

A Prototype of Radiation Imaging Detector Using Silicon Strip Sensors

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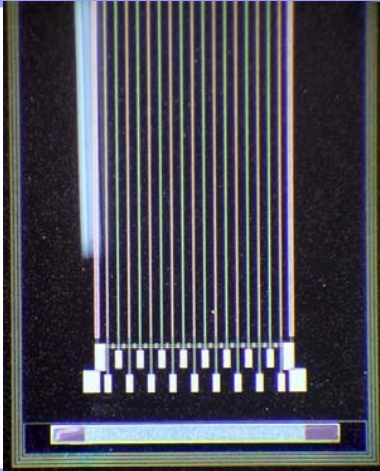
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- **Sensor Prototype**
 - AC-coupled Single-Sided Silicon Strip Detector (SSSD)
 - Specification
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 - Proton beam test
 - ^{90}Sr β^- test
- **Brief introduction to Double-Sided Silicon Strip Detector (DSSD) for X-ray imaging system**
- **Summary**

Applications of Fabricated Silicon Strip Sensor

Silicon Strip Sensor



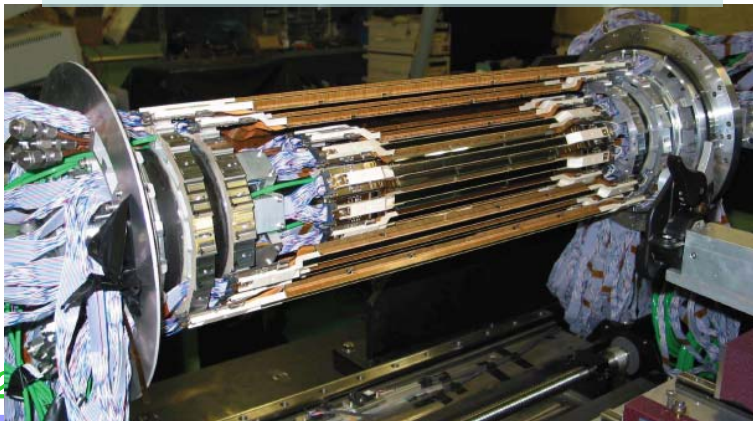
X-ray imaging in medical science



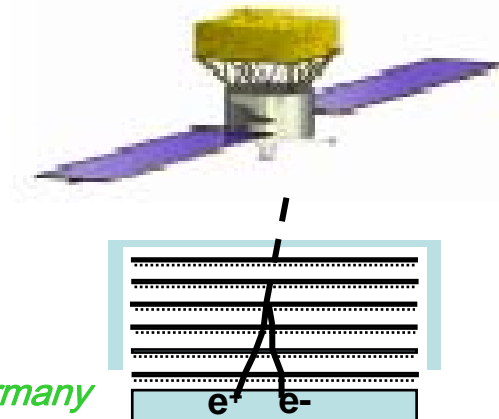
Nondestructive Inspection



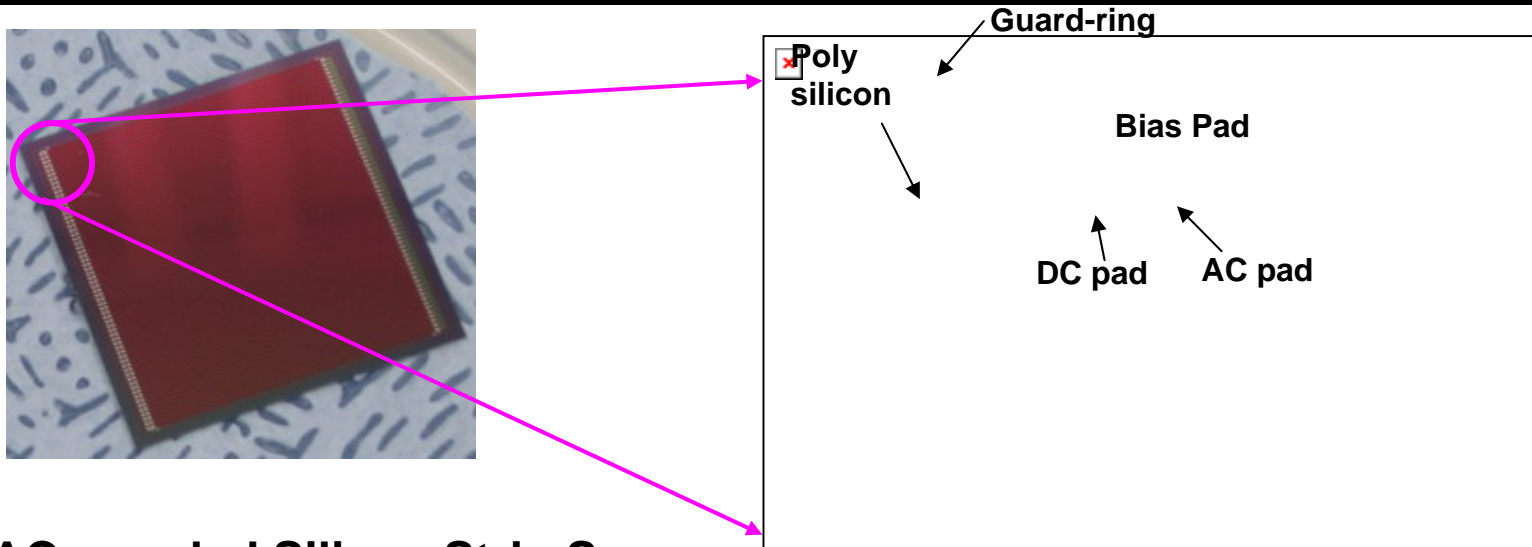
Multiplicity/tracking measurement in particle/nuclear physics



