PeV Explorer 計画 R & D（6）

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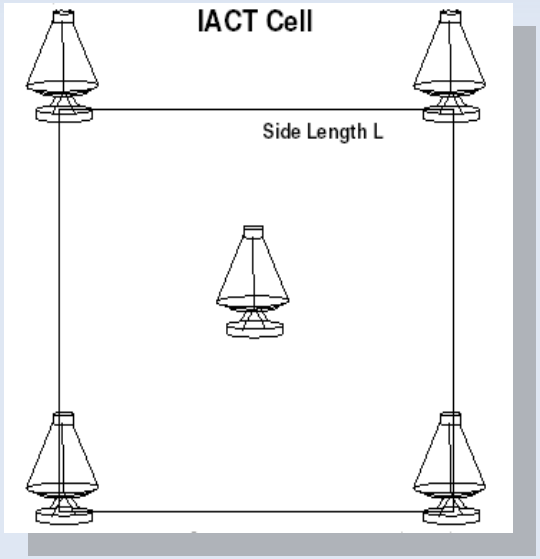
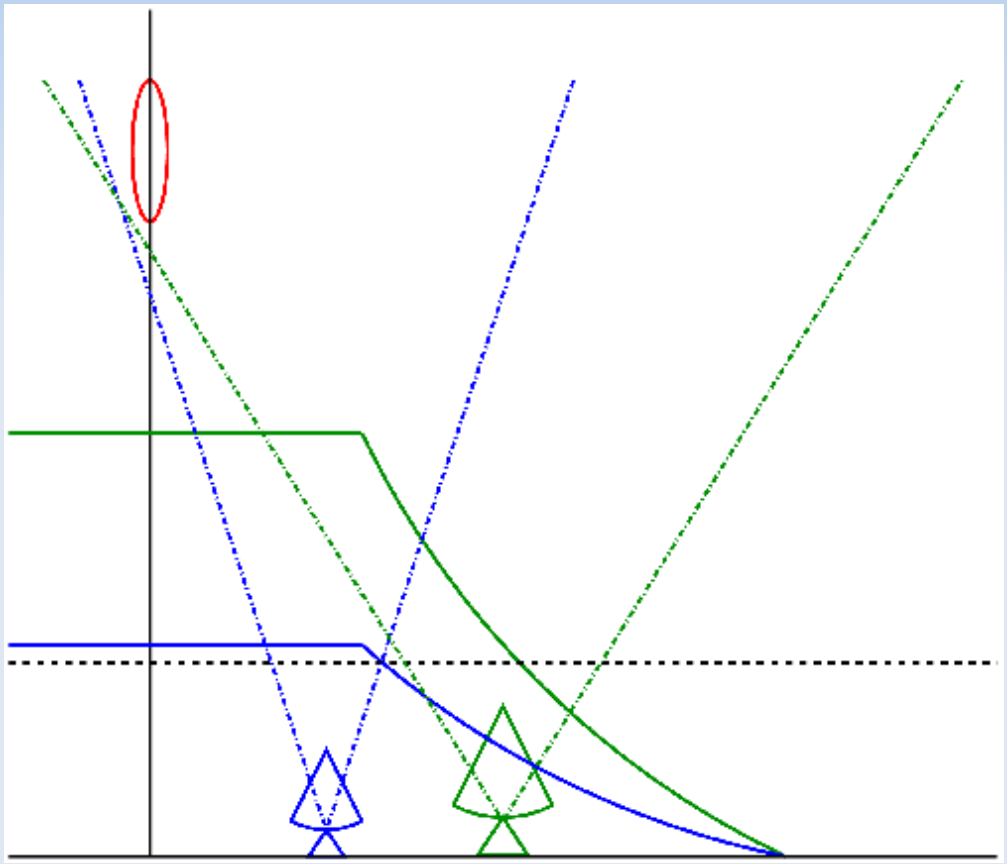
PeV Explorer (PeX)

