GOSSIP Detectors:

An option for low-material tracking in e-p/A colliders?

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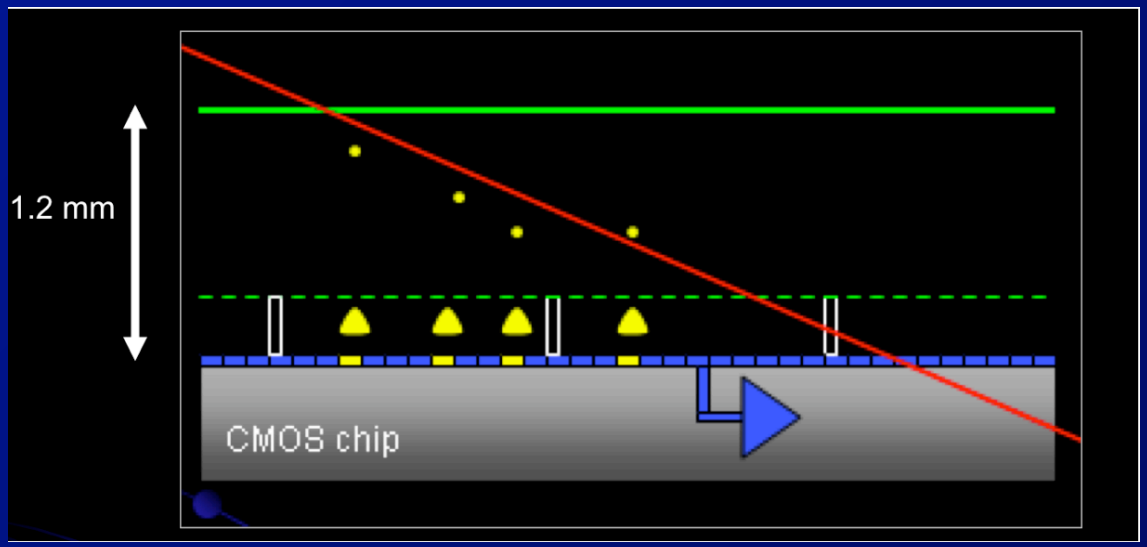
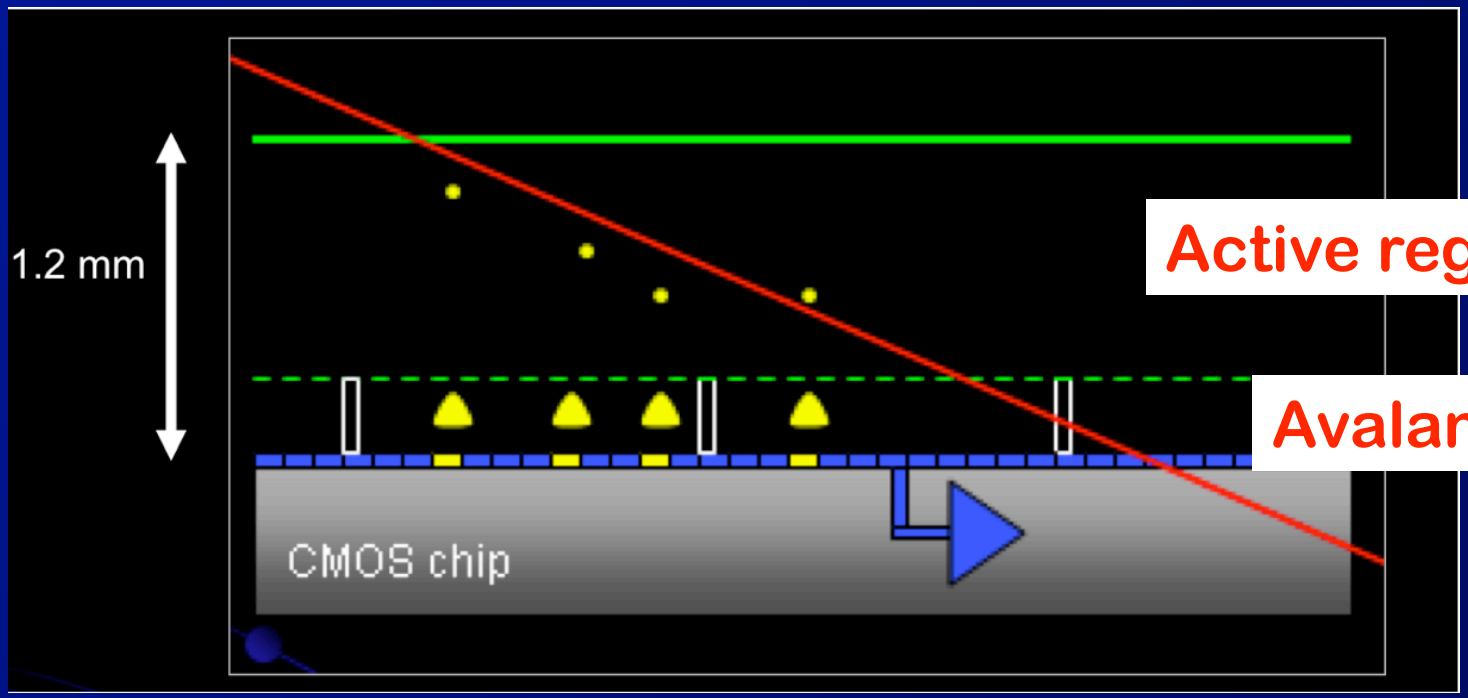


Shamelessly borrowed from LHeC talk by H. Van der Graaf

GOSSIP

- **GOSSIP = Gas On Slimmed Silicon Pixel**
  - Thin (for our purposes) gas detector
  - Read out using "silicon pixel detector"
    - ⇒Originally thinned (50 μm) pixel sensor
    - ⇒More recently, just the pixel readout chip itself!

