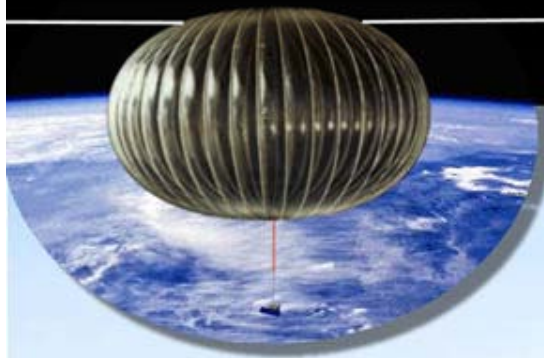


CherCam

the Cherenkov imager
of

Yoann Sallaz-Damaz

C. R. E. A. M.



cosmic ray energetics and mass

for nuclear cosmic rays charge measurements

Outline



- ➔ The CREAM experiment
- ➔ CherCam
 - Principle
 - Architecture and Construction
 - Tests
 - Integration
- ➔ Aerogel
 - Geometrical Properties
 - Optical Properties
- ➔ Simulation
- ➔ Conclusions and Perspectives

The CREAM experiment



CREAM (Cosmic Ray Energetics and Mass) :
balloon borne experiment, dedicated to high energy
cosmic ray elemental spectra measurements

CREAM Collaboration

- 6 U.S. universities : Maryland, Chicago, Penn State, Northern Kentucky, Minnesota, Ohio State
- 3 Korean universities : Ewha Womans (Seoul), Korea Advanced Inst.Sci. and Tech., Kyungpook National University (Taegu)
- Sienna (INFN), Italy
- UNAM Mexico
- NASA Goddard
- LPSC Grenoble + CESR Toulouse

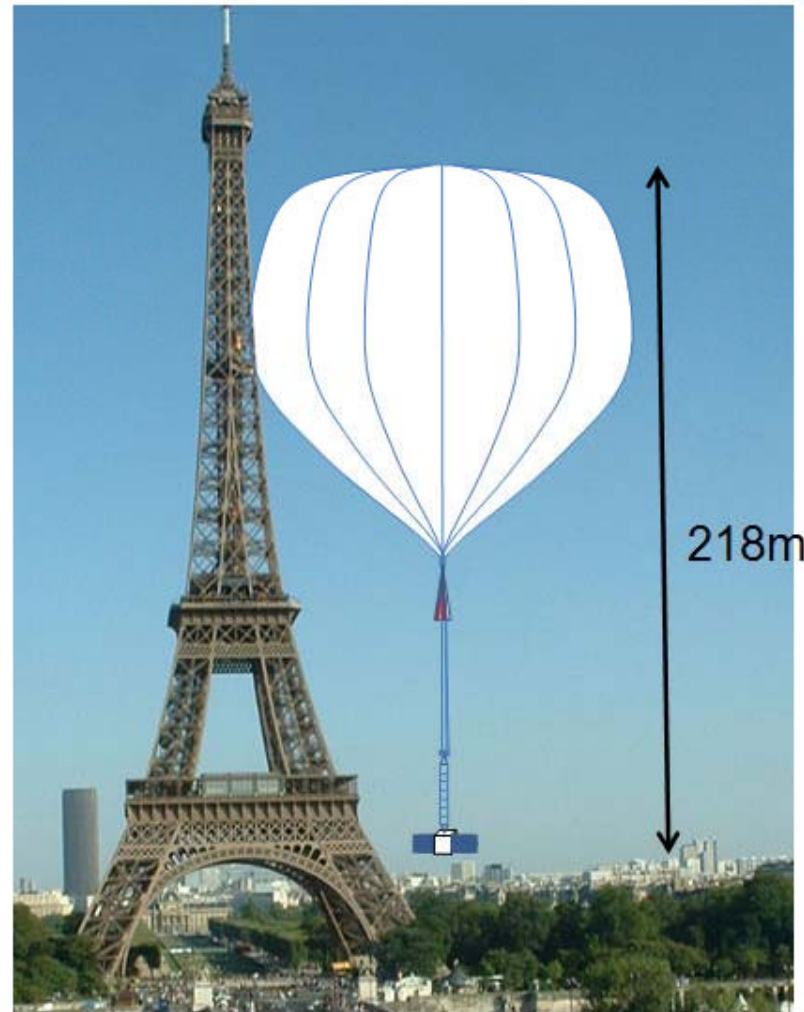
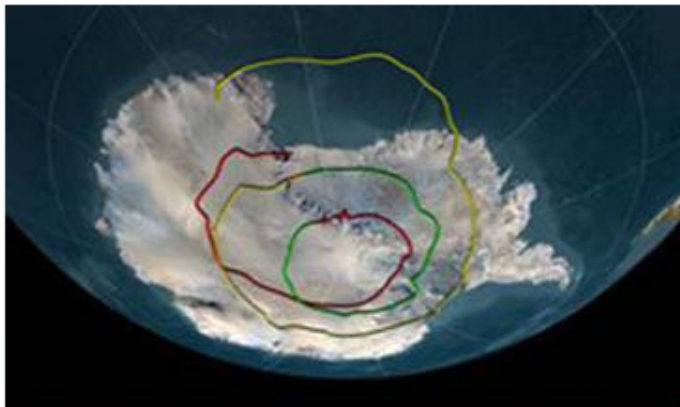


The CREAM experiment



Launched from the US McMurdo base in **Antarctica**
CREAM holds the world duration record for a scientific flight
(**42 days** in the 2004 campaign)

