

ITKPix Beam Telescopes

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Introduction

- Since my QT (Sep 2023 - present), I have been supported by the **WATCHEP** program to continue working on ATLAS hardware

This talk will cover...

- BELLA test beam status & results
- Trigger tagging efforts
- Misc other pixel related things

What is BELLA?

- BELLA is an accelerator center at LBL focusing on developing **Laser Plasma Accelerators (LPAs)**

- What are those?

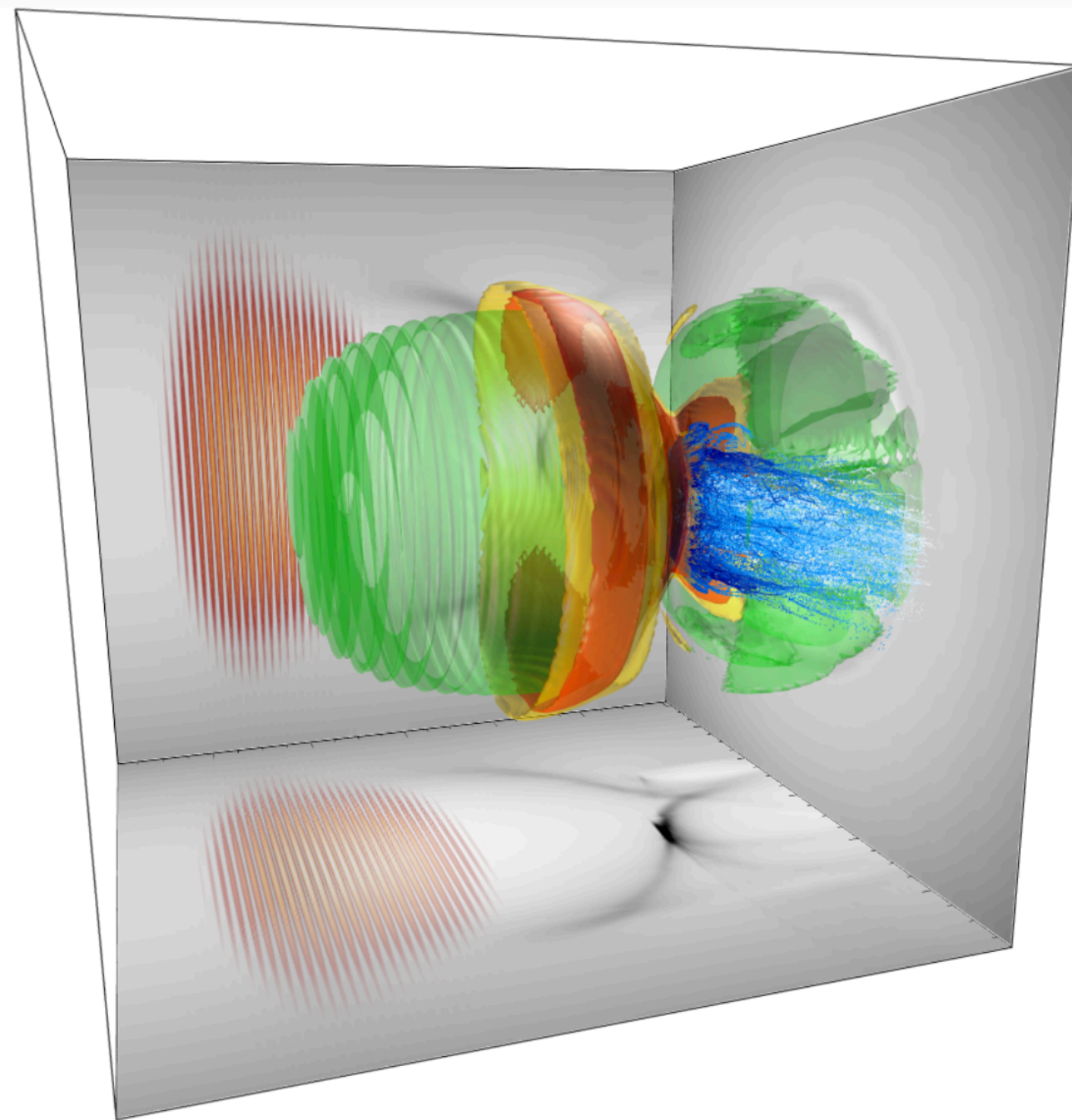


Fig. 2: An example of a three-dimensional wakefield generated by a short, intense laser pulse. Red and yellow, electromagnetic fields; green, electron density; blue, electrons trapped and accelerated by the wakefield. © J. Vieira, IST Lisbon, Portugal.

