MFAA2014 workshop
Pathfinder development for SKA2

Ilse van Bemmel (ASTRON)
Deputy project scientist MFAA
SOC-chair

MFAA2014

Mid-Frequency Aperture Arrays workshop

STIAS Stellenbosch, 22-2-2014

- ASTRON, UCT, Rhodes

Stakeholders:

- AERAP
- MidPrep
- MFAA consortium

AERAP

- Human capital development
- Radio astronomy as an instrument
- Entire continent of Africa

"It's called 'reading'. It's how people install new software into their brains"

MidPrep

- Knowledge exchange
- Radio astronomy as a goal
- Partners:
  - UCT, Rhodes, Stellenbosch (RSA)
  - Chalmers (S)
  - ASTRON (NL)

MFAA consortium

- Instrument development for SKA2
- Radio astronomy as a goal
- Advanced Instrumentation Package

Workshop scope

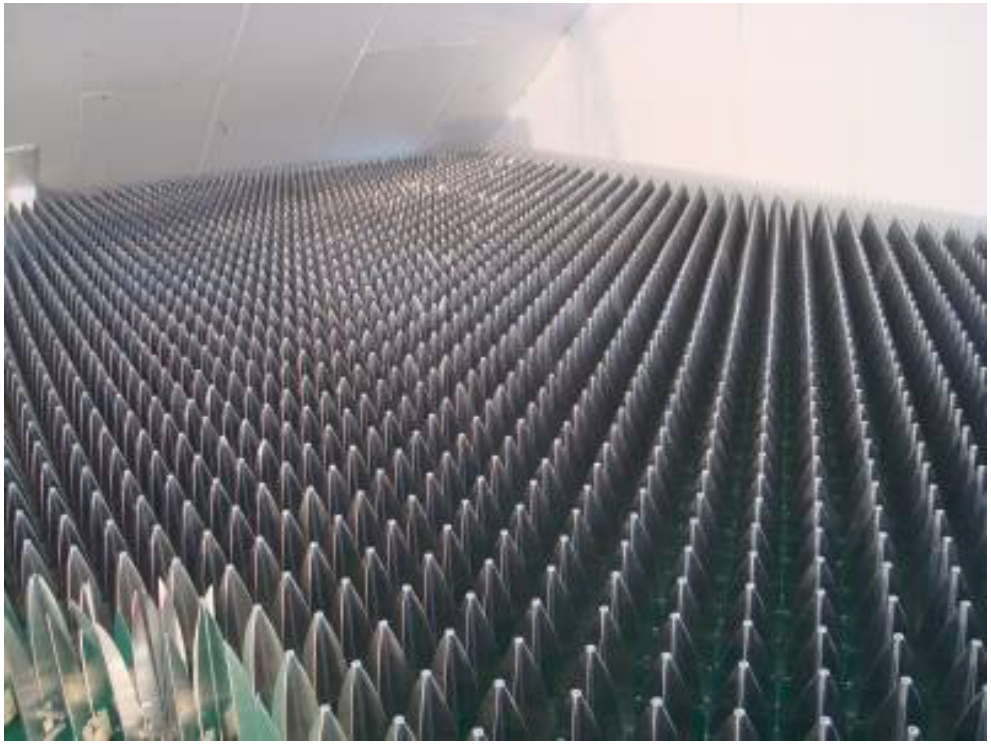
- MFAA technology as a platform for AERAP
- Support for MFAA technology in Africa
- Next steps for MidPrep

- 35 participants:
  - 50/50 engineers vs astronomers
  - Focus on African participation

