The 54th Research Institute of China Electronics Technology Group Corporation

石家庄高新区五十四所信息产业园区
CTI

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CETC54 Profile

Heilongjiang
Jilin
Liaoning
CETC54
Inner Mongolia
Xinjiang
Gansu
Tianjin
Hebei
Qinghai
Shanxi
Shandong
Jiangsu
Henan
Shaanxi
Tibet
Sichuan
Hubei
Anhui
Shanghai
Zhejiang
Chongqing
Jiangxi
Hunan
Guizhou
Fujian
Yunnan
Guangxi
Guangdong
Taiwan
Hong Kong
Hainan
Islands of South China Sea
南海

- One of the Institute of CETC
- Founded in 1952, over 8000 employees
- Leading organization in Electronics SE /SI & Turn key
- Project in China

CETC54- Business Scope

System provider in following area

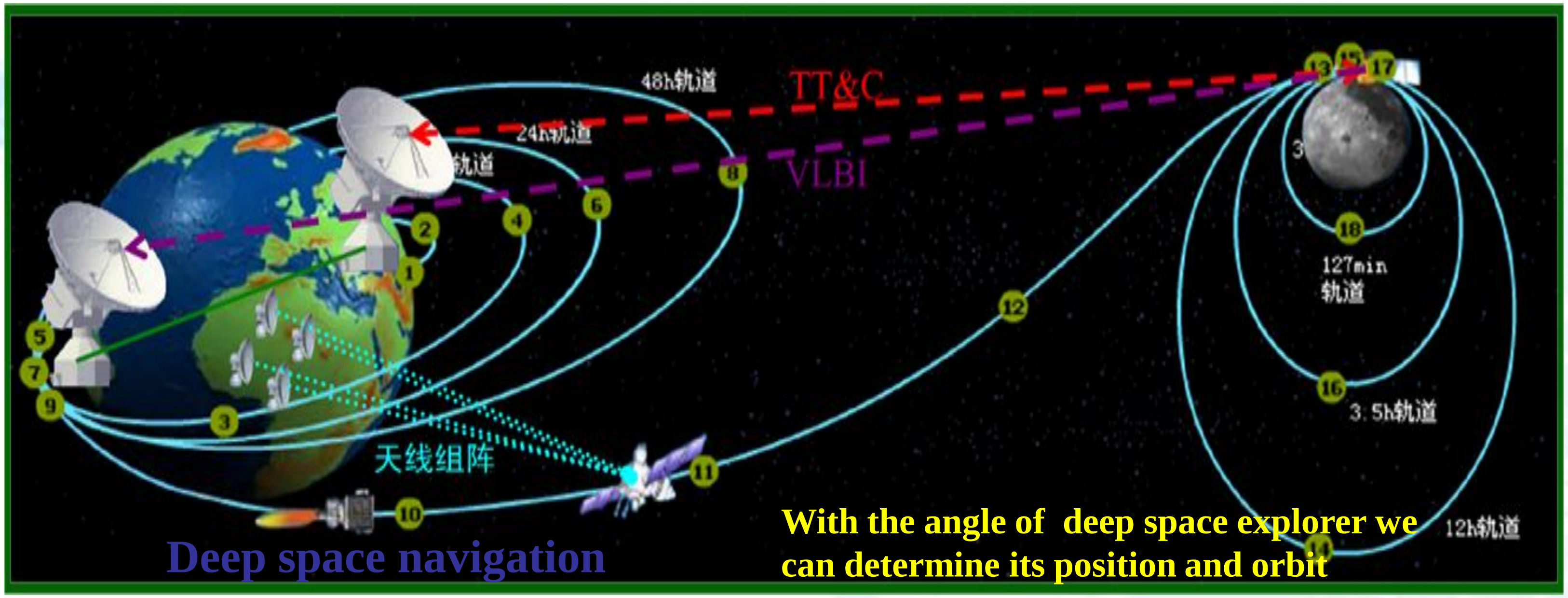
- **SATCom Communication**
- **Aerospace Telecontrol**
- **Public Security**
- **Radio Spectrum Monitoring**
- **Navigation and Positioning**
- **Antenna and servo system**

VLBI'S Application in Chang'E Project

- VLBI's precision of Chang'E Project
- VLBI system of Chang'E Project
- Introduction of other products

"Lunar Exploring Plan of China"

1. VLBI precision of Chang’E Project


48h轨道
TT&C
24h轨道
轨道
VLBI
天线组阵
127min
轨道
3.5h轨道
12h轨道
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

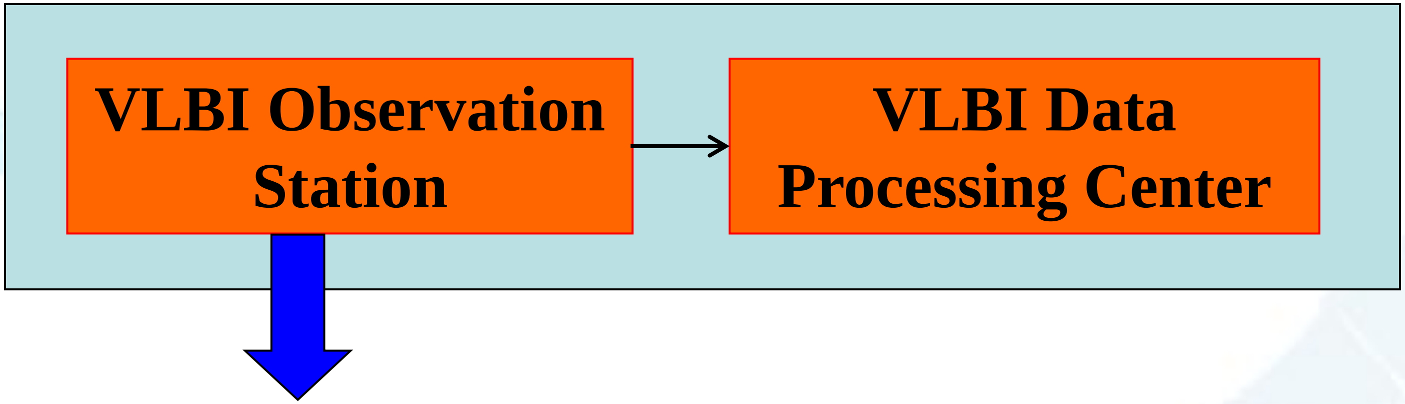
Deep space navigation

With the angle of deep space explorer we can determine its position and orbit

The result of data analysis shows that during the period of earth-moon transfer, circumlunar and lunar-landed, the interferometric accuracy of Chang’E-3 Explorer is 0.75ns, 1.26ns, 0.46ns, respectively. It also indicates the relative position accuracy of Chang’E-3 Lander and Lunar Rover using SBI is at the level of mm.