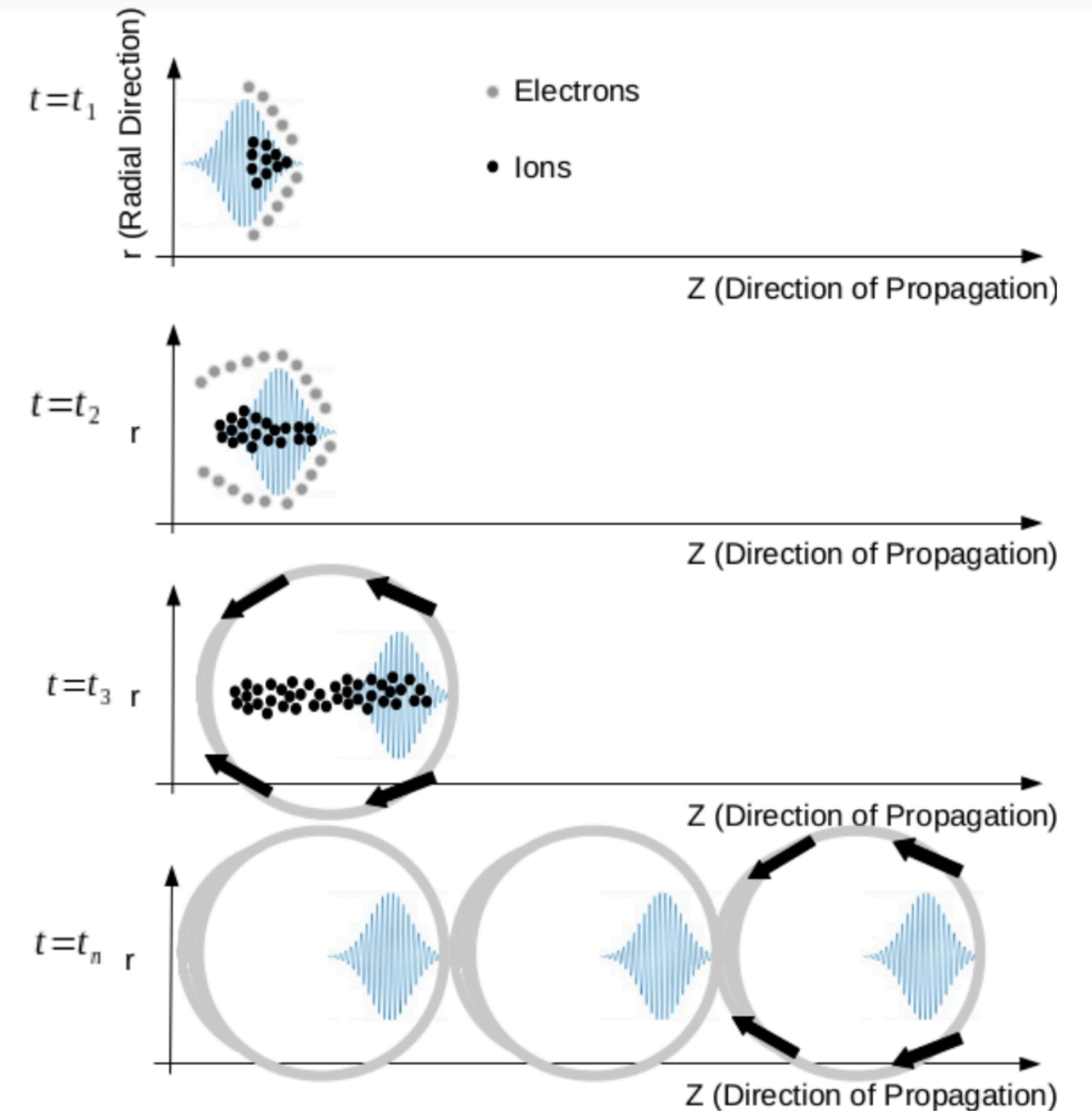
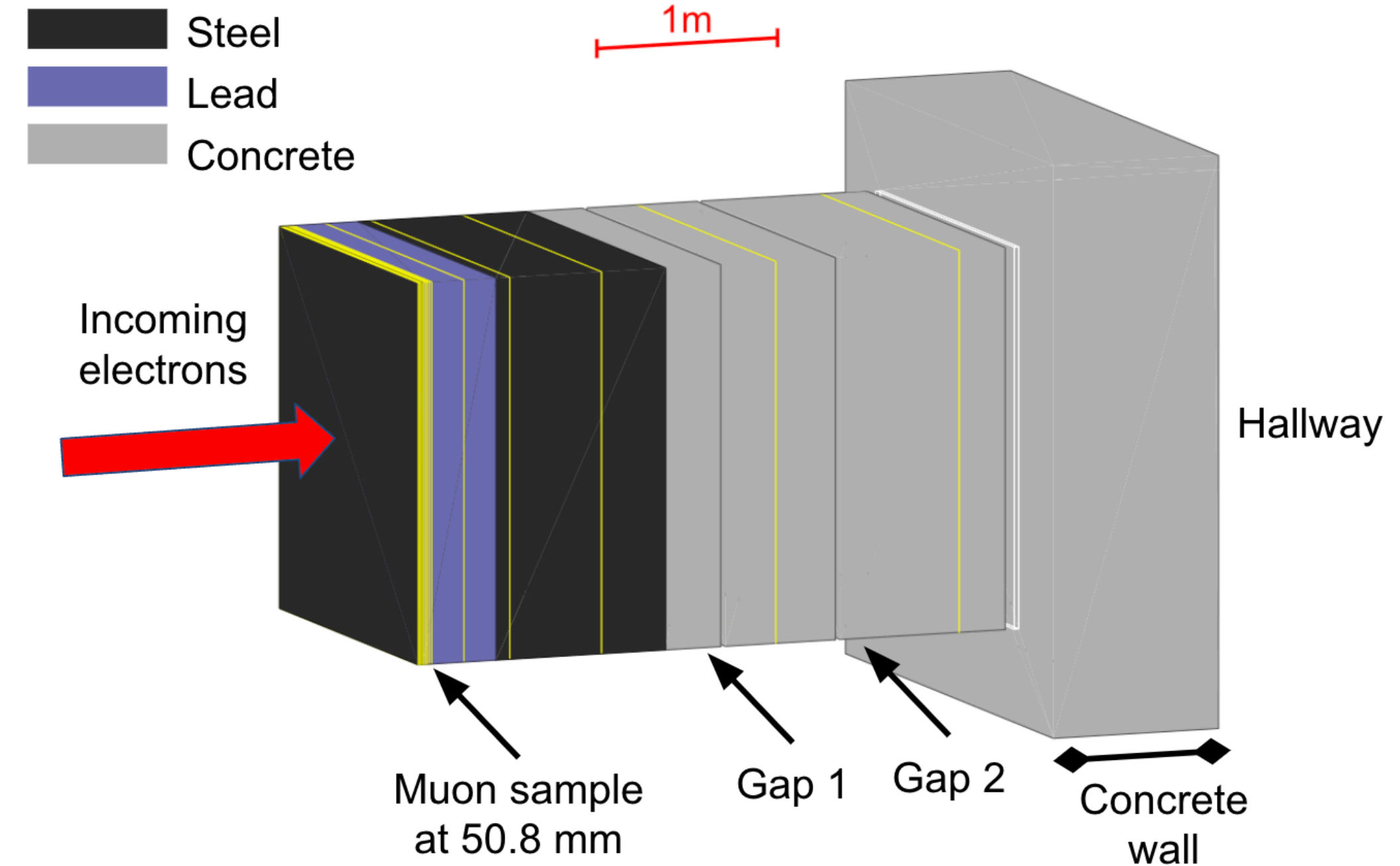


FIGURE 2. Plasma density altered by the massive EM field. At $t = t_1$, the electrons are repelled by the pulse and the ion at the center created a local positive region. At $t = t_2$, the electrons are attracted by the local positive region while the pulse is traveling. At $t = t_3$, the electron density form a bubble led by the pulse. At $t = t_n$, multiple bubbles are formed as a bubble train with multiple pulses.

Why BELLA?

- BELLA can produce femtosecond electron bunches, reaching up to **10 GeV**
- After passing through a concrete beam dump, these electrons convert to muons
- Our group (Maurice, Timon, Maria) has set up an ITkPix telescope to detect these muons (along with anything else that is produced)
- We use **single-chip pixel modules** with 3d sensors, placed in the gaps in the beam dump + hallway



Graphic from Stanimir Kisyov

BELLA ITkPix telescope

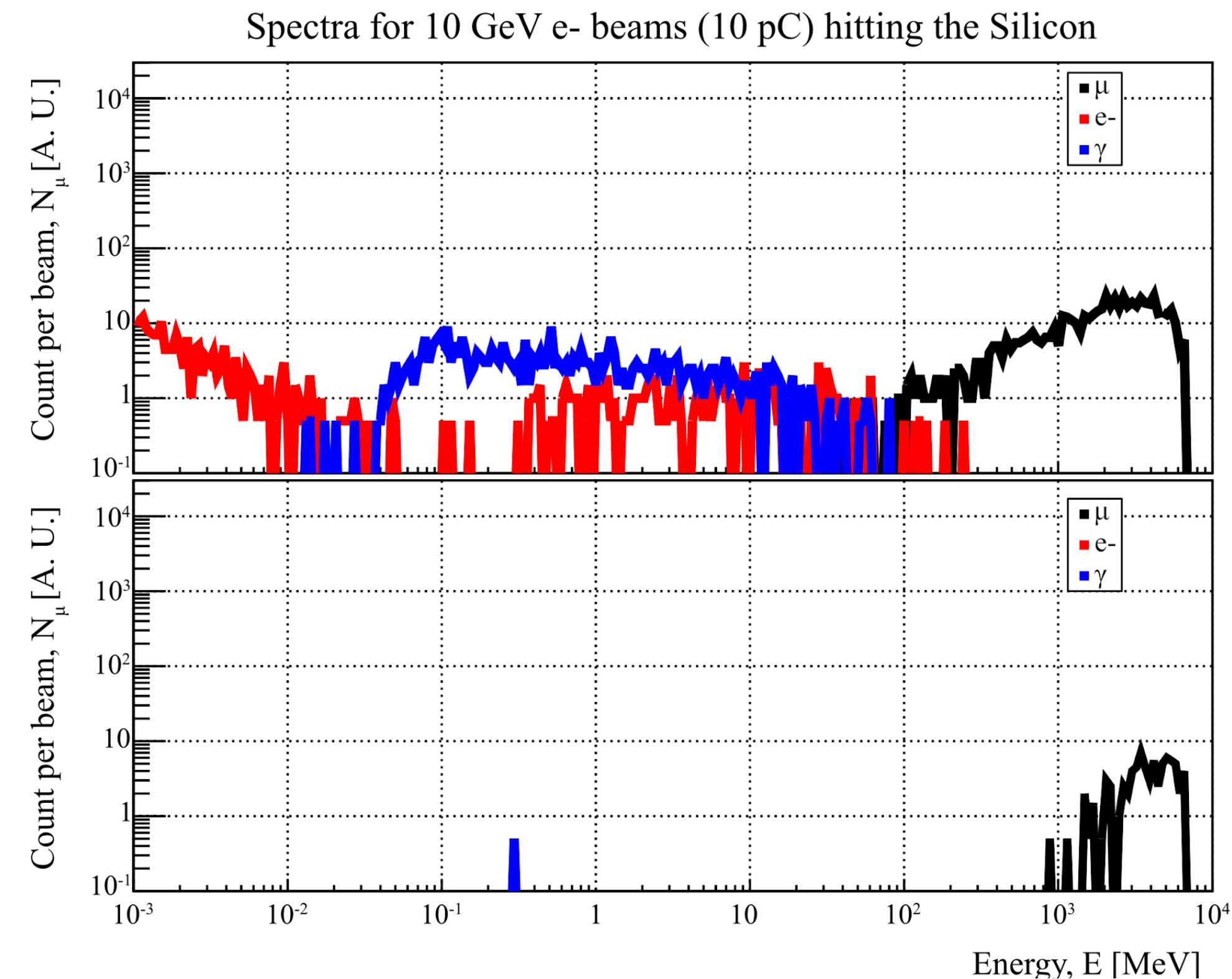
- According to the latest simulation, we expect $O(100)$ muons per beam shot at the max energy of 10 GeV
- Practically, might see $O(10)$ muons with lower beam energies
- Concurrent scintillator setup has already seen some muons (Maurice + Stephen)



