

The SKAO logo is rendered in a bold, white, sans-serif font. The letter 'A' is stylized with a black starburst shape in the center, and several small white dots are scattered around the letters, suggesting a starry sky or a network of antennas.

SKAO Science Model

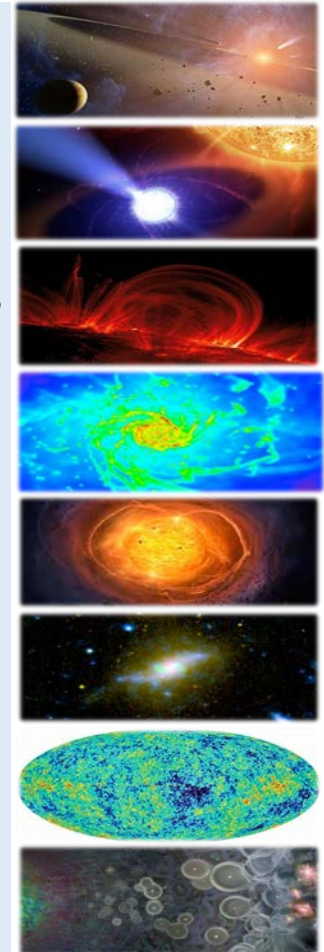
Robert Braun, SKAO Director of Science

28 September 2022

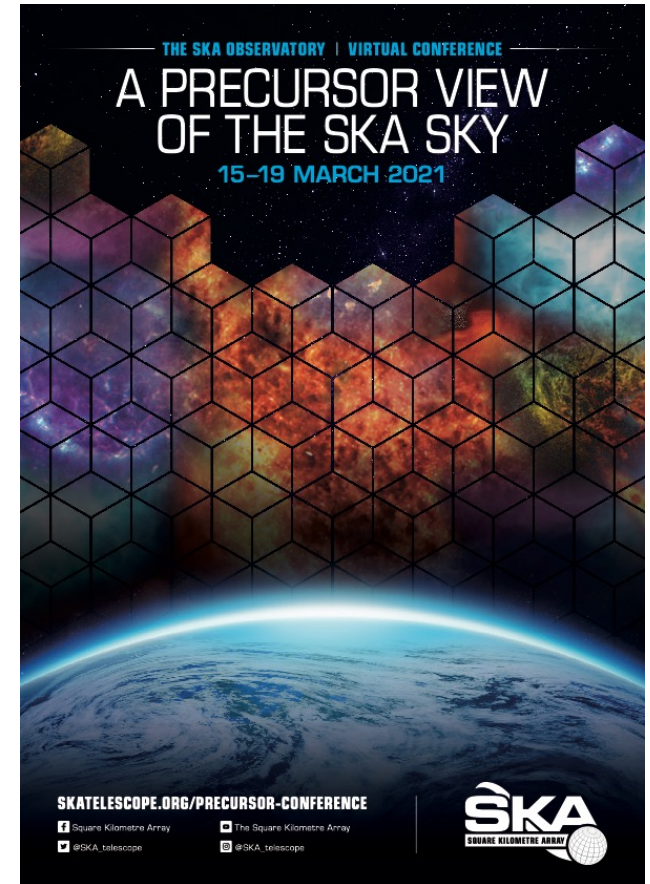
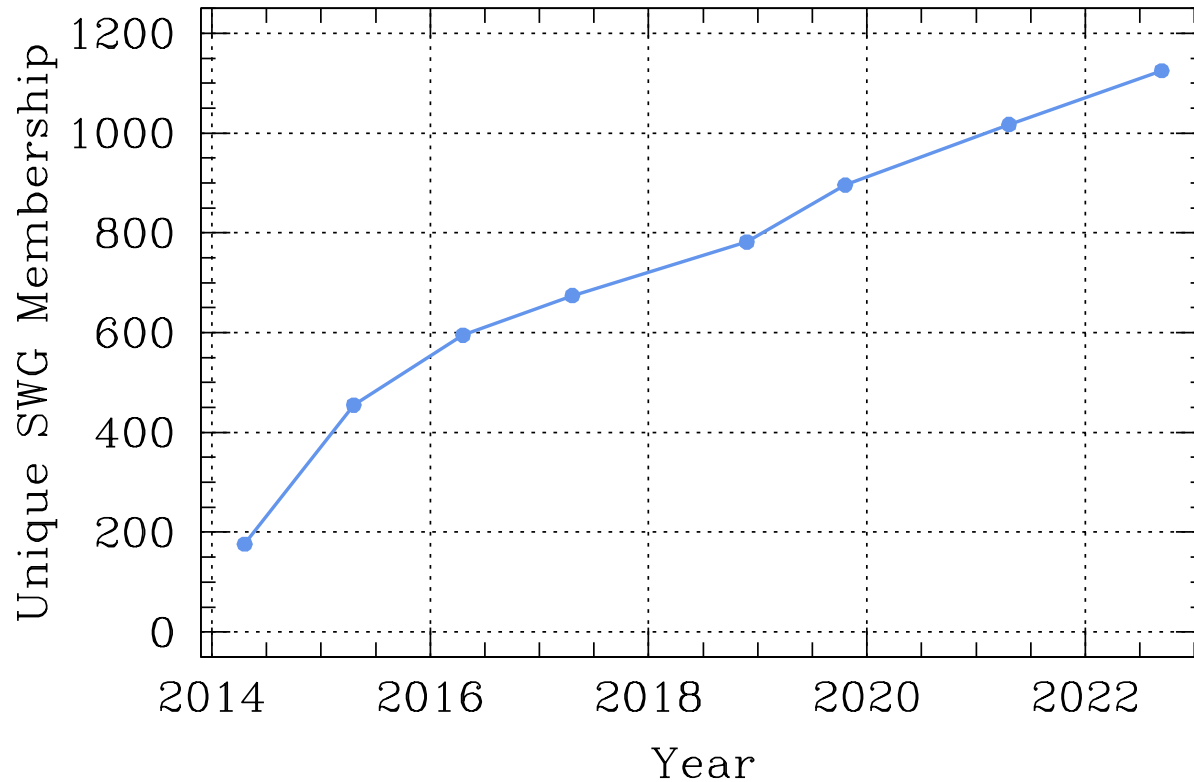


