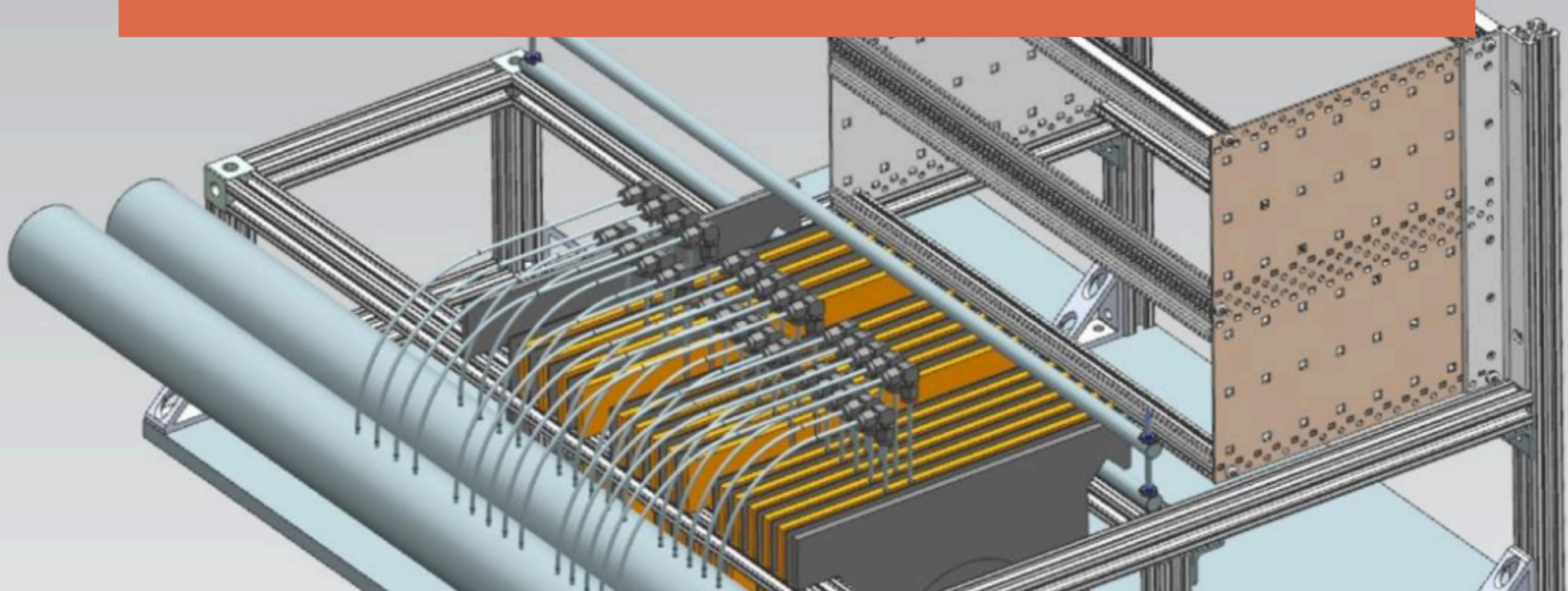


CMS High-Granularity Calorimeter Prototype, First Test Beam Results

