中国空间技术研究院总体部
中国航天 Institute of Spacecraft System Engineering, CAST

Preliminary Design of the eXTP Satellite

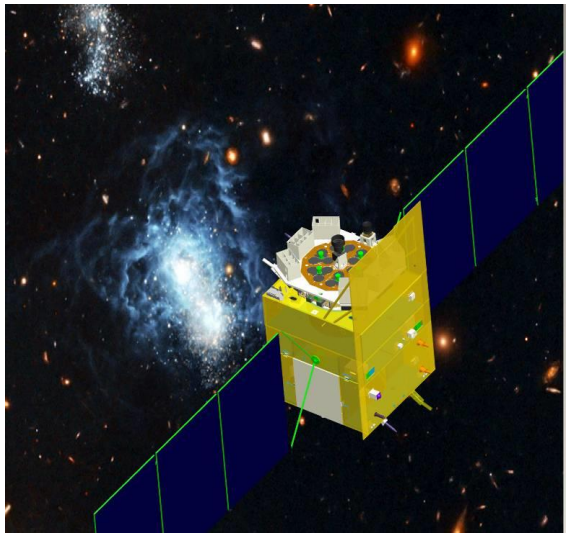
Institute of Spacecraft System Engineering , CAST

Feb 6th , 2017

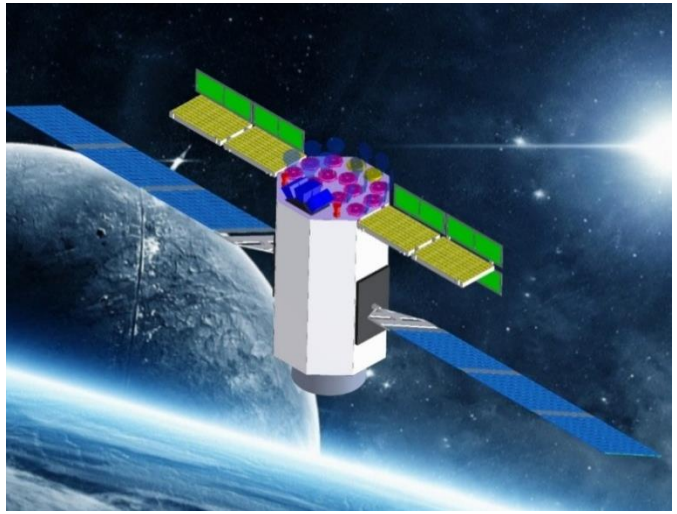
CONTENTS

1. General Description

- **eXTP** , the enhanced X-ray Timing and Polarimetry mission, is a science mission designed to study the state of matter under extreme conditions of density , gravity , and magnetism.
- The planed launch date of the mission is earlier than 2025.
- The next generation of the X-ray detected telescope after **HXMT** in China . The **HXMT** will be launched in the mid-year**, 2017**.



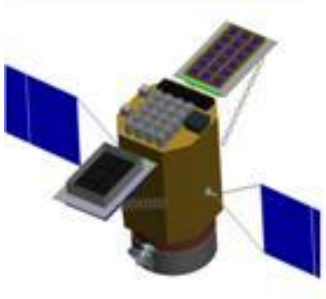
HXMT



eXTP

2. Design Evolution

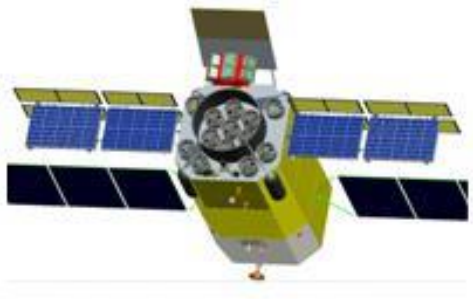
- 2007 The conception of XTP was put forward by IHEP;
- 2008-2012 An advanced research of the XTP was carried out by ISSE;
- 2013-2014 Completed the system analysis and achieved the mission's basic parameters . The first step design of the XTP was finished;
- 2015-2016 With the LAD and WFM adding into the XTP and the parameters of SFA & PFA has changed，redesigned the eXTP satellite;



XTP(2008~2012)
LM-3C/LM-5
4000~4500kg
HFA/LFA/HCA/LCA/
XPT/ACM

XTP(2014)
LM-3C
3000kg
HFA(5)/LFA(10)/WFC
HFA-FL : 5500mm
LFA-FL : 4500mm

eXTP(2015)
LM-3C
3500kg
HFA(5)/LFA(10)
LAD(20)/WFC
HFA-FL : 5500mm
LFA-FL : 4500mm



eXTP(2015-2016)
LM-3C
3500kg
SFA(11)/PFA(2)
LAD(40)/WFM(3pair)
SFA-FL : 4500mm
PFA-FL : 4500mm

3. Basic Parameters

Orbit		550km,28deg or 14deg (0 deg)
Launch vehicle		LM-3C (LM-7)
SC dimensions	Launch configuration	3608mm×3370mm×6330mm
	In orbit configuration	4737mm×16781mm×6330mm
Mass	Launch Mass	3500 kg
	Margin	310 kg
Power	Max demand	2400 W
	Solar array	35 m^2
Communication	Frequency Band	Ka-band
	Data Volume	3.2 Tb per day
	Data Rate	2250 Mbps
Control system	Accuracy of attitude pointing	< 0.01° (3σ)
	Accuracy of attitude measurement	< 0.002° (3σ)
	Attitude Stabilization	0.005°/s(3σ)
Mission duration		5 years (10 years)

4. Preliminary Design

➢ Launch Site

- There are four launch centers in China，**JSLC**，**TSLC**，**XSLC**，**WSLC**.

➢ Telemetry and Control system

- The TC system applies the international USB system . Low tilt angle communication is achieved through utilizing relay satellites or building new TC station.

