IsCMOS camera of CALO

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Outline

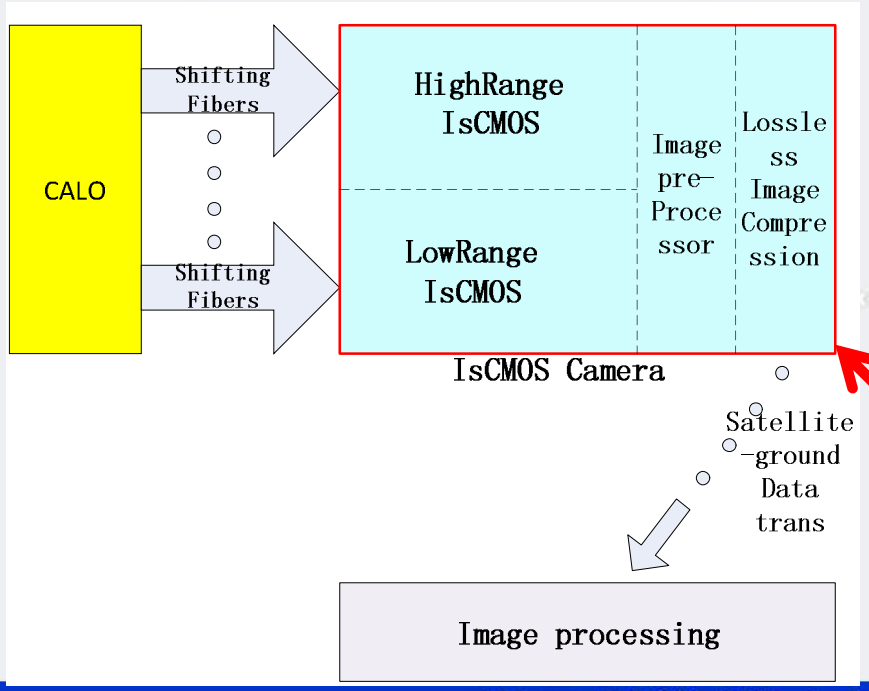
- What to detect?
- Why we choose IsCMOS?
- IsCMOS development review
- Improvement of IsCMOS 2018
- Design for the payload
- Next to do

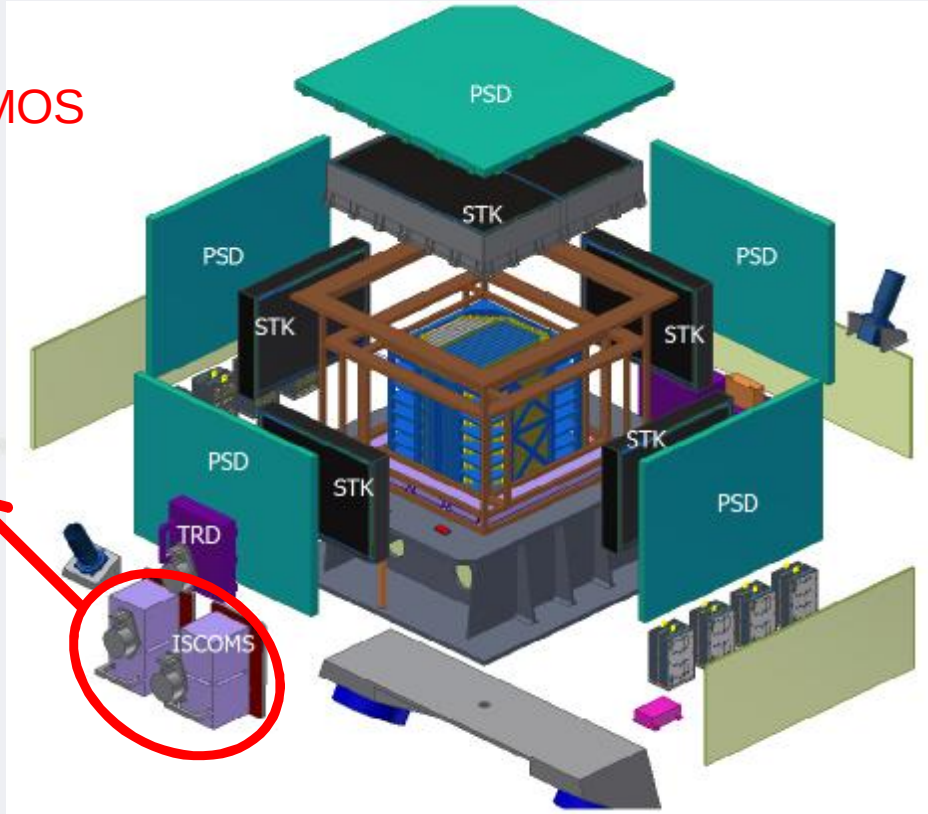
What to detect?

IsCMOS is the calorimeter's readout system of HERD.

