DBBC - A VLBI backend family

G. Tuccari

DBBC (Digital Base Band Converter) family:

- **VLBI back-ends**
- **VLBI network shifters**
- **VLBI data buffers**
- **VLBI digital receivers**

General Functionality
VLBI Schematic Block

Requirements of the backend area

- Demand for an always wider bandwidth: receivers, data transport and correlators play their role, but backend should not be the bottle-neck
- New fast and powerful technologies are every day available
- New connectivity through a fast network is every day increasing
- Improvement of the phase stability in the entire signal path is a must
- Obsolescence and difficulties in the analogue systems maintenance
- New radiotelescopes need new equipment
- More flexibility in number of bands and/or polarization
- More reliability

The need for a fully digital VLBI backend

- ‘Digital Radio’ technology becomes familiar within new telecommunication developments requiring frequency conversion
- Technology ready for the VLBI needed performance
- A new generation of stations without any VLBI terminal could also greatly benefit from the digital backend development

Why more Digital?

Digital is completely deterministic

Precise and predictable modelling/performance

Amplitude/Phase characteristics stable as sampling clock

Wider, flatter pass-band, well matched between systems

No dispersion and group delay distortion across the pass-band

Why more Digital? (cont)

Much more compact implementation

One hardware platform for many architectures and functions

Cost effective for high performance multi-channel systems

Process numerical with all the related implications

RFI Mitigation can be greatly simplified

How to take this into consideration?

A general worldwide trend is to use more digital and less analog for predictability, repeatability, precision, etc. In radio technology this means to perform the conversion from

ANALOG to DIGITAL

anticipating in the processing time as much as possible

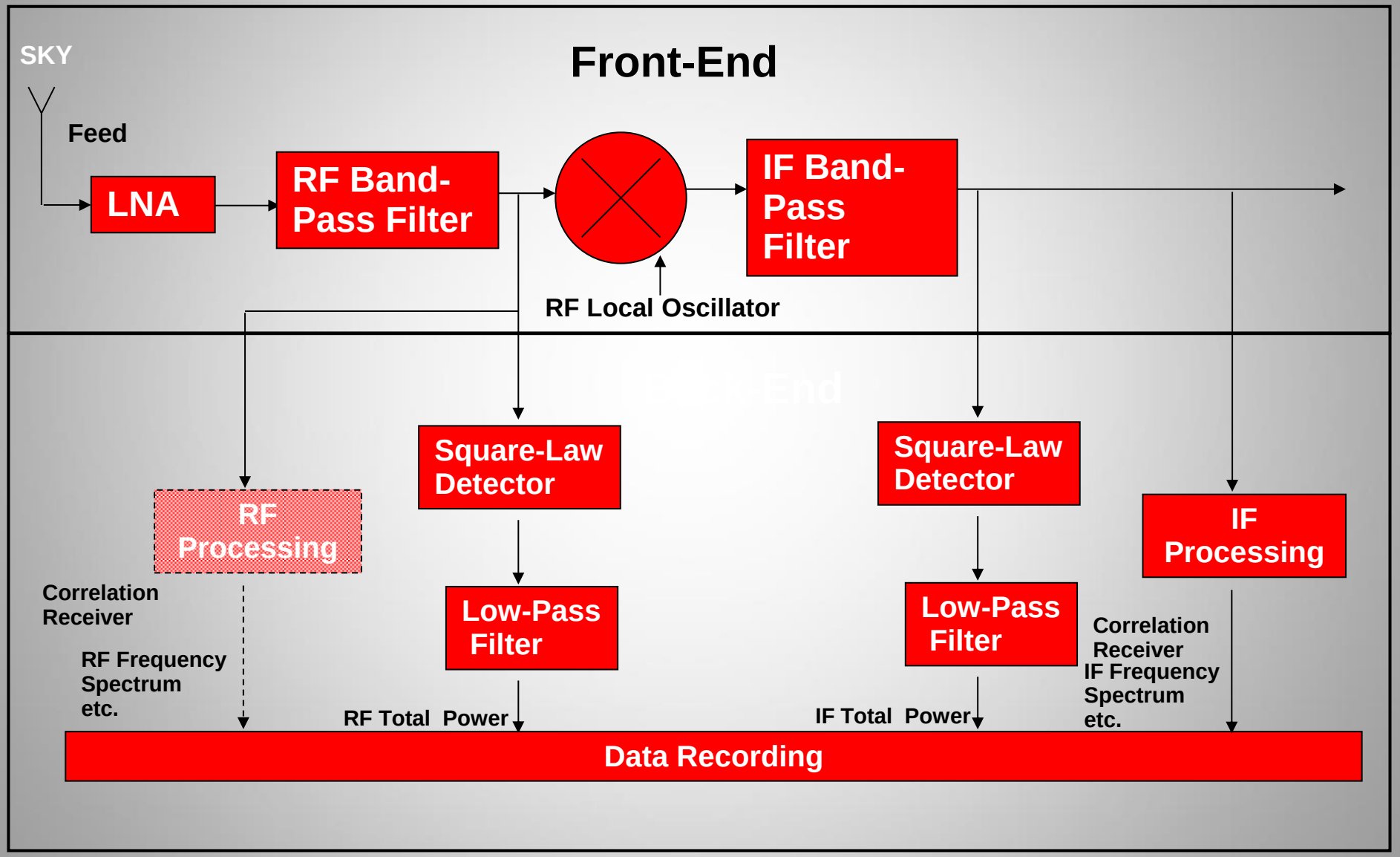
and then use

DIGITAL SIGNAL PROCESS

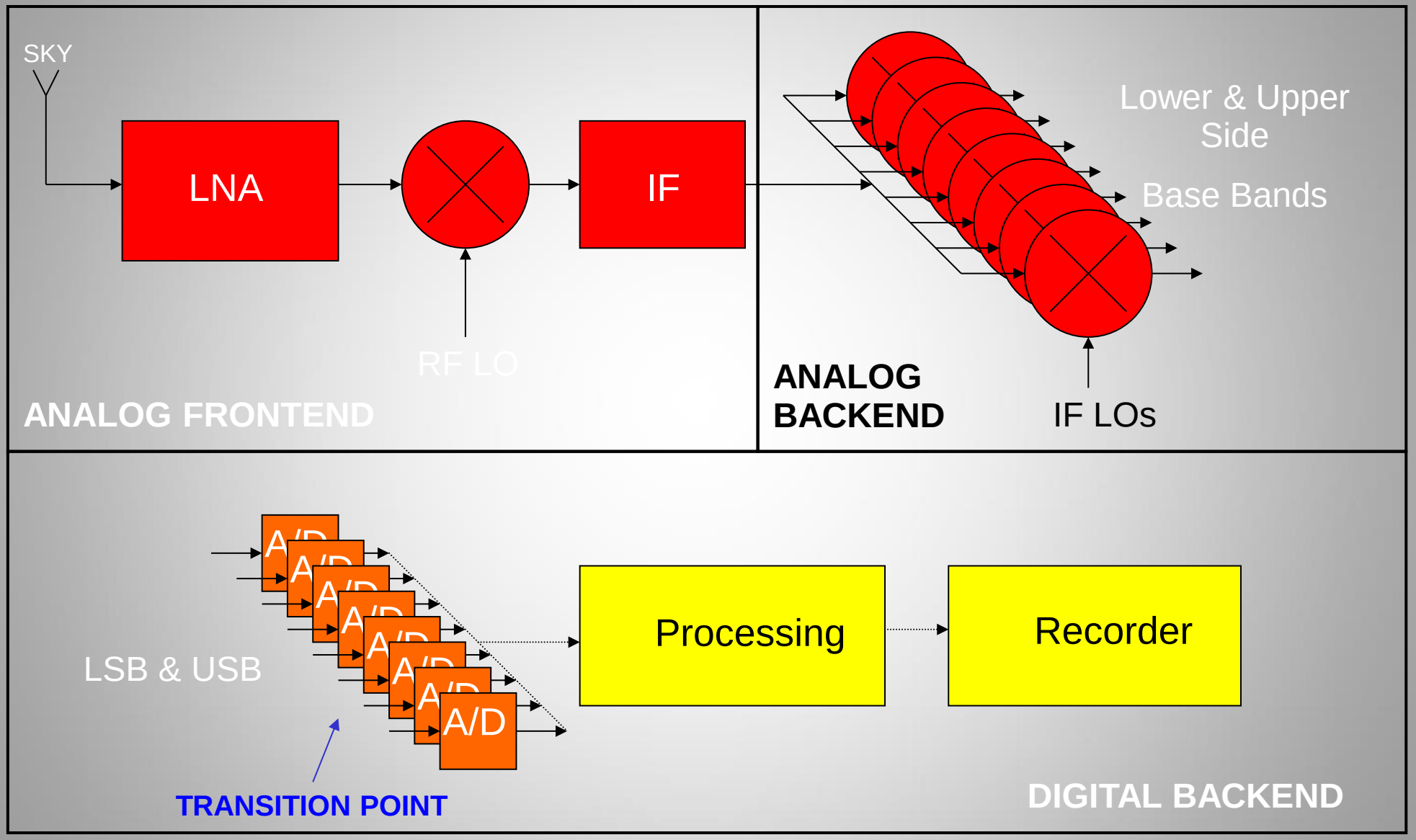
General Functionality
Backend Schematic Block

Analogue to Digital Domain Conversion → **Digital Base Band Forming** → **Output Streaming**

