

# SA1: second year overview

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JIVE



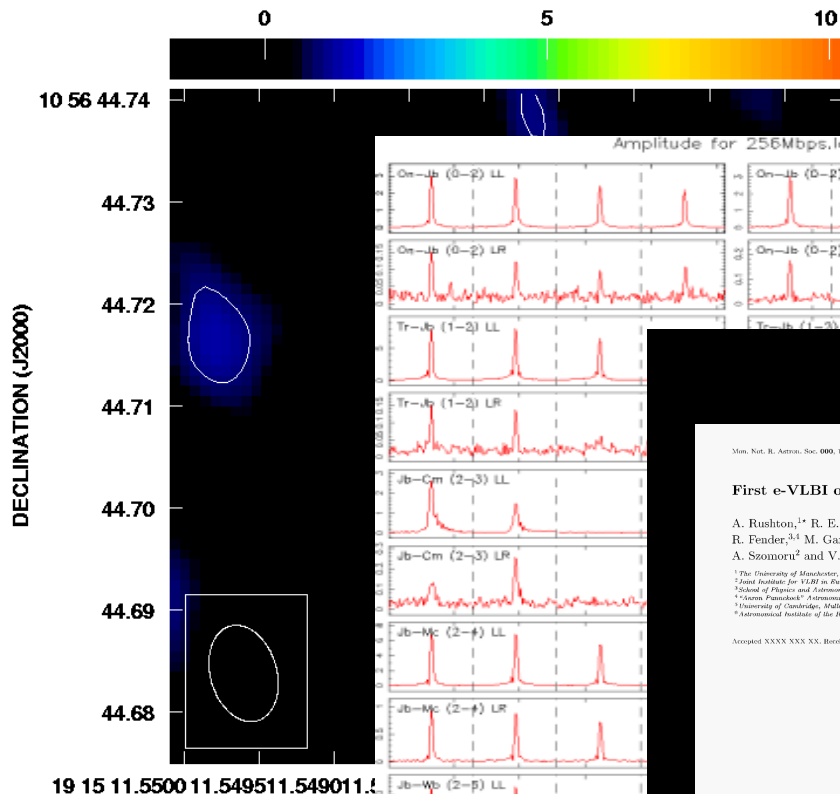
# Outline

- Accomplishments in 2007
- Soft- and hardware developments
- Aims for 2008

# e-VLBI science/test runs

- 18 e-VLBI science projects accepted since 2006:
  - 2 failed (in early 2006)
  - 8 active binary systems (Algol-type, X-ray or gamma-ray binaries);
  - 4 of these were ToO projects, 3 part of multi-wavelength campaign
  - 1 adaptive observation of 16 X-ray binaries (no detections..)
  - 4 determination of compactness of calibrator or target
  - 1 spectral line run
  - 1 supernova ToO
  - Last proposal still waiting for trigger
- Rapid access to EVN provides clear benefit to users (important for calibrator/multi-wavelength projects)
- Follow-up observations of bursting transients were only a moderate success in 2006; two weeks delay between proposal submission and observations is too long
- e-VLBI observing policy was changed in early 2007, to allow quick response to triggered projects (in 24 hours)
- Disconcerting lack of proposals (and triggers)

# e-VLBI results



19 15 11.5500 11.549511.549011.1



Clean I map. Array: EVN  
3C454.3 at 5.006 GHz 2007 Feb 02

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## First e-VLBI observations of GRS1915+105

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### ABSTRACT

We present results from the first successful open call e-VLBI run on the X-ray binary GRS1915+105. e-VLBI science makes possible the rapid production of VLBI radio maps within hours of an observation rather than weeks. Enabling a decision for follow-up observations, 6 telescopes observing at 5 GHz across the European VLBI Network (EVN) were correlated at Jodrell Bank for VLBI in Europe (JIVE) in real time. Data rates of 128 Mbit s<sup>-1</sup> were transferred from each telescope, giving 4 TB of raw sampled data over the 12 hours of the whole experiment. Throughout the GRS1915+105 was observed for a total of 3.5 hours, producing 2.8 GB of recorded visibilities of constant data. A weak flare occurred during our observations, and we detected a slightly resolved double component of 2.7 by 4.2 milliarcseconds was detected at a position angle of 140° ± 2°. The peak brightness was 10.2 mJy per beam, with a total integrated radio flux of 1.1 mJy.

