DiFX Correlator at Bonn

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DiFX

DiFX -> Distributed FX correlator
i.e. its outputs are in frequency domain.

DiFX is a software correlator.

Developed by Adam Deller et al. in 2007.

Deployed at Bonn in 2008 for testing.

Astronomy correlation started in October 2009 : pcal extraction and path into the Mark IV output missing. DiFX was not then yet operational for geodesy.

Geodesy correlation with DiFX started in December 2010 when Mark IV broke beyond repair.

DiFX in Bonn

DiFX runs on a High Performance Compute Cluster

- 60 nodes (8 compute cores each).
- 4 Tflops in the Linpack benchmark test.
- 20 Gbps InfiniBand.
- 10 RAIDs (~380 TB storage).
- 1 control node for correlation (fxmanager).
- 2 user interaction nodes (frontend & frontend2) for post-correlation applications.
- 1 control computer (appliance) for installing and monitoring the cluster.
- Closed loop rack cooling (full load ~20-25 kW).
- Every Mark 5 unit has 2x1Gb Ethernet connections (soon InfiniBand).

DiFX in Bonn

RAIDs

RAIDs + fxmanager

nodes + frontend and frontend2

nodes

DiFX Capabilities I

- Playback units: 14 Mark 5 (4 A's, 2 B's, 8 C's)
- Max no. of stations: 20 tested with but with playback speed reduction (presumably openmpi uses both InfiniBand and Ethernet)
- Playback speed: 1.6 Gbps
- Formats: Mark 5A, Mark 5B, LBA, VDIF
- Sampling: 1 bit, 2 bits
- No. Channels: ≤ 16 SB tested;
  32 SB x 32 MHz channel (4 Gbps) possible, not yet tested.
- Stokes: all Stokes for circular and linear polarization

DiFX Capabilities II

- Geometrical model: CALC 9
- Phase cal.: pcal extraction of all tones/BBC simultaneously
- Integration time: from milliseconds to seconds
- Spectral channels: max no. of FFT tested 2^18
- Export: FITS files

  Interface to Mark IV data format for geodesy
- Pulsar: Pulsar gating possible

Latest DiFX Enhancement Done at Bonn

RFI mitigation (J. Wagner's PhD). DiFX branch version.

Comedia: database to replace the old tape library (H. Rottmann). Currently used in Bonn, soon deployed to DiFX community.

GLOW (LOFAR) application (J. Anderson).

Vex2difx modification for spacecraft tracking (J. Anderson) for Radioastron.

m5bstate part of mark 5 access library programs to read the state counts of data recorded (A. Bertarini). Available to DiFX community.

Fringe finder for 2^18 spectral channels (A. Roy & A. Bertarini) for APEX. Under development.

RFI Mitigation I

Simulation on 1.6 GHz data containing noise + one common strong GPS signal (found in spectral channel 49 on 128 total).

GPS signal is offset from the tracked phase centre.

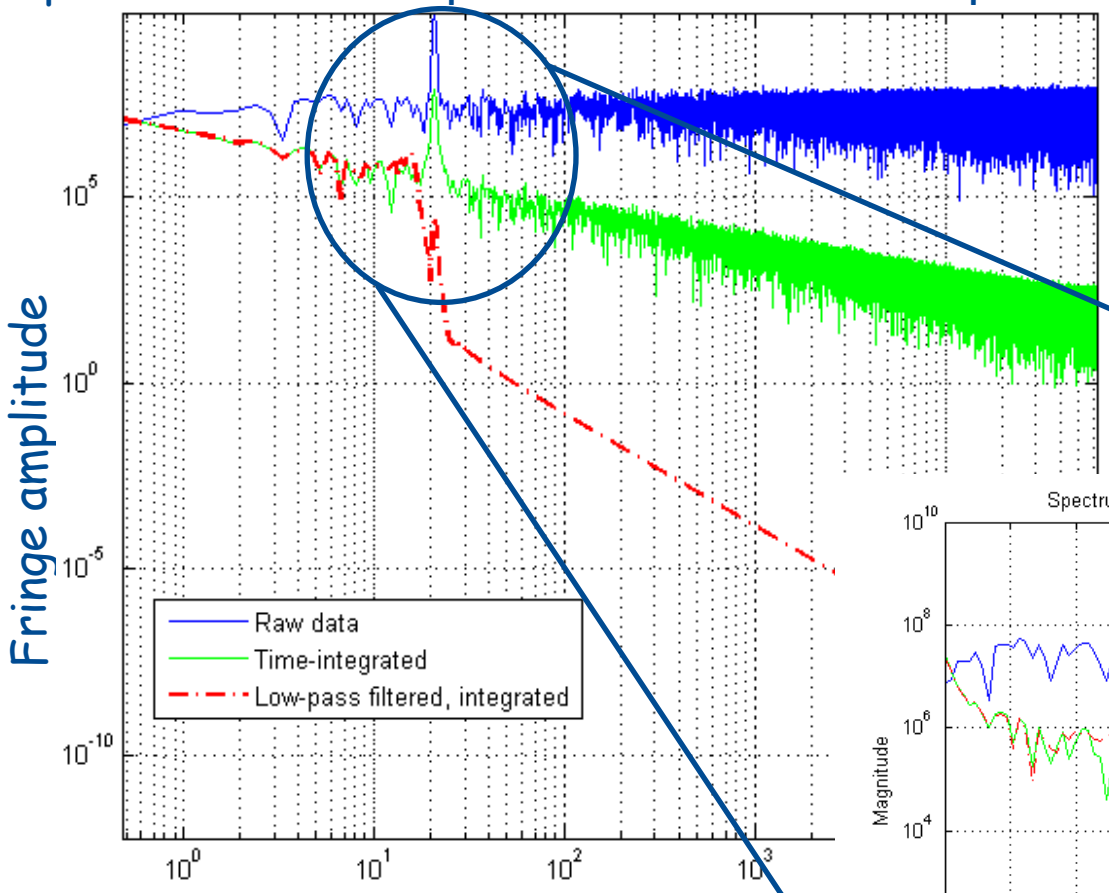
DiFX fringe stopping shift the GPS signal to a non-zero fringe frequency (in the simulated case 22 Hz).

