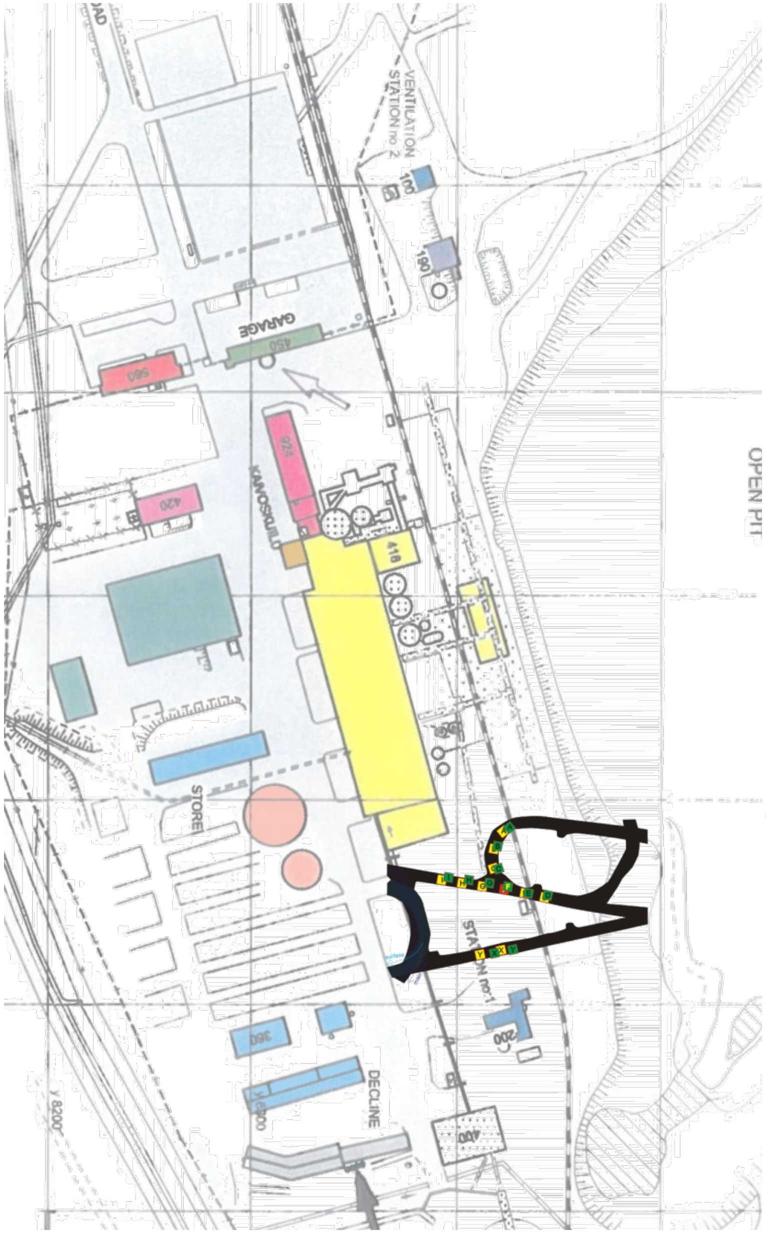
=> Experimental setup

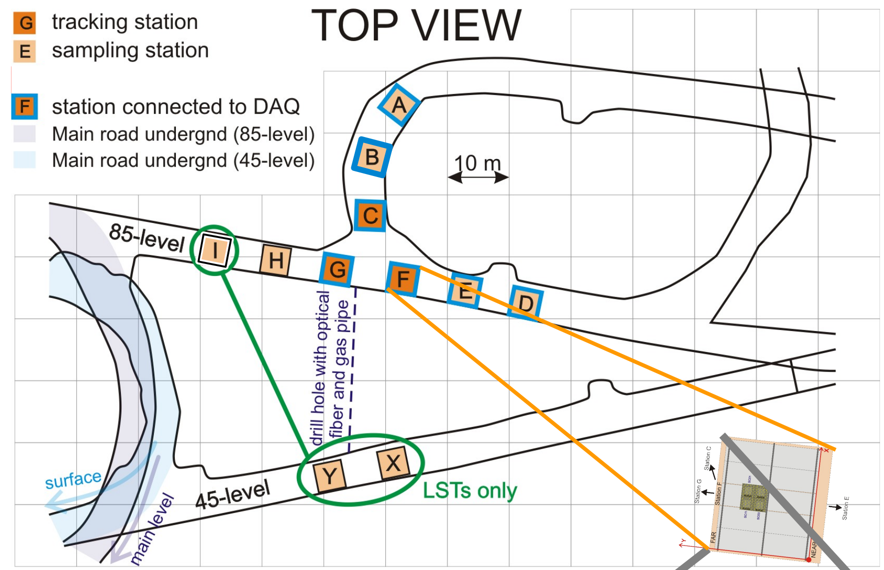
=> Results

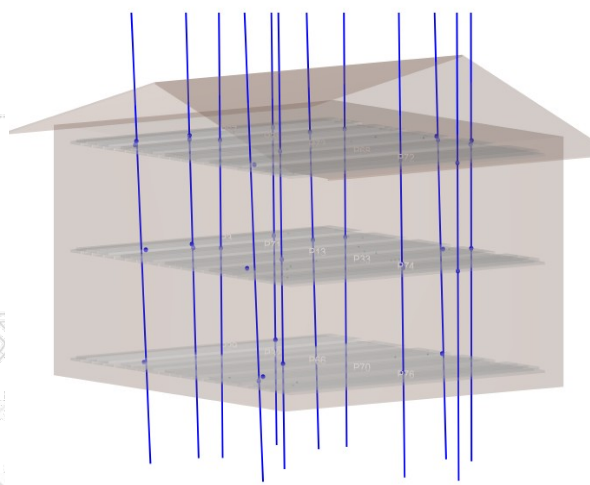
→ At LSC

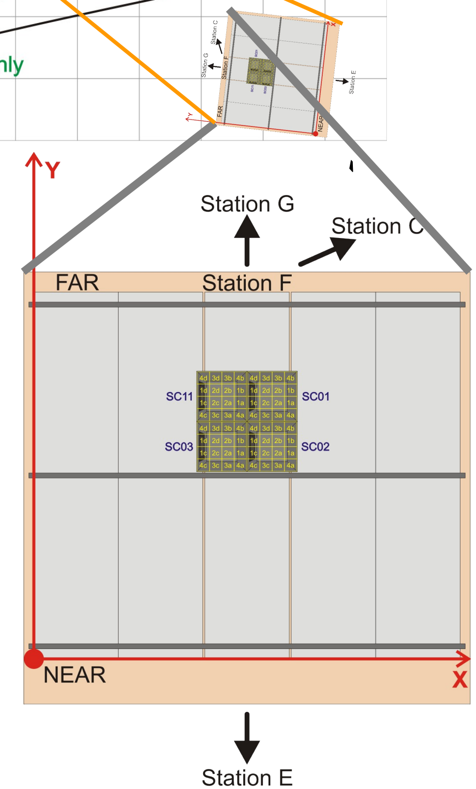
=> Preliminary results

3 EMMA


VENTILATION STATION no 2
GARAGE
STORE
KANOSSULI
DECLINE
OPEN PIT


TOP VIEW
G tracking station
E sampling station
F station connected to DAQ
Main road undergnd (85-level)
Main road undergnd (45-level)
10 m
85-level
45-level
main level
surface
drill hole with optical fiber and gas pipe
LSTs only
A
B
C
D
E
F
G
H
I
X
Y




Y
Station G
Station C
FAR
Station F
SC11
SC01
SC03
SC02
NEAR
X
Station E

4 EMMA - pictures

5 Experimental setup

Geometry:

→ **Temporary** part of a larger setup (**EMMA** experiment)

→ 2 x 2 x 5 SC16s

→ To make it comparable with LSC setup only **3 levels** are used in analysis:

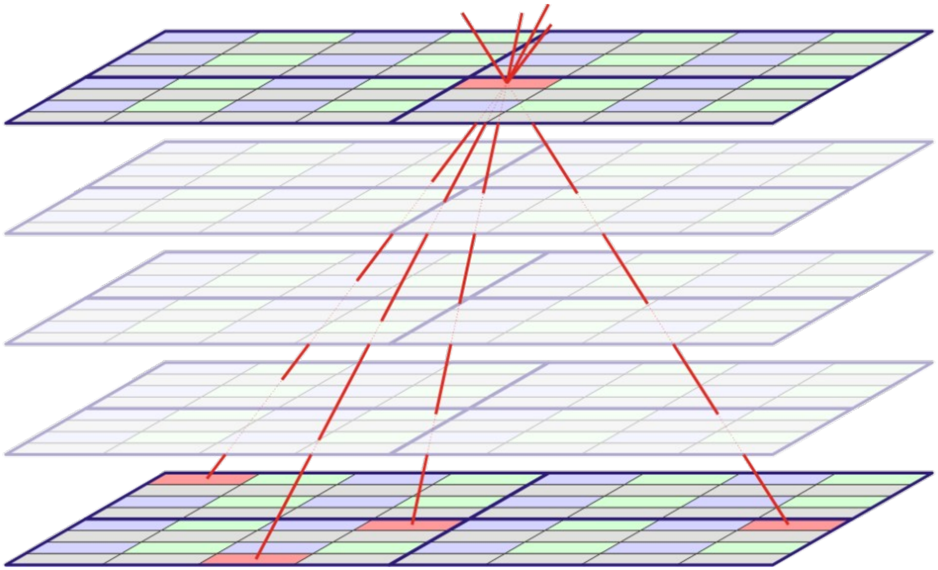
=> 1st (bottom)

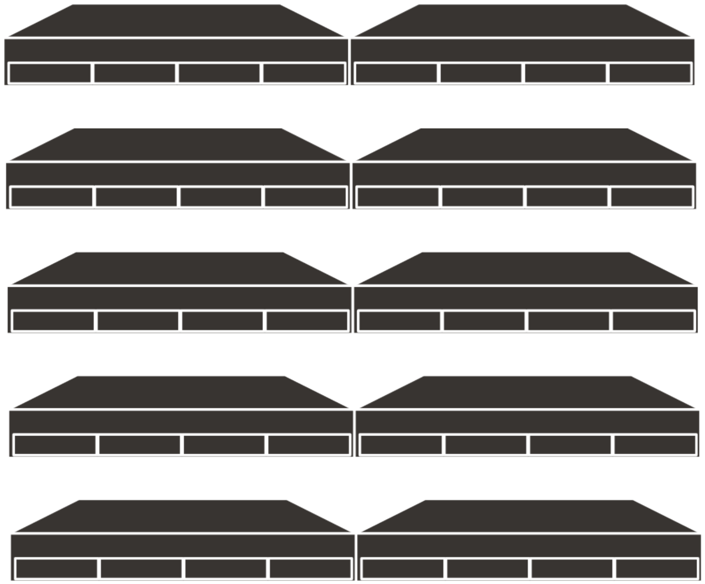
=> 3rd (middle)

