Beamprofile Monitor R&D based on 3D Sensor

Collaboration of
Brunnel, Hawaii, KEK, Stanford, Tohoku

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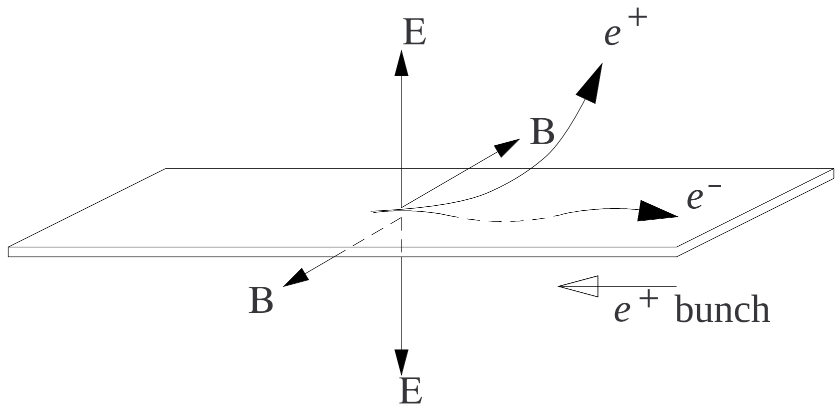
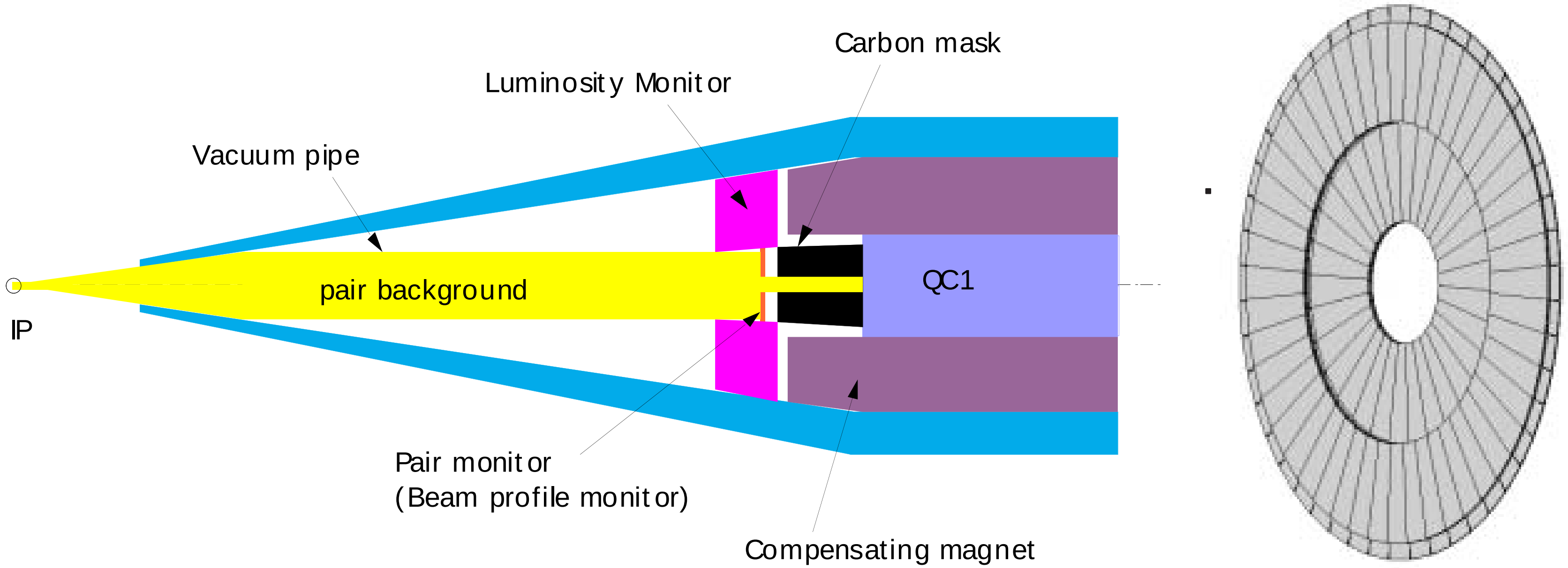
Kinematic Configuration of Pair 'Background'

