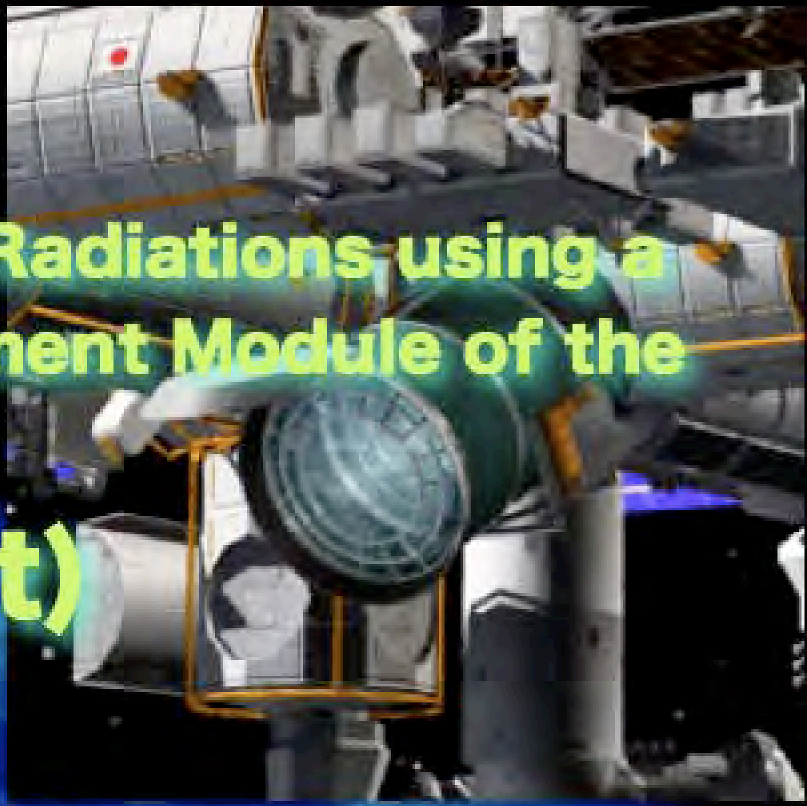
Observation of Extremely High Energy Cosmic Radiations using a Near-ultraviolet Telescope on the Japan Experiment Module of the International Space Station

(JEM-EUSO Project)

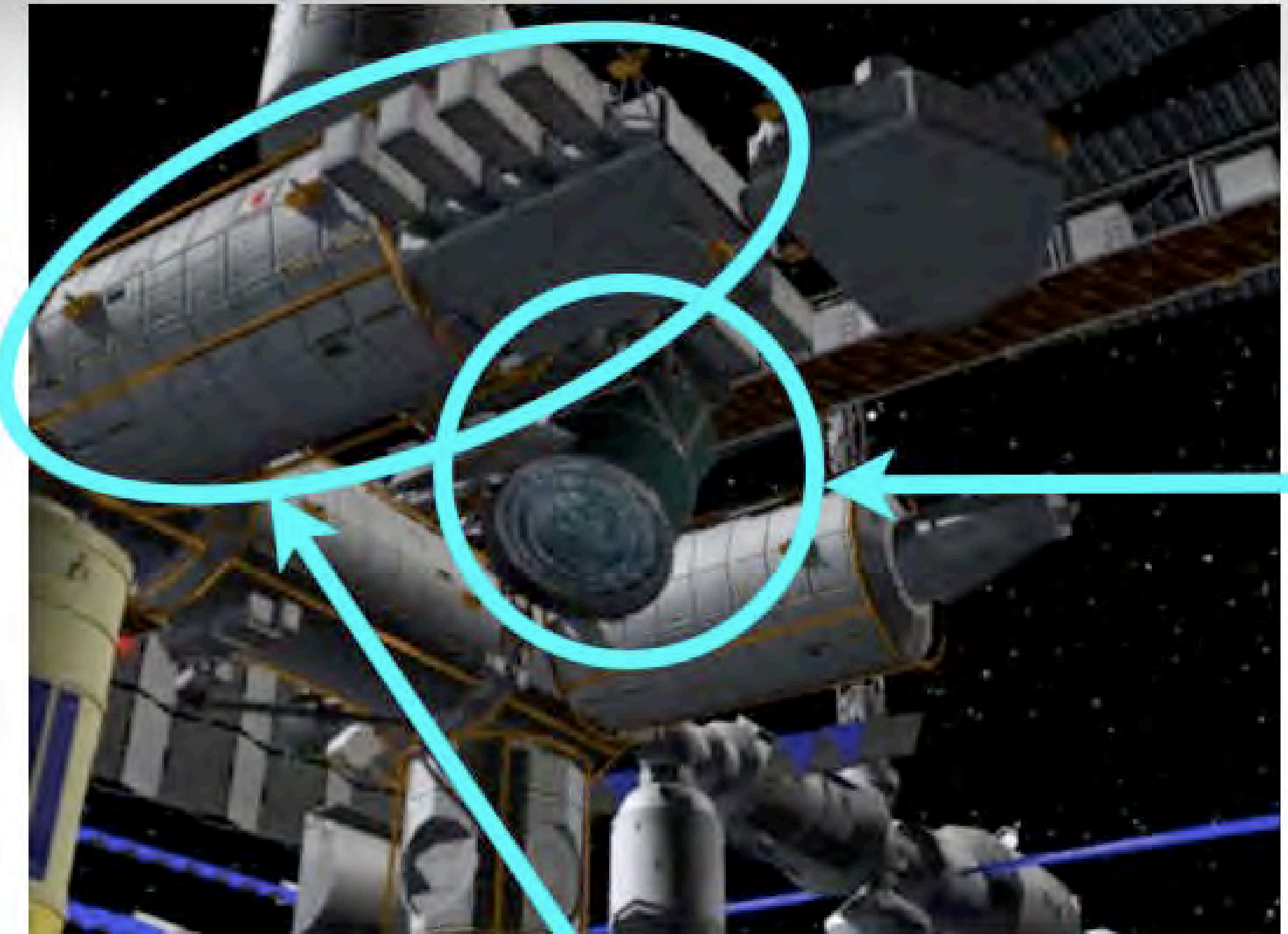


Philippe Gorodetzky
CNRS / APC-Paris

Hirohiko M. SHIMIZU
KEK

Date(2007/05/10) by(P.Gorodetzky, H.M.Shimizu) DocID(X) Class(Presentation) Language(English)
Title(JEM-EUSO Project)
Conf(FJPPL) at(Tsukuba)

JEM-EUSO



EUSO

Extreme
Universe
Space
Observatory

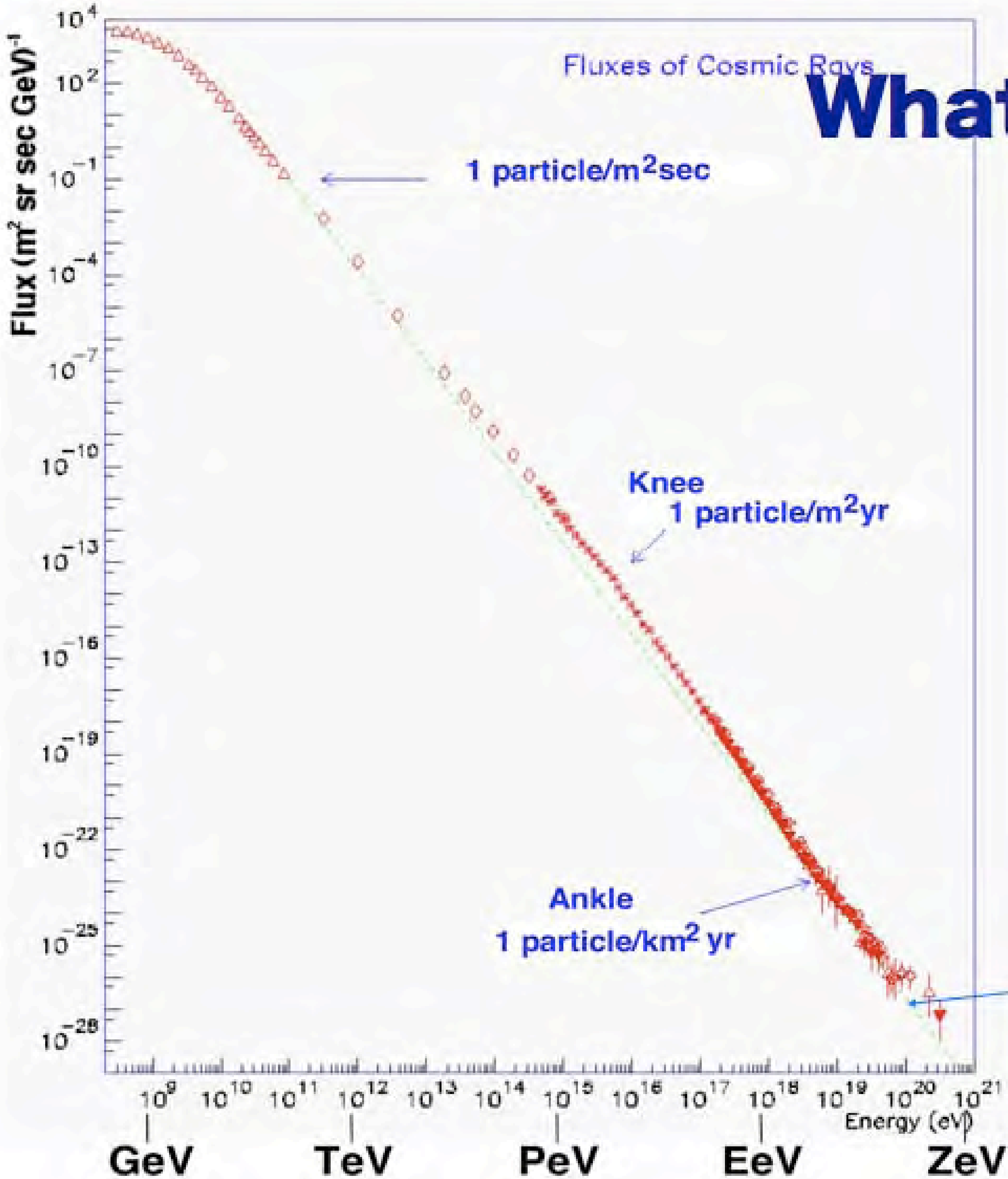
accommodated on **JEM** of **ISS**

Japanese
Experiment
Module

International
Space
Station

Date(2007/05/10) by(P.Gorodetzky, H.M.Shimizu) DocID(X) Class(Presentation) Language(English)
Title(JEM-EUSO Project)
Conf(FJPPL) at(Tsukuba)

‘Highest Energy’



What is the highest energy?

Origin

Where were they born?

Propagation

How are they arriving to the earth?

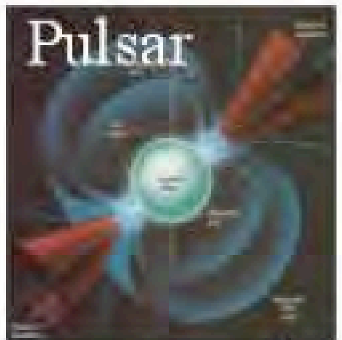
1particle/100km²/yr

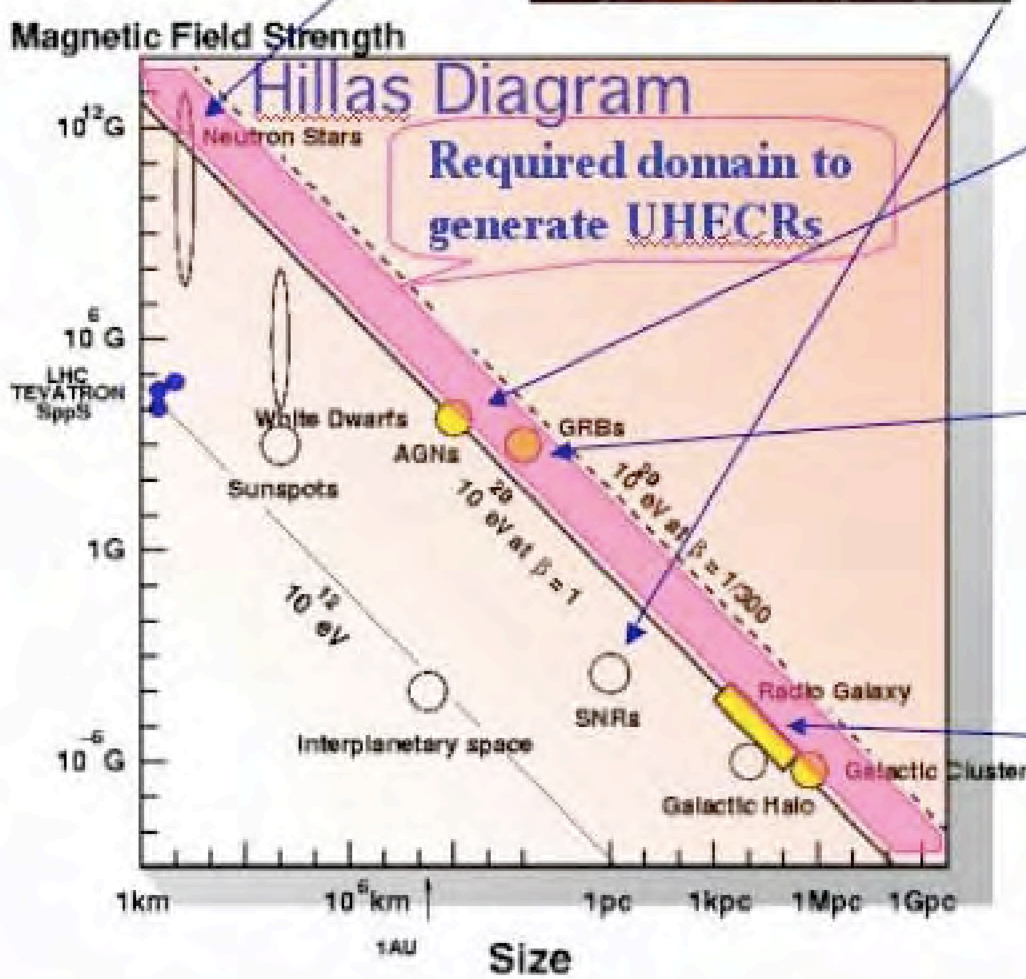
Date(2007/05/10) by(P.Gorodetzky, H.M.Shimizu) DocID(X) Class(Presentation) Language(English)
Title(JEM-EUSO Project)
Conf(FJPPL) at(Tsukuba)

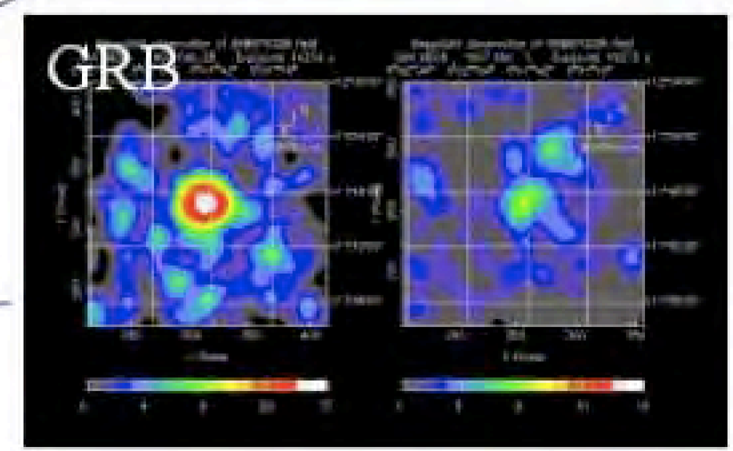
‘Origin’

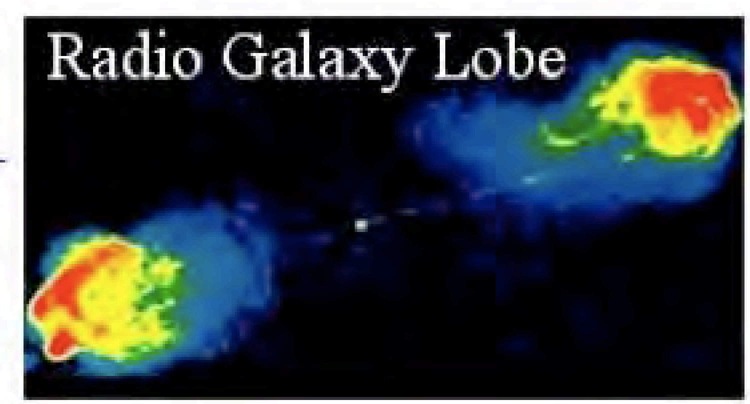
Acceleration Limits: theoretically, < 10^{20} eV

Astronomical objects that can deliver EECRs





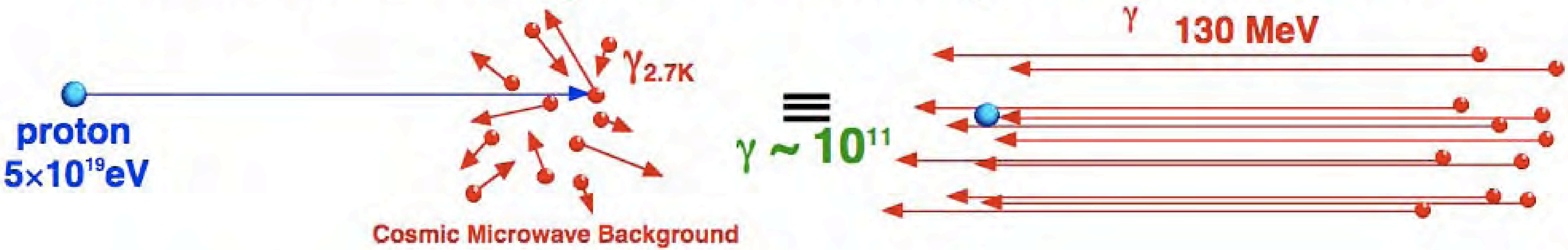




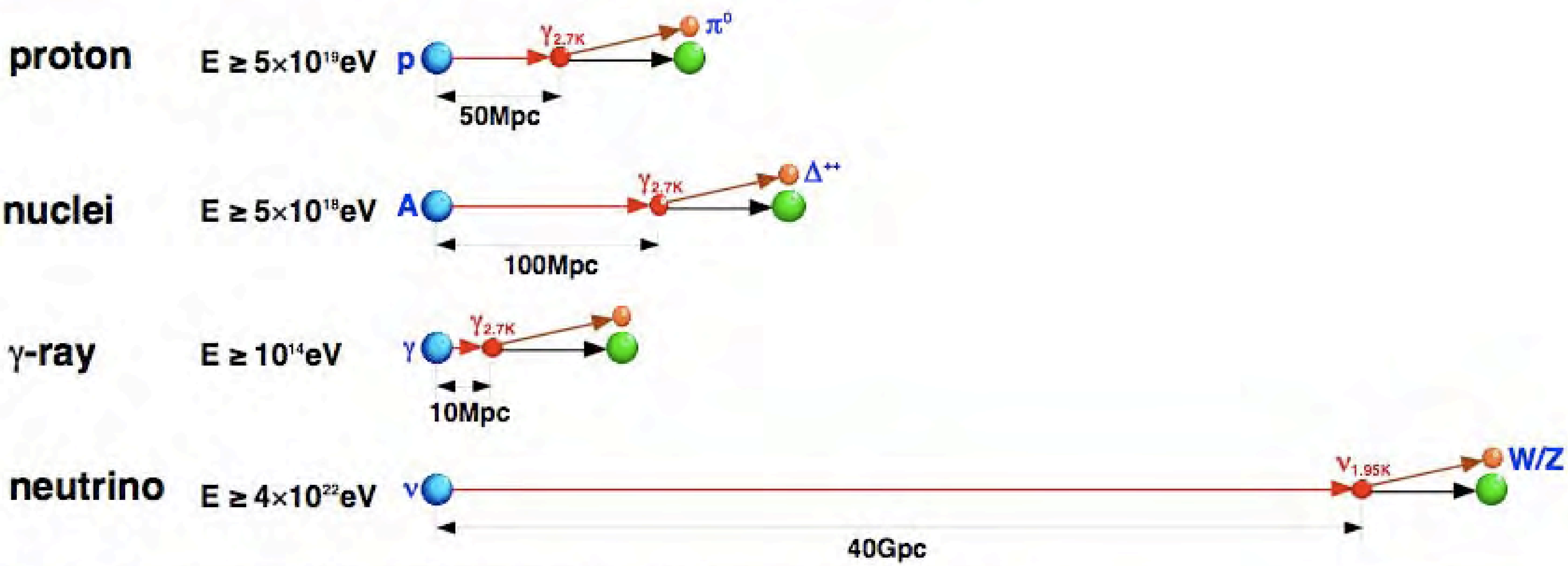
Date(2007/05/10) by(P.Gorodetzky, H.M.Shimizu) DocID(X) Class(Presentation) Language(English)
Title(JEM-EUSO Project)
Conf(FJPPL) at(Tsukuba)

