RF over fibre solutions for the SKA II

ANTENNA NETWORK FOR AA-LO: CONCEPT DESCRIPTION

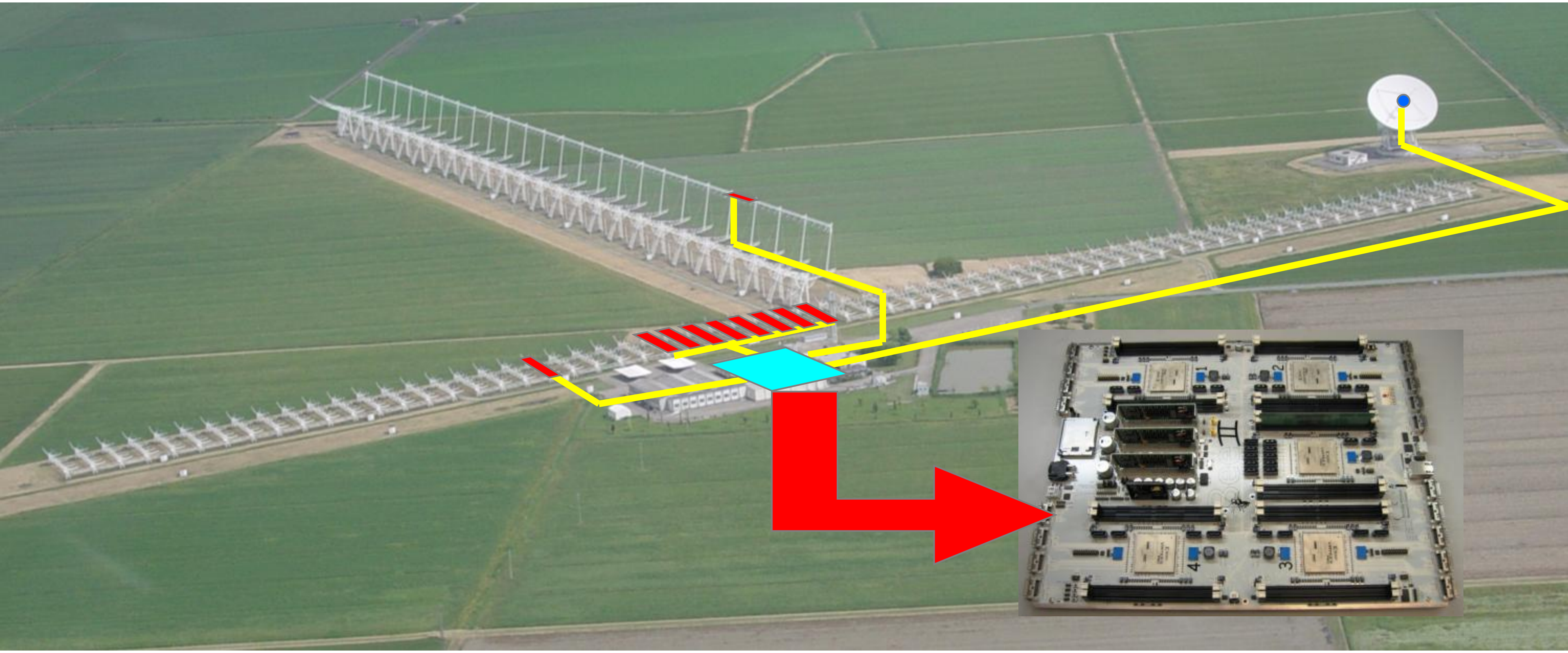
INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

Federico Perini

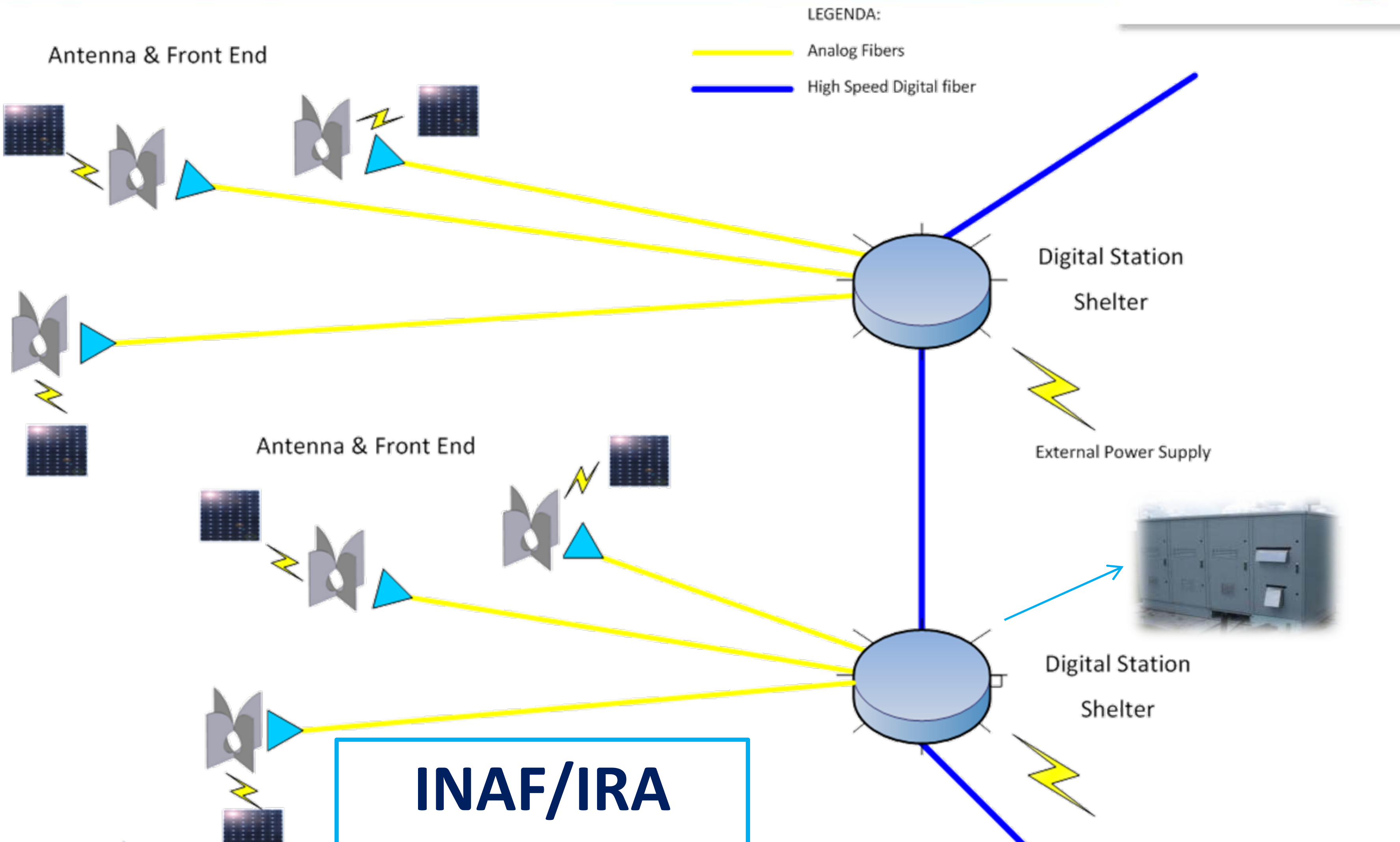
Stan CoDR - Jodrell Bank 26-28 June 2011

General Concept

1) BEST1&2: 16MHz@408MHz, 4 + 32 RoF links, length 200m
2) BEST3lo: 120-240MHz, 16 RoF links, 300m
3) VLBI dish IF links: 0.1-2.1GHz, 8 RoF links, length 500m



