Work Updates

FASER Liverpool Meeting

Pawan Johnson

January 23, 2026

Outline

- Monte Carlo Production
- HistFitter Updates for ALPs
- Four Station Tracking (IFT+Emulsion Analysis)
- Dark Photon Analysis
  - Internal Note v1 circulated
  - Parameterized Efficiencies
  - Neutrino Background
  - Two Track Systematics
  - Statistical Analysis

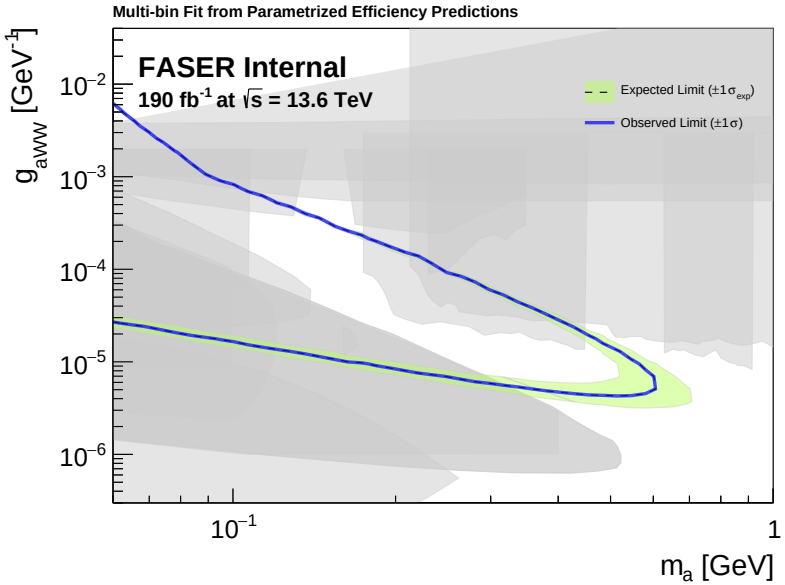
Monte Carlo Production

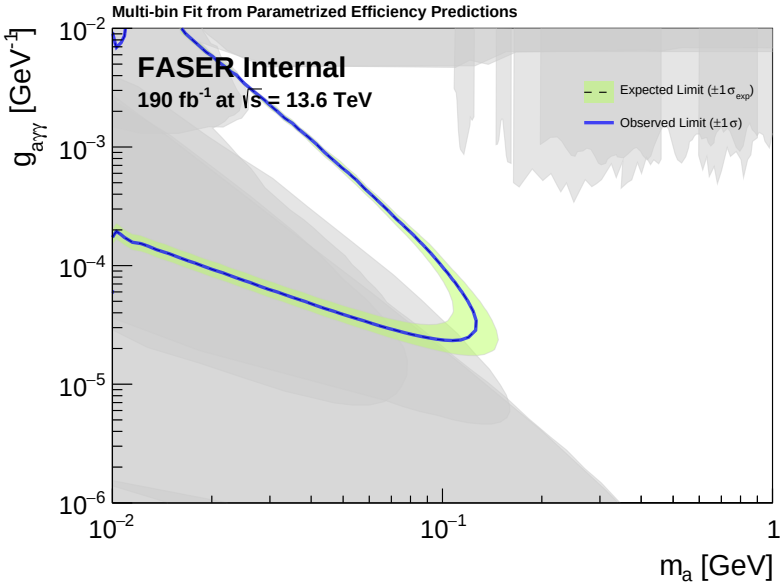
- Production going well.
- Lots of flat samples done.
- Some intial sample on ALP-LSW awaiting validation.
- Overall things going smoothly.

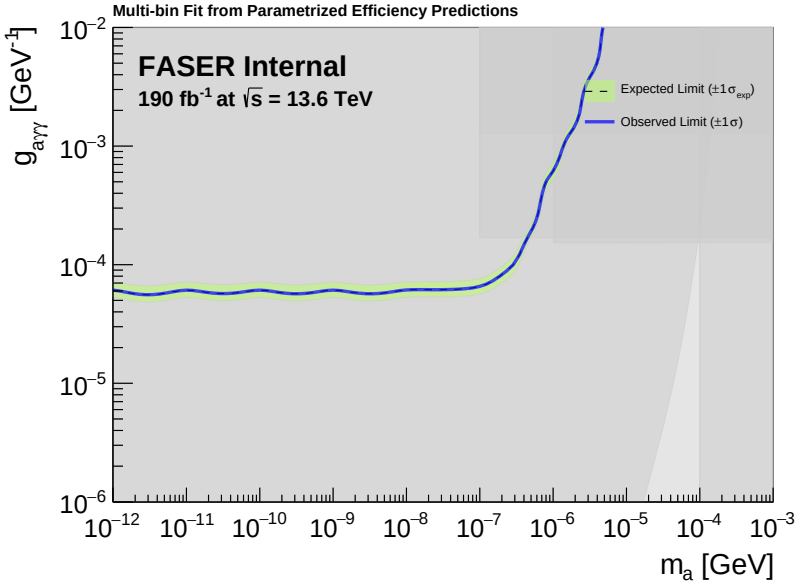
HistFitter Updates for ALPs

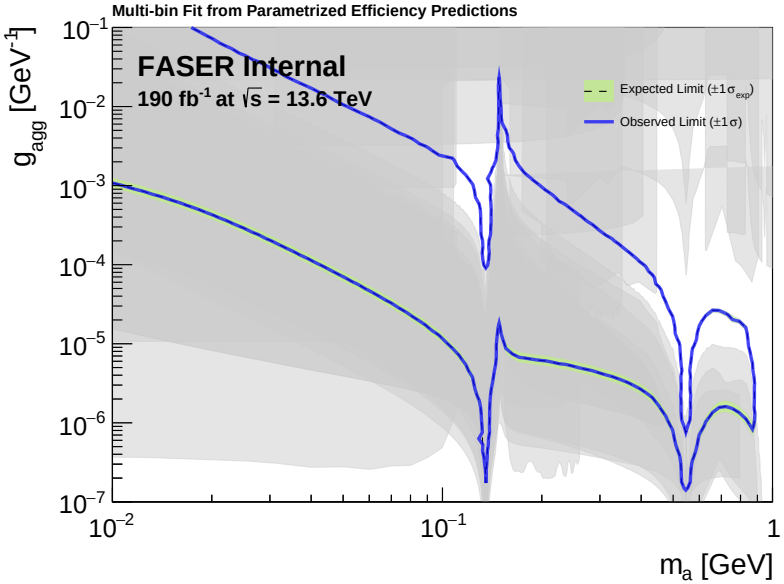
- Was my primary focus for first two weeks this year.
- Preliminary configurations done.
  - First set of plots assuming 0 bkg and no Systematics
  - This went into Internal Note
- Update since then. . .
  - Added Neutrino Background
  - Added Calo and Preshower Systematics
- Things remaining
  - Need to validate the config/inputs
  -

