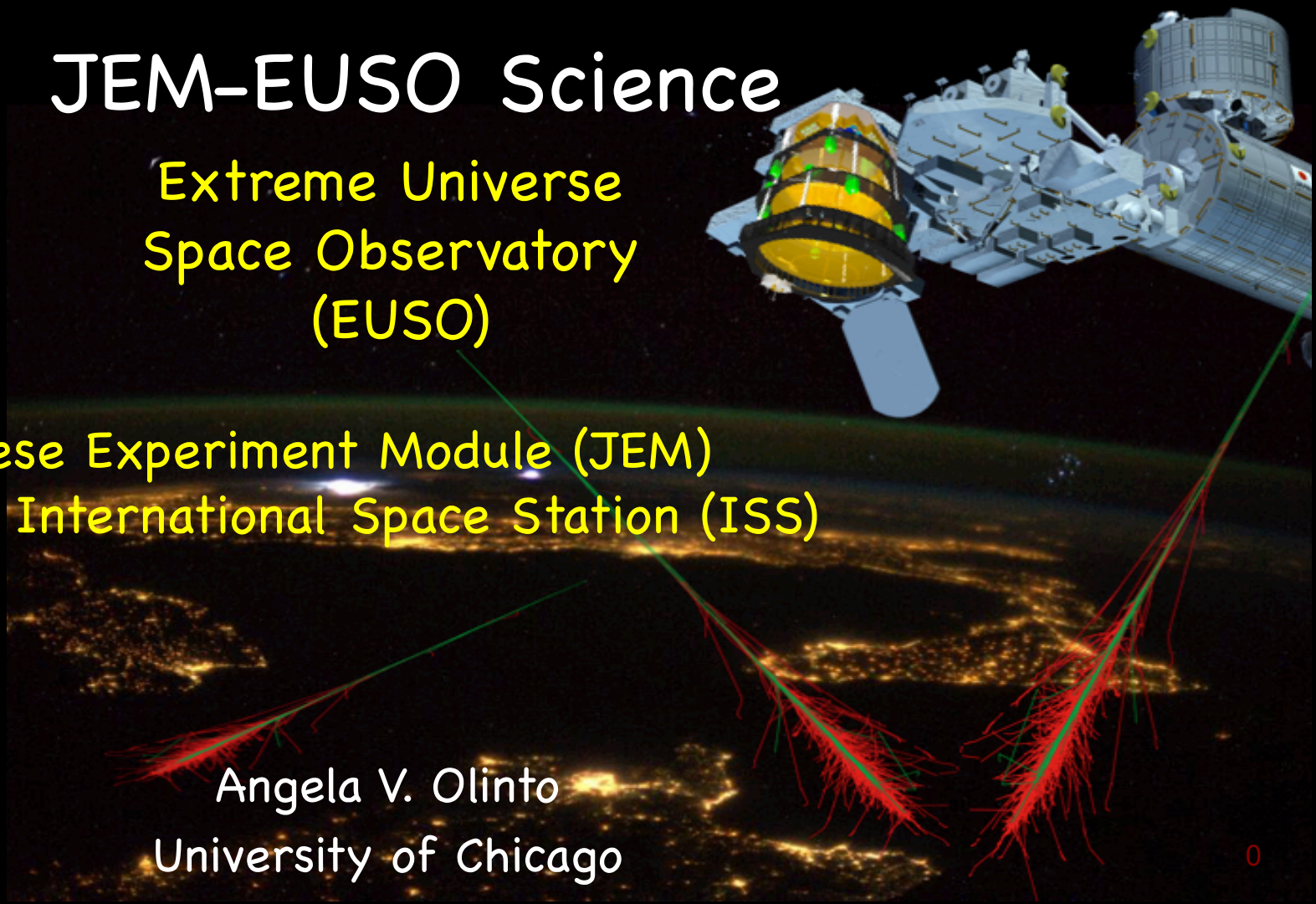
JEM-EUSO Science

Extreme Universe Space Observatory (EUSO)

in the
Japanese Experiment Module (JEM)
of the International Space Station (ISS)



Angela V. Olinto
University of Chicago

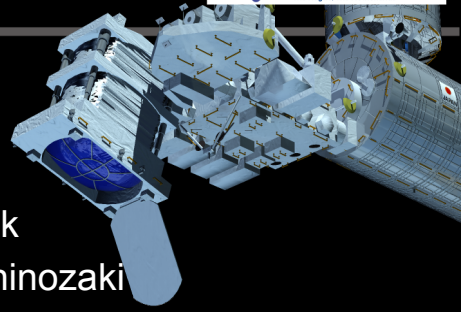
JEM-EUSO Collaboration

Scientists from 16 countries

Piergiorgio Picozza, PI

JEM-EUSO on ISS explores the origin of the highest energy particles in the Universe

ICRC
The Astroparticle Physics Conference
34th International Cosmic Ray Conference
July 30 - August 6, 2015
The Hague, The Netherlands



694 The JEM-EUSO program A. Santangelo

725 The EUSO-Balloon mission P. von Ballmoos

611 The JEM–EUSO energy and Xmax reconstruction performances F. Fenu

577 The Angular Resolution of the JEM-EUSO Mission: an Updated View T. Mernik

682 Evaluation of scientific performance of JEM-with Space-X Dragon option K. Shinozaki

897 Towards a SiPM based fluorescence camera for JEM-EUSO A. Haungs

393 T. Paul
429 J. Adams
432 J. Adams
466 G. Chiritoi
560 M. Ricci
570 A. Guzman
585 E.Iwotschkin
590 T. Mernik
625 S. Dagoret
632 S. Bacholle
639 F. Fenu
661 M. Karus

717 C. Catalano
767 P. Hunt
816 L. Wiencke
836 F. Kajino
854 M. Casolino
860 J. Eser
889 I. Tabone
890 M. Bertaina
899 G. Vankova
914 K. Kudela
925 G. Sugino
939 N. Sakaki
971 A. Jung
979 J. Fernandez / A. Merino

1008 J. Fernandez Soriano / L. Del Peral
1016 C. Moretto
1024 J. Fernandez / G. Saez
1025 G. Osteria
1074 B. Pastircak
1155 B. Panico
1165 P. Klimov
1171 P. Klimov
1198 R. Caruso / G. Contino
1283 M. Frias
1292 L. Del Peral
1302 S. Mackovjak
1309 M. Frias
1364 S. Bacholle / P. Gorodetzky

JEM-EUSO collaboration 16 Countries, 93 Institutes, 351 people

JEM-EUSO on ISS explores the origin of the highest energy partic

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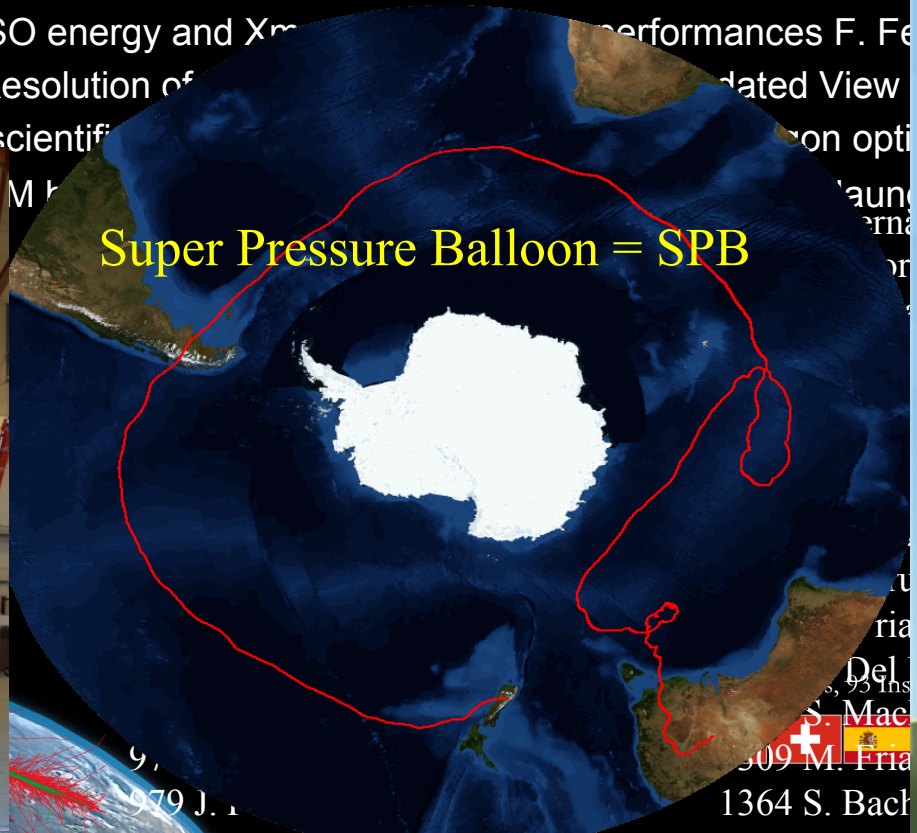

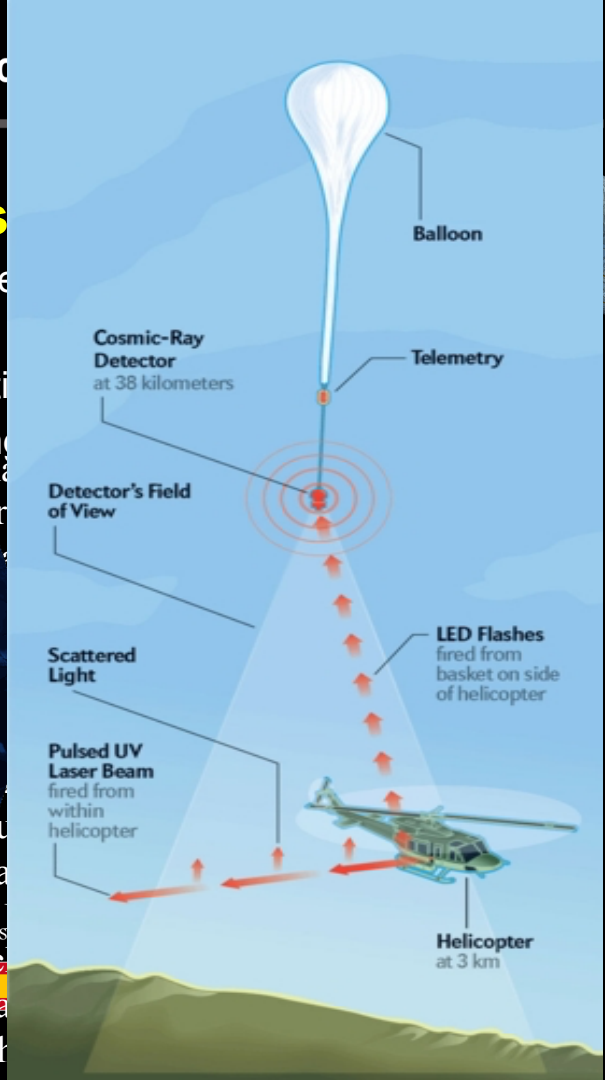

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…309 M. Fria…
…1364 S. Bach…

JEM-EUSO Science objectives

Study of Cosmic Particles at the Highest Energies

Main Science Objectives:
Identify **UHE sources**
Measure energy spectra of individual sources
Measure the trans-GZK spectrum

Exploratory objectives:
Discover UHE Gamma-rays
Discover UHE neutrinos
Study Galactic and Extragalactic Magnetic Fields
Discover Relics from the Early Universe (e.g., SHDM)

Atmospheric Science
Nightglow
Transient luminous events (TLE)
Meteors and meteoroids

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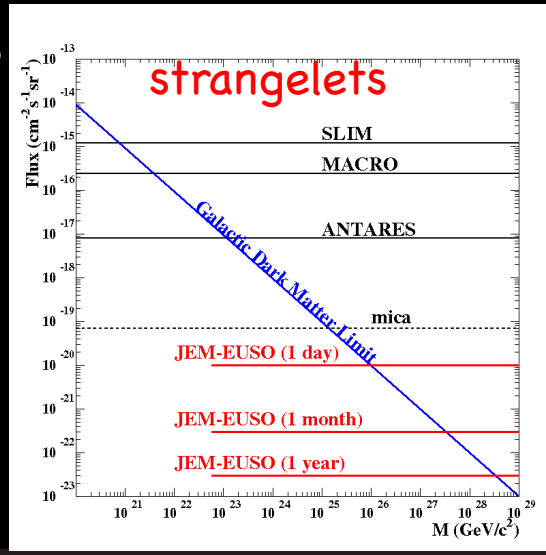
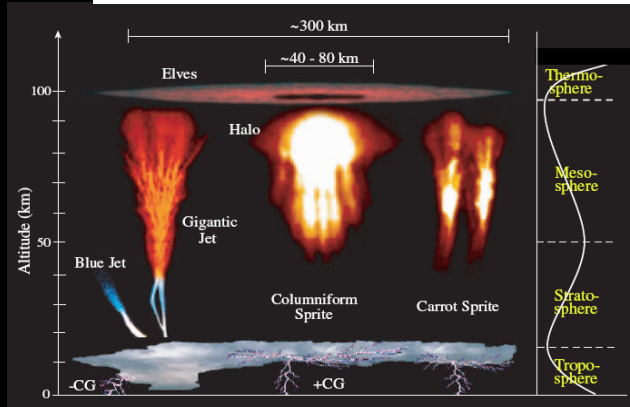
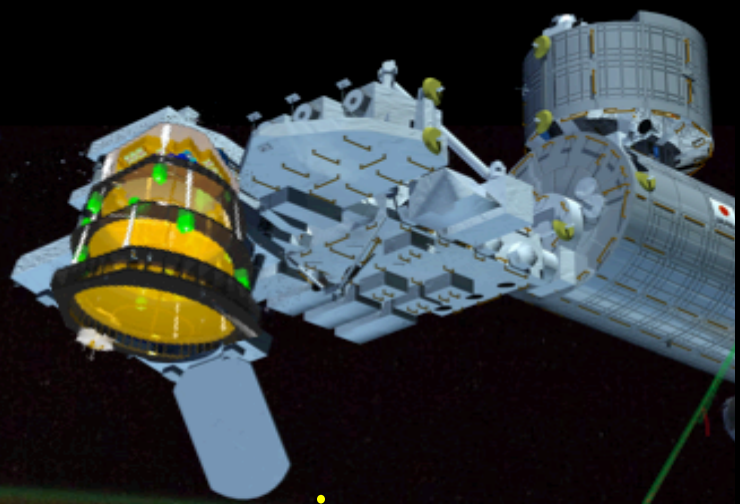