‘Propagation’

Greisen-Zatsepin-Kuzmin (GZK) Process



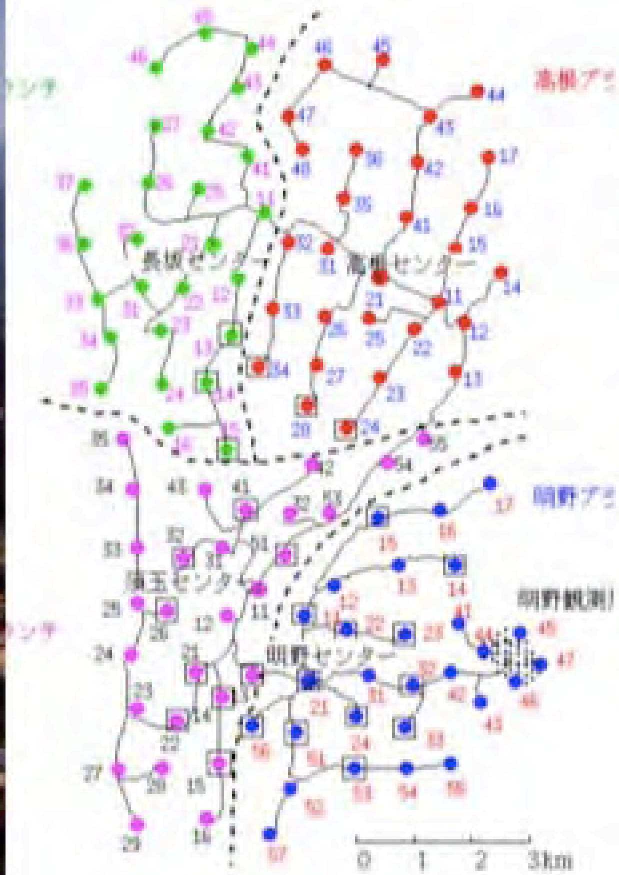
Greisen-Zatsepin-Kuzmin (GZK) cutoff

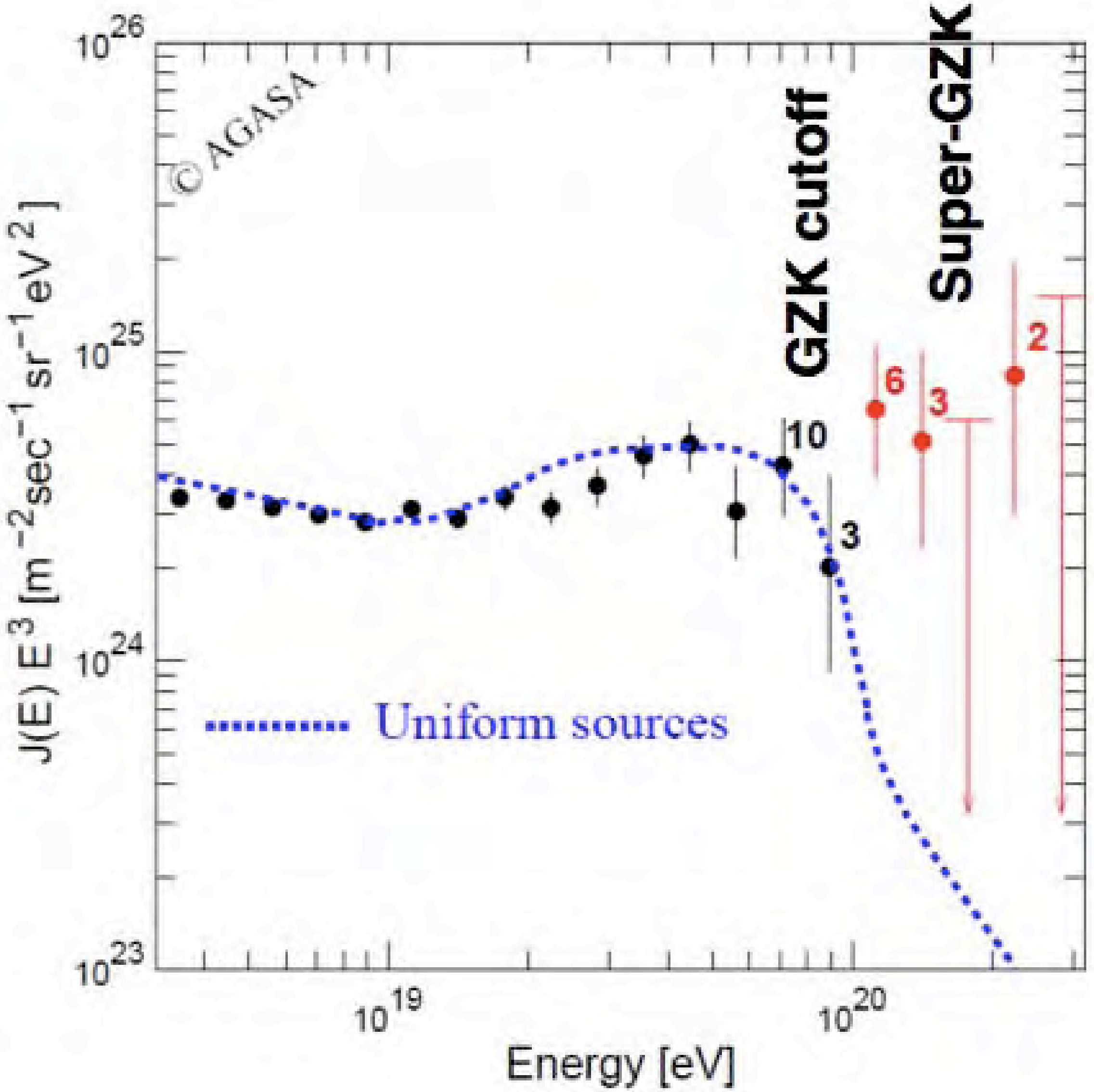


Date(2007/05/10) by(P.Gorodetzky, H.M.Shimizu) DocID(X) Class(Presentation) Language(English)
Title(JEM-EUSO Project)
Conf(FJPPL) at(Tsukuba)

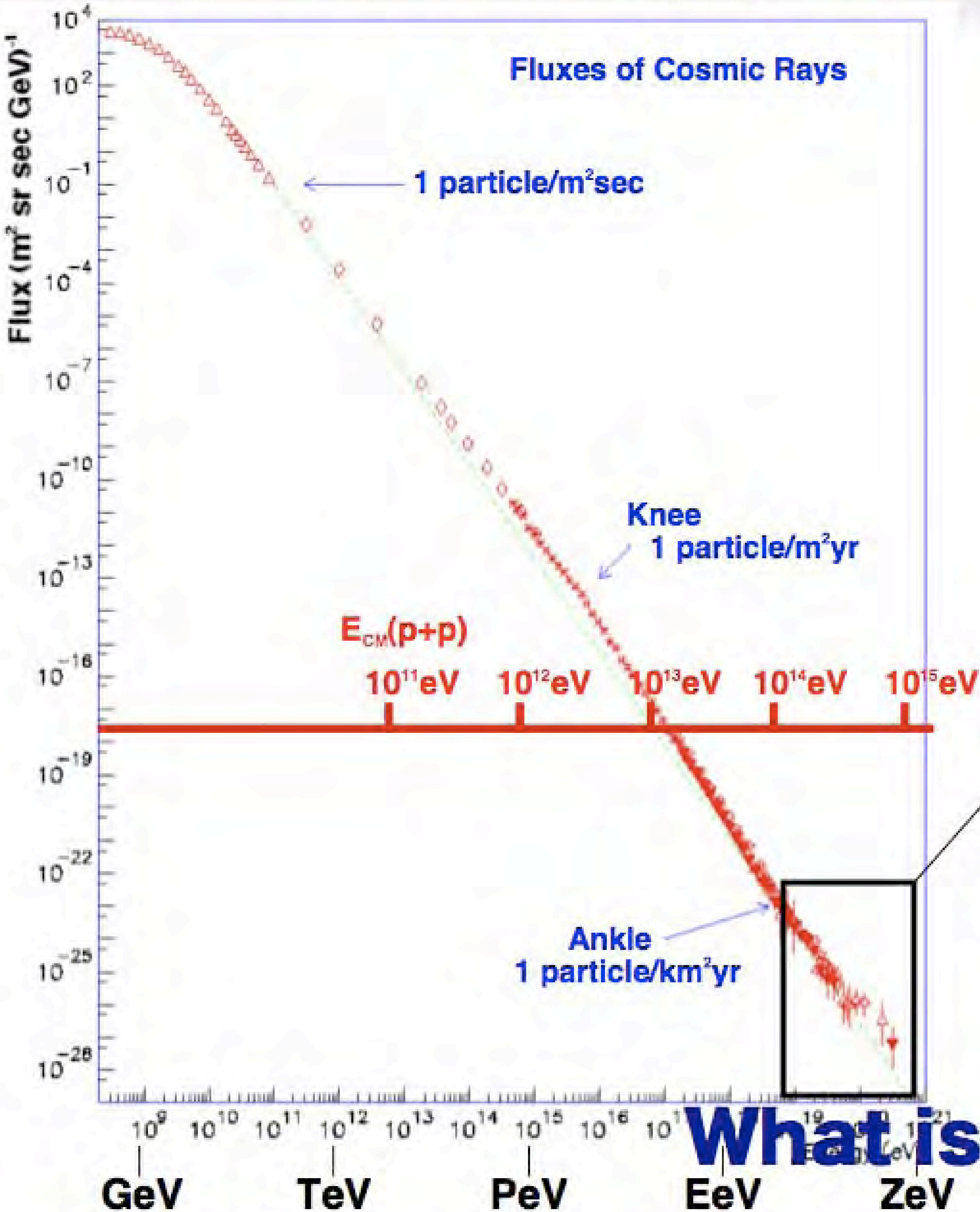
AGASA : Akeno Giant Air Shower Array

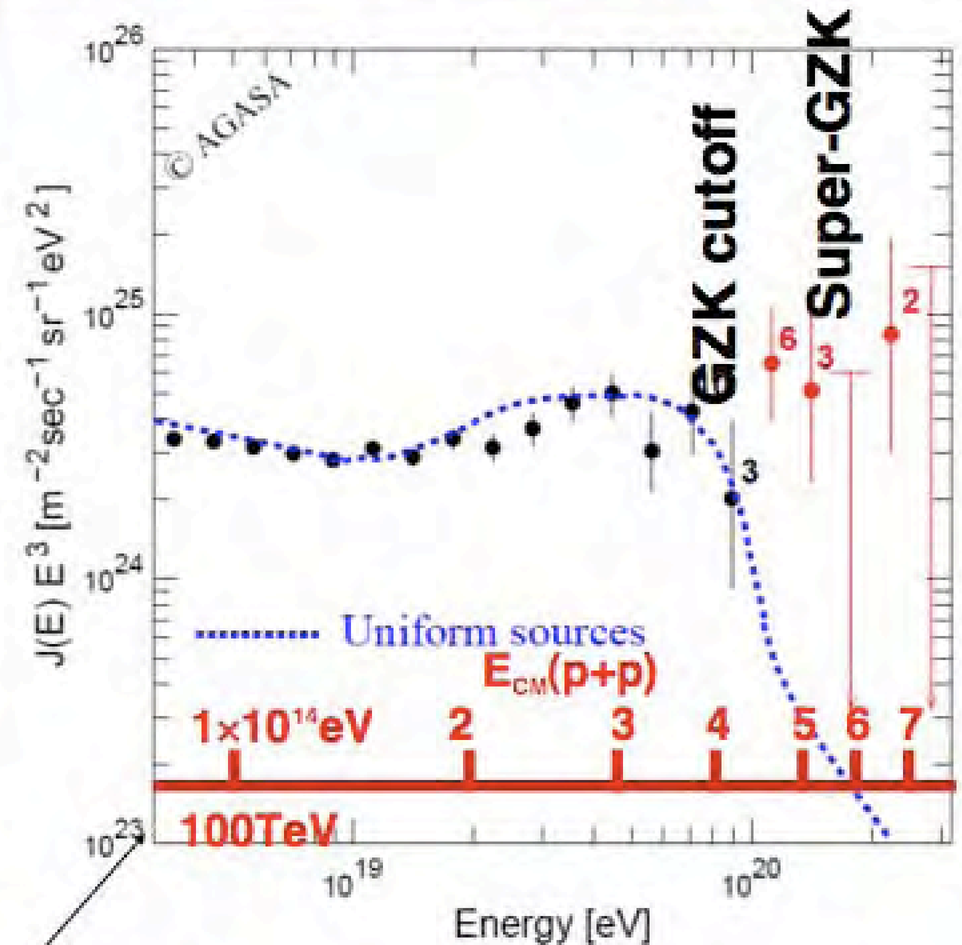
Effective Area = 100km²
E≥10²⁰eV 11 events for 13 years





TeV Physics and Extremely High Energy Cosmic Rays





Origin

Where were they born?

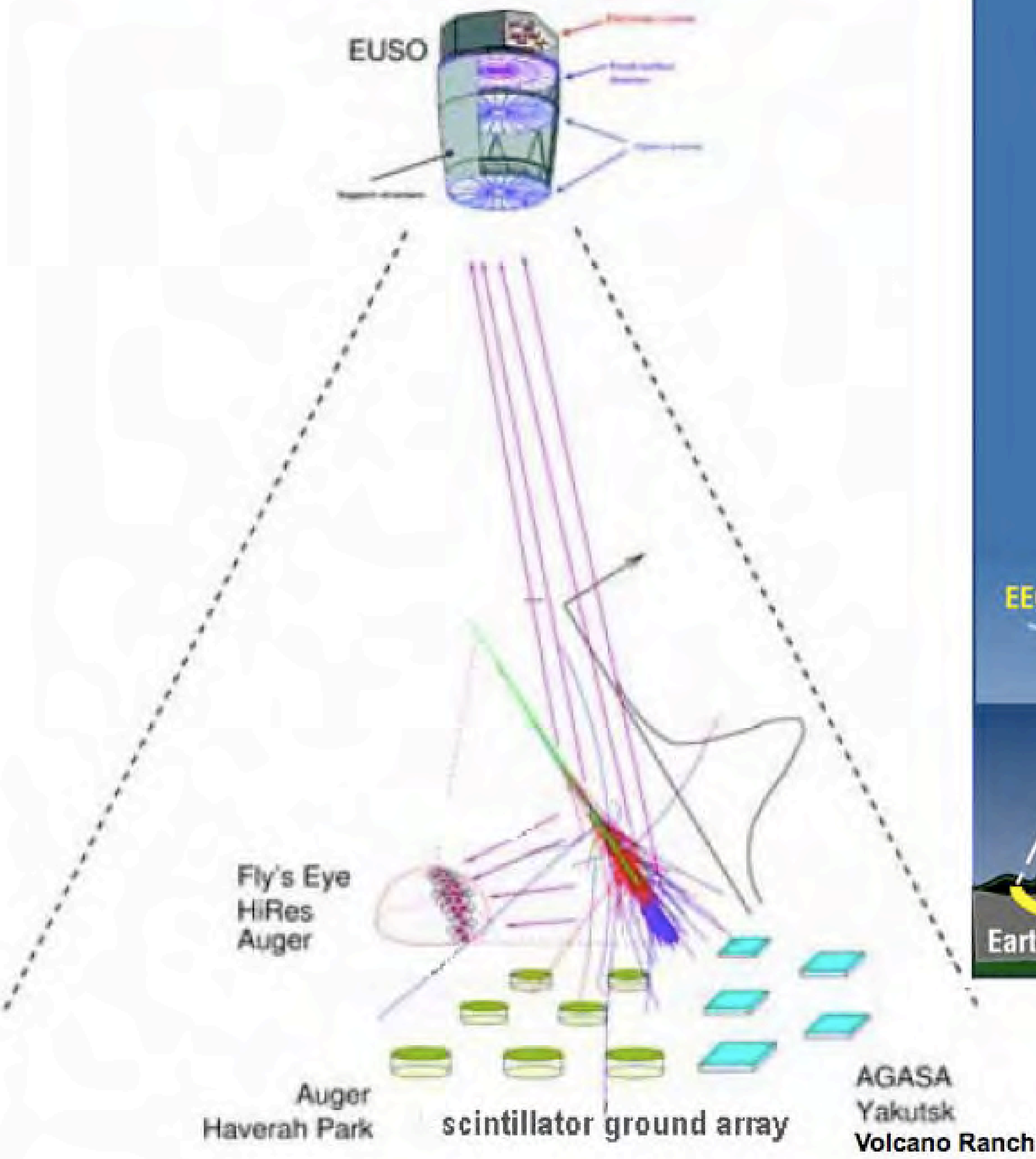
Propagation

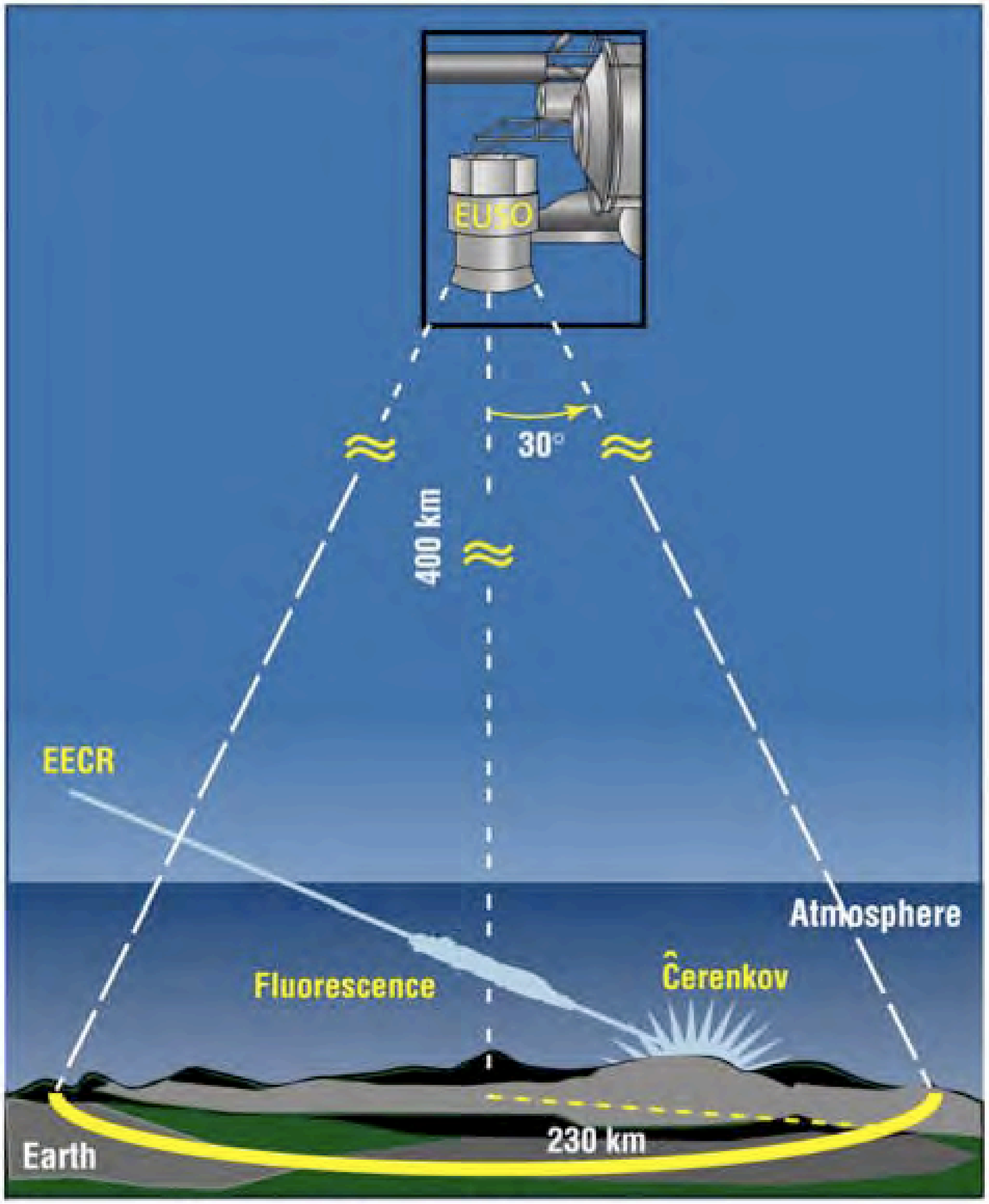
How are they arriving to the earth?

