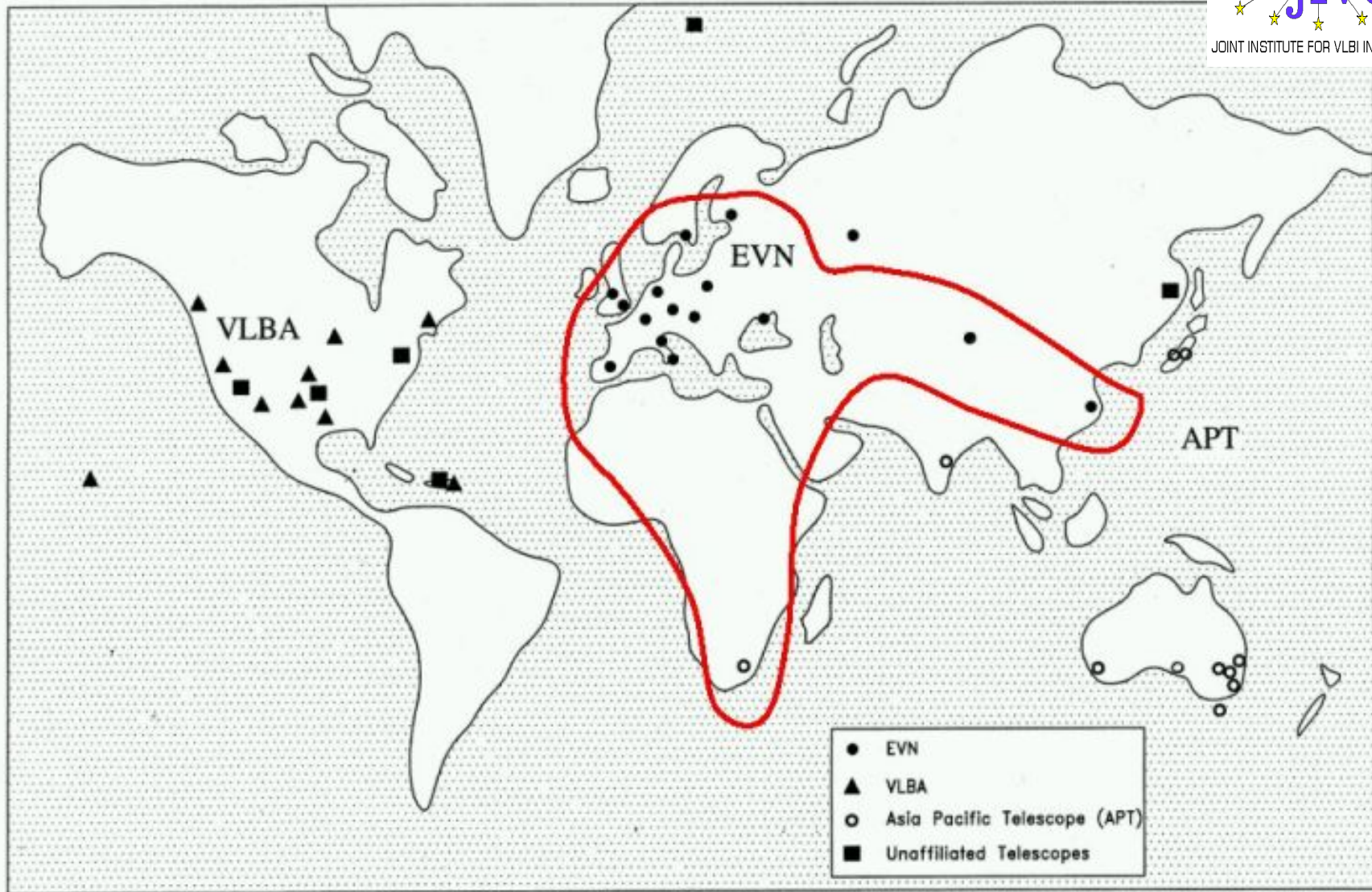


eVLBI Research in the European VLBI Network

Steve Parsley
Joint Institute for VLBI in Europe
Dwingeloo, Netherlands
parsley@jiv.nl

Outline

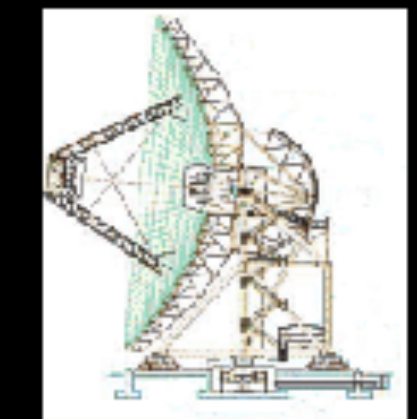
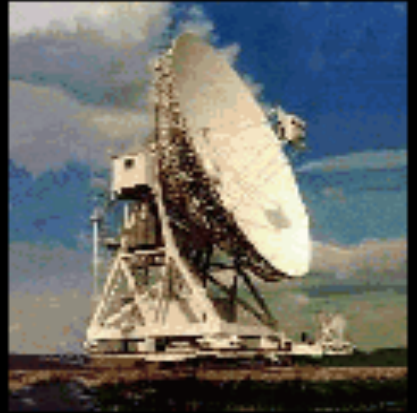
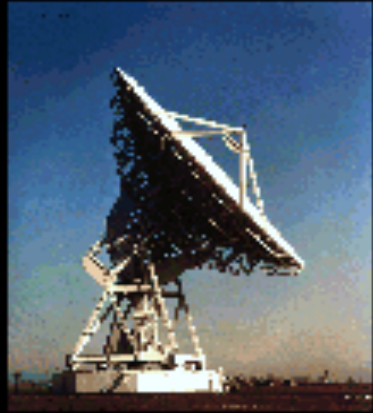
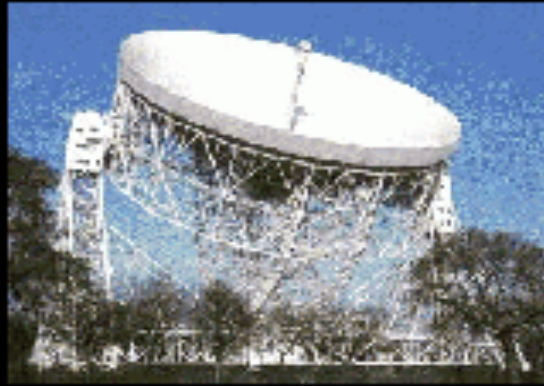
- European VLBI Network (EVN)
- European Research Networks
- Fibre Connection to Dwingeloo
- iGrid Demonstration
- EVN-NREN: Proof of Concept Project

