



Network Connectivity with China via ORIENTplus e-VLBI User Perspective

T. Charles Yun
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Overview

- JIVE
 - the institute, how organized, why important
- Radioastronomy, one to many dishes
 - e-VLBI, the technique, how it works, why it is important
- Projects
 - NEXPreS, EXPreS, Spacecraft tracking
- Partnership with China
 - Chinese facilities
- Networking with China
 - Paths, attributes, looking forward

Joint Institute for VLBI in Europe JIVE



- Embded Acronym
 - *Joint*- 7 Countries: **China**, France, Germany, Italy, Spain, Sweden, United Kingdom, the Netherlands
 - *Institute*- Promote the use and advancement of VLBI for astronomy
 - *VLBI*- Very Long Baseline Interferometry (more on this in a moment)
 - *in Europe*- hopefully obvious...
- Organization
 - Founded in 1993, Dutch Stichting, Part of NWO
 - Financial- Independent Budget; support from partner instittes; national/international project awards
 - People- 31 Employees, 15 nationalities

Joint Institute for VLBI in Europe

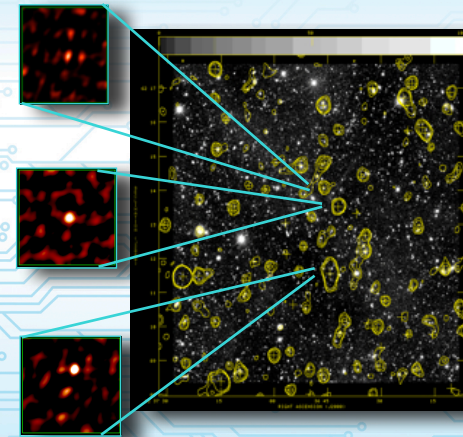
Why JIVE is Important

- Central correlation
 - Correlator is located at JIVE in the Netherlands
 - Dedicated supercomputer for data analysis
- User services
 - Assist in the setup, correlation, analysis and post-processing steps for PIs
- Network support
 - Pushing operational and R&D networking paths between the telescope sites and JIVE
- Innovation, EC liaison/representation
 - National (Dutch), pan-European and international projects

Radioastronomy- from one to many dishes

To see the faint universe...

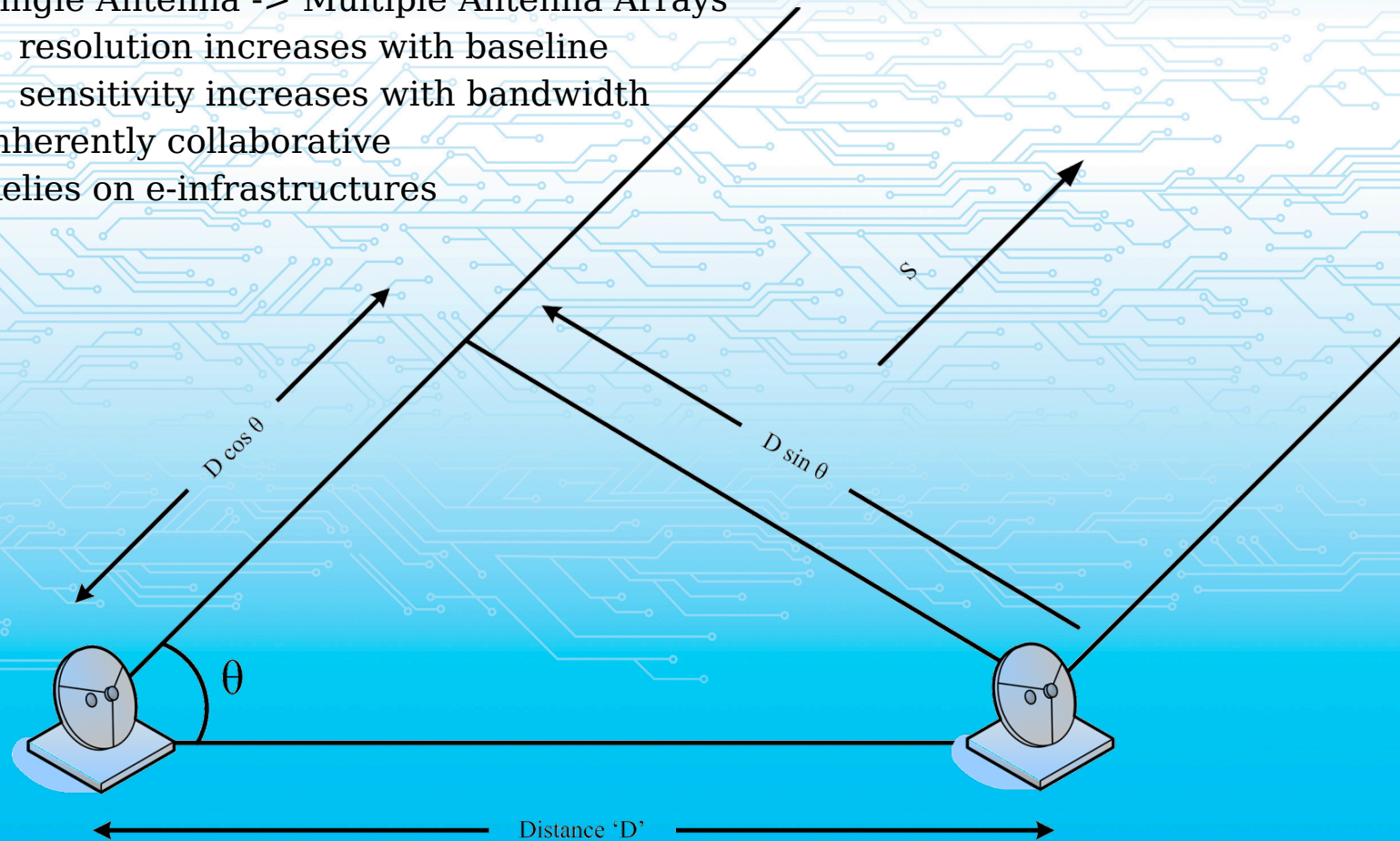
- Need many big telescopes
 - Sample large frequency space
- Bandwidth for sensitivity
 - Bits are not sacred
- Dedicated SUPERcomputer
 - calculate correlation on all baselines
 - Fourier components of sky image



