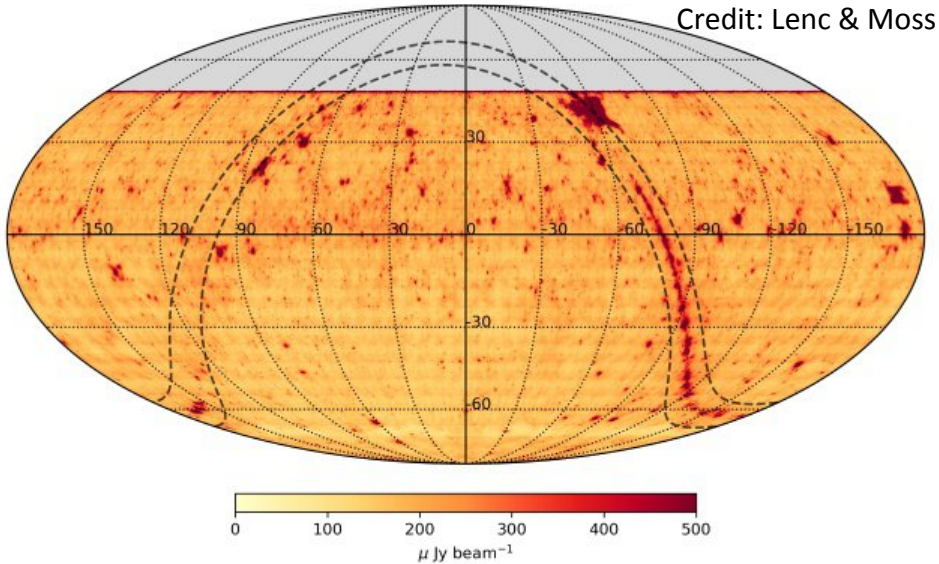
Widefield surveys/ large fields-of-view

Alex Dunning (Technology)
Ivy Wong (Science)

ATUC Science Day | 8 November 2022

Credit: Lenc & Moss



Science value of Widefield / large FOV

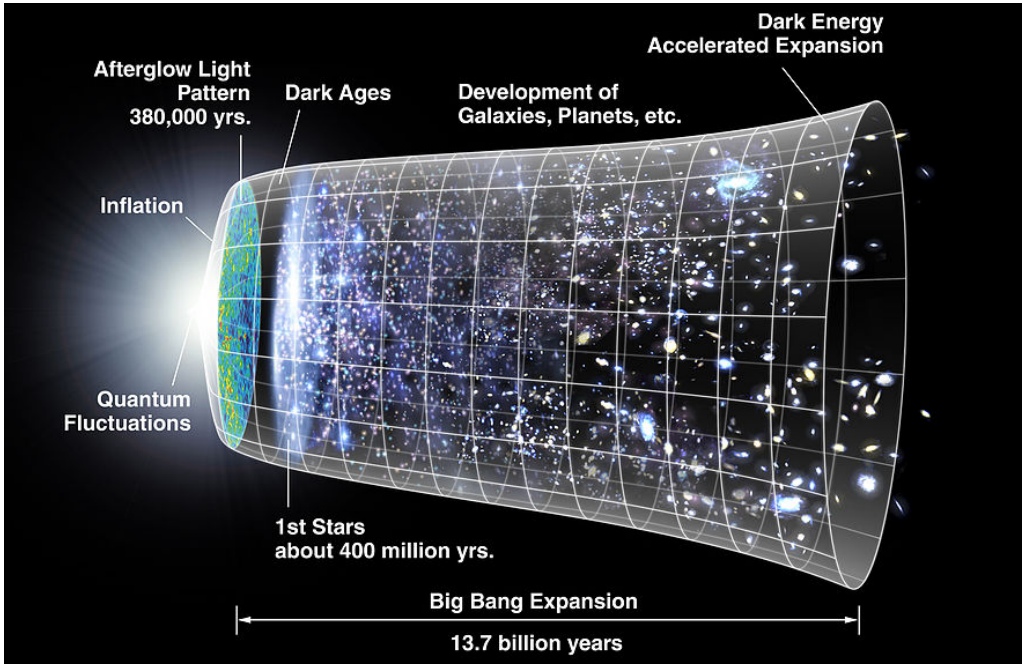
- Galaxy formation models are more sophisticated

