Test beam from CMS HGCAL timing performance study

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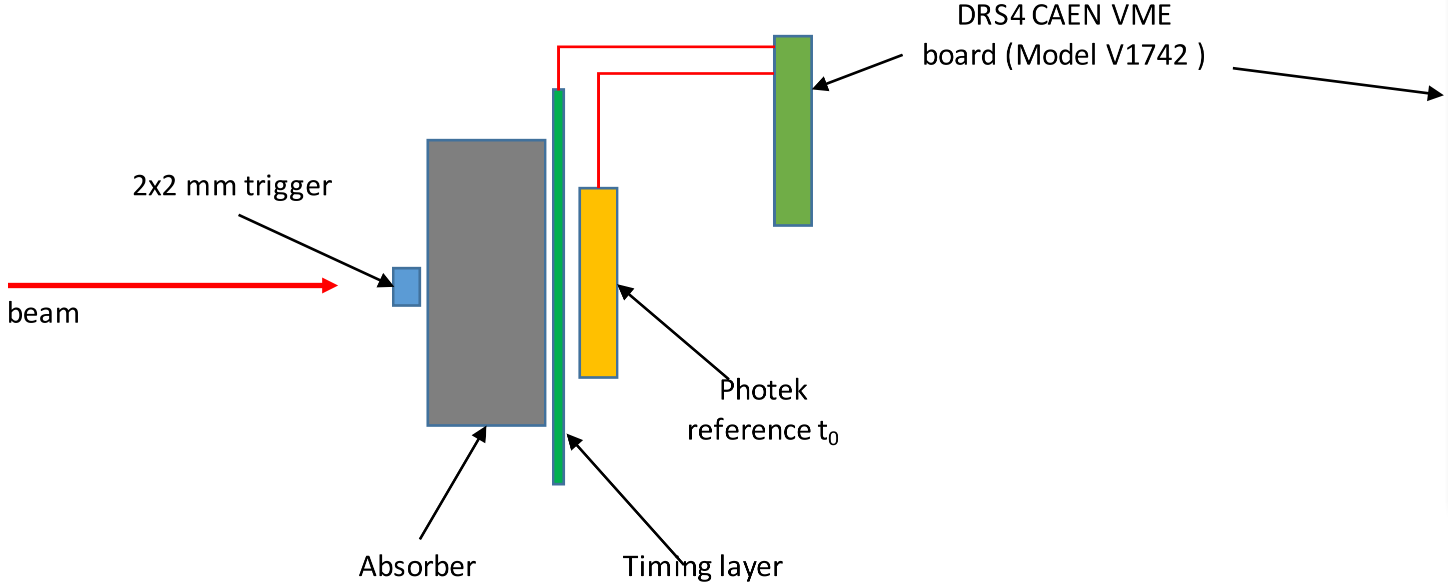
CMS HGCal Precision Timing

- The CMS High-Granularity Calorimeter Prototype consists of layers of Tungsten asborber + silicon sensor active medium
  - Silicon sensor detectors EM shower secondary particles