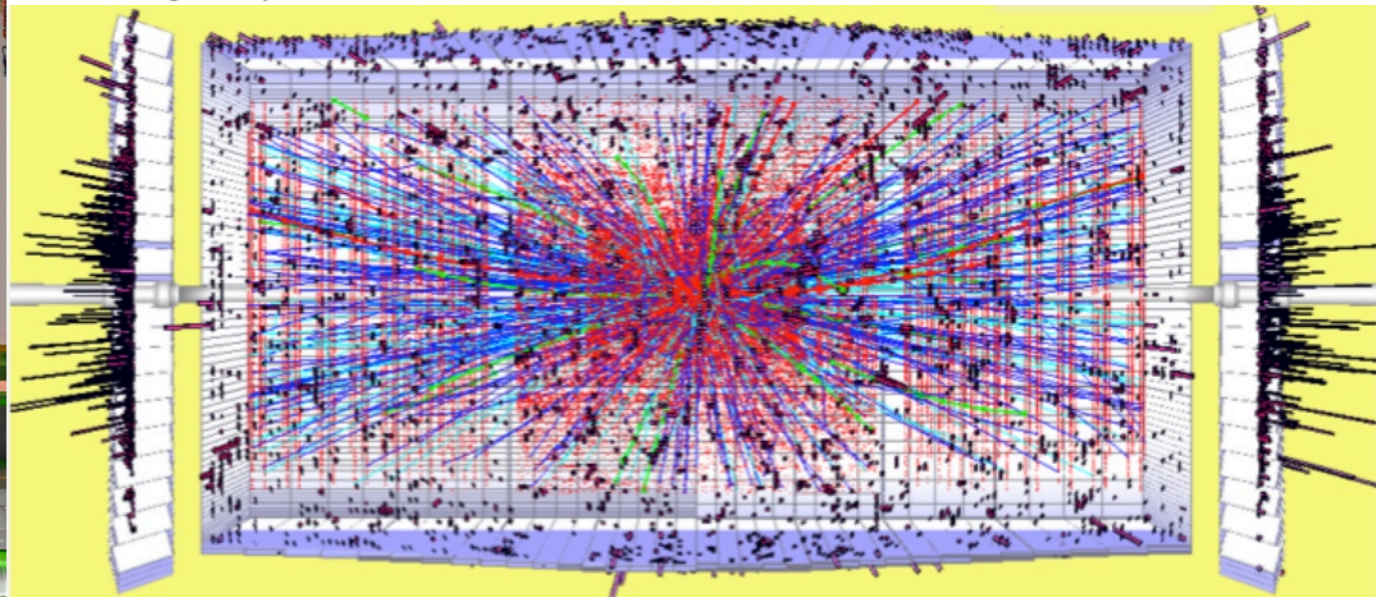
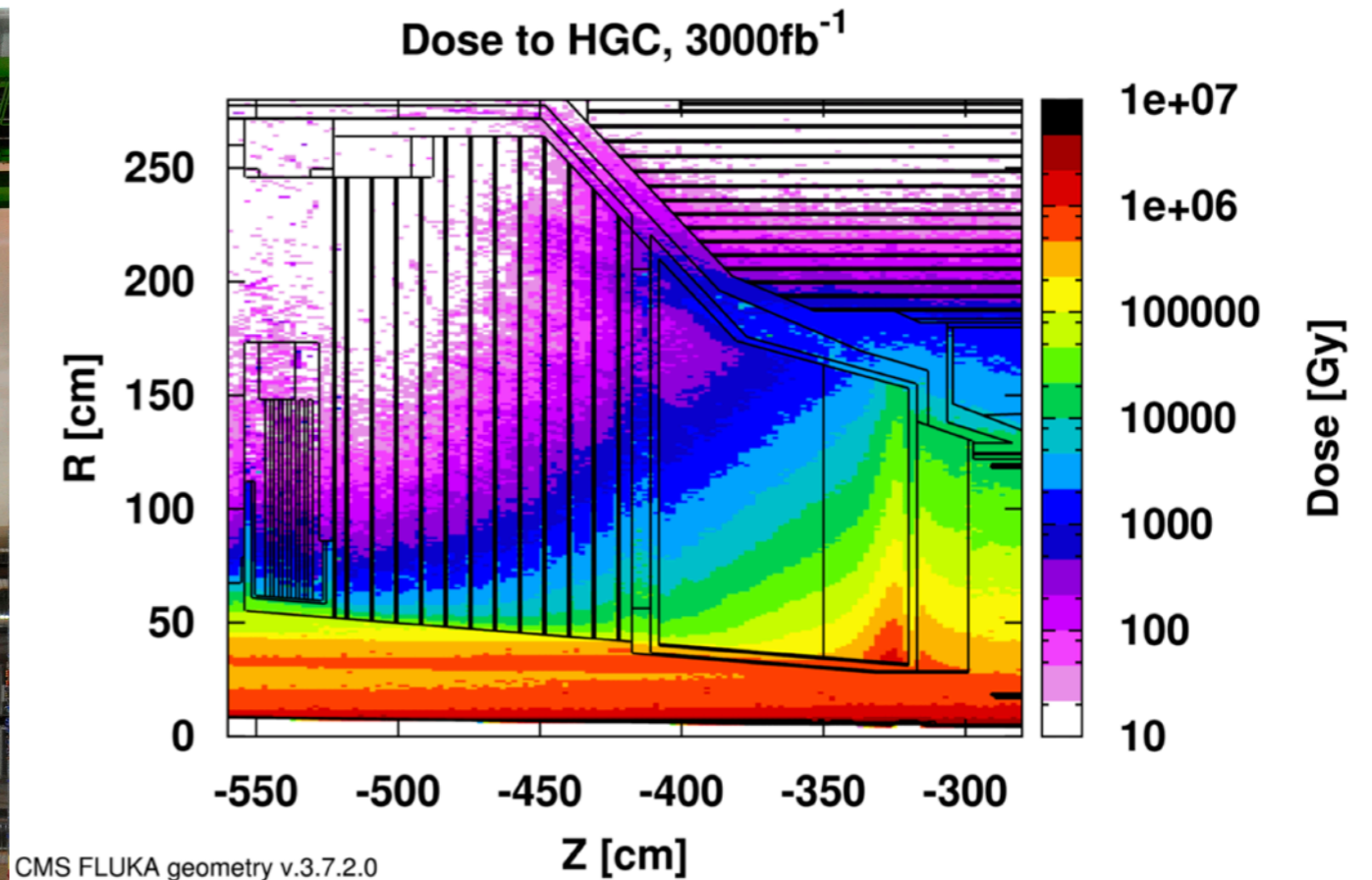
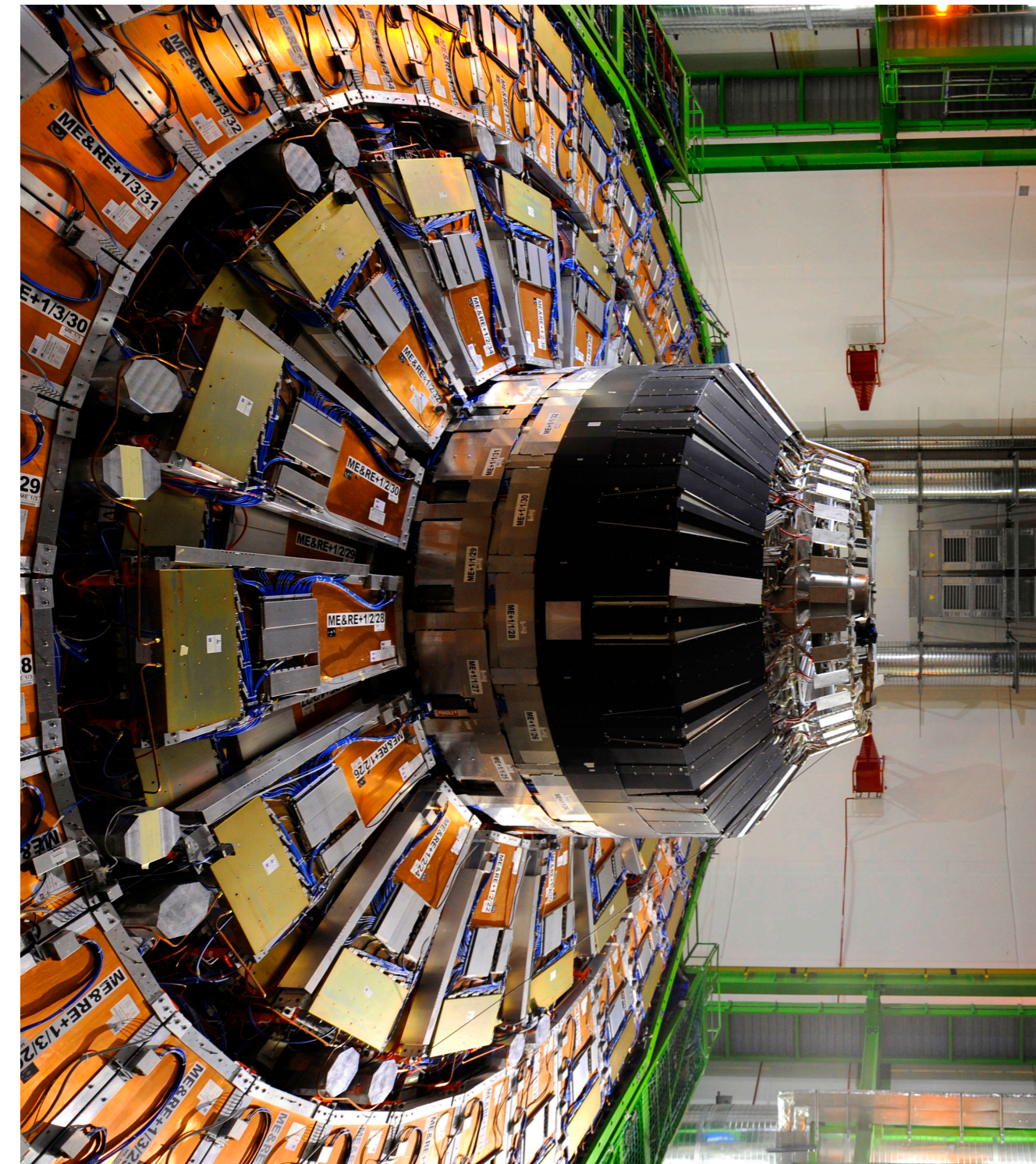