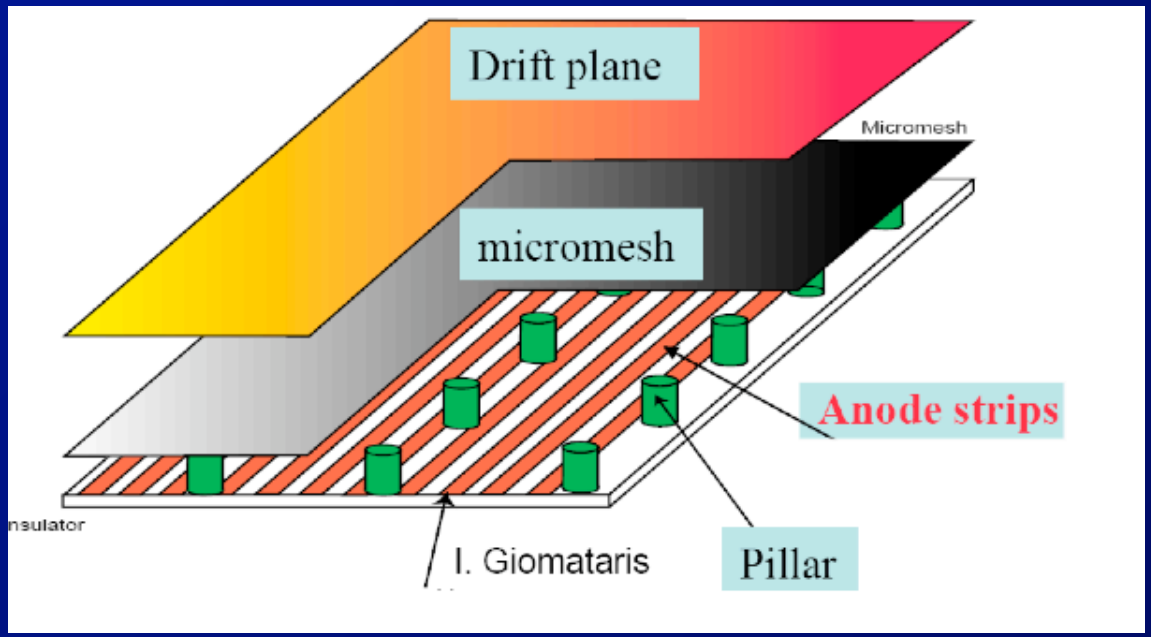


Why Gas+Si?

- **Advantages of gas sensor**
  - Less material than Si-based sensors
  - Multiple samples per track, with dE/dx
    - ⇒For optimal resolution, want time measurement
  - No radiation damage to sensor material
  - Relatively insensitive to neutrons, x-rays
  - Low capacitance ⇒ low noise, low-power pre-amps
  - Can be operated over a wide temperature range
    - ⇒ $-100 < T < 50$ °C
- **Potential disadvantages**
  - Position resolution limited by ionization statistics
  - Sparking/discharges
  - Ageing

GOSSIP: InGrid Technology

- So far, most GOSSIP R&D has been based on Micromegas:



MICROMEsh GASeous detector :

Amplification region : 50-100 micron gap

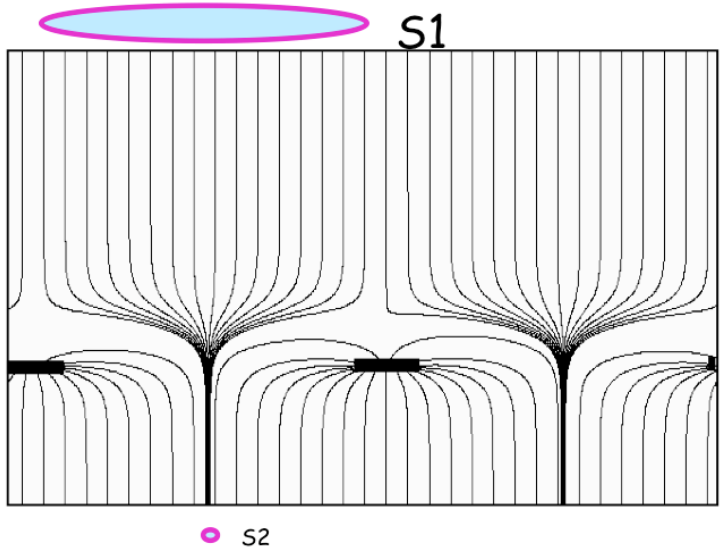
Amplification field >> drift field => efficient collection

Gap small => fast signals

Optimally, anode pad size can be = hole pitch

->**VLSI (CMOS) electronics** (Medipix2)

65000 pixels on 2cm^2



Integrated Micromegas & CMOS (InGrid)

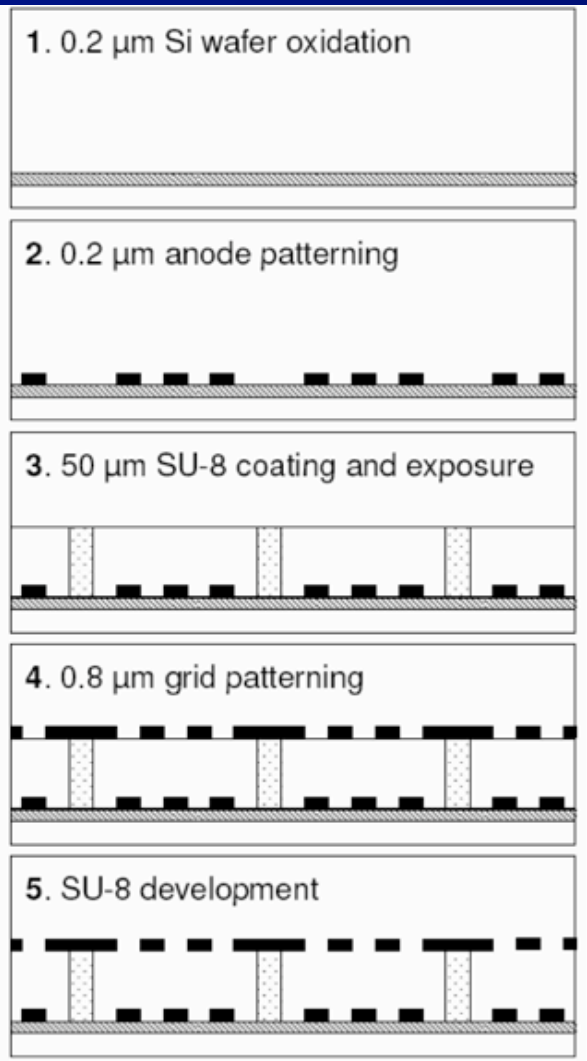
- Alignment very important when coupling Micromegas to highly segmented detector

