# Update on Double injection scan for the RD53B

Thanks to Maurice Garcia-Sciveres, Timon Heim and Magne Lauritzen

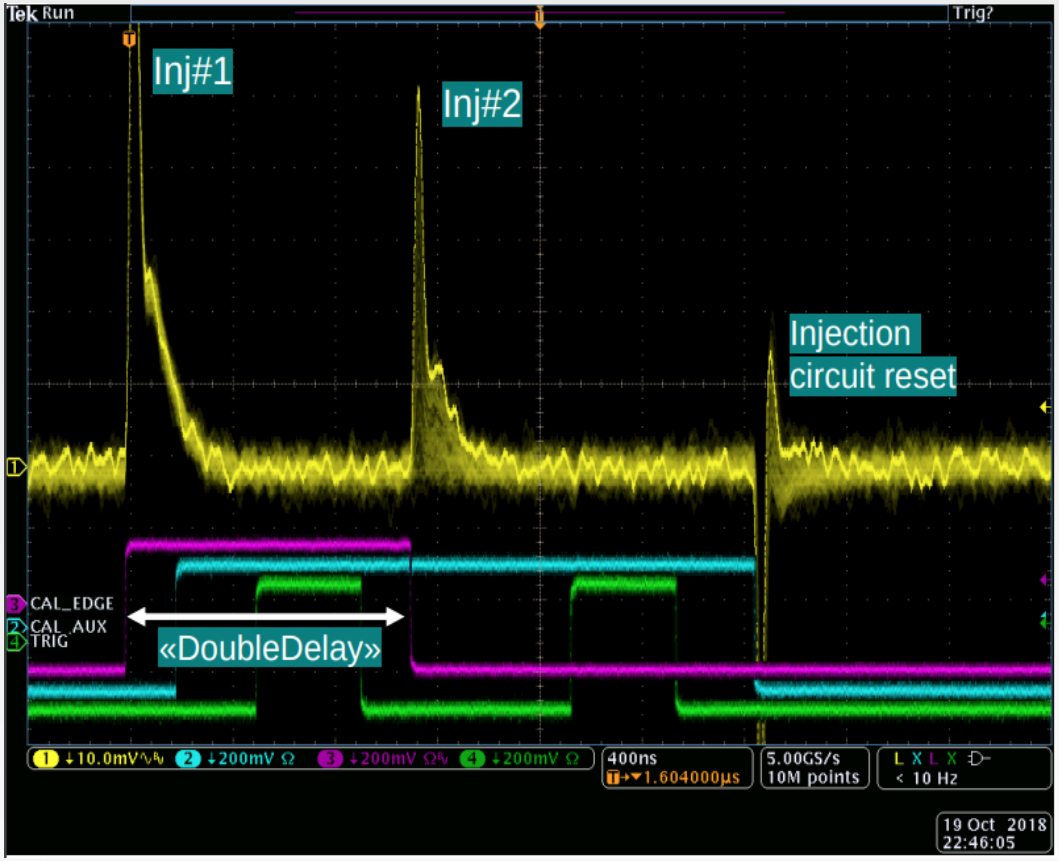
**Presented by Simon K. Huiberts**

ATLAS EXPERIMENT

UNIVERSITY OF BERGEN

# Introduction

- The purpose of the **double injection scan** is to study the behaviour of the Front-end (FE) during charge injections and data readout
- In this study: see how the measured pixel threshold is **affected** by a **preceding injection**
- **The double injection scan** can inject **two consecutive charge injections** into each pixel
  - Done via **Cal commands** which control the capacitor injections for a selected pixel
- **How it's done:**
  - First injecting a constant charge into the selected pixel (Inj#1)
  - Wait a set period (DoubleDelay)
  - Injecting a second charge of varying magnitude into the same pixel (Inj#2)
  - Send triggers to read out the data




Double injection scan taken by an oscilloscope. Figure by Magne Lauritzen

1) Purple line is the CAL_EDGE signal

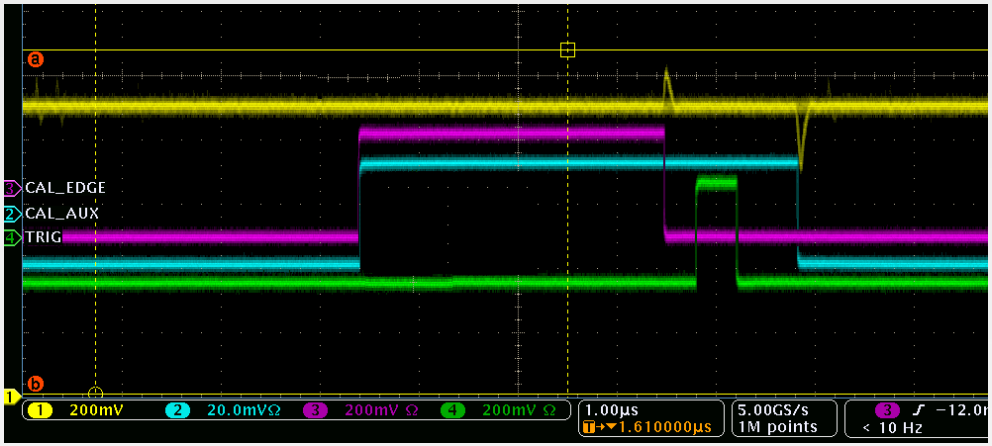
2) Light blue line is the CAL_AUX signal

3) Green line is the trigger signal

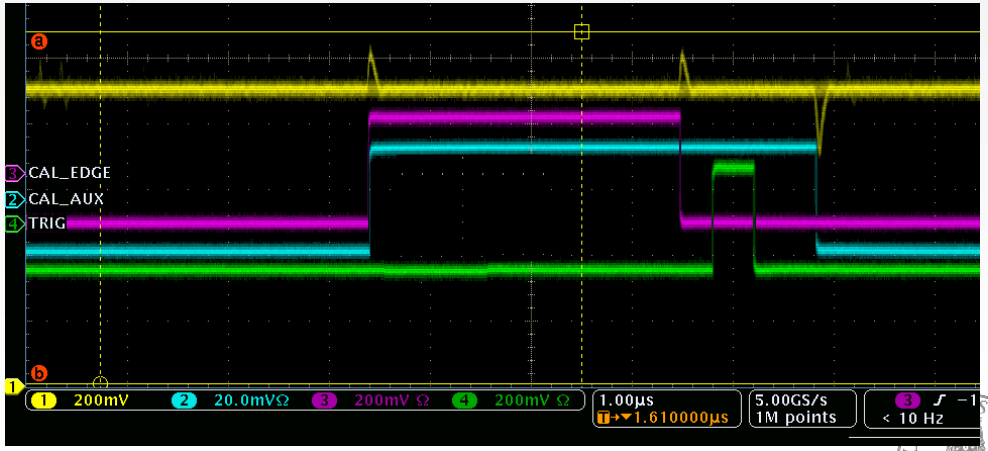
# Method

- For each value of the double delay, perform:
  - A scan with **#Inj1 set to 0e** (Upper figure)
    - Gives a **baseline** threshold used for comparison
  - A double injection scan with a large **#Inj1** (Bottom figure)
    - **#Inj1** crosses the pixel threshold
- **Probe** the effect that the **#Inj1** has on the measured pixel threshold obtain by **#Inj2** by looking at the threshold difference

