The JEM-EUSO time synchronization system
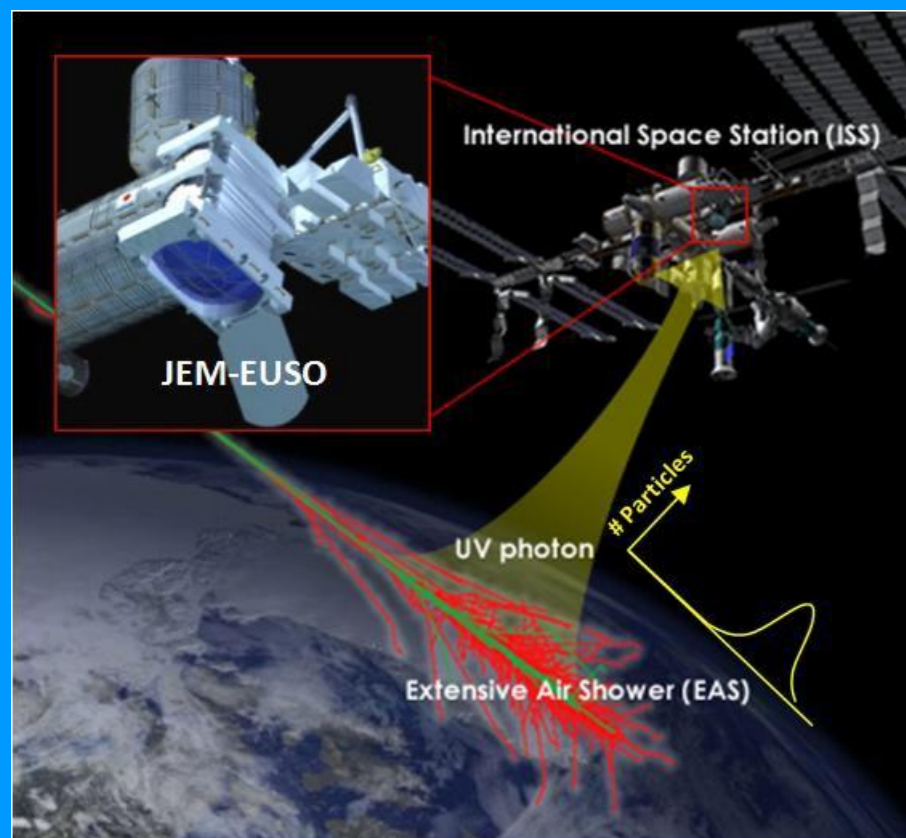
V. Scotti[1,2], G. Osteria[1] on behalf of the JEM EUSO collaboration

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The JEM EUSO mission

Observational Principle

JEM-EUSO is a new type of observatory on board the International Space Station (ISS), which observes transient luminous phenomena occurring in the Earth's atmosphere.

JEM-EUSO is designed to achieve our main scientific objective: astronomy and astrophysics through the particle channel above 10^{20}eV, to identify sources by arrival direction analysis and to measure the energy spectra from the individual sources.