=> 5th (top)

→ Maximum **zenith angle** (solid angle) is **smaller**

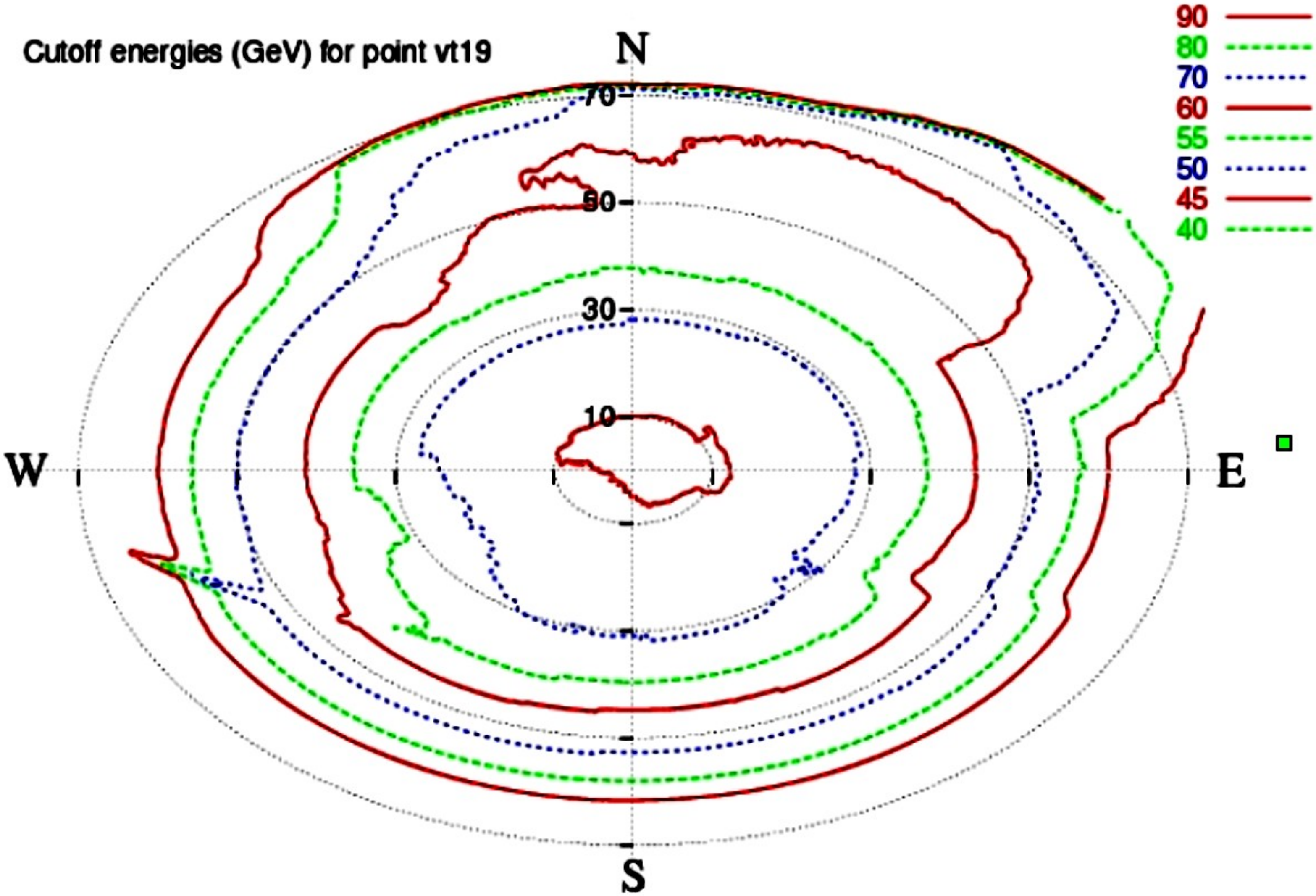
→ otherwise **same analysis tools** can be used for both setups





Map of rock overburden

Rock type, density and layout is **well mapped**
(approximated by 3d boxes, resolution 1x1x1 m^3)



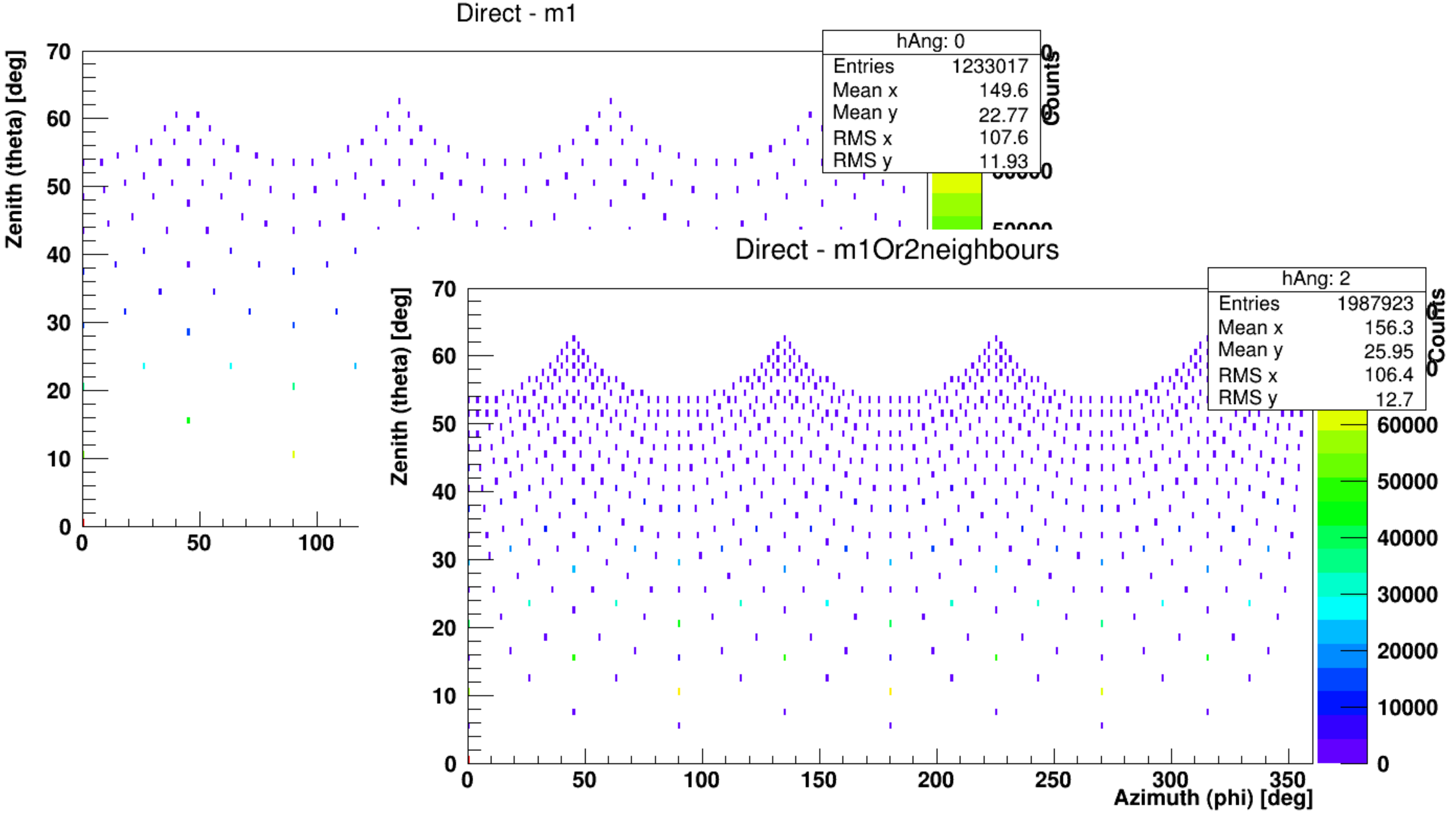
Event selection:

→ **HW Trigger**: Top & Bottom
→ **SW Trigger**: Top & Mid & Bot
→ **Δt** < 20 ns
→ Pixel **multiplicity** per level = 1 or <=2
→ **Tracking** (simplified):
=> use top and bottom coordinates to get a muon track (and angles)
=> check if the track passes through the correct pixel in the middle level – no fitting

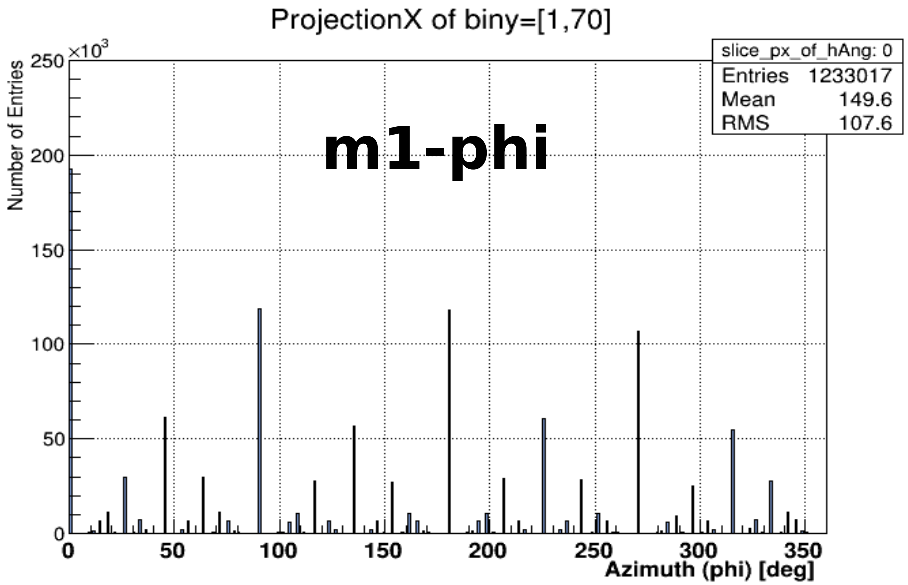
Glossary (plot titles):