Pathfinder instrument

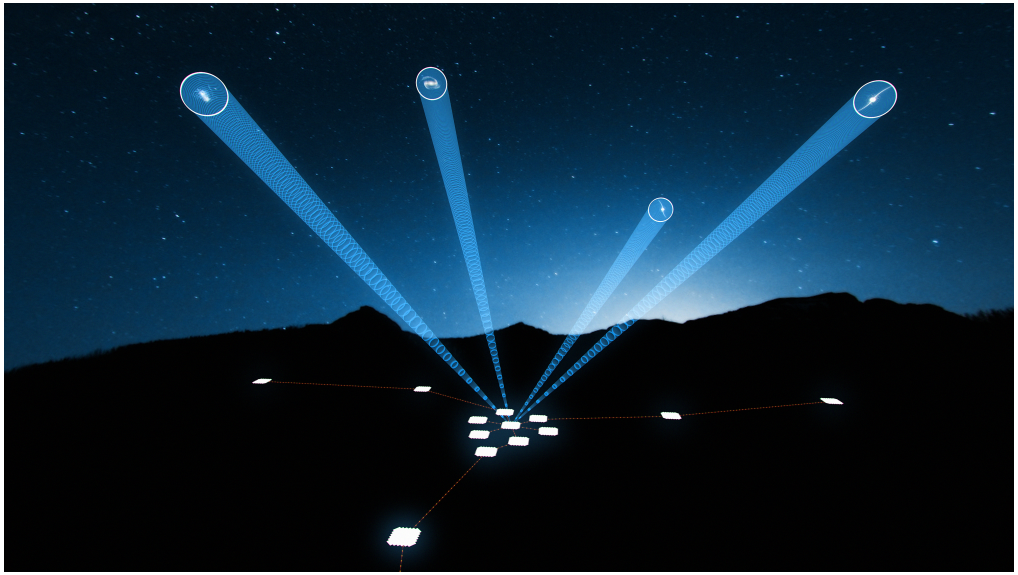
- Path to SKA2

- EMBRACE:
  - Single polarization
  - A/T ~ 1 m^2/K
  - Single dish



AERA^3

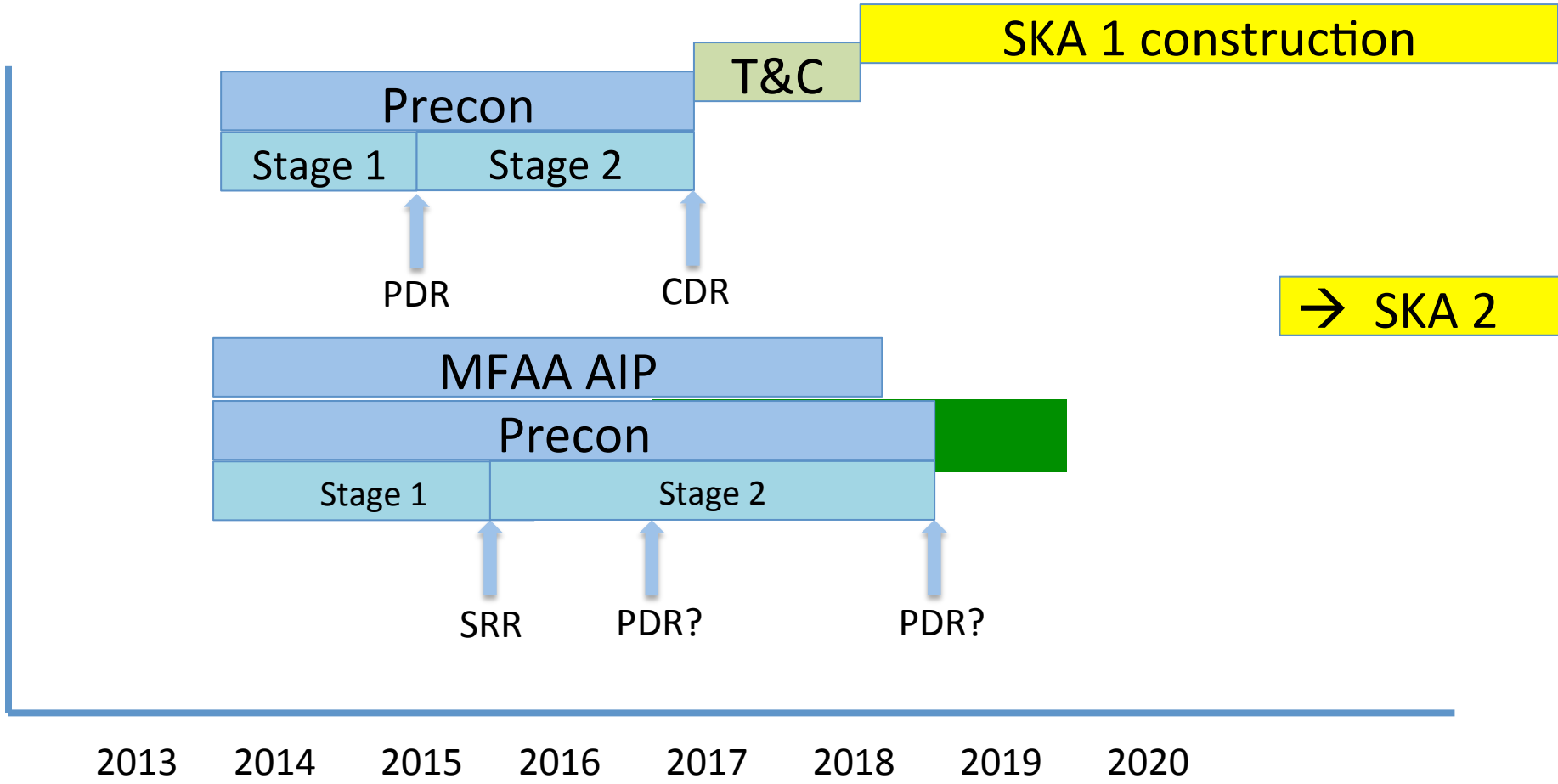
- Science capabable: which science?
- Technology development
- Costing demonstrator
- Human capital development