Preliminary Plots

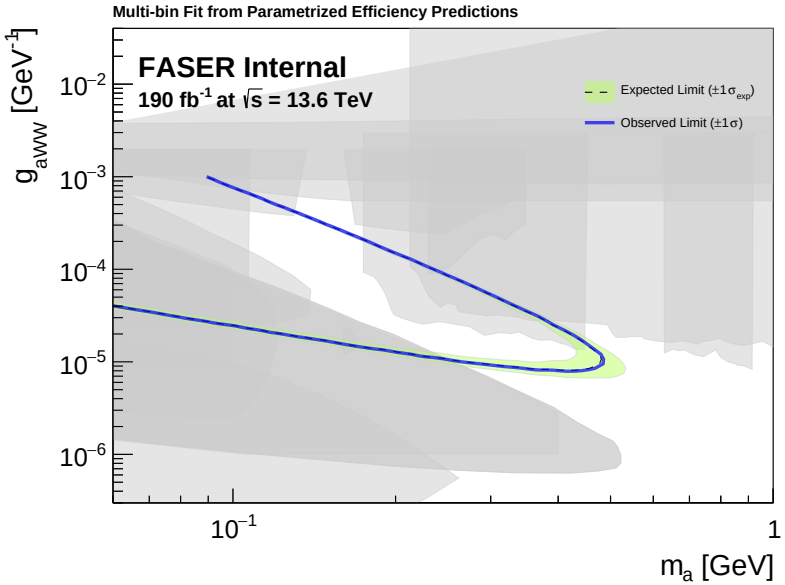


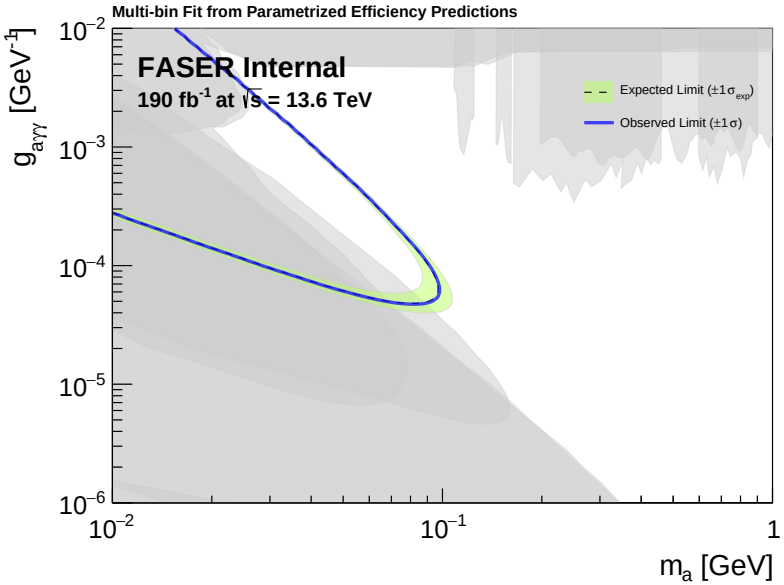


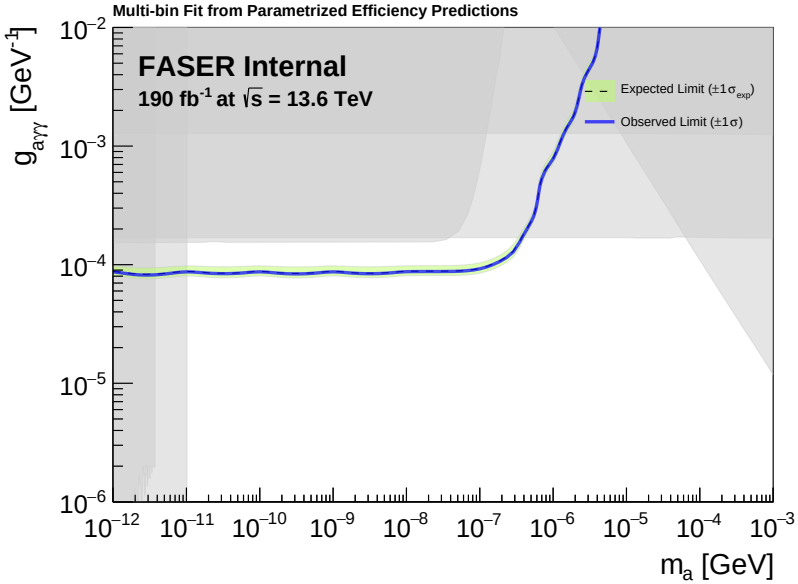


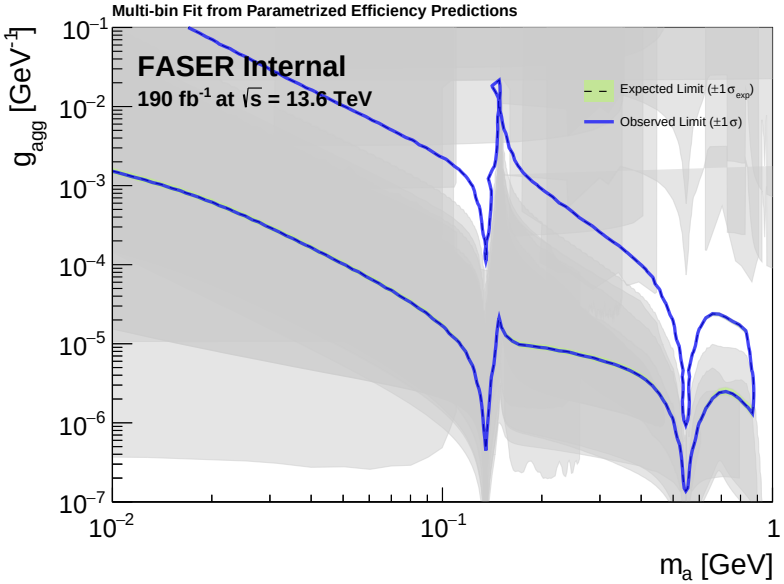


Preliminary Plots w/ Bkg. and Sys.









HistFitter for ALPs Summary

- Overall things working? (I would like to hope so)
- Needs validation both the FitConfig and maybe on the Inputs.

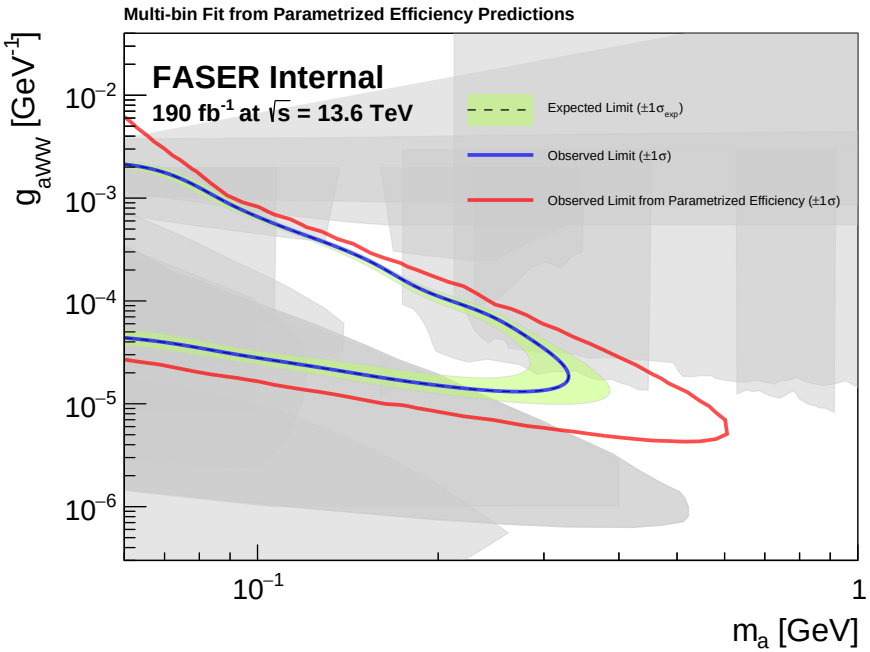
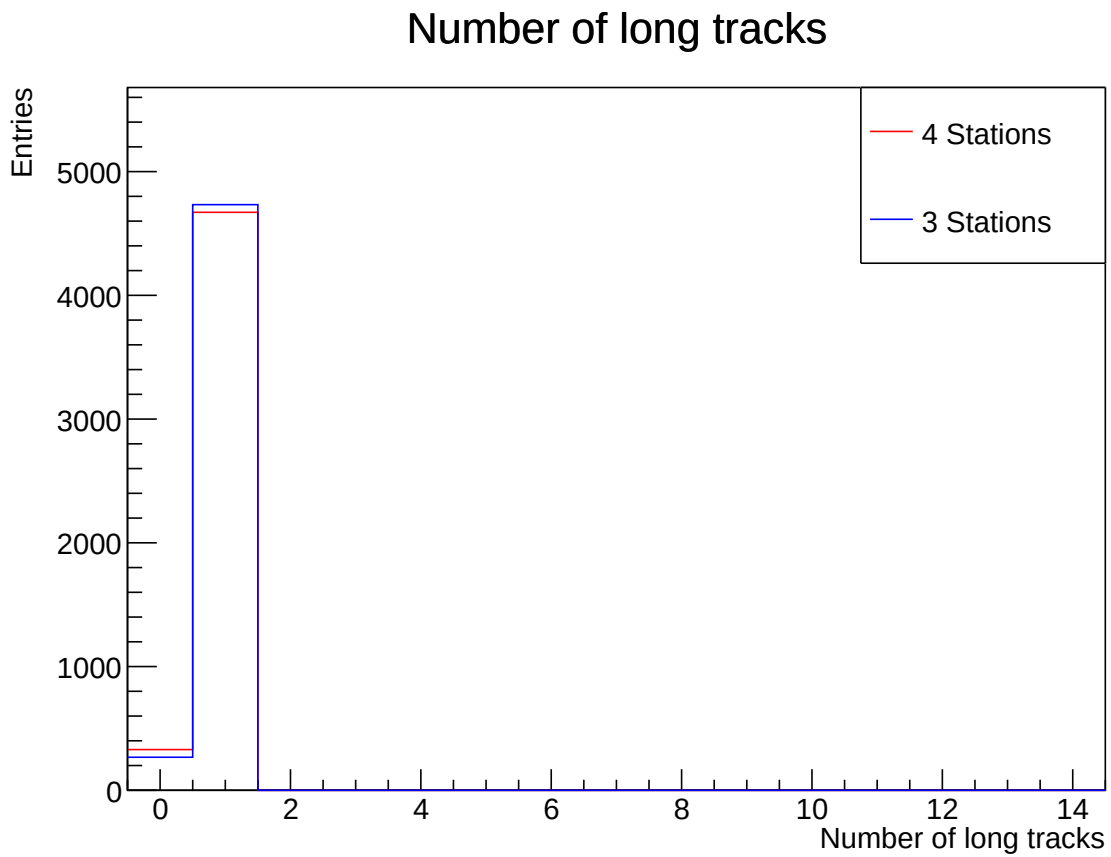


Figure: The red lines are the countours from Parameterized inputs for the multibin fit. The blue line is the contour from the mc22 data to make a contour here since the input is ntuples directly each bin becomes a Signal Region.

Four Station Tracking (for IFT+Emulsion)

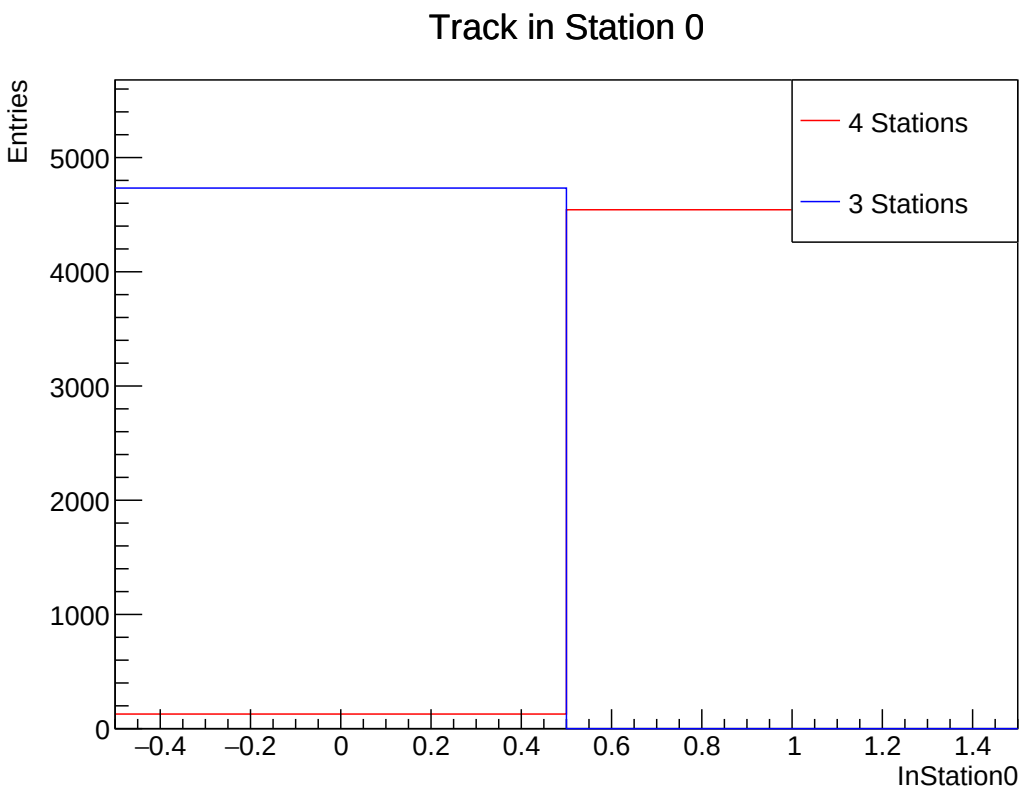
- Recap
  - We were trying to incorporate the IFT with the Tracking Spectrometer
  - In general four station tracking wasn't working as expected
- Work so far
  - Few months on debugging...
  - Turns out the ACTS tracks were fine. But the IFT hits as outliers
  - Fix was quite trivial.
  - Validation ongoing (using muon MC for now)