However,

model Universes

≠

the ***real*** Universe



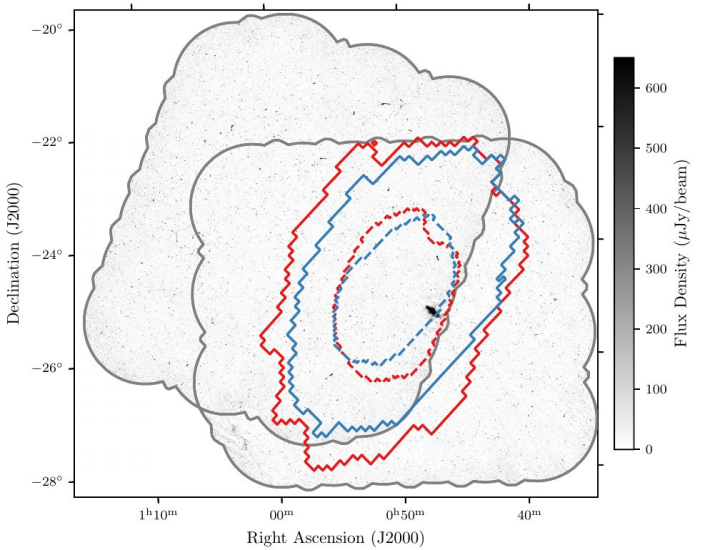
Credit: NASA/WMAP

Missing astrophysical processes require **observations** to progress understanding

Current modus operandi

- Missing astrophysics likely ‘fast’ & potentially transient
- Missing tracers likely faint, extended & low luminosity

- **Deeper + larger + contiguous + untargeted surveys crucial & opening new parameter space**
- **Widefield fantastic for multi-messenger follow-up**
- e.g. connecting transient events to galaxy evolution processes require accurate event localisation

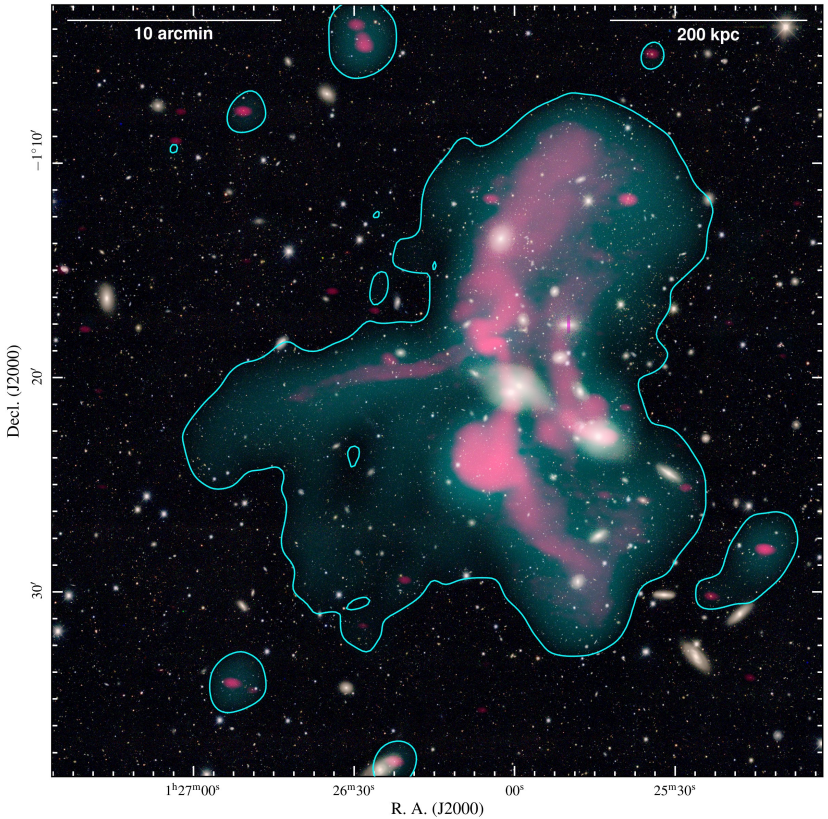


Dobie + 2022

Current modus operandi: early/pilot experiences

- Better sensitivity & resolution across widefield → better constrain evolutionary processes

