Phased Array Feed Design

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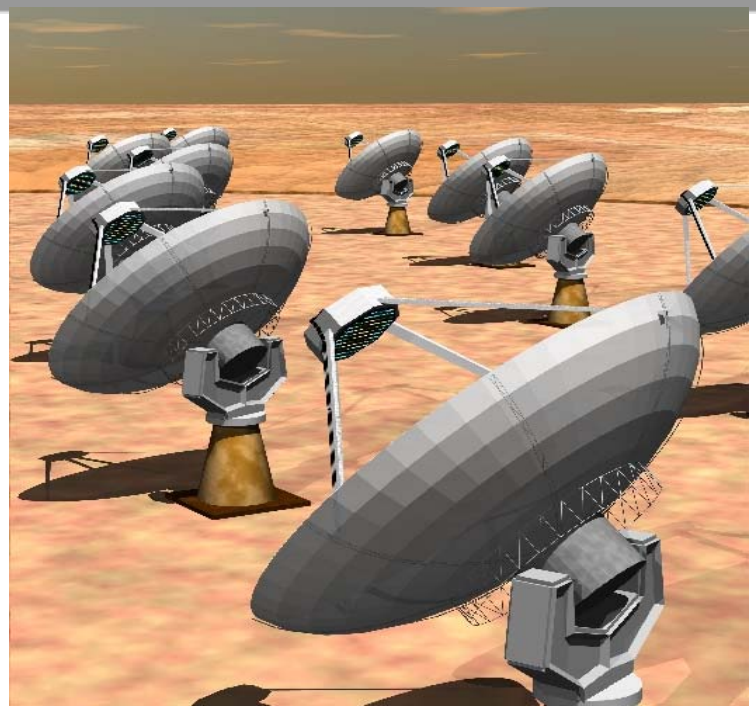
Outline

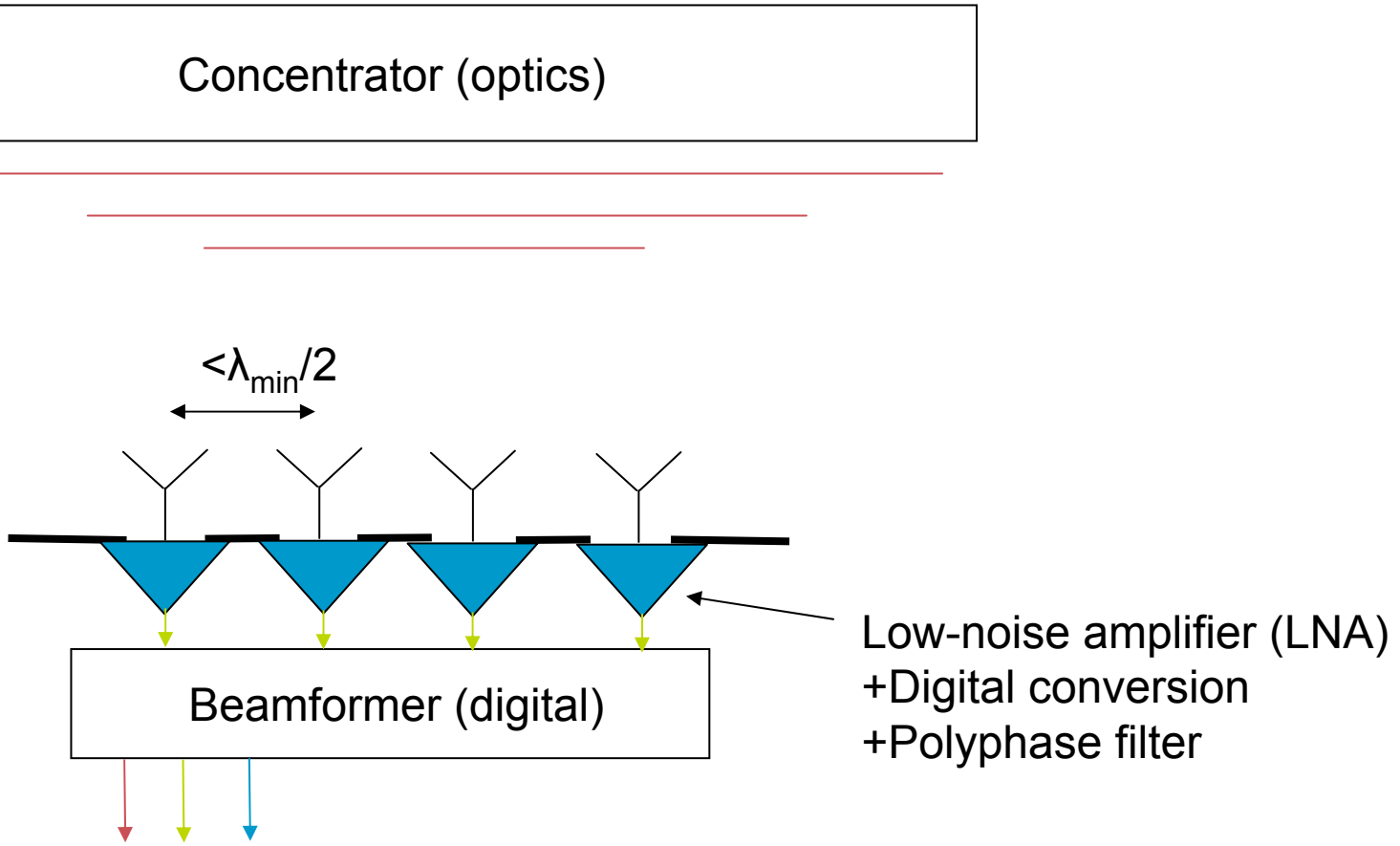
- Why phased array feeds (PAFs) for radioastronomy?
- General features and issues of PAF approach
- Connected-array PAF approach in ASKAP