A low-pass filter before the integration cuts the frequencies above 16 Hz (60 dB suppression at 22 Hz).

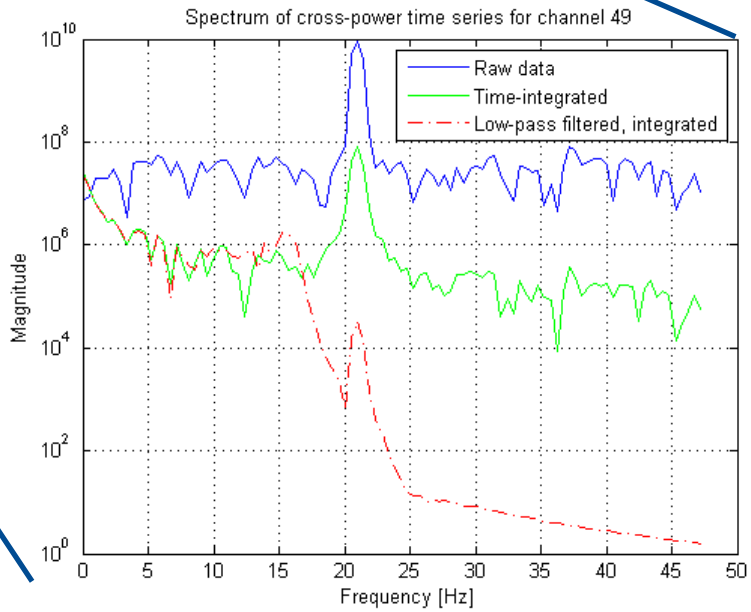
Any oscillation induced by RFI along the cross-correlation data trajectory in the UV plane are attenuated by several tens of decibel.

