Pixel modules tests at ESTB for the ATLAS high-lumi upgrade

Beam Telescopes and Testbeams Workshop 2019

BERKELEY LAB

BERKELEY EXPERIMENTAL PARTICLE PHYSICS

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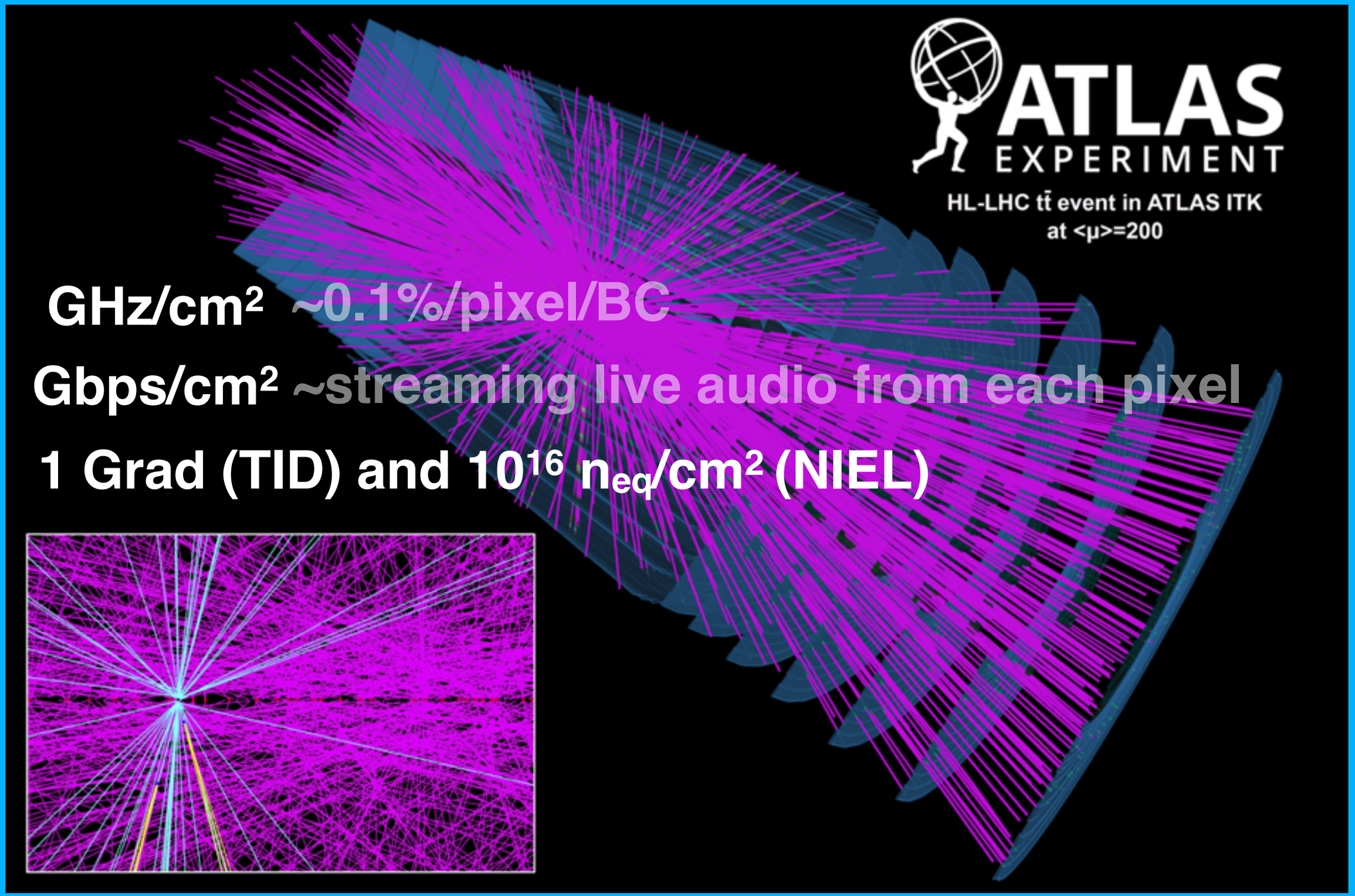
Pixels of the future: Higher bandwidth, hit rate, rad damage



Challenges for pixels at the HL-LHC

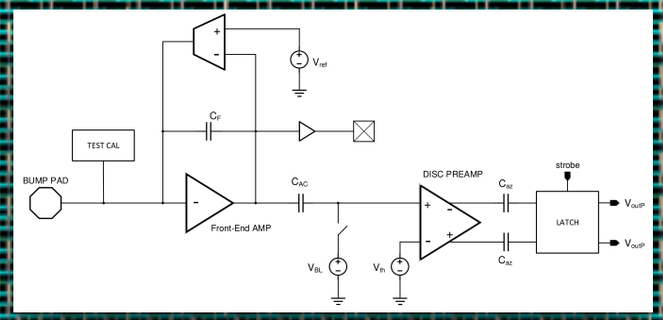
Generation	Run 1 (FEI3, PSI46)	Runs 2+3 (FEI4, PSI46DIG)	Runs 4+5
Chip Size	7.5 x 10.5 mm^2 8 x 10 mm^2	20 x 20 mm^2 8 x 10 mm^2	> 20 x 20 mm^2
Transistors	3.5 M 1.3 M	87 M	~1 G
Hit Rate	100 MHz/cm^2	400 MHz/cm^2	~2 GHz/cm^2
Hit Memory / Chip	0.1 Mb	1 Mb	~16 Mb
Trigger Rate	100 kHz	100 kHz	200 kHz - 1MHz
Trigger Latency	2.5 µs 3.2 µs	2.5 µs 3.2 µs	6 - 20 µs
Readout rate	40 Mb/s	320 Mb/s	1-4 Gb/s
Radiation	100 Mrad	200 Mrad	1 Grad
Technology	250 nm	130 nm 250 nm	65 nm
Power	~1/4 W/cm^2	~1/4 W/cm^2	1/2 - 1 W/cm^2

Working toward an HL-LHC chip: RD53A

RD53A is a chip-of-chips with 3 analog front-ends (output of the cores is the same for each)

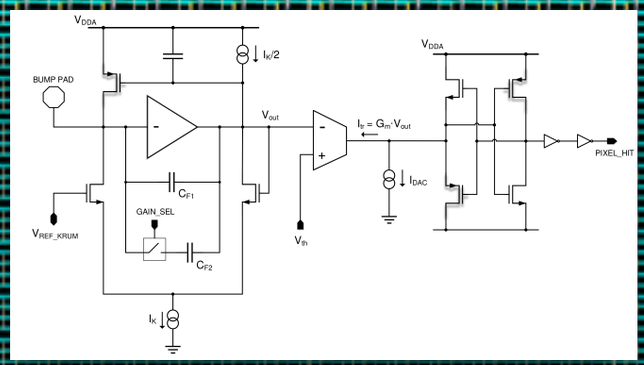
11.8 mm ; 192 pixels

Synchronous



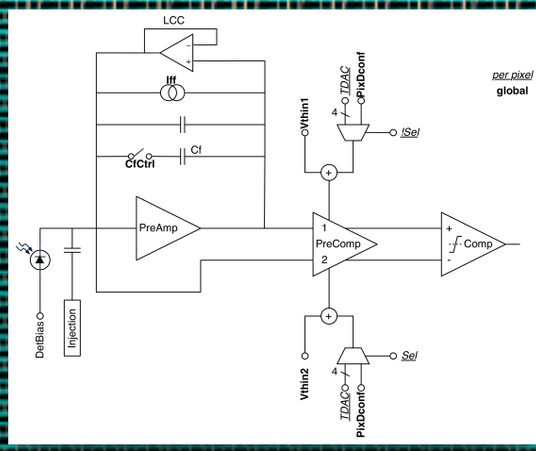
synchronous discriminator can be used for a fast ToT counter