JEM-EUSO telescope will observe fluorescence and Cherenkov photons generated by Extensive Air Showers created by Ultra High Energy Cosmic Rays.
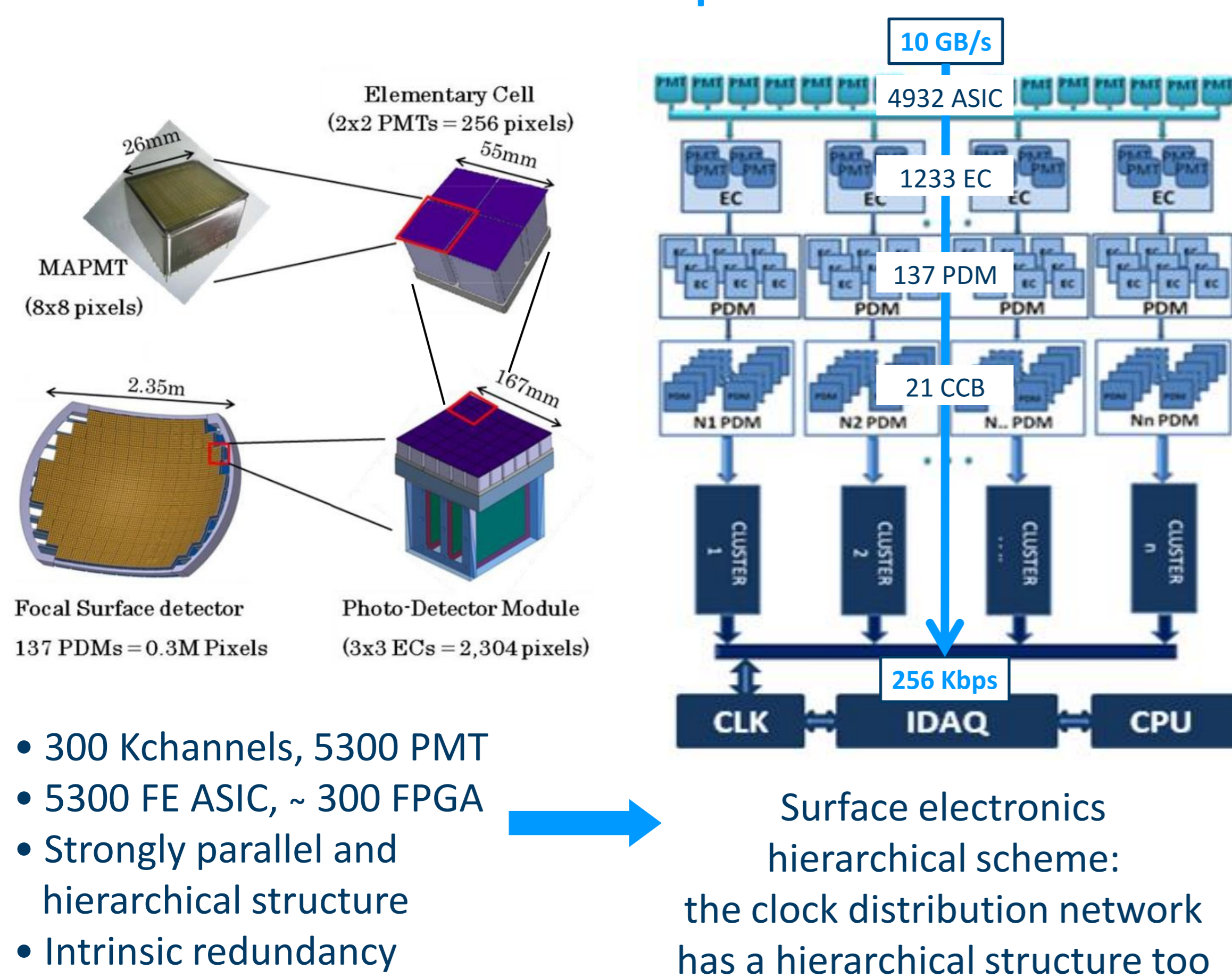