*signal bandwidth：40MHz, 5s integral time

2. VLBI system of Chang'E Project



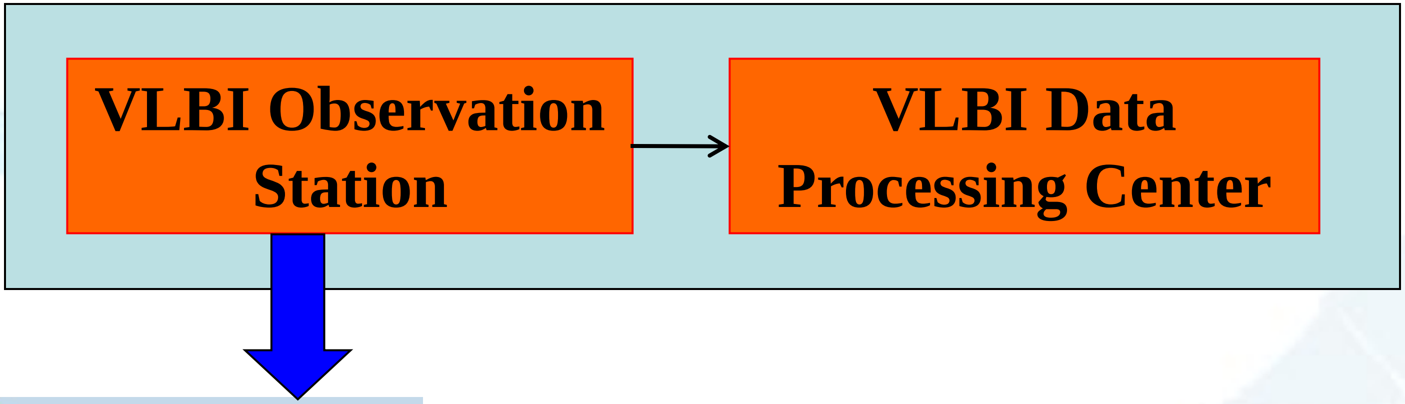
VLBI Observation Station

VLBI Data Processing Center

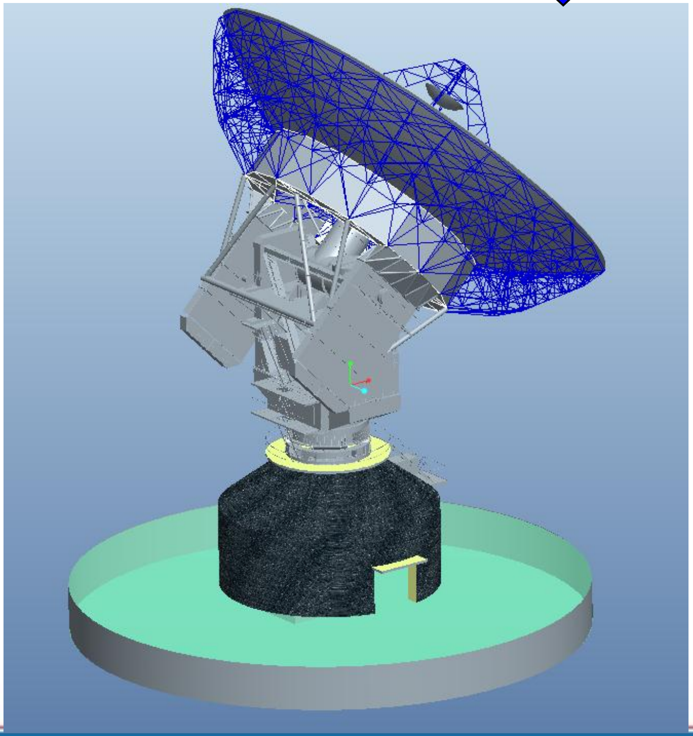
2012/06/27

2012/07/04

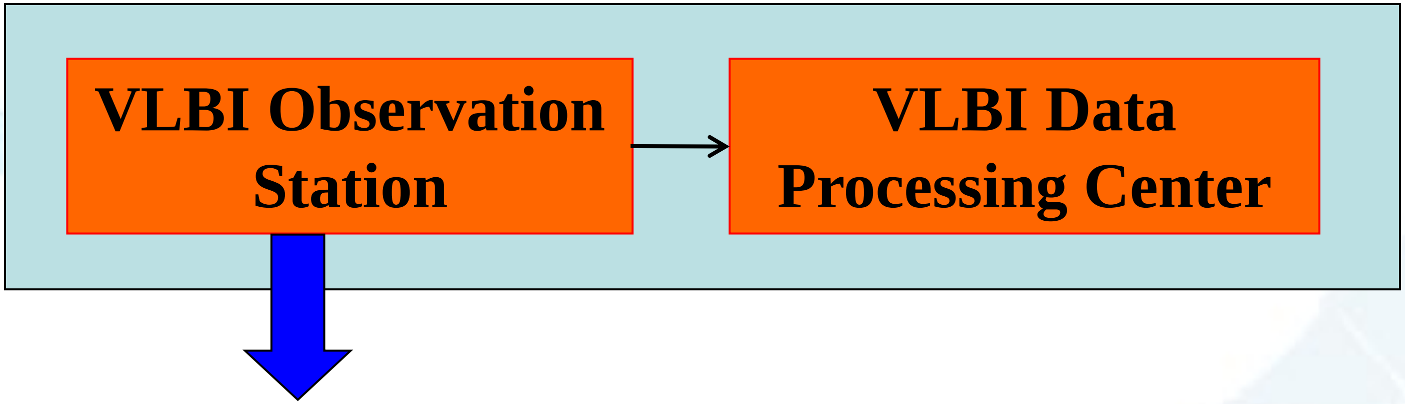
2. VLBI system of Chang’E Project



VLBI Observation Station → **VLBI Data Processing Center**



2. VLBI system of Chang’E Project



VLBI Observation Station

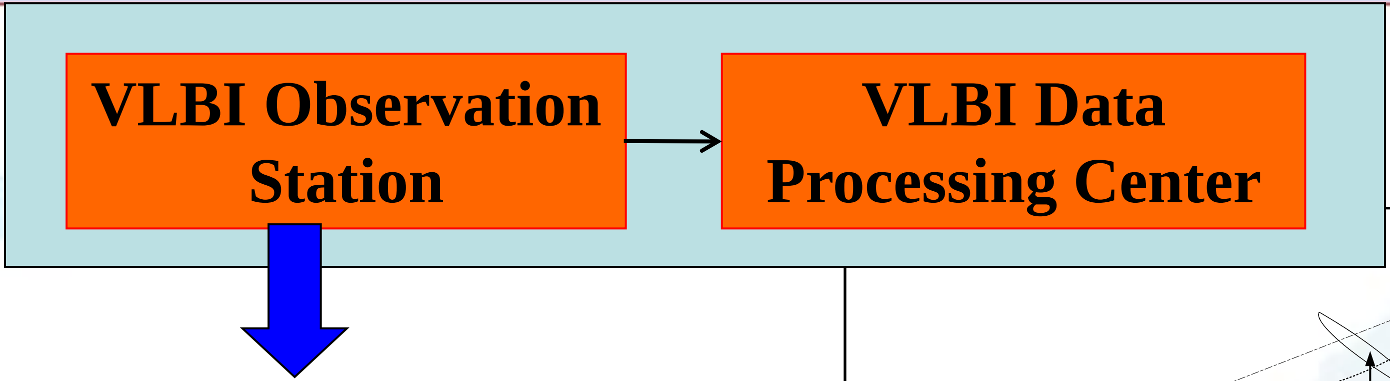
VLBI Data Processing Center

Experiences:

System Design/EMC Design

Equipment: Antenna, Receiver, DBBC and Recorder,Calibration Instruments, etc.

2. VLBI system of Chang'E Project



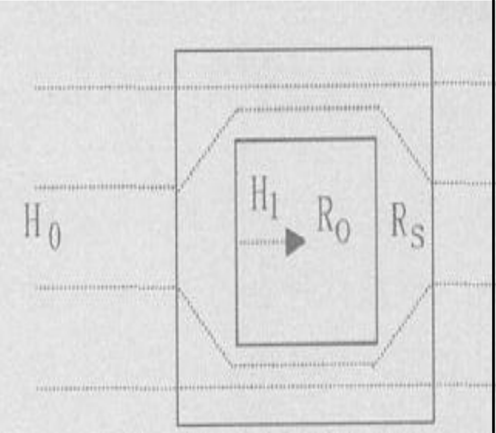
VLBI Observation Station

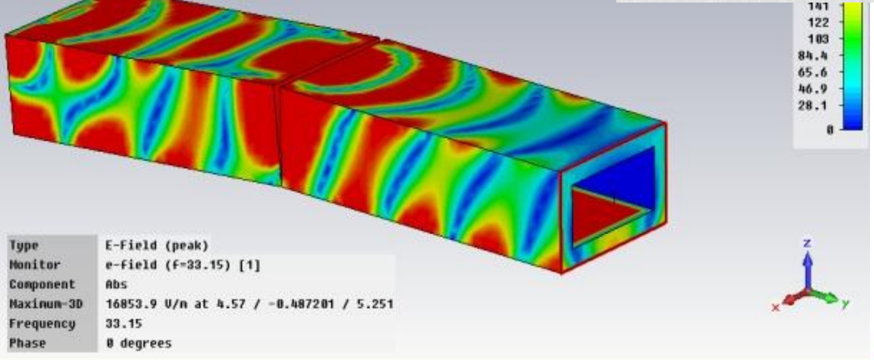
VLBI Data Processing Center

Station EMC design

- ●Microwave signal
- ●Magnetism field
- ●power supply
- ●…

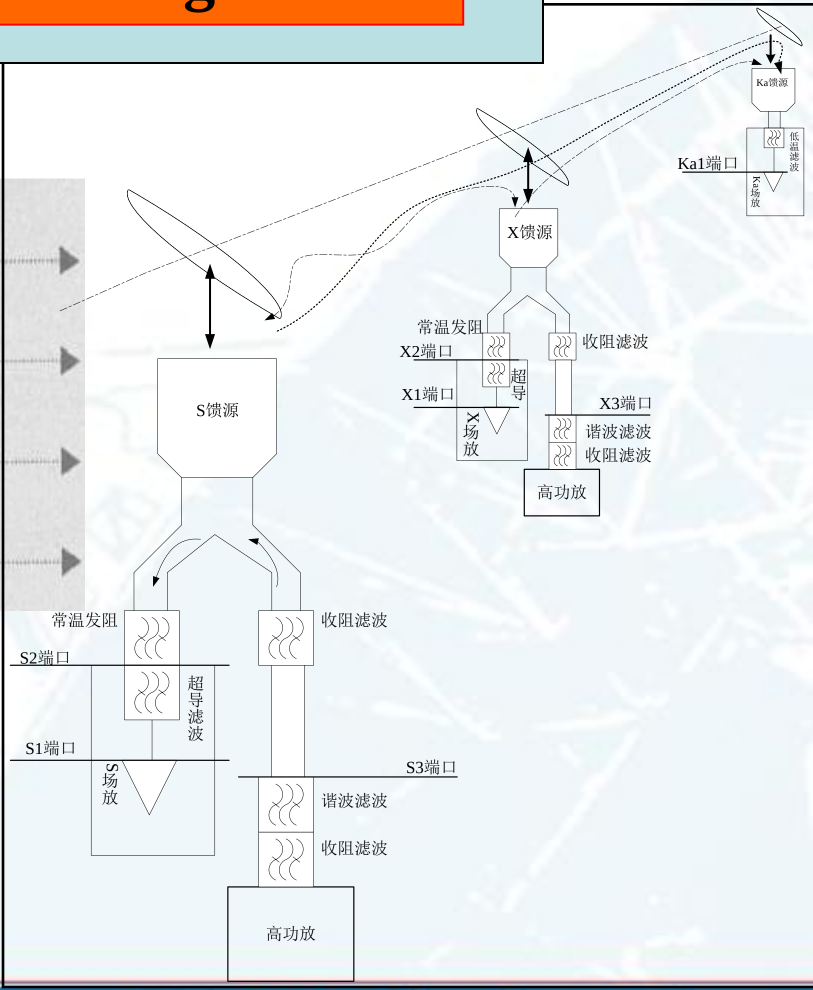
EMC



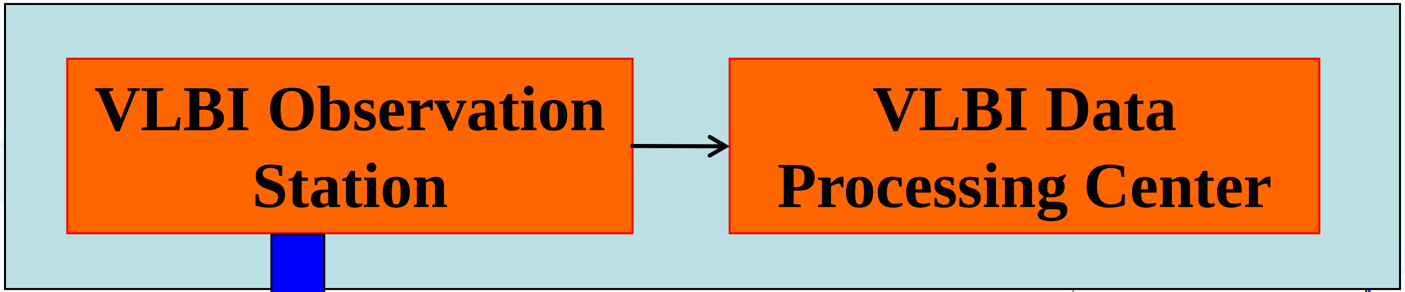

Clamp to range: (Min: 0/ Max: 200)

Type E-Field (peak)
Monitor e-field (f=33.15) [1]
Component Abs
Maximum-3D 16853.9 V/m at 4.57 / -0.487201 / 5.251
Frequency 33.15
Phase 0 degrees

141
122
103
84.4
65.6
46.9
28.1
0
z
x
y


Ka馈源
低温滤波
Ka1端口
Ka场放
X馈源
常温发阻
收阻滤波
X2端口
超导
X1端口
X场放
X3端口
谐波滤波
收阻滤波
高功放
S馈源
常温发阻
收阻滤波
S2端口
超导滤波
S1端口
S场放
S3端口
谐波滤波
收阻滤波
高功放