**Key words:** ISM: jets and outflows - X-ray binaries: individual (GRS1915+105).

### 1 INTRODUCTION

The use of the Internet for VLBI data transfer offers a number of advantages over conventional recorded VLBI, including improved reliability due to real time operation and the possibility of a rapid response to new and transient phenomena. Decisions on follow up observations can be made immediately after the observation rather than delayed by potentially weeks due to problems in alignment of tapes/discs to the correlator. The first open call with a suitable COST range for observations of GRS1915+105 using the e-VLBI (European VLBI Network), gave us the opportunity to test e-VLBI under operational conditions. A number of test runs over the past few years have shown that 128 Mbit sec<sup>-1</sup> data rates can be obtained reliably for the 8 telescope Cambridge, Jodrell Bank, Medicina, Onsala, Tivoli and Westerbork, within Europe, currently connected to national and international networks to the Jodrell Bank Institute for VLBI in Europe (JIVE) operations. Currently Eftinkhof is

not connected to the e-EVN network, limiting the sensitivity and resolution of the current array. Steps are currently being taken to improve the reliability of 236 and 312 Mbit sec<sup>-1</sup> connections with EXPRES's goal to develop a stable 1 Gbit/sec production capacity network.

Microquasars are ideally suited for study by e-VLBI real time techniques since they often have flares associated with the spectra of radio emitting clouds in the form of jets. Timescales are in the range of hours to days at cm wavelengths, and decisions about subsequent observations, if for instance an ejection has been detected, needs to be taken quickly.

GRS 1915+105 was first discovered in 1992 (Coto-Trujillo et al. 1992) by the WALLACE instrument on the GRANAT satellite. The system has a low mass K0 III star (Dotterer et al. 2001b) companion and 14 (4+3) M<sub>⊙</sub> black hole (Gierlmeier et al. 2001a). It was the first galactic source to display superluminal motion, and is well known for its rapid

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<sup>1</sup> Express Production Real-Time e-VLBI Service see www.express-vlbi.org

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## First e-VLBI observations of Cygnus X-3

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### ABSTRACT

We report the results of the first two 5 GHz e-VLBI observations of the X-ray binary Cygnus X-3 using the European VLBI Network. Two successful observing seasons were held, on 2006 April 20, when the system was in a quasi-quietest state several weeks after a major flare, and on 2006 May 18, a few days after another flare. At the first epoch we detected faint emission probably associated with a fading jet, spatially separated from the X-ray binary. The second epoch in contrast reveals a bright, curved, relativistic jet more than 40 milliarcseconds in extent. In the first, and probably also second epoch, the X-ray binary core is not detected, which may indicate a temporary suppression of jet production as seen in some black hole X-ray binaries in certain X-ray states. Spatially resolved polarization maps at the second epoch provide evidence of interaction between the jets and the surrounding medium. These results clearly demonstrate the importance of rapid analysis of long-baseline observations of transients, such as facilitated by e-VLBI.

**Key words:** accretion, accretion discs - stars: individual: Cygnus X-3 - ISM: jets and outflows - radiation mechanisms: non-thermal - techniques: interferometry.

### 1 INTRODUCTION

The X-ray binary Cygnus X-3 was first detected in X-rays by Giacconi et al. (1967). The infrared (e.g. Beukens et al. 1973) and X-ray flares (e.g. Pagnanelli et al. 1973) show a periodicity of 4.8 hours which is interpreted as the orbital period of the system. The nature of the compact object is not known (Schmitt, Galloway & Schall 1996; Mirza 1998). As for the companion star, there is compelling evidence pointing toward a WW Wolf-Rayet star (van Kerkwijk et al. 1995; Fender, Hanson & Pooley 1999; Koch-Miramand et al. 2002).

Close eclipses and large flares have been observed at radio wavelengths in Cygnus X-3 since 1972 (Gregory et al. 1972). In quiescence the soft X-ray emission is correlated with the radio emission, while the hard X-ray is anti-correlated with the radio, in a flare state, the situation is reversed: the hard X-ray correlates with the radio and the soft X-ray emission is uncorrelated (Watanabe et al. 1994; McCollough et al. 1999; Choudhury et al. 2002).