  ⇒InGrid process

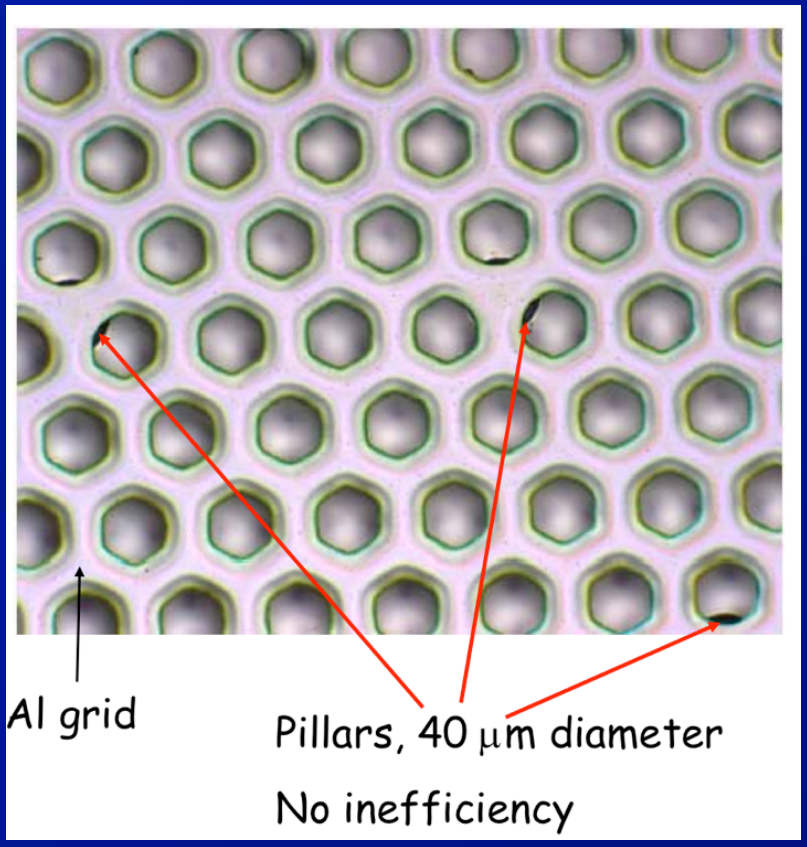
InGrid process

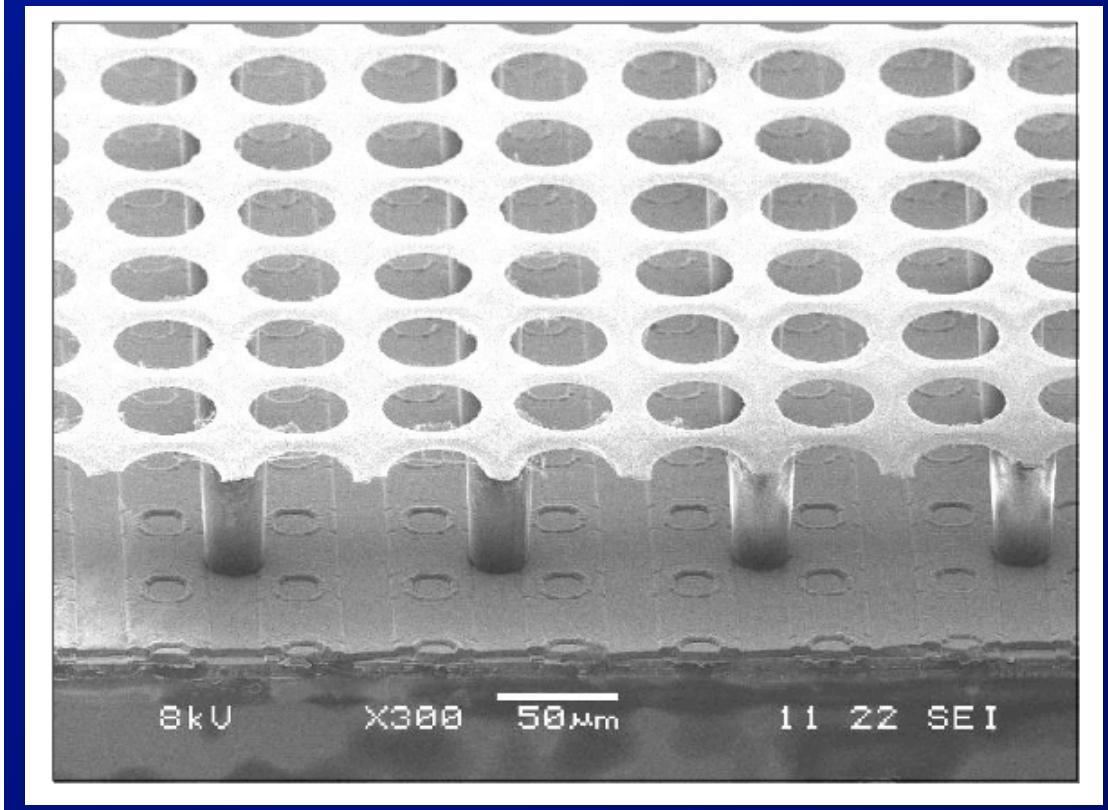
1) Oxide the Si wafer, insulating SiO_2 layer on top
2) Deposition of 0.2 μm of Al for anode, and patterning
3) Deposition of 50 μm photo-resist and UV exposure
4) Deposition and patterning of the grid: 0.8 μm of pure Al
5) Removal of the exposed photoresist

RESULT : a thin mesh (0.8 μm compared to 3-5 μm with best standard techniques), sustained at an accurate 50 μm from the anode.