**Baseline** (Only have the second charge of varying magnitude)

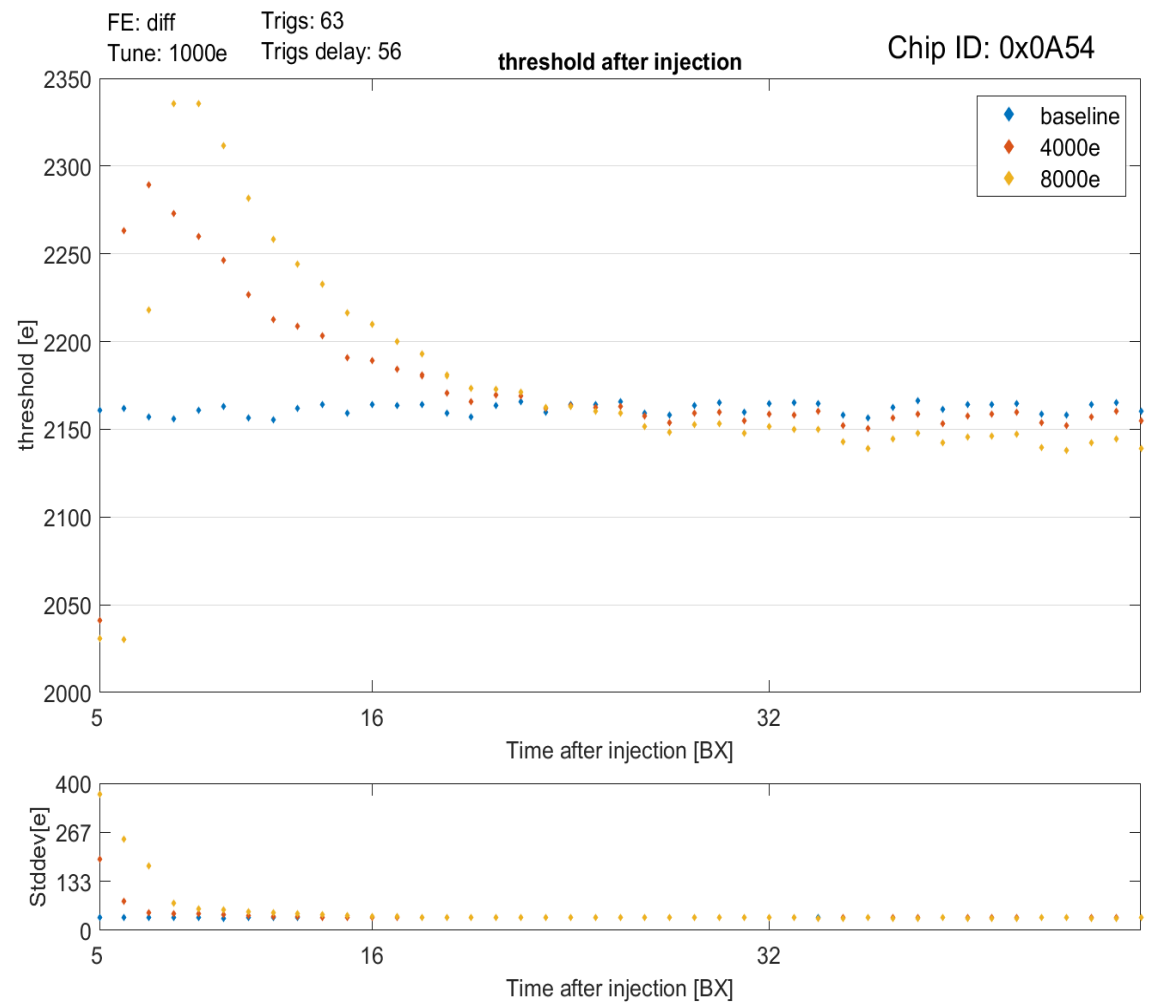



**I.e. Inject 4000e** and then inject a second charge of varying magnitude



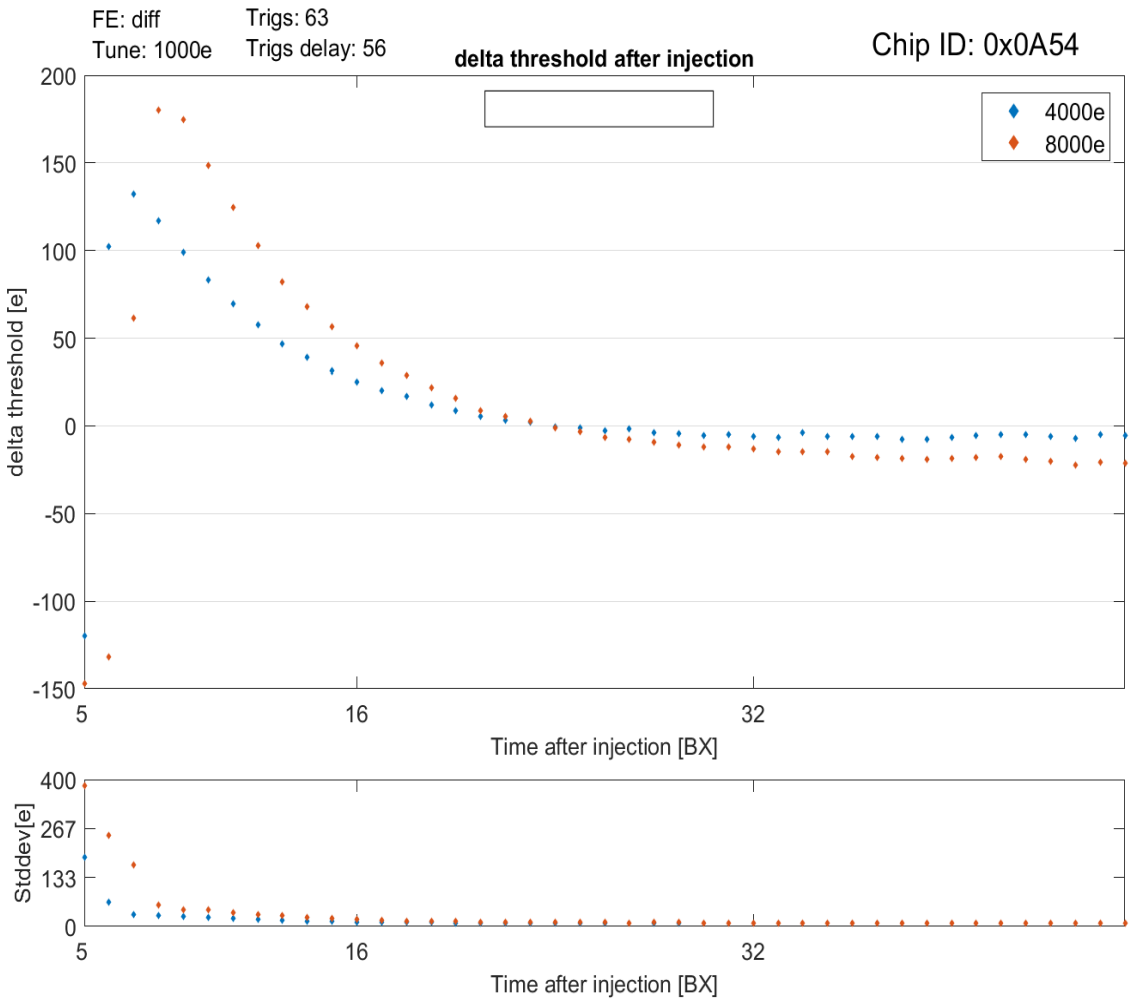
# Results: Mean of the threshold vs. double delay

- Tuned with Vcal_Med = 200
- Blue points: Baseline threshold with **#Inj1 set to 0e**
  - Uniform threshold at ~ 2160e
- Red & yellow points: First injection is 4ke and 8ke respectively
- Threshold top increases with larger injections ~ 2290, 2340
- Threshold top moves to larger BX for larger injections
- Merges with the baseline scan at ~ 23 BX
- Some small fluctuations