Zoltan Gecse
on behalf of the Test Beam Group
April 11, 2016

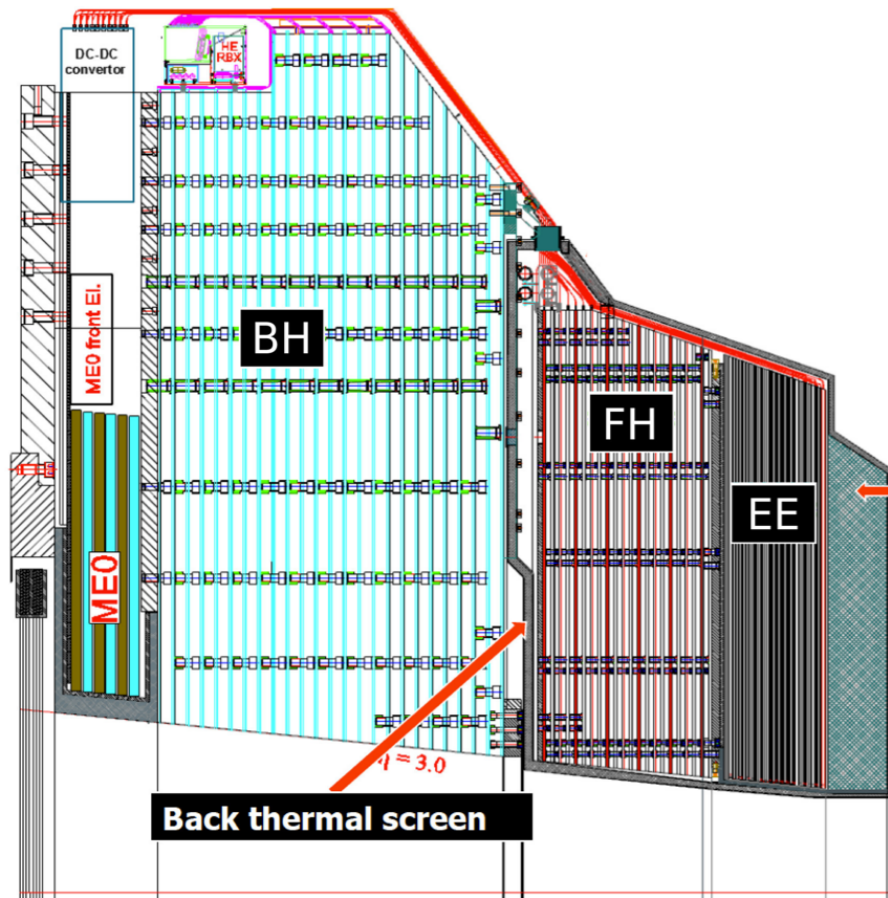


CMS Calorimeter Endcap

- **Calorimeter endcap needs replacement for HL-LHC (3000/fb)**
 - High radiation dose (150Mrad, 10^{16} n/cm²) and high pile-up conditions (200 PU)



The CMS HGC Design



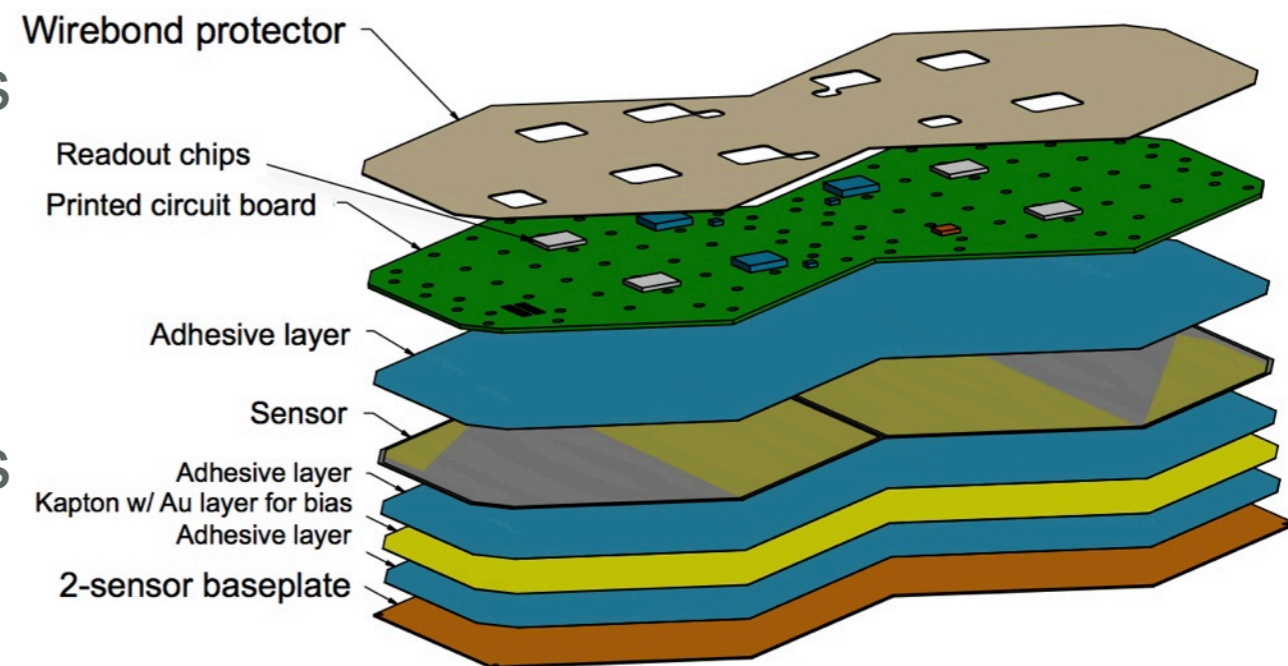
- **System divided into three parts:**

- EE – Silicon with tungsten absorber
28 sampling layers – $25 X_0 + \sim 1.3 \lambda$
- FH – Silicon with brass absorber
12 sampling layers – 3.5λ
- BH – Scintillator with brass absorber
11 layers – 5.5λ

