Beamprofile Monitor R&D based on 3D Sensor

Collaboration of
Brunnel, Hawaii, KEK, Stanford, Tohoku

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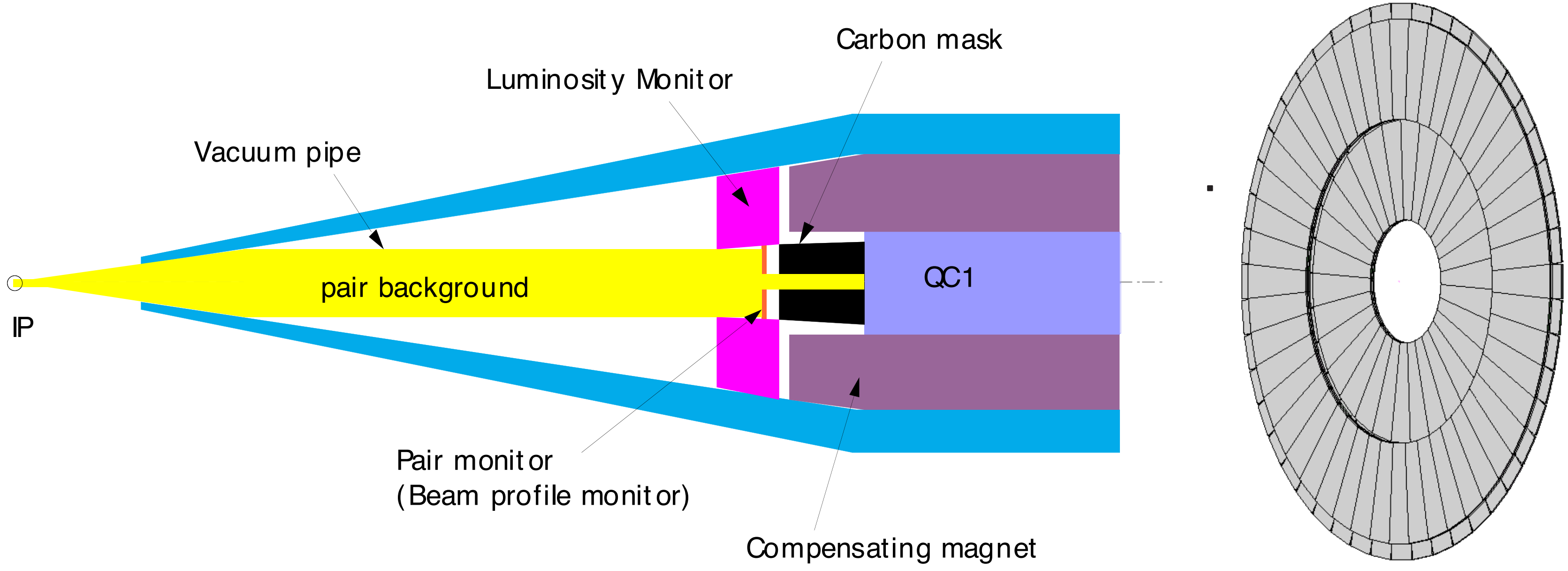
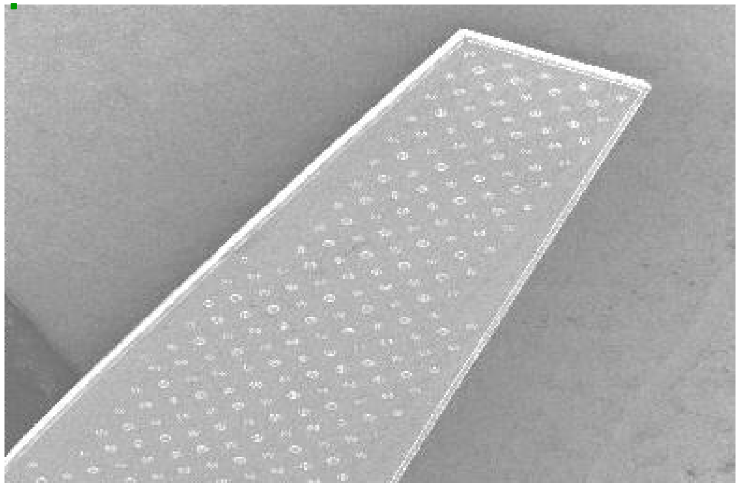
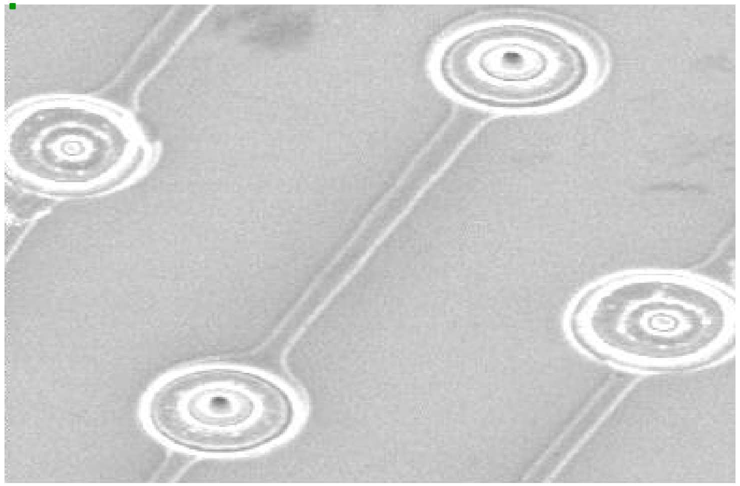
LCWS Paris, April 20, 2004.



