Update on the Software Correlator

Nico Kruithof, Huseyin Özdemir, Yurii Pydoprihora,
Ruud Oerlemans, Mark Kettenis, JIVE

Starting Point

C++ implementation of the correlator used for the Huygens

- FX correlator.
- Monolithic.
- Single-subband, USB only.
- Single-threaded, largey unoptimized.
- Driven by home-grown control file.
- No integrated delay model.
- No fringes on standard EVN data.
- Input data needs conversion.
- Raw output data.

Design Decisions

- Parallelisation in both subbands and time.
- All baselines for a single subband processed on a single cluser node.
- Further course grained parallelisation (in time only) to distribute over multiple clusters.

- Input node (one per station)
- Correlator node (as many as feasable)
- Output node
- Manager node

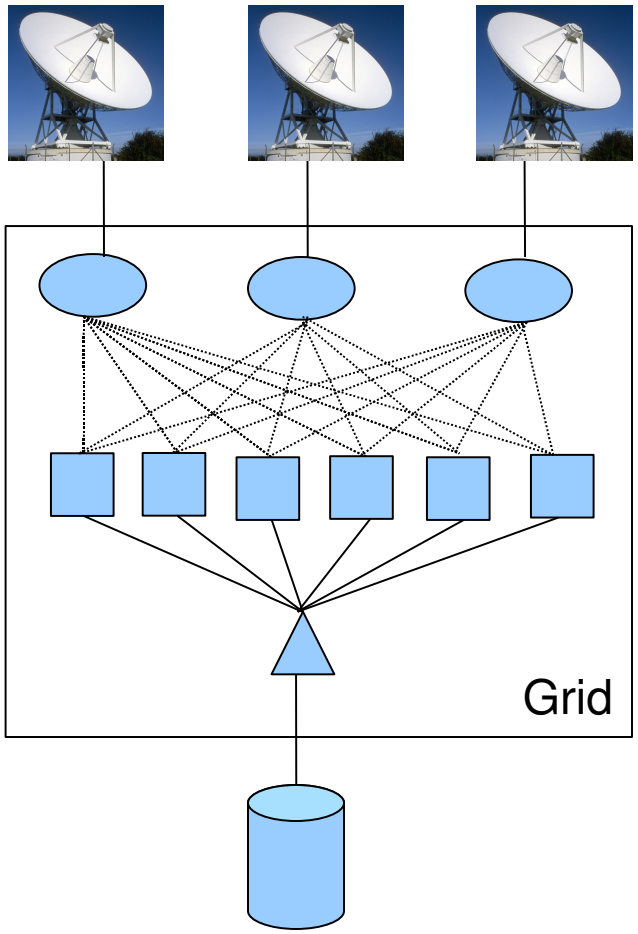
Design Decisions

Telescopes

Input nodes

Correlator nodes

Output node



Time and channel slicing

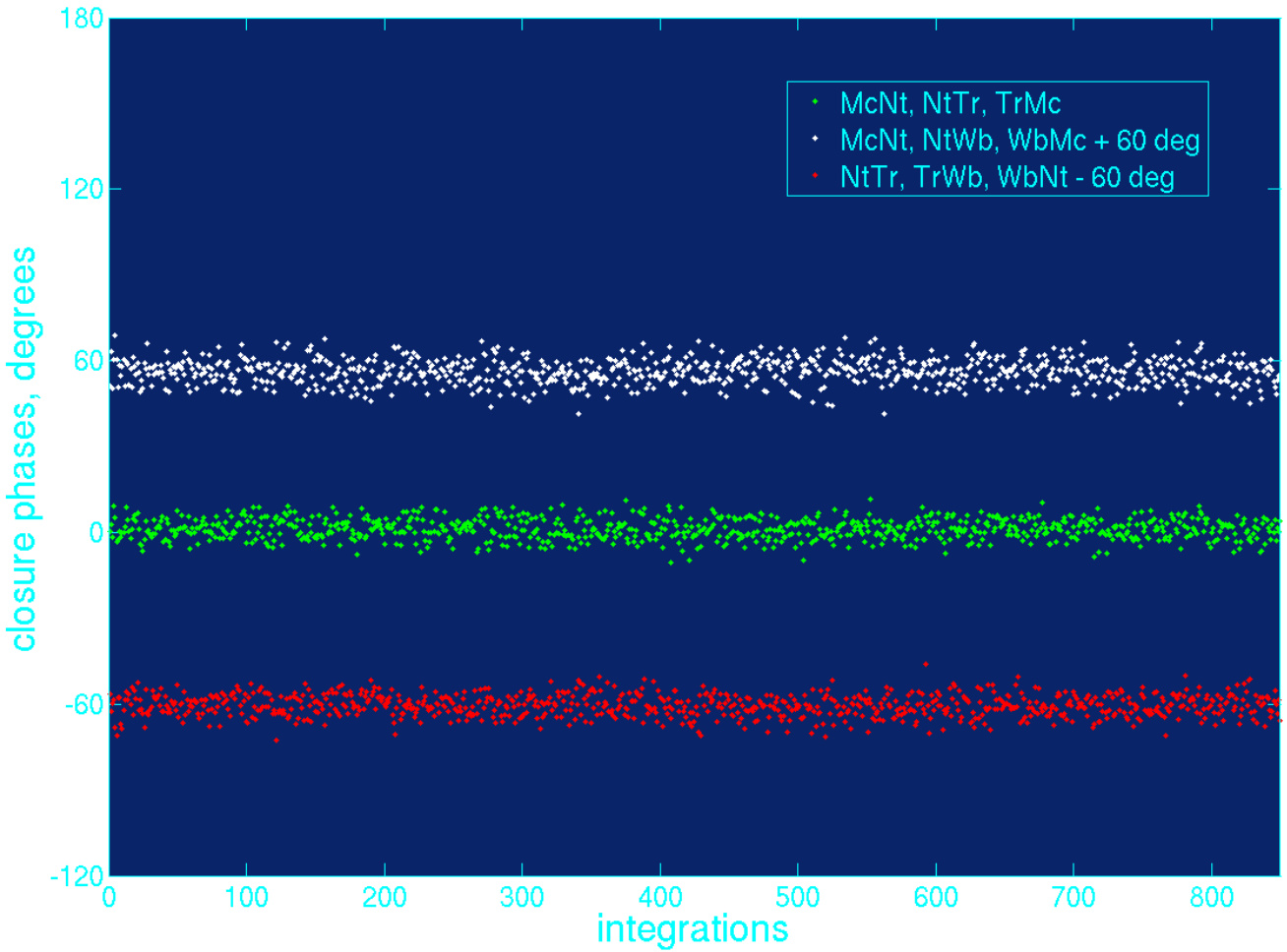
Sorting and merging

Current State

- VEX-driven, with small JSON-based control file specifying correlation parameters.
- Modular.
- Parallelized using MPI.
- Scales from SMP machines to largish clusters.
- Integrated delay model based on CALC 10.
- All subbands processed, both LSB and USB, cross-correlations.
- Still mostly unoptimized: 2.5 min to process 1s of a typical EVN NME on a quadcore SMP machine.
- Takes Mark4 (Mark5A) input data.
- Output data format that includes (some) metadata.

