The Progress of VLBI Digital Backend in SHAO

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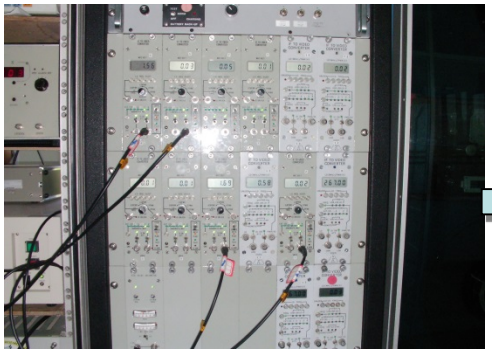
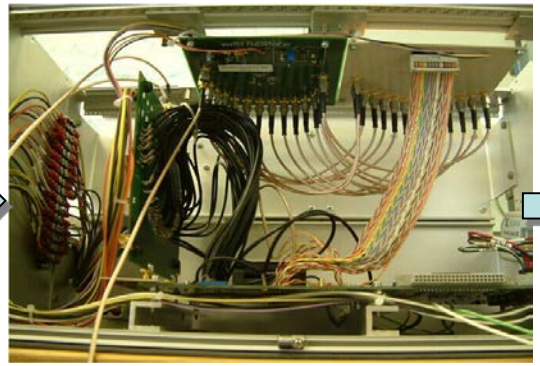
Outline

1. History
2. Current status and applications
3. Development status
4. Future work

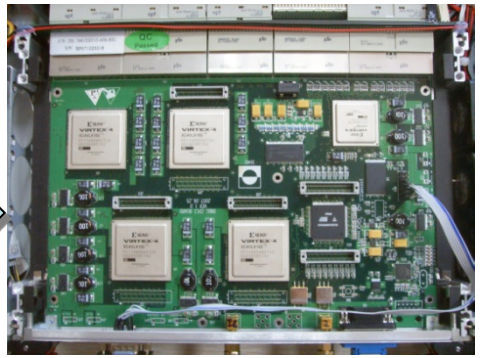
1. History



Analog Baseband Converter (ABBC),<2010



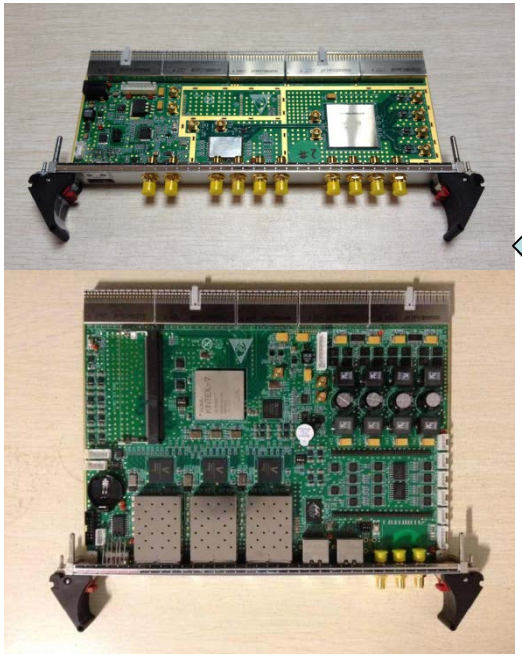
Mini-DBBC (2004)



(2009)

CDAS1 (2010)

CDAS2 (2013)

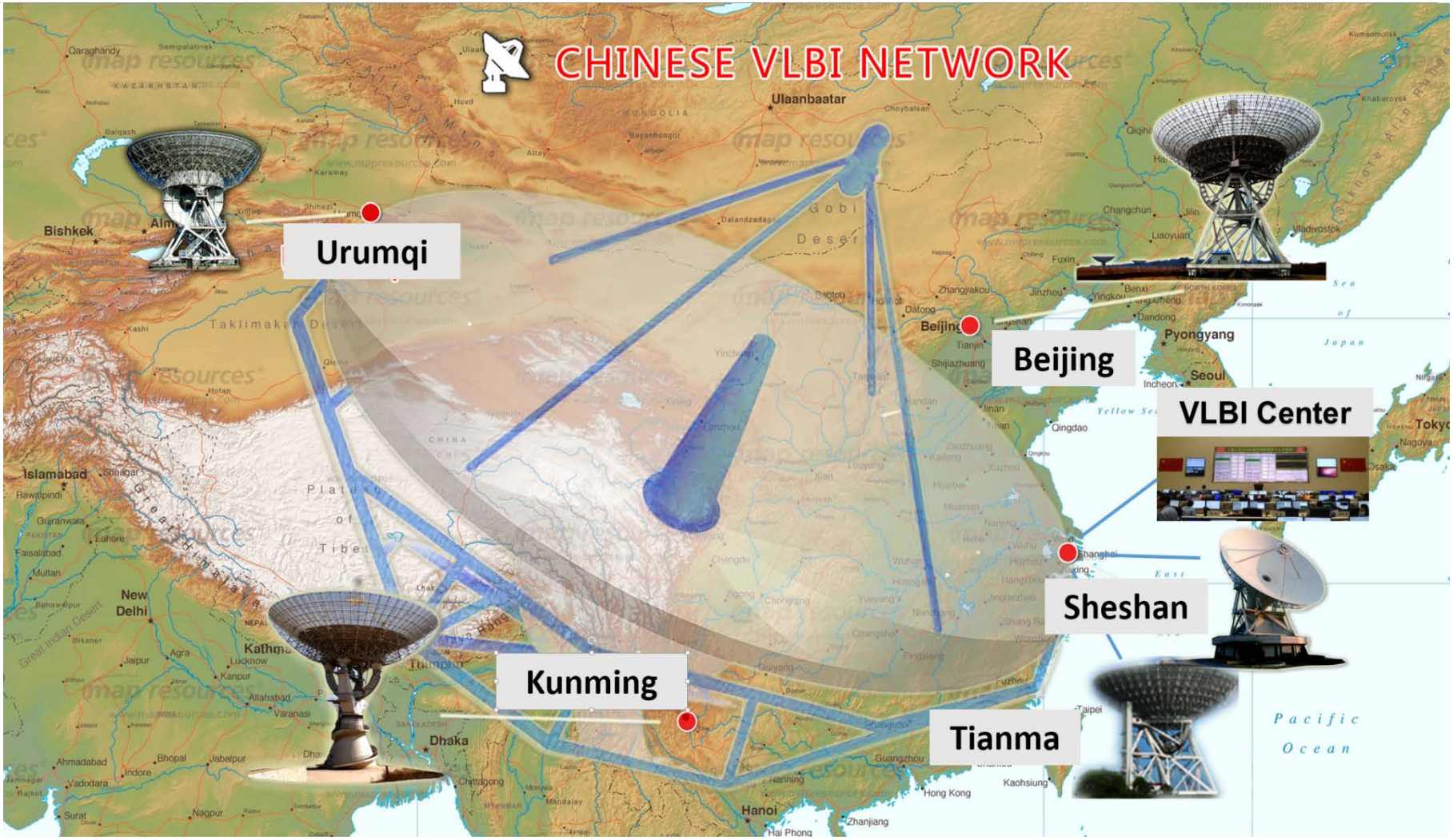


CDAS3 (2015)

