A potential cost saver for the CMS GEM upgrade:

GEM readout with zigzag strips

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Motivation

- **Cost** is one of the biggest current issues for the CMS GEM upgrade project
- The **single-largest** budget item in the current GEM budget estimate is **electronics:**

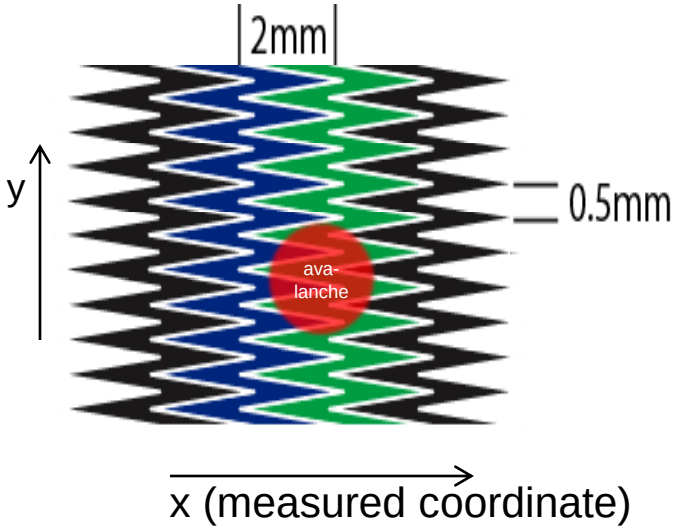
  ~3M out of 6.4M total (TP CMS IN 2012/001)
- Clearly, we should seriously look for ways to reduce the electronics cost if possible
  - One potential real cost saver would be the

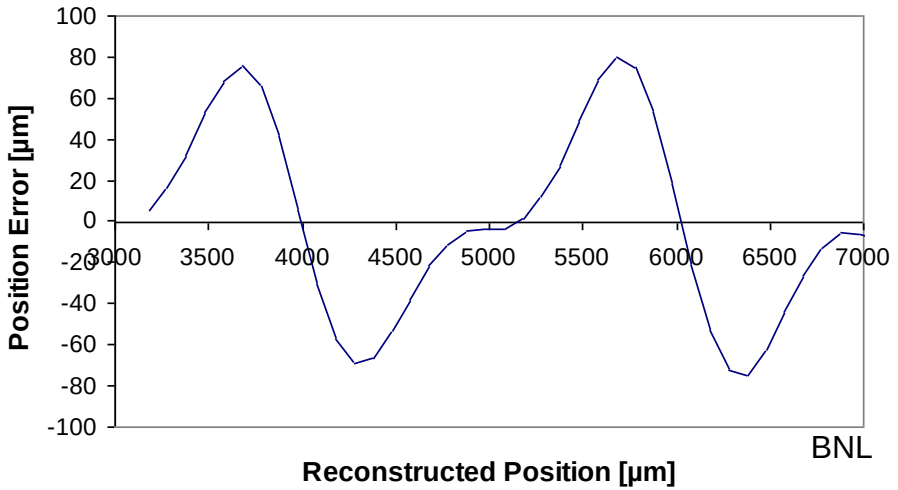
    significant reduction of readout channels

    ⇒ **Can a zigzag strip readout help with that?**

Previous Work @ BNL

Zigzag strips: Previous exp. studies show <100 µm resolution with **2 mm** strip pitch is possible:





Concept:

- Charge sharing among adjacent strips allows quite sensitive **position-interpolation** in x-direction
- We are sacrificing the measurement of the 2nd coord. (y) to gain precision in the 1st coord. (x)
- CMS GE x/1 detectors are currently intended for **1D-coordinate** measurements, so the zigzag approach is applicable to these detectors

Zigzag strips vs. straight strips

	Pitch [mm]	Typical Resolution [μm]
Zigzag strips & analog r/o	**2.0**	**80**
Straight strips & VFAT (current design, short end)	**0.6**	**300**
Improvement factor w/ zigzag strips	**3.33**	**3.75**

Can reduce # of readout channels (and electronics cost) **by 70%** of current design **&** Improve resolution by factor 3-4

