Beamprofile Monitor R&D Based on 3D Sensor

Brunnel, Hawaii, KEK, Stanford, Tohoku Collaboration

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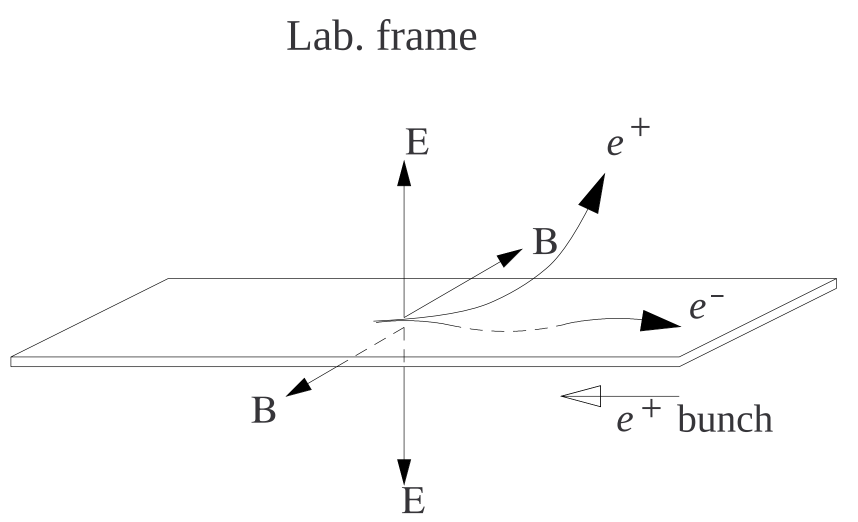
Highlights

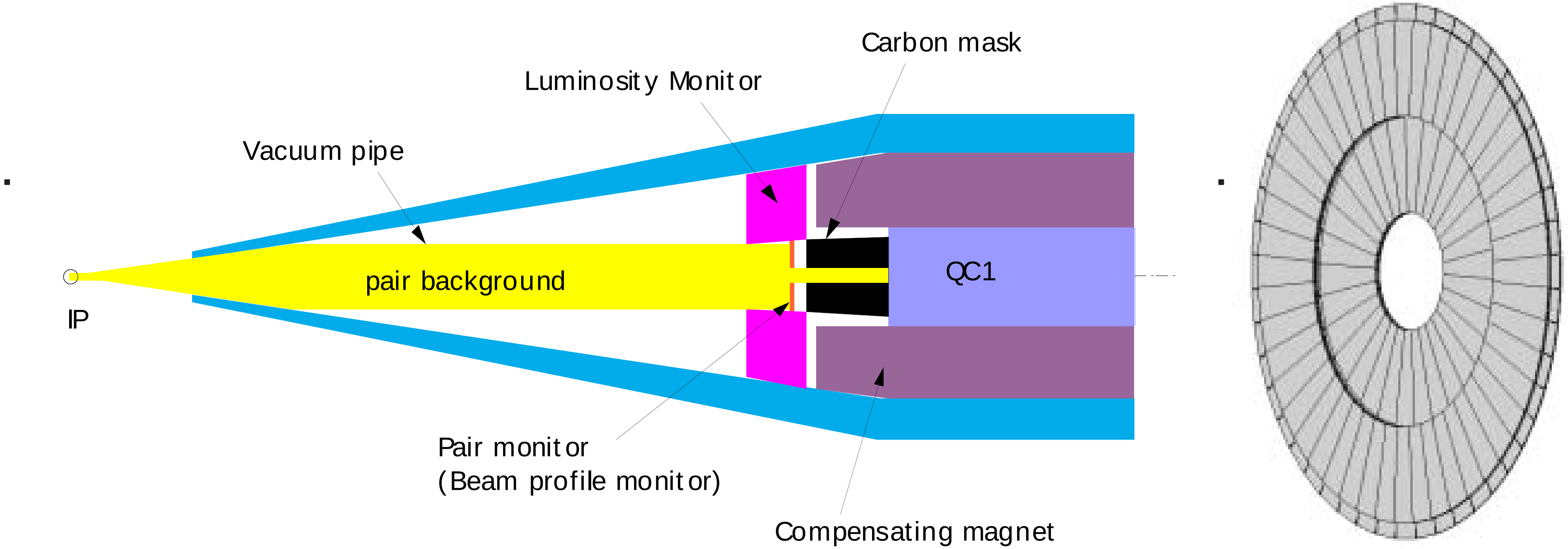
1. Trapezoid 3D sensors fabricated and tested.
2. Pixel readout chip prototype designed, fabricated, and tested.
3. 2 master theses on beanm profile monitor completed:
   Satoshi Tanaka, on the pixel readout electronics.
   Manabu Saigo, on MC study of beam profile measurement.

