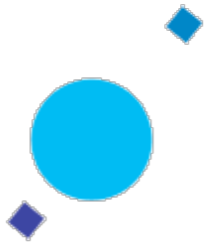


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ISTITUTO DI RADIOASTRONOMIA

Towards the Italian VLBI network: first tests and perspectives

Matteo Stagni - EVN Symposium - Cagliari (Italy) 09-10-2014

Italian baselines

- Mc - Nt - Mt baselines for Geodetic experiments
- Mc - Nt - SRT baselines for Astronomical experiments
- Shortest baseline 500 km
- Longest baseline 900 km









SRT

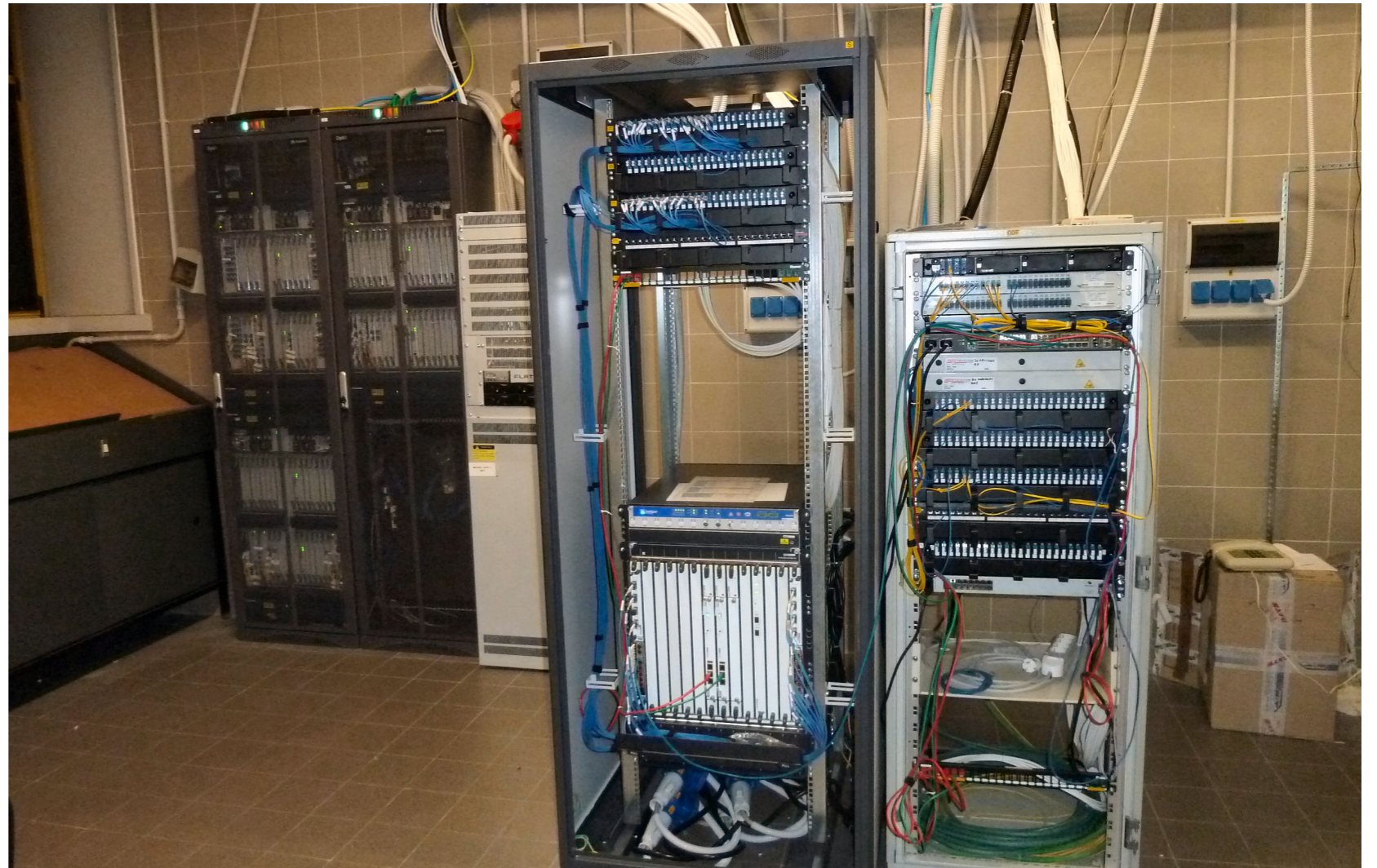
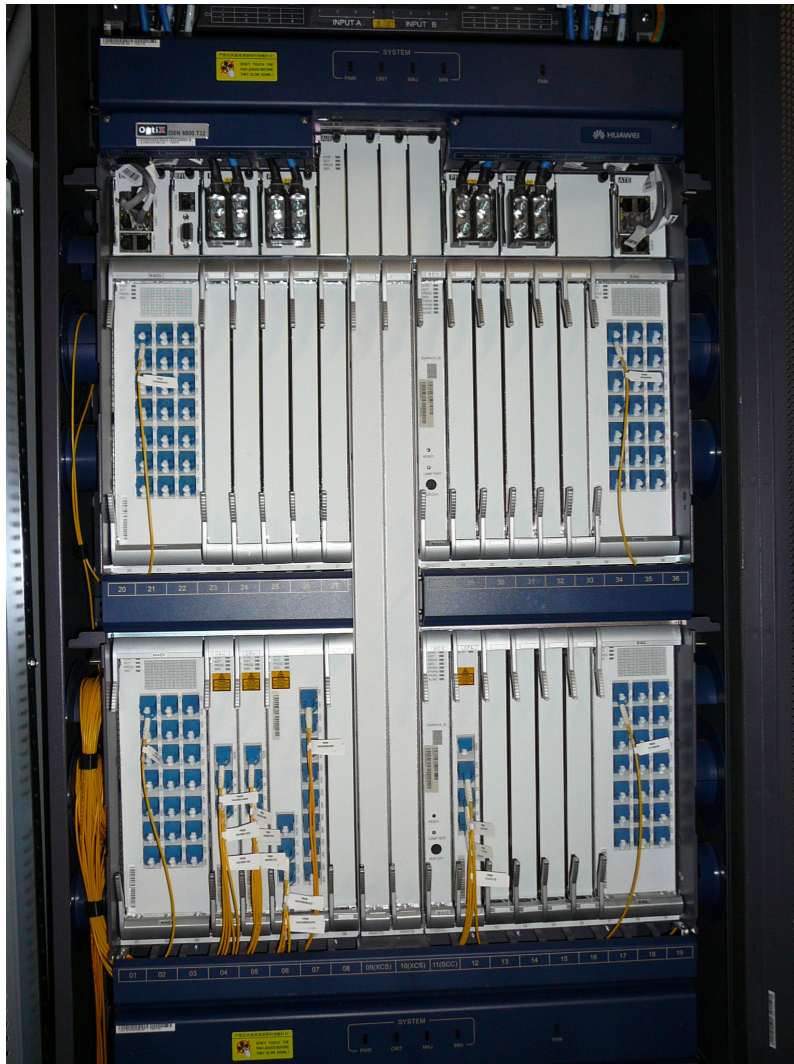
64 mt diameter antenna
Active surface
0.3 -- 100Ghz
high tracking speed

cm	GHz	Resolutive power (arcsec)			
		Medicina	Noto	SRT	VLBI - IT
18	1,6	1474	1474	731	0,02
6	5	472	472	234	0,007
5	9	262	262	130	0,004
2.4	13	181	181	90	0,003
1.3	23	103	103	51	0,002

