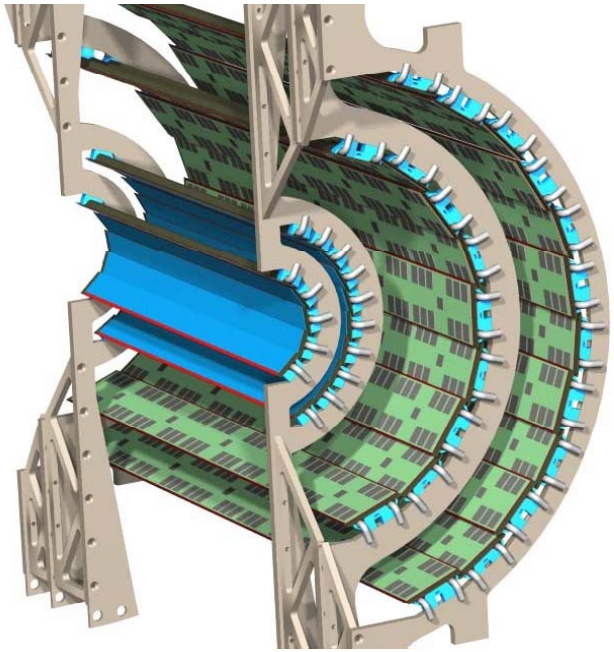
PHENIX VTX upgrade : Strip detector and software development

Manabu Togawa

RBRC review : November 17th 2008



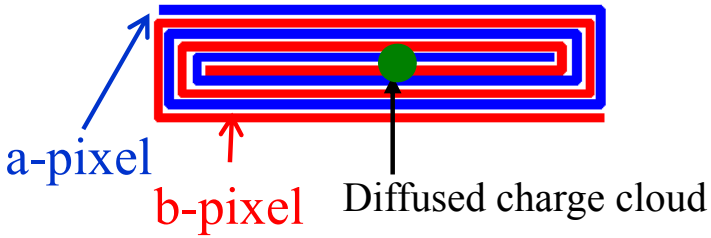
- Strip detector for the PHENIX VTX
  - Introduction
  - Performance study with beta source
  - Performance study with 120 GeV proton beam
- Software
  - Full Monte Carlo Simulation

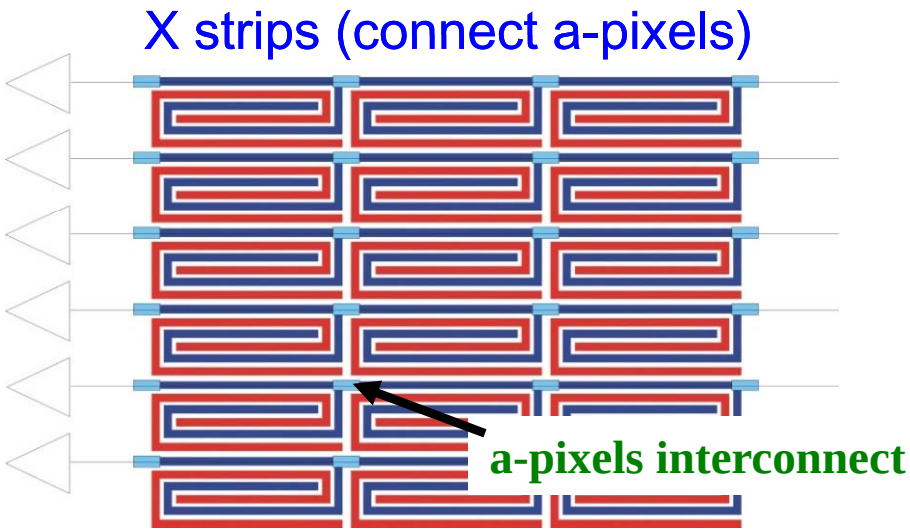
Strip detector : world's first 2-dimensional readout from 1 side

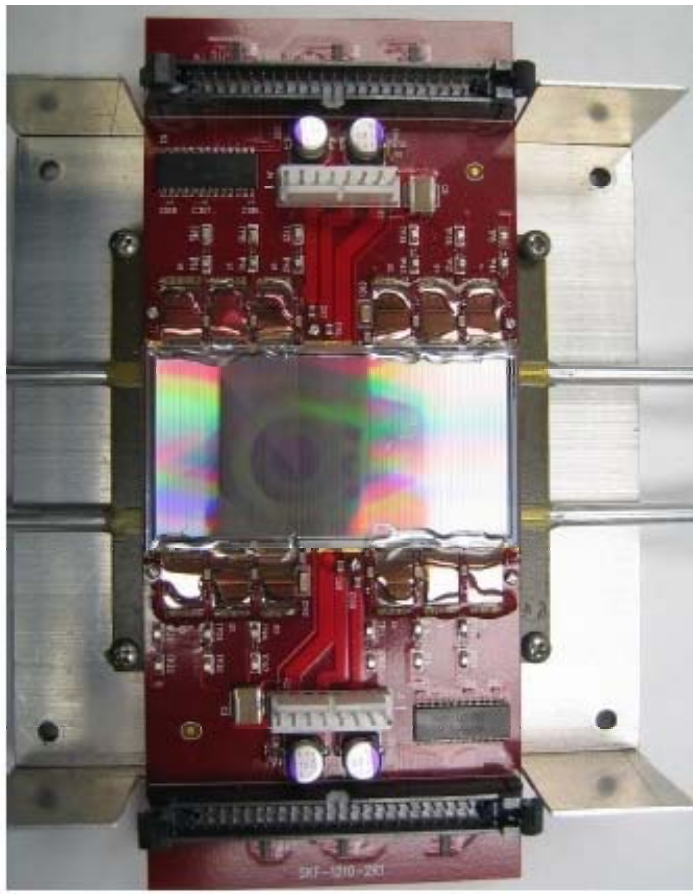
pixel array: 80×1000 μm^2 pitch

Reading by p-side

5 μm line, 3 μm gap, 5 turns







- Pixel array: 80×1000 μm^2 pitch
  - so called "stripixel"
- Single sided (p-side), 2-dim. readout
  - Double metal structure
  - Charge sharing during x and u strip
- Detector size : 3.5×6.2 cm^2 ×625mm
  - 1536 channel / 1 sensor

