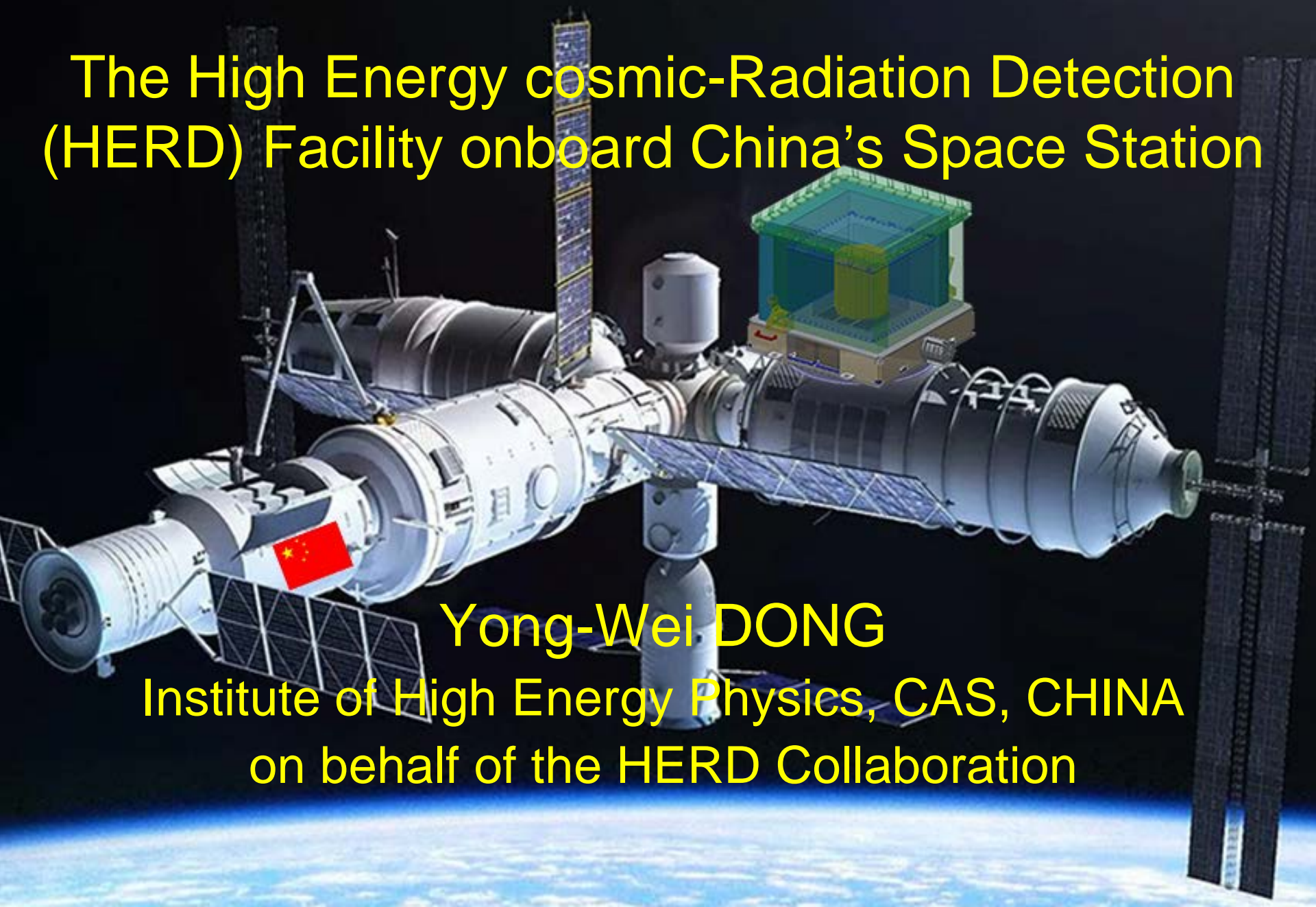


# The High Energy cosmic-Radiation Detection (HERD) Facility onboard China's Space Station



Yong-Wei DONG

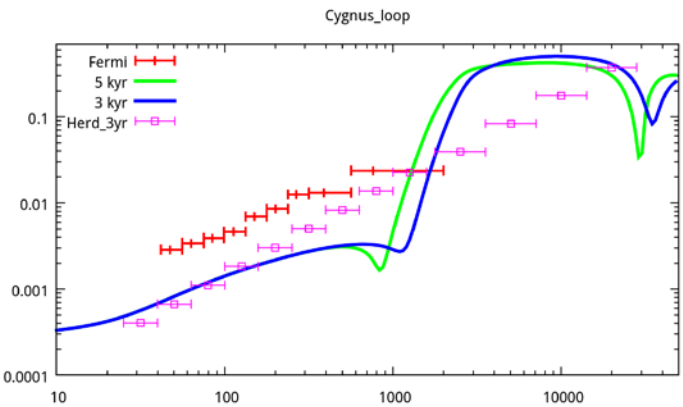
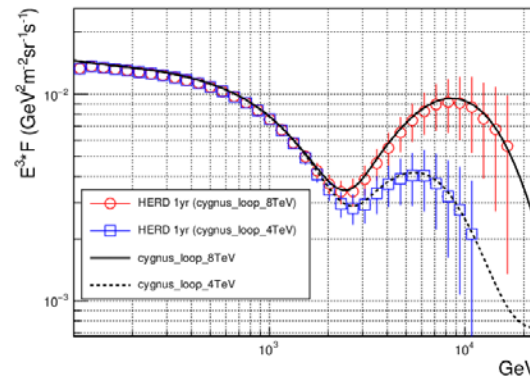
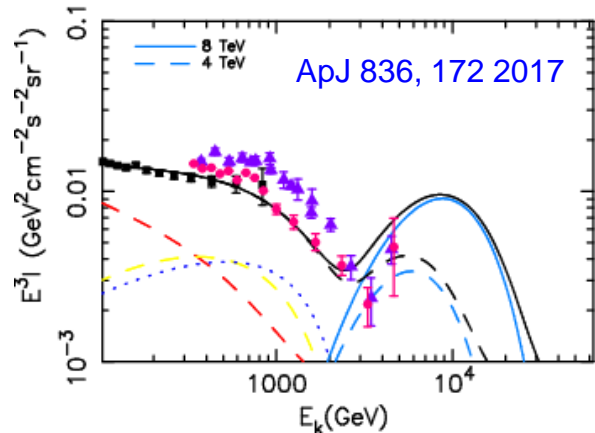
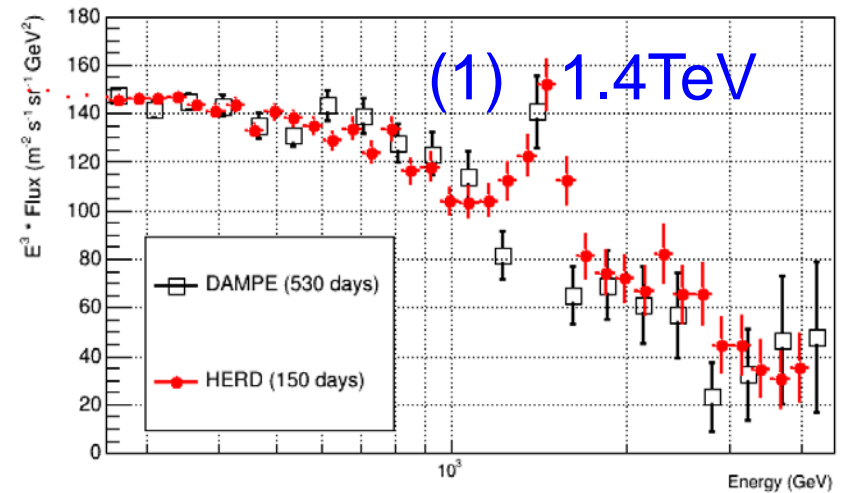
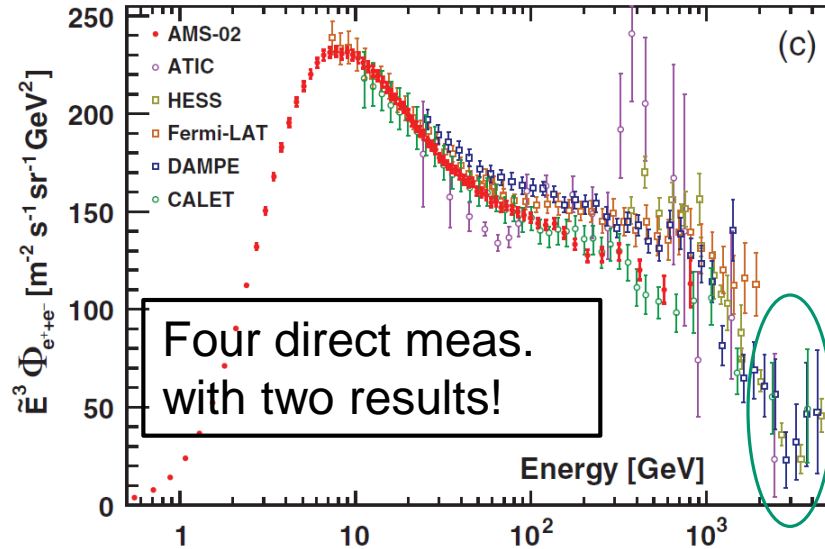
Institute of High Energy Physics, CAS, CHINA  
on behalf of the HERD Collaboration

