



FNAL beam tests for CMS MTD

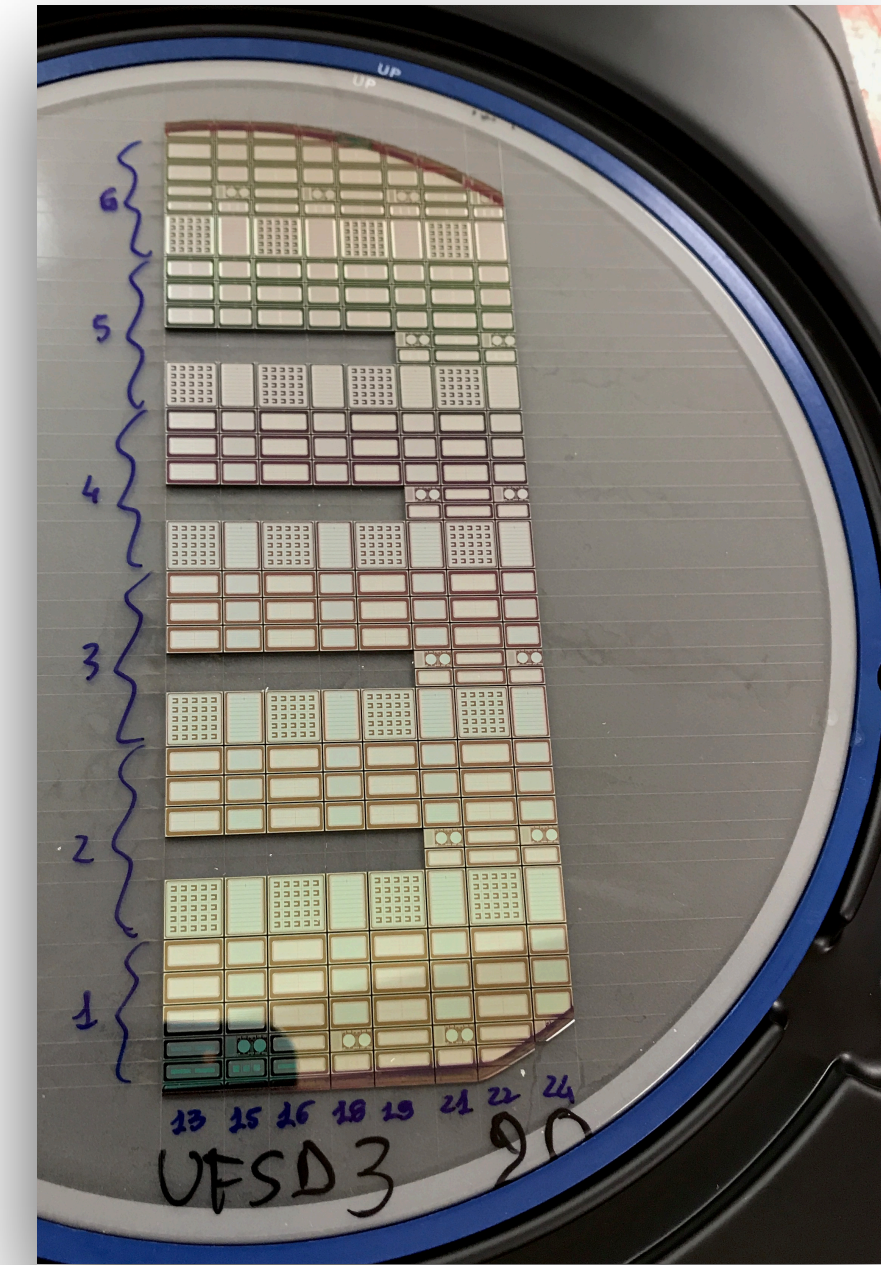
Ryan Heller

US-Japan UFSD meeting

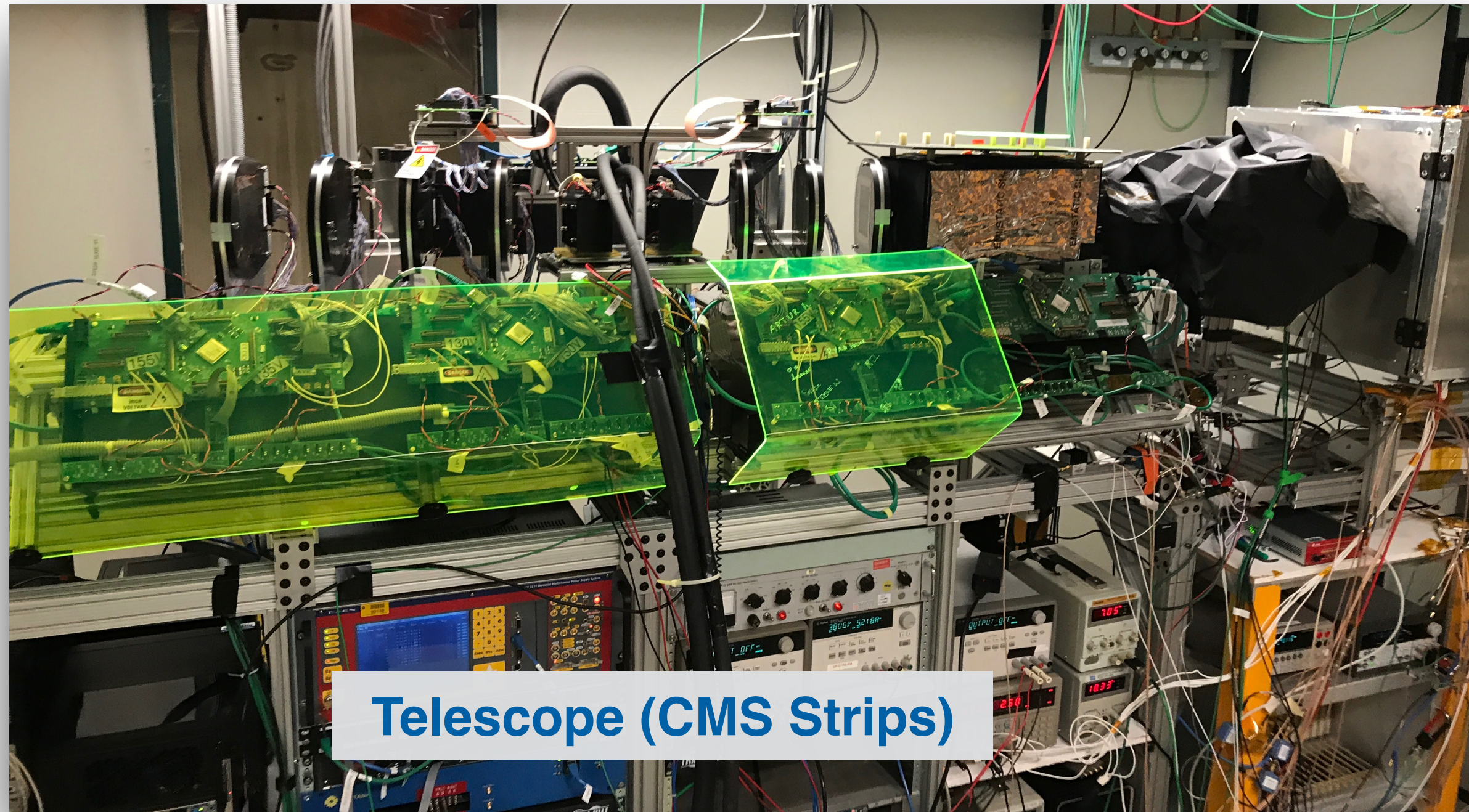
05 March 2019

CMS MTD beam test goals

- Characterize LGADs from 3 potential vendors
 - Hamamatsu
 - Fondazione Bruno Kessler (FBK, Italy)
 - Centro Nacional Microelectrónica (CNM, Spain)
- Primary aspects to understand:
 - Time resolution
 - Want balance of high gain and low noise
 - Radiation hardness
 - Less stringent than ATLAS HGTD: eta from 1.6 to 2.9, so most sensors see $\ll 10^{15}$ neq.
 - Uniformity of large arrays
 - Inter-pad gap
- Beam test:
 - Only way to measure all aspects at once!
 - Uniquely possible: Uniformity of time resolution vs X,Y.

