

DAMPE: DArk Matter Particle Explorer

G. Ambrosi
INFN Perugia

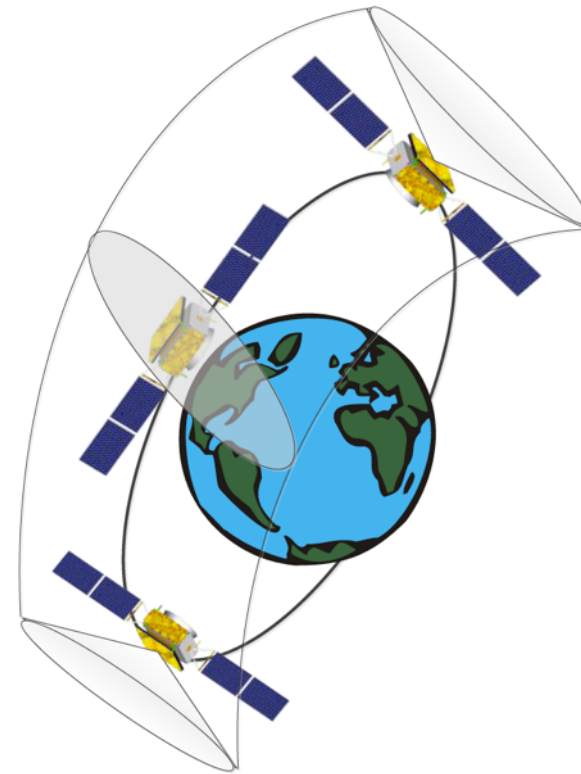
DAMPE: One of the Five Approved Satellite Missions of the Chinese Academy of Sciences (CAS)

- **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)**

DAMPE Satellite

- Planned launch late 2015
 - Total weight ~1900 kg, power consumption ~640 W
 - Scientific payload ~1300 kg, ~400 W
 - Lifetime > 3 year

- Altitude: 500 km
- Inclination: 97.4065°
- Period: 95 minutes
- Orbit: sun-synchronous



Scientific Objectives of DAMPE

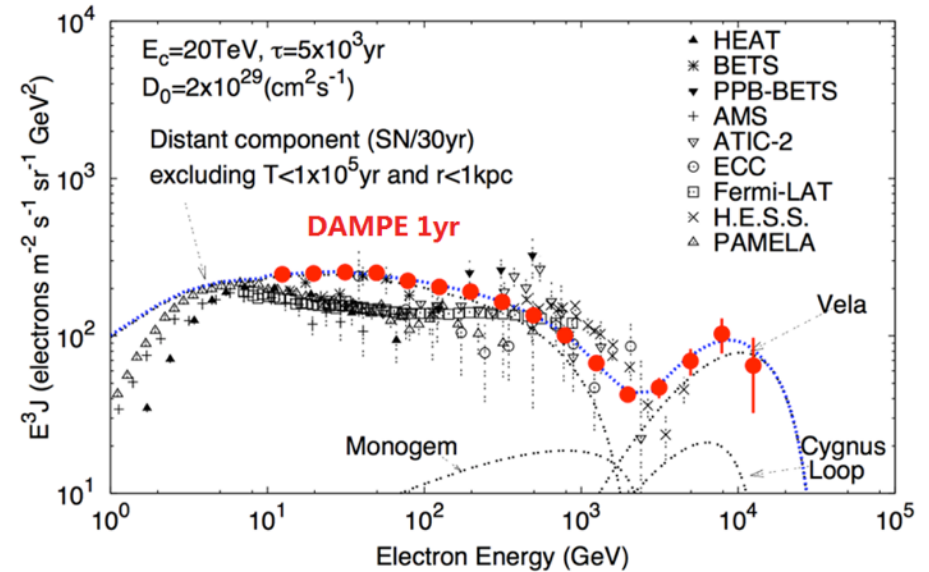
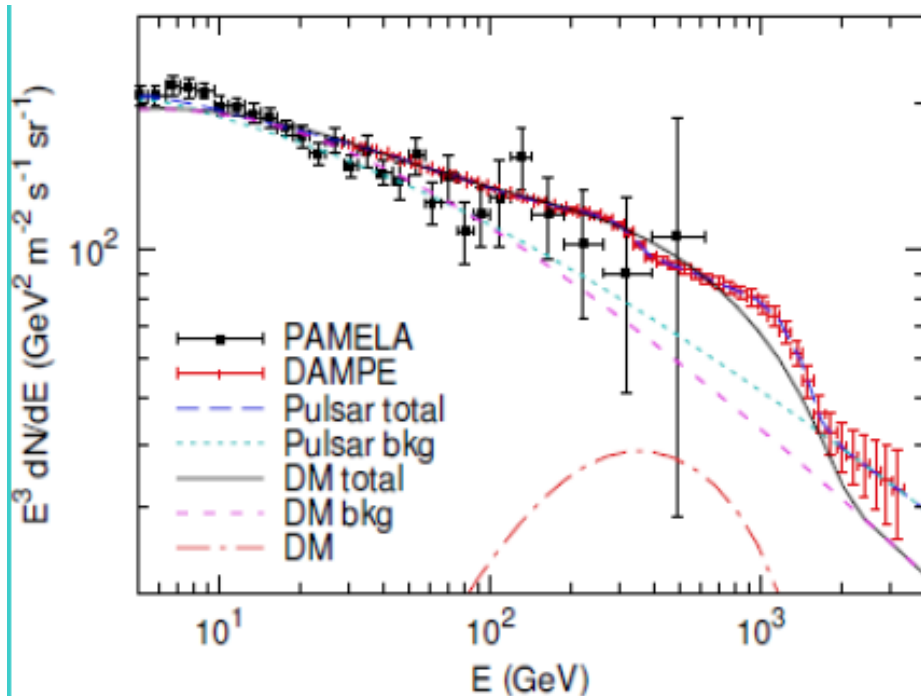
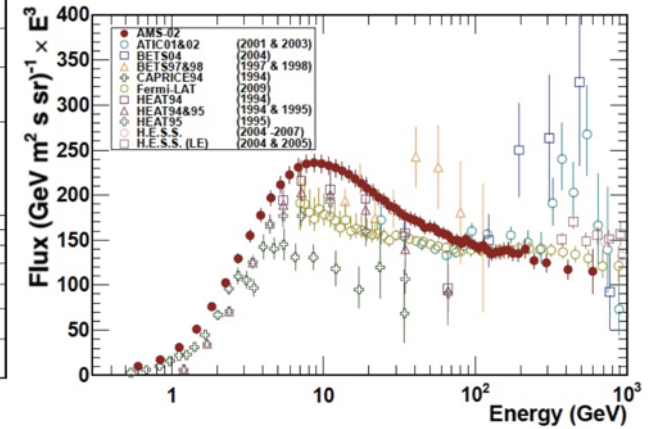
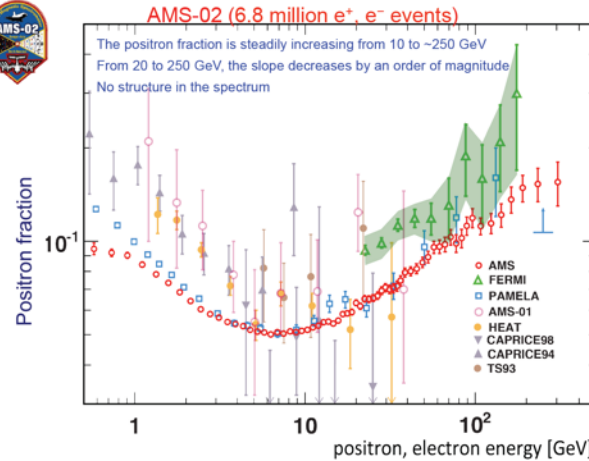
- High energy particle detection in space
 - Search for Dark Matter signatures with e, γ
 - Study of cosmic ray spectrum and composition
 - High energy gamma ray astronomy

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, ISS-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

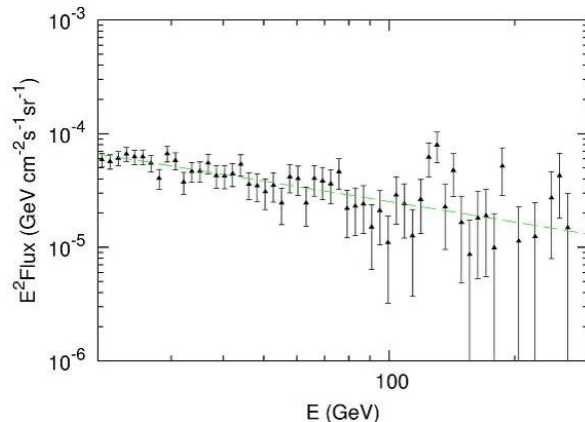
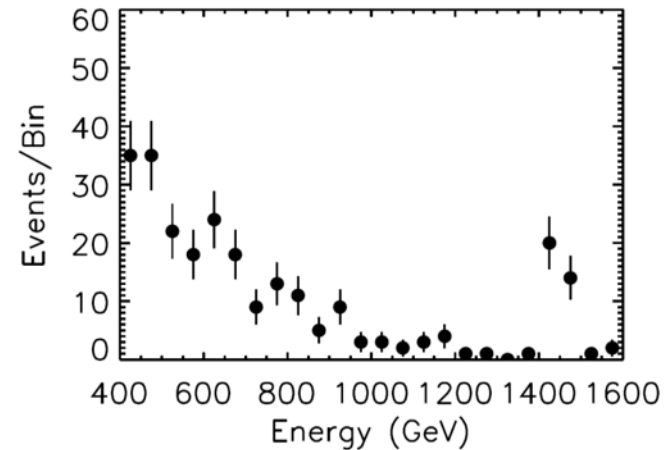
DM or Pulsar?