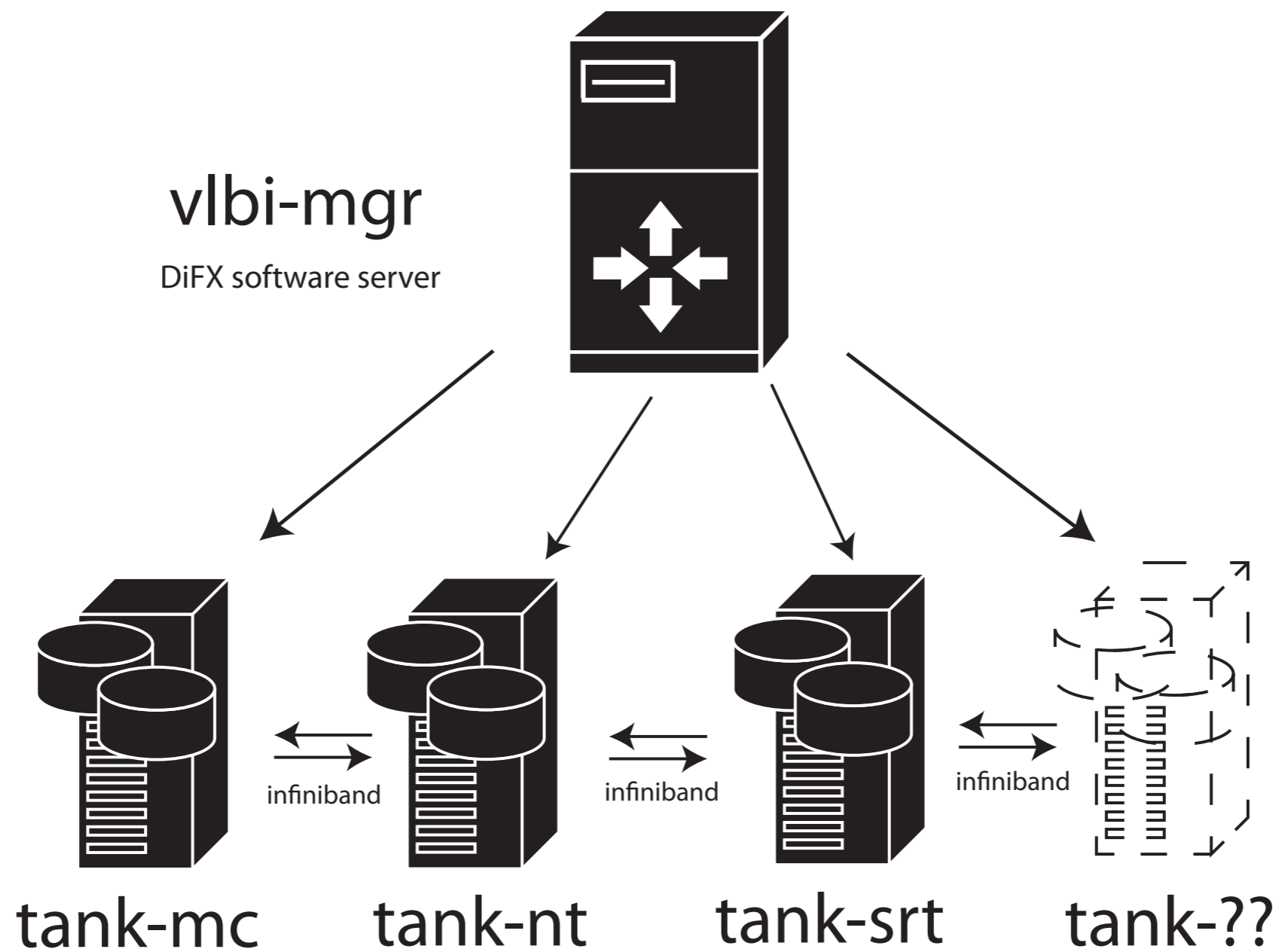
	Antenna	Now	2015	2016
	Mc - 32 mt	10 Gbit/s	10 Gbit/s	10 Gbit/s
	Nt - 32 mt	10 Gbit/s	10 Gbit/s	10 Gbit/s
	SRT - 64 mt	-	-	10 Gbit/s (?)
	IRA - HQ	3 x 10 Gbit/s	3 x 10 Gbit/s	3 x 10 Gbit/s

