The Auger Observatory for High-Energy Cosmic Rays

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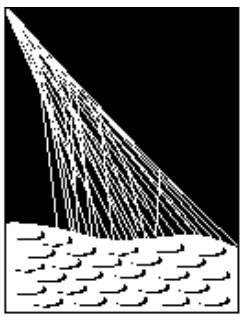
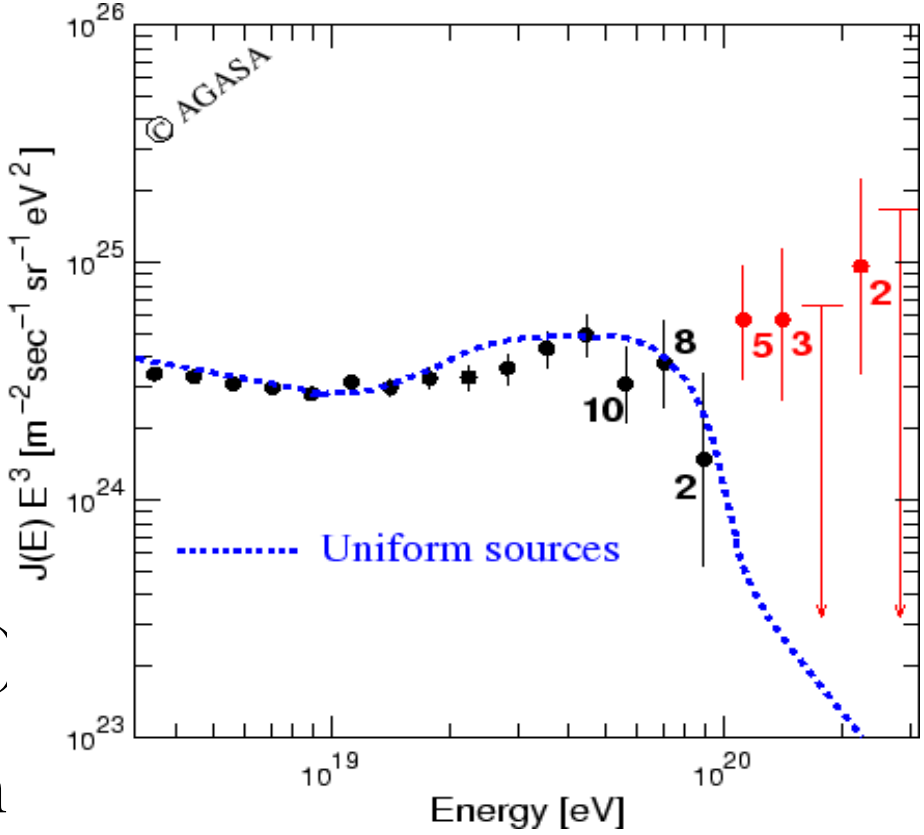
For the Pierre Auger Collaboration



- The physics case
- Pierre Auger Observatory - hybrid system
  Surface and Fluorescence Detectors
- The Engineering Array - first results

The physics case

- **Evidence for Ultra High Energy Cosmic Rays > GZK cutoff**



- Quest for nearby sources (<50 Mpc)
- Production-acceleration mechanism
- Challenging rate:

≈ 1 / km^2 / sr / century above 10^{20} eV!

Auger will measure the properties of the highest energy cosmic rays with unprecedented precision

The Pierre Auger Observatory

✓ **A world-wide Collaboration**

✓ **Full sky coverage**: two Observatories (North and South)
(Malargue, Argentina, approved and financed, under construction)

✓ **Hybrid detector concept**: The same cosmic ray shower is measured by two independent detector systems
Cross-calibration, improved resolution, control of systematic errors

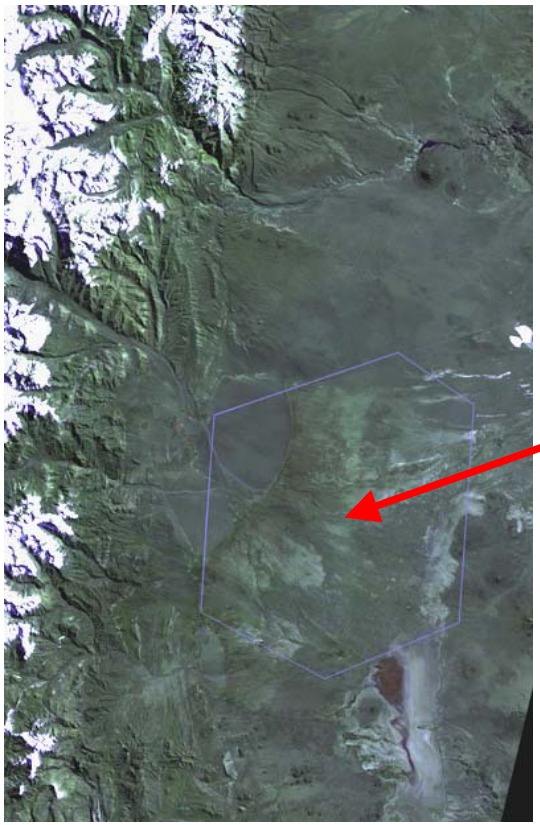
✓ **Large scale detector**:

