Pair Monitor Studies

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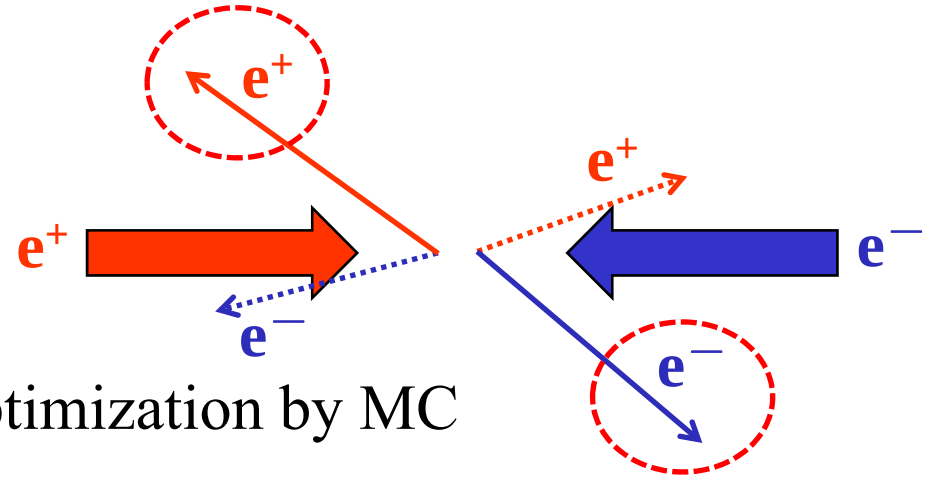
Introduction

Pair monitor

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



Activity of Tohoku group

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

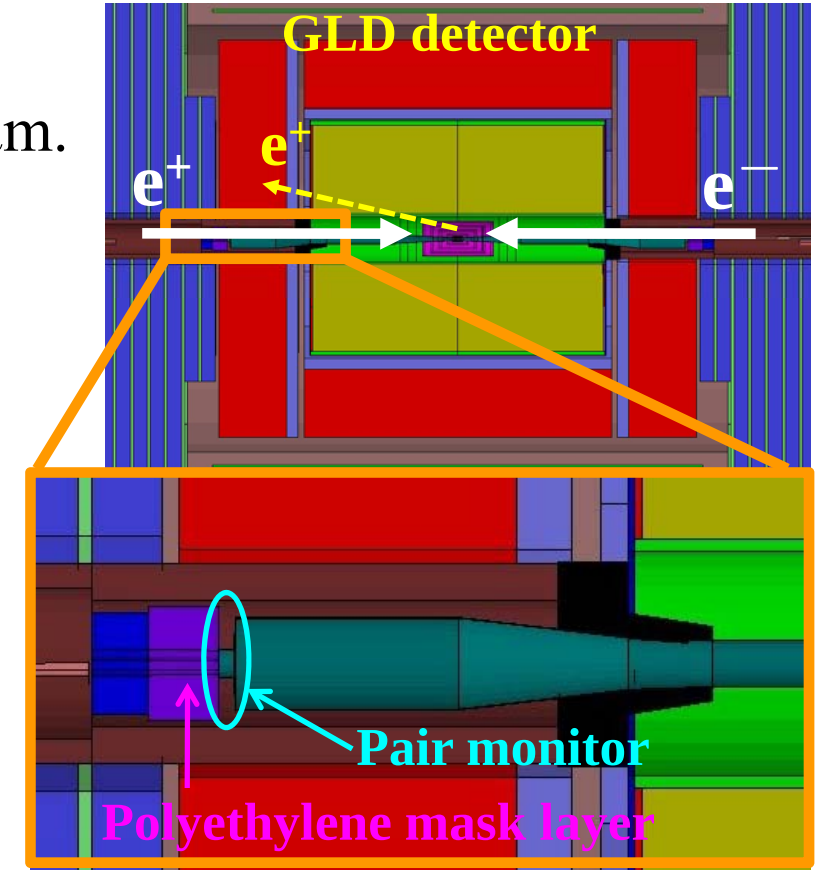
Current status of these items are shown.

Simulation Study

Simulation setup

Simulation setup

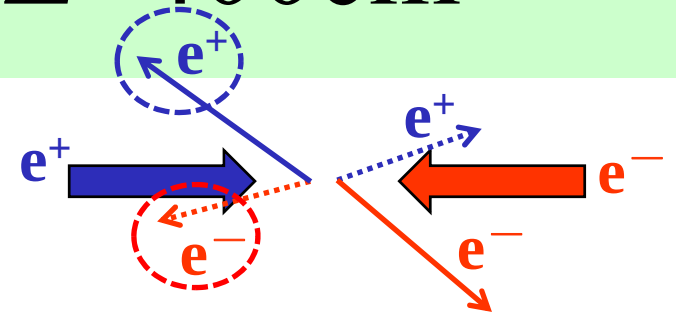
- e^+e^- pair generator : CAIN
  - Beam size : 639nm x 5.7nm x 300μm.
- Tracking simulator : Jupiter
  - Simulator for GLD
  - Simulation based on Geant4
  - Magnetic field : 3T with anti-DID
- Pair monitor
  - Located at 400 cm from IP.
  - In front of Polyethylene mask layer
- Scattered e^+ distribution is studied.