Garr -> Geant now 2 x 40 Gbit/s

Band on Demand to EVN



Juniper POP and Huawei Lambda DWDM devices



Cluster Architecture

A dedicated storage node
for each antenna

Cluster view

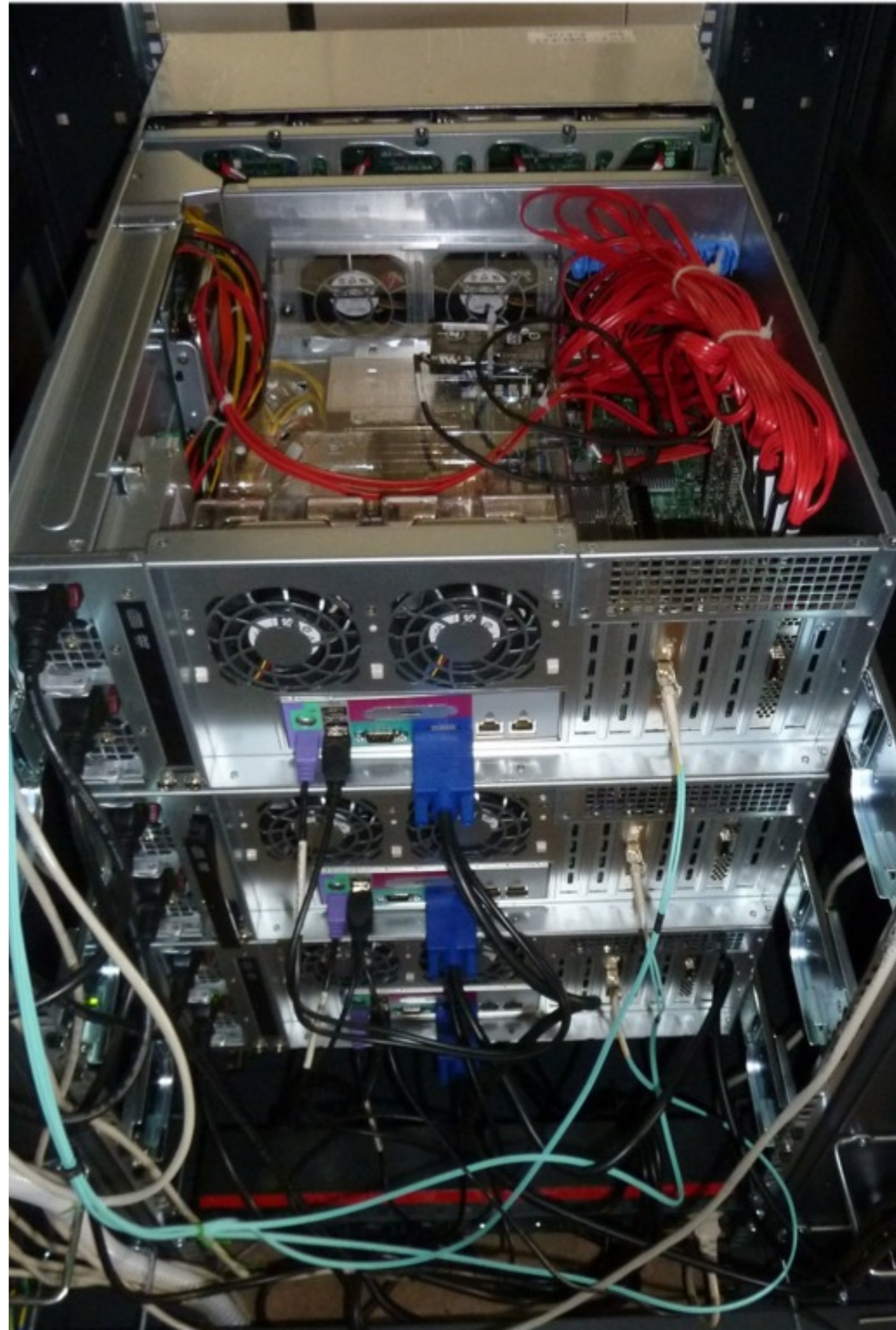
Infiniband connection

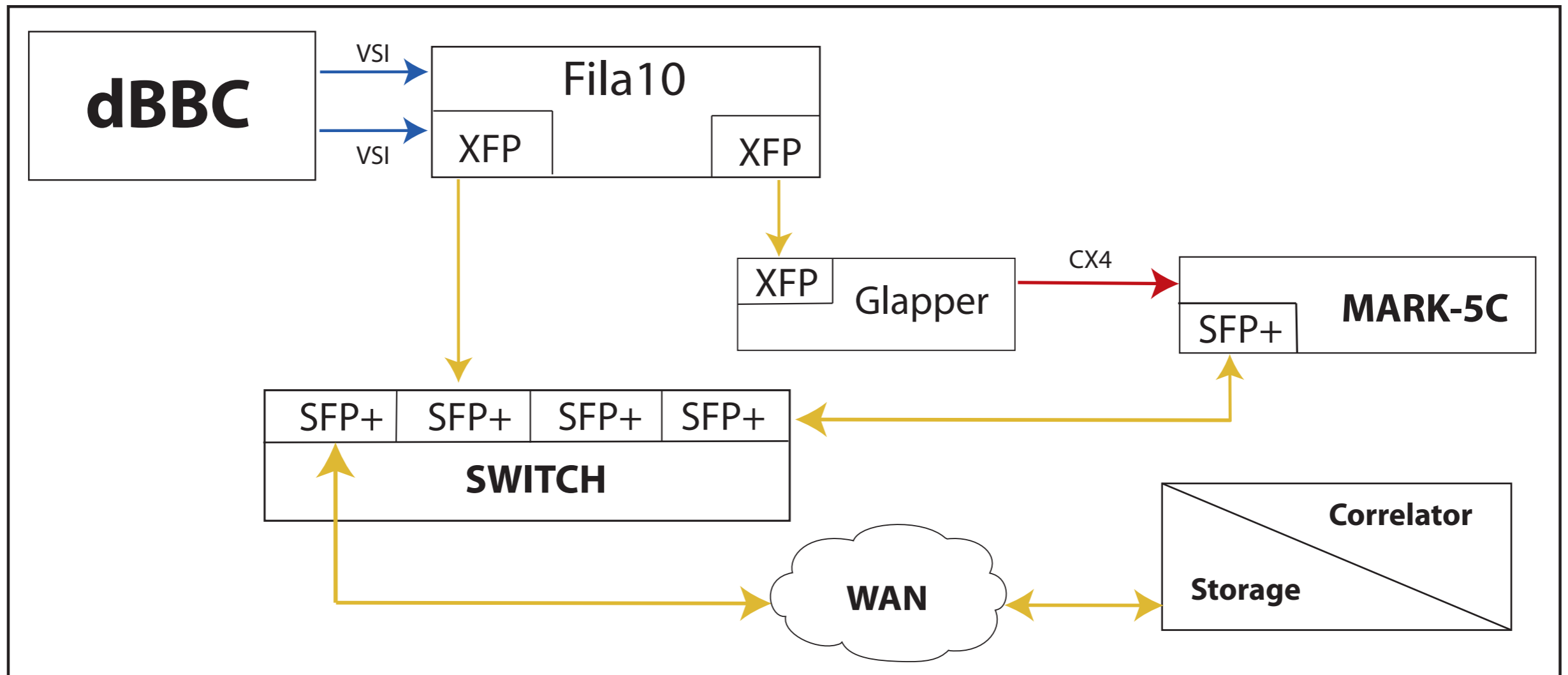
10 Gbit network

24 disks bay

Now 150 TB available

(20 TB SATA + 30 TB SAS each)





Network layout at stations

Fila 10 G

- The Fila board (**F**irst - **L**ast) is connected to the dBBC backend through a VSI cable and transfers the data onto an optical fiber adding a Mark5B or VDIF header



1 hr recording test @ 4 Gbit Medicina -> Bologna

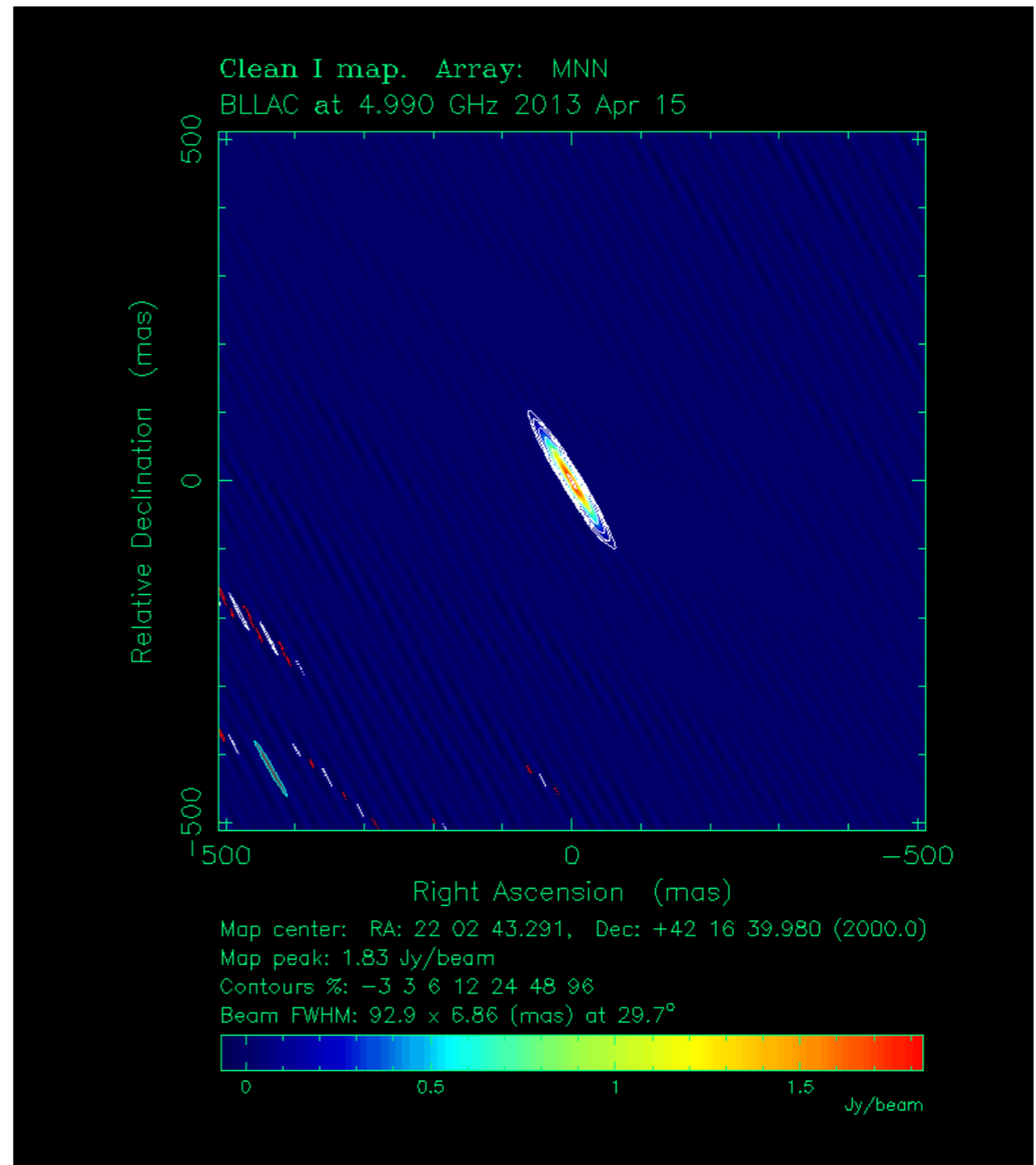
5008 bytes Mark5B - Fila 10 G split packets	SATA RAID 20 TB	SAS RAID 30 TB
Lost packets	5102688	56782
Total packets	363651840	369577856
% lost	1.4 %	0.01 %