What is the highest energy?

Date(2007/05/10) by(P.Gorodetzky, H.M.Shimizu) DocID(X) Class(Presentation) Language(English)
Title(JEM-EUSO Project)
Conf(FJPPL) at(Tsukuba)

Air Shower Observations from Space



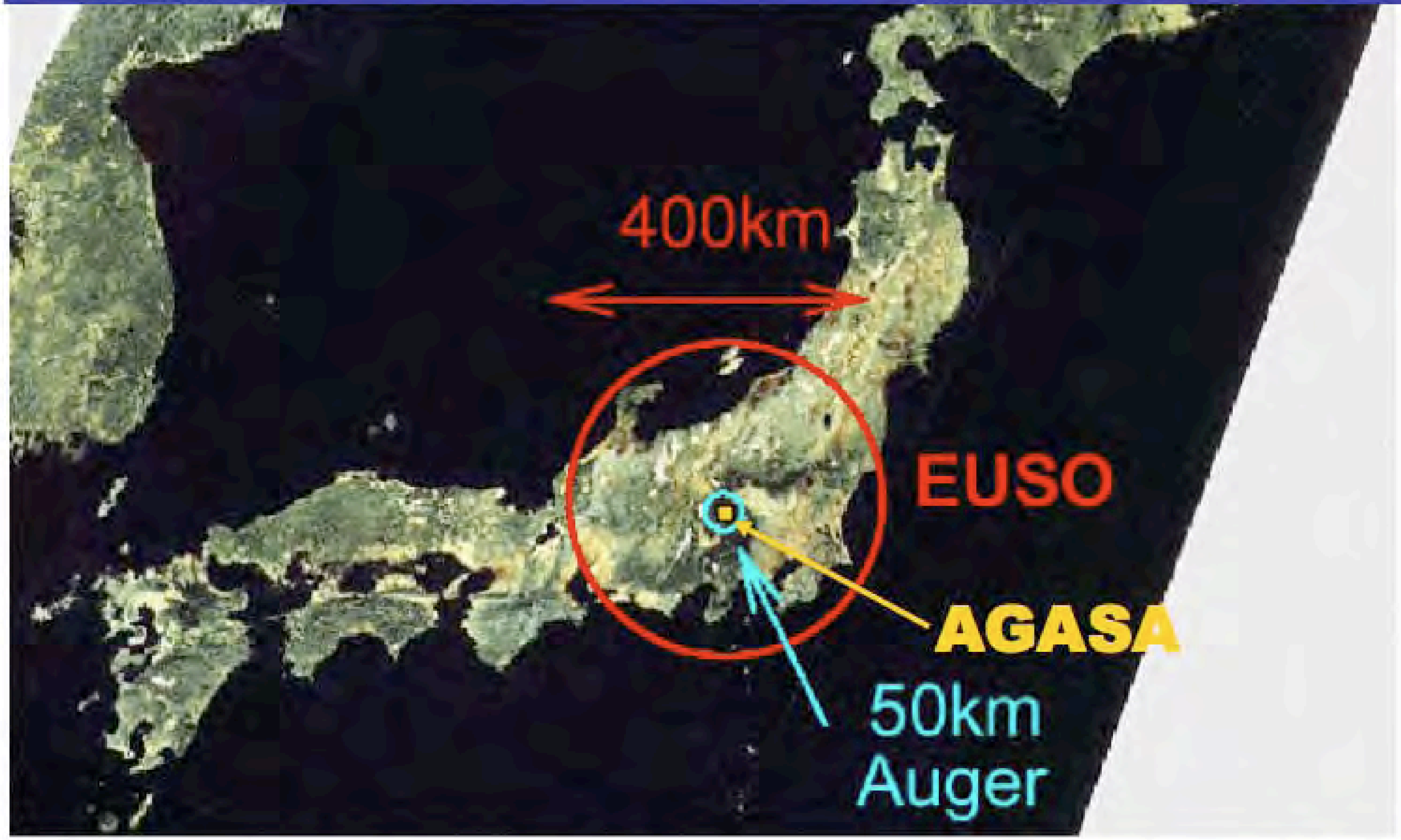


Ground-based Arrays

(1) Scintillator Array

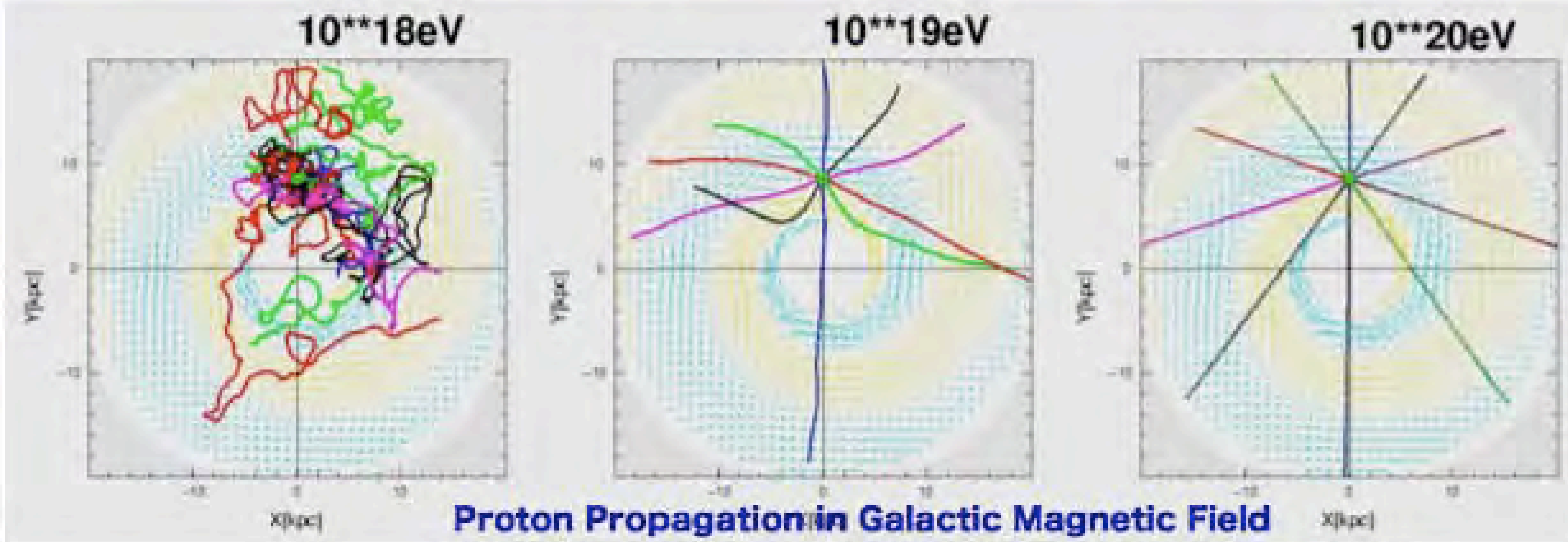
(2) Fluorescence Telescope Array

EUSO ~ 1000 x AGASA ~ 30 x Auger
EUSO (Instantaneous) ~ 5000 x AGASA
~ 150 x Auger

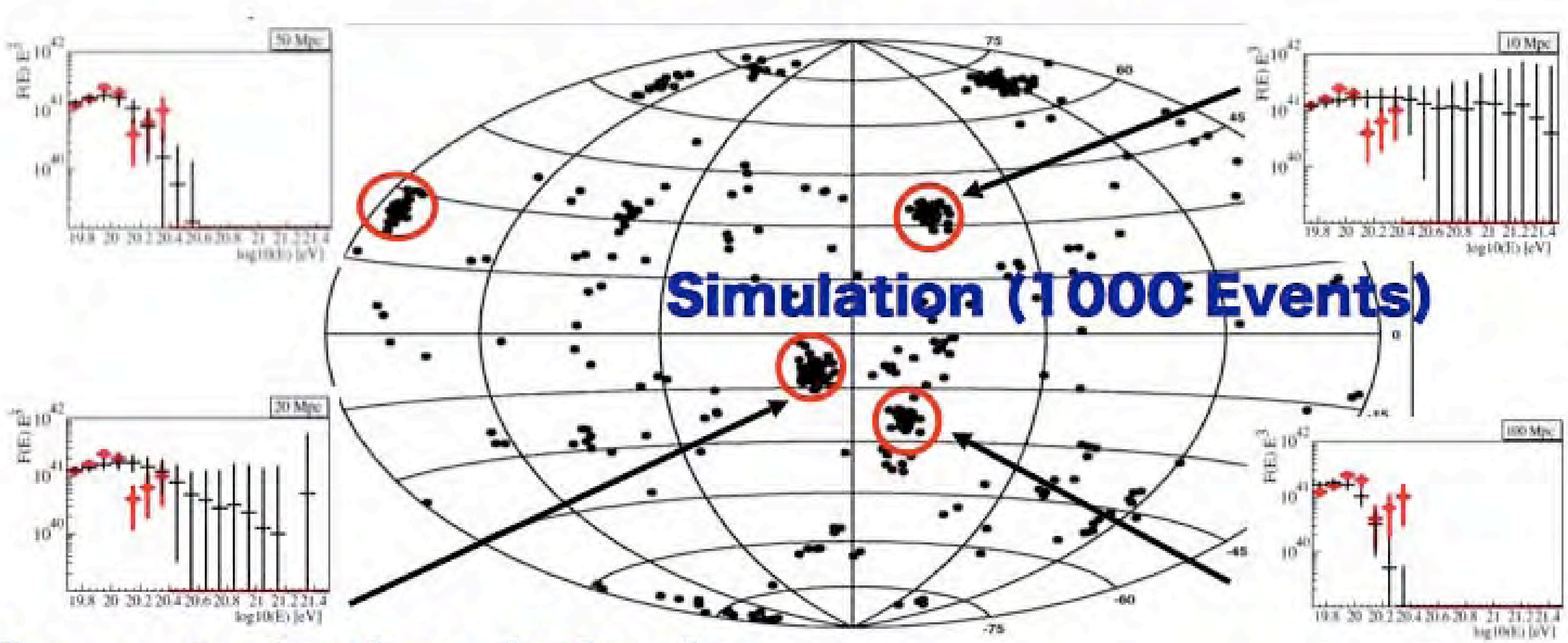


enables to determine spectrum with high statistics

10^{20}eV proton can be traced back to point its source.



Proton Propagation in Galactic Magnetic Field



If 1000 events in the whole sky
tens of cluster can be reliably discovered
spectra can be measured

⇨ **Particle Astronomy**

Date(2007/05/10) by(P.Gorodetzky, H.M.Shimizu) DocID(X) Class(Presentation) Language(English)
Title(JEM-EUSO Project)
Conf(FJPPL) at(Tsukuba)

‘Highest Energy’

Origin
Where were they born?

Bottom-up Senario
Unknown Acceleration Mechanism?
Unknown Cosmic Ray Source?

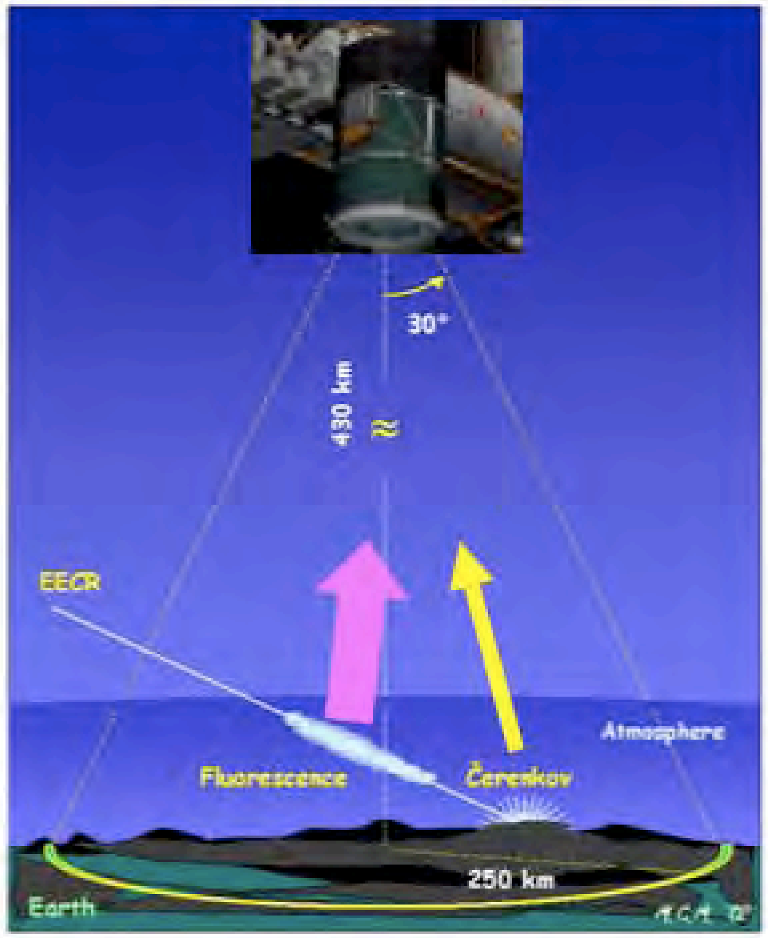
Top-down Senario
Decay of Very Heavy Elementary Particles?

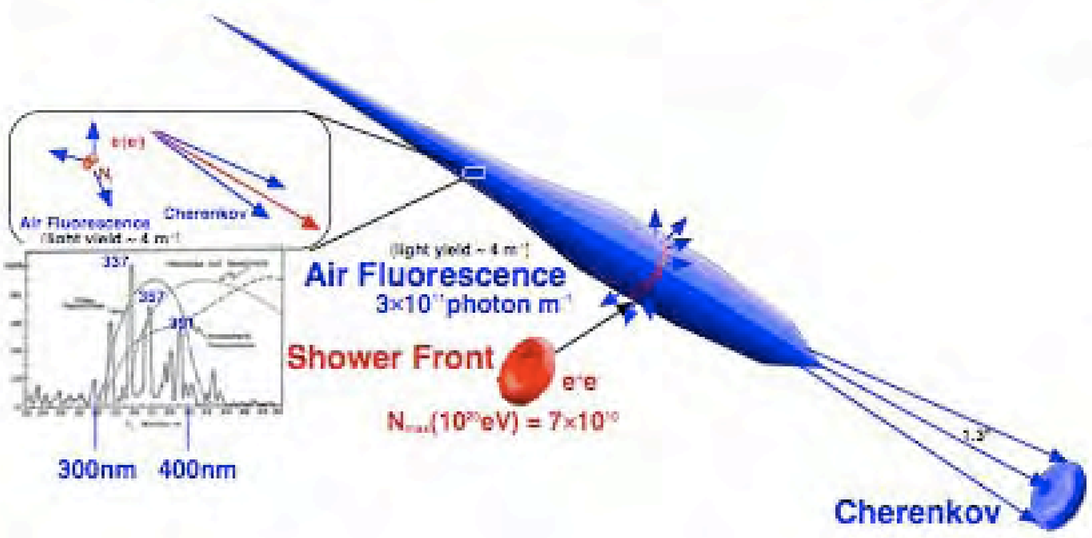
Propagation
How are they arriving to the earth?

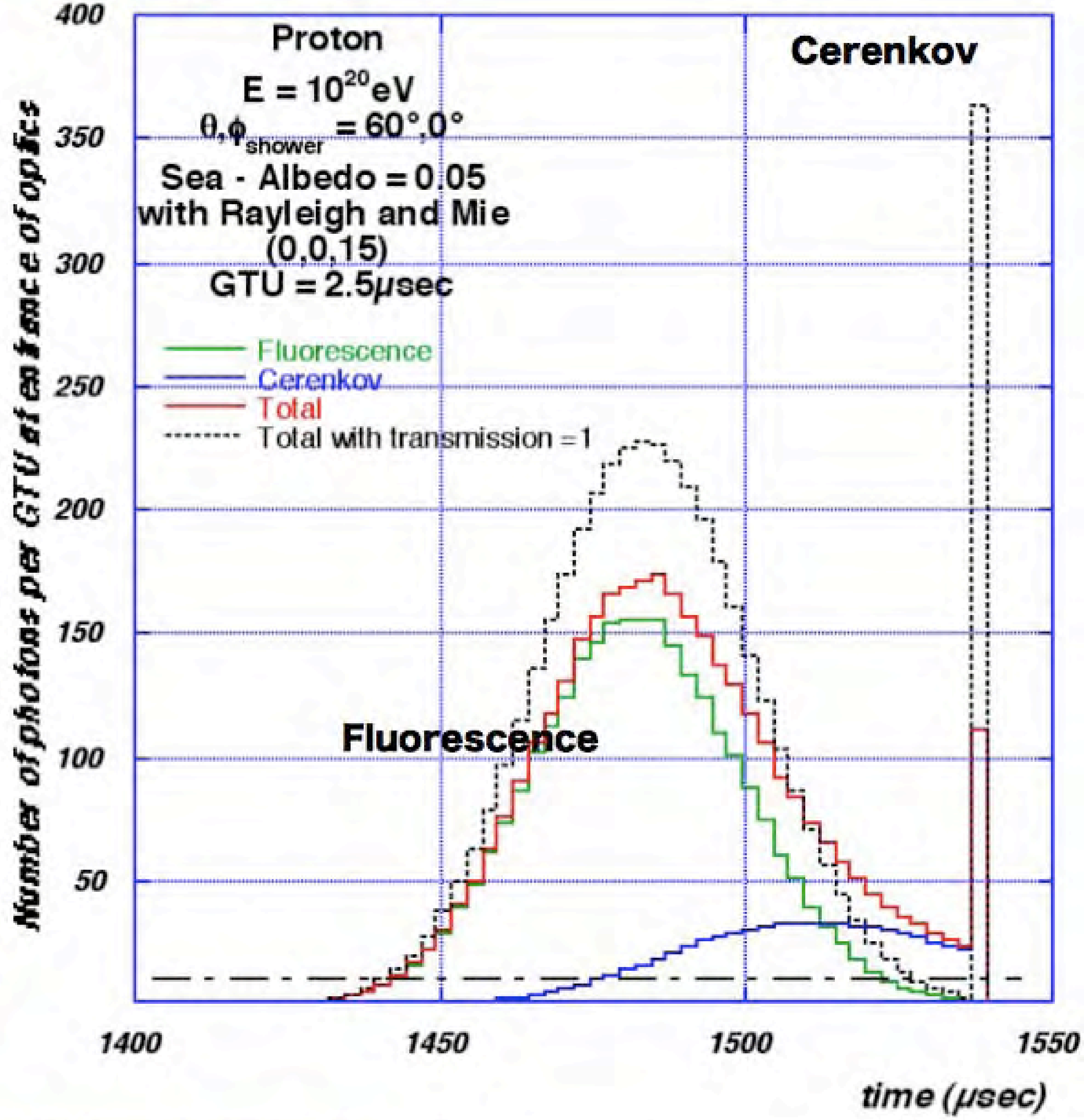
Unknown Nearby Sources
Unknown Acceleration Mechanism?