1st CREAM flight
from 16/12/04 to 26/01/05



The CREAM experiment



Balloon experience

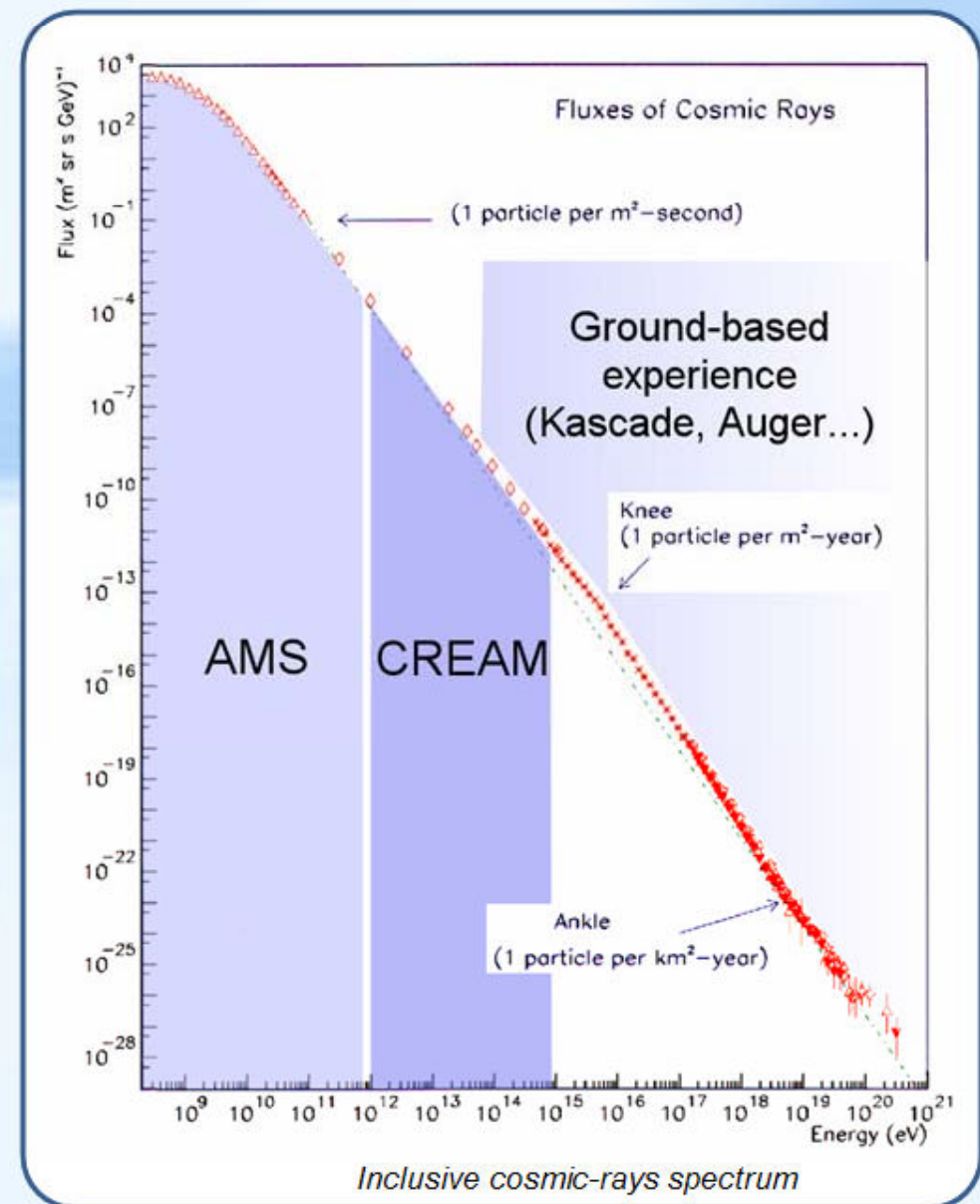
➔ Direct cosmic-ray detection experiment

Energy range

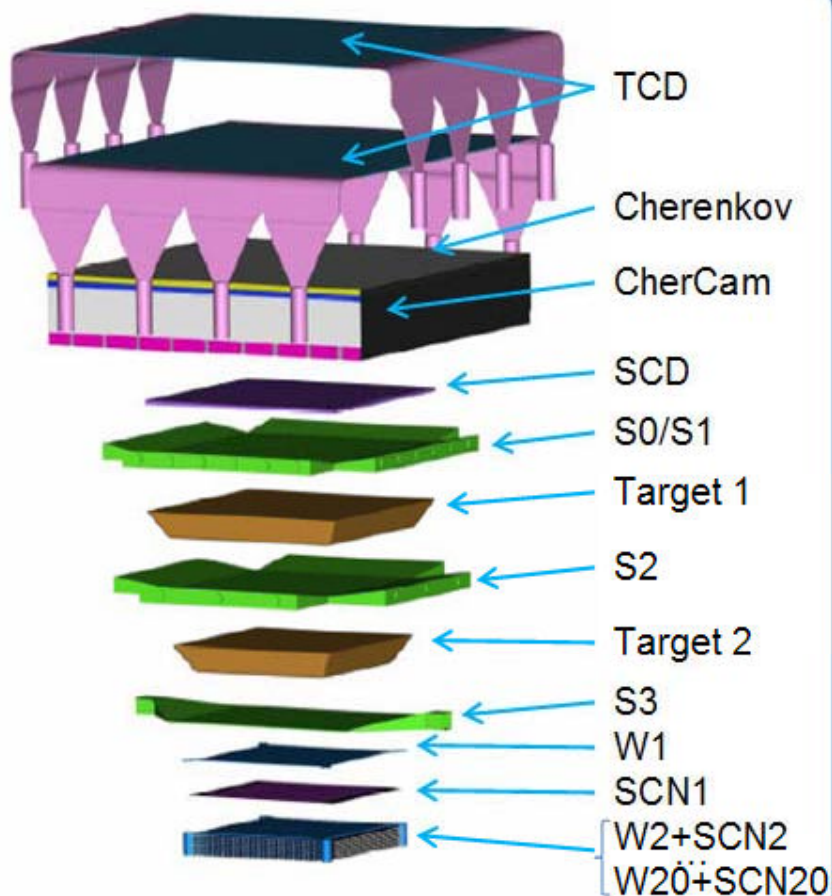
➔ $10^{12} \text{ eV} - 10^{15} \text{ eV}$

Objectives

- ➔ Measurement of the elemental cosmic-ray flux (H to Fe) with a good charge and energy resolution.
- ➔ Cosmic-ray propagation study
- ➔ Search for the elemental cosmic-ray cut-off below the knee
- ➔ Calibration of ground-based detectors



The CREAM experiment



Redundant and complementary charge identification and energy measurement systems :

- ➔ A Timing Charge Detector (TCD), a Rich (CherCam) and a Silicon Charge Detector (SCD) provide charge measurements
- ➔ Four layers of scintillating fibers (S0/S1) give an additional charge determination, and information on particle trajectories.
- ➔ Another scintillating fiber layer (S3) provides timing reference
- ➔ The energy is determined by a hadronic calorimeter, with a resolution almost constant over the 3 orders of magnitude.