JEM-EUSO

main Science Goal

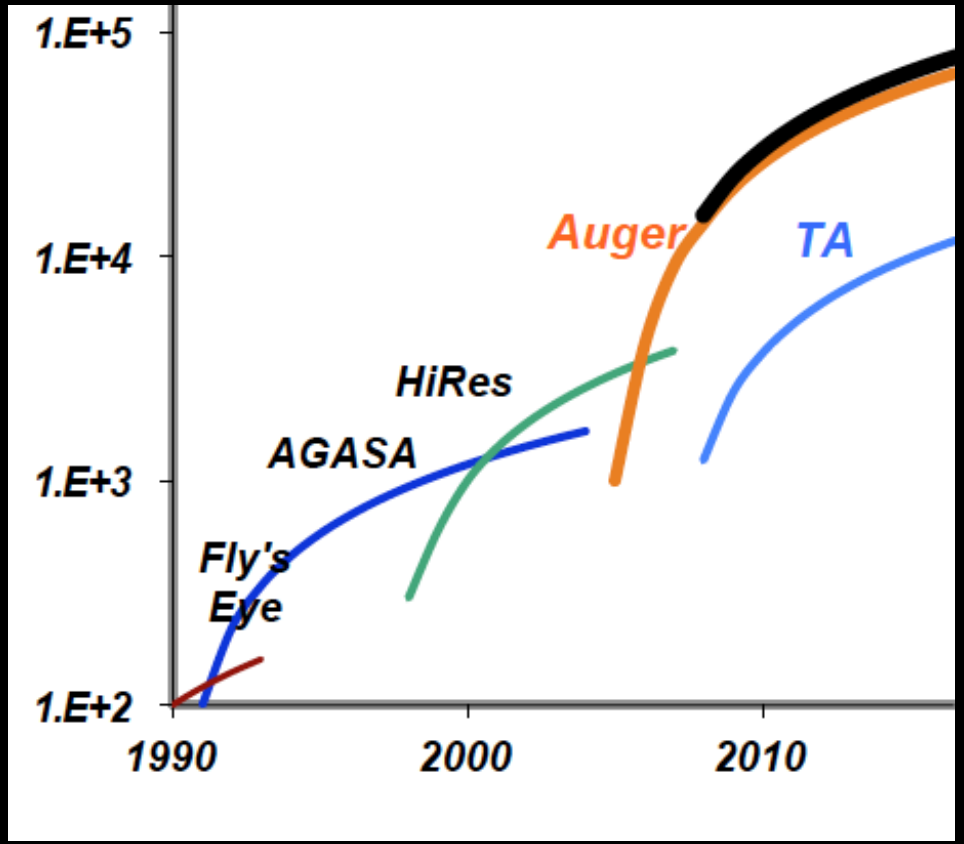


To discover the **most extreme** sources, i.e., Ultrahigh Energy Cosmic rays (UHECRs) sources

through a **significant** (1 o.o.m) increase in exposure to EECRs

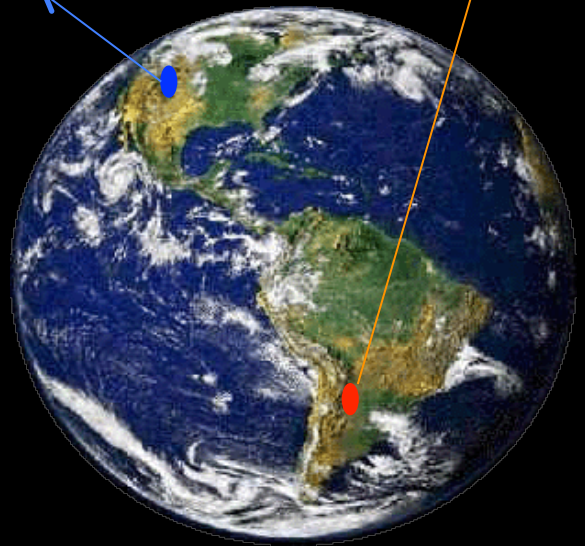
*EECR: E > 60 EeV

Last Significant Increase in Exposure



Pierre Auger Observatory
3,000 km^2, Argentina

Telescope Array
700 km^2, Utah



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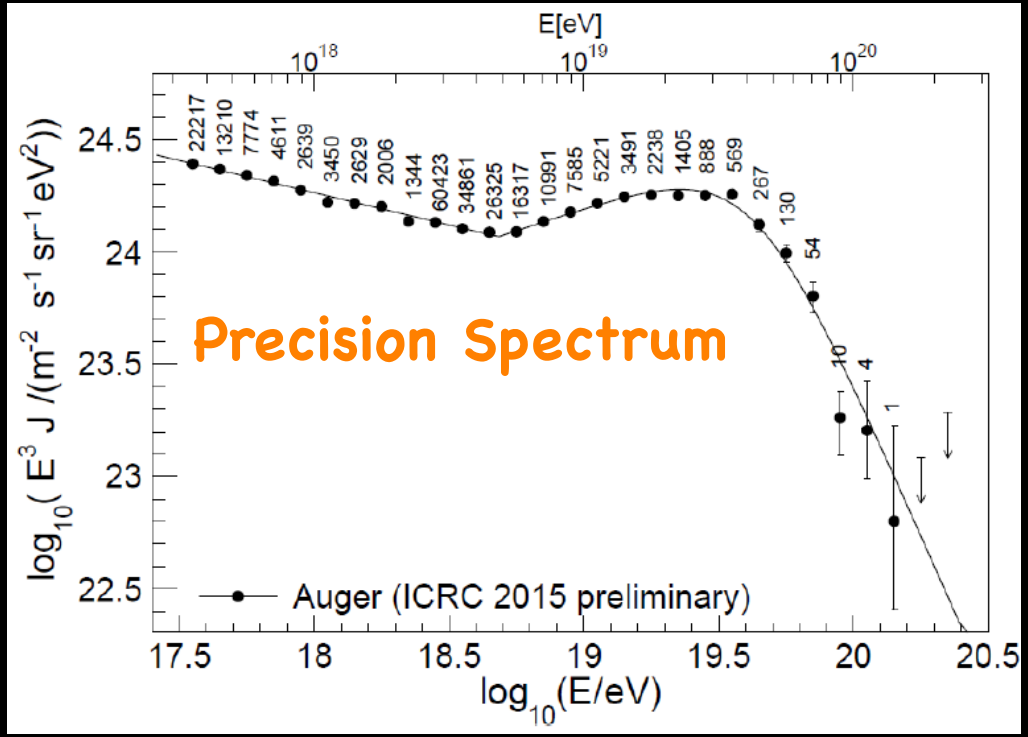
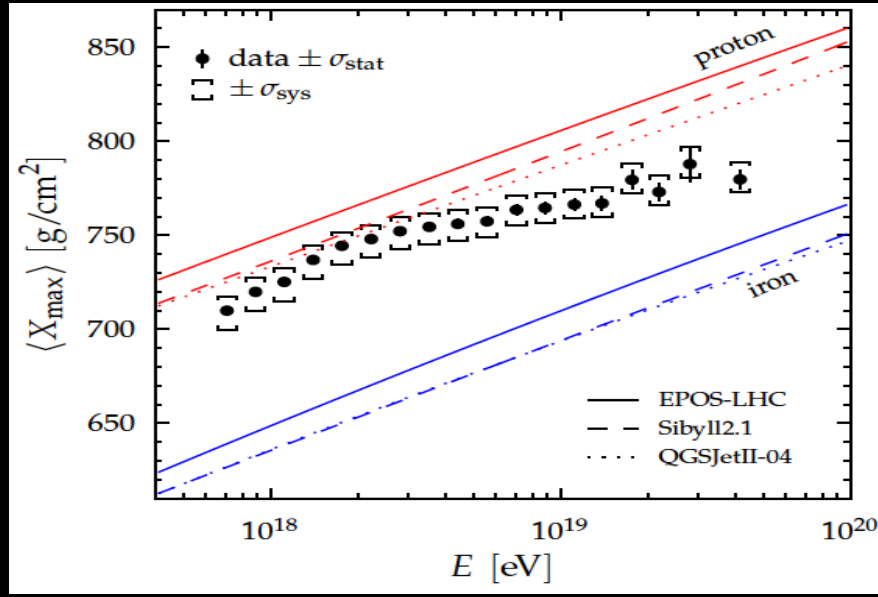
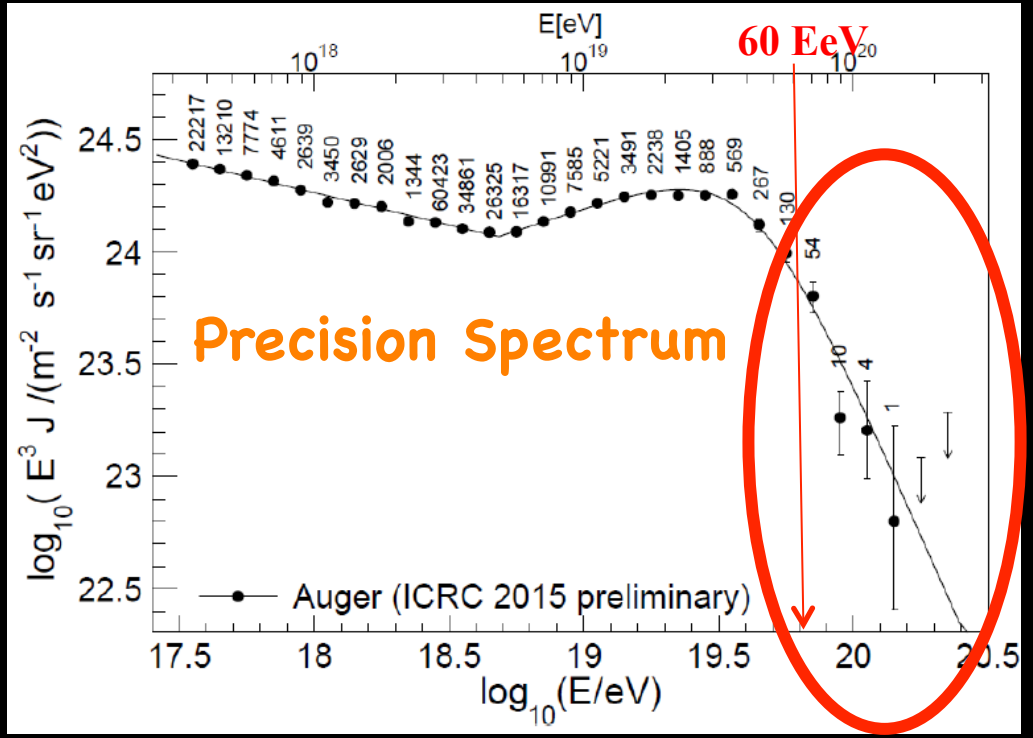
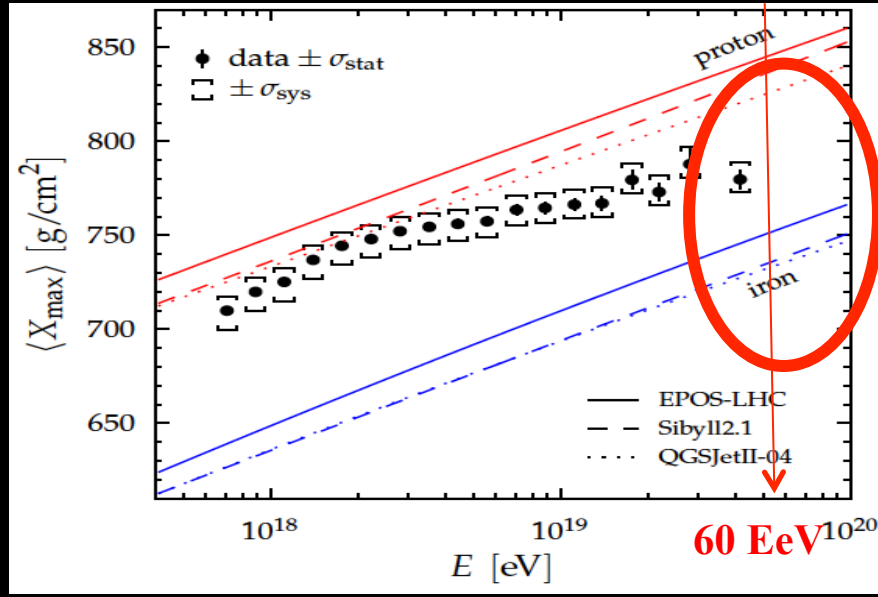




Surprising Composition Trends

Last Significant Increase in Exposure





Surprising Composition Trends

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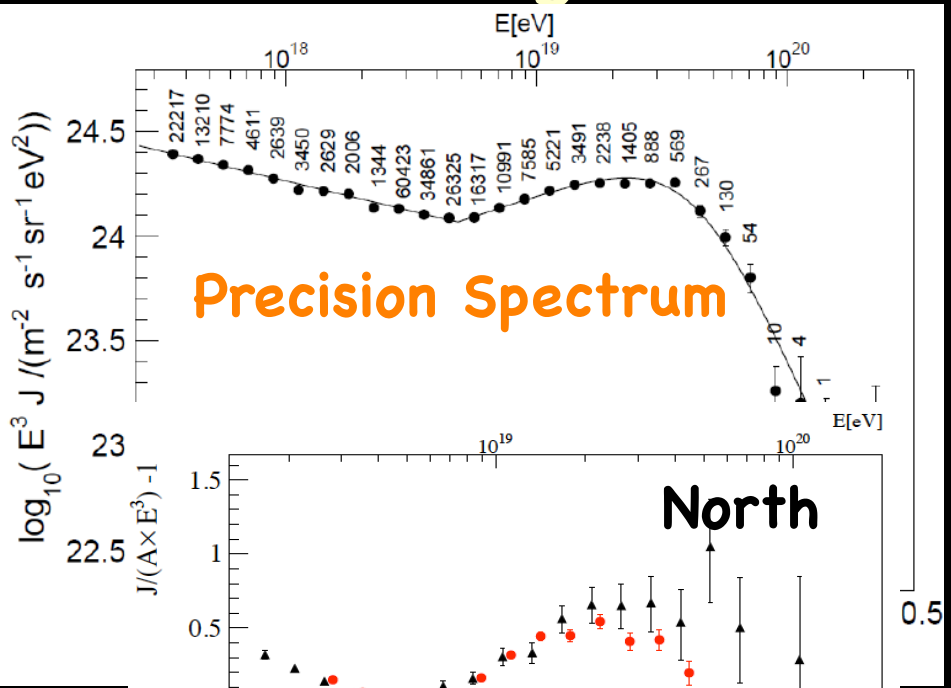
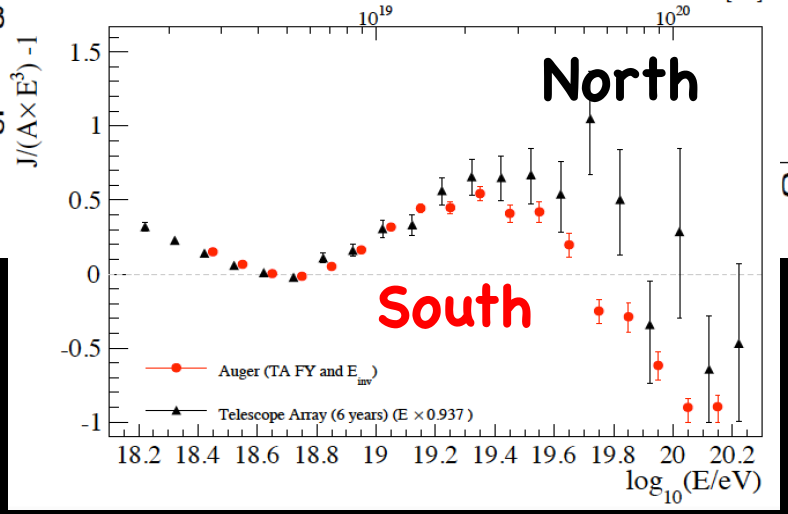
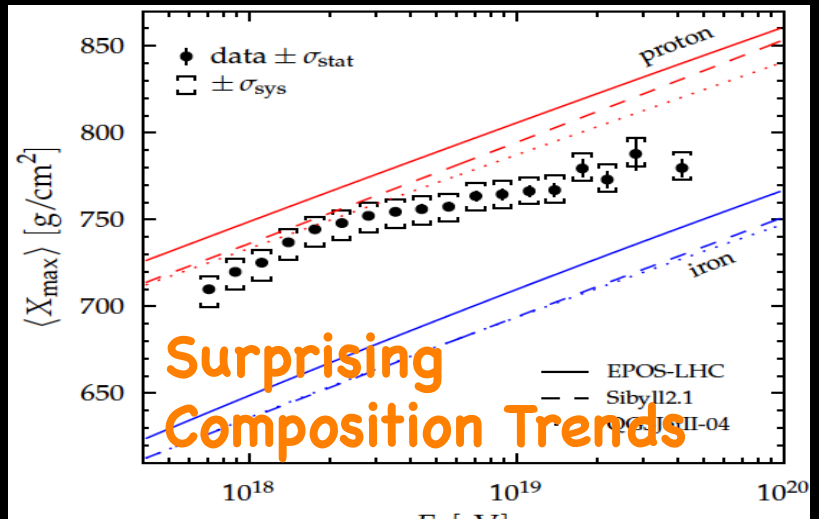
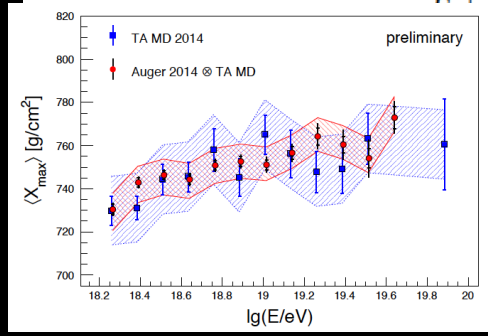
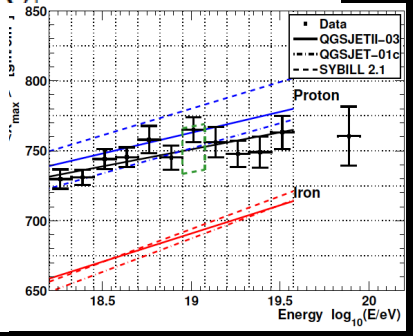




