www.csiro.au

ASKAP Industry briefing

Russell Gough

October 23, 2009

CSIRO

Outline

- Introduction
  - ASKAP specifications
  - Analog System specifications
  - Design constraints
- ASKAP prototype PAF receiver system
  - Design Options
  - Solution
- Key challenges and future directions
  - Mass production and testing of receiver packages
  - Component cooling
  - Integrated receivers (‘system-on-a-chip’)

ASKAP specifications

ASKAP Design Goals:

- High-dynamic range
- Wide field-of-view imaging

Number of dishes	36
Dish diameter	12 m
Max baseline	6 km
Resolution	30″
Sensitivity	65 m^2/Kelvin
Speed	1.3×10^5 m^4/$Kelvin^2$/deg^2
T_{SYS}/η	63 Kelvin (eg. T_{SYS} = 50 K, η = 80%)
Observing frequency	700 – 1800 MHz
Field of View	30 deg^2
Processed Bandwidth	300 MHz
Spectral channels	16 k
Focal Plane Phased Array	188 receiver channels

Analog System specifications

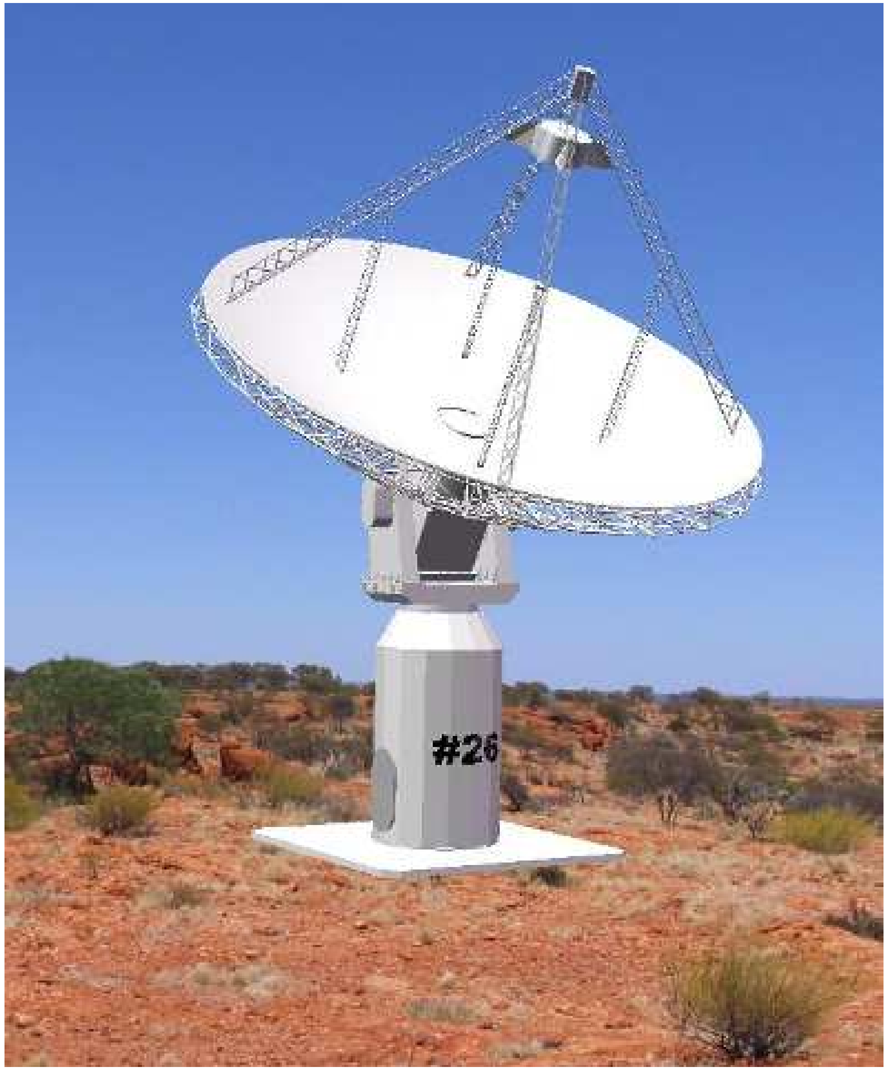
- Phased array receiver size
  - Receiver elements ~200 per antenna
- Frequencies
  - RF band 700 – 1800 MHz
  - Instantaneous bandwidth 300 MHz
  - Sampled band 424 – 724 MHz
  - Sample clock 768 MHz
- Low-noise amplifiers
  - amplifier noise temperature 40 Kelvin
  - amplifier gain 27 dB
- System gain
  - Nominal total nett gain 72 dB
- Output power (to digitiser)
  - Nominal IF output power -19 ±1 dBm into 50 Ohms

Design constraints

- Relatively long f/D ratio (f/D = 0.5)
- PAF receiver weight must be less than 200kg
- High attenuation in coax cable from prime focus to pedestal

