“From sunspots to the birth of Earth-like planets and the earliest galaxies”

Status update on the SKACH band 6 white paper

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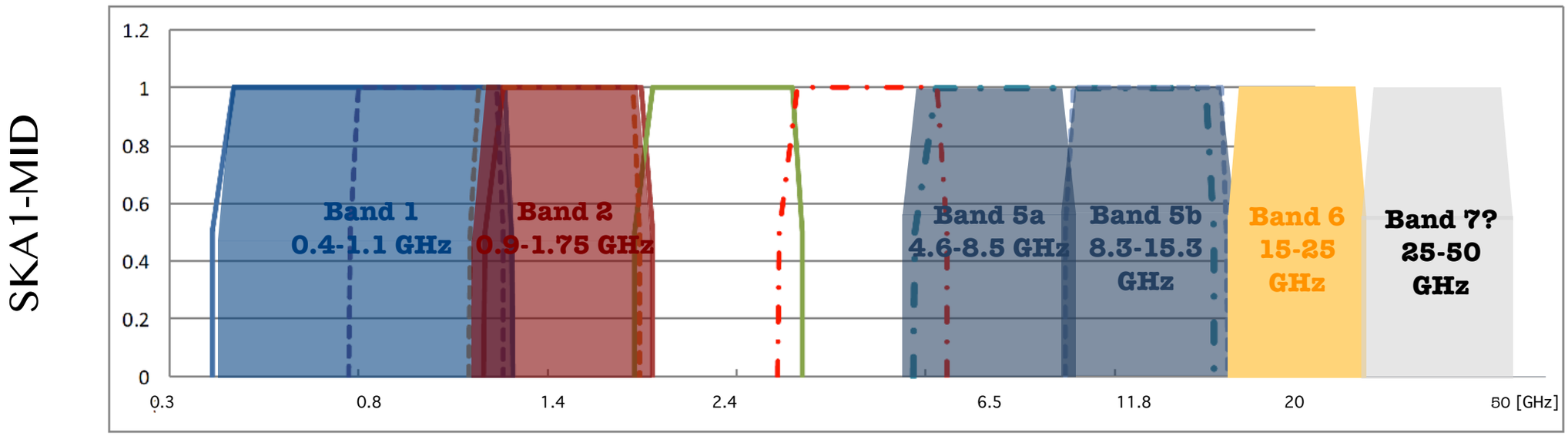
SKACH | INTERNATIONAL SPACE SCIENCE INSTITUTE