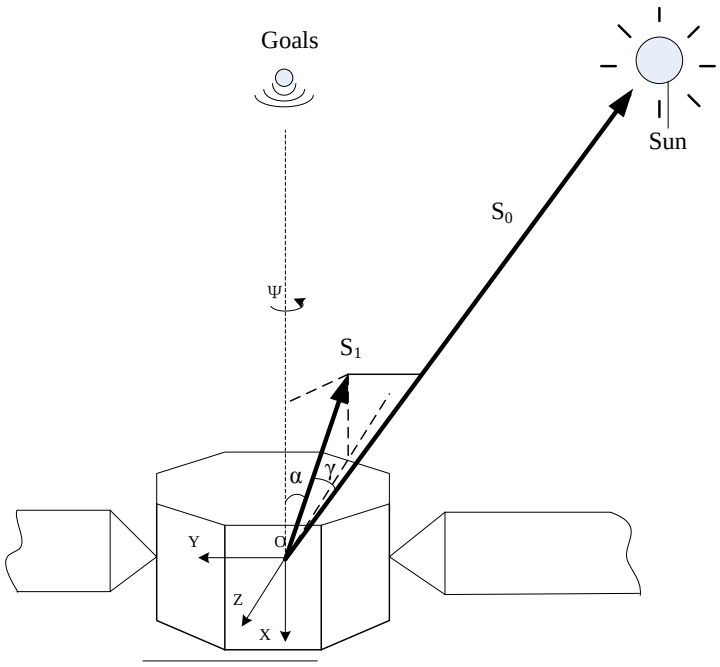
➢ Satellite ground application system

- Data receiving is achieved by stations at Sanya. Or using the ground station at Malindi (3°S Kenya), built by Italian (LOFT team).

4. Preliminary Design

➢ Observation Mode

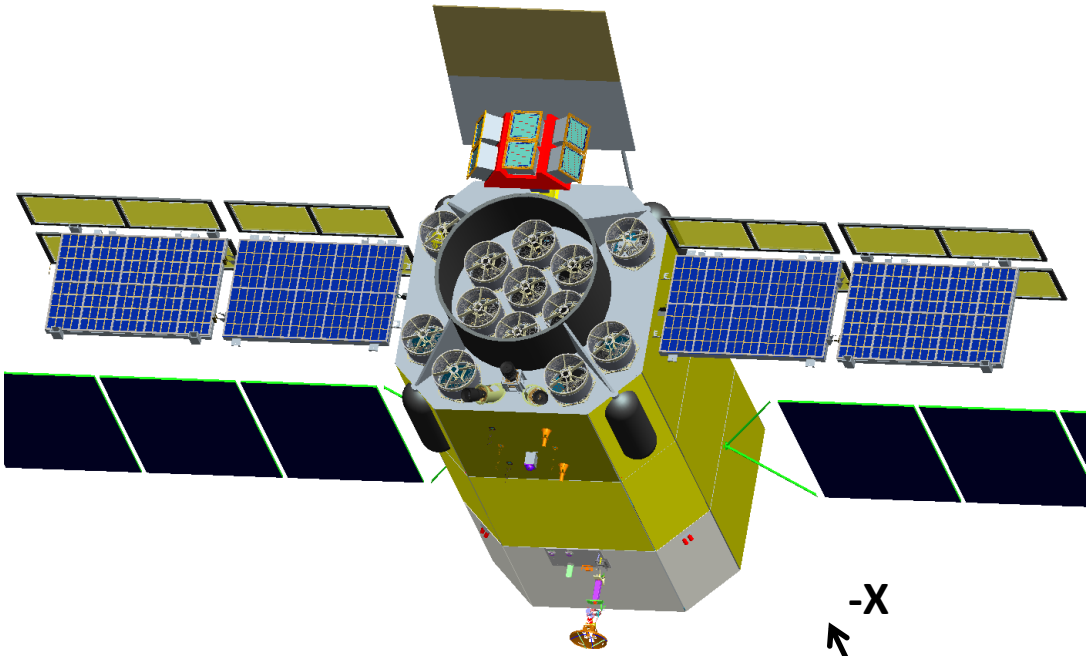
- The –X axis point to the specific goals in the inertial space ;
- The sun vector is controlled in XOZ plane and in a obtuse angle with the +Z axis ;
- The sun vector will perpendicular to the solar array by rotate it ;
- According to the user’ s observation plan to carry out attitude maneuver , aiming at the goals to carry on the observation.