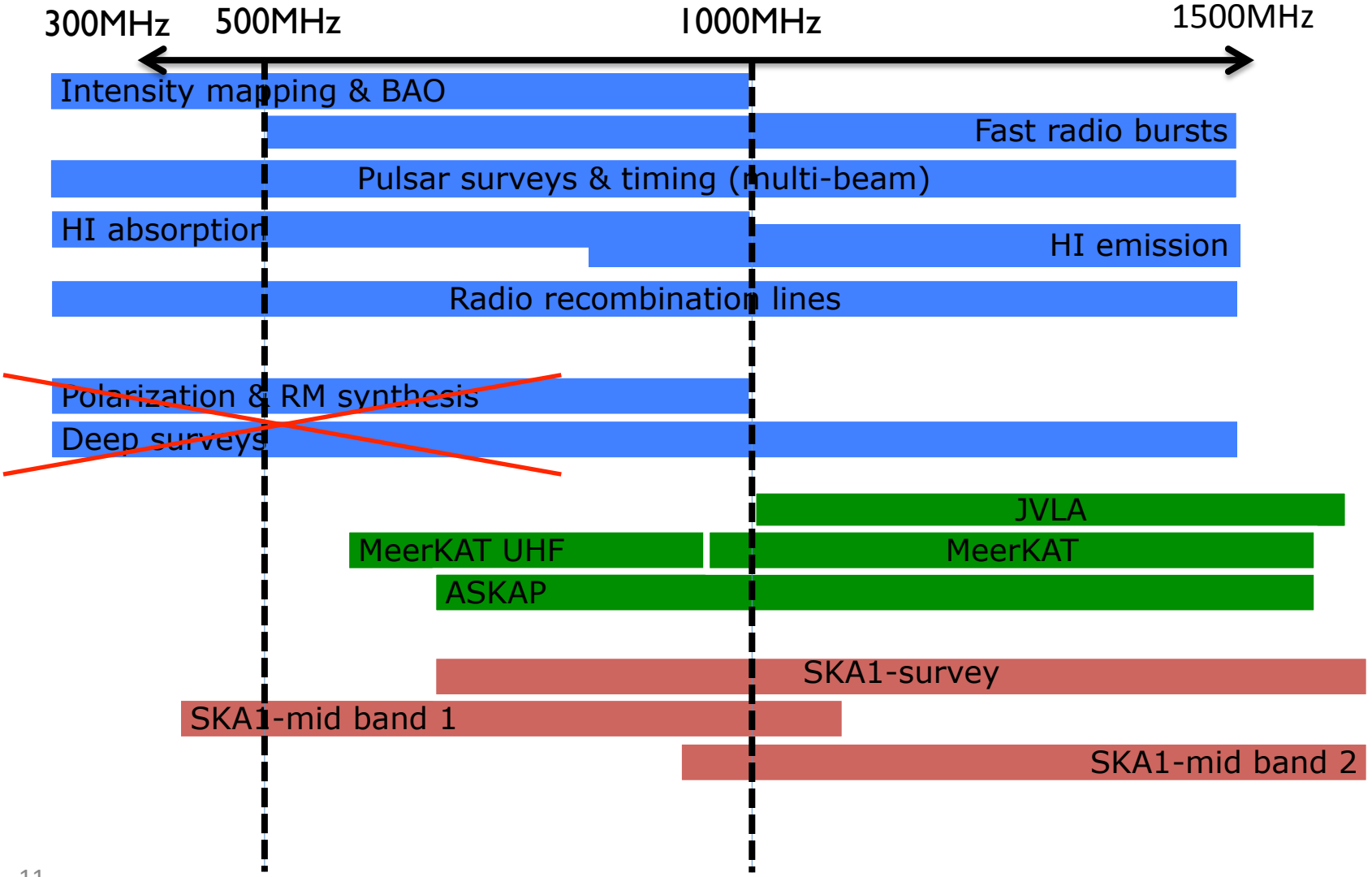
AERA^3

Parameter	Value or range	Units
A_{eff}/T_{sys} at 1GHz	40	m^2/K (see Fig. 1)
Frequency range	300 - 1500	MHz
Bandwidth	300 - 1000	MHz
Baseline length	300 - 1000	m
Compactness	50%	A_{eff} inside 100m
Number of stations	10 - 20	
Independent fields-of-view	≥2	
HPBW (FoV) at 1GHz	15 (175)	deg (deg^2) (see Fig. 2)
Polarizations	Full Stokes	
Time resolution	≥50	μs
Polarization purity	40 (post-calibration)	dB
Scan angle	45	deg

