Pair Monitor Studies

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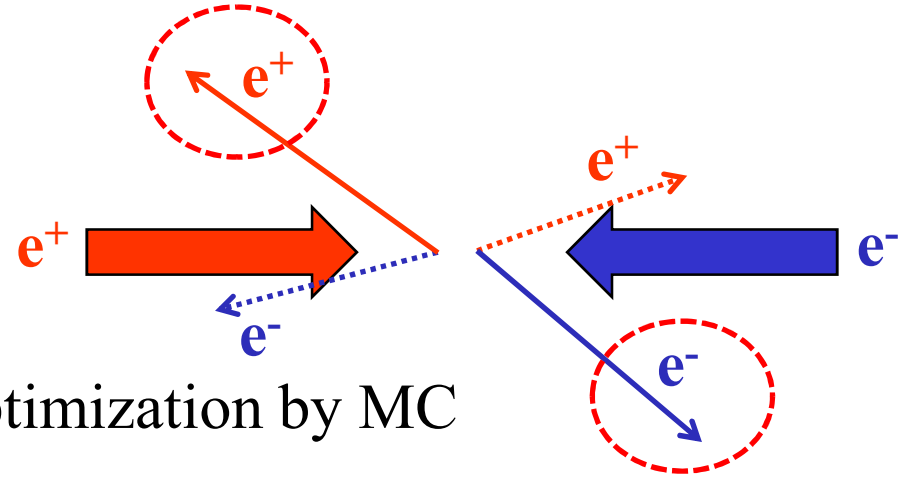
Introduction

Pair monitor

- Monitor of the beam size, position and crossing angle at IP.
- The e^+e^- pair B.G. is used to measure the beam profile.
  - The same charge with respect to the oncoming beam is scattered with large angle.
  - e^+e^- distributions from beam crossing have the beam information at IP.



Activity of Tohoku group

- Performance check and detector optimization by MC
- Development of the readout ASIC

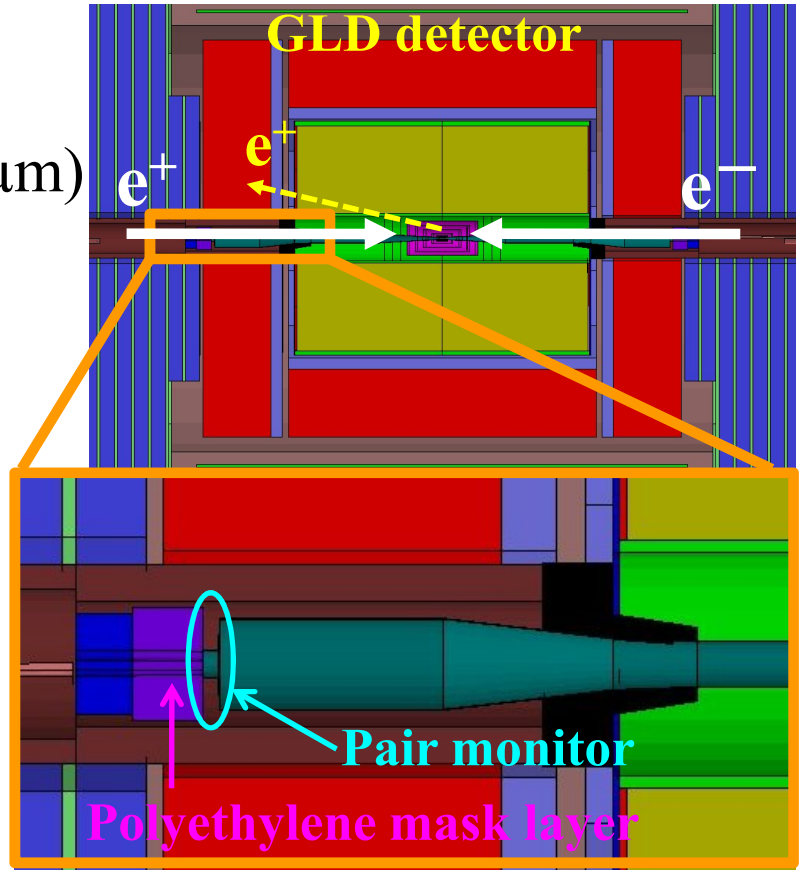
Current status of these studies are presented.

Simulation Study

Simulation setup

Simulation setup

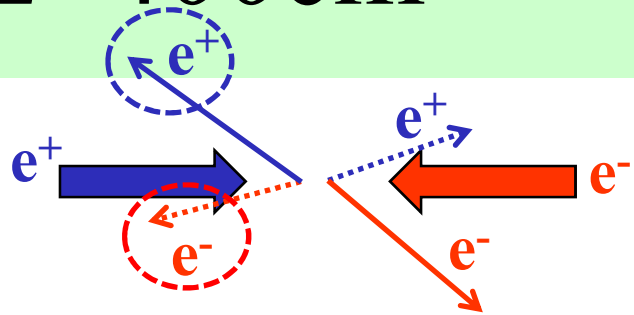
- e^+e^- pair generator : CAIN
  - Beam size :
    $(\sigma_{X0}, \sigma_{Y0}, \sigma_{Z0}) = (639\text{nm}, 5.7\text{nm}, 300\mu\text{m})$
- Tracking simulator : Jupiter
  - Simulator for GLD
  - Simulation based on Geant4
  - Magnetic field : 3T with anti-DID
- Pair monitor
  - Located at 400 cm from IP.
  - In front of Polyethylene mask layer
- Scattered e^+ distribution is studied.