GZK Process Missing
Neutrino?
Very Heavy Unknown Particle?
Deviation from Lorentz Invariance?

Time Resolved Imaging





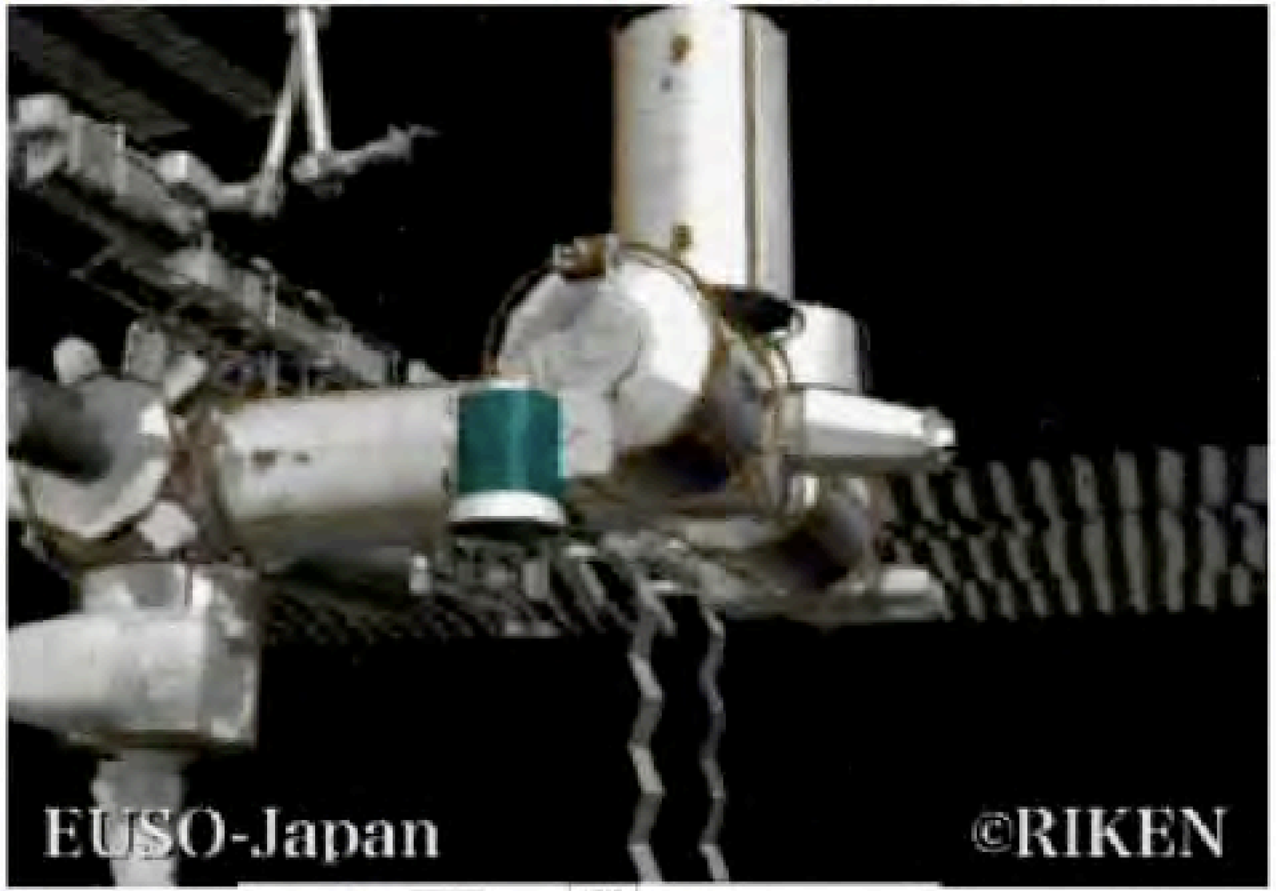


limited by array size

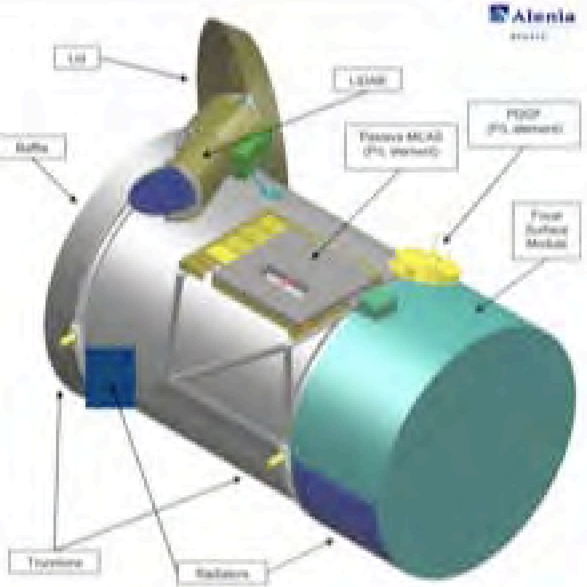
EUSO: Extreme Universe Space Observatory
ESA phase-A completed

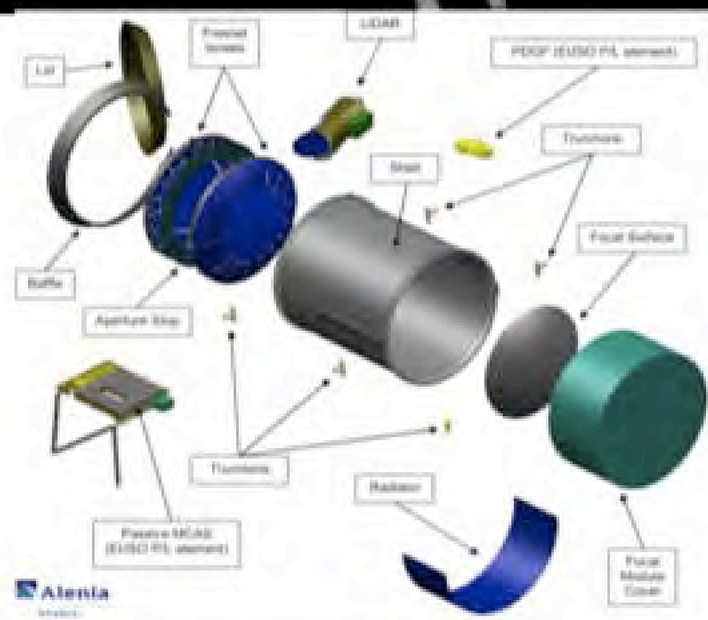
Deployment

time resolved imaging at single photon level



The Instrument

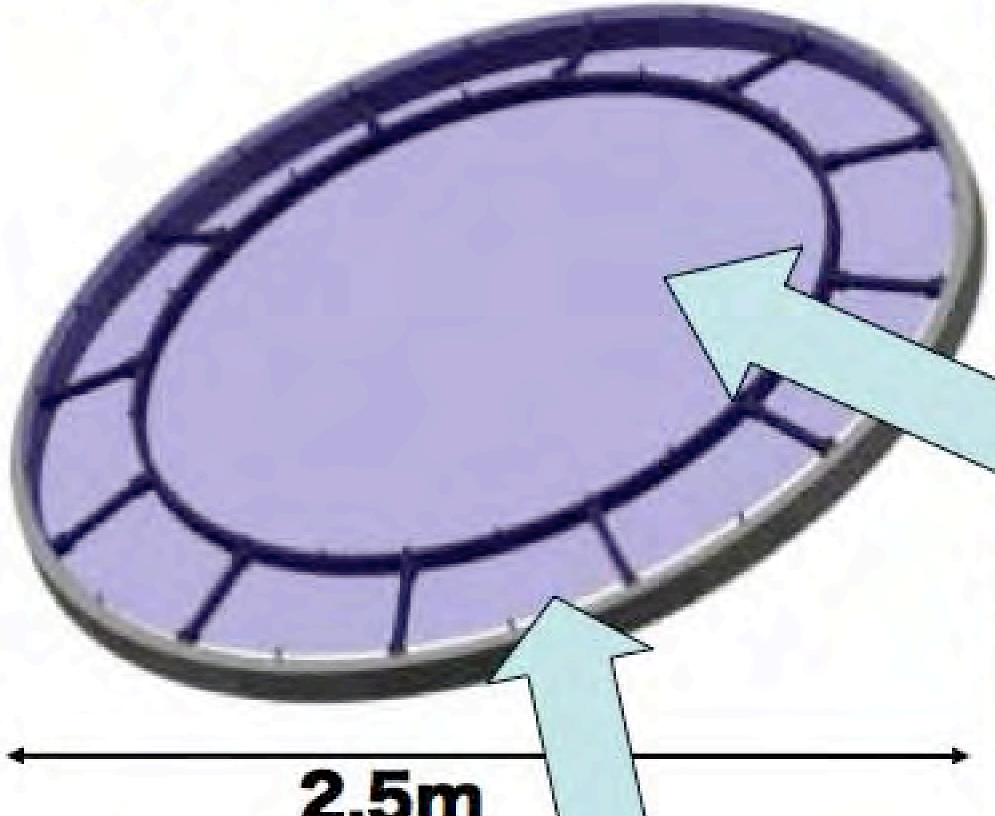


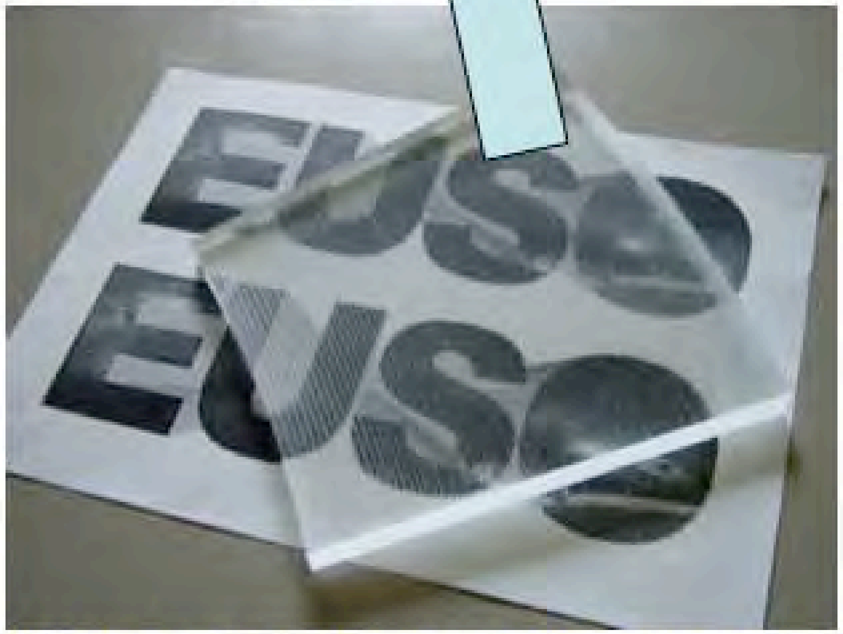


EUSO

EUSO: Extreme Universe Space Observatory
ESA phase-A completed

Optics



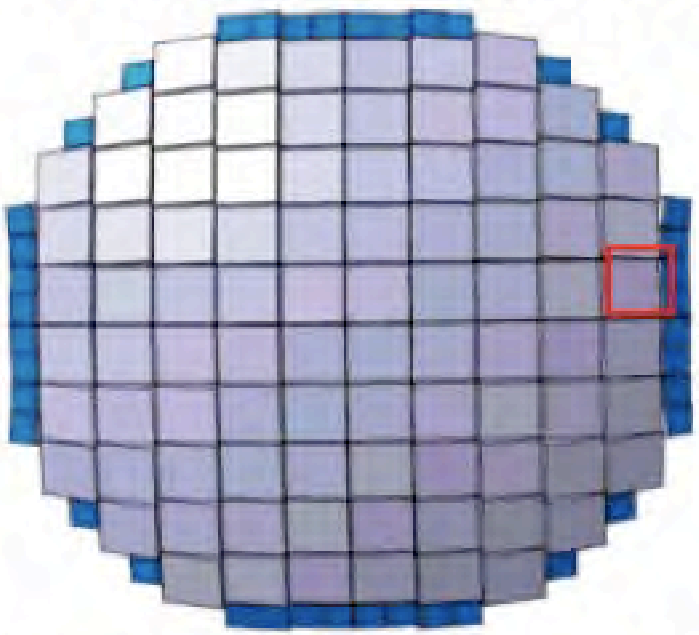


EUSO: Extreme Universe Space Observatory
ESA phase-A completed

Focal Surface

Focal Surface detector

(164PDMs = 0.2M pixels)



2.26 m max

Structural Analysis, Vibration Test DONE
Radiation Damage Test DONE

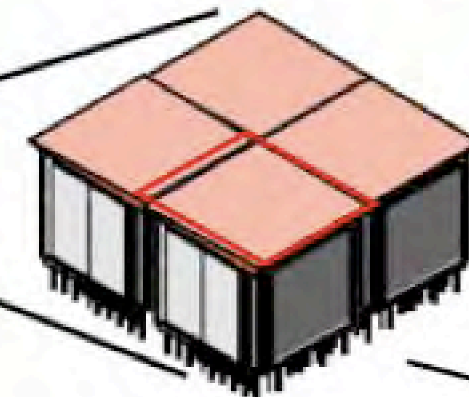
Photo-Detector Module

(3x3 ECs = 1296 pixels)

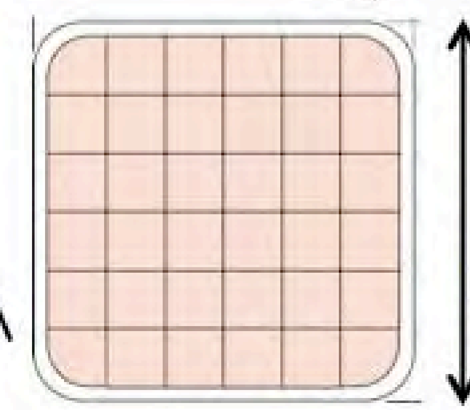
Protection for Intense Illumination DONE

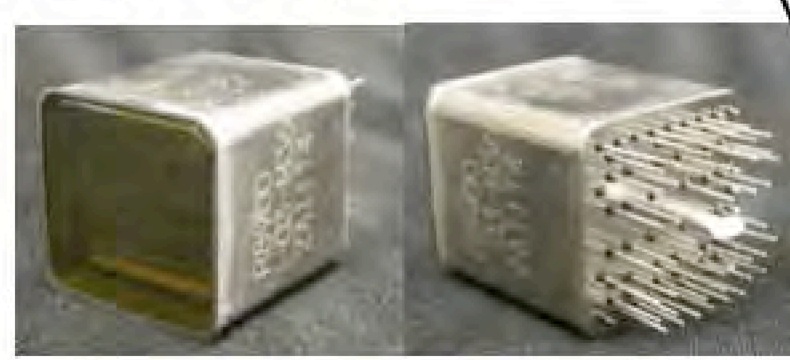
Elementary Cell

(2x2 PMTs = 144 pixels)



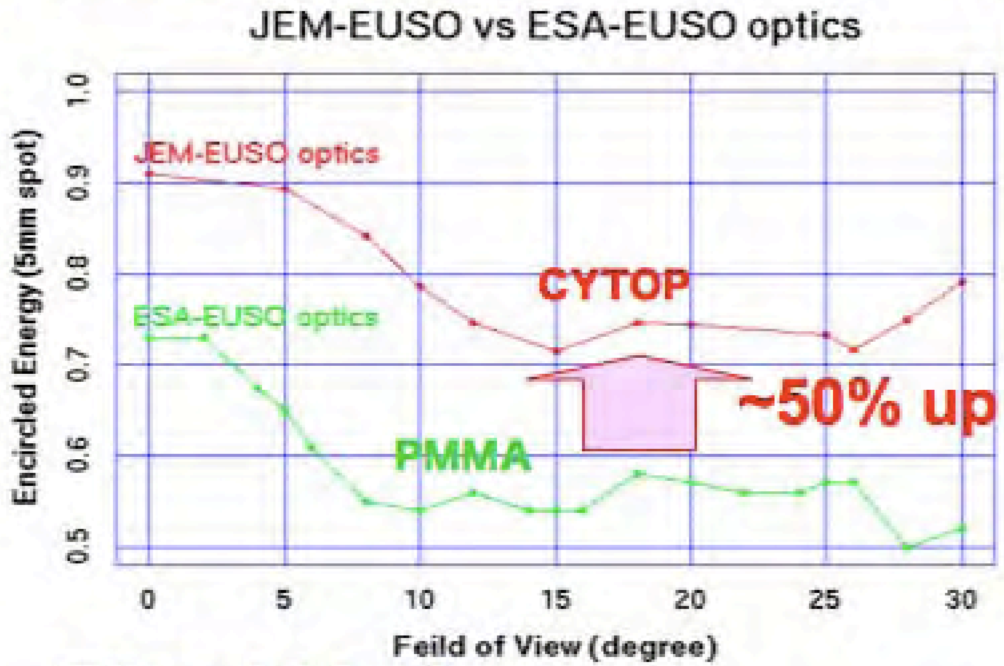
MAPMT
(6x6 pixels)



