JEM-EUSO mission: Doing Astronomy by looking down to the Earth

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CRCタウンミーティング2012年6月30日東京工業大学

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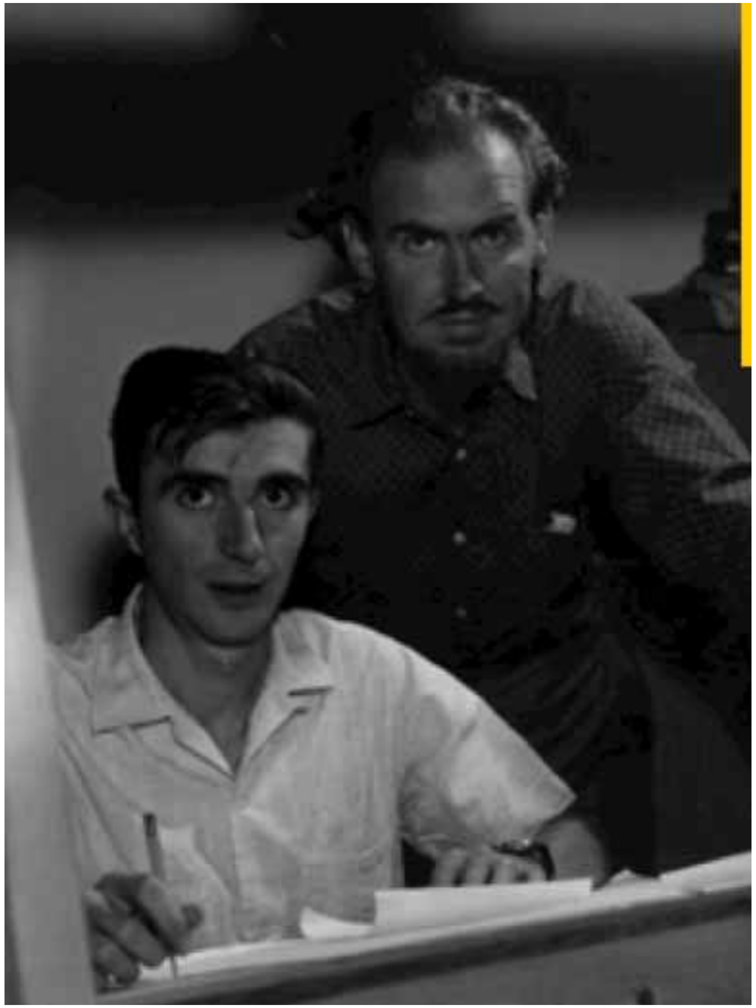
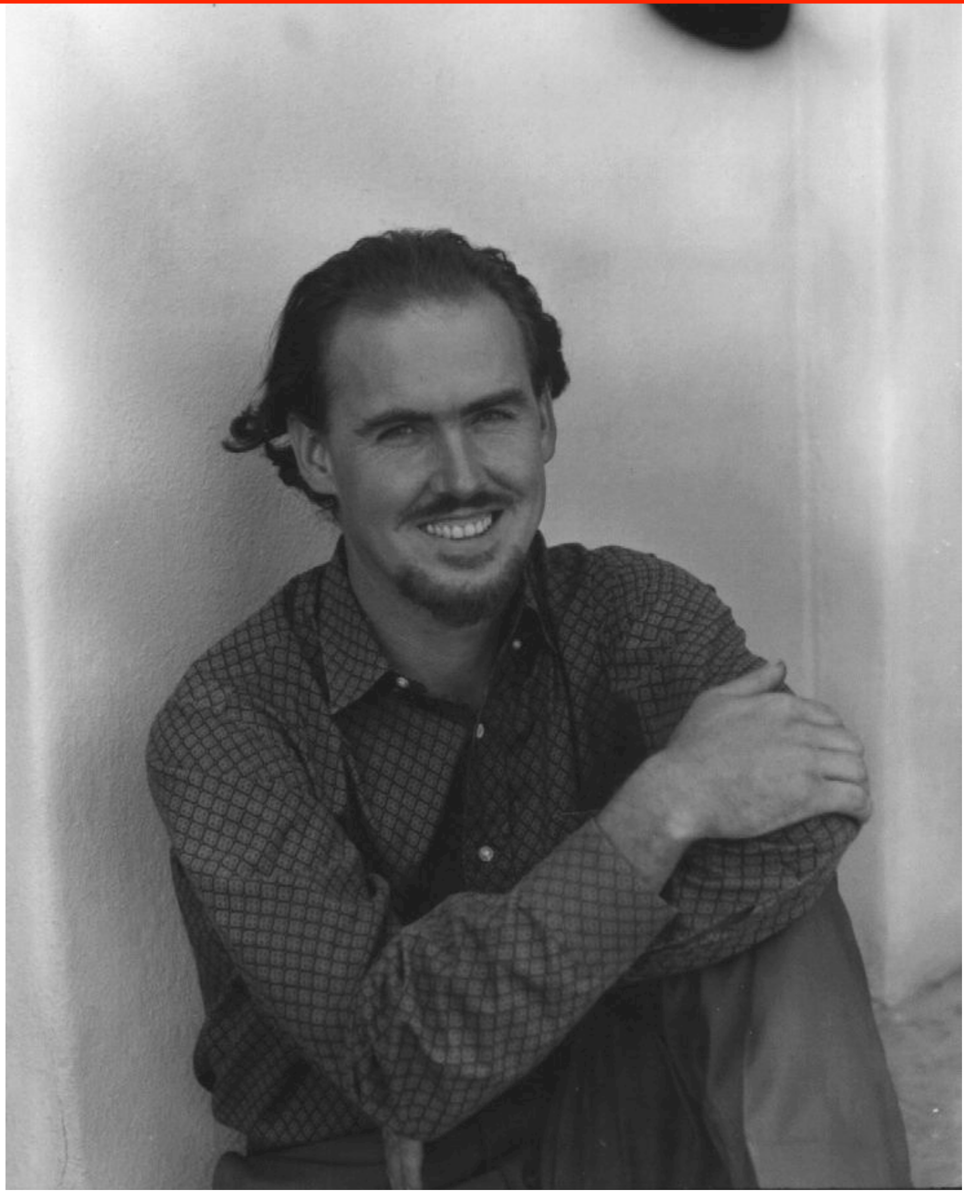
3人の巨人
John Linsley, Livio Scarsi, and 高橋義幸



1979, John Linsleyのアイデア

SOCRAS: Satellite Observatory of Cosmic Ray Showers



John Linsley in 1979 in the Field Committee Report of NASA "Call for Projects and Ideas in High Energy Astrophysics for the 1980s"

The concept to observe, by means of Space Based devices looking at Nadir during the night, the fluorescence light produced by an EAS proceeding in the atmosphere

In Early 1990s John had moved to Palermo to work on the PLASTEX experiment with his old friend Livio Scarsi, and Osvaldo Catalano

高橋義幸 1995

- フレネルレンズ
  - 視野を±30度まで拡大
- 観測領域 100,000 km^2

Livio Scarsi, EUSO PI

First 10^{20} eV event (1963 Phys.Rev. with J. Linsley), PI (Beppo-SAX and EUSO)

2000-2004 EUSO on Columbus (ISS)

EUSO

Vincent Van Gogh, “The starry night”

The EUSO submitted to ESA in Oct. 1999 (as F2-F3 missions) was re-oriented to a payload for the ISS

Extreme Universe Space Observatory

2000-2001 Preliminary Accomodation study by D/MSM and D/SCI

ESA Phase A studies March 2002-2003


EUSO General
Meeting, Annecy
October 2001

EUSO General Meeting, Huntsville, May, 2002

Space Shuttle Columbia Disaster
1st of February 2003

he new dream started at the EUSO Re-foundation meeting in Nov. 2005, in ESTEC

EUSO Historical Remark

- 2004/July:
  - Phase-A study **successfully completed** and approved at the ESA Final Review, including HTV alternative to STS.
- 2005/Feb - Nov: EUSO Re-foundation began, but
  - ESA Phase-B was **postponed for a long time** because of the D/S financial problems and anti-ISS sentiments in Europe, ESA D/S Committees and ASI

- **Japanese and US teams of EUSO sought the possibility to put it on Exposure Facility of Japanese Experiment Module of ISS. (L. Scarsi agreed/encouraged it Jan 2006)**

→ **JEM/EUSO**

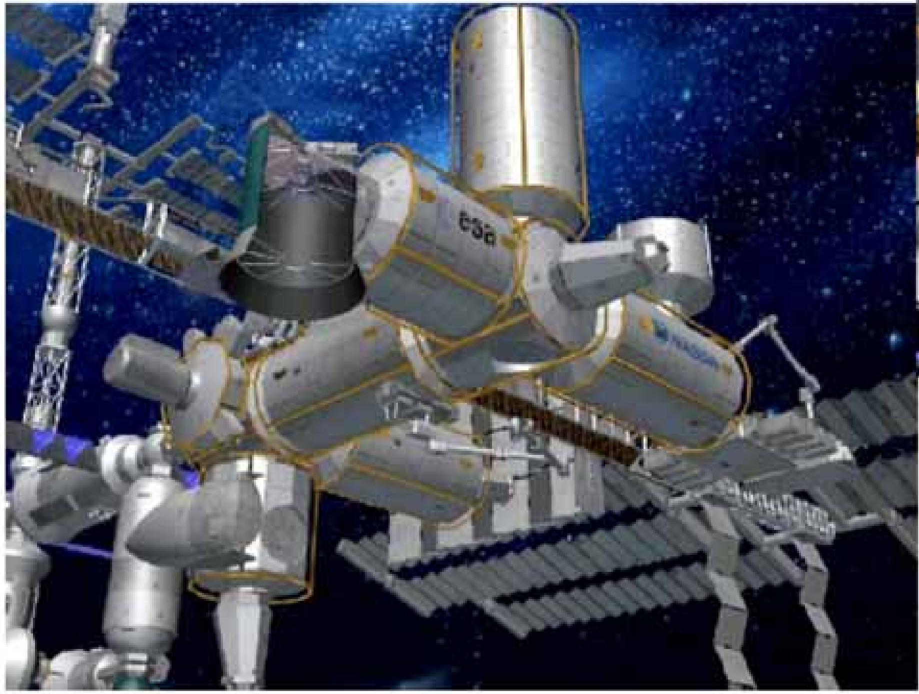
*Y. Takahashi's presentation 2006

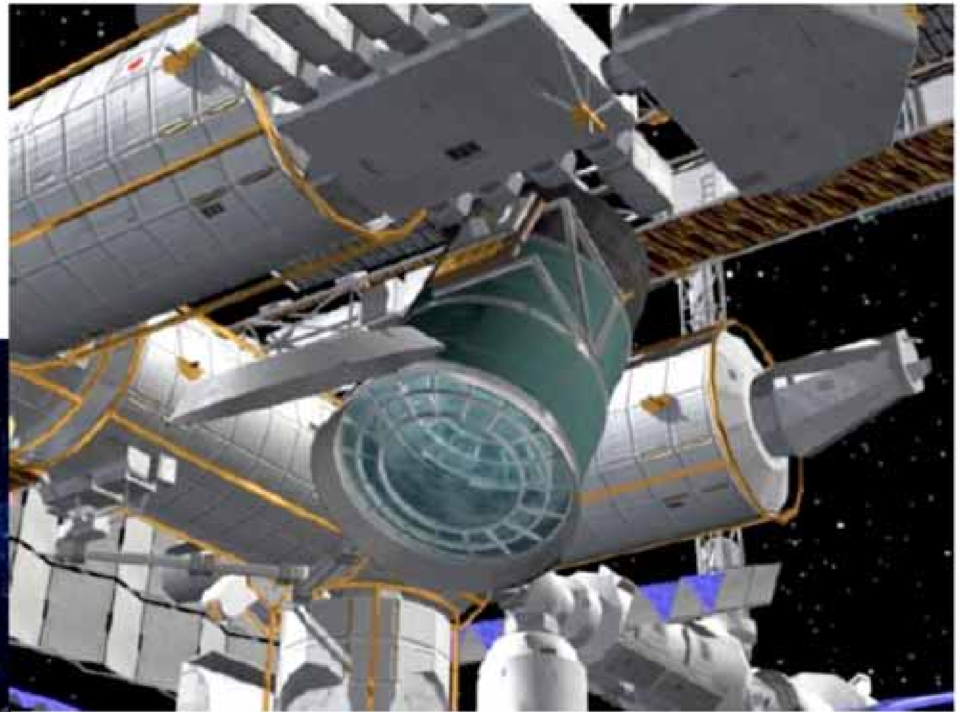
JEM-EUSO Kick-off meeting, June 6-8 2007

EUSO and JEM-EUSO: A Mission to Explore the Extremes of the Universe using the Highest Energy Cosmic Rays and Neutrinos by observing Earth

ESA CEPF case

Launch by STS (2000-4)





JEM EF case
JEM-EUSO launch by HTV

*Y. Takahashi's presentation 2006

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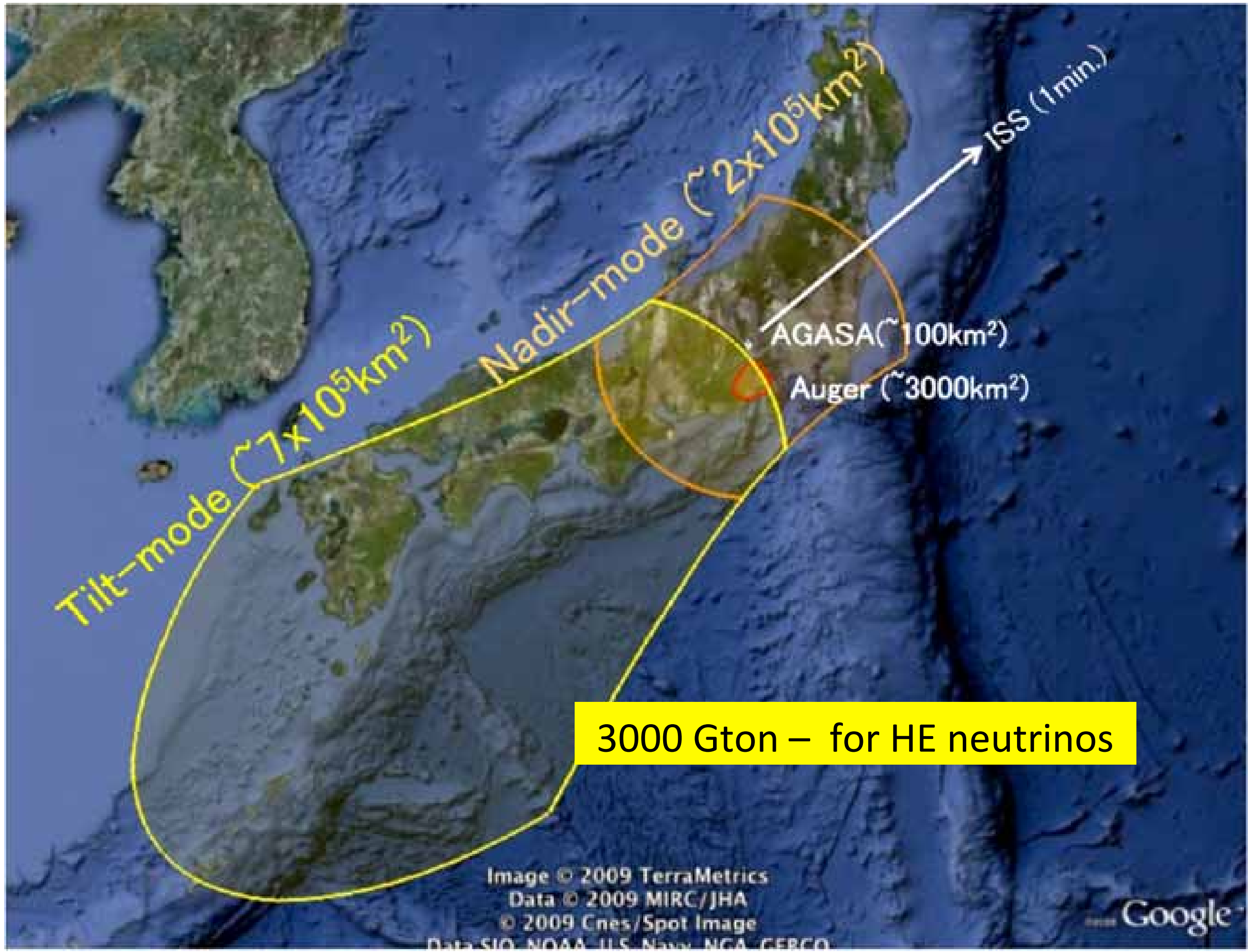
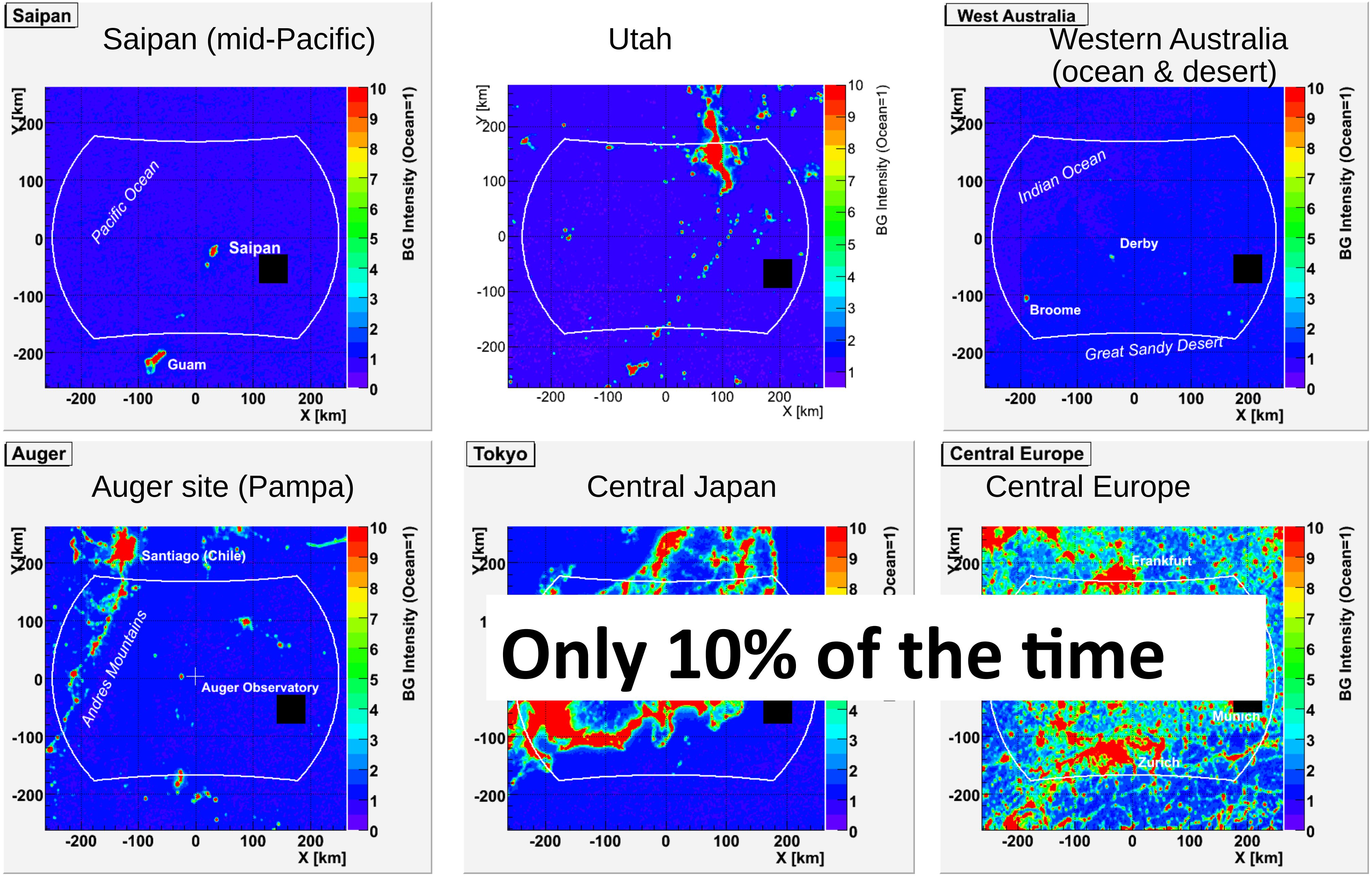
the huge exposure area





Only 10% of the time

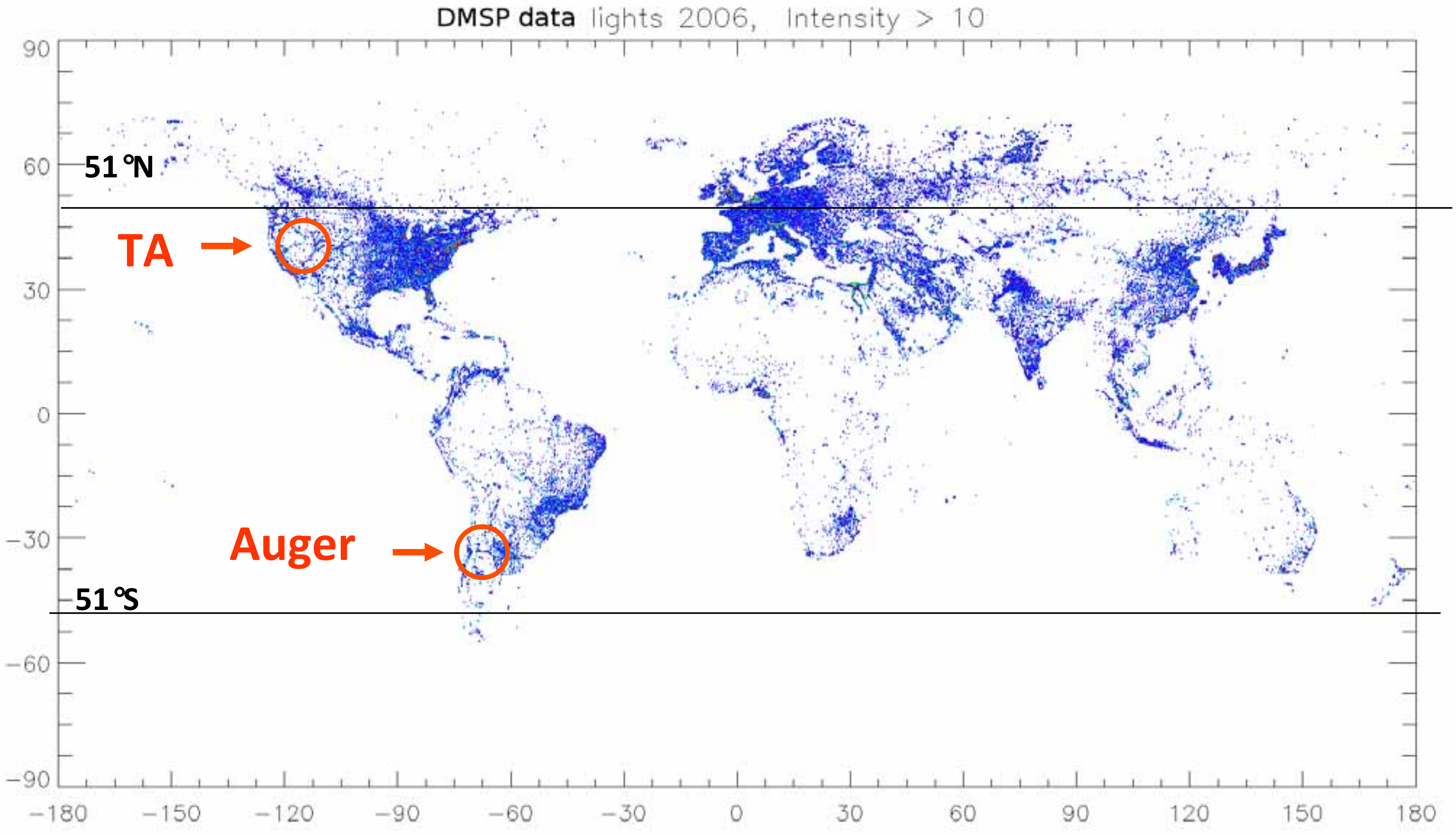
FoV of 1 PDM (27km x 27 km) ■

BG Ocean = 1 = 500 ph/m²/ns/sr

In the city impact we assumed that 1 PDM is blind if 1 km x 1km area sees $I > I_o$

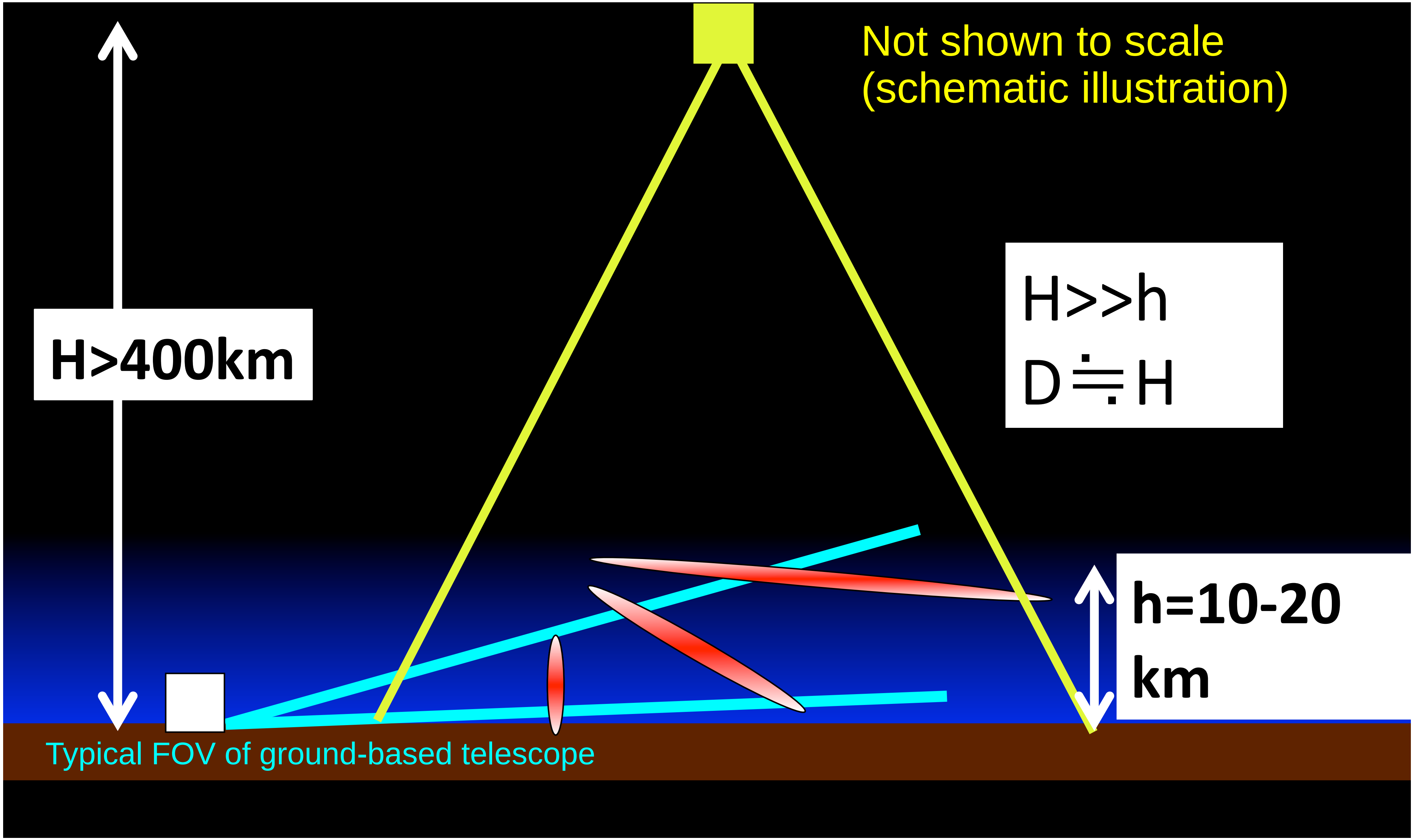
City lights – selection from DMSP data

Intensity > 2000 ph/m^2/ns/sr (9% of FoV)



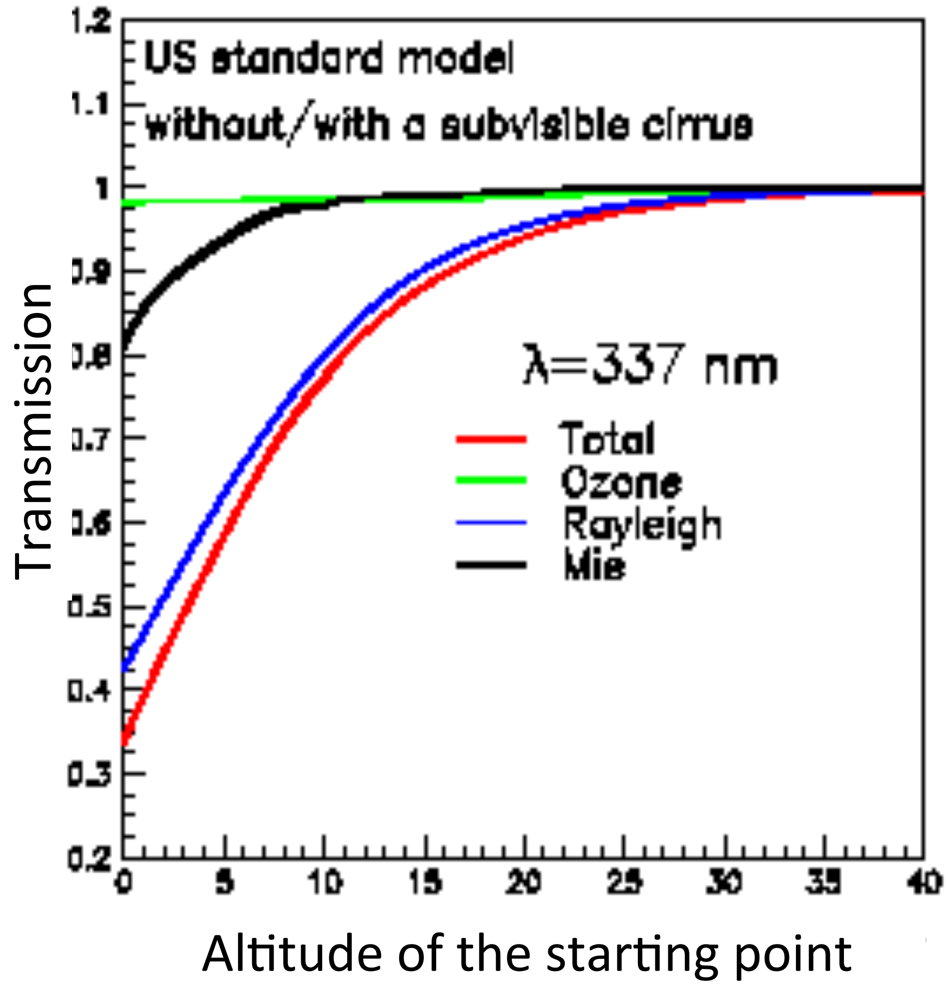
P. Bobik, JEM-EUSO simulation meeting, Kosice, 2011

シャワーまでの距離が幾何学で決まっているステレオ観測は必要ない



上半分の大気は下半分より透明

- 下半分
  - ダストが多い
  - 雲が多い
  - レイリー散乱が強い



雲の被覆率

Clear sky ~ 29%
Green band ~ 60%

F.Garino et al., ID398

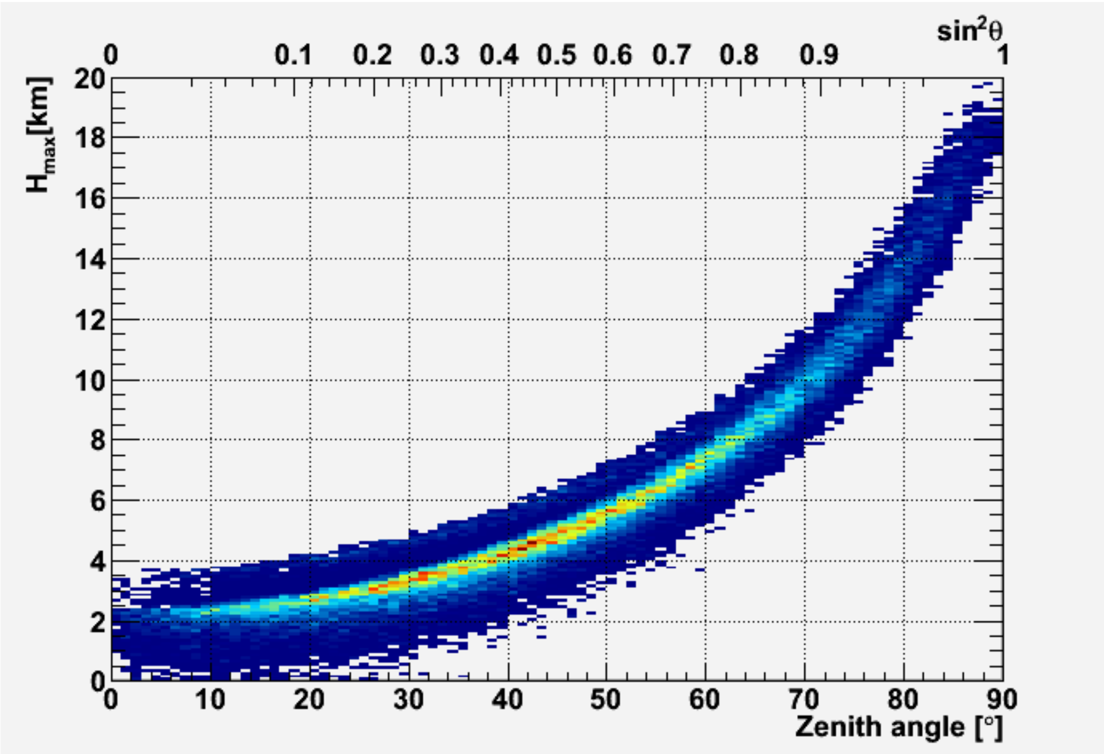
Cloud top

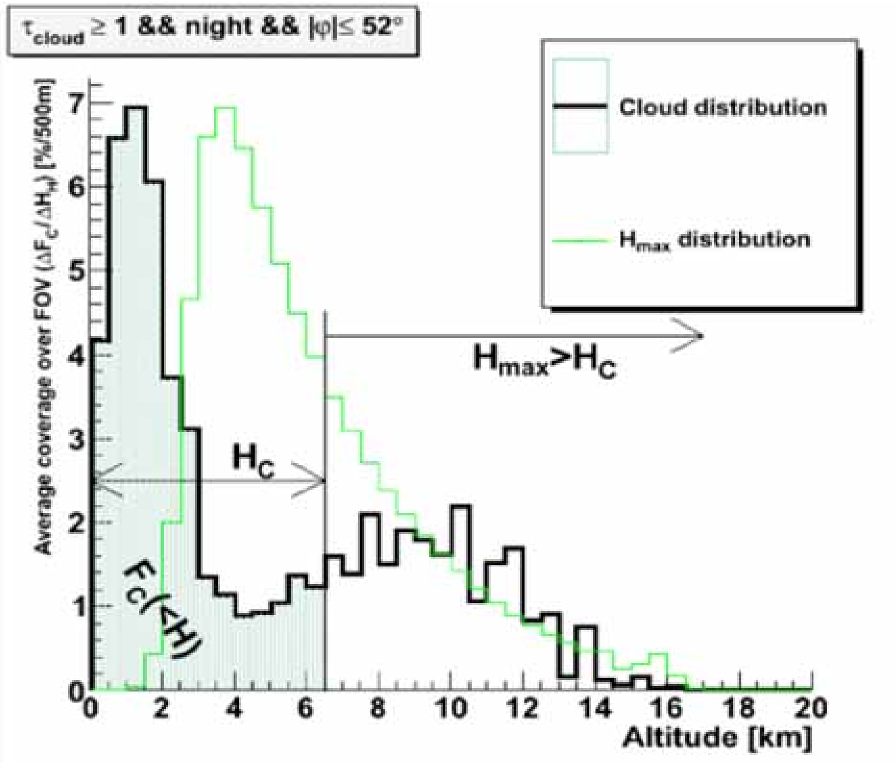
Optical Depth	<3 km	3-7 km	7-10 km	>10 km
OD>2	17.2	5.2	6.4	6.1
OD:1-2	5.9	2.9	3.5	3.1
OD:0.1-1	6.4	2.4	3.7	6.8
OD<0.1	29.2	<0.1	<0.1	1.2

Occurence of clouds (in %) between 50° N and 50° S on TOVS database.
The matrix Optical depth vs. Cloud-top altitude is shown.