Why PAFs?

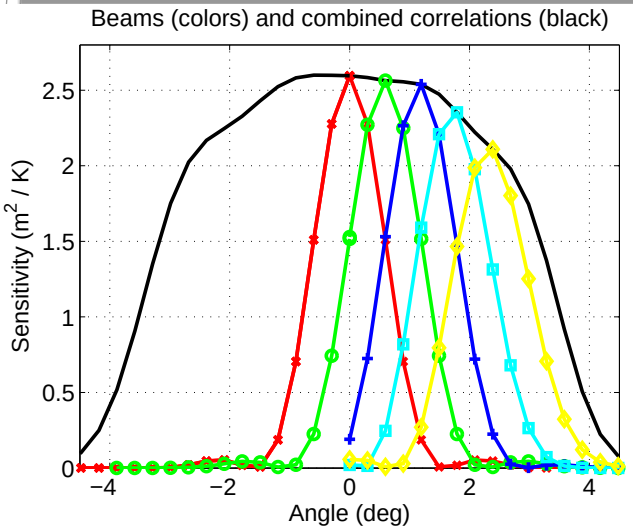


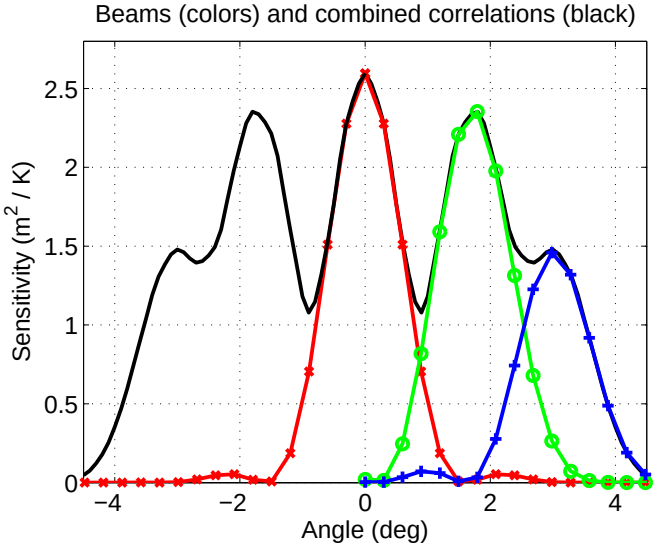
- High sensitivity
- Wide field of view (FoV) (instantaneous and contiguous)
  - Survey speed $(\eta_{ap}A_{phy}/T_{sys})^2 \times \Omega_{FoV}$
  - Possibilities for discovery (eg transient phenomena)
- Large frequency range (0.7-1.8GHz)