✓ Giant array of 1600 Cherenkov tanks, covering 3000 km^2 ,

✓ 24 Fluorescence Detector telescopes

1 Auger year = 30 AGASA, 10 Hires years

Malargue, Argentina



35° S latitude

69° W longitude

≈ 1.4 km altitude

≈ 875 g/cm²

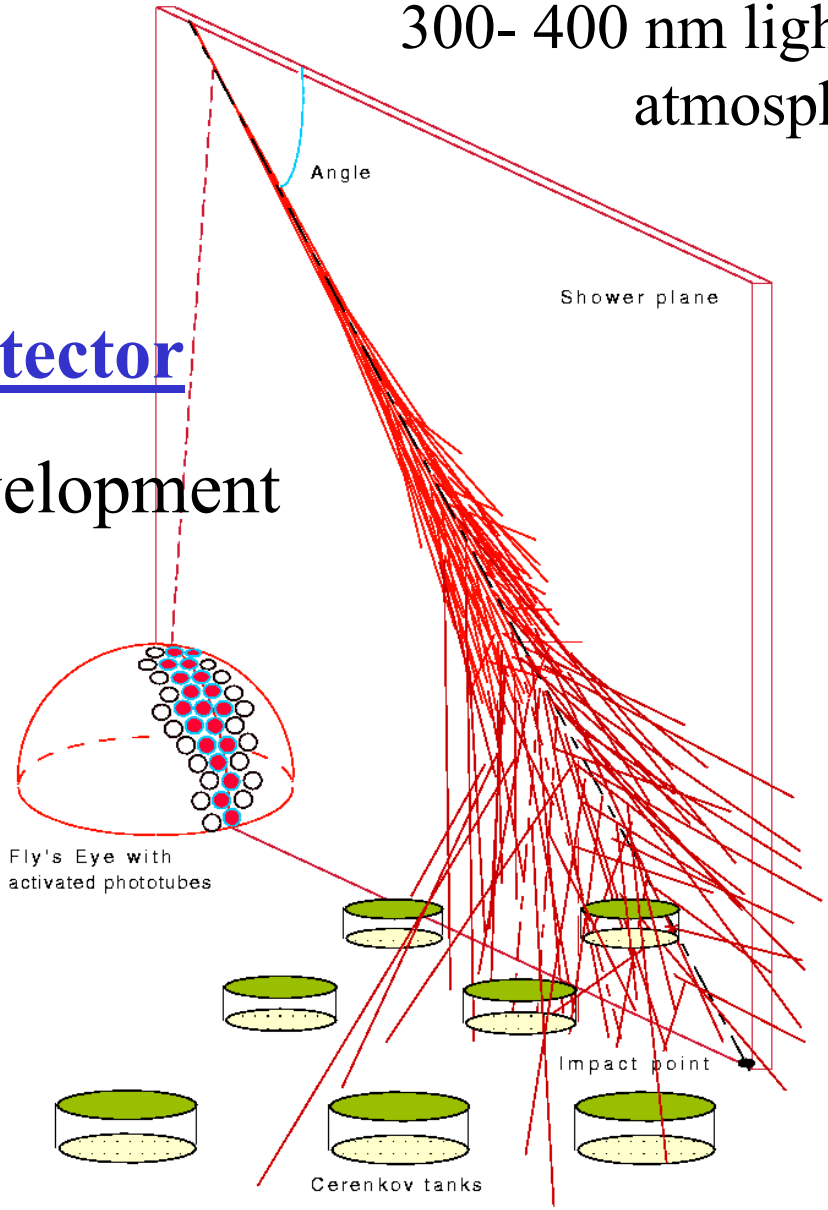
- Low population density (< 0.1 / km²), "Pampa amarilla"
- Favourable atmospheric conditions (clouds, rain, light, aerosol)

The hybrid concept

300- 400 nm light from fluorescence of atmospheric nitrogen

Fluorescence Detector

- Longitudinal development
- Time ≈ direction



Surface Detector

- Shower size ≈ E
- Time ≈ direction

The Observatory

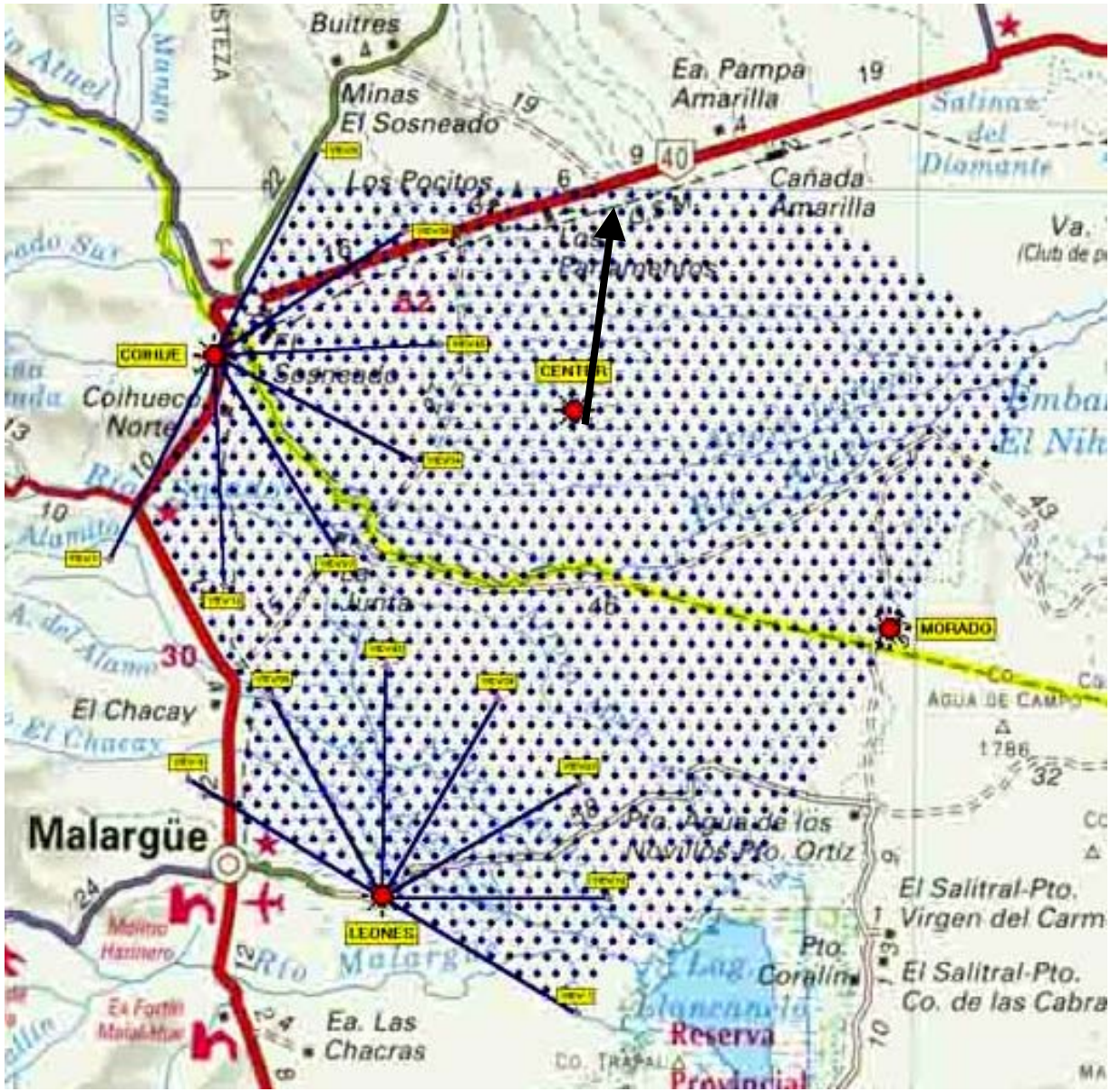
- 3000 km^2 covered

aperture 7400 km^2 sr

- FD (4 peripheral eyes, 6 telescopes each) 11000 PMTs

- 1600 SD Cherenkov tanks (spacing 1.5 km) 4800 PMTs

Wireless RF Communication system



Performances

✓ **Expected rates**

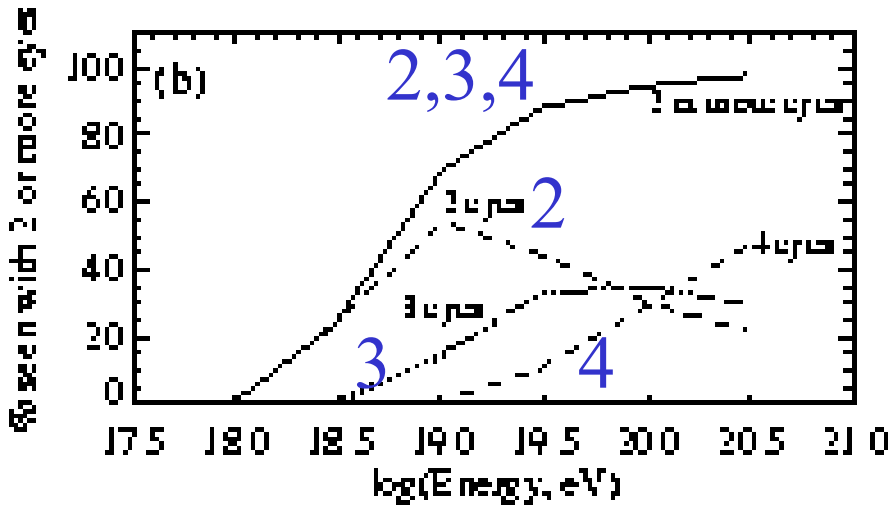
FD duty cycle
12 – 15 %

~ 5000 events/year E > 10^{19} eV
~ 500 events/year E > 5x10^{19} eV
~ 50 - 100 events/year E > 10^{20} eV