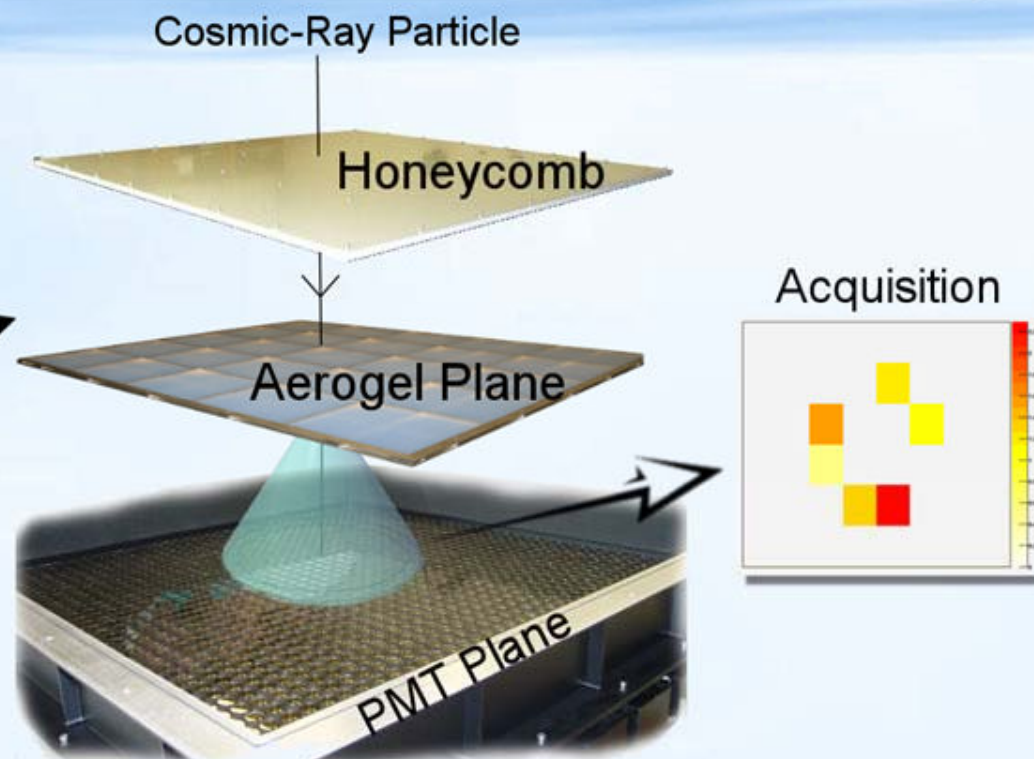
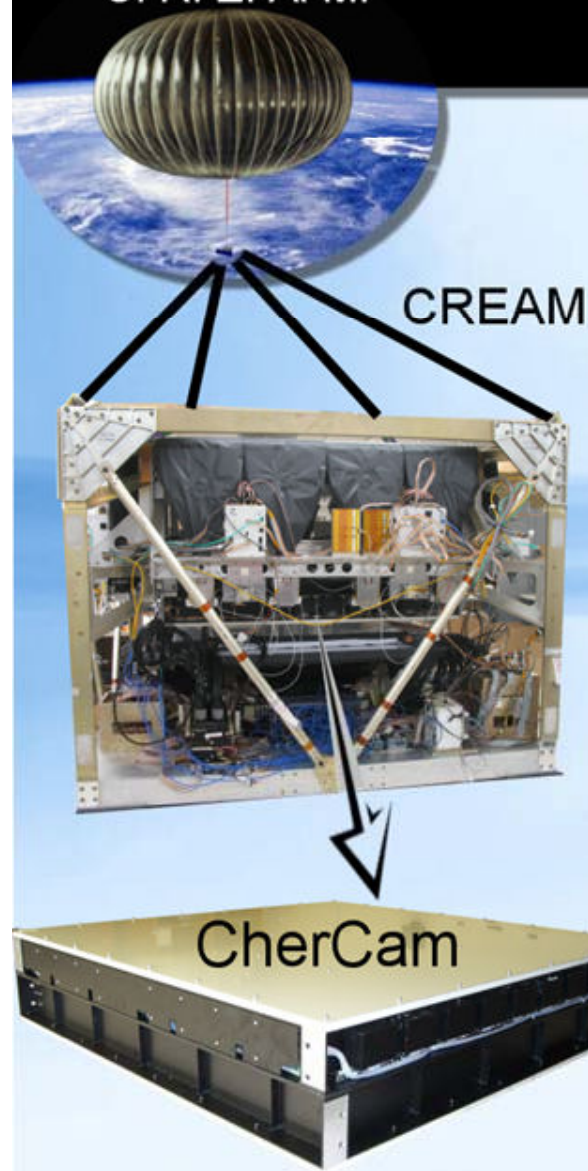
CherCam : Principle

CherCam (CHERenkov CAMera) : one of the sub detectors

Based on the Čerenkov effect :

- ➔ Radiator ➔ 200 silica aerogel tiles
- ➔ Detection ➔ 1600 PMTs (1") plan

French/Mexican contribution to CREAM: entirely proposed, designed, built and integrated in **less than 2 years**

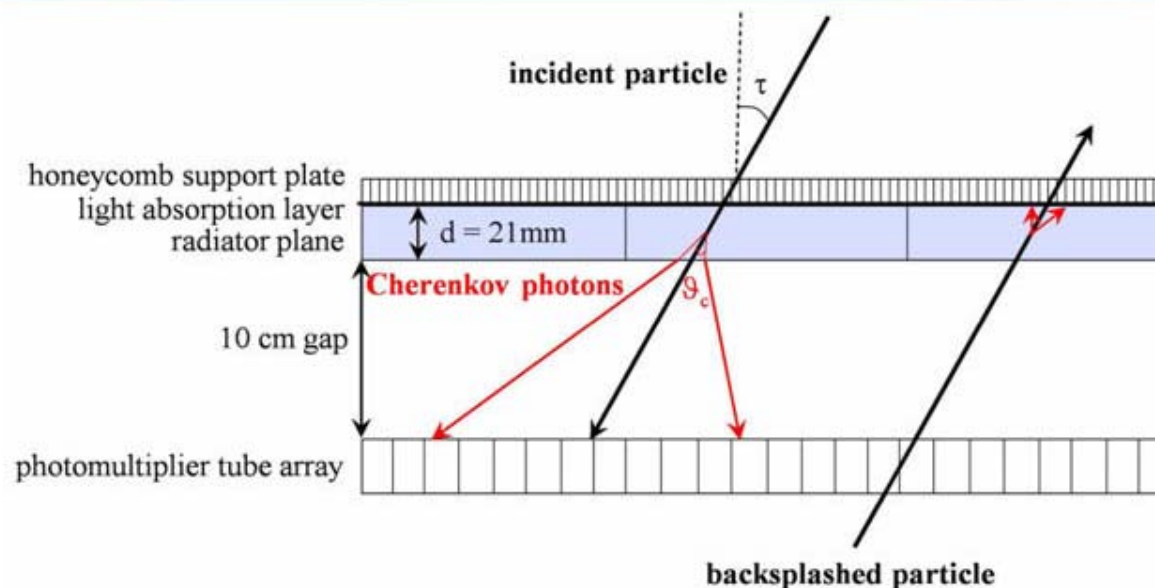


CherCam : Principle

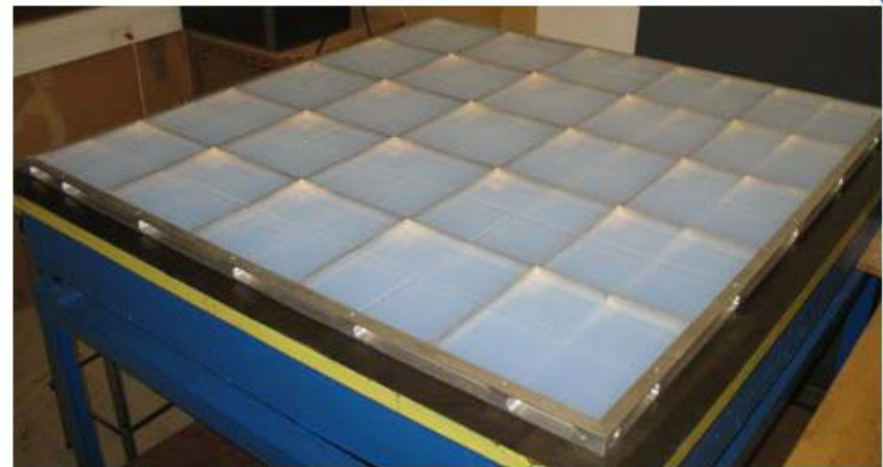
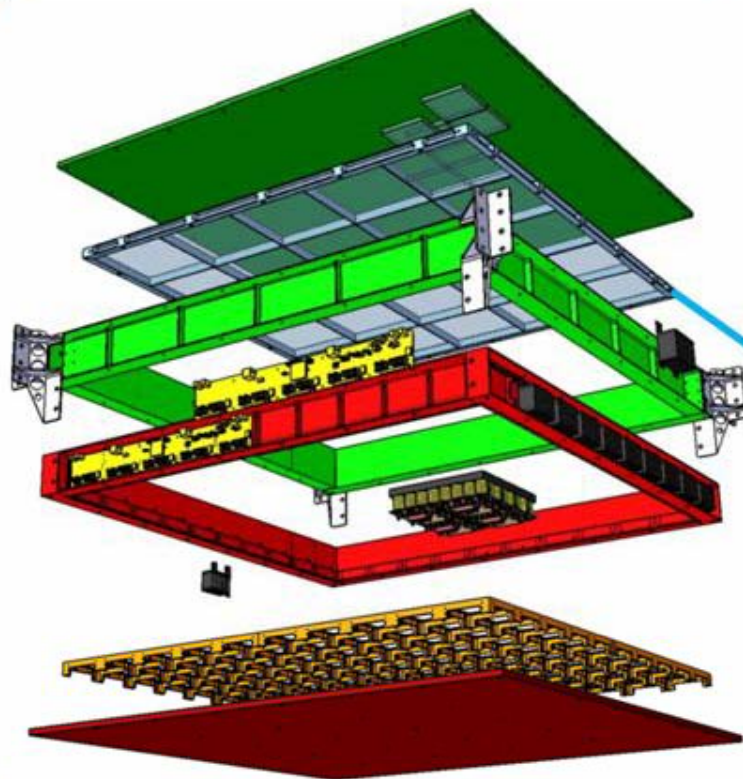