Radioastronomy- from one to many dishes

Multi-Telescope Observation

- Optical (visible light) Astronomy -> Radio Astronomy
- Single Antenna -> Multiple Antenna Arrays
 - resolution increases with baseline
 - sensitivity increases with bandwidth
- Inherently collaborative
- Relies on e-infrastructures



Radioastronomy- from one to many dishes

What is VLBI?

- Radio Telescopes (antenna, dish)
 - Point at something "up" in the sky, and then:
 - receive radio signals, computational analysis, make image, thinking and analysis, results/papers
- A big dish collects more data
 - More data leads to better images
 - Better images lead to better science
- However:
 - big dishes are hard to build, expensive
- Luckily:
 - you can simulate a big dish with many small dishes



Radioastronomy- from one to many dishes

What is e-VLBI

- Traditionally, data was collected at the telescope on tape/disk arrays, packed into boxes by hand, posted to JIVE, unpacked by hand, loaded into the correlation system, and then analyzed.
- e-VLBI:
 - Set up network
 - Begin observation
 - Analyze in real-time
 - Correct problems as they occur
 - Provide fast feedback and results
- e-VLBI enables new classes of science
 - fast response, target of opportunity

Projects

NEXPreS



- FP7 RI-261525, 2010 to 2013 (in process)
 - Develop e-VLBI services of the European VLBI Network (EVN), with the goal of incorporating e-VLBI into every astronomical observation conducted by the EVN
- Make e-VLBI a part of every observation
 - dynamic light paths
 - line-speed storage
 - cloud correlation
 - computing in a shared infrastructure