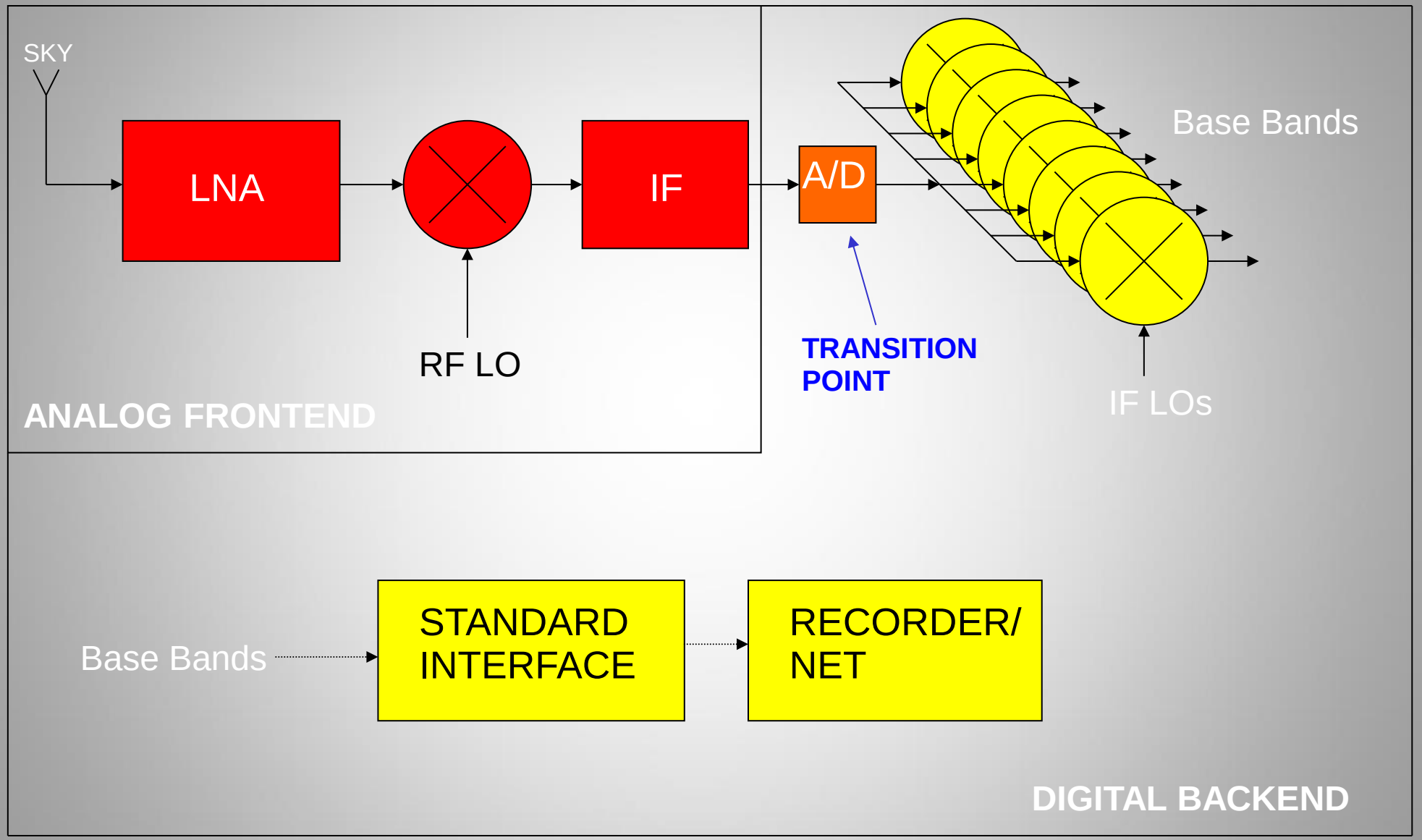
Receiving and Acquisition Chain in the Radiotelescope



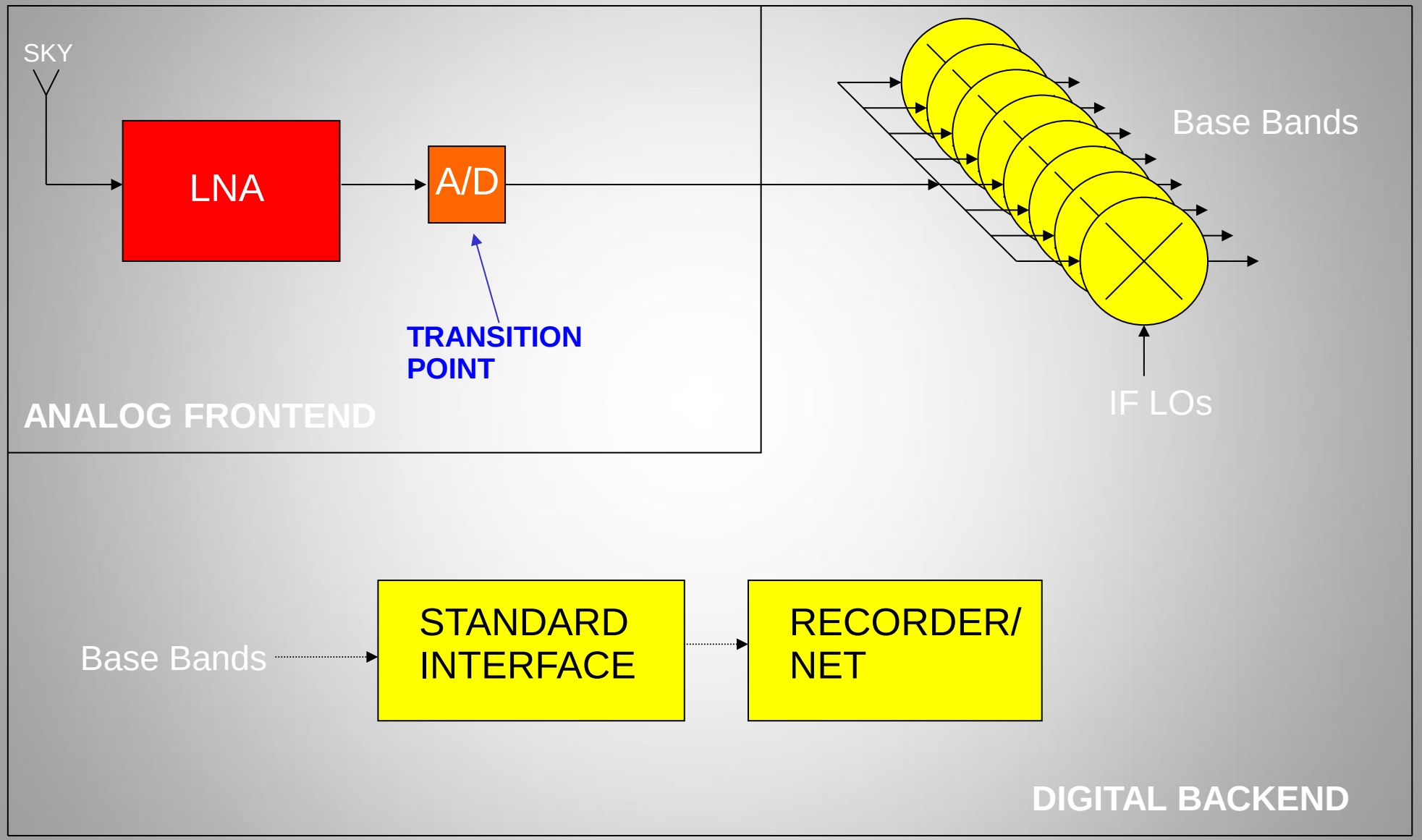
Front- and Back-End Multichannel Chain



Advanced Front- and Backend Chain

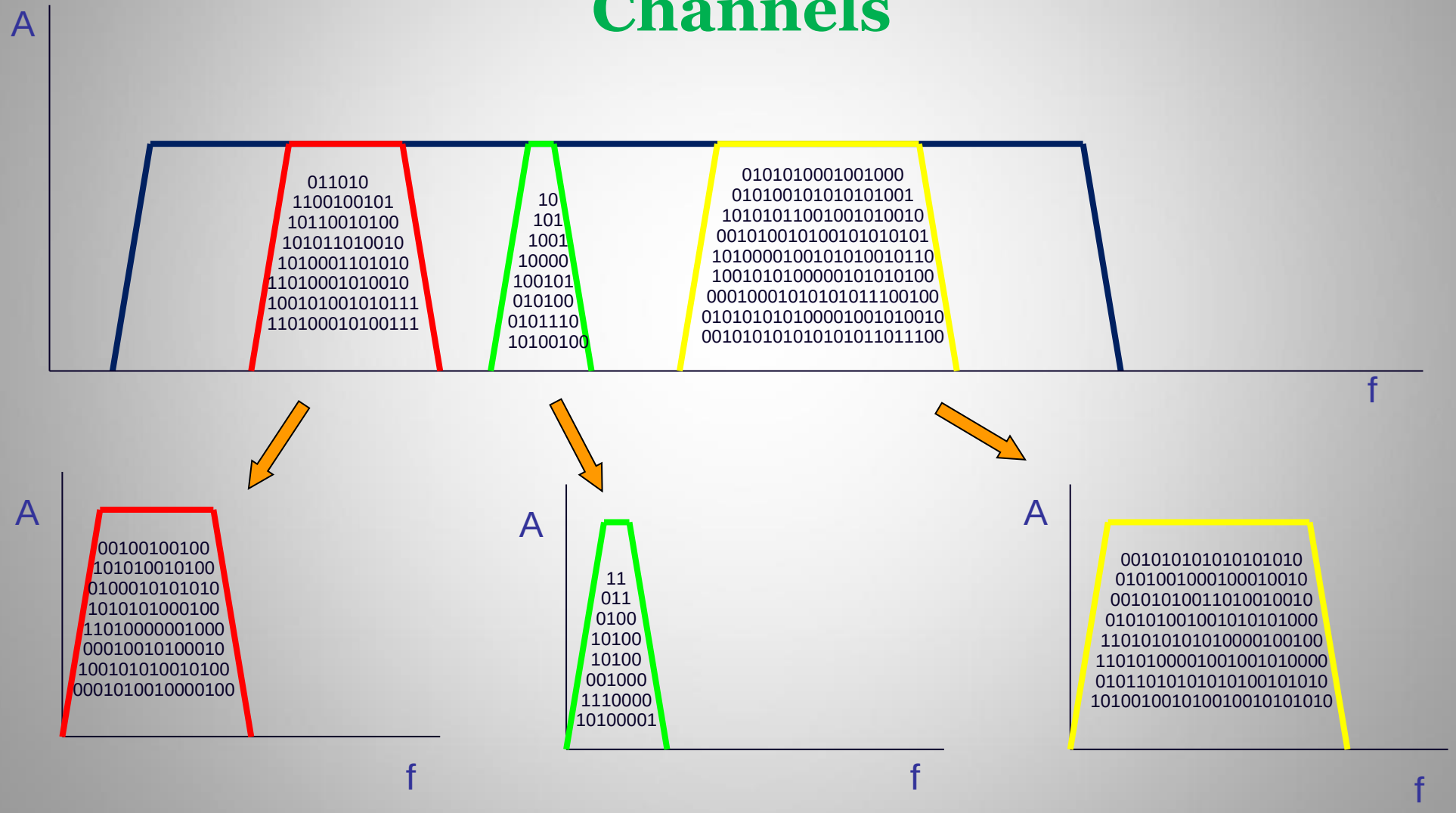


Advanced Front- and Backend Chain



Different modes for converting in a digital backend

DDC - Digital Down Conversion to Base Band of Independent Channels



DDC - Digital Down Converter Configuration

• Direct conversion typically between high data rate sampled IF band and lower data rate base band