Some of the big SKA Science questions

- **The Cradle of Life & Astrobiology**
 - *How do planets form? Are we alone?*
- **Strong-field Tests of Gravity with Pulsars and Black Holes**
 - *Was Einstein right with General Relativity?*
- **The Origin and Evolution of Cosmic Magnetism**
 - *What is the role of magnetism in galaxy evolution and the structure of the cosmic web?*
- **Galaxy Evolution probed by Neutral Hydrogen**
 - *How do normal galaxies form and grow?*
- **The Transient Radio Sky**
 - *What are Fast Radio Bursts and how can we best utilise them? What haven't we discovered?*
- **Galaxy Evolution probed in the Radio Continuum**
 - *What is the star-formation history of normal galaxies?*
- **Cosmology & Dark Energy**
 - *What is dark matter? What is the large-scale structure of the Universe?*
- **Cosmic Dawn and the Epoch of Reionization**
 - *How and when did the first stars and galaxies form?*



The SKA Science Community



- SKA Science Working Group membership has grown dramatically, to > 1100
- SKA 2021 Science Meeting, 968 attendees from 36 countries



Extragalactic Continuum

Science Working Group

Our Galaxy

Science Working Group

Extragalactic Spectral Lines

Science Working Group

High Energy Cosmic Particles

Focus Group

Cosmology

Science Working Group

VLBI with the SKA

Science Working Group

HI Galaxy Science

Science Working Group

Cosmic Magnetism

Science Working Group

Transients

Science Working Group

Cradle of Life

Science Working Group

Solar and Heliospheric Physics

Science Working Group

Epoch of Reionization

Science Working Group

Pulsars

Science Working Group

- 14 SKA Science Working Groups
- More than 1100 members

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+Gravitational Waves



SKA Science Working Groups

<https://www.skao.int/en/science-users/science-working-groups-focus-groups>

- All SWGs are open to new self-nominations from prospective members who satisfy the criterion of being accredited researchers in a relevant field of astrophysics and we actively encourage new membership
- Prospective members DO NOT have to be resident in an SKA Member country
- The SWGs are intended to provide suitably complete coverage of scientific expertise and suitably broad representation of our current (and prospective) member communities
- SWGs consist of two tiers of membership: 1) Core members: Members who are actively contributing to ongoing analysis, with regular participation in meetings and telecons 2) Associate members: Members who are part of the working group, but who may not have the time or resources to make significant contributions on a regular basis
- Membership of a working group is subject to approval by the working group chairs or where escalated/applicable, the SKA Science Director



SKA Science Working Groups

- Forum for information exchange on SKA capabilities and opportunities
- Intended to promote collaboration and facilitate community planning for future SKA observing proposals
- Monthly meetings of SWG Chairs followed by email announcements to all SWG members and posted on-line