Imager principle : based on Čerenkov effect

$$N_{ph} \propto \sin^2 \theta_c \cdot Z^2$$

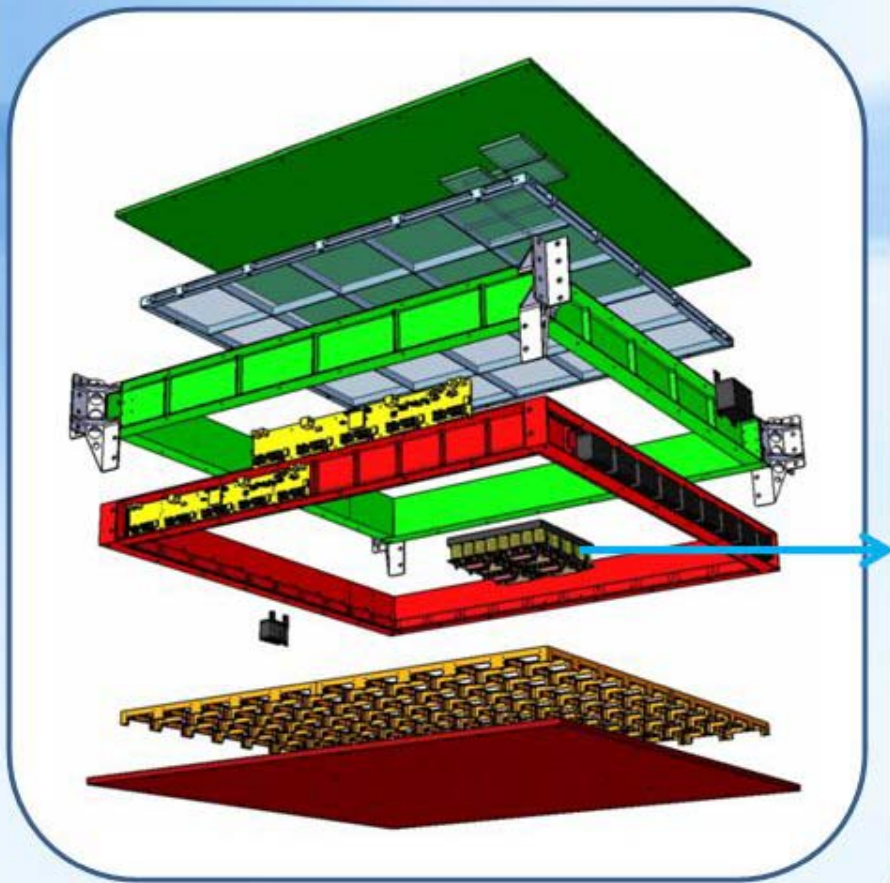


- optimized for charge measurement
- good albedo particle signature
- Constant resolution over the whole range of charges of interest



*Aerogel aluminum frame with
200 Mastushita SP50 tiles*

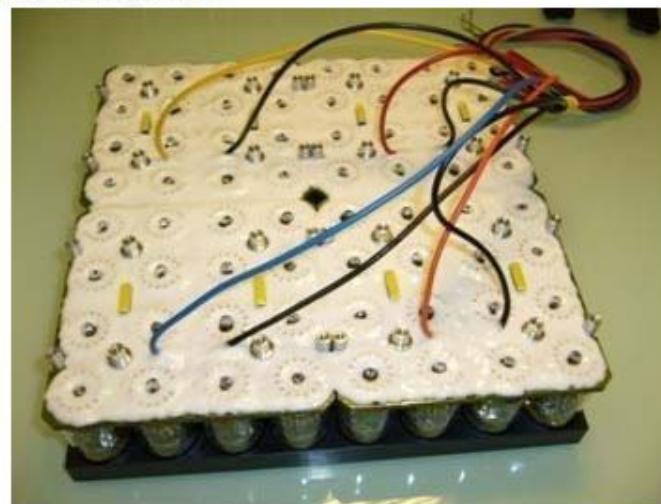
CherCam : Architecture and Construction



8x8 PMTs Module

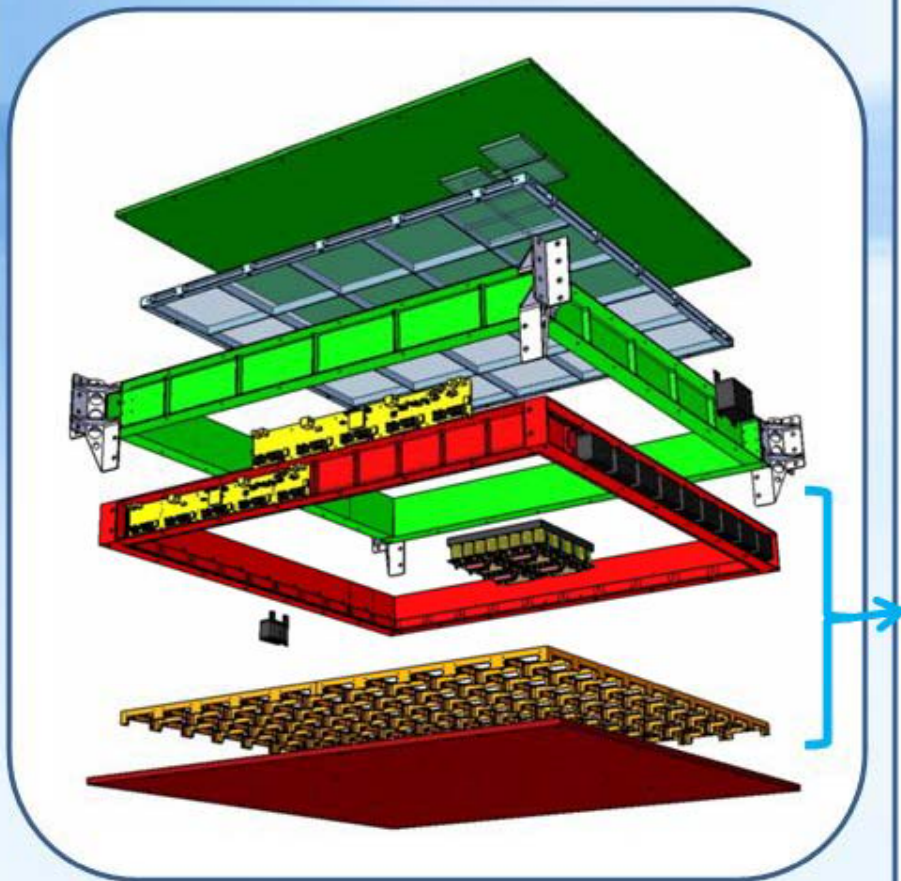


PMT (Photonis XP1232)



