Report of the 2nd HERD International Workshop

IHEP, Beijing, Dec. 2-3, 2013

The 2nd HERD International Workshop was held successfully on Dec. 2-3, 2013 in IHEP, Beijing, China. The workshop announcement, list of participants and agenda can be found in the end of this report (Appendices in section 7). This report is the outcome of the two open discussion sessions on the second day of the workshop, contributed by all participants of the workshop.

1. Mission profile

- Platform: China's space station
- Launch time: ~2020
- Launch mode: issue to be resolved.
  1) piggyback and mounted on the main experiment module, preferred by the manned space flight management, but severe constrain on weight and dimension; or
  2) dedicated launch, preferred by the HERD team, but cargo delivery vehicle not available at the present time in China. Possible European vehicles such as ATV and VEGA are briefly mentioned.
- HERD location on space station: issue to be resolved.
  1) current plan is to place HERD on the top surface of the experiment module of the space station; or
  2) similar to AMS02, but requires complicated installation
- Mode of operation: zenith scanning
- Length of operation: 10 years
- Service during the mission: required for maintaining or even enhancing its scientific capability
- Weight: 2000 k (mission constraint)
- Power: 2 kw (mission constraint)
- Dimension: ~1 m^3 (mission constraint)
- Telemetry: 100 Mbps required
- International participation: welcome based on no fund exchange principle (MOU with ESA in preparation),

2. HERD Scientific objectives and requirements

2.1 Core scientific objectives

The core scientific objectives of HERD are indirect detection of dark matter particles in space and origin of cosmic rays, which are the HERD mission design drivers.

2.1.1 Dark matter search

Based on our current understanding and previous observational constraints of dark matter particles, the possible channels and/or modes of observations are promising in detecting dark matter particles indirectly in space: gamma-ray lines, electron spectral features, anisotropy of electrons and gamma-rays, dedicated earth limb observations.

In order to make these detections and observations, the requirements for HERD design are: energy range (10 GeV to 100 TeV), energy resolution (<1%@>100GeV), angular resolution (0.1 deg for gamma-rays), e/p separation (<10^{-5}), gamma/e separation (<10^{-4}), electron & diffuse gamma effective geometrical factor (>3m^2sr), 5-side converters with multilayer silicon strip trackers; the last requirement is for increased sensitivity of gamma-rays point sources, e.g., DW galaxies as candidate sites of dark matter gamma-ray, Galactic center. In addition, dedicated periodic earth limb observations (e.g., once per week) are also required, in order to understand possible gamma-ray line production mechanisms in earth's atmosphere.

2.1.2 Cosmic ray physics

In order to reveal the century mystery of the origin of high energy cosmic rays in the universe, it is necessary to understand how cosmic rays are produced and propagated in the Milky Way. To do so, HERD must make accurate measurements of the composition, energy spectra, variability, anisotropy of cosmic rays up to the "knee" energy, thus requiring: energy range (100 GeV to 1000 TeV), energy resolution (30%@1 TeV), angular resolution (1 deg@1 TeV), charge sensitivity (0.1 c.u. up to Fe, <0.5 c.u. up to uranium) and effective geometrical factor (>3m^2sr).

2.2 Extended scientific objectives

It is envisioned that with essentially the same instrument design driven by the core scientific objectives, significantly extended scientific objectives may be achieved, which will certainly attract much broader community interests and contributions to the HERD mission. Most of the extended scientific objectives should be on gamma-ray astrophysics, including but not limited to the observations of the following astrophysical objects: gamma-ray bursts, blazars, active galactic nuclei, pulsars, star burst galaxies, gamma-ray binaries, microquasars, etc. In order to make these required observations, HERD is required to have: energy threshold (0.1 GeV to 10 GeV), energy resolution (<10%@1 GeV), angular resolution (<1 deg @ 1 GeV), e/gamma separation (10^{-4}), dedicated low-energy threshold topological trigger (trigger rate < 1 kHz), microsecond timing resolution, addition of dedicated GRB monitor (like GBM onboard FERMI, or GRM onboard SVOM), polarization capability (to be specified).