<https://astronomers.skatelescope.org/swg-chairs-meeting-minutes/>

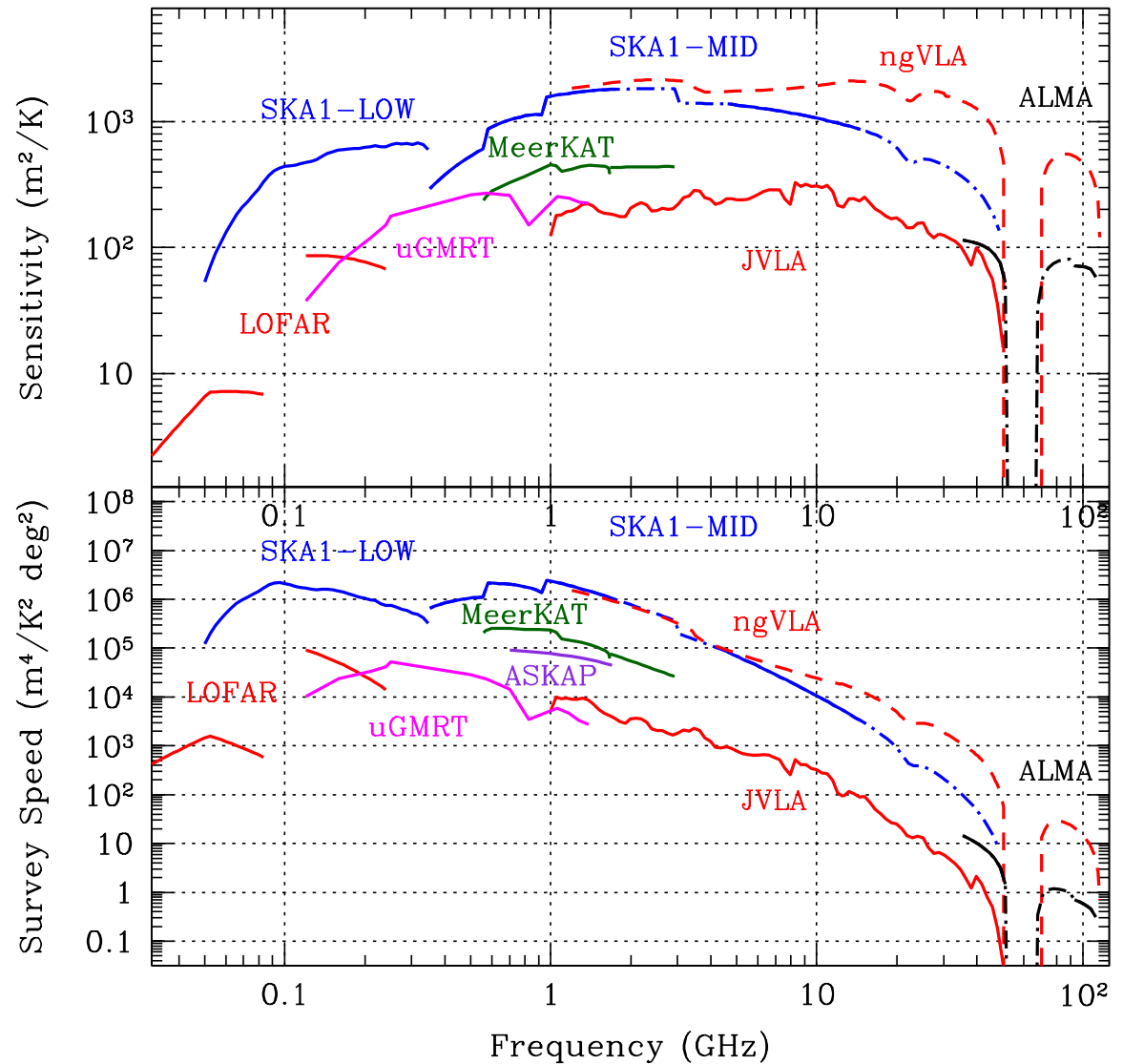
- Regular science conferences and workshops
 - Joint ESO/SKAO Conference and Workshop “Coordinated Surveys of the Southern Sky”, in Garching, Germany, week of 27 February 2023
- Joint SKAO/ngVLA Science Conference week of 30 April 2023, in Vancouver, Canada

<https://www.eso.org/sci/meetings/2023/CSSS.html>



SKA Sensitivity and Survey Speed

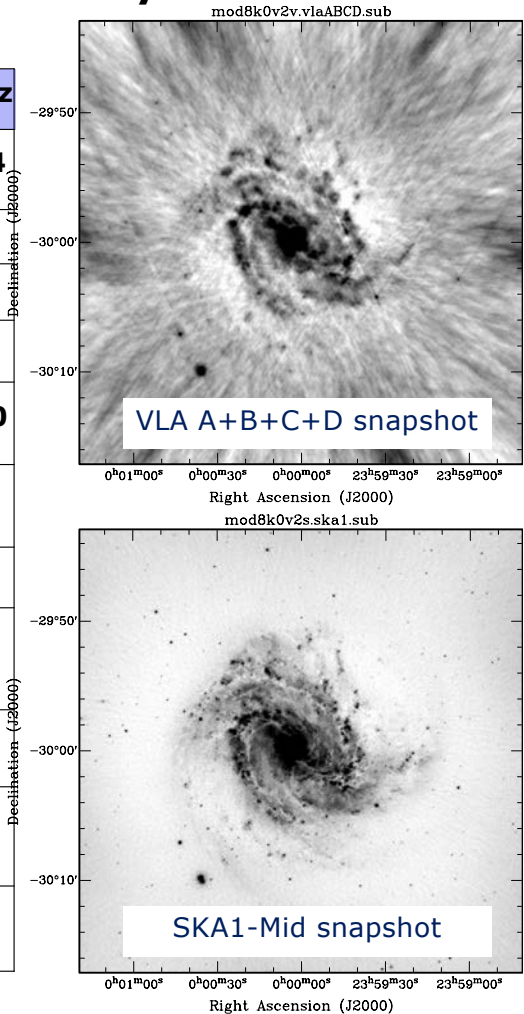
- Proto-type verified performance predictions now available at most frequencies
- Opportunity for seamless interface of SKA to ALMA capabilities
- uGMRT, MeerKAT and ASKAP already starting to open up new parameter space
- ngVLA would supplement high frequency capabilities



