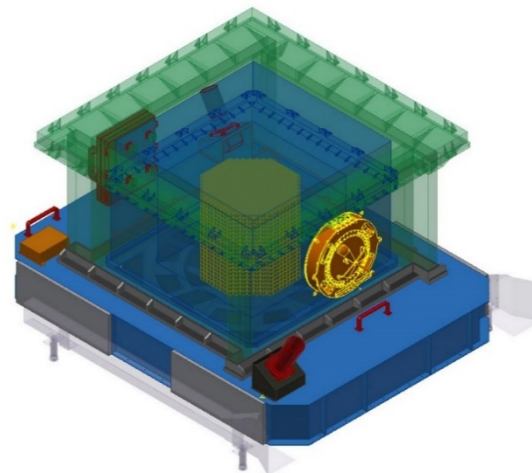

The High Energy cosmic-Radiation Detection (HERD) Facility onboard China's Space Station

Yong-Wei DONG

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

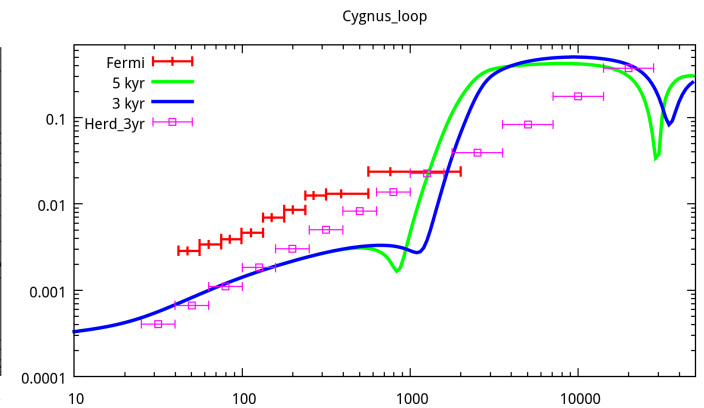
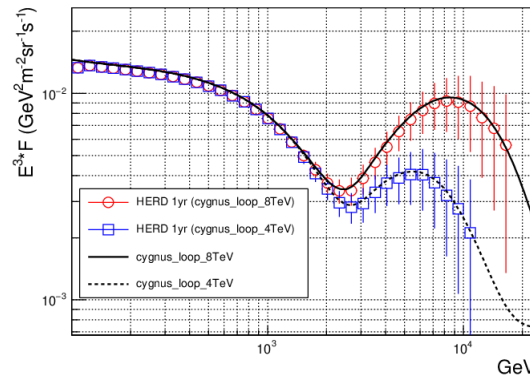
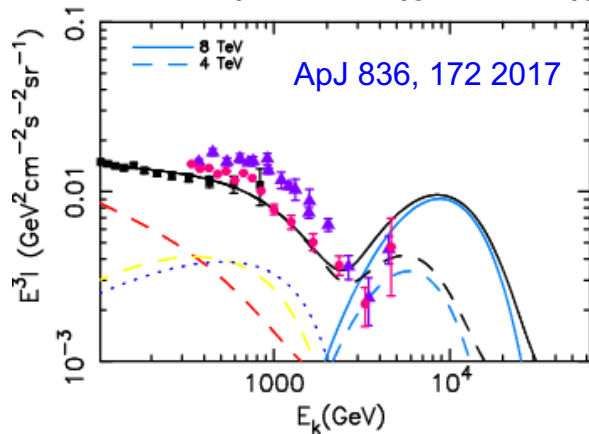
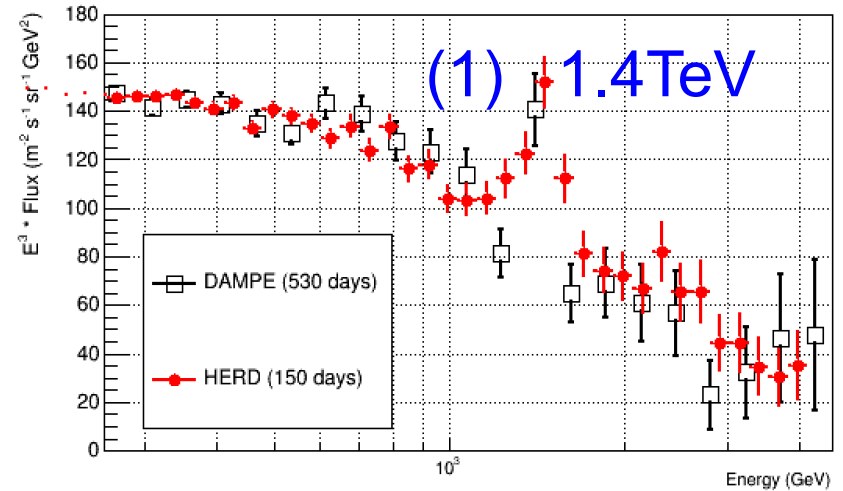
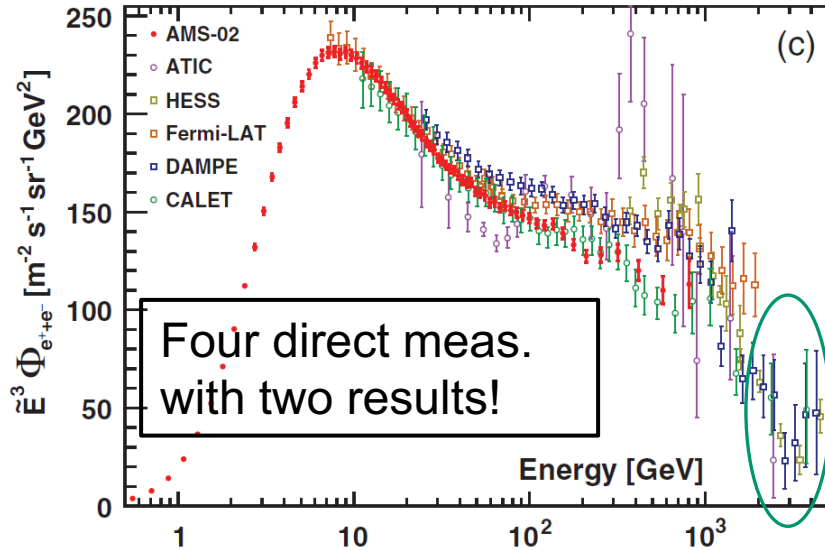
High Energy cosmic-Ray Detection facility