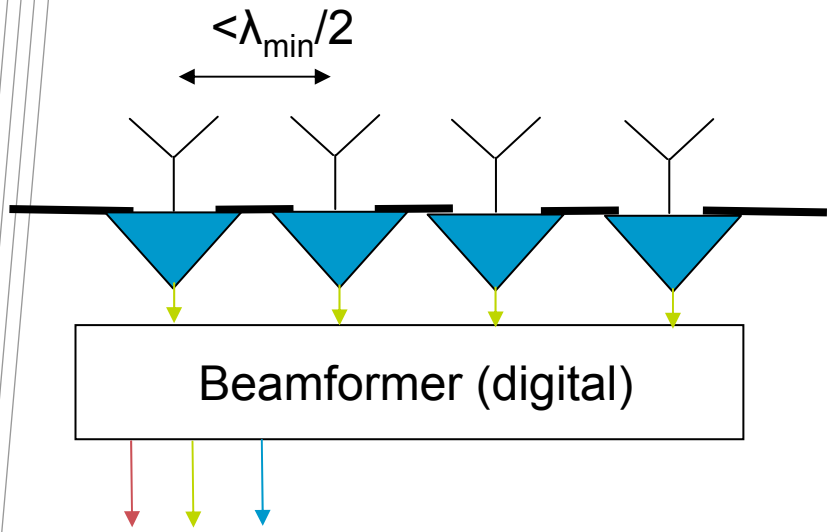
PAFs in general

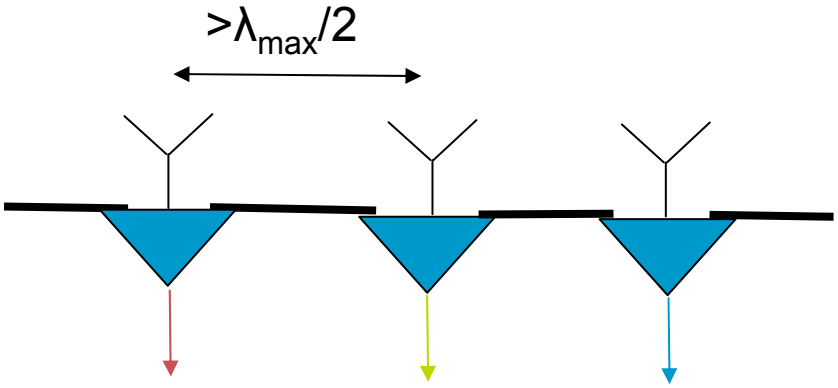


PAFs vs existing multibeam feeds



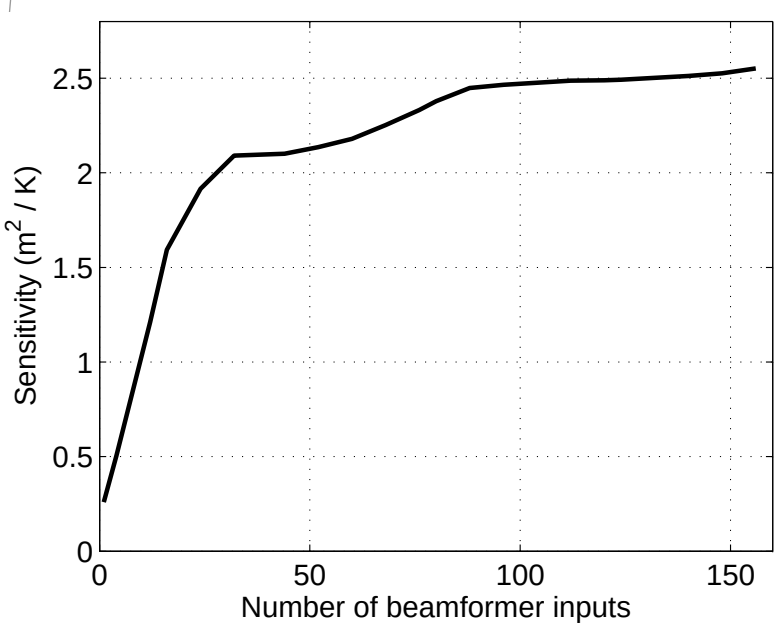


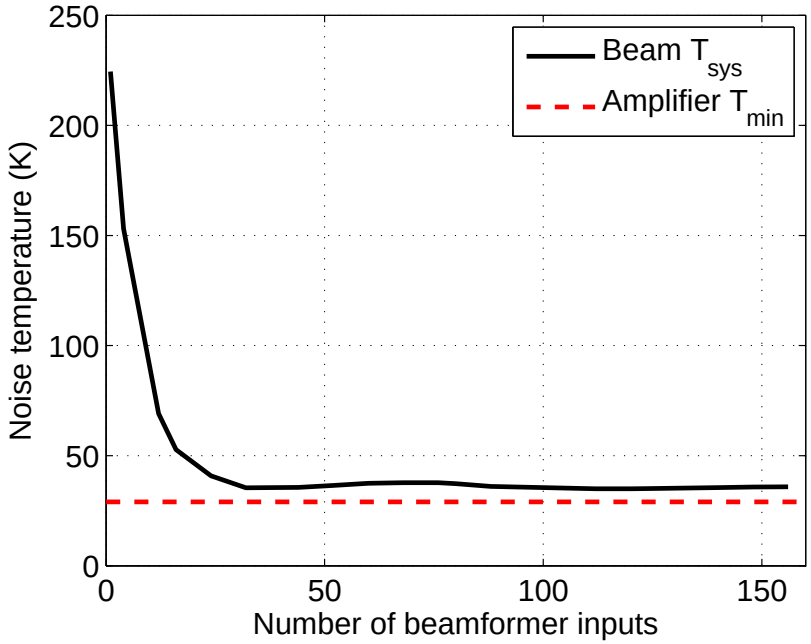




- PAF gives complete high-sensitivity sampling of FoV

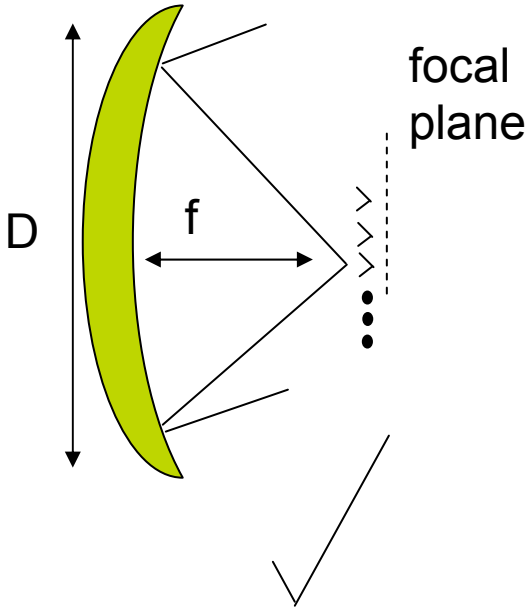
PAFs vs existing multibeam feeds



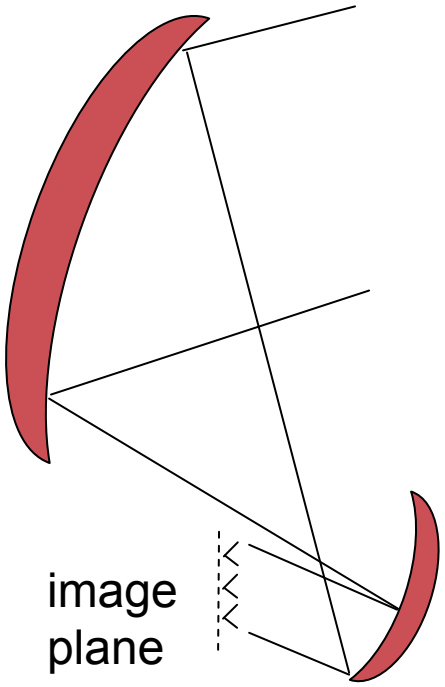