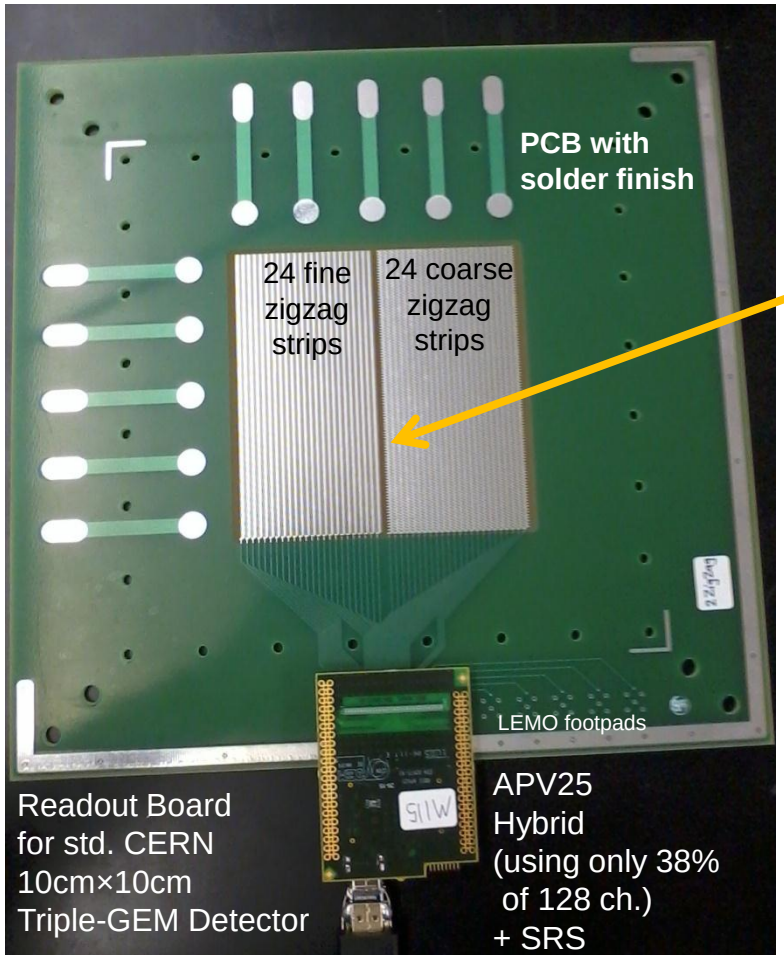
A "figure of merit": 3.33 × 3.75 = 12.5

~ Potential for order of magnitude improvement over current design

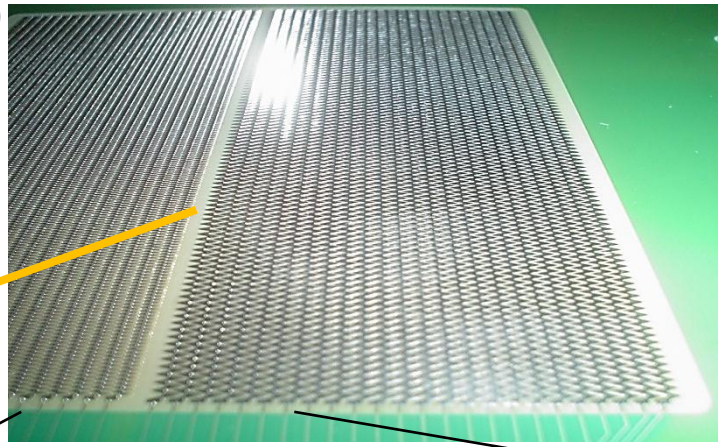
⇒ Well worth a try!

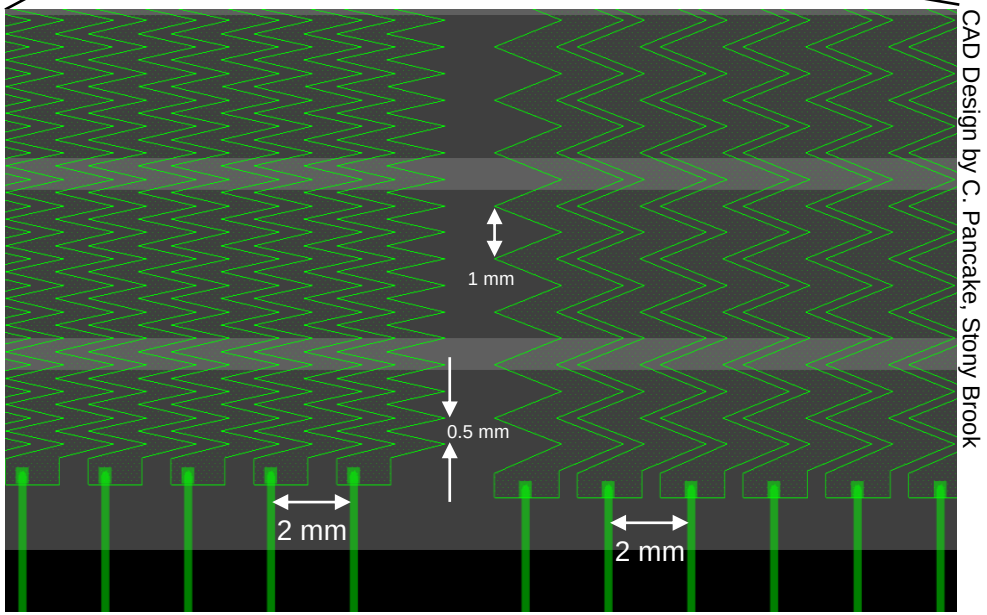
Zigzag r/o PCB (10cm × 10cm)

