

The CREAM calorimeter: Performance in tests and flights

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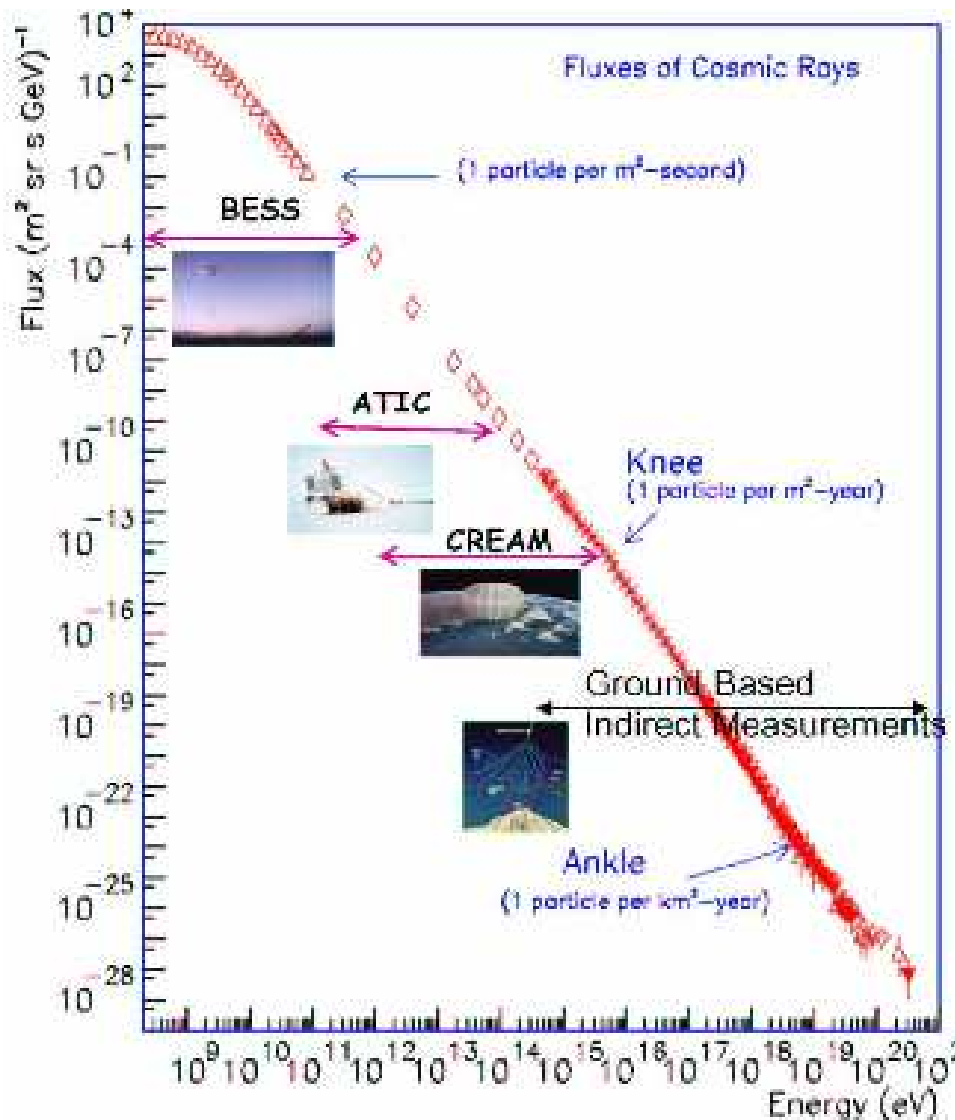
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High Energy Cosmic Rays and Scientific Goals of CREAM

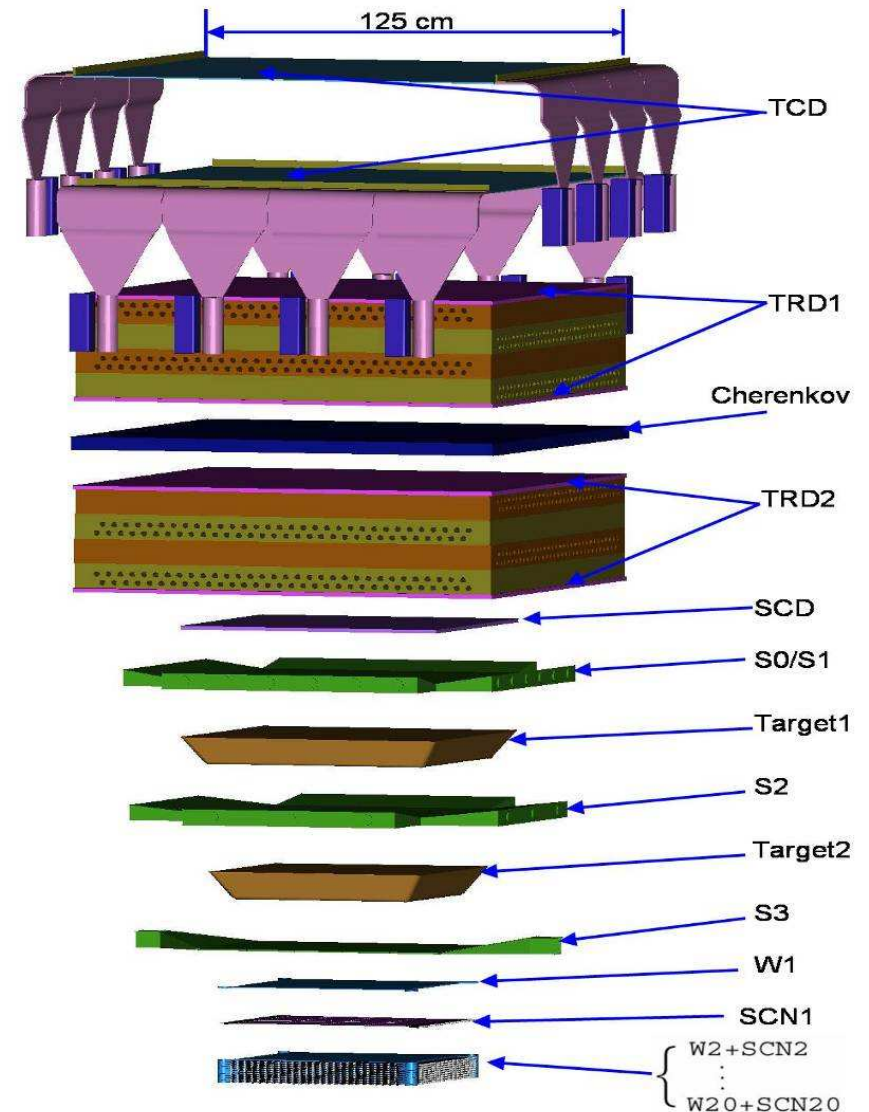


- Direct measurements of elemental compositions up to “knee” energy to test the acceleration theory which predicts acceleration limit of $\sim Z \times 10^{14}$ eV (near Knee)
- Measurement of primary-secondary ratio (i.e., B/C) to study the propagation of cosmic rays
- Provide overlapping data for the calibration of the ground based experiments

CREAM instrument

- TCD (Timing based Charge Detector): to trigger and measure charges of incoming particles
- TRD (Transition Radiation Detector): to measure velocity for $Z \geq 3$
- CD (Cherenkov Detector): to trigger and measure charges of relativistic particles
- SCD (Silicon Charge Detector): to identify particles charges for $1 \leq Z \leq 28$
- S0-S2: Hodoscopes, supplemental particle ID, tracking
- S3: Trigger counter
- CAL: Tungsten-SCN Calorimeter to trigger and measure energy for $Z \geq 1$

- In-flight cross calibration between TRD and CAL
- Trigger aperture: $2.2 \text{ m}^2\text{sr}$



CREAM-1 configuration

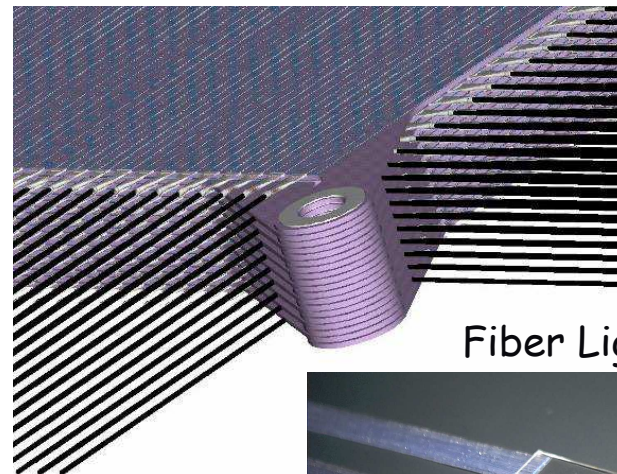
The CREAM calorimeter

- Flared(30°) carbon target to increase hadronic interactions
- measure energies of incident particles from 100 GeV to 1000 TeV:

Optical division with different # of clear fibers + neutral density filters at the cookie assembly + 73 pixel Hybrid Photo Diode (HPD)

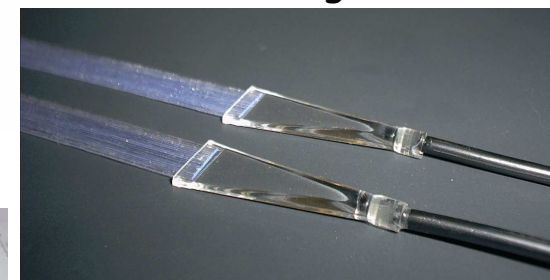
- 2560 channels readout with IDE VA32-HDR2/TA-32C chips
- thin calorimeter for higher trigger rates: alternating tungsten ($1 X_0$) and scintillating fiber ribbon layers in x and y directions (20 layers) with size of 50 cm x 50 cm
- absolute energy scale accurate to < 10%
- energy resolution < 50%
- imaging capability to reconstruct particles trajectories: 50 of 1cm wide ribbons ($\sim 1 \rho_M$ of W) made of 19 of 0.5 mm \varnothing BCF-12 scintillating fibers per layer