SKAO Capabilities

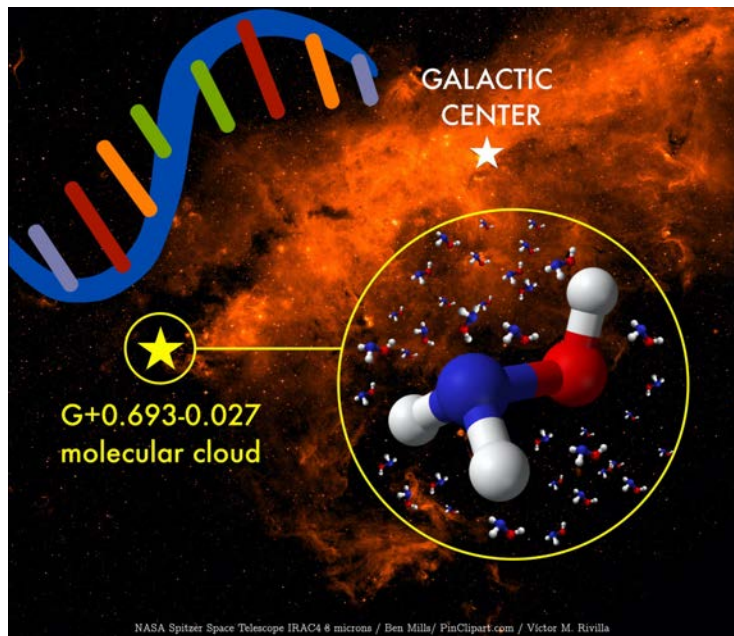
Nominal frequency	110 MHz	300 MHz	770 MHz	1.4 GHz	6.7 GHz	12.5 GHz
Range [GHz]	0.05-0.35	0.05-0.35	0.35-1.05	0.95-1.76	4.6-8.5	8.3-15.4
Telescope	Low	Low	Mid	Mid	Mid	Mid
FoV [arcmin]	327	120	109	60	12.5	6.7
Max. Resolution [arcsec]	11	4	9.5	0.3	0.06	0.03
Max. Bandwidth [MHz]	300	300	700	810	3900	2 x 2500
Cont. rms, 1hr [mJy/beam] ^a	26	14	4.4	2	1.3	1.2
Line rms, 1hr [mJy/beam] ^b	1850	800	300	140	90	85
Resolution range for Cont. & Line rms. [arcsec] ^c	12-600	6-300	1-145	0.6-78	0.13-17	0.07-9
Channel width [kHz]	5.4	5.4	13.4	13.4	80.6	80.6
Spectral zoom windows x narrowest bandwidth [MHz]	4 x 3.9	4 x 3.9	4 x 3.1	4 x 3.1	4 x 3.1	4 x 3.1
Finest zoom channel width [Hz]	226	226	210	210	210	210

Between 10-100 times image fidelity of current facilities

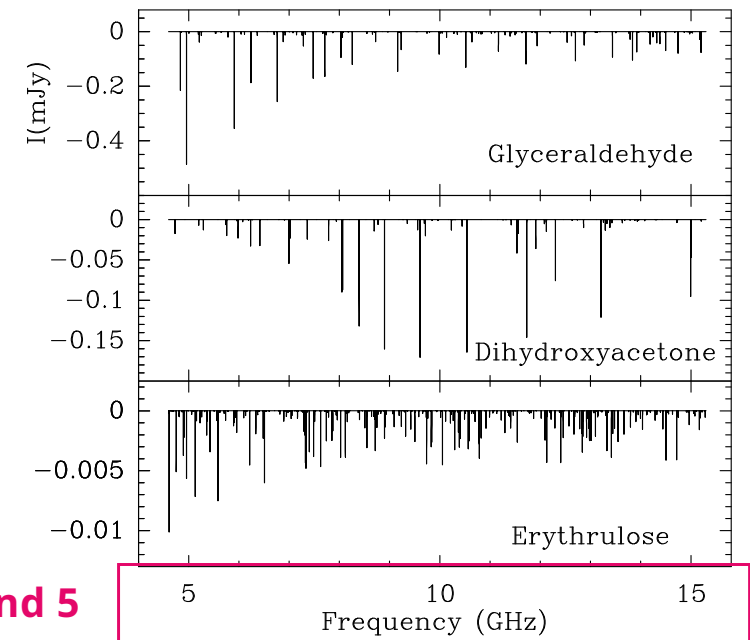


Pre-biotic Molecules in Star-forming Regions

- Building blocks for life on Earth may have arrived from space (panspermia hypothesis)
- Detection of key pre-biotic molecules (e.g. amino acids, complex sugars) in interstellar space is a “holy grail” of Cradle of Life studies