Tracking in astrophysics



A Prototype of AC-Coupled Silicon Strip Sensor



■ AC-coupled Silicon Strip Sensors

high resistivity ($> 5 \text{ k}\Omega\text{-cm}$), $\langle 100 \rangle$, n-type, 5-inch silicon wafer

sensor area (mm^2) 35 x 35

sensor thickness (μm) 380

number of implant strips 64

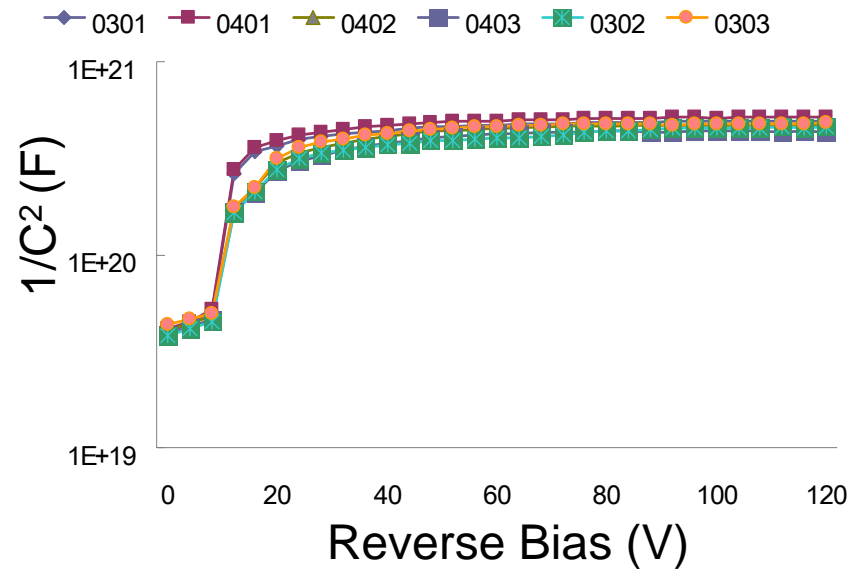
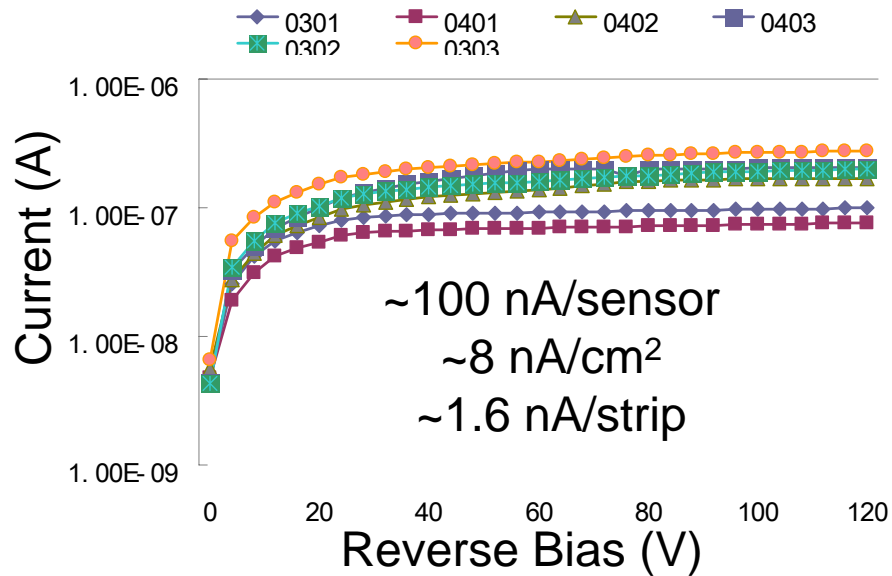
strip pitch (μm) 500

strip implantation width (μm) 400

strip metallization width (μm) 420

Fabrication at ETRI
(Electronics and
Telecommunications Research
Institute, Daejeon Korea)