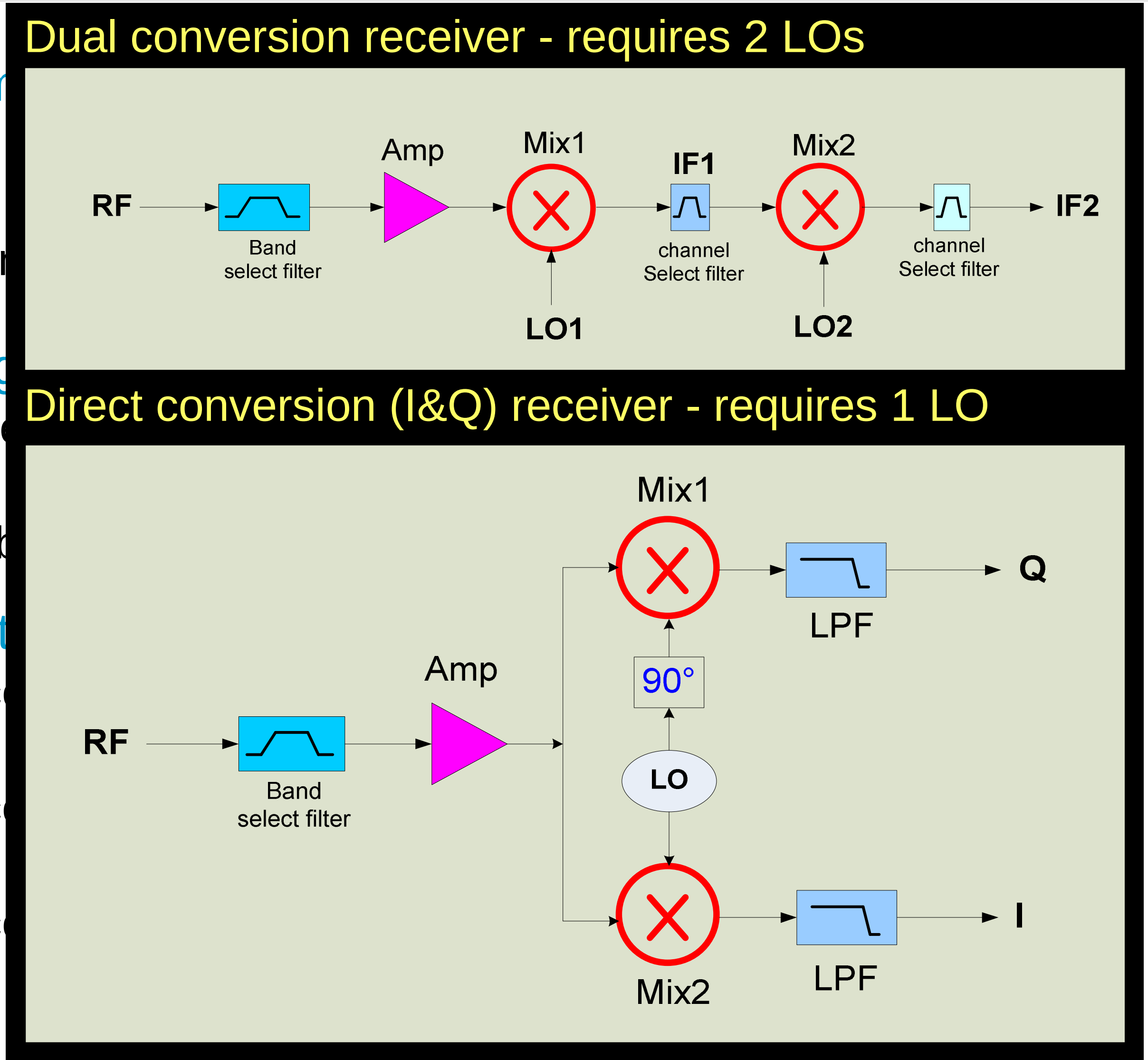
  17dB at 0.7GHz

  31dB at 1.8GHz
- Minimise RFI generated
- Maximise RFI immunity

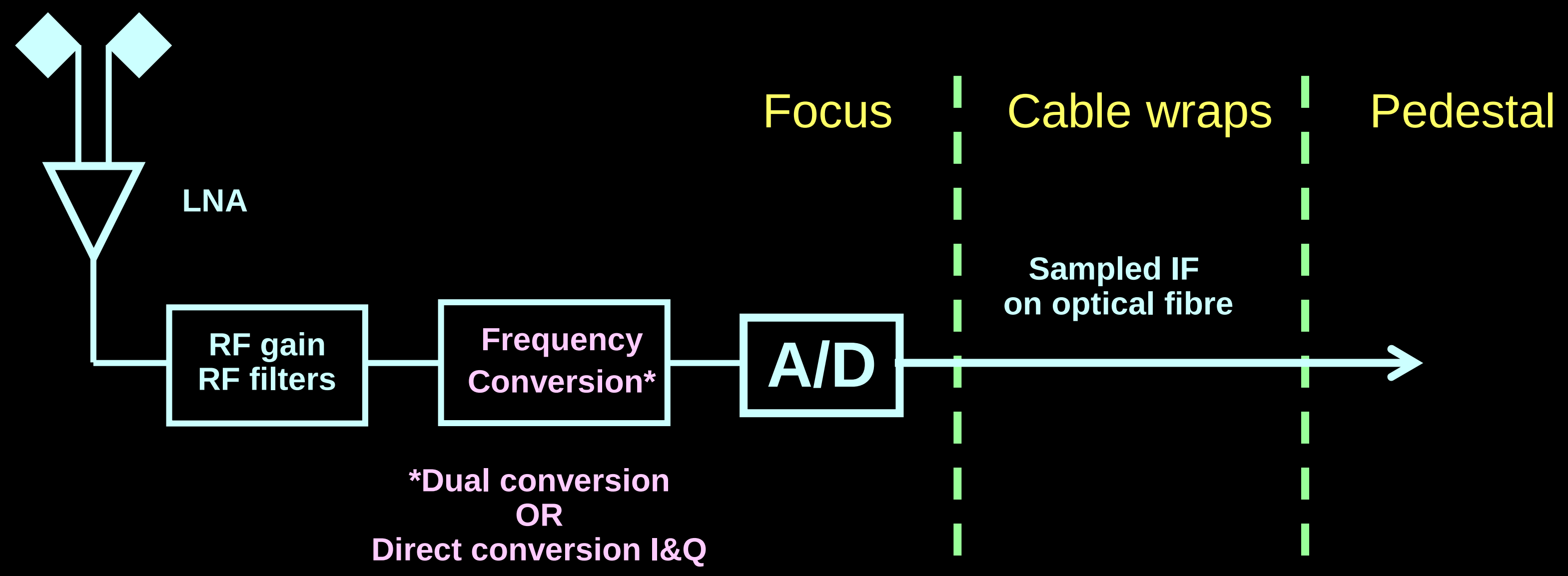


Design options

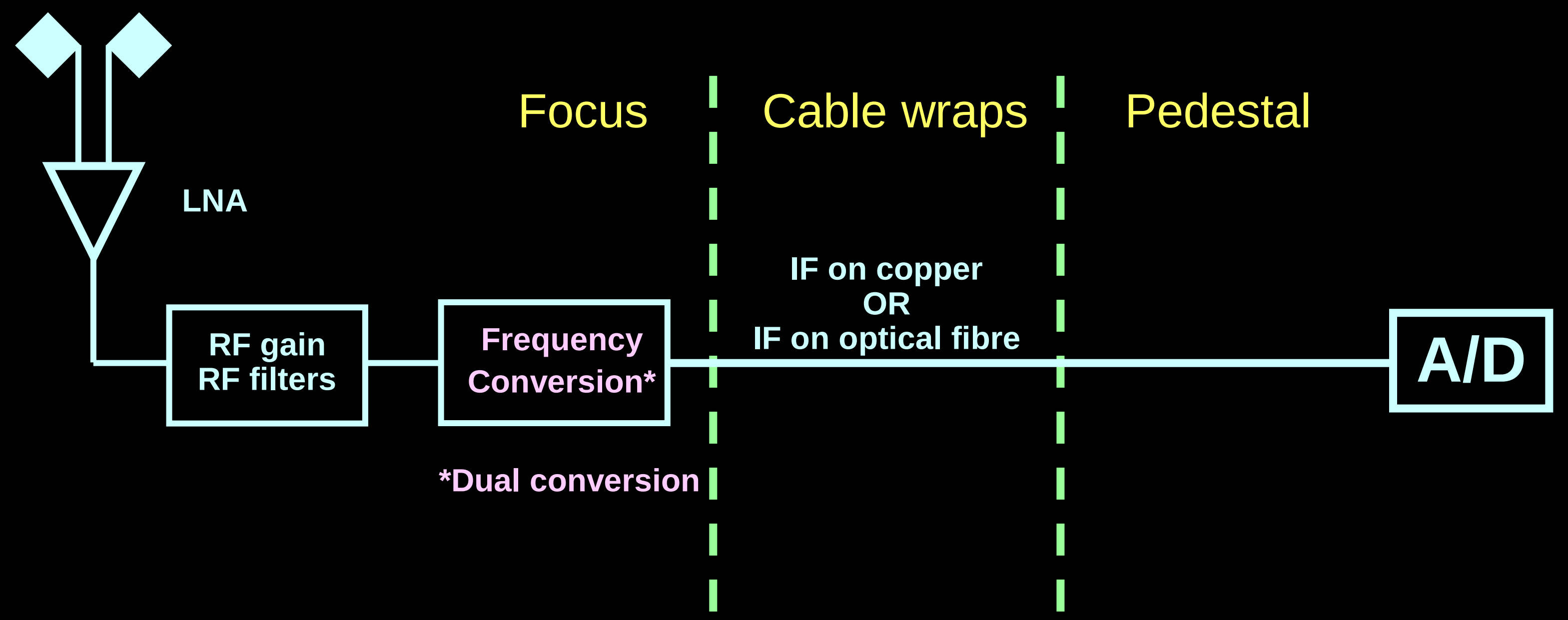
- Conversion schem
  - Dual conversion
    OR
  - Direct conversion
- Analog RF (IF) sig
  - Over optical fibr
    OR
  - Over coaxial cab
- Receiver architect
  - (1) Frequency c
    OR
  - (2) Frequency c
    OR
  - (3) Frequency c