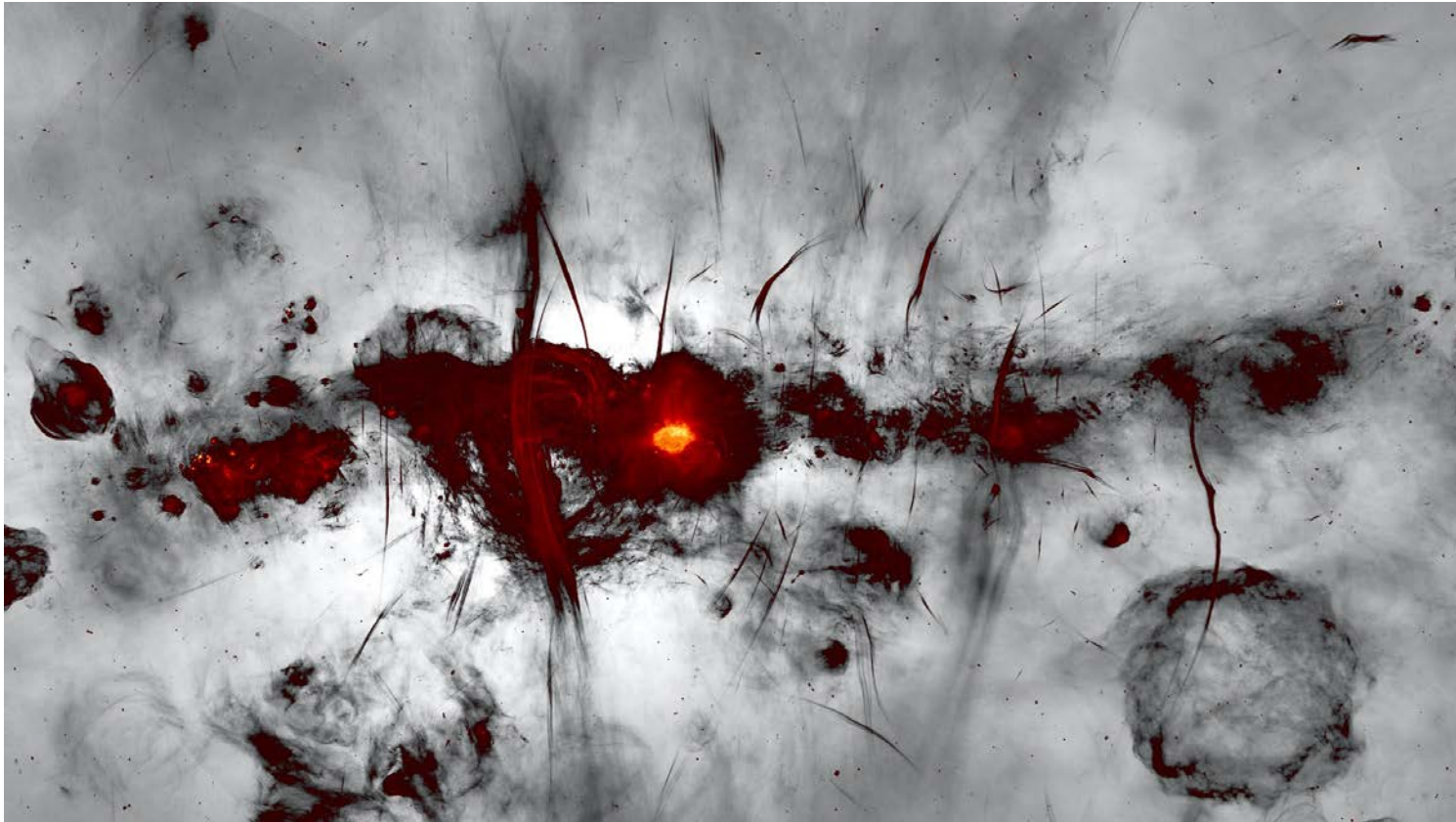
Detection of hydroxylamine (NH_2OH), key precursor to RNA
(IRAM 30-m; Rivilla et al. 2020ApJ...899L..28R)



Predicted spectrum of key large sugars toward G+0693.
Detection of the brightest (ie. deepest) lines requires 10s of hours
integration with SKA1
(Jimenez-Serra et al. 2022FrASS...943766J)



Magnetically Driven Galactic and Cosmic Web Evolution



<https://www.sarao.ac.za/media-releases/new-meerkat-radio-image-reveals-complex-heart-of-the-milky-way/>