Strip detector :
world's first 2-dimensional readout from 1 side

pixel array: 80 × 1000 μm^2 pitch

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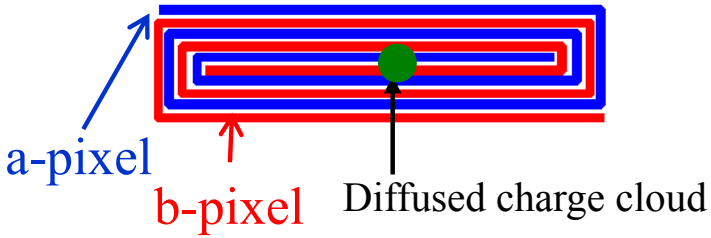
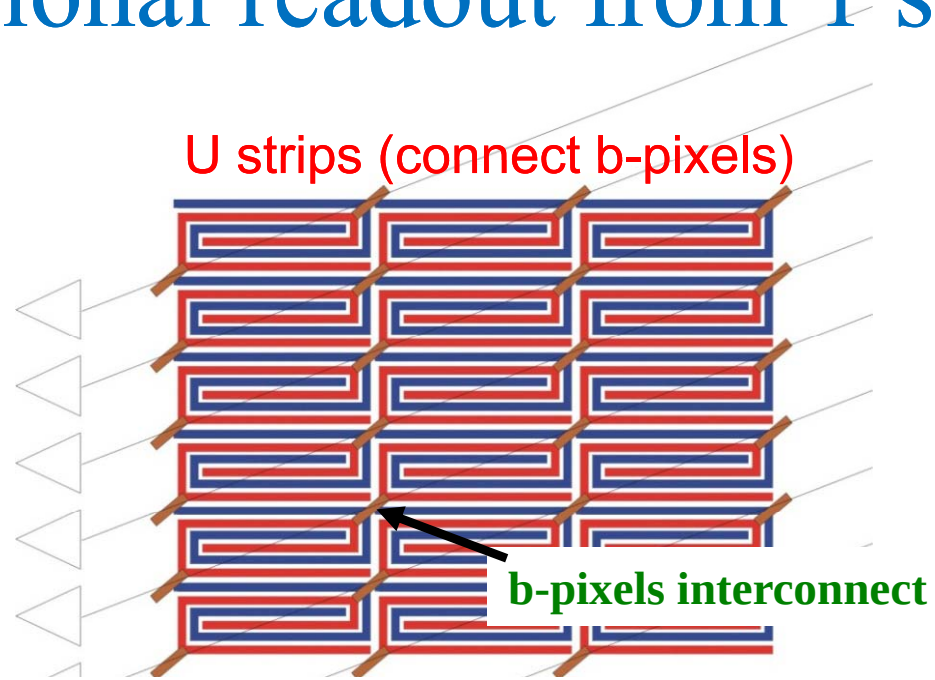
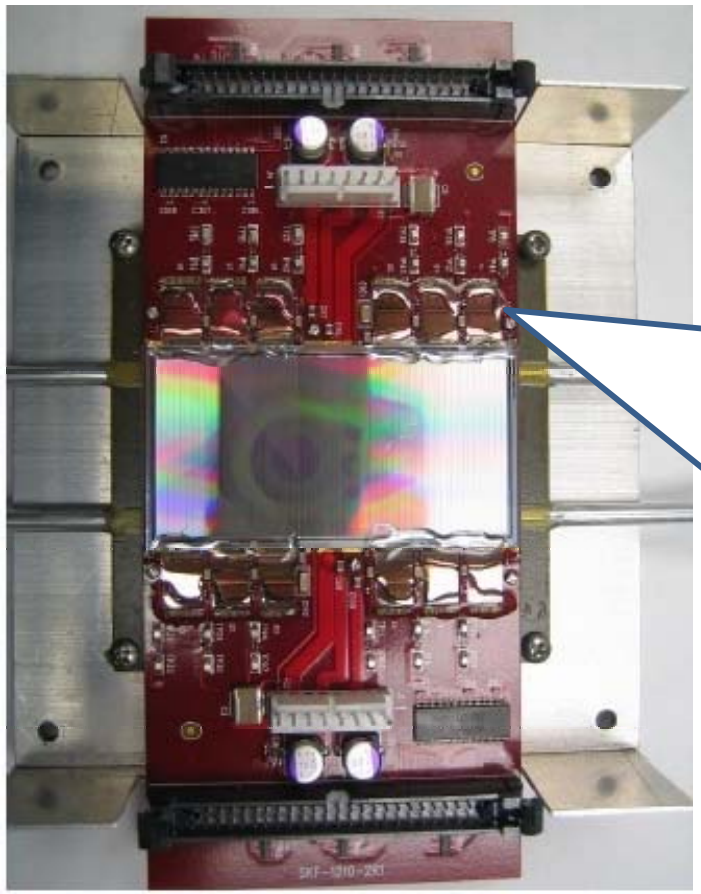
5 μm line, 3 μm gap, 5 turns



