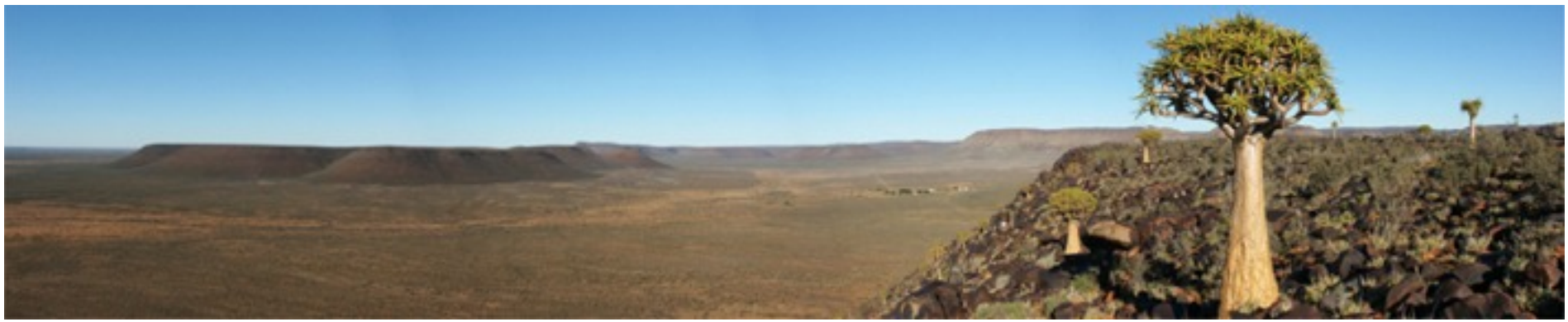
MIGHTEE

MeerKAT International GigaHertz Tiered Extragalactic Exploration



co-PIs

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Some key Science goals

- To trace the **evolution** of strongly star-forming **galaxies** from z~6 to the present day, and quiescent star forming systems from z=1-2, using a wavelength unbiased by dust or molecular emission.
- To trace the **evolution** of **super-massive black holes** throughout the history of the Universe, and understand their relationship to star-formation.
- assess the **AGN** mechanical **feedback** and environmental impact on the intergalactic medium
- To explore an **uncharted region** of observational parameter space

Additional goals

- Identify rare or specific populations (through techniques involving radio spectral index measurement?)

- Explore and develop techniques for extracting the maximum information from deep and potentially confused radio images.

SWG

- **The evolution of accretion activity the exploration of the epoch of reionization**
  - Martin Hardcastle, Isabella Prandoni, Chris Simpson, Matt Jarvis
- **Cosmic star-formation history and galaxy evolution**
  - Philip Best, Seb Oliver
- **Galaxy Clusters**
  - Marcus Bruggen, Ian Smail
- **Cosmology and Large-Scale Structure**
  - Matt Jarvis, Catherine Cress, David Bacon
- **The Polarized Sky**
  - Richard Battye, Anna Scaife, Russ Taylor
- **Transients**
  - PatrickWoudt, Michael Bietnenholz

Technical WG

- **Commissioning**
  - Rob Beswick, Nadeem Oozeer
- **Software & Pipeline Development**
  - Hans-Rainer Klockner, Ian Stewart
- **Polarization Calibration**
  - Jeroen Stil, Bryan Gaensler
- **Science Simulations**
  - Richard Wilman, Marcus Bruggen
- **Telescope Simulations**
  - Ian Heywood, Steve Rawlings
- **Survey Strategy & Field Selection**
  - Matt Jarvis, Kurt van der Heyden
- **Multi-wavelength Cross-identification**
  - Dave Bonfield, Manda Banerji
- **Archive and Virtual Observatory**
  - Nic Walton, Ian Stewart
- **Skills Transfer & Development**
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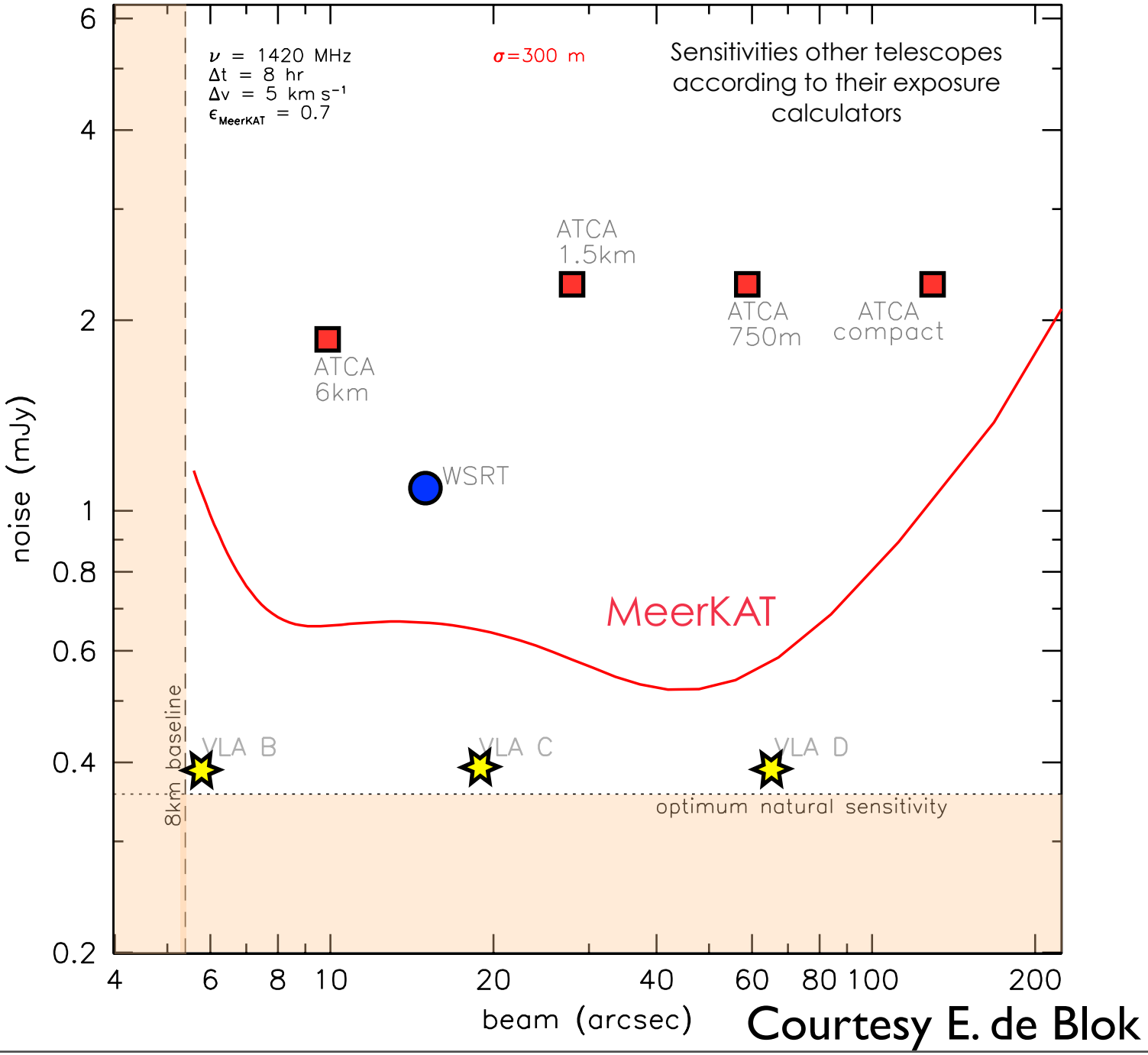
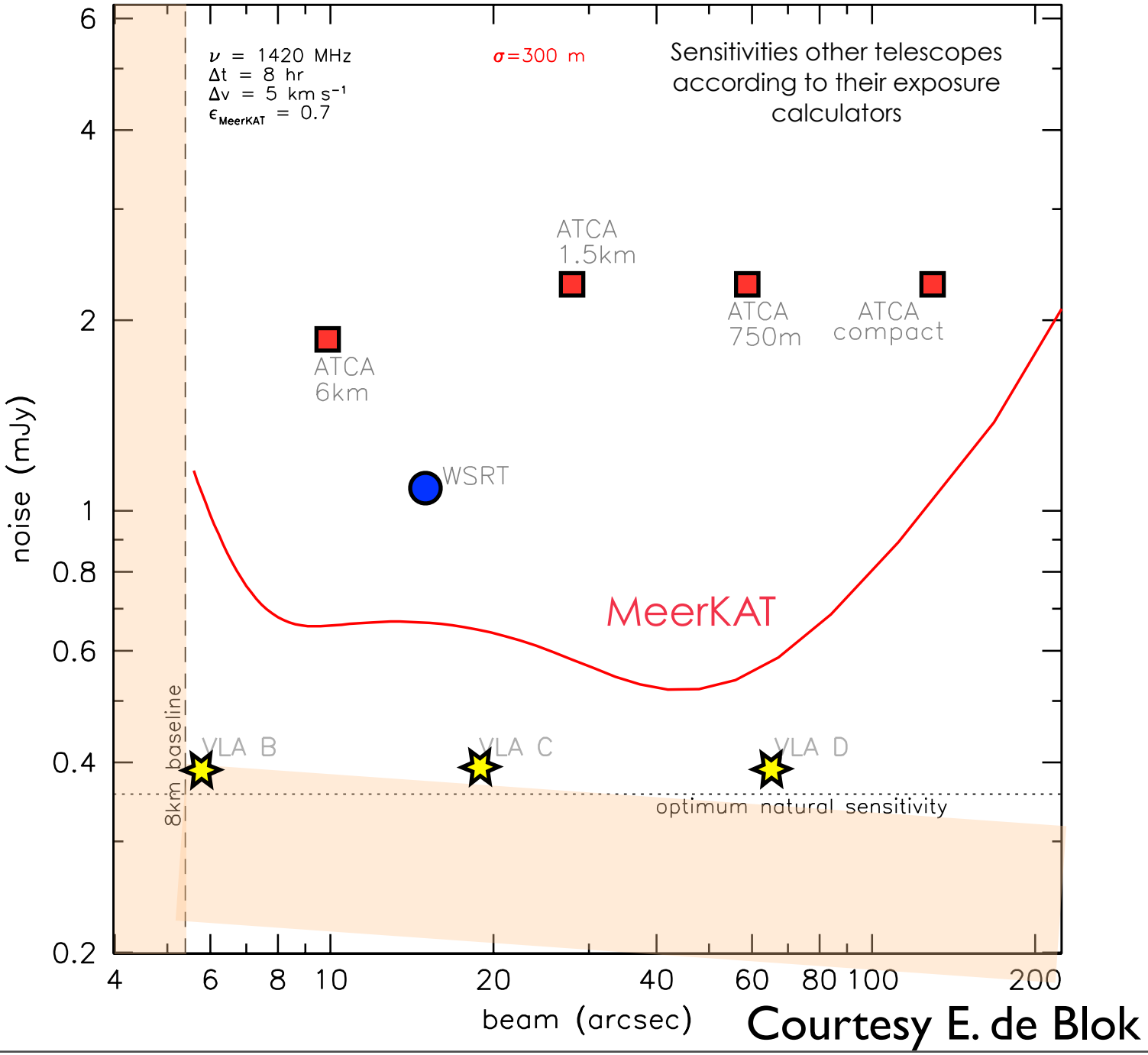
Point source sensitivity