- 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[±]- spectrum & DM search

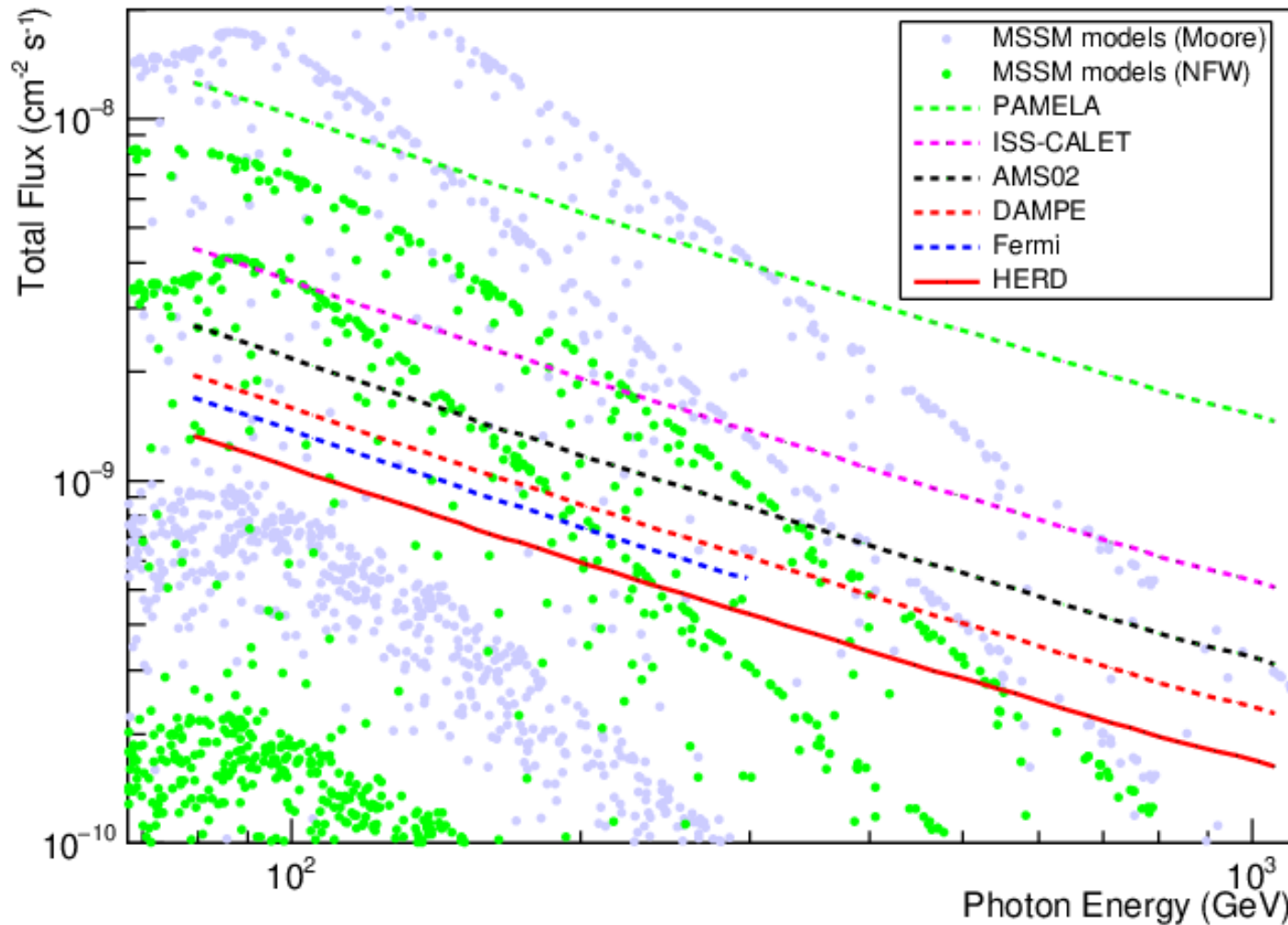
- To confirm ~TeV features in the e[±]- spectrum
- To distinguish different origins of excess & features in the e[±]- spectrum