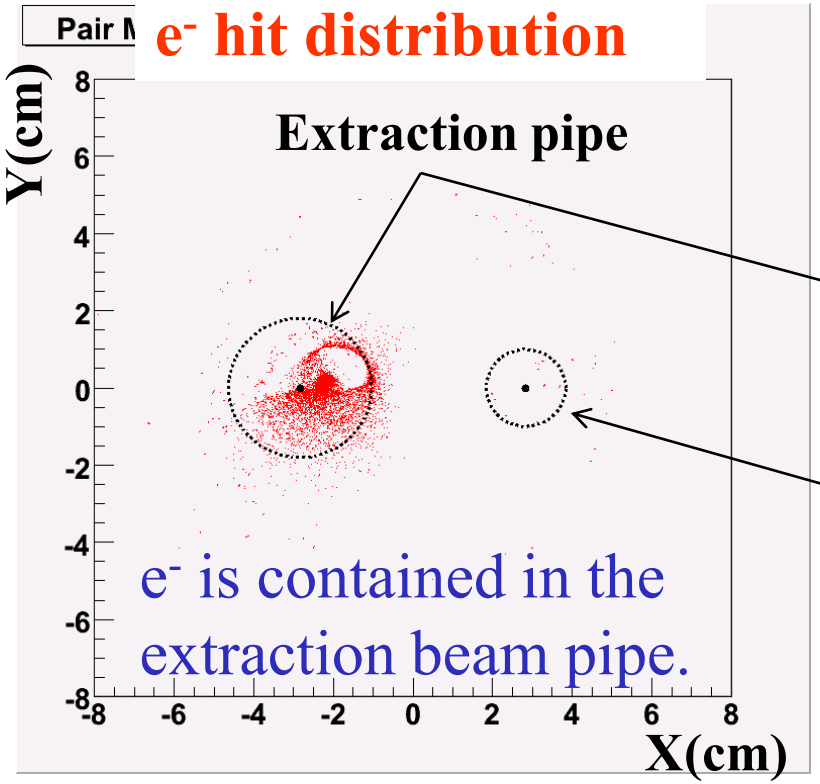


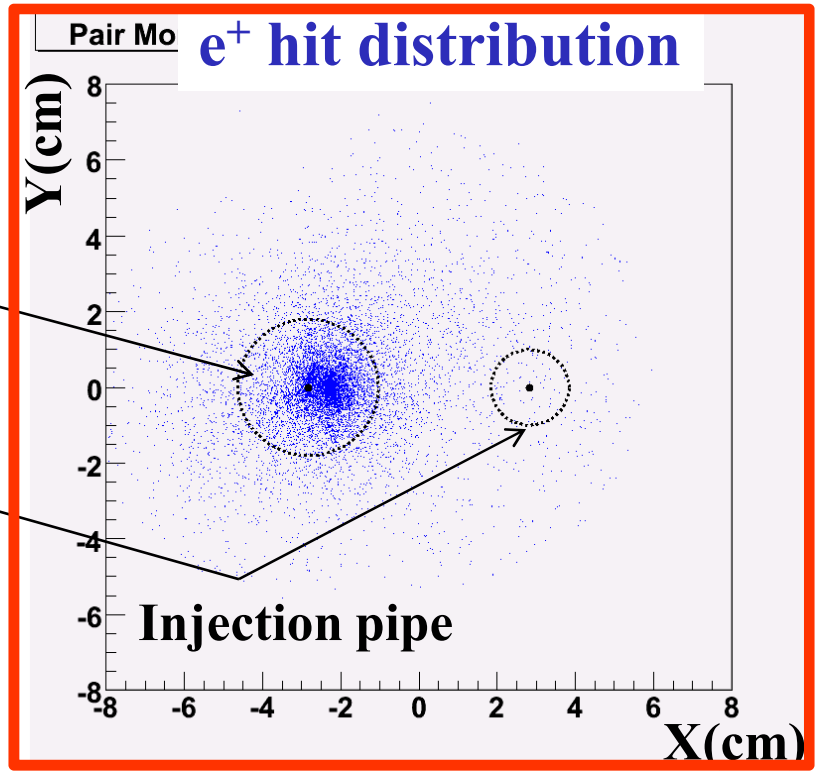
e^+e^- distributions at Z=400cm

e^+e^- distributions are checked at Z=400cm.

- e^- is not scattered so much.
- e^+ is scattered with large angle.

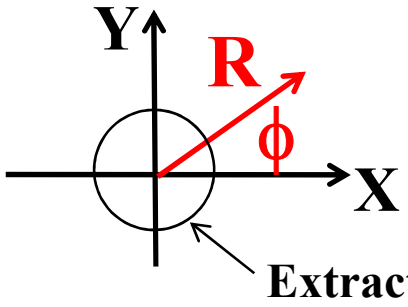






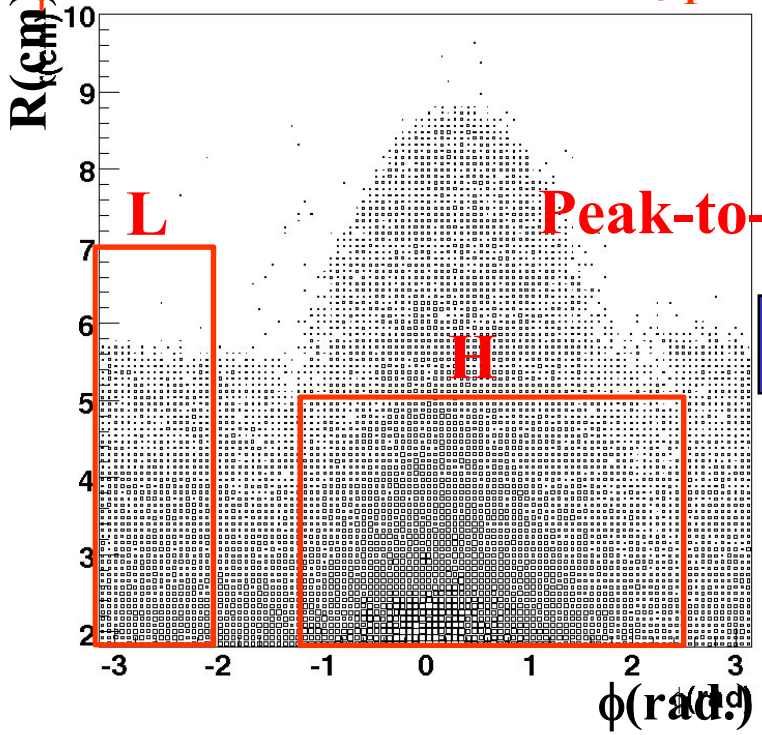
e^+ hit distribution around the extraction beam pipe is used to measure the beam profile.

