Status of the Onsala Twin Telescopes

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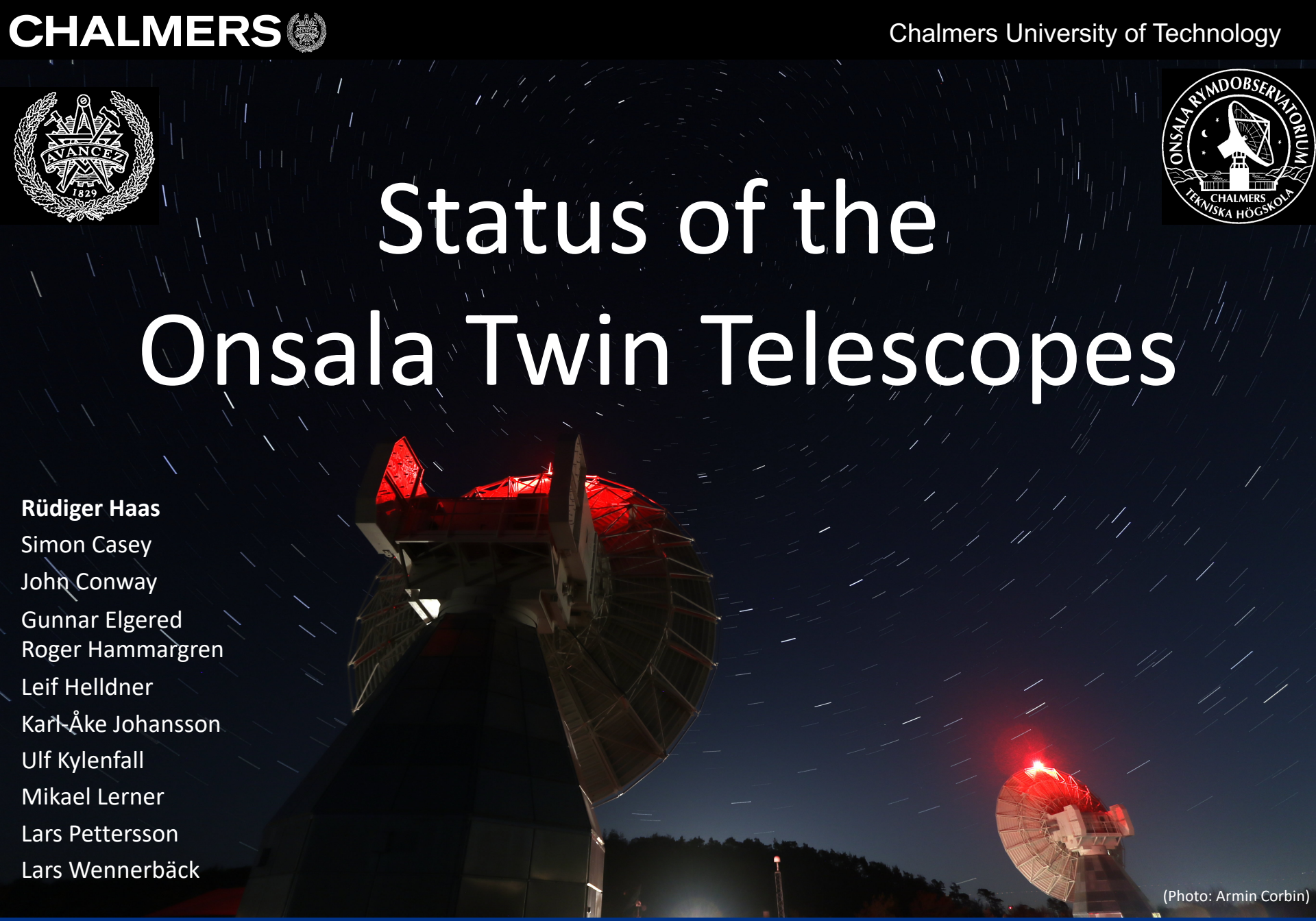
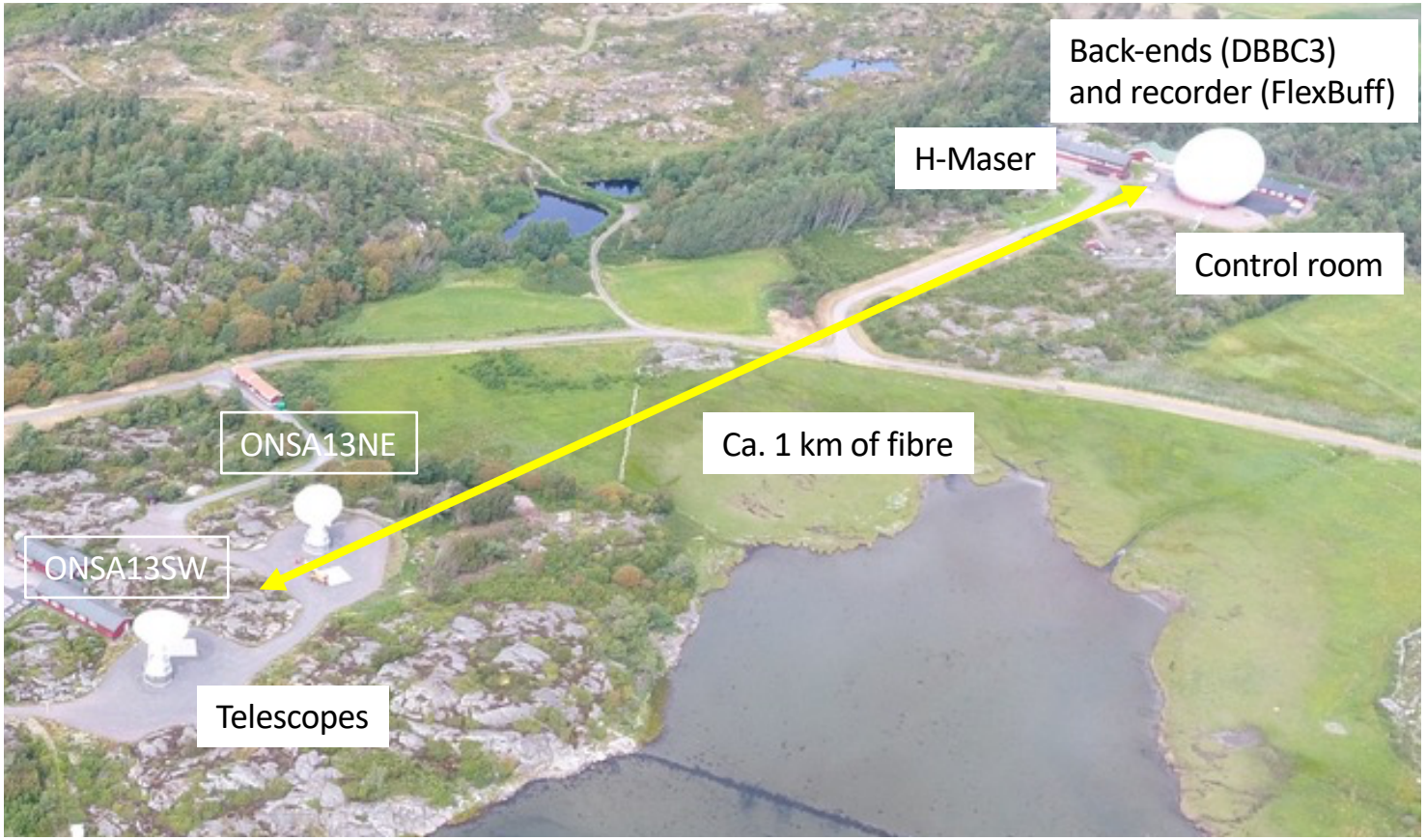


(Photo: Armin Corbin)

The Onsala twin telescopes

- Two identical VGOS telescopes
- MTM, 13.2 m diameter, ring-focus design
- Surface accuracy < 100 µm RMS
- Fast telescopes: 12 deg/s AZ, 6 deg/s EL
- Broadband receivers: 2 – 14 GHz / 3 – 18 GHz
- First light in spring 2017
- Inauguration 2017-05-18
- First fringes:
  - `ONSA13NE`: 2017-09-25 (some bands)
  - `ONSA13SW`: 2017-10-05 (some bands)
  - `ONSA13NE`: 2017-11-13 (all 4 RF-bands)
  - `ONSA13SW`: 2018-02-08 (all 4 RF-bands)


Back-ends (DBBC3)
and recorder (FlexBuff)
H-Maser
Control room
ONSA13NE
Ca. 1 km of fibre
ONSA13SW
Telescopes

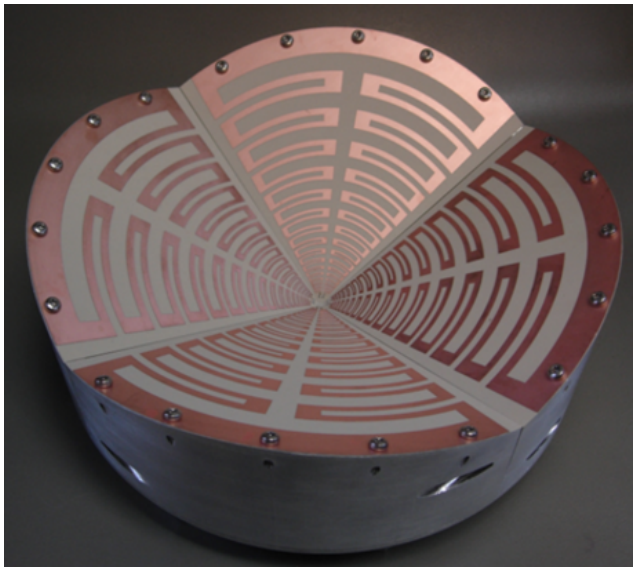
The OTT feeds

- Goals:
  - Compatibility with the S/X-band system on the Onsala 20 m telescope
  - Flexibility for adding new frequency bands above 14 GHz
  - Avoidance of 2G/3G bands
- Two cryogenic front-ends:
  - `ONSA13SW`: 11-Feed, 2 – 14 GHz
  - `ONSA13NE`: QRFH, 3 – 18 GHz

  => The feeds/receivers are interchangeable (!)

Eleven-Feed (2.2 – 14 GHz)

- 2017EFiC-2-14C-8P
- Chalmers design
- Compact and wideband
- $\boldsymbol{\theta_o} \approx 65°$
- 2.2 – 14 GHz
- 2 LNA version with hybrid couplers
- @ ONSA13SW



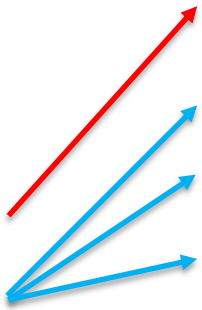
QRFH (3 – 18 GHz)

- QRFH-60S-6-3
- Caltech design
- Compact and wideband
- $\boldsymbol{\theta_o} \approx 60°$
- customized 6:1
- 3 – 18 GHz
- @ ONSA13NE

OTT frequency bands

- Two sub-bands for the RF-over-fibre (RFoF)
- Four sub-bands as input to the DBBC3
- In two linear polarizations

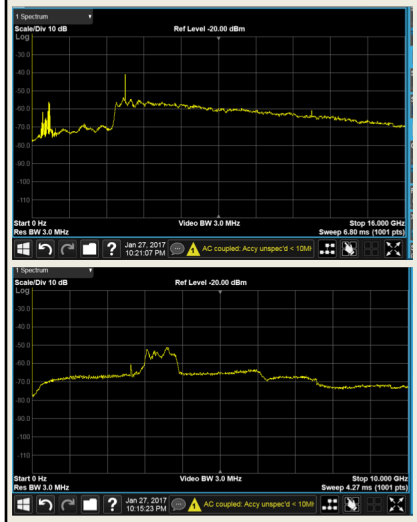
	RFoF [GHz]
Band Low	2.0 – 6.0
Band High	3.8 – 18.0



	ONSA13SW 11-Feed Bandwidth [GHz]	ONSA13NE QRFH Bandwidth [GHz]
Band 1	2.0 – 3.8	3.0 – 3.8
Band 2	3.8 – 7.6	3.8 – 7.6
Band 3	7.6 – 11.4	7.6 – 11.4
Band 4	7.6 – 11.4 (11.4 – 15.2)	7.6 – 11.4 (11.4 – 15.2)

OTT back-ends

4 GHz CW signal is injected via the directional coupler of the receiver and monitored in SA.



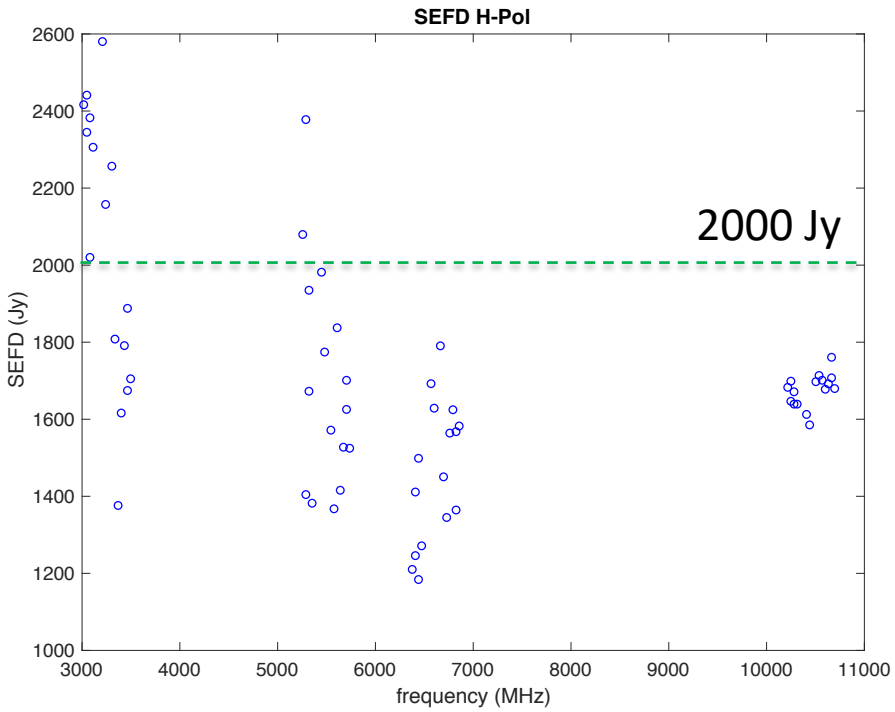
Spectra in Hi band (0 – 16 GHz)

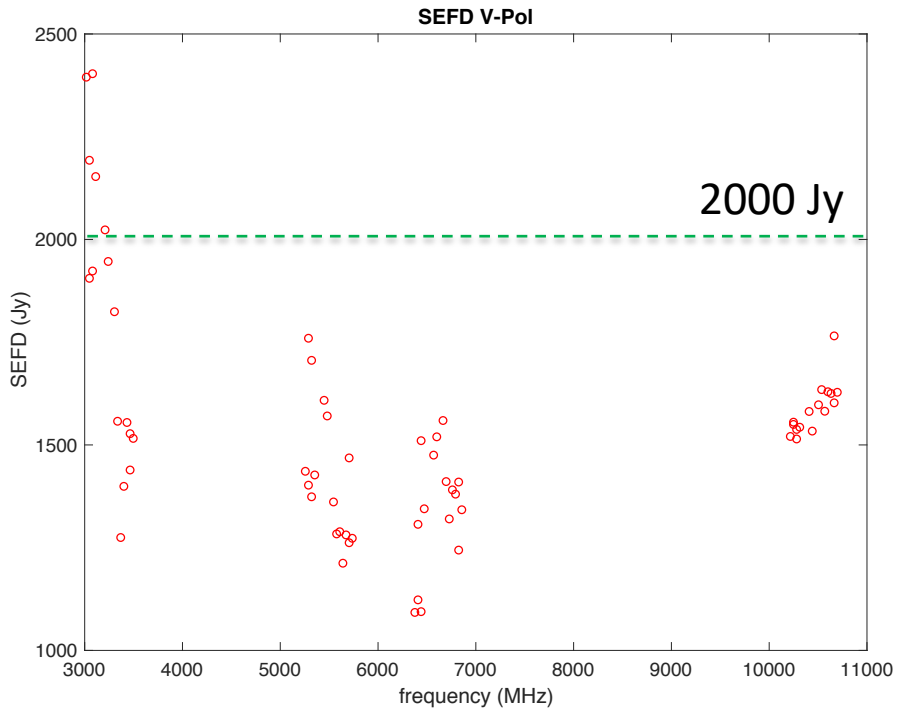
Spectra in Lo band (0 – 10 GHz)

ONSA13SW ONSA13NE

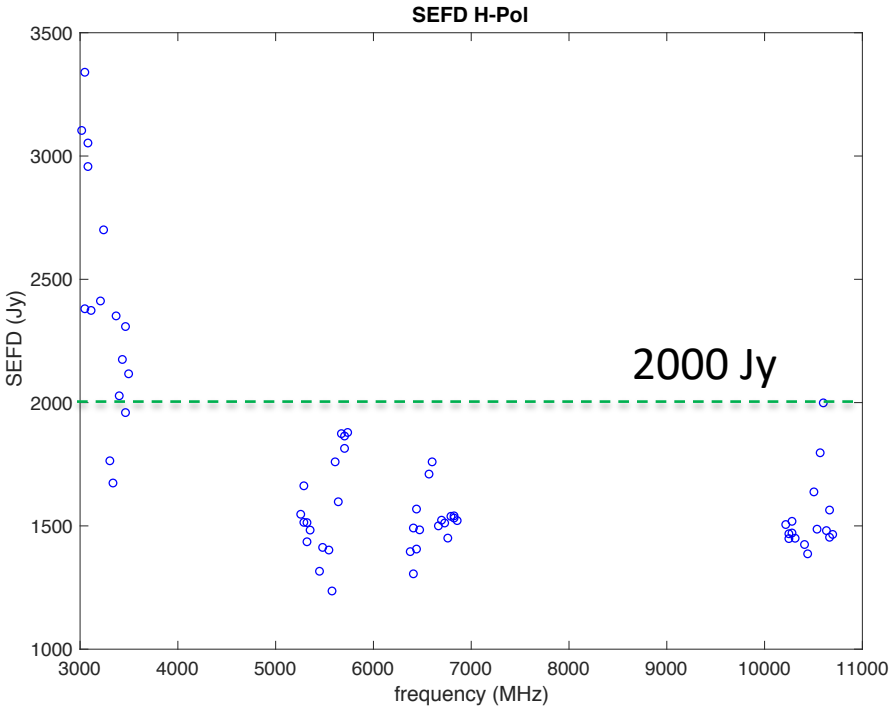
- 1 pps monitor
- Phase cal monitor
- Phase cal monitor unit
- Spectrum analyser
- Spectrum analyser unit
- LO – phase cal extract.
- DBBC IF level
- DBBC3
- RF back-end unit
- RFoF receiver

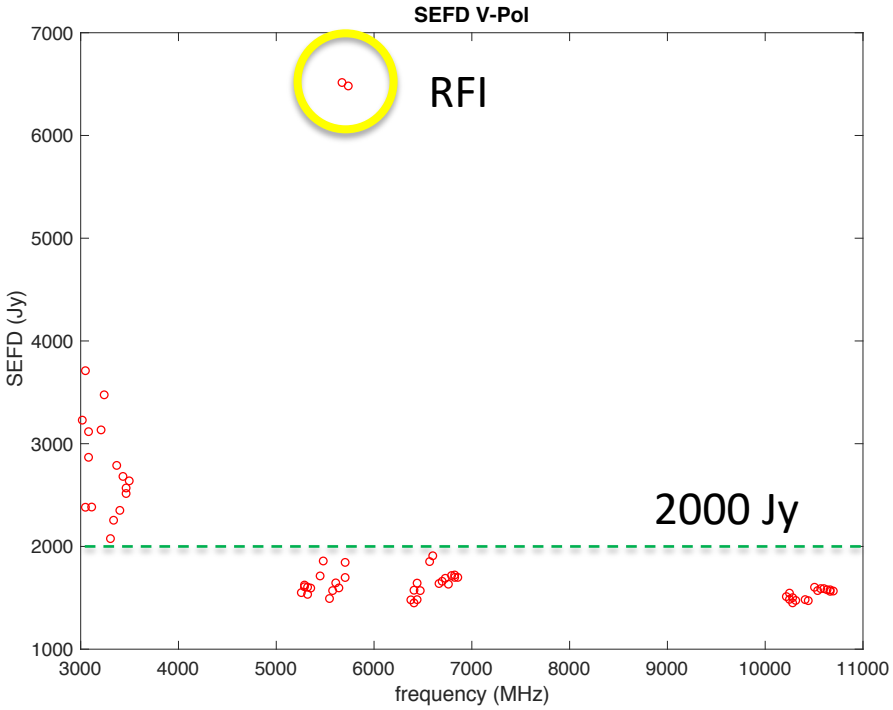
SEFD @ ONSA13SW (11-Feed)





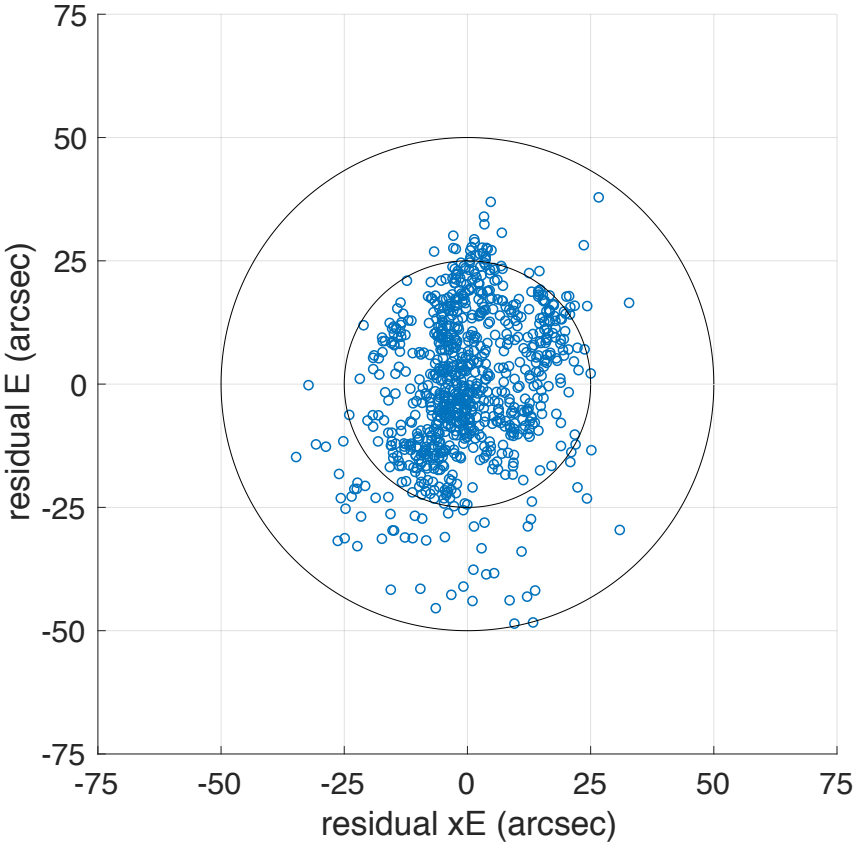
SEFD @ ONSA13NE (QRFH)





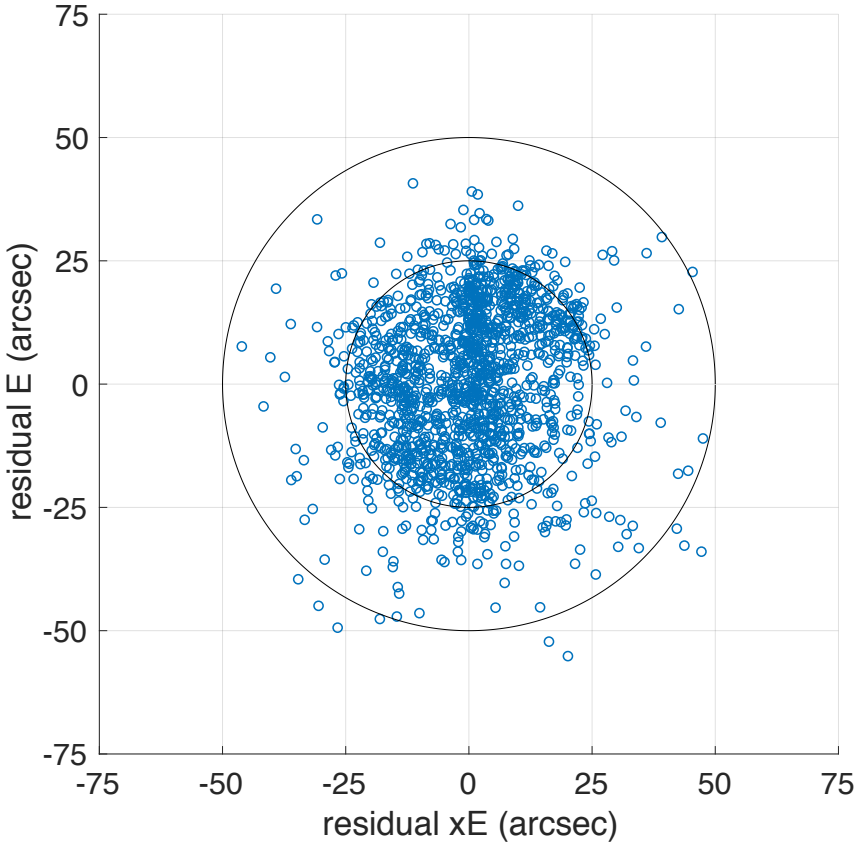
OTT pointing models

ONSA13SW



RMS EL = 14.8 arcsec
RMS XEL = 10.3 arcsec

ONSA13NE



RMS EL = 15.6 arcsec
RMS XEL = 13.2 arcsec

Data recording

- One FlexBuff recorder with 360 TB capacity
- (2nd FlexBuff recorder is in preparation)
- VGOS test sessions with 8 Gbps record about 17 TB per system during 24 hours

- Right now recording up to 24 Gbps is possible
- Flexbuff upgrade possible to reach 32 Gbps

- Flexbuff is connected with 10 Gbps to SUNET 100 Gbps backbone
- (Easy to upgrade the connection to 100 Gbps)

Observing with OTT

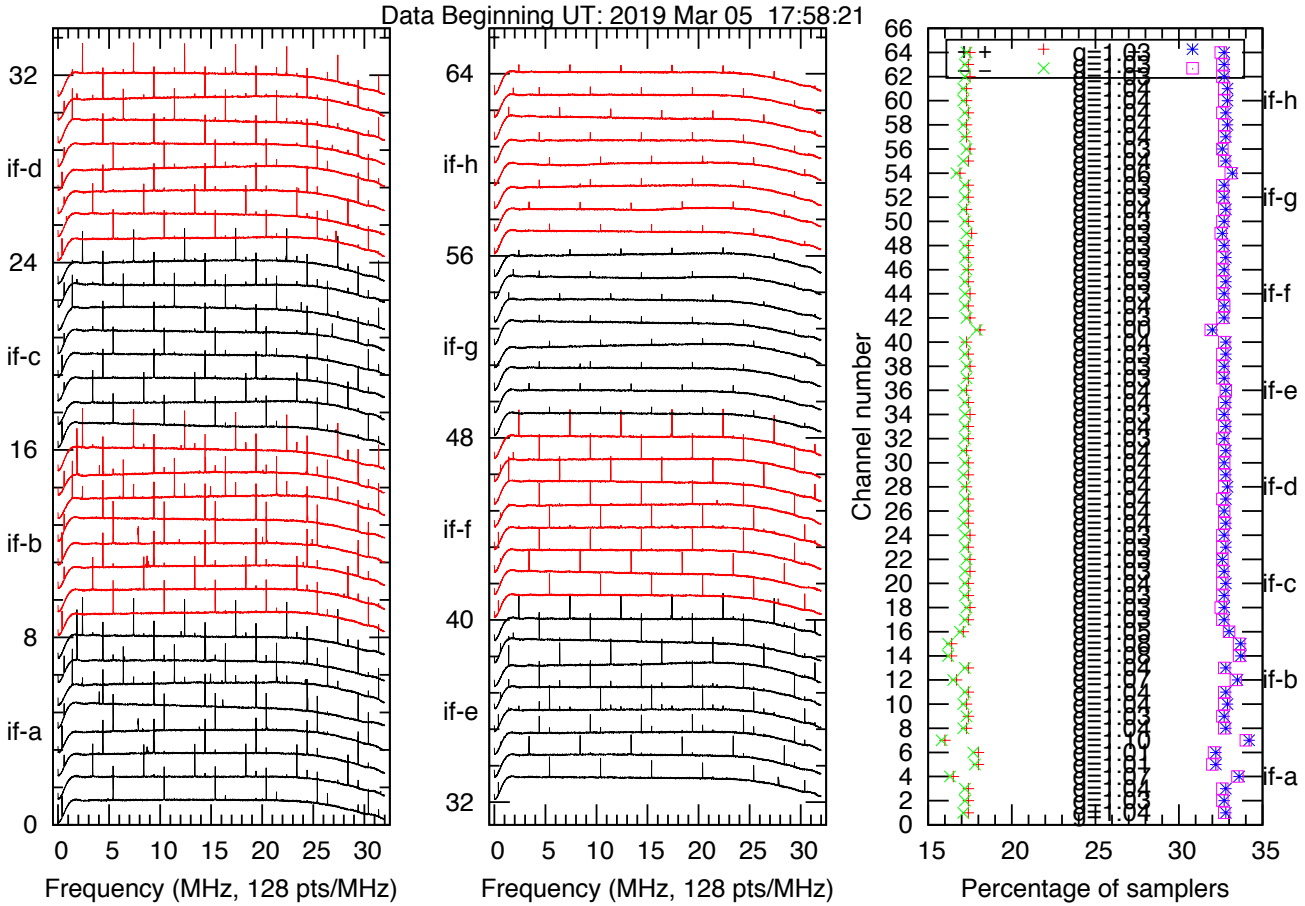
- Field System FS 9.12.12 VGOS branch
- Full FS-control of
  - Antenna ACU
  - DBBC3
  - Data recording
  - CDMS
- One FS each per VGOS system
  - Remote access possible
- Telescope monitoring via live-feed cameras
- Additional monitoring of numerous telescope status parameters with inhouse software “Bifrost”

OTT in VGOS sessions

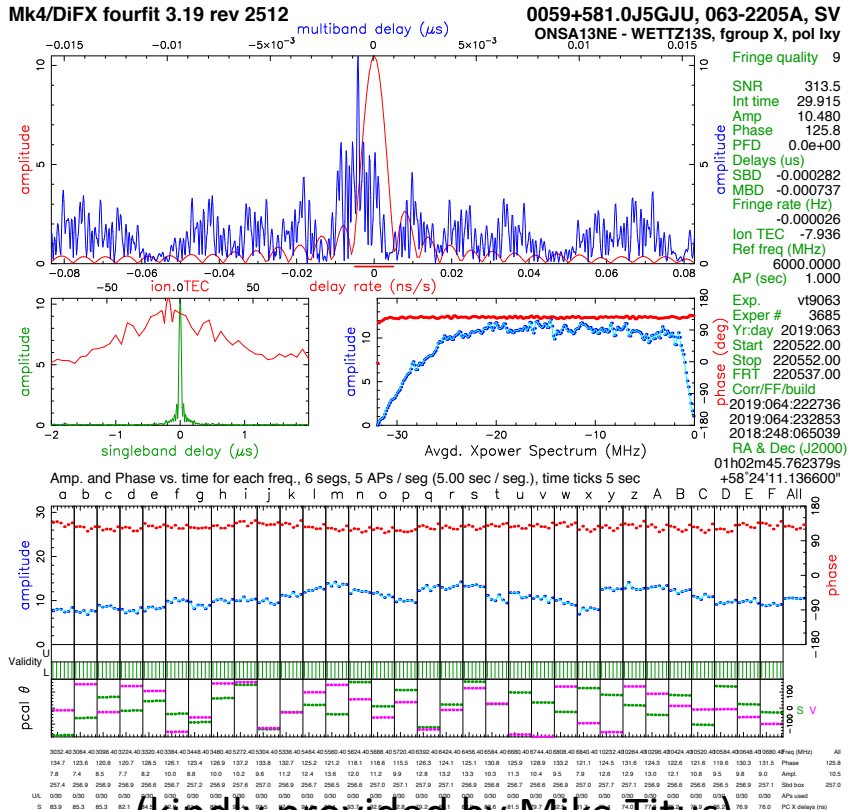
- VT-sessions (8 Gbps):
  - 24 h international VGOS test sessions (26 so far)
  - 32 x 32 MHz channels in 2 polarizations
  - Correlated at Haystack observatory
  - First vgosDBs with OTT: `19JAN07VG & 19JAN22VG`
- VGT-sessions (8 Gbps):
  - 4-6 h EU-VGOS test sessions (OTT + Ws + Yj) (13 so far)
  - Correlated at Bonn
    - See talk O202 by Alef *et al.* today at 15:45
- ”OK”-sessions (16 Gbps):
  - 1–16 h ”VGOS a la Kashima” sessions
  - 4 x 1 GHz channels in 2 polarizations

Bandpass monitoring during observations

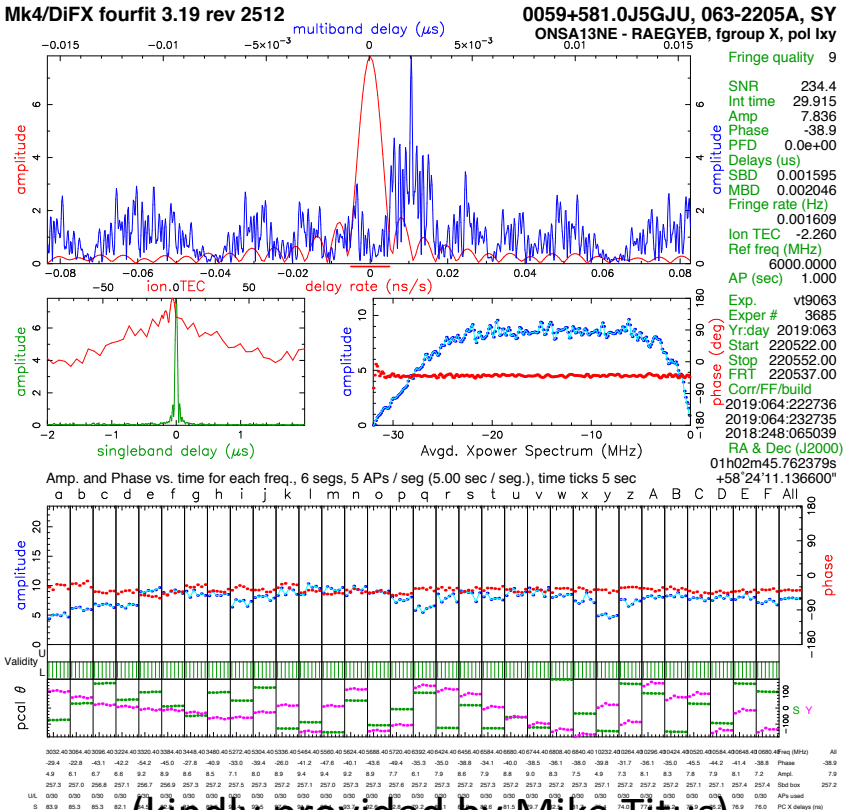
Produced for each scan directly on FS window



Recent fringe plots (VT9063)



(kindly provided by Mike Titus)



(kindly provided by Mike Titus)

Further work done in 2018

- Photogrammetry with an UAV to investigate elevatin-dependent focal length variations
  - See talk O105 by Lösler *et al.* today at 11:00
- A local geodetic survey network has been installed
- Temperature and humidity monitoring systems in the telescope towers have been installed

Summary

- The Onsala twin telescopes are VGOS quasi-operational
  - Broadband sessions (VT, VGT) every 2nd week
  - First vgosDBs with OTT: `19JAN07VG & 19JAN22VG`

- Observing at 8 Gbps and 16 Gbps successful
- Higher data rates will be tested (e.g. EVN 32 Gbps)

- Steep learning curve (RF-levels, PCAL-level, operations as such, …)

Outlook

- MT Mechatronics:
  - Upgrade of ACU software in March
  - Corrosion inspection and treatment in April
- OSO:
  - Maintenance of OTT-receivers and optimizing signal chain
  - Gain curves and system calibration
  - Re-installation of CDMS-system for ONSA13SW
  - Local-tie and reference point measurements
- HatLab:
  - More flexible DBBC3 firmware (e.g. channel bandwidth)
  - DBBC3 bandpass improvements
  - Continuous Cal during VGOS observations

- We expect that OTT will be fully operational at the end of 2019 when the development phase (Wallenberg project) ends