Lab. frame



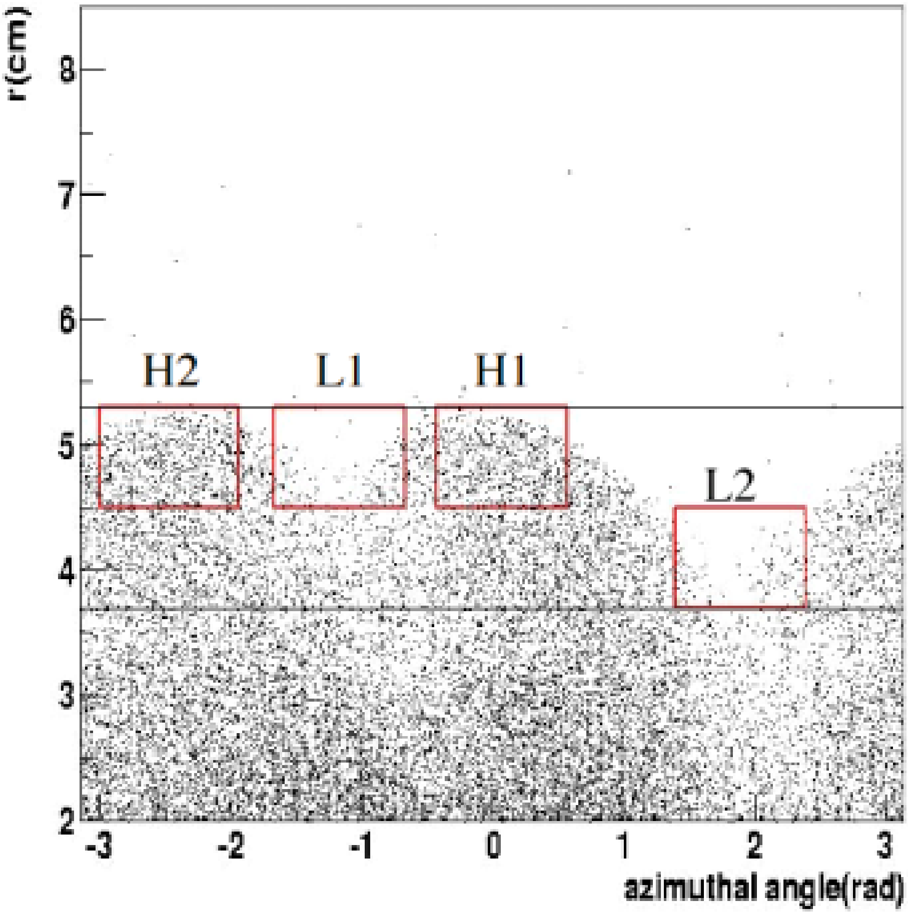
- For an incoming e^+ bunch,
  e^- oscillates around the beam plane.
  e^+ acquires a large p_t kick (vertical).
- Round beam $\rightarrow$ no ϕ dependence,
  ϕ dependence $\rightarrow$ σ_y/σ_x ratio.

- Bunch identification desirable
  (at least roughly: $\sigma_t < 25ns$, train = 270 ns)
- High rate expected (30hits/train/mm^2)



Outer radius ∼8cm. One on each side of IP.
Trapisoidal sensors desirable.

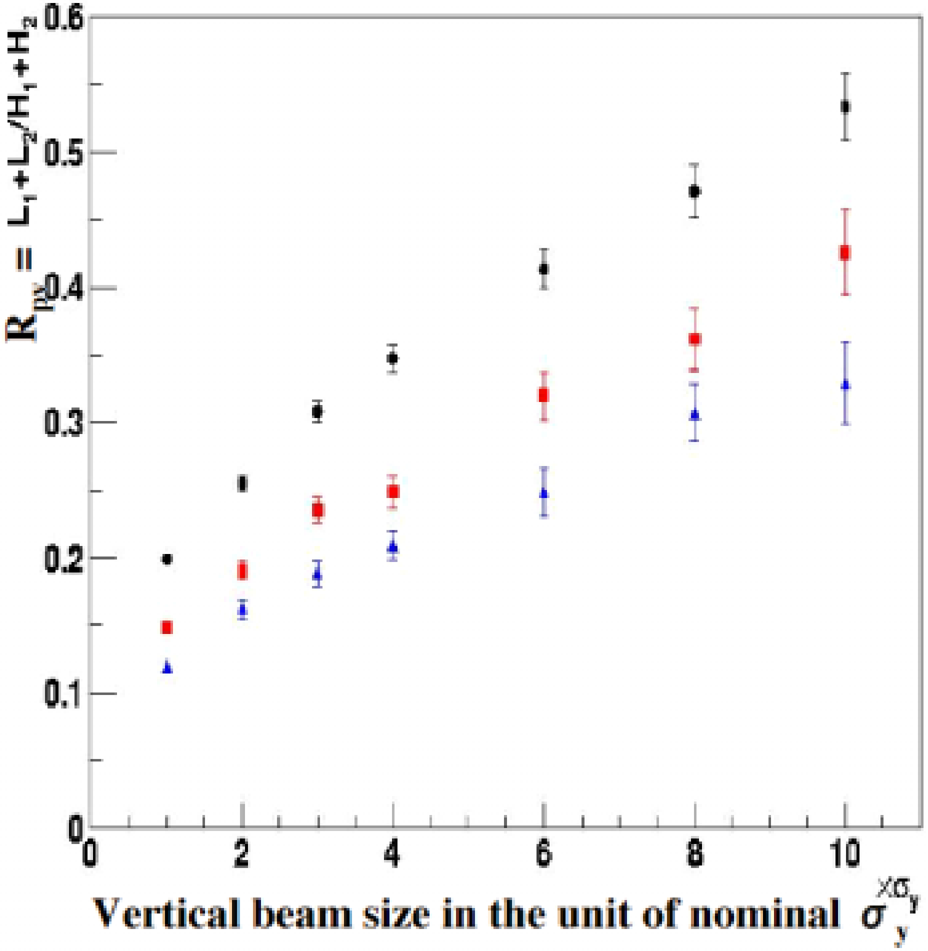
Pair hit distribution on the beam profile monitor



Evaluate

$$R \equiv \frac{L_1 + L_2}{H_1 + H_2}$$

Extraction of σ_y



Nominal :

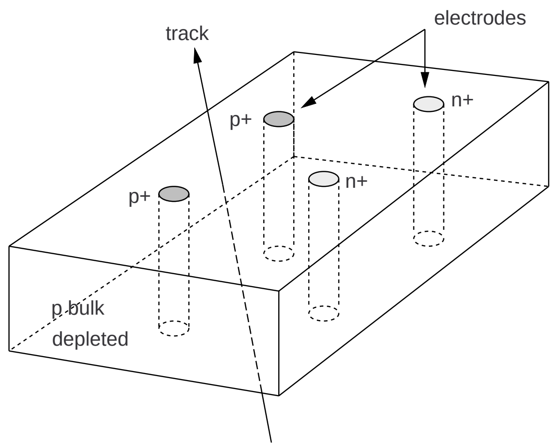
$\sigma_x = 243$ nm

$\sigma_y = 3$ nm

- nominal σ_x
- $1.5\times$ nominal σ_x
- $2\times$ nominal σ_x

σ_x can be obtained by max radius of hits.

