CMS Binary Chip (CBC): status and development

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CBC overview

features

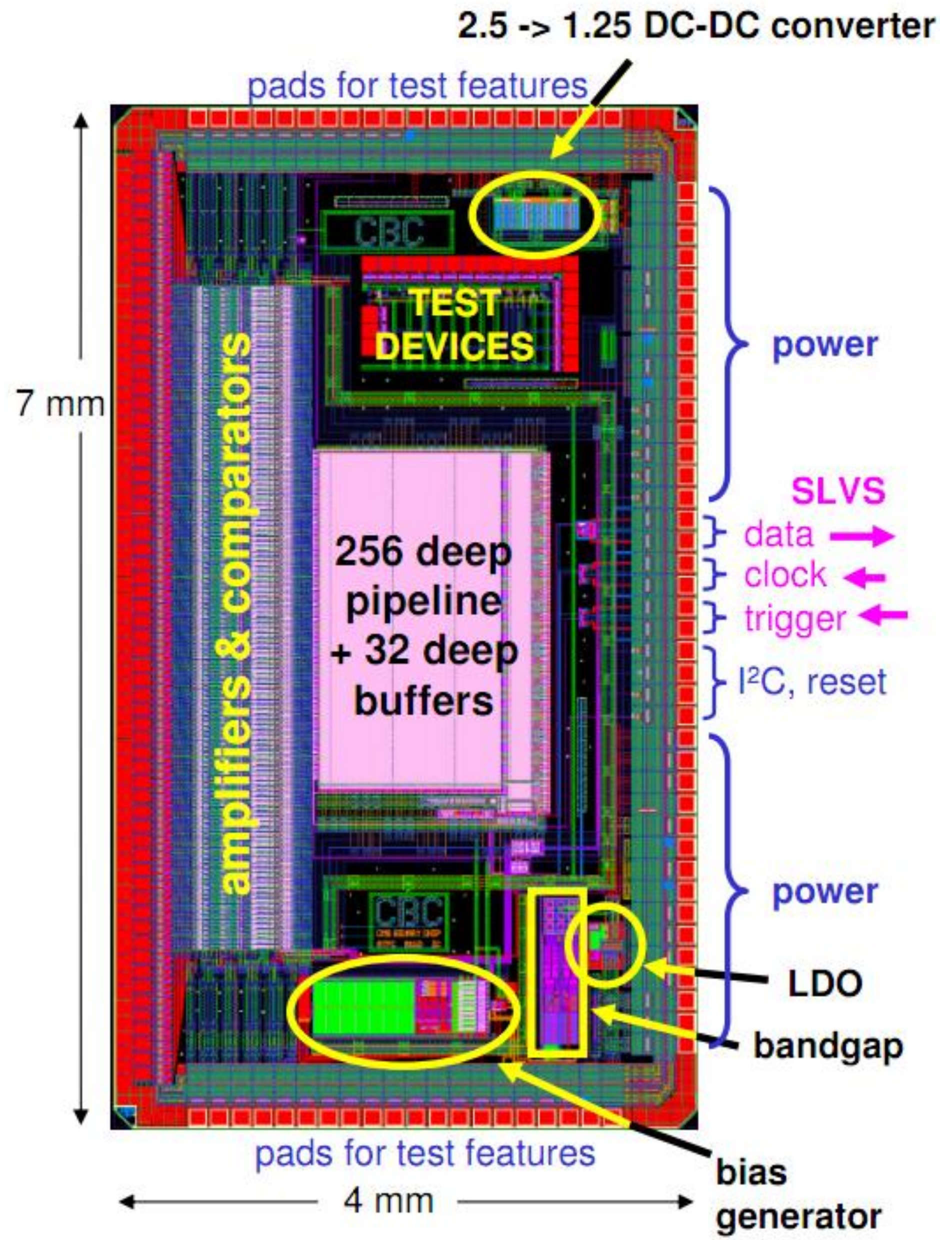
- designed for short strips, ~2.5–5cm, < ~ 10 pF
- full size prototype - 128 channels
  50 µm pitch wirebond
- binary un-sparsified readout
- powering test features
  2.5 -> 1.2 DC-DC converter
  LDO regulator (1.2 -> 1.1) feeds analog FE

main functional blocks

- fast front end amplifier – 20 nsec peaking
- comparator with programmable threshold trim
- 256 deep pipeline (6.4 us)
- 32 deep buffer for triggered events
- fast (SLVS) and slow (I2C) control interfaces