Overview

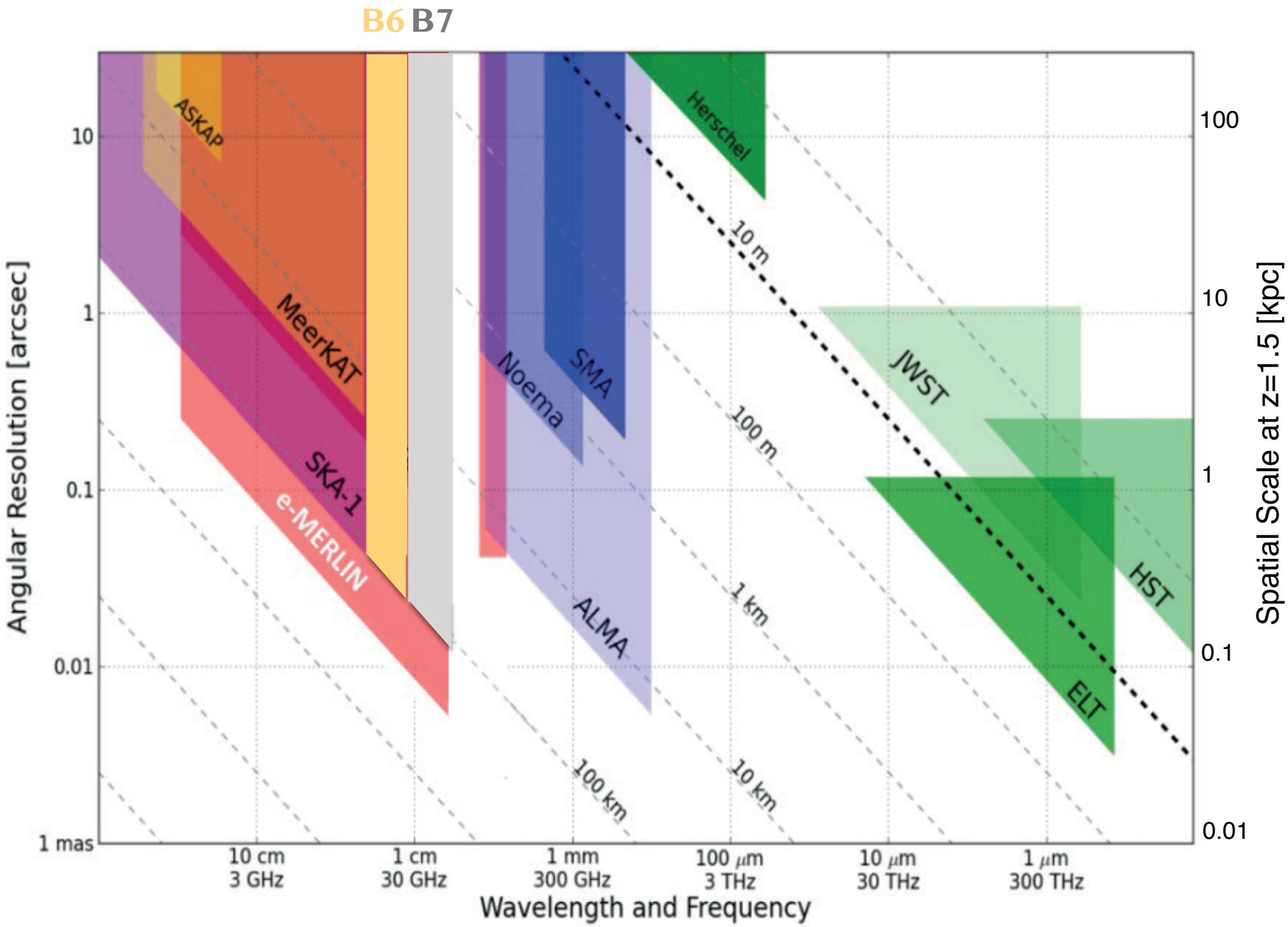
- Technical context & B6 observational parameter space
- Swiss interest in B6 and related on-going projects
- Status update SKACH B6 white paper
- Aims for this session