General Concept



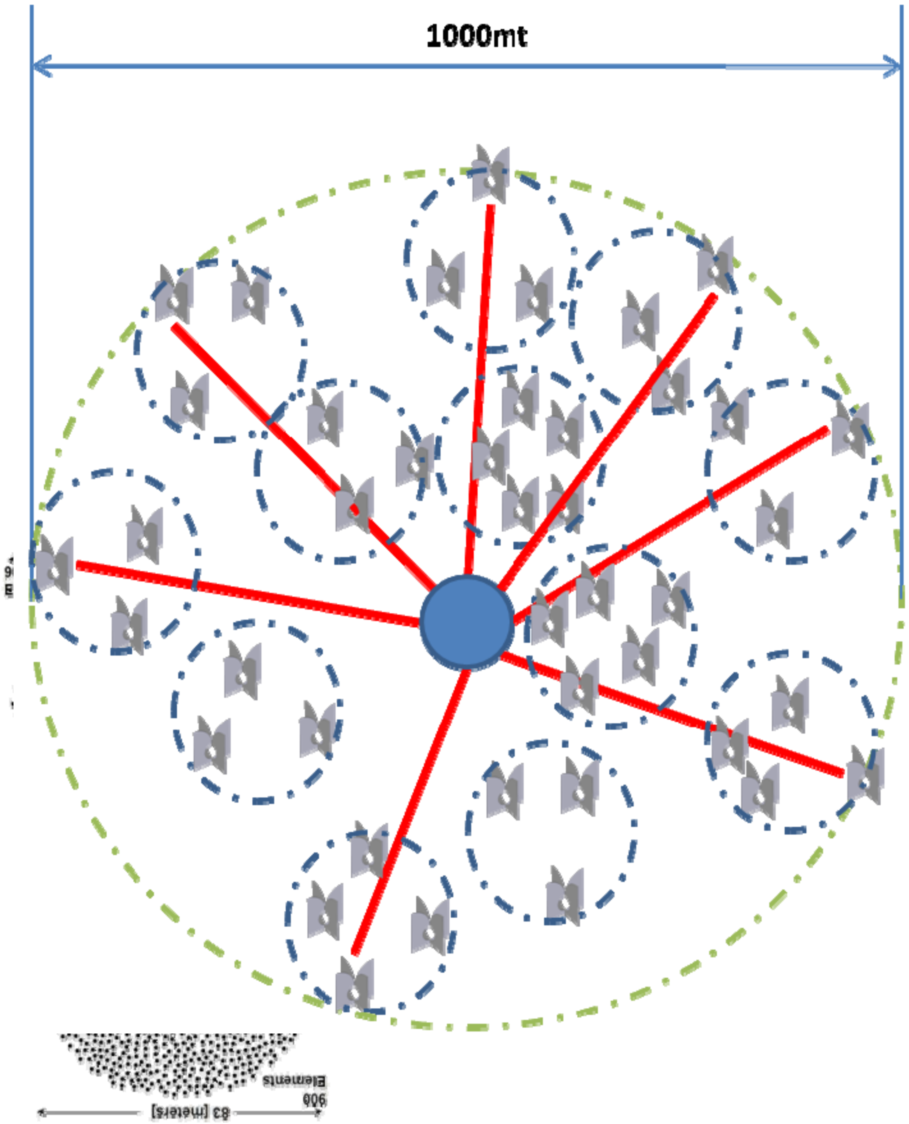
INAF/IRA
AAVP WP5

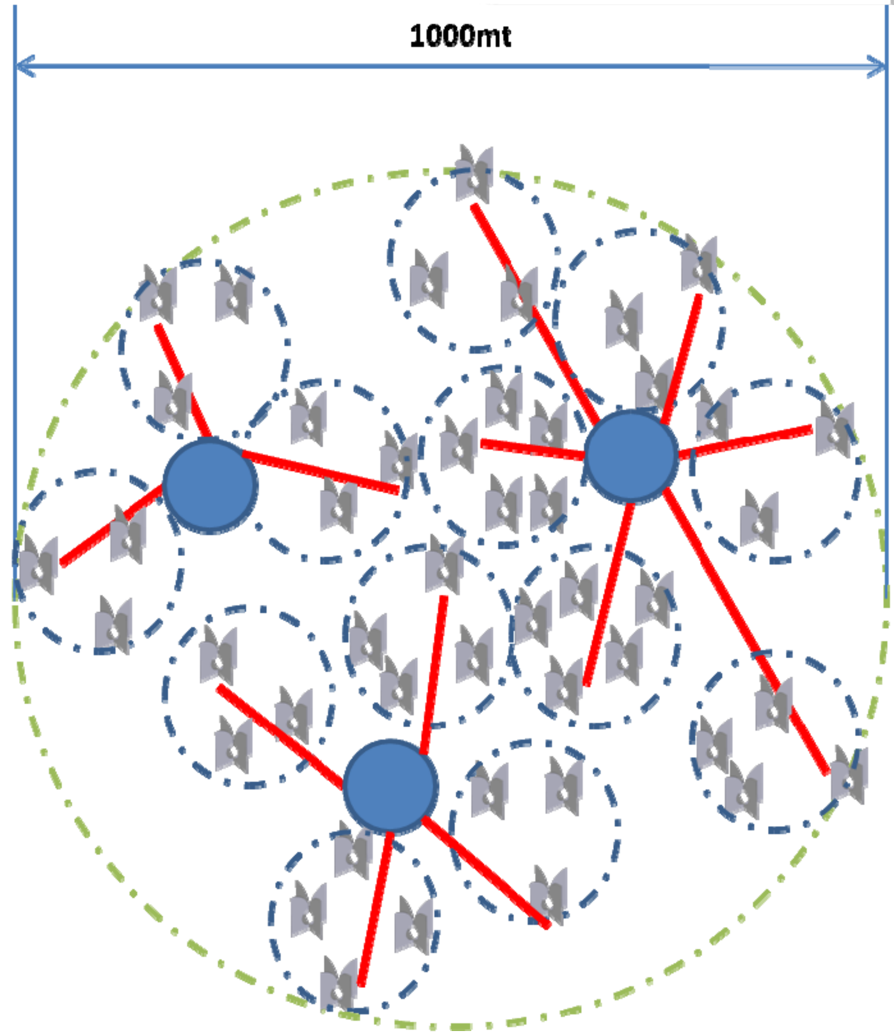
Requirements and Functionality

1) “REQUIREMENTS DOCUMENT FOR SIGNAL TRANSPORT AND NETWORKS” WP2-030.030.000-SRS-001

2) “SKA AA SYSTEM REQUIREMENT SPECIFICATIONS” WP2-010.020.010-SRS-001

Design Concept





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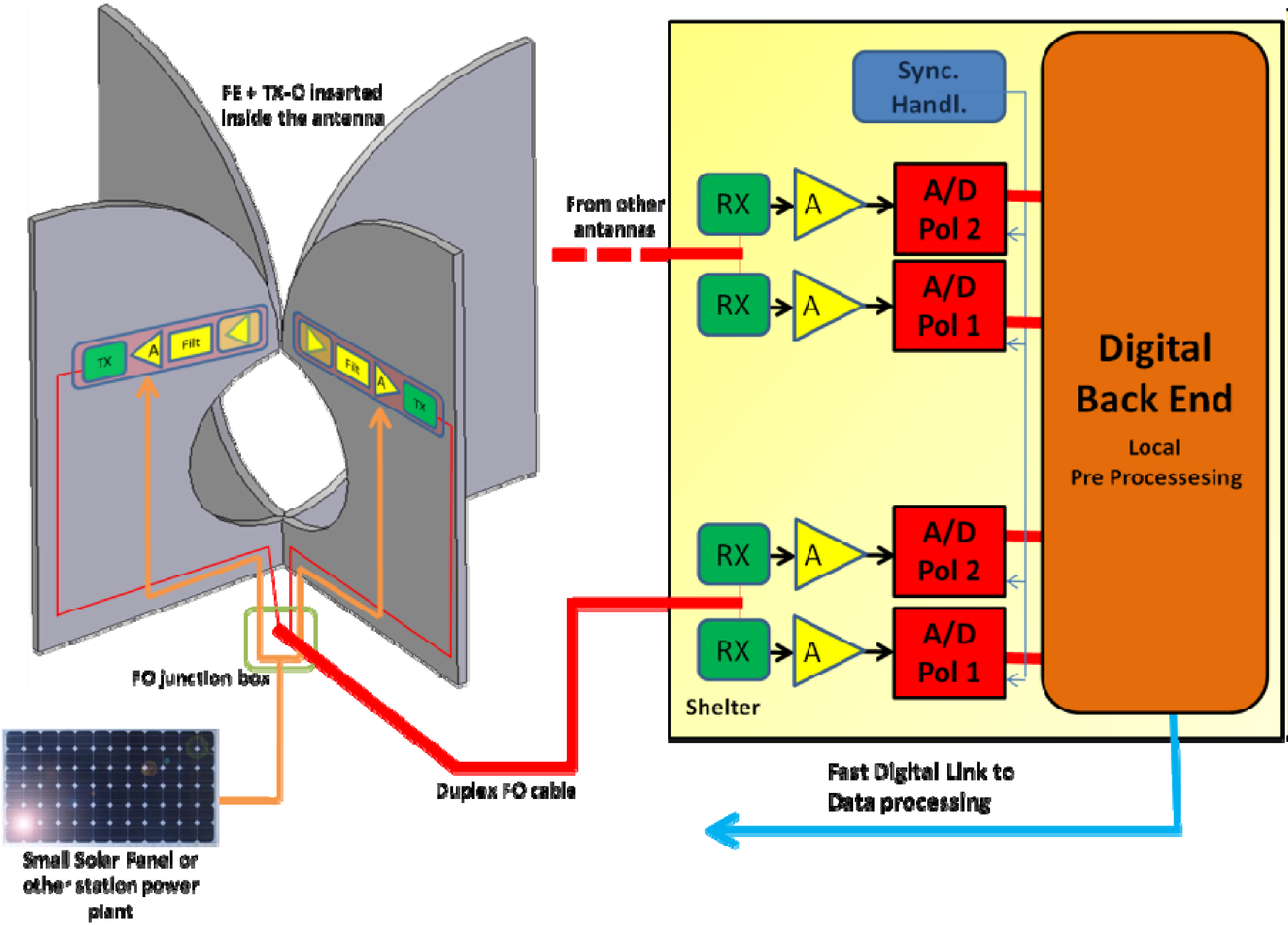
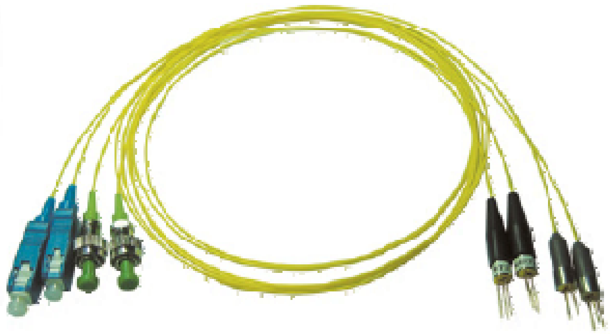
First Draft: Interfaces Description