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

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)

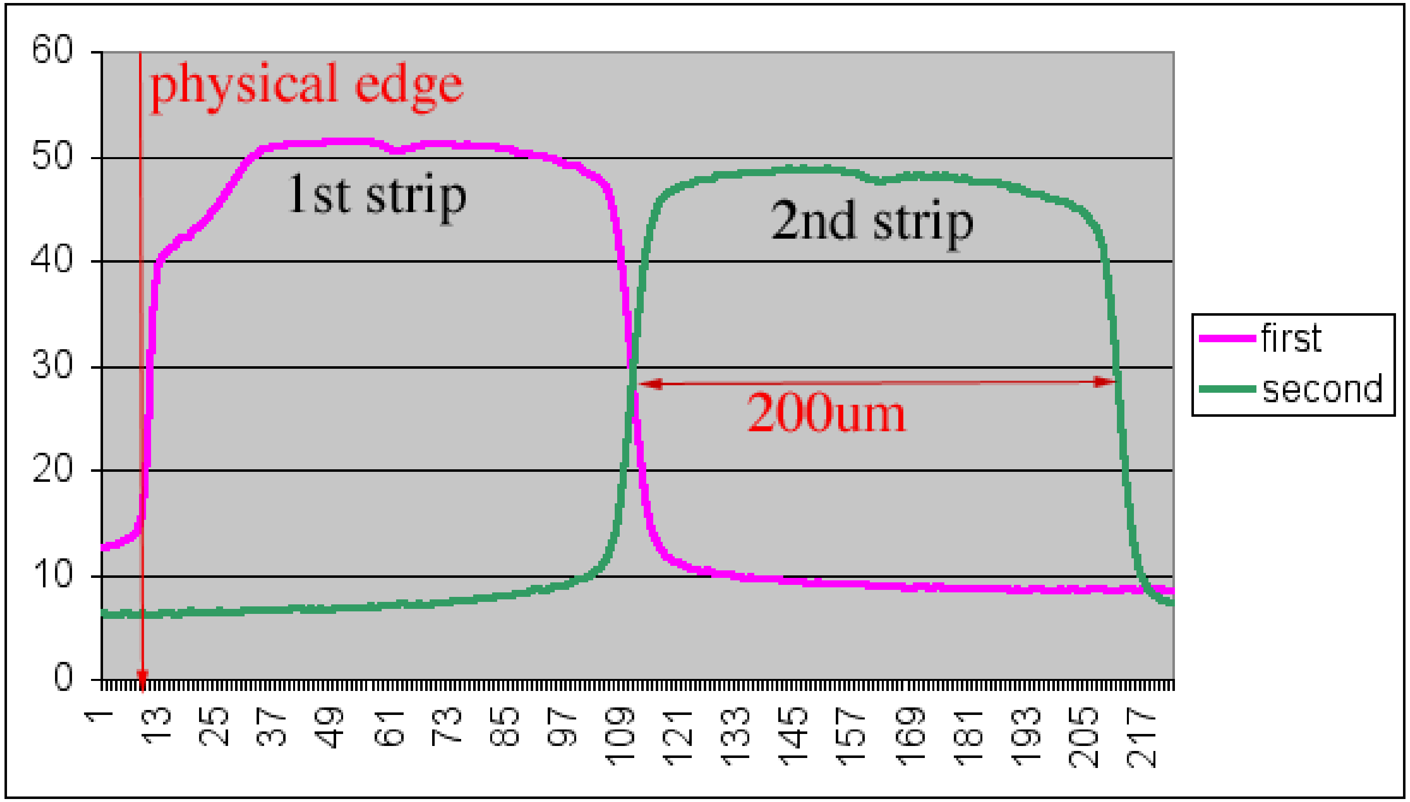
3. Fabrication completed and being tested at LBL and Tohoku.

