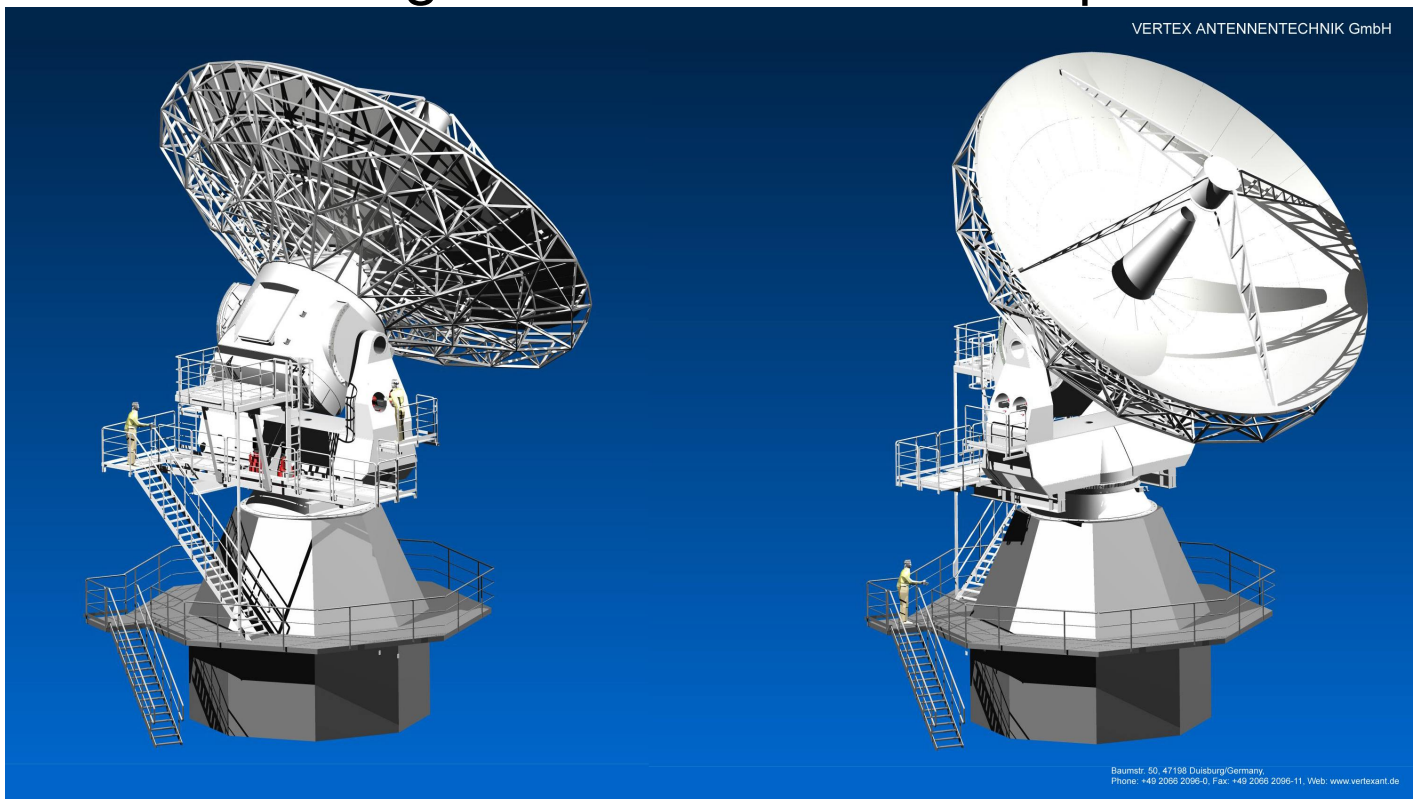
Federal Agency for
Cartography and Geodesy

