JEM–EUSO focal surface electronics

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The EUSO program


2. EUSO-BALLOON 3 Balloon flights from Canada (French Space Agency CNES) 2014-
Conceptual view of the whole JEM-EUSO System

Flight Segment

EECR

HTV

Ground Support Equipment

H-IIB

LIDAR station

Ground Based Calibration System
Xe Flasher

Air Shower

Fluorescence

Cherenkov

UV photons

TDRS (Tracking and Data Relay Satellite)

Ground Segment

Data Center

Mission Operation Control
Conceptual view of the telescope
Optical system prototype

large diameter Fresnel lenses manufactured in Japan and tested in the US at the University of Alabama (Huntsville) and at MSFC (NASA)

Tested performances meet already the requirements (or are close to it)

Spot size is 2.5 mm!
Image is inverted
(Seen from inside)

Control room
ELS accelerator building
Lens precision: 20 nm

3rd groove surface roughness measurement

Electrical noise

RMS surface roughness requirement: < 0.0200um (=20nm)
Focal Surface Mechanics

Photo Detector Module
2304 channels

PDM Frame
EC Base

Three element support, (note sphericity)

FS Structure – Front view

64 channel MAPMT

137 PDMs in the FS – 315 kchannels

2.5 m
FS Shape
Sicily seen from EUSO

- Simulation of UV light
- Environmental monitoring

Simulations by K. Shinozaki
Sicily seen from EUSO

- Simulation of UV light
- Environmental monitoring

$10^{20}$ eV shower

Simulations by K. Shinozaki
Signal of a proton shower (10^{20} eV, 60 deg)

- UltraViolet fluorescence emission
- Cherenkov light

Time 250 µs
Mechanical structure of the...
PMT development

• Collaboration with Hamamatsu M64
• Reduction of size
• Improvement of Quantum efficiency
• Improvement of uniformity of response
• Each of the 137 PDM boxes houses 36 PMTs, 64 channels

UV Filter

Ultra Bialkali ZB0765
Average: (24.4 ± 1.8)%

Hamamatsu Photonics
MAPMT
PDM
- 5760 PMT – 300kch
- 1440 PMT
- 143 PDM
- 20 PDM
- 36 channel UBA PMT

- 300 Kchannels
- Strongly parallel and hierarchical structure
- Intrinsic redundancy
ISS

Lidar

Lid operations

Detector block

CPU block

DAQ

Control block

LVDS to CCB
Texas DSP (21 links)

Infrared Camera
ISS

LVDS to CCB
Texas DSP (21 links)

Piggyback board:
Custom Pin to Pin connector

IDAQ FPGA with links

Detector block

Lidar

Control block

IDAQ

FPGA with links

CPU block

DAQ

Infrared Camera

Detector block

Lid operations
ISS

CPU block
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CPU

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FPGA with links

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Lidar

Infrared Camera

Detector block

Lid operations
ISS

CPU block

DAQ

Control block

Detector block

CPU

MASS MEMORY STORAGE
(Temporary 1-2 Gbyte)

PCI BUS 32 bit

IDAQ
FPGA with links

Custom Pin to Pin connector

Piggyback board:

LVDS to CCB

Texas DSP
(21 links)

Lidar

Infrared Camera

Lidar operations
ISS

**CPU block**

**DAQ Control block**

**Detector block**

- CPU
- CAN bus: HK control
- Housekeeping and slow control Board
- PCI BUS 32 bit
- MASS MEMORY STORAGE (Temporary 1-2 Gbyte)
- IDAQ FPGA with links
- Custom Pin to Pin connector
- Piggyback board:
- LVDS to CCB Texas DSP (21 links)
- Lidar
- Infrared Camera
- Lid operations
CPU
CAN bus: HK control
Housekeeping and slow control Board

PCI BUS 32 bit

MASS MEMORY STORAGE
(Temporary 1-2 Gbyte)

LVDS to CCB
Texas DSP (21 links)

Lidar

Infrared Camera

CPU block
DAQ
Control block

Detector movement (nadir/tilted)

Temperature Boards, FS
Voltage Current

Custom Pin to Pin connector

Piggyback board: HK control

IDAQ FPGA with links

Detector block
CPU
CAN bus:
HK control
Housekeeping and slow control Board

ISS
PCI BUS 32 bit
MASS MEMORY STORAGE
(Temporary 1-2 Gbyte)

LVDS to CCB
Texas DSP
(21 links)

Lidar
Lidar operations

Infrared Camera

Piggyback board:
Custom Pin to Pin connector

detecto block
DAQ
Control block

CPU block

Detector movement (nadir/tilted)

Temperature Boards, FS
Voltage Current

Detector block

LVDS to CCB
Texas DSP
(21 links)

Infrared Camera

Lid operations

HV setting
DC/DC activation
Cooling
CPU CAN bus:
- HK control
- Housekeeping and slow control Board

MASS MEMORY STORAGE (Temporary 1-2 Gbyte)

PCI BUS 32 bit

LVDS to CCB
- Texas DSP (21 links)

Lidar
- Lid operations

Infrared Camera

Star Sensor
- Temperature Boards, FS
- Voltage Current

Detecter movement (nadir/tilted)