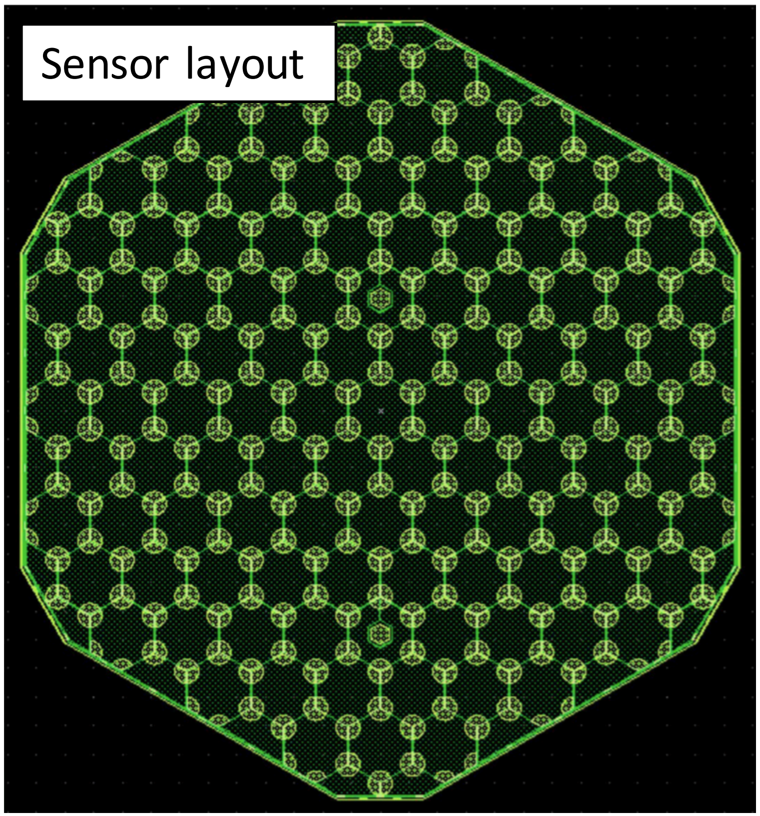
- Purpose of current testbeam:
  - Understand precision timing capabilities of silicon sensors
  - **How do independent time measurements that sample different parts of the EM shower add up**
    - Add in a statistically independent fashion?
    - Or are time jitter among channels highly correlated
    - Do timing measurements along the longitudinal direction complement timing measurements in the transverse dimension?

