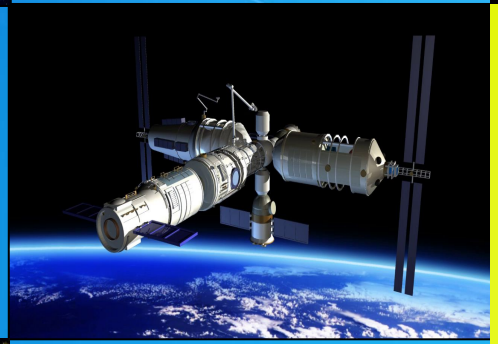
International School of Space Science (ISSS)
"Cosmic Ray Physics in Space"

L'AQUILA (Italy), 12-16 June 2017

UNIVERSITÀ DEL SALENTO

INFN Istituto Nazionale di Fisica Nucleare - Sezione di Lecce



The HERD space mission

High Energy Radiation Detection facility

Margherita Di Santo - University of Salento & INFN Lecce
On behalf of the HERD collaboration

HERD: the mission

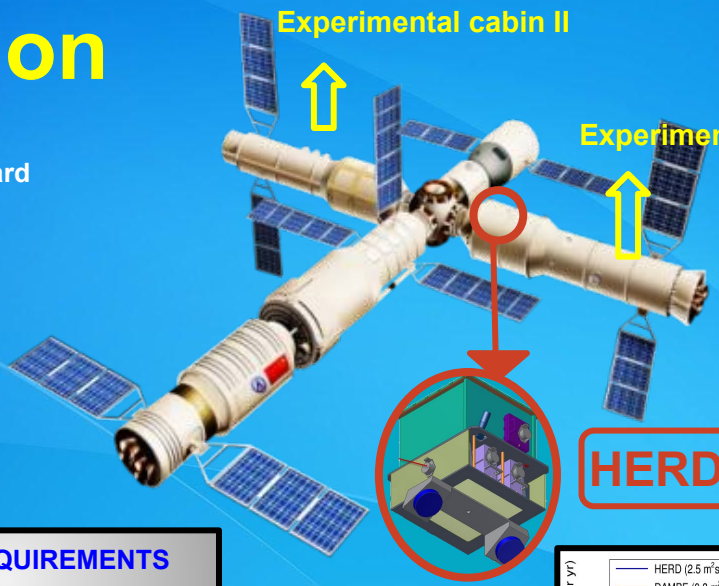
HERD is one of several space astronomy payloads of the Cosmic Lighthouse program on-board China's Space Station that will be built before 2022.

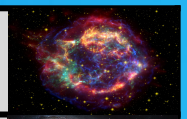
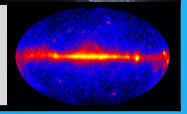
PLANNED LAUNCH : ~ 2023

TIME OF OPERATION : ~ 10 years

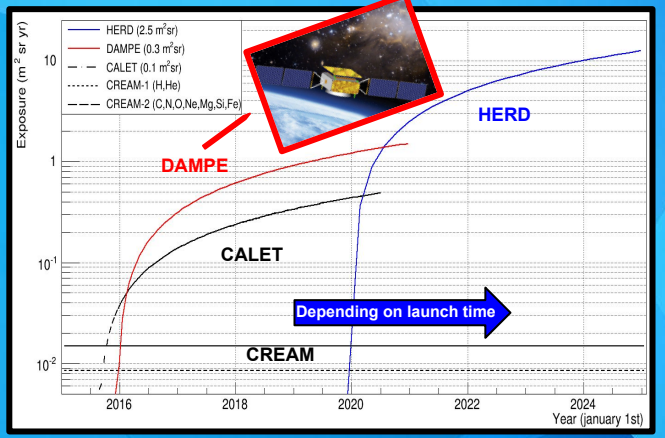
MASS: < 4 tons

FOV: +/-70 ° (goal of +/-90 °)