Kinematic Configuration of Pair 'Background'



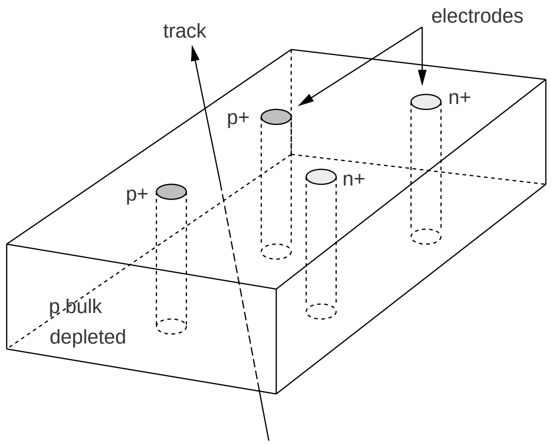
- For an incoming e^+ bunch,
  e^- oscillates around the beam plane.
  e^+ acquires a large p_t kick (vertical).
- Round beam $\rightarrow$ no ϕ dependence,
  ϕ dependence $\rightarrow$ σ_y/σ_x ratio.

- Bunch identification desirable
  (at least roughly: $\sigma_t < 25ns$)
- High rate expected (10hits/train/mm^2)



Outer radius ~8cm. One on each side of IP.

3D pixel sensor



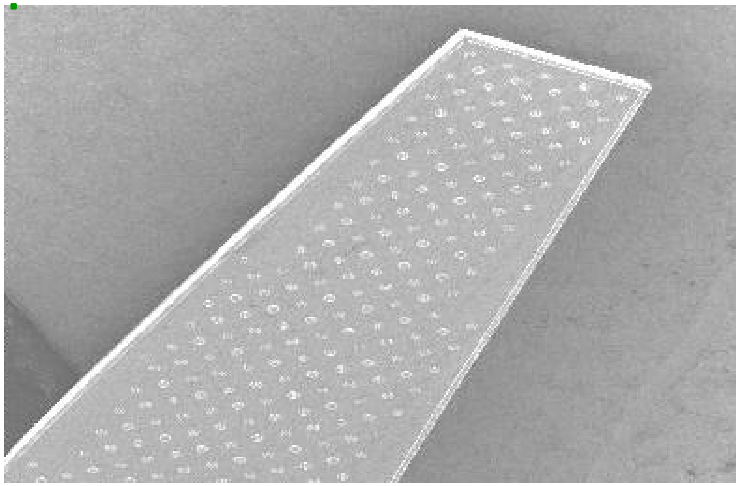
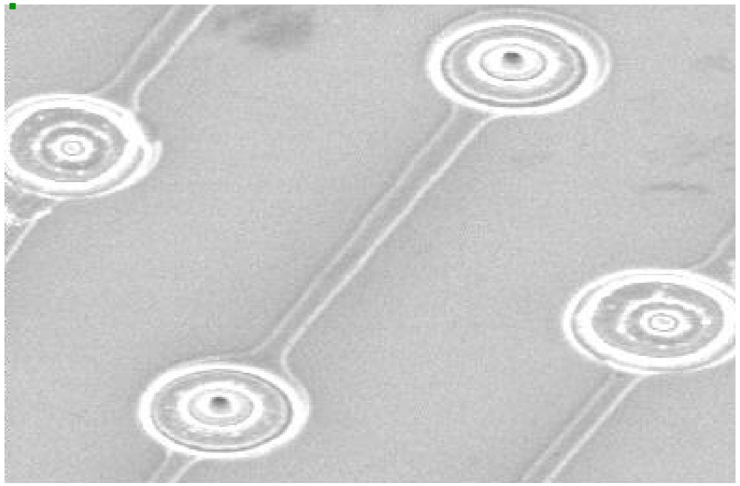
1. Fast. Charge collection time 10ns: ~10 times faster than conventional pixel sensor.