Bella hallway setup (fun spot)

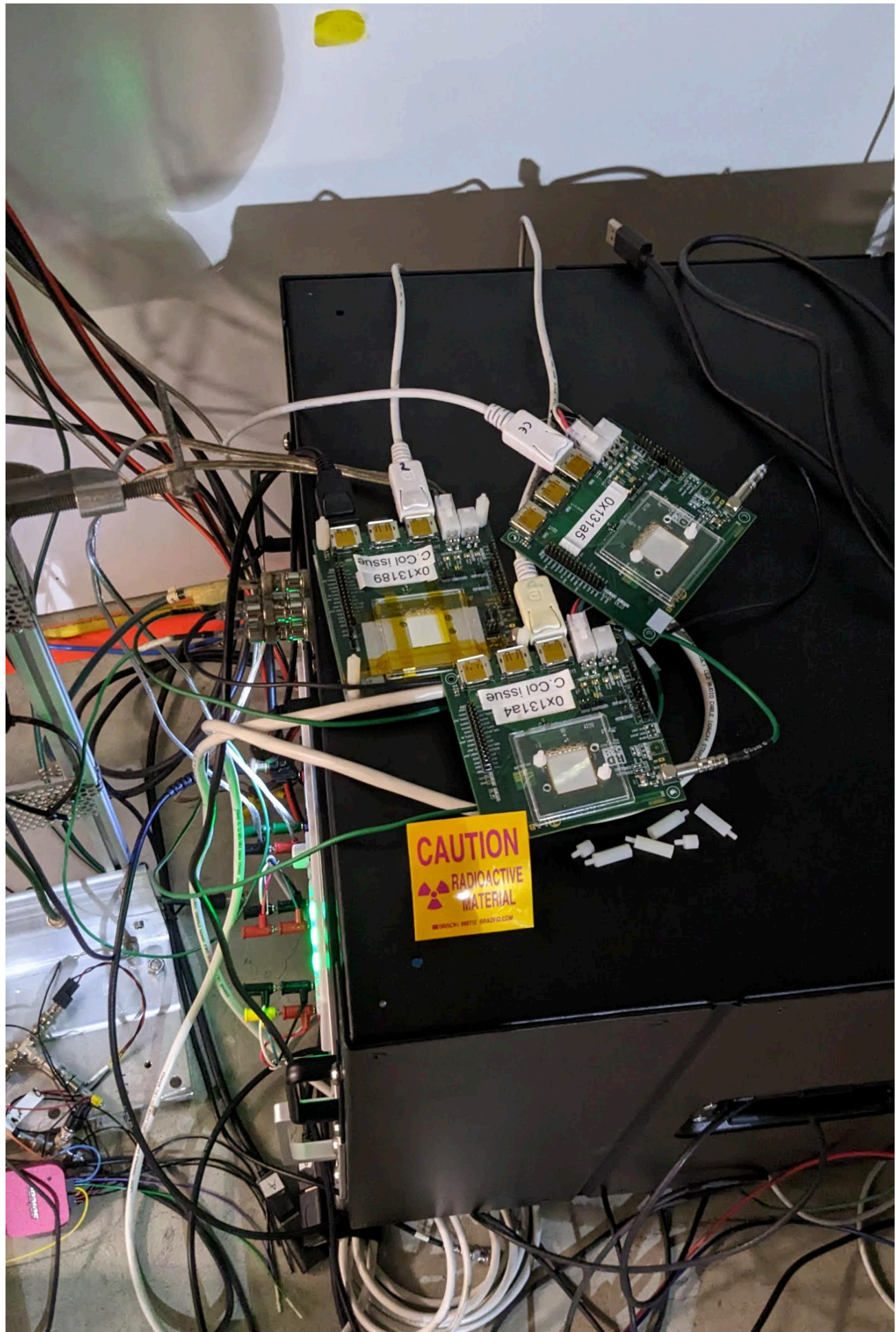
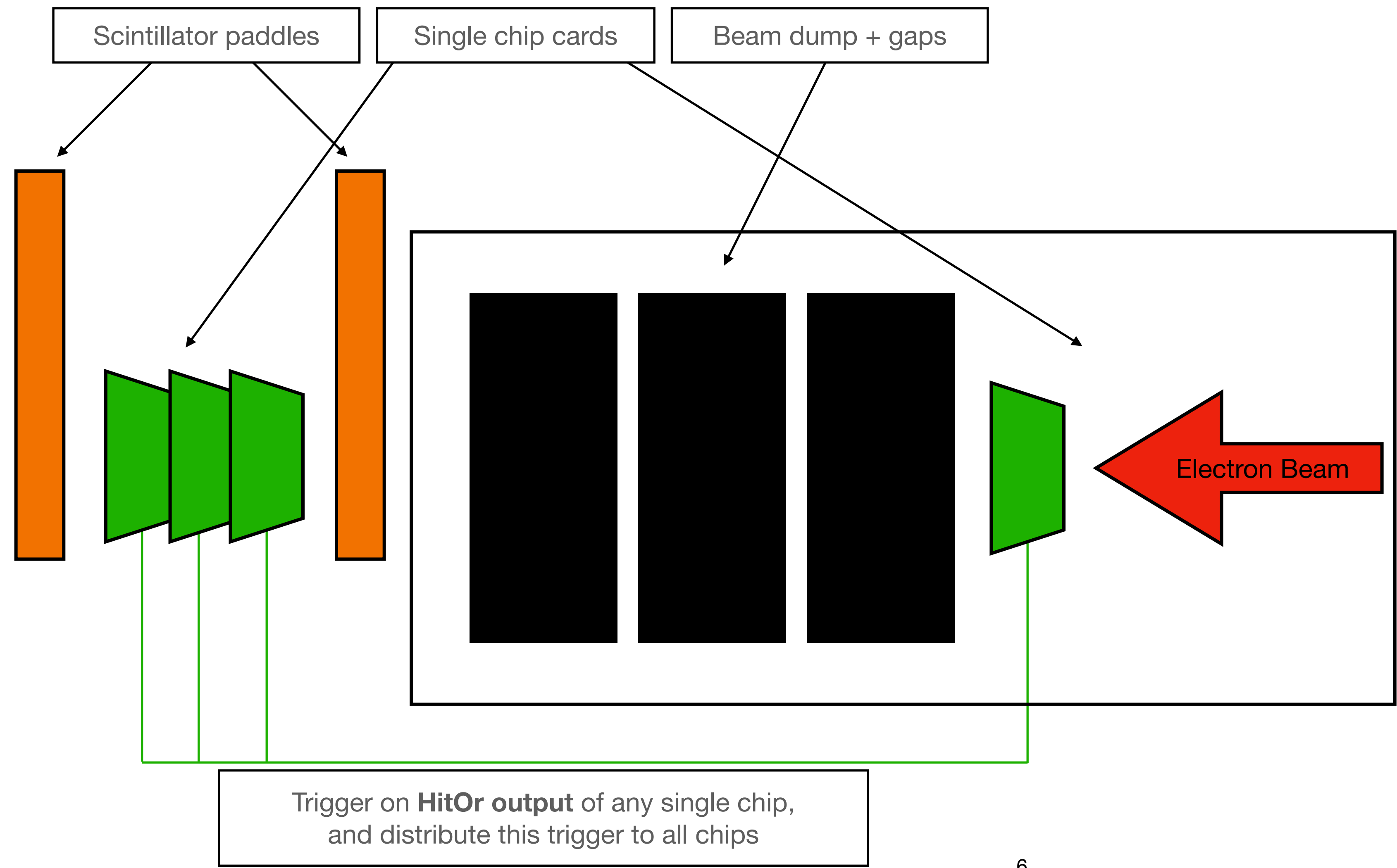