(2) Spectrum in 10s TeV

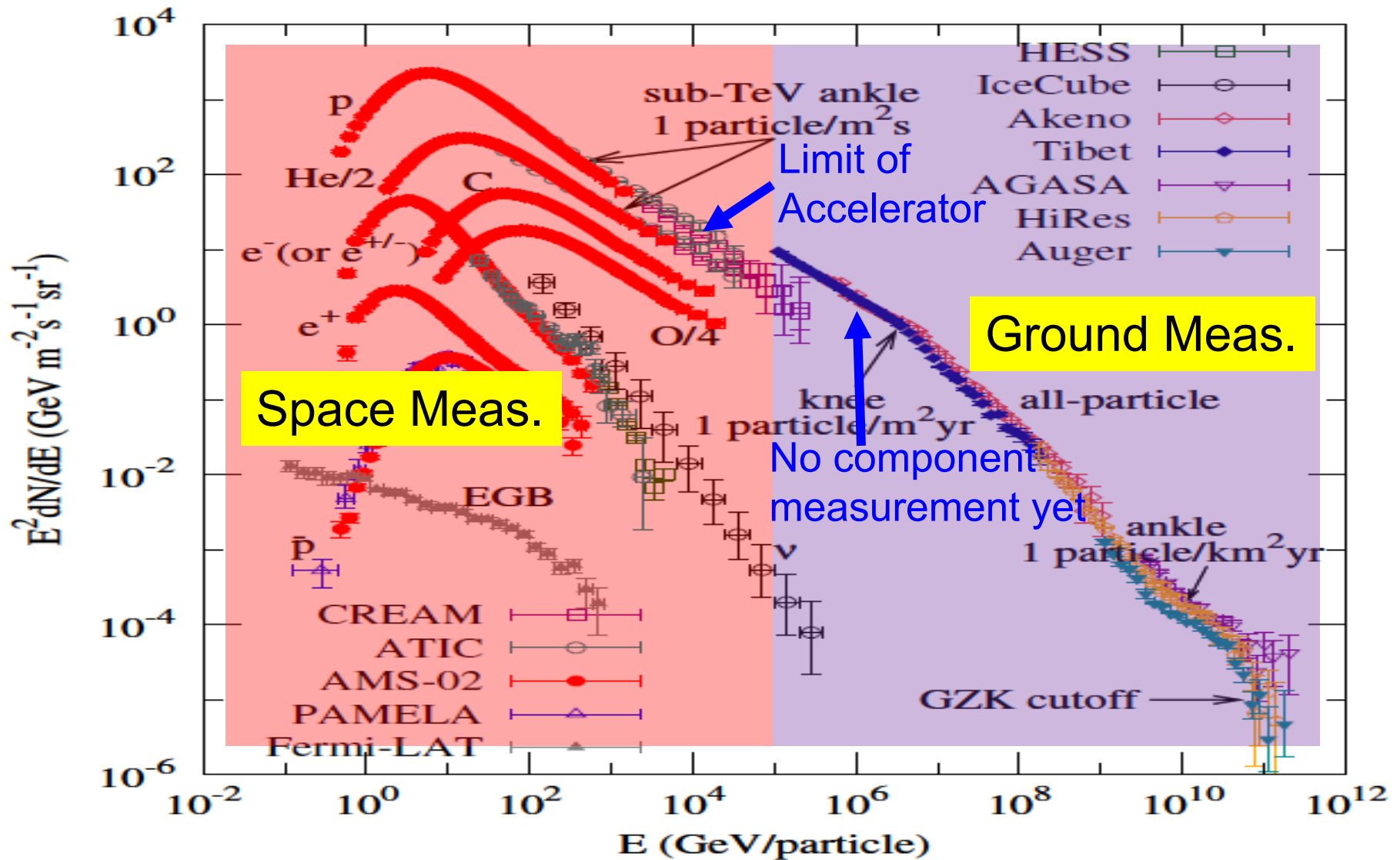
(3) Anisotropy

Sensitivity for γ -line of different experiments

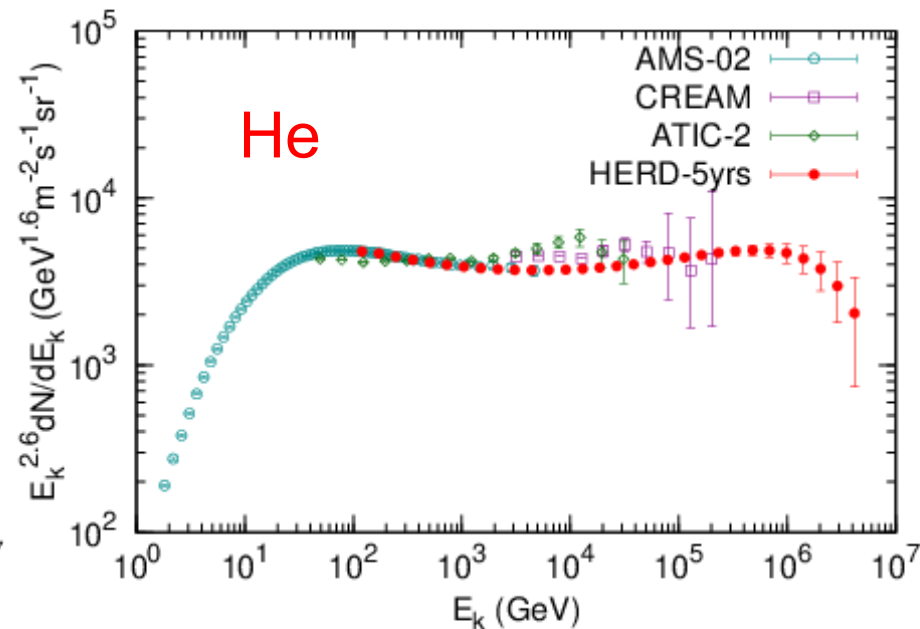
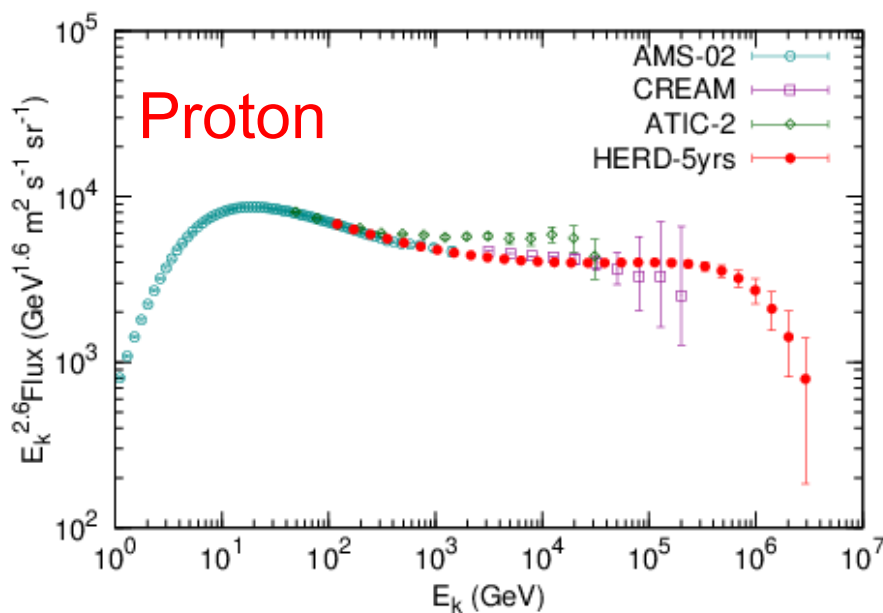