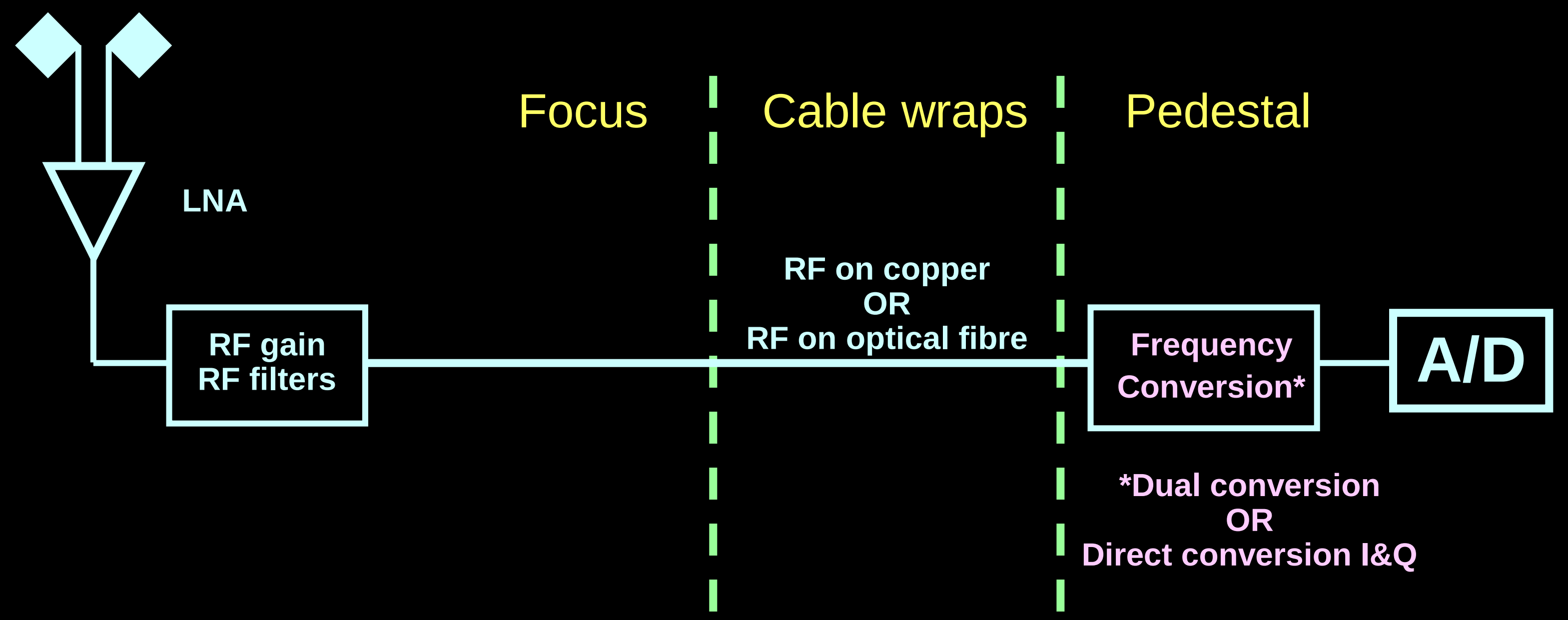
(1) Frequency conversion and sampler at the focus



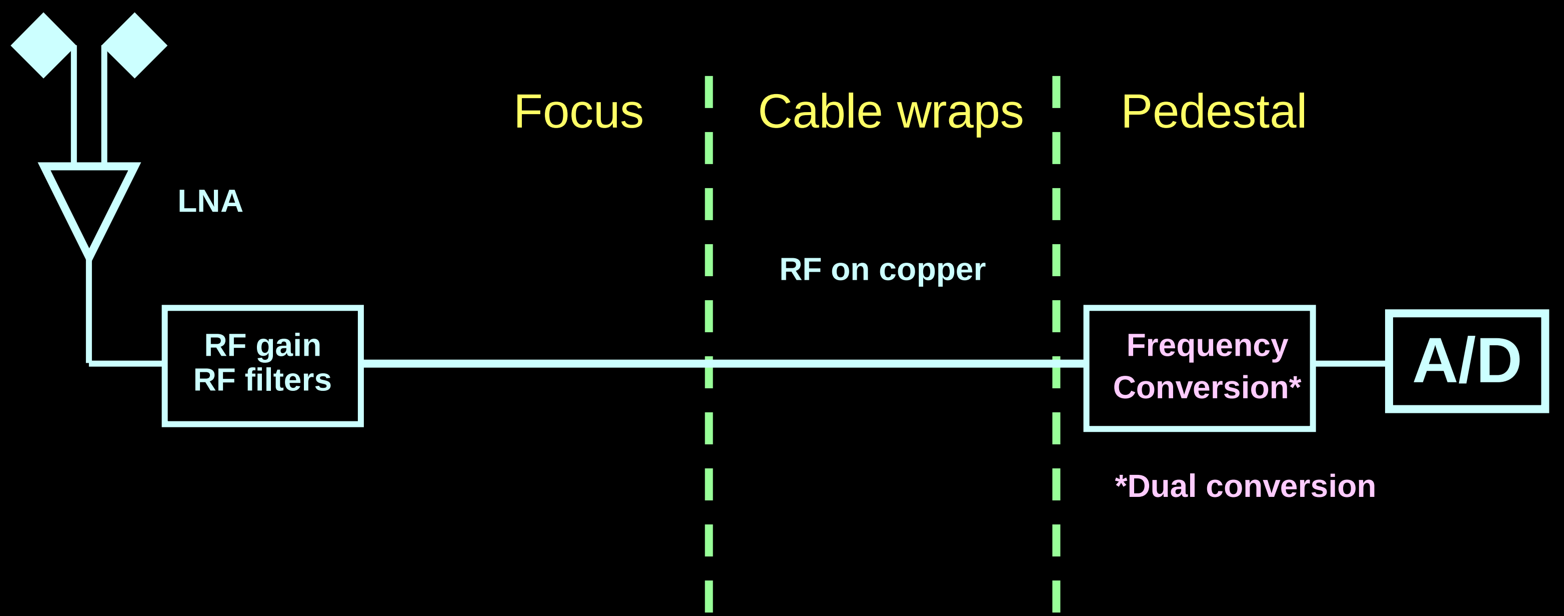
(2) Frequency conversion at the focus, sampler in the pedestal



