# WP2.2 CoDR
# PAF Sub-system Concept Overview & SKA context

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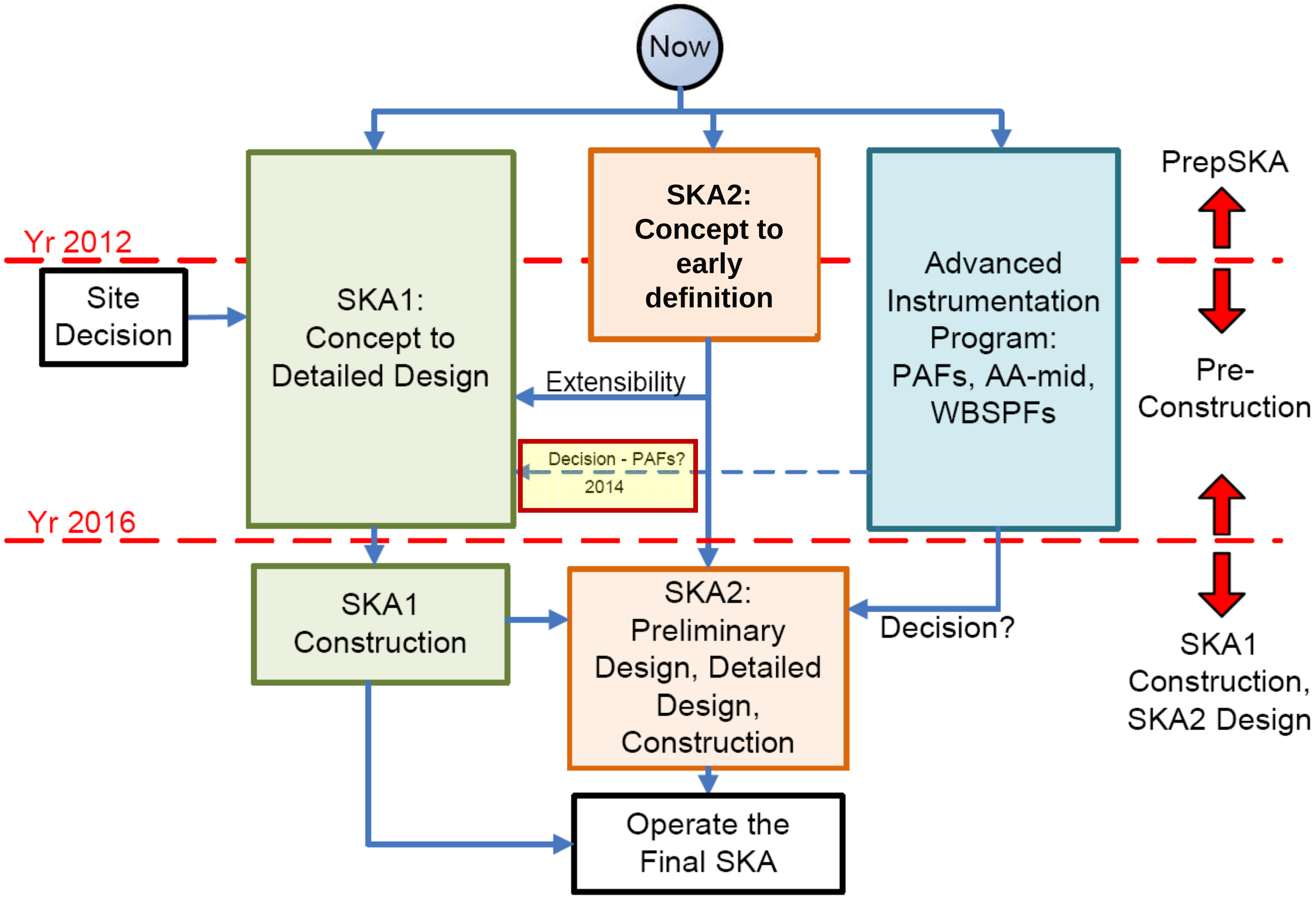
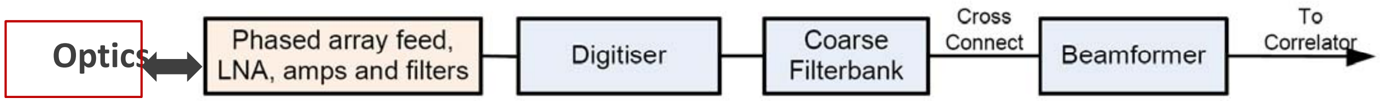
WP2.2.3