- Magnetic filaments in the central 500 pc of the Galaxy as imaged by MeerKAT

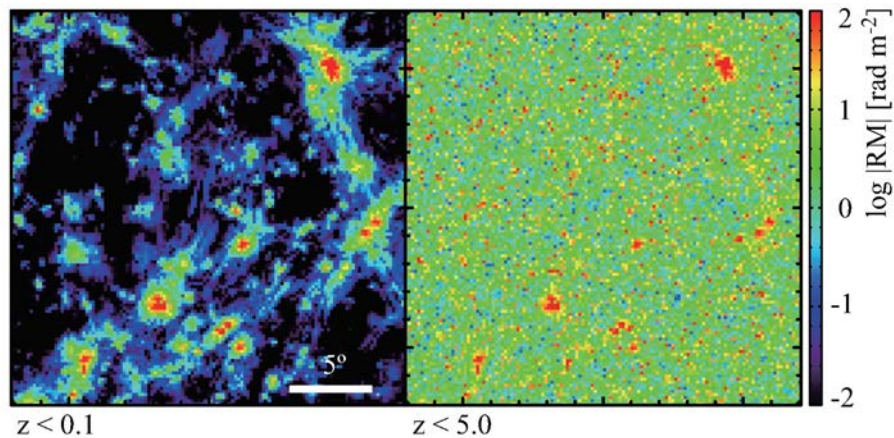
Heywood et al. 2022ApJ...925..165H



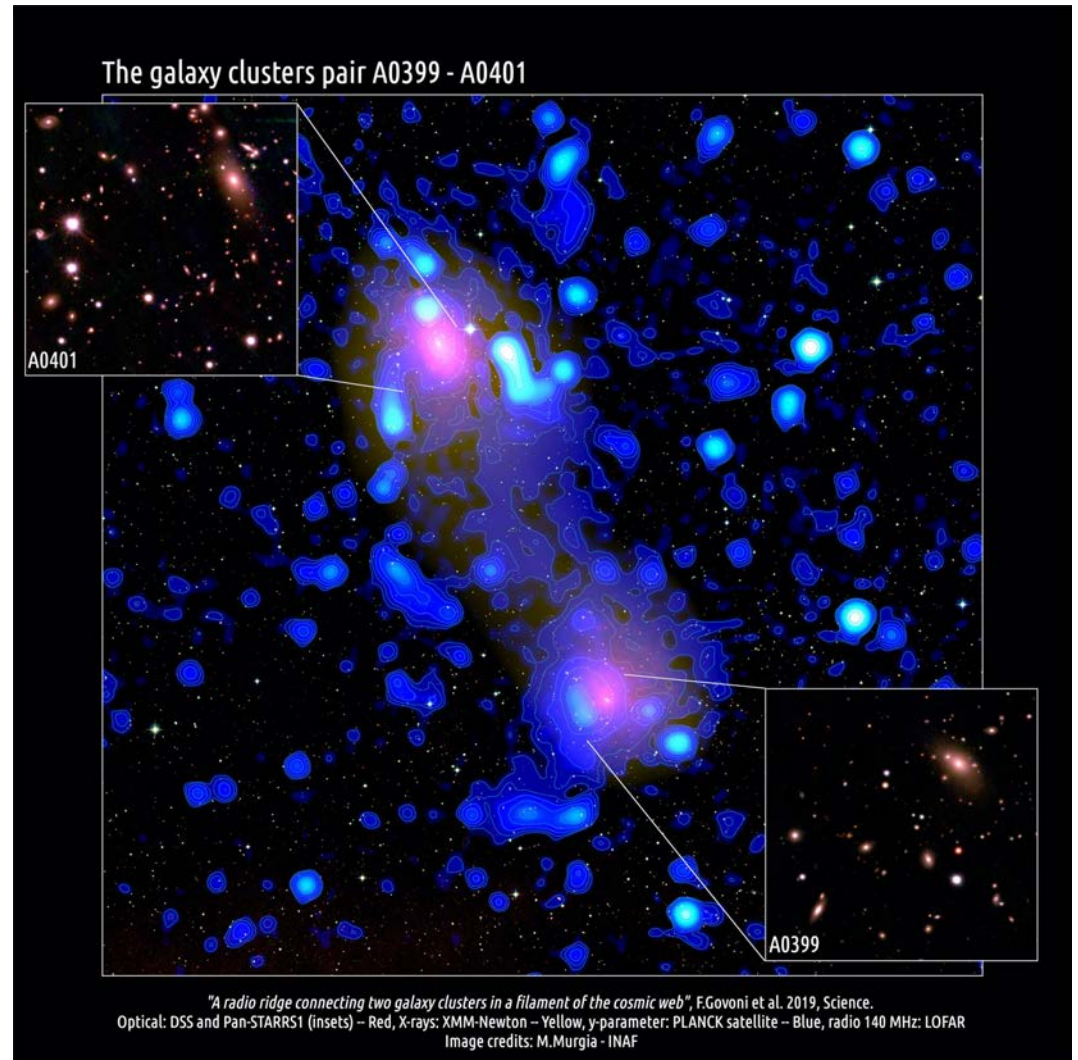
Magnetically Driven Galactic and Cosmic Web Evolution

- The magnetic cosmic web filament connecting the galaxy cluster pair A0399 – A0401 (at $z=0.07$) as imaged by LOFAR

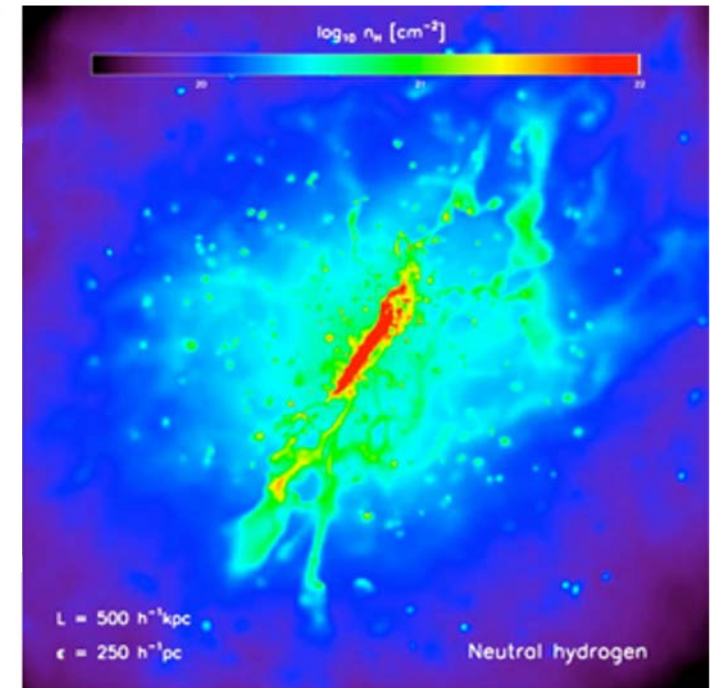
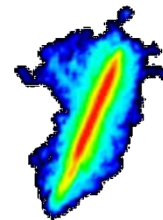
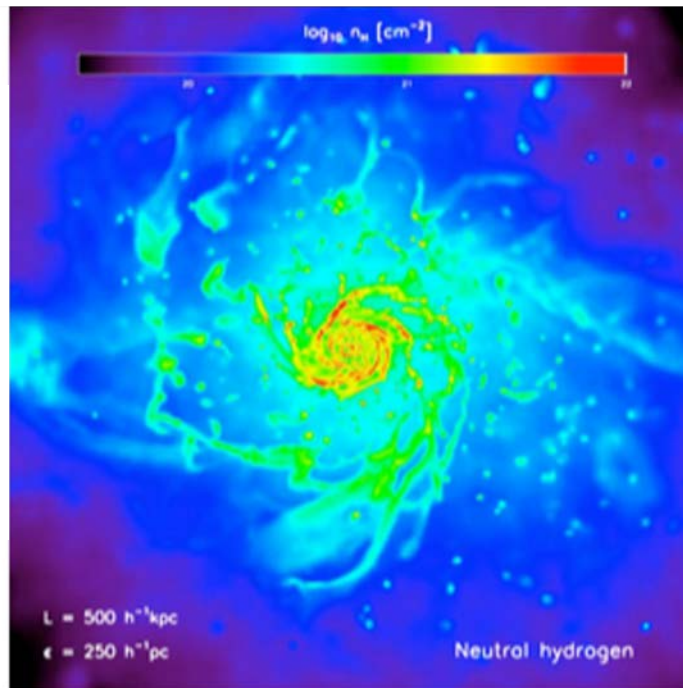
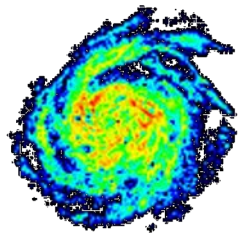
Govoni et al. 2019Sci...364..981G