X-Ray Test (rectangular version)

Goal: establish dead region at electrodes and edges

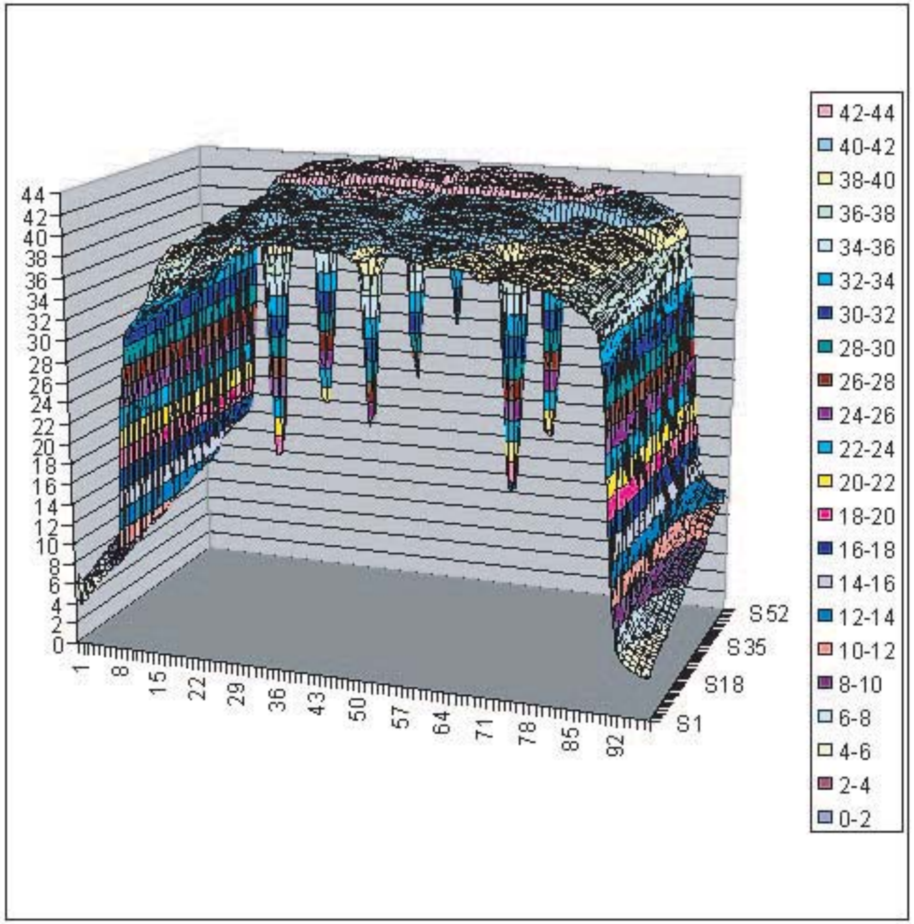
- 180 μm thick, 200 μm readout pitch
- Connected as strips for testing
- ALS (Advanced Light Source) at LBL
- 12 keV synchrotron X-rays
  (penetrates Aluminum metal layers)
- Focused to $\sim 2\mu$m spot size by elipsoisal X-ray mirrors
- Meausre the currents out of strips directly