3D pixel sensor



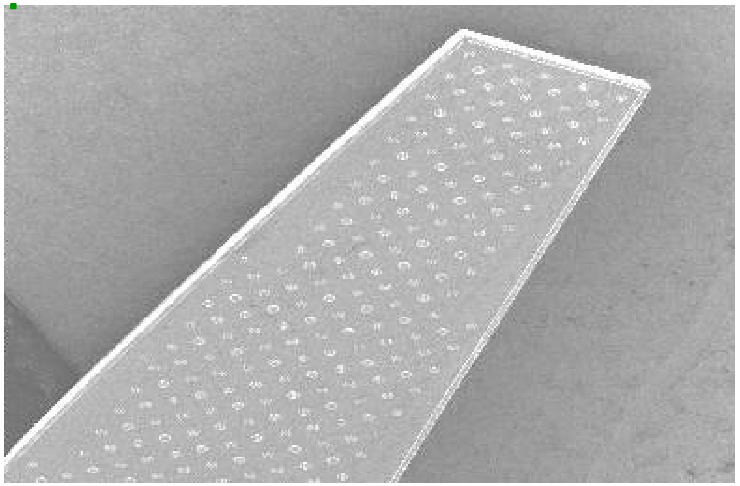
1. Fast. Charge collection time 10ns: ~10 times faster than conventional pixel sensor.

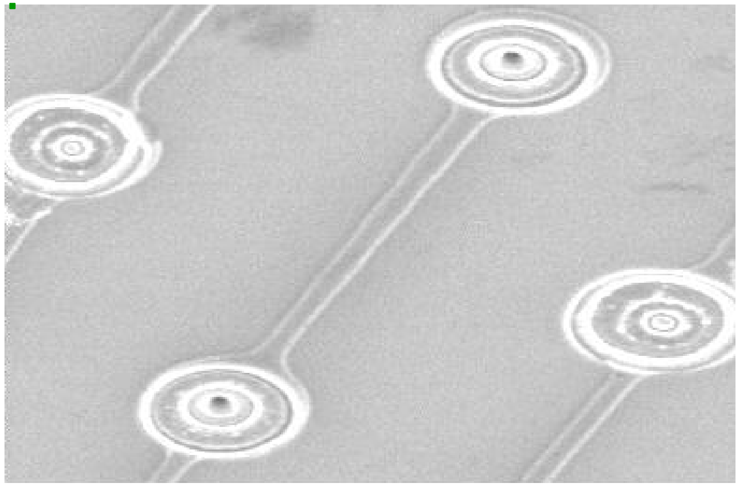
2. Rad-tolerant. Depletion voltage~5V $\rightarrow < 50$ even after heavy dose (~10MRad).

3. Complicated shapes possible (e.g. trapisoid).

4. Can be active all the way to the edge.

Fabrication of 3D pixel sensor





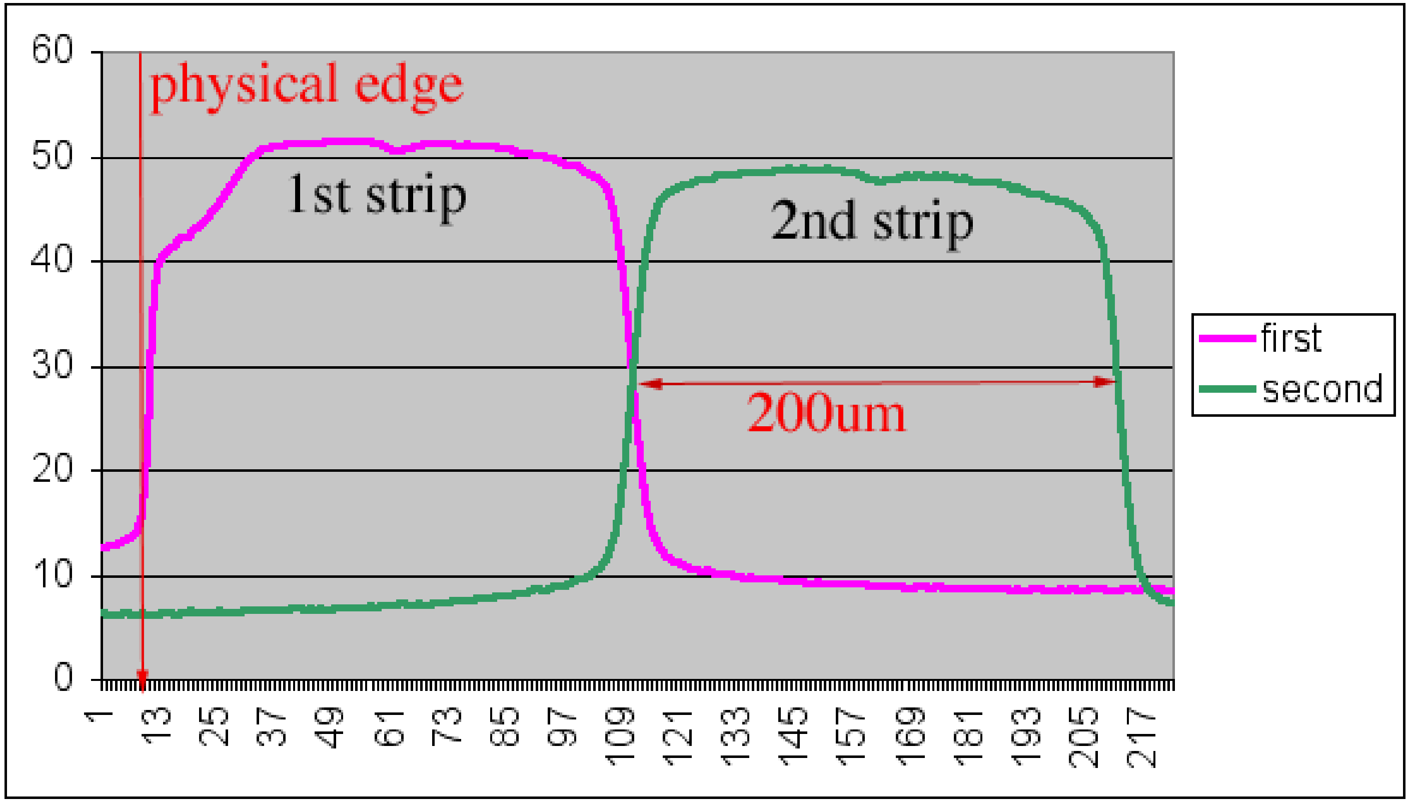
1. Fabricated by S. Parker et. al., at CIS, Stanford).
2. Trapezoidal shape possible for disk or cone. (180μm thick, 200μm readout pitch, 3mm long)
3. Fabrication completed and being tested at LBL and Tohoku.