Confirmed by ISCCP,CACOLO & MERIS database

Cloud impact for shower maximum observability





- Large ZA EAS has limited cloud impact

雲の被覆率

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F.Garino et al., ID398

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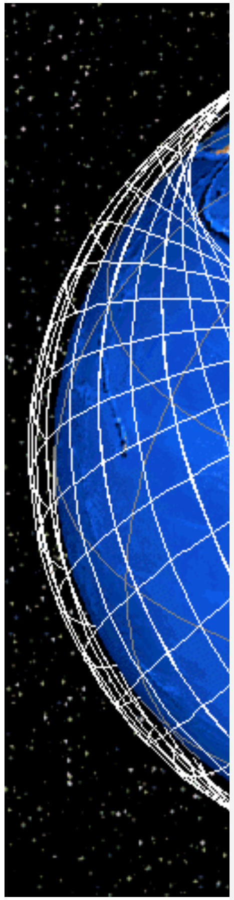
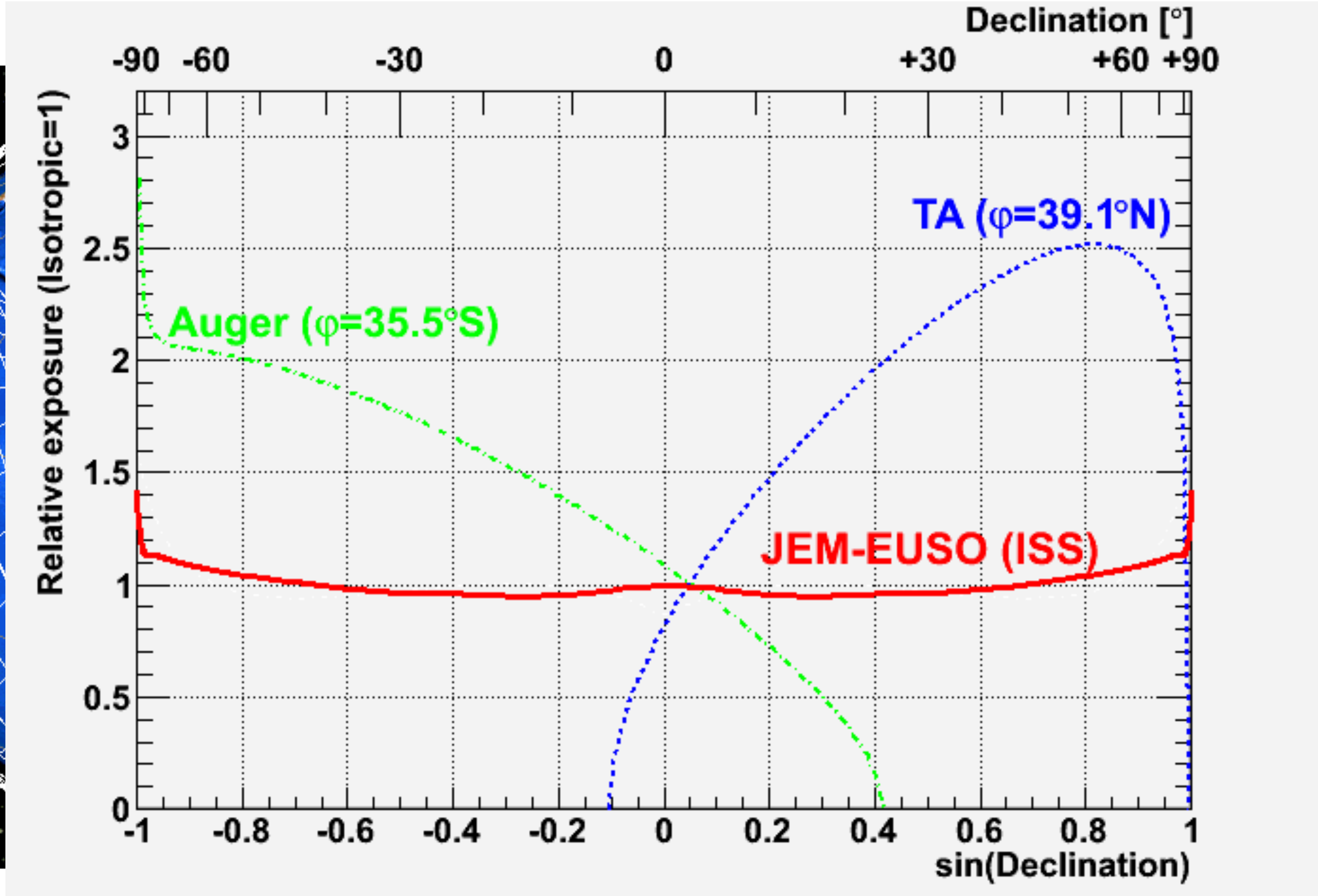
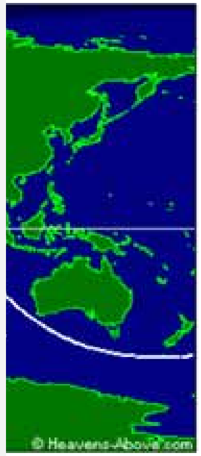
Occurence of clouds (in %) between 50° N and 50° S on TOVS database.
The matrix Optical depth vs. Cloud-top altitude is shown.

Confirmed by ISCCP,CACOLO & MERIS database

ほぼ一様な露出（南北天球）







http://www.nisa.com/

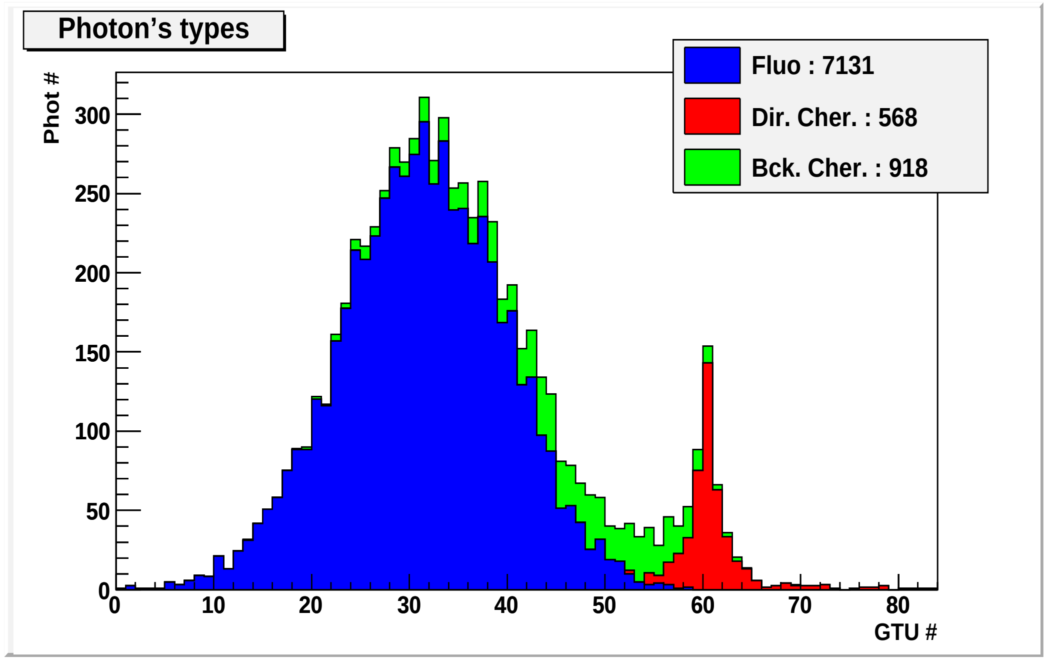
can
on of
ng to
the nature of the ISS orbit.

全球をカバー

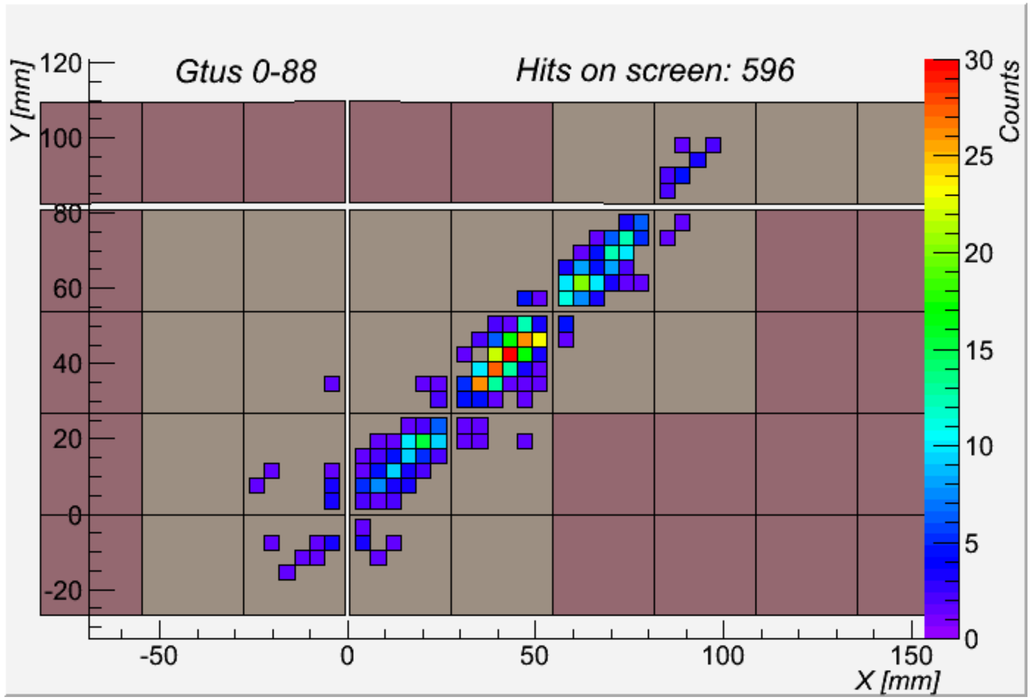
Contents

JEM EUSOコラボレーション

- 日本、米国、韓国、メキシコ、ロシア
- ヨーロッパ：ブルガリア、フランス、ドイツ、イタリア、ポーランド、スロバキア、スペイン、スイス
- 77 機関、250人以上の研究者
- 理研：：取りまとめ機関



GTU time units



a) 蛍光光

b) 散乱チェレンコフ光

c) 地上散乱チェレンレンコフ光

$$1\,GTU = 2.5\ \mu\text{sec}$$

$$Back. = 500\,/\,(\text{m}^2\ \text{sr ns})$$

高速のシグナル

$$duration \approx 50 - 150\ \mu s$$

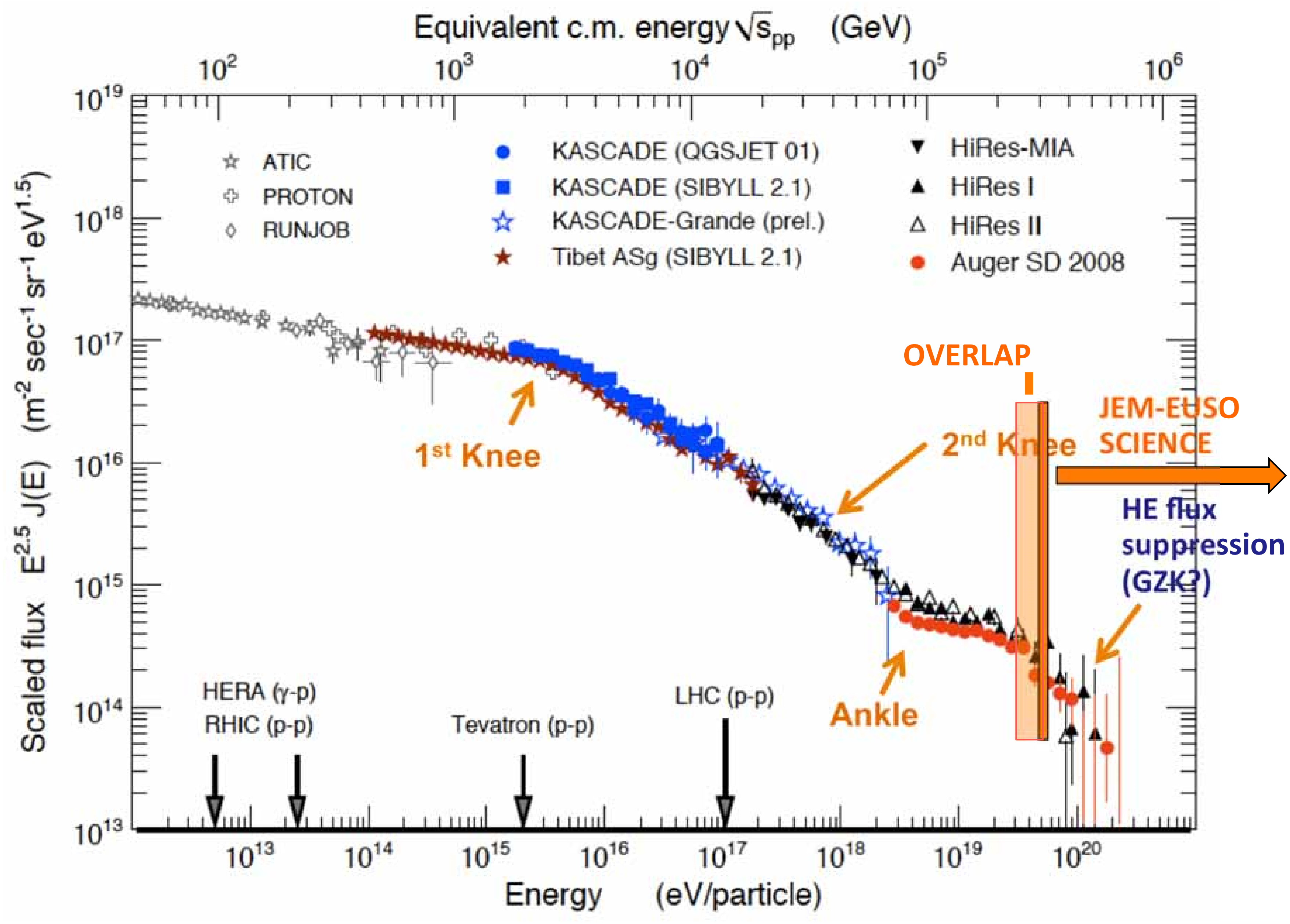
Simulation of the light profile observed at the entrance pupil (above) and of the observed shower image (using the ESAF code)

基本科学目的

- 荷電粒子天文学の確立
  - *高統計到来方向解析による線源の同定*
  - *個々の線源のエネルギースペクトル測定*
  - GZK構造の高統計測定

E>5.×10^{19}eVにおける物理と天文学

JEM-EUSO EE target region



UHECR status in just one word

Previous to Auger / HiRes :

$$\frac{1 \text{ particle}}{100\ km^2\ yr\ sr}$$

UHECR status in just one word

Previous to Auger / HiRes :

$$\frac{1 \text{ particle}}{100 \ km^2 \ yr \ sr}$$

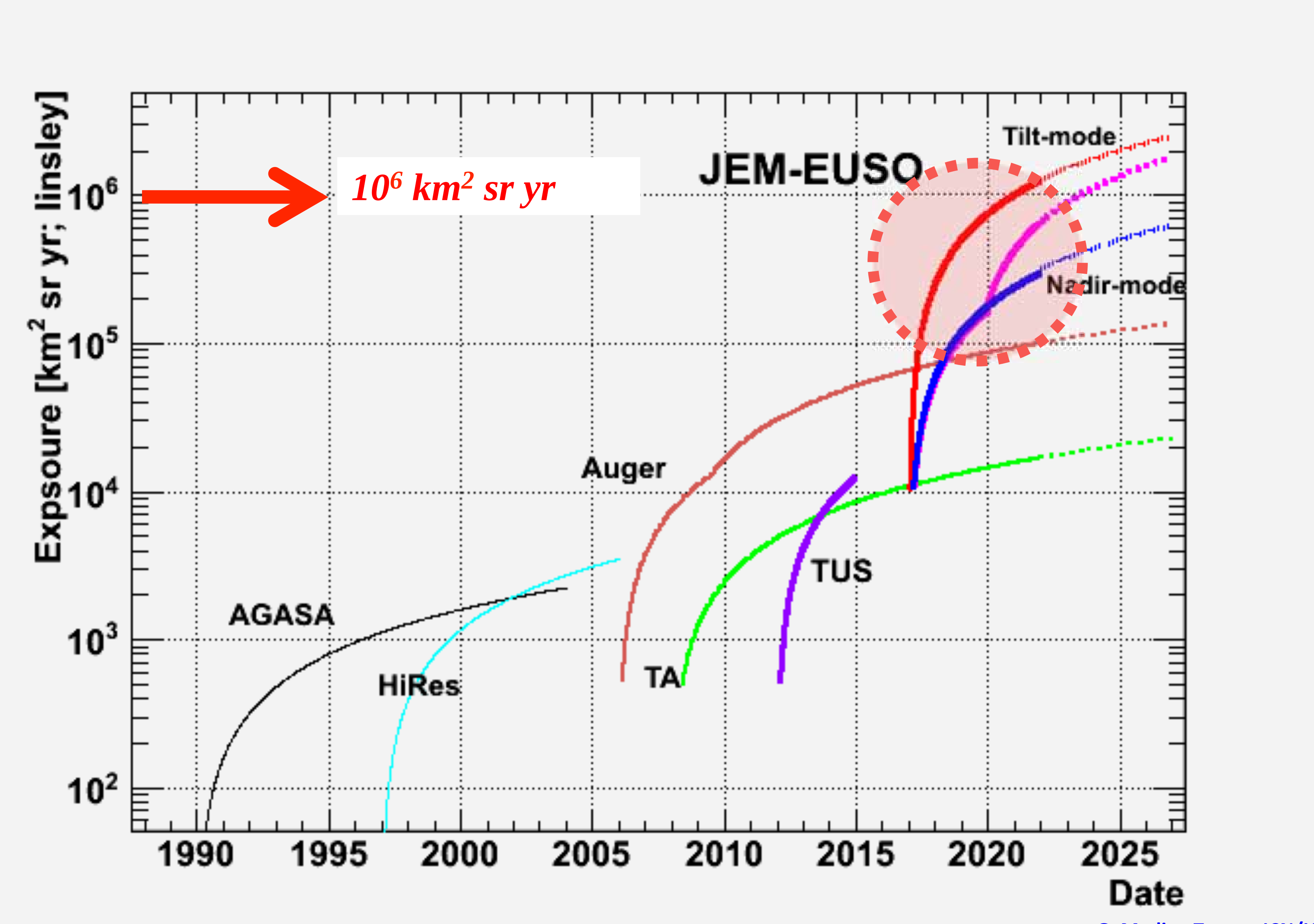
Key Auger / HiRes result:

$$\frac{1 \text{ particle}}{\cancel{100} \ km^2 \ yr \ sr}$$

1000

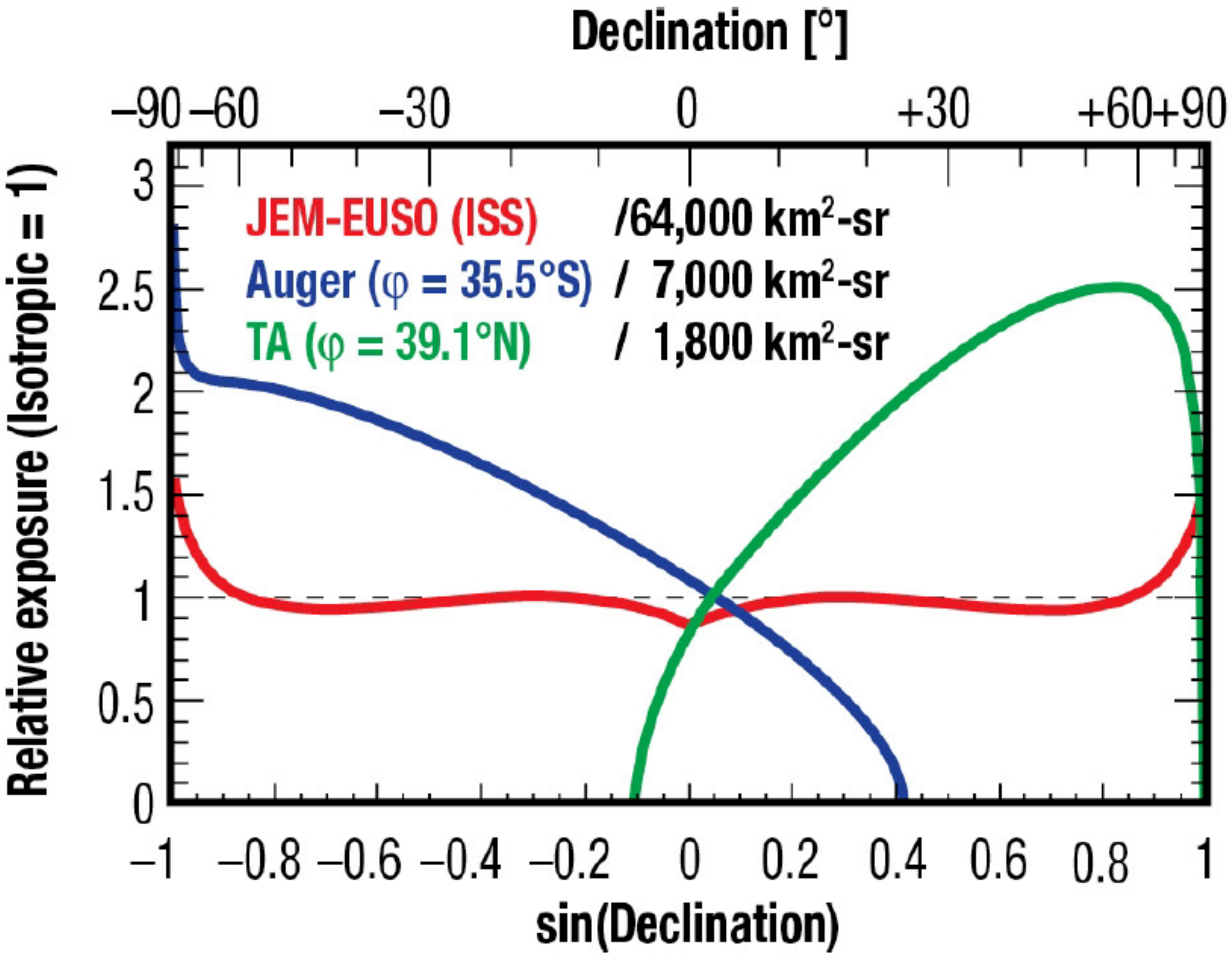
JEM-EUSO uniquenes

Large exposure + Full-sky coverage



G. Medina Tanco - ICN/UNAM

一様で大きな露出

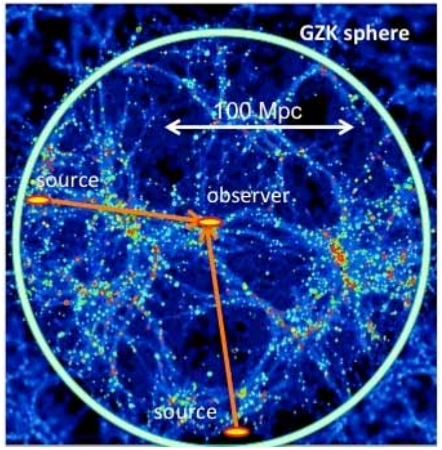


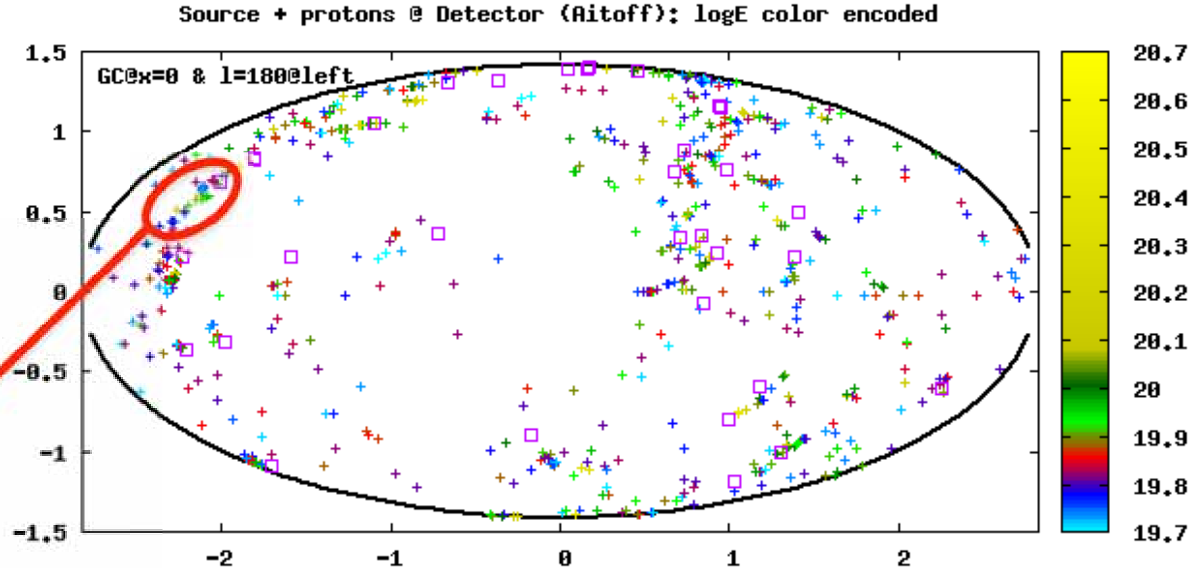
Declination [°]
−90 −60 −30 0 +30 +60+90
JEM-EUSO (ISS) /64,000 km2-sr
Auger (φ = 35.5°S) / 7,000 km2-sr
TA (φ = 39.1°N) / 1,800 km2-sr
Relative exposure (Isotropic = 1)
3 2.5 2 1.5 1 0.5 0
−1 −0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8 1
sin(Declination)

JEM-EUSO science potential

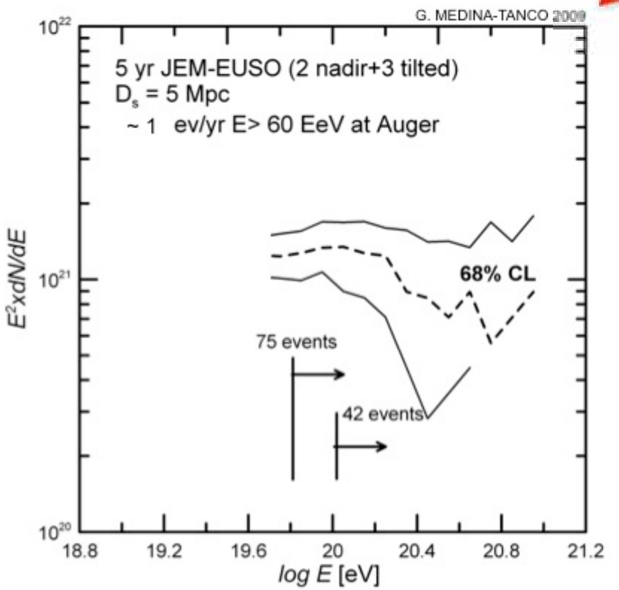
Single source astronomy

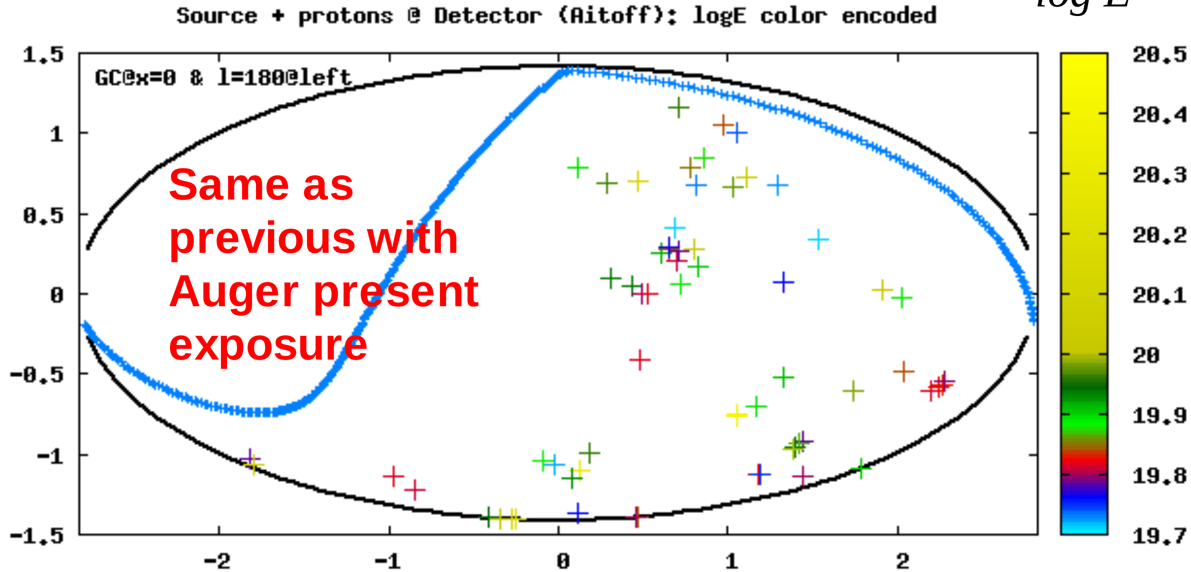
(1) PSF identification, (2) individual spectra, (3) multiplet statistical analysis,
(4) catalogue cross-correlation, (5) multiwavelength study, (6) GMF determination





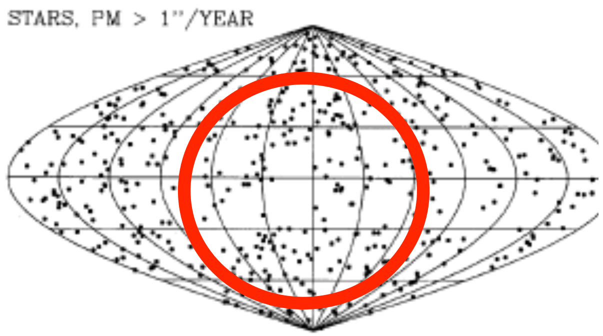
log E



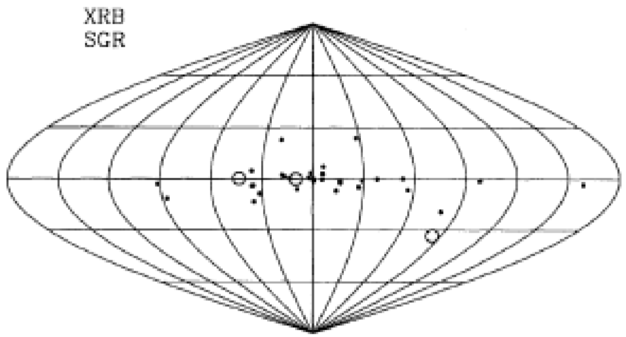


Distribution of Astronomical Objects

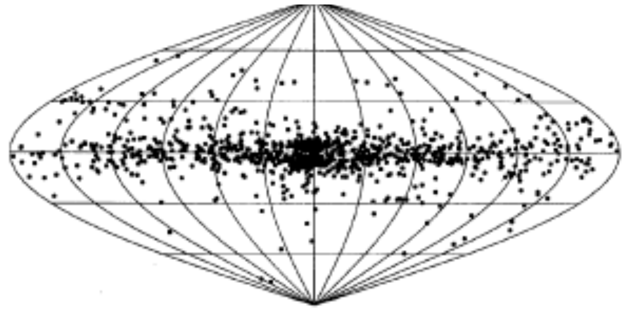
stars



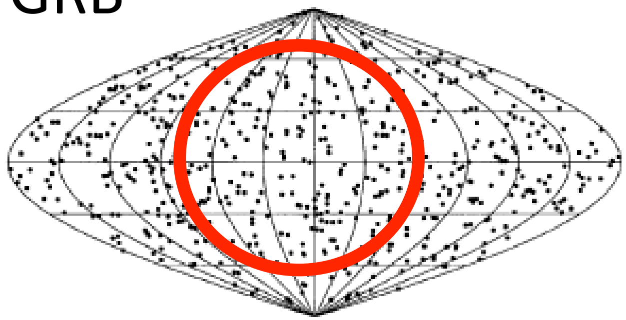
X-ray Burst



Planetary Nebulae



GRB



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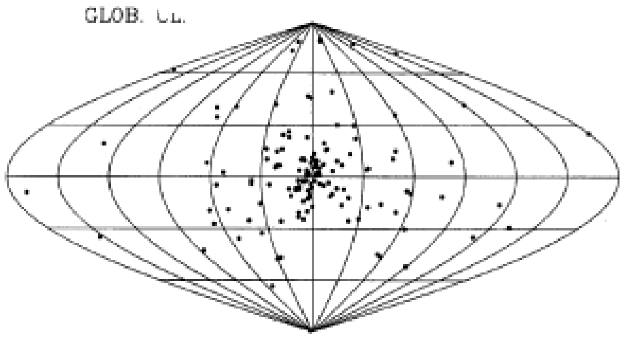
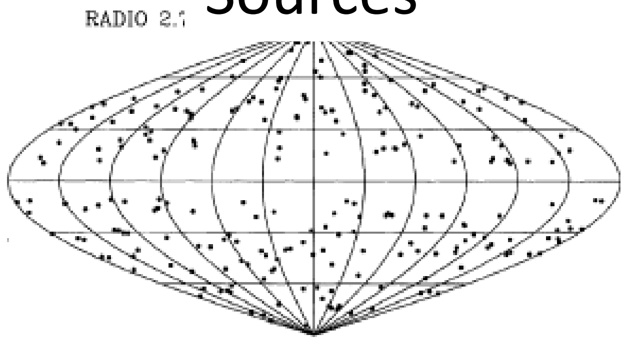
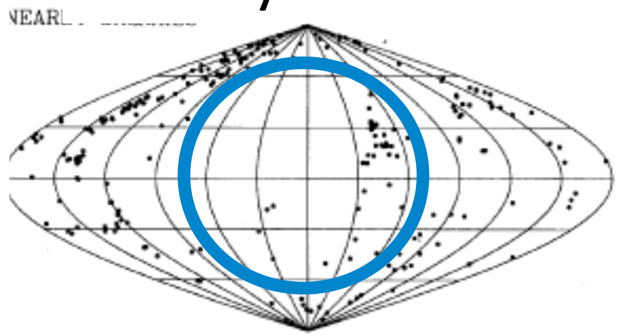
Globular Clusters