✓**Shower reconstruction**

- $\Delta E/E < 10$ %
- Direction < 1°
- Ground impact point < 50 m
- $X_{max} < 20$ g/cm^2

Fraction of stereo FD



Hybrid vs. Surface Detector

	10^{19} eV		10^{20} eV	
	Surface	Hybrid	Surface	Hybrid
$\Delta\theta$	2.0^0	0.4^0	1.0^0	0.4^0
Δ core	80 m	30 m	40 m	30 m
$\Delta E/E$	18 %	4.2 %	7.0%	2.5 %
ΔX_{max}		17 g/cm^2		15 g/cm^2

Observatory Infrastructure

Office and CDAS building

Assembly building

The Surface Detector

Water Cherenkov tank

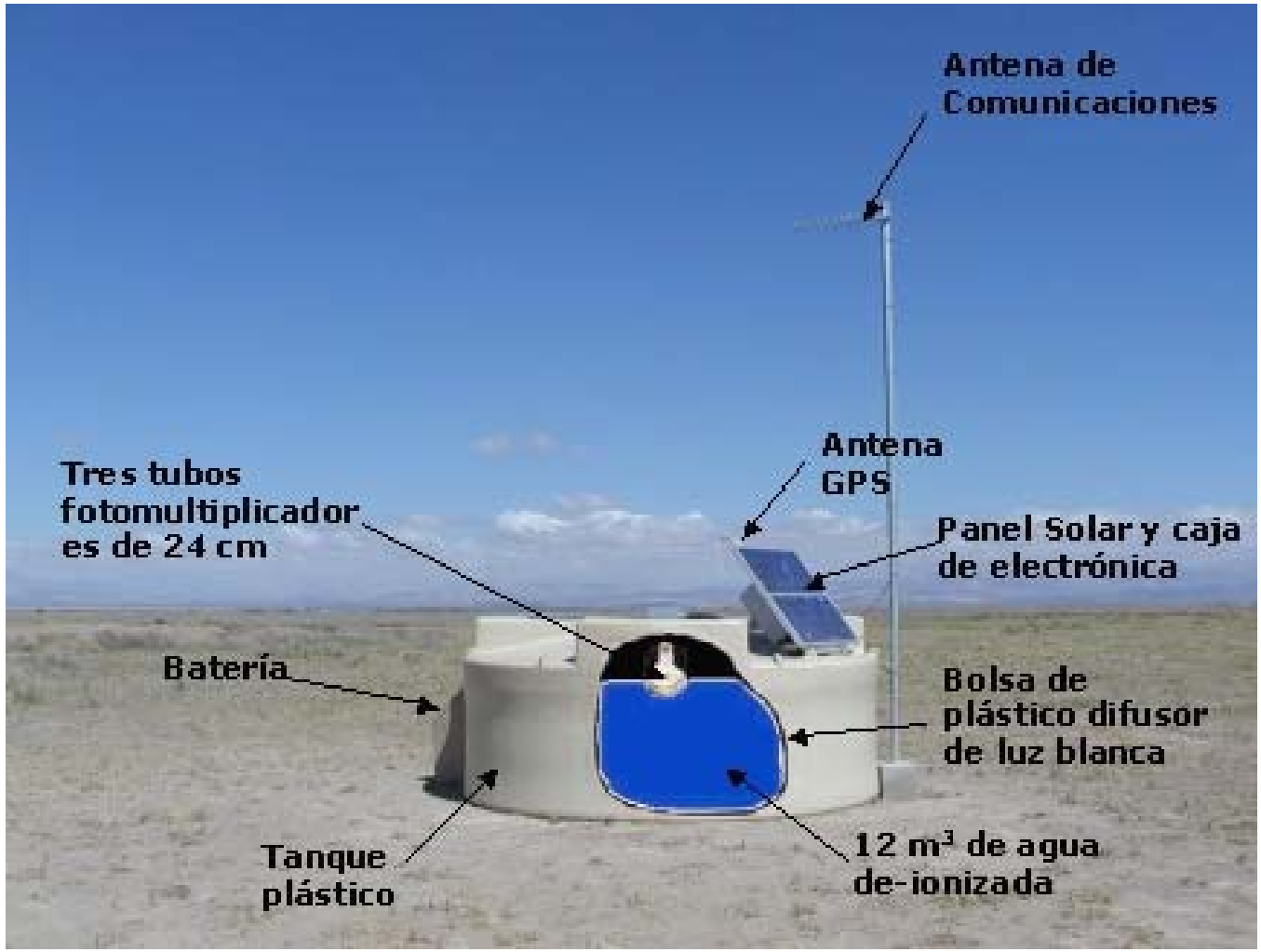
Polyethylene tank

10 m^2 x 1.2 m of purified water, diffusing walls

3 PMTs Photonis 9''

Autonomous unit: solar panel+battery, GPS timing, communication antenna

modest power consumption (10 W)

