Studies of the g12 trigger efficiency

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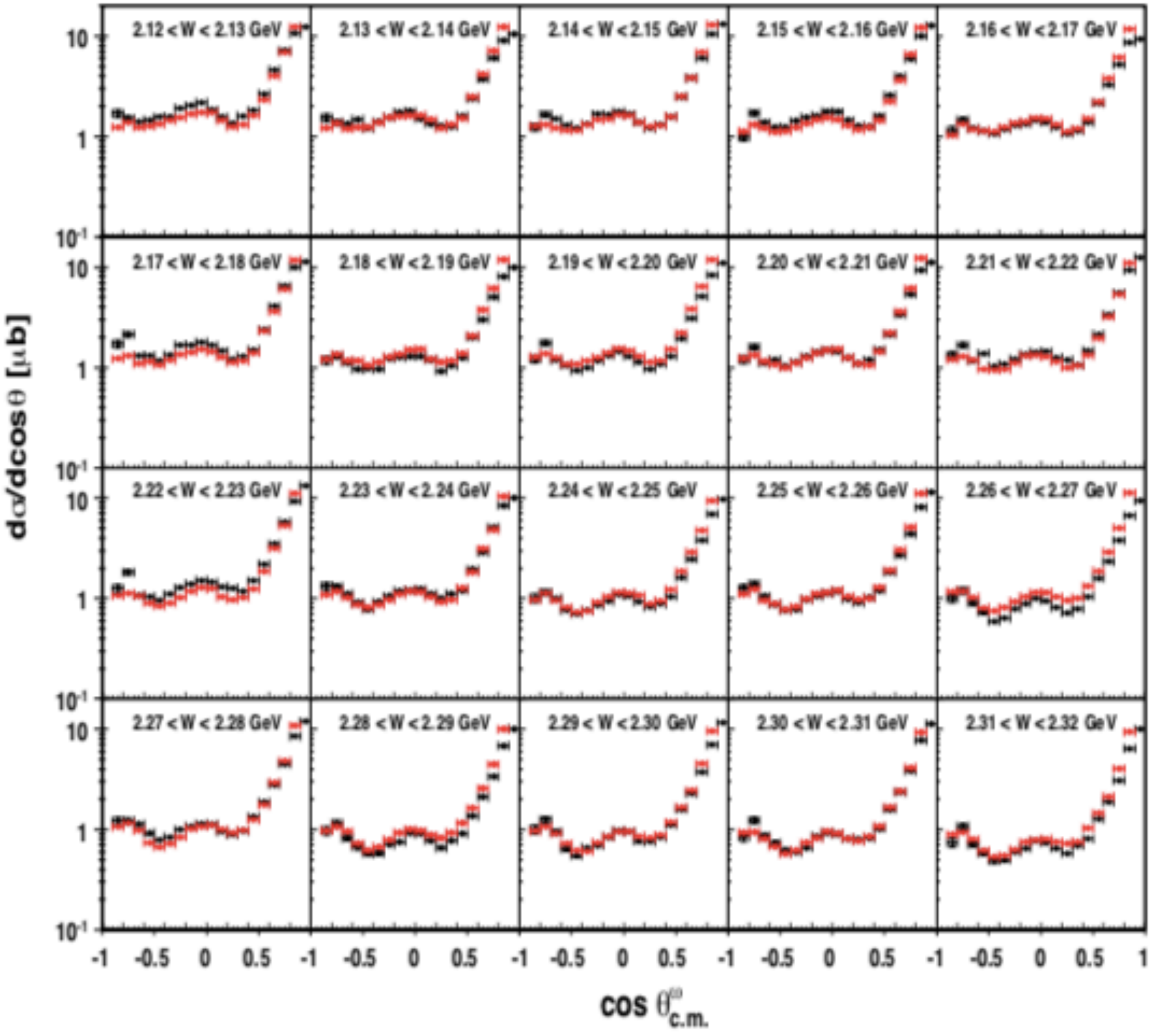
Overview

- The g12 trigger was complicated. Many reactions (2-prong, 3-prong, leptons, etc) were programmed to trigger DAQ.
  - Similar to g11 and other experiments
- The trigger efficiency is needed for cross sections, but how to calculate this efficiency is not straight-forward
  - CLAS publications by g11 included a ~16% correction for trigger efficiency
  - The g12 procedures document did NOT give an approved algorithm
  - Several approaches are known: Johann, MK, FSU
  - This needs to be documented, approved, and added to the g12 procedures
- Here, we start with the FSU procedure and improve upon it.

FSU analysis note: γp -> ωp using g12



Black: g12 data (with trigger efficiency)

Red: g11 data (published by CLAS)

The FSU group followed the same procedure as Mike Williams did for g11 to get the trigger efficiency (CLAS Note 2006-017)

What was the g12 trigger? It changed.

Part 1: runs < 56650

$g12$ runs 56363–56594, 56608–56647			
bit	definition	L2 multiplicity	prescale
1	MORA$\cdot$(ST$\times$TOF)$_1$$\cdot$(ST$\times$TOF)	–	1
2	MORA$\cdot$(ST$\times$TOF)$_2$$\cdot$(ST$\times$TOF)	–	1
3	MORA$\cdot$(ST$\times$TOF)$_3$$\cdot$(ST$\times$TOF)	–	1
4	MORA$\cdot$(ST$\times$TOF)$_4$$\cdot$(ST$\times$TOF)	–	1
5	MORA$\cdot$(ST$\times$TOF)$_5$$\cdot$(ST$\times$TOF)	–	1
6	MORA$\cdot$(ST$\times$TOF)$_6$$\cdot$(ST$\times$TOF)	–	1
7	ST$\times$TOF	–	1
8	MORA$\cdot$(ST$\times$TOF)$\times$2	–	1
11[a]	MORB$\cdot$(ST$\times$TOF)$\times$2	–	1
12	(ST$\times$TOF)$\times$3	–	1

Part 2: runs > 56650

$g12$ runs 56595–56607, 56648–57323			
bit	definition	L2 multiplicity[a]	prescale
1	MORA$\cdot$(ST$\times$TOF)	1	1000/300[b]
2	MORA$\cdot$(ST$\times$TOF)$\times$2	2/–[c]	1
3	MORB$\cdot$(ST$\times$TOF)$\times$2	2	1
4	ST$\times$TOF	1	1000/300
5	(ST$\times$TOF)$\cdot$ECP$\times$2	1	1
6	(ST$\times$TOF)$\cdot$(EC$\times$CC)	2	1
7	MORA$\cdot$(ST$\times$TOF)$\cdot$(EC$\times$CC)	–	1
8	MORA$\cdot$(ST$\times$TOF)$\times$2	–	1
11	(EC$\times$CC)$\times$2	–	1
12	(ST$\times$TOF)$\times$3	–	1

Trigger bit 11 starting with run 56519: MORA = "Master OR of tagger, range A" = tagger Eγ > 3.6 GeV (before 56519)
Master OR split into two halves starting with 56519.

Procedure is documented by FSU

3.7.1 Trigger Simulation

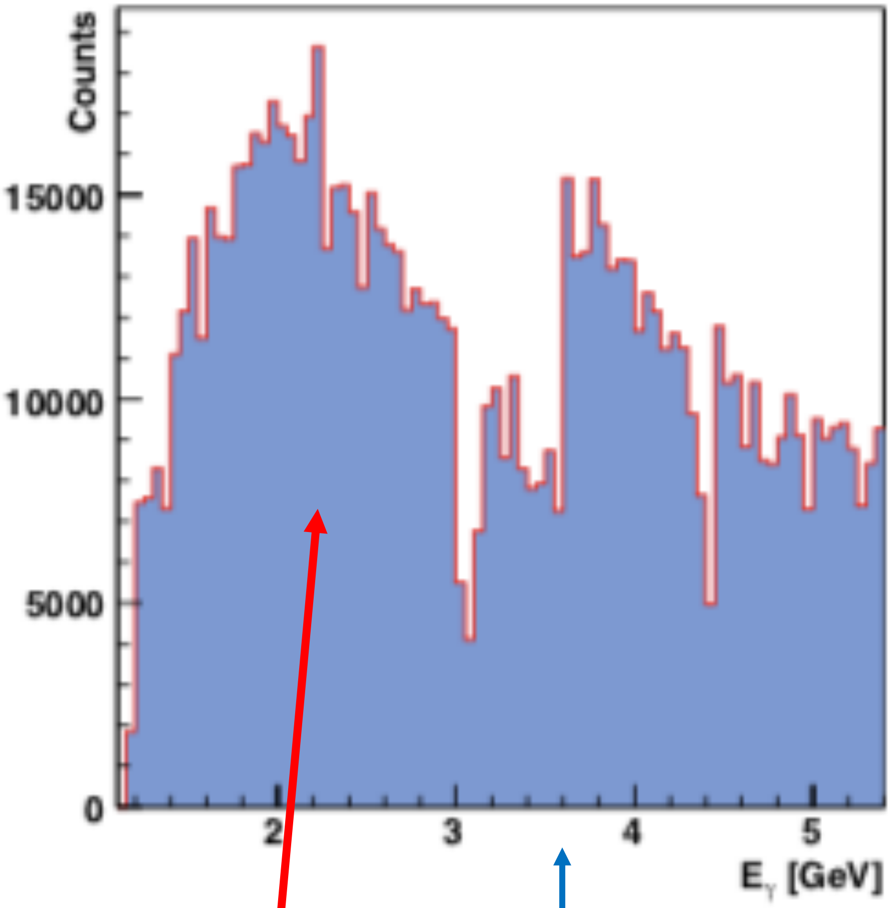
To simulate the trigger conditions for our g12 data, we used the same technique that was developed for the measurement of the ω and η cross sections in the g11a experiment [8, 9]. The procedure is outlined in Ref. [14]. This technique used the *trigger word* or *trigger bit*, which was written into the BOS data during the cooking. Reminder: The trigger conditions for the data that we used are described on Page 5 of Ref. [3]. In summary, the recorded events had:

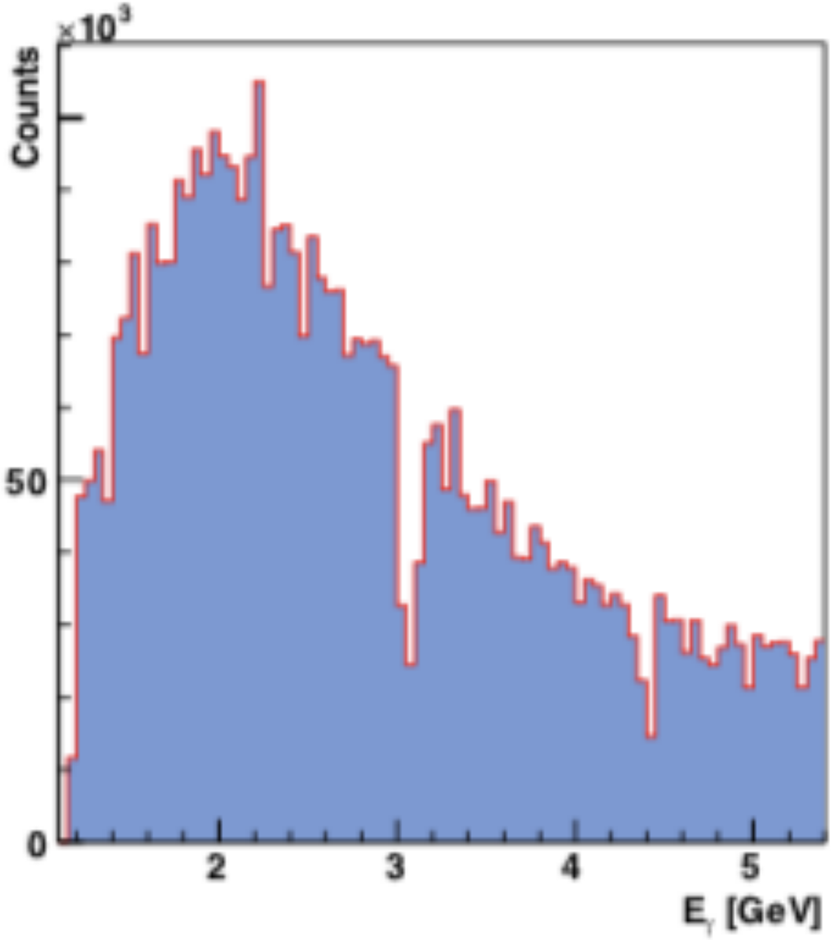
1. Either three charged time-of-flight hits in three different sectors (three-sector events),
2. Or two hits in different sectors (two-sector events), in combination with at least one photon in the beam bucket whose energy was above 3.6 GeV. The term "beam bucket" refers to all photons that were detected during the life time of the trigger (detector).

Therefore, to simulate the trigger conditions in the Monte Carlo events, two pieces of information were needed:

1. The efficiency of the trigger as a function of particle type, momentum, and detector position (trigger efficiency map).
2. The probability for having at least one photon with $E_\gamma > 3.6$ GeV (two-sector events).

Compare: 2-prong and 3-prong events (g12)

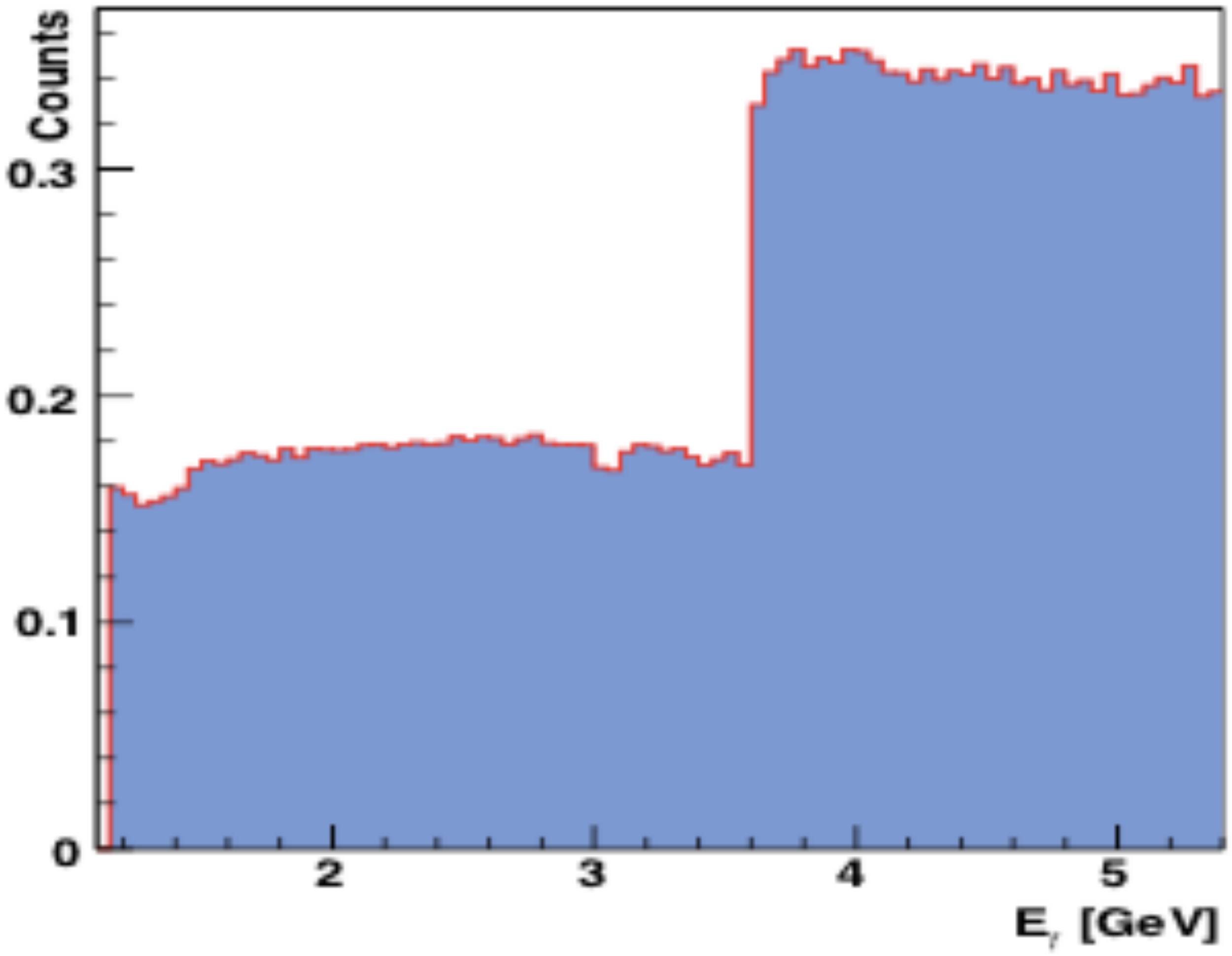




Why are there
ANY events < 3.6?

Discontinuity at 3.6 GeV for 2-sector events (due to trigger)

Ratio of 2-sector to 3-sector triggers: FSU



This ratio is only for the reaction:
$\gamma p \rightarrow p\, \pi^+\pi^-$

We will see that this ratio depends on the final state particles.