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Radio observations made during such large flares at different resolutions with the Very Large Array (VLA), MERLIN, Very Long Baseline Array (VLBA), and European VLBI Network (EVN) (Gaidashvili et al. 1989; Spencer et al. 1990; Molnar, Reid & Grindlay 1988; Schallmair et al. 1995, 1996; Mochanowski et al. 2001; Slatt et al. 2001; Miller-Jones et al. 2002) directly show or are consistent with two-sided relativistic jets (with the notable exception of the VLBA observations of a flare in February 1997, when the jet was apparently one-sided; Mochanowski et al. (2001)).

### 2 OBSERVATIONS

One of the aims of e-VLBI is to enable mapping with long-baseline networks of radio telescopes in a manner which makes it possible to map transient phenomena, such as microquasars, in near real-time. This will provide the ability to make informed decisions about the optimum observing strategy to employ (frequency of observation, array composition, calibration strategies, etc.) and the need for repeated mapping observations, as well as greatly simplifying the ob-

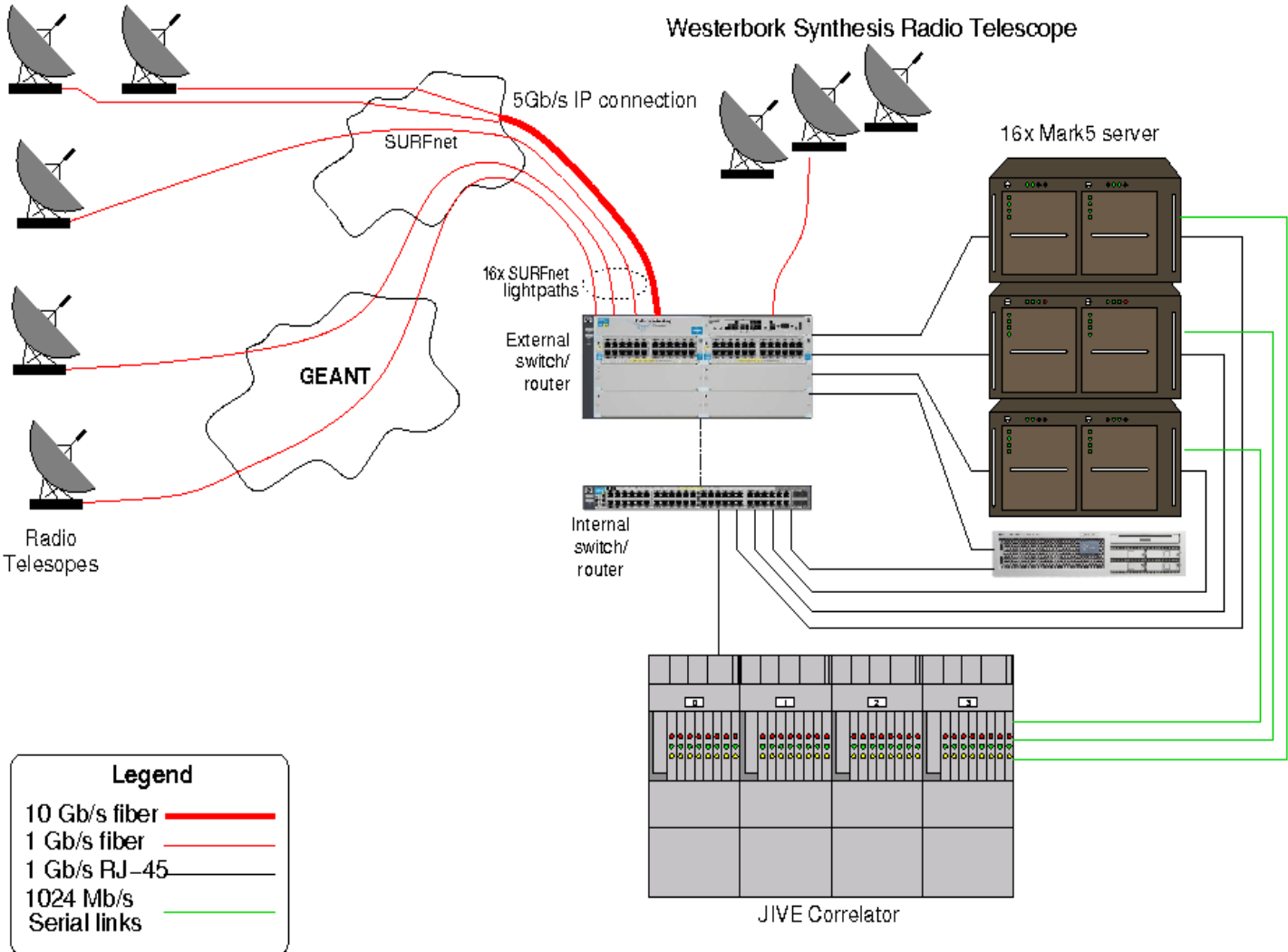
# Operational improvements

- Overall improvement in first year:
  - Robustness
  - Reliability
  - Speed
  - Ease of operation
  - Station feedback
  