RFI Mitigation II

Spectrum of cross-power time series for spectral channel 49



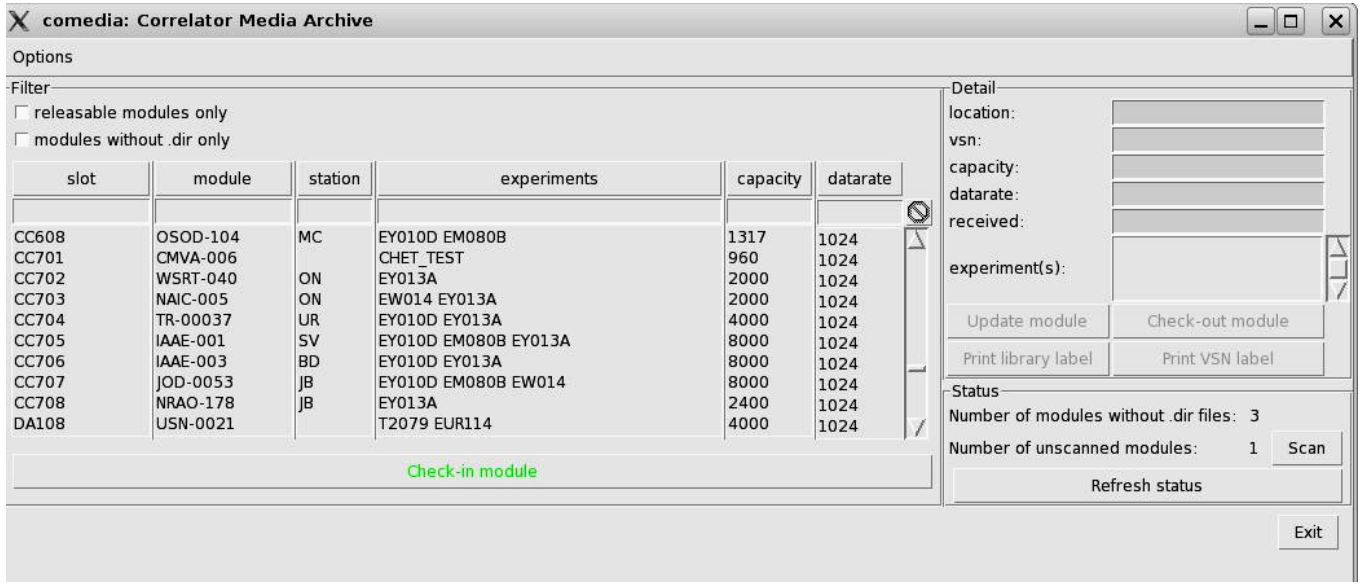
FT of the visibility time series for chan. 49 plotted against fringe frequency.