# SKA development steps



# PAF sub-system overview

**PAF presentations at CoDR**

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# SKA1 Science Drivers

**1. "The History and Role of HI from the Dark Ages to the Present Day"**

Requires spectral-line surveys of HI over wide areas of sky, to probe the history of large-scale structure in the universe and the role of neutral hydrogen in galaxies.

**2. "Pulsars as Probes of Fundamental Physics"**

Benefits from high survey speeds for finding new pulsars (smart- wide field) techniques developed by APERTIF, LOFAR and ASKAP but ultimately requires *high instantaneous sensitivity for pulsar timing*

*-> PAF FoV allows multiple timing and in-field calibration*

*Much SKA science relies on a range of all-sky survey data (multiple surveys).*

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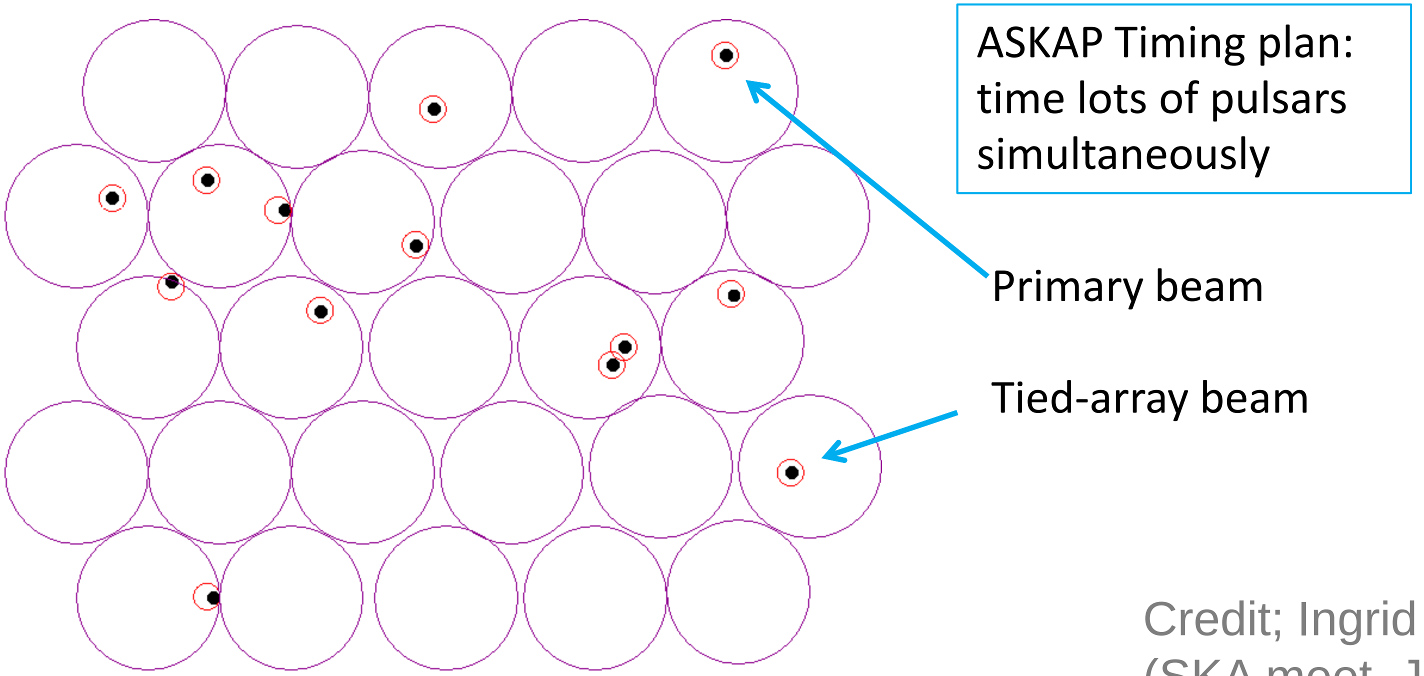
# SKA1 Science Drivers

Pulsar science will benefit from high survey speeds for finding new pulsars (smart-wide field) techniques developed by APERTIF, LOFAR and ASKAP searches but will ultimately also require *high instantaneous sensitivity for pulsar timing.*

-> *PAF FoV allows multiple timing and in-field calibration* .