Measurement of vertical beam size



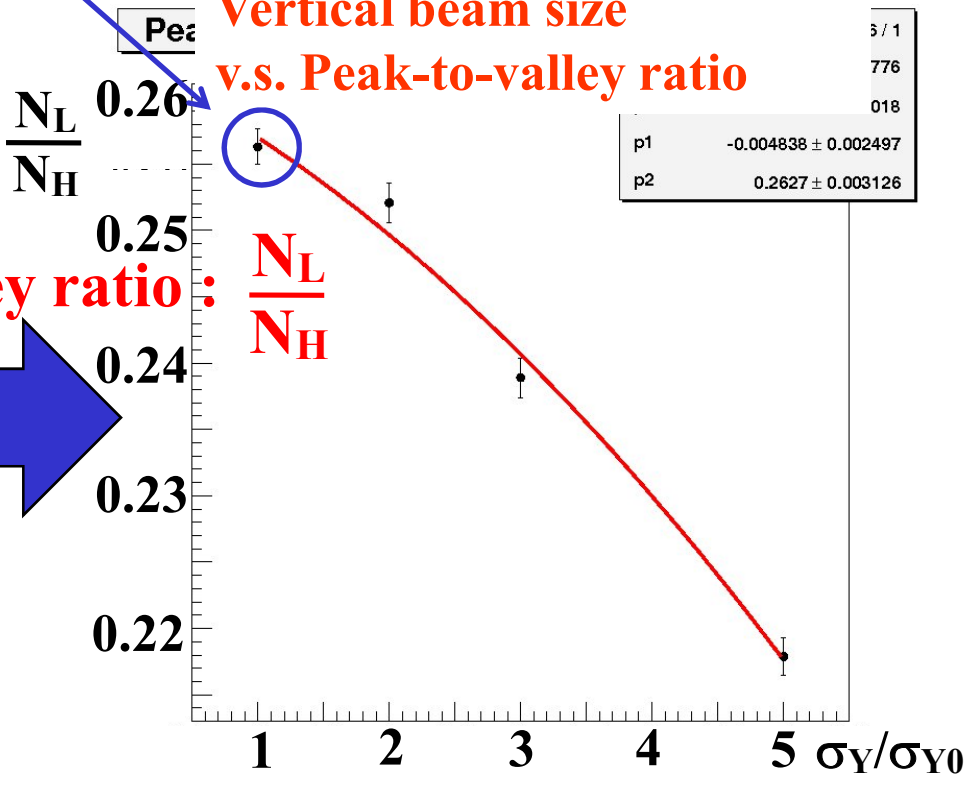
In the previous study for LCWS07, resolution of the vertical beam size was 0.5nm(8%) for 150 bunches.

ϕ–R distribution of e^+ with $\sigma_Y = \sigma_{Y0}$



Peak-to-valley ratio : $\frac{N_L}{N_H}$

Vertical beam size v.s. Peak-to-valley ratio



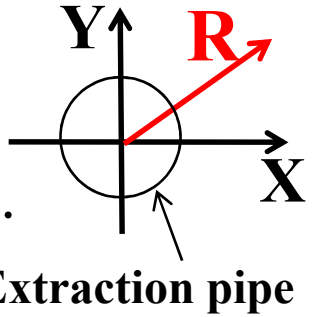
In this talk, measurement of horizontal beam size is presented.