The TWIN-Radiotelescopes Wettzell

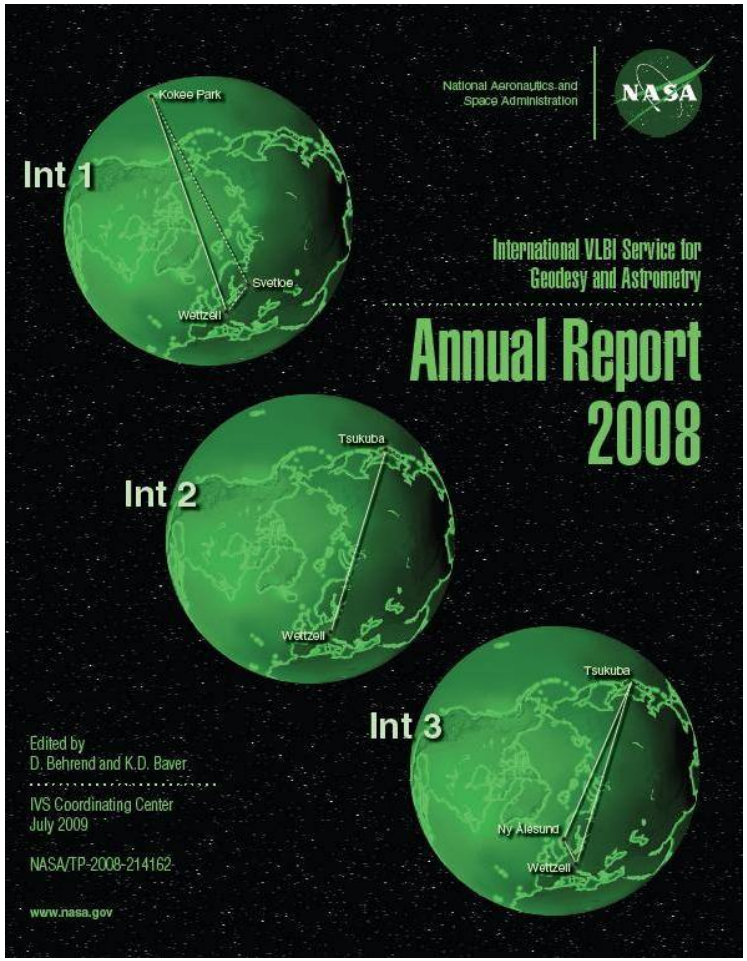
Next generation VLBI-technique



G. Kronschnabl, BKG; Dr. A. Neidhardt, TUM; Dr. K. Pausch, Vertex GmbH; W. Göldi, Mirad; B. Petrachenko, NRCan; A. Emrich, Omnisys;

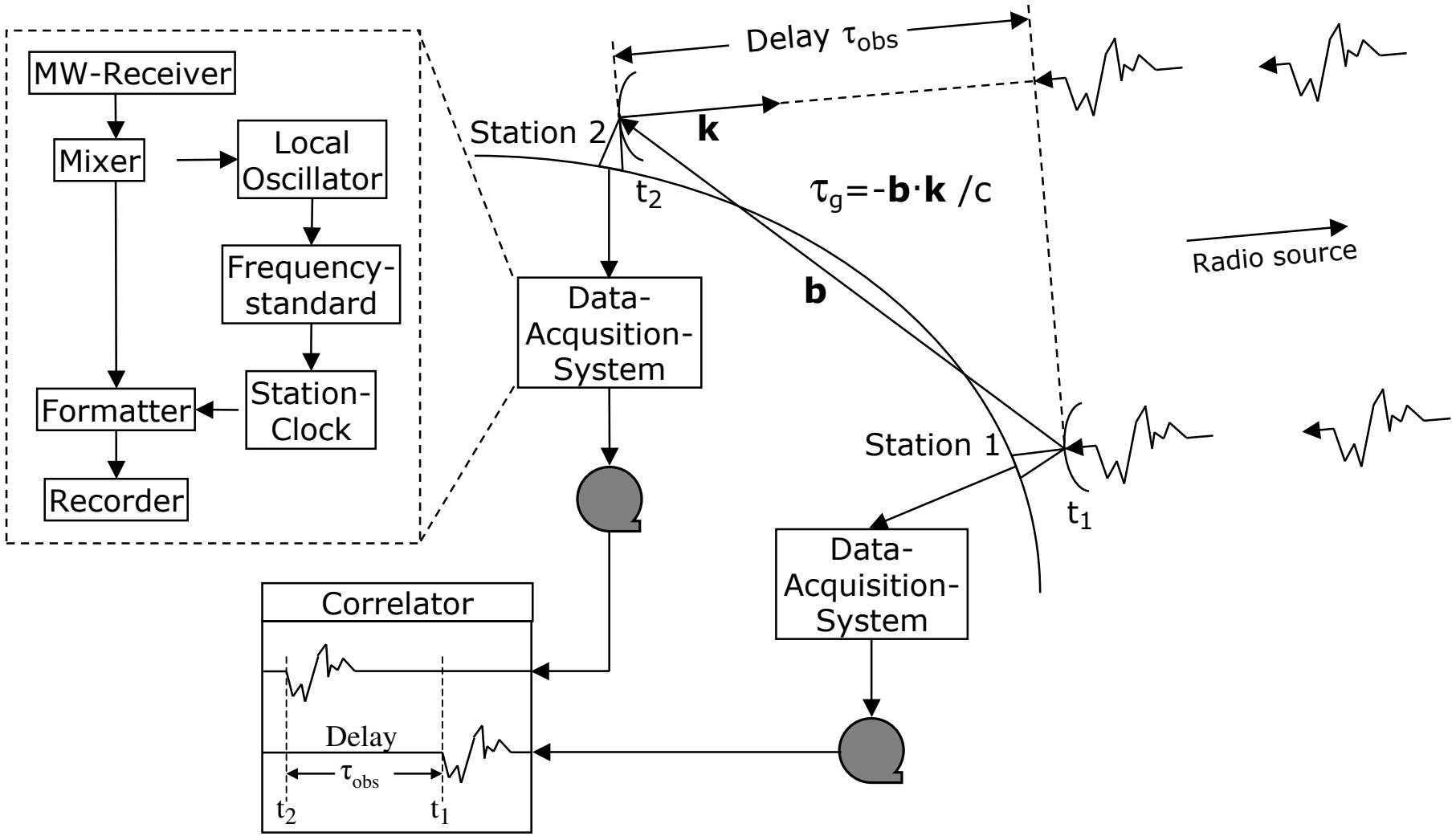
Radioteleskop Wettzell

RTW: D=20m, S/X-Band; Velocities: 3° & 1.5°/s; Tsys=40K; 1Gbps;