Thanks to Harro Verkouter's **jive5ab**

Name	Band	Date	Result	Rec Speed	Mc	Md	Nt	Nd	SRT	Notes
3C84	L	15/3/2013	NO	512	X		X	X		Fringes Nt-Nd
ITVLBI	L	17/3/2013	NO	512	X		X			
apr-15	C	16/4/2013	OK	512	X		X	X		First Fringes Mc - Nt
ivlbi	X	12/10/2013	NO	512	X	X		X	X	Fringes on few scans Mc-Md-Nd
nov25	K	28/11/2013	NO	1024		X		X		Clock problems Md
dec5	X	7/12/2013	NO	1024		X			X	Clock problems Md-SRT
dec17	L	17/12/2013	NO	1024		X		X		Clock problems Md
ivlbi	X	3/1/2014	OK	512	X	X				
temp2	L	13/1/2014	OK	1024		X		X		Fringes Md-Nd-Hh / Nd + 1sec
test5	K	27/1/2014	OK	1024		X			X	First Fringes SRT
test5	K	4/2/2014	OK	1024		X			X	New position SRT
l128	L	18/2/2014	OK	128		X			X	
l1024	L	19/2/2014	NO	1024					X	Clock problems Md-SRT
l512	L	19/2/2014	NO	512		X			X	Clock problems Md-SRT
test10	X	28/2/2014	NO	512		X			X	No fringes SRT
r4620	S/X	19/3/2014	OK	512	X	X				Strong Fringes CTA26 streaming from Md to Bologna
1313	C	28/3/2014	OK	512	X	X		X		Australian campaign
ap30b	C	30/4/2014	NO	1024				X	X	Autocorrelation Nd-Nd streaming only p_cal
3c161	C	15/5/2014	OK	512	X	X		X		Test on 3c161
taurusa	X	15/5/2014	OK	1024	X	X				Transient test Md streaming to Bologna
may23	L	23/5/2014	NO	512	X	X			X	Mc-Md streaming only p_cal