SKA1-MID High-Frequency Coverage

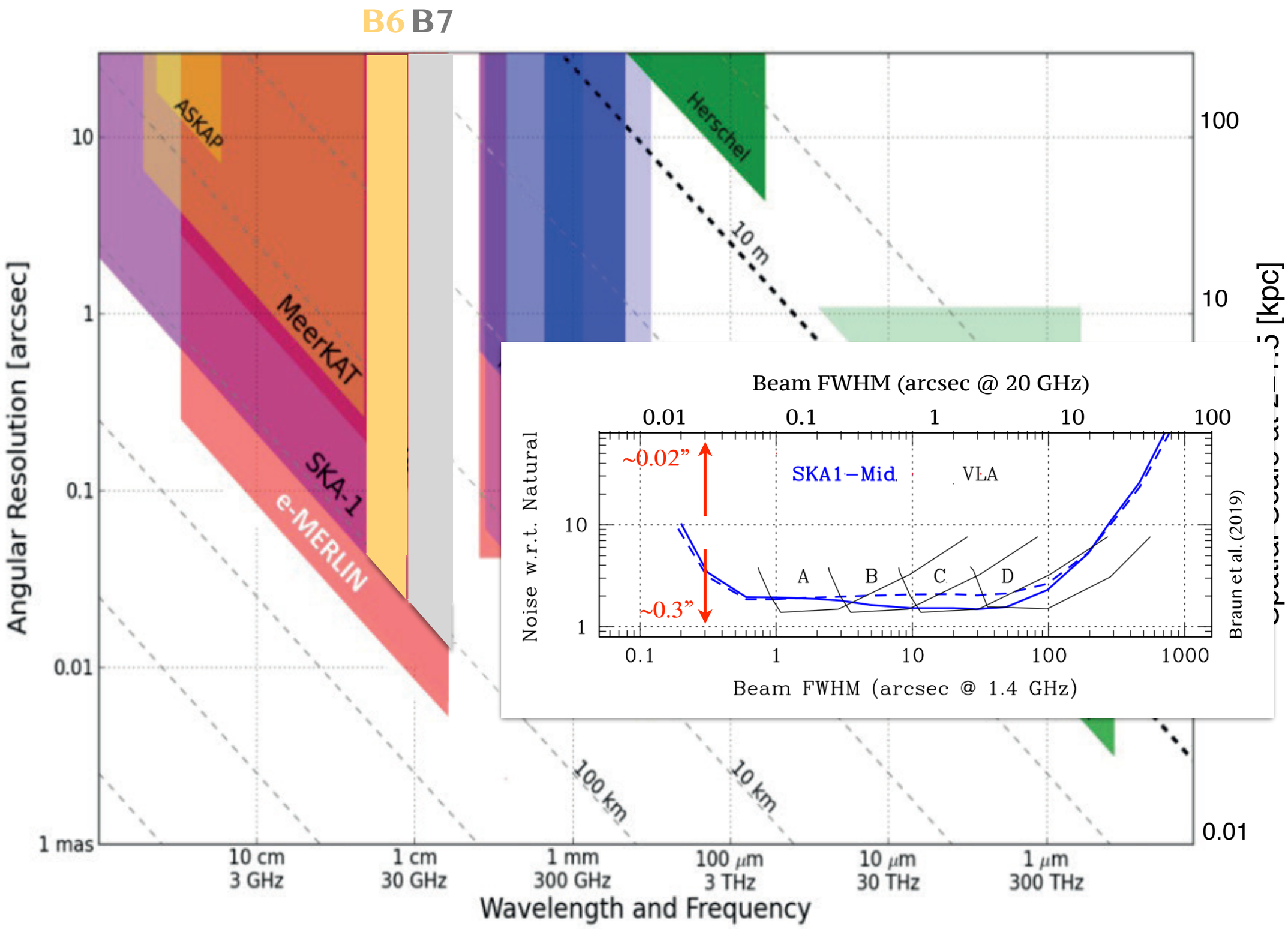


- Band 6: 15-25 GHz (also investigating a band 7 up to ~50 GHz)
- Instantaneous bandwidths in bands 5a/b, 6, 7: 2x2.5 GHz
- Spectral ‘zoom-mode’ capability: resolution up to 0.2 kHz

