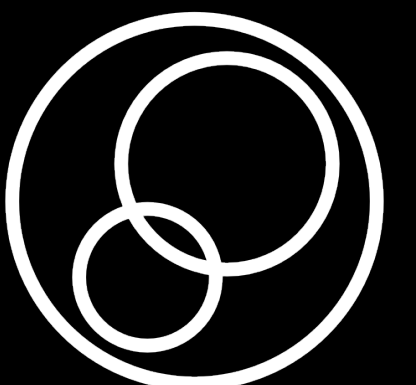




investigation of the  
**BIB BUG**

Tova Holmes  
University of Tennessee, Knoxville



USMCC

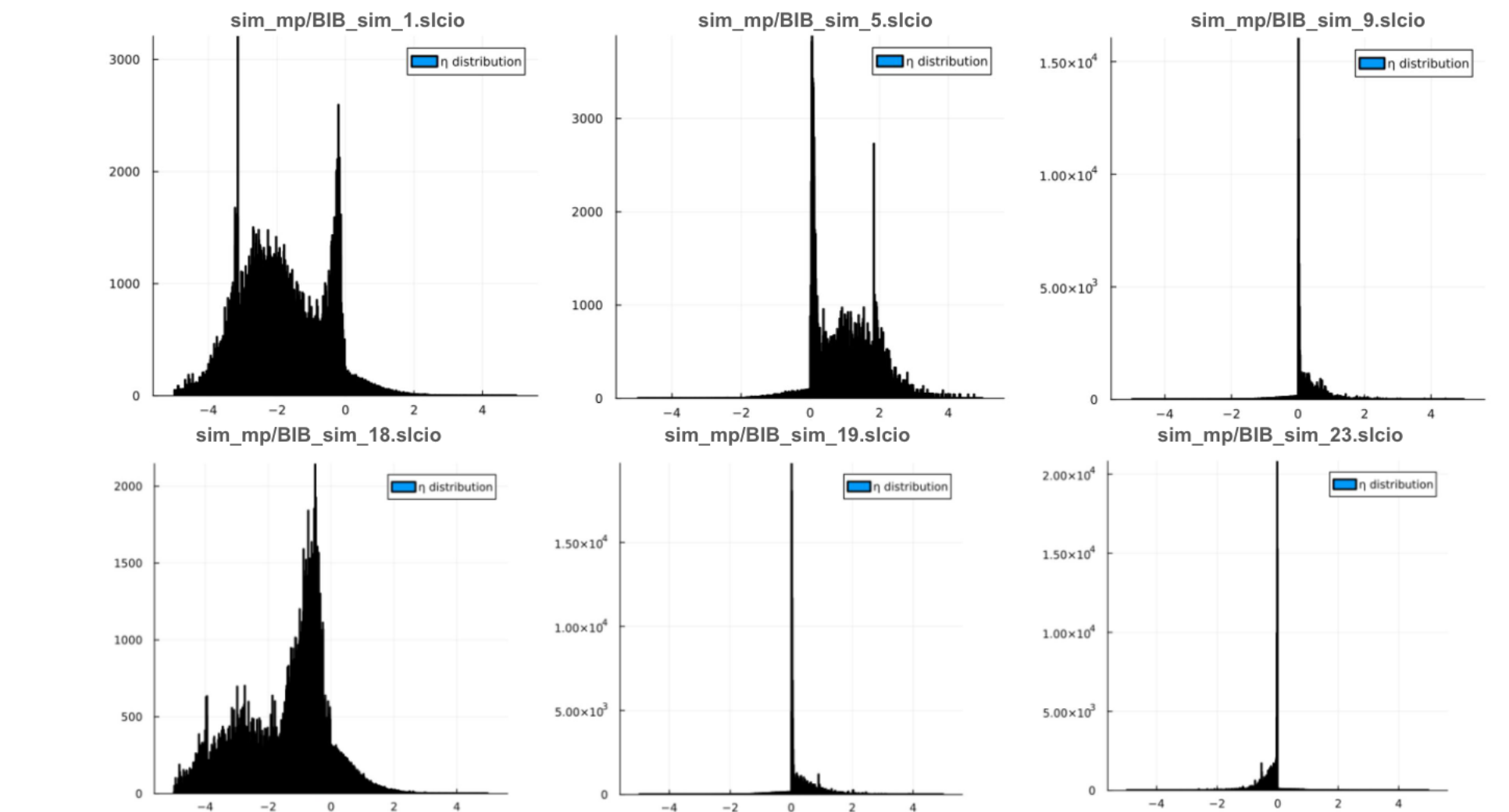
MAIA Meeting  
October 24, 2025

# THE PROBLEM

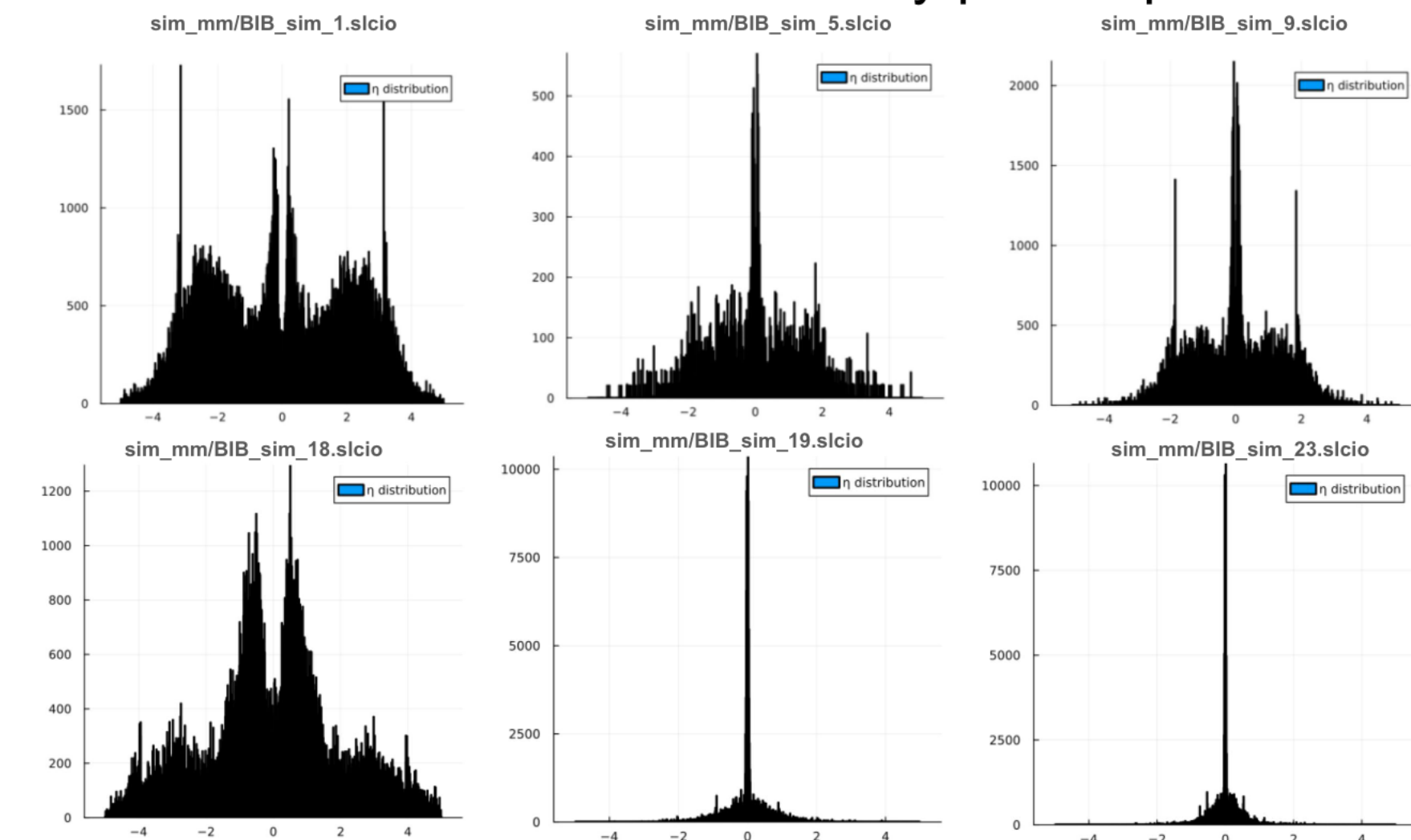
Identified by Hubert Pugzlys

- Troubling BIB distributions in slcio files
  - $\mu^-$  beam appears symmetric
  - suspiciously peaked and totally different for each file (true for both beams)
- Overall resulting asymmetry confirmed by Rose

MCP Eta Distributions Produced by  $\mu^+$  Samples



MCP Eta Distributions Produced by  $\mu^-$  Samples



# WHERE DOES THIS COME FROM?

- Distribution is simulated in FLUKA for one beam ( $\mu^+$ )
  - Files available on osg: /data/fmeloni/FLUKA/summary\*\_DET\_IP.dat
- Python scripts for turning these FLUKA files into slcio files [here](#)
  - Since v4, have been using [fluka\\_remix.py](#)