Electrical Test



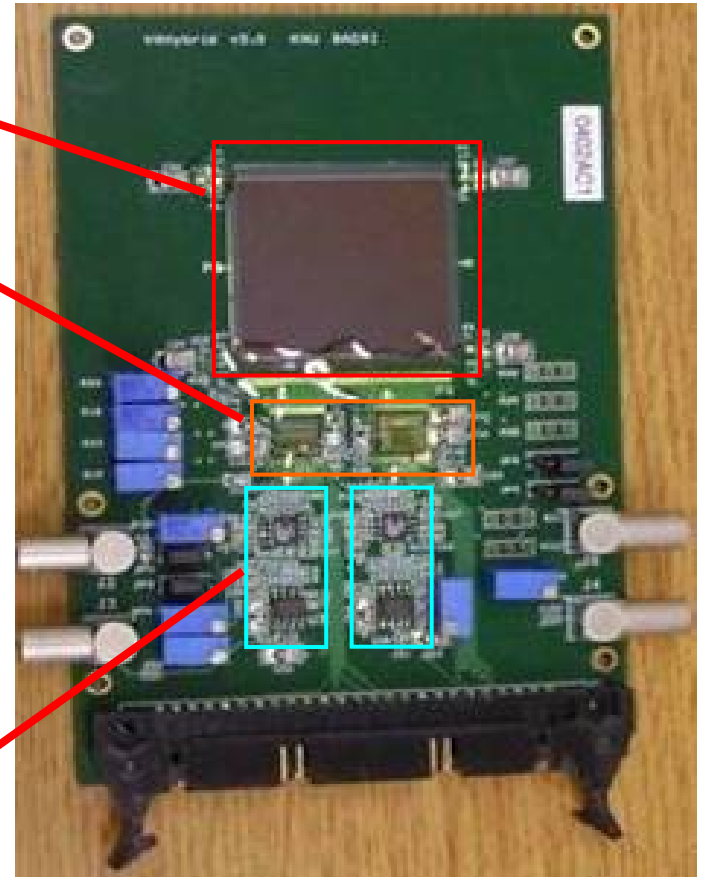
22~24 °C/21%

Readout Electronics

- **Single-photon counting readout electronics**
 - Irradiation can be minimized
 - Better image is expected
- **Event rate**
 - Maximum at 100 kHz
- **Components**
 - VAHybrid
 - A Sensor, 2 ASICs (VA) and operational amplifiers on a single board
 - VAControl
 - Accept a trigger
 - Control signal generation to VAHybrid
 - VAInterface
 - LV/HV supply, logic conversion
 - Flash ADC
 - Digitization of VA analog signal output

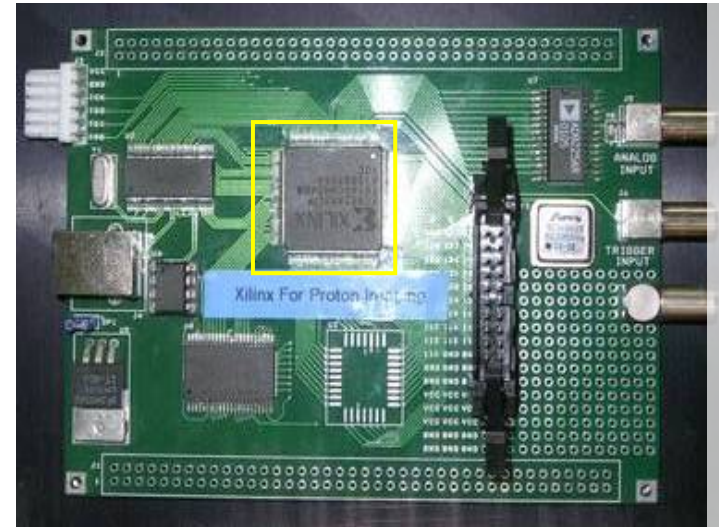
VAHybrid

- **Sensor (AC-coupled, single-sided strip)**
- **VA1_Prime2.3 (Gamma-Medica IDEAS)**
 - 128 channels
 - For each channel
 - a charge sensitive preamplifier ($180 + 7.5/pF$ e^- rms @ 1 μ s peaking time),
 - a shaper
 - a sample-and-hold
 - Analog signal of 128 channels is serially clocked out
- **Variable gain amplification**



VAControl, Flash ADC, and VAInterface

- **VAControl**
 - Xilinx CPLD accept a trigger to generate a control logic to VAHybrid
 - Communication to PC via USB2 (Cypress, 8051)
- **Flash-ADC**
 - 64 MSPS
 - 12-bit resolution
- **VAInterface**
 - HV/LV supply to VAHybrid
 - Logic conversion between VA and TTL