PAMELA: 2006-2016 CALET: 2015-2020; AMS: 2011-2024;
DAMPE: 2015-2020; Fermi: 2008-2018; HERD: 1 year

Cosmic-ray Physics

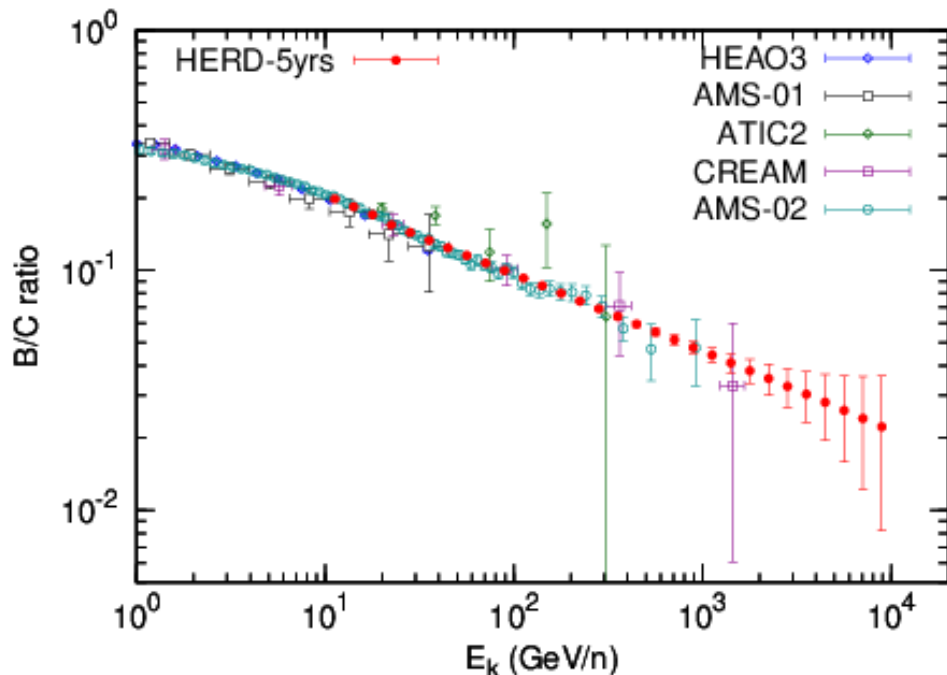


Expected HERD Proton and He Spectra

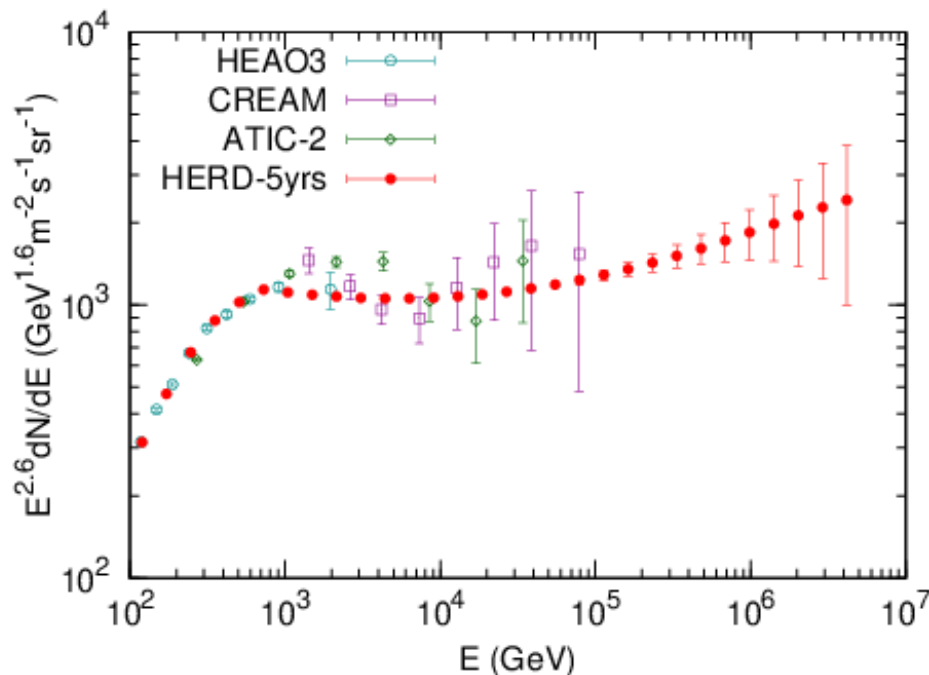


- Well extended to PeV energies
- Critically test any structures between TeV and PeV
- Clearly reveal the knee of light components (Z- or A-dependence)