  - Before that (not sure exactly when) [fluka\\_to\\_slcio\\_new.py](#)
- Notes from [10TeV doc](#) on how to run:
  - `> python3 detector-simulation/Utils/fluka_to_slcio_new.py -n NUMBER path/to/FLUKA/summary1_DET_IP.dat BIBinput.slcio`
    - run with -i 1 to mirror the beam, to get full BIB every input file needs to be run twice, with and without this option.
    - -n NUMBER defines how many times each particle should be cloned to a random phi. The NUMBER depends on the fraction of total bunch crossing that we simulate in FLUKA.

note: using mapping /ospool/uc-shared/project/futurecolliders/data:/data

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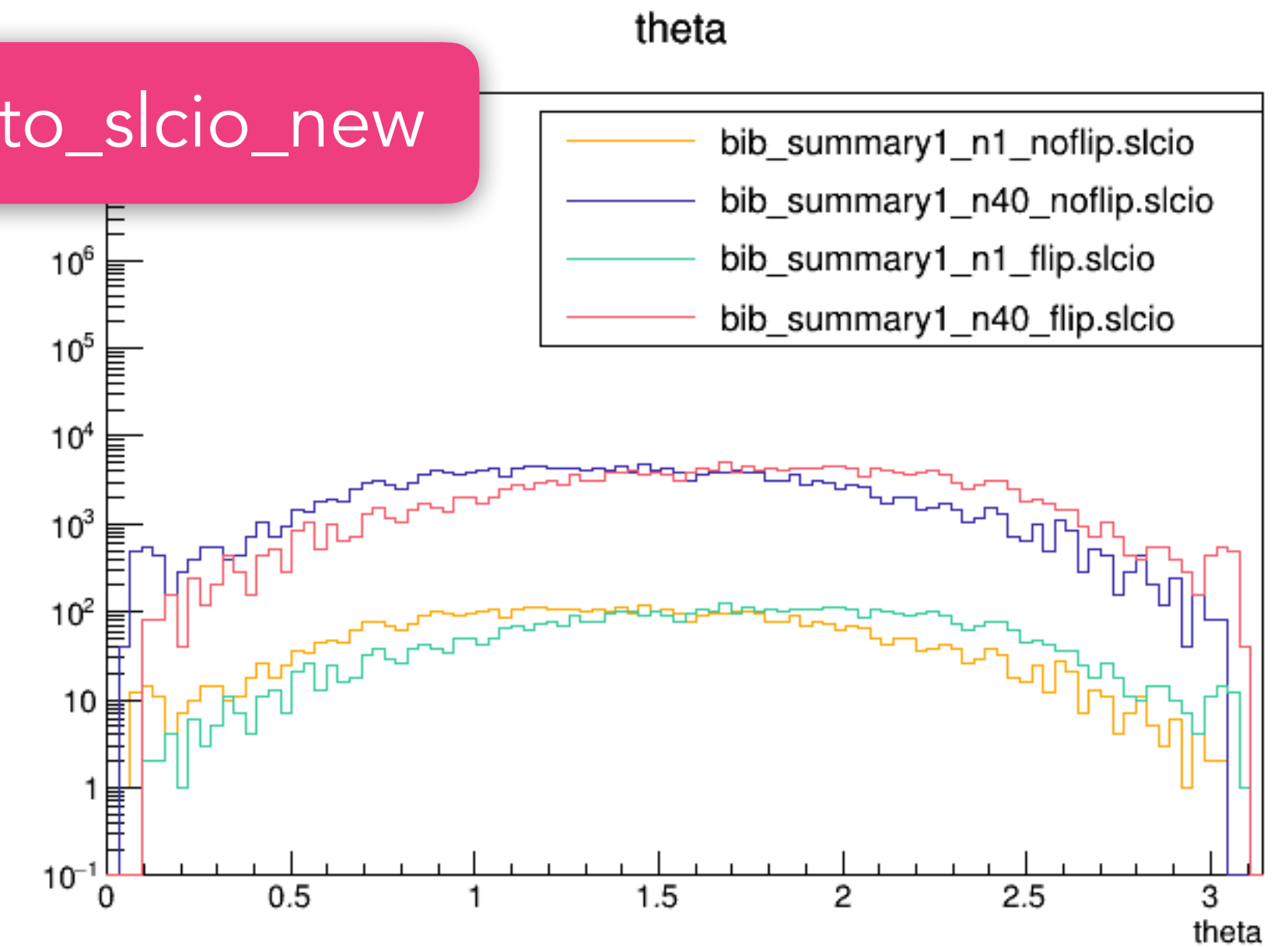
major change with fluka\_remix.py was to rotate all particles with the same parent muon together to preserve correlation  
- resulted in some restructuring of the code