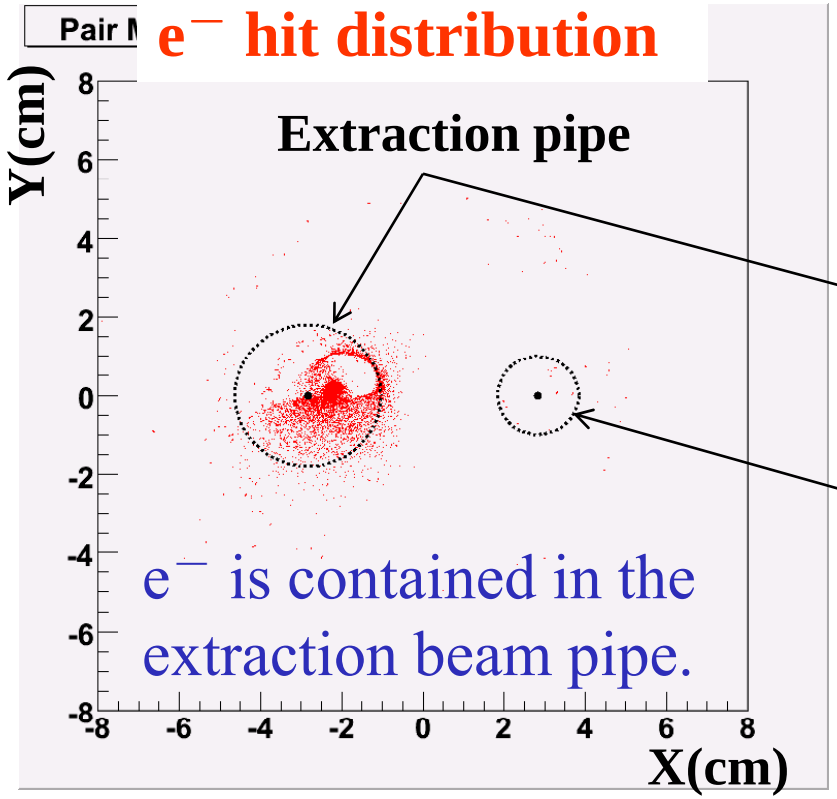


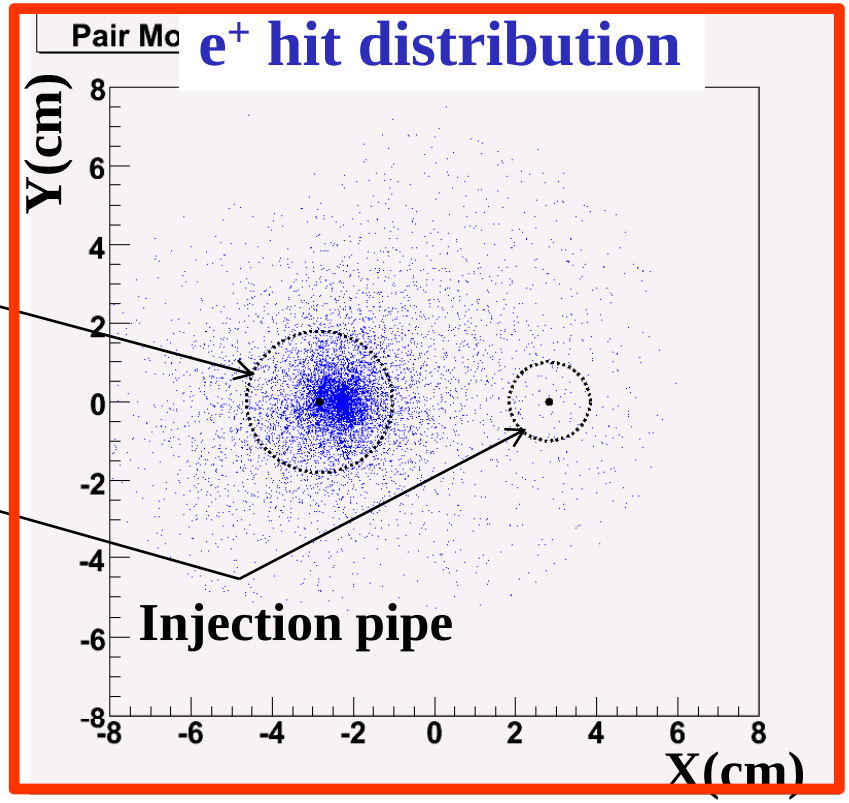
e^+e^- distributions at Z=400cm

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

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





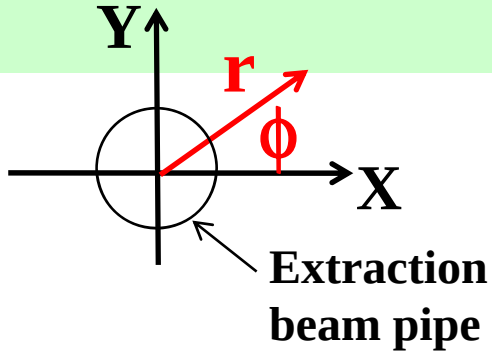


e^+ hit distribution around the extraction beam pipe is studied.

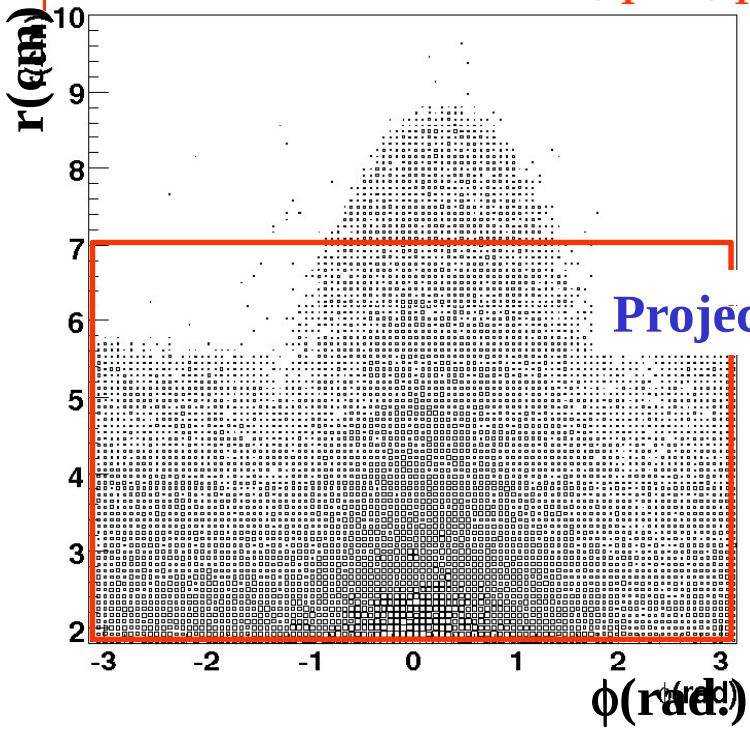
e^+ hit distribution

The hit distribution around extraction beam pipe is compared with different vertical beam size.