B/C ratio, ion & super-iron elements



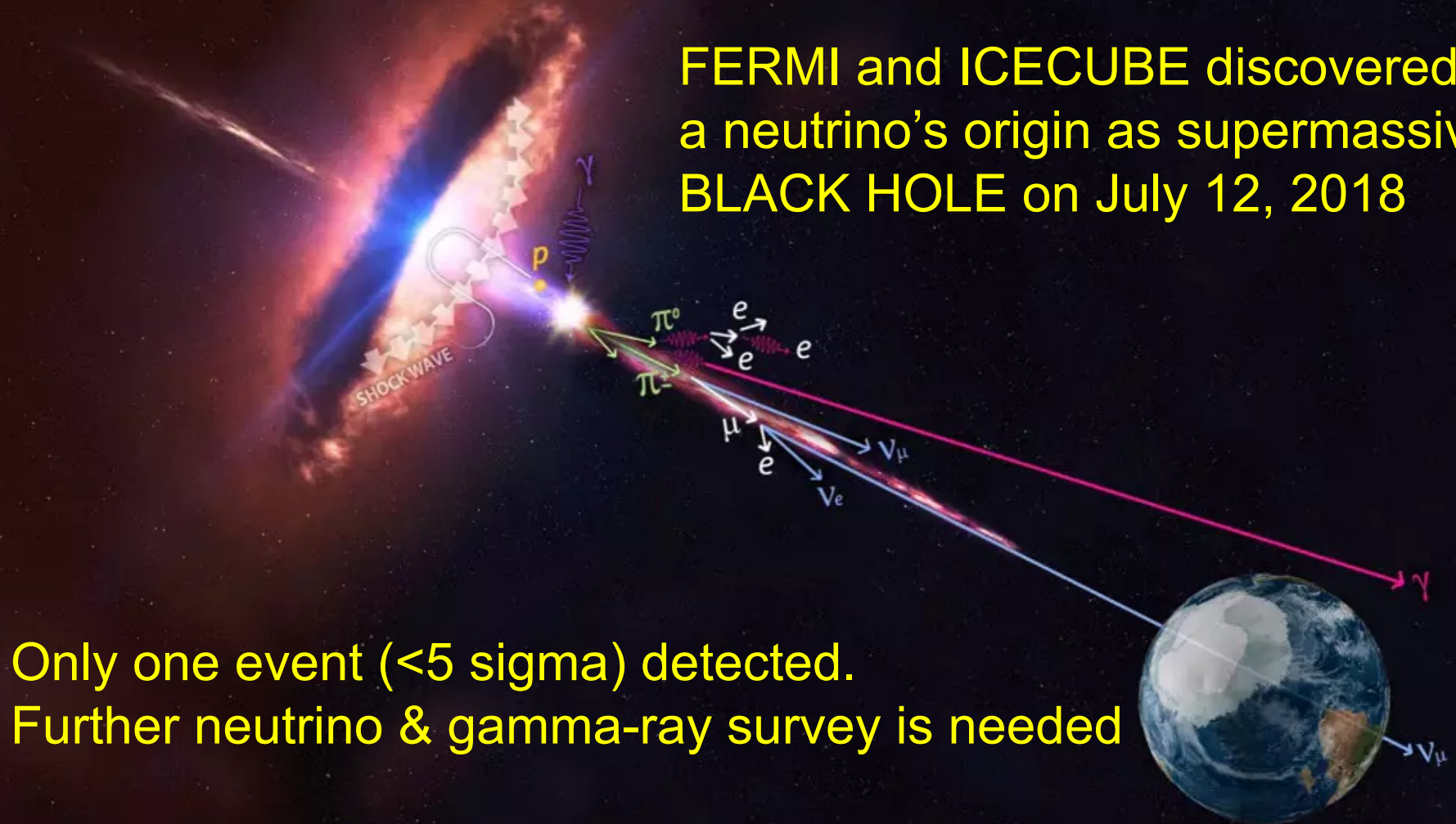
To determine CR propagation parameters and origin of break



