

Fermilab Test Beam

Jessica Metcalfe

- 2017 test beam
- Technologies
- Plans



Highlights

- Ran 9 weeks, 24/7
- 40 pixel CMOS samples tested
- Gamma irradiation at ANL
- RTI pixel modules tested



HVCMOS sensor

- Monolithic matrices
- Capacitively coupled to FEI4 (glued)

Resistivities:

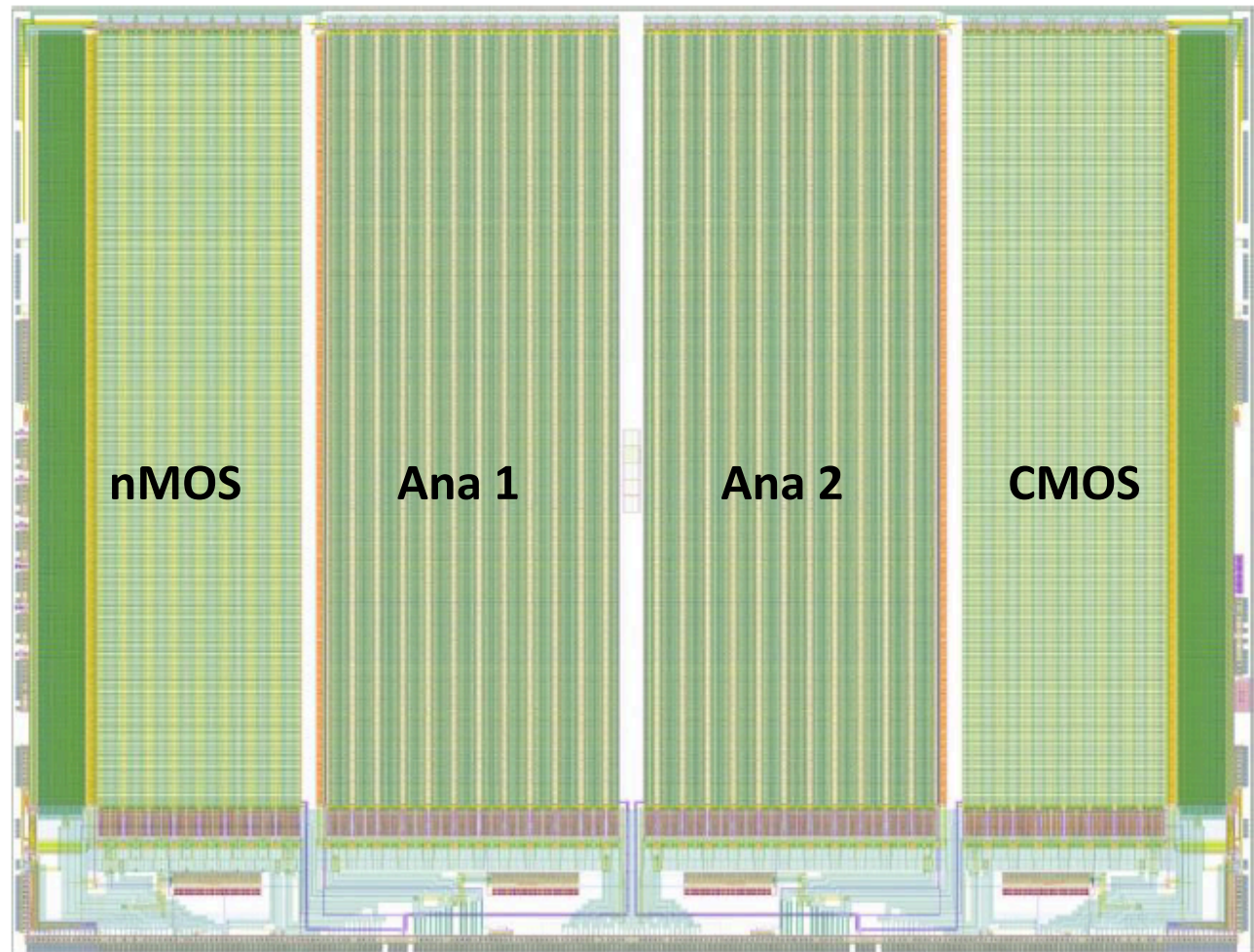
- 20 Ω
- 80 Ω
- 200 Ω
- 1000 Ω

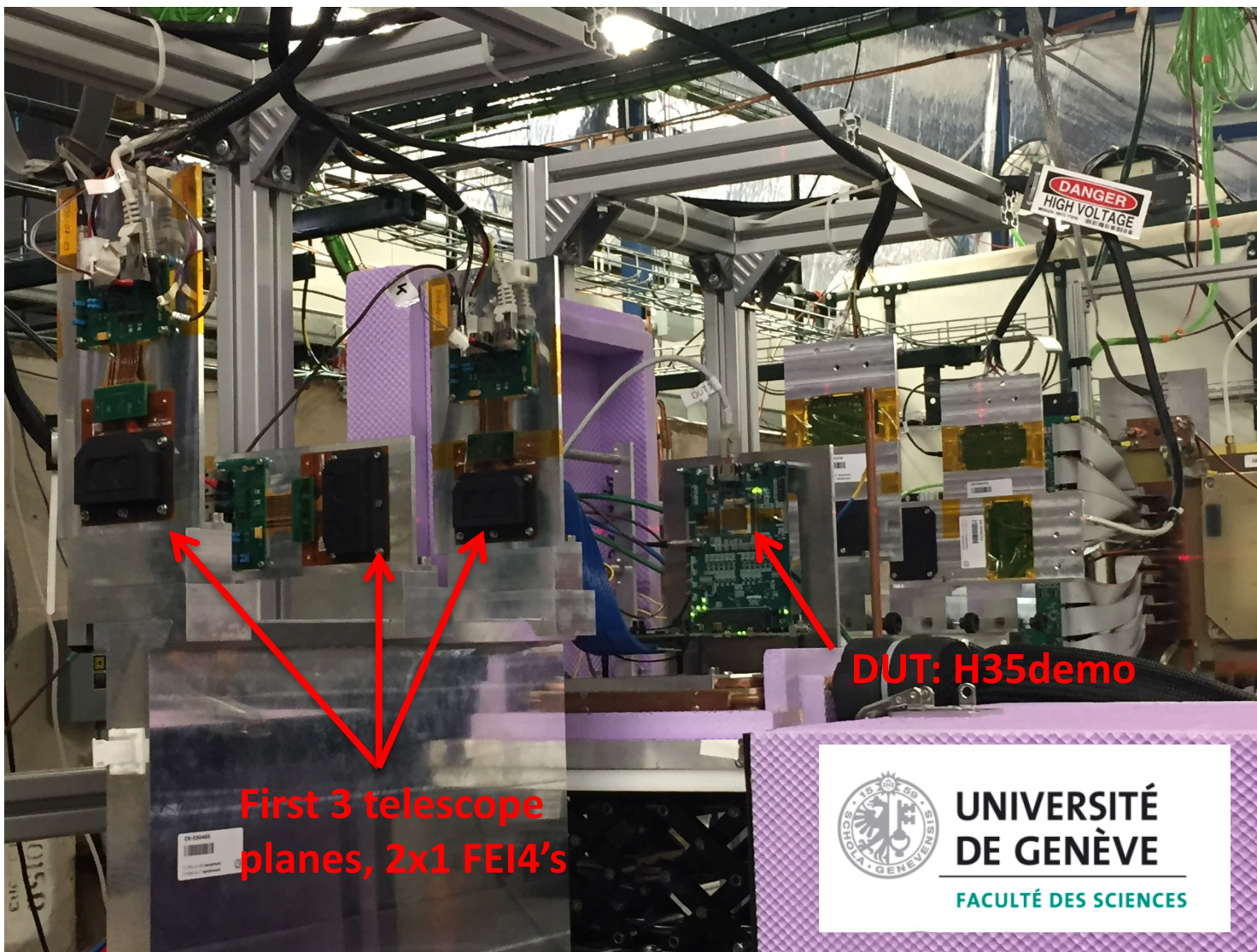
Thickness:

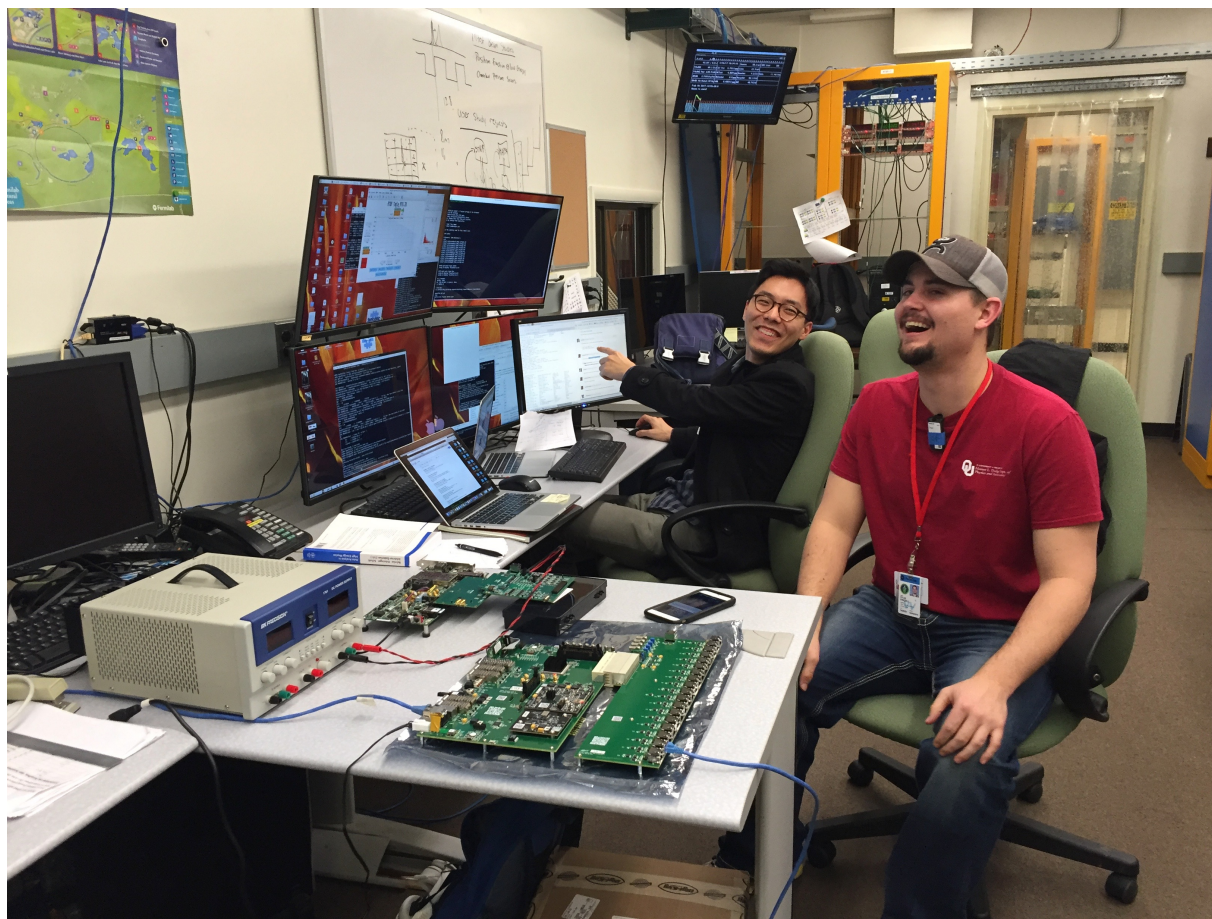
- 300 μm
- 100 μm

Bias voltage:

- Top-side contacts
- Back-side processed for uniform electric field





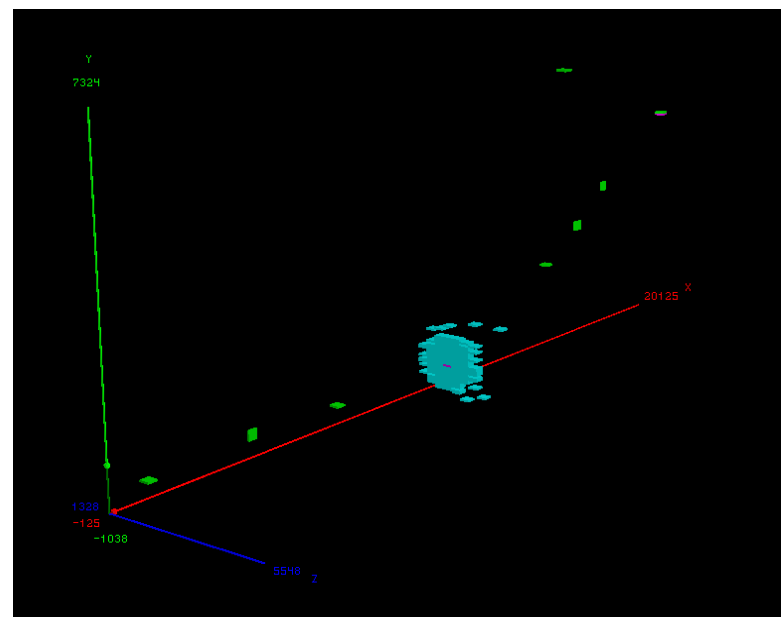
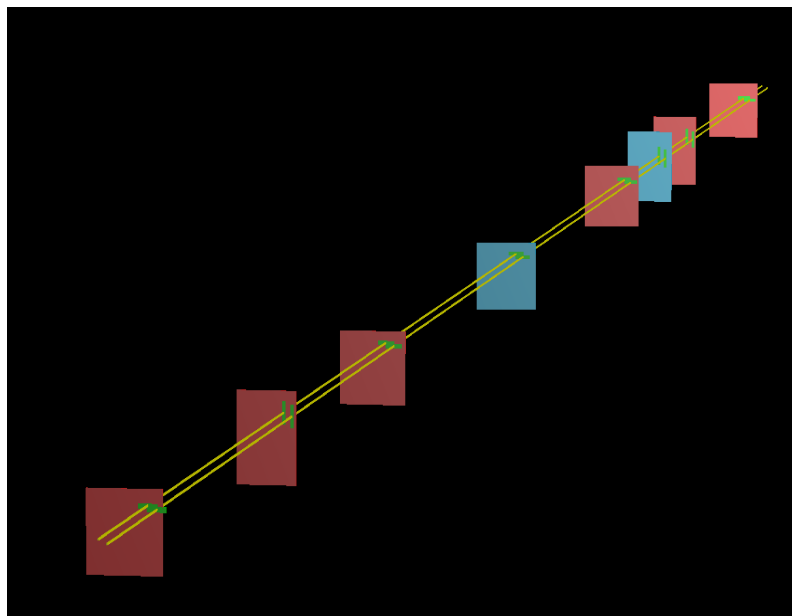


- ASC fellows at Argonne at the 2017 test beam
- Matt Zhang UIUC
- Dylan Frizzell OkU

Next year:

- Wasikul Islam
- ATC grant for 2 OkU students to participate in test beam
- Other expressions of interest from pixel institutes

Test Beam Data Analysis and Visualization SULI student Evan Chang (U. Michigan)



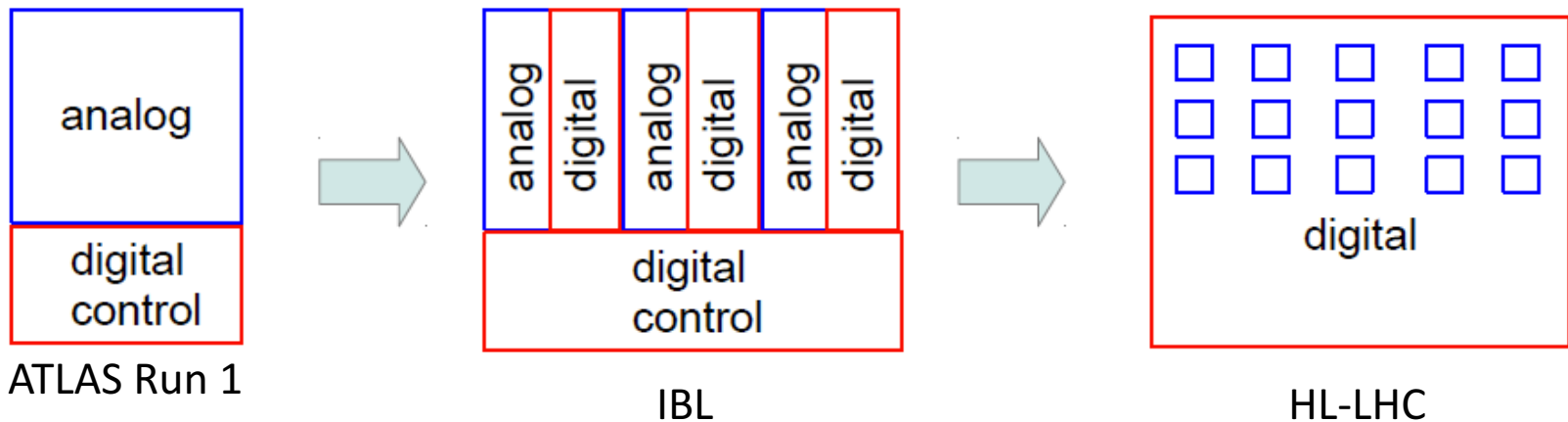
Left: Pixel hits from two tracks. Telescope planes are in red and DUT planes in blue. Pixel are enlarged for visualization and show pixel orientation. Right: A nuclear recoil event observed in the DUT.

Plans for 2018:

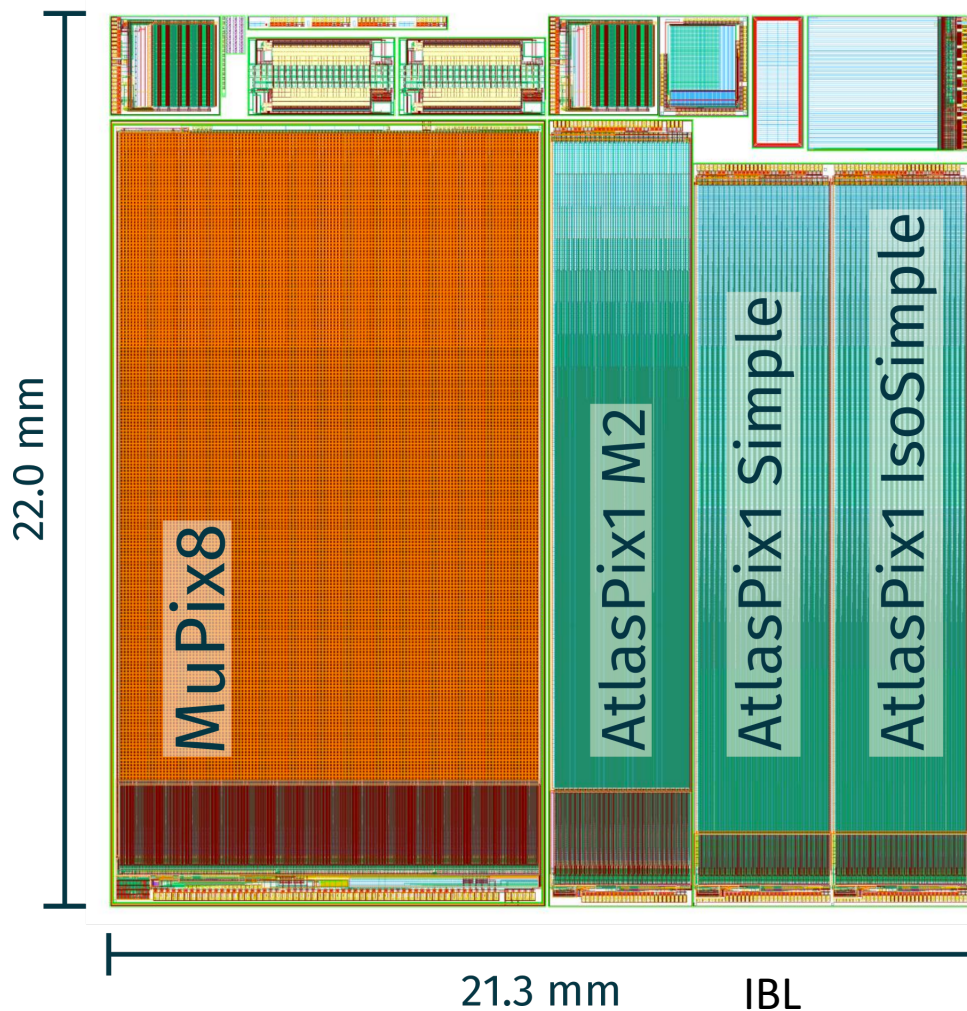
- Build and commission new pixel telescope in Mtest 1B
- Test RD53A modules
 - Critical path item for ATLAS and CMS Phase II Upgrade
 - Initial test beam to verify basic performance
 - Qualifying modules bump bonded by Micross
 - Performance of irradiated modules
 - Felix readout testing for TDAQ
- Test CMOS modules
 - Candidate technology for 5th pixel layer
 - AtlasPix performance
 - Irradiation studies
 - Next version

Future Test Beam Plans: RD53A modules

	RD53	FE-I4
technology	65 nm	130 nm
Pixel dimension	50 μm x 50 μm	50 μm x 250 μm
# of pixels	~140 000	26880
chip dimension	18 mm x 20 mm	19 mm x 20 mm
hit rate	3 GHz/cm ²	0.4 GHz/cm ²
in-time threshold	< 1000 e	< 4000 e
typ. noise (ENC)	< 100 e	< 300 e
bandwidth	5 Gb/s	160 Mb/s
rad. hardness	> 5 MGy	> 2.5 MGy



Future Test Beam Plans: AtlasPix1 modules



M2:

- Parallel-pixel-to-buffer architecture
- 56 320 pixels
- 60 μm 50 μm pitch

Simple, IsoSimple:

- Column-drain architecture
- 25 400 pixels
- 130 μm 40 μm pitch

Plans for 2018:

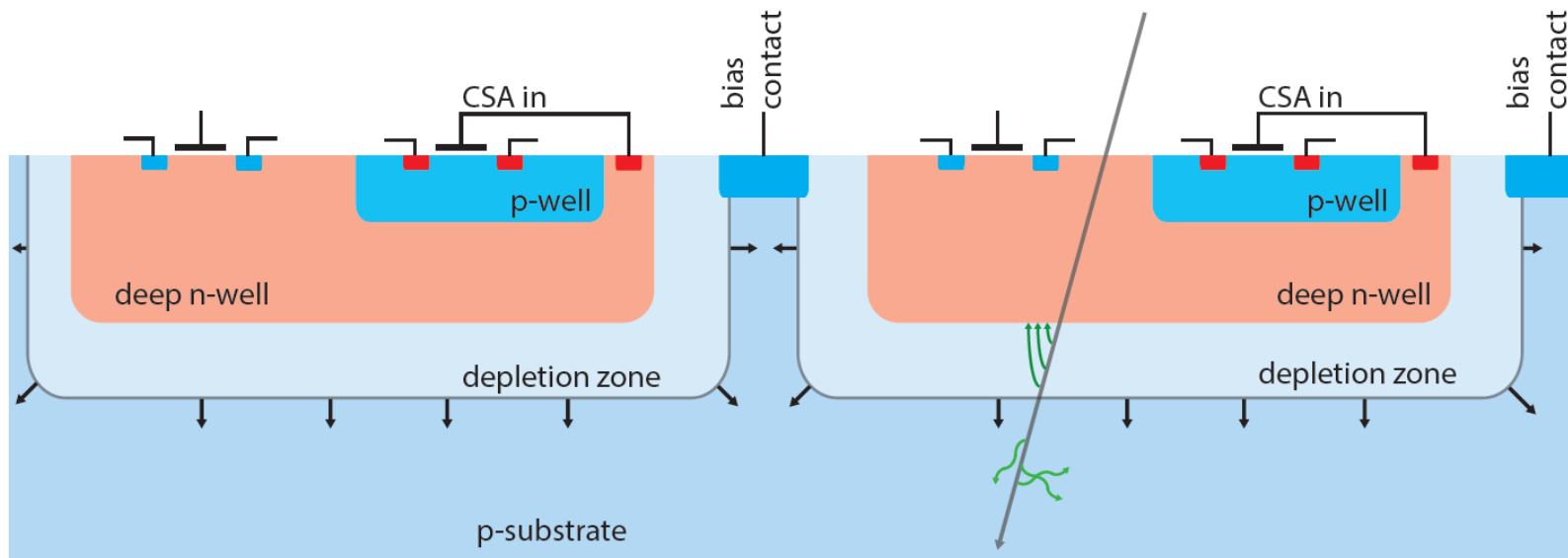
12/13-19 or 1/3-9	commission telescope
February 7-20	first test beam run—RD53A, CMOS (secondary users)
March 28-April 10	RD53A follow-up, AtlasPix follow-up/irradiated modules (secondary users)
April 11-May 8	irradiated RD53A modules
June 20-July 3	can run primary or parasitically anytime