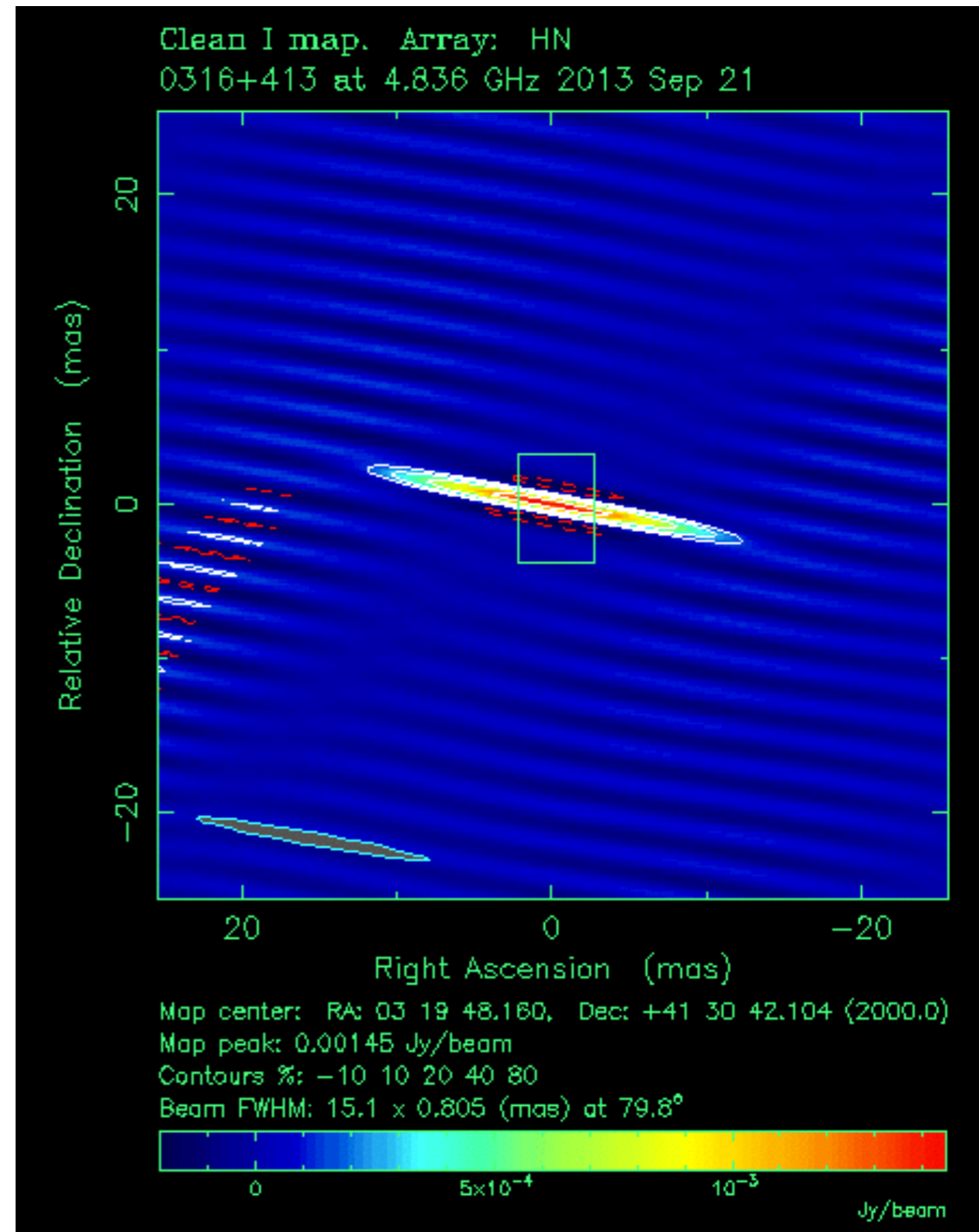
First test

- Medicina - Noto baseline
- 15-04-2013



Noto - Hart (South Africa) baseline

~ 430 GB data
correlated in
Bologna
sent @ 250 Mbit/s



Transient tests

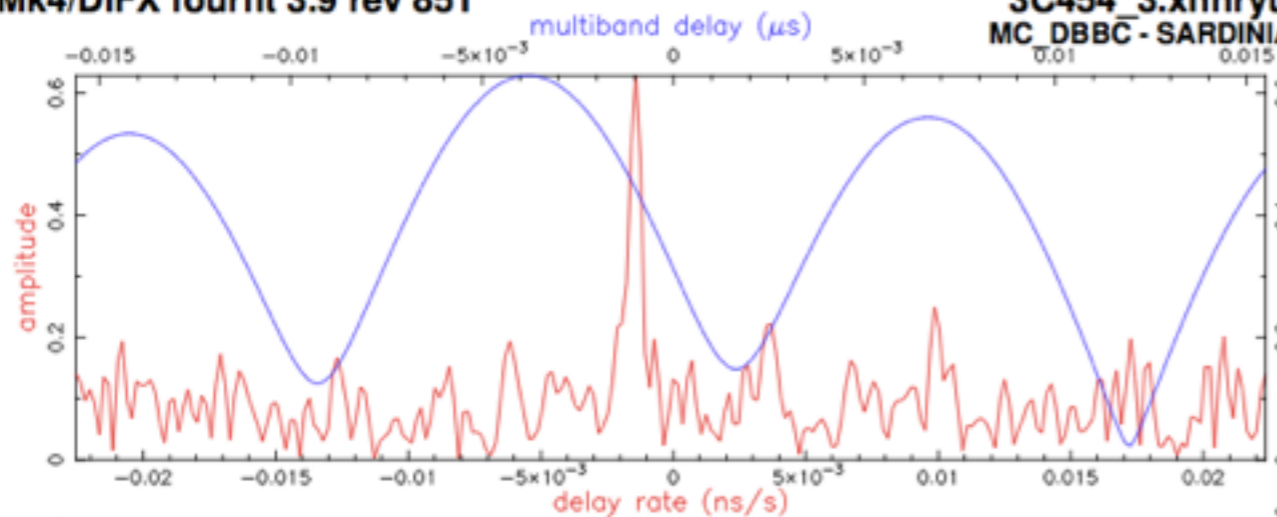
- Medicina - Noto baseline
- SN2013ej - IIP Supernova detection on 12-08-2013

Australian campaign

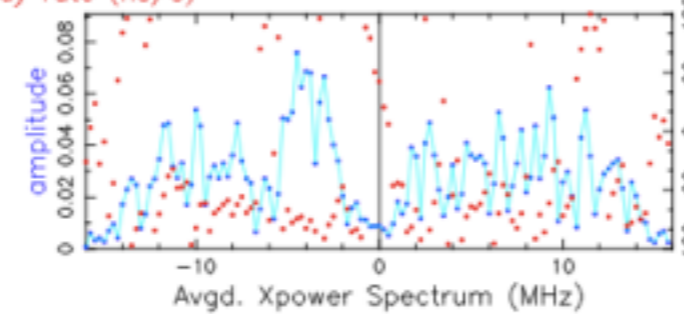
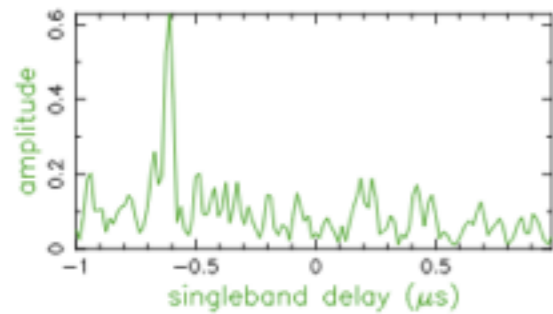
- Observations on calibrators -> stress our equipment
- 6cm C band Mc(Md)-Nt campaign between 22-03-2014 and 22-04-2014
- 12 Experiments 3 hr each -> 11 successfully correlated

Mk4/DiFX fourfit 3.9 rev 851

3C454_3.xhnryu, No0004, LW
MC_DBBC - SARDINIA, fgroup K, pol RR



Fringe quality 9
 Error code H
 SNR 8.5
 Int time 96.000
 Amp 0.637
 Phase -131.2
 PFD 9.6e-11
 Delays (us)
 SBD -0.612395
 MBD -0.003638
 Fringe rate (Hz)
 -0.032891
 Ion TEC 0.00
 Ref freq (MHz)
 22187.4900
 AP (sec) 1.000
 Exp. test5
 Exper # 16383
 Yr:day 2014:027
 Start 123604.00
 Stop 123740.00
 FRT 123650.00
 Corr/FF/build
 2014:026:164637
 2014:027:164515
 2013:290:053232
 RA & Dec (J2000)
 22h53m57.7479s
 +16°08'53.561"



Amp. and Phase vs. time for each freq., 48 segs, 2 APs / seg (2.00 sec / seg.), time ticks 2 sec

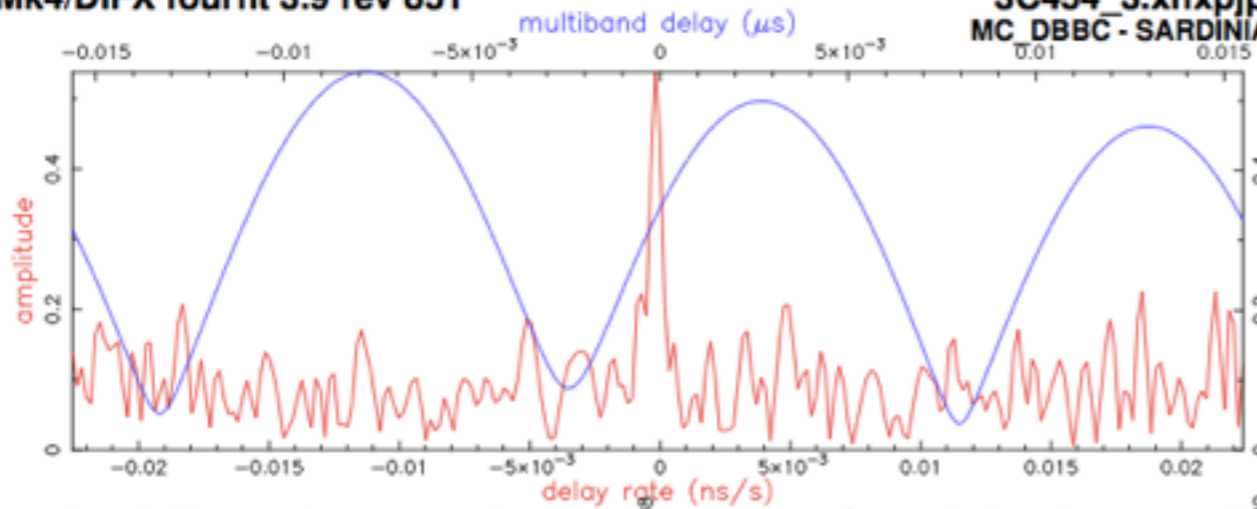
SRT position
measured
more
accurately
after the first fringe