About 7500 cubes of LYSO crystals，

2 outputs for every LYSO crystal to IsCMOS

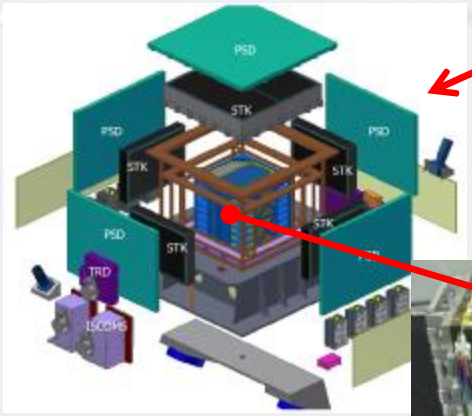


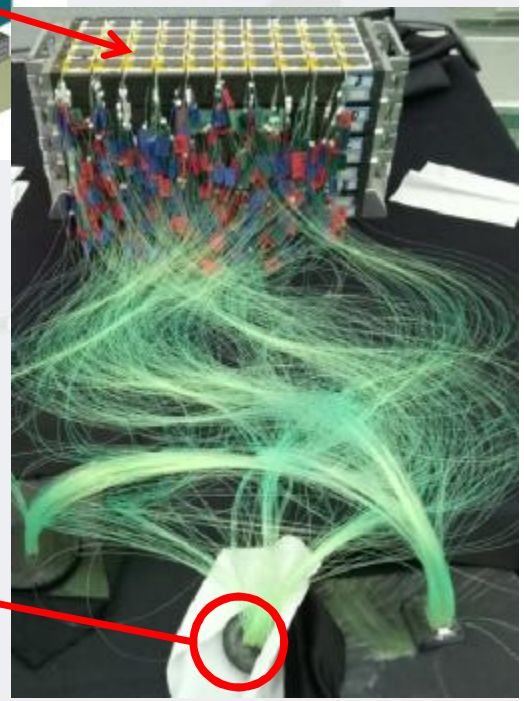


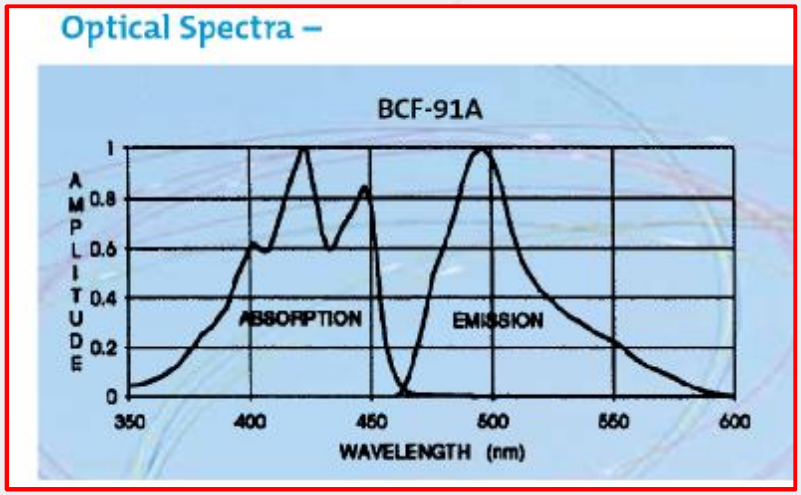
What to detect?

- Decay time of LYSO: 40ns
- Frequency of events: random
- Emission Wavelength of fiber: 450nm～600nm
- Diameter of fiber: 0.3mm
- Numerical Aperture of fiber : 0.74

Super Fast, sometimes Weak, and large energy range.







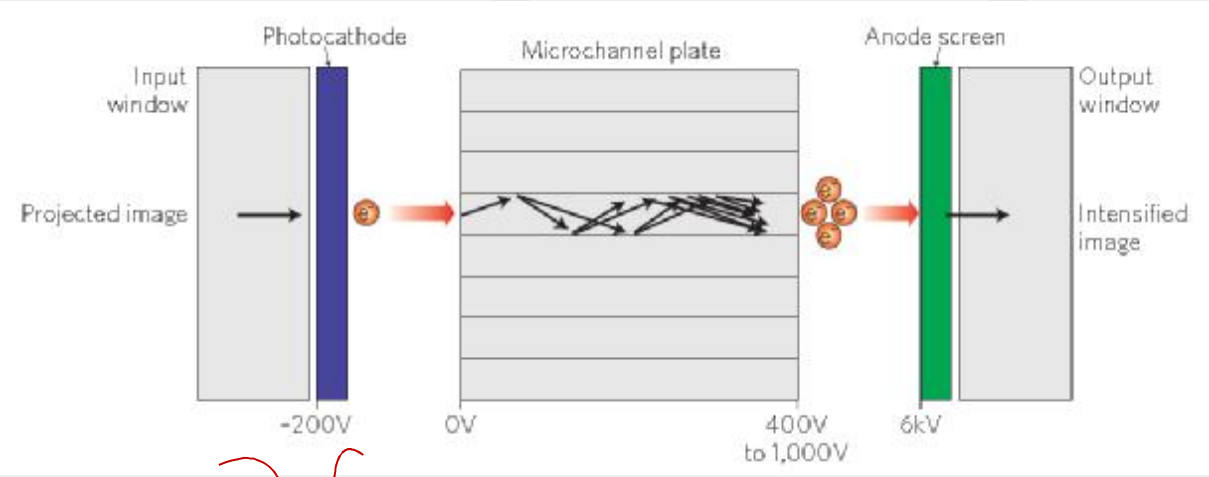
What to detect?

Requirements :

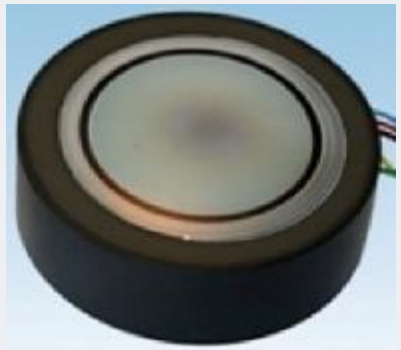
- **Spectral response range:** 450nm～600nm
- **Energy resolution:** 1%@200 GeV
- **Max frame rate:** ≥500fps
- **Dynamic range：** $\geq 5\times10^3$

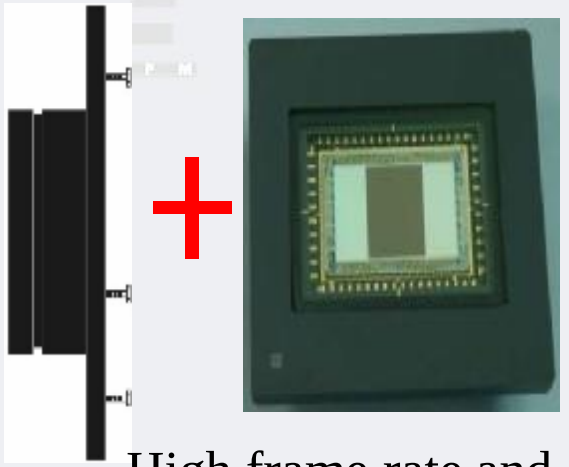
Why we choose IsCMOS?