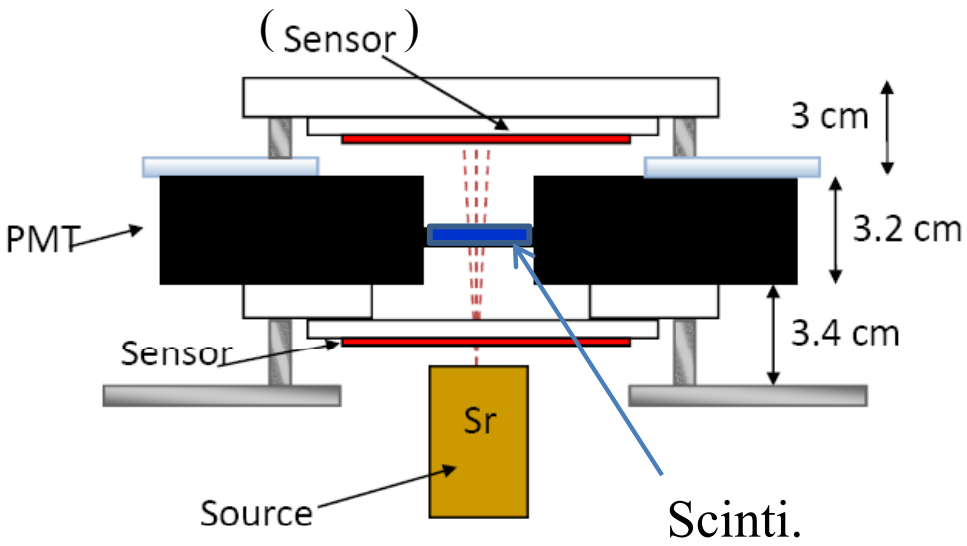


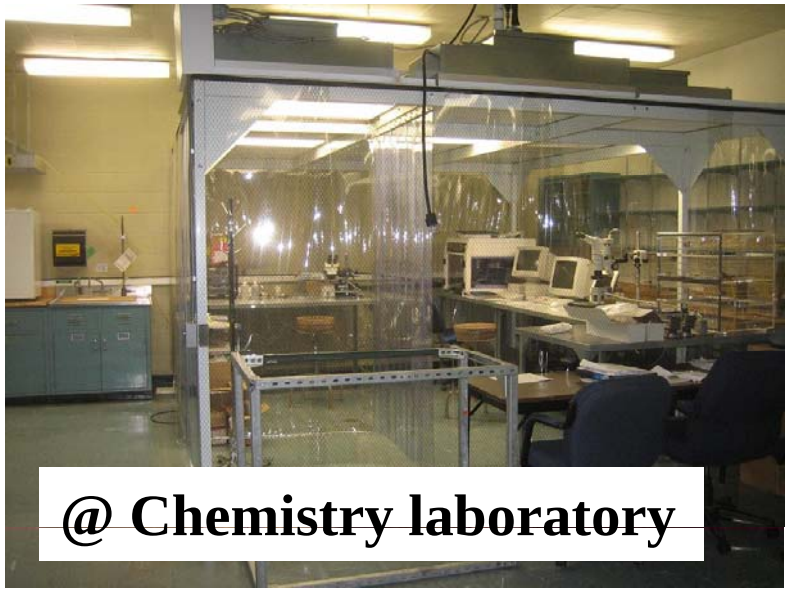


SVX4 chip

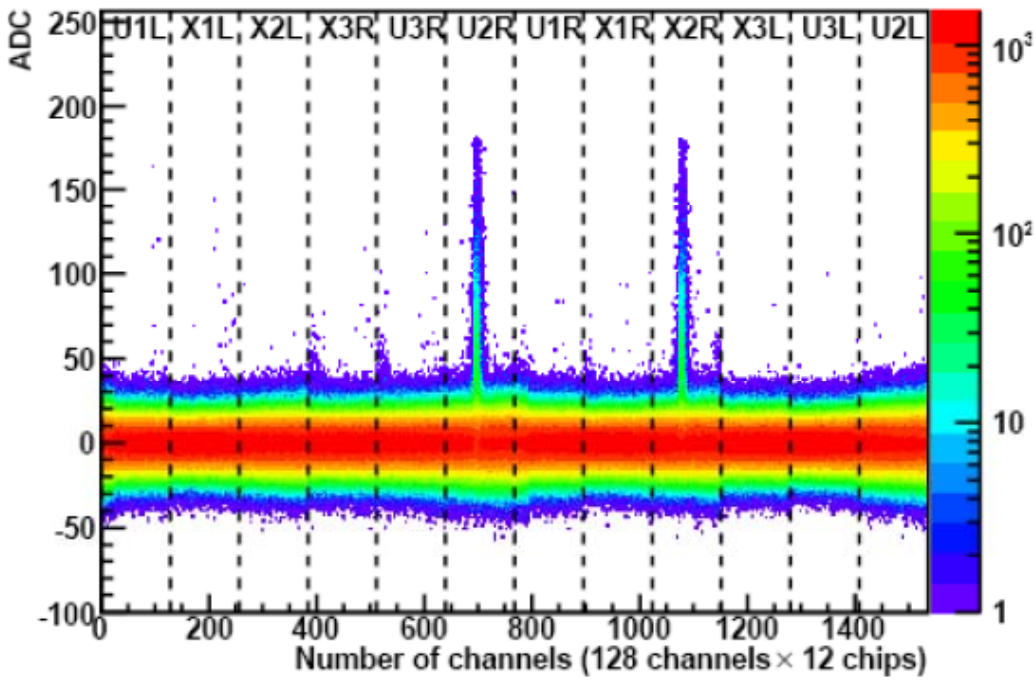
- 8 bit ADC
- 128 channel / chip
- Dead time less readout
- 3 mW / channel