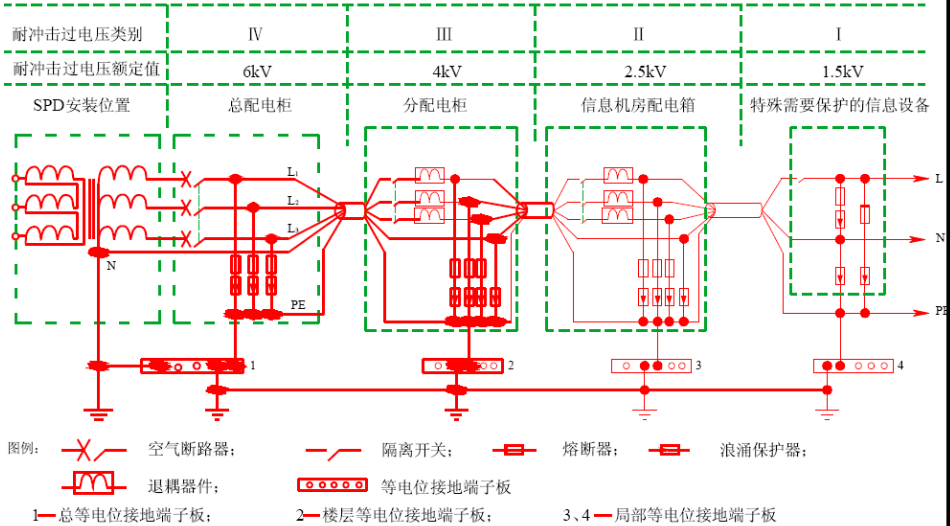
2. VLBI system of Chang'E Project



VLBI Observation Station

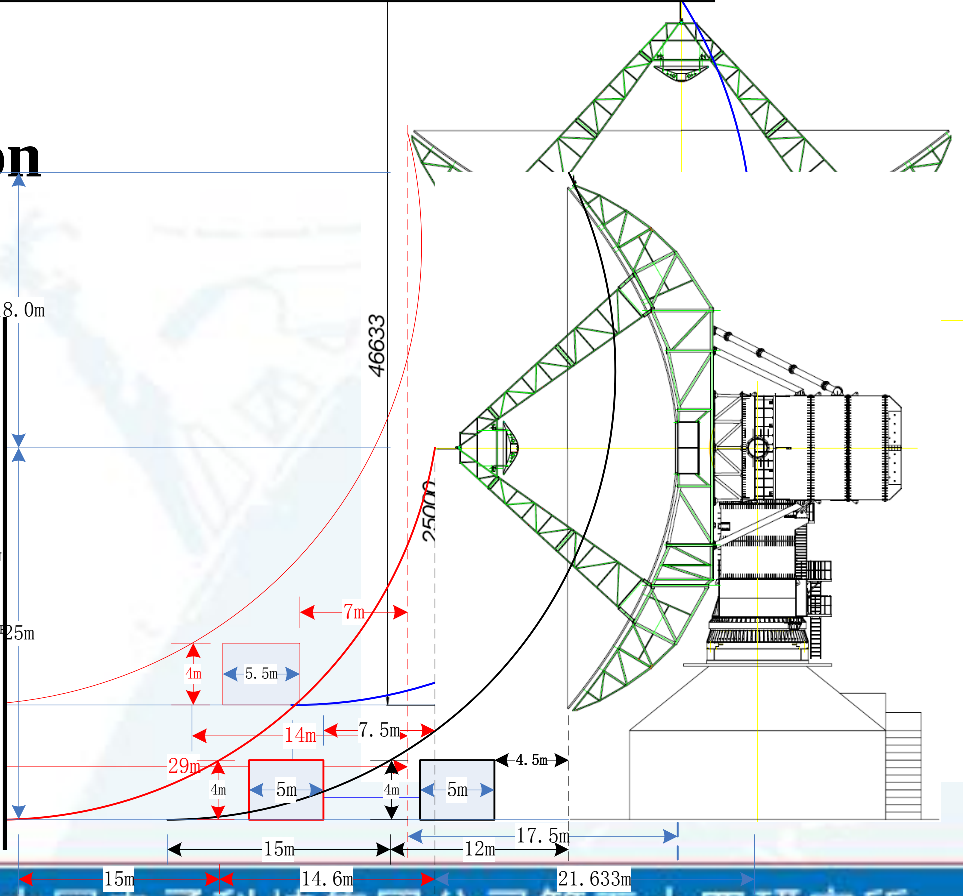
VLBI Data Processing Center

Lighting protect design of station



耐冲击过电压类别	Ⅳ	Ⅲ	Ⅱ	Ⅰ
耐冲击过电压额定值	6kV	4kV	2.5kV	1.5kV
SPD安装位置	总配电柜	分配电柜	信息机房配电箱	特殊需要保护的信息设备

L₁
L₂
L₃
N
PE
L
N
PE
1
2
3
4
图例：
空气断路器；
隔离开关；
熔断器；
浪涌保护器；
退耦器件；
等电位接地端子板
1—总等电位接地端子板；
2—楼层等电位接地端子板；
3、4—局部等电位接地端子板

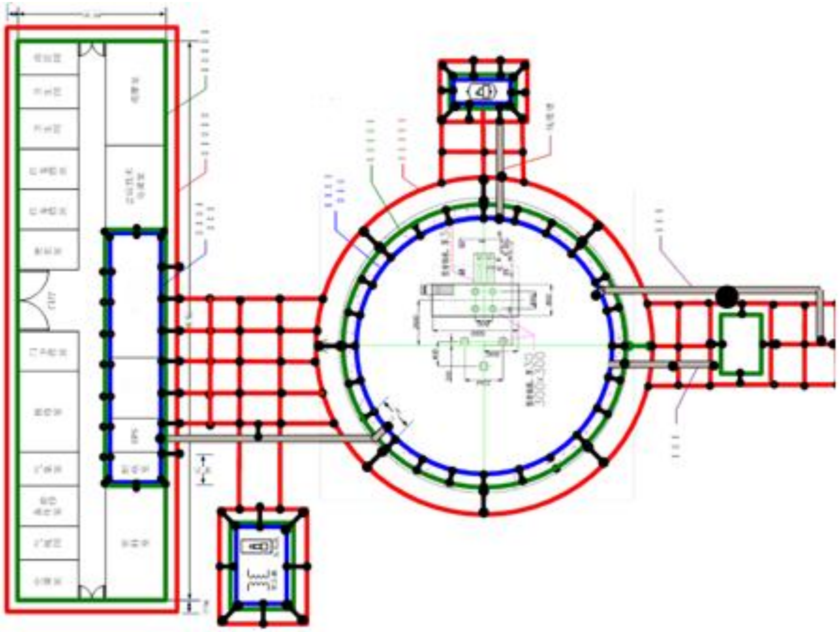


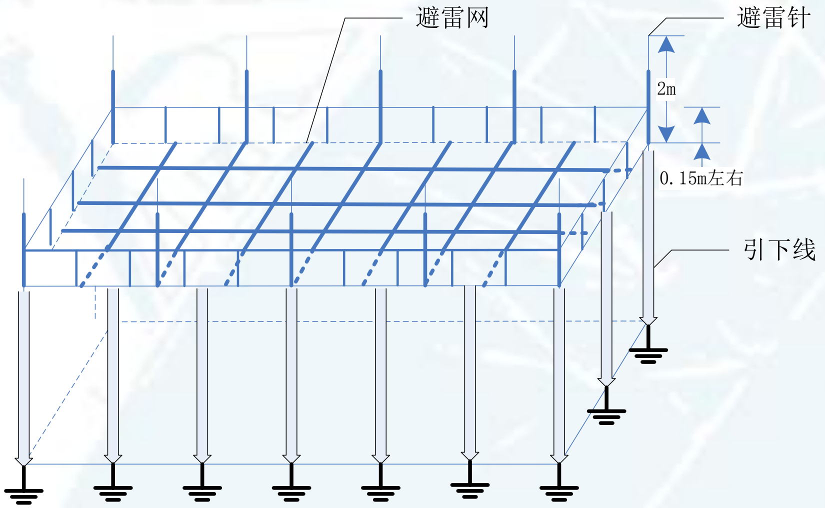
18.0m
46633
25000
25m
7m
4m
5.5m
14m
7.5m
29m
4m
5m
4m
5m
4.5m
17.5m
15m
12m
15m
14.6m
21.633m

2. VLBI system of Chang’E Project

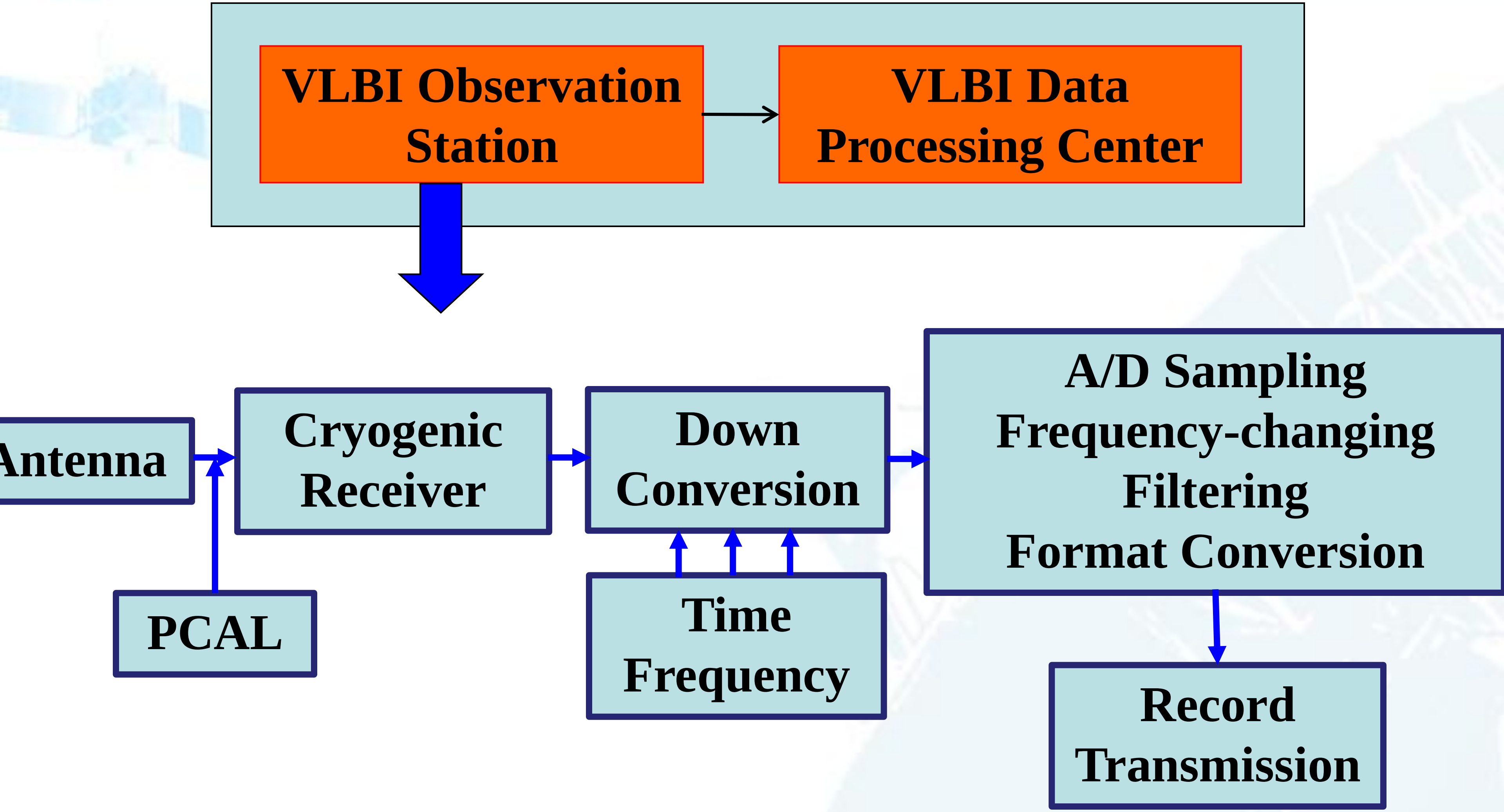
VLBI Observation Station → **VLBI Data Processing Center**

Grounding design of station




避雷网
避雷针
2m
0.15m左右
引下线

2. VLBI system of Chang'E Project



VLBI Observation Station

VLBI Data Processing Center

Antenna

Cryogenic Receiver

Down Conversion

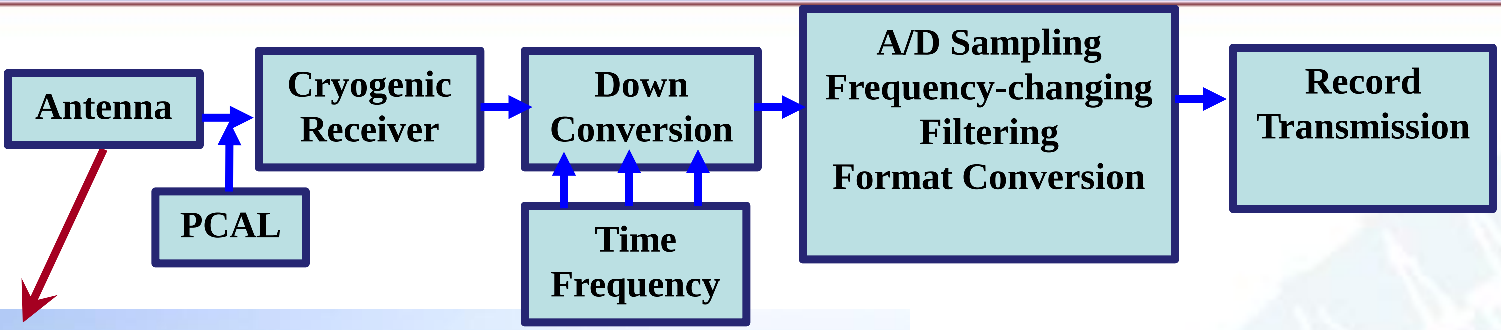
A/D Sampling
Frequency-changing
Filtering
Format Conversion