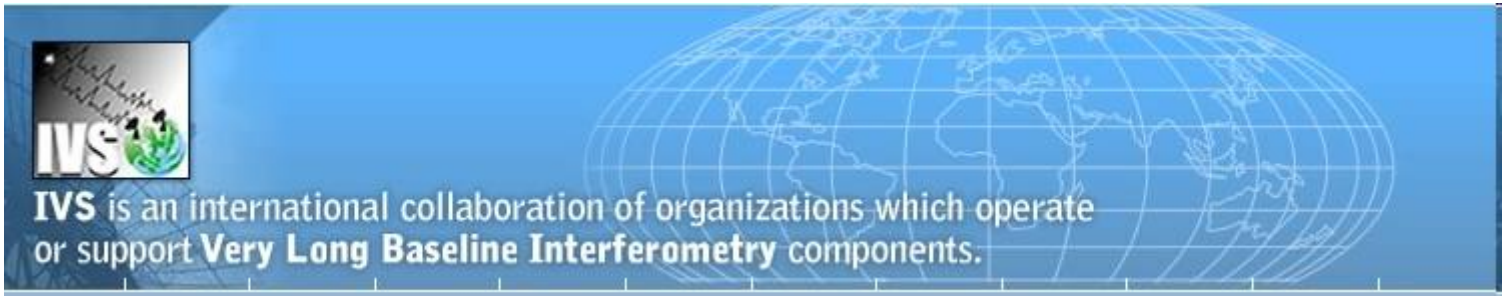
Broadband Delay: VLBI-Working-Scheme

Scheme of VLBI



Quelle: Dr. W. Schwegmann, Dr. A. Neidhardt; VLBI in near-realtime

VLBI 2010



IVS WG 3 – VLBI2010: Current and future requirements for geodetic VLBI Systems

Goals for a next generation VLBI-System:

- Determination of the relative position better than 1 mm / year
- Continuous observation of the Earth Orientation Parameters
- Very fast generation and distribution of the IVS-Products

➔ continuous, improved UT1 monitoring
➔ Improving of the Celestial Reference Frame (CRF)

Source: IVS WG3 Final Report - ftp://ivscc.gsfc.nasa.gov/pub/annual-reports/2005/pdf/spcl-vlbi2010.pdf

Accuracy of the Delay Observable

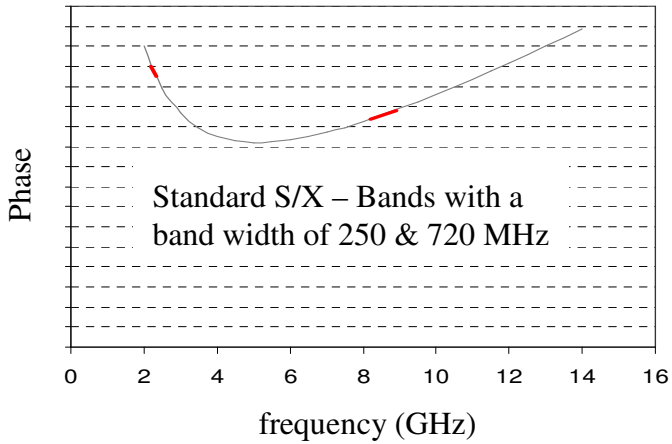
$$\sigma_r = \frac{1}{2\pi SNR \left\langle f^2 \right\rangle^{\frac{1}{2}}} \qquad SNR = \frac{\pi \cdot \mathrm{f} \cdot S \cdot 10^{-26} \cdot D_1 \cdot D_2}{8 \cdot k} \cdot \sqrt{\frac{e_1 \cdot e_2 \cdot BR \cdot t}{T_{Sys\,1} \cdot T_{Sys\,2}}}$$

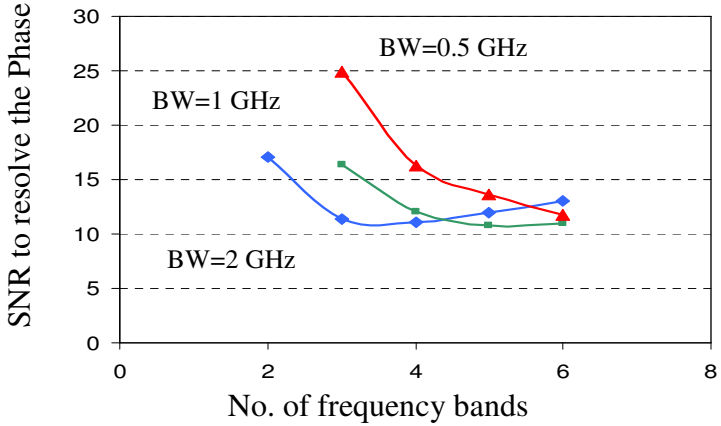
where:
SNR = Signal-Noise Ratio
f = VLBI Processing Faktor (ca. 0.55 for 1bit Data streams)
S = Source-Flux (Jy)
D_i = Antenna diameter per Station
k = Boltzmannkonstante
e_i = Beam efficiency of the antenna
BR = Bitrate
t = Integration time
T_{sys} = System temperature per station (at the same frequency)