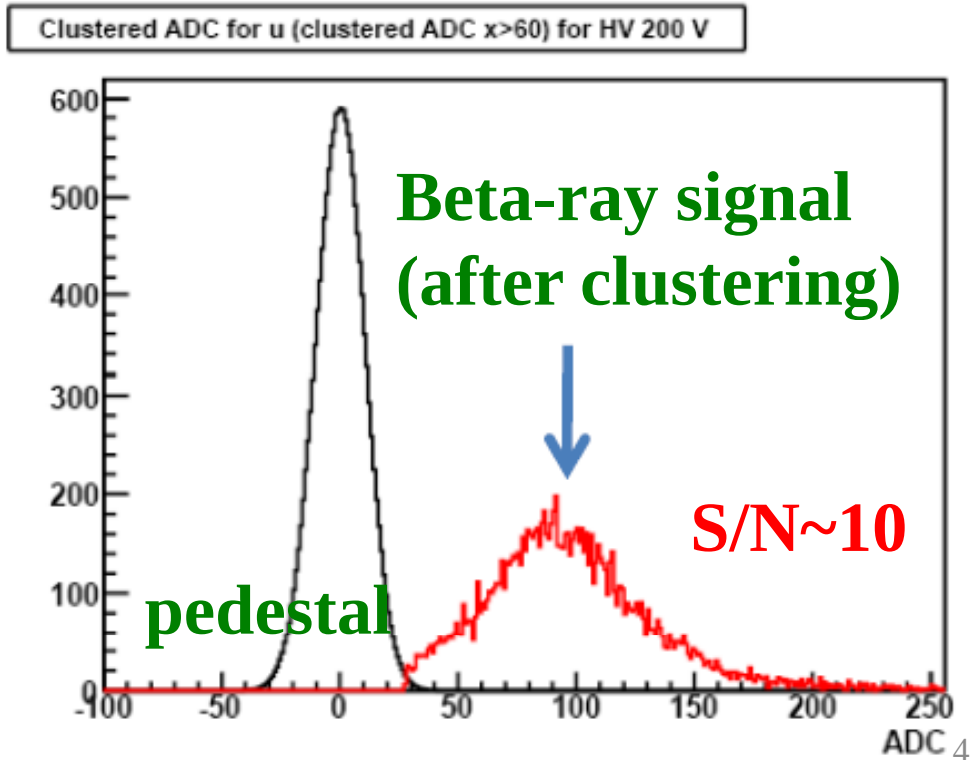
Test with beta source





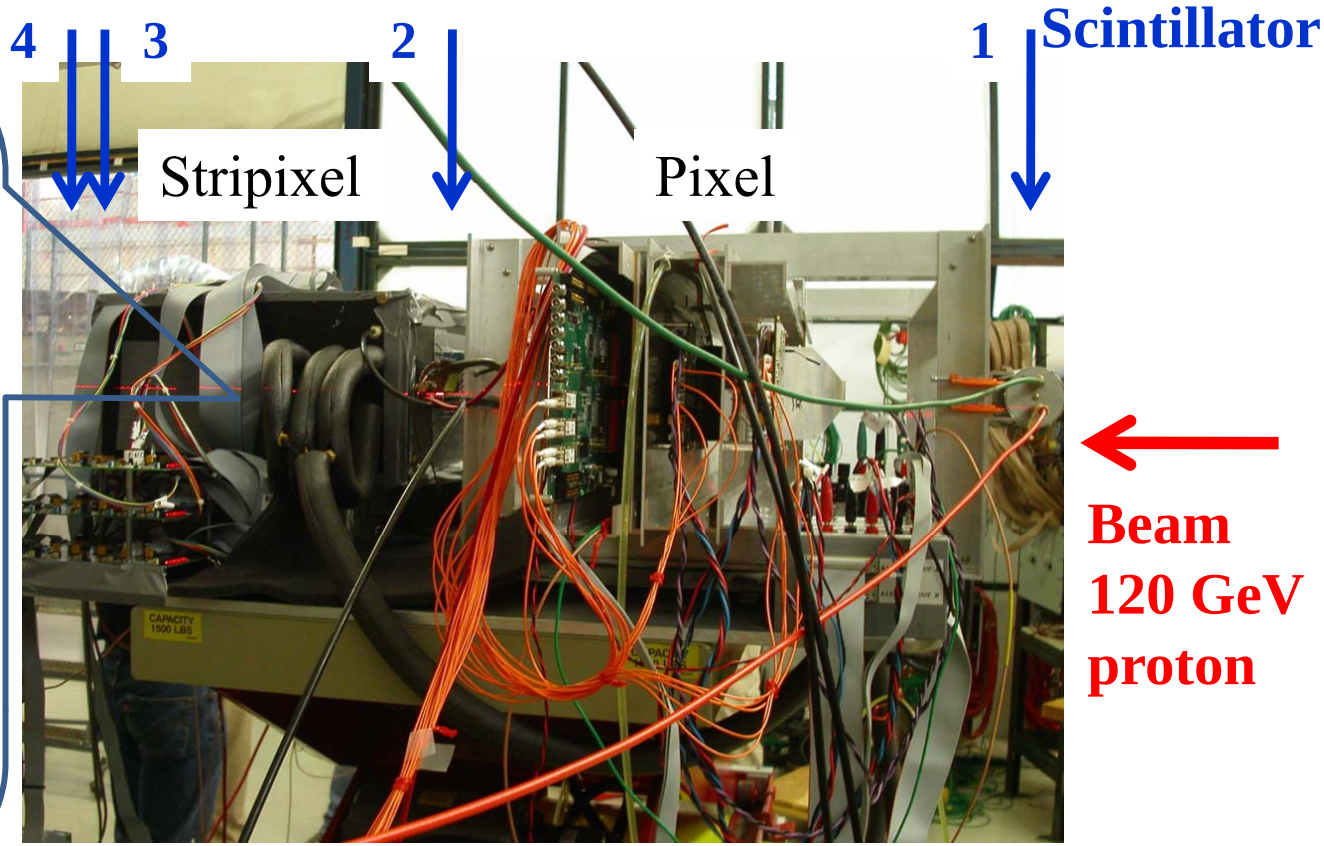
Beta-ray signals (all events)



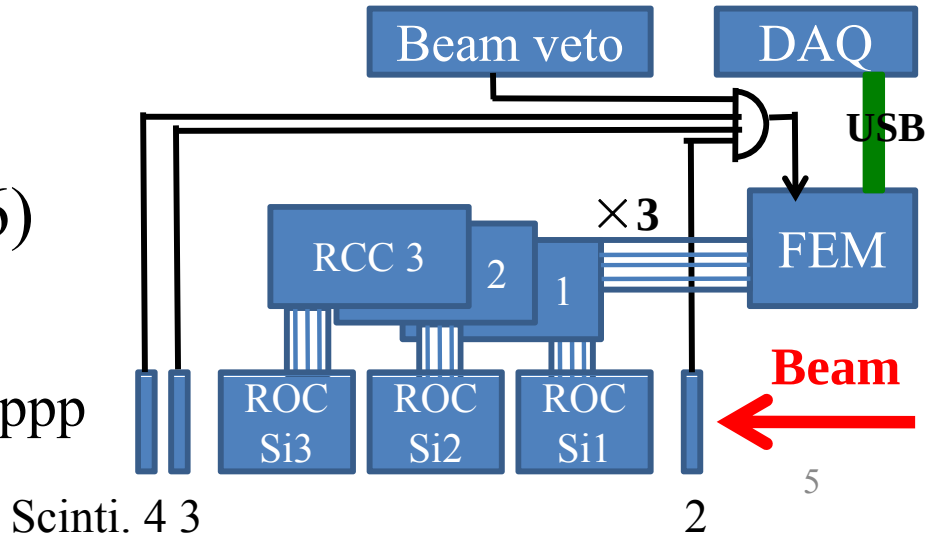


Performance study with 120 GeV proton beam

3 stripixel detectors as hodoscope



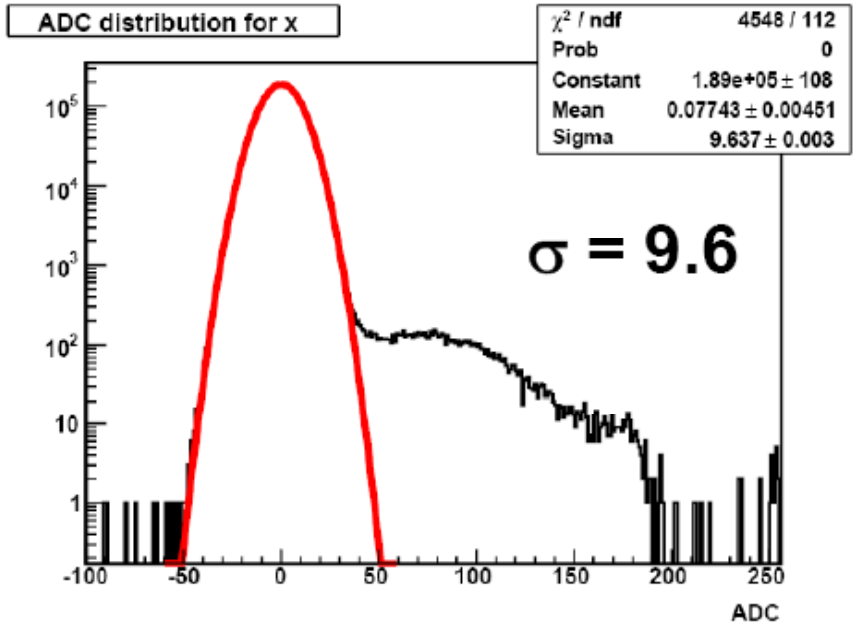
- Test beam at Fermi Lab.
  - T986 at MTBF (2008/Aug./20-26)
  - 120 GeV proton beam
    - 1 spill 4.5 s in each 1 min. 2×10^{10} ppp
    - Beam size : 5 ~ 30 mm