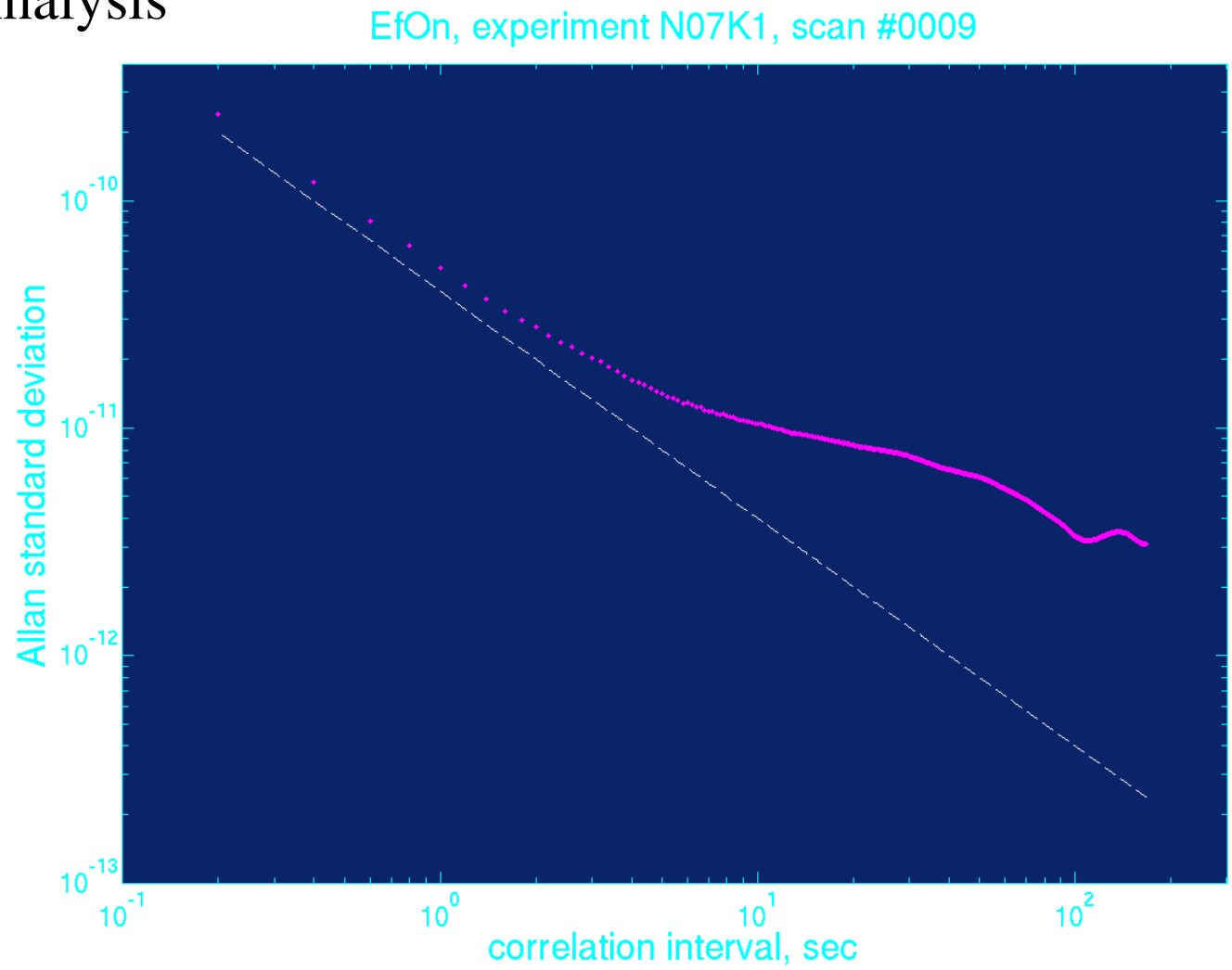
Validation

- Phase Closure



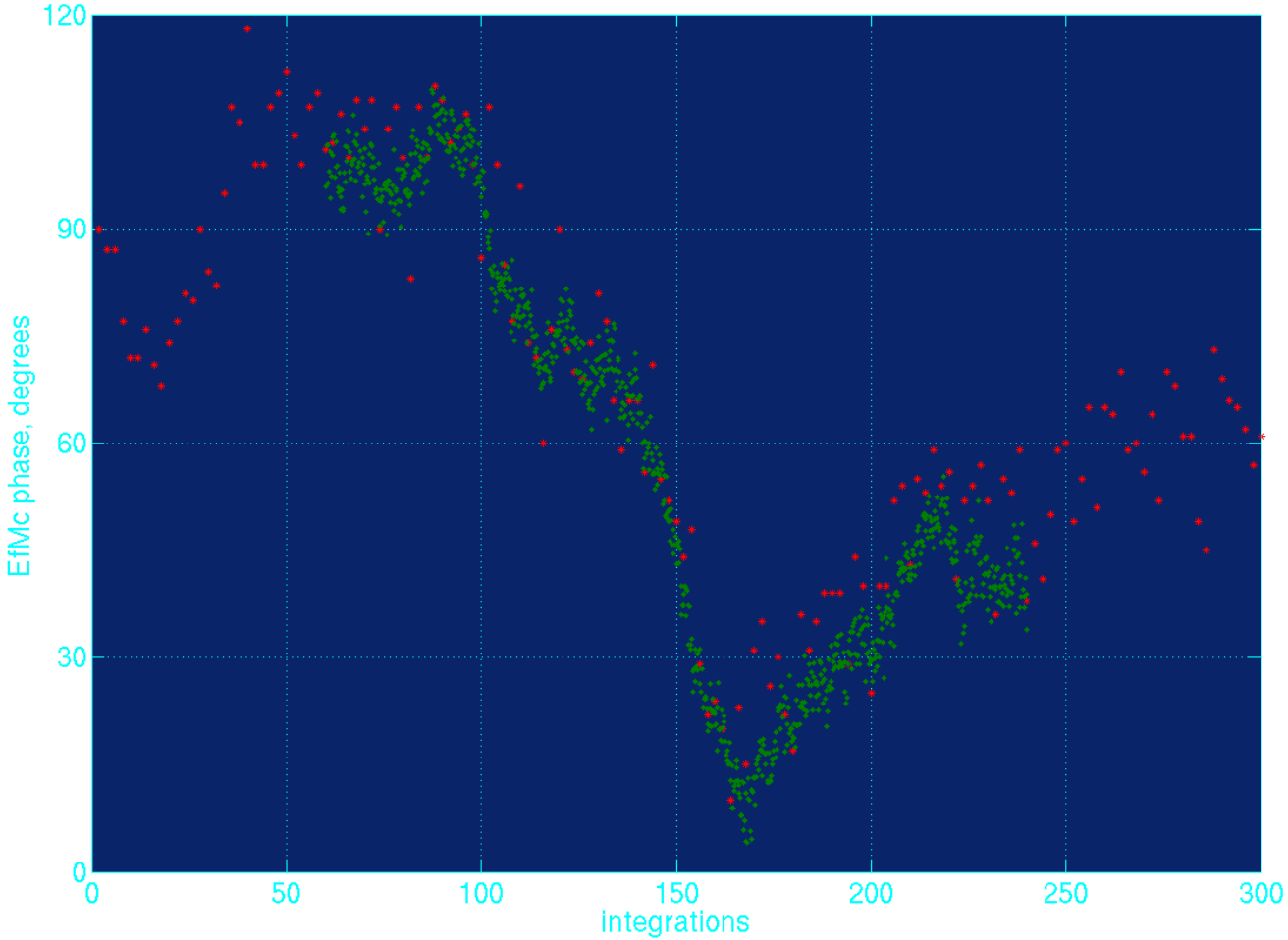
Validation

- Noise Analysis



Validation

- Comparison with the Hardware Correlator



Optimization

- Use single-precision where possible (all double precision now)
- Input data conversion using lookup tables.
- Use Intel/AMD vector libraries.

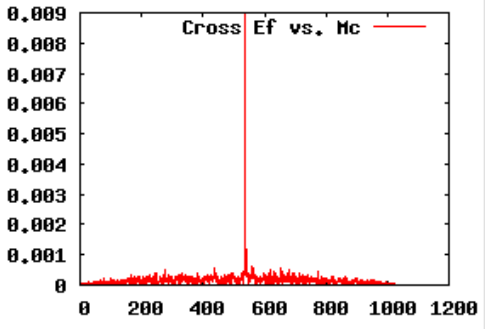
- Fringe rotation before fractional bit shift.
- Fringe rotation after correlation.

Success Story: FTP Fringe Tests

- Cluster running NICT correlator broke down in May
- SFXC was used for May/Jun and Oct/Nov FTP Fringe Tests

Show plots

	Auto correlation				Cross correlation					
	Ef	Nt	Mc	On	Ef-Nt	Ef-Mc	Ef-On	Nt-Mc	Nt-On	Mc-On
CH01, 2203.99 MHz, USB, Rcp	A	A	A	A	34.02	45.62	17.38	20.74	10.95	12.62
CH02, 2219.99 MHz, USB, Rcp	A	A	A	A	30.6	53.39	13.23	26.08	13.67	12.88
CH03, 2243.99 MHz, USB, Rcp	A	A	A	A	29.94	19.99	16.44	13.75	10.98	4.723