# Mean of the pixel threshold differences vs. double delay

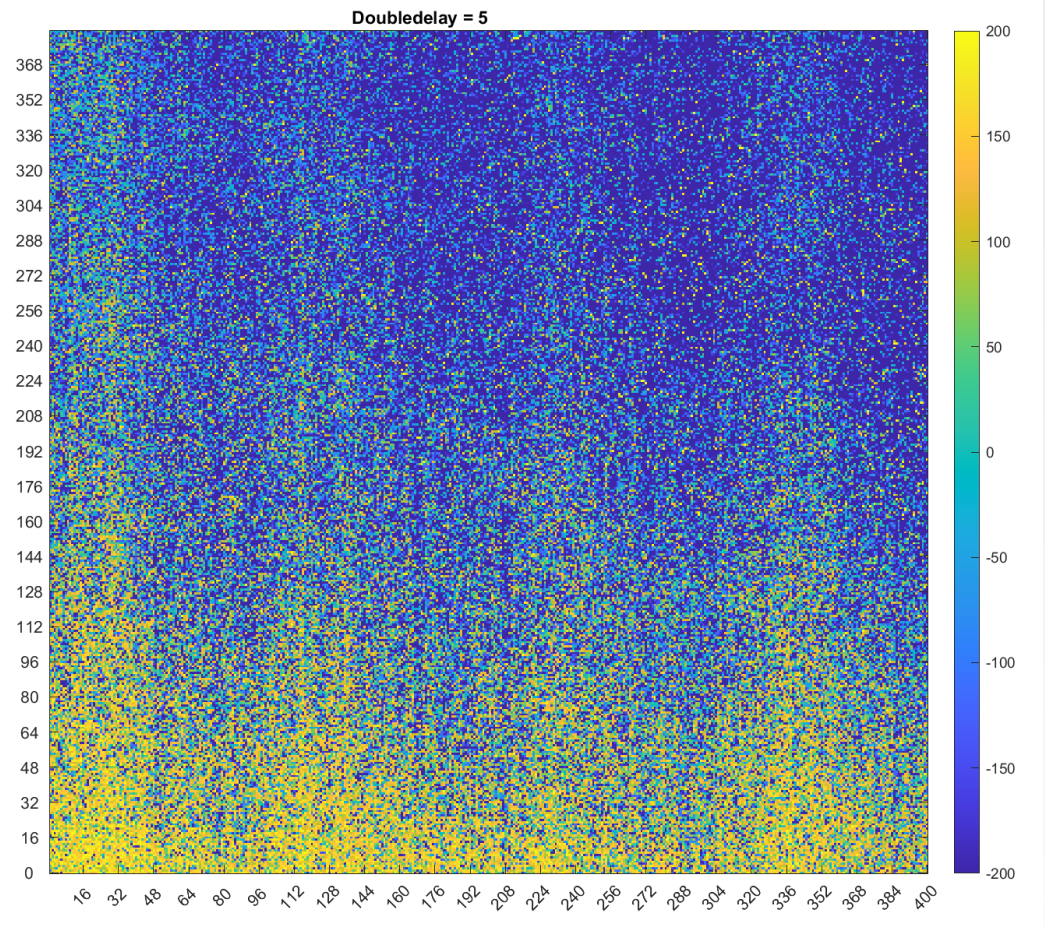
- Tuned with Vcal_Med = 200
- Points: Mean of the pixel threshold difference between the injection scans and the baseline scans
- Blue & Red points: First injection is 4ke and 8ke respectively
- Pixel difference goes up to ~ 140e for 4ke injection and ~ 190e for 8ke injection
- 8ke injection gets a undershoot after 24 BX



# Threshold difference on pixel map

- Tuned with Vcal_Med = 200
- Pixel threshold difference between the 4000e injection scan and the baseline scan
- Double delay = 5 BX
- Colour axis set to +/- 200e
- Think pattern comes from the Vcal_med to gnd tuning

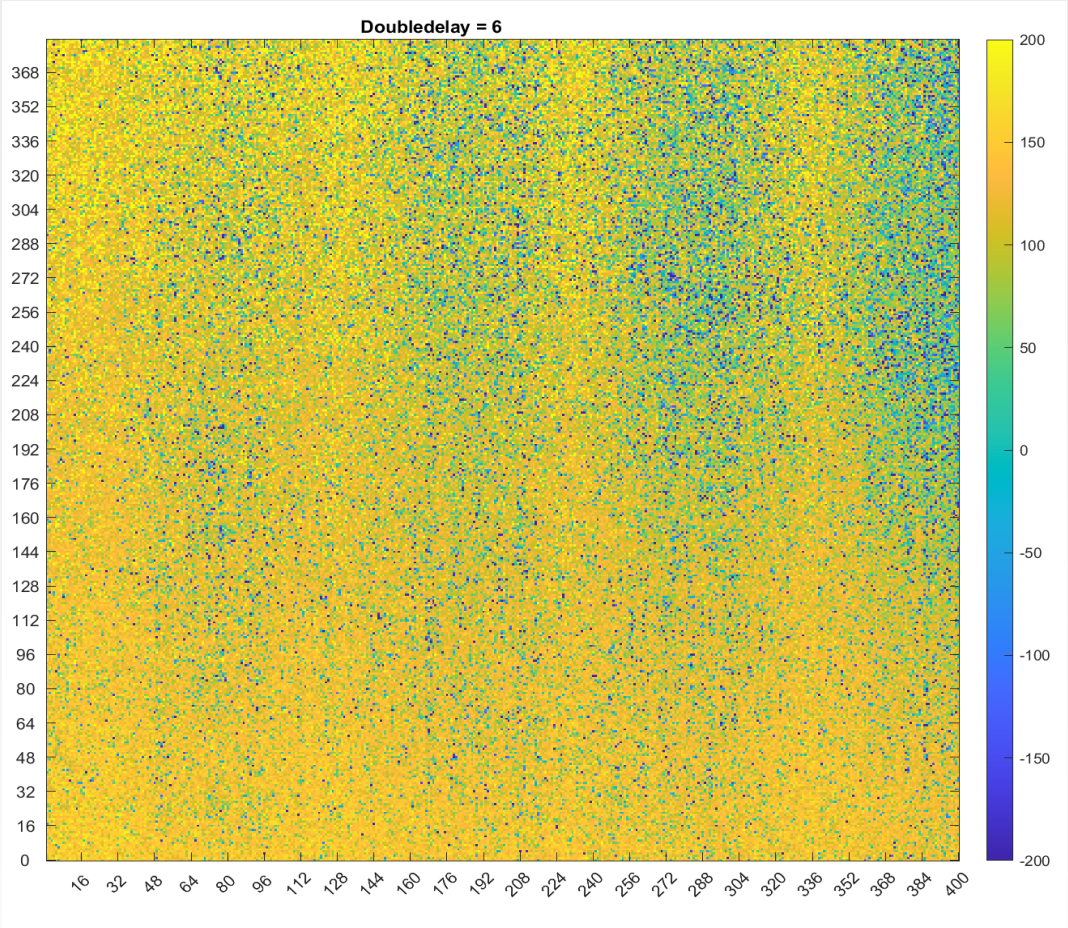
- **Future work**:
- More analysis with the double injection method
- Implement the methods in YARR for the RD53B