- Can improve stability / uniformity / reliability across signal chain
  - Flux + calibration uncertainty across large FOV for large diffuse structures
  - Correlator block drops
  - Is the lower half of ASKAP Band 2 truly unuseable?



Credit: Stefan Duchesne

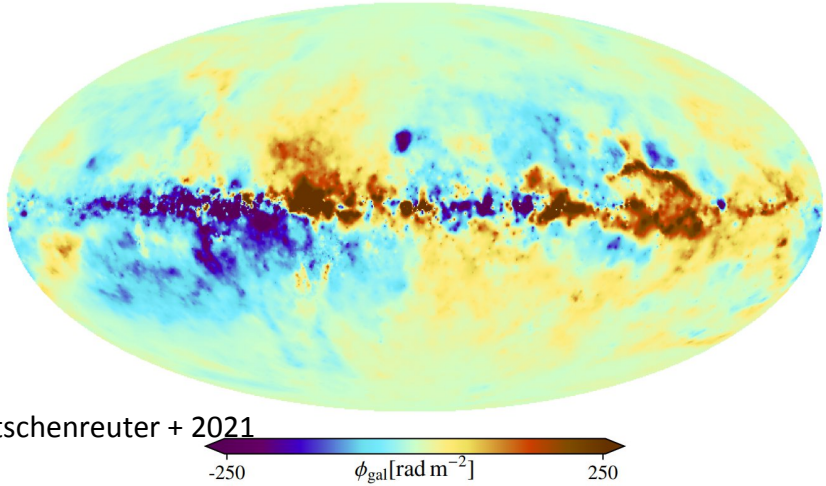
Looking to the future

- Better sensitivity & resolution across large FOVs?
  - @lower freq: map extended emission to lower surface brightness & luminosities
  - @higher freq: more untargeted surveys

- Can better stability across signal chain be in-built?
- Can we use in-built bells & whistles?

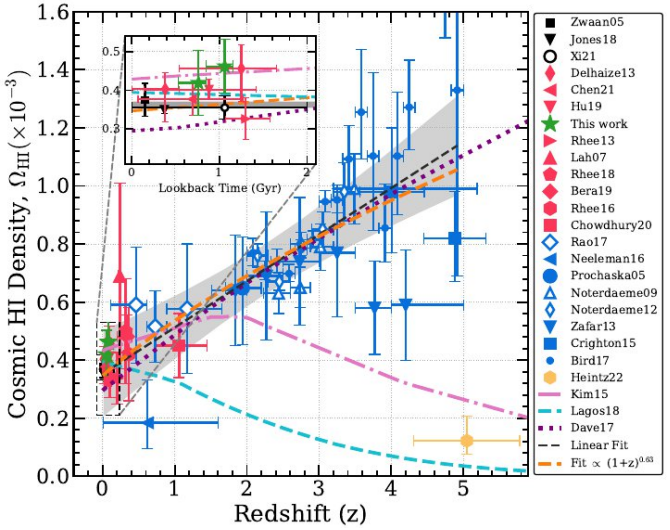
- Alex (amazing technologist): Astronomers are using the PAF like a multibeam
- Ivy (uninformed astronomer): Wait, why?
  - **eg. RFI is limiting spectral line science, sensitivity in continuum, derived RM maps**

Future science



Hutschenreuter + 2021

- Connecting small - large scales for distant galaxies (dwarfs → M*)