Backup

HVCMOS MAPS

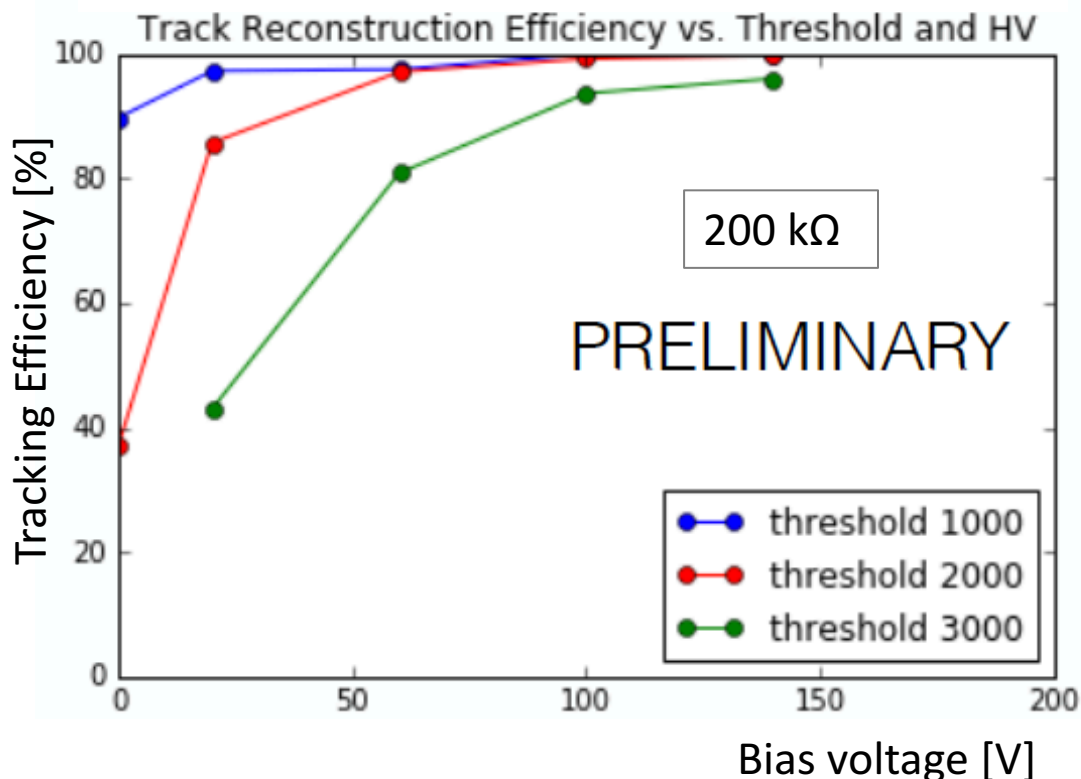
(high voltage complimentary metal oxide semiconductor monolithic active pixel sensor)

- Less expensive by x2 than traditional silicon sensors
 - Integrated sensor + signal amplification
 - Use commercially available CMOS processing with a few modifications
 - Deep n-well to isolate on-pixel electronics
 - high resistivity substrates for high voltage without breakdown
- Timing is currently ~ 1 -100 ns



Tracking efficiency vs bias voltage

- Threshold value is FEI4 value in electrons



W13-10

	0 V	20 V	60 V	100 V	140 V
1000	89.71%	97.22%	97.46%	99.90%	99.93%
2000	37.08%	85.69%	97.07%	99.16%	99.67%
3000	-%	42.95%	80.80%	93.62%	95.98%

Fermilab Test Beam Facility: February 22 to April 25 (9 weeks)

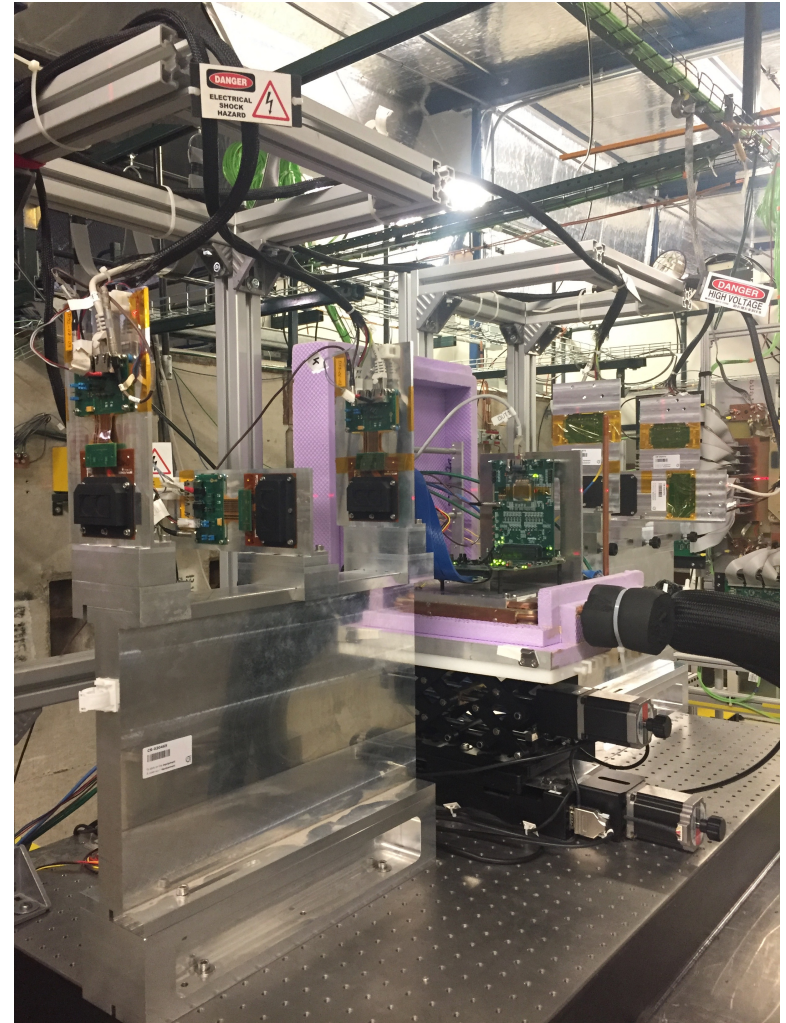
- Coordinating with U. Geneva, M. Benoit

Beam:

- 120 GeV protons;
- 8-60 GeV pions;
- 1-32 GeV pions, kaons, electrons, muons
- Rate $\sim 100\text{kHz}$
- 4.2 s spill every minute
- 300k-500k particles per batch
 - Up to 2.5M per spill
- Spot size $\sim 1\text{ cm}$ (adjustable)

Telescope:

- U. Geneva FEI4 telescope
- HSIO1 readout
- 6 planes of Si sensors
- Trigger rate 6-18 kHz
- Remote controlled scanning stage
- DUT cooling

