


# SKAO

An aerial photograph of the SKA radio telescope array in a desert landscape at night. The foreground shows several large, white, parabolic dish antennas on circular concrete bases. In the background, a vast field of smaller antennas is visible. The sky is dark with a prominent rainbow or aurora-like glow in the distance. A small white pickup truck is parked in the lower-left corner for scale.

# SKA SWG Update

Robert Braun, SKAO Science Director

17 September 2024

# SKA Science Update

**Start Recording!**

- Construction Update
- 2025 SKA Science Meeting (Philippa)
- Science Data Challenge 3b (Anna)
- Reminders & Information
- AOB



# Construction Timeline

- **Target:** build the SKA Baseline Design (197 Mid dishes; 512 Low stations: AA4)
- Not all funding yet secured, therefore following Staged Delivery Plan (AA\*)
- Develop the earliest possible working demonstration of the architecture and supply chain (AA0.5).
- Then maintain a continuously working and expanding facility that demonstrates the full performance capabilities of the SKA Design.

Milestone Event (earliest)		SKA-Mid	SKA-Low
AA0.5	4 dishes 4 stations	2025 Q4	2024 Q4
AA1	8 dishes 18 stations	2026 Q3	2025 Q4
AA2	64 dishes 64 stations	2027 Q3	2026 Q4
<b>Science Verification begins</b>		<b>2027+</b>	<b>2027+</b>
AA*	144 dishes 307 stations	2028 Q2	2028 Q1
Operations Readiness Review		2028 Q3	2028 Q2
End of Staged Delivery Programme		2029 Q1	2029 Q1
<b>Early Operations (Shared Risk)</b>		<b>2029+</b>	<b>2029+</b>
AA4 (Design Baseline)	197 dishes 512 stations	TBD	TBD

AA = Array Assembly

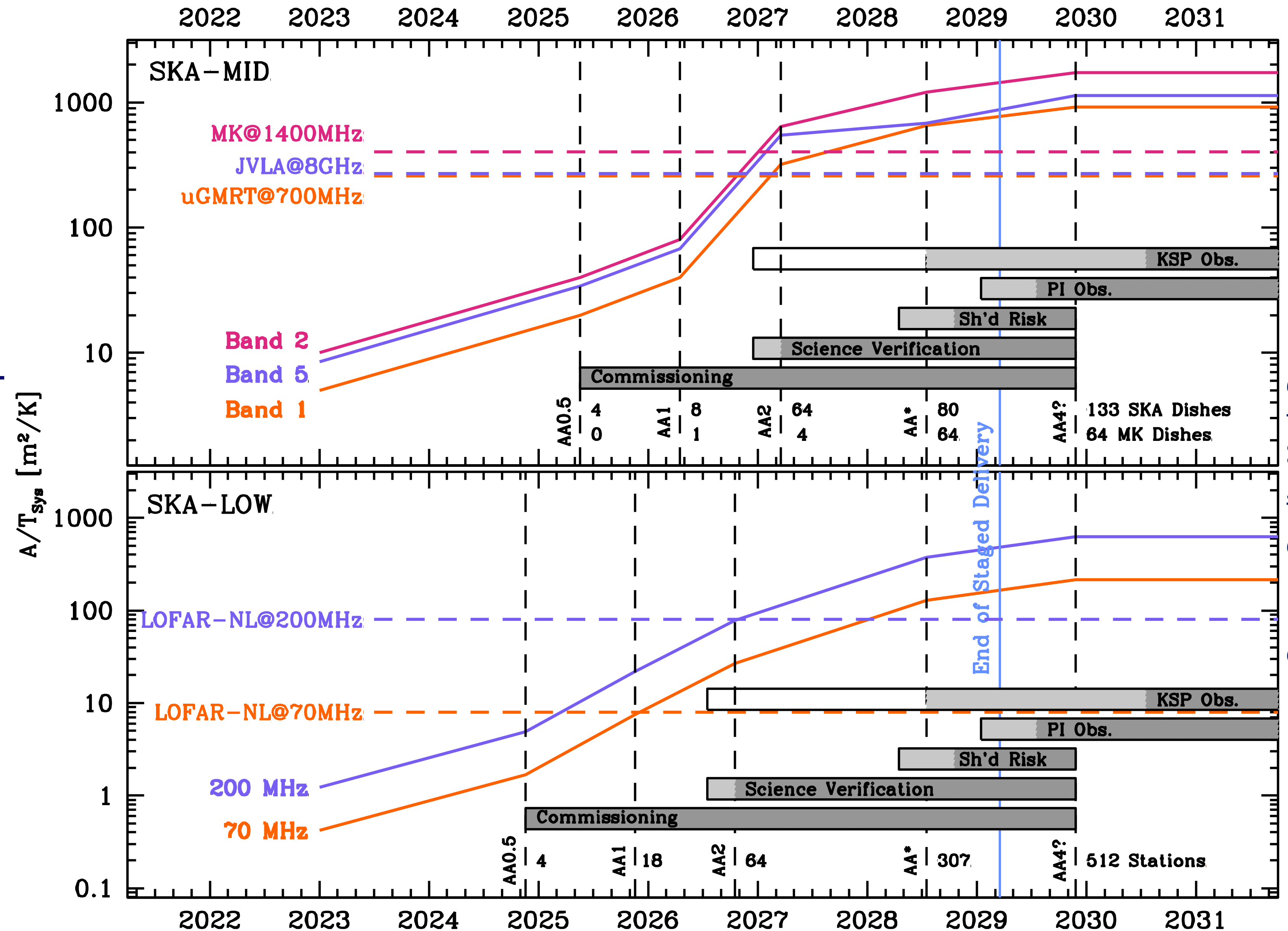
Updated April 2024 (Construction Report)

First Science Verification data release to the community expected in 2027



# Commissioning Timeline

- AA0.5
  - Basic imaging and Tied-Array Beams
  - Off-line reduction
  - Limited BW/ $N_{\text{Chan}}$
- AA1
  - Plus multiple beams/sub-stations
- AA2
  - Plus pipeline reduction, more BW/  $N_{\text{Chan}}$
  - Science verification!
- AA\*
  - Full BW,  $N_{\text{Chan}}$ , zooms
  - Shared Risk Cycle 0
  - PI (and KSP) Proposals!