Strip currents on 1st and 2nd strips



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

Dead region near electrodes



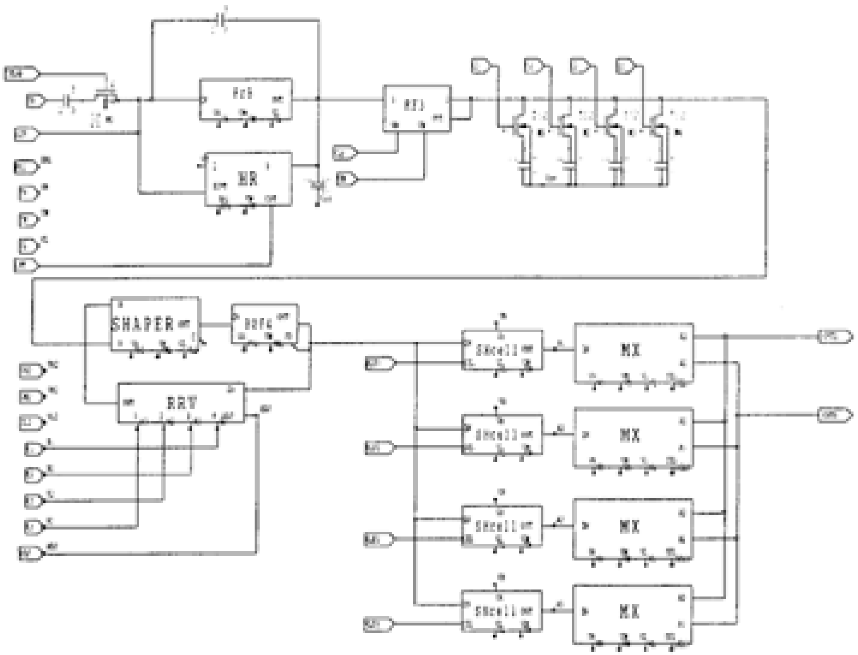
Current on any strip vs X-ray position (unit: 2μm)

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.
7. Modifications in design ready for submission.

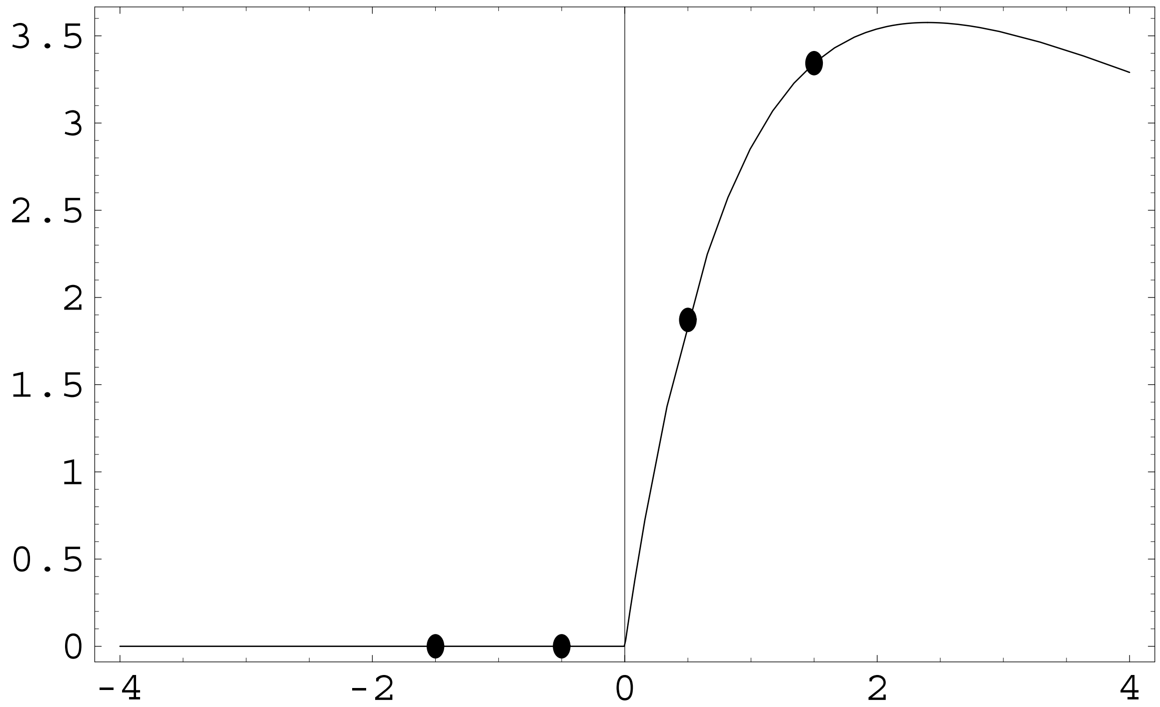
Readout electronics

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.

Reconstruction of the hit time

$$v_1 = A\left(1 - \exp(-\frac{t_1 - t_0}{\tau})\right) e^{-\frac{t_1-t_0}{T}}$$
$$v_2 = A\left(1 - \exp(-\frac{t_2 - t_0}{\tau})\right) e^{-\frac{t_1-t_0}{T}}$$