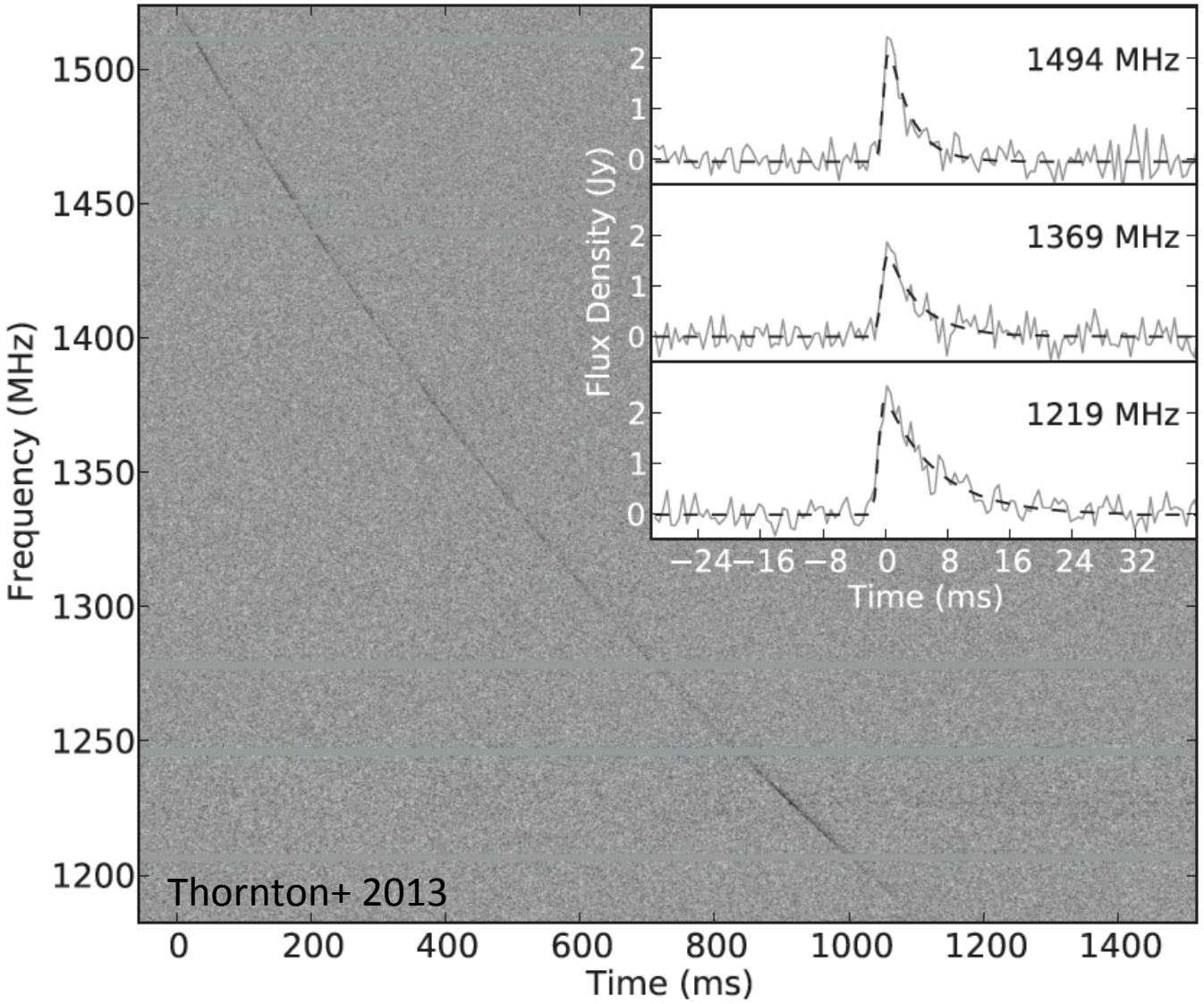
Path to SKA2


SKA 1 construction
T&C
Precon
Stage 1
Stage 2
PDR
CDR
→ SKA 2
MFAA AIP
Precon
Stage 1
Stage 2
SRR
PDR?
PDR?
2013
2014
2015
2016
2017
2018
2019
2020

Science frequency coverage



Fast radio bursts (FRB)



Fast radio bursts (FRB)

- Location
- Physical processes
- Spectral index

Survey metric	$R \propto \Omega S_0^{-2}$	$R \propto \Omega S_0^{-3/2}$	$R \propto \Omega S_0^{-1}$
$R_{AERA\text{-}3}/R_{survey}$ (coherent/fast imaging)	0.1	0.3	1.0
$R_{AERA\text{-}3}/R_{survey}$ (incoherent)	0.7	1.3	2.6

(JP Macquart at MFAA2014)

Low hanging fruit…

Fast radio bursts (FRB)

- Common process (10^4 per day)
- Bright but ms-duration
- Killer science:
  - Missing baryon problem
  - Cosmic rulers to study dark energy
    (this will require full SKA2 capabilities)

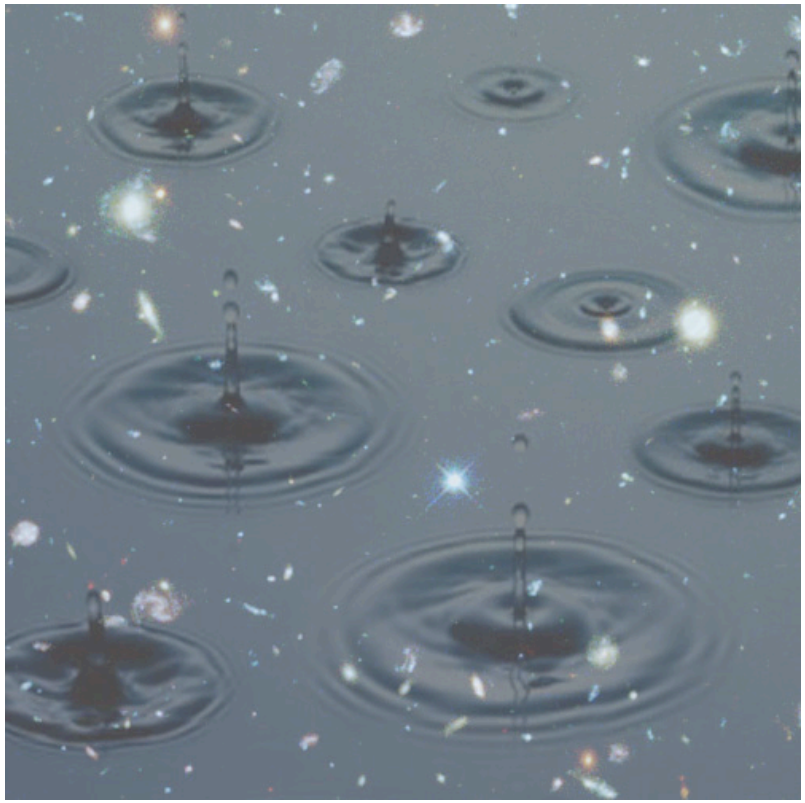
Fast radio bursts (FRB)

Instrument requirements

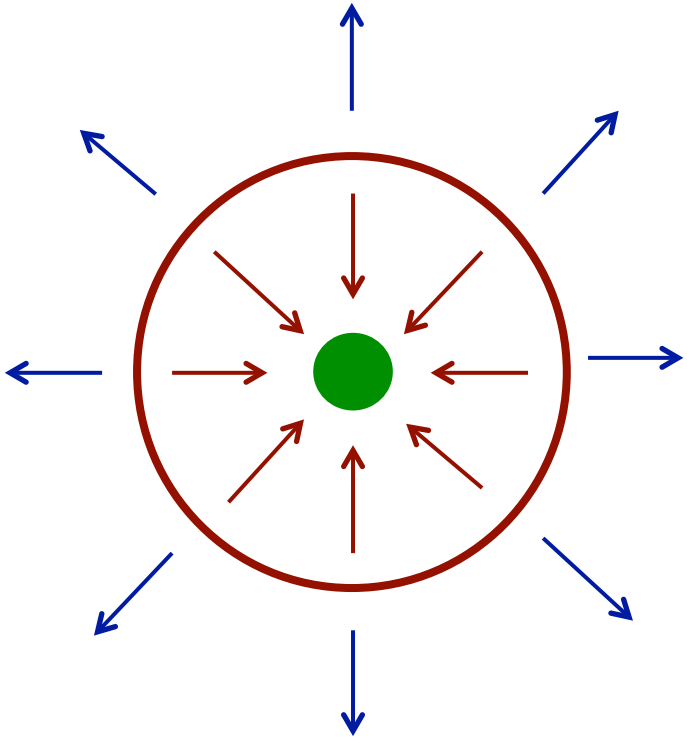
- Strict processing requirements
- May need more A/T
- No trade-off for FoV
- Commensality required