The key devices are **Image Intensifier** and **Detector(sCMOS).**

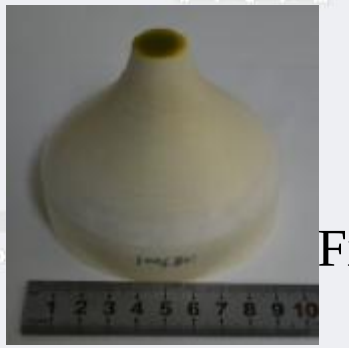


Cathode Gated Intensifier



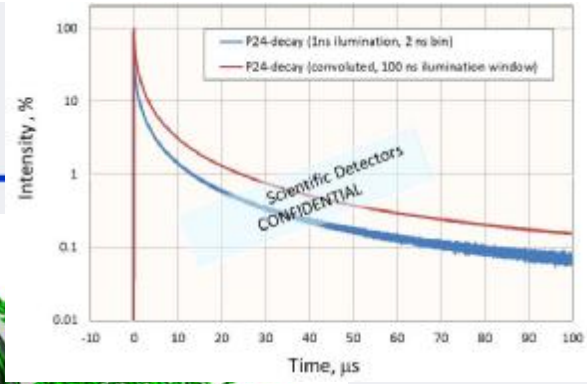


High frame rate and large area sCMOS

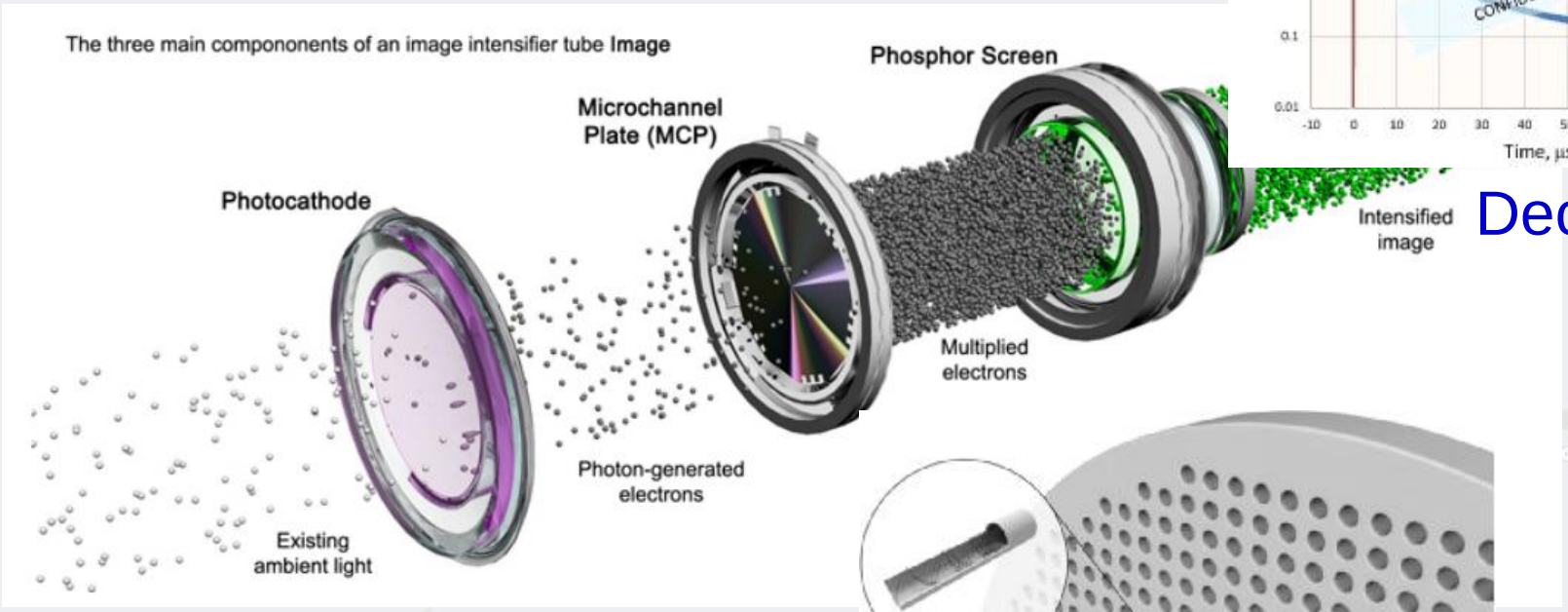


Fiber optical taper

Why we choose IsCMOS?