Radio Sources



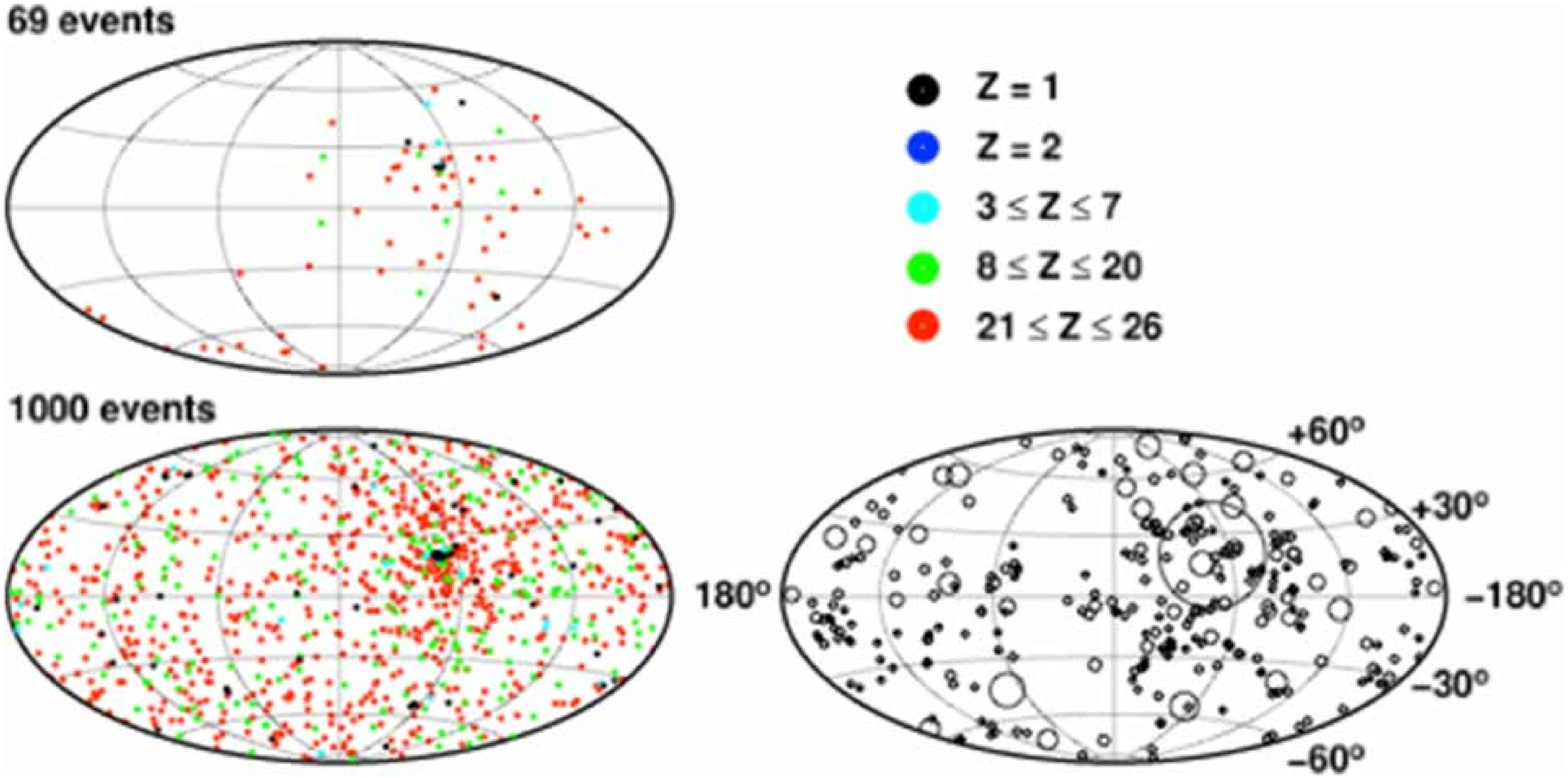
Nearby Galaxies



Arrival Distribution of Heavy Nuclei

A pessimistic case rather than a conservative case

- ✓ Pure Fe composition initially (astrophysically unrealistic, but most pessimistic)
- ✓ Almost upper limit values of GMF and IGMF



Arrival Distribution of Heavy Nuclei

A pessimistic case rather than a conservative case

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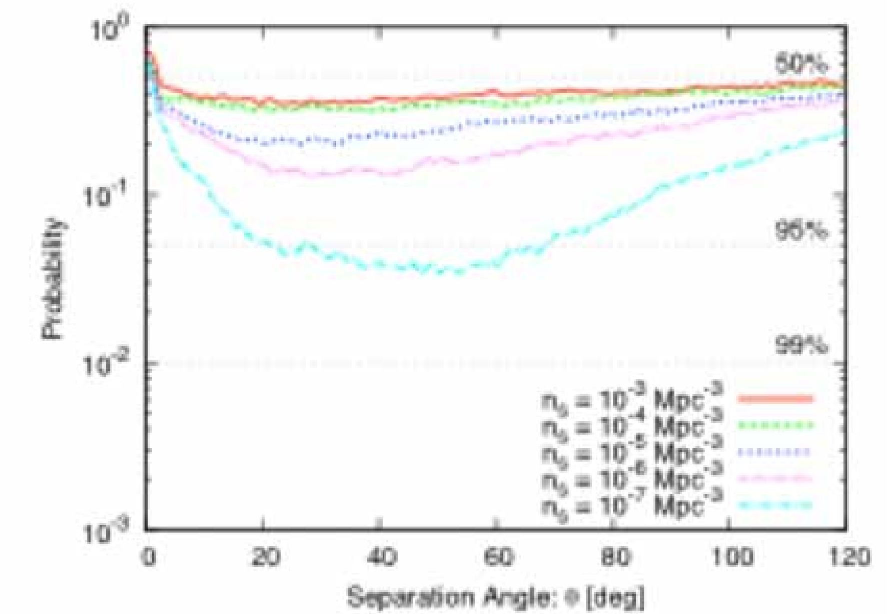
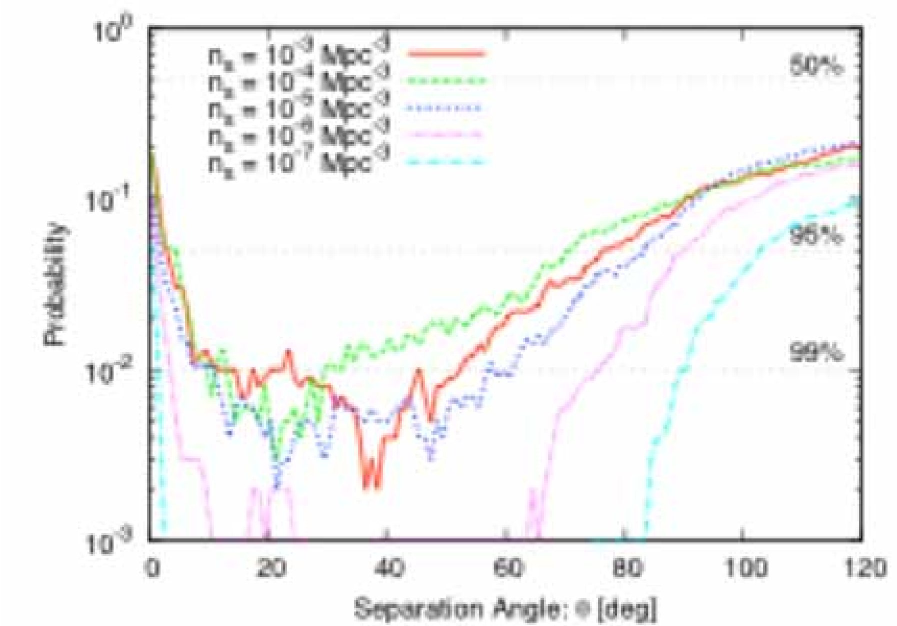
69 events Auger aperture



1000 events, Uniform aperture



- ✓ Anisotropy will appear with > 99%.
- ✓ Anisotropy from the nearest source is expected by JEM-EUSO.

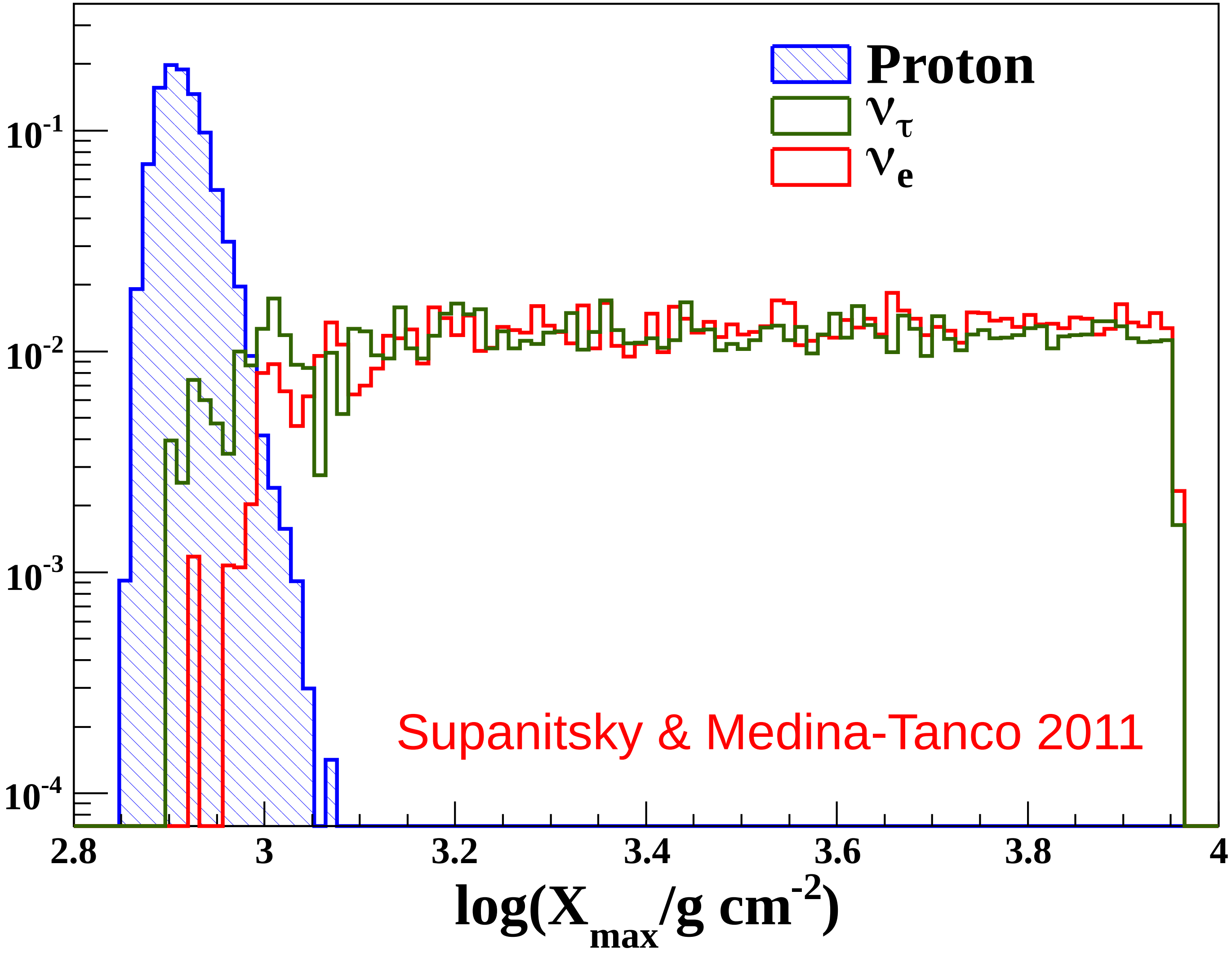
試験的探求研究

- 新メッセンジャー
  - *超高エネルギーニュートリノの検出*
    - X_0 and X_{max}
  - *超高エネルギーガンマ線の検出*
    - X_{max} の変化LPM effect

- 磁場magnetic fields
  - 銀河磁場と局所宇宙の磁場構造に制限

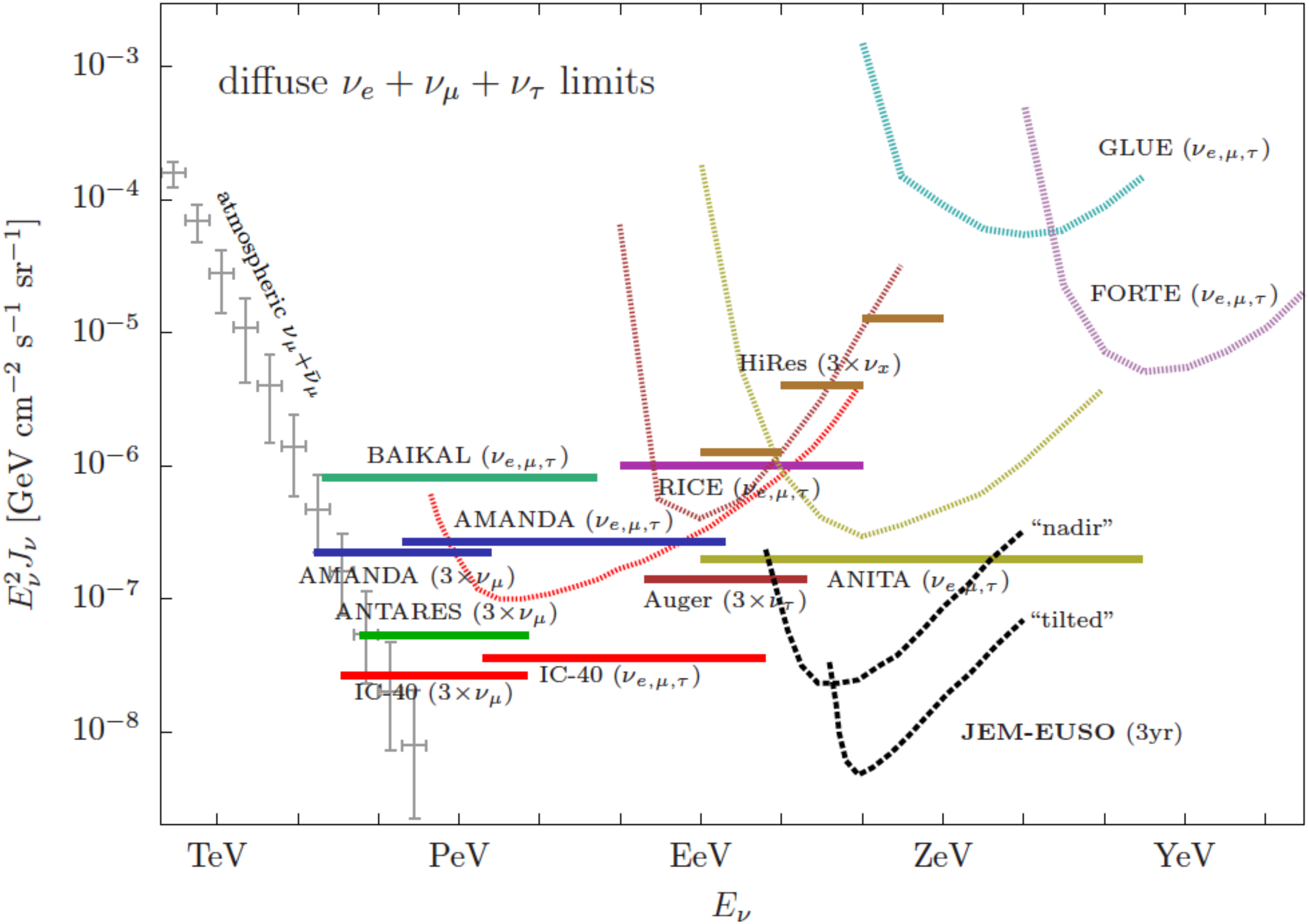
→ 高い発見能力と新しい物理への制限

ニュートリノ と陽子: X_{max}



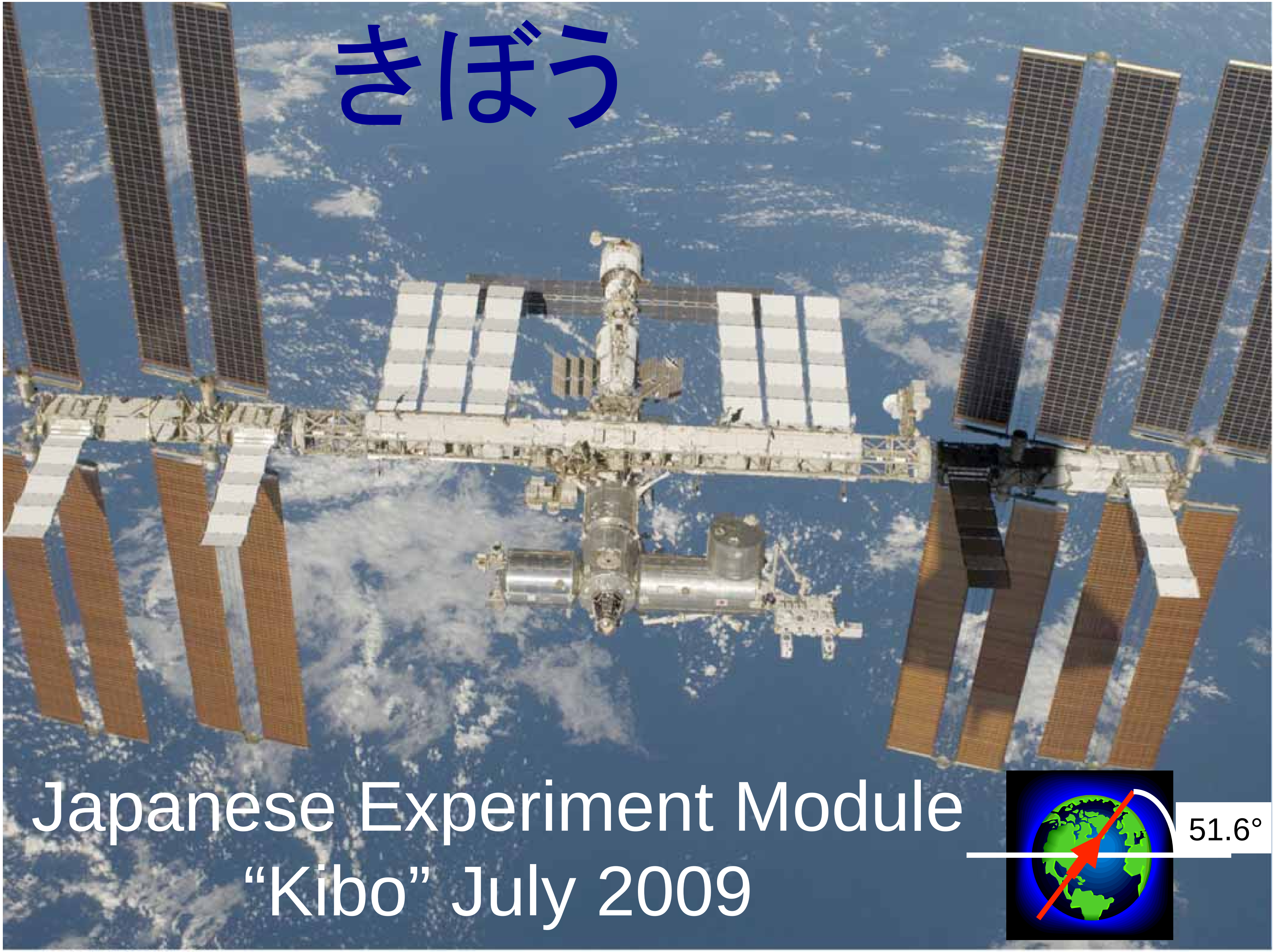
Distribution of X_{max} for protons and neutrinos for E=10^{20} eV and θ=85° (First Peak of the shower profile)

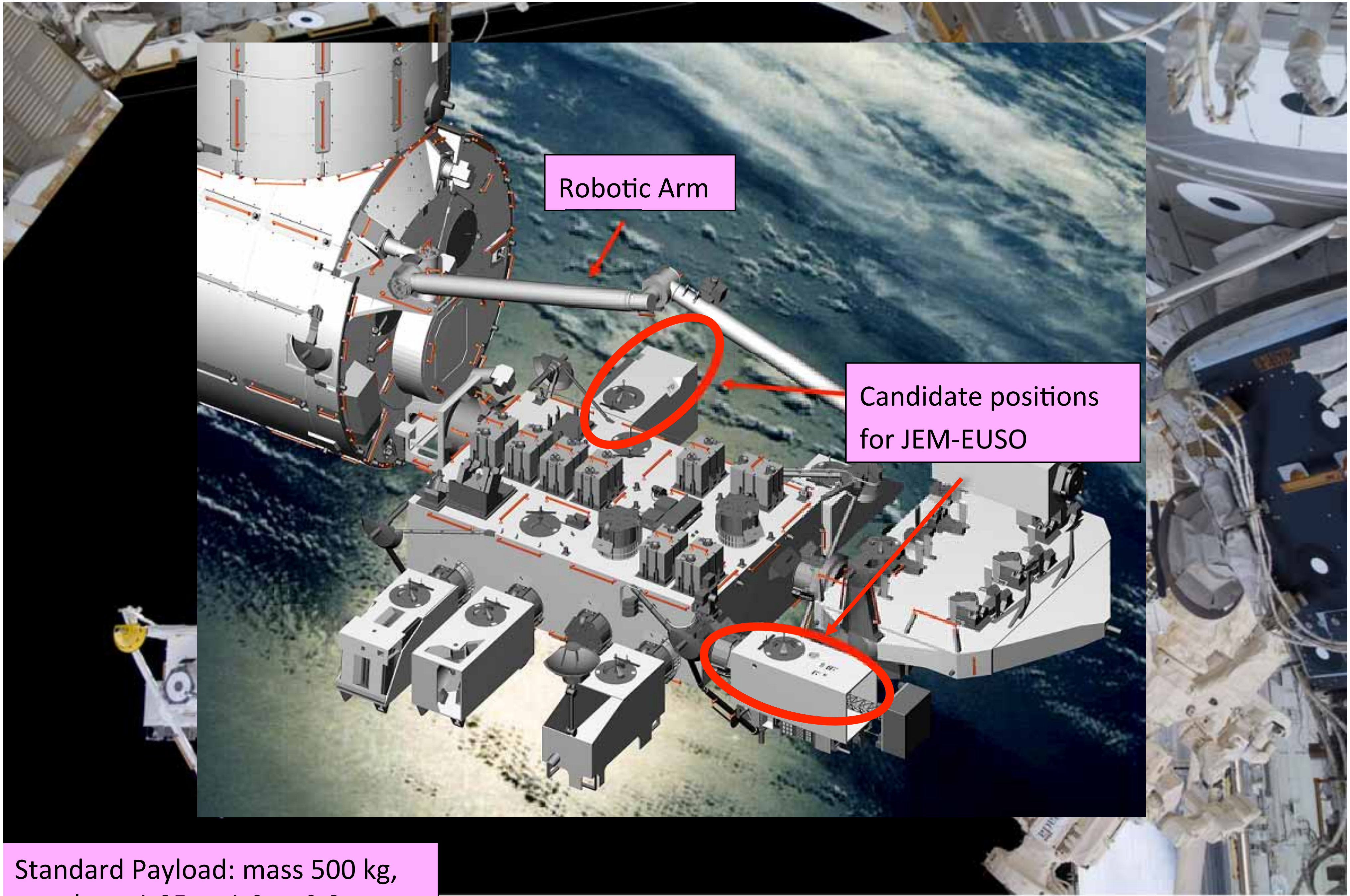
Upper limits on neutrino flux



Key observation and instrument requirements

Observation area (Nadir)	≥1.3×10^5 $(H_{orbit}/400[km])^2$ km^2
Arrival direction determination accuracy	≤ 2.5° (at E=10^{20} [eV] and 60° zenith angle)
Energy determination accuracy	≤ 30% (E=10^{20} [eV] and 60° zenith angle)
X_{max} determination accuracy	≤ 120 [g/cm^2] (E=10^{20} [eV] and 60°zenith angle)
Energy threshold	≤ 5.5×10^{19} [eV]
Duty cycle	≥ 17%
Lifetime	> 3 years (goal: > 5 years)

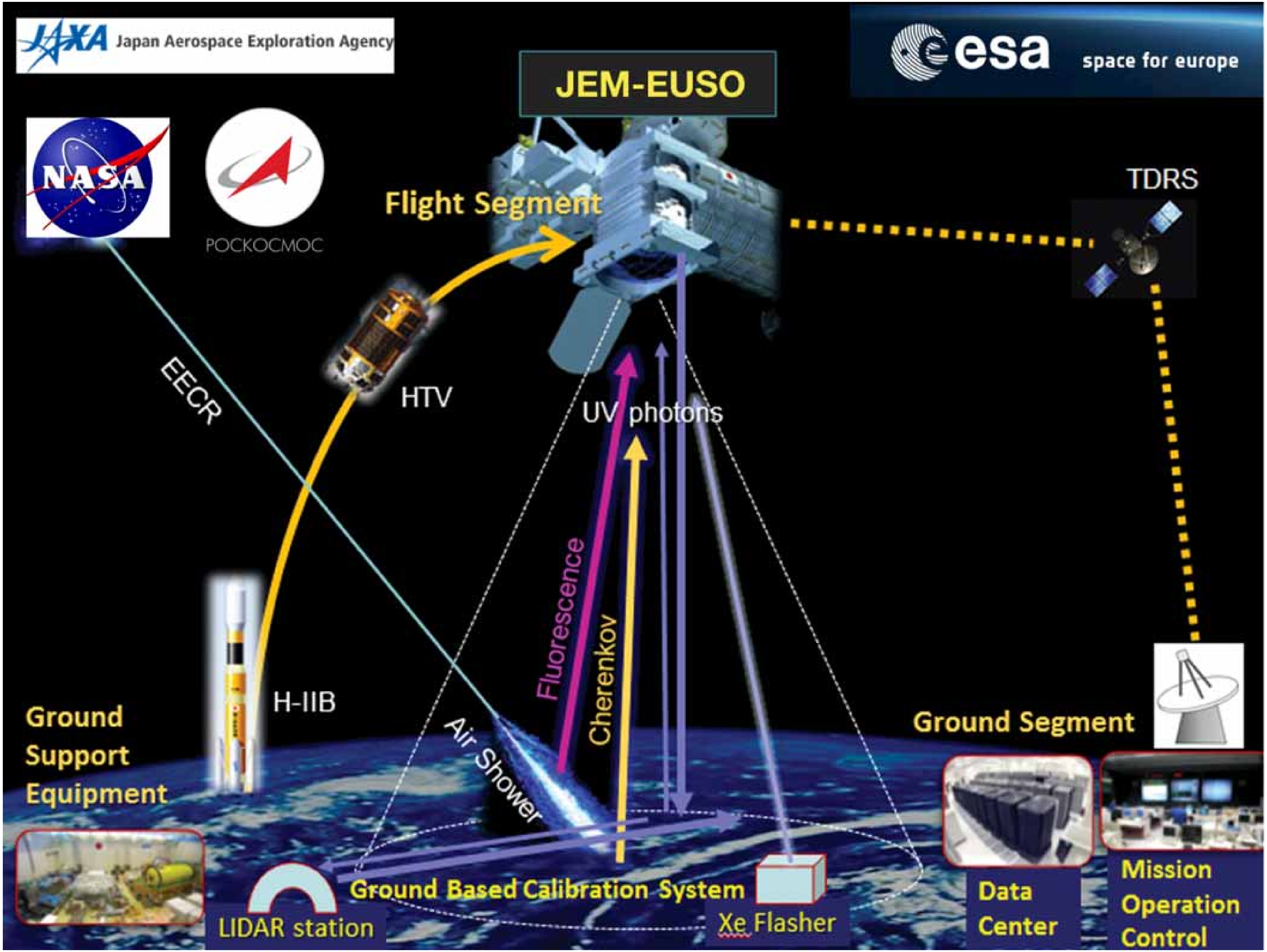

きぼう
Japanese Experiment Module
“Kibo” July 2009
51.6°



Standard Payload: mass 500 kg,
envelope:1.85m×1.0m×0.8m

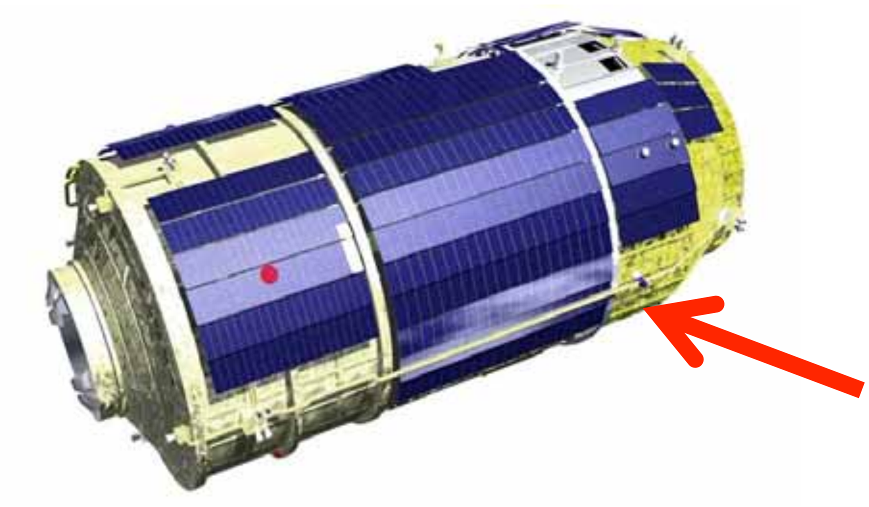
All mission aspects have been successfully studied by JAXA and RIKEN: open issue of ISS resources.

Parameter	Value
Launch date	JFY 2016
Mission Lifetime	3+2 years
Rocket	H2B
Transport Vehicle	HTV
Accommodation on JEM	EF#2
Mass	1938 kg
Power	926 W (op.) 352 W (non op.)
Data rate	285 kbps (+ on board storage)
Orbit	400 km
Inclination of the Orbit	51.6°
Operation Temperature	-10° to 50°



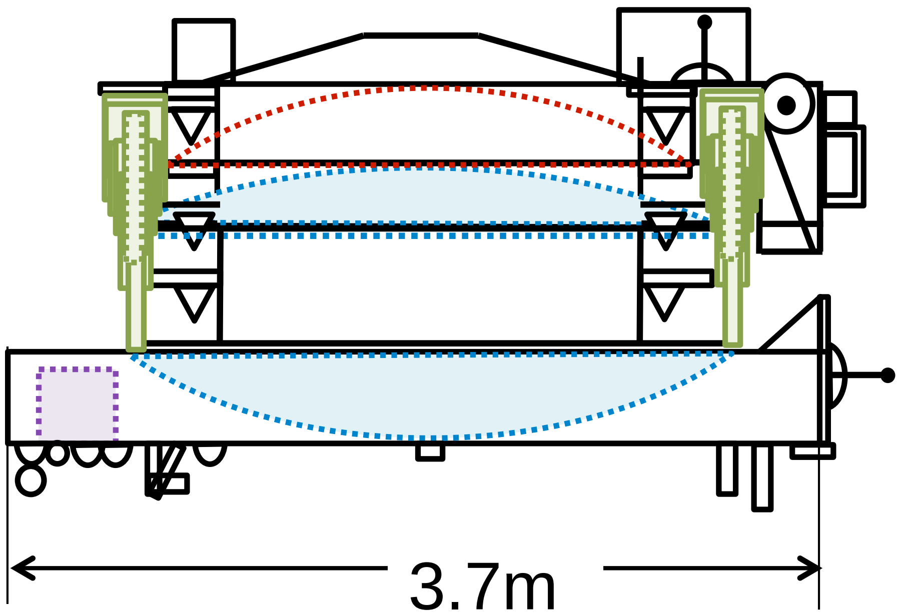
Japan Aerospace Exploration Agency
esa space for europe
JEM-EUSO
РОСКОСМОС
Flight Segment
TDRS
EECR
HTV
UV photons
Fluorescence
Cherenkov
H-IIB
Air Shower
Ground Support Equipment
Ground Segment
Ground Based Calibration System
LIDAR station
Xe Flasher
Data Center
Mission Operation Control

Science Instrument on HTV



H2B Transfer Vehicle (HTV)