Linear



single amplification stage for minimal power consumption

Differential



differential threshold reduces coherent noise

50 x 50 μm^2 pixels

20 mm ; 400 pixels

Testbeam at SLAC

SLAC National Accelerator Laboratory, Archives and History Office

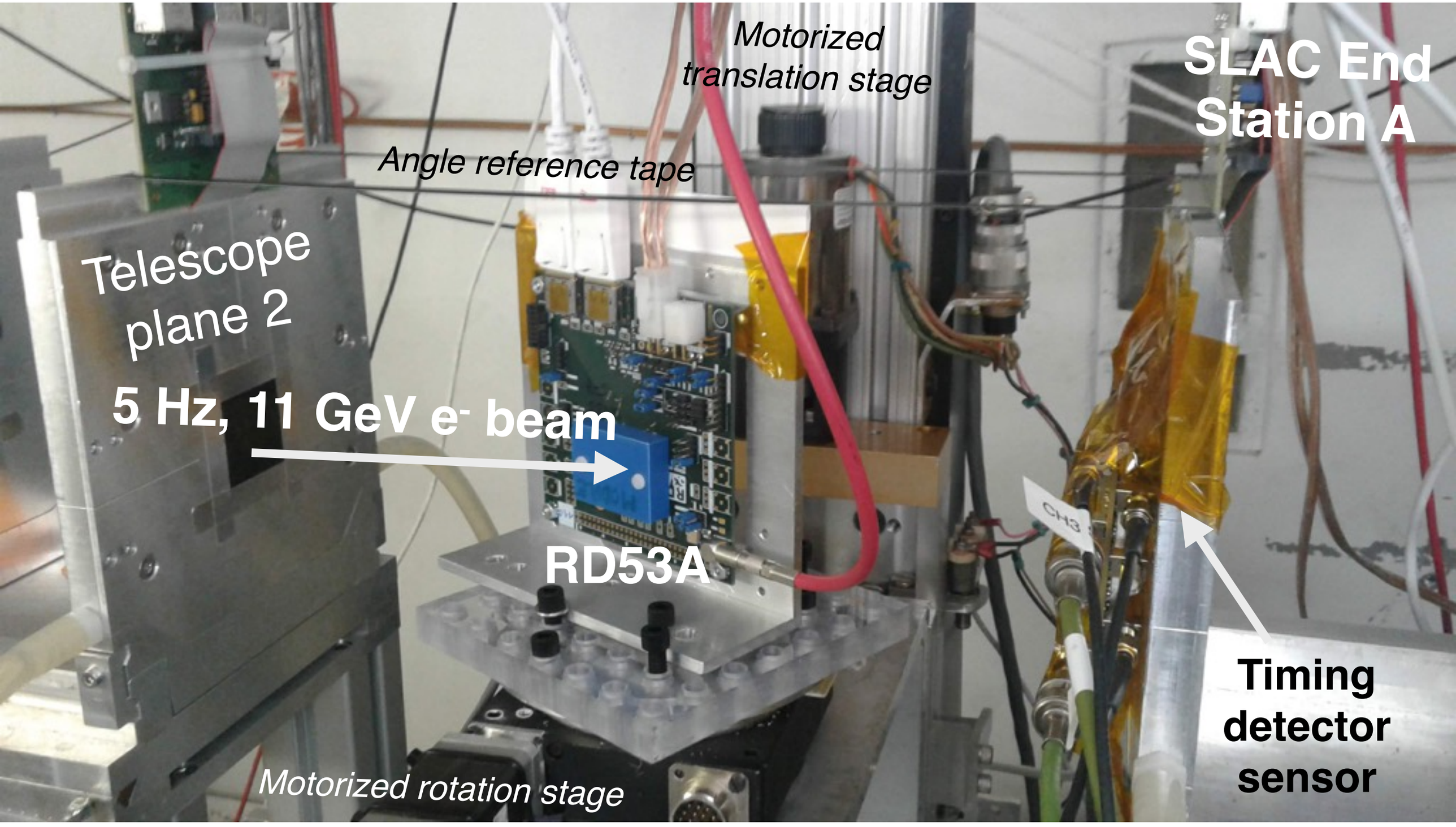
~1 week in May / June 2018

~1 week in November 2018

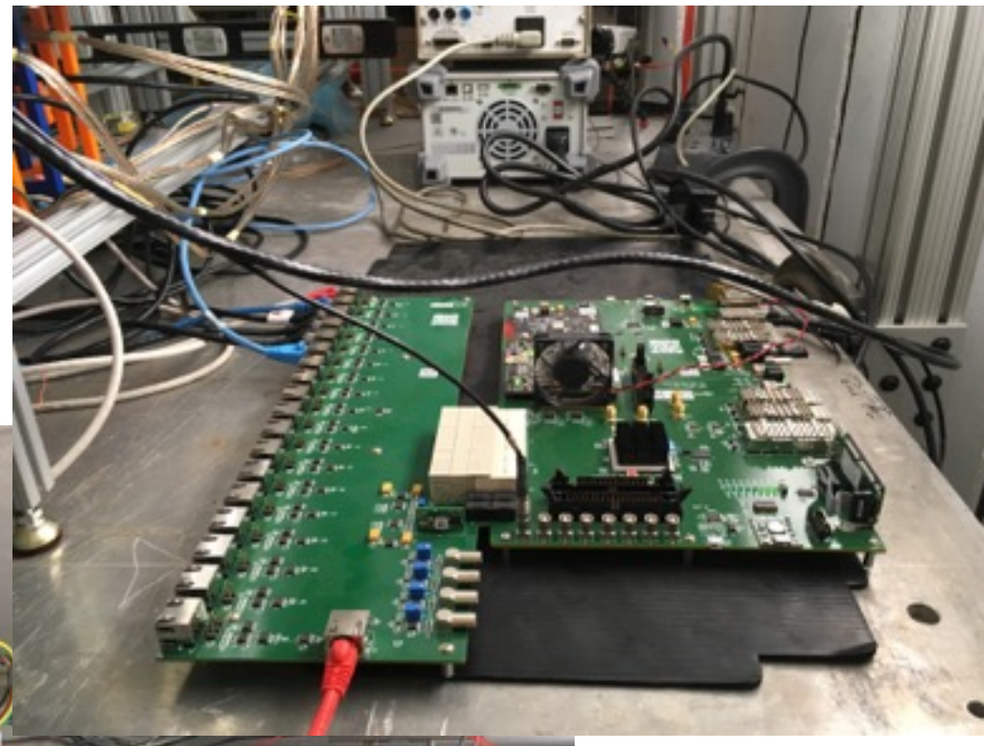
~1 week in December 2018

See Simone's talk from yesterday

Setup


Motorized
translation stage
SLAC End
Station A
Angle reference tape
Telescope
plane 2
5 Hz, 11 GeV e- beam
RD53A
Timing
detector
sensor
Motorized rotation stage