Credit; Ingrid Stairs
(SKA meet, July 2011)

# SKA Receiver Options

Dense Aperture Arrays

Wide FoV option for mid-bands. Computing cost/complexity.
Unlikely to be technologically mature by SKA 1…. SKA 2?

Dishes with Phased Array Feeds

Adds wide FoV capability. For much SKA science, survey speed is key.
Not ultra-wideband, but could be co-mounted with WBF (or multiple PAFs)

Wide-bandwidth single pixel feeds

Wide BW best for radio continuum surveys. Smaller dish = wider FoV, but then more baselines = costly in hardware and data transport/processing.
Under development for SKA2: performance – wide band matching & frequency-independent feed patterns?

*-> For SKA phase1, PAFs for SKA-mid frequency (~0.45 – 3.0 GHz)*
*-> For SKA2, Develop PAFs > 3 GHz*

*Key FoM: Sensitivity (Aeff/Tsys), Survey Speed (SS)*

# SKA Design Concept

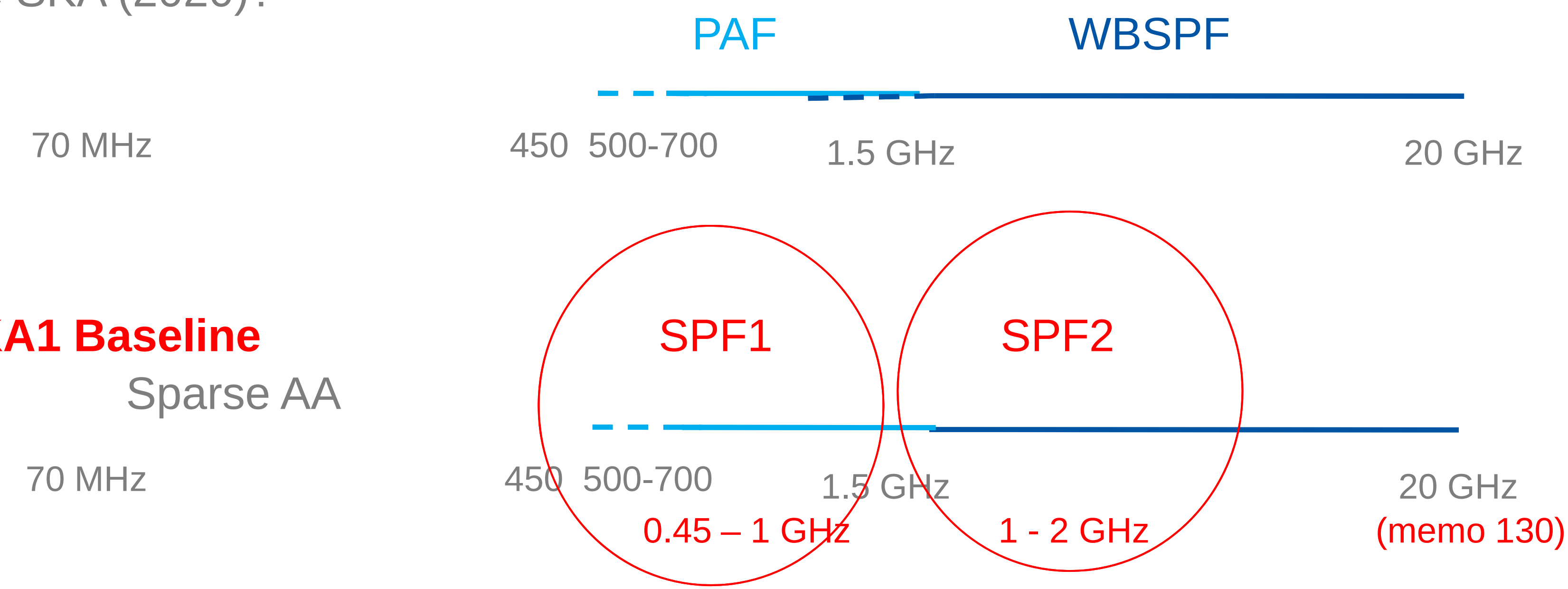
The SKA (2020)?