The problem with complicated triggers

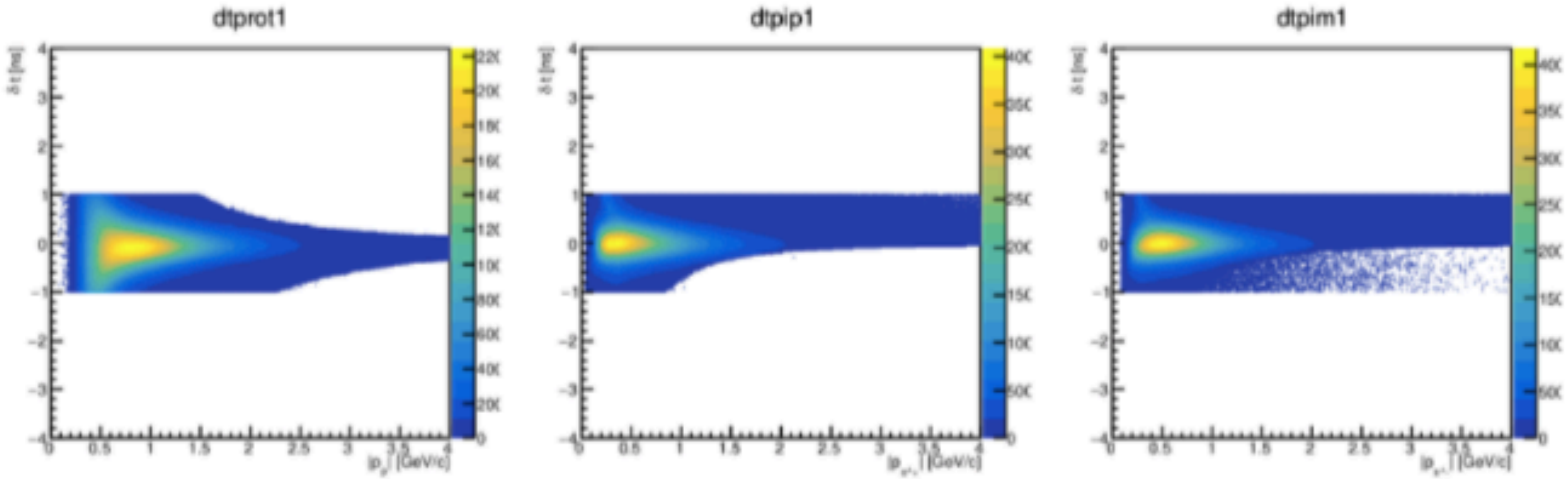
- Due to the high luminosity, and a broad (~150 ns) tagger coincidence window, there were 10-20 tagger hits per event
- Accidental coincidences between two-sector hits (associated with a photon BELOW 3.6 GeV) and a chance photon ABOVE 3.6 GeV.
  - The trigger efficiency for two-sector events with $E\gamma < 3.6$ GeV can be determined empirically for a nearly-constant beam current.
  - Some 3-prong events have 2-prongs in one sector -> trigger is 2-sector
- Bottom line: by following careful procedures, the trigger correction can be done.

The problem with TOF counters

- A common discriminator level was used as the trigger threshold for all TOF counters.
  - These detectors were not perfectly gain-matched.
  - PROBLEM: some TOF counters showed an inefficiency for triggering.
  - SOLUTION: develop a trigger efficiency map, apply this to the Monte Carlo
- In the data analysis, where there are clearly three tracks that can be matched to an exclusive reaction, the trigger didn’t always fire!
  - This is due to one particle hitting a “weak” TOF counter
  - With enough statistics, one can create a MAP of efficiency per TOF vs. ϕ.
  - Maps depend on particle type! (protons deposit more energy than pions)

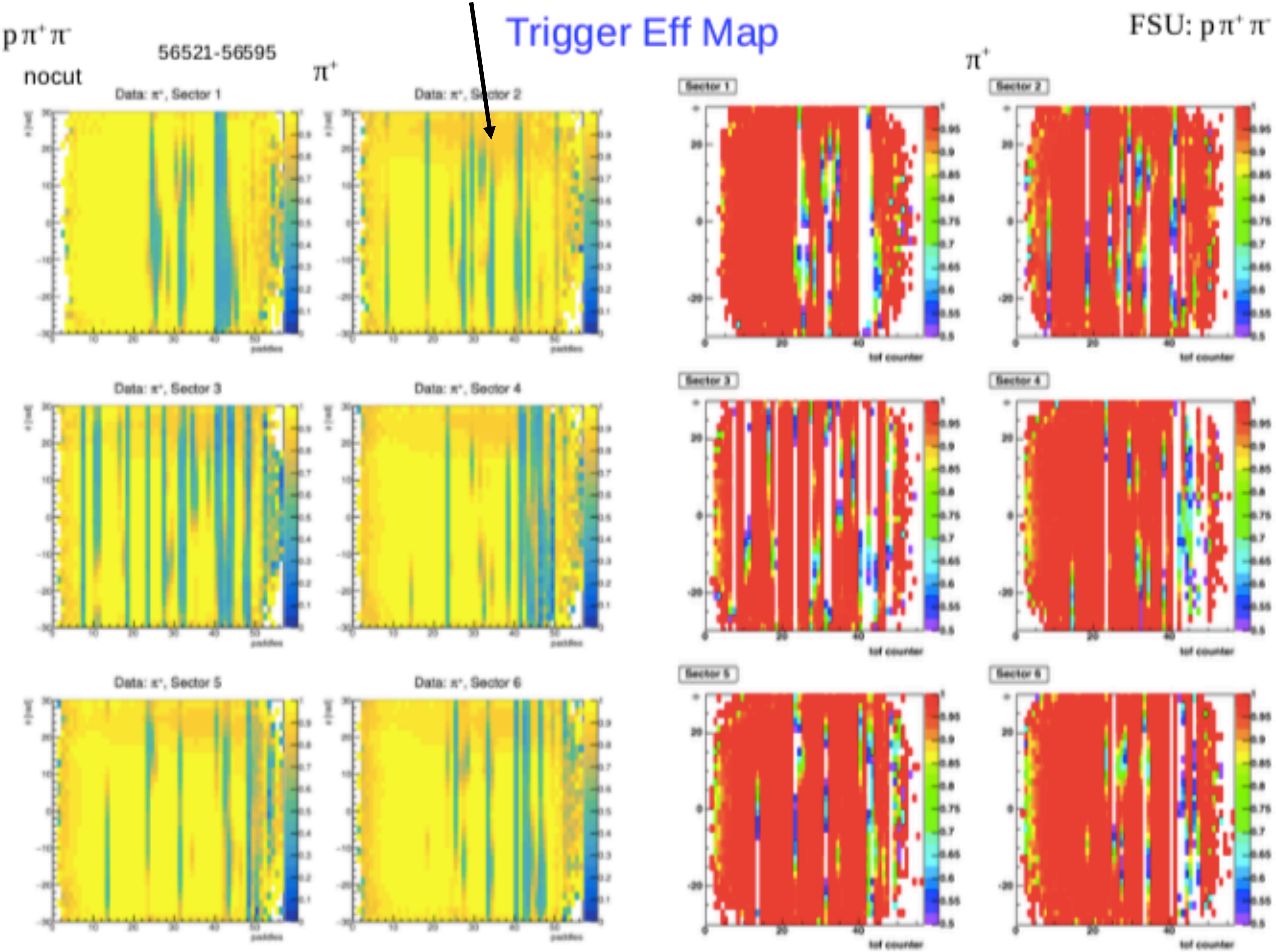
Trigger Map $p\pi^+\pi^-$

- Photon selection → 1 photon case
- PID → p, π^+, π^-. Straight cuts of 1 ns on Momentum Vs Timing plots were made for particle identification (Shown below).
- The run number selected were 56521 – 56595, same trigger set up.
- Trigger total and Trigger Hit was obtained.
- Trigger efficiency map was plotted as the ratio of the hit to total.
- Egam ratio of 2-sec to 3-sec was obtained for pid cut and pidfidn-cut.



Trigger Eff Map

What is this “dark band”??



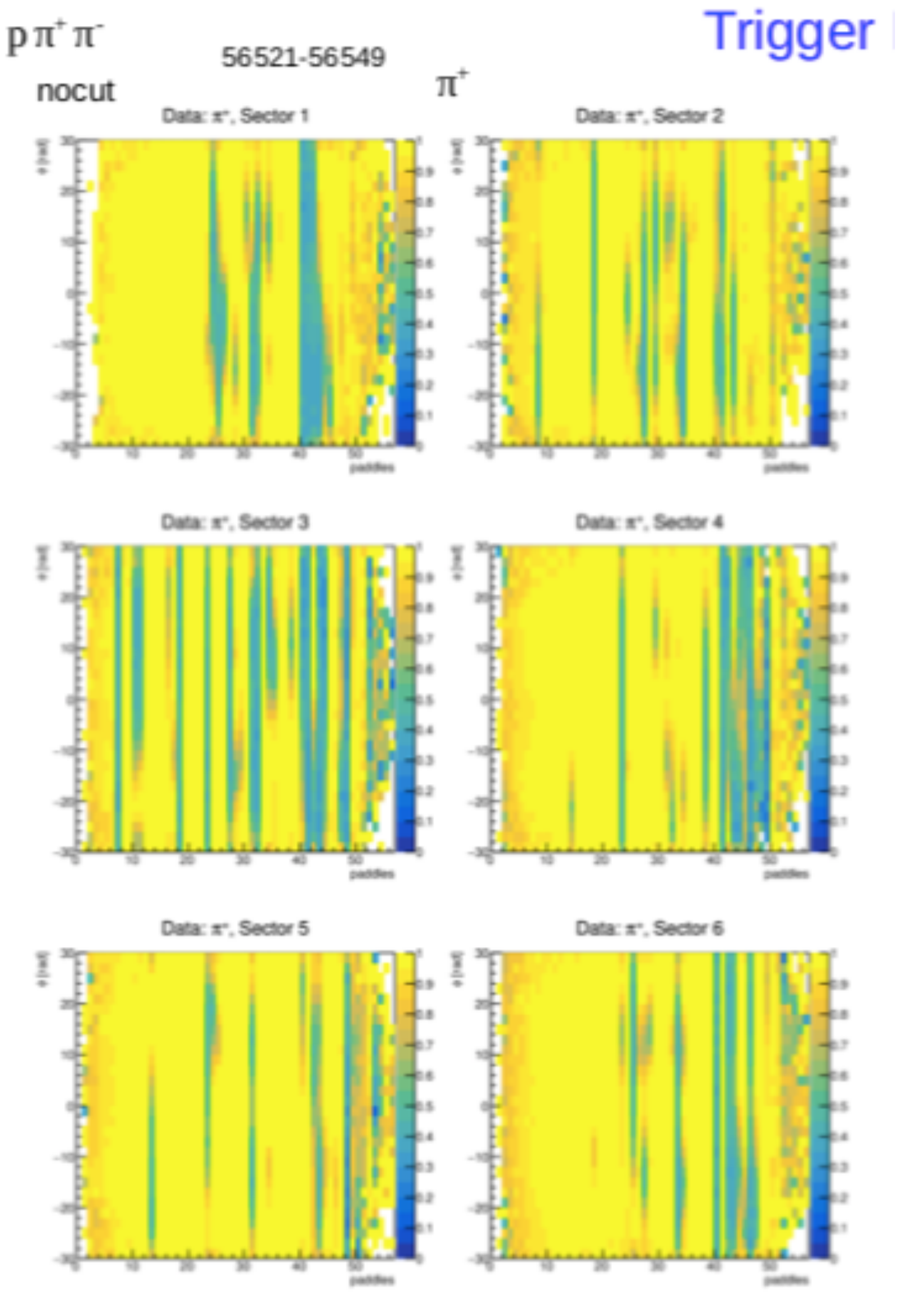
Left side: Ohio

Right side: FSU

Same reaction
Same g12 runs
Different plotting
(color scale)

→We could reproduce maps (with much help from Zulkaida!)