4. Preliminary Design

➢ Configuration

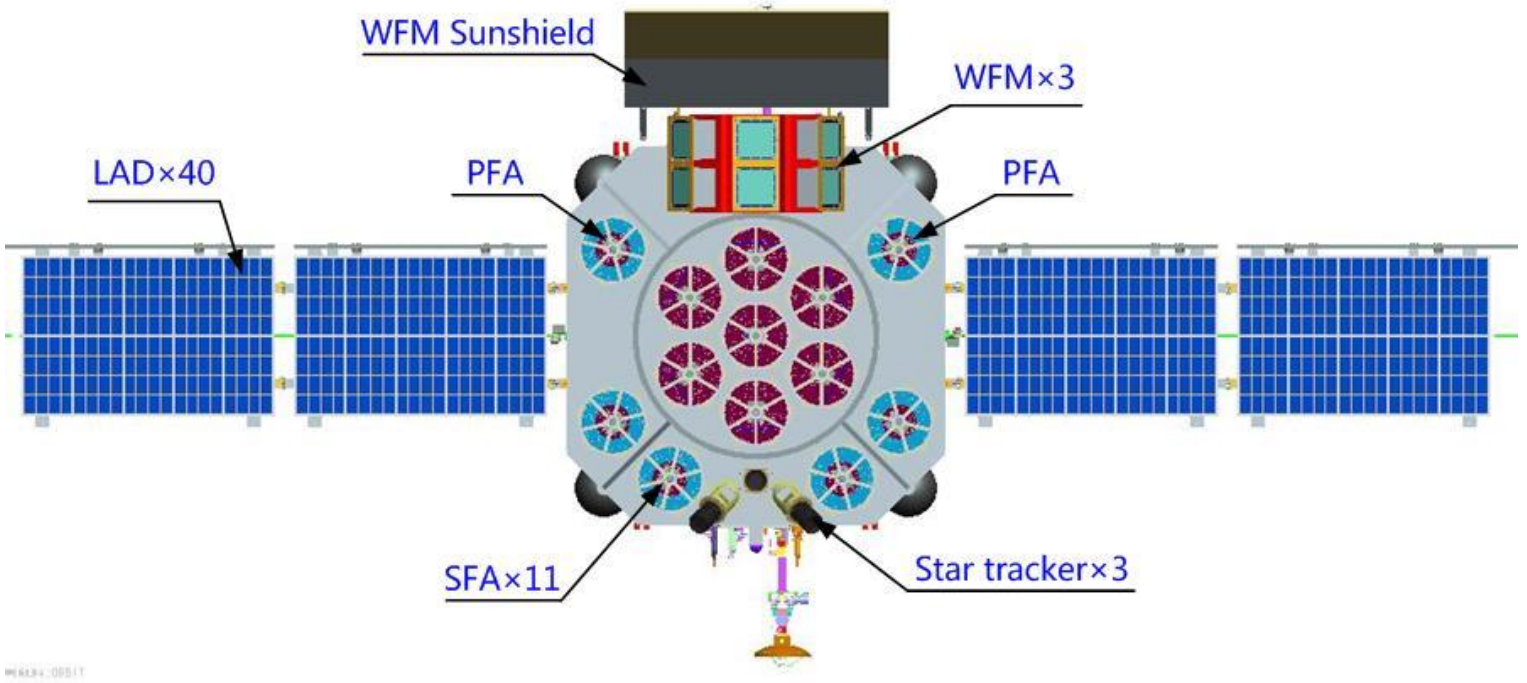
Stowed in fairing



On orbit

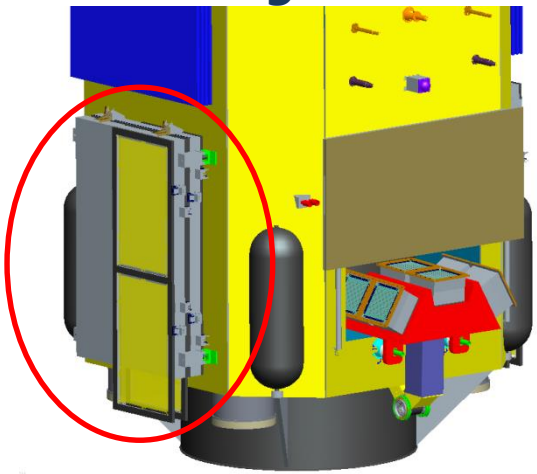
4. Preliminary Design

➢ Configuration

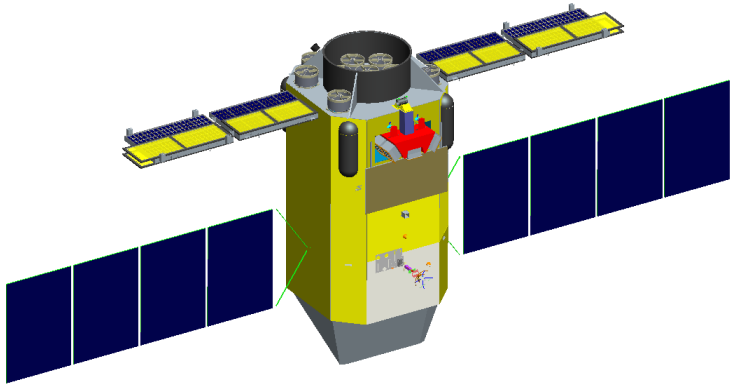


4. Preliminary Design

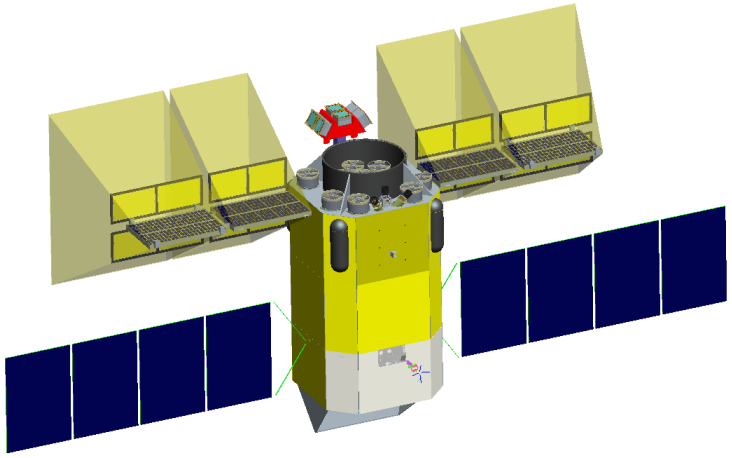
➢ LAD Configuration



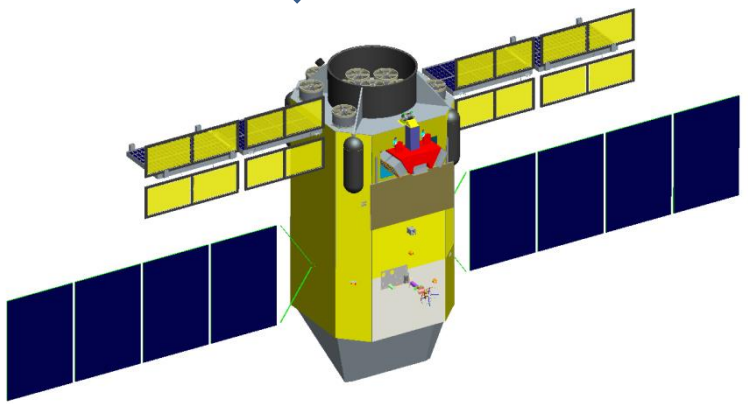
Stowed when launch



Step 1:LAD deployed



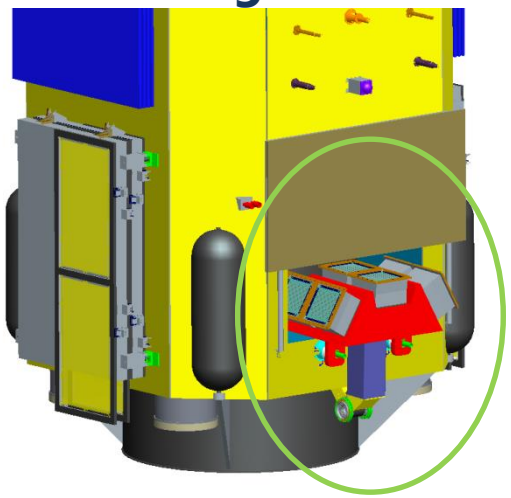
Blocking area of the Sunshield



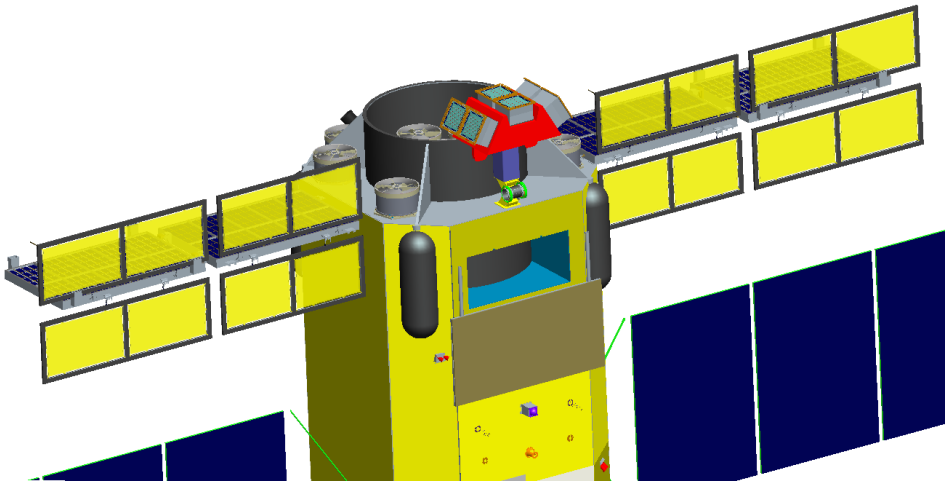
Step 2:Sunshield panel deployed

4. Preliminary Design

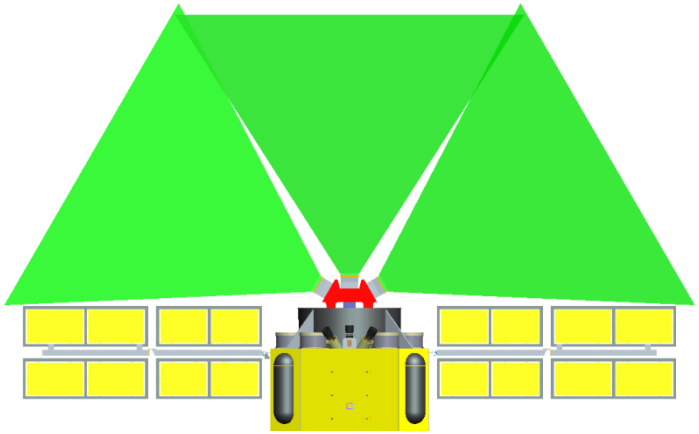