Sparse AA | Dense AA // PAF | WBSPF

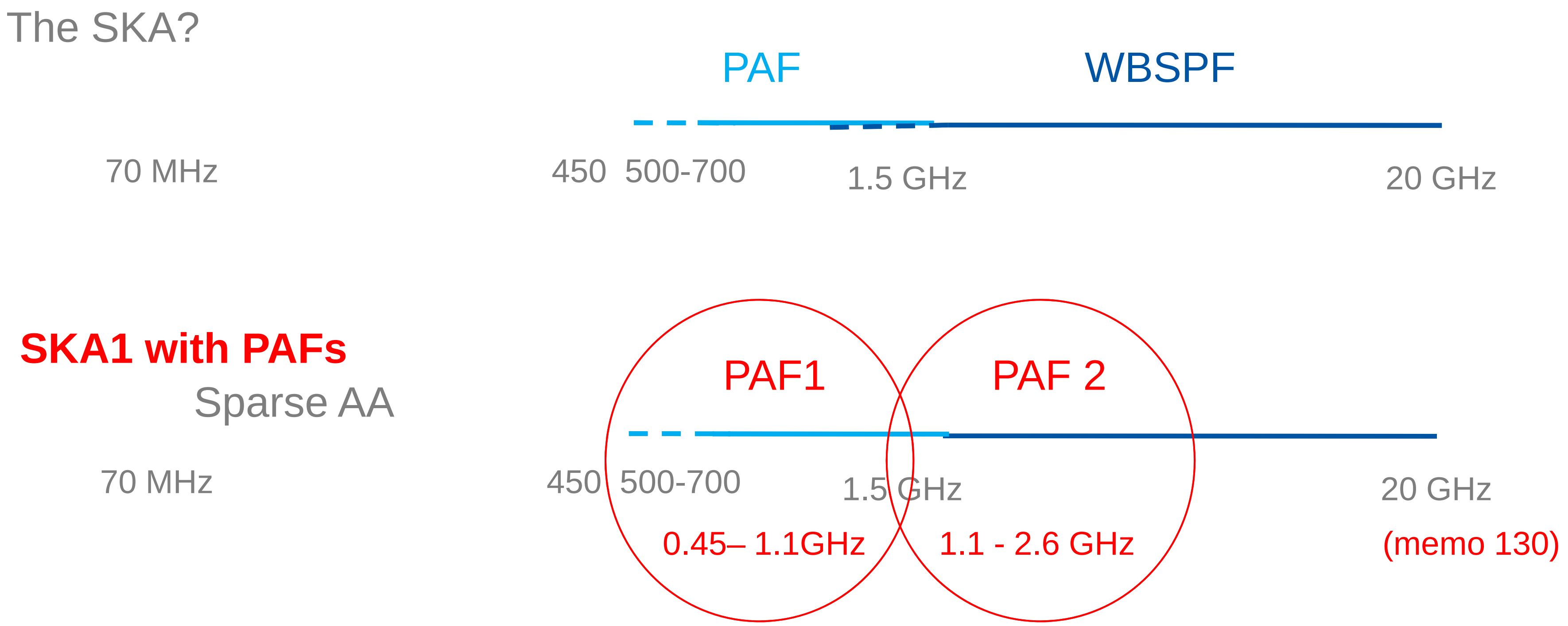
70 MHz | 450 500-700 | 1.5 GHz | 20 GHz

# SKA 1 Design Concept

The SKA (2020)?