(3) Frequency conversion and sampler in the pedestal

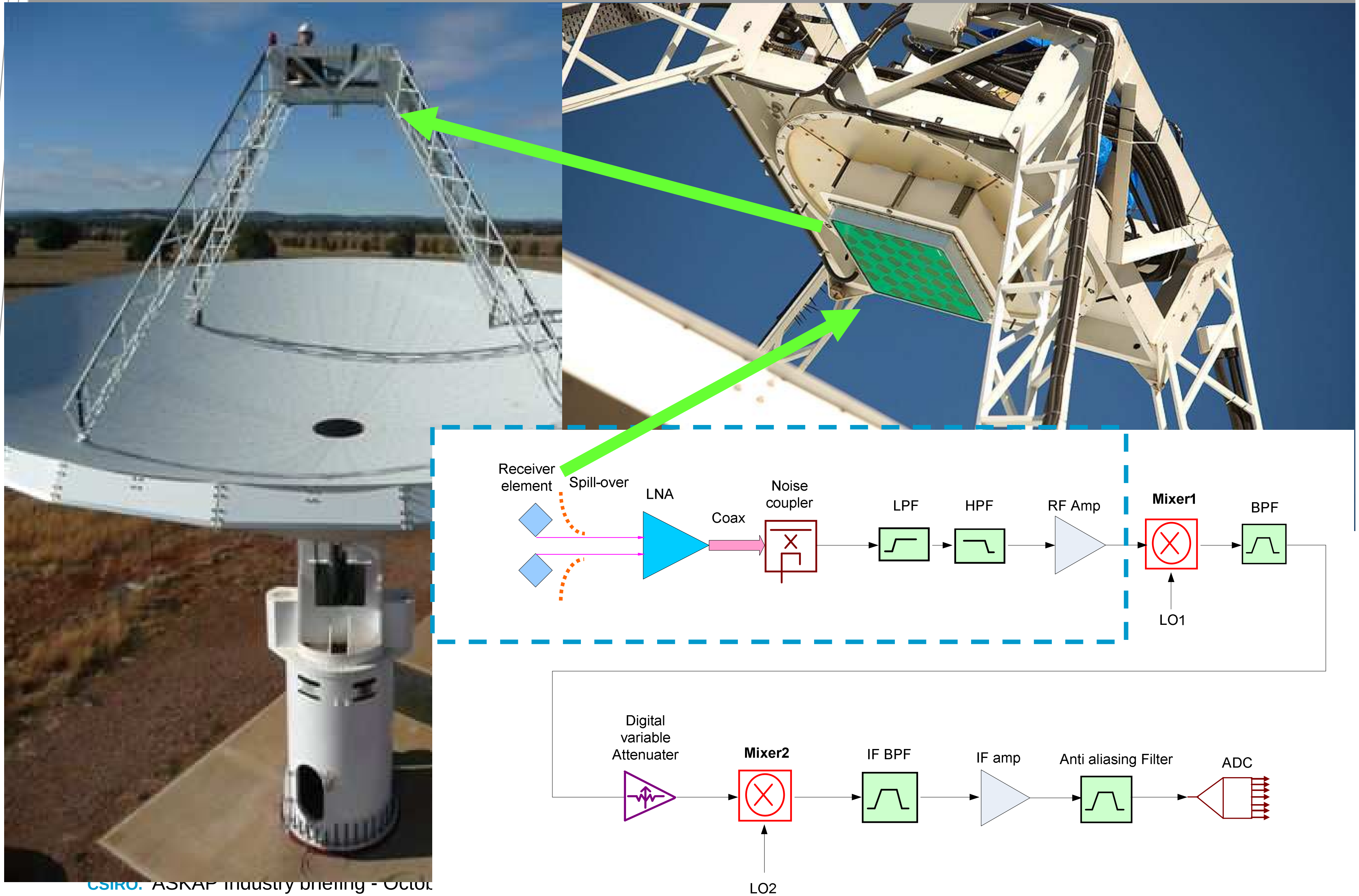


ASKAP Analog System architecture

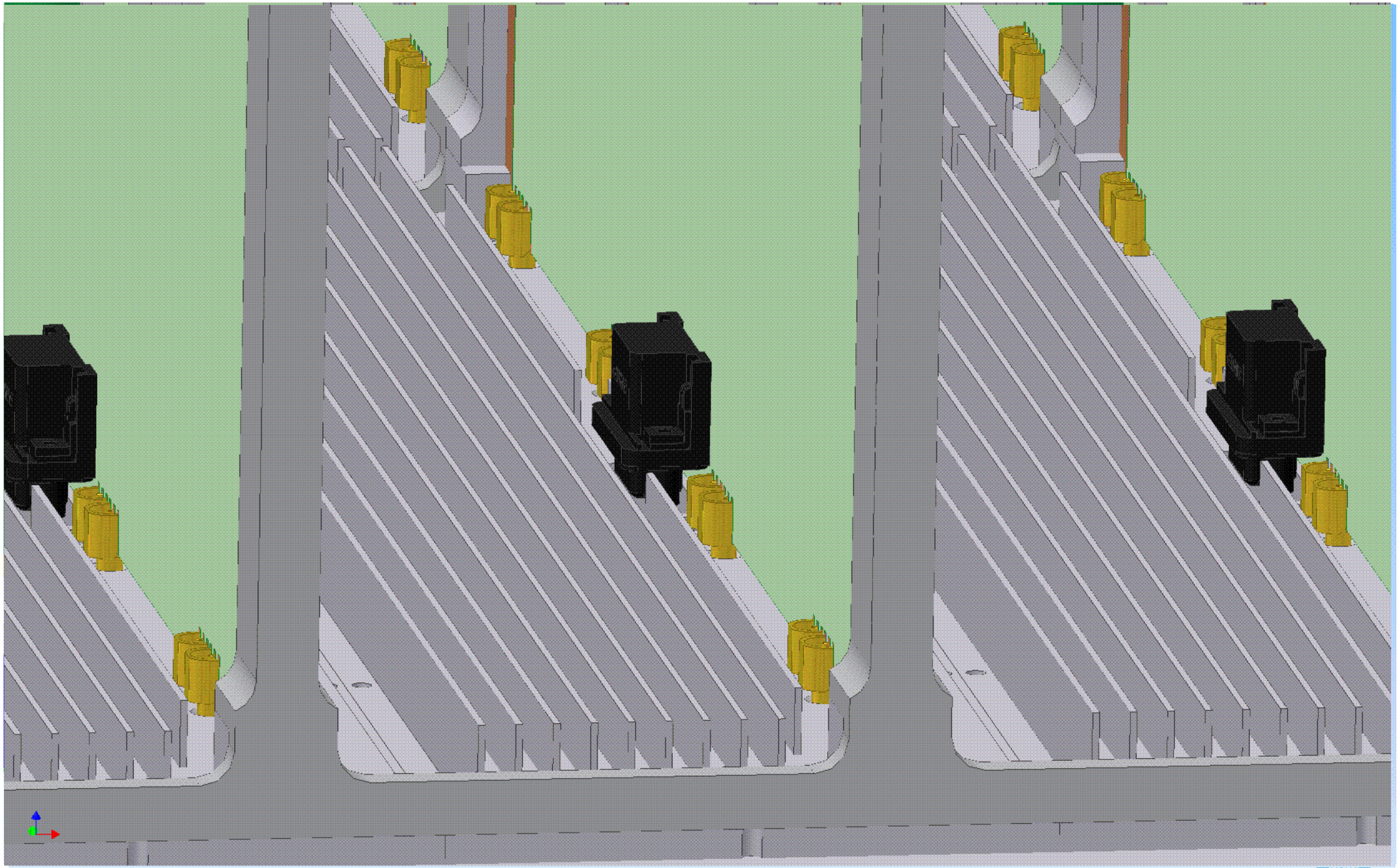


- Frequency conversion and sampler in the pedestal
- Analog RF signal transmission over coaxial cable