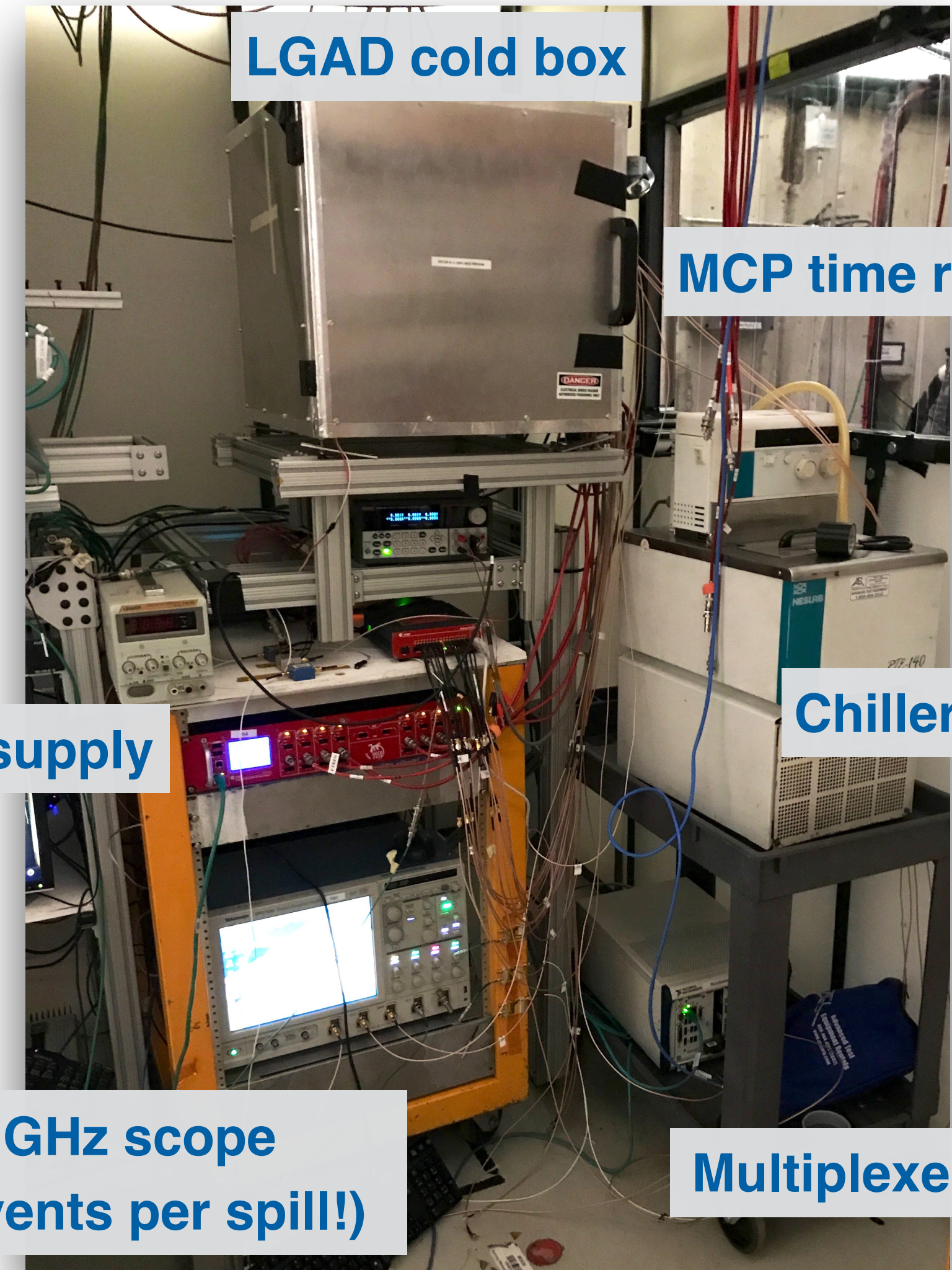


Beam test setup at FNAL



Telescope (CMS Strips)

Coming soon: "region of interest" trigger
(small scintillator + motion stage)