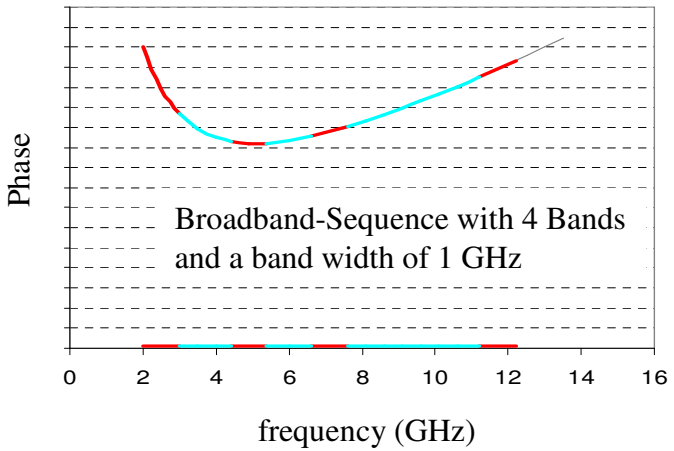
- higher bandwidth
- higher quantization of the signals
- higher effective antenna area
- higher data acquisition rate
- reducing the system temperature

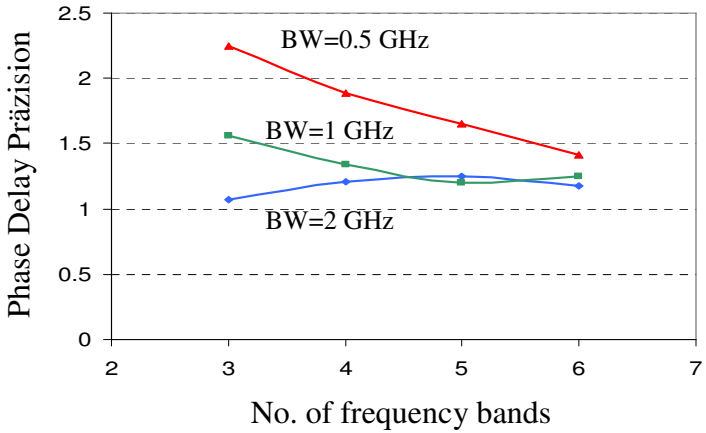
Source: IVS WG3 Final Report

VLBI 2010: Broadband Delay









Source: B. Petrachenko: Broadband Delay Tutorial, FRFF Wettzell 2009

VLBI 2010 requirements

VLBI 2010

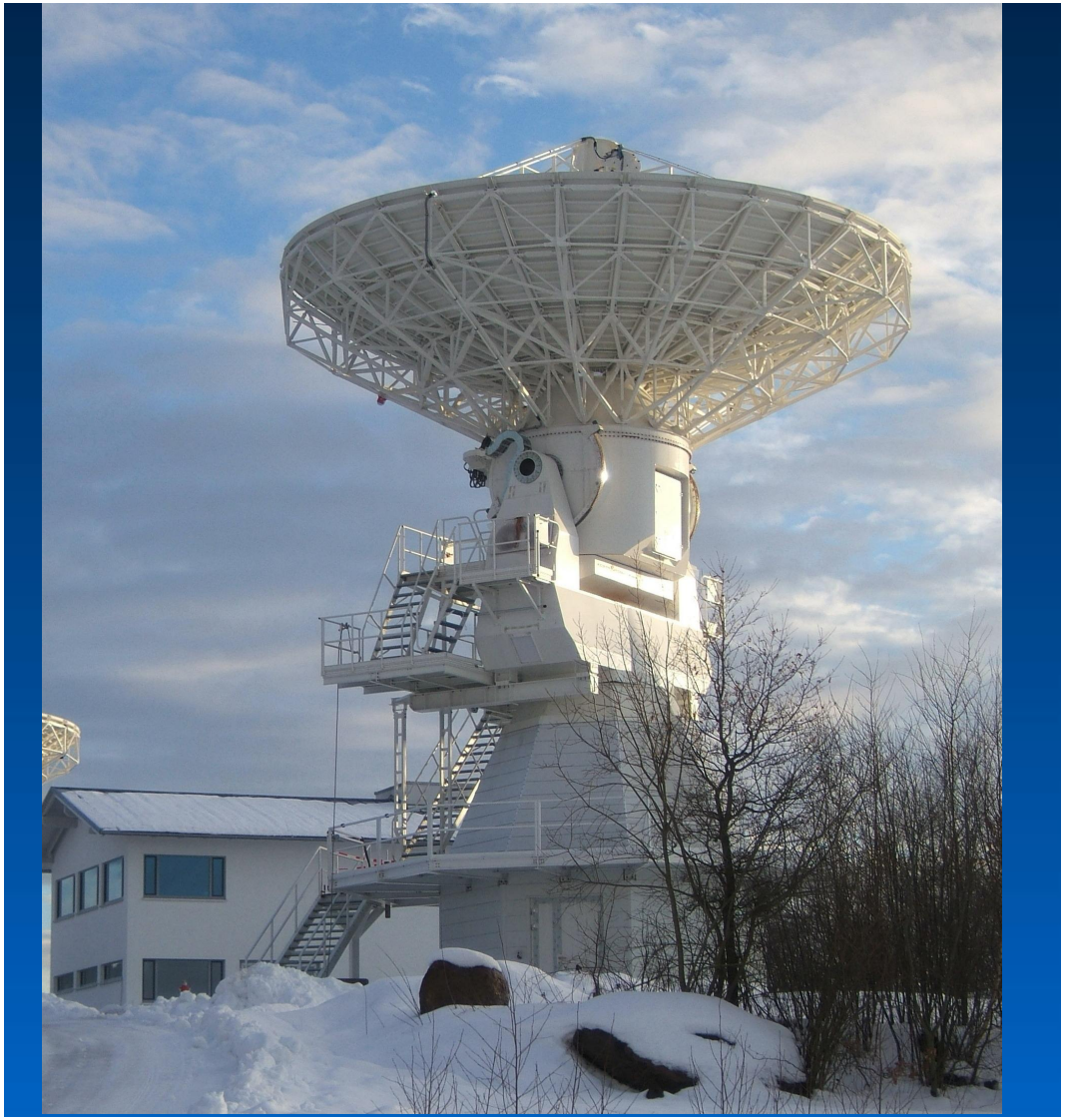
What are the requirements for a new observation system to fulfill the VLBI 2010 specifications?

