SKA Cost Control Report: Cosmology

Mario G. Santos (on behalf of the Cosmology SWG)

Prelude: SKA1 Cosmology?

Cosmology SWG

- Core Team + associate members (total of 67 members)
- Chairs: Mario Santos + Xuelei Chen
- Focus groups:
    - Intensity mapping (Santos)
    - Weak lensing (Brown + Harrison)
    - HI galaxies (Bull)
    - Continuum (Jarvis)
    - Joint probes (Bacon + Camera)
    - SKA-LOW cosmology (Pourtsidou + Pritchard)

Focus groups currently preparing a “red book” to summarise all the latest Cosmology results with SKA1 (to be updated as necessary)

Key surveys for Cosmology

- Large sky survey
  - ~25,000 deg^2 / 10,000 hours on MID band 1 (and 2…)
  - Galaxy continuum and HI intensity mapping (crucial for “transformational science” - signatures of ultra-large scale cosmological effects)
  - requires both interferometer and calibrated single dish data (also useful for other science)
- Medium sky survey
  - ~ 5,000 deg^2 / 10,000 hours on MID band 2
  - Weak Lensing (~ 2.7 sources/$arcmin^2$)
  - HI galaxy survey (~ 2,000 sources/deg^2)
- Cosmology with SKA-LOW
  - Follows proposed EoR surveys

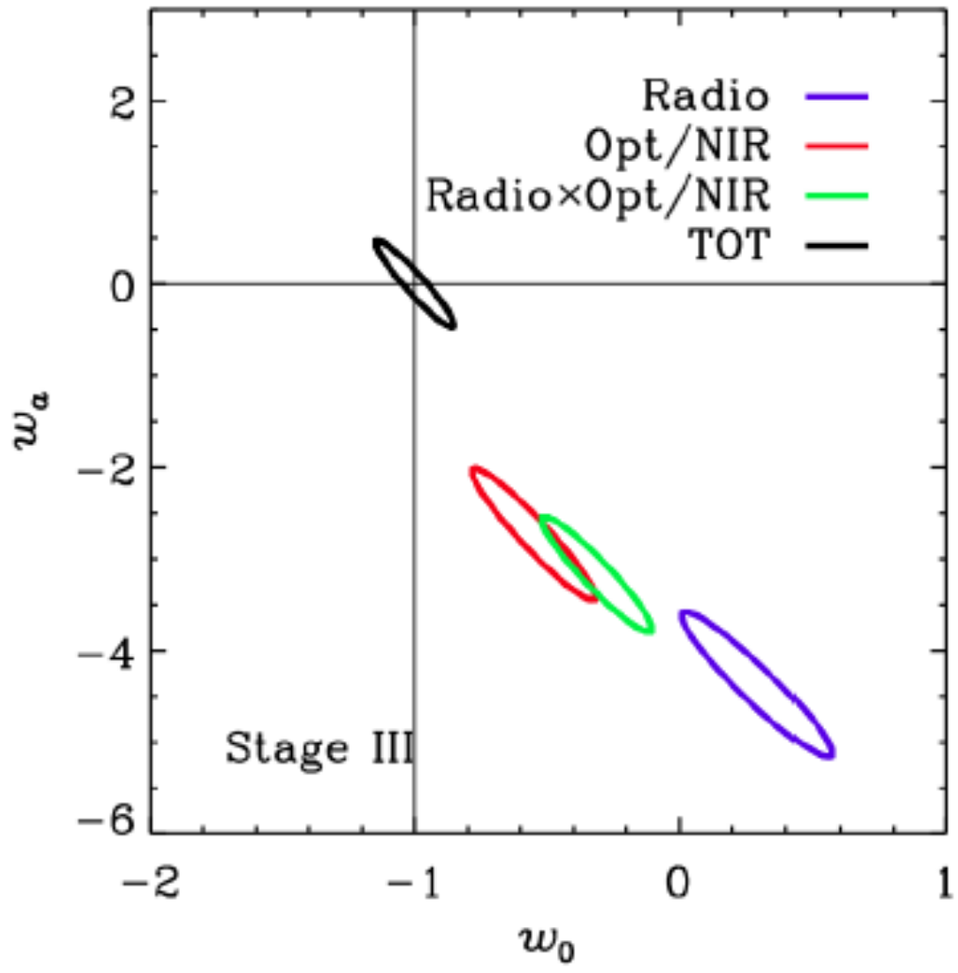
Some highlights: Weak Lensing

- Extensive simulations by the Manchester group

- SKA1 continuum weak lensing is competitive with DES (auto/cross-corr)

- Radio x optical weak lensing crosscorrelation is a powerful way of removing important systematics (hard to trust DES/LSST weak lensing results without SKA1!)