Similar for π^-, p



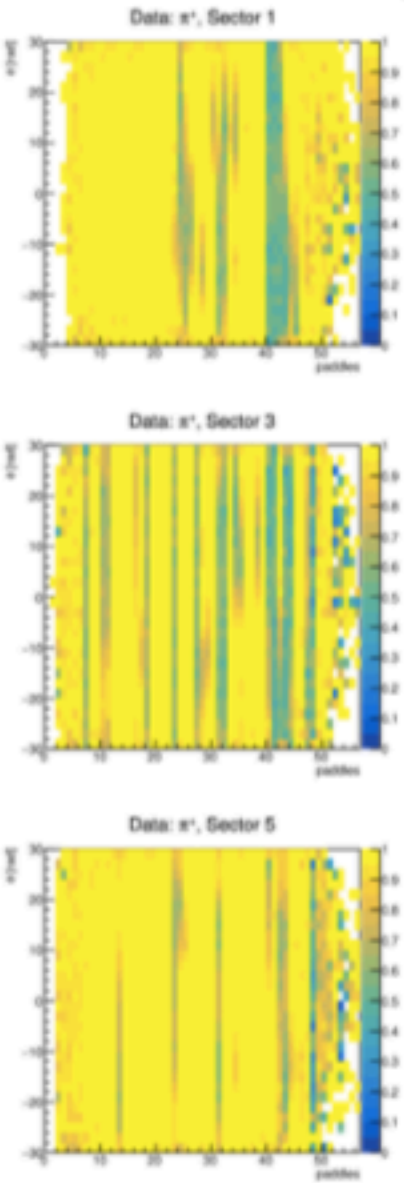
Change the range of runs:
56521 – 56549
”dark band” is gone!?

Something strange happened
to the trigger efficiency in
sectors 2-6 for runs
> 56550

Trigger Eff Map

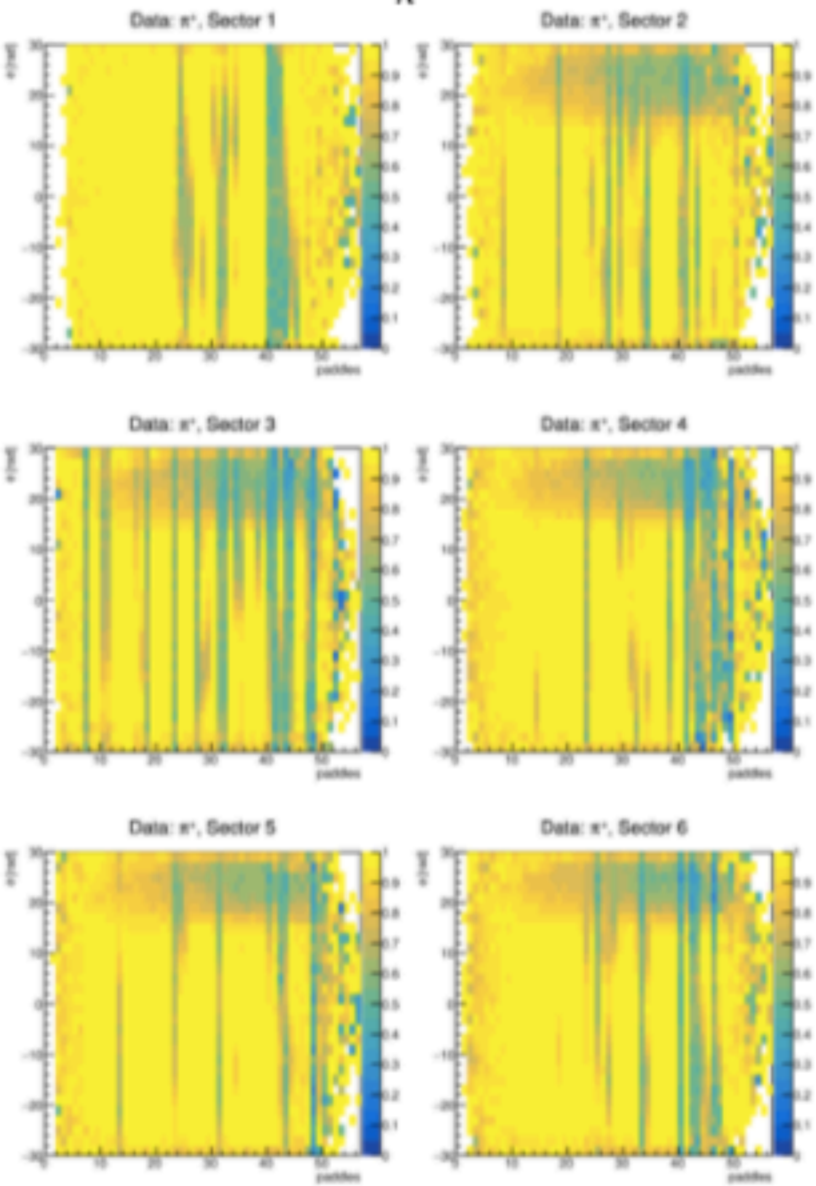
56519-56569

π^+

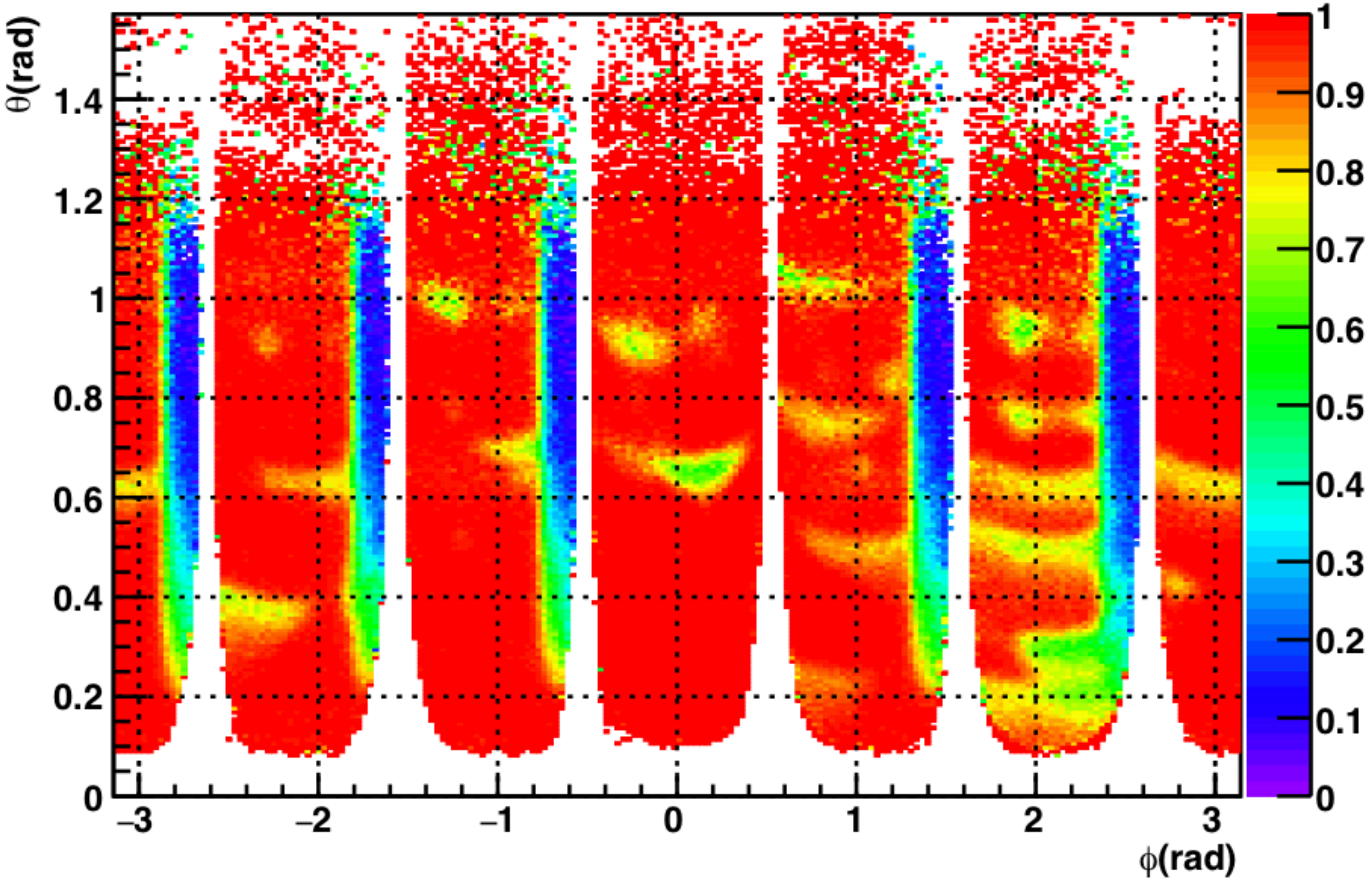


56570-56646

π^+



Possible explanation: FPGA board problem



From the g12 analysis note by Andreas Celantano (under review) where a single-charged particle was detected: mismatch between the ST-SC track match done by the FPGA. Runs 56573-56747 only!