Setup II



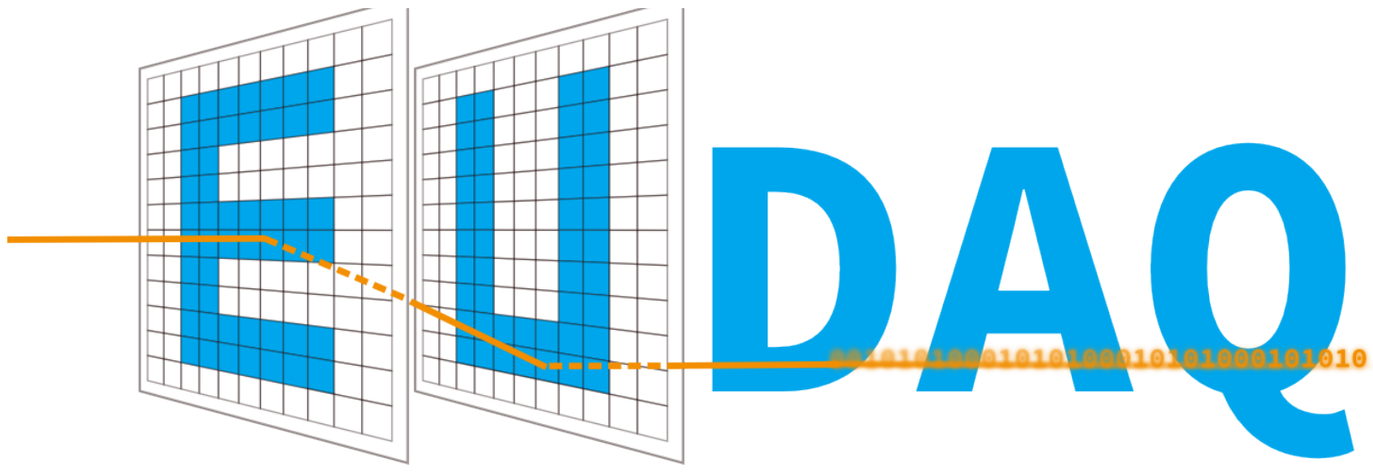
For the Nov. testbeam, we also brought an independent FEI4 telescope, readout with RCE.

Integration w/ EUDAQ

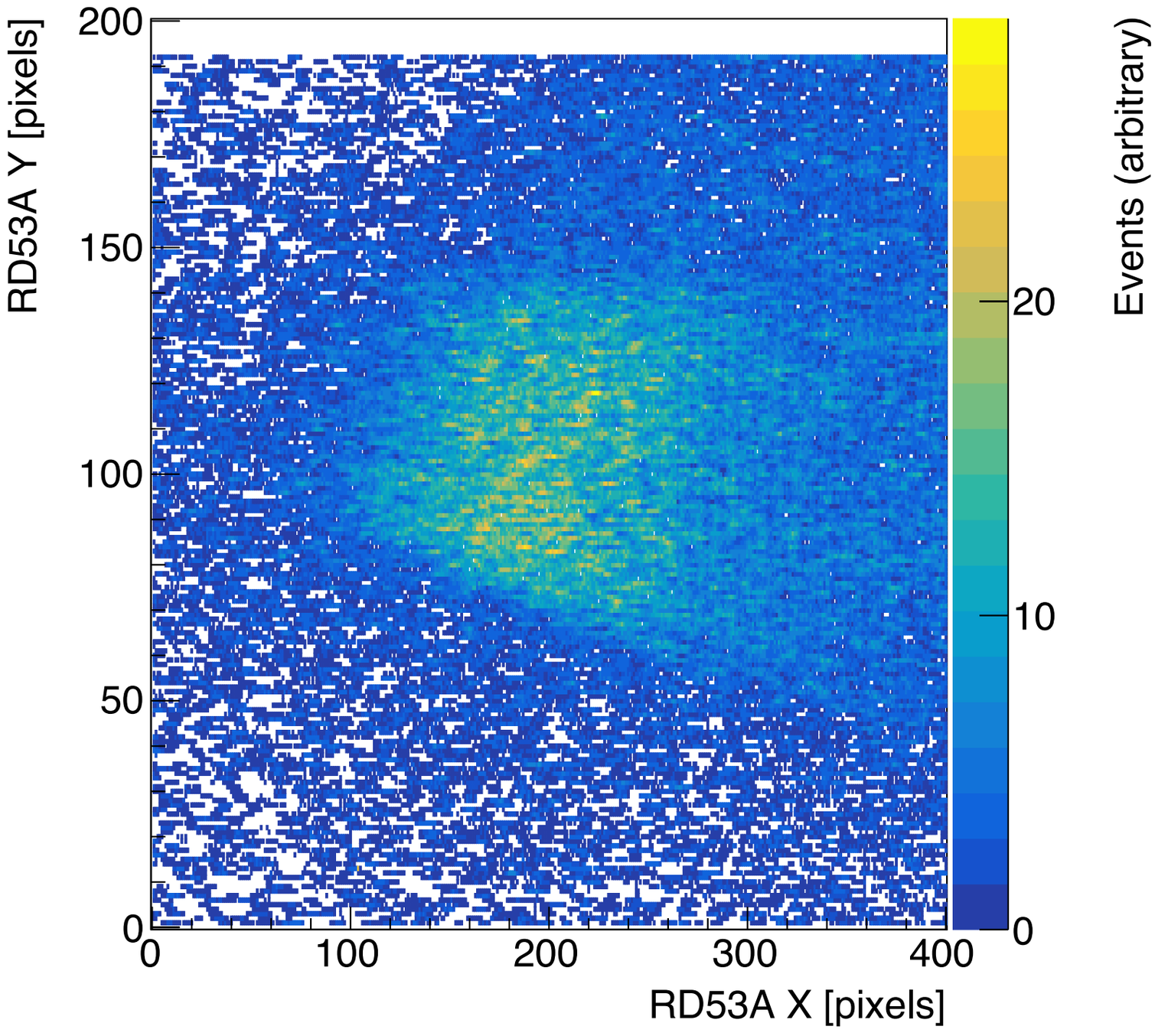
We recently updated to EUDAQ 1.7
(not a small feet without internet on the host computer!)

…in addition, we had to swap our TLU system from running on the NICrate (MS W7) to a linux machine.

Many thanks to Jan Dreyling-Eschweiler for help to make this happen!