Magnetised cosmic web simulation
Akahori 2018Galax...6..118A



Probing Galaxy Assembly and Evolution with Neutral Hydrogen



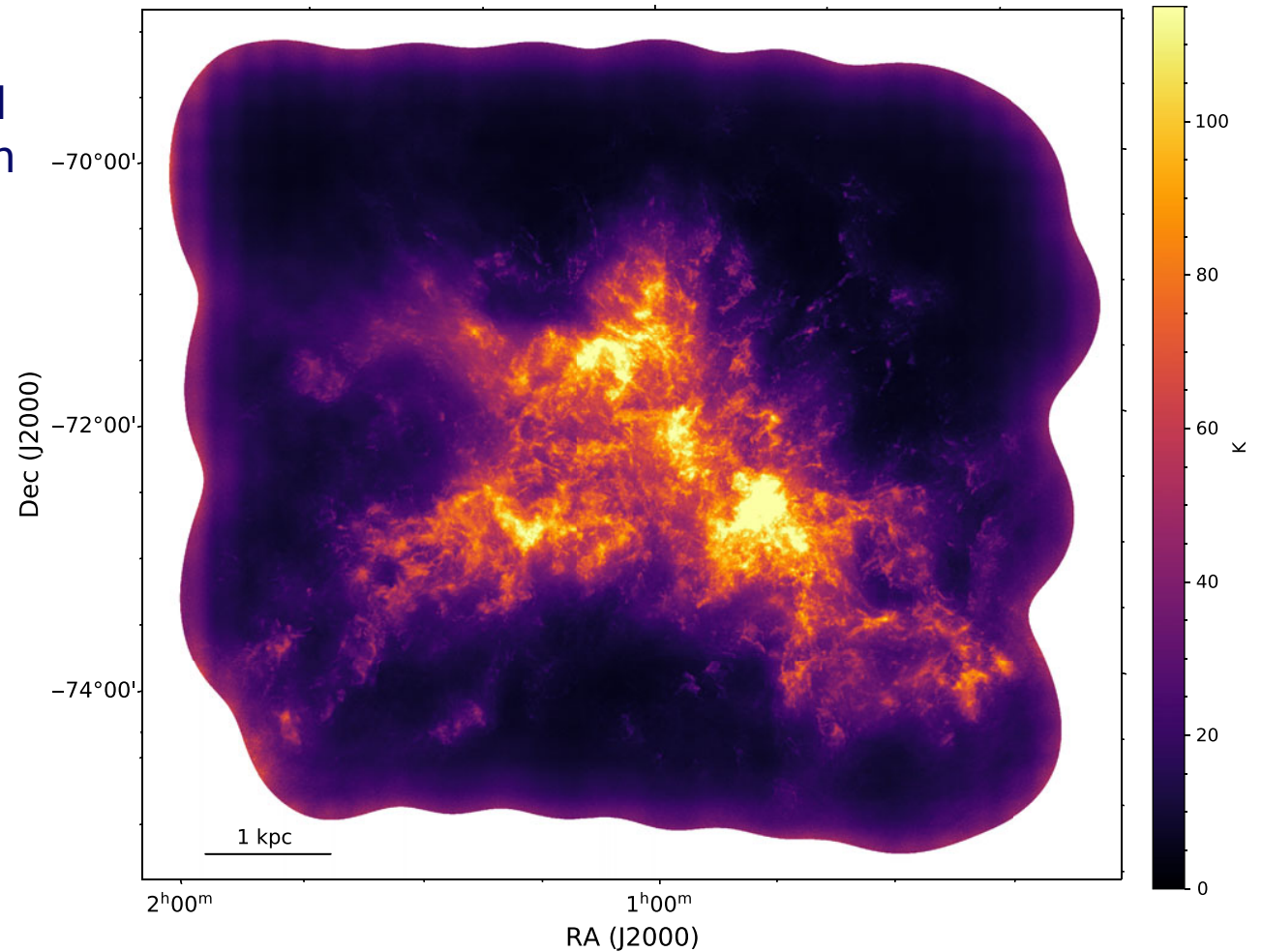
- Contrast of current detection limits (left hand observations, Oosterloo et al.) with predicted galaxy environments (right hand simulations, Schaye et al.) accessible to the SKA



Probing Galaxy Assembly and Evolution with Neutral Hydrogen

- Witnessing accretion and tidal disruption of neutral hydrogen in the Small Magellanic Cloud imaged with ASKAP

Pingel et al. 2022PASA...39....5P



Construction timeline (Design Baseline):

- Now at $T_0 + 12$ months
- Procurement well underway
- 41 contracts, with aggregate committed value of ~€150M, awarded
- Still aligned (+/- weeks) with procurement schedule
- Expect to commit on contracts worth ~€393M in 2022