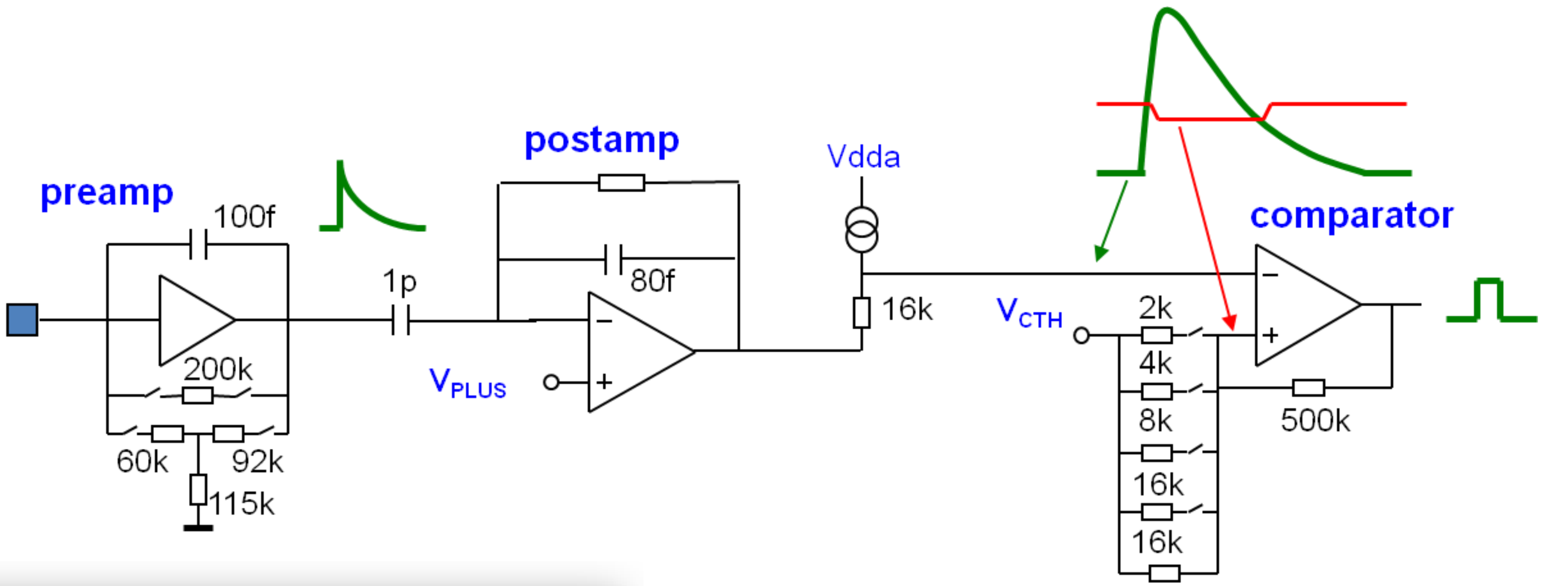
front end

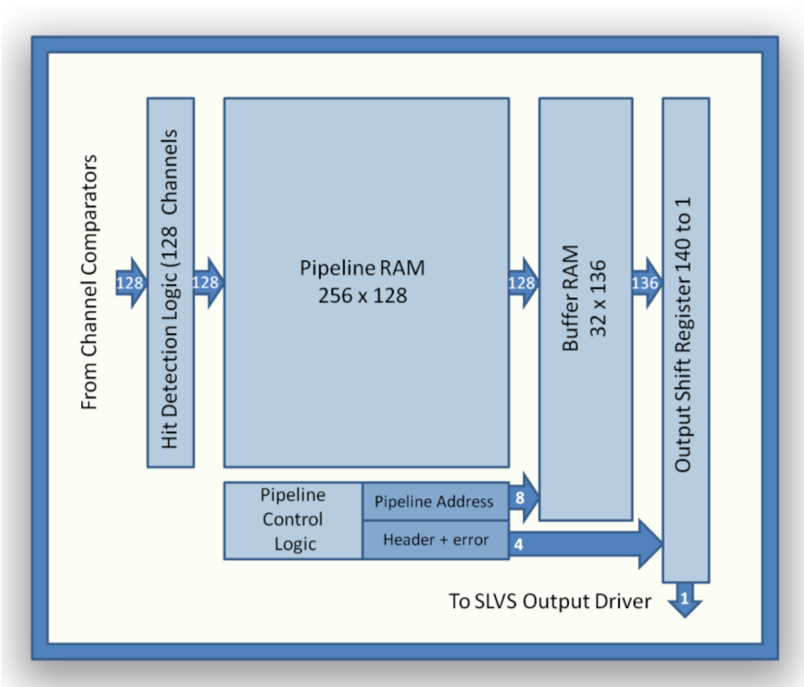
- DC coupling to sensor – up to 1 uA leakage
- can be used for both sensor polarities



from M.Raymond's: http://www.hep.ph.ic.ac.uk/~dmray/CBC_documentation/CBC_status_Oct_2011.pdf

Architecture





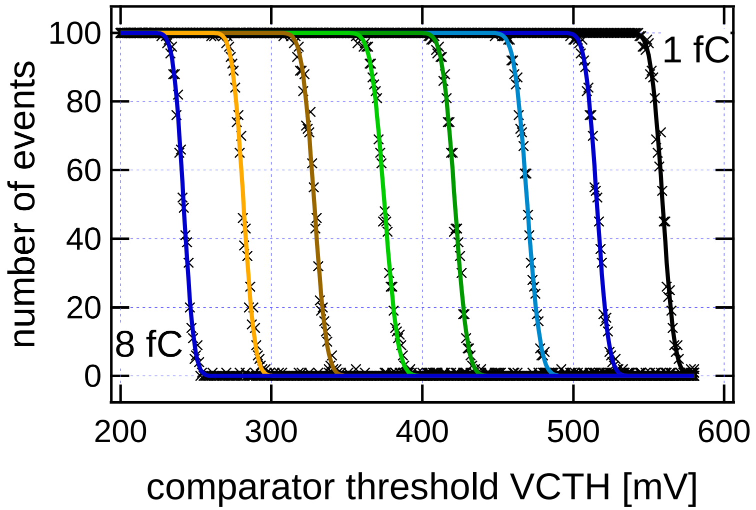
preamp: leakage tolerance 1μA verified, both polarities

postamp: gain: ~ 50 mV / fC

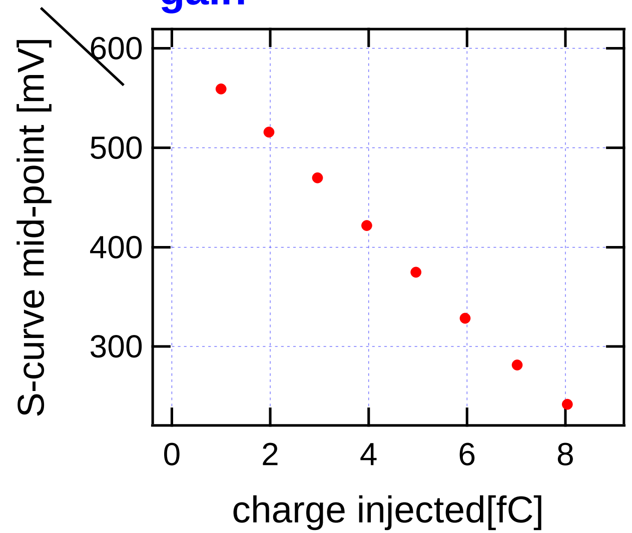
comparator: input peaking time ~20ns
global threshold
8b programmable offset
programmable hysteresis

Test Results

s- curves for range 1 - 8 fC : 1 fC steps



gain

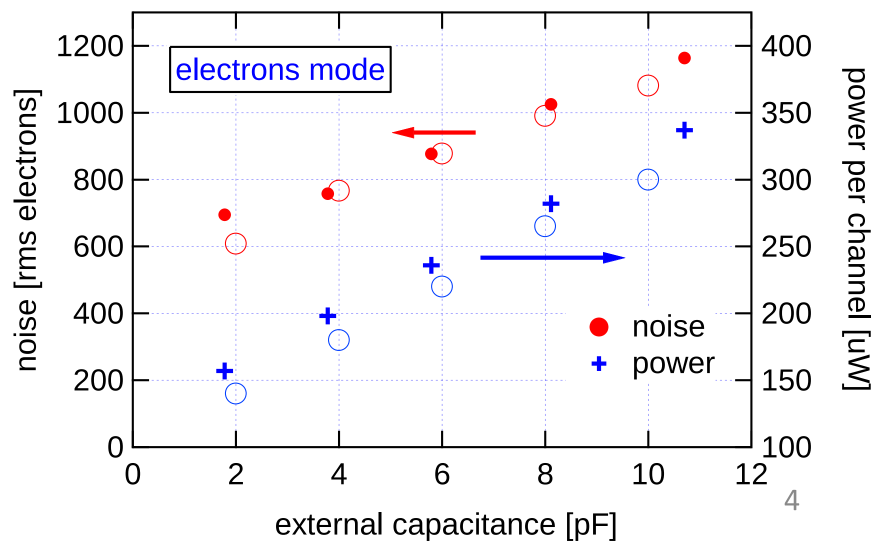


e.g. for 5pF input capacitance:

noise: ~ 800 e_{RMS}

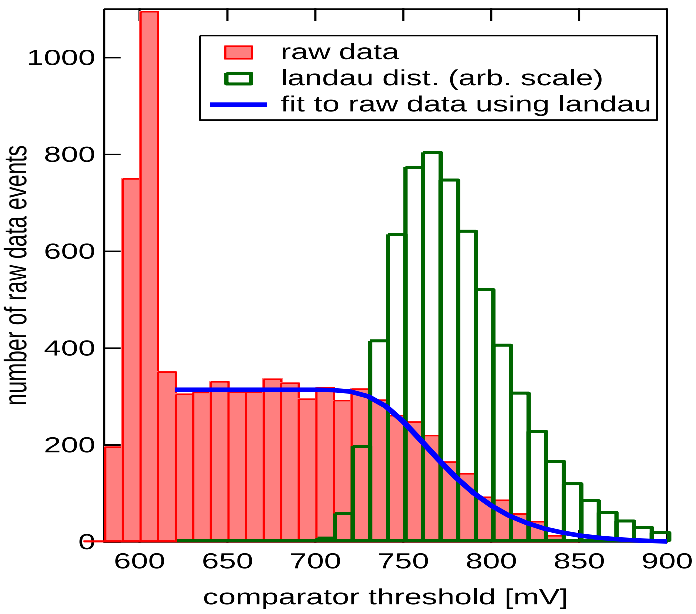
total power: < 300 μW/channel

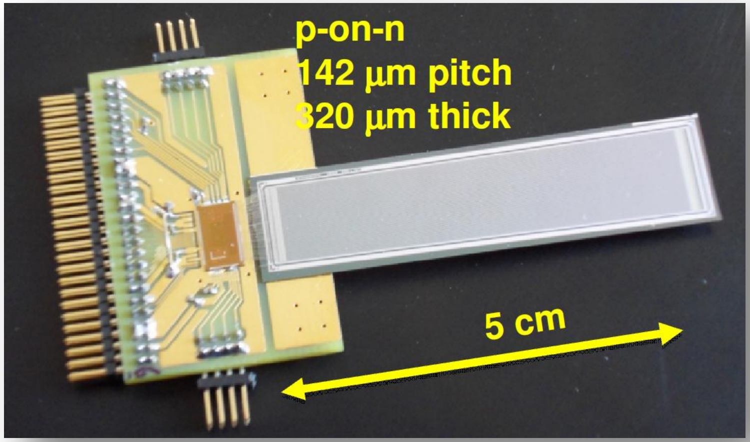
Noise and power

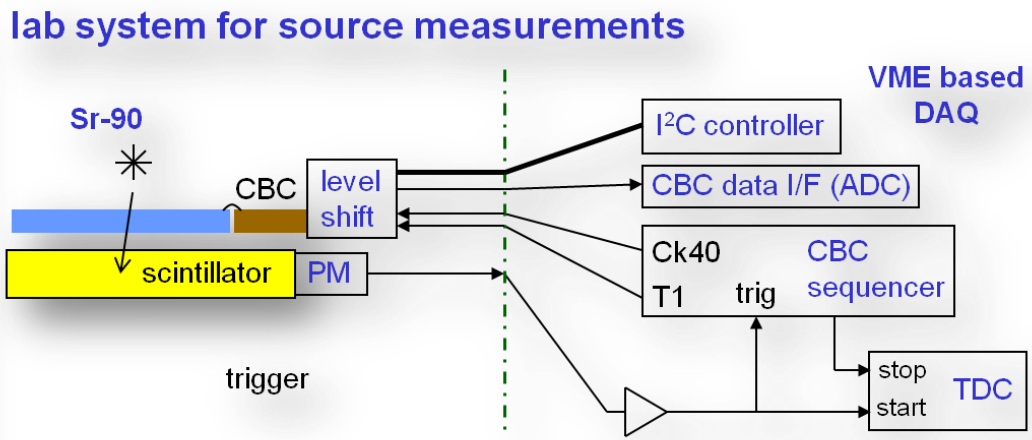


Beta-source results

- Sr-90 source, 5cm p-on-n strip sensor
- Scintillator trigger is time-stamped with 1ns resolution to select events in phase with 40MHz CBC clock
- Landau fitting of correctly-timed events gives 840e noise