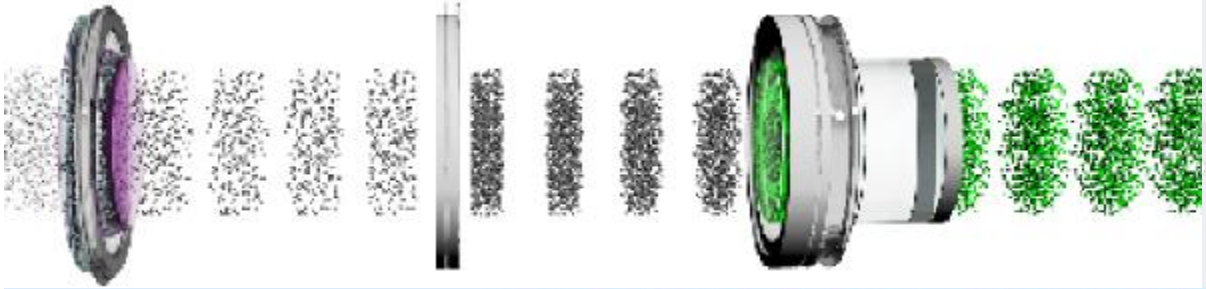


Decay time



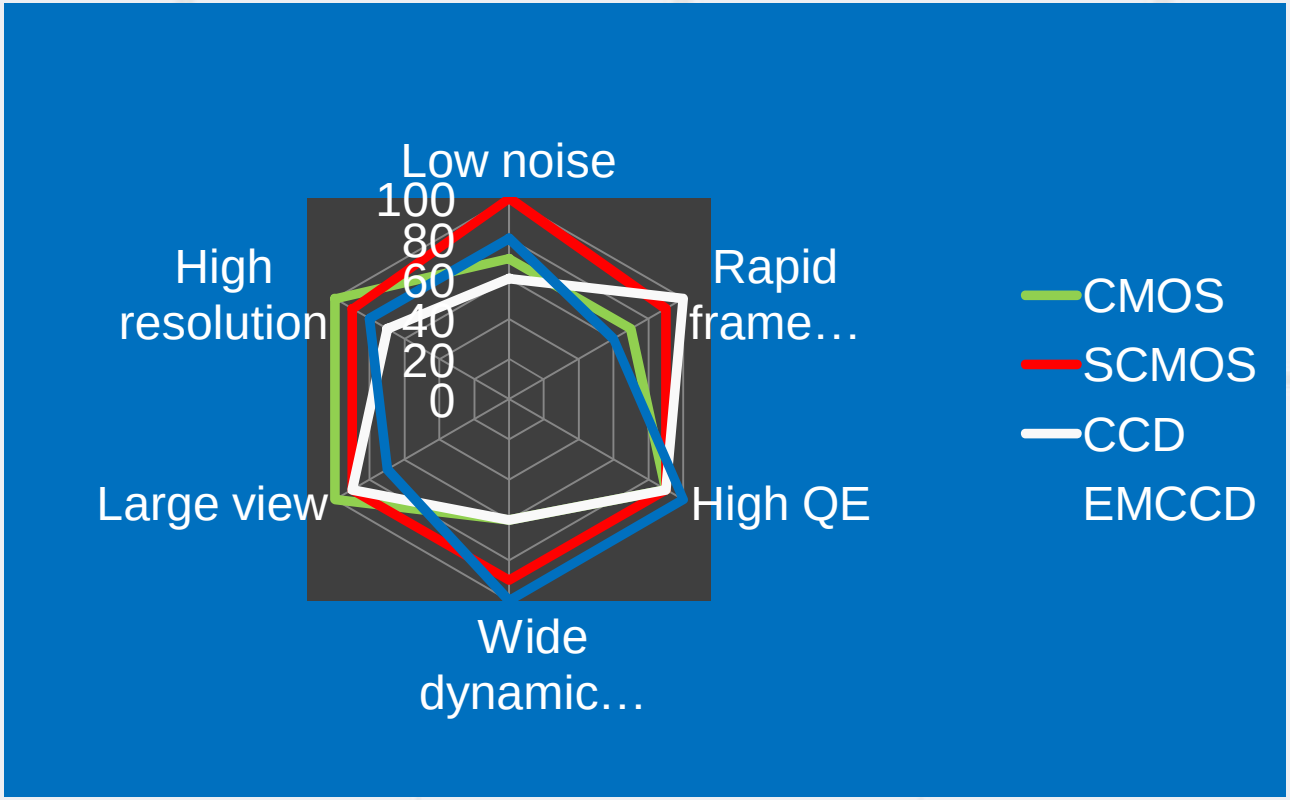
Amplifier

Gated for photocathode



Why we choose IsCMOS?

Why's sCMOS?



Advantage of previous generations of CMOS, EMCCD and CCD-based sensors, SCMOS is uniquely capable of **simultaneously** offering:

※ Extremely low noise ※ Rapid frame rates ※ High quantum efficiency (QE)
※ Wide dynamic range ※ Large field of view ※ High resolution

IsCMOS Development review

2012-optical relay

- Merits: good resolution，no contact with detector
- Demerits: Low transmission efficiency, too larg size and weight

2013-taper coupled 1 gen.

- Merits: higher transmission efficiency, small size.
- Demerits: worse distortion, need contact, CCD window is hard to remove.

2014-taper coupled 2 gen.

- Merits: smaller size and lower weight
- Demerits: CCD window is hard to remove. Frame frequency is low

2015-taper coupled 3 gen.

Merits: CCD window with no window,. Frame frequency is ok

Demerits: without electronic shutter. Pixel size is too large.

2017-taper coupled 4 gen(IsCMOS).

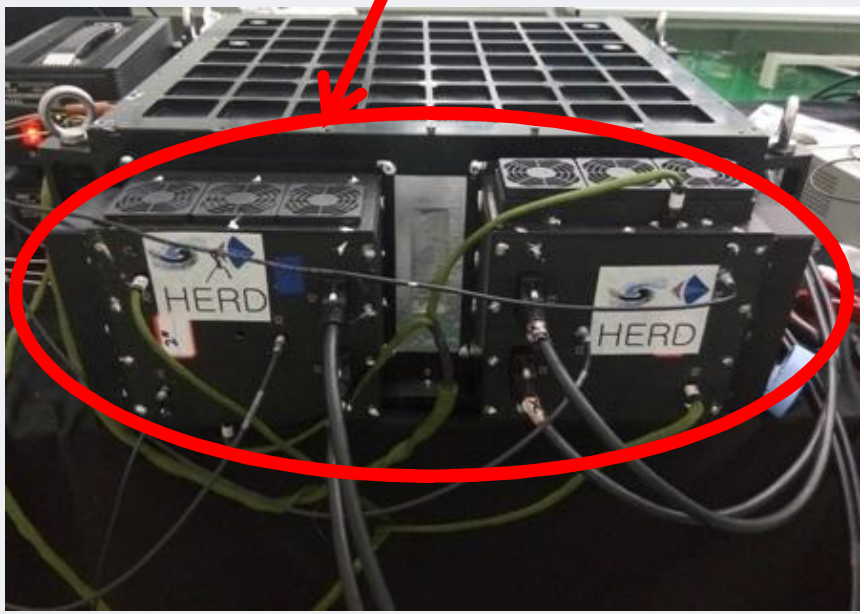
Merits: have electronic shutter, low noise, thermal control, better coupling technology

Demerits: not full use of focal plane, mass data

Beam test

2015.11.01-11.26 done
Beam test at CERN successfully.

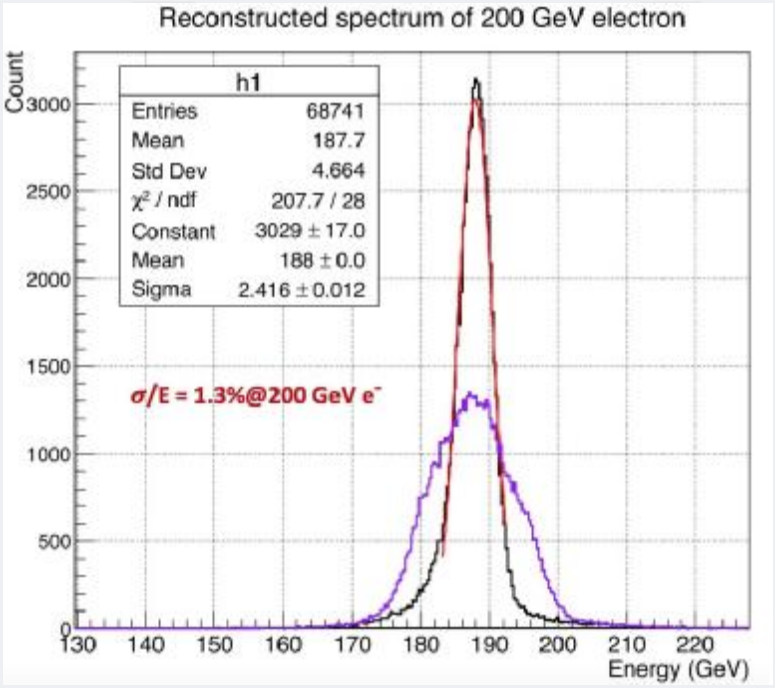
Energy resolution 2%@100 GeV (1 sigma)



Beam test

2017.10.02-11.01 done
Beam test at CERN successfully.