➢ WFM Configuration



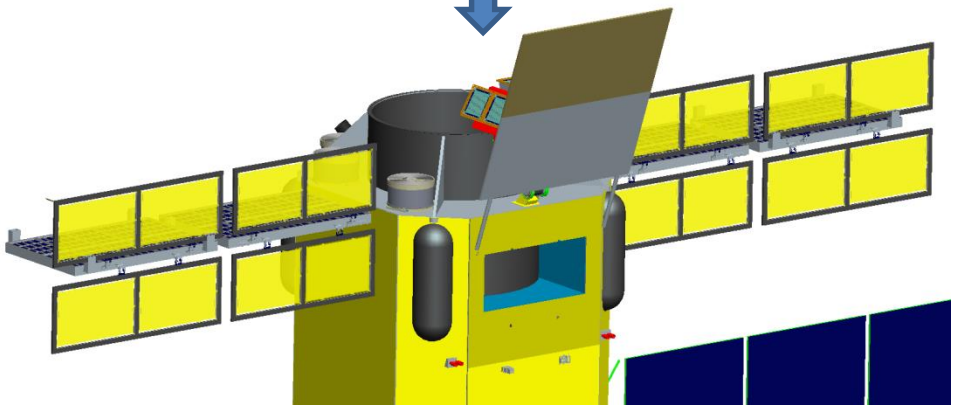
Stowed when launch



Step 1:WFM deployed



FOV of WFM



Step 2:Sunshield panel deployed

➢ Structure and mechanism

Composite Structures

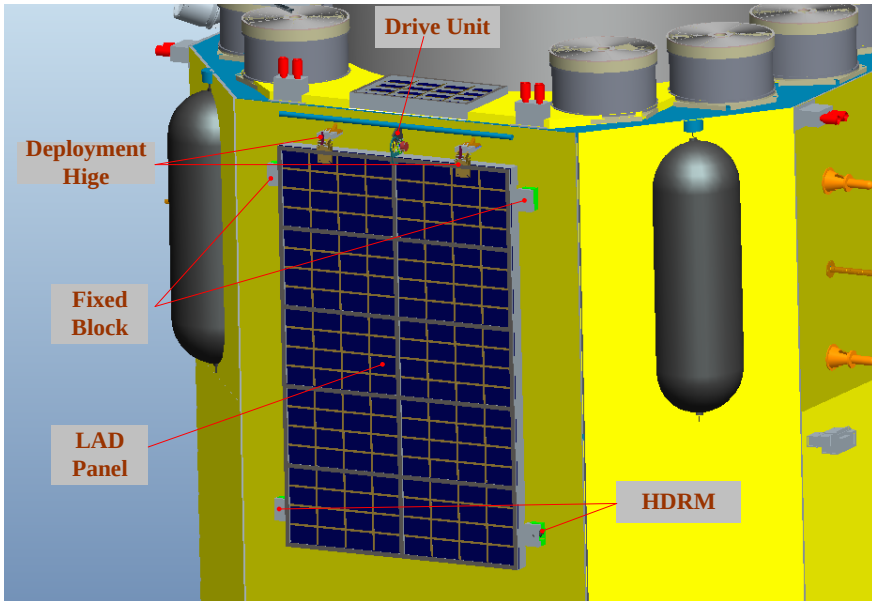
For good dimensional stability，the principle of structure design as follows:

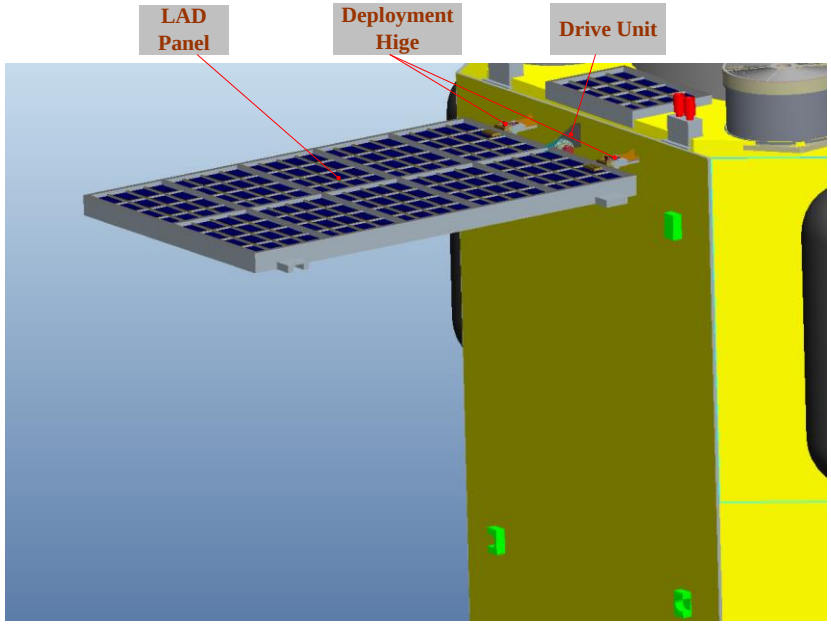
- Choose the materials with minimum coefficients of thermal expansion;
- Optimize the lay-up design for getting Zero Coefficient of Thermal Expansion;
- Thermal recycle test would be done to reduce the residual stress if necessary.