- Dual conversion (superheterodyne) receiver

ASKAP Analog System architecture with 200 receiver elements

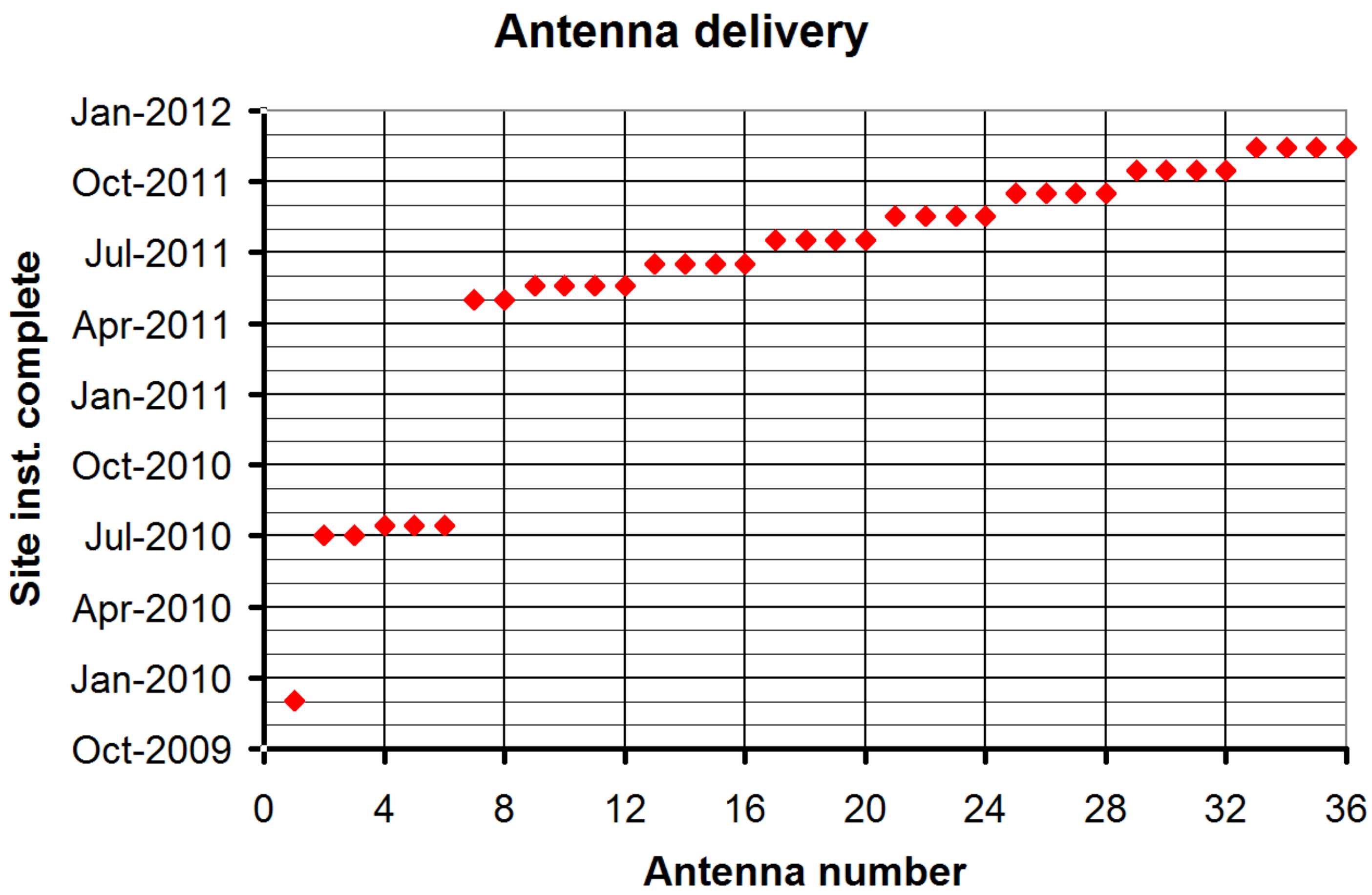


Prime Focus package



Key challenges and future directions

- Mass production and testing of receiver packages
  - With ~200 receiver elements per antenna



