SiPM interdisciplinary application
in the fields of
Astroparticle Physics
and
Bio Molecular Science

Hiroko Miyamoto,
T. Ebisuzaki, K. Hibino, Y. Kawasaki,
I. Minoura, E. Muto, K. Okamoto, Y. Sako,
Y. Takizawa, M. Teshima, K. Ushida
RIKEN, Japan
Max-Planck-Institut für Physik, Germany
**Extreme Universe Space Observatory**

*JEM-EUSO*

A novel space-borne fluorescence telescope

*Astronomy with UHECRs*
JEM-EUSO Telescope Structure

- Electronics
- Structure
- Focal Surface
- Optics

2.5m
JEM-EUSO Focal surface

MAPMT
(8x8 pixels)

Focal Surface detector
137 PDMs = 0.3M Pixels

Photo-Detector Module
(3x3 ECs = 2,304 pixels)

Elementary Cell
(2x2 PMTs = 256 pixels)

26mm
55mm
167mm
2.35m

Readout technology for 0.3 M pixels!
SiPM camera for Cherenkov telescopes

- Application to ground based Cherenkov telescopes such as MAGIC/MAGIC-II, CTA
- LLL sensitivity, fast/good time response/resolution
Bio molecular science

Our targets

- Fast (sub-us), LLL (Low Light Level) camera will open a new window in bio molecular observations!!
From astroparticle experiment to bio molecular science

- Readout a large number of channel
- From fast response/sub-us camera
- With a LLL sensitivity

and a SiPM sub-us camera is expected..

- High PDE
- Good time resolution (<ns)
- Could be better time and cost performance for a large number of channels in the future.
- And other general advantages comparing to a large number of PMTs.

and enable us to open a new window in not only in astroparticle physics experiments, but also in bio molecular science!
Simple DAQ diagram

SiPM/MPPC

Preamp (inverter, only for MPPC)

ASIC (Q-to-T converter)

Flat cables

Ubiquitos board

DNA (Counter, data processing)

Memory

DAP

Ethernet

PC

Power supplys for bias voltage, preamp, and peltier cooling system
SiPM(G-APD)/MPPC

- Hamamatsu 16 ch MPPC produced by Hamamatsu in collaborating MPI
- 256 ch in total (16 x 16ch MPPCs)
- Peltier cooling system

Uniformity < ±0.3C
Temperature fluctuation < ±0.5C
Compensation of MPPC operation voltage variation by a divider circuit

No Bias V adjustment  Bias V adjusted by divide circuit

Combining a thermistor temperature compensation circuit will be also useful in the future
Hamamatsu 16 ch MPPC

- Developed by Hamamatsu-MPI
- Commercial device
- Large detection area!
- Device is ready!
- Used for 256ch prototype camera
- Low dark rate at operation voltage and temperature

*Dolgoshein's SiPM and MPI-HLL's SiMPl are also candidate*
ASIC (KI03 Charge to Time converter)

- Developed for a JEM-EUSO front-end circuit
- Dynamic range of 1/3 pe ~ 300 pe in a unit time window
- Low power consumption (~0.8 mW/ch)
KI03 response
(output pulse width as a function of input charge)
DAP/DNA ~ counter, data processing

- Developed in former project for many kinds of application
- Capable with handling 128ch per chip (board)
- Programmable as suitable for the purpose of data handling
DAP/DNA (Ubiquitos circuit)
DAP/DNA
(Response of Ubiuquitos circuit)

Width = T*DUTY(20-80%)

T = 278nsec

GTU = 201 x 6nsec ≈ 4.3 T

DAPDNA
4.338129 pulse/GTU (GTU:201 * 6nsec)
Sig Width vs Counts

DAPDNA
4.338129 pulse/GTU (GTU:201 * 6nsec)
Counts Cal. vs Mes.
SPEC ~ what can we see?

- Time window < us
- Minimum time resolution 6ns
- KI03 Charge-to-Time converter ASIC, dynamic range of 1/3~300 PEs in a time window
- Single photon sensitive with potentially high PDE (depends on SiPM for sensor)
- Large number of channel readout (currently 256 ch for a breadboard model)
Imaging 40 nm Gold colloid for bio molecular observations

40um gold colloid on microscope

Focusing lens

MPPC camera

CW (DC) laser light source
Centi-EUSO telescope
(EUSO scaled into cm size)

Double sided fresnel lens1
Filter (BG3)
Double sided fresnel lens2
SiPM camera (Hamamatsu 16ch MPPC)

For astroparticle physics applications
Centi-EUSO telescope with MPPC camera

• Check the operation of whole camera system
  (temperature, humidity, dark rate, night sky bkg, etc...)
• Test imaging in night sky background
• Trigger system
Camera response with LED light source

Preamp output pulses

KI03 (ASIC Q-to-T converter) output pulses
An example of trigger algorithm (preliminary!)

Produce ON/OFF data every 8bit with shifting data with 7 bits

External sum trigger is also considered
Summary & Outlook

Summary
• Assembli of sensors and all the breadboard is finished and tests are ongoing
• All the components operation are confirmed at first level
• Observed 40 um gold colloid with ~us time window (Confirmed capability of application in bio molecular science)

Outlook
• Demonstration with using Centi-EUSO to check fundamental capability for the application to Cherenkov telescopes (trigger, nature environment, etc.)
• Trigger algorithm (internal logical/external sum triggers are considered as an option)
Thank you for your attention!