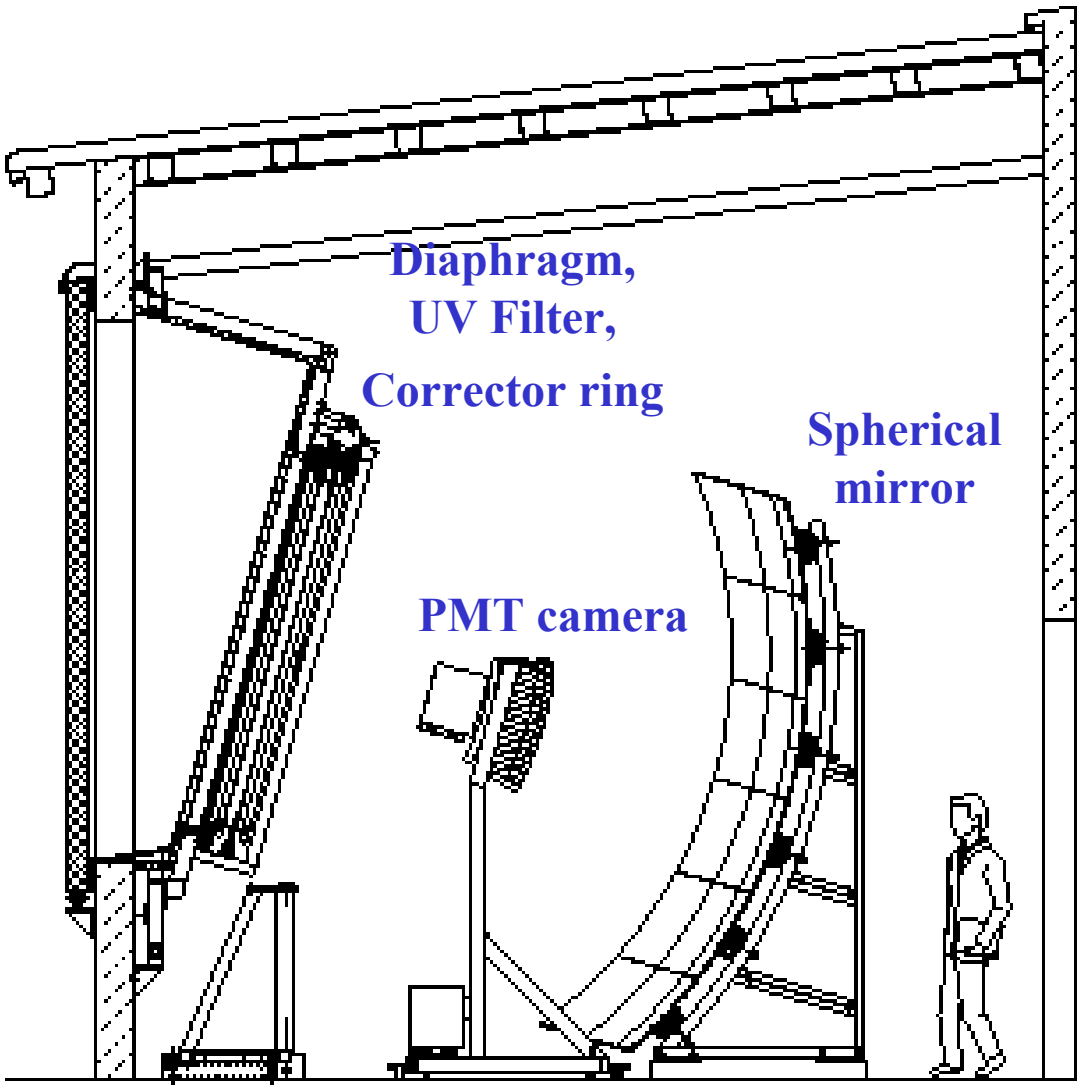



ESSO
Esso

Los Leones FD building

- 6 telescopes
- Communication tower

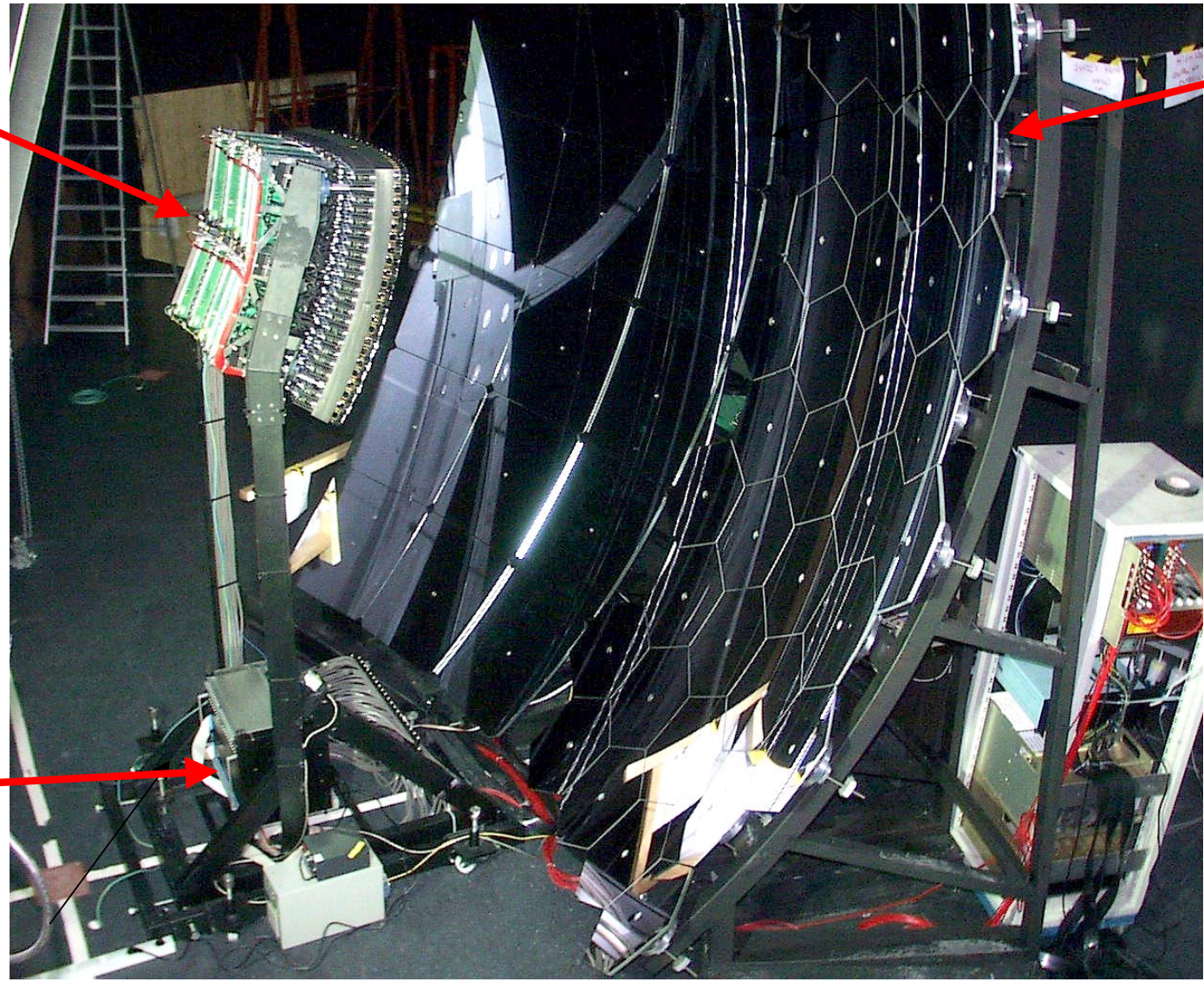
The FD telescope



Schmidt optics:
(eliminates coma)
Spherical mirror
R_{curv} = 3.4 m
2.2 m diameter diaphragm,
corrector ring,
30^o x 30^o aperture
spot size from spherical
aberration: 15 mm

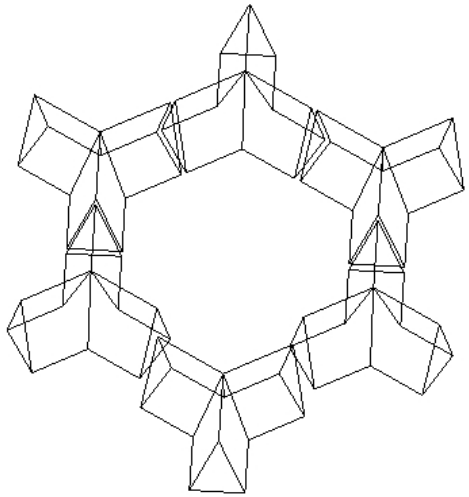
Focal surface:
20 x 22 hexagonal PMT
(Photonis XP3062)
Pixel angular size 1.5^o
(45 mm)