SCIENCE GOALS	MISSION REQUIREMENTS	
primary: GALACTIC COSMIC RAYS	Measuring precisely and directly the energy spectra and composition of primary cosmic rays from 10 GeV up to PeV.	
secondary: DARK MATTER	Searching for signatures of the annihilation products of DM particles in the energy spectra and anisotropy of high energy e and γ from 100 MeV to 10 TeV.	
secondary: HIGH ENERGY GAMMA RAY ASTRONOMY	Wide FOV monitoring of the high energy gamma-ray sky from 100 MeV up to 10 TeV for GRBs, AGN, Galactic microquasars, blazars and other transients.	

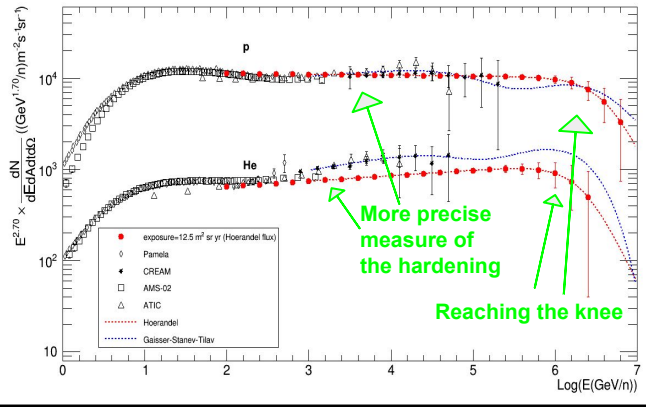
Exposure (GF= 2.5 m² sr)



HERD: scientific objectives

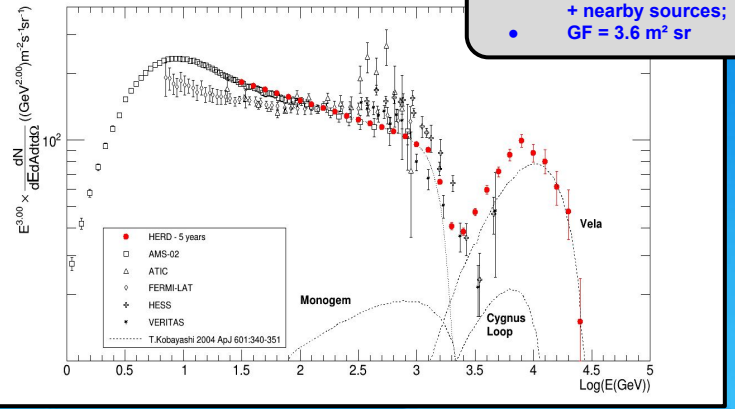
5 years of operation

protons and Helium

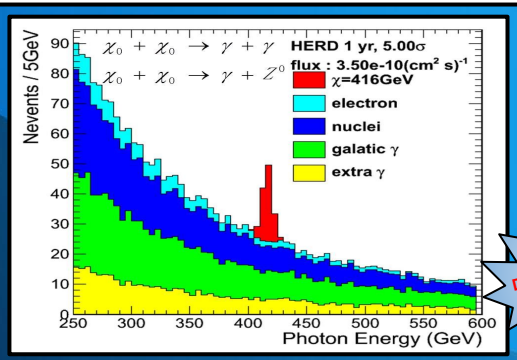


GALACTIC COSMIC RAYS

electrons



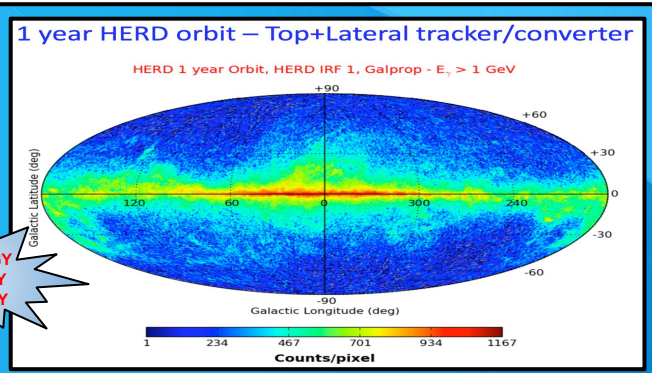
ASSUMPTIONS:
- AMS-02 power law (above 30 GeV) + cutoff + nearby sources;
- GF = 3.6 m² sr



