

# SFXC:

## The current (e-)VLBI correlator at JIVE

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# Collaborators

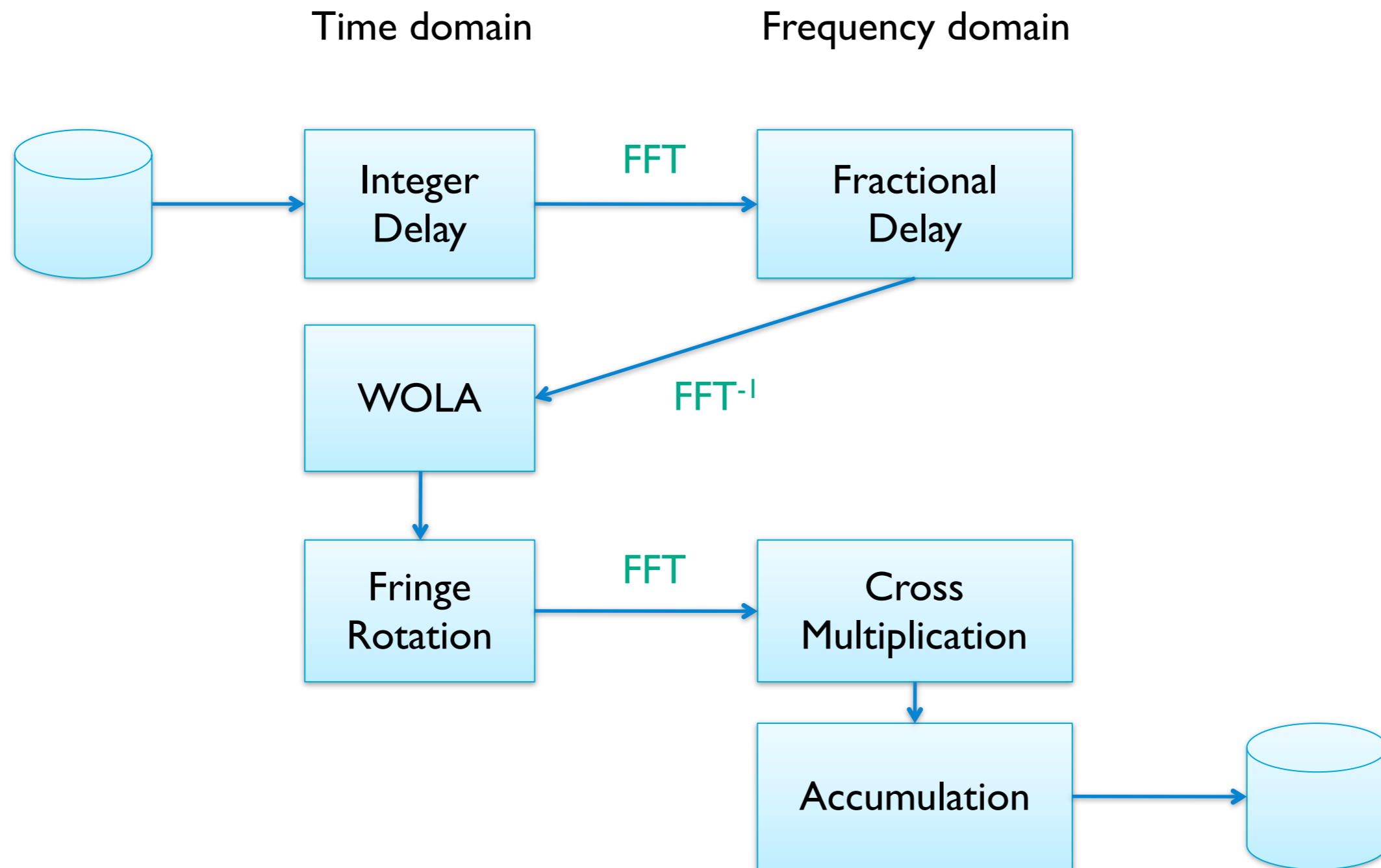
- Aard Keimpema
- Arpad Szomoru
- Bob Campbell
- Bob Eldering
- Des Small
- Dmitry Duev
- Harro Verkouter
- Huib Jan van Langevelde, JIVE/Leiden University
- Wouter Vlemmings, Chalmers
- Franz Kirsten, University of Bonn
- Sergei Pogrebenko



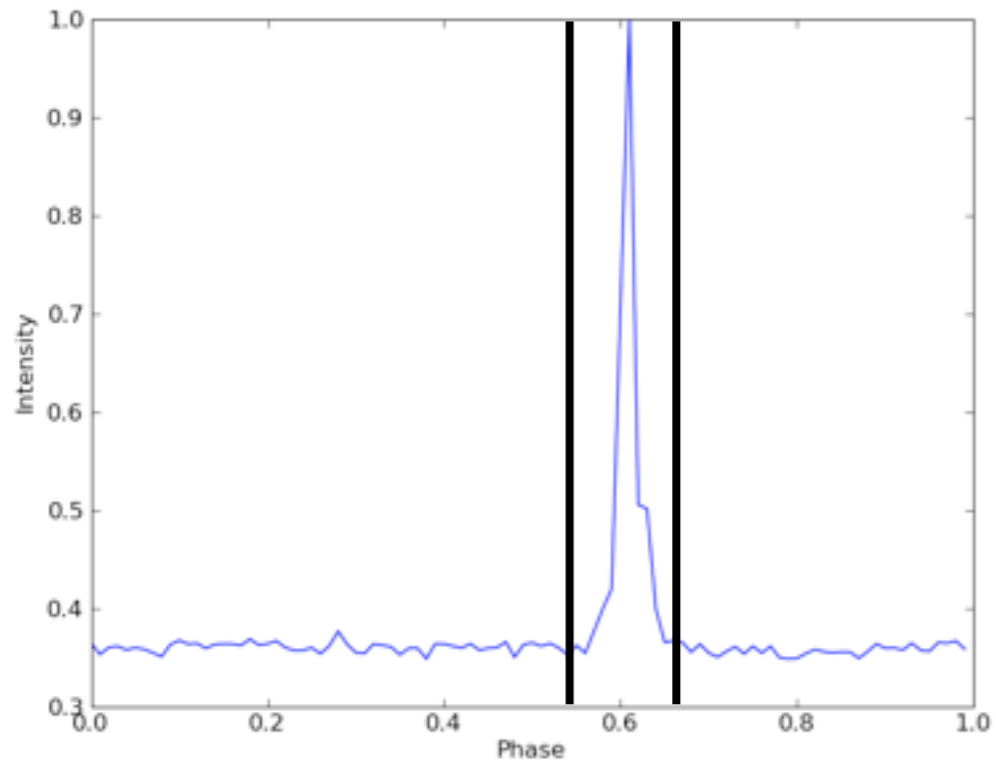
# SFXC Features

- FX software correlator
- Data formats: Mark4, VLBA, Mark5B, VDIF
- Delay model: CALC10 (same as Mark4@JIVE and UniBoard), or external
- WOLA: Hann, Hamming, Cosine, Rectangular
- VEX driven, with JSON configuration file
- Implemented using MPI
- Optionally uses commercial Intel IPP library