The FD telescope at Los Leones



The FD camera

440 PMTs on a spherical surface



Light collectors to recover border inefficiencies

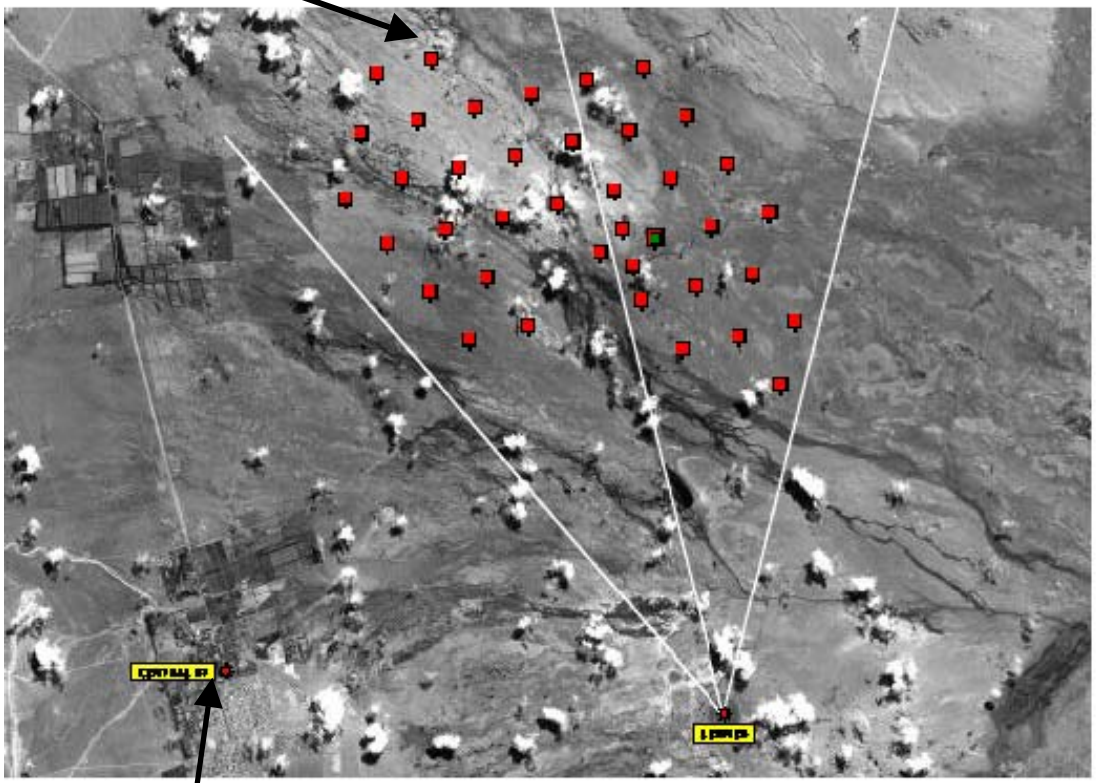
"mercedes star" with aluminized mylar reflecting walls