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

3. Complicated shapes possible.

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

Fabrication of 3D pixel sensor

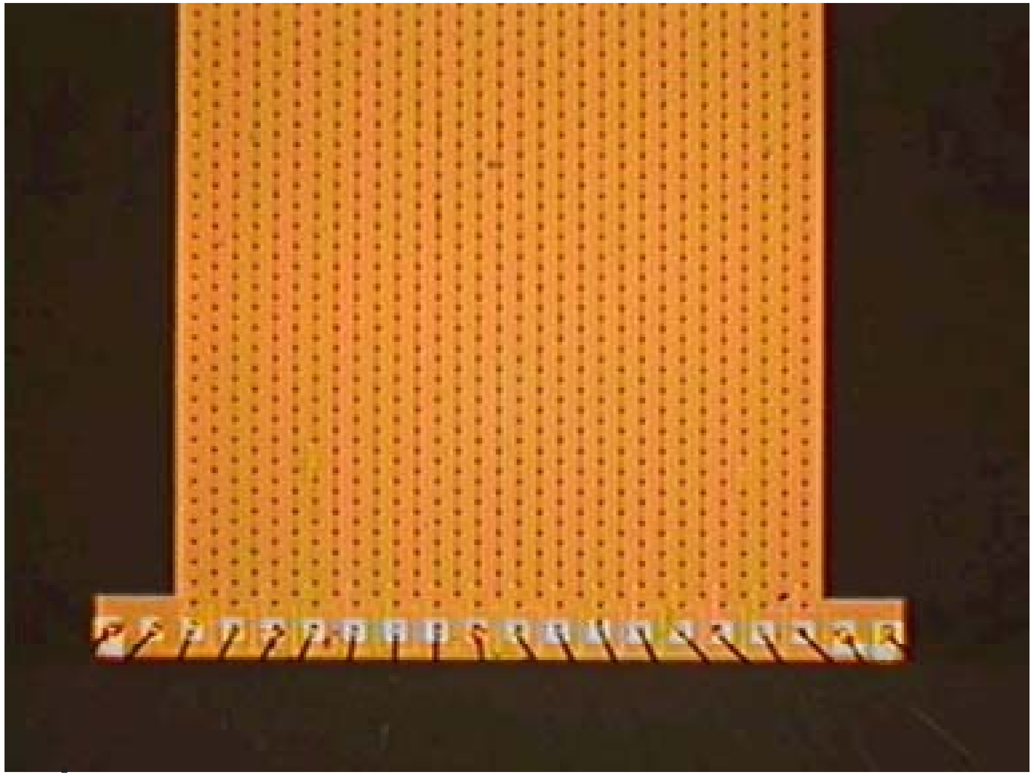
 

1. Fabricated by S. Parker et. al., at CIS, Stanford).

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.

Rectangular version tested by X-ray



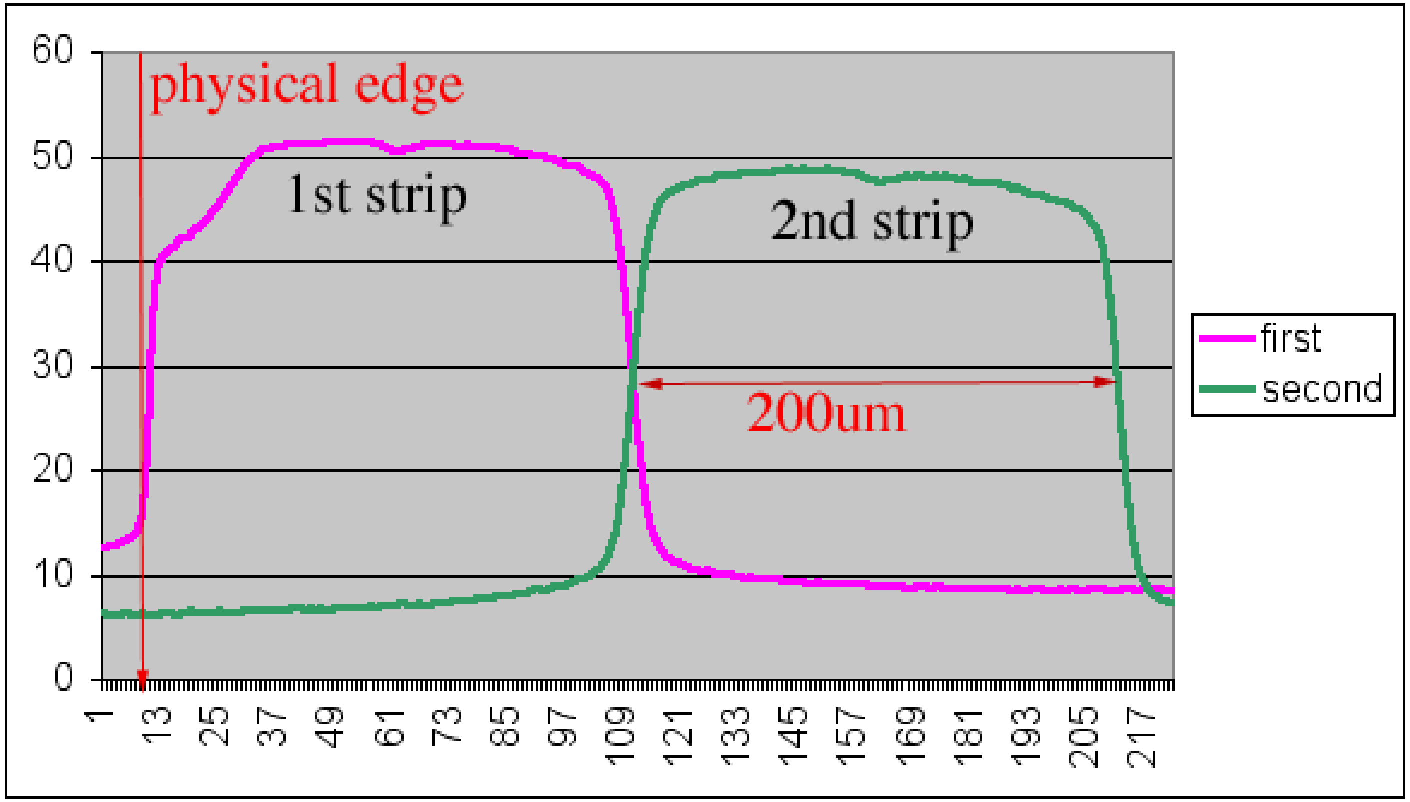
- 180μm thick
- 200μm readout pitch
- electorde $\phi \sim 15\mu$m
- arranged as strips for testing