- **EE and FH are maintained at -30°C , BH is at room temperature**

- **Construction:**

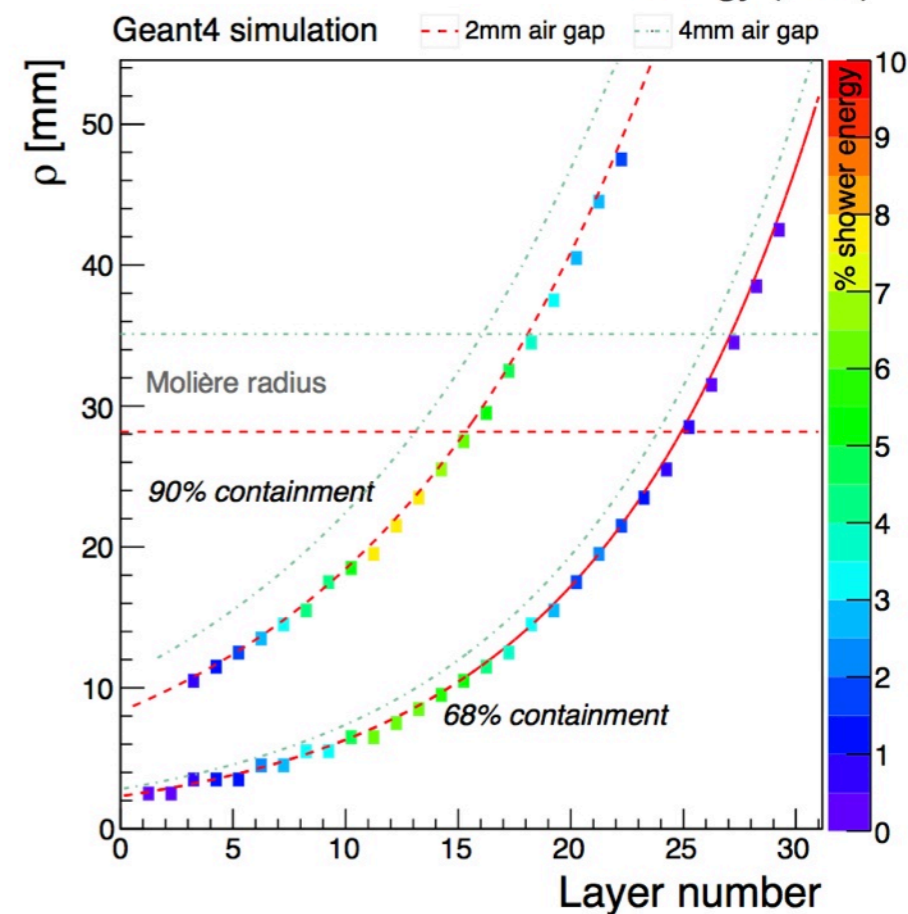
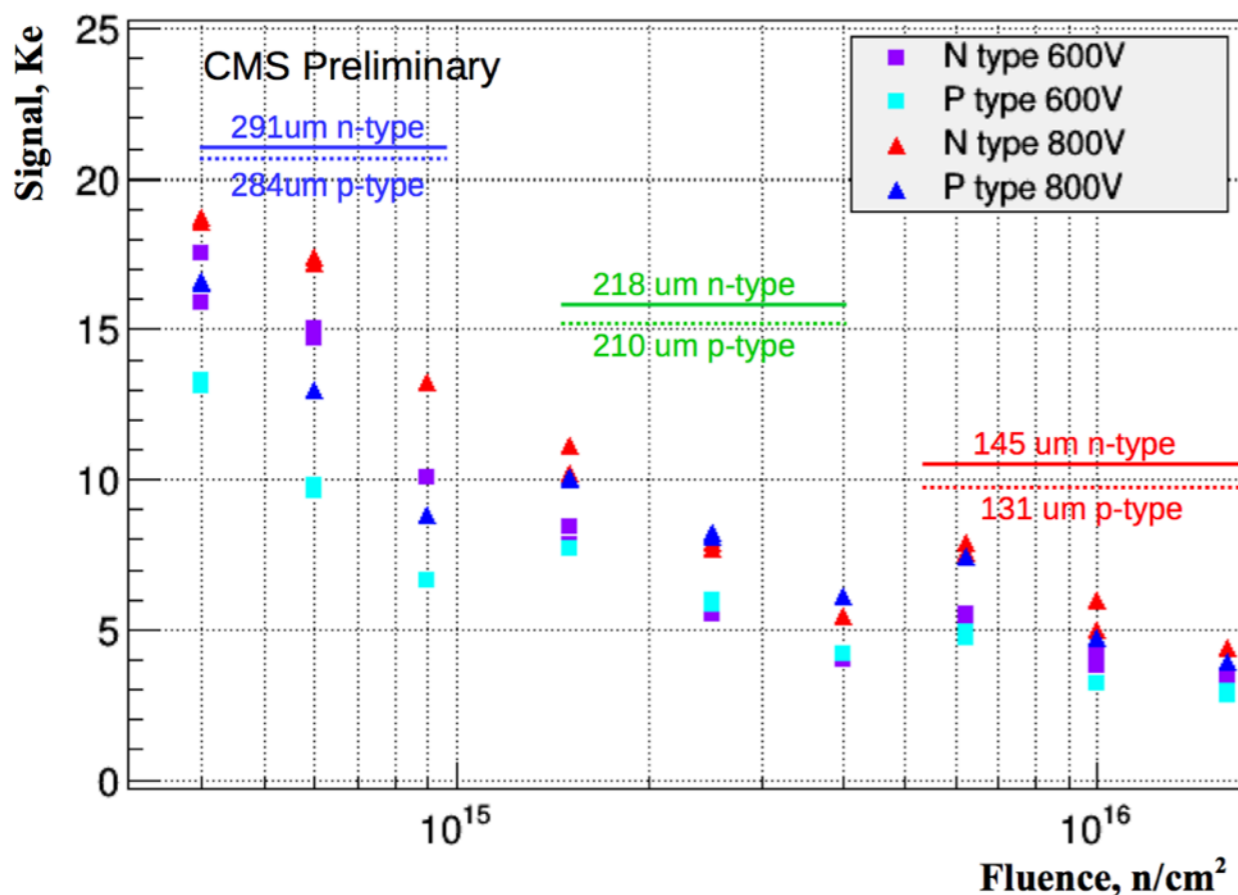
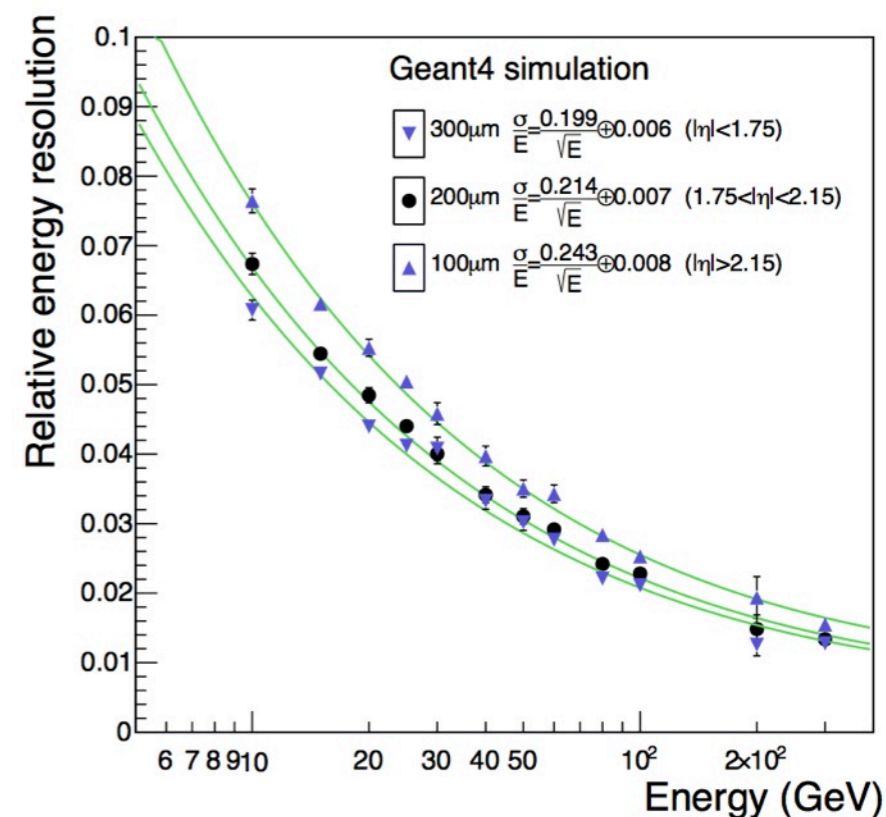
- Hexagonal Si-sensors built into modules
- Modules with a W/Cu base plate and PCB readout board.
- Modules mounted on copper cooling plates to make wedge-shaped cassettes
- Cassettes inserted into absorber structures at integration site (CERN)