- Need a detector in space that can detect electron around 1 TeV with very good energy resolution

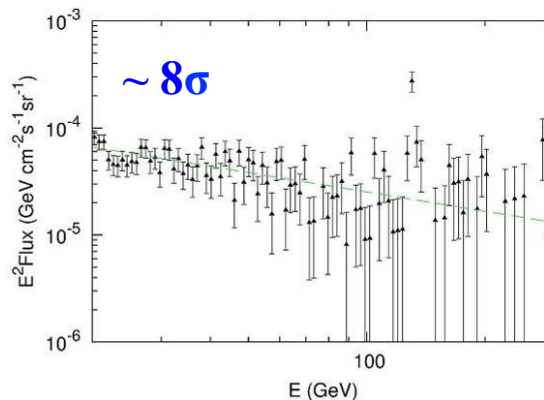


Gamma-ray Line Observation

DAMPE, with an excellent energy resolution of 1% above 100 GeV, is a suitable instrument to detect monochromatic gamma-ray signals from WIMP dark matter annihilation



Fermi, 195 Weeks



DAMPE 3 years

Simulated 1.4 TeV gamma-ray line from dark matter toward the Galactic center ($300^\circ < l < 60^\circ$, $|b| < 10^\circ$) including the Galactic diffuse background for DAMPE 6 Months observations.

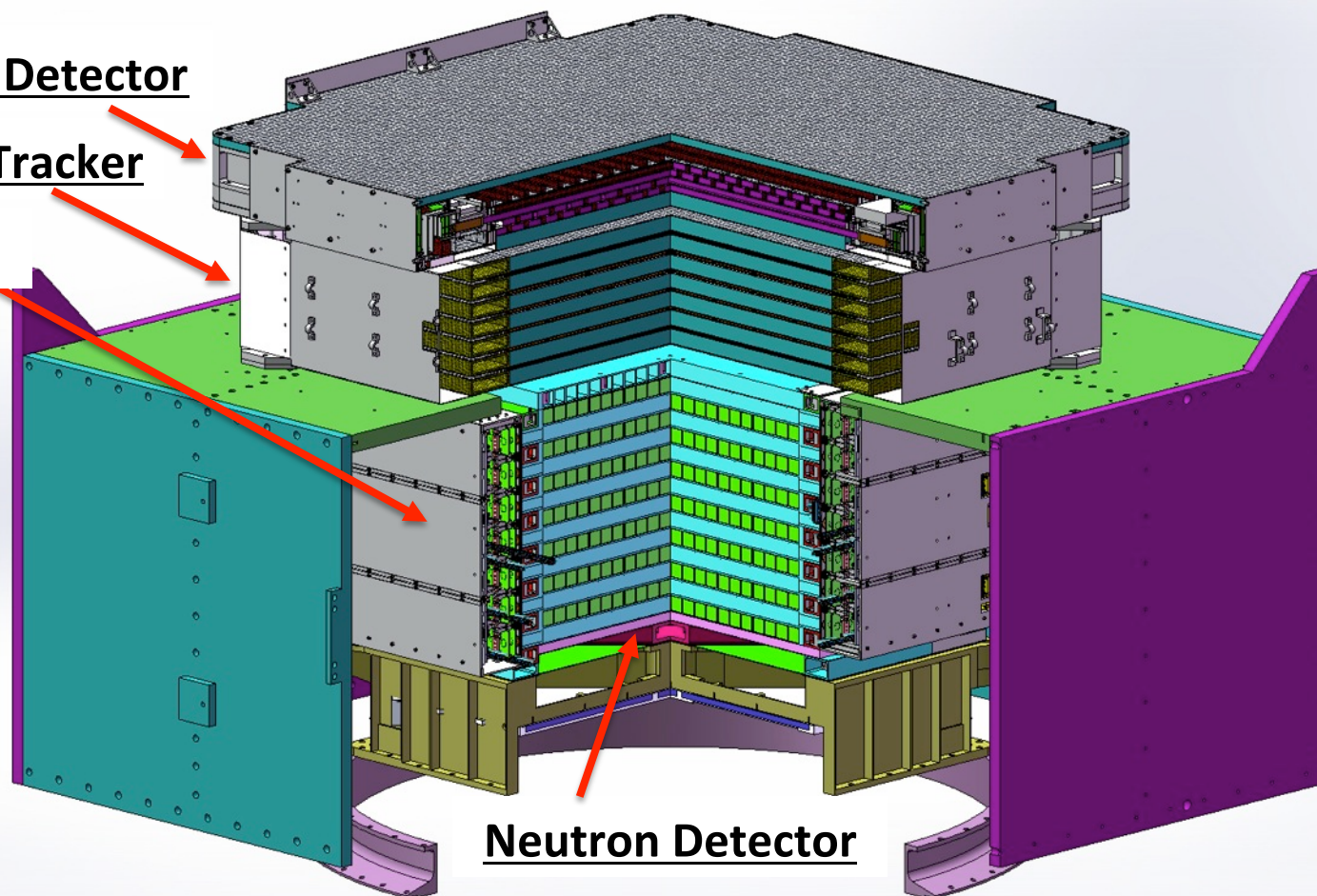
The annihilation cross-section is taken as $\langle \sigma v \rangle_{\gamma\gamma} = 1 \times 10^{-25} \text{ cm}^3 \text{s}^{-1}$ with a NFW halo profile. The distinctive line signature is clearly seen in the gamma-ray spectrum.

The DAMPE Detector

Plastic Scintillator Detector

Silicon-Tungsten Tracker

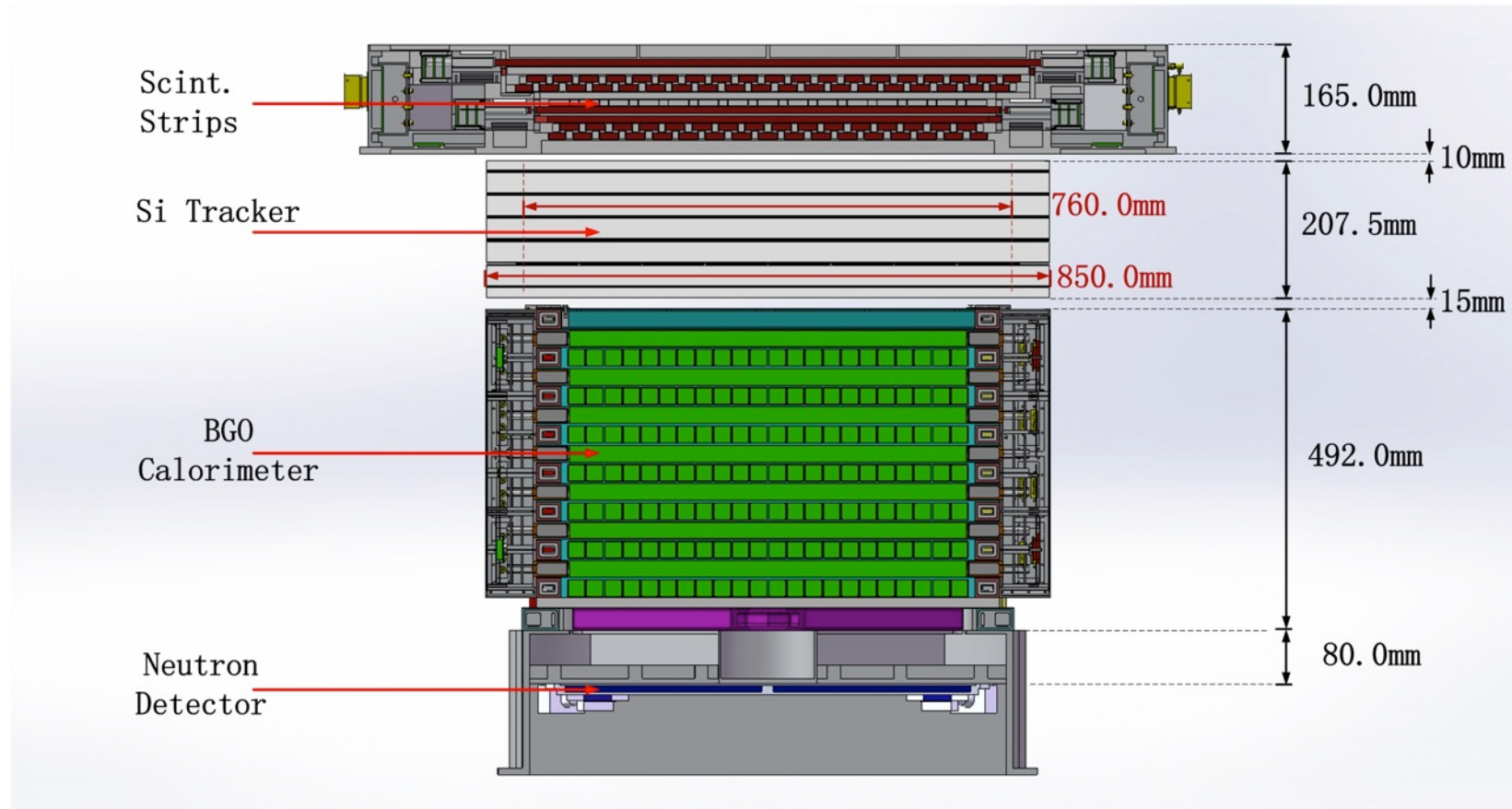
BGO Calorimeter



Neutron Detector

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

The DAMPE Detector



Mass: 1480 Kg
Power: 500 W
Data: 14 Gbyte/day
Lifetime: 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	10^5	$10^5 - 10^6$	10^3
Calorimeter thickness (X_0)	31	17	8.6
Geometrical accep. (m^2sr)	0.29	0.09	1

- Geometrical acceptance with BGO alone: 0.36 m^2sr
 - BGO+STK+PSD: 0.29 m^2sr
 - First 10 layers of BGO (22 X_0) +STK+PSD: 0.36 m^2sr

Detector Overview

Measurement	Detector
Charge	Si μ -Strip & Scintillator Detector
Direction	Si μ -Strip Detector
Energy	BGO Calorimeter (31 r.l.)
Background Rejection	BGO Calorimeter +Neutron detector + W/Si μ -Strip Pre-shower detector



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**



The DAMPE STK Collaboration

- Institute of High Energy Physics, CAS, Beijing
 - Prof. H. Wang, Dr. W. Peng
- INFN Perugia, Italy
 - Dr. G. Ambrosi, Dr. M. Ionica
- INFN Bari, Italy
 - Dr. F. Gargano, Dr. N. Mazziotta
- University of Geneva, Switzerland
 - Prof. M. Pohl, Prof. X. Wu