note: using mapping /ospool/uc-shared/project/futurecolliders/data:/data

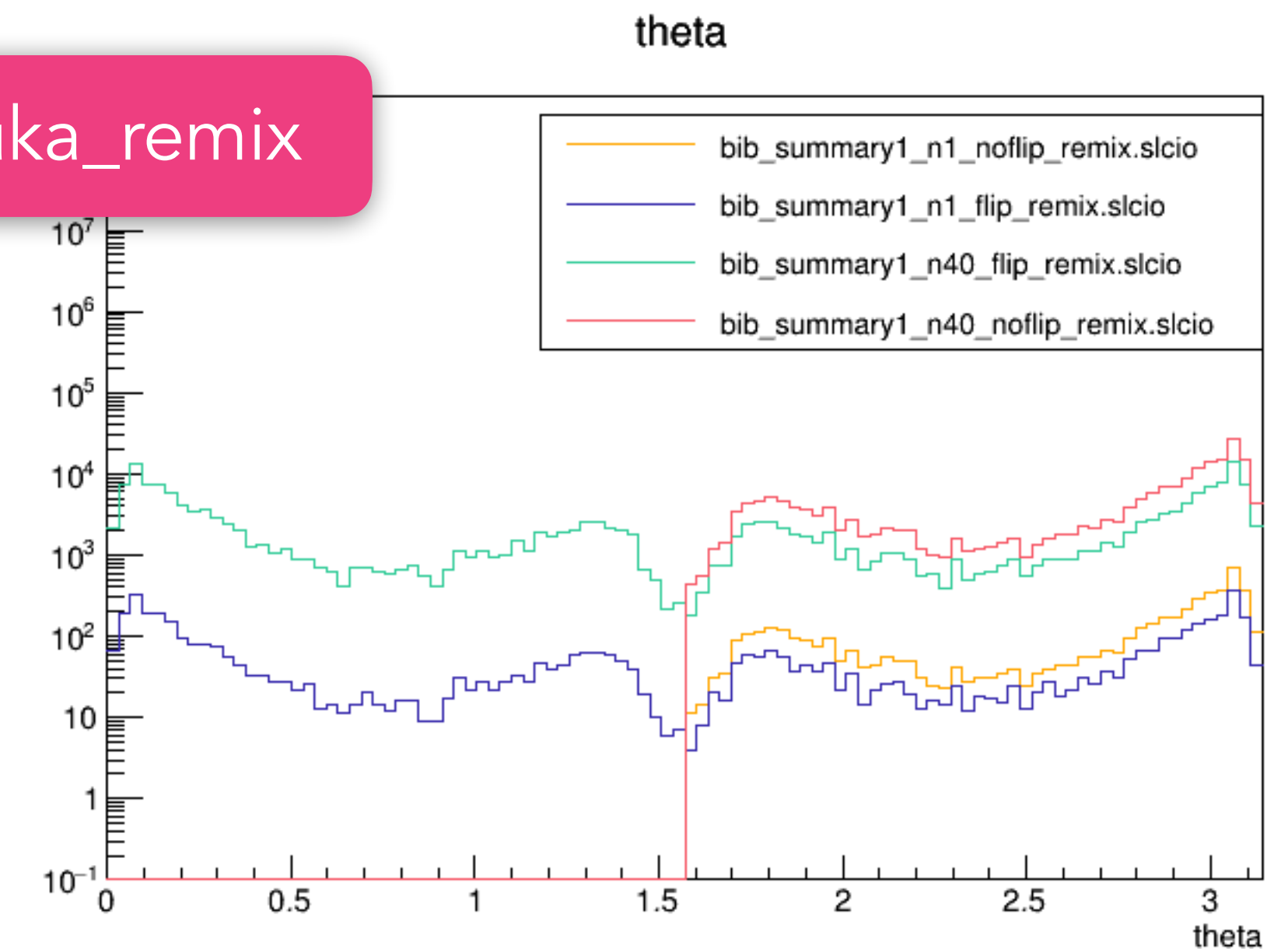
# RUNNING THESE FILES

- In all cases, running on the same input file:
  - /data/fmeloni/FLUKA/  
summary1\_DET\_IP.dat
- Ran version flipped/not flipped, and with just one phi value/40 iterations
- Clearly introduced this bug with the switch to fluka\_remix.py
- With fluka\_remix, see both flipped and non-flipped change, but see the symmetry introduced in the flipped version