Module with potting

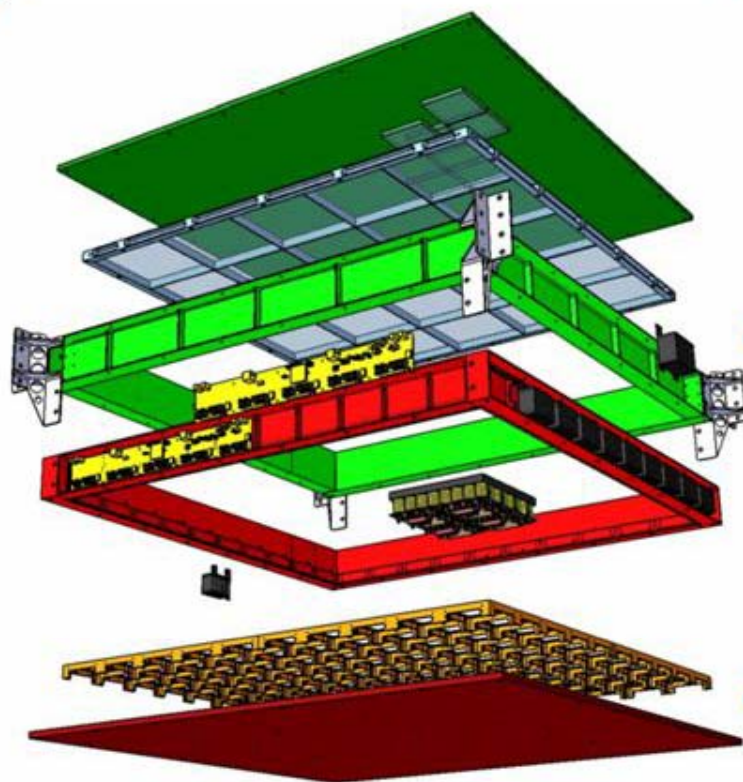
CherCam : Architecture and Construction



Read-out electronics



2x 50 HV modules



Complete PMTs frame

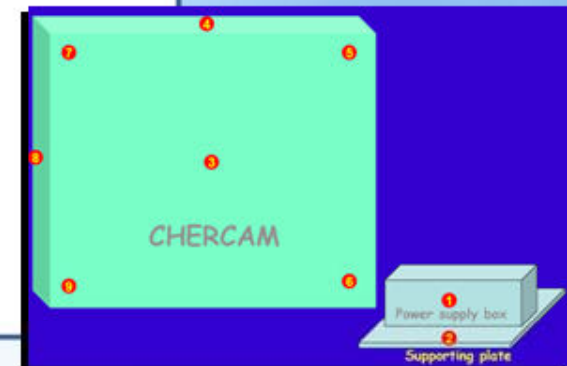
CherCam : Tests

Vacuum and thermal tests

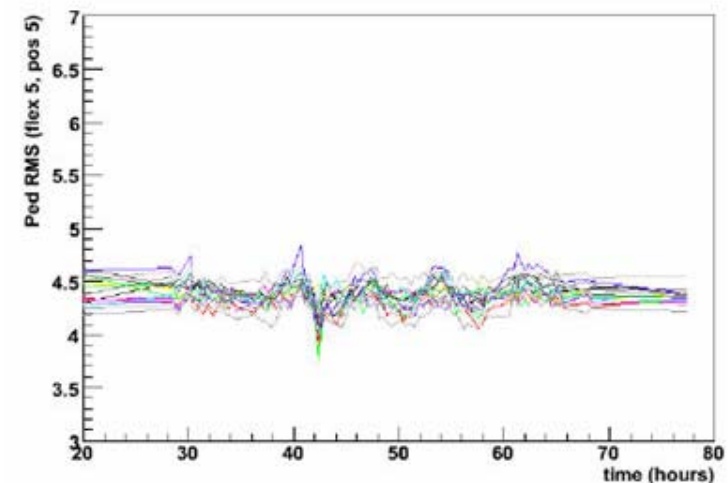
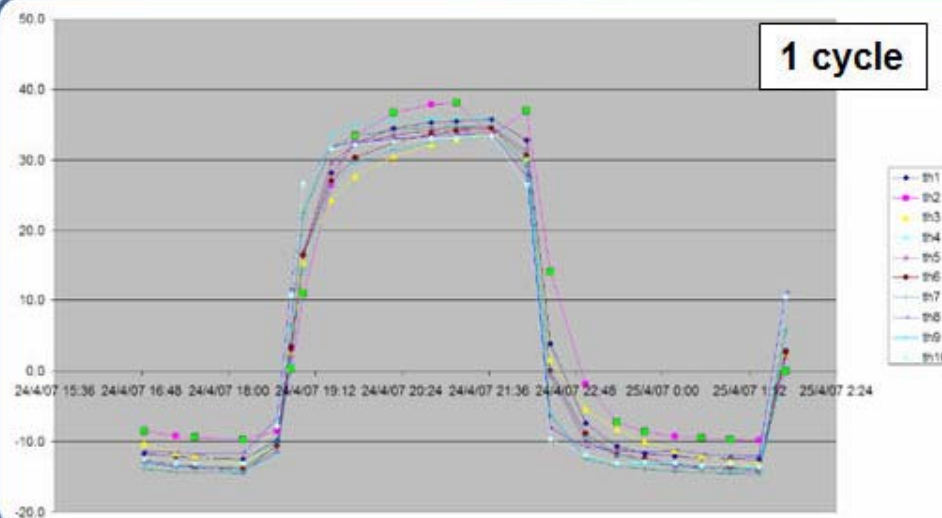
CherCam has to work at « low » temperature and pressure conditions

- ✓ Power switch on tests at -10°C
- ✓ Thermal variation of 20°C at 5mb ($[-10^{\circ}\text{C}$ and $+10^{\circ}\text{C}]$)
- ✓ 4 thermal cycles $[-10^{\circ}\text{C}, +35^{\circ}\text{C}]$ at P_{atm}
- ✓ operational test at 6mb for 23 hours