Side view

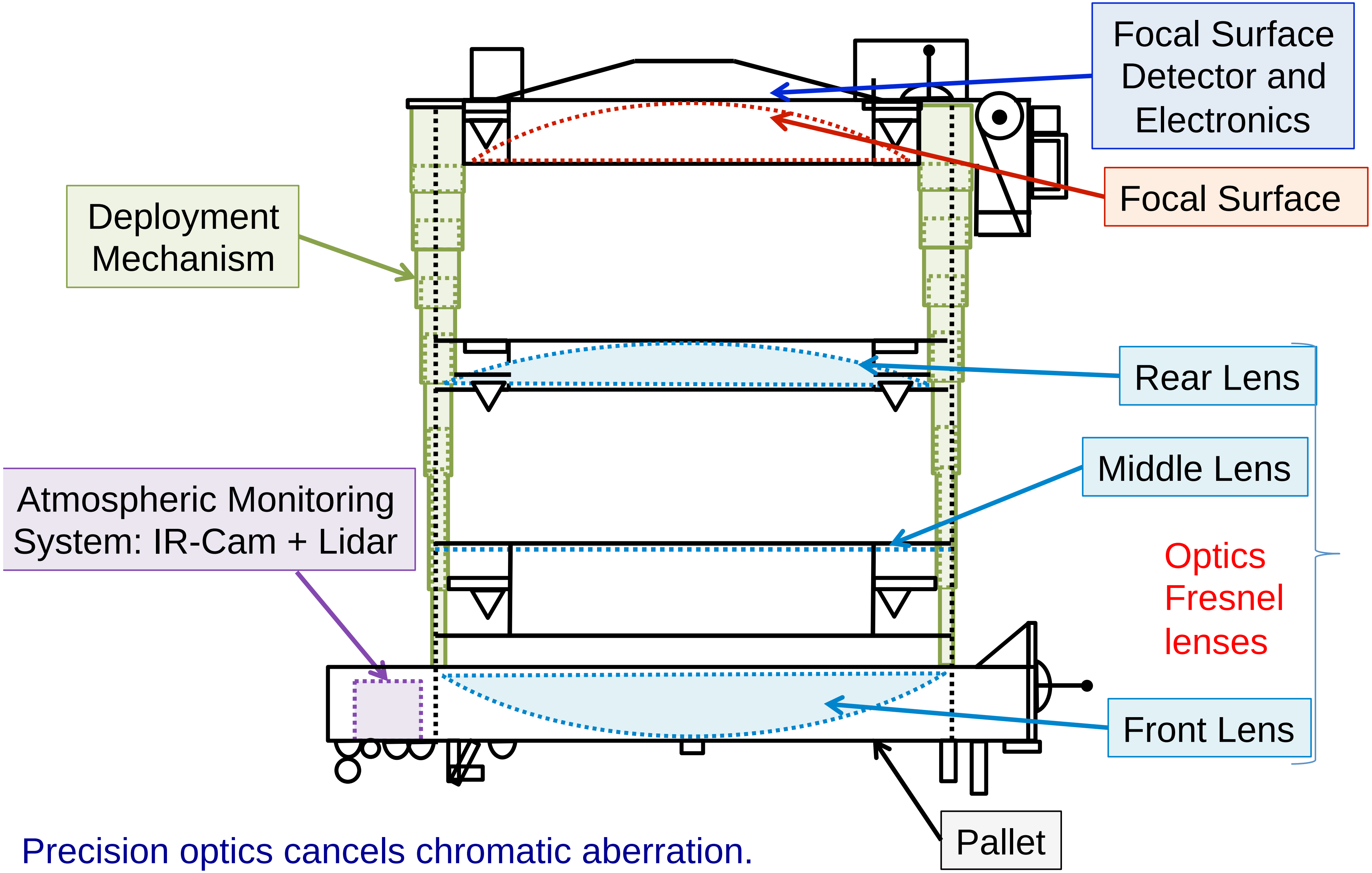


JEM-EUSO Telescope will be deployed after it is attached at the ISS

HTV was successfully launched on September 2009

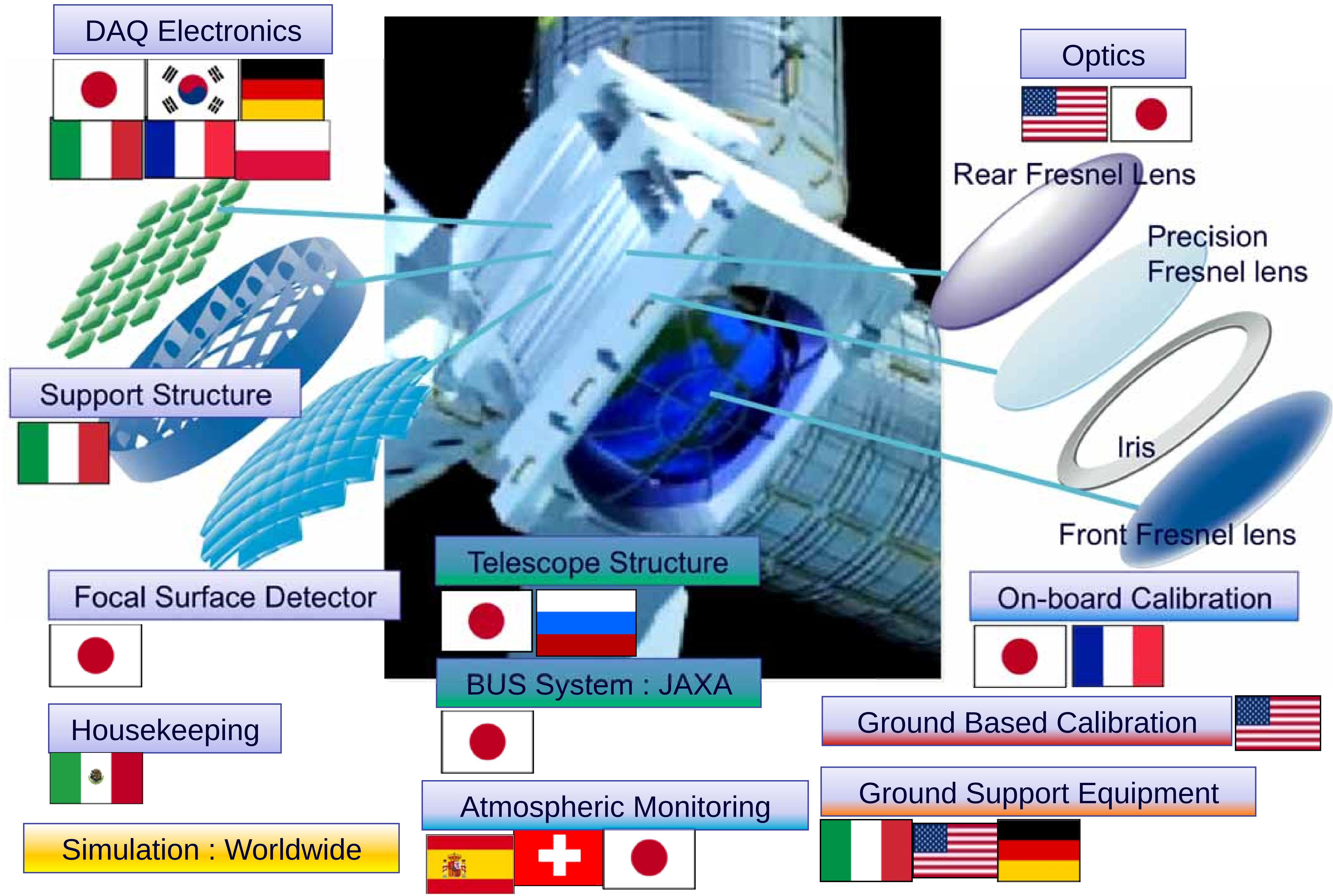
AMS: Poster MD Rodriguez-Frias

Science Instrument: deployed

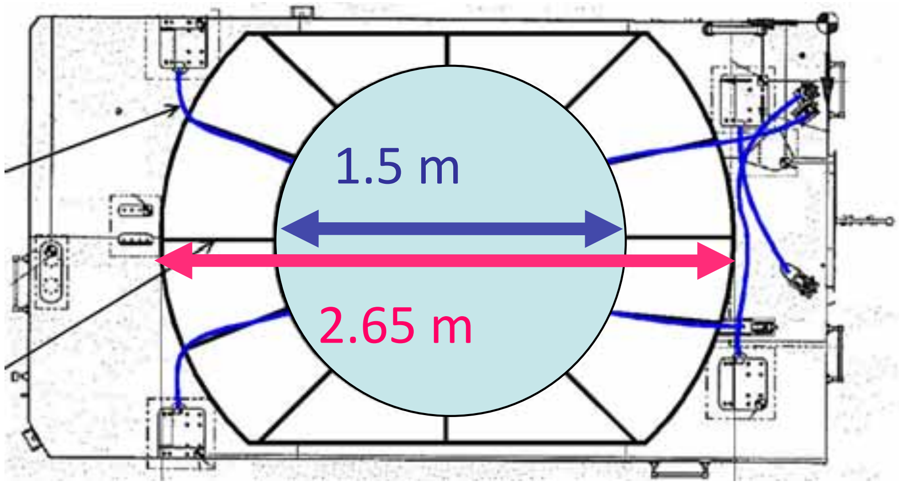


Precision optics cancels chromatic aberration.
Materials: PMMA+CYTOP

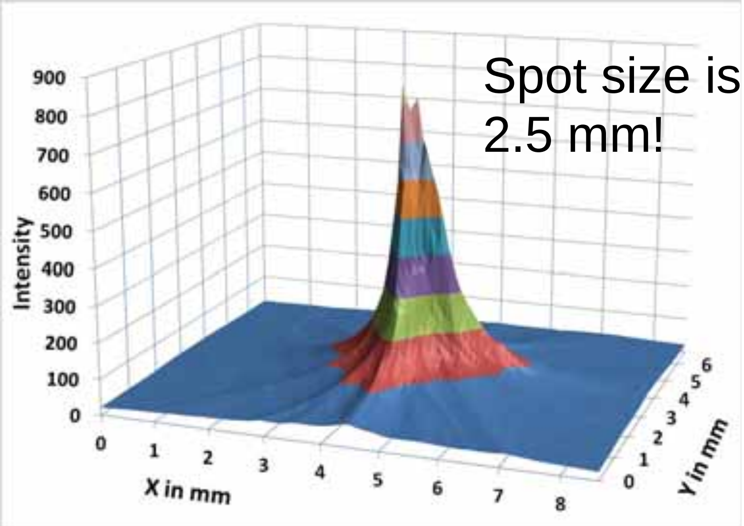
国際協力


DAQ Electronics
Optics
Rear Fresnel Lens
Precision Fresnel lens
Iris
Front Fresnel lens
Support Structure
Telescope Structure
Focal Surface Detector
On-board Calibration
BUS System : JAXA
Ground Based Calibration
Housekeeping
Ground Support Equipment
Atmospheric Monitoring
Simulation : Worldwide

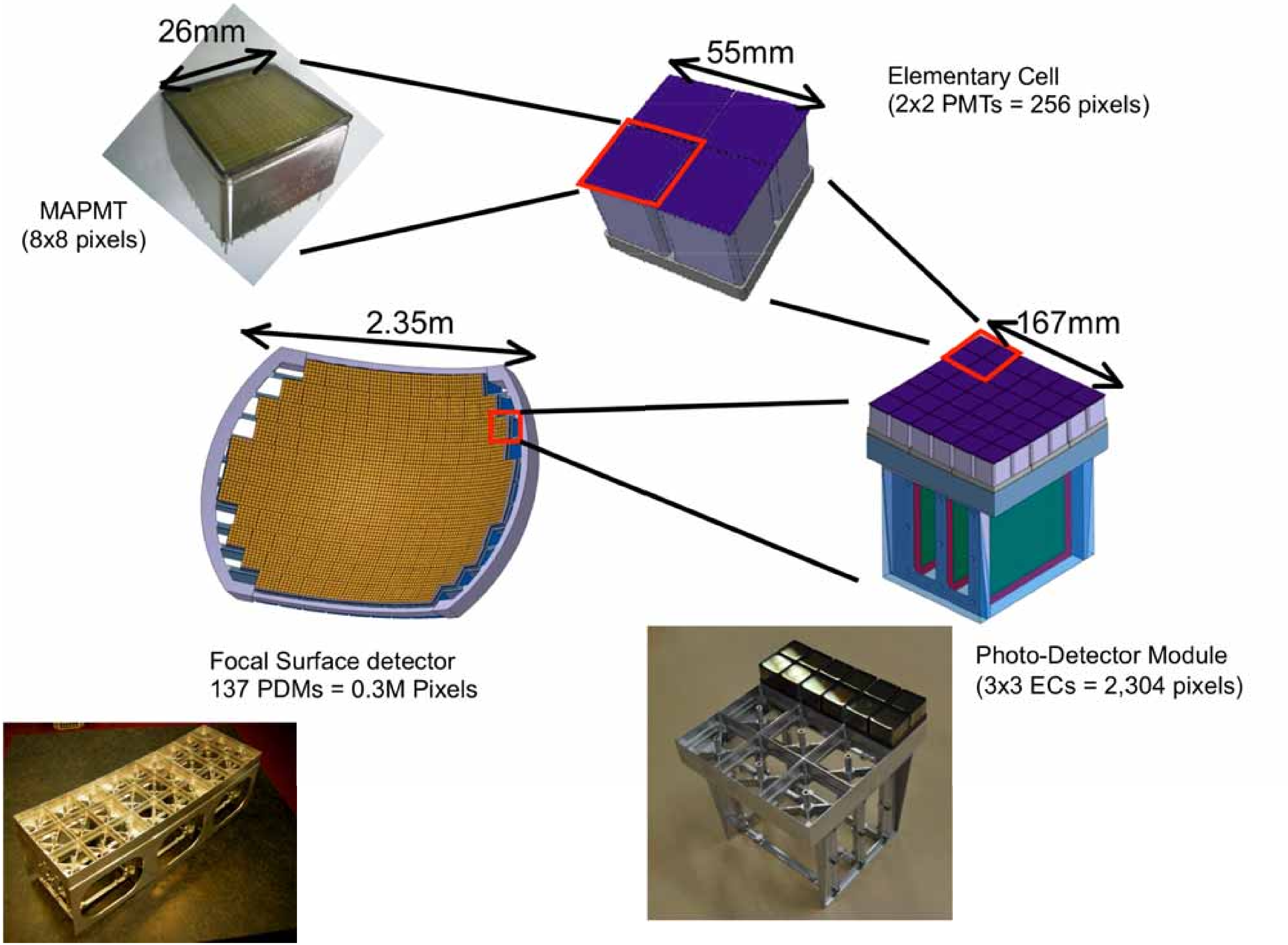
光学系のプロトタイプ



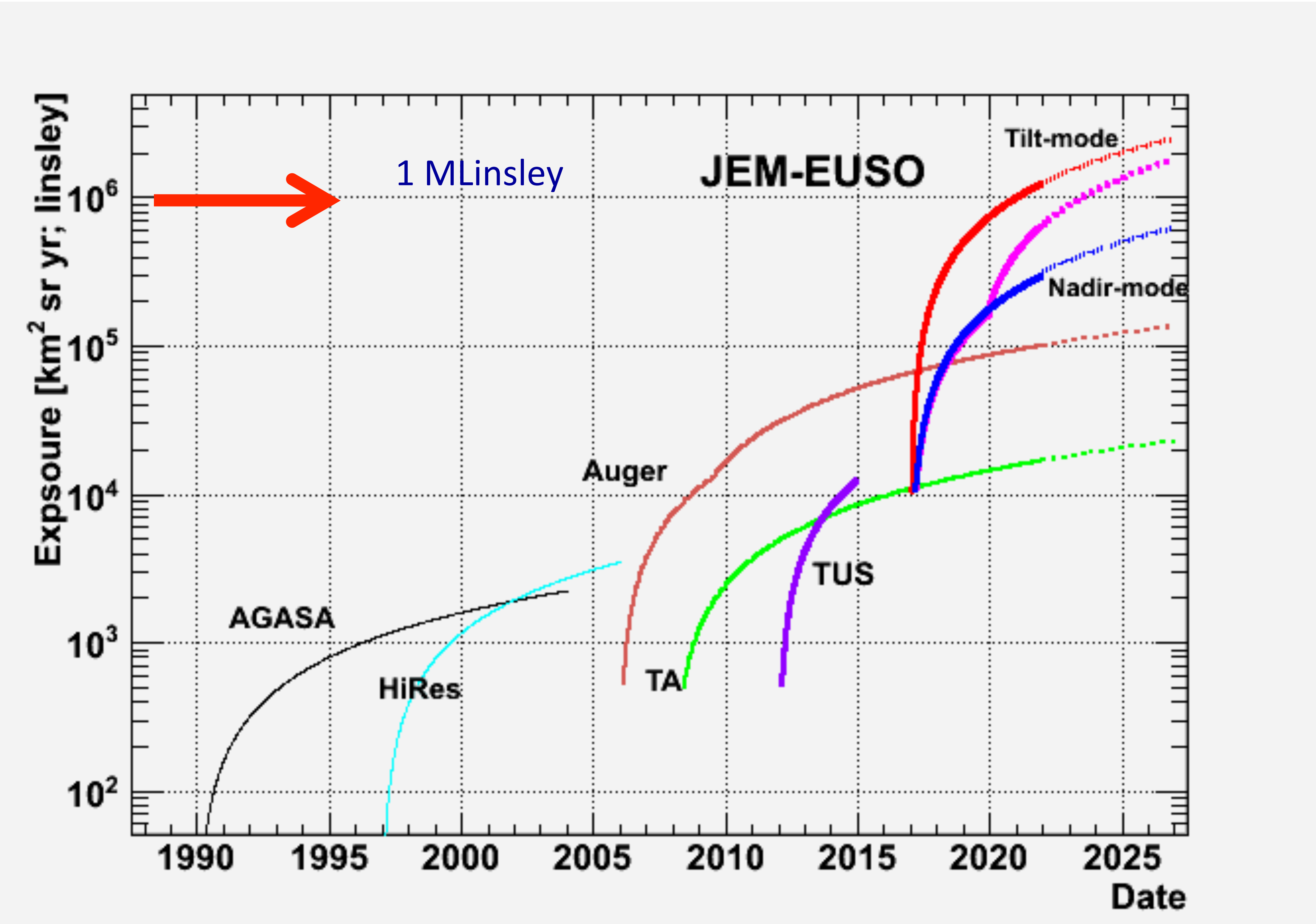
large diameter Fresnel lenses manufactured in Japan and tested in the US at the University of Alabama (Huntsville) and at MSFC (NASA)



Tested performances meet already the requirements (or are close to it)


26mm
MAPMT
(8x8 pixels)
55mm
Elementary Cell
(2x2 PMTs = 256 pixels)
2.35m
167mm
Focal Surface detector
137 PDMs = 0.3M Pixels
Photo-Detector Module
(3x3 ECs = 2,304 pixels)

Why JEM-EUSO? Large exposure + Full sky coverage

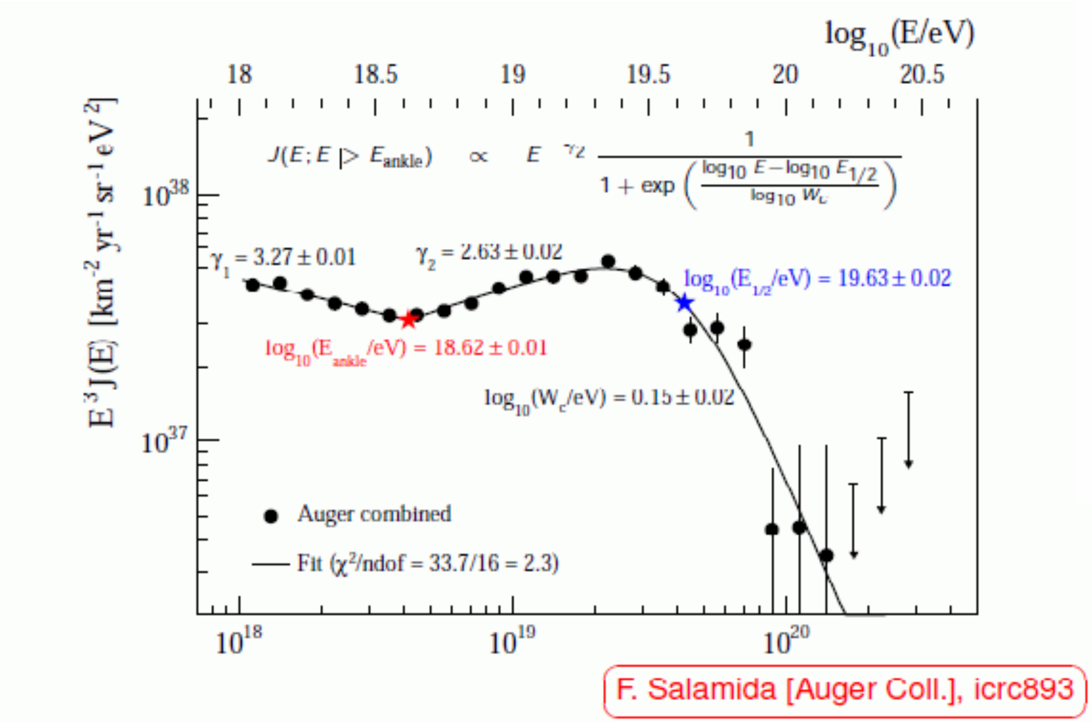


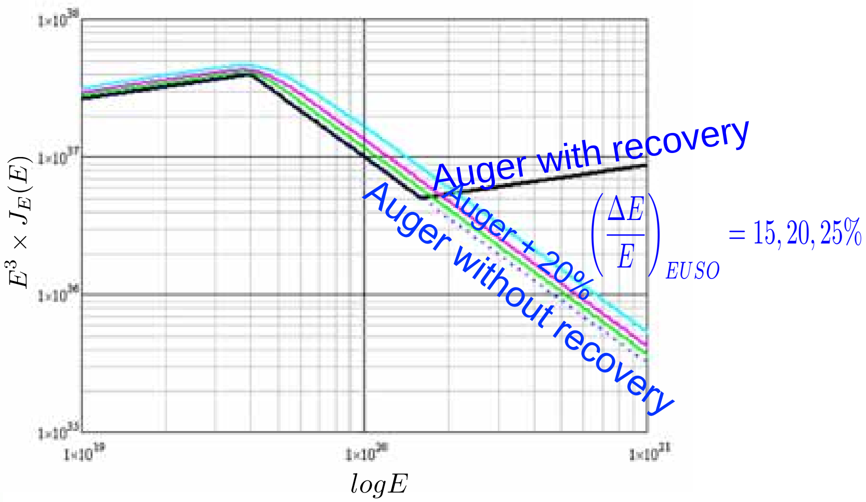
Comparison with current observatories

Observatory	Aperture km^2 sr	Status	Start	Lifetime	Duty cycle	Annual Exposure km^2 sr yr	Relative to Auger
Auger	7,000	Operations	2006	4 (16)	1	7000	1
TA	1,200	Operations	2008	2 (14)	1	1,200	0.2
TUS	30,000	Developed	2012	5	0.14	4,200	0.6
JEM-EUSO ($E \approx 10^{20}$ eV)	430,000	Design	2017	5	0.14	60,000	9
JEM-EUSO (highest energies) Tilted mode 35°	1,500,000	Design	2017	5	0.14	200,000	28

Estimation of event statistics

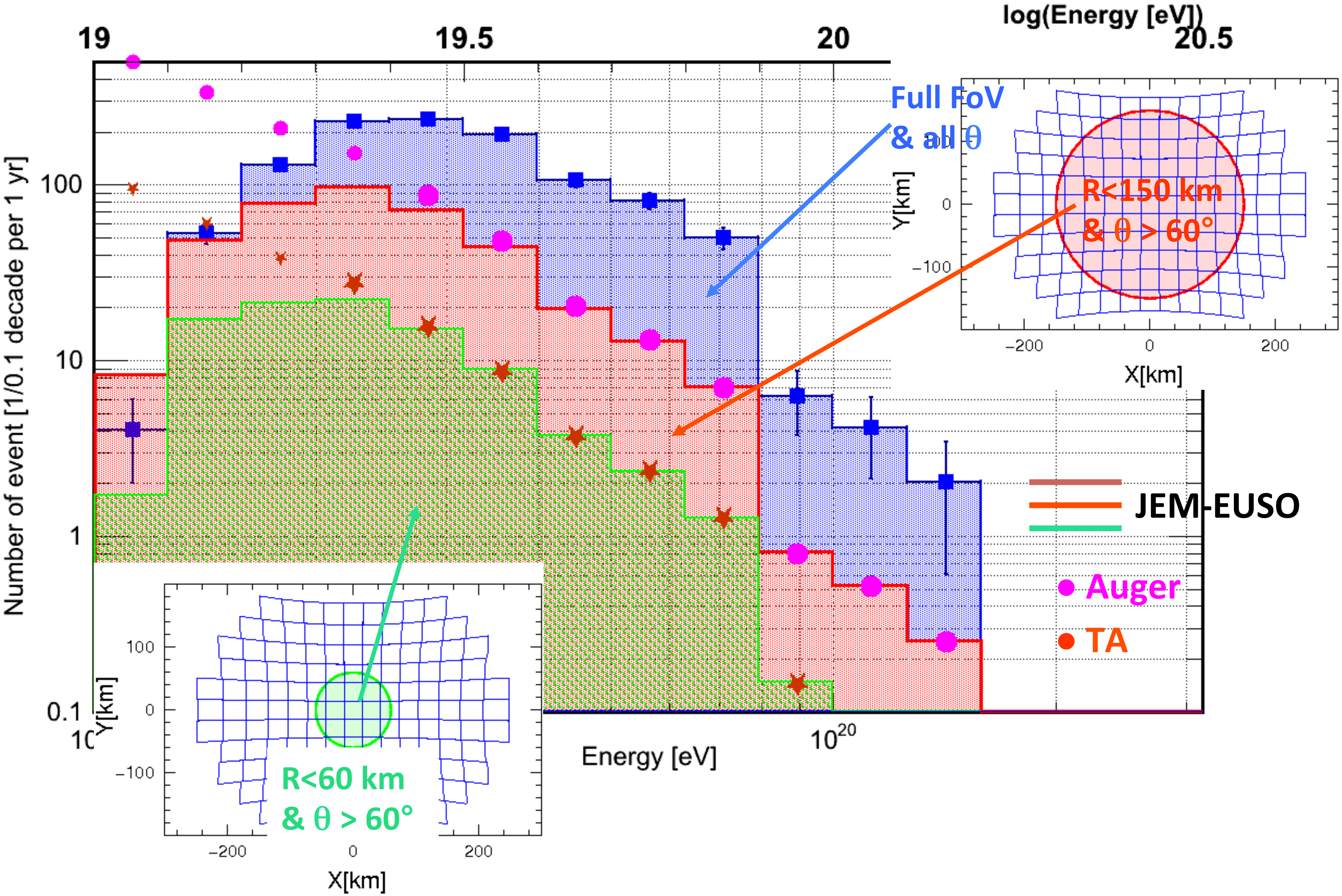
- Observational time 19% & cloud-impact 70%
- Incident spectrum assumed to Auger ICRC2011
- Recovery model (Medina Tanco) also tested



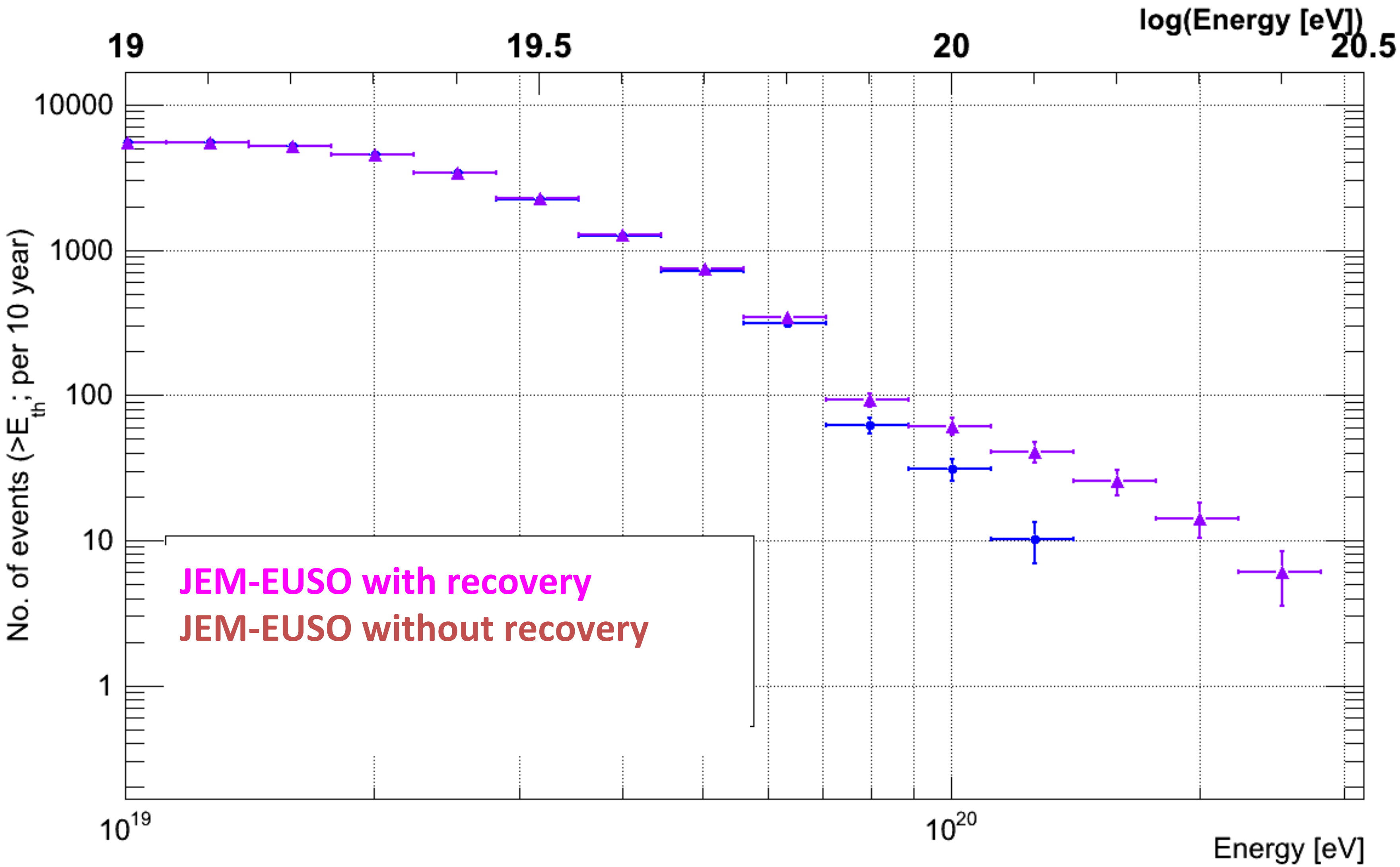


If actual spectrum were Auger without recovery

Expected number of events in 1 year data taking



Expected number of events 5 years (>E)



Contents

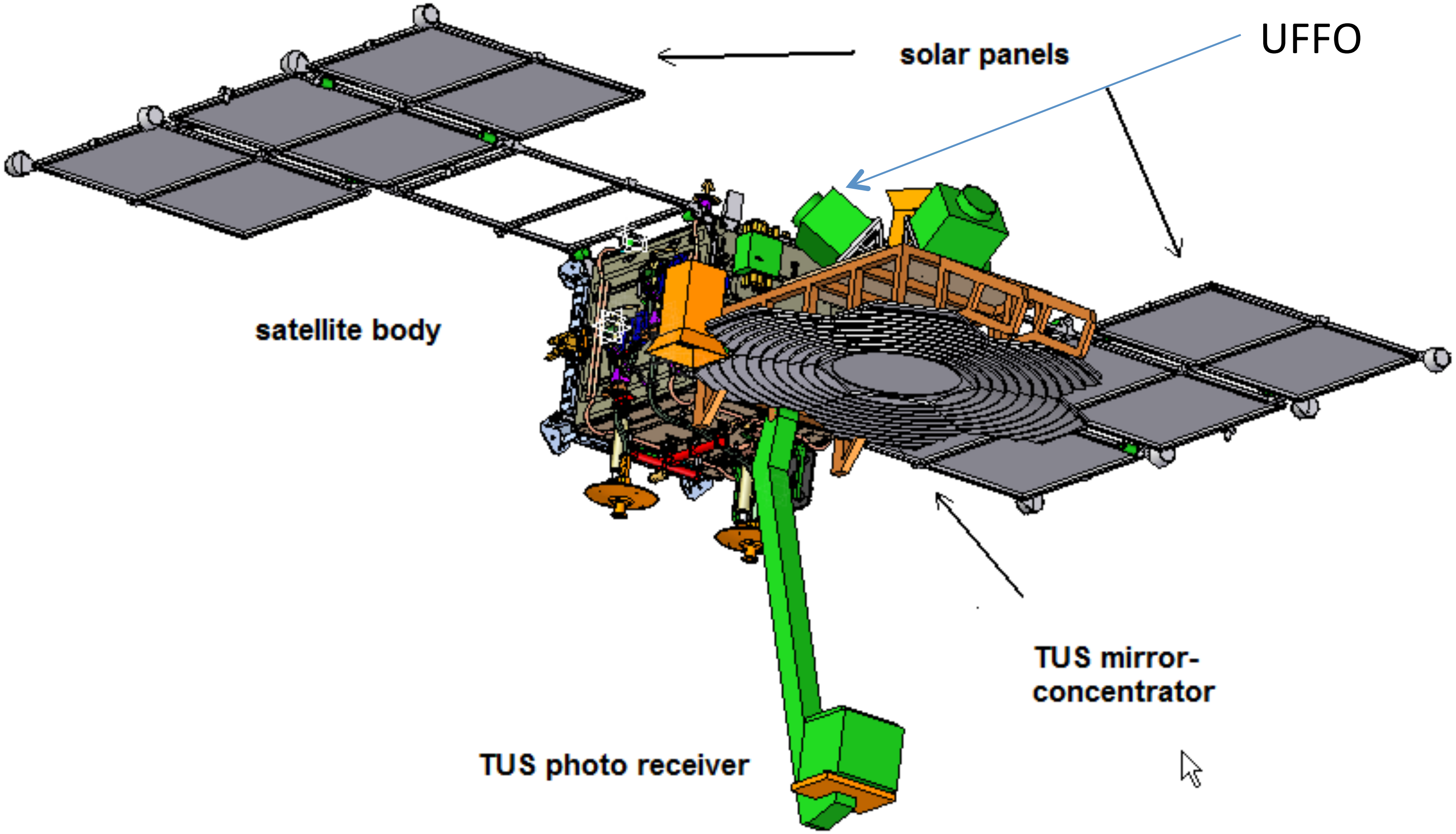
パスファインダーミッション

- TUS (Lomonosov satellite: Russia)
- EUSO-BALLOON (France)
- TA-EUSO (日本)
- MicroUVT (日本)

TUS

- ロシアの衛星 “Lomonosov”
  - 2012内に打ち上げ予定
- Skobeltsyn Institute of Nuclear Physics, Moscow State University, Russia
- 科学的、技術的パスファインダー
    - 宇宙からシャワーを見る
    - UV背景光の観測
    - PMT とエレクトロニクス
    - UFFO (Ultra Fast Flash Observatory)
      - 韓国のガンマ線バーストミッション

Lomonosov Satellite

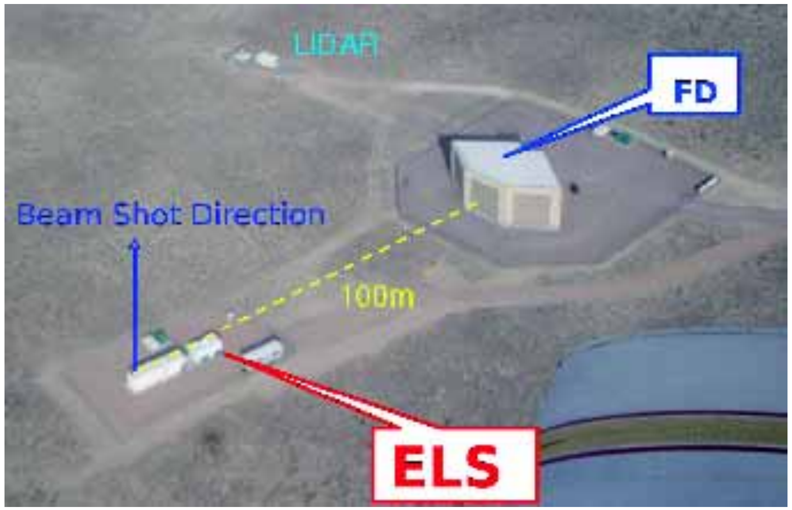


TA-EUSO

2012年の12月までに

Telescope Array (TA) サイトにおける検出器テスト

- TA-EUSO 望遠鏡はBlack Rock Mesaの蛍光望遠鏡の前に置く
  - Electron Light Source at 100m
  - Most nearby SD is at ~3.5 km
  - Central Laser Facility ~21km



Location： Black Rock Mesa

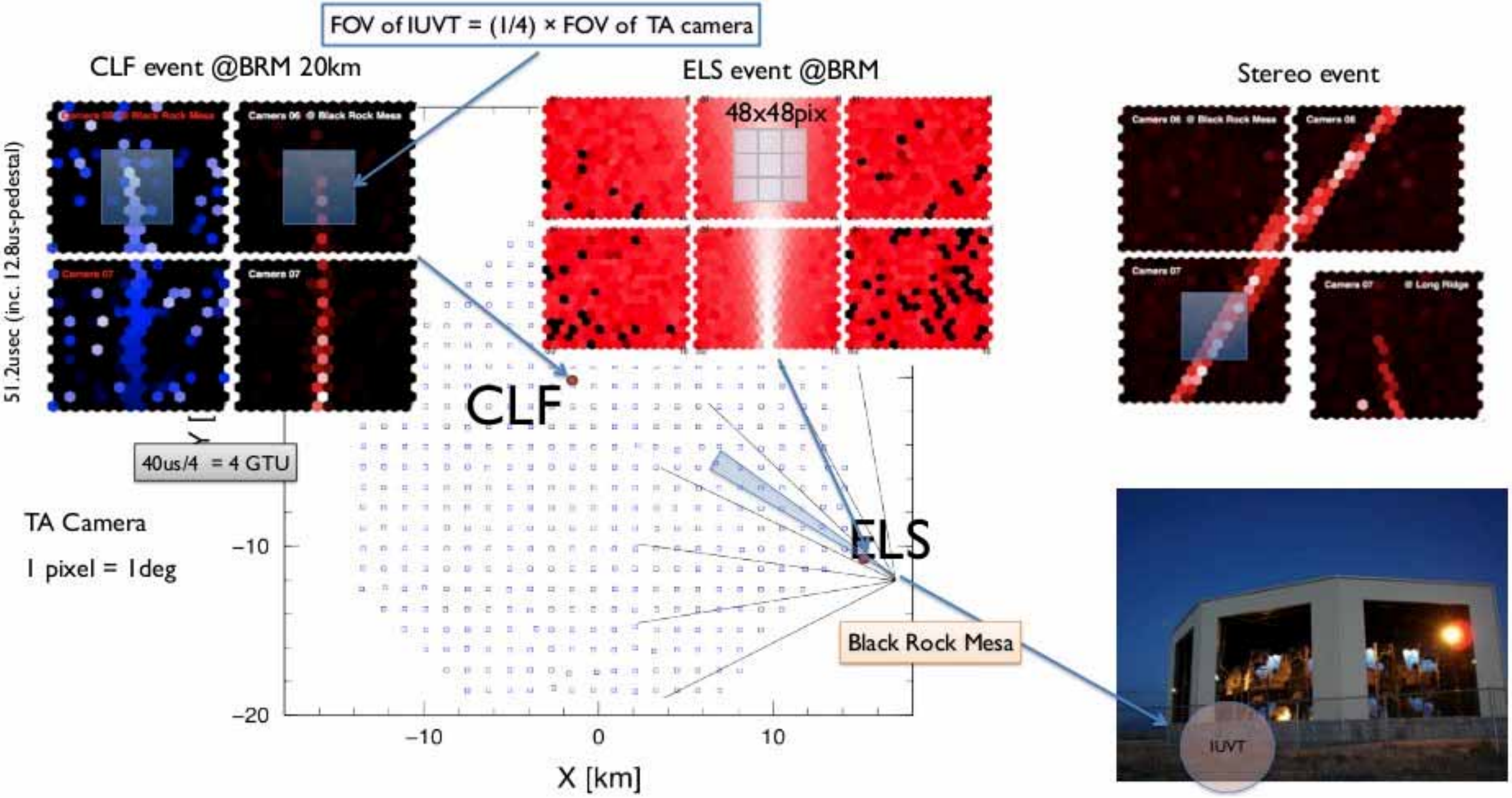
IUVT is able to observe CLF and ELS.