Key Parameters and Performance

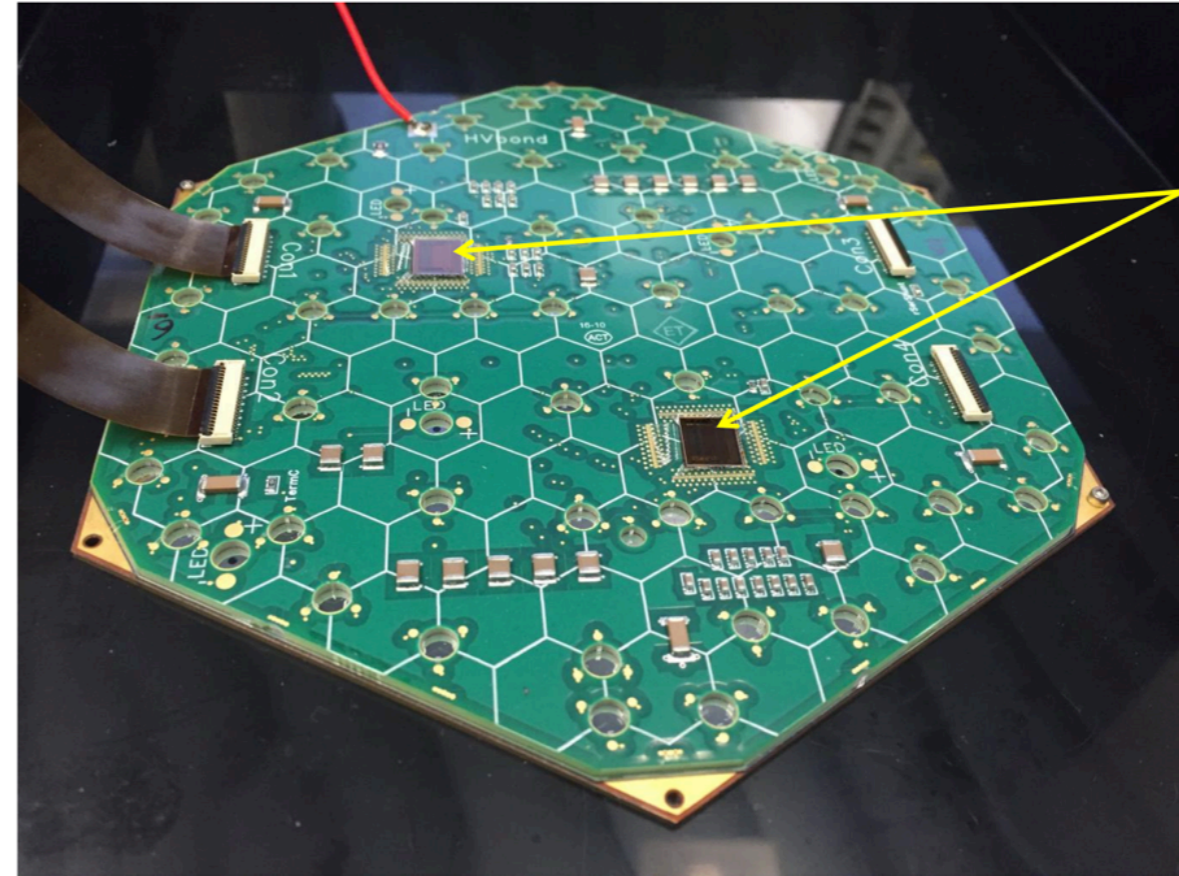
• Key parameters:

- 593 m² of silicon
- 6M ch, 0.5 or 1 cm² cell-size
- 21,660 modules (8" or 2x6" sensors)
- 92,000 front-end ASICs.
- Power at end of life 115 kW



Construction of the First Prototype

- **Beijing:** H. Zhang
- **Caltech:** BA. Apresyan, S. Xie
- **FNAL:**
 - G. Bolla, Z. Gecse, C. Gingu, J. Freeman, R. Lipton, A. Rhonzin, R. Rivera, P. Rubinov, L. Uplegger
- **Iowa:** B. Bilki
- **Minnesota:**
 - R. Chatterjee, E. Frahm, S. Nourbakhsh, R. Rusack
- **Northwestern:**
 - J. Bueghly, A. Kumar, N. Odell, M. Velasco
- **UCSB:**
 - J. Incandela, S. Kyre, M. Miller, D. White