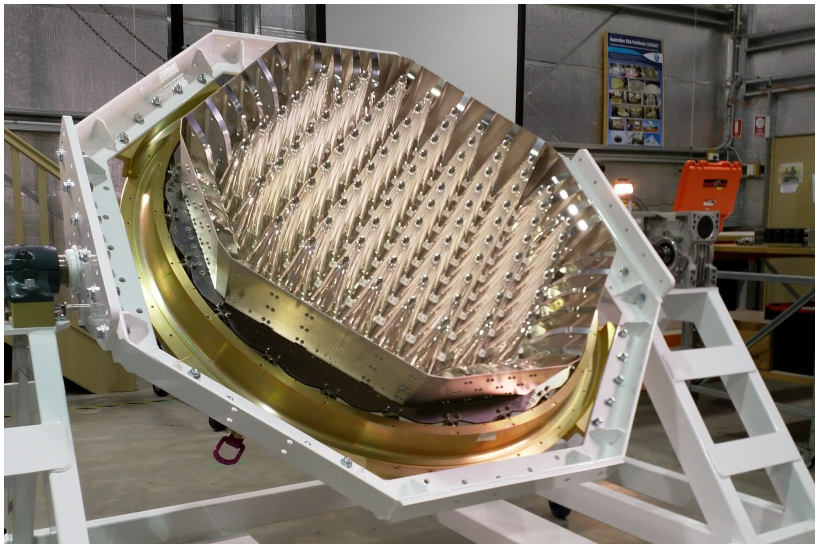


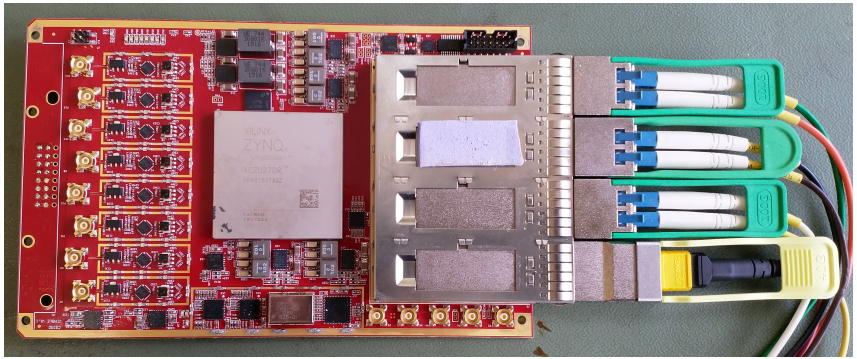
Rhee +2022

- HI detection to cosmologically-interesting *z*
- "All-sky" spectral line surveys other than HI(?)
- Connecting fast & transient events back to galaxy evolution astrophysics

Wide Field of View and Multipixel

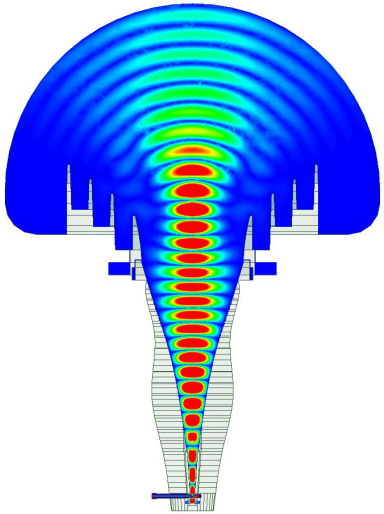
- Cryogenic Phase Arrays for Parkes and Quasar
- Multiport Digitizers and beamformers for Parkes, Quasar and SKA