Time: March. 2012～ → The second half of 2012

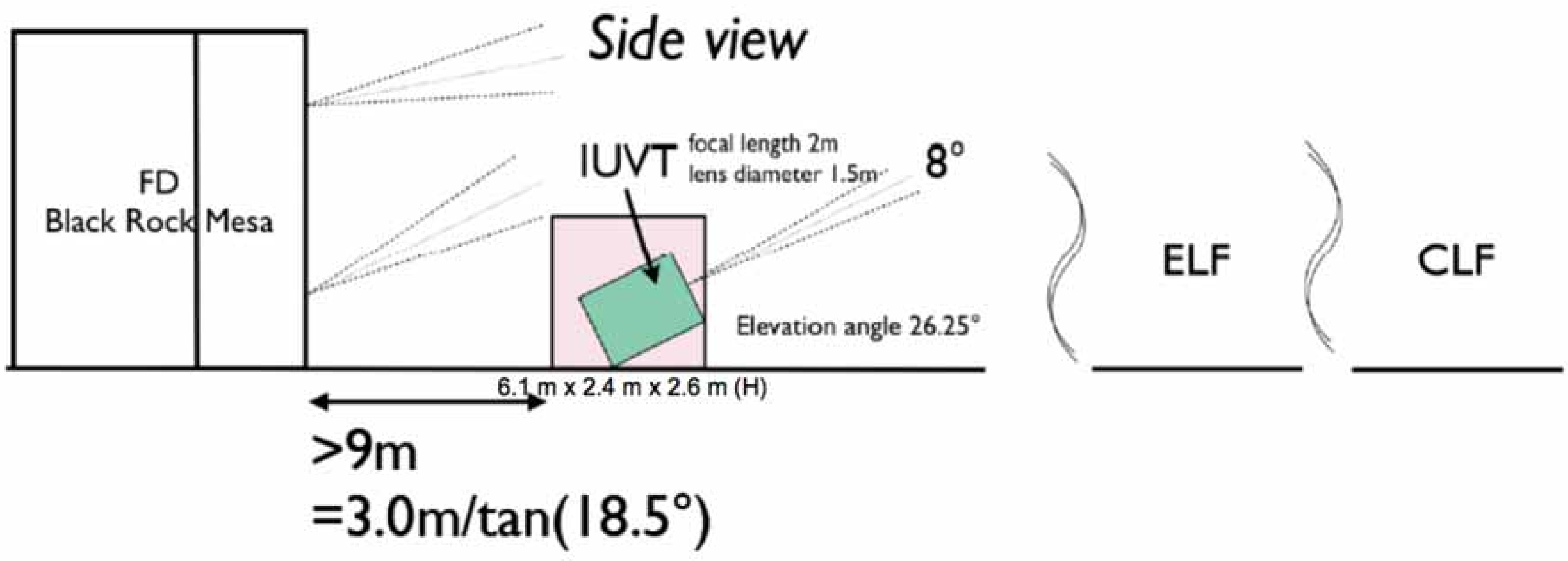
Synchronize between TA and IUVT: GPS time

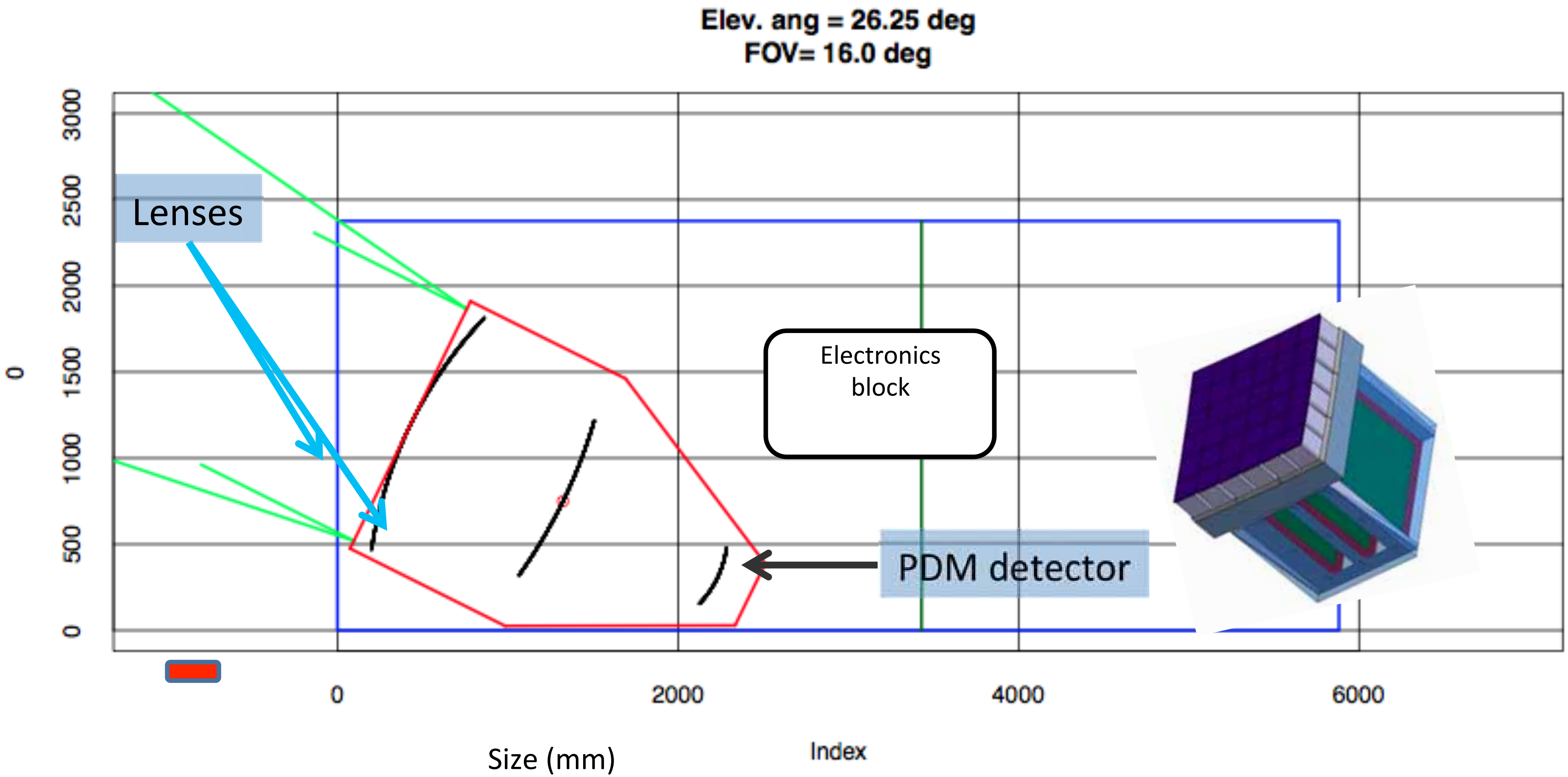
(If possible, we want to use Trg. Signal from TA elec.)

IUVT should have a mechanism to change its elevation.

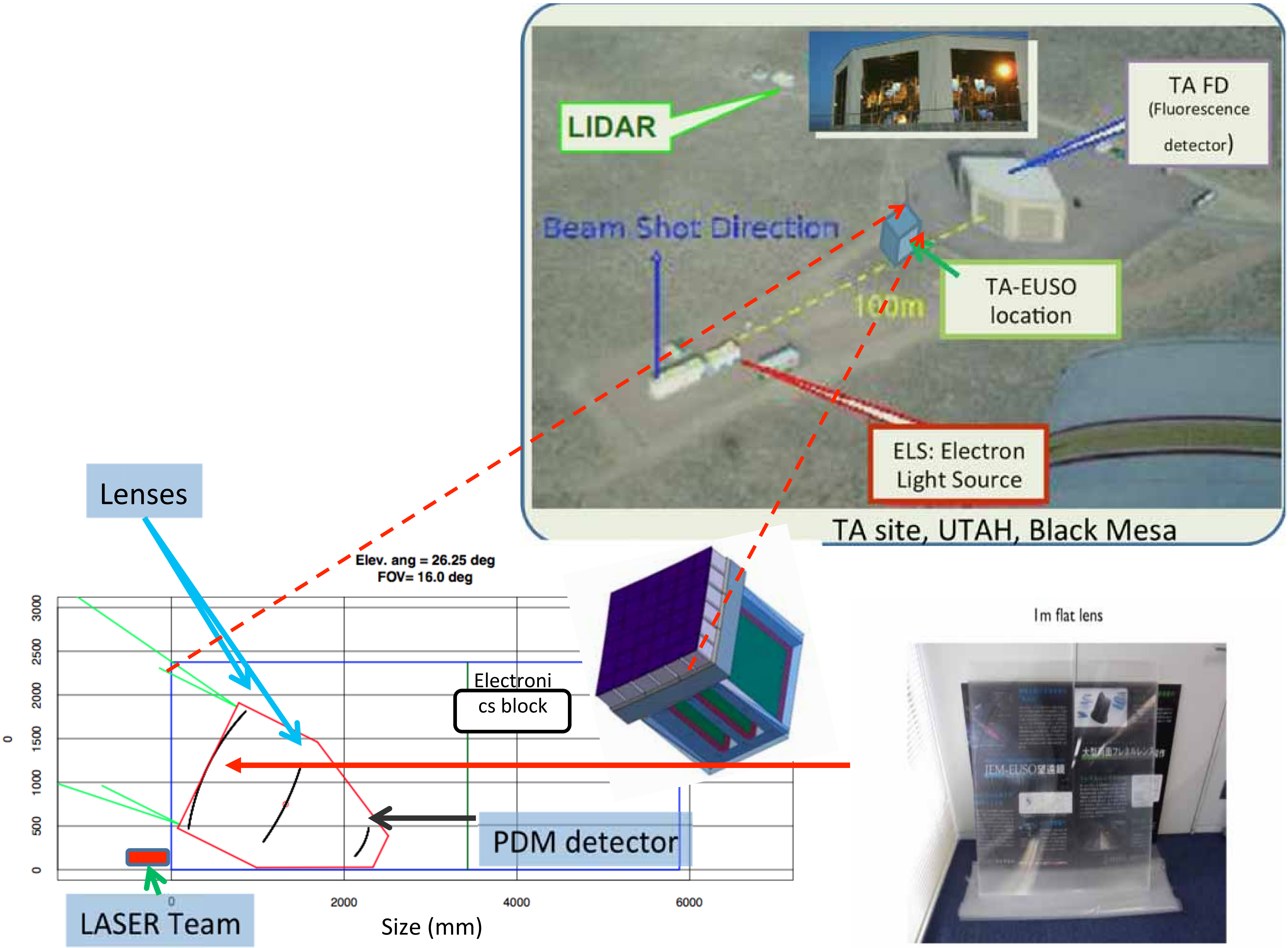


	JEM-EUSO	TA-EUSO
Diameter(m)	2.5	1.2(effective diameter 1m)
FOV/Pix(deg)	0.08	0.17
FOV/PDM(deg)	3.84	±4
Effective Area (km^2)	28,191	3.94
S/sqrt(N)	1	
Target energy (eV)	>3.00E+19	>1.00E+18
Number of PDM	137	1
Event Rate(/h)	0.56	0.1



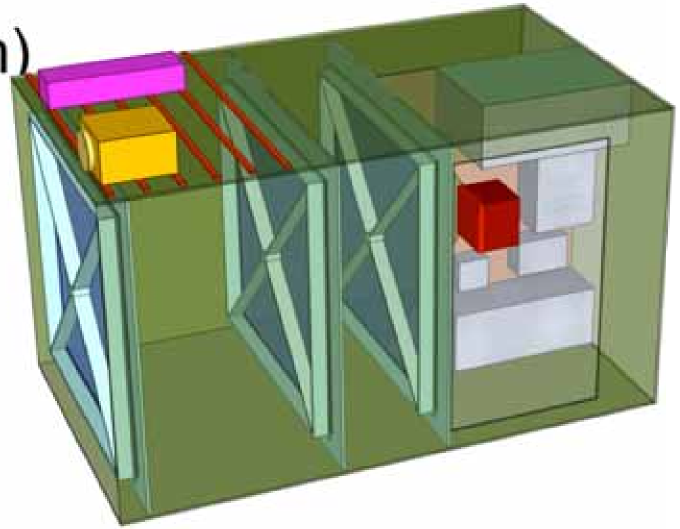


Elev. ang = 26.25 deg
FOV= 16.0 deg
Lenses
Electronics block
PDM detector
0
500
1000
1500
2000
2500
3000
0
2000
4000
6000
Size (mm)
Index

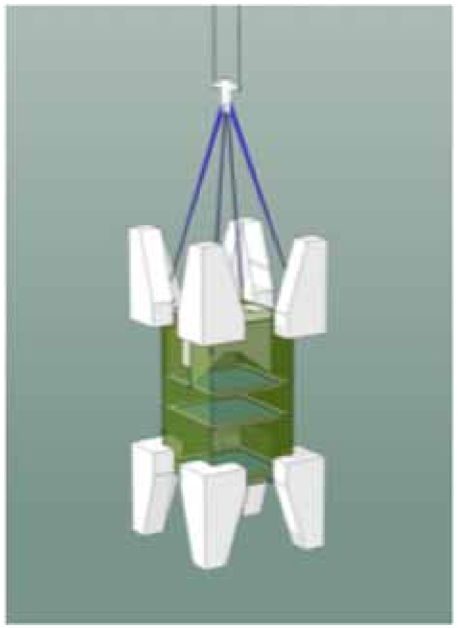

LIDAR
TA FD
(Fluorescence
detector)
Beam Shot Direction
100m
TA-EUSO
location
ELS: Electron
Light Source
TA site, UTAH, Black Mesa
Lenses
Elev. ang = 26.25 deg
FOV= 16.0 deg
Electroni
cs block
PDM detector
LASER Team
0
500
1000
1500
2000
2500
3000
0
2000
4000
6000
Size (mm)
1m flat lens
JEM-EUSO望遠鏡

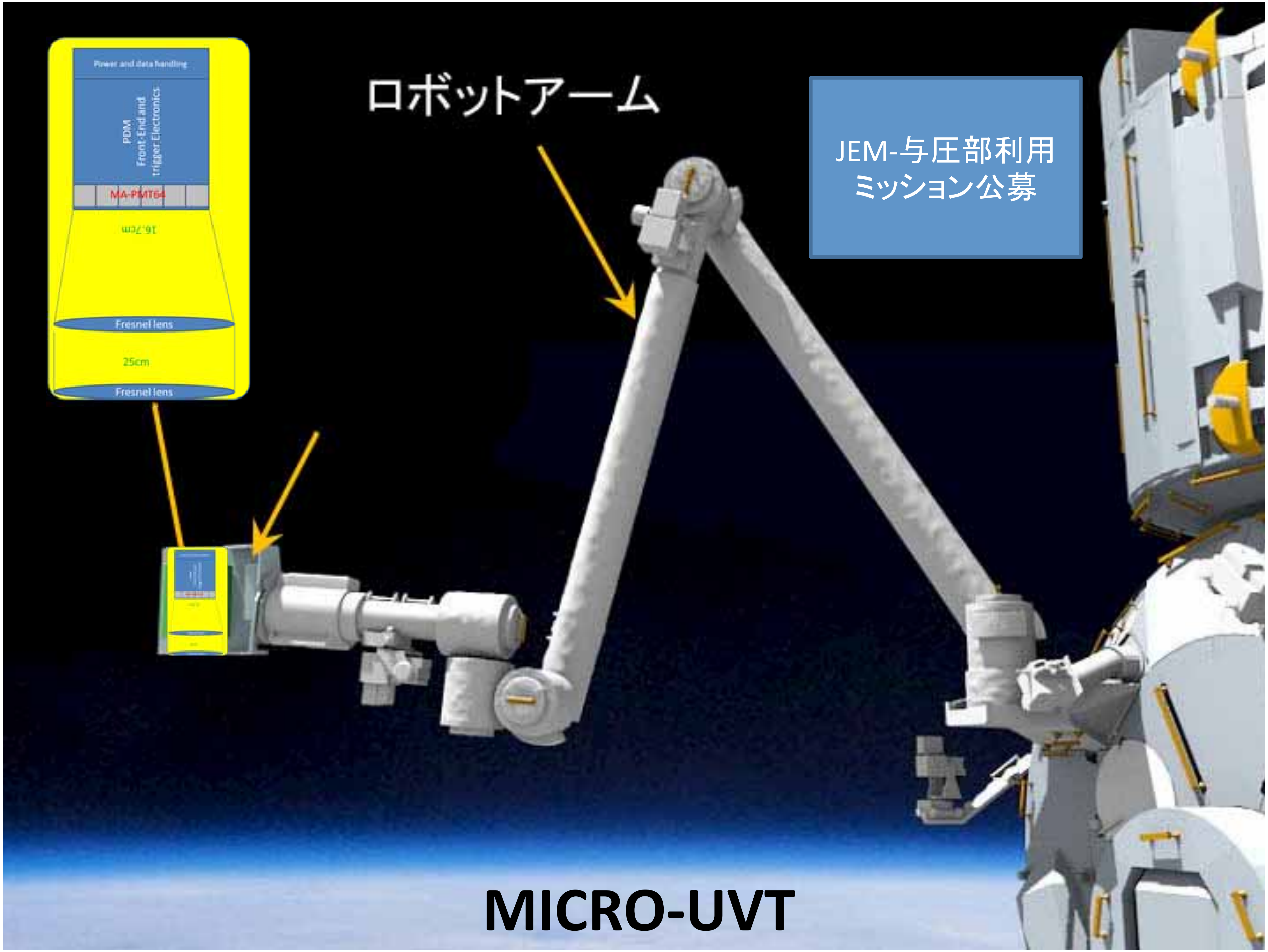
JEM-EUSO Balloon

- 気球から下を見る
  - UV望遠鏡 (PDM EM + 3 lenses system)
- 光学テスト
- 背景光テスト
- 40kmの高さから空気シャワーを見る

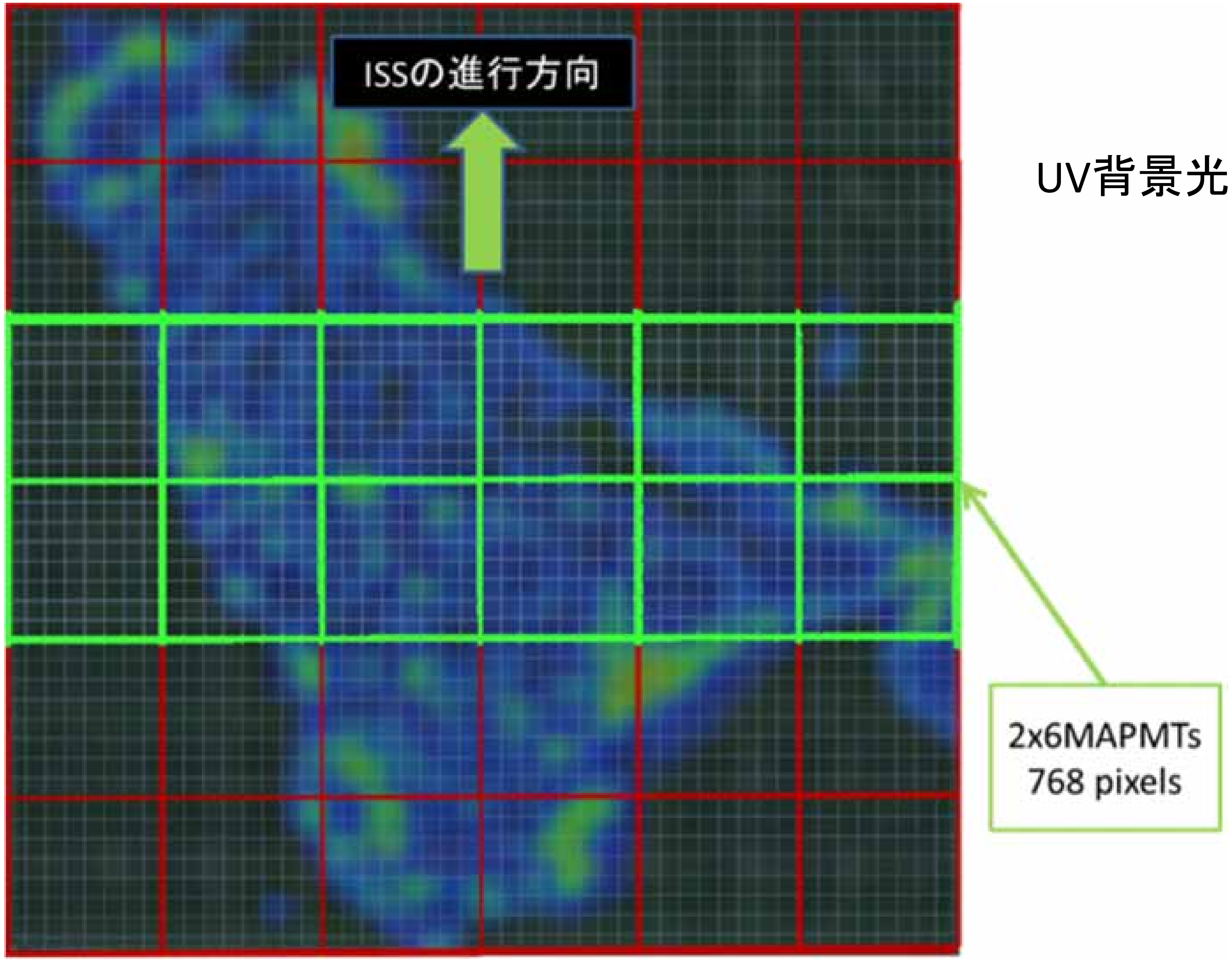


フランス宇宙機関（CNES）
Phase B進行が決定
→2013年の打ち上げを目指す
→数回のフライト




ロボットアーム
JEM-与圧部利用
ミッション公募
Power and data handling
PDM
Front-End and
trigger Electronics
MA-PMT64
16.7cm
Fresnel lens
25cm
Fresnel lens
MICRO-UVT

マイクロUVTの視野



UV背景光のMAP

Contents

1. 宇宙からのエアシャワー観測のアイデア歴史
2. 何が違うのか：見下ろすのと見上げるのと
3. JEM-EUSOミッション概要
4. パスファインダーミッション
5. ミッション状況とまとめ

Programmatics (1)

- **ヨーロッパ宇宙機関（ESA）:** 2010年からELIPSプログラムの一部として研究。ESAは宇宙機関における調整役

- **ロシア宇宙機関（ROSCOSMOS）**
  - Tsniimash (Roscosmos ISS研究機関) Prof. Panasyuk（Russian PI）がJEM-EUSOについてSTEC委員会で報告、了承を得る
  - モスクワ州立大学にて国際JEM-EUSO会合（2012年5月）
  - Tsniimash研究所、ISS担当副所長からROSCOSMOS副理事長に手紙：JEM-EUSOへ参加とISS資源についての国際調整の依頼
  - 望遠鏡構造（含む伸展機構）を担当することで基本合意：MOU交換

ROSCOSMOS
有人プログラム所長への手紙

ЦНИИМАШ

ФЕДЕРАЛЬНОЕ КОСМИЧЕСКОЕ АГЕНТСТВО

To the Director of the Division
of Manned Space Program
of ROSCOSMOS

Alexey B. Krasnov

Dear Alexey Borisovich,

Russian scientists appealed to the Coordination Scientific and Technical Council (CSTC) of ROSCOSMOS requesting for possibility of their participation in the International wide-scale space experiment onboard the International Space Station "JEM-EUSO – International Observatory of the Universe by means of the extreme energy particles".

Currently the status of the Project is set. JEM-EUSO collaboration includes over 250 scientists form 77 organizations of Russia, Japan, USA, Korea, Mexico, Bulgaria, France, Germany, Italy, Poland, Slovakia, Spain, Switzerland.

наблюдения Вселенной с помощью частиц экстремально высоких энергий».

Programmatics (2)

- **米国宇宙機関(NASA):** SALMON AO (2011)は採択されなかった。2012年3月に新PIのAngela Olinto(シカゴ大)のもとARPA/ROSESに新提案:米国の宇宙ステーション資源の提供への道を開く。その他のFunding Agencyへの提案を企画中
- **日本宇宙機関(JAXA):** 2015年ごろの有望ミッションとして推薦。米国およびロシアでの動きを歓迎
- **他の国:** EUSO Balloonや

TA-EUSOへの参加。

JEM-EUSOへの予算の準備を進める

US team のAPRA提案書の一部

Cover Page for Proposal Submitted to the National Aeronautics and Space Administration	**NASA Proposal Number** **11-APRA11-0066**

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This proposal shall be used and disclosed for evaluation purposes only, and a copy of this Government notice shall be applied to any reproduction or abstract thereof. Any authorized restrictive notices that the submitter places on this proposal shall also be strictly complied with. Disclosure of this proposal for any reason outside the Government evaluation purposes shall be made only to the extent authorized by the Government.

SECTION I - Proposal Information

Principal Investigator	E-mail Address	Phone Number
Angela Olinto	**olinto@kicp.uchicago.edu**	**773-702-8206**

Street Address (1)	Street Address (2)
5640 S Ellis Ave	**LASR 228**

City	State / Province	Postal Code	Country Code
Chicago	**IL**	**60637-1433**	**US**

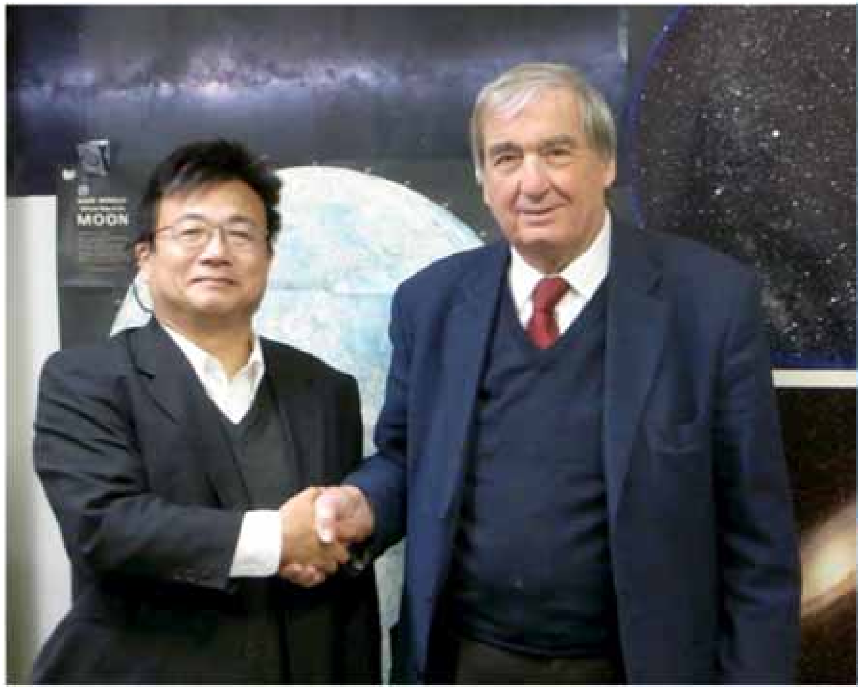
Proposal Title : **U.S. Participation in the Extreme Universe Space Observatory on the Japanese Experiment Module**

Proposed Start Date	Proposed End Date	Total Budget	Year 1 Budget	Year 2 Budget	Year 3 Budget	Year 4 Budget	Year 5 Budget
01 / 01 / 2013	**12 / 31 / 2017**	**494,105.57**	**67,747.90**	**67,394.62**	**68,656.18**	**144,183.55**	**146,123.32**

New Organization

- PI: Piergiorgio Picozza
- Deputy PI: Toshikazu Ebisuzaki
- Global Coordinator

  Andrea Santangelo

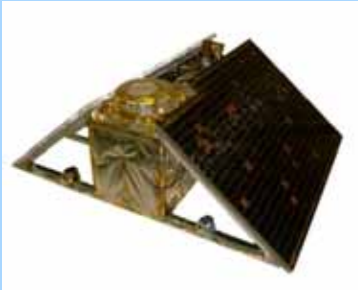


The Wizard Program

MASS-89, 91, TS-93, CAPRICE 94-97-98

NINA-1

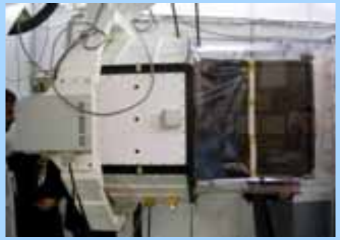
NINA-2

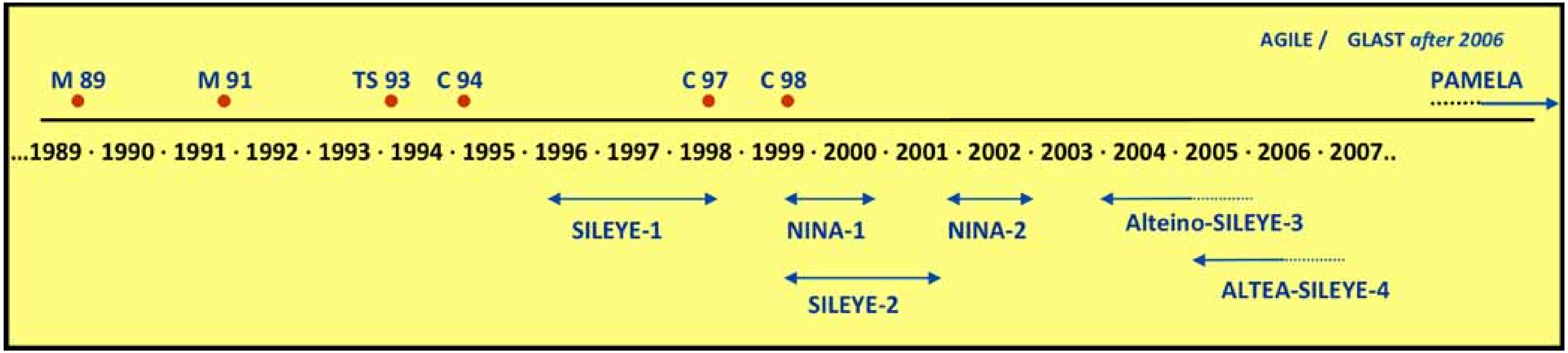


PAMELA

GLAST

AGILE





SILEYE-1

SILEYE-2

ALTEINO: SILEYE-3

LAZIO SIRAD

ALTEA

まとめ

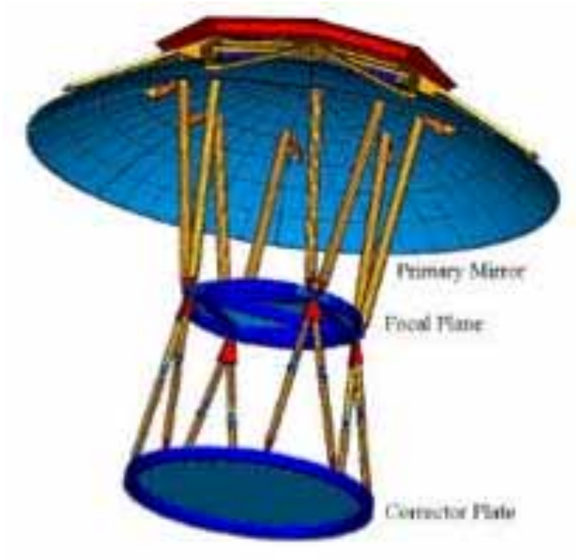
- 挑戦１：新しい観測手法
  - 宇宙から空気シャワーを見る最初のミッション
- 挑戦２：荷電粒子天文学
  - 極限エネルギー宇宙線の線源を同定
  - 個々のスペクトルを図る
  - 露出の飛躍的な増加
    - 10^{20}eVでPAOの9倍、最高エネルギーで27倍
  - 一様な露出
- 挑戦３：物理の基本原理
  - ローレンツ不変性、新物理への制限
- 挑戦４：国際協同
  - 3つの大陸にまたがった広範な国際協力
  - 国際宇宙ステーション