2 sets of 10cm zigzag strips with different zigzag pitch (along strip)



BNL/FIT/Stony Brook Collaboration

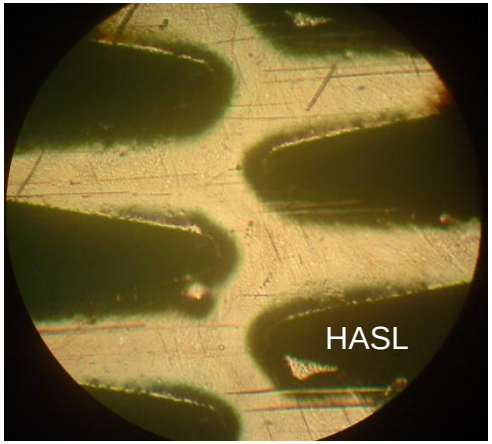


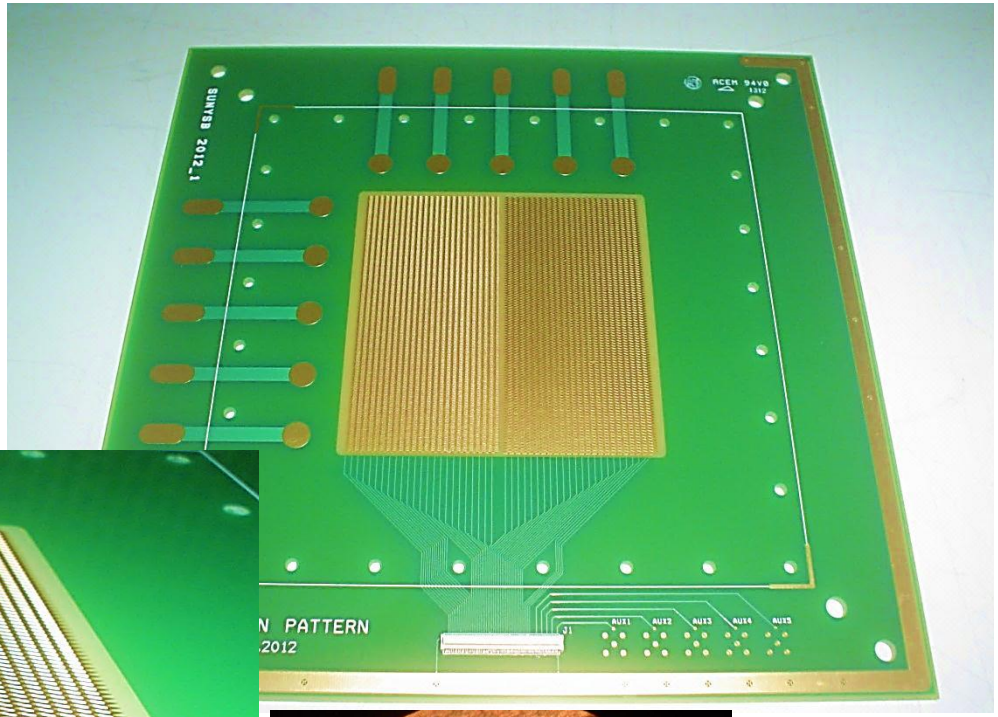


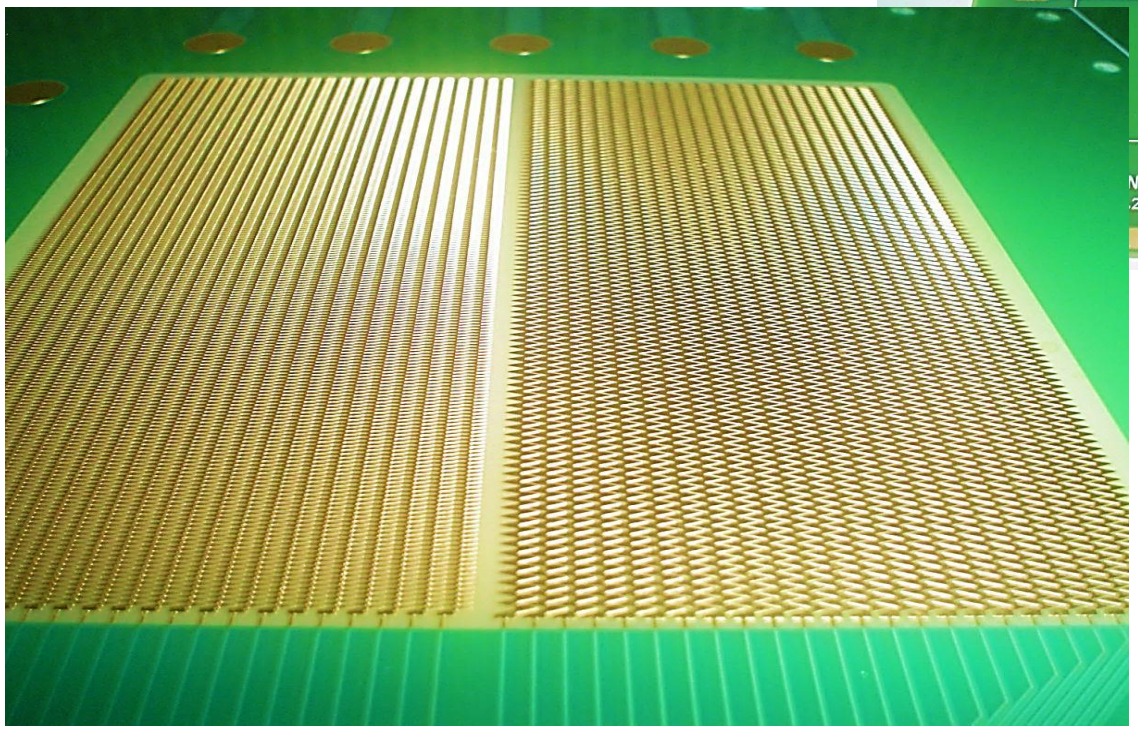
Solid ground plane on the back side.