With the above capabilities, HERD will also be able to monitor extremely sensitively and accurately the space radiation environment around and in the space station.

3. Revised HERD baseline design

The current HERD baseline design of the 3-D calorimeter meets the above requirements. However the shower converters need to added to the four sides, in order to increase the effective exposures for high energy gamma-rays. The detailed design of the 5-side silicon strip trackers with converters needs to be further optimized, with considerations of the extended scientific objectives.

4. HERD Proto-Collaboration

Only after the HERD mission is officially selected and approved in China, the official HERD collaboration can start to be established, with the required MOUs between the involved national agencies. At this stage, only the HERD Proto-Collaboration can be setup.

Following the established mode of collaboration of the POLAR experiment onboard China's Tiang-Gong 2 spacelab, bilateral MOUs between IHEP and the interested institutions outside China shall be signed as early as possible, covering the cooperative activities on scientific research and R&D efforts related to HERD.

4.1 Participating institutions

- In China

The current HERD team in China includes IHEP, PMO, USTC and XIOPM. It should be further discussed if other AMS teams in China should be invited to join HERD.

- Outside China

Members of the following institutions outside China have expressed interests in contributing to the HERD mission: U. Geneva, IAPS/INAF, Bari/INFN, Florence/INFN, Pisa/INFN, Perugia/INFN, Trento/INFN, and KTH. More institutions outside China are welcome to join HERD, perhaps through the working group sign-up process.

4.2 Working groups

It is now the right time to setup various working groups, in order to address optimize the HERD design and many technical problems in the HERD R&D.

- Coordination team

This team is made of representatives of the major participating countries to the HERD mission. Currently team members: Shuang-Nan Zhang (IHEP, China), Jin Chang (PMO, China), Giovanni Ambrosi (INFN, Italy), Martin Pohl (Geneva, Switzerland). This team can be changed and/or expanded, as the HERD mission further develops.

- Science & Simulation teams

Three working groups are planned at this stage on HERD science and simulations: 1) dark matter search; 2) cosmic ray physics; and 3) gamma-ray astrophysics.

- Instrument teams

Five working groups are planned at this stage on HERD instruments:.1) calorimeter; 2) silicon trackers; 3) trigger & veto; 4) electronics & DAQ; 5) space engineering (mechanical and thermal).

5. Action items

- Distribution of this report for further comments (by S.N. Zhang)
- Sign-up for working groups (by coordination team)
- Assignment for working group leaders (by coordination team)
- Monthly working group meetings: It is suggested that each working group should organize at least one group meeting every month, usually using skype/vidyo. A brief summary on each group meeting should be sent to the coordination team.
- SPIE meeting presentation (Montréal, Quebec, Canada, 22 - 27 June 2014. Abstract Due: 9 December 2013; Author Notification: 21 February 2014; Manuscript Due Date: 26 May 2014): it is agreed that S.N. Zhang will submit the abstract before the deadline on behalf of the HERD collaboration. The names of all people contributed to the HERD mission, e.g., in the form of participating in HERD workshops and group meetings, will be added when submitting the manuscript before 26 May 2014.

- Next annual collaboration meeting (Europe: location and time to be decided between Martin Pohl and Roberto Battiston)

6. Outstanding issues

Currently there are a number of outstanding issues to be resolved, which have significant impacts to the HERD mission definition and instrument designs.

- Launch mode: cargo vehicle availability
- HERD location on space station: directly on top of the experiment module or stretched out like AMS02
- Silicon strip tracker design: layout plan of silicon strips and tungsten converters

7. Appendices

7.1 Announcement of the workshop

The High Energy cosmic-Radiation Detection (HERD) facility onboard China's Spacestation is planned for operation around 2020. Its main scientific objectives are indirect dark matter search in space, precise cosmic ray spectrum and composition measurements up to the "Knee" energy, and high energy gamma-ray monitoring and survey.