- Standard vertical beam size : $\sigma_{Y0} = 5.7$nm

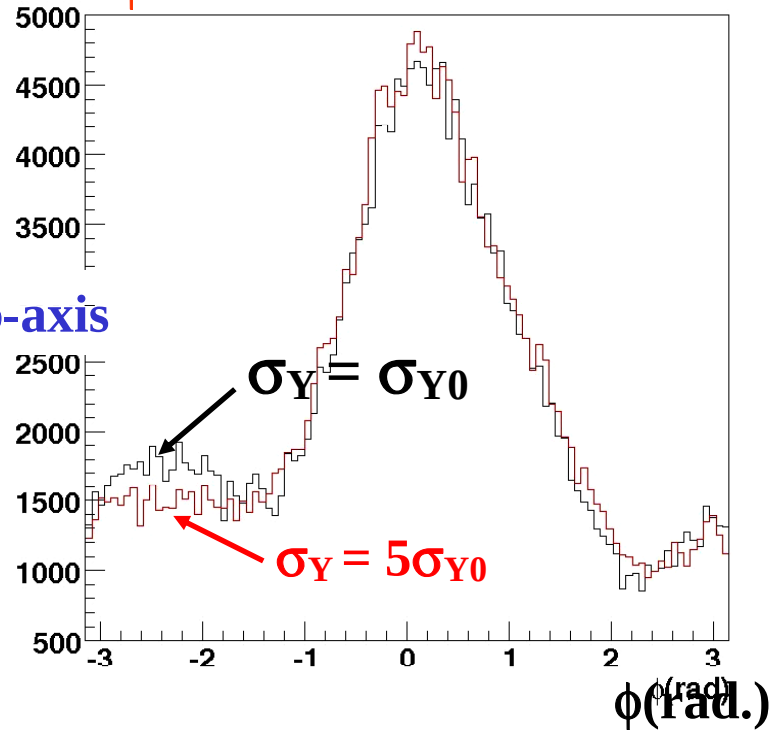


r-ϕ distribution of e^+ with $\sigma_Y = \sigma_{Y0}$



Projection to the ϕ-axis

ϕ distribution in r=2~7cm



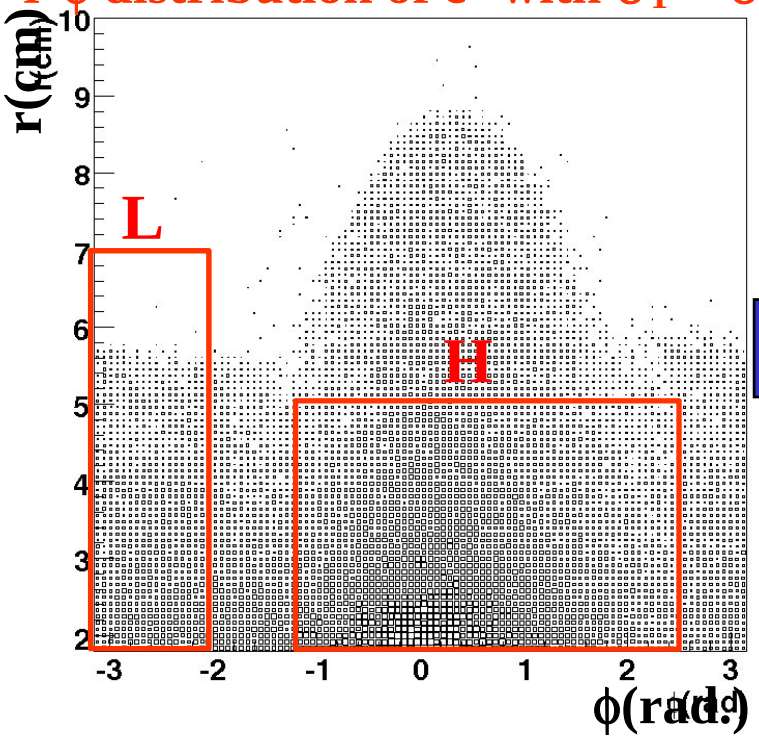
The hit distributions have information of the beam size.

Peak-to-valley ratio

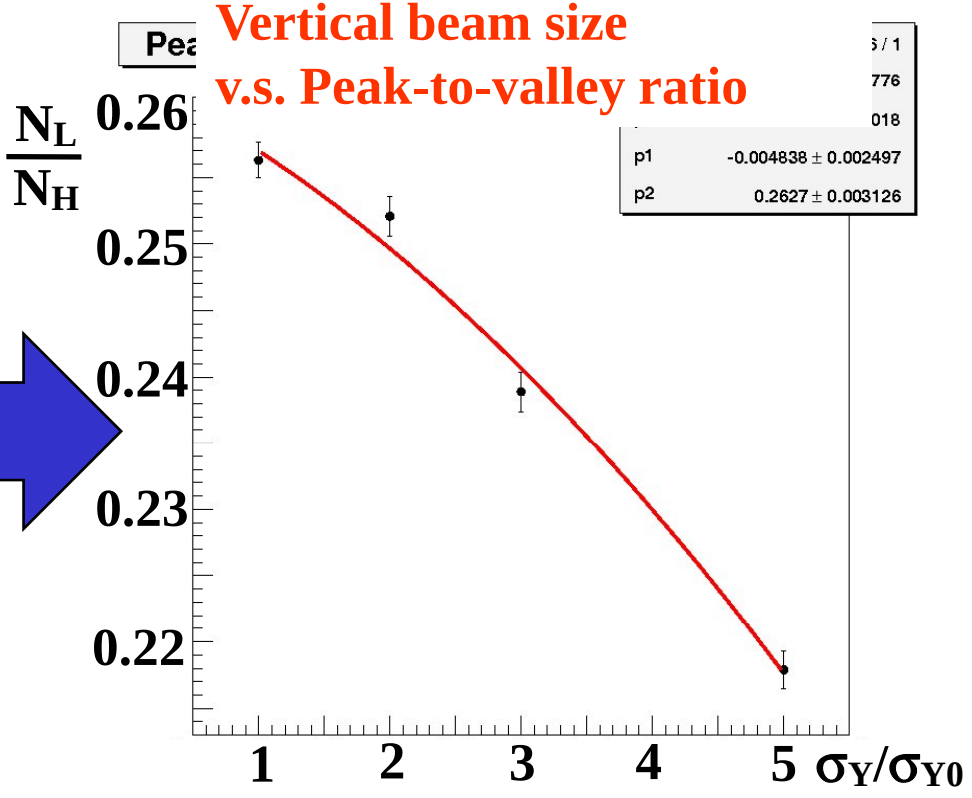
Peak-to-valley ratio is used to obtain the relation with σ_Y.

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

r-ϕ distribution of e^+ with $\sigma_Y = \sigma_{Y0}$



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

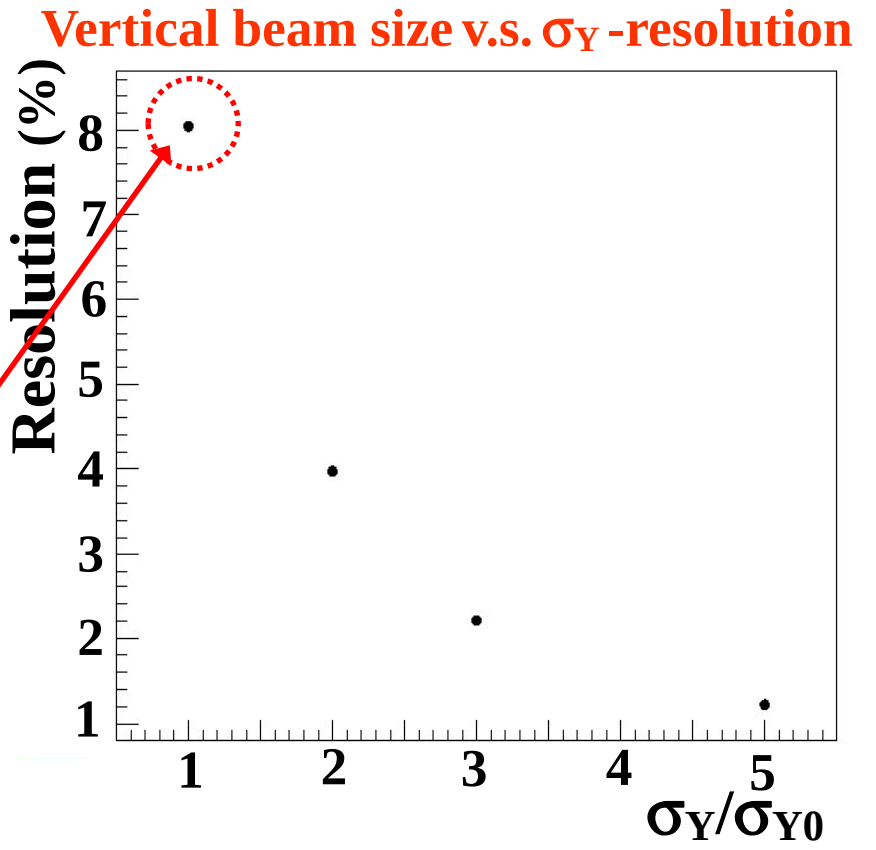


By using this relation, the resolution of beam size measurement is estimated.