4. Preliminary Design

➢ Structure and mechanism

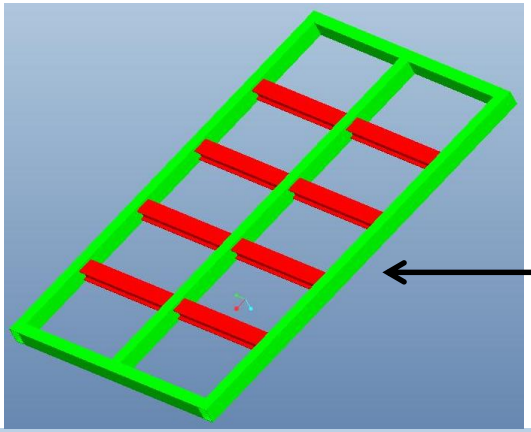
The DM Design consists of deployment hinge with a motor(DH), Hold Down and Release Mechanism(HDRM), LAD Panel Structure and LAD sunshield.





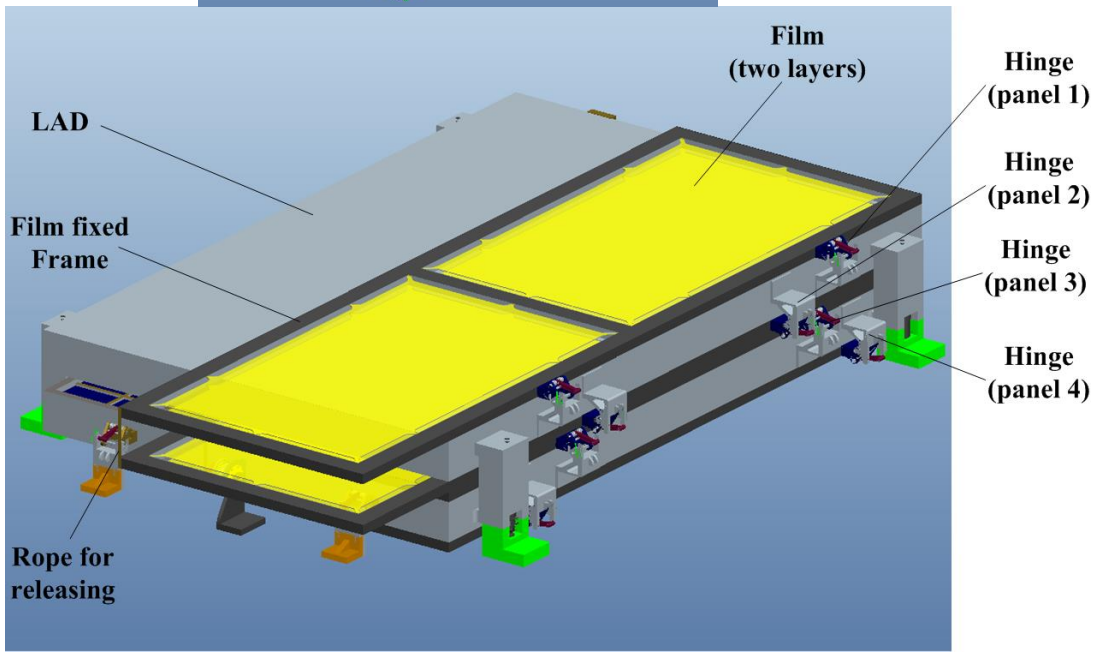
4. Preliminary Design

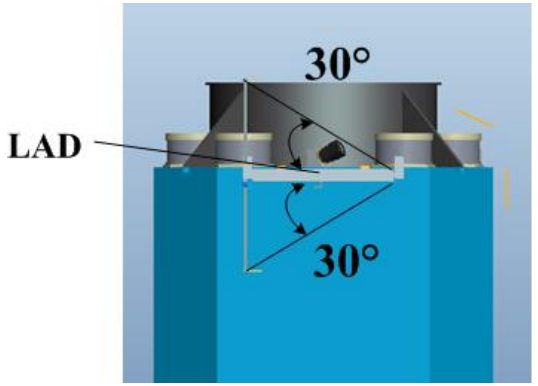
➢ Structure and mechanism



High thermal conductivity CFRP material

Item	Type2: panel using hinges
Area	13 m^2
Pros	Simple structure Simple drive unit(spring) light(~ 25Kg),
Cons	Not fully covered, the edge of LAD will be uncovered