Tungsten / Scintillating Fiber Stack



Fiber Light Guides

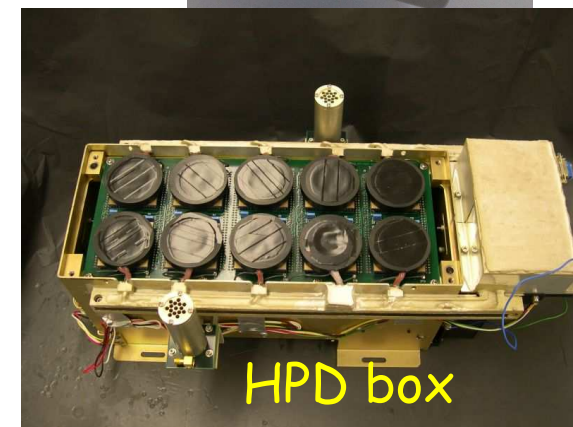
Tungsten Plates



Cookie with fiber bundles

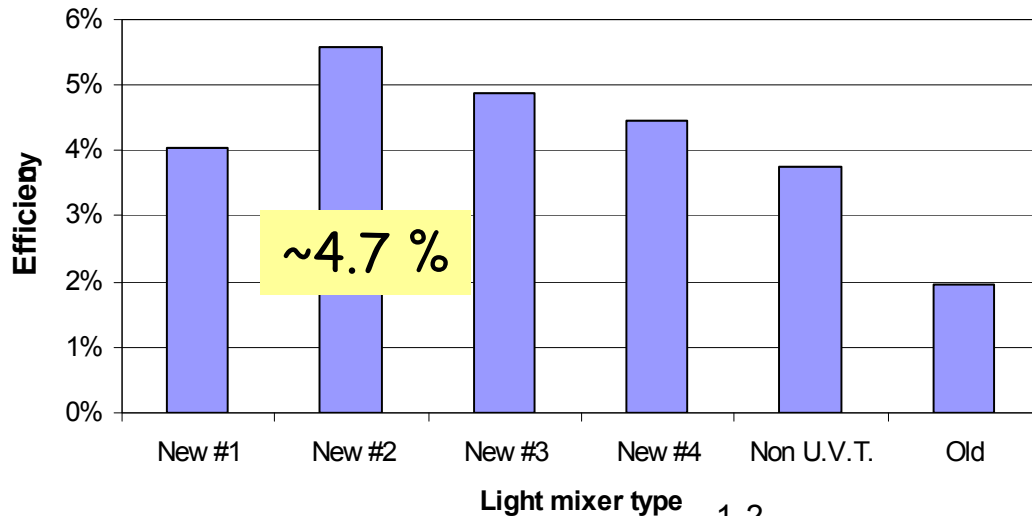


Mounted HPD



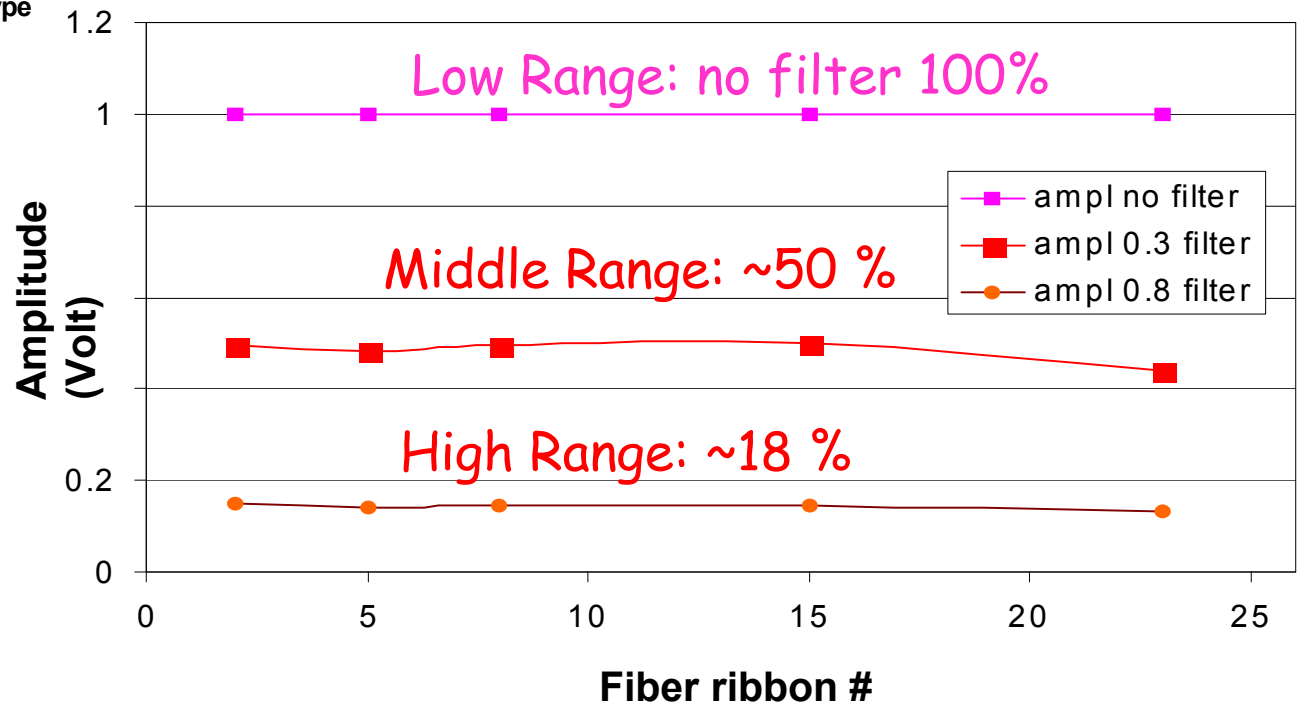
HPD box

Tests of optical properties of light mixers and filters



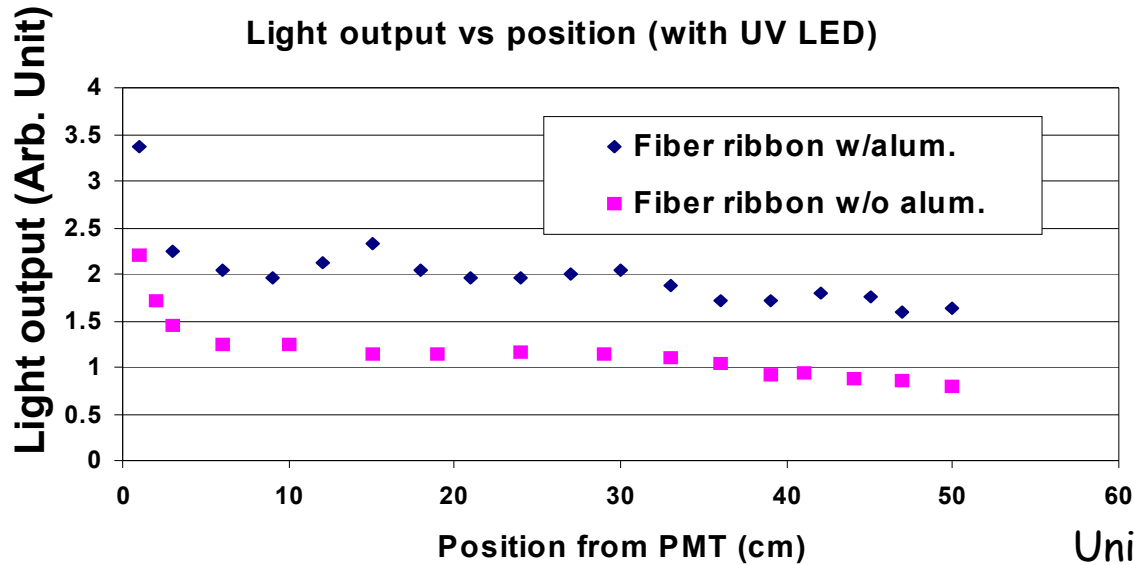
Transmission efficiencies of light mixers with LED and PMT

Transmission efficiencies of neutral density filters with LED and PMT



Fiber ribbon uniformities with UV LED and electron beam

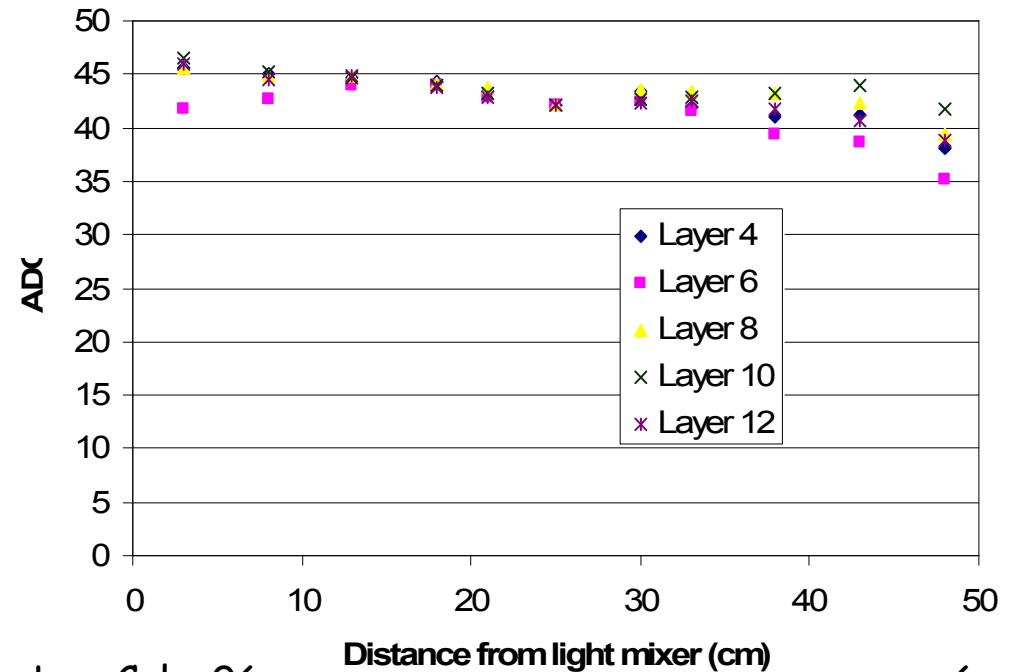
Light output vs position (with UV LED)