Concept Credit: Mark Sargent



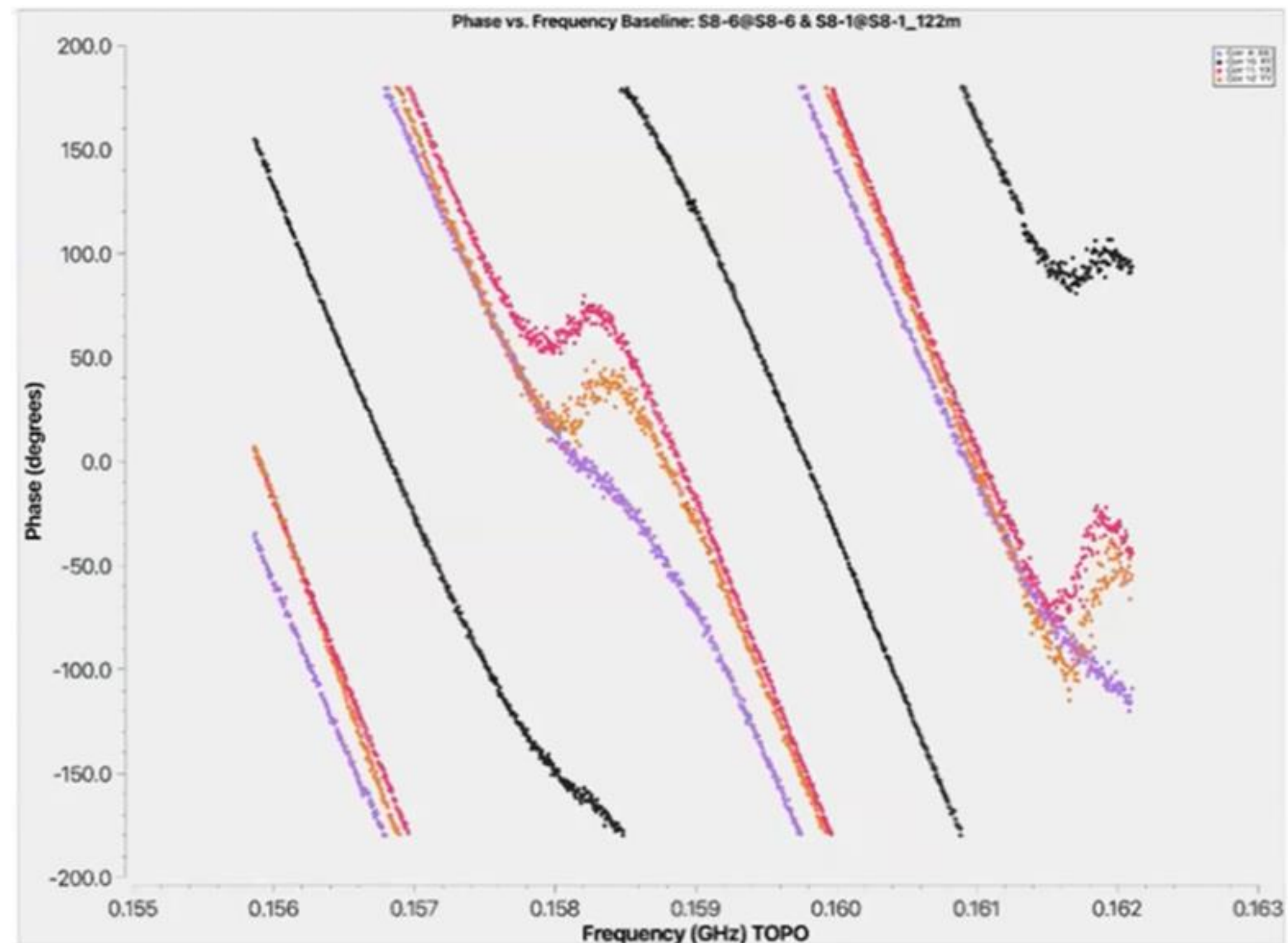
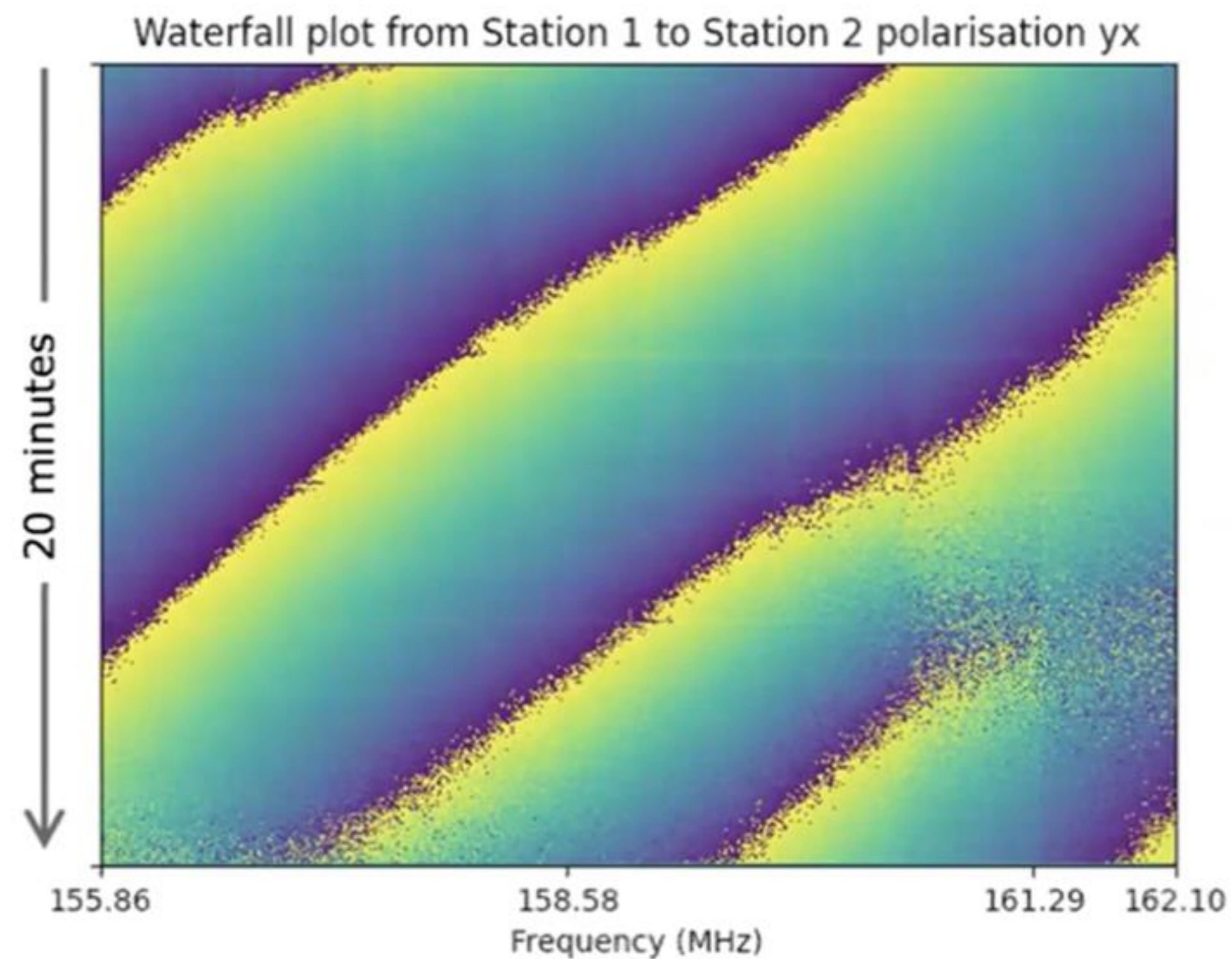
# Construction Update

- SKA-Mid AA0.5 – to be well under way by end 2024
  - First SKA-Mid dish “big lift” of main reflector occurred on 4 July
  - Second pedestal assembled 6 September, with third soon to follow



# Construction Update

- SKA-Low AA0.5 – to be complete by end 2024
- First two SKA-Low stations, S8-1 and S8-6, handed over for commissioning on 4 July
- First fringes (Cen A) acquired 12 September 2024 at ~13:30 AWST!!!



# SKAO Science Meeting and new Science Book



# 2025 Science Meeting: overview

- **Name:**
  - Advancing Astrophysics II: Preparing for Science with the SKAO
- **Dates:**
  - 16th-20nd June 2025
- **Location:**
  - Görlitz, soon to be the home of the brand new German Center for Astrophysics (Deutsches Zentrum für Astrophysik, DZA)
- **Numbers:**
  - In person: ~300
  - Virtual attendance to be supported for all sessions
- **Themes:**
  - *Noting the transition from SKAO commissioning to science verification and observing*
  - The science meeting will feature presentations from authors of the new SKA Science Book. While the book will provide an up-to-date coverage of the science questions that will be addressed by AA4 (and beyond), at this meeting we will hear about the opportunities for early SKA science: **presentations will focus on AA\* capabilities**
  - “Observing with the SKAO” sessions





# Science meeting programme

- **Plenary sessions**

- Organised by broad Science theme, following book section themes
- Plus “Observing with SKAO” special plenary session

- **Parallel sessions**

- In order to facilitate SWG interaction and collaborations, organise into SWGs
- Will also enable Operations to be able to tailor talks for different technical requirements
- See Wendy’s corner plot illustrating SWG overlaps; will use this information to identify which sessions to run at the same time
- Participants will be asked at registration to indicate priority of (up to three) parallel sessions, in order to assign rooms (of differing sizes) to sessions
- 1.5 days dedicated to parallel sessions

- **Posters**

- ‘Lightning’ talks: aim to organise relatively early in the week in order to promote speakers’ posters for viewing