Piggyback board:
- Custom Pin to Pin connector

IDAQ FPGA with links

DAQ Control block

CPU block

1553 connection:
- Telecommand
- Alive information

Telecommand
- HV setting
- DC/DC activation
- Cooling

Infrared Camera

Star Sensor

Lidar

LVDS to CCB
**ISS**

**CPU block**

- Housekeeping and slow control Board
- CAN bus: HK control

**DAQ Control block**

- Custom Pin to Pin connector
- IDAQ FPGA with links
- Piggyback board:

**Detector block**

- Star Sensor
- Infrared Camera
- Lidar

**Connection Details**

- Mass Memory Storage (Temporary 1-2 Gbyte)
- PCI BUS 32 bit
- 1553 connection:
  - Telecommand
  - Alive information
  - Downlink data
- Redundant Time, GPS
- Time, GPS info
- FDDI / Ethernet Connection
- Temperature Boards, FS
- Voltage Current
- HV setting
- DC/DC activation
- Cooling

- Lid operations
ISS

CPU

CAN bus:
HK control
Housekeeping and slow control Board

IMA

PCI BUS 32 bit

MASS MEMORY STORAGE
(Temporary 1-2 Gbyte)

Downlink to ISS
Storage on Hard Disk

LVDS to CCB
Texas DSP (21 links)

Lidar

Star Sensor

Infrared Camera

Detector block

Detector movement (nadir/tilted)

Temperature Boards, FS
Voltage Current

1553 connection:
Telecommand
Alive information

FDDI / Ethernet Connection
Downlink data

Redundant Time
GPS

Downlink to ISS

Time
GPS info
Attitude info

IDAQ FPGA with links

Custom Pin to Pin connector

Piggyback board:

CPU block

DAQ Control block

HC 50/55

IDAC

1553

Telecommand

Alive information

LVDS to CCB
Texas DSP (21 links)
JEM-EUSO DAQ – CURRENT Electronic System scheme

140 GB/s (FS)  
3*10^-3 compression

137 PDM New design

137 PDM Control Board

Cluster Control Board

20 CCB

1PDM

FPGA

Fine Trigger

1CPU

1 CLOCK

1 GPS

½ Housekeeping storage

Telemetry Interfaces

1 Board

297 kbit/s

3 Gbyte/day (downlink)

Storage on SSD will give factor 3–5, up to 10 Gbyte/day
Return with Soyuz or Dragon

300kch
1,287 EC

36 x 64 channels

1 PDM

137 PDM Modules

PhotoDetector Modules

PMT

FEE

ASIC + FPGA

Count

137 Boards

20 Board
TA EUSO DAQ – CURRENT Electronic System scheme

1GB/s (FS)

4\times 10^{-3} \text{ compression} \quad \text{no compression}

3Mbyte/s \quad 10 \text{ Gbyte/hour}

1 \text{ PDM}

1 \text{ EC BOARD}

2 \text{ PMT}

9 \text{ EC}

FEE

ASIC + FPGA

Count

PMT

1 \text{ CCB}

1 \text{ CPU}

1 \text{ CLOCK}

1 \text{ GPS}

\frac{1}{2} \text{ Housekeeping storage}

CPU

Spacewire Clock Board

GPS

Data Storage Software

Telemetry Interfaces

1 \text{ PDM Control Board}

Cluster Control Board

Fine Trigger

2304 \text{ ch}

9 \text{ EC}

1 \text{ Boards}

1 \text{ Boards}

PhotoDetector Modules

36 \times 64 \text{ channels}

20 \text{ PMT}

1 \text{ CC B}

1 \text{ CLOCK}

GPS

\frac{1}{2} \text{ Housekeeping storage}

CPU

Spacewire Clock Board

GPS

Data Storage Software

Telemetry Interfaces

1 \text{ Board}

2 \text{ Board}

Most data

Stored on SSD

17 \text{ GB/hour (save all stream)}

17 \text{ GB/hour (save all stream)}
• **3 different PCBs:**

  - First one (**EC DYNODE board**) allows to reroute half of the dynodes of 1 MAPMT so that they are aligned perpendicularly to the others. It covers the 4 MAPMTs.
  
  - Second one (**EC ANODE board**) covers one MAPMT but has dimensions reduced allowing a flex pcb to get out. It is used to collect signal from the anodes and send them to the ASICs.
  
  - Third one (**EC HV board**) covers one MAPMT. It welcomes the dynodes and supplies the HV (up to 1000 V) to the EC-dynode board which transmits it to the 4 MAPMTs.

**Per EC unit:**
- 1 EC-DYNODE board
- 4 EC-ANODE boards
- 1 EC-HV boards

**Diagram notes:**
- UV filter
- MAPMT
- Flexible pcb toward EC-back
- Central column
- HV cables toward HV box
6 EC-ASICS, each with 3+3 Asics
PDM EC-ASIC EC-UNIT
Laser Light
Spot seen in the focal point
Real-time
On board calibration
Individual channel
CNES approved balloon mission
First flight 2014
**Balloon–EUSO**

The EUSO–Balloon is a Pathfinder–mission to perform a complete end-to-end test of JEM–EUSO' s key technologies and instrumentation.

Multiple launches planned in 2014 at altitude ~ 40 km

- Data processing
- Photo detection
- Optical system