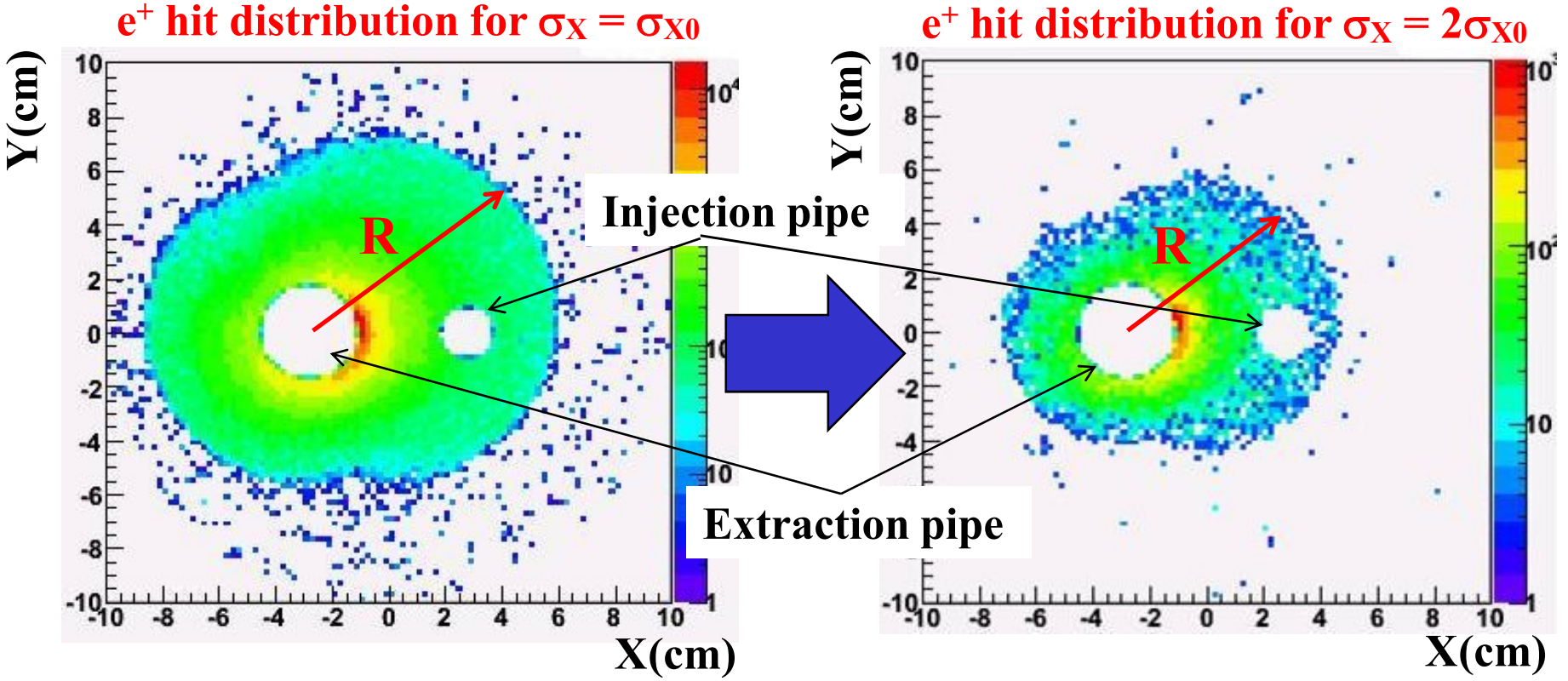
Measurement of horizontal beam size

Measurement of horizontal beam size

- R : Distance of the e^+ hit from the extraction beam pipe.
- R distribution seems to depend on the horizontal beam size.

→ R distribution was studied.

