DAMPE
DArk Matter Particle Explorer

I. De Mitri

Consiglio di Sezione
INFN Lecce
Luglio 2014

DAMPE: One of the Five Approved Satellite Missions of the Chinese Academy of Sciences (CAS)

- **Hard X-ray Modulation Telescope (HXMT)**
- **Quantum Science Experimental Satellite**
- **DArk Mater Particle Explorer (DAMPE)**
- **Retrievable Scientific Experimental Satellite**
- **Kuafu Space Weather Project (3 satellite)**

China's Future Space Astronomy Missions

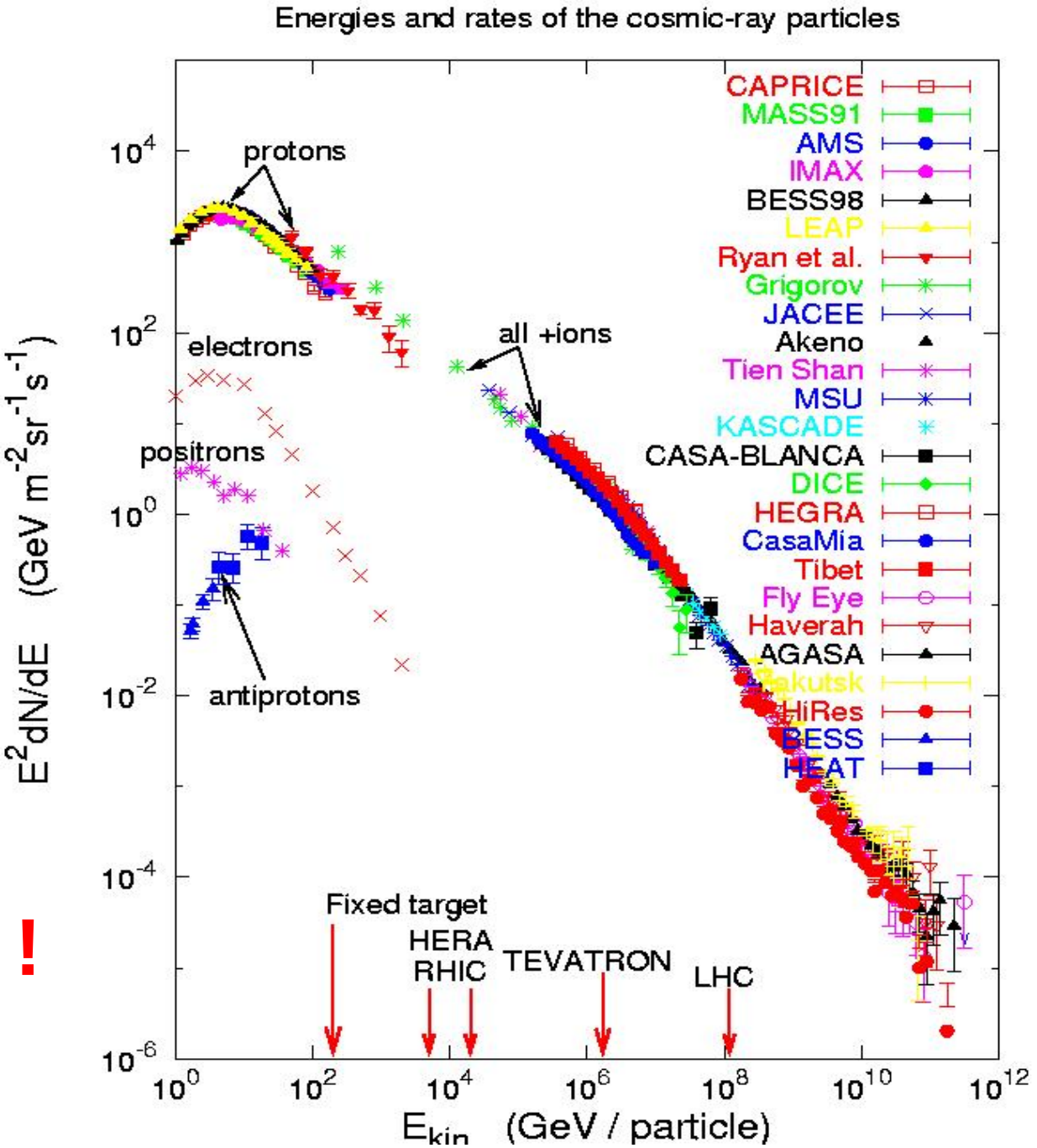
Scientific Objectives of DAMPE

- **High energy particle detection in space**
  - **Study of the cosmic e, γ spectra and Search for DM signatures**
  - **Study of cosmic ray (nuclei) spectrum and composition**
  - **High energy gamma ray astronomy**

Detection of 10 GeV - 10 TeV e/γ, 100 GeV - 500 TeV CR
Excellent energy resolution and tracking precision
Complementary to Fermi, AMS-02, CALET, ISS-CREAM, …

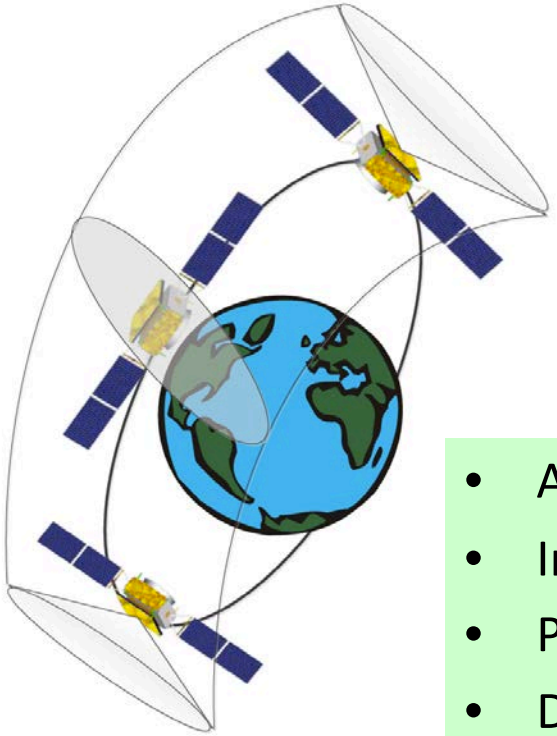
- **Follow-up mission to both Fermi/LAT and AMS-02**
  - **Extend the energy reach to the TeV region, providing better resolution**
  - **Overlap with Fermi on gamma ray astronomy**
  - **Run in parallel for some time**

The beam !