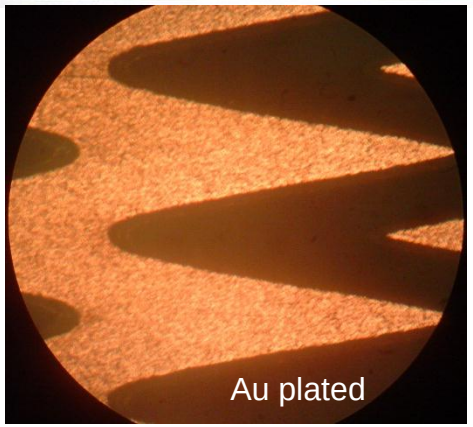
2nd batch: Gold plating finish

Ordered second batch with gold plating finish because hot-air **solder** leveling (HASL) finish shows non-uniform surfaces:









Much higher surface quality

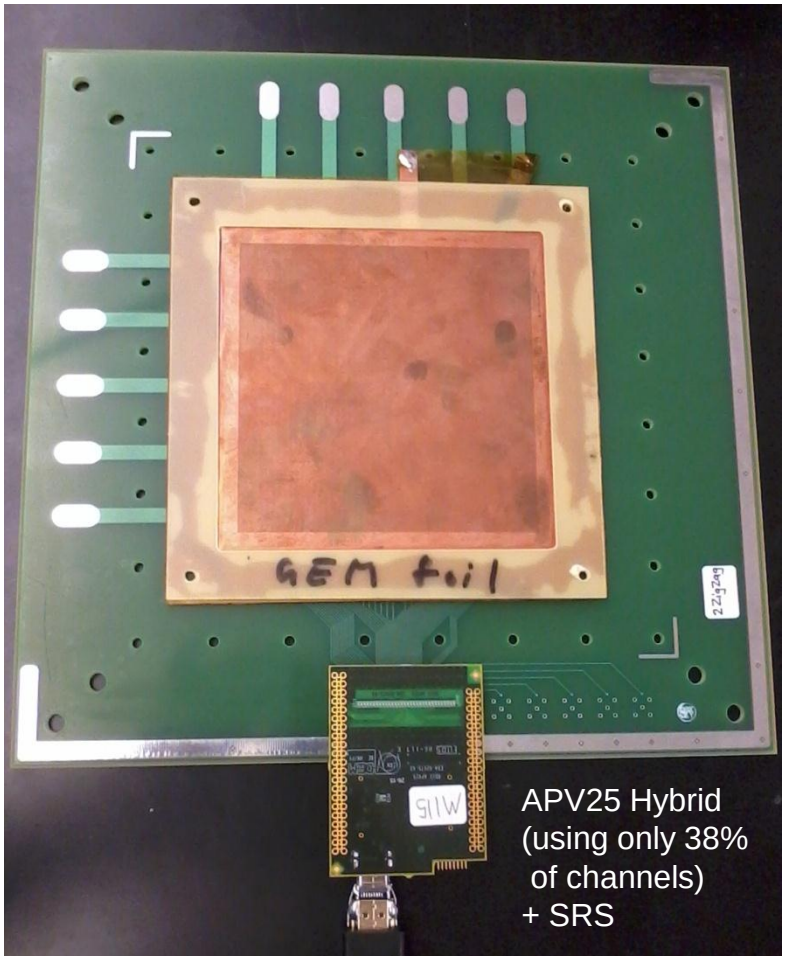
WHAT ABOUT NOISE?