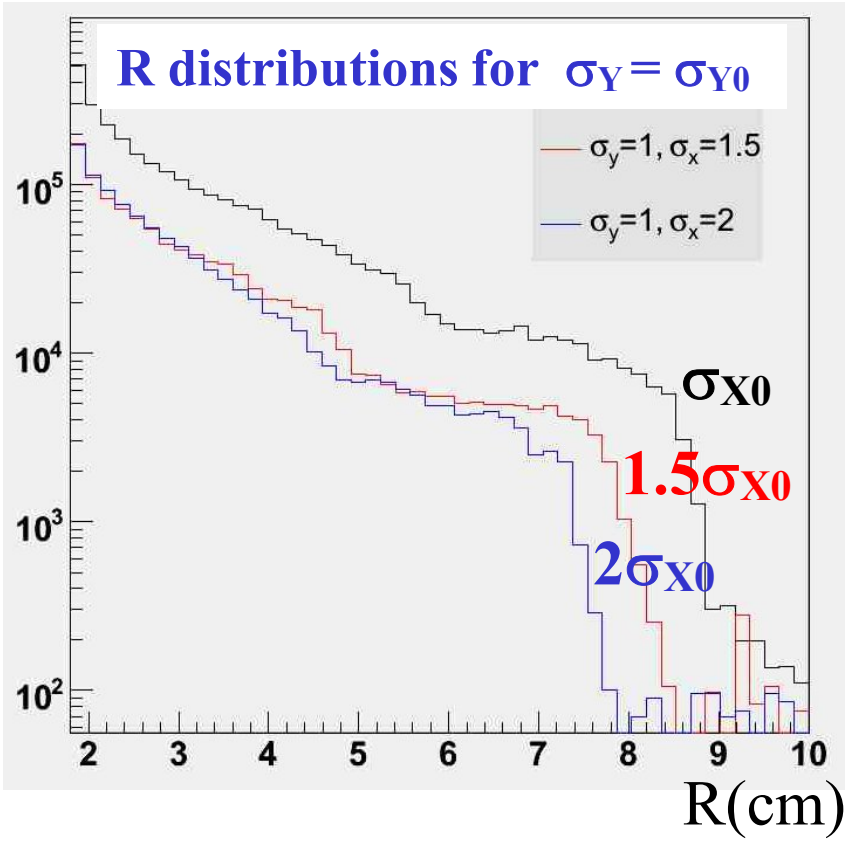


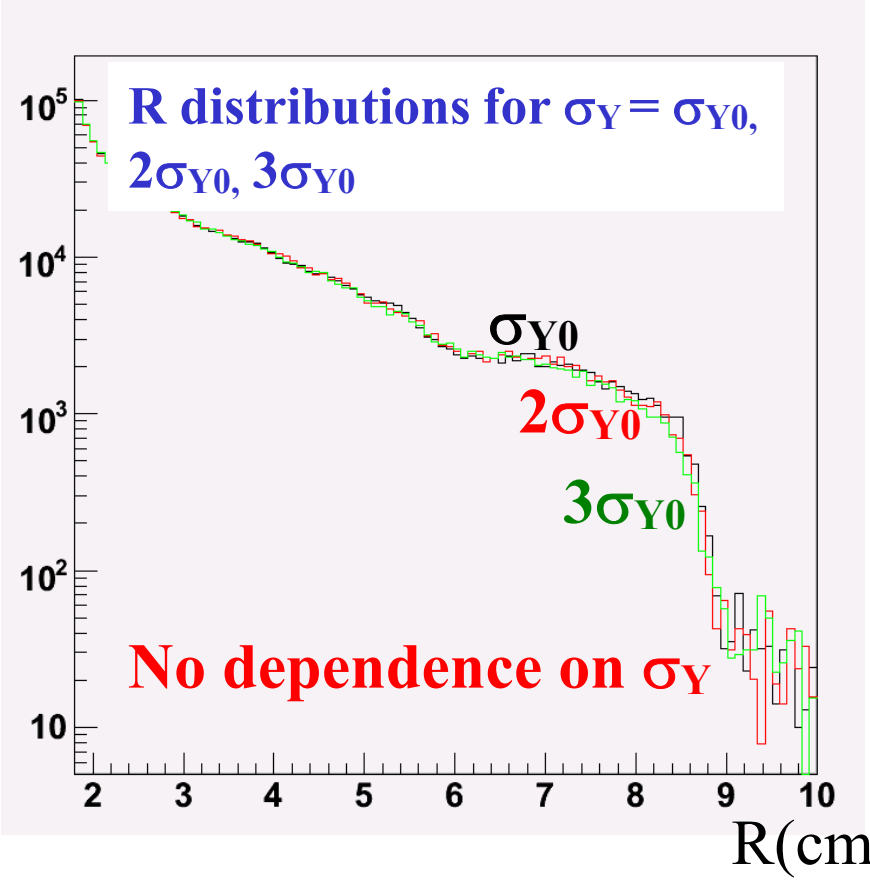


Horizontal beam size v.s. R distribution

- R distribution depends on the horizontal beam size (σ_X).
- R distribution dose not depend on the vertical beam size (σ_Y).

R distribution has the information of σ_X, independent of the vertical beam size.



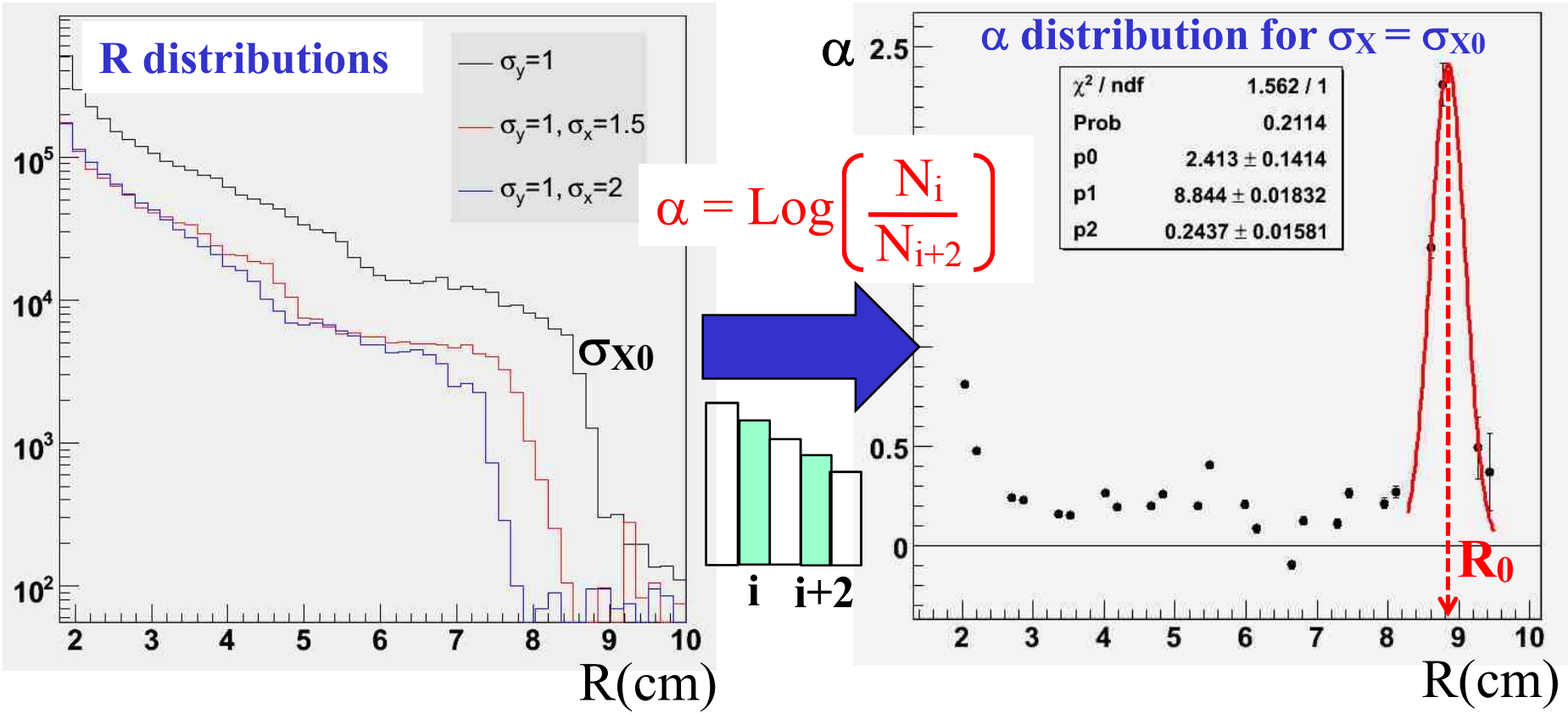


Extraction of σ_X information.

R_0 is used to extract the σ_X information.

- R_0 : R of the largest statistical change rate.

➡ Relation between σ_X and R_0 was studied.