Key challenges and future directions

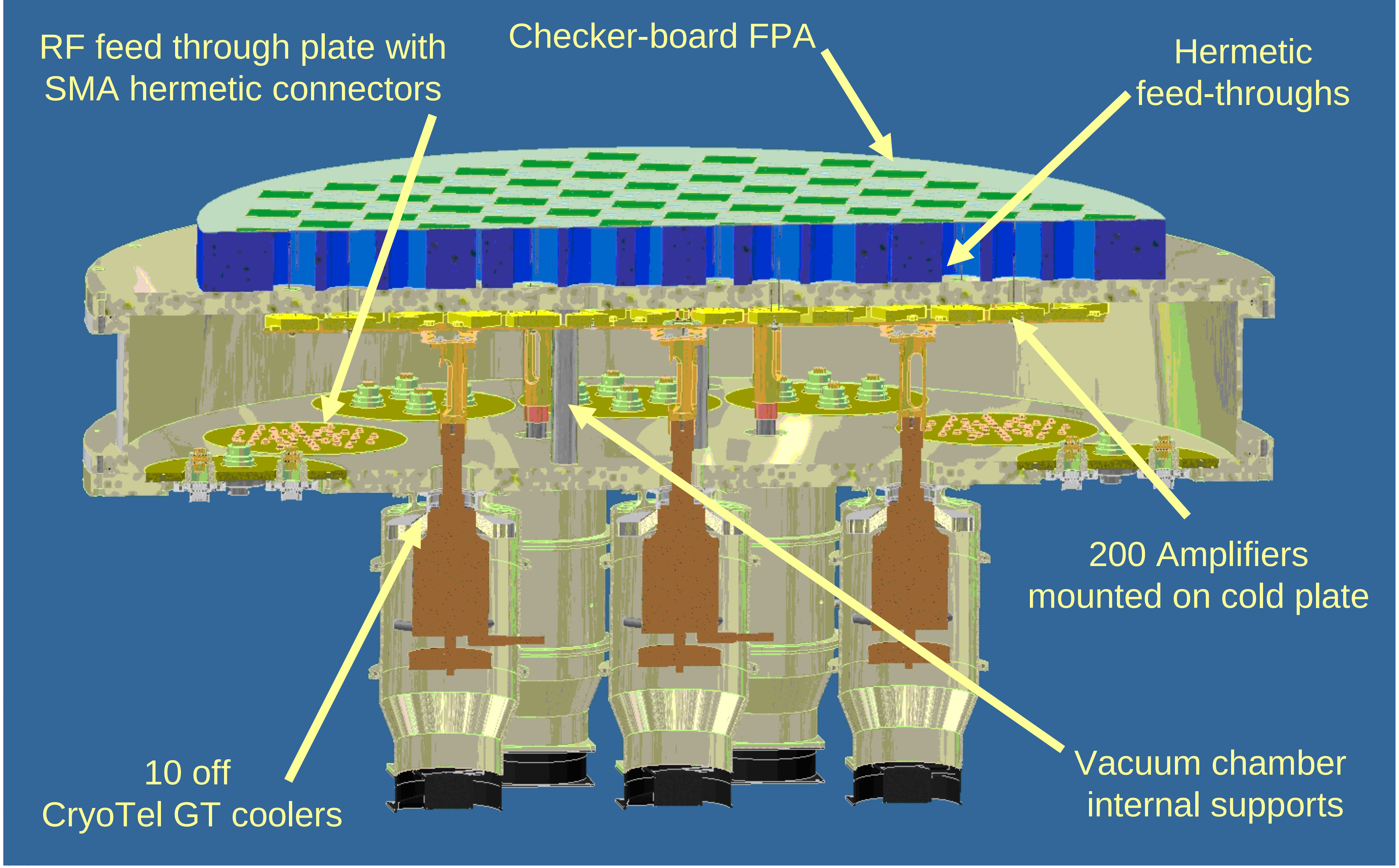
- Mass production and testing of receiver packages
  - With ~200 receiver elements per antenna
- Component cooling
  - Low-noise amplifier dissipation: 120 mW
  - Cryogenic cooling of critical components of the receiver electronics (eg. low-noise amplifiers) significantly improves receiver sensitivity
  - Cryogenic cooling is especially important at higher frequencies -
    where the potential improvement in system sensitivity is greater
    - Cryogenic cooling to 20 Kelvin or 70 Kelvin.
    - Cooling of the whole receiver package
      or
      distributed cooling of individual low-noise amplifiers.

Key challenges and future directions

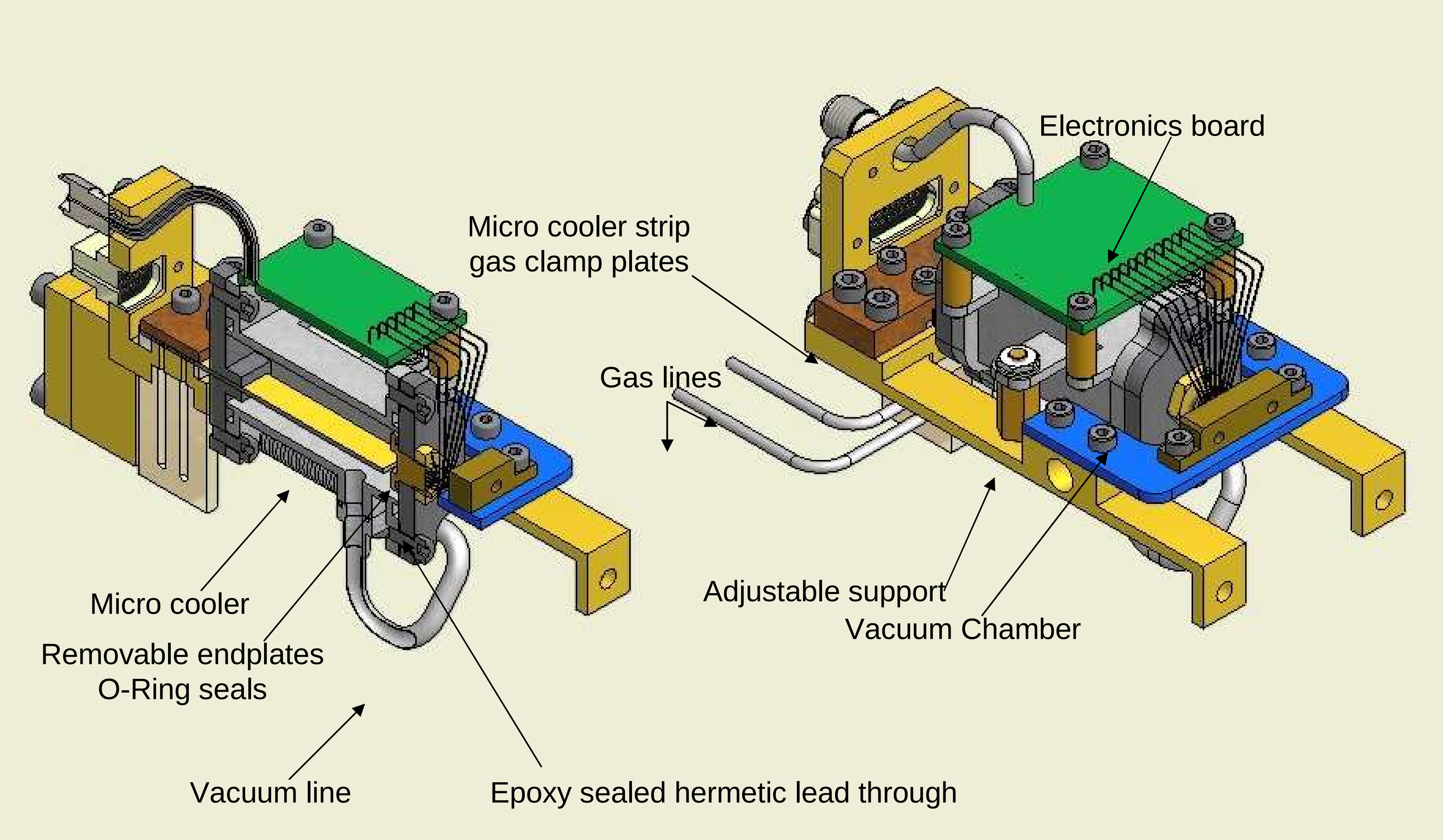
- Mass production and testing of receiver packages
  - With ~200 receiver elements per antenna
- Component cooling
  - Low-noise amplifier dissipation: 120 mW