Resolution of the vertical beam size

Estimation of beam size resolution

- The statistical error is scaled to that of 150 bunches.
  - Data will be taken for each 150 bunches to get enough statistics.
- **σ_Y can be measured by 8% for the standard beam size.**



The next step

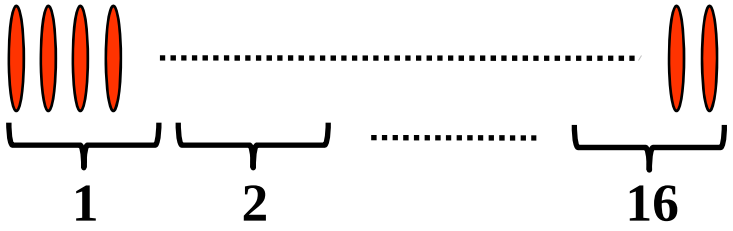
- Estimation of the σ_X resolution.
- More optimization of analysis method and pair monitor setup

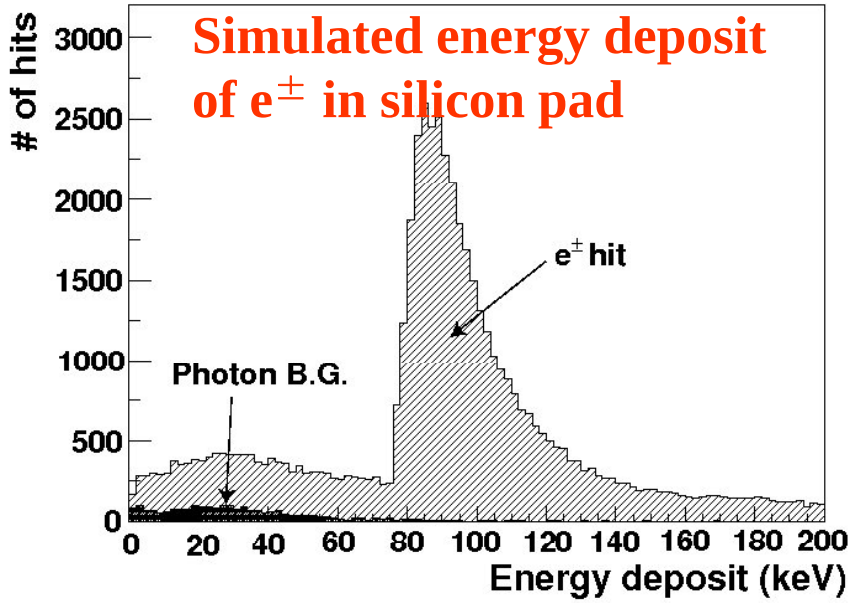
Development of Readout ASIC

Design concept of readout ASIC

Design concept of readout ASIC

- Counting a number of the hit
  - Hit distribution is obtained.
- Measurement for each timing in a train
  - 16 timing parts in one train.
- Date is read within a each train.
  - Timing width : ~200 ms.
- Si detector is assumed as a detector.
  - Thickness : 200 μm
  - Signal : 15000 electrons.



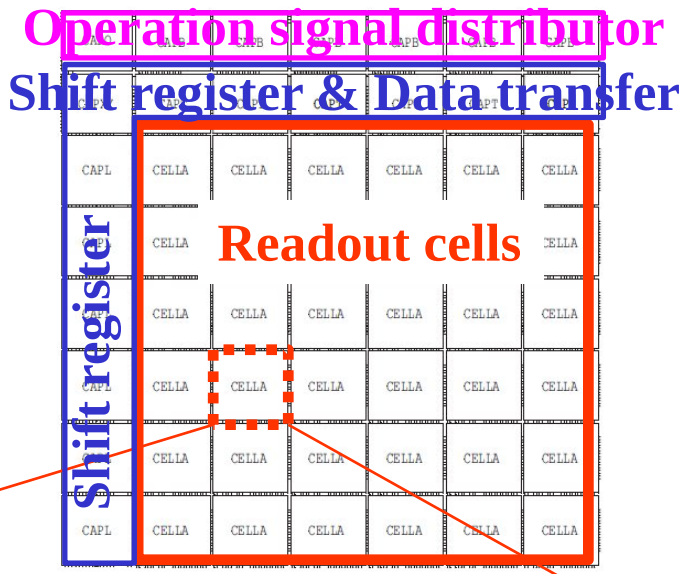


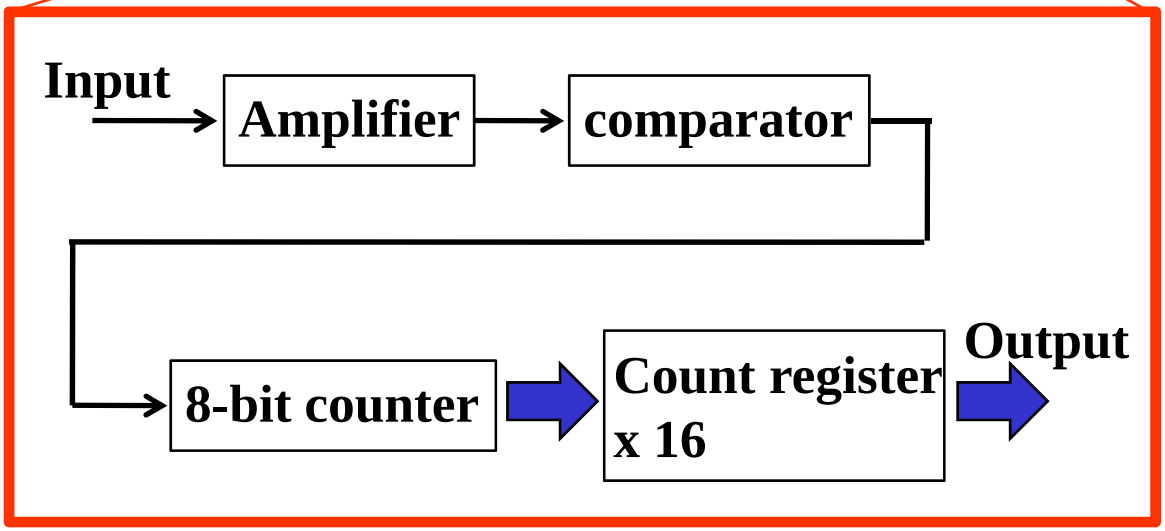
The readout ASIC is designed to satisfy these design concept.