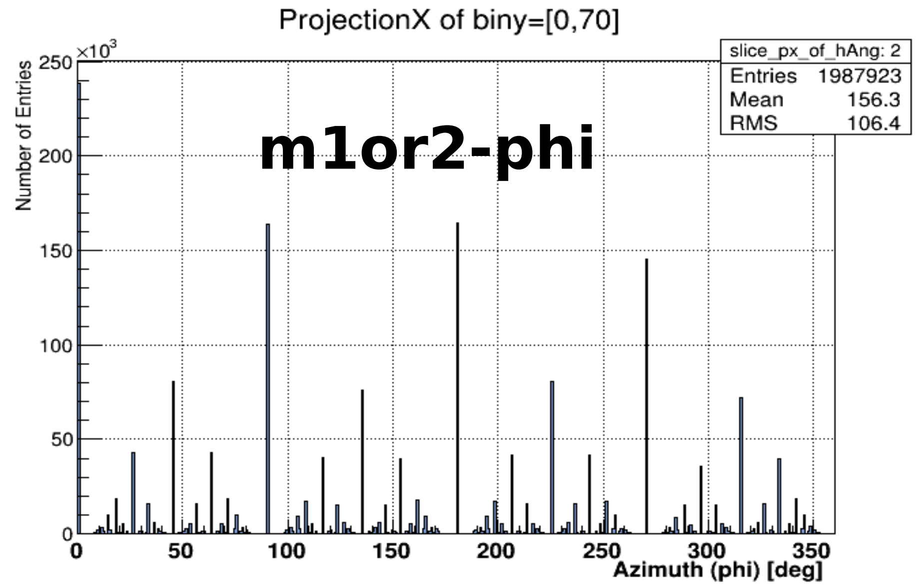
→ **m1** – **muliplicity** per level == 1
→ **m1or2** – **multiplicity** in every level is <=2
=> if there are two hits per level additional condition of **closest neighbours** is requred – no diagonals
→ **Direct** – **centers of pixels** are used to define a muon track
→ **Smeared** – a **random position within a pixel** is used to define a muon track
=> 100 x randomization with the weight of each result = 0.01
=> The result is sort of a probability distribution of real muon track direction

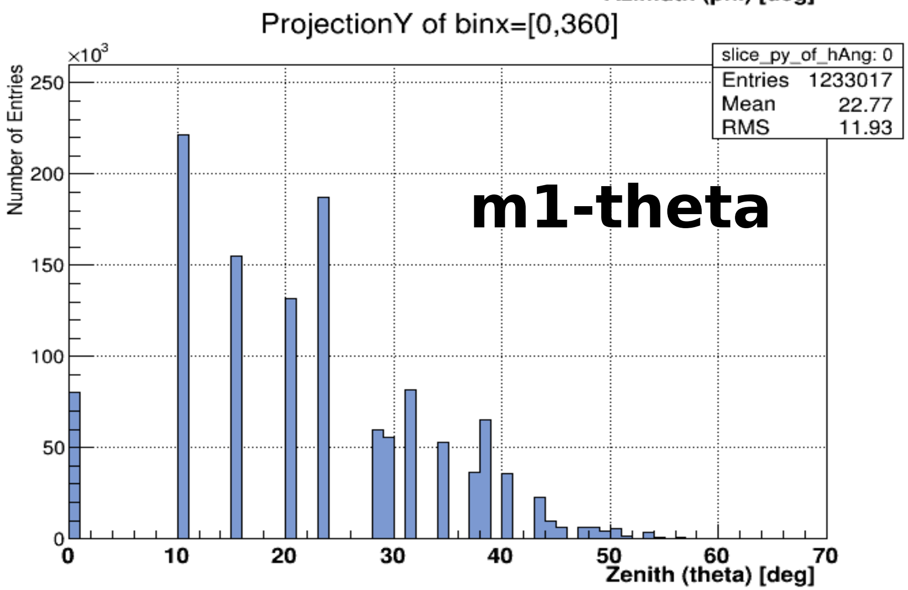
Phi and theta distributions (direct)

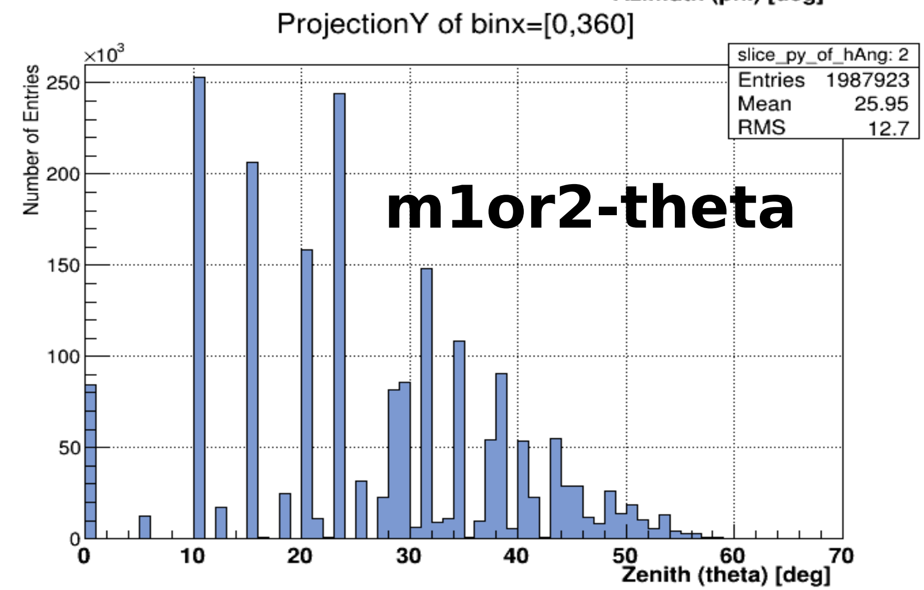


Phi and theta distributions (direct) - projections







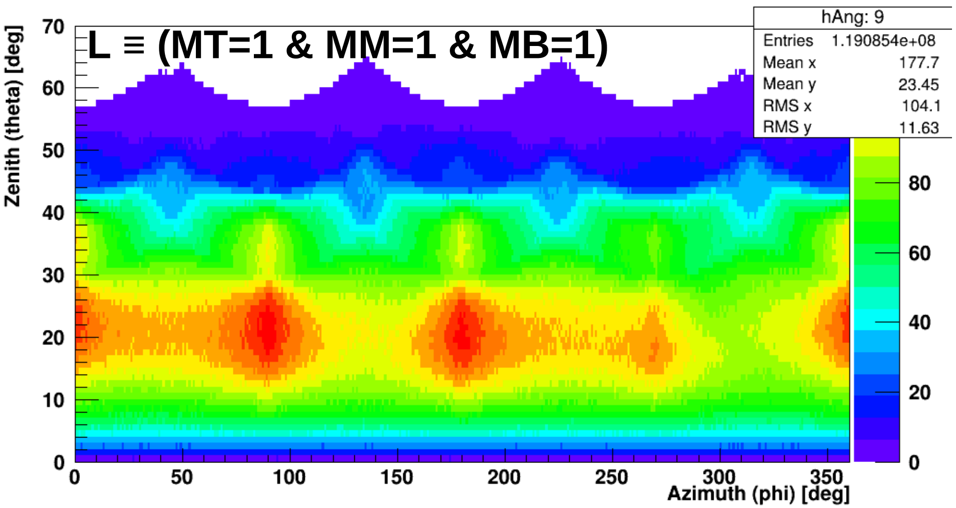


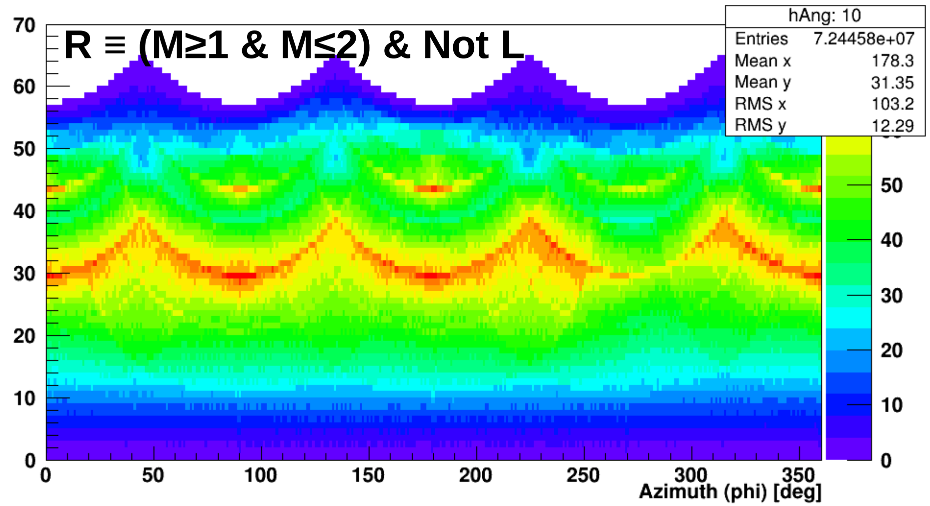
Extract from angular distribution at CUPP (1/5)

Why M=1 is not enough?