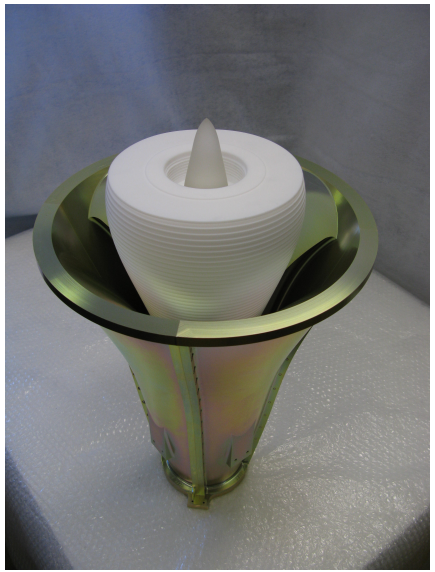


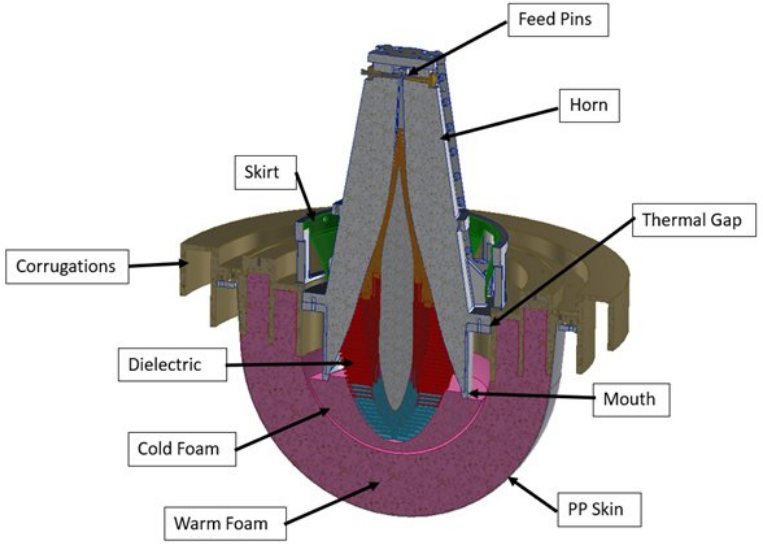


Wide Bandwidth Systems

- Wideband receivers/feeds for Parkes, Effelsberg and ngVLA







Low Noise Receivers and LNAs

- We continue to develop MMICs with current foundries
- Investigating a collaboration with IAF Fraunhofer for state of the art noise temperature devices
- Investigating potential collaborations with Australian quantum groups to exploit quantum phenomena for low noise amplifiers

Survey Speed

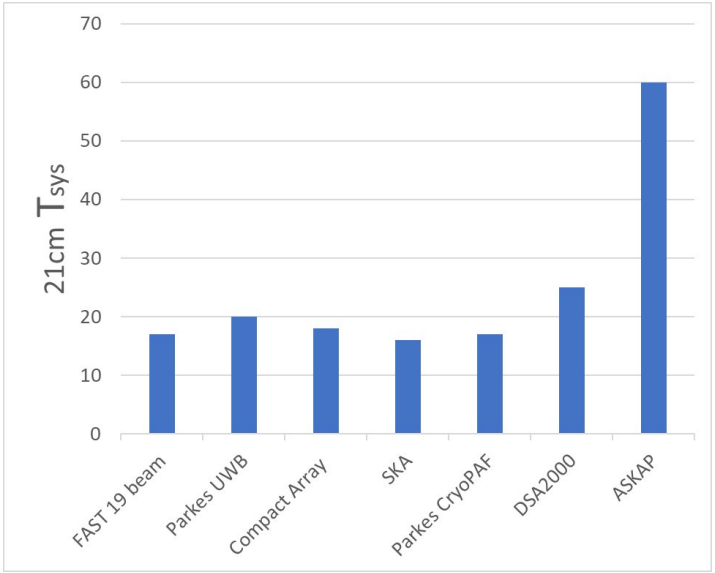
$$Survey\ Speed = \frac{A_{eff}^2\ FOV\ BW}{T_{sys}^2}$$