scope

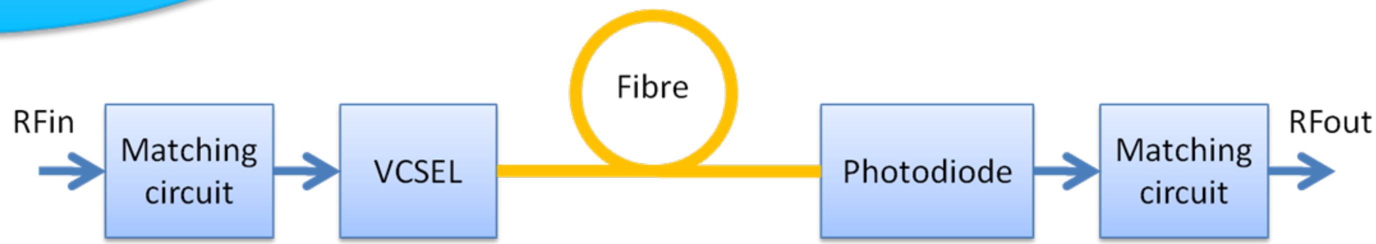
First Draft: Physical Interface



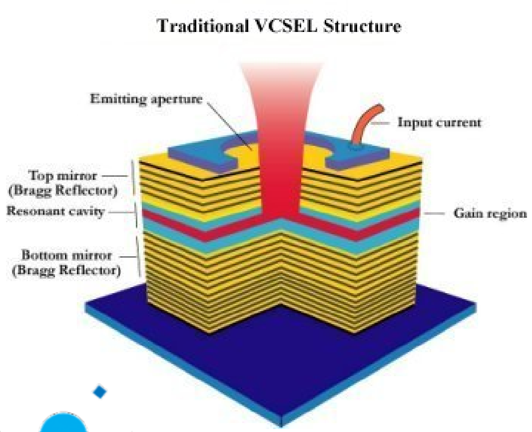
Design Concept

Low Cost,
Mass Production,
Reliability, …

IM-DD architecture



VCSEL

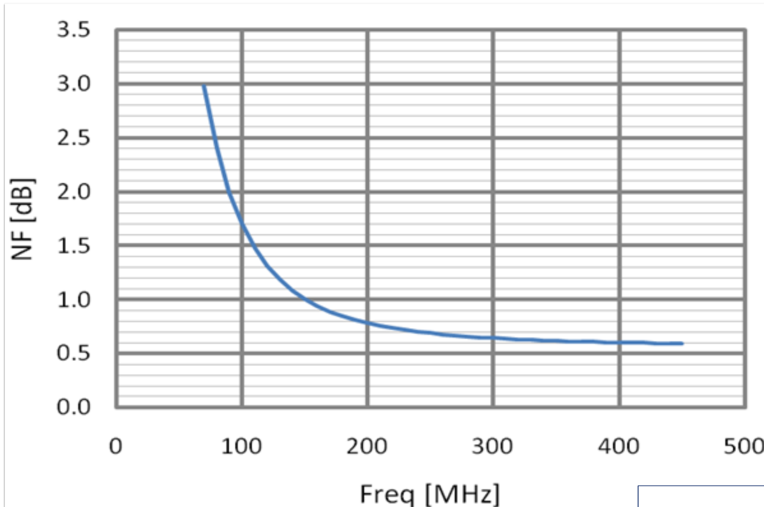


RF Transmission Over Multimode Fibers Using VCSELs - Comparing Standard and High-Bandwidth Multimode Fibers.
C. Carlsson , A. Larsson, A. Apling.
IEEE Journal of Lightwave Technology, 2004.

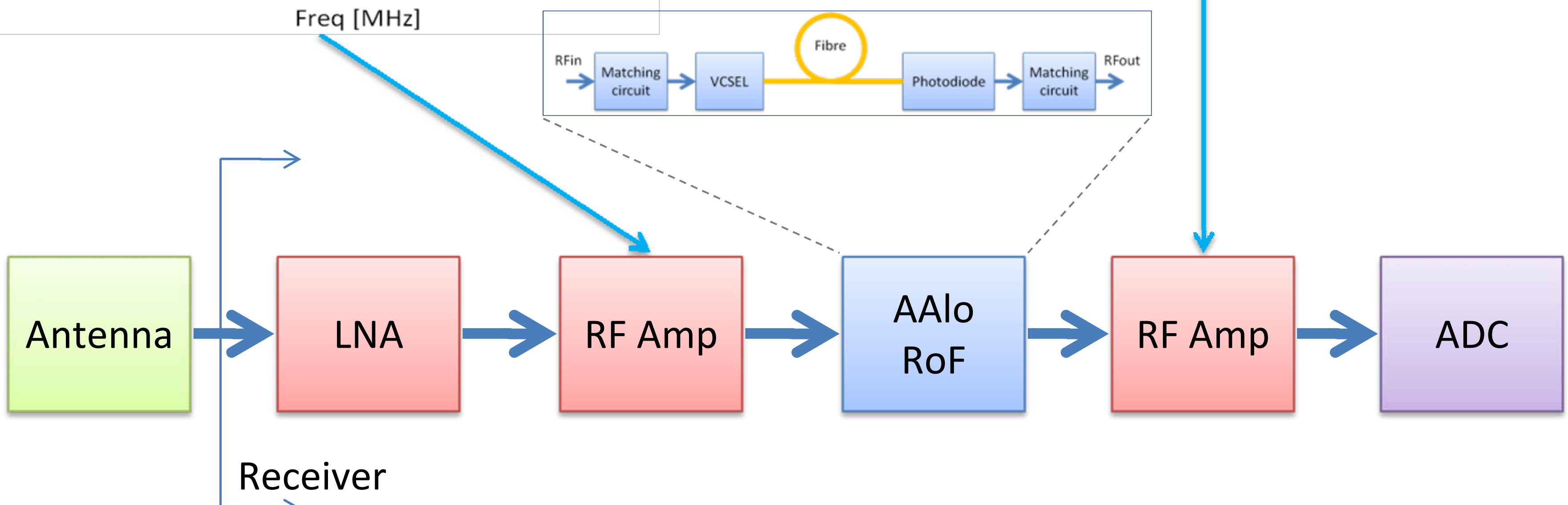
SFDR (dB/Hz$^{2/3}$)	104
Gain (dB)	-29
NF (dB)	39
OIP3 (dBm)	-8

500m link on MMF

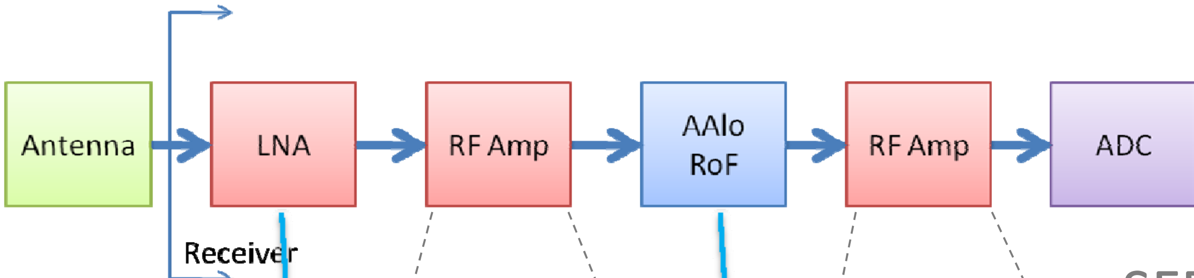
Design Concept



~ -100dBm Input Power
(noise at the antenna level)
→ 70dB min Gain



Design Concept



	IRA LNA	GALI-52	GALI-6	VCSEL link	GALI-3[illegible]	[illegible]	Cascade Total
NF (dB)	0.5	3	4.5	39	3[illegible]	[illegible]	[illegible]
Gain (dB)	22	22	13	-29	19	24	71.00
OIP3 (dBm)	31	30	35	-8	28	35	31.85