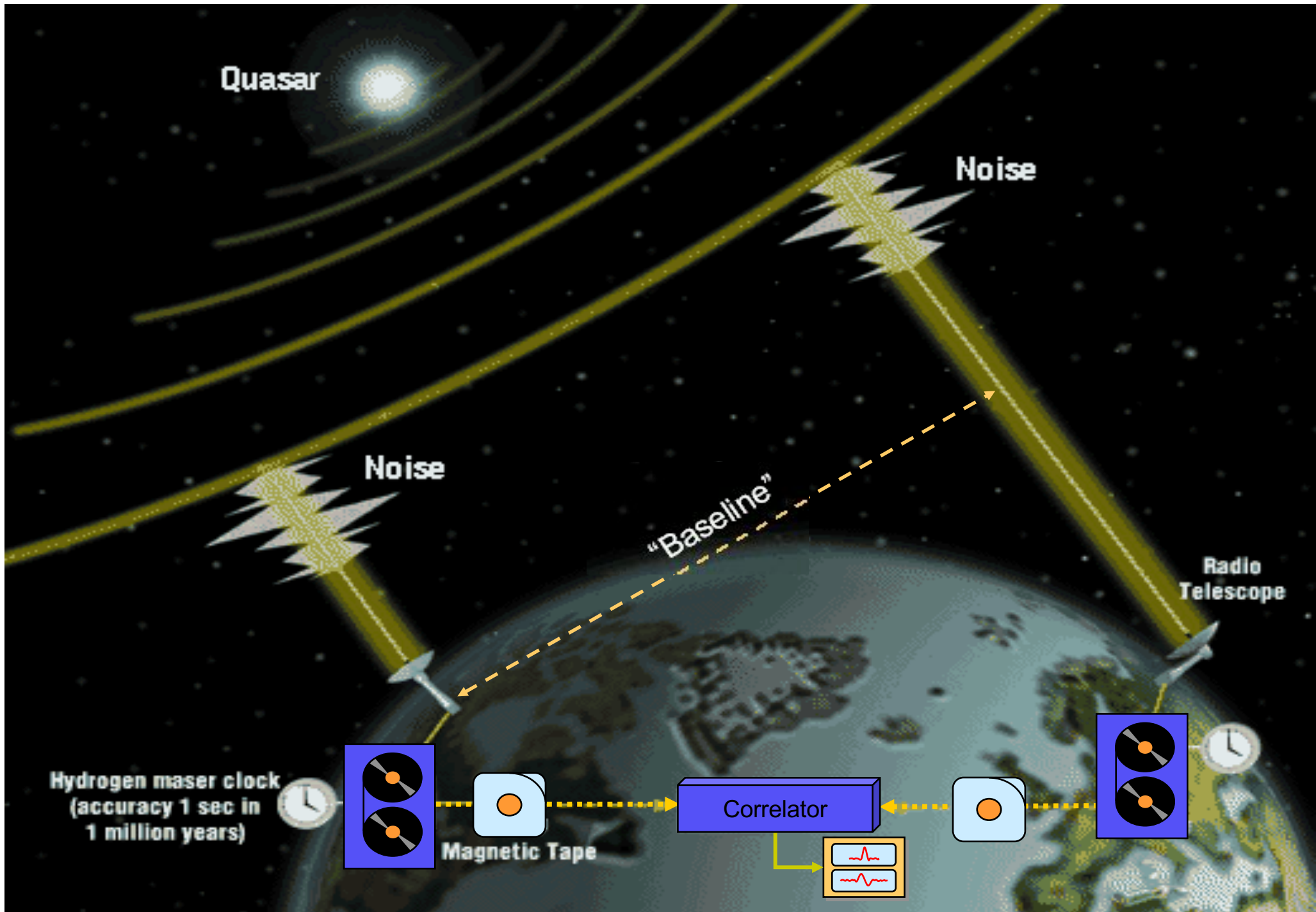


The European VLBI Network



EVN Telescopes





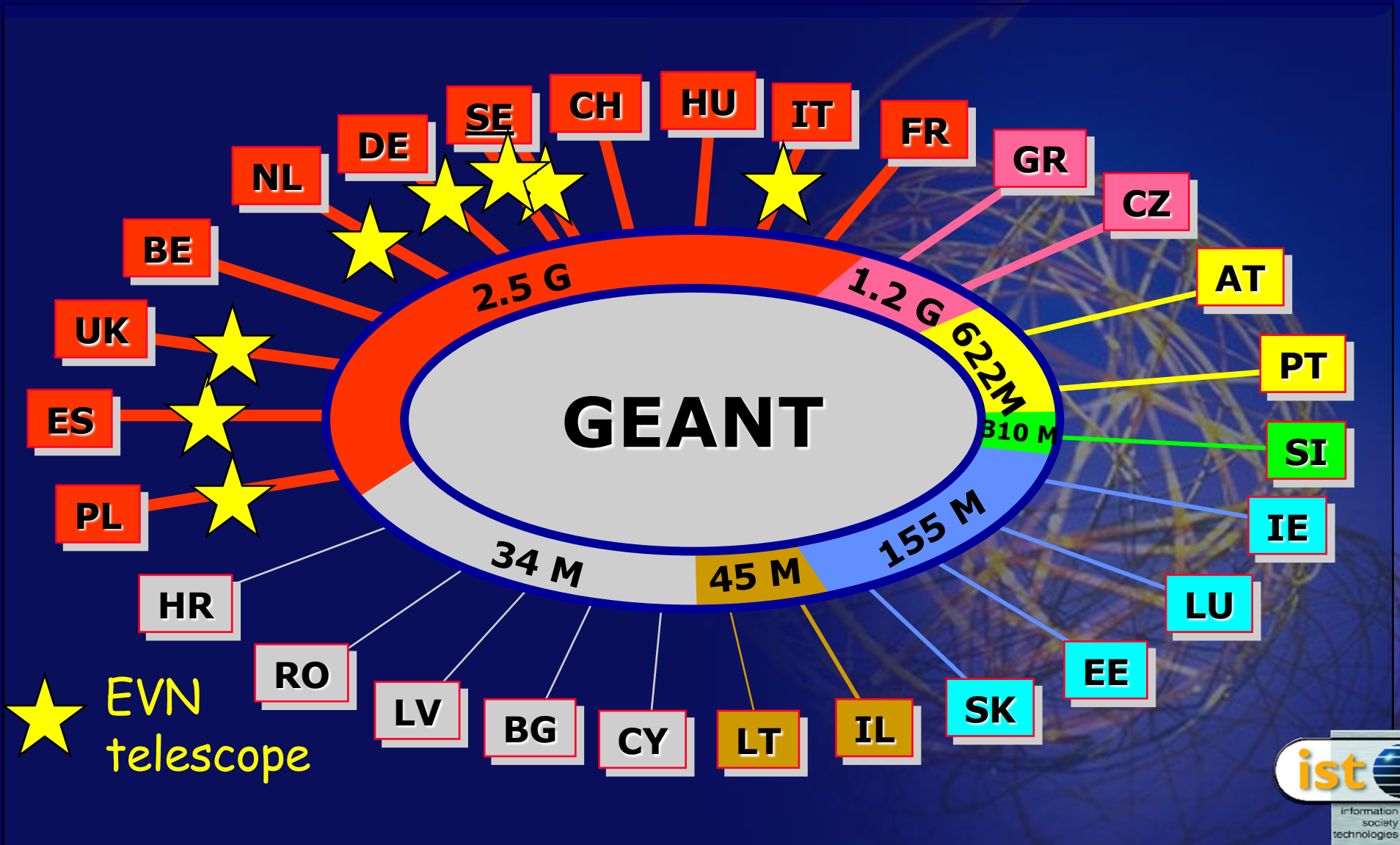




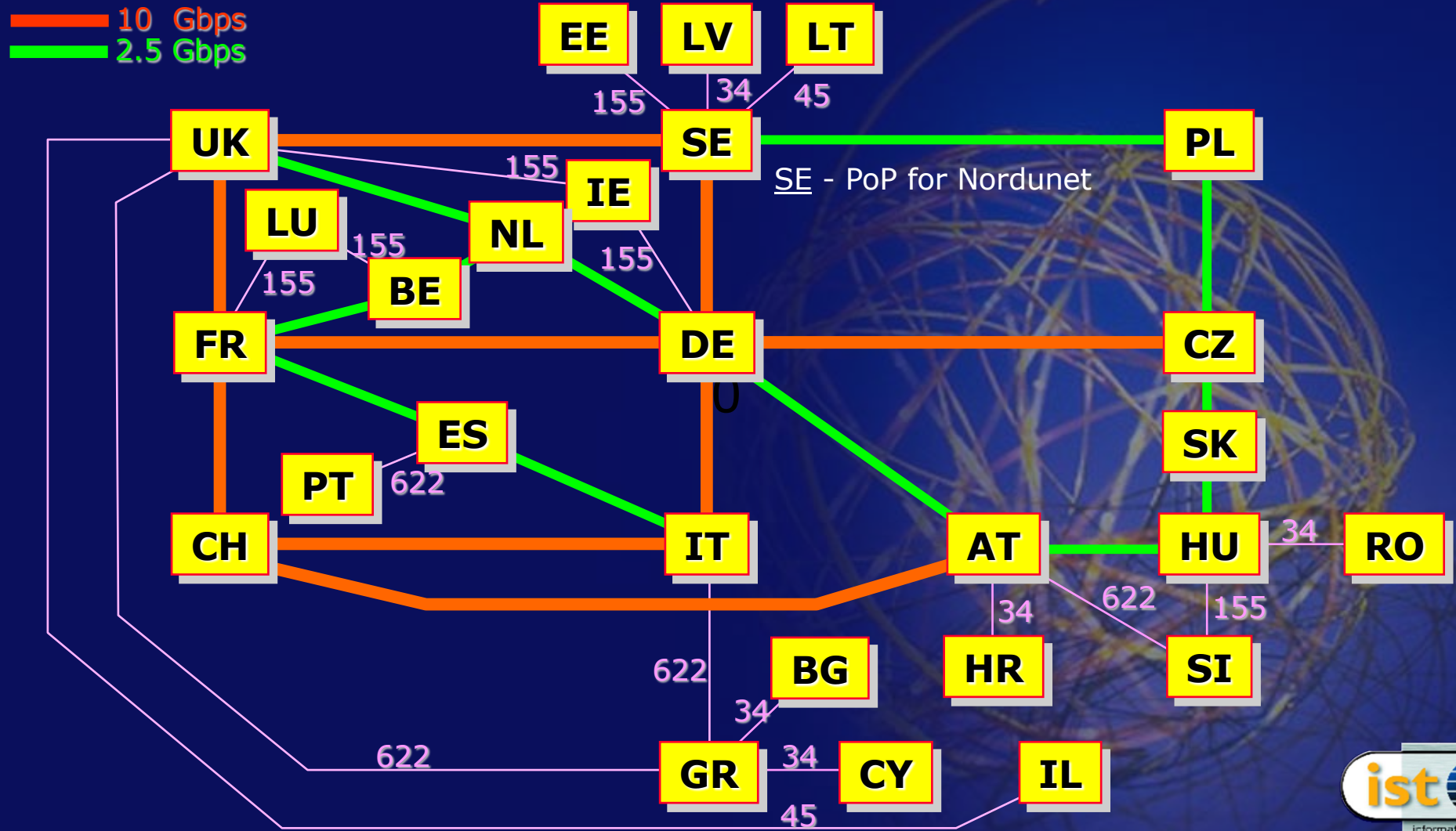
European Research Networks

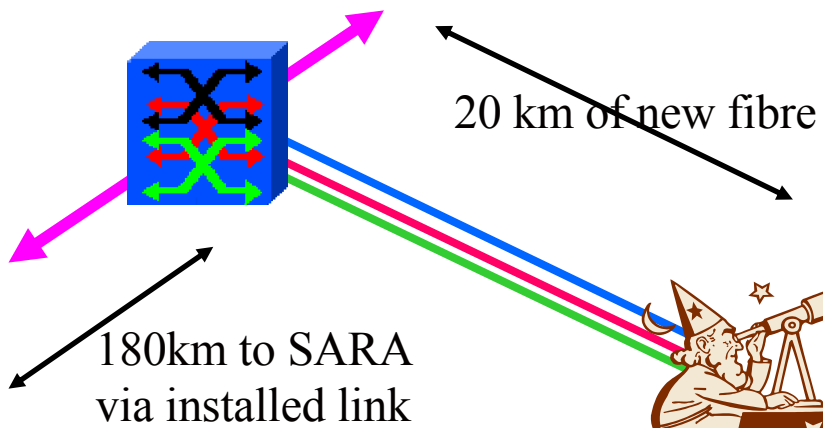
- National
 - NREN = National Research and Education Network
 - UKERNA, SURFnet, GARR, DFN, PSNC, NORDUnet
- International
 - GÉANT = Pan-European Research Network

GÉANT: Access of NRENs to GÉANT



GÉANT: The connectivity at 10 Gbps

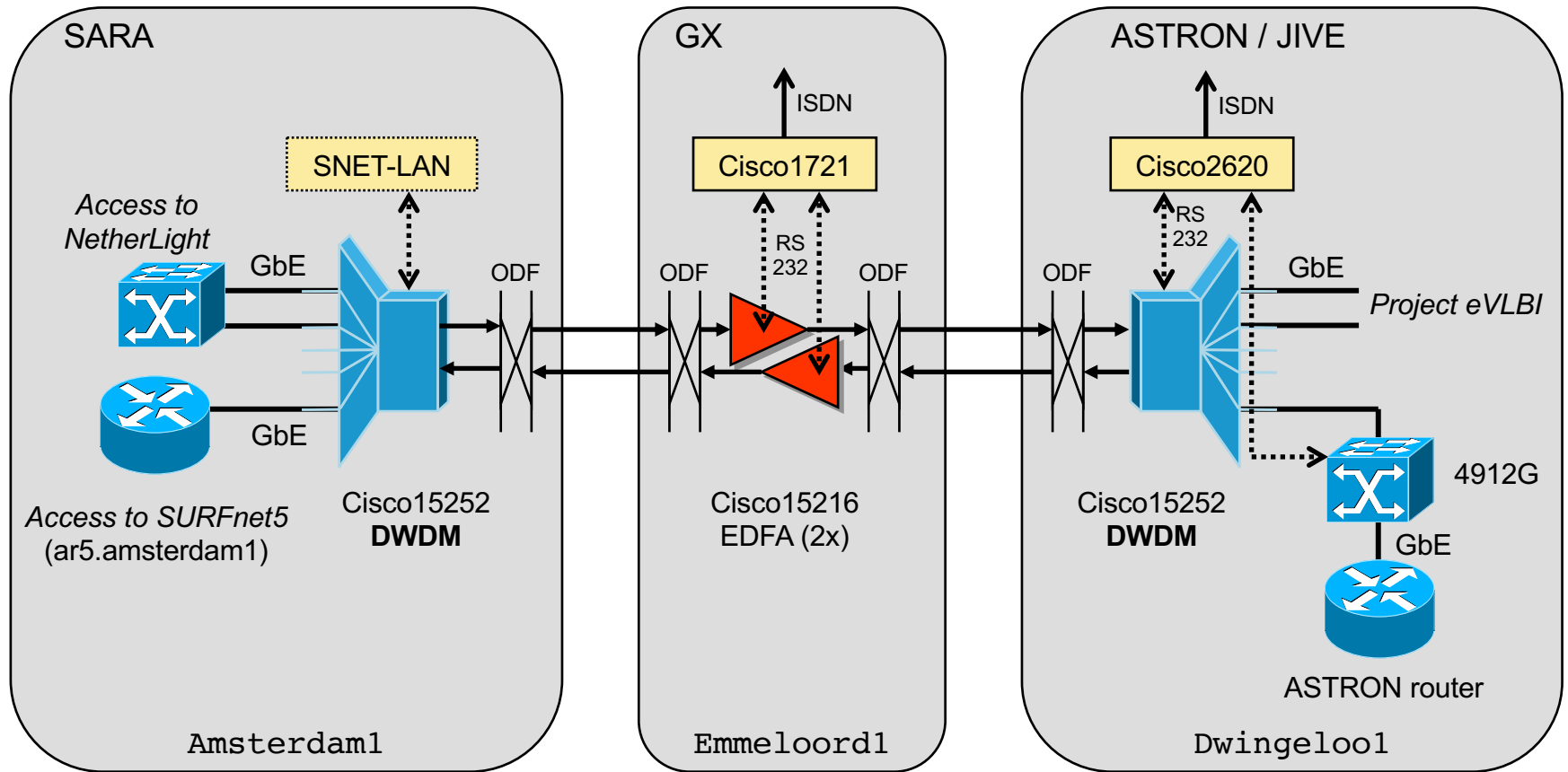




3 colours @1Gbps
from Dwingeloo to
Amsterdam Internet
Exchange



Network SARA - ASTRON / JIVE



The logo for iGrid 2002 features a stylized lowercase 'i' in red with a red dot, followed by the word 'Grid' in a large, black, sans-serif font, and the year '2002' in a smaller, black, sans-serif font. The text is positioned above a horizontal line that is intersected by a vertical line on the left side, creating a grid-like structure.

iGrid 2002

The International Virtual
Laboratory

www.startup.net/igrd2002
www.igrd2002.org (COMING SOON)