Bella inside beam dump



Graphic from Stanimir Kisyov

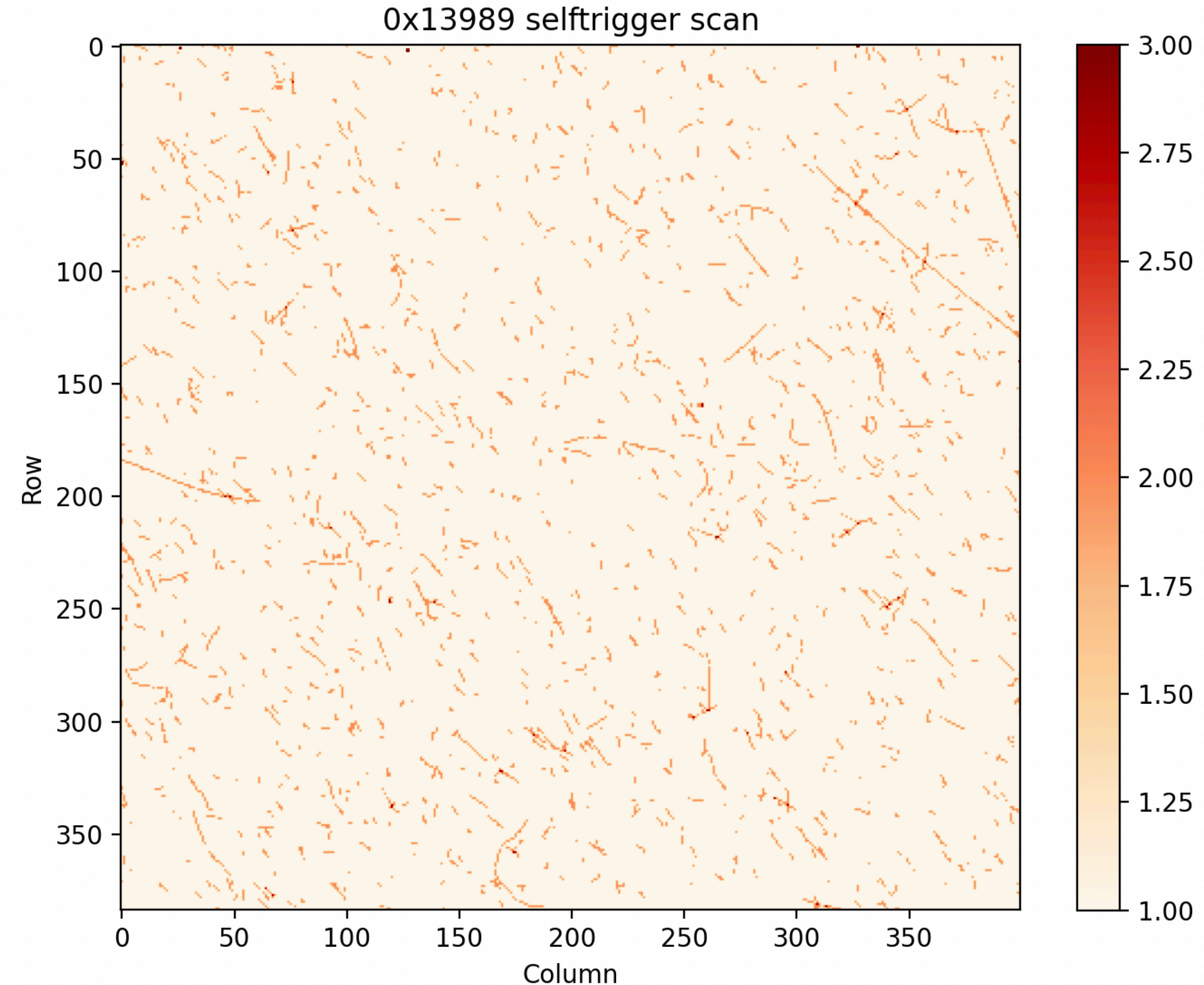
BELLA ITkPix telescope setup



Deconstructed module stack (for rad testing)

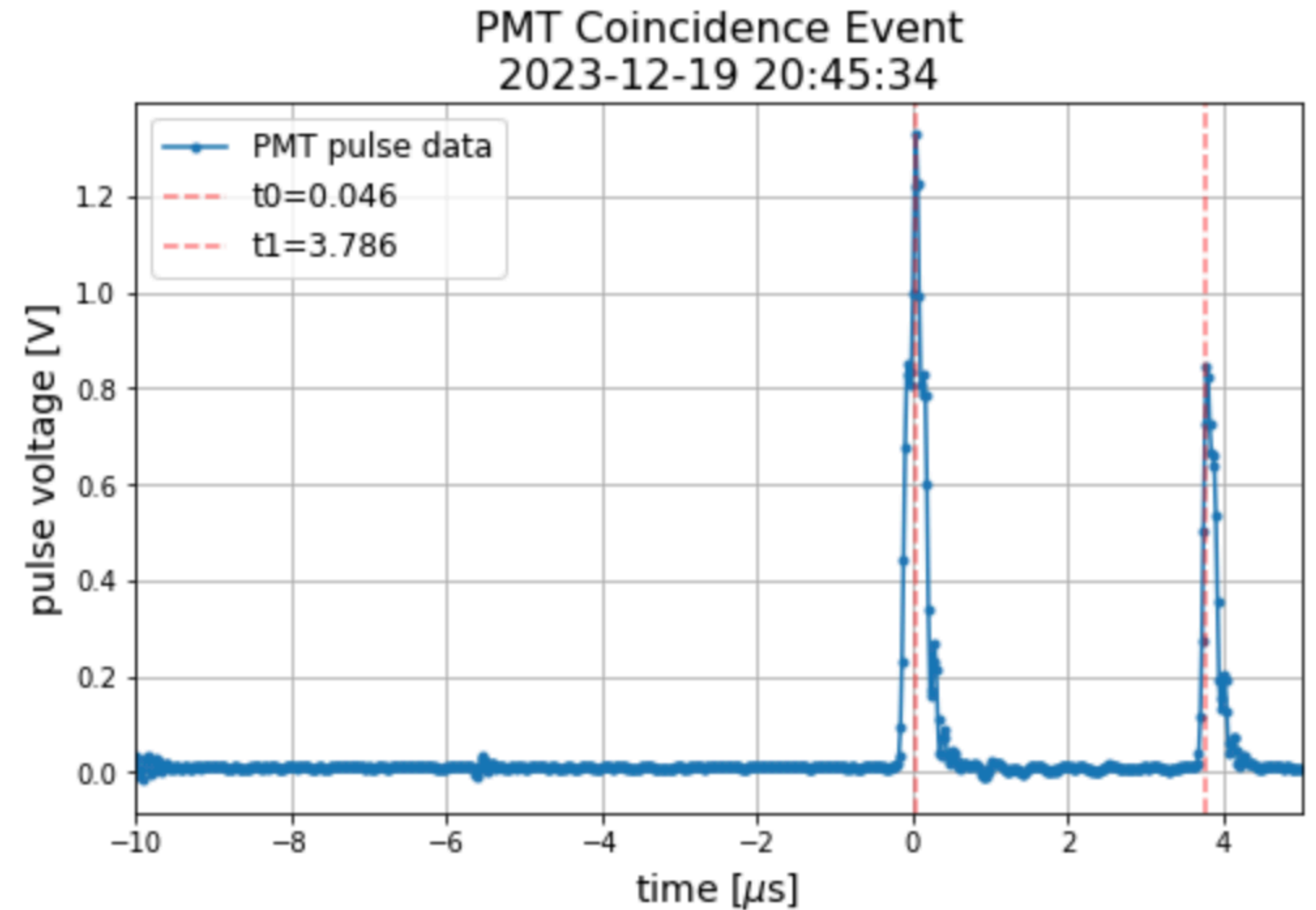
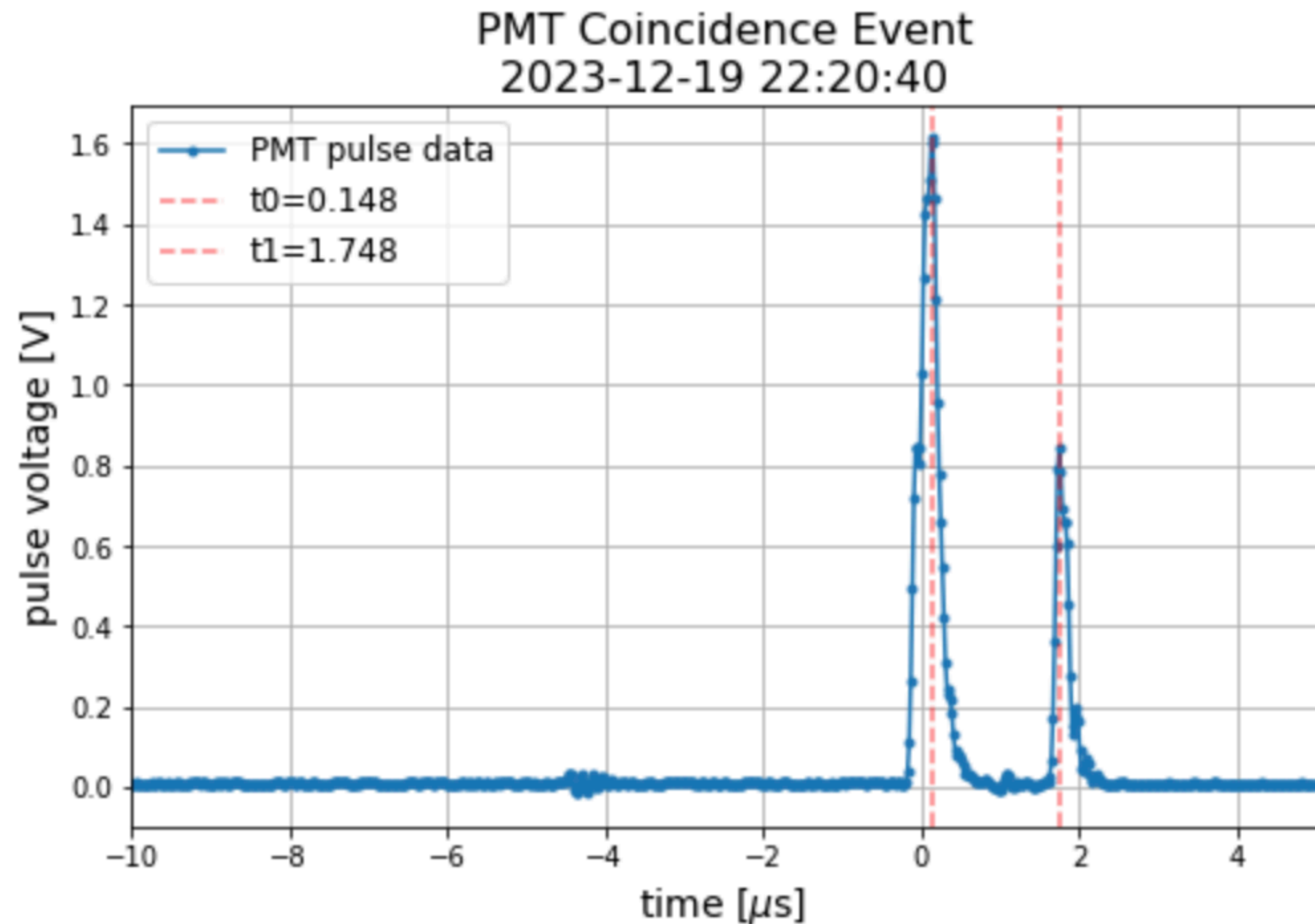
BELLA data