PCAL

Time Frequency

Record Transmission

2. VLBI system of Chang'E Project


Antenna

PCAL

Cryogenic Receiver

Down Conversion

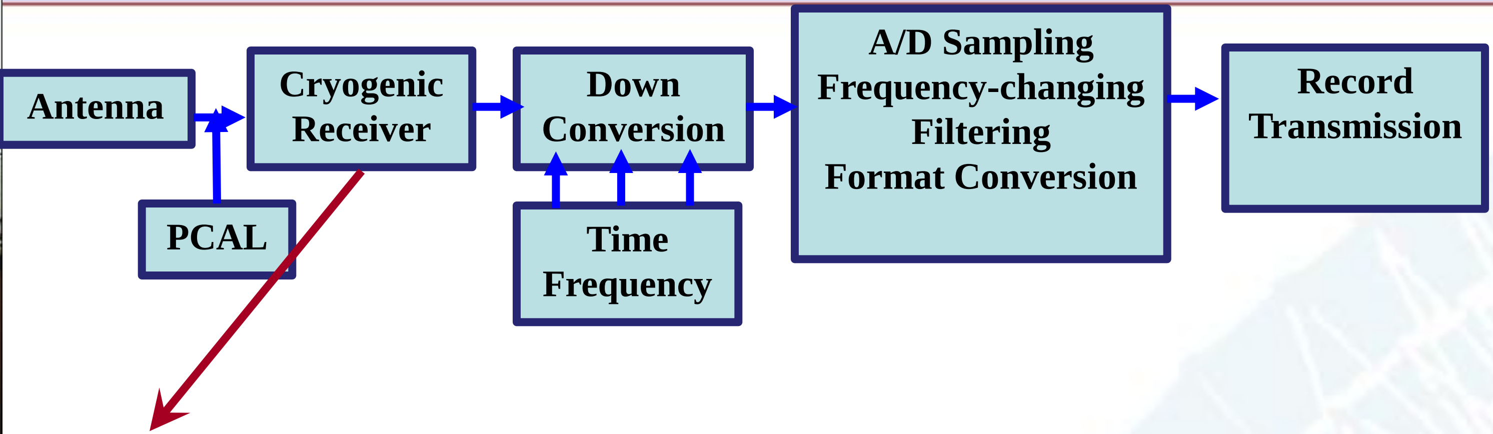
Time Frequency

A/D Sampling
Frequency-changing
Filtering
Format Conversion

Record Transmission

35-meter antenna
S band to Ka band
Operated in 2013

2. VLBI system of Chang’E Project



Antenna

PCAL

Cryogenic Receiver

Down Conversion

Time Frequency

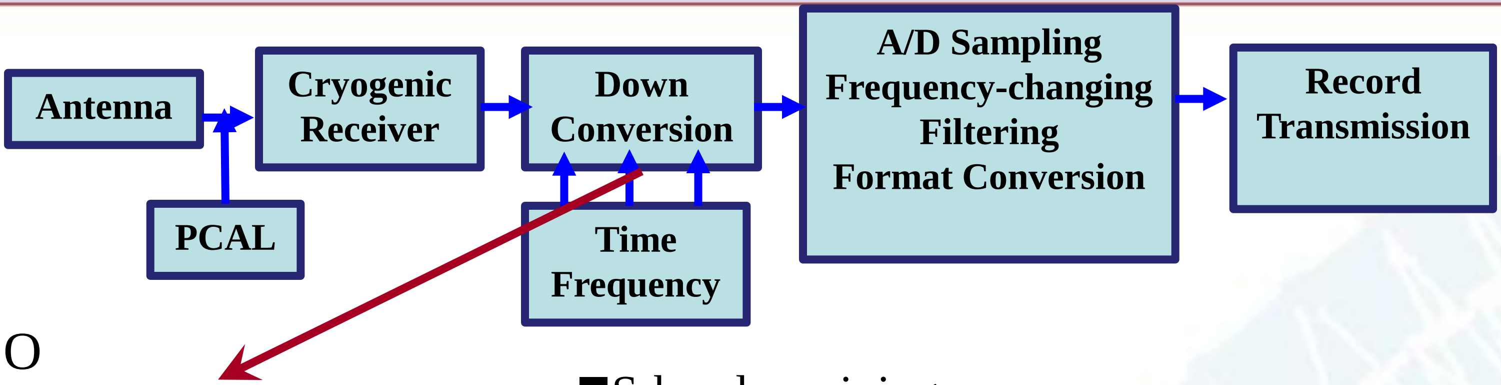
A/D Sampling
Frequency-changing
Filtering
Format Conversion

Record Transmission

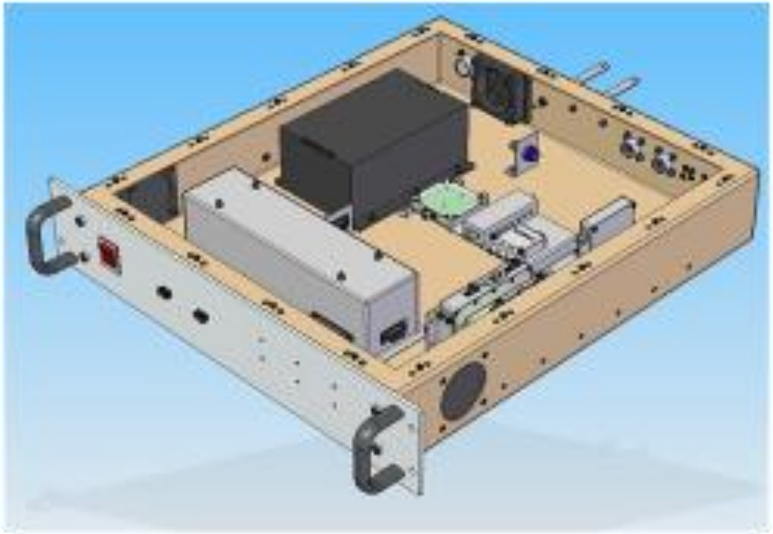
S band：14K
X band：14K
Ka band：40K

2012/09/20

2. VLBI system of Chang’E Project


Antenna
Cryogenic Receiver
Down Conversion
A/D Sampling
Frequency-changing
Filtering
Format Conversion
Record Transmission
PCAL
Time Frequency

S/X/Ka band LO
Very low phase noise at 1Hz



■S-band receiving:
-64dB 1Hz≤f≤10Hz
-70dB 10Hz＜f≤1.5MHz
-120dB 1.5MHz＜f≤8MHz

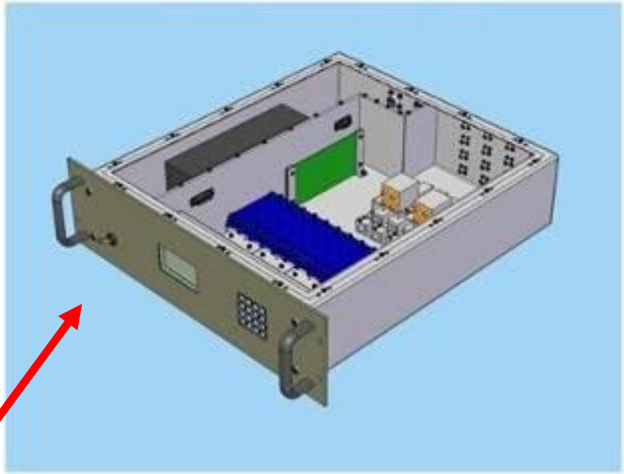
■X-band receiving:
-54dB 1Hz≤f≤10Hz
-70dB 10Hz＜f≤1.5MHz
-120dB 1.5MHz＜f≤8MHz

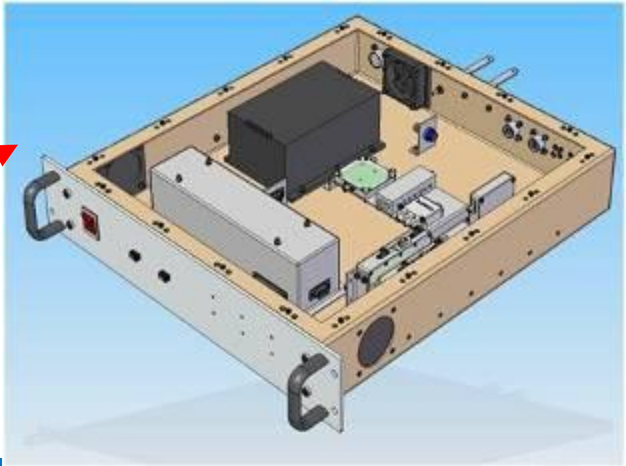
■Ka-band receiving:
-50dB 1Hz≤f≤10Hz
-70dB 10Hz＜f≤1.5MHz
-120dB 1.5MHz＜f≤8MHz

NPORT-5630
Temperature Acquisition Monitor
Temperature Acquisition Monitor
X-band LO Divider
X-band DC A
X-band DC B
X-band DC C
X-band DC D
X-band DC E
X-band DC F
X-band RF Switch Unit
X-VLBI LO
X-VLBI DC
Machine Cabinet Interposer