fluka\_to\_slcio\_new



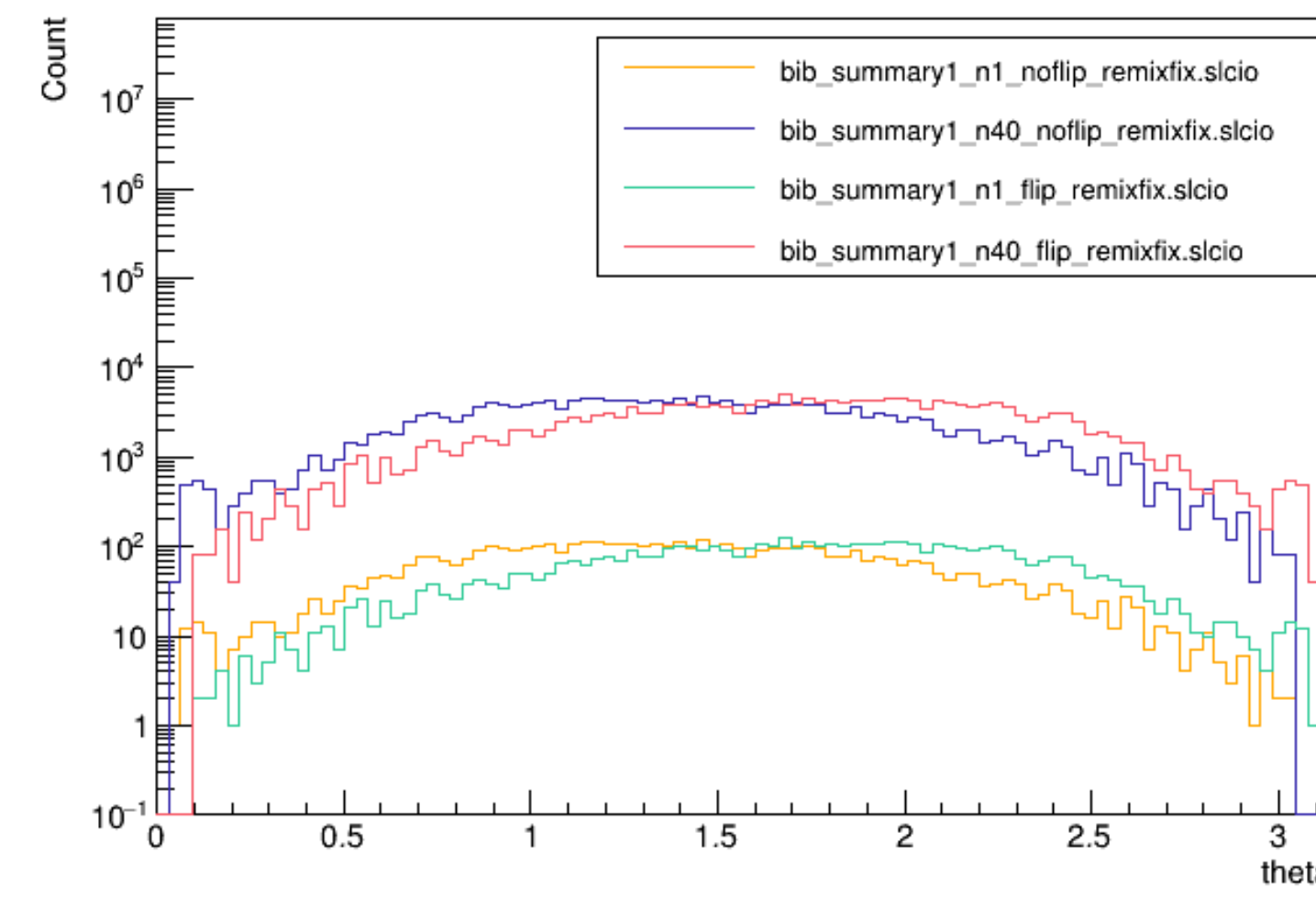
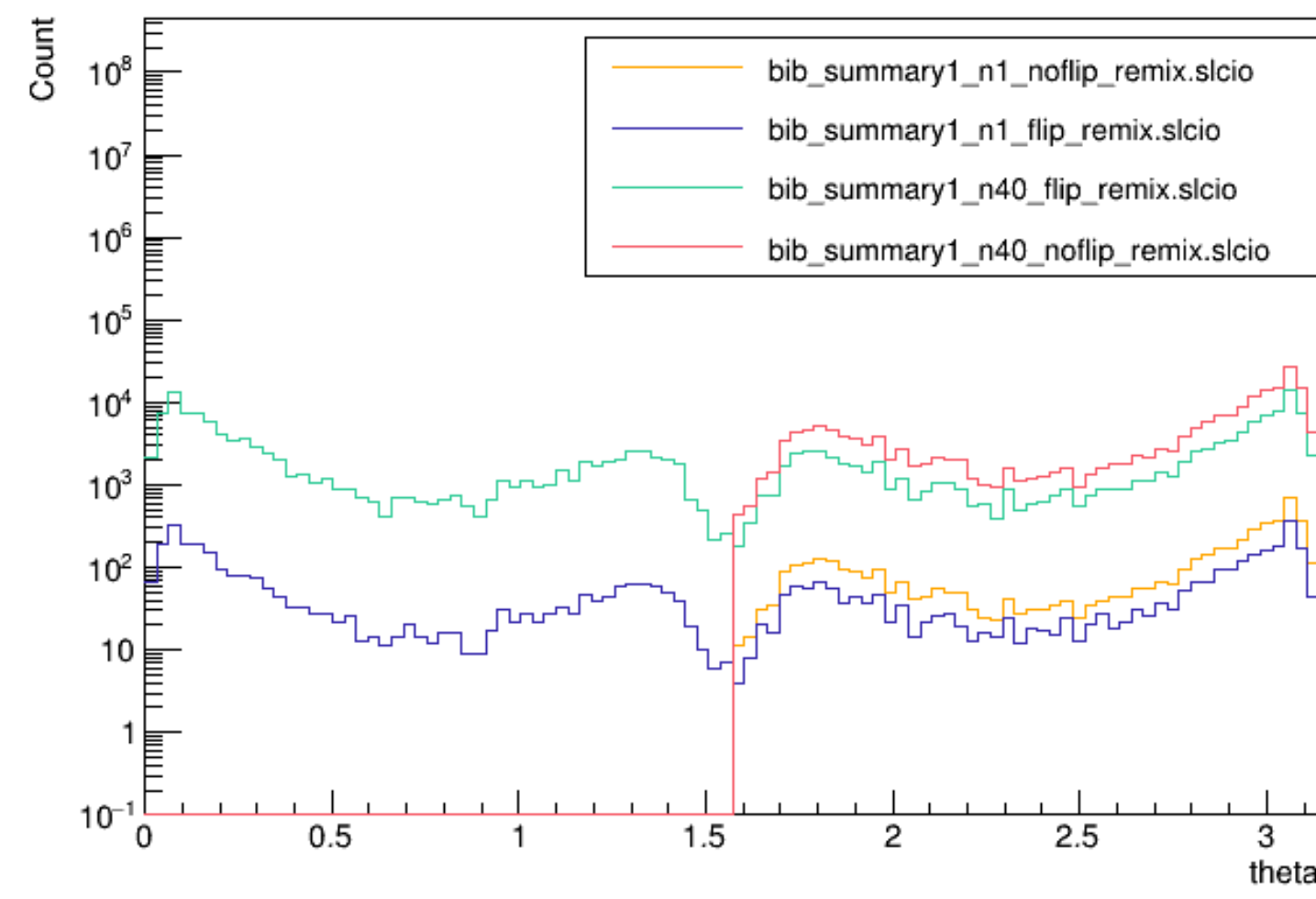