Integration with EUDAQ

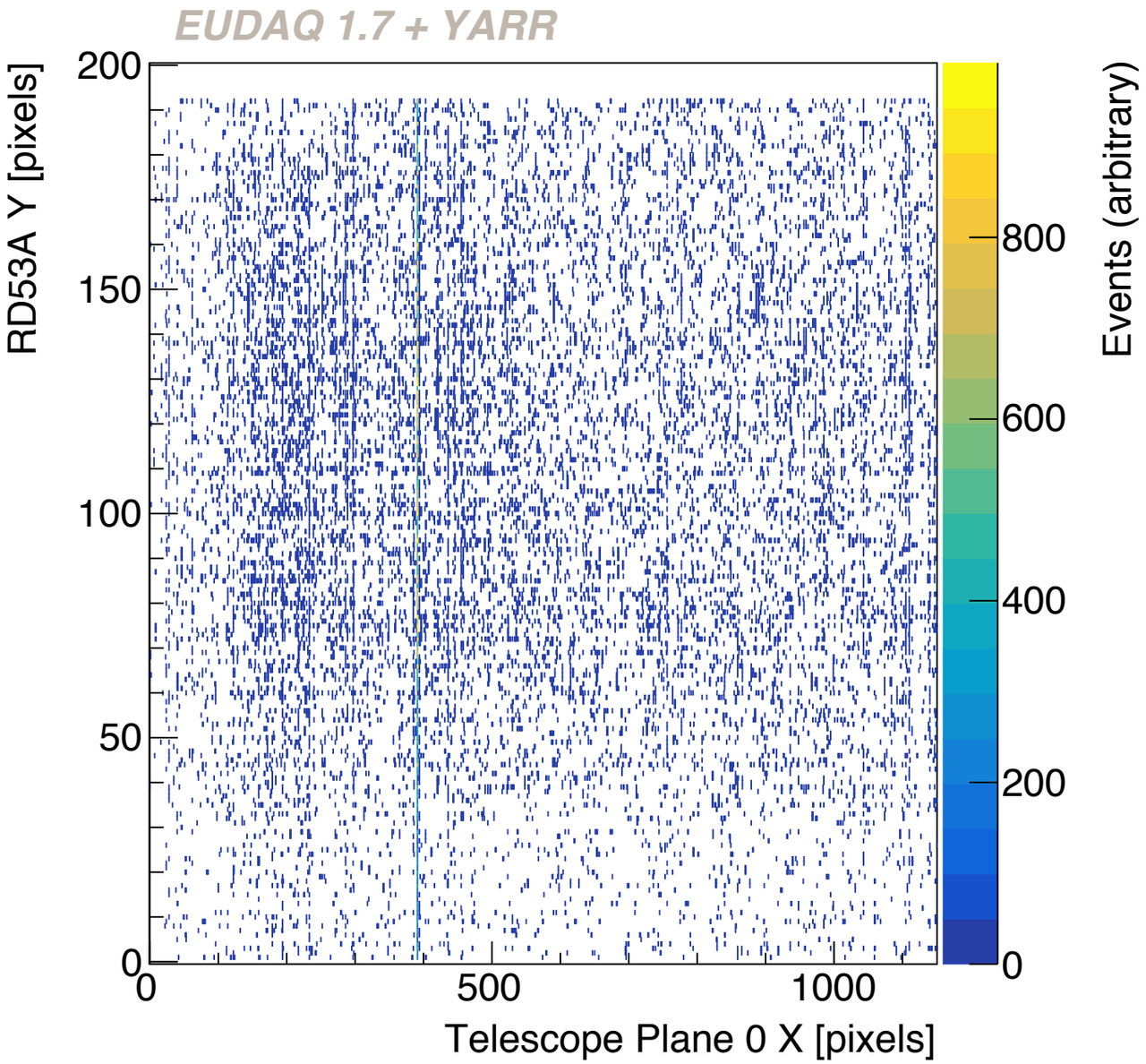


We wrote a YARR <u>producer/converter</u> to integrate the RD53 data with EUDAQ.

Here is an occupancy map from one of the early runs with RD53!

(N.B. beamspot is a wedge, not a circle)