Four Station Validation



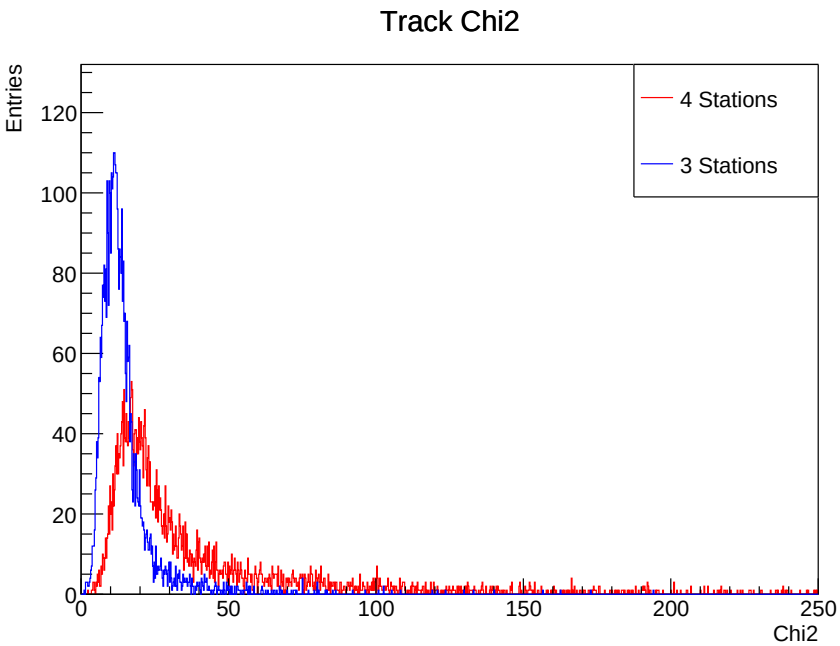
- Similar number of tracks in both NTuples (3Station vs 4Station)

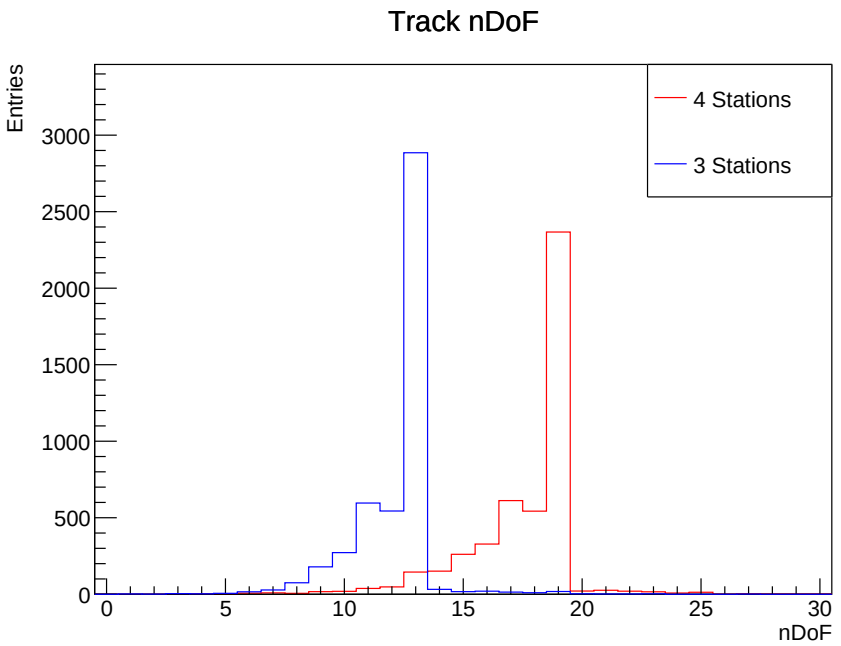
Four Station Validation



- This variable tells us if the track had a hit/cluster in station 0 (IFT)
- Most four station tracks have a hit in station 0
  - This is a known issue. We need to update the long track definition in the ntuple side
- But this could be taken as evidence that almost all the three station tracks are now being reconstructed as four station tracks

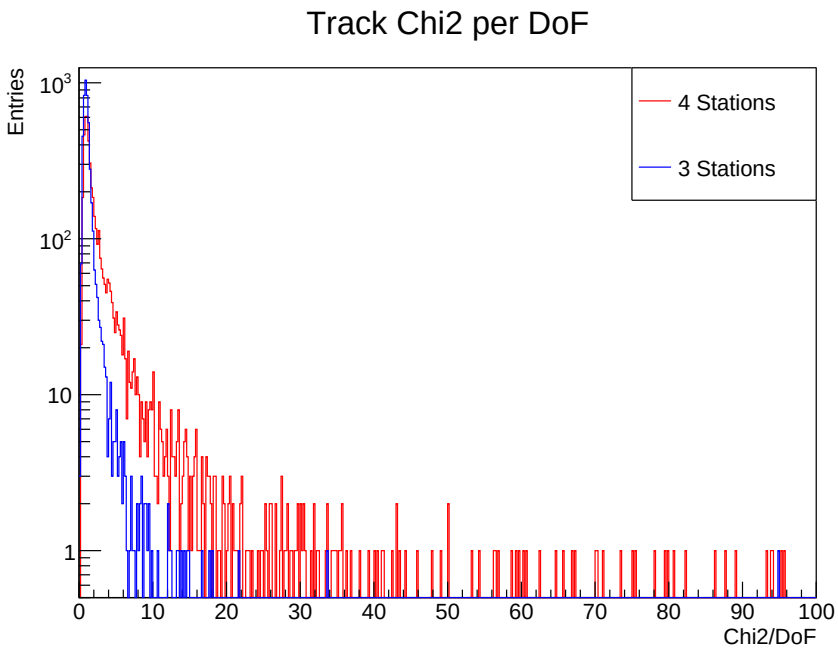
Four Station Validation

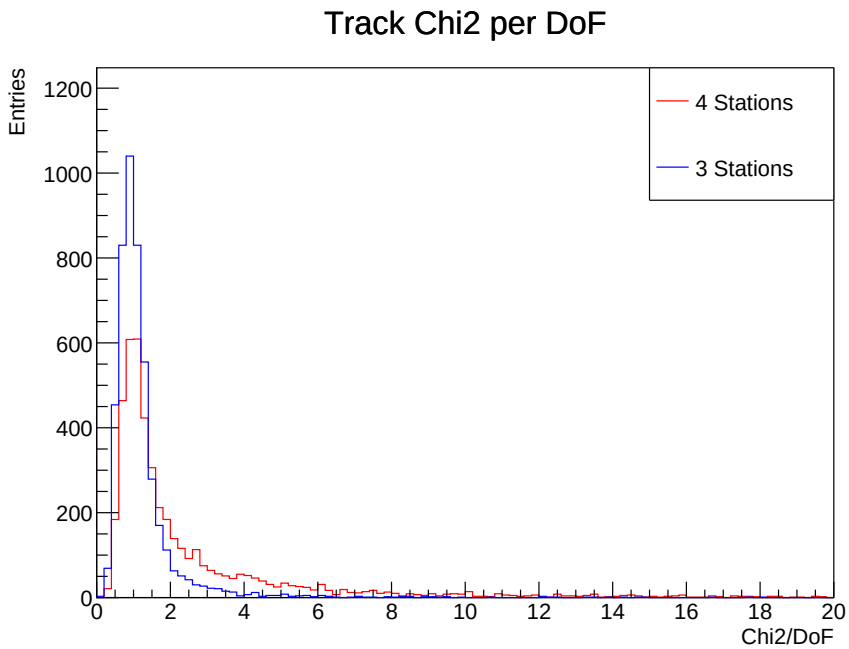




- The Chi2 for four station tracks is higher simple because it now has to fit to more measurements
- The four station tracks gain 6 measurements as expected

Four Station Validation





- Was hoping that the Chi2/DoF would be better for the four station tracks...
- Unfortunately doesn't seem to be the case.

Summary Four Station Tracking

- Things seems okay for MC.*
  - Only backward tracking been tested for now on muon MC
- Oscar checking alignment – seems okay.
- Needs the fix to be merged to master
- Need to perform check on data and forward tracking.
- Next Steps
  - Tomo wants to show improvement in momentum reconstruction and charge identification
  - Hoping once we have that we can present in a Physics meeting

Summary of IFT+Emulsion anlysis

- I think we decided on a list of common events on a specific neutrino MC
- FaserNu shared their “data” and “eventList”
- Idea is to look at the same events on the electronic side to see if they match?
- But in principle they will match anyway since G4 will simulate the underlying particle continously from Emulsion to electronic detector?
- Is there a better way to do this in MC?
- Anyway lots of things happening here...

Dark Photon Analysis

- Internal note submitted.
- Work pending on my end
  - Parameterized Efficiencies
  - Neutrino Systematics
  - 2 Track Systematics
  - Statistical Analysis

Parameterized Efficiencies

- With Ansh's help (uproot Analysis) we got the histograms
- I performed the final fits.
- Passed the fits to Felix to get predictions from FORESEE
- So the output format is same as output format for the ALPs predictions
  - I could use the ALPs HistFitter code directly... No changes needed
  - Again possible question of MultiBin vs MultiSR