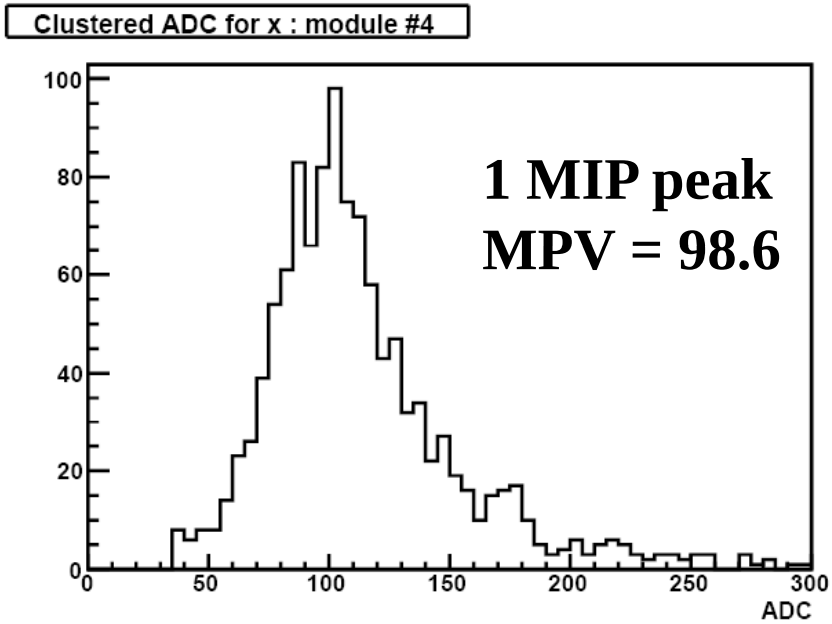
S/N ratio

preliminary

Raw ADC distribution



Clustered ADC distribution



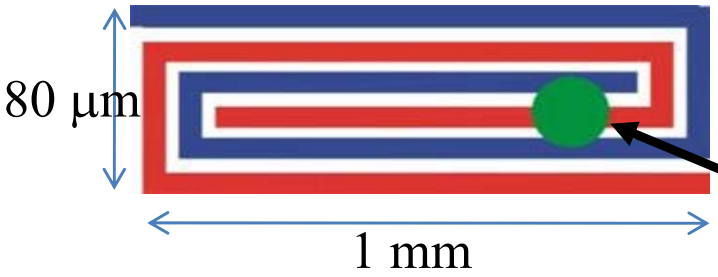
Channels "Stripixel"	Pedestal σ	MIP MPV	S/N
x	9.6	98.6	10.3
u	10.1	102.2	10.1

S/N ratio ~10 : consistent with the result of beta-ray

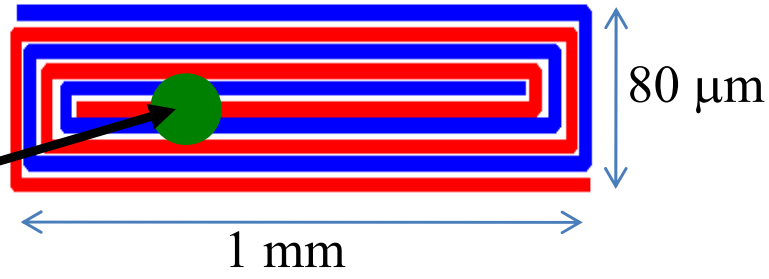
→ Evaluation of the position resolution and detection efficiency with this S/N ration

Charge sharing in x and u for 0 Degree

Prototype (3 turns)



Current production (5 turns)

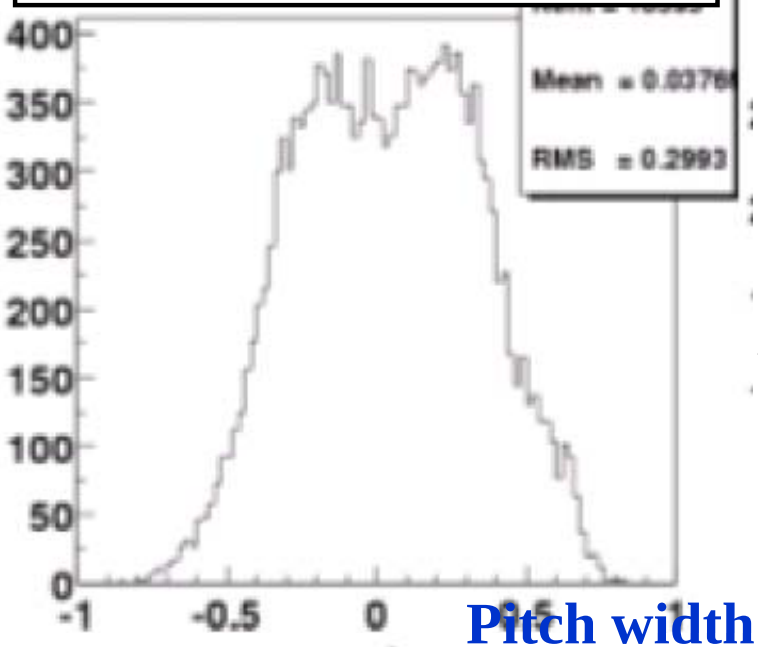


Diffused charge cloud

Important parameter

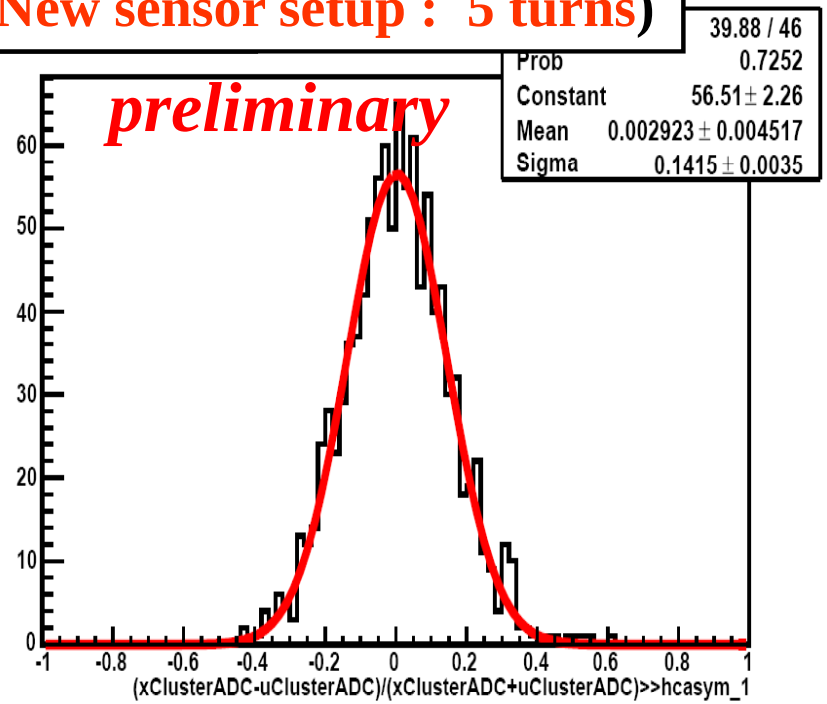
$$A_Q \equiv \frac{Q_x - Q_u}{Q_x + Q_u}$$

From KEK test
(Old sensor setup : 3 turns)