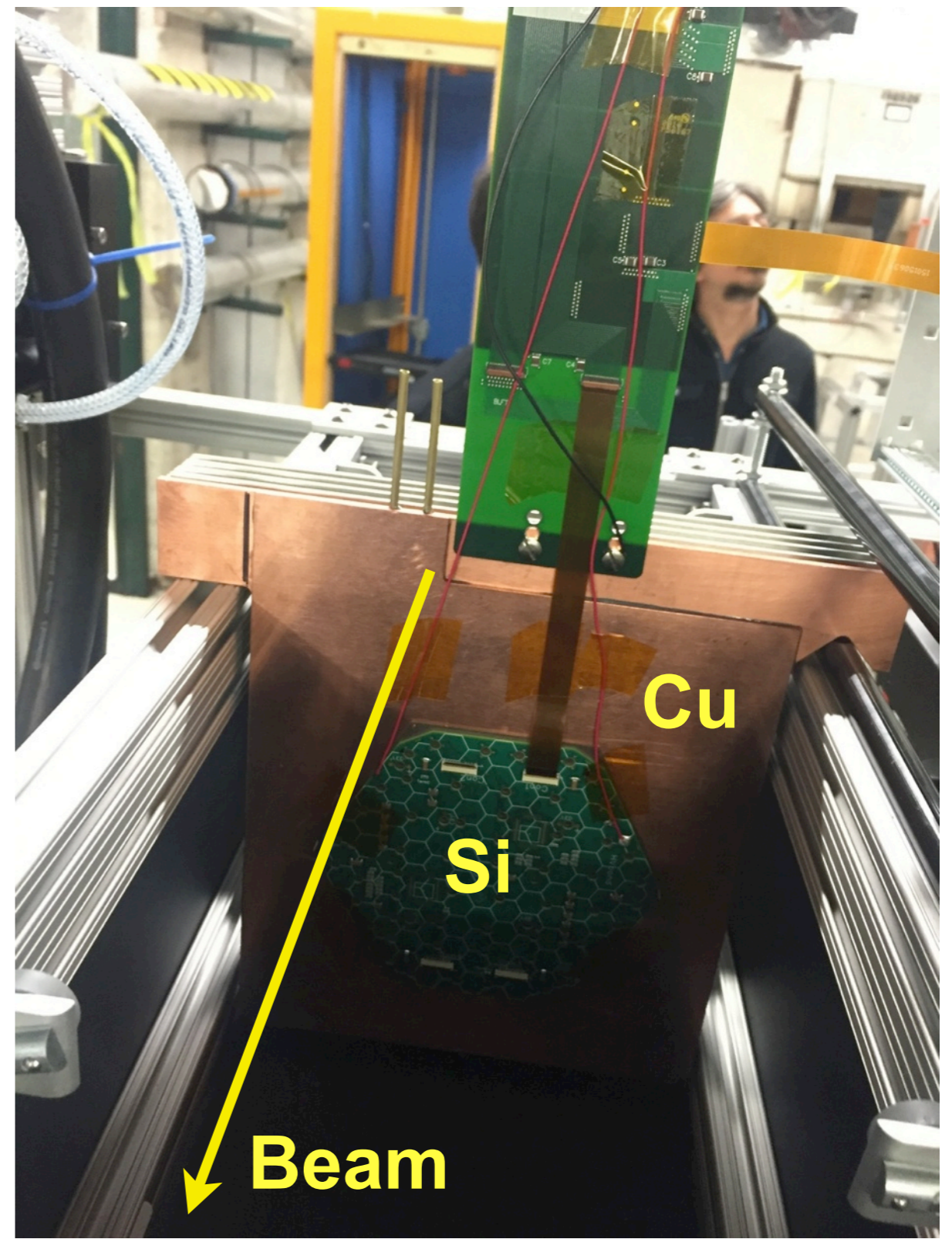
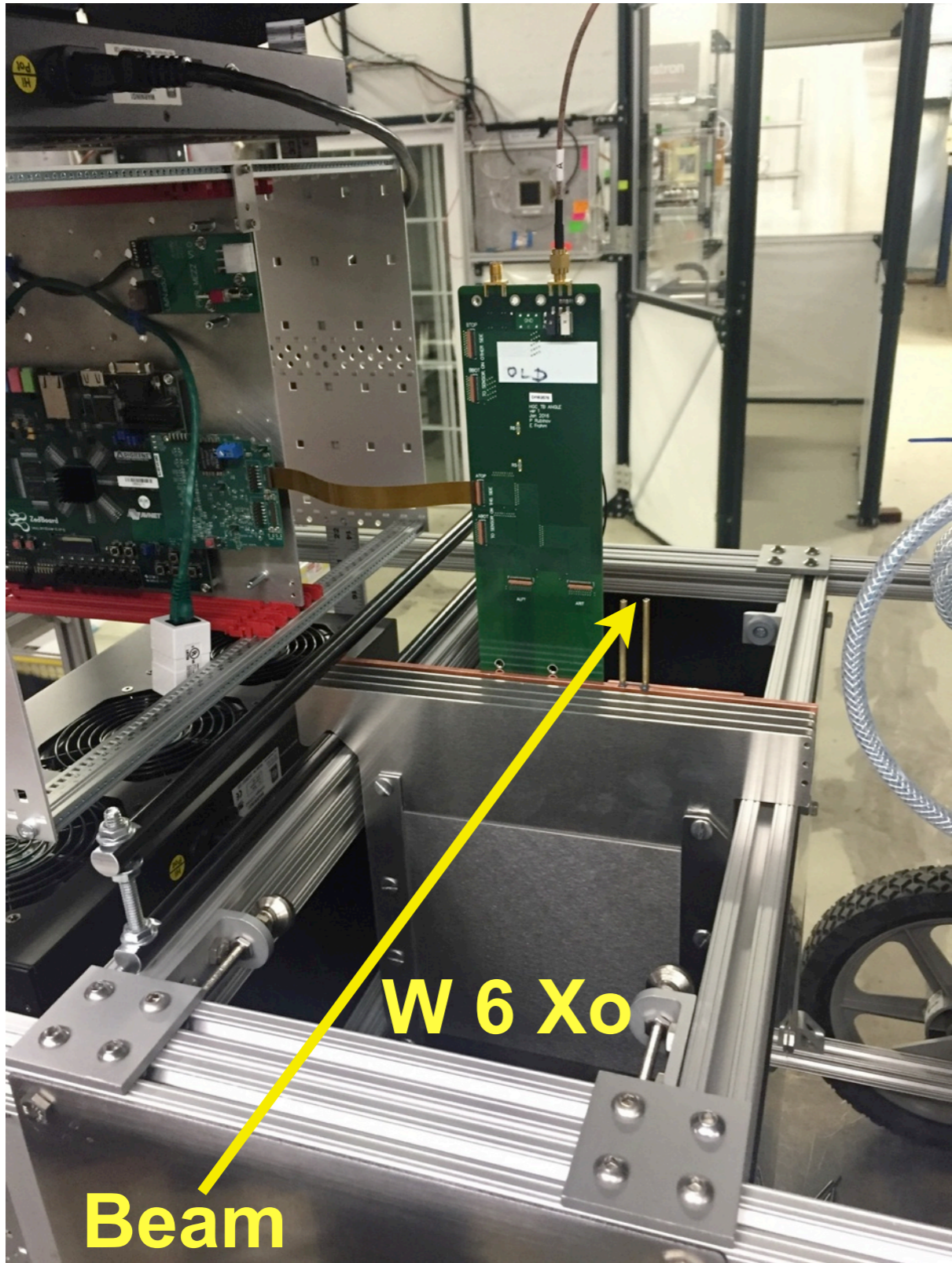


SKIROC2
ASIC

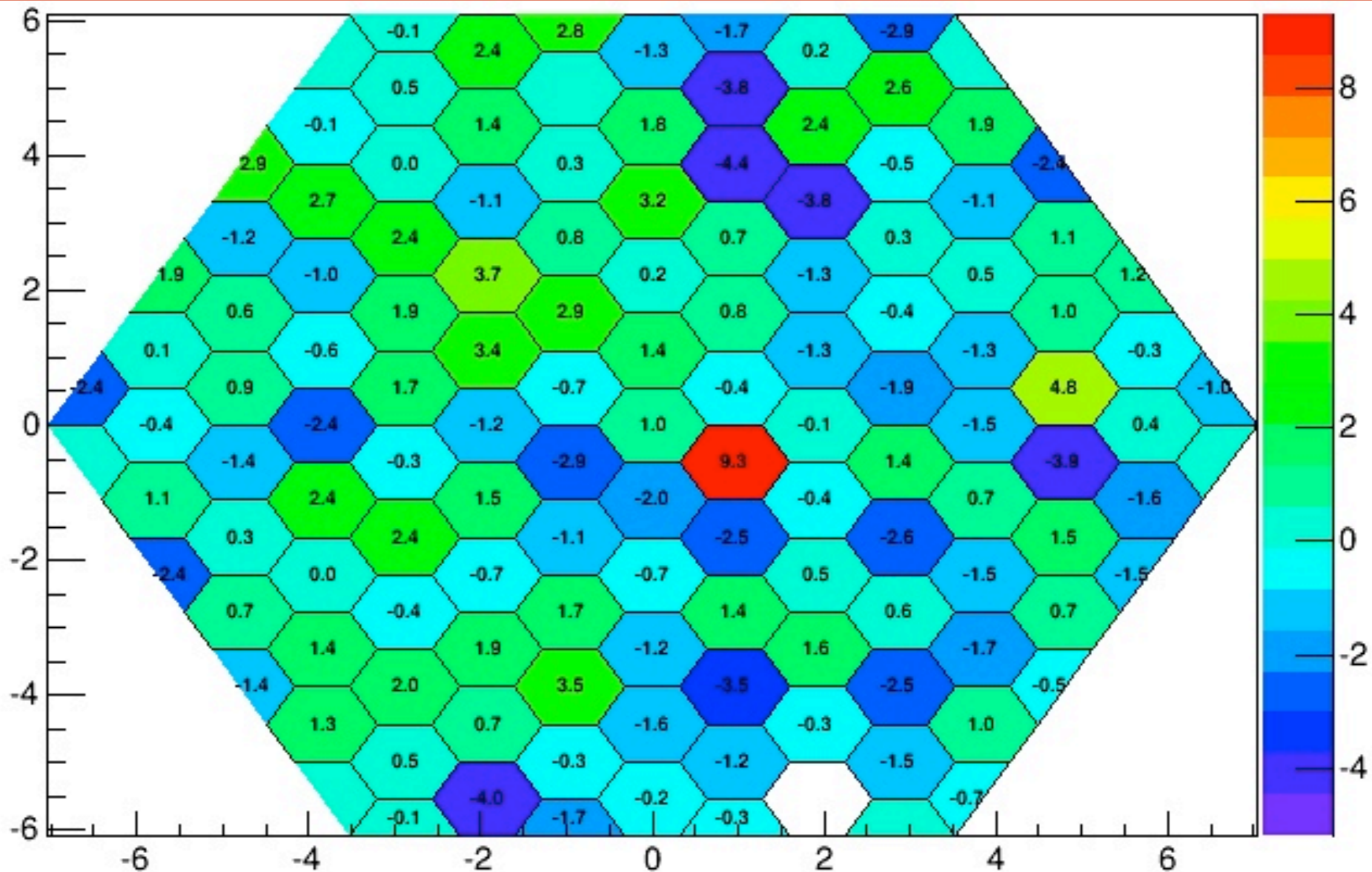
6-inch module with W/Cu plate and 128 channels readout.