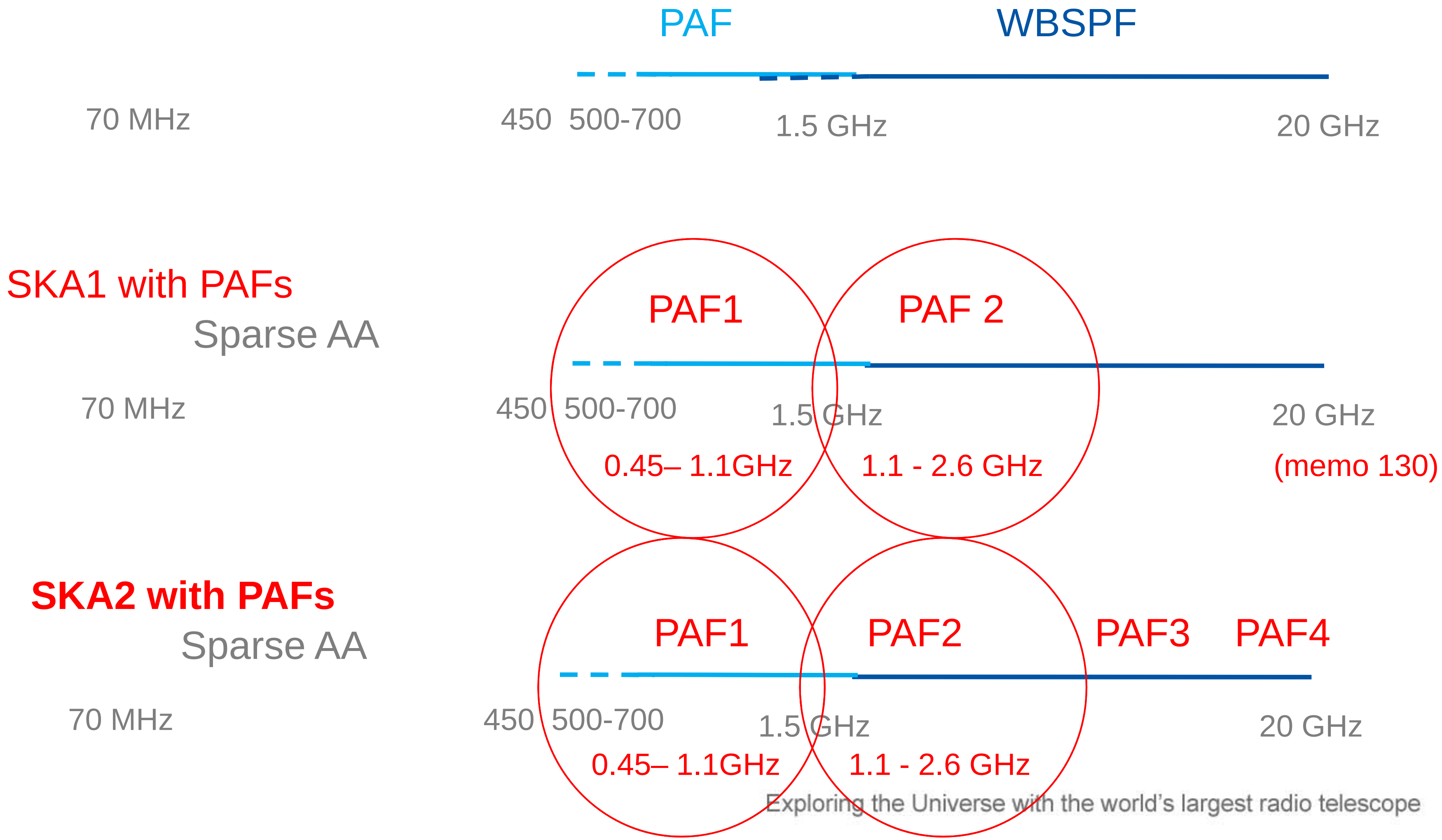


# SKA 1 Design Concept



# SKA 1 Design Concept

The SKA?



# Why PAFs?

PAF = an alternative approach (to Single Pixel Feed (SPF) systems) to feeding the dish in each frequency band.