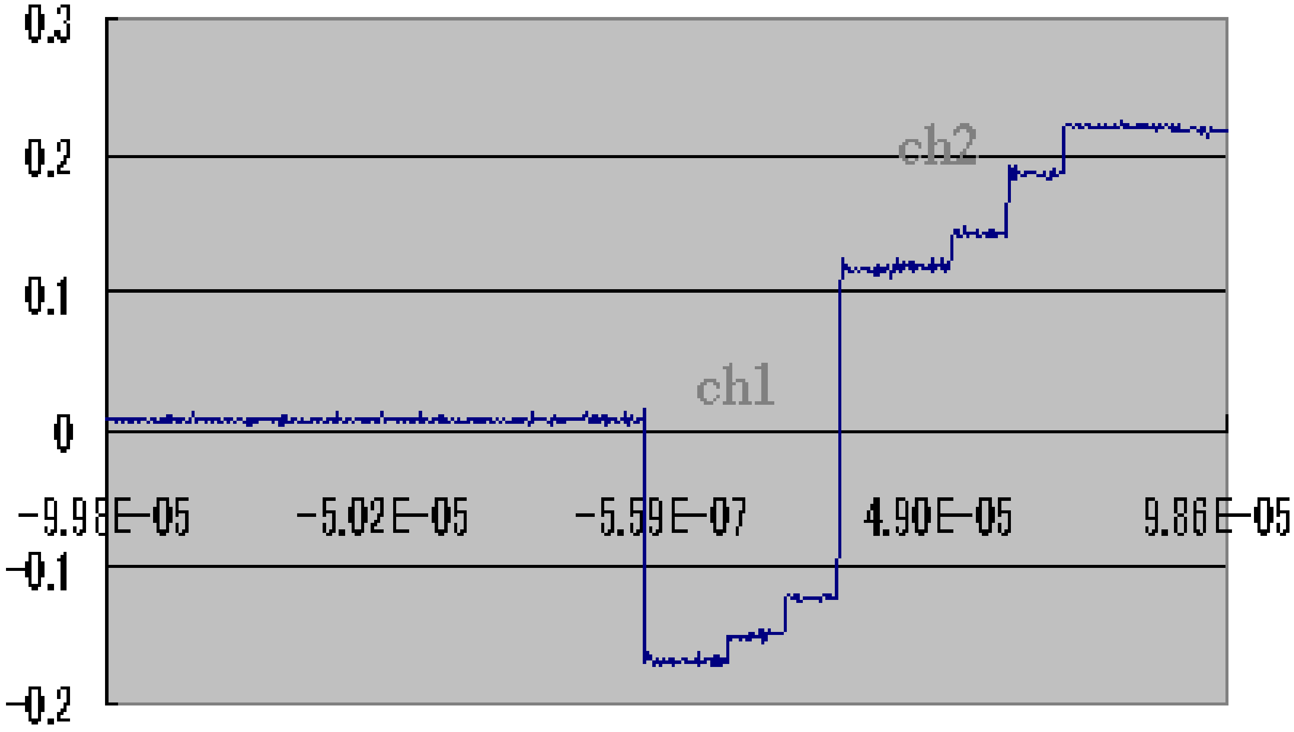
$\tau = RC$: time constant of the rise time.
T: time constant of the decay time.

$$t_0 = \tau \log \frac{v_2 - v_1}{v_2 \exp(-\frac{t_1}{\tau}) - v_1 \exp(-\frac{t_2}{\tau})}$$

Then the pulseheight A can also be rfeconstructed.