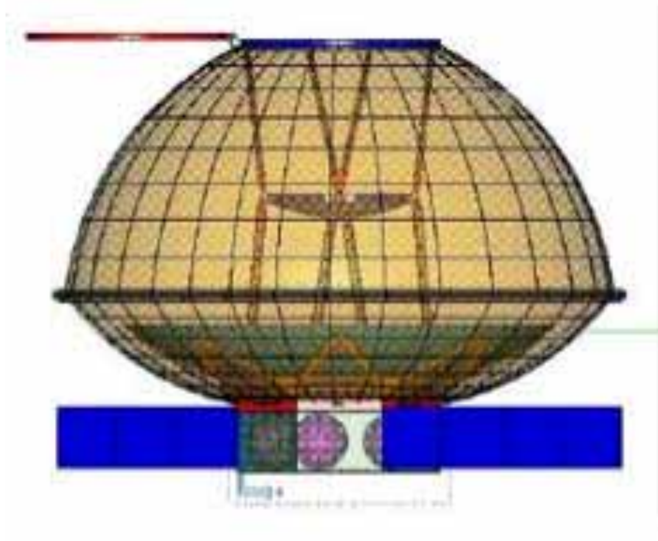
これは始まりに過ぎない

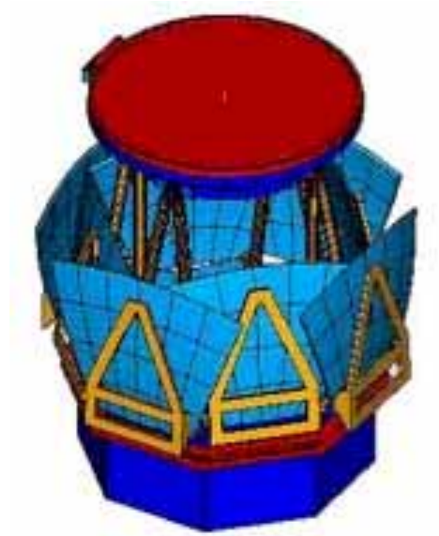
S-EUSO

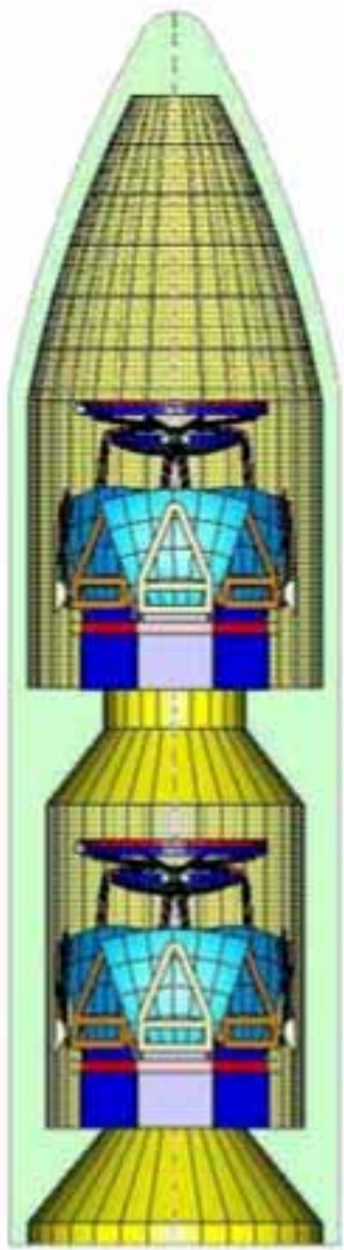
- Photon Corrector Mirror: 8 m
- FoV: > 50°
- Pixel Size: 0.02°
- Assembly and Tune-up in orbit (ISS)
  - Space Factory Concept
  - Make a Free-Flyer

Price tag $700M
Out of Strategic Planning
2002-2003



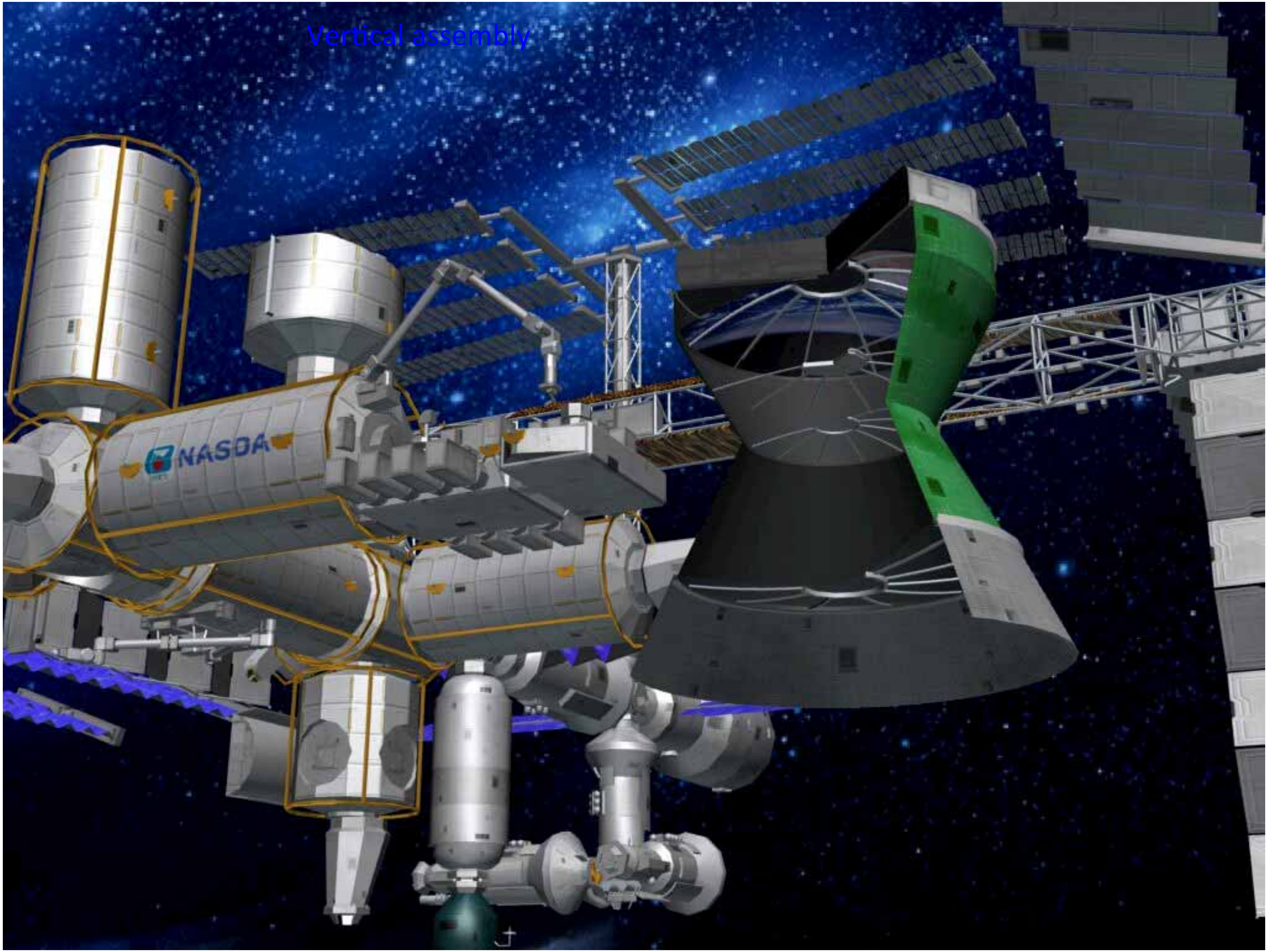


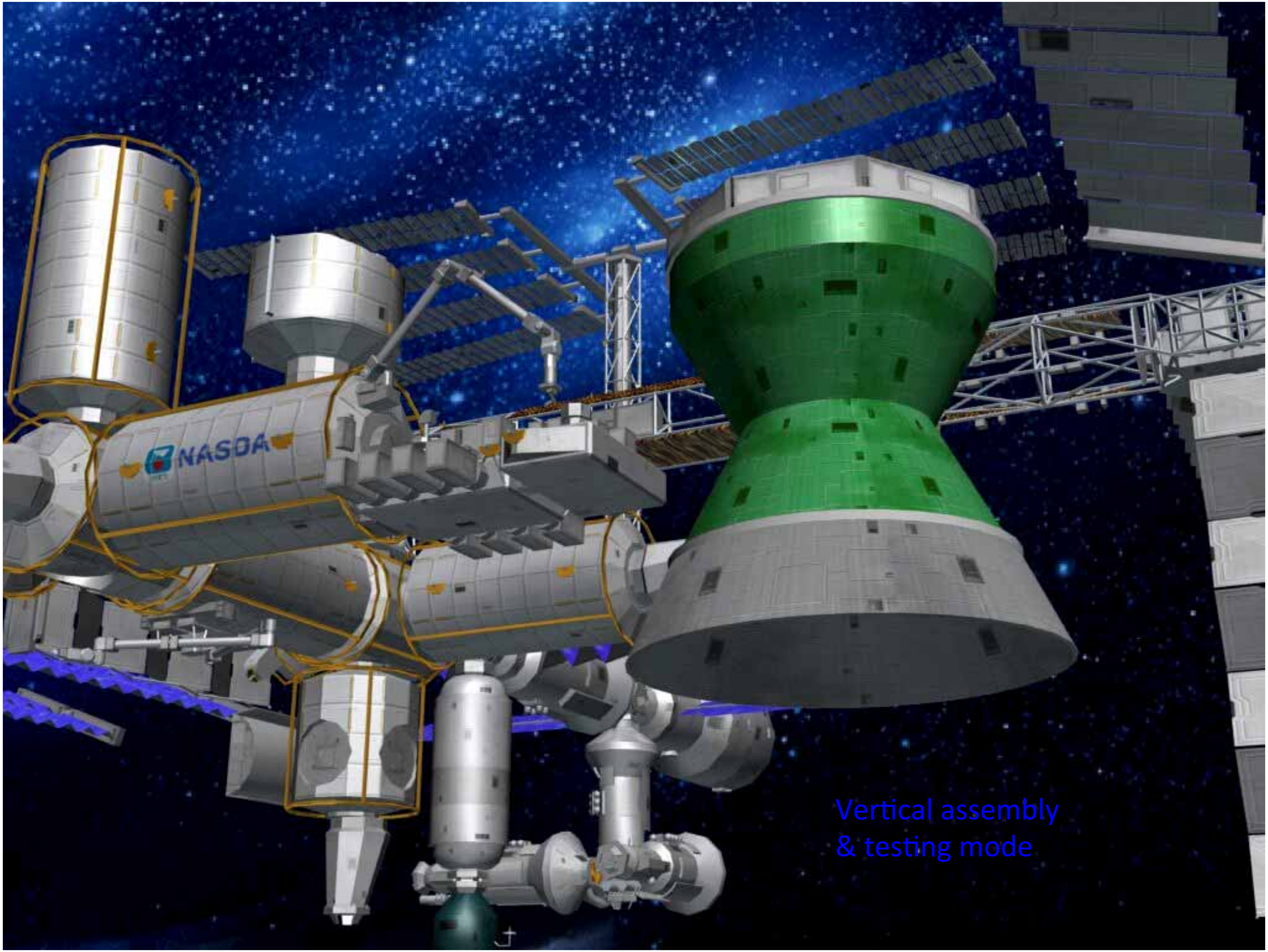


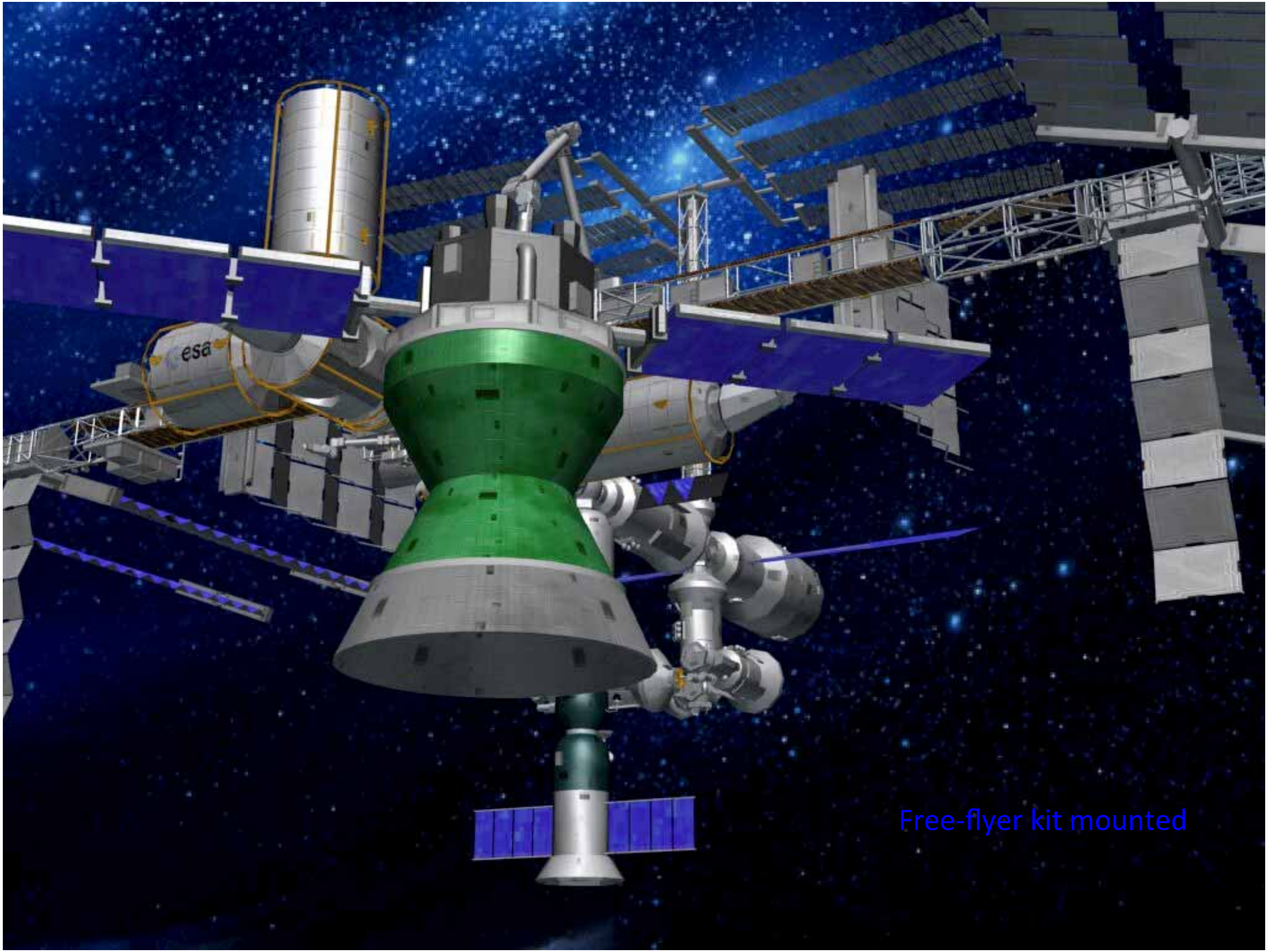


Optics option 15° FOV
Limited by Schmidt

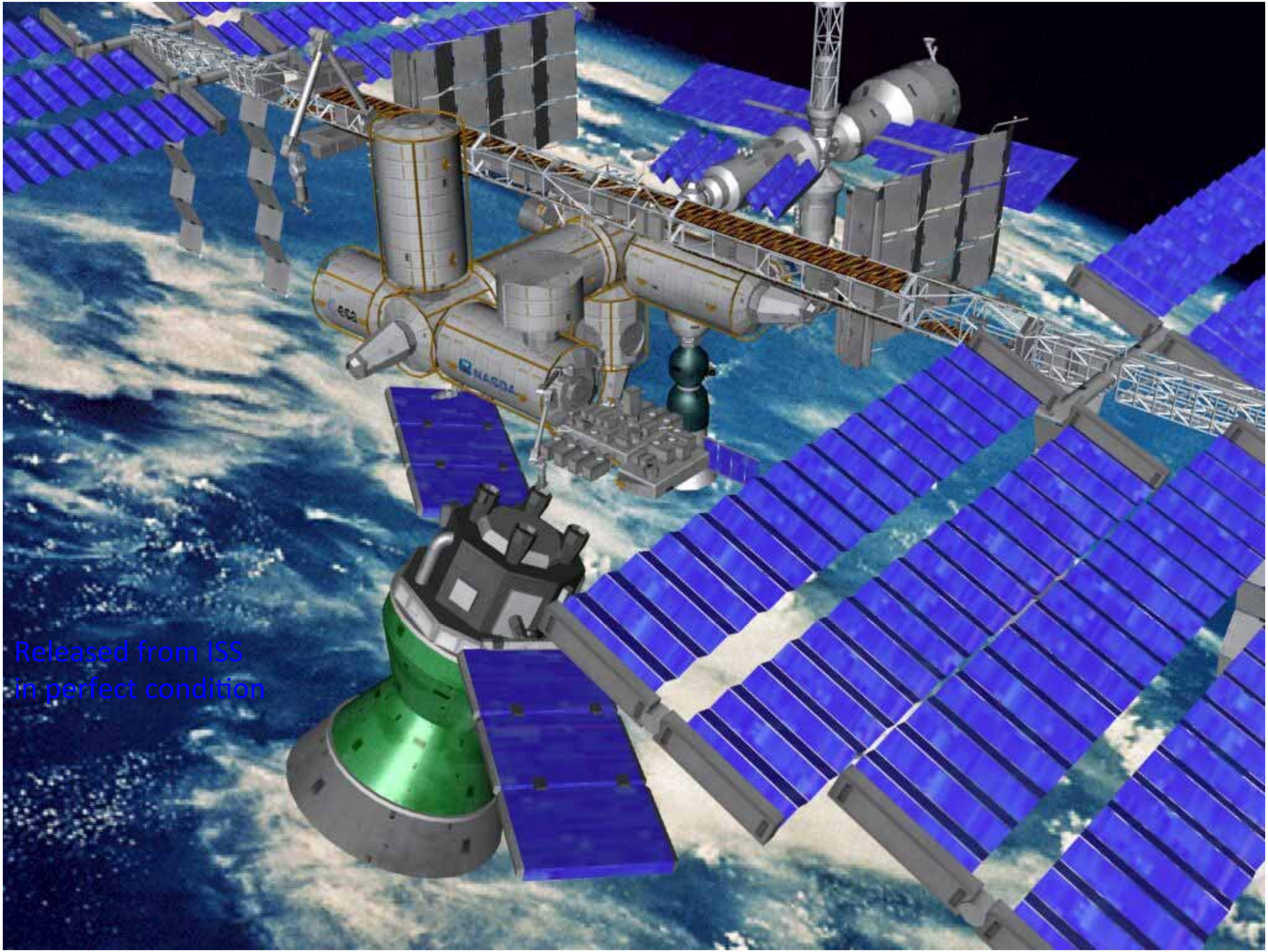
Vertical assembly



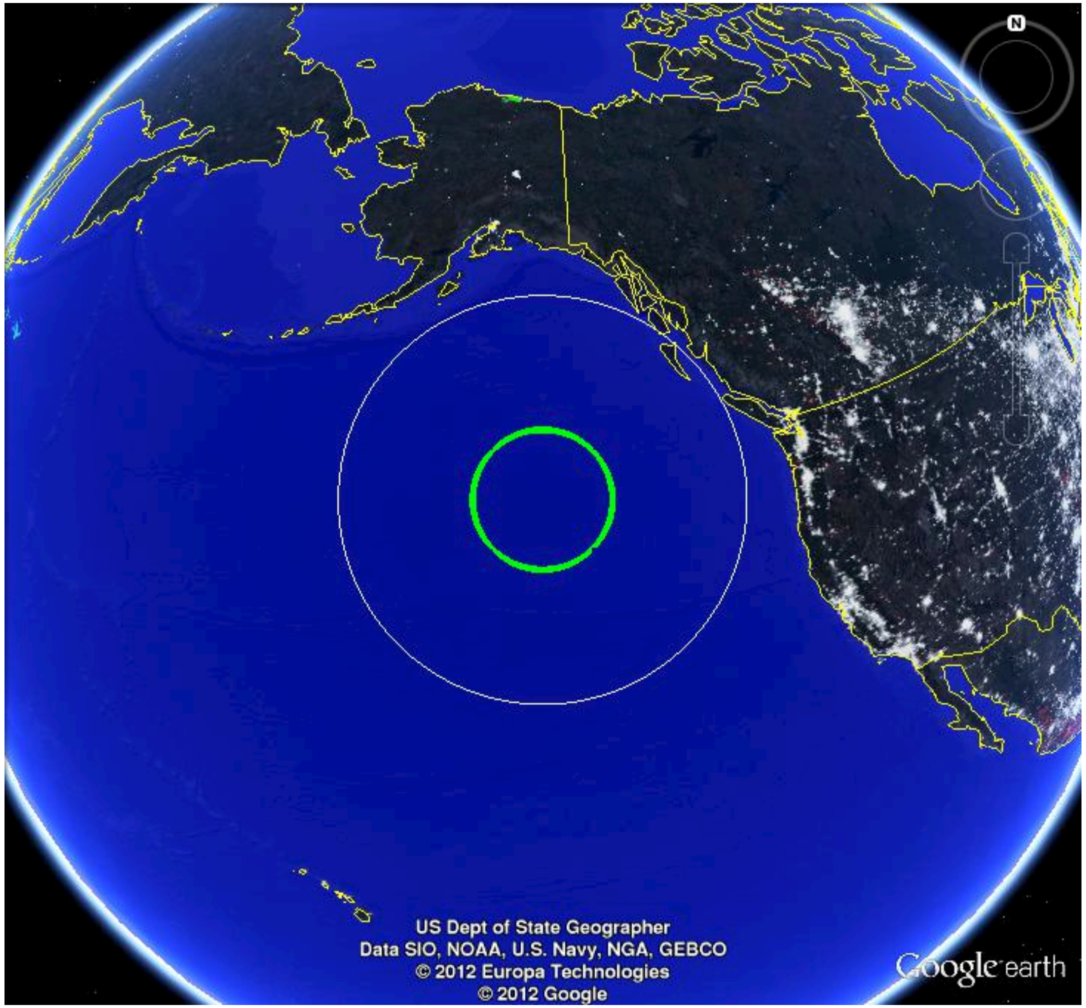

NASDA
Vertical assembly
& testing mode


esa
Free-flyer kit mounted


Y. Takahashi 1999
Great observatory made &
deployed from the renewed ISS
heading for its own orbit


esa
NASDA
Released from ISS
in perfect condition

Huge Pacific Ocean will be our Detector

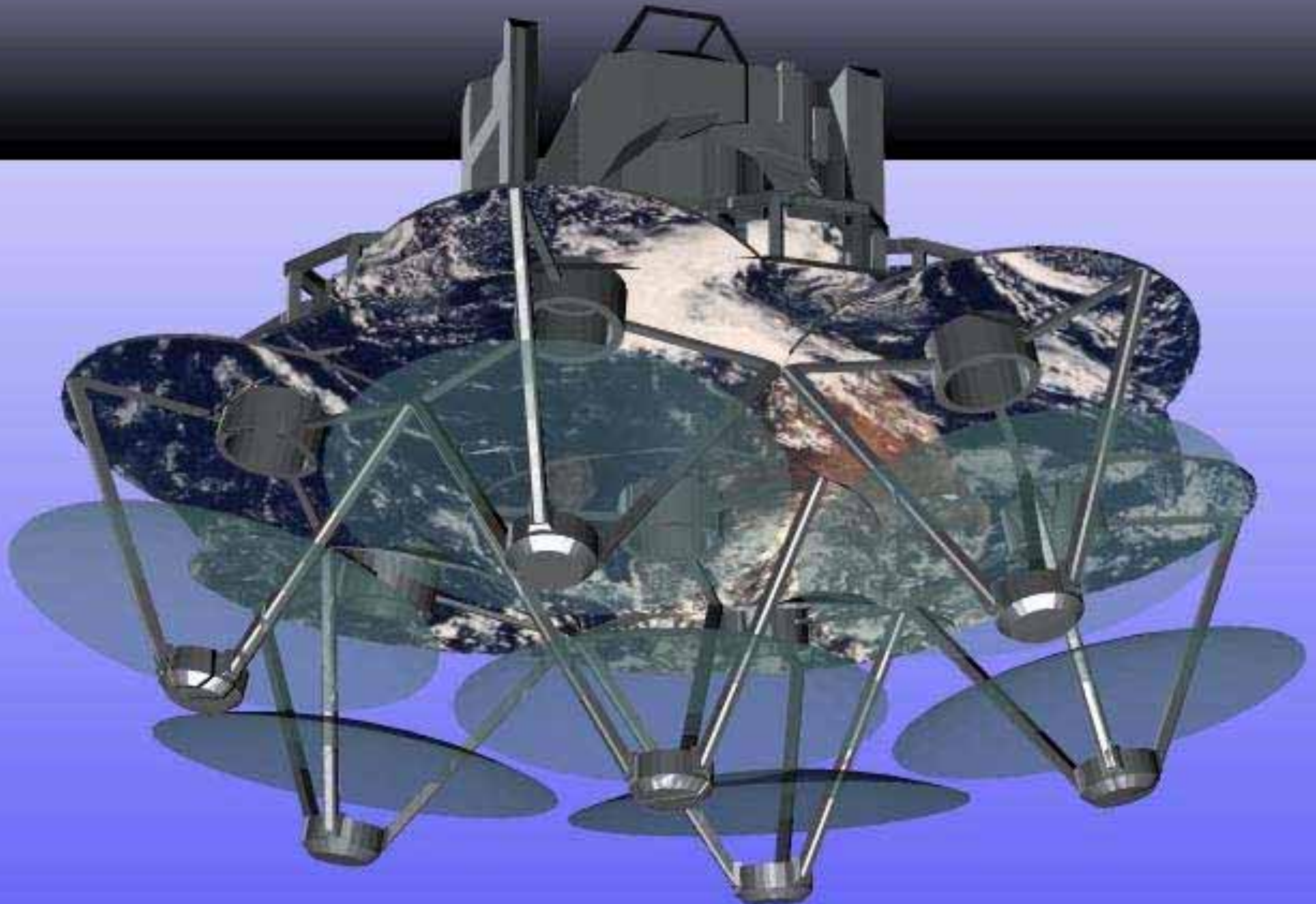


White circle → HORIZON from S-EUSO (900km)

Four Space-Based Missions

	Optics Aperture [m^2]	FOV	Pixel side	Orbit altitude [km^2]	Geom. aperture [km^2 sr]	Annual exposure [linsley yr^{-1}]
TUS (2012—)	1.8	9°x9°	0.6°	500	2.0×10^4	2,700
JEM-EUSO (2017—)	4.5	60°ϕx48° (40°ϕ)	0.07°	400	4.0×10^5 (5.5×10^4)	60,000 (7000)
S-EUSO (2025—)	38	50°ϕ	0.04°	~900	2.0×10^6	300,000

Old Multi-OWL1996



Multi-units and/or multi-fleet
2 x 3 makes 6 times

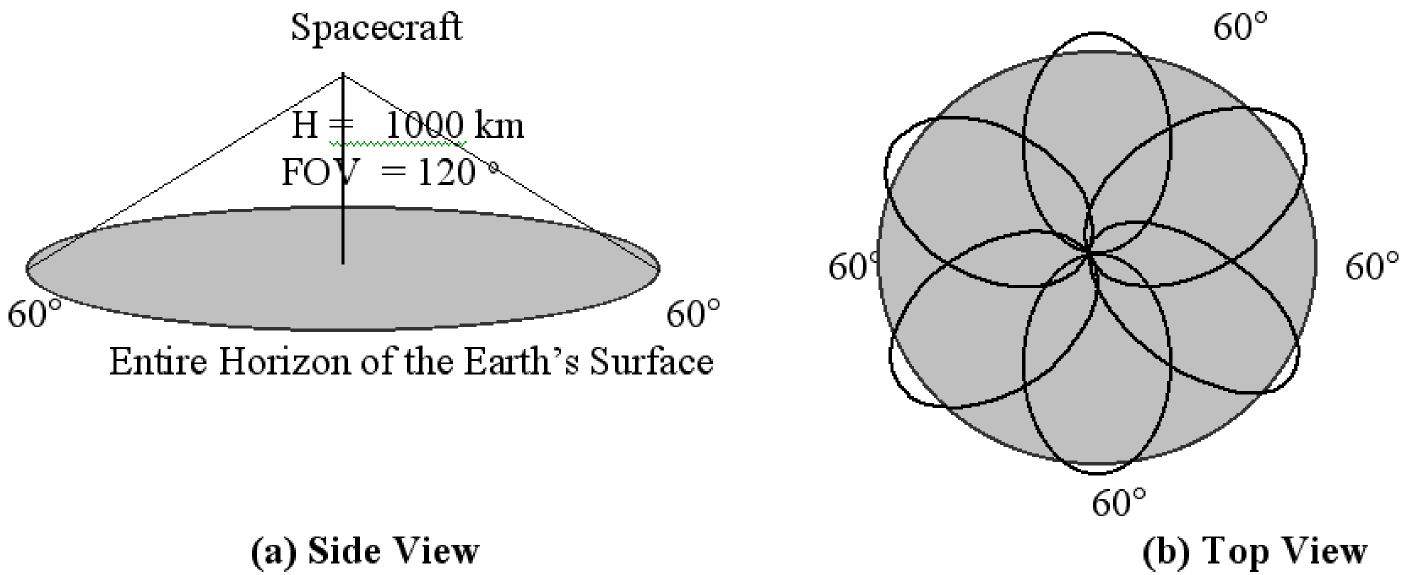
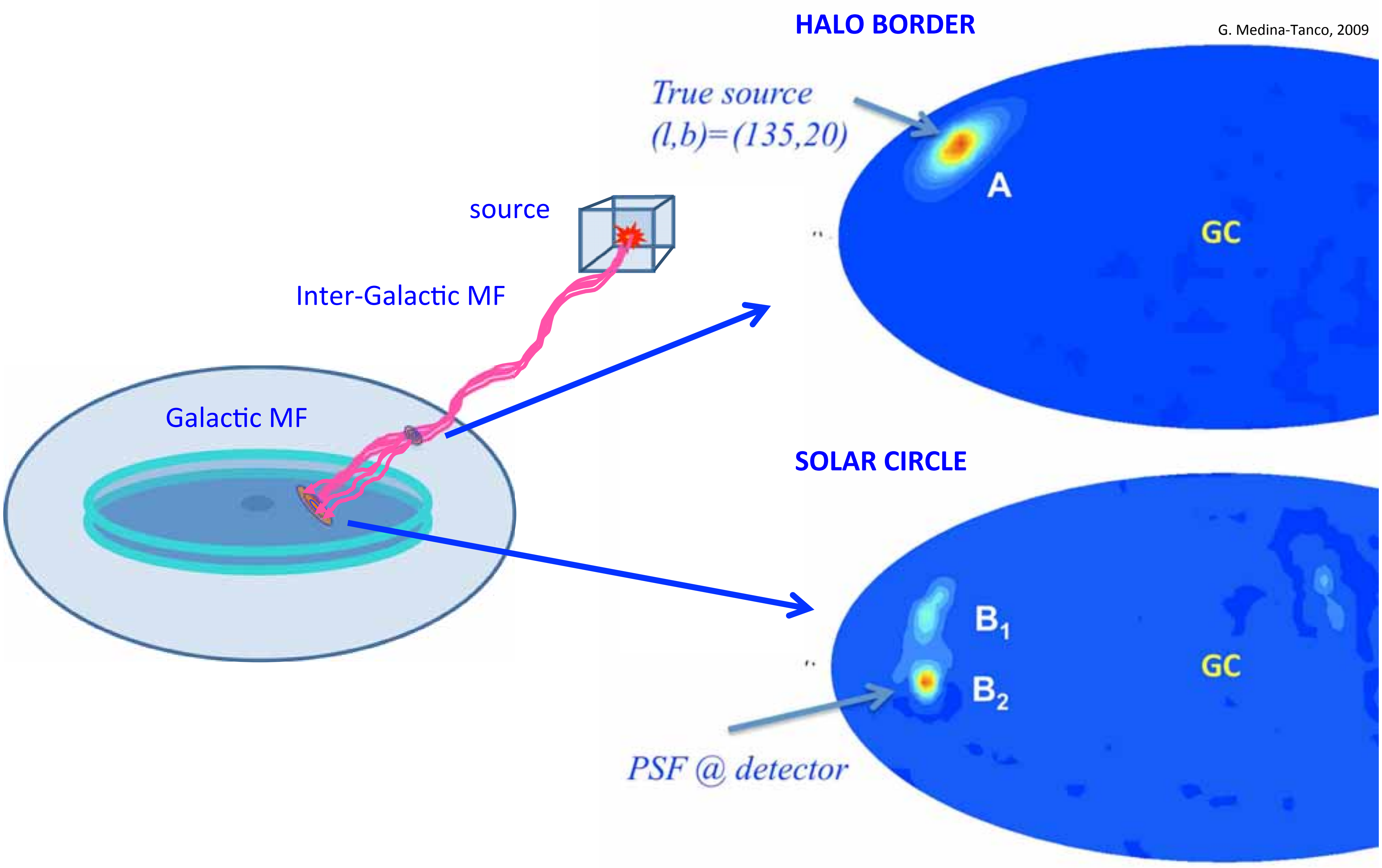


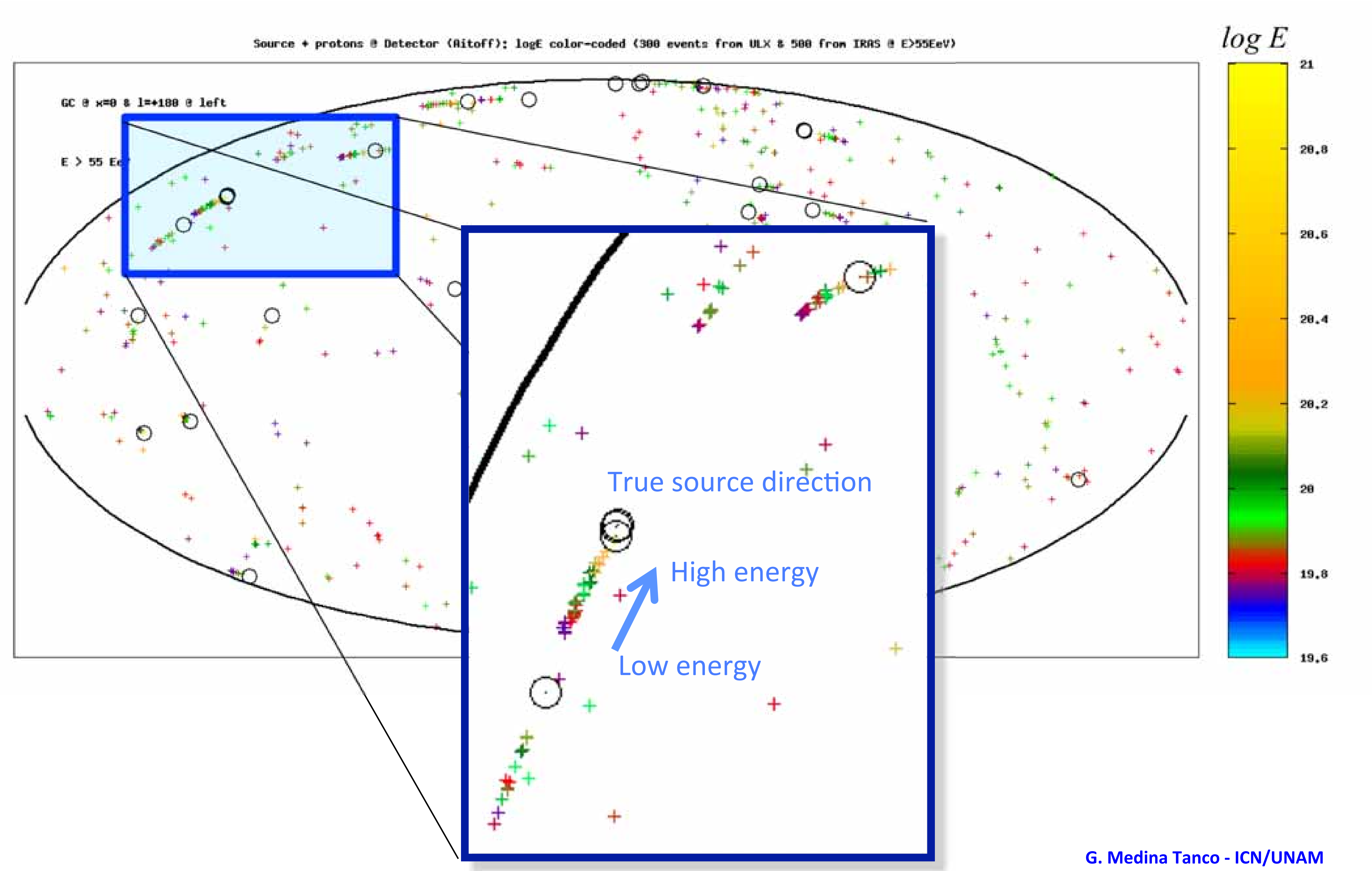
FIGURE 1. Combined Field-of-View of the Multi-OWL units.

