# DAMPE: Dark Matter Particle Explorer

G. Ambrosi INFN Perugia 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)

### **Scientific Objectives of DAMPE**

- High energy particle detection in space
  - Search for Dark Matter signatures with e,  $\gamma$
  - Study of cosmic ray spectrum and composition
  - High energy gamma ray astronomy

Detection of 5 GeV - 10 TeV e/γ, 100 GeV - 100 TeV CR Excellent energy resolution and tracking precision Complementary to Fermi, AMS-02, CALET, 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

#### **NEWS & ANALYSIS**

#### Science, 20 May 2011

SPACE SCIENCE

### Chinese Academy Takes Space Under Its Wing

#### LOFTY AMBITIONS

Mission	Chief scientist	Goals	Estimated launch			
HXMT	Li Tipei, CAS Institute of High Energy Physics and Tsinghua University	Survey of x-ray sources; detailed observations of known objects	2014			
Shijian-10	Hu Wenrui, CAS Institute of Mechanics	Study physical and biological systems in microgravity and strong radiation environment	Early 2015			
KuaFu Project	William Liu, Canadian Space Agency and CAS Center for Space Science and Applied Research	Study solar influence on space weather	Mid-2015			
Dark Matter Satellite	Chang Jin, CAS Purple Mountain Observatory	Search for dark matter; study cosmic ray acceleration	Late 2015			
 Quantum Science Satellite	Pan Jianwei, University of Science and Technology of China	Quantum key distribution for secure communication; long- distance quantum entanglement	2016			

#### Strategic Priority Research Program in Space Science

#### Dark Matter Particle Explorer Satellite

#### MOU signed on April 30<sup>th</sup> 2013

#### CAS (China), Geneva Uni (Switzerland), INFN (Italy)





### **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
  - INFN and University of Lecce





#### **DAMPE** Satellite

- Planned launch: December 18<sup>th</sup> 2015
  - Total weight ~1900 kg, power consumption ~640 W
    - Scientific payload ~1300 kg, ~400 W
  - Lifetime > 3 year





#### **The DAMPE Detector**



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

#### **Electrons: Dark Matter or nearby sources**



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



#### **CR Spectrum & Composition with DAMPE**



### **Photons**



#### **The DAMPE Detector**



Mass: 1400 Kg Power: ~ 400 W Data: 12 Gbyte/day Liftime: 5 years

### **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 <sup>5</sup>	10 <sup>5</sup> - 10 <sup>6</sup>	10 <sup>3</sup>			
Calorimeter thickness (X <sub>0</sub> )	31	17	8.6			
Geometrical accep. (m <sup>2</sup> sr)	0.29	0.09	1			

- Geometrical acceptance with BGO alone: 0.36 m<sup>2</sup>sr
  - BGO+STK+PSD: 0.29 m<sup>2</sup>sr
  - First 10 layers of BGO (22  $X_0$ ) +STK+PSD: 0.36 m<sup>2</sup>sr

### Silicon-Tungsten Tracker (STK)



- Weight: ~ 150 Kg
- Total power consumption: ~85W

#### Si Ladder and Layer



768

80

SU

a silicon sensors



#### 12 layers, 6-x and 6-y

73728 channels

192 ladders

### **Several Layers**



#### the Silicon Tracker



#### the Silicon Tracker



#### the Silicon Tracker



### FM STK test with cosmics (05/2015)

	Mag	rath	ea ev	ent vi	iewer (	TRB 2	strea	am /ł	nome/	damp	e/Des	ktop/F	Mdat	a/run	_0508	/nor0	508_3	2015051	4_0804	I_TRE	32.bin	)		×
Main	Cal	bratio	n Da	ta Q	uick TRE	3 View	Clust	ers [	Data pa	ackets														
ADC count Signal Occupancy																								
<u> </u>	1	-	ladder 20-		1		1		-ladder 21-		1		1		ladder 22-					la	dder 23		1	
-75						-75						-75						-75						
-50						-50						-50						-50						
-25	64	128	192	256	320	25	64	128	192	256	320	-25	64	128	192	256	320	-25	64 1	.28	192	256	320	
		-	ladder 16-	-				-	-ladder 17-	:				-	-ladder 18-	-				la	dder 19	-	-	۳
-75						-75						-75						-75						
-50						-50						-50						-50						
-25	64	128	192	256	320	25	64	128	192	256	320	-25	64	128	192	256	320	25	64 1	28	192	256	320	
	:		ladder 12-						-ladder 13-	:			:		ladder 14					10	dder 15			٢
-75						-75						-75						-75						
-50						-50						-50						-50						
-25	64	128	192	256	320	25	64	128	192	256	320	-25	64	128	192	256	320	25	64 1	28	192	256	320	
			-ladder 8-					- <b>i</b>	ladder 9						ladder 10-					: 10	dder 11-	-		٢
-75						-75						-75						-75						
-50						-50						-50						-50						
-25	64	128	192	256	320	-25	64	128	192	256	320	-25	64	128	192	256	320	-25	64 1	28	192	256	320	
	-i		-ladder 4-			_			-ladder 5-						-ladder 6-		i;		i	1	odder 7			۲
-75						-75						-75						-75						
-50						-50						-50						-50						
-25	64	128	192	256	320	25	64	128	192	256	320	-25	64	128	192	256	320	25	64 1	28	192	256	320	
		-	-ladder 0-	-				-	-ladder 1-			_ل_		-	-ladder 2-	-			<u>i</u>	i . la	odder 3			=
-75						-75						-75						-75						
-50						-50						-50						-50						
5-25	64	128	192	256	320	-25	64	128	192	256	320	-25	64	128	192	256	320	25	64 1	28	192	256	320	
الم		-	-					-				مار							Dala	-	-	<u>.</u>		
[events]: 108437 Ladder 0 🗘 Delay 0 🗘 uS >>																								