Component	Heat load (Watts)
Radiation load: Cold plate	6
Radiation load: Amplifier Bodies	4
Radiation from epoxied feed throughs	0.4
200 off low-noise amplifiers (3V/40mA each)	24
Bias wiring for 200 amplifiers	11
400 Feed pins from focal plane array	4
Total heat load for receiver with 200 LNAs	**50 Watts**

Component cooling – using commercial cryo-coolers



Component cooling – distributed cooling of individual low-noise amplifiers

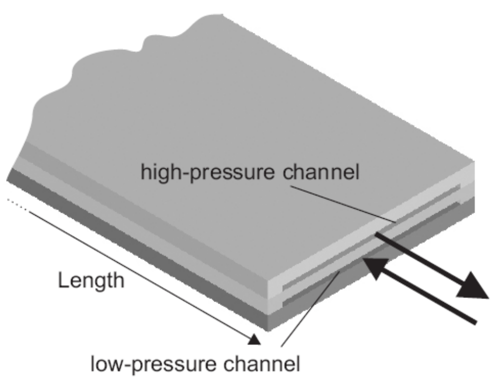


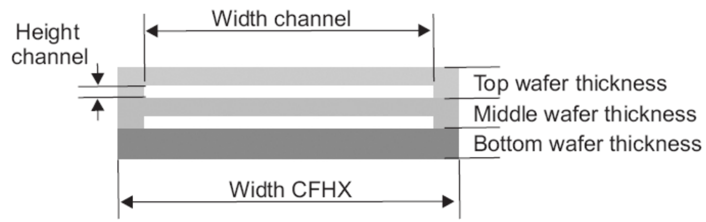
Component cooling – with an array of micro-coolers

Vacuum Valve ready for connection to pump

MEMS microcooler

Fabrication of a micro cryogenic cooler using MEMS-technology





- Size: 30 mm x 2.2 mm x 0.5 mm
- Nett cooling power: 10 mW @ 96 K

Fig. 3. 3D-view of a part of the CFHX and cross-section of the CFHX.

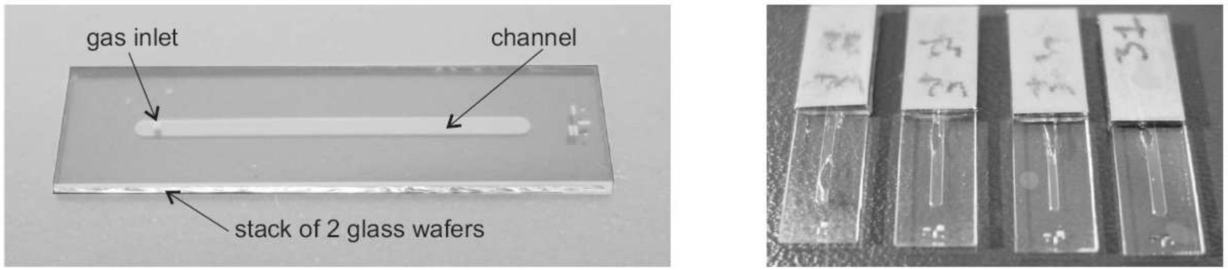


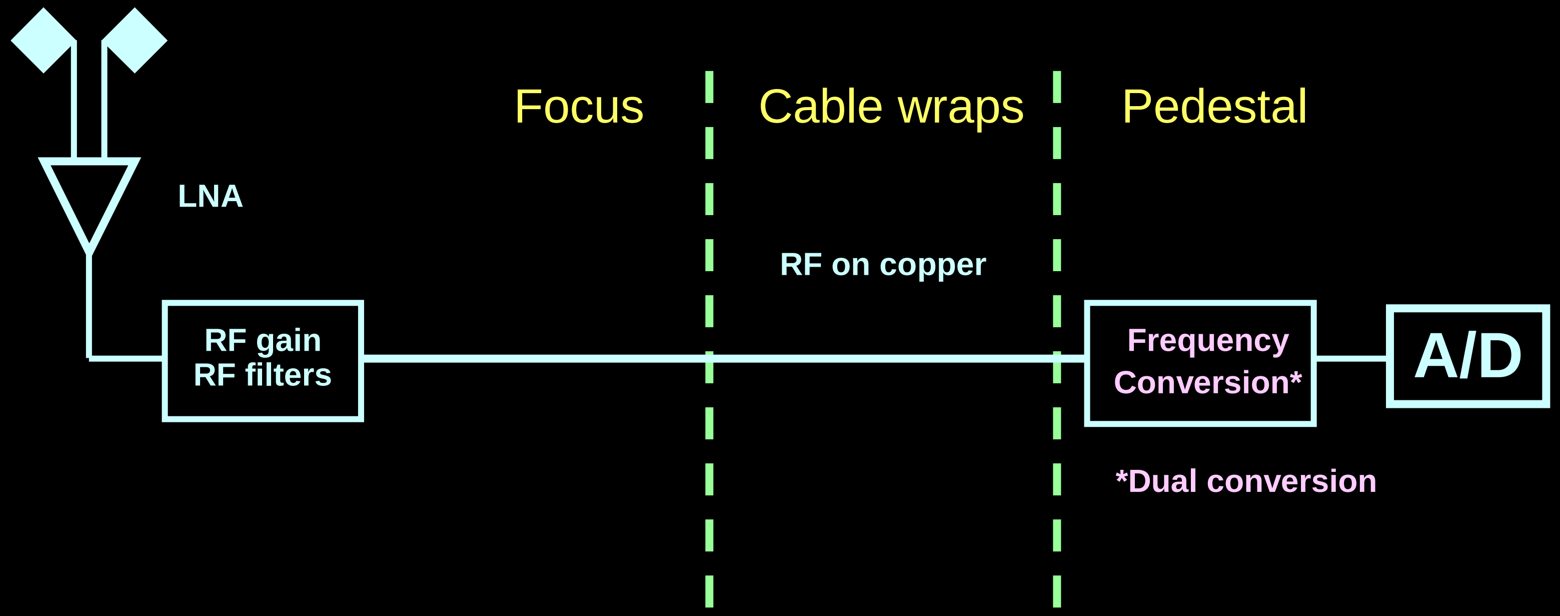
Fig. 4. Pressure test samples. Left: single channel, the width is 780 μm. Right: various tested samples glued onto stainless steel connection plates.

