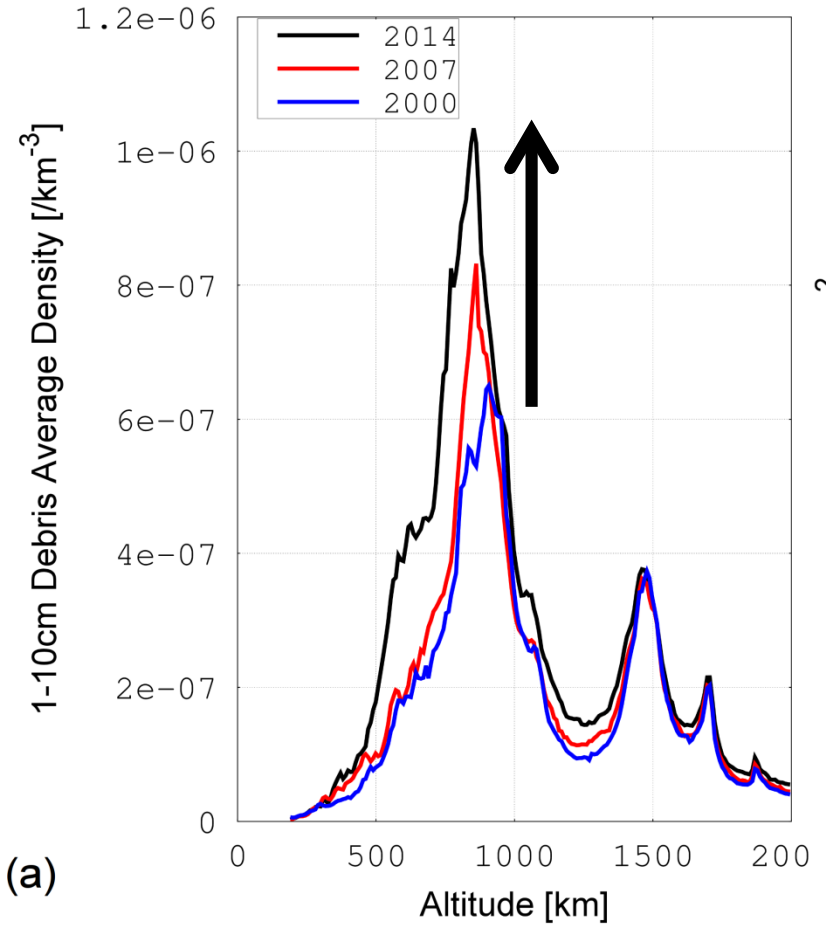
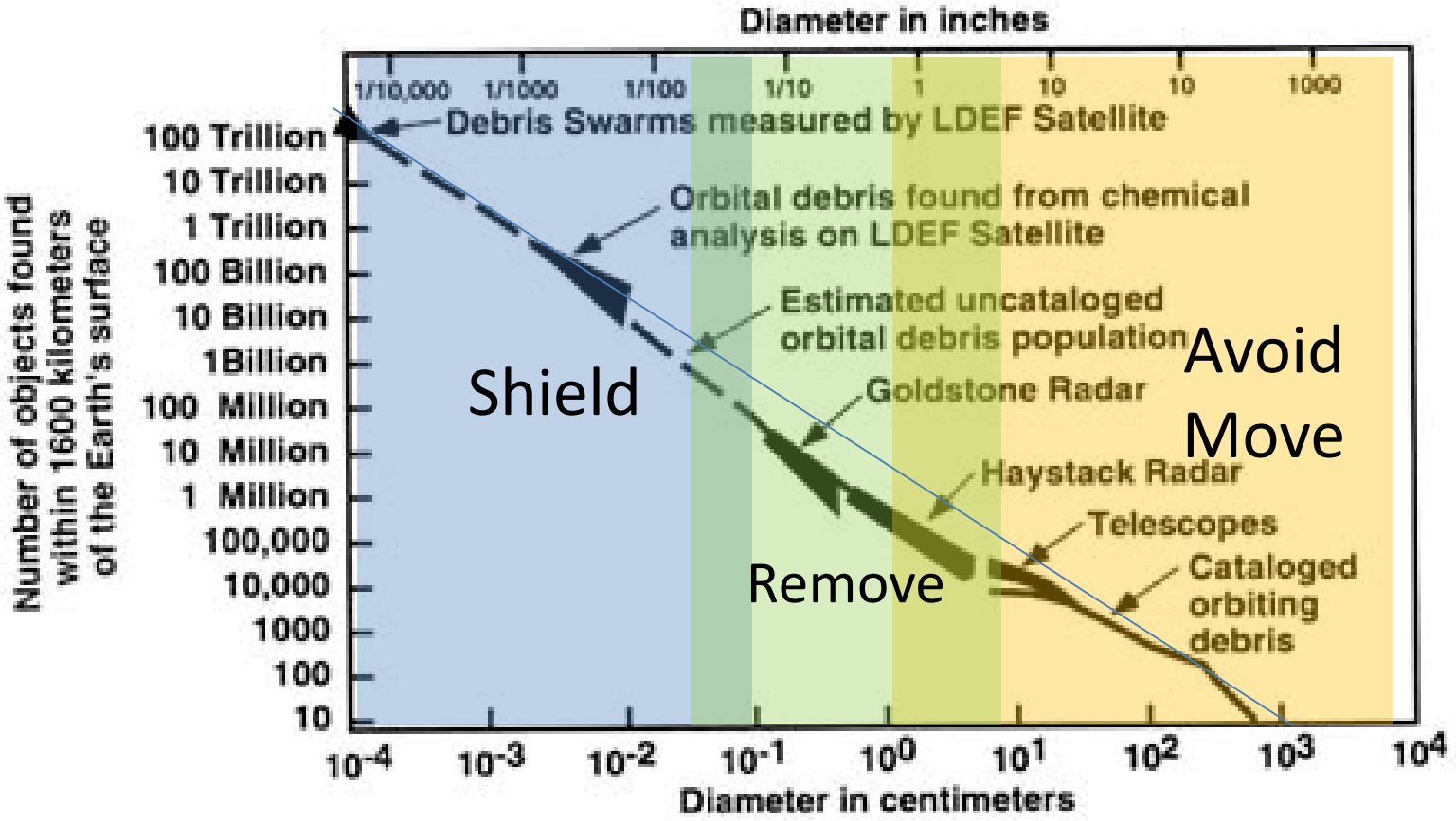
Deorbiting of Space Debris by Laser Ablation

Toshikazu Ebisuzaki and Satoshi Wada (RIKEN)