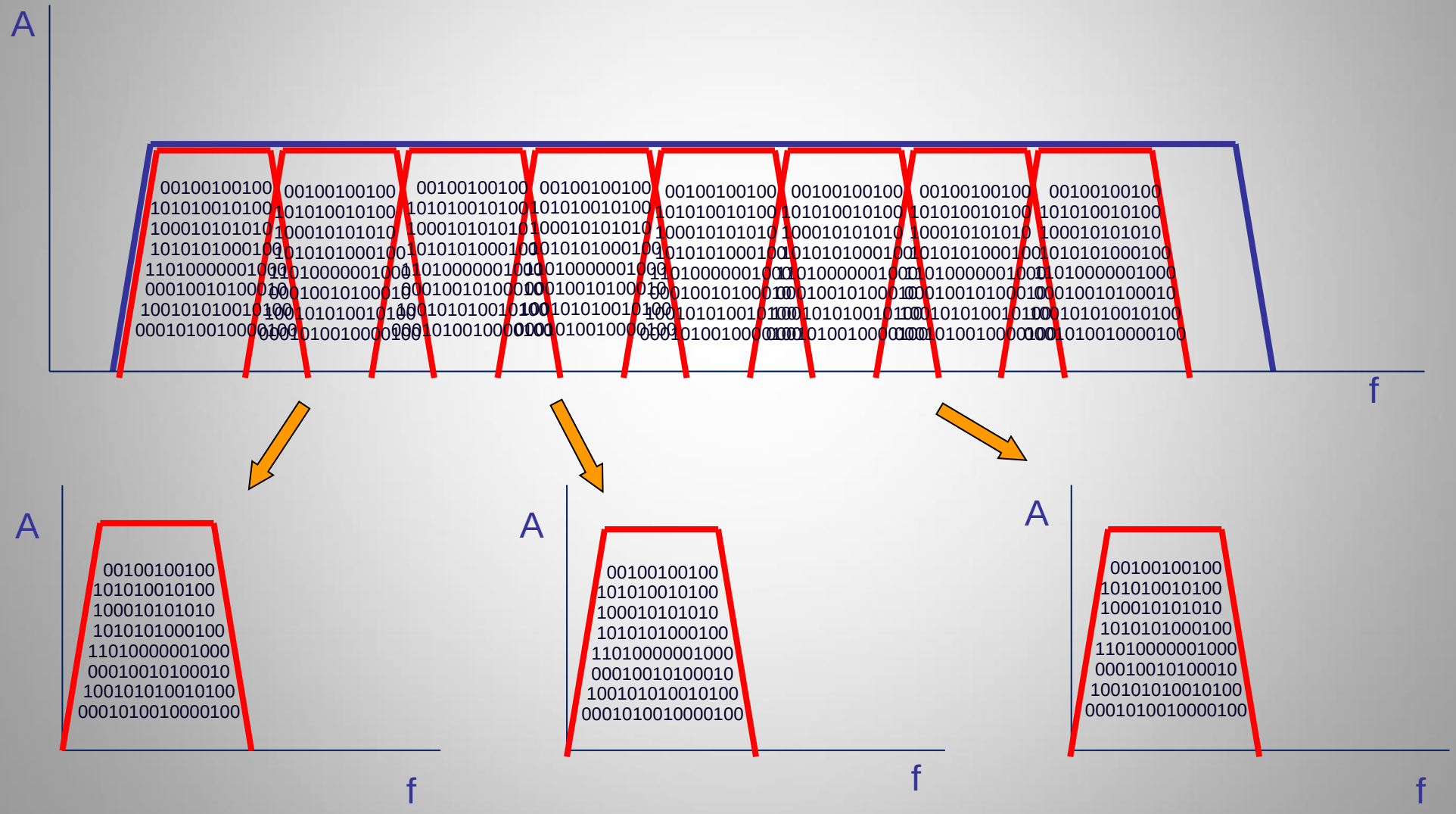
• LO as a Numerically Controlled Oscillator

• Mixer as Complex as Look Up Table multiplier

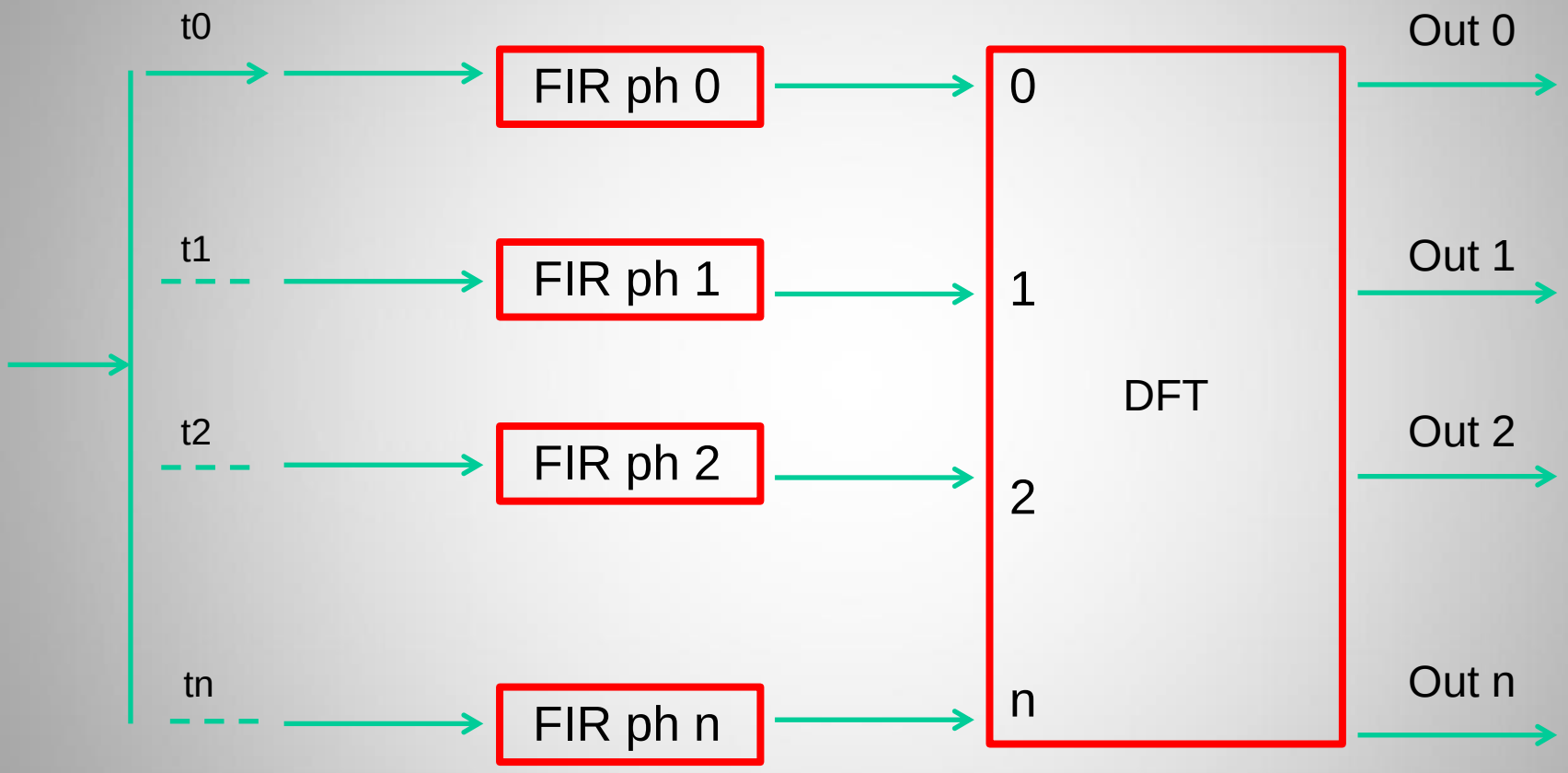
• Low-pass band filter Finite Impulse Response (FIR) filters cascade

• Decimation because of the high ratio between IF and output data rate performed with multirate/multistage FIR

