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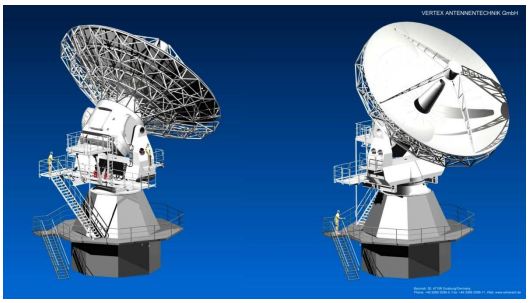
VLBI2010 – Current status of the TWIN radio telescope project at Wettzell, Germany



Alexander Neidhardt, FESG/TU München (on behalf of the BKG)

G. Kronschnabl, (BKG); Hase, H. (BKG); Schreiber, U. (BKG);
K. Pausch (Vertex GmbH); W. Göldi (Mirad); B. Petrachenko (NRCan);
A. Emrich (Omnisys) and the VLBI team Wettzell

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The geodetic observatory Wettzell and the current VLBI System

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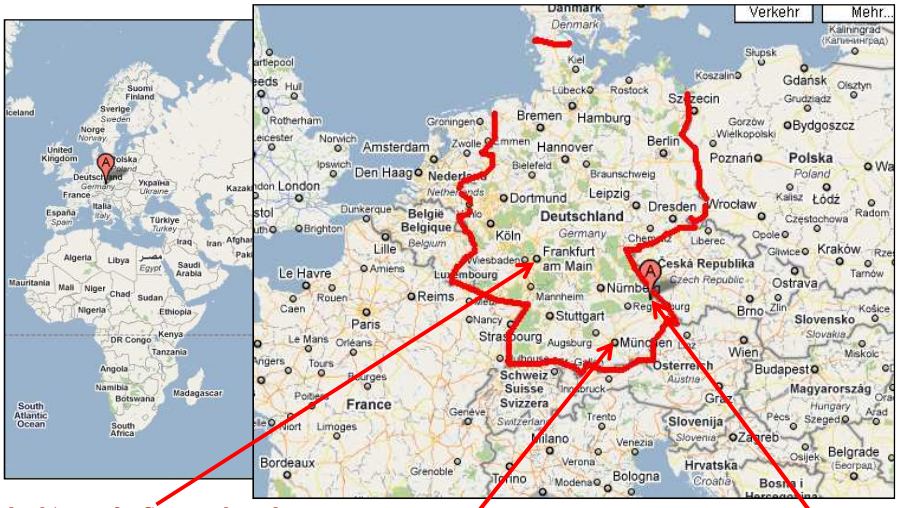
The geodetic observatory Wettzell and ist location



See: http://maps.google.com/, Download 2010/0217

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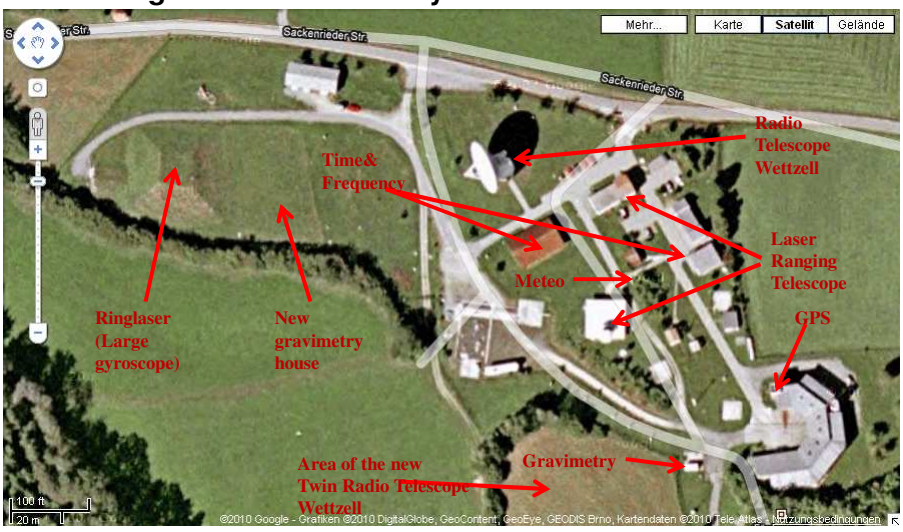
The geodetic observatory Wettzell and ist location



See: http://maps.google.com/, Download 2010/0217

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Radio telescope Wettzell (RTW) and its team

RT Wettzell/Germany

The Wettzell VLBI crew (from left to right):
Ch. Plötz, E. Bauernfeind, G. Kronschnabl,
R. Schatz, W. Schwarz, R. Zeitlhöfler, A. Neidhardt
(missing in picture: E. Bielmeier).