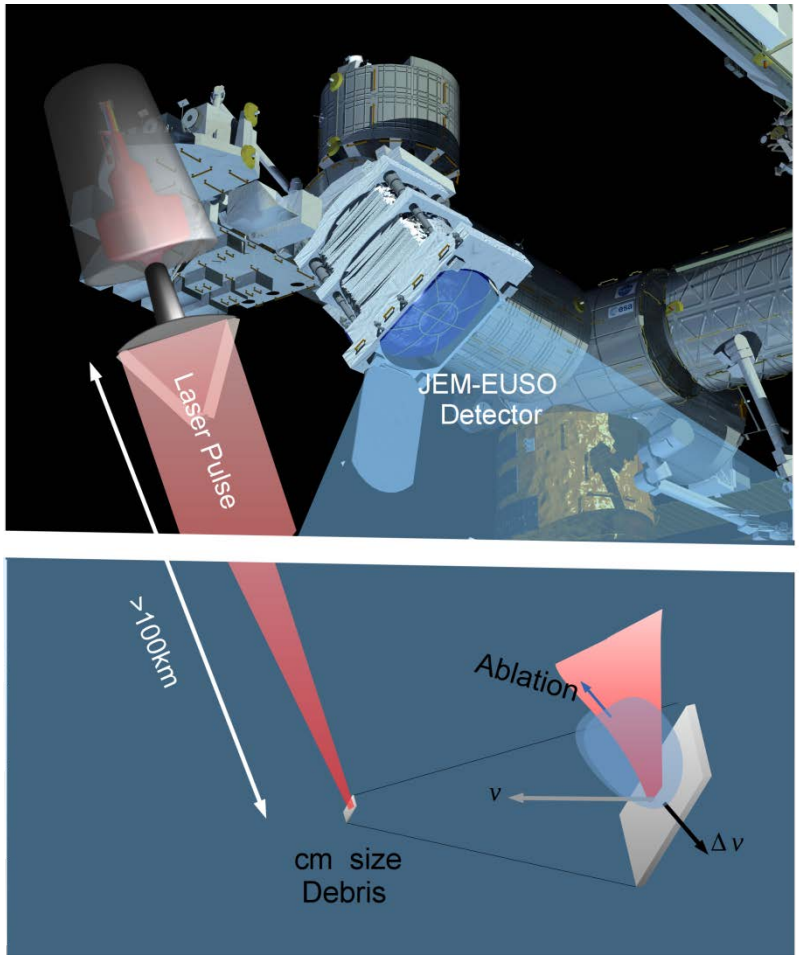
Space Debris



Debris population



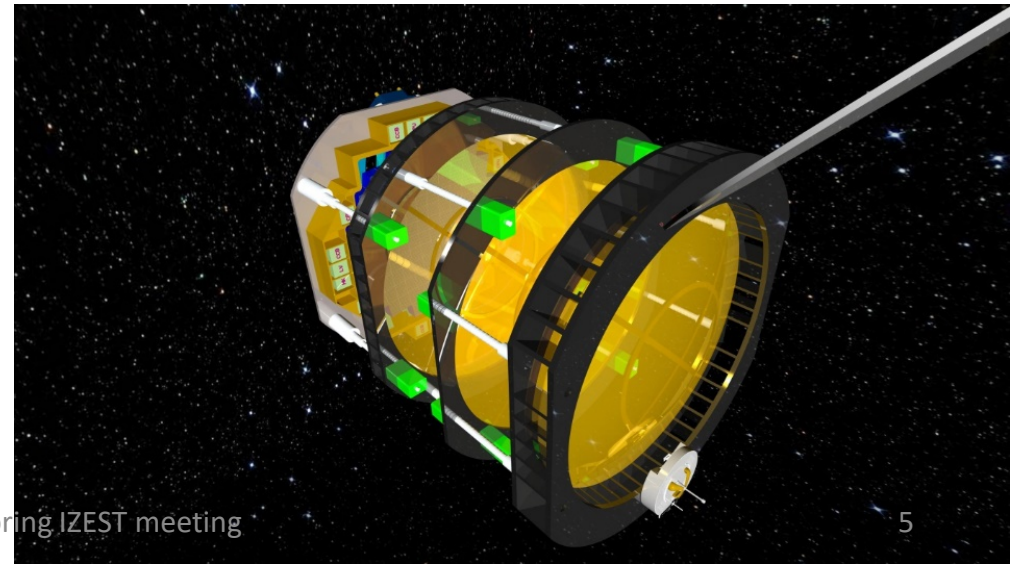
Concept of our the laser removal of 0.5-10 cm space debris



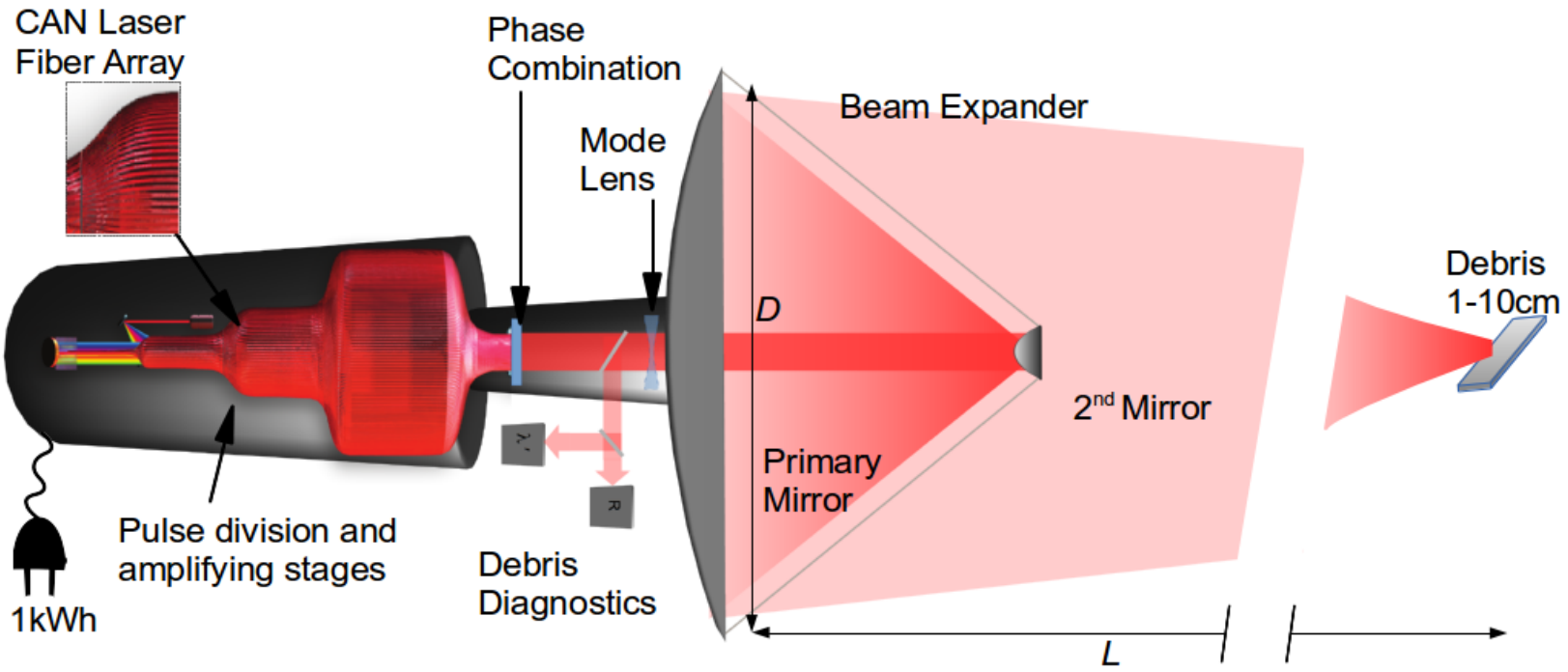
- EUSO (Wide Field Camera)
  - Detection
  - Position and velocity
    - Crude determination
- CAN laser system
  - Search beam
  - Position and velocity
    - Fine determination
  - Shooting Operation

Super Wide-Field Telescope

- EUSO (Extreme Universe Space Observatory):
  Developed for the detection of cosmic rays
- **Super Wide-field** : ±30 degrees
  - Refractive optics : Three lenses system (RIKEN)
- **Super high speed** : 2.5μs
  - Multi-Anode Photo-Multiplier (Hamamatsu Photonics)
  - position sensitive (8x8 pixels)
- **Super High-sensitivity**
  - One photon counting
  - 2.5 m in diameter