Key challenges and future directions

- Mass production and testing of receiver packages
  - With ~200 receiver elements per antenna
- Component cooling
- Integrated receivers ('system-on-a-chip')

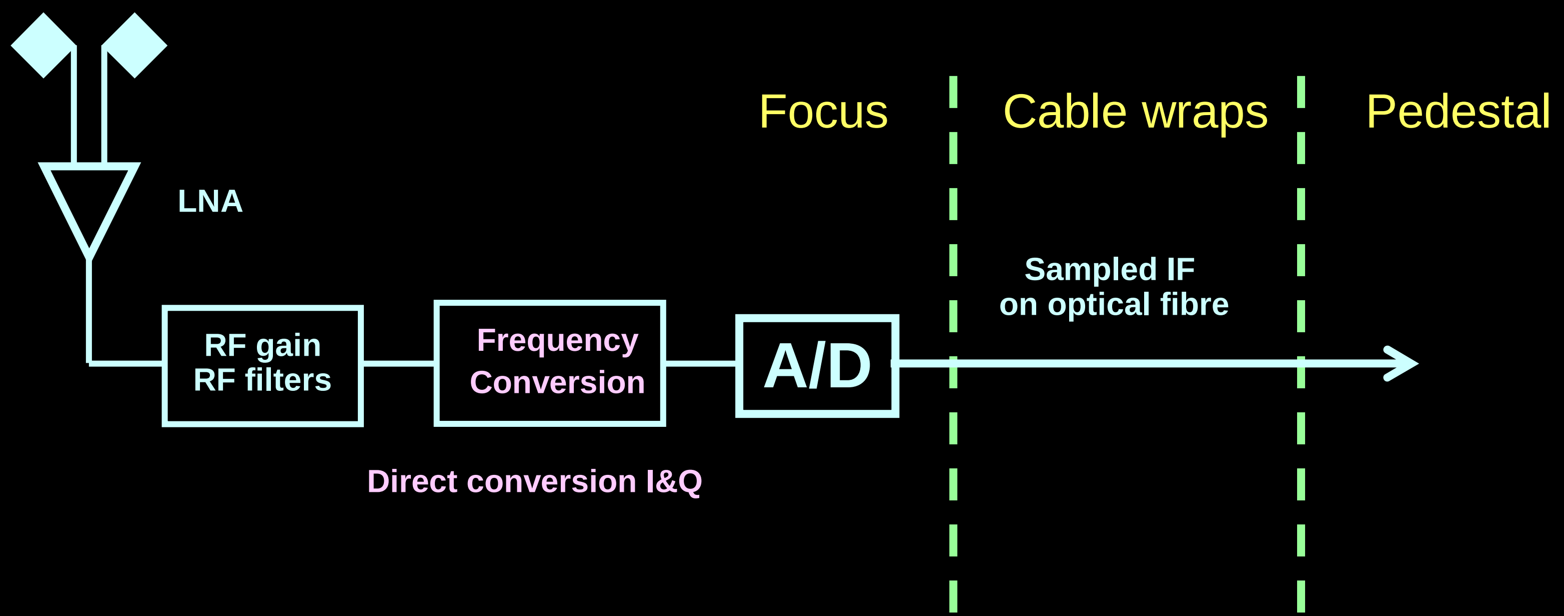
Key challenges and future directions

Current receiver architecture



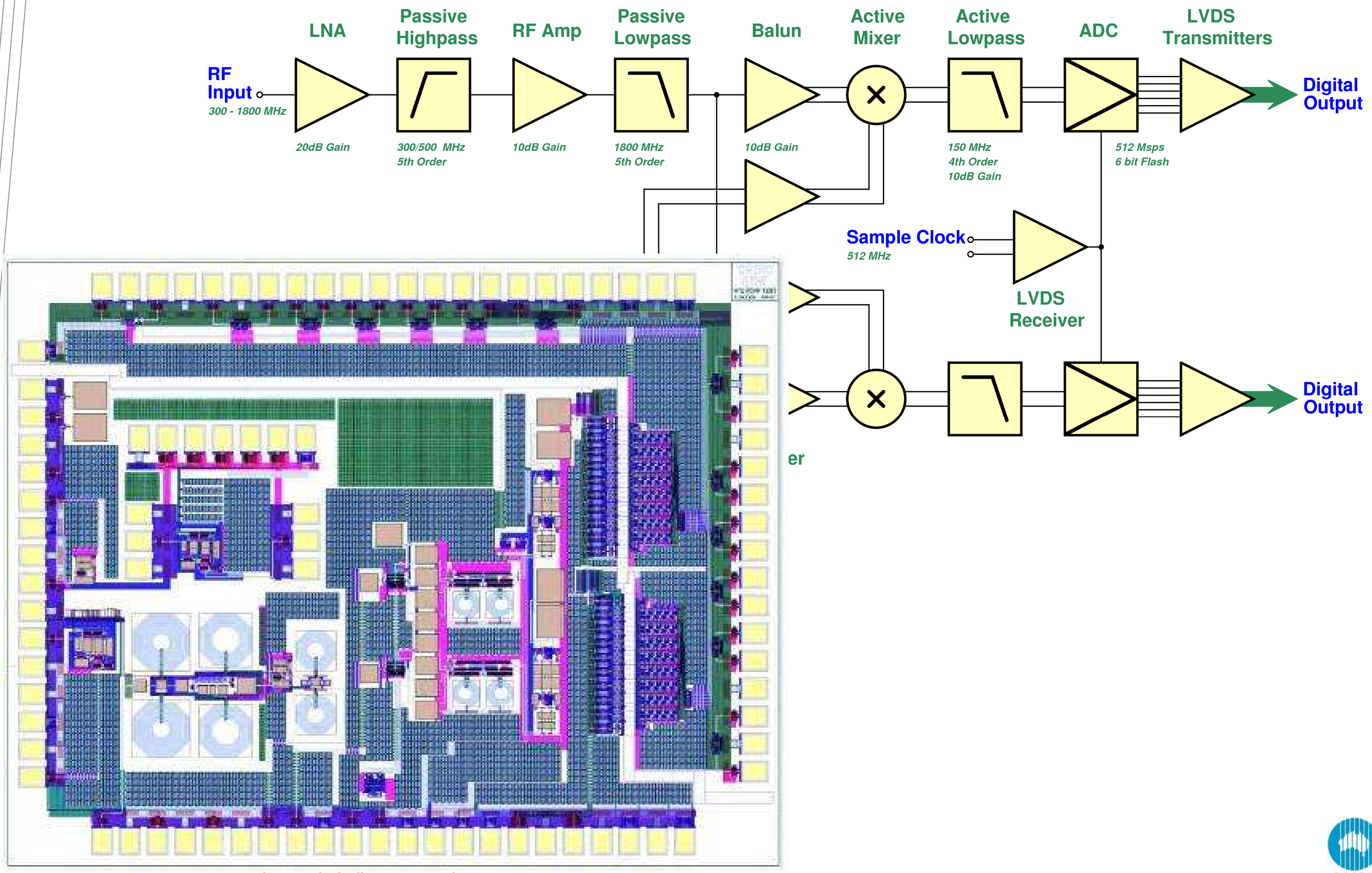
Key challenges and future directions

Preferred receiver architecture



- Frequency conversion and sampler at the focus
- Digital signal transmission over optical fibre
- Direct conversion (I&Q) receiver

Integrated receivers: System-on-a-chip



Australia Telescope National Facility

Russell Gough

October 23, 2009

Web: www.atnf.csiro.au

www.csiro.au

Thank you

Contact Us
Phone: 1300 363 400 or +61 3 9545 2176
Email: enquiries@csiro.au Web: www.csiro.au

CSIRO