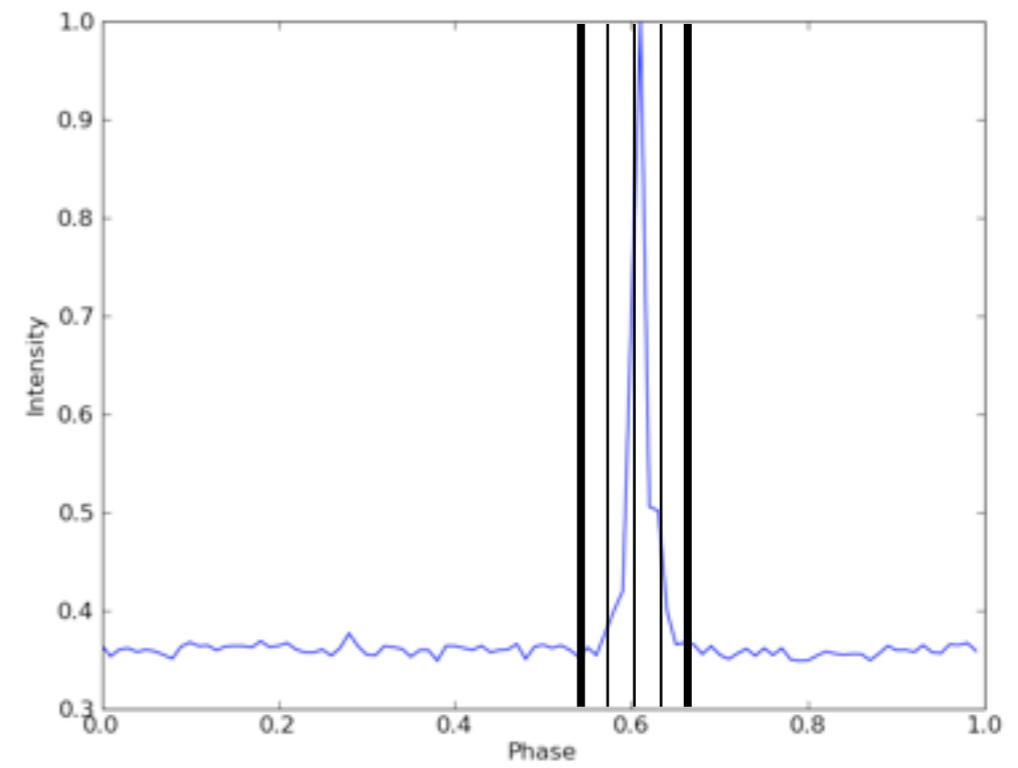
# SFXC Algorithm



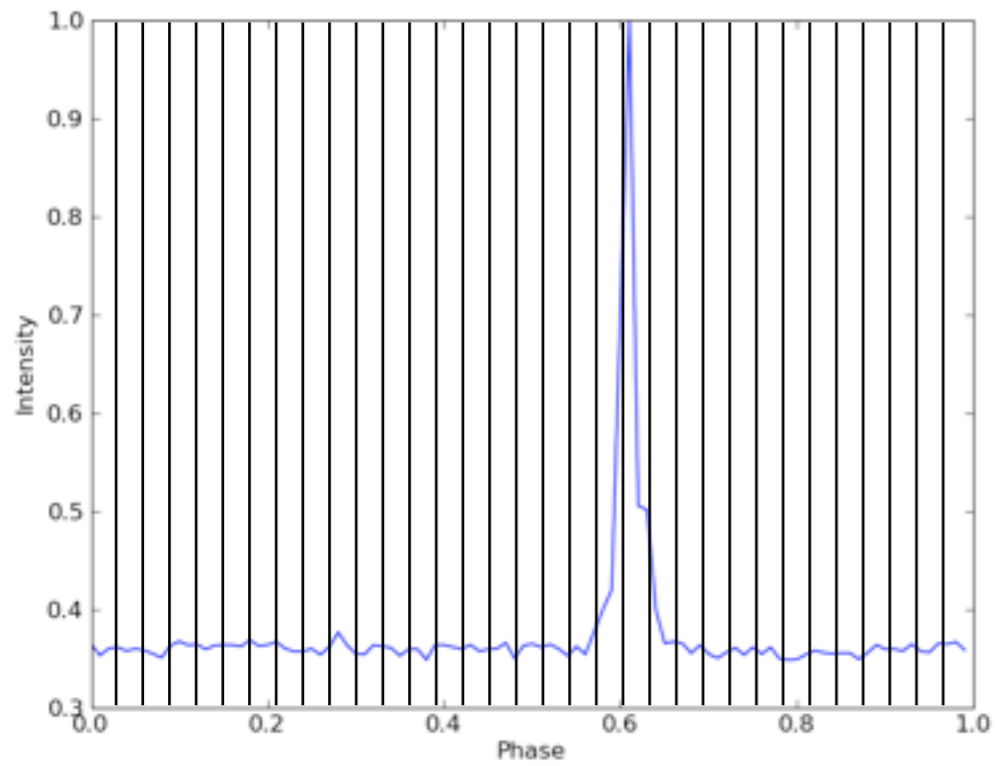
# Gating



# Gating + Binning

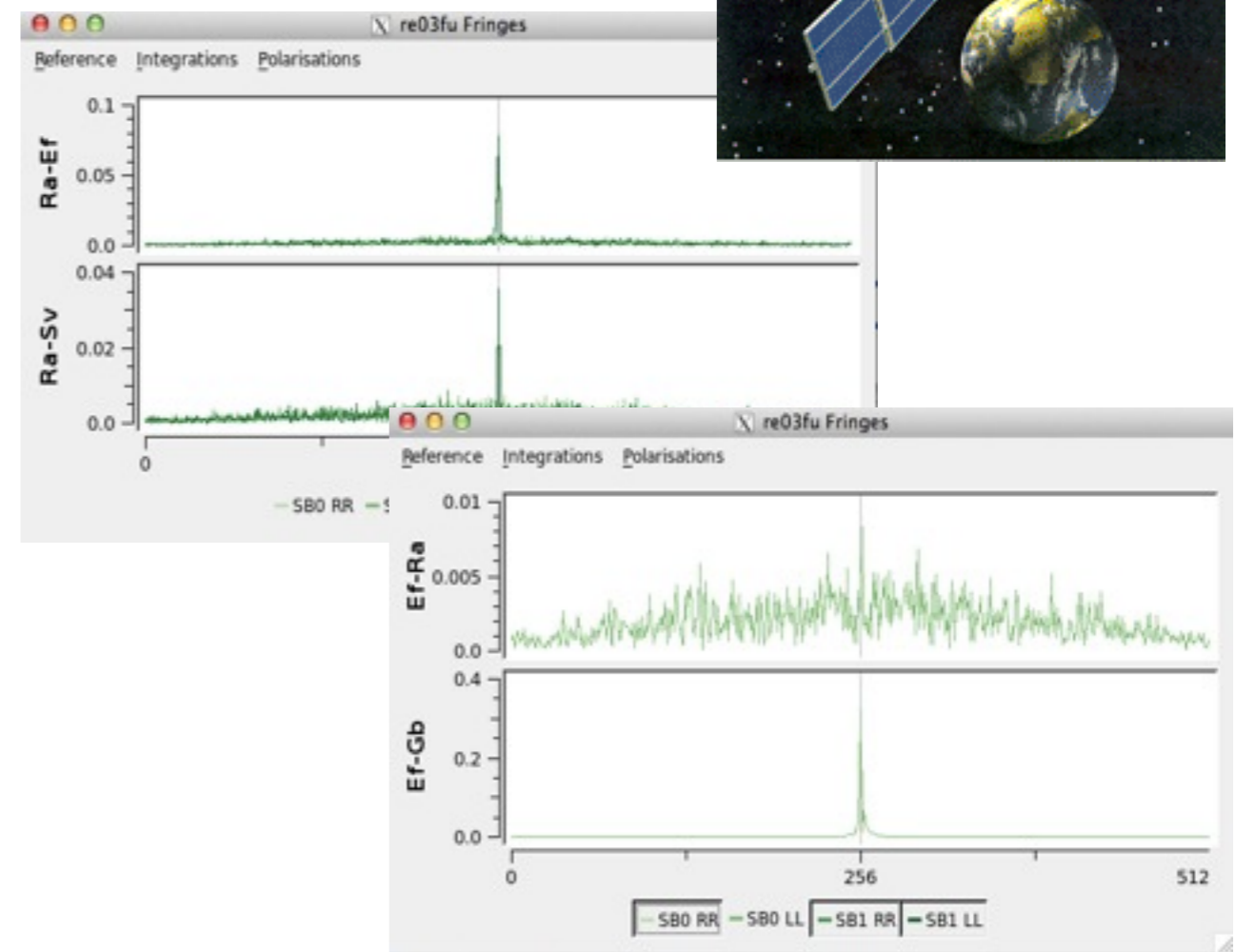
