Performance of 10-100GeV gamma ray camera "CheSS" for SUBARU telescope

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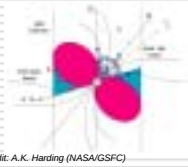
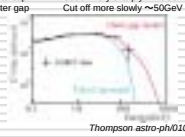
Motivation

This energy region (10-100GeV) is quite important for gamma-ray pulsars. There are two classes of models to explain high energy pulsed emission from pulsars. **They predict clearly different behaviors above the 10GeV region.**



Credit: A.K. Harding (NASA/GSFC)

•Polar cap — Cut off very sharply ~20GeV
•Outer gap — Cut off more slowly ~50GeV



Thompson astro-ph/0101039

Our first target: **Crab pulsar/nebula**

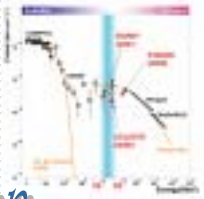
The standard candle for gamma-ray detectors.
SUBARU has a good location to observe it. <- Pass through near the zenith.
Wide band pulsed emission. <- Extend above 10GeV ?

Below ten GeV, Compton Gamma Ray Observatory (CGRO) revealed high energy phenomena, and over 100GeV, Ground-based detectors using Imaging Atmospheric Cherenkov Telescope are working now.
In the 10 to 100 GeV region, however, only a few detectors have explored until now.

Satellites

●COMPTEL
MeV region
●EGRET
~**10GeV**

Two new points over 10GeV
D.Bersh et al., Gamma 2001



Ground

Conventional Cherenkov detectors
Over **300GeV**
Two new type Cherenkov detectors

●STACEE
One point at **200GeV**
M. De Naurois et al., 566, pp. 343-357
●CELESTE
One point at **60GeV**
D.A Williams et al., Proc. of Heidelberg 2000

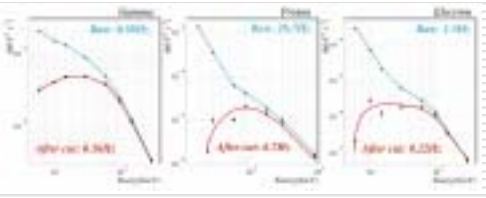
10-100GeV region has not been observed enough.

Simulation

At first, we calculate how much the night sky background is detected by CheSS. According to Jelley's data, **expected the night sky background is about 6 photo-electrons per event**.

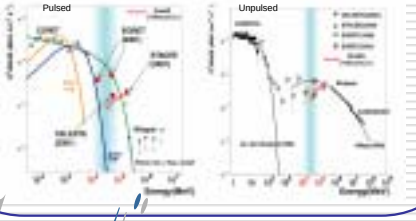
Secondly, we simulated the expected energy spectrum of SUBARU with CheSS under the night sky background(Blue lines). Expected trigger rate which is estimated from the energy spectrum is about **26.7 Hz for protons, 0.9 Hz for gamma-rays, 2.2 Hz for electrons**. Thus the total trigger rate is about 30Hz **which is consistent with the observed trigger rate** in December 2001.

Third, to reduce the night sky background and improve the signal to noise ratio, we cut the events that the sum of photo-electrons is under 7 photo-electrons. After this cut, we got the energy spectrum shown by red lines. We can find that **the energy threshold for gamma-ray flux is about 30 GeV for the Crab pulsar/nebula**.



Thus, the expected sensitivity for the unpulsed component can reach **~ 10sigma** level and more for pulsed one during **10 hours** on-source pointing.

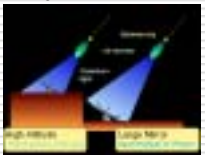
Sensitivity -- on-off chopping only --



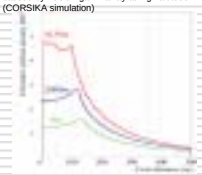
Observation

Cherenkov lights caused by 10-100GeV particles are too faint.

High Altitude Observation



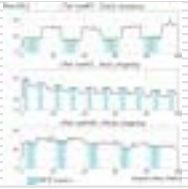
The density distribution of Cherenkov light photon caused by 10GeV gamma-ray at high altitude. (CORSIKA simulation)



10m mirrors at 4000m allow us to detect faint Cherenkov light caused by particles in 10GeV region.

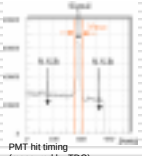
In Dec 2001, we observed **Crab pulsar/nebula and three different points** which are 5, 10 and 12 minutes away from Crab pulsar/nebula in order to measure the background. **Total observation time was about 24hours** (ON-OFF).

Trigger rate at each OFF point were **distributed between 7 Hz and 35Hz** since it depends on the condition of the night sky background.



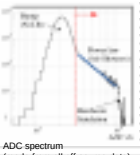
***Analysis method**

Timing cut



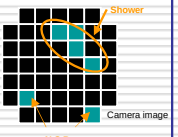
PMT hit timing (measured by TDC)

ADC cut



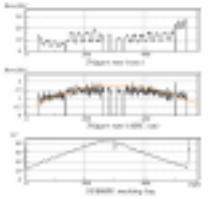
ADC spectrum (made from all off-source data)

Clustering cut



N.S.B

And other new cuts (Now trying ....)



This figure show the evidence that we've detected Air Shower event on the top of the Mt. Maunakea.

Top panel shows observed trigger rate.
Middle panel shows the trigger rate after ADC cut (over 3000 channel).
It's clear to see the trigger rate depends on zenith Angle (cf. bottom panel. That shows the telescope Movement).

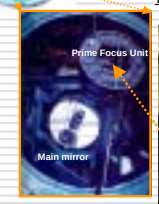
We are going on analysis now.
I'm sorry but I can't show you more figures!

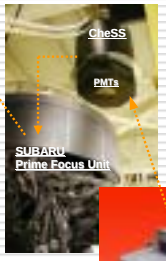
Instruments

* SUBARU telescope

FOV:	0.75deg (Primary focus)
Focal length:	15m
Mirror diameter:	8.2m
Altitude	4200m (Mt. Maunakea, Hawaii)
Mirror reflectivity:	91%(380nm)
Transmittance of correction lenses:	68%(380nm)

These parameters are ideal for IACTs.

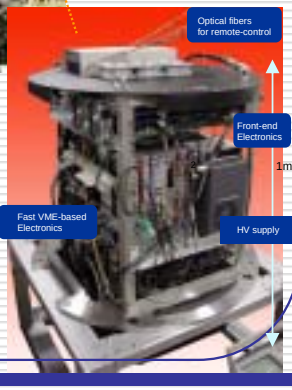




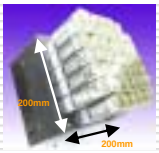
CheSS basic data

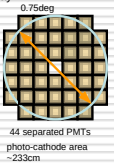
•Cylindrical shape (Height ~ 1m)
•Weight~ 200kg
•Power consumption under 700W
•44ch VME-TDC (ΔT =0.75nsec)
•Onboard VME-CPU
•3ch VME-ADC
•GPS module

*** How to set CheSS up?**



* PMT array





44 separated PMTs
photo-cathode area ~233cm (without light guides)

CheSS
(Cherenkov light detecting System on Subaru)

Summary

□Gamma-ray pulsars in 10GeV region:
•Two emission models. polar cap or outer gap?

□Cherenkov light detecting System on SUBARU:
•Compact detector. 1m X 1m cylindrical shape, 200 kg weight.
•Energy threshold is about 30GeV (simulation).

□Observation of Crab
•On 17, 18, and 19, Dec 2001
•Total time; On 12hours and Off 12hours.