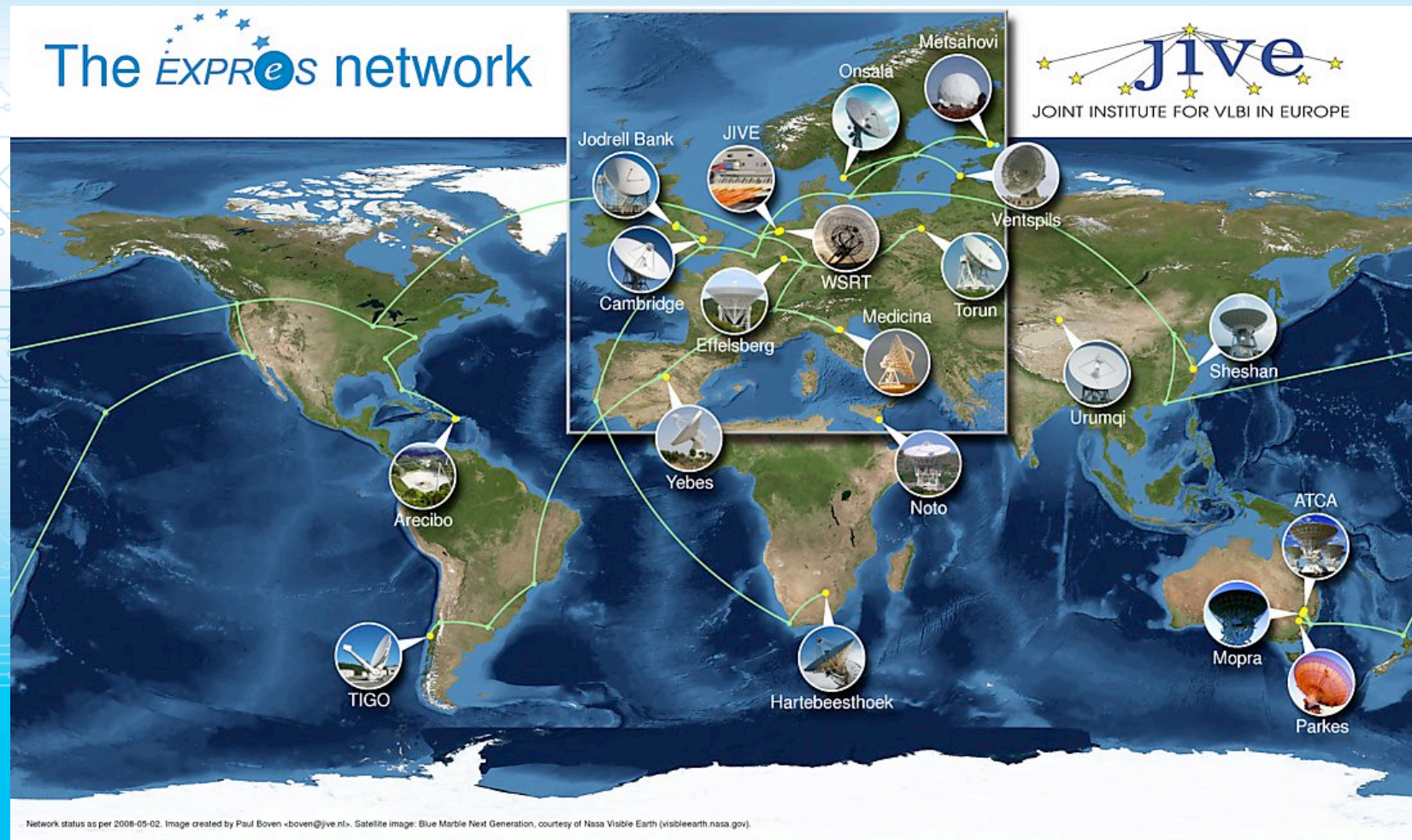
Projects EXPR_eS



- FP6 026642, 2006 to 2009 (completed)
 - Create an astronomical instrument of continental and inter-continental dimensions using high-speed communication networks to connect some of the largest and most sensitive radio telescopes in the world.
- Make e-VLBI “routine, reliable and realistic”
 - Connect telescopes
 - Build real-time tools
 - Establish operational procedures
 - Demonstrate the benefits to researchers



Projects EXPReS Network



The background of the slide is a composite image of space. On the left, a large portion of Jupiter is visible. In the center, the Moon is shown. On the right, the Earth is depicted with its continents and oceans. Two spacecraft are shown: one in the upper left and another in the lower left. Red dotted lines radiate from the Earth towards the spacecraft and other points in space, representing tracking signals. A blue streak is visible in the upper right.