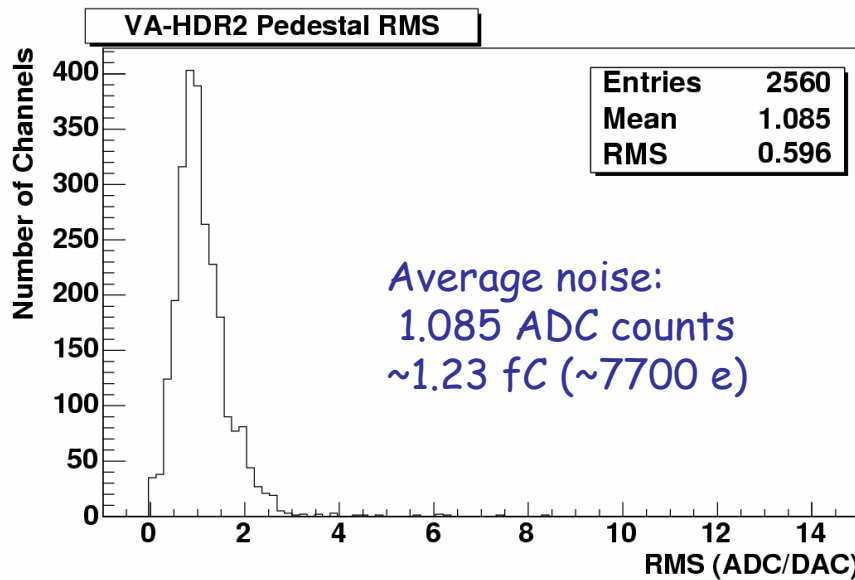
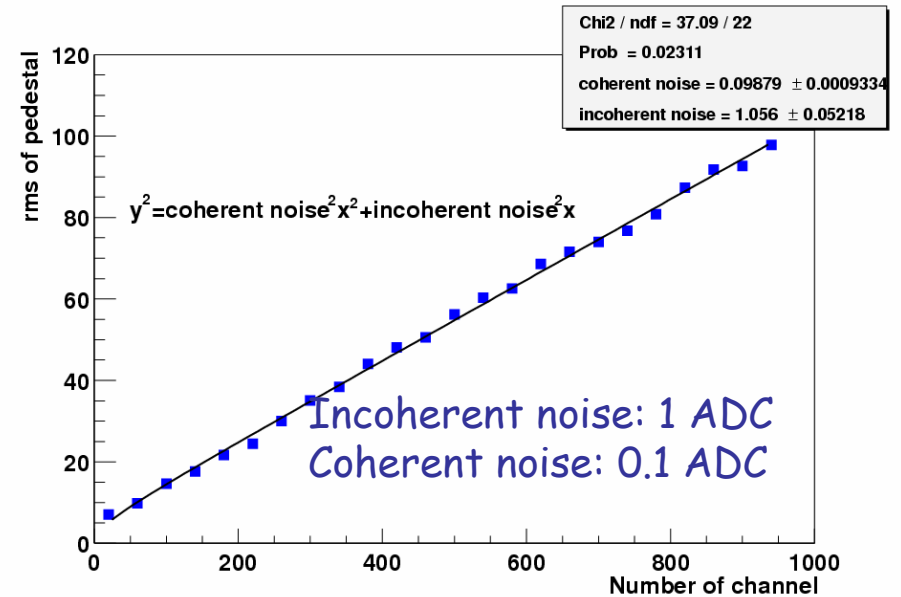
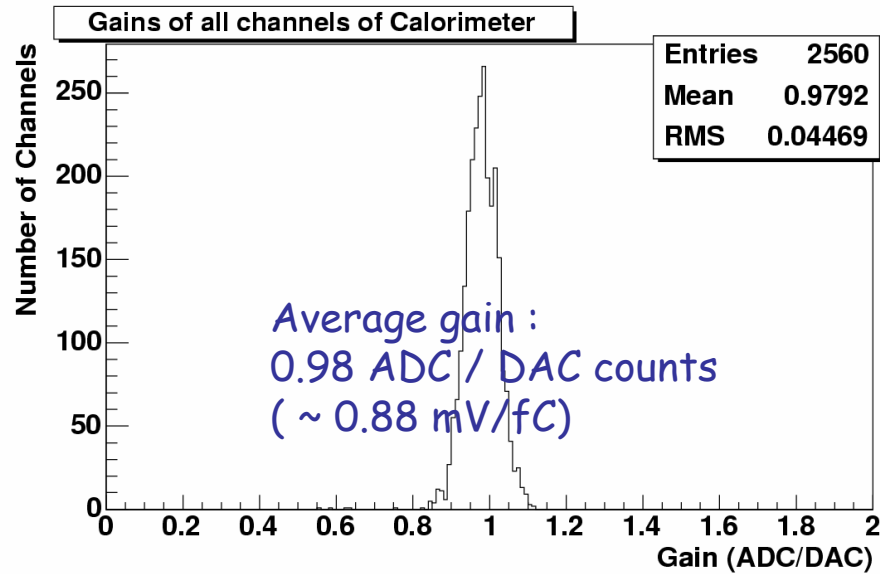
Light output increased by ~60 %

Uniform within $\pm \sim 10\%$,
No need for correction
for first order
calibration of flight
data.

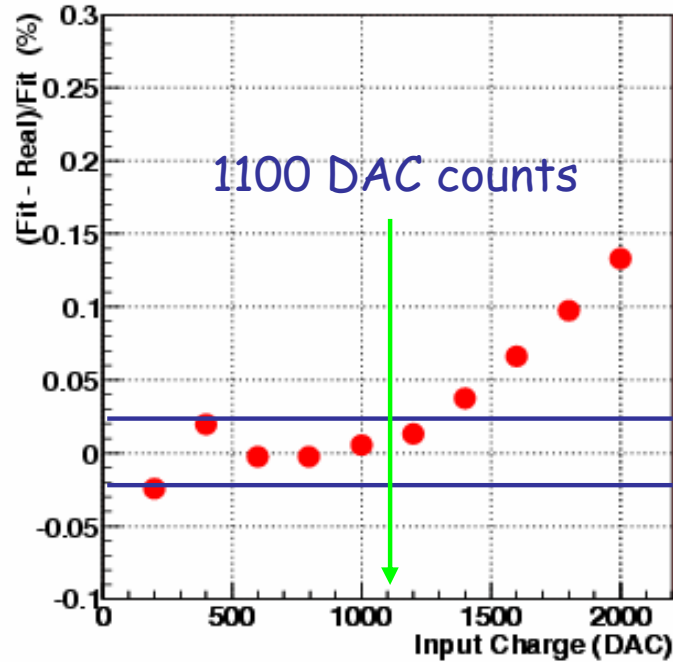
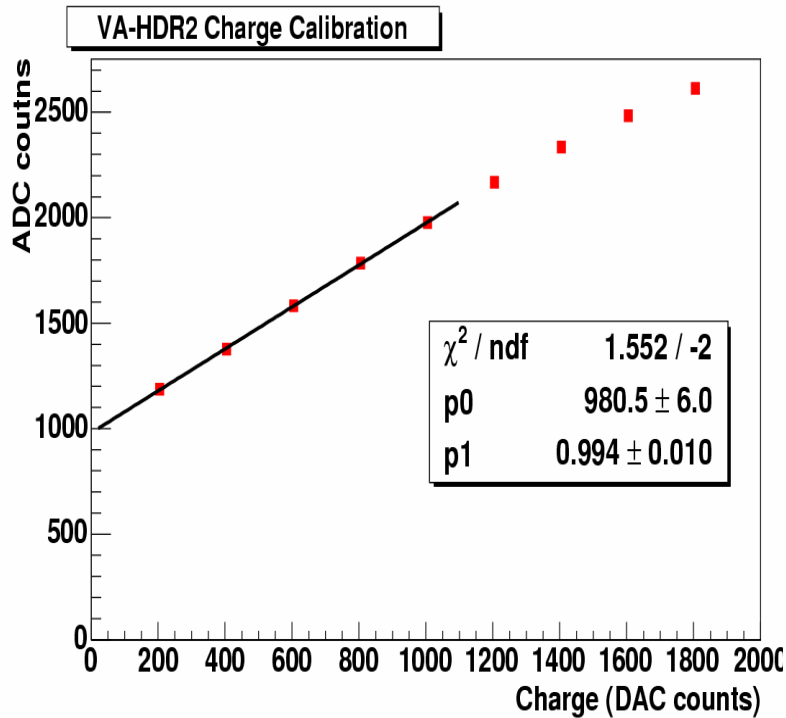
Uniformity with 150 GeV electron beams at CERN