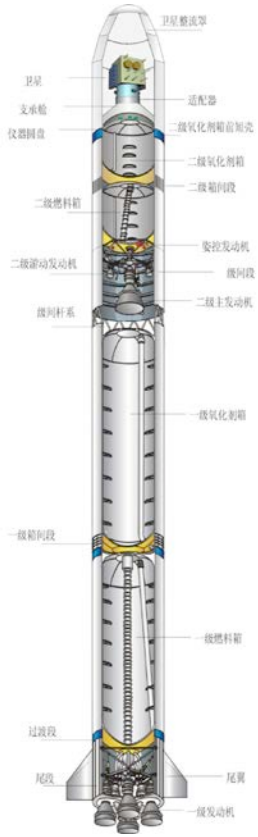

Energies and rates of the cosmic-ray particles
protons
electrons
positrons
antiprotons
all +ions
CAPRICE
MASS91
AMS
IMAX
BESS98
LEAP
Ryan et al.
Grigorov
JACEE
Akeno
Tien Shan
MSU
KASCADE
CASA-BLANCA
DICE
HEGRA
CasaMia
Tibet
Fly Eye
Haverah
AGASA
Yakutsk
HiRes
BESS
HEAT
Fixed target
HERA
RHIC
TEVATRON
LHC
E^2dN/dE (GeV $m^{-2}sr^{-1}s^{-1}$)
E_{kin} (GeV / particle)

Dark Matter Particle Explorer Satellite

- One of the 5 satellite missions of the Strategic Priority Research Program in Space Science of CAS
  - Approved for construction (phase C/D) in Dec. 2011
  - Scheduled launch date 2015-2016

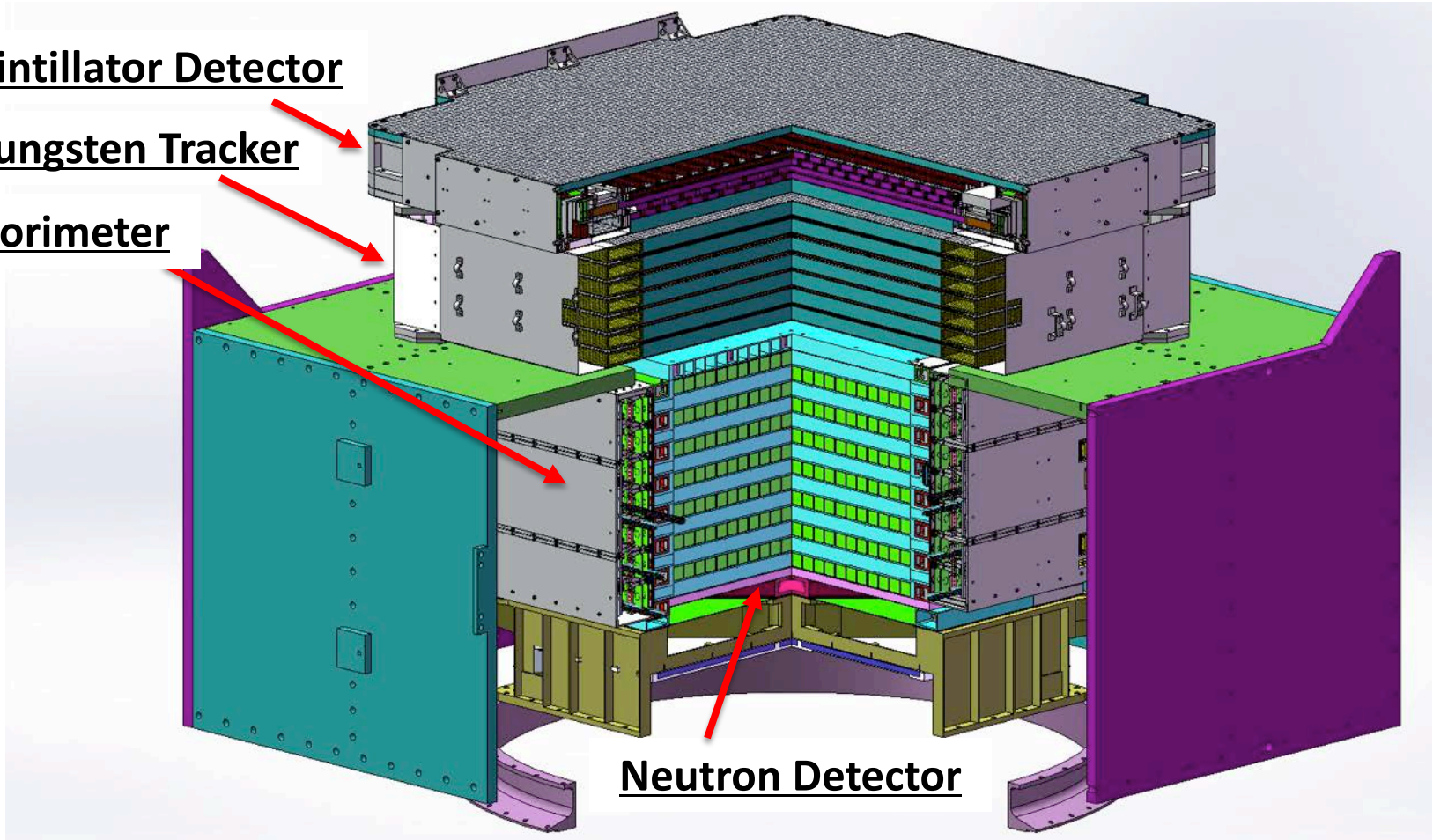


- Satellite < 1900 kg, payload ~1340kg
- Power consumption 840W
- Lifetime > 3 years
- Launched by CZ-2D rockets



- Altitude 500 km
- Inclination 87.4065°
- Period 90 minutes
- Dawn/dusk (6:30 AM) sun-synchronous orbit