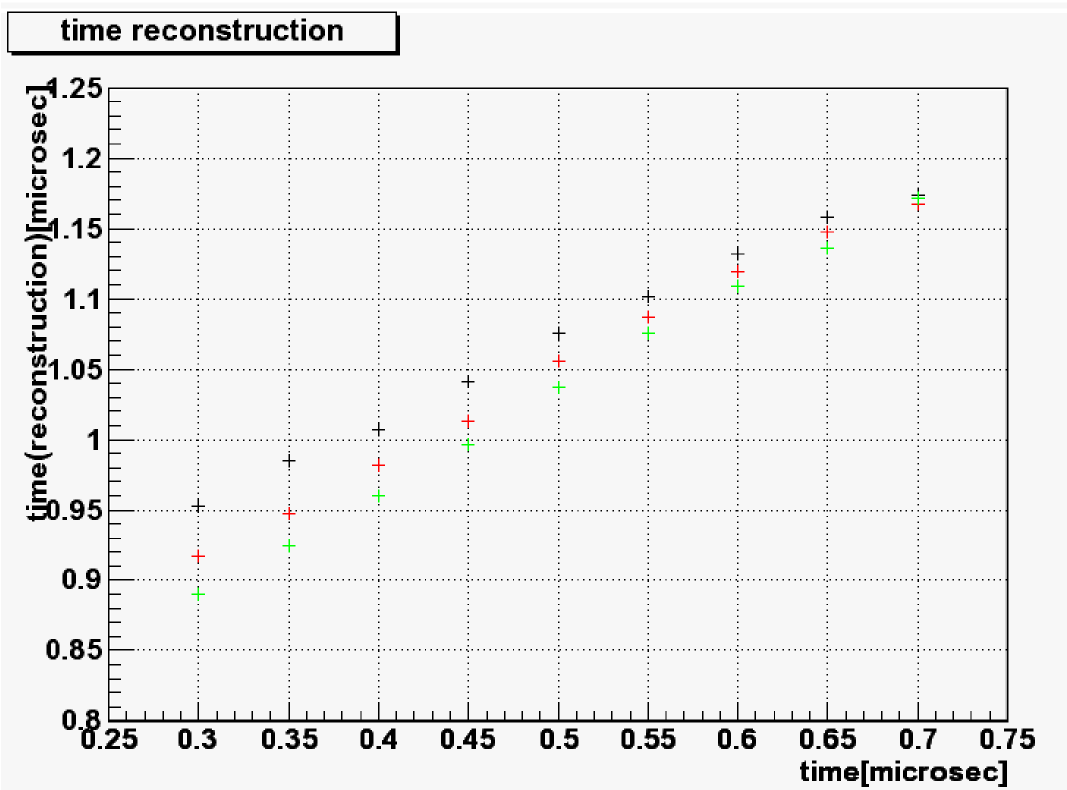
$$A = \frac{v_1}{\left(1 - \exp(-\frac{t_1-t_0}{\tau})\right) e^{-\frac{t_1-t_0}{T}}}$$

Serial readout output



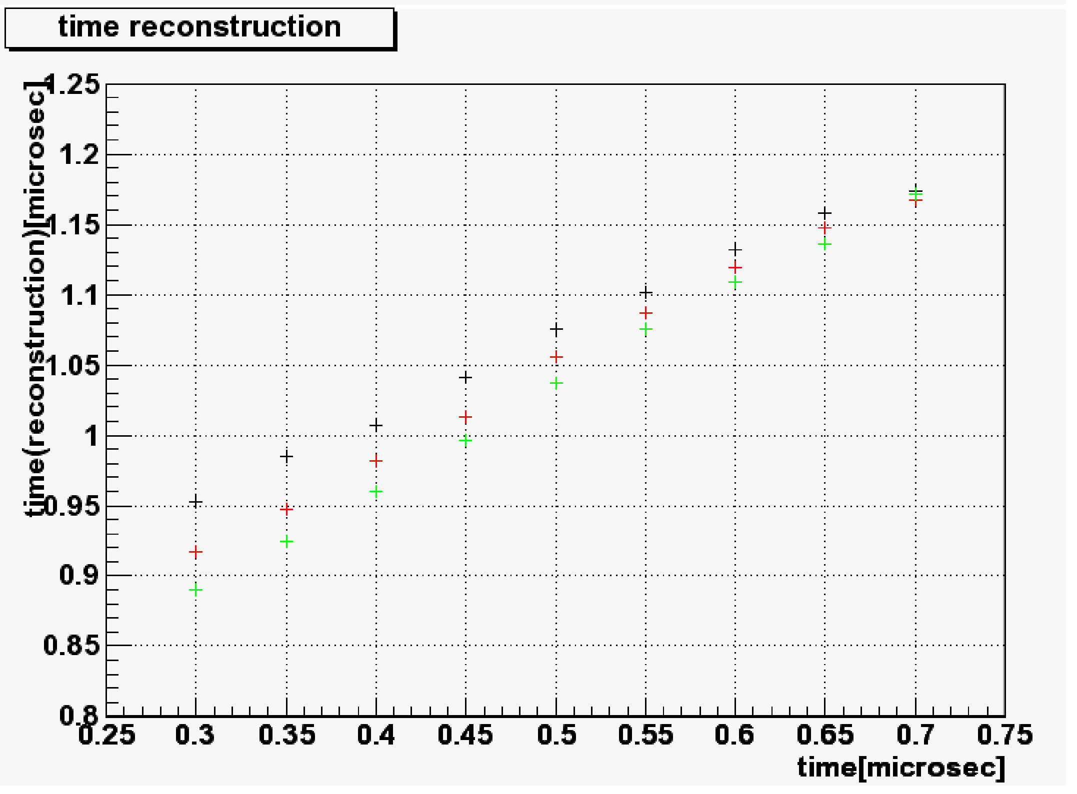
Large offests for each channel observed.
Some channels saturated.