### FM STK test with cosmics (05/2015)

![](_page_20_Figure_1.jpeg)

#### **FM STK noise performance**

![](_page_21_Figure_1.jpeg)

### **BGO Calorimeter (BGO)**

- 14-layer BGO hodoscope, 7 x-layers + 7 y-layers
  - BGO bar 2.5cm×2.5cm, 60cm long, readout both ends with PMT
    - Use 3 dynode (2, 5, 8) signals to extend the dynamic range
  - Charge readout: VA160 with dynamic range up to 12 pC
  - Trigger readout: VATA160 to generate hit signal above threshold
    - Detection area 60cm×60cm

Total thickness 31X<sub>0</sub>

Measure electron/photon energy with great precision between 5 GeV - 10 TeV

![](_page_22_Figure_9.jpeg)

#### **Calorimeter components**

![](_page_23_Figure_1.jpeg)

### **Calorimeter assembly**

![](_page_24_Picture_1.jpeg)

#### **Carbon Fiber Structure**

![](_page_24_Picture_3.jpeg)

#### BGO crystal installation

![](_page_24_Picture_5.jpeg)

**PMT** installation

![](_page_24_Picture_7.jpeg)

Cableing

![](_page_24_Picture_9.jpeg)

Cable connector

![](_page_24_Picture_11.jpeg)

**BGO Calorimeter** 

### Test beam activity at CERN (nov '14 - nov'15)

#### • 14days@PS,29/10-11/11 <u>2014</u>

- e @ 0.5GeV/c, 1GeV/c, 2GeV/c, 3GeV/c, 4GeV/c, 5GeV/c
- p @ 3.5GeV/c, 4GeV/c, 5GeV/c, 6GeV/c, 8GeV/c, 10GeV/c
- π-@ 3GeV/c, 10GeV/c
- γ @ 0.5-3GeV/c
- 8days@SPS, 12/11-19/11 2014
  - e @ 5GeV/c, 10GeV/c, 20GeV/c, 50GeV/c, 100GeV/c, 150GeV/c, 200GeV/c, 250GeV/c
  - p @ 400GeV/c (SPS primary beam)
  - γ@ 3-20GeV/c
  - $\mu$  @ 150GeV/c,
- 17days@SPS, 16/3-1/4 2015
  - Fragments: 66.67-88.89-166.67GeV/c
  - Argon: 30A- 40A- 75AGeV/c
  - Proton: 30GeV/c, 40GeV/c
- 21days@SPS, 10/6-1/7 2015
  - Primary Proton: 400GeV/c
  - Electrons @ 20, 100, 150 GeV/c
  - $-~\gamma$  @ 50, 75 , 150 GeV/c
  - $\mu$  @ 150 GeV /c
  - π**+ @10, 20, 50, 100 GeV/c**
- 6days@SPS, 20/11-25/11 2015
  - -- Pb 030 AGeV/c (and fragments)

![](_page_25_Picture_23.jpeg)

#### Some beam test events

#### DAMPE XZ

DAMPE YZ

![](_page_26_Figure_3.jpeg)

CERN recognized experiment **RE29 : DAMPE** 9 Institutions, 55 Participants

#### **Electron Energy Reconstruction**

**FRELIMINARY** 5 GeV electron (simulation & test beam data)

![](_page_28_Figure_2.jpeg)

#### **Electron Energy and Angle Reconstruction**

(linearity and resolutions)

![](_page_29_Figure_2.jpeg)

### Photon tagging

![](_page_30_Figure_1.jpeg)

## Protons @5 GeV PRELIMINAR

![](_page_31_Figure_1.jpeg)

#### 😣 🖨 💿 🛛 DAMPE BGO Event Display

![](_page_31_Picture_3.jpeg)

![](_page_31_Figure_4.jpeg)

#### Ions in the BGO calorimeter

![](_page_32_Figure_1.jpeg)

![](_page_33_Figure_0.jpeg)

#### STK preliminary performance evaluation

![](_page_34_Figure_1.jpeg)

### FM final integration (06/2015)

![](_page_35_Picture_1.jpeg)

G. Ambrosi

![](_page_36_Picture_0.jpeg)

- DAMPE FM detector has been completed according to schedule
- Acceptance test for flight are being performed
- Launch date fixed: December 18<sup>th</sup> 2015
- In parallel with the construction an intense campaign of beam test has been performed: detailed detector's performance under study
- Stay tuned for performance results in orbit and physics results in the near future