PeV Explorer 計画 R & D（7）

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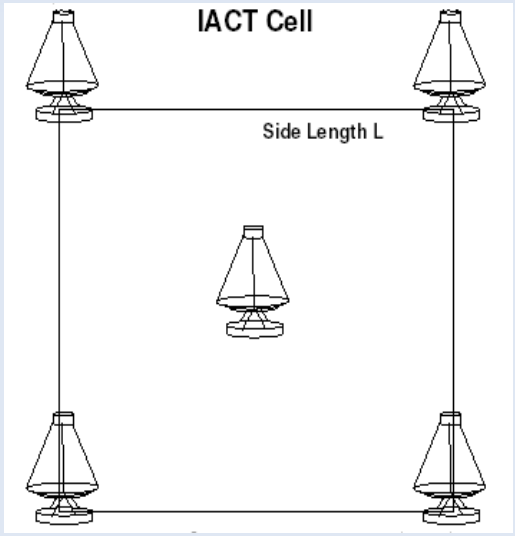
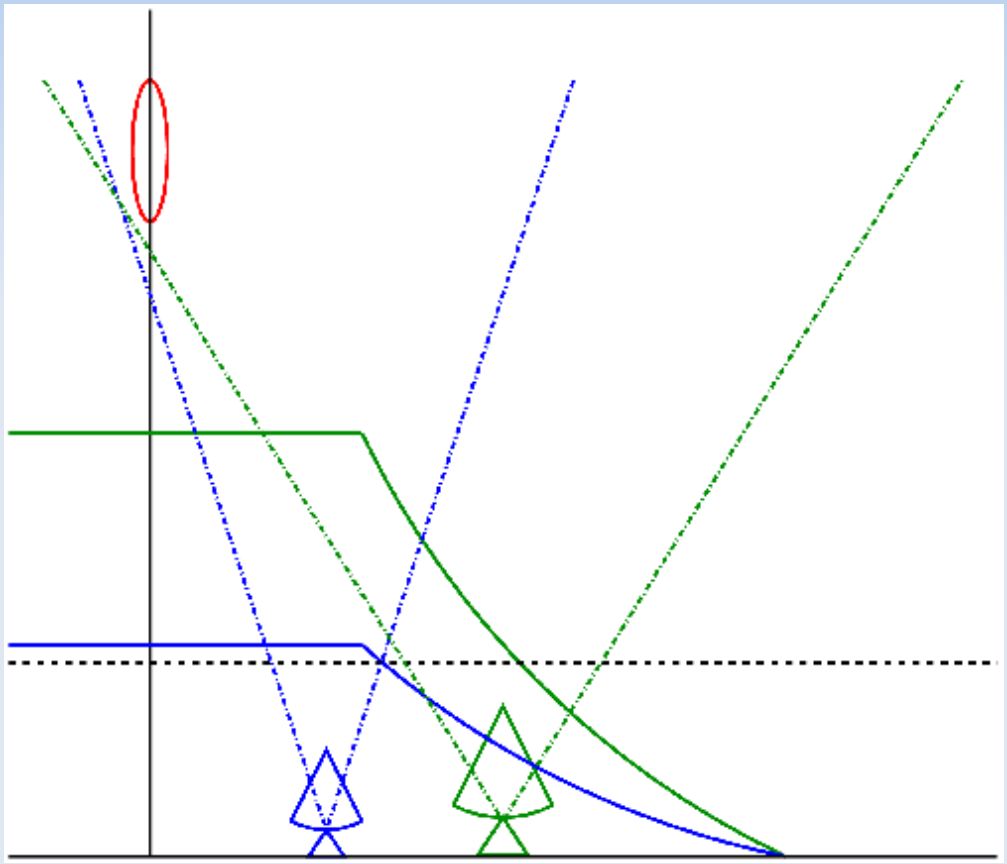
PeV Explorer (PeX)

- TenTen Project
  - Effective area of 10 km^2 at energies > 10 TeV
  - Stereoscopic array of 30–50 telescopes
- PeX: one cell of TenTen
  - Cost-effective design:
    - Inter-telescope spacing > 300 m
    - Mirror diameter 3–5 m
    - Field of view ~ 8°
  - Long exposure (several 100 hr) → key science
    - Origin of Galactic cosmic rays up to the “knee”, etc.