PFB - Multi Equispaced Channel Conversion to Base Band Polyphase Filter Bank



PFB – Poly Phase Filter Bank Solution



DSC – Direct Sampling Conversion

DBBC Back-ends evolution

DBBC1 2004 - 2008

in: 4 x IF-512MHz

out: **DDC** 16 x bbc (1-2-4-8-16MHz)@32MHz

0.512/1.024 Gbps

DBBC2 2007 – today

in: 4 x IF-512/1024MHz

out: **DDC** 16 x bbc (1-2-4-8-16-32MHz)@32/64MHz

PFB 4 x 16 x (32-64 MHz)@64/128MHz

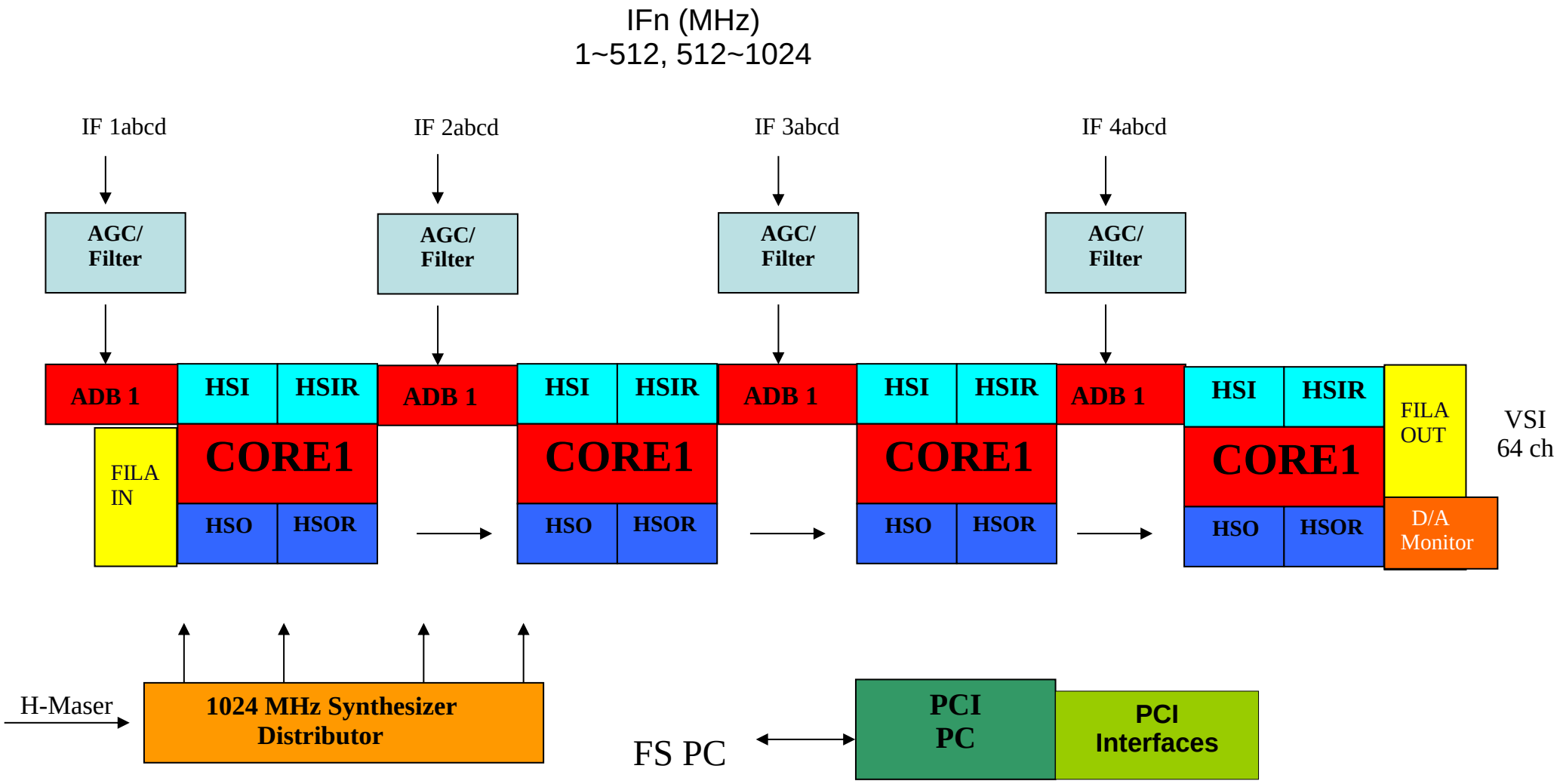
4.096/8.192 Gbps

DBBC2010 2009 – today

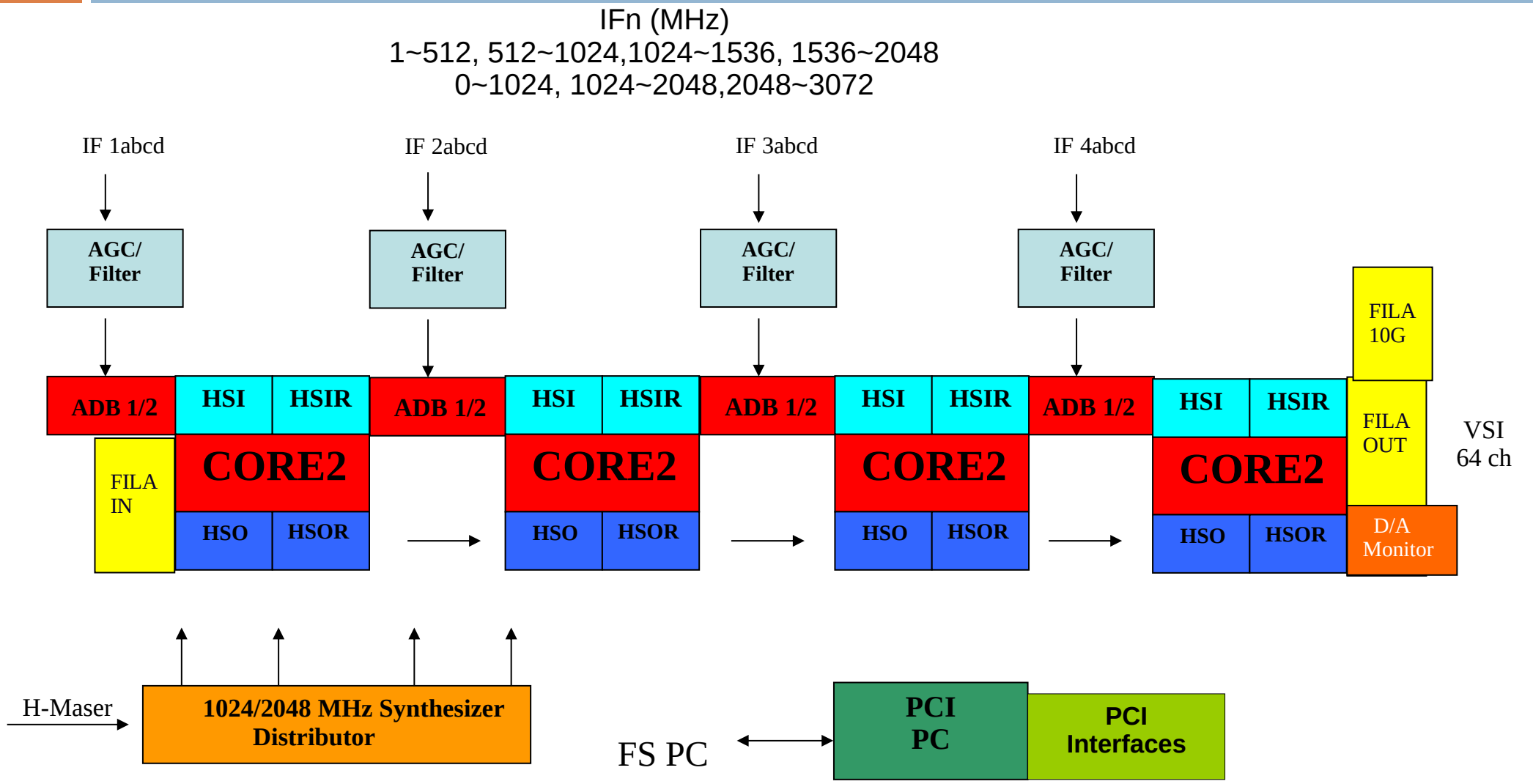
in: 8 x IF – 512/1024MHz

out: **PFB** / **DSC** **16.384/32.768 Gbps**

DBBC1 Architecture



DBBC2 Architecture



The evolution is Radionet3 JRA project

DBBC3 dedicated to:

Astronomy

- **EVN wide-band VLBI backend**
- **mmVLBA network**
- **EHT (Event Horizon Telescope)**