- Minimizing data loss by careful scheduling
- Increase of production data rate from 128 Mbps to 256 Mbps
- 5-station fringes at 512 mbps
- Inclusion of Metsähovi and Medicina telescopes

# Operational improvements

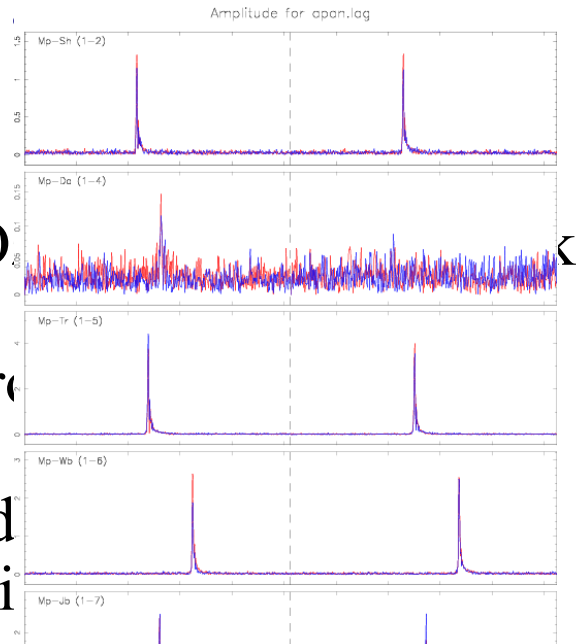
- Main focus during second year:
  - Increase of network capacity (lightpaths)
  - Reliable high data rates
  - Operational efficiency
  - Hardware upgrade
  - Long-distance connectivity
- Demonstration of global e-VLBI (China, Australia)

# Network status e-EVN

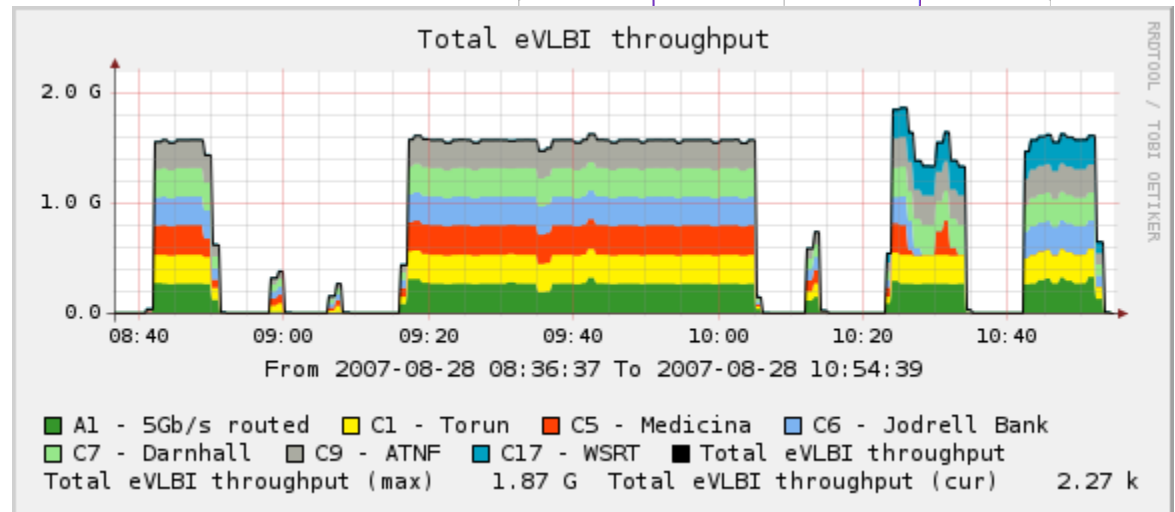


# Towards global baselines.

- Concentrated effort to make Xi'An and O
- Impossible without local Mark5 control development
- Use of alternative protocols, UDP and
- Opening up of trans-Siberian connecti



- Technical solutions
- Excellent PR
- Watershed?