Energy resolution 1.3%@200 GeV



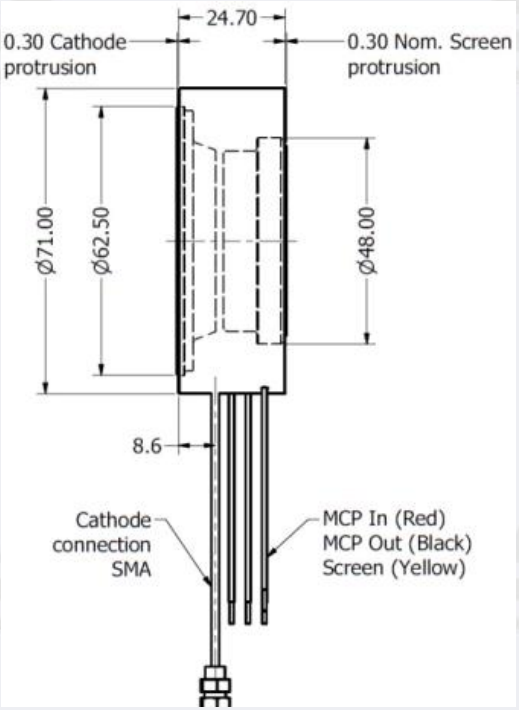
Improvement of IsCMOS 2018

Improve electronic design---more sensitive, faster response, less noise and stronger data processing capability.

Improve I.I.---design a new High-Voltage-Unit with super stabilization to avoid unexpected noise result from unstable high voltage source.

I.I. ---MCP140

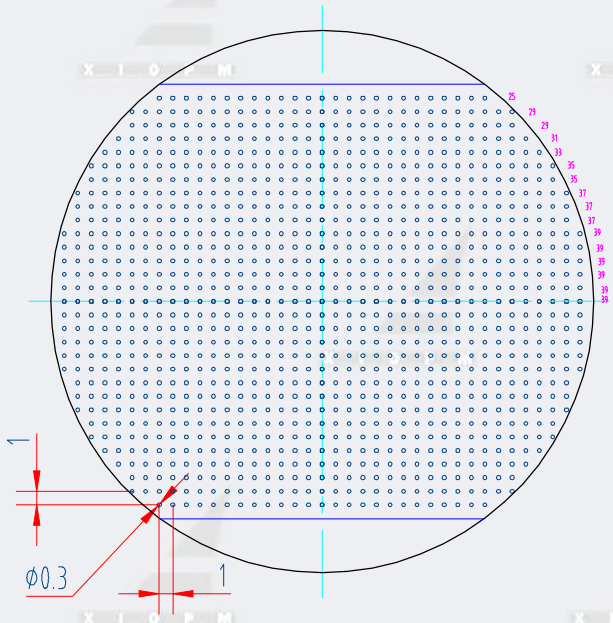
- Dia.: 40mm
- Photocathode: S20
- Phosphor Screen: P20
- MCP: 1



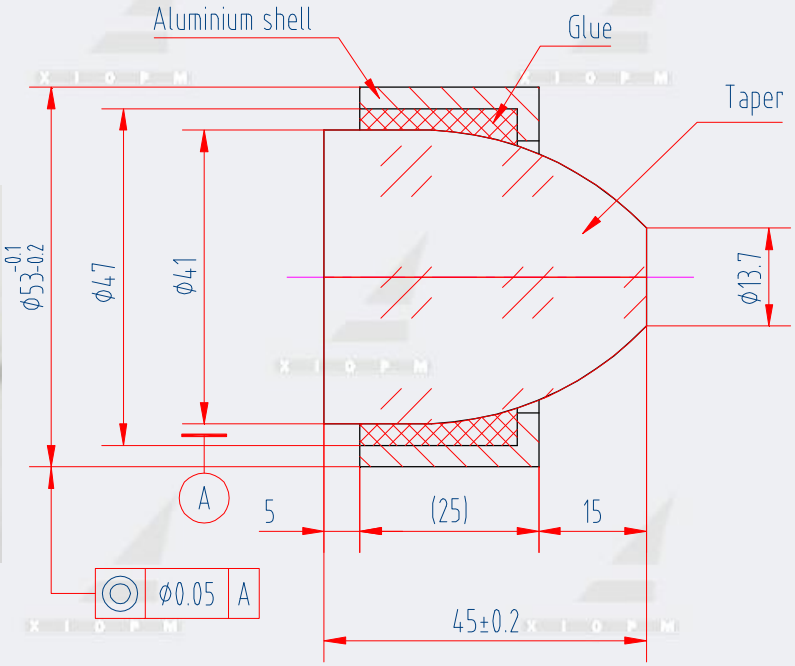
Improvement of IsCMOS 2018

Enlarge the active area of the input size to contain 500 WSFs(two optical taper).

Adjust the parameters of optical taper and **coupling technology** to improve energy efficiency.