- PAF has significant mutual coupling effects
  - However beam T_{sys}→ amplifier T_{min} with optimum (active) noise matching of array/amplifiers and optimum beamforming

PAF optics - focal vs image plane



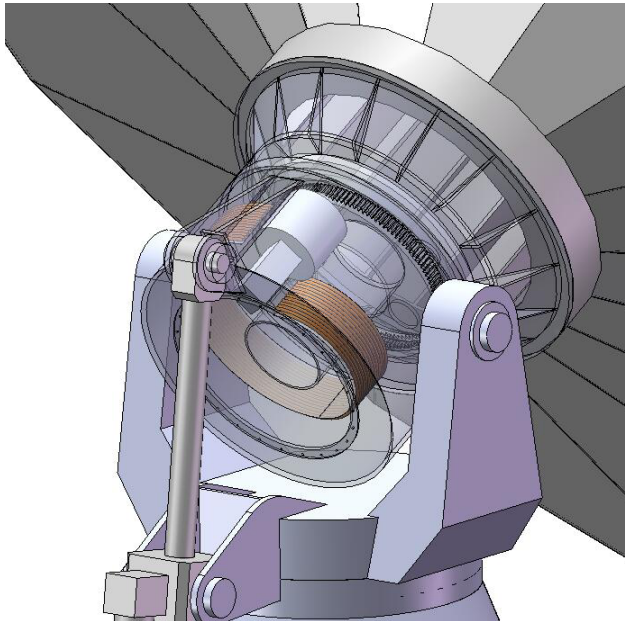
- #elements α $(f/D)^2$ and area of FoV
- Compromise between f/D and η
- Can beamform subsets of elements
- Can expand FoV by adding more elements (upgrade path)