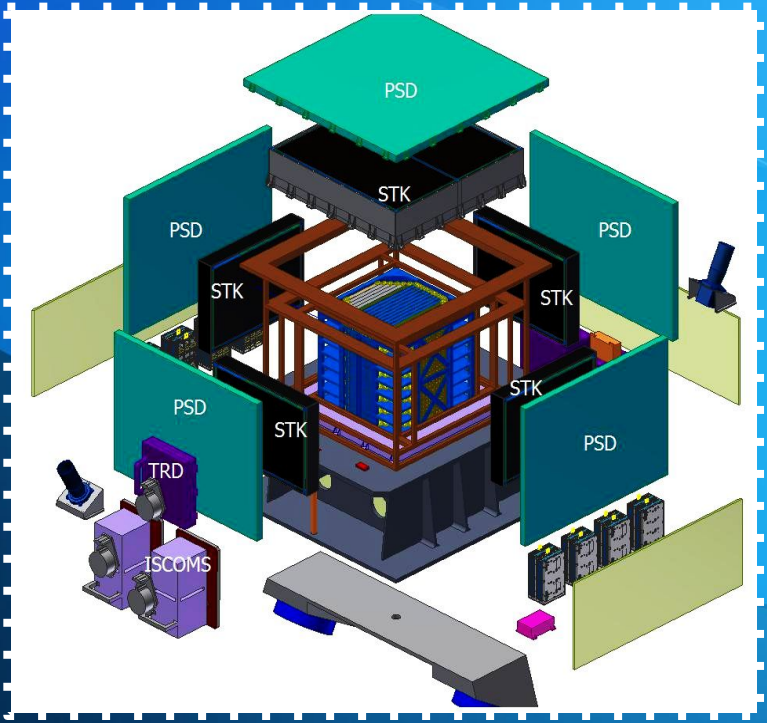
PRELIMINARY: γ ray smoking gun (dark matter annihilation signal) observation by HERD.

DARK MATTER

HIGH ENERGY GAMMA RAY ASTRONOMY



HERD: the detector



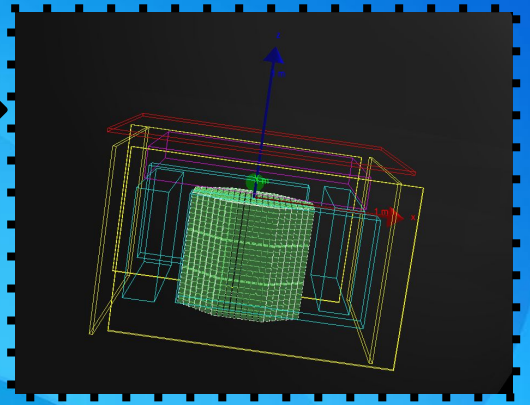
★ Detector simulation code using GEANT4.

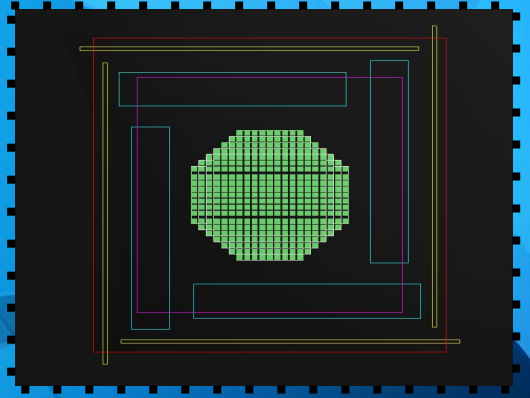
★ Current layout based on the preliminary mechanical design from engineering team.