予備

Individual source identification



Protons: E>55 EeV - 300ev from ULX + 500ev (bckgr) from IRAS

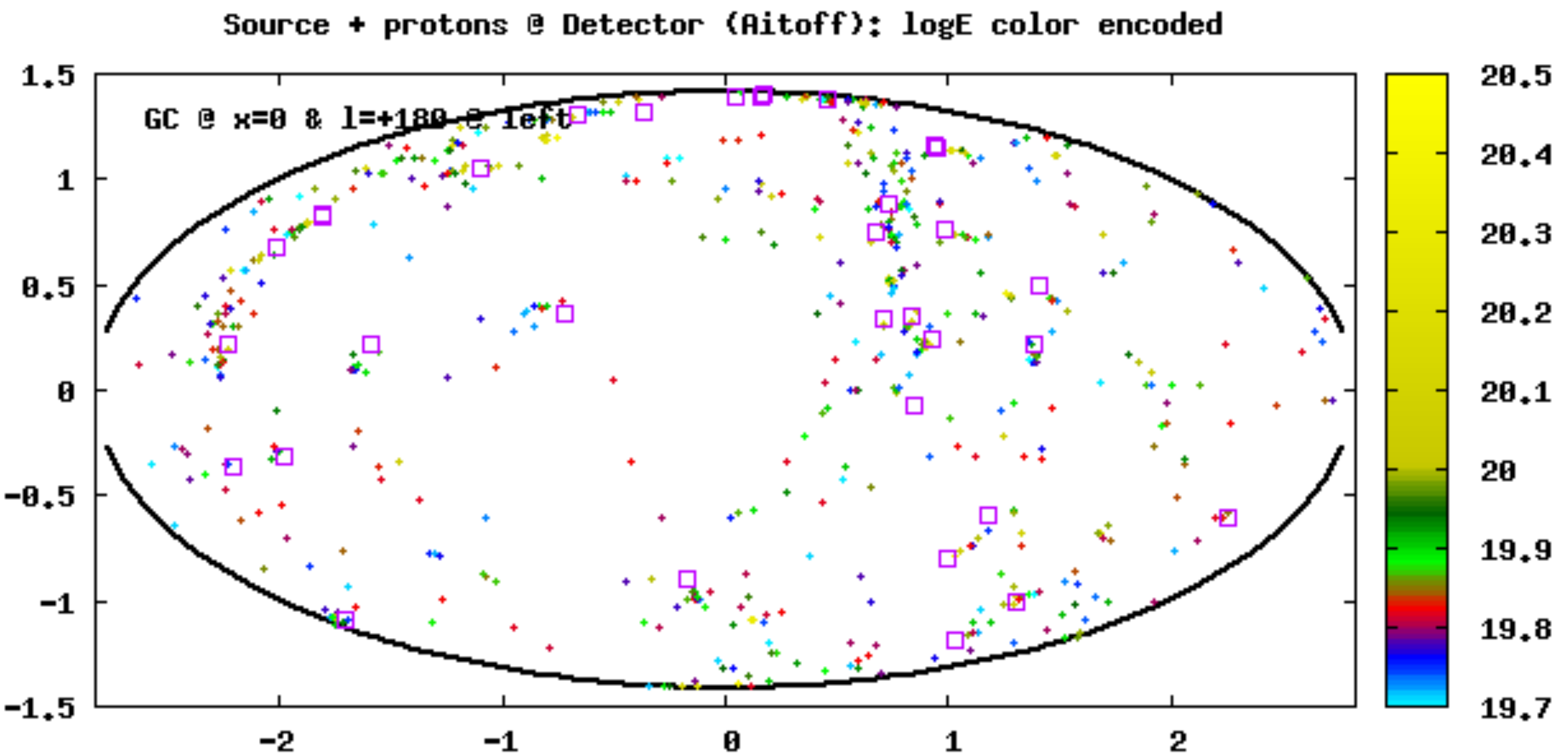


G. Medina Tanco - ICN/UNAM

JEM-EUSO @ 5 yr

$$\vec{B} = 1 \times \vec{B}_{Ahn}$$

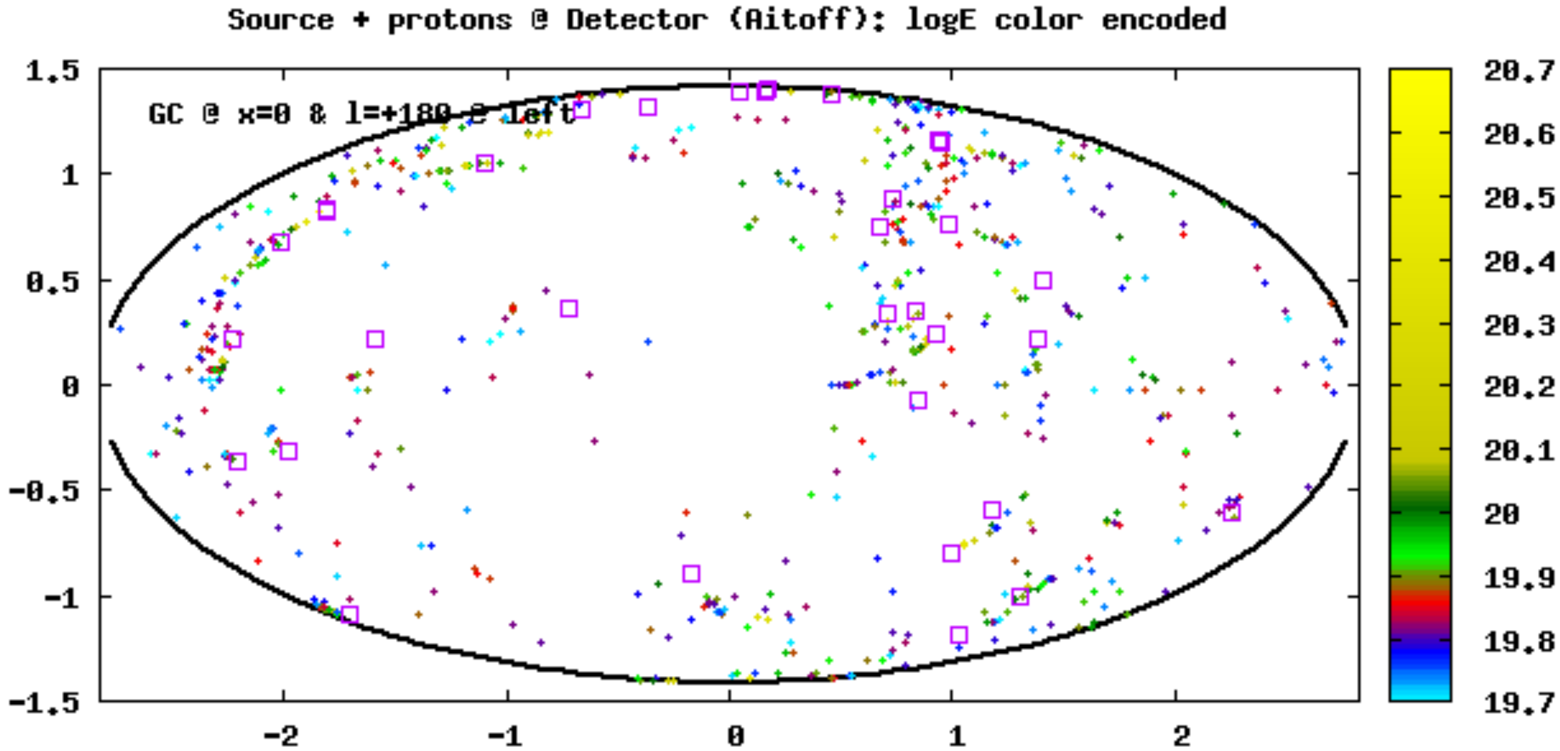
800 events: 70% bckgr from IRAS LSS + 30% from ULX PSrc



JEM-EUSO @ 5 yr

$$\vec{B} = 2 \times \vec{B}_{Ahn}$$

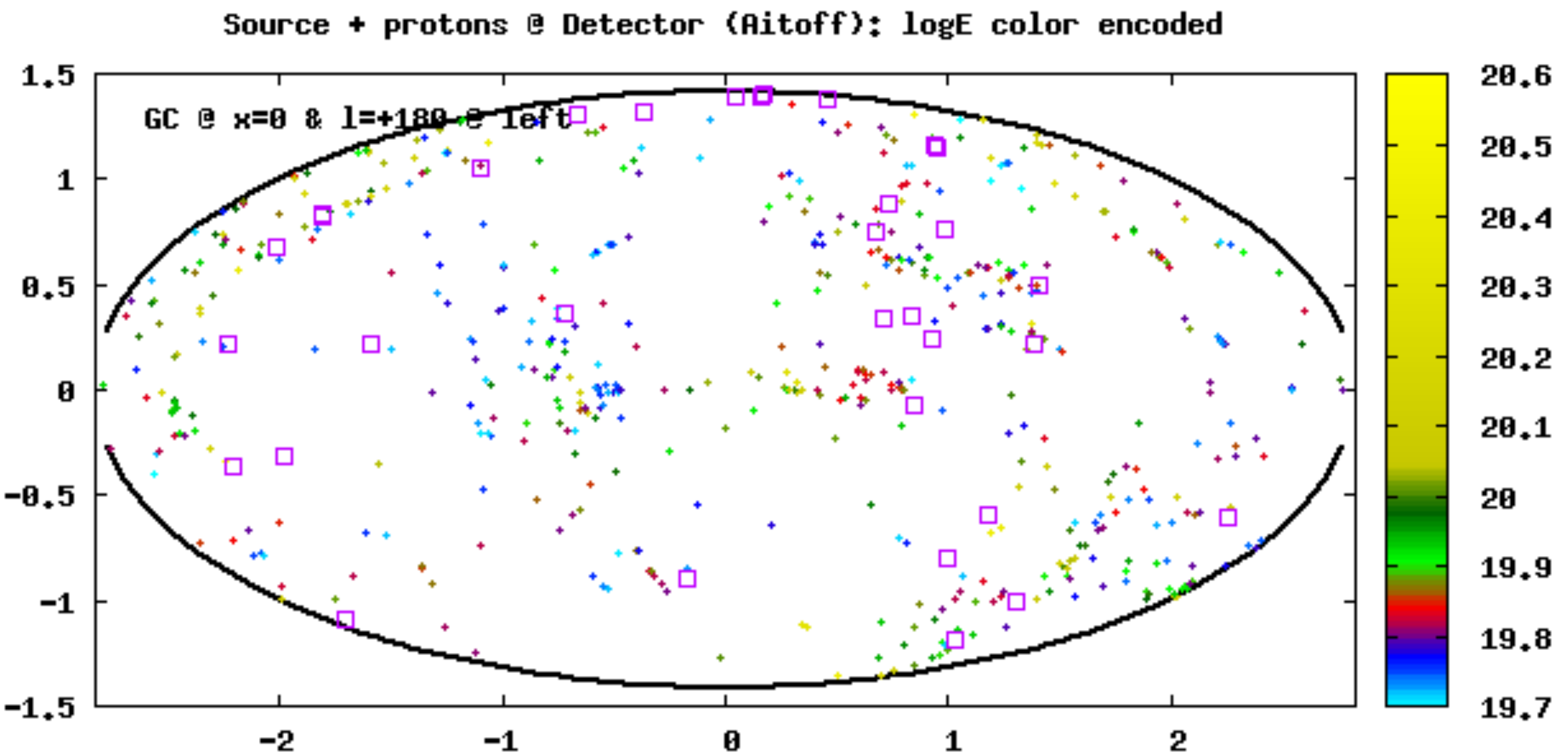
800 events: 70% bckgr from IRAS LSS + 30% from ULX PSrc



JEM-EUSO @ 5 yr

$$\vec{B} = 5 \times \vec{B}_{Ahn}$$

800 events: 70% bckgr from IRAS LSS + 30% from ULX PSrc

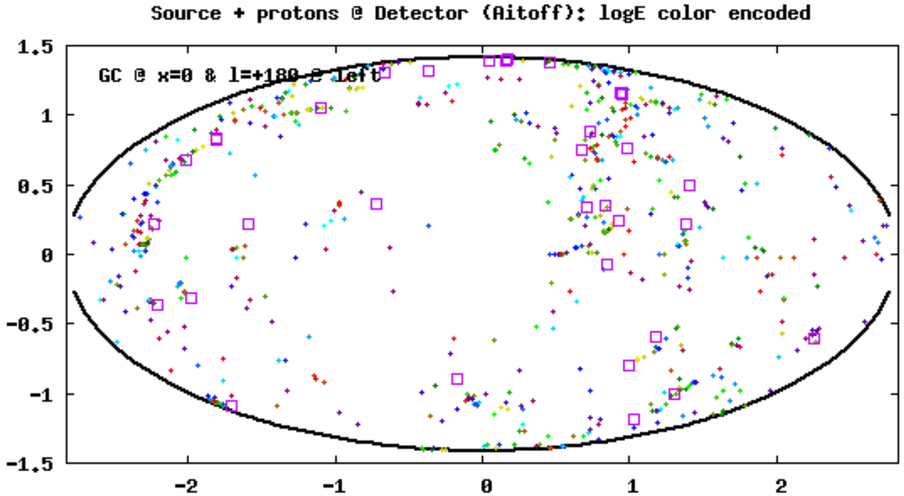


G. Medina Tanco - ICN/UNAM

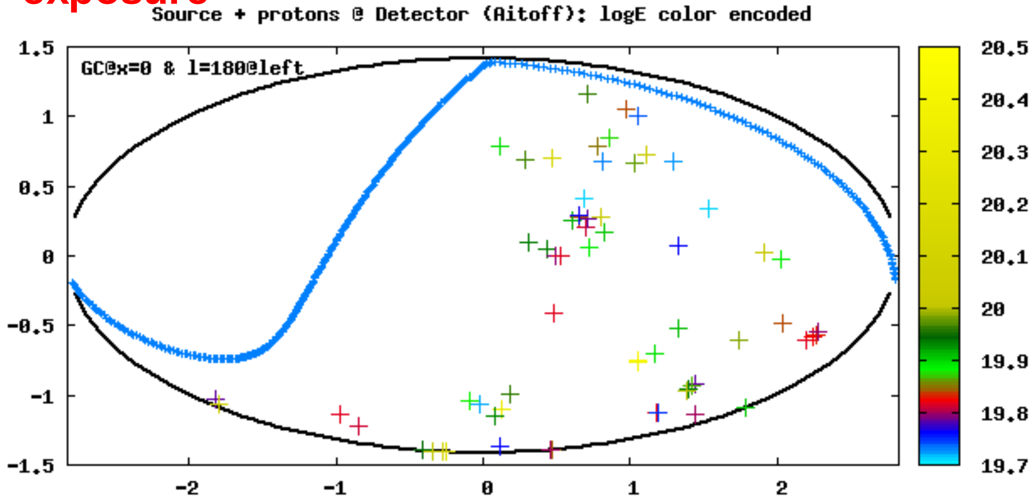
JEM-EUSO @ 5 yr compared to Auger

$$\vec{B} = 2 \times \vec{B}_{Ahn}$$

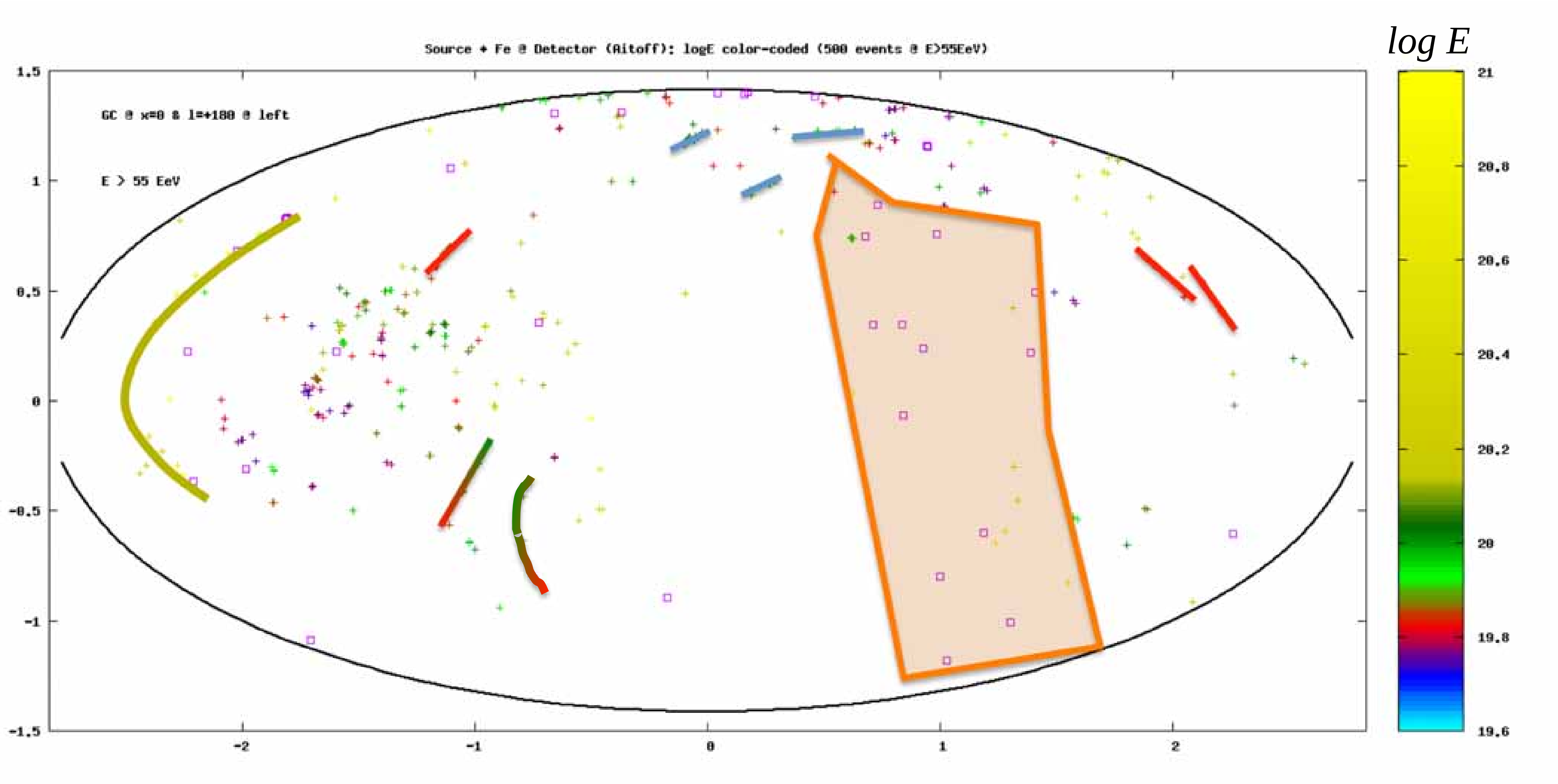
800 events: 70% bckgr from IRAS LSS + 30% from ULX PSrc



Same as previous with Auger present exposure

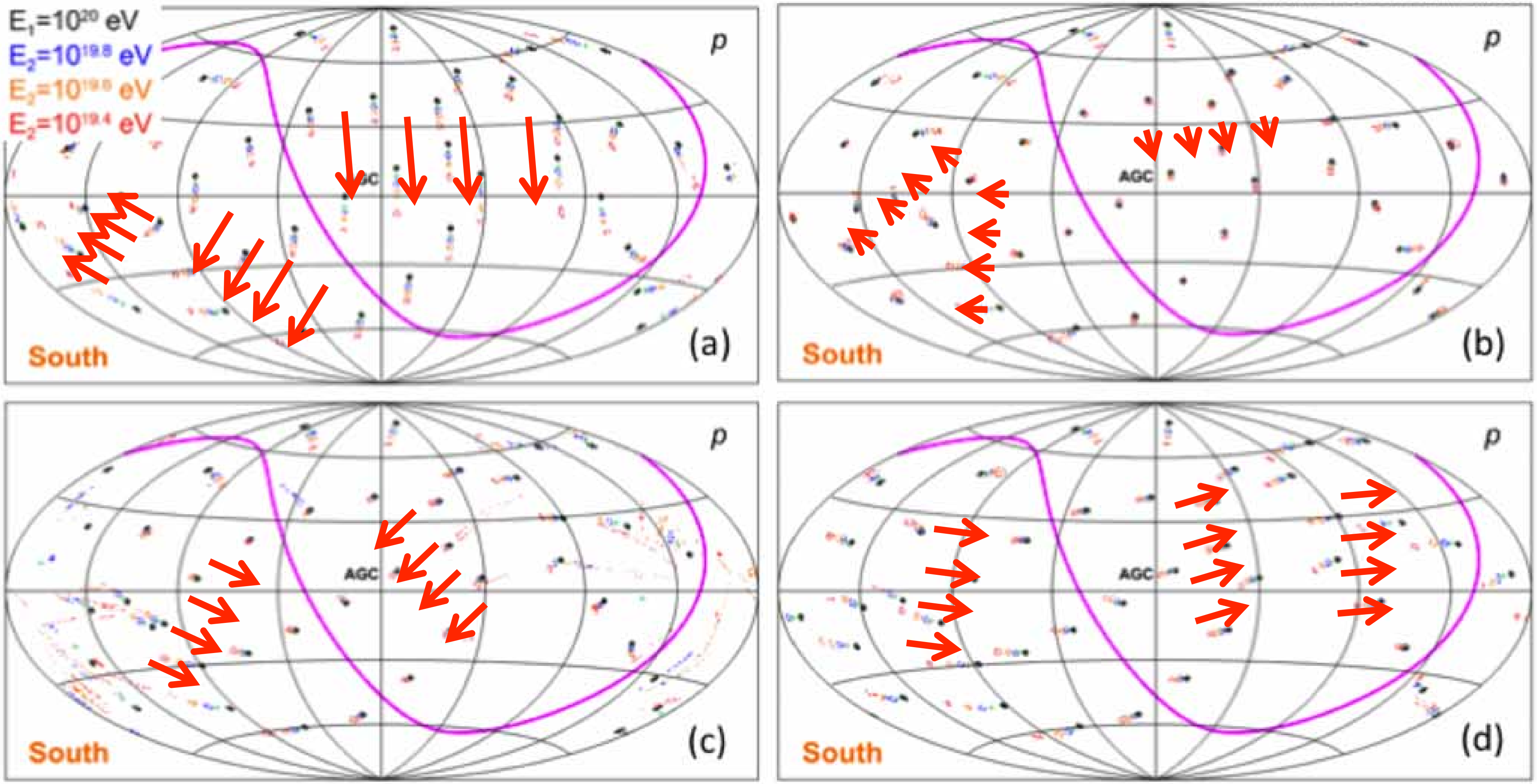


Fe: 500ev from ULX & no background events

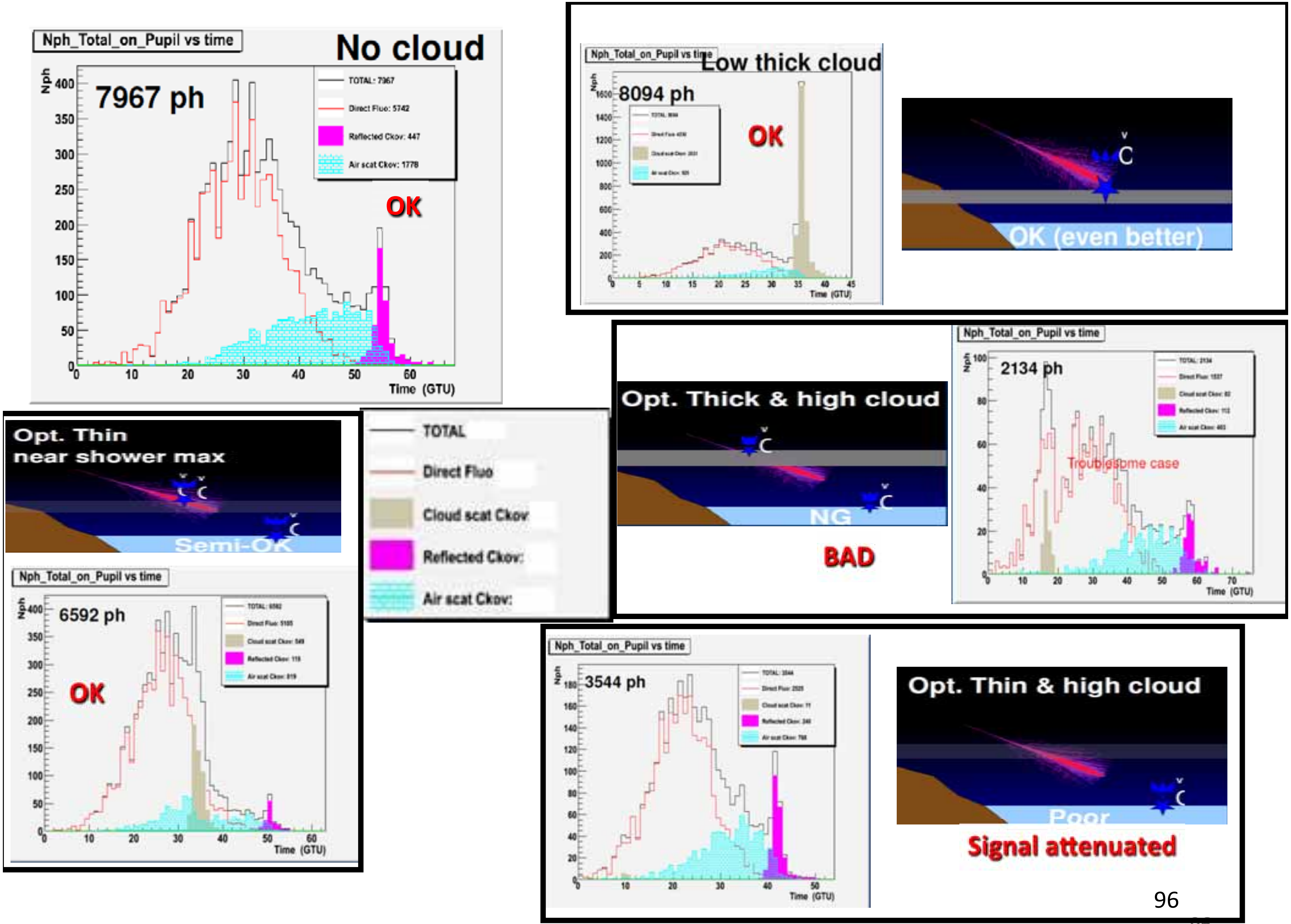


GMF assesment through PSF global patterns

Medina-Tanco & Teshima (2003)



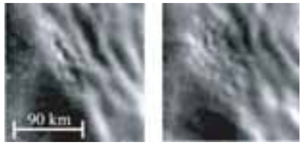
Individual PSFs do not need to be visible – 2D correlation function in (l,b) is enough to recover the structure.



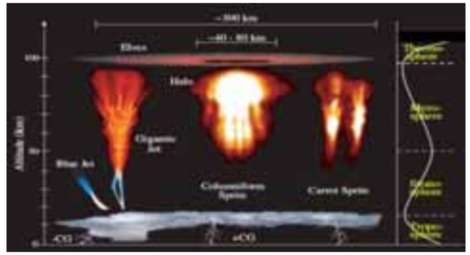
L.Saez et al., ID1034

Scientific Objectives 3

- Exploratory Objectives: Atmospheric science
  - *Nightglow*



  - *Transient luminous events*



  - *Space-atmosphere interactions and climate change*

- Exploratory Objectives: Meteors and meteoroids

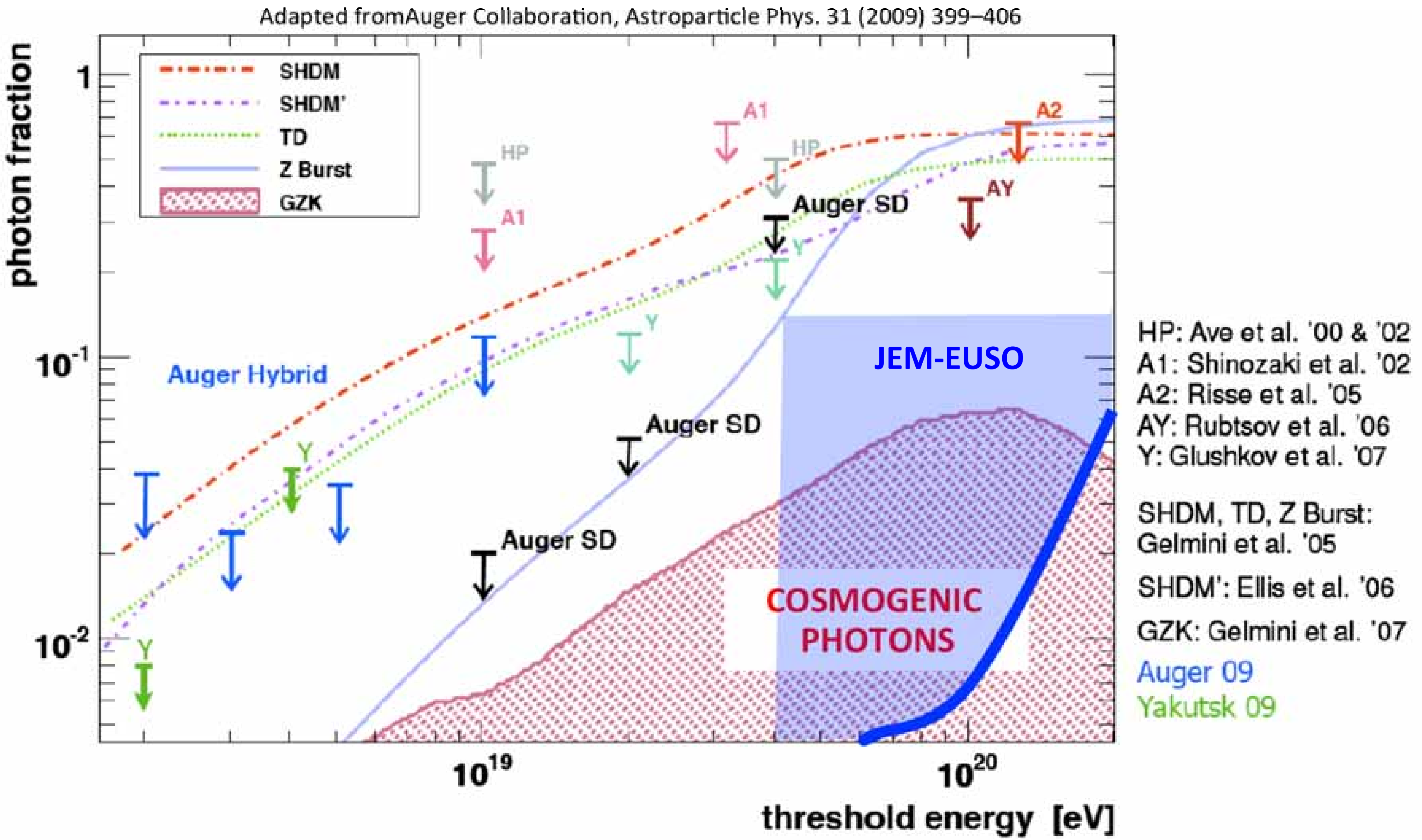
→ A fast UV monitoring of the atmosphere

The UV Telescope Parameters

Parameter	Value
Field of View	±30°
Monitored Area	>1.3×10^5km^2
Telescope aperture	≥2.5 m
Operational wavelength	300-400 nm
Resolution in angle	0.075°
Focal Plane Area	4.5 m^2
Pixel Size	<3 mm
Number of Pixels	≈3×10^5
Pixel size on ground	≈560 m
Time Resolution	2.5 μs
Dead Time	<3%
Detection Efficiency	≥20%

Optics Throughput

Upper limits on the photon-abundance – simple approach



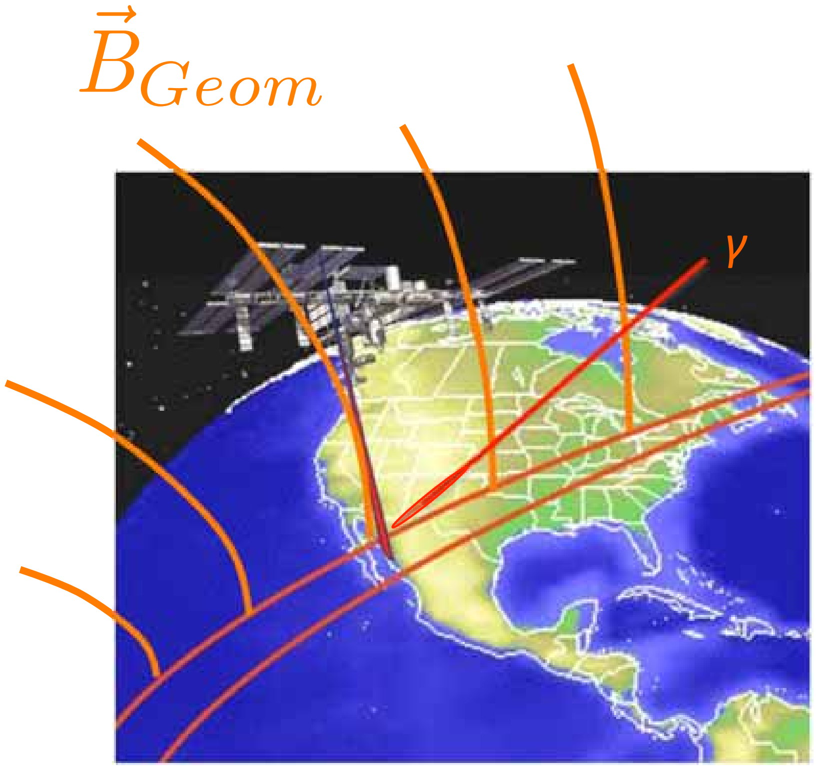
For a sample of size N, a rejection level α, and the ad hoc assumption that there are no γ events in the sample ⇒

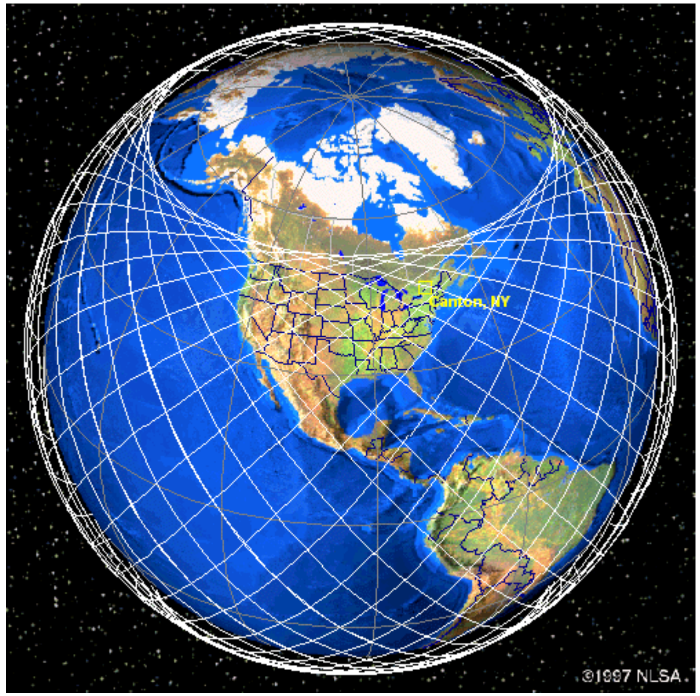
$$\mathcal{F}_{\gamma}^{min} = 1 - (1-\alpha)^{1/N}$$

Photon discrimination

ISS samples all possible relative configurations of the geomagnetic field vs. EAS direction.