Gossip using InGrid

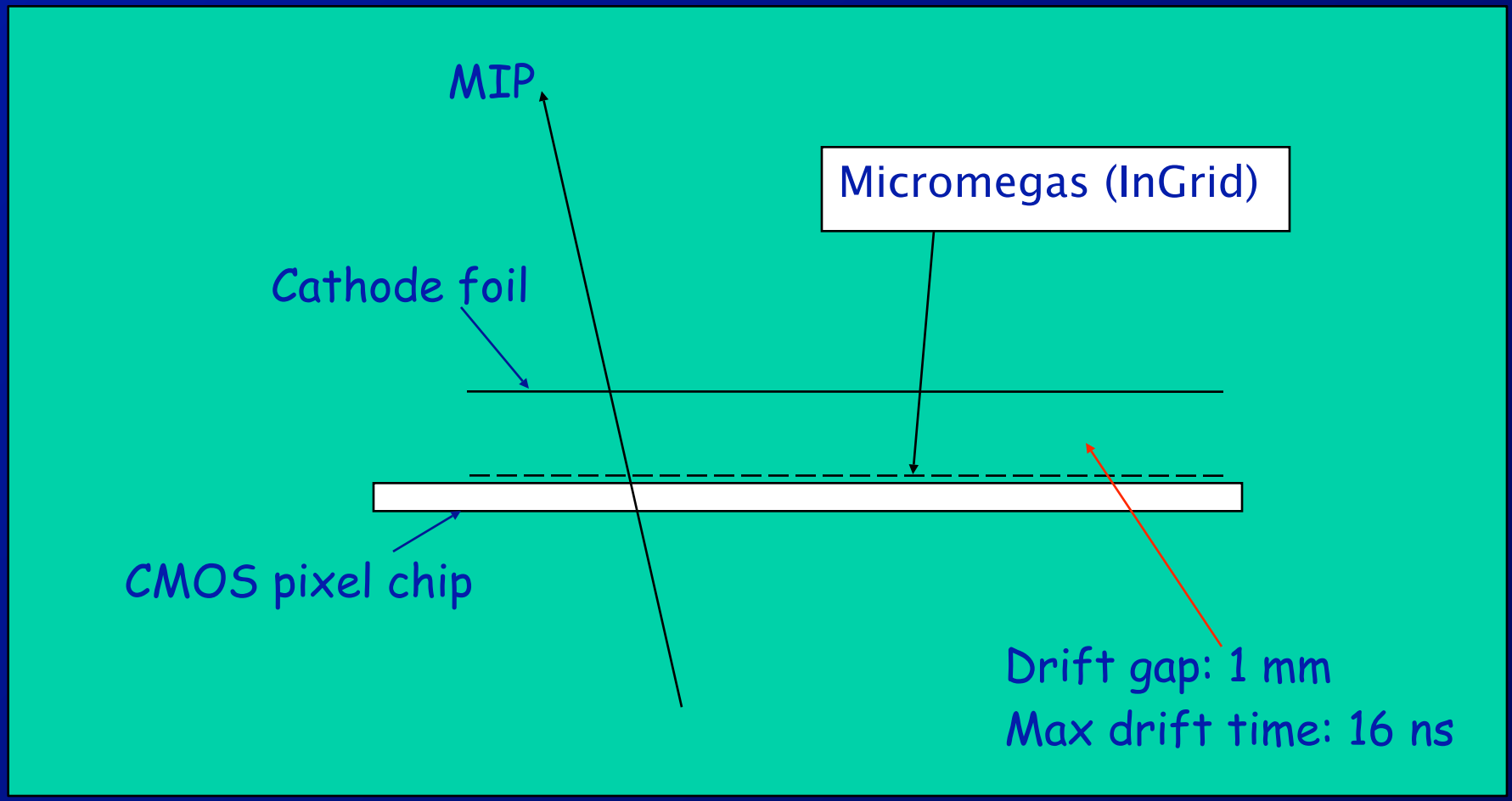




- **Micromegas grid and anode are single unit**
  - Mechanically simple, no complicated alignment
- **Uses Medipix derived chips**
  - With built-in discharge protection layer

GOSSIP a la Van der Graaf

GOSSIP: Gas On Slimmed SIlicon Pixels



- **Drift gap determined by trade-off between**
  - **Efficiency, diffusion, drift time**

GOSSIP: Some numbers

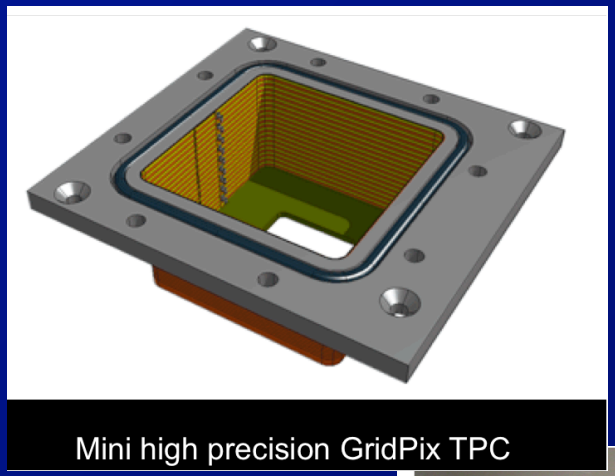
All from Slides by H. Van der Graaf

(http://www.nikhef.nl/~d90/gossip/CMOS_Gossip.ppt)