➔ total of ~ 70 hours test



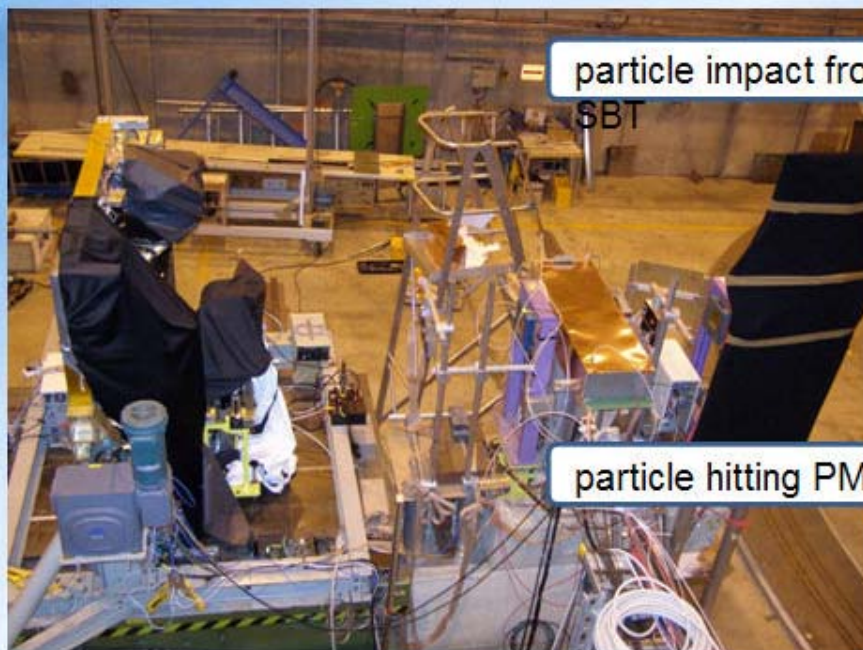
➔ detector behavior (in particular 100 HV units working conditions) fully validated



CherCam : Tests

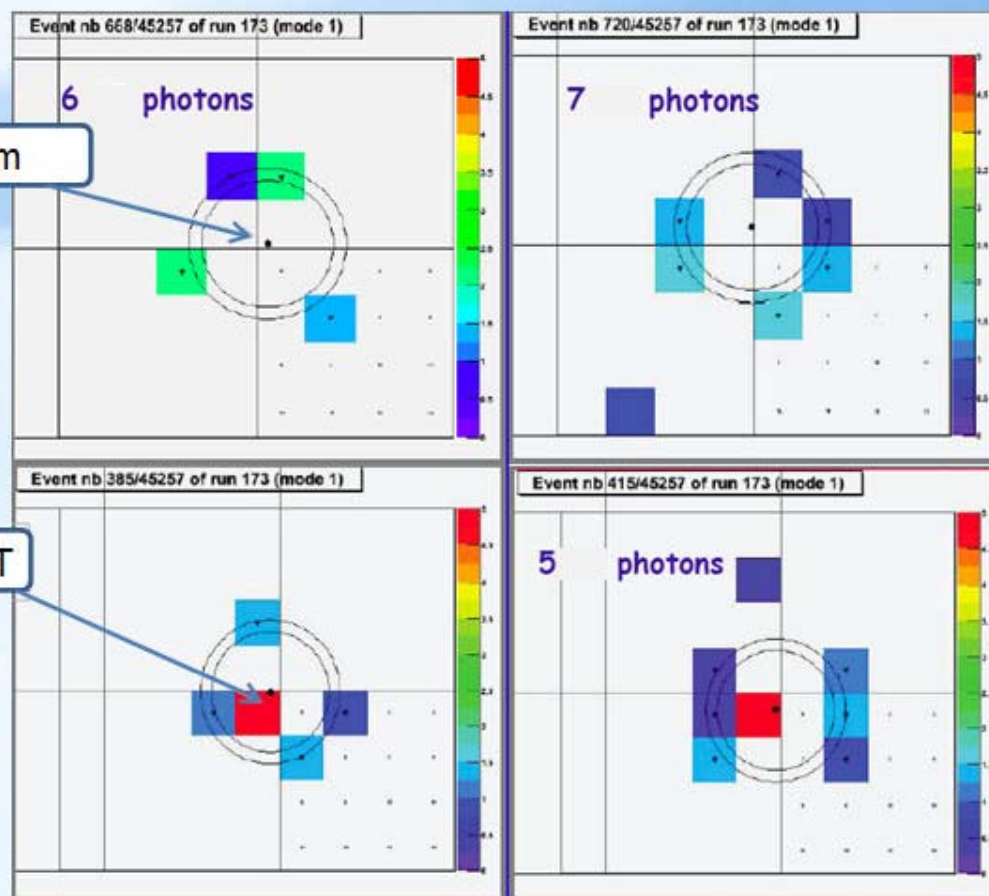


Beam Test (CERN - October 2006 and 2007)
Proton, pion and electron beams, 100-300 GeV



particle impact from
SBT

particle hitting PMT



Prototype tested with success.

Analysis still ongoing

Preliminary charge resolution for $Z=1$: 0.21 charge unit

C. R. E. A. M.

CherCam : Integration

Integration (Maryland University)



Arrival at Maryland



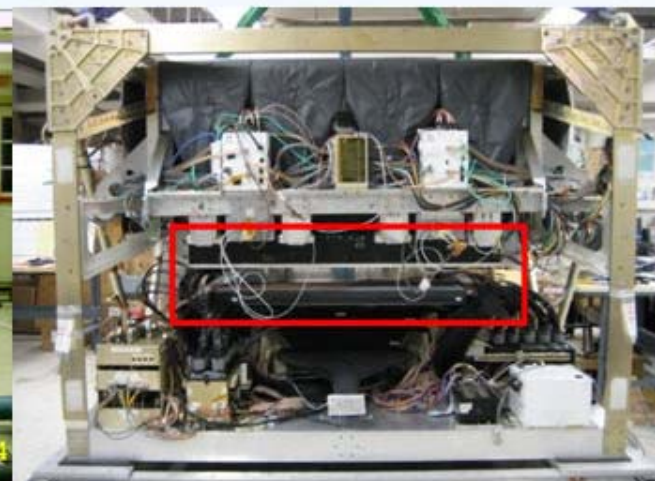
Unpacking...



First tests



CREAM without CherCam



CREAM with CherCam

Aerogel



CherCam uses 200 aerogel tiles SP50 - 105x105x11 mm
(producer: Matsushita-Panasonic)



Tile properties determine the counter performance :

Optical :

➔ Optical index dispersion **between** each tiles

➔ Optical index dispersion **in** each tiles

} $< 10^{-3}$

Geometrical :

➔ The thickness variation of the aerogel **must be less than 0.2mm**

➔ Matsushita don't guarantee this performance
and and therefore it is necessary to analyse all the tiles