The DAMPE Detector

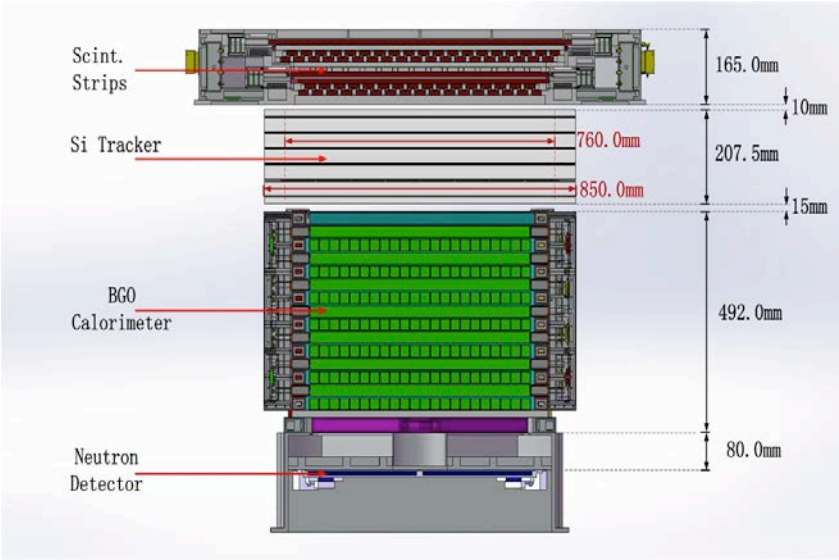


W converter + thick calorimeter (total 33 X_0) + precise tracking + charge measurement ➡ high energy γ-ray, electron and CR telescope

Comparison with AMS-02 and Fermi

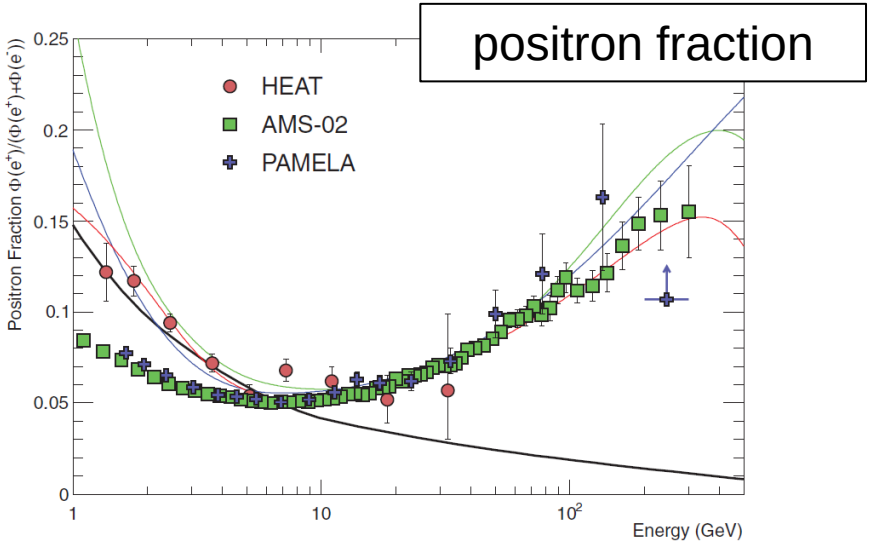
	DAMPE	AMS-02	Fermi LAT
e/γ Energy res.@100 GeV (%)	1.5	3	10
e/γ Angular res.@100 GeV (°)	0.1	0.3	0.1
e/p discrimination	10^5	10^5 - 10^6	10^3
Calorimeter thickness (X_0)	31	17	8.6
Geometrical accep. (m^2sr)	0.29	0.09	1

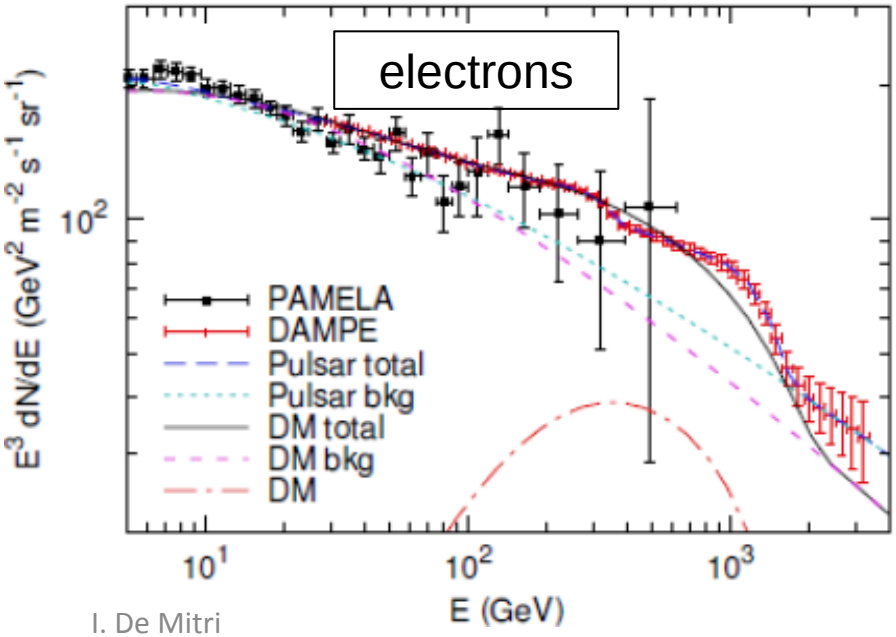
- **Geometrical acceptance with BGO alone: 0.36 m^2sr**
  - **BGO+STK+PSD: 0.29 m^2sr**
  - **First 10 layers of BGO (22 X_0) +STK+PSD: 0.36 m^2sr**