PeX Concept

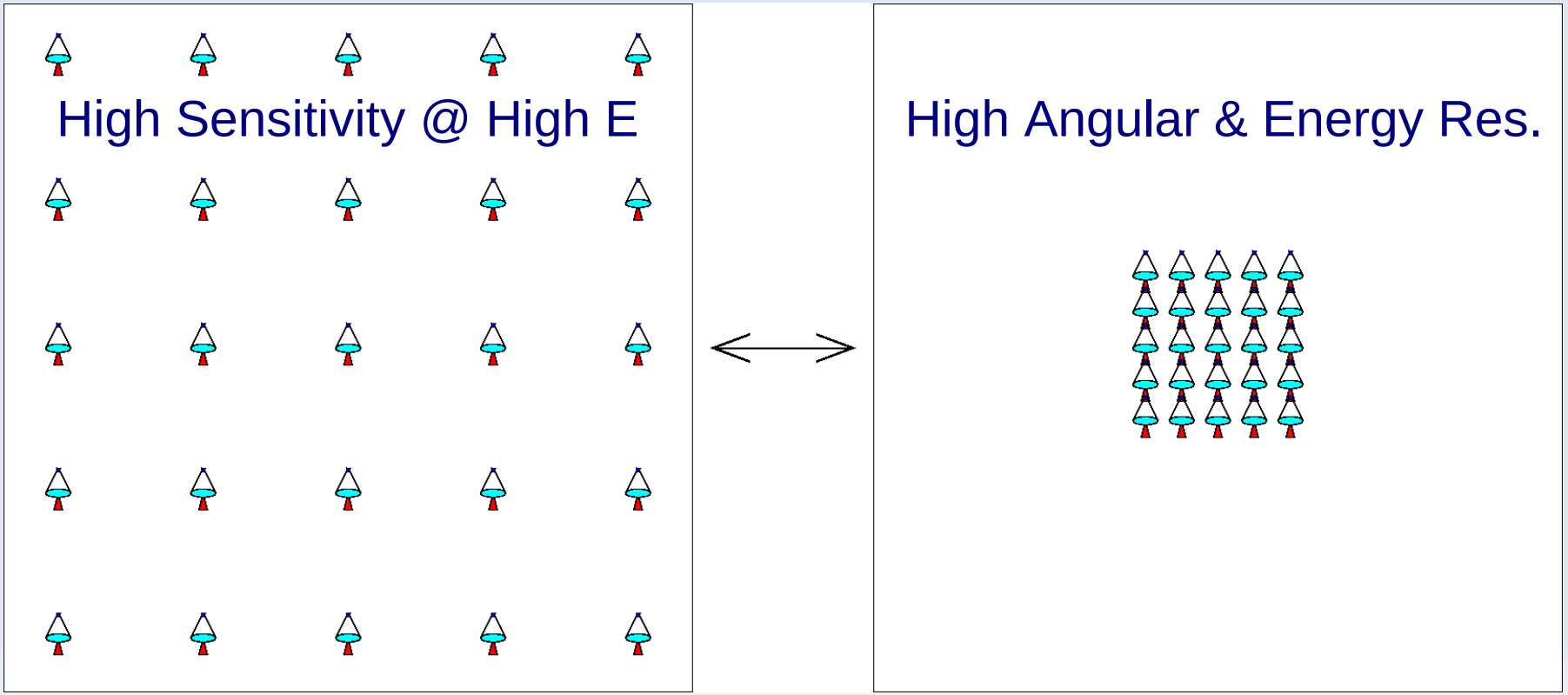


Plyasheshnikov et al. (2000)

- Cherenkov plateau
  - Radius ~ 150 m
- Cherenkov tail observable with larger aperture (or at high E)
  - Expand effective area
- Wider FoV necessary
- Effective area is a function of:
  - Aperture, span, FoV

Expansion Plan

- “Mobile Telescope Array”
  - Reduce the risk in array optimization
  - Telescopes independent of power line needed