Space CAN laser system
CAN=Coherent Amplify Network

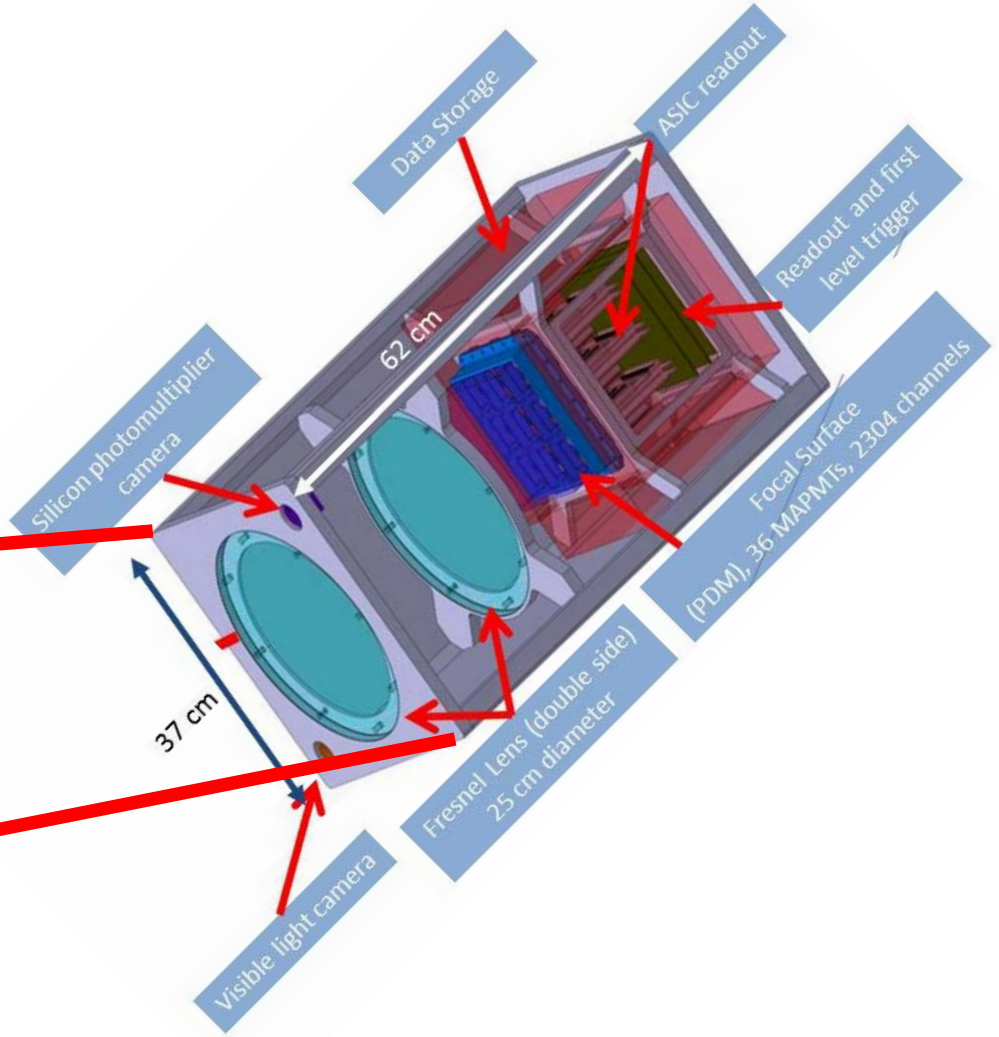


One laser fiber: 1mJ and 50KHz
10,000 fibers in parallel : 10 J and 50 KHz
in coherent Amplification and combination

Three Step Approach with ISS cosmic-ray missions

1. 25㎝ class Telescope: mini-EUSO at International Space Station
   - Technical demonstration of debris detection
   - Launch Scheduled in 2017
   - 25 cm UV telescope
   - Collaboration of Italy, Russia, Italy, France, and Japan
2. 2.5m class telescope (KLYPVE/K-EUSO)
   - Planning in collaboration with Russia, Italy, France and Japan
   - +High intensity laser Demonstration of Tracking
3. Dedicated Free-Flyer
   - EUSO＋CAN laser
   - Altitude 600-900km

Mini-EUSO in Russian module in ISS




MINI-EUSO
Multiwavelength Imaging New Instrument
Extreme Universe Space Observatory
RIKEN
MINI-EUSO
Multiwavelength Imaging New Instrument
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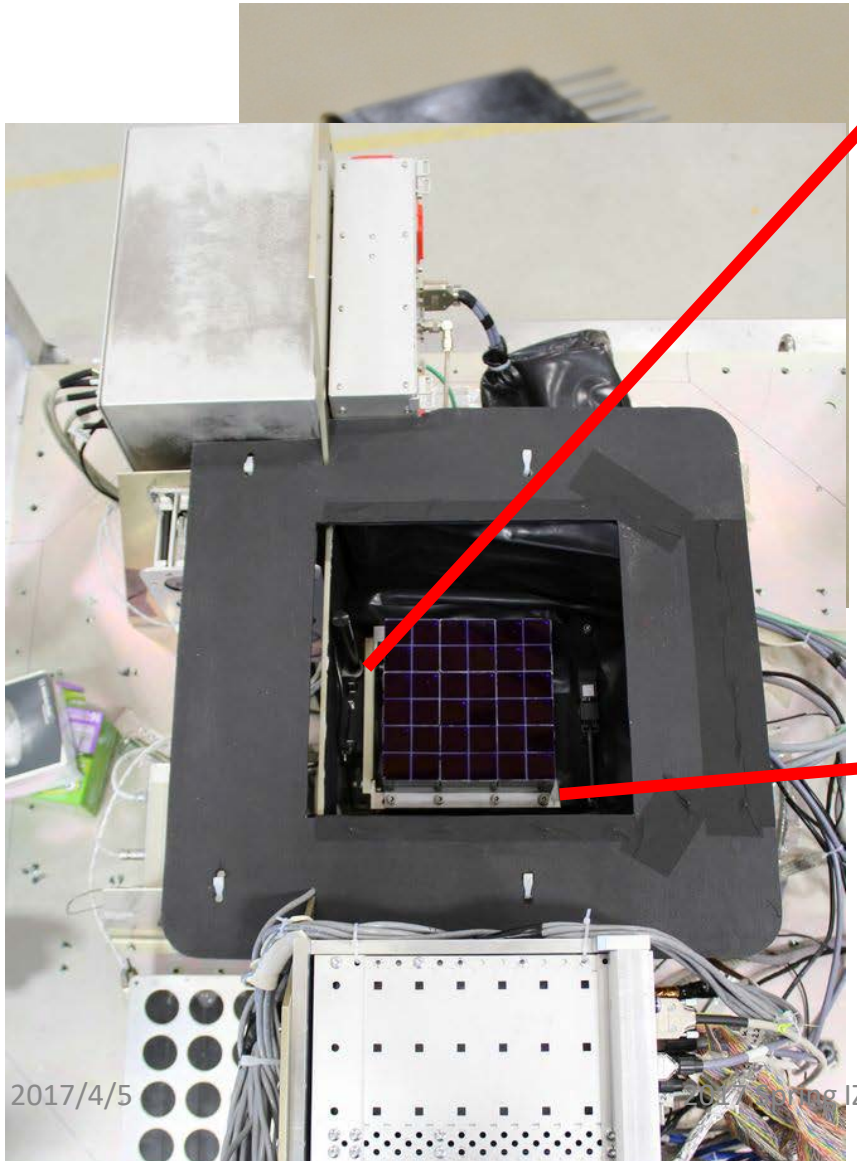
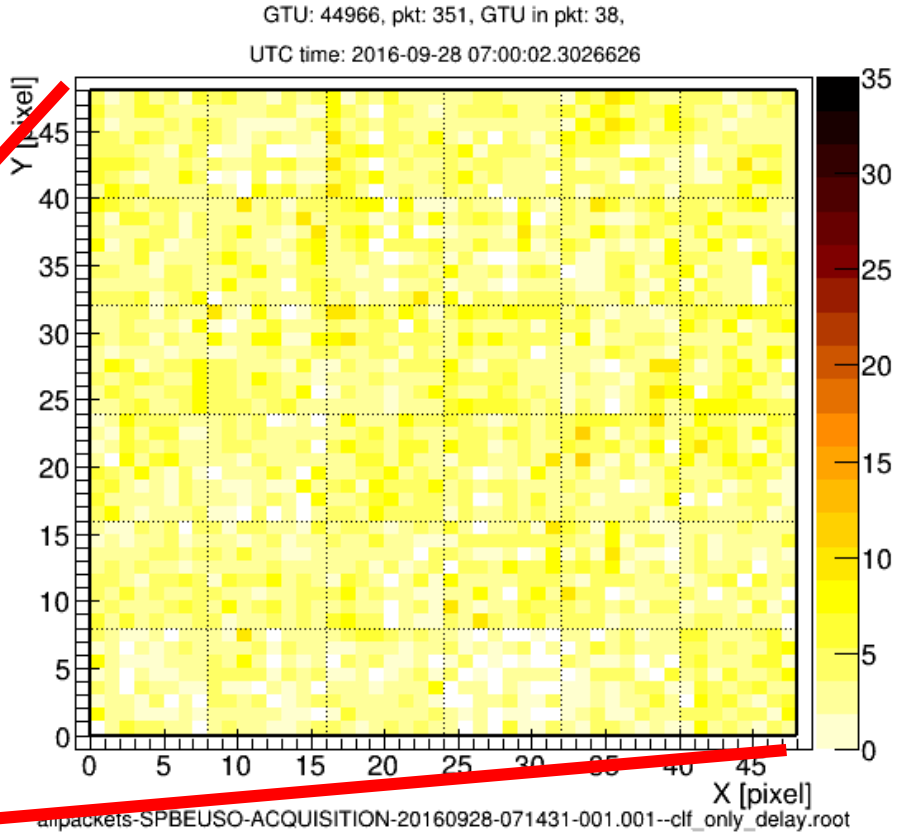
RIKEN
MINI-EUSO
Multiwavelength Imaging New Instrument
Extreme Universe Space Observatory
JEM-EUSO collaboration
PDM structure