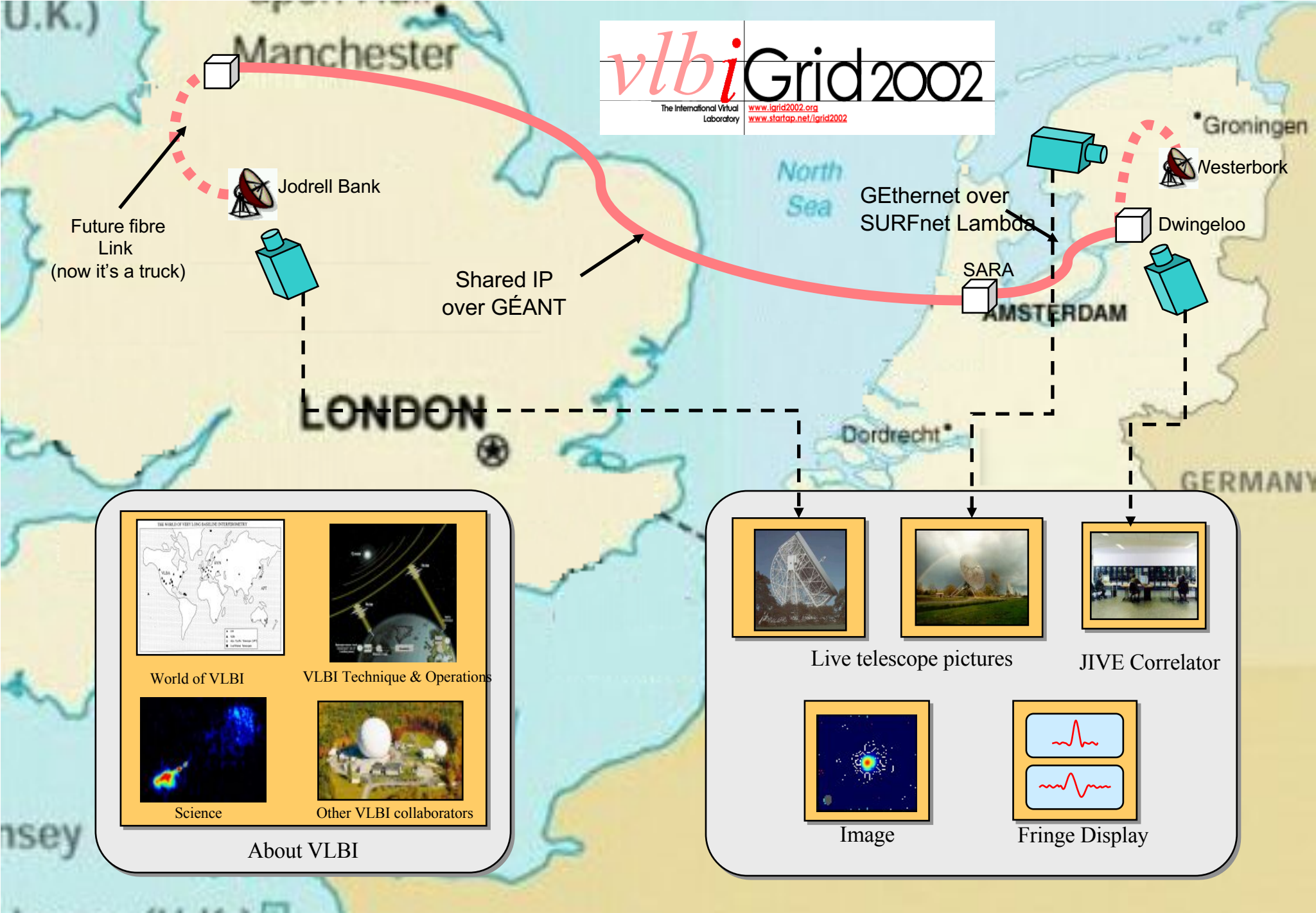
24-26 September 2002
Amsterdam Science and Technology Centre (WTCW)
The Netherlands

Call for Applications with Insatiable Bandwidth Appetites!

“We hereby challenge the international research community to demonstrate applications that benefit from huge amounts of bandwidth!”

vlbiGrid2002

The International Virtual Laboratory www.lgrid2002.org
www.startap.net/lgrid2002



About VLBI

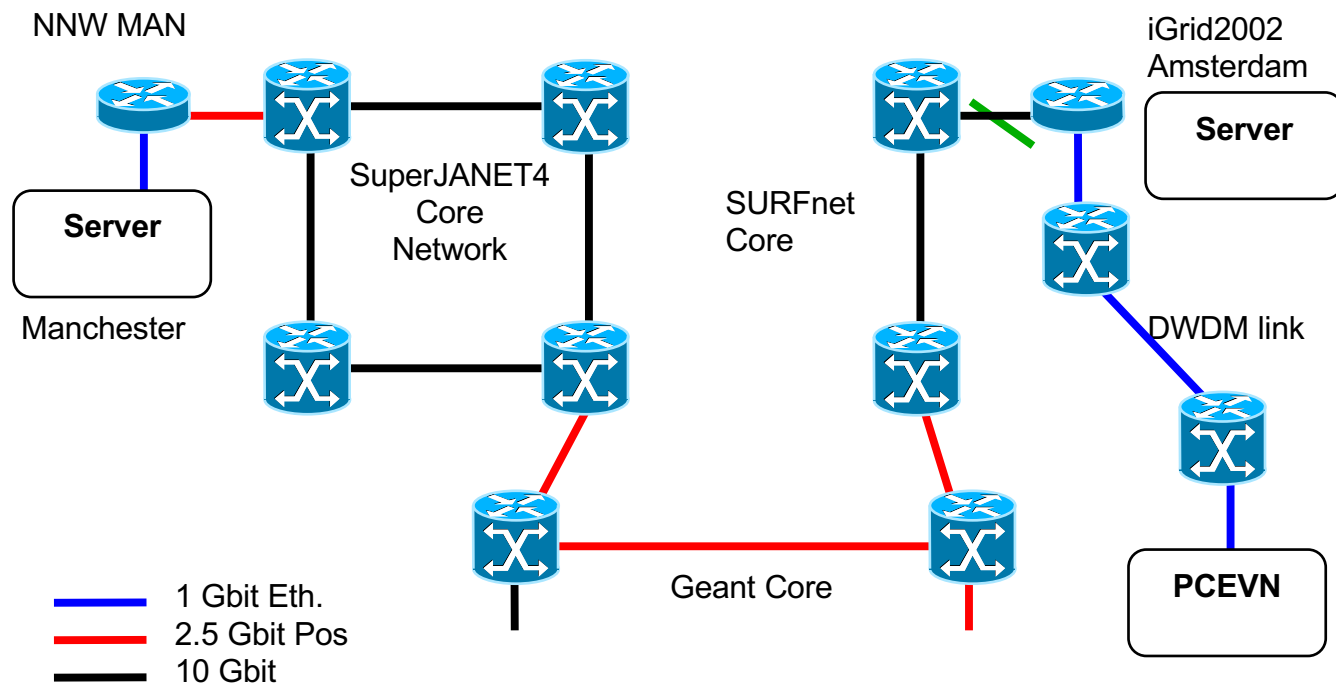
- World of VLBI
- VLBI Technique & Operations
- Science
- Other VLBI collaborators

- Live telescope pictures
- JIVE Correlator
- Image
- Fringe Display

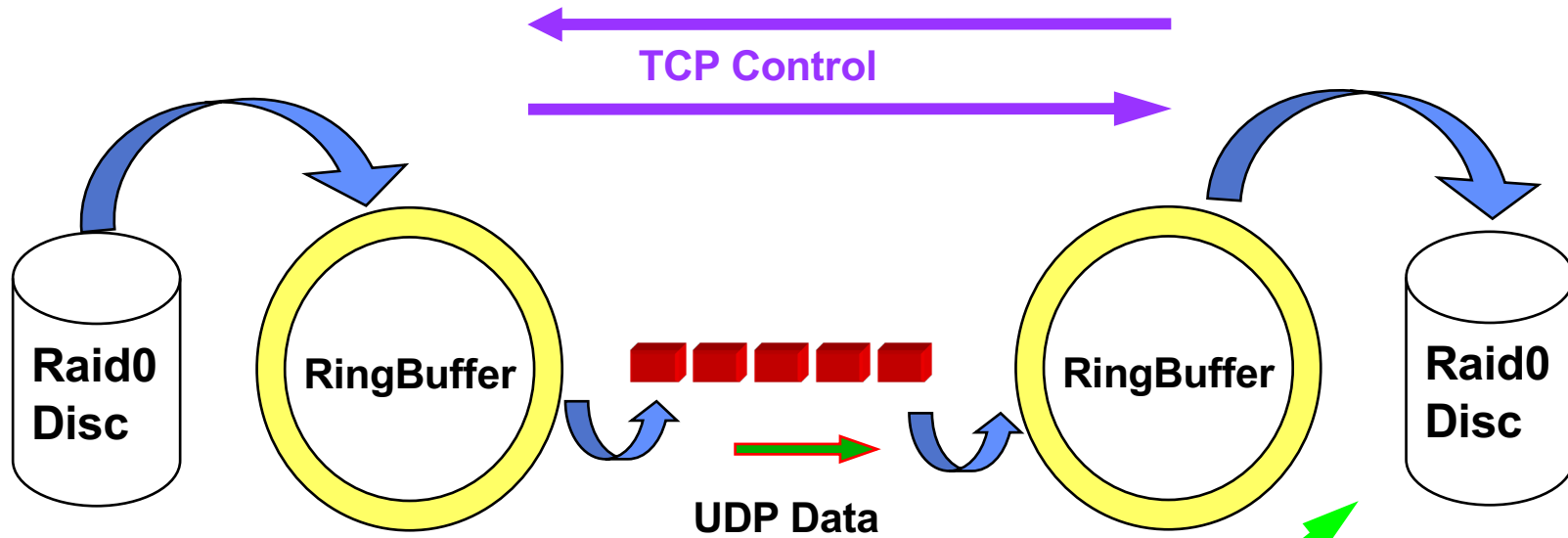
*vlbi*Grid Objectives

- Trial use of UDP for VLBI data transfer across production research networks:
 - Data rates
 - Packet loss
 - Packet reordering
- Exercise new link to JIVE
- Demonstrate eVLBI fringes
- Publicise VLBI to network researchers

iGrid Network Routing

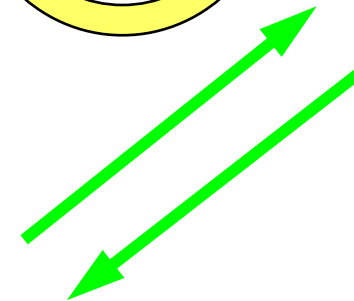


Data Transfer Process:



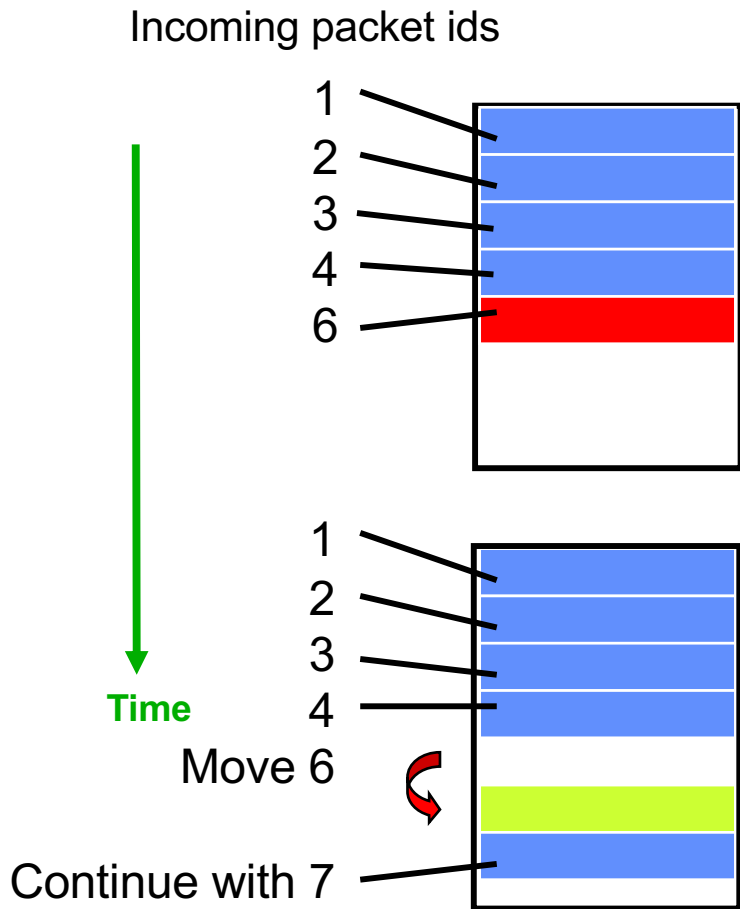
The screenshot shows a web interface for "Radio Astronomy VLBI Data Transmission". It includes logos for iGrid2002, Jodrell Bank Observatory, and the Joint Institute for VLBI in Europe (JIVE). The interface features a "Progress Monitor" with a grid of colored squares (green, yellow, red) representing the status of data transfer for different files. A "VLBI Transmission Statistics" table is also visible.