Preliminary Exclusion from Parameteriztion

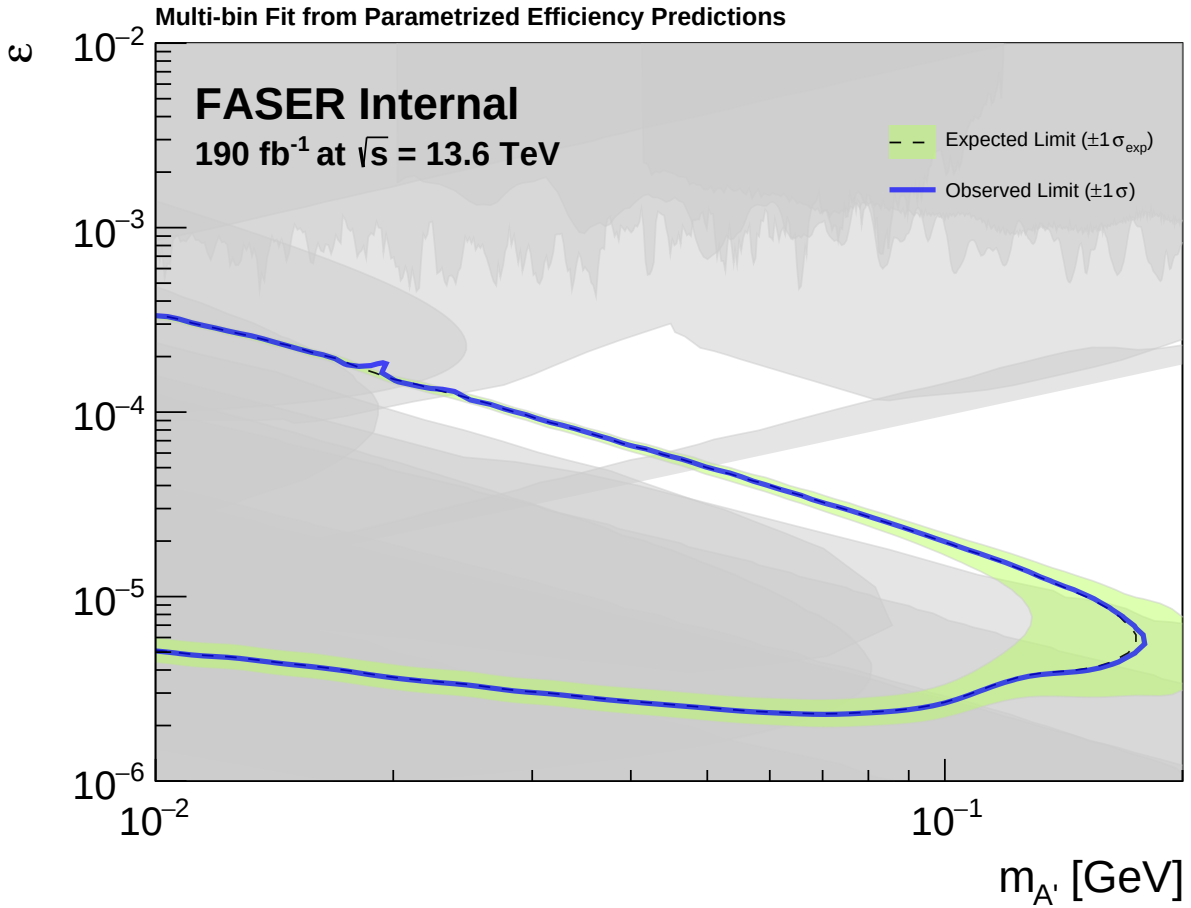


Figure: Again this is assuming zero Background and no Systematics

Preliminary Exclusion from Parameteriztion

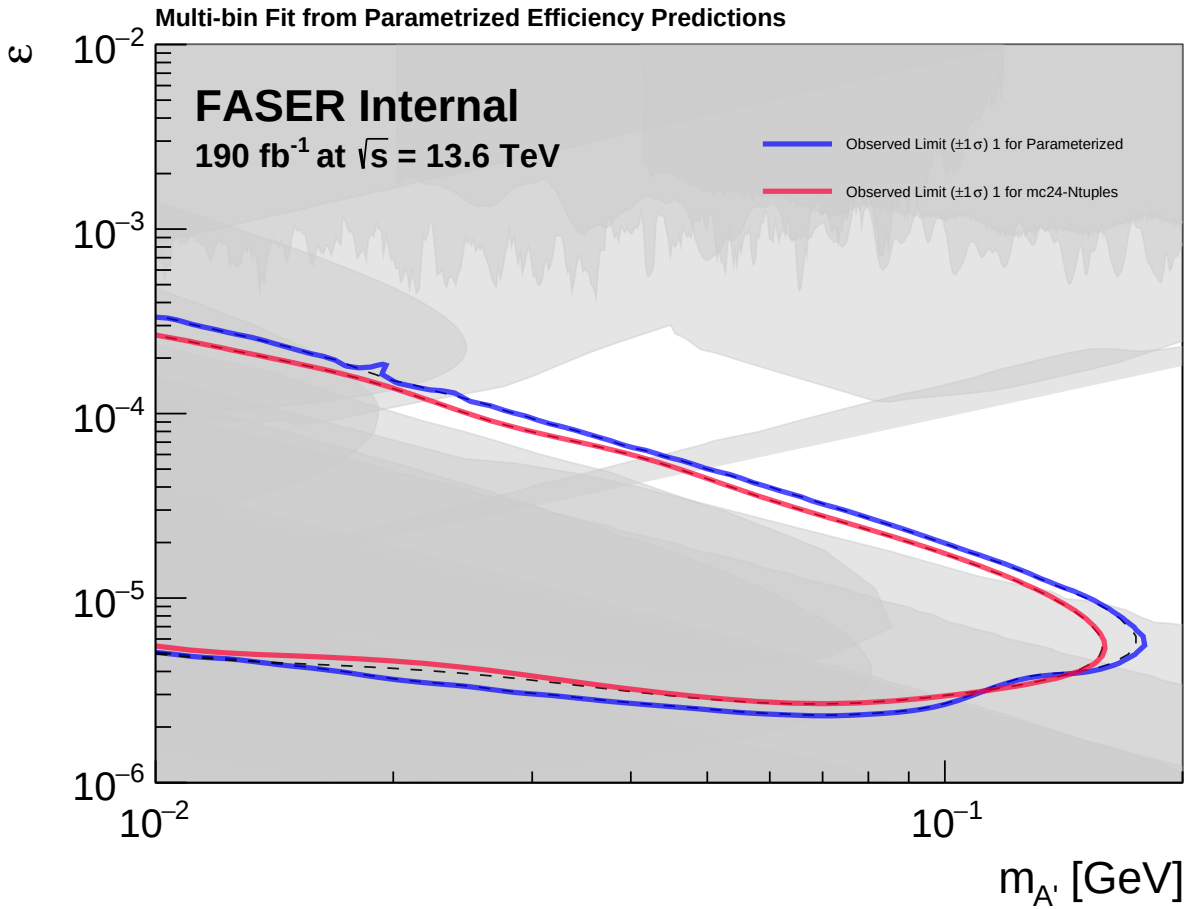
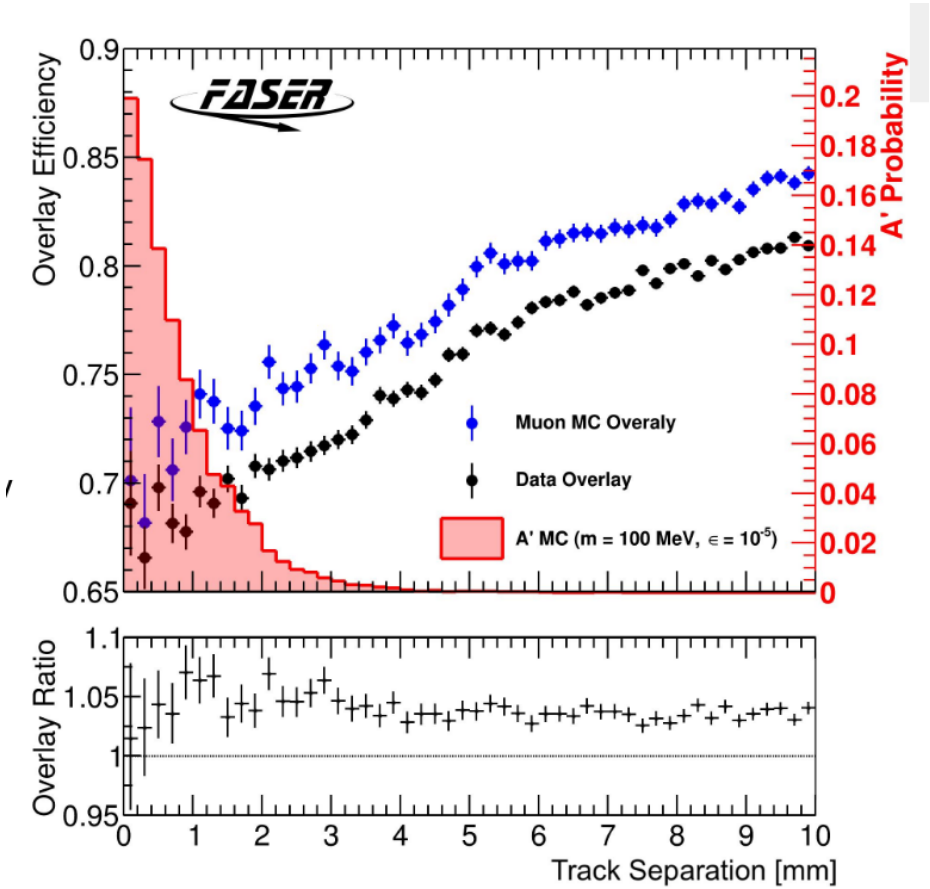


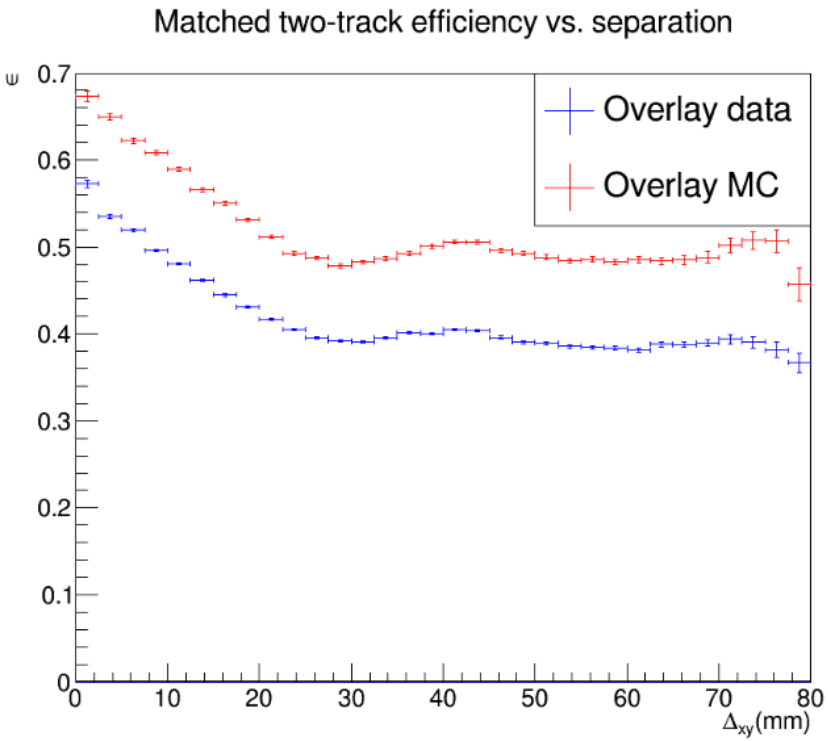
Figure: Again this is assuming zero Background and no Systematics. And doing a multibin fit for the Parameterized inputs while doing a multi SR fit for the mc24 Ntuples...