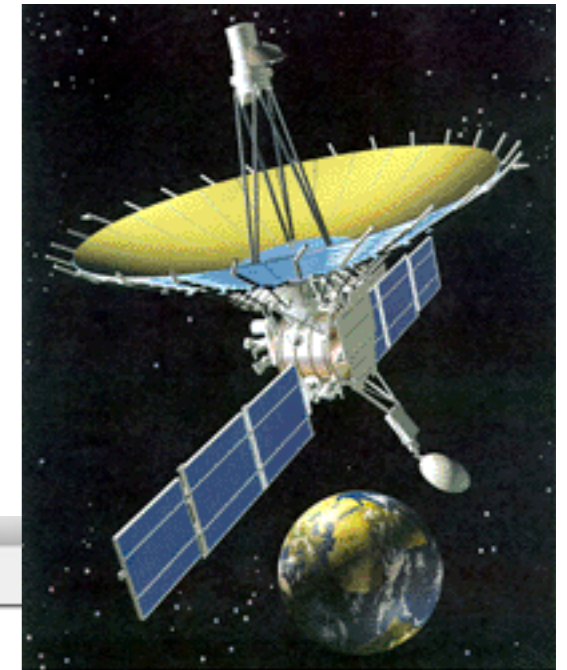


# Binning

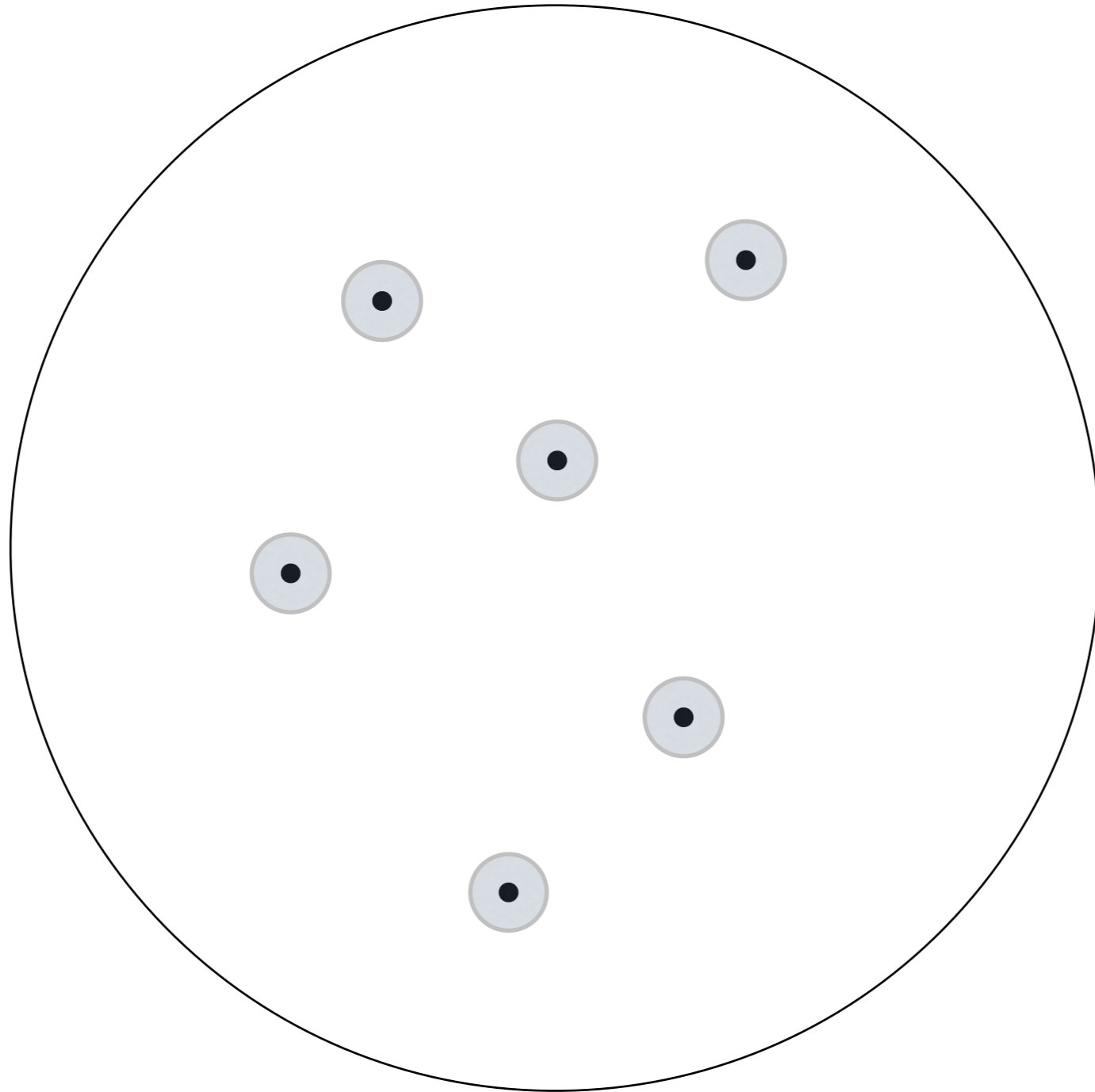


# Space Science

- PRIDE, Space VLBI
- “near-field” model
- space craft model
- “negative” delays
- large delays