VLBI Transmission Statistics	
Number of packets received	1239605
Number of packets lost	74
Number of packets badorder	10
Total bytes transferred	1819740140
Recevd data rate Mbit/s	488
Wire data rate Mbit/s	510



Web Interface

Receiving Packets

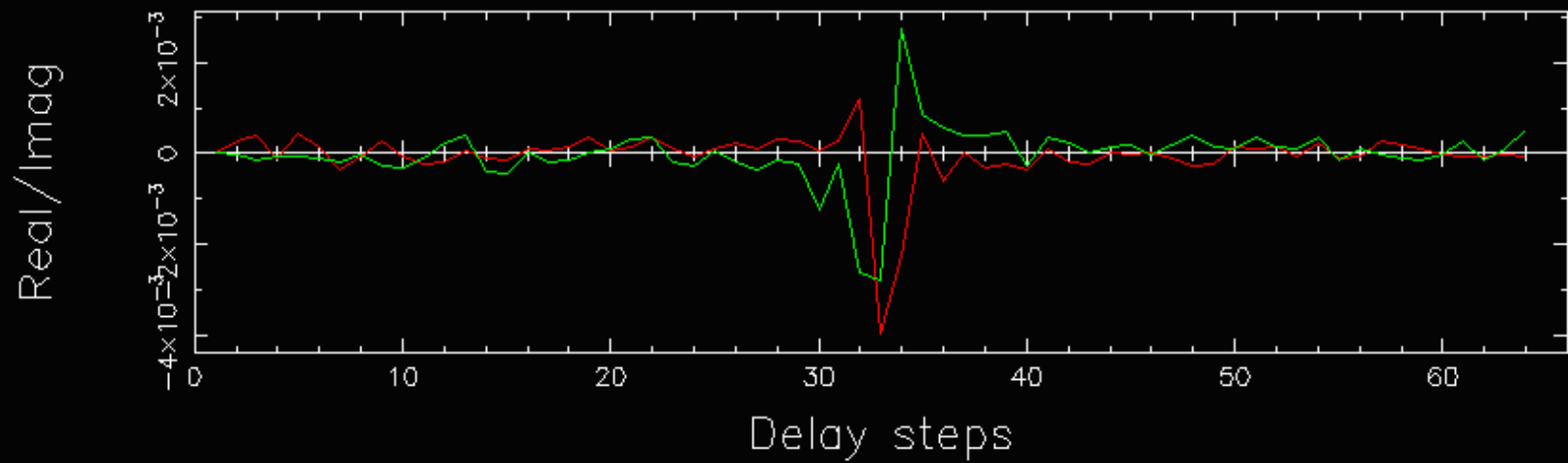


- **Packets have Header with packet id + Data**
 - Put header directly into control area
 - Put data directly into ring buffer
 - No extra copy
- **Assume UDP packets arrive in order none lost**
 - Deposit data into next consecutive slot
- **Inspect Header**
 - Move data onward to correct location
 - Record:
 - The received inter-packet spacing
 - 1-way delay

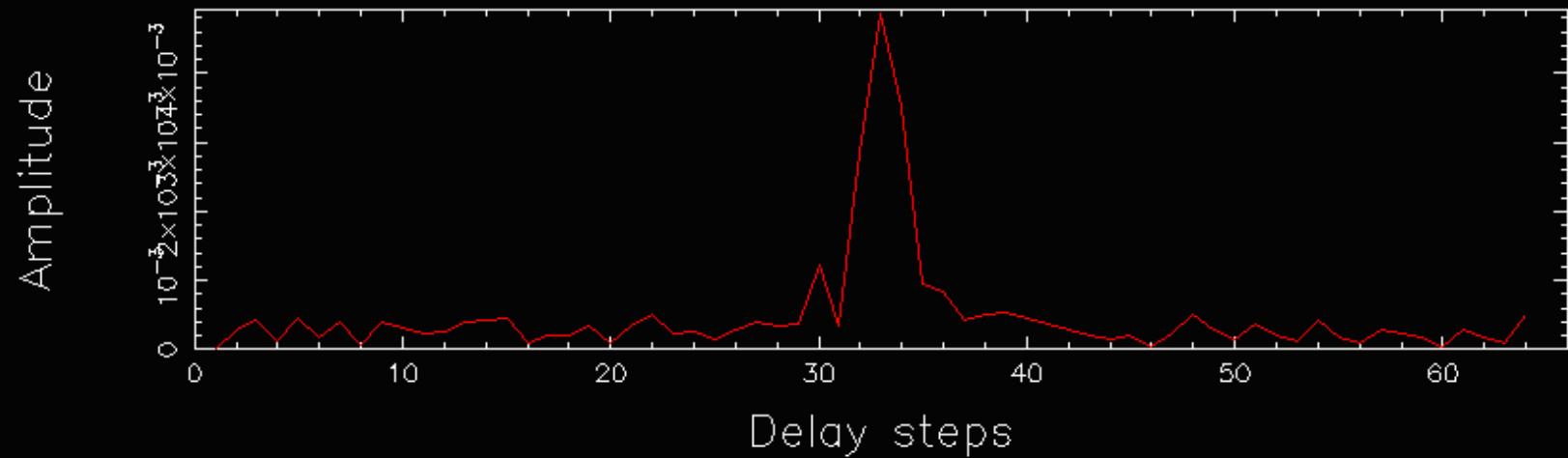
iGrid Results

- UDP across GÉANT (server-server) :
 - ~500Mbit/s
 - $<6E-5$ lost packets
 - $<1E-5$ reordered packets (all exchanges)
- FTP to Dwingeloo:
 - ~40Mbit/s
 - Normal fringes detected
- PR:
 - Great success, new link used three days after first light
 - Much interest in VLBI data rates and volumes

Intf 9; Subband 0; X Ant 13 Pol 1; Y Ant 14 Pol 1; Systick



Max. amp @ lag= 33.10 (after fit)



iGrid Lessons Learned



- 500Mbit/s VLBI data transfer on the production network using a simple UDP based protocol is feasible.
- Acceptable packet loss is achievable .
- Packets may be re-ordered. A simple data moving strategy corrects for this.
- Control/monitoring data should be on a separate, reliable channel.
- End hosts must have sufficient power in both compute cycles and input/out capability.

An initial specification would include:

- 64bit 66MHz PCI bus
- 2 GHz processor
- Gigabit Ethernet interface:
 - Intel Pro 1000
 - SysKonnnect
- Fast disks with high speed buses
 - Maxtor D740 EIDE 133

Proof of Concept Project (PoC)

- Target:
 - Up to 5 radio telescope sites (not incl NL) connected in real-time to JIVE correlator
- Duration:
 - Up to end of GÉANT contract (Nov 2004)
- Support:
 - Best effort IP service transiting NRENs and GÉANT
 - No significant upgrades to GÉANT (initially)
 - Support 512M and 1G real time modes of operation
 - Use existing NREN access ports
 - Limited resilience

Proof of Concept Participants

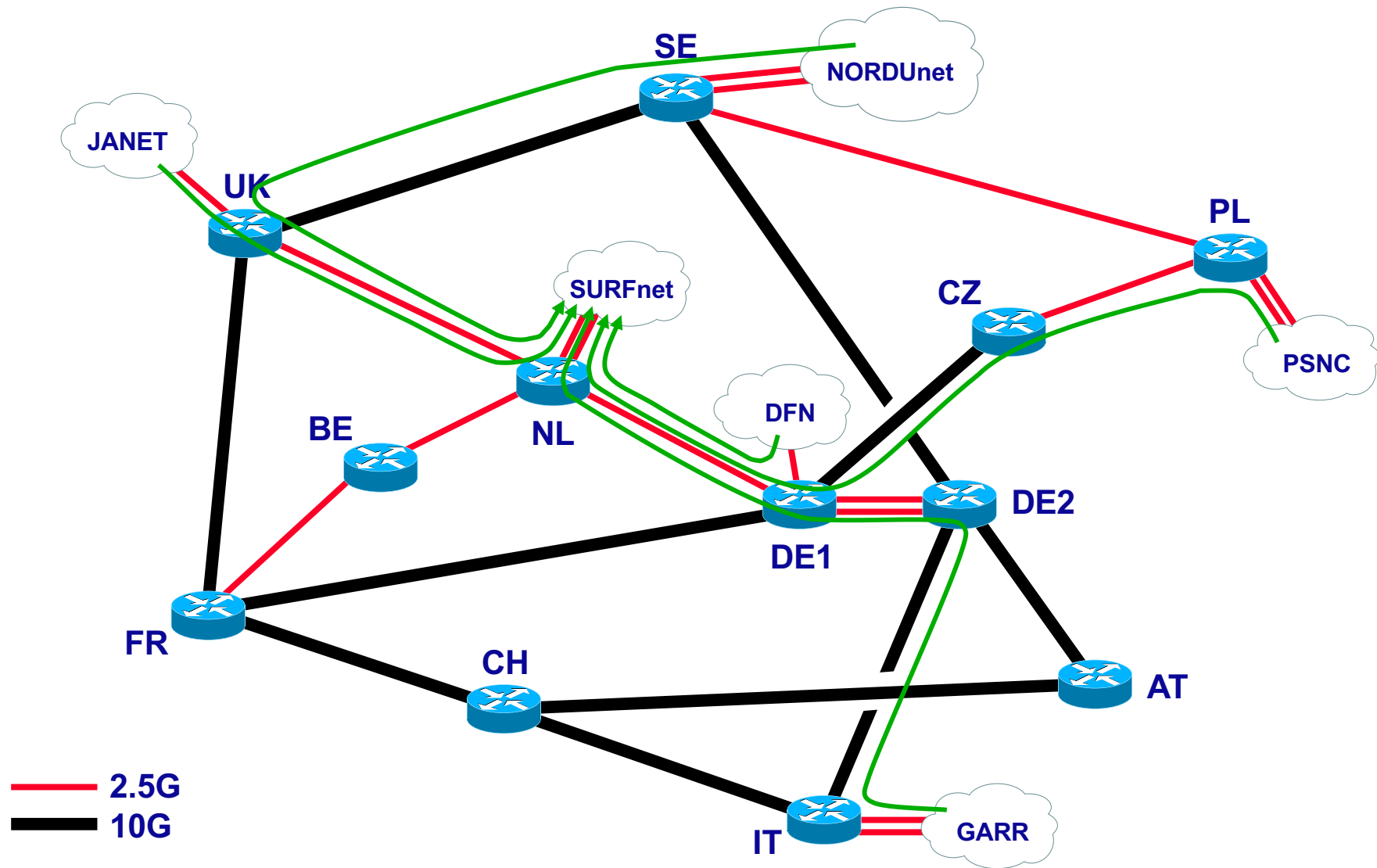
- DANTE
 - GARR
 - UKERNA
 - PSNC
 - DFN
 - SURFnet
 - KTHNOC/NORDUnet
 - Manchester University
 - JIVE
 - Westerbork telescope
 - Onsala Space Observatory
 - MPIfR
 - Jodrell Bank
 - TCfA
 - CNR IRA
- Pan-European Network
 - Italian NREN
 - UK NREN
 - Polish NREN
 - German NREN
 - Dutch NREN
 - Nordic NREN
 - Network application software
 - EVN Correlator
 - Netherlands
 - Sweden
 - Germany
 - UK
 - Poland
 - Italy

Success Criteria (for PoC)

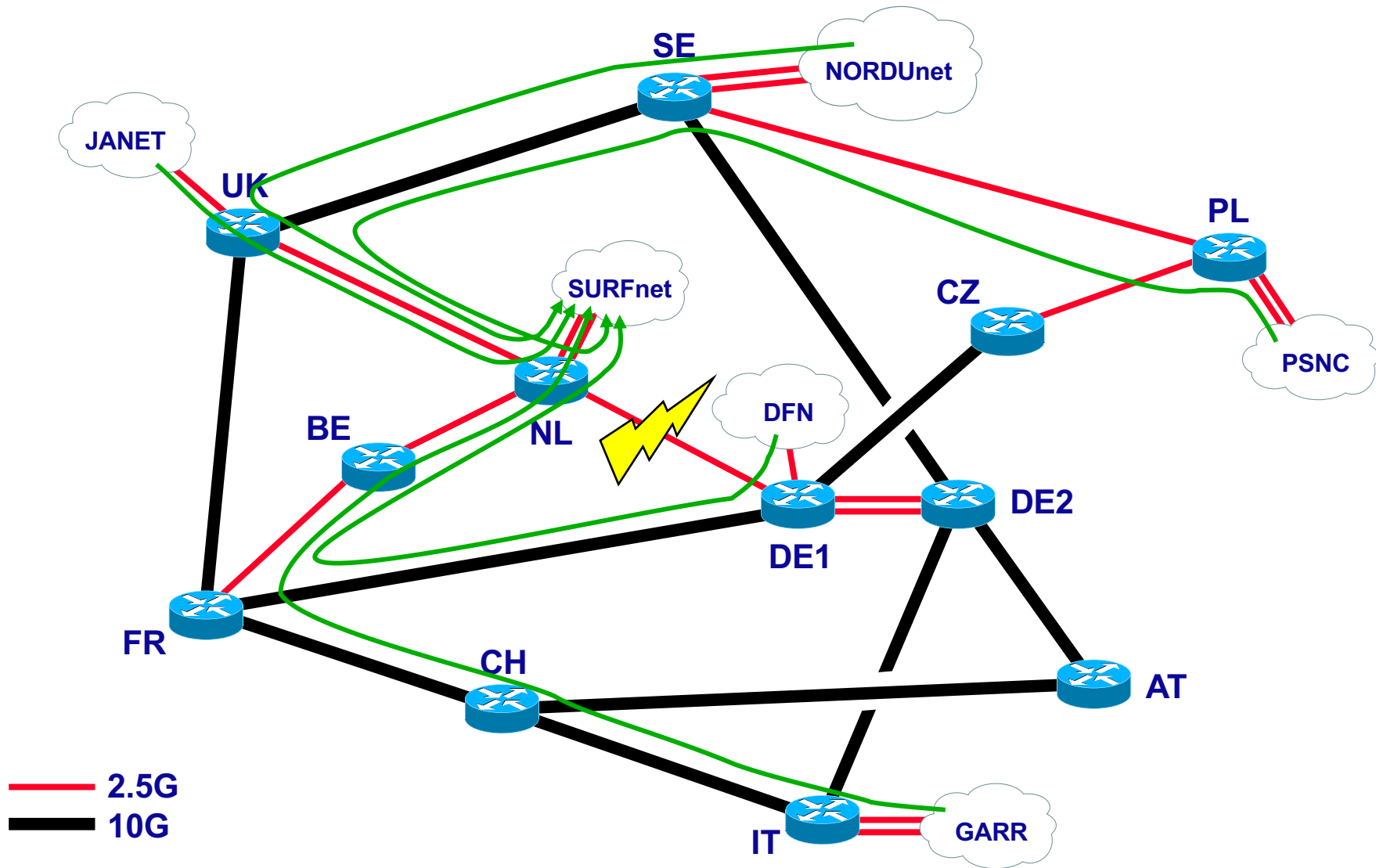
- NREN/GÉANT point of view:
 - Connect at least three sites to JIVE
 - Observe significant usage (time and BW)
- EVN point of view:
 - Same-day imaging of 12hour, 1Gb/s observation
 - Real time network verification of transient phenomenon

Traffic Engineering on GÉANT...