To set very stringent limit on super-iron elements

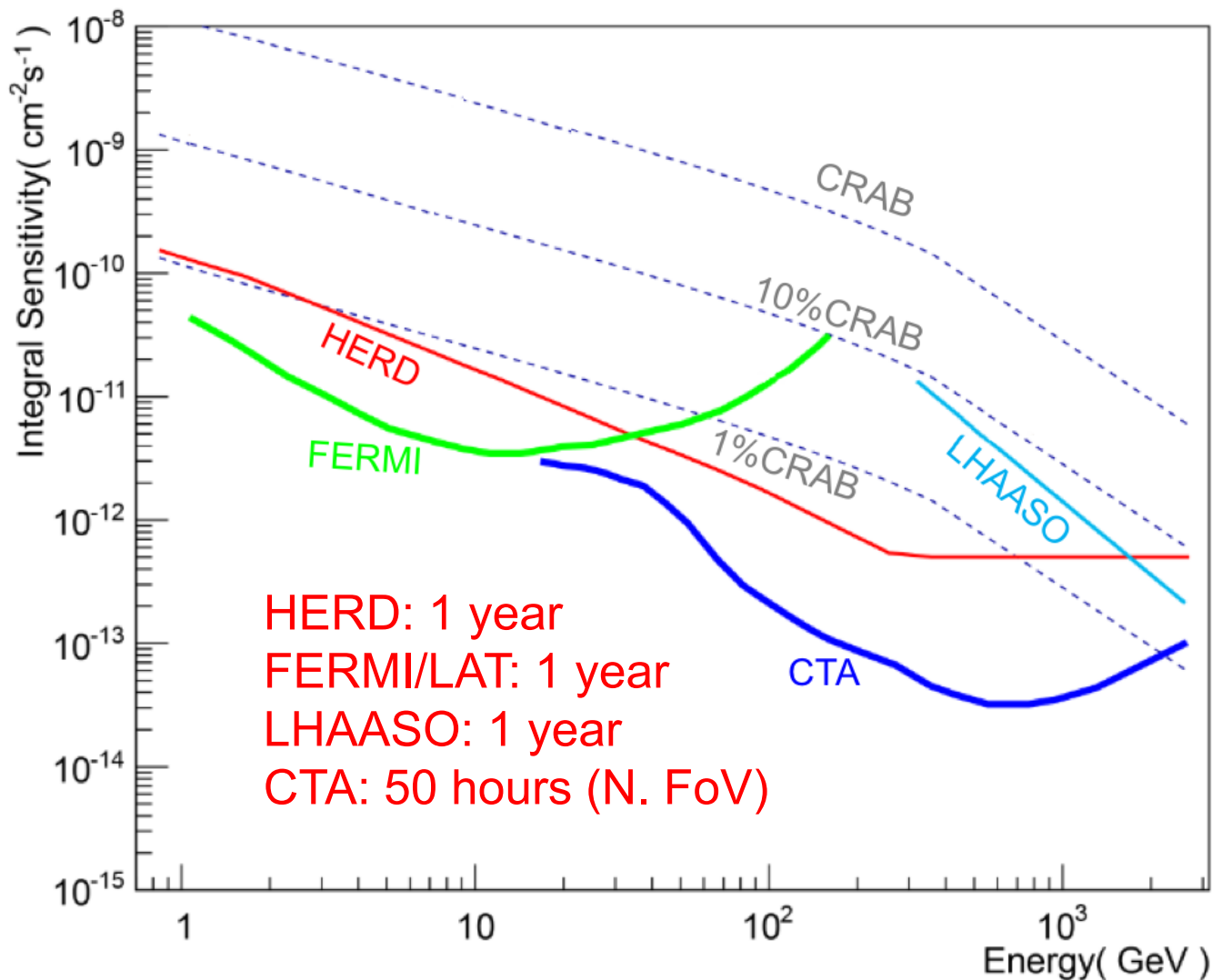
Gamma-ray monitoring & survey

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

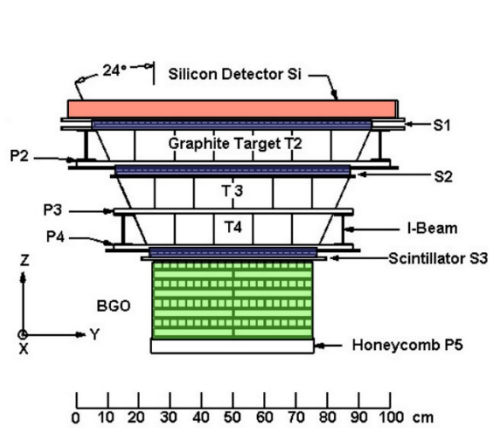


Expected HERD gamma-ray sky survey sensitivity (5 σ)

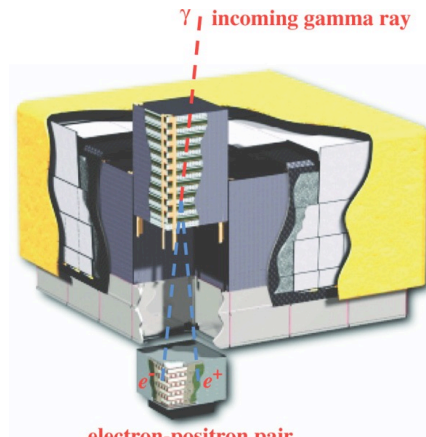
HERD specifications

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	$\pm 70 \text{ deg}$ (targeting $\pm 90 \text{ deg}$)
Envelope (L*W*H)	$\sim 2300*2300*2000 \text{ mm}^3$
Weight	$\sim 4000 \text{ kg}$
Power Consumption	$\sim 1400 \text{ W}$

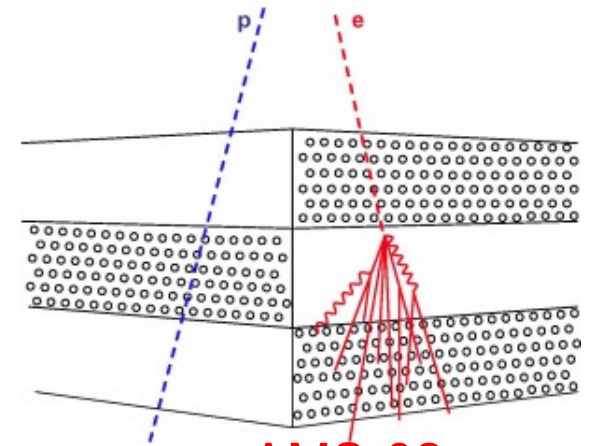
The 3-d imaging calorimeter: from bars to cubes