Making friends with Mimosas

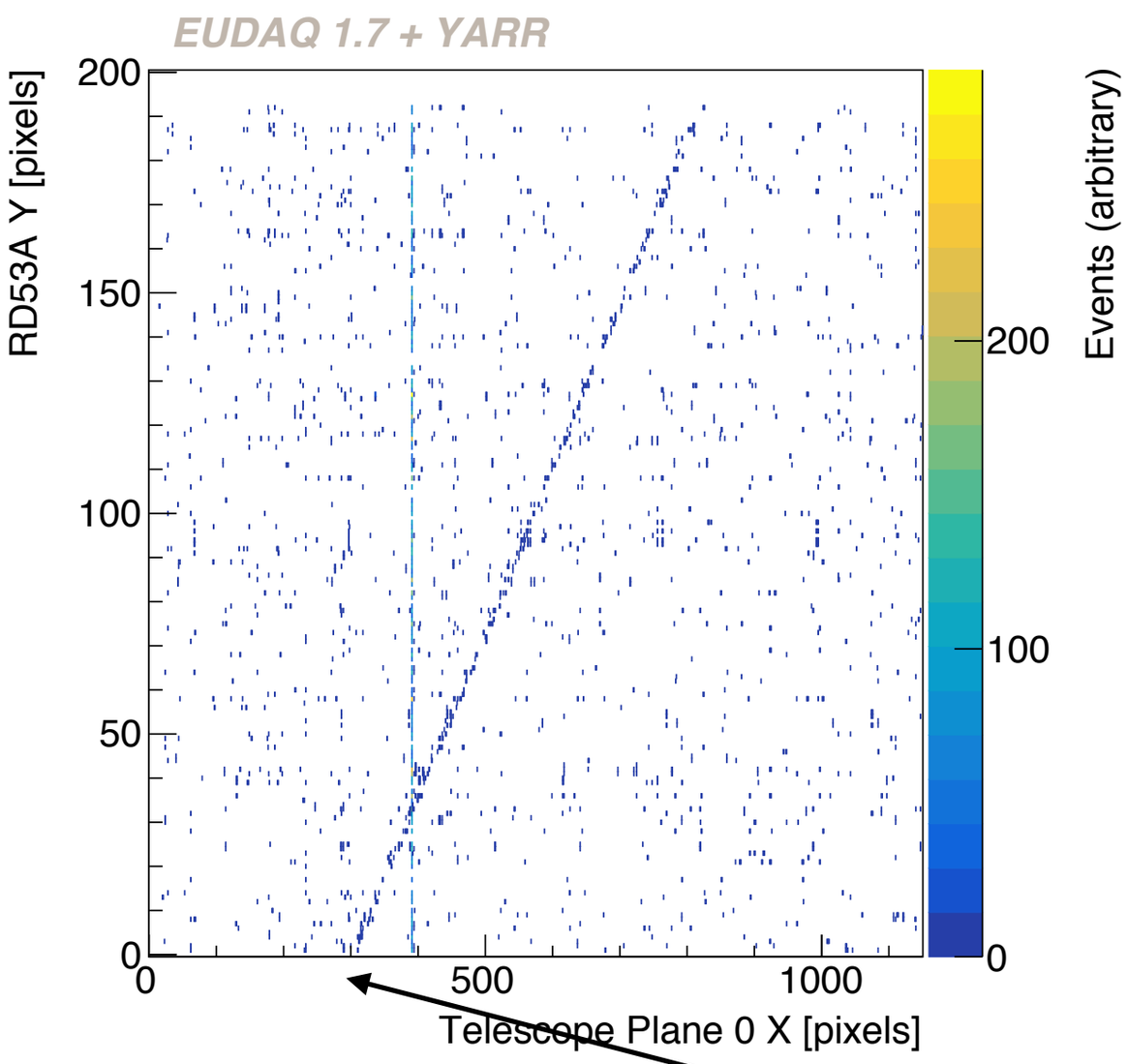


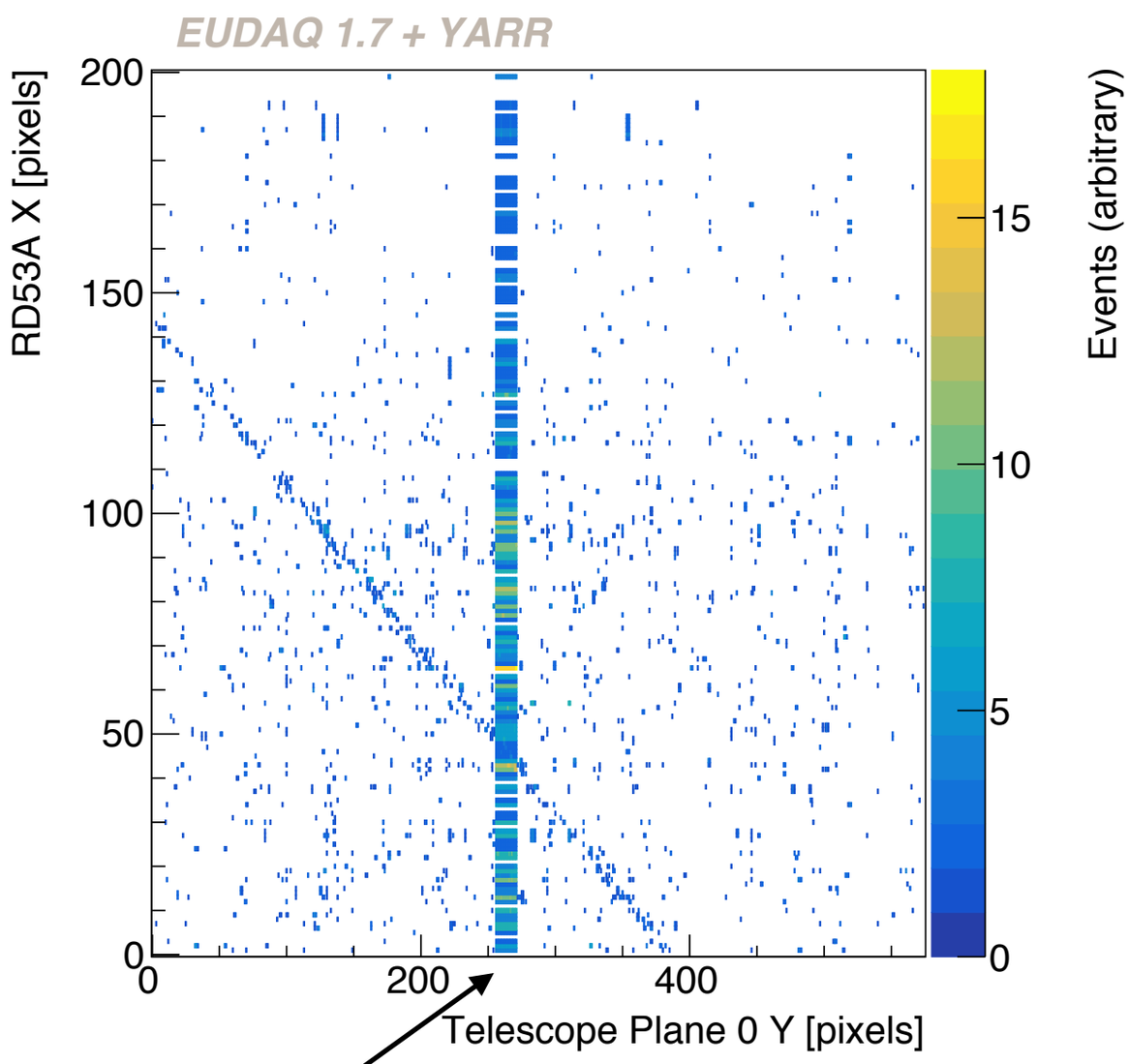
After integrating RD53 with EUDAQ, we noticed that there were no correlations with the telescope planes*.

After some quick debugging, we found that there was some garbage data being sent to EUDAQ. After fixing this …

*Could not see this in the online monitor because RD53 was rotated.
Was critical to be able to quickly analyze the data offline!

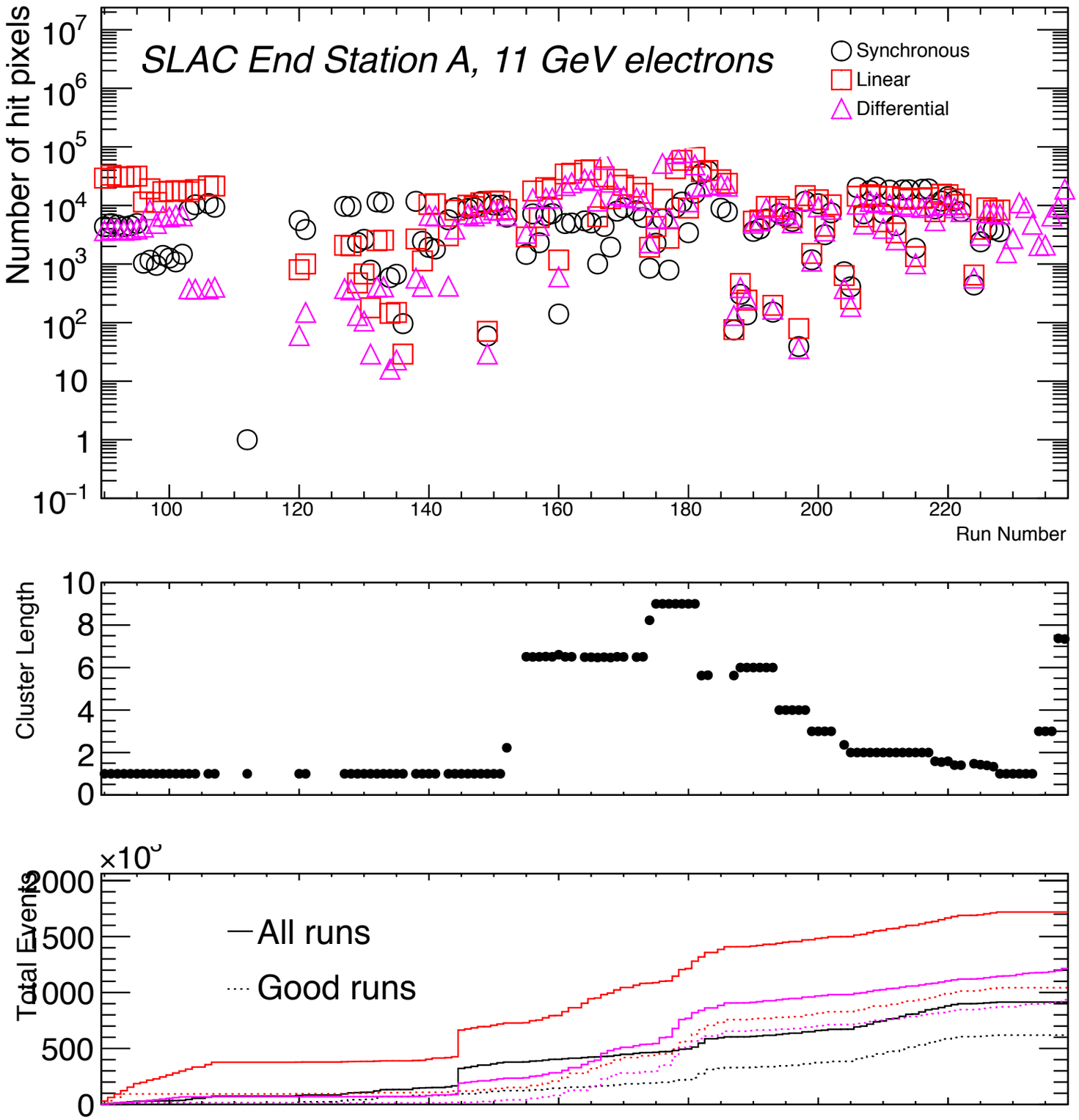
Telescope tracks !