# Threshold difference on pixel map

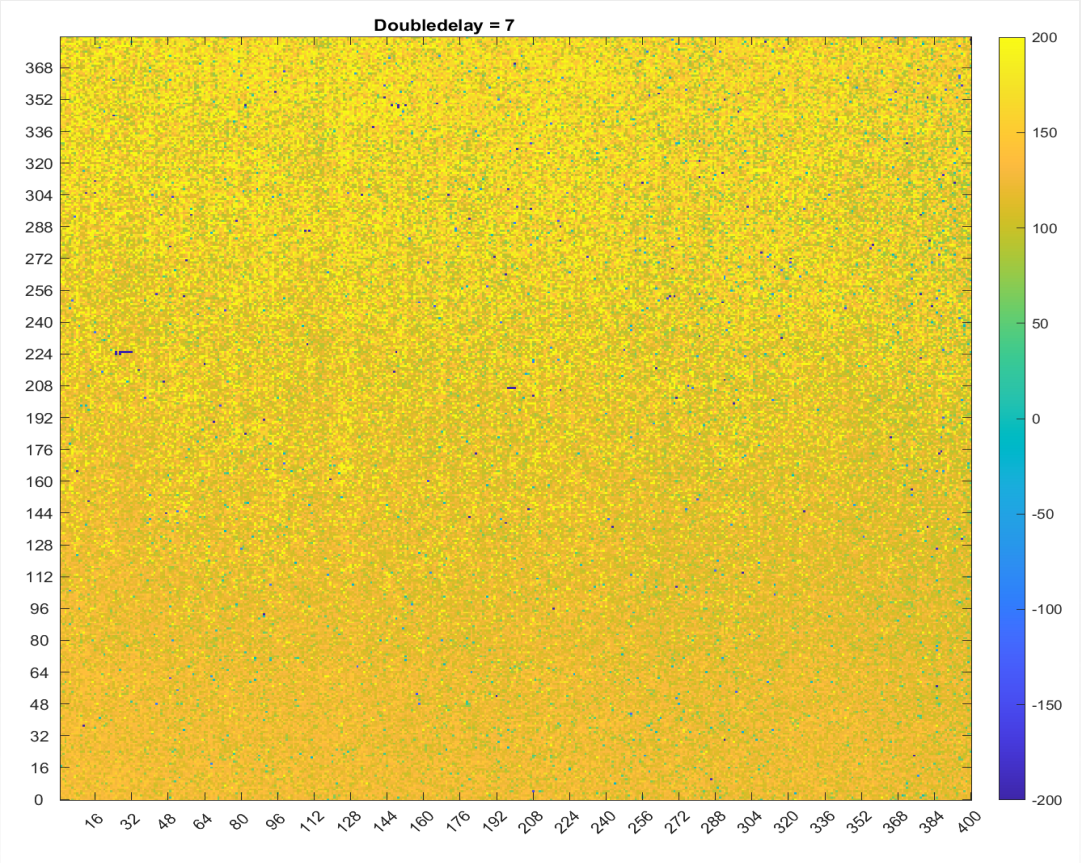
- Tuned with Vcal_Med = 200
- Pixel threshold difference between the 4000e injection scan and the baseline scan
- Double delay = 6 BX
- Colour axis set to +/- 200e
- Think pattern comes from the Vcal_med to gnd tuning

- **Future work**:
- More analysis with the double injection method
- Implement the methods in YARR for the RD53B



# Threshold difference on pixel map

- Tuned with Vcal_Med = 200
- Pixel threshold difference between the 4000e injection scan and the baseline scan
- Double delay = 7 BX
- Colour axis set to +/- 200e
- Think pattern comes from the Vcal_med to gnd tuning

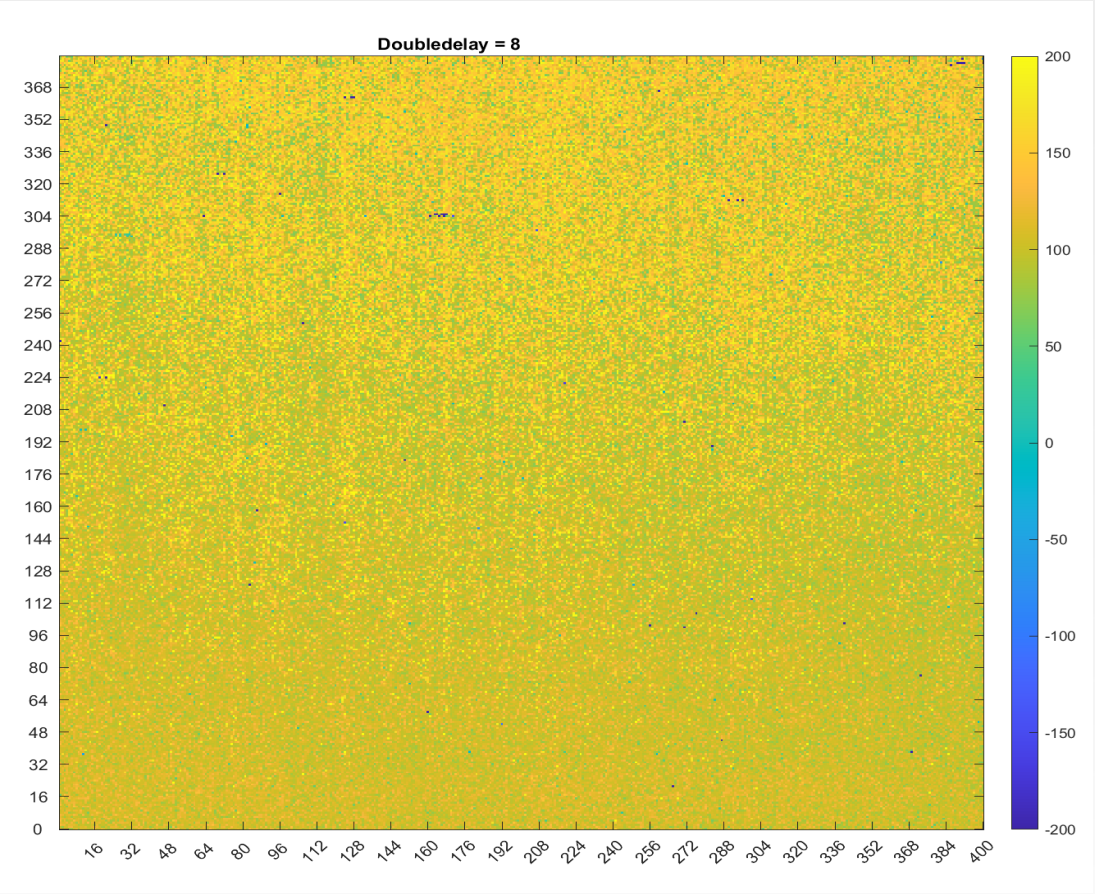



- **Future work**:
- More analysis with the double injection method
- Implement the methods in YARR for the RD53B

# Threshold difference on pixel map

- Tuned with Vcal_Med = 200
- Pixel threshold difference between the 4000e injection scan and the baseline scan
- Double delay = 8 BX
- Colour axis set to +/- 200e
- Think pattern comes from the Vcal_med to gnd tuning

- **Future work**:
- More analysis with the double injection method
- Implement the methods in YARR for the RD53B