LGAD cold box

MCP time reference

Chiller

8-channel HV supply

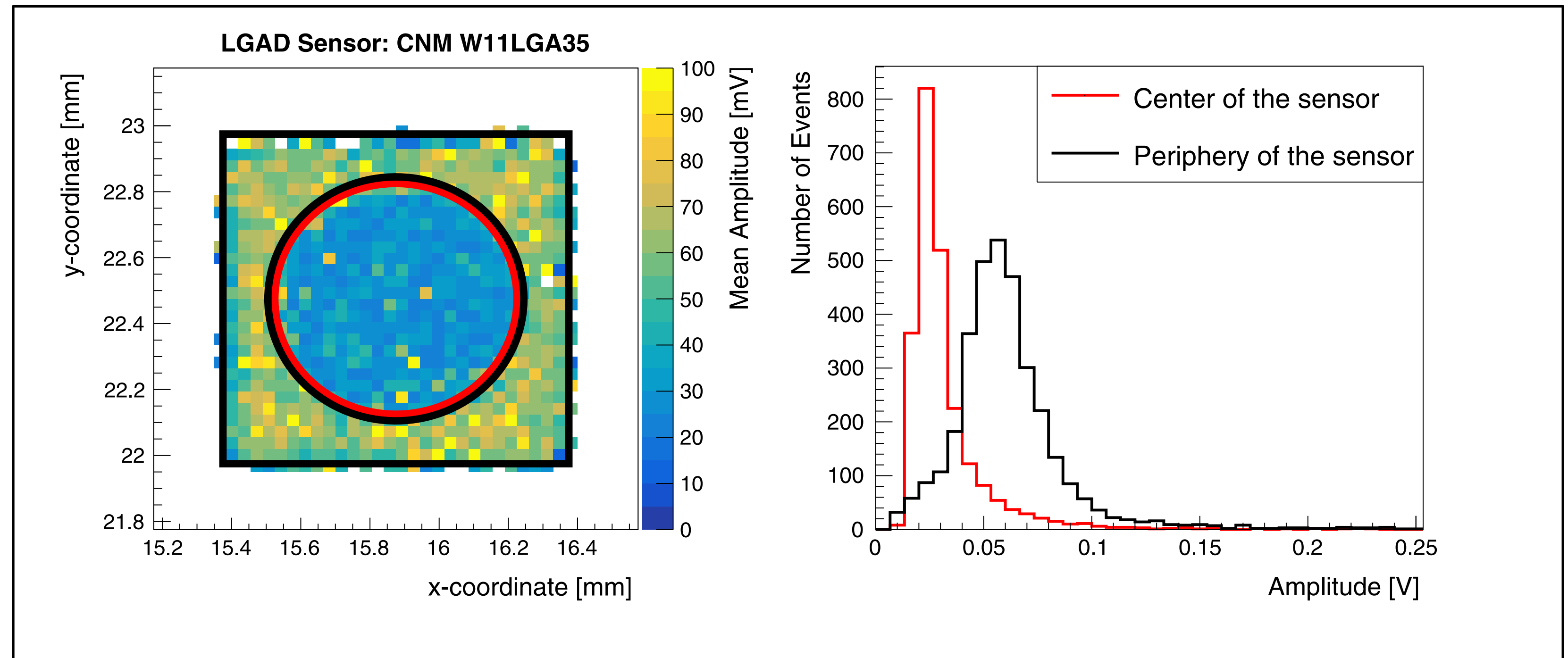
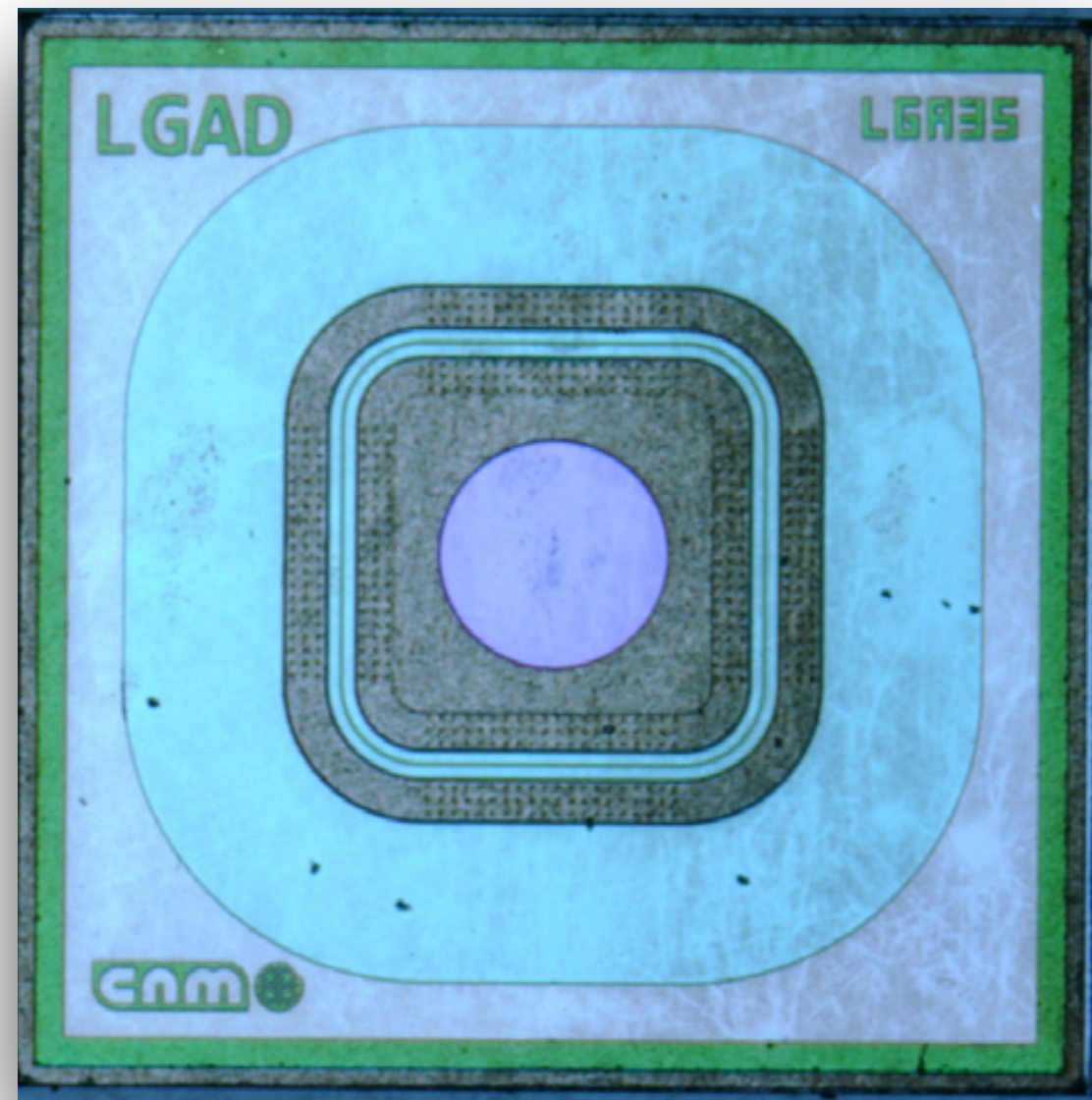
2.5 GHz scope
(30k events per spill!)