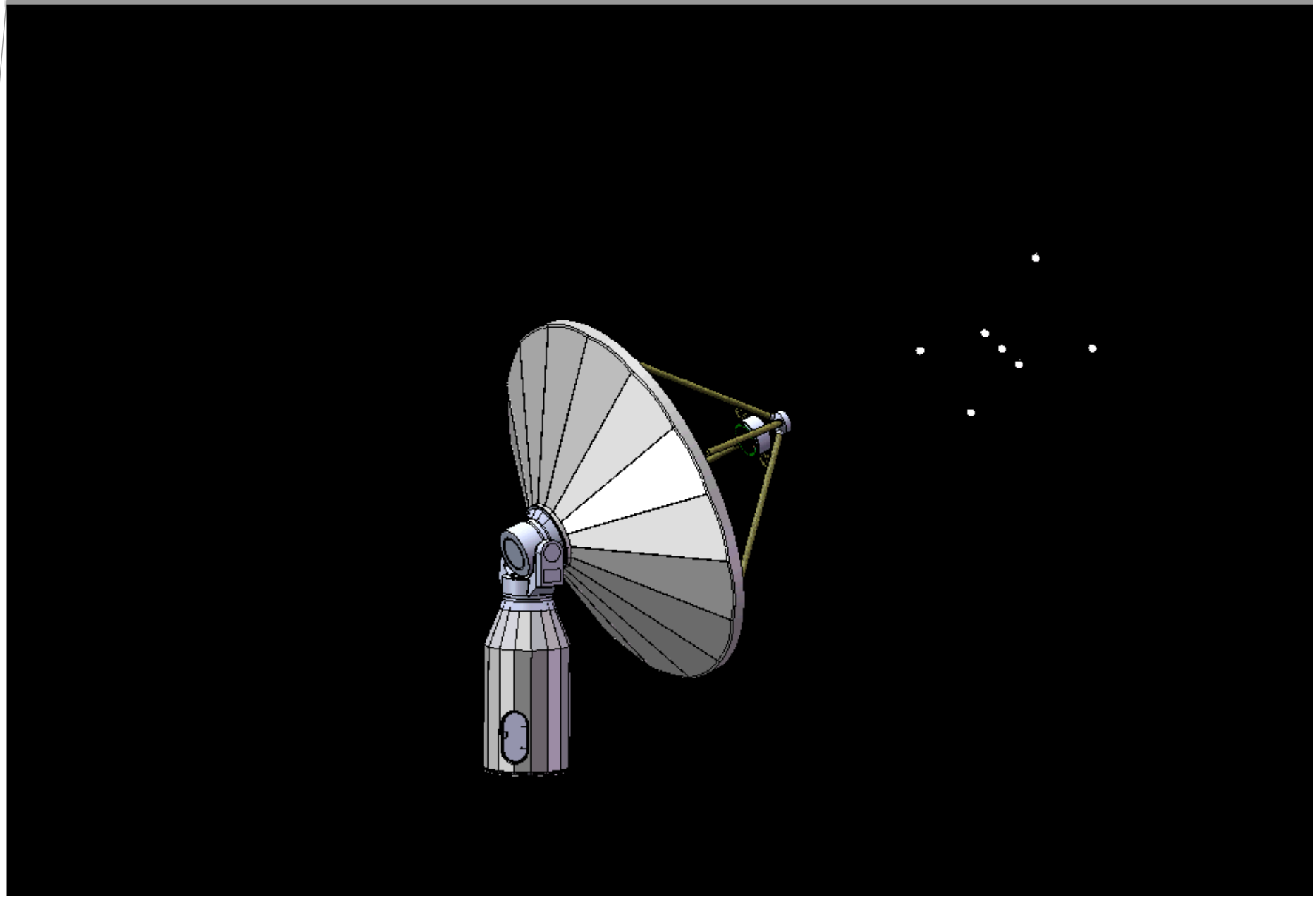
- #elements determined by magnification
- All elements must be beamformed for good η
- FoV limited by subreflector size