→ bigger zenith angle

=> higher probability for 2 pixels fired by 1 muon





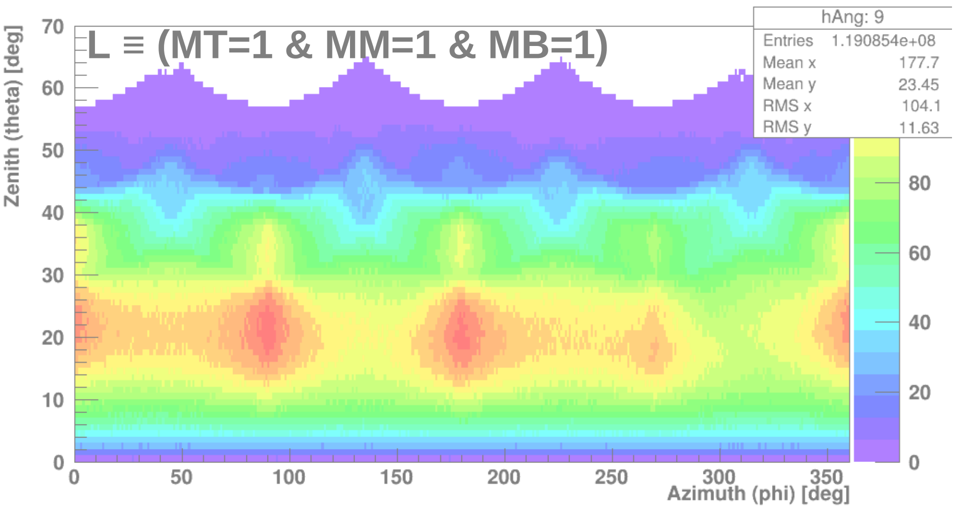
Z-scale: linear

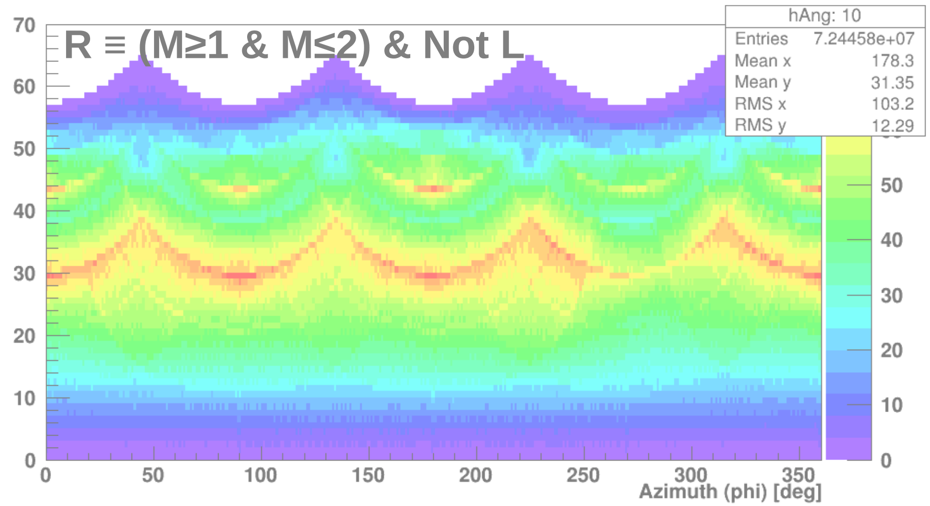
Extract from angular distribution at CUPP (2/5)

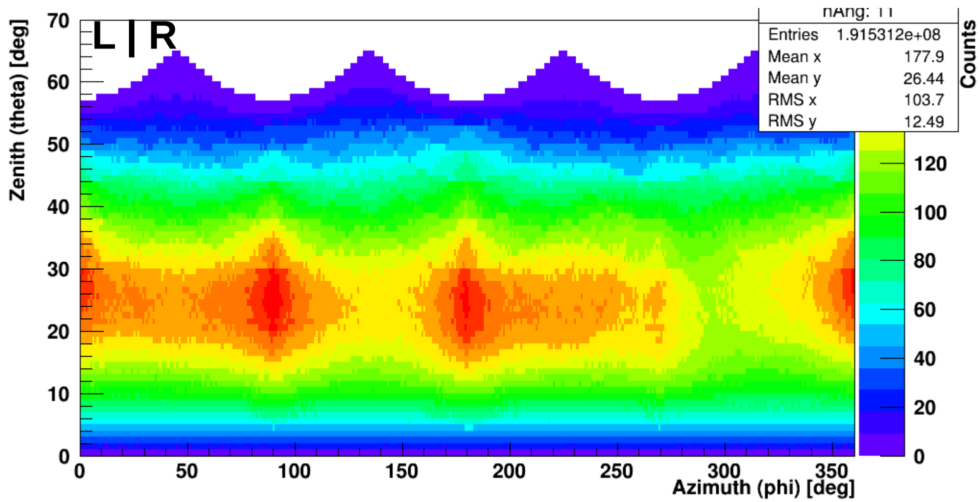
Why M=1 is not enough?

→ bigger zenith angle

=> higher probability for 2 pixels fired by 1 muon





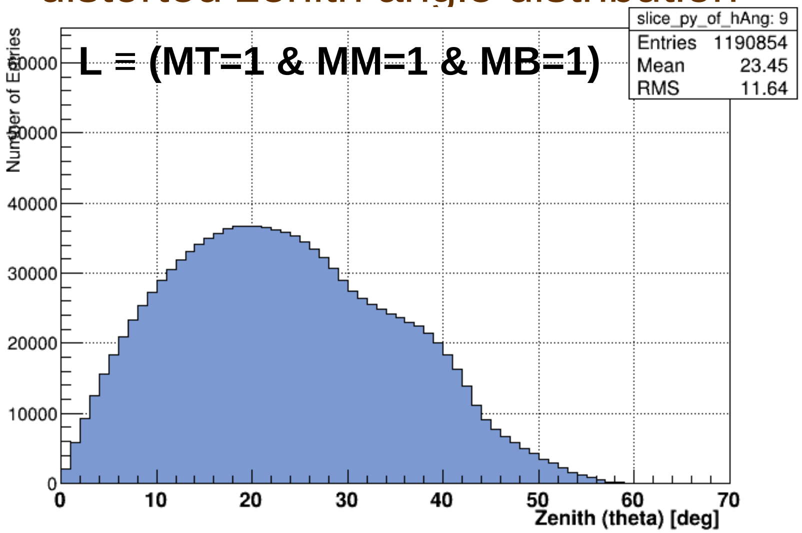


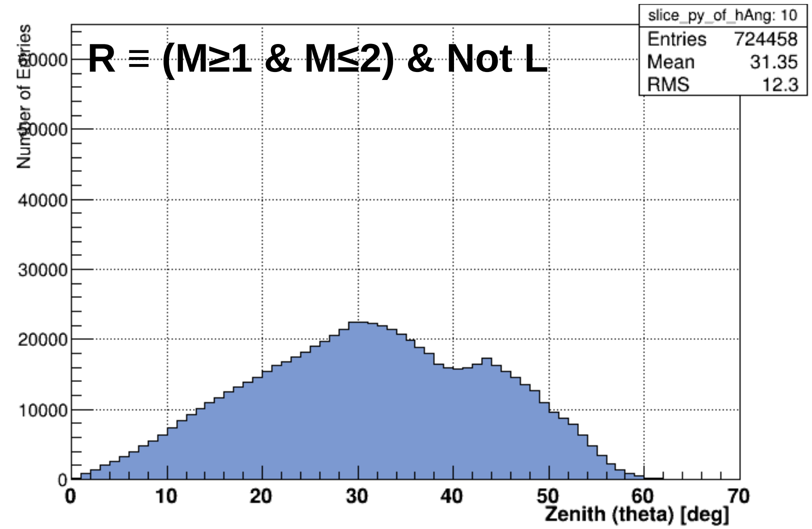
Z-scale: linear

Extract from angular distribution at CUPP (3/5)

Why M=1 is not enough?

→ distorted zenith angle distribution





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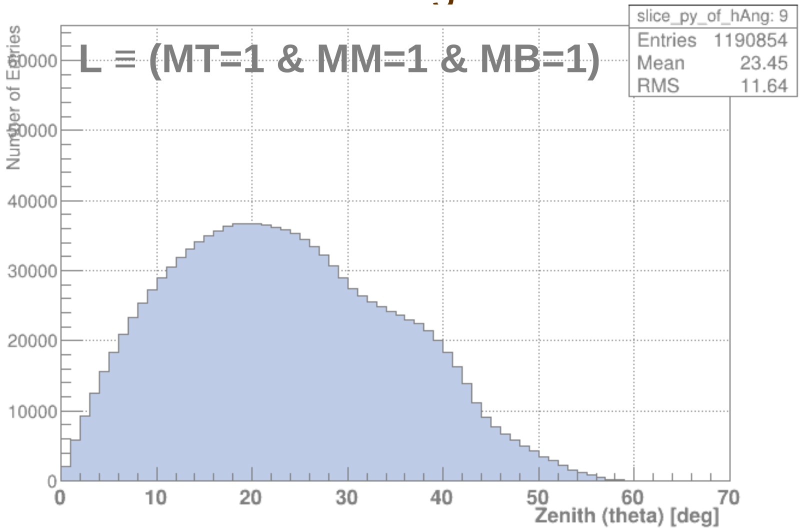
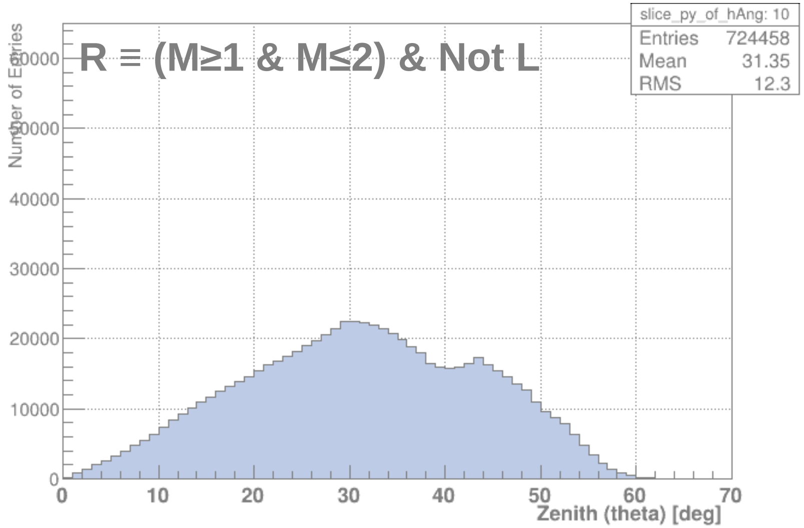
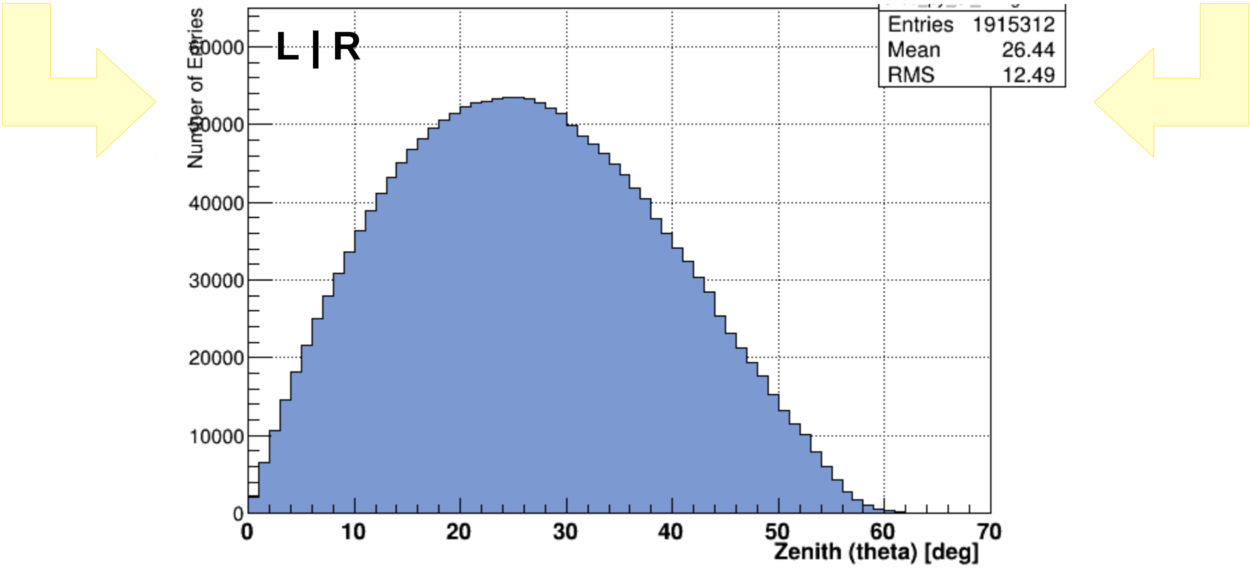