90 cm

The Engineering Array

30°, FD
2 telescopes

40 SD tanks



Central Campus,
Malargue

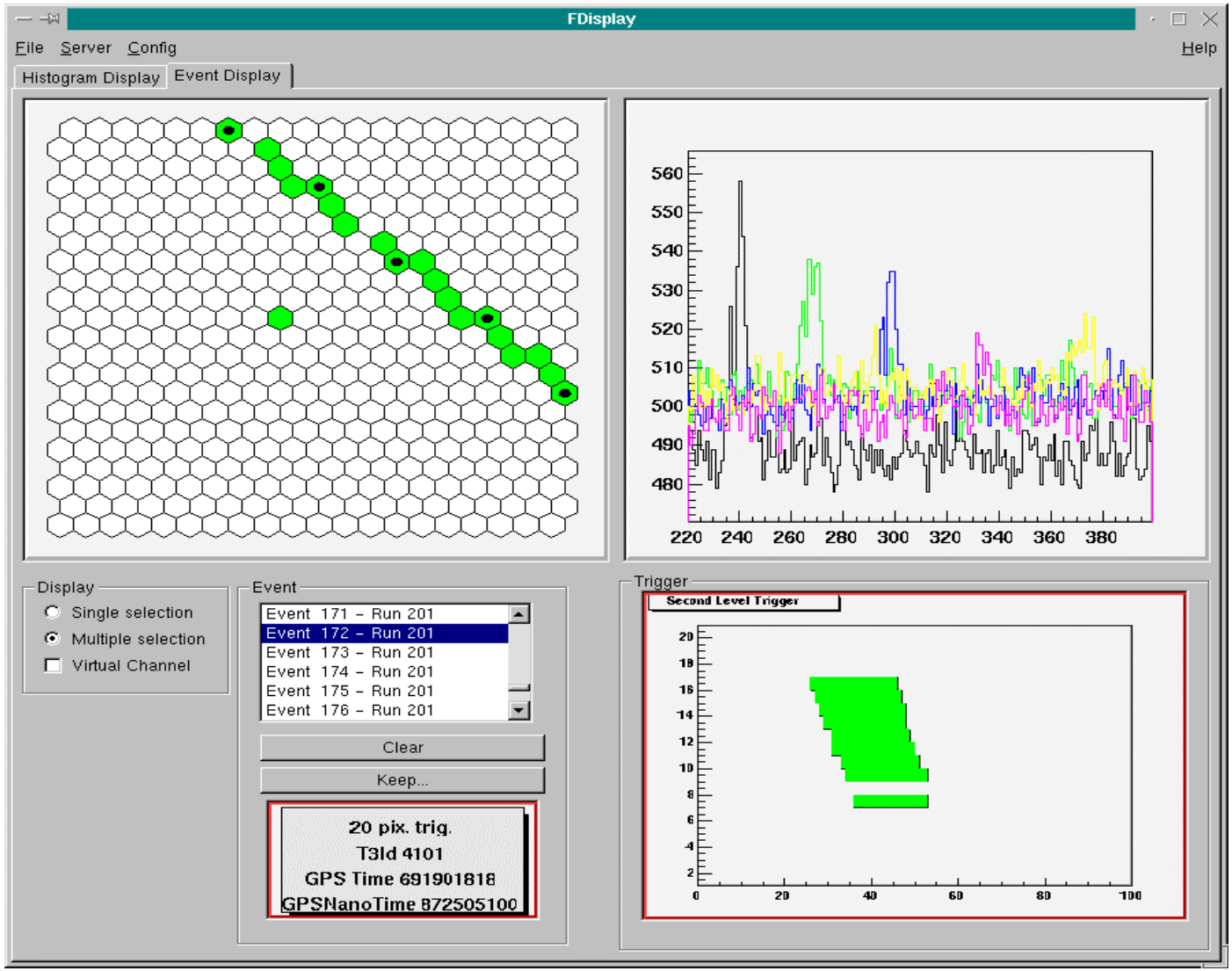
Los Leones
FDeye

Aims

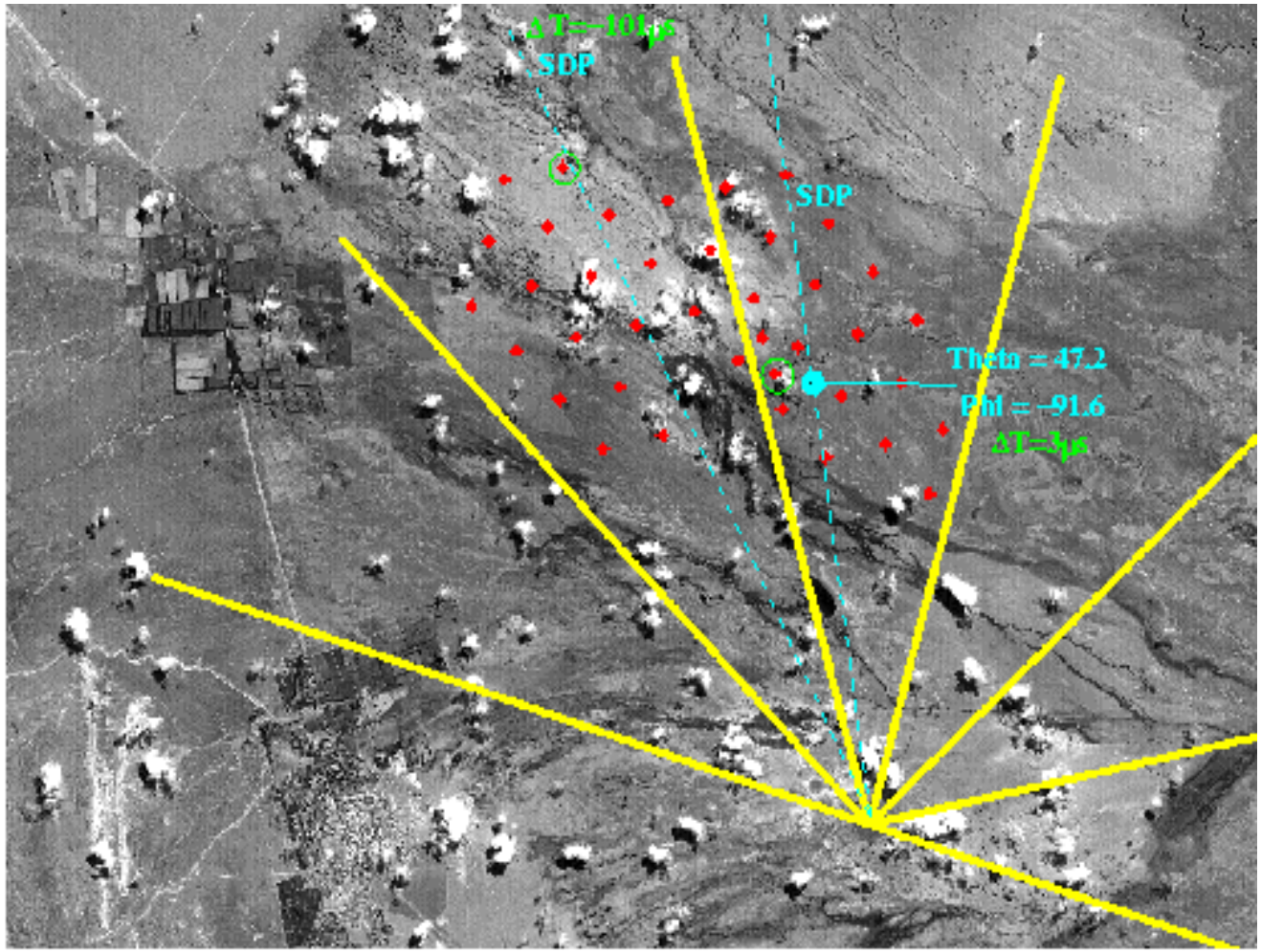
- **Installation and commissioning of tanks and telescopes,**
- **Communications**
- **Hybrid trigger and timing, CDAS**
- **Internet connection with data mirroring in US and Europe, data analysis**
- **First showers observed May 2001**