Time reconstruction (test pulse injection)



$+$: $\tau = 0.3\mu$s, $+$: $\tau = 0.5\mu$s, $+$: $\tau = 0.8\mu$s

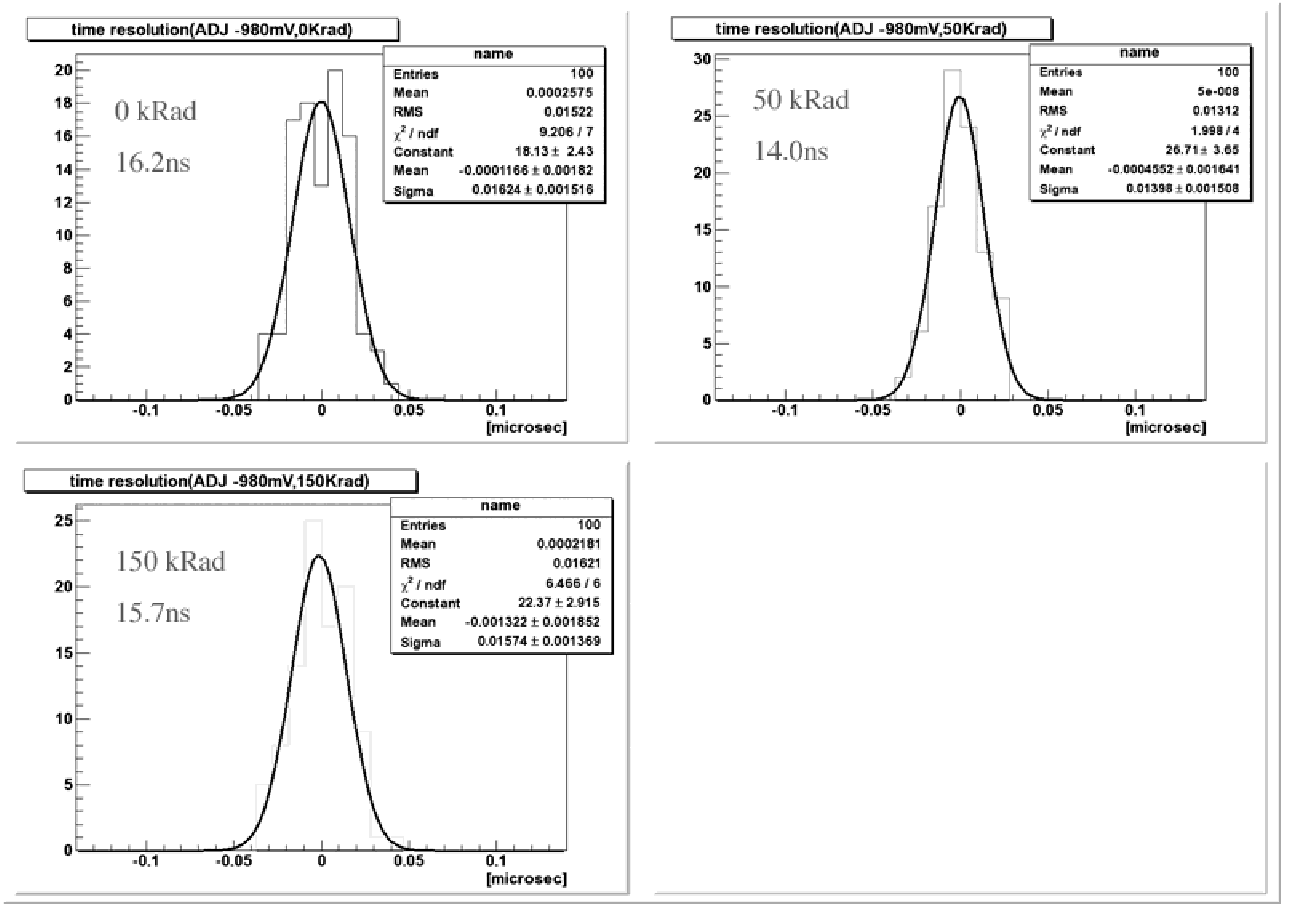
Pulse height reconstruction (test pulse injection)



+: $\tau = 0.3\mu$s, +: $\tau = 0.5\mu$s, +: $\tau = 0.8\mu$s

Find the effective τ that works.