Ground telescope

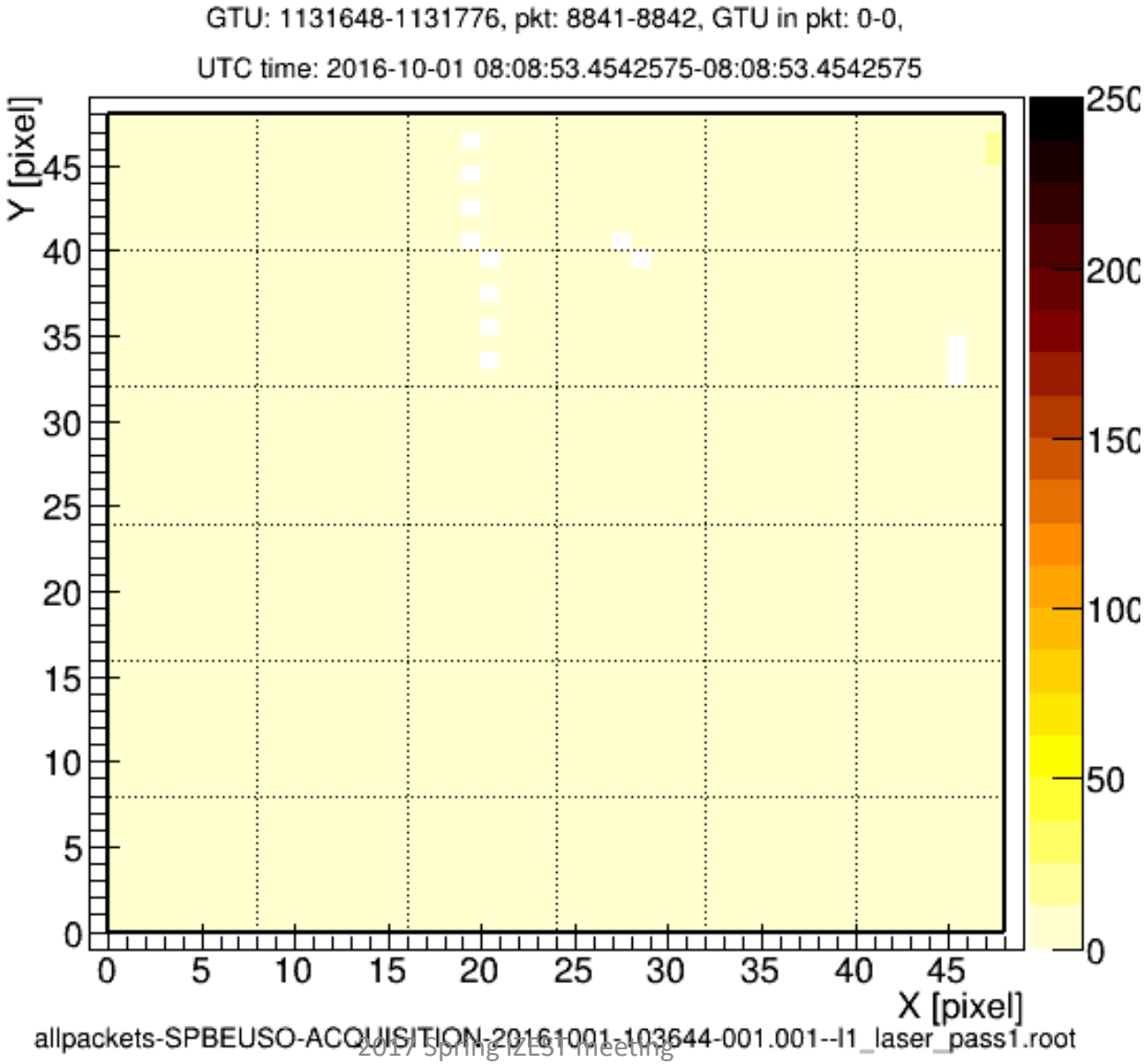
Detector





$\mathrm{GTU} = 2.5\ \mu\mathrm{s}$

Meteors


GTU: 1131648-1131776, pkt: 8841-8842, GTU in pkt: 0-0,
UTC time: 2016-10-01 08:08:53.4542575-08:08:53.4542575
Y [pixel]
X [pixel]
0
5
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30
35
40
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50
100
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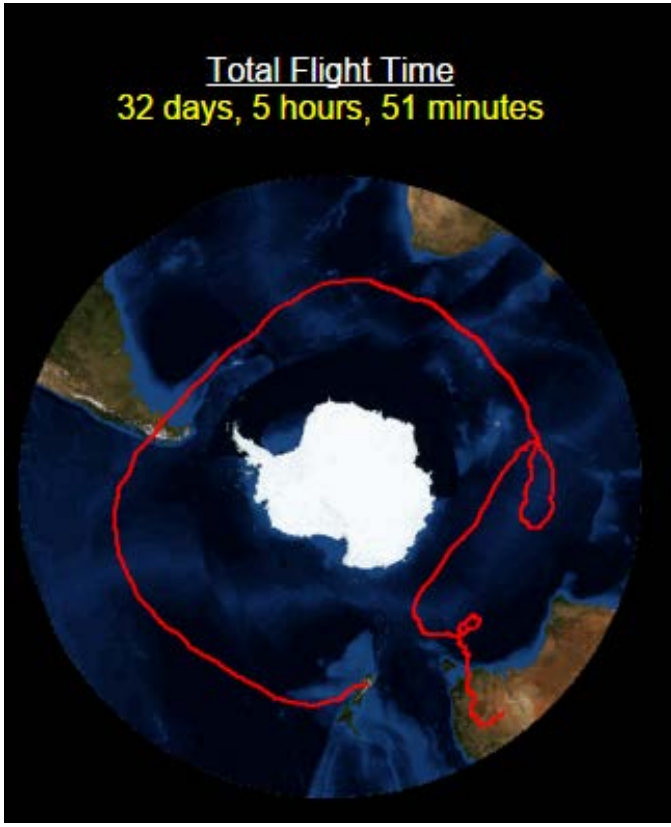
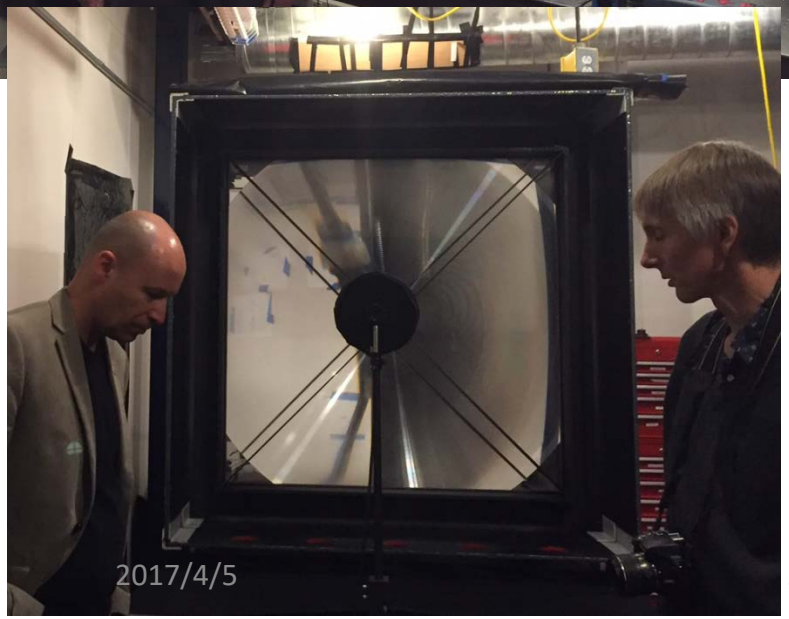
allpackets-SPBEUSO-ACQUISITION-20161001-103644-001.001--l1_laser_pass1.root