- A fast moving antenna system with an antenna diameter of 12m or higher
- A broadband receiving system at least from 2 to 14 GHz, with an optional receiver at Ka-Band
  - ➔ S- und X-Band compatibility (RCP)
  - ➔ stable phase centre and stable reference point
  - ➔ high antenna efficiency and low system temperature
- Improved reference and calibration systems
- New digital data acquisition systems

TWIN - Radioteleskop

Technical Data:

- Main reflector: 13.2m
- Ringfocal-Design
- f/D = 0.29
- Path Length Error <0.3mm
- ALMA Mounting with drive velocities of 12°/s in Azimuth and 6°/s in Elevation
- Balanced antenna design
- Excellent bearings
- 27Bit Encoder : 0.0003° resolution
- Subreflector adjustable by a Hexapod



TWIN – Radioteleskop: Path Length Error

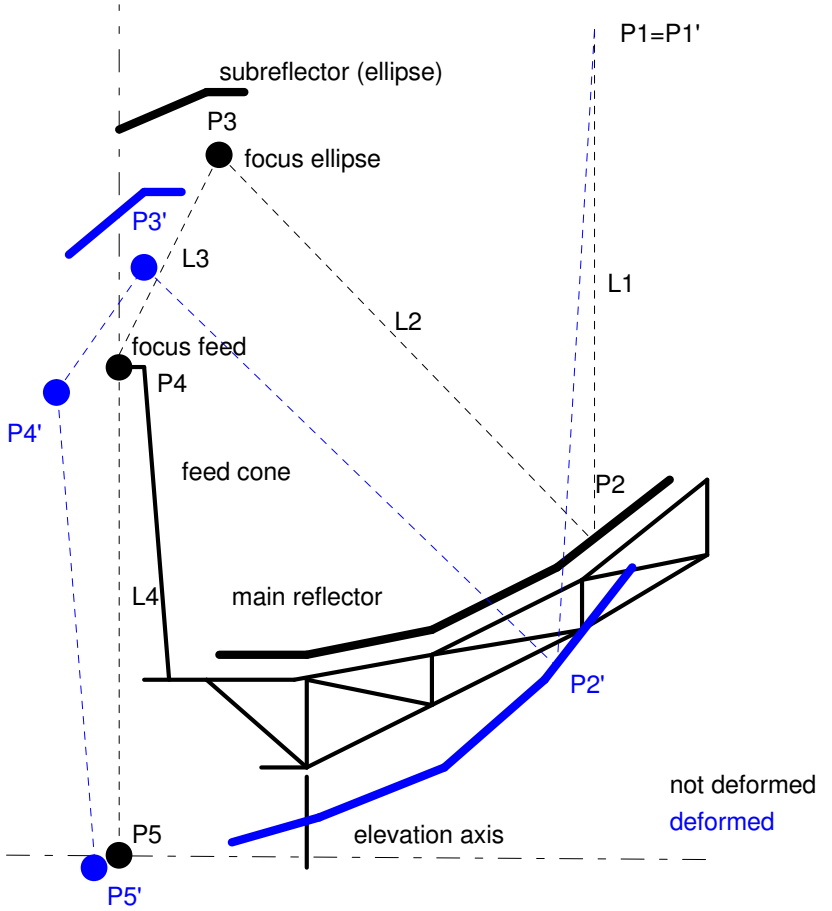
The TTW-Antenna is designed for a Path Length Error of less than 0.3mm !!