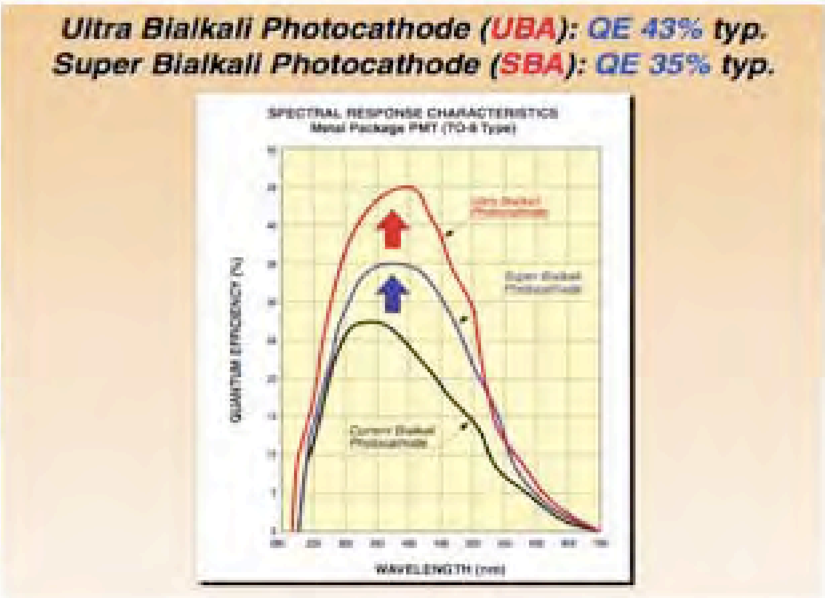


EUSO → JEM-EUSO

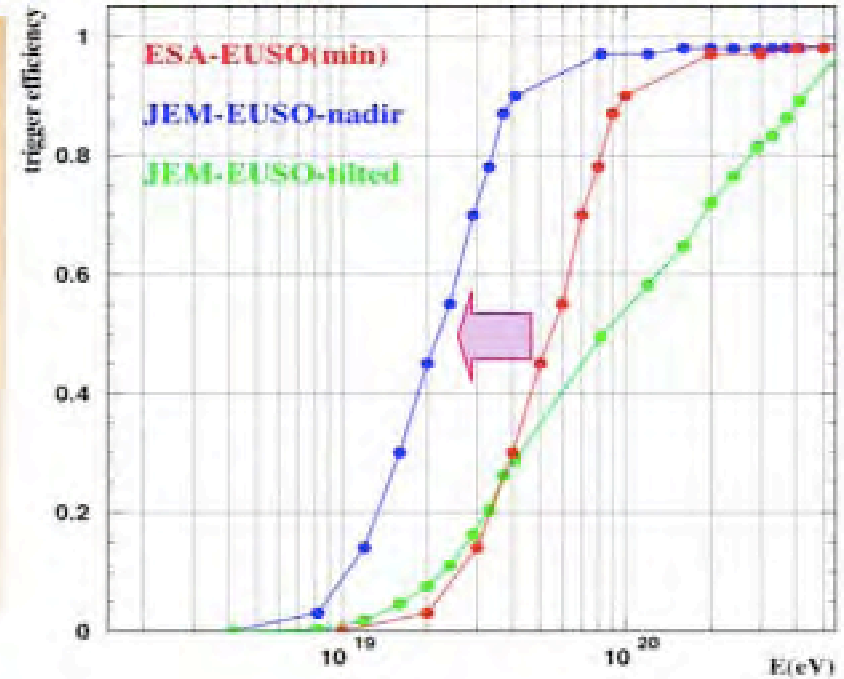
Lens Material



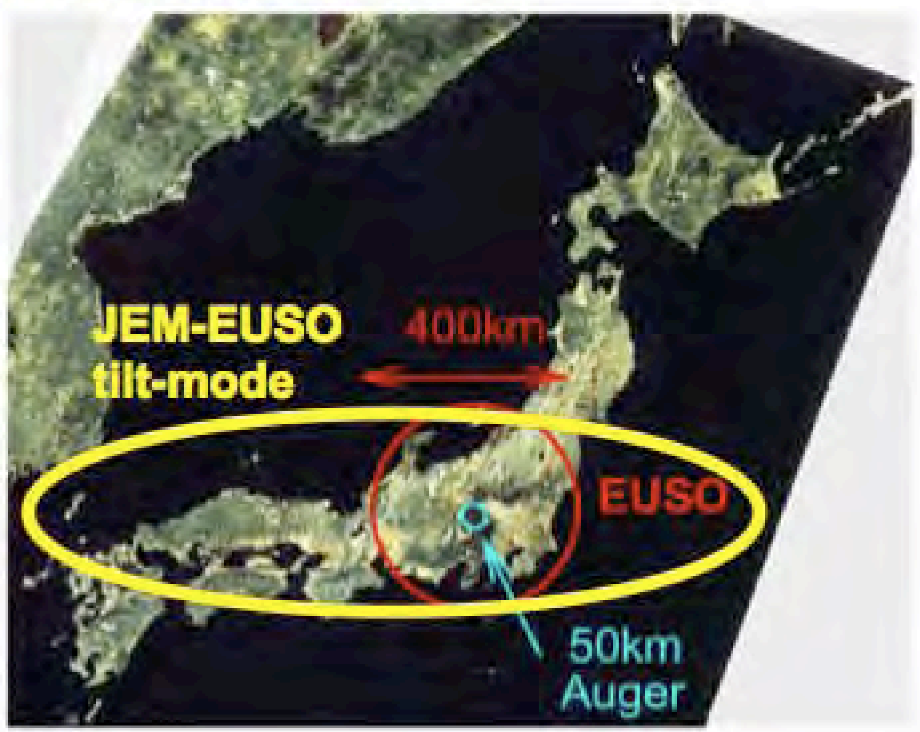
High Quantum Efficiency



Trigger Algorithm



Tilted Mode



Cloud Monitor

Laser and Infra-red Camera

to improve evaluation accuracy of exposure

to improve reliability of detection of near-threshold airshowers

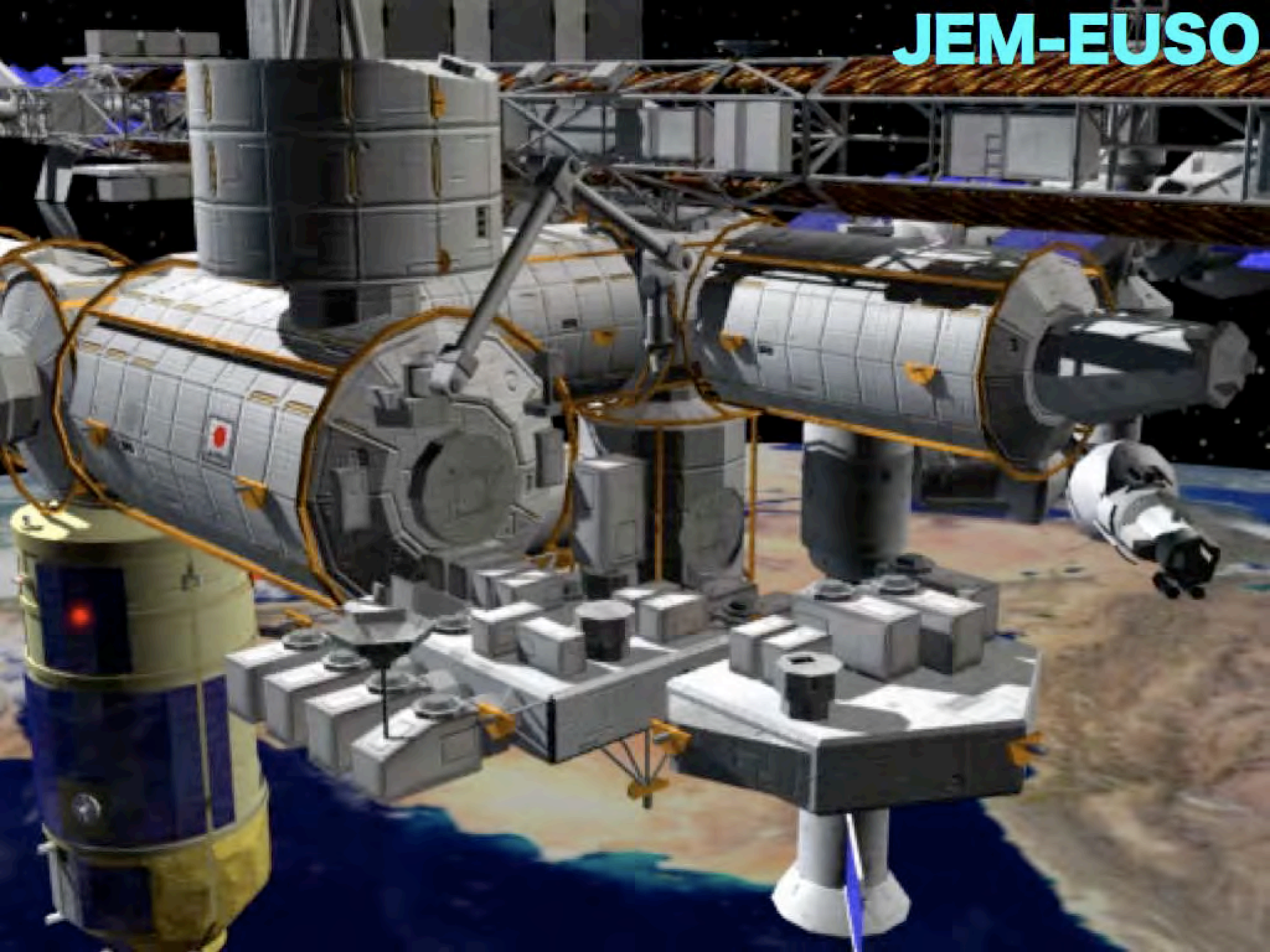
×5 exposure at E ≥10^{20} eV

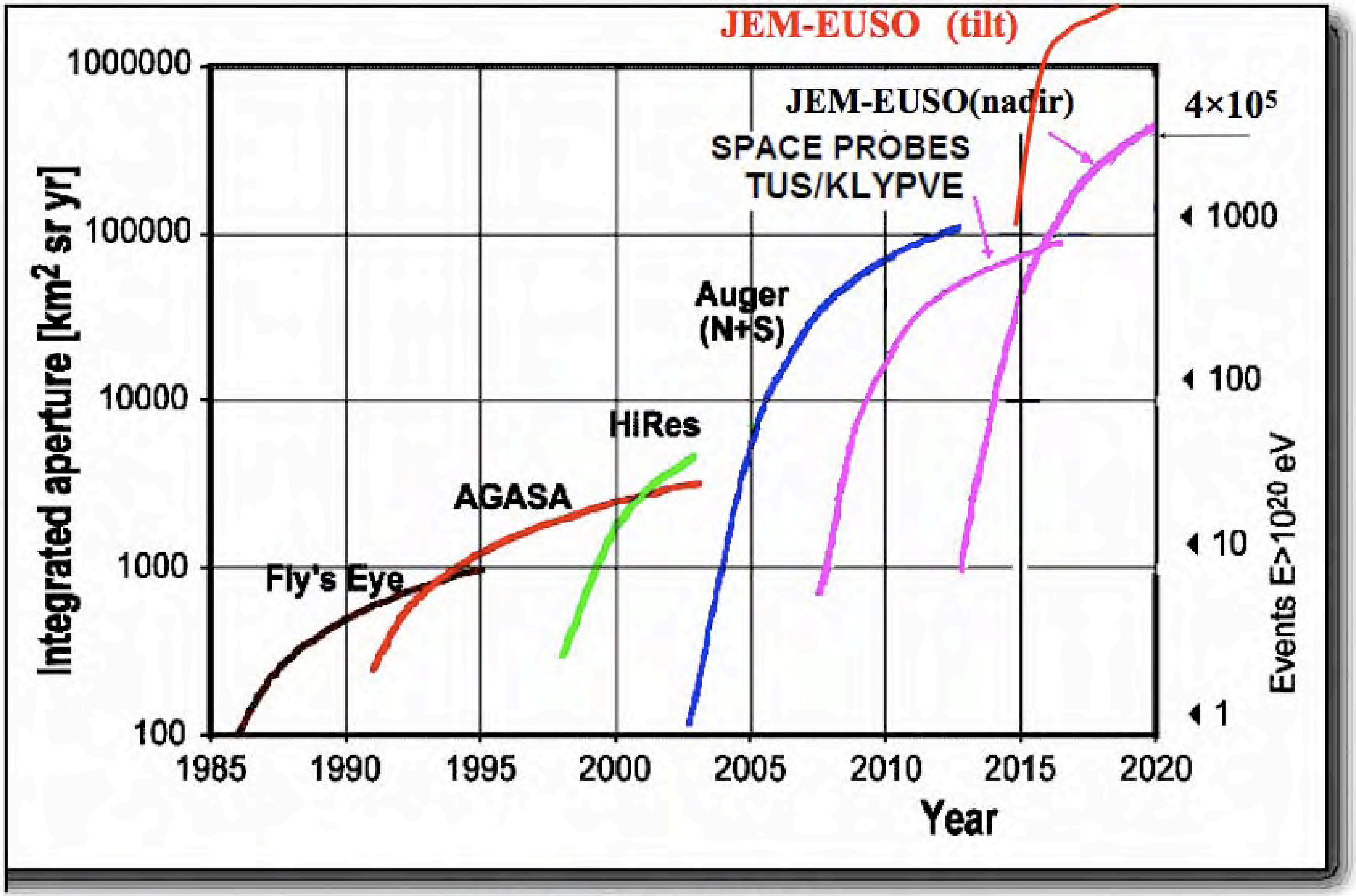
Date(2007/05/10) by(P.Gorodetzky, H.M.Shimizu) DocID(X) Class(Presentation) Language(English)
Title(JEM-EUSO Project)
Conf(FJPPL) at(Tsukuba)

JEM-EUSO Collaboration

- Japan : T. Ebisuzaki, Y. Uehara, H. Ohmori, Y. Kawasaki, M. Sato, Y. Takizawa, T. Wada, K. Kawai (*RIKEN*), F. Kajino, M. Sakata, H. Sato, Y. Yamamoto, N. Ebizuka, (*Konan Univ.*), M. Nagano, Y. Miyazaki (*Fukui Inst. Tech.*), N. Sakaki, T. Shibata (*Aoyama Gakuin Univ.*), N. Inoue (*Saitama Univ.*), Y. Uchihori (*NIRS*), K. Nomoto (*Tokyo*), Y. Takahashi (*Tohoku Univ.*), M. Takeda (*ICRR, Univ. Tokyo*), Y. Arai, Y. Kurihara, H.M. Shimizu, J. Fujimoto (*KEK*), S. Yoshida (*Chiba Univ.*), K. Asano, S. Inoue, Y. Mizumoto, J. Watanabe (*NAOJ),* H. Ikeda, M. Suzuki, T. Yano (*ISAS, JAXA*), T.Murakami, D. Yonetoku (*Kanazawa Univ.*), N. Sugiyama *(Nagoya*), Y. Ito (*STEL, Nagoya Univ.*), S. Nagataki (*YITP, Kyoto Univ.*), A. Saito(*Kyoto Univ.*), S. Abe, M. Nagata (*Kobe Univ.*), T. Tajima (*KPSI, JAEA*)
- USA : J. H. Adams Jr., S. Mitchell, M.J. Christl, J. Watts Jr., A. English, R. Young (*NASA MSFC*) , Y. Takahash, D. Gregory, M. Bonamente, P. Readon, V. Connaughton, K. Pitalo, J.Hadaway, J. Geary,R. Lindquist, P. Readon (*Univ. Alabama in Huntsville*), H. Crawford, C. Pennypacker (*LBL, UC Berkeley*), K. Arisaka, D. Cline (*UCLA*), T. Weiler, S. Czorna (*Vanderbilt Univ.*)
- France : J-N. Capdevielle, P. Gorodetzky P. Salin (*CNRS*), J. Dolbeau (*Coll. de France*), T. Patzak, F. Vanucci (*Univ. Paris 7*), J. Weisbard *(IN2P3)*
- Germany: M. Teshima, T. Schweizer (*Max Planck Munich*), A. Santangelo (*Tuebingen*), P. Biermann (*MPI Bonn*), K. Mannheim (*Wuerzburg*)
- Italy : S. Bottai. P. Spillantini, A. Zuccaro (*Firenze*), A. Anzalone, O. Catalano, M.C. Maccarone, P. Scarsi, B. Sacco (*IAS-PA/INAF*), G. D'Ali Saiti (*U. Palermo*), B. Alpat, R. Battiston, B. Bertutti, E. Fiandrini, P. Zuccon (*Perugia*), M. Casolino, M.P. De Pascale, A. Morselli, P. Picozza, R. Sparvoli (*Roma 2*), A. Cappa, M. Dattoli, P. Vallania (*INAF-IFSI Torino*), P. Galleotti, C. Vigorito, M. Bertaina (*Univ. Torino*), A. Gregorio (*Trieste*)
- Mexico: G. Medina-Tanco, J.C. D'Olivo, J.F.Valdes (*Mexico UNAM*), H. Salazar, O. Martines (*Puebla*), L. Villasenor (*UMSNH*)
- Republic of Korea : S. Nam, I. H. Park (*Ehwa W. Univ.*)
- Russia: Garipov G.K., Khrenov B.A., Klimov P.A. Panasyuk M.I., Yashin I.V. (*SINP MSU*), Naumov, D., Tkachev. L (*Dubna JINR*)
- Switzerland : A. Maurissen, V. Mitev (*Neuchatel, Switzerland*)