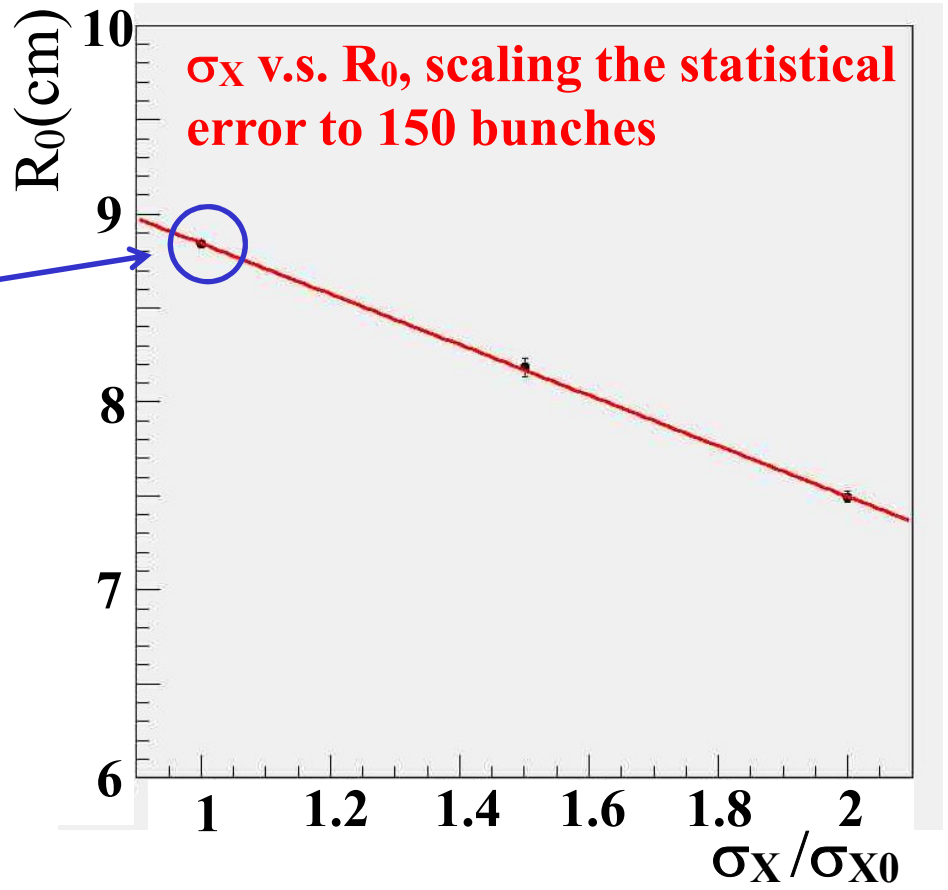


Resolution of horizontal beam size

R_0 has the linear dependence on σ_X.

- σ_X-resolution can be estimated, converting the vertical error to horizontal error.

σ_X -resolution of 5nm(0.08%) is obtained for $\sigma_X = \sigma_{X0}$.



Resolution of the beam size

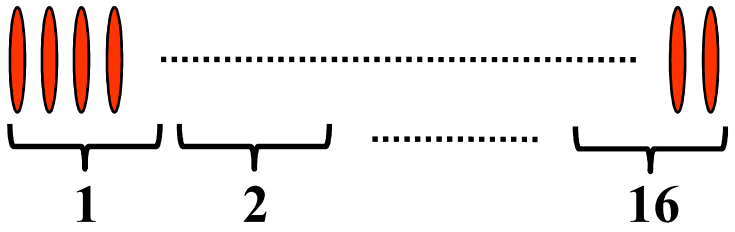
- Horizontal beam size : 5nm
- Vertical beam size : 0.5 nm

Development of Readout ASIC

Design concept of readout ASIC

Design concept of readout ASIC

- e^+e^- pair distribution is measured.
- Measurement is done for each timing in a train.
  - ~150 bunches are necessary for the measurement.
  - 16 timing parts in one train.
- Data is read within a each train.
  - Timing width : ~200 ms.
- Si detector is assumed as a detector.



The readout ASIC measures the hit count for each timing parts.

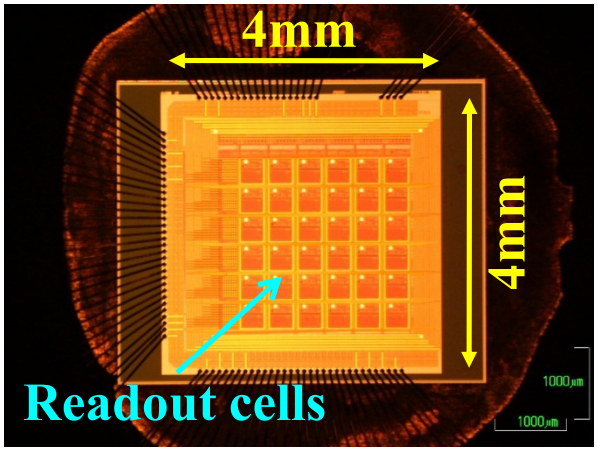
- Information of energy deposit in a detector is not necessary.

The readout ASIC prototype was developed to satisfy these design concept.

Design of the readout ASIC

Prototype of readout ASIC

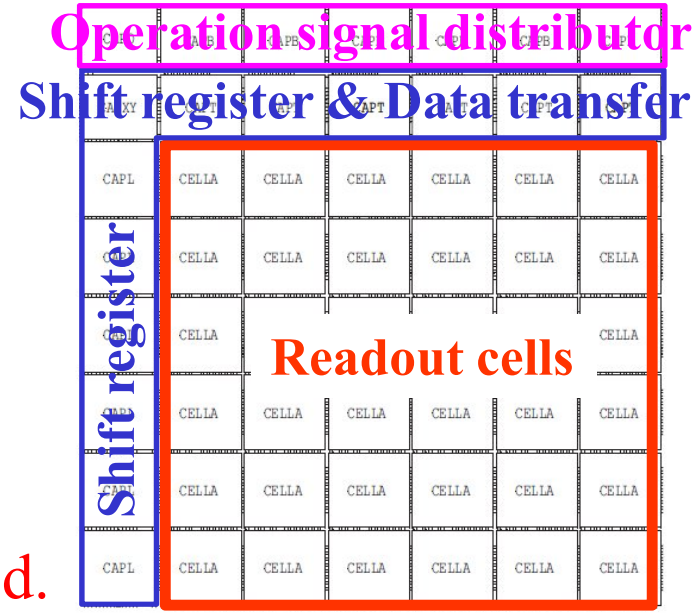
- Produced with 0.25μm process
- Size : 4 x 4 mm^2
- Readout cell size : 400 x 400 μm^2



Structure of readout ASIC

- Distributor of the operation signals.
- Data transfer to the output line.
- Shift register to specify a readout cell.
  - Response was confirmed in LCWS07.
- 36 readout cells

In this study, the readout cells were checked.