# SKAO Operations: Observing with SKAO

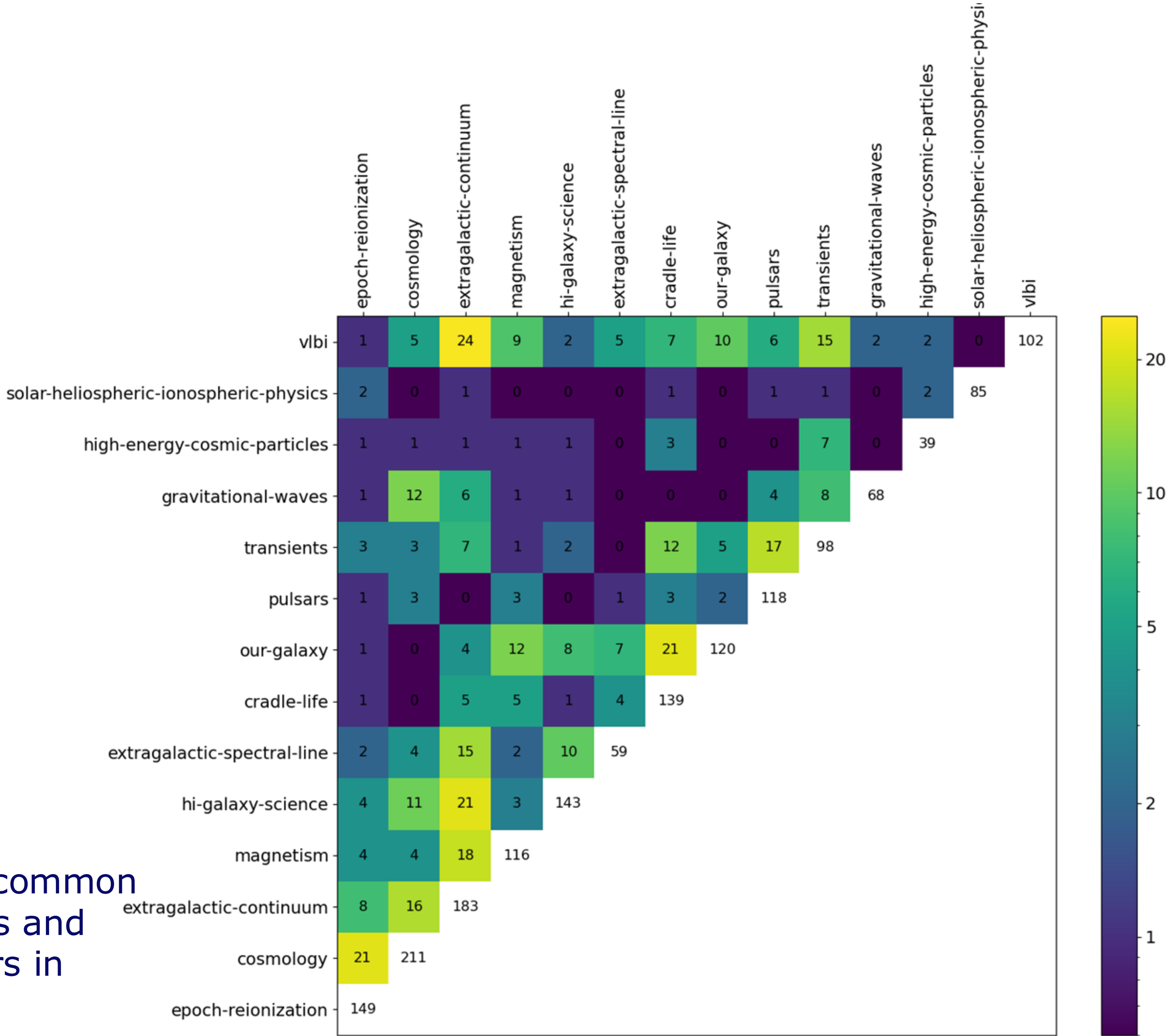
- Half day of plenary sessions dedicated to “Observing with the SKAO”
  - Detailed telescope capabilities
  - Operational policies
  - The user experience (tools, SRCNet etc)
  - Timeline to science (SV, cycle 0)
- SKAO Operations team will also hold interactive sessions with each SWG
  - Tailored capability presentations and Q&A sessions



# Parallel sessions

- Eight sessions in parallel
- 14 SWGs
- Overlapping members between SWGs should help to group SWGs for parallel sessions

Number of members in common between each pair SWGs and total number of members in each SWG



# Current status (Science Meeting):

- Next SOC meeting week beginning 23<sup>rd</sup> September
  - A closer look at the talk programming: number of talk slots and length
  - A look at the grouping of SWGs for parallel sessions
- Görlitz site visit by members of the Events Organising Committee
  - E.g. Room capacity, AV requirements, travel time (on foot) between venues
- Science Meeting poster and website design has begun



# Science Book: overview

- “Advancing Astrophysics II: Preparing for Science with the SKAO”
- This will be an updated version of the existing SKAO Science Book
- Some chapters may not have changed much; some will have evolved; some brand-new chapters based on new science cases
- Aim is two-fold:
  - Facilitate SWG-coordinated chapters (both new and updated)
  - Opportunity for researchers to connect with and join the SWGs
- *The new book will provide an up-to-date coverage of the science questions that will be addressed by the full design baseline (and beyond).*



# Science Book content

## Goal of individual chapters

- Self-contained description of a science application including background and motivation
  - Main focus of a chapter:
    - Demonstrate the science outcomes that are enabled by the capabilities of a particular component of the **SKA design baseline, Array Assembly 4 (AA4)**
  - Supplementary focus:
    - Document the extent to which scientific outcomes might be achieved by the **end of staged delivery (AA\*)**
    - Document the types of **enhancements to the design baseline** that could further support the science goals
- Also consider:
  - Highlight **synergies** with other instruments
  - *Guidance on SKAO commensal observing to be provided to chapter authors*



# Science Book structure

## Science book editorial board

- SKAO Science Team and SWG chairs

## Book sections

- SKAO introduction
- A set of SWG introduction chapters
  - A high level overview of the activities of each SWG
  - Describing how the various science chapters fit into the work of the SWG
  - Also looking at the technical aspects of the group's work, particularly for the more technically-themed SWGs
  - Page length TBD
  - The introductory chapters will be written once all science chapters are available
- A set of sections based on broad science themes
  - Sections made up of science chapters: each chapter a single paper
  - Overview science chapters will not be needed



# Science Book structure: science sections

broad categories confirmed; lay questions will be added to/modified according to chapter submissions

## **Section title**

*Lay "big questions"*  
(Related SWGs)

## **Planetary systems**

*How do planets form? Are we alone?*

(Cradle of Life; Our Galaxy; Solar, Heliospheric and Ionospheric Physics; VLBI)

## **Sun and Stars**

*How do galaxies turn gas into stars? How do stars behave at the centres of galaxies?*

(Solar, Heliospheric and Ionospheric Physics; Our Galaxy; VLBI)

## **Galaxies**

*How do normal galaxies form and grow? What resides in the space between galaxies? Why do galaxies have huge black holes at their centres? Why do only some quasars produce powerful jets?*

(Our Galaxy; Extragalactic Continuum; Extragalactic Spectral Line; Cosmic Magnetism; VLBI)

## **The Cosmos**

*How and when did the first stars and galaxies form? What is the large-scale structure of the Universe? What are dark matter and dark energy? What is the role of magnetism?*

(Cosmology; Epoch of Reionisation; Extragalactic Continuum; Extragalactic Spectral Line; Cosmic Magnetism; VLBI)

## **The Extreme Universe**

*Was Einstein right about gravity? How does matter behave at extreme densities? What are cosmic rays? What new physics will particle cascades unveil? What are Fast Radio Bursts? How do supermassive black holes collide?*

(Pulsars; Transients; High Energy Cosmic Particles; VLBI)





# Coordination of book chapters (see [Coordination of chapter submissions](#))

*The coordination of chapter submissions is led by our science working group chairs: **thank you to all our chairs for dedicating your time and effort to this process***

## Chapter Call Phase 1:

- Within SWGs: SWG chairs to invite abstracts describing intended contributions from within their SWG
  - Aiming for full representation of a group's science, with updated versions of all chapters from *Advancing Astrophysics 2015* included
    - *Chapters from AASKA 2015*: <https://pos.sissa.it/215/>
    - Long-standing science cases from 2015 book may only need minimal updates (e.g., new references added)
    - On the other hand, some science cases may have evolved in the last decade: more significant updates or perhaps splitting into more than one chapter
    - May also be brand new science cases
- Outside SWGs: A call for chapter abstracts to be advertised to the wider astronomy community.
  - Within this call, authors will be requested to tag one or more relevant SWGs (or none, if brand new area).
  - SKAO office will forward abstracts on to the relevant SWG chairs
  - Abstract authors are also be invited to request membership of relevant SWGs at this stage.
  - New SWG joining form is available
- Deadline date for abstracts: **September 30th**



# Coordination of book chapters (see [Coordination of chapter submissions](#))

## Chapter Call Phase 2:

- SWG chairs will compile a list of chapter titles based on abstracts received (both internally and externally) and on internally-identified updates, evaluating for overlaps and duplication.
- Chairs to invite authors to prepare draft chapter manuscripts.
- We encourage all viable science ideas to be submitted as chapters for the book; note that we are not bound at this stage by a maximum number of submissions.
- At this stage we will request *advanced drafts* for submission
- Full instructions for authors and a LaTeX template will be provided prior to the abstracts deadline
- Submissions to be made by draft authors to online submissions platform
- Deadline date for advanced drafts: **January 30<sup>th</sup>**



# A flexible, two-phase approach

**Phase 1: Call for chapter abstracts, deadline September 30th**

**Phase 2: Authors invited to prepare advanced drafts of chapter manuscripts, deadline January 31st**

- Flexible approach:
  - Recognising that work on chapter updates has been ongoing in some SWGs since early 2024 or before, some authors might be invited to begin preparing draft manuscripts prior to the Phase 1 deadline
  - Remaining authors might be invited after the September 30<sup>th</sup> deadline
- For reference:
  - [Coordination of chapter submission](#)
    - *Includes plan for coordination of contributions; timeline; SOC members, FAQs*



# Coordination of book chapters (see [Coordination of chapter submissions](#))

## Talk/poster selection in February 2025:

- The 2025 Science Meeting Scientific Organising Committee will select a set of draft chapters for presentation at the meeting.
- Authors invited to focus presentations on the early science opportunities from the first few years of Operations (AA\*)
- Presentations to be given in the form of plenary talks, splinter session talks, and posters (accompanied by 'lightning' talks).