Geodesy

- **VGOS broad-band VLBI system**

DBBC Back-ends evolution

DBBC3L (-2L2L/H) 2014 – today **EVN32Gbps/ EHT**

in: 2 x IF-4096 / 4 x IF-2048 / 8 x IF-1024

out: **DSC** 1024 - 2048 - 4096 MHz

DDC 2-4-8-16-32-64-128 MHz

PFB 32 - 64 - 256 MHz

16/32 Gbps

DBBC3L (-4L4H) 2014 – today **VGOS half-compliant**

in: 4 x IF-4096 / 8 x IF-2048 / 16 x IF-1024

out: **DSC** 1024 - 2048 - 4096 MHz

DDC 2-4-8-16-32-64-128 MHz

PFB 32 - 64 - 256 MHz

16/32/64 Gbps

DBBC Back-ends evolution

DBBC3L (-8L8H) 2014 - today **VGOS full-compliant**

in: 8 x IF-4096 / 16 x IF-2048 / 32 x IF-1024 MHz

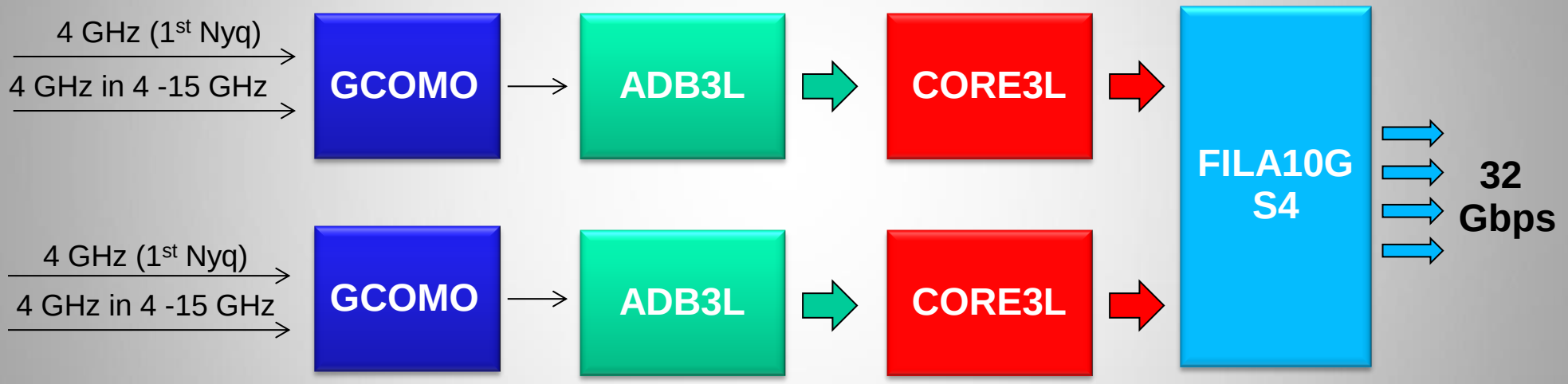