Design of the readout ASIC

Structure of readout ASIC

- Distributor of the operation signals.
- Shift register to specify a readout cell
- Data transfer to the output line
- 36 readout cells
  - Amplifier
  - Comparator
  - 8-bit counter
  - 16 count registers



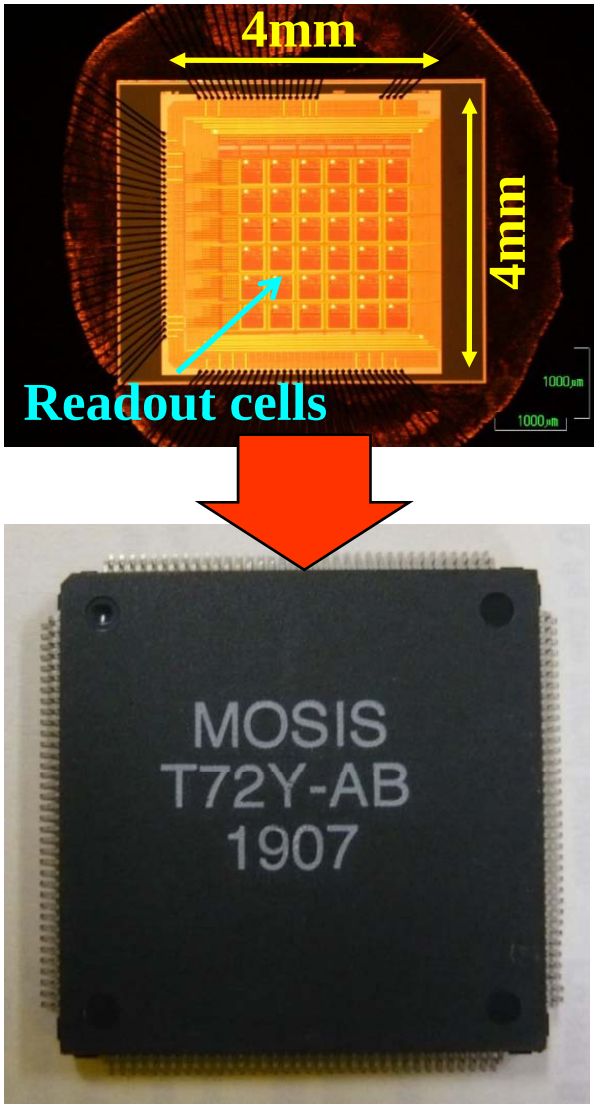


Prototype of readout ASIC

Prototype of readout ASIC

- Produced with 0.25μm process
- Size : 4 x 4 mm^2
- Readout cell size : 400 x 400 μm^2
- Readout chip is covered with package
  - MQFP produced by I2A Technologies
- So far, the 1st and 2nd prototypes were developed as explained later.

The response test of the readout ASIC is performed.

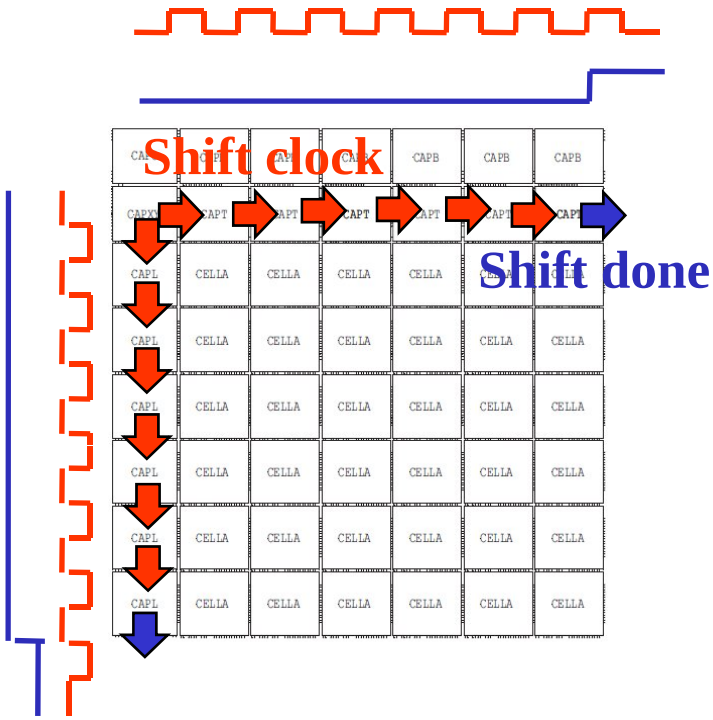


Test of the shift register

For the first test, response of the shift register was checked.

Shift register

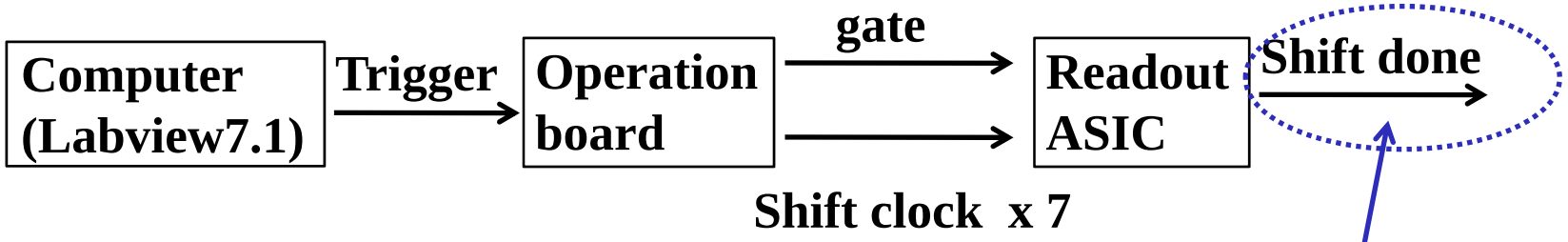
- Specification of the readout cell
  - Specification is done by shift clocks for X and Y direction.
- At the timing of the 7th shift clocks, shift done signal is output.

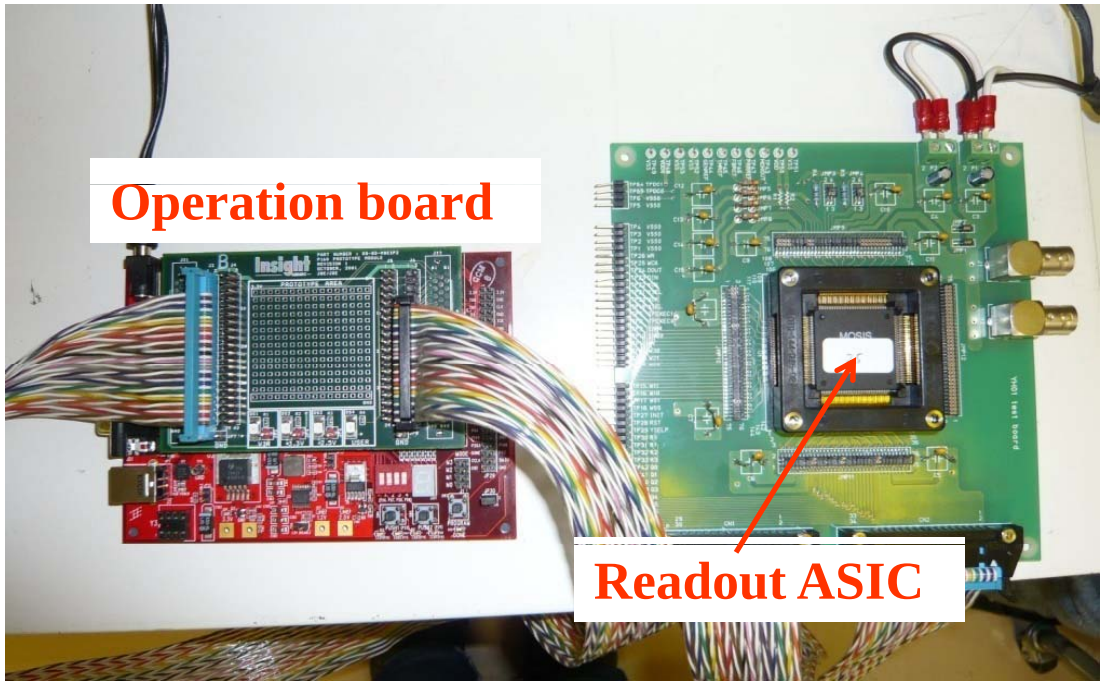


Response of the shift register can be confirmed by checking the shift done signal after inputting the 7 shift clocks to one direction.