Pitch width is not enough narrow for charge diffusion

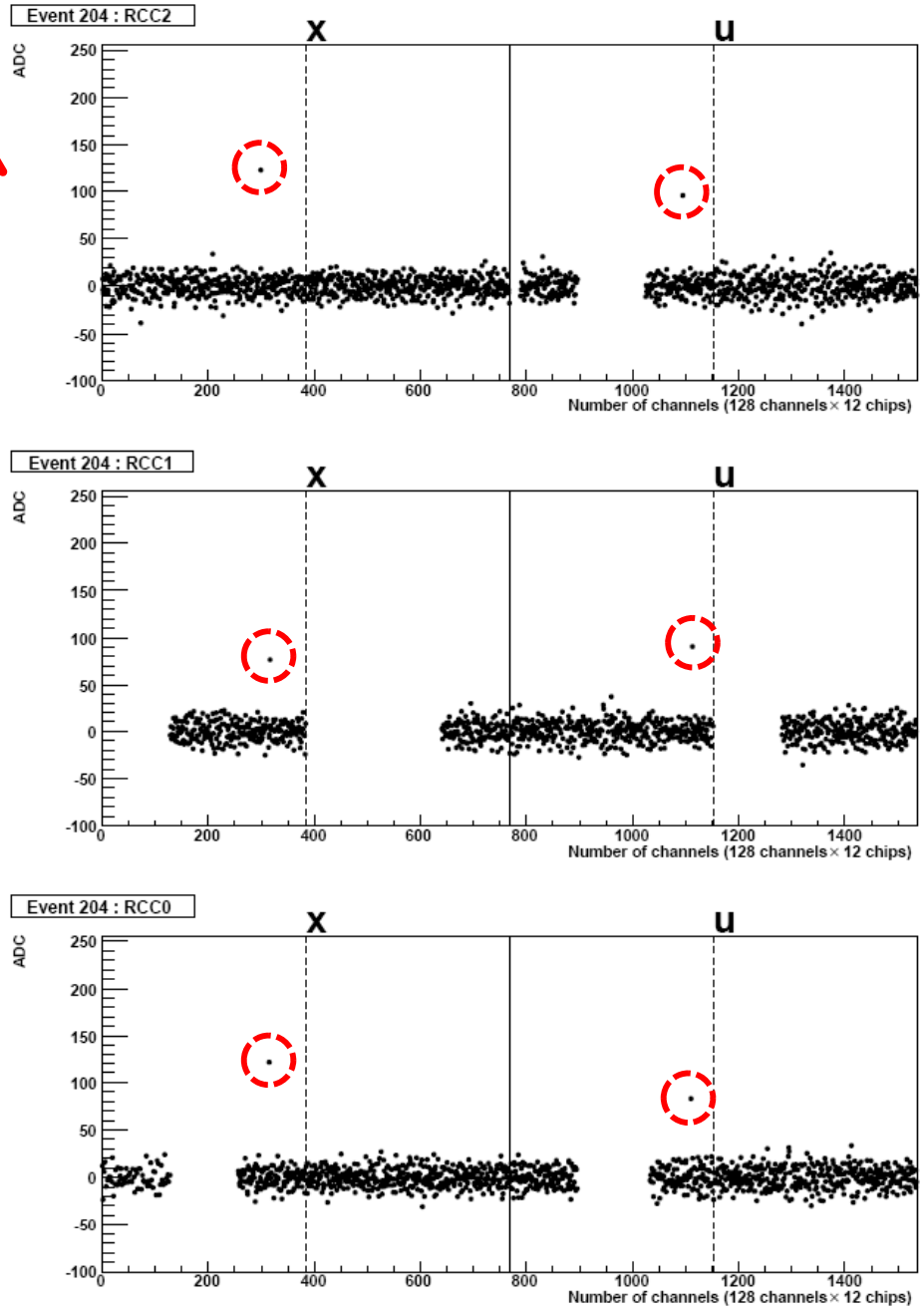
From Beam Test (FNAL):
(New sensor setup : 5 turns)