VAControl

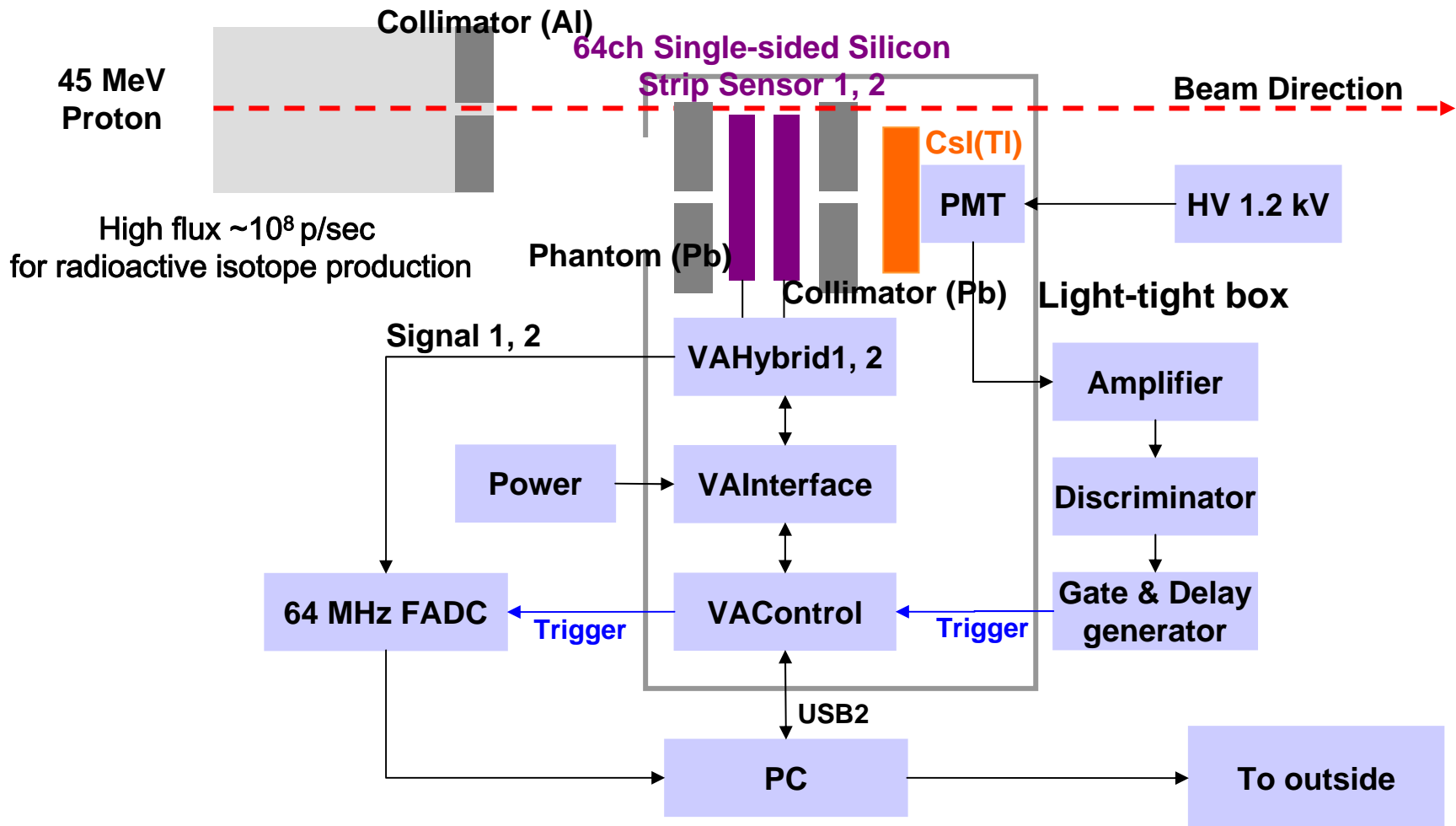
Flash-ADC



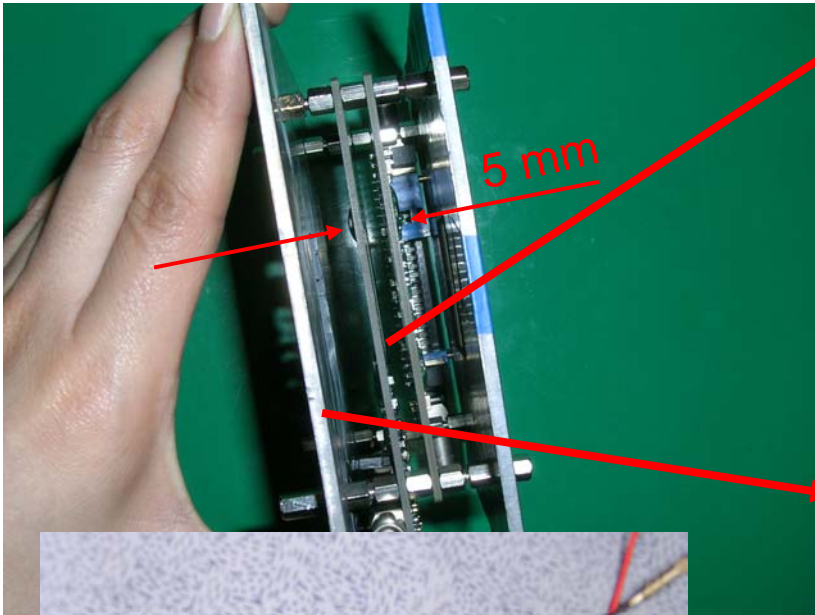
VAInterface

Proton Beam Test

Block Diagram of Experimental Set-up

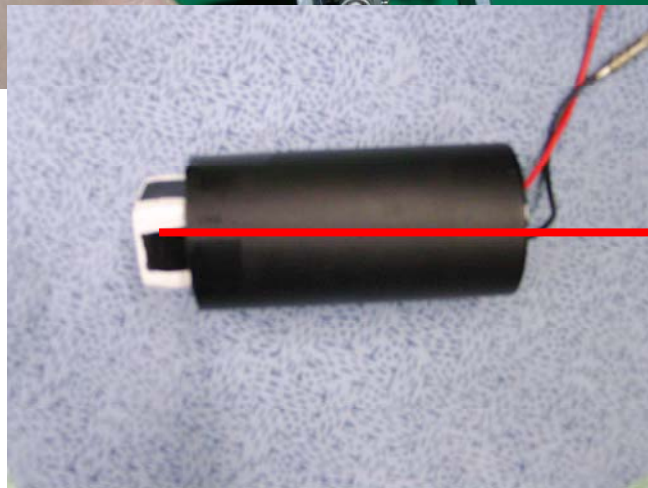


Detector Assembly



- 2 Sensors
 - Mounted orthogonally each other
 - 2-D position information
 - 5 mm space gap
 - Room temperature
 - Bias at ~50 V