Courtesy E. de Blok

Point source sensitivity



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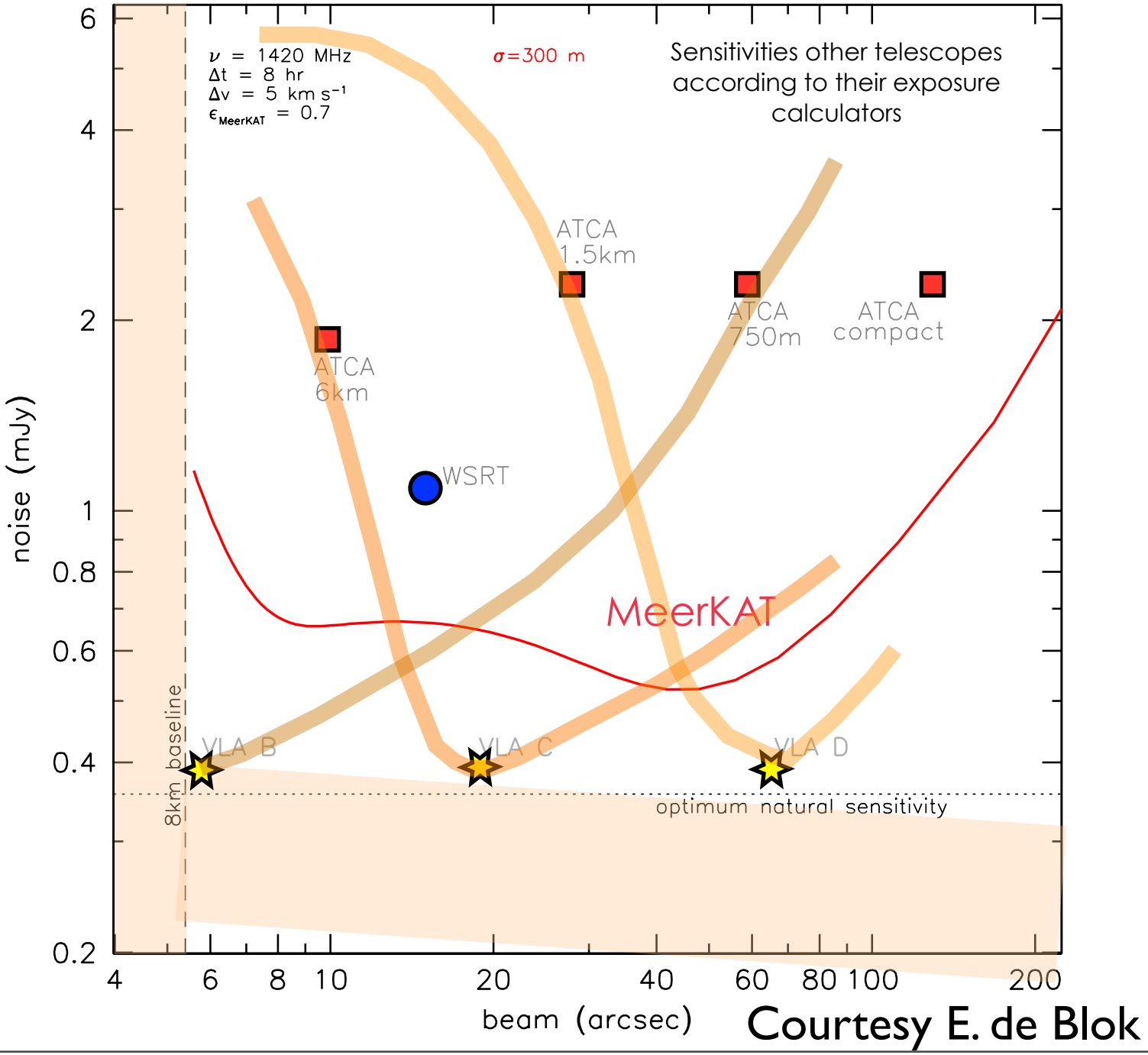
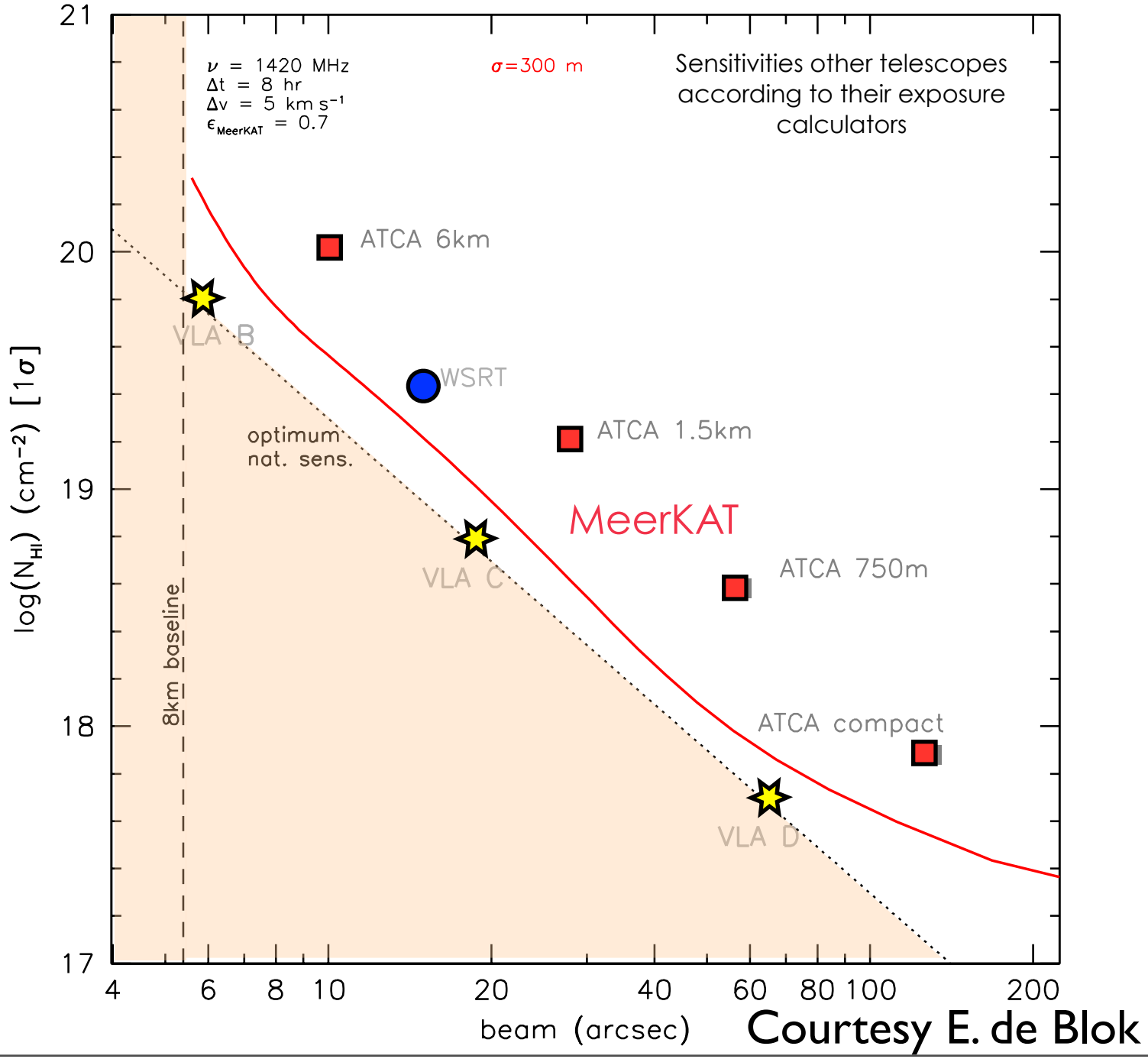