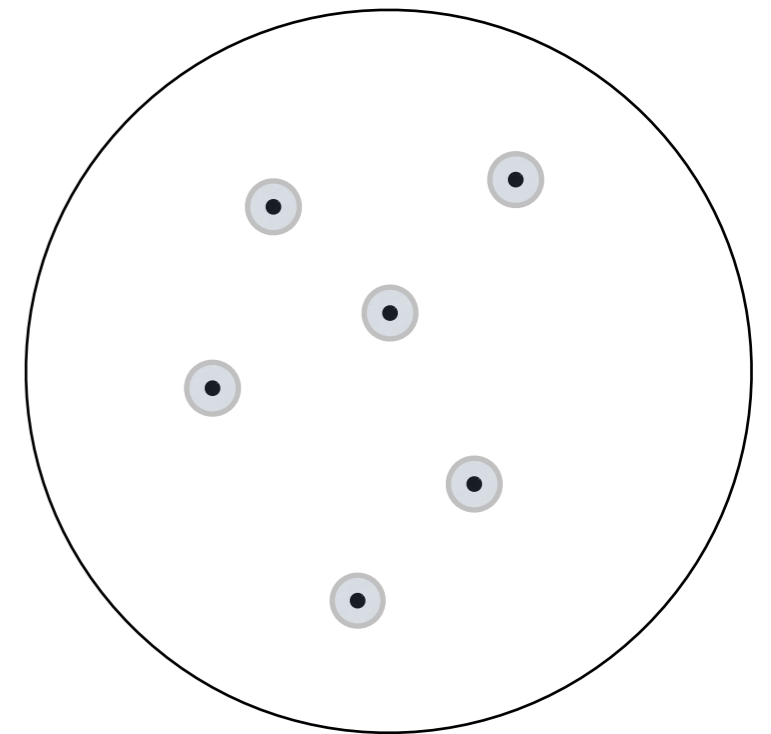


# Multiple Phase Centers



# Multiple Phase Centers

- 30% slowdown with reasonable S/N loss
- Small additional overhead per phase center
- Model evaluated for each phase center
- No WOLA (yet)



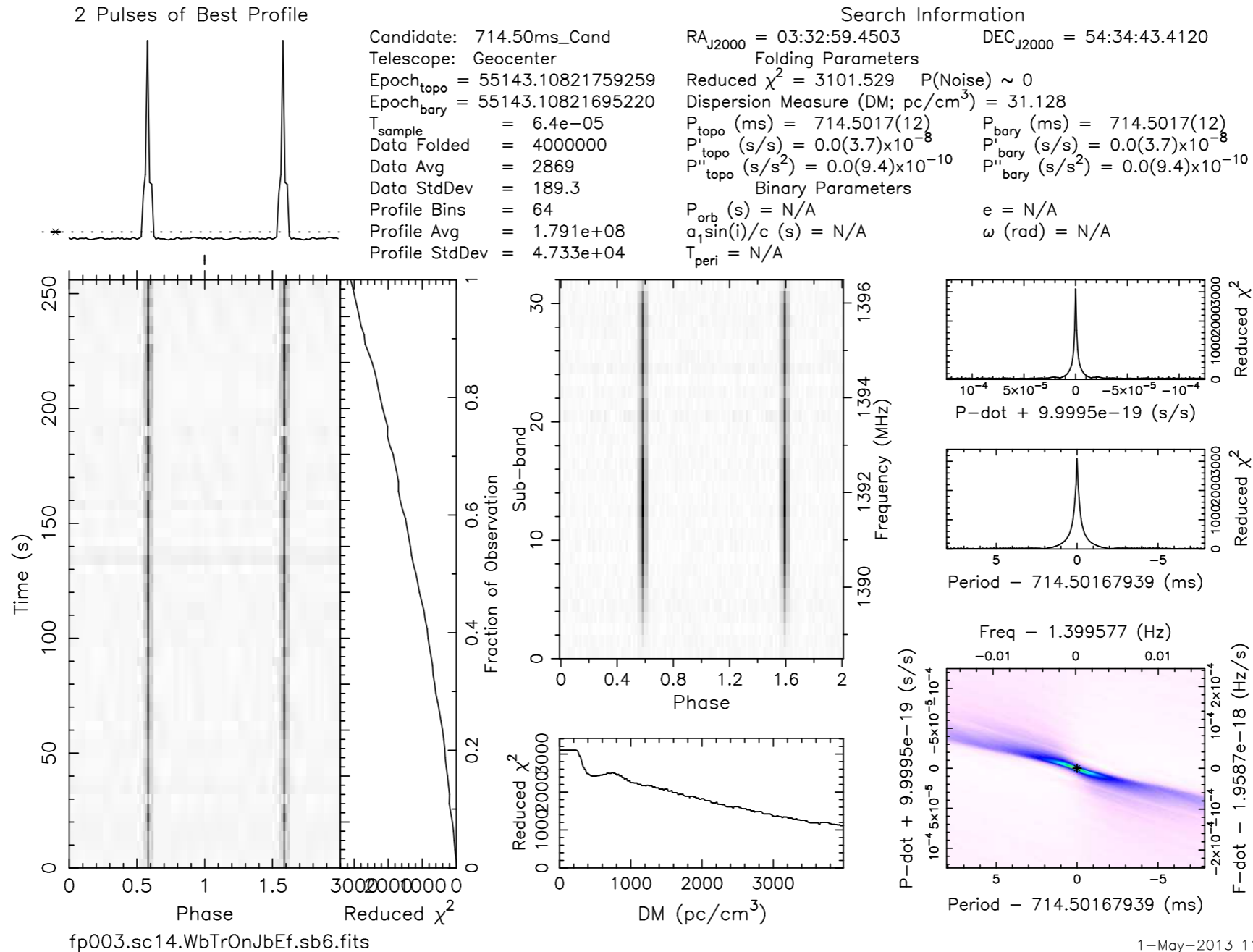


# Phased Array Mode

1. Apply AIPS calibration during delay compensation
2. Sum stations
3. Integrate total power per frequency bin
4. Resample
5. Convert to PSR FITS