On the time scale of two years the goal is to design, assemble, test, qualify a Silicon Tracker for a space satellite: use the heritage from AMS

MOU & schedule

MOU signed on April 30th 2013



MOU & schedule

- MOU signed on April 30th 2013
- EQM (Engineering Qualification model) ready by July 2014
- FM (Flight Model) to be delivered to Shanghai Engineering Center for Microsatellites in spring 2015
- DAMPE is a CERN recognized experiment since March 2014



Memorandum of Understanding

between the

University of Geneva
Département de physique nucléaire et corpusculaire (DPNC)
Uni Dufour
24, rue du Général-Dufour
CH-1211 Genève 4
Switzerland
represented by
Mr Stéphane Berthet, Secretary General

and the

Istituto Nazionale di Fisica Nucleare (INFN)
Via Fermi n. 40
IT-00044 Frascati
Italy
represented by
Professor Fernando Ferroni, President

and the

Institute of High Energy Physics (IHEP)
Chinese Academy of Sciences
19B YuquanLu, Shijingshan District, Beijing, 100049
People's Republic of China
represented by
Professor Huanyu Wang, Deputy Director of IHEP

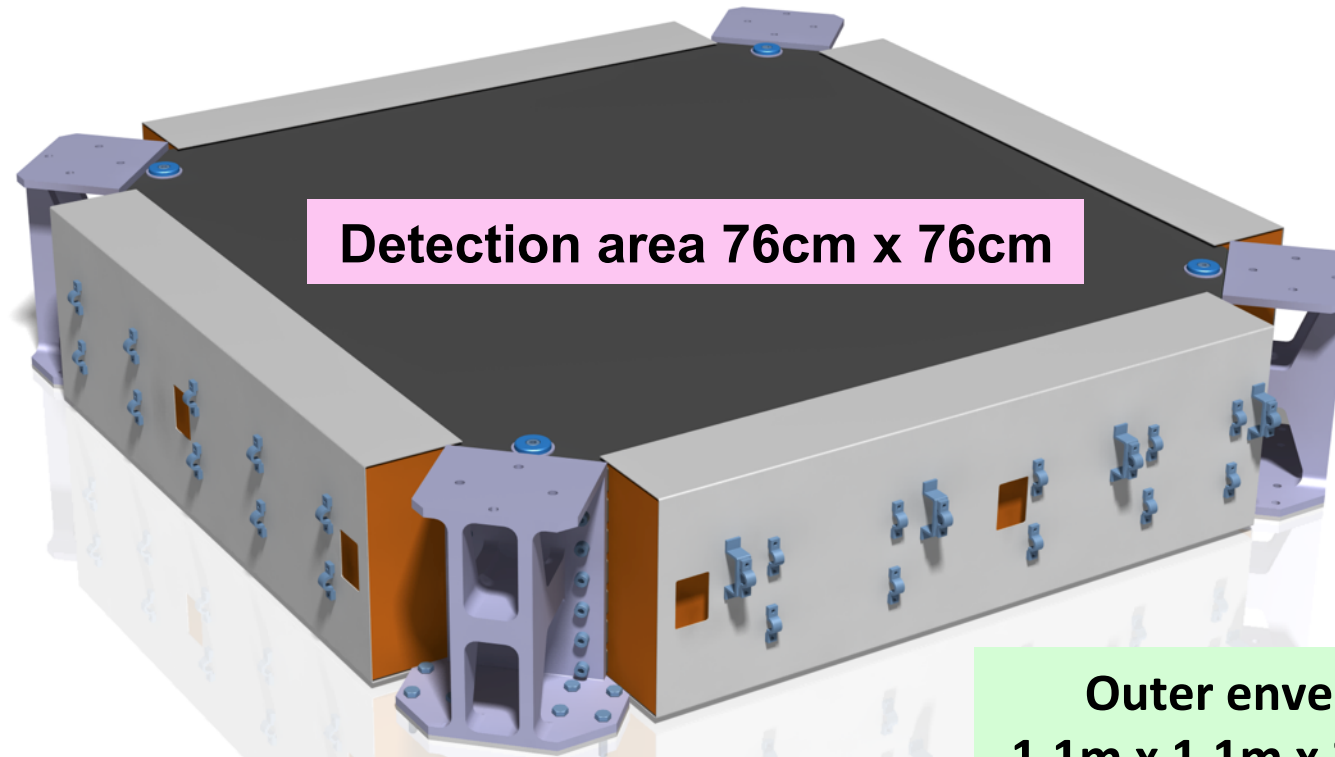
and the

Purple Mountain Observatory (PMO)
Chinese Academy of Sciences
Tianwentai Road, Xuanwu, Nanjing, Jiangsu
People's Republic of China
represented by
Professor Jin Chang, DAMPE Principle Investigator

Silicon-Tungsten Tracker (STK)