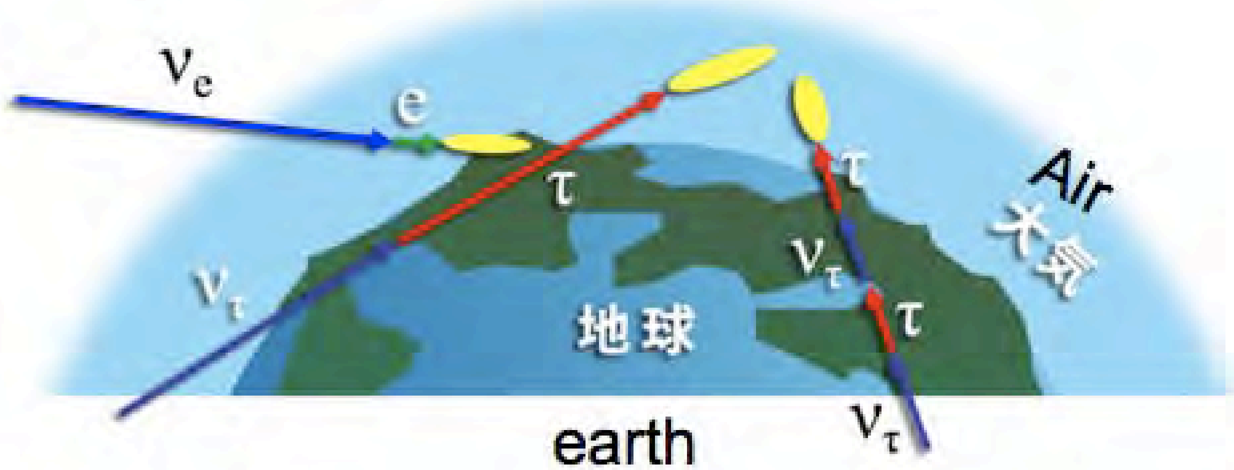
JEM-EUSO

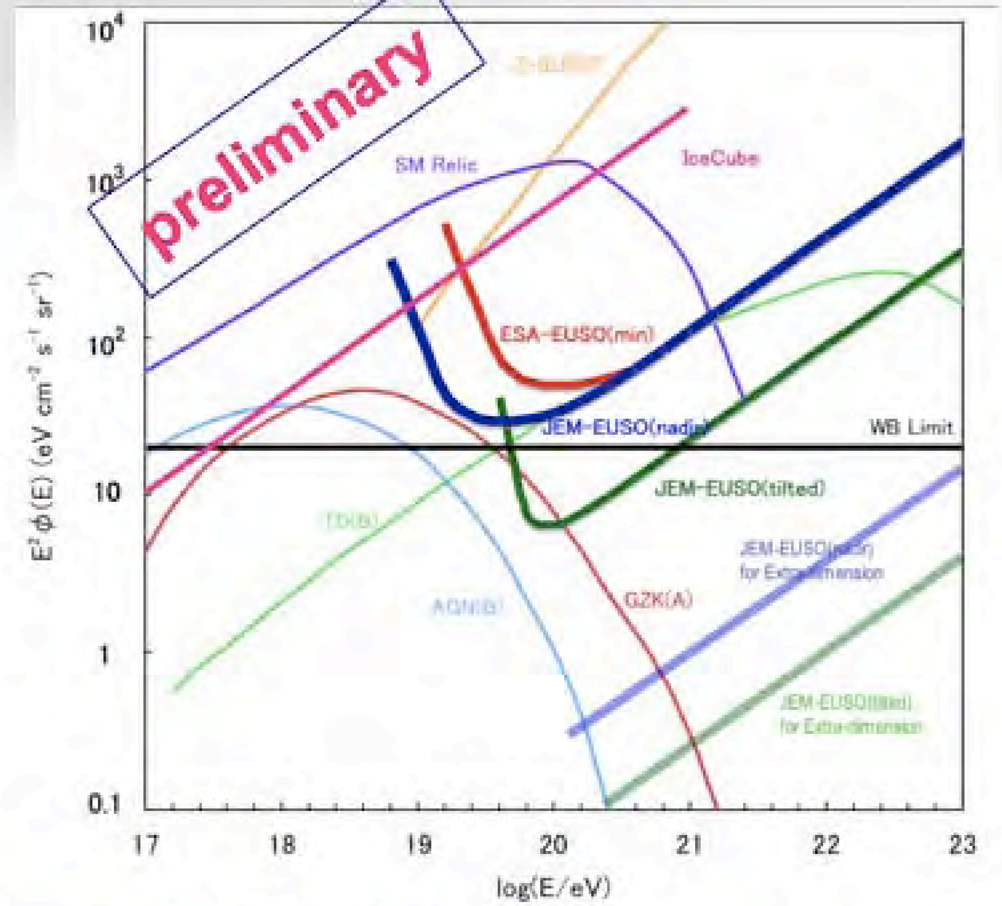




by Boris Khrenov 2006

Neutrino Detection



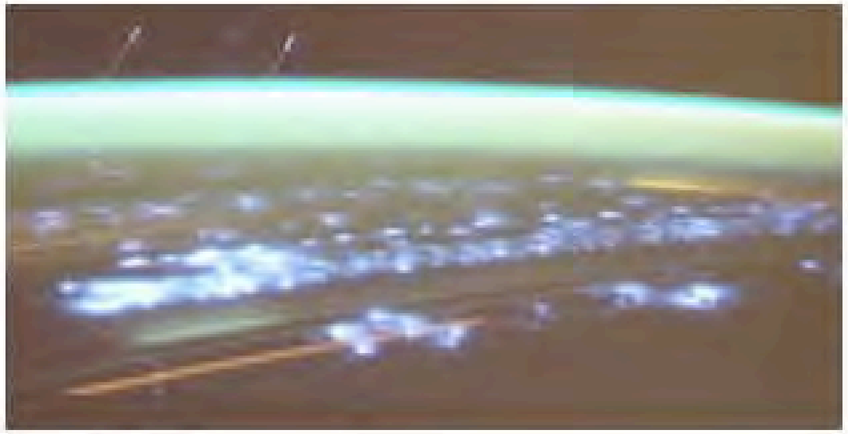


100 times more events expected if large extra-dimension

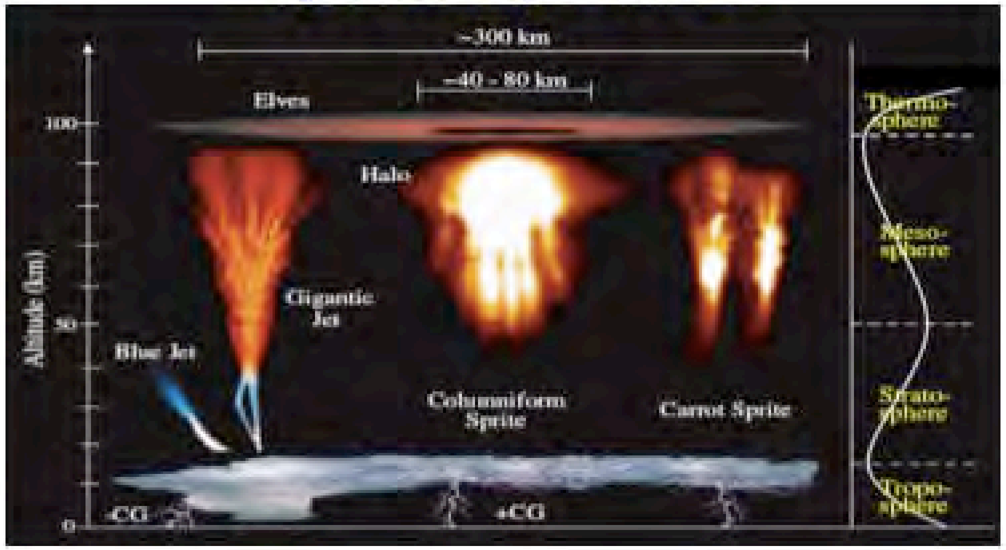
Atmospheric UV-emissive Phenomena

Metoroids

Lightening



Sprites, Elves



Scientific Requirements

statistics

$\geq$1000 events for $E \geq 7\times10^{19}$eV

(minimum 500 events)

accuracy

arrival direction		$\leq$ 2 deg
primary energy		$\leq$ 30%
X_{max}	atmospheric depth at shower maximum	$\leq$ 120 g cm^{-2}

for primary particle identification

Instrument Requirements

optics

aperture≥2.5m

field of view≥±30deg

spot size≤5mm RMS

efficiency ≥ 0.5@0deg, 0.3@30deg

filter transmission ≥ 0.9

focal surface

spherical

detection efficiency ≥ 0.12

pixel size ≤ 4.5 mm

area ≥ 4.415 m^2

trigger efficiency ≥ 0.95 @ $E=10^{20}$eV θ=60deg

sampling time ≤ 2.5 μs

calibration

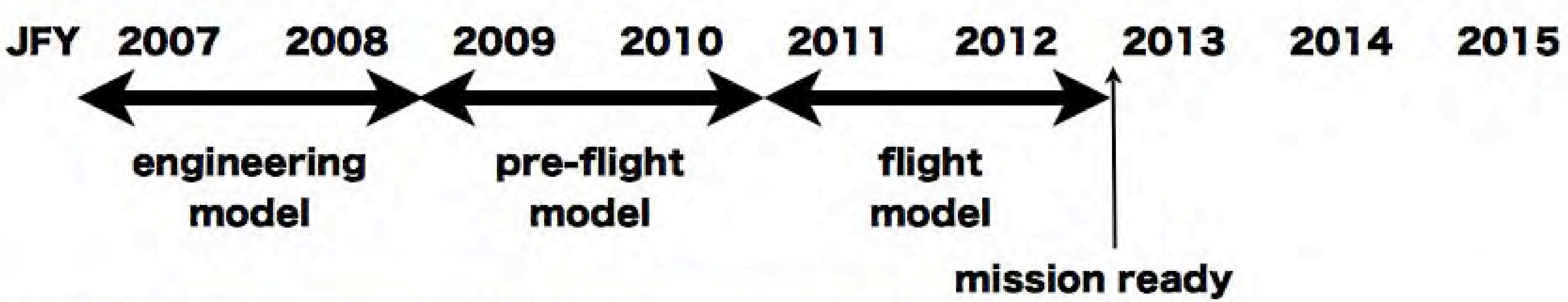
wavelength region = 330-400 nm

detection efficiency calibration accuracy ≤ 0.18

atmospheric monitor

cloud top altitude determination accuracy ≤ 500 m in entire field of view

Schedule



Date(2007/05/10) by(P.Gorodetzky, H.M.Shimizu) DocID(X) Class(Presentation) Language(English)
Title(JEM-EUSO Project)
Conf(FJPPL) at(Tsukuba)

French contribution to JEM-EUSO

Jean-Noel CAPDEVIELLE, Director of Research at CNRS,
Jean DOLBEAU, Maître de Conférences at College de France, Philippe GORODETZKY, Director of Research at CNRS,
Thomas PATZAK, Professor at Paris 7 University,
Pierre SALIN, Engineer at CNRS,
François VANUCCI, Professor at Paris 7 University
Jack WAISBARD, Engineer at IN2P3.

Université Paris Diderot-Paris 7, Laboratoire APC,
Bâtiment Condorcet, Case 7020, 75205 Paris Cedex 13

If the JEM-EUSO proposal is selected by JAXA, the French-EUSO Collaboration will seek support from French sponsors for participation in JEM-EUSO as outlined above.

French contribution to JEM-EUSO

a) The absolute calibration of the focal surface PMTs with an accuracy of about 2%

b) Theoretical studies of the high energy shower generations and developments.

c) Advice on systems engineering and project management to the JEM-EUSO collaboration.

d) A precise (better than 5%) measurement of the nitrogen fluorescence yield in air, in conditions corresponding to altitudes between 0 and 40 km.

e) Participation in mission planning, operations and data analysis.

f) Organisation of "Communications and Outreach" in Europe.

g) Supply to the Japanese team the focal surface structure that was designed in 2004 for ESA-EUSO phase A.

a)The absolute calibration of the focal surface PMTs with an accuracy of about 2%

d) A precise (better than 5%) measurement of the nitrogen fluorescence yield in air, in conditions corresponding to altitudes between 0 and 40 km.

This is the continuation of a three years work at the College de France which led to the thesis of Gwenaelle Lefeuvre held in Paris, July 5, 2006:

"Mesure Précise du Rendement de la Fluorescence de l'Azote dans l'Air. Conséquences sur la Détection des Rayons Cosmiques d'Ultra Haute Energie."

and a french patent:

N° 01067-01 "Appareillage et méthode pour déterminer très précisement l'efficacité de tout dispositif optique".

It was all based on the initial discovery that all fluorecence measurements are limited to some 15% accuracy because the photomultipliers used are known only to that precision.

PMT absolute calibration

We aim 1% accuracy

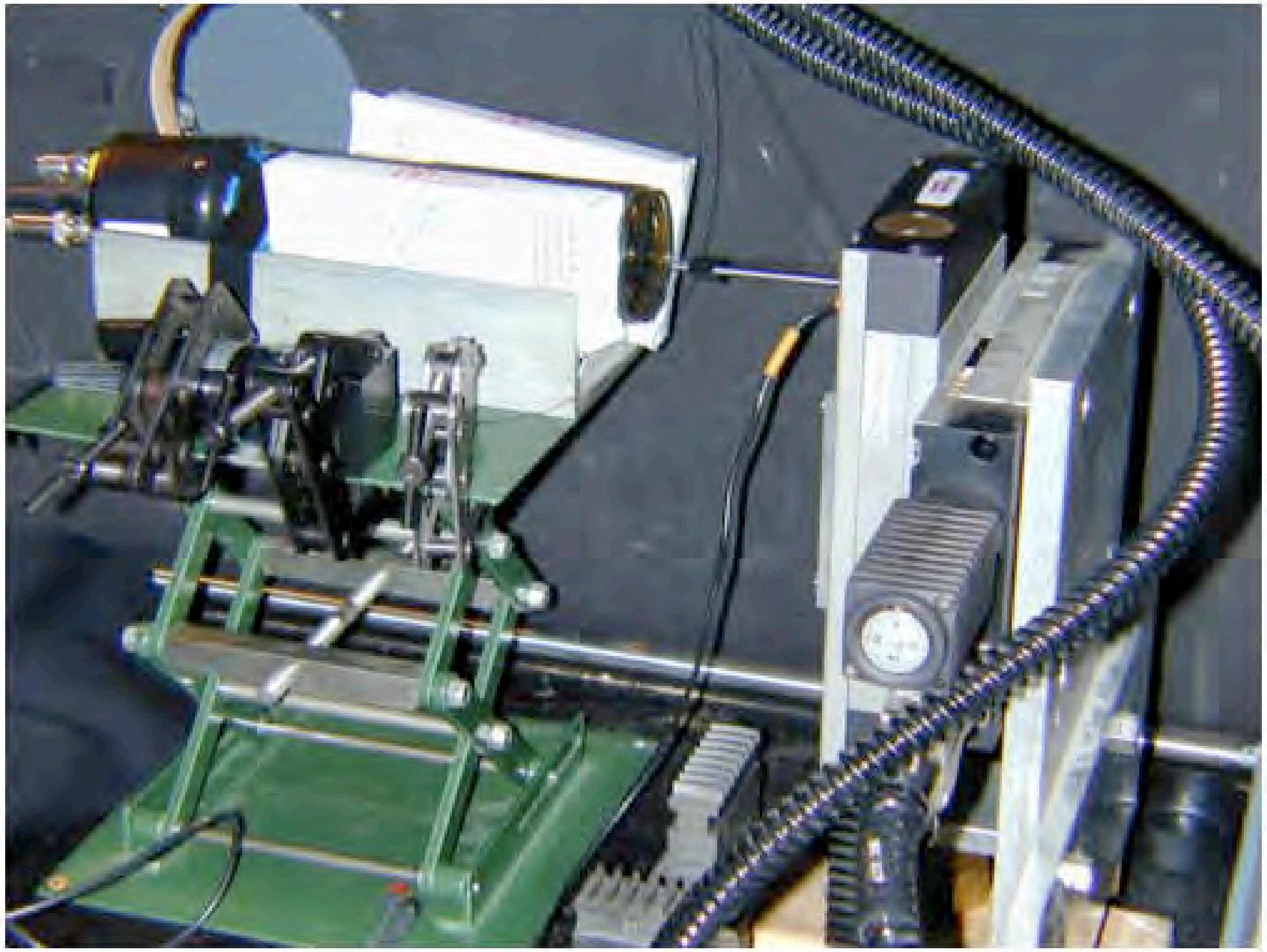
Use of a reference light source does not work: angular variations make the illuminated surface non-uniform

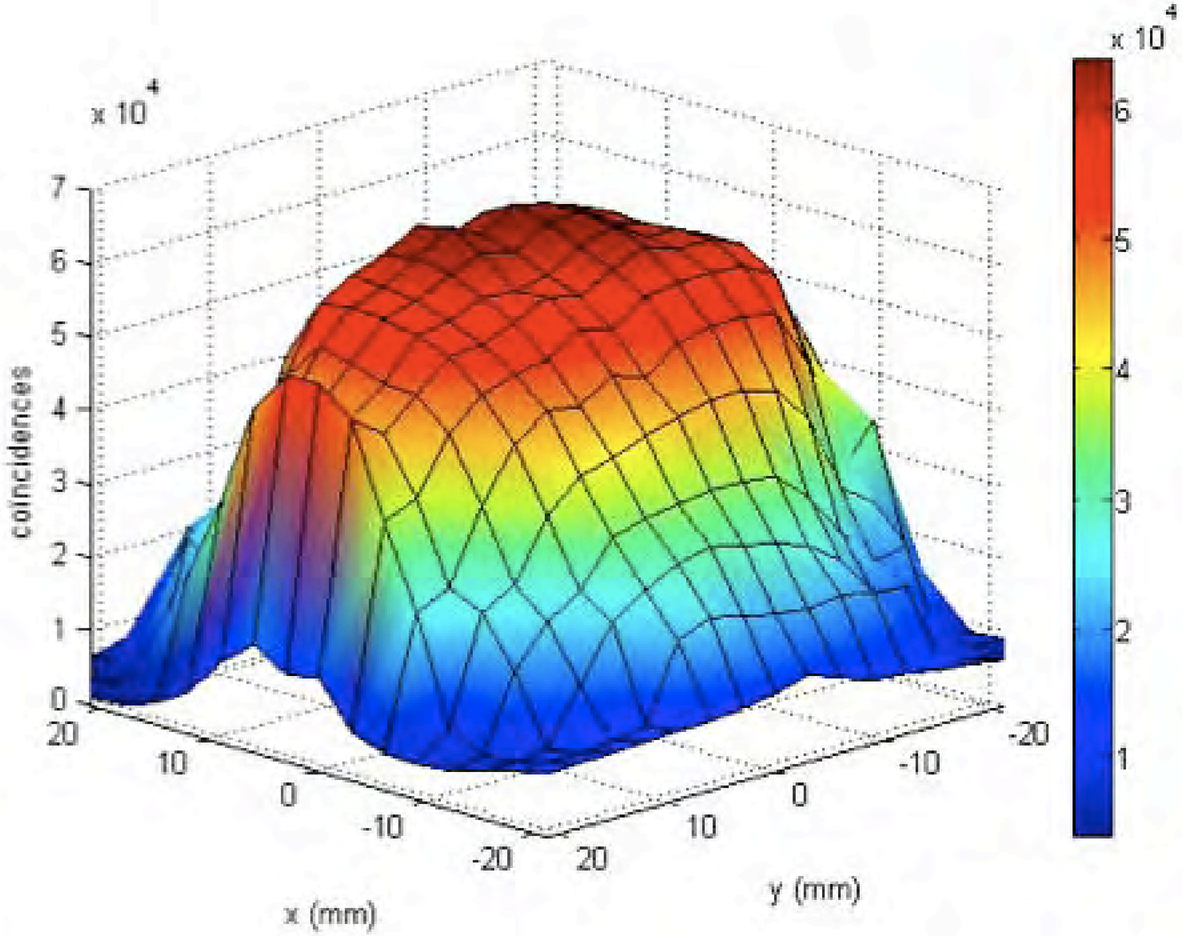
Use of a calibrated detector (NIST) works: basically compare one after the other the NIST and the PMT. However, time variations have to be controlled.

Two operations: a mapping of the photocathode (relative) and an absolute measurement on one point of the map.