➡ Can be used as input for standard Pulsar tools

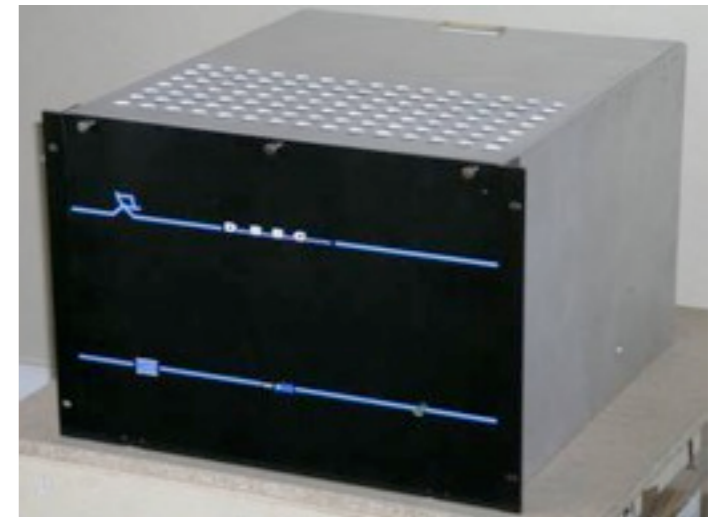
# Phased Array Mode



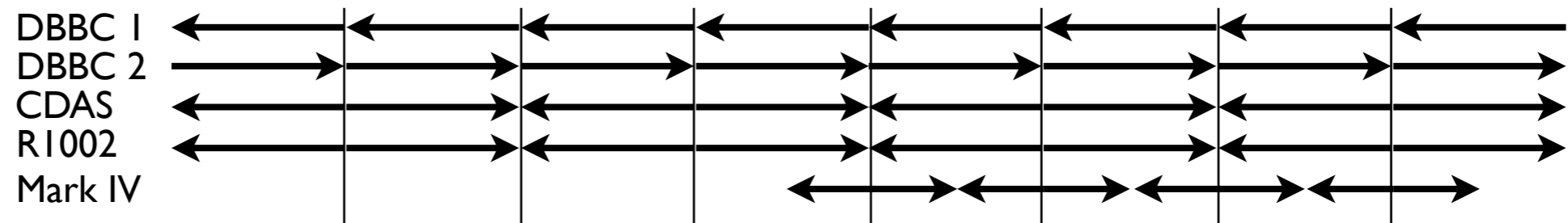
Pulse profile for B0329+54 summing Ef, Jb, On, Tr and Wb

# Mixed Bandwidth Correlation

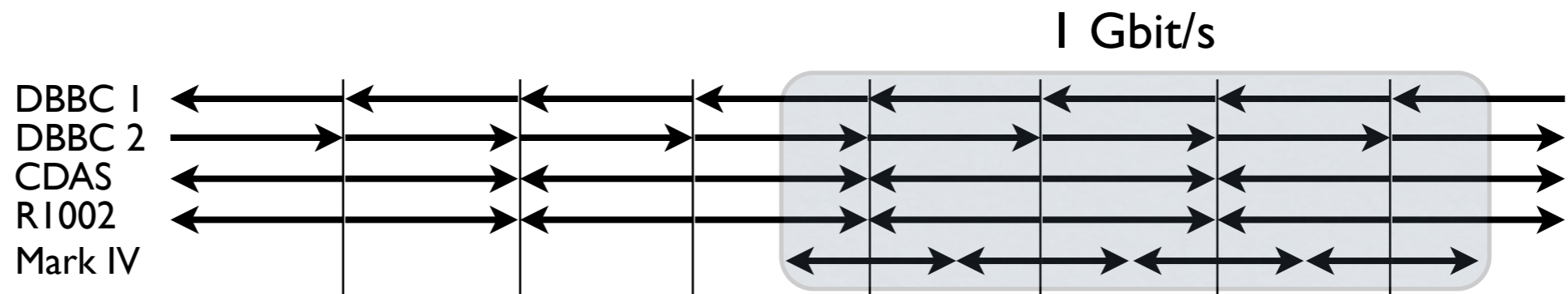
- New digital backends are incompatible
- EVN: Offer 2/4 Gbit/s on selected baselines  
16 MHz with 32 MHz
- Global VLBI: RDBE in DDC mode  
16 MHz with 32/64 MHz
- Need to flip sidebandedness



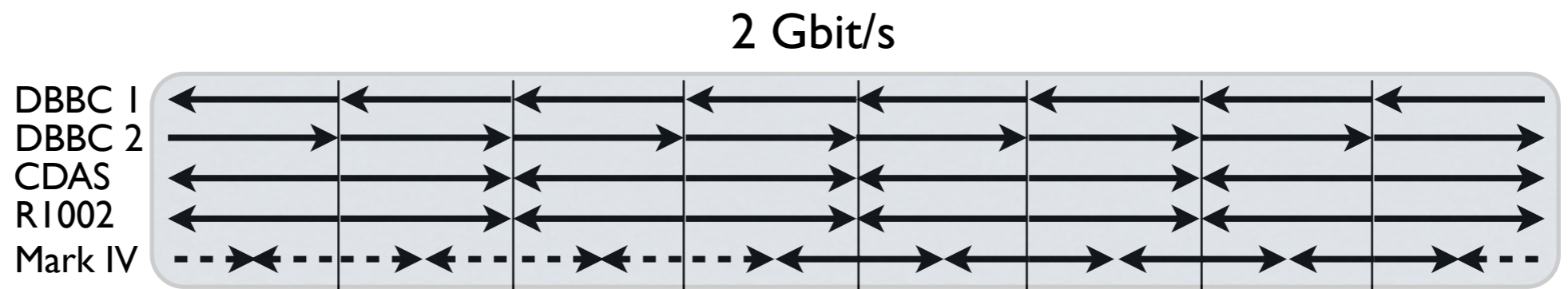
# Mixed Bandwidth Correlation



Combined VEX file:



Edited VEX file (with fake 2 Gbit/s, 16 MHz station):