X band LO&DC

- **Low phase noise LO**
- **High stability DC.**



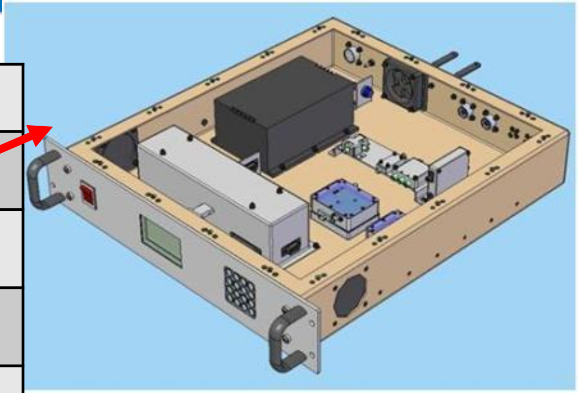


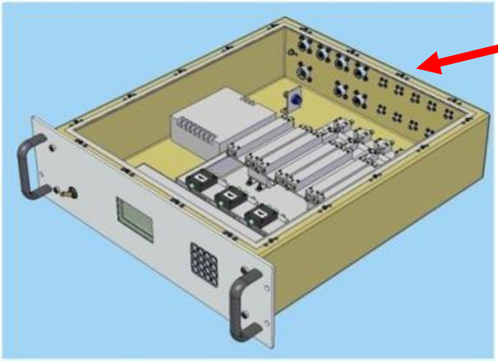
Ka band LO & D/C

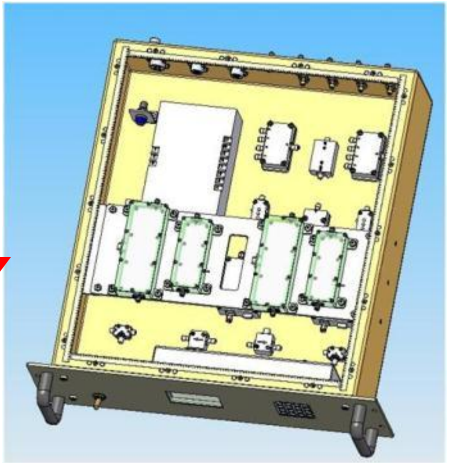
Ka band LO&DC

- Low phase noise LO
- High stability DC

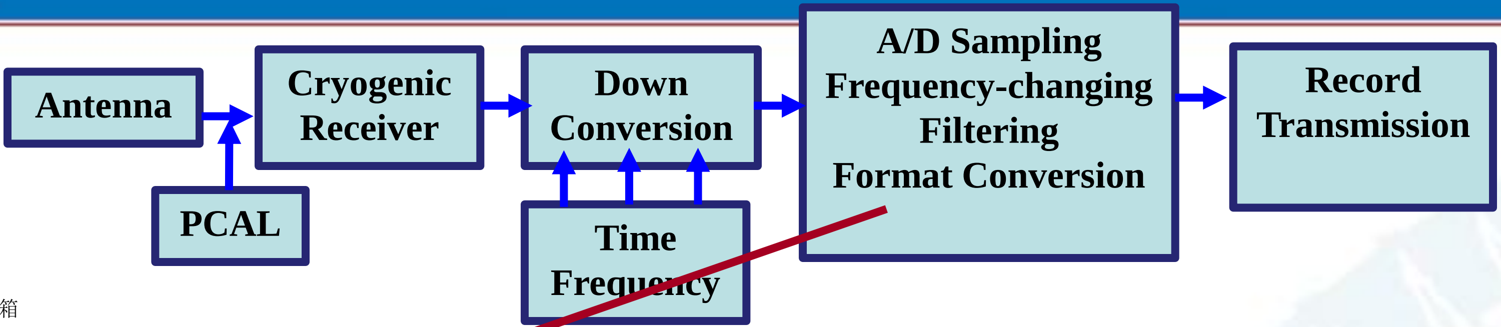
NPORT-5630
Ka-VLBI Receiver LO
Temperature Acquisition Monitor
Temperature Acquisition Monitor
Ka-band LO Divider
Ka-band LO A
Ka-band LO B
Ka-band DC A
Ka-band DC B
Ka-band DC C
Ka-band DC D
Ka-band Switch Unit
Ka-band RF Simulator
Ka-VLBI DC
Machine Cabinet Interposer







2. VLBI system of Chang’E Project



Antenna

PCAL

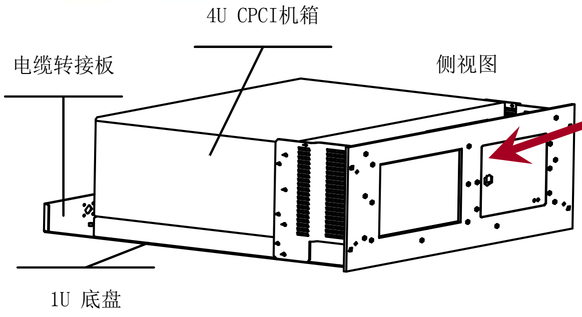
Cryogenic Receiver

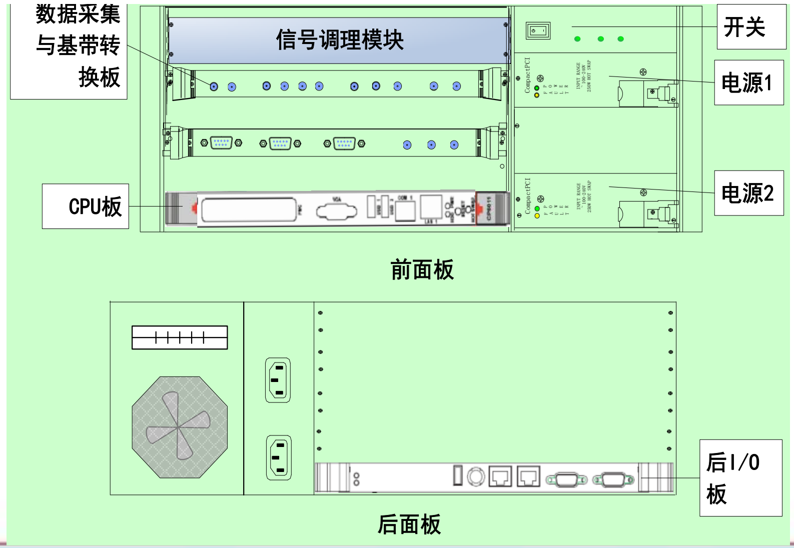
Down Conversion

Time Frequency

A/D Sampling
Frequency-changing
Filtering
Format Conversion

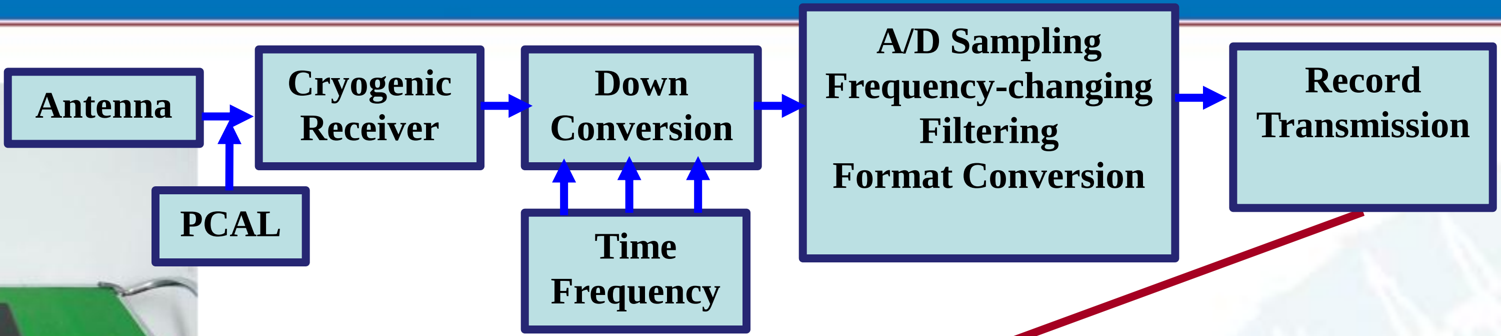
Record Transmission





- Numbers of medium frequency input channels：2 channels
- Medium frequency input ：320MHz
- Medium frequency sampling bandwidth：
- S band: ≥100MHz
- X band: ≥100MHz
- Channel bandwidth of video signal: 1KHz, 2KHz, 4KHz, 8KHz, 16KHz, 25KHz, 50KHz, 100KHz, 200KHz, 500KHz, 1MHz, 2MHz, 4MHz, 8MHz, 16MHz available
- Dynamic range of input signal level: 120dB（at most 40dB of signal level variation in the same arc）
- Numbers of video signal output channels： at most 16 500KHz channels (dual-band) and at least 4 16MHz channels, changing manually from 4 to 16.
- Residual error of phase-frequency curve fitting for sub-channel : ≤0.4ns
- Time delay variations of sub-channel: ≤0.2ns（including time drift, level variation, temperature drift, etc）
- Time delay variations between sub-channels: ≤0.2ns（the same channel bandwidth）
- The center frequency of output video signal can be set with the frequency resolution of 10 Hz
- Quantization bits of output video signal: 16bit, 8bit, 4bit, 2bit, 1bit available
- Output data interface: applicable to the interface standard for VSI-H, VSI-S, VSR and e-interferometric measurement

2. VLBI system of Chang'E Project



Antenna

PCAL

Cryogenic Receiver

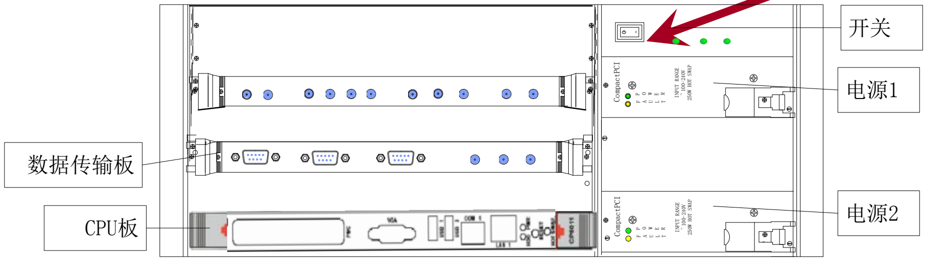
Down Conversion

Time Frequency

A/D Sampling
Frequency-changing
Filtering
Format Conversion

Record Transmission

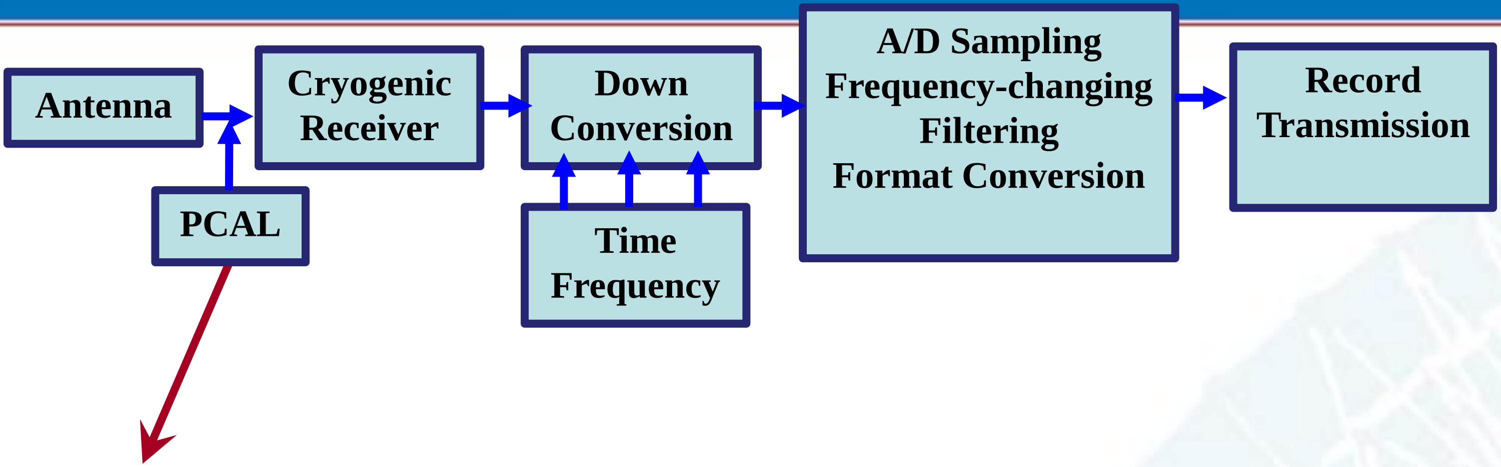
- Numbers of channels recording data flow: at most 16 channels
- Maximum recording velocity of single-channel: 64 Mbit/s
- Capacity of record: ≥10TB
- Sustained recordable time: ≥12h
- Operation mode: idle, recording and replaying
- Optional data recording format, concrete format requirements refers to related documents of data interface.
- External interface applicable to the standard for VSI-H, VSI-S.
- Supporting the transmission network interface standard for e-interferometric data.