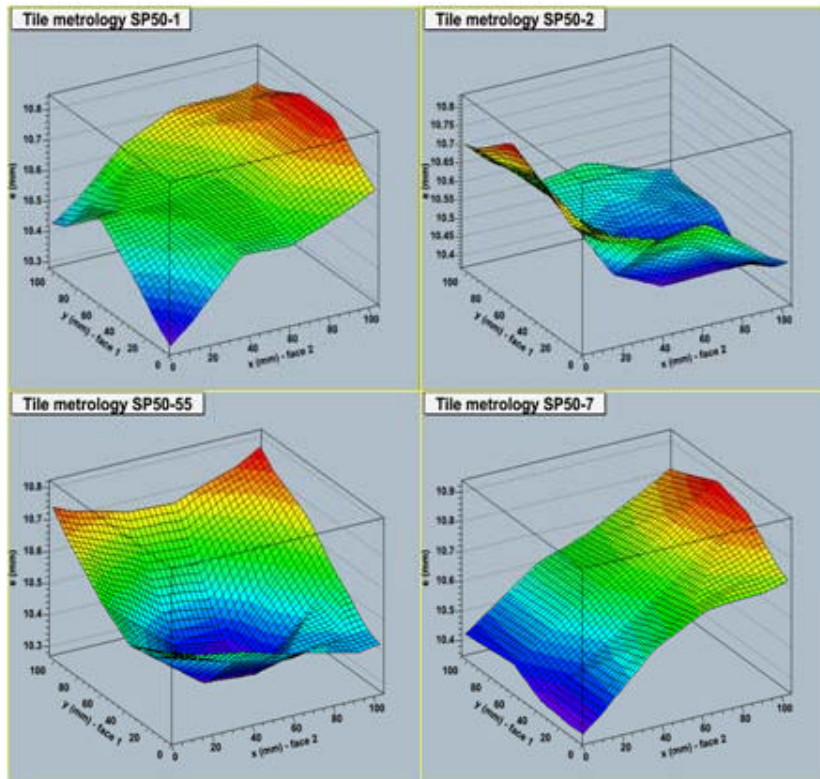
Aerogel : Geometrical Properties



Geometrical Properties :

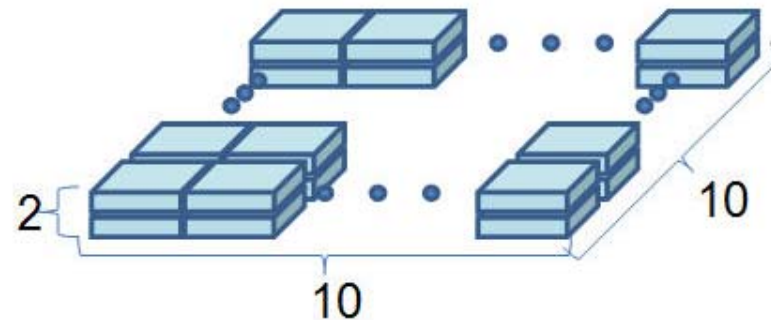
The thickness of each tile was measured

Thickness of 4 tiles



Each tile taken independently

➔ thickness variation > 0.5 mm



But...

tiles are paired with both n and thickness matching.

Then the thickness variation of the entire plane is less than 0.2 mm.

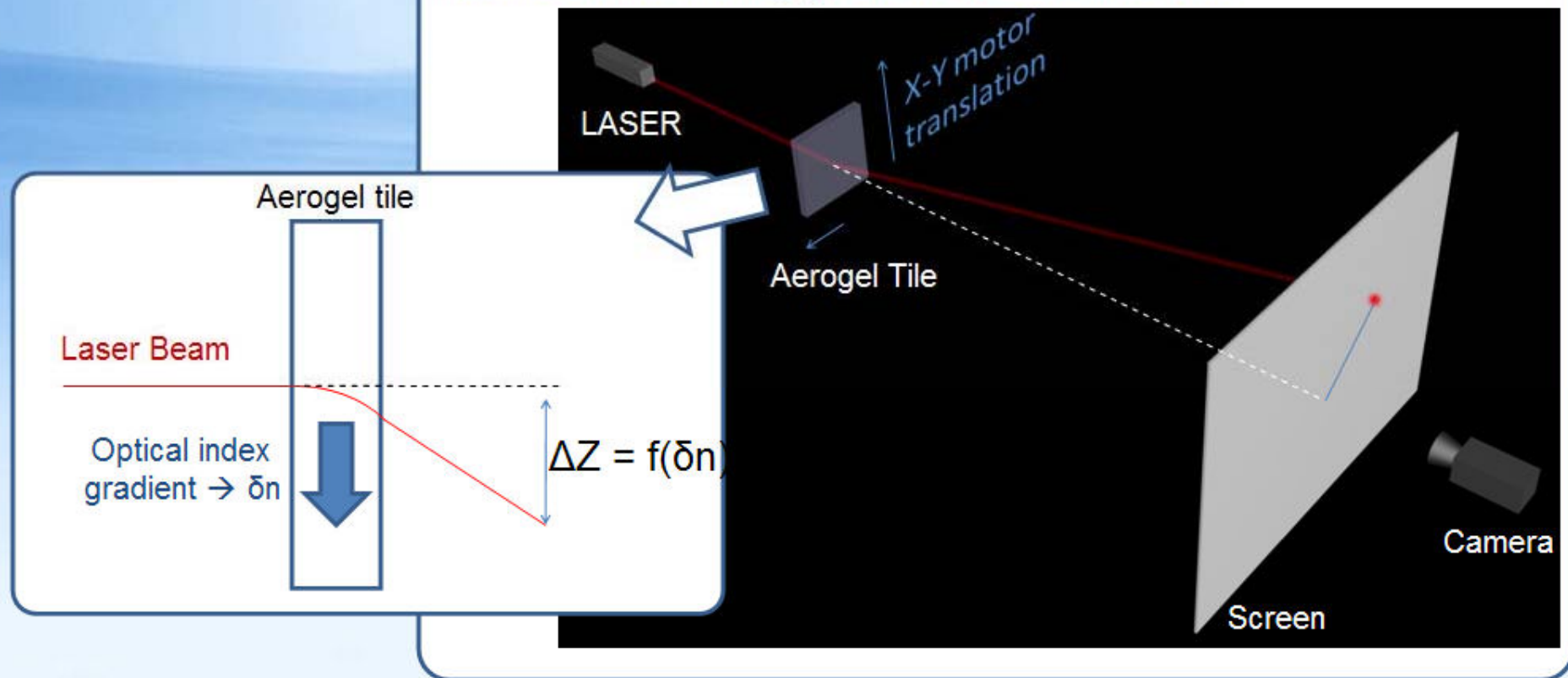
Aerogel : Optical Properties



Optical Properties :

By laser scanning and weight measurement, we can determine the optical index in each point of the tile

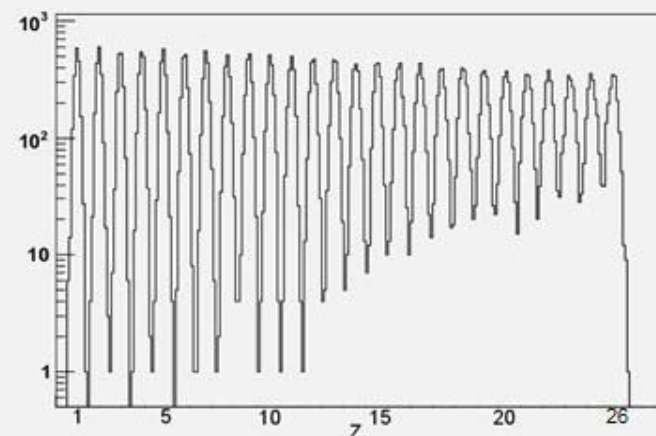
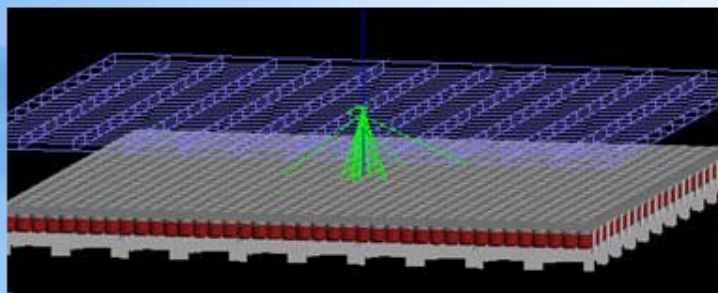
Index determination by parallel side measurement