- Using single chip HitOr output to trigger the other 2 or 3 chips
- Limited to 3 modules at once right now - 1/4 ports needed for external trigger
- Still have not been able to collect good data, but have 2 more weeks (hopefully!)



BELLA data

- Scintillator Muon coincidences from Stephen + Maurice
- These are stopped muons - the two pulses show arrival time + time of decay for a single muon



BELLA: good news!

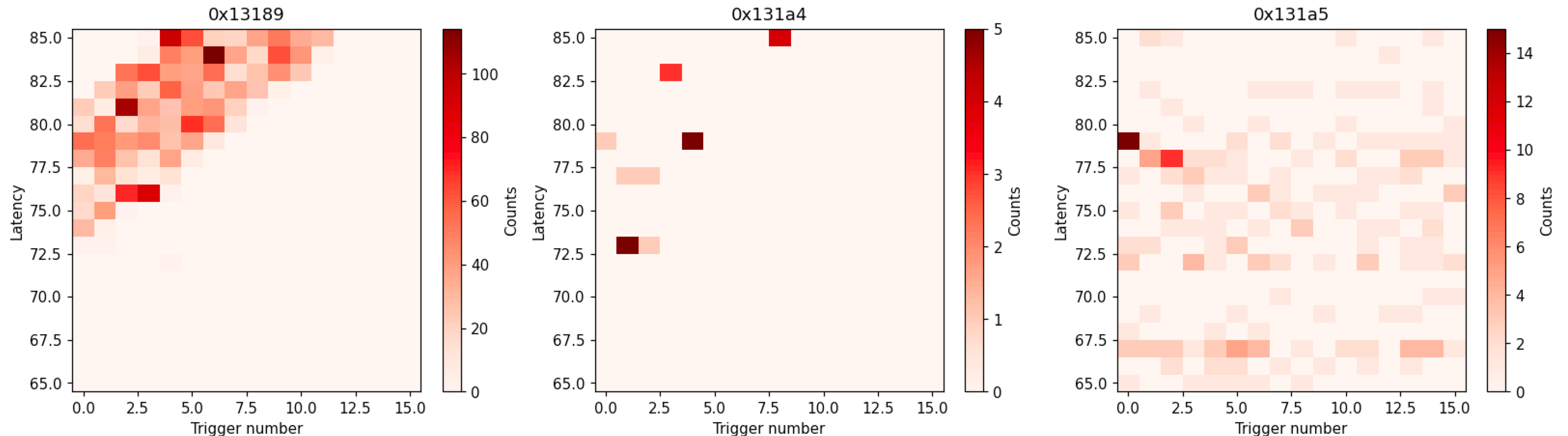
- The original plan for Bella was to stop high energy beam production **today**, before we have had much of a chance to collect data
- Luckily it looks like they will be extending production for another two weeks, giving us some more time

	iP2	Everything else
1/15/2024		HEP OFI electrons
1/22/2024		OFI muons
1/29/2024		OFI muons
2/5/2024		laser maintenance: LBOs. plasma cleaning. SLM

Proposed BELLA schedule revamp (from Kei)

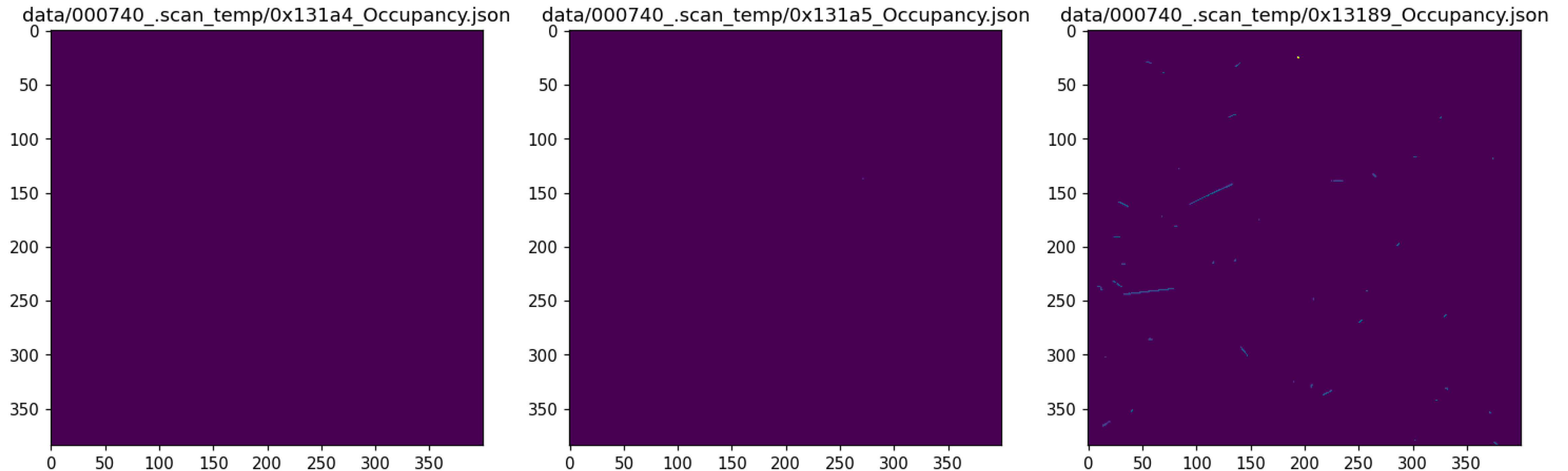
BELLA timing

- We want to adjust FPGA latency such that entire events are captured
- For 300 second scans, where do events fall in the trigger window (typically 8 to 32 triggers sent per trigger received)?
- Hard to check correlation when we don't have beam



BELLA timing

- For now, our detectors are radioactive, so we can not bring them back to the lab for timing
- Hopefully we will get beam soon!