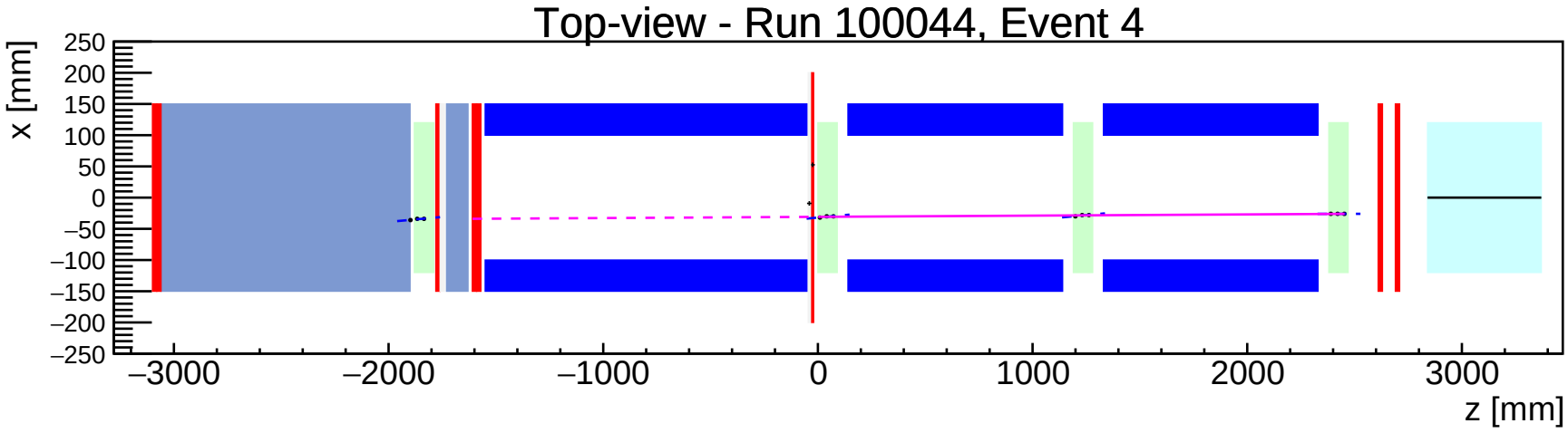
- They match a little too well.

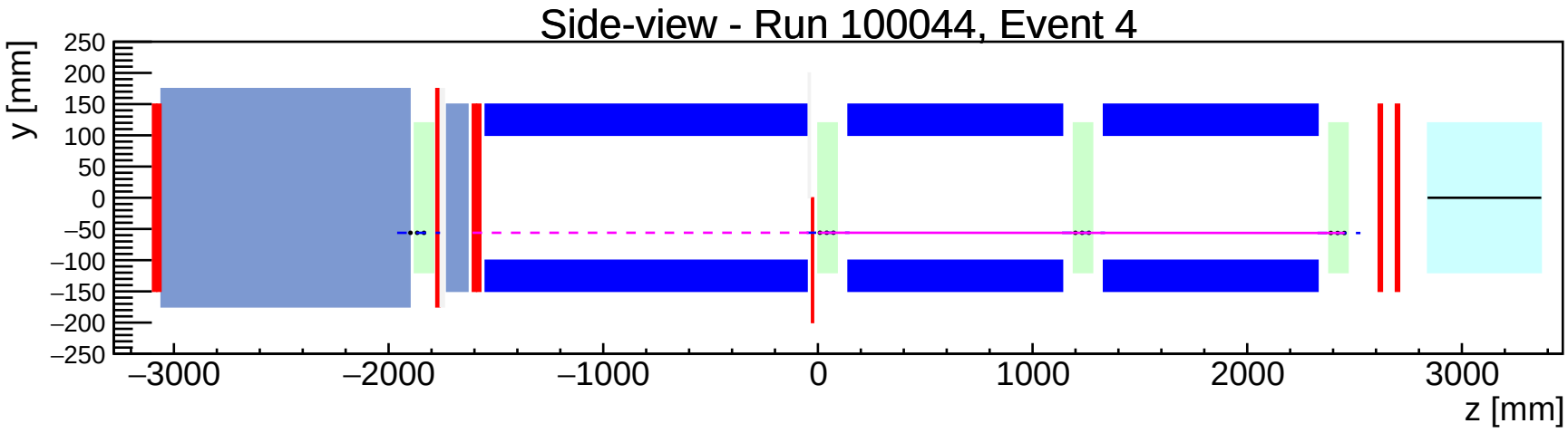
Two Track Overlay

- Idea is to reproduce the old two track efficiencies
- Works by creating a two track event by merging two one track events