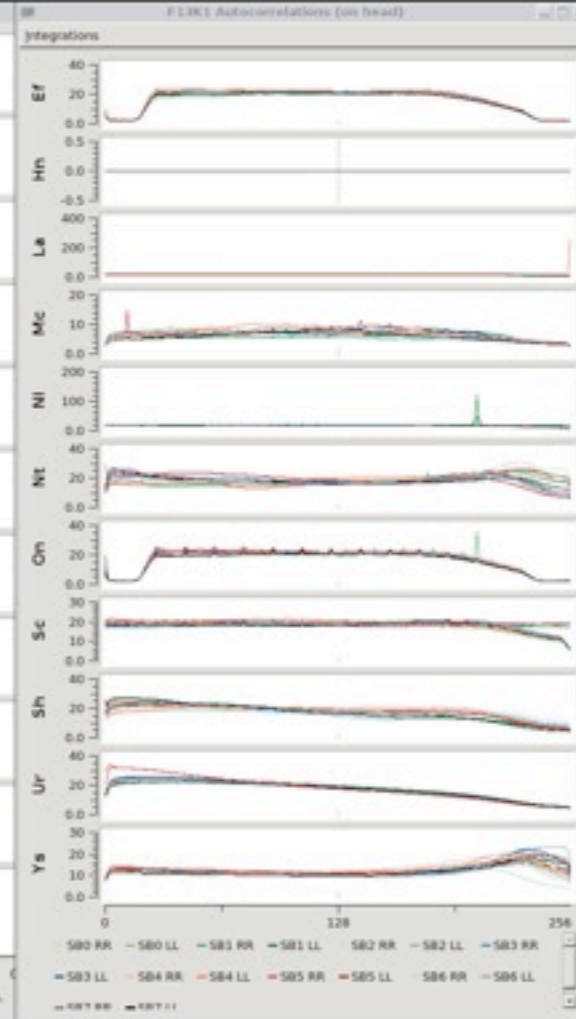
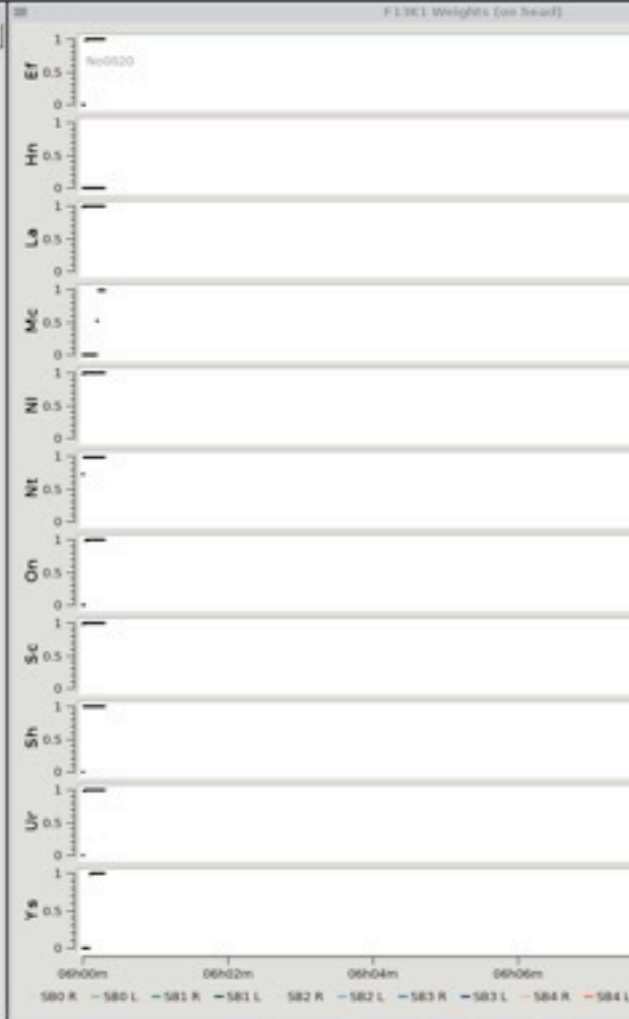
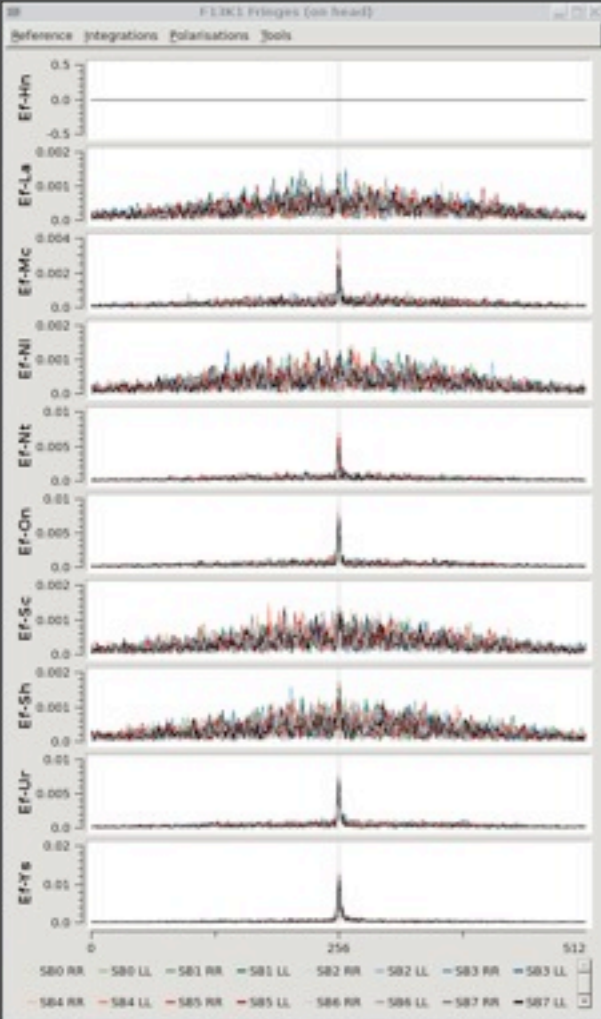
# SFXC replaced Mark4

- First science project correlated in fall 2011
- SFXC primary correlator for disk since session I 2012
- All disk-VLBI on SFXC since summer 2012
- First real-time e-VLBI in december 2012
- No more Mark4 correlation ever since



# Operational Tools

- Weight plot & Fringe plot
- Clock search tool
- Database integration
- Mark5 integration



File Edit View Terminal Help

| File | Size        | View      | Terminal            | Help |
|------|-------------|-----------|---------------------|------|
| UR   | 4,561       | 1.25e-07  | 2013-09-27 18:21:40 |      |
| UR   | 4,561       | 1.25e-07  | 2013-09-30 08:36:57 |      |
| UR   | 4,622120301 | 1.25e-07  | 2013-09-30 13:46:50 |      |
| UR   | 4,6221      | 1.25e-07  | 2013-10-01 11:46:08 |      |
| UR   | 4,561       | 1.25e-07  | 2013-10-01 11:56:12 |      |
| UR   | 4,561       | 1.25e-07  | 2013-10-01 13:41:31 |      |
| UR   | 4,561       | 1.25e-07  | 2013-10-01 13:55:19 |      |
| YY   | -10,376     | -8.56e-08 | 2013-09-27 18:21:40 |      |
| YY   | -10,376     | -8.56e-08 | 2013-09-30 08:36:57 |      |
| YY   | -10,376     | -8.56e-08 | 2013-10-01 11:46:08 |      |
| YY   | -10,376     | -8.56e-08 | 2013-10-01 11:56:12 |      |
| YY   | -10,376     | -8.56e-08 | 2013-10-01 13:41:31 |      |
| YY   | -10,376     | -8.56e-08 | 2013-10-01 13:55:19 |      |
| ZC   | 214,755     | 0         | 2013-09-27 18:21:40 |      |
| ZC   | 214,755     | 0         | 2013-09-30 08:36:57 |      |
| ZC   | 214,90442   | 0         | 2013-09-30 13:46:50 |      |
| ZC   | 214,9044    | 0         | 2013-10-01 11:46:08 |      |
| ZC   | 214,755     | 0         | 2013-10-01 11:56:12 |      |
| ZC   | 214,755     | 0         | 2013-10-01 13:41:31 |      |
| ZC   | 214,755     | 0         | 2013-10-01 13:55:19 |      |

Job status (on jw31)

Job Info: Experiment: PI3K1, Frequency: 22171MHz-22283MHz, Bandwidth: 16.0MHz, 64.0MHz, Data rate: 1024Mbps, Stations: EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys, P.I.: Bob Campbell

Clock Search: Reference station: EF, Job start offset (s): 0, From: 03-10-2013 06:33:24, To: 03-10-2013 06:38:24, Clock search interval: 5 minutes

| Last Job | A  | B        |
|----------|----|----------|
| 0        |    |          |
| 1        | On | WERT-052 |
| 2        | La | WERT-014 |
| 3        | EF | SMAC-032 |
| 4        |    |          |
| 5        | Ys | JOD-0074 |
| 6        | Mc | BOB-0056 |
| 7        | Ur | ZAD-1011 |
| 8        | Hn | BAIC-007 |
| 9        | NI | NYAL-003 |
| 10       |    | WERT-073 |
| 11       | Sc | MPI-0103 |
| 12       | Sh | WERT-079 |
| 13       |    |          |
| 14       |    |          |
| 15       | Ty | MPI-0058 |
| 16       |    |          |
| c00      |    |          |
| c01      |    |          |
| c02      |    |          |
| c03      |    |          |
| c04      |    |          |
| c05      | Mc | 0800-372 |
| c06      |    |          |