# Science Book: final submissions and publishing

- Chapter reviewing will take place *after* the meeting
- SWG chairs to suggest reviewers for individual chapters
- Editing by SWG chairs and SKAO Science Team
- Publish both hard copy and online versions
- Hard copy versions: could be printed as individual sections
  - Mindful of the environmental impact of physical books
- Online version: facility to update over time (as is possible on ArXiv, for example)
  - Looking at *either Proceedings of Science* <https://pos.sissa.it/> or SKAO hosting



# Current status (Science Book):

## *Updates from SKAO*

- External Expressions of Interest call made in July
  - Circulated by SKAO Comms team and SKAO partners
  - Information and abstract submission form hosted on SKAO website
  - Form for SKAO SWG membership included
  - Submissions collated and shared with SWG chairs via google sheet
    - *Please let PH know if you do not yet have access to the submissions*
- Second google sheet to collate all chapter titles (internal to SWGs and external in one place)
- Instructions for Authors and LateX template being prepared at the time of writing
- Suggest a further meeting of SWG chairs, facilitated by SKAO, either next week or early Oct, to take a look together at the collated list of abstracts and identify gaps and crossover (noting that the number of working groups has grown since 2015)



# Current status (Science Book)

*Updates from working groups*

- Updates, questions and discussion



# Timeline

June 2024

Save the Date announcement

July 2024

Chapter abstracts sought

September 30th

Chapter abstract deadline

October 1st 2025

Submission platform open for advanced drafts of chapters

October 2025

Conference poster launch

Mid December 2024

Launch website

January 30th 2025

Submission period ends

Mid/late Jan 2025

Registration open

Feb to mid-March 2025

Talk/poster selection

Mid March 2025

Speaker notification

March 2025

Early bird registration close

May 2025

Registration close

June 16th 2025

Meeting begins

Second half of 2025

Final book chapter reviews and publication





# SKA Science Data Challenge 3b

## *EoR Inference*

*the first step in bringing together the global  
21cm interpretation community*



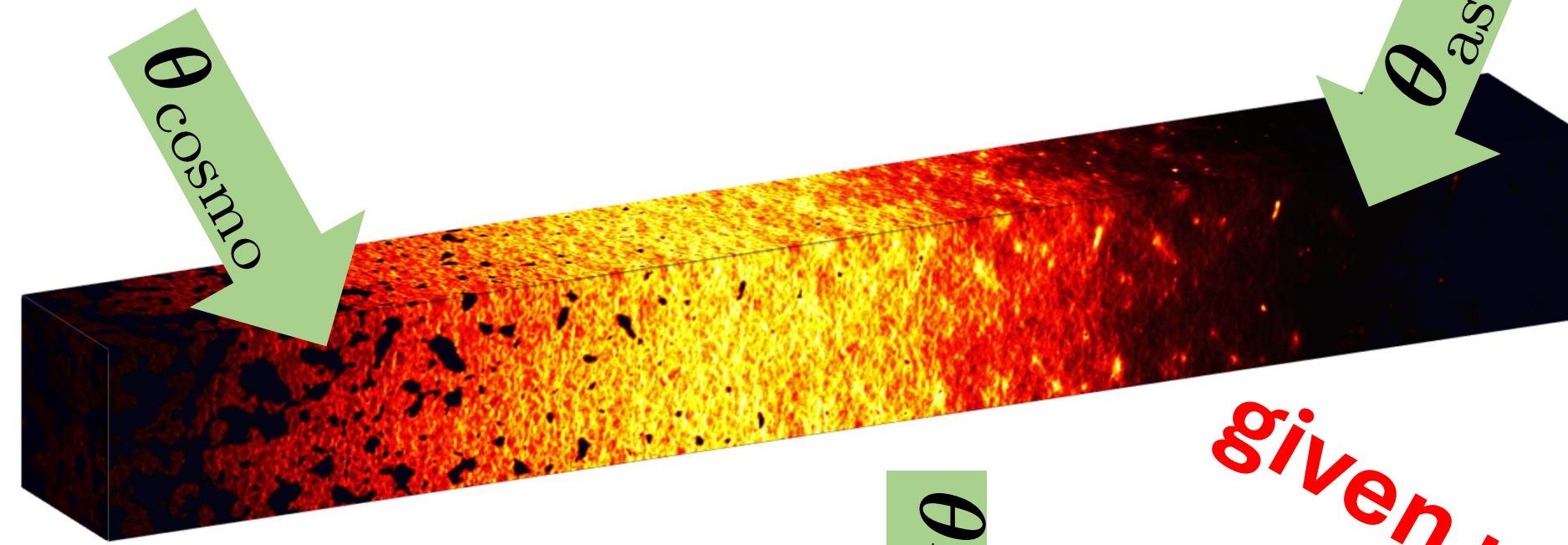
**GIVEN**

Cosmology

# Simulation

Astrophysics

# Observation

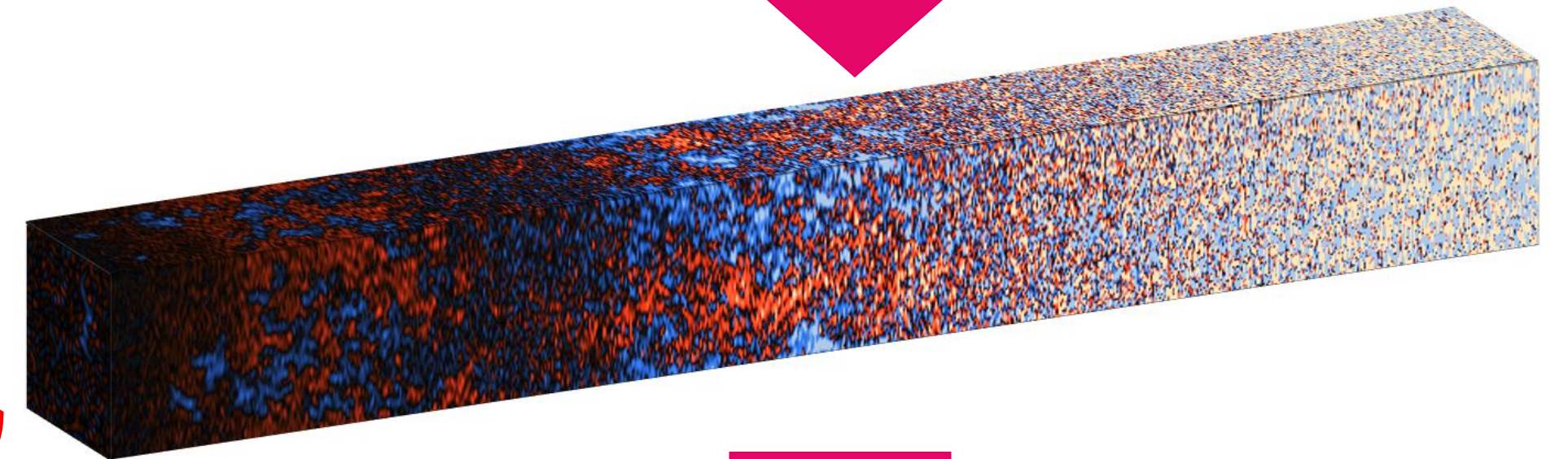
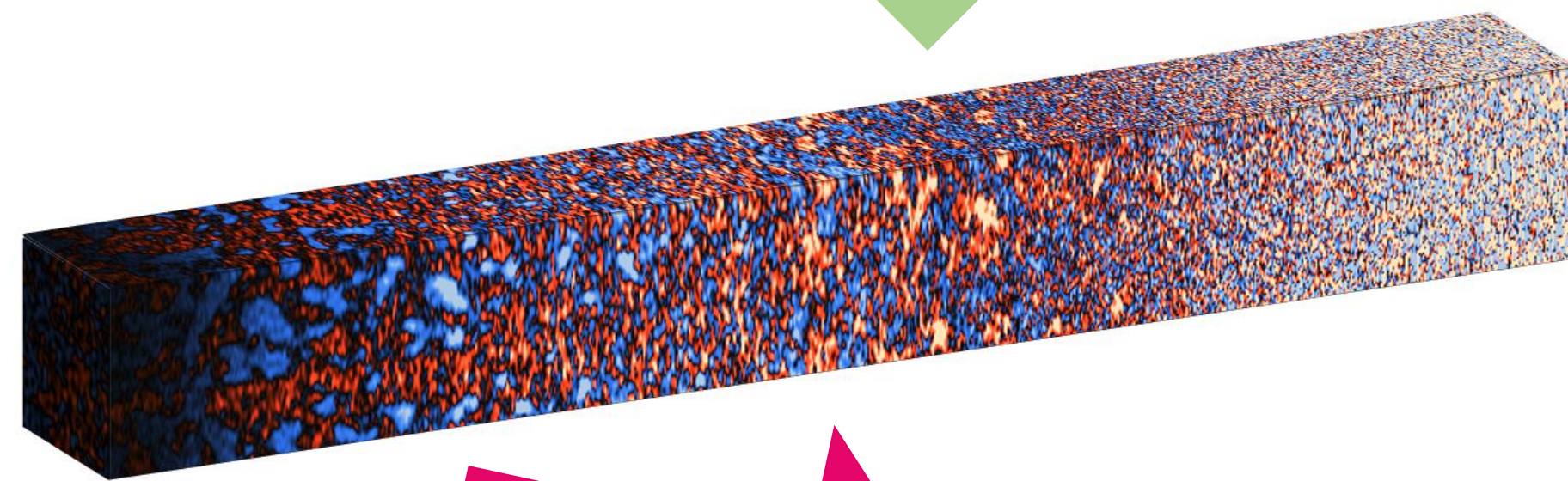