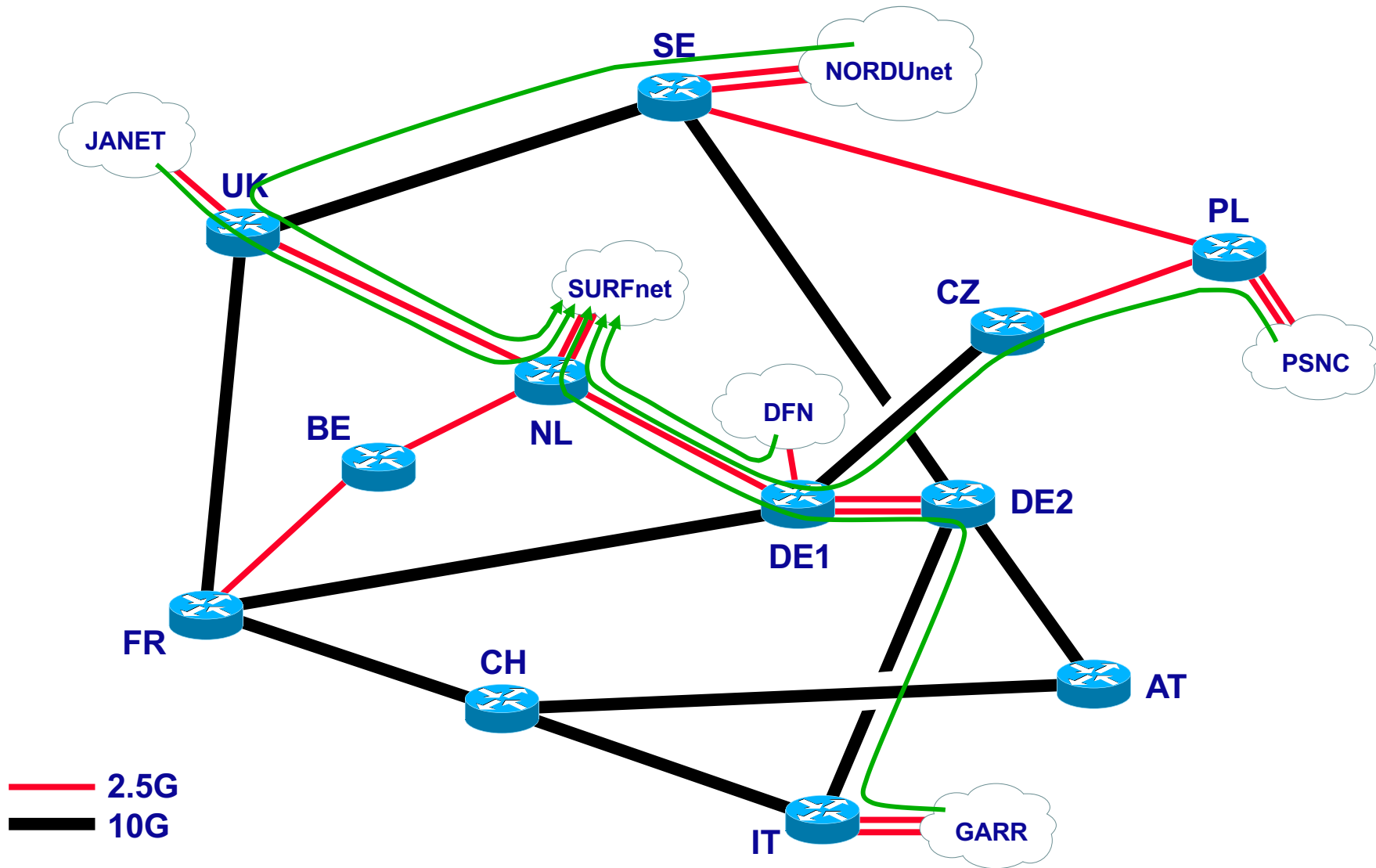
GÉANT Nodes Affected by EVN Traffic



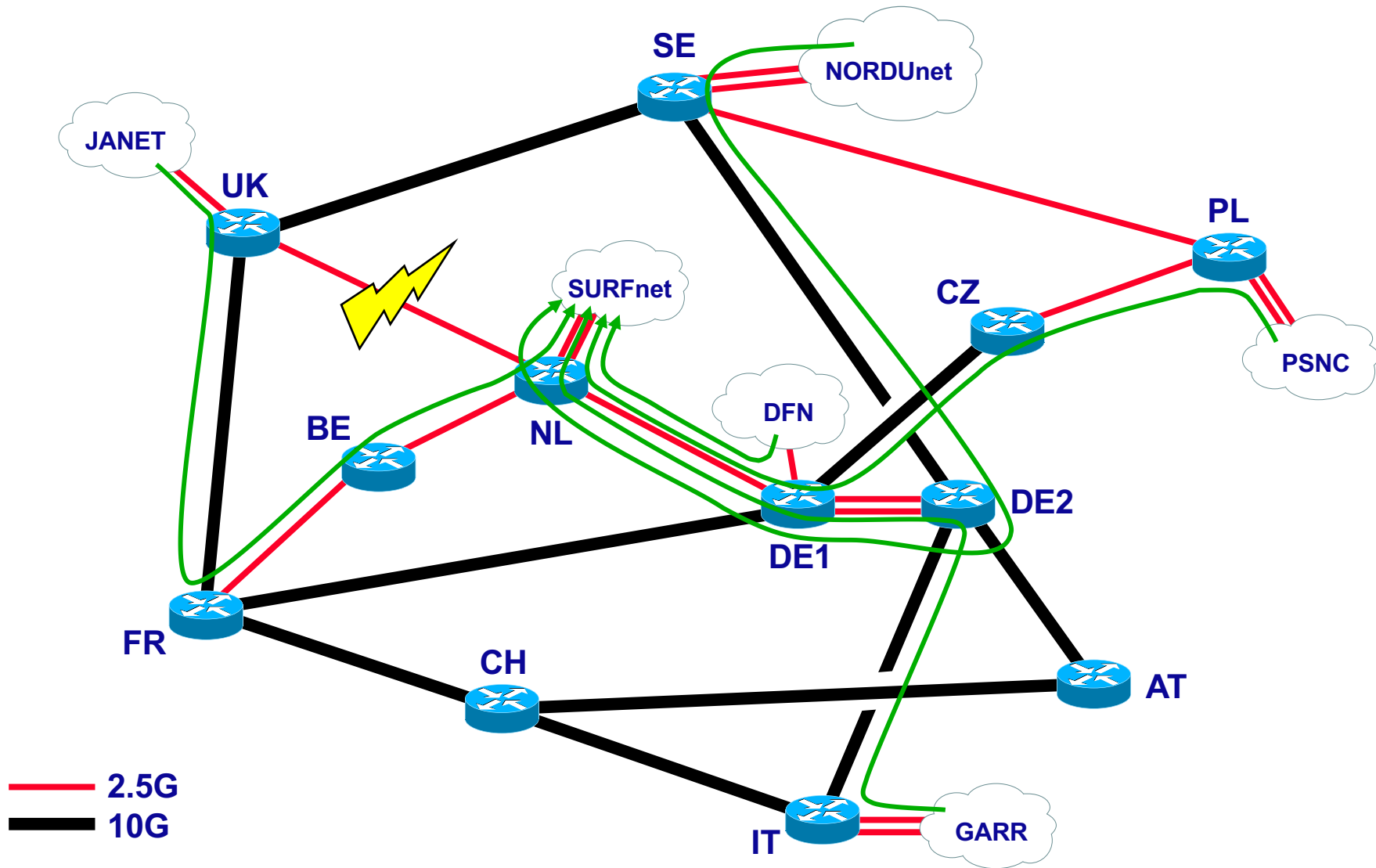
Failure Scenarios #1



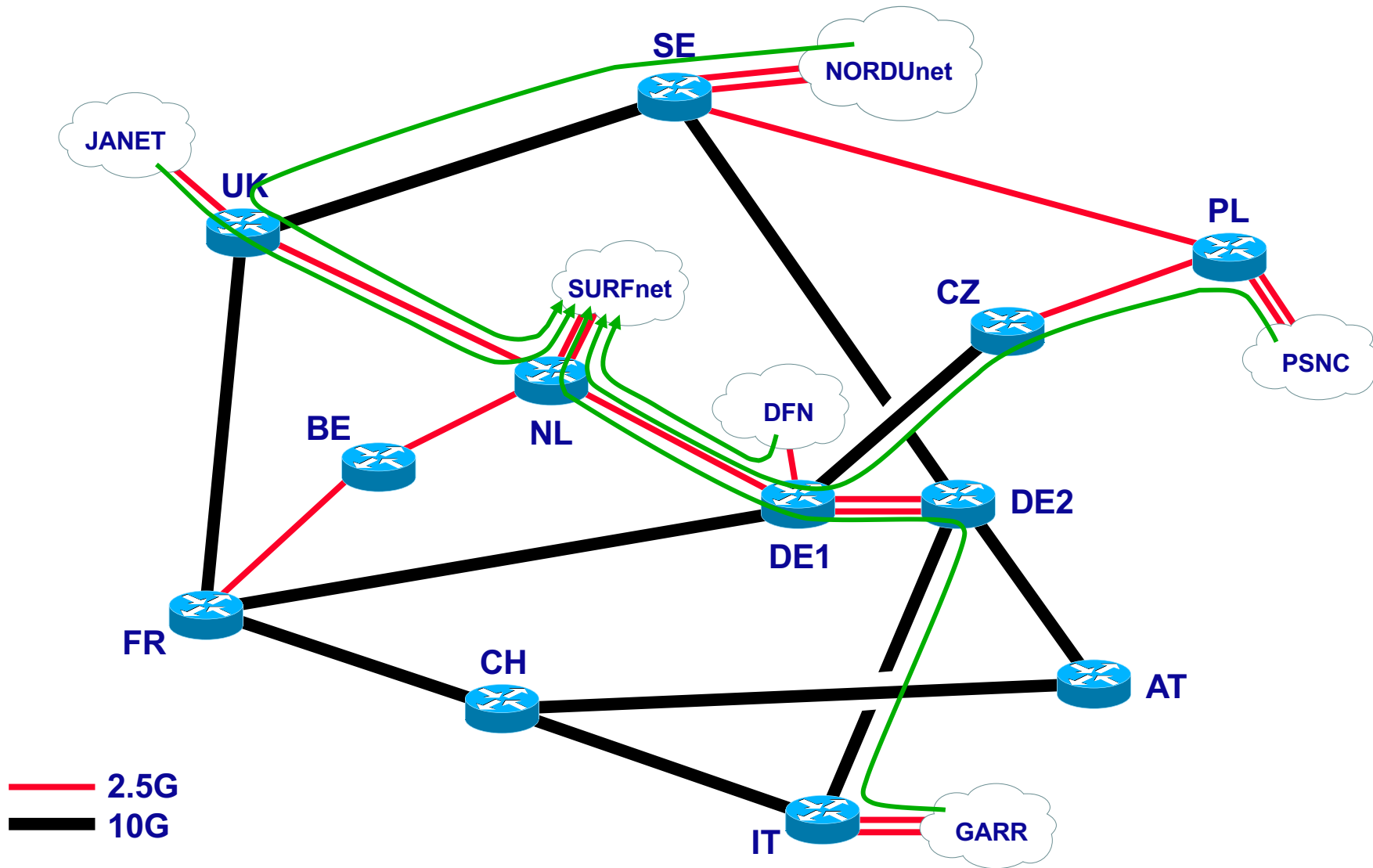
Failure Scenarios #1



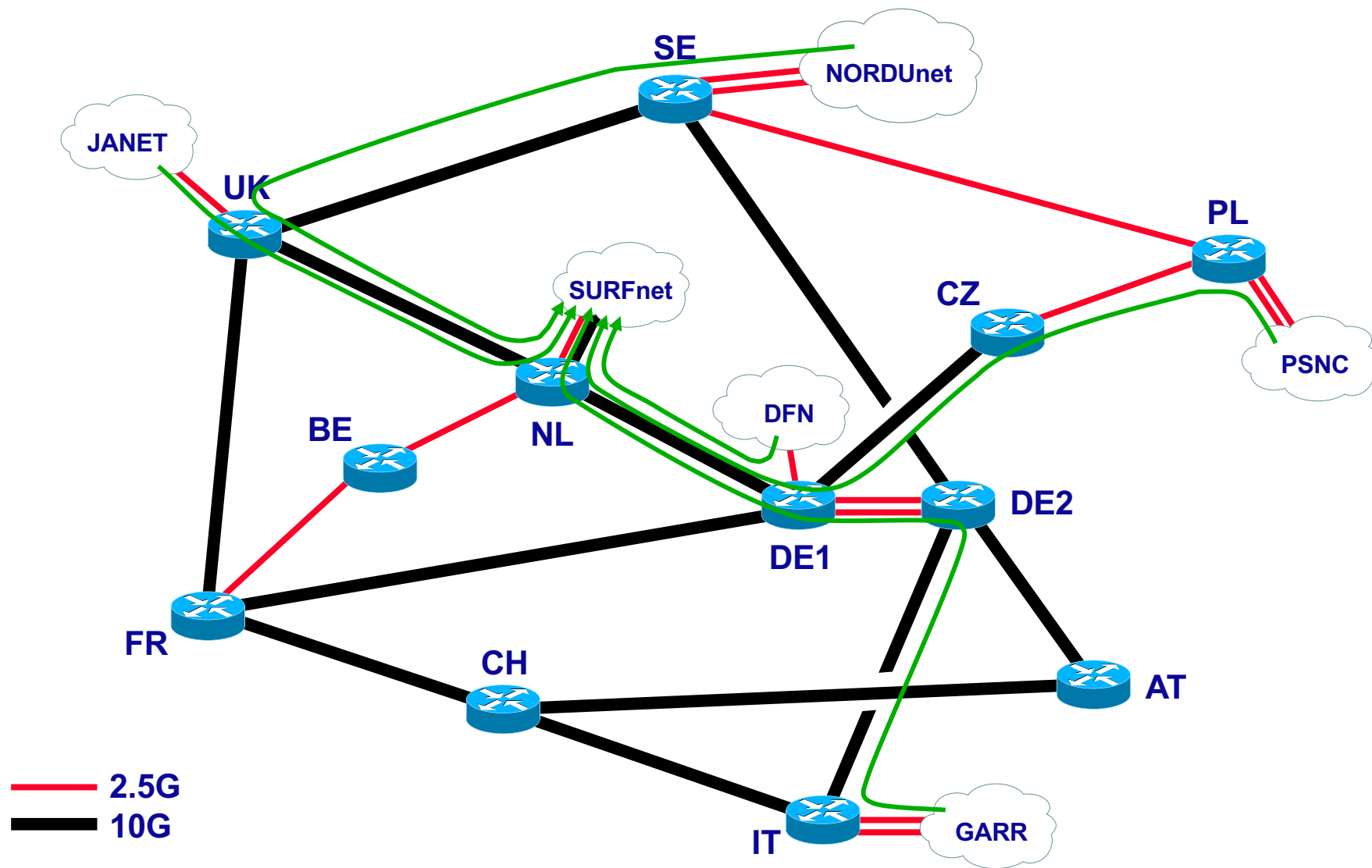
Failure Scenarios #2



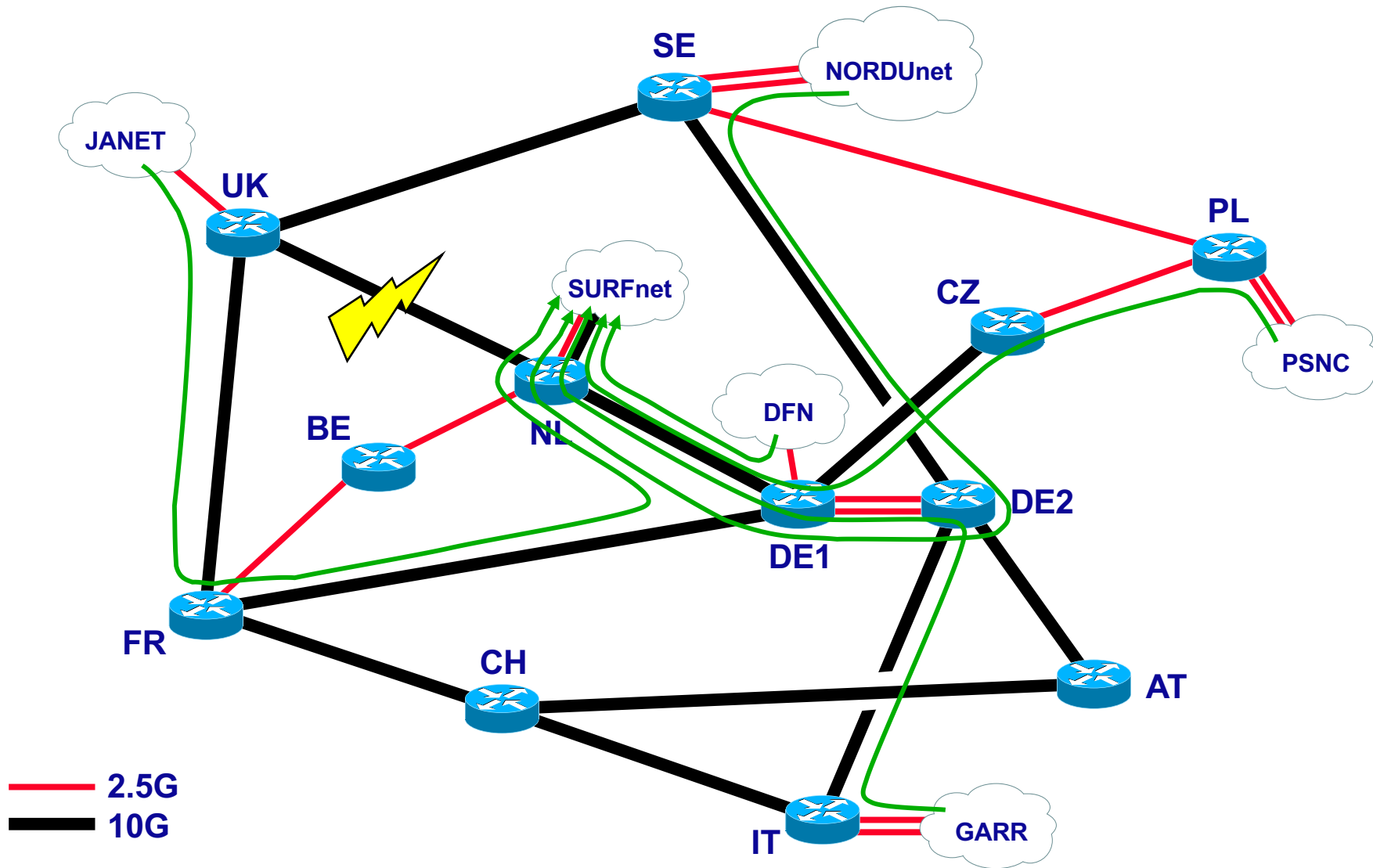
Failure Scenarios #2



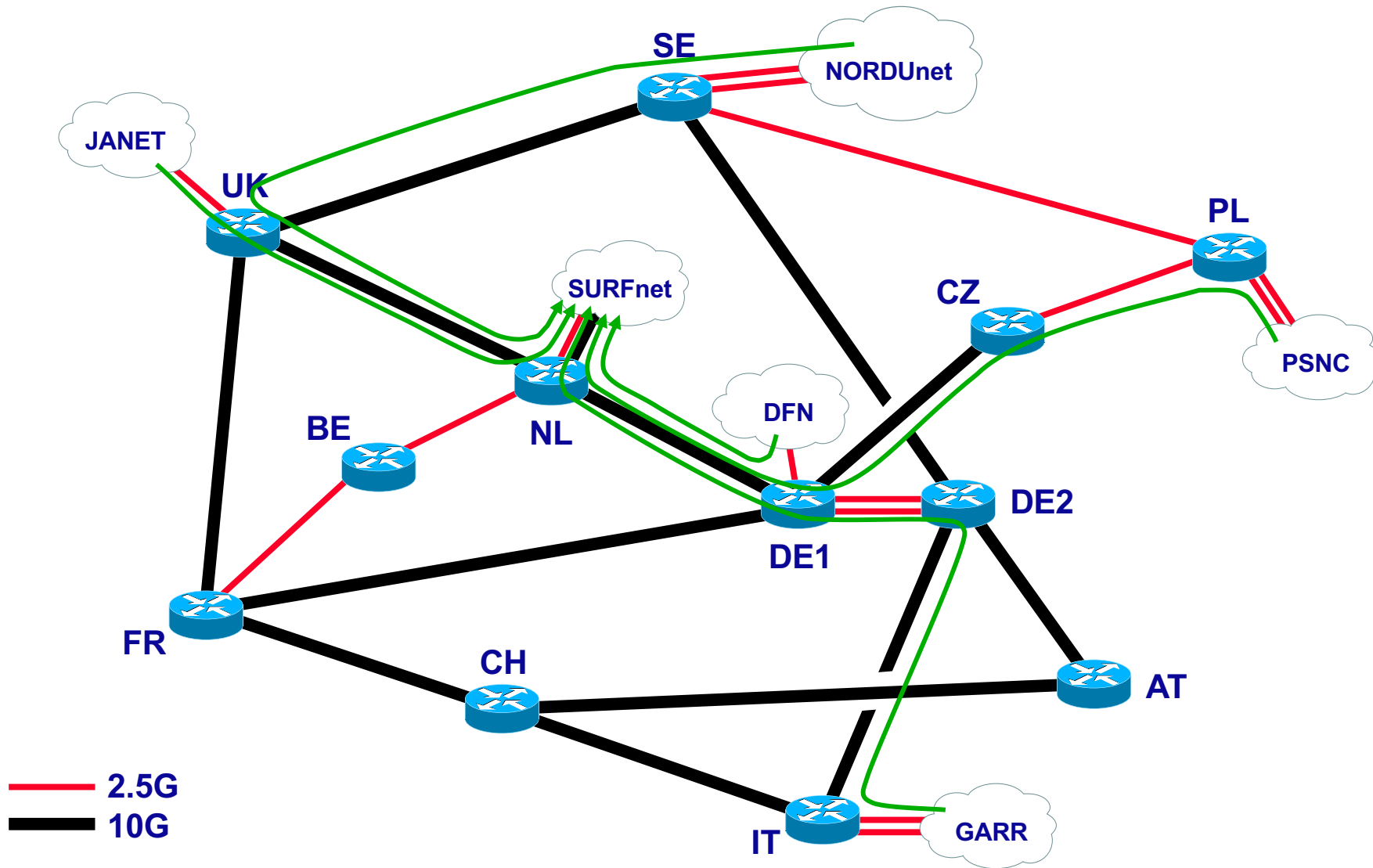
Potential Upgrades to GÉANT



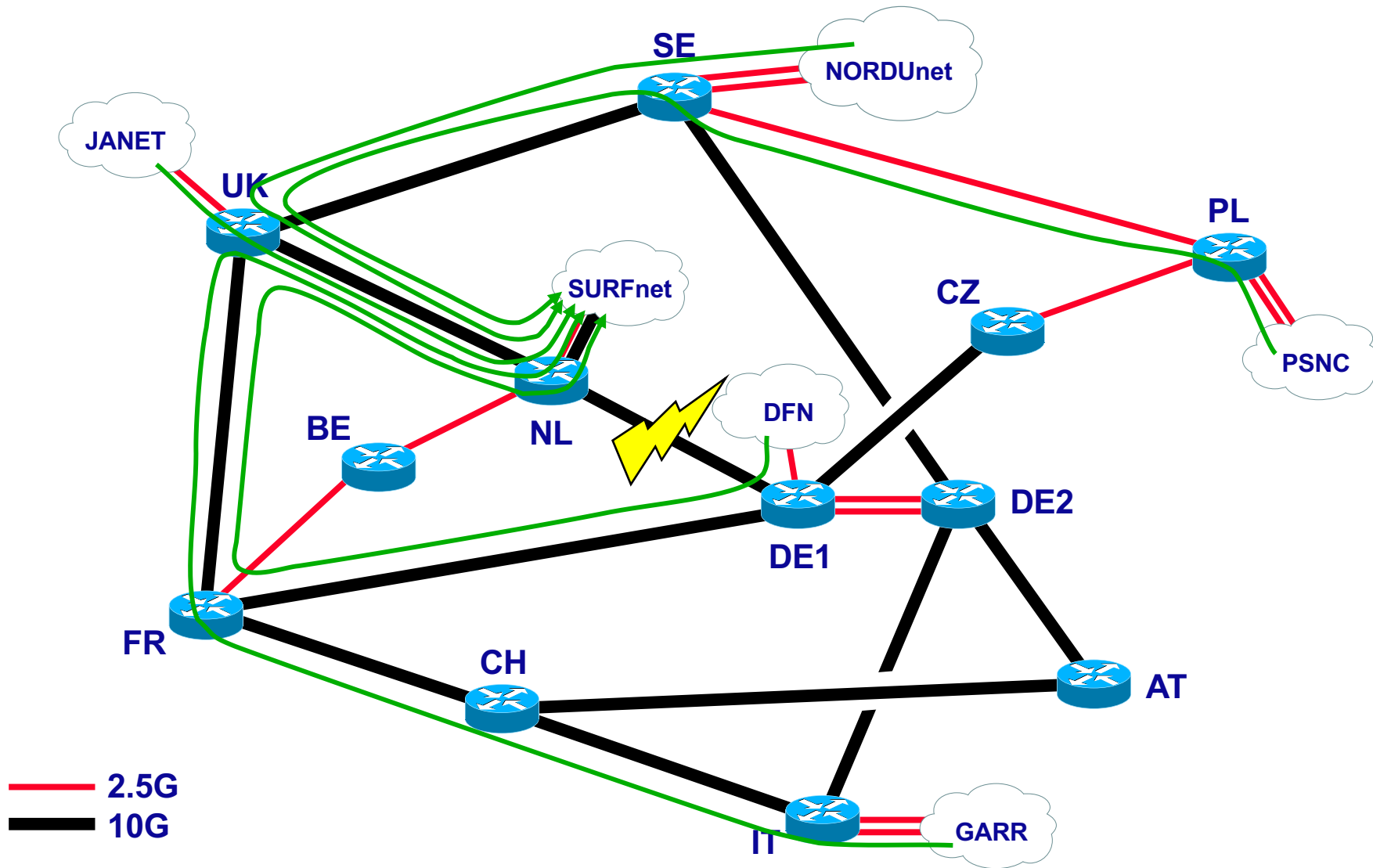
Failure Scenarios #3



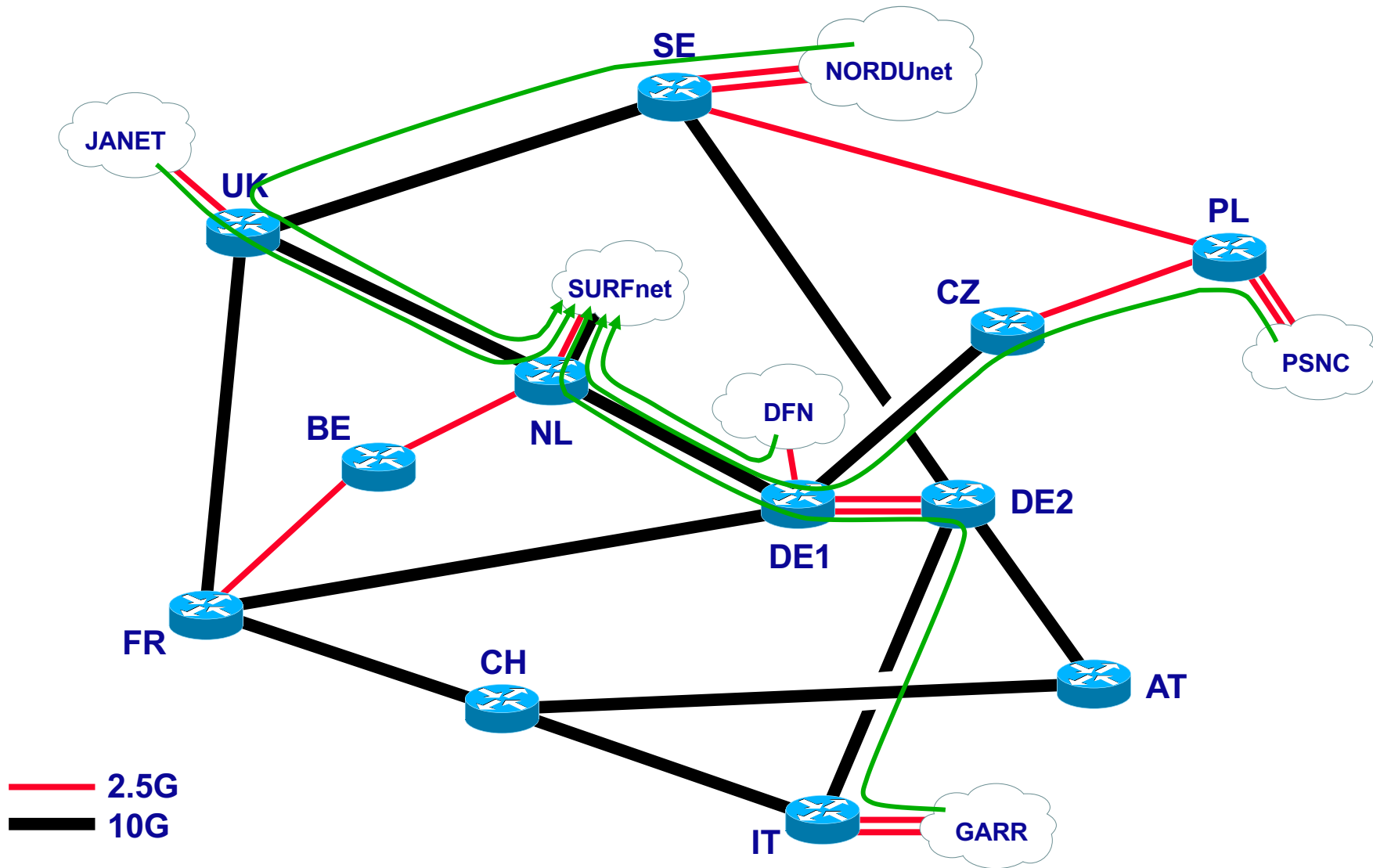
Failure Scenarios #3



Failure Scenarios #4

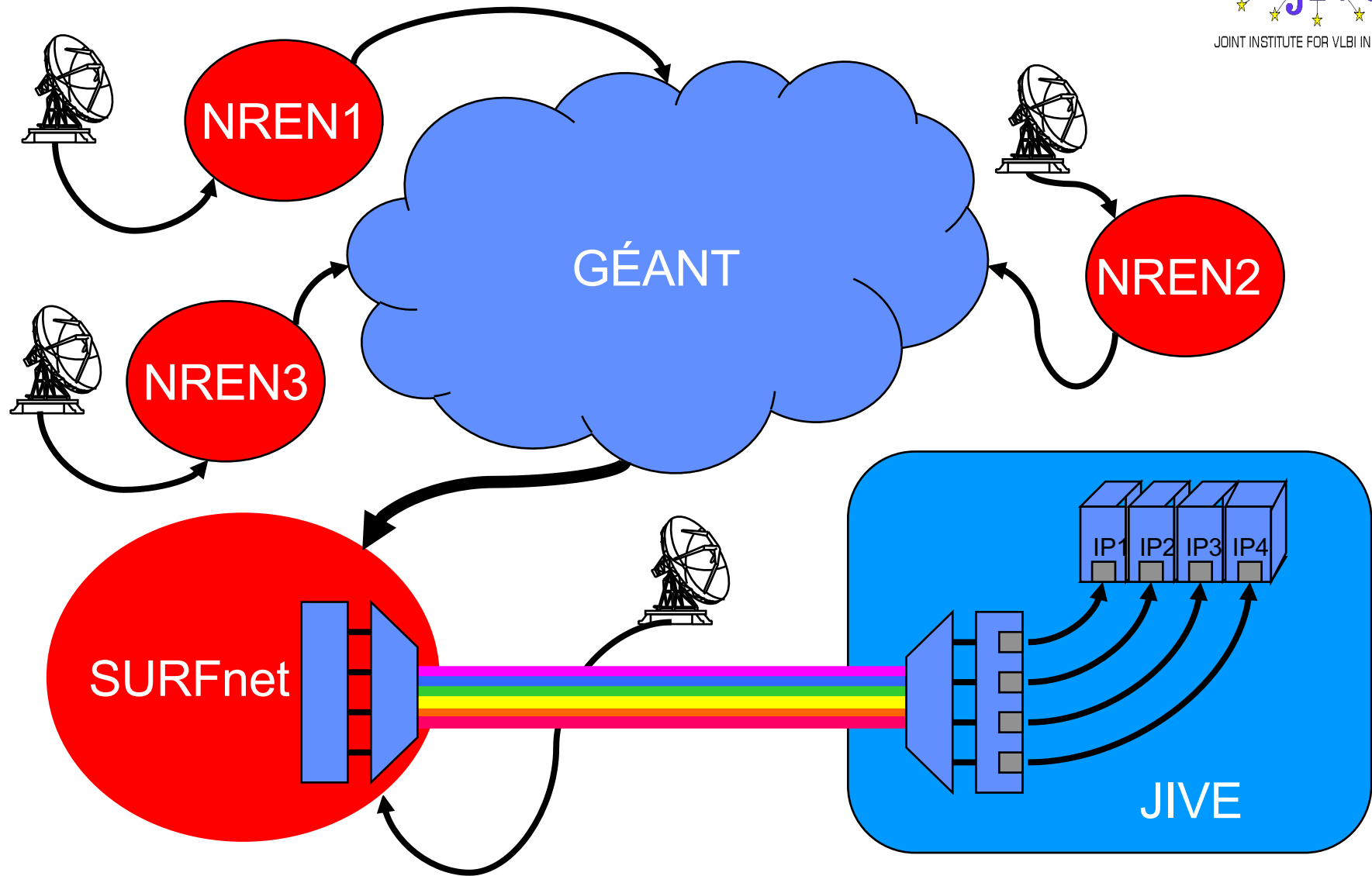


Failure Scenarios #4



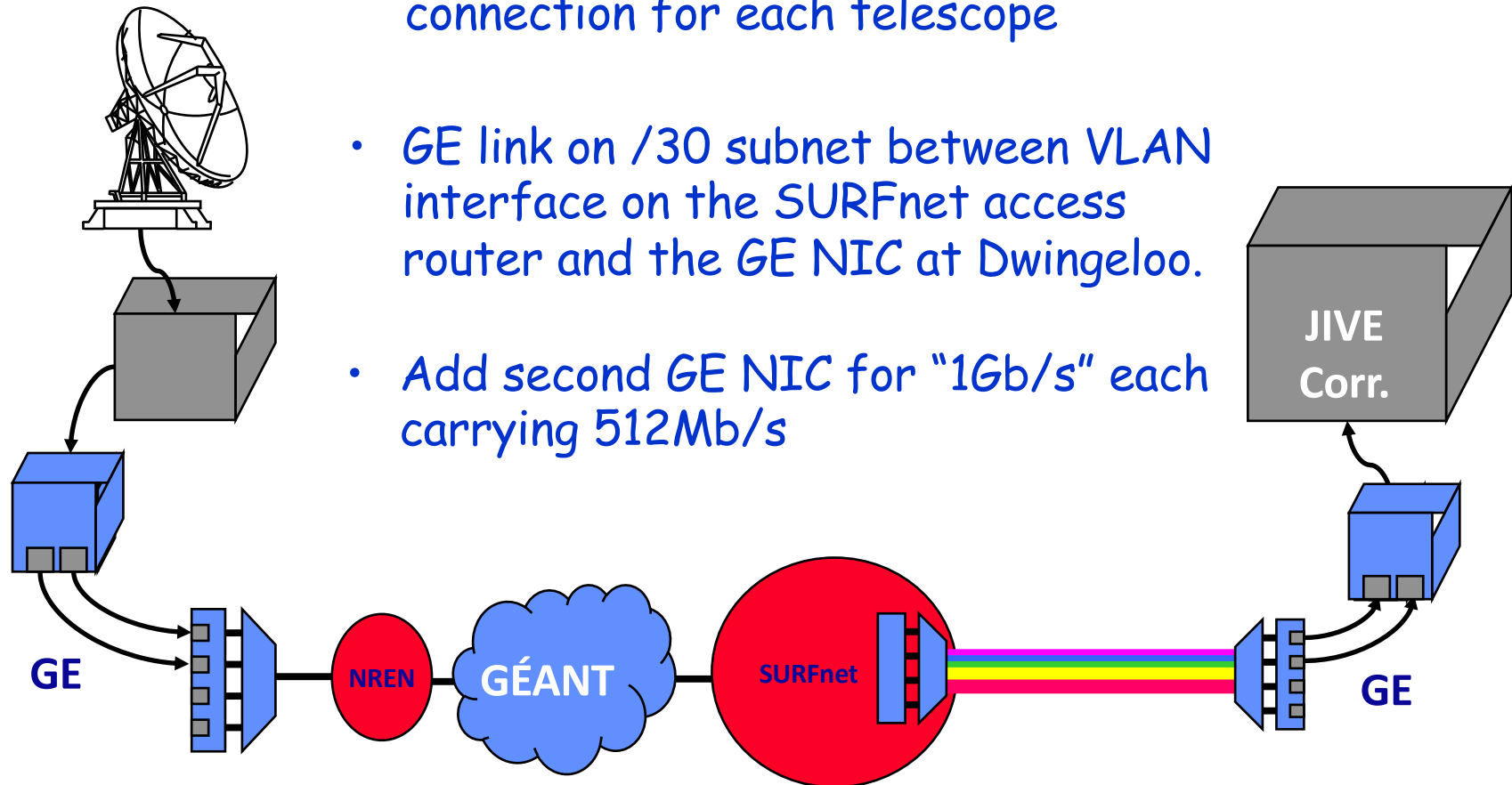
Some Technical Issues

- Packet re-ordering, due to architecture of Juniper M160 routers in GEANT backbone. VLBI UDP application must fix this.
- VLBI data rates are restricted to "octaves"