PAF optics - beam stability

- Beam stability with respect to the astronomical sources is required for high dynamic range image formation
- Possibly solutions in clear-aperture (offset-fed) optics and electronic beam rotation through beamformer weights
- ASKAP will use a 3-axis antenna design



PAF optcis - beam stability

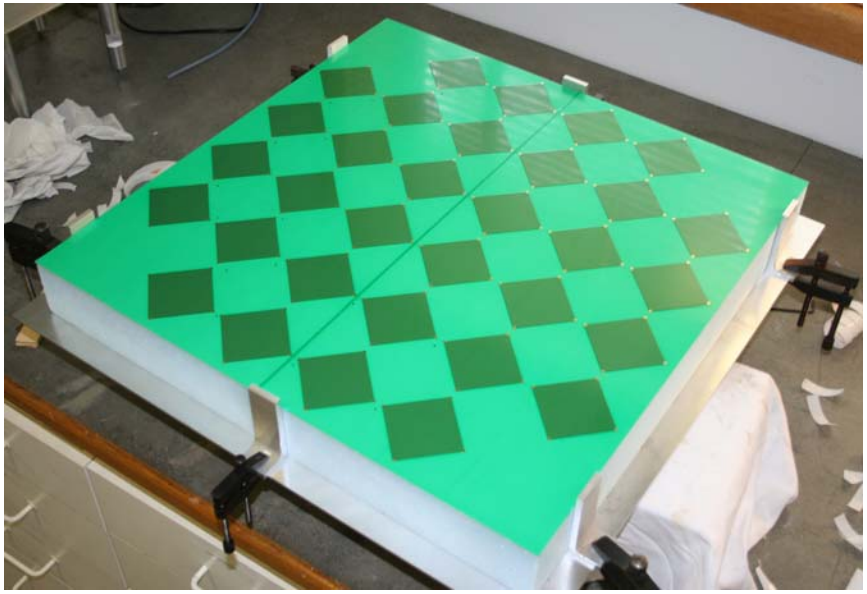


PAF/LNA issues

- Uncooled LNAs with T_{min} in 20-40K range over 0.5-2GHz have been developed
  - T_{sys}/η_{ap} < 70K realistic target that would make PAFs competitive
- Cooling PAFs is not straightforward
  - Many coupled elements distributed over large area
  - However should be further considered
- Differential LNAs and LNAs with >50Ω noise-match impedance are desired for some PAF designs
  - Reduce balun loss
  - Minimize LNA T_{min}
  - LNA modelling and measurements require further work