Park+2019  
 $T_s \gg T_{\text{cmb}}$

given noise PS (tbc)

$\theta_{\text{telescope}}$

Telescope simulator



Cleaning  
(backward modeling)

Compression

Compression

sim 2D PS

Likelihood (analytic / LFI)

data 2D PS

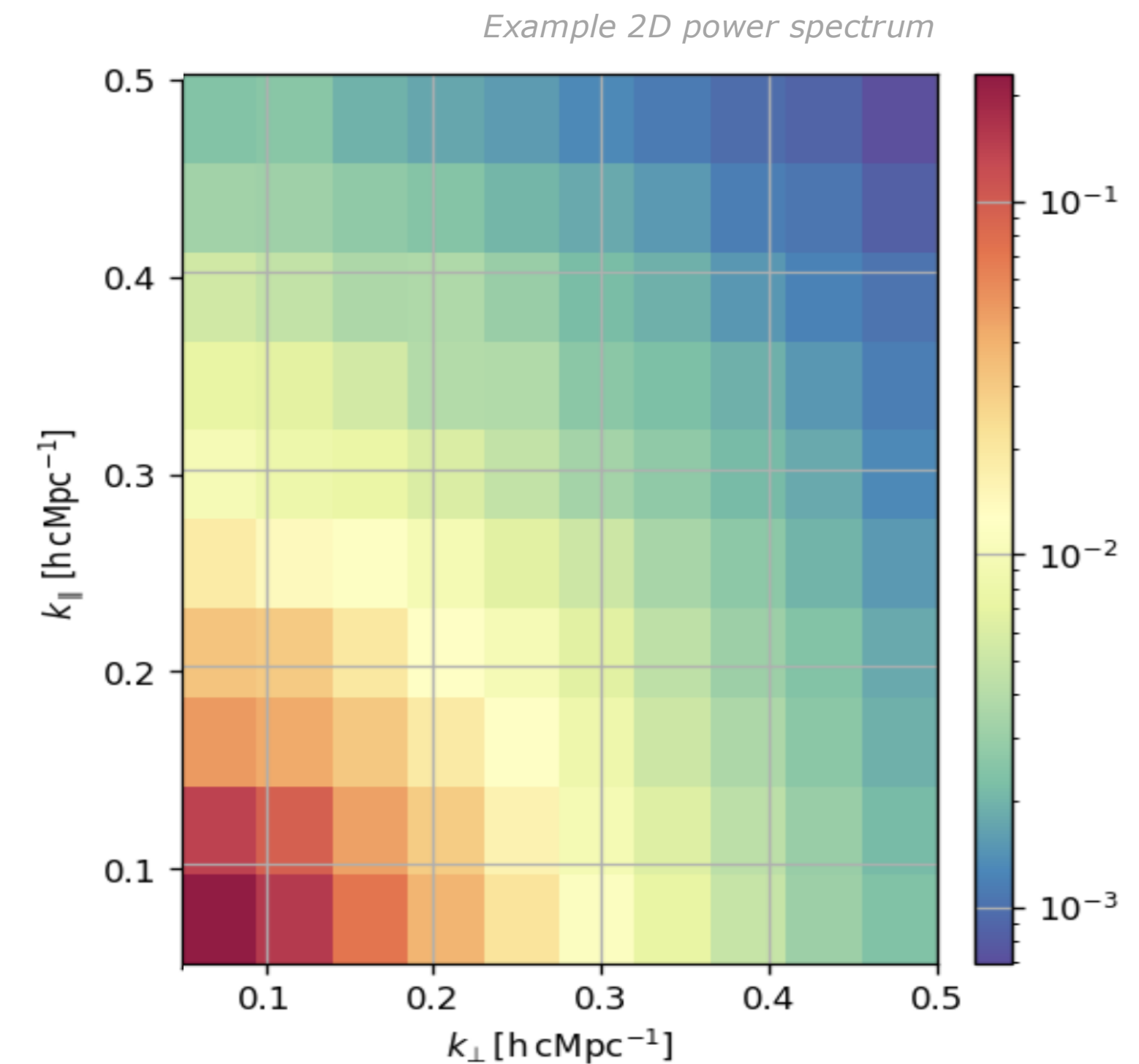
$P(x_{\text{HI}}(z) | \text{data 2D PS})$