EUSO-Balloon 2nd flight, April 2017 Wanaka, New Zealand



NASA Mission. 2nd
Payload built by JEM-EUSO collaboration
New lenses, Focal Surface,
Improved Electronics
More than 30 days
Goal: First UV UHECR shower observation from above

y on a Super Pressure Balloon



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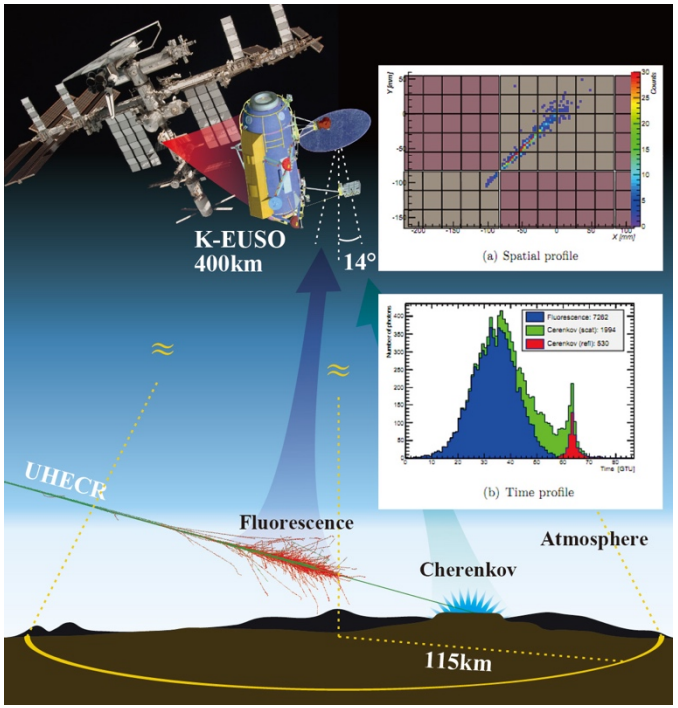
Technical demonstrator of Laser Removal
EUSO class telescope →KLYPVE/K-EUSO