out: **DSC** 1024 - 2048 - 4096 MHz

DDC 2-4-8-16-32-64-128 MHz

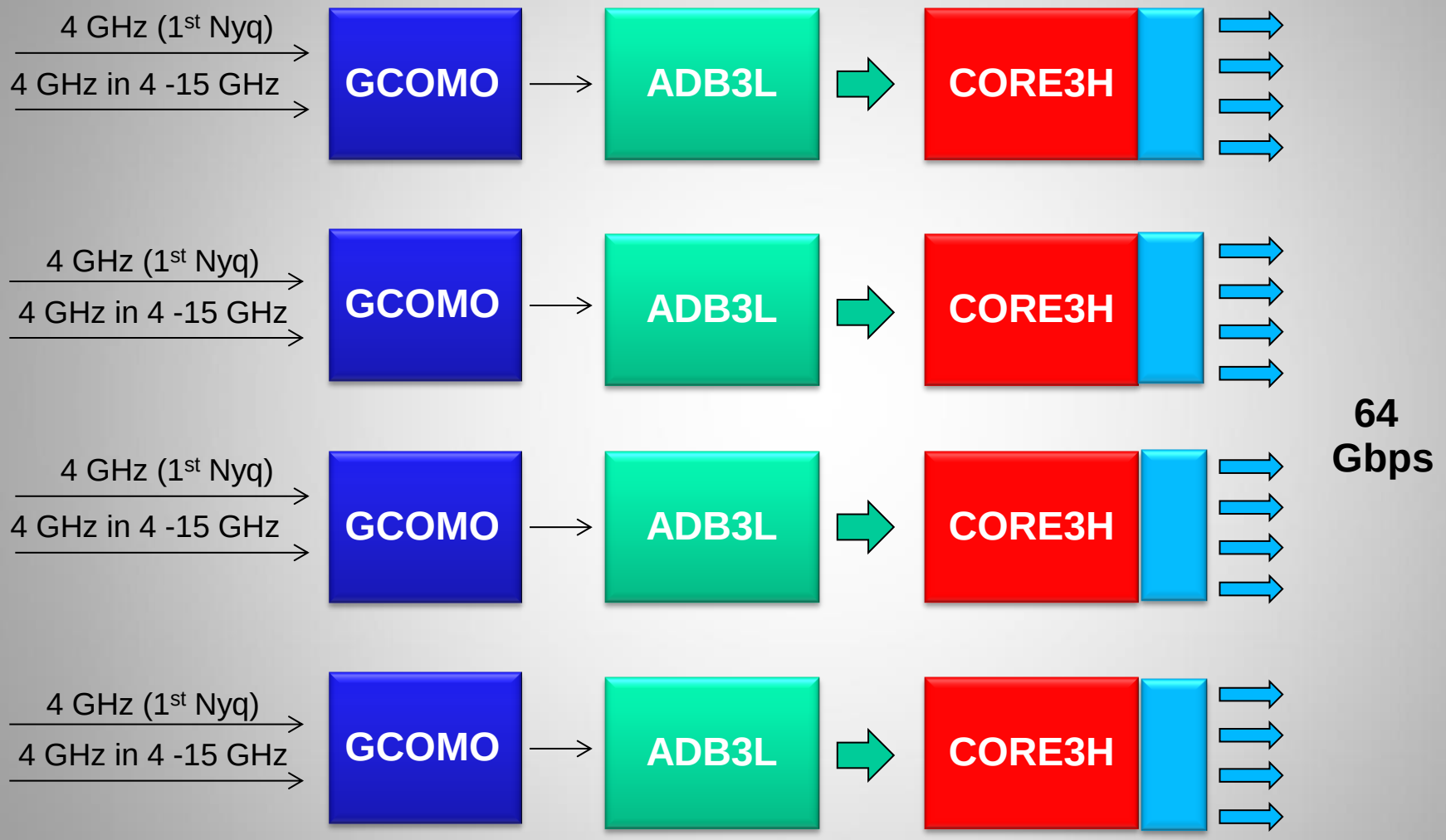
PFB 32 - 64 - 256 MHz

16/32/64/128 Gbps

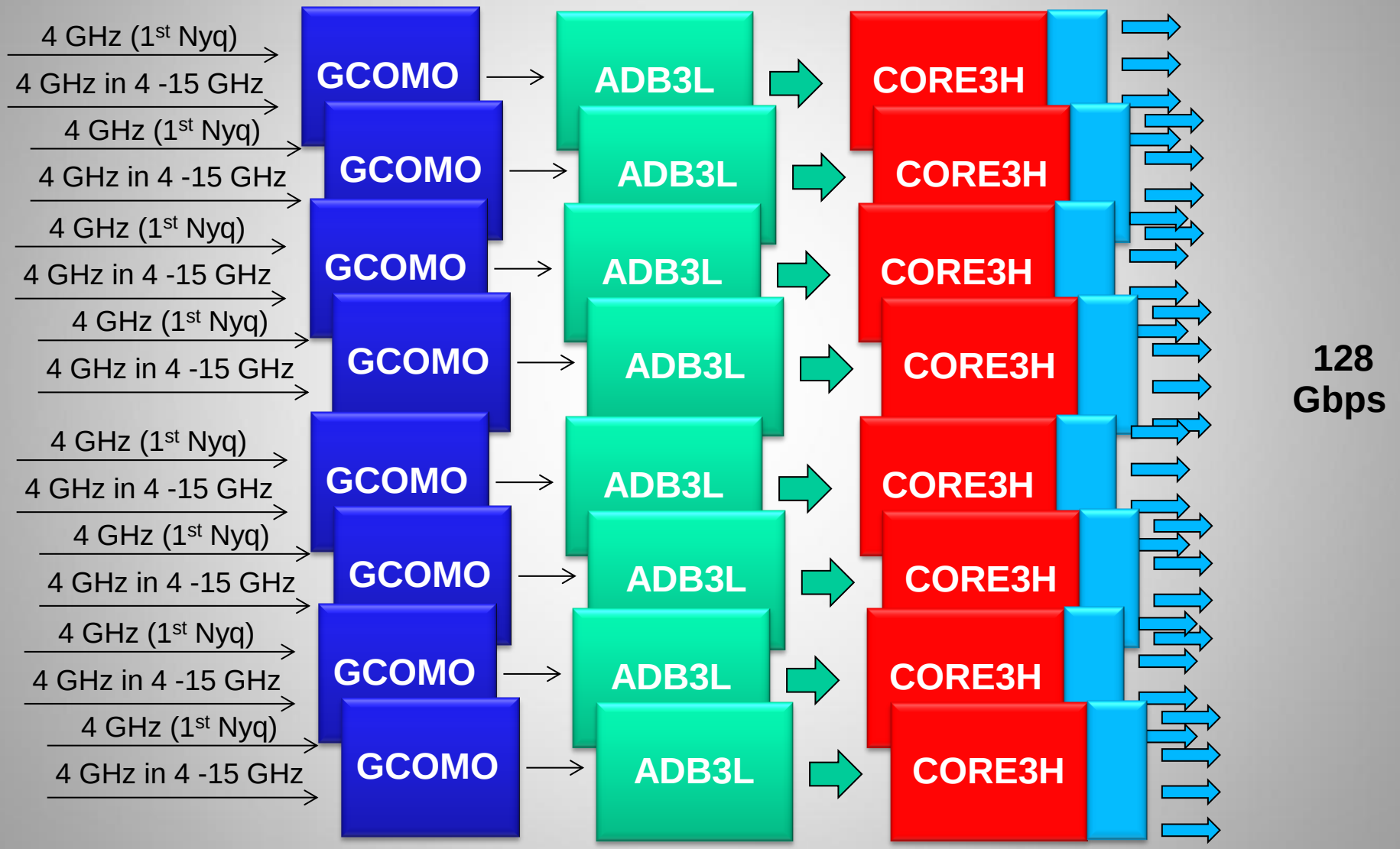
DBBC3L-2L2L Architecture



DBBC3L-4L4H Architecture

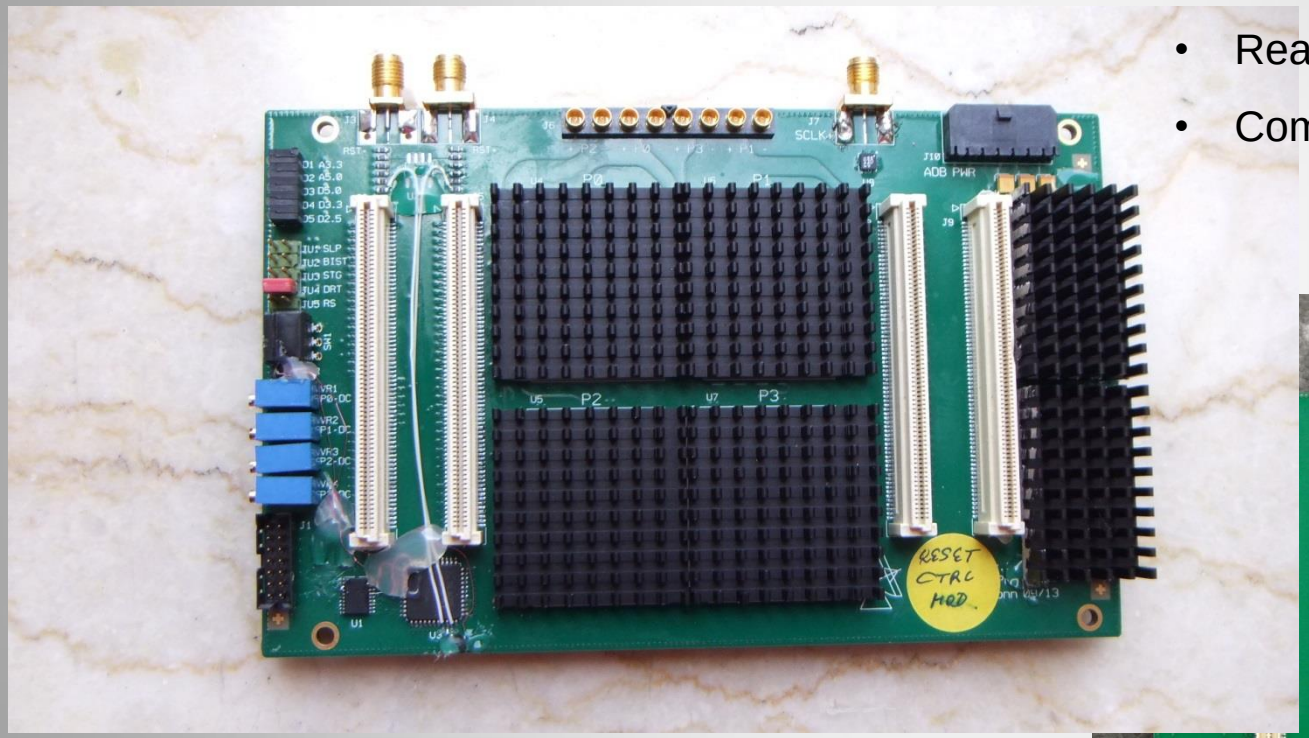


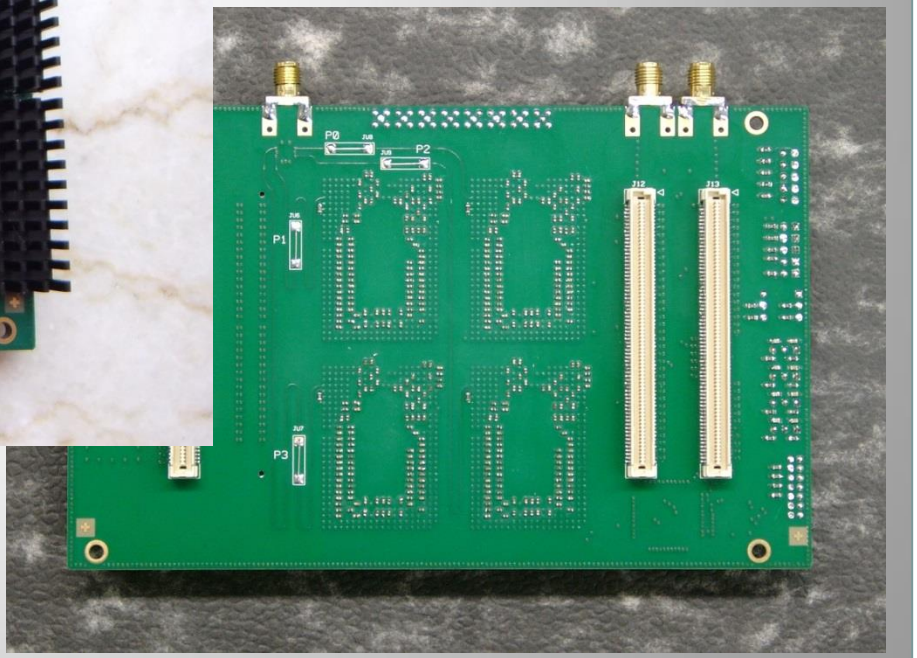
DBBC3L-8L8H Architecture



ADB3L

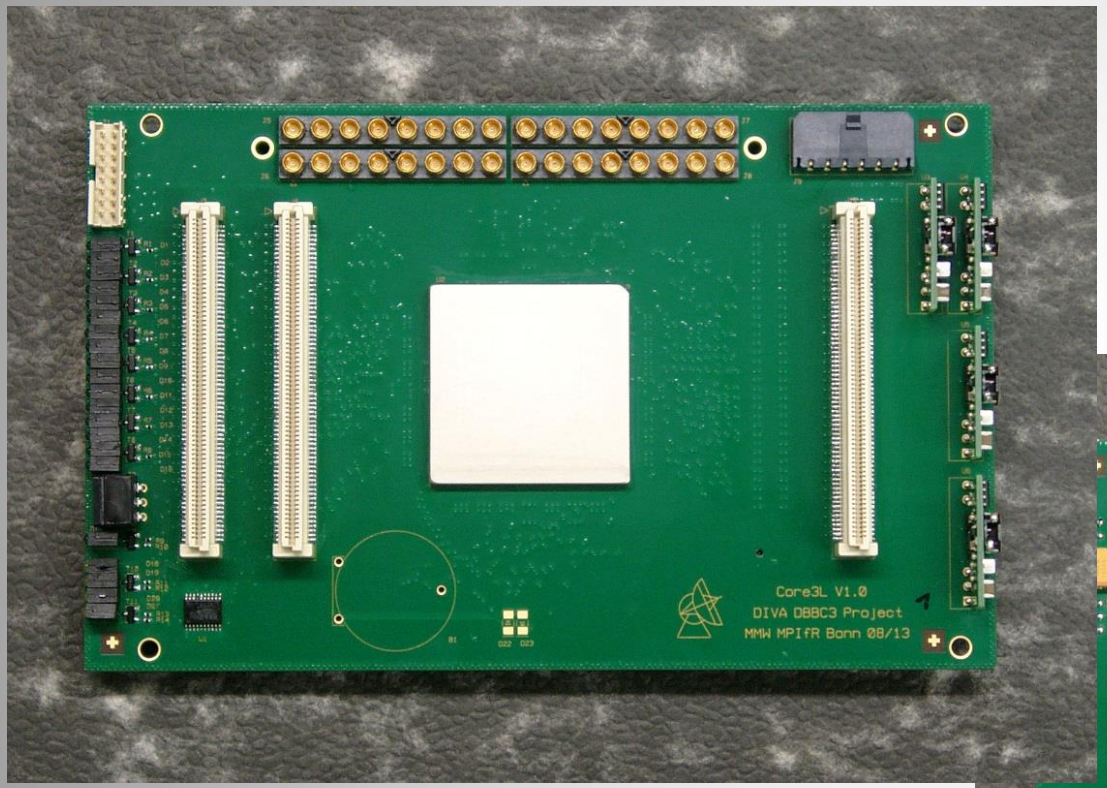
- Number of IFs: **1 - 4**
- Equivalent Sample Rate IF: **8 GSps**
- Instantaneous bandwidth: **4 GHz**
- Sampling representation: **10 bit**
- Real/Complex Sampling
- Compatibility with existing DBBC