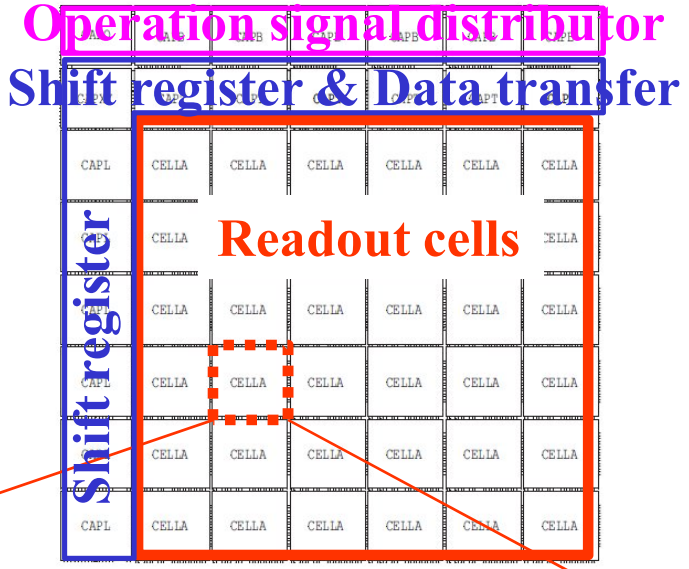


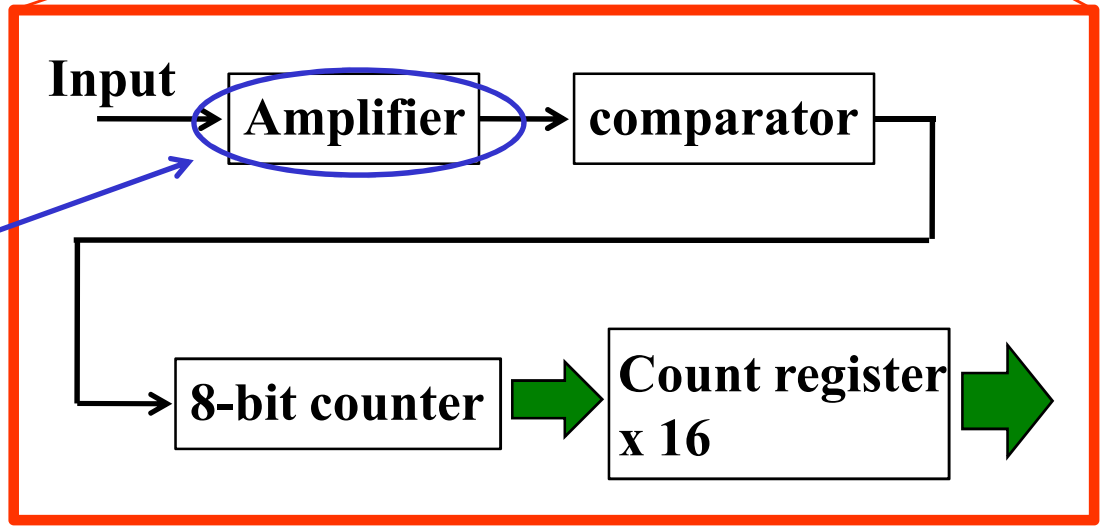
Structure of readout cells

Structure of readout cells

- Amplifier
- Comparator
- 8-bit counter
  - A number of the hit is counted.
- 16 count registers
  - The hit counts of each 16 timing parts are stored.

Response of the amplifier was checked.