Courtesy E. de Blok

Column density sensitivity



Continuum Proposal

Tier-1: 1000 square degrees to 5μJy (rms) ; possible fields VISTA-VIKING and KIDS fields. large-scale structure of the Universe at z ~1;
Possibly combine UV data with EMU. Time estimate: 1250 hours

Tier-2: 35 square degrees to 1μJy (rms); possible fields Elais-S1 (0037-43), XMMLSS (0218-05), ECDFS (0332-27) and COSMOS (1000+02). sensitive to starbursts of 100 M yr^{-1} at z ~4 and SCUBA-type galaxies with > 500 M yr^{-1} up to z > 7. Time estimate: 1050 hours

Tier-3: A single pointing to 0.1μJy (rms), possibly over Chandra-Deep-Field South - push the telescope to its limit and studies of star-formation and AGN activity to levels

Tier-4: 0.25 square degrees @ 12 GHz to 1μJy (rms), Study AGN/Starburst morphology

Tier-5: 0.01 square degrees @ 12 GHz to 0.2μJy (rms), Study AGN/Starburst morphology

Current major 20cm surveys

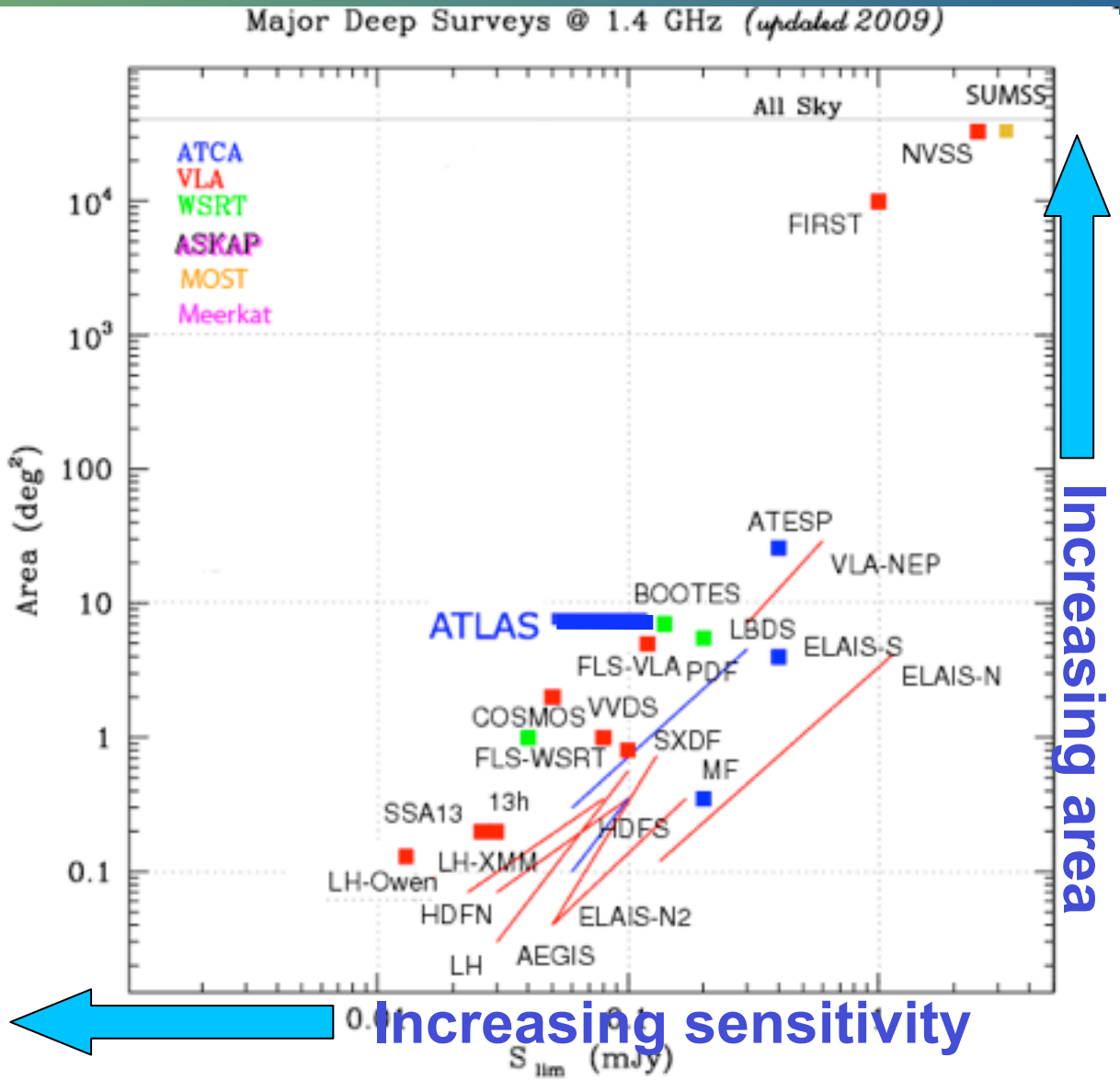


Diagram courtesy of Ray Norris /Isabella Prandoni

Current major 20cm surveys

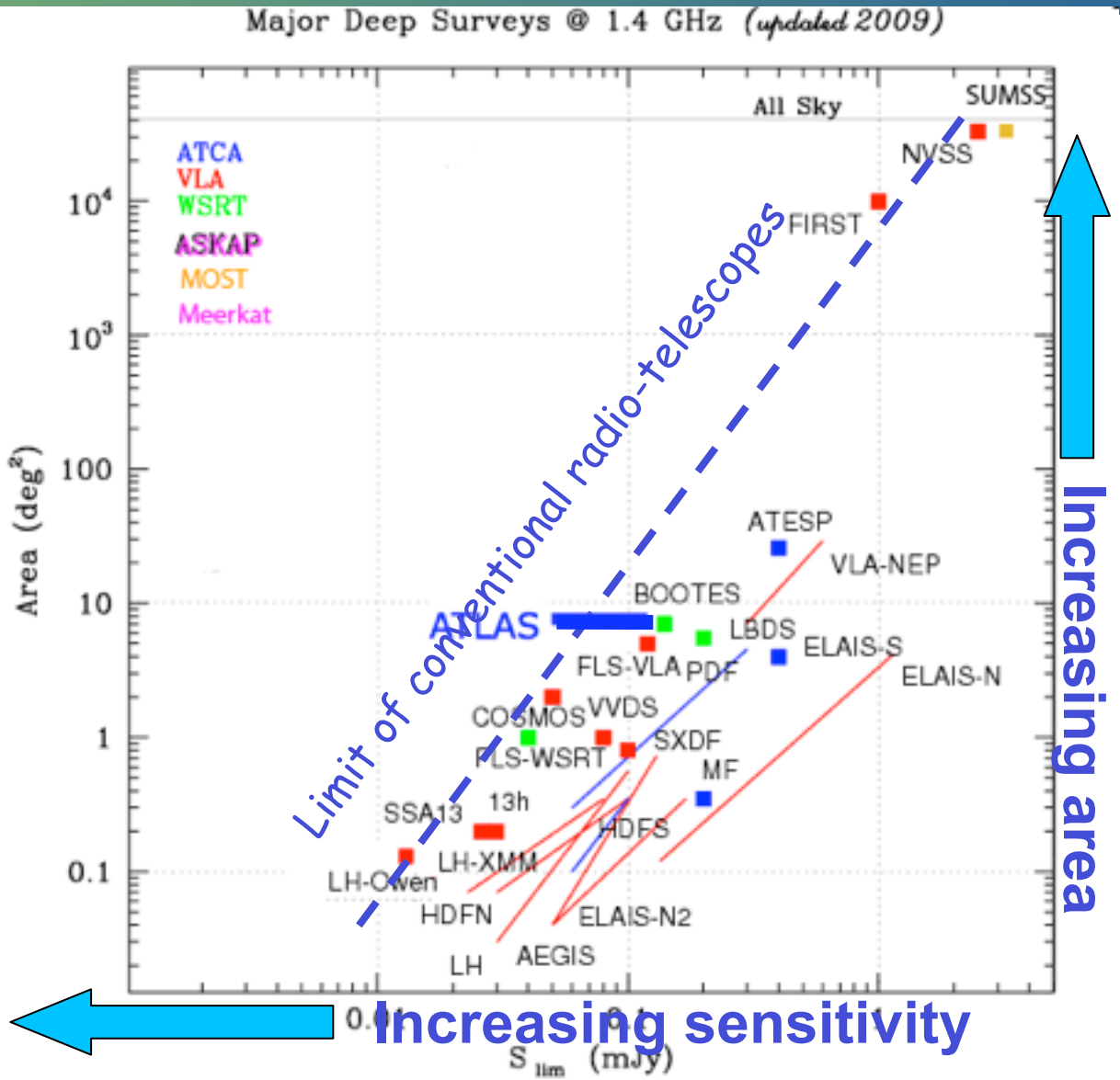


Diagram courtesy of Ray Norris /Isabella Prandoni

Current major 20cm

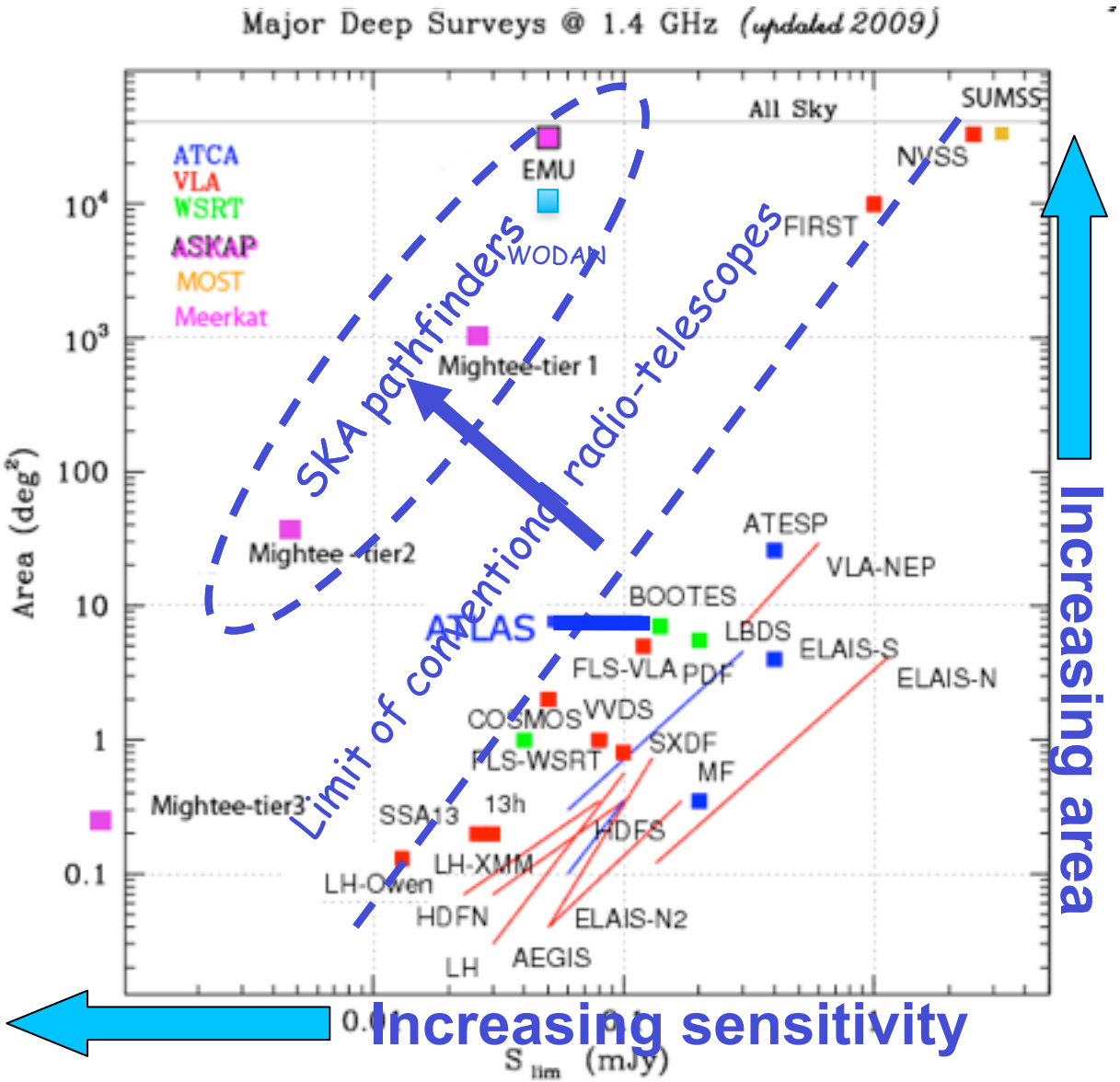
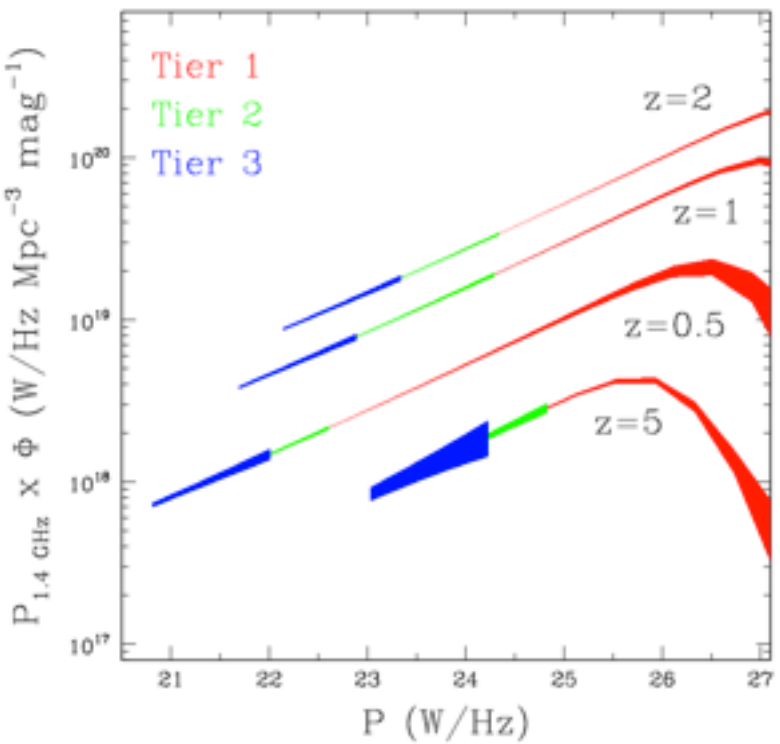