	SKA-Low	SKA-Mid
Start of construction (T0)	1ST JULY 2021	1ST JULY 2021
Earliest start of major contracts (C0)	AUGUST 2021	AUGUST 2021
Array Assembly 0.5 finish (AA0.5) SKA-Low = 6-station array SKA-Mid = 4-dish array	FEBRUARY 2024	MARCH 2024
Array Assembly 1 finish (AA1) SKA-Low = 18-station array SKA-Mid = 8-dish array	FEBRUARY 2025	FEBRUARY 2025
Array Assembly 2 finish (AA2) SKA-Low = 64-station array SKA-Mid = 64-dish array, baselines mostly <20km	FEBRUARY 2026	DECEMBER 2025
Array Assembly 3 finish (AA3) SKA-Low = 256-station array, including long baselines SKA-Mid = 133-dish array, including long baselines	JANUARY 2027	SEPTEMBER 2026
Array Assembly 4 finish (AA4) SKA-Low = full Low array SKA-Mid = full Mid array, including MeerKAT dishes	NOVEMBER 2027	JUNE 2027
Operations Readiness Review (ORR)	JANUARY 2028	DECEMBER 2027
End of construction	JULY 2029	JULY 2029



Construction timeline (Staged Delivery):

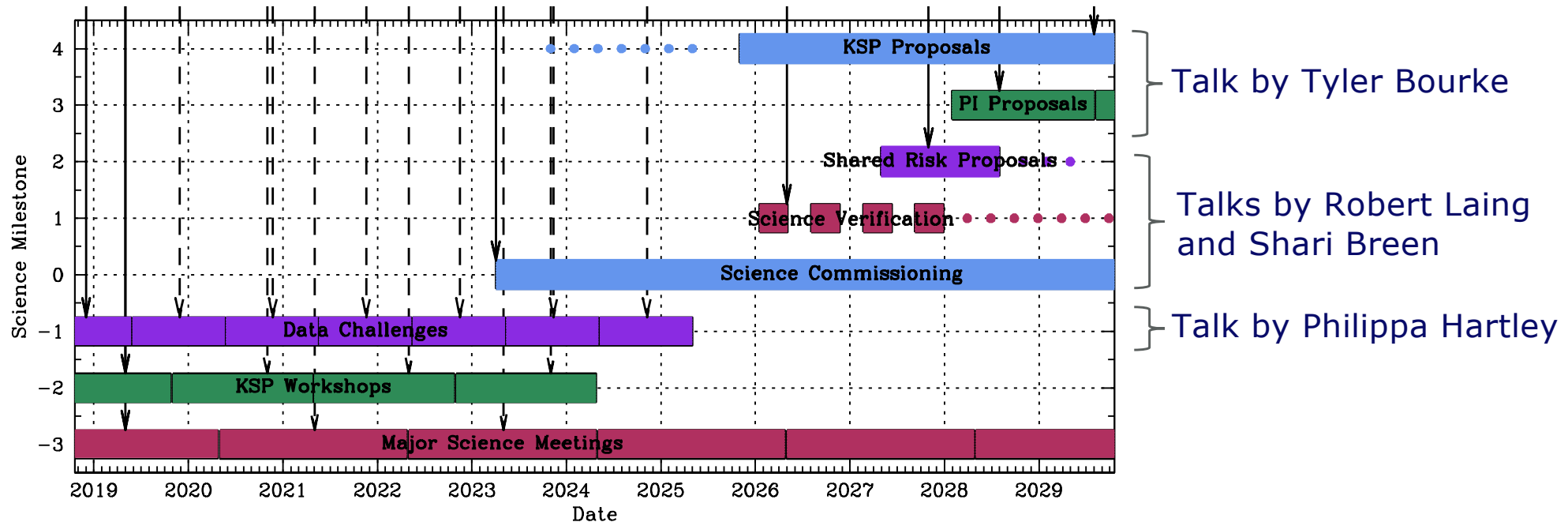
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Event	Date (MID)	AA (mo)	Date (LOW)	AA (mo)
Earliest AA0.5	Jun 2024 - Dec 2024	7	Jan 2024 - Jun 2024	6
Earliest AA1	Jan 2025 - Nov 2025	11	Jul 2024 - May 2025	10
Earliest AA2	Dec 2025 - Sep 2026	10	Jun 2025 - Jul 2026	14
Earliest AA*	Oct 2026 - Aug 2027	9	Aug 2026 - Aug 2027	13
Earliest Operations Readiness Review	Nov 2027		Oct 2027	
ORR Closeout End construction (including contingency; Monte Carlo 80%)	Jul 2028		Jul 2028	



The SKA Science Timeline (*approximate!*)

- Dates will depend on when funding for full Design Baseline is secured



SKAO Data Challenges

- Three different categories of SKA Data Challenges:
 1. SDP for calibration, imaging and pipeline development leading to science-ready data products, (now in Programme Increment 16)
 2. SRC for data visualisation, data product distribution and advanced data product development, (now in SRC Programme Increment 1)
 3. Science for science extraction from SKA-like data products: fully calibrated image cubes, pulsar or transient time domain candidates and in rare cases calibrated time averaged visibilities, (now soon to release SDC3, see talk by Philippa Hartley)



Thank you

*We recognise and acknowledge the
Indigenous peoples and cultures that have
traditionally lived on the lands on which
our facilities are located.*

SKAO

www.skao.int