X-Ray Test (rectangular version)

Goal: establish dead region at electrodes and edges

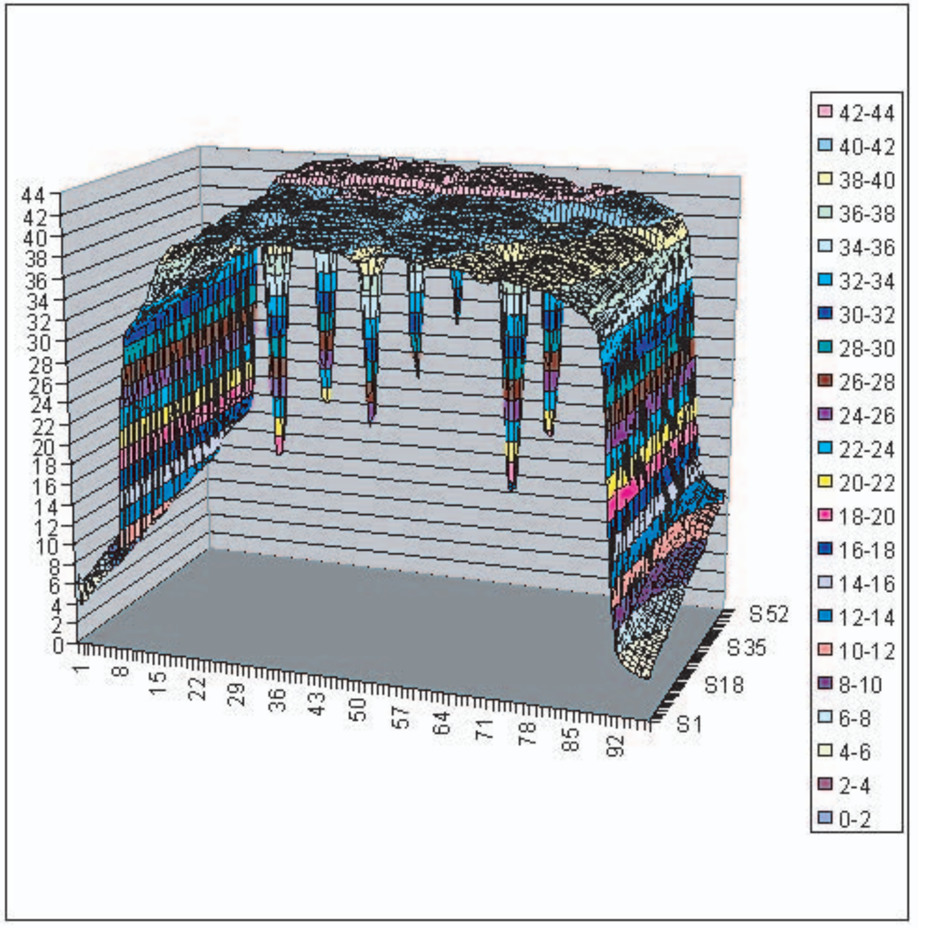
- 180 μm thick, 200 μm readout pitch
- Connected as strips for testing
- ALS (Advanced Light Source) at LBL
- 12 keV synchrotron X-rays
  (penetrates Aluminum metal layers)
- Focused to $\sim$2μm spot size by elipsoisal X-ray mirrors
- Meausre the currents out of strips directly

Strip currents on 1st and 2nd strips



Dead region near edge $2 \pm 2\mu$m

Dead region near electrodes



Current on any strip vs X-ray position (unit: $2\mu m$)

Pixel Readout Chip Prototype.