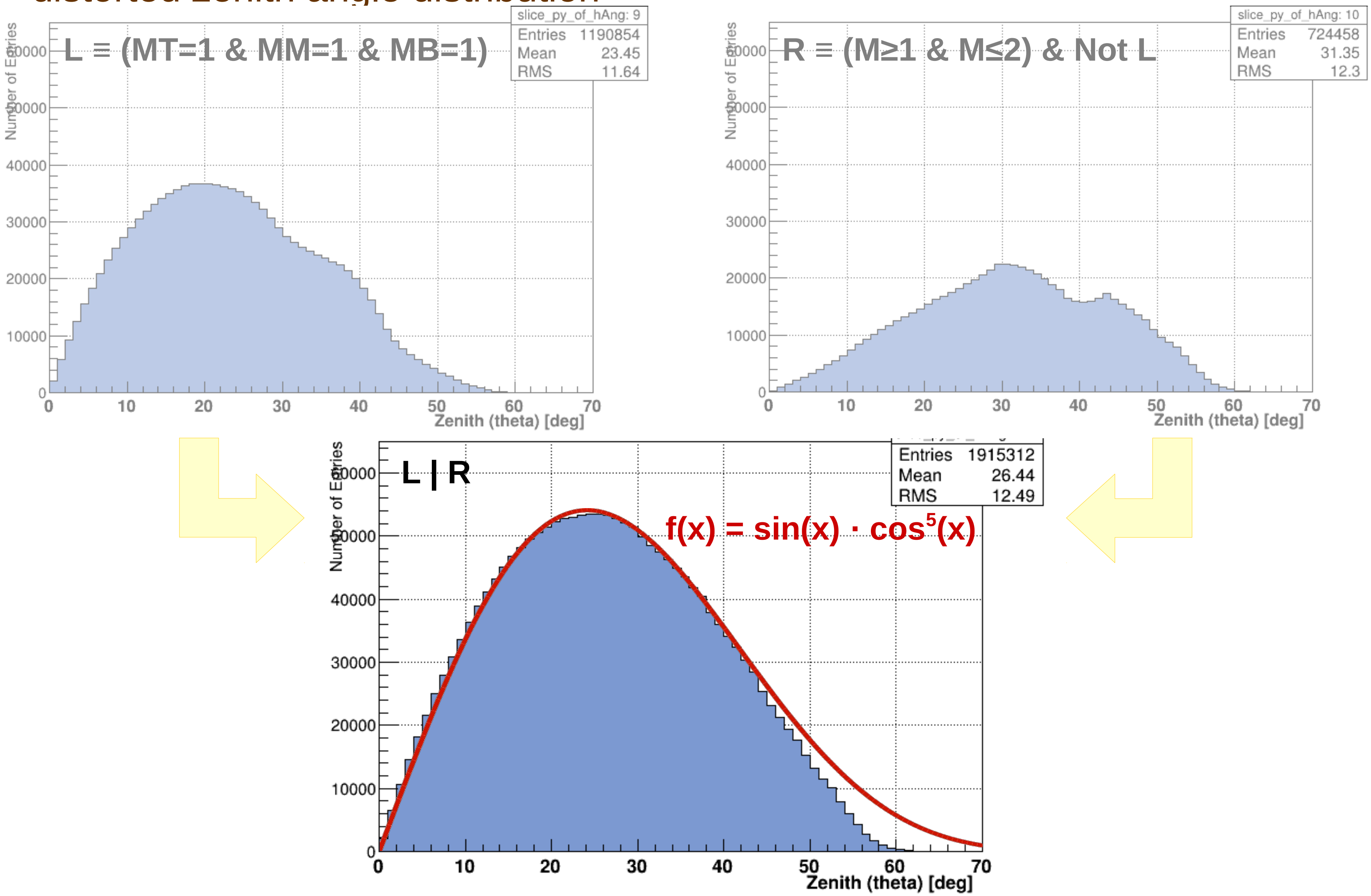




Extract from angular distribution at CUPP (5/5)

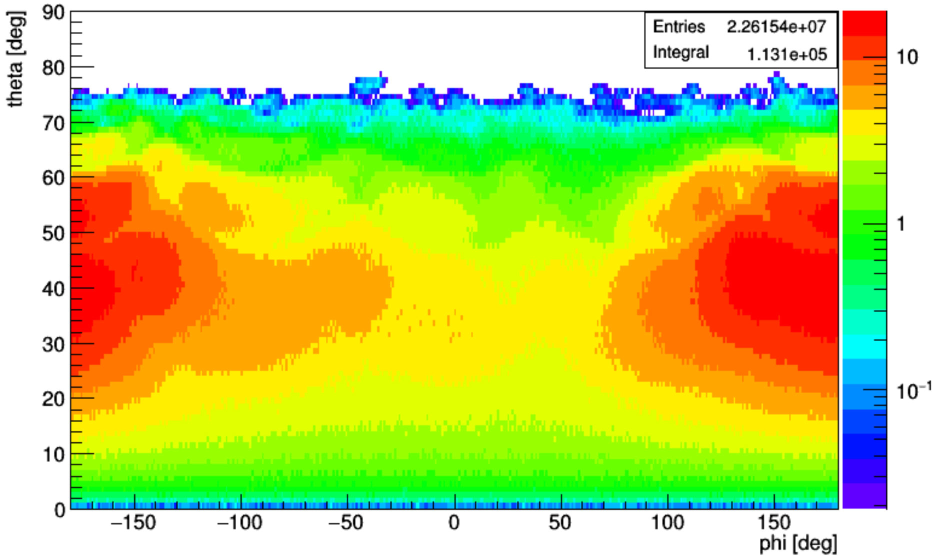
Why M=1 is not enough?

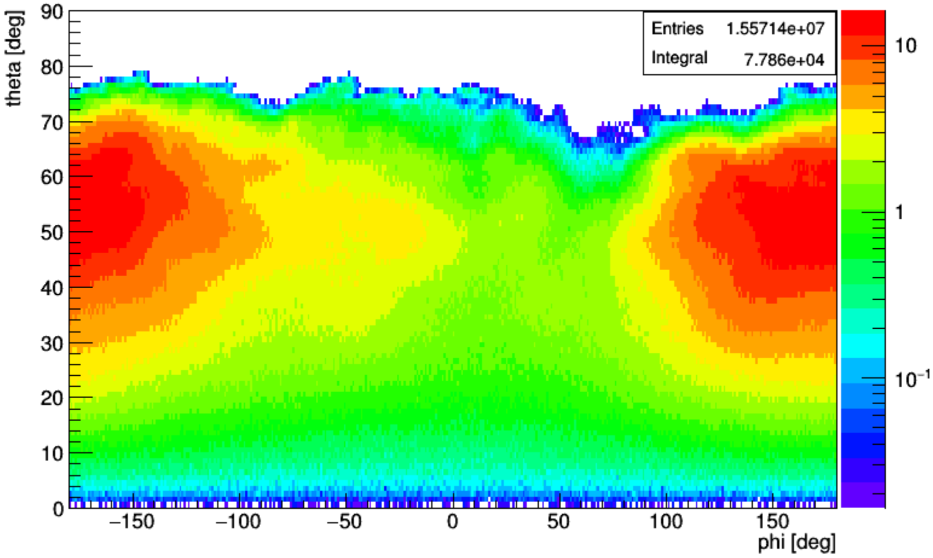
→ distorted zenith angle distribution



How do these distributions
look like at LSC?

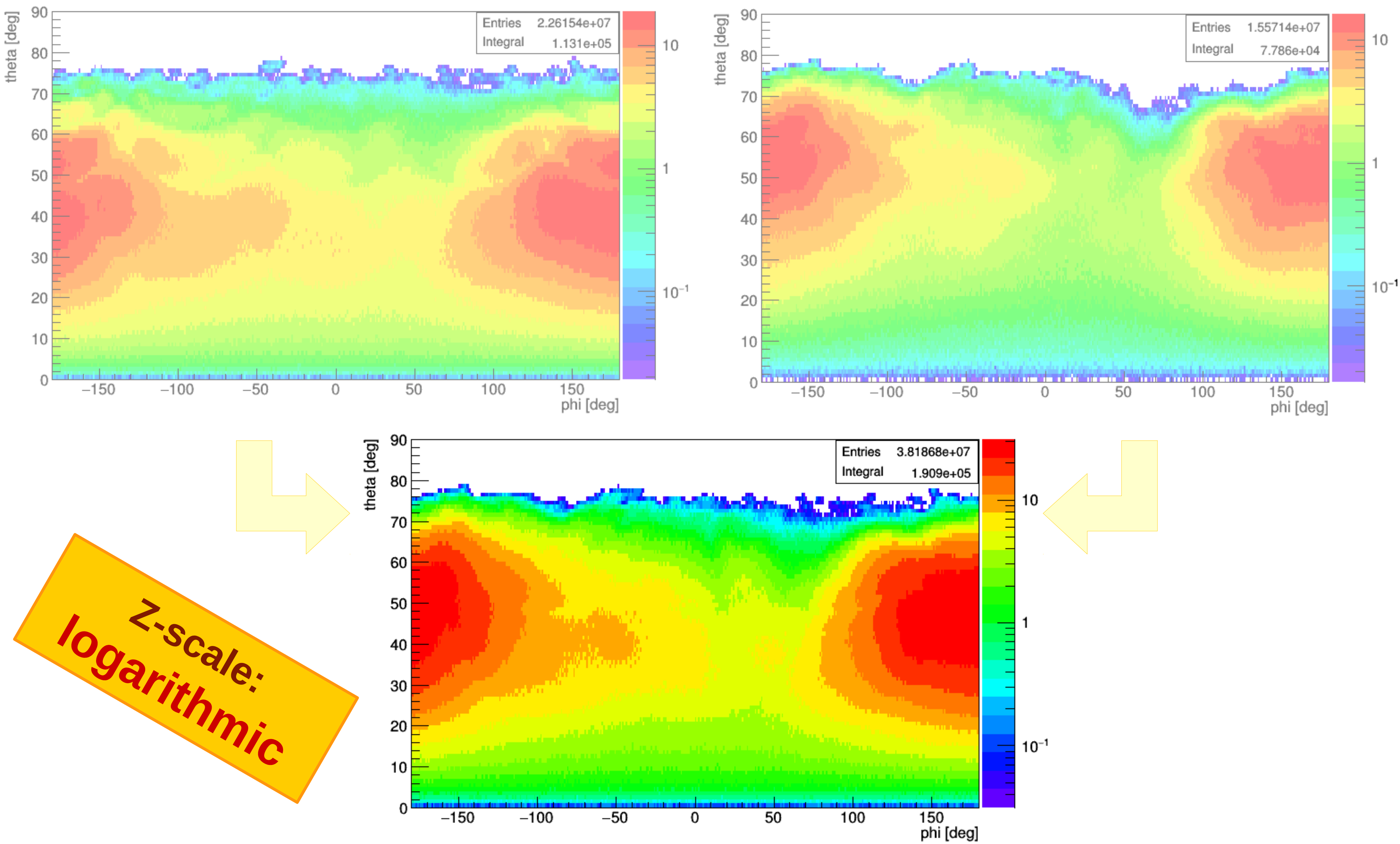
Angular distribution at LSC (2/6)