Noisy pixels in telescope plane

June Run Summary (Nov. still processing)



~1M events (remember, only 5 Hz!)

SFE tuned to 800e

Data Analysis

Two streams:

"Simple"

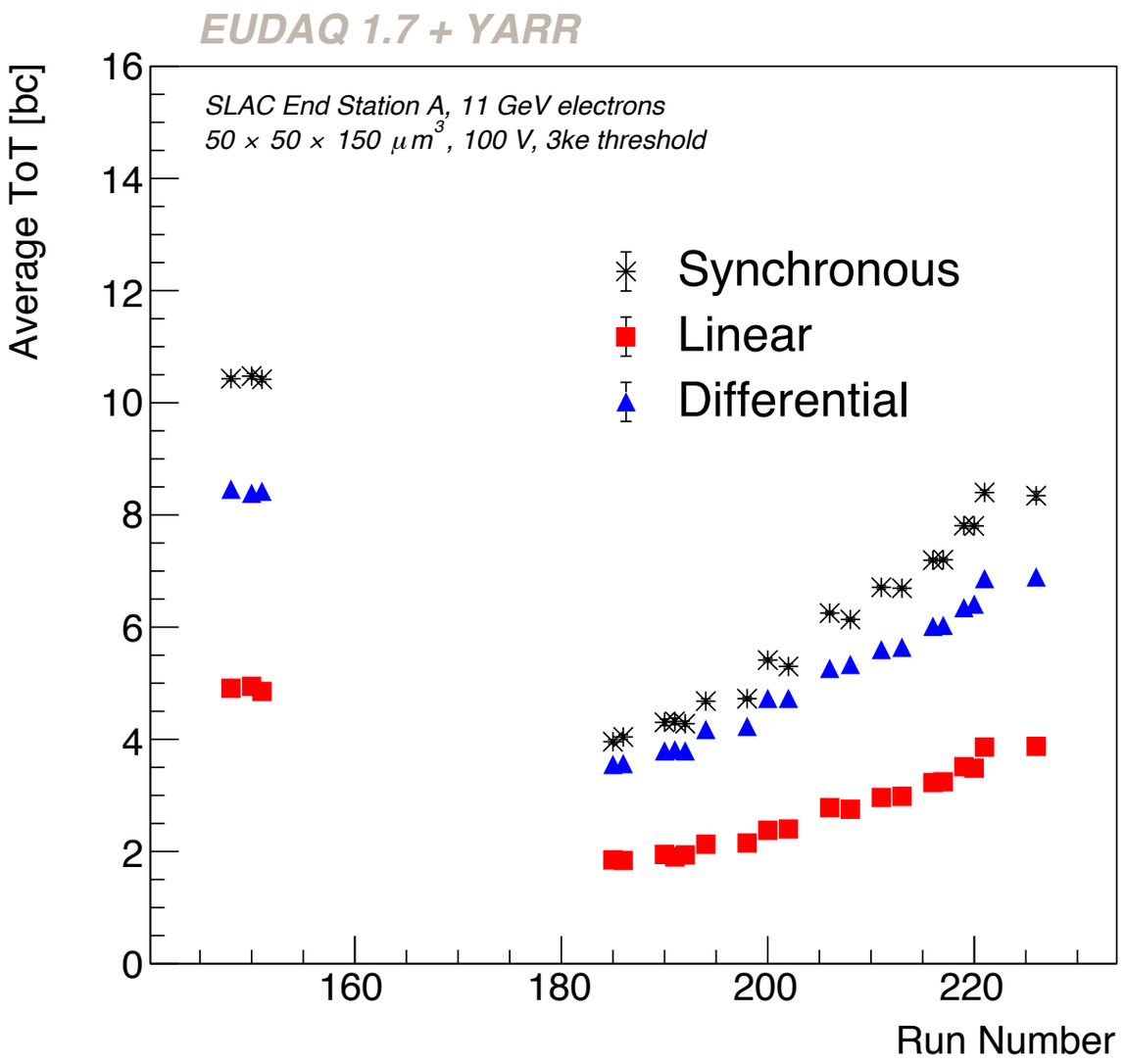
Use EUDAQ script (standalone) for converting .raw to .root

Data analysis on these .root. This is all I will show today.