Indicative Band 6 Performance



Indicative Band 6 Performance



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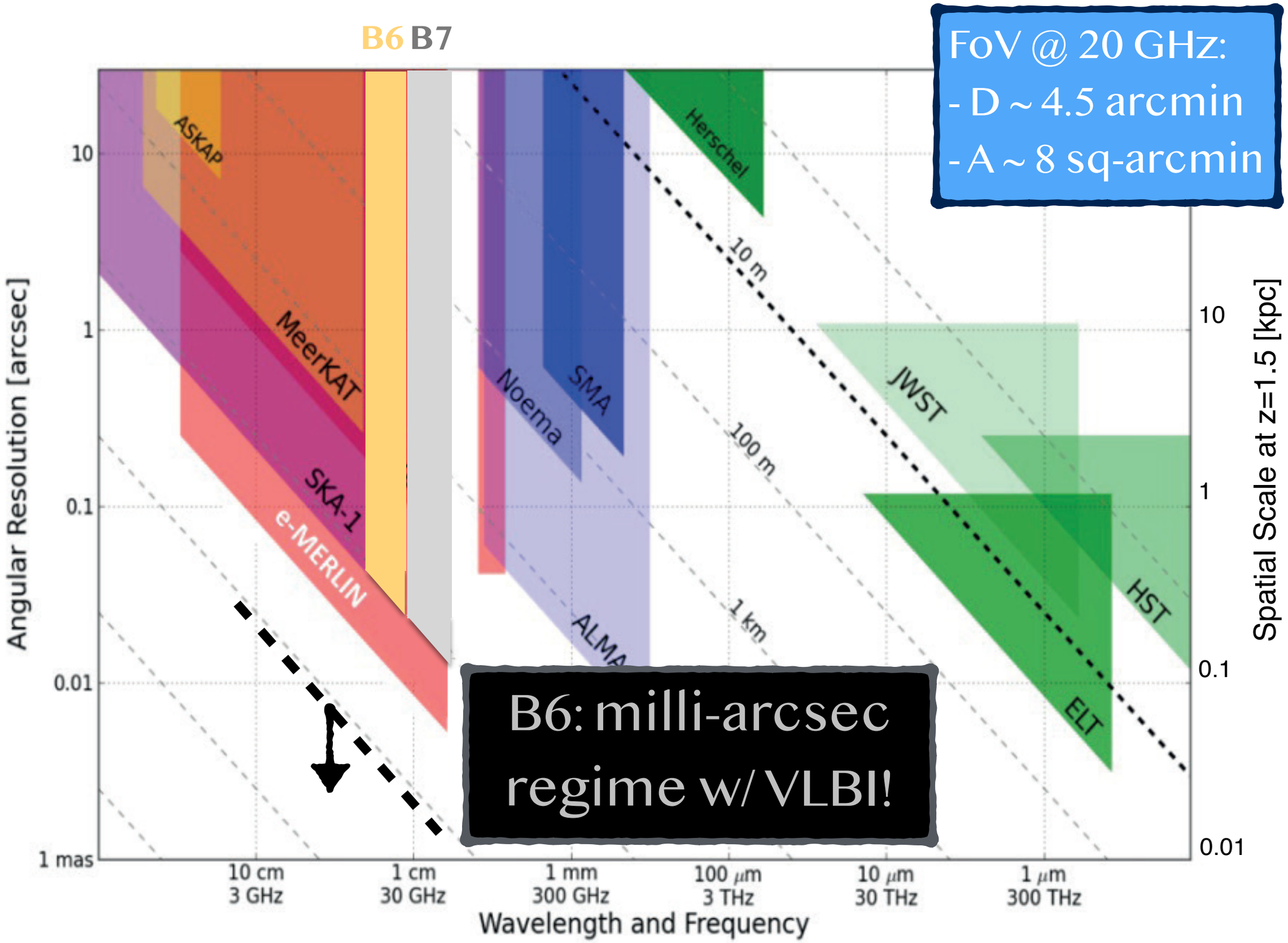
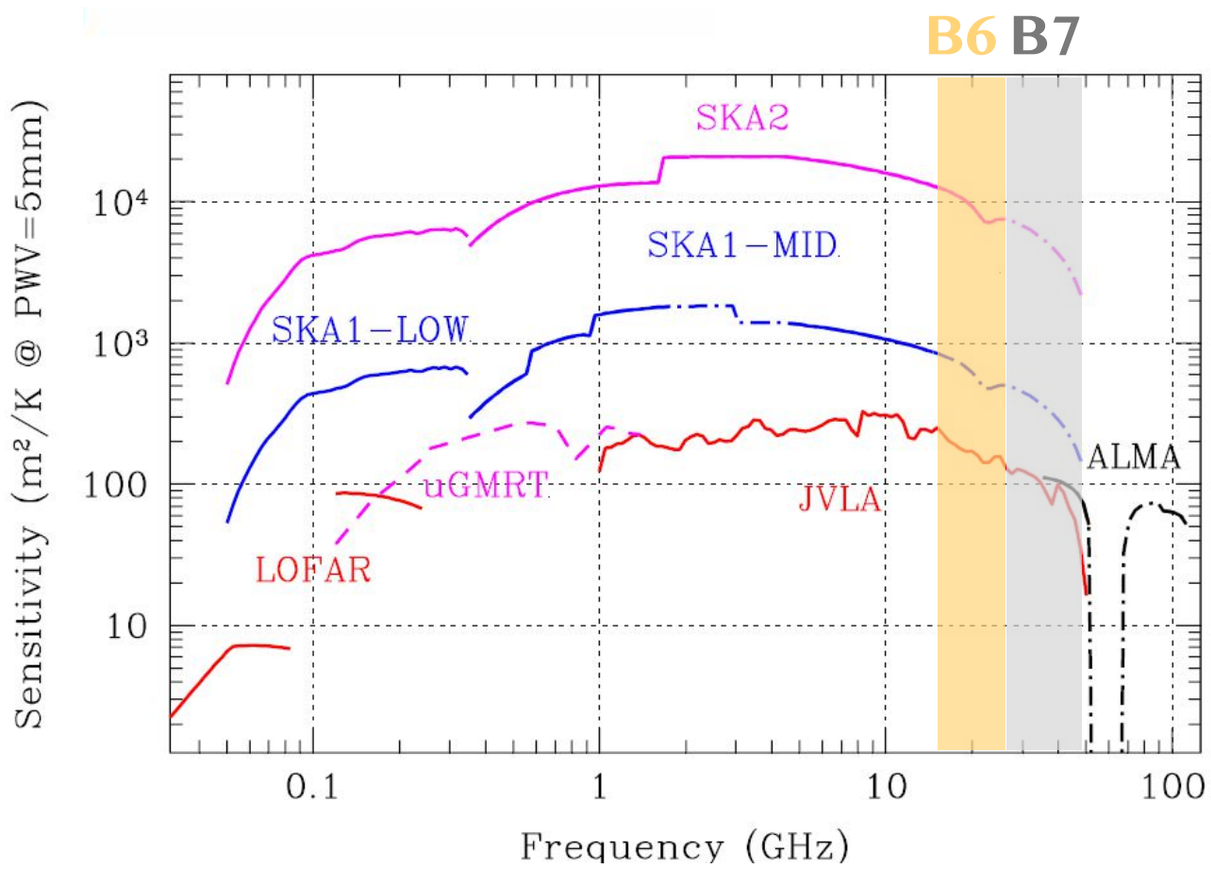
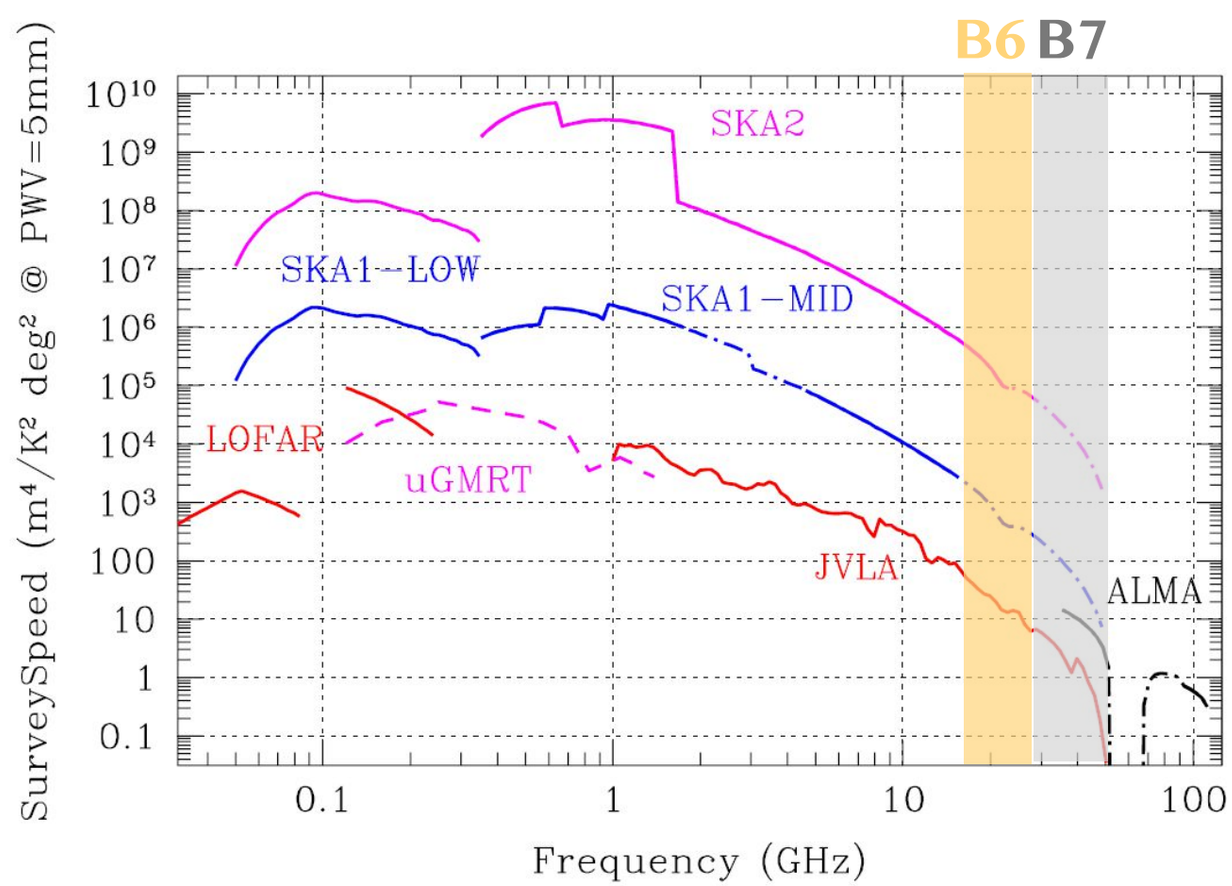