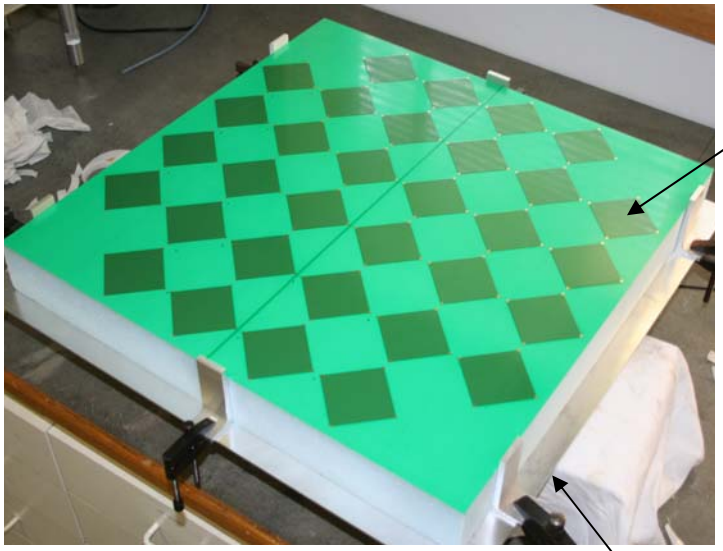
Connected-array approach to PAF

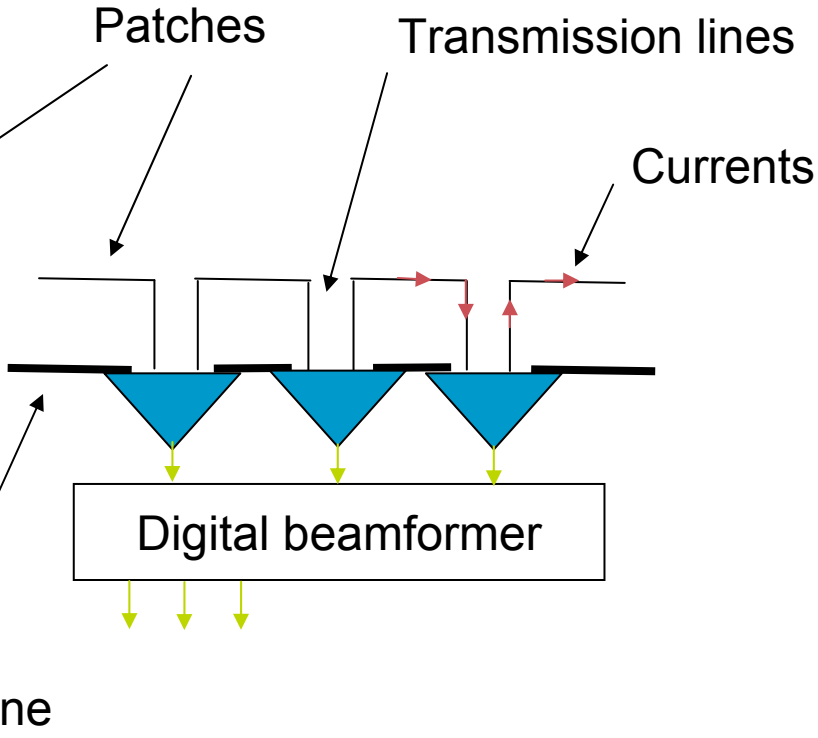
- Broaden PAF investigation
  - Previously focussed on Vivaldi (ASTRON and DRAO)
- Planar connected arrays
  - Alternative viewpoint emphasizing mutual coupling
  - Possible advantages of planar and low-profile structure
    - Cost
    - Loss
    - Integration
    - Noise coupling?
    - Cooling?
    - Other?