L1 = distance main axis – reflector surface
L2 = distance reflector surface – subreflector
L3 = distance subreflektor – feed focus
L4 = distance feed focus – axis intersection point

Definition: Path Length Error

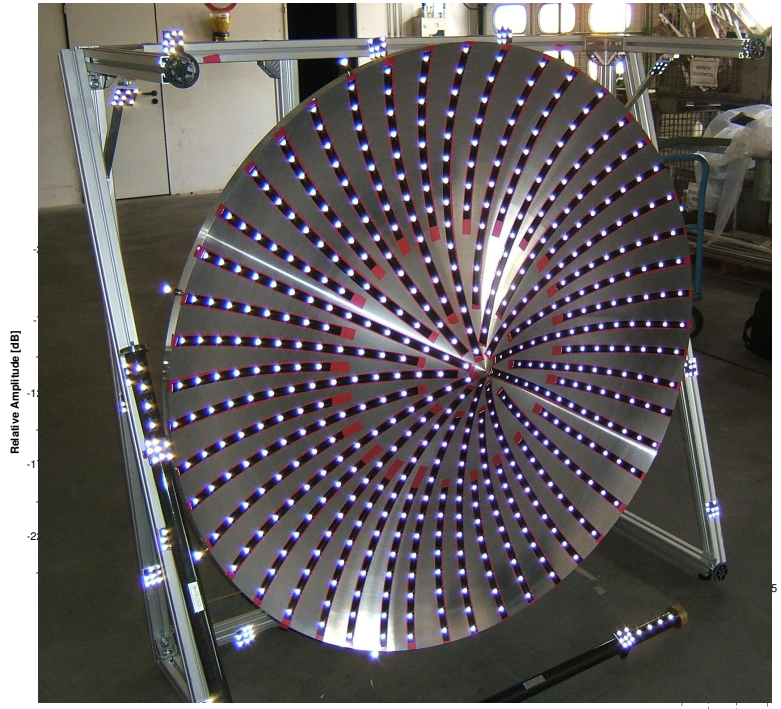
- Lnot_deformed = L1+L2+L3+L4
- Ldeformed = (L1+dL1)+(L2+dL2)+ (L3+dL3)+(L4+dL4)
- L_Error = Ldeformed - Lnot_deformed

$$PathLengthError = \frac{\sum_{i=1}^{192} \left(A_i \cdot PathLengthError_i \right)}{\sum_{i=1}^{192} A_i}$$

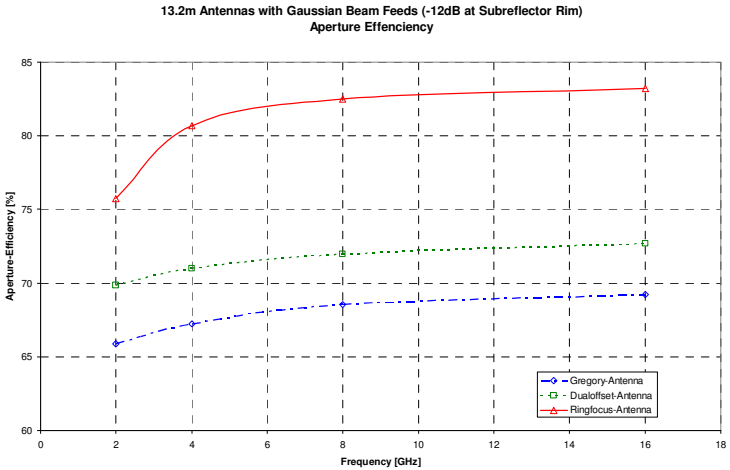


Source: Vertex Design Review; Dez. 2008

TWIN Radioteleskop: Hauptreflektor

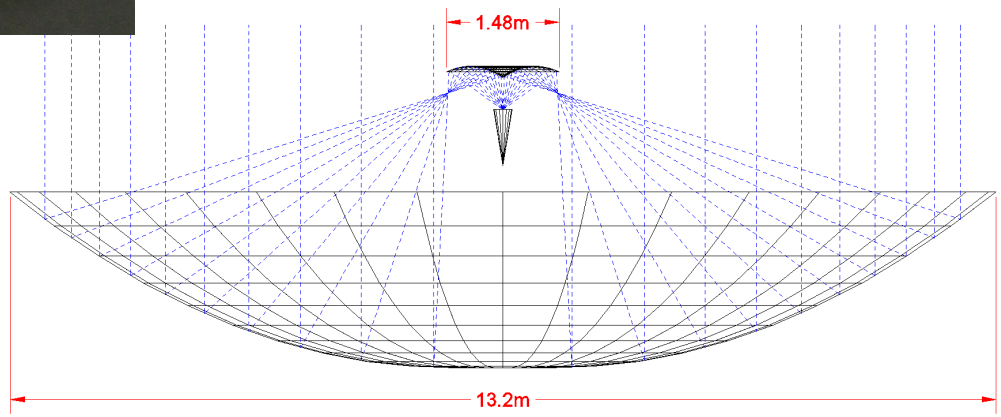


Effective beam efficiency



Ringfocal-Design

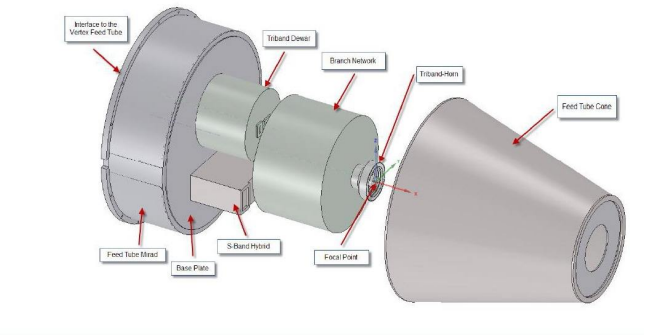
- Dual-Reflector receiving system
- optimal for large flare angles
- no blockage by the subreflector
- high illumination efficiency
- the feed horn is prevented by radiation from the sun