	IRA LNA	GALI-52	GALI-6	Optel Link	GALI-6	Cascade Total
NF (dB)	0.5	3	4.5	35	4.5	0.55
Gain (dB)	22	22	13	1	13	71.00
OIP3 (dBm)	31	30	35	34	35	34.55

$SFDR_{RXchain} = 91dB/Hz^{2/3}$

$SFDR_{Link(DFB)}=113dB/Hz^{2/3}$

$SFDR_{RXchain} = 90dB/Hz^{2/3}$ $SFDR_{Link(VCSEL)} = 104dB/Hz^{2/3}$

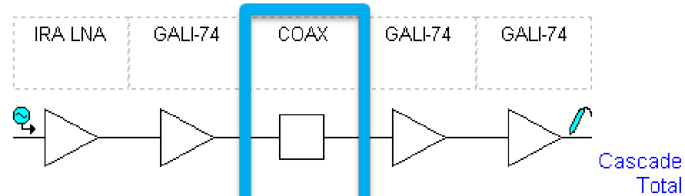
Design Concept

LOFAR Coax Cable (75Ohm/TV)

Freq	Att.	Attenuation vs Length[dB]			
[MHz]	[dB/m]	50m	100m	200m	500m
50	0.041	2.05	4.1	8.2	20.5
100	0.056	2.8	5.6	11.2	28
200	0.082	4.1	8.2	16.4	41
400	0.118	5.9	11.8	23.6	59

2-PAD Twisted Cable (CAT-7)

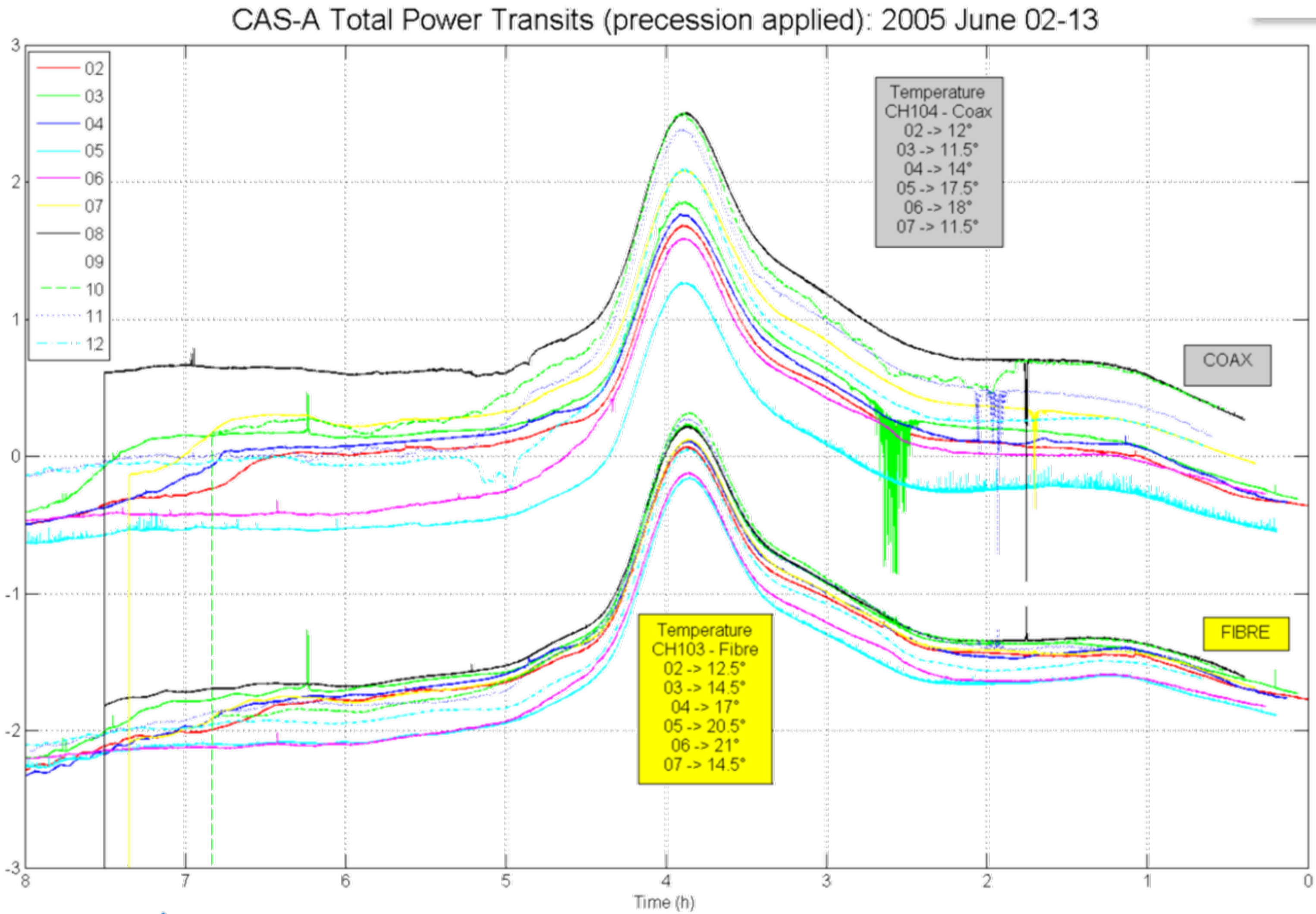
Freq	Att.	Attenuation vs Length[dB]			
[MHz]	[dB/m]	50m	100m	200m	500m
500	0.45	22.5	45	90	225



	IRA LNA	GALI-74	COAX	GALI-74	GALI-74	Cascade Total
NF (dB)	0.5	2.7	23	2.7	2.7	0.56
Gain (dB)	22	24	-23	24	24	71.00
OIP3 (dBm)	31	35	100	35	35	34.97

$SFDR_{RXchain} = 91.6 dB/Hz^{2/3}$

Stability vs Temperature (Amp.)



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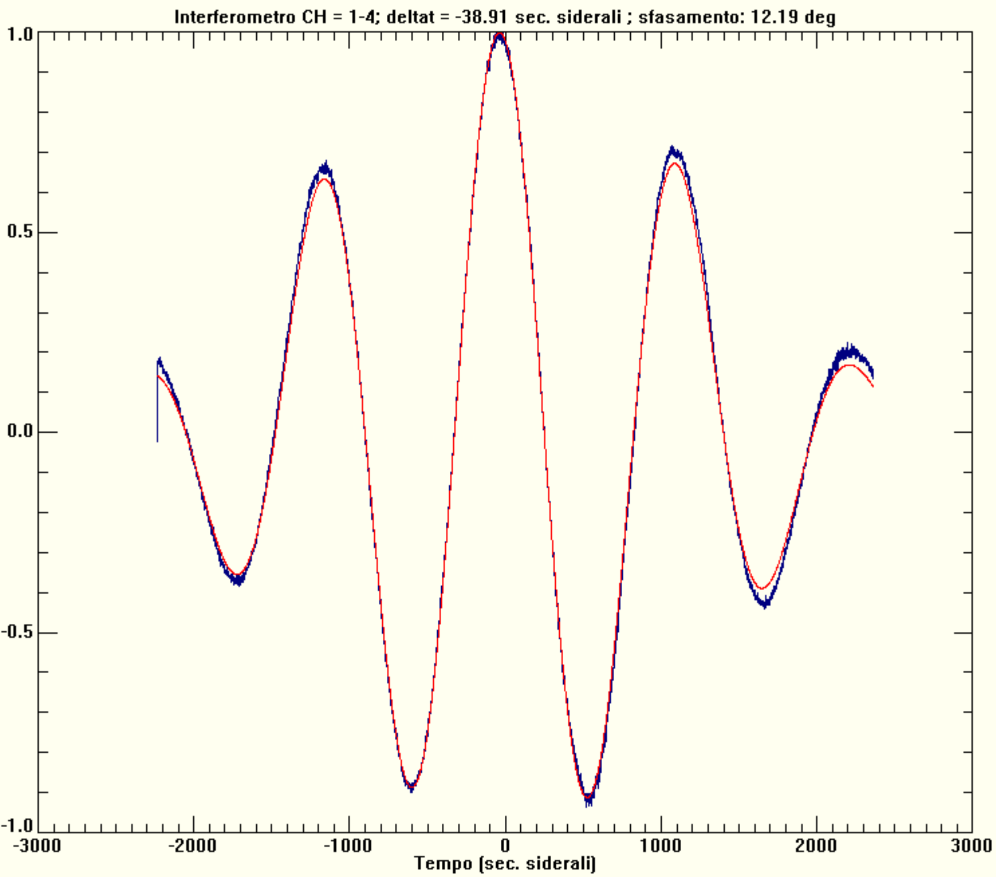
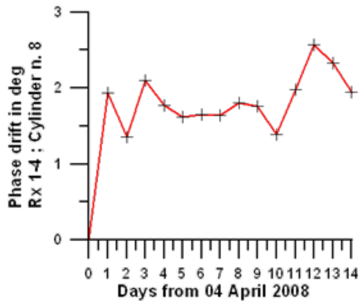
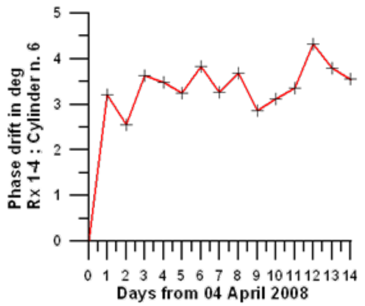
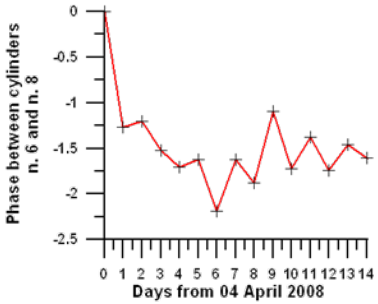
Stability vs Temperature (Phase)



Phase difference computed by comparison of simulated and detected fringes.