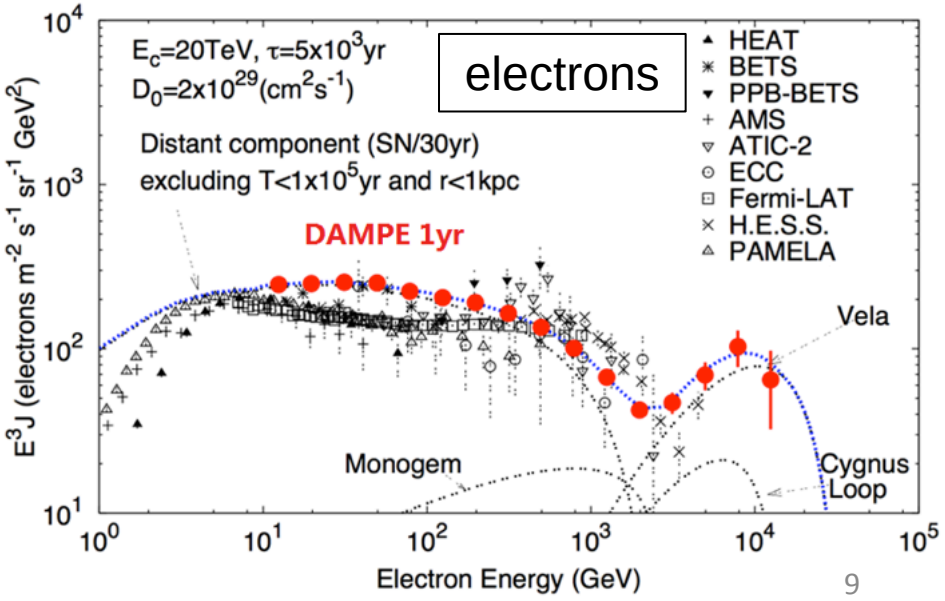


DM or Pulsar ?

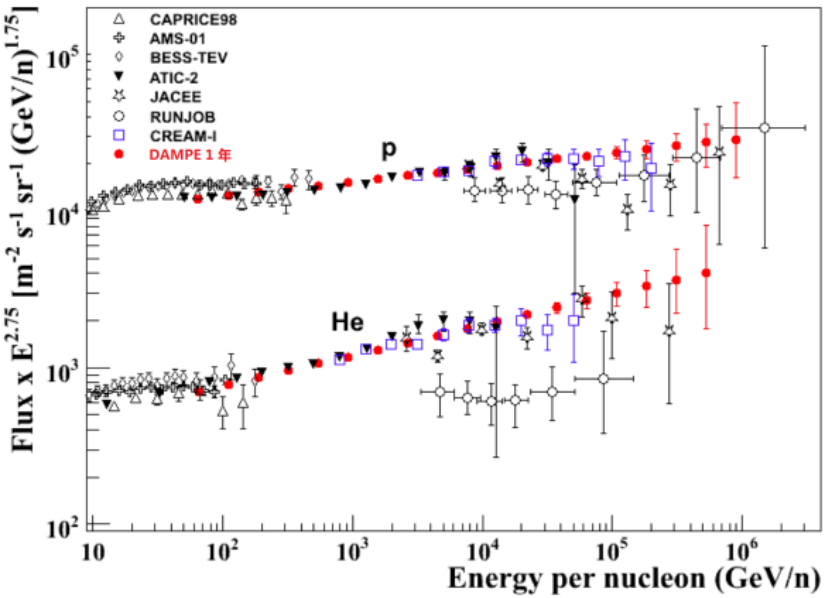
Need a detector in space that can detect electrons around 1 TeV with very good energy resolution

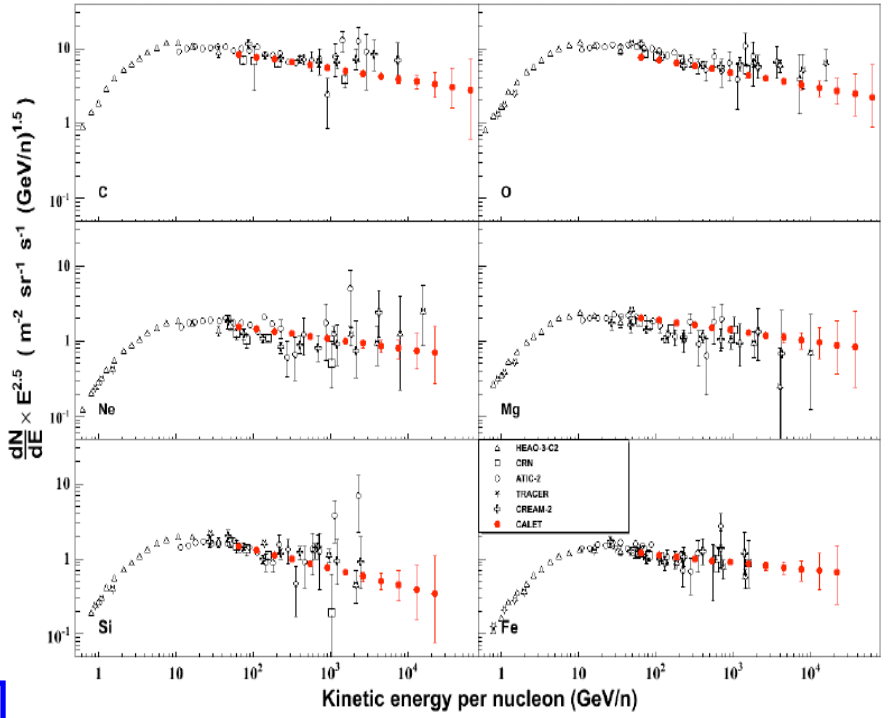




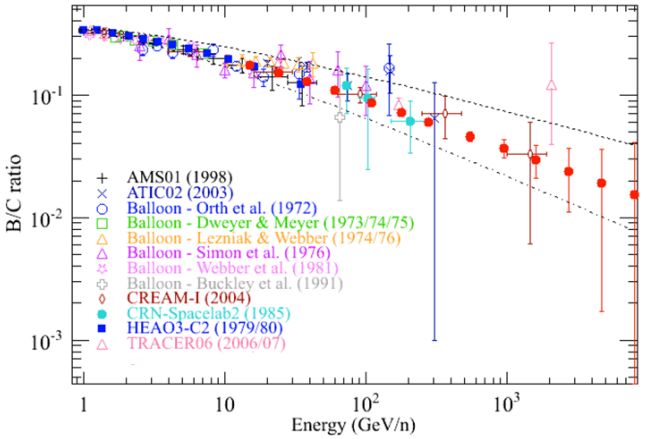


CR Spectra & Composition with DAMPE





Proton spectrum to ≈ 900 TeV
He spectrum to ≈ 400 TeV/n
Spectra of C, O, Ne, Mg, Si to ≈ 20 TeV/n
B/C ratio to ≈ 4-6 TeV/n
Fe spectrum to ≈ 10 TeV/n