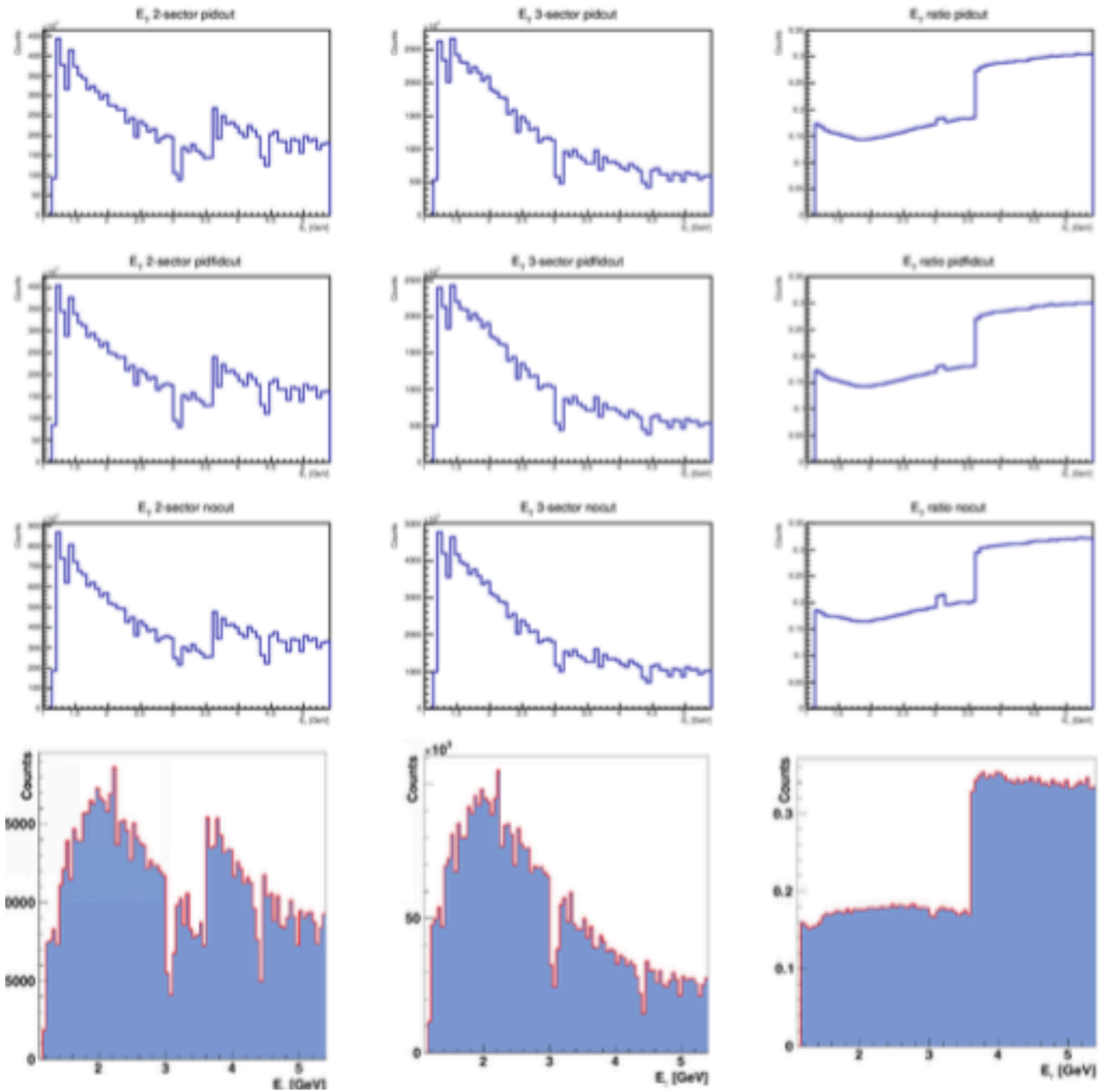
This effect would be taken into account by the trigger efficiency method used by FSU & Ohio.

Eγ Ratio

56521-56549

$p\pi^+\pi^-$

pidcut



pidfidn-cut

nocut

FSU: $p\,\pi^+\,\pi^-$

2-sector/3-sector ratio depends on the cuts!

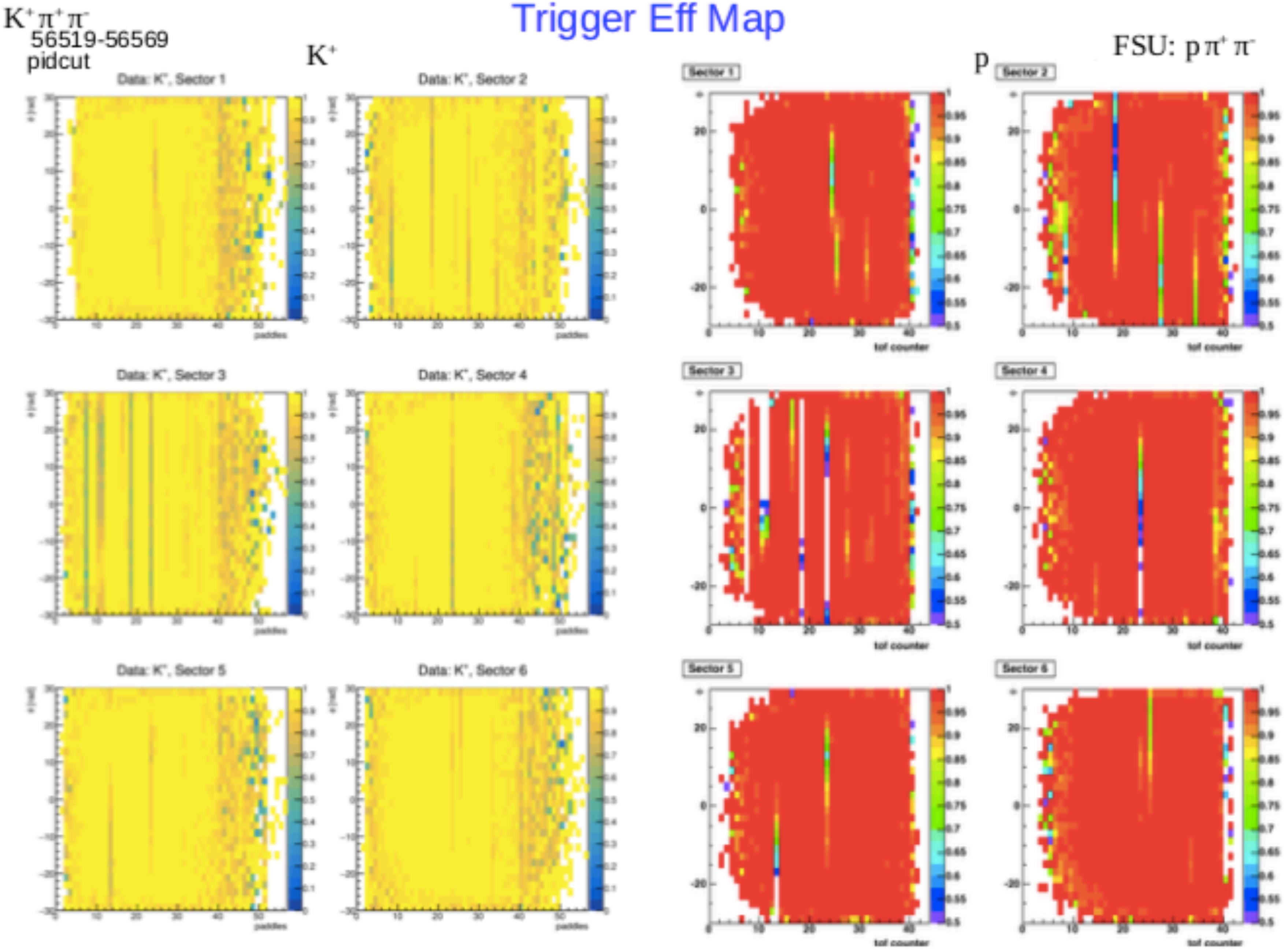
We get almost the same results as FSU, but not exact. To get exact, we need the same cuts.