slide courtesy of A. Mesinger



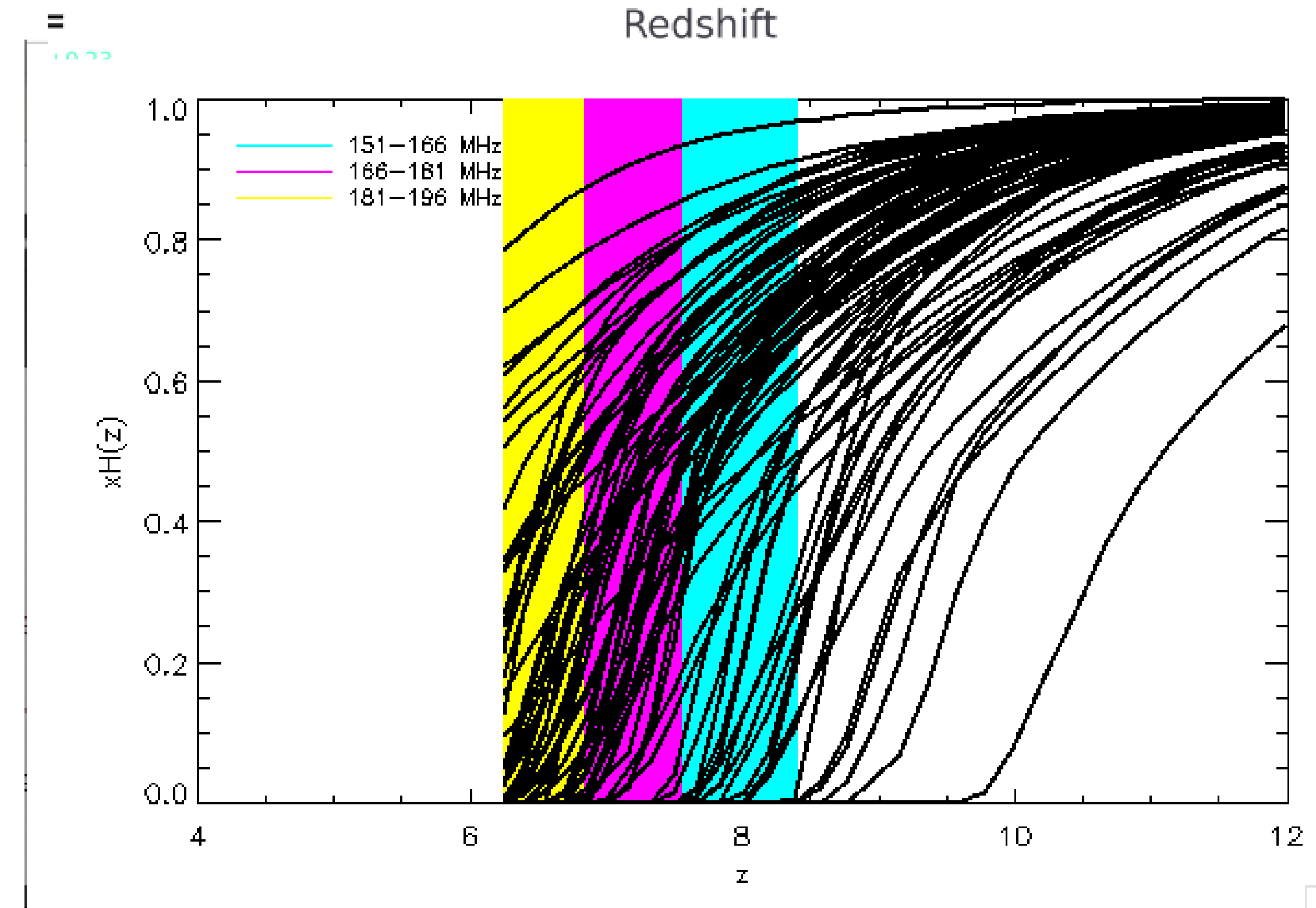
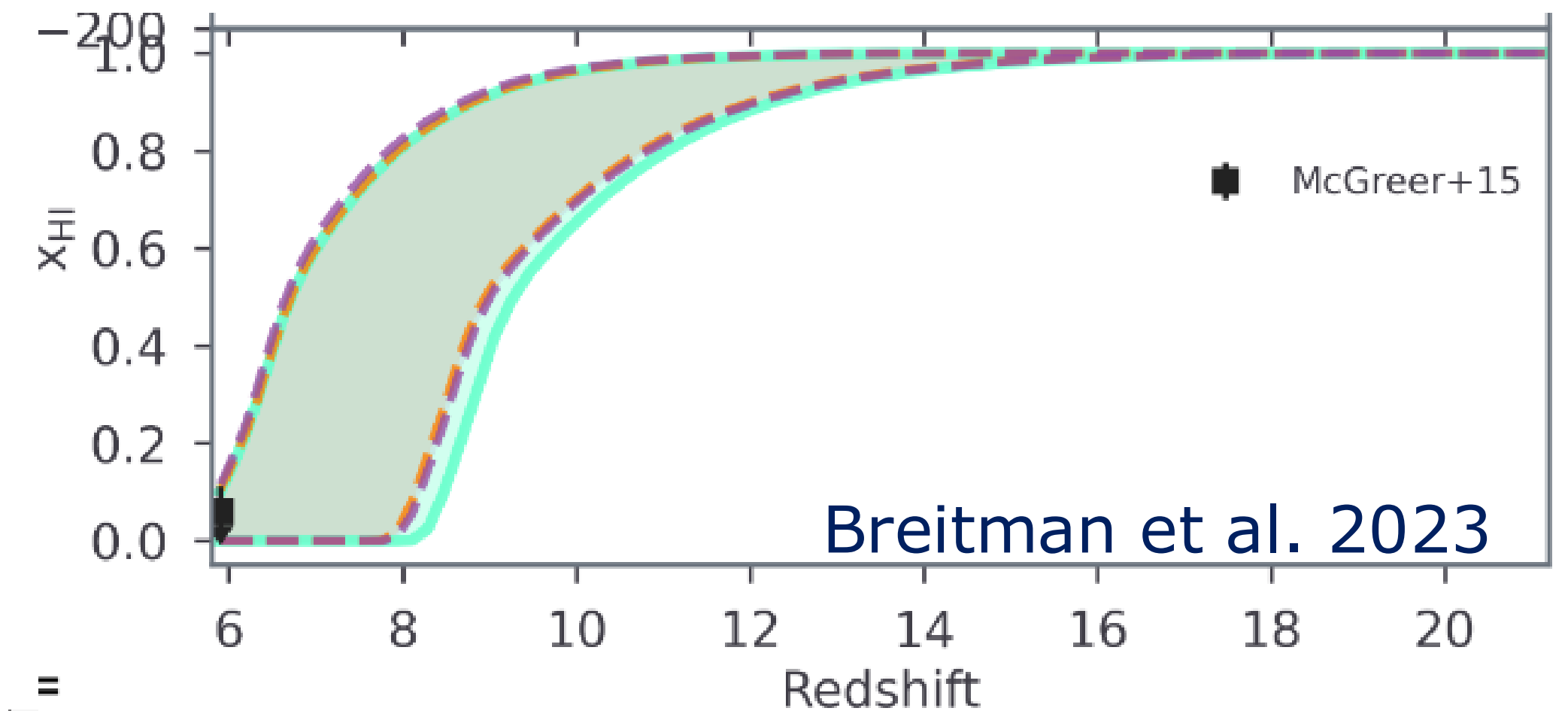
# Science Data Challenge 3b: EoR Inference

- Inference of reionization fraction for EoR
  - 2D power spectra
  - Imaging cubes
- Two simulators used: 21cmfast and C2ray
- Power spectra sets:
  - PS1, PS2: EoR + noise, different simulator and different astrophysical parameters
    - Investigation of effect of different EoR simulators
  - PS3: EoR + noise + residual foreground contamination
    - Investigation of effect of residual foreground contamination
- Imaging set (TBC)
  - IM1: EoR + noise + residual foreground contamination
    - Investigation of effect of residual foreground contamination on image-based inference techniques



# Science Data Challenge 3b: EoR Inference

- Frequency range 151-196 MHz, ( $z=6.25-8.4$ ) where models display large variance
- Three 15 MHz frequency ranges:
  - 151-166 MHz ( $z=8.41-7.56$ )
  - 166-181 MHz ( $z=7.56-6.85$ )
  - 181-196 MHz ( $z=6.85-6.25$ )
- Evolution is present within the 15 MHz frequency range
- 30 h (TBC) integration for PS sets PS1, PS2, PS3
- 1000 h (TBC) for imaging set IM1
- Ancillary: a set of at least 10 noise realizations to characterize noise bias and noise variance