Instruments
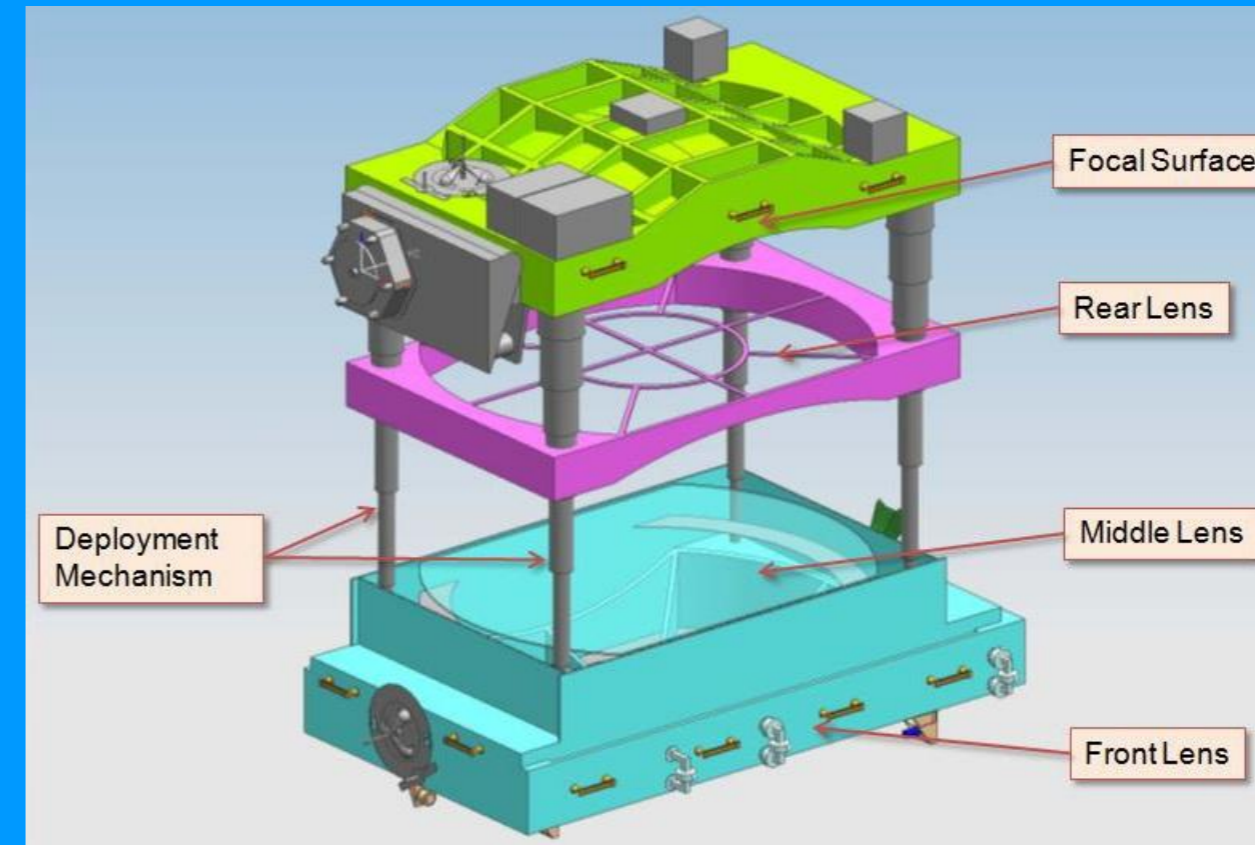
- **IR CAMERA**: imaging of clouds temperature inside FOV
- **LIDAR:** ranging observation using UV laser