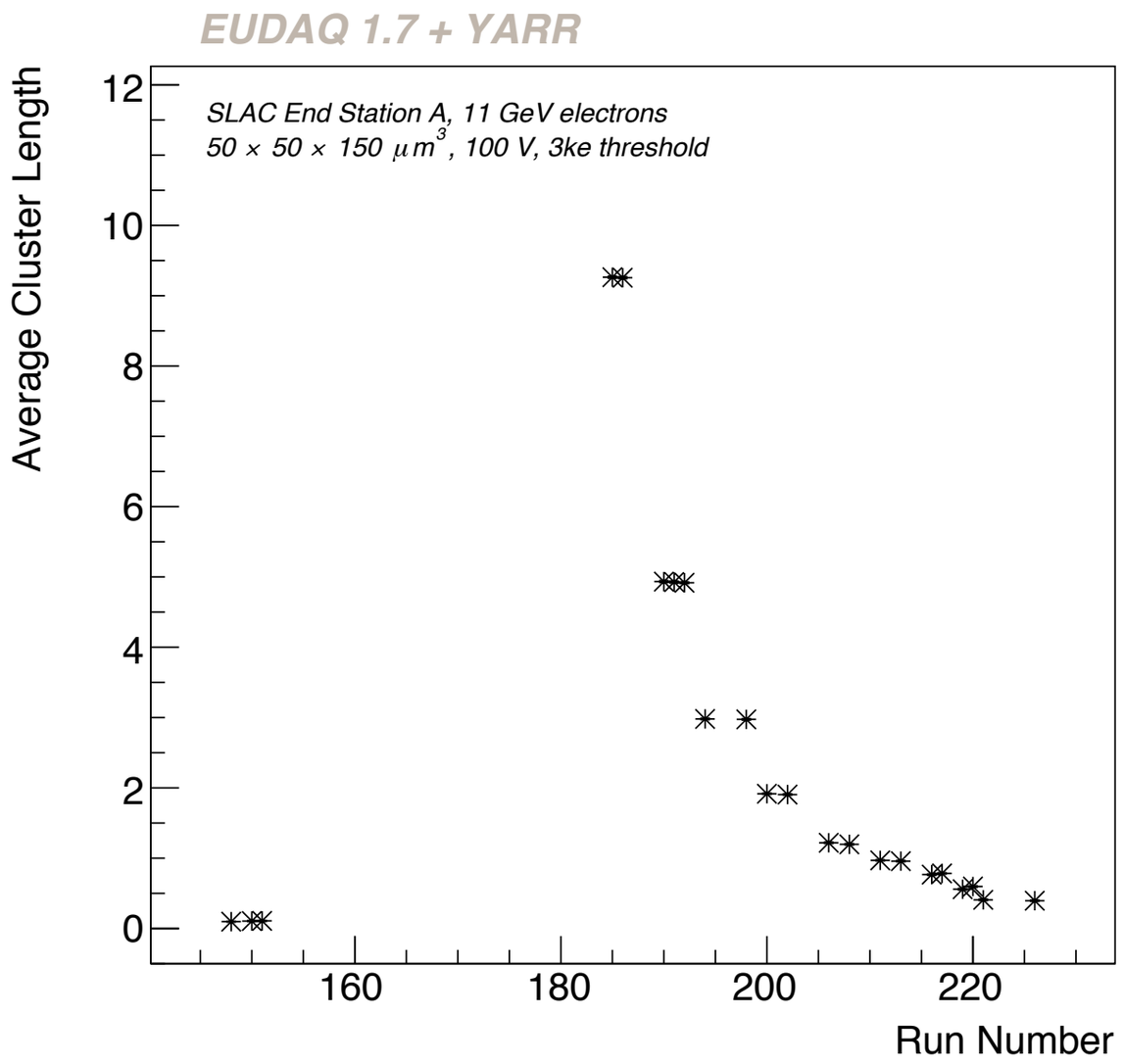
"Full"

Fit tracks from full telescope (proper alignment, etc.) using EUTelescope. Work ongoing.