前面板

后面板

2. VLBI system of Chang’E Project



Antenna

Cryogenic Receiver

Down Conversion

A/D Sampling
Frequency-changing
Filtering
Format Conversion

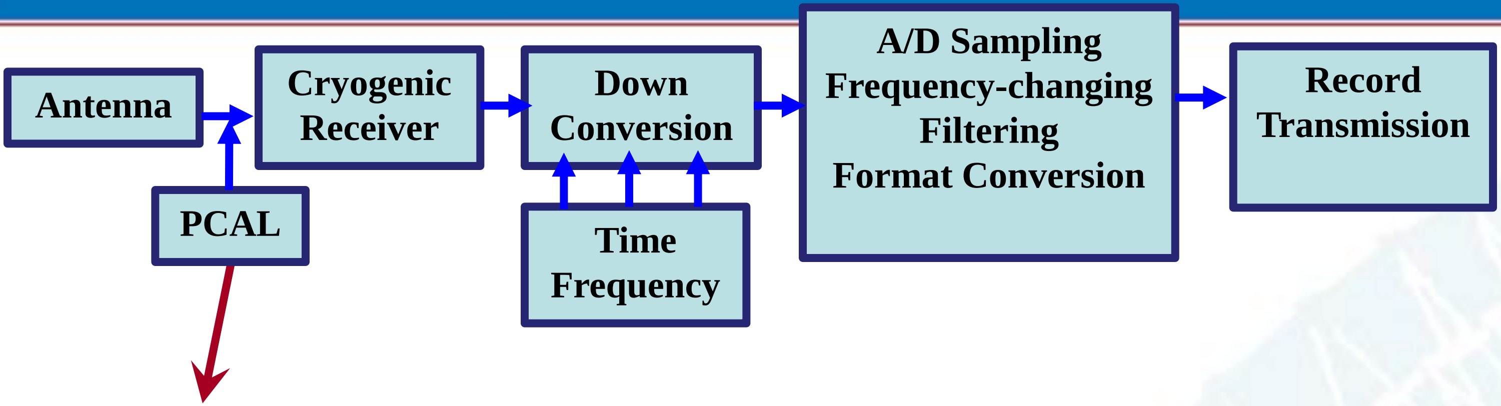
Record Transmission

PCAL

Time Frequency

- ➢Frequency band: S/X/Ka available
- ➢Delay calibration signal frequency: 5/n MHz, n=5~ 99
- ➢Pulse width: 20ps~50ps
- ➢Amplitude of output signal: single spectrum amplitude ranges from -190dBm to -130dBm
- ➢Amplitude dithering of output signal: ±1dB/24h
- ➢Phase dithering of output signal: ≤1°
- ➢On-line calibrating time delay of 100MHz/10MHz transmitting feeder line
- ➢Temperature control requirements for pulse generating unit: temperature fluctuation of ±0.5℃

2. VLBI system of Chang'E Project



Antenna

PCAL

Cryogenic Receiver

Down Conversion

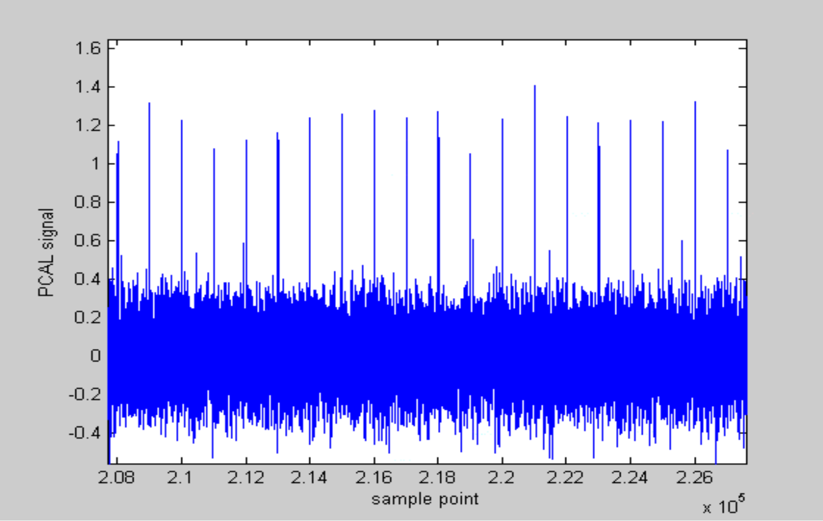
Time Frequency

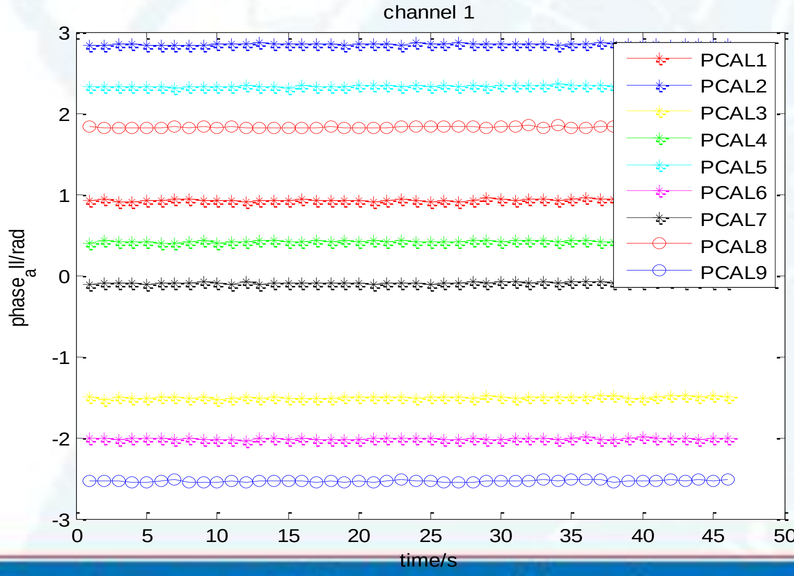
A/D Sampling
Frequency-changing
Filtering
Format Conversion

Record Transmission

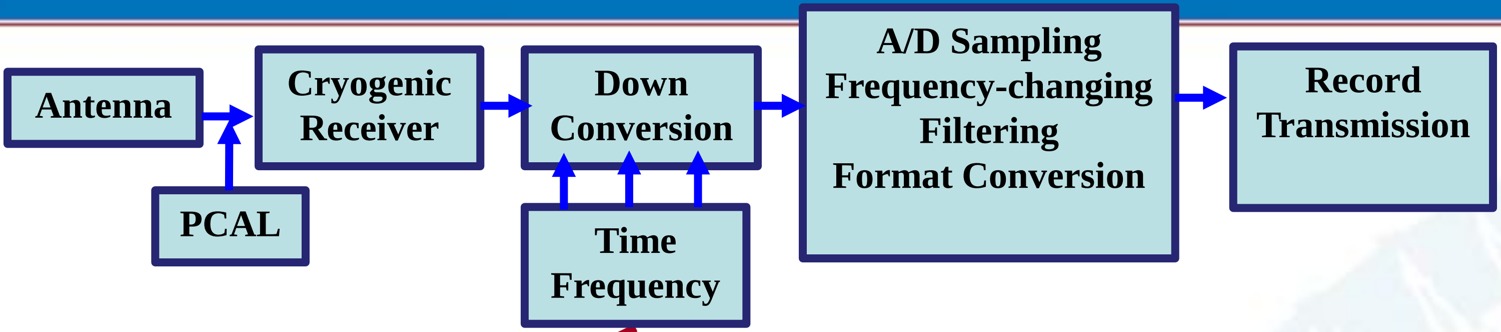
Device time delay correction : PCAL data processing with high precision

correction accuracy: superior to 5ps





2. VLBI system of Chang'E Project



Antenna

PCAL

Cryogenic Receiver

Down Conversion

Time Frequency

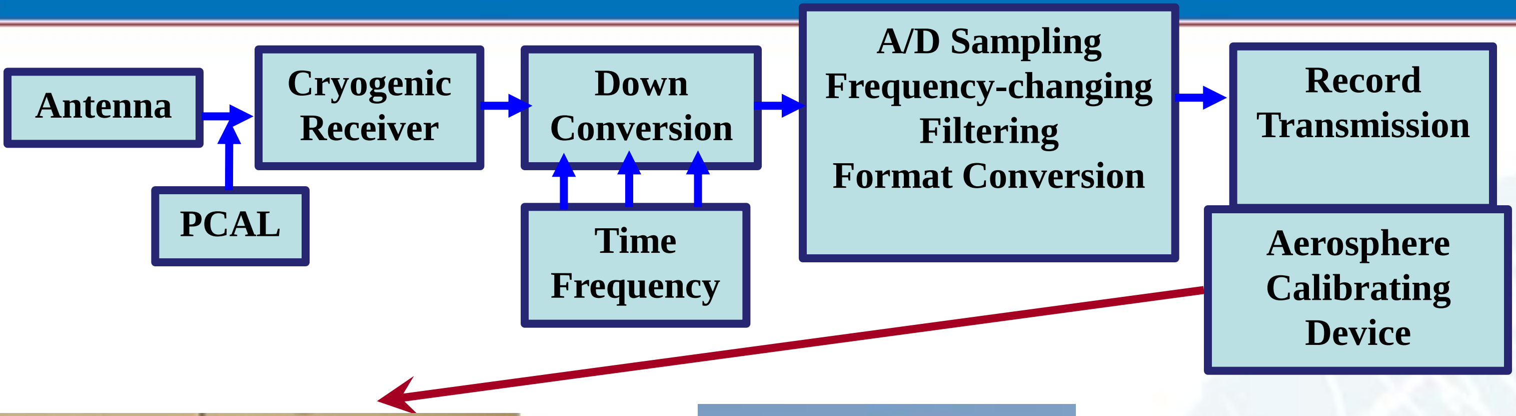
A/D Sampling
Frequency-changing
Filtering
Format Conversion

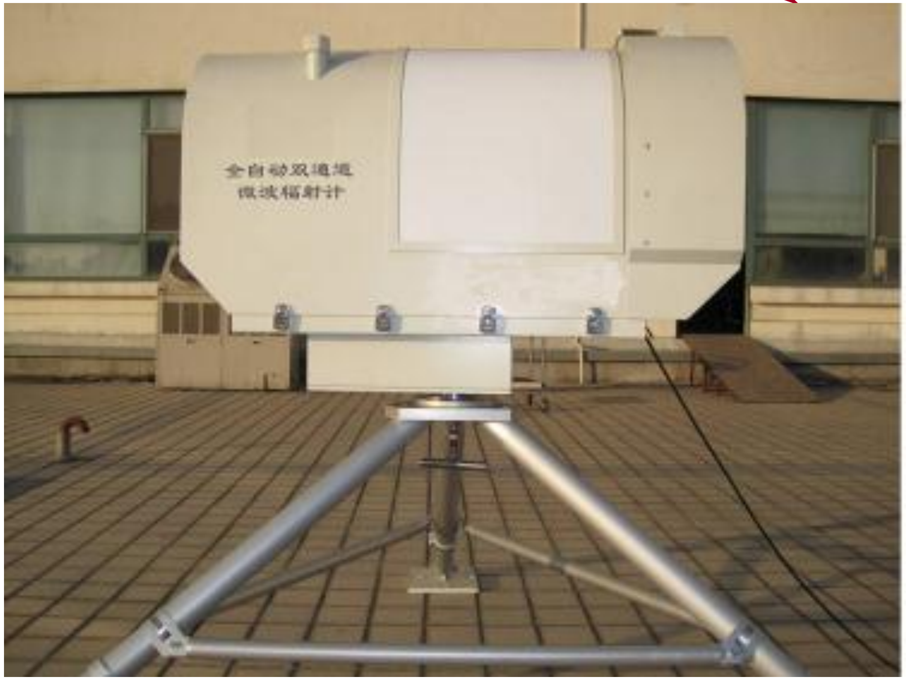
Record Transmission

2012/09/20

System indexes		Hydrogen clock
Standard output		5MHz 10MHz
Frequency accuracy		±5×10^{-13}
Frequency Stability	1s	3～6×10^{-13}
	10s	6～9×10^{-14}
	100s	1～4×10^{-14}
	1000s	8～9×10^{-15}
	100000s	3～5×10^{-15}
Phase noise (10MHz frequency standard)	1Hz	－100dBc/Hz
	10Hz	－130dB/Hz
	100Hz	－135dB/Hz
	≥1000Hz	－145dB/Hz