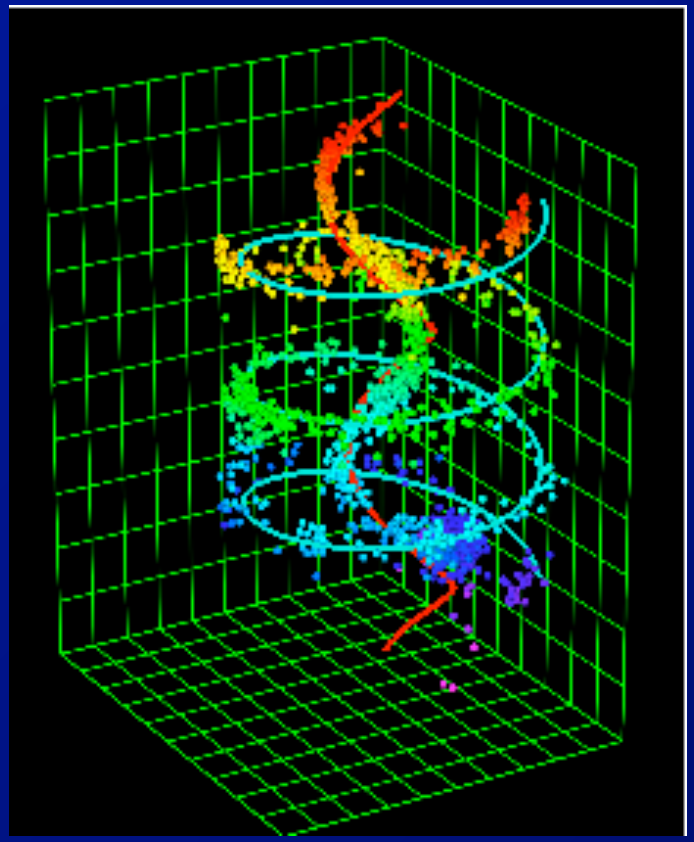
- Required gas gain: ~ 5k
- Input capacitance: < 10 fF (!!)
- In 1 mm or Ar-Iso: diffusion resolution ~ 10 µm
- Pixel sizes (square!): 20-50 µm
- Material
  - 'Slimmed' Si CMOS chip: 20 µm Si
  - Pixel resistive layer 1 µm SU8 eq.
  - Anode pads 1 µm Al
  - Grid 1 µm Al
  - Grid resistive layer 5 µm SU8 eq.
  - Cathode 1 µm Al

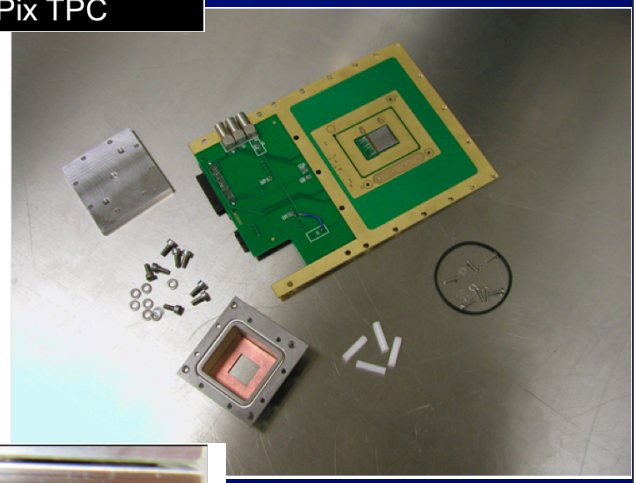
GOSSIP & Related Prototypes

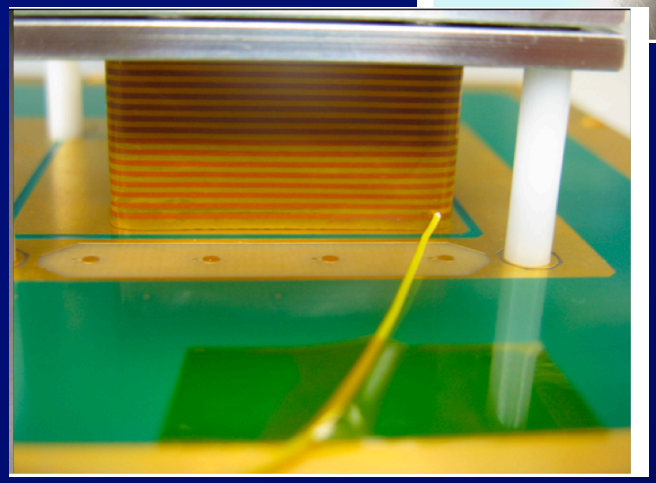
- **GridPix TPC**
  - Uses InGrid readout
  - 3 cm drift region
  - Detected internal conversion (e^+, e^-)



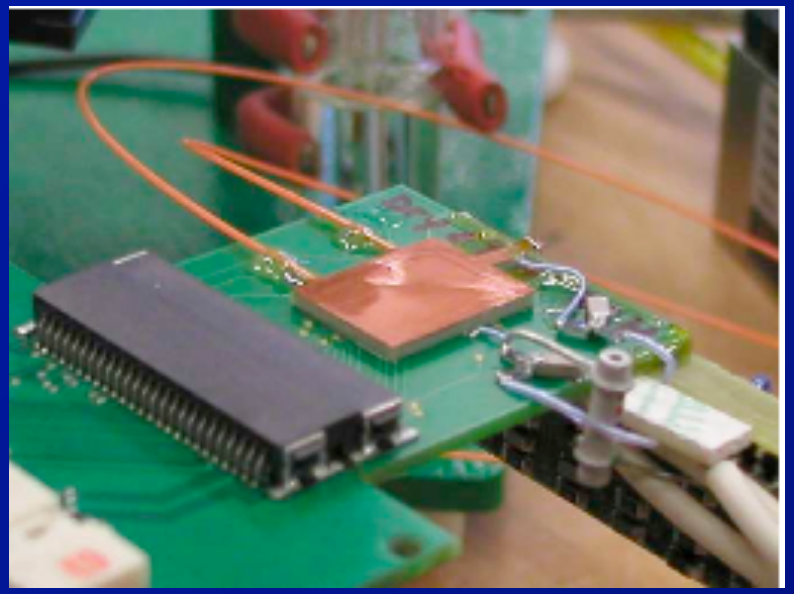
Mini high precision GridPix TPC







GOSSIP and Related Prototypes (2)