The 1st international workshop on HERD, held at IHEP in Beijing in October 2012, was a great success; many leading scientists in particle physics, astrophysics, cosmic ray physics attended the workshop and contributed a lot to the scientific objectives, mission definition and design concept.

Since then, there has been gradual evolution in both mission concept and hardware development during the past year. Several versions of baseline designs have been made and evaluated with extensive Monte-Carlo simulations. The most recent one is made of a full-3D calorimeter surrounded by Si-trips from all five sides; a recent presentation of mine on this baseline design is available on the website of this meeting for your reference. In the mean time, we have also made some progress in the fiber-ICCD readout system, which is essential for reading out the signals of the around ten thousands LYSO crystals in the 3D calorimeter.

Recently AMS02 team has released several interesting results, highlighting the scientific needs for further high precision measurements of cosmic high energy radiation up to much higher energies and with much larger acceptance. Considering the fact that CALET and CREAM will be operating at ISS from 2014 and DAMPE satellite will be launched in late 2015, we believe it is now the right time we work together to design and build the next generation experiments beyond AMS02, CALET, CREAM and DAMPE.

The 2nd international workshop on HERD will be held in Beijing during December 1-4, 2013. It will focus on 1) up-to-date progress in observations and theories of space dark matter search, cosmic ray physics and high energy gamma-ray astronomy; 2) HERD scientific objectives; 3) HERD payload configuration, requirements and feasibility; 4) HERD technical progress and possible solutions; 5) any related scientific and technical subjects.

7.2 Participants of the workshop

Name	Position / Title	Affiliation
International Participants		
Oscar ADRIANI	Professor	University of Florence and INFN Firenze, Italy
Sebastiano ALBERGO	Professor	INFN-Catania, Italy
Giovanni AMBROSI	Doctor	INFN-Perugia, Italy
Roberto BATTISTON	Professor	University and INFN of Trento, Italy
Raffaello D'ALESSANDRO	Doctor	University of Florence and INFN Firenze, Italy
Fabio GARGANO	Doctor	INFN-Bari, Italy
Nicola GIGLIETTO	Professor	INFN and Politecnico Bari, Italy
M. Nicola MAZZIOTTA	Doctor	INFN-Bari, Italy
Martin POHL	Professor	DPNC, University of Geneva, Switzerland
Piero SPILLANTINI	Professor	INFN and University of Florence, Italy
Meng SU	Doctor	MIT/Harvard, USA
Roland WALTER	Doctor	University of Geneva, Switzerland
Xin WU	Professor	University of Geneva, Switzerland
Chinese Participants		
Yi-Dong GU	Senior Adviser, Academician	Center for Space Utilization, CAS
Yang YANG	International Cooperation Office of CSU, Manager	Center for Space Utilization, CAS
Jian-Hua Guo	Doctor	Purple Mountain Observatory, CAS
Guang-Shun HUANG	Professor	University of Science and Technology of China
Xiao-Lian WANG	Professor	University of Science and Technology of China
Zi-Zong XU	Professor	University of Science and Technology of China
Yun-Long ZHANG	Doctor	University of Science and Technology of China
Chi WANG	Doctor	University of Science and Technology of China