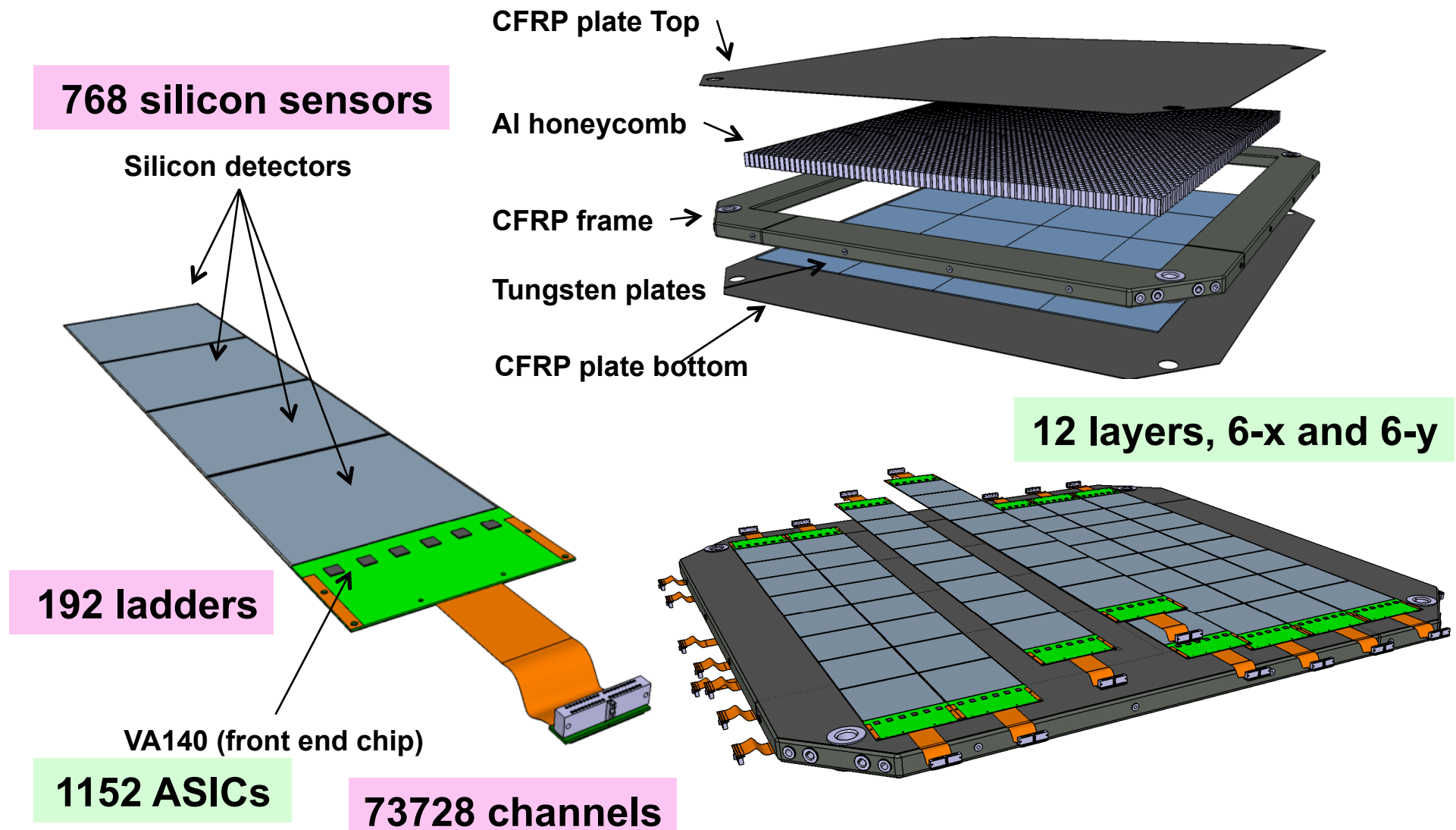
Project Leader: X. Wu

Technical Coordinator: G. Ambrosi

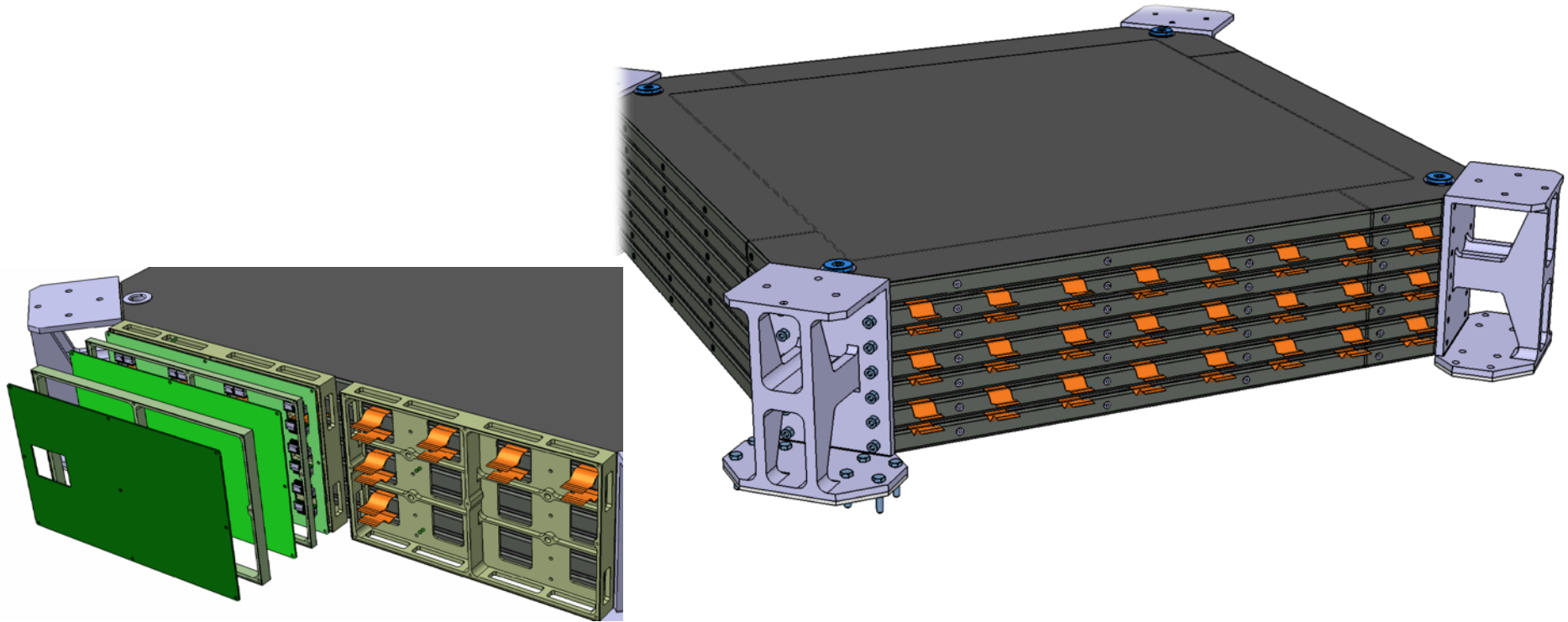


- **Weight: ~ 150 Kg**
- **Total power consumption: ~85W**

Si Layer and Ladders (INFN)



STK Structure (DPNC)



- 12 layers of silicon micro-strip detector mounted on 7 support trays
 - Tray: carbon fiber face sheet with Al honeycomb core
- Tungsten plates integrated in trays 2, 3, 4 (from the top)
 - Total $\sim 1 X_0$ for photon conversion
- 8 readout boards on 4 sides

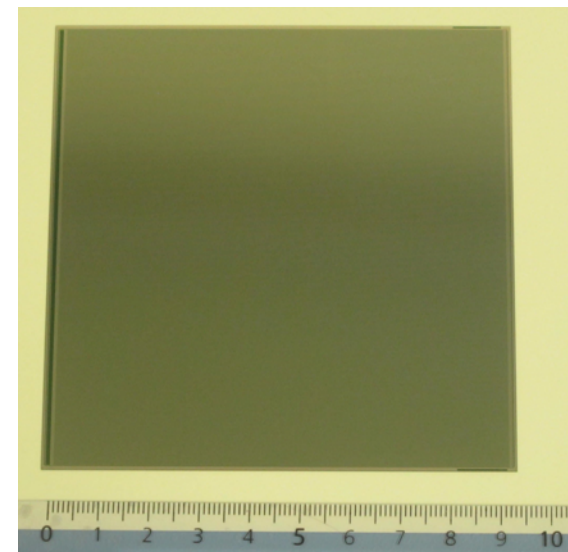
Silicon Sensor and Front End Electronics

- Silicon strip detectors produced by Hamamatsu Photonics

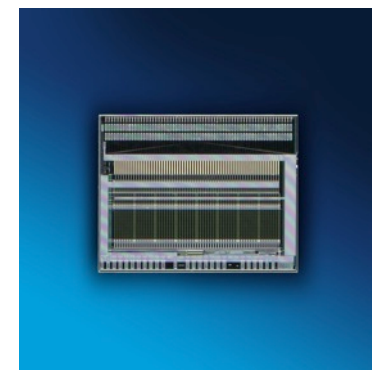
- 9.5 x 9.5 cm²
- 320±15 µm thick
- 768 strips with 121 µm pitch
- Resistivity 5-8 kΩ, V_{fd} 10-80 V
- <I_{leak}> ~ 150 nA, max 280 nA

- VA140 chip (AMS like) produced by IDEas

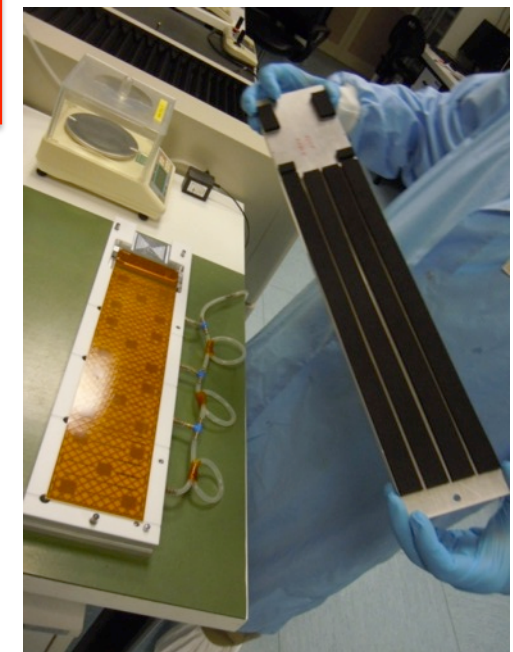
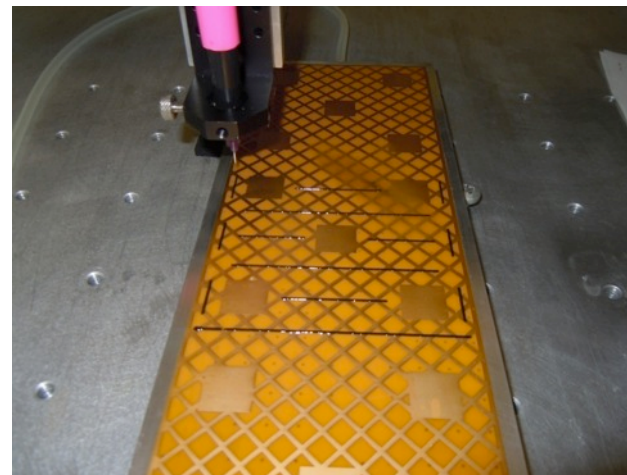
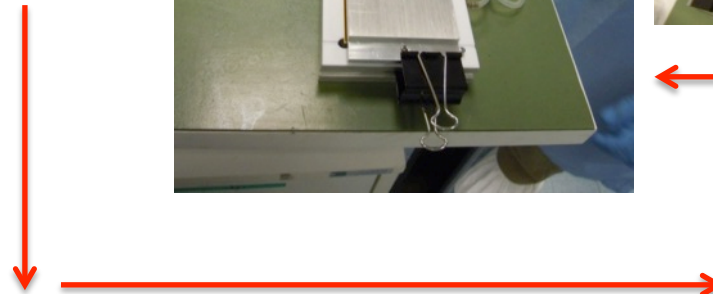
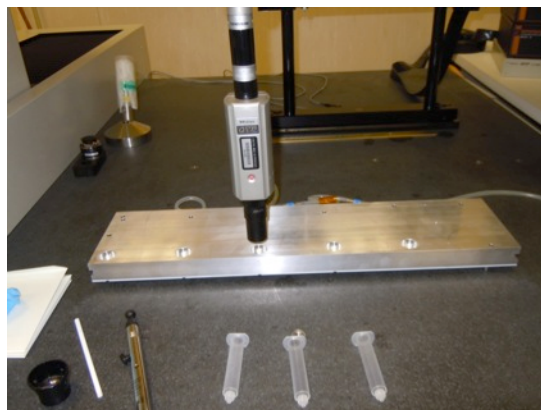
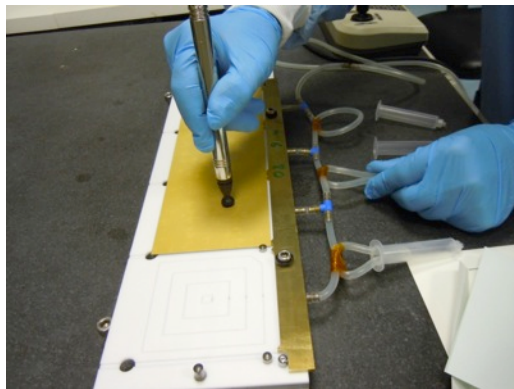
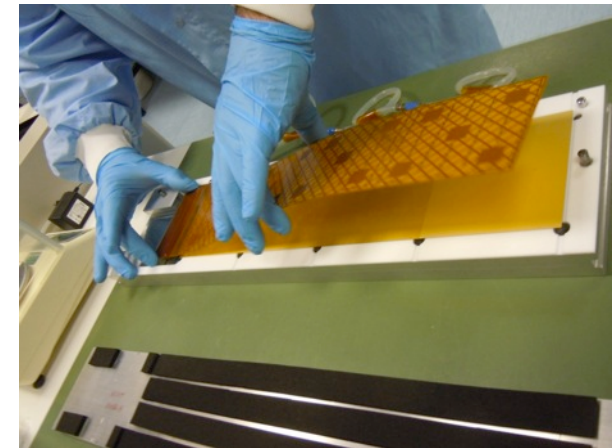
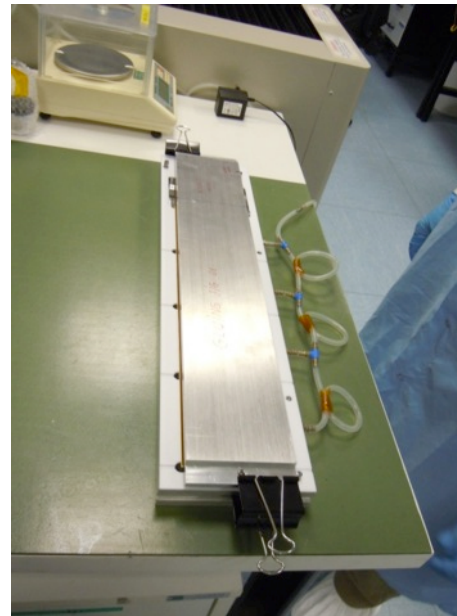
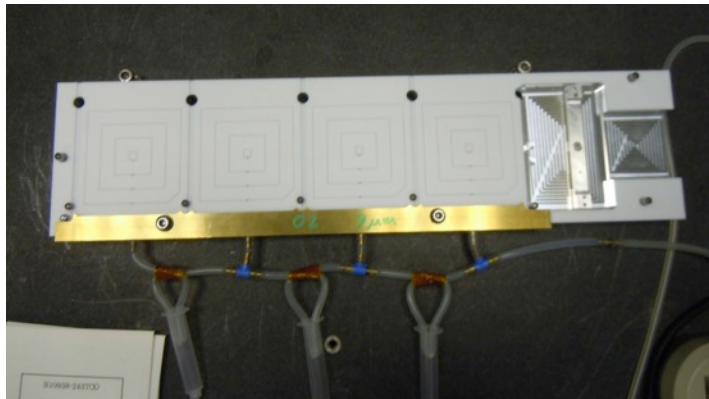
- 64 channel per chip
- Readout pitch 242 µm
- Expected position resolution better than 70 µm