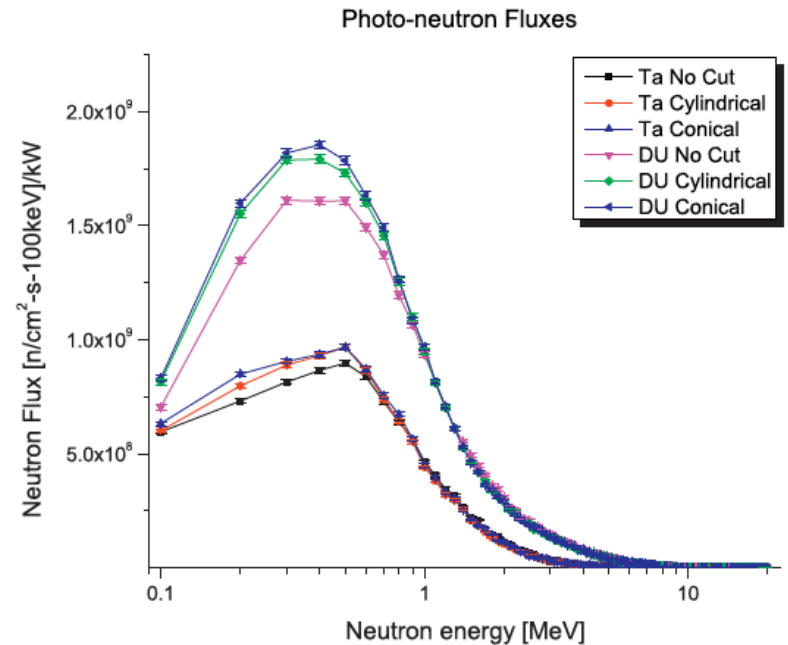


Irradiations @ Argonne:

- Test modules in test beam before and after irradiation

Argonne Low Energy Accelerator Facility (LEAF)

- 55 MeV electron beam
- Neutron Irradiations
 - Photoneutron source
 - Peak energy 0.3-0.5 MeV up to 1 MeV
 - Flux up to 8×10^{11} n/cm² s
 - Fluence target: 3×10^{15} 1 MeV n_{eq}/cm²
 - Plan: lead-boron shield for thermal neutrons, gammas
- Gamma Irradiations
 - range of 1-3 MeV
 - 100 Mrad
 - ~4 days TBC