Telescope parameters (base line)
- Field of View: $\pm 30°$
- Aperture Diameter: 2.5m
- Optical bandwidth: $330 \div 400$nm
- Angular Resolution: $0.1°$
- Pixel Size at the ground: 750m

The data acquisition

Elementary Cell (2x2 PMTs = 256 pixels)
MAPMT (8x8 pixels)
Focal Surface detector 137 PDMs = 0.3M Pixels
Photo-Detector Module (3x3 ECs = 2,304 pixels)

10 GB/s
4932 ASIC
1233 EC
137 PDM
21 CCB
256 Kbps
CLK   IDAQ   CPU

- 300 Kchannels, 5300 PMT
- 5300 FE ASIC, ~ 300 FPGA
- Strongly parallel and hierarchical structure
- Intrinsic redundancy

Surface electronics hierarchical scheme: the clock distribution network has a hierarchical structure too

The time synchronization system

1. Generates and distributes system clock (40 MHz), GTU clock (400 KHz, duty cycle 2%) and the synchronization signal to all the devices of the Focal Surface electronics through three level of boards
2. Provides for time synchronization of the event and measures the arrival time of the particles on a scale of few microseconds
3. Interfaces with the JEM EUSO GPS system or with ISS/JEM time system (to be used in case of failure of GPS system)
4. Manages the trigger signals: receives CCB 2nd level trigger signals and forwards to CCBs any test triggers coming from CPU
5. Measures live-time and dead-time
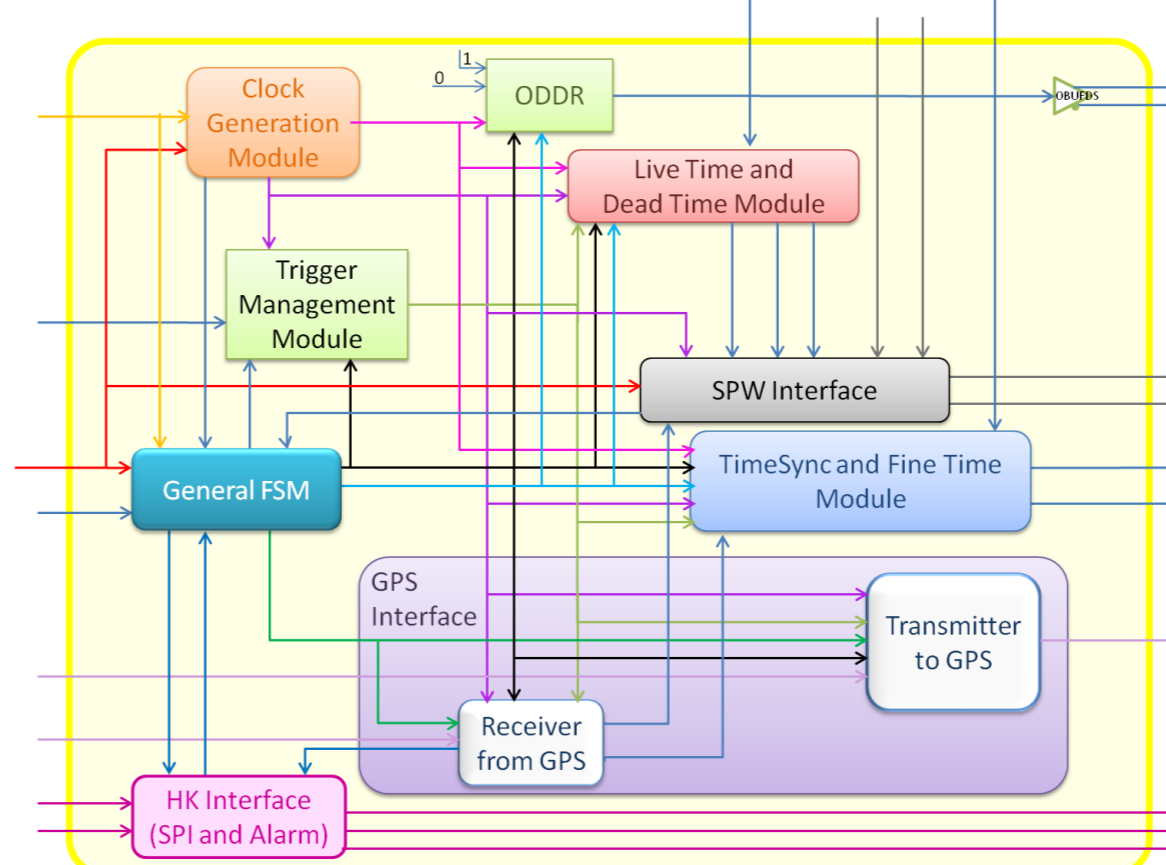
The system was designed and tested on a commercial Virtex-5, but will be soon implemented on a space qualified FPGA.
This is the block diagram, as implemented on the FPGA prototype board.