1. Cuicuit design by KEK and Tohoku.

2. SPICE Simulation study by Tohoku.

3. VLSI layout by a company in Hiroshima.

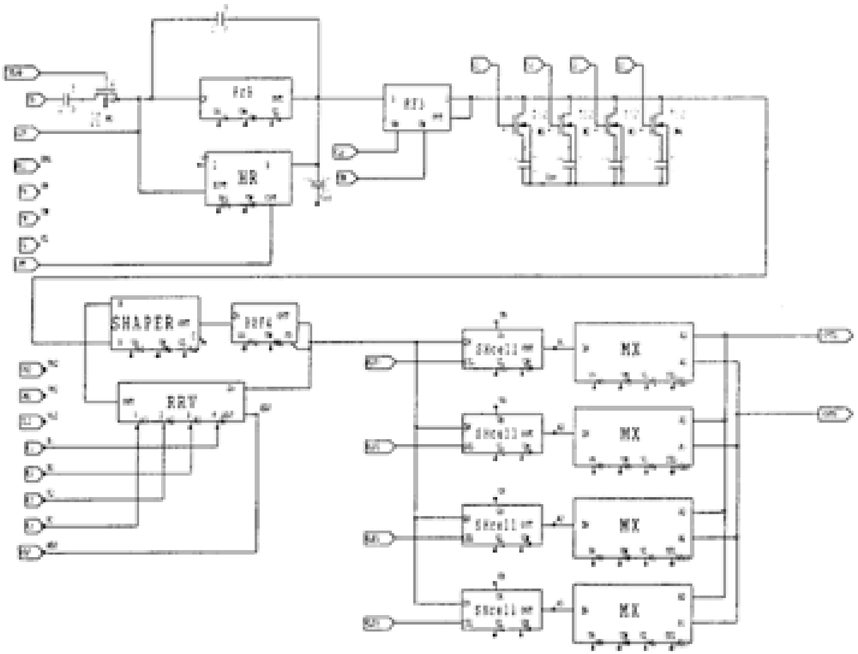
4. Submitted to VDEC (Rohm 0.35μm).

5. Delivered on Jan 20, 2003.

6. Tested at Tohoku.

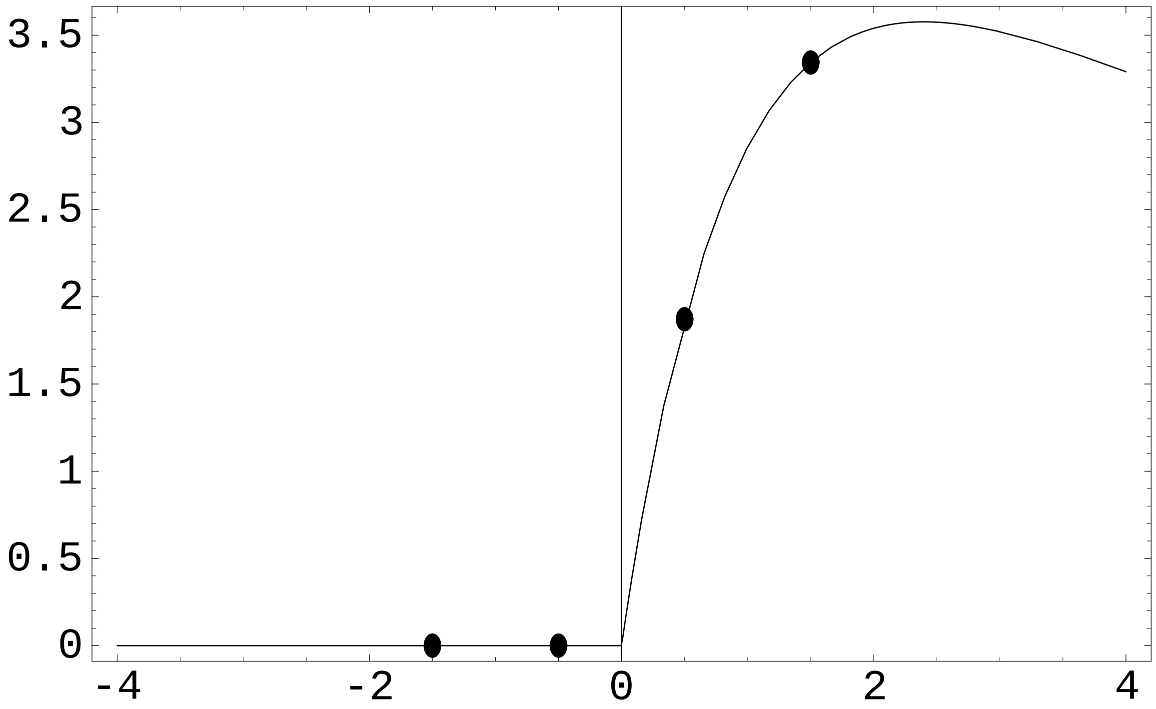
Readout electronics

Block diagram of the circuit



- 32ch per chip (prototype)
- Preamp → RC filter
  → Voltage amp. shaper
  → Sample and Hold
- 4 samplings →
  time and pulseheight
- Serial output of 4 vals/ch.
  as a step function.
- All functions verified.