about 1085 fibers



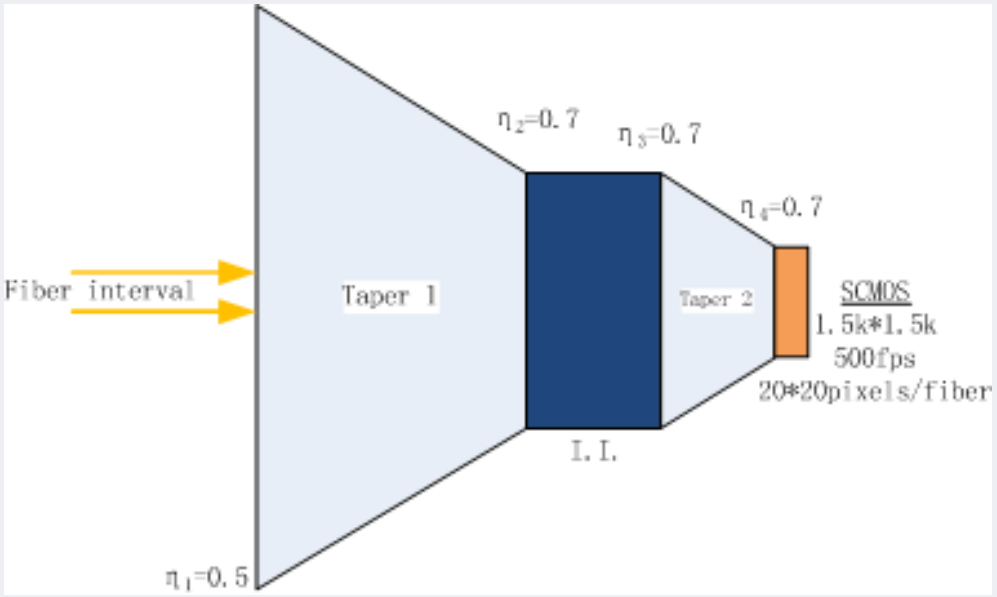
Design for the payload

Energy transmission efficiency

Size of Selected Devices

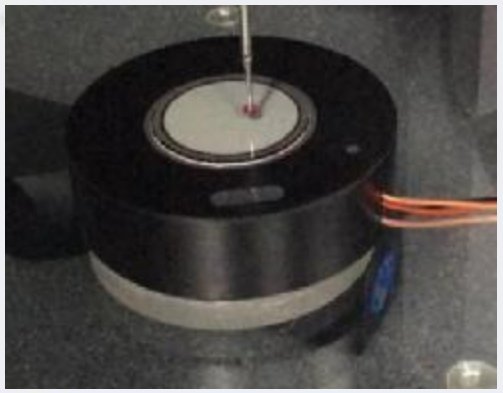
Performance of Selected Devices

Number of Coupled WLSF



About 7,500 LYSO crystals, each IsCMOS should be coupled about 3,750 fibers.

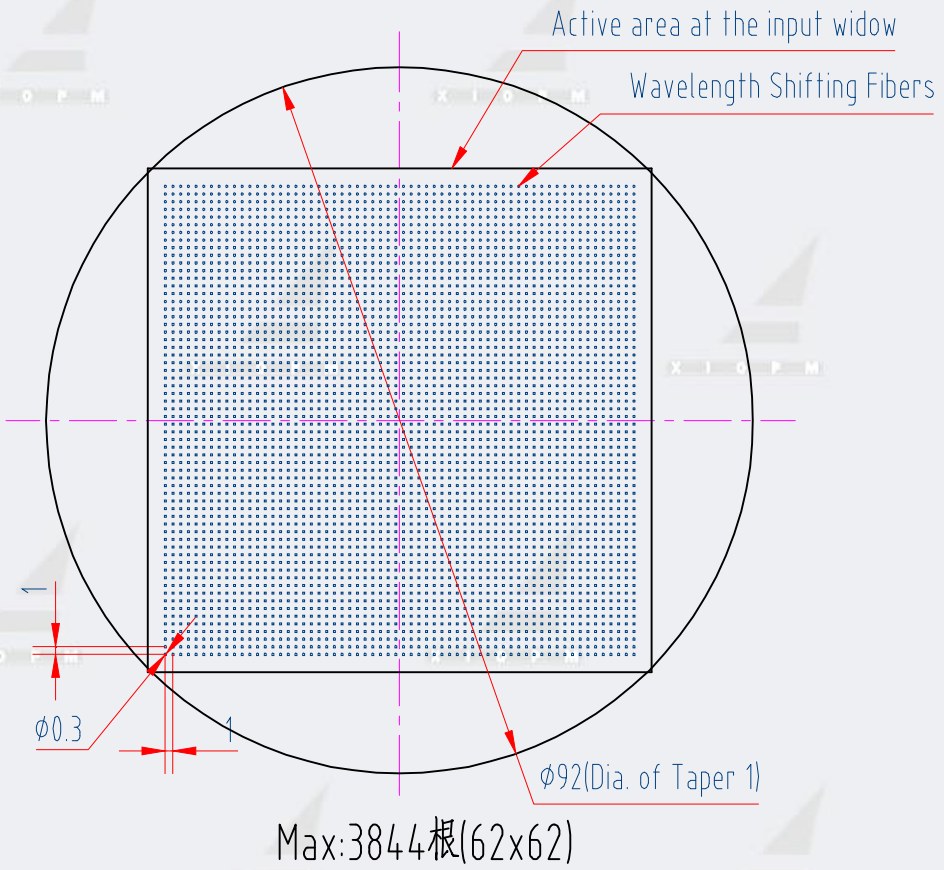
Taper1: φ92 (2.3:1)
Taper2: φ40 (1.8:1)
Total ratio: 4.14:1



Design for the payload

The design of layout number of optical fibers at the input Taper(92mm) is about **3844**. The distance between each fiber is 1mm at the input surface of first optical fiber.

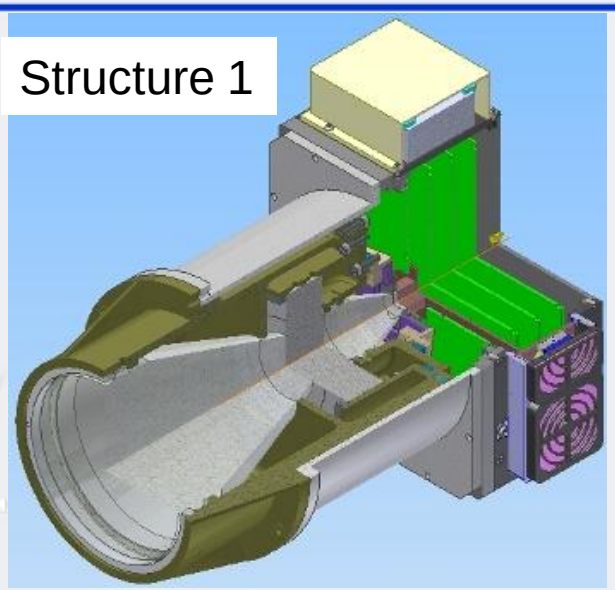
3844 fibers per camera, fps: 500, fiber distance: 1mm, dia. of fiber: 0.3mm	
Dia. Of Taper 1(mm)	92
Ratio of Taper 1	2.3:1
Dia. Of I.I.(mm)	MCP40
Dia. Of Taper 2(mm)	40
Ratio of Taper 2	1.8:1
Active pixels of SCMOS	1320×1320
Size of pixel(μm)	12