Gain/Noise of ASIC VA-HDR32/TA-32c Chips



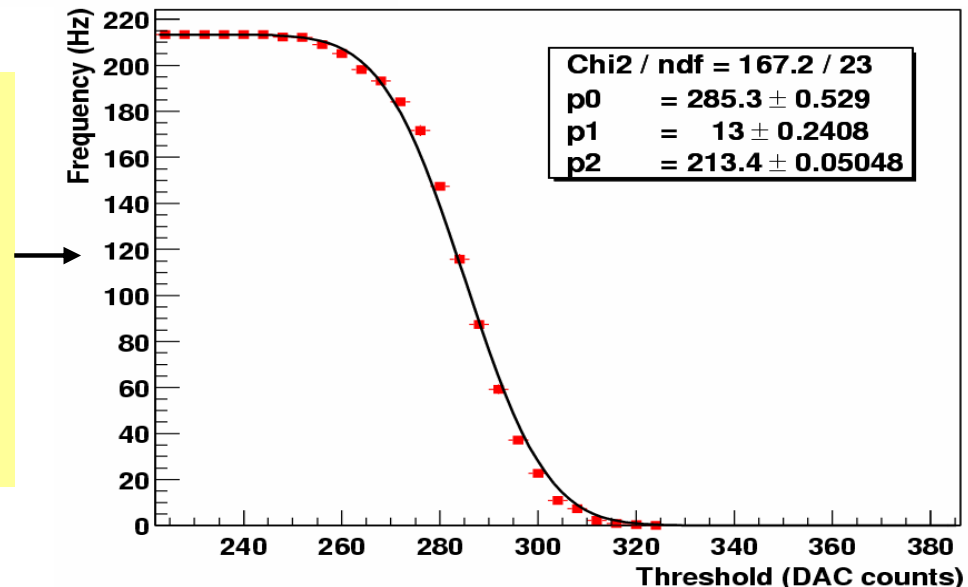
Performance of VA-HDR32/TA-32c Chip



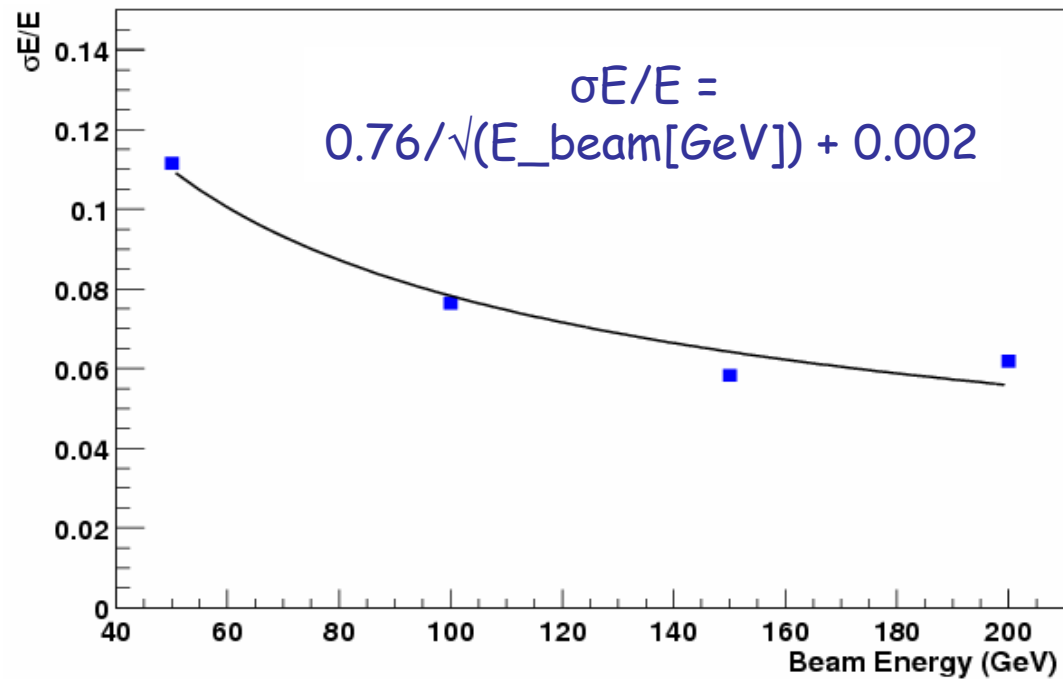
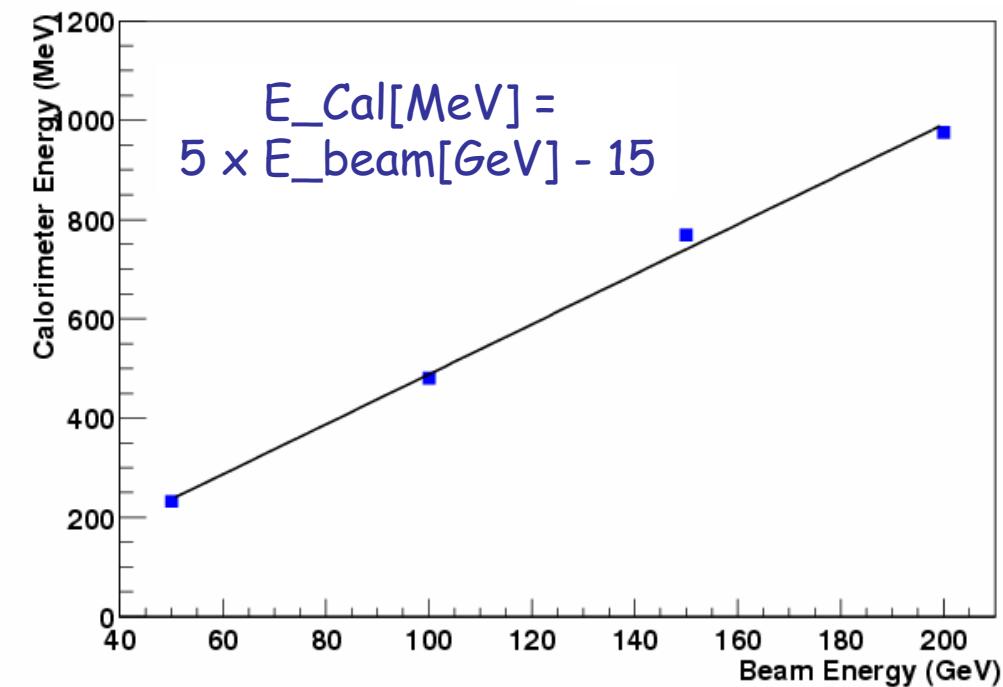
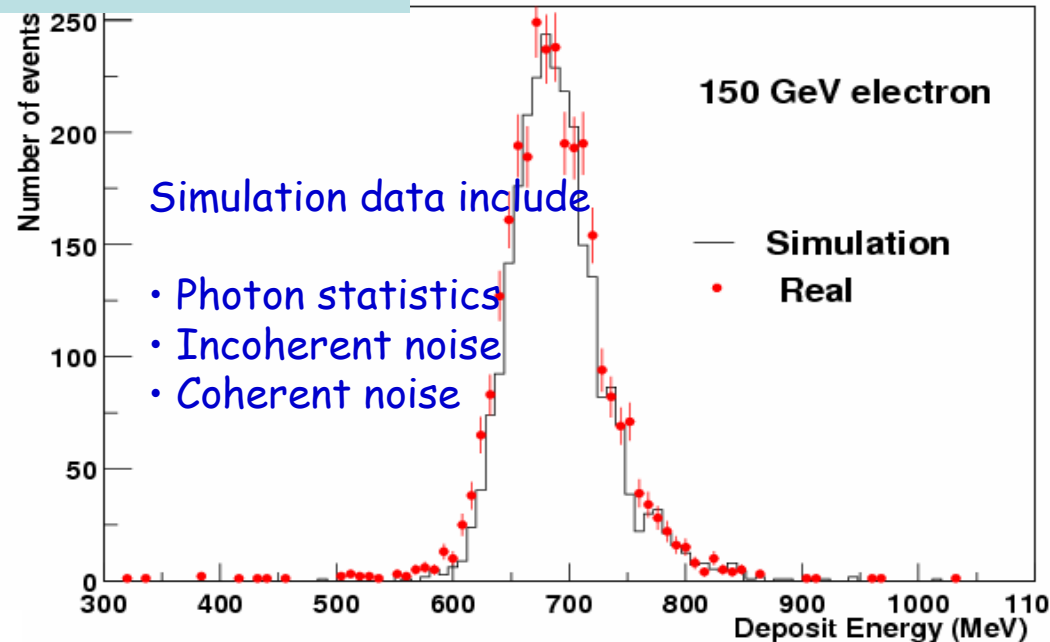
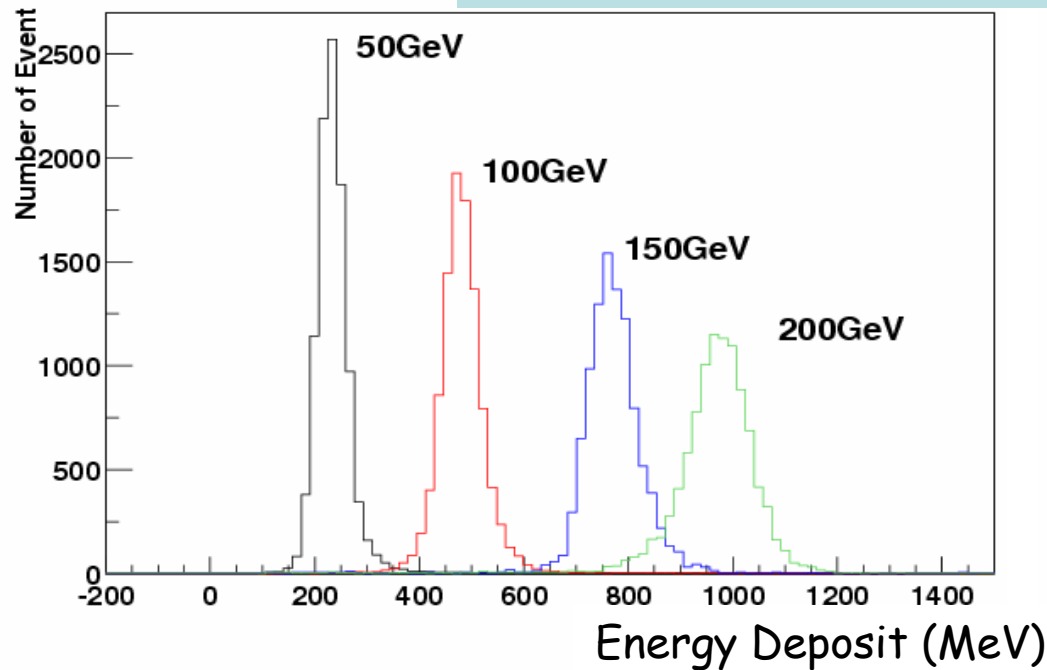
Linear dynamic range of 1:1000 (1100 ADC counts above pedestal, or ~ 1 pC with ~ 1.1 ADC counts noise),