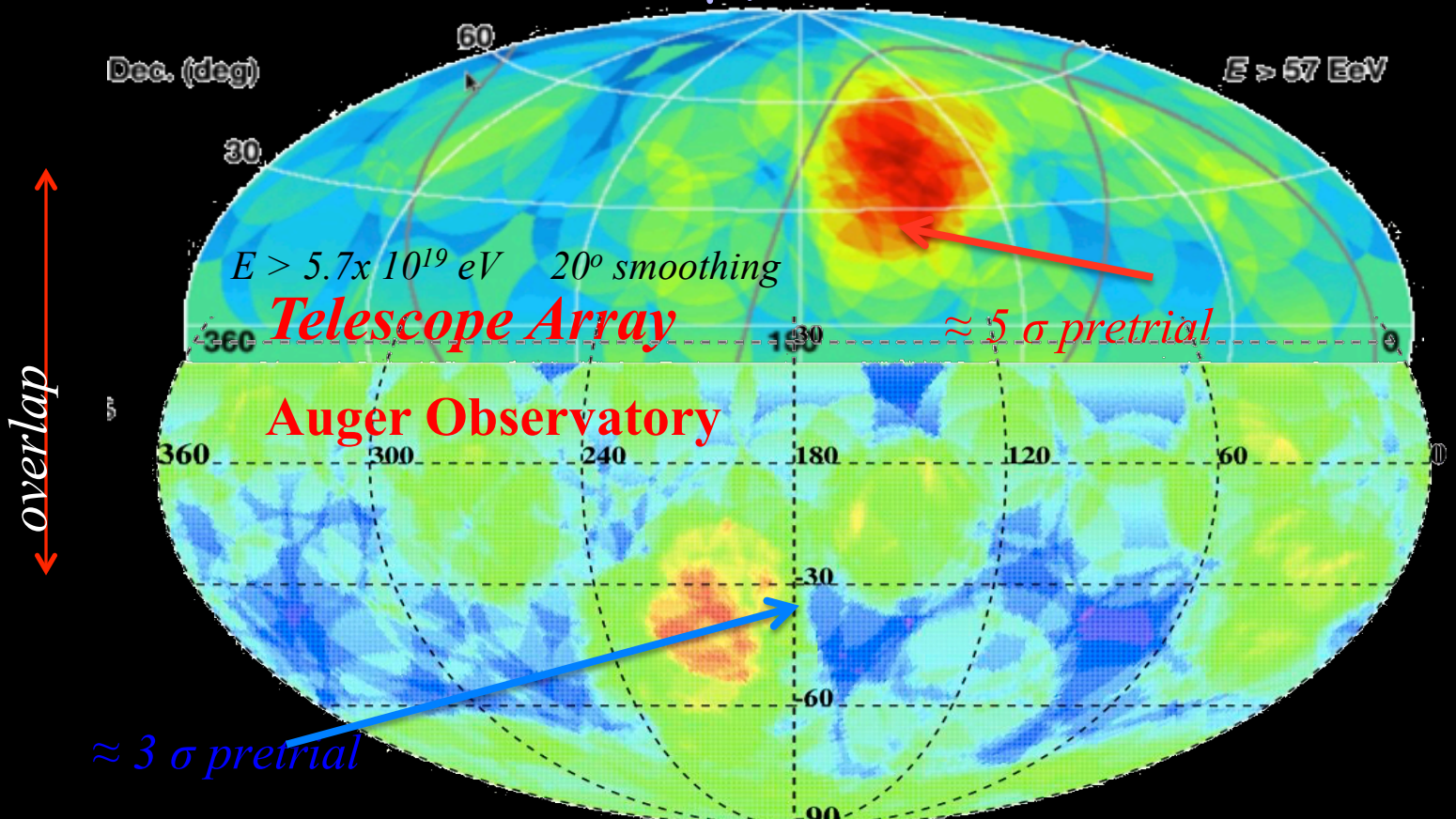






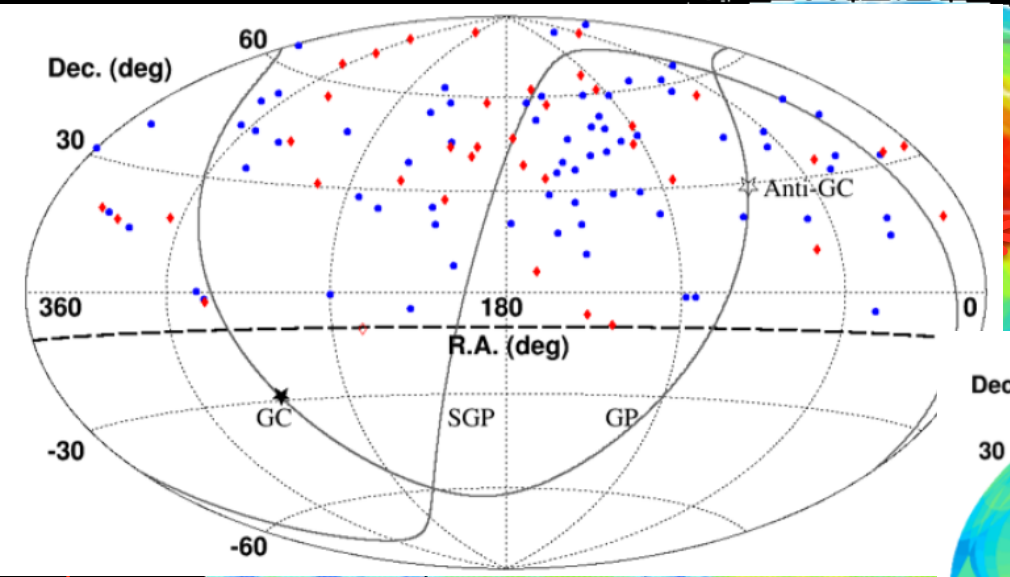
Last Significant Increase in Exposure

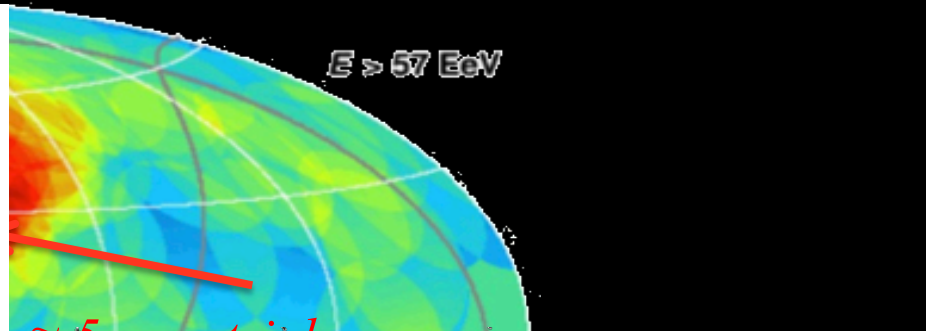
Anisotropy Hints > 60 EeV

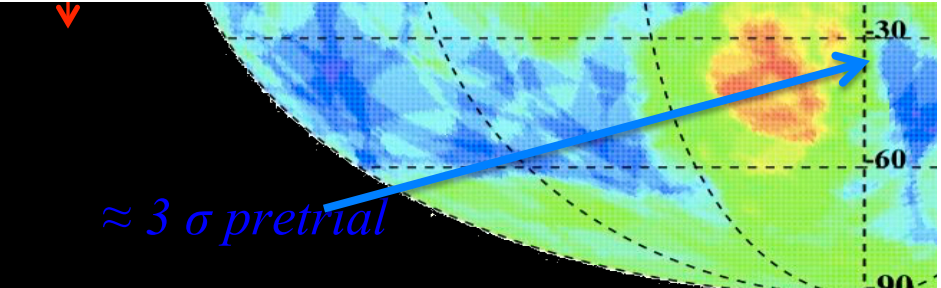


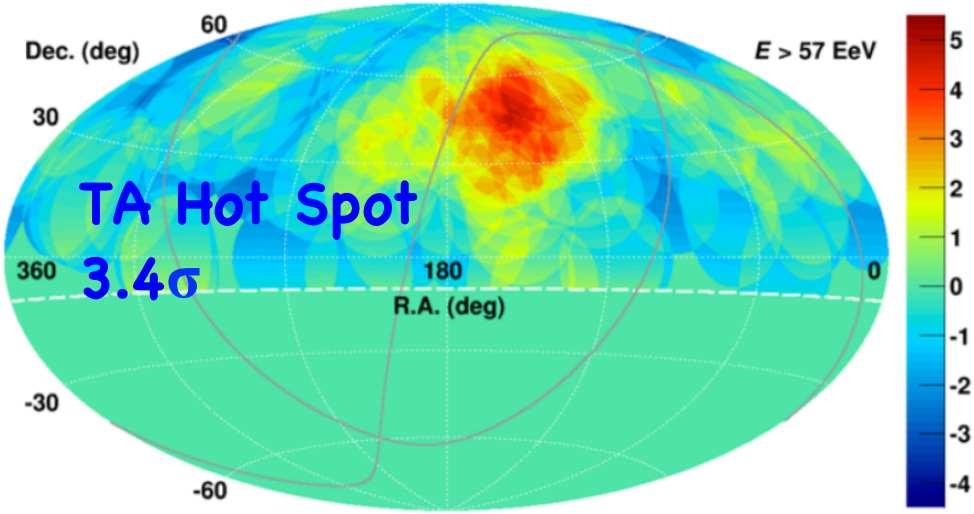
Significant Increase in Exposure

Anisotropy Hints > 60 EeV

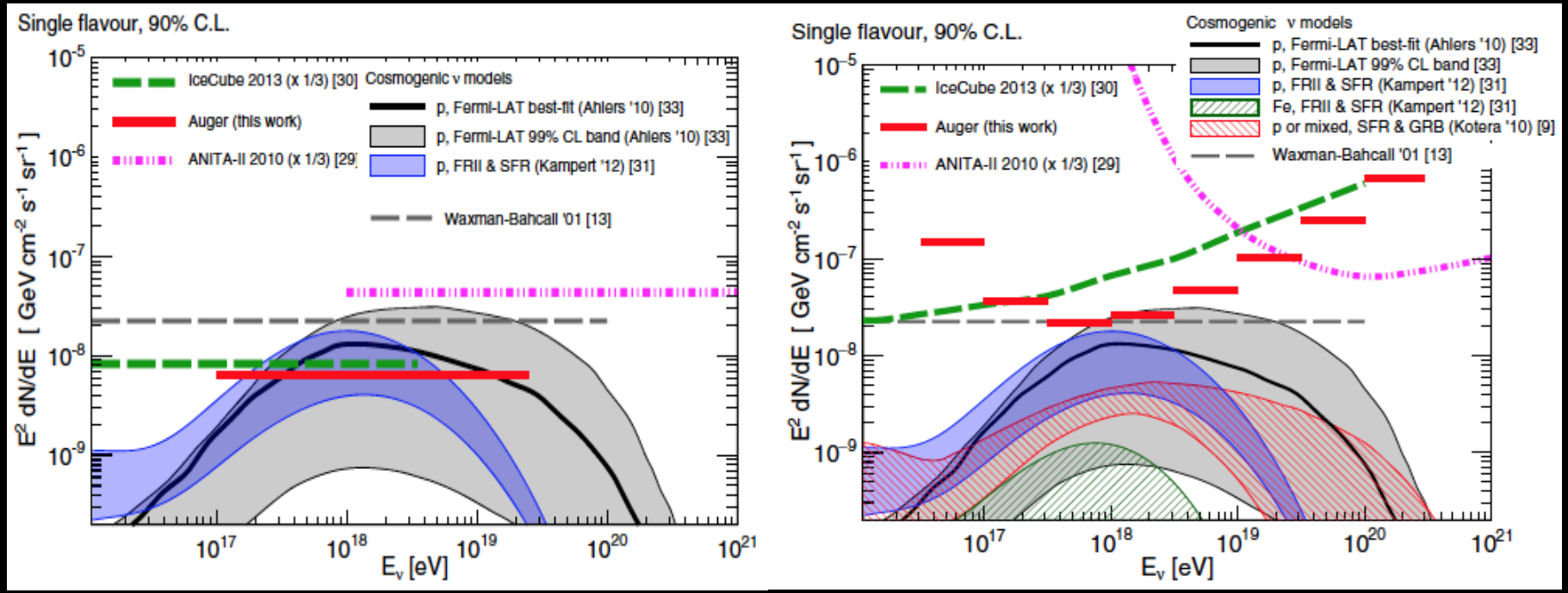






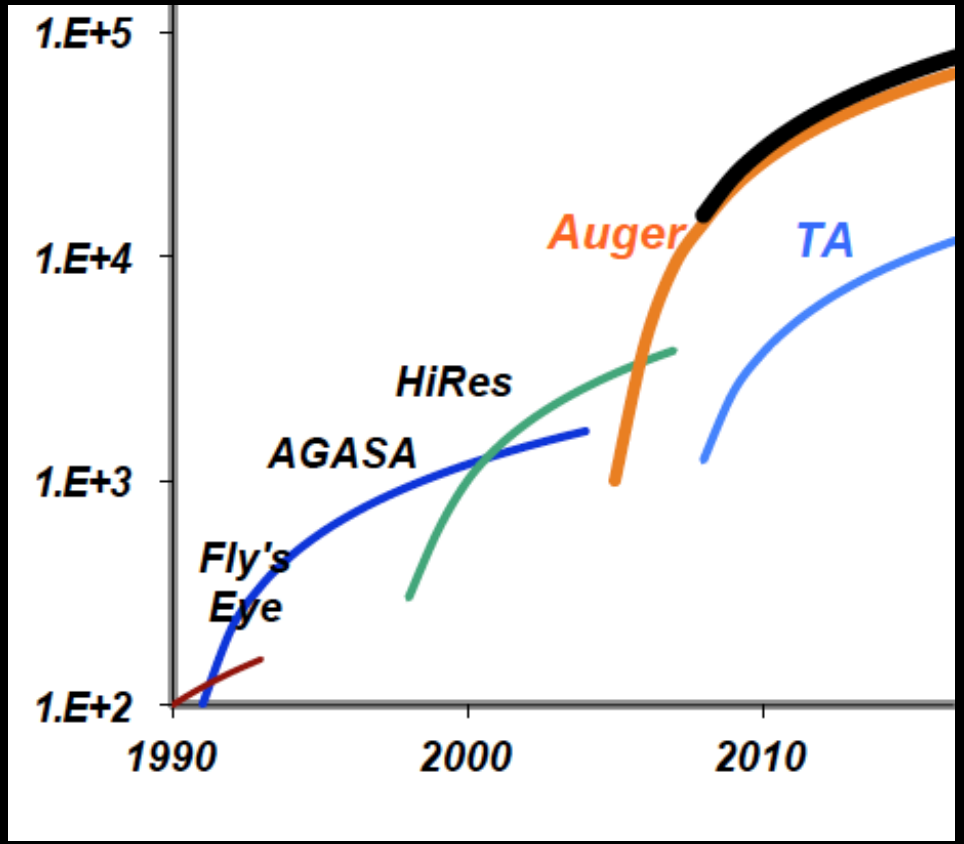


Multimessenger



Auger Collab., Phys RevD 91, 092008 (2015)

How to Increase in Exposure Significantly???



Pierre Auger Observatory