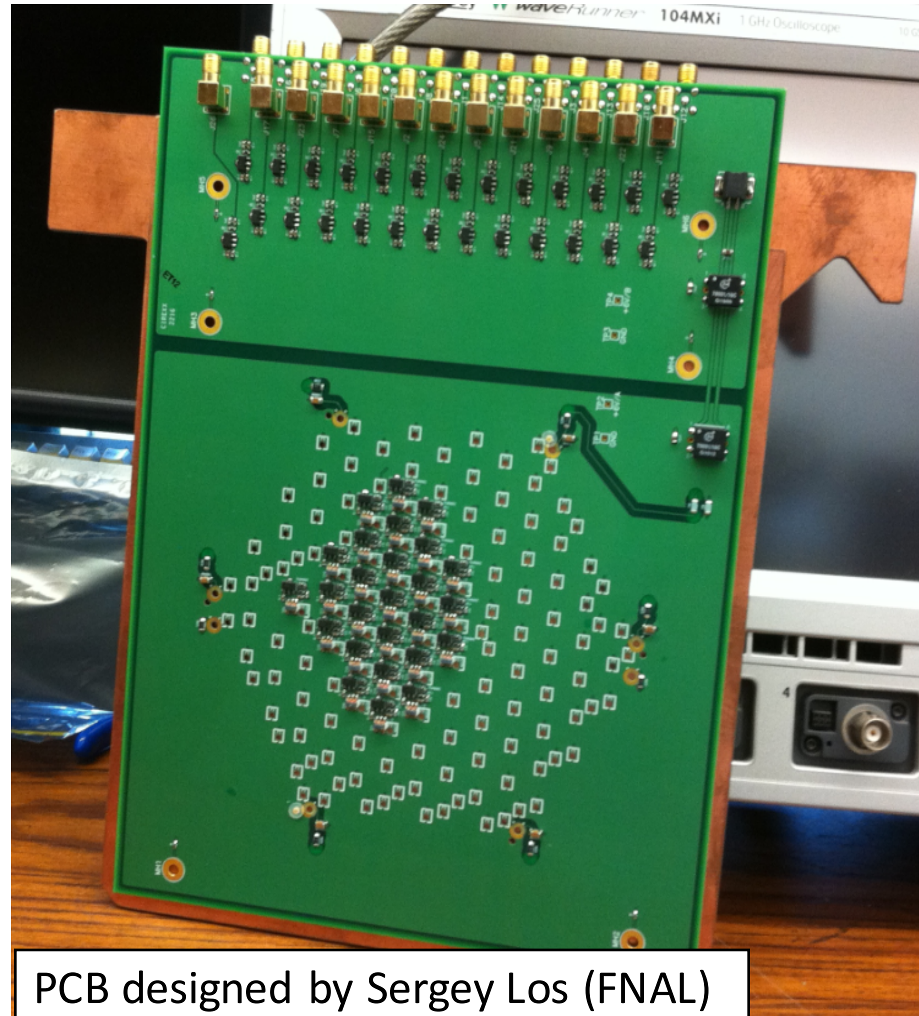
Experimental Setup



- 300 μm sensor thickness to explore the best expected performance
- Only 25 cells are readout, each with a discrete amplifiers
- Readout performed with the DRS4 32-channels CAEN VME board
- Runs taken with
  - varied amount of absorber (Pb and W), electron beam energy (8-32 GeV), and space between absorber and timing layer (0.1-7 cm)