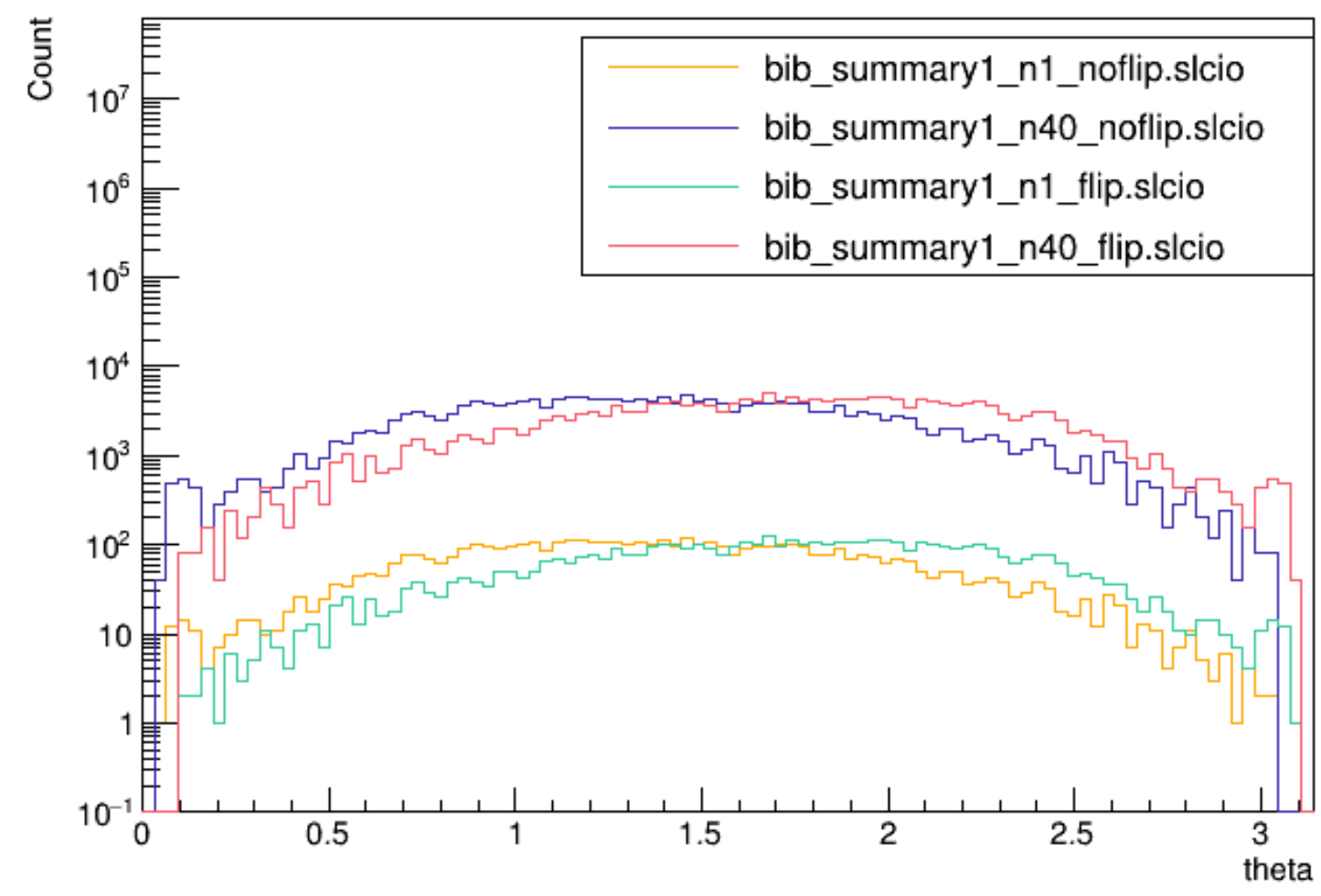
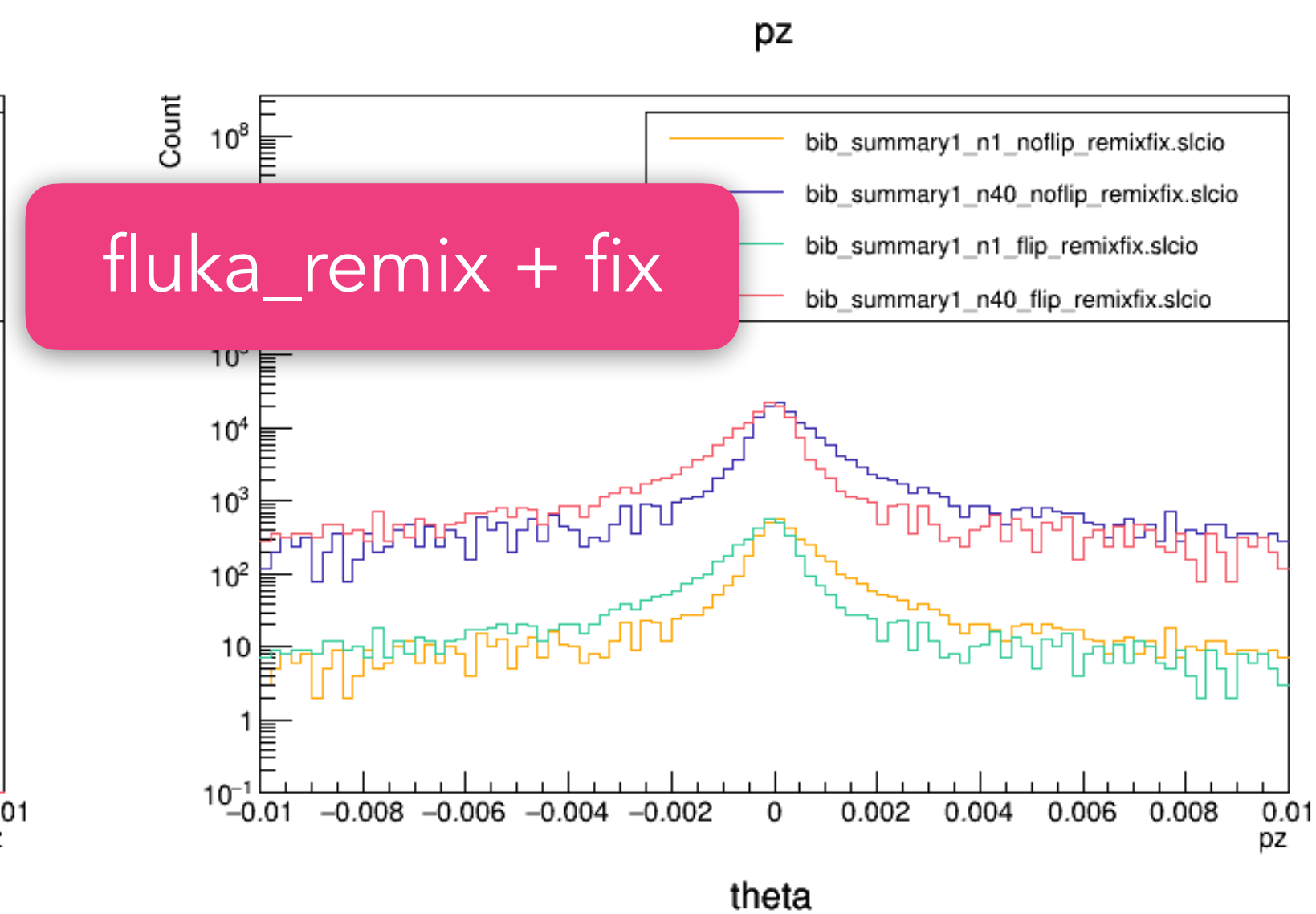