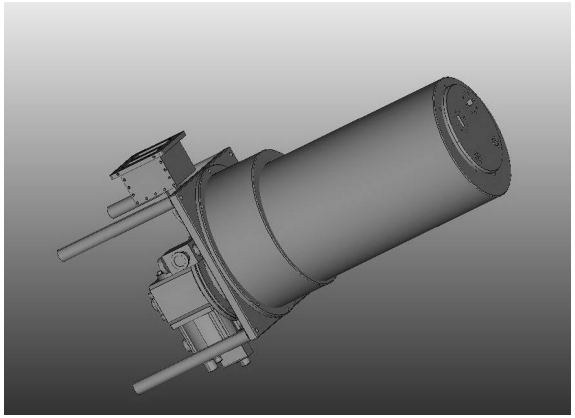


Source: Willi Göldi, Mirad; FRFF-Workshop 2009, Wettzell

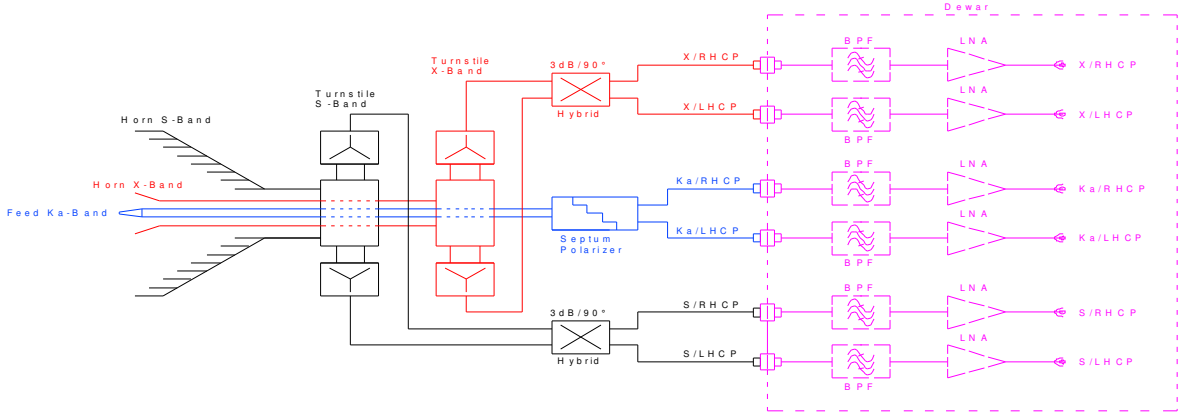
Broadband Receiving System: Triband-Feed

1 Feed Concept





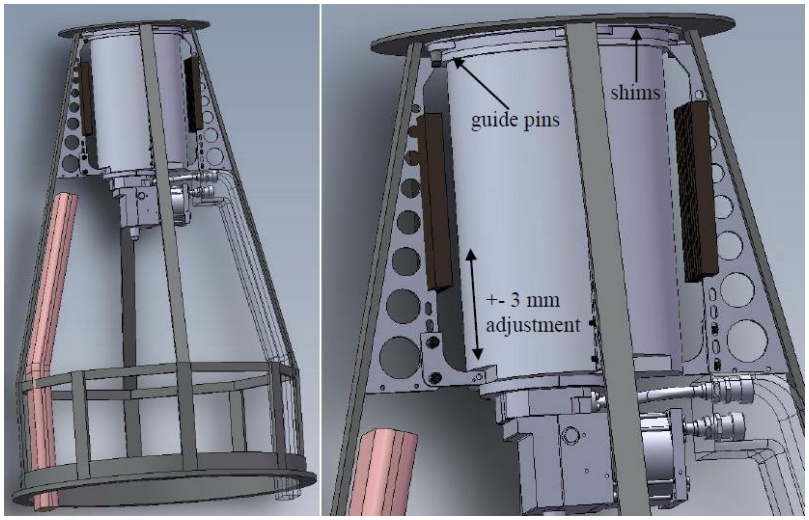
Dewar for the Triband-Feed



Schematic Triband-Feed

Broadband-Receiving-System: Eleven-Feed

Design proposal for the Eleven-Feed



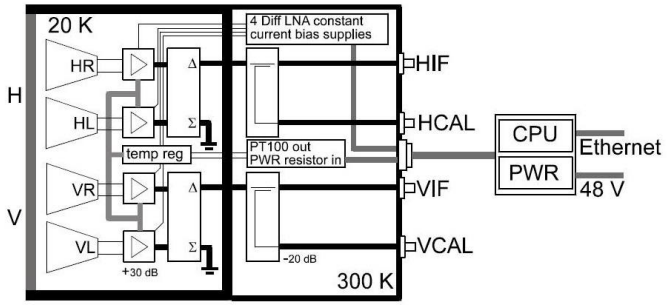
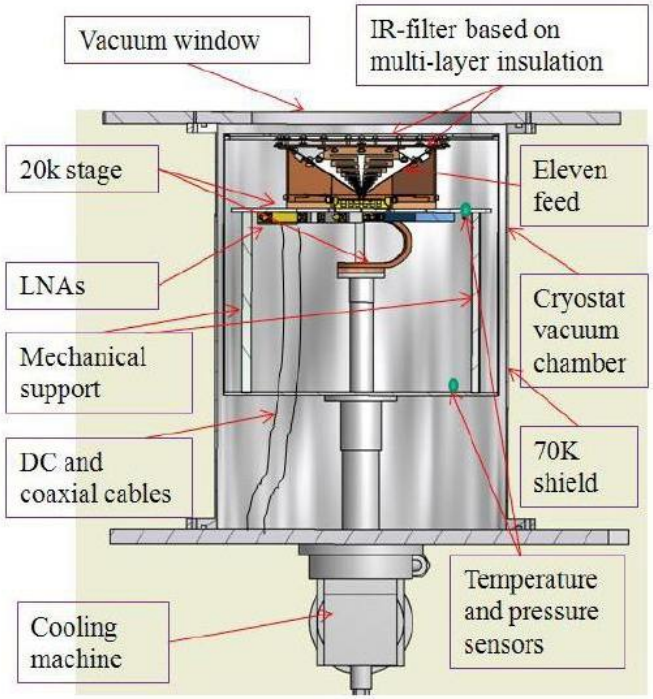