PSD: 5 SIDES;
- LOW ENERGY γ IDENTIFICATION;
- CHARGE.

STK: 5 SIDES;
- CHARGE;
- TRAJECTORY;
- γ TRACKING.

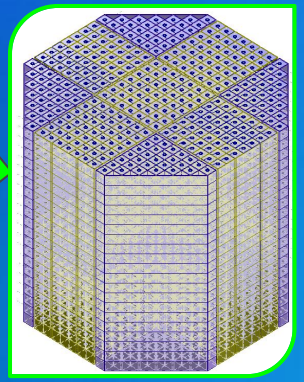
CALO: HEXAGONAL;
- e/γ/CR energy;
- e/p discrimination.





HERD: the sub-detectors

Prototype of HERD's calorimeter



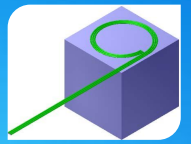
Calorimeter (CALO) hexagonal composed by ~10 granulate 3 cm x 3cm x 3 cm *LYSO crystals* .

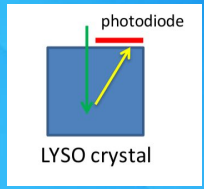
A deep and high granularity calorimeter is important for electron/proton separation and energy resolutions of all particles.

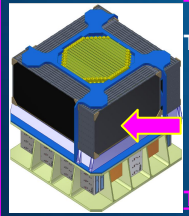
Inorganic scintillator crystals which have the advantages of:

1. high light output ;
2. quick decay time ;
3. excellent energy resolution;
4. 55X0 and 3λ ;
5. fluorescence intensity linear with the energy deposition induced by incident particles.

The output signal of crystals will be read with fibers and there is also a proposal to equip the cubes with photodiodes to have a cross calibration of light measurement with fibers technology and an alternative particle energy measurement.



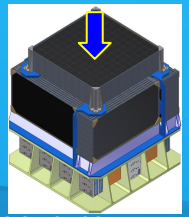




4 SIDE STK: a minimum of three SSDs.

These STKs can:

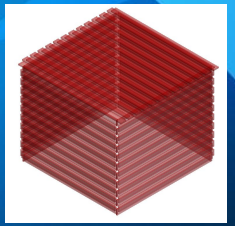
- Measure the charge of incident particle;
- Detect the direction of incoming particle;
- Gamma-ray converter & imaging;
- Reject backsplash tracks from the showers in CALO.



TOP STK: seven layers of silicon micro-strip detectors (SSDs) sandwiched with tungsten foils . So the top STK can also measure accurately the incident directions of gamma-rays by studying the electrons-positrons pairs generated inside the layers.

The PSD system consists of many scintillating strips (1 cm thick, 12 cm wide). The length of the strip is related to the size of the internal detector. There is an overlap between adjacent plastic scintillators to avoid gap.
The PSD will be used for:

I. γ veto;
II. charge recognition.



HERD: work in progress...

- **Science goals and requirements have been already selected:**
  - **High Energy CR spectroscopy up to the knee region;**
  - **Information on High energy electron propagation/sources;**
  - **Fundamental inputs for understanding galactic CR sources and acceleration/propagation mechanisms;**
  - **Dark Matter signatures;**
  - **High energy gamma astronomy .**

- **The design concept is generally decided but technical reviews may happen anytime, even for launch, transportation and installation on the CSS. Starting from current design, the other goals are :**
  - **Maximize acceptance (calorimeter mass) and dynamic range;**
  - **Ensure ion identification up to iron;**
  - **Provide smart on-orbit calibration tools;**
  - **Carefully optimize the trigger logics;**

- **Work in progress for detailed MC simulations (Geant & Fluka)**
  - **Orbit and exposure;**
  - **Geometry and features of sub-detectors;**
  - **Performances for photons and background**
  - **...**