The DAMPE Collaboration

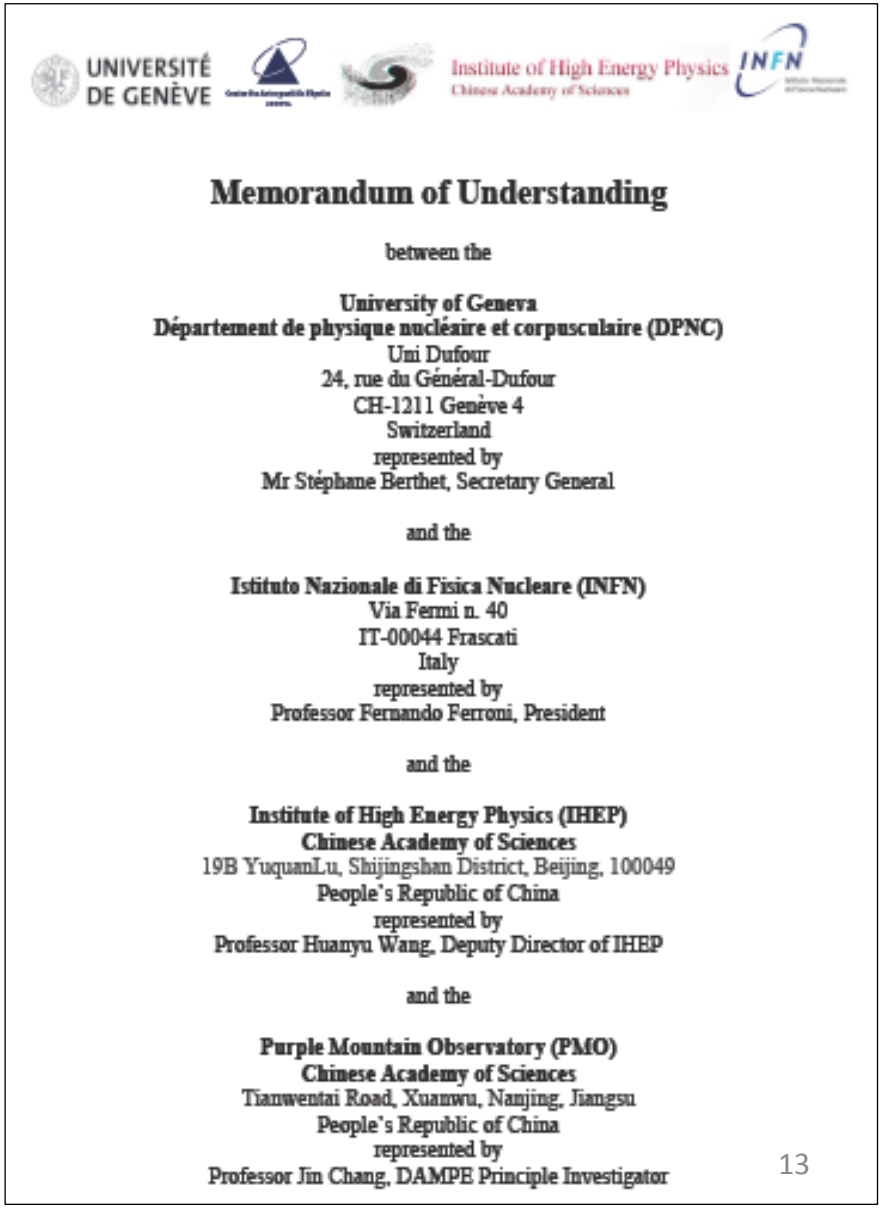
- China
  - Purple Mountain Observatory, CAS, Nanjing
    - Chief Scientist: Prof. Jin Chang
  - Institute of High Energy Physics, CAS, Beijing
  - National Space Science Center, CAS, Beijing
  - University of Science and Technology of China, Hefei
  - Institute of Modern Physics, CAS, Lanzhou
- Switzerland
  - University of Geneva
- Italy
  - INFN and University of Perugia
  - INFN and University of Bari

MOU & schedule

MOU signed on April 30th 2013

MOU & schedule

- MOU signed on April 30th 2013
- EQM (Engineering Qualification model) ready by July 2014
- FM (Flight Model) to be delivered to Shanghai Engineering Center for Microsatellites in spring 2015
- DAMPE is a CERN recognized experiment since March 2014



UNIVERSITÉ DE GENÈVE — Institute of High Energy Physics, Chinese Academy of Sciences — INFN

Memorandum of Understanding

between the

University of Geneva
Département de physique nucléaire et corpusculaire (DPNC)
Uni Dufour
24, rue du Général-Dufour
CH-1211 Genève 4
Switzerland
represented by
Mr Stéphane Berthet, Secretary General

and the

Istituto Nazionale di Fisica Nucleare (INFN)
Via Fermi n. 40
IT-00044 Frascati
Italy
represented by
Professor Fernando Ferroni, President

and the

Institute of High Energy Physics (IHEP)
Chinese Academy of Sciences
19B YuquanLu, Shijingshan District, Beijing, 100049
People's Republic of China
represented by
Professor Huanyu Wang, Deputy Director of IHEP

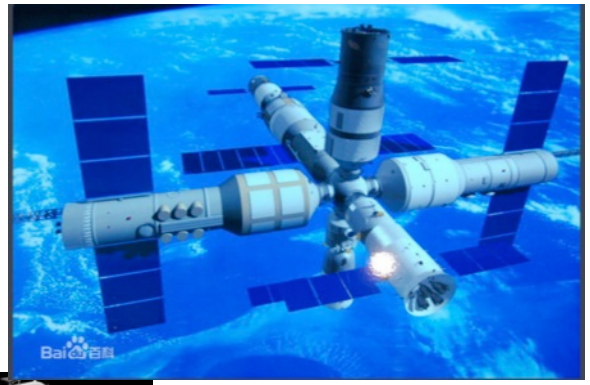
and the

Purple Mountain Observatory (PMO)
Chinese Academy of Sciences
Tianwentai Road, Xuanwu, Nanjing, Jiangsu
People's Republic of China
represented by
Professor Jin Chang, DAMPE Principle Investigator