Delay reduced by
0.1 μsec

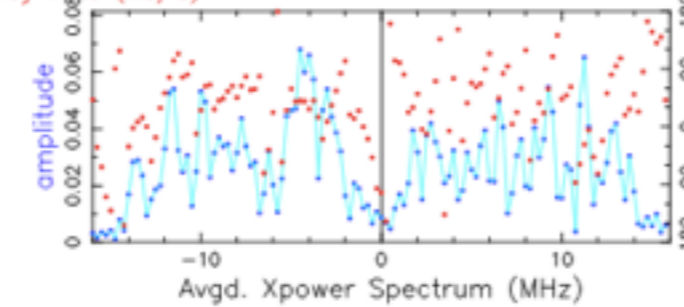
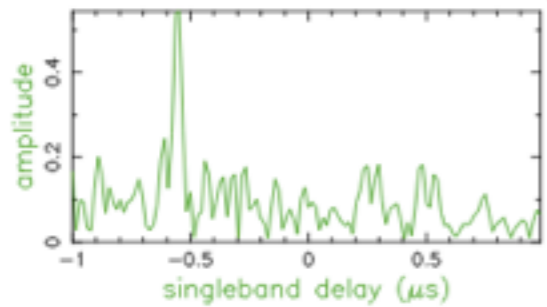


Mk4/DiFX fourfit 3.9 rev 851

3C454_3.xhxpjp, No0004, LW
MC_DBBC - SARDINIA, fgroup K, pol RR



Fringe quality 9
 Error code H
 SNR 7.9
 Int time 96.000
 Amp 0.586
 Phase 38.9
 PFD 2.1e-08
 Delays (us)
 SBD -0.554420
 MBD -0.008194
 Fringe rate (Hz)
 -0.005832
 Ion TEC 0.00
 Ref freq (MHz)
 22187.4900
 AP (sec) 1.000
 Exp. test5
 Exper # 16383
 Yr:day 2014:027
 Start 123604.00
 Stop 123740.00
 FRT 123650.00
 Corr/FF/build
 2014:034:180724
 2014:035:180715
 2013:290:053232
 RA & Dec (J2000)
 22h53m57.7479s
 +16°08'53.561"



Amp. and Phase vs. time for each freq., 48 segs, 2 APs / seg (2.00 sec / seg.), time ticks 2 sec

Weather problems
in Sardinia

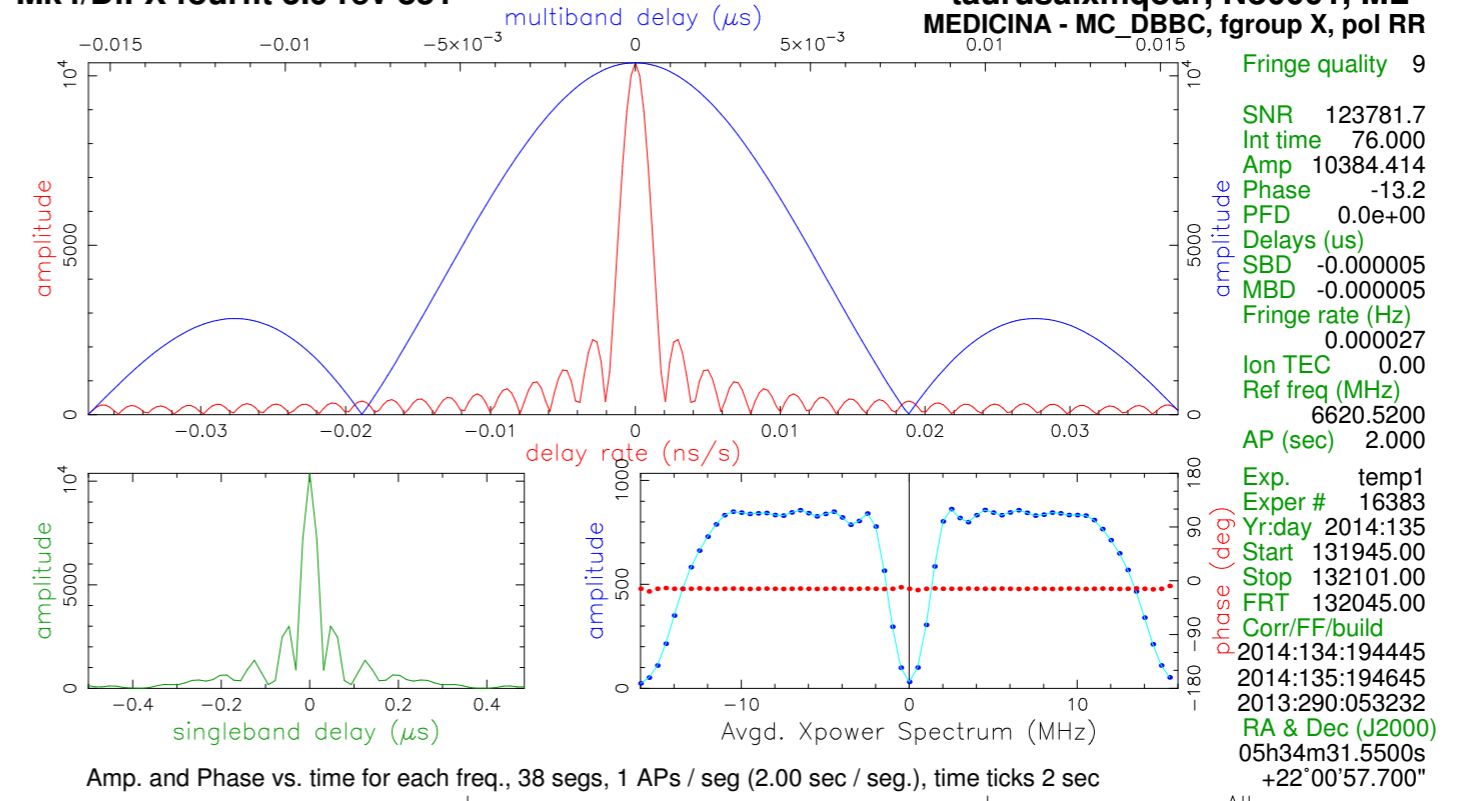


Medicina dBBC
streaming to Bologna
@ 1 Gbit
while recoding with
Mark5C at the station

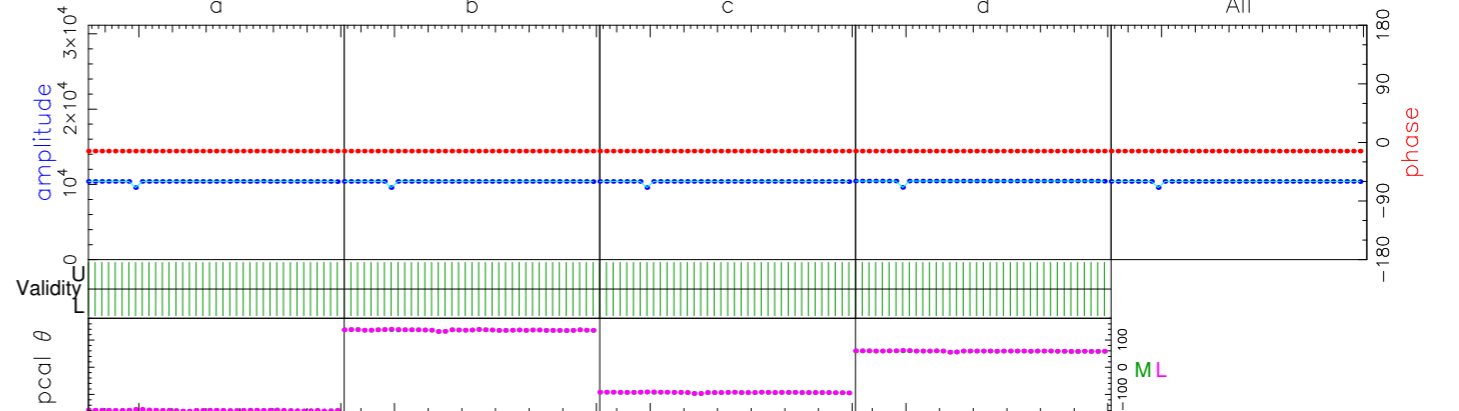
Taurus A passing over
a **stopped** antenna...