# Thank you for your attention!

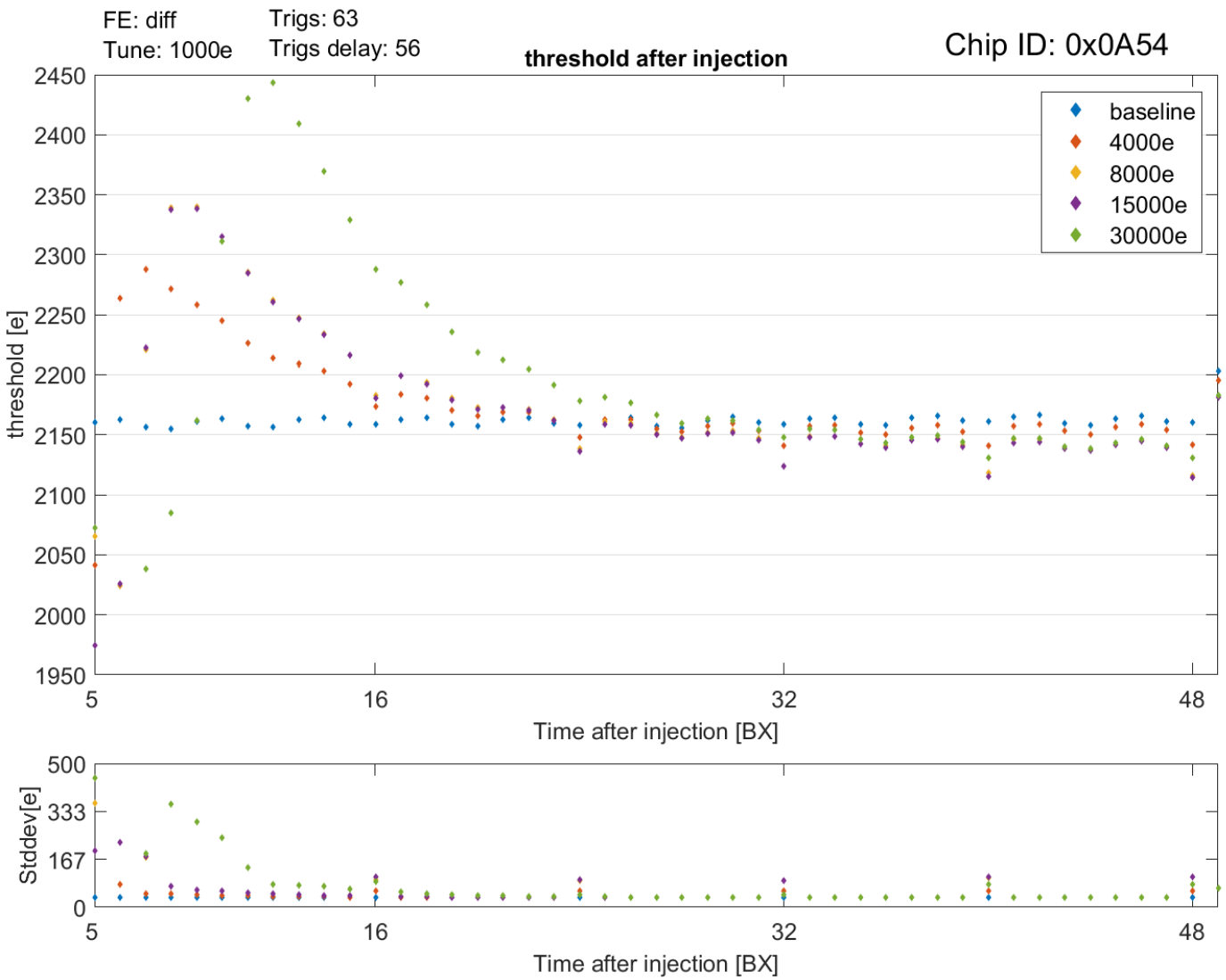

UNIVERSITY OF BERGEN

# Backup

ATLAS EXPERIMENT

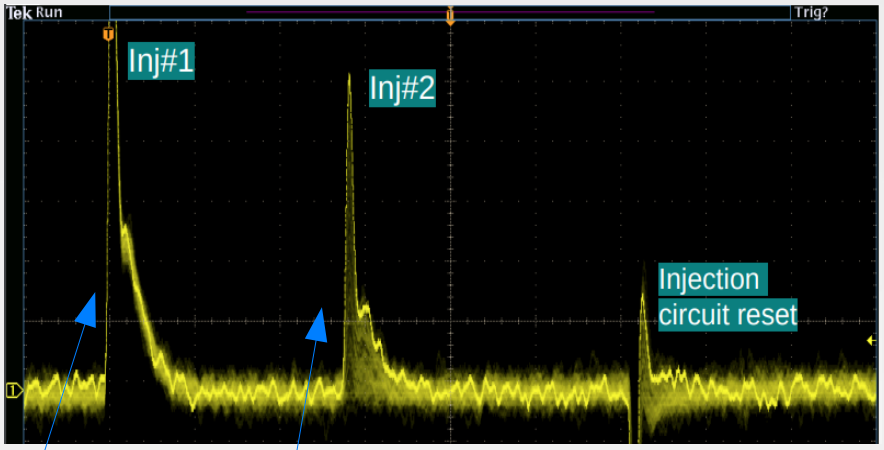
UNIVERSITY OF BERGEN

# Mean of the pixel threshold differences vs. double delay

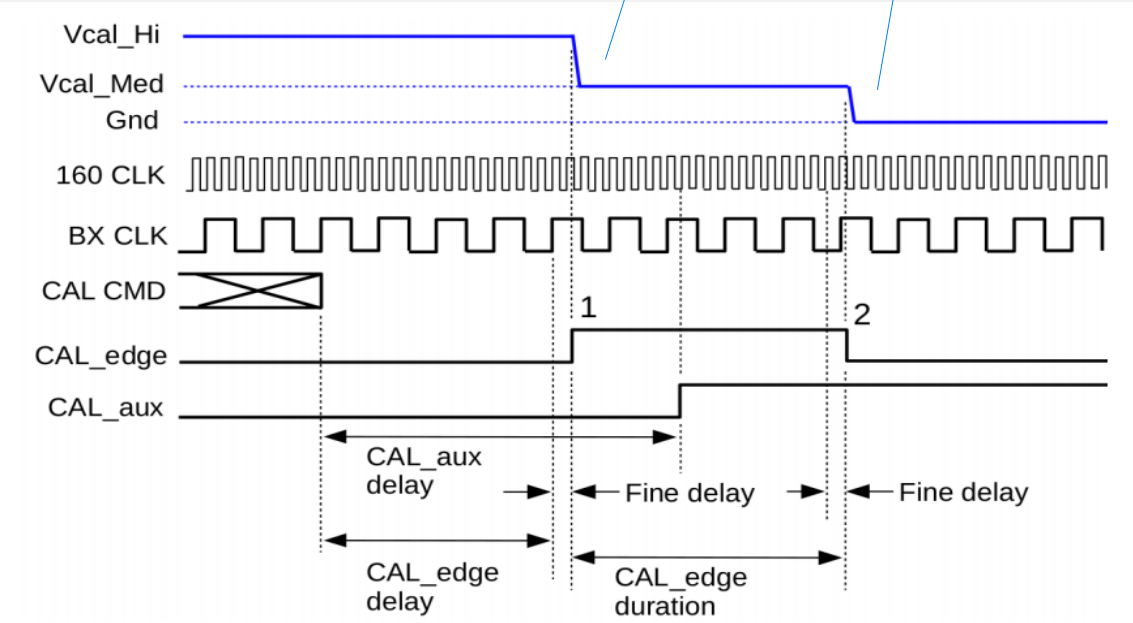


# Method 1: Single Cal command

- A double injection can be produced by sending a **single cal command** or by sending **two cal commands** to the chip
- **Single cal command** method shown in figure:
  - Inject charge from **Vcal_Hi to Vcal_Med** and then from **Vcal_Med to Vcal_gnd**