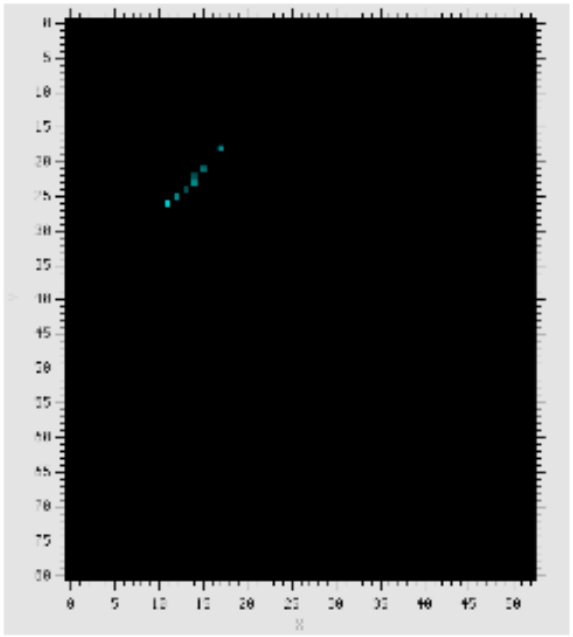


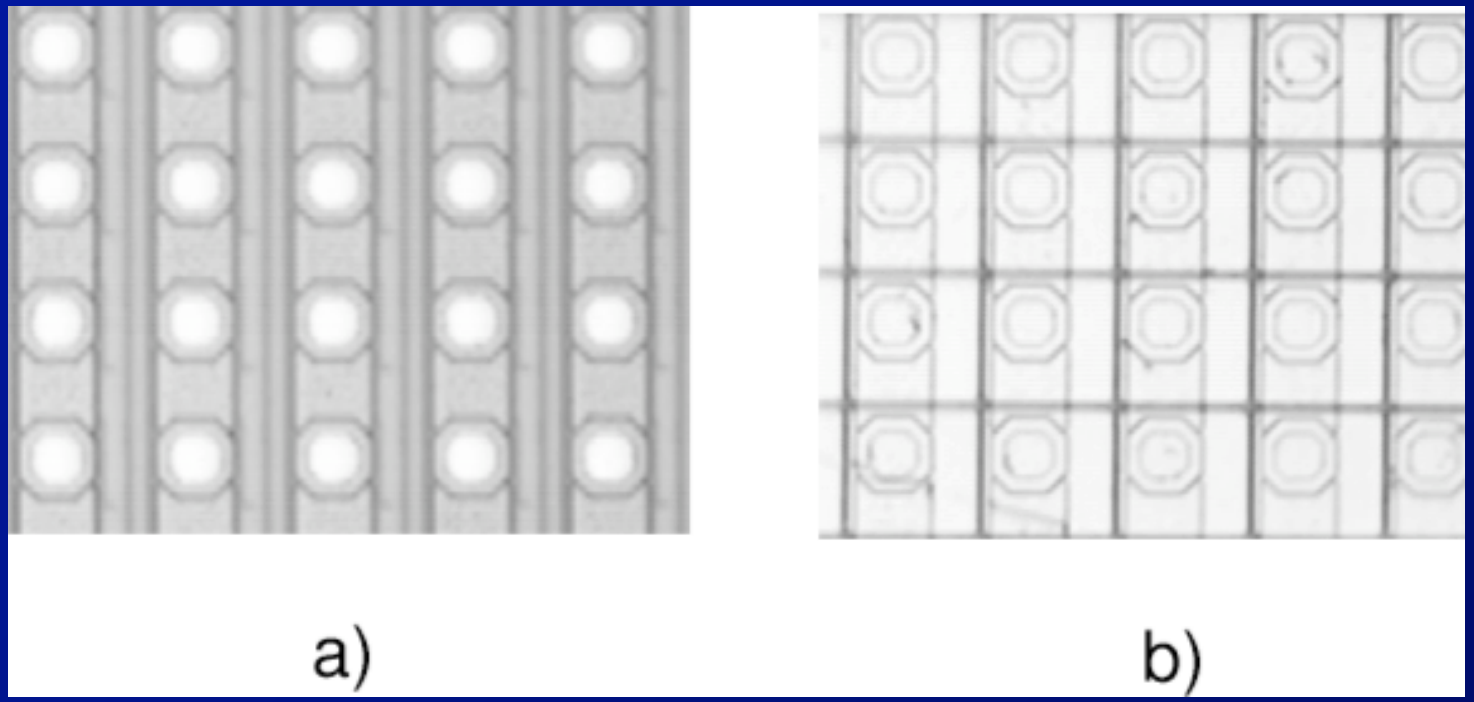
Fig. 5 A β-track from ^{90}Sr, measured with the Gossip prototype.The PSI-46 chip has 52 x 80 pixels of 100 x 150 μm.