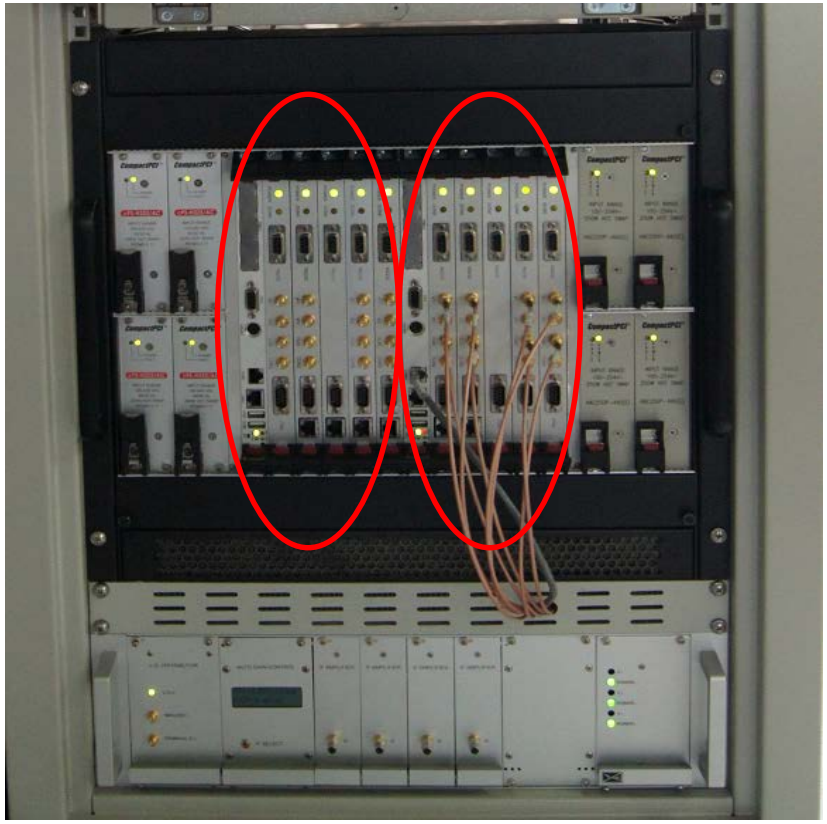
CDAS：

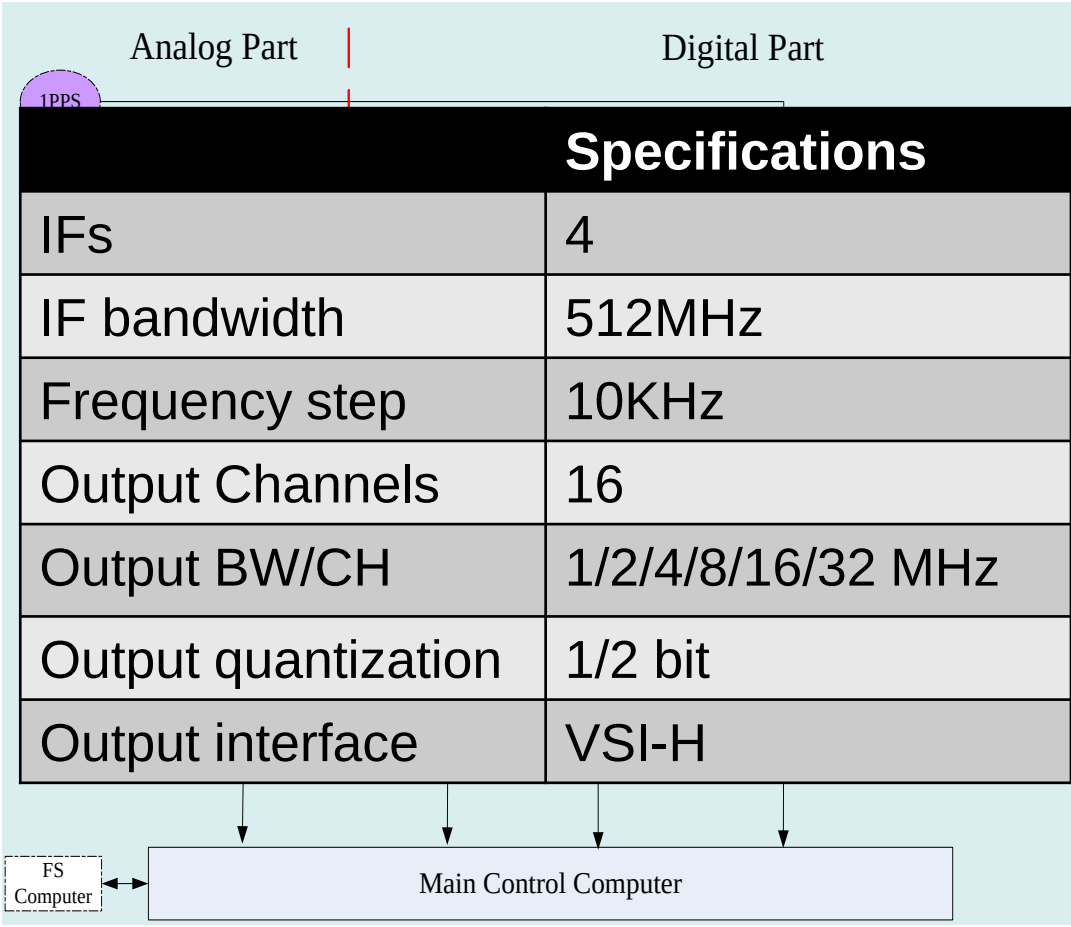
Chinese VLBI Data Acquisition System

2.Current status and applications



CDAS1 specifications

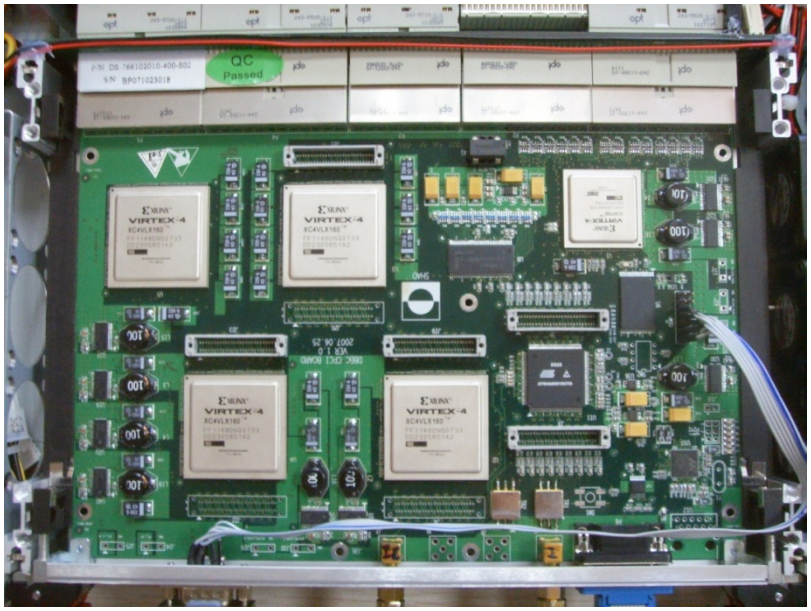




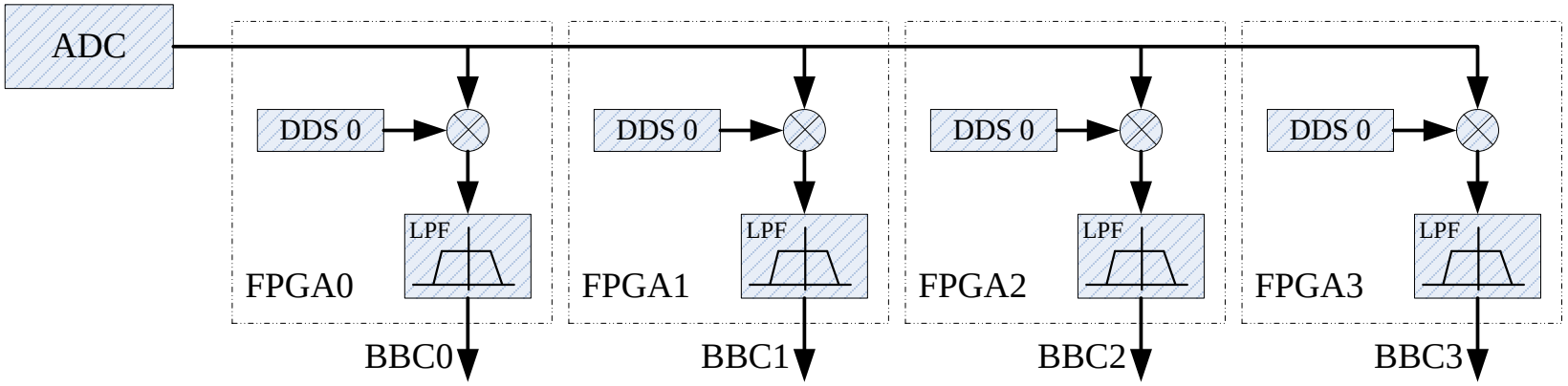
	Specifications
IFs	4
IF bandwidth	512MHz
Frequency step	10KHz
Output Channels	16
Output BW/CH	1/2/4/8/16/32 MHz
Output quantization	1/2 bit
Output interface	VSI-H

- **Dual redundant unit(Digital Part)**
- **Mainly serving for Chinese Lunar Projects**

CDAS1 Platform



- 1Gsps sampler
- Daisy Chain structure
- DDC Algorithm
- Each FPGA produce one BBC including USB and LSB