# High Energy cosmic-Ray Detection facility

- HERD, a China-led mission with a key European contribution led by Italy, is proposed by IHEP as an astronomy and particle astrophysics experiment onboard the China's Space Station, which is planned for operation starting around 2025 for about 10 years.
- Main Sciences
  - Dark matter: Dark matter search with unprecedented sensitivity
  - Cosmic-ray: Precise cosmic ray spectrum and composition measurements up to the knee energy
  - Gamma-ray: Gamma-ray monitoring and full sky survey

# Total e<sup>+</sup>/<sub>-</sub> spectrum & DM search

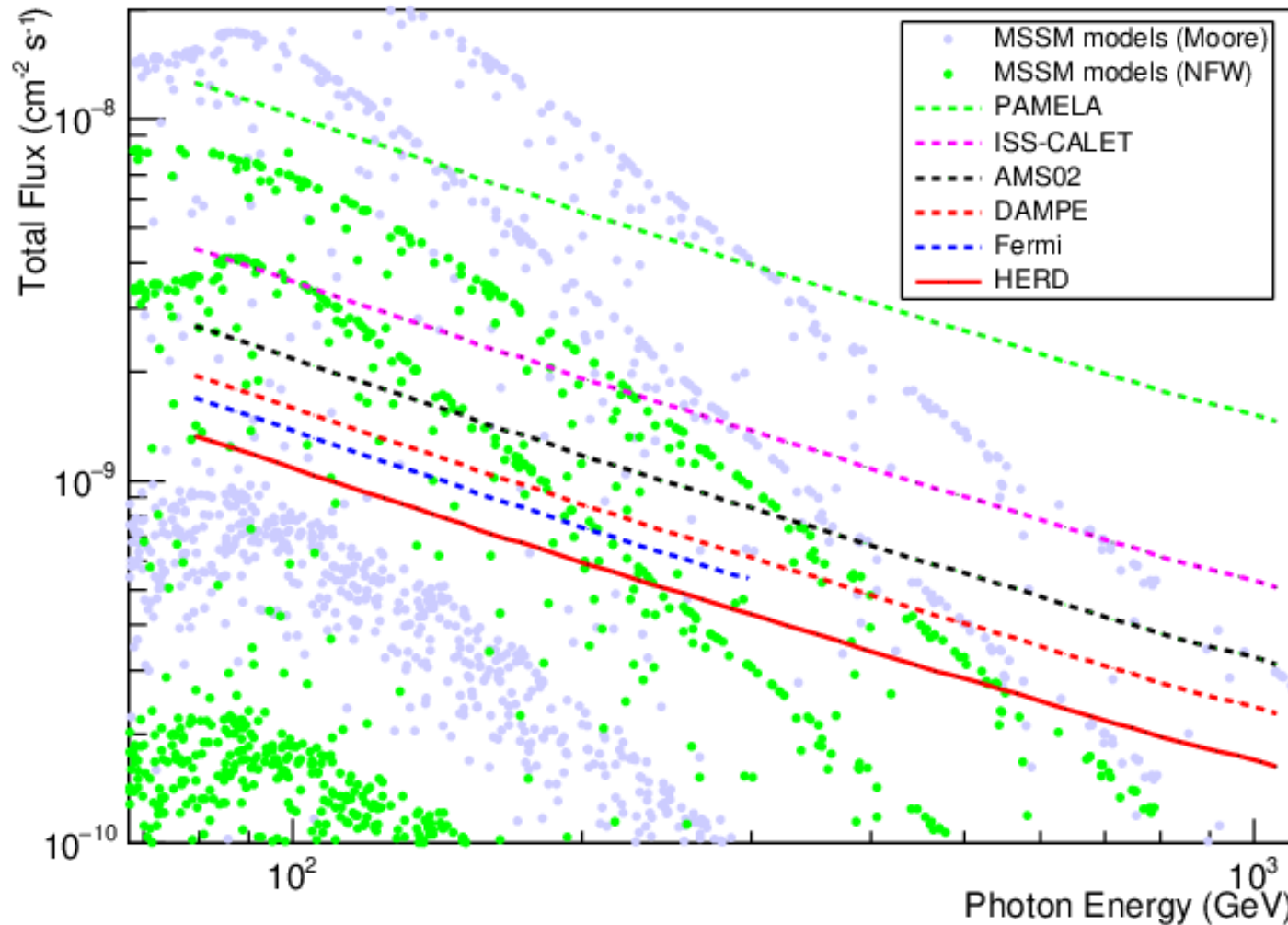
- To confirm ~TeV features in the e<sup>+</sup>/<sub>-</sub> spectrum
- To distinguish different origins of excess & features in the e<sup>+</sup>/<sub>-</sub> spectrum