$\pm 2\%$

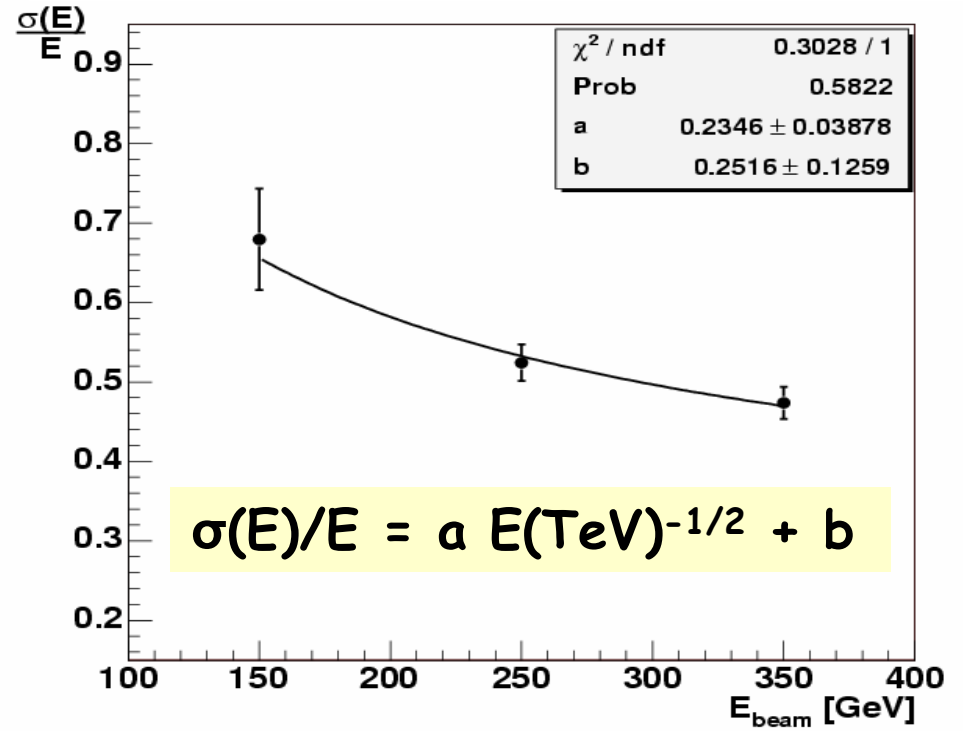
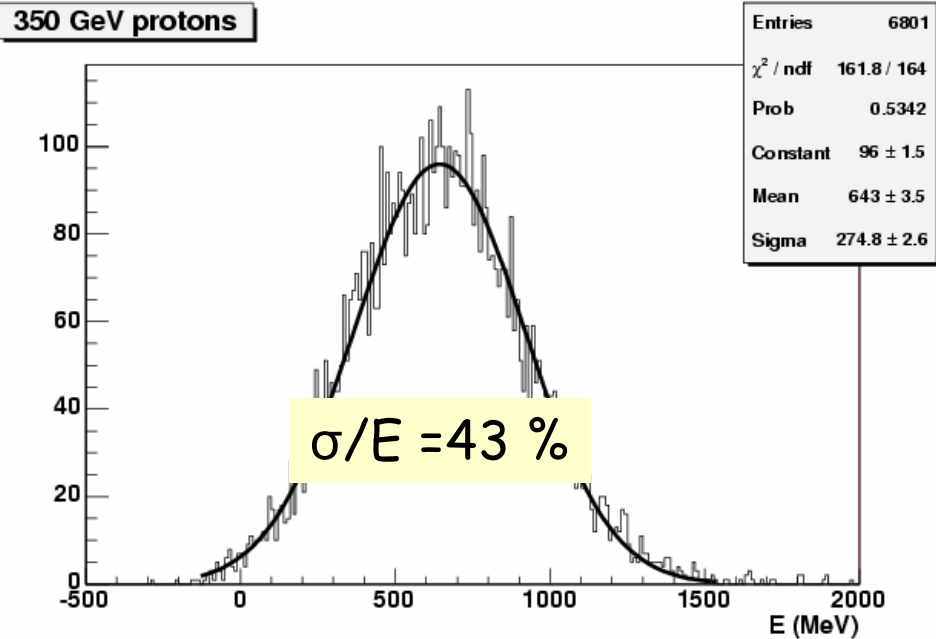
Input charge: 100 DAC counts (~ 100 ADC counts)
 Fitted trigger threshold: 285 DAC counts
 Gain: ~ 2.85 DAC-counts-at-threshold / ADC-counts
 The fitted noise level of the TA circuit: ~ 13 DAC counts (~ 4.5 ADC counts).
 Reducing trigger noise at a 5σ level requires a minimal threshold level of ~ 65 DAC counts (~ 22.5 ADC counts).



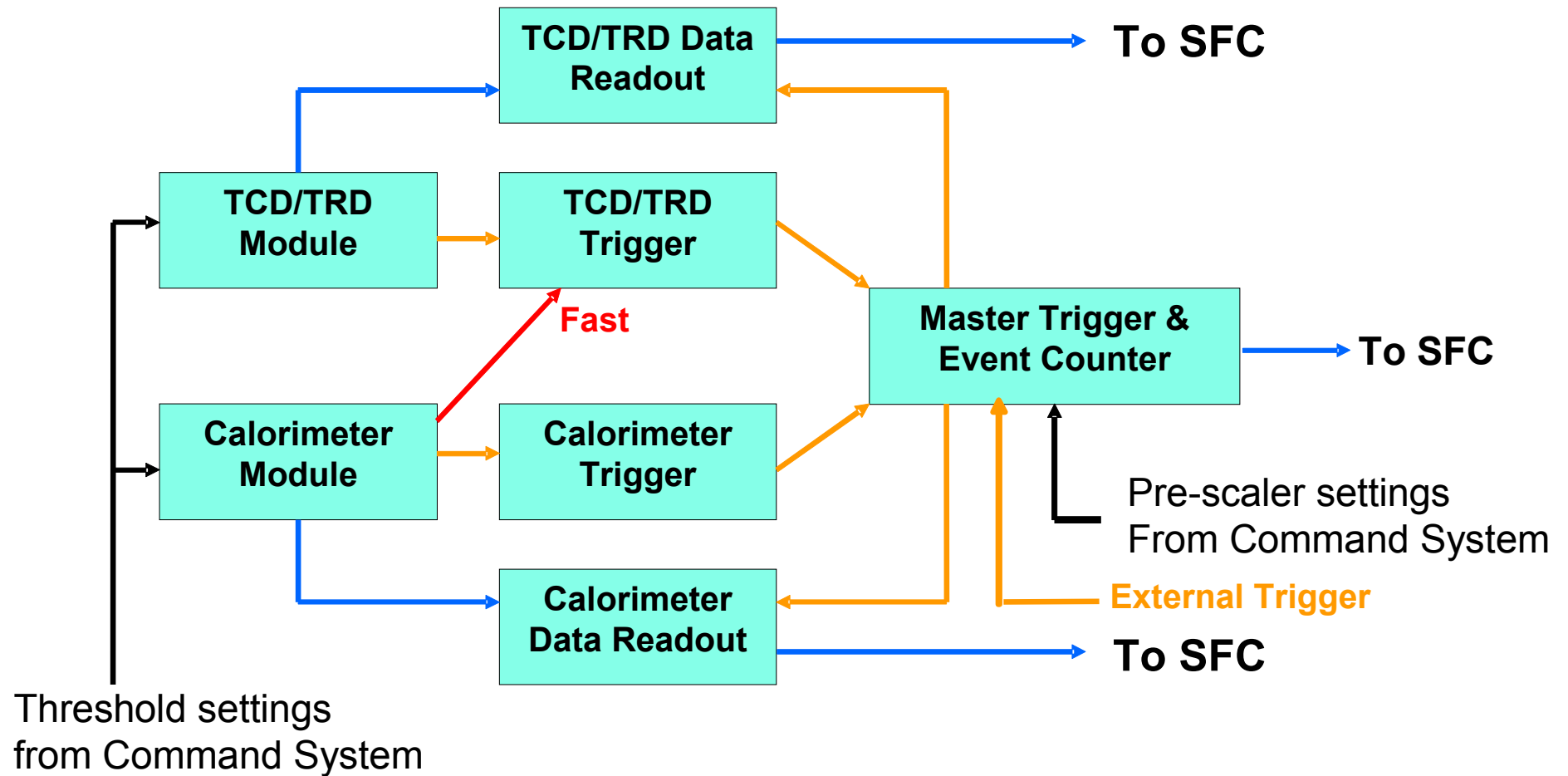
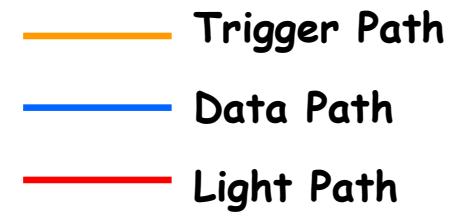
Responses to Electrons from 50 to 200 GeV