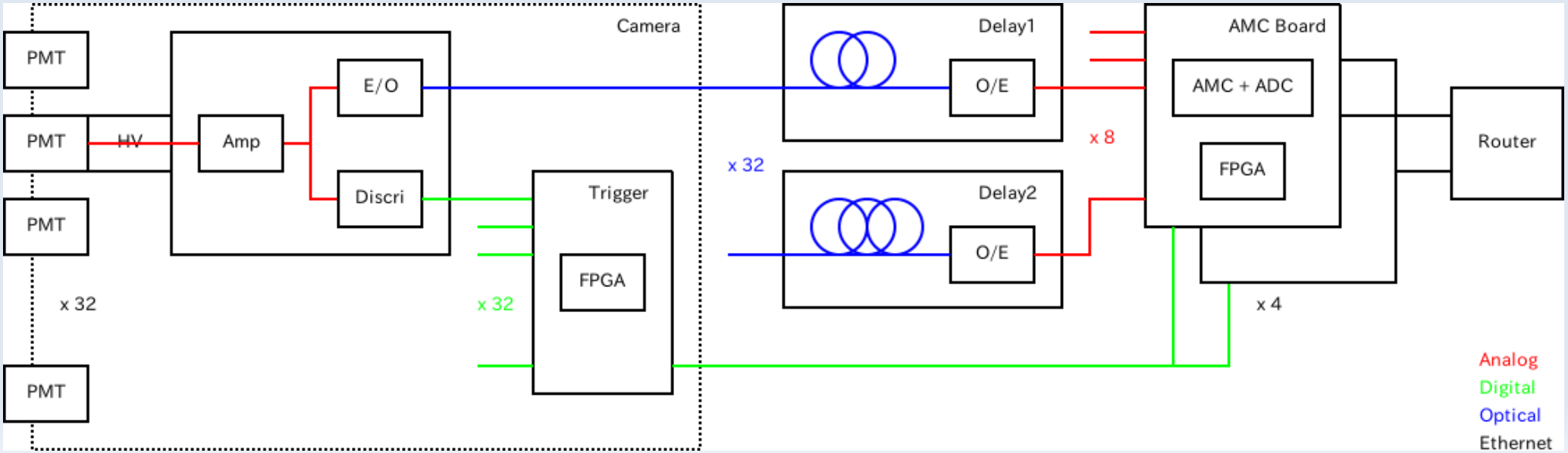


R & D

- Prototyping for PeX
  - With performance estimation based on simulations
    - Cherenkov image time gradient, etc.
- Basic research for Mobile Telescope Array
  - Low power consumption system & high capacity battery
    - Make telescopes independent of the power line
    - Analog Memory Cell (AMC) ASIC
    - Compact analog delays
- Test observations at Akeno
  - Reuse a secondhand atmospheric Cherenkov telescope