(2) Spectrum in 10s TeV

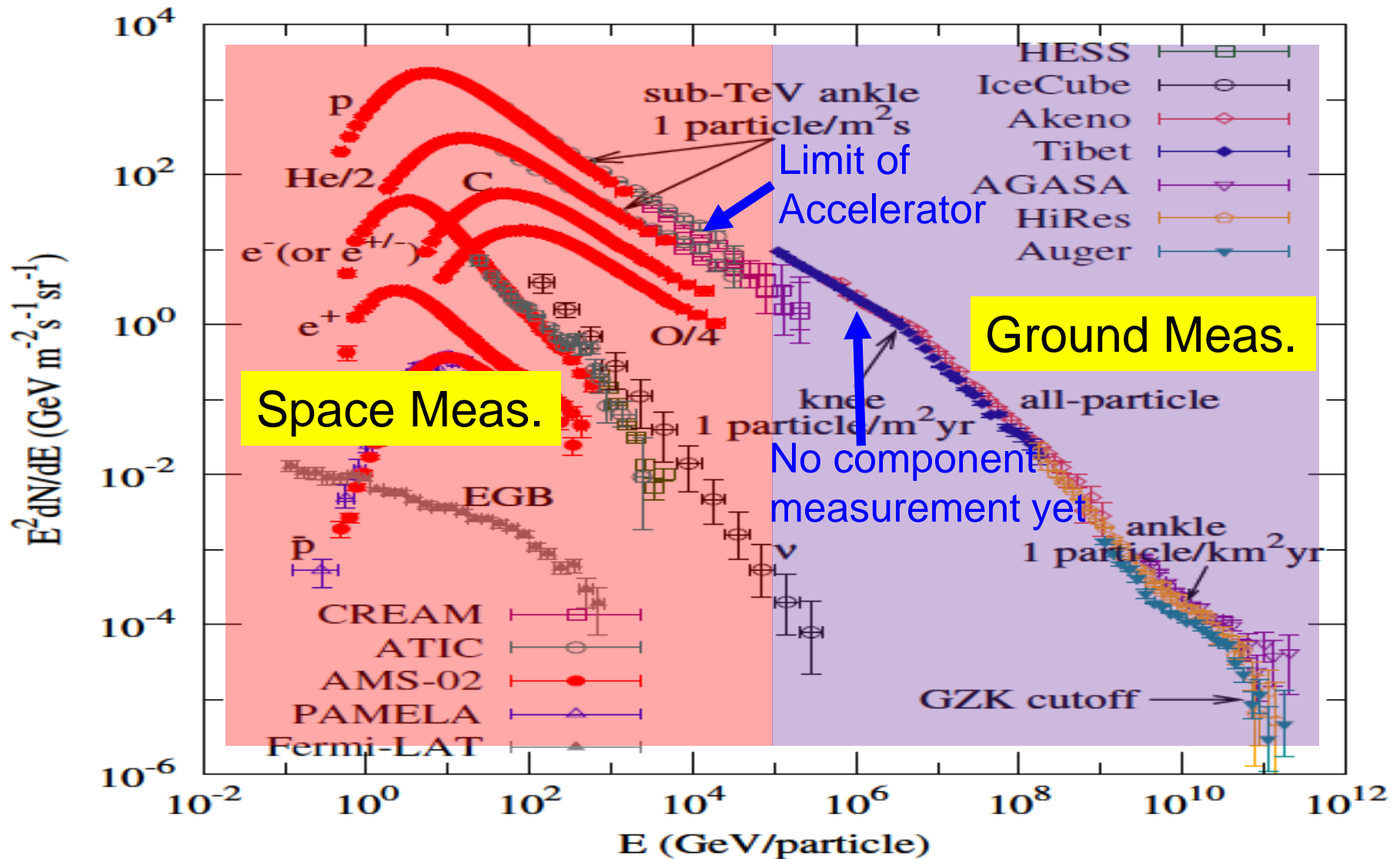
(3) Anisotropy

# Sensitivity for $\gamma$ -line of different experiments



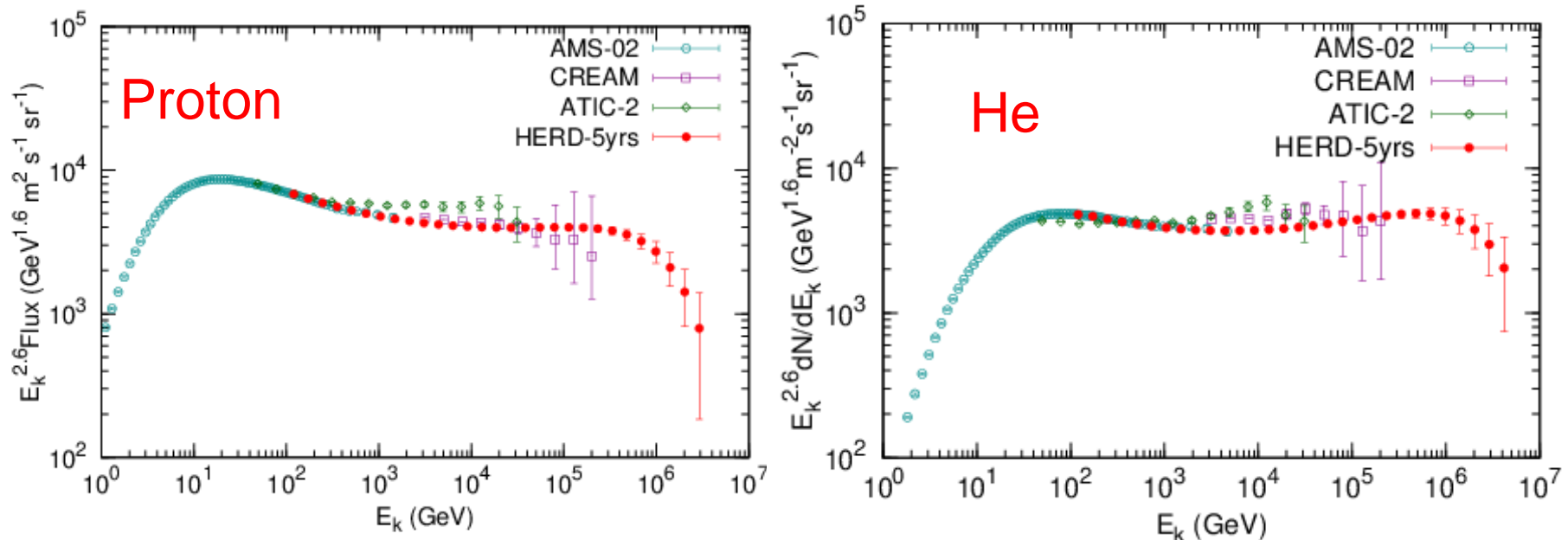
PAMELA: 2006-2016 CALET: 2015-2020; AMS: 2011-2024;  
DAMPE: 2015-2020; Fermi: 2008-2018; HERD: 1 year