- Bayesian approach allows to extract a large number of redshifts using the HI line in combination with continuum information (Harrison+)

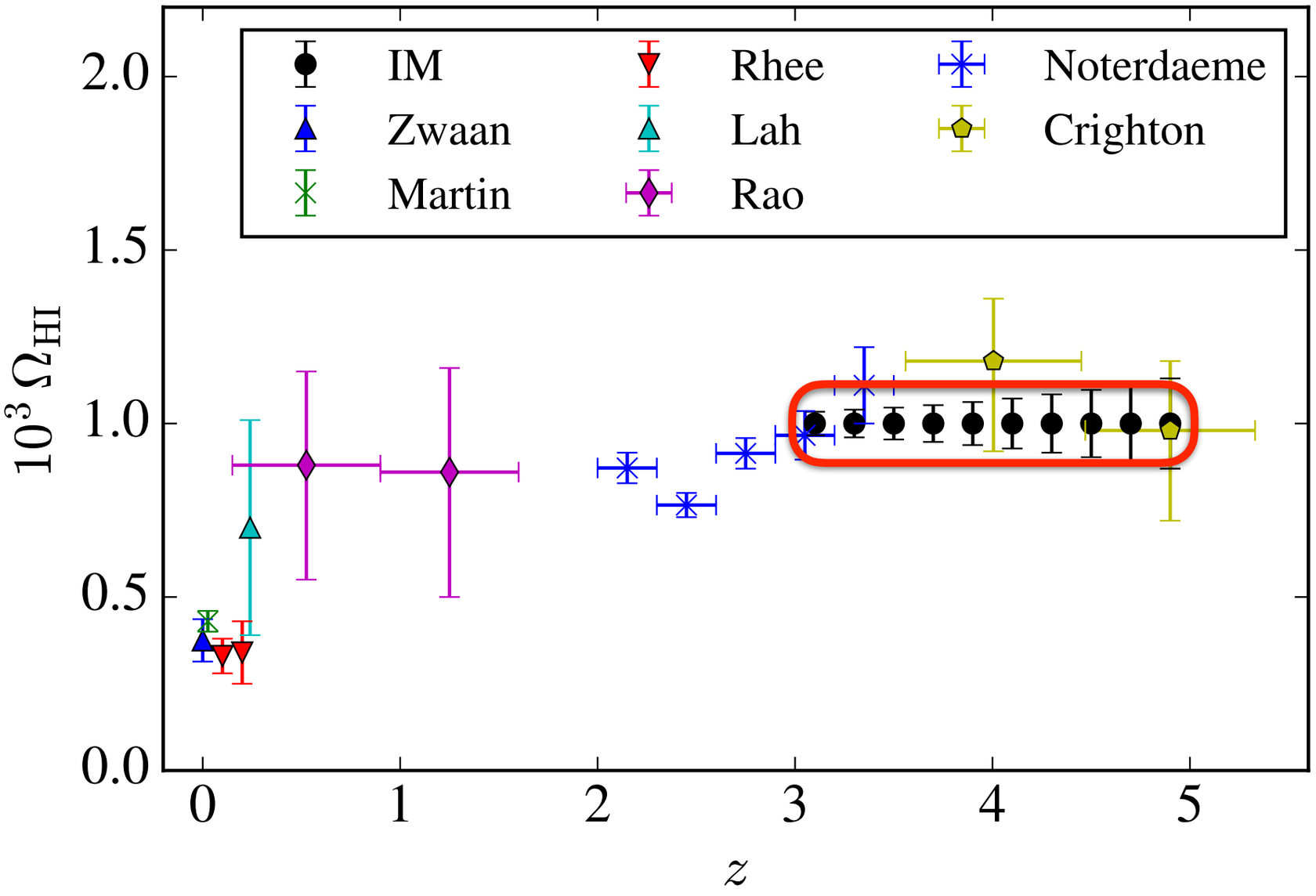


Camera, Harrison, Bonaldi, Brown

Some highlights: Cosmology with SKA1-LOW

Intensity Mapping Survey with SKA1-Low at 3<z<5

- Can get IM maps with SKA-Low at 250-350 MHz
- Need wide-ish survey
- Use data to constrain HI and cosmology
- Synergies with SKA-Mid, BOSS Ly-α, ...
- Currently working towards more realistic forecasts using simulations