Multiplexer (20 GHz)

Interesting result: radiation damage

Irradiated LGAD (CNM)
6e14 neq

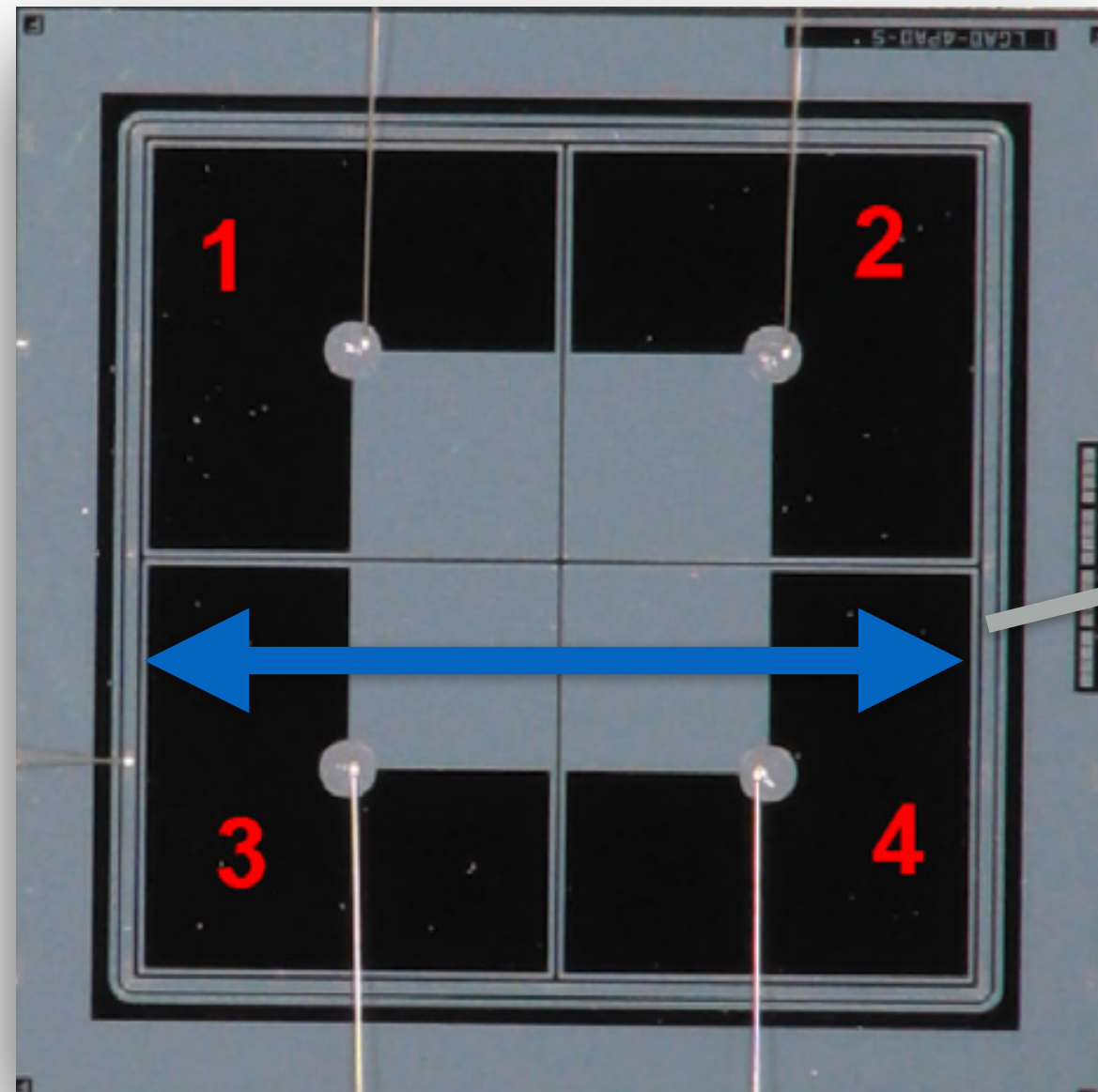
Map of mean amplitude



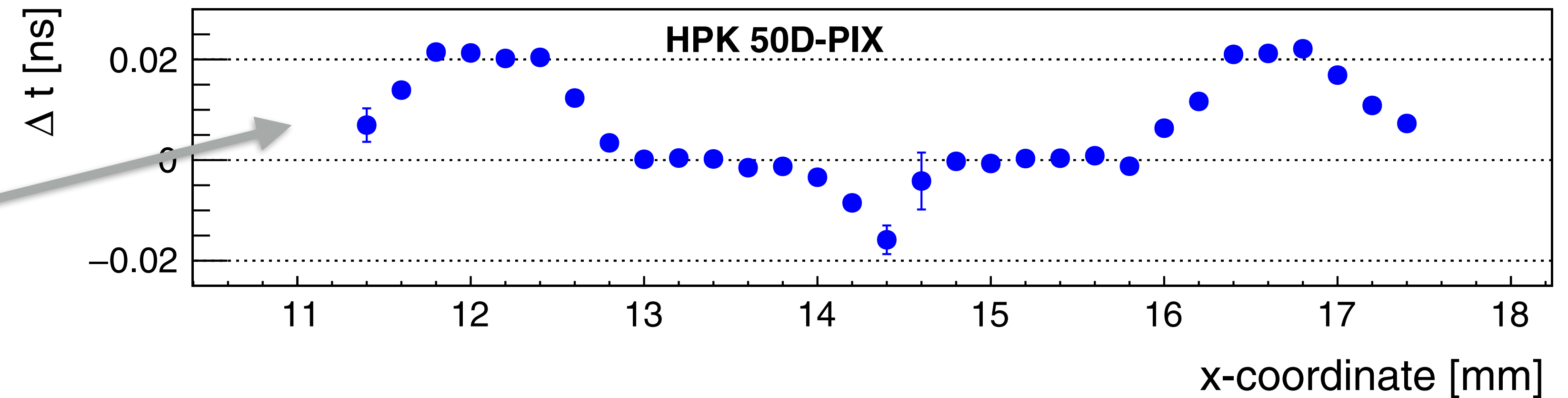
Metallization provided some protection against radiation damage!