Test bench to check shift registers

Block diagram of test bench





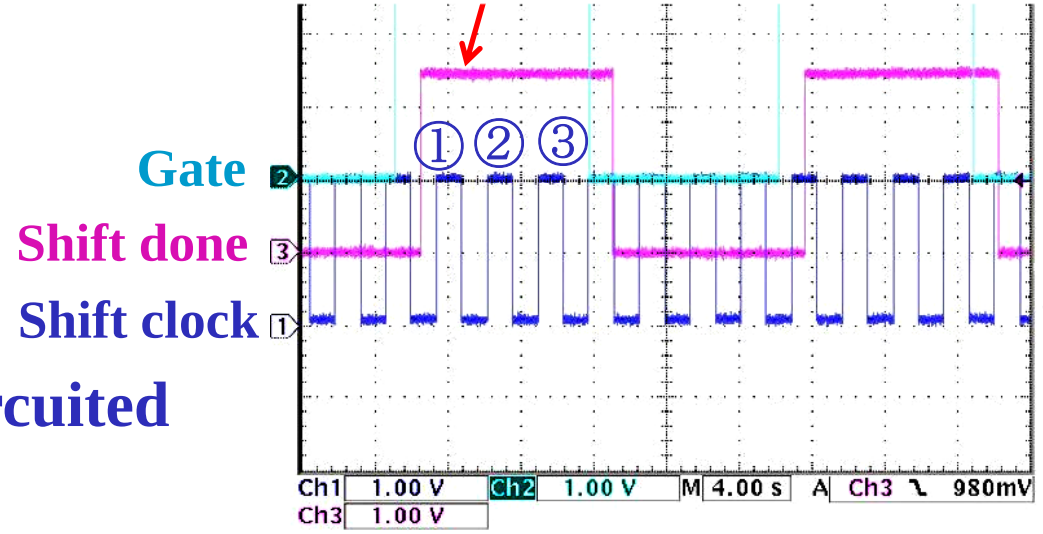
Shift done signal from readout ASIC is checked.

Shift register test for the 1st prototype

Shift register test for the 1st prototype

- Produced in February, 2005
- Shift register did not work correctly.
- The resistance for the protection of the digital input was insulated.

Shift done signal is not output at the timing of the 7th shift clock.

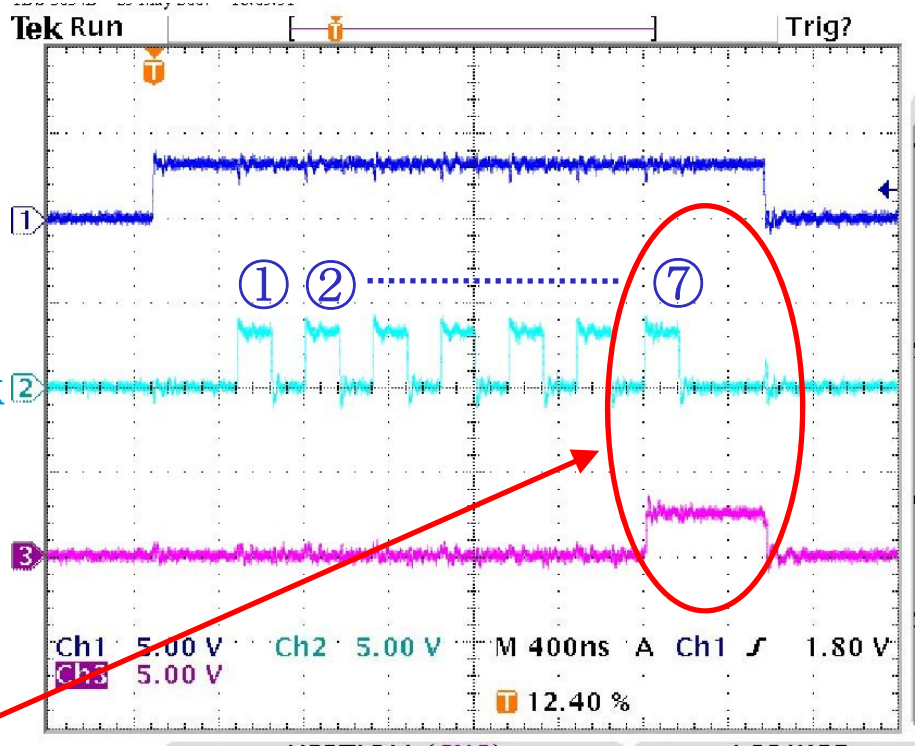


The digital input was short-circuited in the 2nd prototype.

Shift register test for the 2nd prototype

Shift register test for the 2nd prototype

- Produced in May, 2007
- The digital input is short-circuited.



The shift register works correctly!

The next step is response test for the readout cell.

Summary

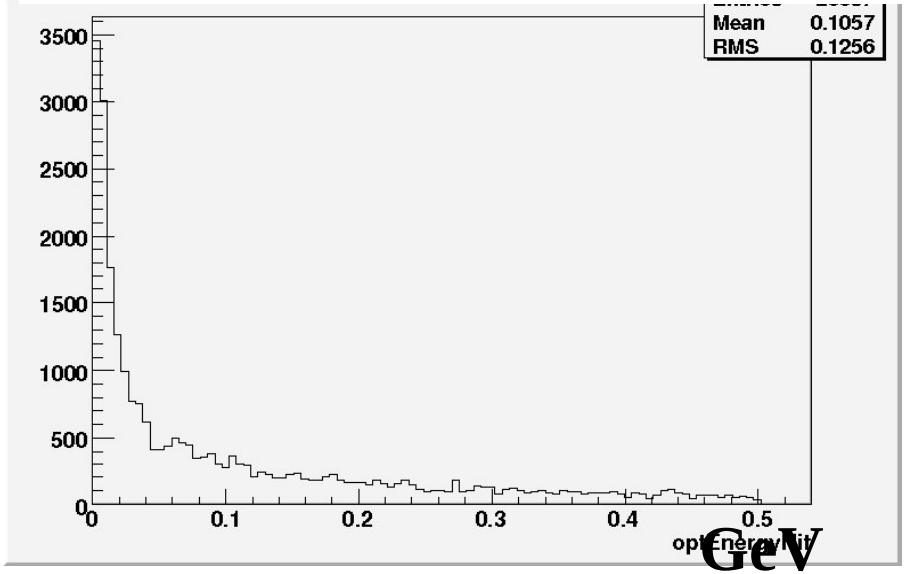
- We continue to study the pair monitor.
- Performance of the pair monitor is studied by MC.
  - The beam size can be measured with 8% accuracy.
- Prototype of the readout ASIC is developed.
  - Response of the shift register was checked.
  - The problem was found in the digital input of the 1st prototype.
  - The shift register work well in the 2nd prototype.