- 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

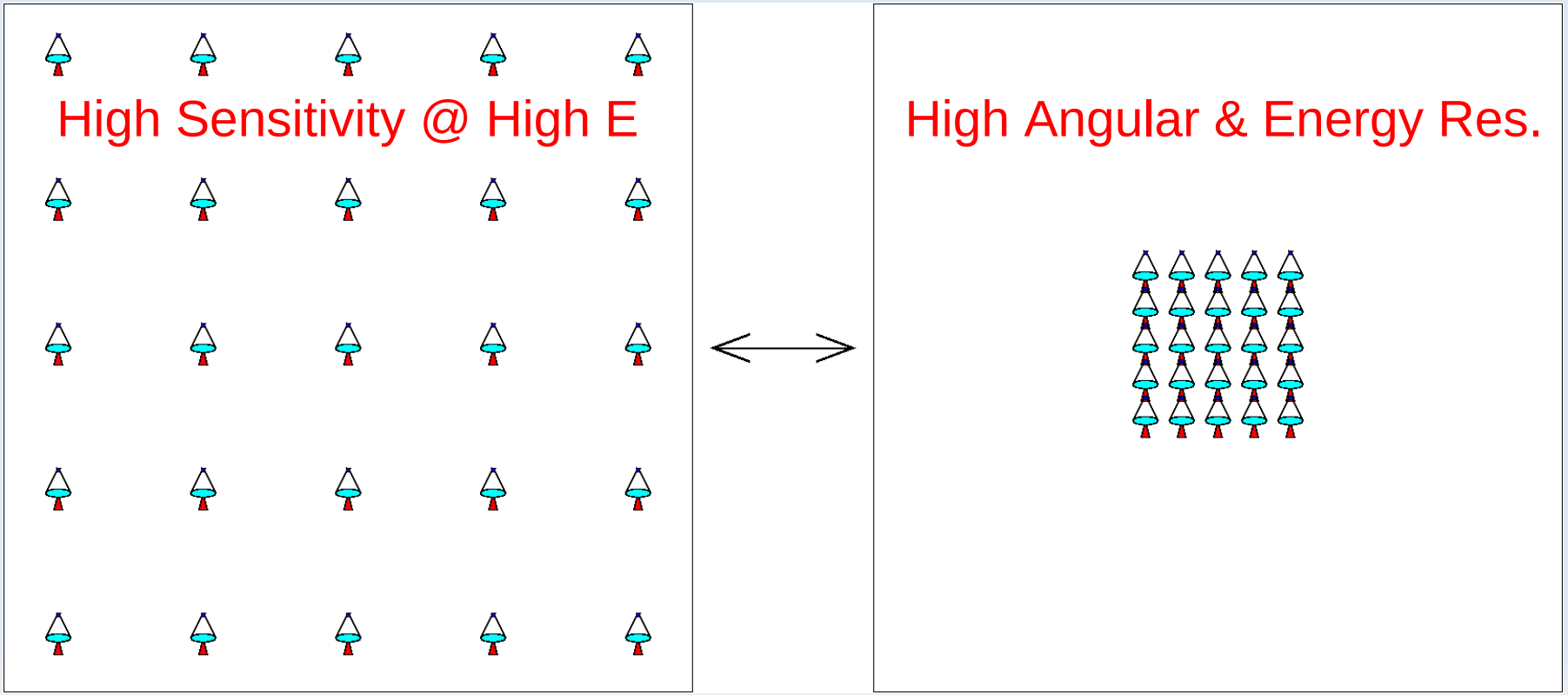


Plyasheshnikov et al. (2000)

- Cherenkov plateau
  - Radius ~ 150 m
- Cherenkov tail observable with larger aperture (or at high E)
  - Extpand 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