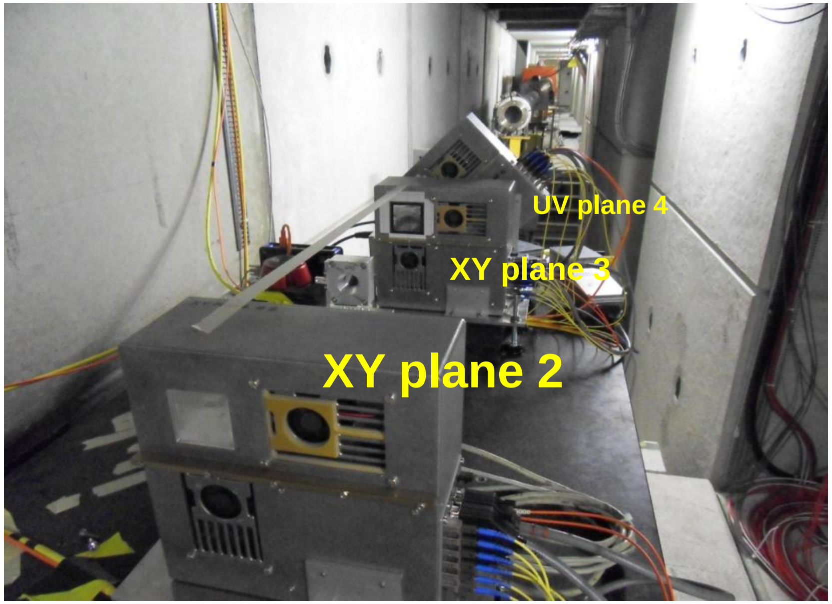


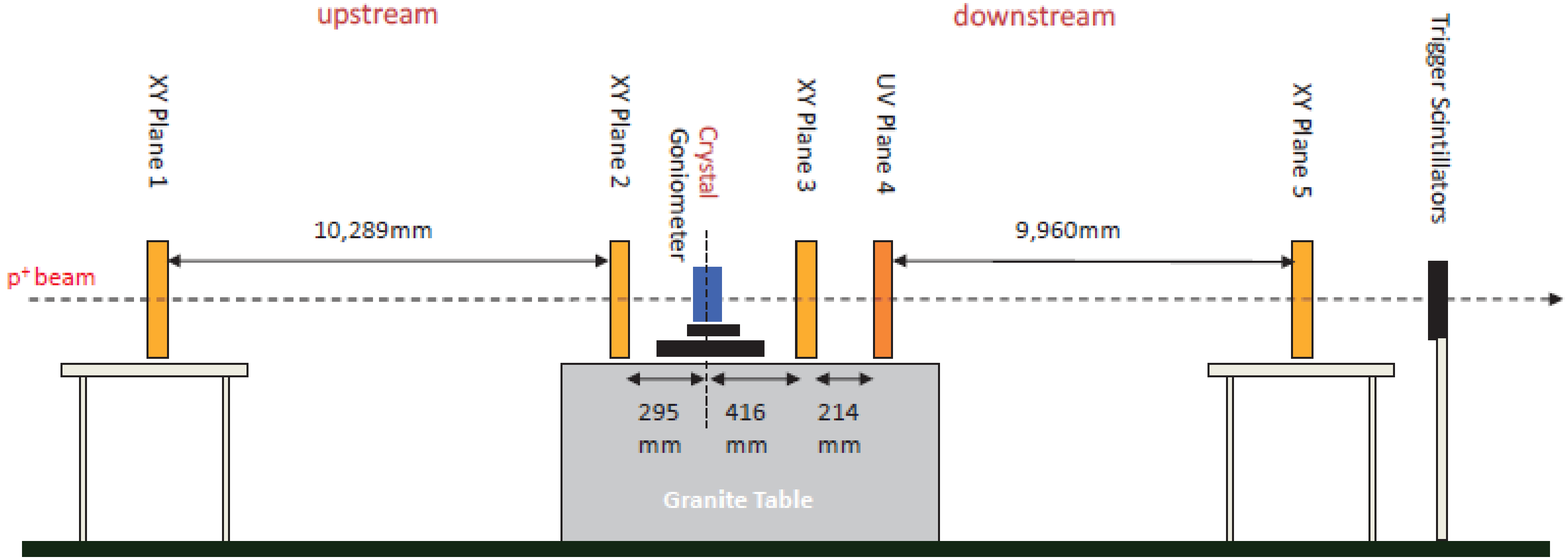




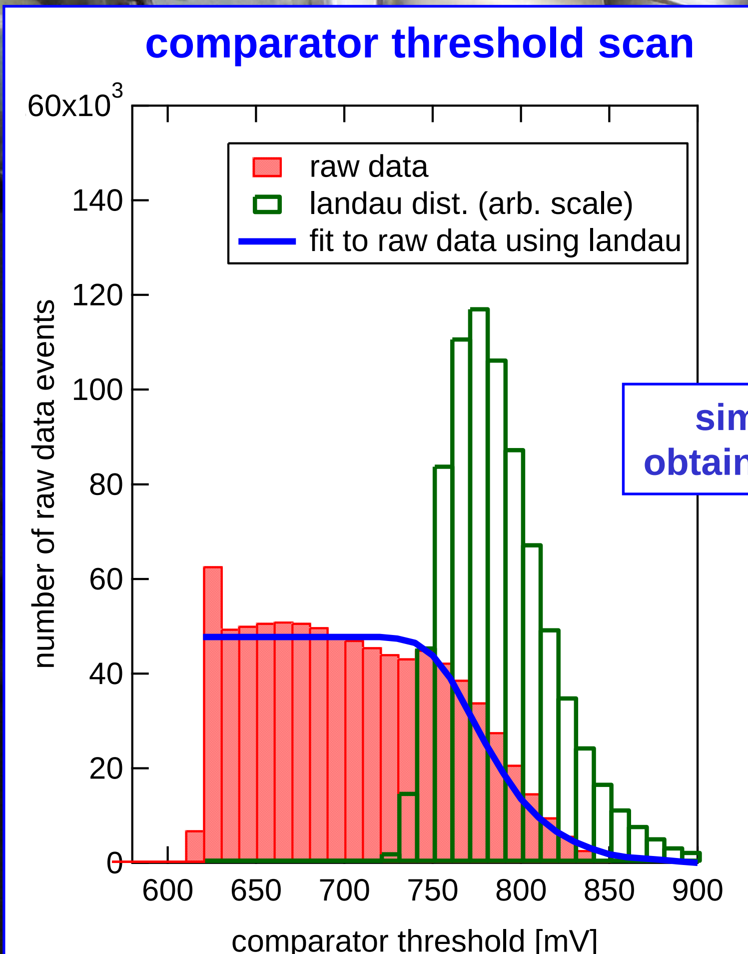
Parasitic beam test

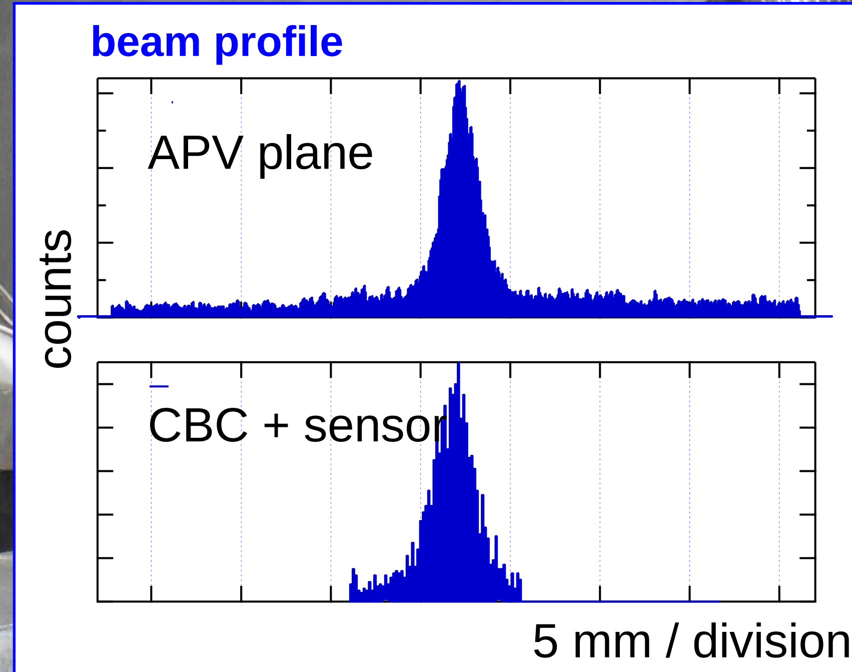
- CBC+sensor recently operated parasitically in 400GeV proton beam (UA9 crystal collimation test – September 2011)
- for further details see: M.Pesaresi et al 2011 JINST 6 P04006