- Prototype GOSSIP using CMS PSI-46 chip

Medipix Modifications (post-processing)

From GOSSIP slides by H.Van der Graaf, NIKHEF

MediPix modified by MESA+, Univ. of Twente, The



Pixel Pitch: 55 x 55 μm^2

Bump Bond pad: 25 µm octagonal

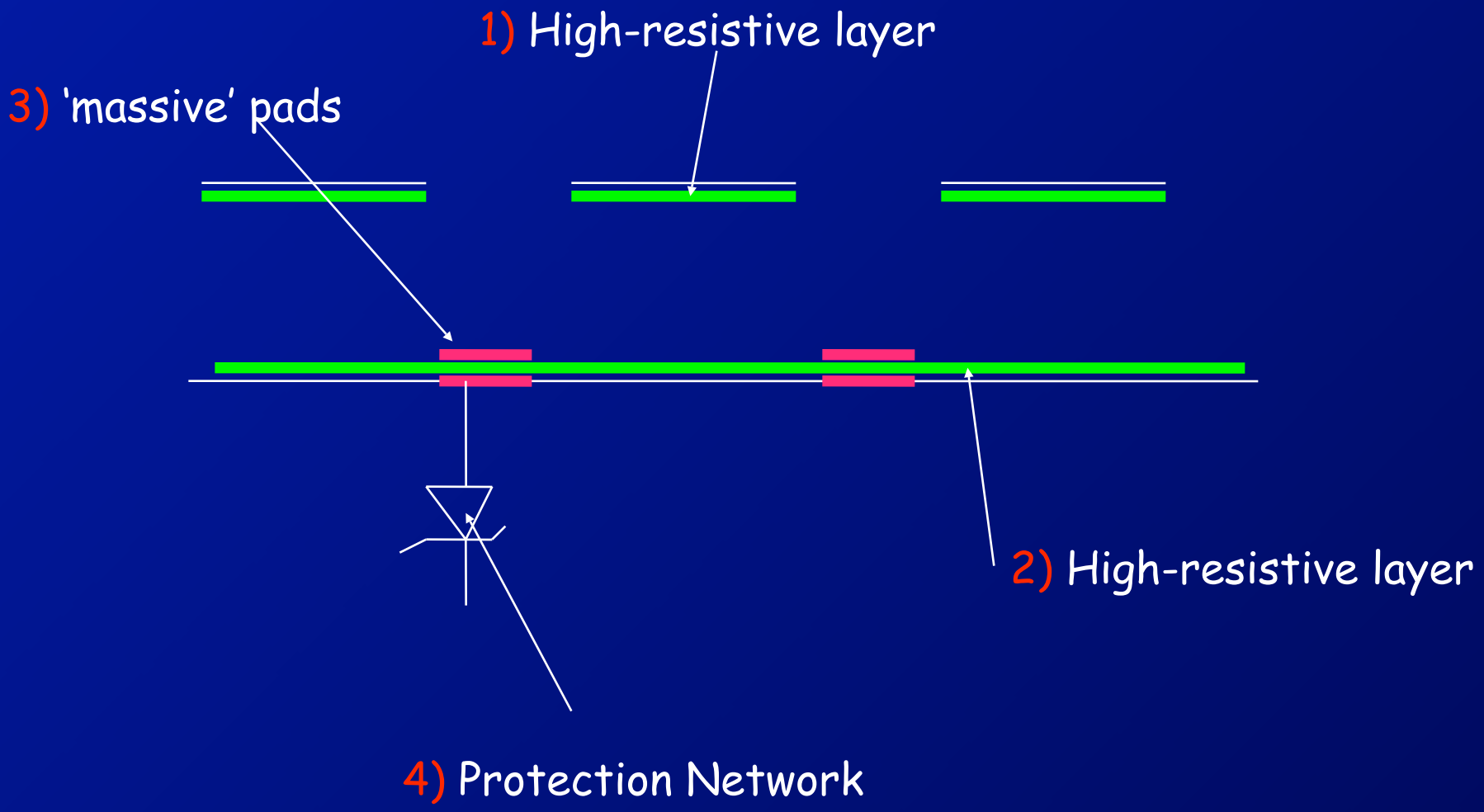
75 % surface: passivation Si_3N_4

New Pixel Pad: 45 x 45 μm^2

Insulating surface was 75 %

Reduced to 20 %

Discharge protection



- **Significant effort has been devoted to attacking the obvious potential problem w/ discharges**

InGrid Discharge Studies

From H. Van der Graaf, LHeC Talk, Divonne 2009

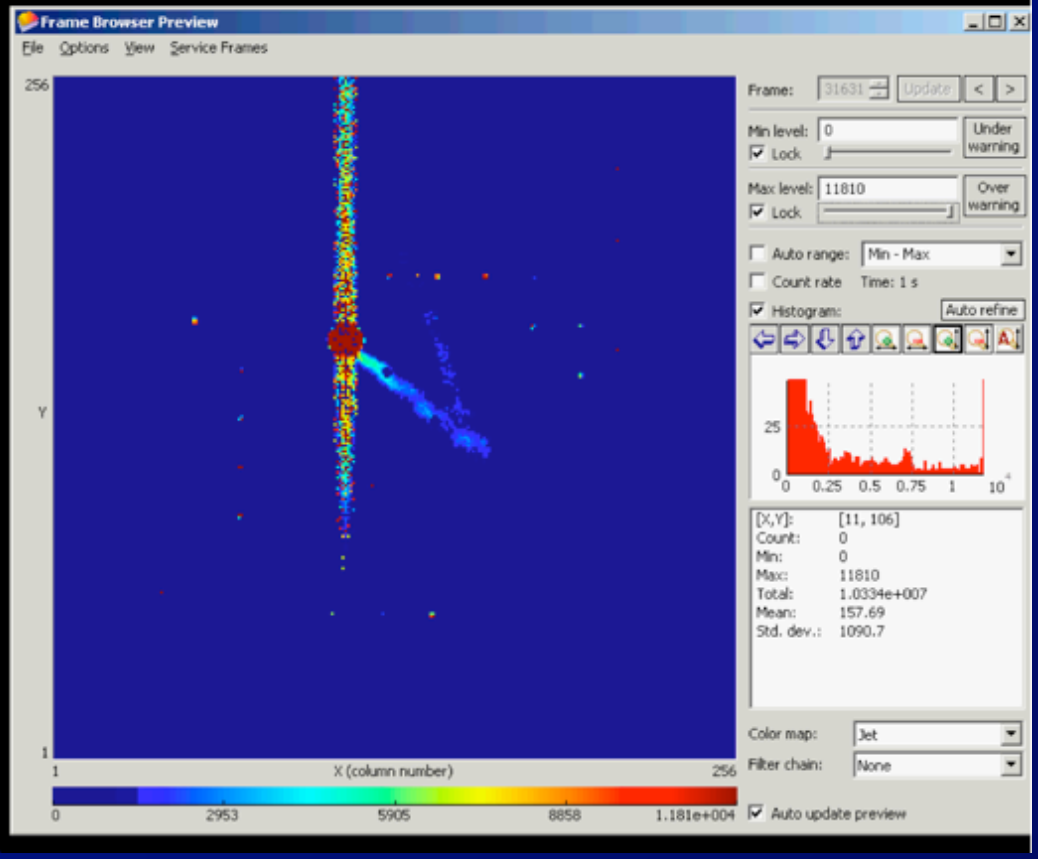
… discharges are observed !