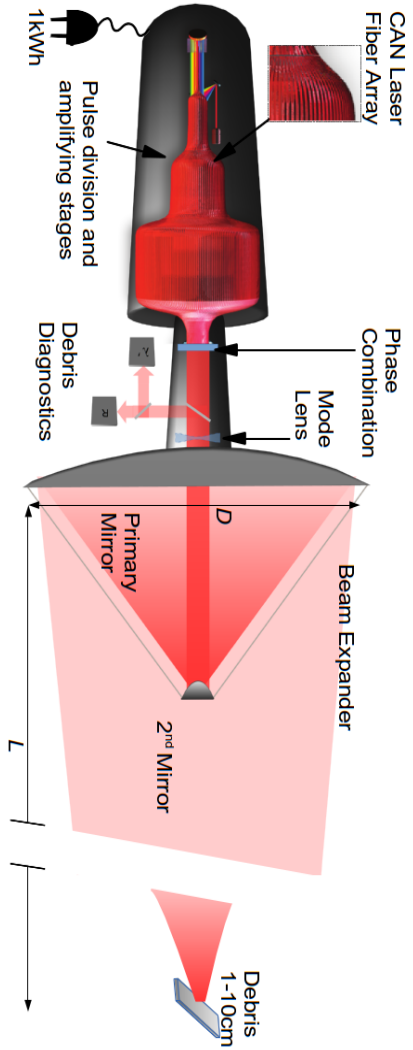
Space experiment step 2

Demonstration of the debris detection & de-orbiting using EUSO class telescope

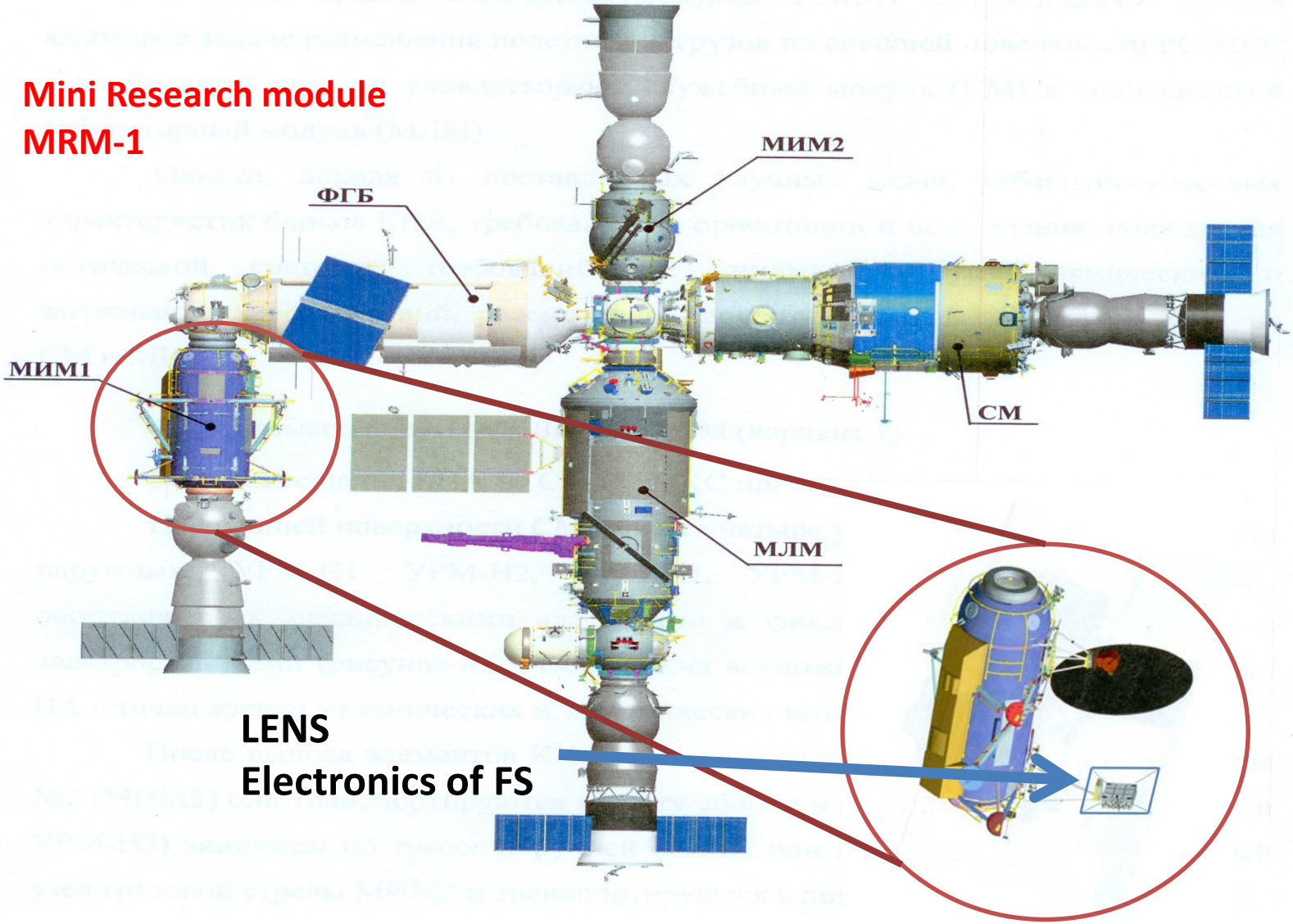
K-EUSO & Laser system



1.5 m Cassegrain for tracking CAN laser system



Location on ISS



Deployment module: MRM-1

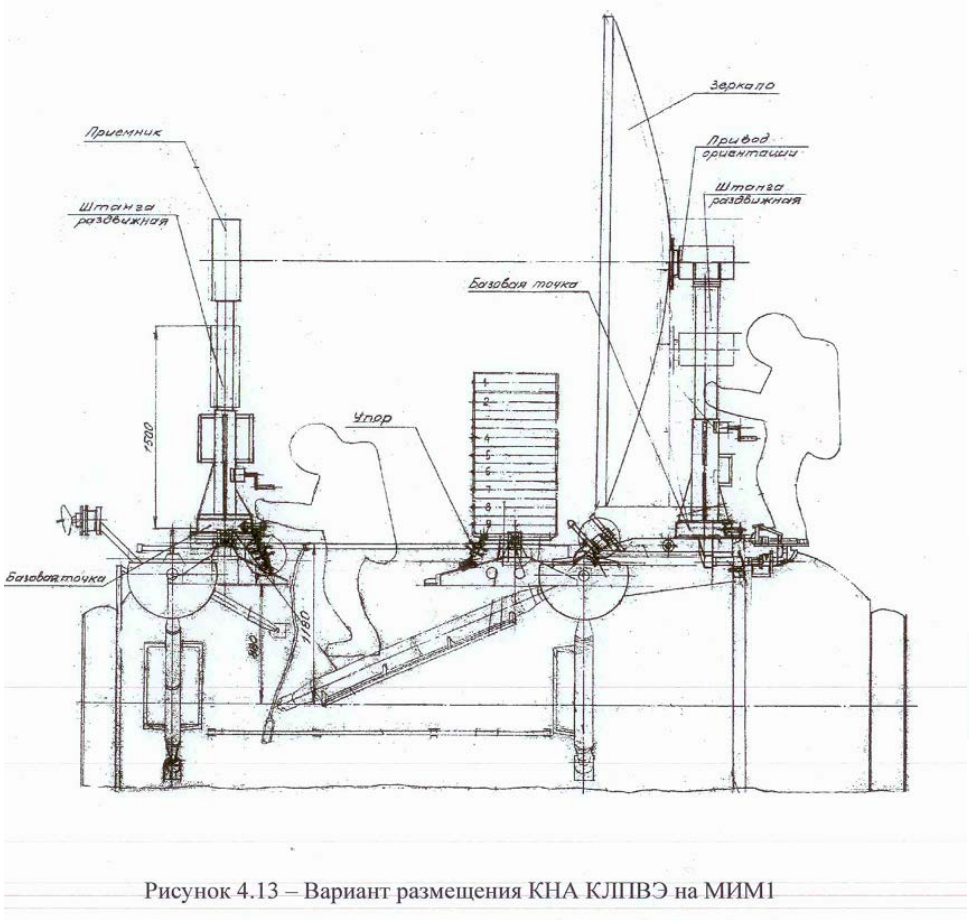
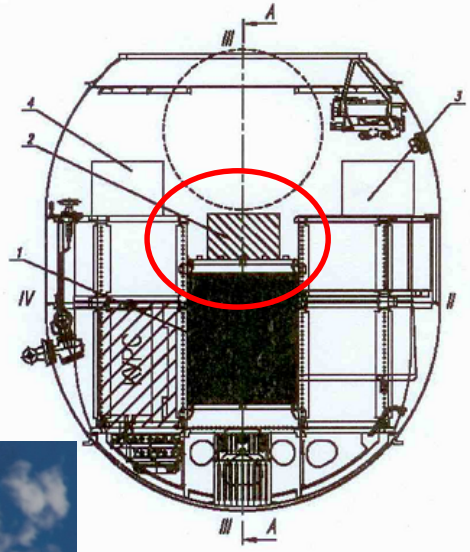
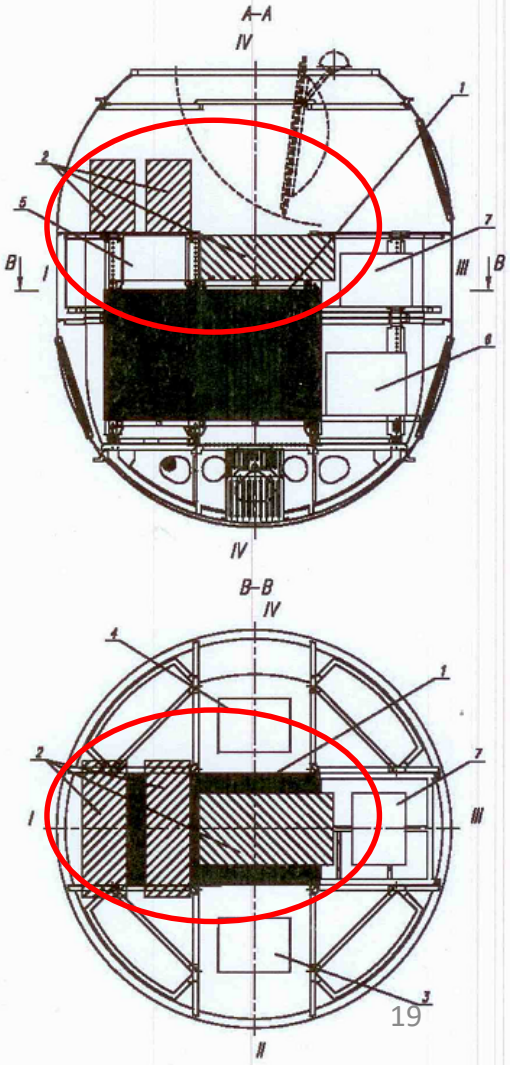