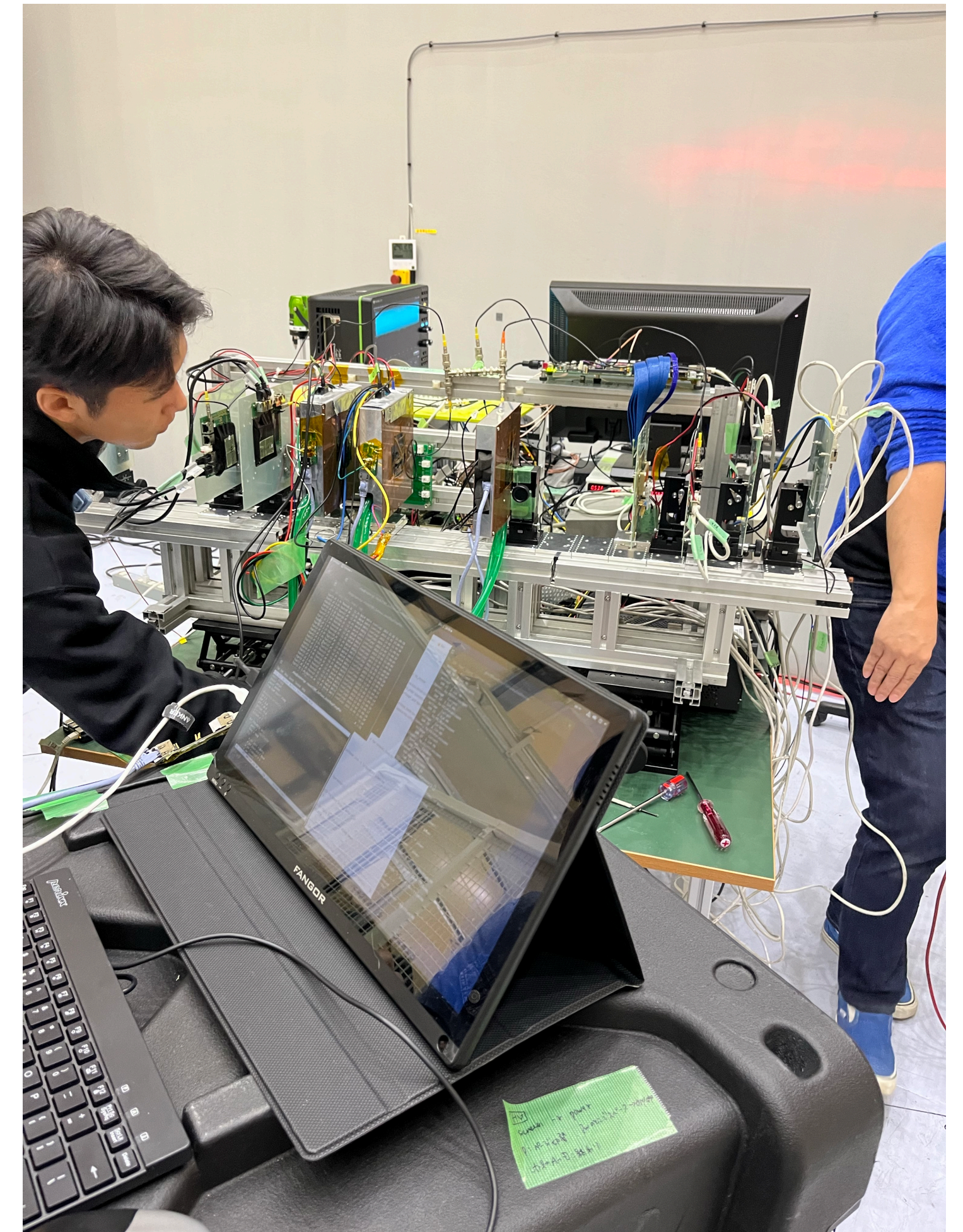
Occupancy scans for latency=82, showing lack of correlation between triggered module

Trigger Tagging

What is trigger tagging?

- At a very high trigger rate, ITkPix chips can drop silently **drop events**
- This can lead to desynchronization between **triggers** and **data**
 - Big problem at test beams/chip telescopes, where we want to be able to align all chips in a telescope
- Trigger tagging modifies the ITkPixel firmware to assign **sequential** identifiers to each trigger sent to the chips, which are then stored in data
- These tags make it possible to **re-align** testbeam data after the fact

Maria and I were able to develop a working version of trigger tagging during our visit to KEK, but there is still work to be done to figure out the **timing** of the new firmware.



LBNL crate at KEK + beam telescope

-> Hope to do this at bella!

Pixel module webcam

- I've also been working on a pixel module “**webcam**,” which shows a live module event readout in the terminal
- This is helpful for alignment, debugging, and general sanity checks
- Also possibility of being an interesting **outreach** project
 - One can imagine webcam showing hits side-by-side with a 2 or 3-layer telescope
 - Draw tracking lines on-screen in real time (possible for cosmics or low intensity beta gun)

```
Frame: 1 (real fps 0.0)
Module 0 (0x131a4)
- Displayed hits: 142(/142 total in this cycle) (cumulative 142)
- Events: 12 (cumulative 12)
- File Position: 1292
Module 1 (0x131a5)
- Displayed hits: 123(/123 total in this cycle) (cumulative 123)
- Events: 78 (cumulative 78)
- File Position: 3818
Module 2 (0x13189)
- Displayed hits: 64(/64 total in this cycle) (cumulative 64)
- Events: 43 (cumulative 43)
- File Position: 2024
Total Hits: 329
Cumulative Hits: 329
```