Projects

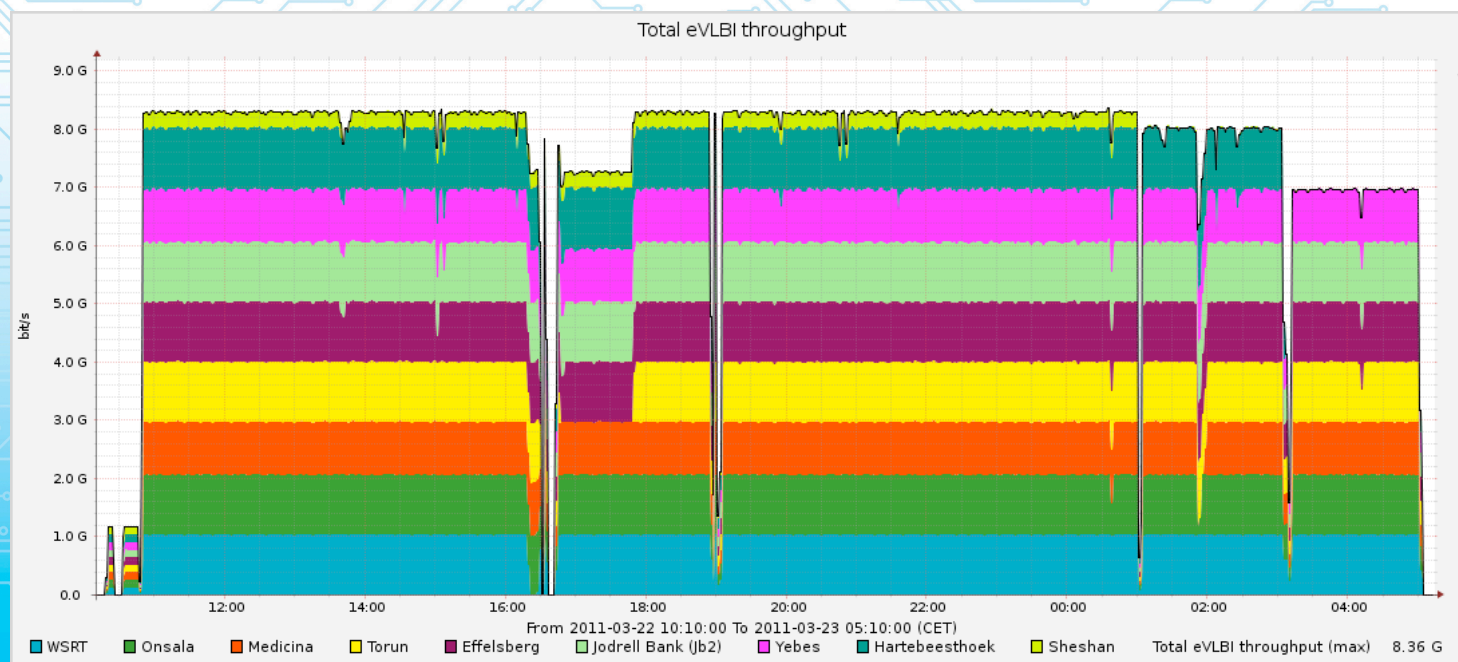
Spacecraft Tracking

- PRIDE- Planetary Radio Interferometry and Doppler Experiment
 - Exploit e-VLBI to track spacecraft with better accuracy than pure doppler measurement
 - Work executed in conjunction with ESA, NASA, CNSA, JAXO, IKI
- JIVE is working on several next-generation space missions: Phobos-Grunt, Yinhua-1, Bepi-Columbo, ExoMars, EJSM
- JIVE is working to improve the accuracy of observations to constrain estimate of location to tens of cubic meters at Mars class distances (80 million kilometers)

Partnership with China

Chinese Telescopes (1 of 2)