# Cosmic-ray Physics



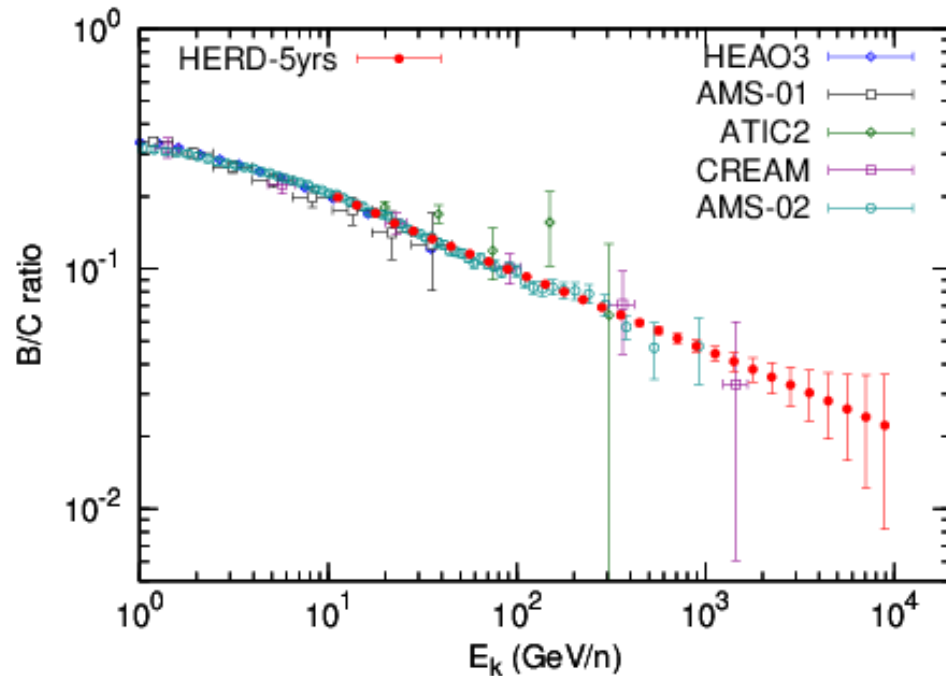


# Expected HERD Proton and He Spectra

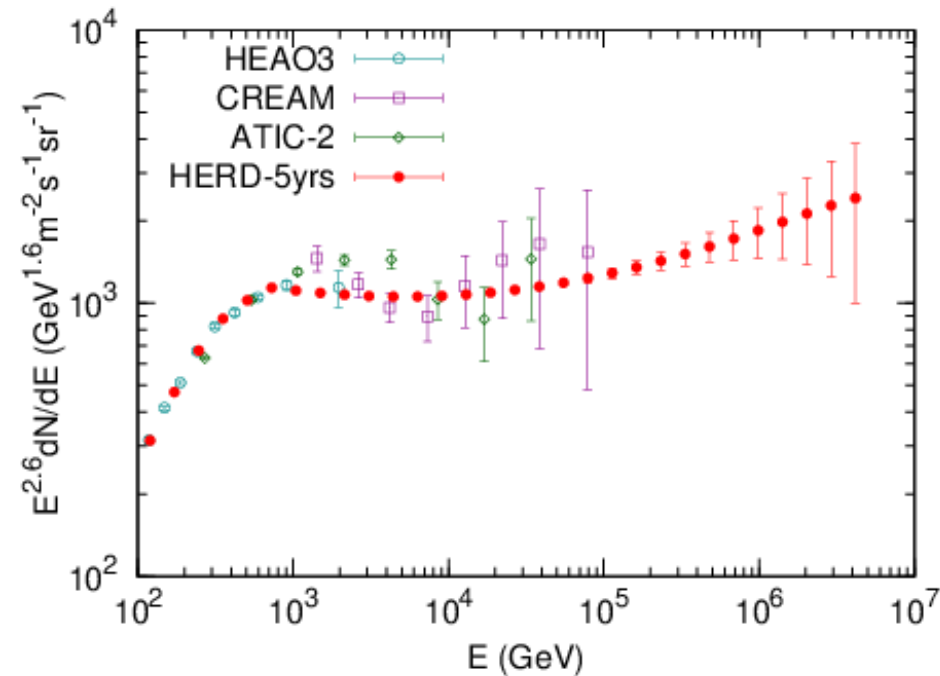


- Well extended to PeV energies
- Critically test any structures between TeV and PeV
- Clearly reveal the knee of light components (Z- or A-dependence)