 - : - 256M, 512M, 1G
 - "1Gbps" eVLBI flows are >1Gbps
 - → two GE channels will be needed to support "1Gbps" from each telescope.



PoC Design

- Separate, GE point-to-point connection for each telescope
- GE link on /30 subnet between VLAN interface on the SURFnet access router and the GE NIC at Dwingeloo.
- Add second GE NIC for "1Gb/s" each carrying 512Mb/s



Local Loops - Status

- Italy:
- Poland:
- Germany:
- UK:
- Sweden:
- The Netherlands:
 - SURFnet: 2.5Gbit/s border connection will soon be upgraded to 10Gbit/s
 - JIVE: 190km dark fibre link from JIVE to Amsterdam (SARA) in place.
 - Westerbork: 24 fibre link directly to Dwingeloo by June'03

Project Timeline



JOINT INSTITUTE FOR VLBI IN EUROPE

2003			Qtr 2, 2003			Qtr 3, 2003			Qtr 4, 2003			Qtr 1, 2004			Qtr 2, 2004			Qtr 3, 2004			Qtr 4, 2004			Qtr 1, 2005			Qtr 2, 2005				
Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep

FACILITIES

February Mk5 tests

◆ Disk Data available

Network Provision

- ★ Local loops
- ★ SARA - Dwingeloo Upgrades
- ★ Local network expansion
- ★ GEANT Netherlands links upgrade

○ Local loops installed

○ 10G access to Netherlands

PROJECT PHASES

Disk - N/W - Disk

- ★ Instrumented mem-mem tests
- ★ Protocol/Network "tuning" for Max data rate
- ★ High data rate astronomy

Disk - N/W - Correlator

- ★ Correlator N/W I/f and buffering
- ★ Correlator synchronisation
- ★ Correlator job control

Telescope - N/W - Correlator

- ★ Telescope & Correlator synchronisation
- ★ Observation job control
- ★ 512Mb/s -> 1Gb/s

RESULTS & MILESTONES

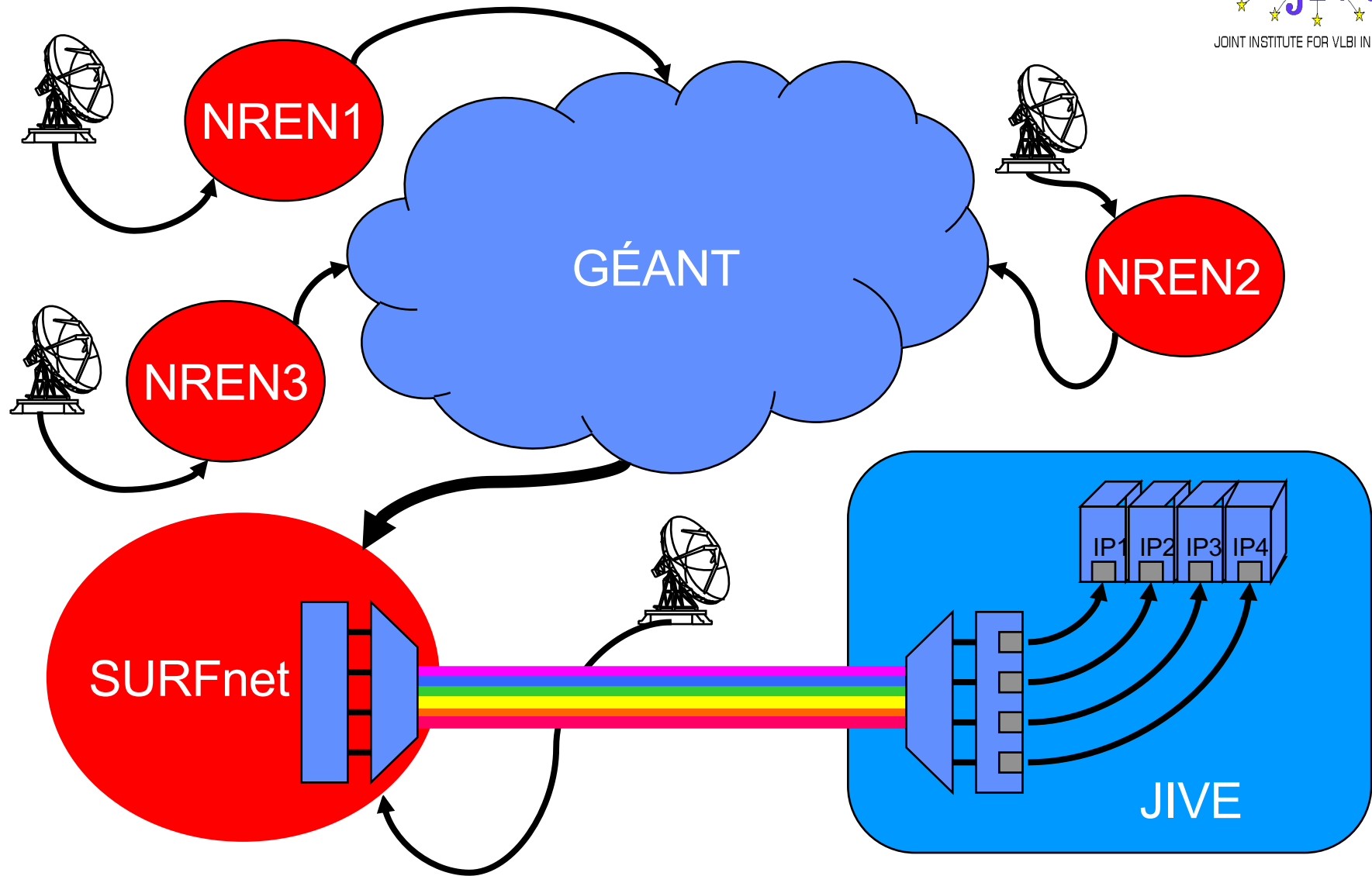
◆ Multi-telescope:- Image

◆ Gbit Fringes

◆ Next-day fringe checks

◆ Real-time Fringes