[Chapman, AP, Pritchard, Wolz 2017]

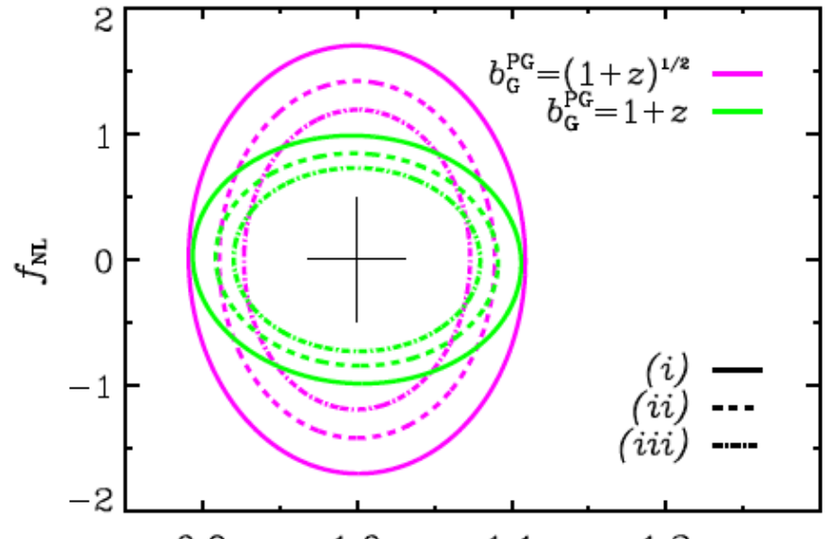
Some highlights: HI intensity mapping

- BAO/RSDs (dark energy) constraints competitive with other surveys (e.g. Euclid)

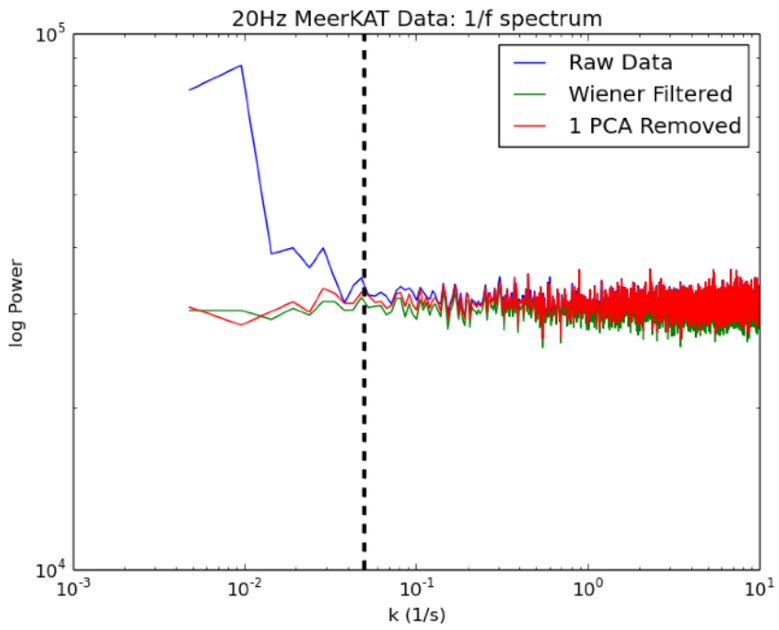
- SKA1 IM x LSST cross-correlation is the only known survey combination sensitive enough to detect relativistic effects on ultra-large scales

- Several simulations being developed to test foreground cleaning and instrumental effects for single dish

- Tests being done with the KAT7 system/MeerKAT



Fonseca et al.