Next step: study other reactions

- Utsav Shrestha: γp --> $K^+ \pi^+ \pi^-$ (n).
- Joey Rowley: γp --> $K^+ \Lambda$, followed by ΛN -> ΛN (final state: pp π^-).
- Kevin Ward (& Will Phelps): γp --> p p anti-p.

- All above reactions have 3-particle final states.
    - Each case needs its own trigger efficiency map & 2-sector/3-sector ratio.
    - Same procedures followed in each case.

Trigger Eff Map



Now $K^+\pi^+\pi^-$ data, compare K^+ (Ohio) with proton (FSU).

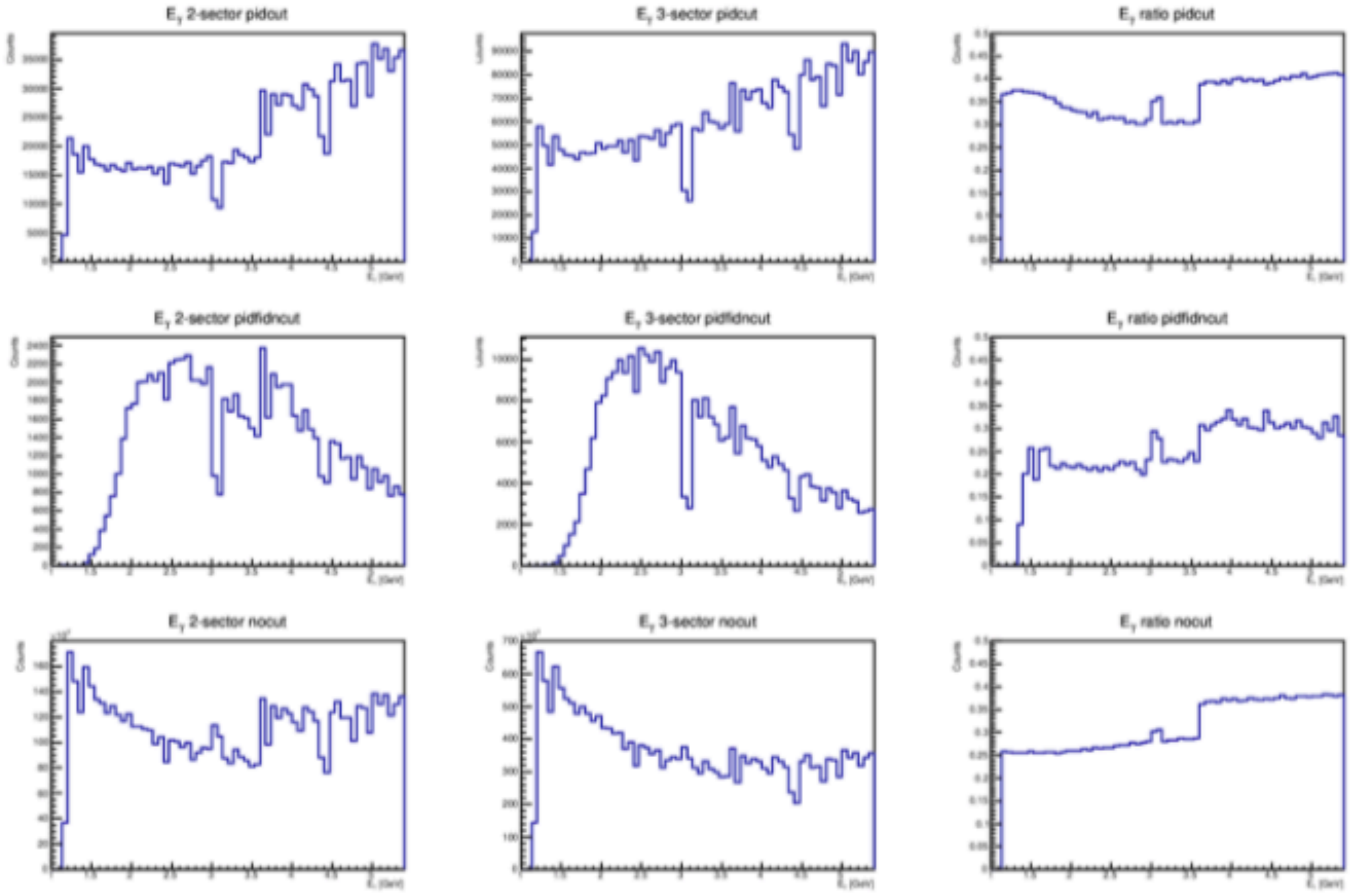
Both K^+ and p deposit more energy in the TOF detector.

(Restrict to ”clean” run range < 56570.)

Eγ Ratio

56521-56595

$K^+ \pi^+ \pi^-$

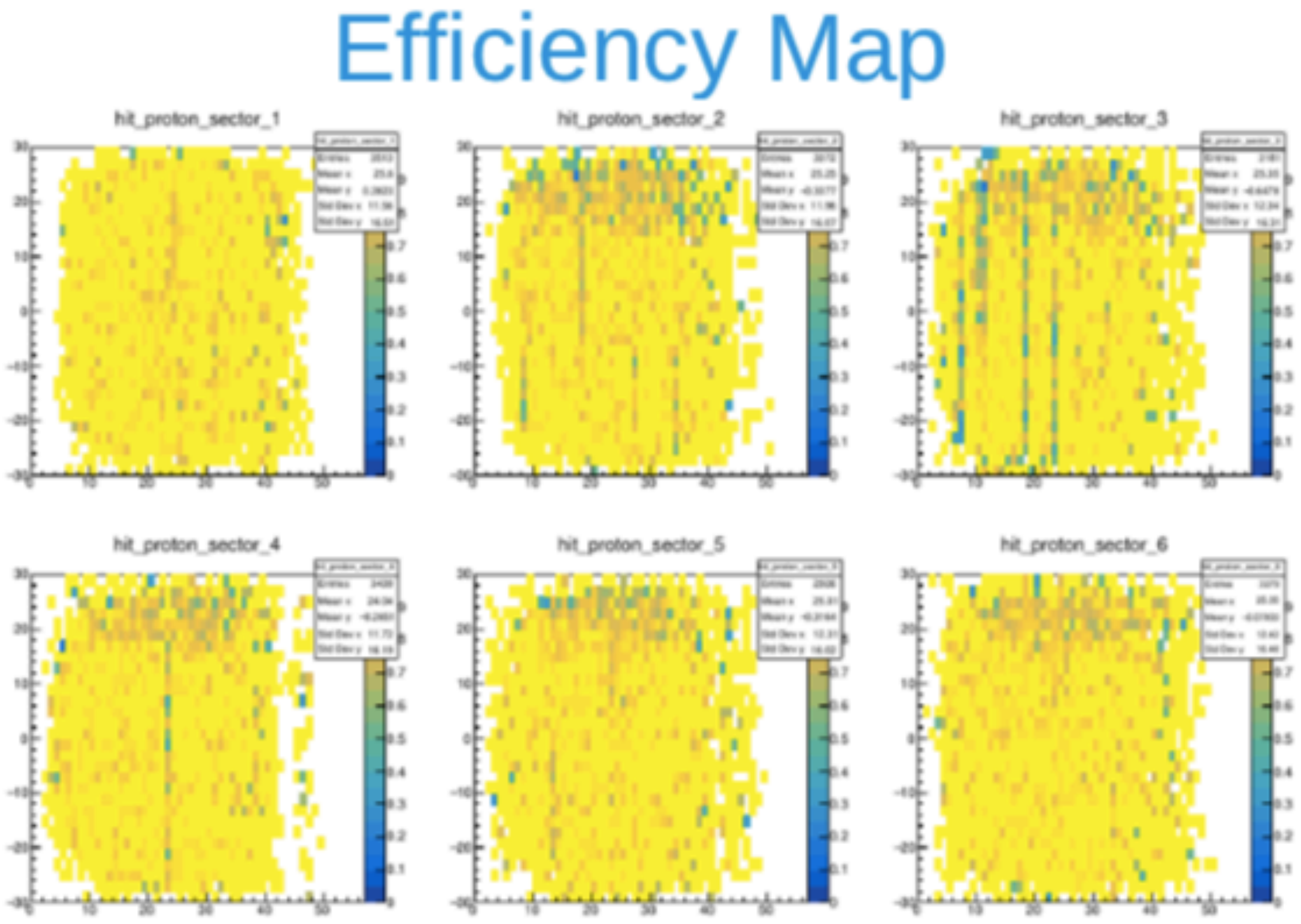


pidcut

pidfidn-cut

nocut

Final state: pp π^- (from ΛN scattering)