Pixel module webcam: germanium sensor



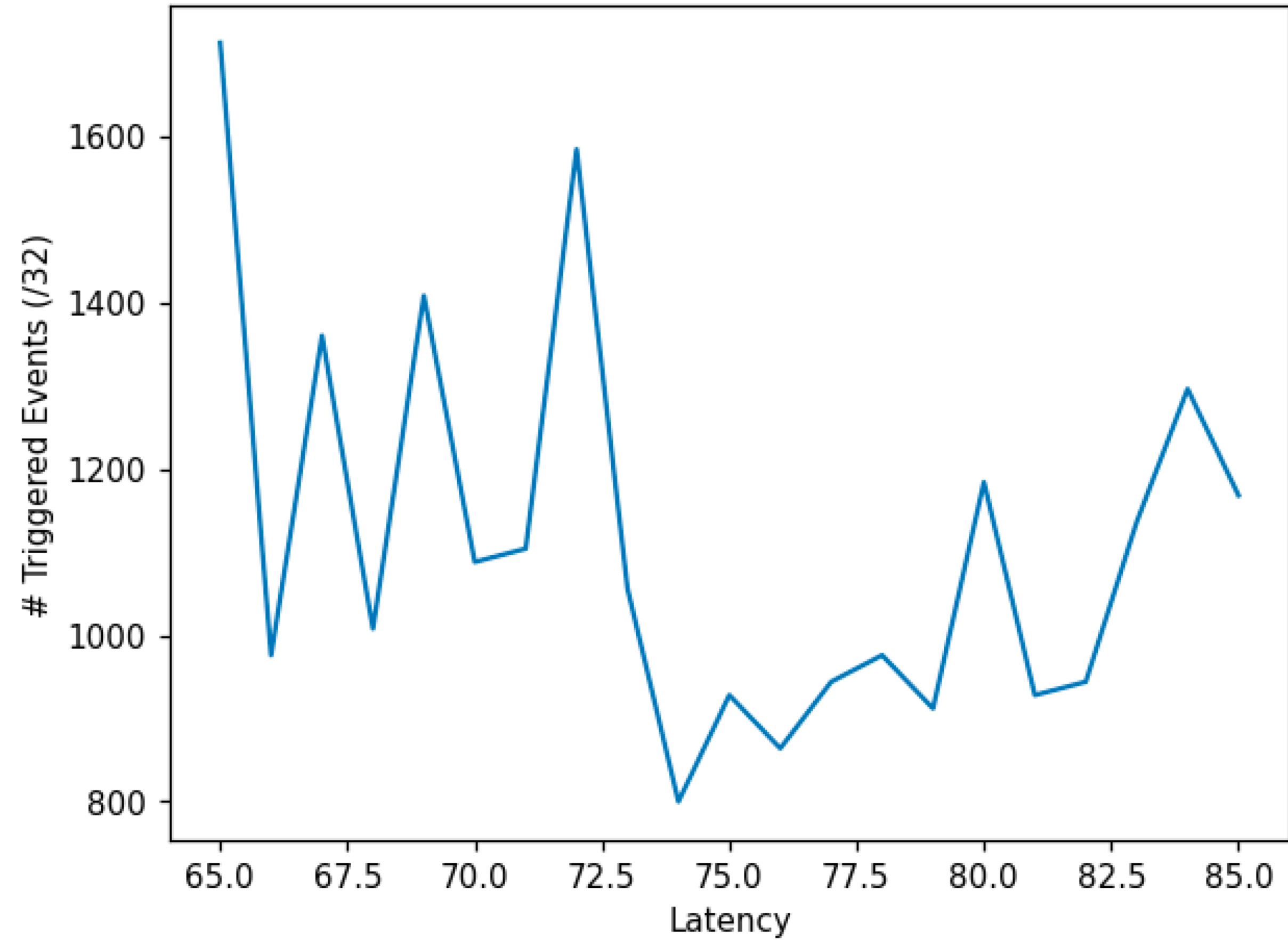
Future Plans

- Figure out trigger tagging timing with Bella
- See muons at Bella
- Help with the transition to trigger tagging firmware at the next test beams (CERN in early April)
- Start to explore ways to increase ITkPix readout speed - eventually looking for **MHz test setup** and identifying bottlenecks in our current firmware