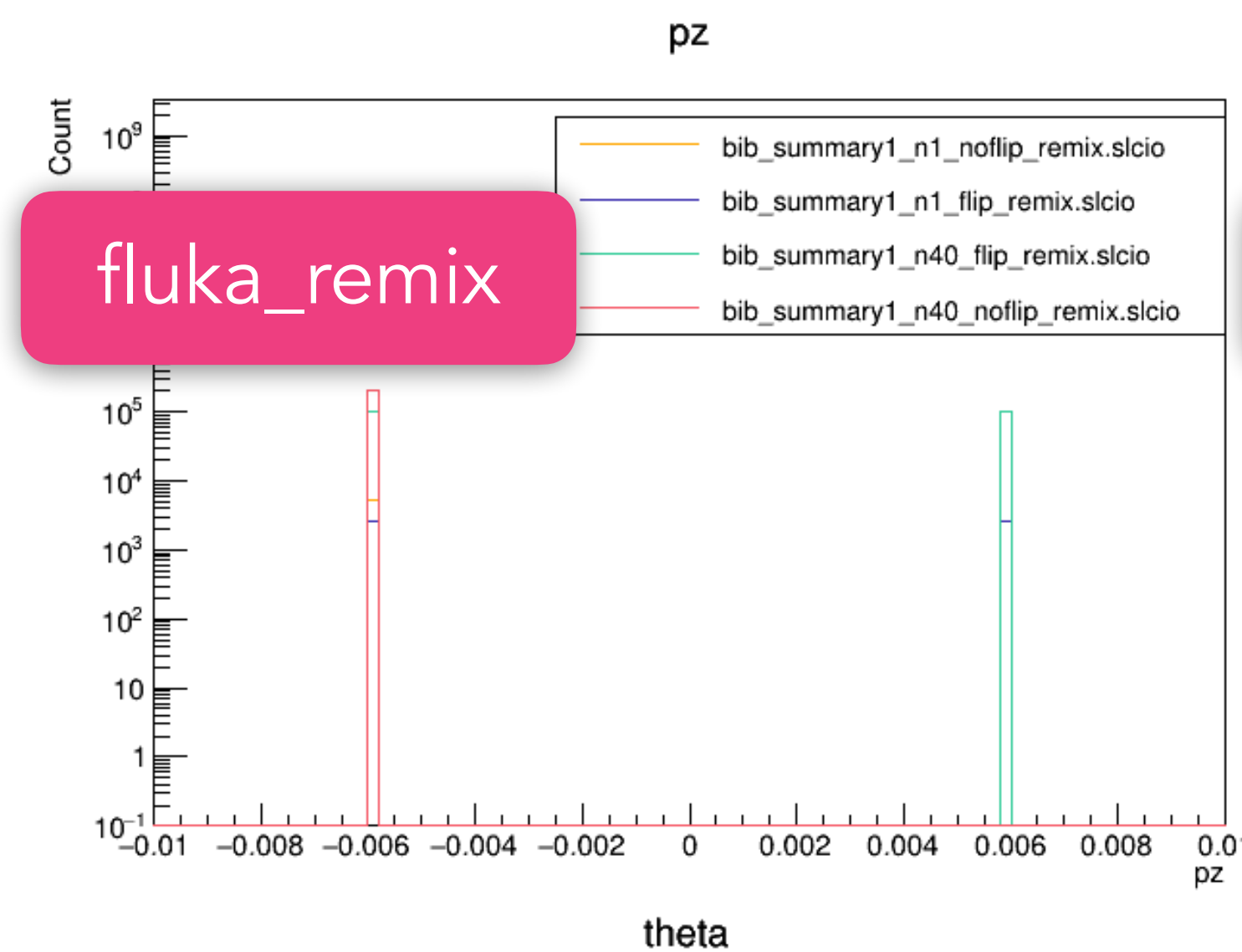
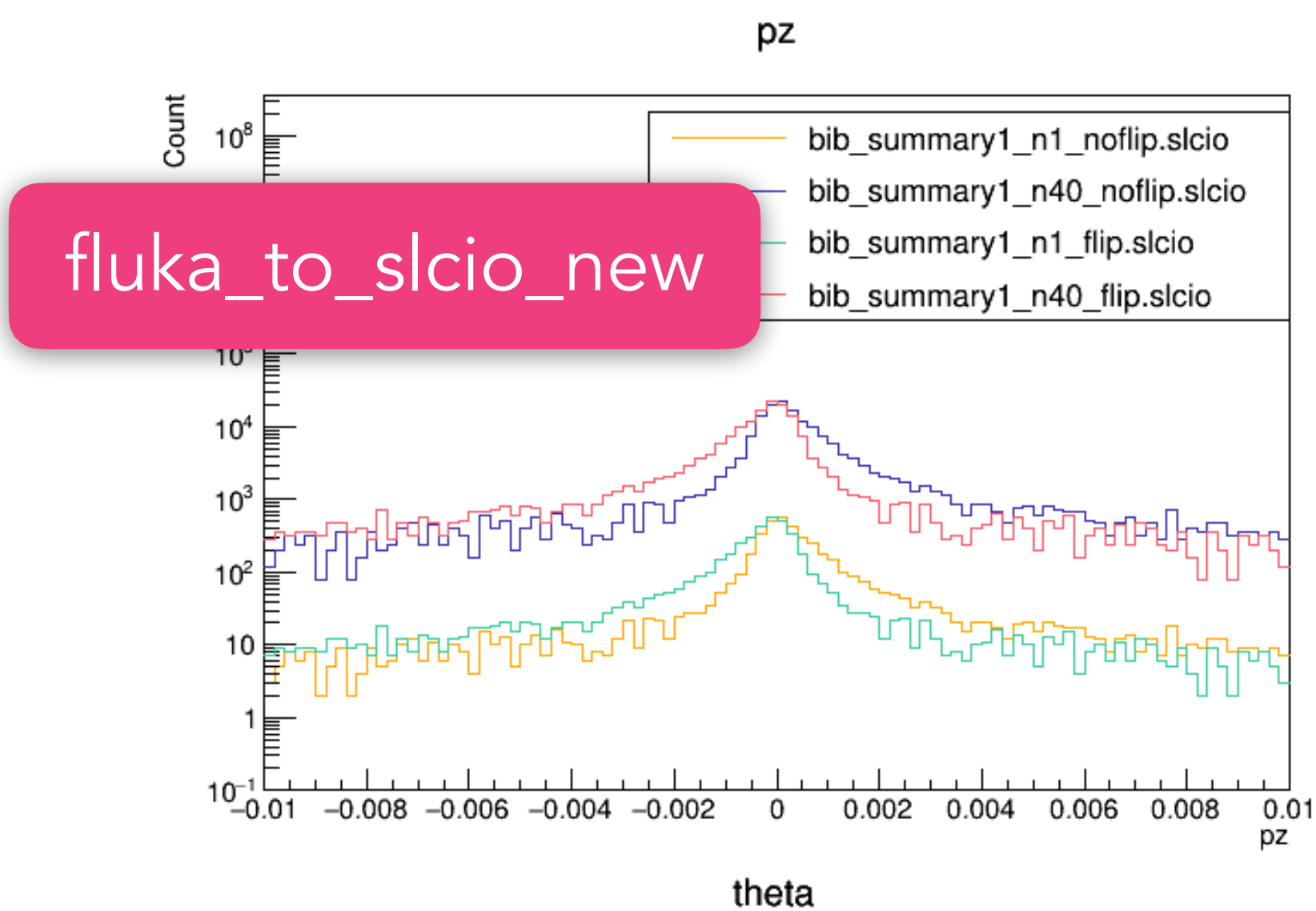
fluka\_remix