China's Space Station Program

2020

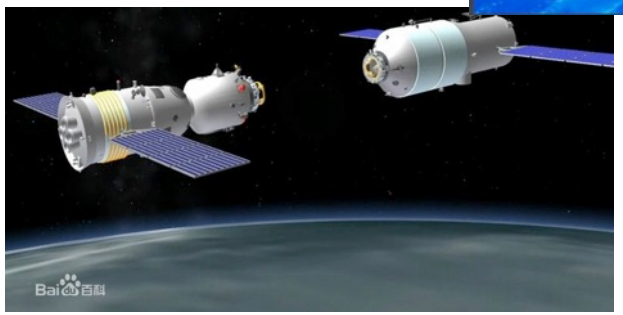
Phase -II



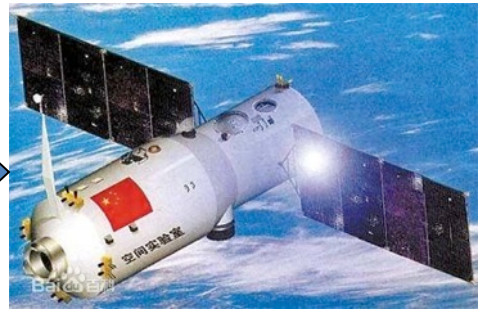
Space Station
3 large modules
~ 60 tons
~10-year lifetime