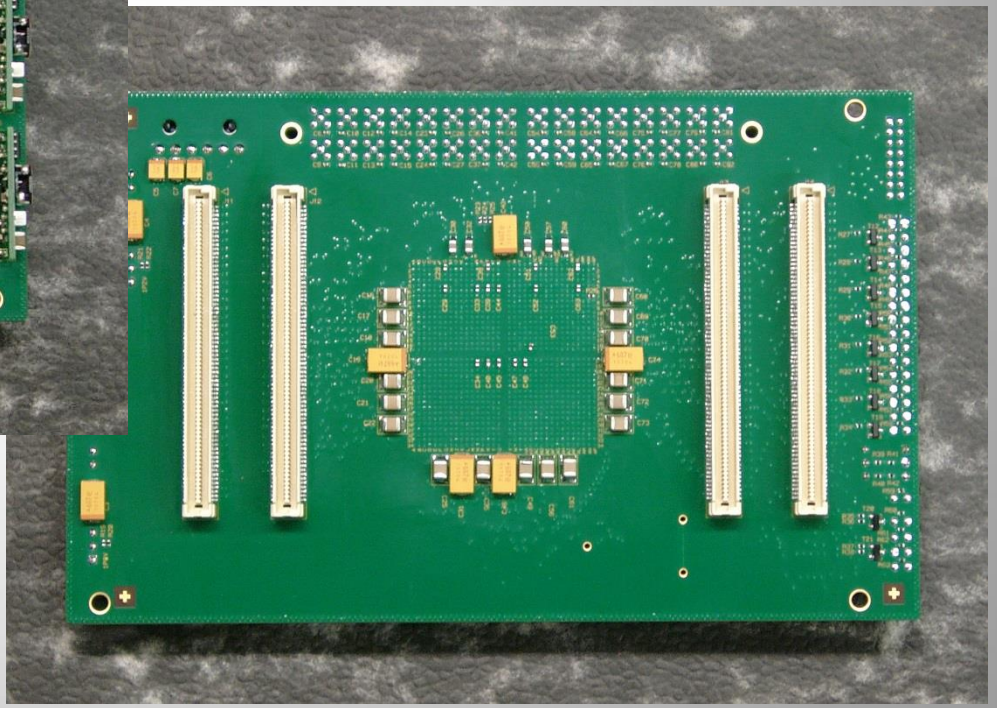




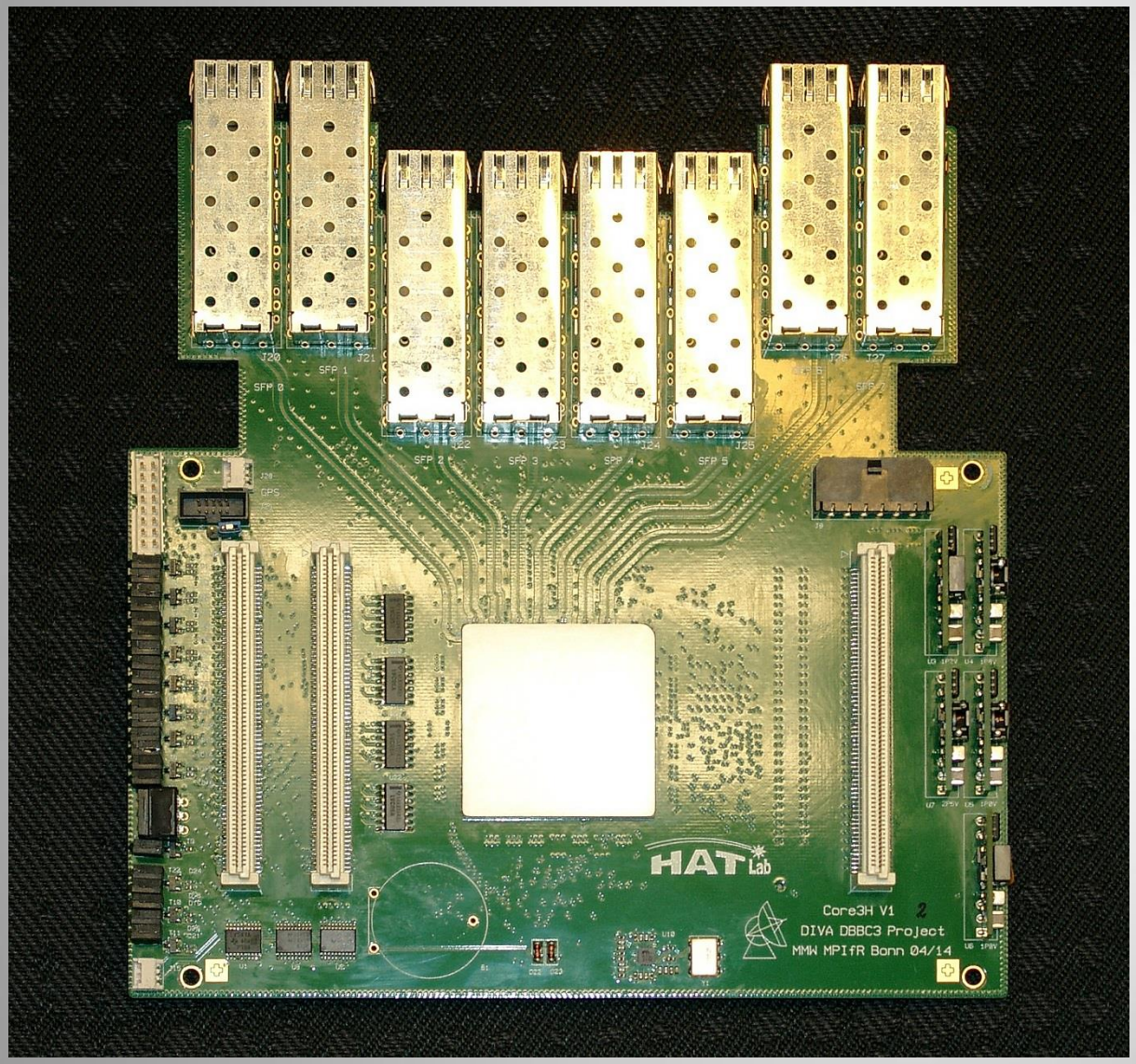
CORE3L

- Input bus: **HSI & HSI2**
- Input sampling representation: **8-10 bit**
- Input bandwidth : **1 x 4GHz, 2 x 2GHz, 4 x 1GHz**
- Processing capability: **DDC, PFB, DCS**
- Output bus: **HSO**
- Output bus mode: **DDR VSI-H**
- Inter-board bus: **4 Input + 4 output Cu 10GE**
- Compatibility with existing DBBC environment



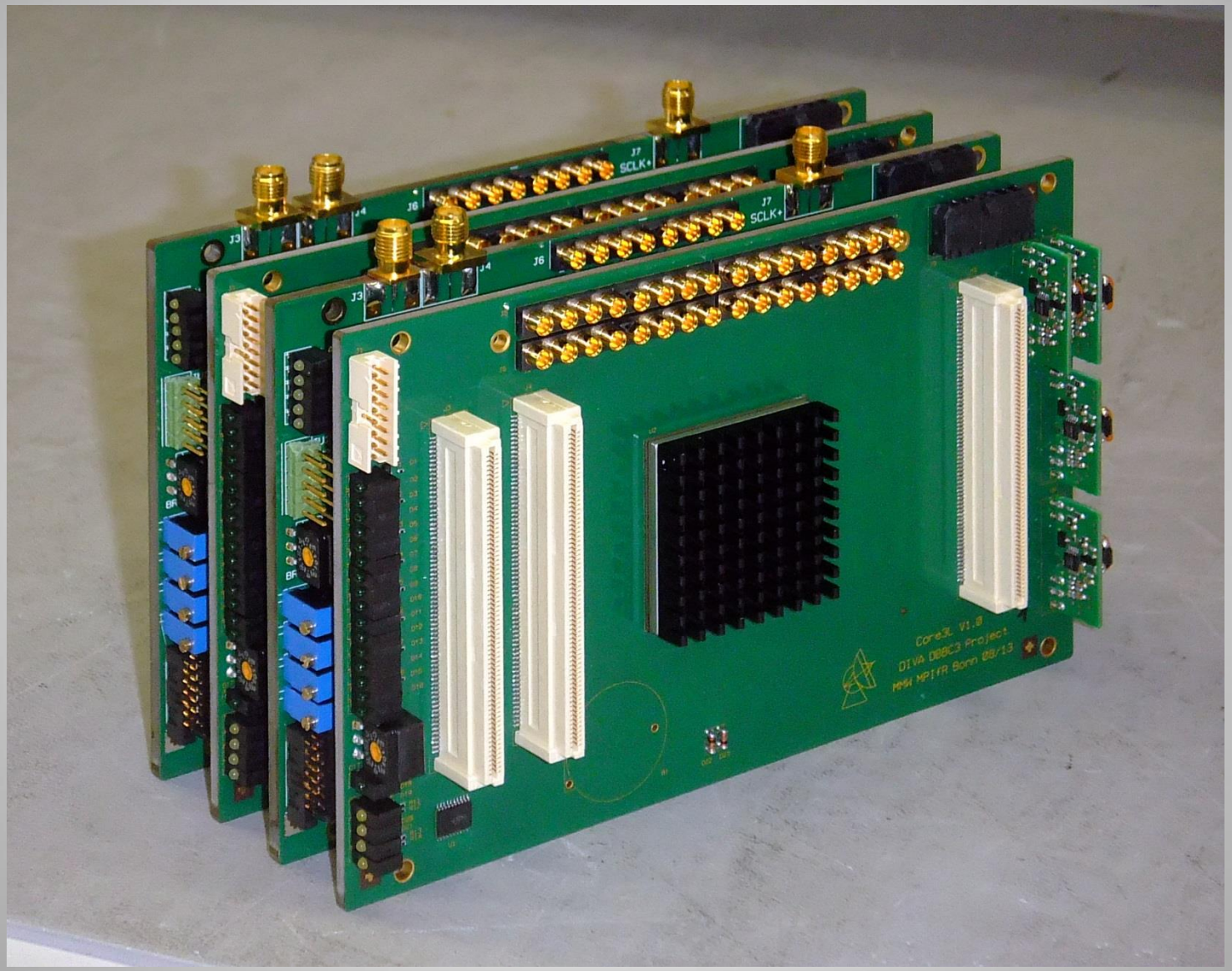


CORE3H



- Input bus: **HSI & HSI2**
- Input sampling representation: **8-10 bit**
- Input bandwidth : 1 x **4GHz, 2 x 2GHz, 4 x 1GHz**
- Processing capability: **DDC, PFB, DCS**
- Output: **8 x 10GE SFP+**
- Inter-board bus: **8 Input 10GE SFP+**
- Compatibility with existing DBBC environment

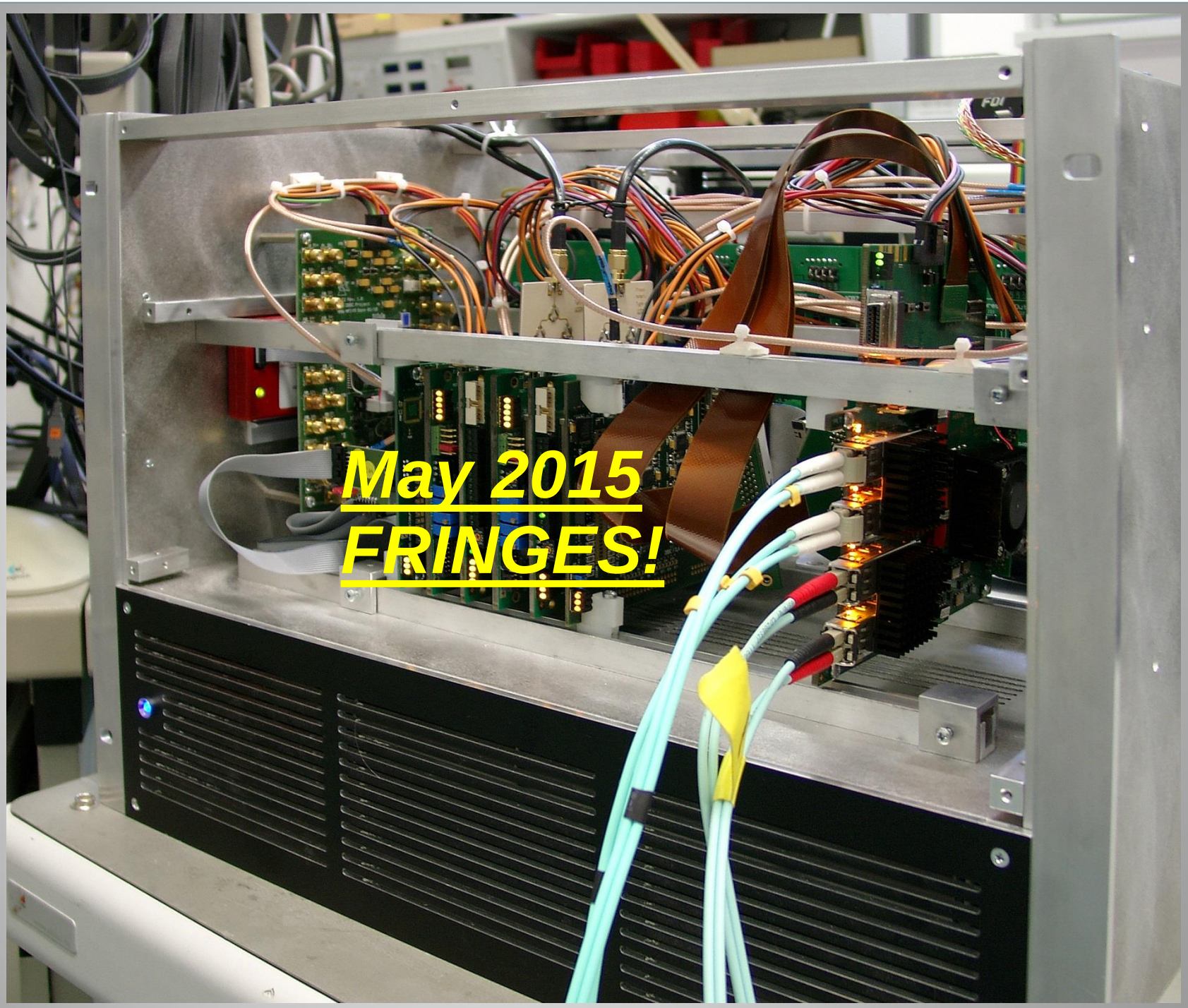
Stack with 2 ADB3L and 2 CORE3L
4 GHz bwd dual polarization