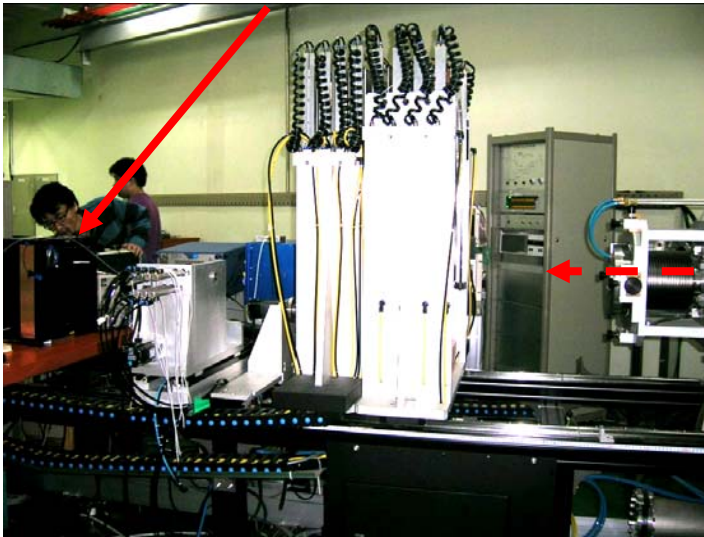
- Phantom
 - 3-mm-thick Pb
 - Absorb the proton beam



- CsI(Tl) Scintillation crystal
 - To trigger events
 - Energy measurement
 - 3.5 x 3.5 x 2.0 cm³

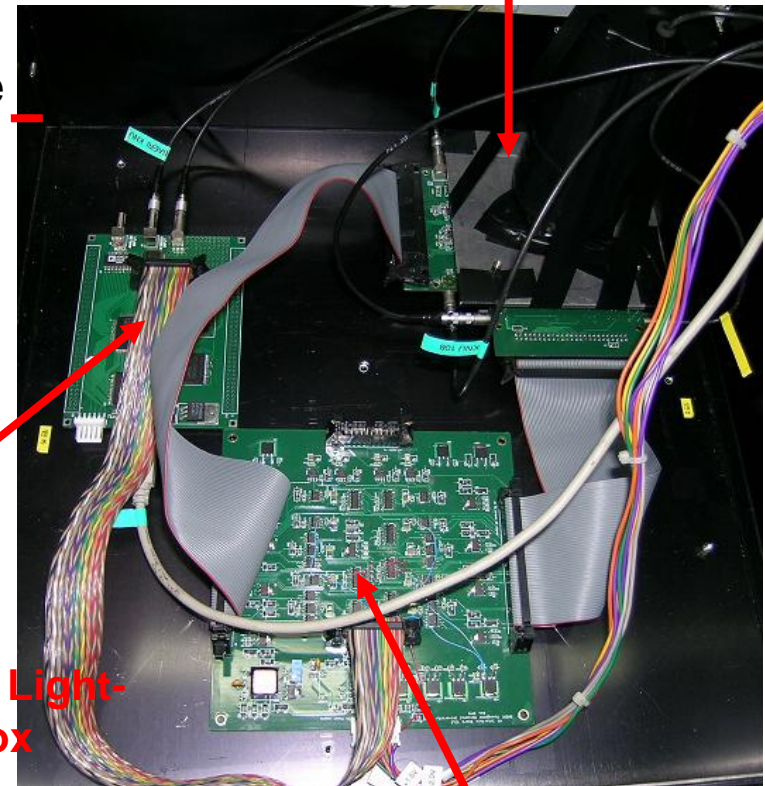
Proton Beam Test Set-up

Detectors and Electronics Assembly



**Proton Beam Line
at KIRAMS, Korea**

Pb Phatom, Silicon Strip Detectors
and CsI(Tl)