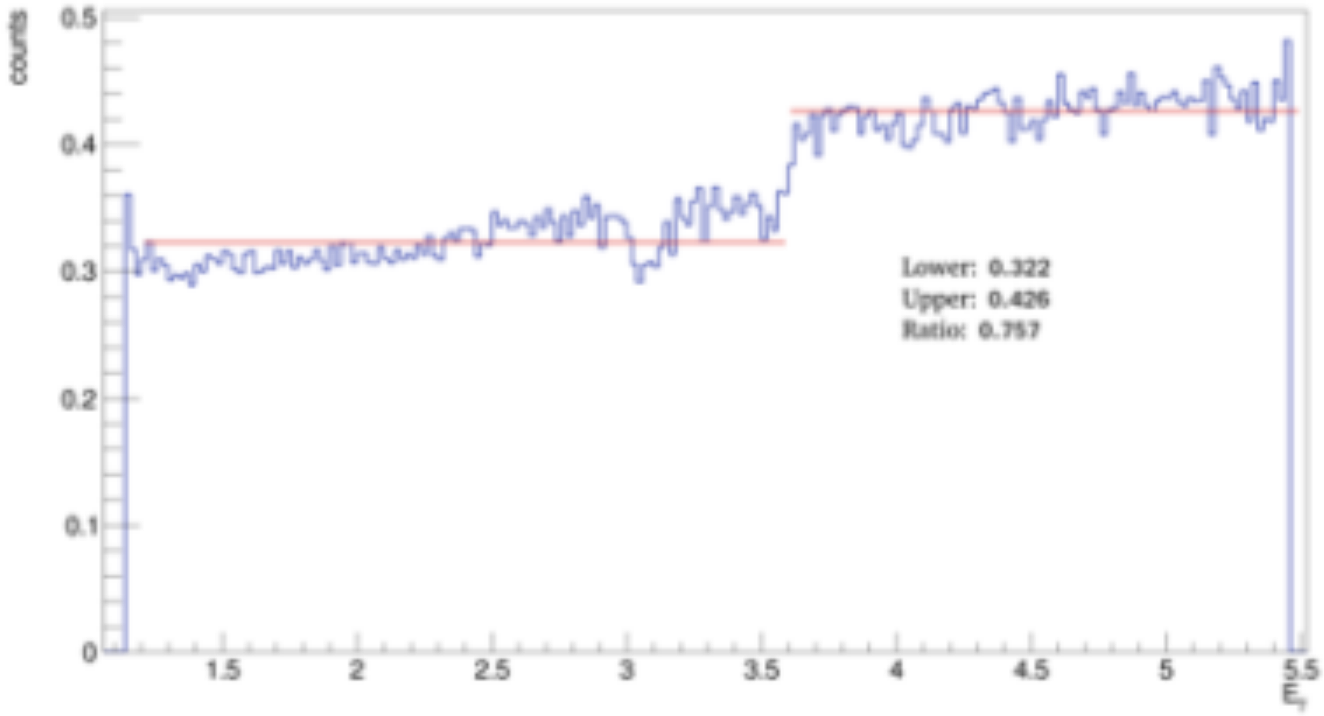
Proton trigger efficiency for each sector, for the “trigger-part-1” runs.

We see the same dark band for sectors 2-6.

Protons deposit more energy, showing a better overall trigger efficiency.

Final state: pp π^- (from ΛN scattering)

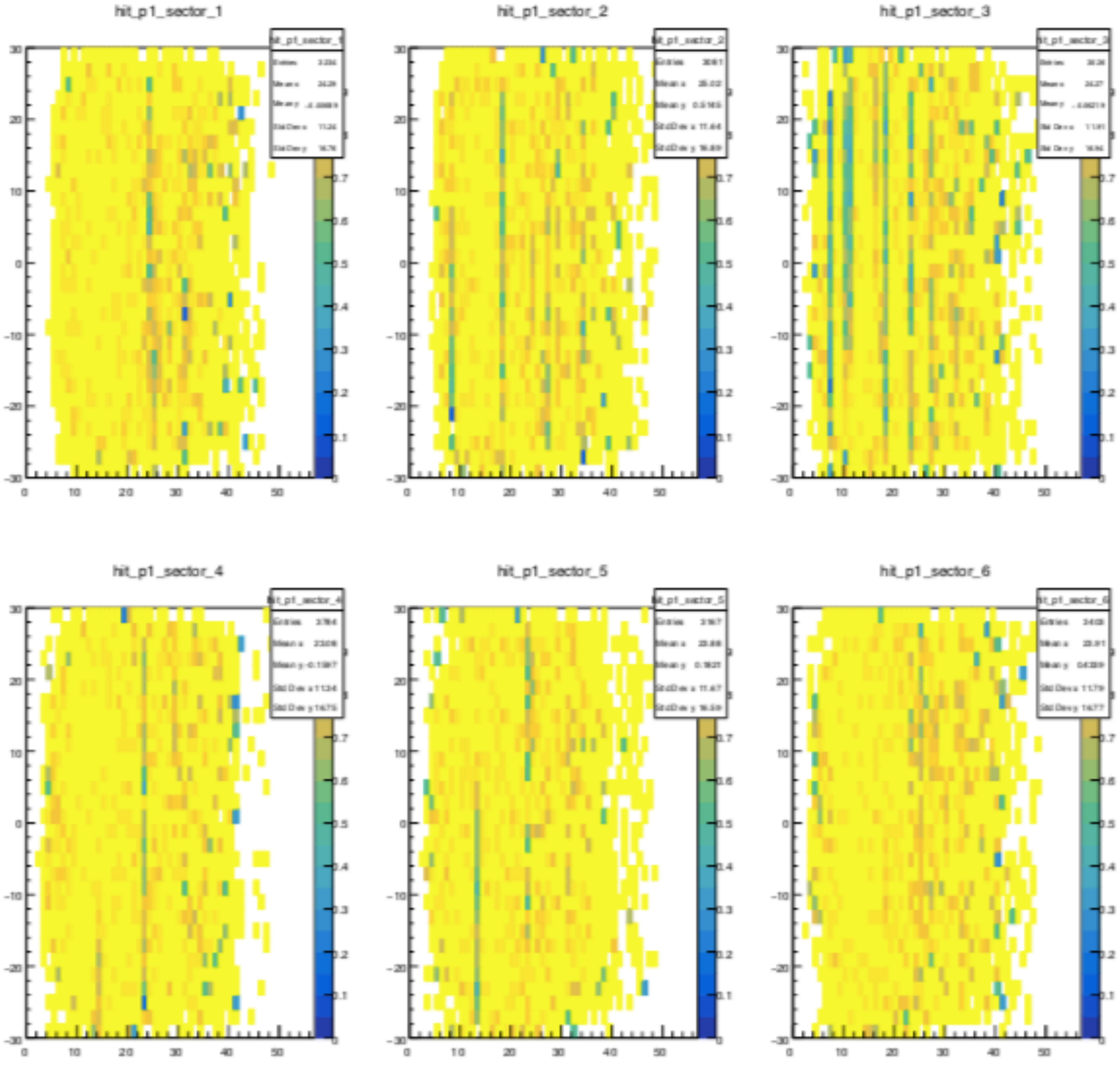
Ratio of 2 and 3 sector events



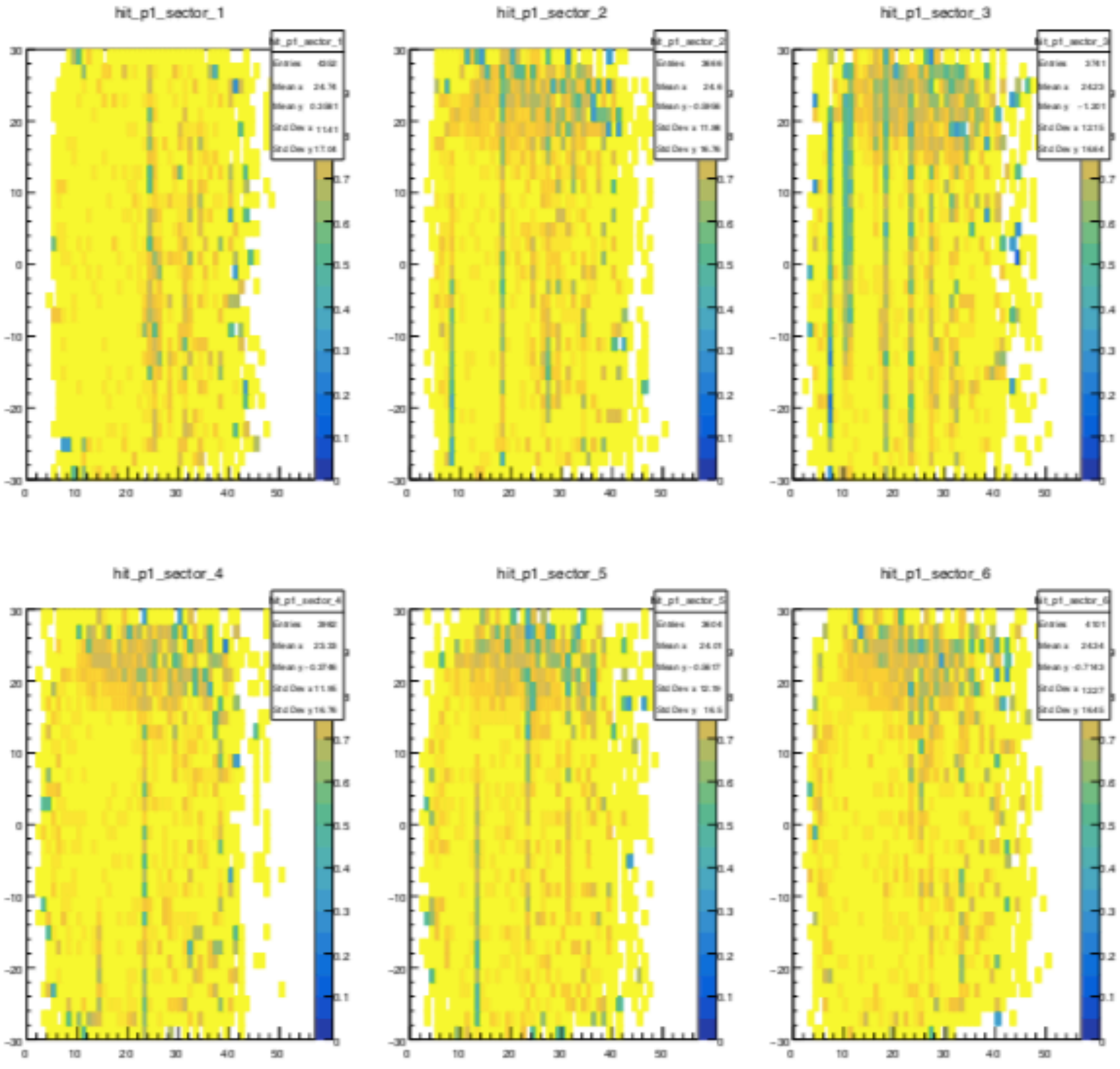
Ratio tells us the probability for 2 sector events having a photon (<3.6 GeV) in the beam bucket