# Science Data Challenge 3b: EoR Inference

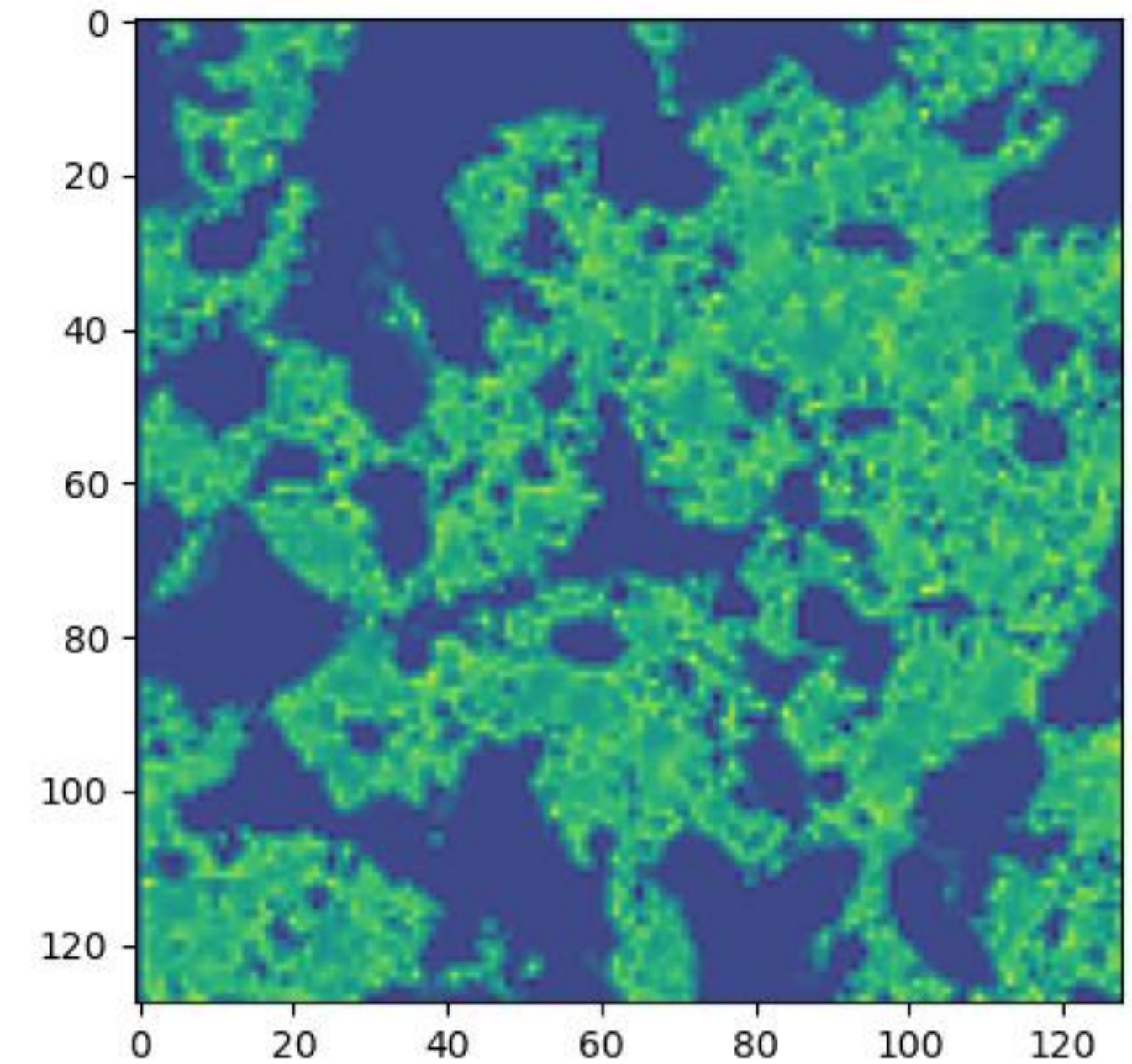
- 21cm simulation specs:
  - 700 x 700 cMpc on 350 X 350 box
  - Planck18 cosmology



21cmFast v4  
(Davies, AM et al. in prep)



pyC2Ray  
(Hirling, Bianco et al. 2024)



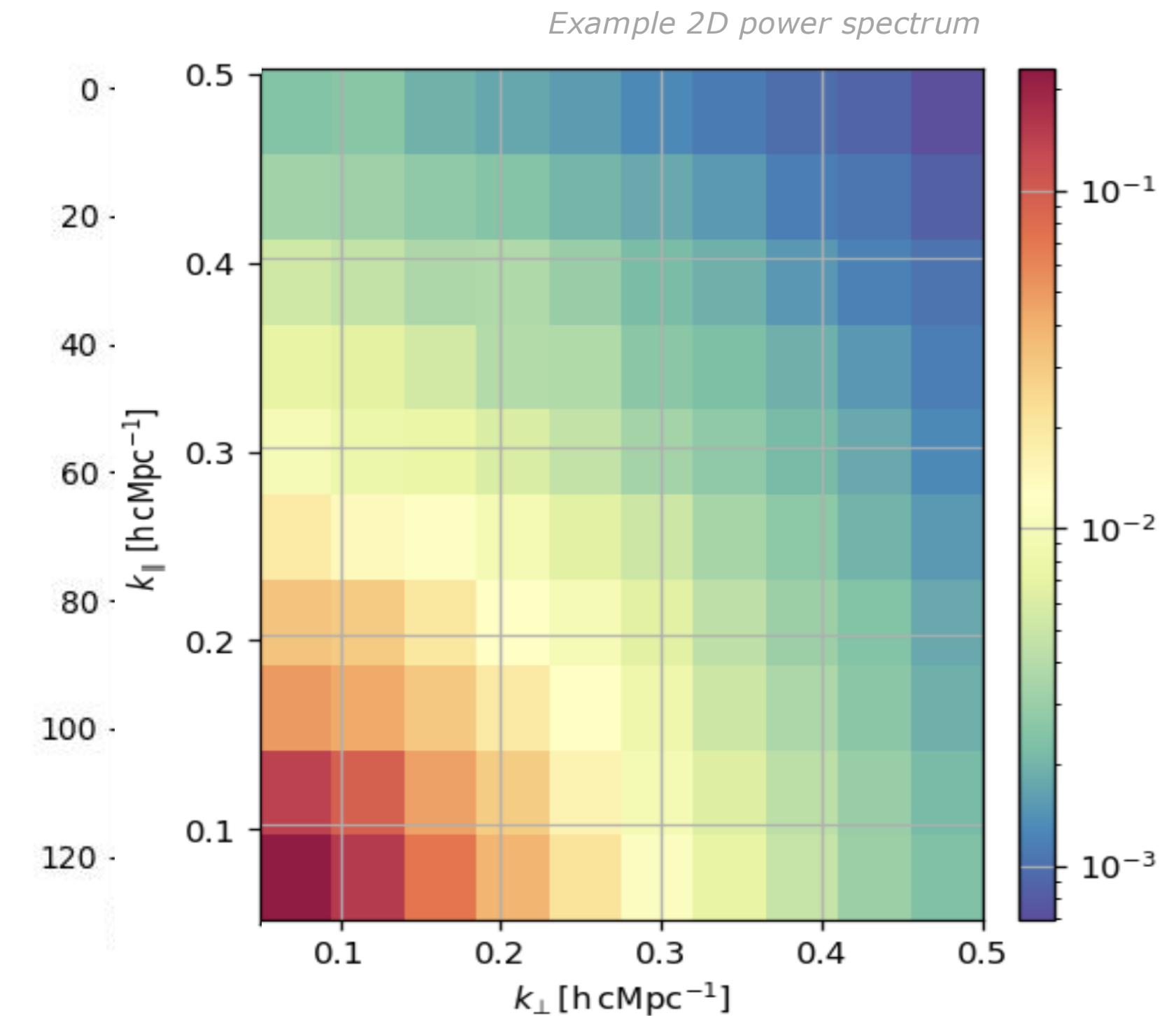
In collaboration with M. Bianco, James Davies, A. Mesinger, Sambit Giri, and the rest of [theory\\_challenge\\_skao](#) slack channel!

- Park+2019 astrophysical parametrization w. scatter
- Only ionizing radiation:  $T_s \gg T_{\text{cmb}}$
- Vary BOTH astrophysical parameters AND simulators



# Science Data Challenge 3b: EoR Inference

- 21cm simulation specs:
  - 700 x 700 cMpc on 350 X 350 box
  - Planck18 cosmology
  - Produce lightcones of 8X8 deg
  - SKA-Low simulation
  - 2D power spectrum estimation on the inner 4 X 4 deg



In collaboration with M. Bianco, James Davies, A. Mesinger, Sambit Giri, and the rest of theory\_challenge\_skao slack channel!



# Scoring

- For each data set,  $\mathbf{d}_i$ , submit posteriors,  $\mathbf{p}(\mathbf{x}_{\text{HI}}(\mathbf{z}_1), \mathbf{x}_{\text{HI}}(\mathbf{z}_2), \mathbf{x}_{\text{HI}}(\mathbf{z}_3) \mid \mathbf{d}_i)$ : a 3D array with pre-specified bins (tbc)
- Score of that data set will be the value of the *truth* in the posterior:

$$\mathbf{p}(\mathbf{x}^{\text{true}}(\mathbf{z}_1), \mathbf{x}^{\text{true}}(\mathbf{z}_2), \mathbf{x}^{\text{true}}(\mathbf{z}_3) \mid \mathbf{d}_i)$$

- Score is not important! Goal is international participation, and testing pipelines on “out-of-distribution” data.