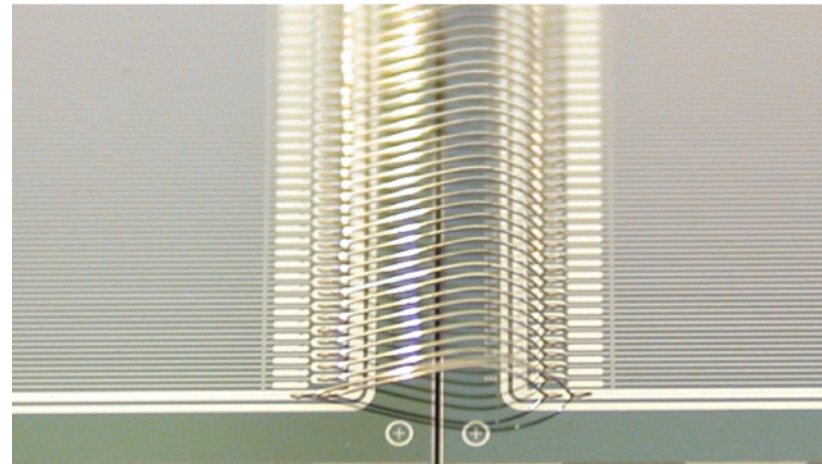
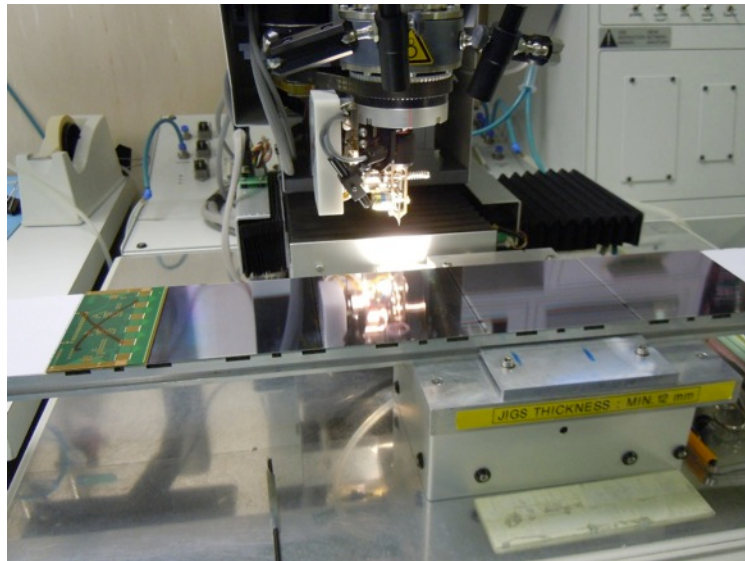
Parameter	VA64HDR9A	VA140
Noise, Cd=50pF (eRMS)	520	430
DNR	+100fC,-200fC	±200fC
Power cons. (mW/channel)	0.8	0.29
SEL thrshd (MeV·cm ² /mg)	22	21-22



Ladder Assembly Work Flow (INFN)

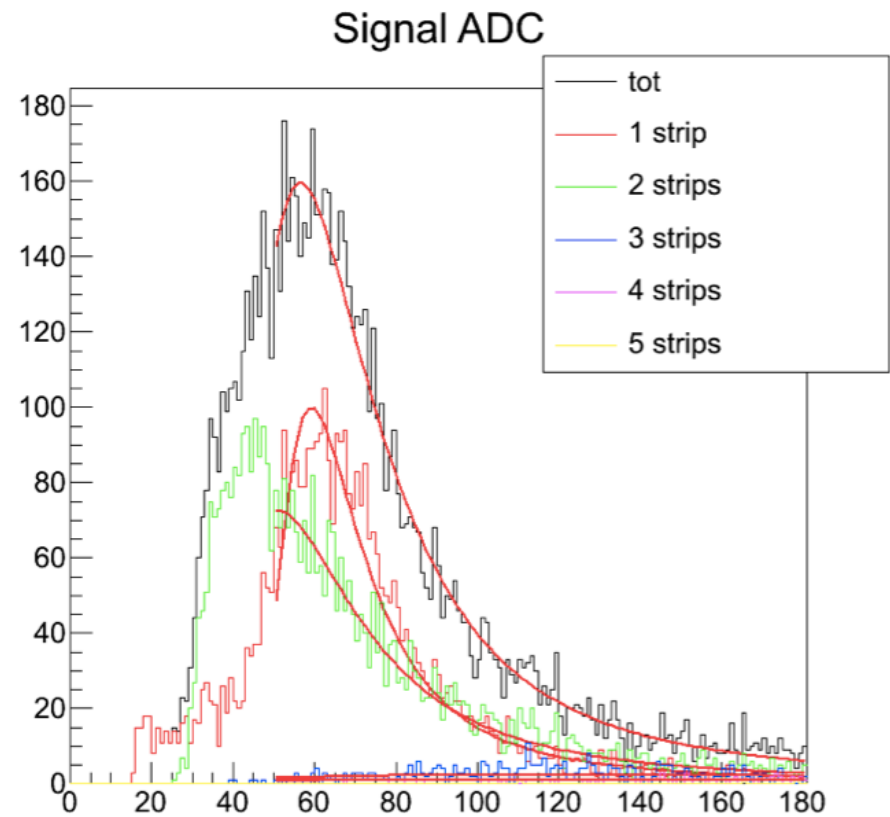
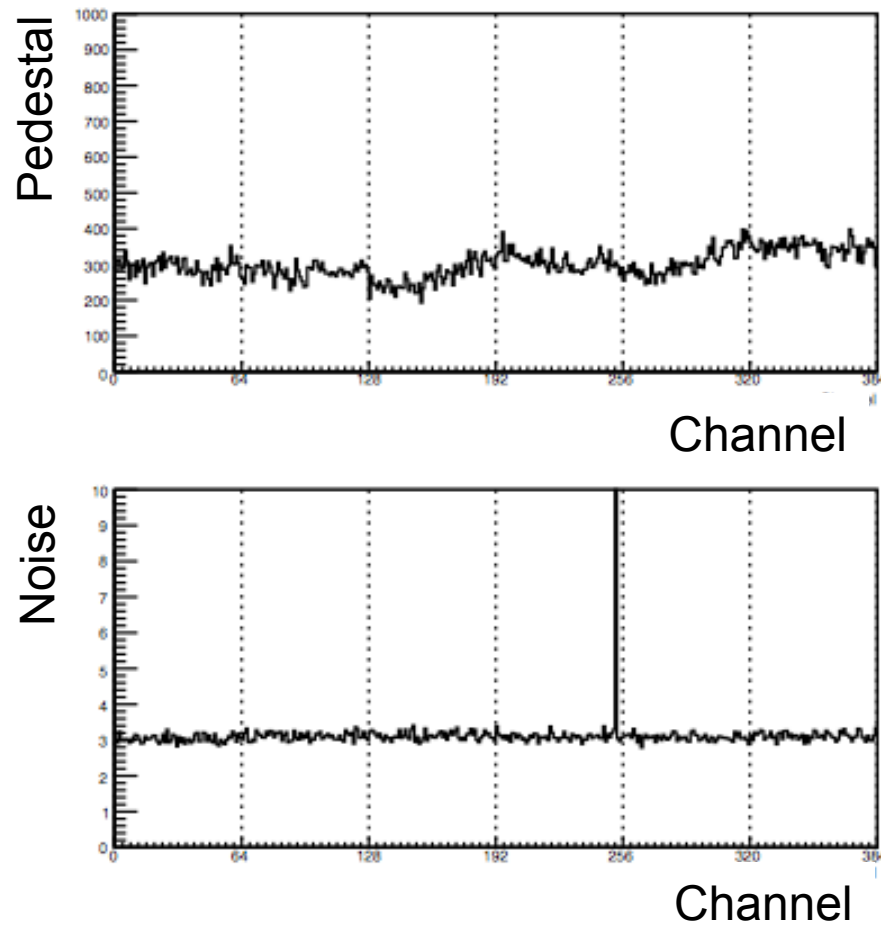