Yi-Feng WEI	Doctor	University of Science and Technology of China
Bing-Liang HU	Professor	XI'AN Institute of Optics and Precision Mechanics, CAS
Le WANG	Doctor	XI'AN Institute of Optics and Precision Mechanics, CAS
Yi-Fang WANG	Director of IHEP, Professor	Institute of High Energy Physics, CAS
Huan-Yu WANG	Deputy Director of IHEP, Professor	Institute of High Energy Physics, CAS
Shuang-Nan ZHANG	PI of HERD, Professor	Institute of High Energy Physics, CAS
Bo-Bing WU	Professor	Institute of High Energy Physics, CAS
Jun-Guang LV	Professor	Institute of High Energy Physics, CAS
Jing HUANG	Professor	Institute of High Energy Physics, CAS
Xiao-Jun BI	Professor	Institute of High Energy Physics, CAS
Li-Ming SONG	Professor	Institute of High Energy Physics, CAS
Yan-Guo LI	Professor	Institute of High Energy Physics, CAS
Yong-Wei DONG	Doctor	Institute of High Energy Physics, CAS
Zhi-Gang WANG	Doctor	Institute of High Energy Physics, CAS
Xi-Lei SUN	Doctor	Institute of High Energy Physics, CAS
Ming XU	Doctor	Institute of High Energy Physics, CAS
Zheng QUAN	Doctor	Institute of High Energy Physics, CAS
Min-Nan KONG	Engineer	Institute of High Energy Physics, CAS
Wei-Wei XU	Doctor	Institute of High Energy Physics, CAS
Xin LIU	Doctor	Institute of High Energy Physics, CAS
Tian-Wei BAO	Doctor	Institute of High Energy Physics, CAS
Li ZHANG	Doctor	Institute of High Energy Physics, CAS
Jun-Ying CHAI	Doctor	Institute of High Energy Physics, CAS
Rui-Jie WANG	Doctor	Institute of High Energy Physics, CAS

7.3 Agenda of the workshop

Location: Main building A415, IHEP, CAS, Beijing			
08:00-08:30	**Registration at A415**		
Time	Speaker	Affiliation	Title
Morning, December 2, 2013, session 1, Chair: Shuang-Nan ZHANG			
08:30-08:40	Yong-Wei DONG	IHEP	Workshop logistics
08:40-08:50	Yi-Fang WANG	IHEP	Welcome speech
08:50-09:10	Shuang-Nan ZHANG	IHEP	Introduction to HERD
09:10-09:40	Ming XU	IHEP	Progress of HERD simulation
09:40-10:10	Roberto BATTISTON	INFN Trento	What are we learning form AMS02
10:10-10:40	Group photo, Coffee break and registration		
Morning, December 2, 2013, session 2, Chair: MartinPOHL			
10:40-11:10	M.Nicola MAZZIOTTA	INFN Bari	DM search with Fermi LAT instrument
11:10-11:40	Meng SU	MIT/Harvard	Excess of Diffuse Gamma-ray Emission from the Inner Galaxy: Bubbles, Jets, Dark Mater
11:40-12:10	Xiao-Jun BI	IHEP	Implications of the AMS02 results
Lunch box at A415, IHEP			
Afternoon, December 2, 2013, session 3, Chair: Sebastiano ALBERGO			
13:30-14:00	Jin CHANG	PMO	The DAMPE mission
14:00-14:30	Oscar ADRIANI	INFN Florence	The CaloCube project
14:30-15:10	Jing HUANG	IHEP	Cosmic-ray energy spectrum around the knee
15:10-15:40	Roland WALTER	University of Geneva	HERD and gamma astrophysics
15:40-16:00	Coffee break		
Afternoon, December 2, 2013, session 4, Chair: Nicola GIGLIETTO			
16:00-16:25	Giovanni AMBROSI	INFN Perugia	DAMPE Silicon tracker

16:25-17:10	Xin WU	University of Geneva	HERD tracker simulation and Some General Issues on the HERD Tracker
17:10-17:35	Zhi-Gang WANG	IHEP	Progress of HERD calorimeter
17:35-18:00	Bing-Liang HU	XIOPM	Progress of HERD ICCD readout
Dinner at Ying-Fu-Lou near IHEP			
Morning, December 3, 2013, session 5, Chair: Roberto BATTISTON			
08:30-10:00	All workshop participants		Open discussion on HERD scientific objectives andinternational team
10:00-10:20	Coffee break		
Morning, December 3, 2013, session 6, Chair: Shuang-Nan ZHANG			
10:20-11:40	All workshop participants		HERD mission definition and next steps
11:40-12:00	Shuang-Nan ZHANG	IHEP	WorkshopSummary
Lunch box at A415			
- End of the workshop -			