#SPs=3
#Seg=1

0.8pC
0.8mV
nanns
stat=1

#SPs=3
#Seg=1

#SPs=3
#Seg=1

#SPs=3
#Seg=1

0.3pC
0.9mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

0.3pC
0.9mV
nanns
stat=1

117.1pC
234.8mV
nanns
stat=0

p0=1340.0 GeV, χ^2/nDof=9.8/13, 9 layers

4.8pC
13.3mV
nanns
stat=0

0.5pC
1.0mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

191.5pC
383.9mV
nanns
stat=0

24.8pC
89.1mV
nanns
stat=0

4.5pC
12.2mV
nanns
stat=0

0.5pC
0.9mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

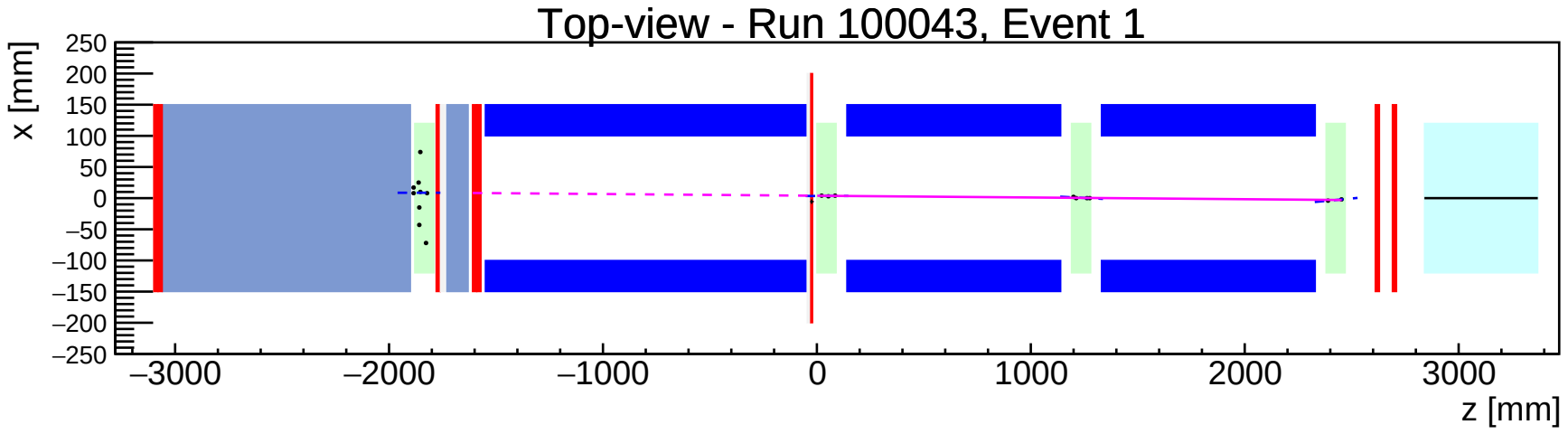
24.7pC
89.4mV
nanns
stat=0

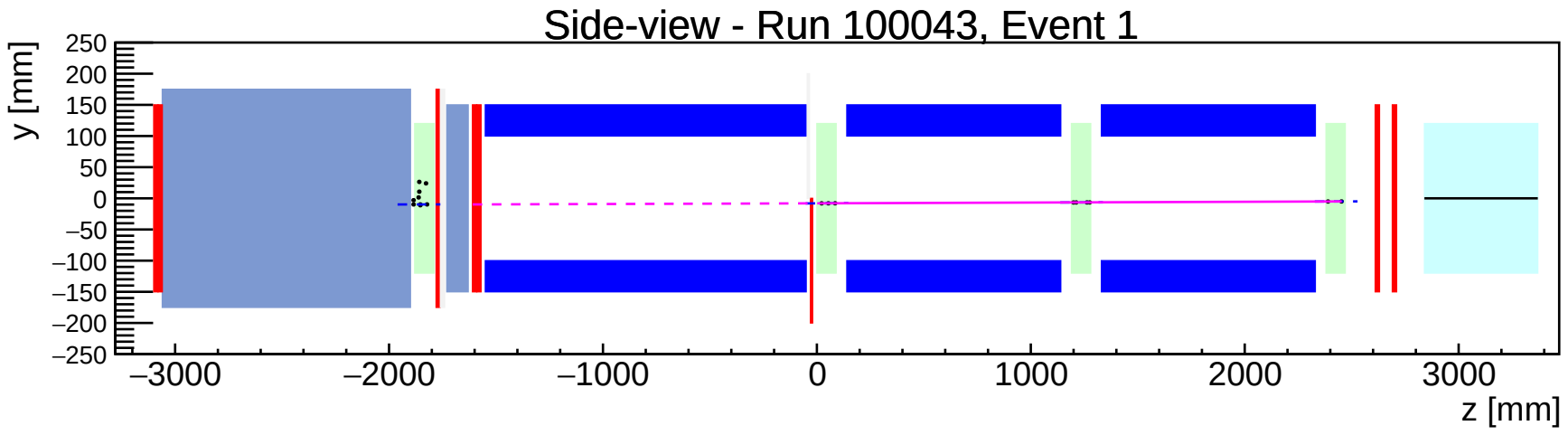
0.7pC
1.1mV
nanns
stat=1

Calo: 9.3 GeV

Truth: P=1354.5 GeV

Truth: PDG=-13





#SPs=9
#Seg=1

0.7pC
0.8mV
nanns
stat=1

#SPs=3
#Seg=1

#SPs=4
#Seg=1

#SPs=2
#Seg=1

0.5pC
0.9mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

0.4pC
0.8mV
nanns
stat=1

362.6pC
724.4mV
nanns
stat=0

p0=-1942.9 GeV, χ^2/nDof=17.6/15, 9 layers

4.1pC
11.3mV
nanns
stat=0

0.3pC
0.7mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

317.8pC
634.4mV
nanns
stat=0

26.3pC
95.9mV
nanns
stat=0

6.1pC
16.4mV
nanns
stat=0

0.4pC
1.3mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

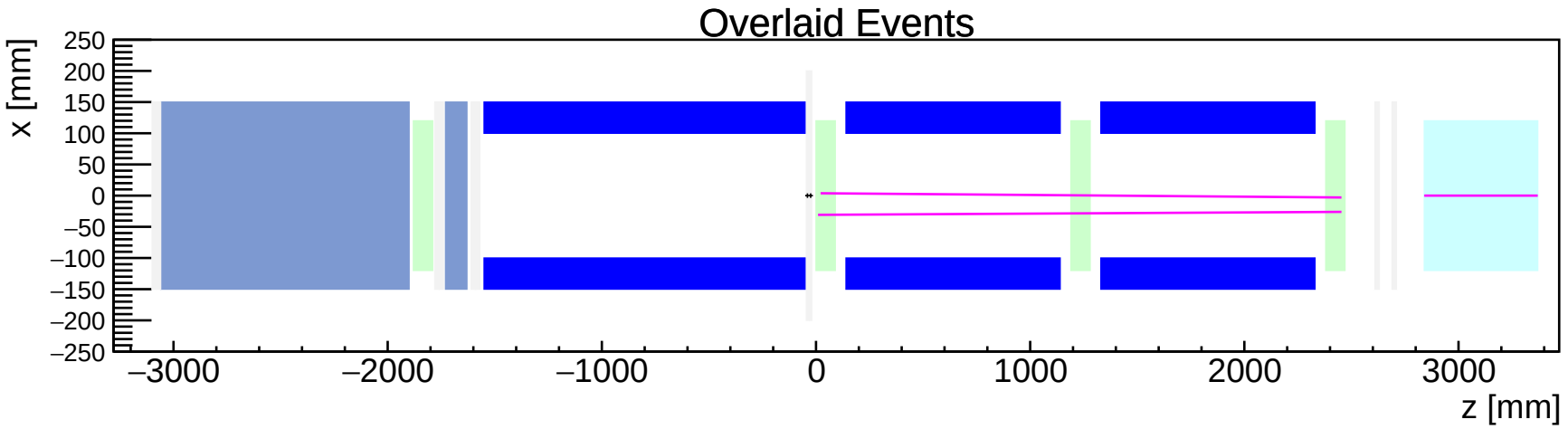
26.6pC
96.3mV
nanns
stat=0

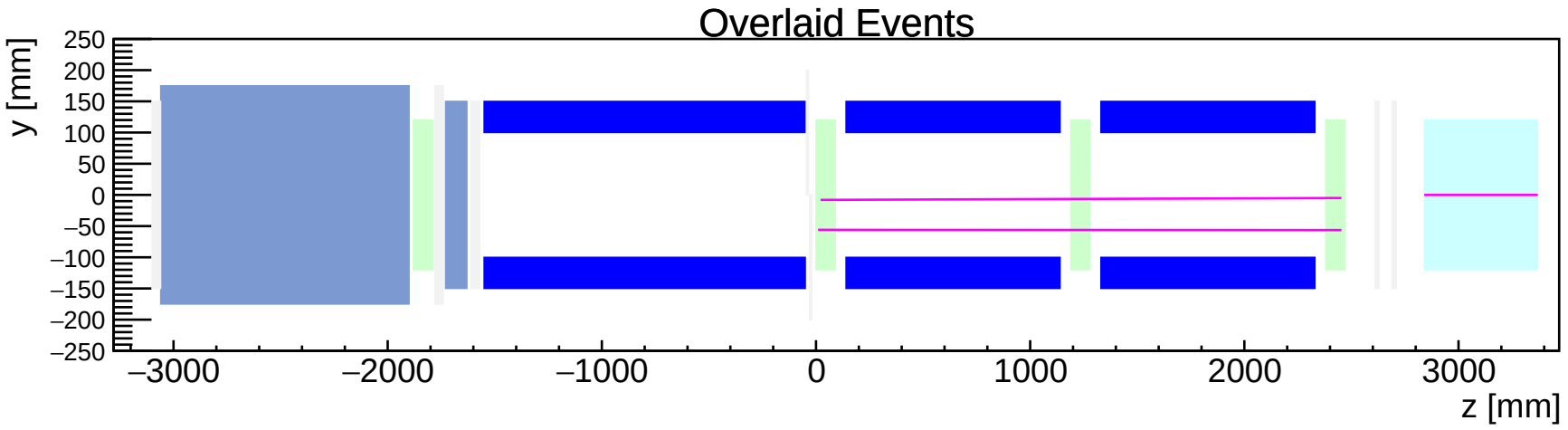
Calo: 8.4 GeV

Truth: P=1339.8 GeV

Truth: PDG=13

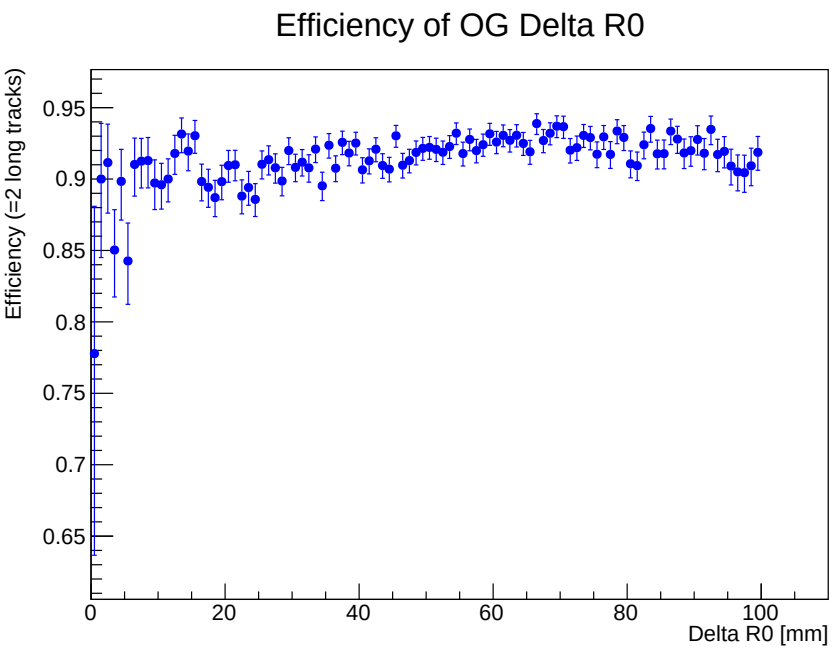
0.6pC
0.9mV
nanns
stat=1

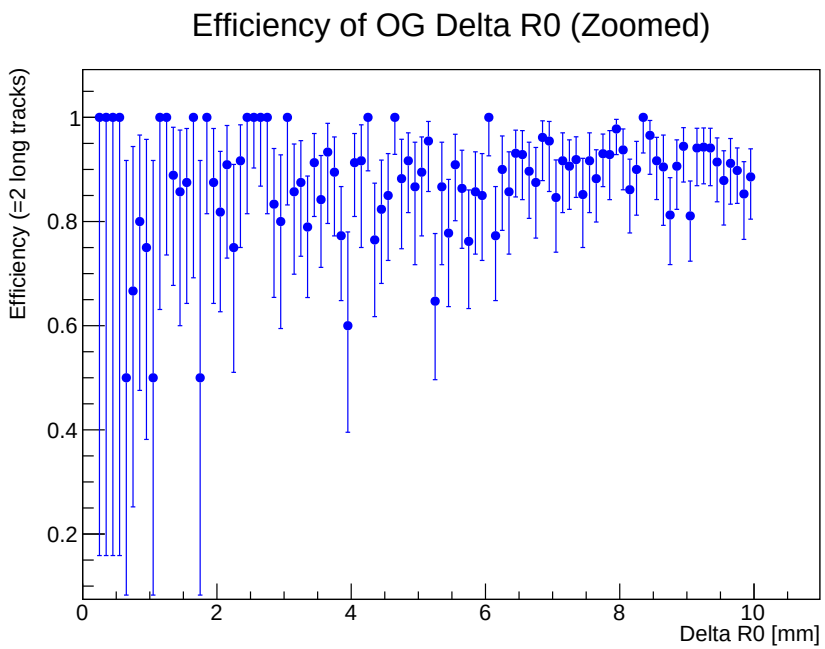




x0=3.8, y0=-8.0
x0=-30.8, y0=-56.0

My attempts ...


Efficiency of OG Delta R0
Efficiency (=2 long tracks)
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0
20
40
60
80
100
Delta R0 [mm]


Efficiency of OG Delta R0 (Zoomed)
Efficiency (=2 long tracks)
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
Delta R0 [mm]

Validation Steps?

- Some major differences are that we don't see a gradual rise.
- Our efficiency plateau's at 94% rather than 80%
- Could be that we got the code wrong
  - Unlikely, I didn't change much of the underlying algorithms
  - Partially can be attributed to efficiency definition differences
- If we want to redo the previous one exactly for Validation
  - We need to know which run was used previously (most likely 009166 [r0013])
  - This release no longer exists... To redo exactly we would have to re-reco this run on a centos7 machine/container
  - Would be work. Do we want to do this? (Assuming we have the raw data?)
- We also need to do the muon MC for the same

Discussion from the Analysis Meeting

- We don't want a full validation.
- As long as we can explain the increase in efficiencies.
- We want to use the exiting muon samples for the muon MC
  - Tried doing this...
  - Turns out the code does not work too well with MC
  - So how did we do it last time
- For data, I was asked to come up with a list of runs proportional to the lumi of the years to perform the overlay.

Year	Luminosity (ifb)	Lumi/TotalLumi	Runs to use for overlay	Lumi of Run (ipb)	Lumi/TotalLumi
2022	27	0.15194147439504785	8749	108.9	0.1434593597681465
2023	30.7	0.172763083849184	10698	116.5	0.15347121591358187
2024	120	0.6752954417557682	15391	533.7	0.7030694243182717
Total	**177.7**	**1**		**759.1**	**1**

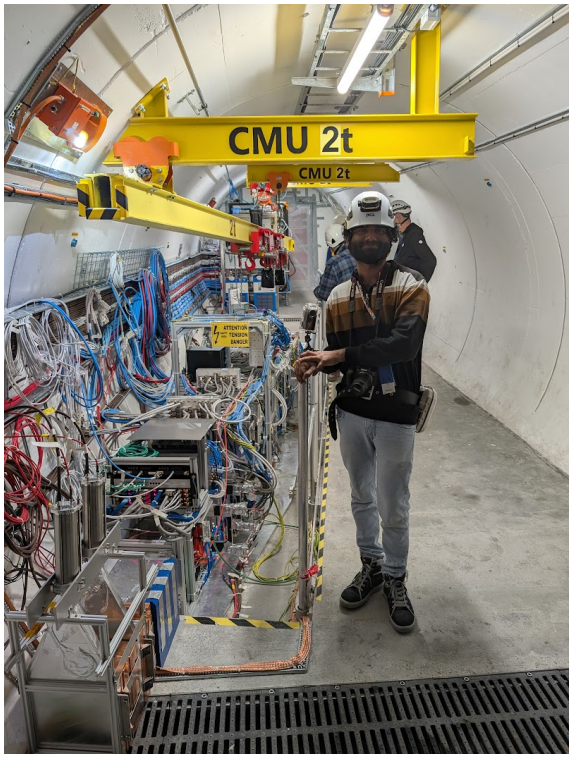
- Qn. Concerns on accidental unblinding?