# B/C ratio, ion & super-iron elements



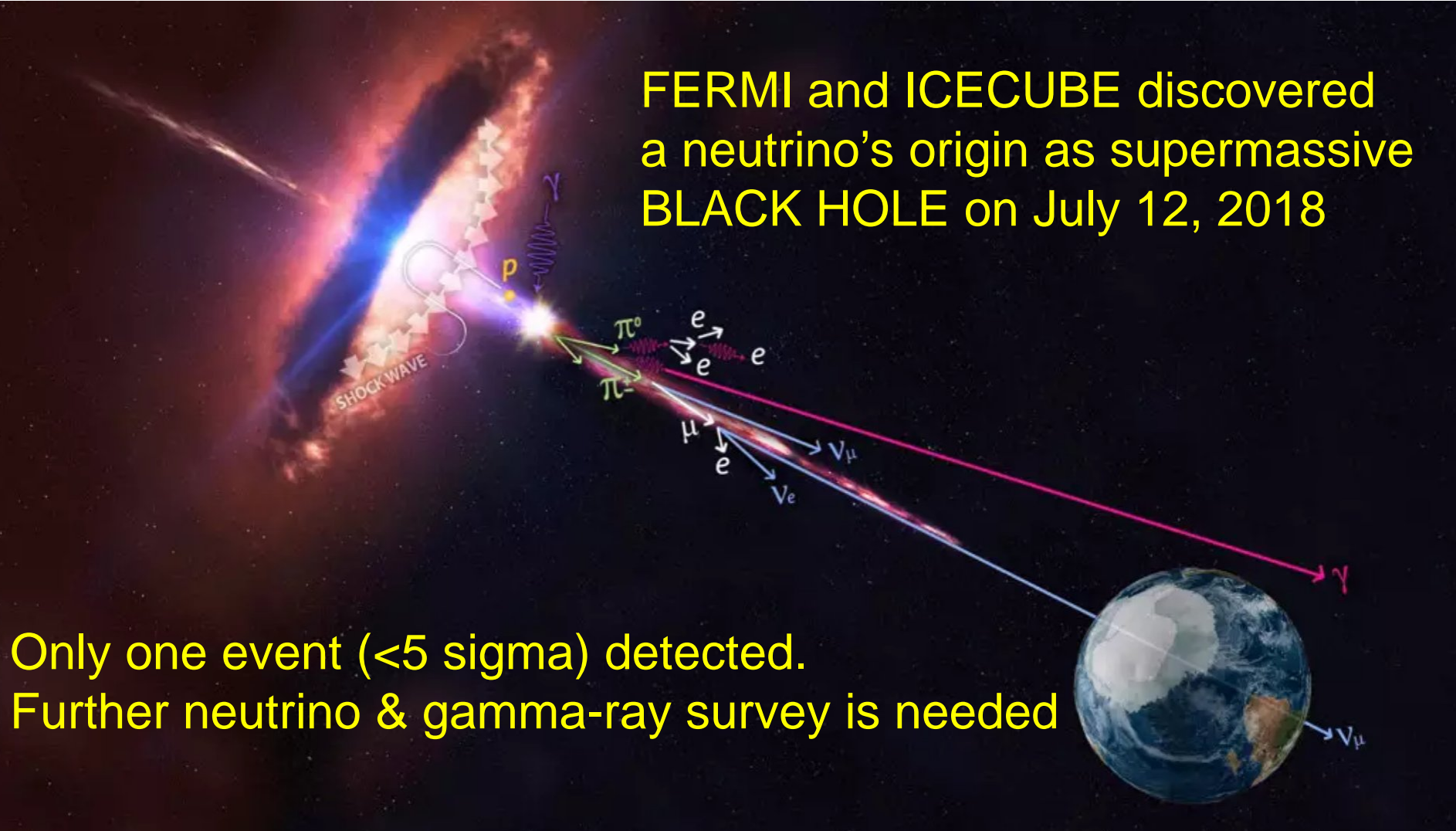
To determine CR propagation parameters and origin of break



To set very stringent limit on super-iron elements

# Gamma-ray monitoring & survey

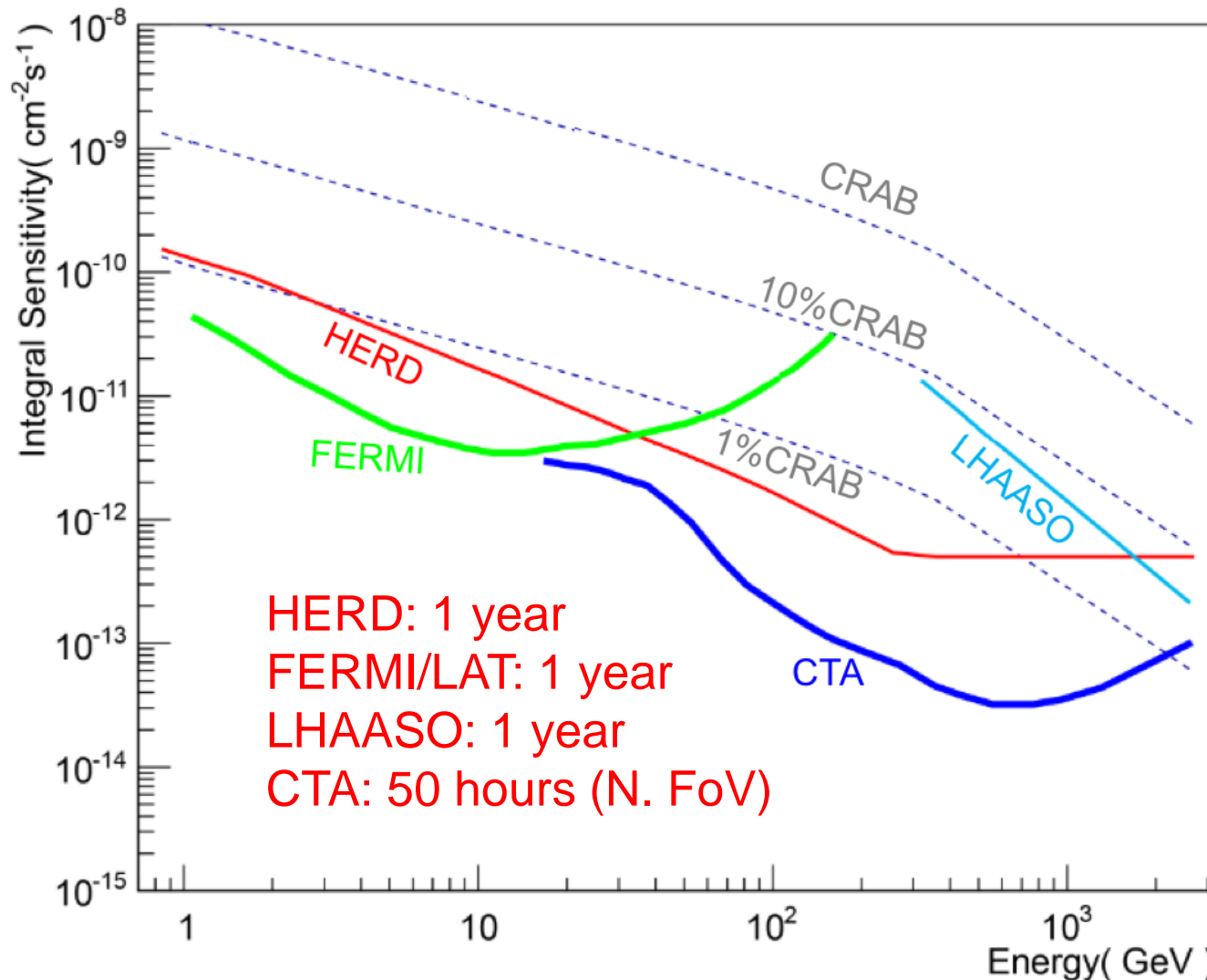
FERMI and ICECUBE discovered  
a neutrino's origin as supermassive  
BLACK HOLE on July 12, 2018



Only one event ( $<5$  sigma) detected.  
Further neutrino & gamma-ray survey is needed