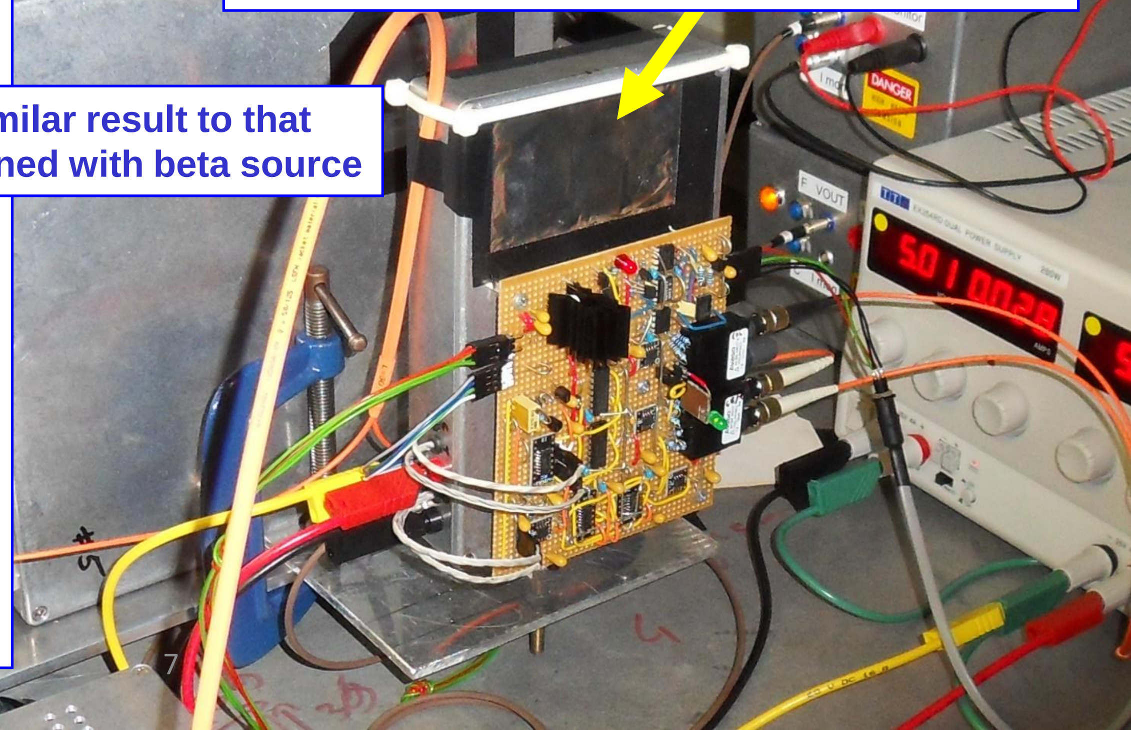


First results

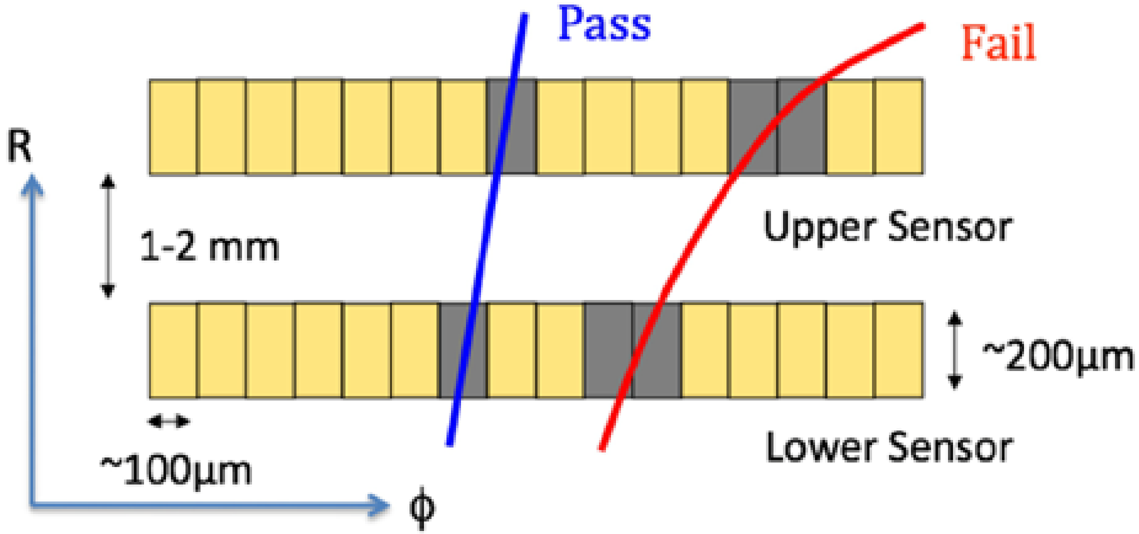


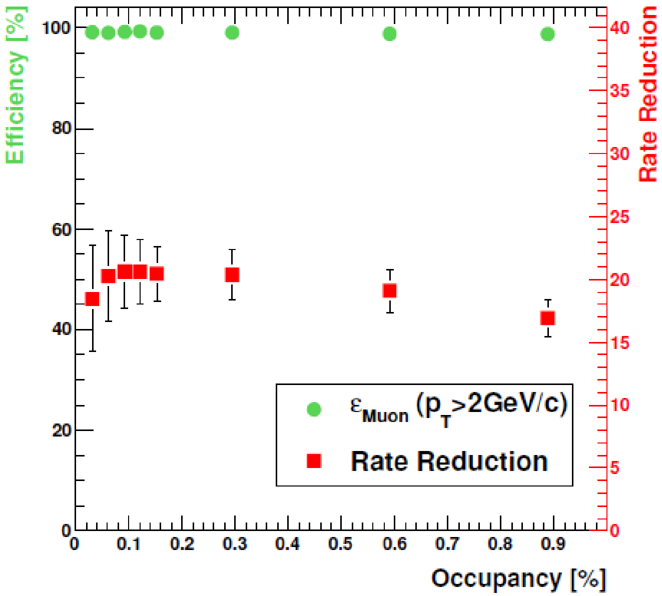


similar result to that obtained with beta source



P_T Discrimination



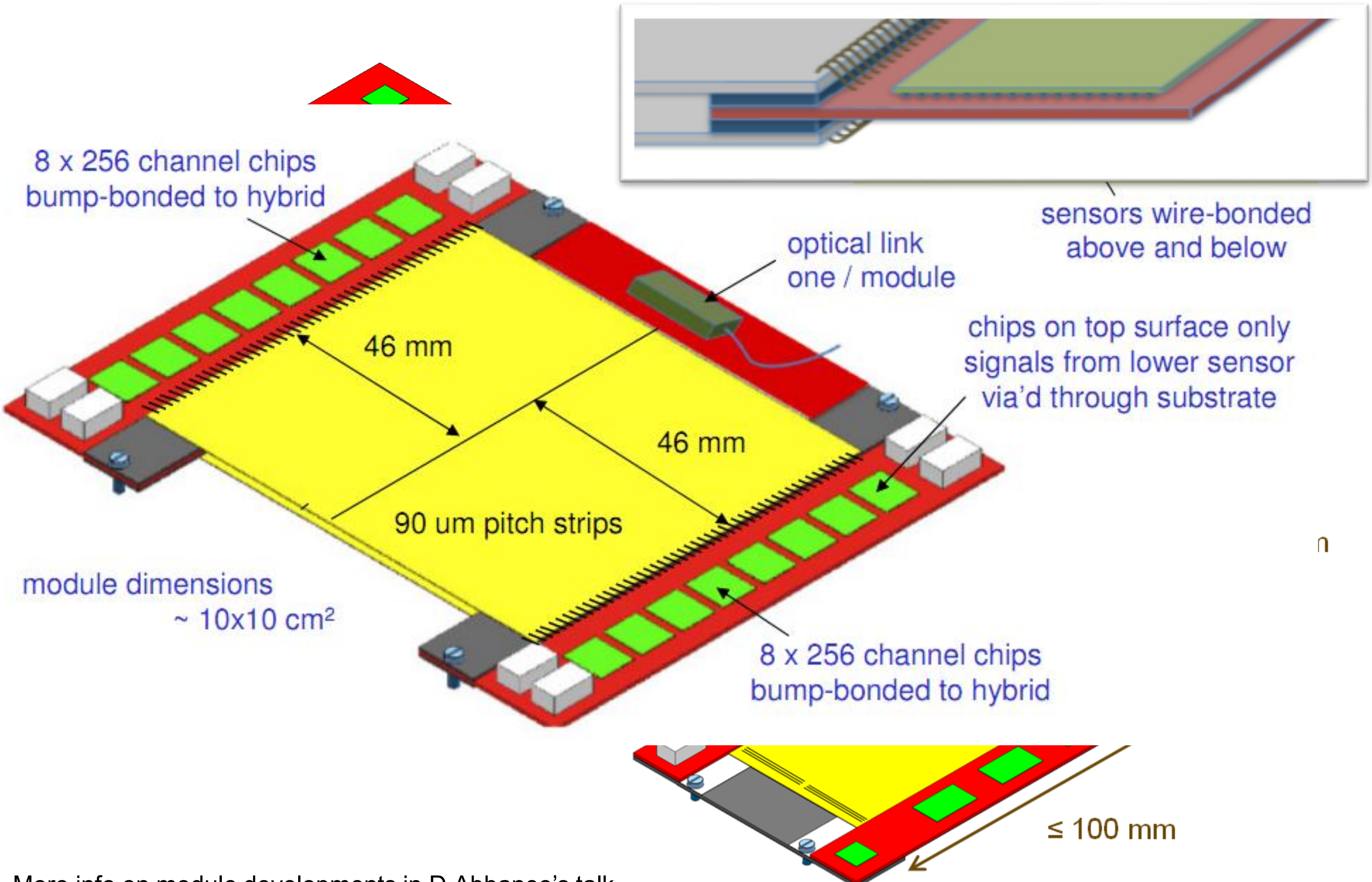


Correlates hits in two closely separated sensors to discriminate between high and low P_T tracks