# BUG HUNT

- Compared the two files to hunt down the bug
- Eventually identified the source:
  - due to the code restructure, a momentum vector was not being re-initialized with each new particle
  - $p_x$ ,  $p_y$  were being recalculated due to the phi rotations, overwriting the uninitialized value, but  $p_z$  was either left alone or flipped in sign (depending on flip or no flip)
  - symmetry in flipped file was due to flipping the same  $p_z$  over and over
- Committed a fix [here](#)

# FIX IMPACT



# NEXT STEPS

note: would be great one day to have some CI/CD capable of running these spot checks!

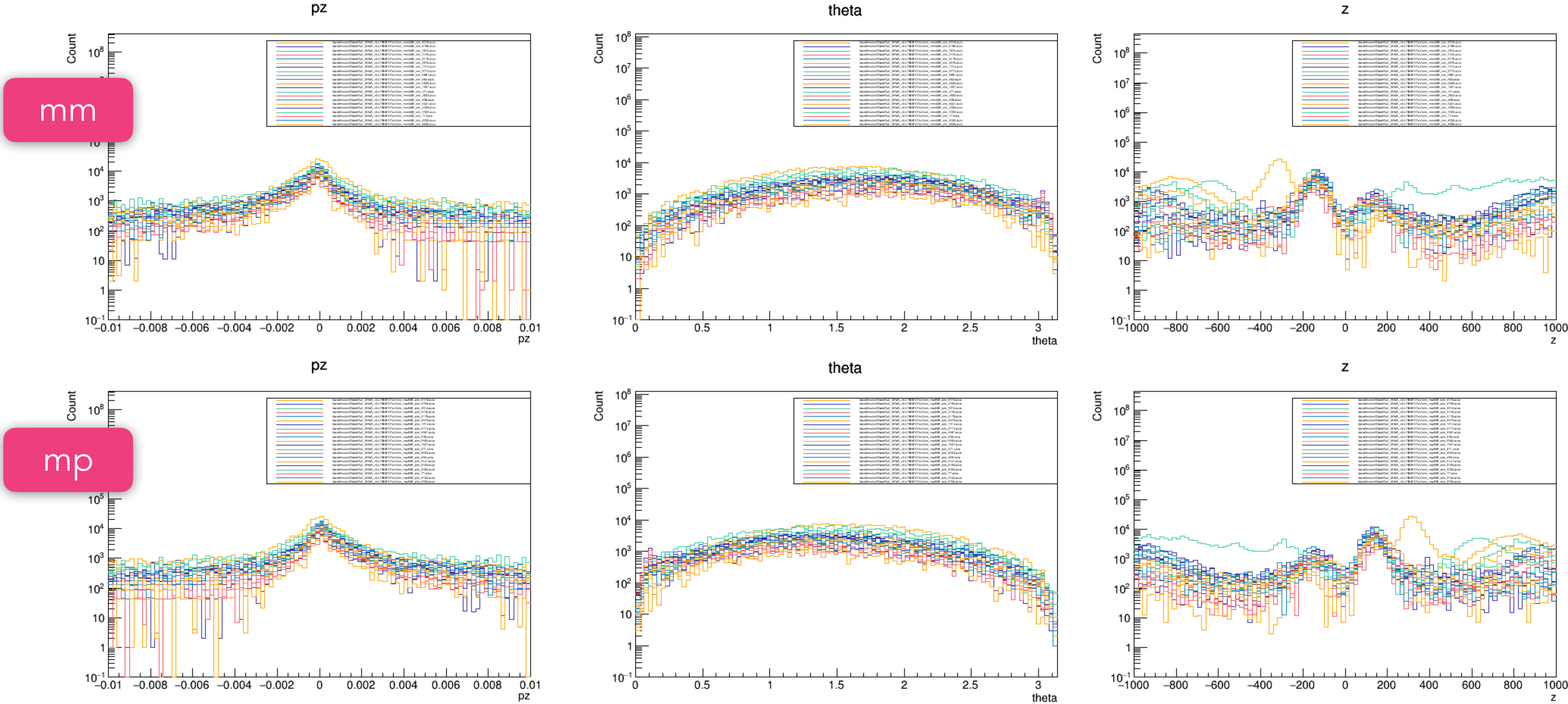
- Fix is in, now need to
  - re-run on all FLUKA files (and ideally run a validation script on those)
  - propagate to all our samples
  - re-make all our plots
- Impact?
  - the asymmetry should go away
  - the amount of BIB won't change
  - only  $p_z$  was affected, and each file would have had a different value — not clear if this would have created many systematic effects besides asymmetry? we shall see!