# Gamma-ray sky survey

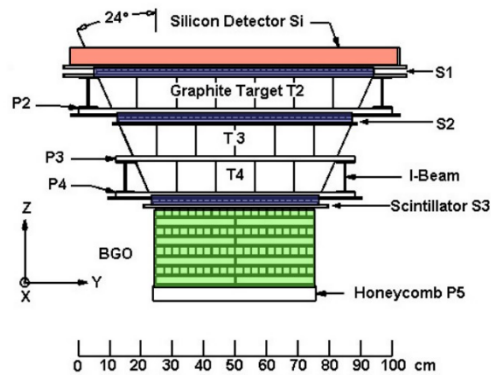


Expected HERD gamma-ray sky survey sensitivity ( $5\sigma$ )

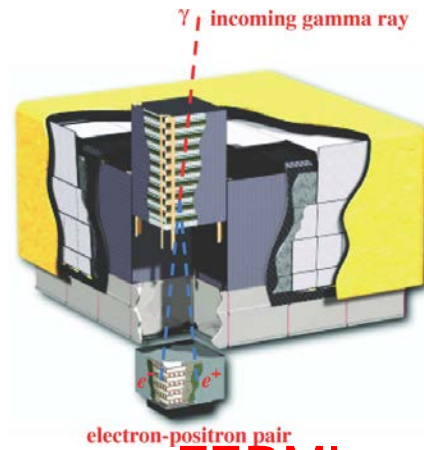
# HERD specifications

Item	Value
Energy range (e/γ)	10 GeV - 100 TeV (e); 0.5 GeV-100 TeV (γ)
Energy range (CR)	30 GeV - 3 PeV
Angle resolution	0.1 deg.@10 GeV
Charge resolution	0.1-0.15 c.u
Energy resolution (e)	1%@200 GeV
Energy resolution (p)	20%@100 GeV - PeV
e/p separation	$\sim 10^{-6}$
G.F. (e)	$>3 \text{ m}^2\text{sr}@200 \text{ GeV}$
G.F. (p)	$>2 \text{ m}^2\text{sr}@100 \text{ TeV}$
Field of View	+/-70 deg (targeting +/-90 deg)
Envelope (L*W*H)	$\sim 2300*2300*2000 \text{ mm}^3$
Weight	$\sim 4000 \text{ kg}$
Power Consumption	$\sim 1400 \text{ W}$

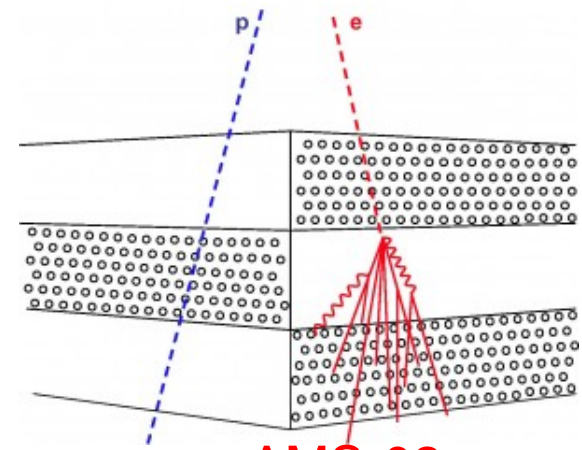
# The 3-d imaging calorimeter: from bars to cubes