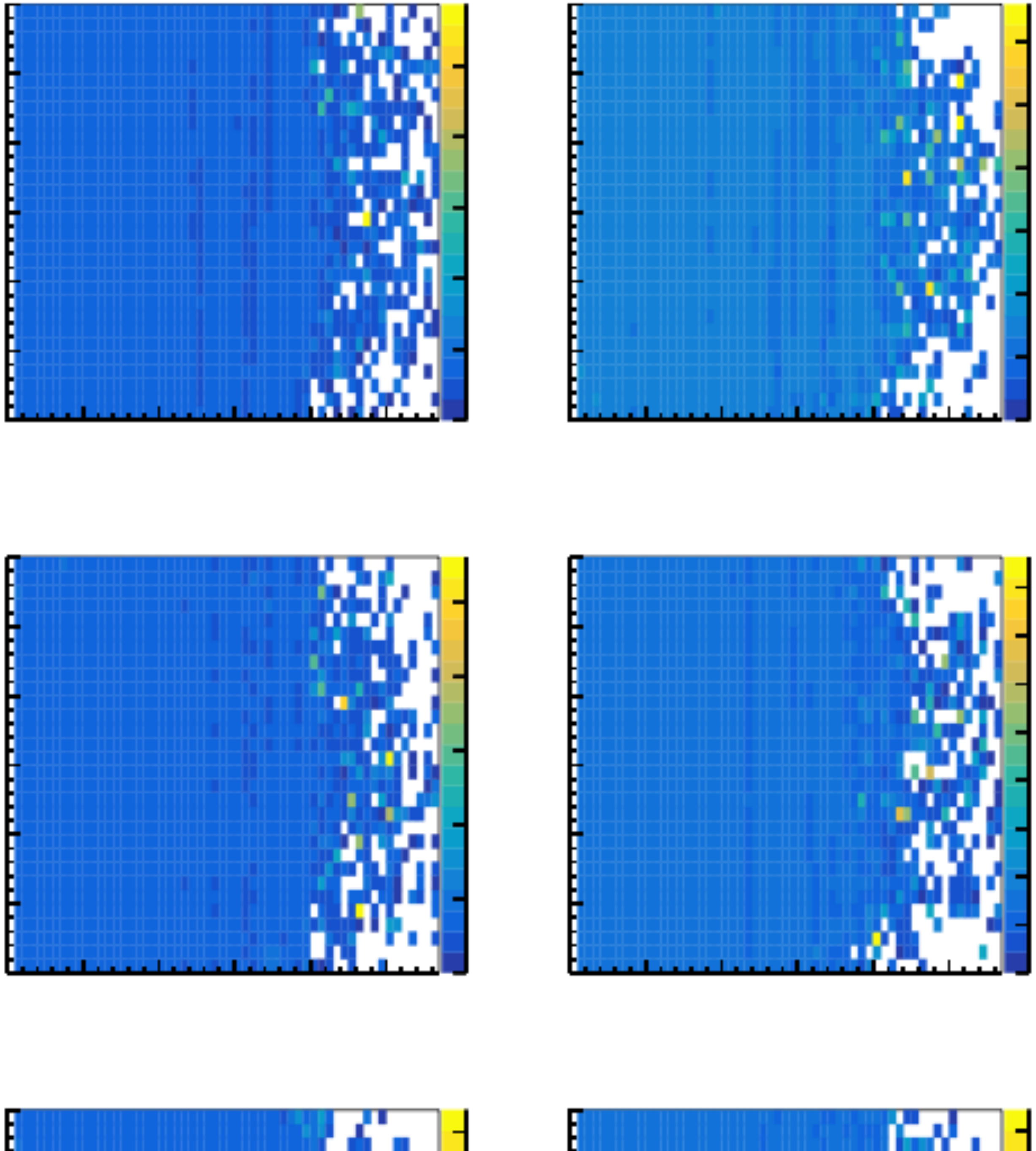
Reaction: $\gamma p \to pp\ \text{anti-}p$

Runs 56521 - 56569

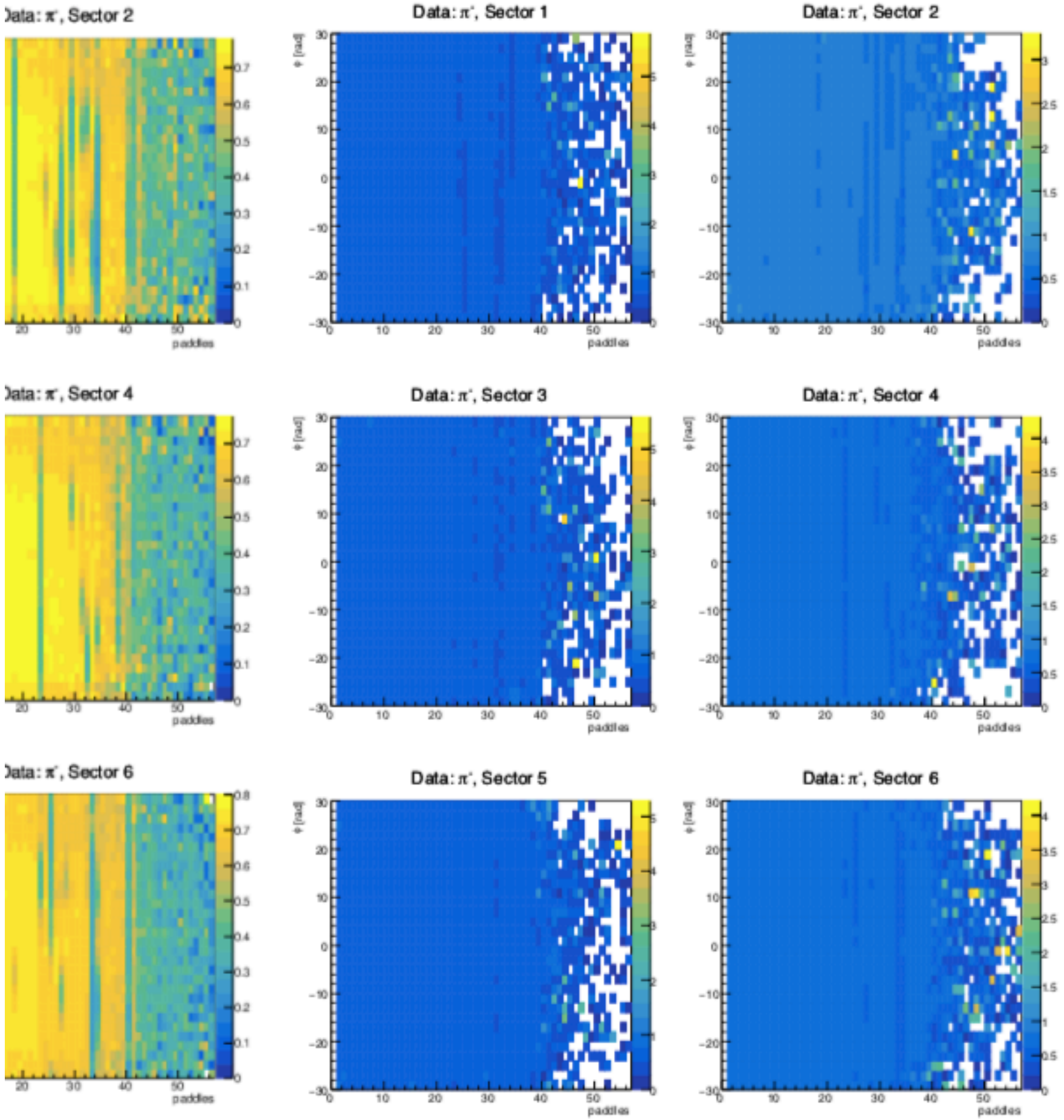


Runs 56570 - 56646





and part-2 runs



Ratio of effic. Map trig1/trig2

Summary

- The g12 experiment had a complicated trigger. This leads to the necessity of doing a trigger efficiency study.
  - Different trigger efficiencies for “part 1” and “part 2” of the g12 data, which had different trigger programing.
  - Some regions of the runs had some unknown problems: it’s best to avoid these sets of runs.
  - The main problem is the “weak” TOF counters. This depends on the final state particles. But the correction is straight-forward to apply.
- A careful study of the trigger efficiency should also be done for other runs, not just g11 and g12.
  - clas12 data might also need a trigger correction. This should be studied.