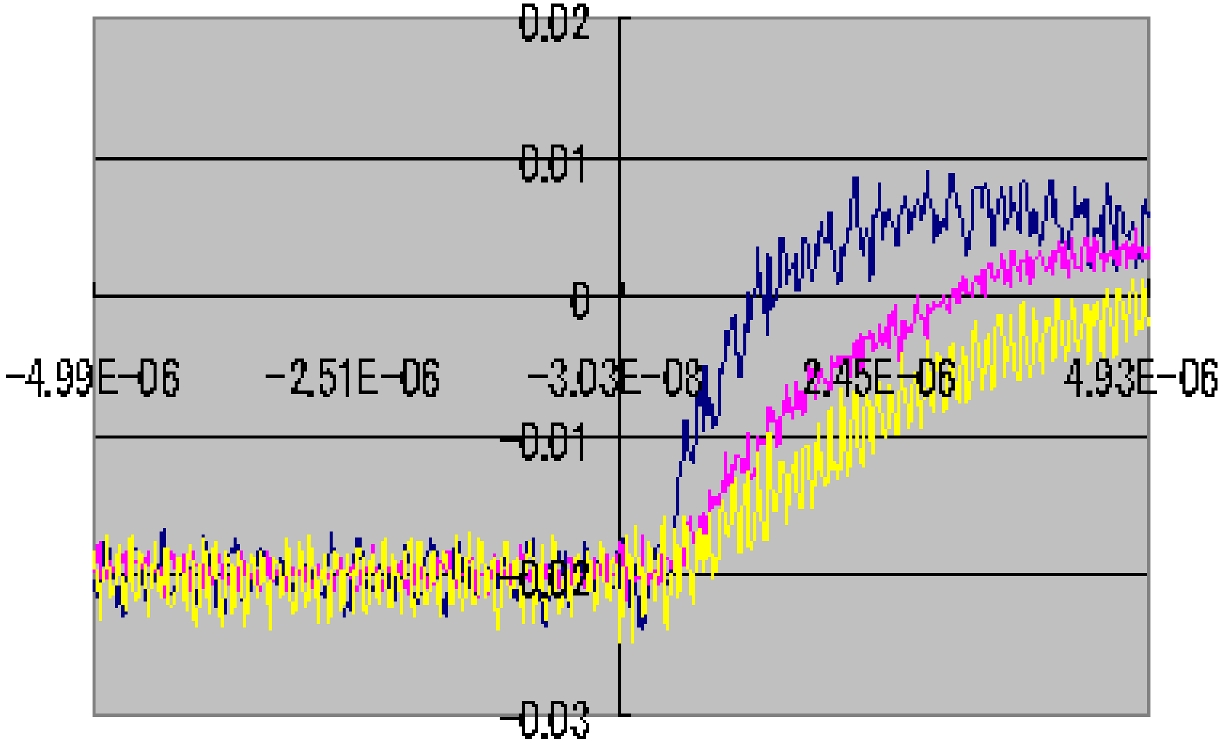
Timing measurement by 4 sample-and-holds 500 ns apart



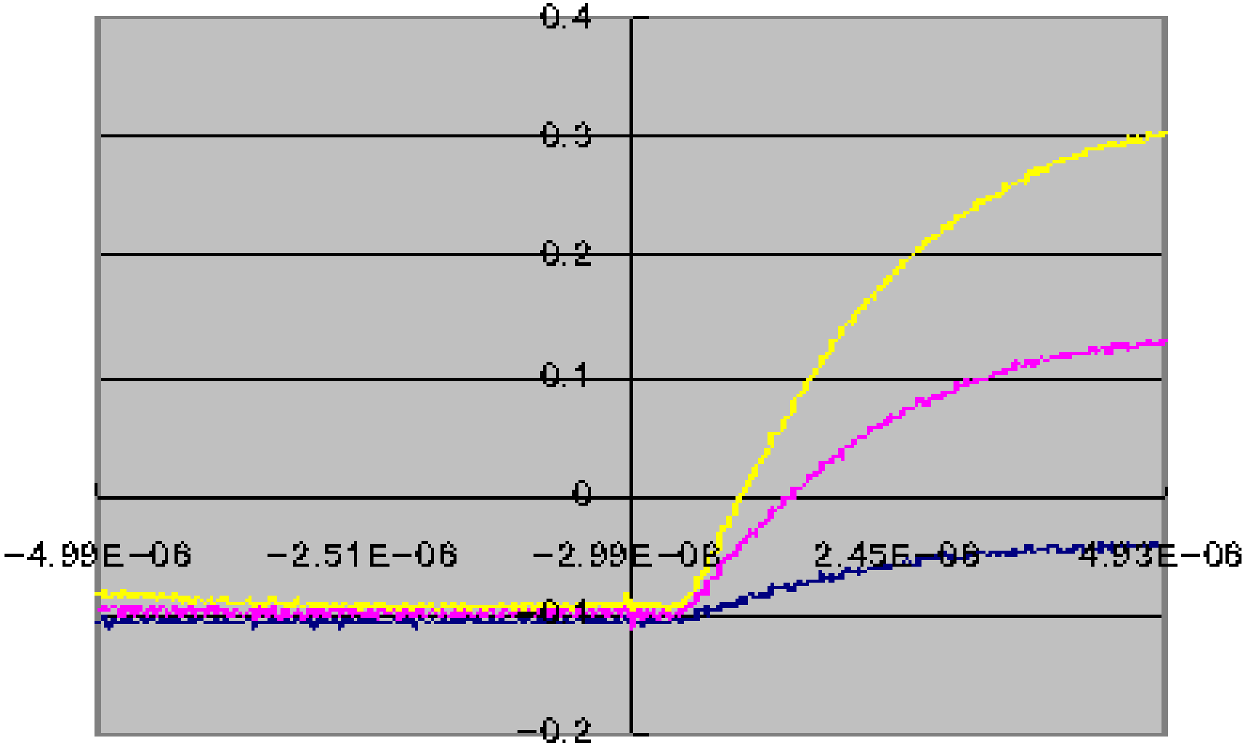
Fit the parametrized function → time and pulse height.