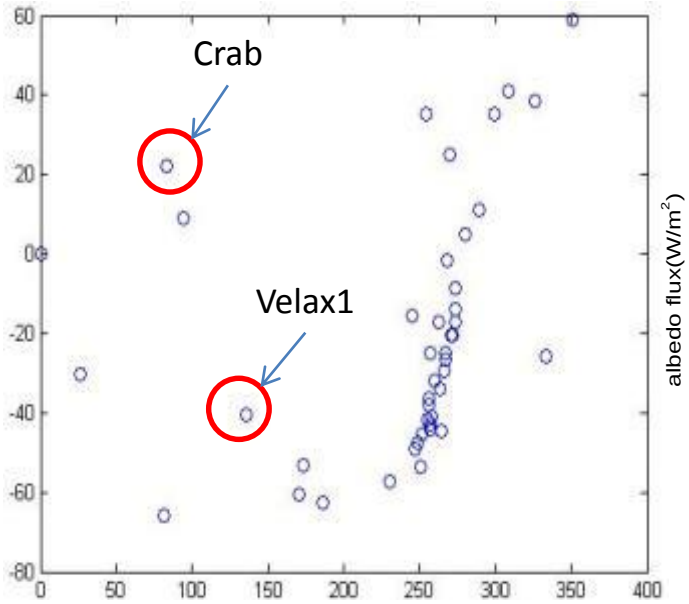




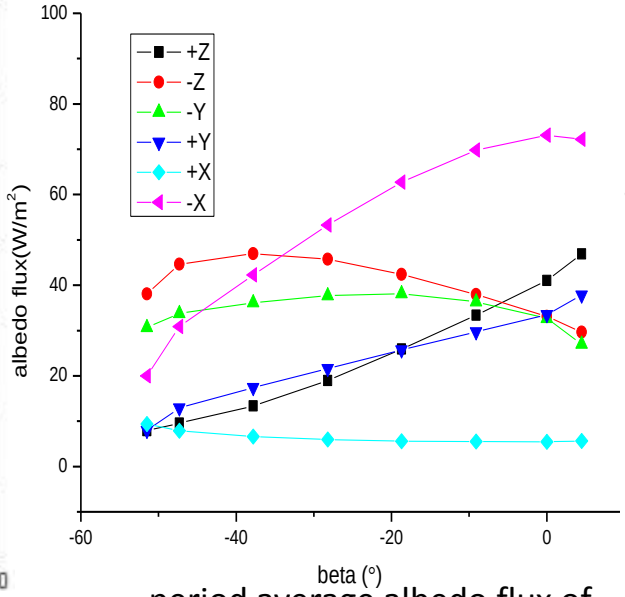
3. Preliminary Design

➢ TCS: Outside heat flux

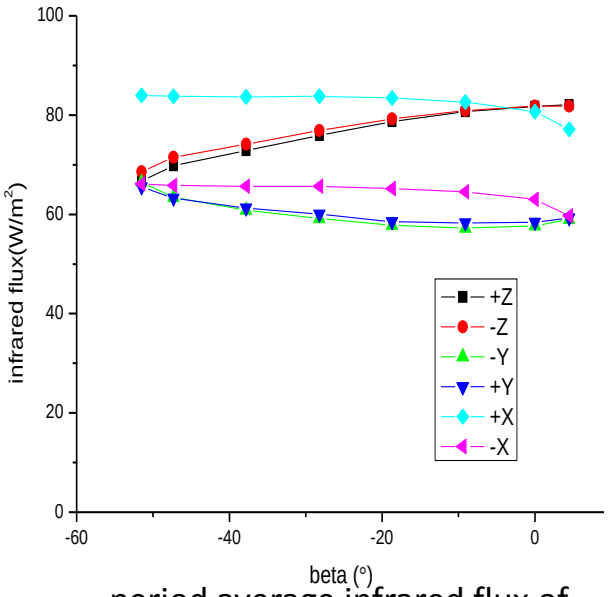
- Observation goals scope：celestial sphere latitude:66.8°~58.82°, celestial sphere longitude :25.92°~350.9°
- Based on focus observation mode, the +Z direction side ,±Y direction side and±X direction side are suitable for the satellite radiator, which albedo flux(3.6~86.2W/m^2) and infrared flux(57.6~81.7W/m^2) are correspondingly small.



Observation goals scope



period average albedo flux of Crab observation resource on midwinter with different β angles

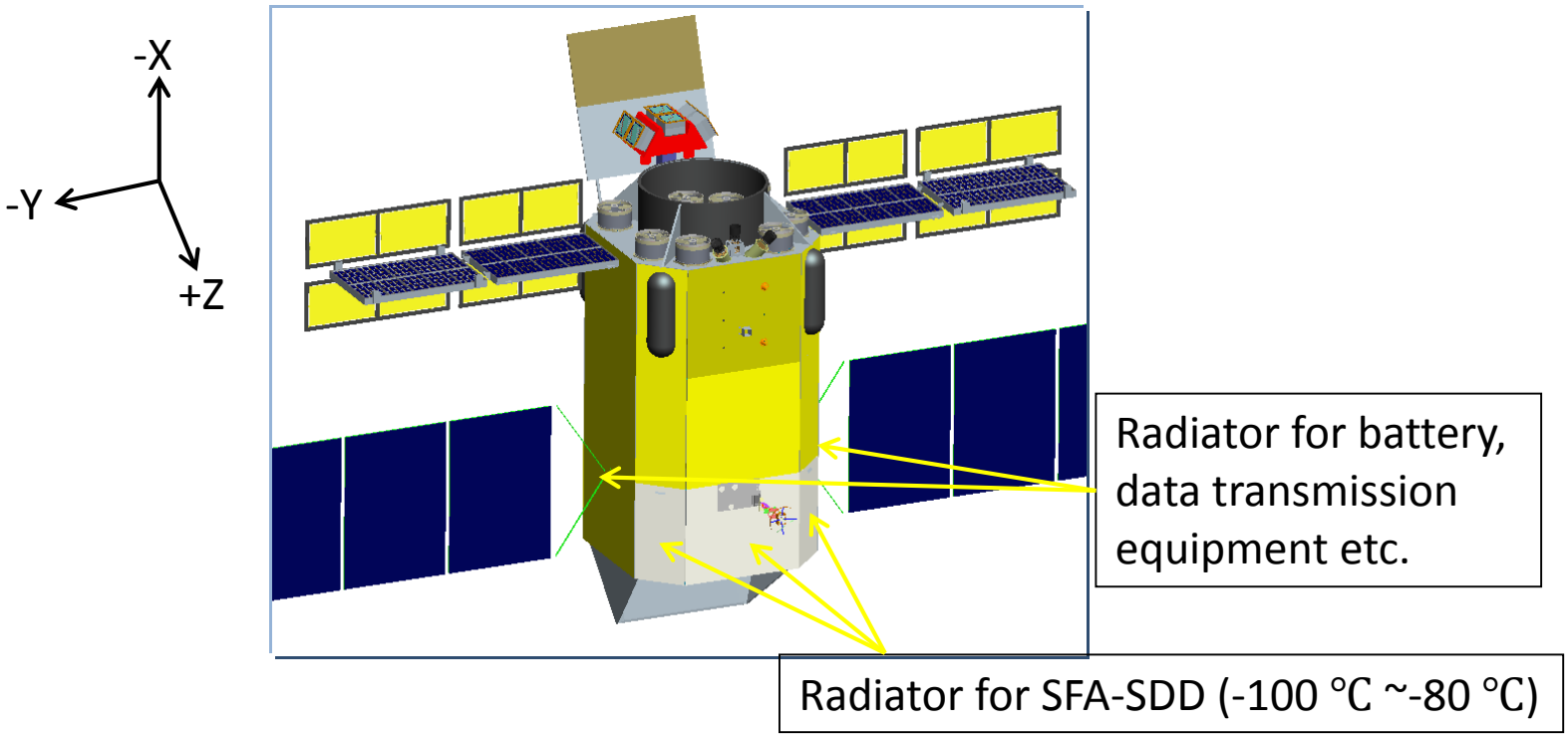


period average infrared flux of Velax1 observation resource on midwinter with different β angles