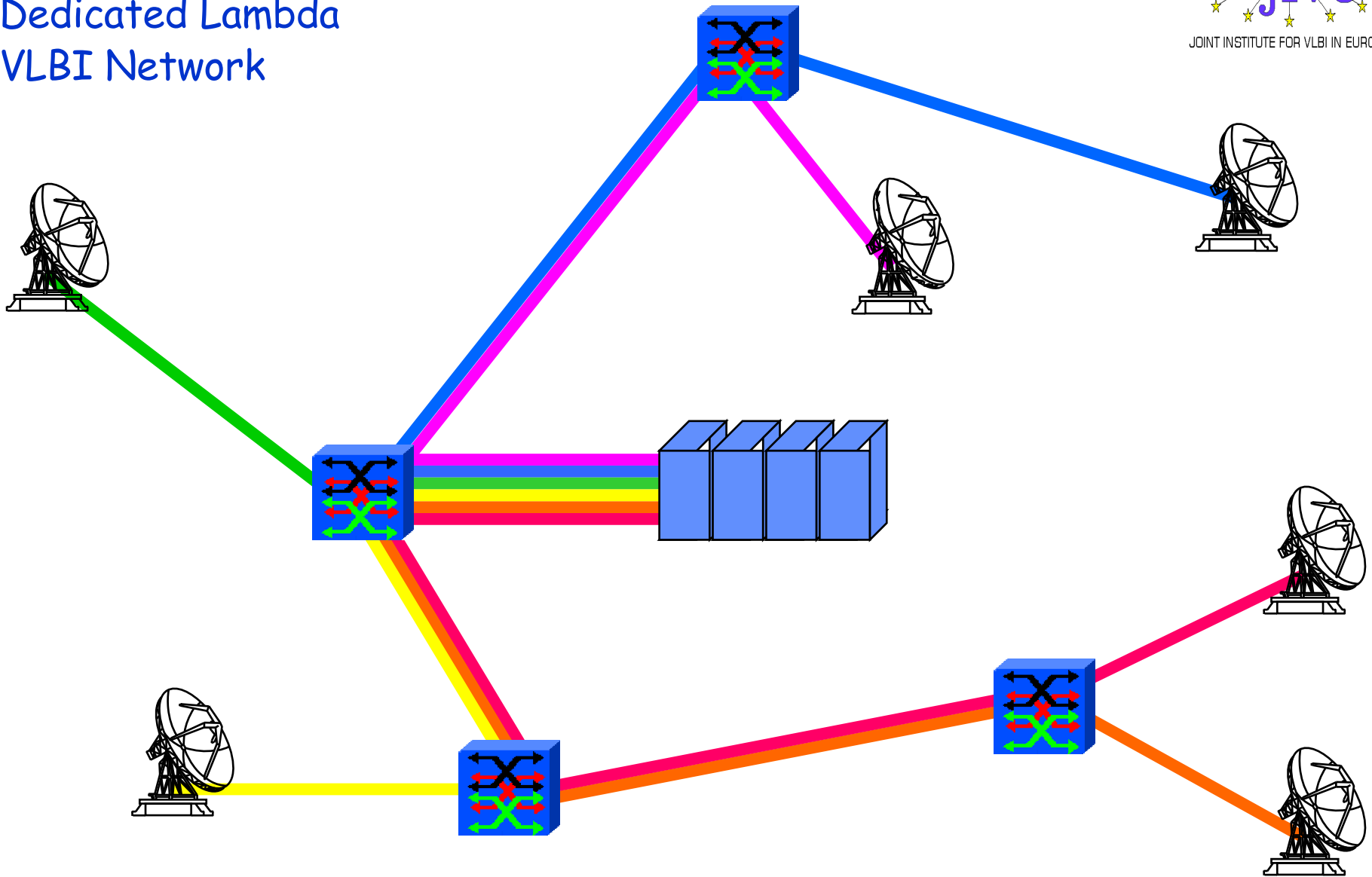
◆ 4 - 5 telescopes R/T VLBI at 1Gb/s



UKLight Proposal

- Initiative to attract funding to create:
 - UK point-of-access (PoA) to the international test-bed
 - Intra UK optical test-bed
- Draft projects:
 - Development of a common optical control plane
 - Secure Optical Community Services
 - A project to use a dark fibre infrastructure
 - **An applications demonstration based upon very long baseline interferometry (VLBI) for Radio Astronomy**

Dedicated Lambda VLBI Network



2nd eVLBI Workshop

15-16 May 2003, Dwingeloo, Netherlands

- First Announcement 10th Jan '03
- Second Announcement 1st March '03
- Abstract Deadline 19th March '03
- Final Announcement 3rd April '03
- Registration Deadline 20th April '03
- Hotel Deadline 15th April '03
- Workshop 15-16th May '03

http://www.jive.nl/jive/evlbi_ws/meeting