X-Ray Test

Goal: establish dead region at electrodes and edges

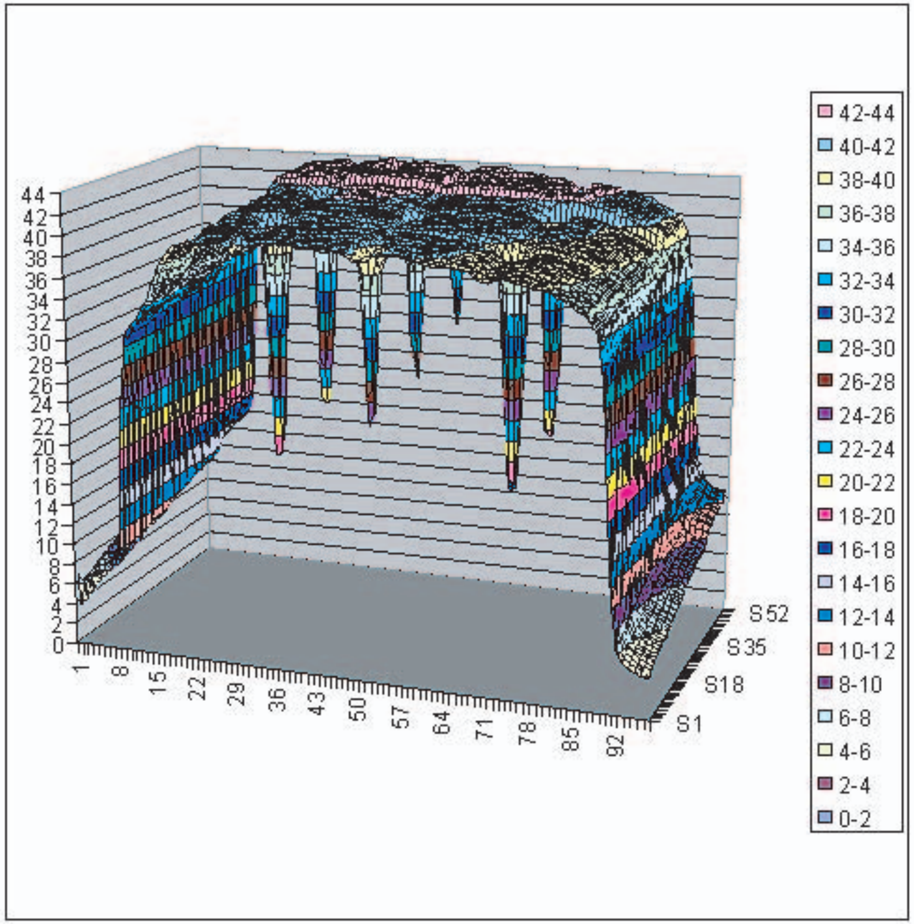
- ALS (Advanced Light Source) at LBL
- 12 keV synchrotron X-rays
  (penetrates Aluminum metal layers)
- Focused to $\sim 2\mu$m spot size by elipsoisal X-ray mirrors
- Meausre the currents out of strips directly

Strip currents on 1st and 2nd strips



Dead region near edge $5 \pm 5\mu$m

Dead region near electrodes



Current on any strip vs X-ray position (unit: 2μm)

Silicon Lab. at Tohoku U.

1. Summit 9551U probe station (operational).
2. Kulicke&Soffa manual bonder (operational).
3. Agilent 4156c parametric analyser (operational).
4. IR laser system (being implemented).

Trapezoidal 3D sensors to be tested soon.

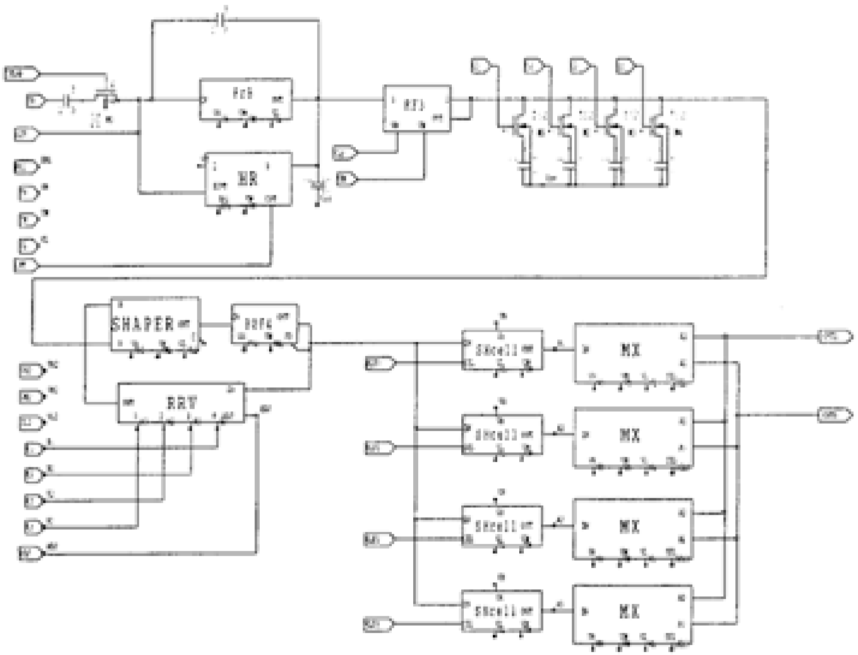
Pixel Readout Chip Prototype.