Schedule: Now: 12-06-2013 06:00:00, Time scale: 1 hour

First: No0020, Current: No0020, Last: No0026

Progress (on head)

Scan: No0020, Job ID: 7906, Time: 06:00:19, Subjob ID: 87358

1%

177 09h28m10s716ms, 00, start 2013y063006h01m06s000ms, channel 5.10 to correlation node 153  
 09h28m11s066ms, 00, start 2013y063006h01m06s000ms, channel 7.15 to correlation node 160  
 09h28m12s296ms, 00, start 2013y063006h01m06s000ms, channel 12.14 to correlation node 163  
 09h28m12s440ms, 00, start 2013y063006h01m07s000ms, channel 0.3 to correlation node 171

Configuration: Experiment: PI3K1, Profile: prod, Select data input type: VDM, Stations: EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ty, Frequency points: 256, Integration time: 1

Correlator: Correlator: SPXC, Monitor job:  Monitor job, SPXC specifics: Pulsar Binning, Use node reservation ID: [ ], Use pre-generated delays:  [ ], Setup station: EF

| Scan   | Start time          | End time | Source     | Stations                                   | Mode             | Status |
|--------|---------------------|----------|------------|--|------------------|--------|
| No0020 | 12-06-2013 06:00:00 | 06:12:00 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc | Tried  |
| No0021 | 12-06-2013 06:12:26 | 06:18:06 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc | Tried  |
| No0022 | 12-06-2013 06:18:28 | 06:18:36 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc |        |
| No0023 | 12-06-2013 06:18:56 | 06:23:06 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc |        |
| No0024 | 12-06-2013 06:23:26 | 06:25:06 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc |        |
| No0025 | 12-06-2013 06:25:26 | 06:29:36 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc |        |
| No0026 | 12-06-2013 06:29:56 | 06:34:06 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc |        |
| No0027 | 12-06-2013 06:37:06 | 06:38:46 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc |        |
| No0028 | 12-06-2013 06:39:06 | 06:43:16 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc |        |
| No0029 | 12-06-2013 06:43:36 | 06:47:46 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc |        |
| No0030 | 12-06-2013 06:48:06 | 06:49:46 | J2005+7752 | EF, Hn, La, Mc, NI, Nt, On, Sc, Sh, Ur, Ys | X5. evm, rdbeddc |        |

Operator: Hana, Start, Reload from database, Save profile, Show status, Show Log, Quit

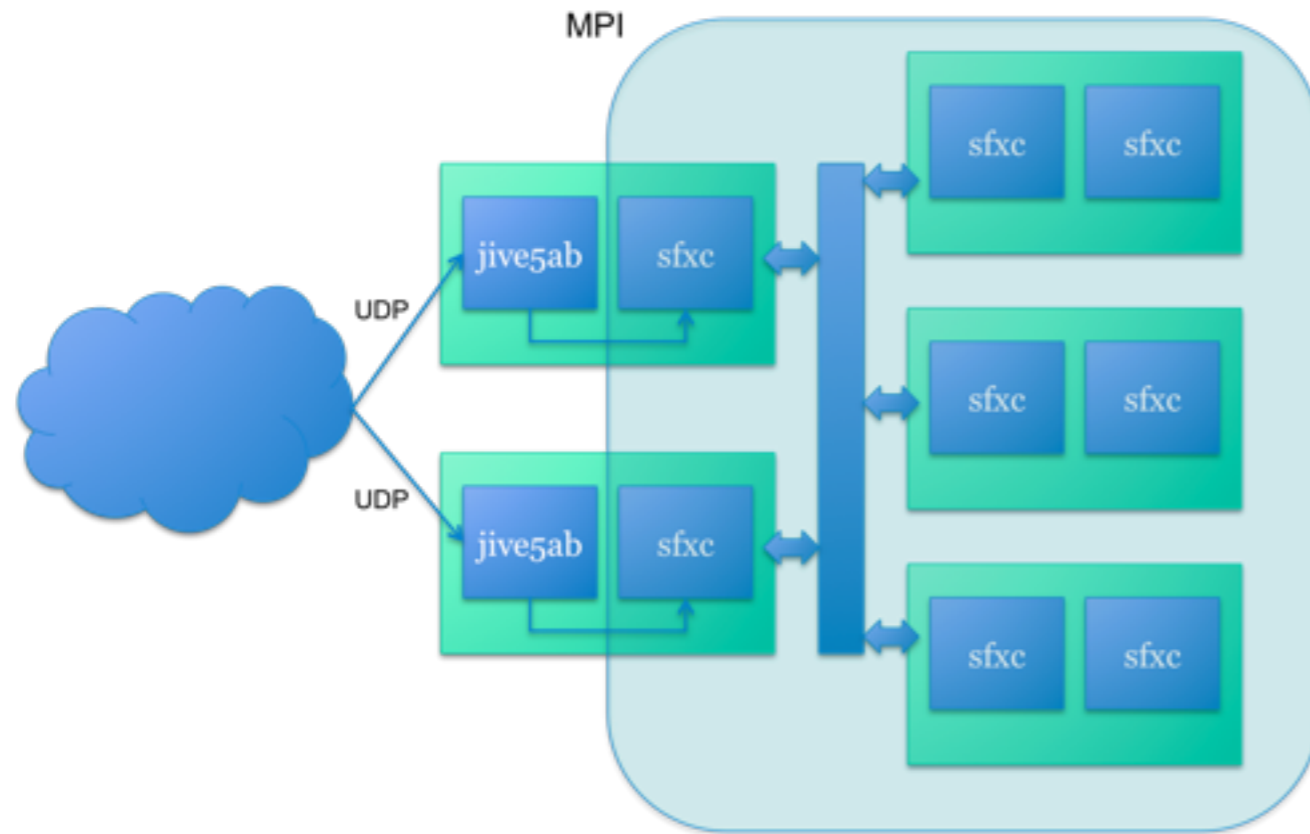
# SFXC Hardware

- 40 nodes; 384 cores  
(Intel Xeon 5500/5600/E5-2600)
- QDR Infiniband interconnect  
(32 Gbit/s)
- 8 nodes with 10 GbE  
(currently limited to 20 Gbit/s total)
- 14 stations @ 1 Gbit/s real-time  
(with cross-polarisations)