Рисунок 4.13 – Вариант размещения КНА КЛПВЭ на МИМ1

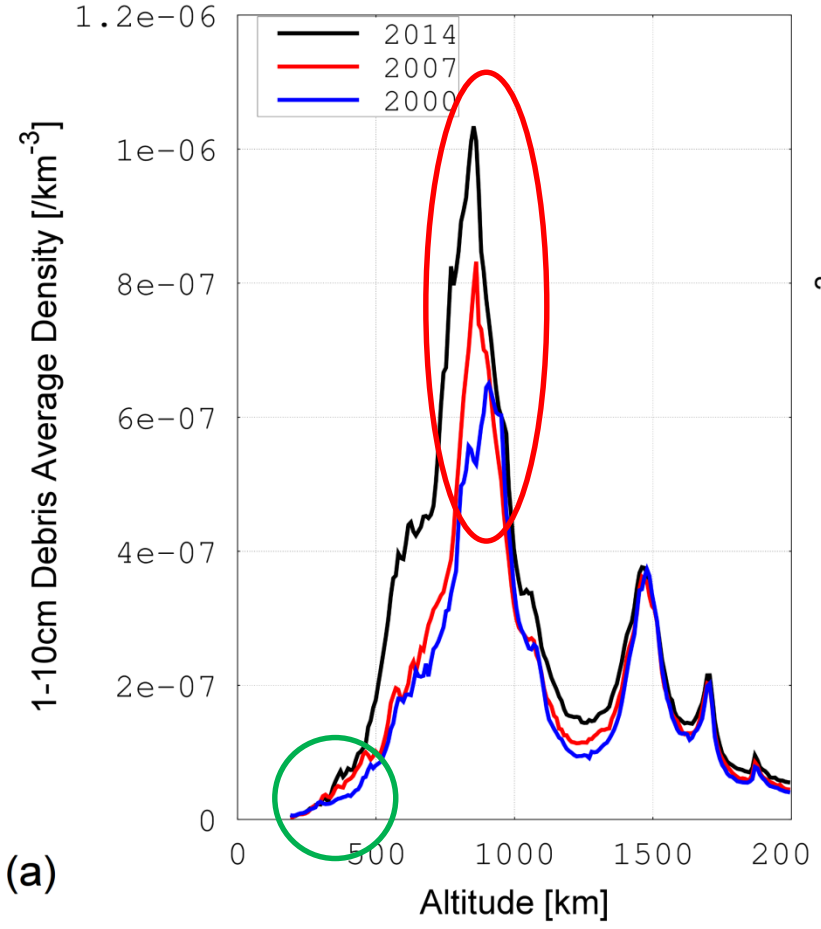
Allocation in Progress

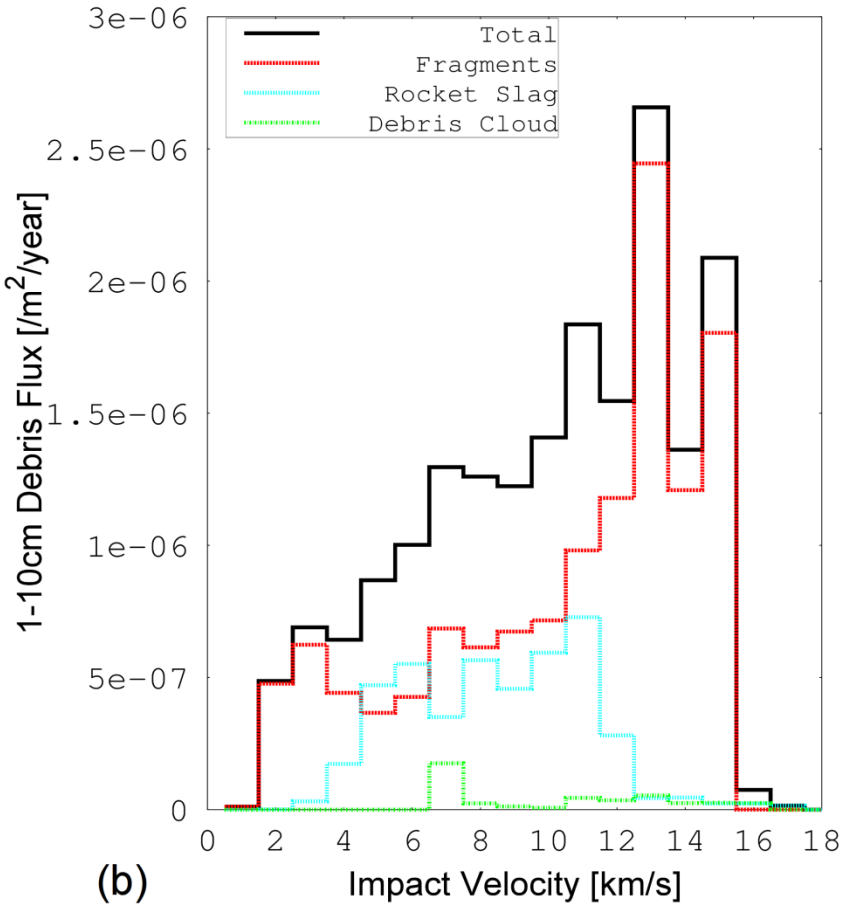
- Segmentation in 120*70*70 cm blocks





Space Debris





Dedicated Free Flyer mission

- Eccentric orbit with **altitude 900-600** km
- **Sun-synchronous**: inclination=98.3 degree
- **Always in twilight zone**

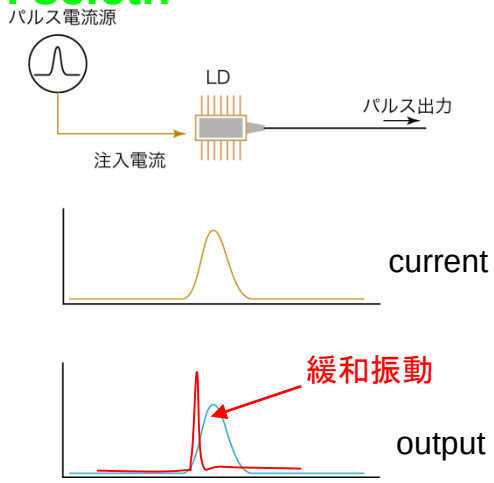
  Observe anti-sun direction
- 2.5 m **EUSO** + Space **CAN laser** (50-500 kW)
- Range: 50-100km
- 10^5 operation per year
- Significant fraction of

  the orbital debris (0.5m-10 cm) ～five years

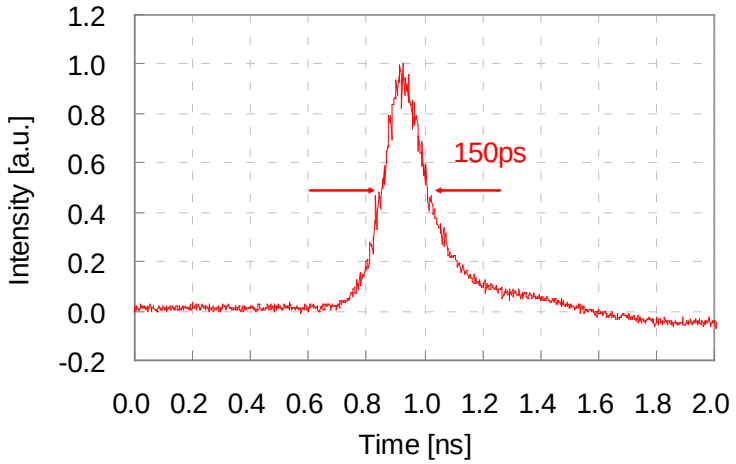
High Power laser Development for sapace in RIKEN

Pulse generation (achieved)