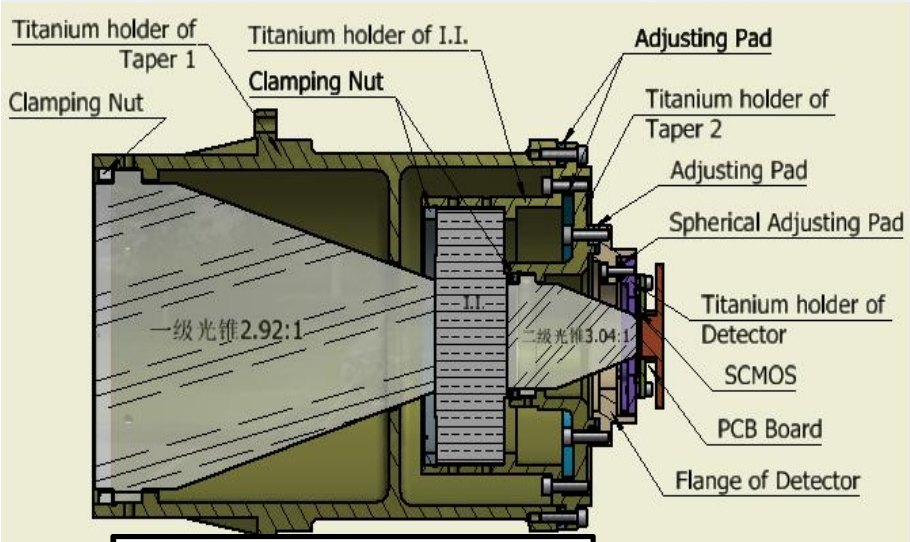


Design for the payload

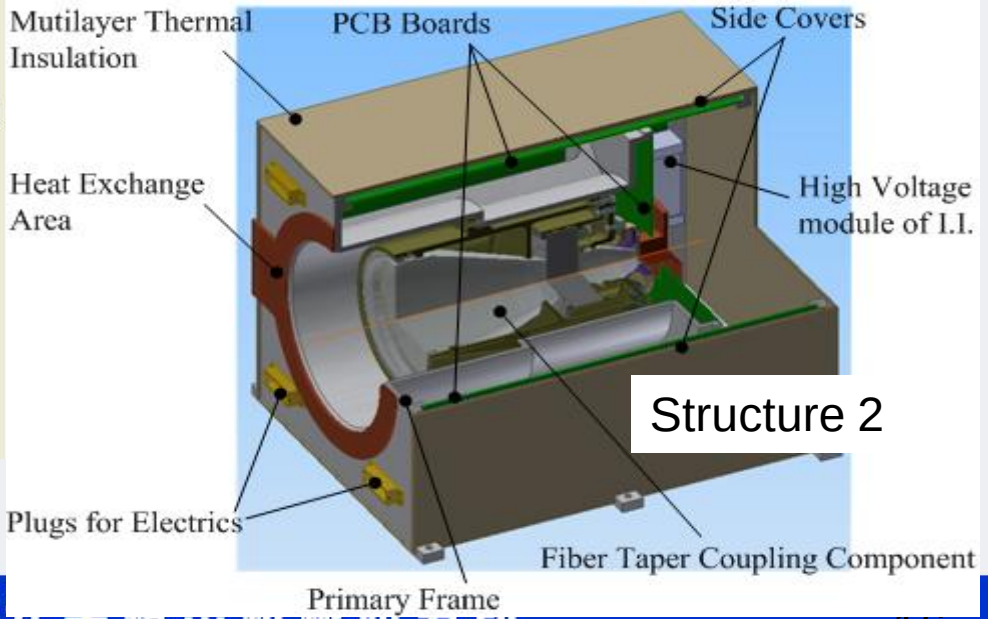
- Size: 300mm(W)*300mm(H)*400mm(L)
- Weight: ~12kg
- Power consumption: ~9mW/channel

electronic connectors and thermal exchange pads located in front panel





Taper Coupling Unit.