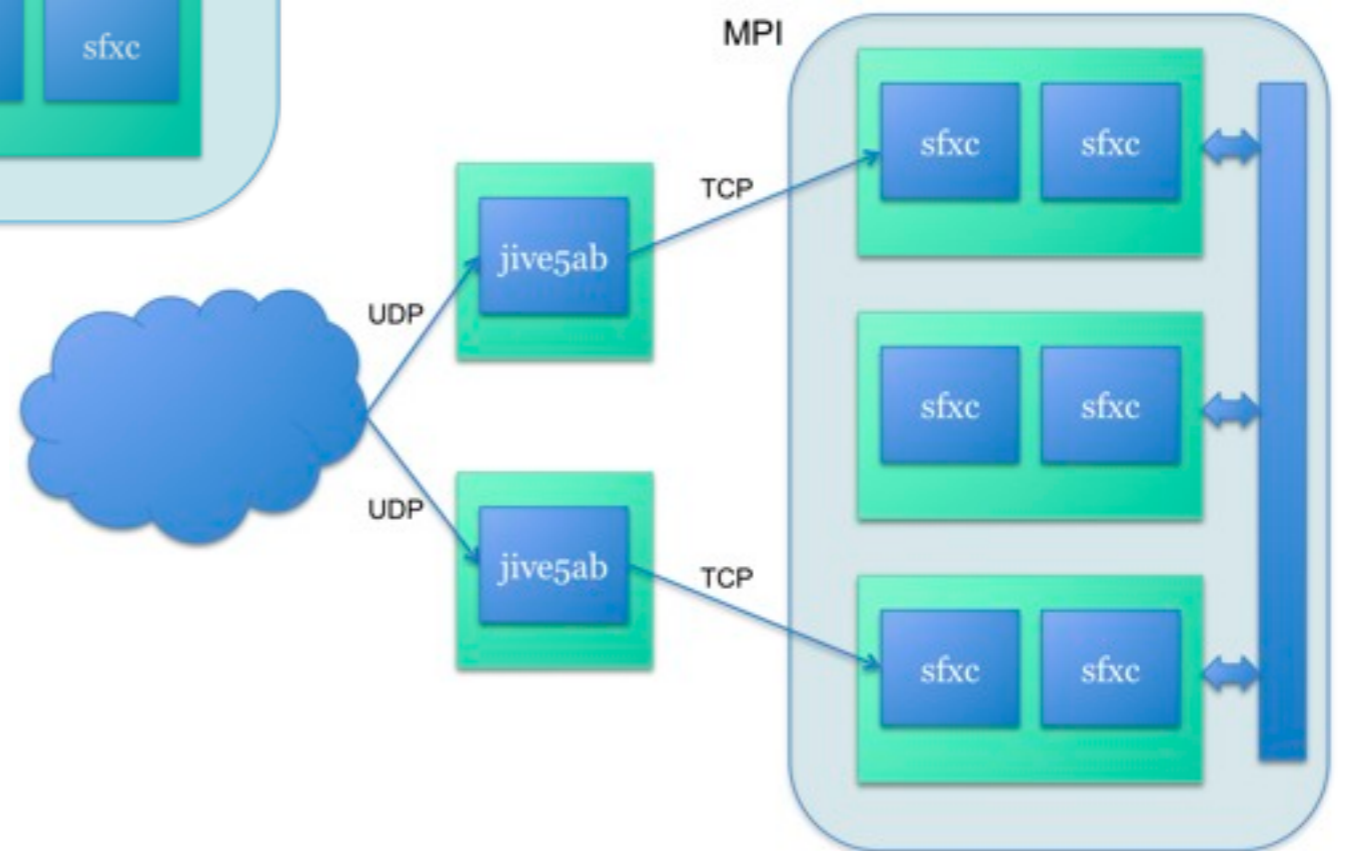




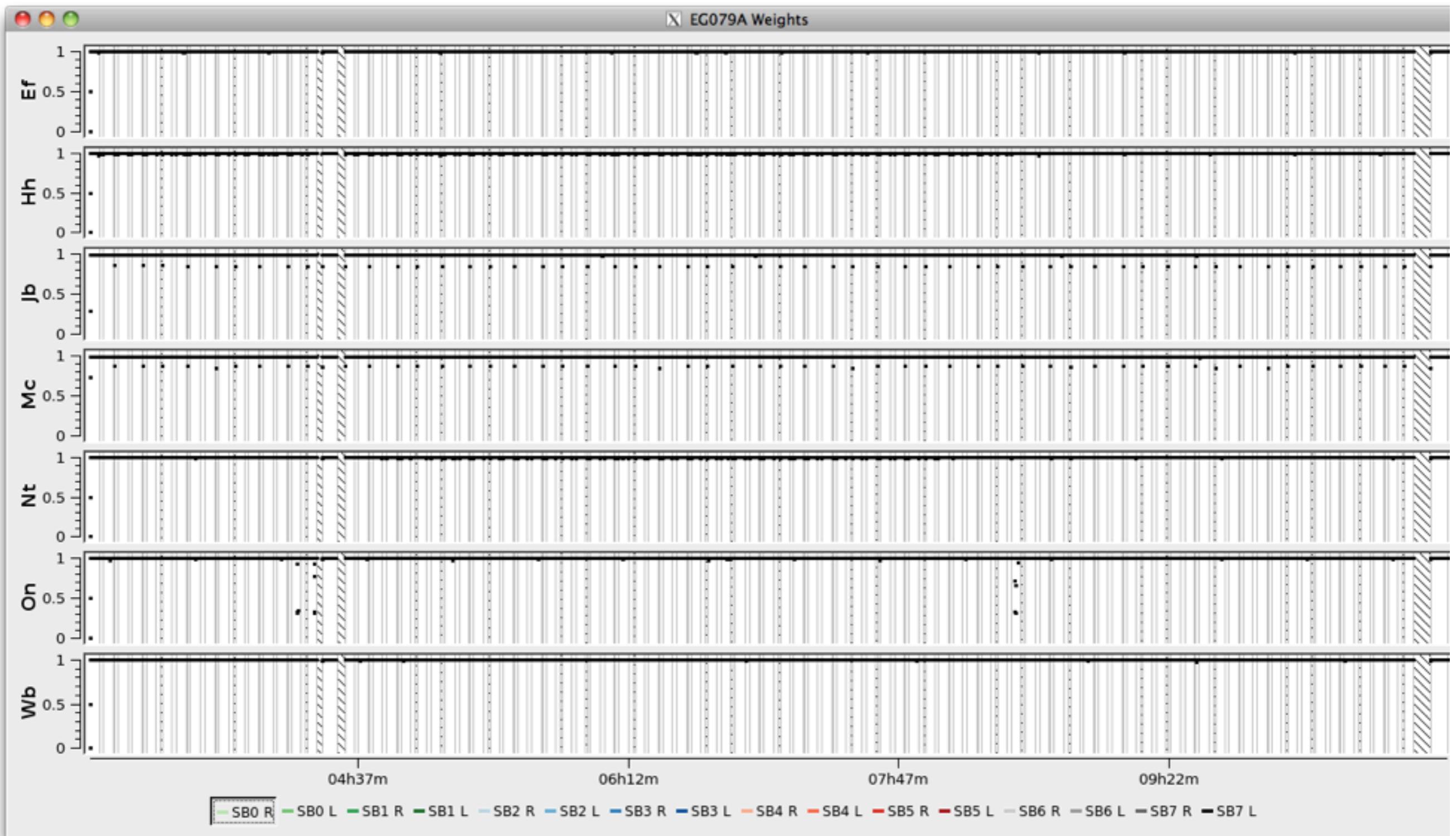
# Real-time e-VLBI with SFXC



Using of bridge nodes for data input



# e-VLBI Reliability



# Questions?



SFXC is Open Source software available under  
GPL version 2 or later  
Contact the speaker for details