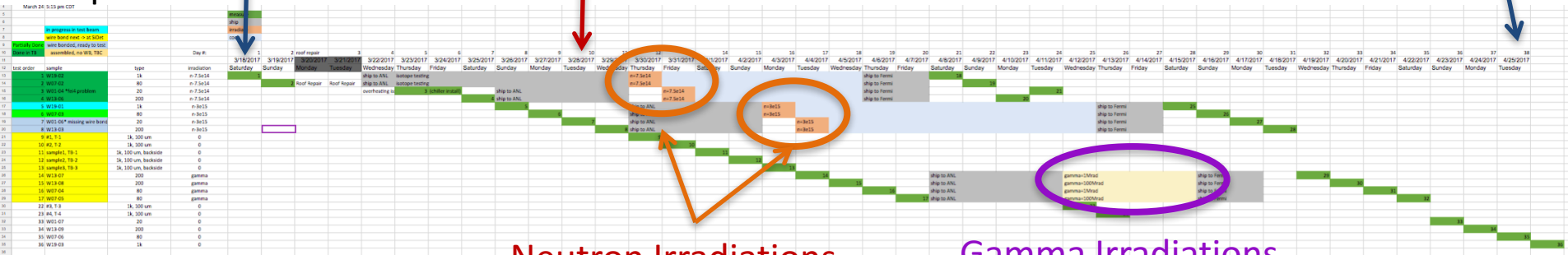
Makarashvili, NIMA 696 (2012) 136-140

April 25

March 18

Today

Samples



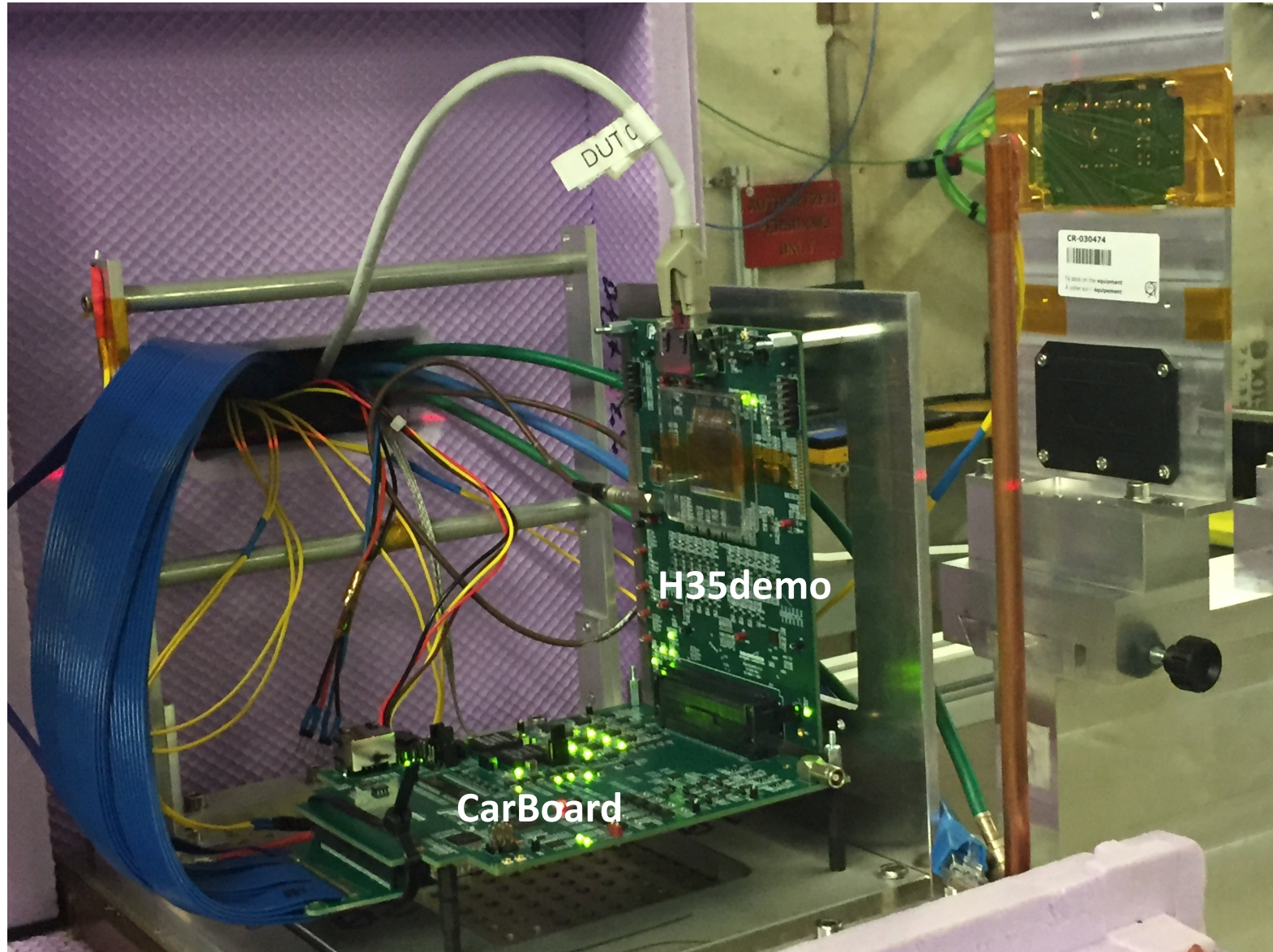
Neutron Irradiations

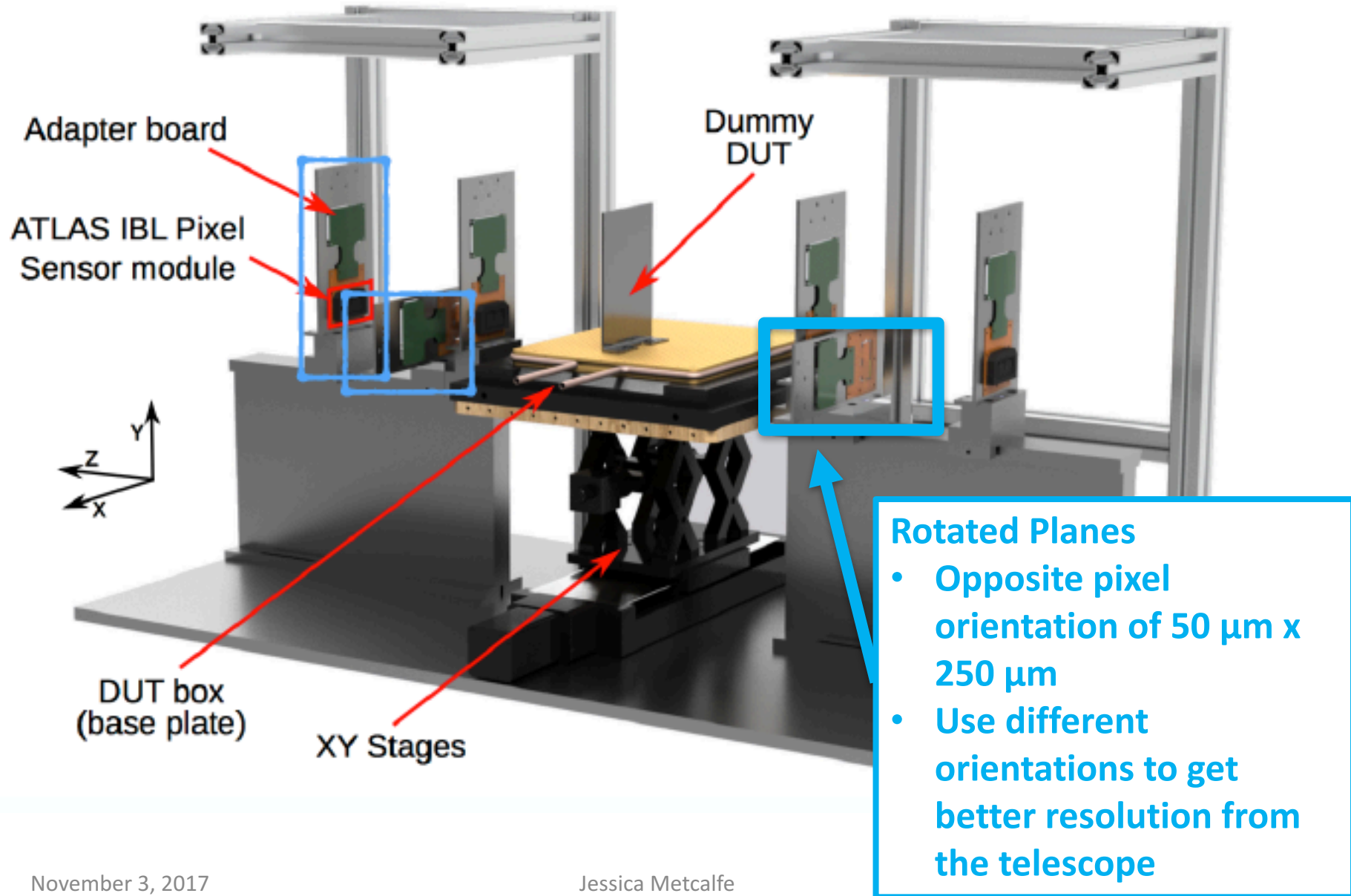
- 7.5e14 1 MeV n_{eq}/cm^2
- 3e15 1 MeV n_{eq}/cm^2

Gamma Irradiations

- 100 Mrad (max)