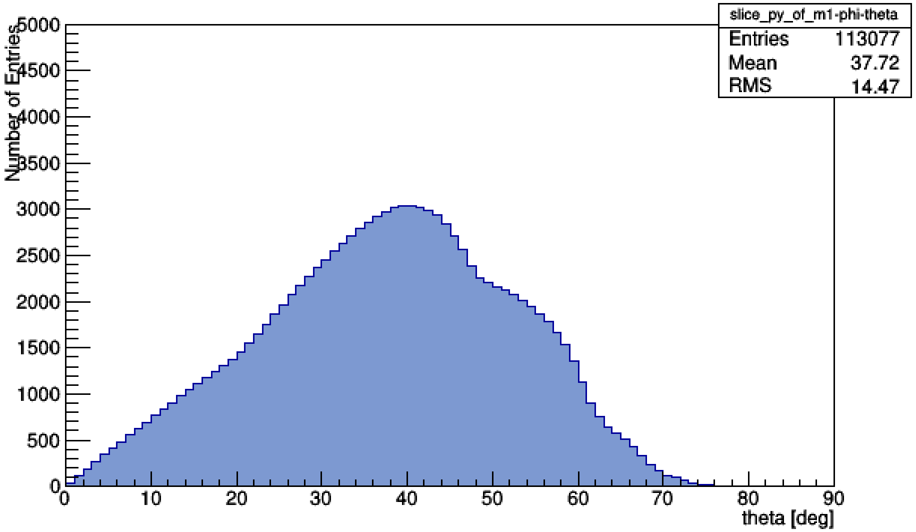
Z-scale: logarithmic

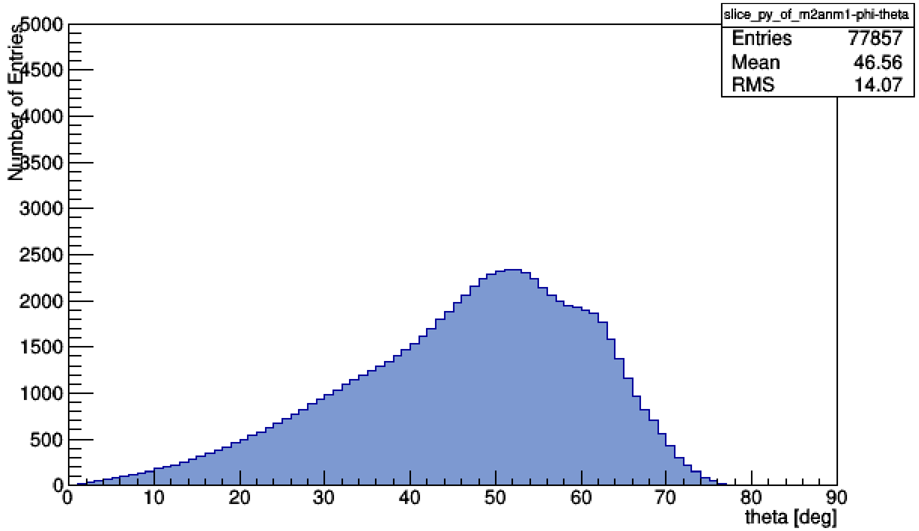
Angular distribution at LSC (3/6)



Angular distribution at LSC (4/6)

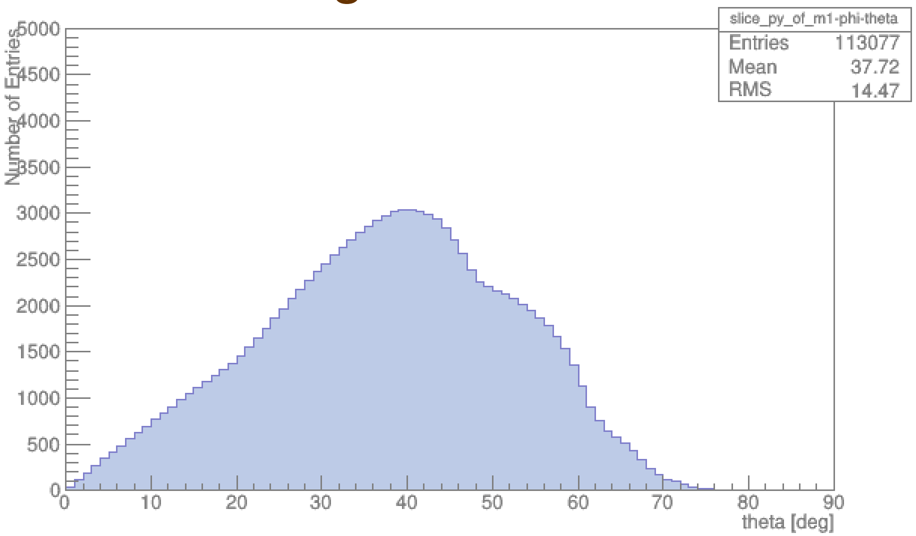
Zenith angle distributions at LSC

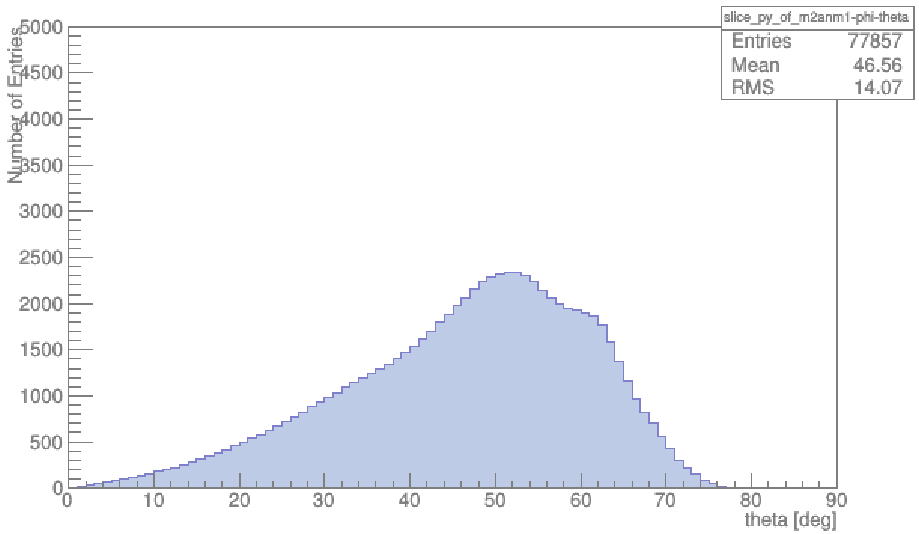


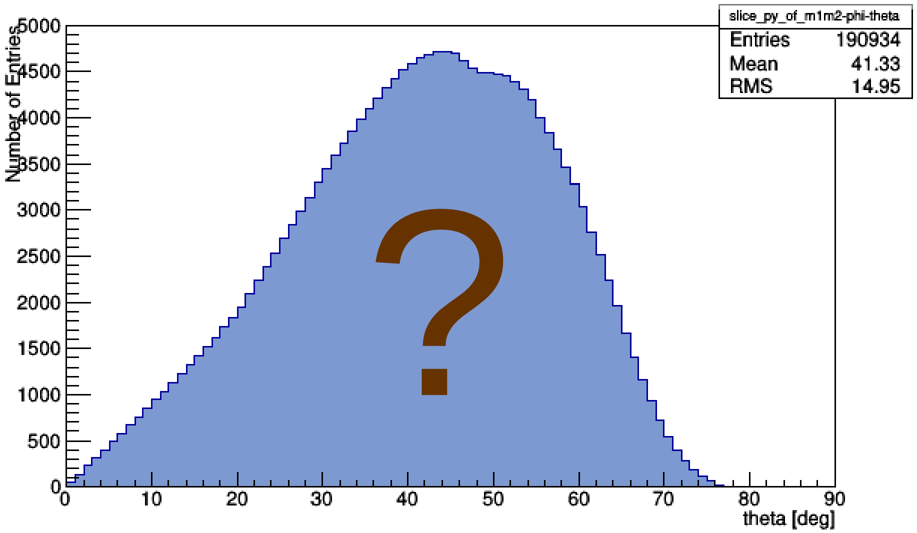


Angular distribution at LSC (5/6)