Readout Chip Test w/ Test Pulses

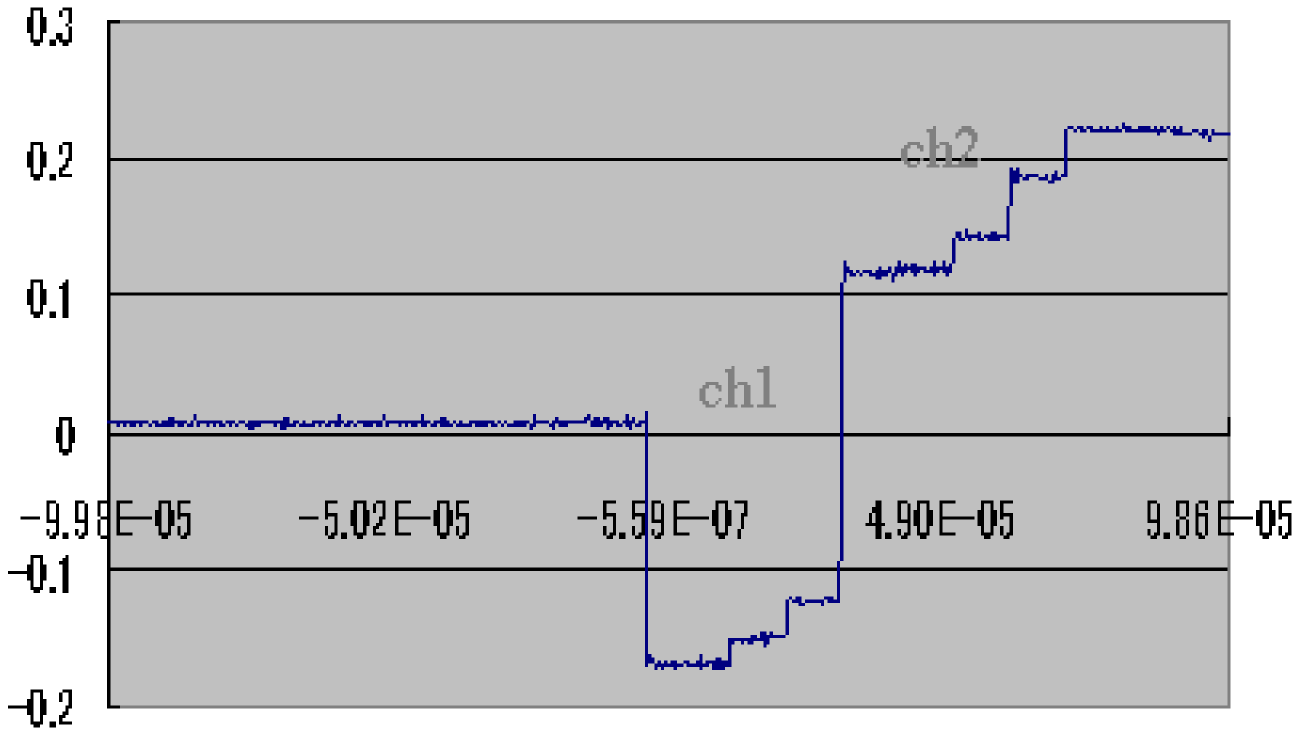
RC filter output (time contant varied)



Voltage amplifier output (gain varied)