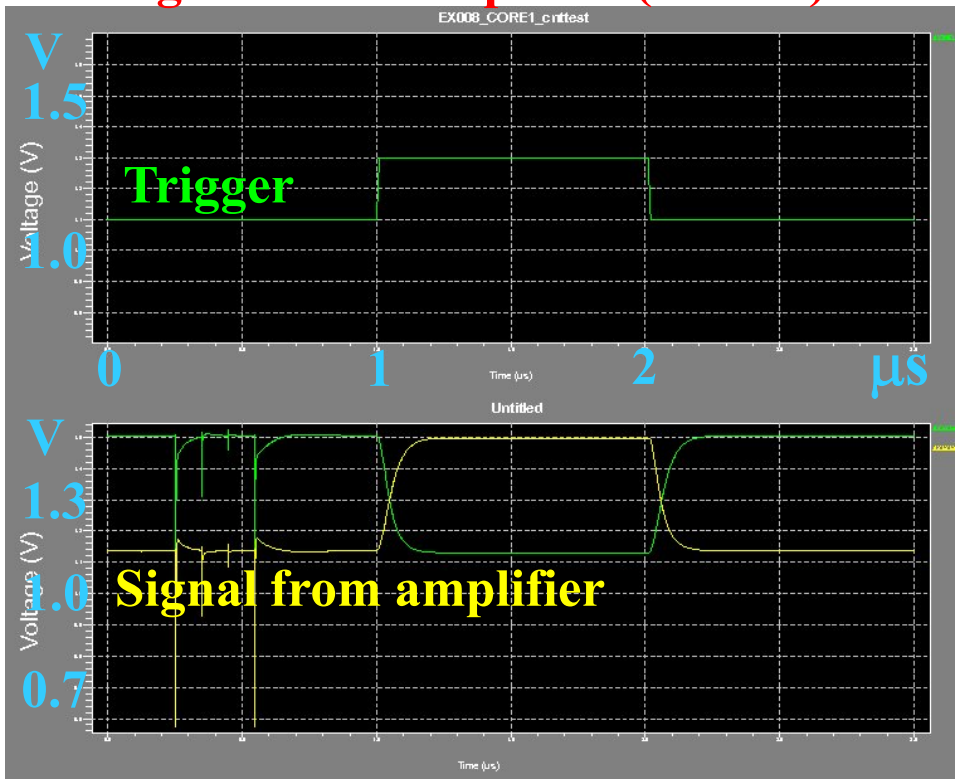


Test of analog amplifier

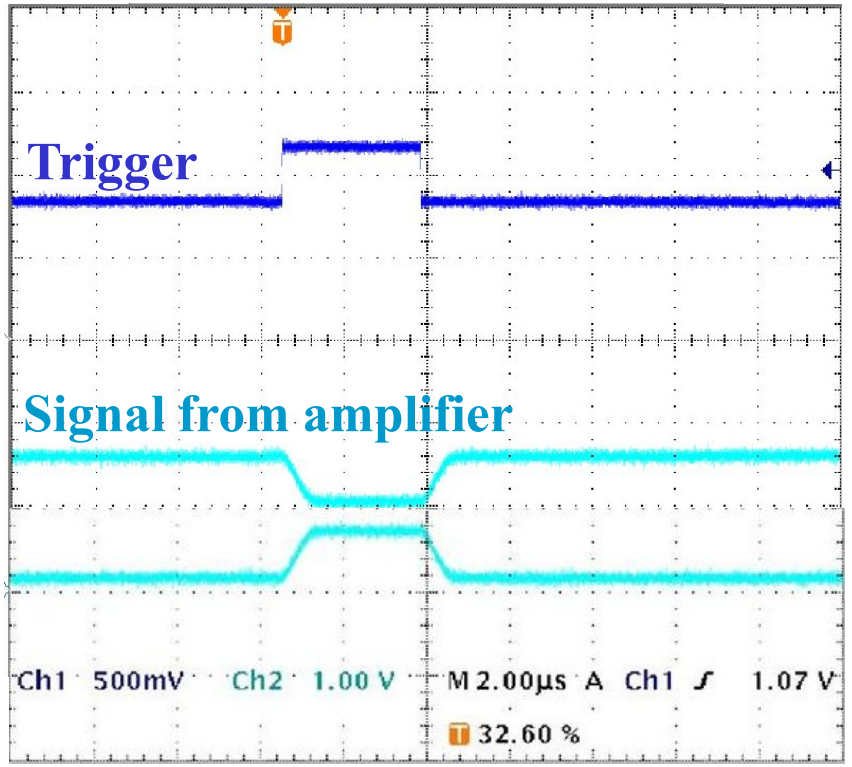
- Response of the differential amplifier was checked.
- The design value of the voltage gain (~3.5) was obtained.

The amplifier works correctly.

Signals from amplifier (SPICE)



Experimental result of the amplifier

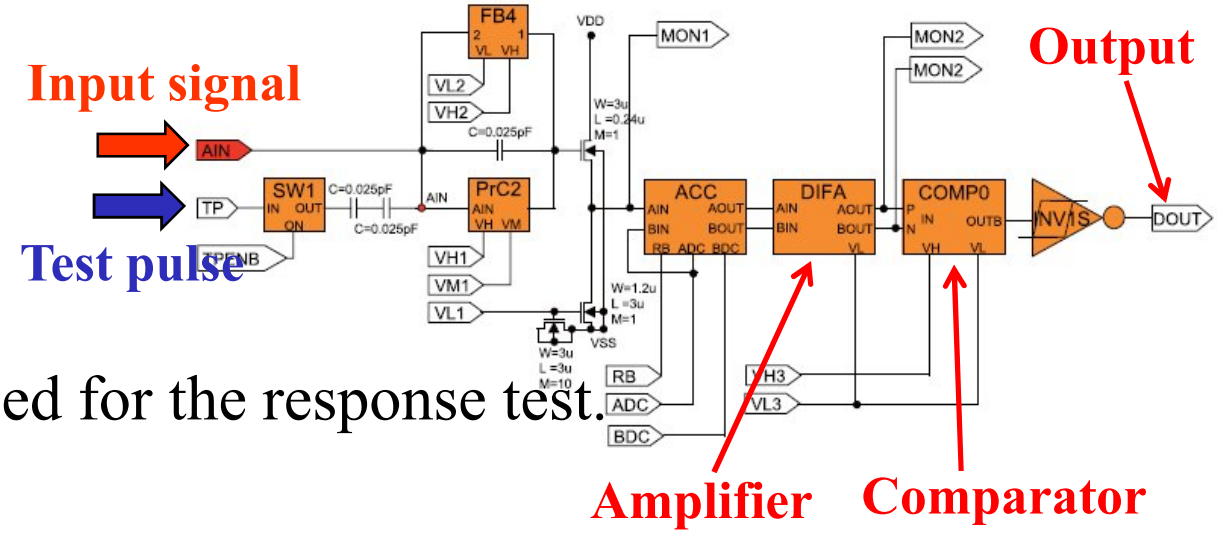


Summary

- We continue to study the pair monitor.
- Performance of the pair monitor is studied by MC.
  - The horizontal beam size can be measured with 5nm(0.8%) accuracy.
  - Measurement of the displacement and rotation will be studied as the next step.
- Prototype of the readout ASIC is developed.
  - Response of the amplifier was confirmed.
  - Counters and registers in a readout cell will be checked.

Analog part

Analog part



- Signal input
  - Test pulse can be used for the response test.
- Amplifier
- Comparator
  - B.G. event below threshold is rejected.
- Signal monitoring after and before the amplifier.
  - The readout cell and monitoring part can be specified by the operation signal.
- The digitized signal is sent to the digital part.

Digital part

Digital part

- Counting # of input signals
  - 8 bit counter
- Restoring the hit count for each timing
  - 16 count registers
  - Writing and reading cell can be specified by a operation signals.