1. Collaboration with KEK (Prof. Ikada).
2. Cuicuit design by Ikeda (KEK) and Tanaka (a Tohoku student).
3. SPICE Simulation study by Tohoku (Tanaka).
4. VLSI layout by a company in Hiroshima.
5. Submitted to VDEC (Rohm 0.35μm).
6. Delivered on Jan 20, 2003.
7. Tested at Tohoku.

All functions verified. (it's working!)

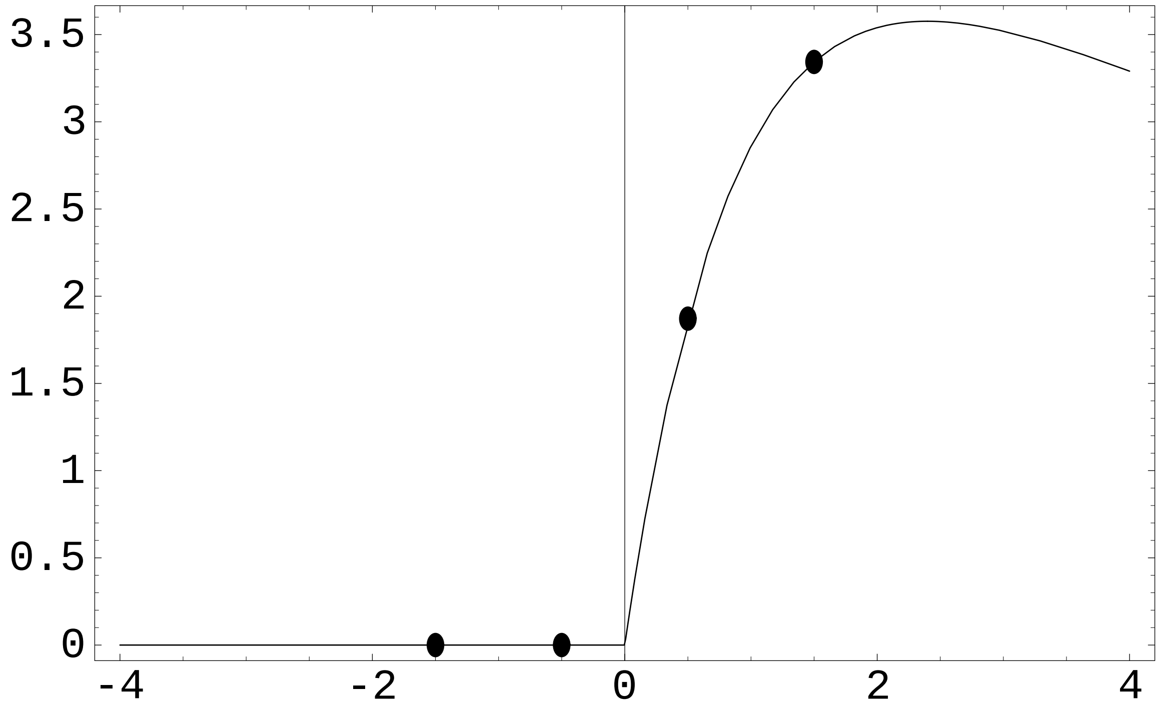
Readout electronics

Block diagram of the circuit



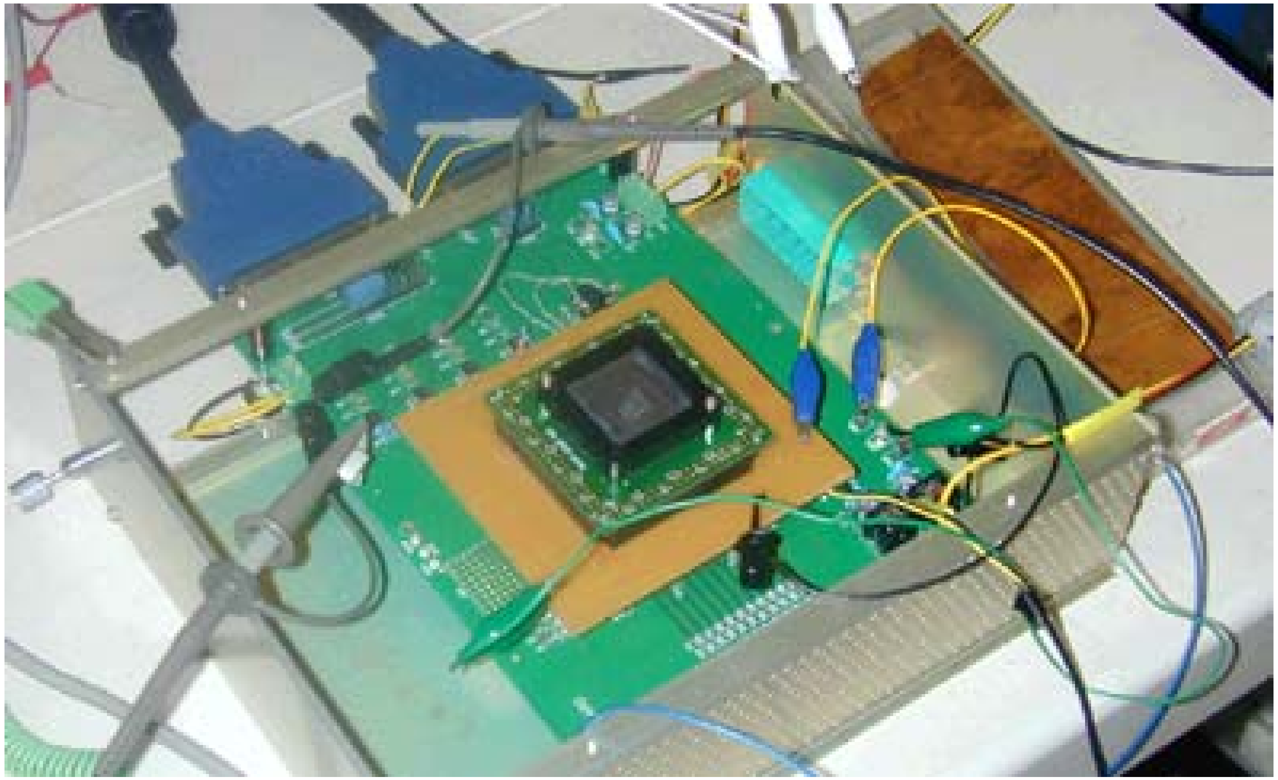
- 32ch per chip (prototype)
- Preamp → RC filter
  → Voltage amp. shaper
  → Sample and Hold
- 4 samplings →
  time and pulseheight
- Serial output of 4 vals/ch.
  as a step function.