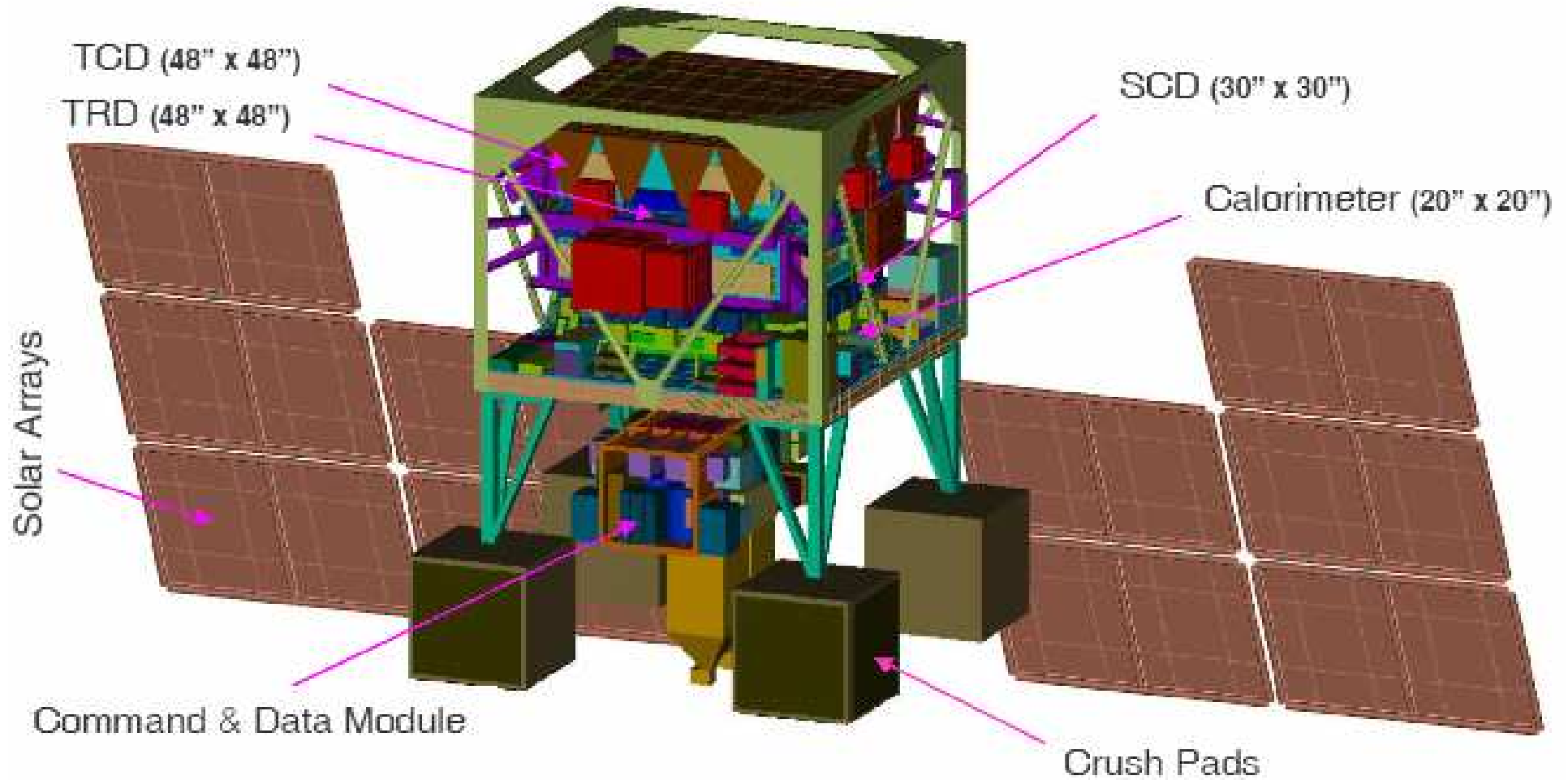
Responses to Protons from 150 to 350 GeV



Trigger and Signal Flow



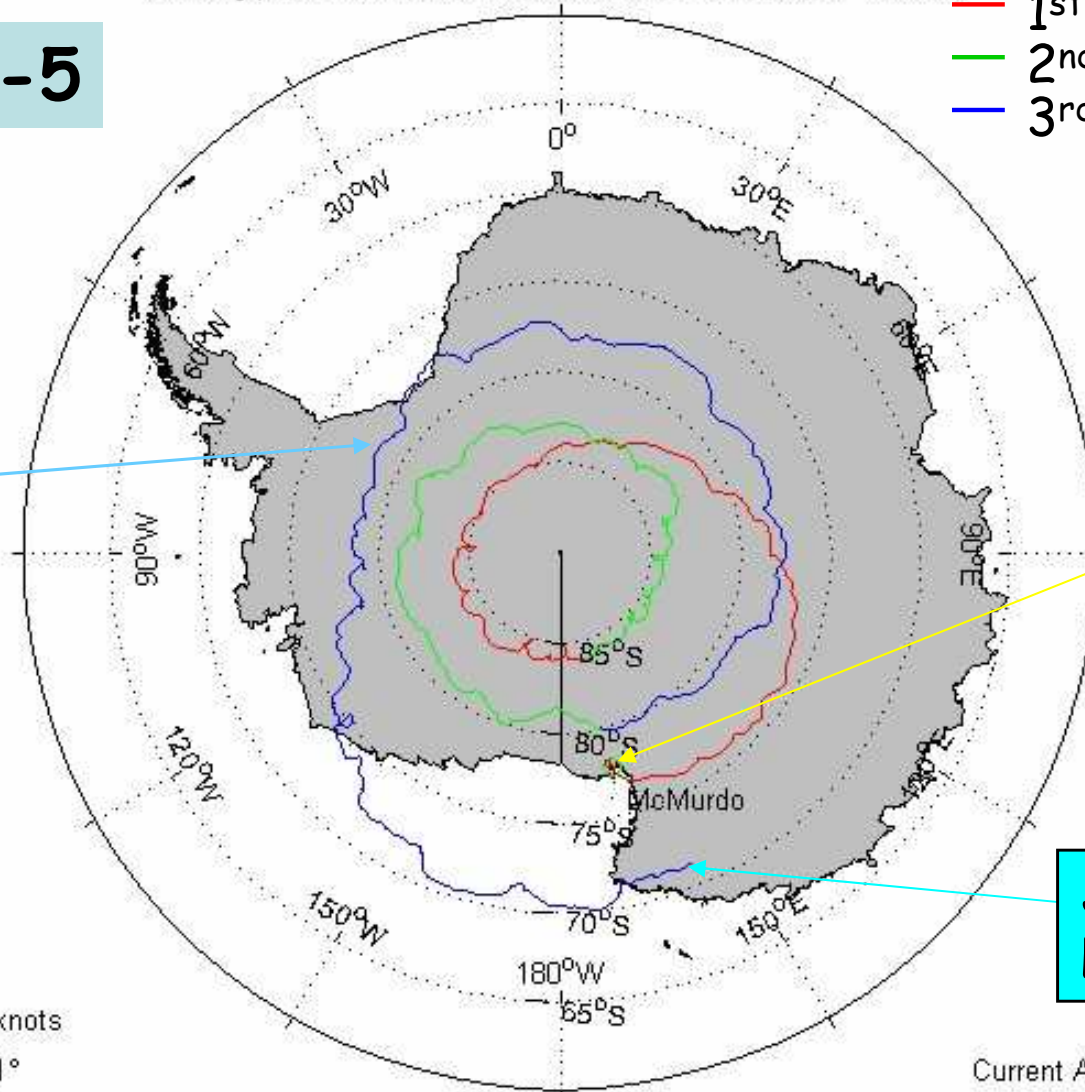
CREAM flight configuration



CREAM Flight Data: Trajectory
Covering period from: 2004-12-15 23:22:56 to 2005-01-27 02:00:31

CREAM 2004-5

- 1st circumnavigation
- 2nd
- 3rd



Jan. 16th 2005
Break the record
of 31 days and
20 hrs.

Dec. 15th 2004
Launch from
McMurdo.

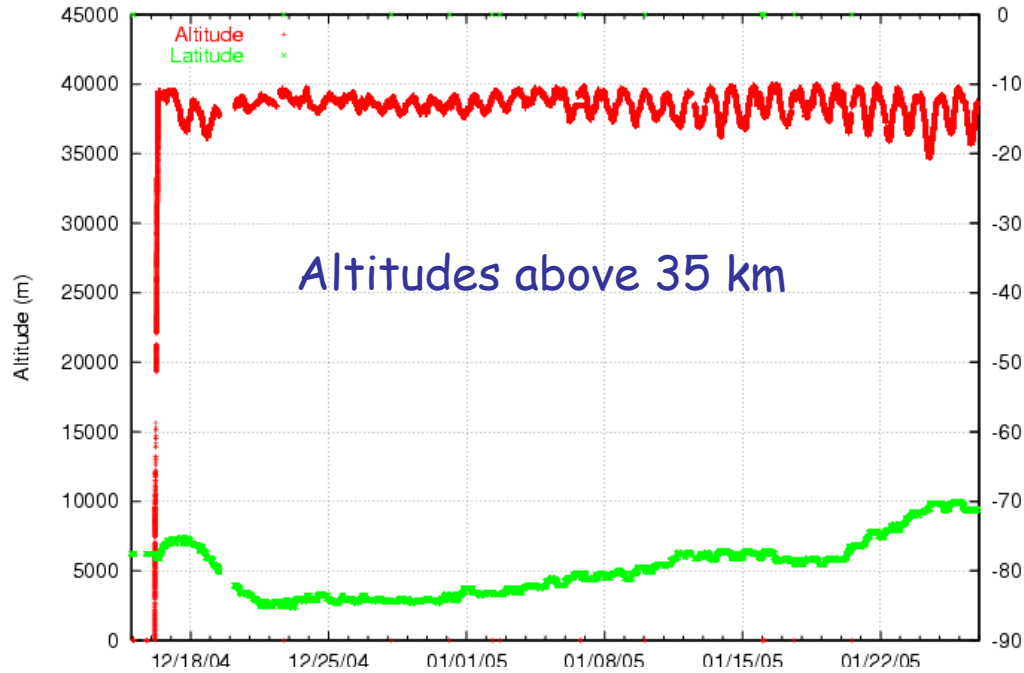
40 GB of data
collected.

Jan. 27th 2005
Landing.