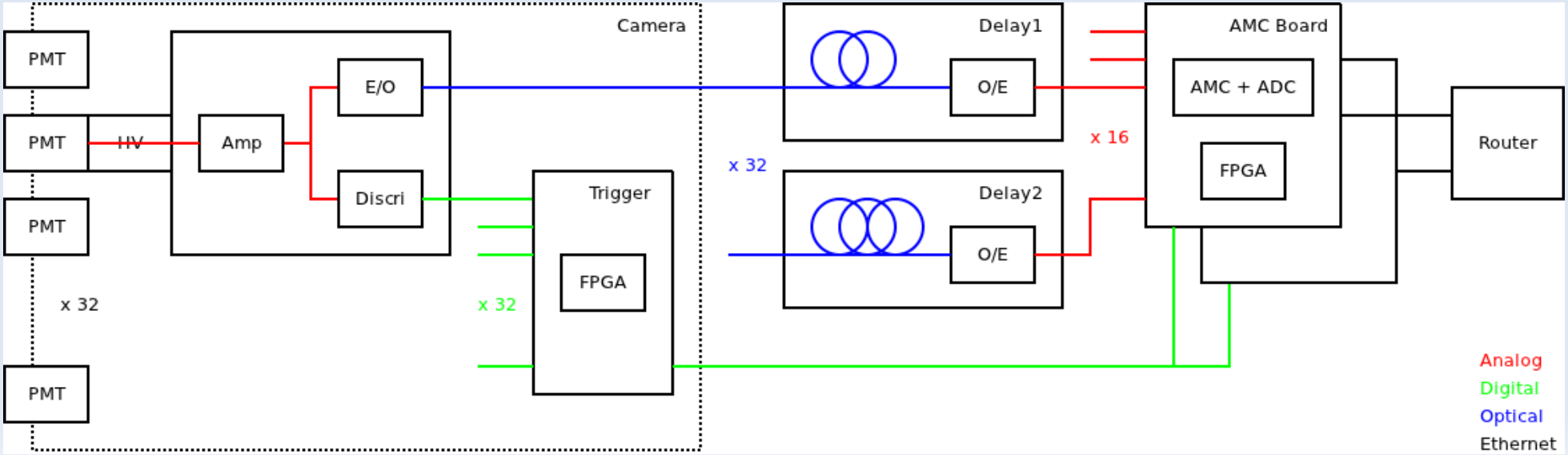


R & D

- Low power consumption system & high capacity battery
  - Make telescopes independent of the power line
  - Analog Memory Cell (AMC) ASIC
  - Compact analog delays
- Simulation study
  - Cherenkov image time gradient, etc.
- Test observations at Akeno
  - Reuse a secondhand Cherenkov telescope

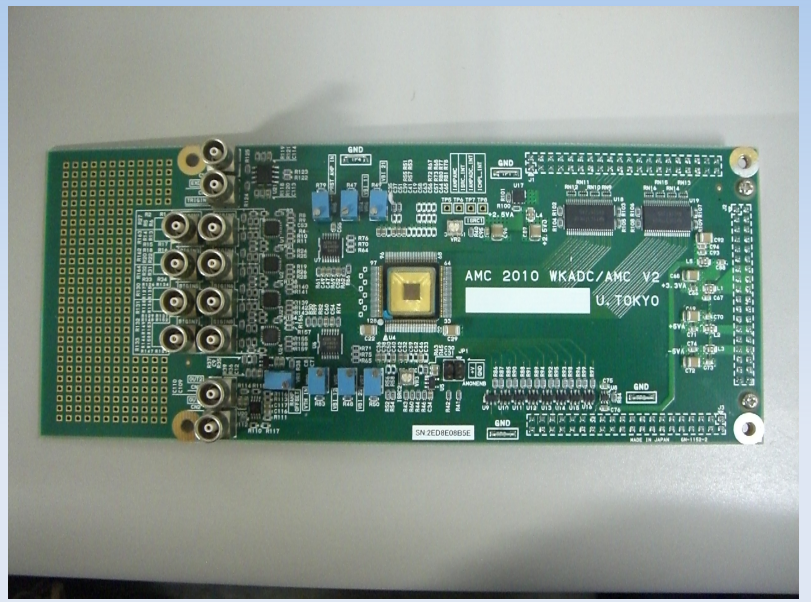
R & D System Plan

- 32 pixel (PMT) camera (FoV ~ 3°)
  - Hamamatsu R11265-100 (SBA photocathode)
- AMC ASIC with Wilkinson ADCs incorporated (OpenIt)
  - 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)