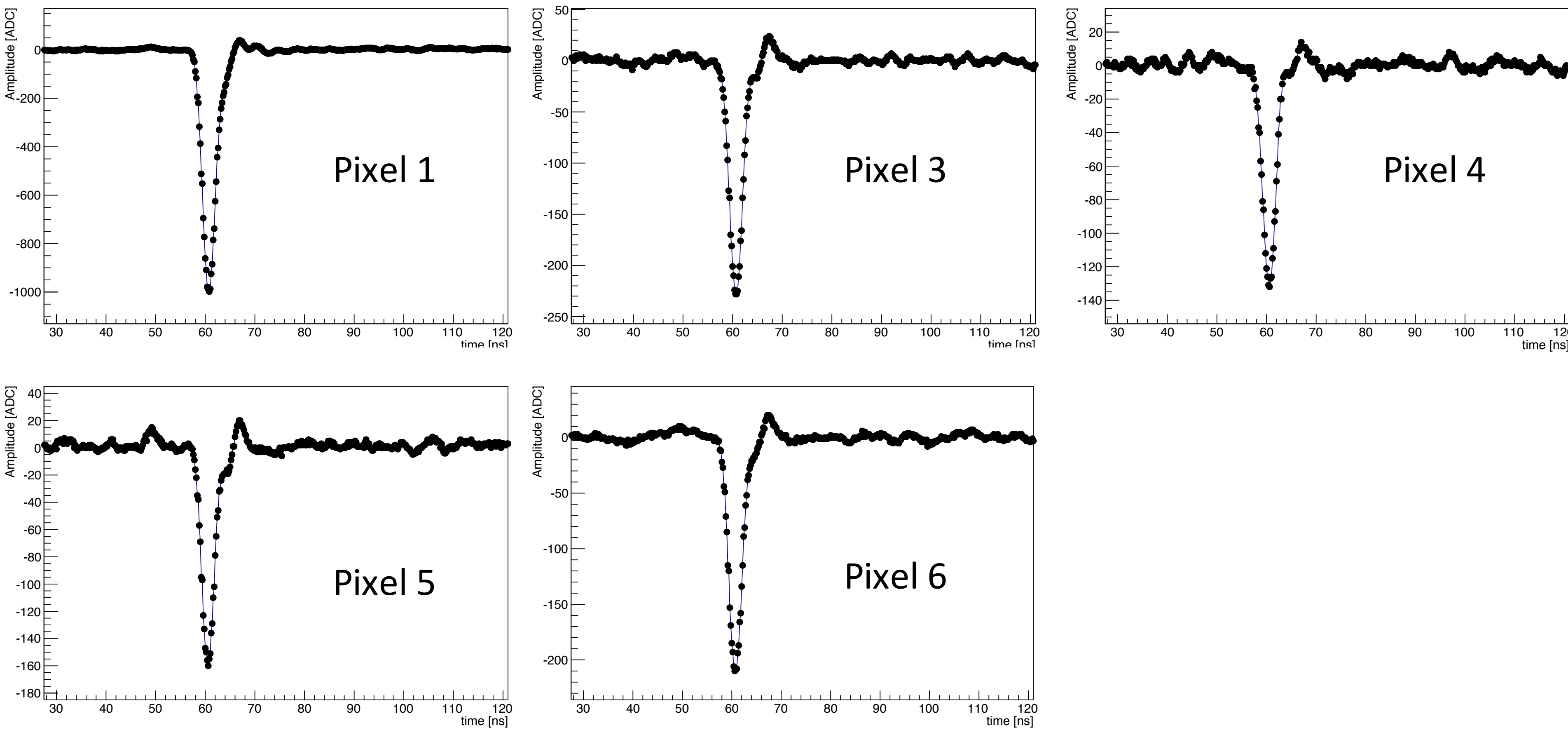
Timing layer


Sensor layout



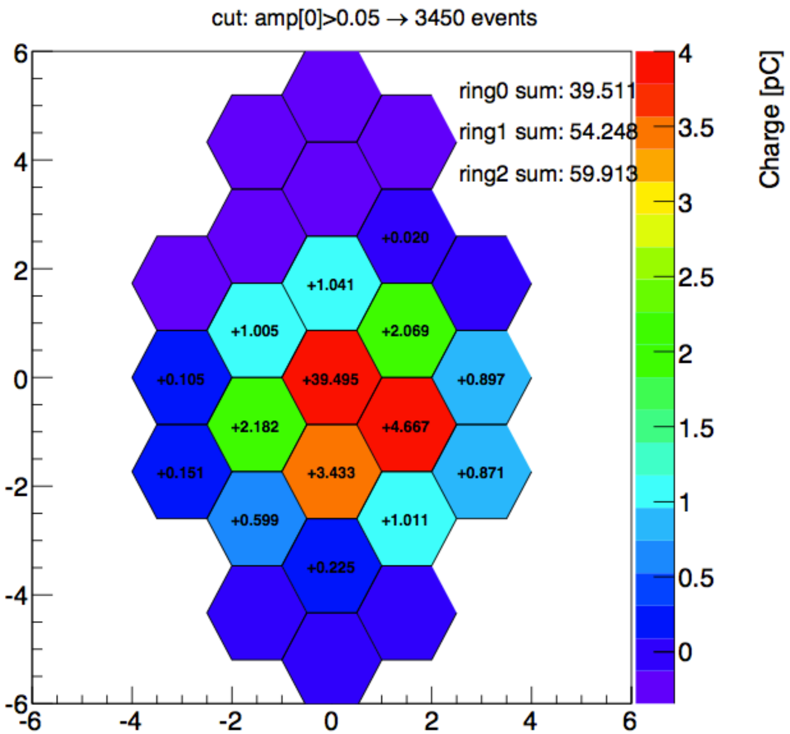
PCB designed by Sergey Los (FNAL)

Pulse shapes

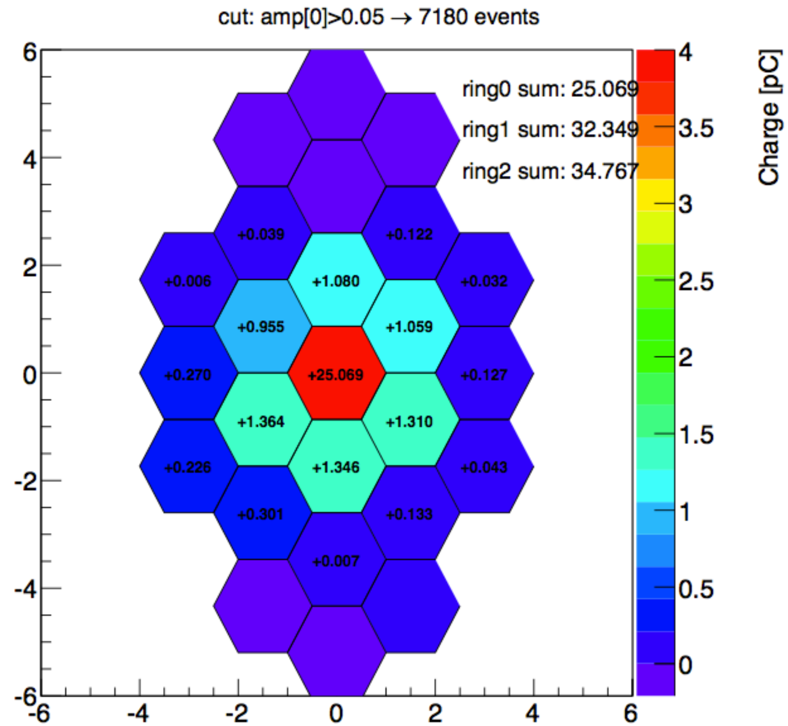


- Fast digitizer allows reading pulses with 200 psec granularity
  - Rise time about 2ns (shaped by amplifier and transformer), full width about 8 ns
- Sample pulses from 32 GeV electron shower event (same event)