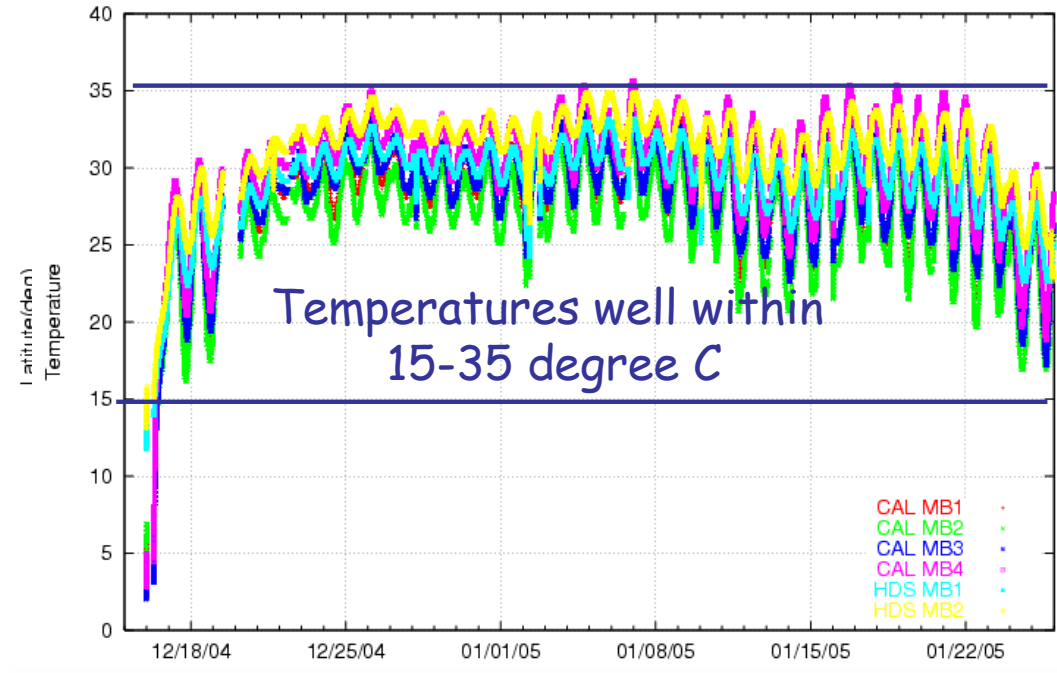
Current Speed: 17.2 knots
Current Course: 128.1°
Current Lat: -71°17'3.72"
Current Lon: 157°52'54"

Current Altitude: 13828.7402 feet
Current MET: 41 days 21 hrs 31 mins 30.783 sec since launch
Current Time: 2005-01-27 02:00:31 UTC

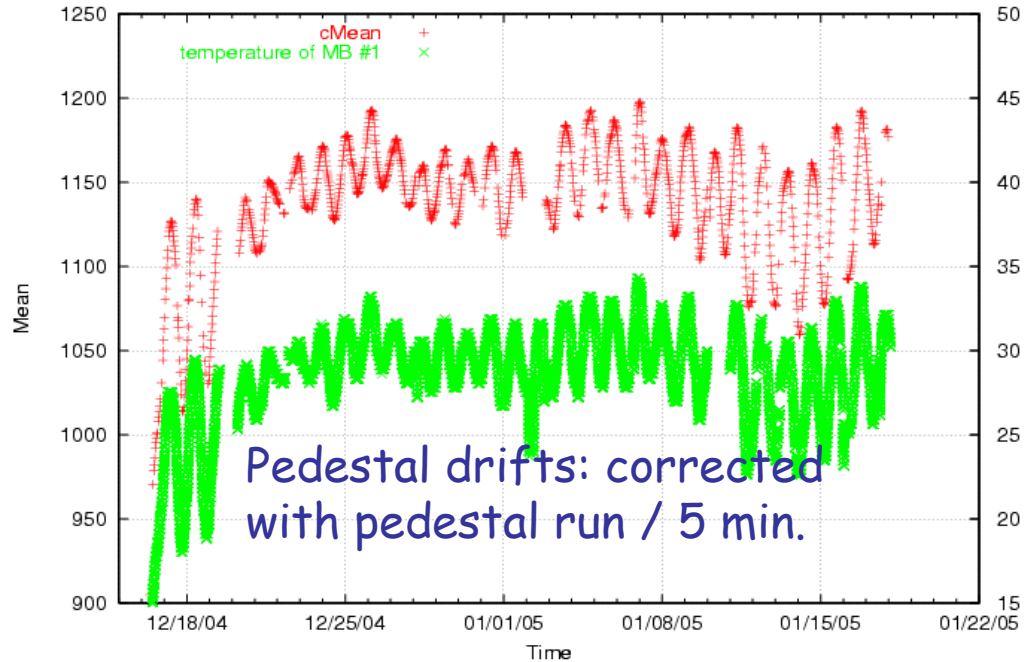
CREAM Flight: Altitude and latitude (from 15 Dec 2004 to 26 Jan 2005)



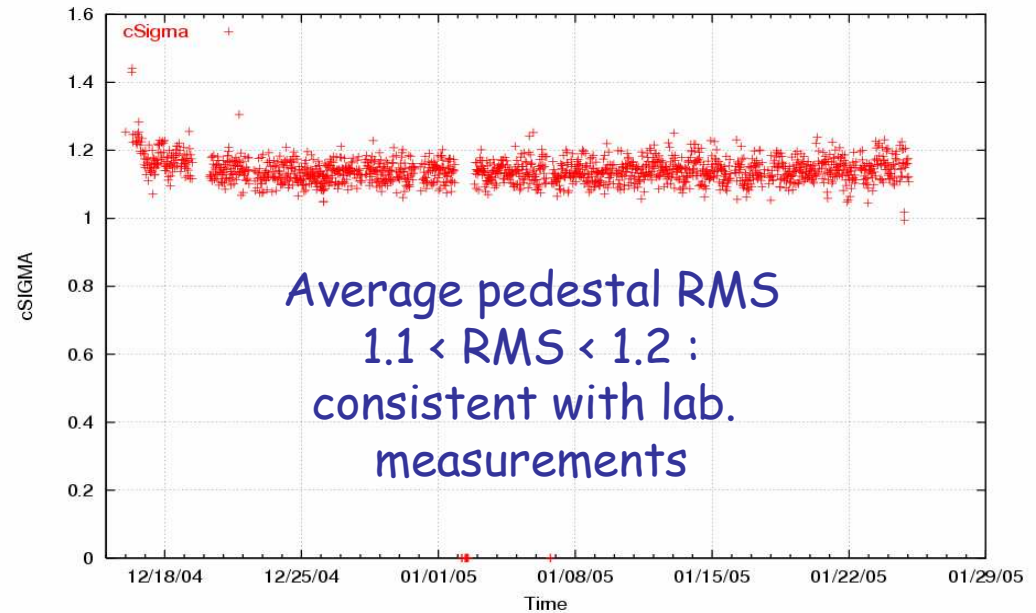
Temperature of Calorimeter (MB1,MB2,MB3 and MB4) and Hodoscope (MB1 and MB2)



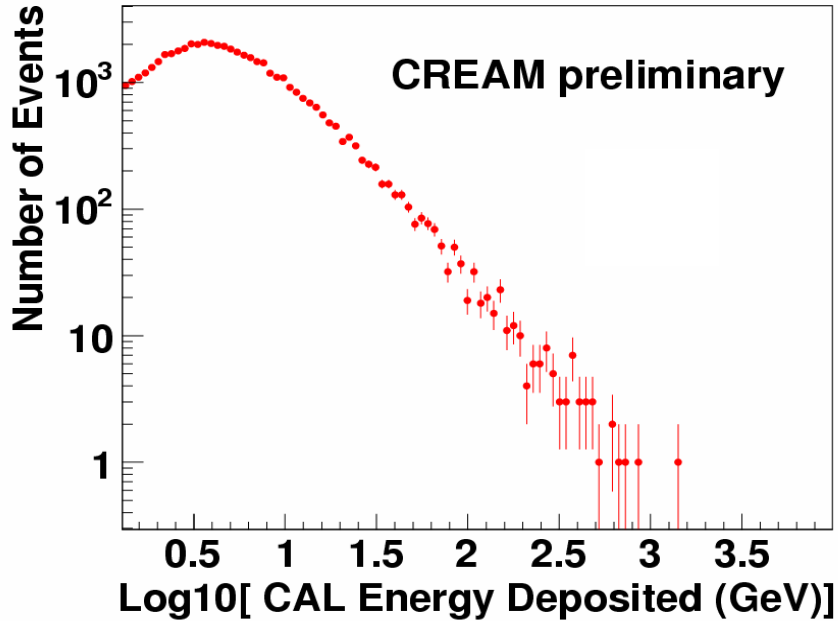
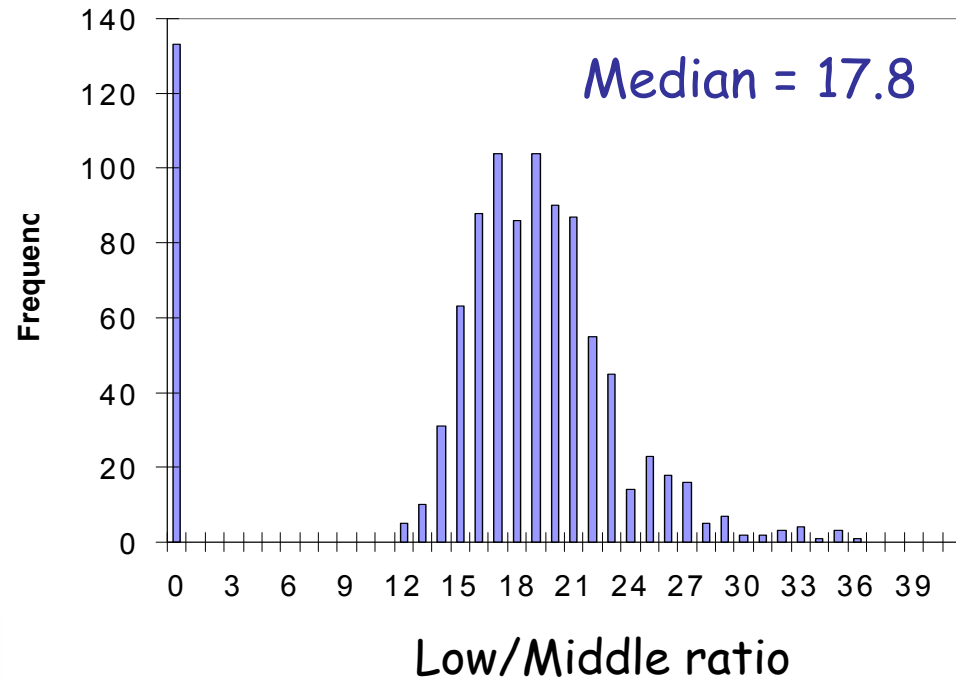
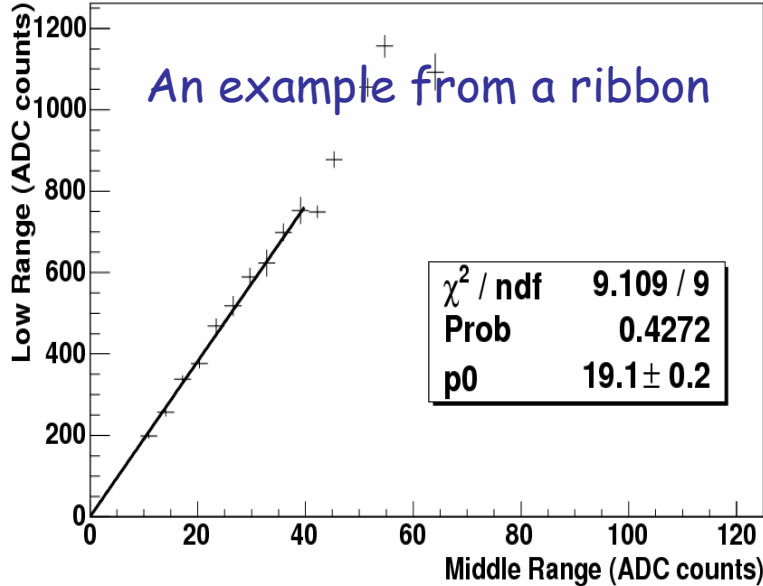
Average Mean Value of Calorimeter of every 5 minute pedestal run (100 events)