Simulation parameter

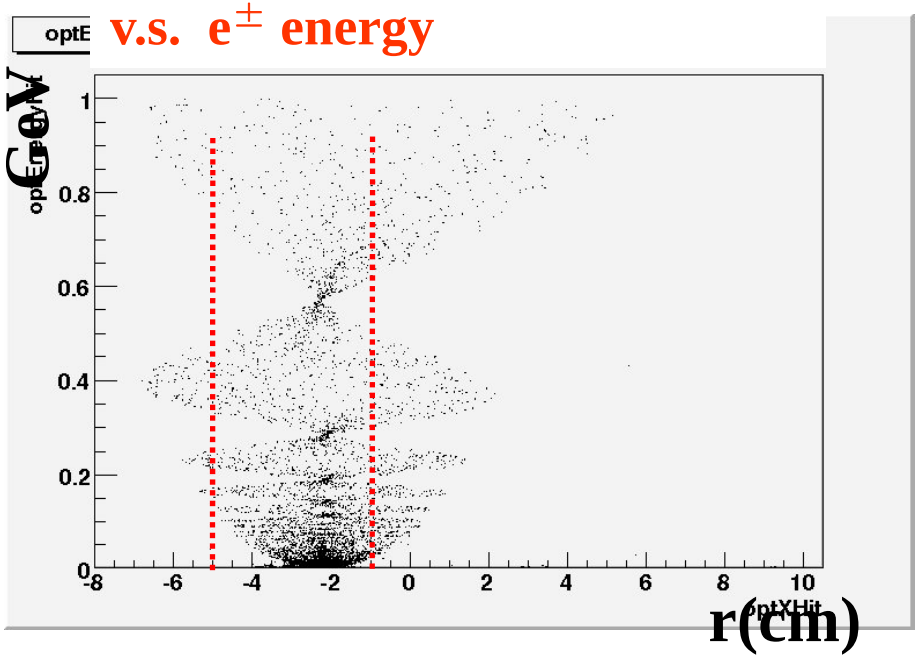
- Injection beam pipe : r=1.0cm
- Extraction beam pipe : r=1.8cm
- anti-DID parameter : 1.2