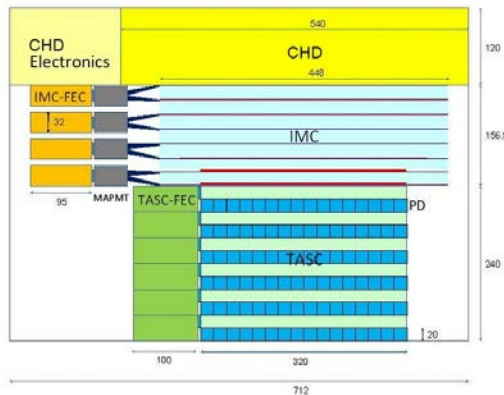
ATIC



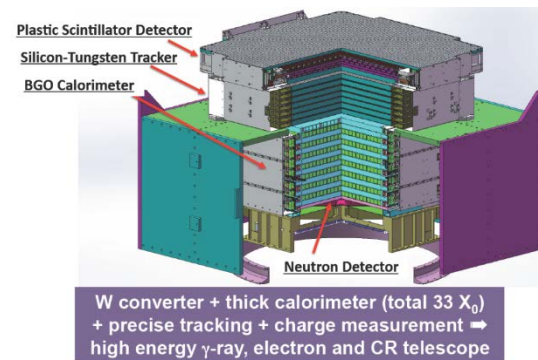
FERMI



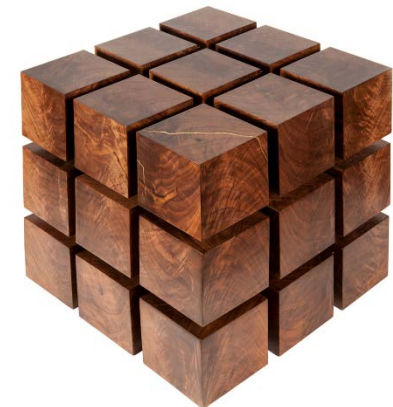
AMS-02



CALET



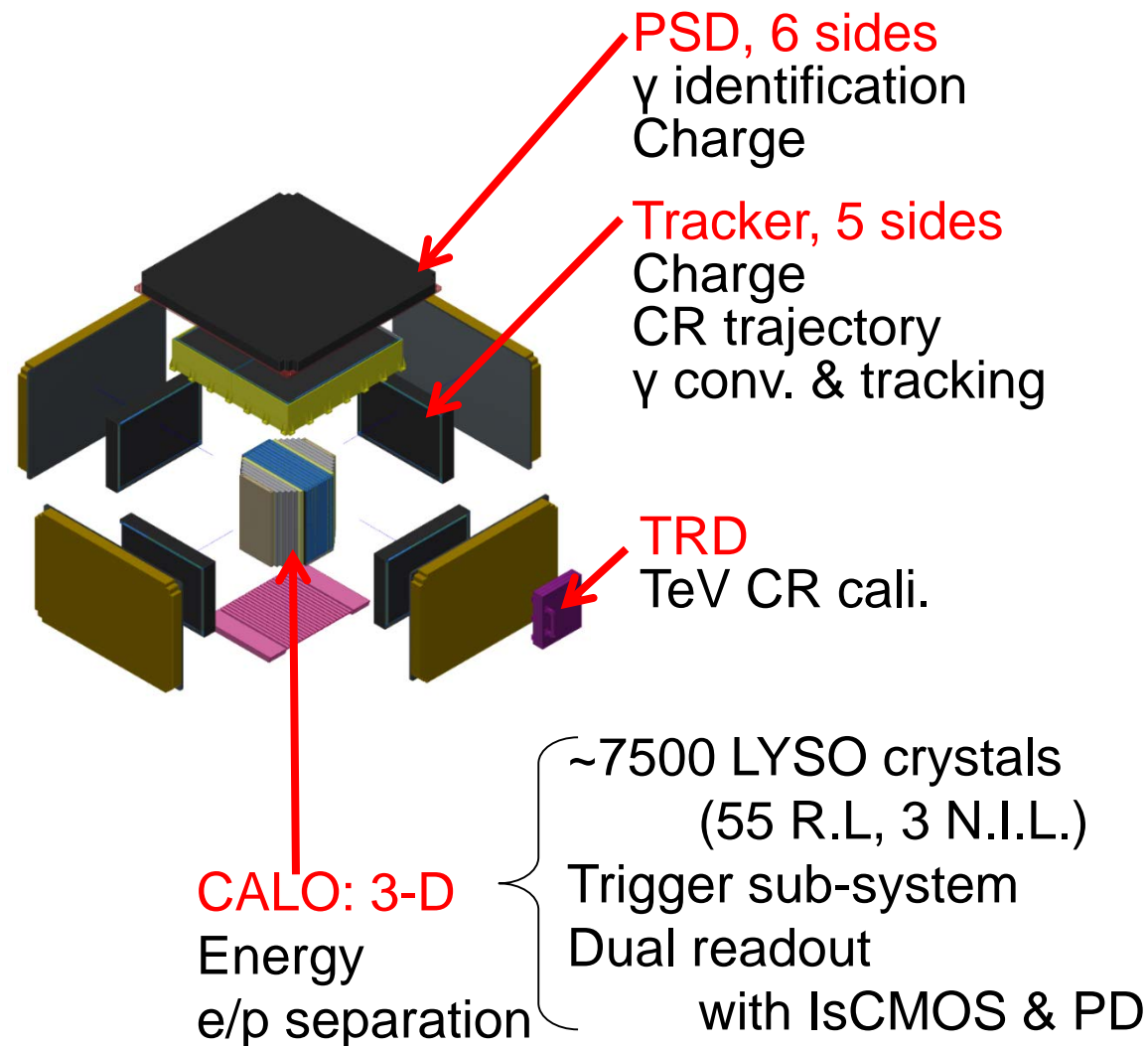
DAMPE



HERD

The novel design of 3-d imaging calorimeter could significantly increase GF, improve particle discrimination and reduce systemic error

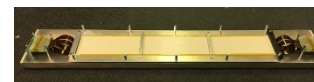
# HERD payload



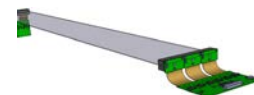
See also: CRDPOS1-8, 24, 26

## PS + SiPM

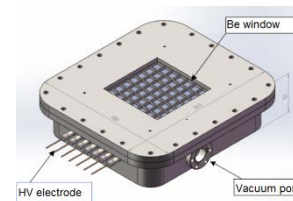
@INFN Bari & IHEP



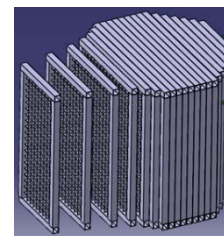
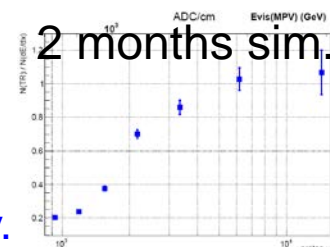
Silicon Track  
@INFN Perugia



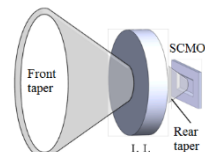
Fiber Tracker  
@Univ. of Geneva



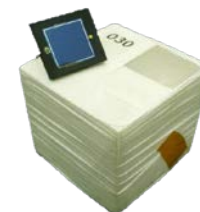
@Guangxi Univ.



@IHEP



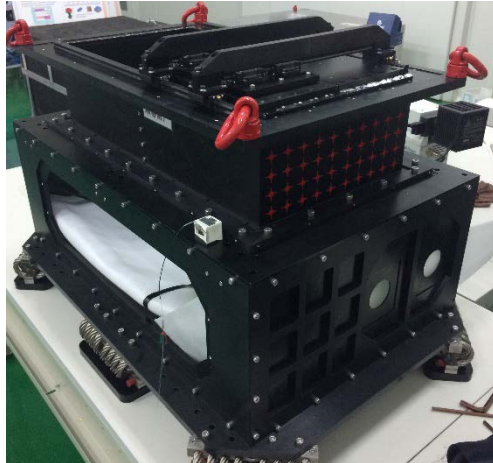
@XIOPM



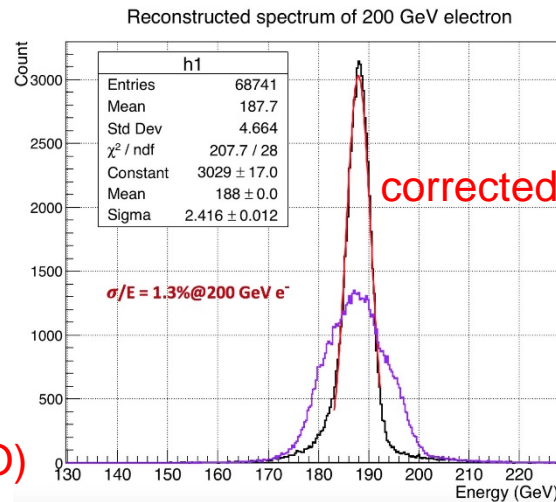
@INFN Florence 12/16

# Beam test of HERD prototypes

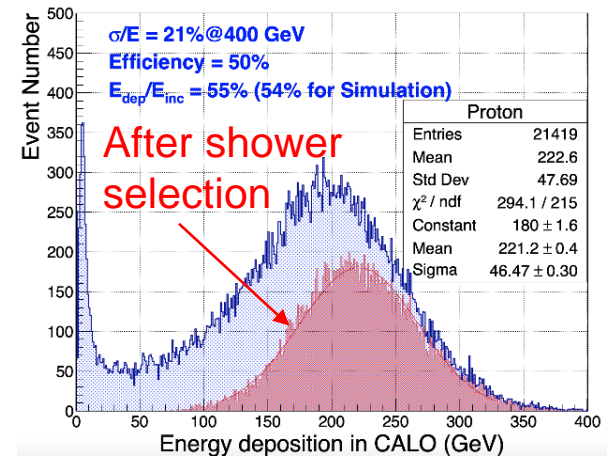
- All key specifications of HERD instruments were tested & verified in the CERN SPS beam tests, with major help from Italy & Switzerland.