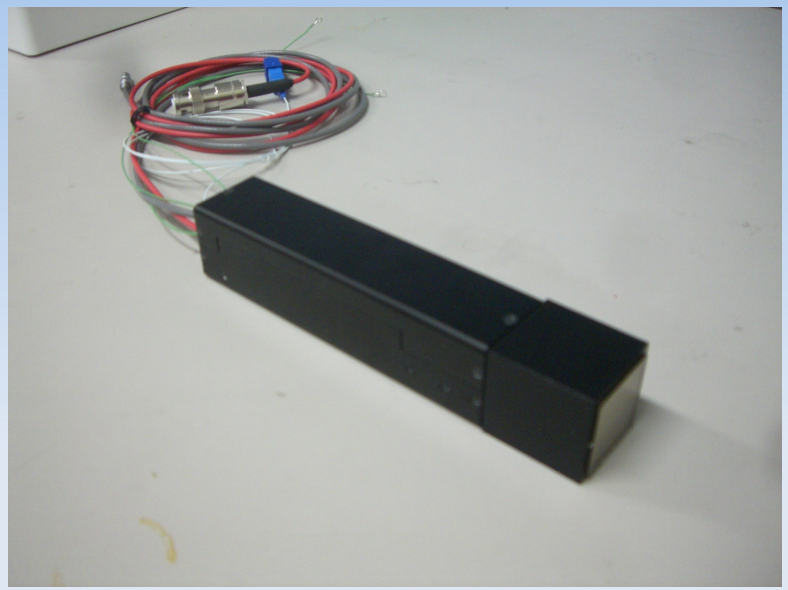
R & D System Plan

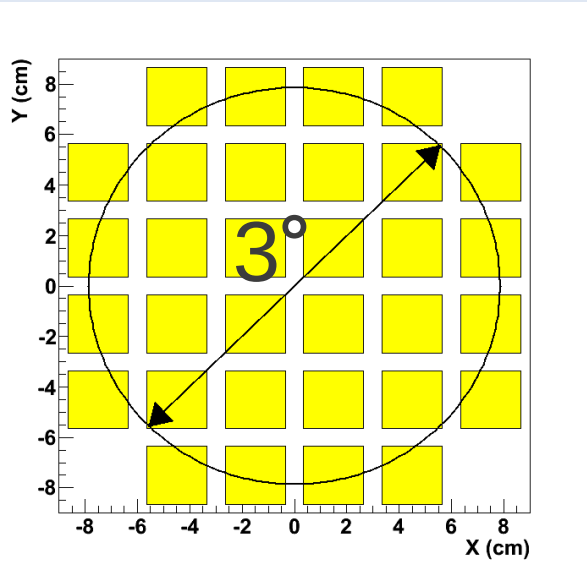
- 32 pixel (PMT) camera
  - Hamamatsu R11265-100 (SBA photocathode)
- Readout system with AMC ASIC
  - 1 GS/s, analog bandwidth > 200 MHz
  - Minimize sampling depth / pixel (64 ns) - utilize differential optical delays
- FPGA trigger board just behind the camera
  - Simple trigger logic (adjacent 2)

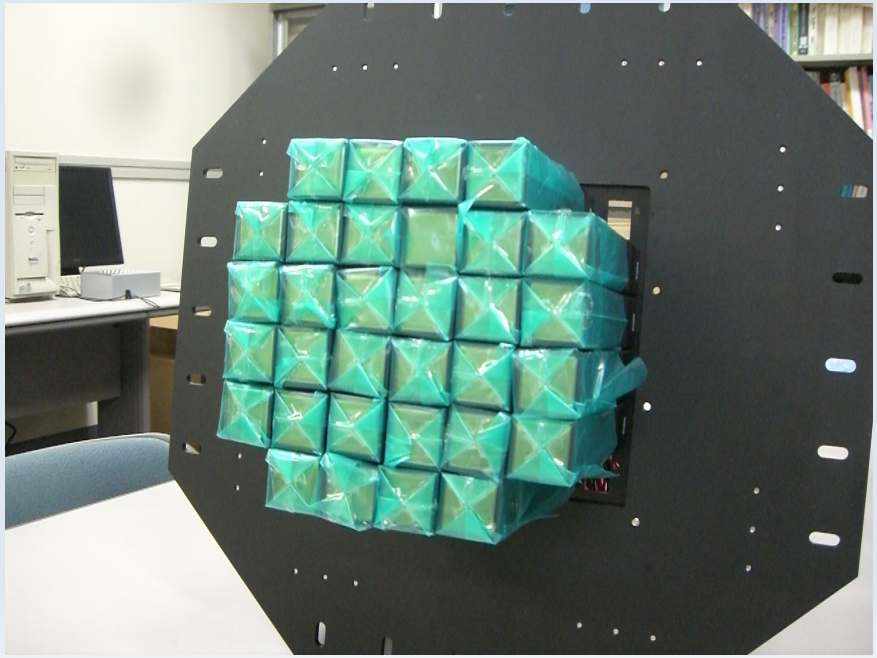


PMT Camera

- 32 pixels → FoV ~ 3°
  - Hamamatsu R11265-100 (SBA)
- PMT module includes
  - Preamplifier
  - E/O converter
  - Discriminator
- Mass production completed