For the 1st time: image of discharges are being recorded

Round-shaped pattern of some 100 overflow pixels

Perturbations in the concerned column pixels
- Threshold
- Power

Chip keeps working



- **No CMOS chip failures after > 1000 discharges**

GOSSIP Electronics

- Low capacitance allows for low-noise (75 e RMS), low-power (1 µW/channel !!) electronics
  - News new electronics R&D to utilize
- In progress (GOSSOP02)

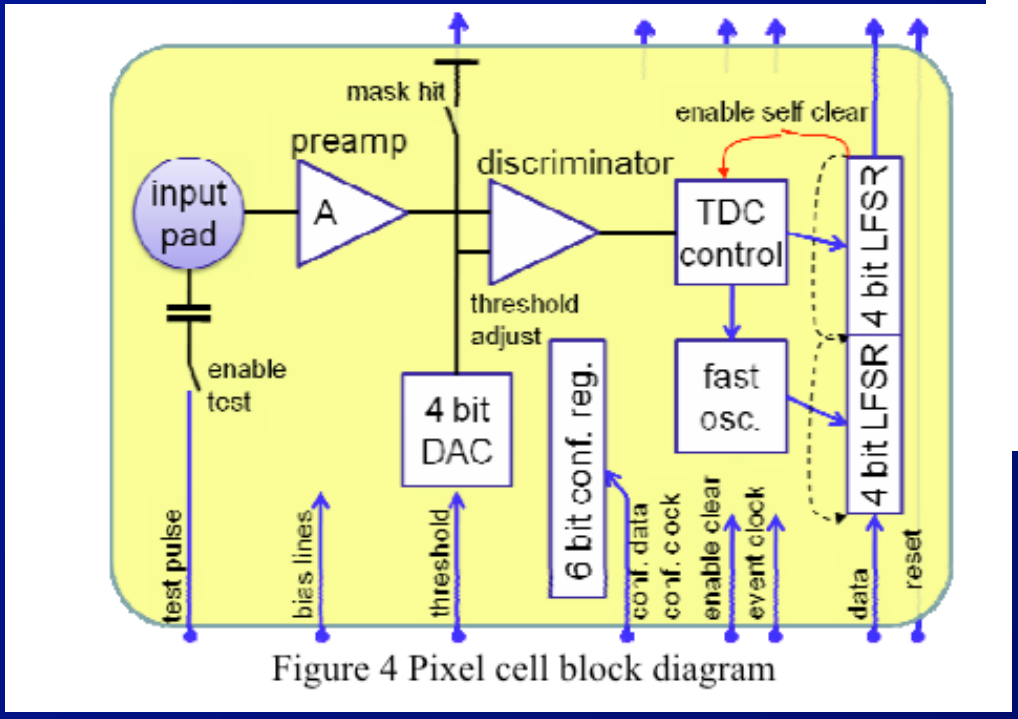


Figure 4 Pixel cell block diagram

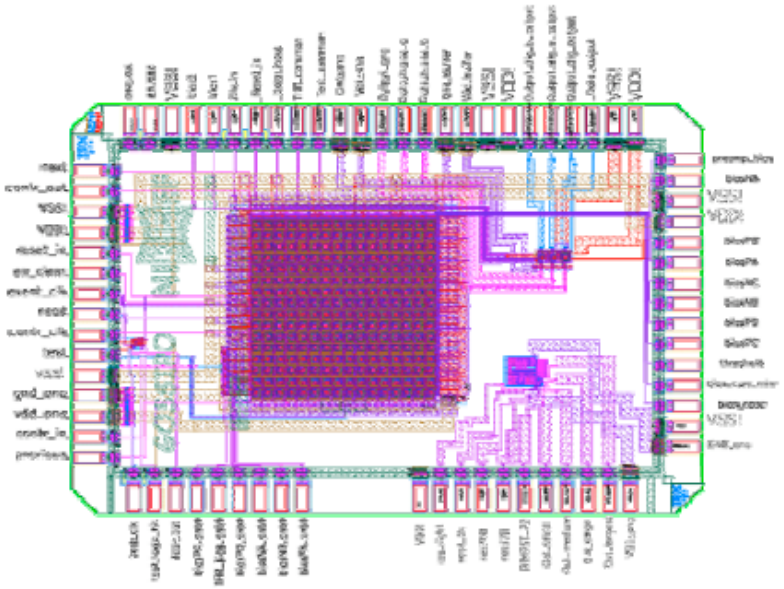


Figure 3 layout of the GOSSIPO chip

Why GOSSIP for EIC?

- **Motivations**
  - Low material
    - ⇒Crucial for suppressing electron bremsstrahlung
    - ⇒And reducing conversions
  - Insensitivity to x-rays
  - (in gas) dE/dx measurements
    - ⇒Valuable for particle identification
  - Radiation insensitive “sensor”
  - Can use existing technology/experience with Si detector readout
- **But, still an R&D project**
  - Continued work on discharge protection
  - Ageing -- needs much more work
  - Scaling up to full detector