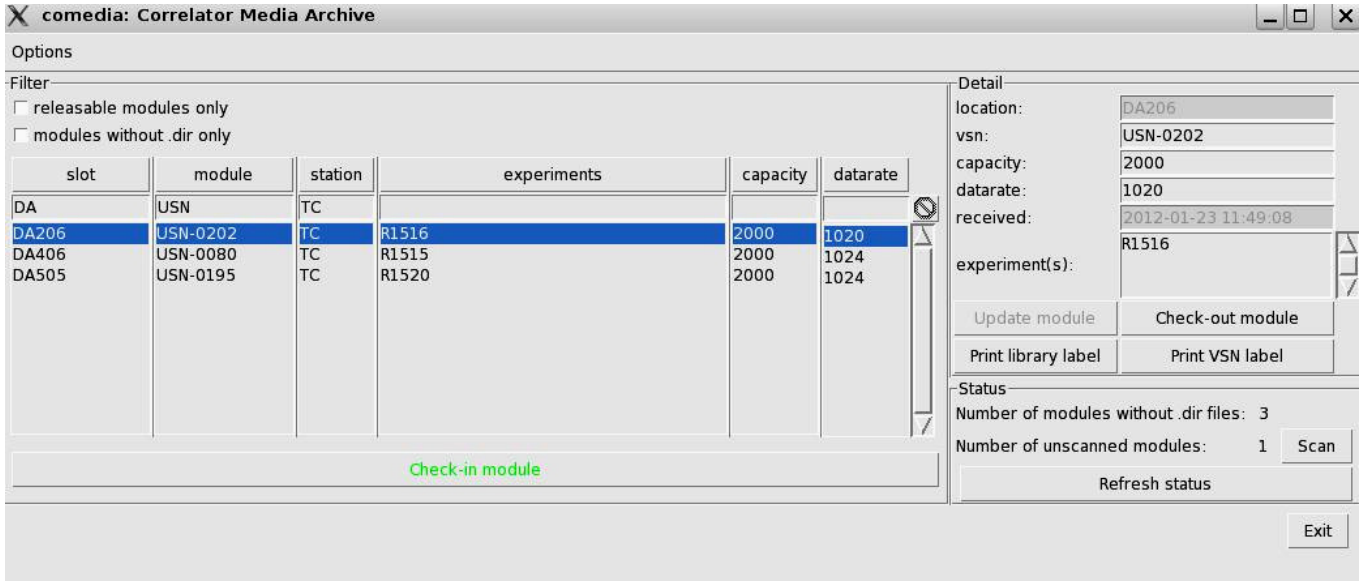


60 dB

Figures: J. Wagner

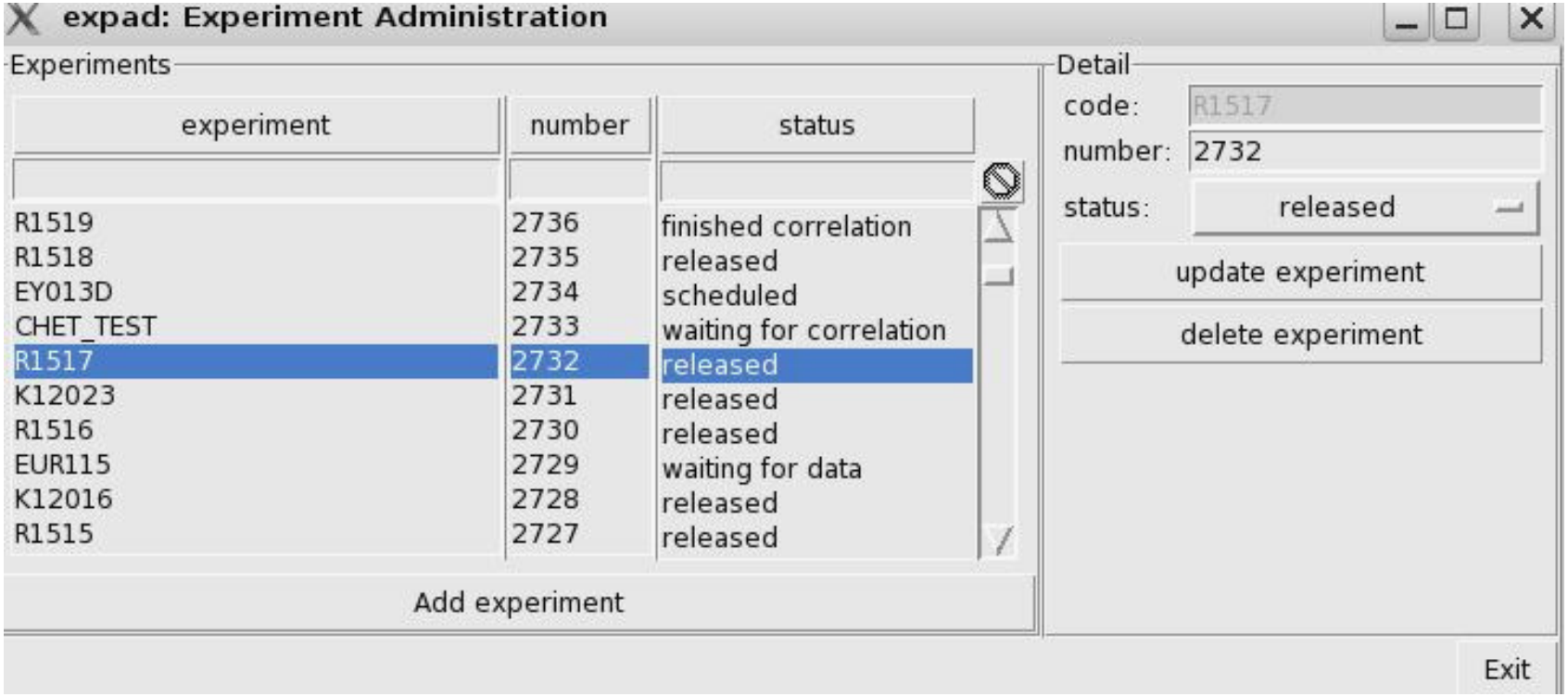
Comedia I





Correlator media archive database

Experiment administration database:



More than DiFX

- DBBC development (G. Tuccari, M. Wunderlich et al.): DBBC3 project (32 Gbps data rate) financed by EU.
- Equipping of APEX for mm VLBI (A. Roy et al.)
- MK4IN enhancement and testing for IYA 2009 (D. Graham, W. Alef)
- DBBC testing (L. la Porta, A. Bertarini)
- Binary black holes systems (S. Bernhart)
- LBA Calibrator Survey mapping (L. Vega, A. Bertarini)
- Testing new DiFX releases for geodesy (all)
- Mantaining and upgrading VLBI systems at Effelsberg, Pico Veleta and Plateau de Bure (M. Wunderlich, H. Rottmann et al.)

Correlator Experiments Status in 2011

Bonn DiFX time is 50 % for geodesy and 50 % for astronomy

65	R1		5	3 mm (GMVA)
6	EURO		7	Pulsar (EVN)
7	T2		5	EVN sessions
6	OHIG		1	1 mm
40	INT3			
		geodesy		astronomy

~ 10 DBBC tests (downconversion mode)

~ 5 DBBC tests (PFB mode)