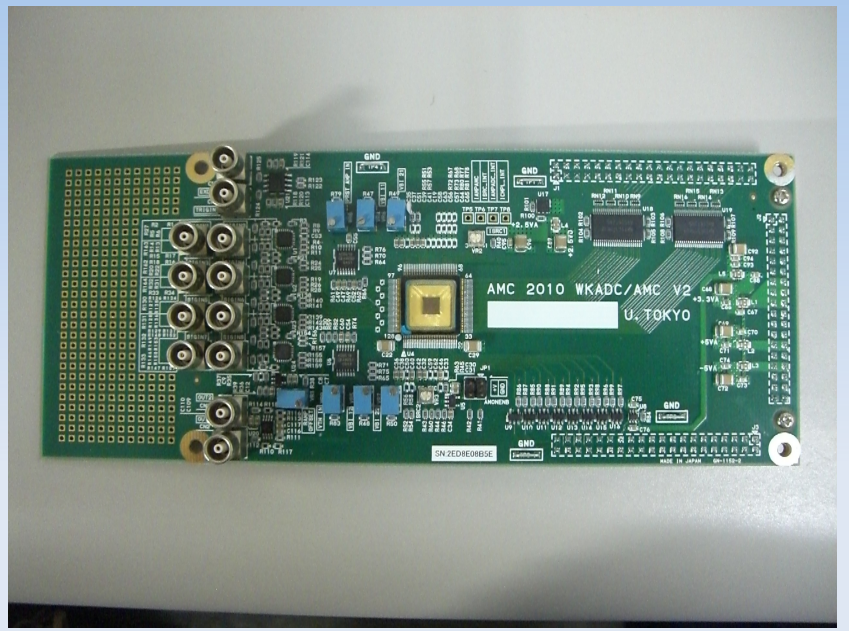






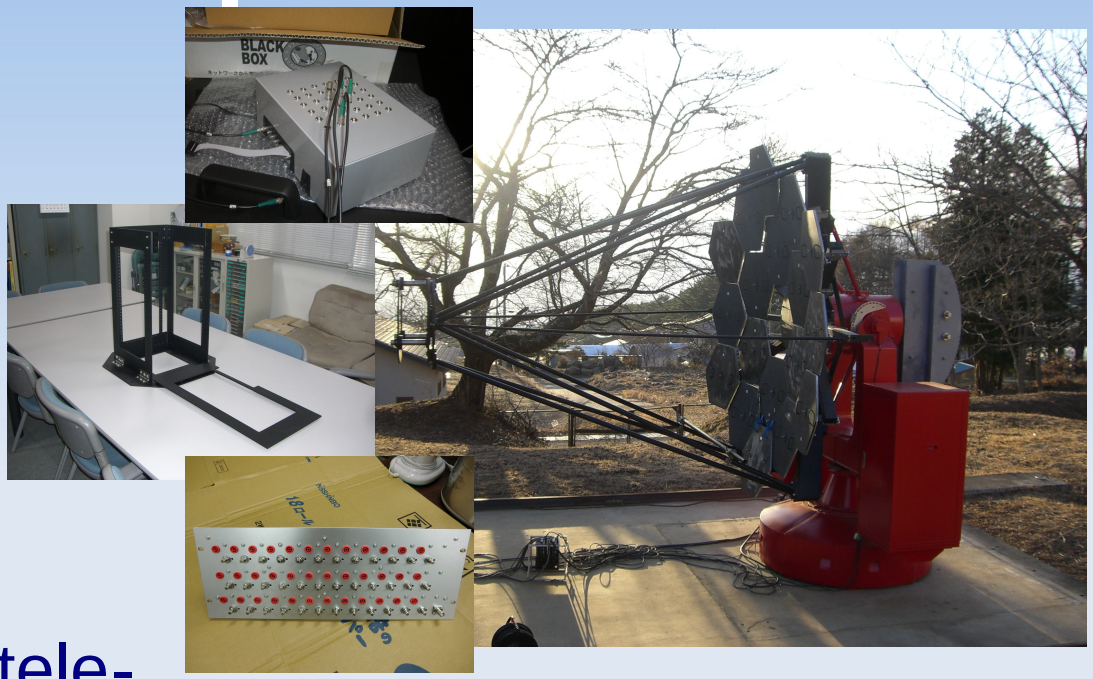
Readout System

- AMC ASIC
  - 1 GHz sampling
    - Sampling depth 64 ns × 8 ch
  - Dynamic range ~ 2.2 V
  - Resolution 10 bits
  - Analog bandwidth > 200 MHz
  - Wilkinson ADCs incorporated
  - Power consumption < 180 mW / ch
- Read by FPGA board
  - Transferred to PC via LAN
  - Under adjustment
- Developed with Open-It