Jitter measurements

40 MHz
400 KHz
-90.0 ps   0.0 s   90.0 ps

After a 2nd level of FPGA
400 KHz
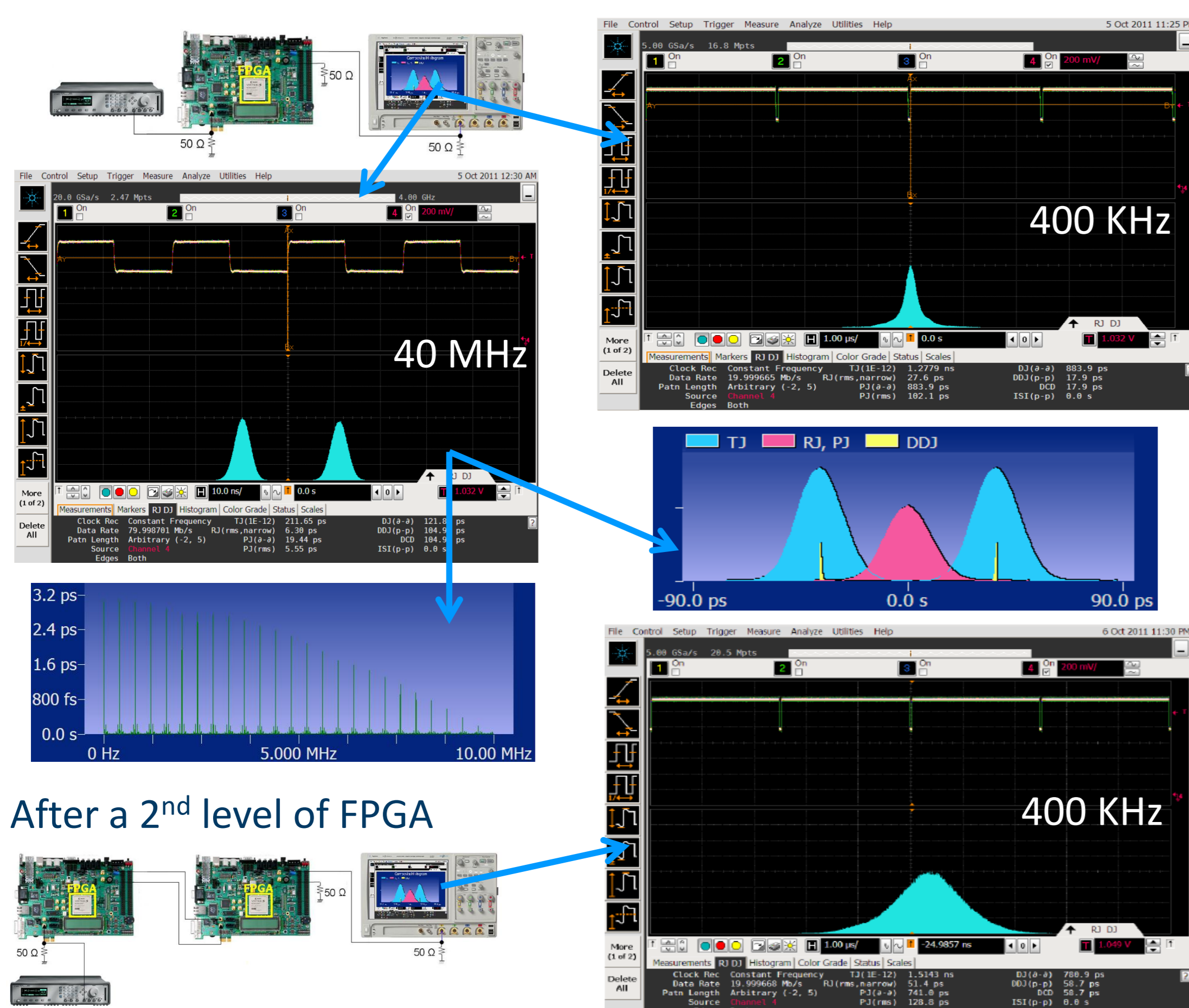
EUSO-BALLOON and Telescope Array test

Two pathfinder missions have been planned for 2013. In the first, called EUSO-BALLOON, a telescope of smaller dimension than the one designed for the ISS will be mounted onboard a stratospheric balloon. EUSO-BALLOON will measure the UV background and will serve as an evaluative test-bench for any future mission dedicated to the observation of EASs from space. In the other, the same prototype will be installed in the Telescope Array site (Utah, USA). This will allow also an absolute calibration of the two detector. The prototypes will be constituted by only one MAPMT, followed by a single acquisition chain (ASICS-PDM-CCB).
The CLK-Board will be implemented on a Virtex-5 Industrial grade.

Balloon CLK-Board Interfaces