P_T cut of ~2GeV should give reduction rate of ~20

(see M.Pesaresi Development of a new silicon tracker at CMS for Super-LHC, CERN-THESIS-2010-083)

P_T module: strip+strip (2S)



More info on module developments in D.Abbaneo's talk
http://indico.cern.ch/getFile.py/access?contribId=168&sessionId=29&resId=0&materialId=slides&confId=120853

Next Version

250µm C4 Bump Bonding

256 channels

Internal test pulse calibration

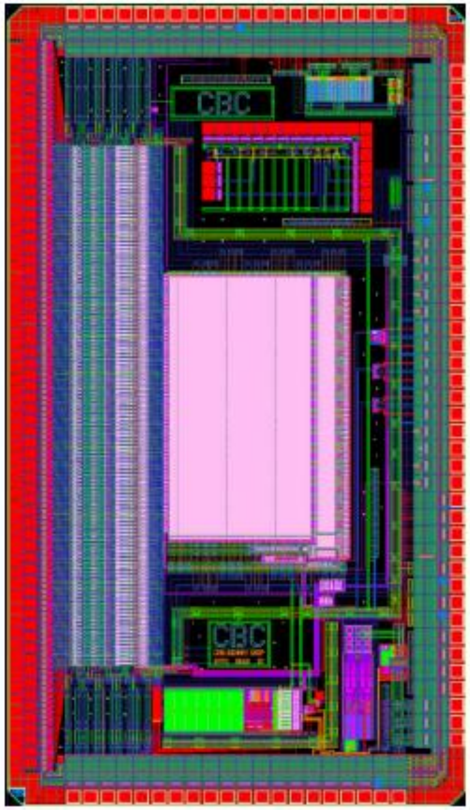
Monitoring ADC

Keep DC_DC and LDO

Multi-mode readout:

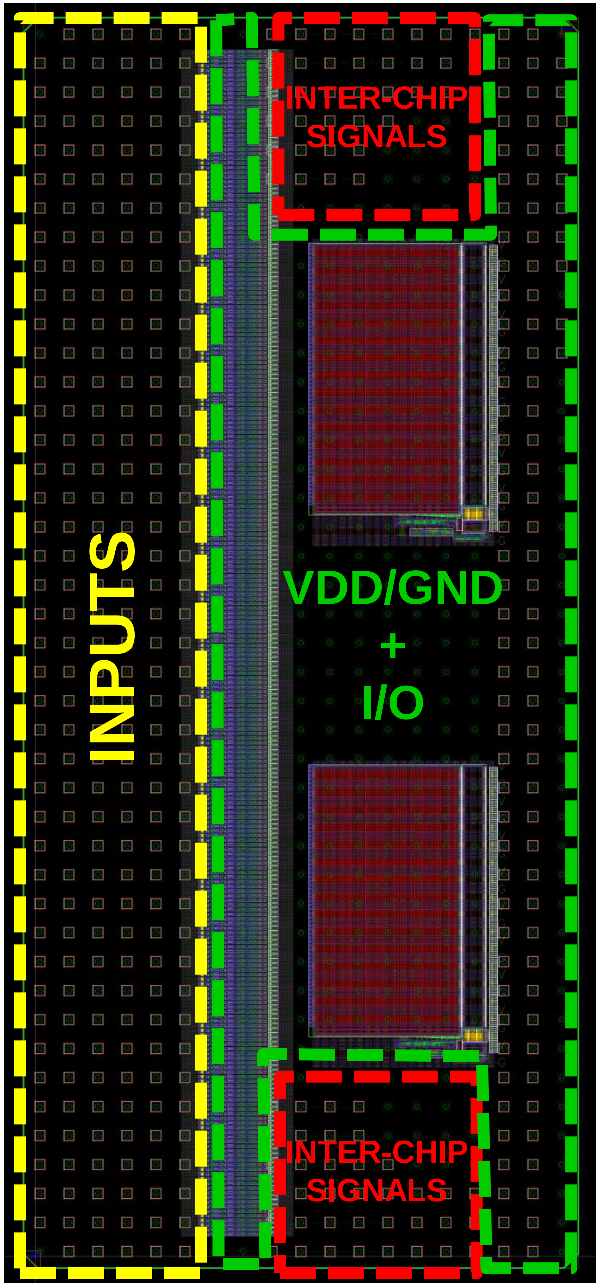
(3 consecutives frames when triggered)

Layout reuses existing blocks where possible



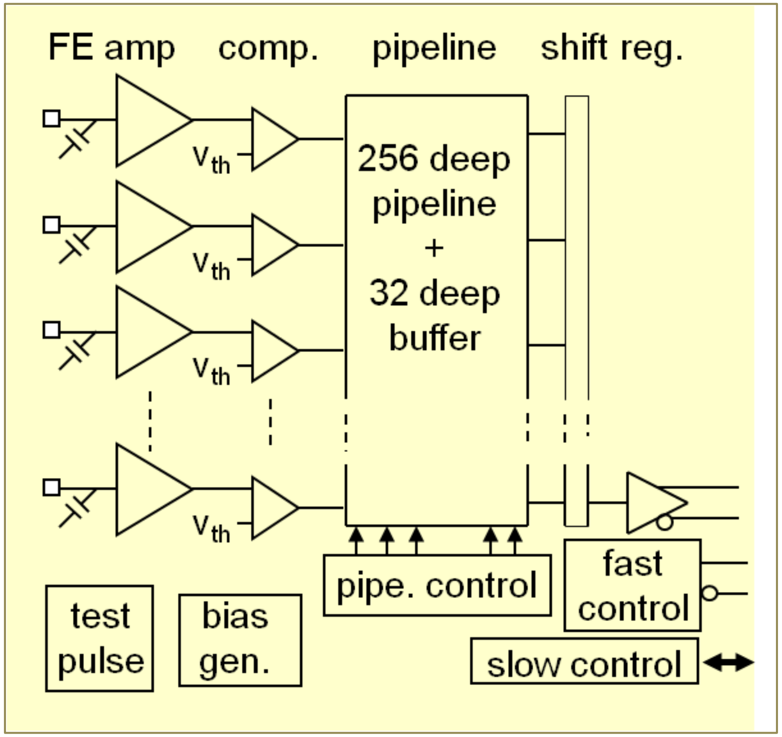
existing chip
128 channels
wirebond: 50 um pitch
7mm x 4mm