Table 2. RTW observations in 2008

program	number of 24h-sessions
IVS R1	49
IVS R4	51
IVS T2	6
IVS R&D	9
RDV/VLBA	6
EUROPE	5
CONT08	15
total	141
total (in hours)	3384

program	number of 1h-sessions
INT1(Kokee-RTW)	234
INT2/K(Tsukuba-RTW)	100
INT3/K(Tsukuba-RTW-NyAl)	41
total (in hours)	375

special program	number of experiments
SELENE	19
total (in hours)	92

TIGO Concepción/Chile

GARS O'Higgins/Antarctica

And in the future:
TTW Wettzell

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

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Radio telescope Wettzell (RTW) and its team

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Radio telescope Wettzell (RTW) and its team

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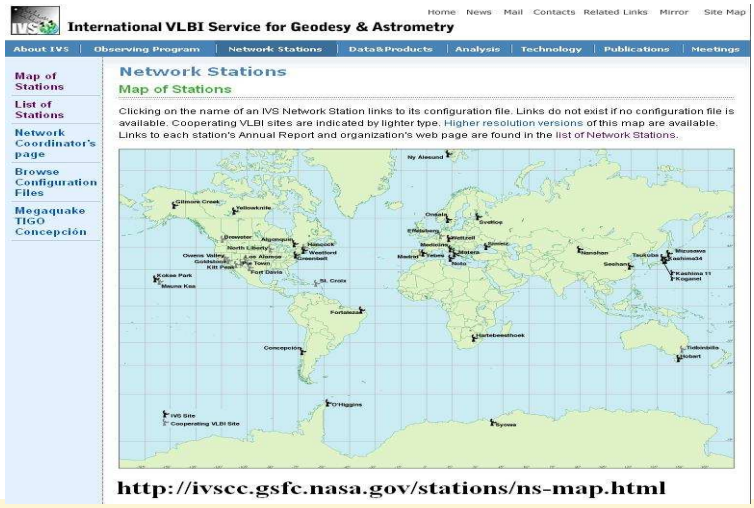
Main participation – International VLBI Service for Geodesy and Astrometry



http://ivscc.gsfc.nasa.gov/stations/ns-map.html

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VLBI2010

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VLBI2010 – a vision

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 (EOP)
- Very fast generation and distribution of IVS-products and results
  - continuous and precise UT1 monitoring for UT1-UTC determination
  - improvement of the Celestial Reference Frame (CRF)

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

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Improvements

$$\sigma_\tau = \frac{1}{2\pi SNR \left\langle f^2 \right\rangle^{\frac{1}{2}}} \qquad SNR = \frac{\pi \cdot f \cdot S \cdot 10^{-26} \cdot D_1 \cdot D_2}{8 \cdot k} \cdot \sqrt{\frac{e_1 \cdot e_2 \cdot BR \cdot t}{T_{Sys_1} \cdot T_{Sys_2}}}$$

where:
SNR = signal to noise ratio
f = VLBI processing factor (ca. 0.55 for 1bit Data streams)
S = source-flux (Jy)
D_i = antenna diameter per Station
k = Boltzmann constant
e_i = beam efficiency of the antenna
BR = bit rate
t = integration time
T_{sys} = system temperature per station (at the same frequency)

- **higher bandwidth**
- **better quantization of the signals**
- **higher effectivity of the dish**
- **higher data acquisition rate**
- **reduced system temperature**
- **better path lengths behaviour**

Source: IVS WG3 Final Report

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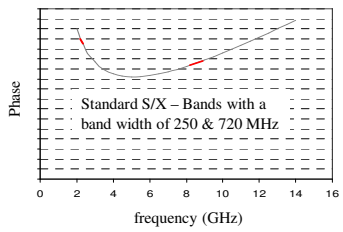
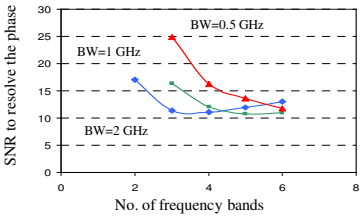
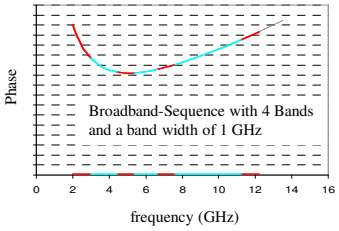
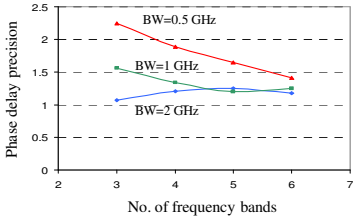
New frequency band simulations









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

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Basic antenna and system requirement definitions

- Fast moving antenna (6°/sec)
- Antenna dish diameter of min. 12m
- Broadband receiving system (2 to 14 GHz or higher including S- and X-band for compatibility to the current systems; optional Ka-band)
- 1 mm position and 1 mm/year velocity stability of reference position (stiff construction, new system calibrations)
- Optimized antenna dish and receiving system efficiency
- Digital data acquisition systems with high sampling rates and quantization (min. 2 Gbit/sec with 2, 4 and 8 bit)
- Phase center stability over different frequencies
- Phase delay measurement systems
- High mechanical quality for gears, motor servos, bearings, etc.
- More than one antenna at one site
- Remote controllable, automatable techniques
- …

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A complete realization – the TWIN radio telescope concept

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A complete realization – the TWIN radio telescope concept

Technical details:

- Main reflector: 13.2m
- Ring focal 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
- 27Bit Encoder : 0.0003° resolution
- Adjustable sub-reflector using a Hexapod
- Lifetime min. 20 years

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Ground and soil analysis

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Location analysis

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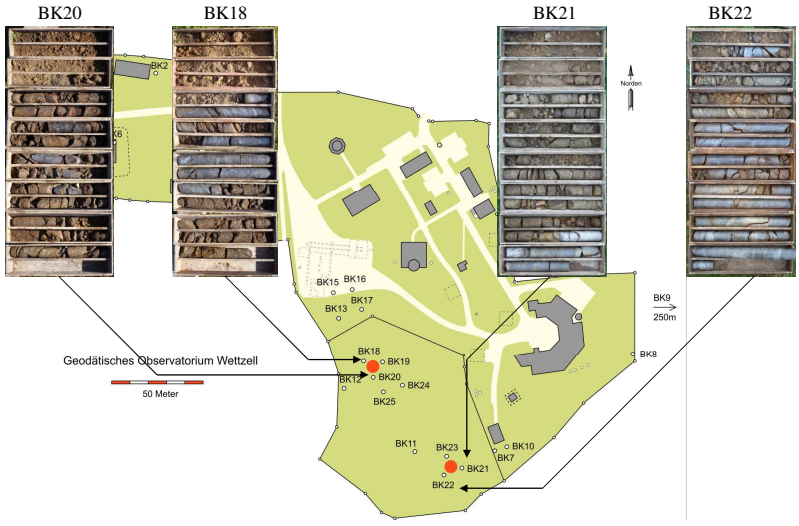
Location analysis



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Ring focus design

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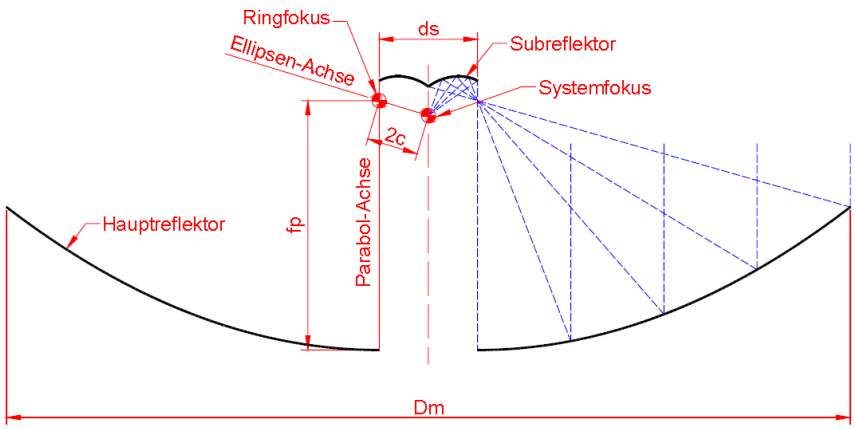
The ring focus design (1)



Source: Hase, H.; et. al.: TWIN Telescope Wettzell – A VLBI2010 project. FRFF Workshop, 2009

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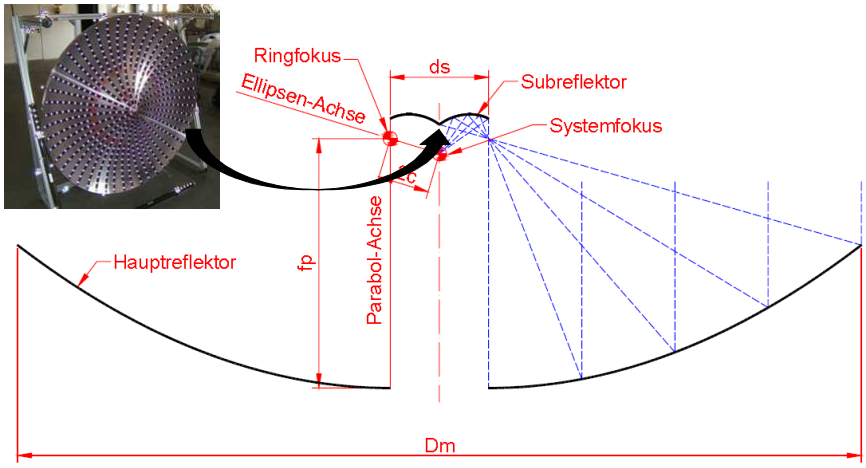
The ring focus design (1)



Source: Hase, H.; et. al.: TWIN Telescope Wettzell – A VLBI2010 project. FRFF Workshop, 2009

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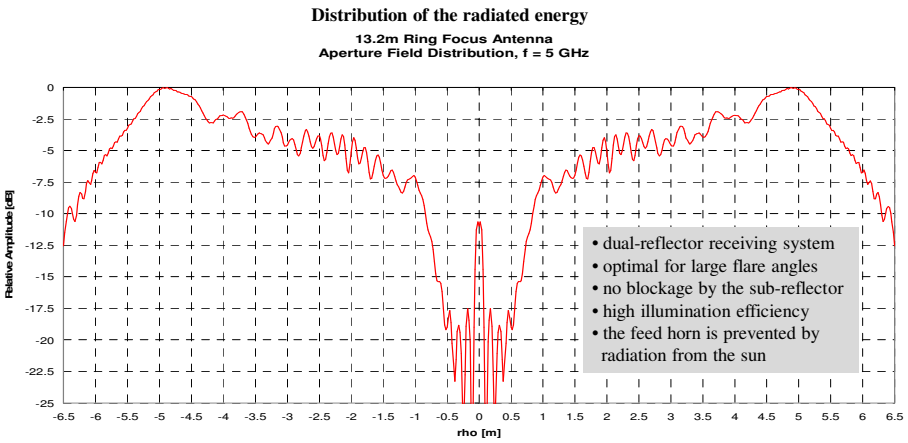
The ring focus design (2)



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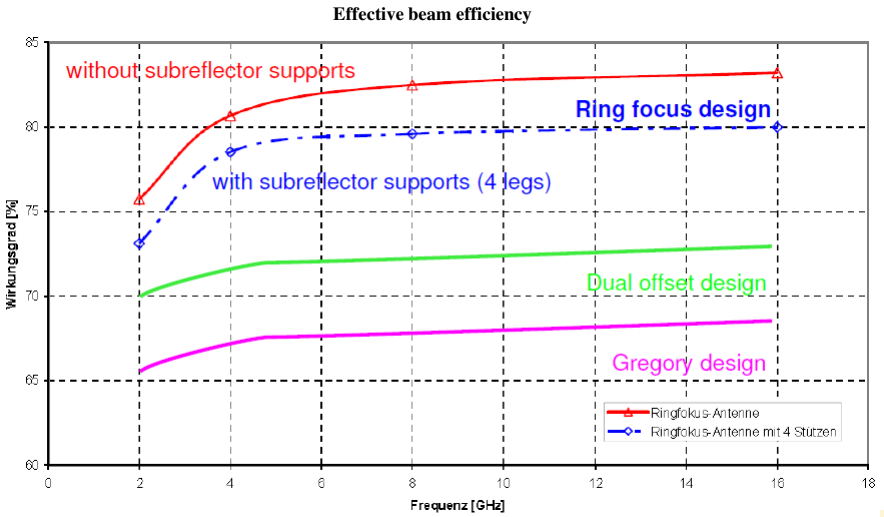
The ring focus design (2)



Source: Hase, H.; et. al.: TWIN Telescope Wettzell – A VLBI2010 project. FRFF Workshop, 2009

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Reduction of deformations

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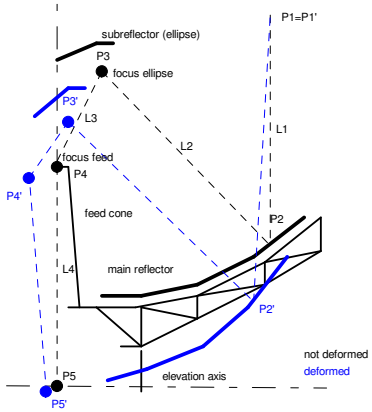
A stable path length (error < 0.3 mm)



Reduction of the gravitational effects using a hexapod to position the sub-reflector

L1 = distance main axis to reflector surface
L2 = distance reflector surface to sub-reflector
L3 = distance sub-reflector to feed focus
L4 = distance feed focus to axis intersection point

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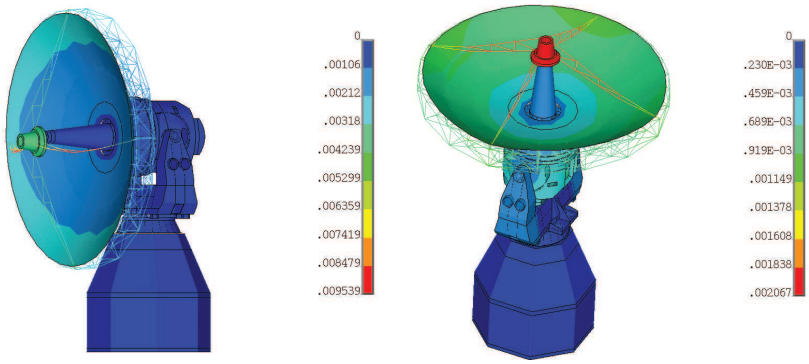
Gravitational deformation



Quelle: Vertex Design Review; Dez. 2008

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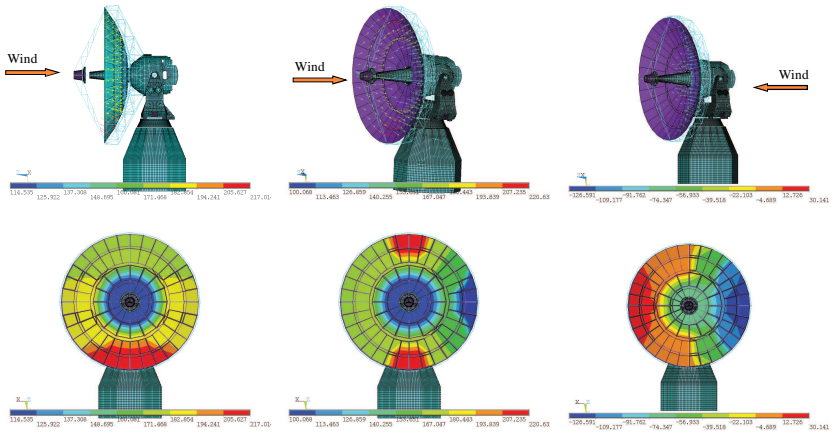
Wind uploads (40km/h)



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Quelle: Vertex Design Review; Dez. 2008

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Surface accuracy

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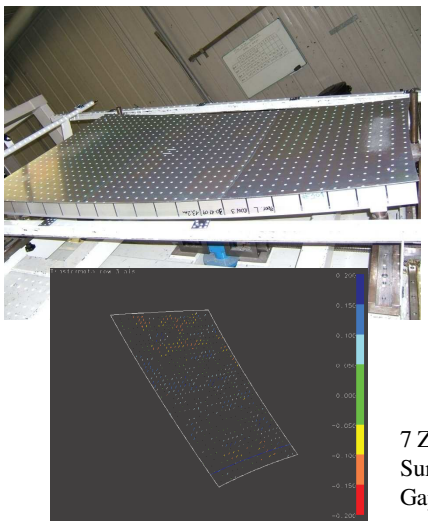
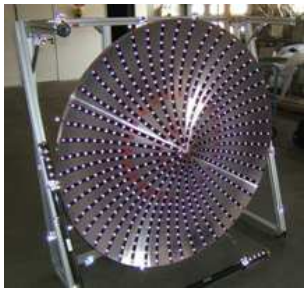
Surface quality





7 Z-profile supports on the backside
Surface error RMS < 65 um
Gap between panels < 1mm

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A complete realization – the TWIN radio telescope concept

Broadband receiving system

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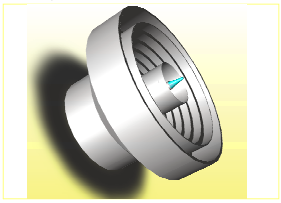
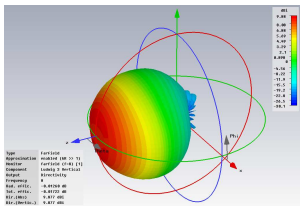
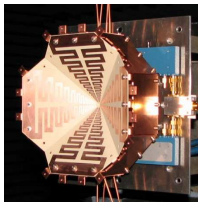
The planned horns

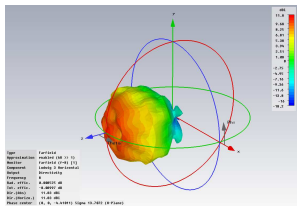
Tri-band corrugated horn
(Mirad)
S-, X- and Ka-band





Eleven feed
(Omnisys/Chalmers University Goteborg)
2-11 GHz





Quelle: Willi Göldi, Mirad; M. Pantaleev, Chalmers Univ.; Schweden

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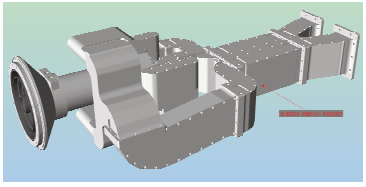
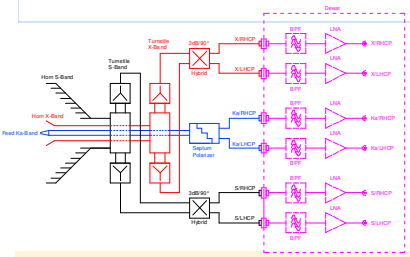
The planned horns

Tri-band corrugated horn
(Mirad)
S-, X- and Ka-band





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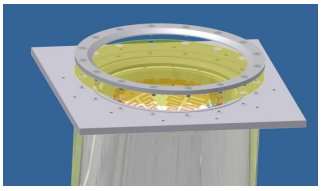
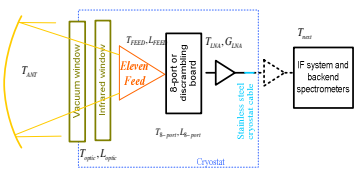
(Omnisys/Chalmers University Goteborg)
2-11 GHz





Quelle: Willi Göldi, Mirad; M. Pantaleev, Chalmers Univ.; Schweden

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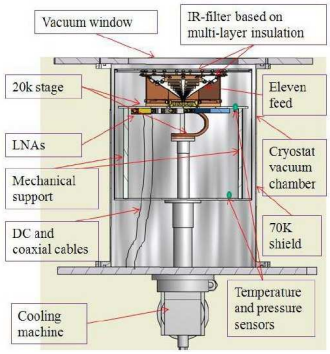
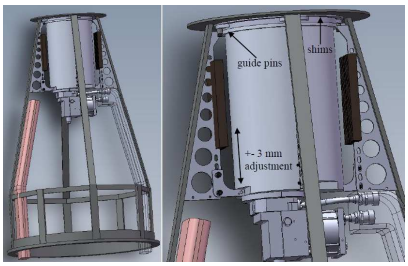
Cryogenic dewar for the Eleven feed (Omnisys/Chalmers University Goteborg)





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Quelle: A. Emrich; Omnisys.; Schweden

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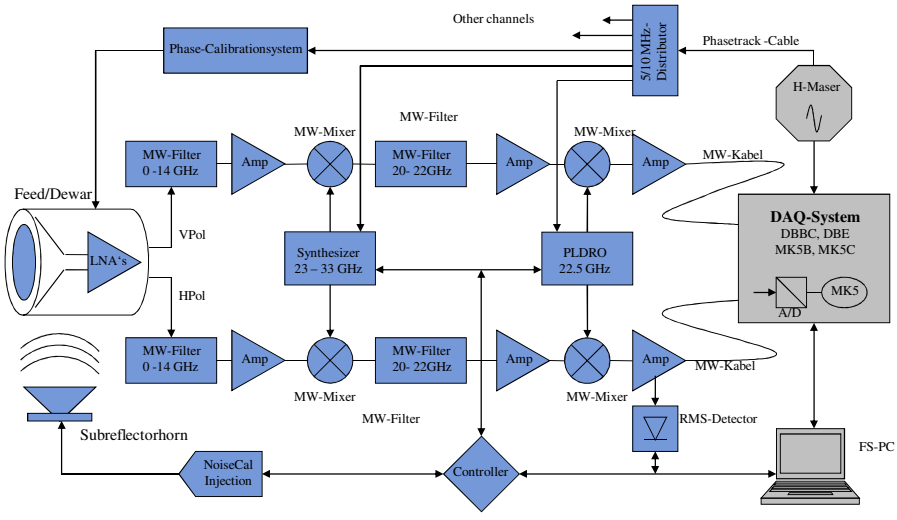
The whole receiving system



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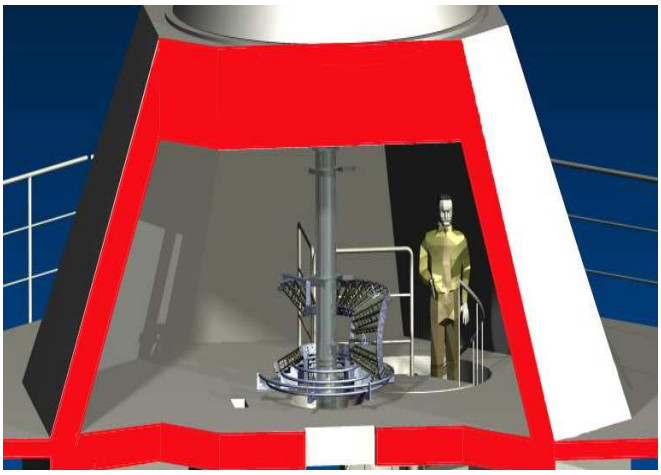
Cable wrap optimized for cable delay stability and used space



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A complete realization – the TWIN radio telescope concept

Remote control and unattended observations

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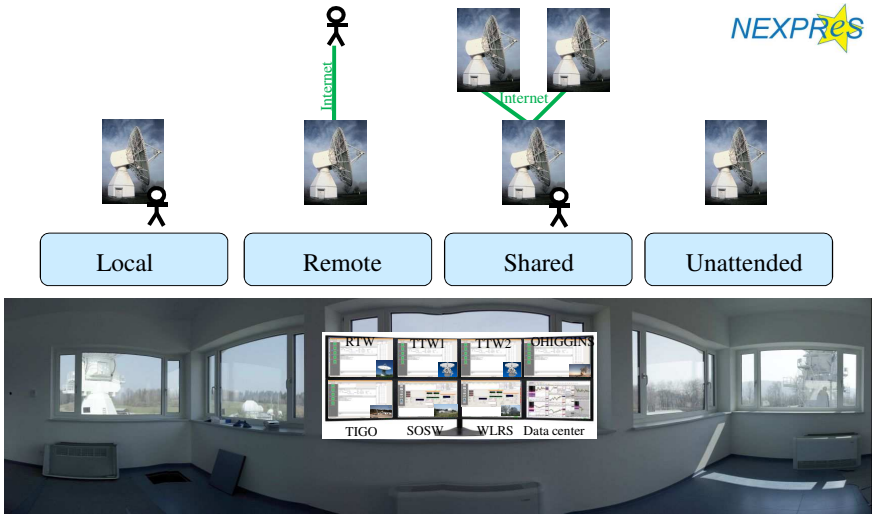
The new observation strategies in a new operator room



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The TWIN radio telescope – some impressions

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Impressions of TWIN construction

Rock at location 1

Soil exchange at location 2

Basement armor of the concrete towers

Concrete Tower 1

Already movable Antenna 1

Reflector Backstructure

Turning Head Antenna 1

Mounting of Antenna 1

Fixing the Reflector 1

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Thank you!