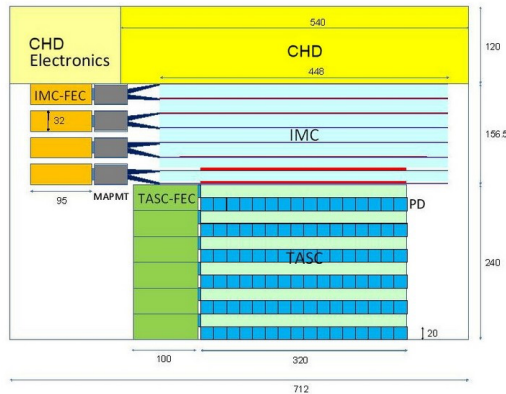
ATIC



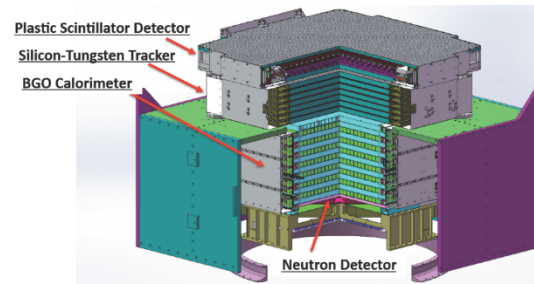
FERMI



AMS-02

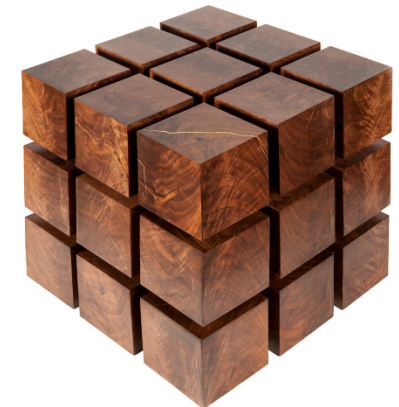


CALET



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

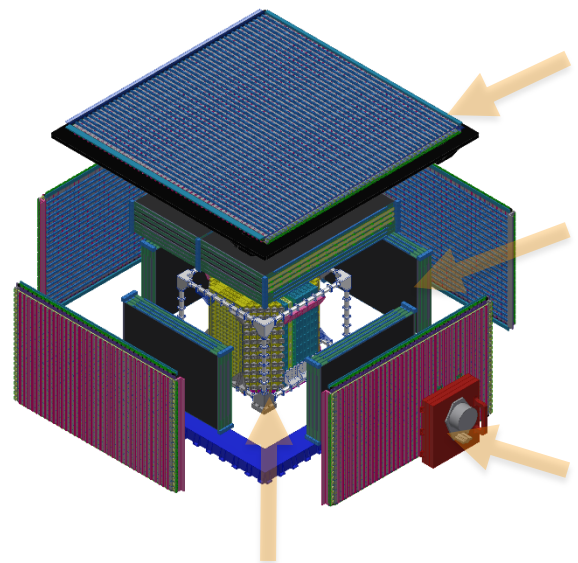
DAMPE



HERD

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

HERD payload



PSD, 6 sides
 γ identification
 Charge

Tracker, 5 sides
 Charge
 CR trajectory
 γ conv. & tracking

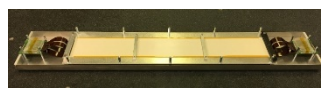
TRD
 TeV CR cali.

CALO: 3-D
 Energy
 e/p separation

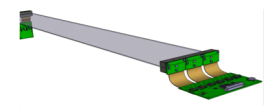
~7500 LYSO crystals
 (55 R.L, 3 N.I.L.)
 Trigger sub-system
 Dual readout
 with IsCMOS & PD

PS + SiPM

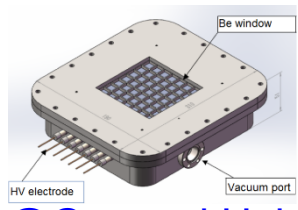
@INFN Bari & IHEP



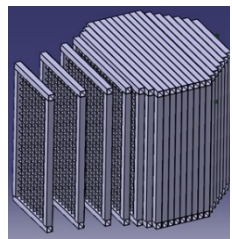
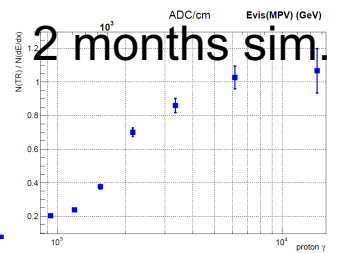
Silicon Track
 @INFN Perugia



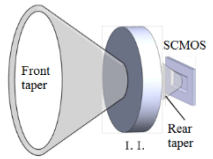
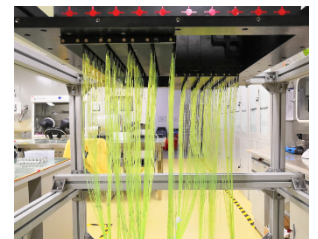
Fiber Tracker
 @Univ. of Geneva



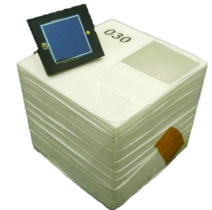
@Guangxi Univ.