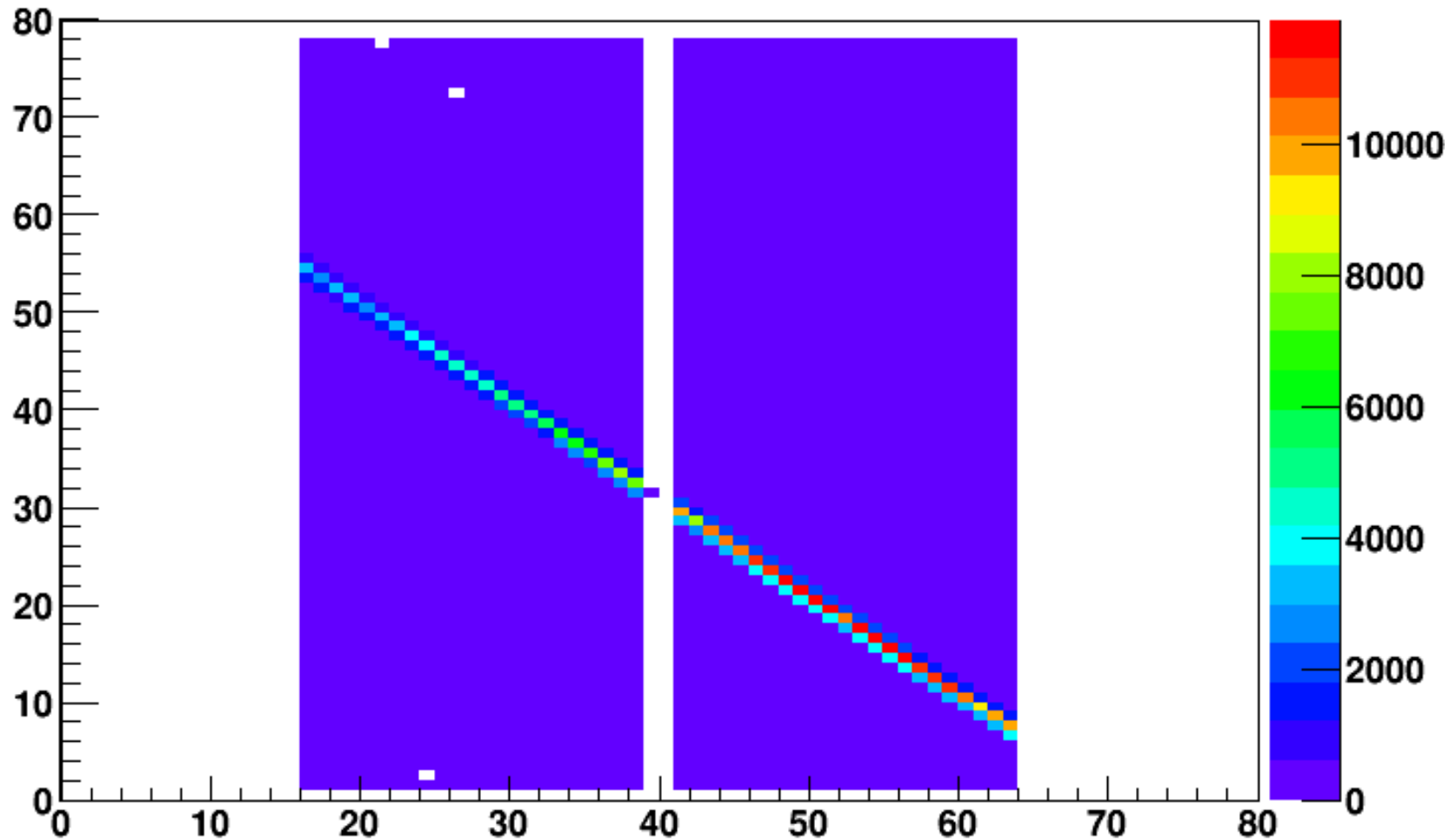
- Data taking progressing smoothly now
- First preliminary results look promising
- First irradiations in the next week
- Possibility to scan pion energies
- Let the analysis begin!





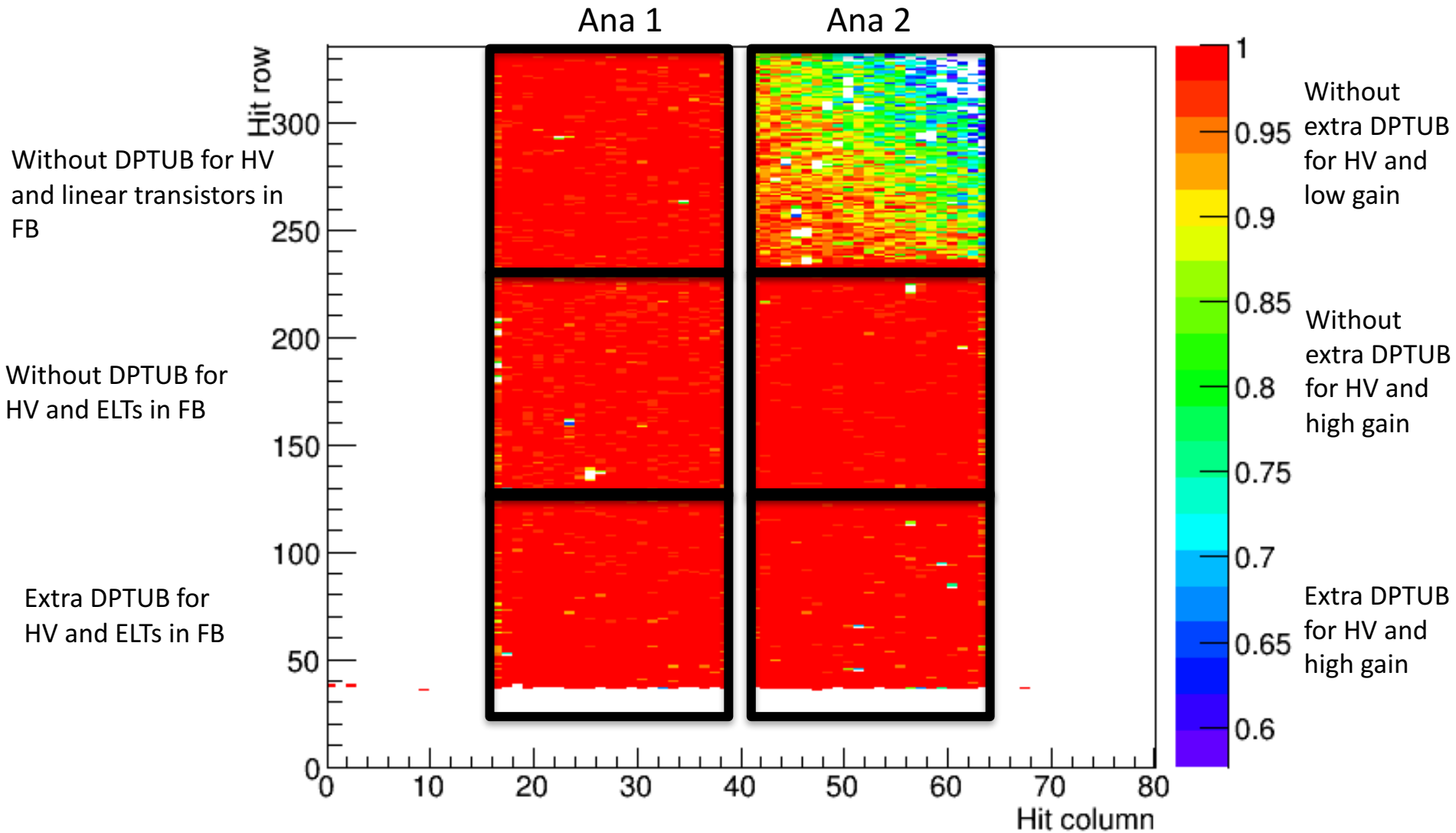
Correlation Plot

Correlation plot for the alignment of the telescope



Preliminary Results

W13-06 200 Ω



W7-02

- 80 Ω
- Threshold = 2000e
- Basic tracking cuts applied

Basic cuts applied:

- 1 track/event
- Chi2/dof < 10
- Track cluster distance < 2 mm