Mk4/DiFX fourfit 3.9 rev 851

taurusa.xmqour, No0001, ML
MEDICINA - MC_DBBC, fgroup X, pol RR



Fringe quality 9
SNR 123781.7
Int time 76.000
Amp 10384.414
Phase -13.2
PFD 0.0e+00
Delays (us)
SBD -0.000005
MBD -0.000005
Fringe rate (Hz)
0.000027
Ion TEC 0.00
Ref freq (MHz)
6620.5200
AP (sec) 2.000
Exp. temp1
Exper # 16383
Yr:day 2014:135
Start 131945.00
Stop 132101.00
FRT 132045.00
Corr/FF/build
2014:134:194445
2014:135:194645
2013:290:053232
RA & Dec (J2000)
05h34m31.5500s
+22°00'57.700"



	6620.52	6652.52	6684.52	6716.52	6748.52	6780.52
6620.52	6652.52	6684.52	6716.52	6748.52	6780.52	
-13.2	-13.2	-13.2	-13.2	-13.2	-13.2	
10384.6	10364.1	10374.1	10414.8	10414.8		
33.0	33.0	33.0	33.0	33.0		
U/L 38/38	38/38	38/38	38/38	38/38		
M 1480	1480	1480	1480	1480		
L 1480	1480	1480	1480	1480		
M:L 116:116	-129:-129	-33:-33	91:91			
M:L 0:0	0:0	0:0	0:0			
M 35	33	36	32			
L 35	33	36	32			
M X00UR,X00LR	X01UR,X01LR	X02UR,X02LR	X03UR,X03LR			
L X00UR,X00LR	X01UR,X01LR	X02UR,X02LR	X03UR,X03LR			

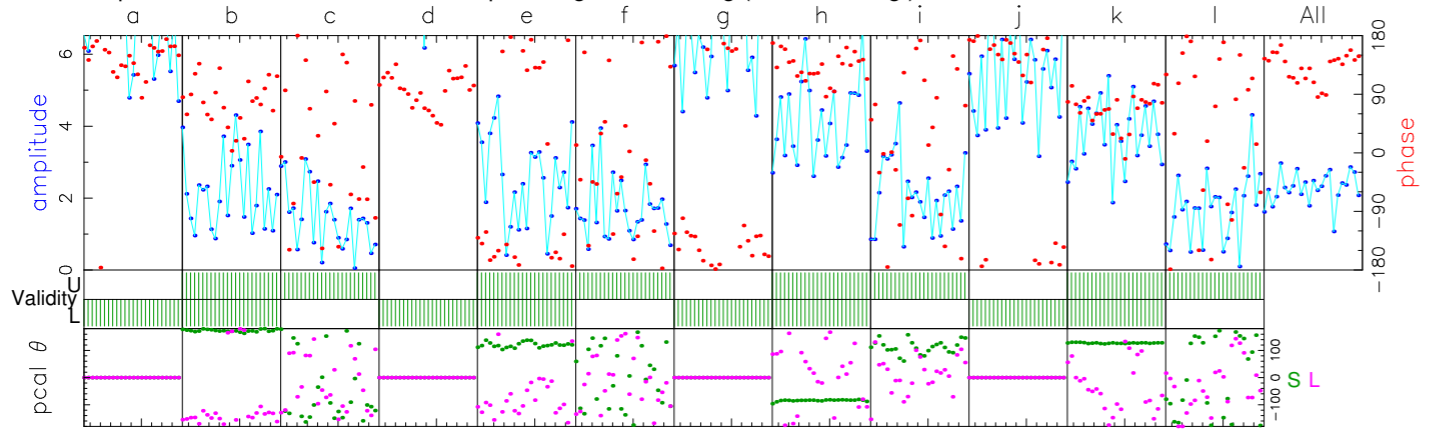
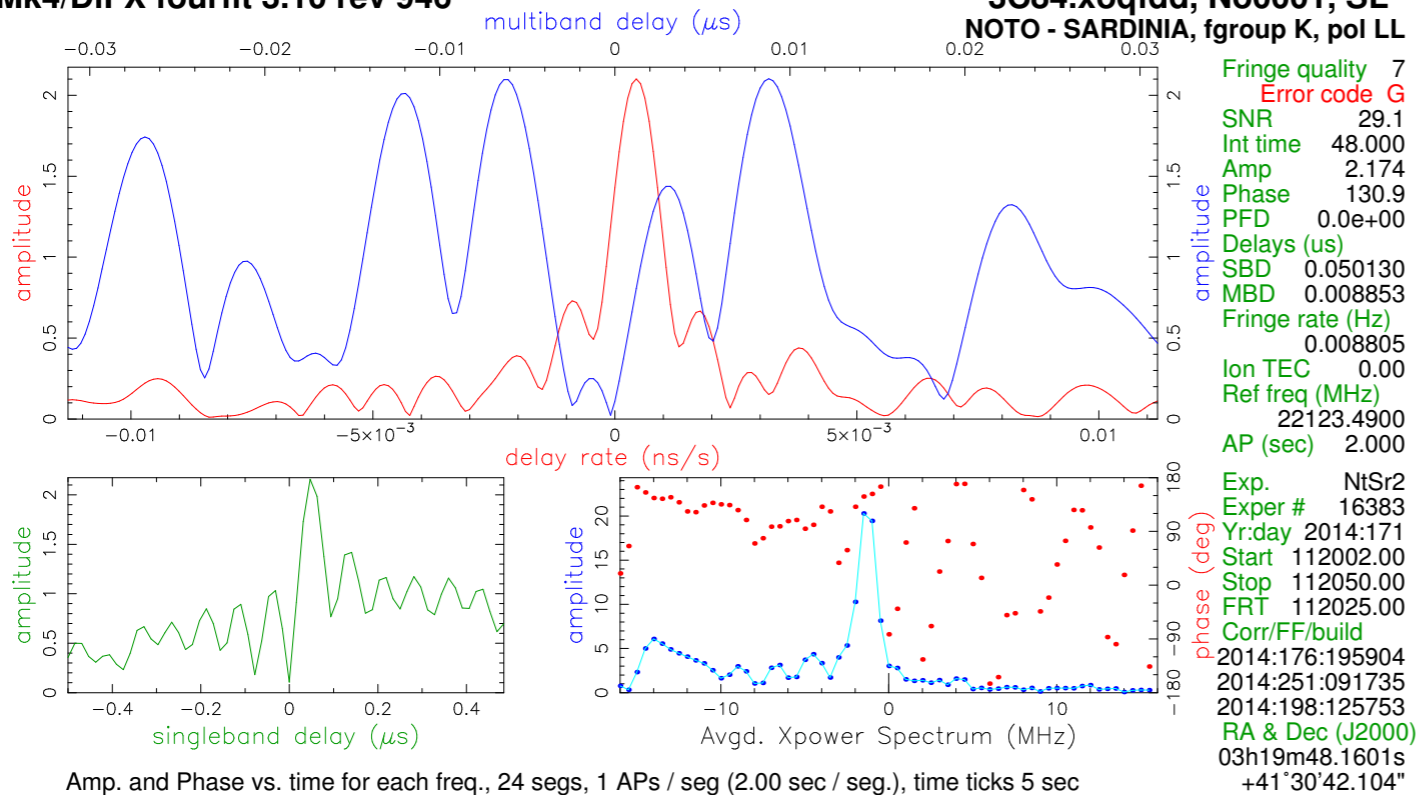
Group delay (usec) 2.67591944068E-07 Apriori delay (usec) 5.58009194407E-06 Resid mbdelay (usec) -5.31250E-06 +/- 3.6E-08
Sband delay (usec) 5.80091944068E-07 Apriori clock (usec) 0.0000000E+00 Resid sbdelay (usec) -5.00000E-06 +/- 1.4E-07
Phase delay (usec) 3.16403082114E-08 Apriori clockrate (us/s) 0.0000000E+00 Resid phdelay (usec) -5.54845E-06 +/- 1.9E-10
Delay rate (us/s) -1.50216366286E-09 Apriori rate (us/s) -4.09225084263E-09 Resid rate (us/s) 2.59009E-09 +/- 8.9E-12
Total phase (deg) 0.1 Apriori accel (us/s/s) 7.90787509034E-14 Resid phase (deg) -13.2 +/- 0.0