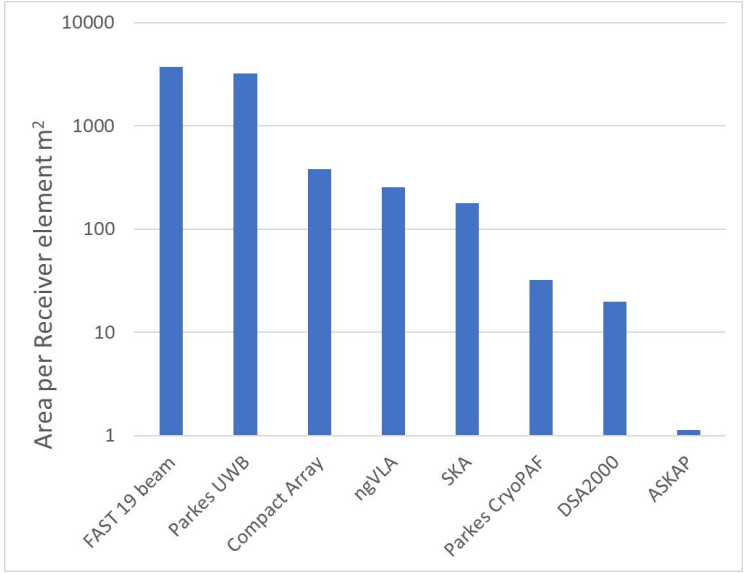
Phased Arrays

Wideband Receivers

Cryogenics and LNAs

ASKAP as a survey instrument





$$Survey\ Speed \sim \frac{A_{eff}\ n_{beam}\ BW}{T_{sys}^2}$$

Proposed upgrades

- LNA upgrade with the possibility of halving Tsys
- Additional dish surface increasing the aperture by up to 50%
- Transparent feed legs
- Extra bandwidth

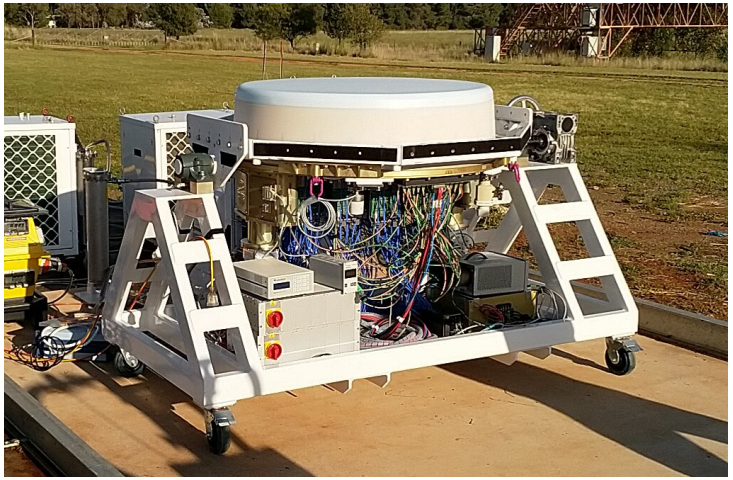
- Implementing all of these is estimated to increase the survey speed by 6-8x

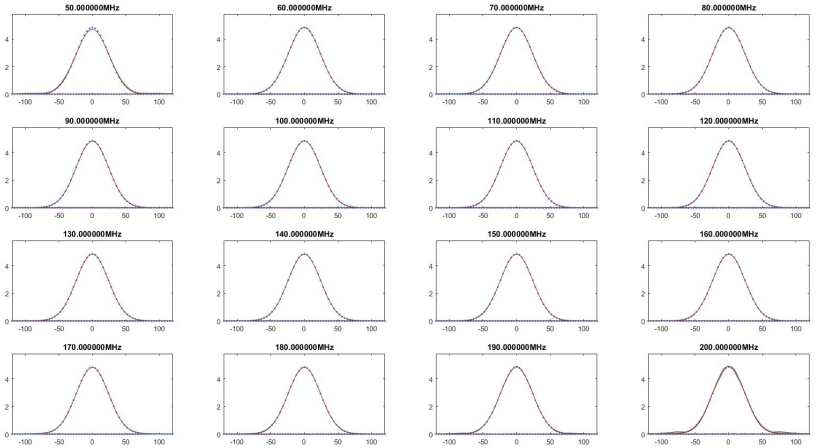
Some questions

- If we want to remain competitive on a 20 year time scale do we need to consider upgrading ASKAP to an instrument with a much larger aperture?
- Is addressing T_{sys} alone likely to prove sufficient?
- Are 12m dishes equipped with phased arrays are an efficient technology for such an array?
- Large upgrades have a long lead time. Should we start now?