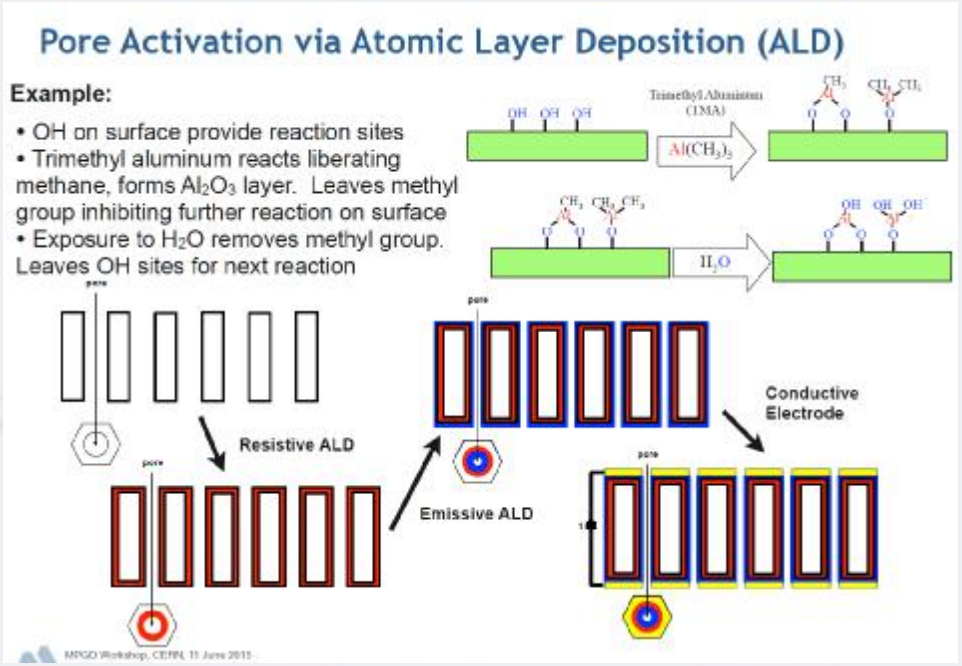


Design for the payload

Improve the performance of ISCMOS

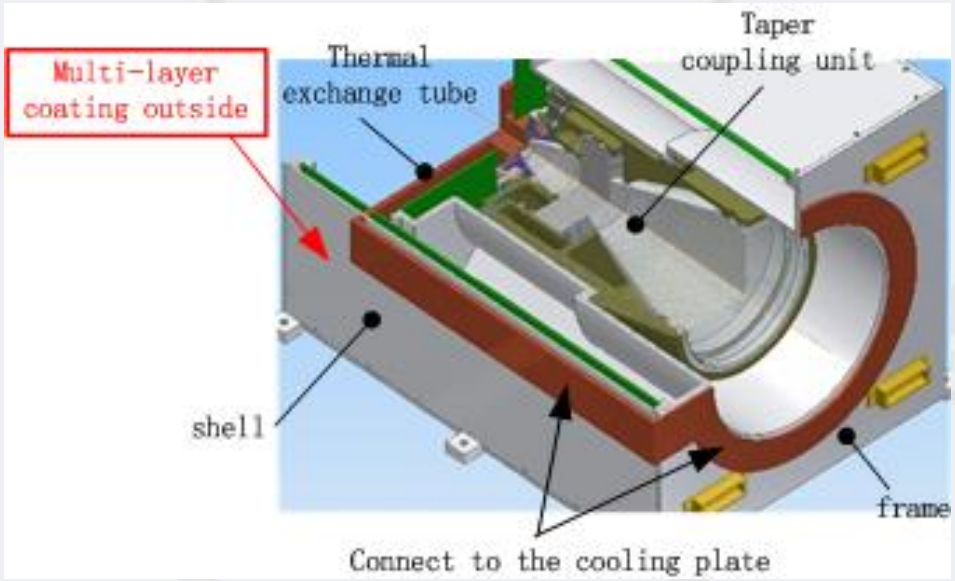
- Customized SCMOS and I.I. make dynamic range of IsCMOS ≧5E3
- Choose Phosphor Screen with faster decay time(P24– 100us)

Next generation： ALD-MCP IIT
R&D
10^5 Dynamic Range MCP: ALD Technology

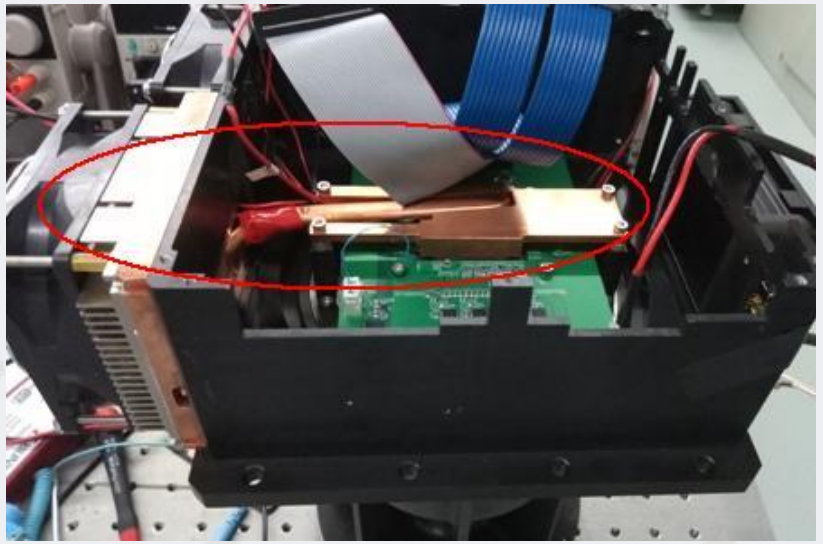


Design for the payload

- Cooling sCMOS passively by high effective heat exchange tube , which is connected with the cooling plate of HERD.



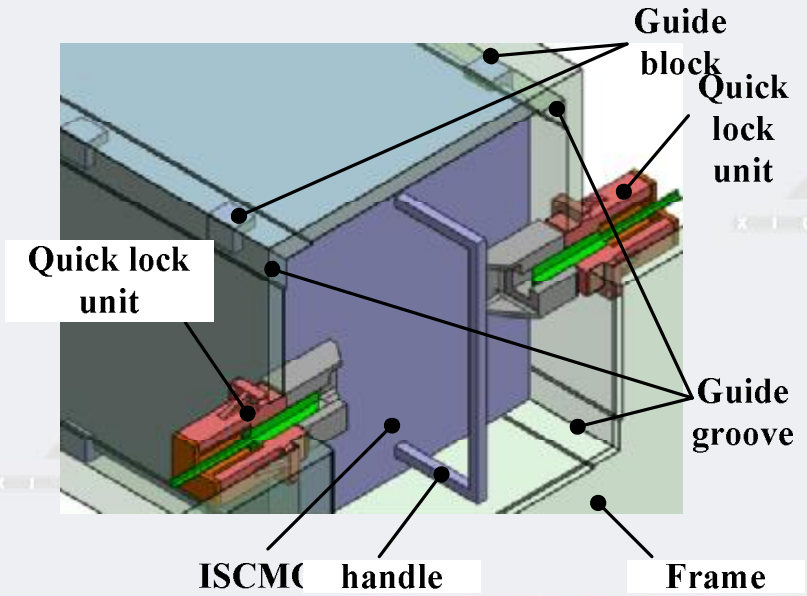
Thermal control in 2017 test

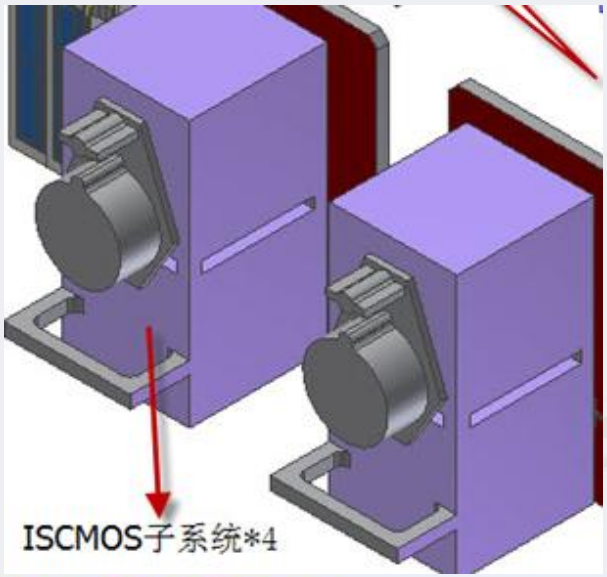


Design for the payload

- Limited by lifetime of I.I., the cameras will be replaced on the orbit.
  - The whole structure of ISCMOS should be easy to replace.
  - Connector(including mechanics, electronics, data transmission and thermal exchange) should be simple and reliable.
  - How to coupling with WSFs and how to lock and unlock rapidly and reliably for astronaut?

Need more cooperation with other teams!





Next to do

- Last beam test in CERN in 2018
- Detailed design of IsCMOS for payload

THANKS!