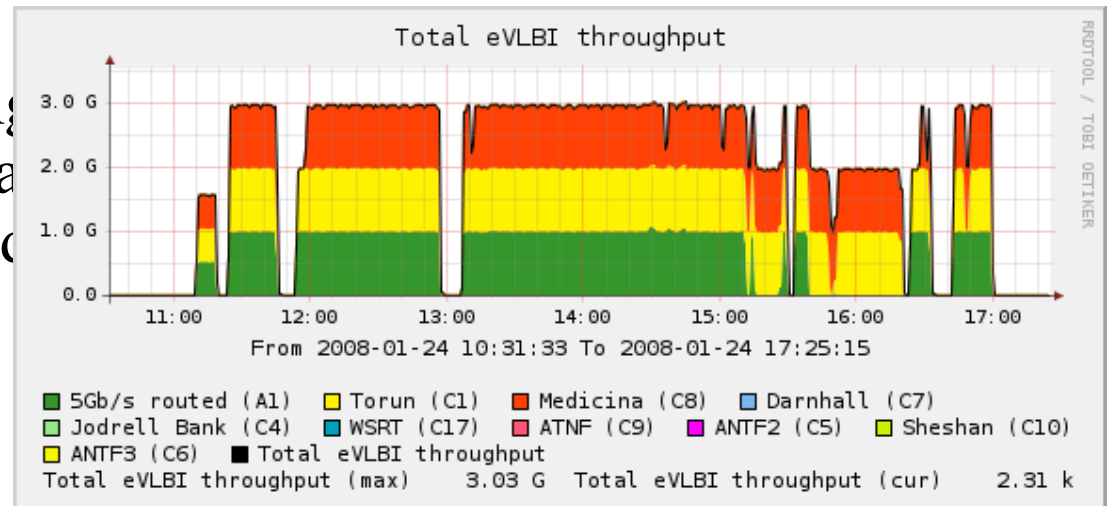




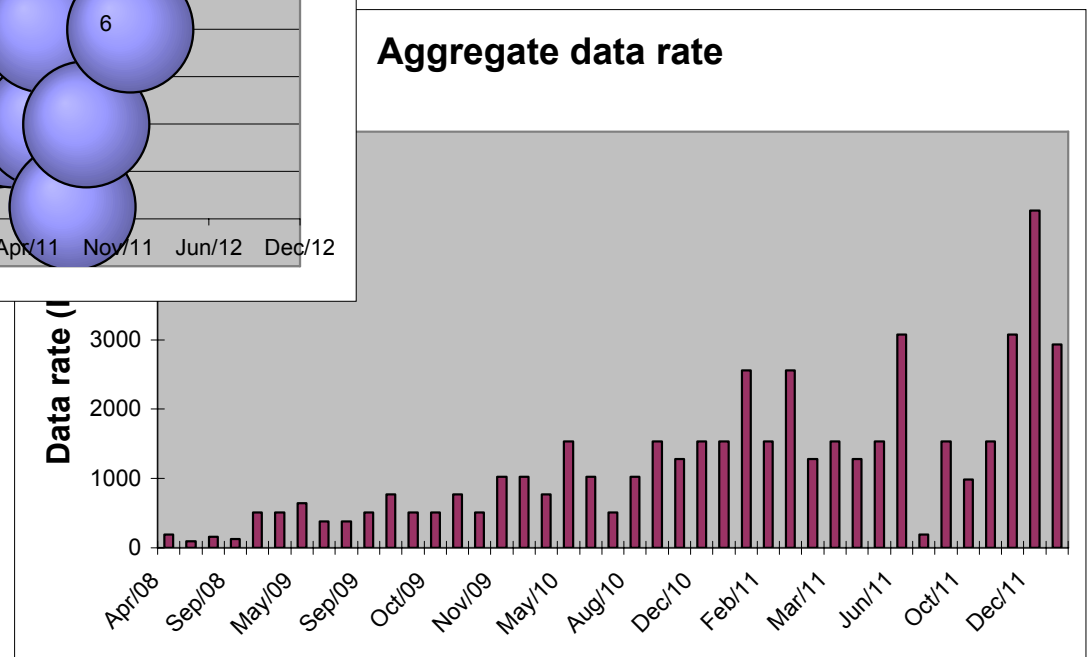
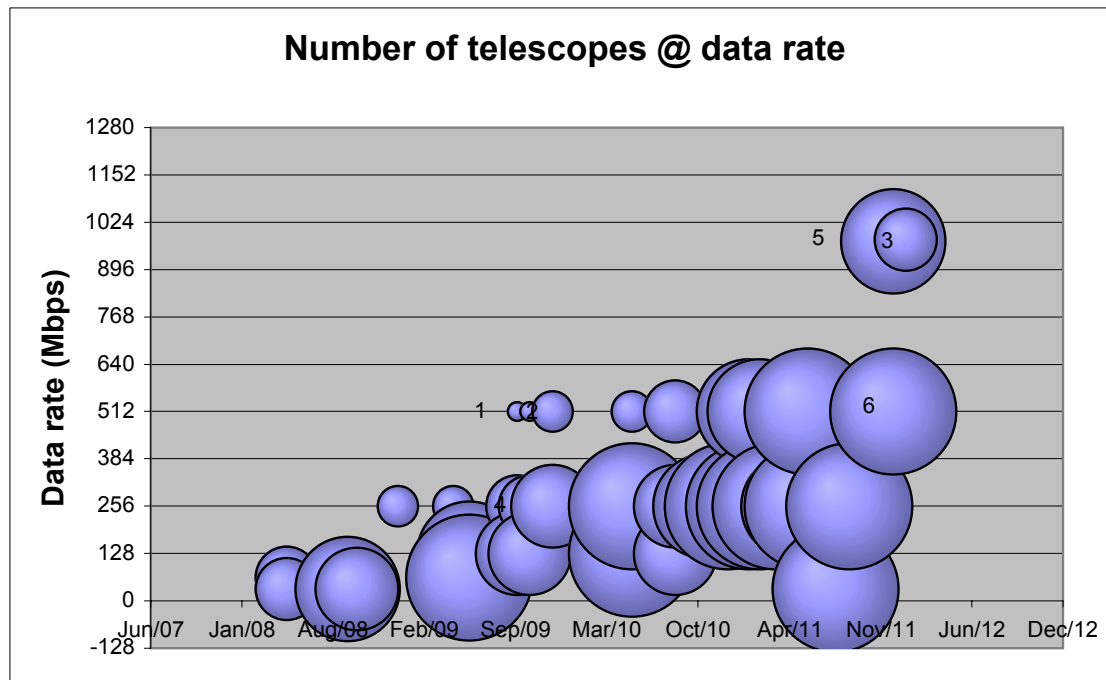
# ...and higher data rates

- Home-grown version of Mark5 control code
  - Much increased stability, speed
  - Deal with packet re-ordering, loss
  - Fill links to capacity by dropping packets at sending side, padding data stream with dummy packets at receiving side (courtesy of Casey and Hughes-Jones)

- Selective packet dropping
- Perfect synchronization a
- More demanding for hardware



# Data rate improvements



# ...and various operational improvements

- Reconnecting stations on-the-fly
- Use of WSRT synthesis data for e-VLBI calibration (absolute flux calibration, polarization calibration, source selection)
- Space-craft tracking mode
- Station feedback

# Mark5 upgrade:

- e-VLBI capability in Mark5B (nonexistent)
  - Dimino most important for now, will allow stations to move to B
  - Results expected within 1 month
- Mark5B playback at EVN correlator
  - First fringes
  - But some issues remain

# Ongoing/upcoming software developments

- On-the-fly fringe fitting
- Real-time download and extraction of station information
- Automated correlator diagnostics
- Investigation of a 1024M sub-array
  
- Adaptive observing

# And more global connections

- Arecibo at 512 Mbps (for limited periods)
  - But 128 Mbps continuously
  - TIGO: opportunity to increase bandwidth to ~500 Mbps (for demo purposes)
  - Ef currently connected, tests planned
  - Yb: getting close to first tests
  - Chinese telescopes back in business soon (rumors of fast connection to Ur)
- 
- Demo during TERENA 2008, in Bruges, Belgium
  - Key-note address on e-VLBI
  - Ar, TIGO, Mc, On, Wb, Ef (?)

# End of 2008:

- Flexible scheduling
- Provide global baselines
- Access to big dishes
- Guaranteed high data rates
  
- “real” e-VLBI capability
  
- Turn-over point