Intensity mapping

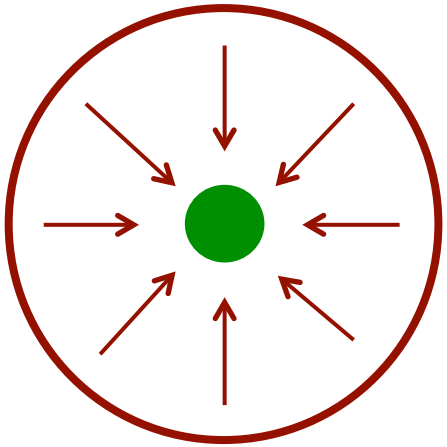
- Sample acoustic ripples
- Changes in ripples as function of distance
- Precision cosmology

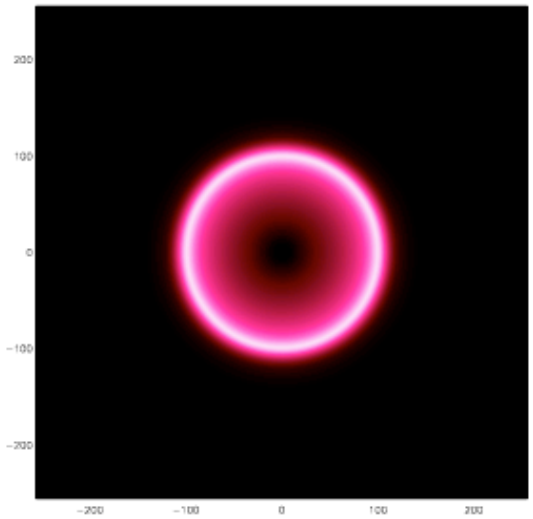


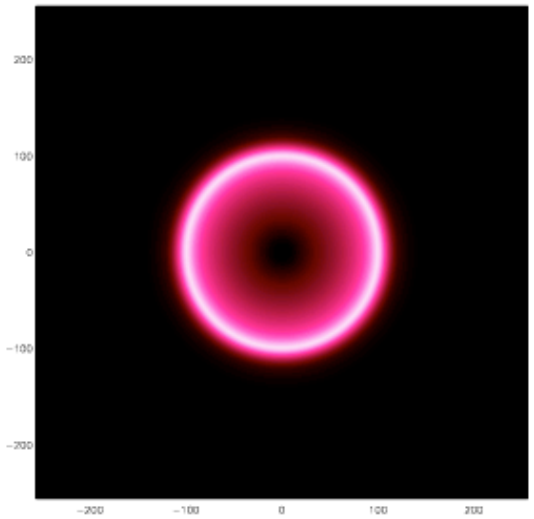
The early days

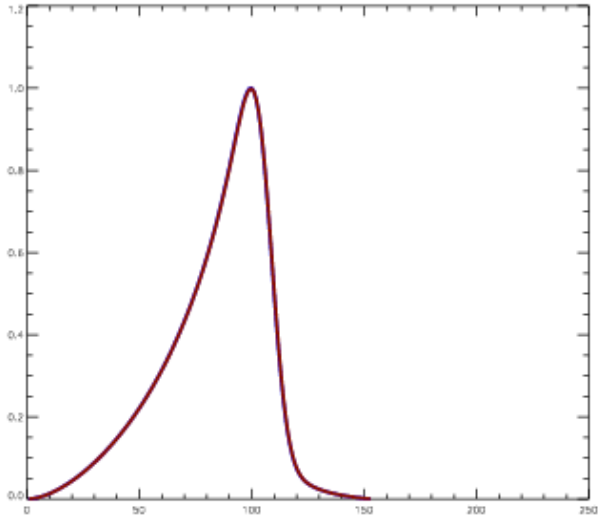


Recombination



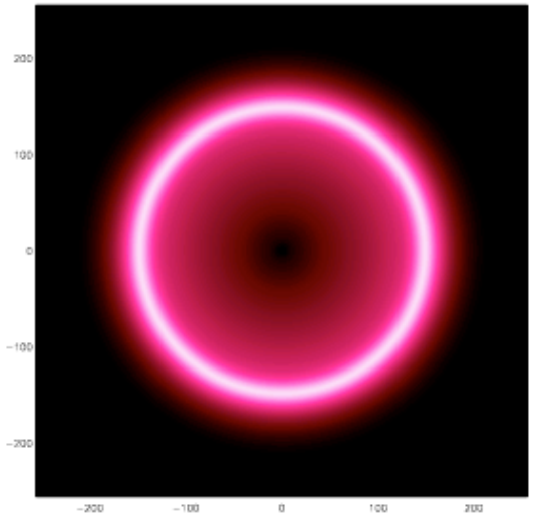


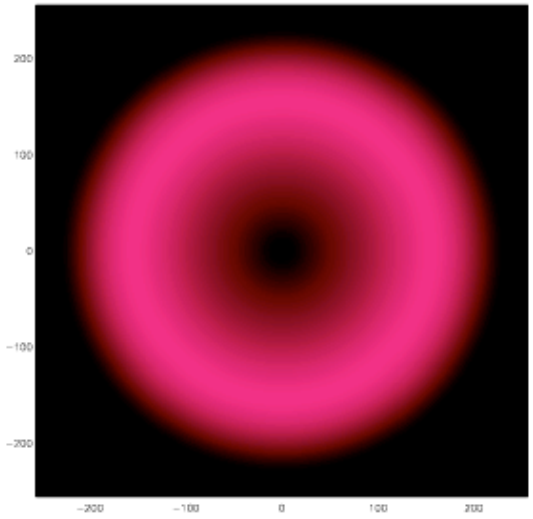