Shower shapes



32 GeV electrons, $6X_0$ W 1mm
from timing layer

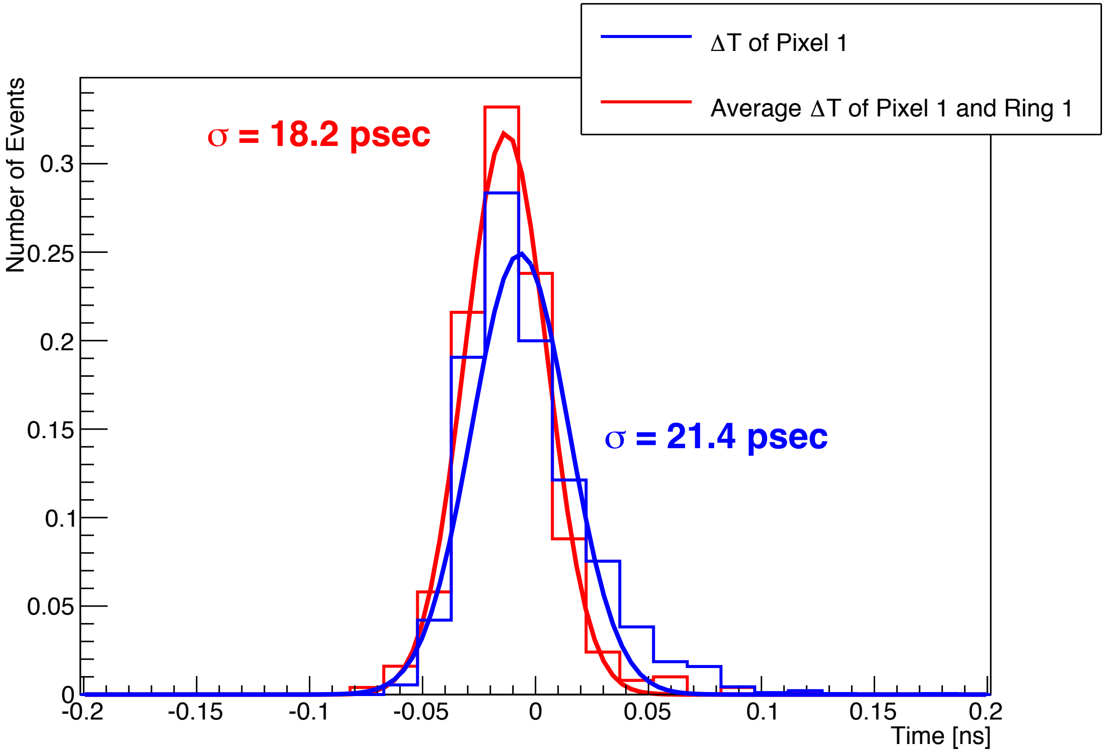


16 GeV electrons, $6X_0$ W 1mm
from timing layer

- Clearly see shower shape in the pixels surrounding central one
- Linear behavior of energy sums with the change of energy

Timing measurements

- Measure time resolution with respect to reference as the σ of Gaus fit to the $\Delta t = t_{pixel} - t_0$
- 25 psec resolution with the central (largest charge) pixel
- Adding neighboring pixels (ring1 around central pixel) brings the resolution to 17-18 psec, and removes the non-Gaussian tales



Summary

- Very successful first tests of the HGCal prototototype with fast readout
- Measured pulse shapes in HGCal sensor within an EM shower
- Measure time resolution measurements ~17-18 psec for EM showers