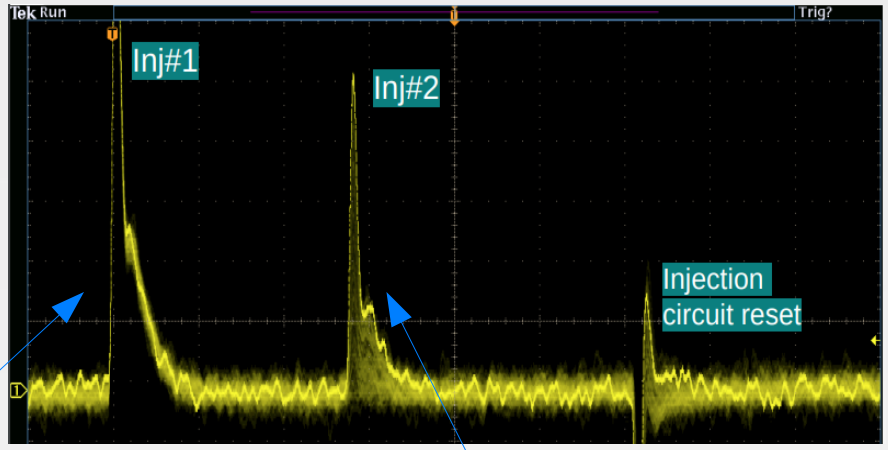



Two injections with one cal command

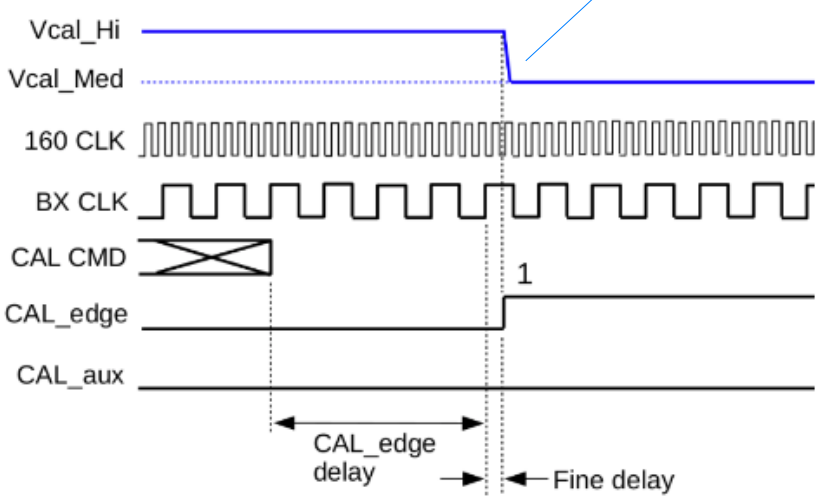


# Method 2: Two Cal commands

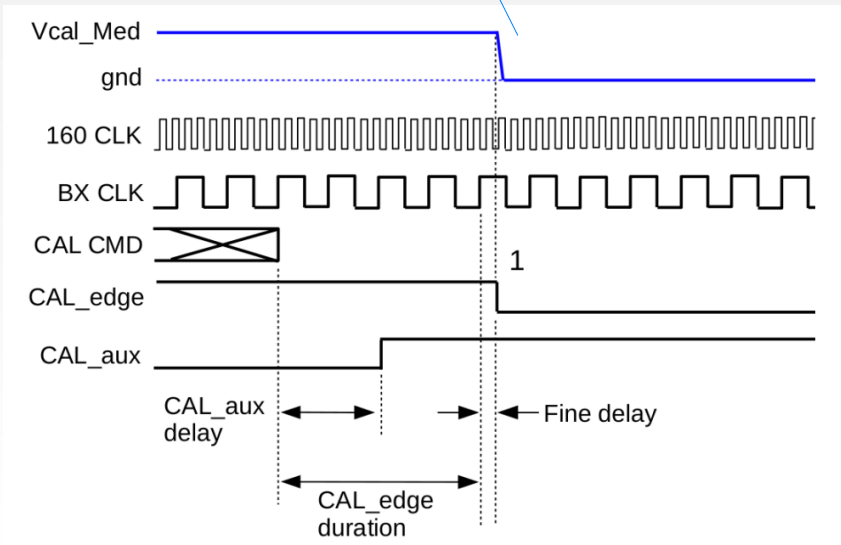
- A double injection can be produced by sending a **single cal command** or by sending **two cal commands** to the chip
- **Two cal commands** as shown in figures:
  - First cal command: Inject charge from **Vcal_Hi to Vcal_Med**
  - Second cal command: Inject charge from **Vcal_Med to Vcal_gnd**




First injection with first cal command

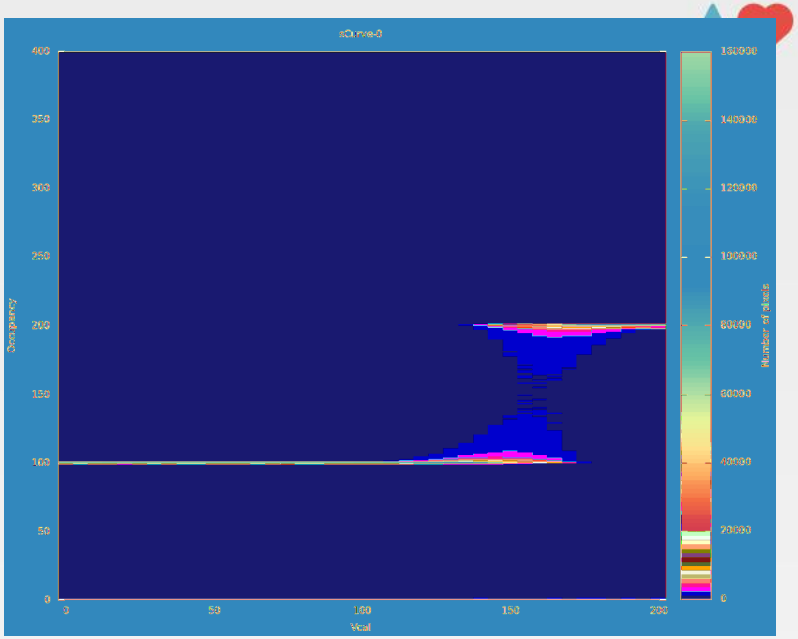


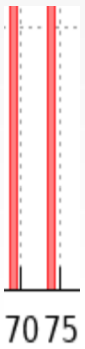

Second injection with second cal command

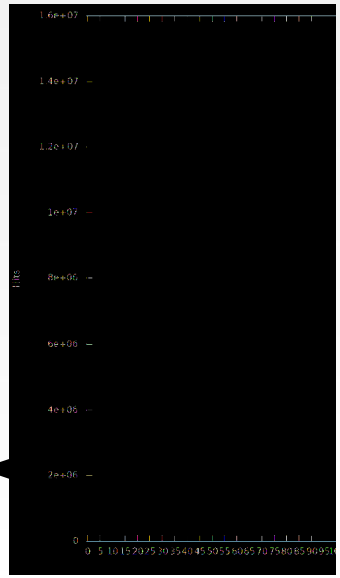


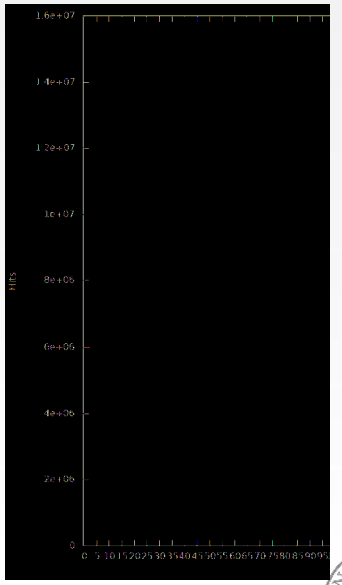
# Results on 1 method: Single Cal cmd

- First injection was set to be 2000e → always above threshold
  - Occupancy is 100 at the start of threshold scan
- As the second injection then increases in charge from 0 to 2000e:
  - Gradually goes above the pixel threshold
  - An S-curve is made showing the occupancy going from 100 to 200 hits
- Tag histogram showing the BX value of the trigger (the time that the pixels hits are read out)
- Difference in tag value is 5 BX
  - Matched the Cal_edge duration set in the cal command → controls the time between the two injections
- **Result**: The double injection with a single cal command worked exactly as it should!