- **December 2001–March 2002 stable data taking ≈ 80 hybrid events**

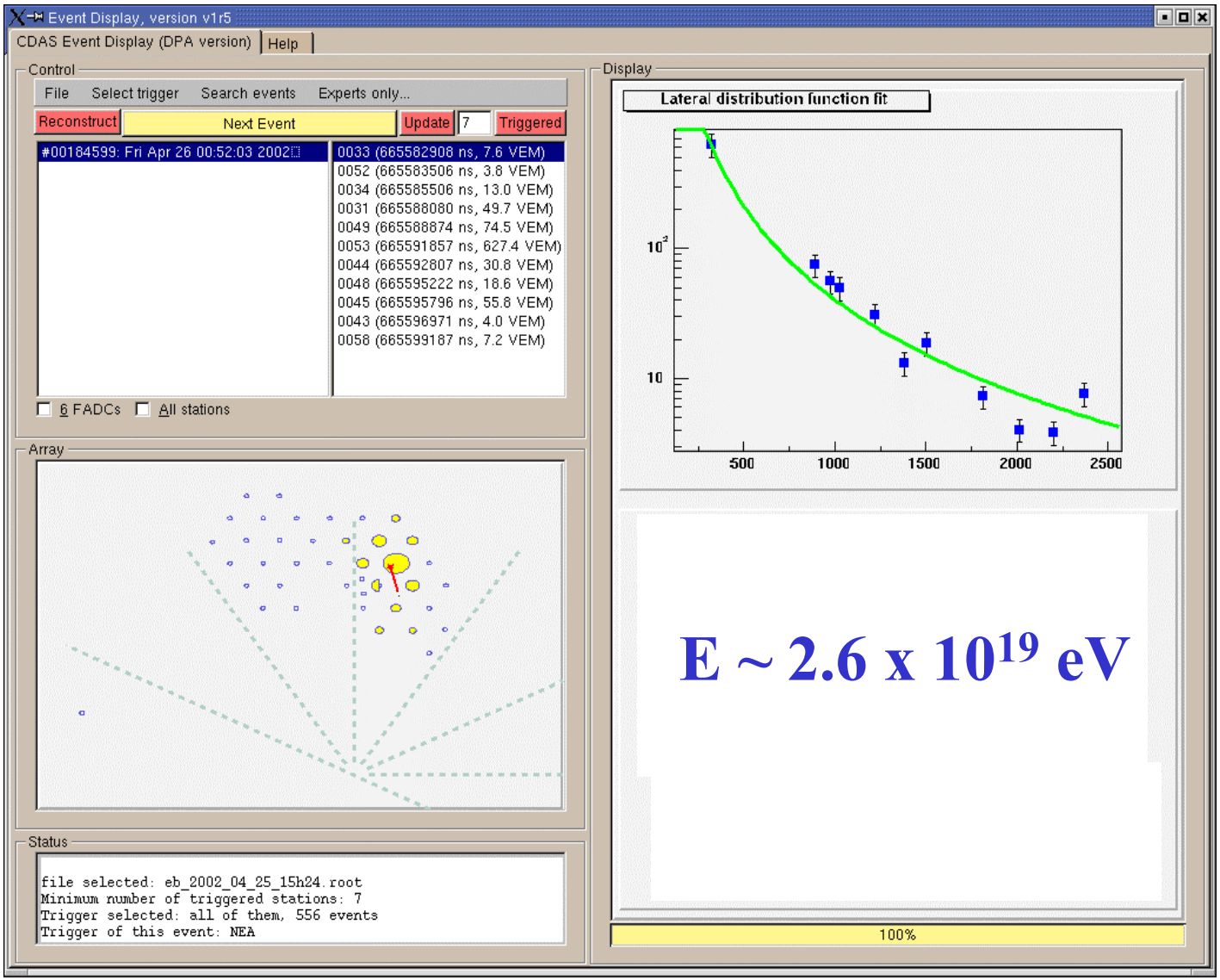
First hybrid event FD on line display



FD – SD matching



11-fold event



11 tanks triggered

April 2002

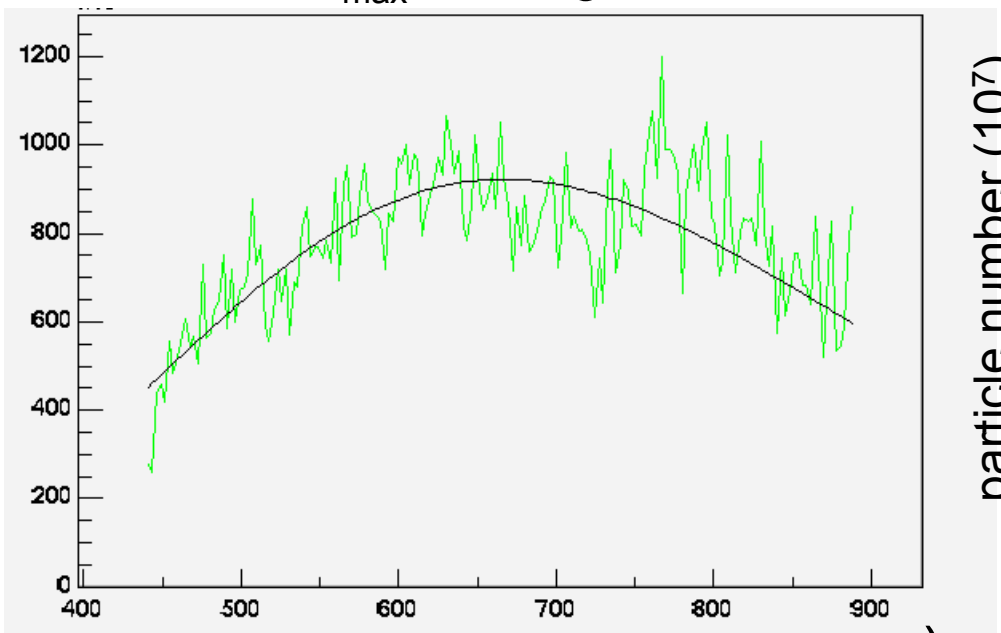
E ~ 2.6 x 10^{19} eV

Preliminary energy estimate!

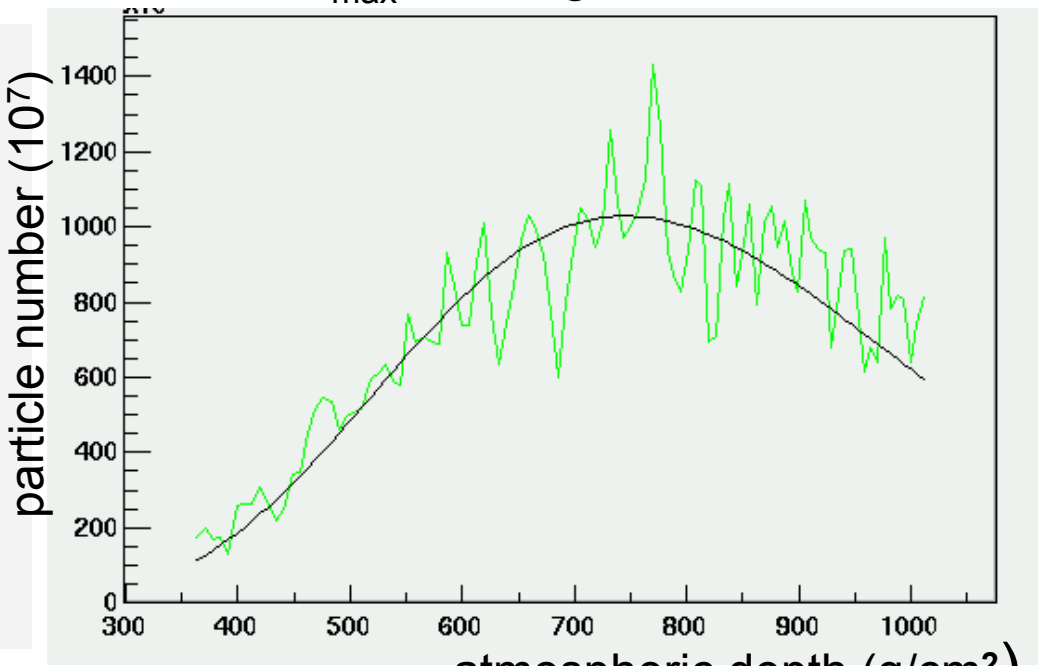
Shower longitudinal development

atmospheric corrections, FD pixel calibration, fluorescence yield, Gaisser-Hillas fit…