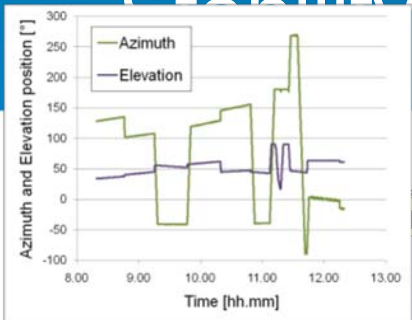


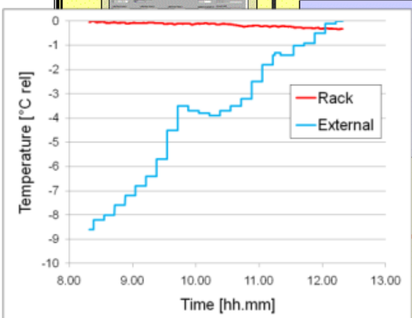


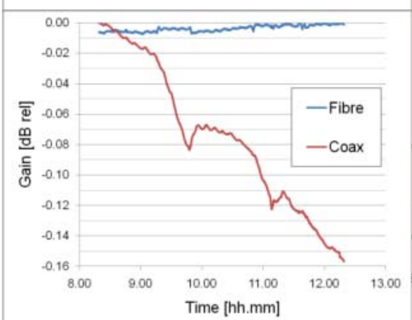


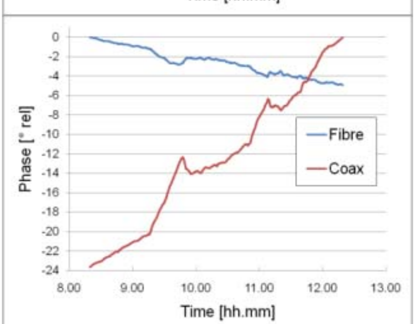
4 BEST-2 receivers on 2 different N/S cylinders, half a month observation.

Stability vs Temperature

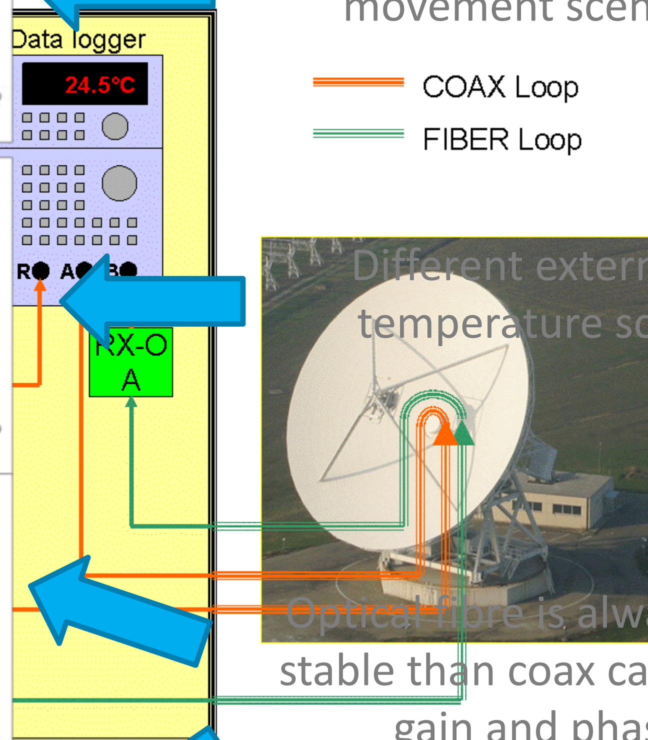








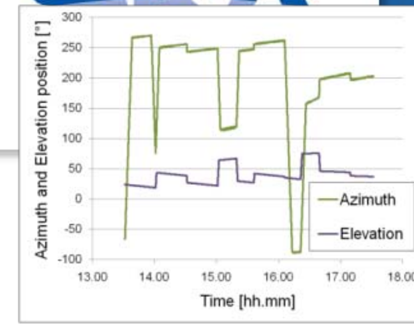
Similar antenna movement scenarios

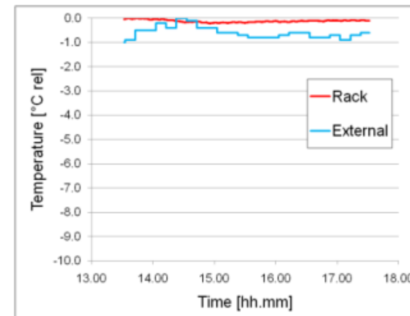


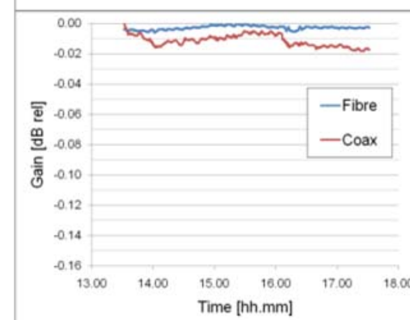
Different external (air) temperature scenario

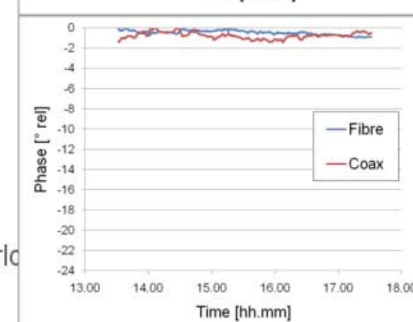
Optical fibre is always more stable than coax cable (both gain and phase).

The main influence factor is the external temperature variation rather than the antenna movements