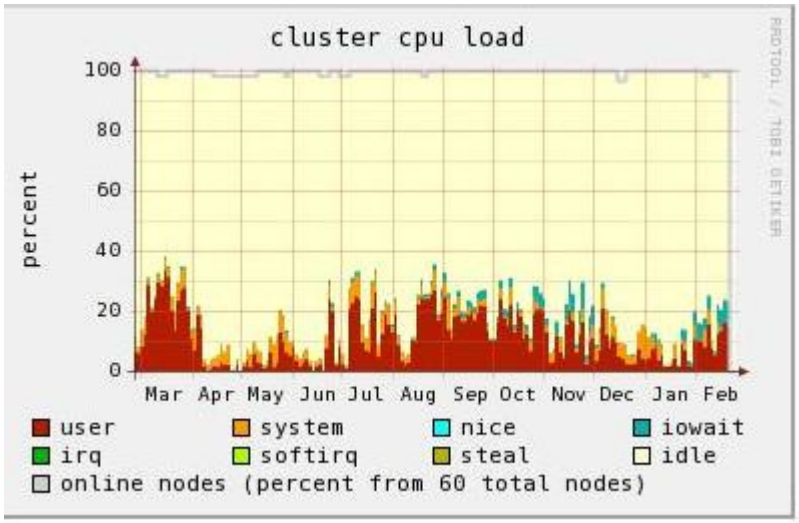
~ 32 1 mm trial correlations

near-real-time ftp fringe checks for GMVA and 1 mm

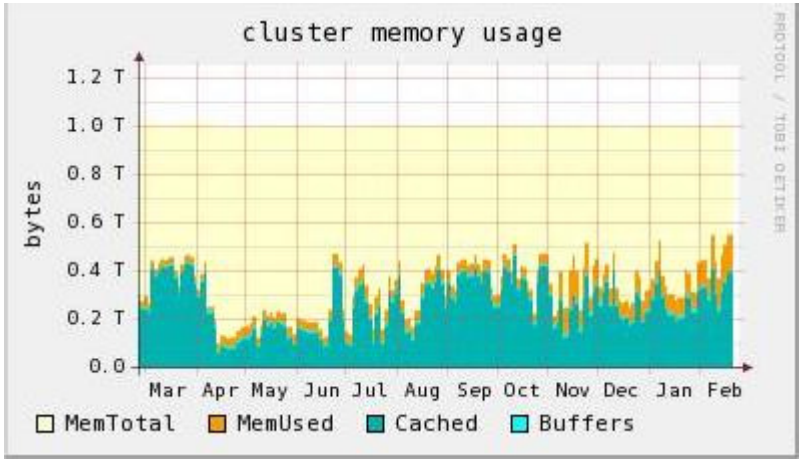
Still the cluster is not fully loaded

Correlator Load Status in 2011

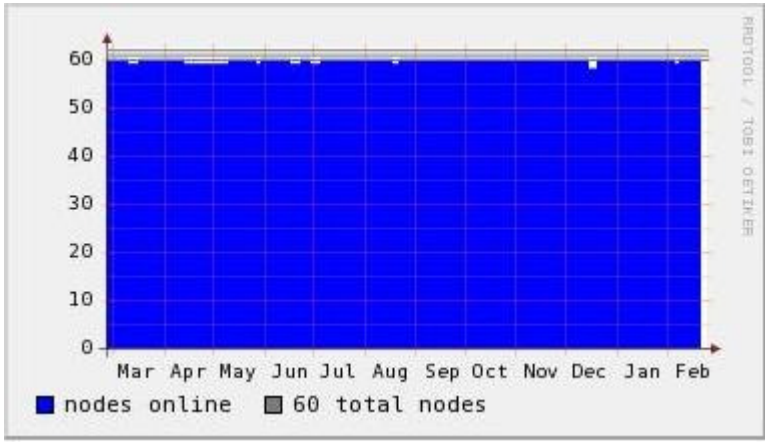
2011 Cluster CPU load: peak 40 %. Average: 10 %



2011 Cluster memory usage: peak RAM 0.4 TB



2011 Nodes availability: 100 %



Very reliable cluster

Summary I

- DiFX code is fast but still sensitive to problematic data.

→ Debugging still required.

- Very good support from Haystack for the interface to Mark IV data format.

- Very good support by DiFX developer community.

- Correlation is potentially very fast: a 24 h experiment with 8 stations, 256 Mb/s, 1 bit sampling, 1 pol. could run in < 10 h (against ~ 30 h with Mark IV).

→ Bottleneck: Mark 5s or processing nodes crash at night.

- DiFX upgrades happen often.

→ Test experiments are correlated for every upgrade and stream correlation runs on stable versions.

Summary II

• DiFX offers more opportunity to screw up everything but happily correlate.
→ Geodesy always uses the same mode.

• DiFX users requires more sysop skills and programming skills than for the Mark IV.
→ We are learning.

• DiFX users need to have more radio interferometry knowledge than for the Mark IV.
→ But we are radio astronomers.