Akeno Atmospheric Cherenkov Telescope

- Specifications
  - Davies-Cotton optics
    - 3 m diameter, f/d = 1
  - 18 small spherical mirrors
    - Recoated in 2011–2012
  - Altazimuth mount
- Test bench of Cherenkov tele-scope systems
  - Only Cherenkov telescope in Japan
  - Test observations planned also with
    - CTA SC-SST camera (Nagoya)
    - MPPC camera (Tokai)

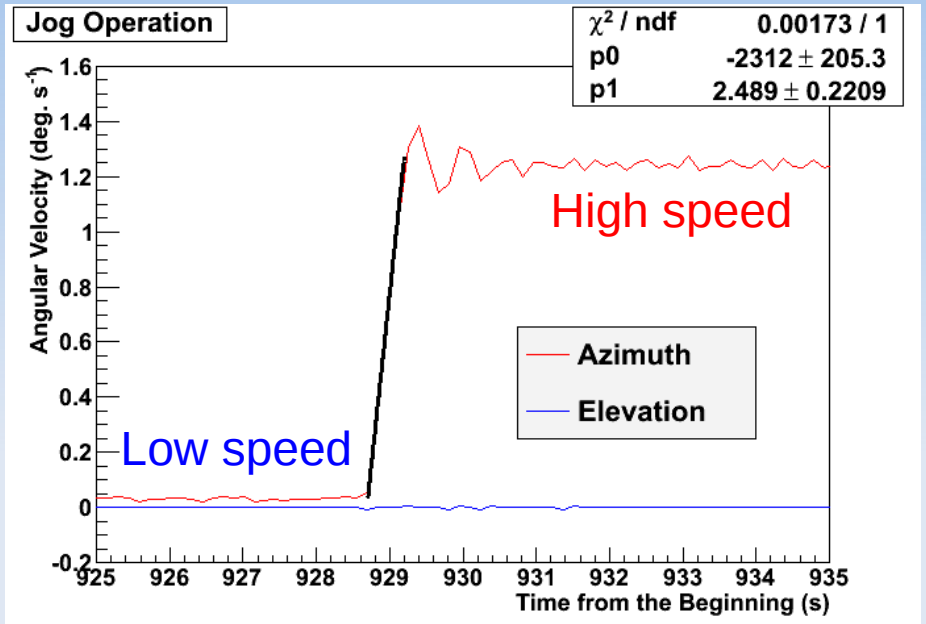


Telescope Control

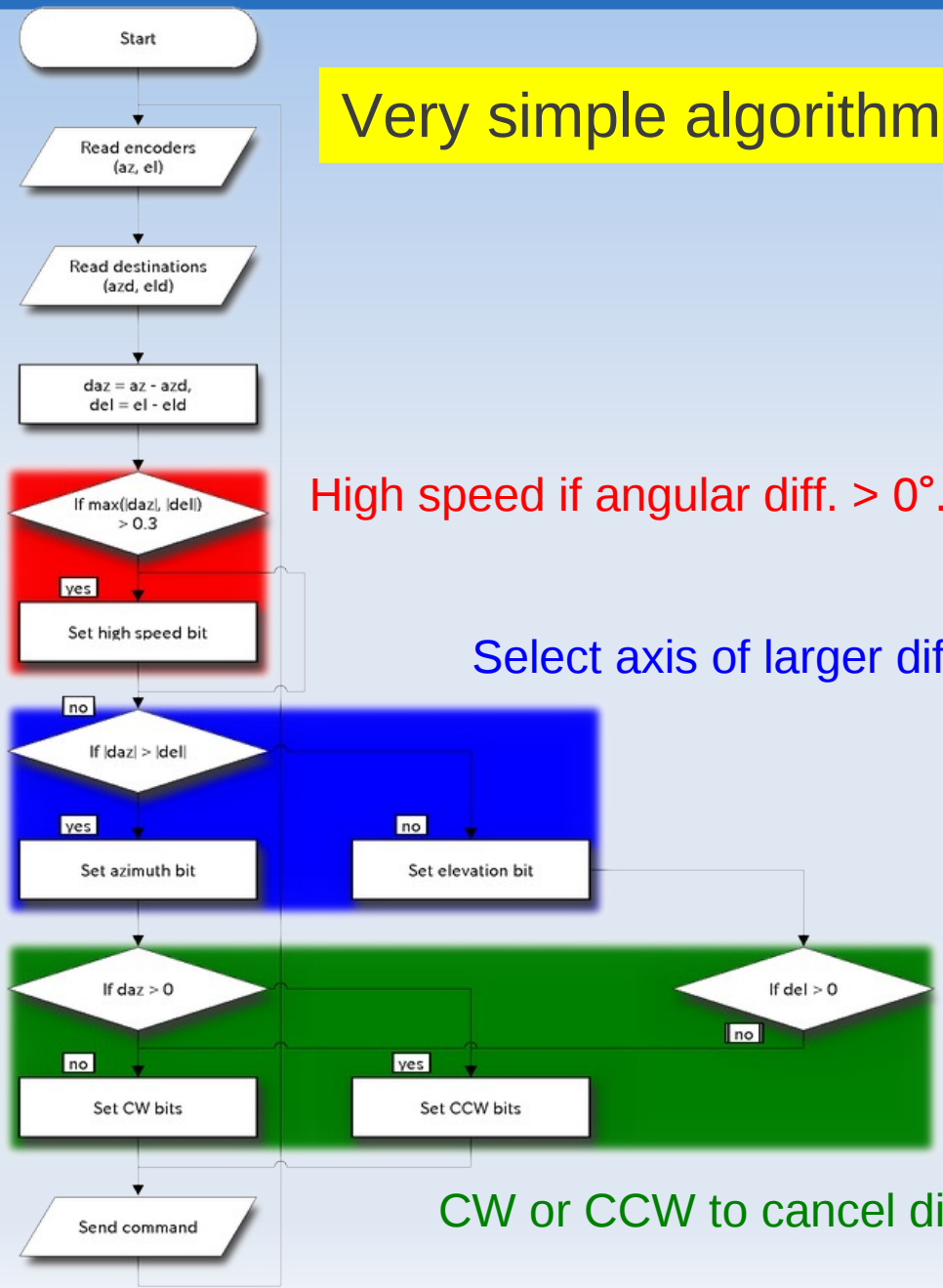
- AC servomotor: Sanyo Denki P60B13150HXS
  - Positioner: Keyence HC-50/55
  - Digital IO board to control positioner: CONTEC PIO-16/16RY(PCI)
    - Command output from PC sent via PCI bus
- Encoder: Heidenhain ROD456
  - Resolution 0°.001
  - Counter: Heidenhain ND920
    - Serial connection to PC
- Primary target
  - Tracking accuracy better than 0°.01 for both axes

Software Development

- Specifications
  - High speed: ~ 1°.2/s
  - Low speed: ~ 0°.03/s
  - Max. acceleration: ~ 2°.5/s^2
  - Above numbers can be modified
  - Only one axis operated at one time
- Establish each connection, loop control, convergence algorithm
  - Master thesis (Yahashi 2013, Ritsumeikan U.)