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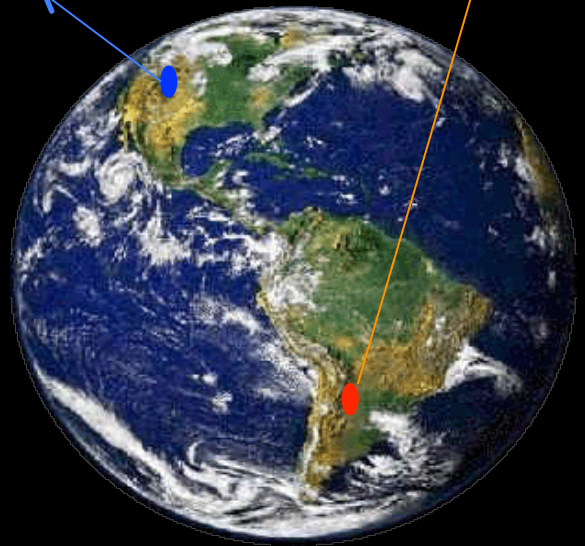
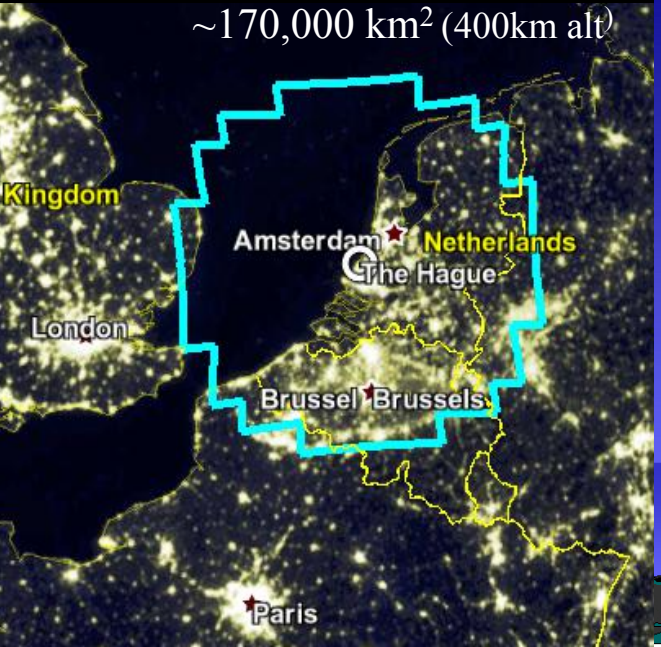
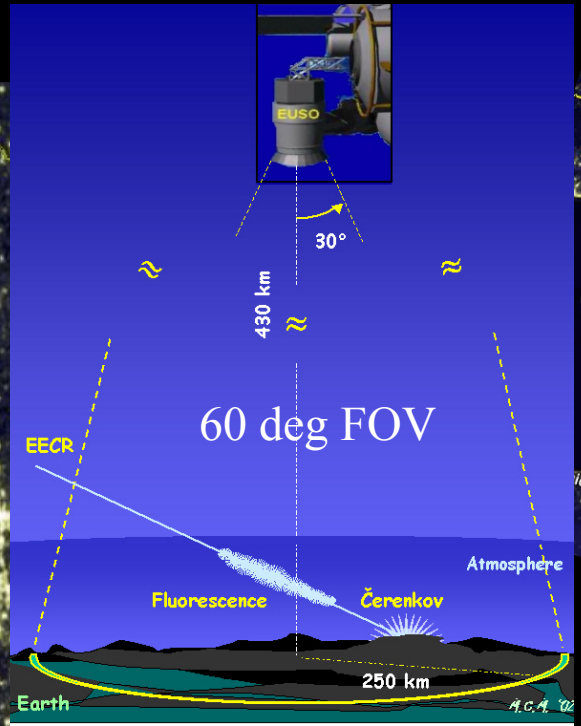
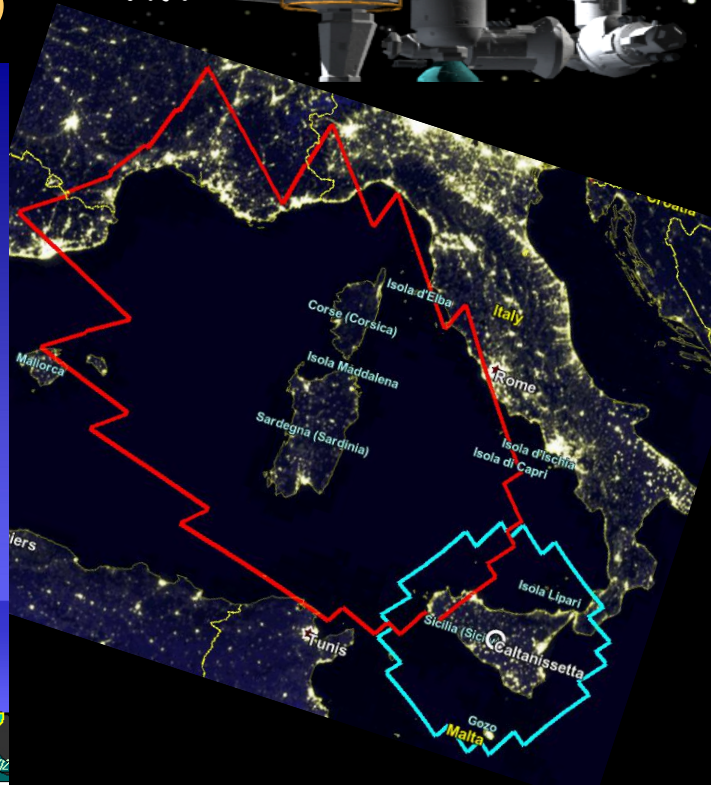


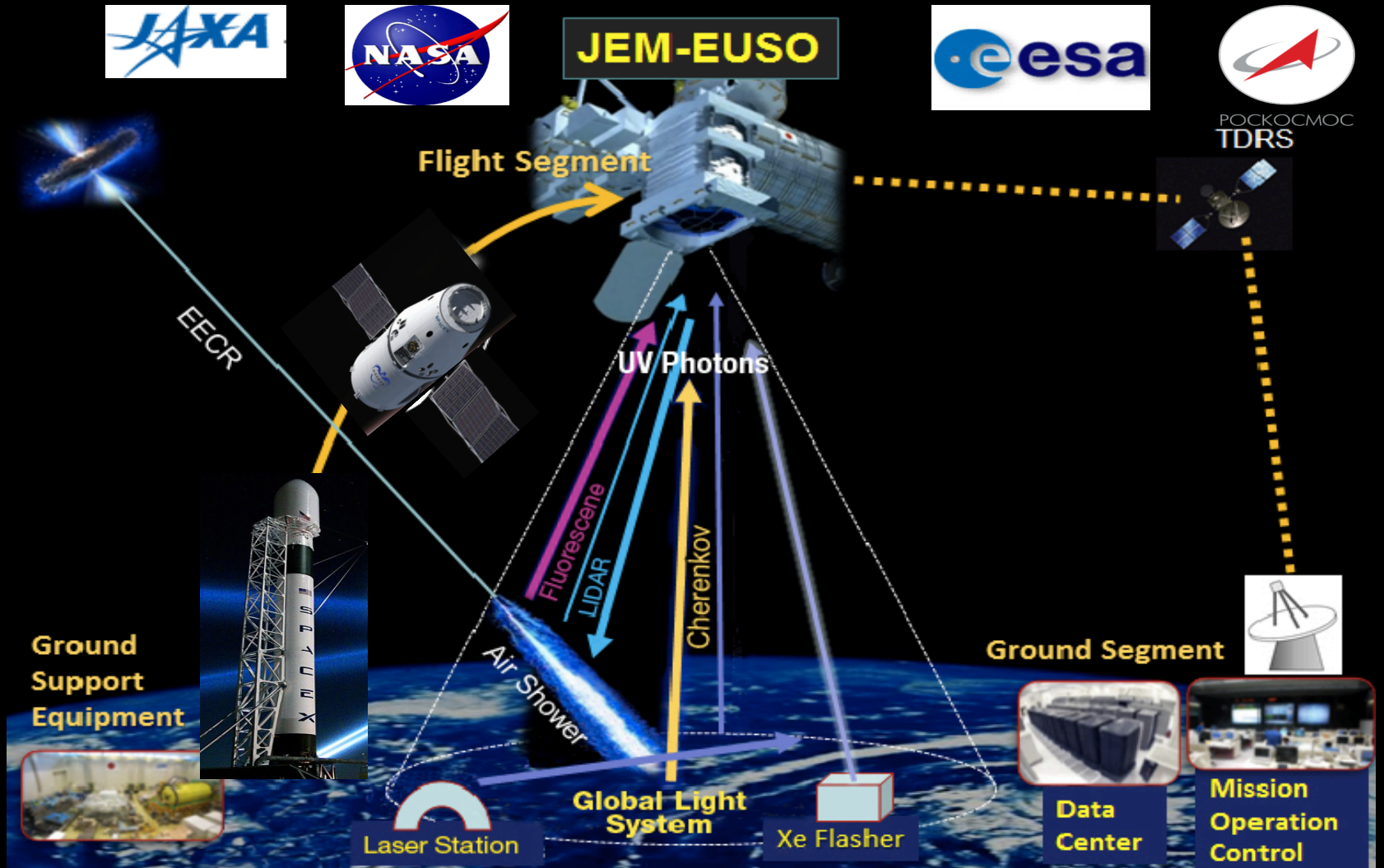
Fluorescence from SPACE

John Linsley (1925-2002)

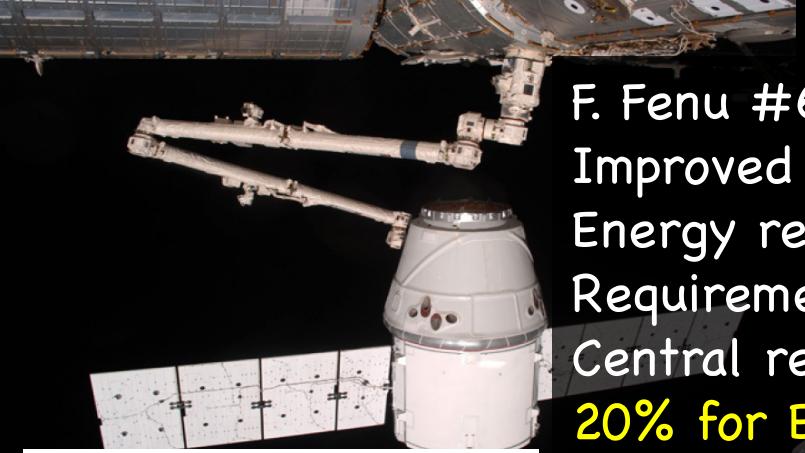


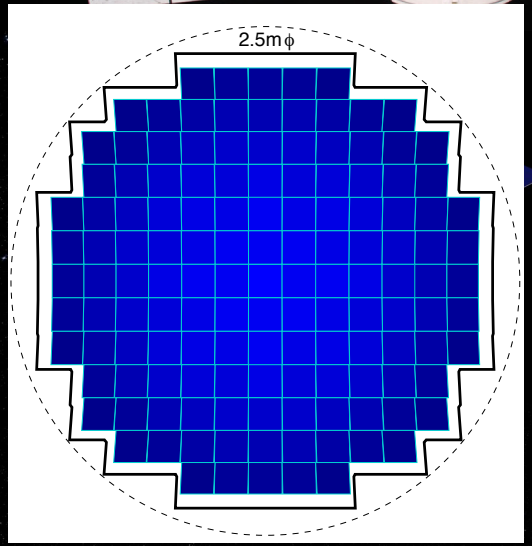





JAXA
NASA
JEM-EUSO
esa
РОСКОСМОС
TDRS
Flight Segment
EECR
UV Photons
Fluorescene
LIDAR
Cherenkov
Air Shower
Ground Support Equipment
Ground Segment
Laser Station
Global Light System
Xe Flasher
Data Center
Mission Operation Control