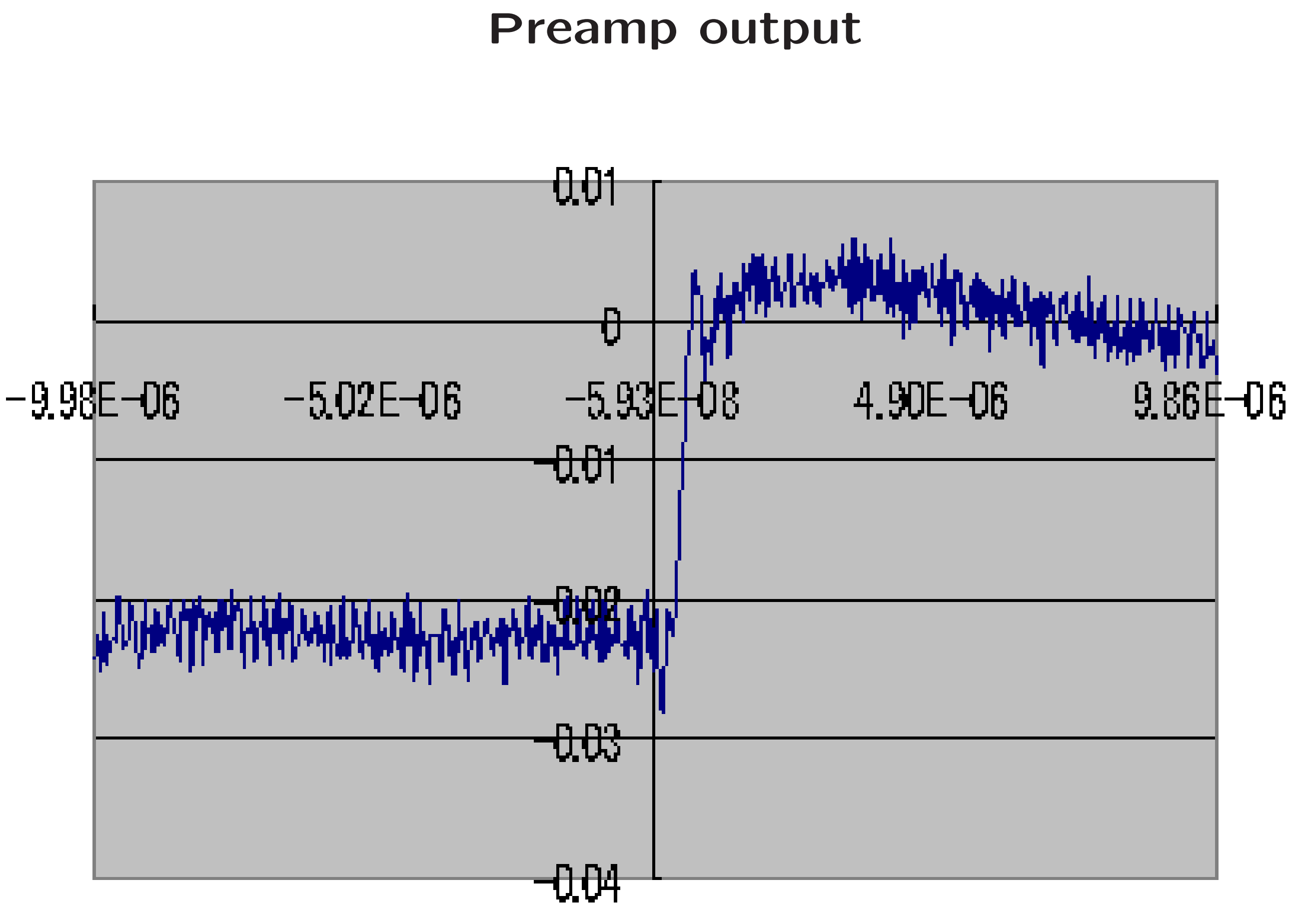
Timing measurement by 4 sample-and-holds