⇒ **First commissioning step addressed noise question:**

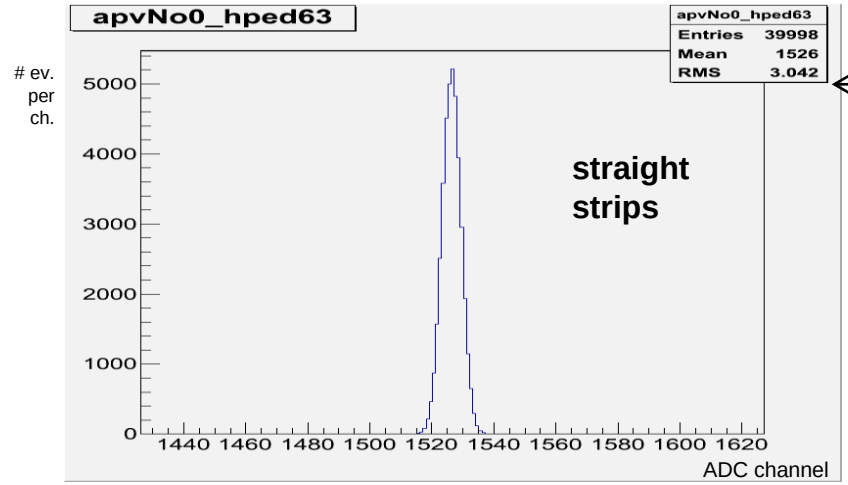
- Measure **pedestals** and compare with regular straight strips
- Does the **noise** increase substantially due to the increased strip area and capacitance?

Pedestal Distributions

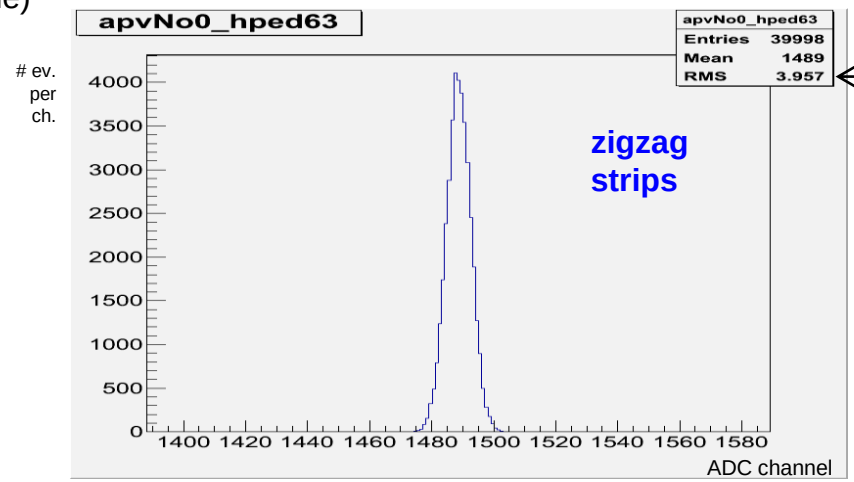
Readout Board with 10cm long zigzag strips covered with one GEM foil placed 2 mm above induction plane:



APV ch. 63
(example)

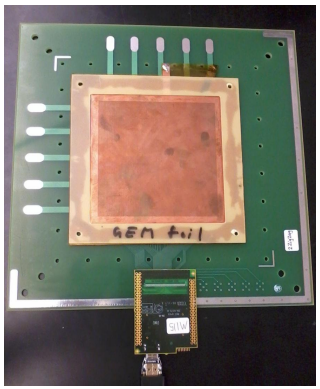


pedestal width: r.m.s 3 → 4 cts.