Ladder Assembly

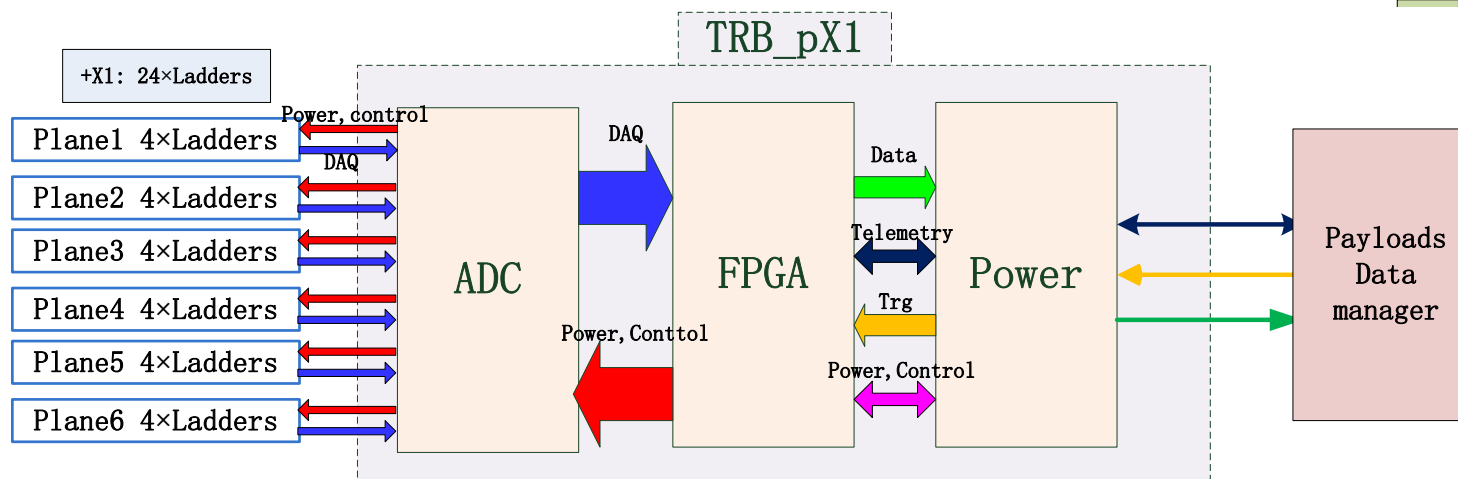
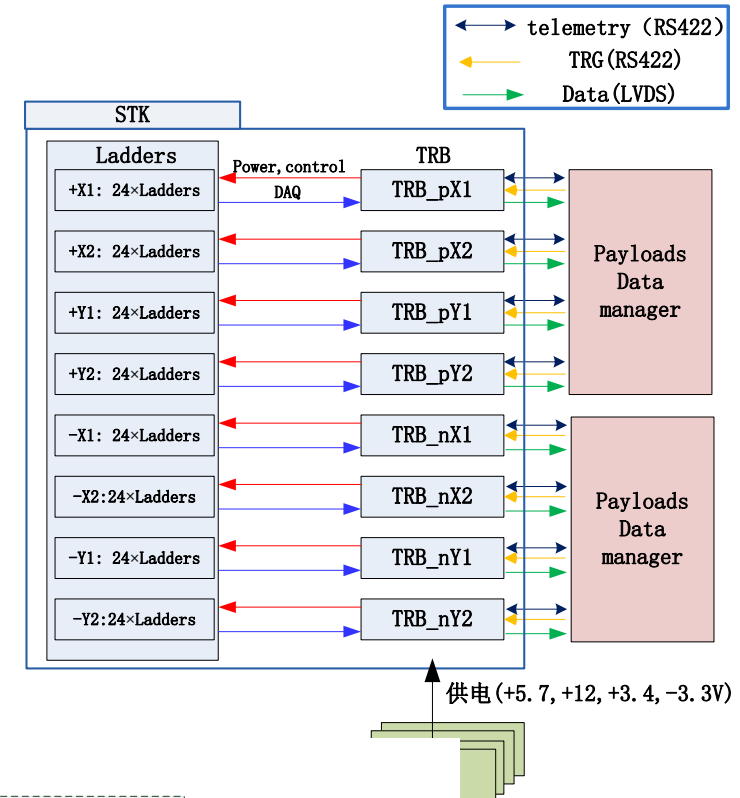
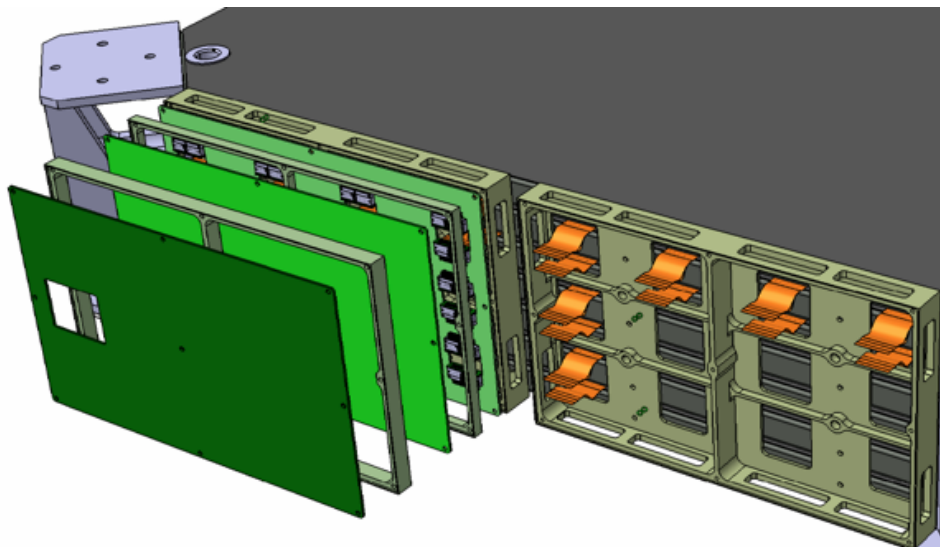


- **Precise jigs to assemble (align, glue and bond) 4 sensors to a ladder**
 - **20 μm alignment precision and planarity**

Ladder Test



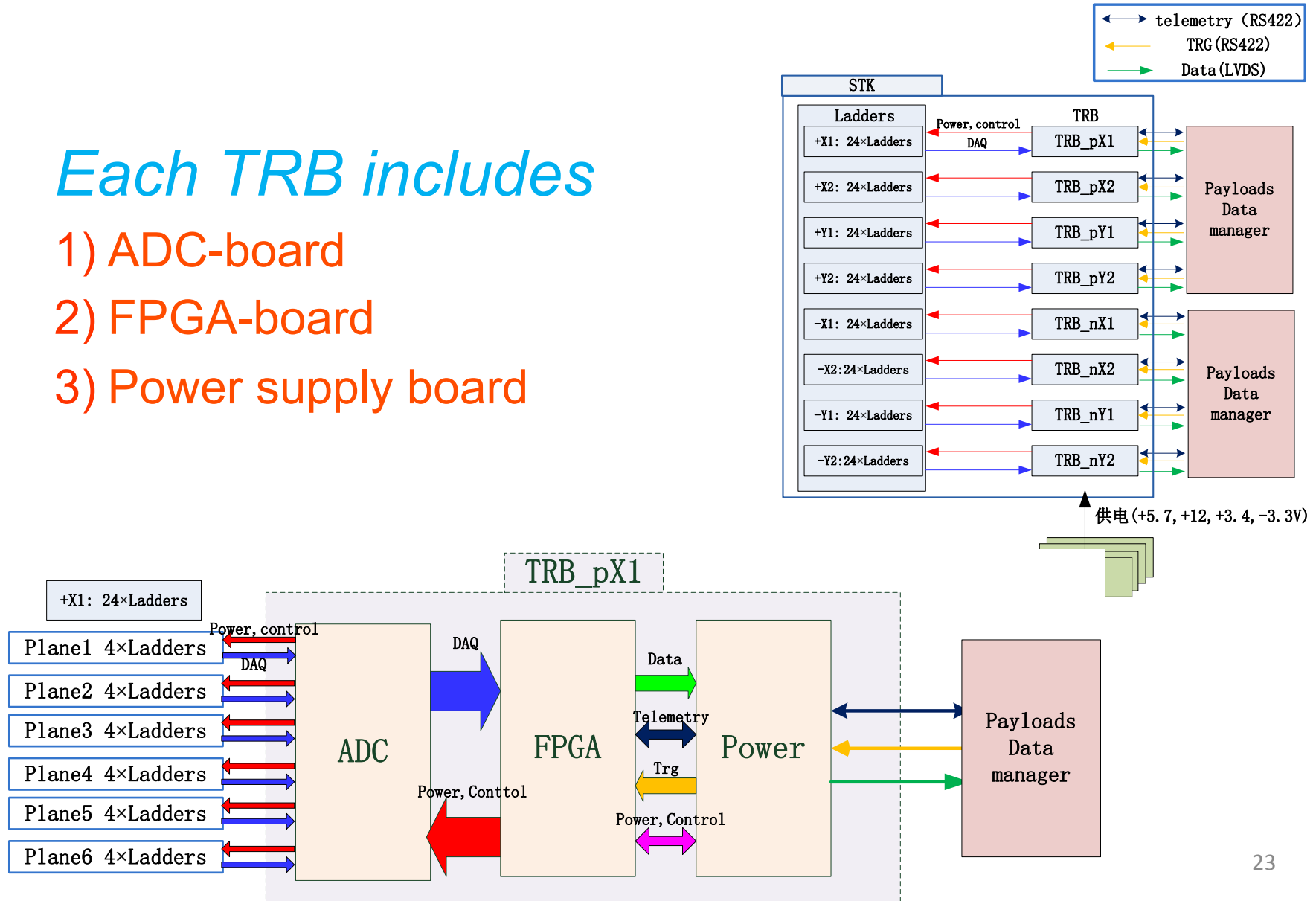
Readout and Power electronics (IHEP)