Energy distribution of $e^{\pm}$

Energy of $e^{\pm}$ hitting the pair monitor

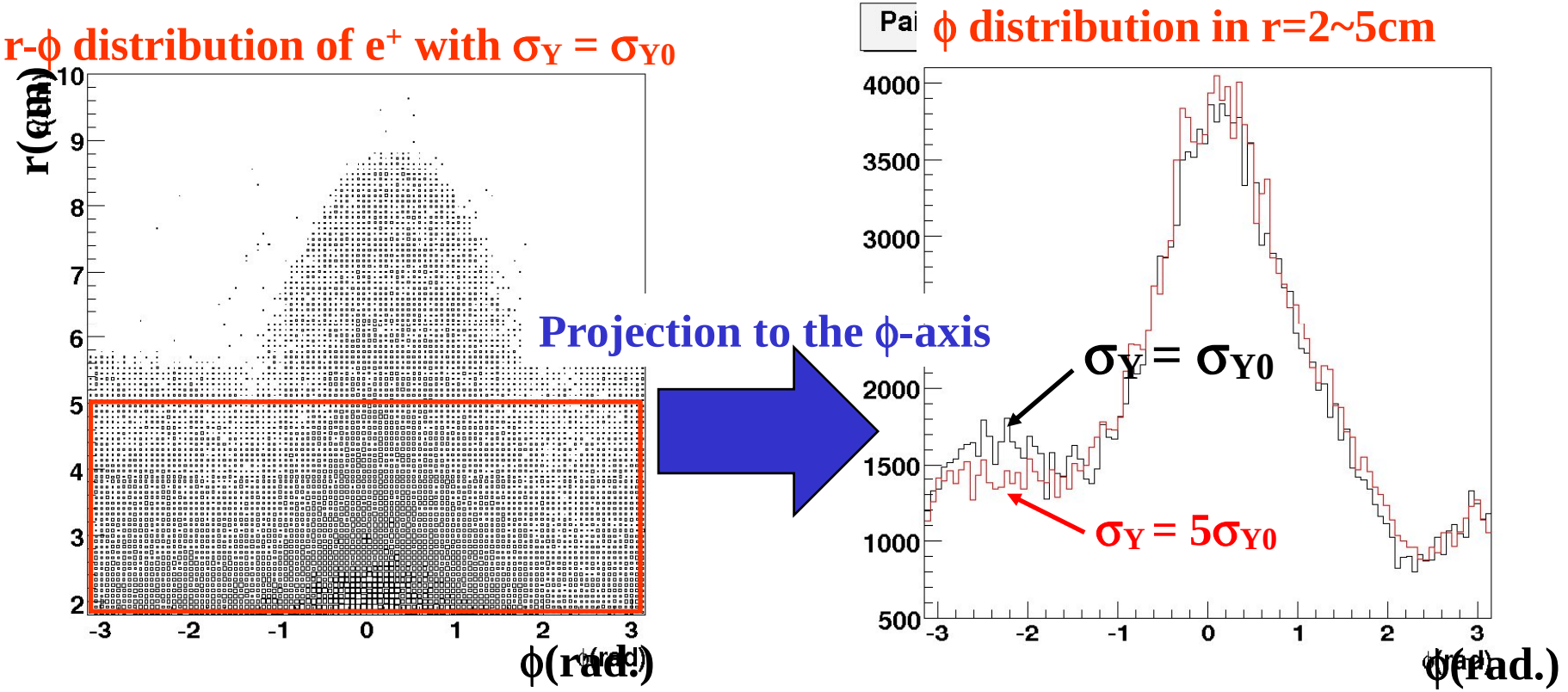


r of the extraction beam pipe v.s. $e^{\pm}$ energy



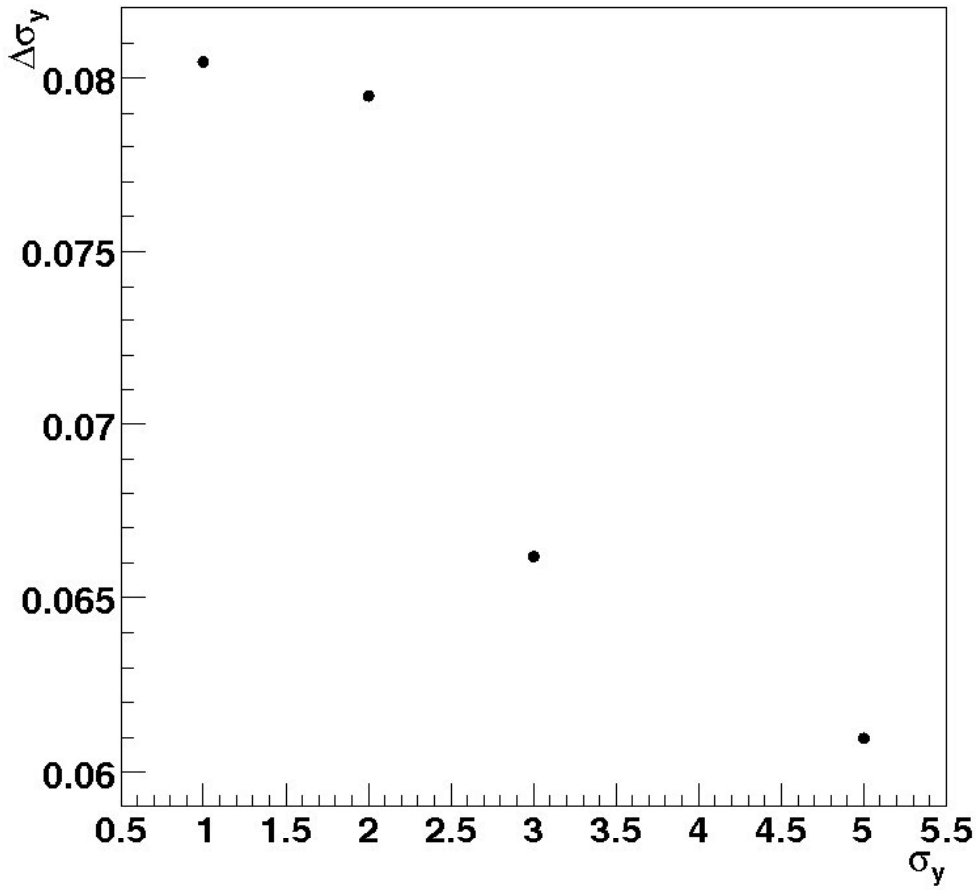
Low energy particles are in the extraction beam pipe.

r-ϕ distribution



σ_Y resolution

σ_Y -resolution v.s. σ_Y



Design of the readout ASIC

Structure of readout ASIC

- Cells to distribute operation signals.
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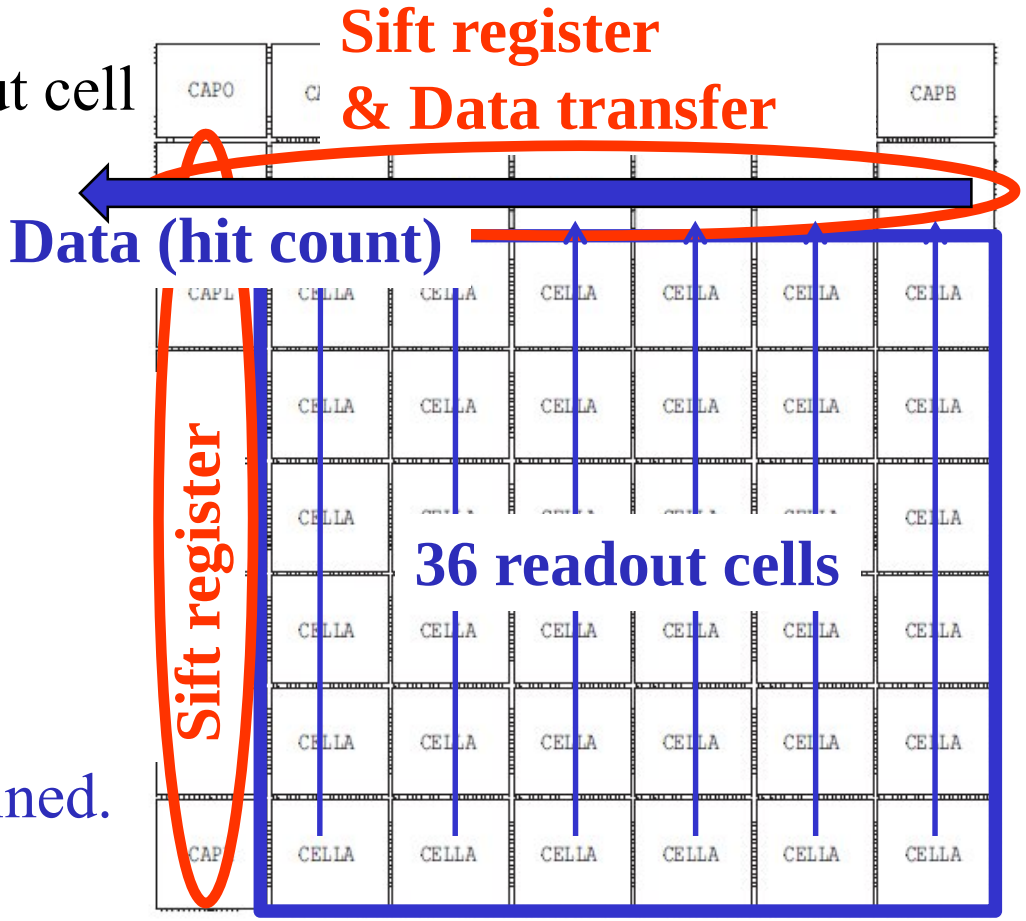
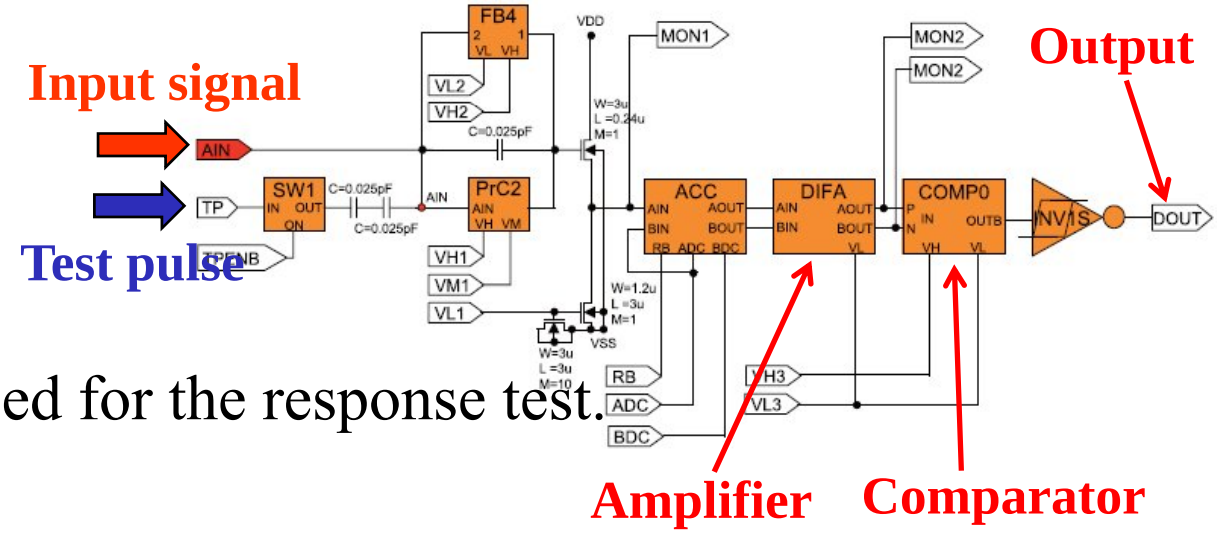
- 36 readout cells



Structure of readout cell is explained.

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.