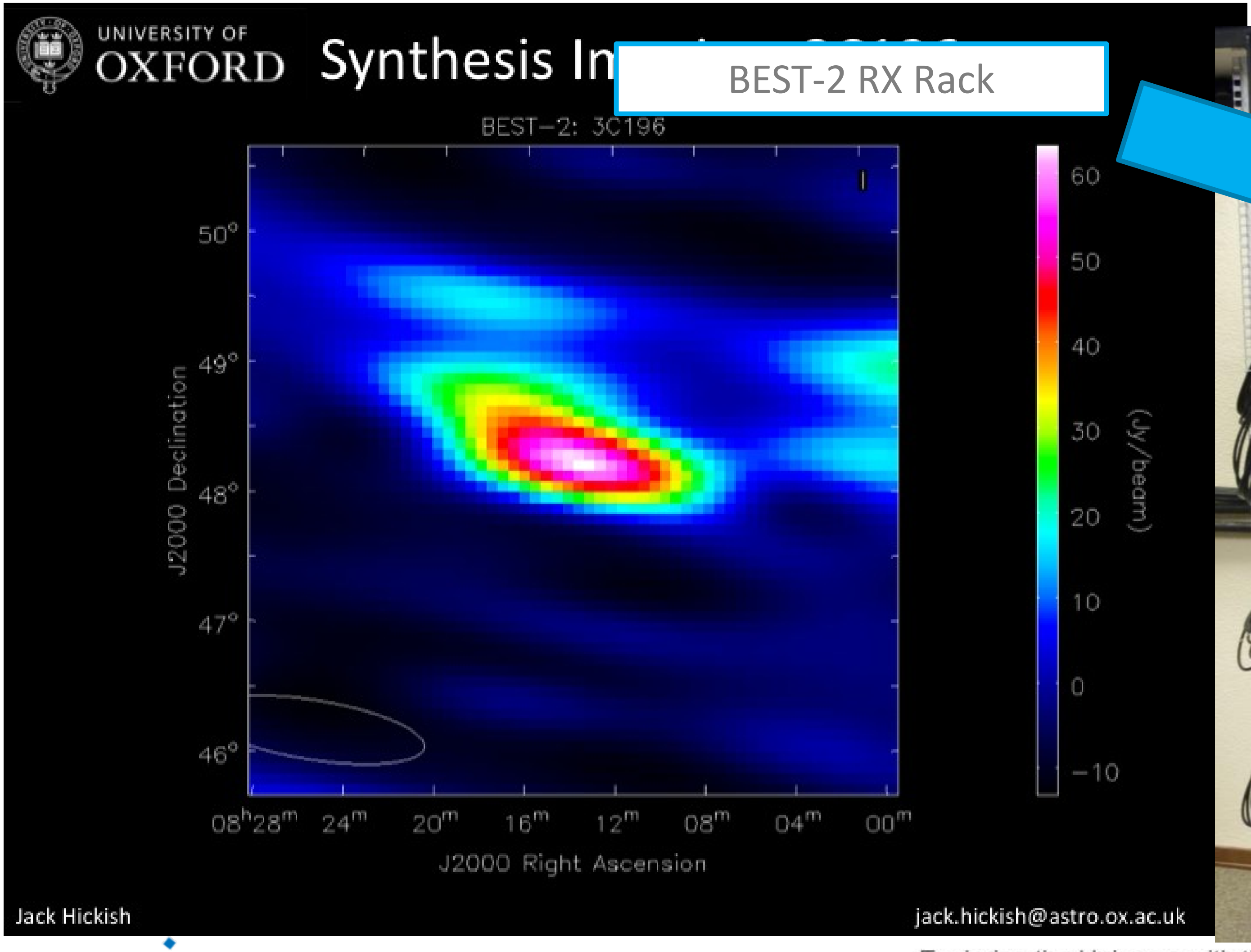






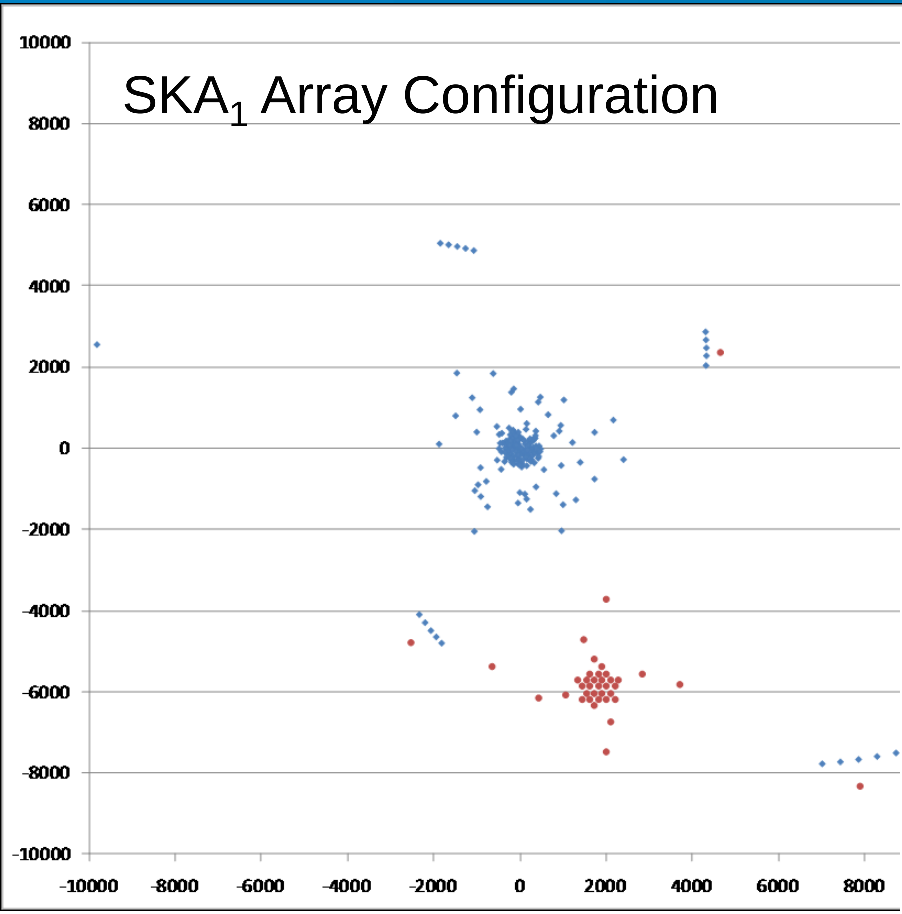


Dynamic range



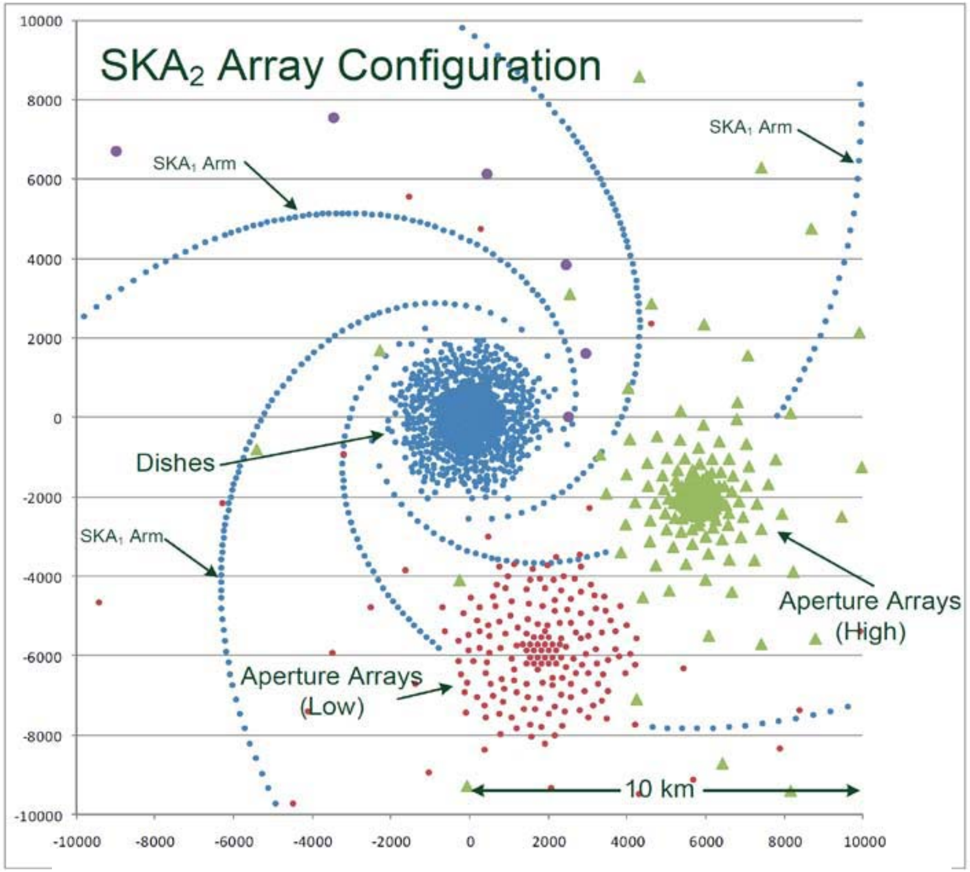
BEST-2 RX Rack

From SKA1 to SKA2



Nstation=50

Max Baseline=100Km



Nstation=250

Max Baseline=180Km

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