Prototype connected-patch FPA

Connected-array approach

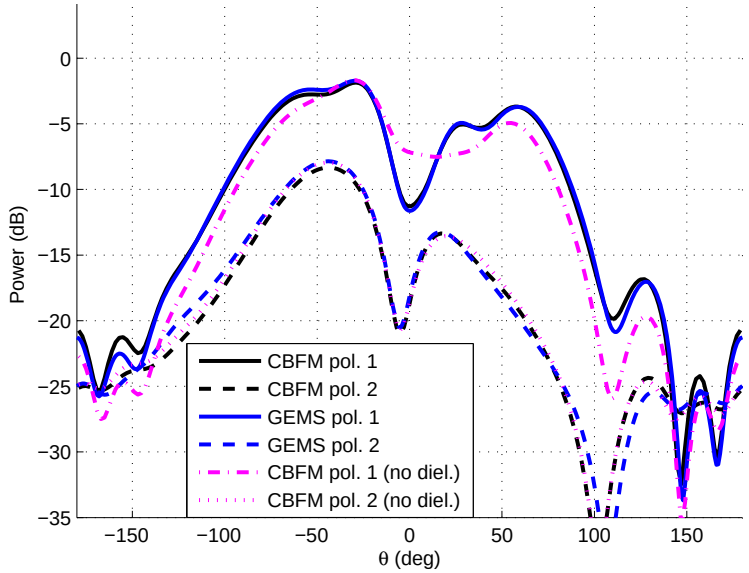


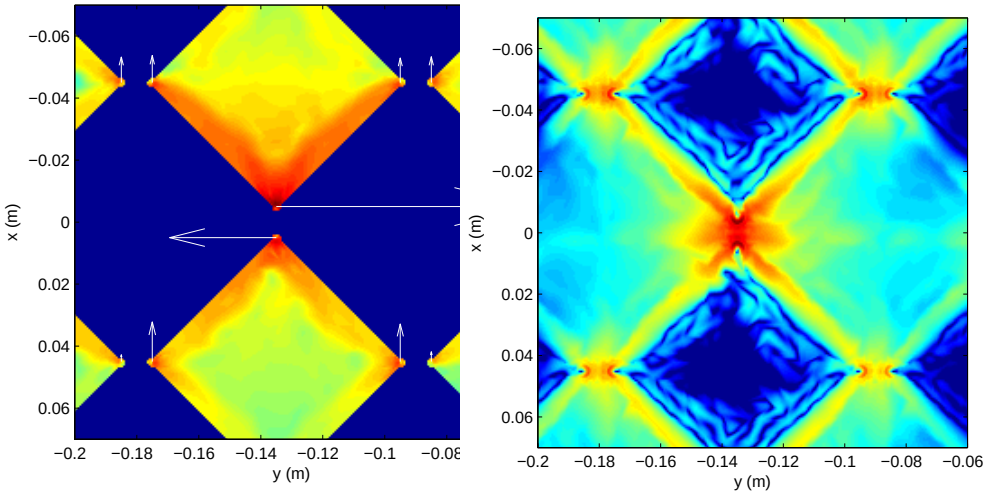


- Current continuity enhances bandwidth (element spacing <λ/2)
- Target 0.7-1.8GHz frequency range
- 9x10x2 elements for ~30 sq deg FoV
- D=12m front-fed reflector with f/D=0.5

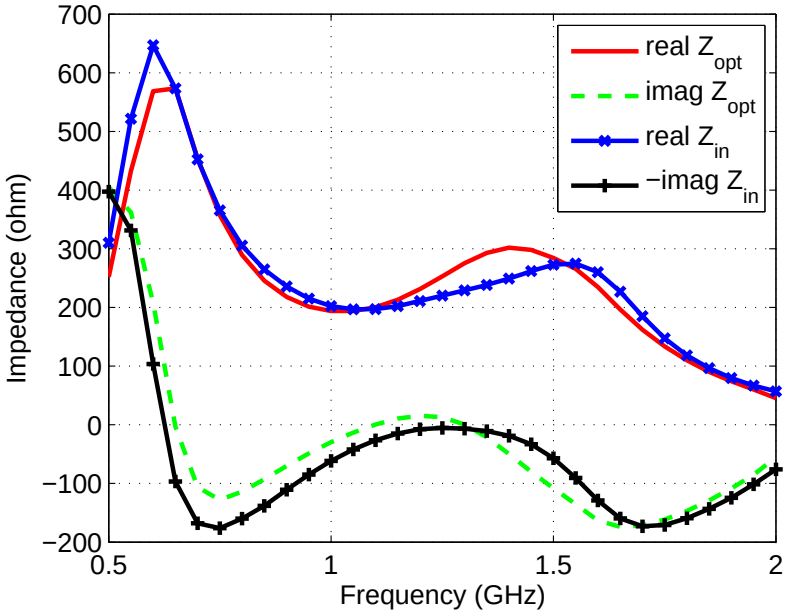
Approach to the design

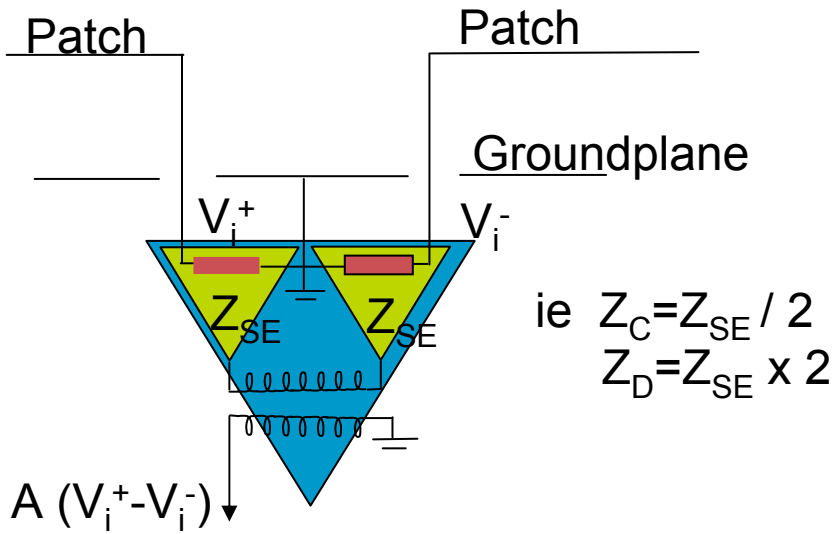
- Develop modelling capability
  - Electromagnetic modelling of array
  - Electronic modelling of LNA
- Numerical and experimental investigations of prototype
  - Resonances and matching to LNA
  - Radiation pattern in chamber
  - Parkes 12m testbed
- Optimize larger design for ASKAP





Connected-array matching





- Z_{diff}~377Ω LNA optimum noise-match impedance in mutually coupled array environment
- Lower Z_{diff} modifications to array will lessen sensitivity to parasitics

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Thank you

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