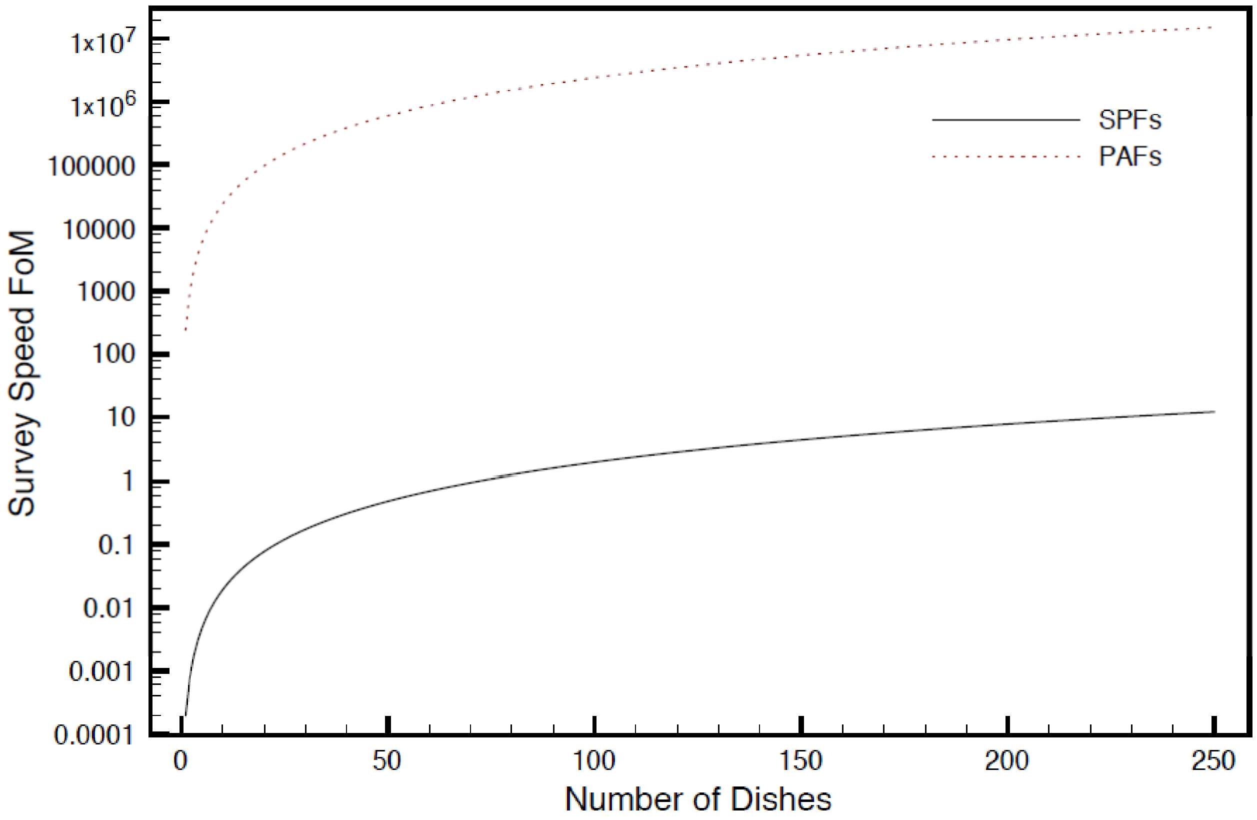
*The SKA system specification is to maximise $A/T_{sys}$*

A PAF system provides flexibility to dynamically choose between a range of system optimisations to match specific science objectives, e.g.

*- The instantaneous FoV is much larger than SPFs; many large-area sky surveys (key SKA science) become tractable;*

# Why PAFs?

*PAF survey speed vs SPFs (15m dishes; 400 MHz BW; PAF FoV 30 sq deg, 1 uJy)*




Ref: Harvey-Smith et al (PAF science paper draft)

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*- The instantaneous FoV is much larger than SPFs; many large area sky surveys (key SKA science) become tractable;*
*- The beamformer weights can be chosen to maximise gain, polarisation purity, survey speed, side-lobe suppression or RFI rejection;*
*- All can be (re)set within seconds.*

PAF performance improvements (over SPFs) will be just as dramatic for off-axis polarisation purity, side-lobe suppression and RFI rejection.