@IHEP



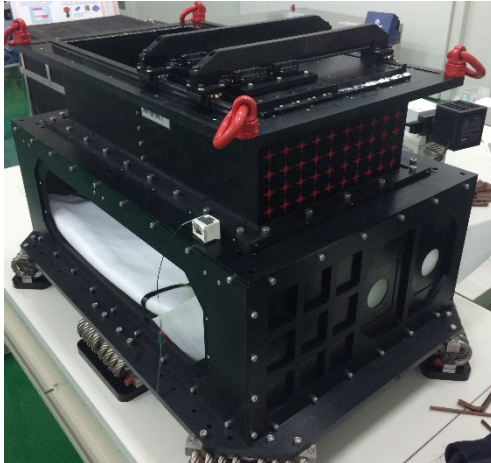
@XIOPM



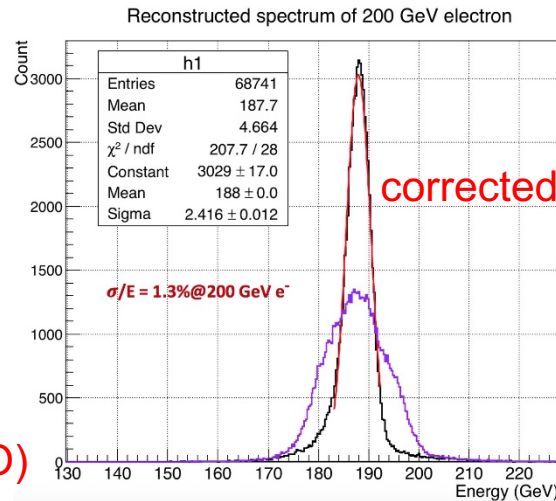
@INFN Florence 12/17

Beam test of HERD prototypes

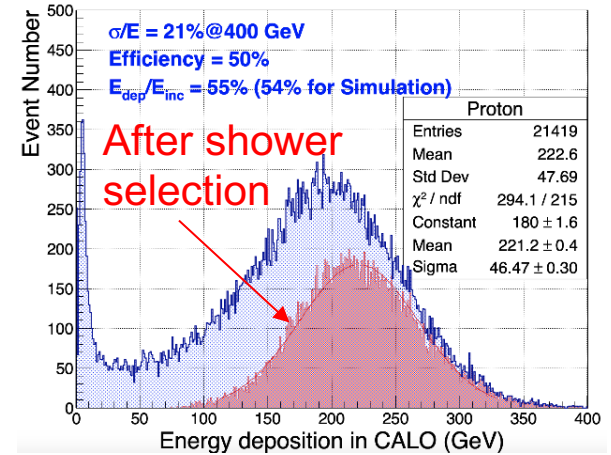
- All key specifications of HERD instruments were tested & verified in the CERN SPS beam tests, with major help from Italy & Switzerland.



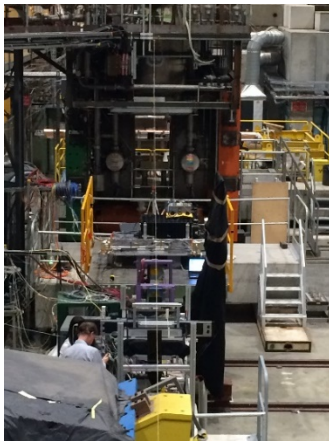
CALO prototype (500 LYSO)



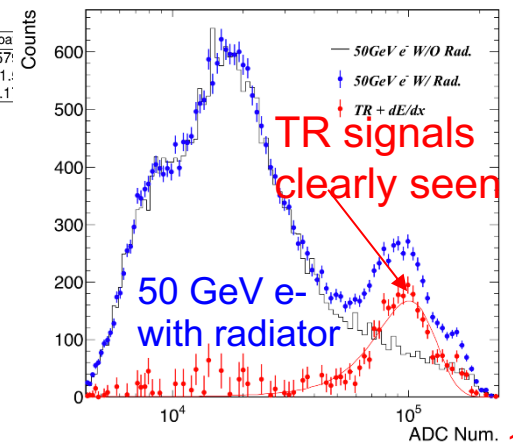
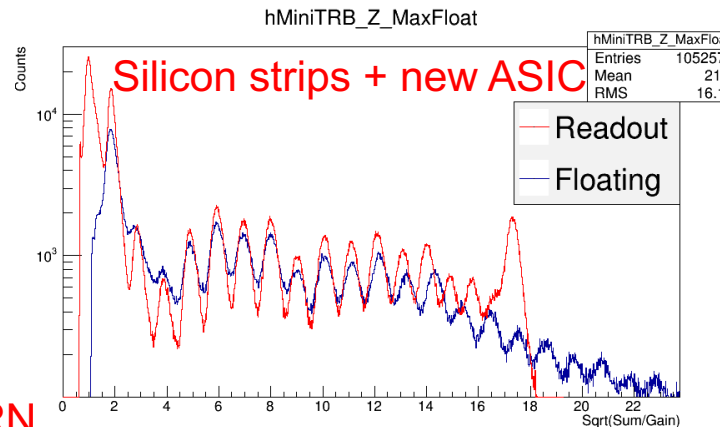
1.3% @ 200 GeV e-



20.7% @ 400 GeV proton

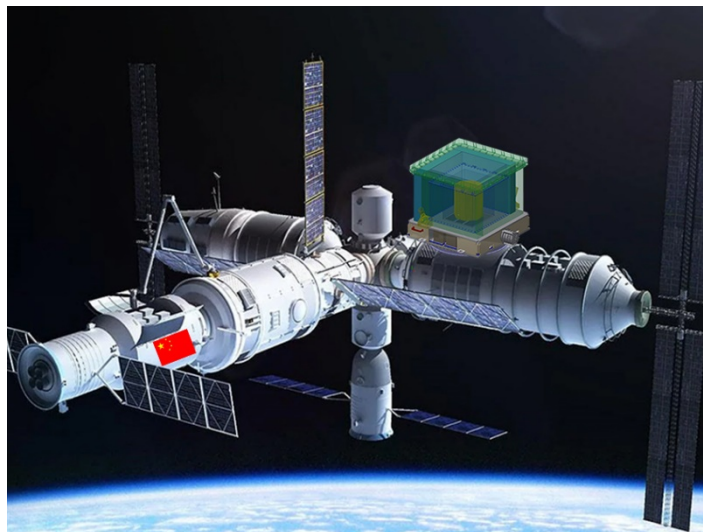


HERD prototypes at CERN



HERD mission concept

- Mission concept
 - Launched by dedicated service module, transported by robotic arm and installed on top of CSS.
 - Periodic calibration is performed every 3-6 months.
 - Key devices are replaced or upgraded every 3-4 years.
 - Telemetry is achieved with the help of relay satellites.
- 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 **150+** scientists from China and Europe.
 - Most of the members have been collaborating on previous high energy experiments in science and hardware development.
- **8** 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.



HERD responsibilities

Name	Responsible institutions
HERD	
Payload Module	IHEP
CALO	IHEP, XIOPM, INFN Florence , CIEMAT
STK (and SCD)	INFN Perugia, Univ. of Geneva, CIEMAT, IHEP
PSD	INFN Bari, IHEP
TRD	Guangxi University
Ground calibration	IHEP, Guangxi Univ., Italy, Switzerland, CERN
Science center	IHEP, SDU, Italy, Switzerland
Sciences	IHEP, PMO, USTC, NAOC, IGG, XAO, TSU, PKU, SYSU, YNU, GXU, NJU, SDU, Taiwan, Hongkong Italy, Switzerland, Spain, Germany, Denmark, Sweden, Japan ,Russia

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 γ -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!