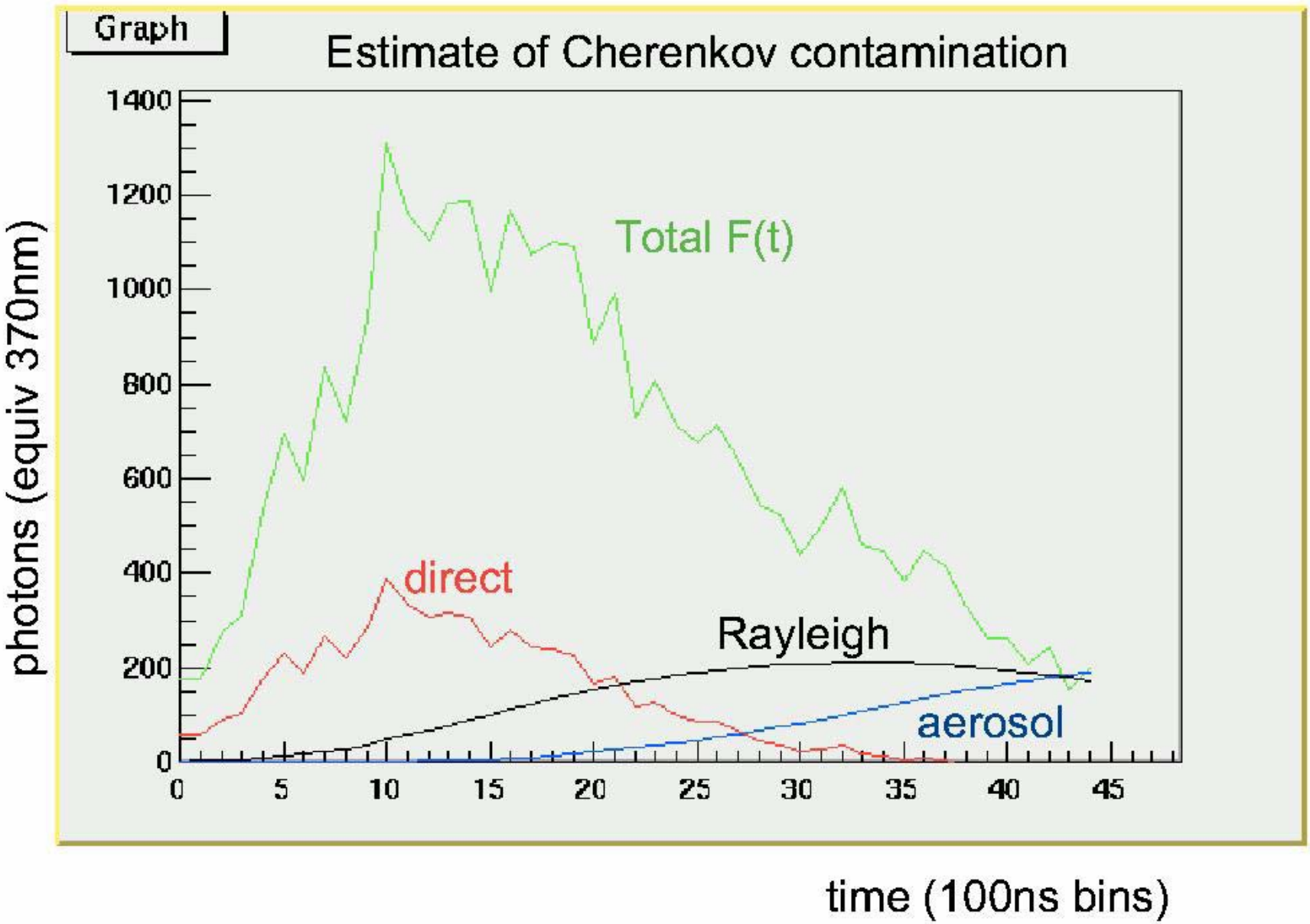
E= 1.3 x 10^{19}eV, S_{max}= 9.2 x 10^{9}, X_{max} = 670 g/cm²



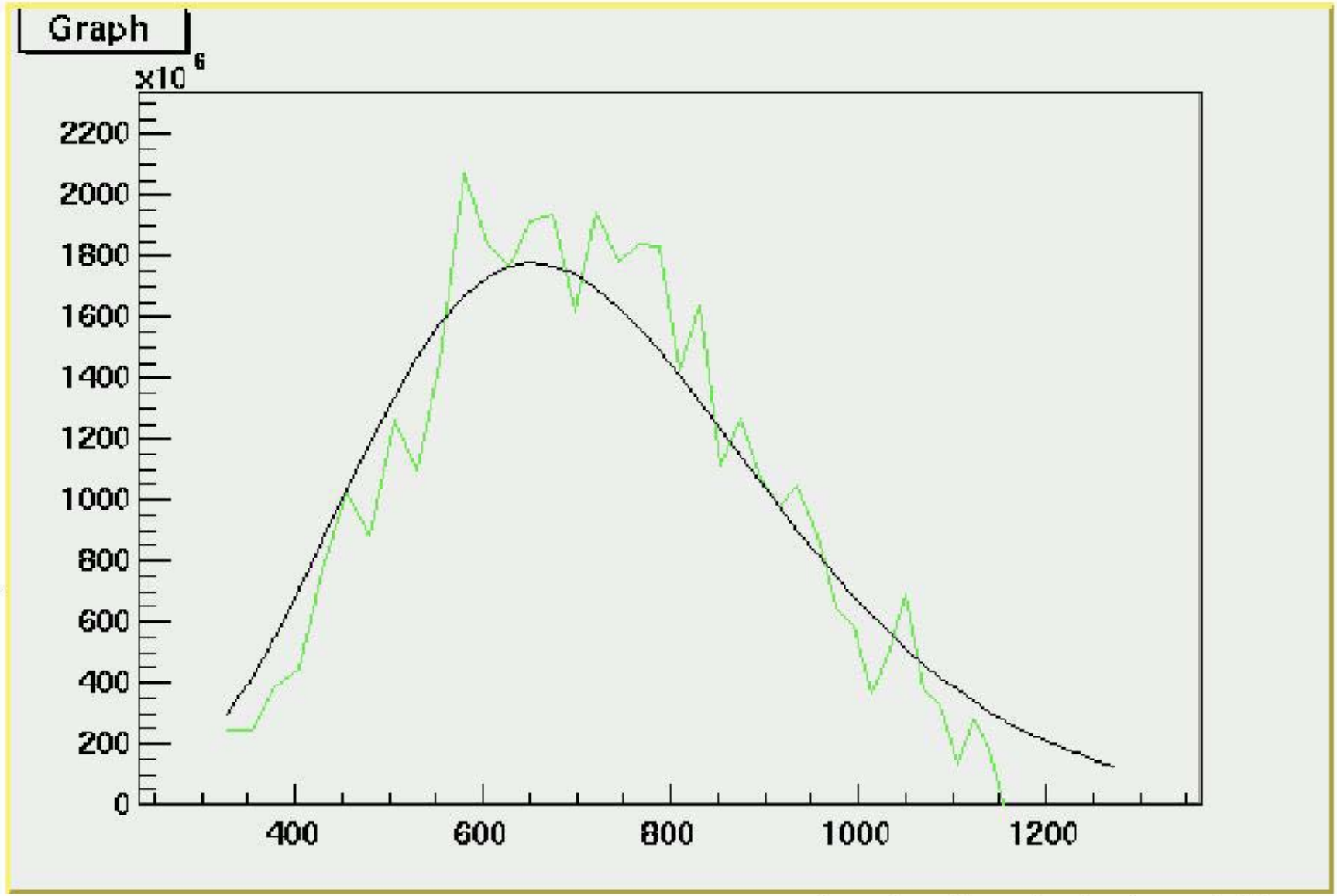
E= 1.5 x 10^{19}eV, S_{max}= 1.0 x 10^{10}, X_{max} = 746 g/cm²



Preliminary energy estimates!


Graph
Estimate of Cherenkov contamination
photons (equiv 370nm)
time (100ns bins)
Total F(t)
direct
Rayleigh
aerosol
0
200
400
600
800
1000
1200
1400
0
5
10
15
20
25
30
35
40
45

$E=2.5\times10^{18}eV$, $S_{max}=1.8\times10^{9}$, $X_{max}=650g/cm^2$



Preliminary energy estimate

Outlook

- A large part of the Auger Observatory infrastructure near Malargue, Argentina already built.

- **The Engineering Array goals were successfully accomplished. We can operate the hybrid system, hybrid trigger, wireless communications**

- Mass production of the components has started.

- In 2003 installation and commissioning of 12 FD telescopes and 500 additional tanks).

- Observatory to be completed by 2005.