# Science Data Challenge 3b: EoR Inference

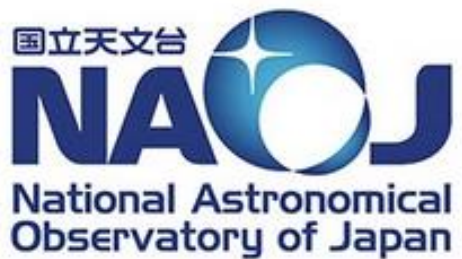
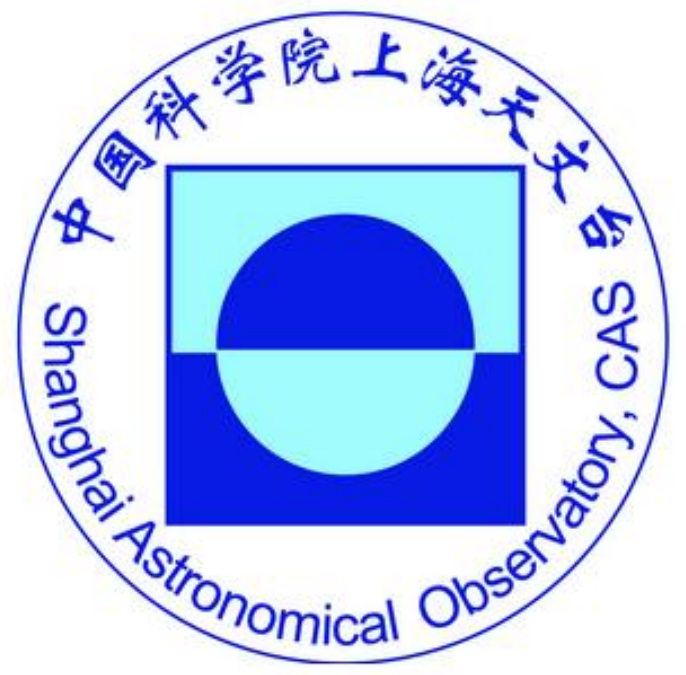
- Status:
  - Teams have registered and have accessed/are accessing their allocated computational resources
  - 40 teams/ 53 methods have registered
  - A first test dataset has been released
    - 1 EoR power spectra set + ancillary
    - Data description document v0
  - Final SDC3b datasets in production
    - PS1, PS2
    - IM1, PS3





# Science Data Challenge 3b: EoR Inference

SDC3 receives generous support from our international HPC partner facilities, who will provide computational resources to teams for processing the challenge data.





# Reminders & Information

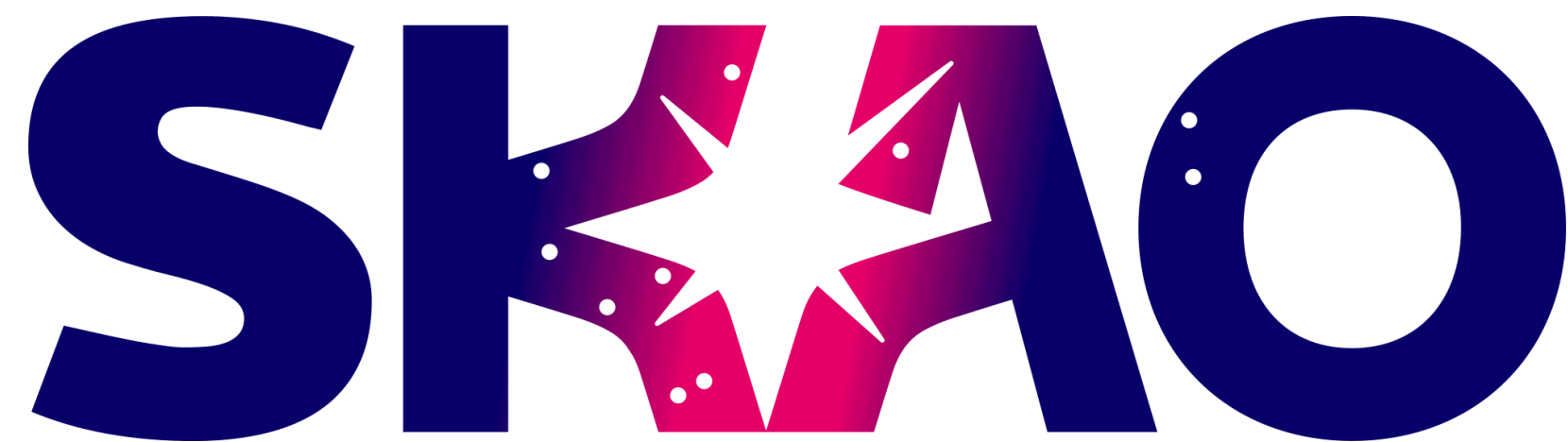
# Outreach & Engagement

- **CONTACT** is the SKAO magazine aimed at the entire SKA community <https://www.skao.int/en/news-events/contact-skao-magazine>
- Ideas for articles for CONTACT are always welcome (email Tyler). These include:
  - Let's Talk About (Feature length ... science focussed)
  - Pathfinders & precursors. Short pieces on recent results
  - SKA-related events (e.g. SPARCS, etc)
  - any other news of SKA relevance (award/honours, job openings, ...)
- Encourage your SWG members to [sign up](#)



# SKA Positions

- SKAO positions (HQ Manchester UK, Australia-Low, South Africa-Mid)  
<https://recruitment.skao.int/vacancies.html>
- SARAQ employee SKA positions (Cape Town, Carnarvon)  
<https://www.sarao.ac.za/vacancies/>
- CSIRO employee SKA positions (Perth, Geraldton)  
<https://www.csiro.au/en/careers/career-opportunities/skao>

The SKAO logo features the letters 'SKAO' in a bold, dark blue font. The 'K' and 'A' are stylized with a red-to-white gradient and contain white starburst patterns.The logo for the South African Radio Astronomy Observatory (SARAQ). It features the word 'SARAQ' in a large, grey, sans-serif font. Below it, 'South African Radio Astronomy Observatory' is written in a smaller, black, sans-serif font.

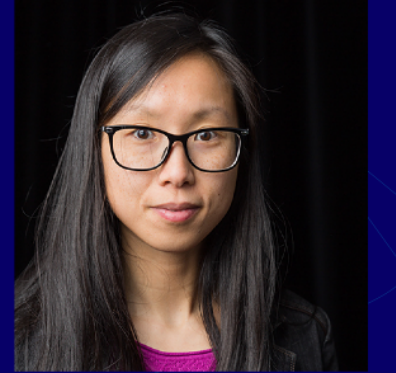
# SKAO Speaker Series

- SKAO Speaker Series

- series of interesting talks, accessible to all within the broader SKA community, covering a wide range of topics, from astronomy to physics, engineering, big data and computing, EDI, and more.
- Encourage your SWG members to sign up to give a talk (and consider giving a talk yourself).
- Talks recorded – all available for reviewing via the [Speaker Series](#) page (2020+)

## SKAO SKAO Speaker Series

My personal journey as a female astronomer of colour



**Cherry Ng**

Permanent Astronomer  
Centre National de la Recherche Scientifique (CNRS)  
Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E)  
Orléans, France

This talk is a collection of reflections on my career: from X-ray binaries to exoplanets, from pulsars to Fast Radio Bursts and SETI; on the challenges of motherhood and how it shapes my personality, and on the search for my cultural identity moving through six countries.

Wednesday 13 March 2024

10.00am UTC

[Click to access the Speaker Series talk here](#)

## SKAO SKAO Speaker Series

Establishing an Evolutionary Picture of Fast Radio Bursts



**Di Li**

Chief Scientist - FAST

With FAST, the largest single-dish telescope ever built, we have designed the Commensal Radio Astronomy FAST Survey (CRAFTS), which realizes, for the first time at any major facility, simultaneous data recording of pulsar search, HI imaging, HI galaxies, and transients (FRB and SETI). CRAFTS has discovered ~200 pulsars, ~10 FRBs including the only persistently active repeater FRB 20190520B, and ~5000 d<sup>2</sup> HI images with 1% calibration consistency, 5-10 times better than what is available from Arecibo.

Based on CRAFTS, we derived a FRB event rate ~ 120K per day per 4pi. We find universal frequency-dependent depolarization among repeating FRBs, which can be well fitted by multi-path scattering and a single free parameter sigma\_RM that described the complexity of the magnetized environments of FRBs. We have published in 2021 the first complete energy distribution toward any FRB, which is clearly bimodal between 10<sup>37</sup> and 10<sup>40</sup> erg. Such bimodality was borne out in the subsequent monitoring of active repeaters. Recently, 10% drop of FRB 121102's DM on a decade time scale, is being robustly detected. I am proposing an evolutionary picture of FRBs, which aims to unify not only repeating FRBs, but most if not all non-repeaters.

Tuesday 23 April 2024

11.00am UTC (12noon BST)

[Click to access the Speaker Series talk here](#)



# Any Other Business

- News from SWG Chairs?

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



[www.skao.int](http://www.skao.int)

[www.skao.int/en/science-users](http://www.skao.int/en/science-users)