Good charge sharing in x and u

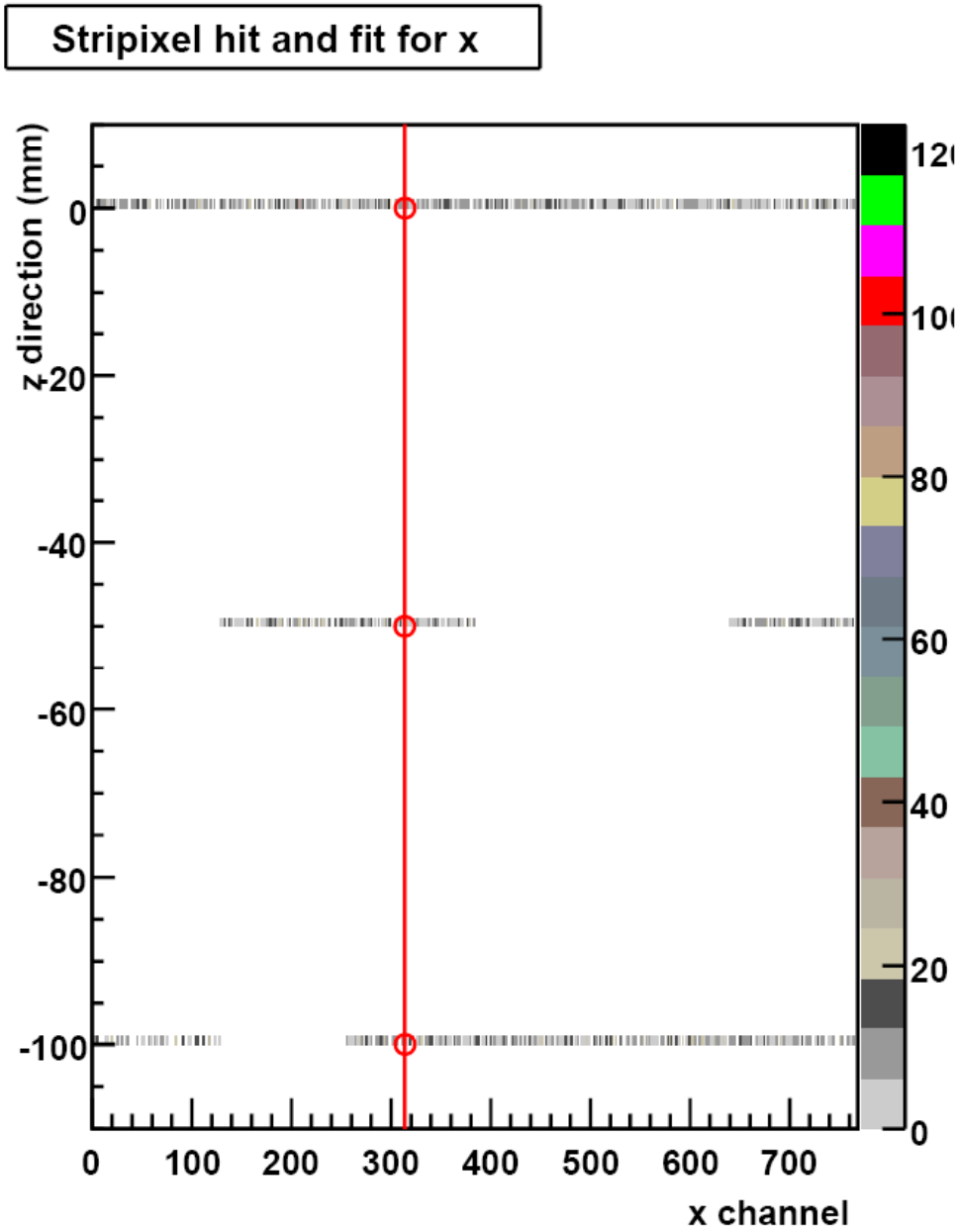
Event display & Tracking

preliminary



beam

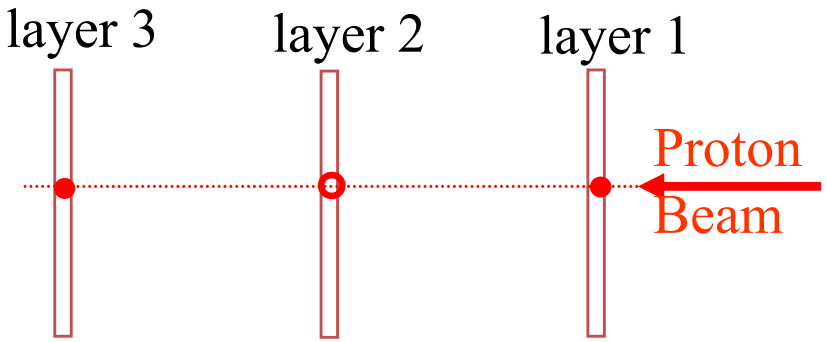
1 event display

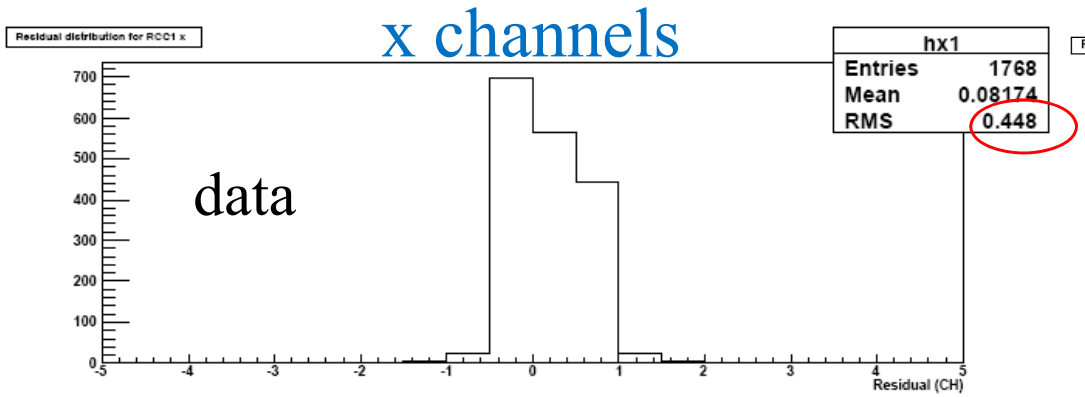


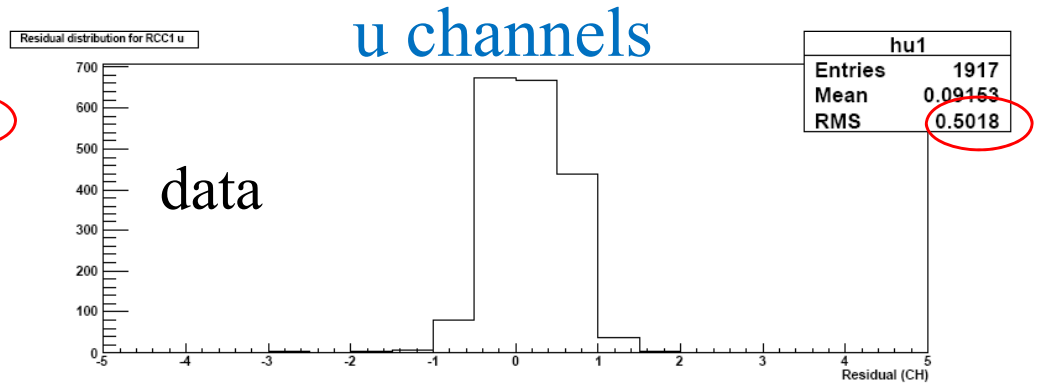
Tracking using 3 sensors

Residual distribution *preliminary*

- Difference btw hit position in layer 2 and expected position by tracking using layer 1 and 3







Residual RMS in layer2 :

for channels x: 0.45 (RMS) x 80 μm (pixel size) = 36 μm

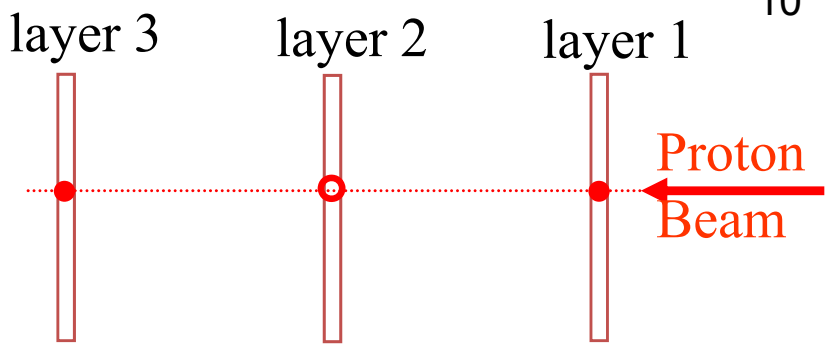
for channels u: 0.50 (RMS) x 80 μm (pixel size) = 40 μm

Shape of the distribution is consequence of the three-plane-resolution with imperfect alignment

Detection efficiency

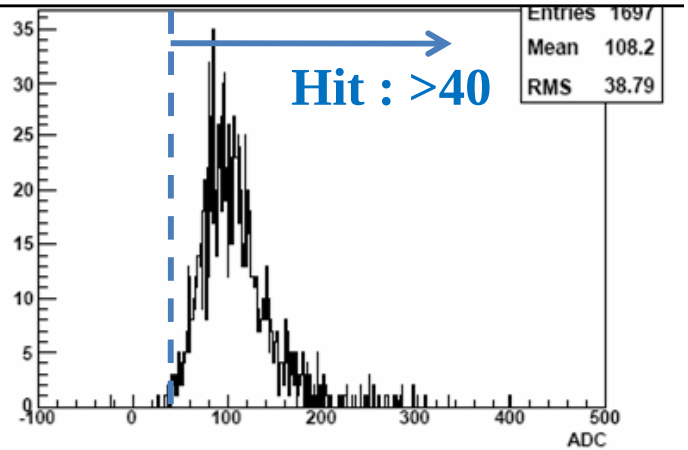
preliminary

- Energy deposit in expected CH in layer 2 from the tracking using layer 1 and 3.



$$Eff \equiv \frac{(\text{All count}) - (\text{Count in ADC} < 40)}{\text{All count}}$$