SPACEX
DRAGON



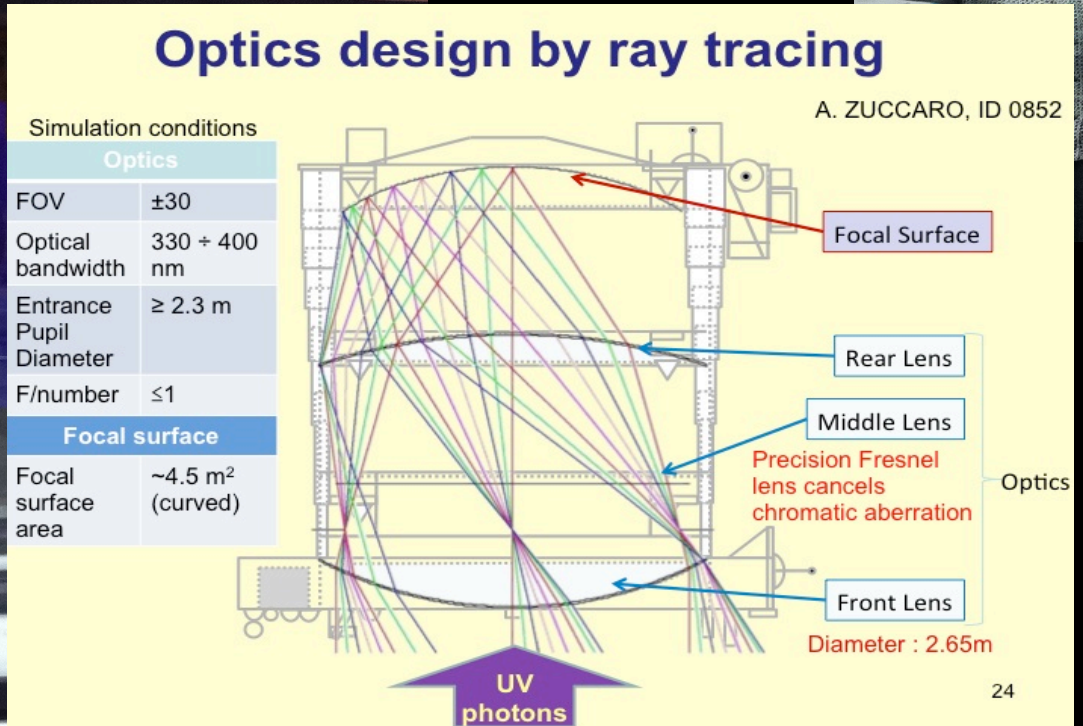


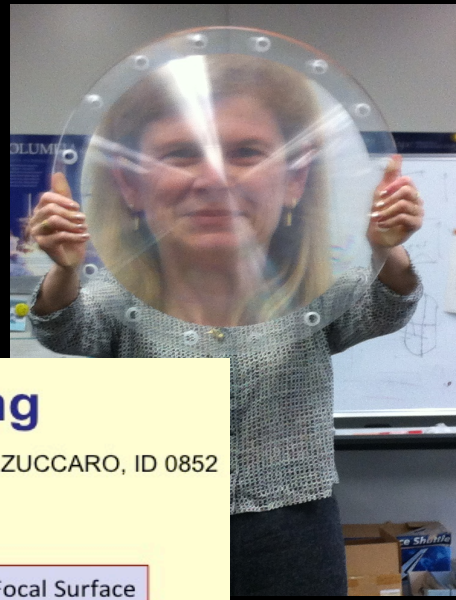
F. Fenu #604
Improved
Energy resolution:
Requirements: 30% for E > 80 EeV
Central region
20% for E > 50 EeV;
5 to 10% for E > 300 EeV

X_{max} resolution
Requirements: 120 g/cm^2 for 200 EeV
Central region
100 g/cm^2 for E> 50 EeV;
50 g/cm^2 for E > 300 EeV

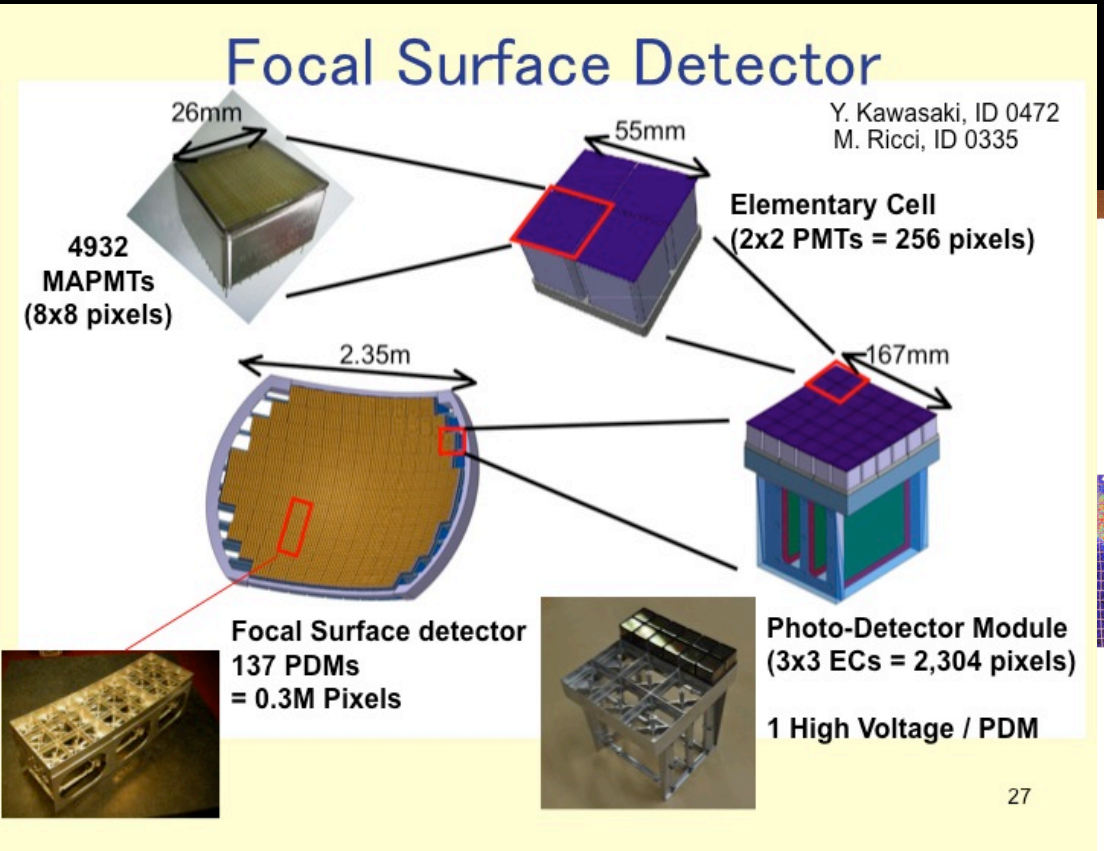
#577 T. Mernik; #570 A. Guzman

JEM-EUSO
Fresnel Lens Refractor
60 deg FOV



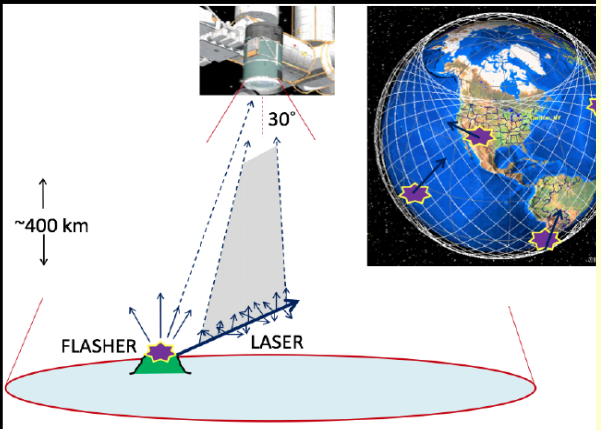


JEM-EUSO
0.3M pixel MAPMT ultrafast camera



#694 The JEM-EUSO program
A. Santangelo

Atmospheric Monitoring System



GLS - Some Candidate Locations

- **IR Camera**

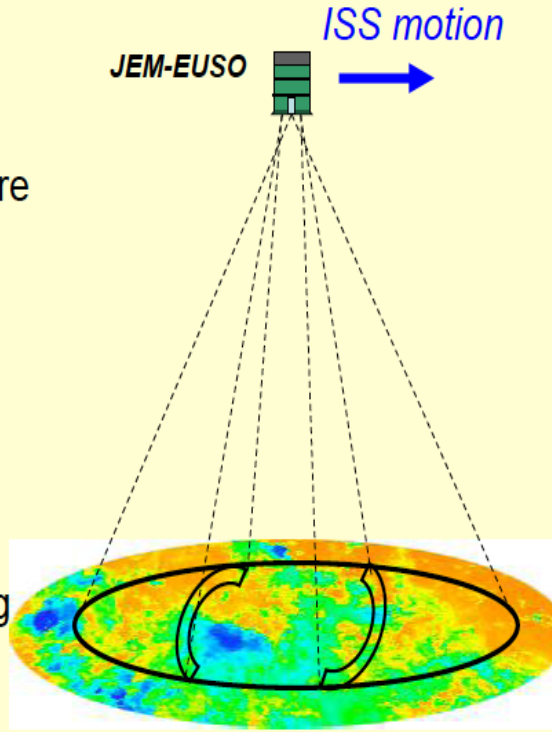
  Imaging observation of cloud temperature inside FOV of JEM-EUSO

- **Lidar**

  Ranging observation using UV laser

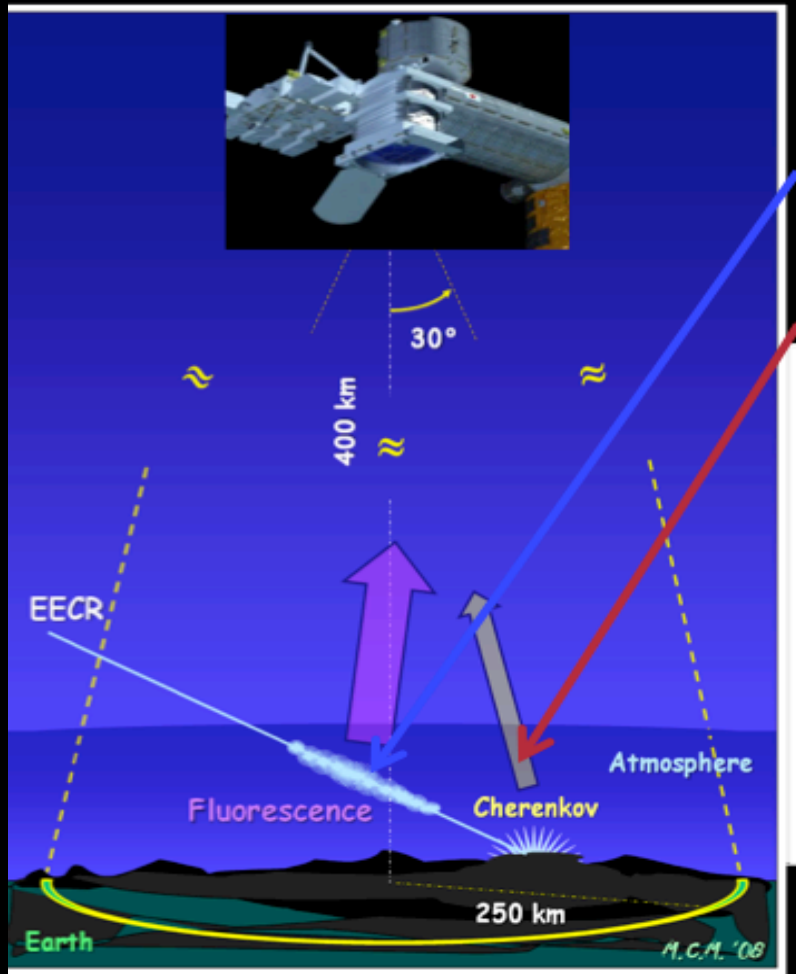
- **JEM-EUSO "slow-data"**

  Continuous background photon counting



- *Cloud amount, cloud top altitude*: (IR cam., Lidar, slow-data)
- *Airglow*: (slow-data)
- *Calibration of telescope*: (Lidar)

Fluorescence from SPACE

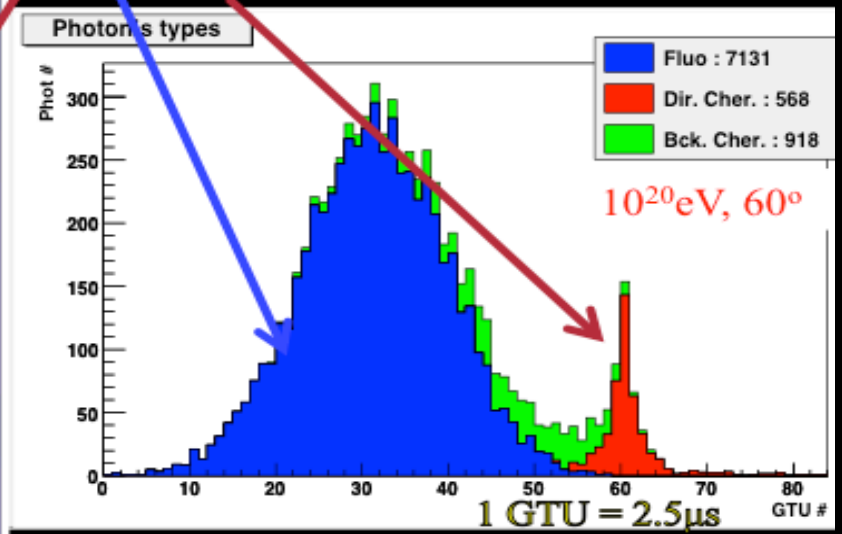


Fast Signal: 50 -150 μs

a) Fluorescence

b) Scattered Cherenkov

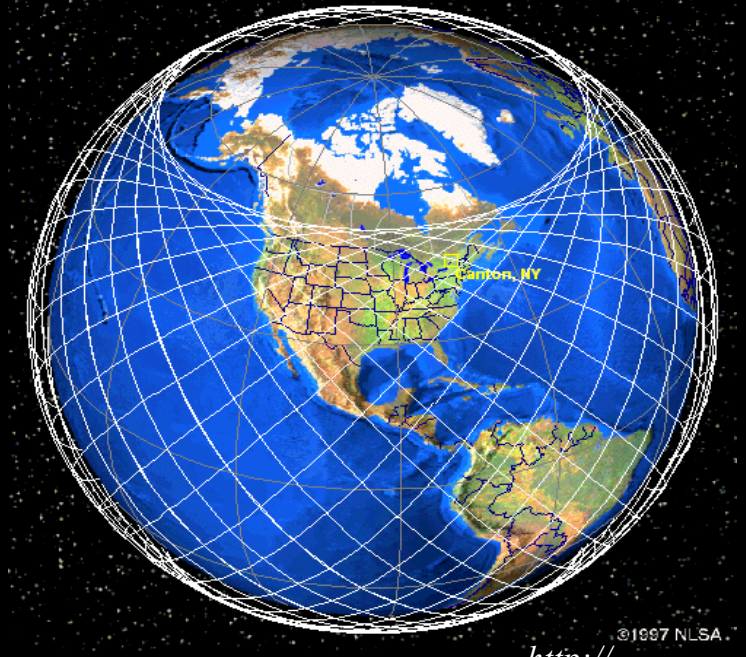
c) Direct (reflected Cherenkov)