Dark Photon Analysis Summary

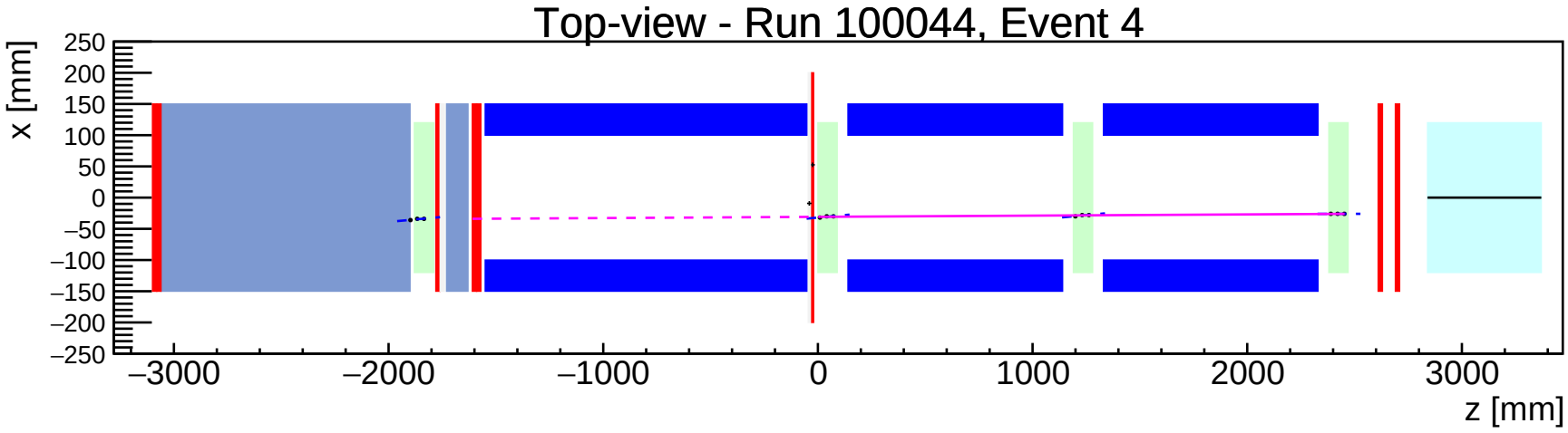
- Things picking up pace.
- Parameterized mostly done on my end
  - Validation to be done
  - Need to do two track case
- Major things remaining
  - Neutrino Background Systematics
  - Overlay studies
  - Statistical Analysis

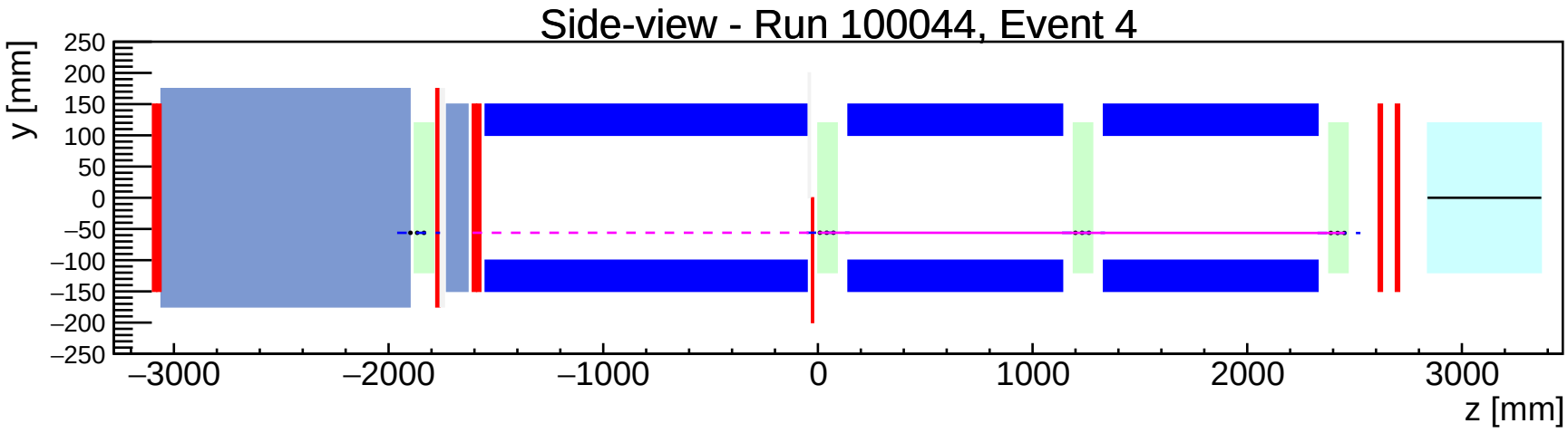
Summary

- Things going well..
- ALPs haven't mentioned anything else they need on statistics end
- Dark Photon Analysis speeding up
- Do we want to do something vis-a-vis the Preshower Software
- Visited FASER last week