3. Preliminary Design

➢ TCS: Radiators

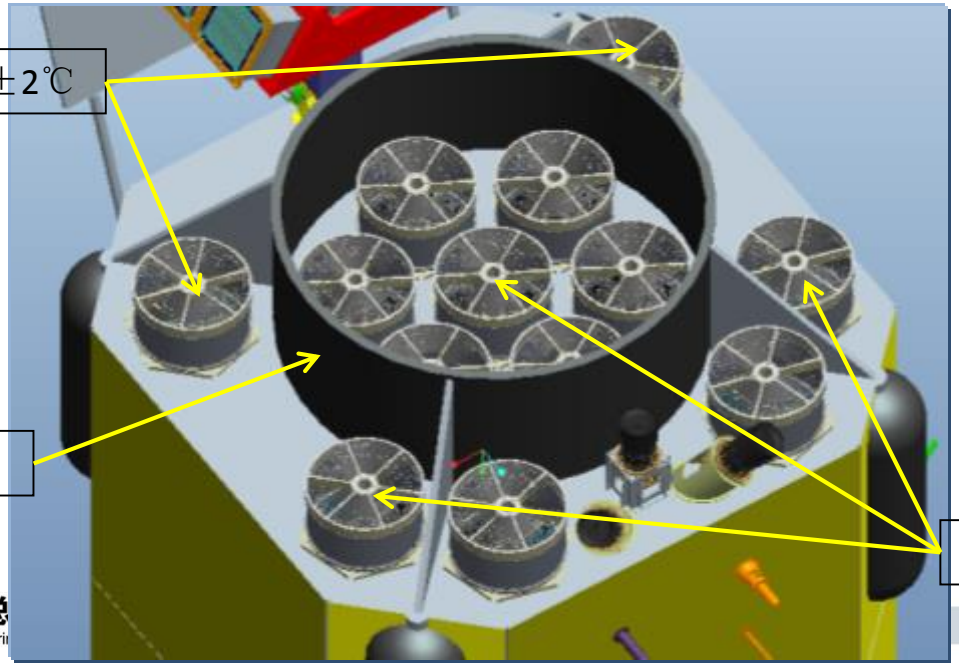
- The satellite primary radiator locates on the +Z direction side, which is mainly used for the low temperature SFA payload.
- The satellite accessorial radiators locate on the ±Y direction side and ±X direction side, which are mainly used for battery, data transmission equipment, etc.



3. Preliminary Design

➢ TCS: SFA-SGO& PFA-Nickel optics thermal design

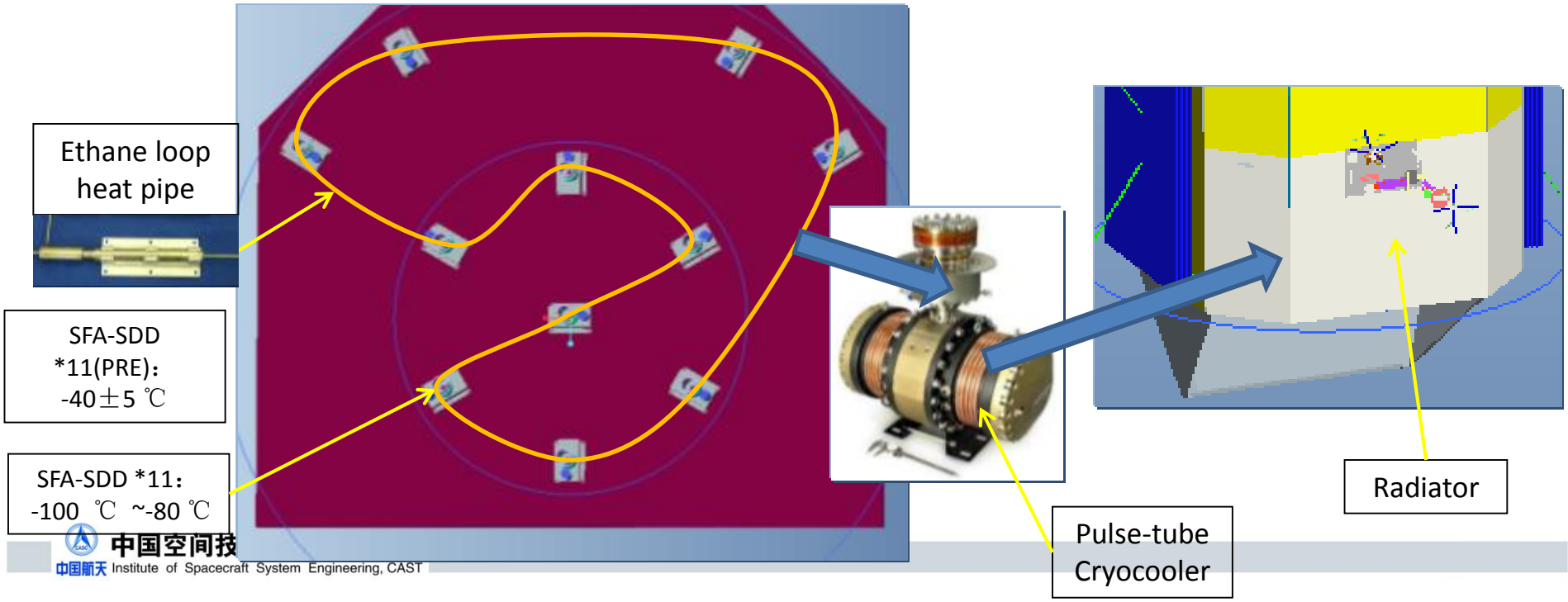
- The **insulating washers**(fiberglass) is used to limit the conductive heat transfer between the SFA-SGO & PFA-Nickel optics and optical bench.
- The SFA-SGO & PFA-Nickel optics are covered by **15-layer MIL** to insulate heat radiation among internal or external parts of satellite.
- The outside of central cylinder is used for the SFA-SGO & PFA-Nickel optics with SR-107ZK white painting. Electric heating loops(20W power) are applied around every SFA-SGO & PFA-Nickel optics. The total power needed is 240W.