Sensitivity & Survey Speed Expectations





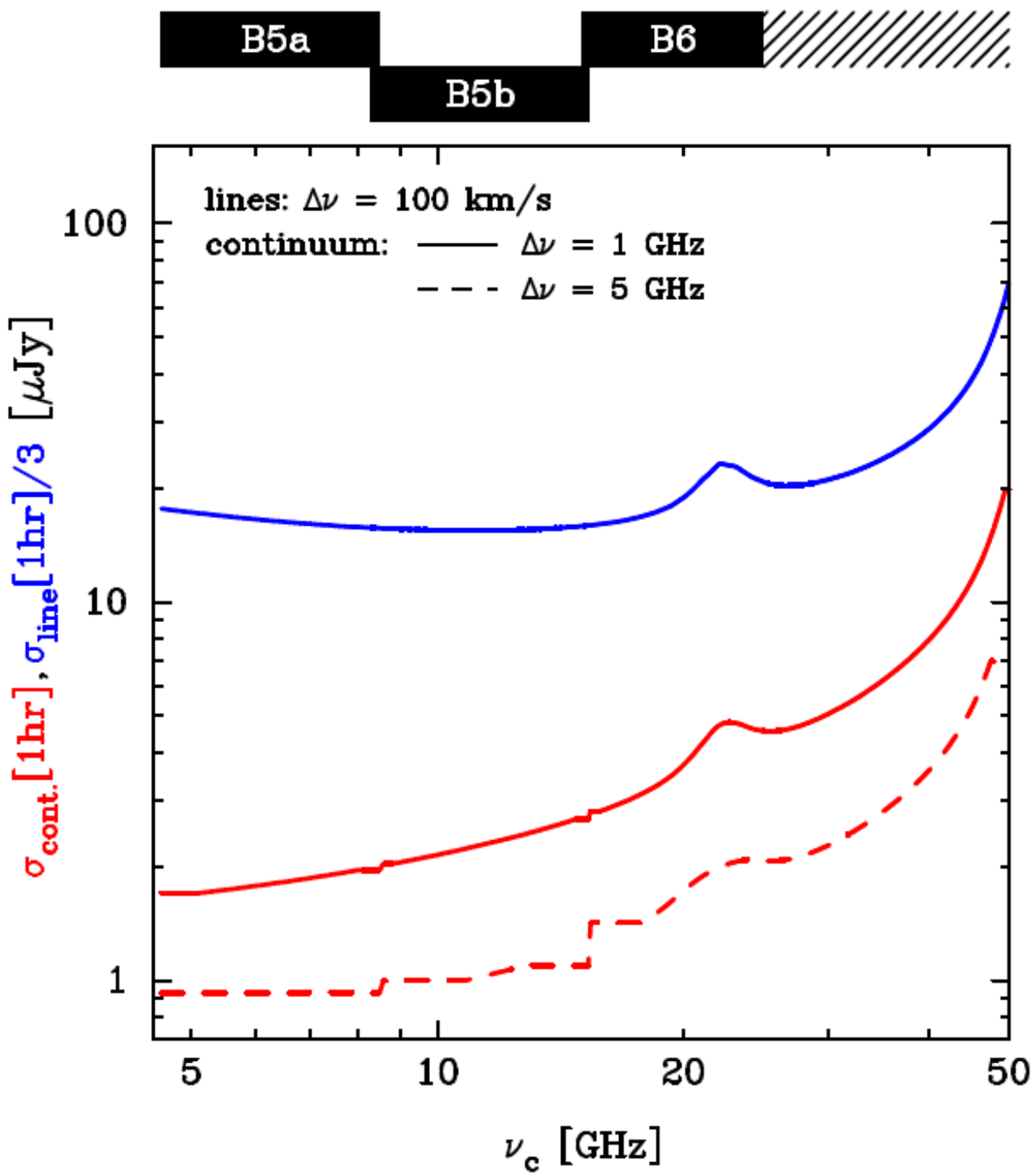
B6: ~3x sensitivity improvement (vs. JVLA K-band)

B6: ~20x faster survey speed (vs. JVLA K-band)

B7: ~2x sensitivity improvement (vs. ALMA band 1)

B7: ~5x (20x) faster survey speed (vs. ALMA band 1 (JVLA Q-band))

B6/7 Performance Estimates: Array Sensitivity



M. Sargent/B6 sensitivity primer (link on final slide)

Indicative 1hr sensitivities (1σ) at ~20 GHz (zenith, pvw=5mm, standard SKAO assumptions on degradation of image noise compared to "natural" array sensitivity):