CH04, 2283.99 MHz, USB, Rcp	A	A	A	A	25.51	53.06	14.29	23.27	12.13	9.903
CH05, 2299.99 MHz, USB, Rcp	A	A	A	A	35.51	4.39	13.7	2.677	13.71	3.064
CH06, 2331.99 MHz, USB, Rcp	A	A	A	A	2.304	41.2	11.97	2.685	2.646	12.37
CH07, 8211.99 MHz, LSB, Rcp	A	A	A	A	86.87	144.1	37.35	26.65	5.897	10.25
CH08, 8211.99 MHz, USB, Rcp	A	A	A	A	112.5	208.6	46.89	33.62	6.784	12.25
CH09, 8227.99 MHz, USB, Rcp	A	A	A	A	105.7	209.4	41.66	33.51	5.963	12.1
CH10, 8251.99 MHz, USB, Rcp	A	A	A	A	2.694	4.214	2.609	31.76	5.27	12.23
CH11, 8315.99 MHz, USB, Rcp	A	A	A	A	85.97	201	38.35	32.83	8.808	14.01
CH12, 8427.99 MHz, USB, Rcp	A	A	A	A	103.9	192	42.19	38.02	7.186	10.66
CH13, 8499.99 MHz, USB, Rcp	A	A	A	A	92.58	199.3	42.48	37.24	6.661	13.43
CH14, 8539.99 MHz, USB, Rcp	A	A	A	A	80.98	201.6	44.96	28.93	8.184	14.69
CH15, 8579.99 MHz, LSB, Rcp	A	A	A	A	33.49	141.8	35.61	8.895	3.097	12.05
CH16, 8579.99 MHz, USB, Rcp	A	A	A	A	11.14	182.4	42.42	3.811	3.607	14.92