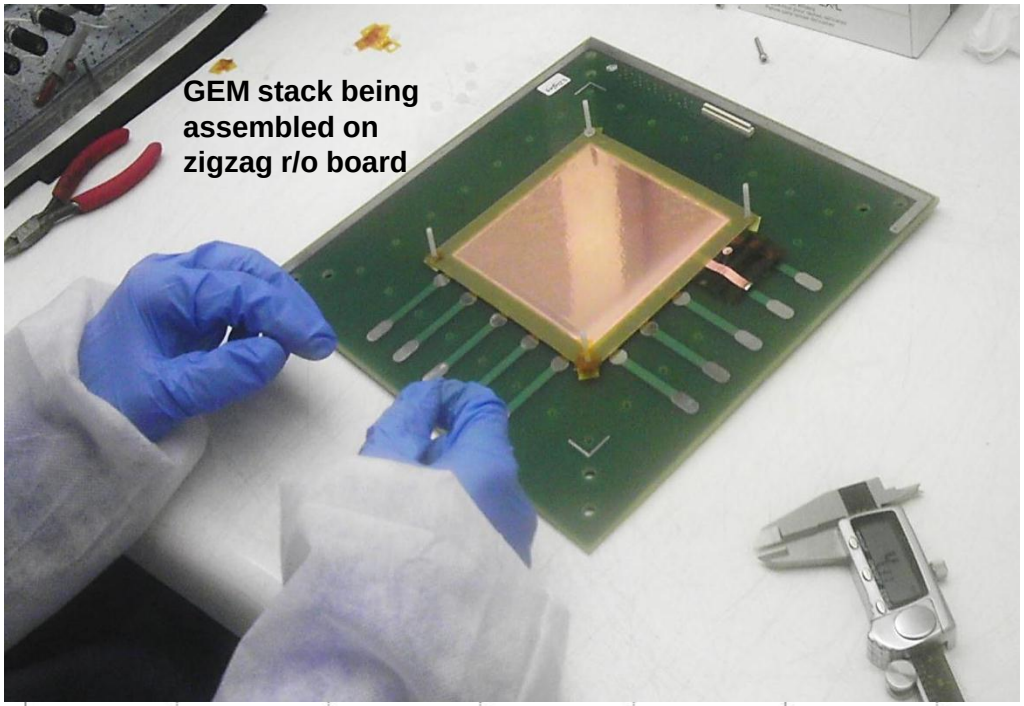


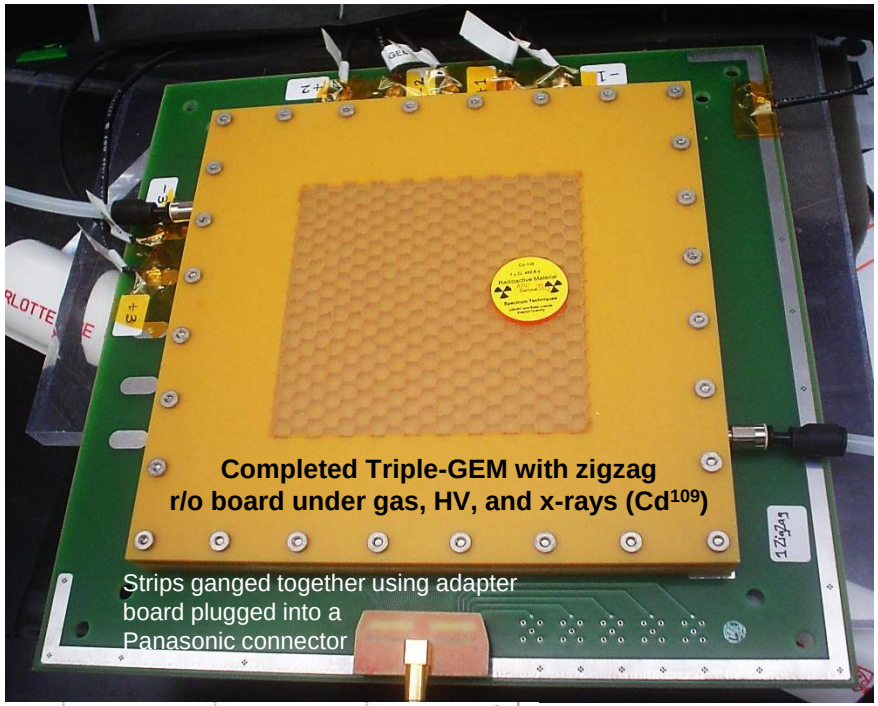
Pedestals for all channels

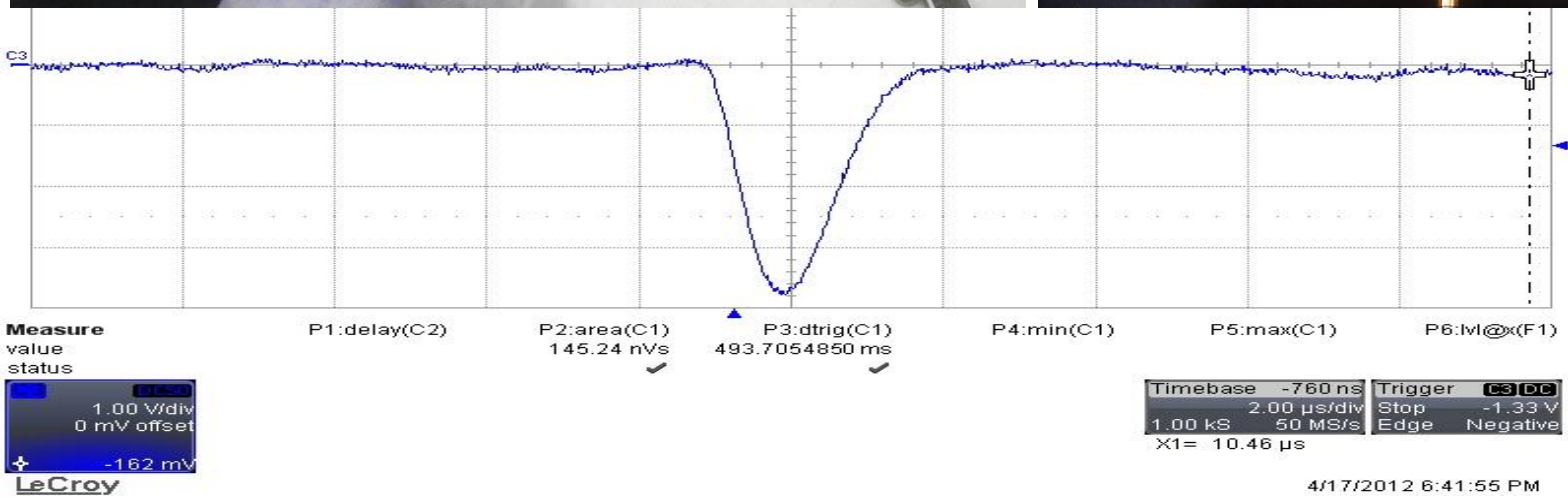
Readout Board with 10cm long zigzag strips covered with one GEM foil placed 2 mm above induction plane:



First pulses with zigzag r/o







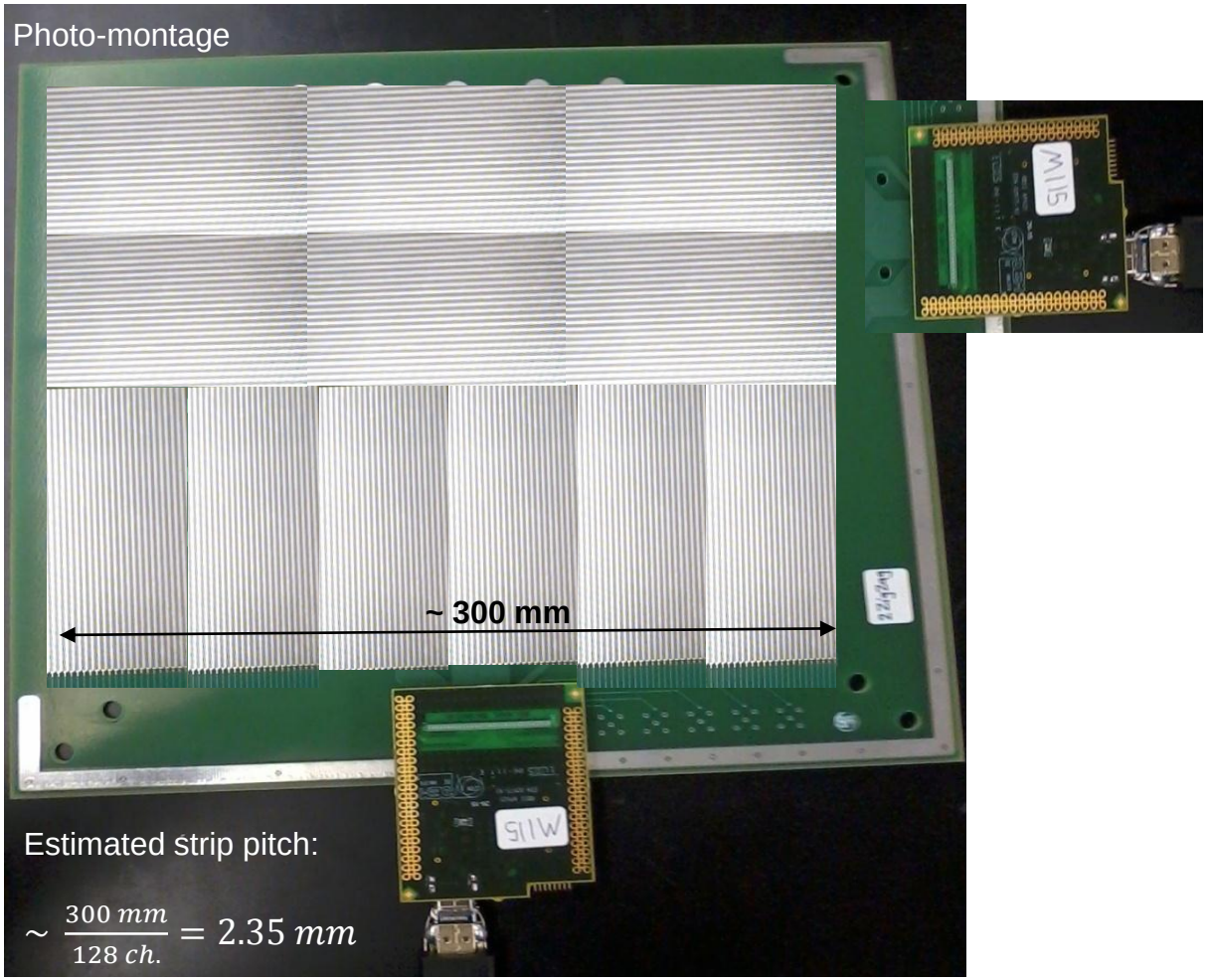
Pulses recorded with ORTEC preamp and (slow) lin. amp.