First analysis: <ToT> and cluster length

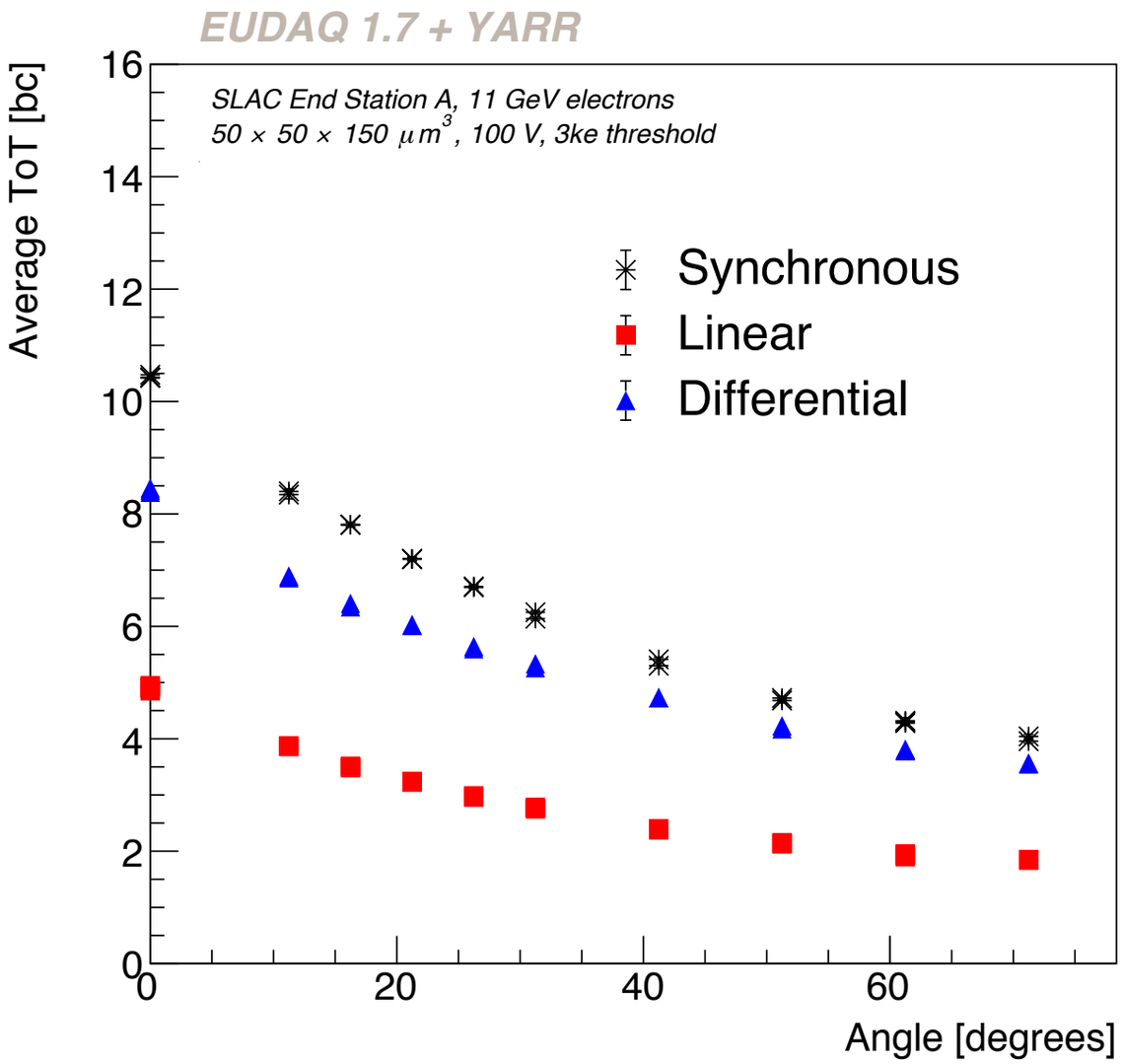


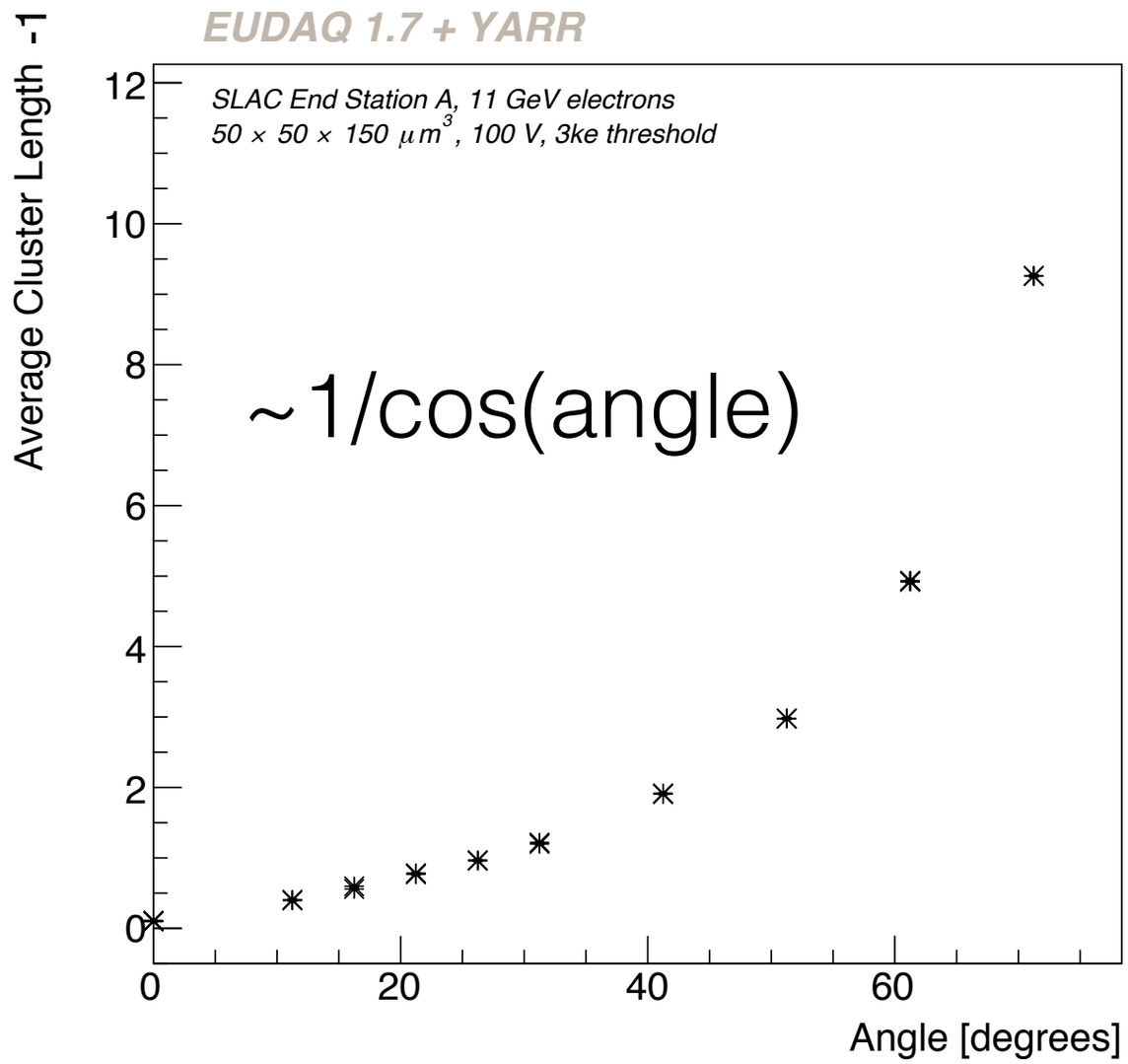
Shallower angle -> less path length per pixel -> less charge



Shallower angle -> go through more pixels

First analysis: <ToT> and cluster length





All FE's are tuned to 3ke, but the threshold (variation) is not the same for all of them.

Conclusions / Outlook

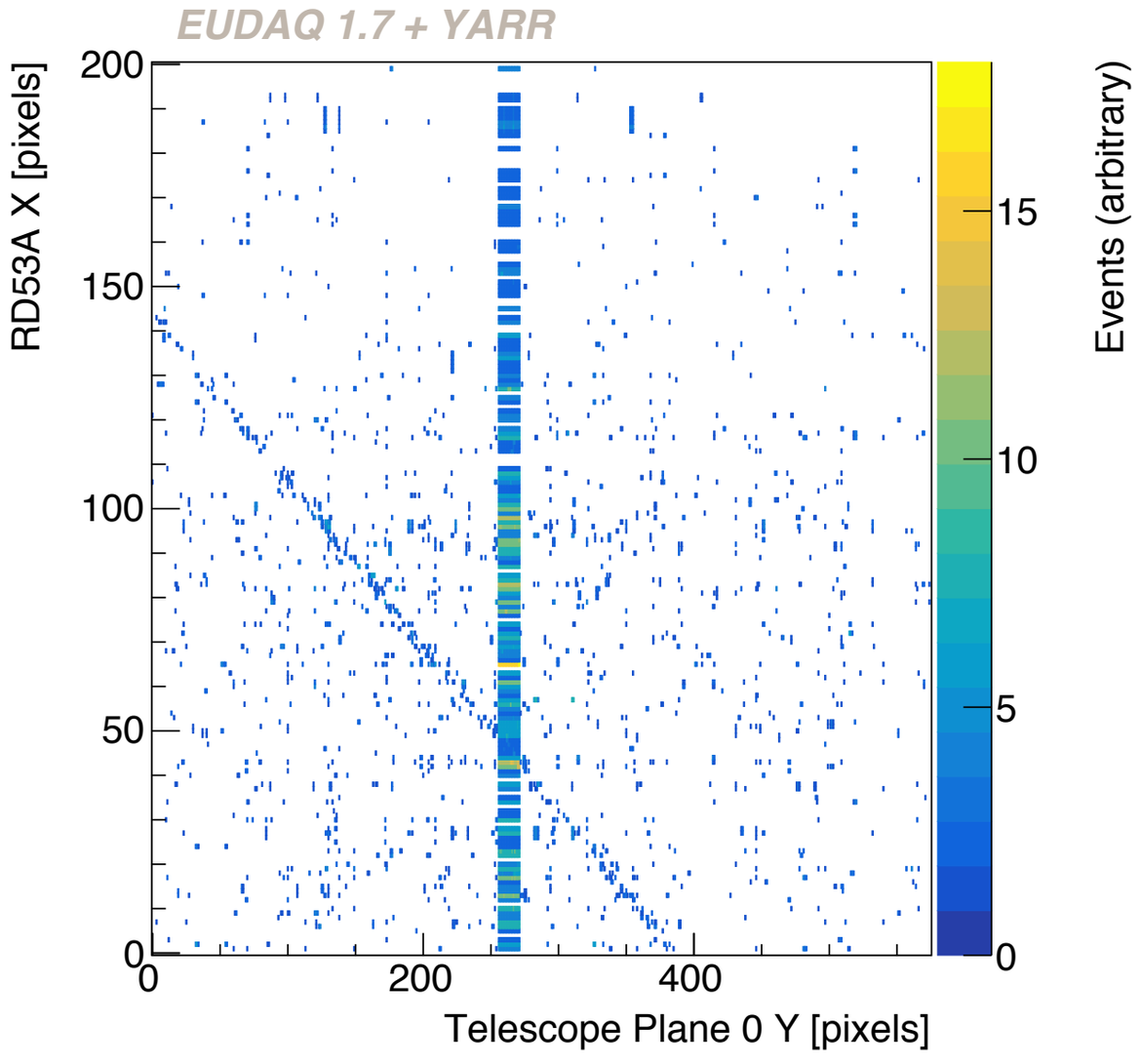
We have exercised the full setup at SLAC for RD53A + YARR + EUDAQ multiple times in 2018 and the data are still being analyzed.

SLAC is a convenient and flexible testbeam location.

Even though the rate is low, the energy is high(ish) and the pulse is very narrow.

(we even saw and resolved double pulses!)

Unfortunately, the SLAC beam is now in a shutdown period.



Questions?