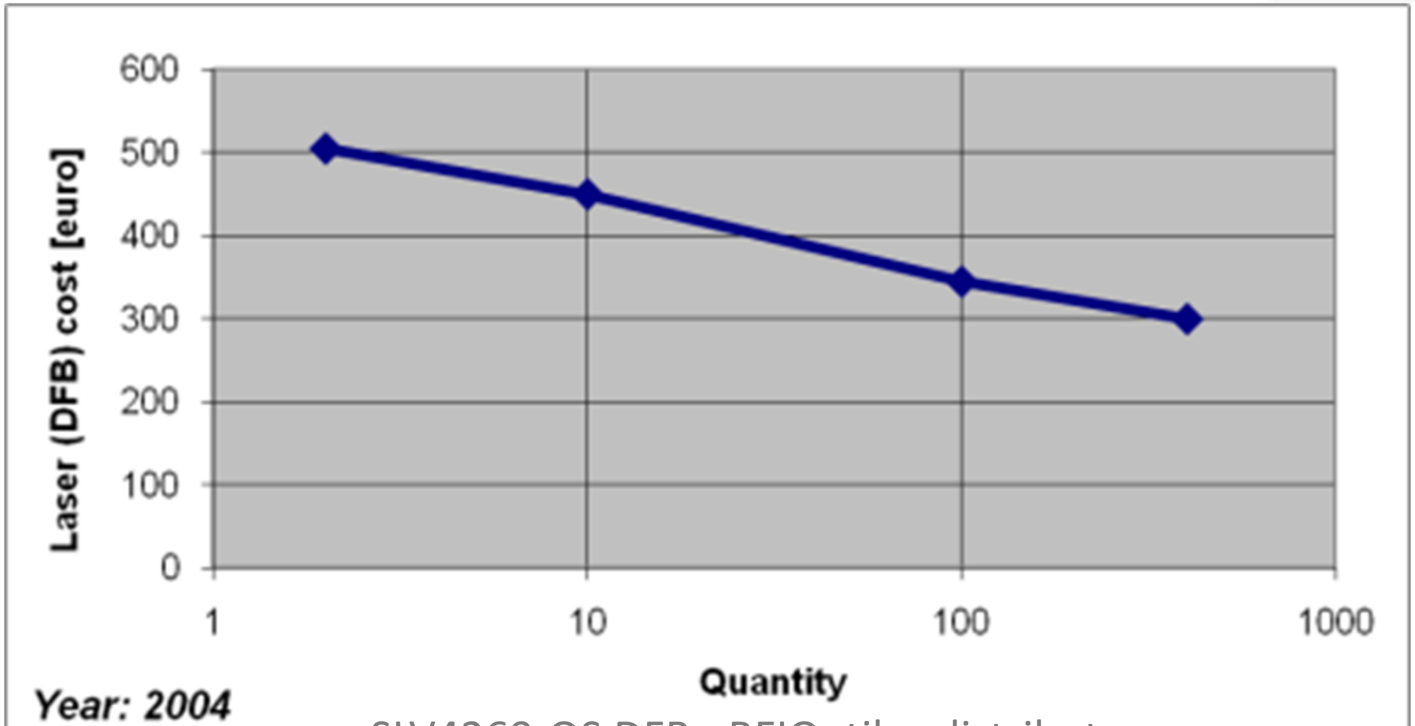
Quantity and Cost

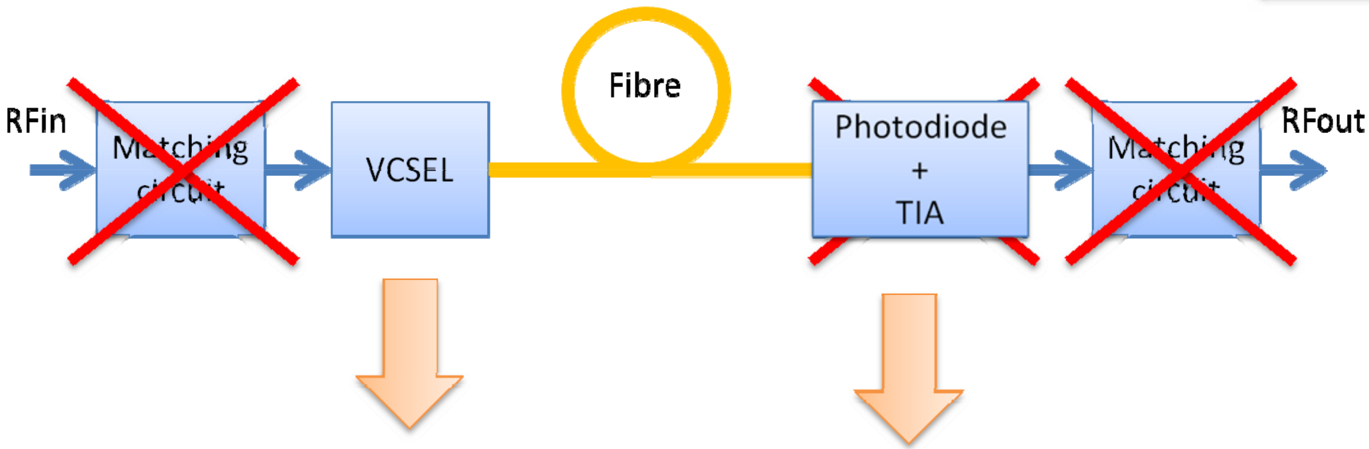


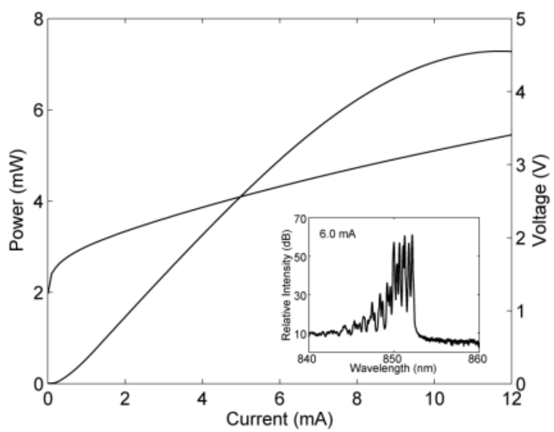
SLV4260-QS DFB - BFIOptilas distributor

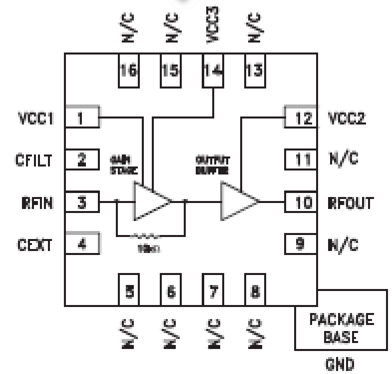
RoF links: 500-1000€ (Commercial & Custom, DFB, SMF, APC connectors)