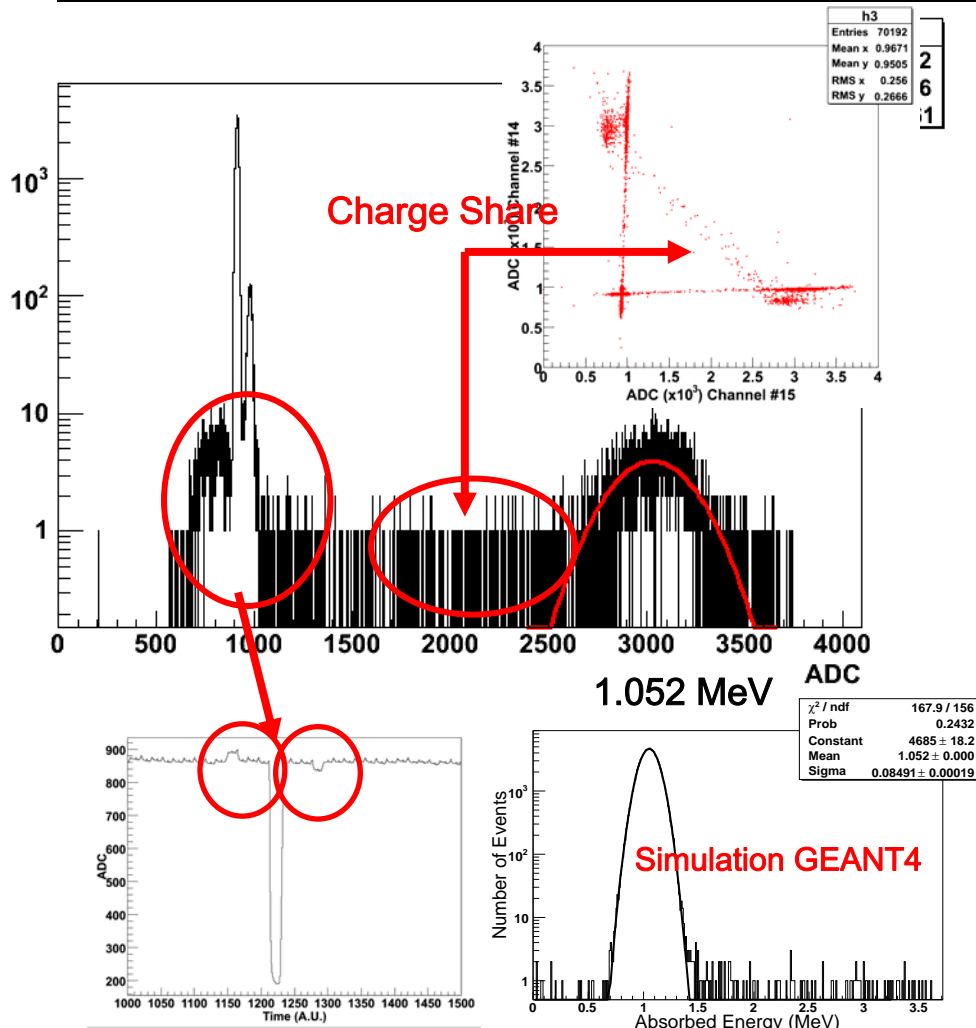
Beam Line

VAControl

**Inside of the Light-
Tight Box**

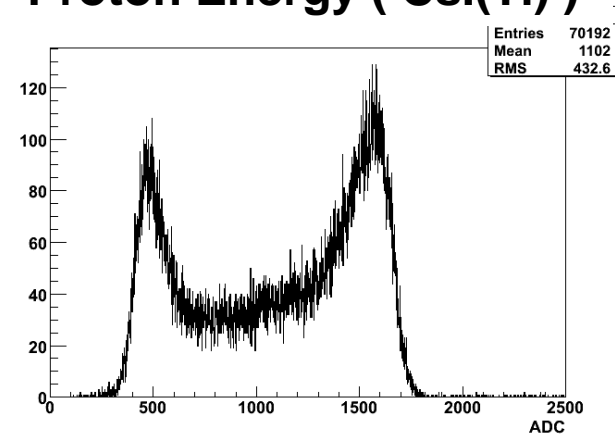
VAlnterface

Sensor Performance Tests with a Proton Beam



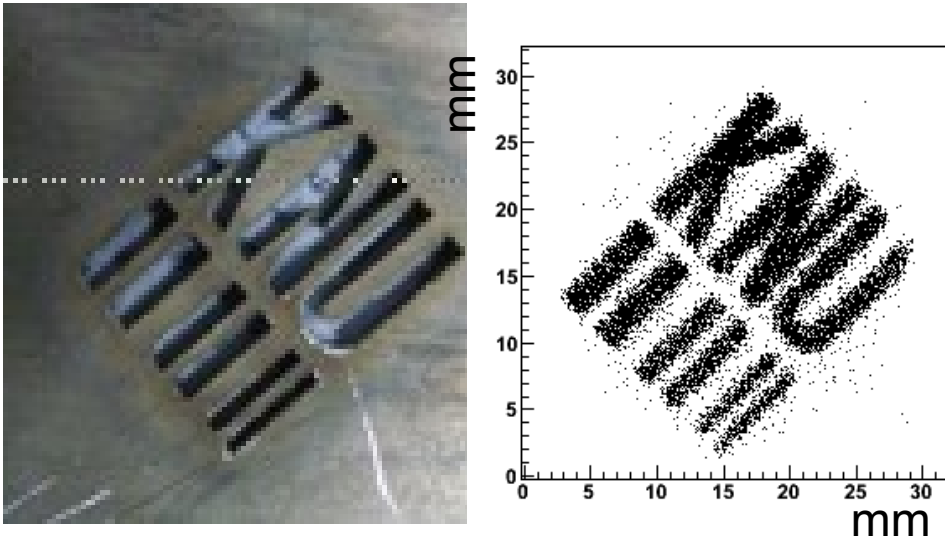
- ~3 % cross talk on both neighboring channels
 - Cause is under investigation

Proton Energy (CsI(Tl))



- CsI(Tl)
 - To trigger events
 - Energy information could be used for analysis

SNR and Phantom Imaging with a Proton Beam

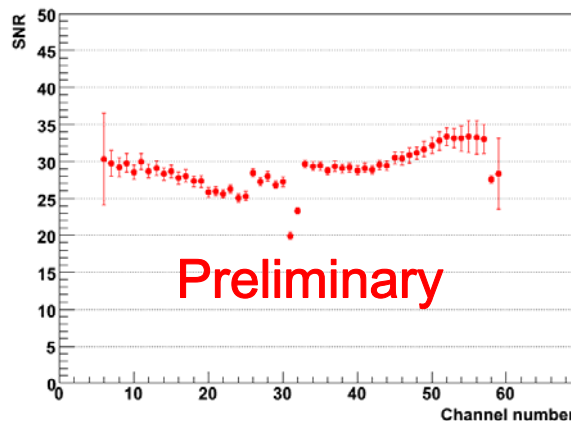


- Pb phantom
 - 3 mm thick
 - Widths of lines : 1~2 mm
 - Multiple scattering
 - Analysis is going on