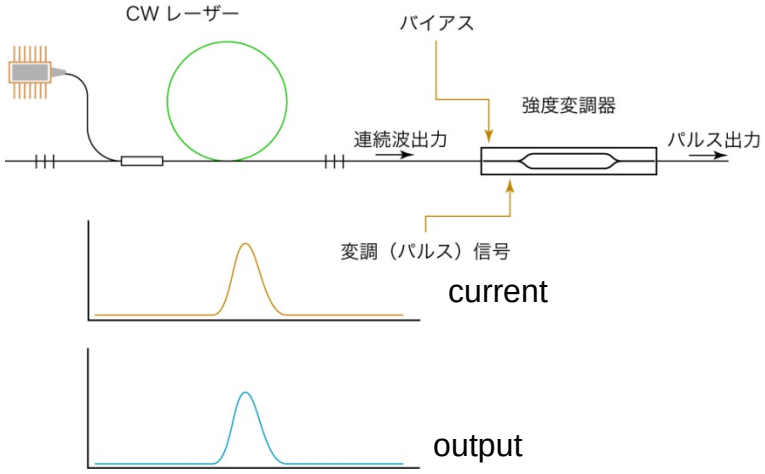
Gain seicth



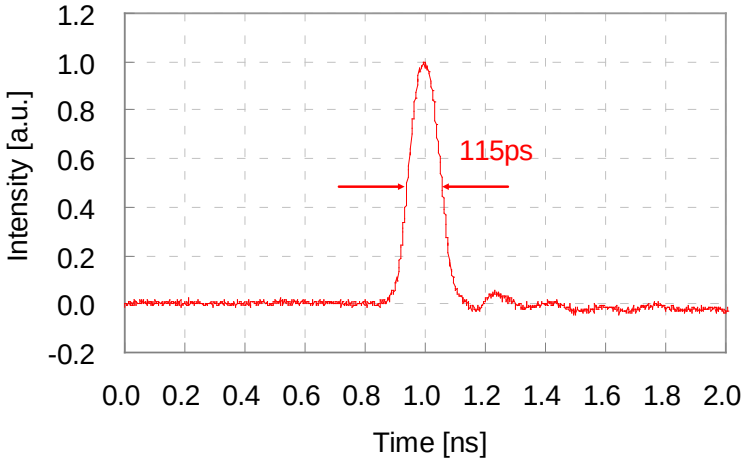
Pulse width : 150ps



Pulse selection



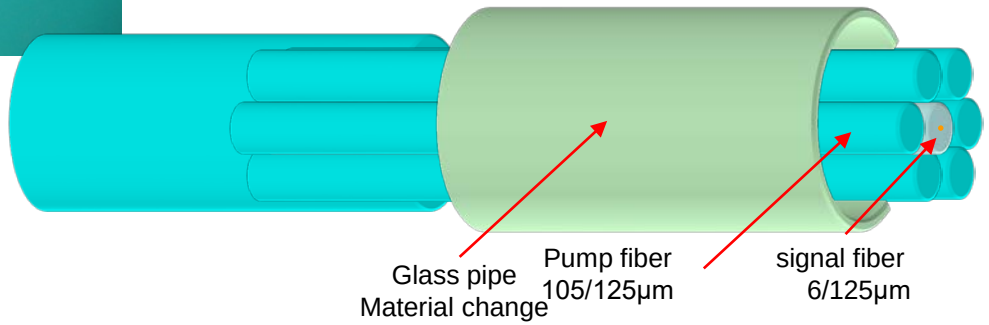
Pulse width : 115ps



Development of Pump unit.

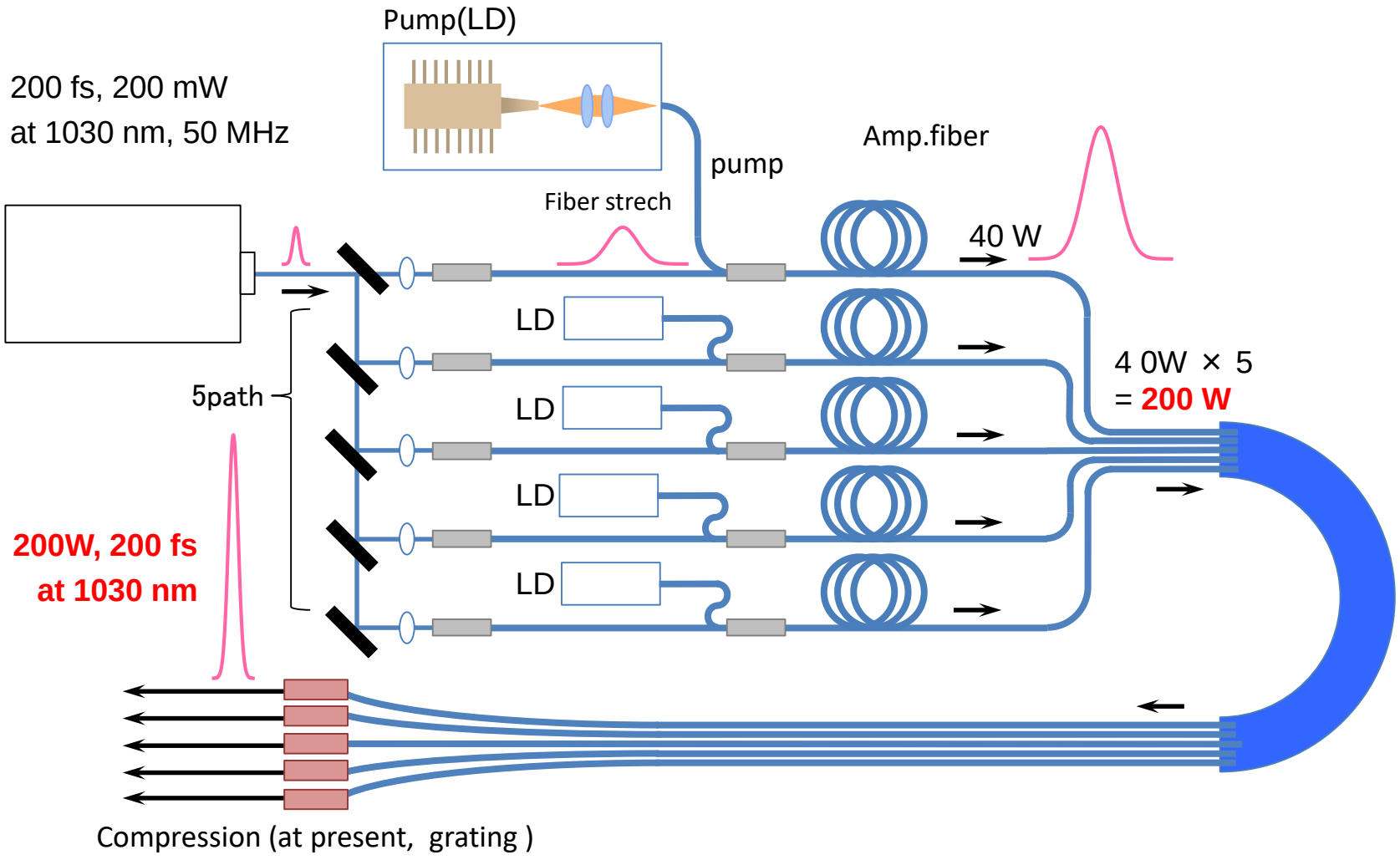
Model No.	NLC-FCM-SE-010/105-915-22A		
Fiber light output	Pf	W	10
Center Wavelength	λc	nm	910
Threshold current	Ith	A	1.05
Operating current	Iop	A	12
Operating voltage	Vop	V	1.79
Fiber core diameter	φcore	μm	105
Fiber clad diameter	φcore	μm	125
Fiber N.A.	---		0.22

2. Beam combiner（TFB）



Efficency >90%

200W, 200 fs, 1030 nm fiber laser



Summary

- Deorbiting space debris by laser ablation:

  10 cm or less

- Laser illumination from the spacecraft
  - **Detection** by EUSO telescope
    - Super wide-field（～60 degrees）, high-speed（micro-seconds）, and high sensitivity (one photon counting)
  - **Tracking**
  - **Illumination** by 1.5 m Cassegrain telescope with CAN laser
- Three-step approach
  - **Mini-EUSO**: demonstration of detection 2017 at ISS
    - Sponsored by Italian and Russian space agencies
  - **Balloon-EUSO**: detector demonstration in Balloon (Apr. 2017)
    - Sponsored by NASA
  - **K-EUSO**: demonstration of detection & deorbit at ISS
    - Selected at Russian space agency
  - **Dedicated Free-Flyer**: