Continuous comparison polarimetric receiver for 22, 37/43 and 86 GHz

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Science motivation

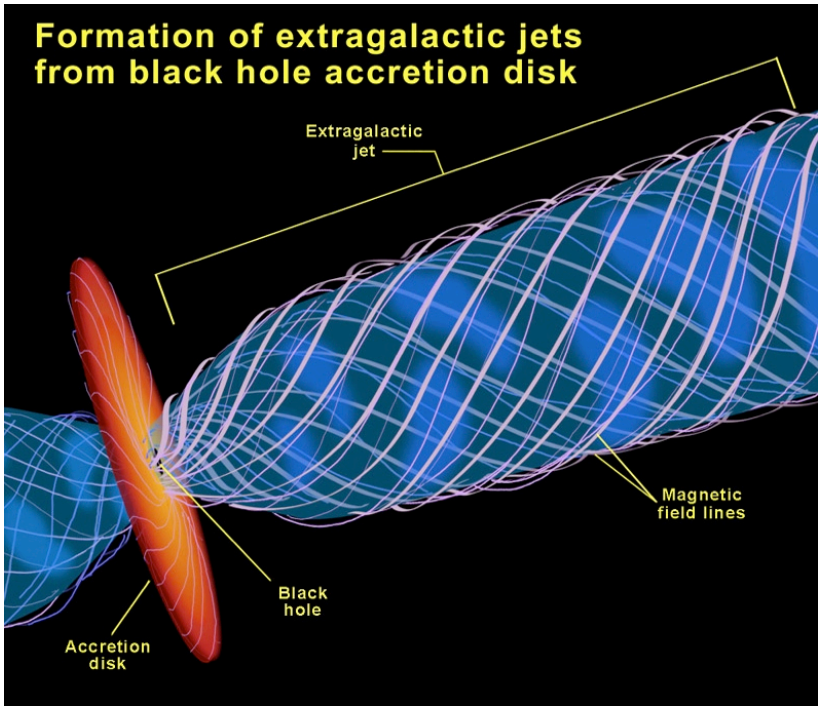
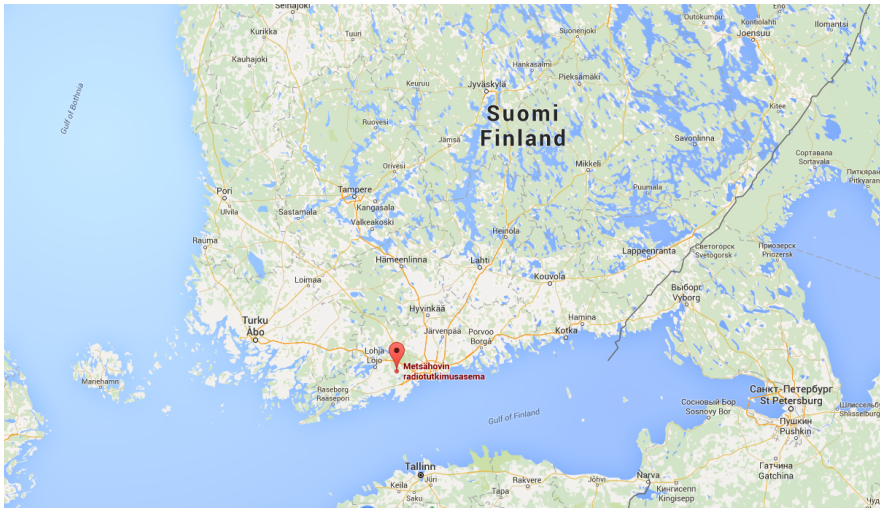
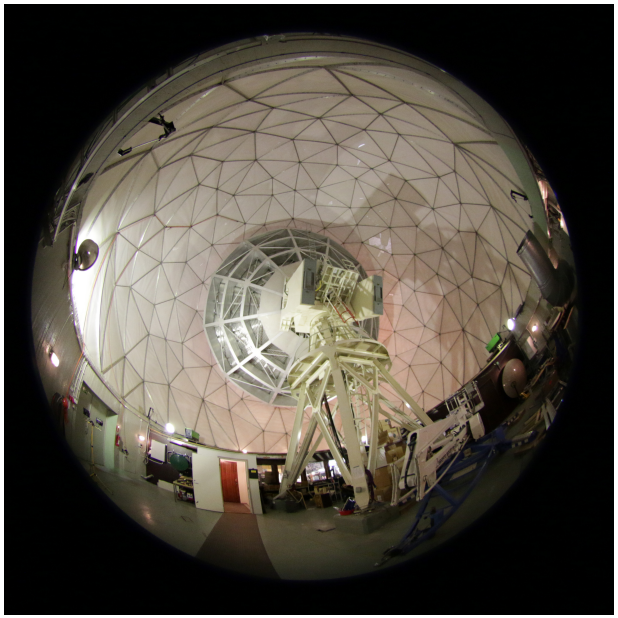


Image credit: NASA / Ann Field

- Jets form through interaction between magnetic fields and black hole / accretion disk
- Polarization is a probe for magnetic fields
- Fast-cadence single-dish observations can help to distinguish ordered and turbulent B-field models
- Circular polarization probes particle composition

Metsähovi Radio Observatory





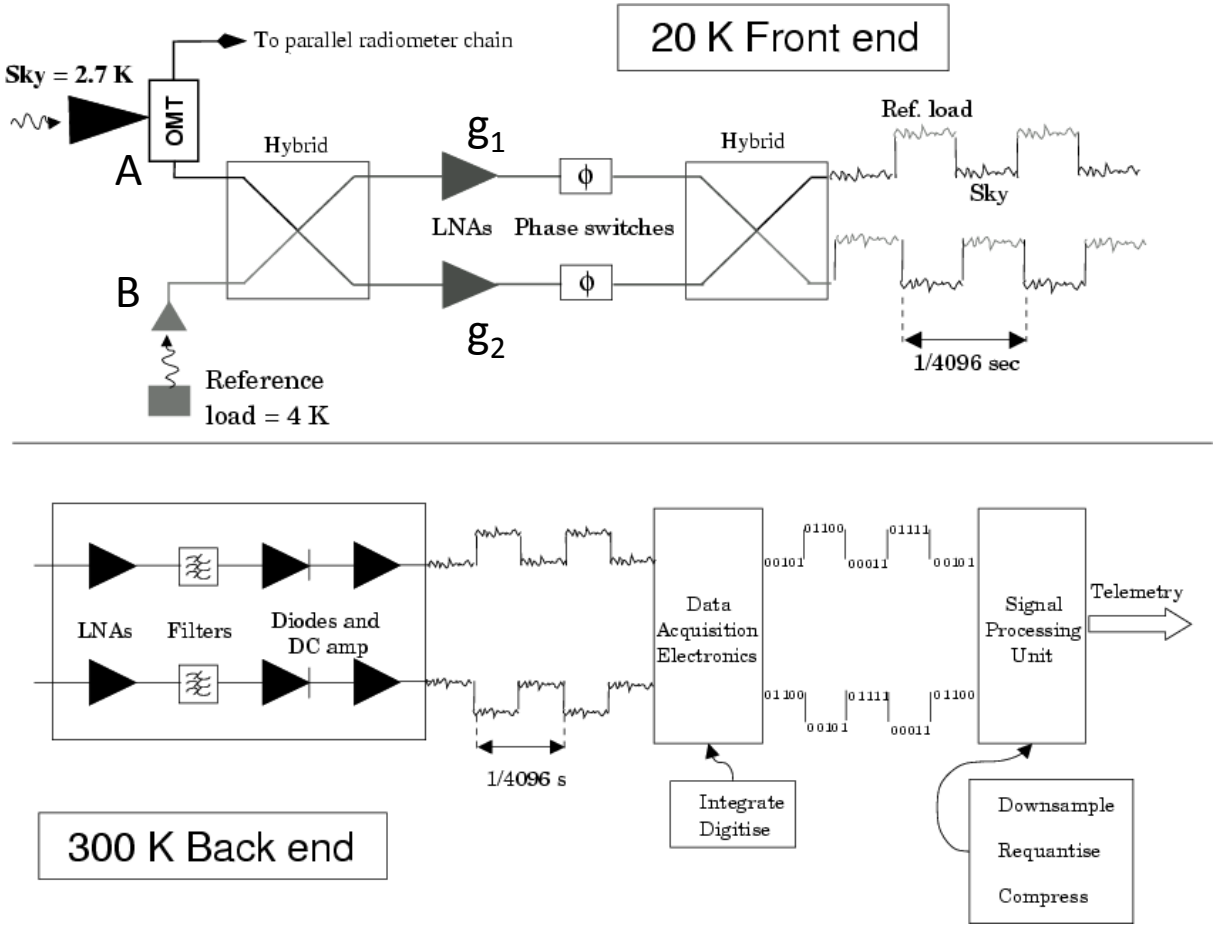
- Radome-enclosed 14-m telescope
- Currently most of the observing time is devoted to 22/37 GHz observations of AGN
- Participates in EVN, GMVA and Geodetic VLBI sessions

Most beneficial would be to have one receiver that can do everything!

Technical requirements

- Polarimetric receiver
  - Both linear and circular
- Multiple frequencies (22 / 37-43 / 86 GHz)
  - Fast switching for VLBI to enable phase transfer
- Capable for single-dish observations as well
  - High sensitivity (~10 mJy source brightness)
  - Reduction of 1/f noise
- Confined to a relatively small space (max diameter 500mm)

Continuous comparison receiver



Baseline Planck LFI Pseudo-correlation receiver (Mennella et al. 2003, A&A, 410, 1089)

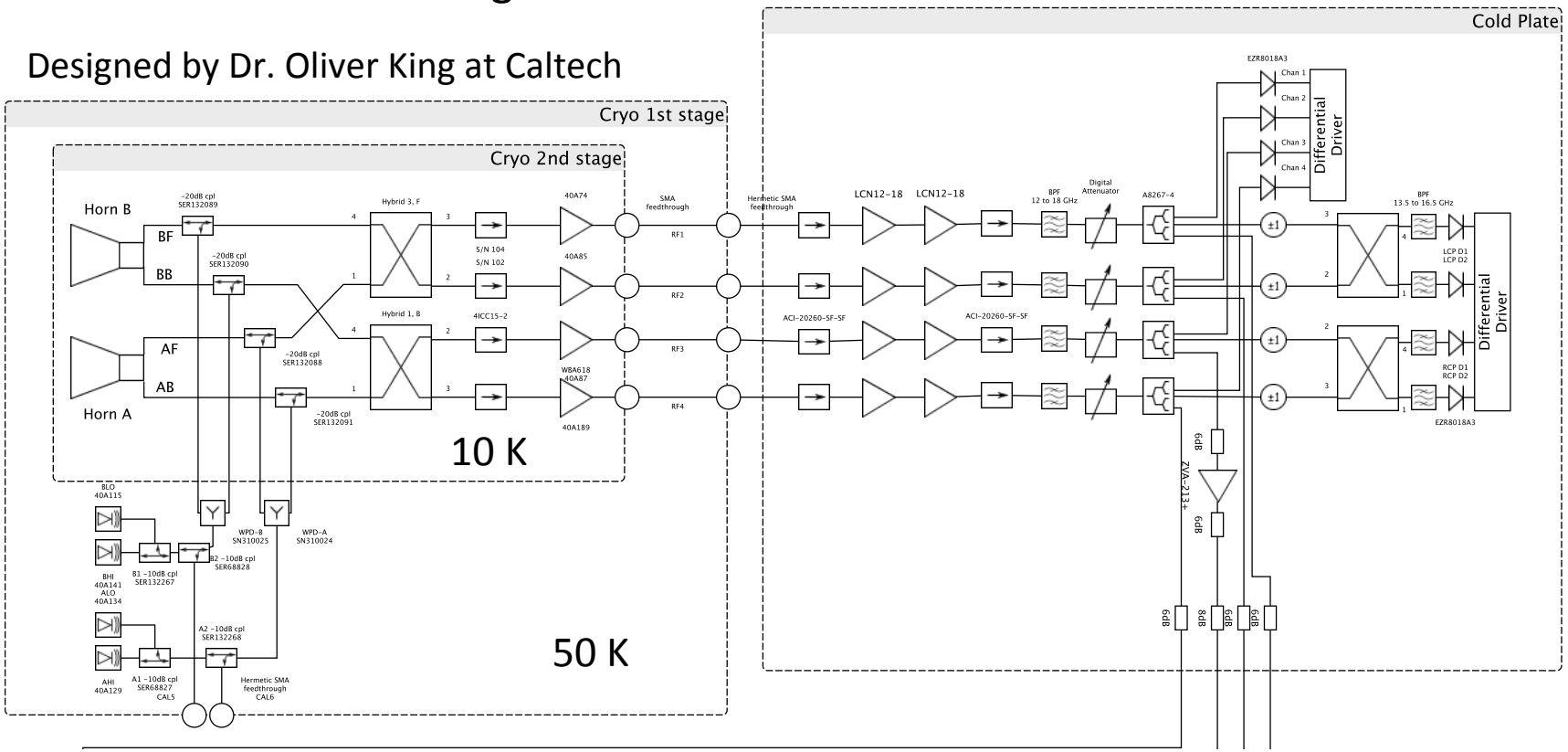
$$V_l - V_r = \mp s(A^2 - B^2)g_1(t)g_2(t)$$

$(A^2\text{-}B^2)$ is much smaller than the sum of the first terms so that the effect on gain variations is smaller

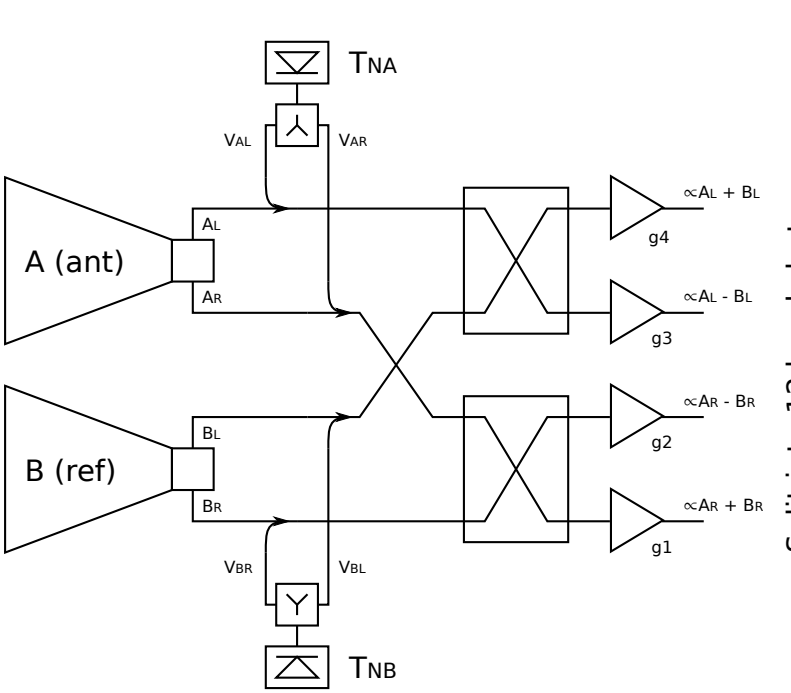
12-18 GHz polarization receiver KuPol

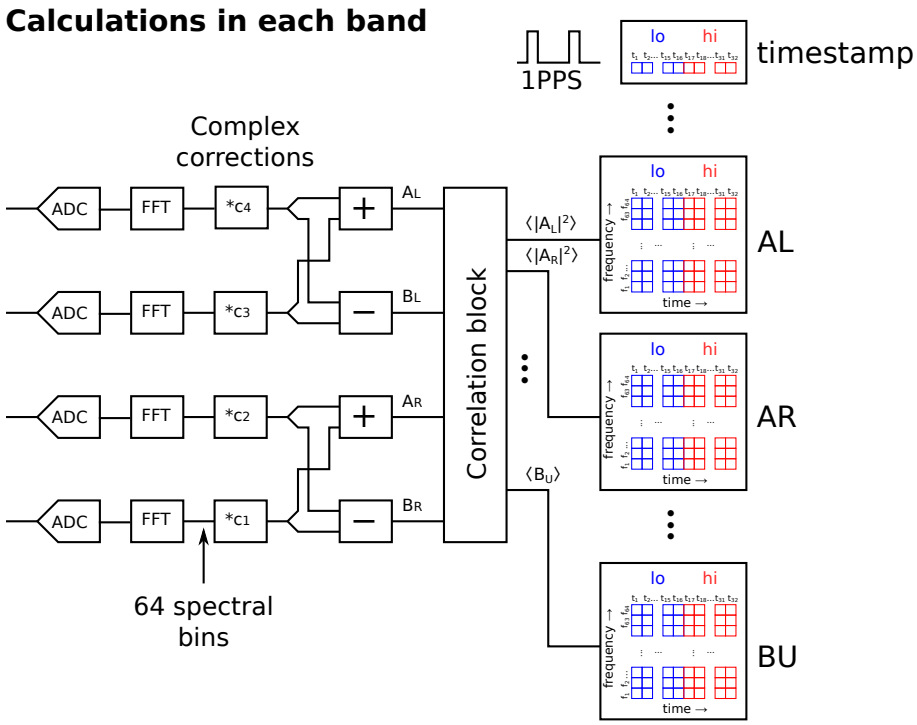
- Mounted on the 40-m telescope at Owens Valley Radio Observatory (Caltech)
- Operational since May 2014
- Hybrid design with both analog and digital backends to reduce commissioning time

Designed by Dr. Oliver King at Caltech



Polarization through correlation

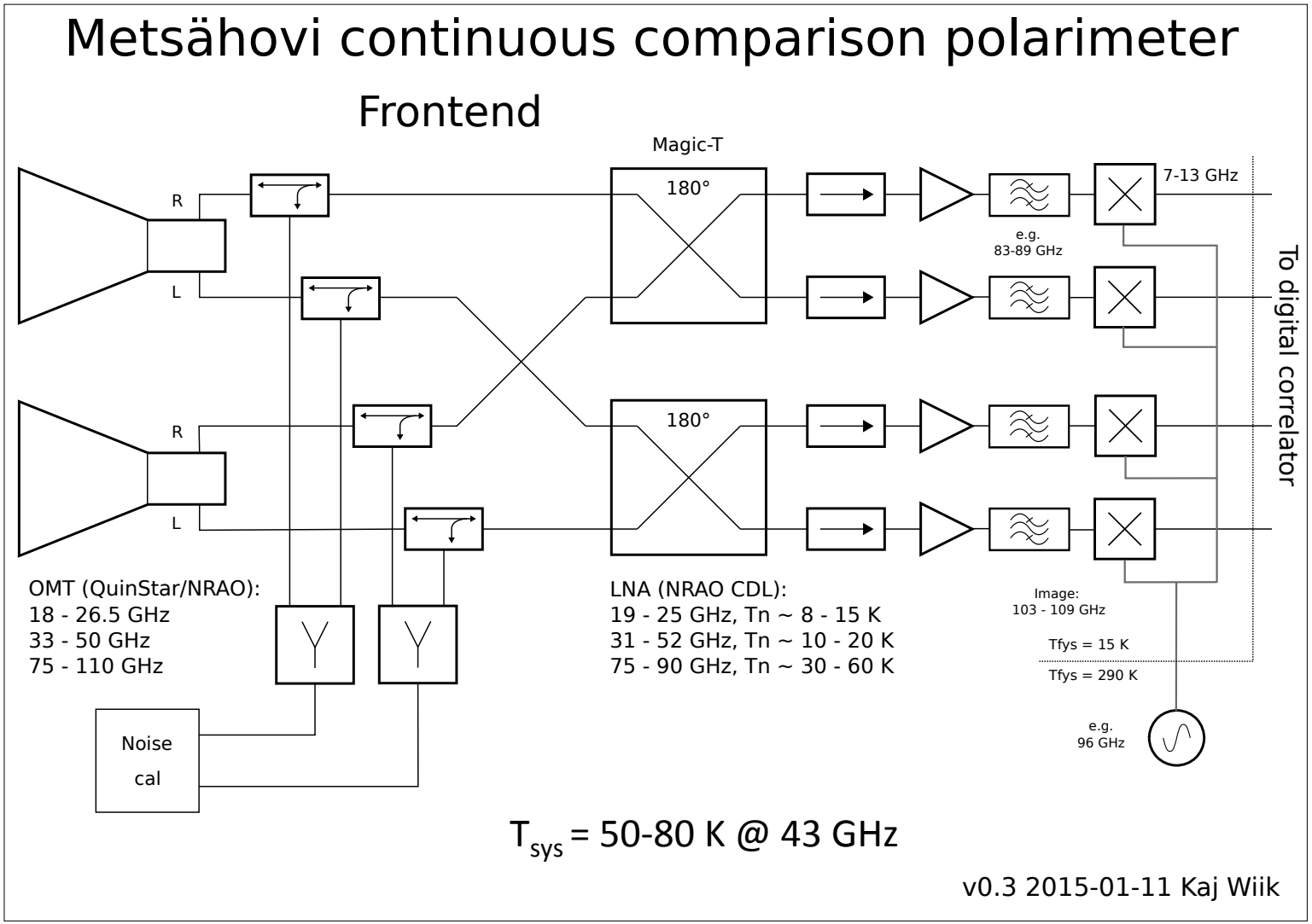




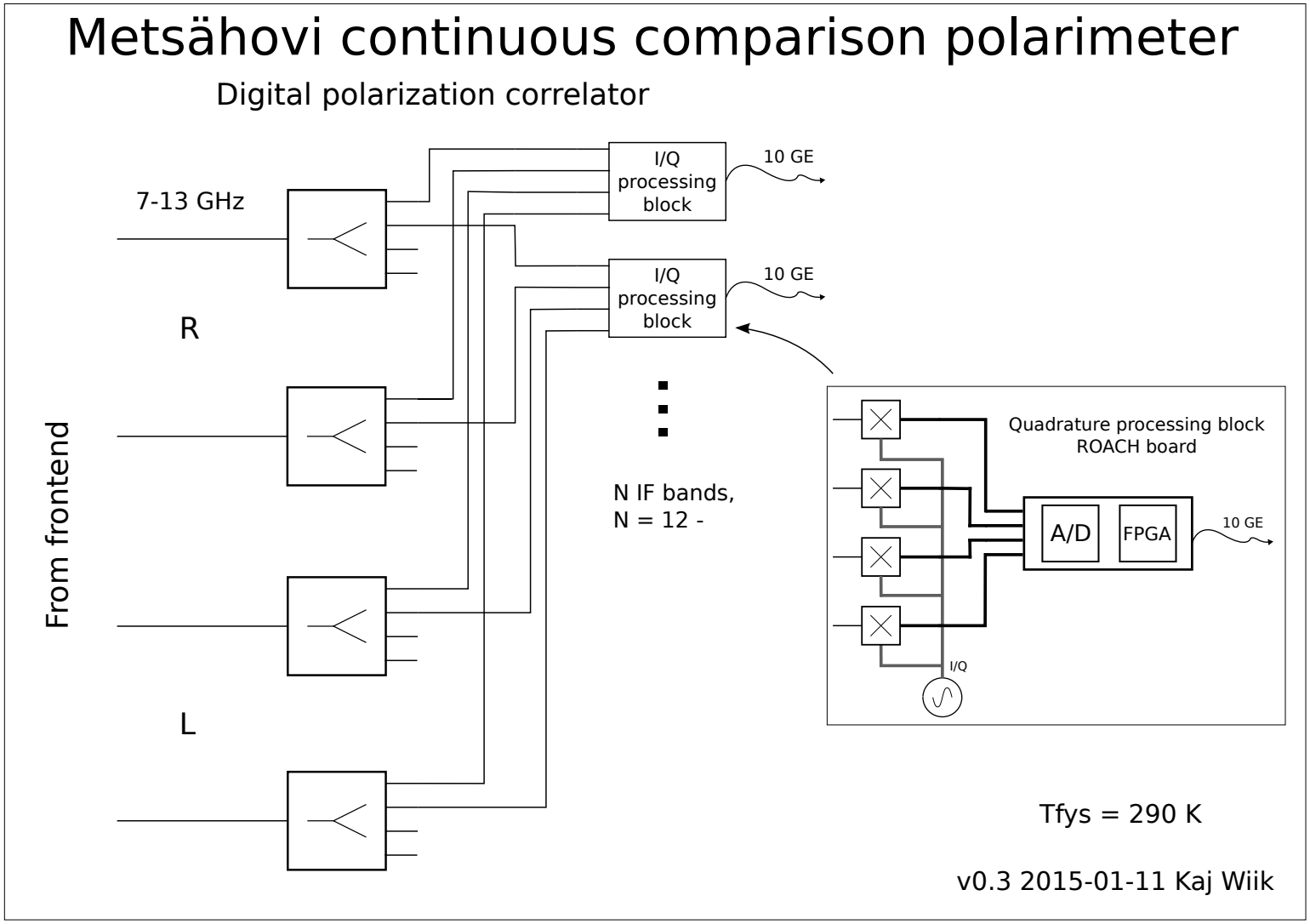
Courtesy of Dr. O. King

Calculations performed with ROACH boards

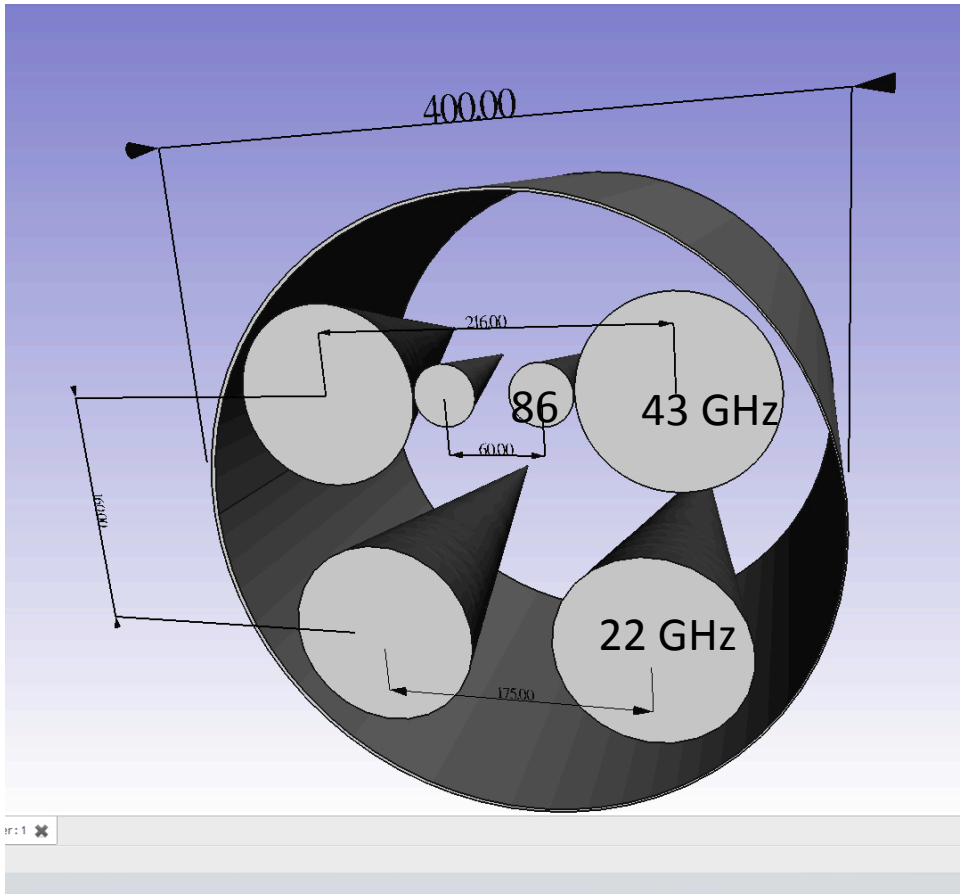
Metsähovi frontend



Digital backend



Multifrequency setup



- All horns in a single cylinder
- Switching between frequencies done by changing pointing offsets
  - Between 43-86 GHz takes about 0.9-1.2s depending on elevation
  - Additional stabilization period of (currently) 2s

⇒ Short enough for phase transfer from 43 to 86 GHz (Middleberg et al. 2003, A&A, 433, 897)

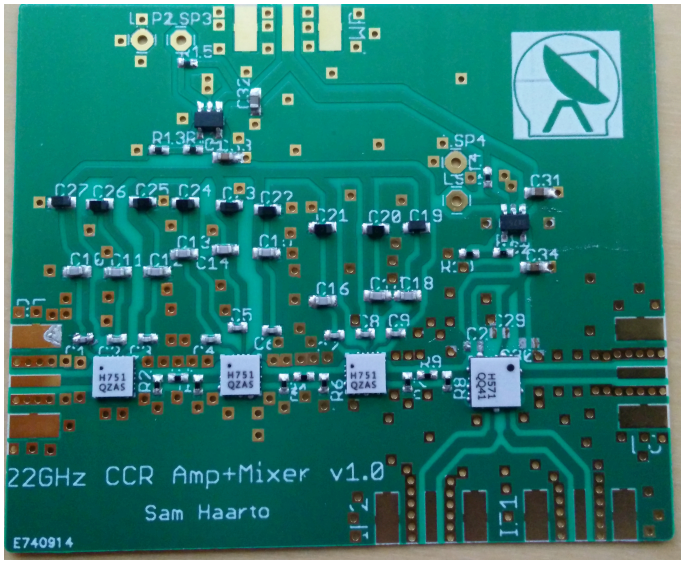
Rough cost estimate

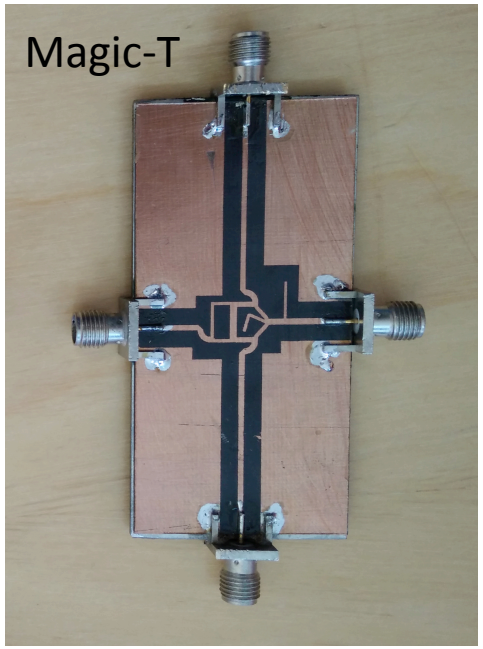
- Cryostat 55 k euro
- Frontends for K / Q / W bands 100k euro each
- Microwave / IF processing 50k euro
- Digital backend 100 k euro

500 k euro in total (VAT or manpower not included)

Warm test receiver at 22 GHz

- Master's student project
- Linear feeds
- DBBC for data readout
- Plan to implement a software simulator for digital backend testing





Summary and outlook

- Need for a receiver that can do both single-dish and VLBI observations
  - Requires high sensitivity (~10 mJy)
- Multiple frequencies and fast switching
- Linear and circular polarization

→ Continuous comparison receiver

  - Start with 37/43 GHz to test concept and add 22 and 86 GHz later
  - Work on a 22 GHz test setup on-going as a Master's student project