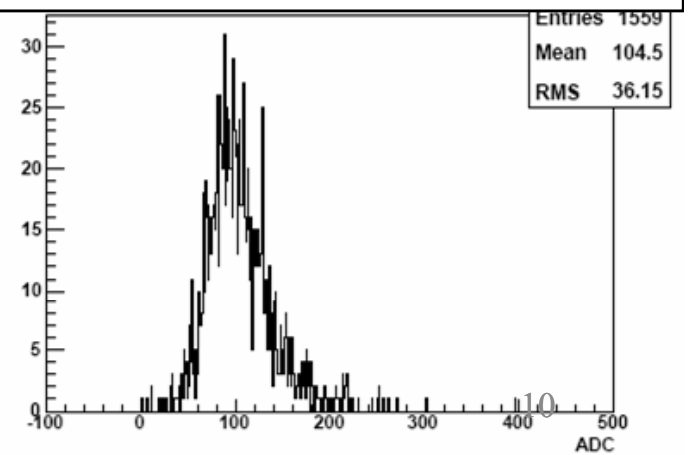
Sum of ADC in expected CHs (x) in layer2



By tracking (x)

Layer #	All count	Count in ADC < 40	Efficiency (%)
2	1697	9	99.5±0.2

Sum of ADC in expected CHs (u) in layer2



By tracking (u)

Layer #	All count	Count in ADC < 40	Efficiency (%)
2	1559	18	98.9±0.3

Results satisfy performance demand

→ Preparing for mass production

Sequence of mass production (Plan)

Silicon sensor QA
(RBRC room)

RBRC laboratory (physics building)

ROC
(made by Hughes company)

↓

Mounting svx4 chips → test
(private company or FNAL)

↓

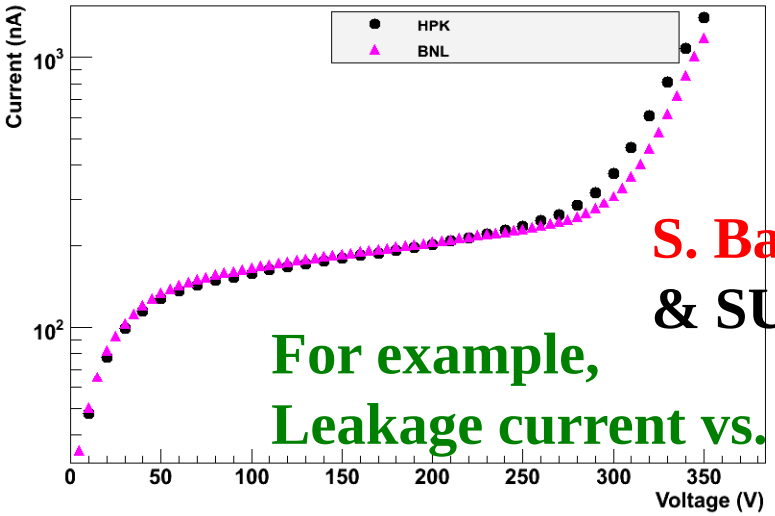
Mounting sensor → wire bonding → test
→ encapsulation (VTX people @ FNAL)

↓

Testing & ladder assembly
(BNL : chemistry lab.)

↓

Barrel assembly
(BNL : chemistry lab.)

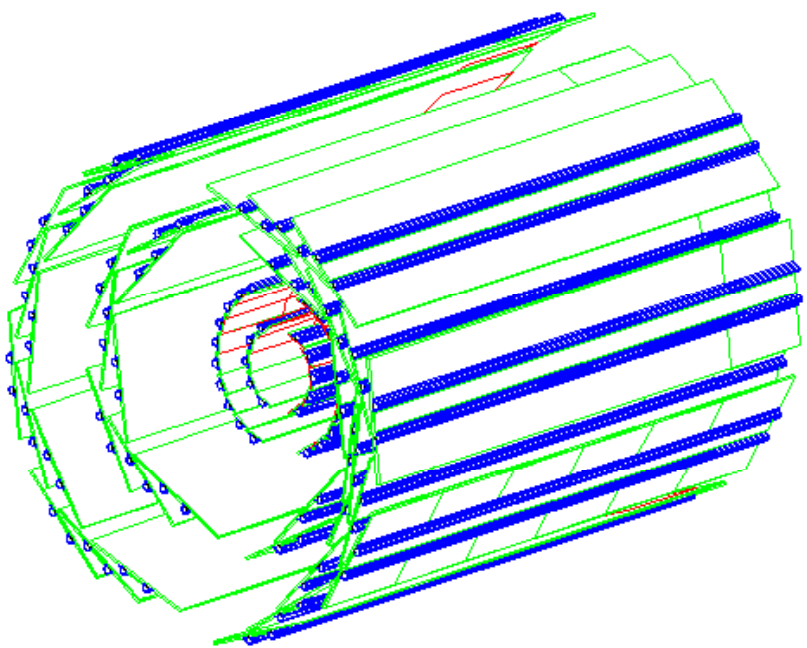


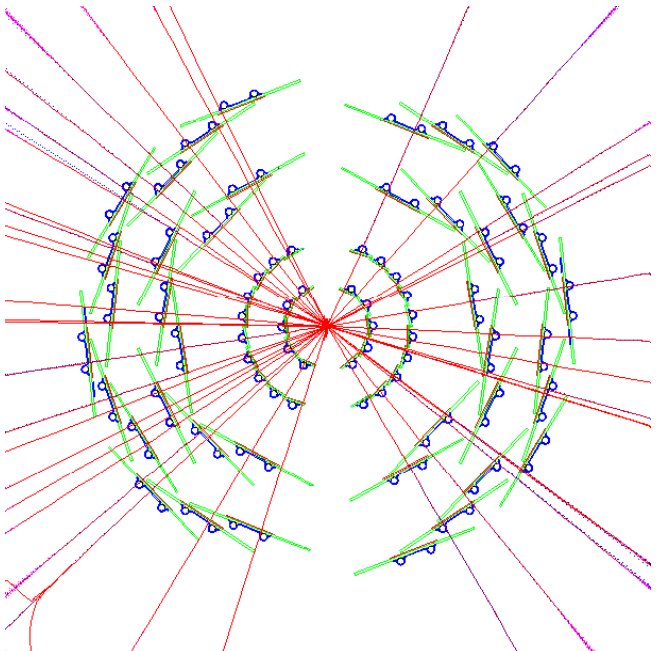
S. Bathe, K. Boyle,
& SUNY group

For example,
Leakage current vs. HV

Full Monte Carlo Simulation

- Constructed based on the results of performance test
  - Configuration, material
    - Pixel : 1.3% / layer, Stripixel : 3.6% / layer
    - Total : ~10%
  - Charge sharing, S/N ratio
  - Data format is same as actual format we will take via DAQ.
    - Developing analysis code and perform blind analysis.
- We are preparing large amount of simulation data





Summary

- We are developing the silicon strip detector for the PHENIX VTX tracker
  - This is world's first 2-dimensional readout from 1 side (p-side).
- Performance study for the strip pixel detector were done with beta-ray and 120 GeV proton beam.
  - S/N ratio : 10
  - Residual : 36μm
  - Detection efficiency : >98%
  - Good charge sharing btw x and u strips.

  preliminary

  These performances satisfy a need for VTX tracker. Final adjustment for mass production is ongoing toward 2010 install.
- Full Monte Carlo simulation has been constructed based on these results.
  - Development of analysis code and blind analysis are ongoing