- **Goals:**
 - FNAL Test Beam I, EE 1 layer, March 23
 - FNAL Test Beam II, EE 28 layers, May 15
 - CERN Test Beam I, EE28 + HF12, August
 - CERN Test Beam II, EE28 + HF12, Sept.

Installed HGC Prototype, FNAL March 23



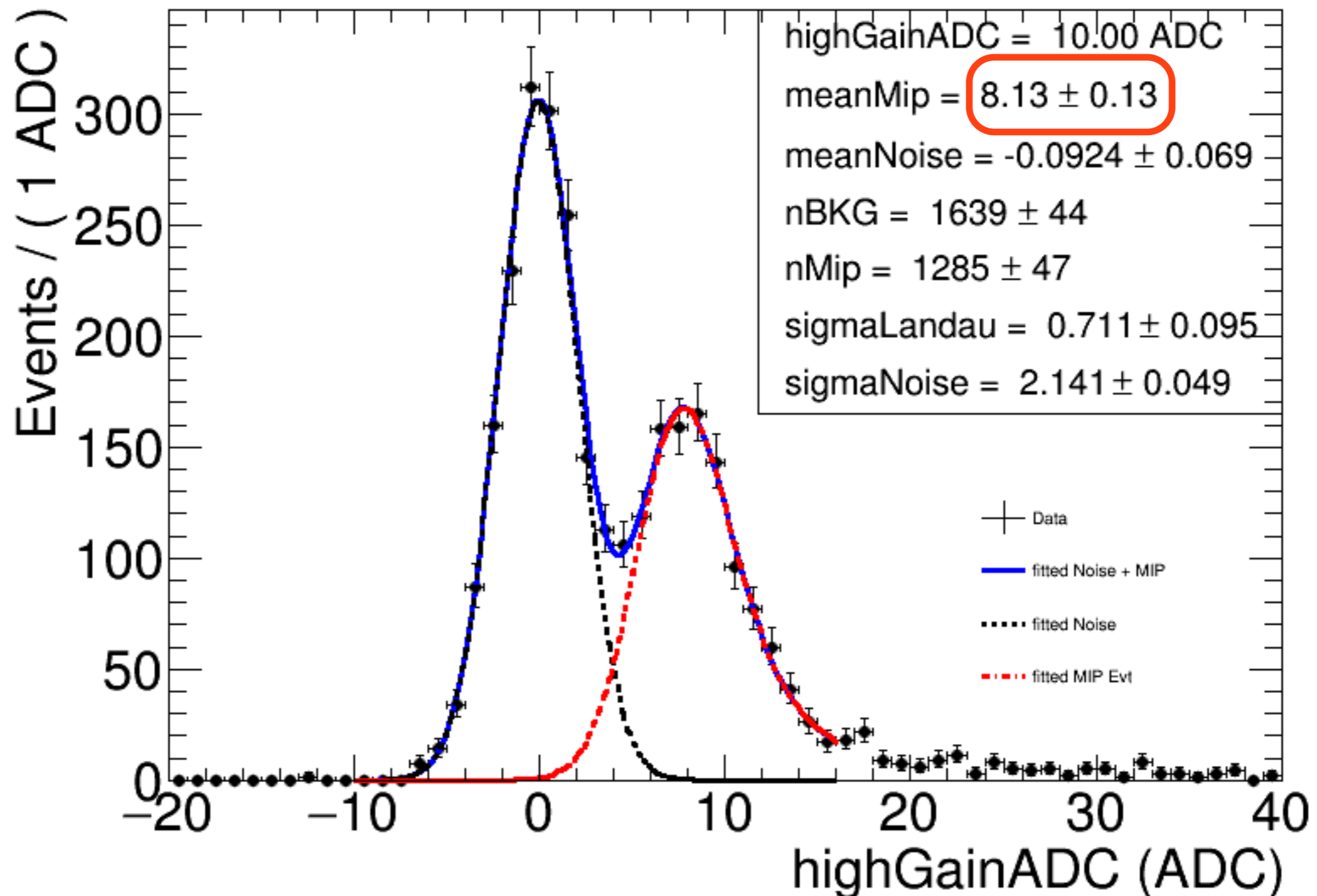
120 GeV Proton, Event Display



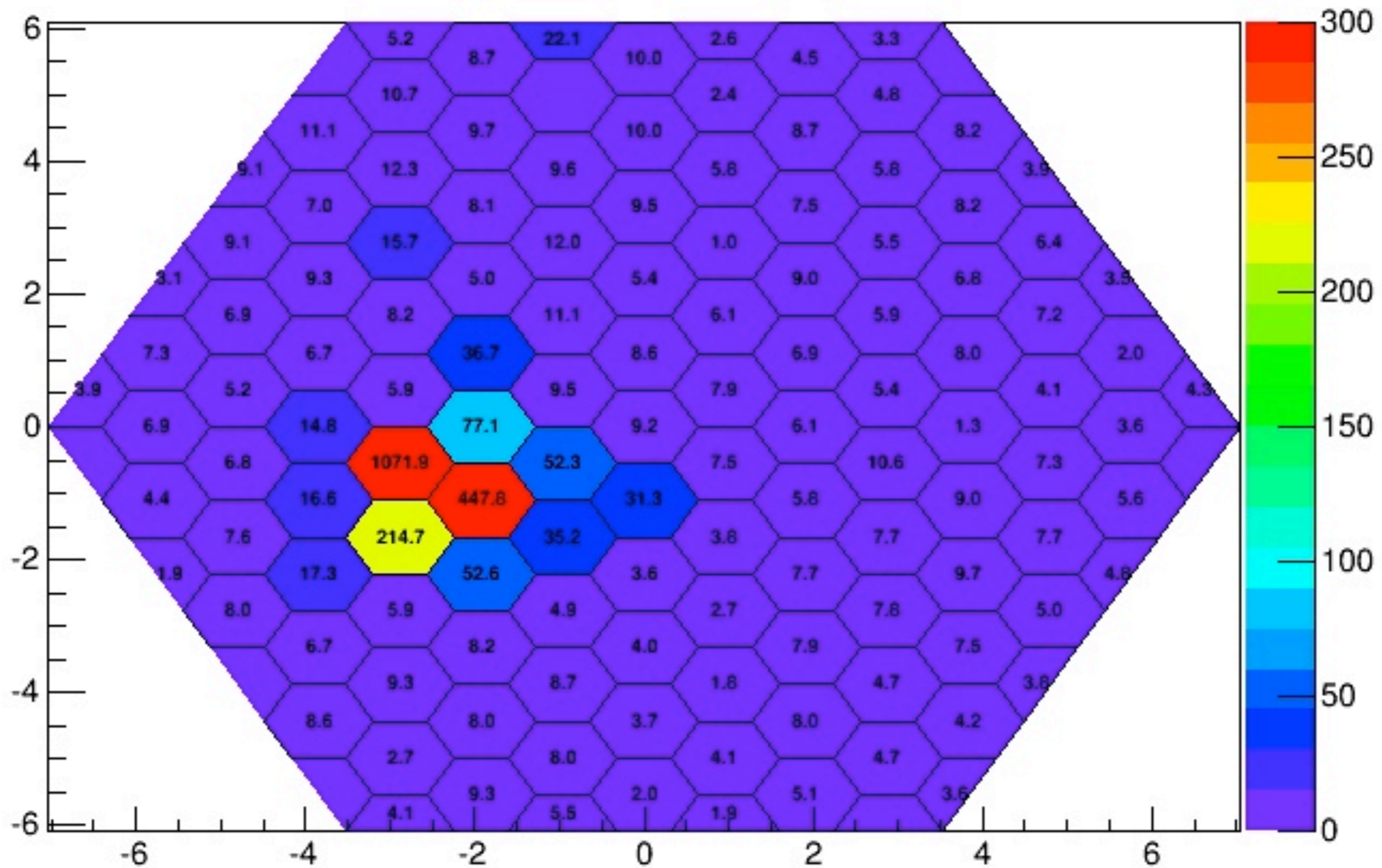
- **After pedestal subtraction**

Calibration with 120GeV Protons (MIP)

- Run contains cosmic triggers (blue peak) and proton triggers (read peak)