Status

- AMC boards
  - 4 boards made and being tested
- E/O and O/E
  - Under production
- Akeno atmospheric Cherenkov telescope
  - All (18) mirrors recoated at OAO (NAOJ)
    - → 大石講演
  - PC control system
    - Spec. Fixed
    - Software under development



Consideration of Background Light

- Night Sky Background (NSB) light
  - Airglow, zodiacal light, dark stars
  - Almost uniform in the FoV
  - Trigger level must be determined so that the accidental rate is not too high
- Starlight
  - Localize in some pixels
  - Bad effects to PMTs
  - ζ-Tau (m_v = 3.0) in the FoV in Crab observations

Night Sky Background (NSB)

- Photon flux of NSB light (Jelley 1958):

$$\frac{d^3N}{dSdtd\Omega} = 9.6 \times 10^7 \,\text{photons}\,\text{cm}^{-2}\,\text{s}^{-1}\,\text{sr}^{-1}$$

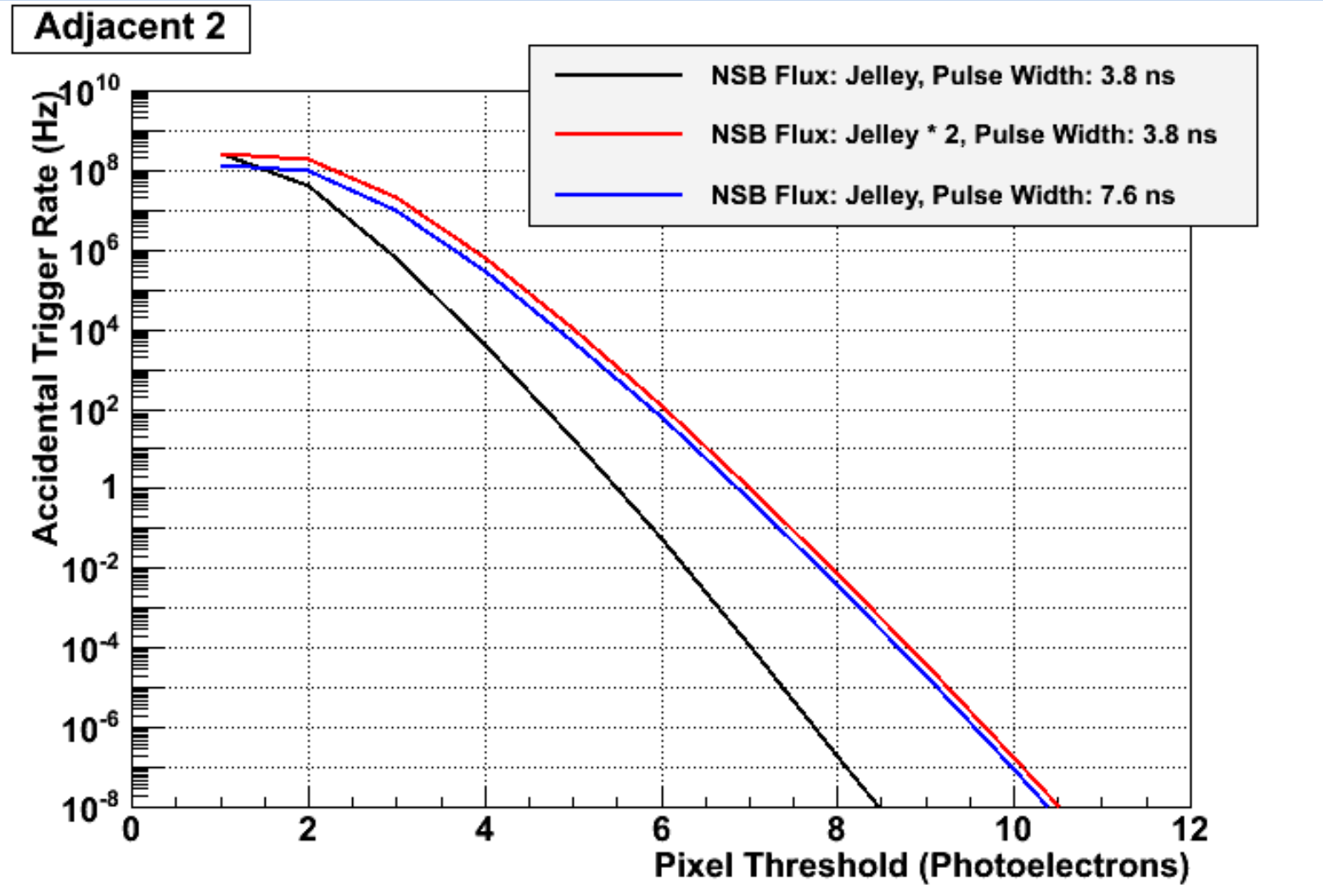
- Photoelectron rate per pixel:

$$\frac{dN}{dt} = 8.8 \times 10^7 \left(\frac{S}{5.7 \times 10^4 \,\text{cm}^2}\right)\left(\frac{\varepsilon_r}{0.9}\right)\left(\frac{\theta}{0.^\circ 44}\right)^2\left(\frac{\varepsilon_q}{0.3}\right)\,\text{photoelectrons}\,\text{s}^{-1}$$

- Integration within a pulse width
  - 3.8 ns (measured) → 0.33 p.e.
- Pixel hit rate
  - Compare Poisson fluctuation with pixel thresholds
  - 1 s / 3.8 ns = 0.26 G trials per second

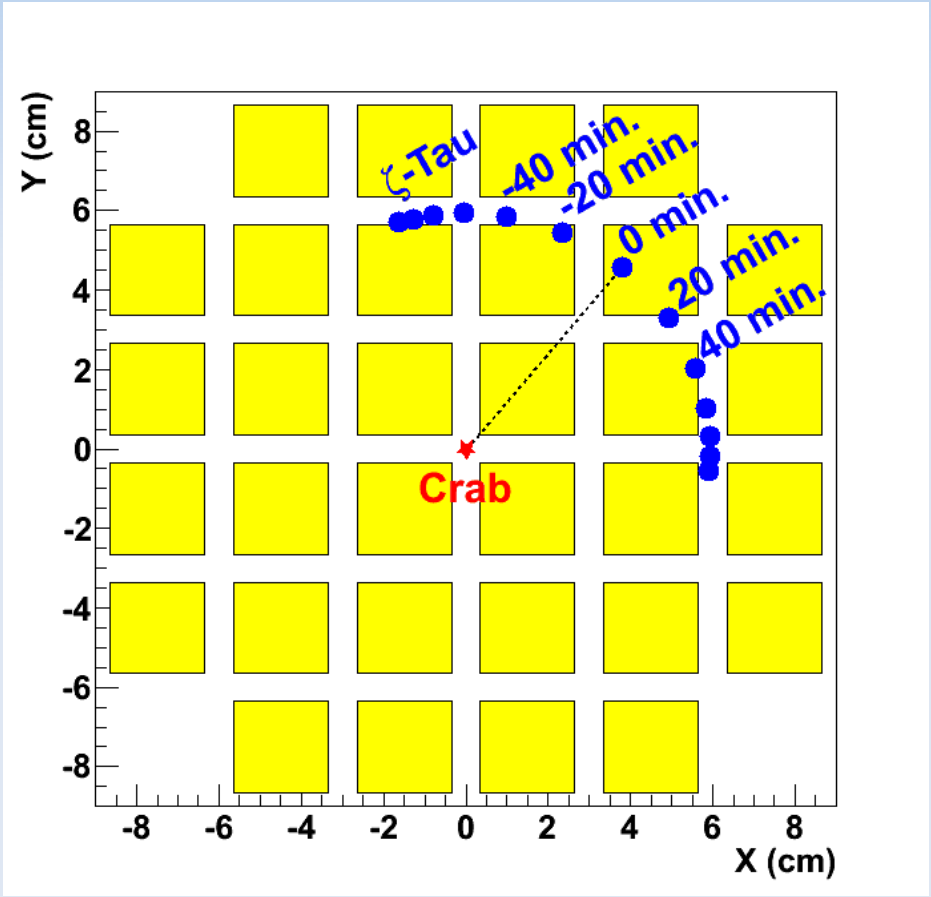
Expected Accidental Trigger Rate (NSB)