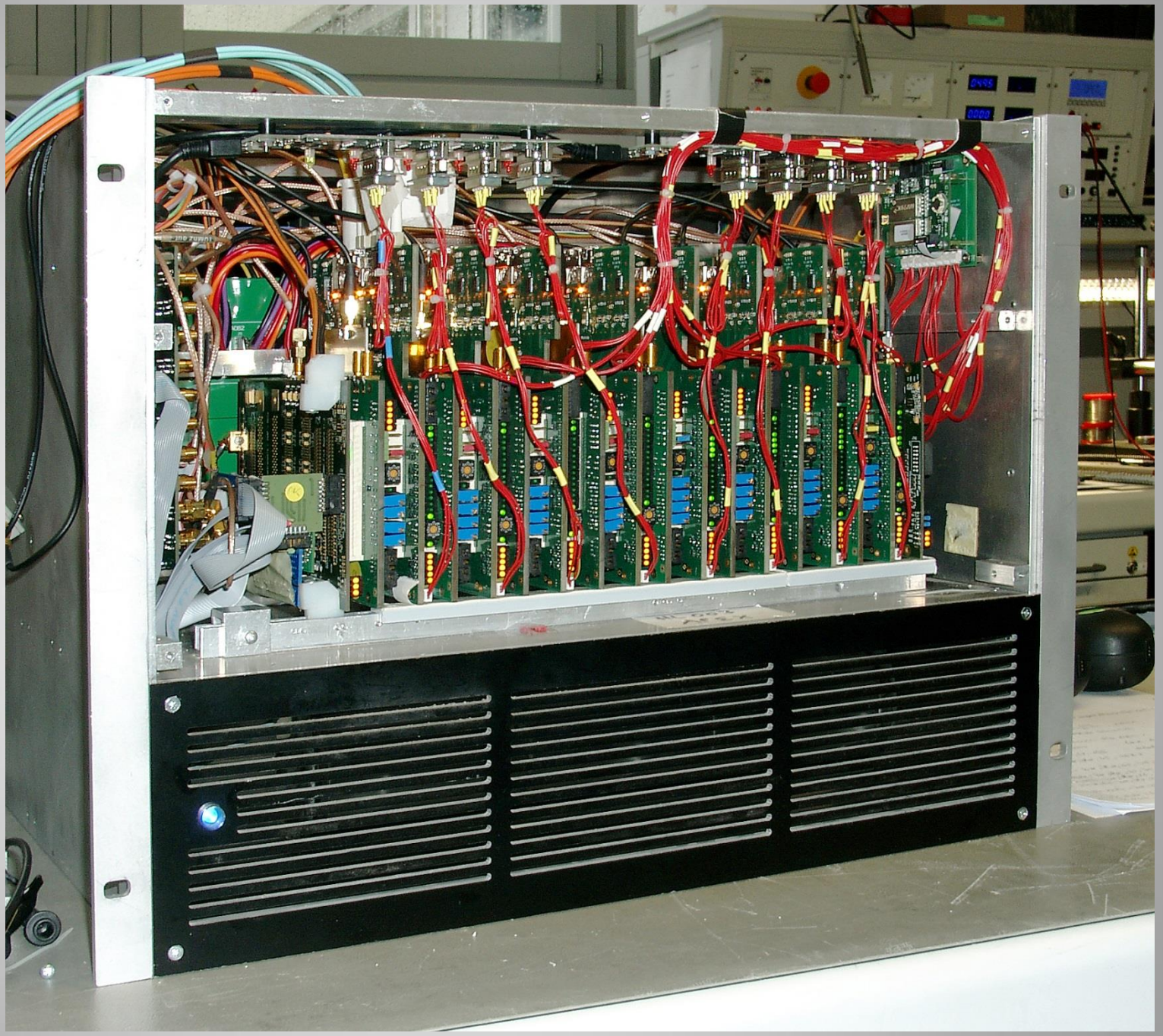

D B B C 3
EUROPEAN
NETWORK
HAT Lab

DBBC3L -2L2L

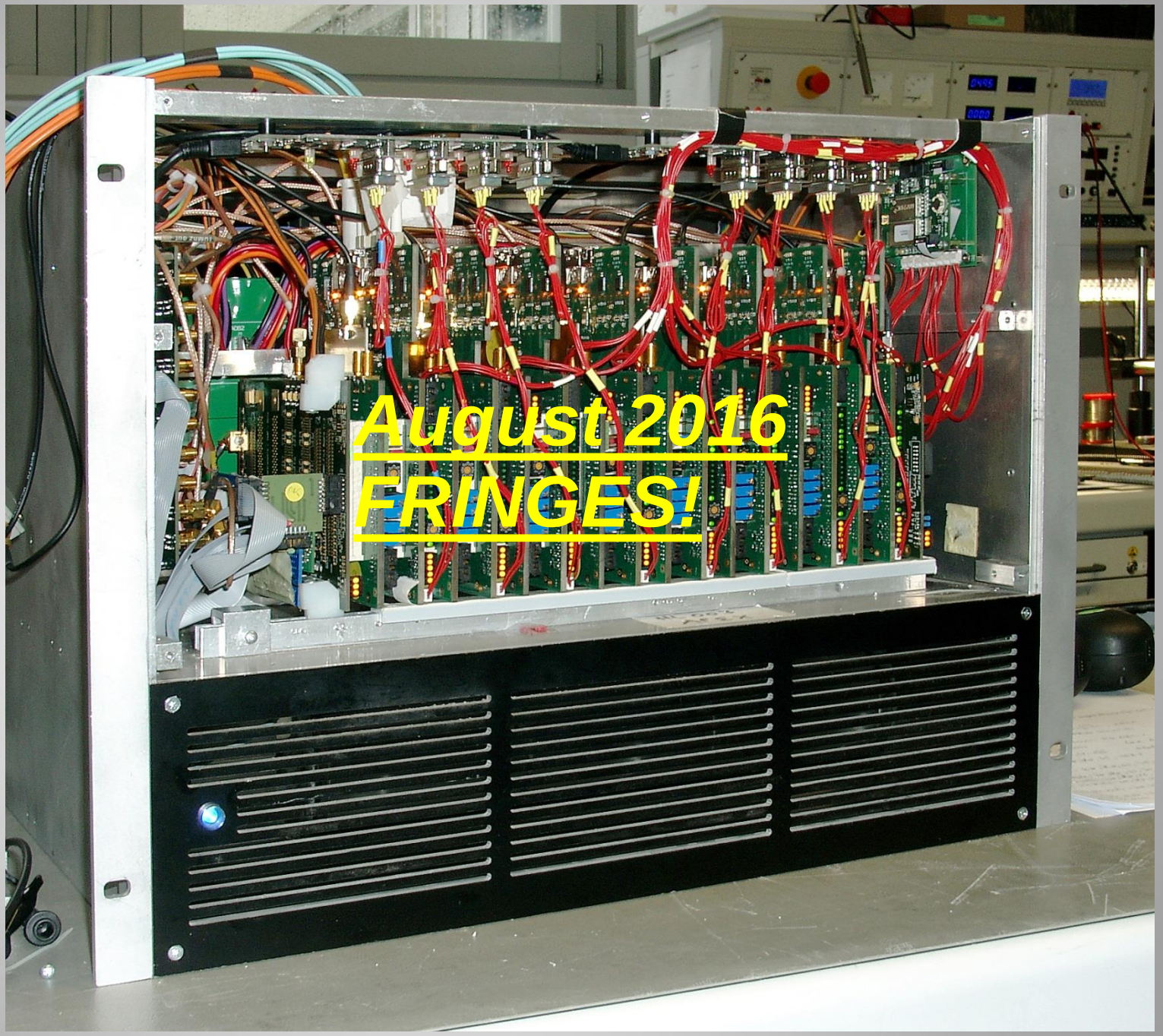
DBBC3L -2L2L



VGOS DBBC3L-8L8H



VGOS DBBC3L-8L8H



Where

delivery 2007- 08

DBBC1 Noto (later updated to DBBC2), Italy

DBBC1 Wettzell1 (later updated to DBBC2), Germany

DBBC1 Wettzell2 (later updated to DBBC2), Germany

DBBC1 Wettzell3 (later updated to DBBC2), Germany

DBBC2 Effelsberg, Germany

DBBC2 Yebes, Spain

DBBC2 Auscope1 (Hobart12M), Australia

delivery 2009-10

DBBC2 Onsala1, Sweden

DBBC2 SRT, Italy

DBBC2 Pico Veleta, Spain

DBBC2 APEX, Chile

DBBC2 Wark12M, New Zealand

DBBC2 Auscope2 (Kath12M), Australia

DBBC2 Auscope3 (Yarr12M), Australia

delivery 2010-11

DBBC2 Torun, Poland

DBBC2 Irbene1, Latvia

DBBC2 Hartebeesthoek1, South Africa

DBBC2 Hartebeesthoek2, South Africa

DBBC2 Auscope4 (Ceduna), Australia

delivery 2011-12

DBBC2 Medicina, Italy

DBBC2 Metsahovi, Finland

DBBC2 Auscope5 (Hobart26), Australia

delivery 2012-13

DBBC2 Seshan65, China

DBBC2 Warkworth2, New Zealand

DBBC2 Hartebeesthoek3, South Africa

delivery 2013-14

DBBC2 Ny Alesund, Norway

DBBC2 Onsala2, Sweden

DBBC2 Yebes2, Spain

DBBC2 Jodrell Bank, UK

delivery 2014

DBBC2 Yebes3, Spain

DBBC2 Wettzell4, Germany

DBBC2 Westerbork, The Nederlands

delivery 2015

DBBC2 Warkworth3, New Zealand

DBBC2 Shanghai2, China

DBBC2 Urumqi, China

DBBC3L Upgrade kit APEX, Chile

DBBC3L Upgrade kit PicoVeleta, Spain

DBBC3L Hobart, Australia

delivery 2016

DBBC2 Irbene2, Latvia

DBBC2 SRT2, Italy

DBBC3L-EVN Yebes, Spain

DBBC3L-VGOS Onsala1, Sweden

DBBC3L-VGOS Onsala2, Sweden

delivery 2017

DBBC3L-EVN Effelsberg, Germany

DBBC3L-VGOS Ny Alesund1, Norway

DBBC3L-VGOS Ny Alesund2, Norway

DBBC2 TIGO, Argentina

THANK YOU!