Interesting result: timing

HPK 50D



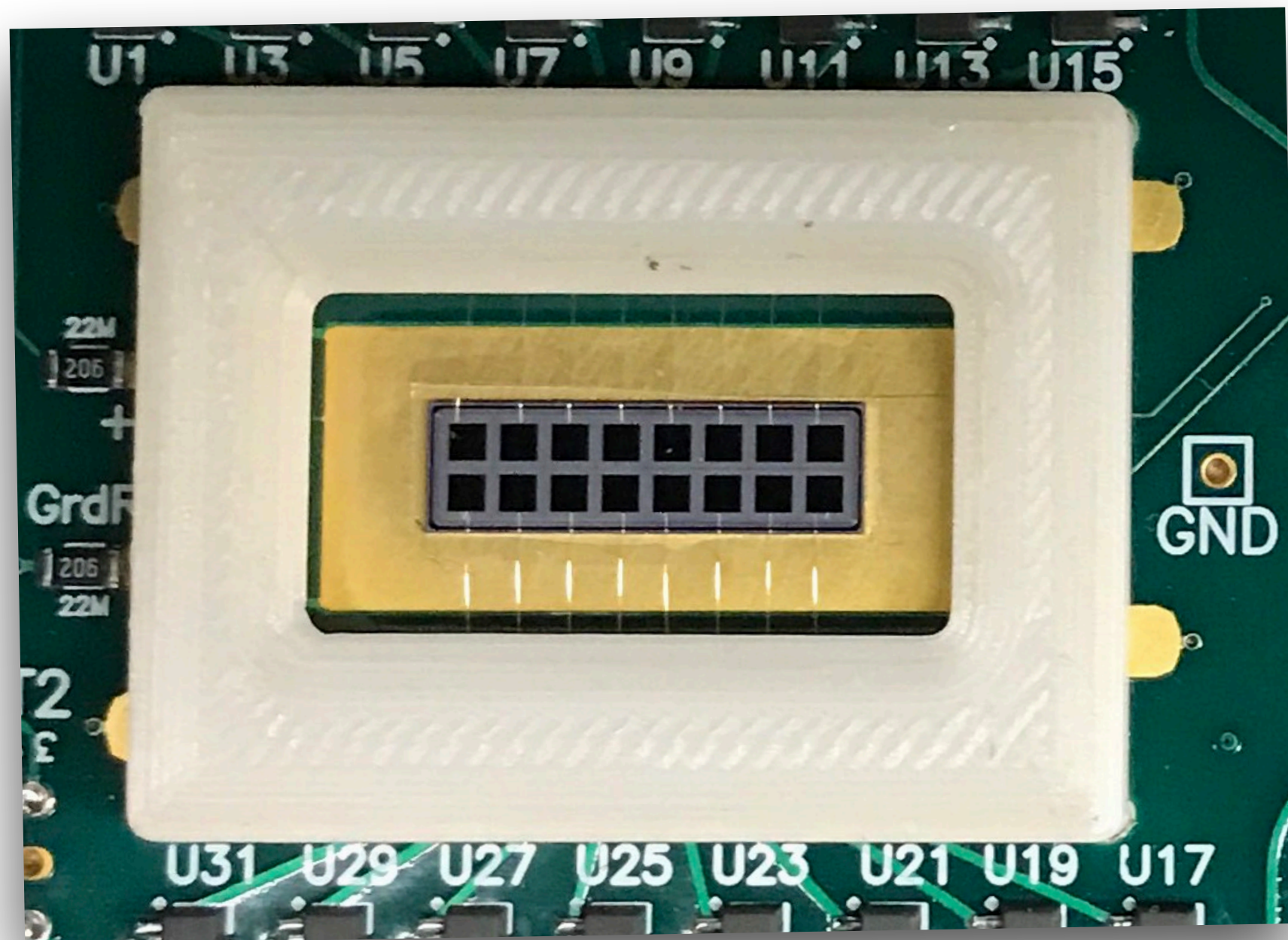
Delta T with respect to MCP reference



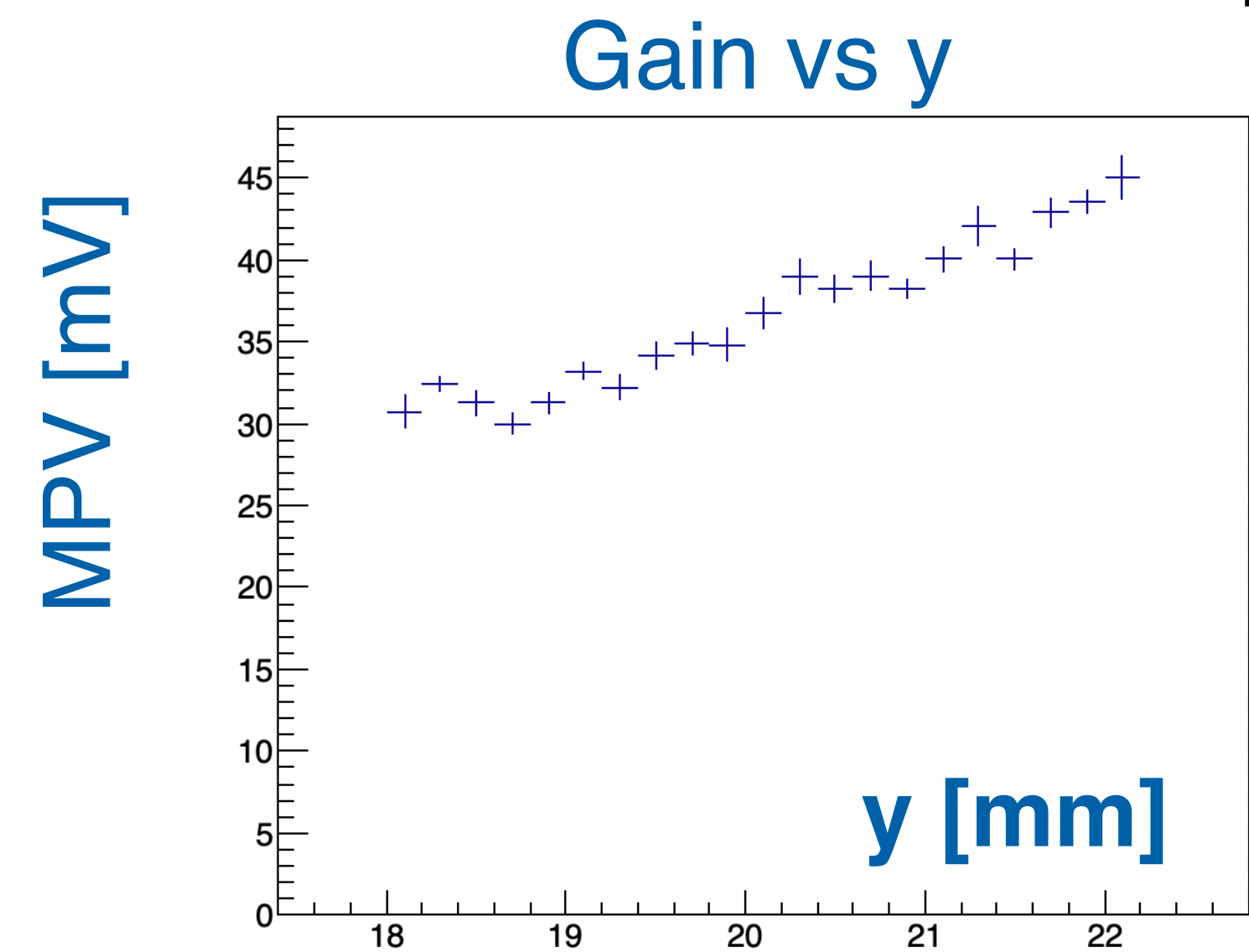