Currently setting up for cosmics test with APV + SRS…

30cm × 30cm zigzag PCB

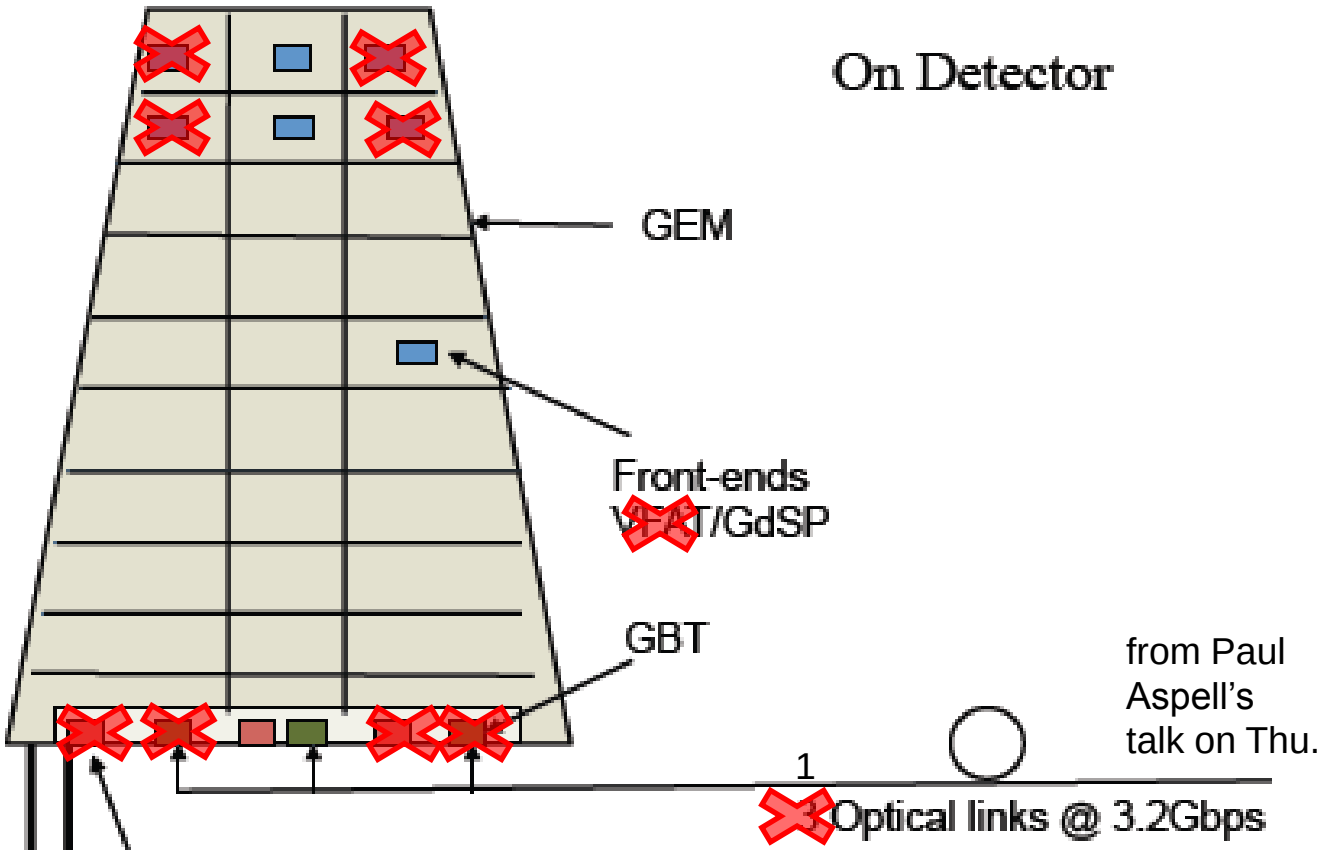
Plans for next design:

- Design and build a zigzag readout pcb for the 30cm × 30cm self-stretch CMS GEM (on order w/ Rui)
- 128 zigzag strips of 10cm length covering the **full 30cm width** & read out by a **single** APV25 hybrid + SRS
- Test also 30cm long strips on same board (given the good noise performance of the 10cm long strips)



Impact on electronics design

⇒ Potential for removing the need for 2/3 of the electronics of current baseline design:



Implications

- Potential for saving 70% of readout channels and ~50% (?) of electronics cost, could mean potentially saving 1-1.5 MCHF on the project
- Simplifies also cooling, cabling, power, etc., which would lead to additional cost savings
- Total project cost < 5 MCHF possible ?!
- Analog pulse height measurement is mandatory for charge interpolation, so VFAT3 would not work → need a GdSP design

Conclusion & Outlook

- Noise increases by only 1.5 ADC counts (~ 0.1% of range) for zigzag strips compared w/ straight strips. **Encouraging!**
- Can potentially read out one GE1/1 strip row with single 128-ch. front-end hybrid while improving spatial resolution; **could lead to substantial channel number & cost savings**.
- **Next:**
  - Measure spatial resolution using tracked cosmics
  - Test zigzag prototype in 2012 test beam
  - Design, produce & test larger prototype boards