# FOLLOW UP

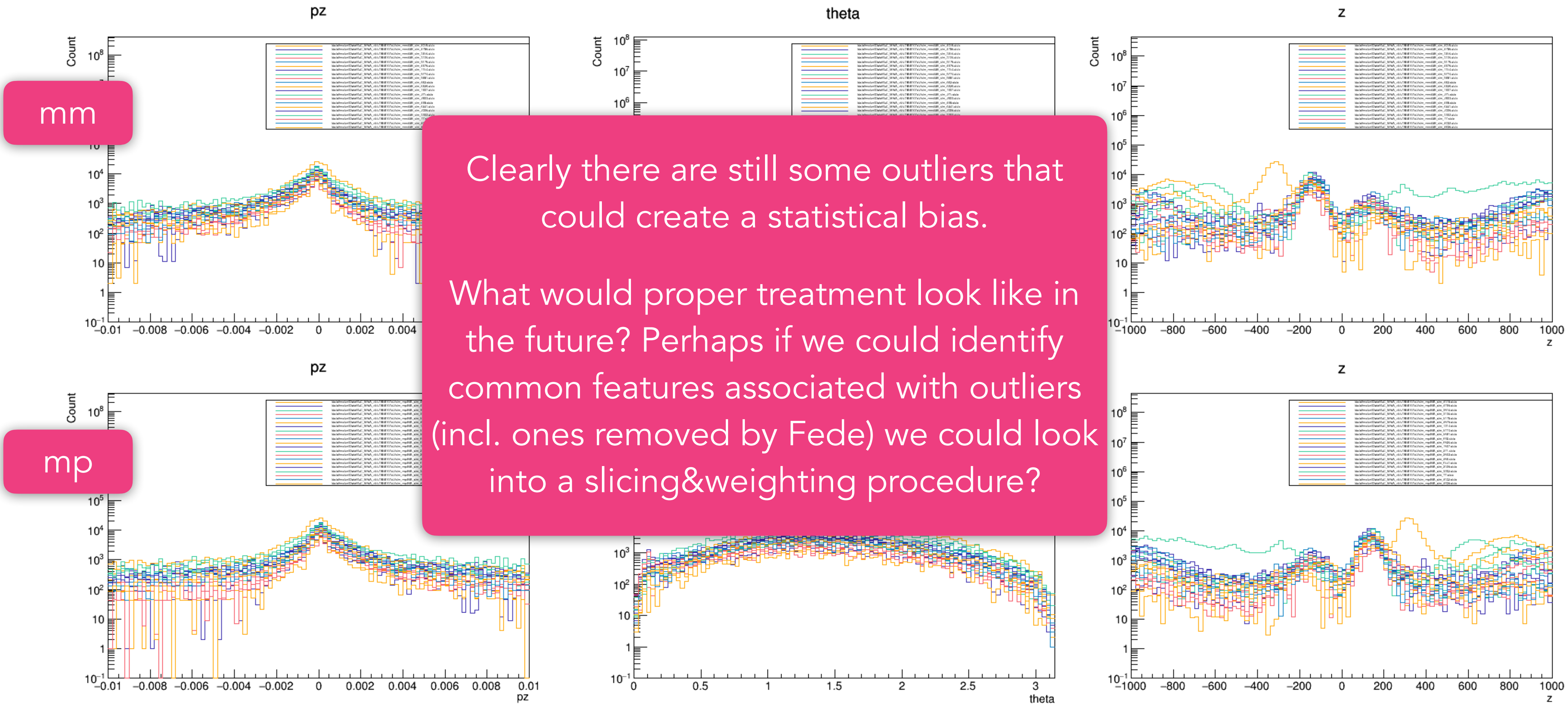
- Federico turned around new input files very quickly!
  - /ospool/uc-shared/project/futurecolliders/data/fmeloni/DataMuC\_MAIA\_v0/v7/BIB10TeV
  - Note from Fede: “there were 3 files where the 42x particle cloning resulted in files that were huge outliers in particle multiplicity/file size ( $\gg 1$  GB per file instead of the typical  $< 20$  MB). I have arbitrarily removed these as they could easily bias our overlays”
- Made some quick plots from them to see if things look OK

# SPOT CHECKING

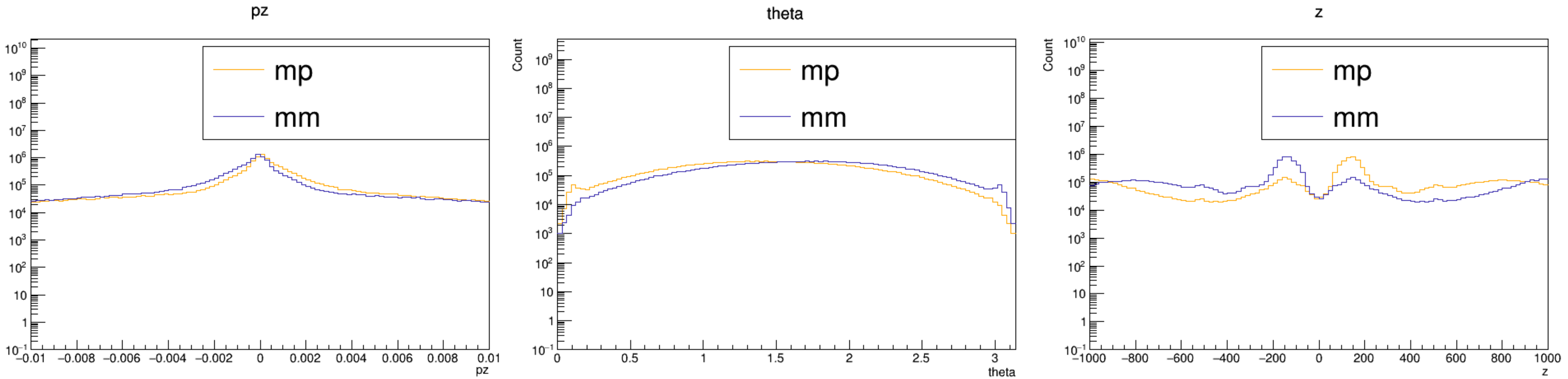
20 random files from mm and mp each  
(same file numbers for each sign)



# SPOT CHECKING



# OVERALL DISTRIBUTIONS



# WHAT STATISTICS DO WE EXPECT?

- In an example input file I looked at, there were 62 unique mother muons resulting in around 5000 particles
  - We replicate each of these 62 by a factor of 42 with random phi rotations
- We have 6663 input files for mm, 6661 for mp (after removal of a few outlier files), so around 400,000 unique mothers, each replicated 42 times
  - Difference potentially due to difference in sim random seed?
- Our total sample with all the rotations produces 4 events worth of data
  - We randomly select  $\frac{1}{4}$  of them for each event to overlay
  - i.e. each mother particle shows up  $\sim 10x$  in a given event

# HOW COULD WE SLICE?

- Seems likely that the outlier events are due to showers with very little pathlength through the nozzle
  - Could be possible to correlate that with parent muon properties (or parent electron?)
  - Unfortunately only have this information in the FLUKA/ files, so would need to run on those to figure out potential solutions