Figure 2. Eleven feed based VLBI2010 front-end

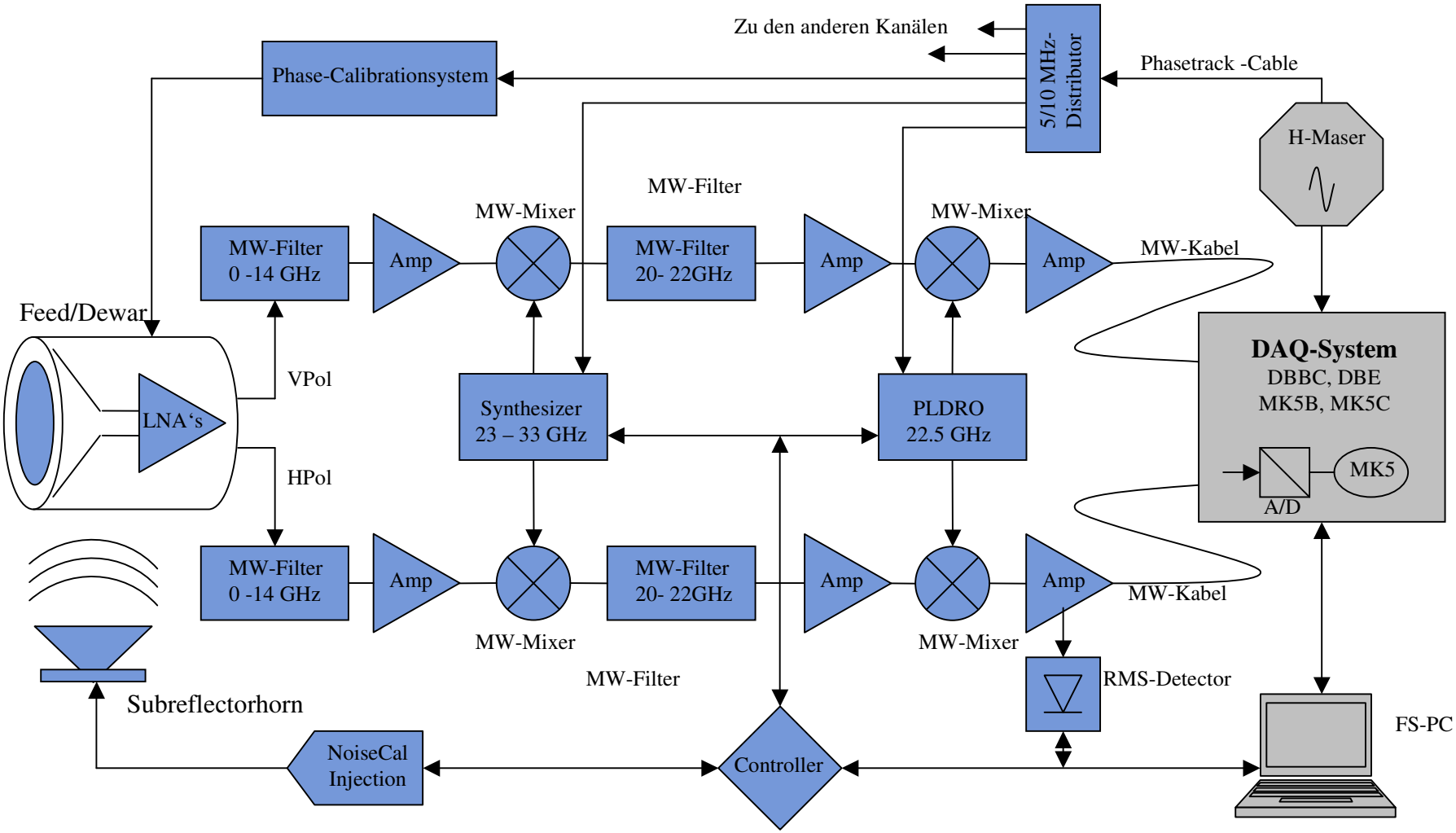
Design Proposal Dewar



Principle Schematic

Quelle: A. Emrich; Omnisys.; Schweden

Receiving-System: Wideband-Receiver



February 2011

Mounting of the Telescopes