next version
256 channels
bump-bond: 250 um pitch
10.75mm x 4.75mm

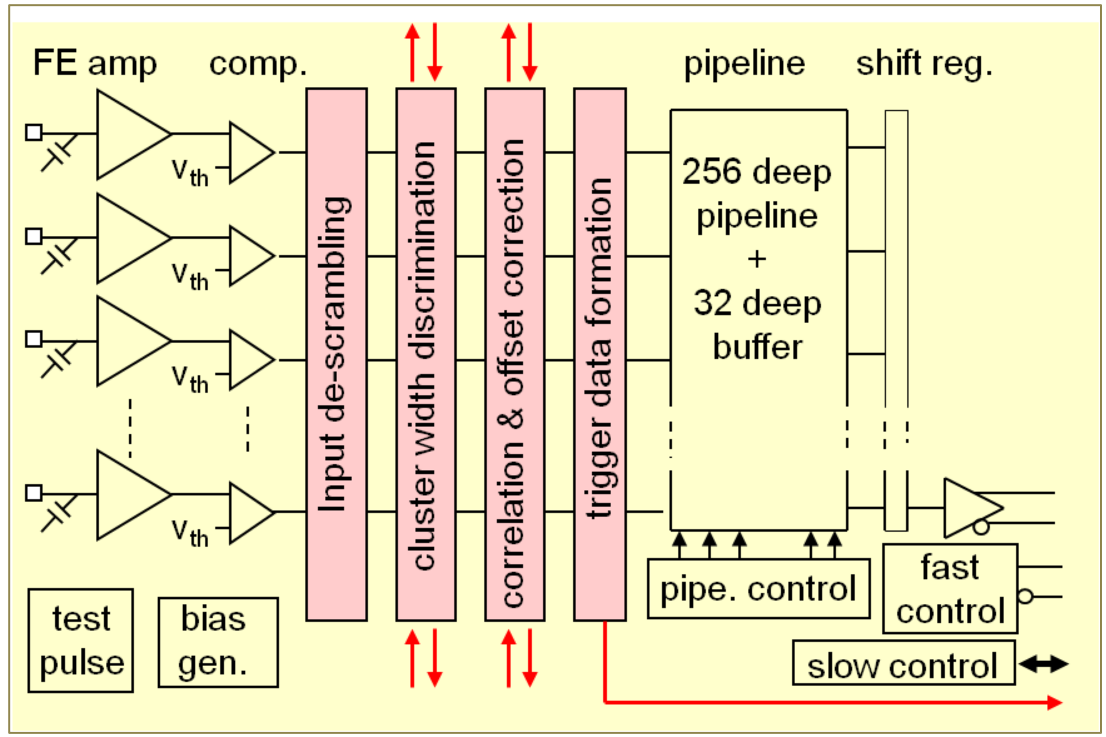


Trigger Logic

current CBC



CBC + added triggering logic



input de-scrambling allows for flexible connections on the module prototype

cluster width discrimination excludes wide clusters

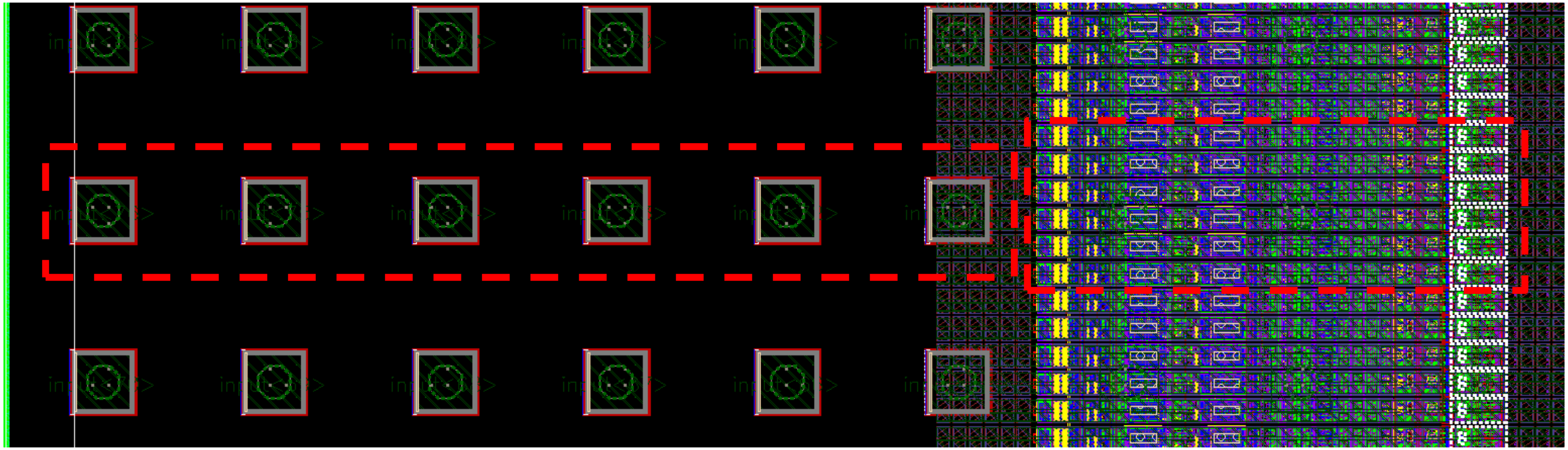
correlation & offset correction corrects for phi offset across module and perform correlation

trigger data formation and off-chip transmission just simple OR for next version

→ 1 bit to signify high PT stub detected (no stub address)

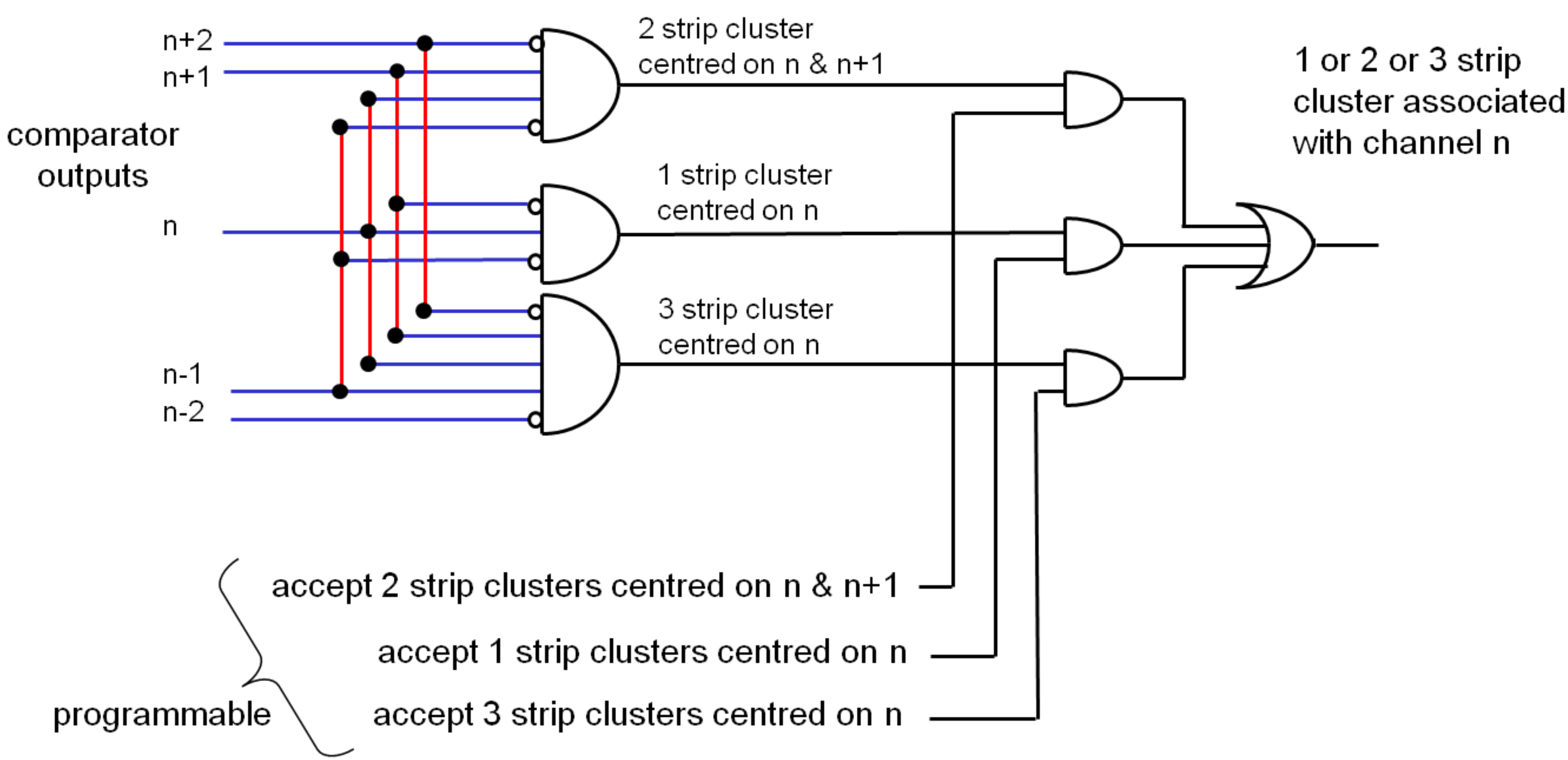
final requirements still under consideration: synchronous or asynchronous options are possible