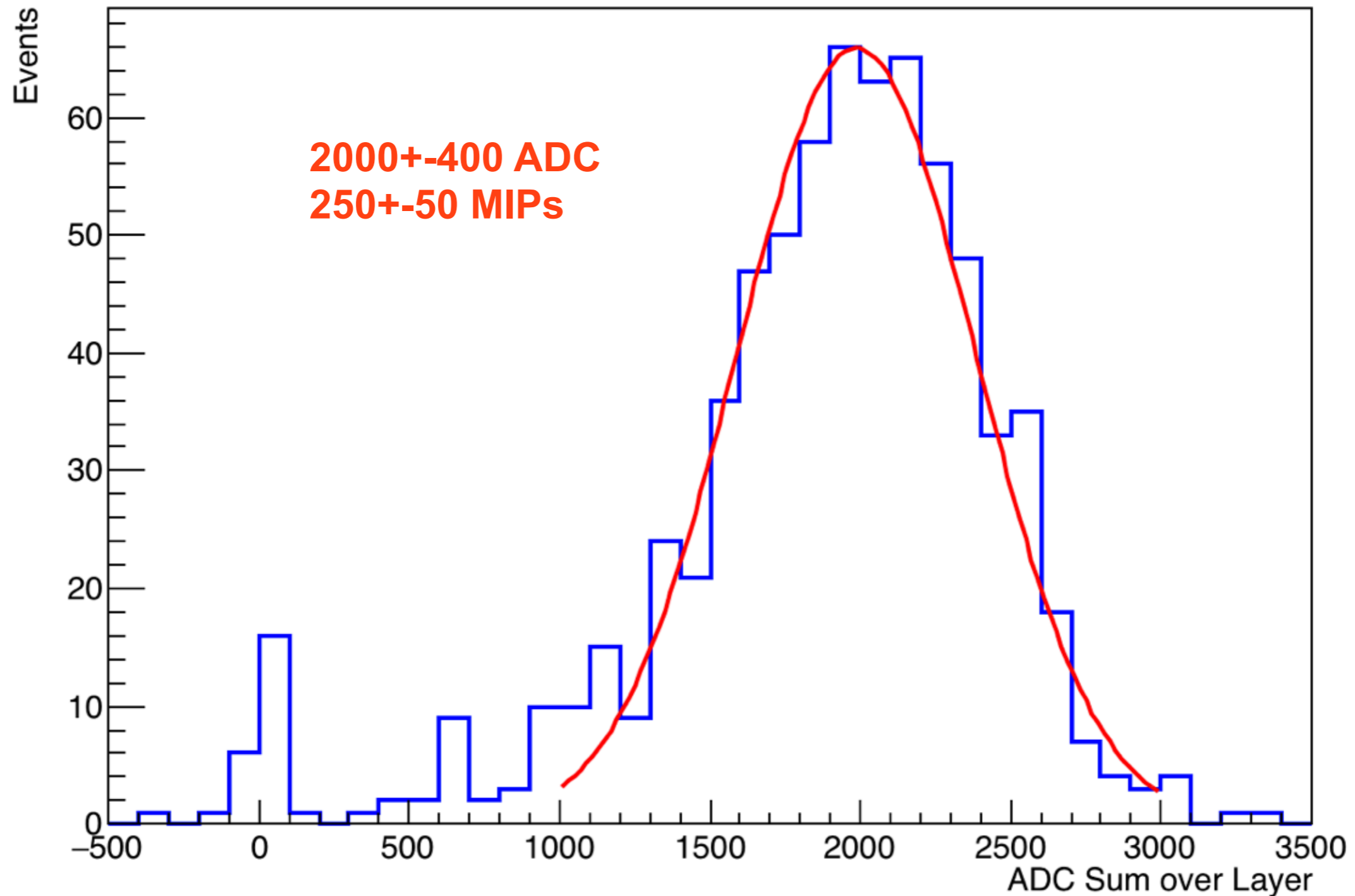
32 GeV e^- Event Display



- Event display of an electron candidate
- The pedestals have been subtracted
- Size of cluster \sim 20mm radius

Response to 32GeV e^- at Shower Max

- After pedestal subtraction, all cells summed up in the event



Next Steps

- **Build a prototype with 28 Si layers**
- **Use improved (v2) module PCB**
- **Collect Test Beam data starting May 15**
- **Compare performance to MC simulations**