Diagram courtesy of Ray Norris /Isabella Prandoni

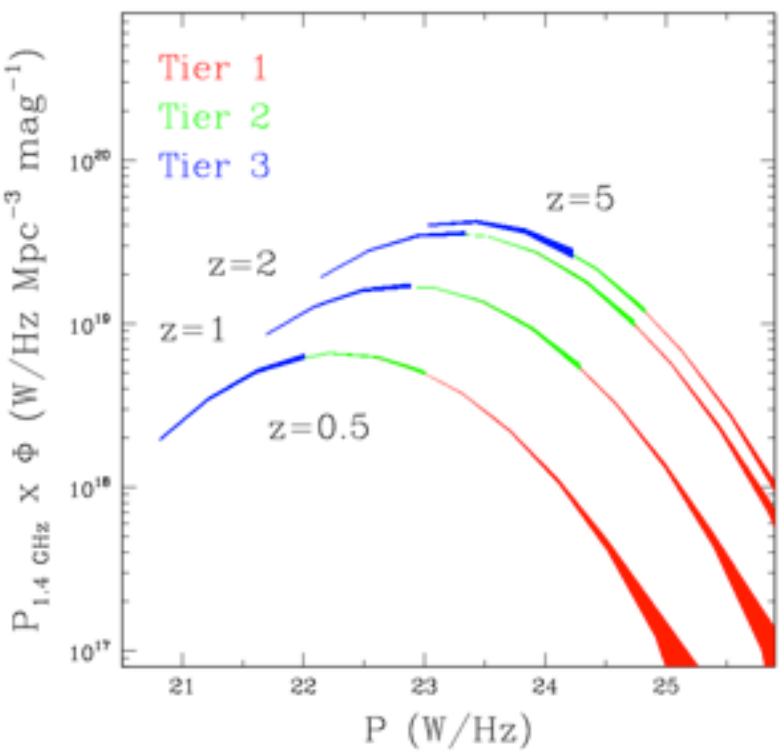
AGN & EOR

- Relationship between AGN & Star Formation activity in galaxies
- Evolution of low power AGN
- AGN feedback in galaxy evolution
- Finding high redshift radio sources - SKA follow-up 21cm forest to study EOR

AGN


Tier 1
Tier 2
Tier 3
z=2
z=1
z=0.5
z=5
$P_{1.4\ GHz} \times \Phi$ (W/Hz Mpc^{-3} mag^{-1})
P (W/Hz)

SFG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P (W/Hz)

Galaxy Clusters

- Non-thermal components of Clusters - how do they relate to merger activity
- How do non-thermal components affect the thermodynamical evolution and mass of clusters

Cosmology & LSS

- Clustering properties of radio galaxies - how are these related to the underlying DM distribution
- Evolution of clustering with redshift
- Weak lensing: leap in survey area - generate DM maps from the radio

Weak Lensing

- Need large number densities of objects → only available in the optical.
- Radio surveys soon to have massively increased sensitivities and will also detect large numbers of normal star forming galaxies over large fields-of-view.
- Radio also offers some benefits over the optical in terms of systematics.
- Done with FIRST and also on radio observations of

Cosmic Shear with MeerKAT

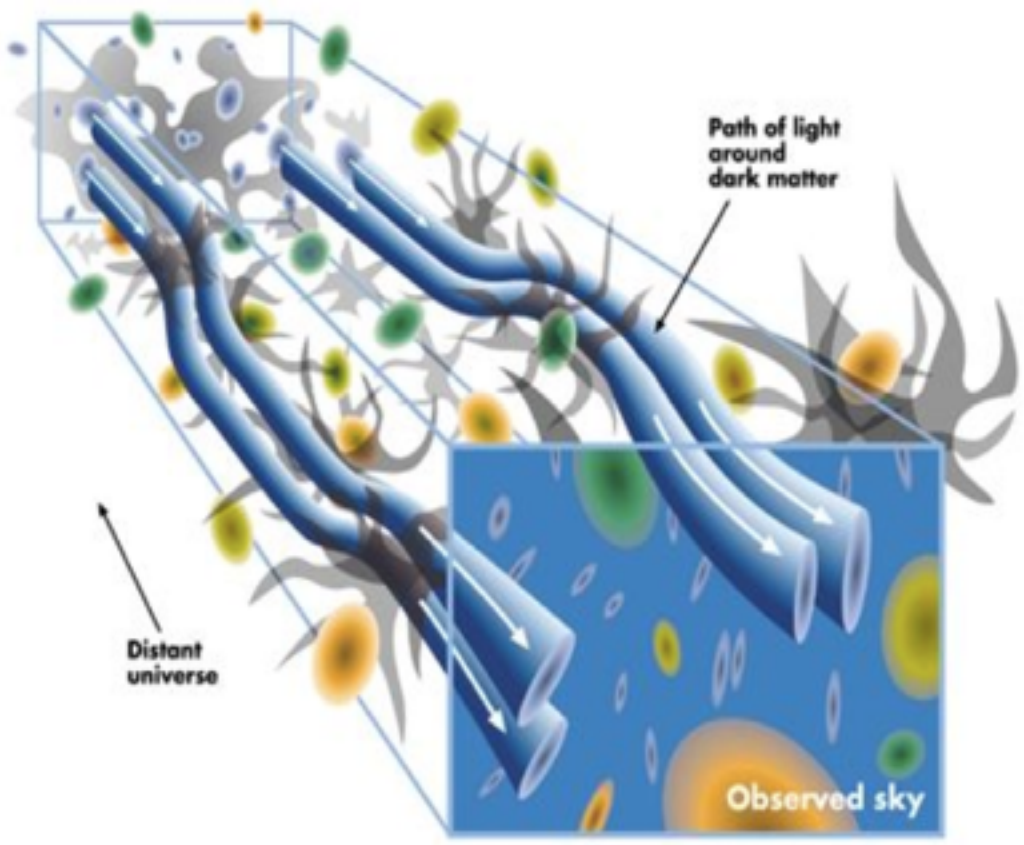
Light rays are deflected by the dark matter distribution – causes distortion to galaxy shapes.

Measure the distortions = measure the dark matter.

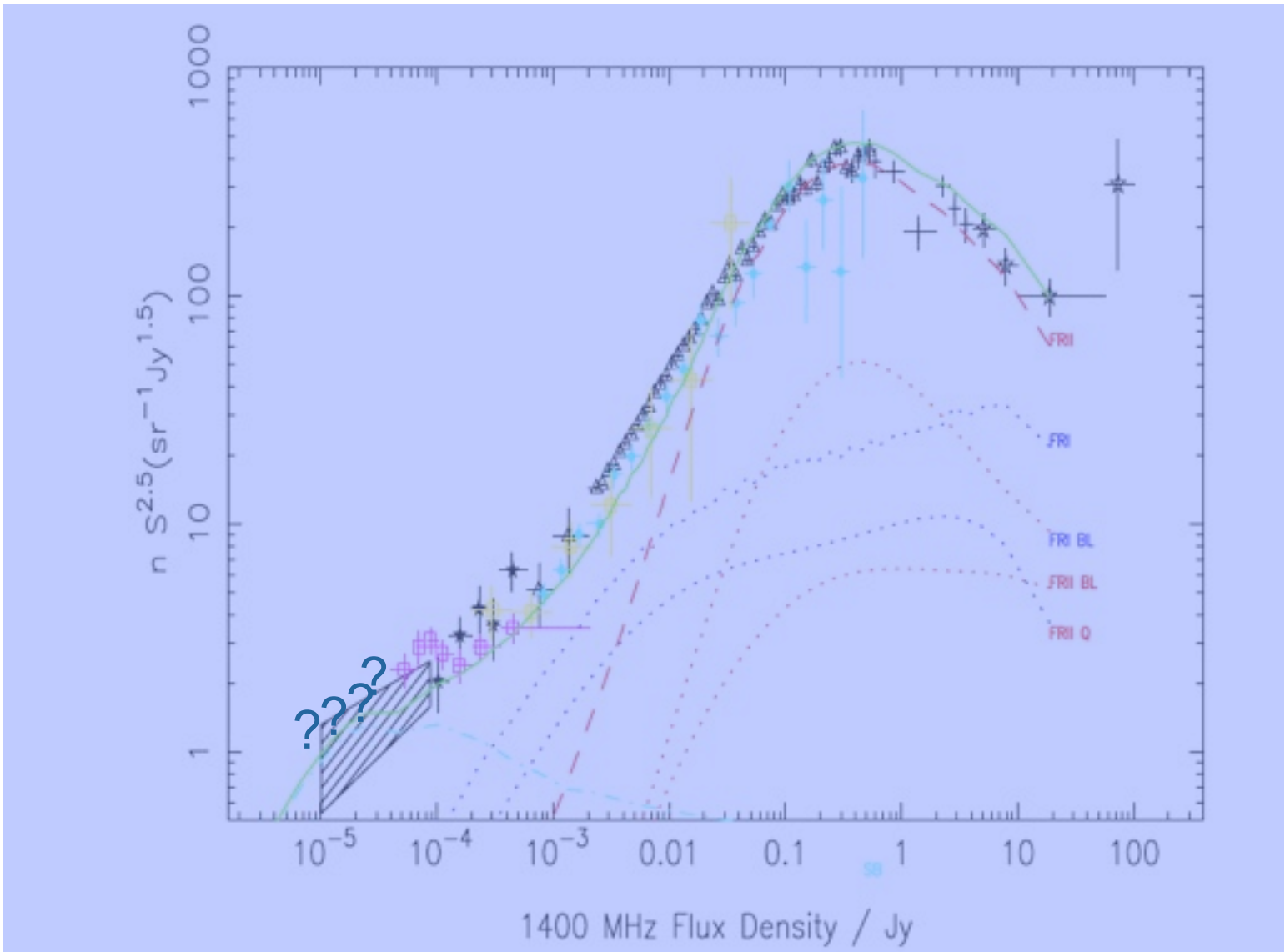
BUT….