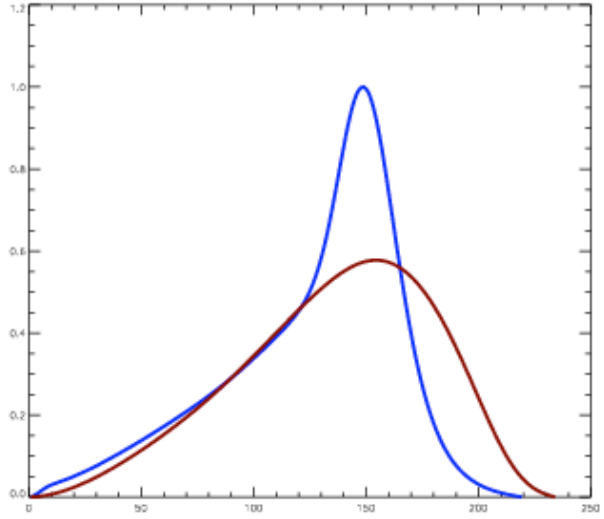


Evolution

- Universe expands
- Overdensities contract

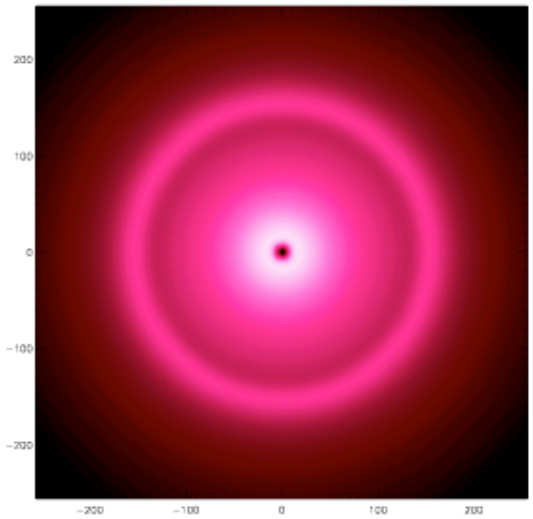


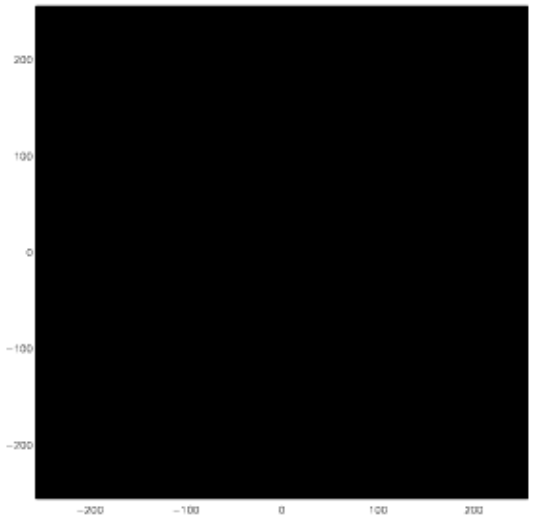


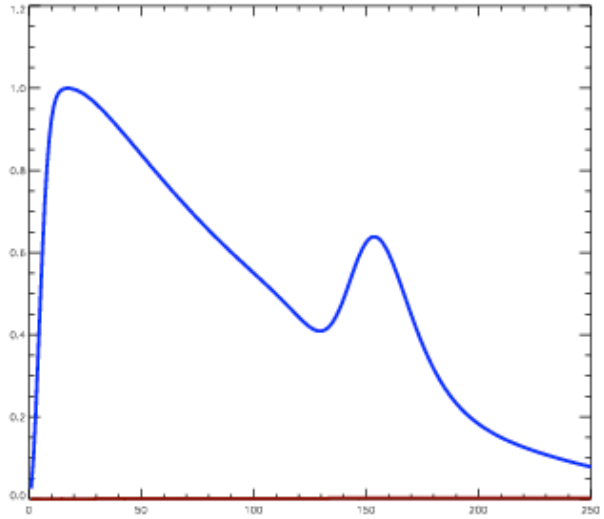


End result

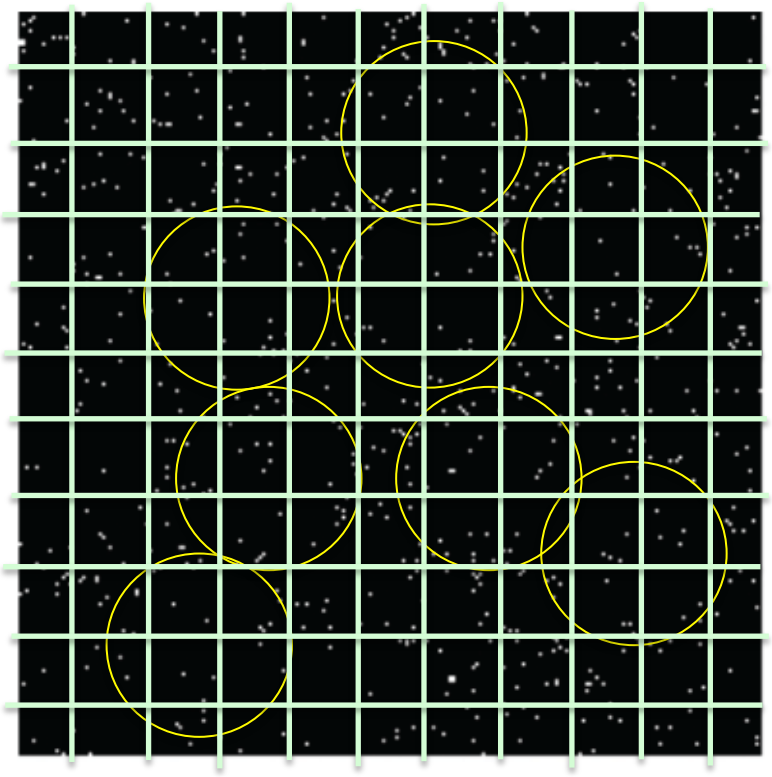
- Standard ruler of 150 comoving Mpc
- Requires giga-pc cubed volumes to measure