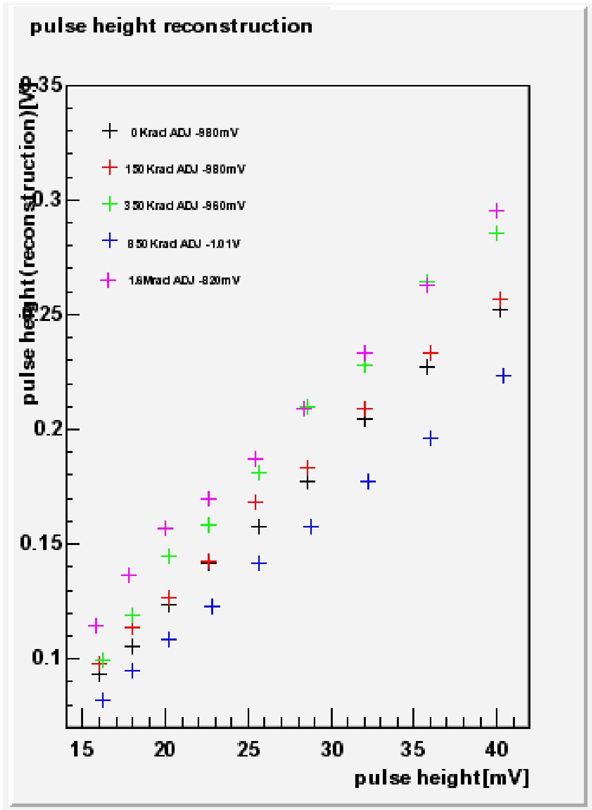
Time resolution

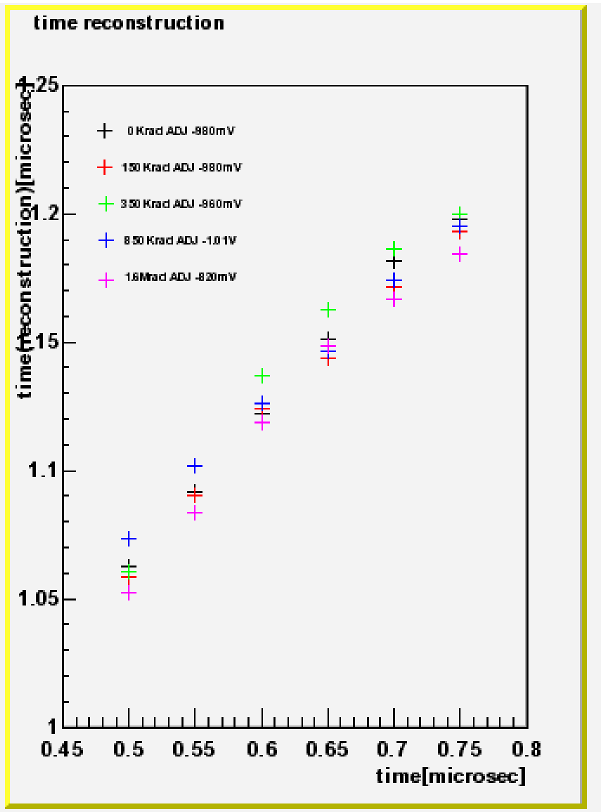


Radiation test (Co60)

(2 MRad/yr expected close to the beam.)

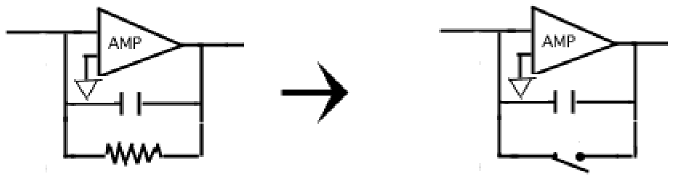
Withstands up to (at least) 1.8 MRad





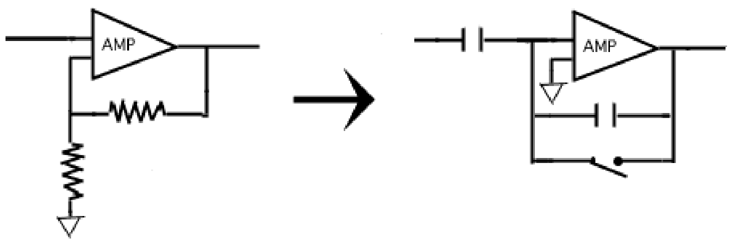
Modification of the ciriut

Preamp



Removes uncertainly of time constant.
Possibly better time (and pulse height) resolution.

Output amp



Hope to reduce the channel-dependent offset.

→ Submitting to VDEC

Next Steps

1. Fabrication of the modfified cuitcuit.

2. Tests of the modified chips.

3. Shrink the size.

4. Noise tolerance.