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Shanghai Astronomical Observatory



Current status of Chinese VLBI network (CVN) software correlator

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EVGA, March 24, 2009, Bordeaux



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1. Background

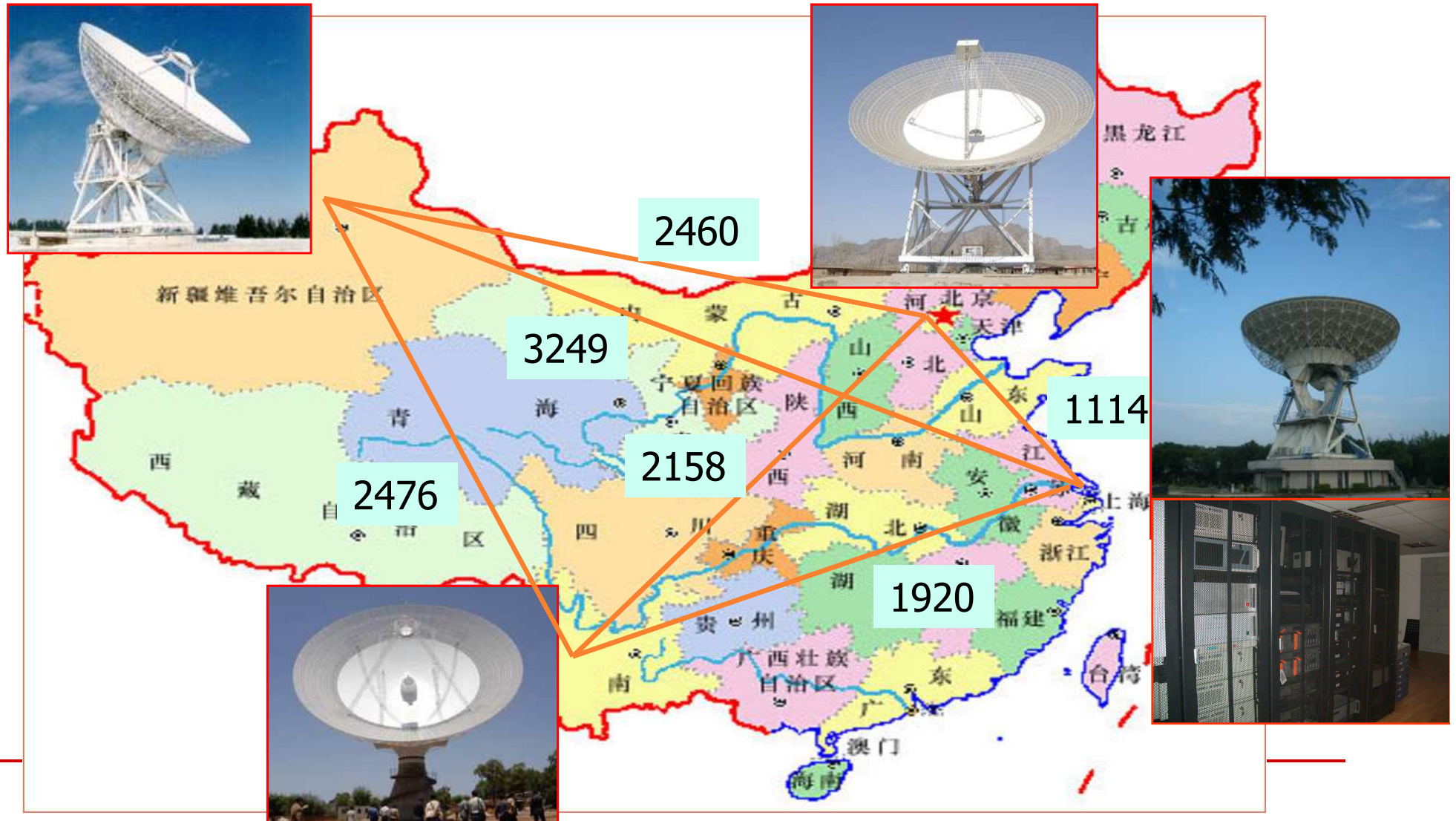
- ◆ CVN software correlator was from Chang'E-1 (CE-1), first Chinese lunar exploration project
- ◆ CE-1 TT&C system: USB + VLBI
- ◆ Oct 24, 2007 – Mar 1, 2009
CE-1, first Chinese lunar probe

TT&C: Tracking, Telemetry and Control

- USB: Traditional Unified S-Band command system for range & rate, Radar
 - CVN: Chinese VLBI Network for delay & rate and angular position, VLBI
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CE-1 Two-stage Tracking task

1. Critical flying mission (Oct 25,-Nov 30, 2007)

■ Near-real time mode:

Data latency < 5 minutes

➤ Data rate: 16Mbps/station, network

➤ 15hours/day



CE-1 Two-stage Tracking task

2. Long-term in-orbit operation (Dec 18,2007-Mar 1, 2009)

■ Post processing mode:

➤ Data latency < 2 wakes
2days/week

➤ Data rate: 128Mbps/station, Mark5A

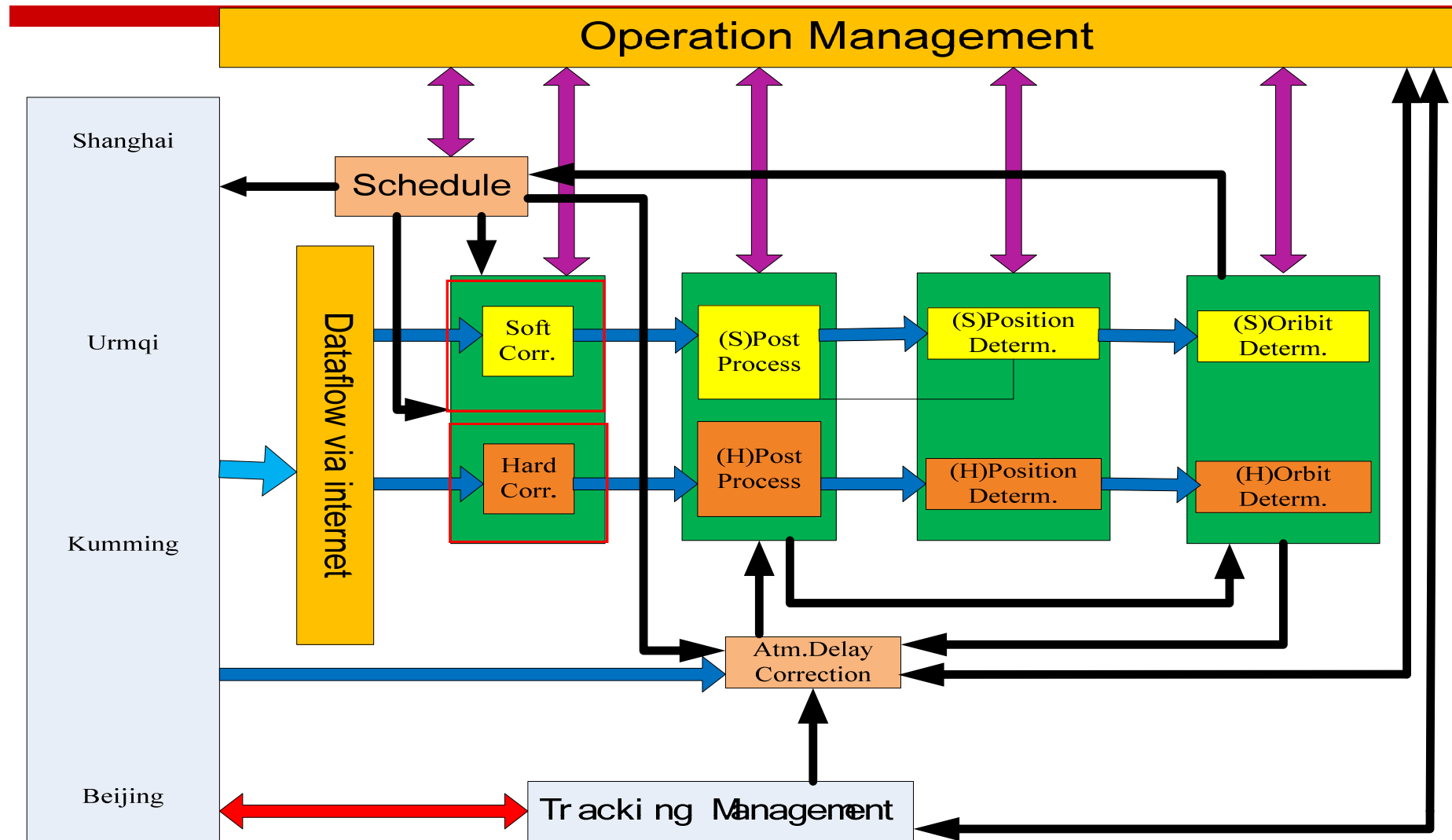
■ Near-real time mode:

➤ Fringe check

➤ Orbit maneuver experiment



Software correlator + hardware correlator





2. SMP software correlator for CE-1

☐ FX type correlator

4-station in CE-1 project, maximum 10-station

☐ Hardware platform:

SMP (Symmetric Multiple Processor) PC server
X86, 4 CPUs (dual core → quad core), 2.2GHz

☐ Software platform:

Linux enterprise OS



- ☐ **Near real time correlation ability (< 3 min)**
 - ☐ **Special functions:**
 - 1. Fast satellite fringe search and model reconstruction**
 - 2. Full PCAL detection ability, CE-1 mode**
 - ✓ 8 PCALs, 4-channel, BW=2MHz/channel**
 - ✓ 64PCALs, 8-channel, BW=8MHz/channel**
 - ☐ **Correlation speed:**
 - >128 Mbps/station, 2bit sample, 4 stations,**
 - on 16-CPU core server**
-

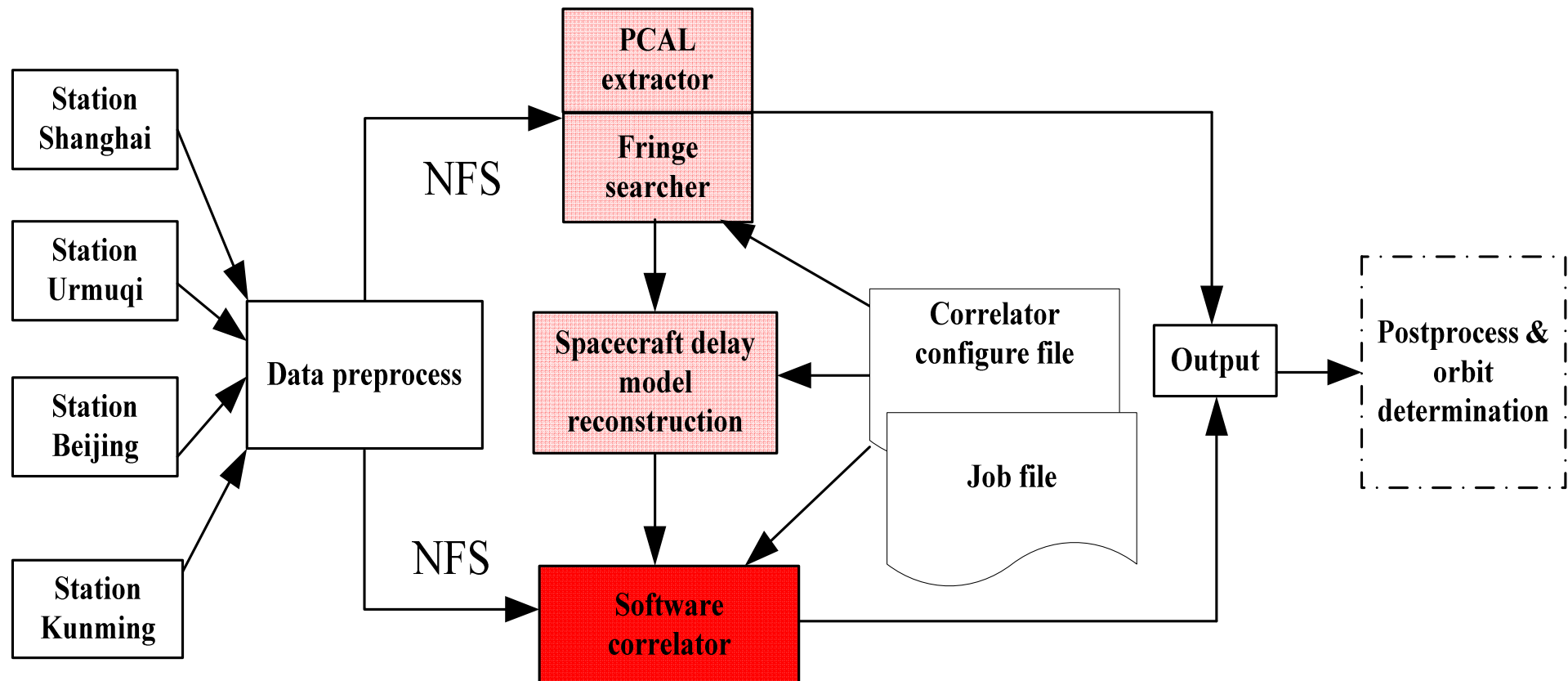


Correlator Capabilities

Correlation station number	1~10
IF number	1~16
FFT points/ IF	32 ~65536/IF
Integration period	0.1~60 second
Input data format	Mark5A(1:1, 1:2, 1:4 fanout)
Sampling	1bit, 2 bit
Output data format	CVN (one-minute based)
Fringe search	2-4 stations
Correlation speed	>128Mbps/station (4 stations, 1024/IF)
Data latency	< 3 minutes
PCAL detection	Yes



Block diagram



One-minute based
NFS: Network File System

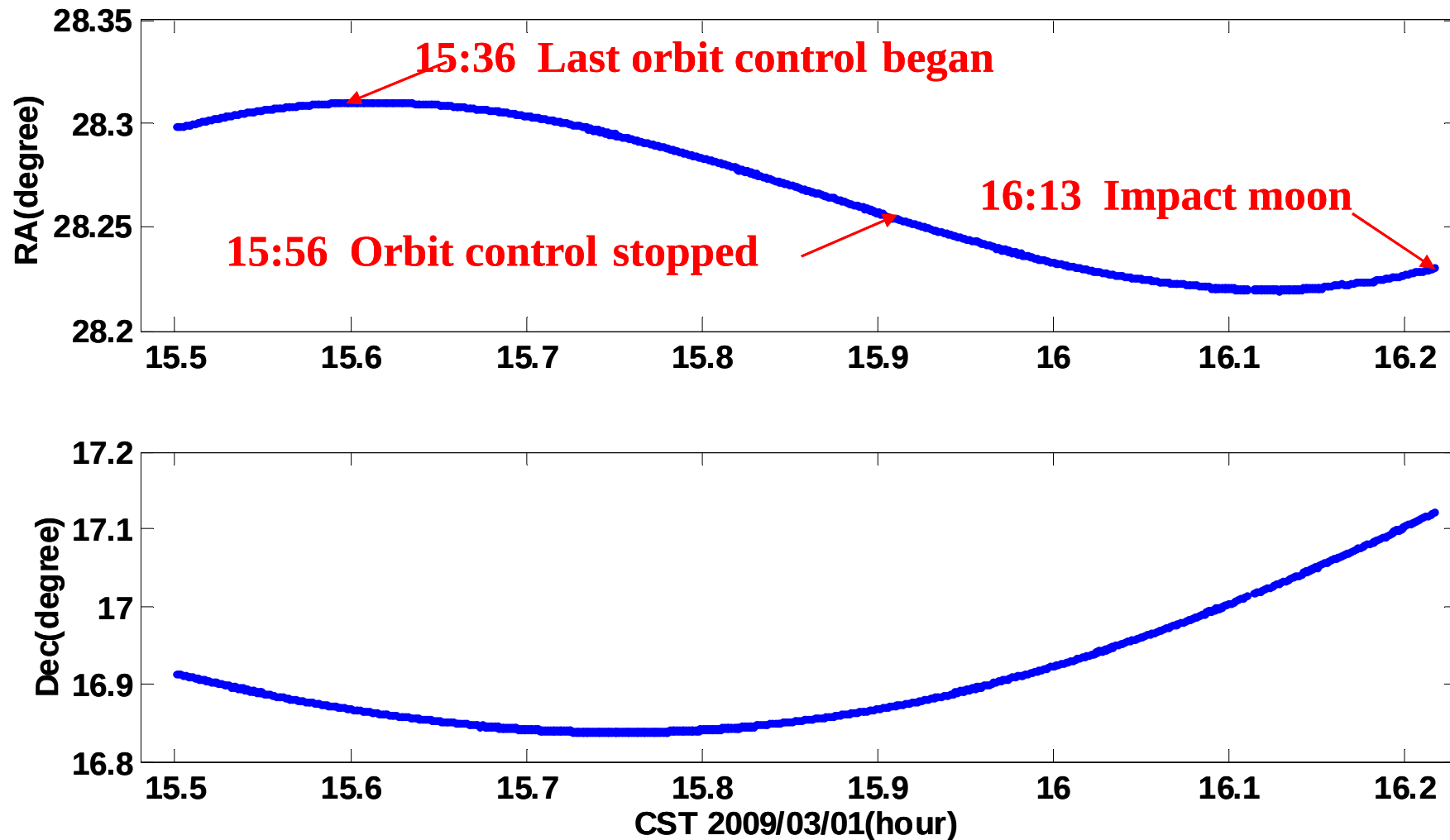


3. Applications in CE-1 project

- ❑ Reliable, flexible, Important in CE-1
 - ❑ Processed 1006.9 hours data
 - Critical flying mission
 - 36 near-real time experiments, 336.55 hours sent out 336.55 hours
 - Long-term in-orbit operation
 - 113 experiments, 670.35 hours sent out 434.02 hours
 - ✓ Including real-time CE-1 maneuver tracking
 - ✓ Geodesy (CVN station position)
-



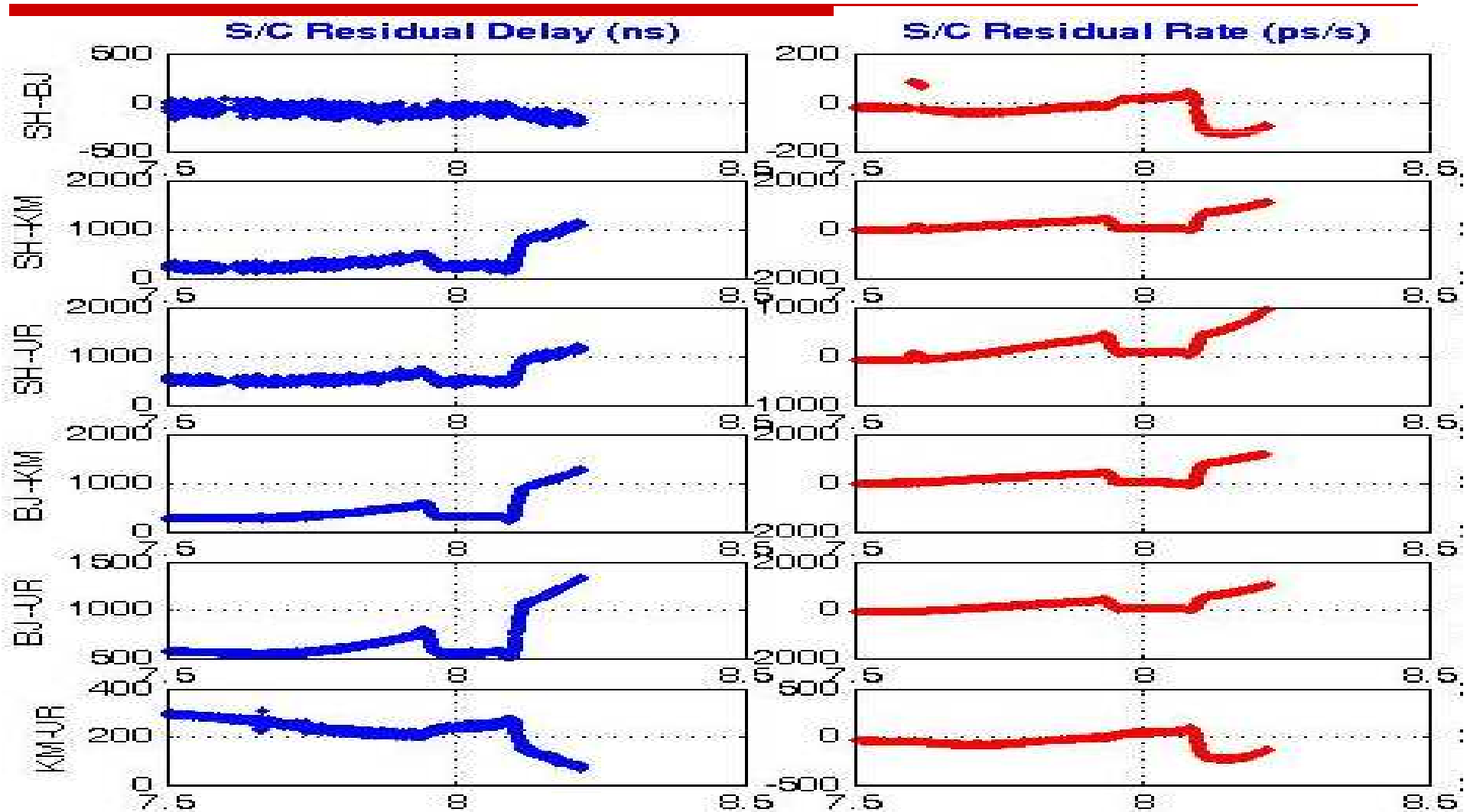
Angle position of CE-1 in moon impact



2009-3-1



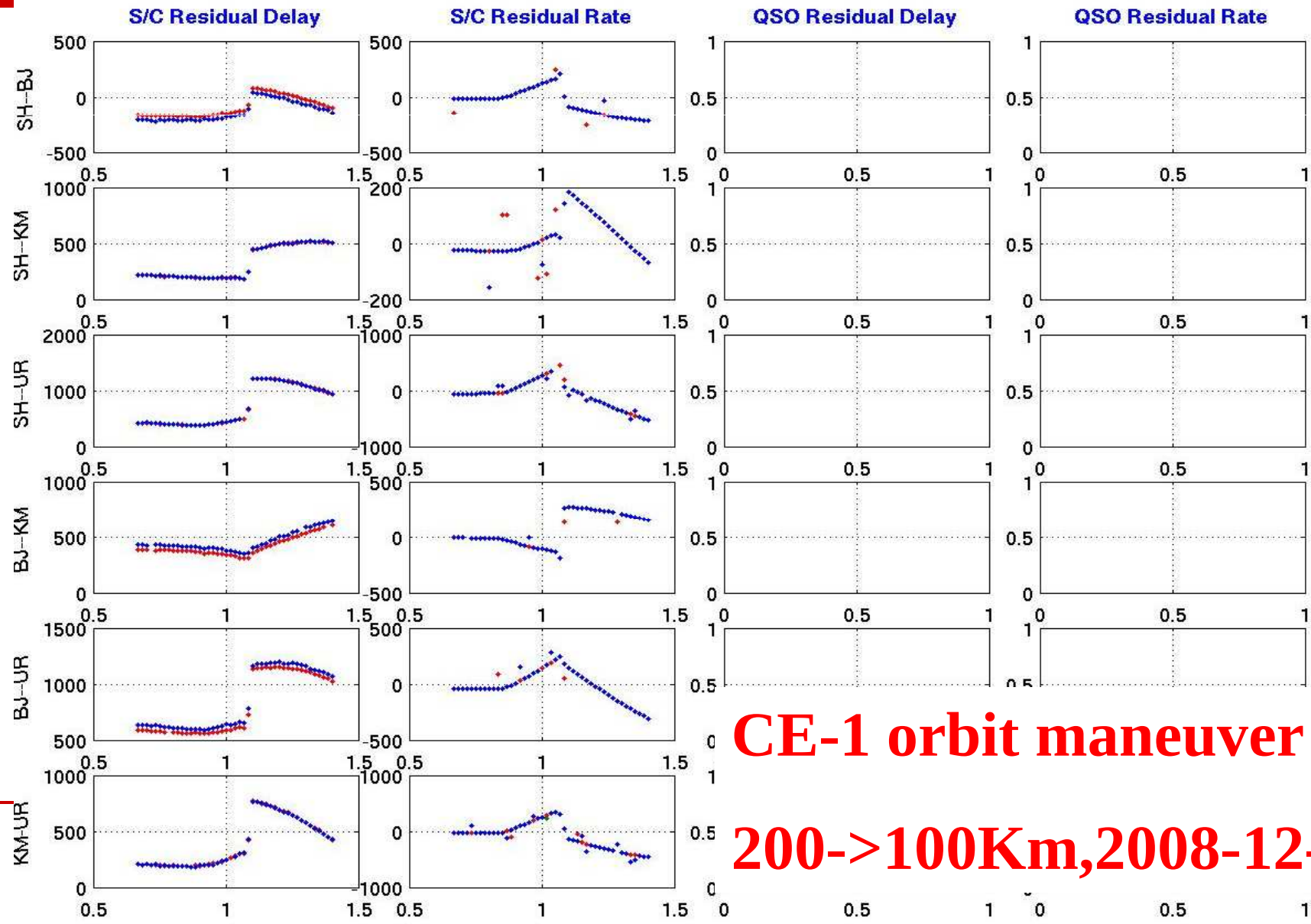
O-C value of delay & delay rate



2009-3-1



O-C value of delay & delay rate





4. Wideband software correlator prototype

For Astronomy applications:

□ PC cluster with Two-level parallelisms:

➤ Intra-node

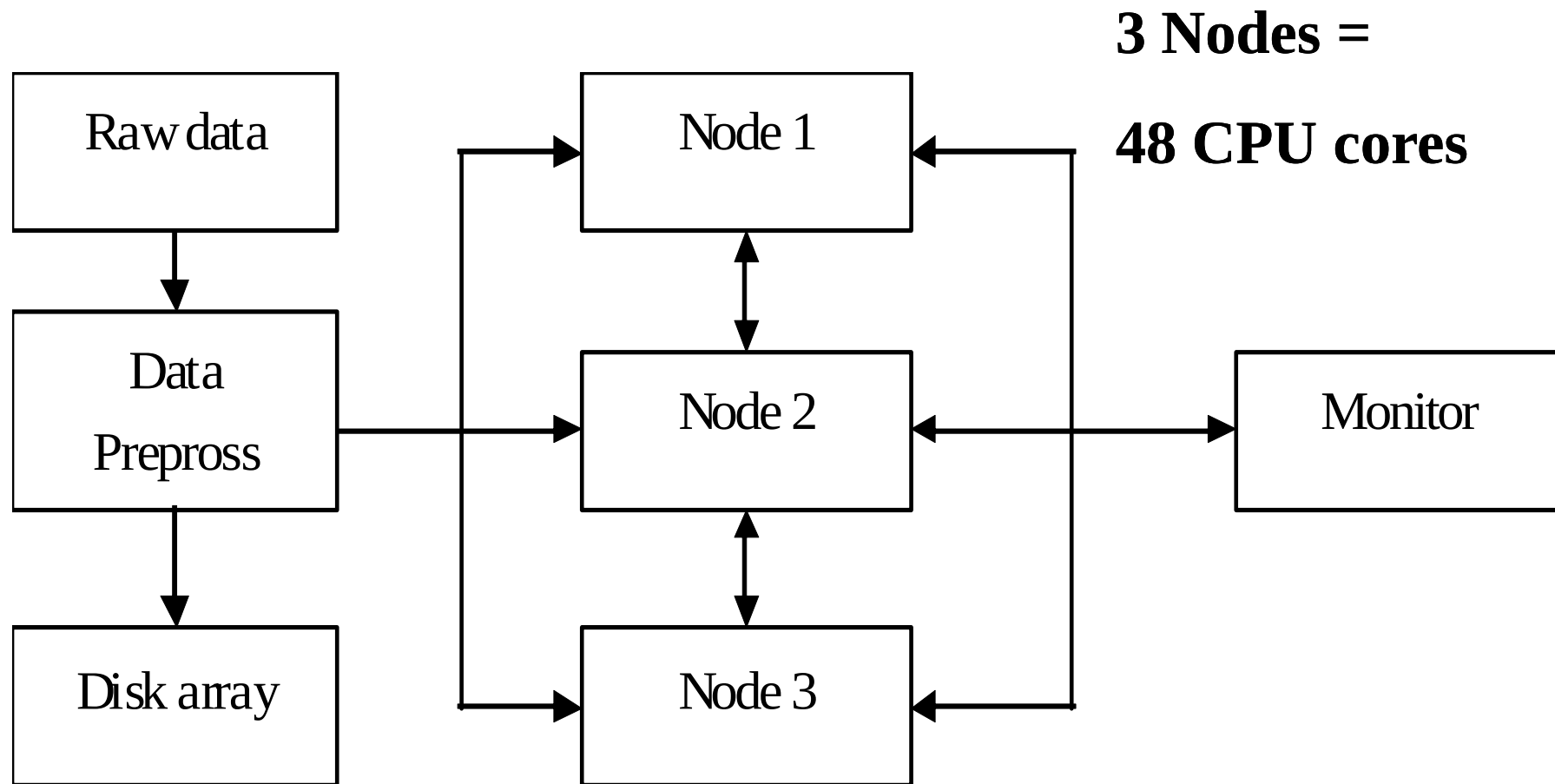
Shared-memory programming mode (pthreads)

➤ Inter-node

Message-Passing Programming mode (MPI)



Correlator architecture of SMP cluster



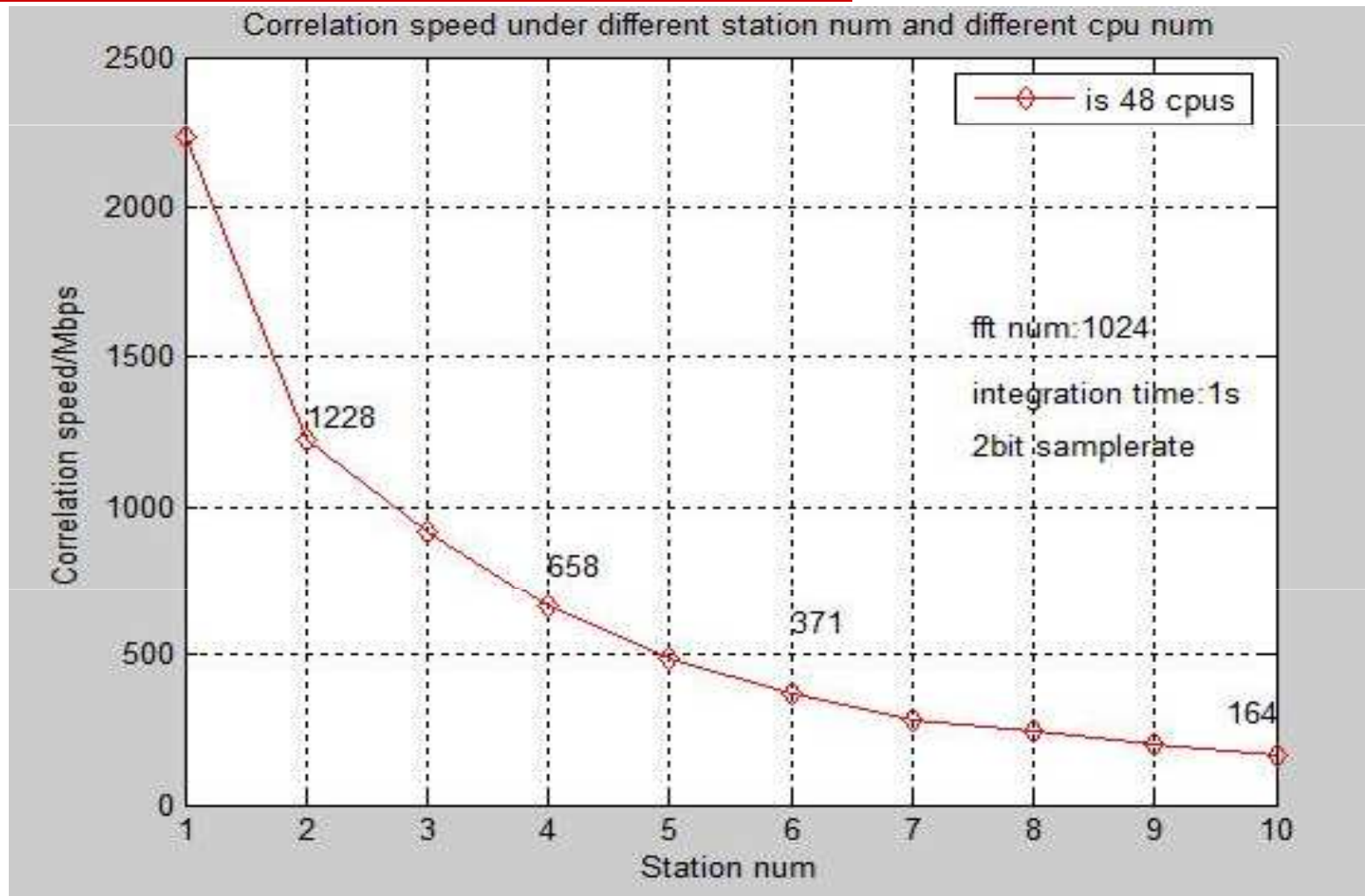


Correlator Capabilities

Correlation station number	1~10
IF number	1~16
FFT points/ IF	32 ~4096/IF
Integration period	0.1~60 second
Input data format	Mark5A(1:1, 1:2, 1:4 fanout)
Sampling	1bit, 2 bit
Output data format	CVN
Correlation speed (1024/IF)	>1Gbps/station (2 stations) >512Mbps/station (4 stations)



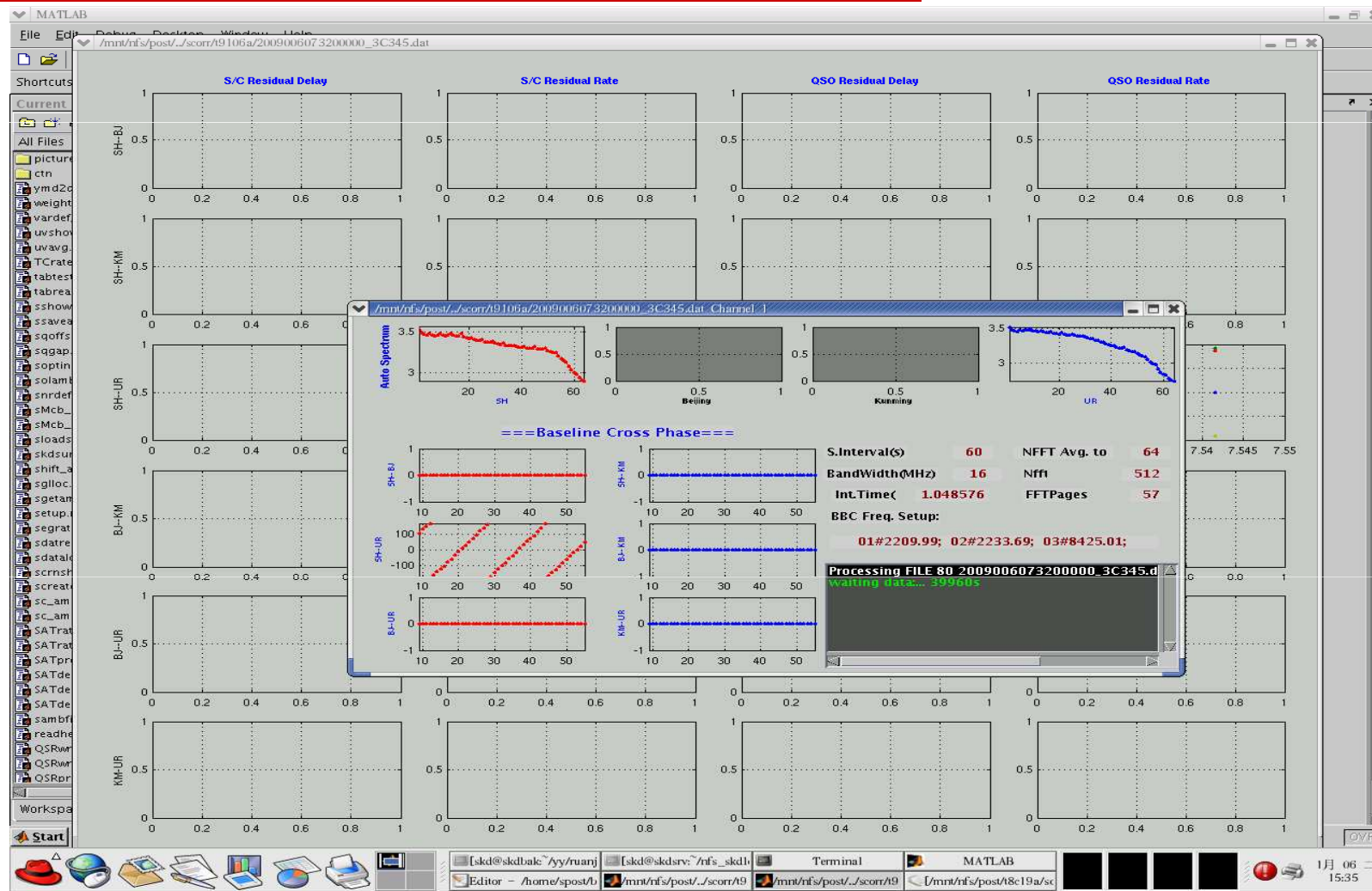
10-station SMP cluster prototype correlator



Correlator speed vs. station number



Sh-Ur baseline e-VLBI demonstration (IYA2009)



2009-1-6, data rate:256Mbps/station



5. Outlook

CVN application:

1. Astronomy

Domestic astronomer observation

2. Geodesy

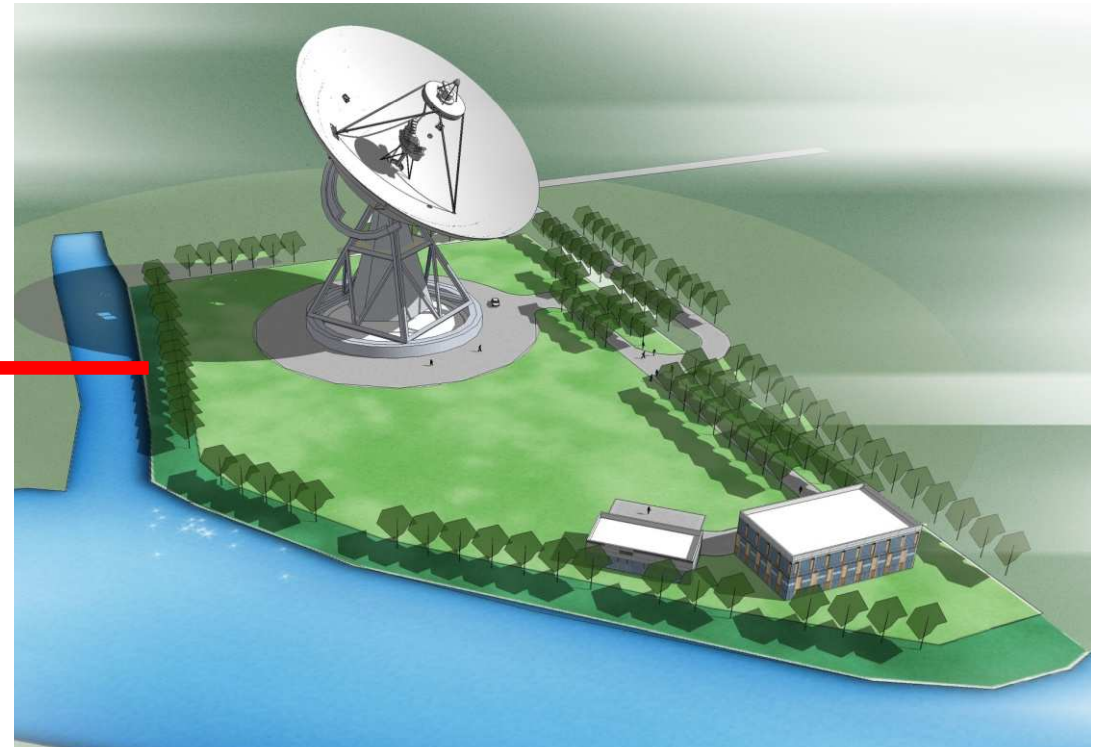
**Project CMONC (Crustal Movement Observation
Network of China) Dr. Shu
Sino-Russian VLBI corporation**

3. Deep space exploration

Lunar, Mars probe tracking



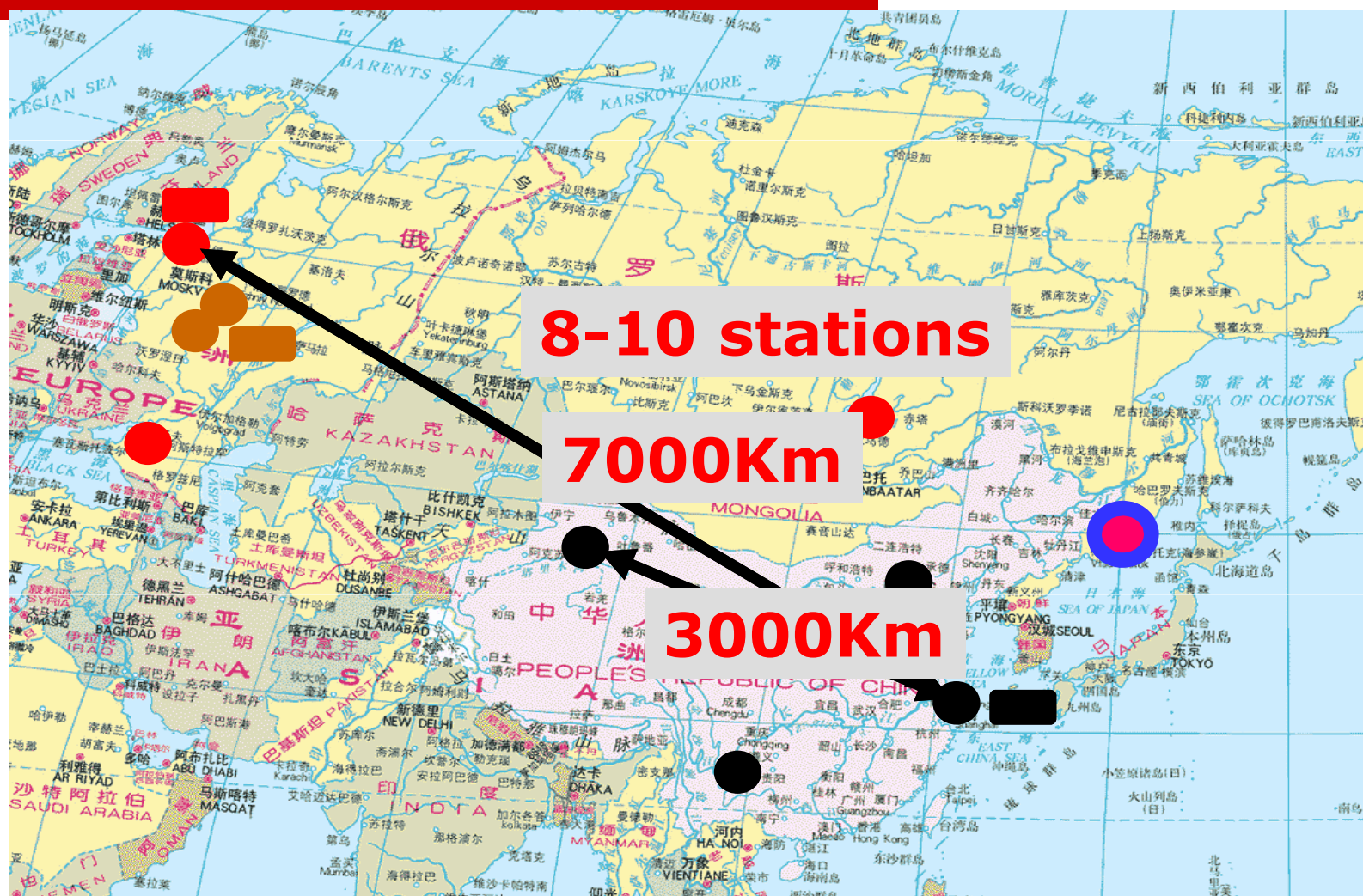
New 65m telescope in Shanghai



**Specs: 8 bands (1.4–43 GHz); active surface;
operational at S/X bands before 2012
will improve 42% sensitivity of CVN**



Sino-Russian VLBI station





Outlook

Characteristics of new correlator:

- One-minute based mode → scan-based
 - Data output format :
CVN → FITS
Format transfer program “makeFITS”
Beijing, Kunming log file system update
 - e-VLBI (Real-time ability)
Latency < 1min, under development
 - 10 stations, high speed: >1Gbps/station
Software correlator with CPU+GPU structure
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Thanks for your attention