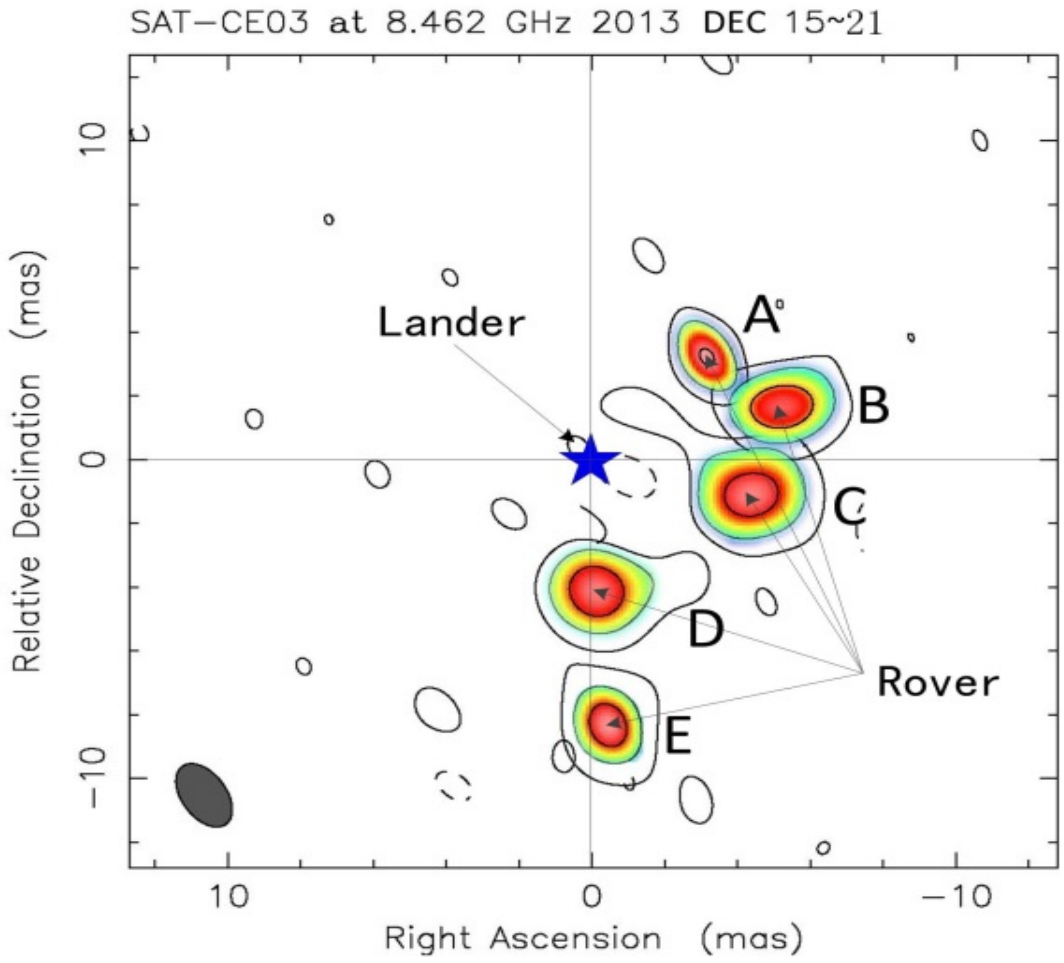
CDAS1 application in CVN

(1) Chinese Lunar Exploration Project

(2) Geodesy and astrometry observation

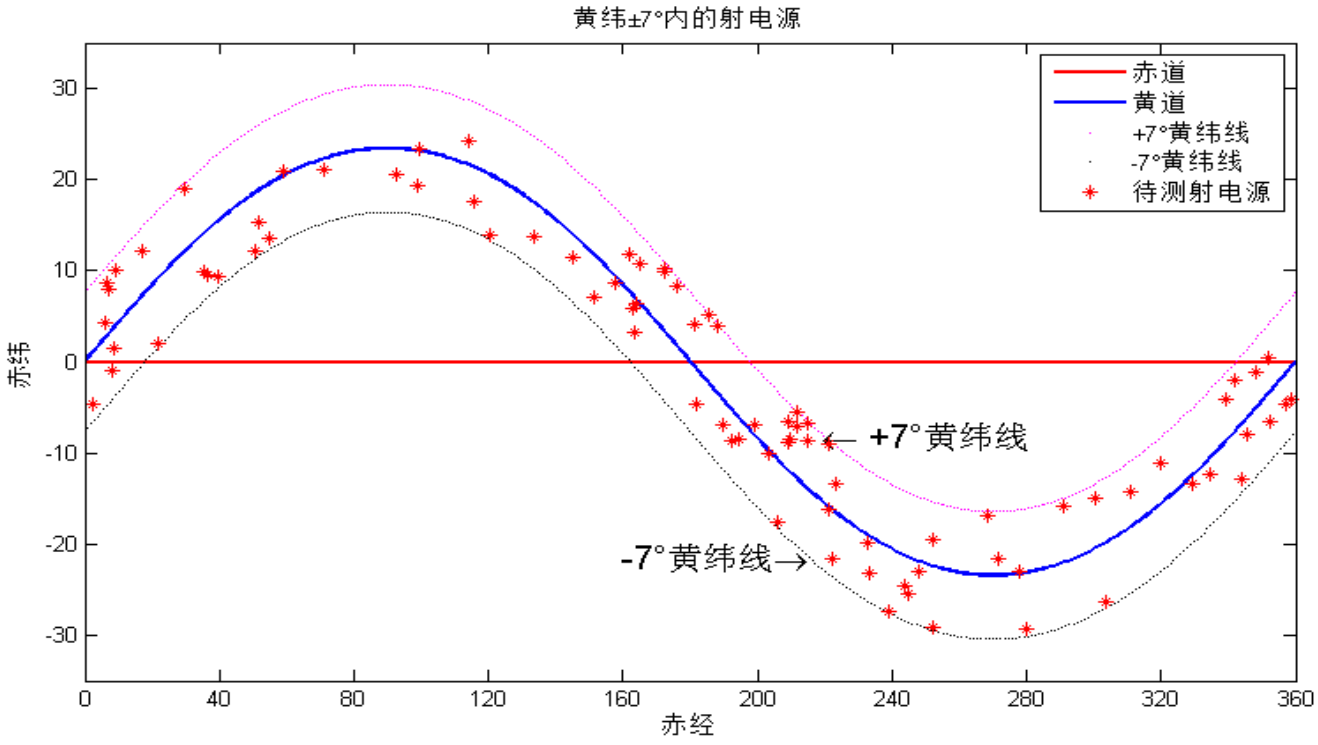
(3) Astrophysics observation

Rover & lander VLBI same-beam phase-referencing map positioning



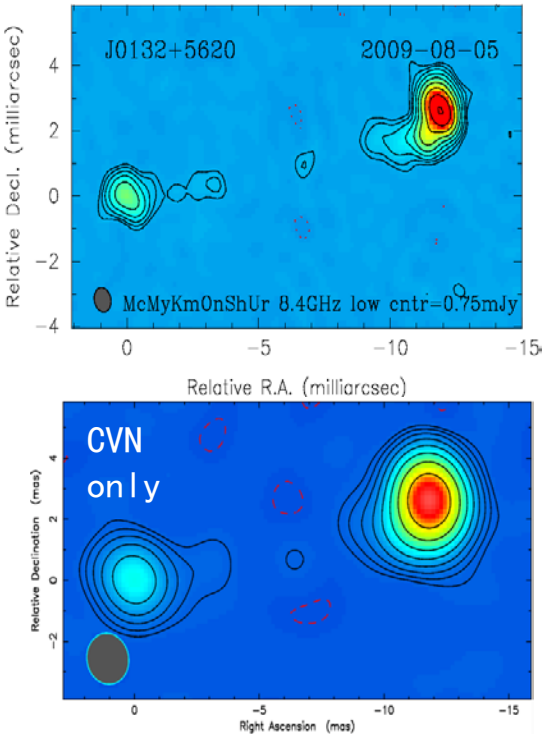
VLBI Ecliptic Plane Survey

- In June 2013, we made the first trial VEPS observations by using Chinese VLBI stations equipped with CDAS. Observing mode: 1024(Mbps)-16(Channel)-1(bit)
- 85 ecliptic sources as shown in the plot with total flux > 0.1 Jy have been observed. There are 29 sources observed by VLBI for the first time. Among them, we successfully detected 18 new weak sources with estimated correlated flux lower than 0.1 Jy.



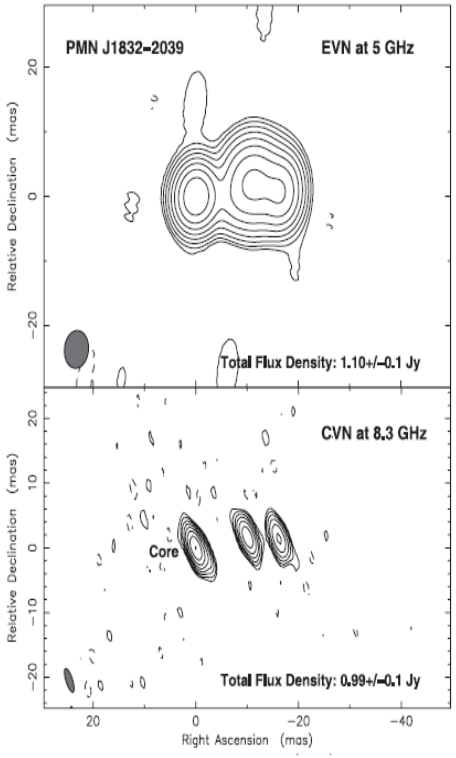
Fine structure of compact object

Movement of compact radio source



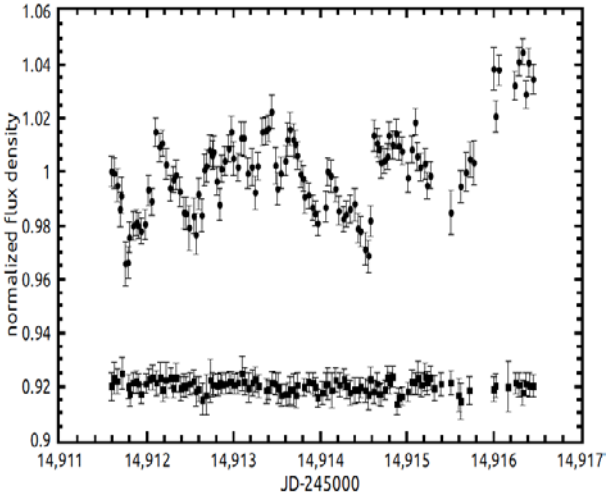
An Tao et al. 2012

Radio structure of BHB



Yang Jun et al. 2012

Radio radiation of Gamma-ray source



Single Dish: Traffic Monitoring

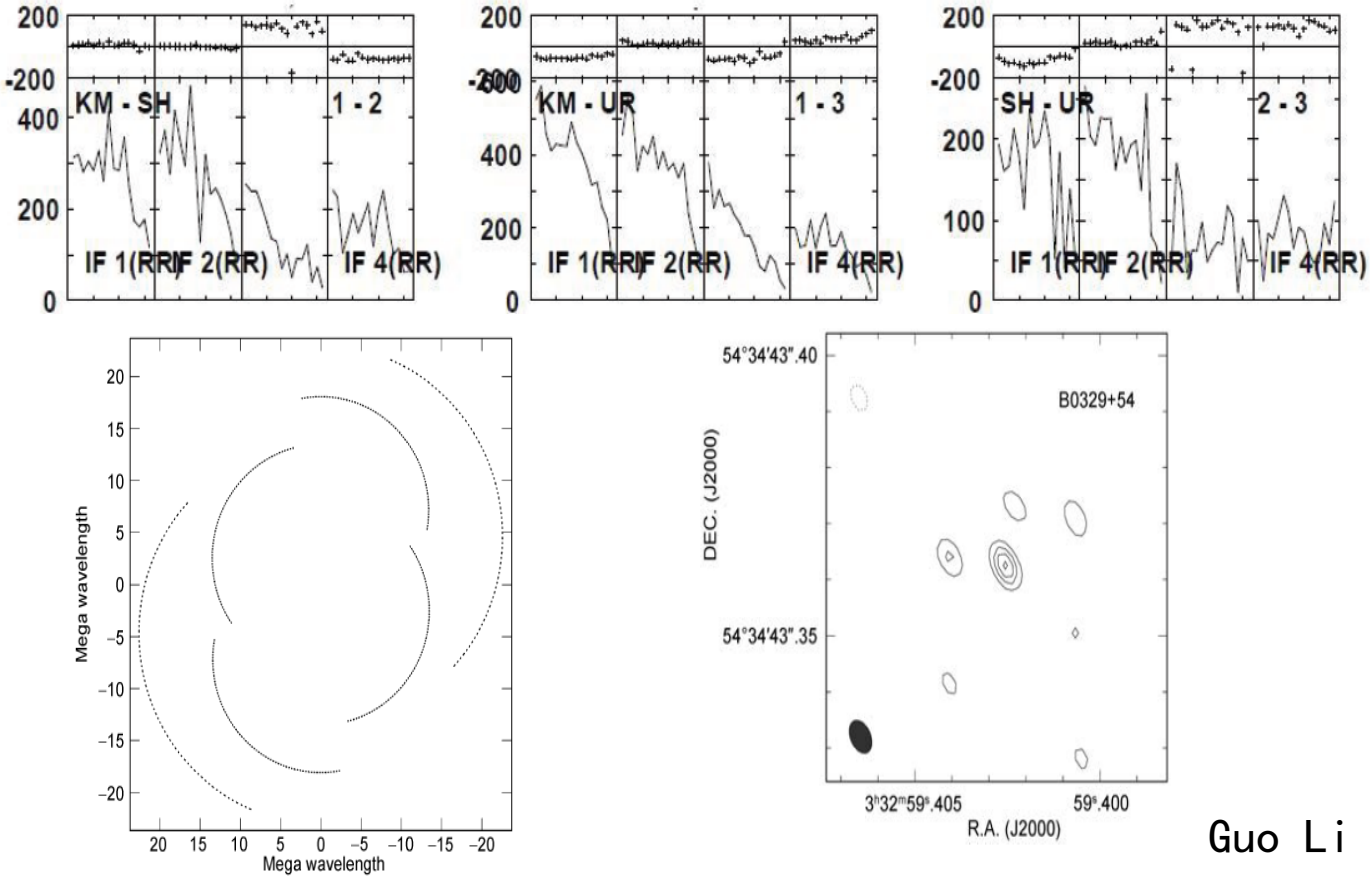
CVN: Structural Changes

Liu Xiang et al. 2012

High-precision pulsar astrometry

CVN (Km+Sh+Ur); PSR B0329+54 (200 mJy @ 1.4 GHz); phase-ref

~3 hr (2008 Oct 16) @ S-band; **software correlator (DiFX)**

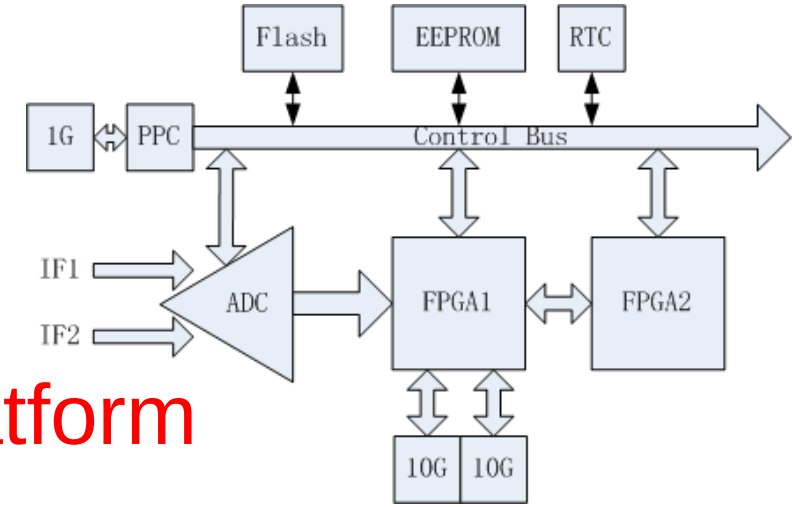


Guo Li et al. 2010

Figure 1 The (u, v) coverage obtained for PSR B0329+54 at 2.2 GHz from 3 baselines formed from the CVN antennas Shanghai Kunming and Urumqi.

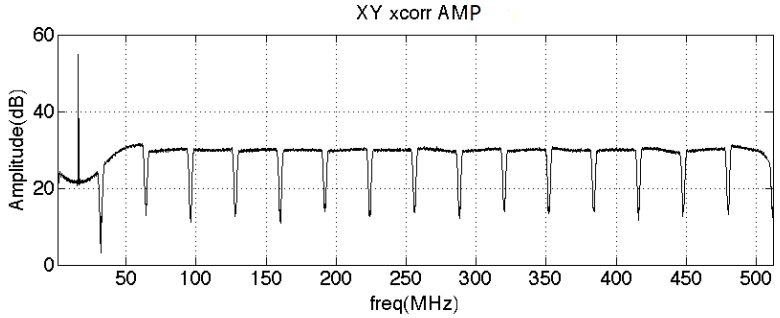
Figure 4 Image of PSR B0329+54 observed with CVN at 2.2 GHz. Contour levels are spaced linearly at 8.0 mJY beam^{-1} (2σ). The peak flux density is 23 mJy beam^{-1}.

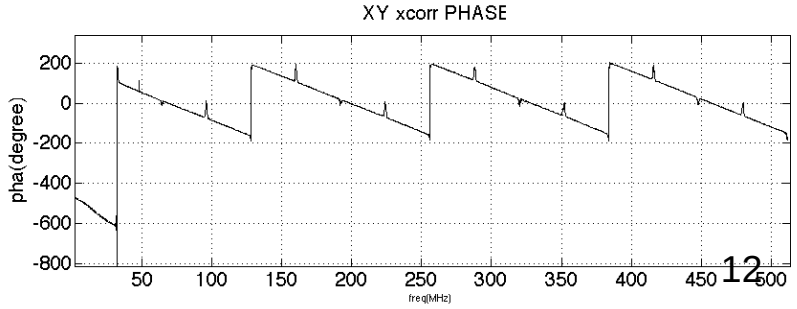
3. Development status



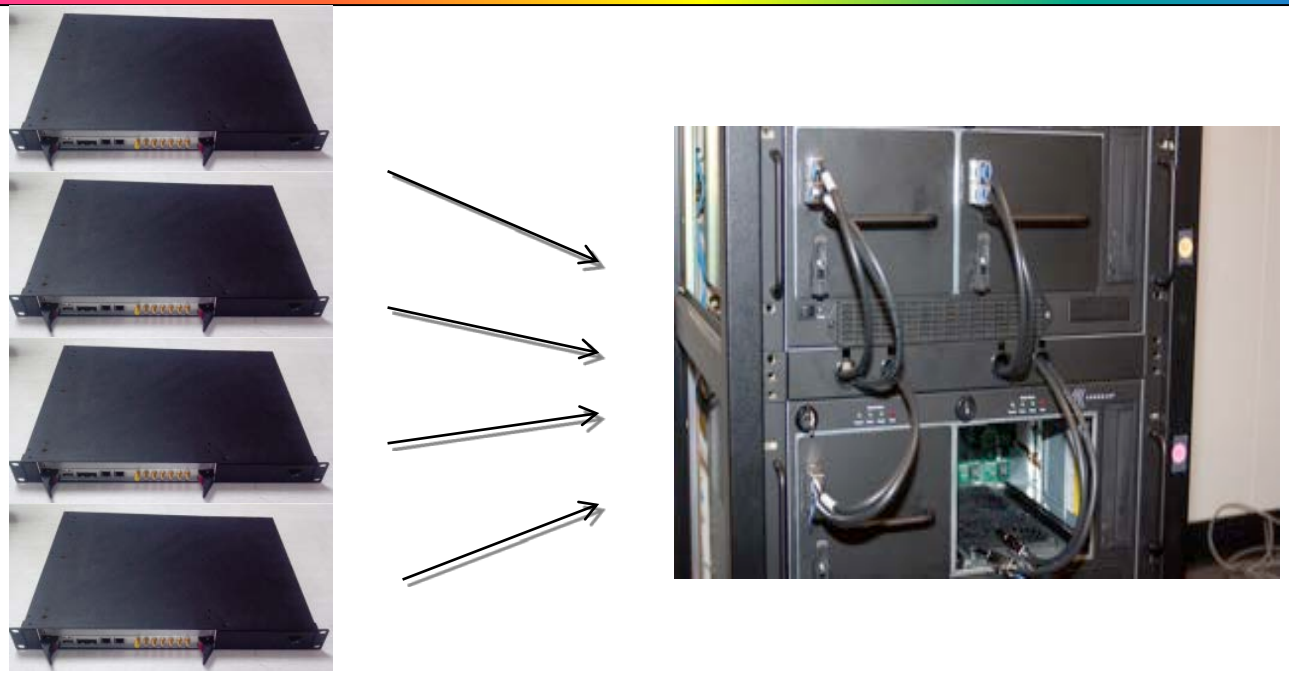
CDAS2 Platform

- **Xilinx K7 Platform**
  - **512MHz x 2 IF or 1024MHz x 1 IF**
  - **10GE x 2 output**
  - **1GE x 1 output**
- **Firmware:**
  - **PFB Algorithm(finished)**
  - **DDC Algorithm(verifying)**
  - **VDIF Formatter(finished)**
  - **10GE data transfer(finished)**



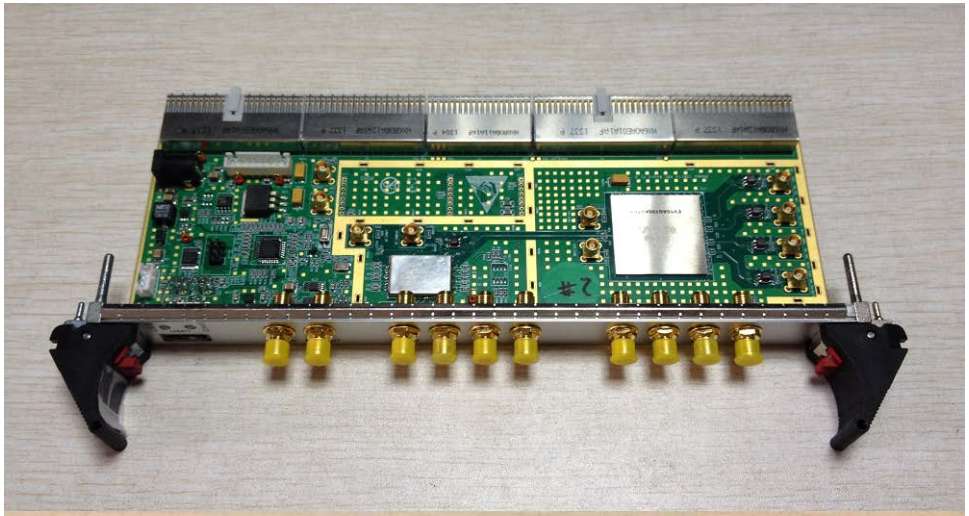


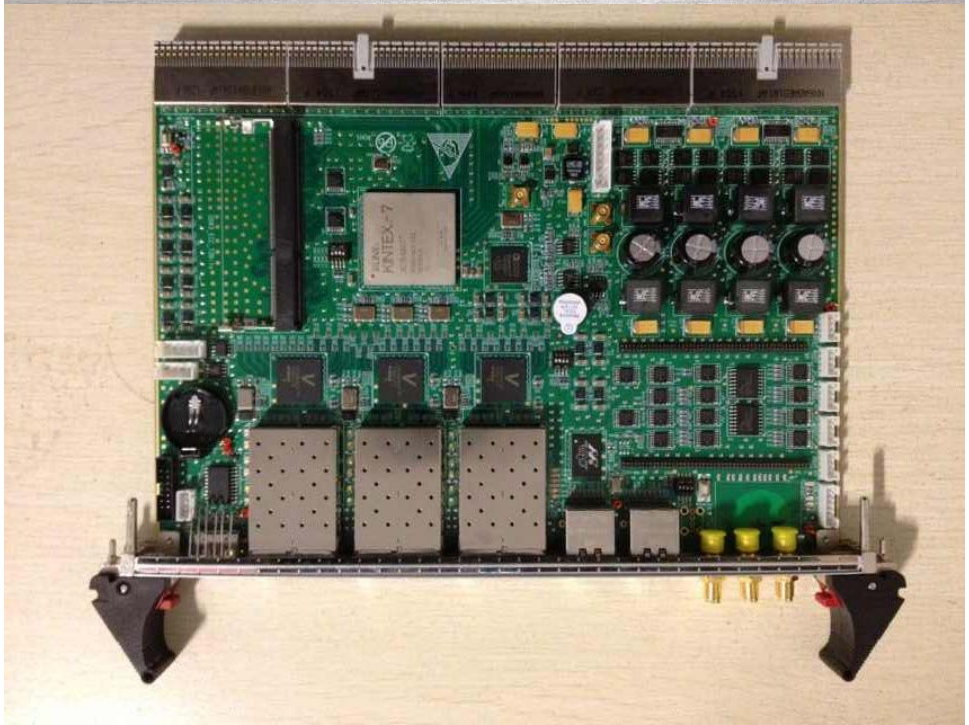
Connect with Mark6



- **CDAS2**
  - 4Gbps or 8Gbps for each
  - 4 data streams connected to Mark6 by 4 10GE
- **Mark6**
  - 4 x 10GE SFP+
  - 16Gbps@continuous mode
  - 32Gbps@burst mode

CDAS3





- **ADC Module**
  - 5Gsps ADC
  - Frequency synthesizer
- **DSP Module**
  - Xilinx K7 FPGA
  - 8GB DDR3
  - 6 SFP+ for 10GE
  - 2 RJ45 for 1GE
  - DAC on board

Comparison

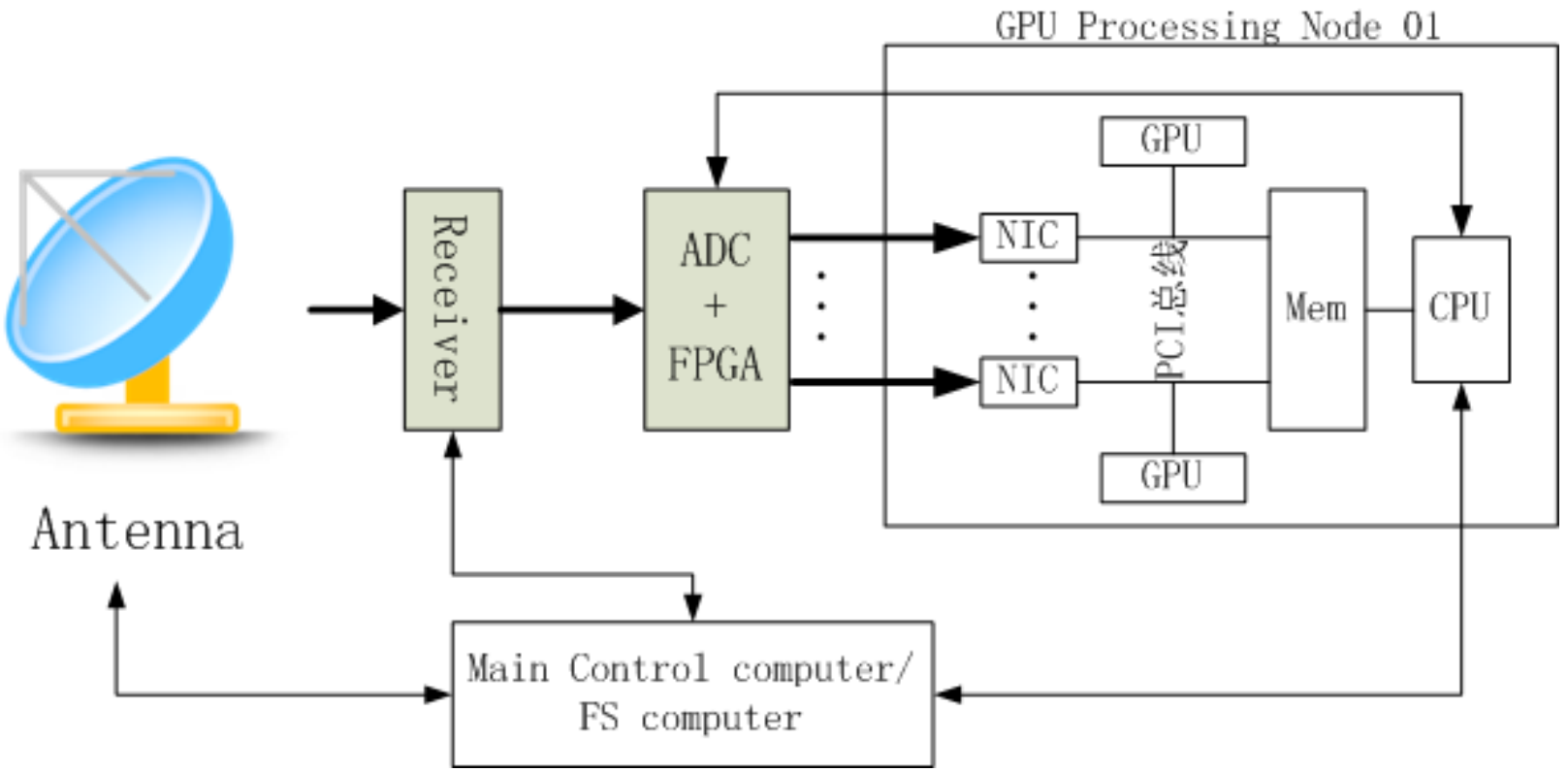
Platform	CDAS	CDAS2	CDAS3
Number of inputs IFs for each board	1	2	4
Sample mode	1CH@1024Msps	2CH@2048Msps 1CH@1024Msps	4CH@1024Msps 2CH@2048Msps 1CH@4096Msps
Type of FPGAs	4 x Virtex4 LX60 4 x Virtex4 LX160	2 x Kintex7 355T 2 x Kintex7 420T 2 x Kintex7 480T	1 x Kintex7 355T 1 x Kintex7 420T 1 x Kintex7 480T
Data Interface	VSI (interface board needed)	10GE x 2 VSI(interface board needed)	10GE x 6
Memory	No	No	8GB DDR3
DAC	No	No	Yes
Schedule	Finished	Firmware and software testing	2016 or later