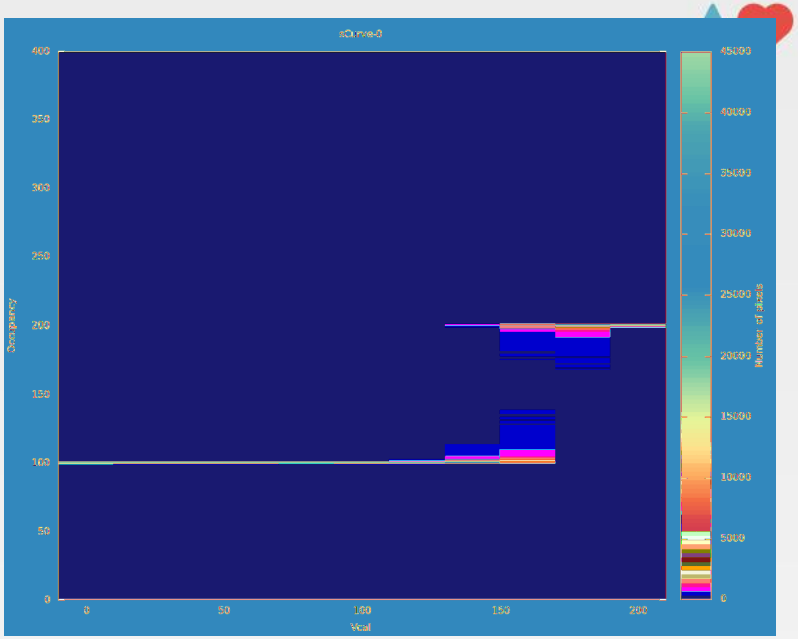


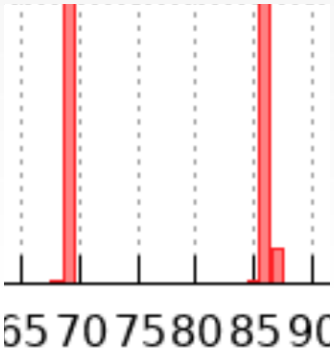



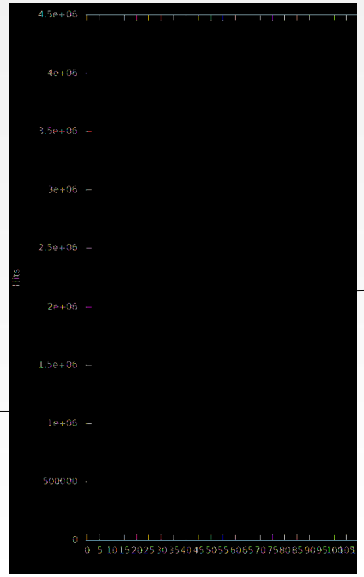


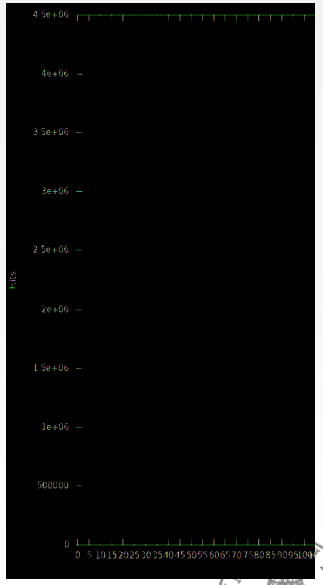
# Results on 2 method: Two Cal Cmds

- Same procedure when testing the two Cal command method: First injection was set to be 2000e and second injection from 0 to 2000e
- Tag histogram showing the BX value of the trigger
- Difference in tag value is 17 BX
  - Matched the cal command space (16 BX) + Cal_edge duration (1 BX)
- **Result**: The double injection with two cal commands also worked as it should!
- Good news as the RD53A chip had a bug where the cal edge would go low (if high) right after receiving a CAL CMD.



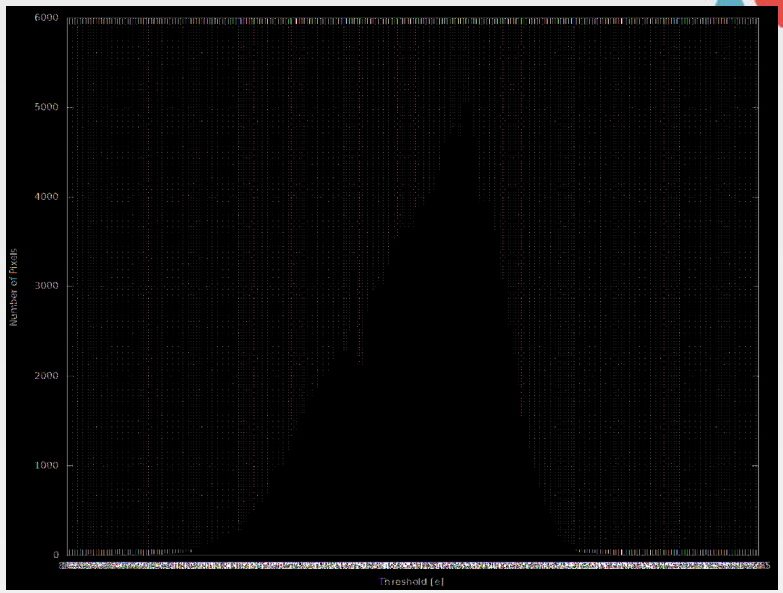


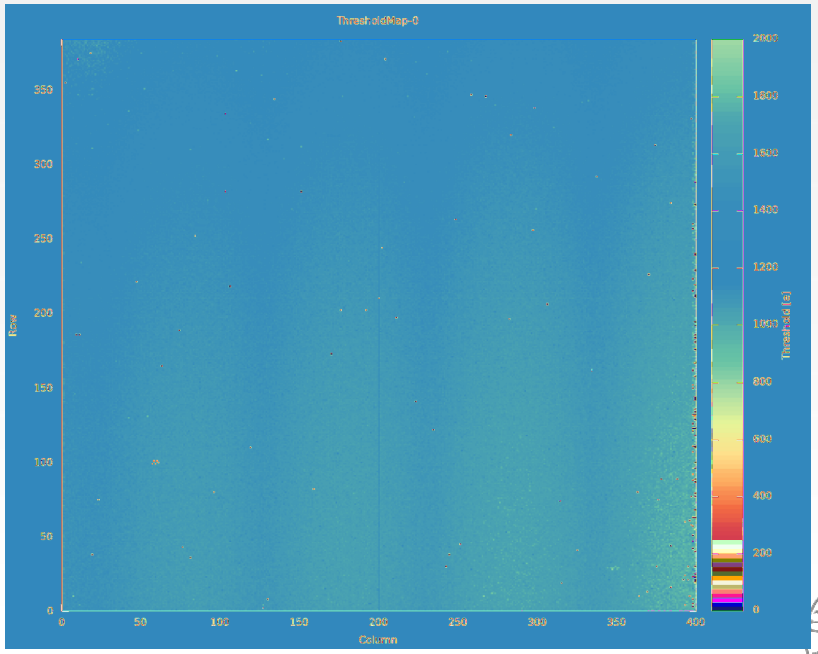





# Double injection threshold result

- Threshold distribution taken at double delay = 5 BX (time between the two injections)
- Threshold mean ~ 1300e and looked skewed
- Threshold maps show a 4-fold structure which was expected
  - The hits from the first injection changes the power consumption of the chip → changes the ground potential
  - Effects the second injection as it goes from Vcal_med to ground
  - Suspect that this is fixed in the V1.1 chip
  - **Next**: Run double injection at different BX values to make a plot of the threshold mean [e] vs. time after injection [BX].