Commercial VCSEL/TOSA and PD/ROSA for few € even for small quantity

Power Consumption





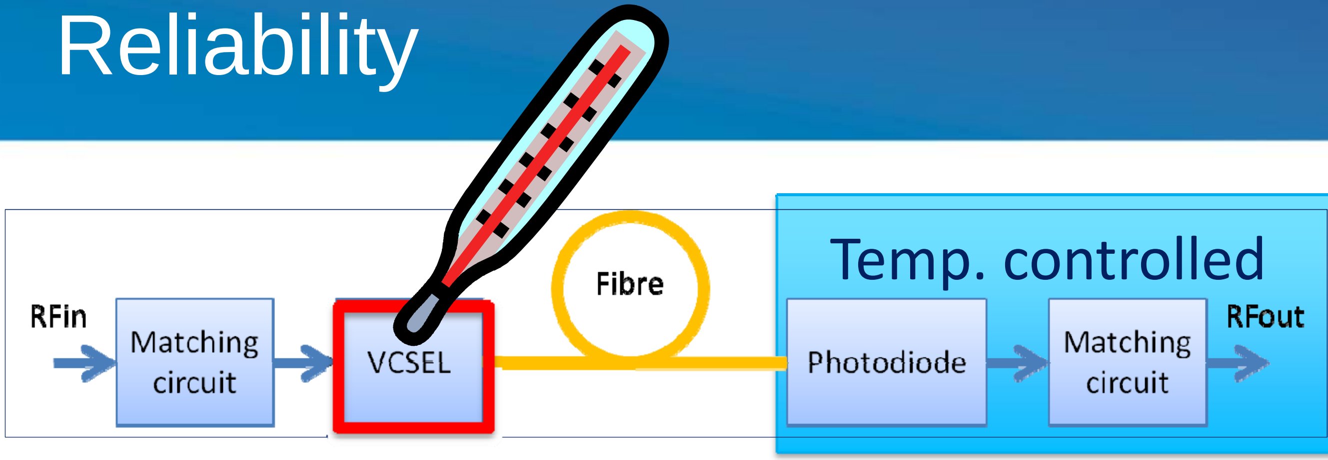


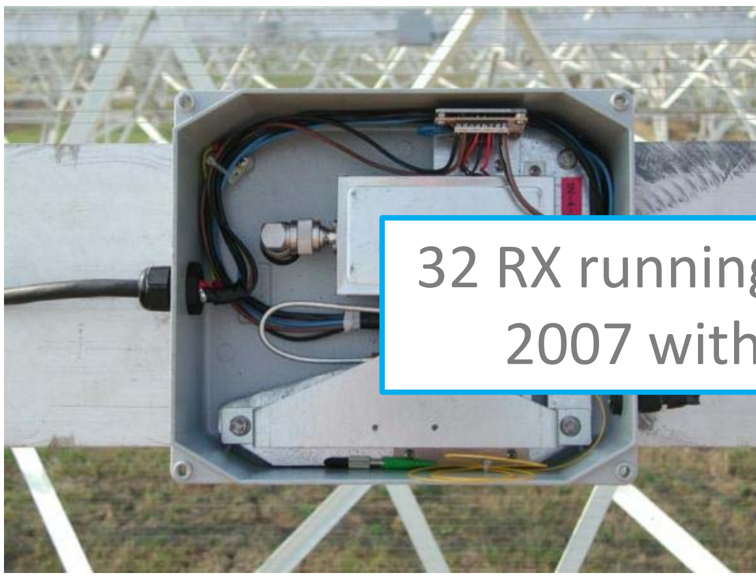
HMC799LP3E

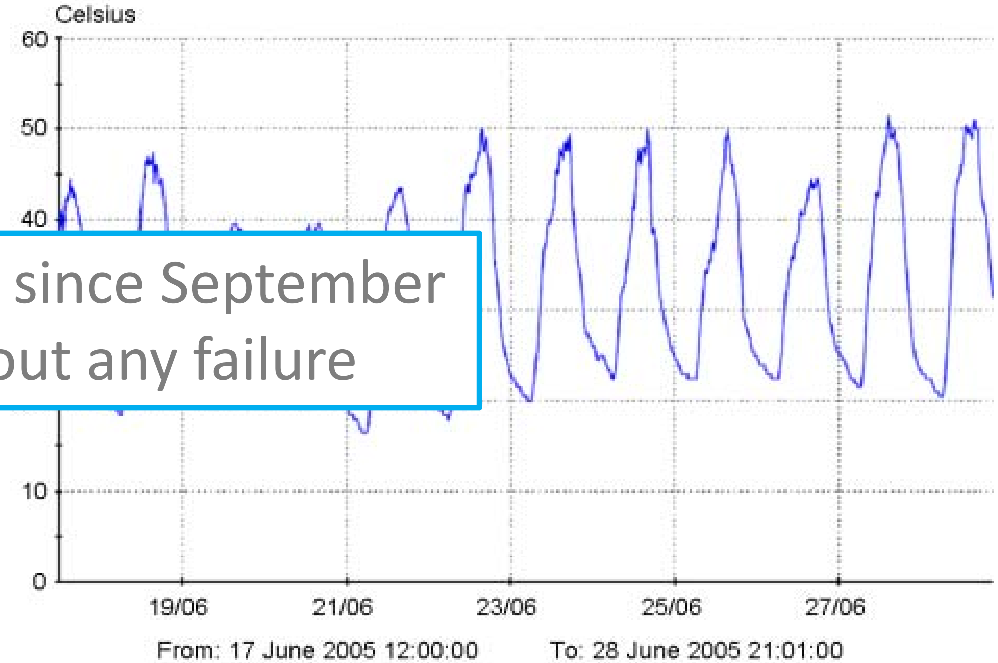
P_{tx}=25mW (Id=7mA, Vd=3V)

P_{rx}=350mW (Id=70mA, Vd=5V)

Reliability





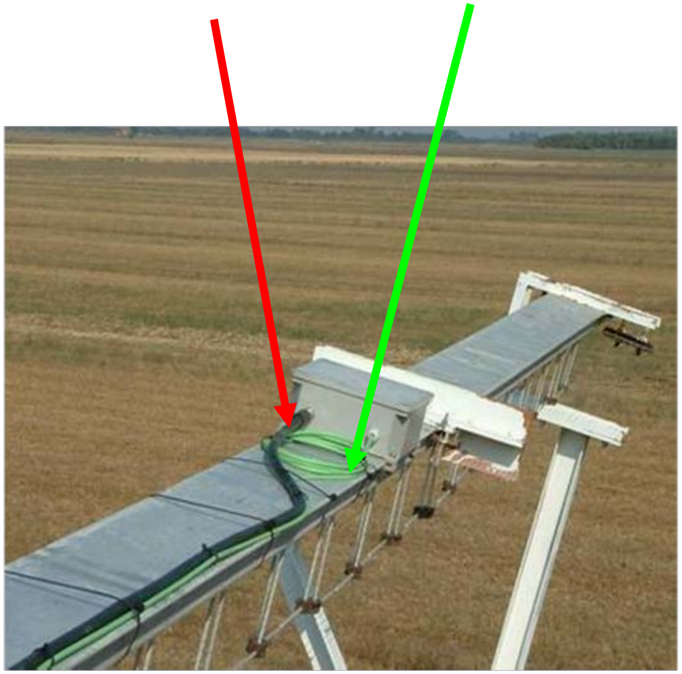


32 RX running since September 2007 without any failure

Reliability

Coax vs Fibre

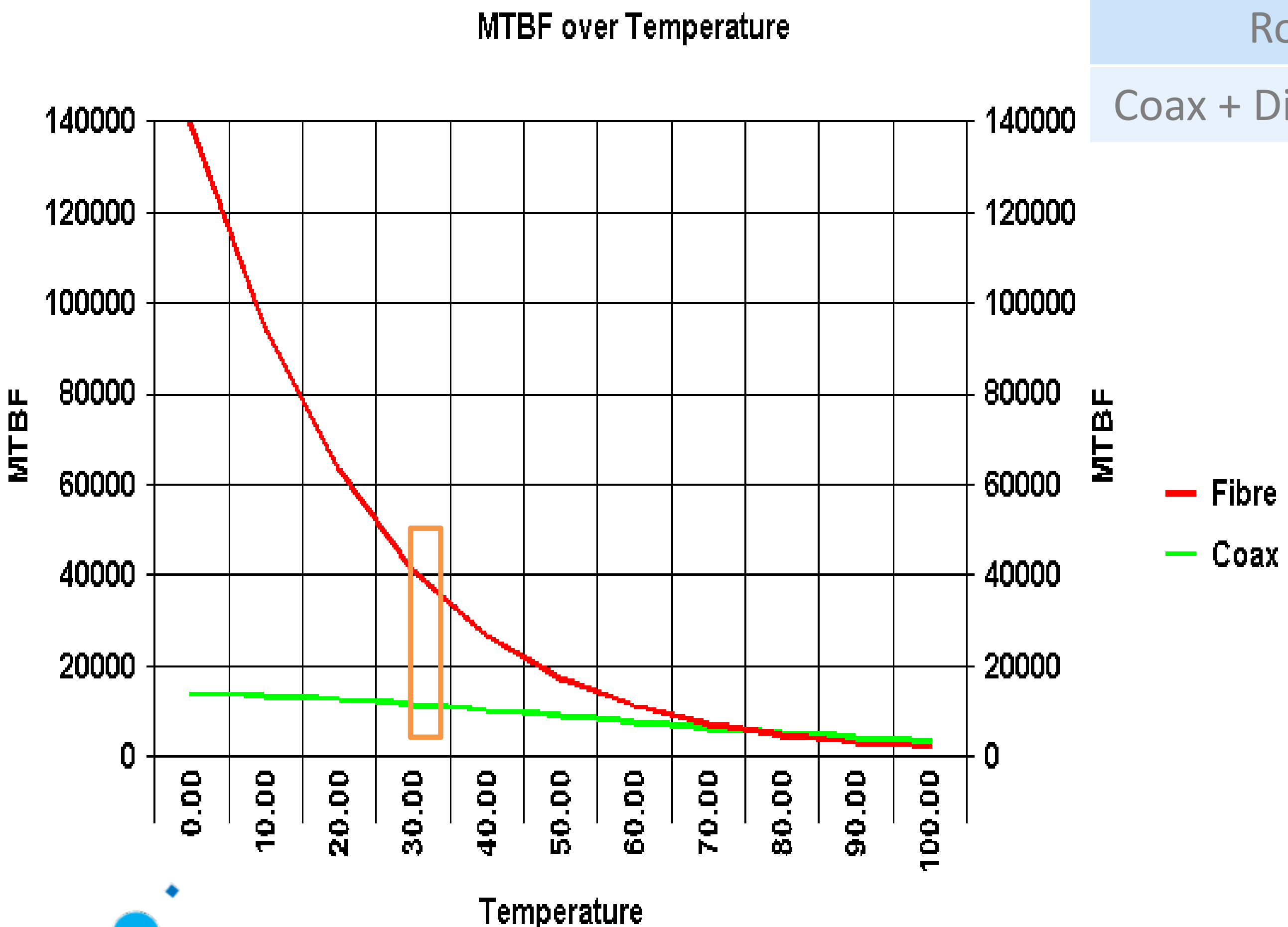
Coaxial cables to external cabins where signals can be digitized and sent via Fast Ethernet links to the processing room



Analogue Optical Links directly from Focal Lines to the Processing Room

The costs of both of them are very similar (hardware and manpower)
Which solutions?

Reliability



BEST architecture	MTBF
RoF	37137h -> ~4.2y
Coax + Digital link	10624h -> ~1.2y

- MIL-HDBK-217-FN2 data base
- series reliability model
- 100% duty cycle
- operating temperature: 30°C
- environments:
  - GM (Ground Mobile) for antenna equipment
  - GF (Ground Fixed Uncontrolled) for cabin equipment
  - GB (Ground Benign Controlled) for processing room equipment

Risks

- Ad hoc VCSEL chip: costs and performances

?

- Lack of scientists to deeply evaluate the systems through observations, tests and experiments…

Future Plans

- Collaboration with CNR – IEIIT (Turin)

U·L·M PHOTONICS

VERTILAS

CHALMERS

- AAVS0 (9 dual pol. elements array - low sensitivity)

- Comparison of VCSEL/MMF with DFB/SMF using:
  - -BEST2: 32 elem. 2D, A_c=1400m^2
  - -BEST3-lo: 16 elem. 1D, A_c=800m^2

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Thanks!