# PAFSKA

**Developing PAFs for the SKA**

Collaborative program of Phased Array Feed R&D for the SKA.
Many institutes; each focussing on one or more aspects of PAFs

Individual institutes have long-standing PAF development projects.

PAFSKA commenced mid-2010

Based on the PAF-specific PrepSKA work packages + whole-system developments ASKAP and APERTIF.

*Ultimate goal of delivering a PAF which meets the total SKA specification: technical performance, operational performance and cost.*

Developing ‘L band’ PAFs – but system adaptable to adjacent frequencies

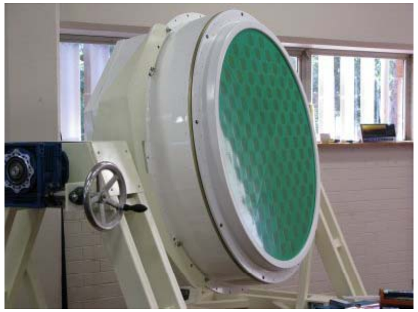
# PAFs in development 2011

SKA
SQUARE KILOMETRE ARRAY

ASTRON

PAFSKA

NRC-CNRC



CSIRO

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BRIGHAM YOUNG UNIVERSITY

NRAO
National Radio Astronomy Observatory

Cornell University
National Astronomy and Ionosphere Center

# PAFs in development 2011

**PAFs and Dish Design options**

ASKAP PAF on 12-m axi-symmetric dish (highly optimised for survey speed)
APERTIF on 25m WRST equatorial symmetric dish

# PAFs in development 2011

**PAFs and Dish Design options**

ASKAP PAF on 12-m axi-symmetric dish
APERTIF on 25m WRST equatorial symmetric dish

*APERTIF & ASKAP are SKA pathfinders…. Plus PAFSKA*
Providing critical lessons for SKA:

1. Need to optimise dish-feed design, and not build-out flexibility re feeds
2. Optimised for survey speed – demonstrate PAF flexibility (DR, FoV etc)
3. Advantages of a sky-mount axis (DR, ….for any feed type?)
4. Full system builds (far better than single prototypes or paper-based design concepts)
5. Develop & test calibration, imaging, etc schemes – to be well understood
in time for SKA

5. Astronomers will learn to expect PAF performance & flexibility on the SKA –
Wide FoV is not a pieced-together mosaic; it is a singly-imaged flat field.

# PAF Concept Documentation

*A. The requirements specification, propagated from the top-level SKA requirements:*

1. PAF sub-system requirements: ***WP2-025.030-RS-001-A***

*B. The description of the technologies*

2. PAF sub-system concept ***WP2-025-030-TD-001-A***
3. PAF feed payload concept: ***WP2-025.035-TD-001-A***
4. PAF receiver concept – RF-over-fibre: ***WP2-025.050-TD-001-A***
5. PAF receiver concept – I/Q mixer: ***WP2-025.050-TD-002-A***
6. PAF receiver concept – full band sampling: ***WP2-025.050-TD-003-A***

*C. Supporting documentation*

7. PAF sub-system risk register: ***WP2-025.030-RE-001-A***
8. PAF sub-system Strategy & Plans for next phase: ***WP2-025.030-PLA-001-A***
9. PAF sub-system Cost estimates: ***WP2-025.030-TD-002-A***
10. PAF sub-system Logistics Engineering: ***WP2-025.030-MP-001-A***
11. PAF sub-system Software description: ***WP2-025.030-SD-001-A***
12. PAF sub-system Technology roadmap: ***WP2-025.030-TD-003-A***

# PAF sub-system overview

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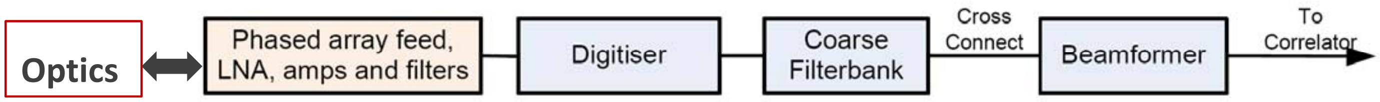


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