Distortions are very small, of order ~1% → need accurate shape measurement i.e. arcsecond resolution (long baselines).

Most likely not possible without the high resolution of images.



Uncharted territory



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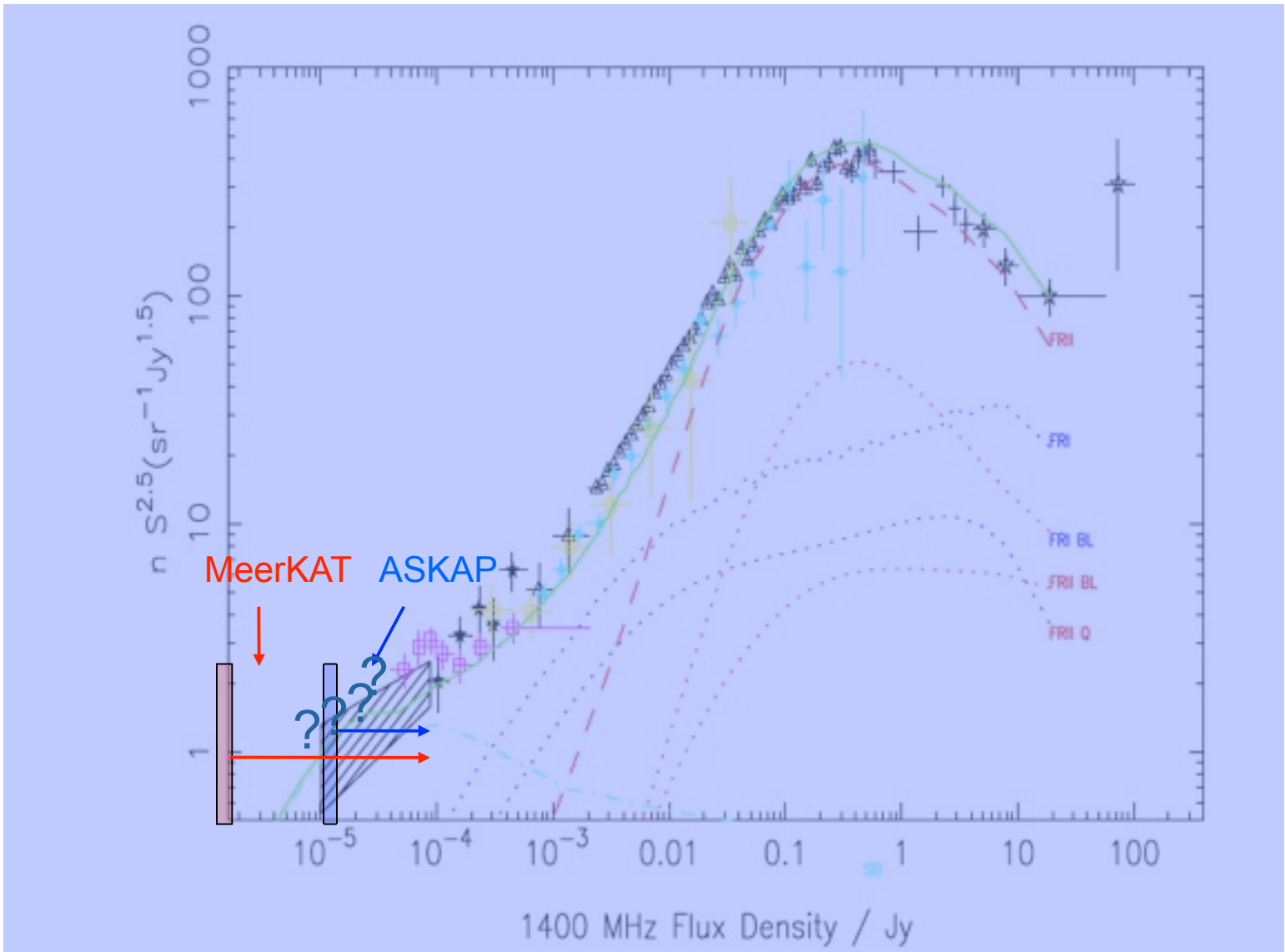

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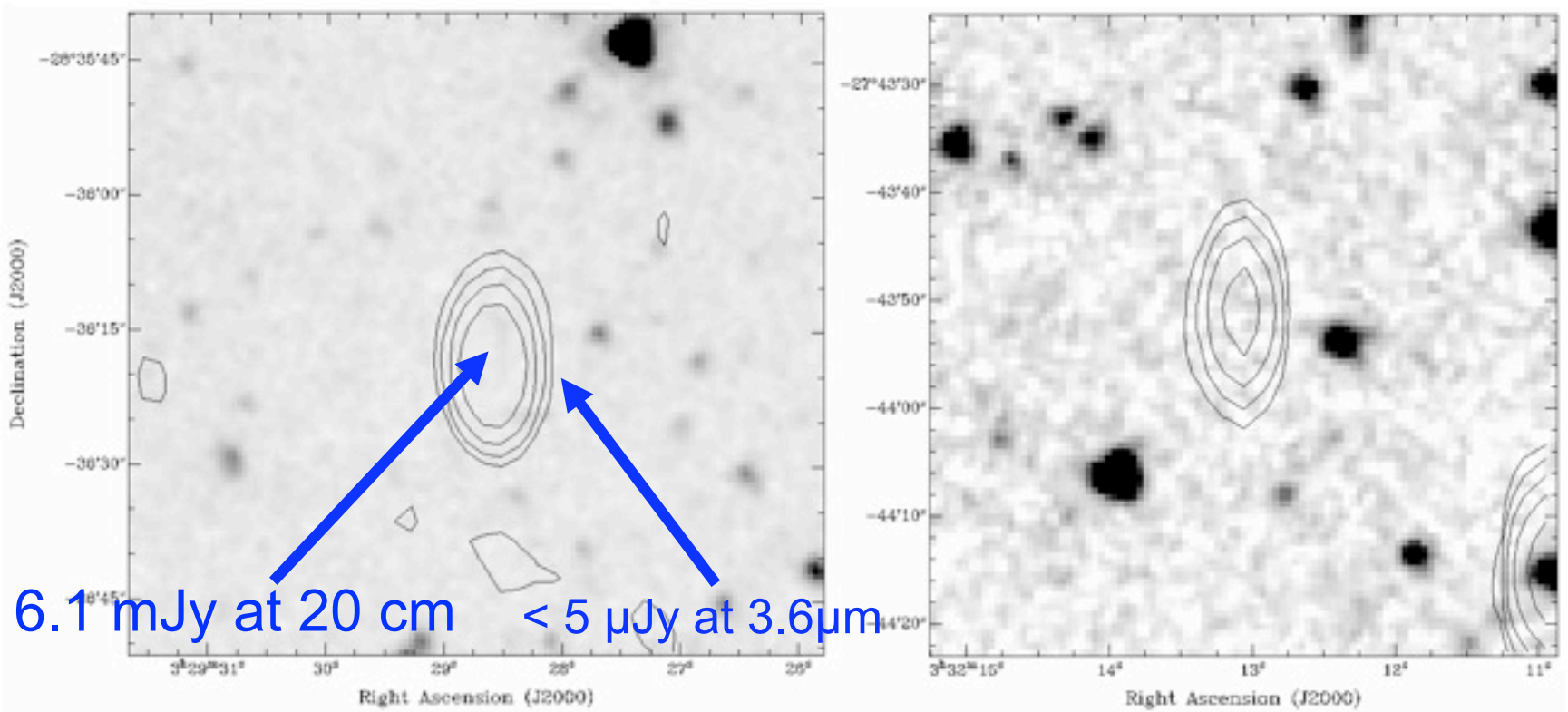
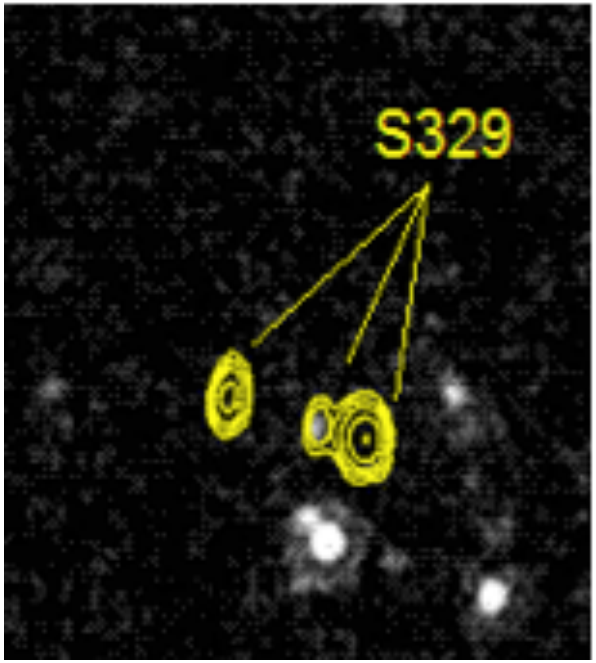