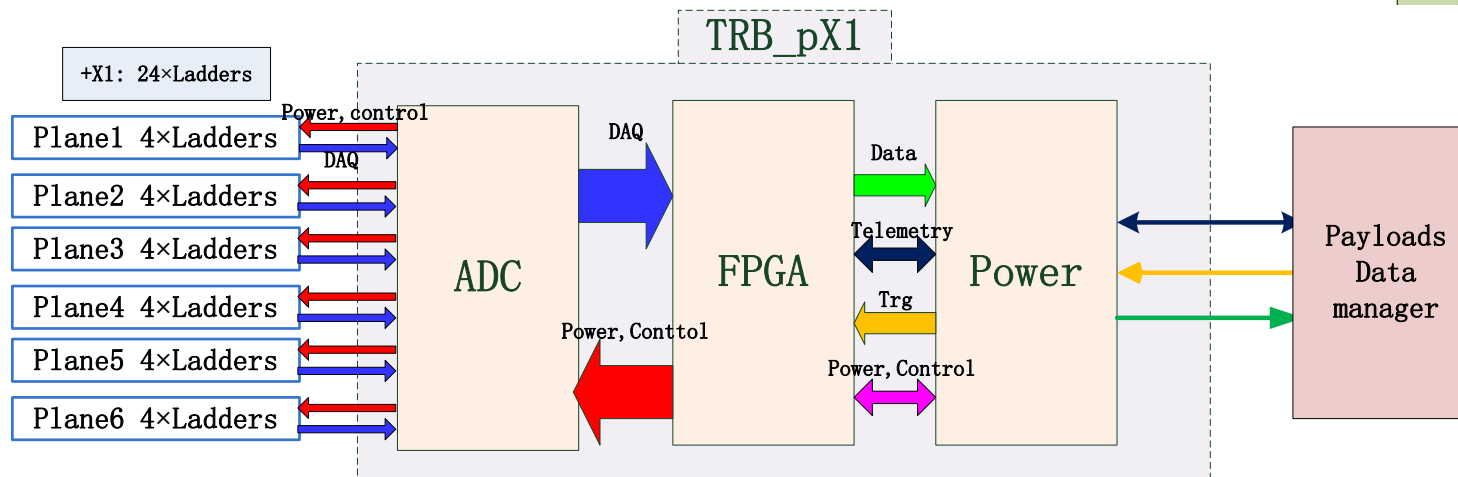
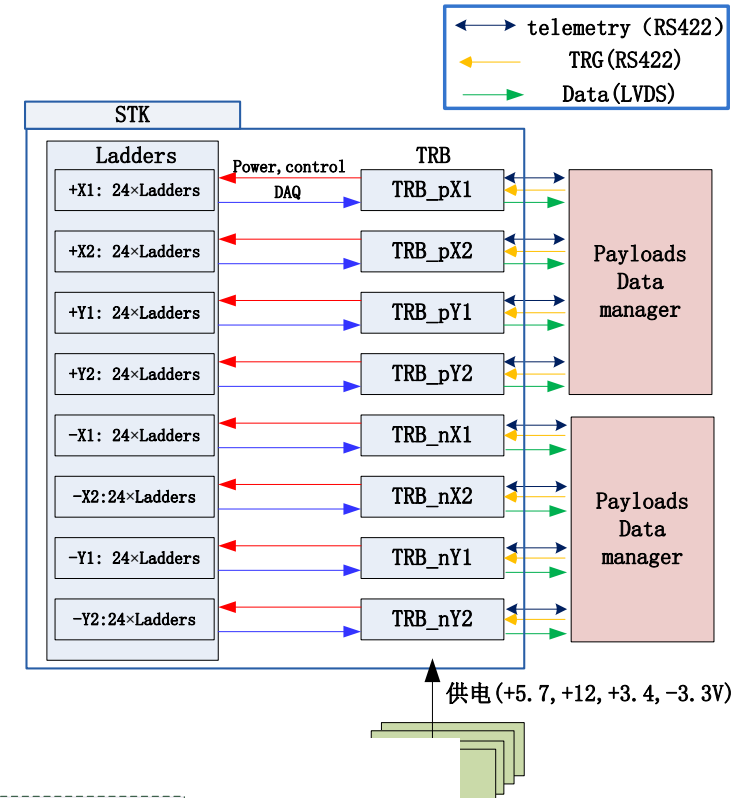
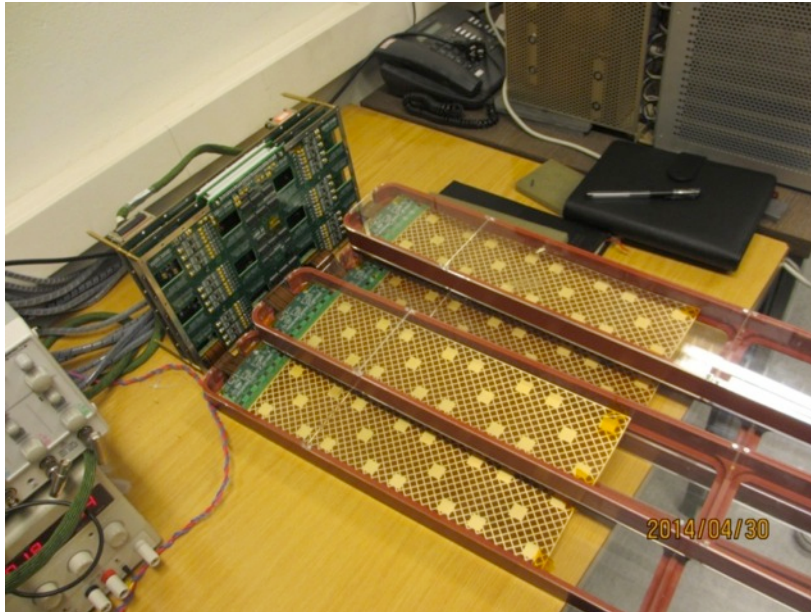
Readout and Power electronics

Each TRB includes

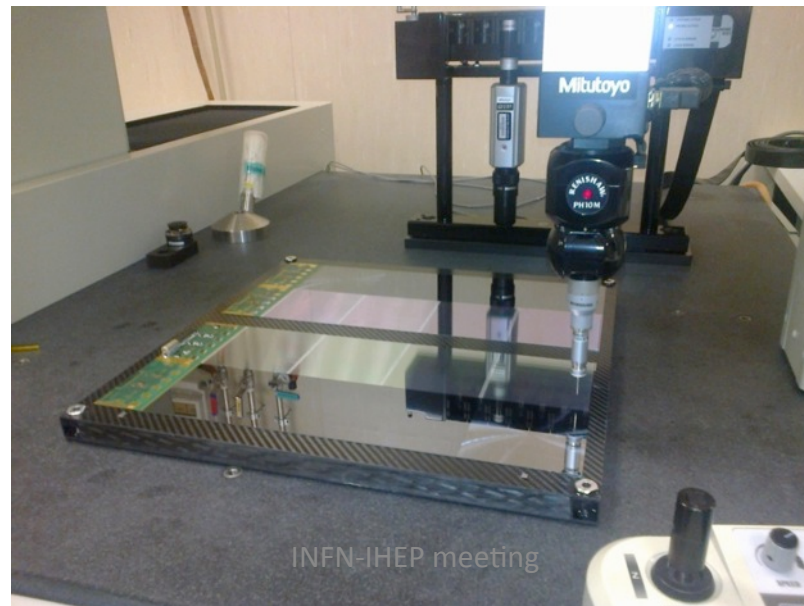
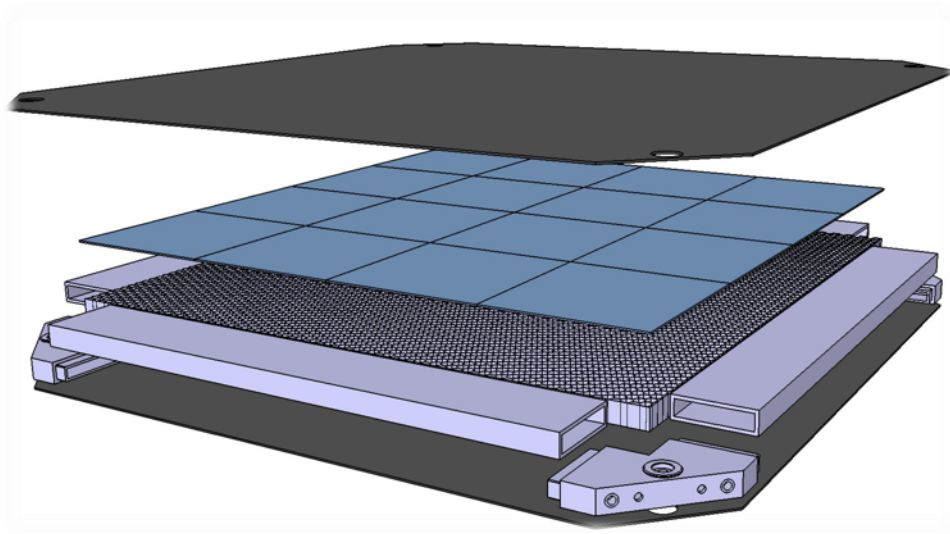
- 1) ADC-board
- 2) FPGA-board
- 3) Power supply board



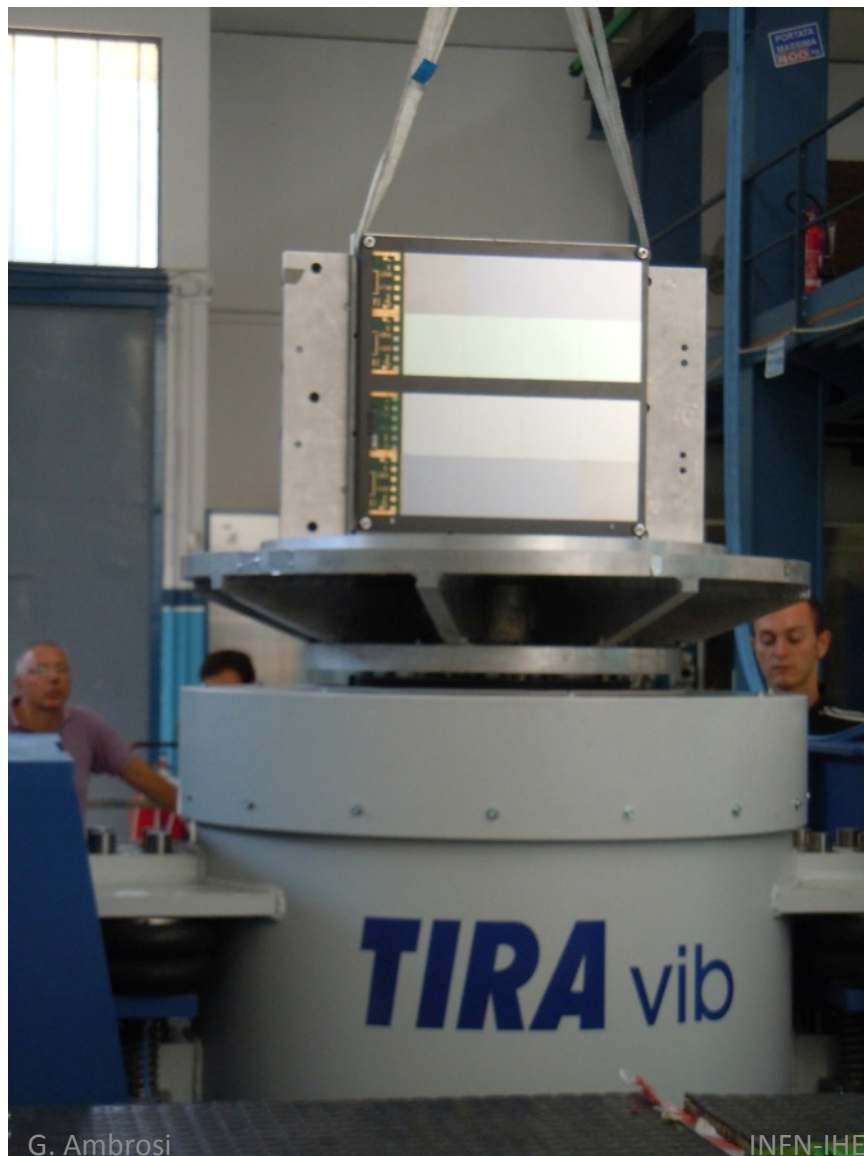
Readout and Power electronics



STK Quarter Plane (2013)