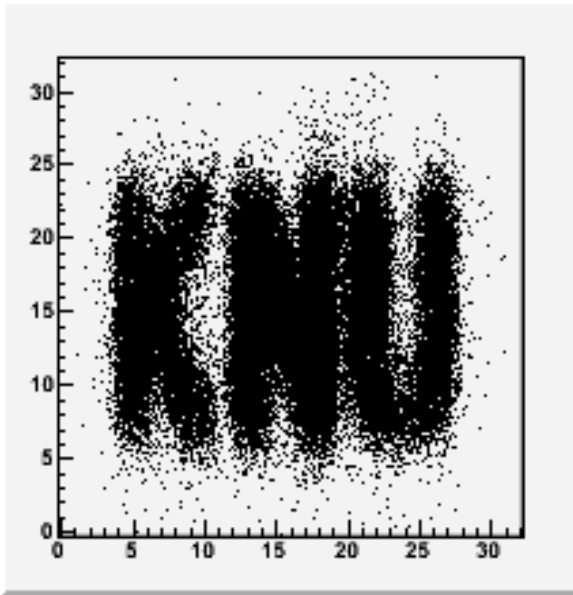
▪ Signal-to-noise ratio

$$S / N = \frac{MPV - \langle Pedestal \rangle}{\sigma_{Pedestal}}$$

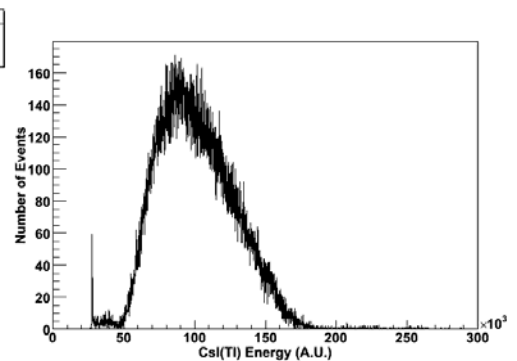
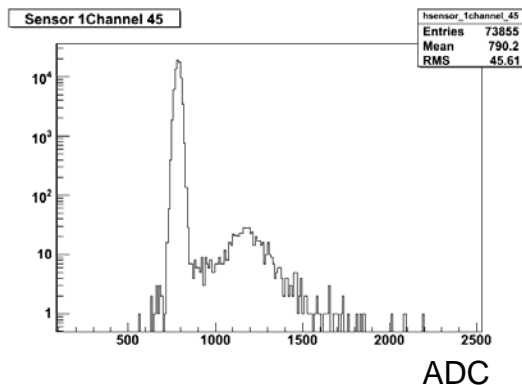
- S/N=29.1 +- 2.2
(a MIP equivalent)
~1,000 e- rms (Preliminary)



SNR and Phantom Imaging with a ^{90}Sr



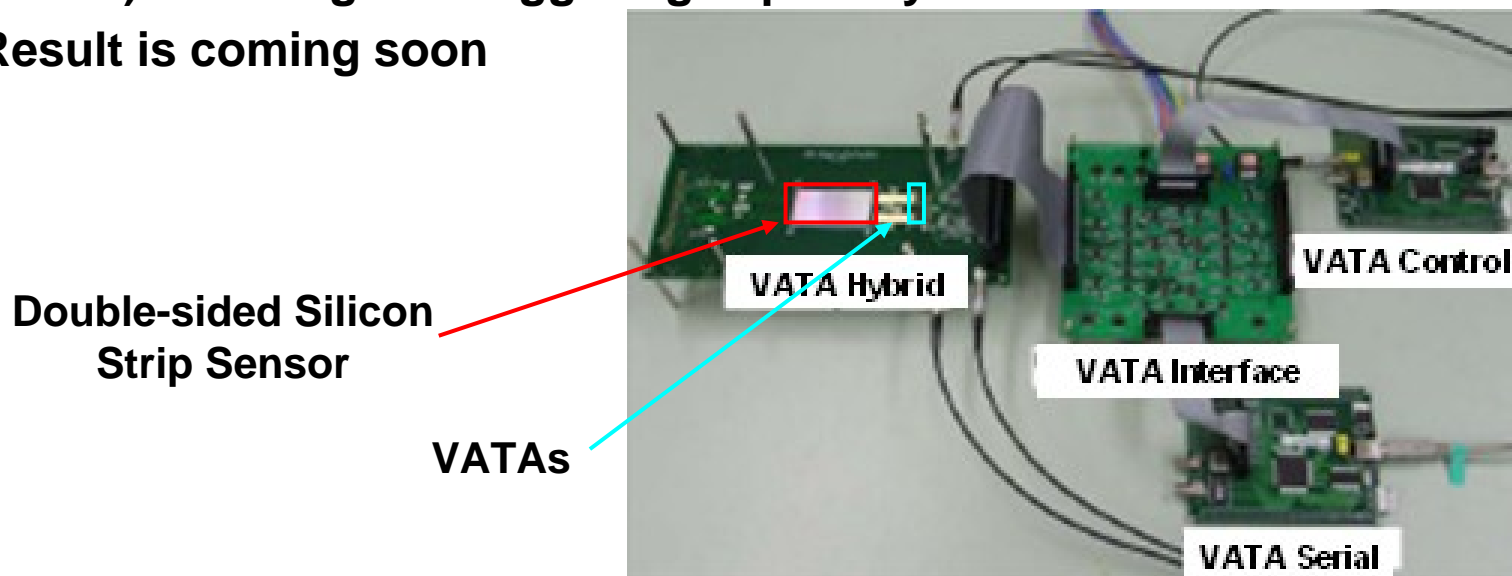
- Many stray hits in phantom image
 - Multiple scattering of electrons
 - In sensors
 - Off Pb edges
 - Air gap (5 mm) between 2 sensors
- Signal-to-noise ratio
 - 26.4 for MIP (Preliminary)
 - Consistent with proton beam test result
 - Further analysis is going on



- CsI(Tl)
 - Trigger events
 - Energy information could be used for analysis

Development of X-Ray Imaging System

- We are developing X-ray imaging system
 - Low energy (~ 20 keV) X-ray
 - Double-sided Silicon Strip Detector (DC-coupled)
 - RC chip for biasing and coupling to preamplifier
 - Single photon counting electronics using VATA (Gamma-Medica IDEAS) featuring self-triggering capability
 - Result is coming soon



Summary & Plan

- **Signal-to-noise ratio**
 - Better than 25 for a MIP with a 45 MeV proton beam and a ^{90}Sr radioactive source
 - Further analysis is going on
- **The feasibility study as an imaging detector**
 - 3-mm-thick Pb phantom by using a 45 MeV proton beam and a ^{90}Sr β^-
 - Further analysis is going on
- **Development of X-ray imaging system using double-sided silicon strip sensor and single-photon-count electronics**