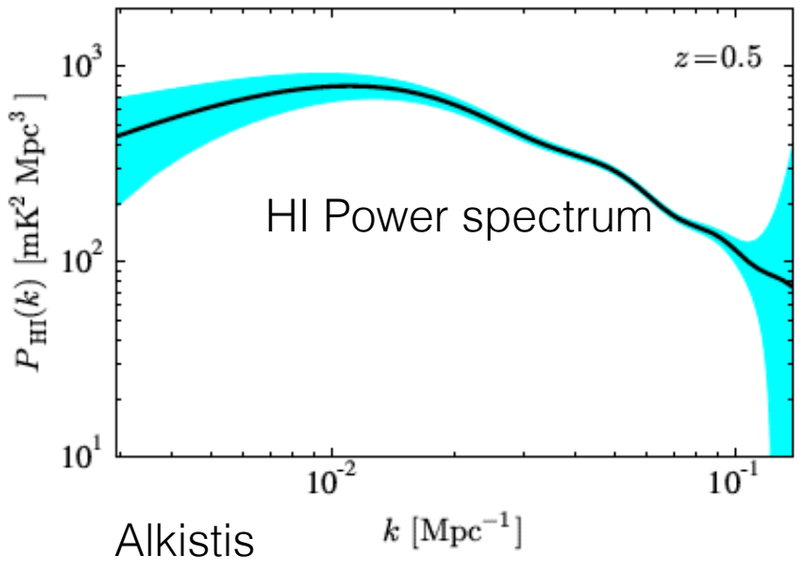


Patel et al.

A cosmology survey precursor for SKA1-MID with MeerKAT

- Prepare the pipeline for SKA-1 MID
- Test the HI intensity mapping technique
- Produce state of the art cosmological constraints:
  - BAO/RSDs/dark energy
  - Cross-correlations with galaxy/lensing surveys (DES)
  - primordial non-Gaussianity with the multi-tracer technique
  - (and lots of other non-Cosmology science)
  - ~ 4,000 deg^2 in L-band down to ~ 5 uJy continuum (~ 4,000 hours) - detect about 10 million galaxies

Note: MeerKAT now running with 32 dishes! (press-release on Tuesday)



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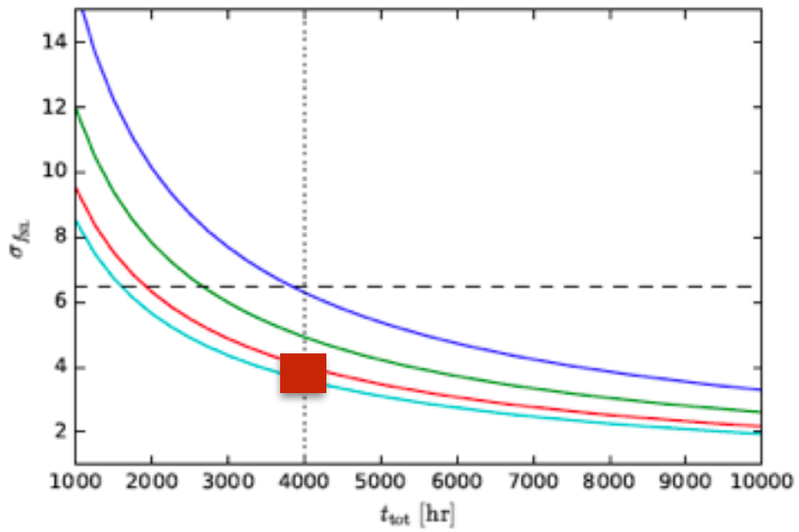


Fonseca et al.

Assessment of the impact of the proposed cost savings measures

Impact of SDP Pflop Reduction?

- Intensity mapping survey: aim is to scan the sky (~1 sec dump rate), use both the interferometer and dish auto-correlations and use the full bandwidth with ~ 0.1 MHz resolution