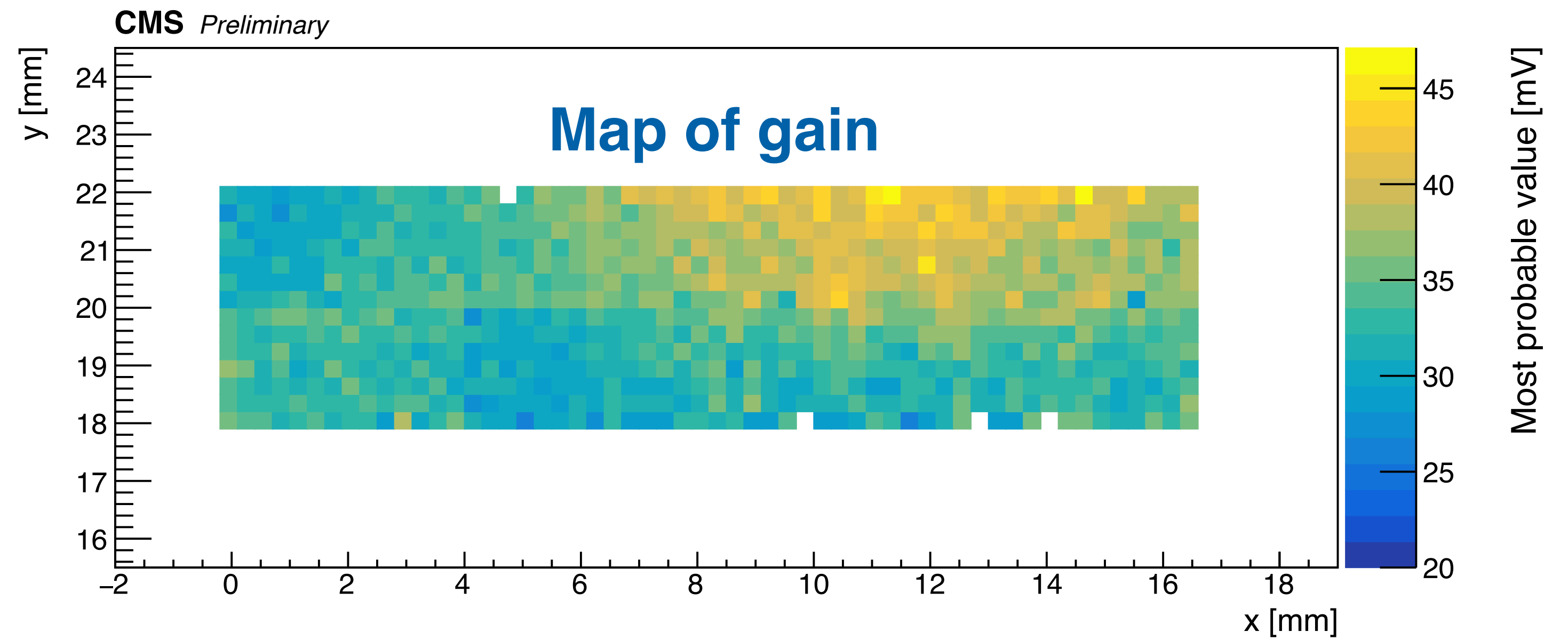
- Major difference in arrival time underneath metallization
- Can only observe this with test beam!