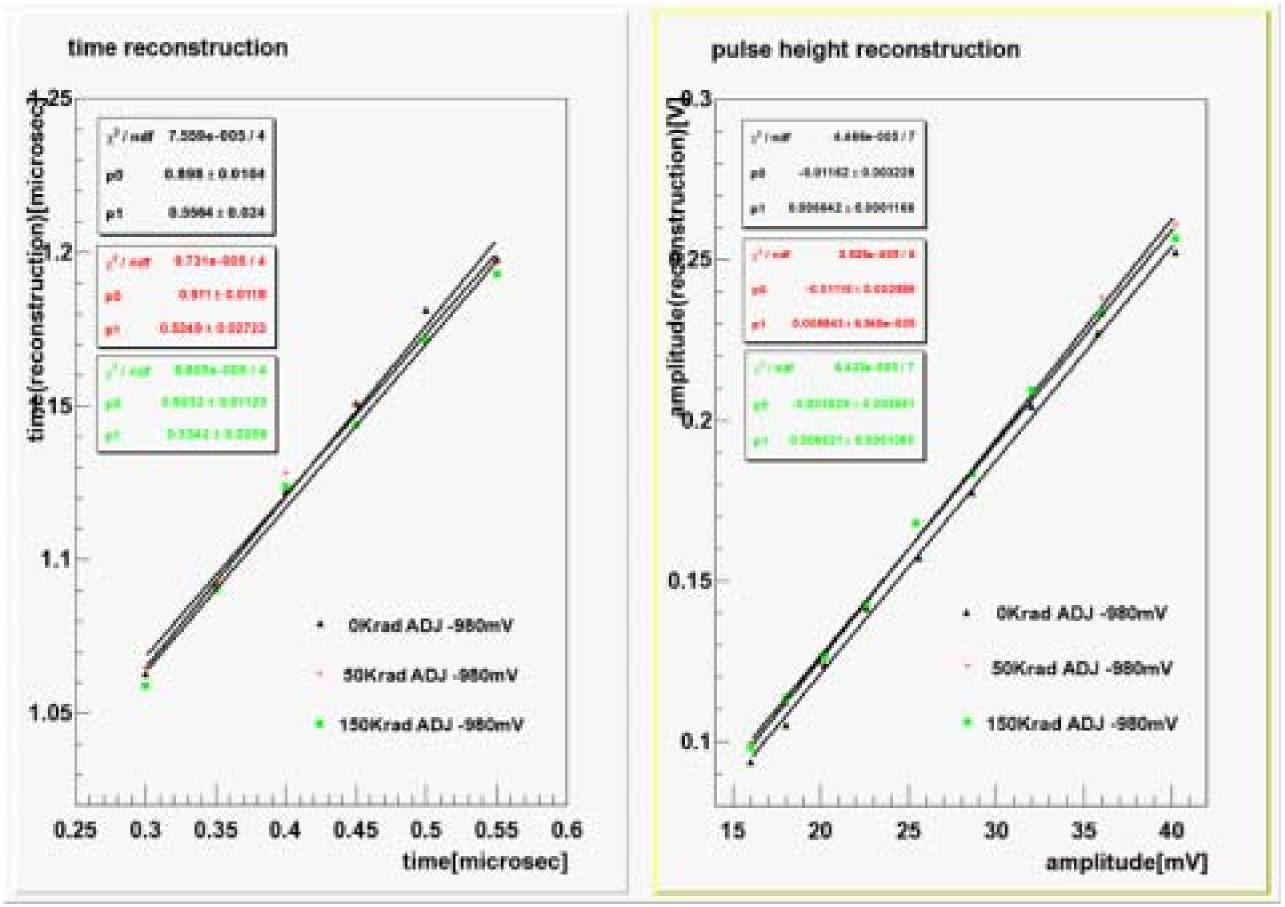


Serial readout output



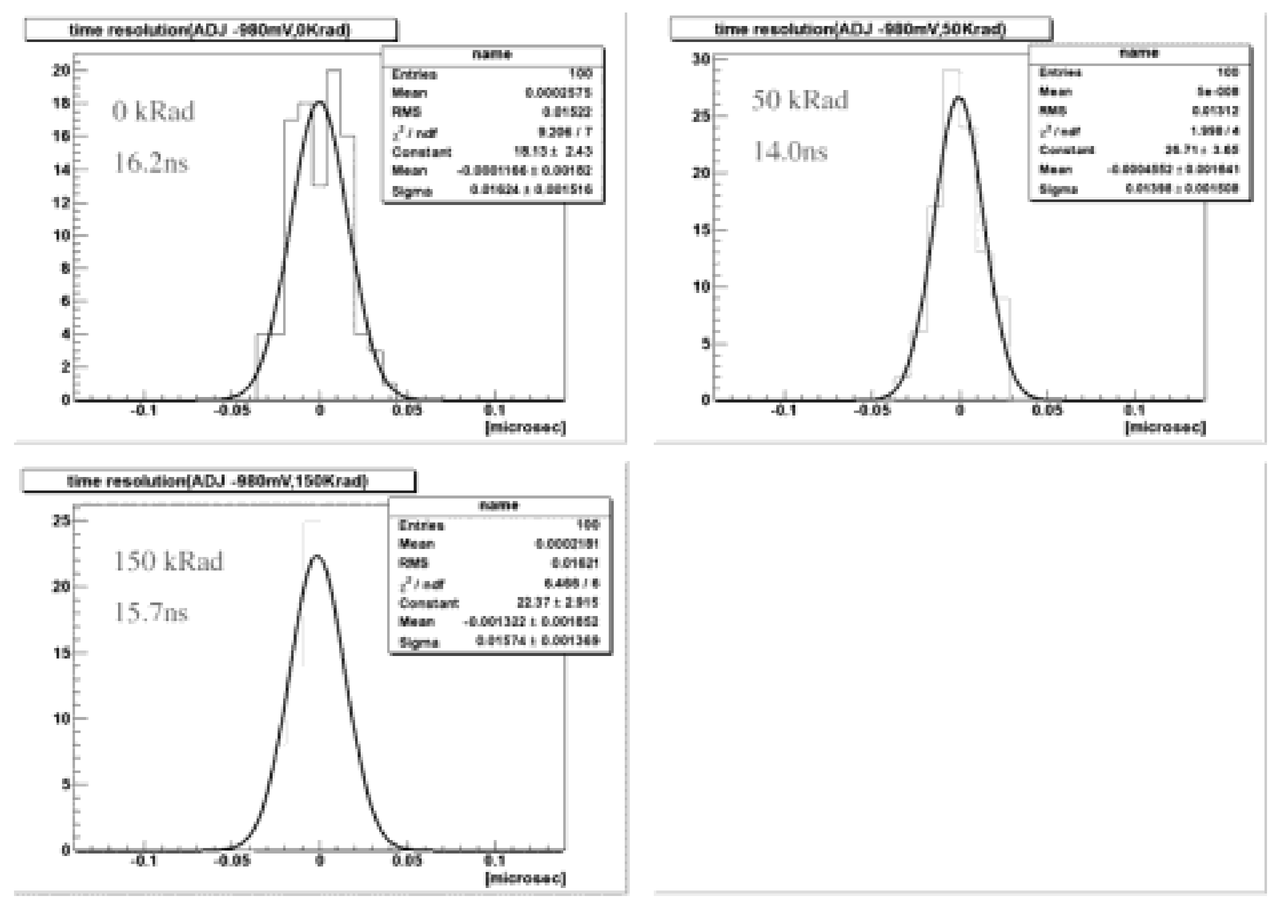
Radiation test (Co60)

2 MRad/yr expected close to the beam.
Just started : upto 150 kRad now - test is on-going.



Radiation test (Co60)

No degradation up to 150 kRad ($\sigma_t \sim 16$ ns)



Next Steps

Sensor

1. Complete the test of the trapezoidal 3D sensor:
   (a) I-V C-V curves.
   (b) IR laser tests.
   (c) Edge effects.

2. Connect an amplifier (candidate is the Viking chip) to the 3D sensor $\rightarrow$ IR laser tests.

Readout chip

1. Complete the radiation test of the readout chip.
2. Design modifications and resubmission (if needed).
3. Solve size issue.
   (it should fit in 0.01 mm^2 and radhard to $\sim$10 MRad)
4. Noise hits?