Background: 500 /m^2 sr ns

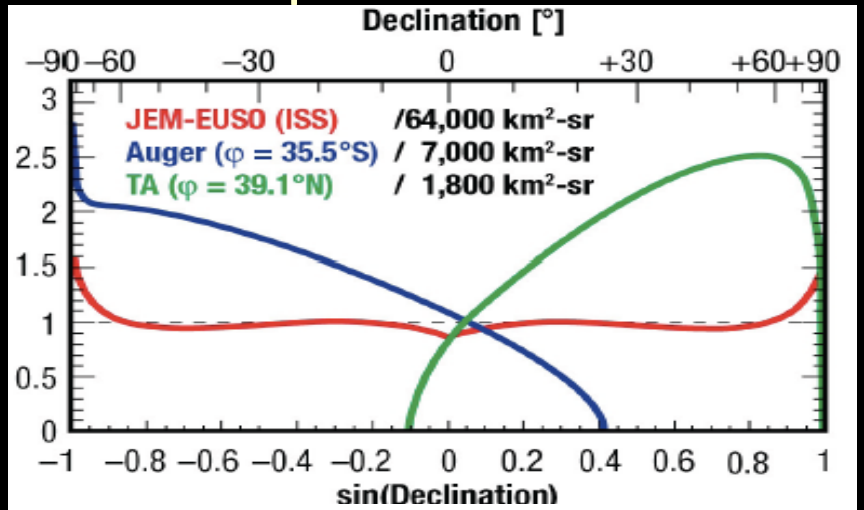
JEM-EUSO Full Sky Coverage
with nearly uniform exposure