Gradient in gain

FBK UFSD2, 2x8 array

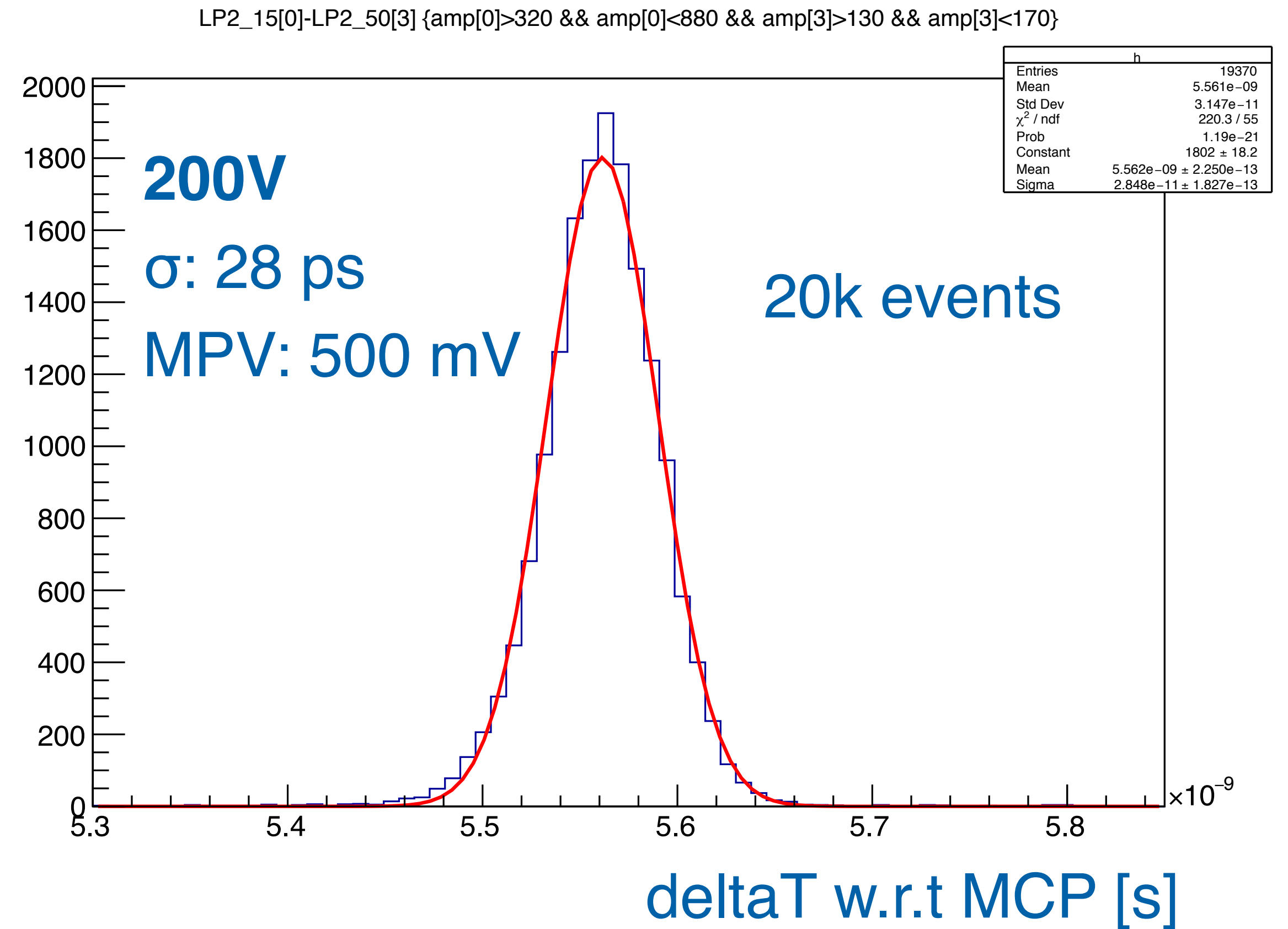
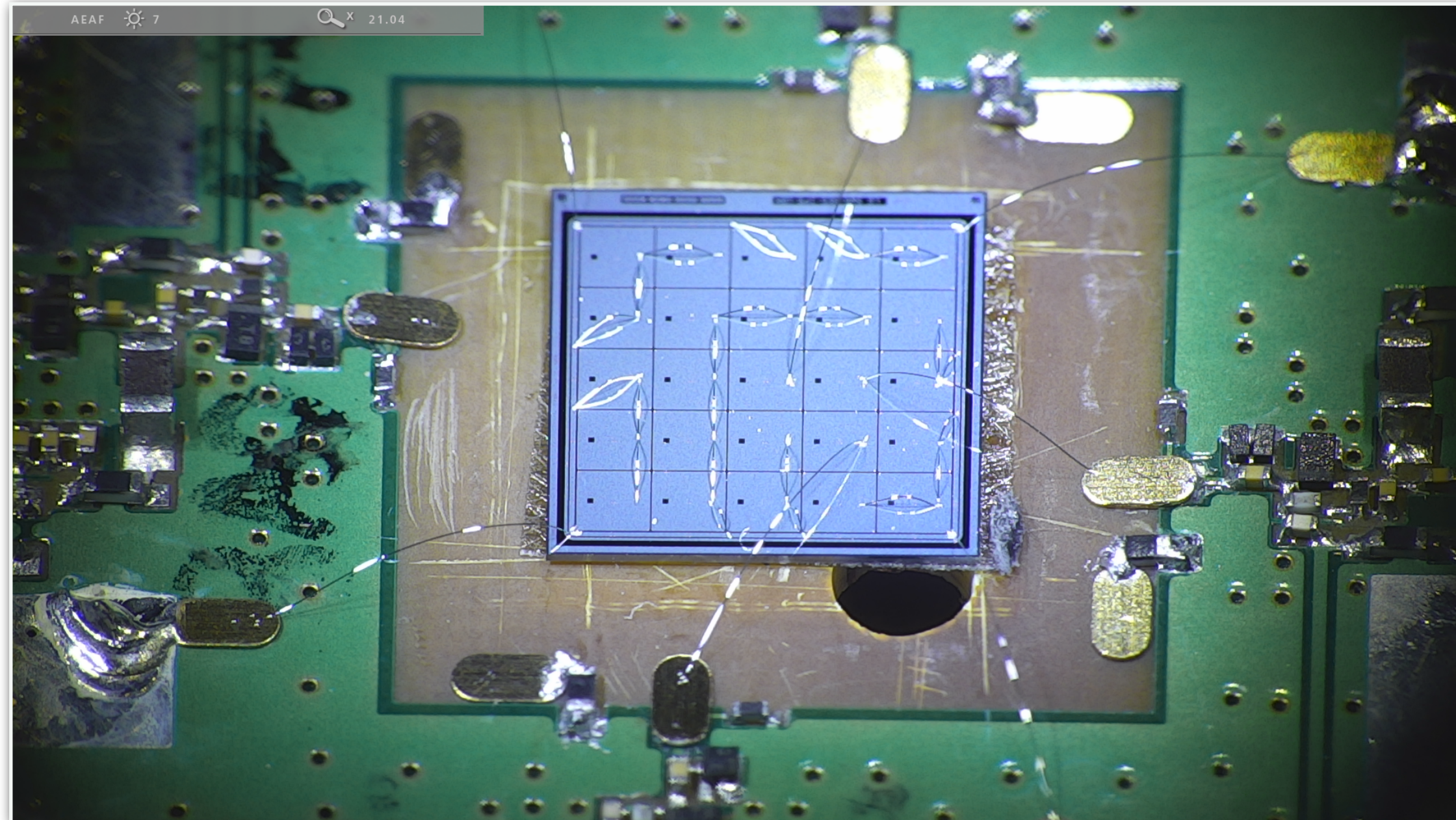


Hot spot in gain!



Latest results

- HPK 3.1 5x5 array



- See great results with un-irradiated array!

Future plans

- Continue testing sensors from HPK 3.1 and HPK 3.2
 - Will receive larger arrays soon!
- Testing of ASIC prototype
 - ETROC0: available in few months— test analog part
 - ETROC1: later this year— analog+digital