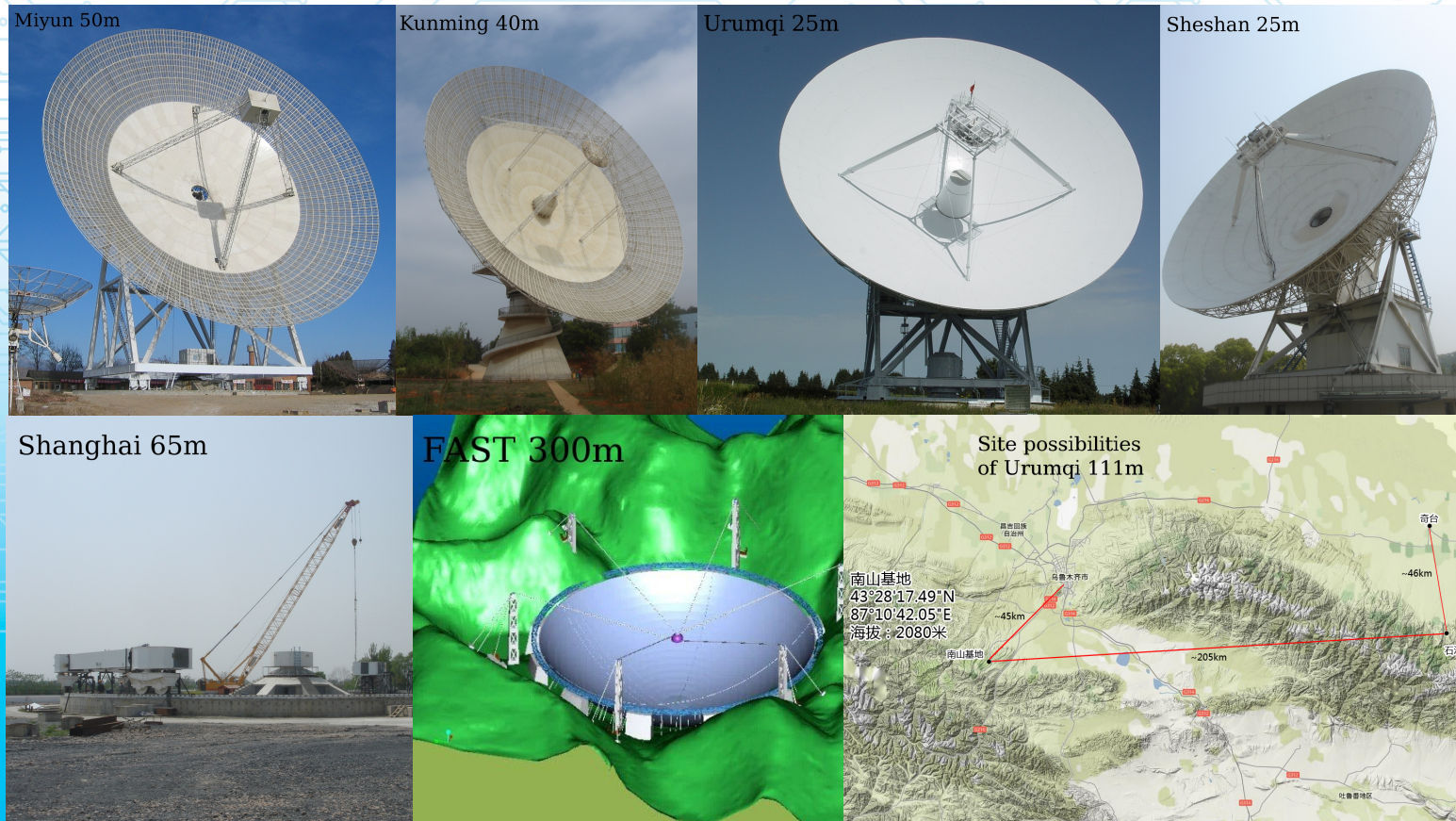
- Several available now and participate in e-VLBI
- Cactii throughput graph from 2011-03-22 session



Partnership with China

Chinese Telescopes (2 of 2)

- More coming soon, including large (read: will be popular) dishes



Partnership with China

Chinese participation

- Adding Chinese facilities:
 - Adds significant new collecting area
 - Improves baselines
 - Better flexibility (ToO)
- Increased collaboration deepens the depth of expertise on all sides

...resulting in better science and
additional collaboration

Network Paths to China

- There are a multitude of organizations, issues and paths to navigate, optimize and discover when sending bits
 - DANTE, GEANT, SURFnet, CSTNET, CERNET, ORIENT, GLIF, various landing points and exchanges...
- Networks are about connectivity
 - Network engineers are interested in paths
 - End users want the bits
 - The path is often not under their direct control
 - We hope ORIENTplus will help address these issues
- And our needs are growing
 - 1 Gbps today, 4 Gbps soon, planning 10 Gbps/station
 - Note the number of planned telescopes in China...

Networking with China

Connectivity with China

- R&E networking should be superior to commercial solutions: flexibility, capabilities, capacity growth, cost,...
- Connectivity should be as invisible as possible
- Open is always better in the long run
 - Exchanges, protocols, tools
 - Improves overall flexibility
 - Other large network-use-communities are trending in this direction
- NEXPreS is investigating:
 - dynamic light paths, bandwidth on demand
 - distributed storage and computation

Networking with China

Advancing the State of the Net

- The radio astronomy community believes that that we help push the capabilities of the network at large
- Our requirements are extreme: geographically disperse, “last mile” issues, high bandwidth, long duration flows
- Our flexibility is high: (mostly) planned flows, able to sustain loss of packets, technology risk tolerant, deep engineering expertise/support
- Strong second order benefits due to last mile connectivity
- Our needs scale in time with the advancement of the network

Contact Info & Questions

- T. Charles Yun
tcyun@jive.nl
<http://www.jive.nl/>

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