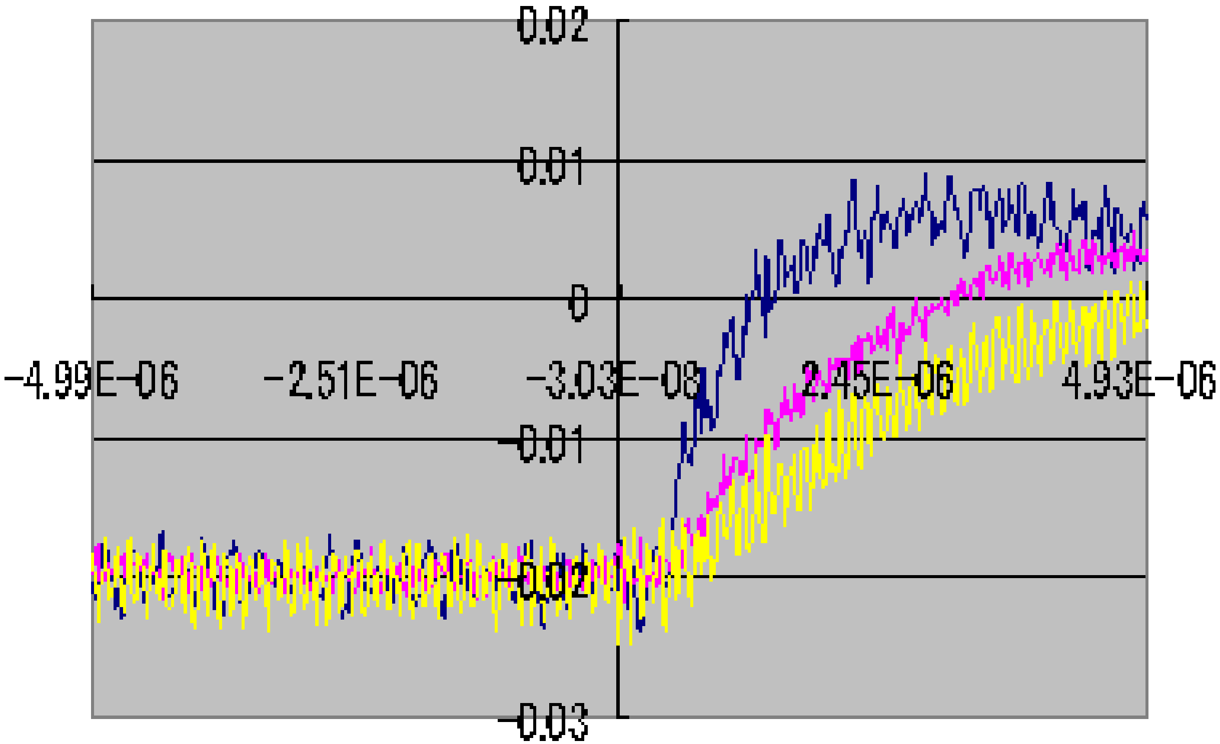
Preliminary resolution: ~ 10ns achielved.