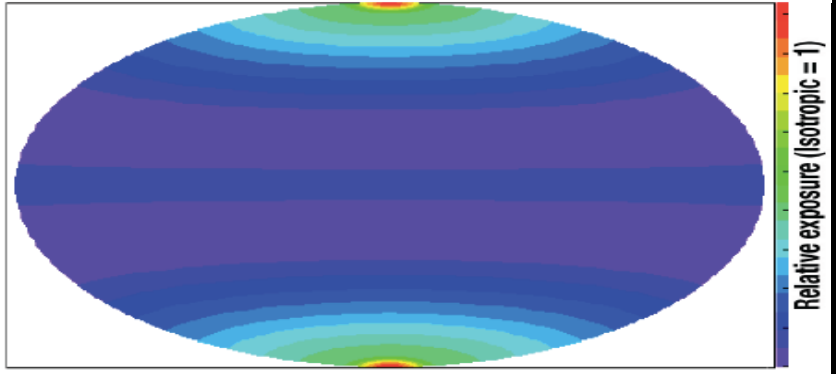
The ISS ORBIT



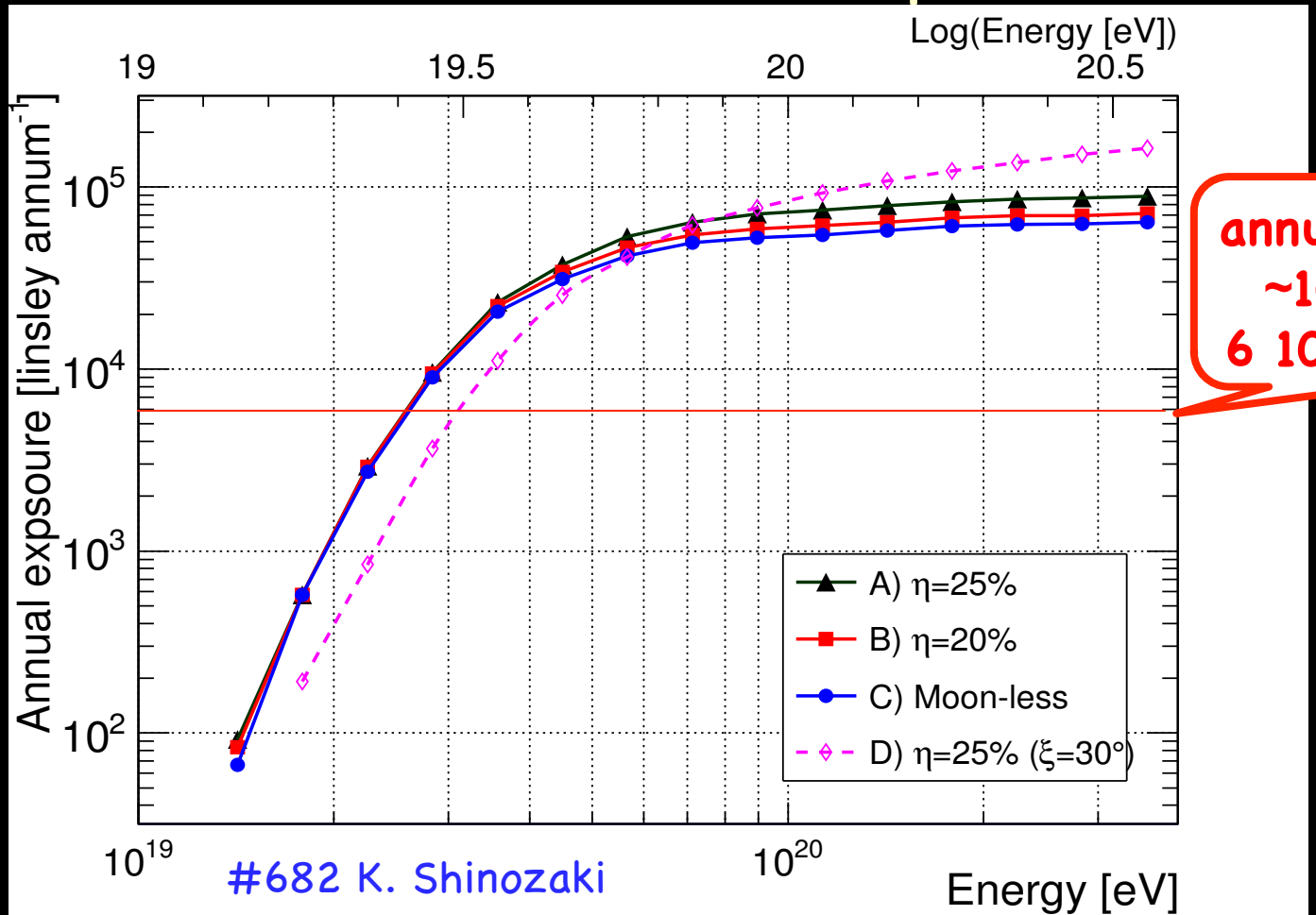
http://www.nlsa.com/

Inclination: 51.6°
Height: ~400km





JEM-EUSO Annual Exposure

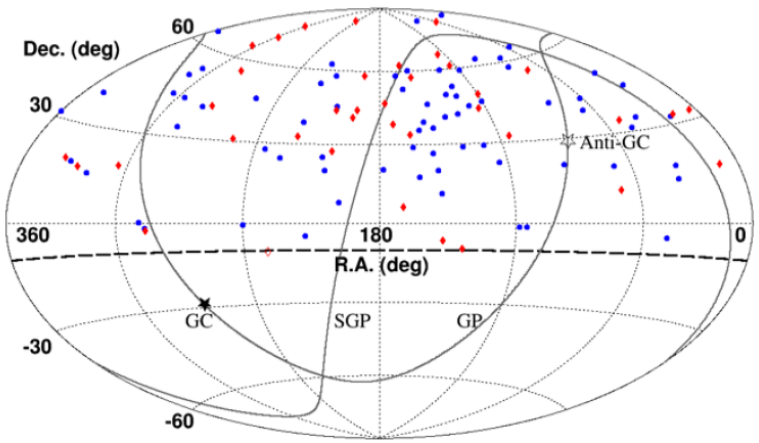


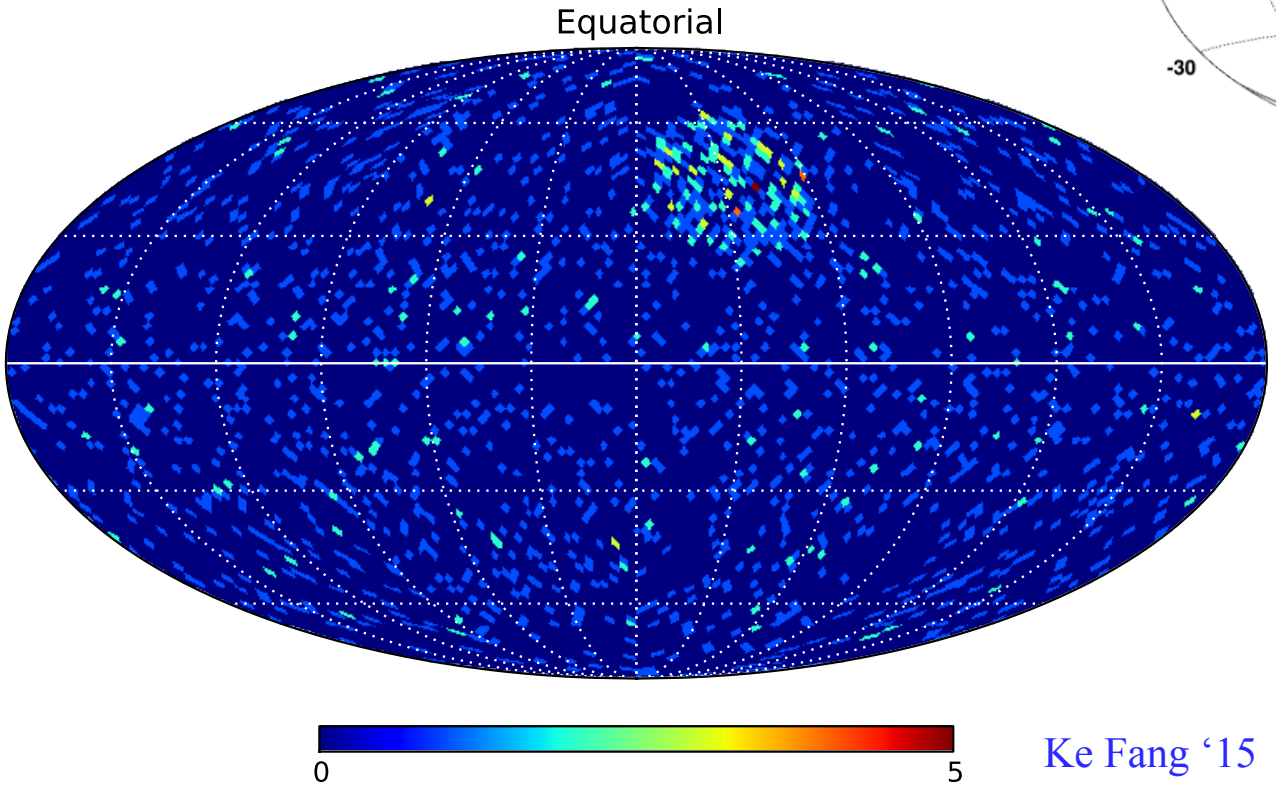
#682 K. Shinozaki

annual exposure
~10 x Auger
6 10^4 km^2 sr yr

JEM-EUSO Source Identification

2620 events > 57 EeV over the entire sky
240 events > 57 EeV from HotSpot

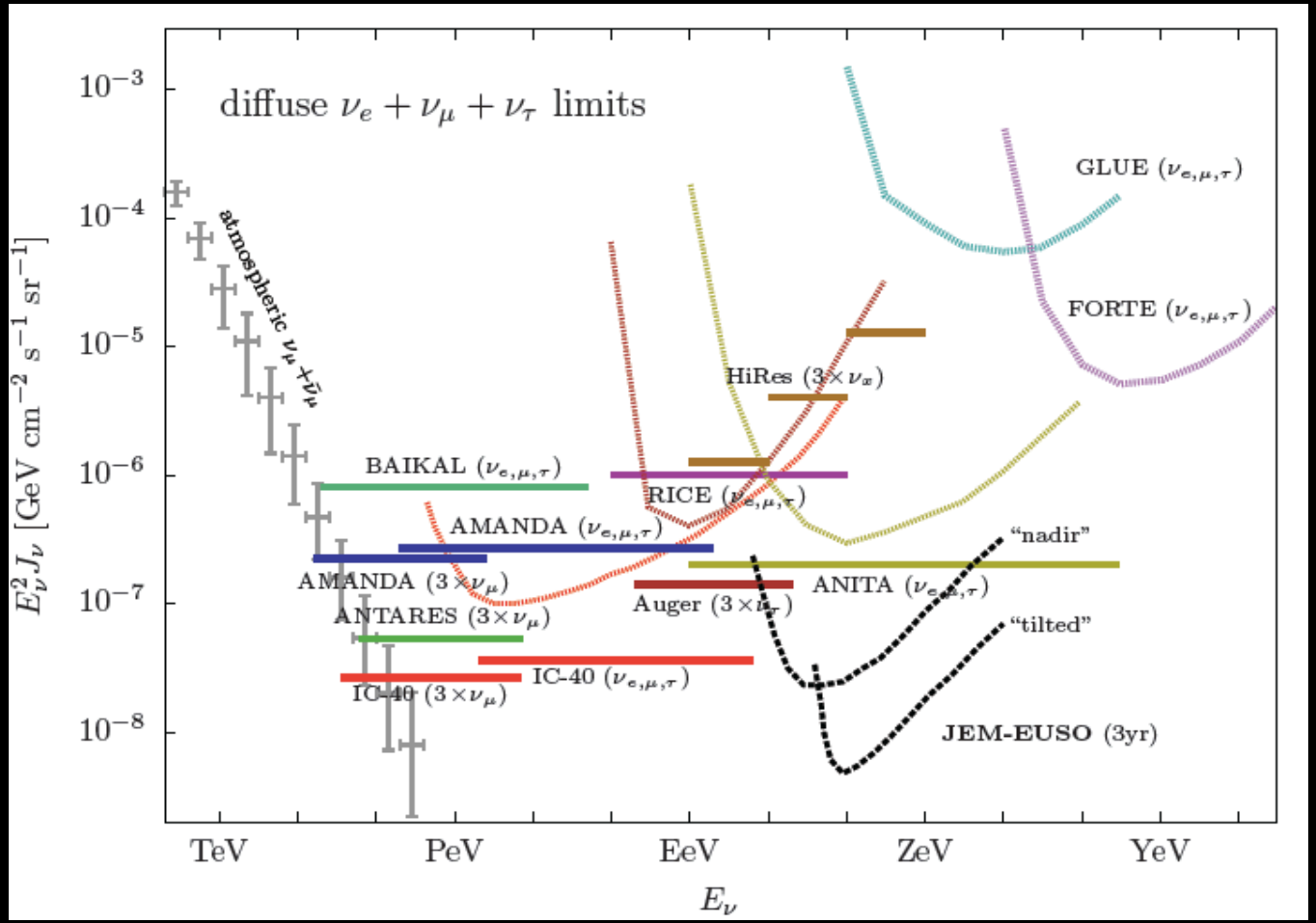


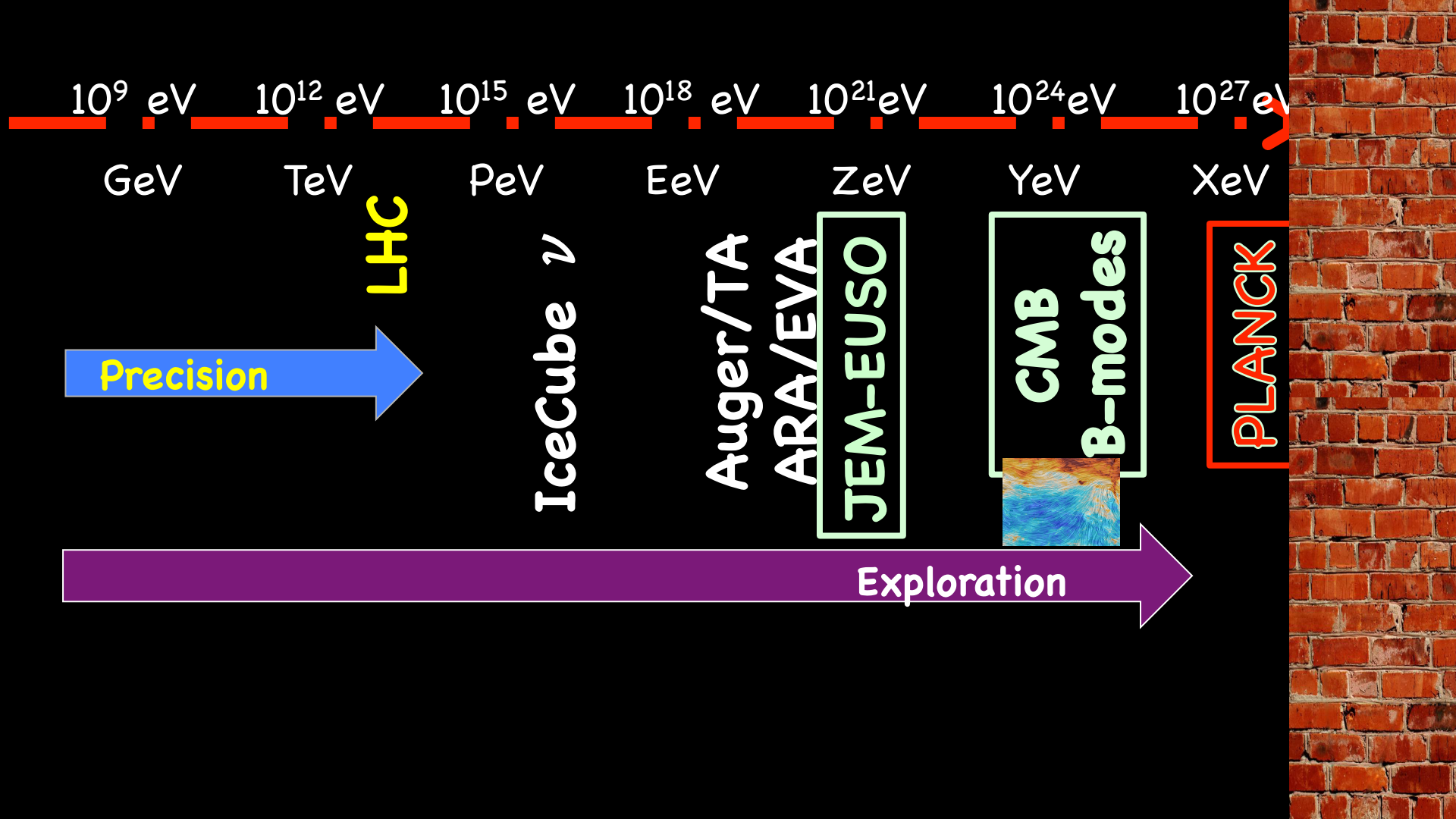


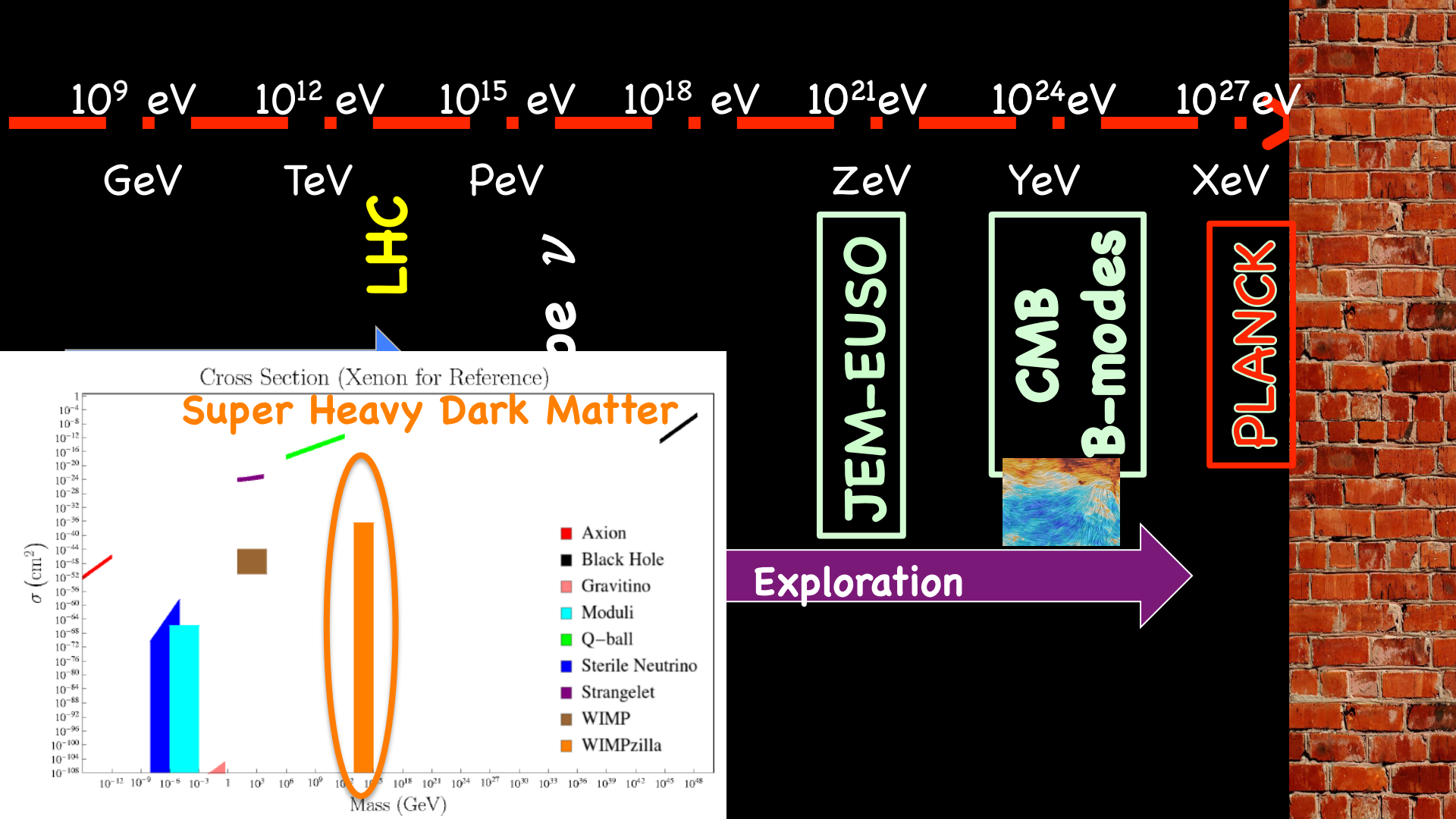
Ke Fang '15

5 yr Mission
using TA 7yr numbers
(1 JE yr = 40 TA yr
= 10 TAx4 yr)

ZeV neutrinos?



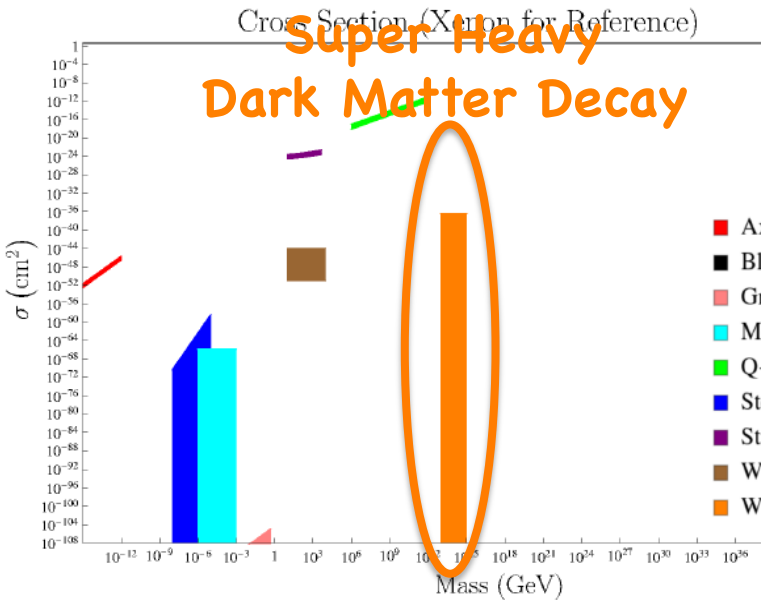

10^9 eV
10^{12} eV
10^{15} eV
10^{18} eV
10^{21}eV
10^{24}eV
10^{27}eV
GeV
TeV
PeV
EeV
ZeV
YeV
XeV
LHC
IceCube ν
Auger/TA
ARA/EVA
JEM-EUSO
CMB
B-modes
PLANCK
Precision
Exploration

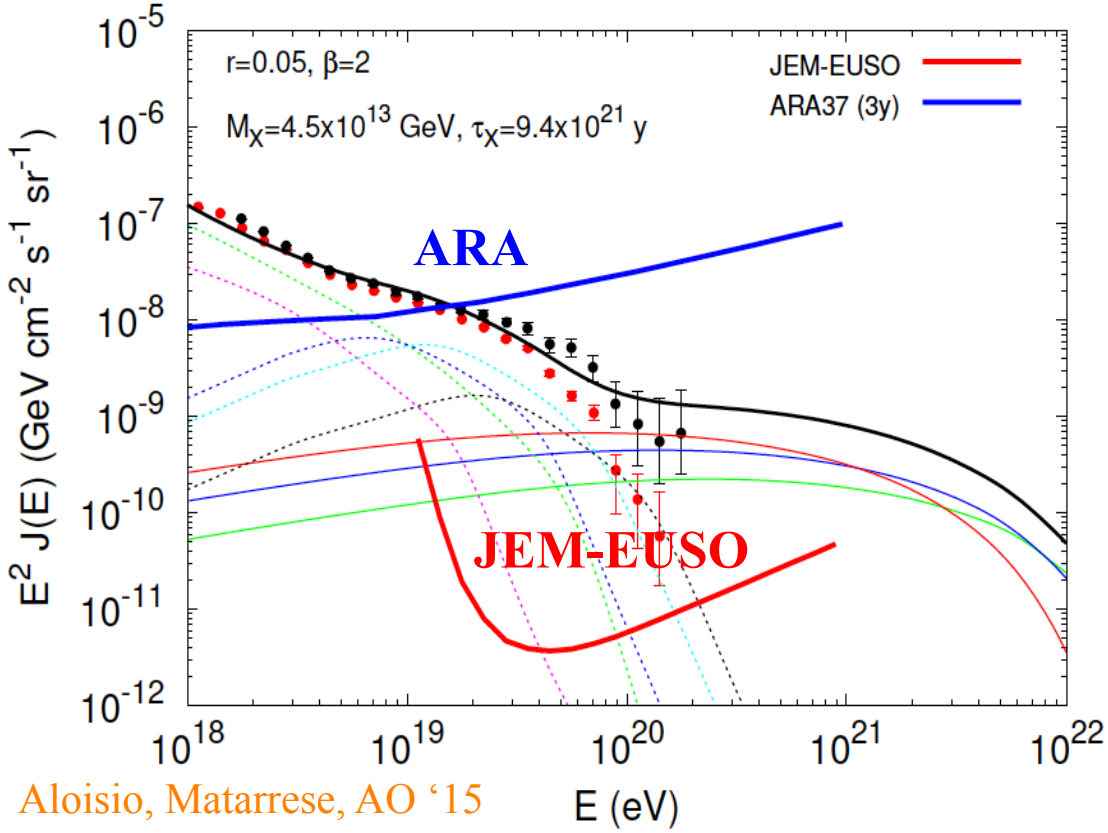

10^9 eV
10^{12} eV
10^{15} eV
10^{18} eV
10^{21}eV
10^{24}eV
10^{27}eV
GeV
TeV
PeV
ZeV
YeV
XeV
LHC
JEM-EUSO
CMB
B-modes
PLANCK
Cross Section (Xenon for Reference)
Super Heavy Dark Matter
Axion
Black Hole
Gravitino
Moduli
Q–ball
Sterile Neutrino
Strangelet
WIMP
WIMPzilla
σ (cm^2)
Mass (GeV)
Exploration