Post Processing

- JIVE uses j2ms2 to convert hardware correlator output into MeasurementSet.
- J2ms2 has been adapted to accapt old SFXC output format.
- Currently being adapted to accept new SFXC output format.

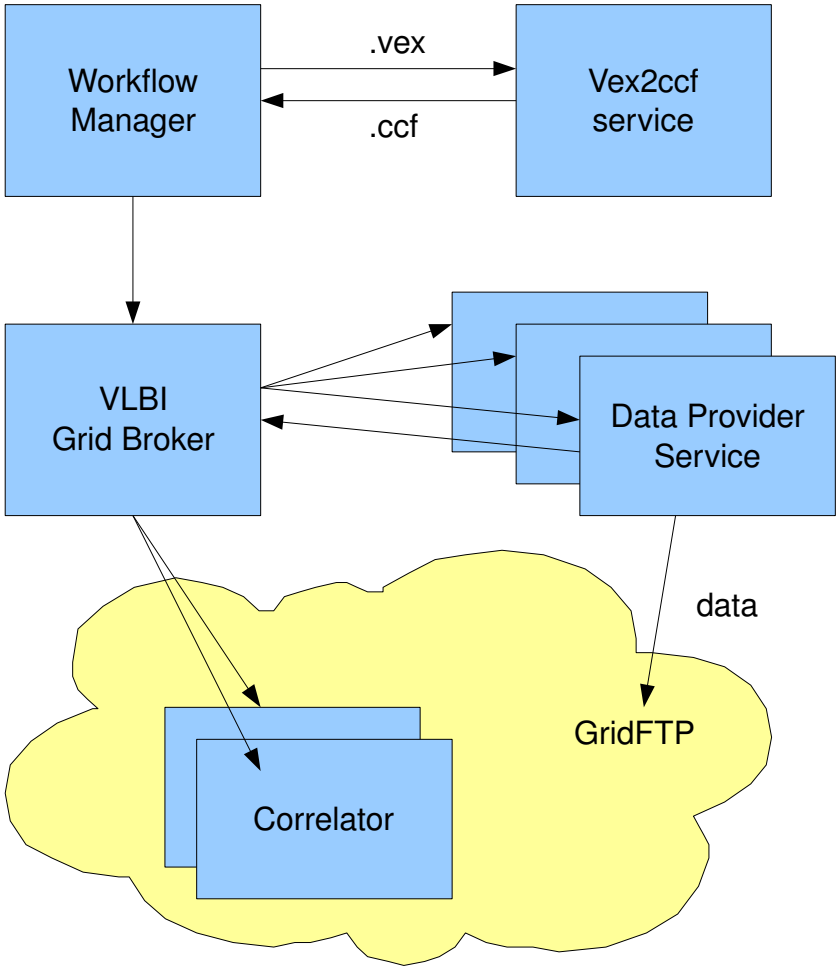
- Translation into FITS through standard pipeline.

The Bigger Picture

How to get things on the Grid?

- Workflow Manager (PSNC)
- VLBI Grid broker (PSNC)
- Web Services
  - Vex2ccf: Creates control file template from VEX
  - Data providers: Provides chunks of data and transfers them to GridFTP servers.

The Picture


Workflow Manager
.vex
.ccf
Vex2ccf service
VLBI Grid Broker
Data Provider Service
data
GridFTP
Correlator

Future Directions

- Make things faster
- Real-Time eVLBI
- Accept Mark5B Input Data

- SCARIe: Running SFXC on DAS-3 & Startplane