# Debugging

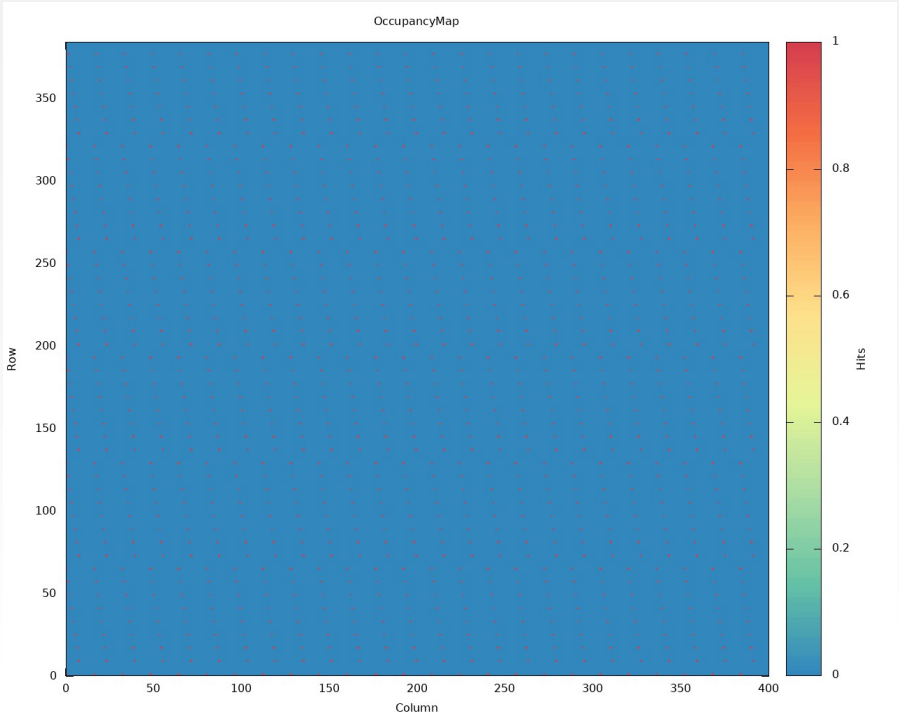
- Ptot_threshold scan gave these errors:
- Fixed by changing power supply!

```
"[15:04:23:569][  info  ][ Rd53bMaskLoop ]:  ---> Mask Stage 100 (Activated 200 pixels)
[15:04:24:673][  info  ][ Rd53bMaskLoop ]:  ---> Mask Stage 101 (Activated 200 pixels)
terminate called after throwing an instance of 'std::bad_alloc'
  what():  std::bad_alloc
Aborted (core dumped)
```

And this:

```
[15:09:11:200][  info  ][ Rd53bMaskLoop ]:  ---> Mask Stage 56 (Activated 200 pixels)
[15:09:12:251][ error  ][Rd53bDataProcessor]: Expect new stream while NS = 0
[15:09:12:301][  info  ][ Rd53bMaskLoop ]:  ---> Mask Stage 57 (Activated 200 pixels)
```

- Also the chip didn't go to low power mode after running std_digitalscan
- Fixed by a error in the triggerlop after implementing double injection

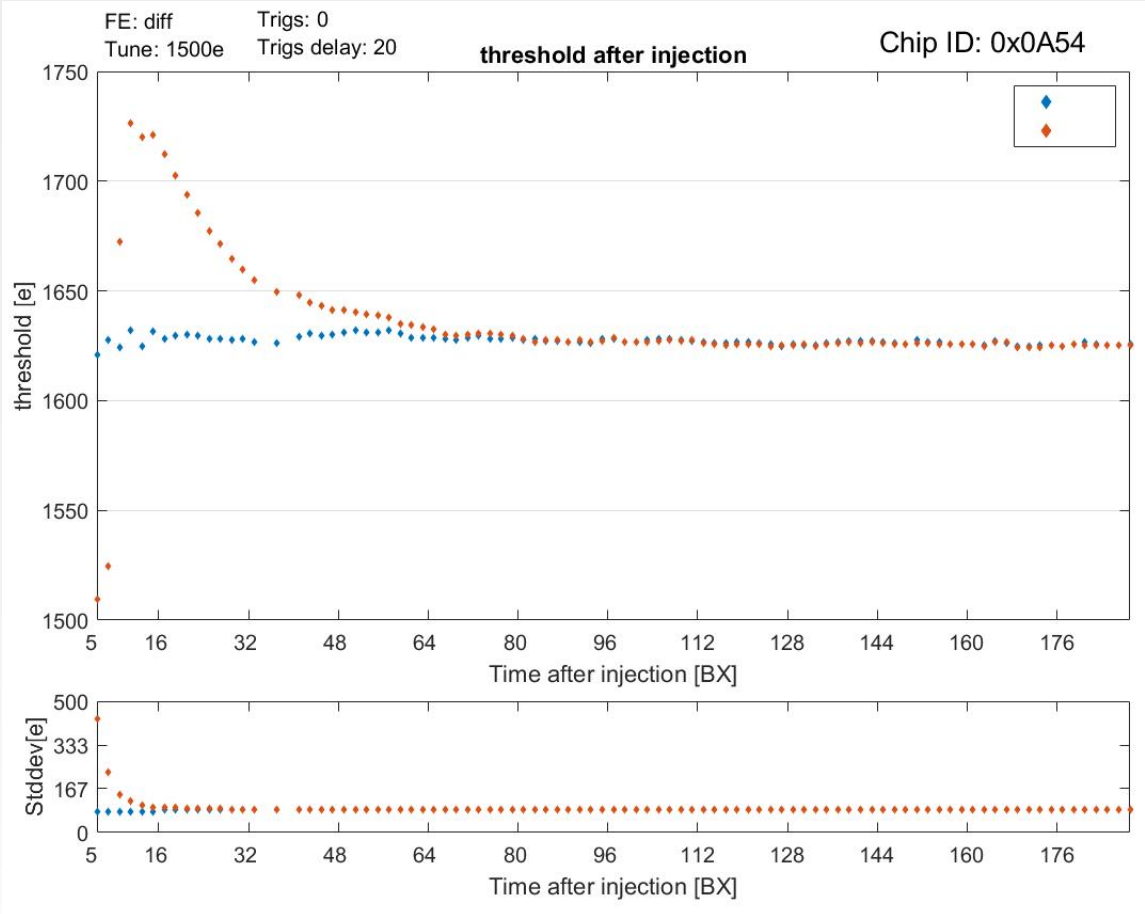


# Double injection on RD53A

- Good news as in the RD53A chip had a bug in the cal command
- The cal edge would go low (if high) right after receiving a CAL CMD.
- Had to change the cal cmd procedure in order to make this work

# Threshold mean vs. Double delay (Differential FE)

- Diff FE: Tuned to 1500e
- Blue points: **Baseline** (Only have the second charge of varying magnitude)
- Red points: I**nject 2000e** and then inject a second charge of varying magnitude
- X-axis shows the time between the two injections (double delay)
- When the double delay is small - > the mean of threshold increases when having a first injection of 2000e (Red points)
- Most likely caused by the disturbance of the first analog injection or the readout




UNIVERSITAS
BERGENSIS