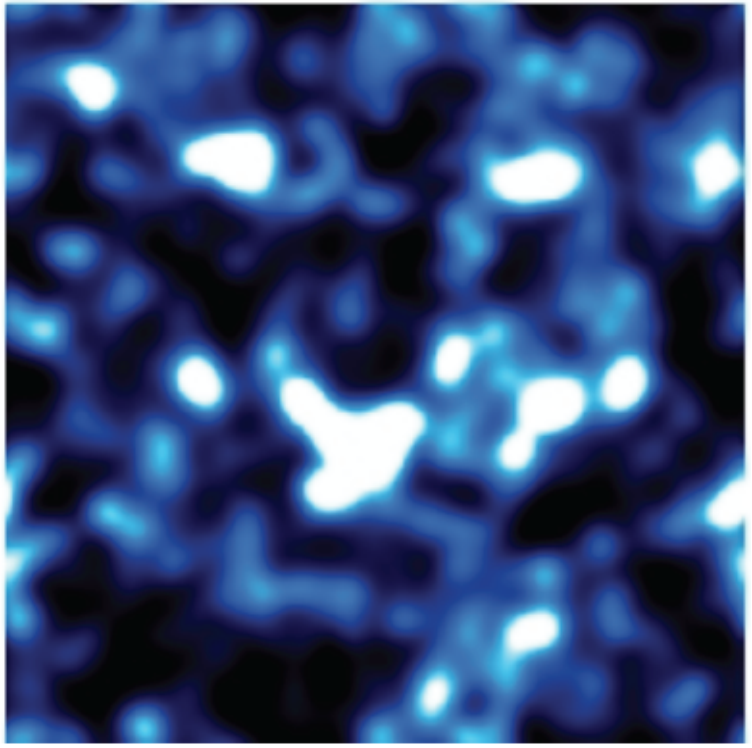






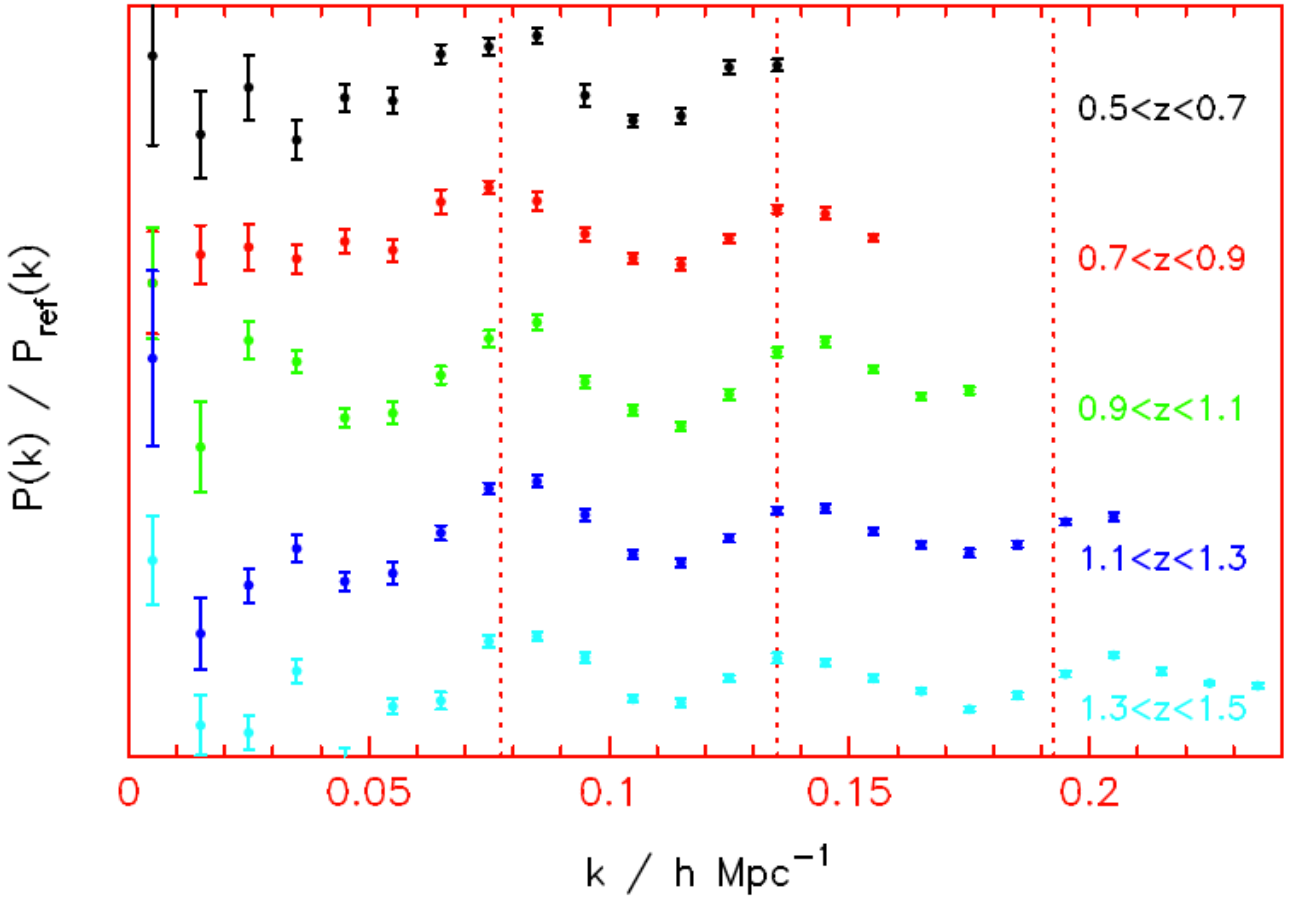
Intensity mapping





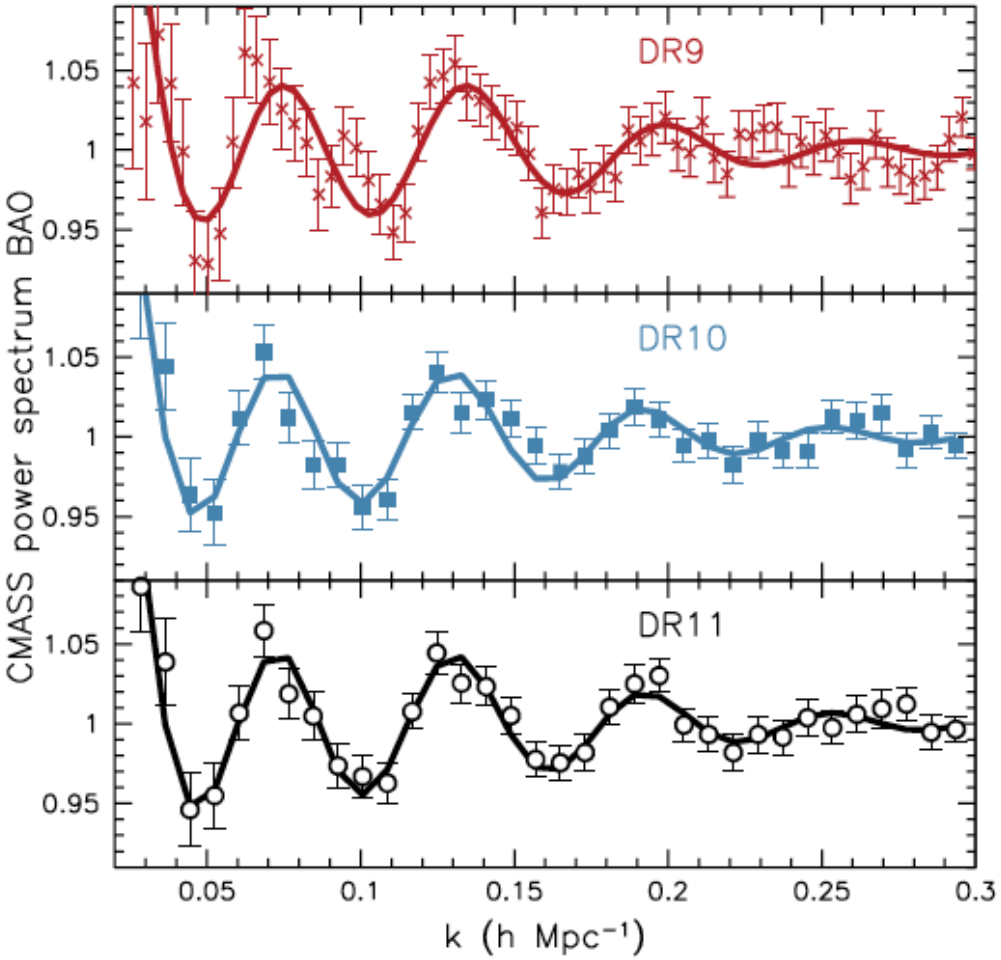
Nyquist sample the acoustic waves

Intensity mapping



Blake+ 2004

BAO measurements



Anderson+ 2013

Radio advantage

- less/no bias
- no line confusion
- IM: no individual source detection

Intensity mapping needs

- 400-1000MHz, with 125MHz bandwidth
- Compact configuration
- *uv*-coverage on short spacings: 10m baselines
- Can start small…

Strong competition ongoing!

AERA^3 decisions

- Frequency range, bandwidth, critical frequency
- Key science case: FRB, pulsars vs BAO
- Demonstrator properties
- Configuration
- Location
- …

AERA^3 part of path to SKA2…

Human capital

- Construction
- Operations
- Data processing
- Analysis
- Science

Train African people to do this

Buy your own AERA^3 in preparation for SKA

Lessons from workshop

- Planning towards SKA
- Costing & power
- Simulations for AERA^3 & SKA2
- Consolidate MFAA performance
- EMBRACE still has much to teach
  - High-cadence monitoring
  - Calibration
  - System stability

Thanks

- Oleg Smirnov, Patrick Woudt (SOC)
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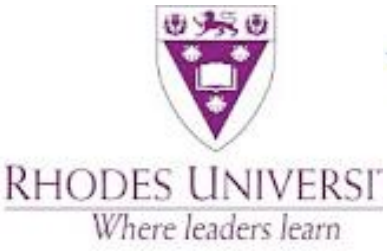
- Gert Kruithof
- Joeri van Leeuwen
- Truus van den Brink
- Erwin de Blok
- MFAA consortium MT

For talk transcripts see:
www.astron.nl/mfaa2014



MARIE CURIE ACTIONS

ASTRON
Netherlands Institute for Ra

NWO

SEVENTH FRAMEWORK
PROGRAMME

www.astron.nl/mfaa2014