- Pattern trigger: adjacent 2 (32 pixels)



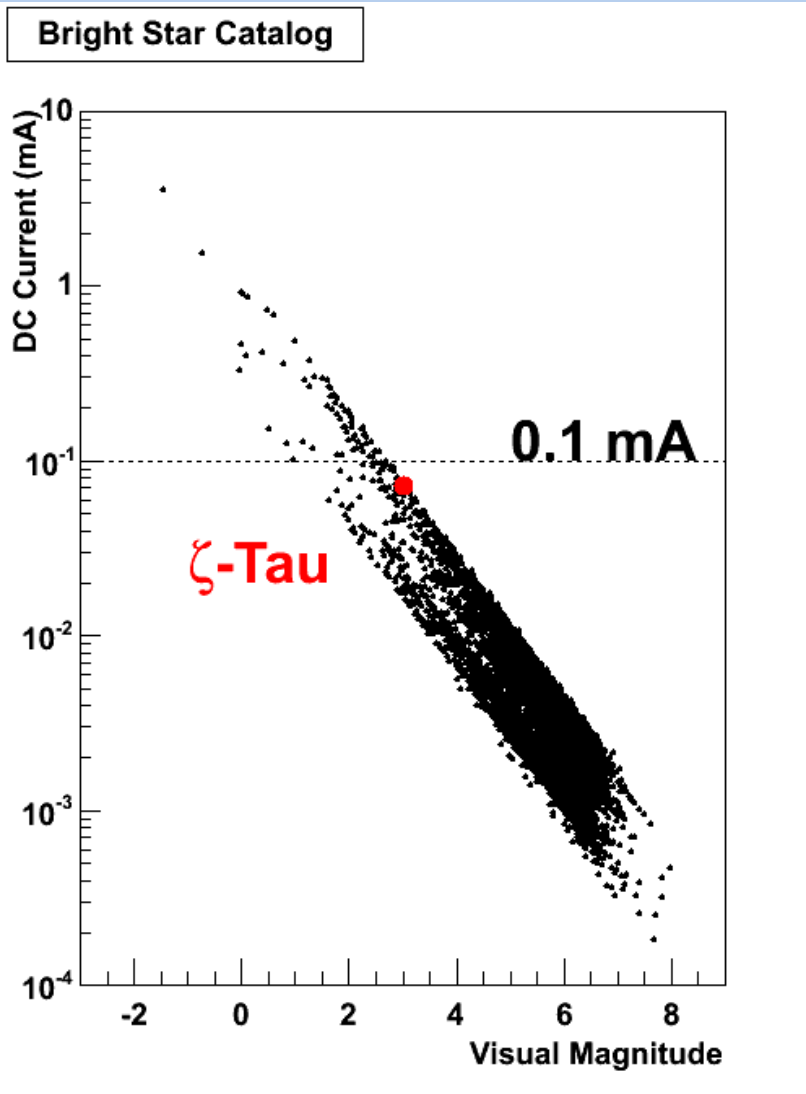
Effect of Bright Stars

- No HV control system
  - HV not turned off when a brignt star is within the pixel
- Problem in linearity?
  - Max. average anode current: 0.1 mA
- Crab observations
  - ζ-Tau (m_V = 3.0) in the FoV



PMT Currents Due to Bright Stars

- Stars from the Bright Star Catalog
- Calculation considering:
  - Starlight: blackbody radiation
    - T_{eff} obtained from B – V
  - Atmospheric transmissivity
  - Mirror reflectivity: 90 %
  - 100 % conained in a photocathode
  - SBA quantum efficiency
  - PMT gain: 2×10^5
- ζ-Tau is acceptable
  - But the noise level should be checked in real observations



Summary

- PeV Explorer (PeX) aims to explore:
  - Origin of Galactic cosmic rays up to the “knee”
  - Astrophysics at energies > 10 TeV
- R & D for PeX
  - Production of the system ongoing
  - Effects of background light considered
- Akeno atmospheric Cherenkov telescope
  - Usable for various R & D
  - Test observations with the developed system