PMT mapping

Has to be done in very pure single photo electron mode

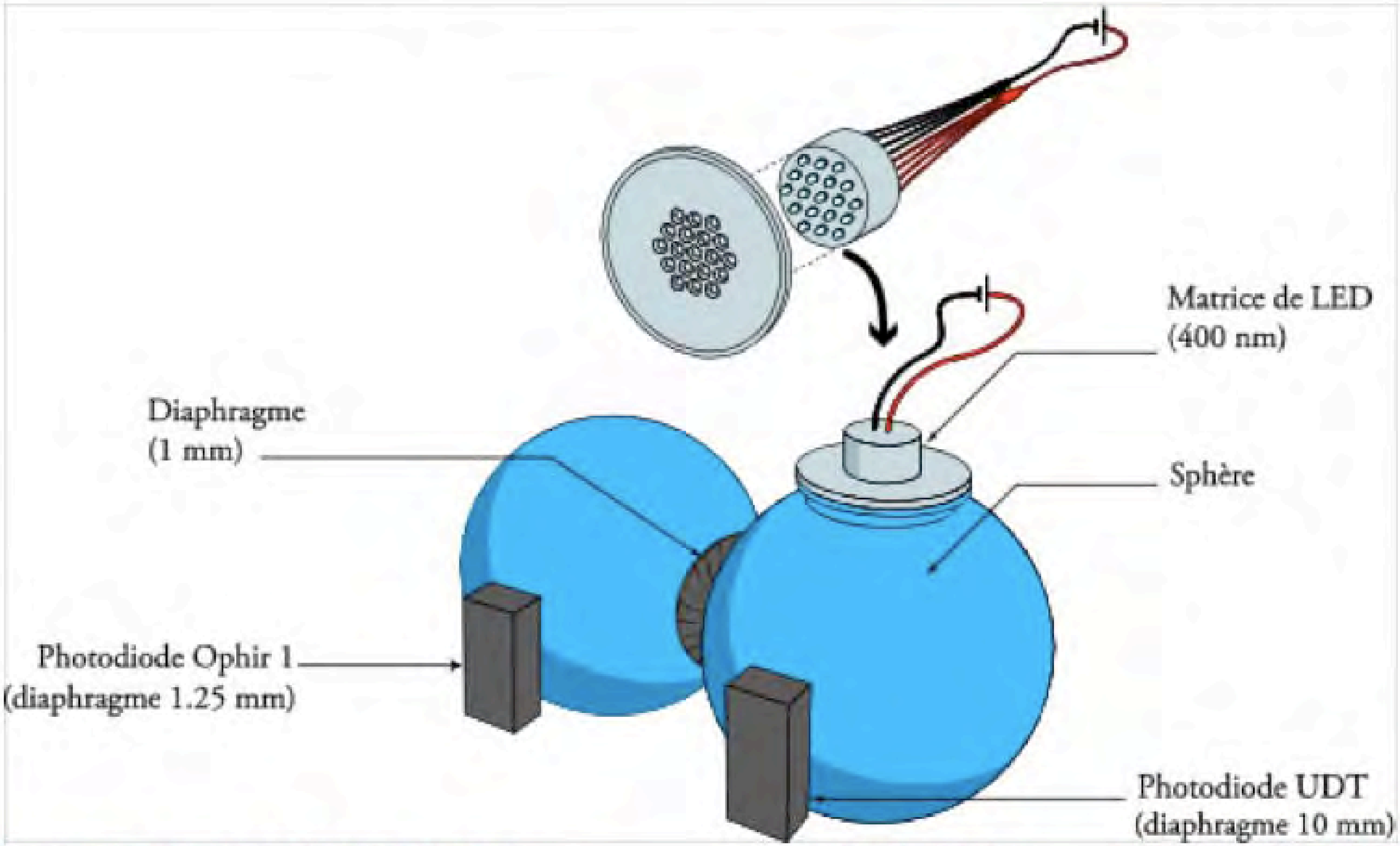




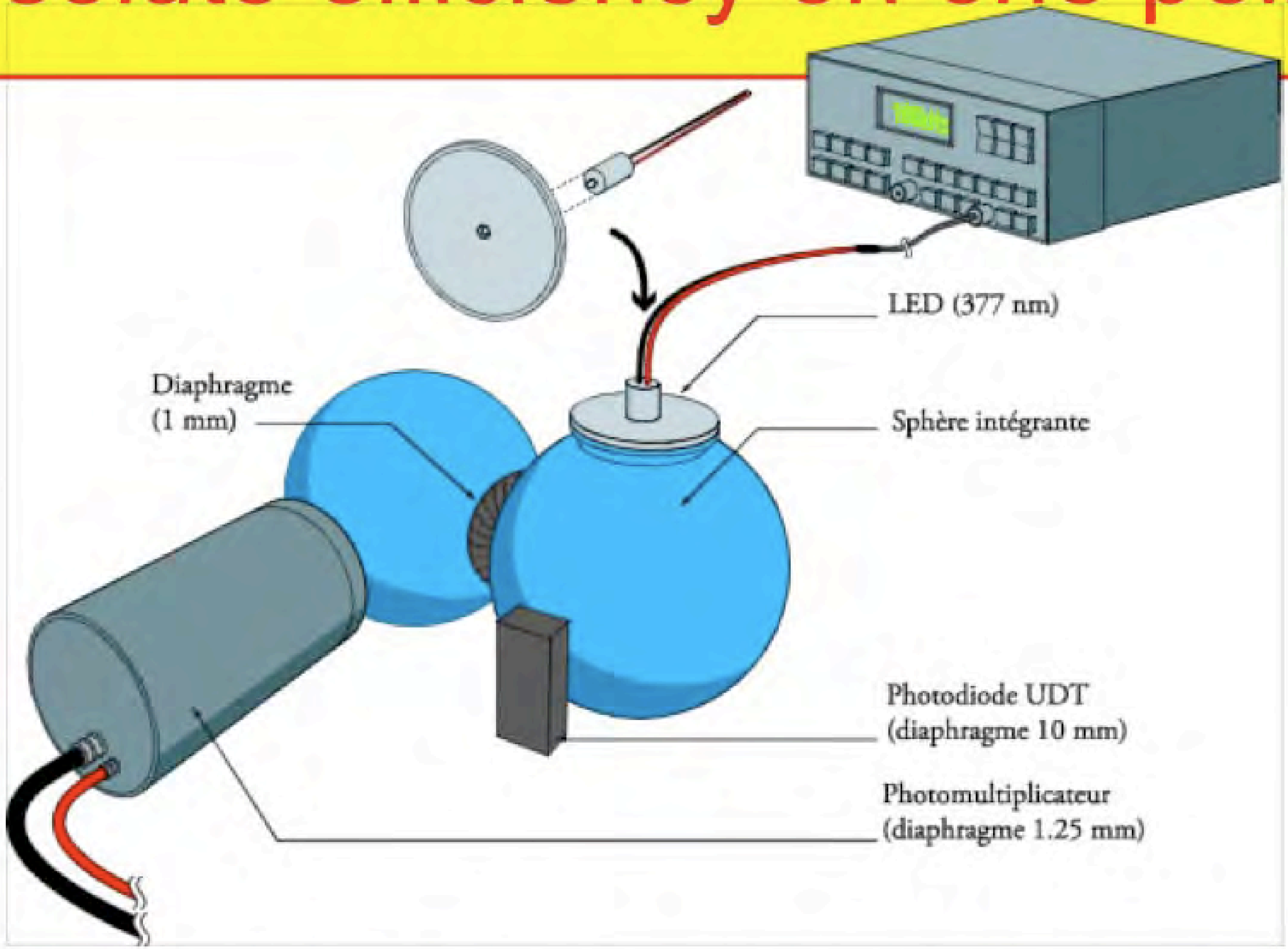
Absolute efficiency on one point

PMT has a gain 10^7 time the NIST gain

==> must reduce the light 10^7 times: use integrating spheres

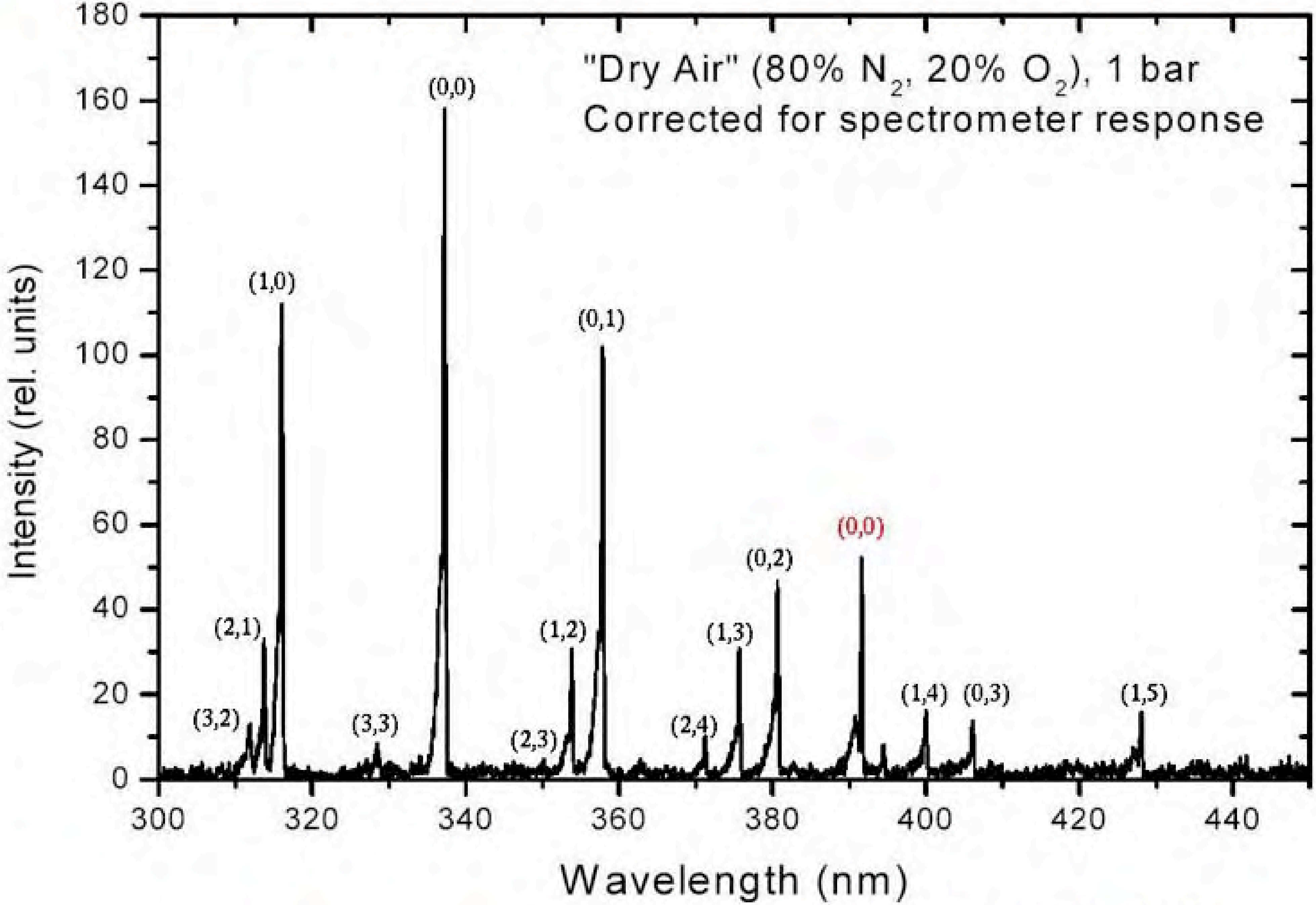


Absolute efficiency on one point



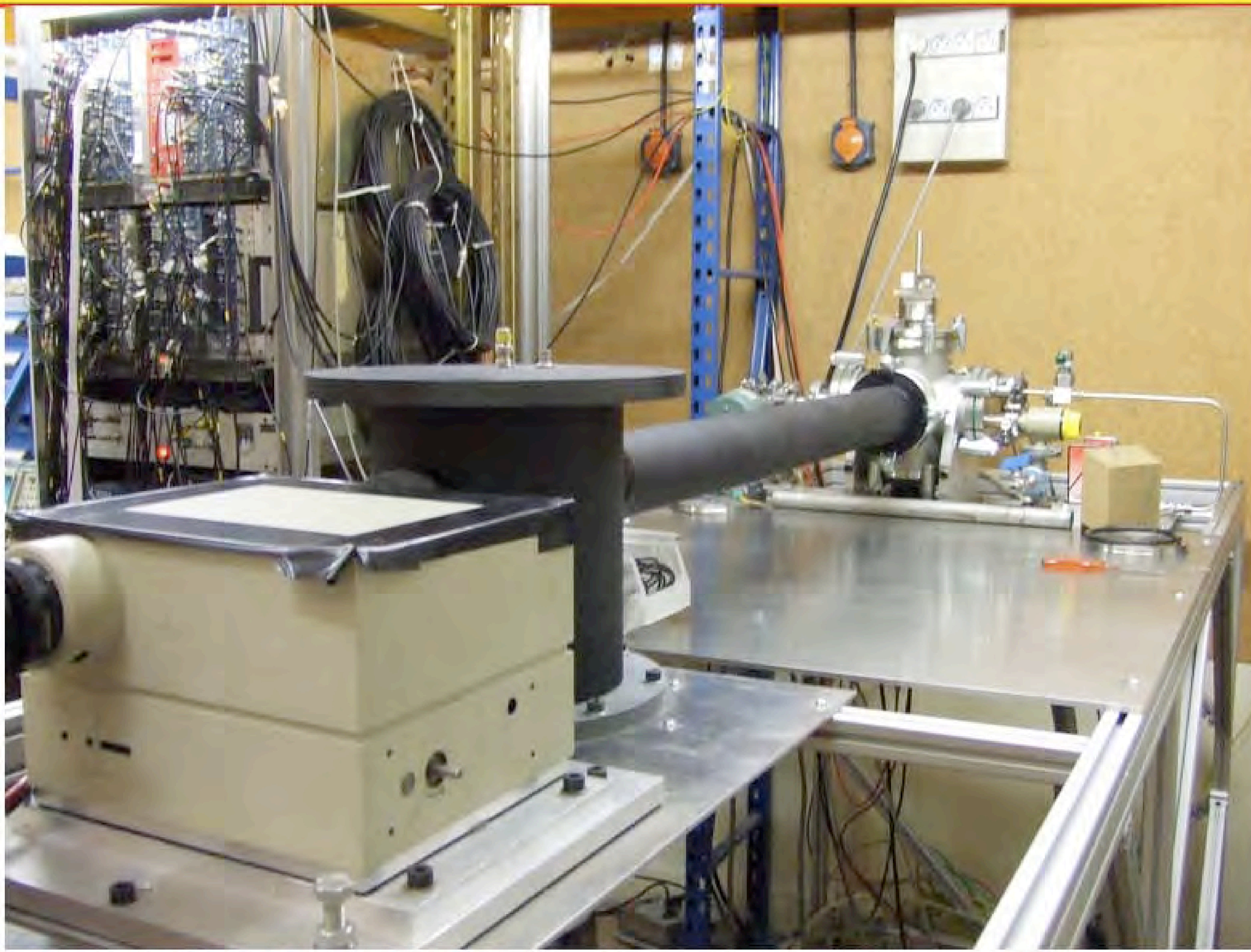
We find for a brand new XP2020Q: (18.9 ± 0.3)% (1.7 % accuracy) at 377 nm in single pe mode (instead of some 22 % given by Photonis)

Fluo measurement

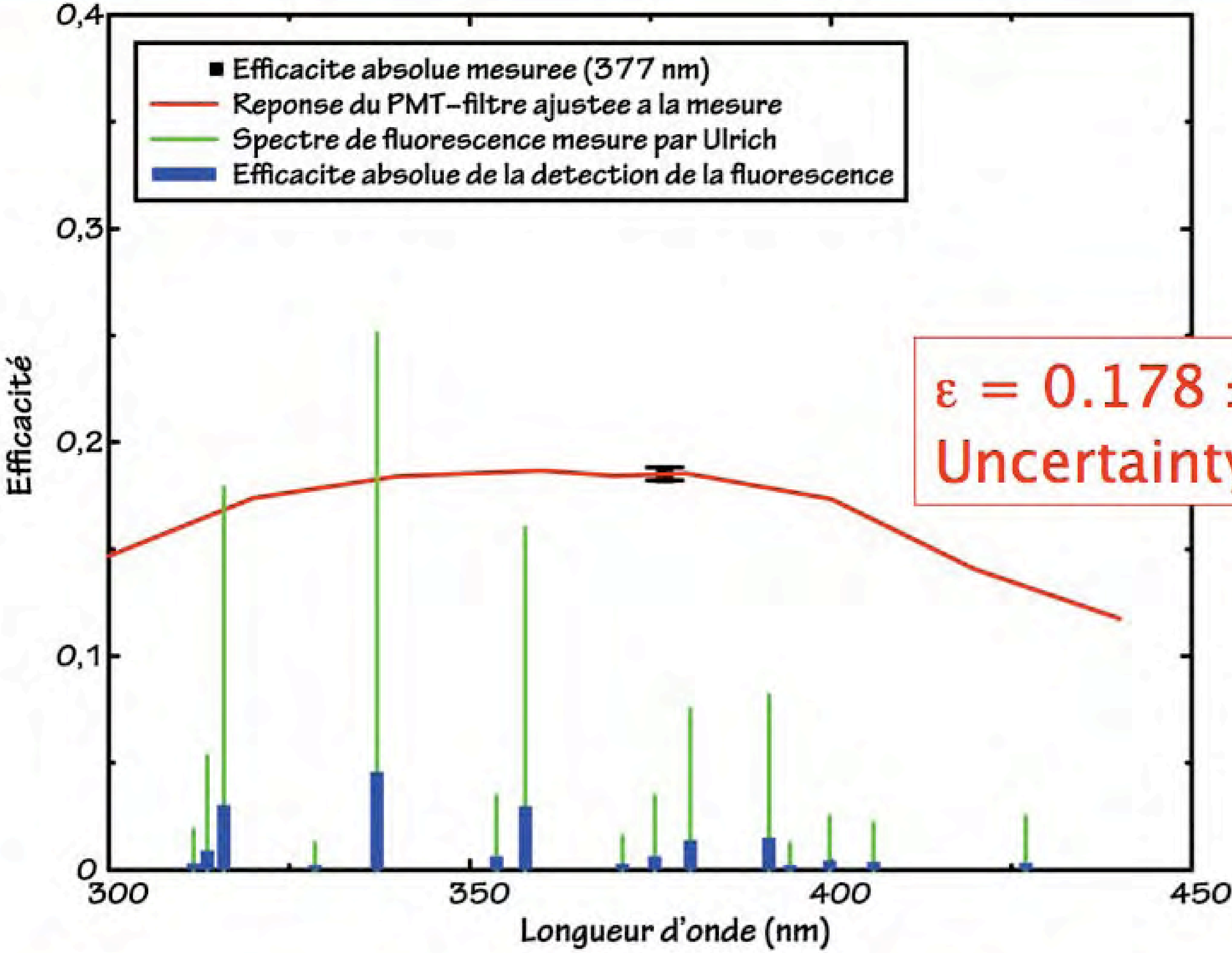


(Ulrich, Airlight workshop, 2003)

Fluo measurement



Fluo measurement



$\varepsilon = 0.178 \pm 0.004$

Uncertainty : 1.7 %

Fluo measurement

4.23 ± 0.20 photons / m (5% accuracy)

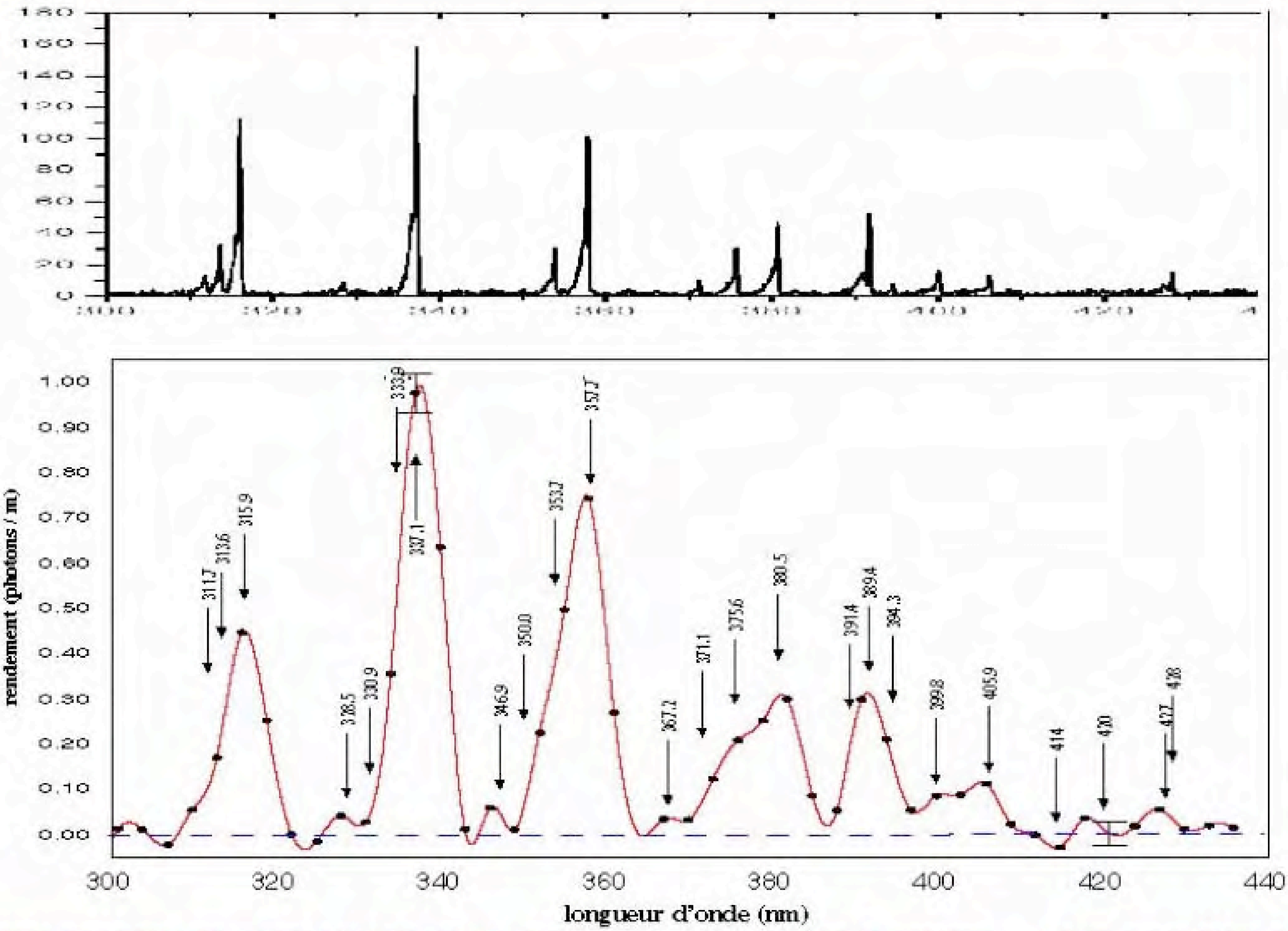
For the normalized conditions: $E_e = 0.85$ MeV
P, T = US standard