JEM-EUSO is ideally suited to exploit interplay between LPM & photon splitting





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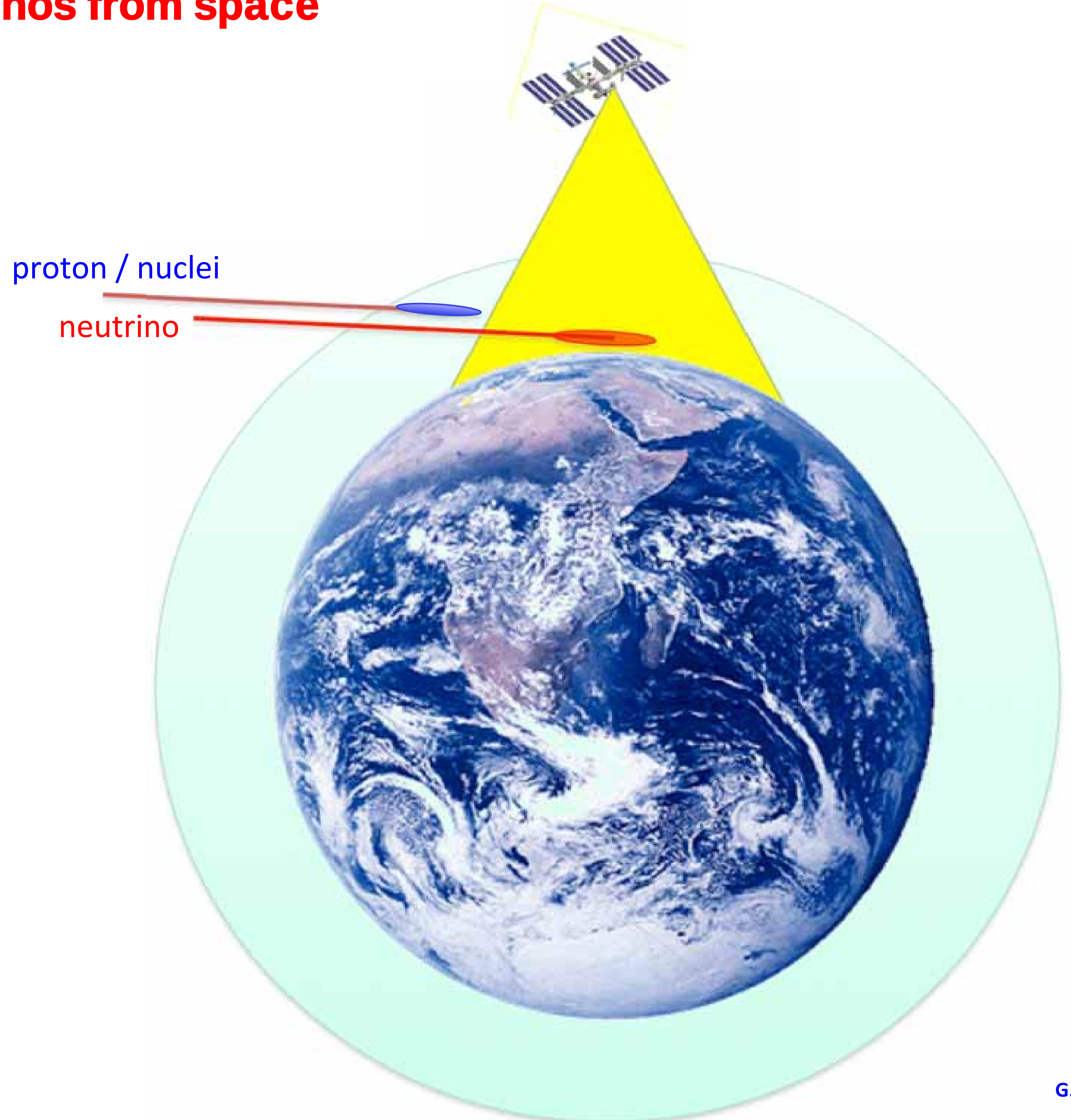
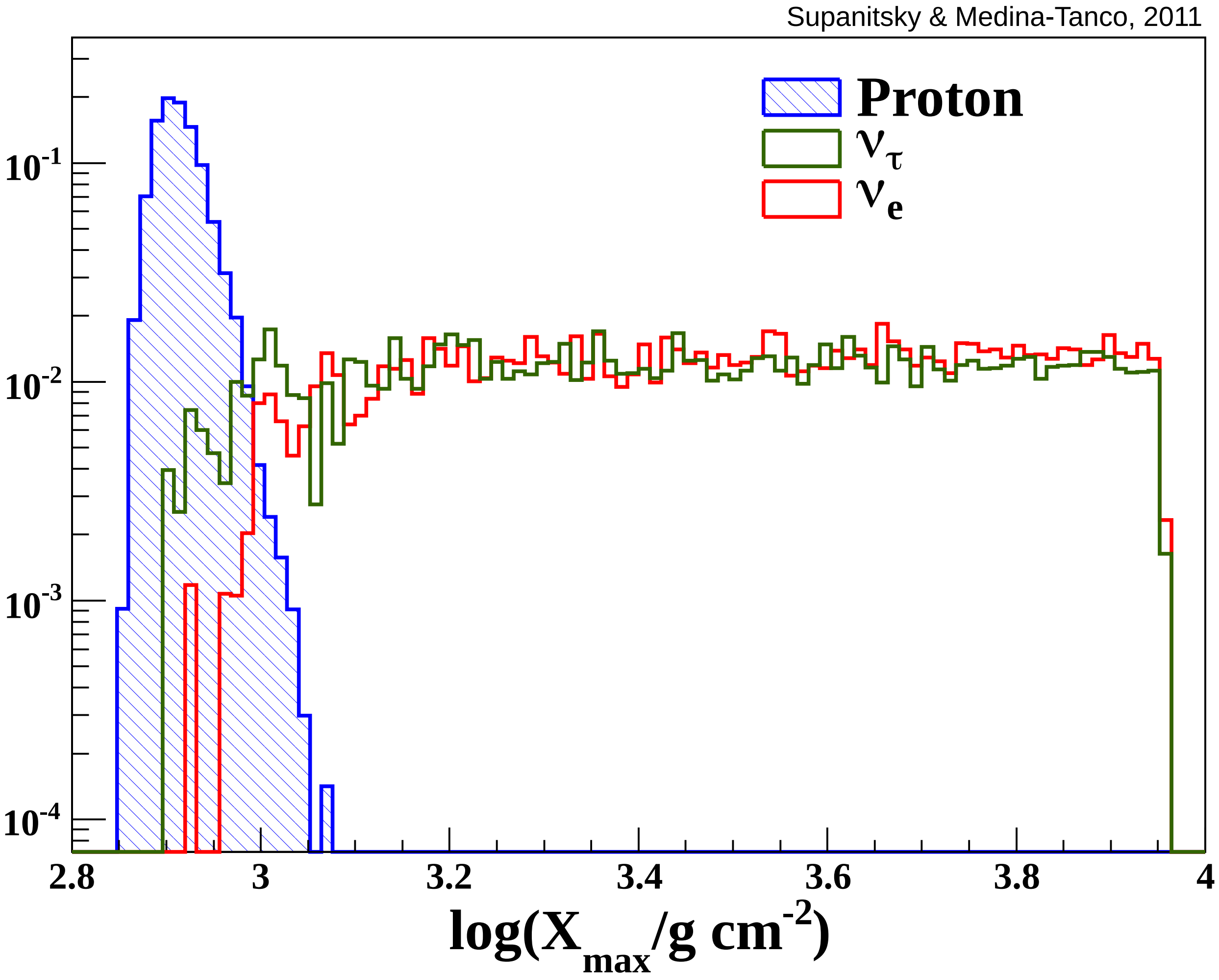
Neutrinos from space

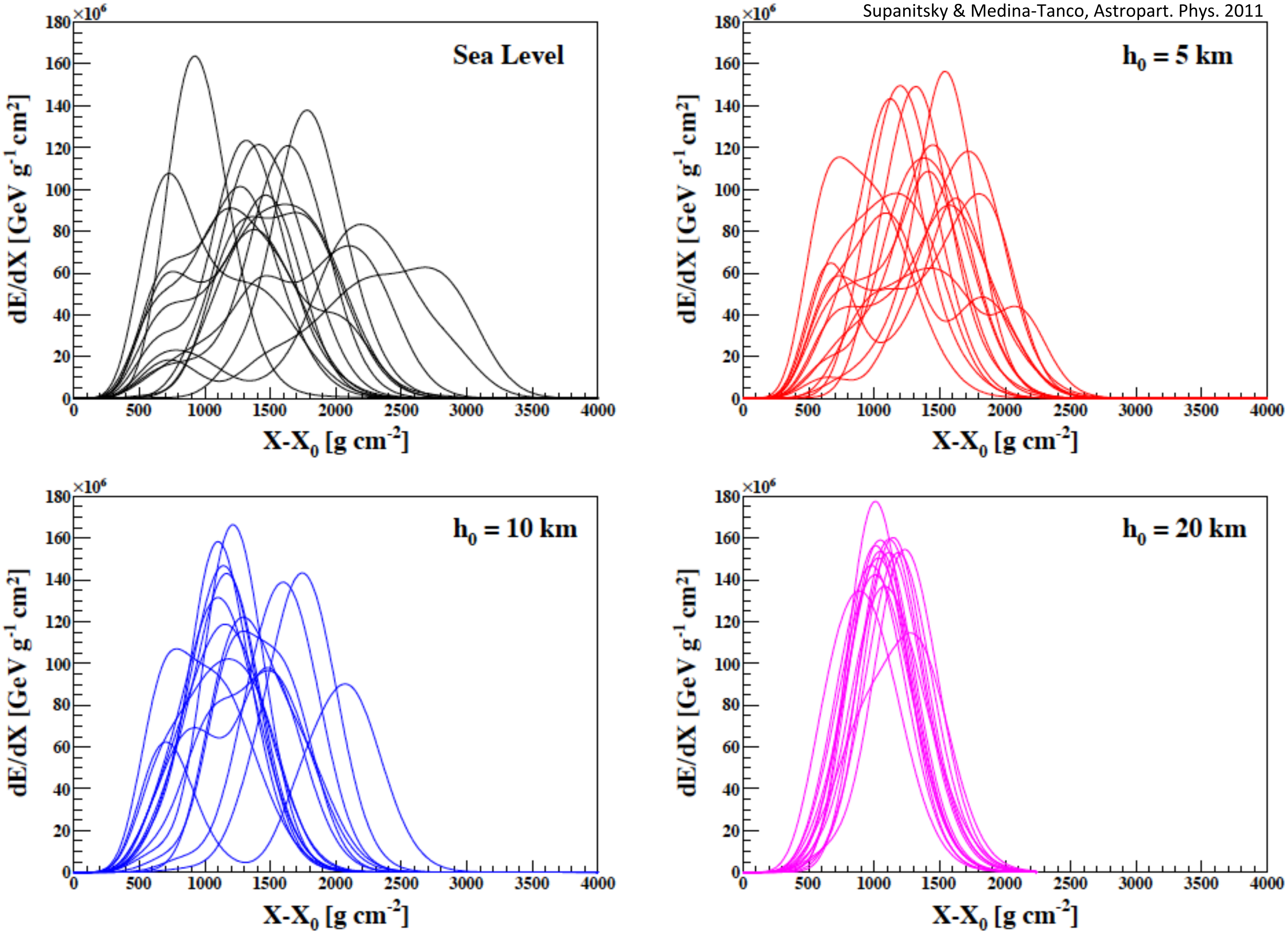


Neutrino discrimination: down-going neutrinos



Distribution of the first peak of the profiles for proton and neutrinos of E = 10^{20} eV and θ= 85°.

Inclined down-going $\nu_e - \nu_\tau$ discrimination



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LIV for HE electrons and photons

The same argument of Glashow & Coleman can be applied to the decay of photons into $e^{\pm}$-pairs → $\delta_{e\gamma} = c_e - c_\gamma$

If $\delta \neq 0$ ⟶ $\gamma \to e^+ + e^-$ is kinematically allowed for all photons with:

$$E > m_e \sqrt{\frac{2}{|\delta|}}$$

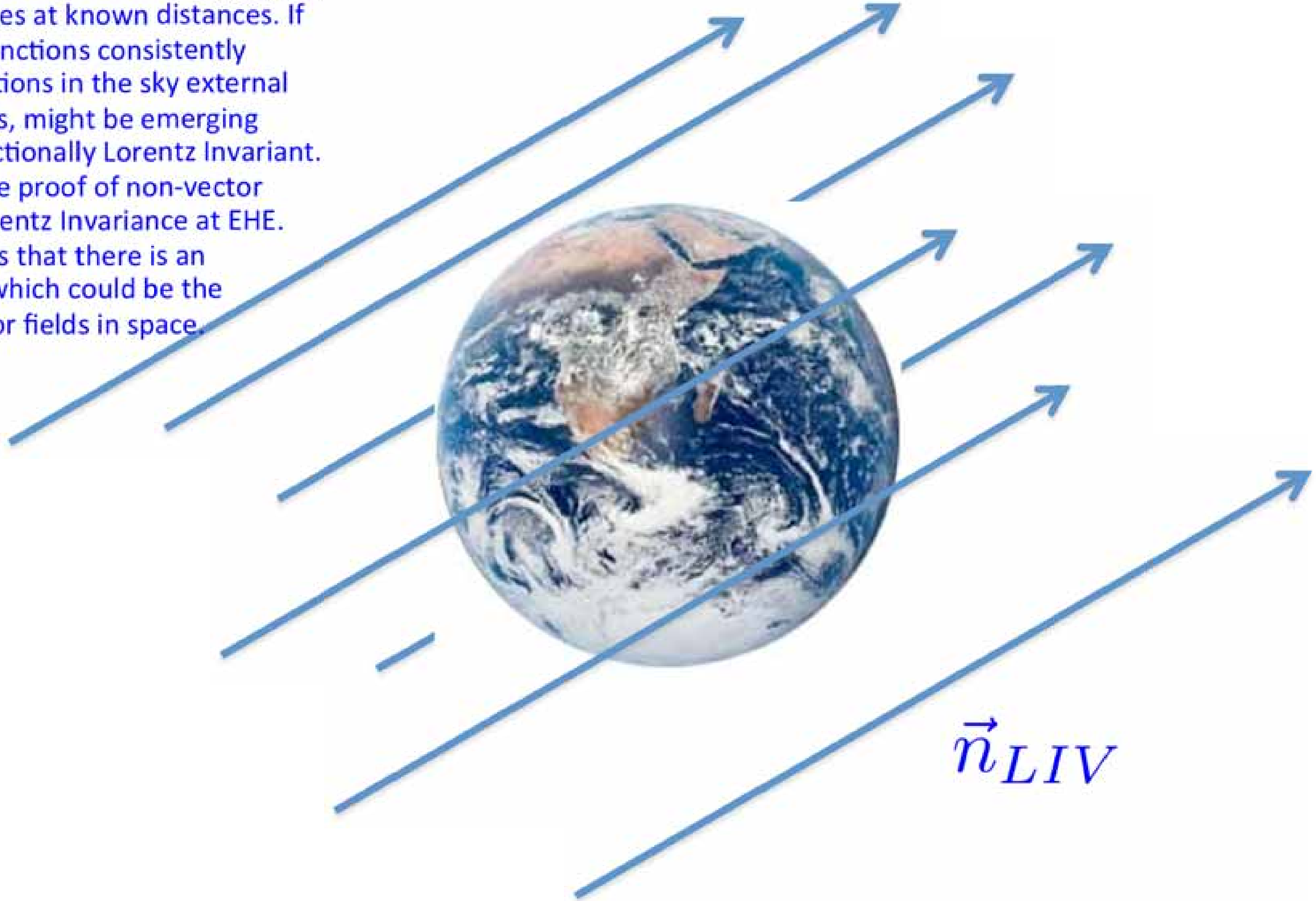
Thus even a trivial (but still restrictive) limit on δ comes from the mere eventual observation of HE photons by JEM-EUSO at ~ 10^{20} eV:

$$\delta_{e\gamma} < \frac{2m_e^2}{E_{\max}^2} \approx \frac{2\times\left(5\times10^5\right)^2}{\left(10^{20}\right)^2} \sim 5\times10^{-29}$$

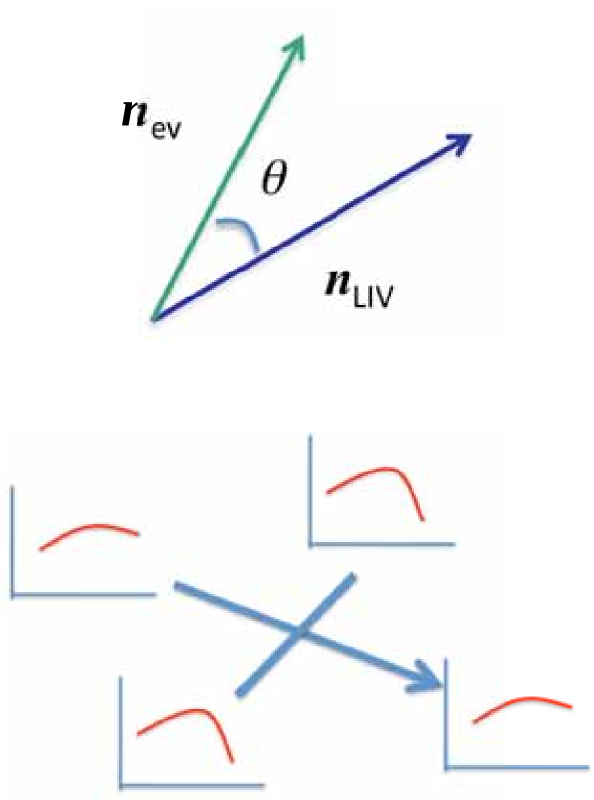
LI space symmetry violations

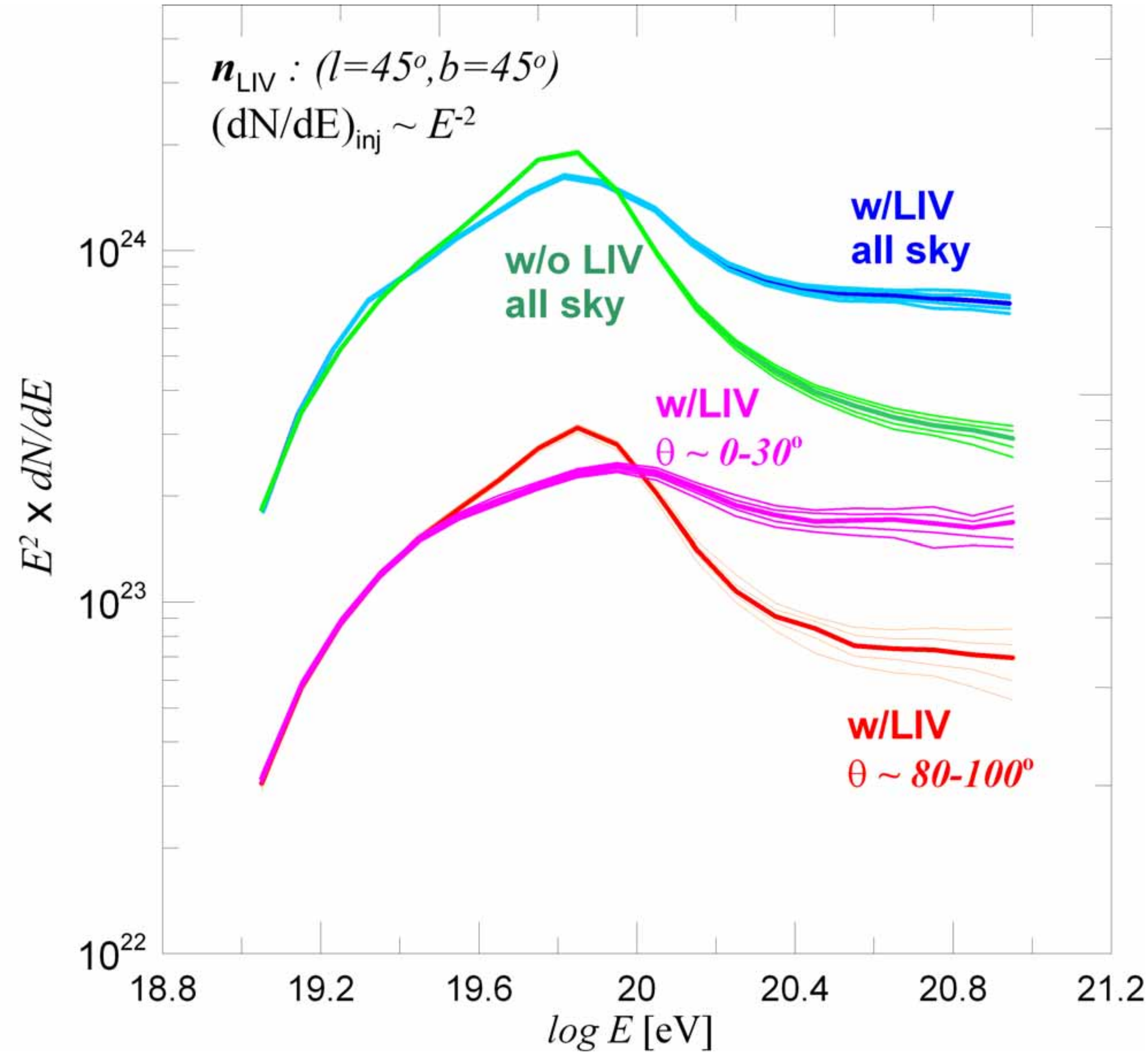
The possibility exists that there is an asymmetry in space, which could be the manifestation of vector fields in space.

A stringent test of relativity could be made from high multiplicity sources at known distances. If the GZK steepening functions consistently deviate at some directions in the sky external fields, like vector fields, might be emerging which are not unidirectionally Lorentz Invariant. On the other hand, the proof of non-vector fields would verify Lorentz Invariance at EHE. The possibility remains that there is an asymmetry in space, which could be the manifestation of vector fields in space.



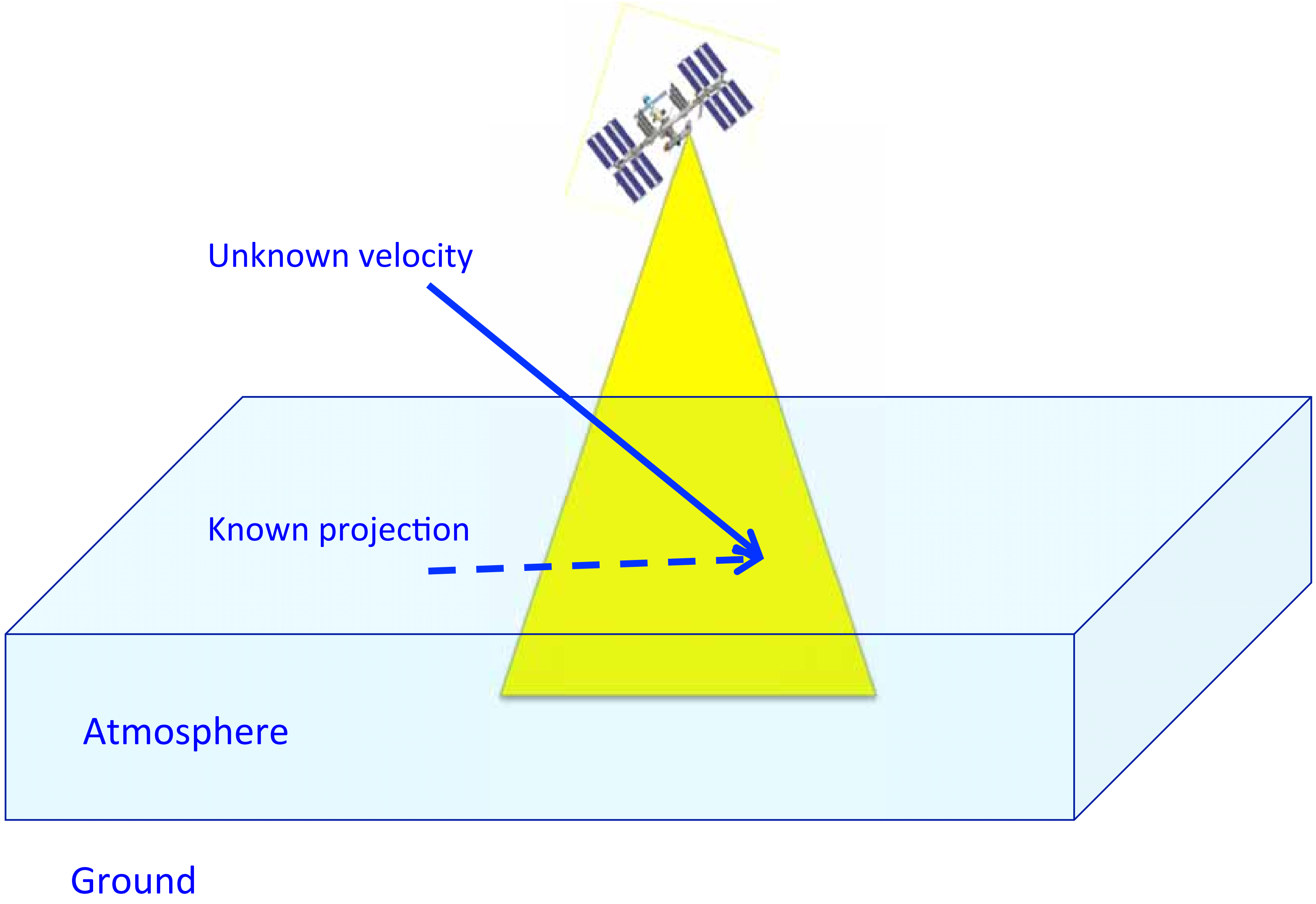
UHECR spectra at different region of the sky



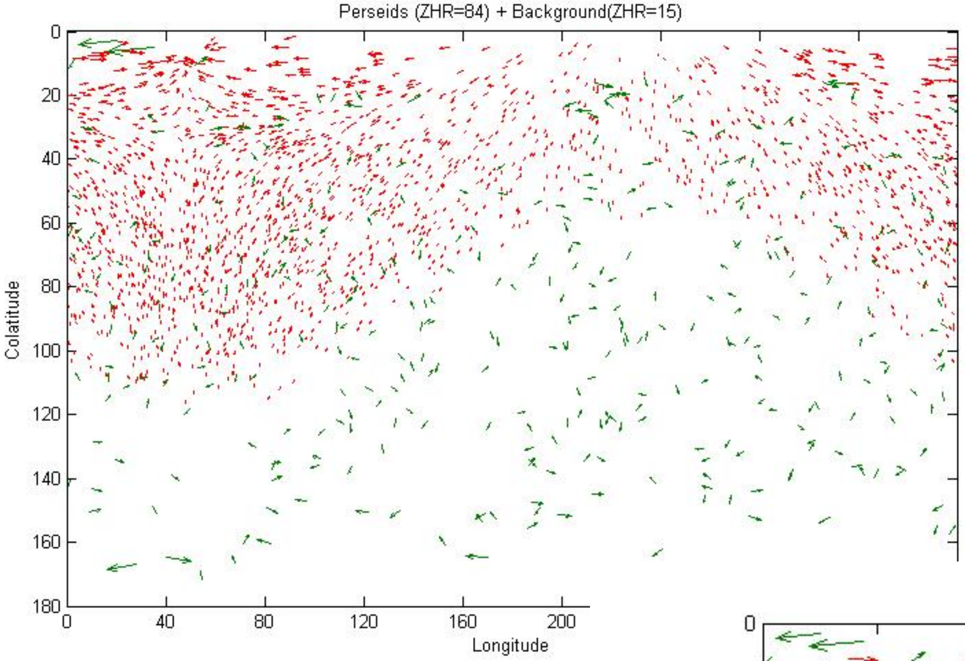


C.L.: 68% & 95%
ICRC2011 exposure
& trigger efficiency

Micrometeoritos

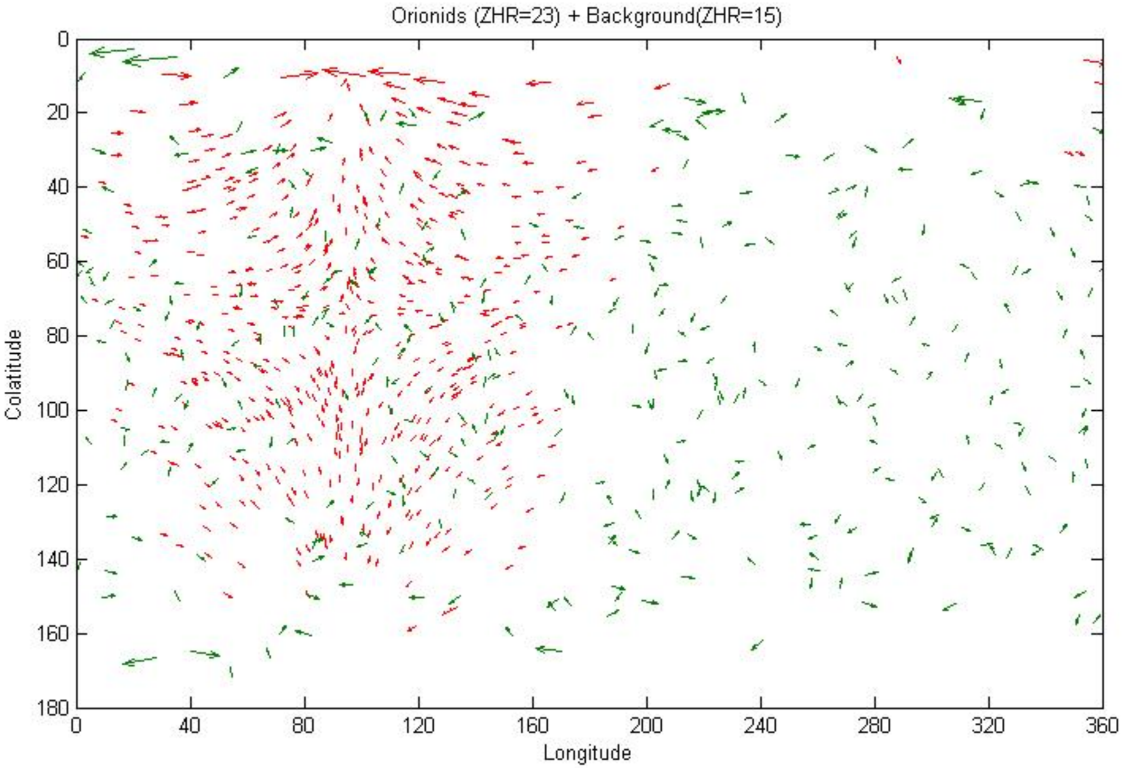


Micrometeoritos: search for and characterization of small debris



Perseids + background

Orionids + background



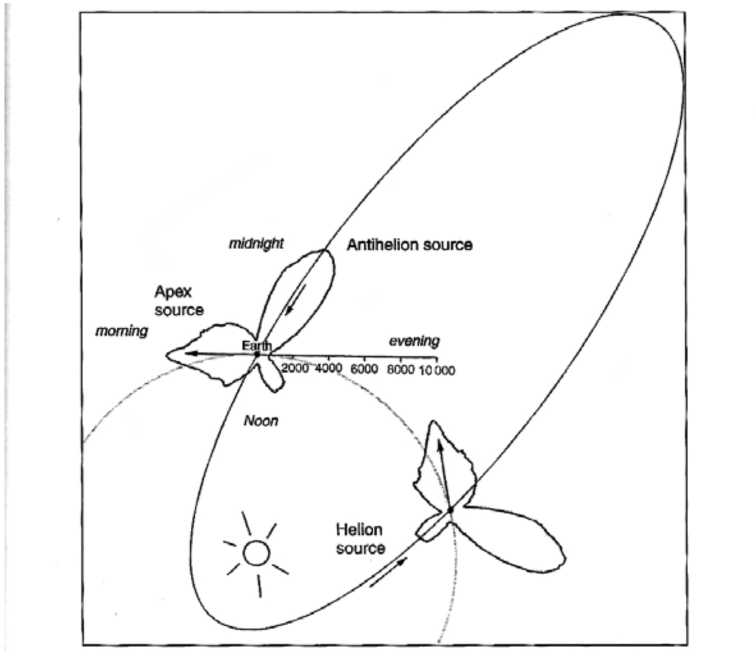
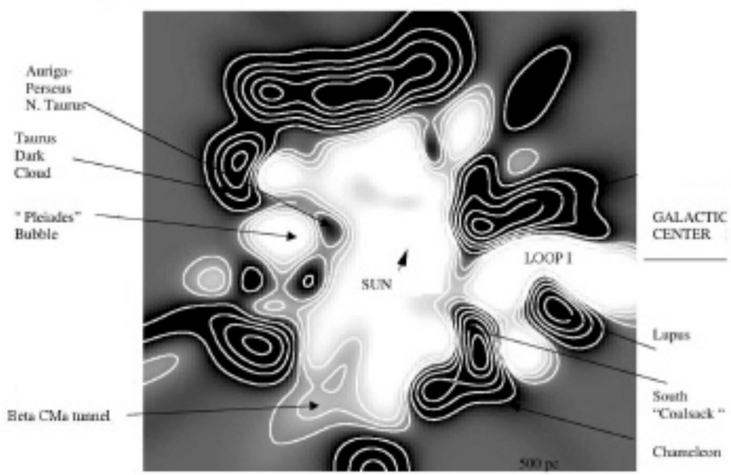
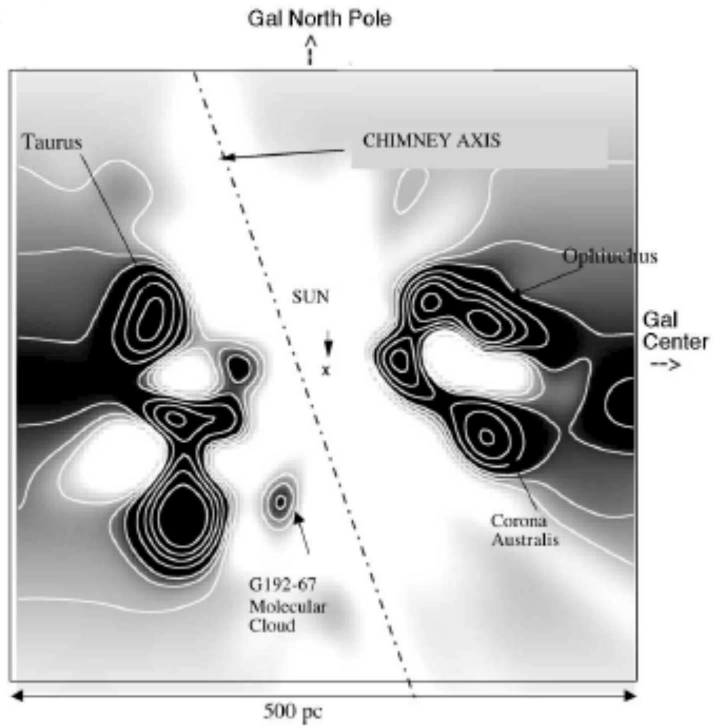


Fig. 28.1 The direction of origin of 132 996 meteors detected in 1990 and 1991 with the AMOR radar by Jack Baggaley, University of Christchurch.

太陽系周辺の物質分布





Welsh and Shelton 2009