Norris et al 2007, MNRAS, 378, 1434; Middelberg et al 2008, AJ, 135, 1276; Garn & Alexander, 2008, MNRAS,391,1000; Huynh et al.,2010, ApJ, 710, 698; Middelberg et al., 2011, A&A, in press, Norris et al. 2011, ApJ, submitted.

Source detection & cross IDs

- **We have to develop a pipeline to automate cross-IDS**
  - using intelligent criteria
  - not simple nearest-neighbour
  - work closely with other survey groups



Survey Summary

Tier	Frequency (GHz)	Sensitivity (rms)	Resolution (arcsec)	Area (degree^2)	Time (hours)	MeerKAT Phase	Key Science Drivers	Other Drivers
Tier 1	1.4	5.0μJy	8.5	1000	2400	Phase 1	Evolution of clusters, relics, haloes, LSS, rare sources, RM map	HI absorption *Herschel* IDs
Tier 2	1.4	1.0μJy	8.5/3.5	35	1950	Phases 2-3	Star formation/AGN evolution, Evolution of Clusters Deep RM map	HI absorption Weak Lensing *Herschel* IDs
Tier 3	1.4	0.1μJy	3.5	1.0	1700	Phase 4	Star formation/AGN evolution, Weak Lensing, Deep RM map	HI absorption Proto-clusters
Tier 4	12	1.0μJy	3.2/0.4	0.25	700	Phases 2-3	AGN/starburst morphology	*Herschel* IDs
Tier 5	12	0.2μJy	0.4	0.01	440	Phases 3-4	AGN/starburst morphology	RM map

MeerKAT RFP	KAT-7 2010	Phase 1 2013	Phase 2 2014	Phase 3 2015	Phase 4 2016
Number of dishes	7	80	80	87	87
Low freq. range (GHz)	1.2–1.95	0.9–1.75	0.9–1.75	0.9–1.75	0.58–2.5
High freq. range (GHz)	—	—	8–14.5	8–14.5	8–14.5
Maximum processed bandwidth (GHz)	0.256	0.850	2	2	4
Min. baseline (m)	20	20	20	20	20
Max. baseline (km)	0.2	8	8	60	60

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Tier 1 - Not competitive with ASKAP EMU

Tier 4 - inadequate resolution to seperate AGN & SBG

Tier 3 - obtained in parallel with the deep HI survey

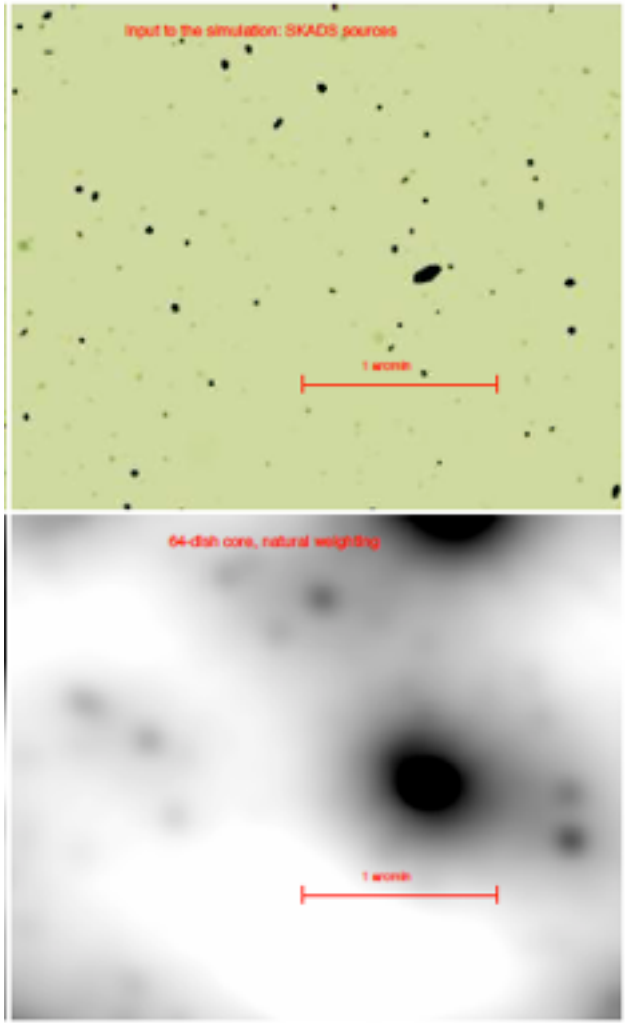
Tier 5 - obtained in parallel with MESMER

Survey Strategy

- **Optimise MIGHTEE survey strategy**
  - Can/how we observe commensally with other surveys? (eg MESMER,LADUMA, THUNDERKAT)
  - What is the optimum observing frequency/parameter
  - What is the optimum tiling strategy?
  - Day/night observing

- **Discussions with other survey projects to identify/resolve potential obstacles to commensal observing.**
  - Data analysis (interferometry techniques etc)
  - Software – data simulation, modeling, source confusion algorithms, source identification & parameterisation
  - Optimisation of commensal observations
  - Data storage, Joint source catalogues/databases
  - Interchange/sharing of expertise (staff, PDR, students) & resources?