Backup





#SPs=3
#Seg=1

0.8pC
0.8mV
nanns
stat=1

#SPs=3
#Seg=1

#SPs=3
#Seg=1

#SPs=3
#Seg=1

0.3pC
0.9mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

0.3pC
0.9mV
nanns
stat=1

117.1pC
234.8mV
nanns
stat=0

p0=1340.0 GeV, χ^2/nDof=9.8/13, 9 layers

4.8pC
13.3mV
nanns
stat=0

0.5pC
1.0mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

191.5pC
383.9mV
nanns
stat=0

24.8pC
89.1mV
nanns
stat=0

4.5pC
12.2mV
nanns
stat=0

0.5pC
0.9mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

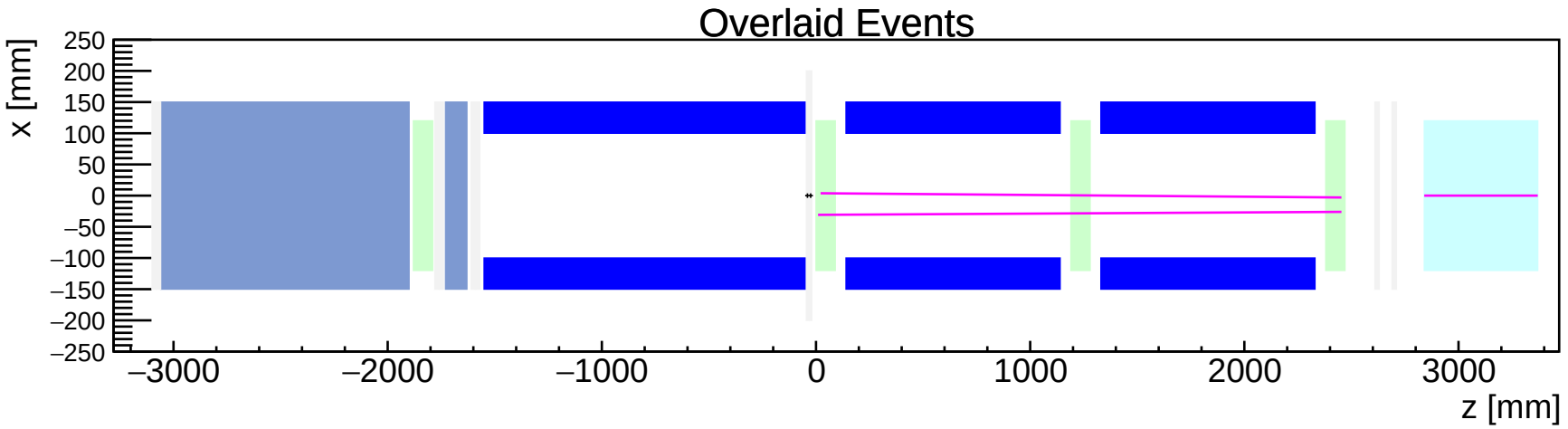
24.7pC
89.4mV
nanns
stat=0

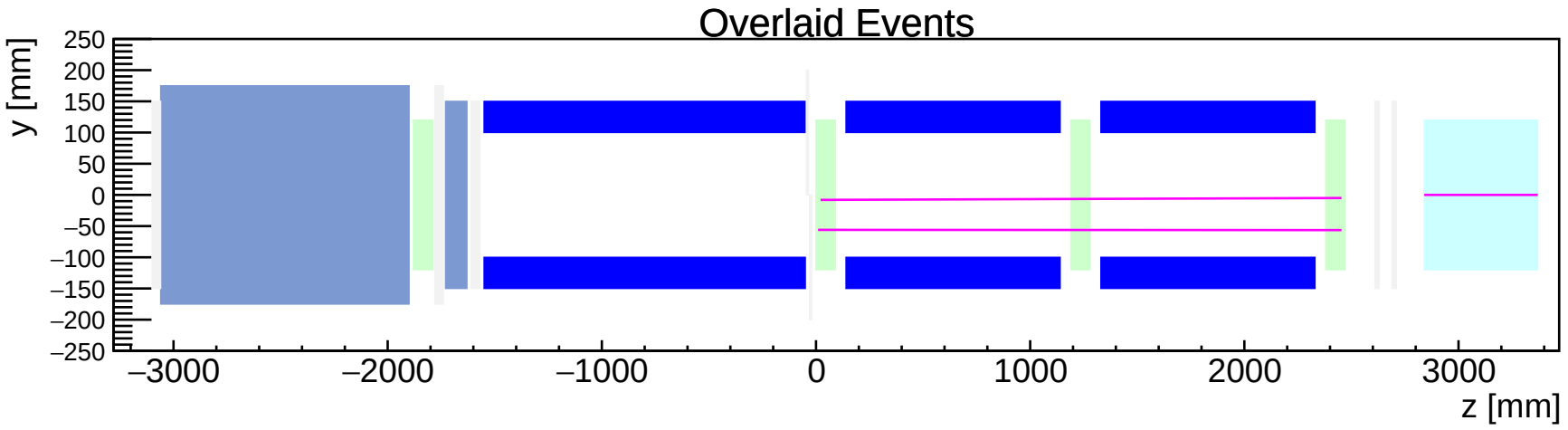
0.7pC
1.1mV
nanns
stat=1

Calo: 9.3 GeV

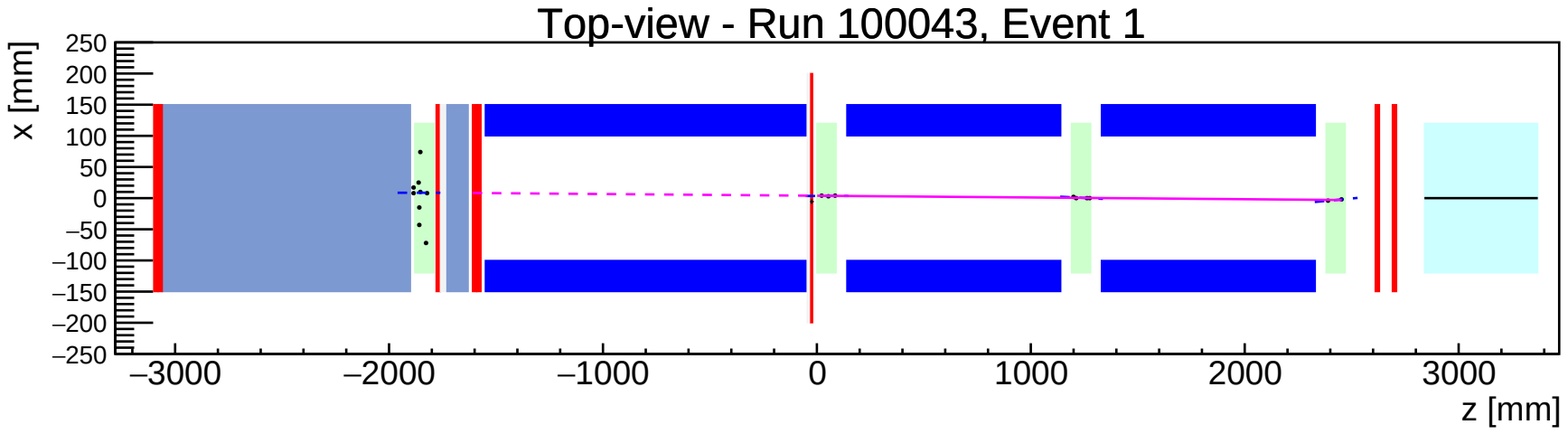
Truth: P=1354.5 GeV

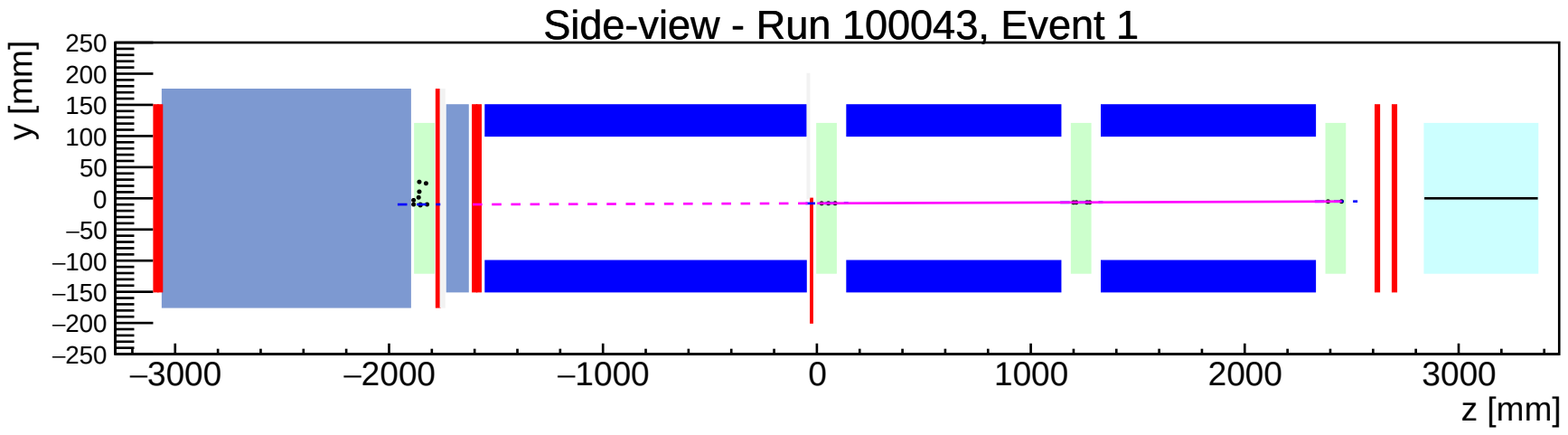
Truth: PDG=-13





x0=3.8, y0=-8.0
x0=-30.8, y0=-56.0





#SPs=9
#Seg=1

0.7pC
0.8mV
nanns
stat=1

#SPs=3
#Seg=1

#SPs=4
#Seg=1

#SPs=2
#Seg=1

0.5pC
0.9mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

0.4pC
0.8mV
nanns
stat=1

362.6pC
724.4mV
nanns
stat=0

p0=-1942.9 GeV, χ^2/nDof=17.6/15, 9 layers

4.1pC
11.3mV
nanns
stat=0

0.3pC
0.7mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

317.8pC
634.4mV
nanns
stat=0

26.3pC
95.9mV
nanns
stat=0

6.1pC
16.4mV
nanns
stat=0

0.4pC
1.3mV
nanns
stat=1

nanpC
nanmV
nanns
stat=nan

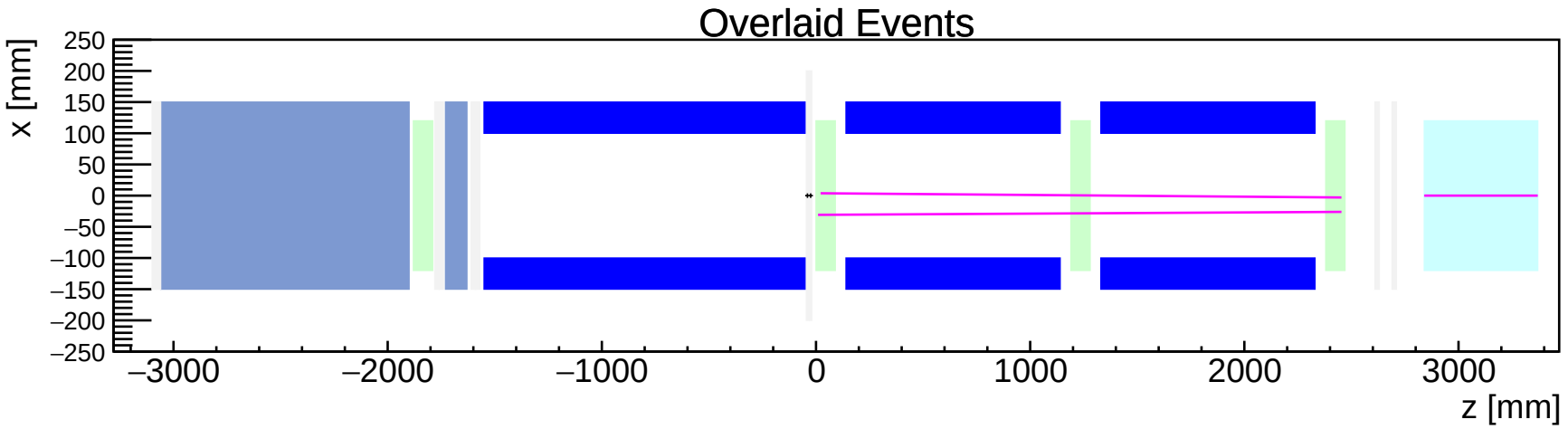
26.6pC
96.3mV
nanns
stat=0

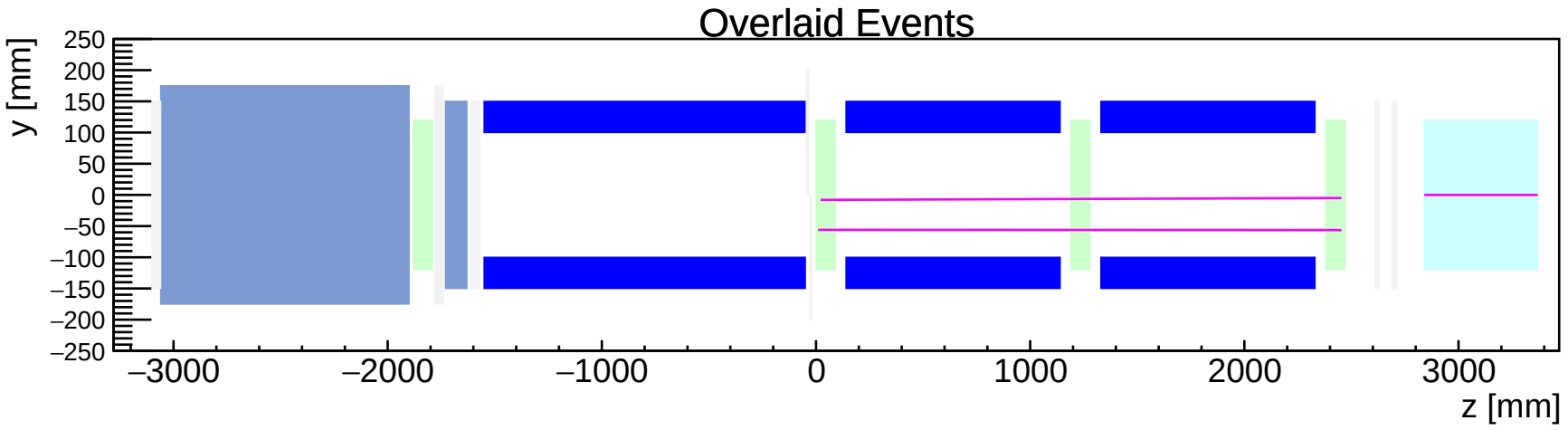
Calo: 8.4 GeV

Truth: P=1339.8 GeV

Truth: PDG=13

0.6pC
0.9mV
nanns
stat=1





x0=3.8, y0=-8.0
x0=-30.8, y0=-56.0