2016

Phase -II



Space lab:
no living cabin



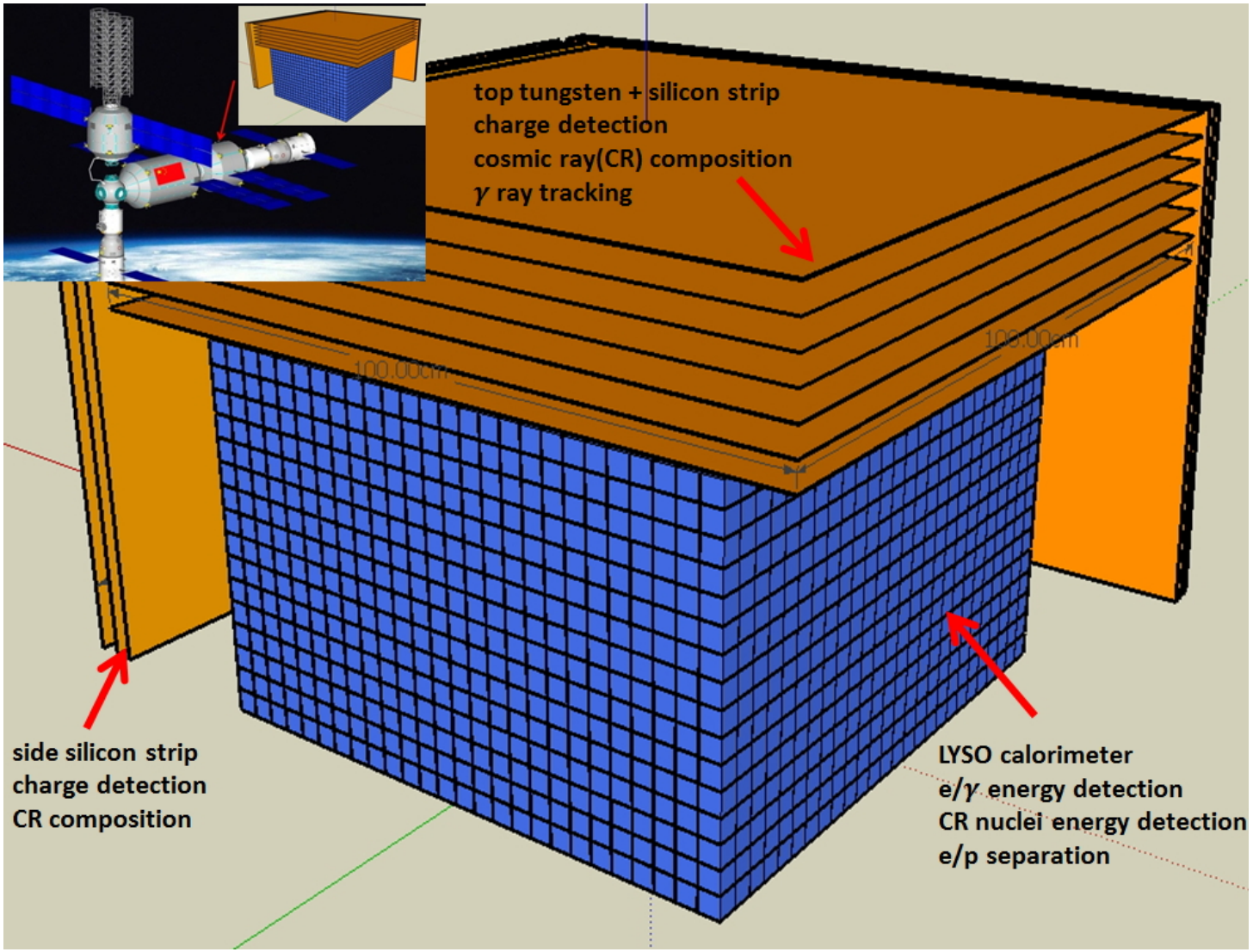
2011

Phase -I

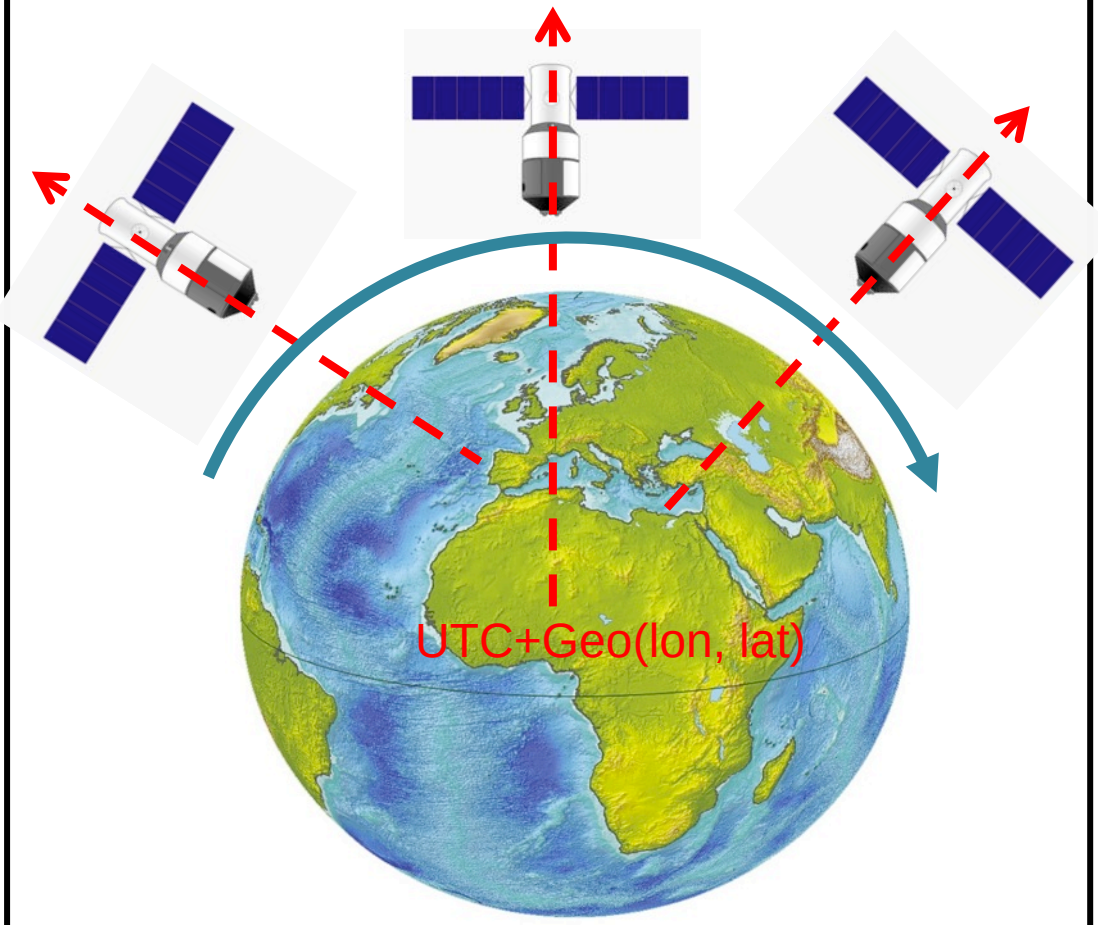
10 astronauts in 5 flights → space walk

2003

High Energy Radiation Detector

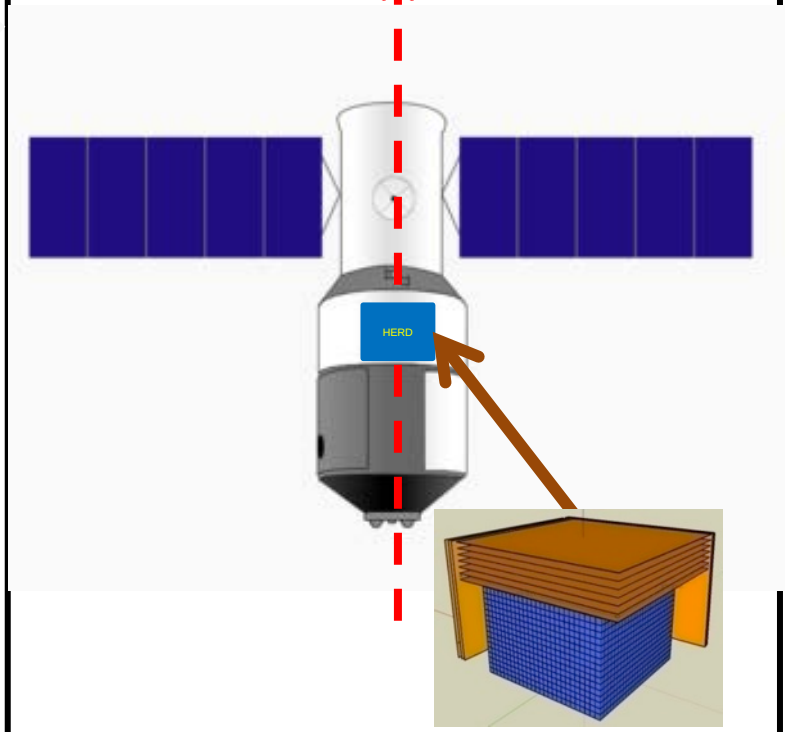


HERD in Space



schematic diagram of
ST orbit and pointing

schematic diagram of
HERD onboard ST



HERD: High Energy cosmic-Radiation Detector

Science goals	Mission requirements
Dark matter search	Better statistical measurements of e/γ between 100 GeV to 10 TeV
Origin of Galactic Cosmic rays	Better spectral and composition measurements of CRs between 300 GeV to PeV with a large geometrical factor

Other science goals:
- Monitoring of GRBs,
- Microquasars
- Blazars and other transients.