20.46 ± 0.98 ph/MeV

N_2 / Air = 4.90 ± 0.01

A NIMA paper is in publication and can be read on arXiv 0704.1532

Fluo measurement



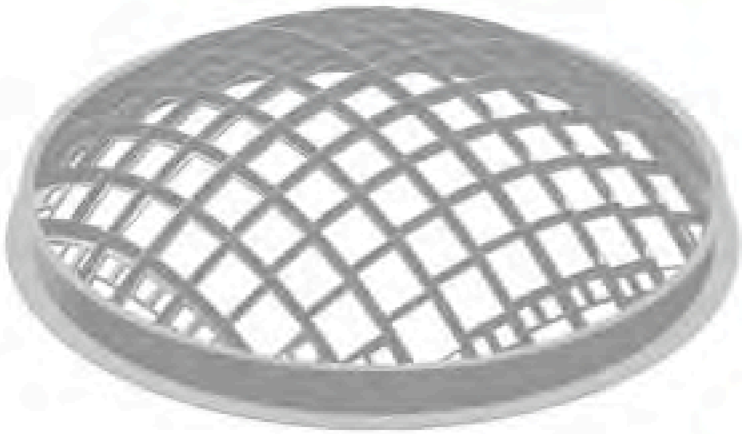
PMT efficiency, Fluo measurement next future

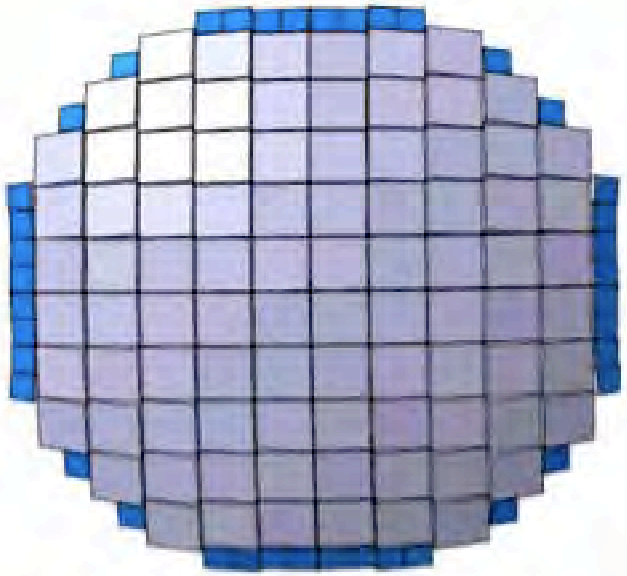
Design a system to illuminate the PMT with a narrow beam instead of the cosθ specific to spheres
Build mechanics to scan the focal surface

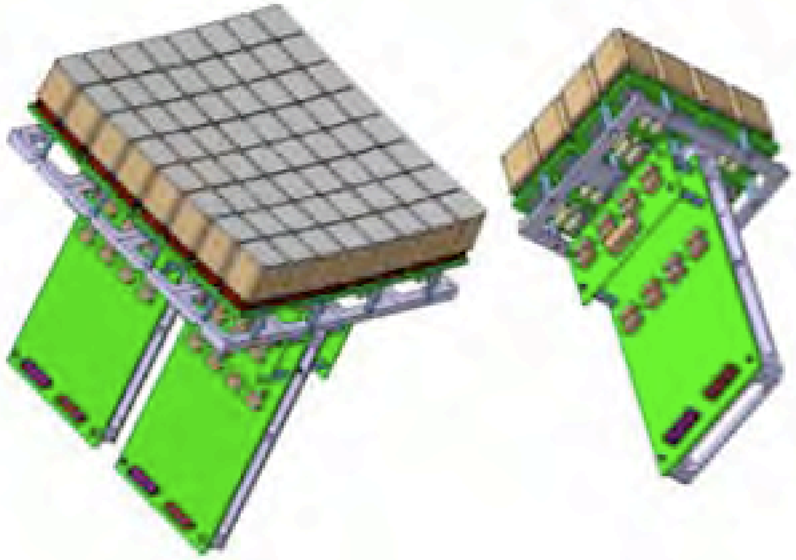
Use any wavelenght: **source** = "old" spectrometer, **receptor** = new spectrometer with CCD and image intensifier

Vary pressure, temp, impurities

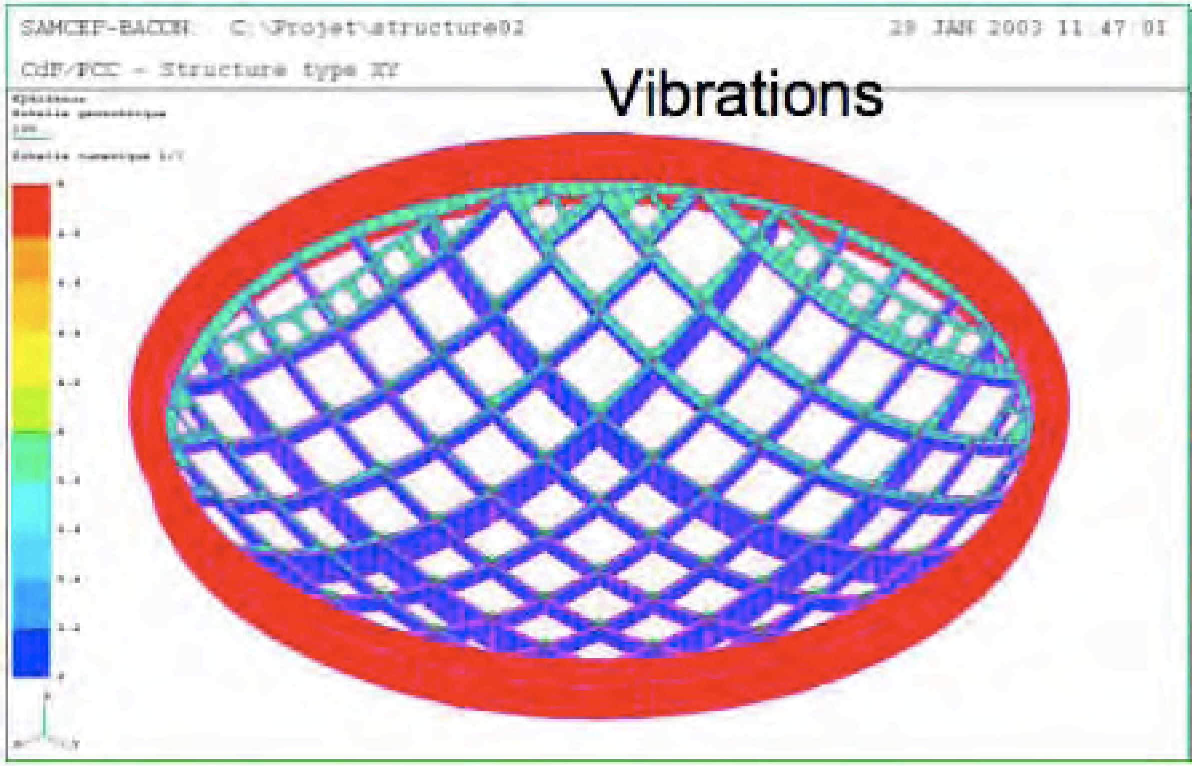
g) Supply to the Japanese team the focal surface structure that was designed in 2004 for ESA-EUSO phase A.

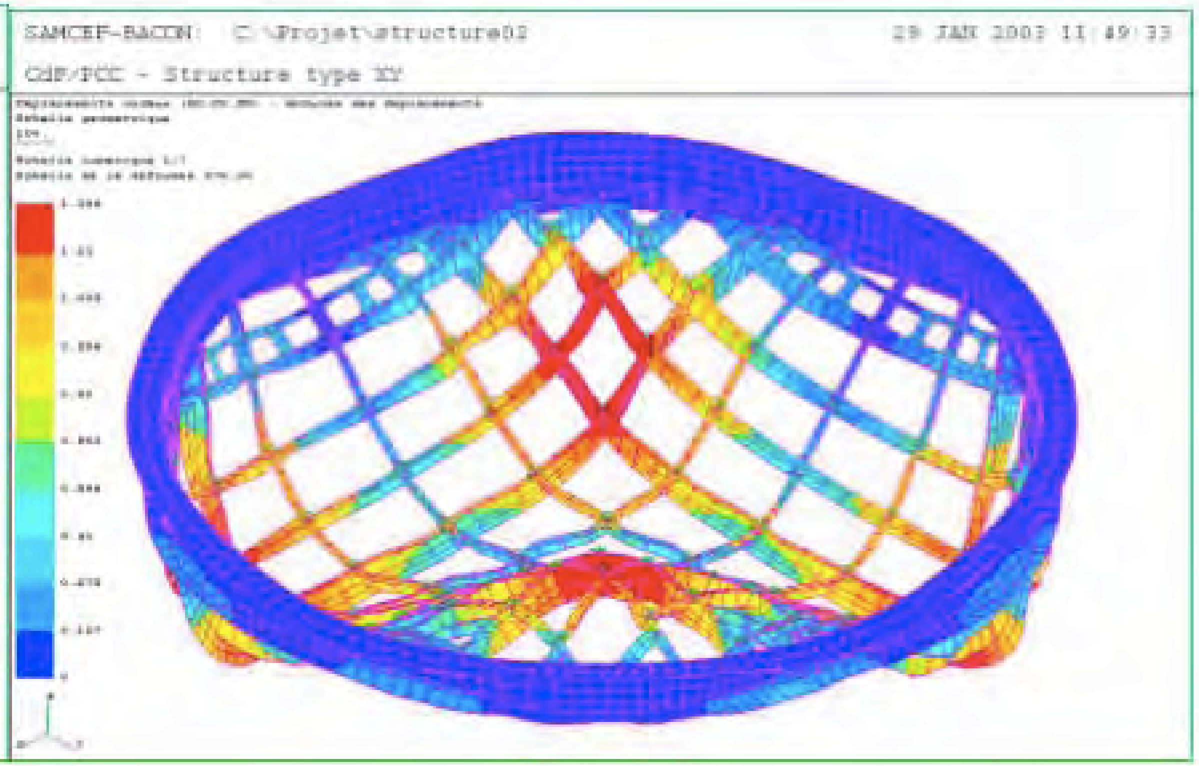






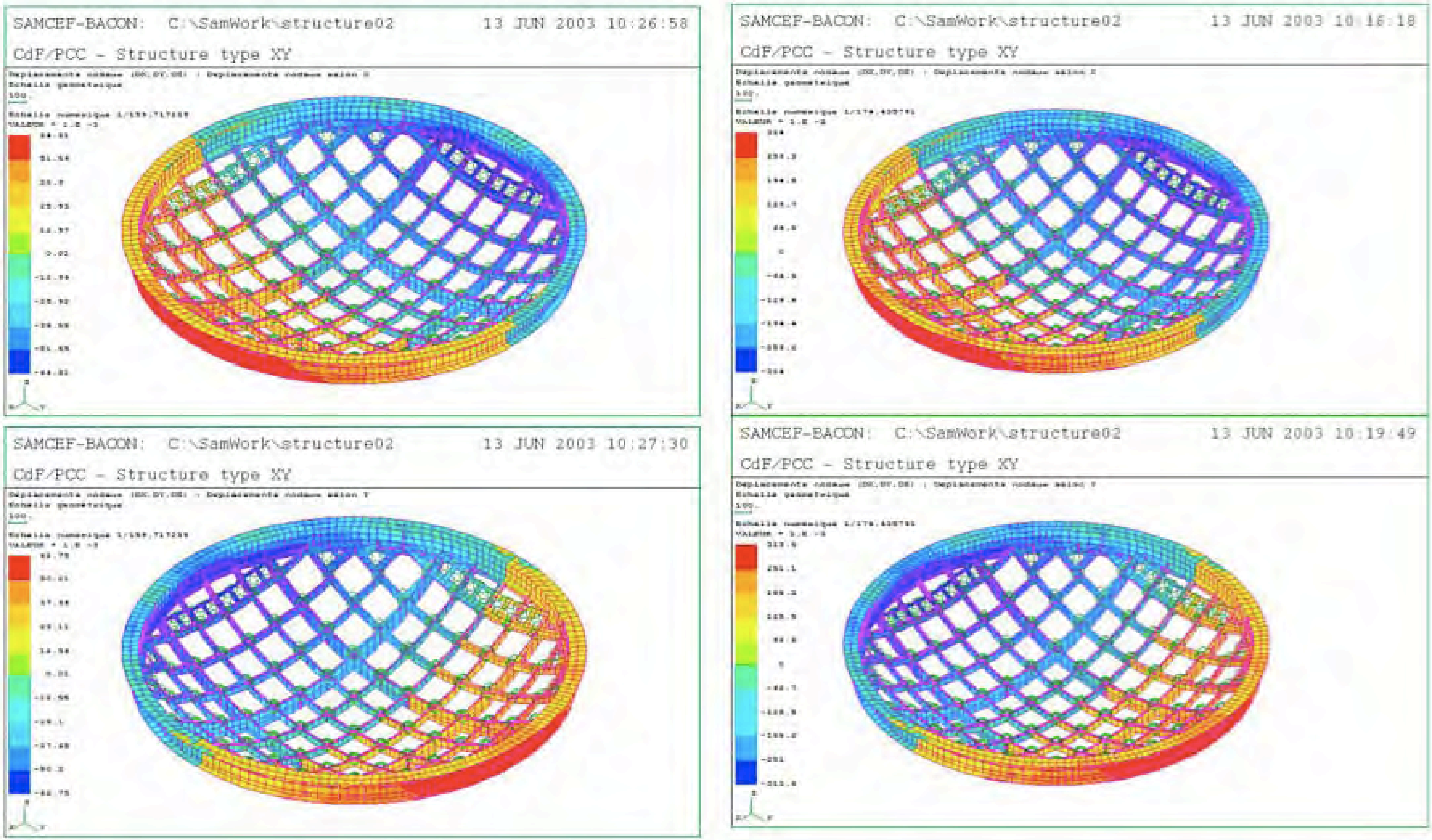
Vibrations





g) Supply to the Japanese team the focal surface structure that was designed in 2004 for ESA-EUSO phase A.

Thermal



f) Organisation of "Communications and Outreach" in Europe.

Mainly François Vanucci (already there in ESA-EUSO)

1) The Education and Public Outreach Program
   - information, to develop interest in the general public about science and technology, and
   - education, to reach the young people within the educational system.

Society at large: a web site
Colleagues: Conferences, papers, etc.
Journalists
The general public
- A model of the experiment available for display in scientific museums.
- A display of large photographs in public areas such as airports, commercial centres, public gardens...
- A series of conferences for the public at large.
- A film tracing the progress of the EUSO experiment since its beginning.
- A book on "EUSO and the cosmic rays".

Teachers: conferences, lab visits...
Students: experiments on cosmic rays

2) Communication within the Consortium
   Web site
   News bulletin

3) Plans and Needs
   Contacts with museums
   Money

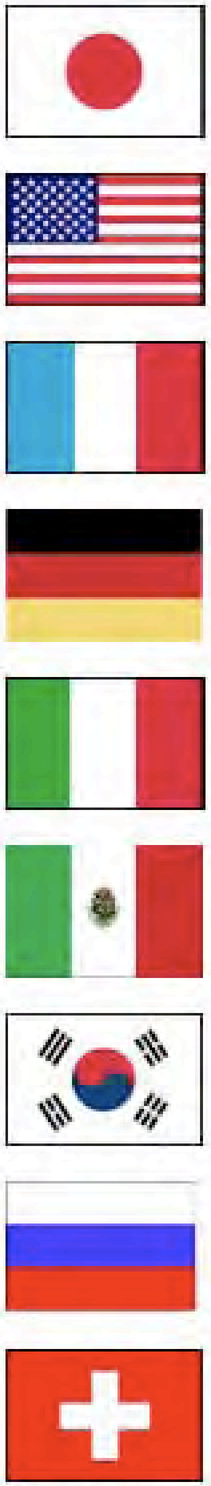
c) Advice on systems engineering and project management to the JEM-EUSO collaboration.

It will be nearly impossible to prevent the french part of the collaboration not to do that!

e) Participation in mission planning, operations and data analysis.

Naturally!

JEM-EUSO Collaboration



- **Japan** : T. Ebisuzaki, Y. Uehara, H. Ohmori, Y. Kawasaki, M. Sato, Y. Takizawa, T. Wada, K. Kawai (*RIKEN*), F. Kajino, M. Sakata, H. Sato, Y. Yamamoto, N. Ebizuka, (*Konan Univ.*), M. Nagano, Y. Miyazaki (*Fukui Inst. Tech.*), N. Sakaki, T. Shibata (*Aoyama Gakuin Univ.*), N. Inoue (*Saitama Univ.*), Y. Uchihori (*NIRS*), K. Nomoto (*Tokyo*), Y. Takahashi (*Tohoku Univ.*), M. Takeda (*ICRR, Univ. Tokyo*), Y. Arai, Y. Kurihara, H.M. Shimizu, J. Fujimoto (*KEK*), S. Yoshida (*Chiba Univ.*), K. Asano, S. Inoue, Y. Mizumoto, J. Watanabe (*NAOJ),* H. Ikeda, M. Suzuki, T. Yano (*ISAS, JAXA*), T.Murakami, D. Yonetoku (*Kanazawa Univ.*), N. Sugiyama *(Nagoya*), Y. Ito (*STEL, Nagoya Univ.*), S. Nagataki (*YITP, Kyoto Univ.*), A. Saito(*Kyoto Univ.*), S. Abe, M. Nagata (*Kobe Univ.*), T. Tajima (*KPSI, JAEA*)
- **USA** : J. H. Adams Jr., S. Mitchell, M.J. Christl, J. Watts Jr., A. English, R. Young (*NASA MSFC*) , Y. Takahashi, D. Gregory, M. Bonamente, P. Readon, V. Connaughton, K. Pitalo, J.Hadaway, J. Geary,R. Lindquist, P. Readon (*Univ. Alabama in Huntsville*), H. Crawford, C. Pennypacker (*LBL, UC Berkeley*), K. Arisaka, D. Cline (*UCLA*), T. Weiler, S. Czorna (*Vanderbilt Univ.*)
- **France** : J-N. Capdevielle, P. Gorodetzky, P. Salin (*CNRS*), J. Dolbeau (*Coll. de France*), T. Patzak, F. Vanucci (*Univ. Paris 7*), J. Weisbard *(IN2P3)*
- **Germany**: M. Teshima, T. Schweizer (*Max Planck Munich*), A. Santangelo (*Tuebingen*), P. Biermann (*MPI Bonn*), K. Mannheim (*Wuerzburg*)
- **Italy** : S. Bottai. P. Spillantini, A. Zuccaro (*Firenze*), A. Anzalone, O. Catalano, M.C. Maccarone, P. Scarsi, B. Sacco (*IAS-PA/INAF*), G. D'Ali Saiti (*U. Palermo*), B. Alpat, R. Battiston, B. Bertutti, E. Fiandrini, P. Zuccon (*Perugia*), M. Casolino, M.P. De Pascale, A. Morselli, P. Picozza, R. Sparvoli (*Roma 2*), A. Cappa, M. Dattoli, P. Vallania (*INAF-IFSI Torino*), P. Galleotti, C. Vigorito, M. Bertaina (*Univ. Torino*), A. Gregorio (*Trieste*)
- **Mexico**: G. Medina-Tanco, J.C. D'Olivo, J.F.Valdes (*Mexico UNAM*), H. Salazar, O. Martines (*Puebla*), L. Villasenor (*UMSNH*)
- **Republic of Korea** : S. Nam, I. H. Park (*Ehwa W. Univ.*)
- **Russia**: Garipov G.K., Khrenov B.A., Klimov P.A. Panasyuk M.I., Yashin I.V. (*SINP MSU*), Naumov, D., Tkachev. L (*Dubna JINR*)
- **Switzerland** : A. Maurissen, V. Mitev (*Neuchatel, Switzerland*)