10^9 eV 10^{12} eV 10^{15} eV 10^{18} eV 10^{21}eV 10^{24}eV 10^{27}eV

GeV TeV PeV

LHC



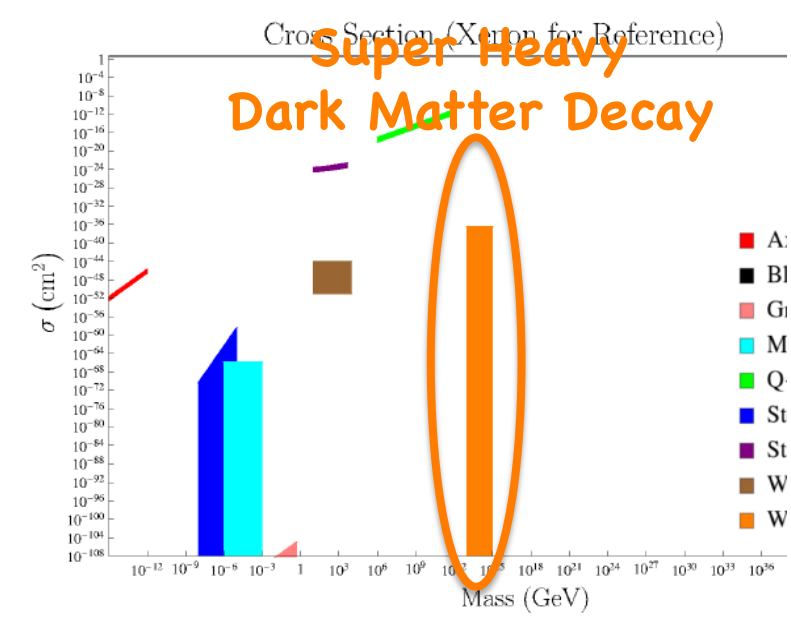


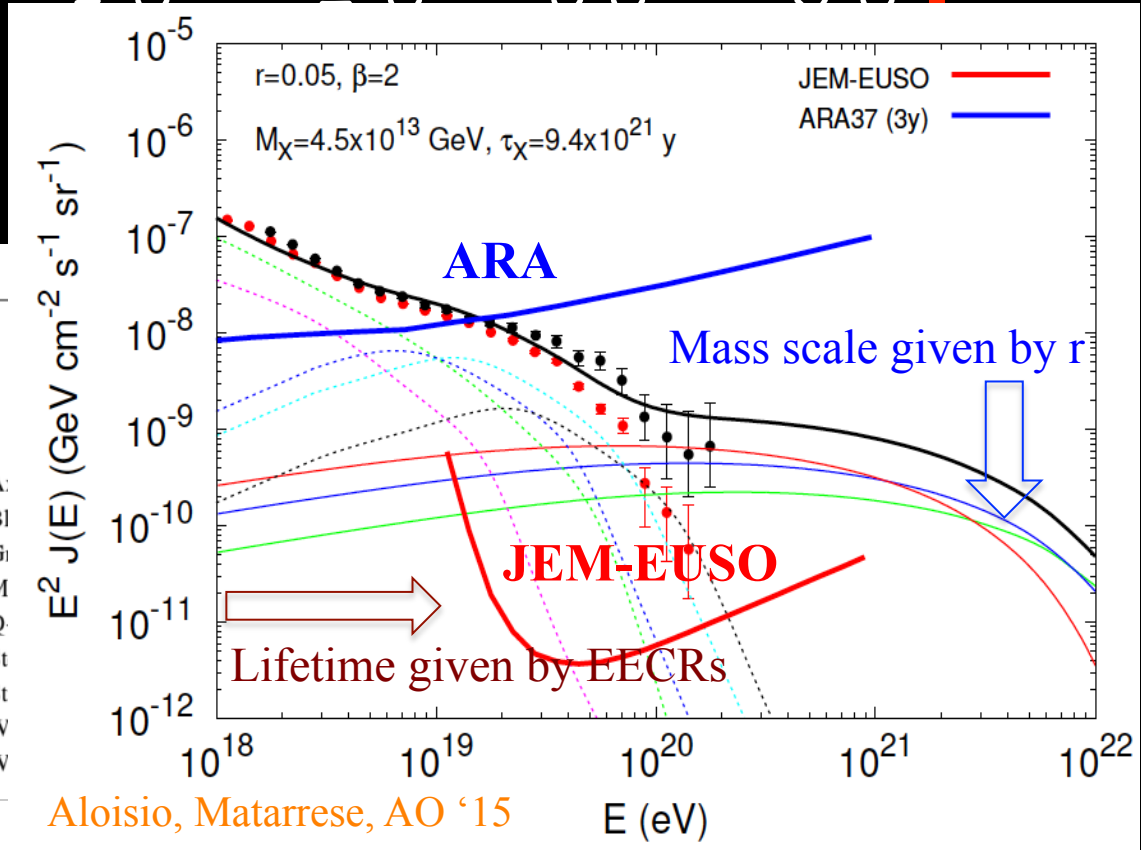
Aloisio, Matarrese, AO '15

10^9 eV 10^{12} eV 10^{15} eV 10^{18} eV 10^{21}eV 10^{24}eV 10^{27}eV

GeV TeV PeV

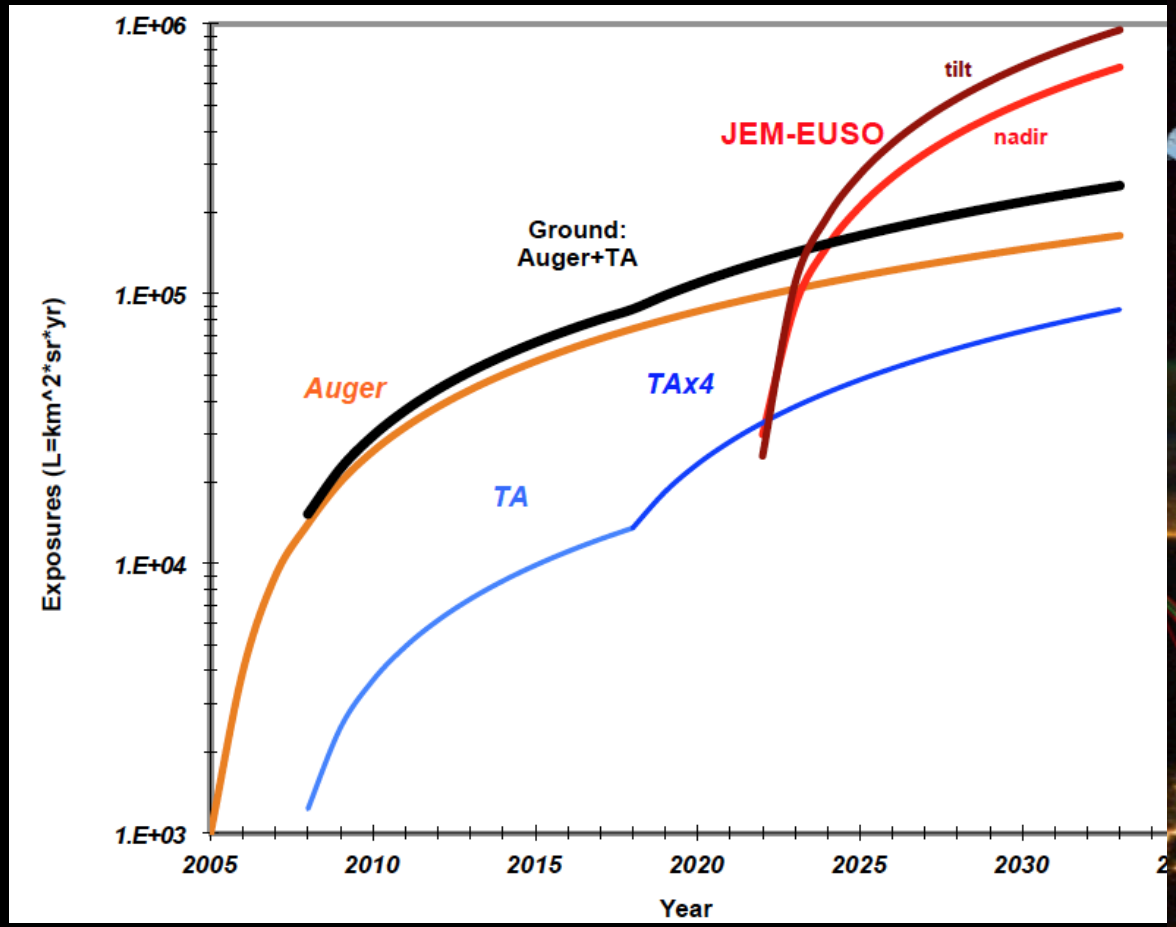
LHC

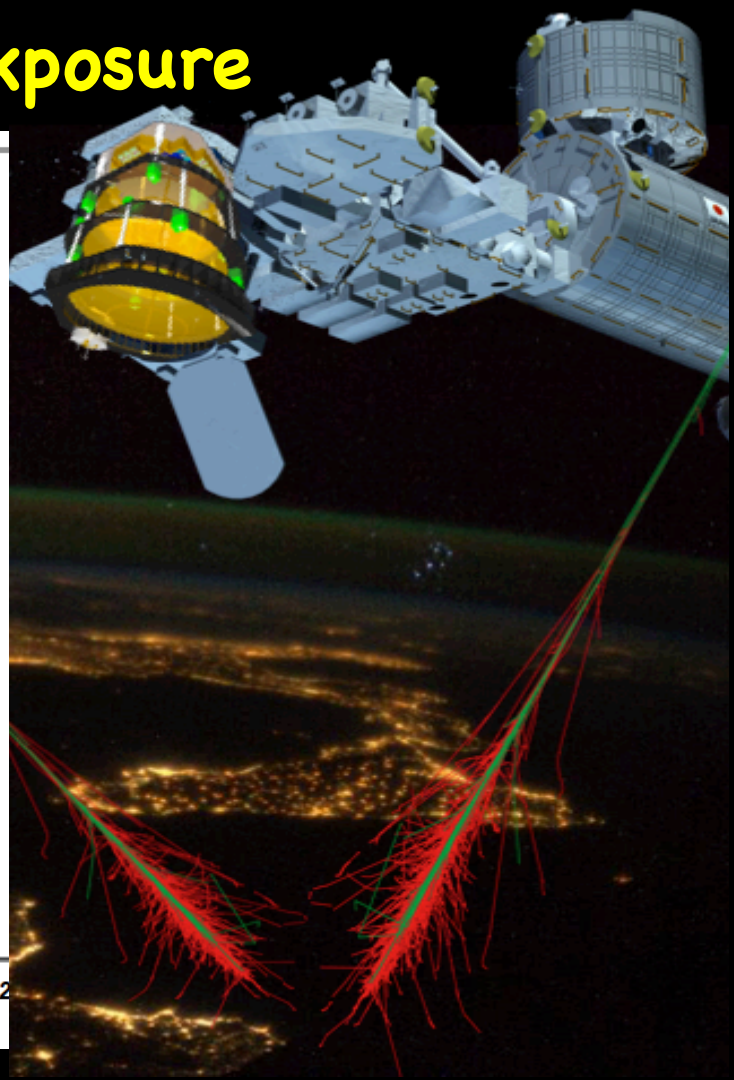




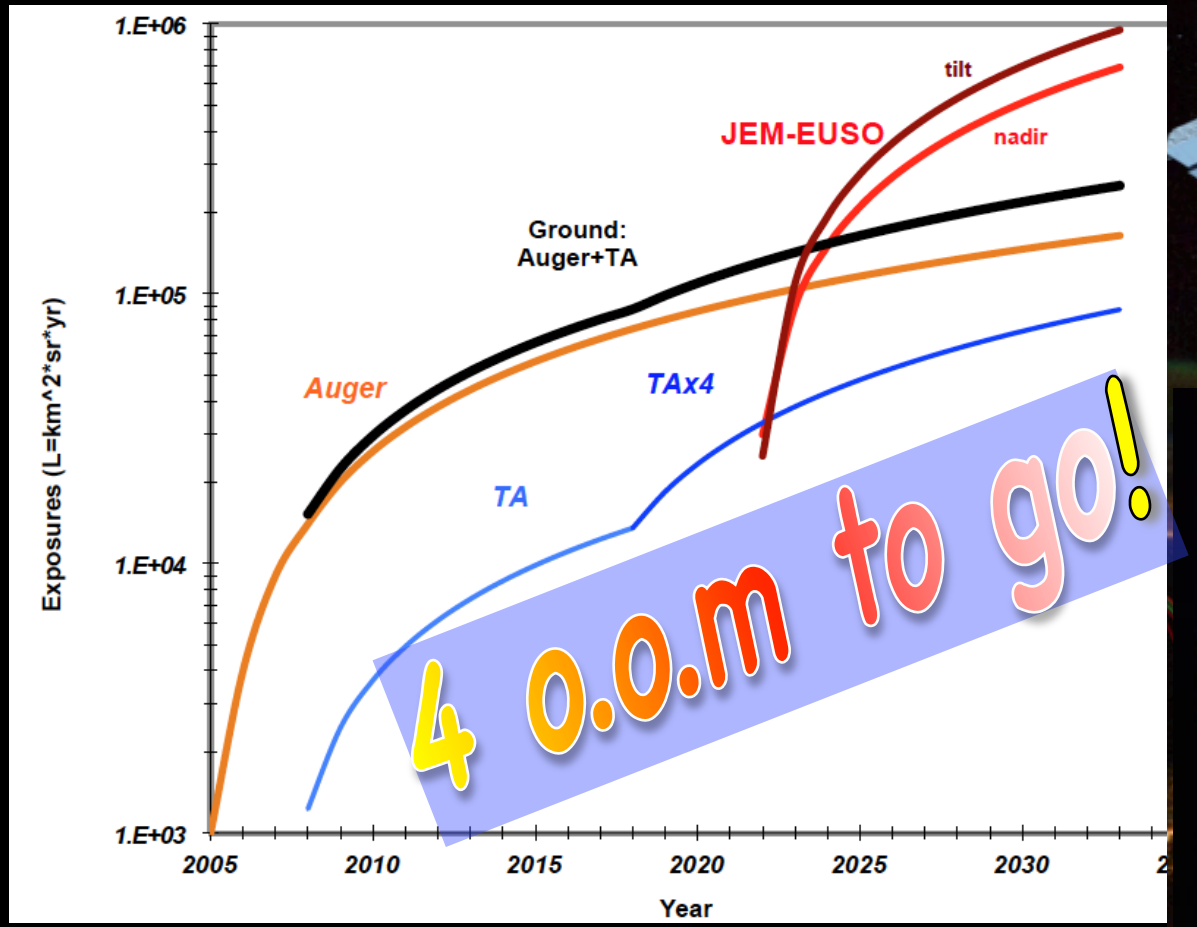
Aloisio, Matarrese, AO '15

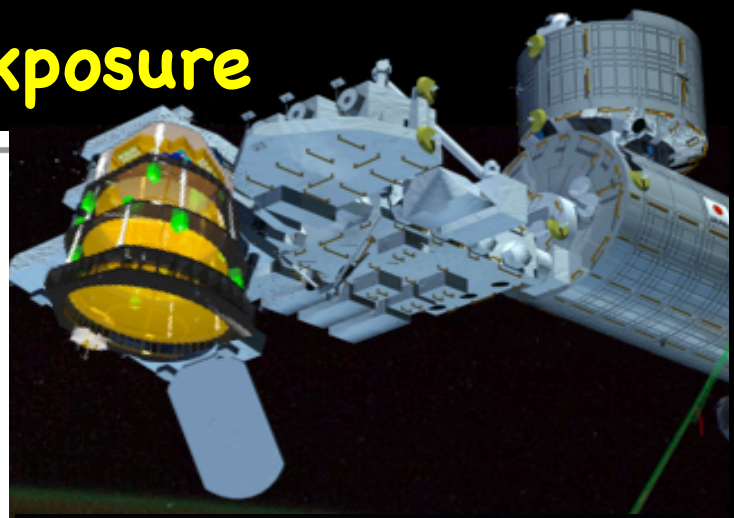
Next Significant Increase in Exposure





Next Significant Increase in Exposure






JEM-EUSO
will study the 1st sources of UHECRs
and explore particle relics @ ZeVs
from Space!!!