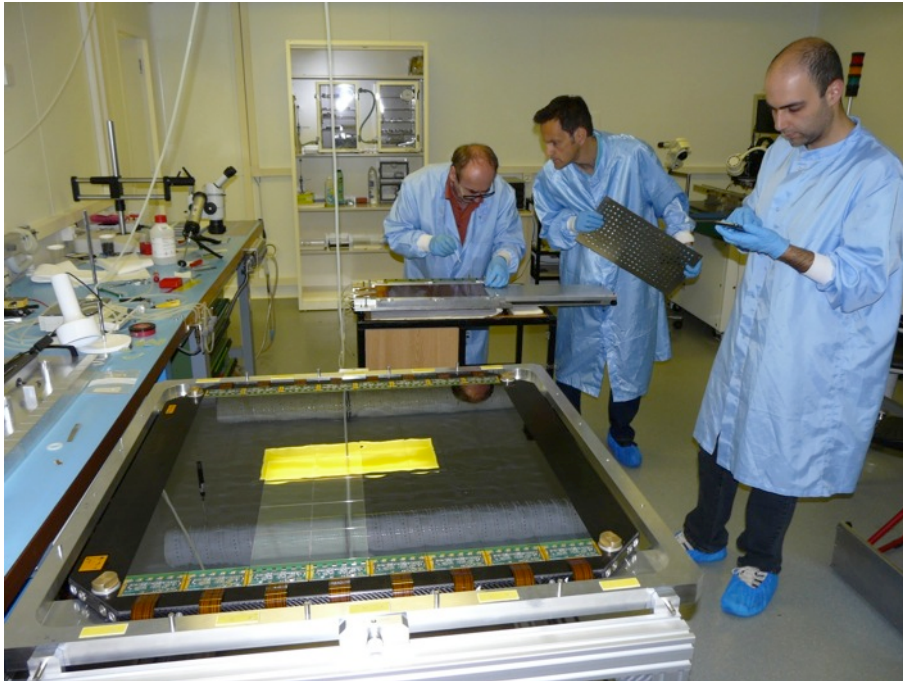
STK Quarter Plane Test (2013)



- 3 mechanical and one electrical ladder prototypes mounted on the plane
- Vibration and shock test
- Thermal cycling
- Results:
 - Electrical behaviour is unaffected by stress
 - Silicon detector 'move' by few microns

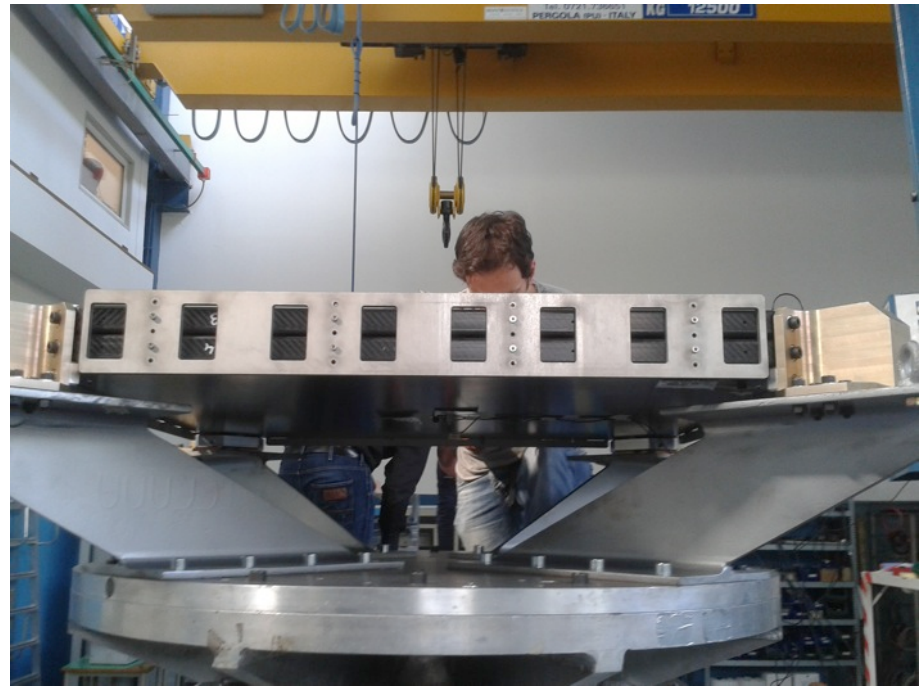
SERMS laboratory in Terni (Italy)

STK Full plane integration (4/2014)



STK Full Plane Test (02/2014)

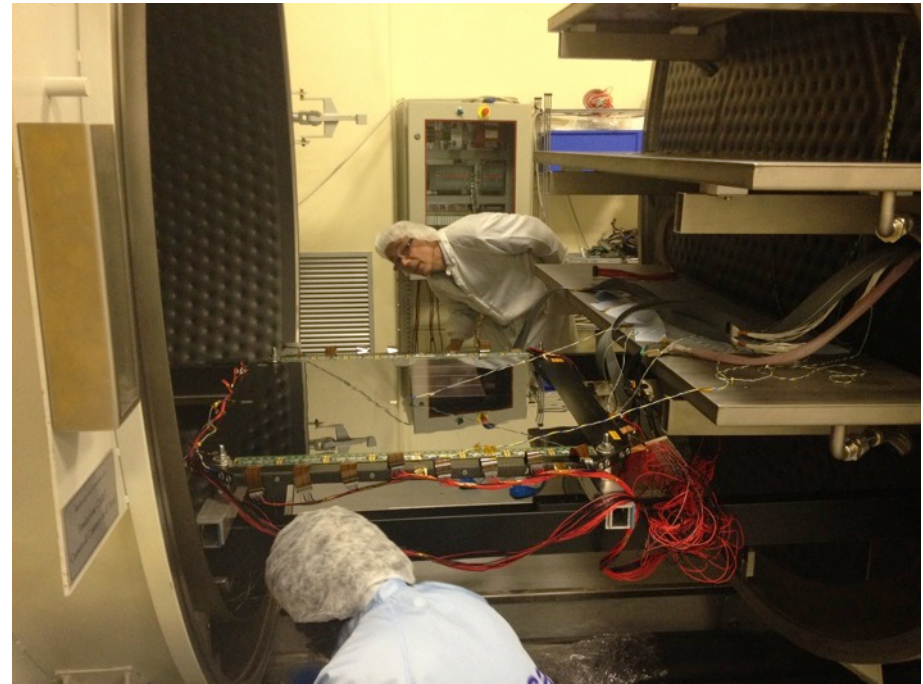
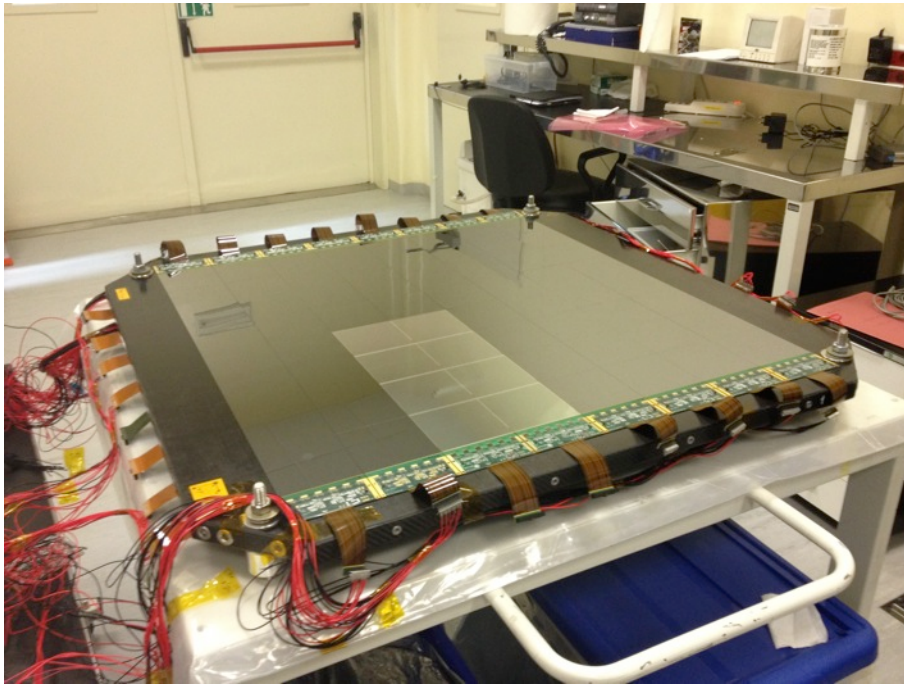
- Vibration test of EQM planes



SERMS laboratory in Terni (Italy)

STK Full Plane Test (05/2014)

- ThermoVacuum test of the first fully equipped EQM plane



SERMS laboratory in Terni (Italy)

What next

- July 2014
 - STK EQM delivery to China
 - STK test beam at CERN
- September 2014
 - Start STK FM production
- November 2014
 - Full DAMPE EQM test beam at CERN
- Spring 2015
 - STK FM delivery to China
- End of 2015
 - DAMPE launch

Conclusions

- **Detector design completed**
- **Engineering-Qualification Model production completed for PSD, BGO, NUD**
- **Engineering-Qualification Model production well advanced for STK**
- **STK group almost ready to start Flight Model construction**
- **International collaboration is being consolidated**
- **Systematic activity on simulation, and preparation for data analysis is in progress**