2. VLBI system of Chang’E Project


Antenna
PCAL
Cryogenic Receiver
Down Conversion
Time Frequency
A/D Sampling
Frequency-changing
Filtering
Format Conversion
Record Transmission
Aerosphere Calibrating Device


全自动双通道
微波辐射计

Microwave radiometer for troposphere calibration

dual-frequency GPS for ionosphere calibration

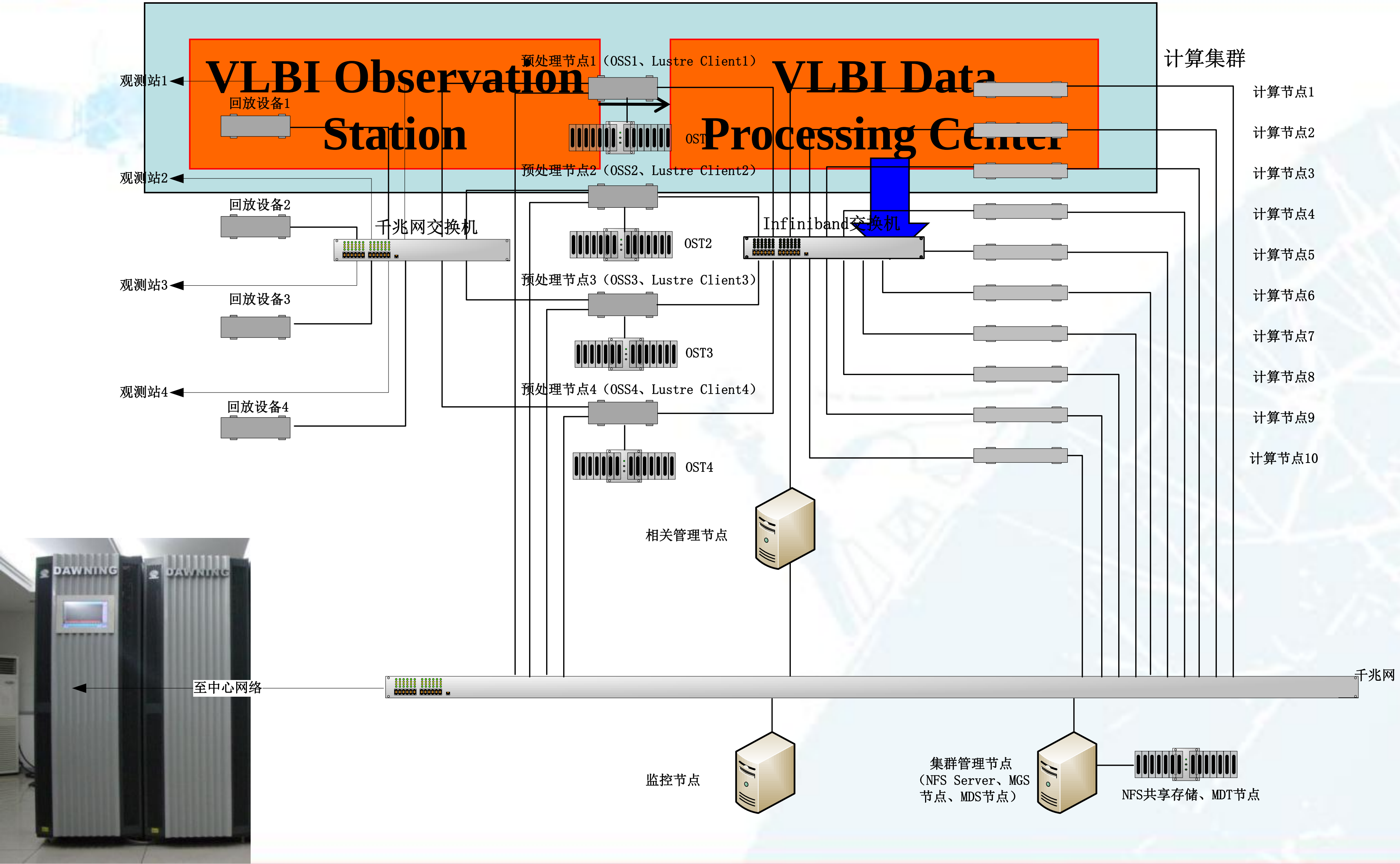
2. VLBI system of Chang’E Project

VLBI Observation Station → **VLBI Data Processing Center**

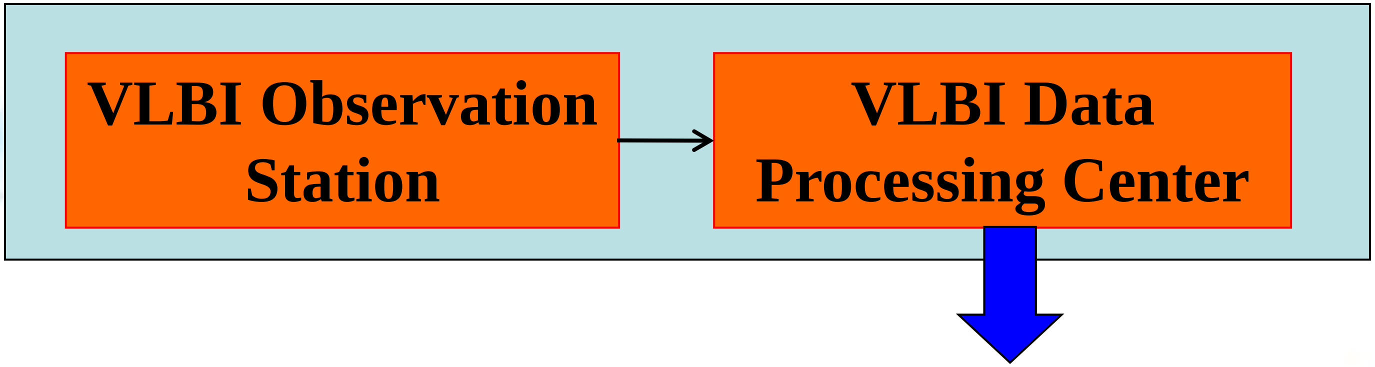
- High performance cluster computing platform （320 cores）
- Infiniband high speed data exchange （40Gbps）
- Adaptable to VSI and VSR data format
- Supporting international VLBI joint measurement and deep space guidance
- Super high spectral resolution （1Hz）
- Achieving 6-baseline (4-station random combined) real-time data correlation processing with 256Mps of data rate per station

DAWNING
DAWNING

2. VLBI system of Chang’E Project


VLBI Observation Station
VLBI Data Processing Center
计算集群
观测站1
观测站2
观测站3
观测站4
回放设备1
回放设备2
回放设备3
回放设备4
千兆网交换机
预处理节点1（OSS1、Lustre Client1）
OST
预处理节点2（OSS2、Lustre Client2）
OST2
预处理节点3（OSS3、Lustre Client3）
OST3
预处理节点4（OSS4、Lustre Client4）
OST4
Infiniband交换机
计算节点1
计算节点2
计算节点3
计算节点4
计算节点5
计算节点6
计算节点7
计算节点8
计算节点9
计算节点10
相关管理节点
至中心网络
千兆网
监控节点
集群管理节点
（NFS Server、MGS
节点、MDS节点）
NFS共享存储、MDT节点
DAWNING
DAWNING

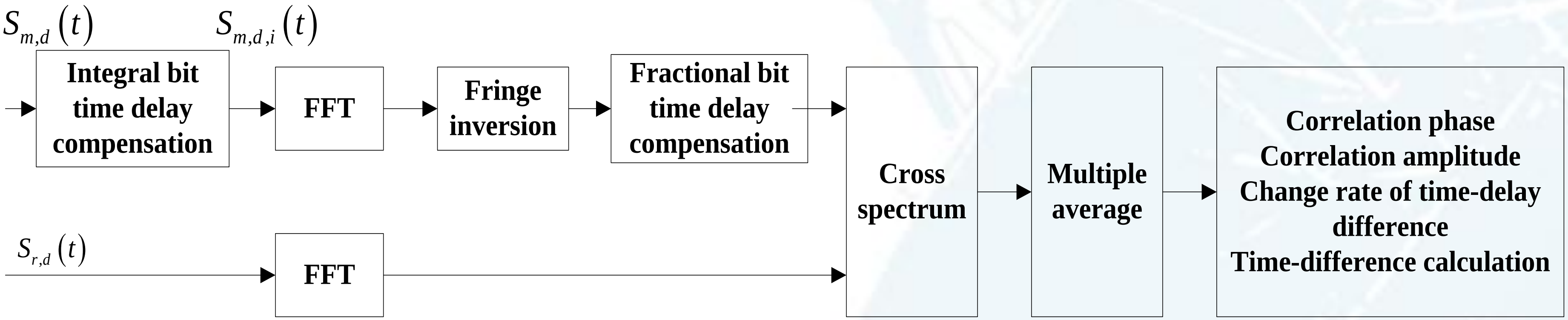
2. VLBI system of Chang’E Project



VLBI Observation Station

VLBI Data Processing Center

- With the help of large scale cluster computers and pure-software, we adopt the advanced FX scheme to accomplish high precision VLBI data processing performance.



$S_{m,d}(t)$

Integral bit time delay compensation

$S_{m,d,i}(t)$

FFT

Fringe inversion

Fractional bit time delay compensation

$S_{r,d}(t)$

FFT

Cross spectrum

Multiple average

Correlation phase
Correlation amplitude
Change rate of time-delay difference
Time-difference calculation

2. VLBI system of Chang’E Project

Summary of our VLBI system：

- Satisfying the standard interface of international VSI, VSR(CCSDS-REEF) and e-VLBI
- The system adopts all digital base-band conversion (DBBC) and recording equipment with good channel consistency.
- Adopting high precision time-delay calibration system with the an accuracy superior to 5ps.

2. VLBI system of Chang’E Project

- FX structure software processor based on high performance cluster computing. / 6-baseline(4-station random combined) data real-time processing with 256 Mbps of data rate per station/.
- The system output : time-delay difference, change rate of time-delay difference, Doppler frequency difference, correlation amplitude, correlation phase, etc.
- Further output: earth orientation parameter, stations’ position errors etc.