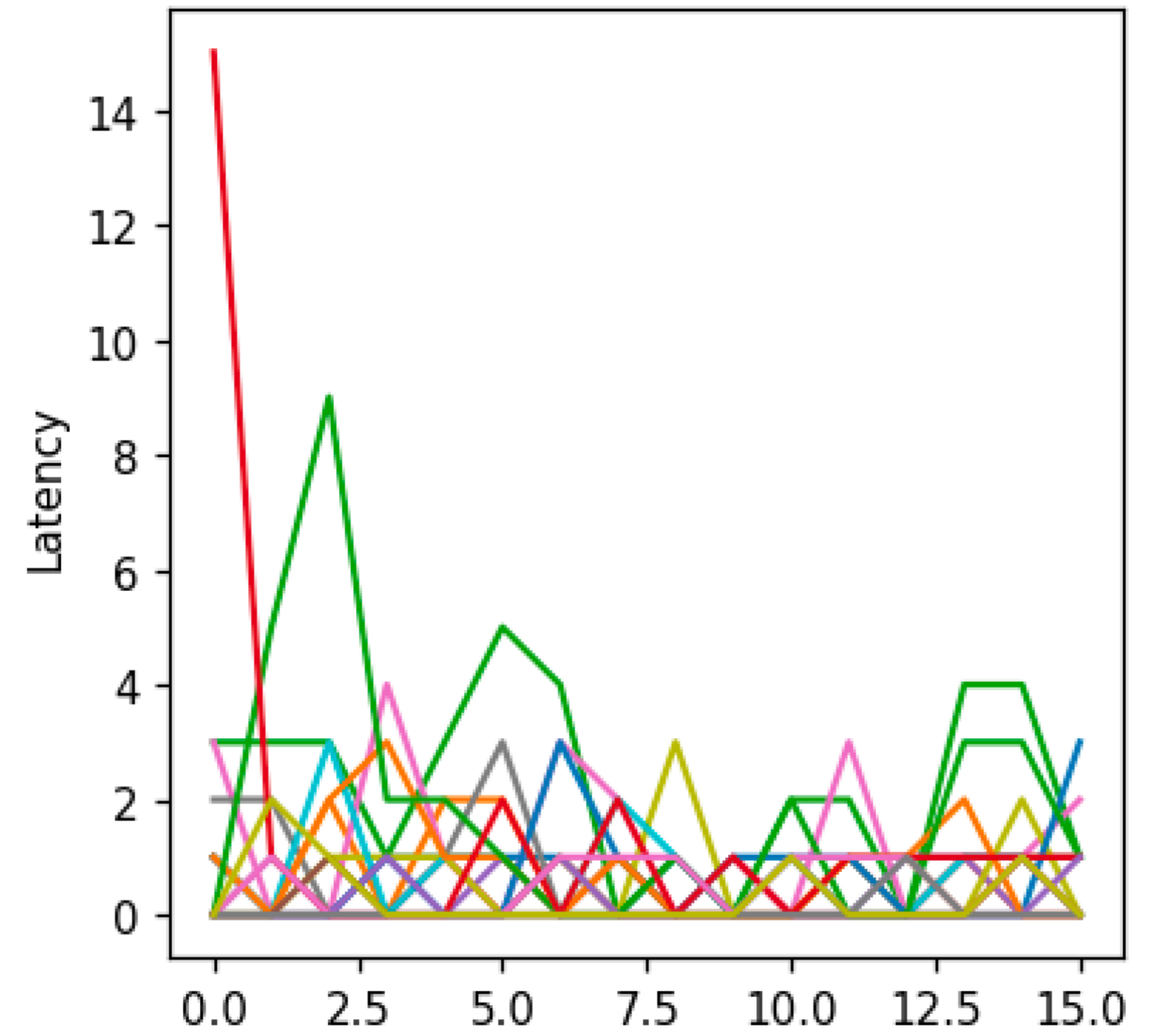
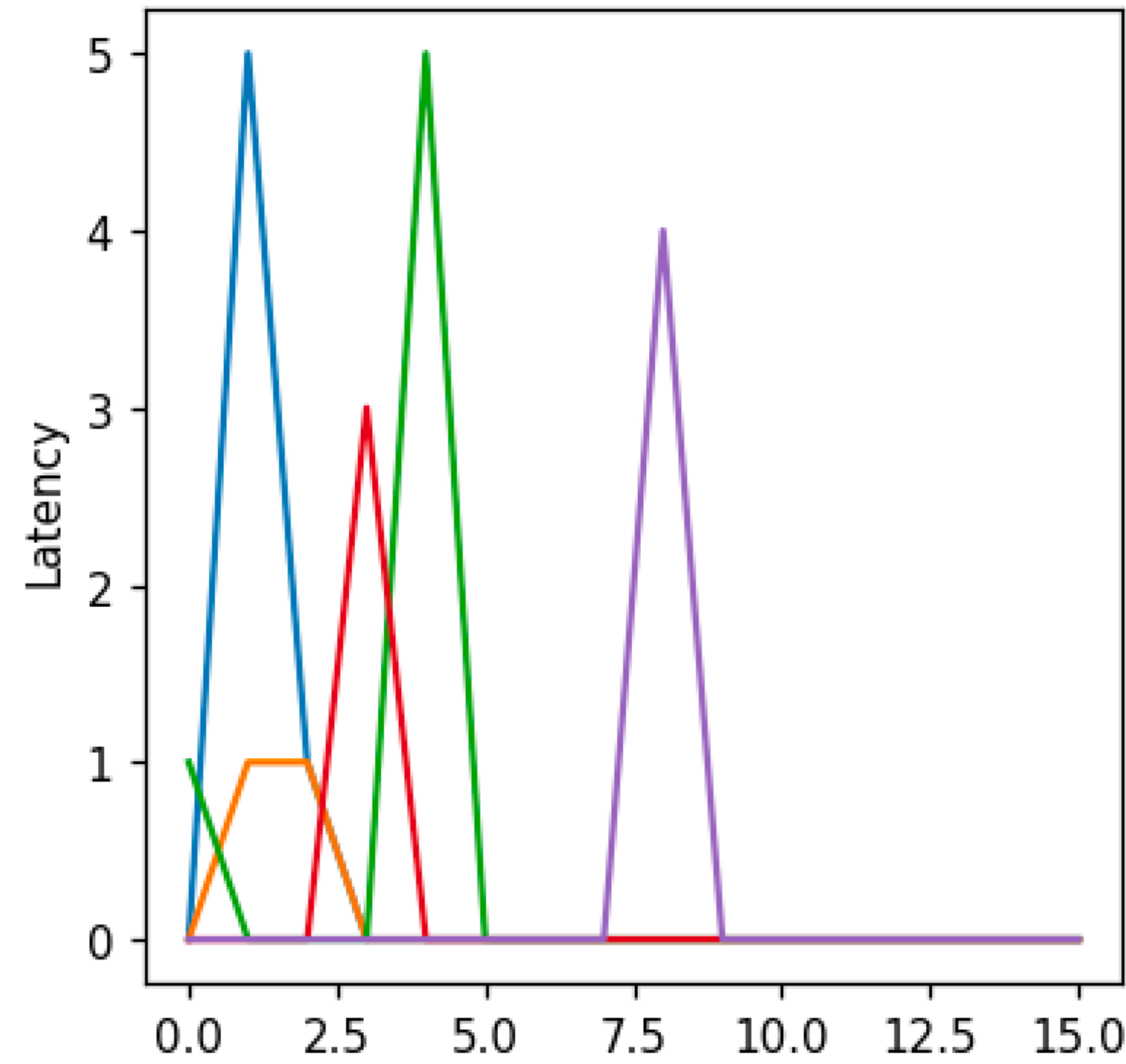
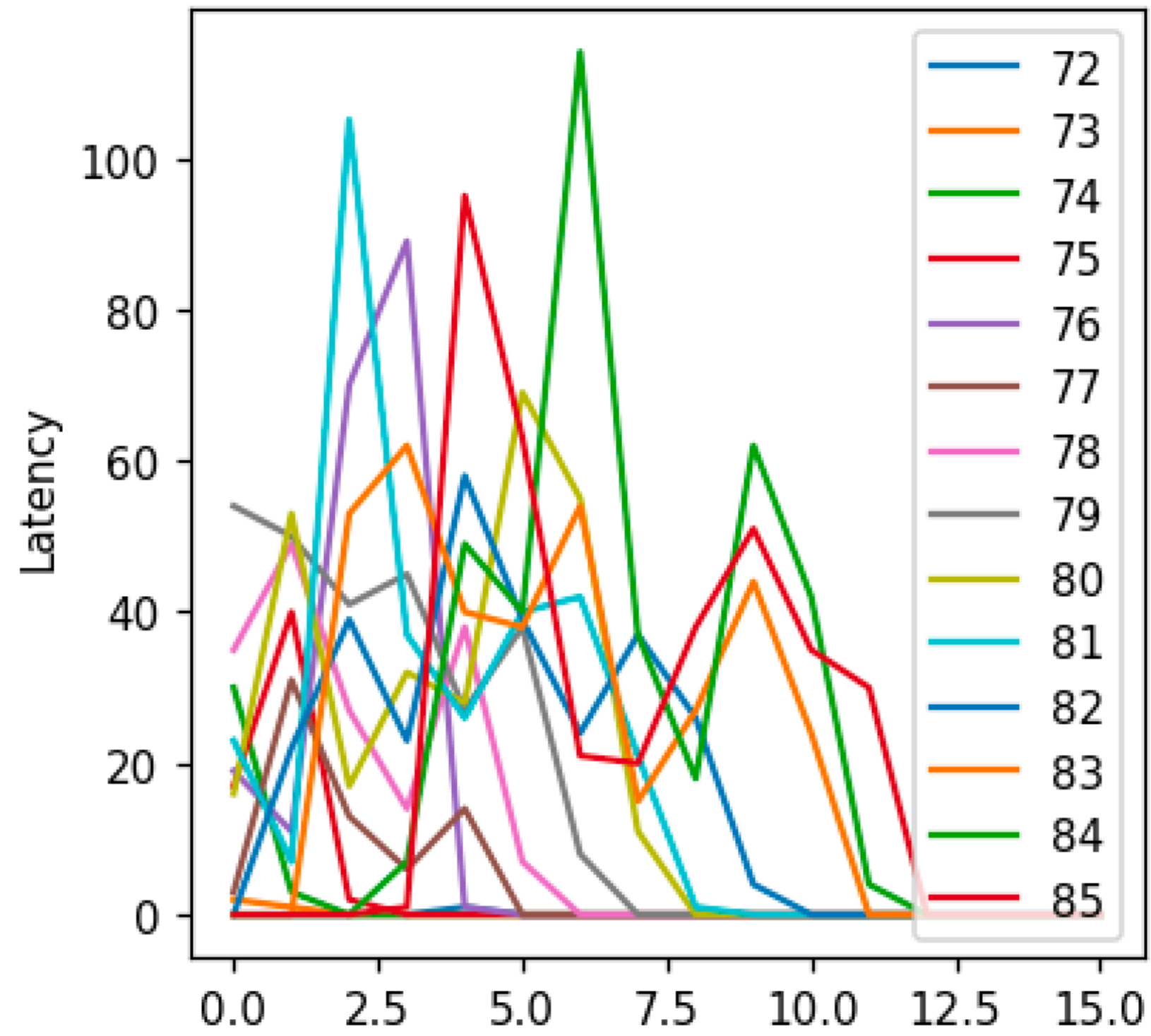
thank you!

backup

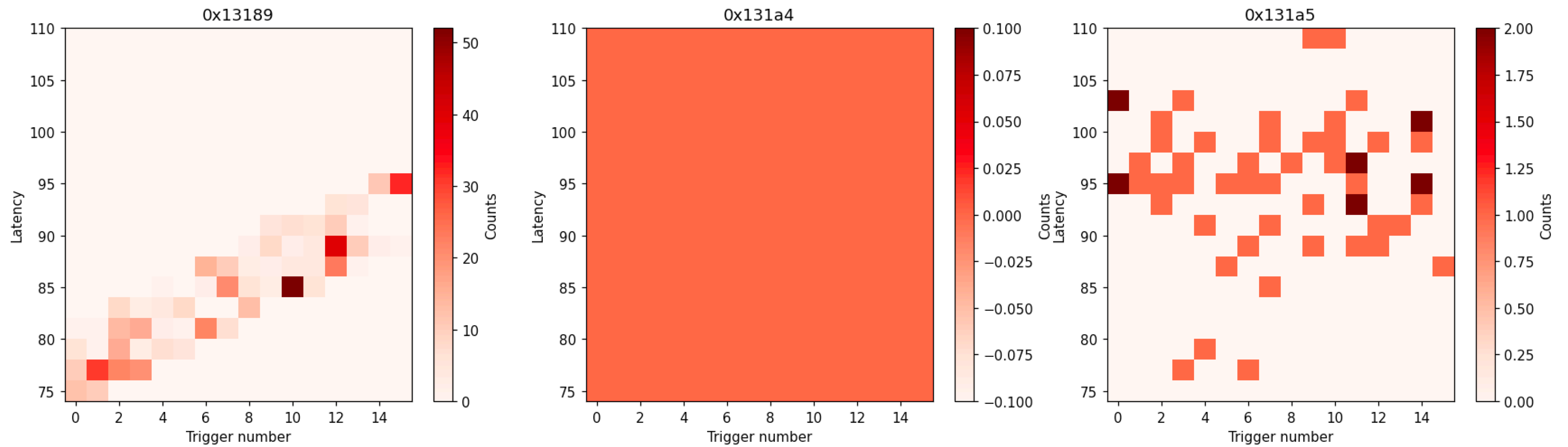
More timing plots



More timing plots



More timing plots



More timing plots