Test Operation

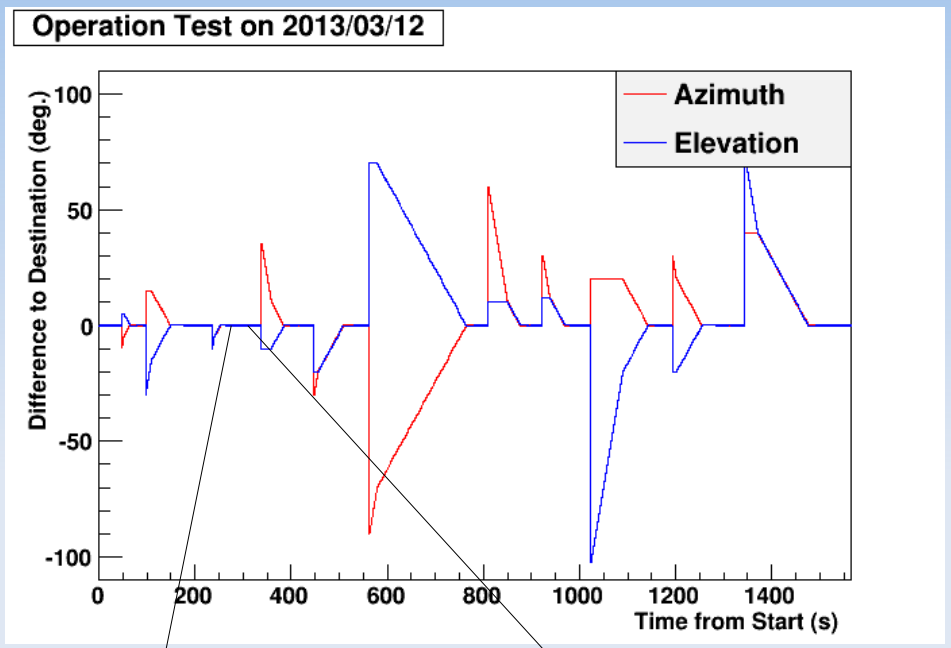


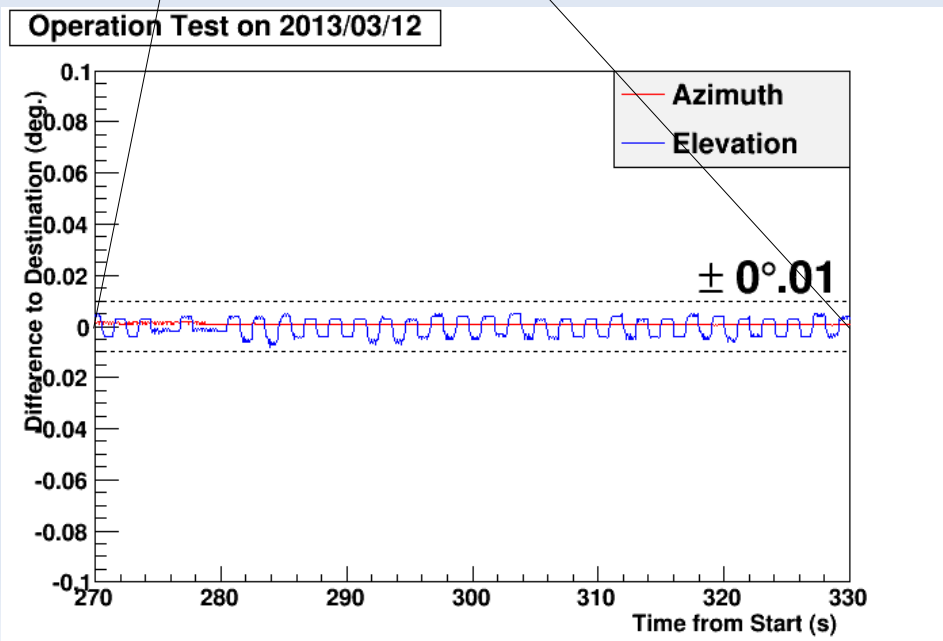
Very simple algorithm

High speed if angular diff. > 0°.3

Select axis of larger diff.

CW or CCW to cancel diff.





Summary

- PeV Explorer (PeX) aims to explore:
  - Origin of Galactic cosmic rays up to the “knee”
  - Astrophysics at energies > 10 TeV
- PeX concept will likely be realized in CTA SST
- R & D for PeX and Mobile Telescope Array
  - Production of the system ongoing
    - PMT modules, readout system, ...
- Akeno atmospheric Cherenkov telescope
  - Usable for various R & D
  - Telescope control system almost established
  - Test observations with the developed system will take place in 2013