Input de-scrambling/mapping



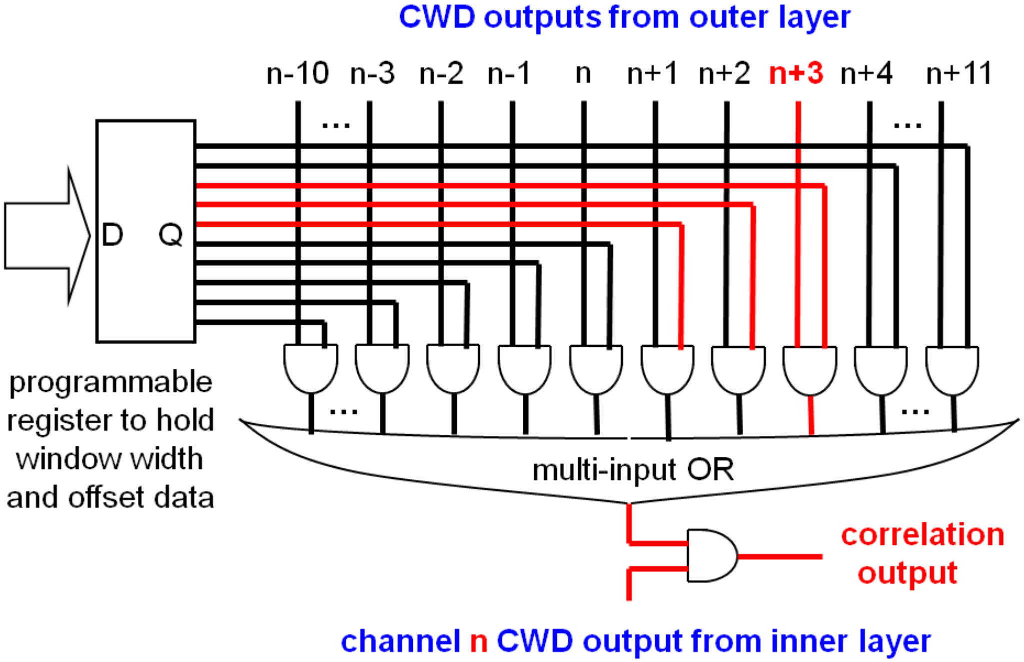
- Input PADs arranged in rows of 6: these 6 pads can be connected to any combination of 3 channels from the inner sensor layer and 3 channels from the outer sensor.
- Comes after the comparator so does not affect the front-end.
- Allows flexibility in module-prototyping.

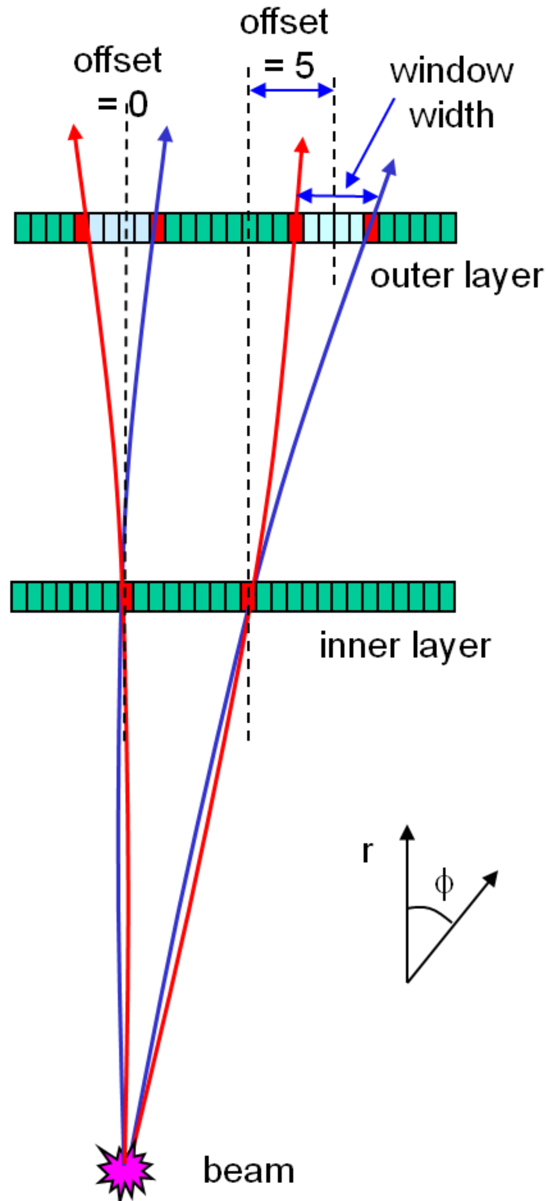
Cluster Width Discrimination



- **Looks at adjacent channels from same detector layer**
- **Rejects clusters above a programmable max-width**
- **Needs inputs from neighbouring chips at the edges**

Correlation & Offset Correction





- Window width determines Pt cut
- Offset varies depending on location across sensor (& separation between layers)

Needs also inputs from neighbouring chips at the edges

Summary

STATUS:

- **Results on test bench and with beta source confirm expectations**
- **CBC + detector also recently tested in proton beam. Preliminary results encouraging.**

FUTURE PLAN

- **Submission of next version featuring 256 channels, bump-bonded PADs and coincidence logic for L1 trigger - early next year**
- **Future tests of radiation hardness**