Zenith angle distributions at LSC

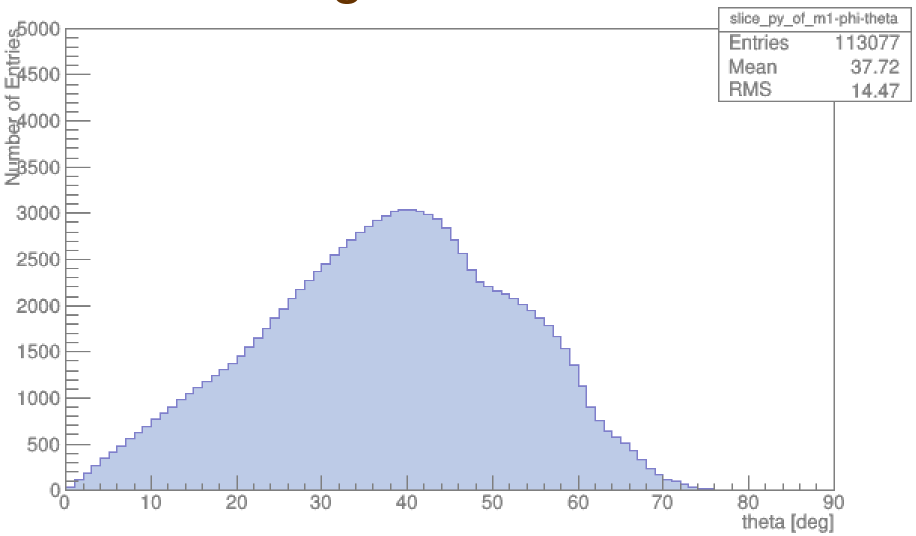


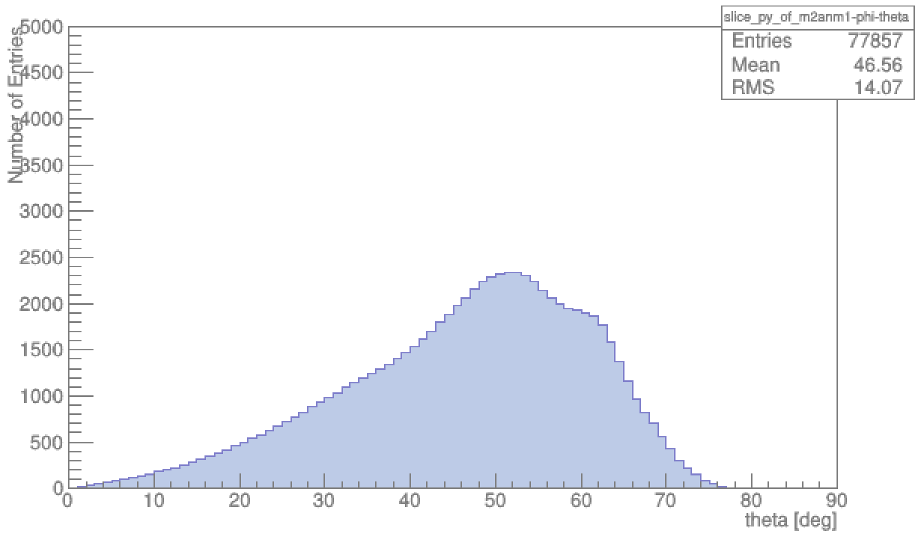




Angular distribution at LSC (6/6)

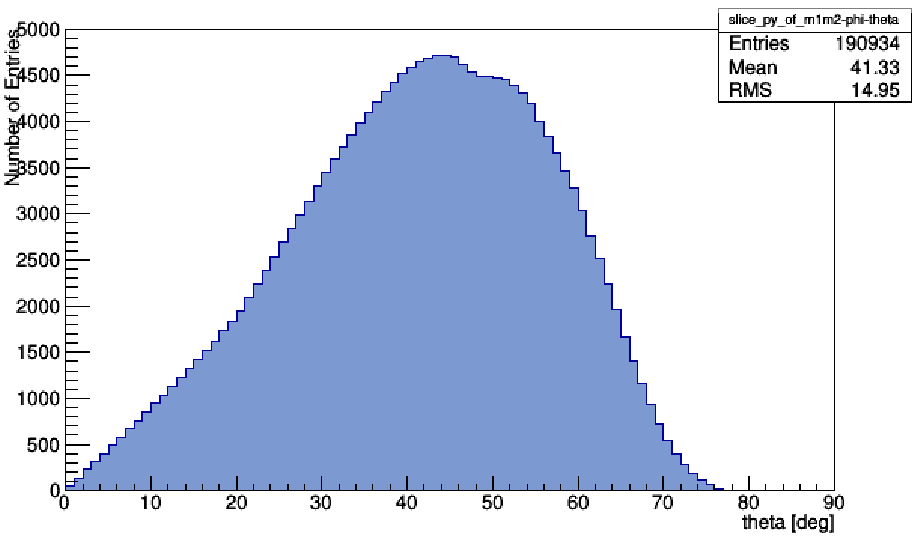
Zenith angle distributions at LSC





The following effects convolute:

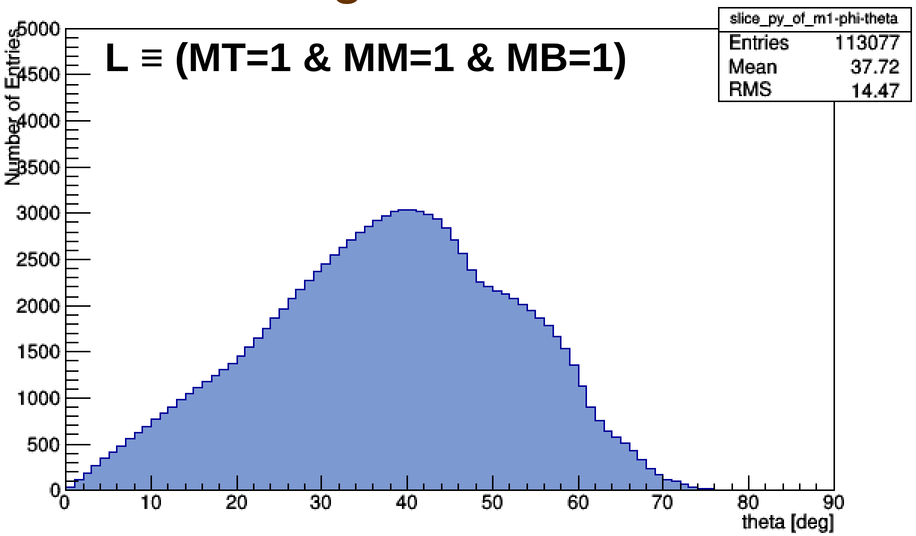
- → Shape of rock overburden
- → Density distribution of rock above
- → Inefficiencies of pixels
- → Primary cosmic-ray distribution

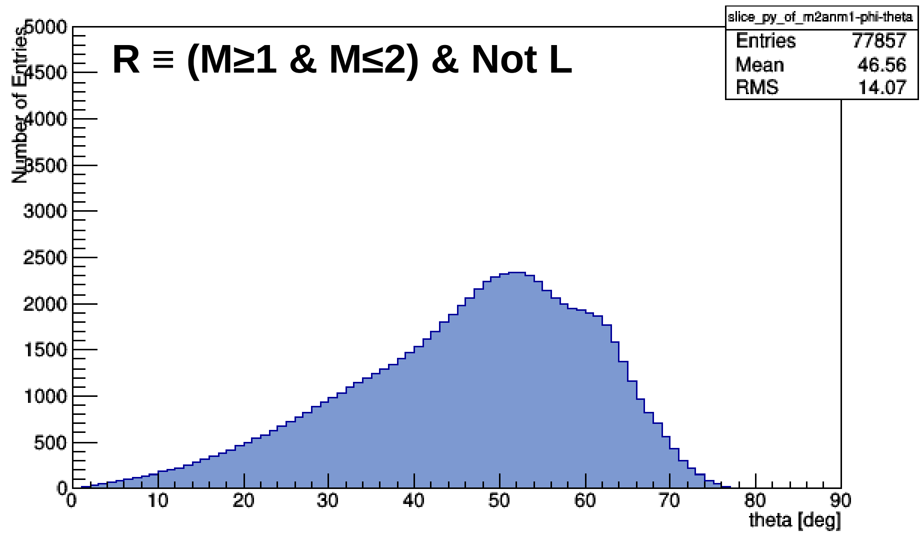


How to extract single quality?

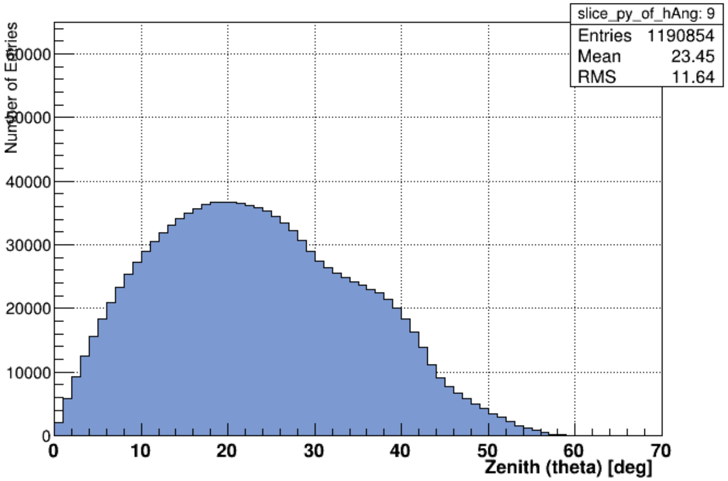
Comparison of theta distributions

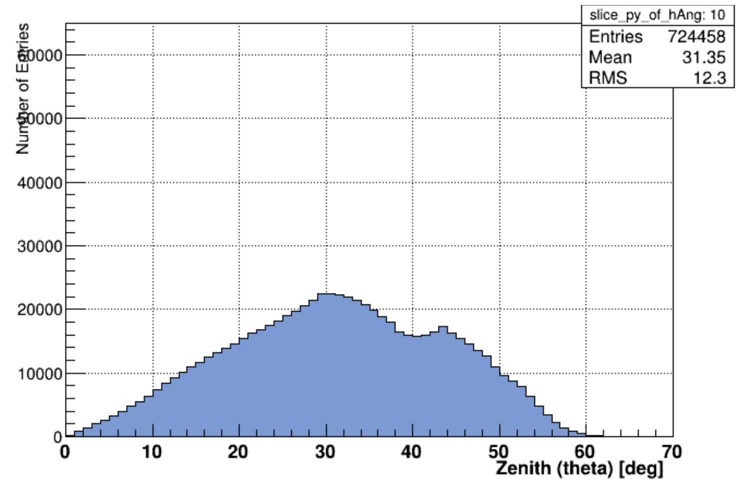
Zenith angle distributions at LSC



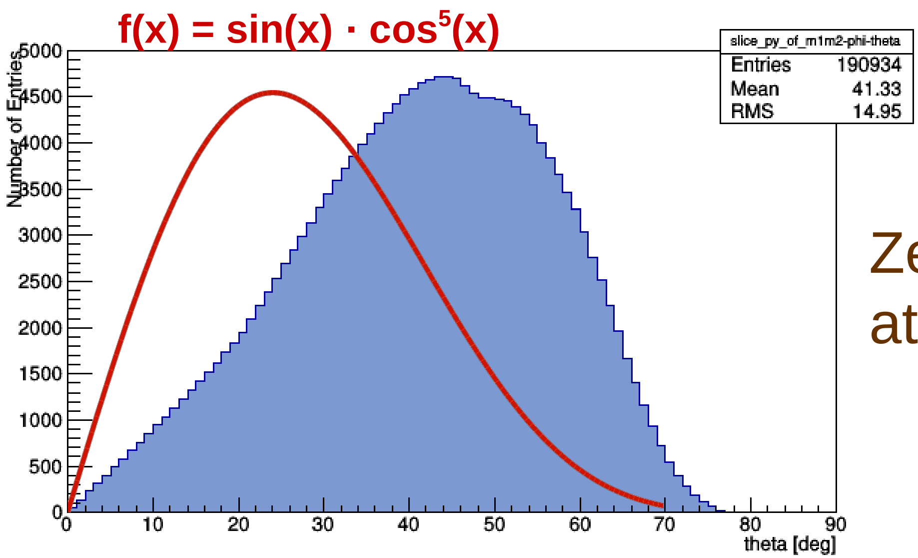


Zenith angle distributions at CUPP (EMMA level)