➡ Maximum measured variation $< 10^{-3}$

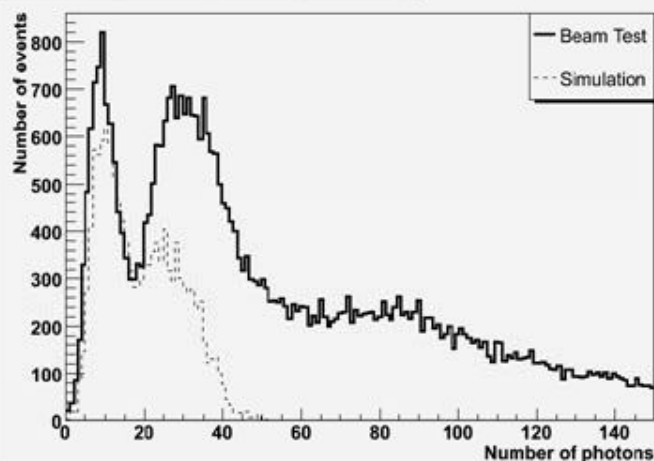


Geant 4 CherCam Simulation

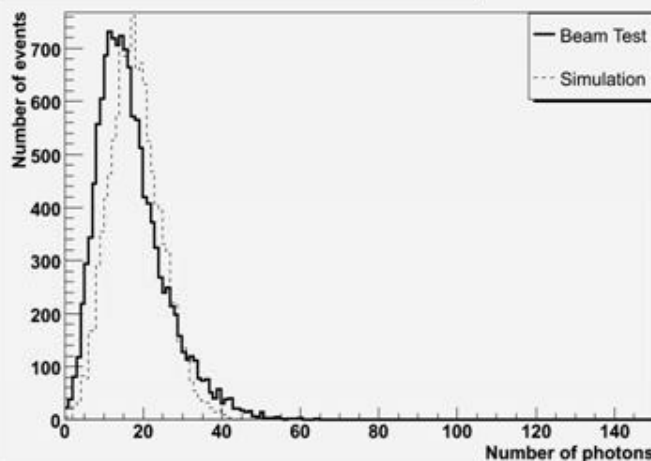


Charge reconstruction, including photomultiplier simulation, geometrical efficiency, photon reflection/refraction and Rayleigh scattering (44000 simulated events, uniformly distributed in charge)

Number of photons per event (Raw data)



Number of photons per event (Corrected data)



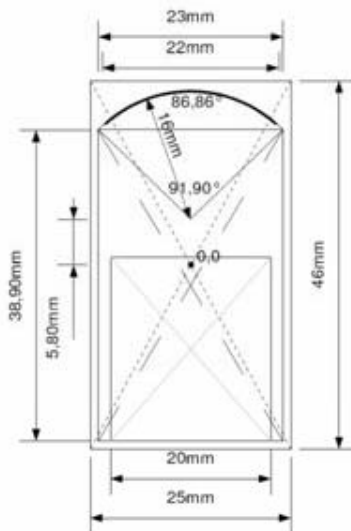
CERN beam test Results with 100 GeV electrons : Data vs. Simulation



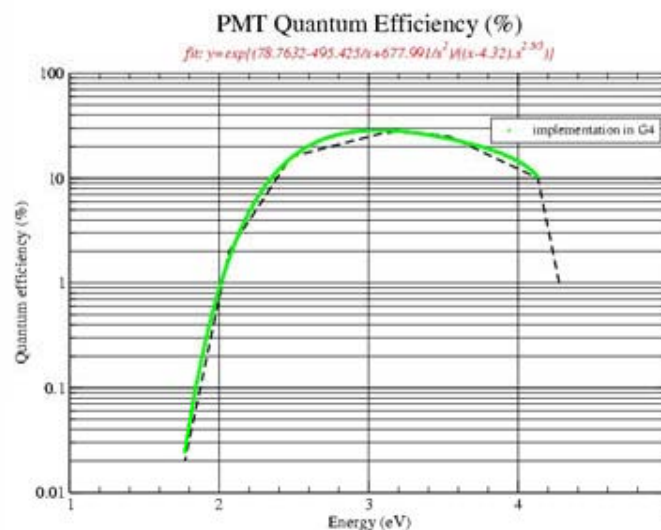
Photomultiplier Tube simulation



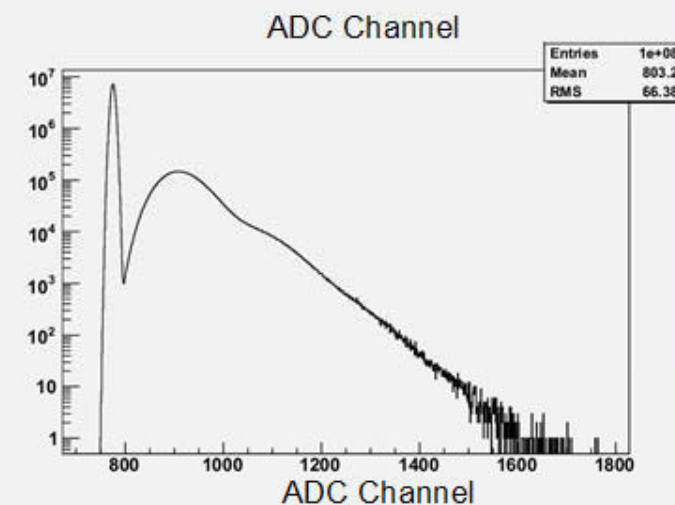
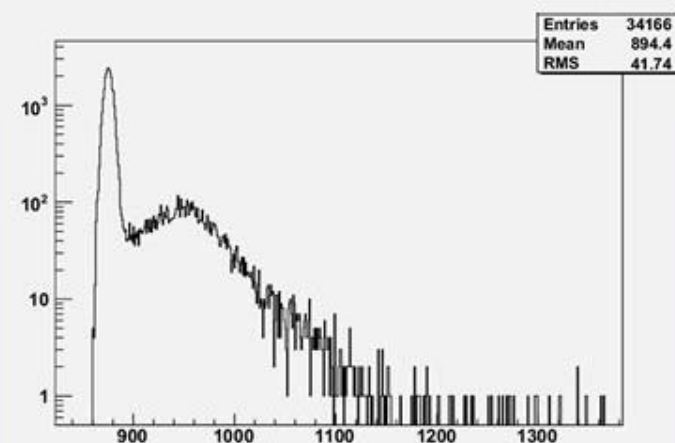
Geometry



Quantum Efficiency



PMT spectrum between real data (top) and simulation (bottom)



Conclusions and Perspectives



- ➡ CHERCAM designed and built in less than 2 years
- ➡ Tested* (thermal, vacuum, beam test) and fully operational.
- ➡ Preliminary results from test beam really encouraging; the preliminary estimate of the charge resolution of 0.2 charge unit.
- ➡ A complete GEANT4 simulation has been developed
- ➡ Data analysis preparation ongoing
- ➡ CREAM just leaving for McMurdo for next launch (December 2007)
- ➡ looking forward to seeing CHERCAM flying!

* P.S. : "crash test" done...also convincing....



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