Expected performance of HERD

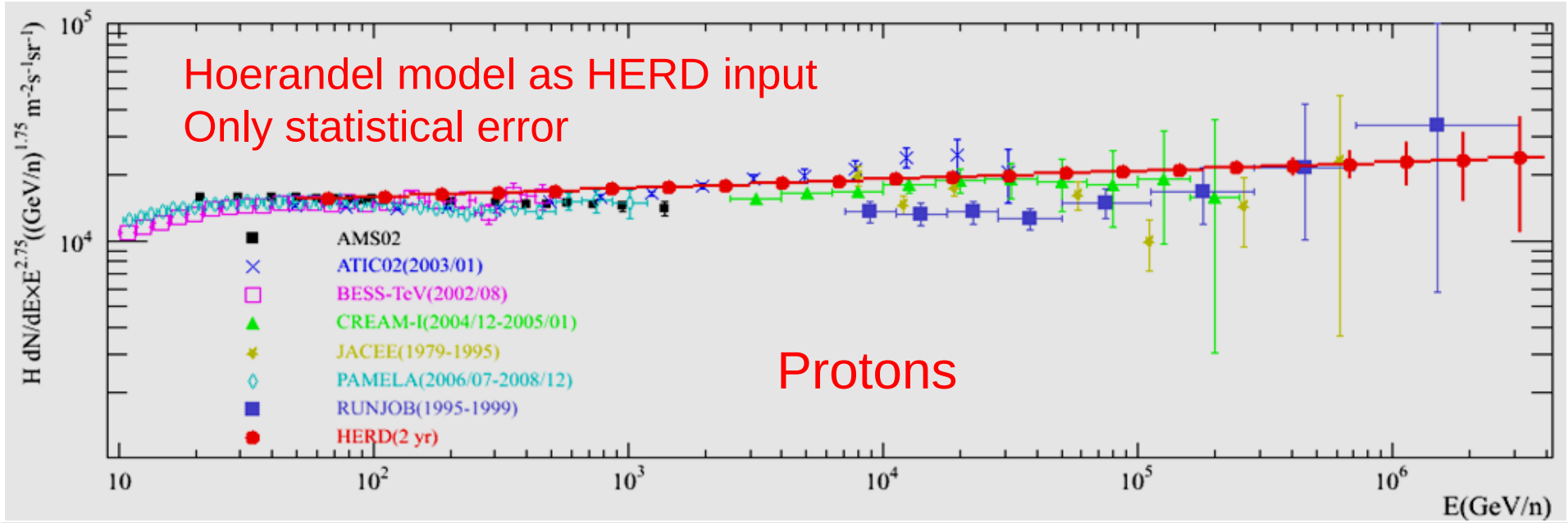
γ/e energy range (CALO)	tens of GeV-10TeV
nucleon energy range (CALO)	up to PeV
γ/e angular resol. (top Si-strips)	0.1^{o}
nucleon charge resol. (all Si-strips)	0.1-0.15 c.u
γ/e energy resolution (CALO)	<1%@200GeV
proton energy resolution (CALO)	20%
e/p separation power (CALO)	$<10^{-5}$
electron eff. geometrical factor (CALO)	3.7 m^2sr@600 GeV
proton eff. geometrical factor (CALO)	2.6 m^2sr@400 TeV

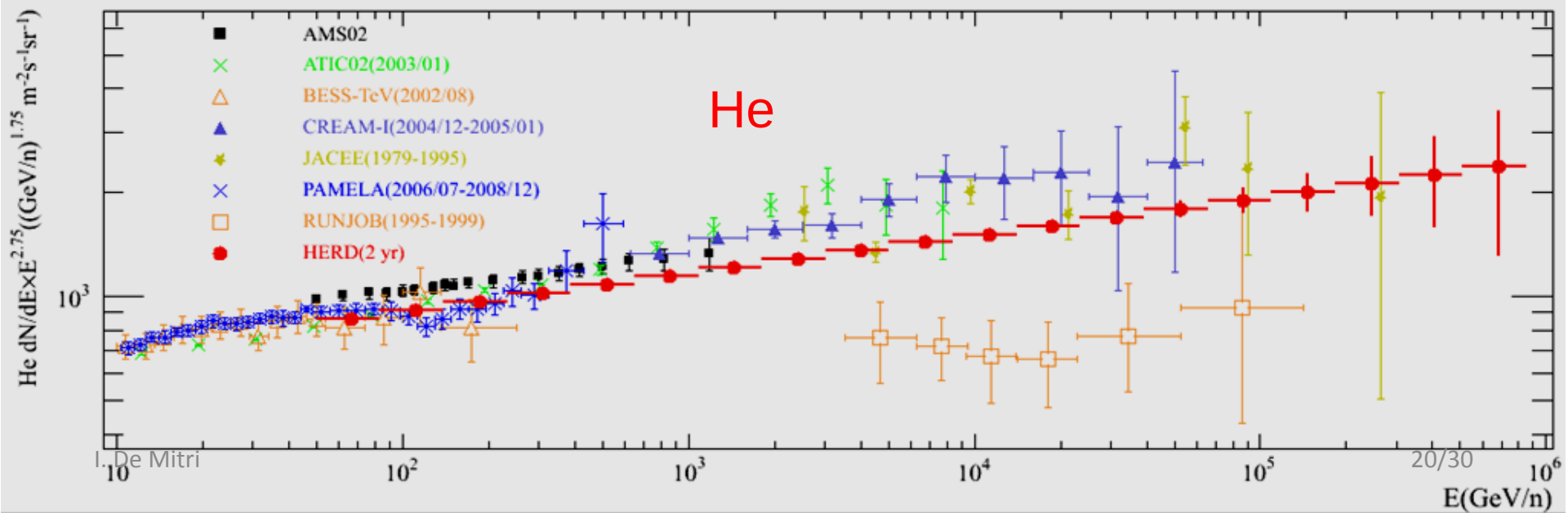
Characteristics of HERD components

	type	size	X_0 , λ	unit	main functions
tracker (top)	Si strips	70 cm × 70 cm	2 X_0	7 x-y (W foils)	Charge Early shower Tracks
tracker 4 sides	Si strips	65 cm × 50 cm	--	3 x-y	Nucleon Track Charge
CALO	~10K LYSO cubes	63 cm × 63 cm × 63 cm	55 X_0 3 λ	3 cm × 3 cm × 3 cm	e/γ energy nucleon energy e/p separation

Total detector weight: ~2000 kg

Expected HERD Proton and He Spectra





Conclusions

- **DAMPE is among CAS funded projects for space**
- **Better performance than existing detectors for e/γ/CR**
- **International collaboration is being consolidated**
- **Systematic activity on simulation, and preparation for data analysis is starting**

- **DAMPE will be studying high energy CR and photons in two years from now**

- **HERD is an opportunity to further increase the energy range and the detection reach in CR measurement**

Conclusions (II)

Il gruppo di Lecce (lista non congelata, in evoluzione):

P. Bernardini
A. D'Amone
I. De Mitri
G. Marsella
A. Surdo

Elettronica: 20% P. Creti
Meccanica: 1 m.u.

Tot. 2 FTE

Richieste (quasi definitive)

MI	Test beams, meetings	29.5k
INV	CPU + spazio disco	5.5k
TOT		35k

Impegni (in fase di definizione):
- Partecipazione test beam e analisi dati
- Partecipazione test termo/meccanici
- Sviluppo tool di simulazione e analisi dati
- Studio performance e potenzialità nella fisica dei RC
- Partecipazione design HERD