cSIGMA of Calorimeter

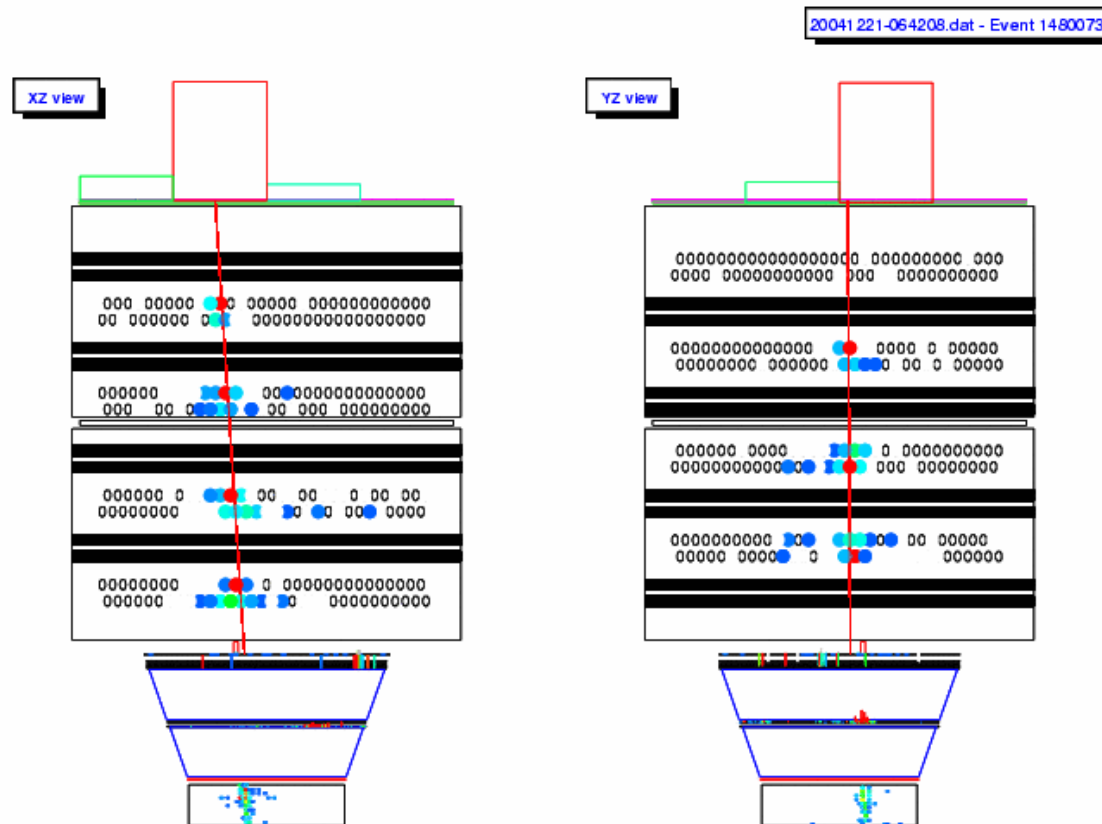


Performance of the calorimeter from flight data



Trigger condition :
A set of 6 consecutive active layers each observed a signal exceeding a threshold of ~ 60 MeV

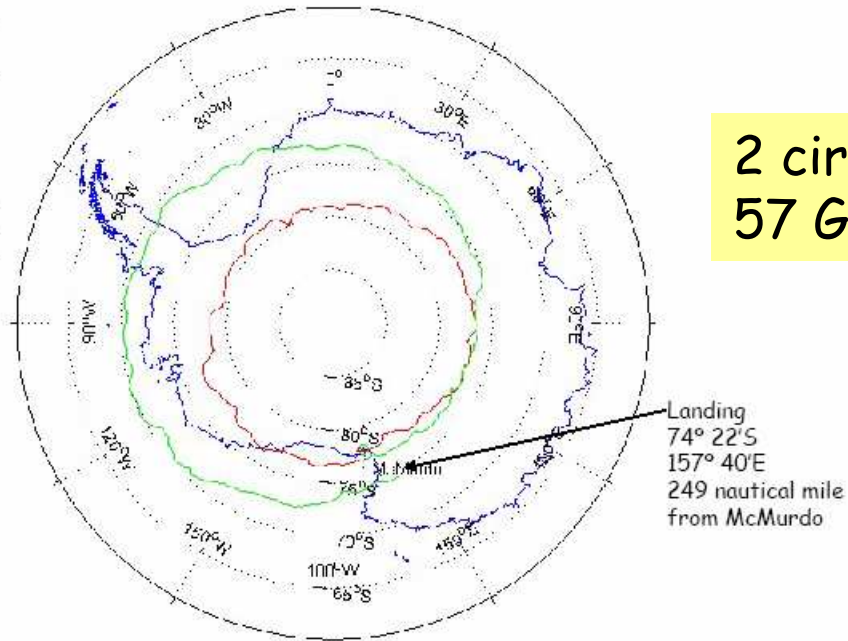
A CREAM event : ~ 10 TeV Fe candidate



CREAM-2 flight in 2005-6 (28 days 9 hours and 52 minutes)

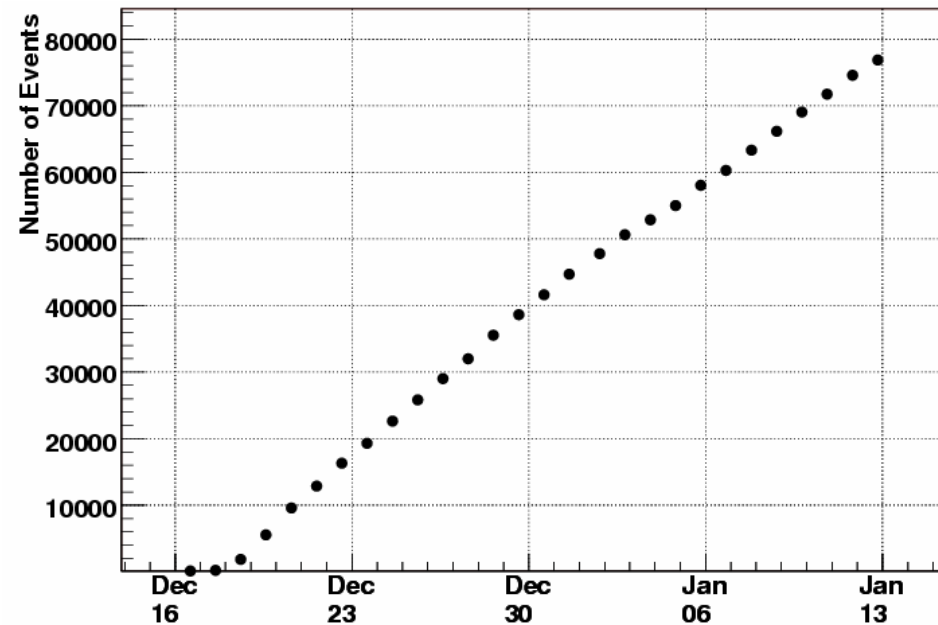
Launch
Dec 16 05:12 NZT
Dec 15 11:12 EST
Dec 15 16:12 GMT

Termination
Jan 13 14:22 NZT
Jan 12 20:22 EST
Jan 13 01:22 GMT



2 circumnavigations
57 GB of data collected

Integrated # of events
with CAL trigger



SUMMARY

- ❑ CREAM calorimeters were assembled, tested, calibrated, and integrated for flights.
- ❑ Two successful flights of total 70 days in two years have collected about 117 GB of data.
- ❑ Analyses of flights data are in progress.
- ❑ The preparation of the third flight in 2007 December has already started.
- ❑ Beam test at CERN is planned in this year.

Thanks to:

- o NASA
- o CSBF
- o WFF
- o NSF
- o CERN



**COLUMBIA SCIENTIFIC
BALLOON FACILITY**



**Wallops Flight Facility
Goddard Space Flight Center**