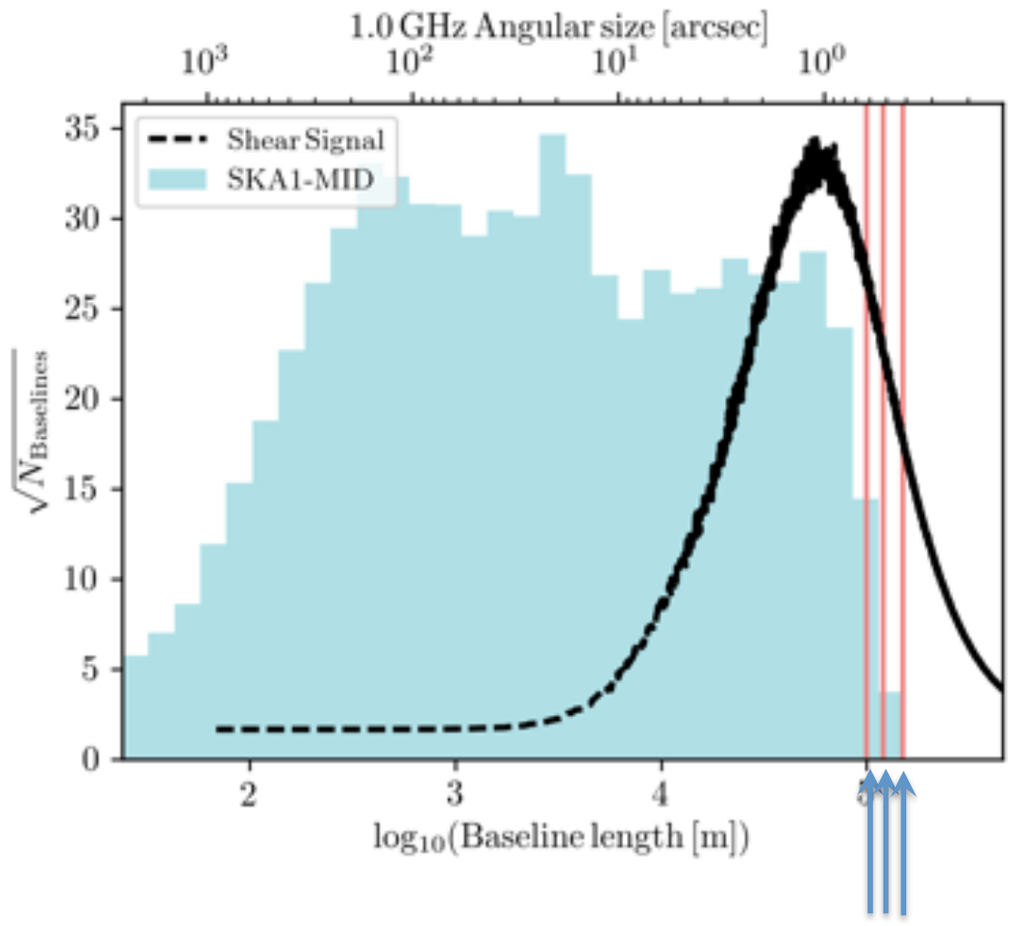
- WL requires high spatial resolution (sub 0.5 arcsec) and large FoV (1 deg^2) and high frequency (0.03 MHz) and time (0.5 seconds) resolution from correlator to avoid smearing.

- Cosmological constraints also benefit strongly from commensal HI observations for spectroscopic redshifts - **commensality** is the key!

How many of these will still be possible after SDP reduction?

Impact of Bmax MID Reduction Weak Lensing

- For Band 2 continuum survey, appreciable amounts of shear signal fall on >120 km baselines
- Want to measure morphology of ~1 arcsec galaxies
- Only being able to sample <2 pixels across a galaxy at 1.0 GHz not enough!
- Reducing 150Km baseline -> reduce number of galaxies with measured shapes -> potentially high impact for WL - would argue for increasing Science Impact of 5.24.X to **3**
- The understanding of radio shape measurement is still evolving - danger to design WL out of the telescope



Harrison et al.

Summary

- Above the “thick line” cut two main issues have been identified:
  - Reduction of SDP power - it is not clear if they will impact our processing requirements or affect commensality
  - Reduction of SKA1-MID 150 Km baseline - might put WL science at risk (if it had to happen, the option to leave the infrastructure in place in order to allow including the dishes at a later stage, is preferred)
- Other crucial issues for Cosmology such as gain/bandpass stability or calibration of auto-correlations (noise diodes…), do not seem affected in this proposal
- Another important factor is the possible loss of the high frequency band part of SKA1-LOW -> this would create a “desert” gap in redshift between MID and LOW ($3 < z < 6$)