3. Preliminary Design

➢ TCS: SFA-SDD thermal design

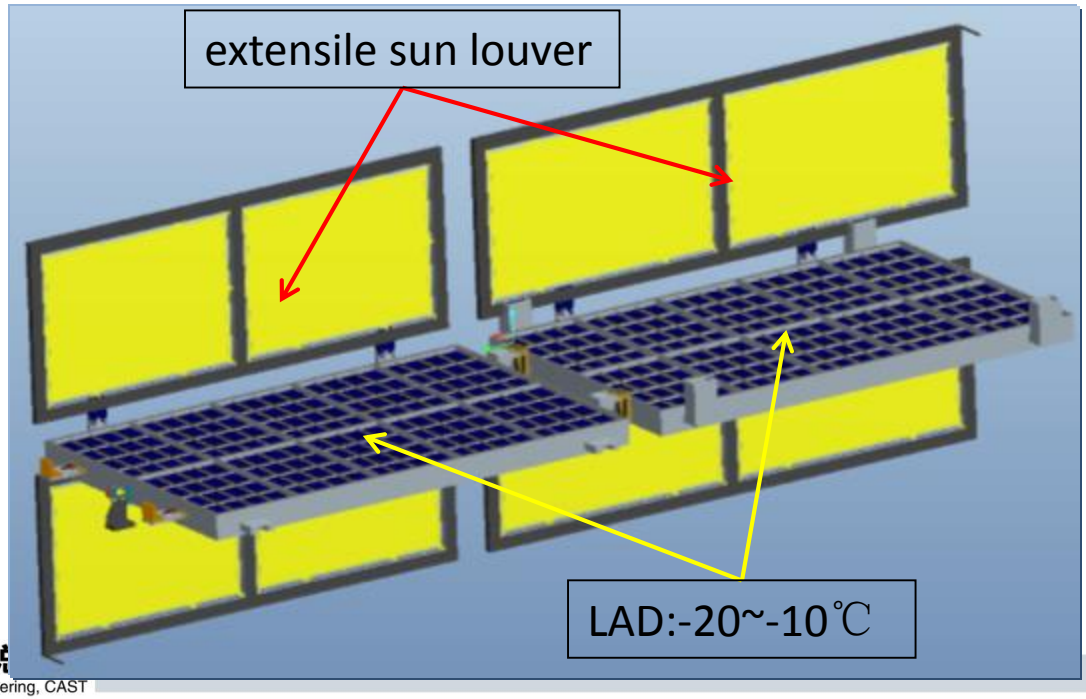
- The +X panel with 11 SFA-SDD is connected to the satellite primary structure by insulating washers.
- The insulating washers is used to limit the conductive heat transfer between the SFA-SDD and +X panel.
- The SFA-SDD are covered by 10-layer MIL.
- The 11 SFA-SDD heat dissipation are firstly collected by the ethane loop heat pipe, then the collected heat dissipation is refrigerated by the pulse-tube refrigerator(5W@180K ,power 120W). Finally, the hot junction heat dissipation of refrigerator is transmitted to the +Z panel individual radiator by the ethane heat pipe.



3. Preliminary Design

➢ TCS- LAD thermal design

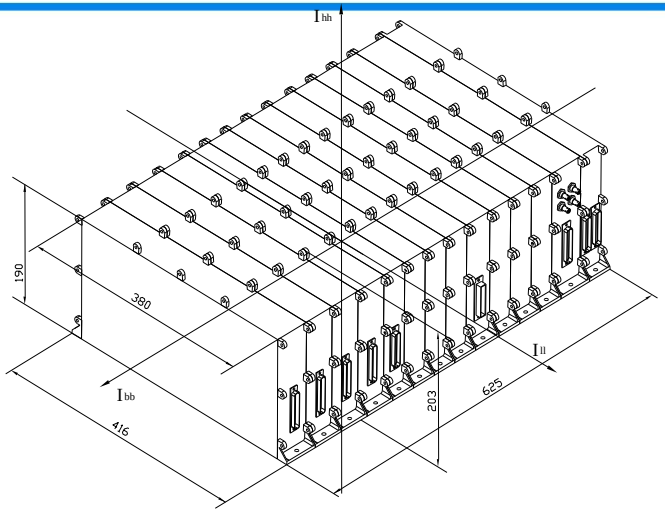
- The LAD sunshield could directly insulate heat radiation from the sun.
- The side of the sunshield face to LAD is covered by 15-layer.
- The LAD heat dissipation(5.4W*40=216W) is radiated by the top and the bottom face of itself.
- Electric heater(50W power) is applied in LAD for maintaining the -20℃ lower limit.



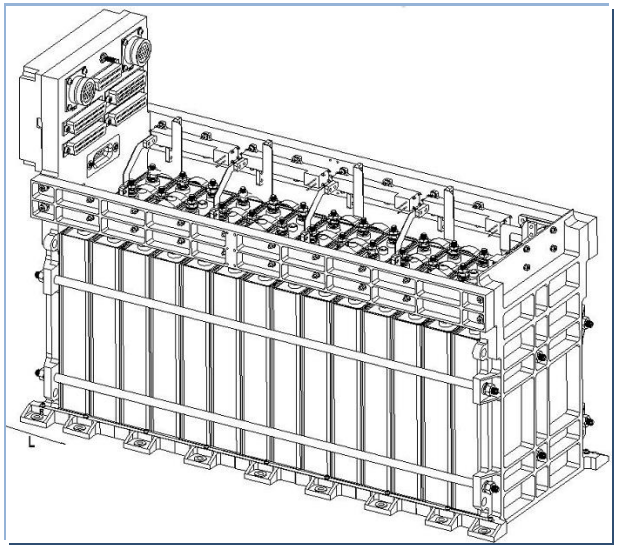
4. Preliminary Design

➢ Power system

- Two Identical Wings(4 panels each)
- $GaInP_2$/InGaAs
- 35m² effective area（ 2 wings ）
- More than 28.6% efficiency
- Two Lithium Batteries（ 2×150 Ah ）
- DOD ≤ 20% (on average)
- One Power Control Unit(PCU)
- One Power Distribution Unit (PDU)



Power Control Unit(PCU)



LI battery（ 2 ）

4. Preliminary Design

➢ AOCS

◆ Attitude Control Accuracy

- Zero-Momentum control is used in satellite attitude control, 3 high precision star trackers for attitude measurement, 6 big torques MW(or CMG) for attitude control and 3 magnetorquers for magnetic unloading. The configuration above can achieve 0.01 °(3σ) attitude control accuracy.

The ability of 0.01° attitude control is similar to existing satellite platform product of CAST.

◆ Attitude Maneuver

- Requirement: Finish 30°attitude maneuver in10 mins
- Specification: angle rate of satellite body shall be 0.06°/s, angle acceleration shall be 0.001°/s^2 ,
- Configuration: 6 big torques MW(0.5Nm)

5. Conclusions and recommendations

- The preliminary design of eXTP refers to the experiences of HXMT , do not use any unproven technologies;
- The key technologies , such as integrated structure , low temperature thermal control, have been solved;
- The preliminary design of eXTP satellite could meet the requirements of science;
- The requirement baseline of payload needs some consolidation (number/mass/power);
- We want to know more details about LAD and WFM in next step for detailed design of the eXTP satellite.

中国空间技术研究院总体部
中国航天 Institute of Spacecraft System Engineering, CAST

Thanks for your attention !

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