4. Future work: General purpose backend

- Versatile
  - Compatible with different receivers, different post processing hardware, and different observation modes
- Huge data sampling, transmission and processing
  - Real time processing(mm pulsar search)
- Complexity
  - Signal processing based on GPU cluster
  - Multi-functions(different pre-processing and data format)
- EMC design, RFI mitigation

Target…

- **General Wideband Backend:**
- **VLBI, single dish Pulsar (cooperated with XAO)**



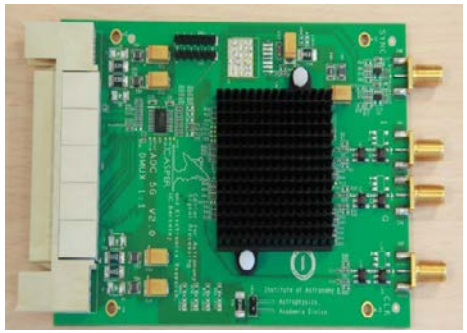
Performance

- **For VLBI (SHAO)**
  - 512MHz BW x 4 (depend on the resources in FPGA)
  - 16 channels with PFB algorithm
  - VDIF Data frame
  - 10GE output
- **For Pulsar (XAO)**
  - 2Gsps x 1 @ 8-bits
  - Minimum BW : <0.25KHz
  - PSRFITS supported
  - 10GE output

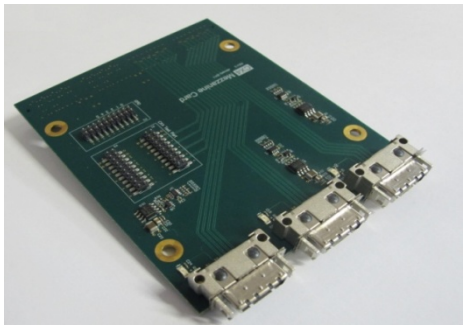
General Wideband Backend(ADC + FPGA)

- **ADC + FPGA**
  - **With Roach2 Platform**

Roach2 XC6VSX475T



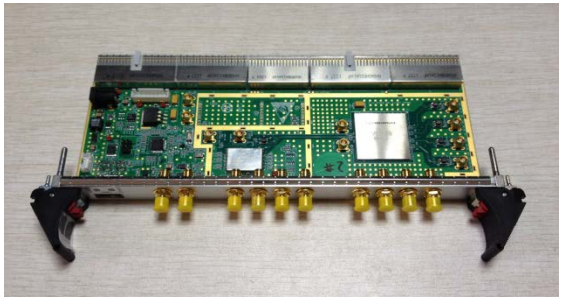
ADC 5Gsps



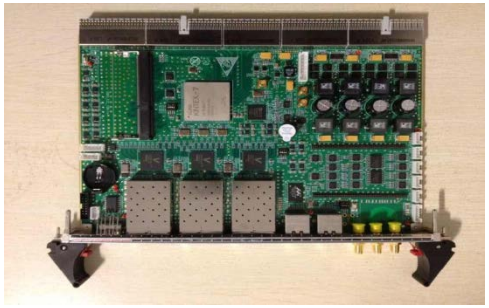
10GE CX4*

* Should be SFP+, but can not find the picture

  - **With CDAS3 Platform**



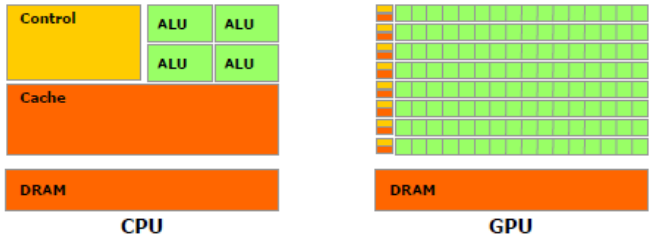
ADC 5Gsps & synchronizer

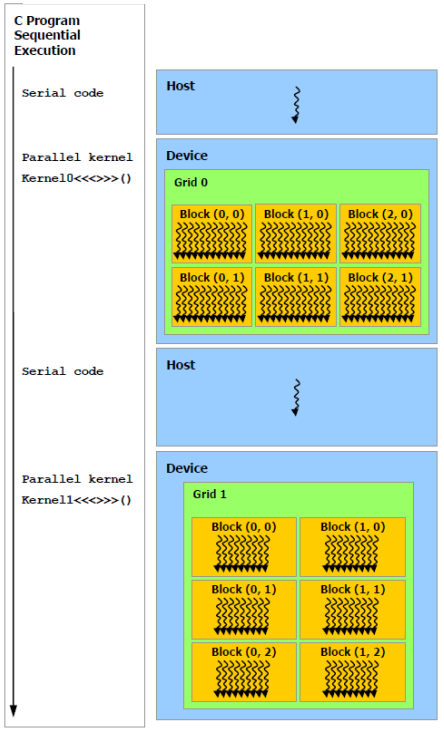


FPGA XC7K480T & 10GE

General Wideband Backend(GPU)

- **Function**
  - Data checking、decoding and storing
  - Coherent dedispersion and incoherent dedispersion
  - High-resolution spectral analyzing
  - Data format generating
- **Platform**
  - Workstation + GPU
  - Nvidia Tesla GPU



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