Pcal mode: NORMAL, NORMAL Pcal period (AP's) 9999, 9999
Pcal rate: -9.962E-09, -1.143E-08 (us/s) sb window (us) -0.500 0.500
Bits/sample: 2 SampCntNorm: disabled mb window (us) -0.016 0.016
Sample rate(MSamp/s): 32 dr window (ns/s) -0.038 0.038
Data rate(Mb/s): 512 nlags: 32 t_cohere infinite ion window (TEC) 0.00 0.00

M: az 181.2 el 67.5 pa 0.9 L: az 181.2 el 67.5 pa 1.4 u,v (fr/asec) -0.000 0.000 simultaneous interpolator
Control file: control Input file: /space1/realtime2/1234/No0001/ML..xmqour Output file: Suppressed by test mode

Mk4/DiFX fourfit 3.10 rev 946

3C84.xoqfdd, No0001, SL
NOTO - SARDINIA, fgroup K, pol LL



22123.49	22139.49	22155.49	22187.49	22203.49	22219.49	22251.49	22267.49	22283.49	22315.49	22331.49	22347.49	Freq (MHz)	All	
147.3	74.6	12.6	97.1	-171.0	-53.9	-154.2	131.7	-28.4	169.0	69.7	107.4	Phase	130.9	
6.5	1.8	0.3	8.4	2.1	0.4	5.7	3.9	0.2	4.9	3.4	0.5	Ampl.	3.1	
36.0	30.2	4.2	37.4	30.2	63.3	35.9	36.4	22.7	35.7	36.5	20.3	Sbd box	36.2	
U/L 0/24	24/24	24/0	0/24	24/24	24/0	0/24	24/24	24/0	0/24	24/24	24/0	APs used		
S 1510	1510	1510	1510	1510	1510	1510	1510	1510	1510	1510	1510	PC freqs		
L 1510	1510	1510	1510	1510	1510	1510	1510	1510	1510	1510	1510	PC freqs		
S:L 0:0	173:-150	-137:-97	0:0	120:-106	97:-156	0:0	-84:87	111:30	0:0	127:-61	173:-64	PC phase		
S:L 0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	ManI PC		
S 0	2	0	0	1	0	0	5	1	0	5	0	PC amp		
L 0	0	0	0	0	0	0	0	0	0	0	0			
S K00LL	K01UL,K01LLK02UL	K03LL	K04UL,K04LLK05UL	K06LL	K07UL,K07LLK08UL	K09LL	K10UL,K10LLK11UL					Chan ids		
L K00LL	K01UL,K01LLK02UL	K03LL	K04UL,K04LLK05UL	K06LL	K07UL,K07LLK08UL	K09LL	K10UL,K10LLK11UL					Tracks		
												Chan ids		
												Tracks		
Group delay (usec)(model)	-9.78668091364E+02		Apriori delay (usec)		-9.78676944821E+02		Resid mbdelay (usec)		8.85346E-03		+/-		7.5E-05	
Sband delay (usec)	-9.78626814821E+02		Apriori clock (usec)		5.6880002E+00		Resid sbdelay (usec)		5.01300E-02		+/-		5.9E-04	
Phase delay (usec)	-9.78676928388E+02		Apriori clockrate (us/s)		1.9881507E-08		Resid phdelay (usec)		1.64325E-05		+/-		2.5E-07	
Delay rate (us/s)	-9.06773493216E-02		Apriori rate (us/s)		-9.06777496490E-02		Resid rate (us/s)		4.00327E-07		+/-		1.8E-08	
Total phase (deg)	-85.8		Apriori accel (us/s/s)		2.54379336546E-06		Resid phase (deg)		130.9		+/-		2.0	
ph/seg (deg)	RMS	Theor.	Amplitude	2.174 +/- 0.075		Pcal mode: NORMAL, NORMAL		Pcal period (AP's) 9999, 9999						
amp/seg (%)	22.1	9.6	Search (64X64)	2.145		Pcal rate: -1.597E-08, -1.362E-08 (us/s)		sb window (us)		-0.500		0.500		
ph/frq (deg)	20.3	16.8	Interp.	0.000		Bits/sample: 2		SampCntNorm: disabled		-0.031		0.031		
amp/frq (%)	94.6	6.8	Inc. seg. avg.	2.246		Sample rate(MSamp/s): 32		dr window (ns/s)		-0.011		0.011		
	129.6	11.9	Inc. frq. avg.	3.073		Data rate(Mb/s): 1024		nlags: 32		t_cohere infinite		ion window (TEC)		
												0.00		
S: az 291.7 el 56.4 pa 83.4	L: az 286.5 el 61.5 pa 81.4		u,v (fr/asec) 178.381 -15.677										simultaneous interpolator	
Control file: control Input file: /space3/corrNtSr2/1234/No0001/SL...xoqfdd Output file: Suppressed by test mode														

K Band test
in single polarization
to meet K5 Japanese
format



Low SNR for calibrator!

wrong cabling -> missing some IFs



Experiments

- First aim of tests was to verify the network infrastructure and **SRT** equipment
- Evaluate the different dBBC backend pipelines:
Mark5B - Mark5C - Fila10G

Experiments

- As of today more than 40 experiments, scheduled by INAF or EVN have been correlated in Bologna
- Half of them have **failed**

Experiments

What we have learned the hard way:

- Human errors (cabling, wrong schedule name...)
- Weather (Snow, wind, fog)
- Hardware errors (Wrong clock setups, failures...)

That's why they call them
experiments!

Correlation experiences

PROS

- Flexibility of Bologna storage facility
- High capacity network infrastructure
- Ability to operate in *almost* any condition
- Possibility of hosting data *and* distributed correlation

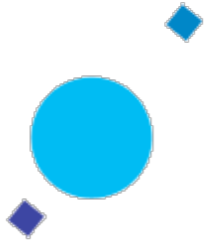


Valley of sorrow

CONS

- SRT missing network
- *Sched* doesn't fully support dBBC setups
- VDIF format is yet to be thoroughly tested
- Vex2 is much awaited

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Thank you

Matteo Stagni - EVN Symposium - Cagliari (Italy) 09-10-2014