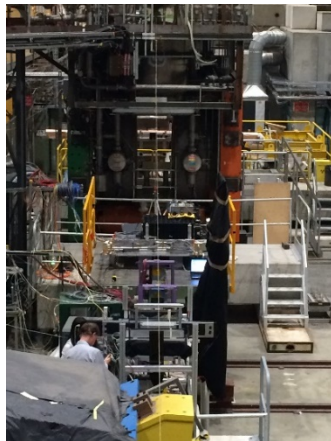
CALO prototype (500 LYSO)



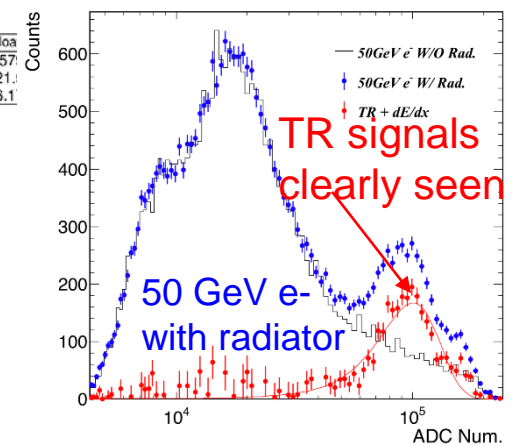
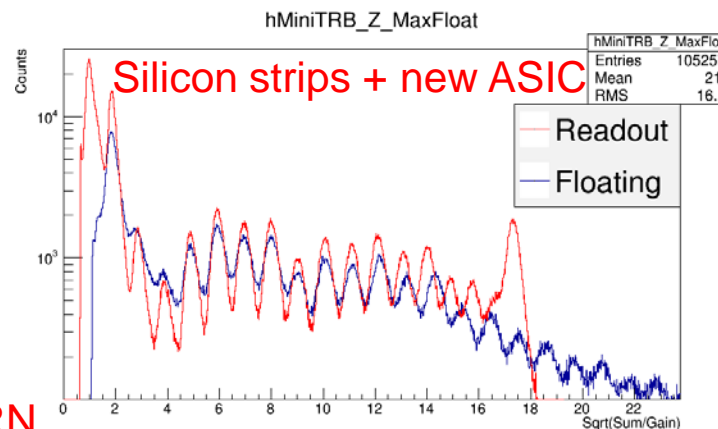
1.3% @ 200 GeV  $e^-$



21.0% @ 400 GeV proton



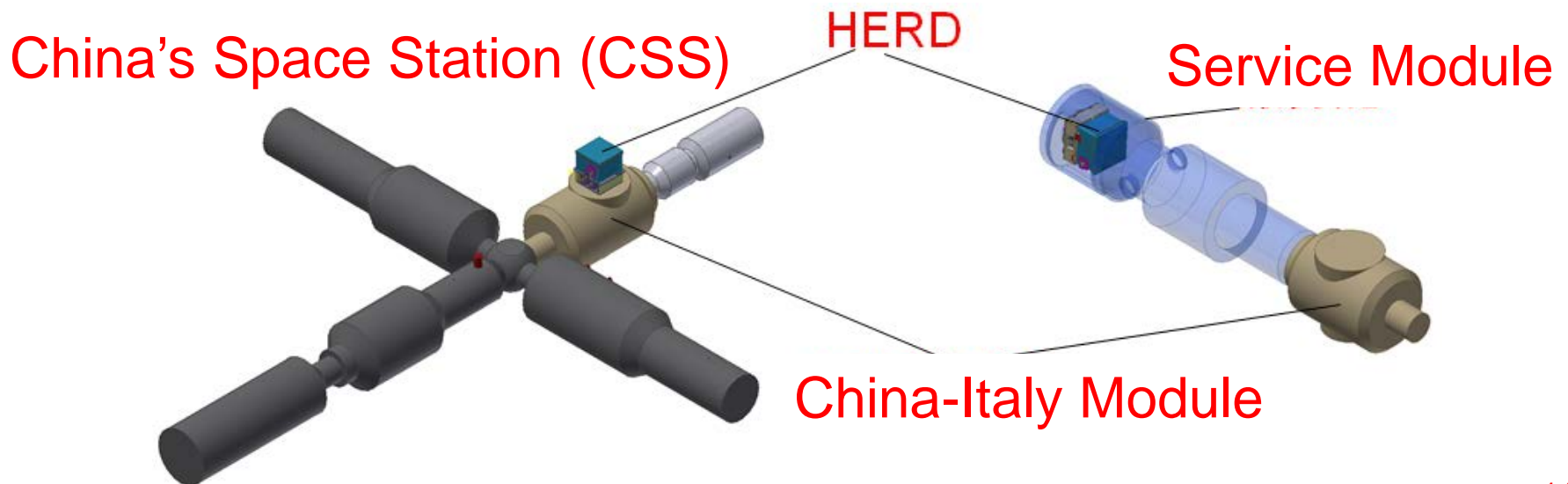
HERD prototypes at CERN





# HERD mission concept

- Mission concept
  - Launched with the China-Italy Module and installed on the Module.
  - Periodic calibration is performed every 3-6 months.
  - Several devices are replaced or upgraded every 3-4 years.
  - Telemetry is achieved with the help of relay satellites.
- The HERD proposal was reviewed positively in May 2018 at ASI.
- HERD is written into the joint declaration between China & Italy during the visit of President XI Jinping in March 2019.



# HERD consortium

- The HERD consortium includes 130+ scientists from China, Italy, Switzerland, Spain, Germany, Denmark, Sweden, Russia, etc.
  - Most of the members have been collaborating on previous high energy experiments in science and hardware development.
- 7 HERD international workshops have been organized in China and Europe since 2012.
- 3 CERN beam tests on HERD prototypes have been successfully implemented by Chinese and European colleagues.

6th HERD Workshop & Joint Working Team Meeting  
IHEP, Beijing, 26-27th March, 2018



JOINT REVIEW MEETING FOR HERD PROPOSAL

ASI HQs, ROMA, 11th MAY, 2018



# Summary

- HERD: Important and frontier scientific objectives in DM search, CR observation and gamma-ray astronomy
  - Confirm & distinguish possible DM and astrophysical origins of excess and features in high-E electron spectrum, and extend the energy range up to  $>10$  TeV
  - Direct measurements of CR composition up to PeV
  - Large acceptance & sensitive high-E  $\gamma$ -ray sky monitoring

HERD will be a flagship and landmark scientific experiment on board the China's Space Station !



From 2016.09.15



To 2019.07.19



TG-2 spacelab: POLAR

CSS: POLAR-2, CSST, HERD

*Thanks!*