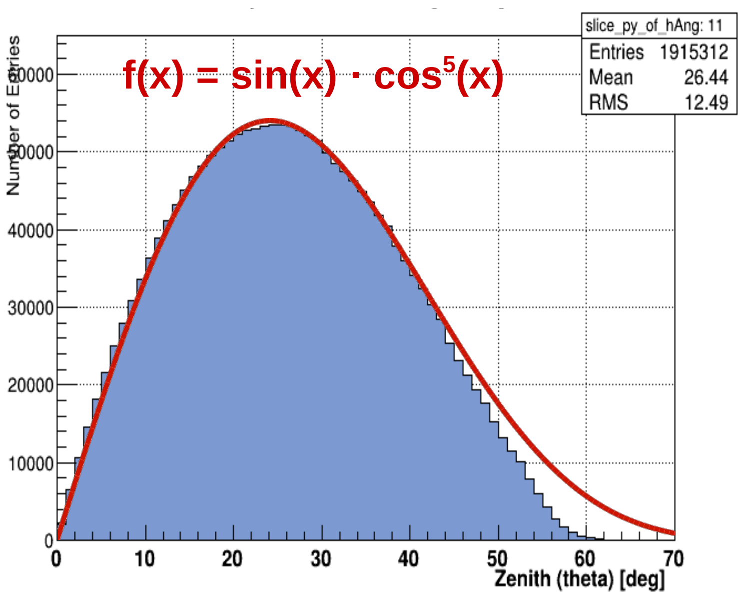




Comparison of theta distributions



Zenith angle distribution at LSC



Zenith angle distribution at CUPP (EMMA level)

Irregular zenith angle distribution:

→ **Asymmetric** rock overburden

→ Something wrong with **event selection**?

=> favouring large zenith angles?

→ Very preliminary

→ Simulation needed

=> Including (even rough **map of rock overburden**)

→ Maps, mountain cross-sections?

→ **A new task to create this map?**

=> Estimate muon energy cutoff (or m.w.e) vs. zenith angle, based on rock maps

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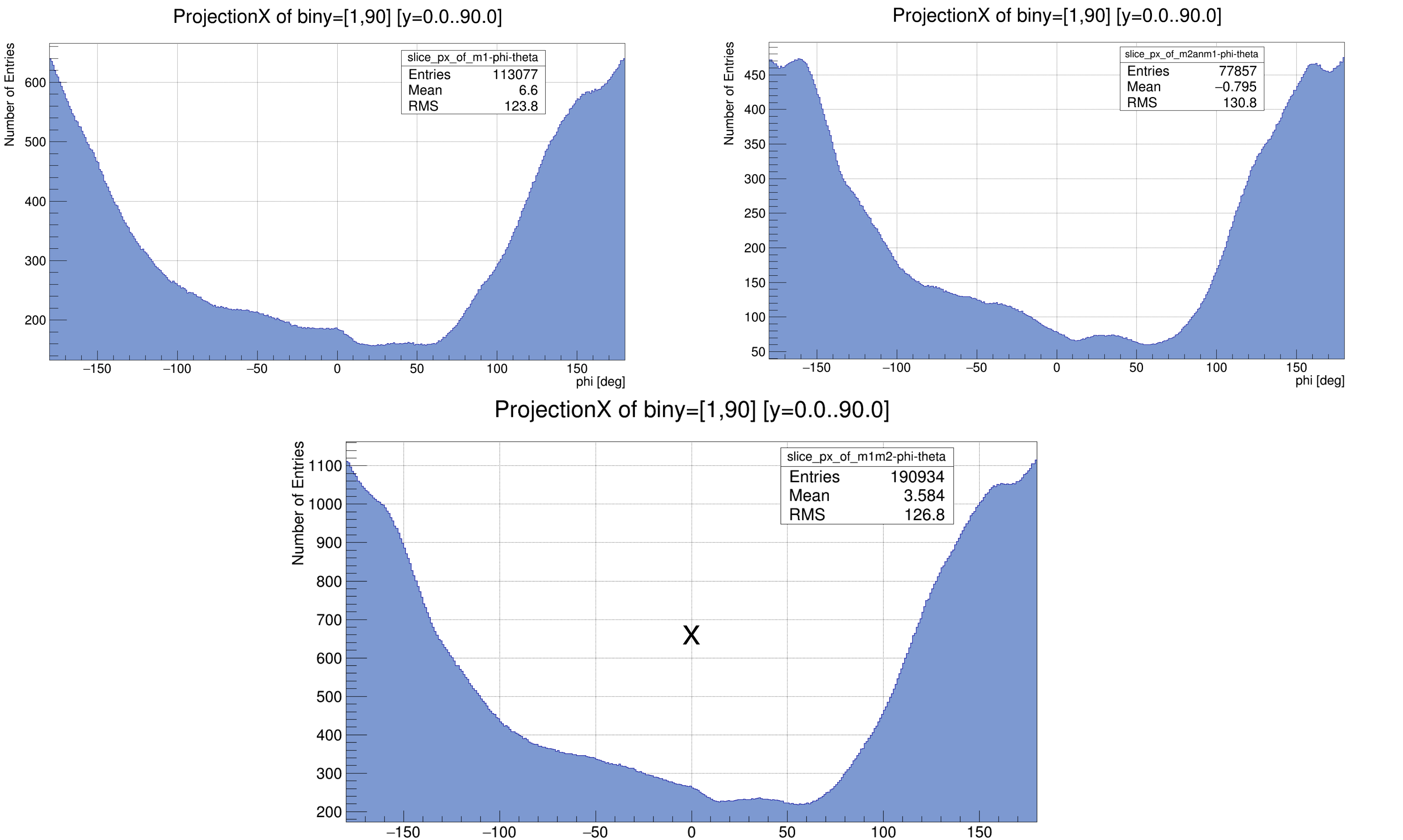
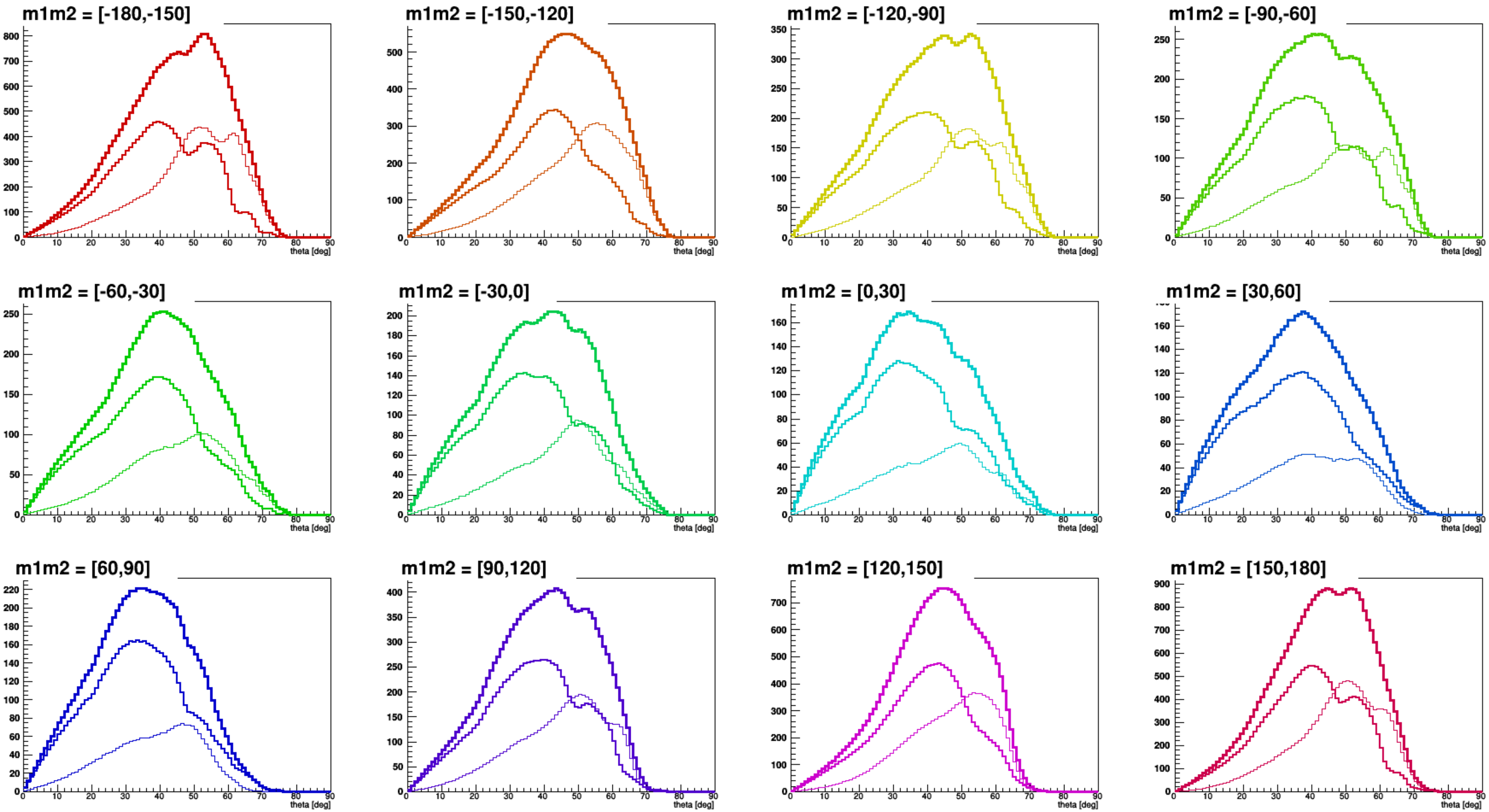
Thank you for your attention

Azimuth distributions @ LSC (X-Projections of slide 17):



Zenith distributions @ different azimuth slices (30 degrees wide)



Zenith distributions @ different azimuth slices (30 degrees wide)