Need for longer BL



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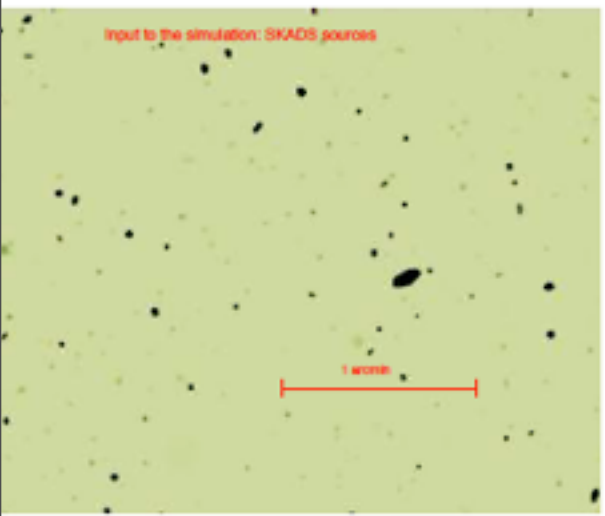
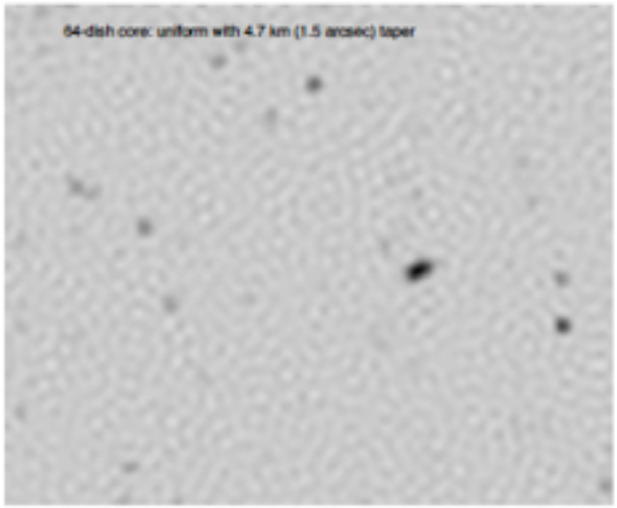
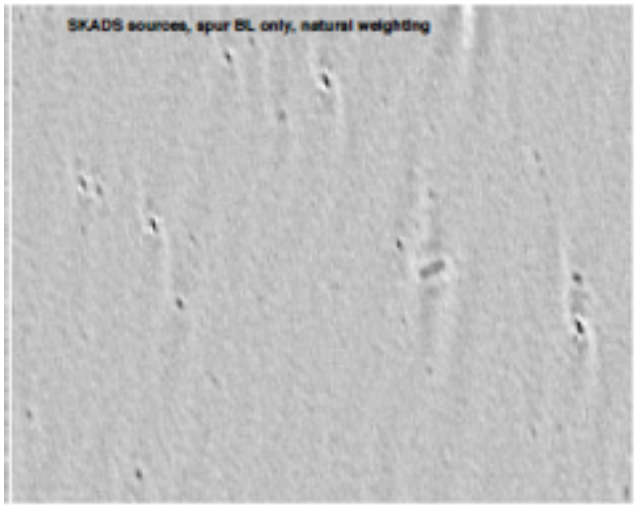
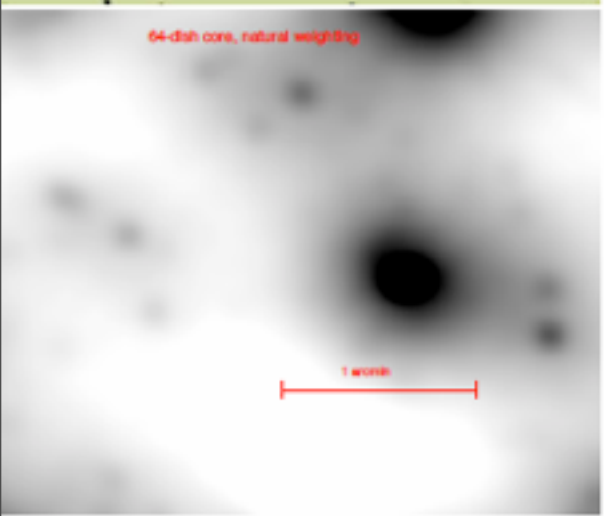
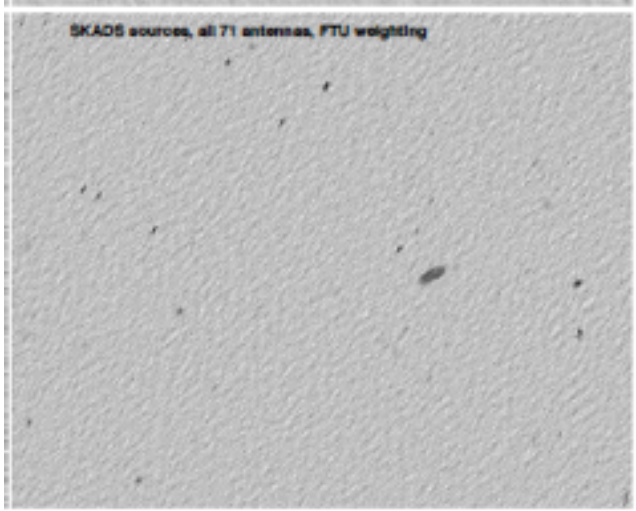






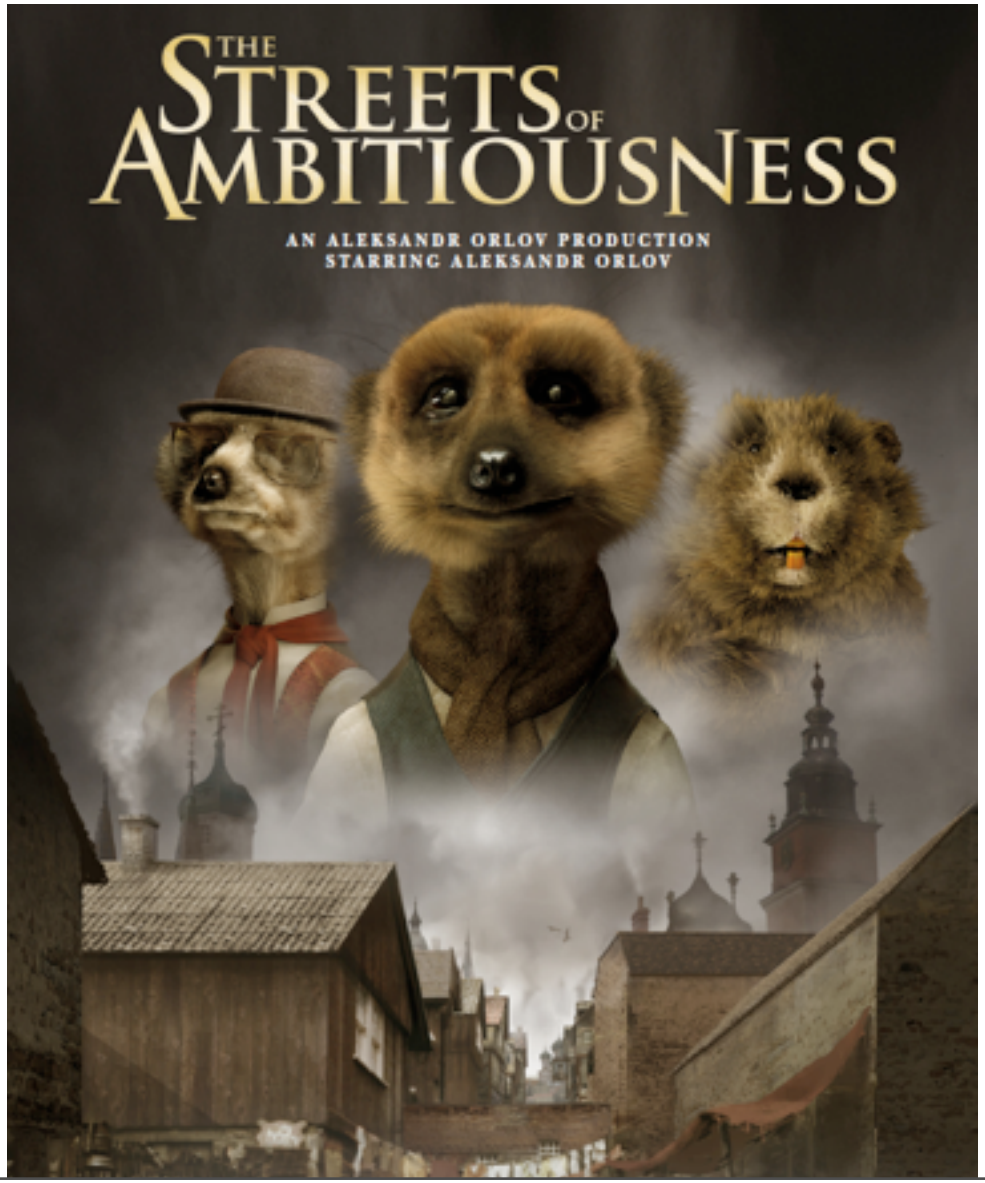




..... not just confusion

- Weak lensing cleanly probes the dark matter distribution of the universe.
- Requires large numbers of objects, extra sensitivity of upcoming radio instruments should provide this.
- For cosmic shear also requires high resolution imaging (need MeerKAT long baselines).
- MeerKAT will also provide doorway to study the systematics involved in these new, large instruments paving the way for SKA.

Thanks!!


THE STREETS OF AMBITIOUSNESS
AN ALEKSANDR ORLOV PRODUCTION
STARRING ALEKSANDR ORLOV

Cosmic Magnification with MeerKAT

Look for the systematic increase/decrease in the number density of sources behind foreground lenses → doesn't need the high resolution images (needs accurate astrometry), and contains same cosmological information.

Essentially a cross-correlation of background and foreground surveys.

Already been attempted with NVSS and SDSS.