# Balloon-borne gamma-ray telescope with nuclear emulsion

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## All sky map in high energy gamma-rays with Fermi Large Area Telescope launched in June 2008



Fermi Large Area Telescope First Source Catalog

Large scale observation has been achieved since CGRO/EGRET (1991). Fruitful results are being obtained in the observation of high energy gamma-ray.

Further precise observation is important as the next step.

### Emulsion gamma-ray telescope



### Performance

		—
	Emulsion telescope	Fermi LA I
Angular resolution @100MeV	10mrad	61mrad
@1GeV	1.4mrad	10mrad
Energy range	10MeV~100GeV (under study below 50MeV)	20MeV~300GeV
Polarization sensitivity	Expected (under study)	No
Aperture area	>1m²	1m <sup>2</sup>
Field of view (full width)	$ ightarrow 90^{\circ}$ (1.6sr, 12.5% all of sky)	<b>120°</b> (2.4sr, 19.1% all of sky)
Dead time	Dead time free	<b>26.5</b> $\mu$ sec(readout time)
Area*Time [m² day]	16(current)	365
	507(future)	
Emulsion analyzing canability in a year (100 films) (Flight duration: 150hours(6.25days))		

Emulsion analyzing capability in a year (100 films)

Current system: 3m<sup>2</sup> flight Future system: 80m<sup>2</sup> flight

Long duration flight(150hours) Repeating flight(>4flights/year) Fermi-LAT



Public LAT data (Fermi Science Support Center)

>1-3GeV

>6 months

-2010/01/17 01:02:33 ~ 2010/07/16 00:58:52

>Front + Back

>All incident angle



### Simulation

>150 m<sup>2</sup> hours

-1.5years full scale observation (current)

>Signal

-Flux on Fermi First Source Catalog (1-3GeV) -Point source

- -Angle resolution 1.4mrad @ 1GeV (gaussian)
- >BG

-Atmospheric gamma-ray flux (BETS, >1GeV, 5g/cm<sup>2</sup>)

### Balloon Exp. @ Sanriku (2004)





### Automatic Emulsion Scanning System "S-UTS"

### Emulsion scanning facility

# 5 SUTSs are running constantly.

### Angular resolution



### Energy range





### Multi-stage shifter



S.Takahashi et al., Nucl. Instr. And Meth. A, 620 (2010) 192-195

### Flight model of multi-stage shifter

Co-development with Mitaka Kohki Co., Ltd. Effective area : 12cm\*10cm





### Summary & Outlook

- By detecting starting point of electron pair with emulsion, precise gamma-ray direction and polarization can be detected.
- With recent advancement in scanning system, emulsion analyzing capability is becoming powerful.
- By basic study, the perspective has been obtained for the observation of cosmic gamma-ray with emulsion.
- Emulsion gamma-ray telescope can do complementary observation for Fermi LAT
- We start the observation of cosmic gamma-ray by balloon flight with emulsion gamma-ray telescope.
  - − The 1st model (aperture 1/10m) → flight ready
    - Test under the balloon flight environment with the flight duration above several hours
    - Measurement of background
    - (Observation of transient phenomena)
  - The 2nd model (aperture 1/2m)  $\rightarrow$  flight ready by next spring
    - Observation of known gamma-ray object with the flight duration above 6h
       3sigma detection for Geminga with 1m<sup>2</sup> hour
    - Test with over all
    - (Observation of transient phenomena)
  - The future model (aperture >1m)
    - Starting full scale observation with long duration flight(150hours) and repeating flight(>4flights/year)