All sky telescopes

- Offer the possibility of extremely controlled beam patterns for all sky experiments
- Open a new parameter space for the study of rare but bright events
- Extremely effective as RFI references for larger telescopes
- Relatively modest cost compared to other possible new instruments
- More attractive at low frequencies due to area scaling





Simulated low frequency beam patterns

Thank you

We acknowledge all the traditional owners of the lands in which we live and work across Australia. And we pay our respect to their Elders past & present.

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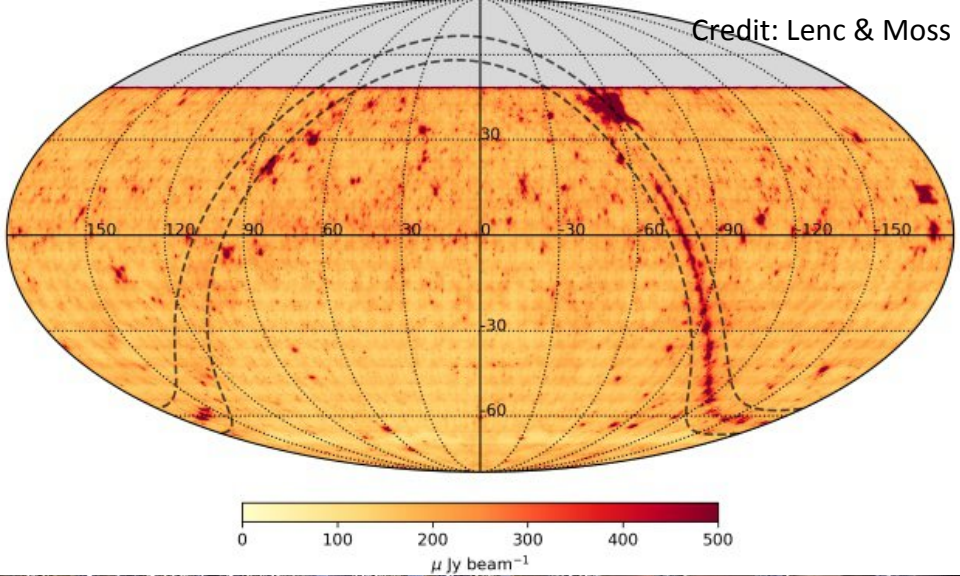

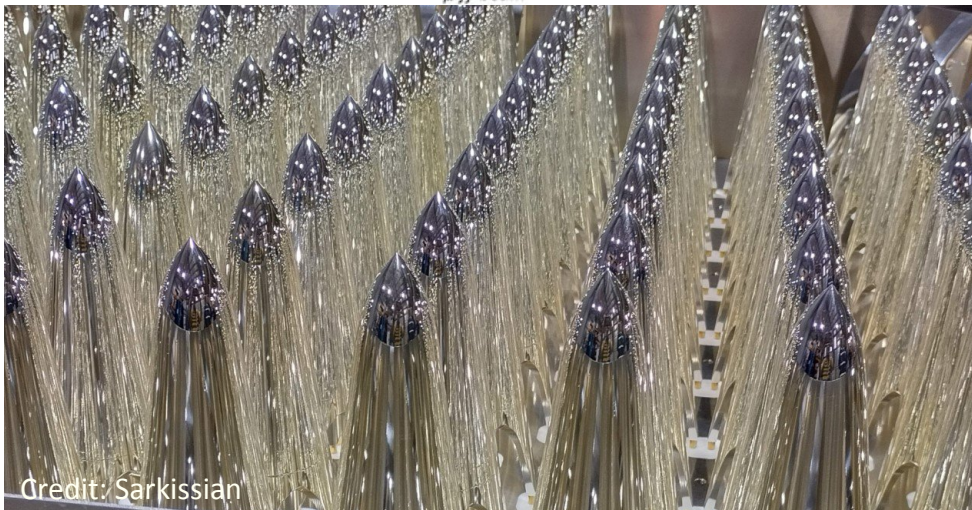


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