3. Introduction of other products

Receiver

S band：

1. Operation bandwidth： 300 MHz
2. Equivalent noise temperature： ≤ 18K
3. System overall gain： ≥65dB
4. Cryogenic temperature ： ≤ 20K
5. Input interface： BJ22-type waveguide

X band：

1. Operation bandwidth： 800 MHz
2. Equivalent noise temperature： ≤ 20K
3. System overall gain： ≥65dB
4. Cryogenic temperature ： ≤ 20K
5. Input interface： BJ84-type waveguide

3. Introduction of other products

The products of receiver

Main （switch included）：

1.Operation bandwidth：1000 MHz

2.Noise temperature：

right-hand polarized channel：

20K （Cryo）

60K（room temperature）

left-hand polarized channel ：60K

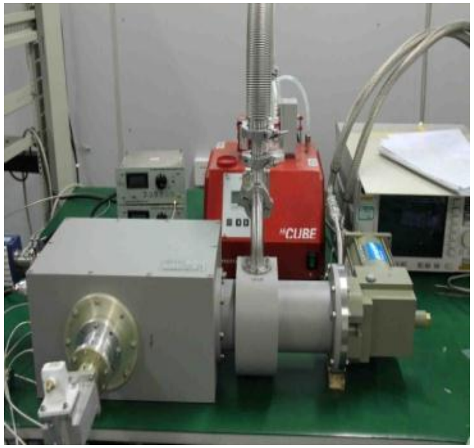
3. Gain ：≥50dB

3. Introduction of other products

Receiver

S-band：

1. Operation bandwidth： 300 MHz
2. Equivalent noise temperature： 10K
3. System overall gain： 75dB
4. Cryogenic Temperature： 12K
5. Input interface： BJ22-type waveguide



X-band：

1. Operation bandwidth： 800 MHz
2. Equivalent noise temperature： 15K
3. System overall gain： 73dB
4. Cryogenic Temperature： 15K
5. Input interface： waveguide

3. Introduction of other products

Receiver

wide-band cryogenic receiver
of 13-meter antenna

Main：

1. Frequency range： L band to X band

   Operation bandwidth： 7800MHz

2. System noise temperature： 50K

3.System overall gain ： ≥50dB

4.Format of input port： feed source

VLBI Antenna

We and MTM Germany co-designed the 13m antenna for VLBI 2010 standard. It is employed with ring-focus reflector, four-ridge horn ultra-wideband feed, AZ-EL pedestal, all-digital antenna controller and program tracking system.

Specifications

- Operation frequency and polarization mode:

Wideband (dual linear polarization): 2 GHz～20 GHz;
X/Ka (dual circular polarization): X: 7.0 GHz～9.5 GHz; Ka: 28 GHz～34 GHz.

- Accuracy of main reflector: ≤0.3mm (rms）
- Accuracy of subreflector: ≤0.1mm
- First sidelobe level: ≤-14dB
- Operation frequency: 2.0 GHz～ 34 GHz
- Antenna tracking pointing accuracy:

Guaranteed accuracy: 18″ (wind speed: 10.7m/s)

- Antenna moving range:

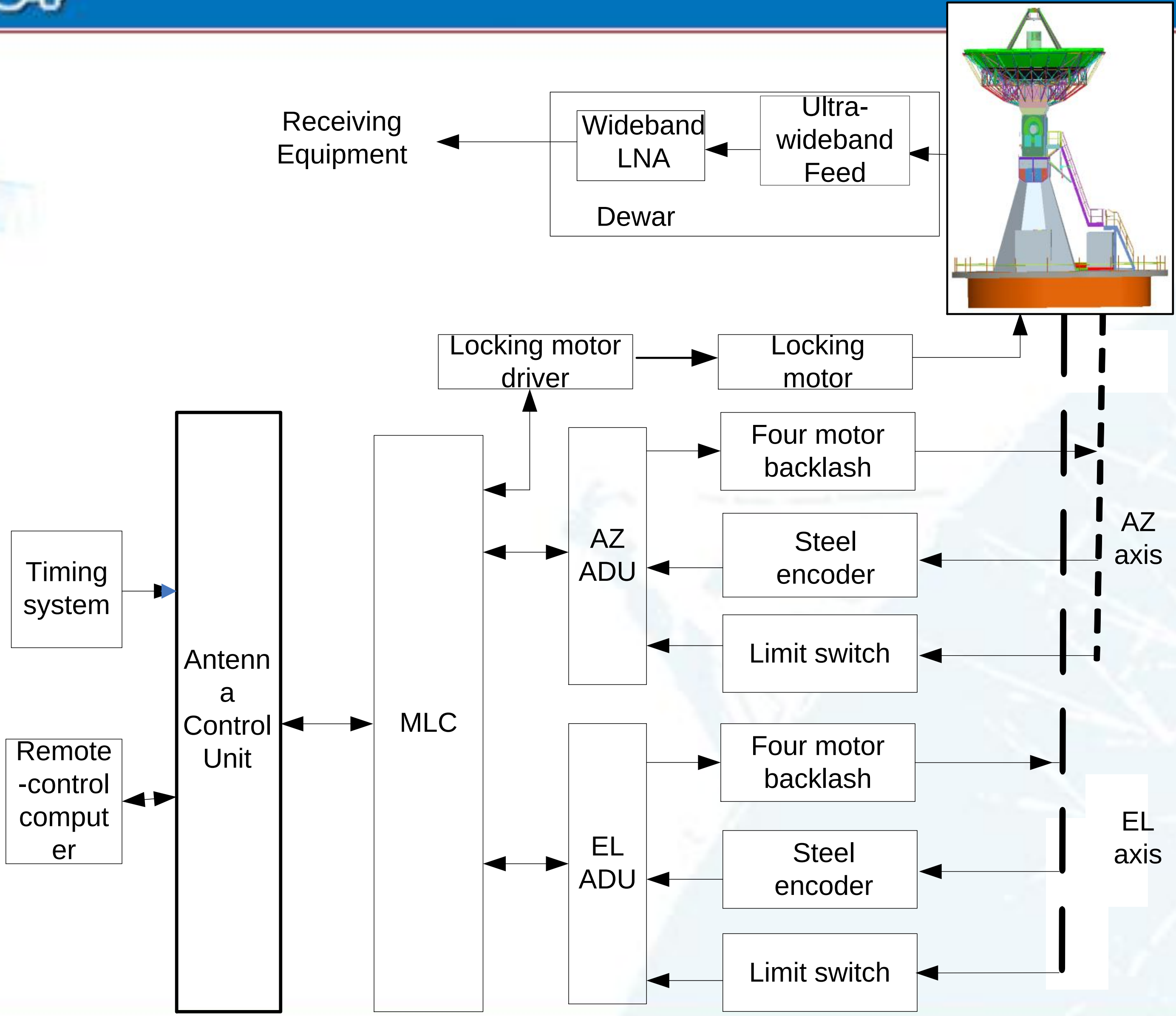
Azimuth: -270° ～+270° ; Elevation: 0° ～100°

- Max moving speed and velocity:

Azimuth: 12° / s, 3° / s^2 ; Elevation: 6° / s, 3° / s^2

- Antenna resonant frequency: ≥3.5 Hz
- Equipped with wideband 2～14 GHz and X/Ka dual-band feed receiver.

Antenna Composition



Receiving Equipment

Wideband LNA

Ultra-wideband Feed

Dewar

Locking motor driver

Locking motor

Four motor backlash

Steel encoder

Limit switch

AZ ADU

AZ axis

Timing system

Antenna Control Unit

MLC

Remote-control computer

Four motor backlash

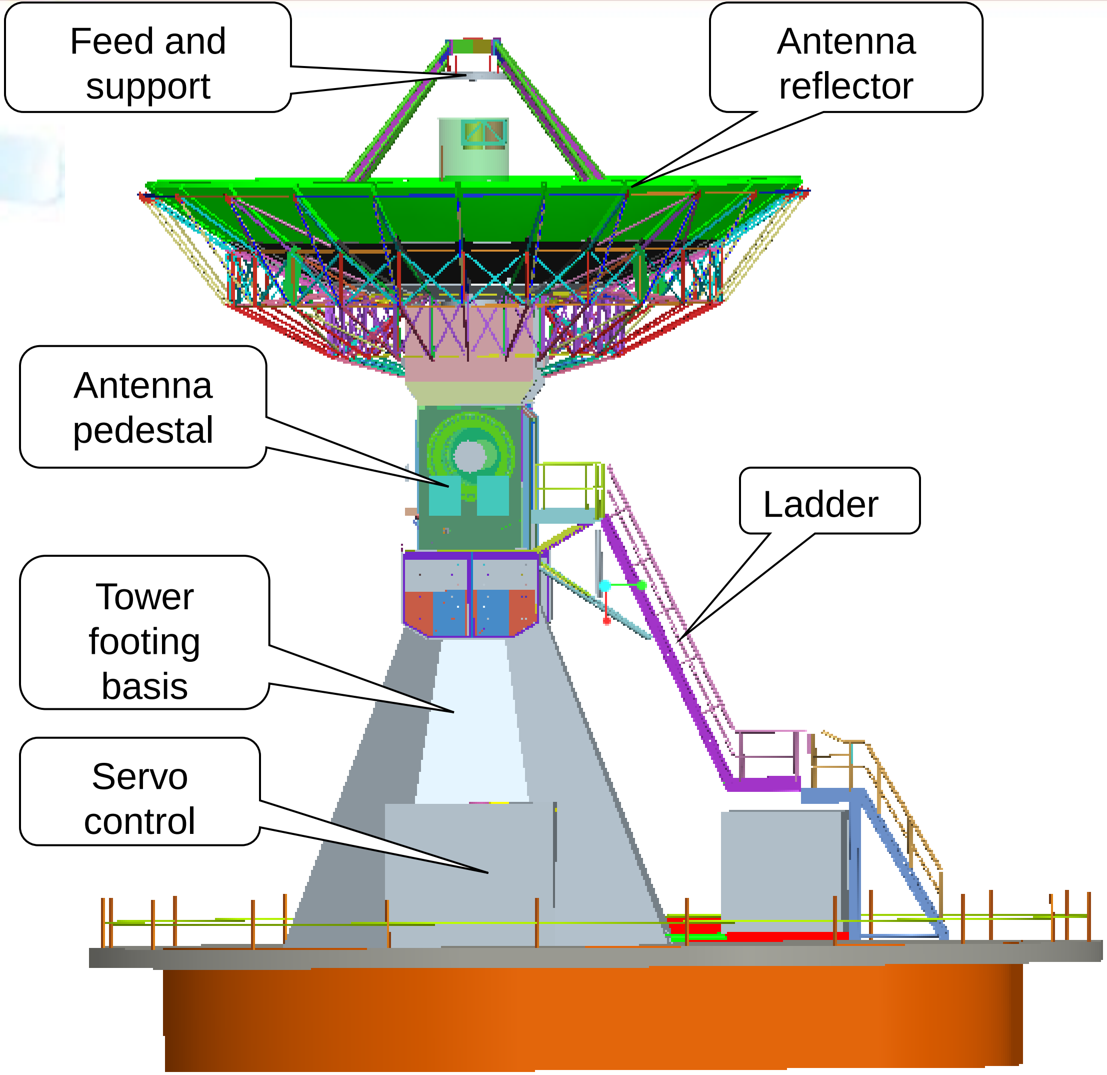
Steel encoder

Limit switch

EL ADU

EL axis

Antenna Composition


Feed and support
Antenna reflector
Antenna pedestal
Ladder
Tower footing basis
Servo control

- Antenna feed subsystem includes: antenna curve surface, wideband feeder, filter, directional coupler, low-noise amplifier, Dewar, etc.
- Mechanical structure subsystem includes: 13m antenna reflector, AZ-EL antenna pedestal, AZ driving equipment and EL driving equipment.
- Servo control subsystem includes: ACU, ADU, axis-angle encoding unit, safety protection equipment, power supplier and external interface.
- Total weight of antenna: 75t; power consumption: 60kW.

Typical Projects

Radio Telescope Antenna

50m Antenna for
National Astronomical Observatory

65m Antenna
(L, S/X, C, X/Ka, Ku, K, Q bands)
for Shanghai Astronomy Observatory

2010/01/09 05:50

MRO Opening Ceremony on 5 Oct, 2012
the 24th Antenna is named as Wajarri Janimarrun (Chinamen)

Thank You !

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