Readout Chip Test

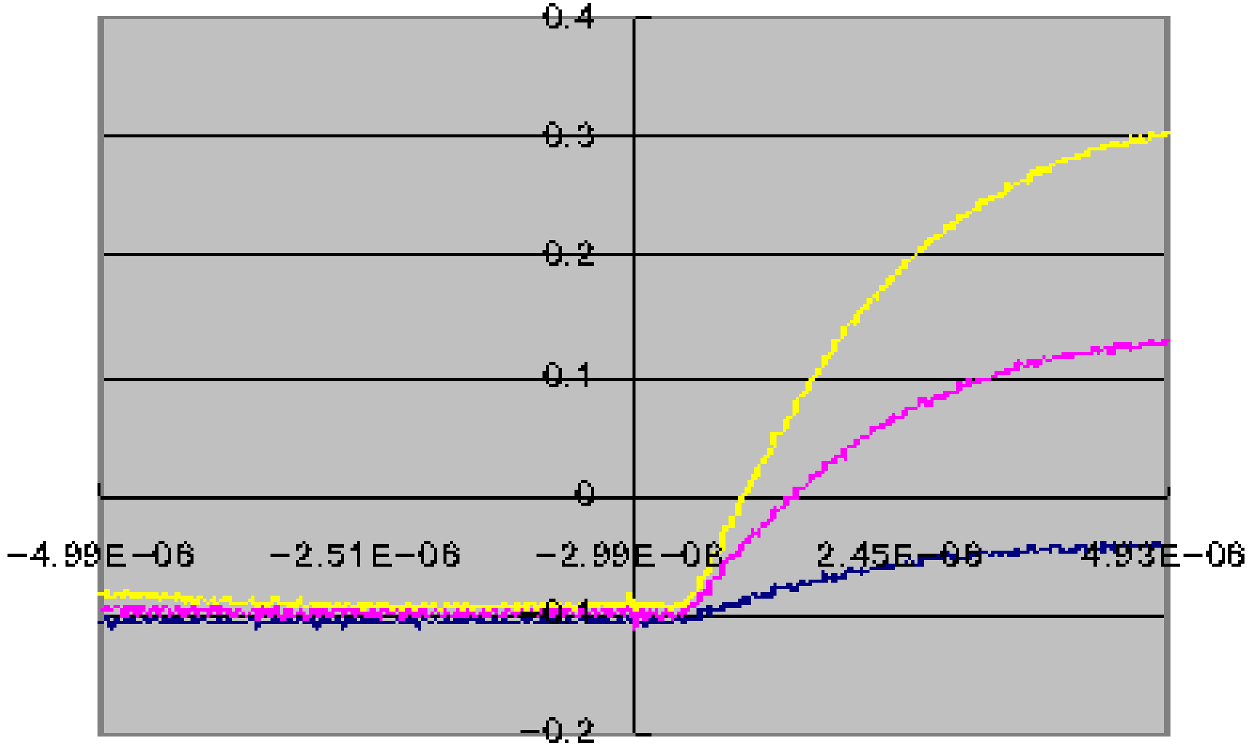



Preamp output
0.01
0
-0.01
-0.02
-0.03
-0.04
-9.98E-06
-5.02E-06
-5.93E-08
4.90E-06
9.86E-06

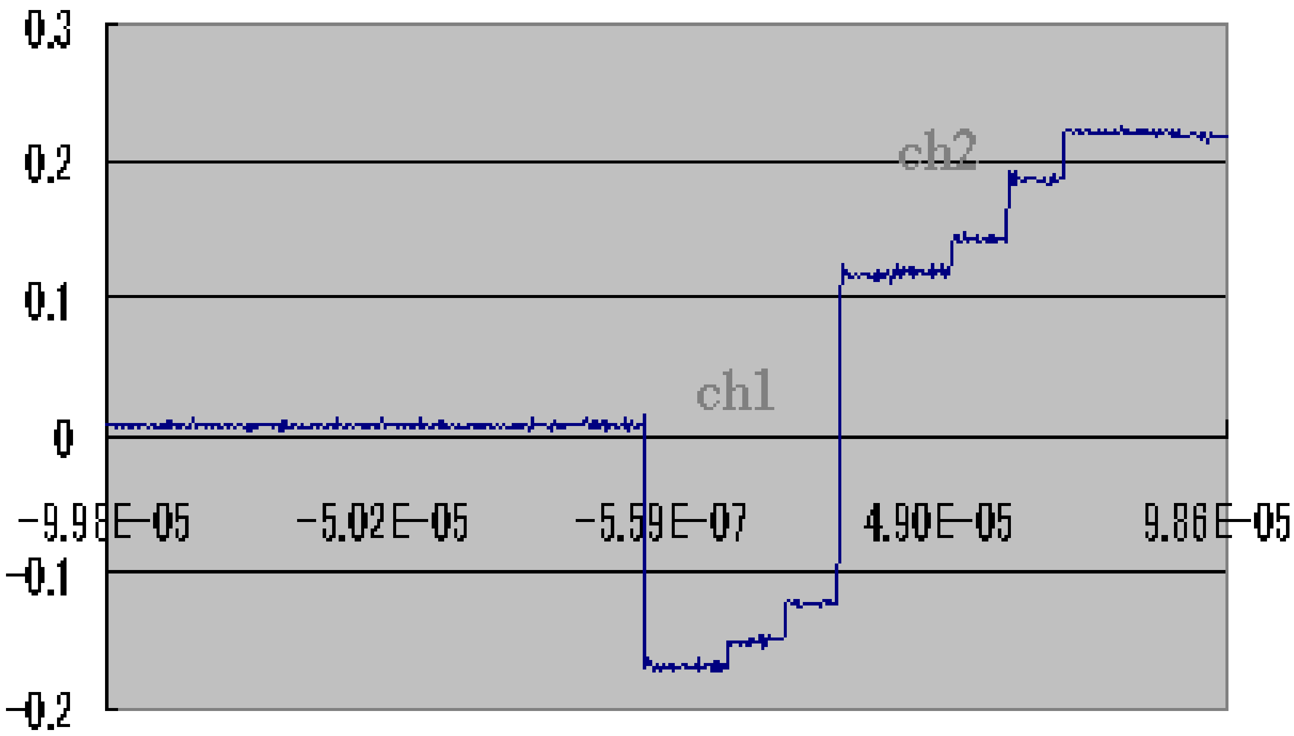
RC filter output (time contant varied)



Voltage amplifier output (gain varied)



Serial readout output



Next Steps

- A new student assigned (Uneda-kun).
- A new postdoc to arrive specifically for this project this summer (Tohoku U.).

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 $\longrightarrow$ IR laser tests.

Readout chip

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