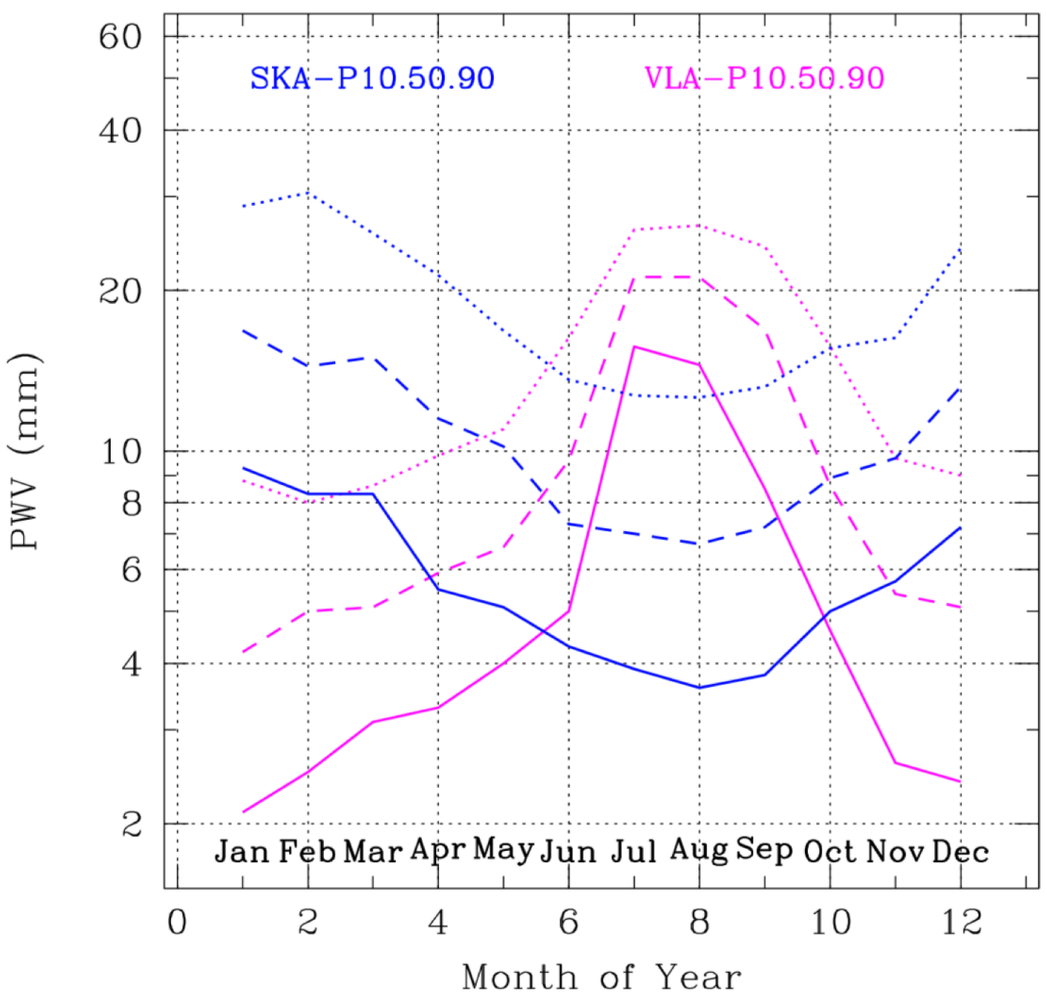
- line sensitivity (100 km/s channel): 57 uJy
- continuum sensitivity (5GHz BW): 1.7 uJy

At 40 GHz:

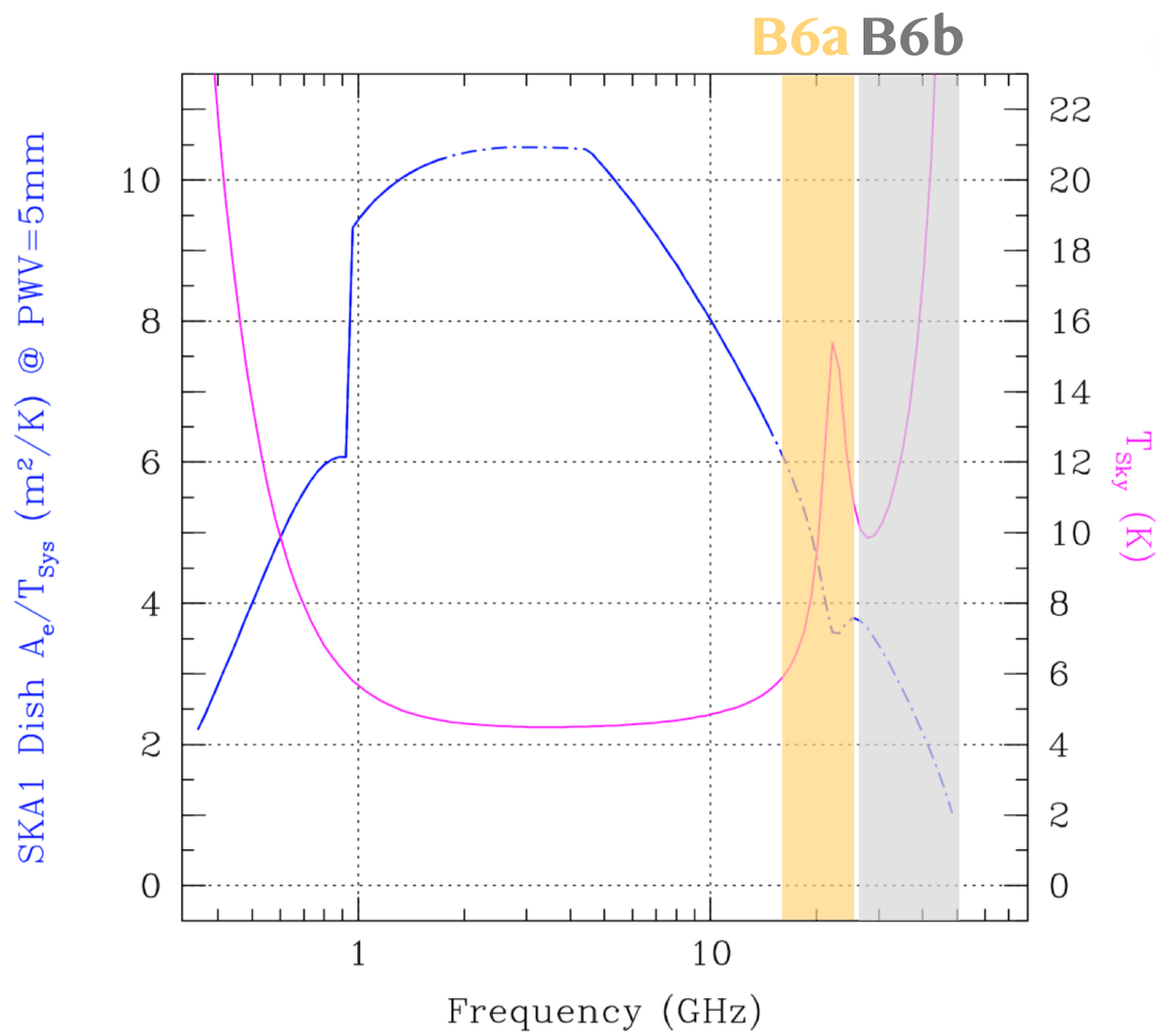
- lines: 86 uJy
- continuum: 3.6 uJy

B6/7 Performance Estimates: Site & Dish Sensitivity

Avg. seasonal pvw level variation for MID and VLA sites (2010-2015; P. Forkman)



Predicted single-dish sensitivity (zenith, dry weather w/ pwv=5mm)



(see "Anticipated SKA1 Science Performance", Braun+ 2017, SKA-TEL-SKO-0000818)

International & Swiss landscape

- Current facilities operating in B6 frequency range: JVLA, ALMA, e-MERLIN, ATCA, several single-dish observatories

- Upcoming facilities: ngVLA - highly ranked in US Astro2020 decadal survey, but NSF funding not yet secured (full science in 2037?)

- B6 is not part of SKA1 deployment baseline (i.e. it's not funded), ODP is proposal-driven
  ➜ SKAO memo/white book on "SKA1 beyond 15GHz" (6 science areas; 35 example sci. cases; 131 pages)

- SERI support for SKACH in a constrained environment
  ➜ funding for hardware development will be easier to secure if backed up by strong community sci. interest

International & Swiss landscape

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International & Swiss landscape

ghz
emission
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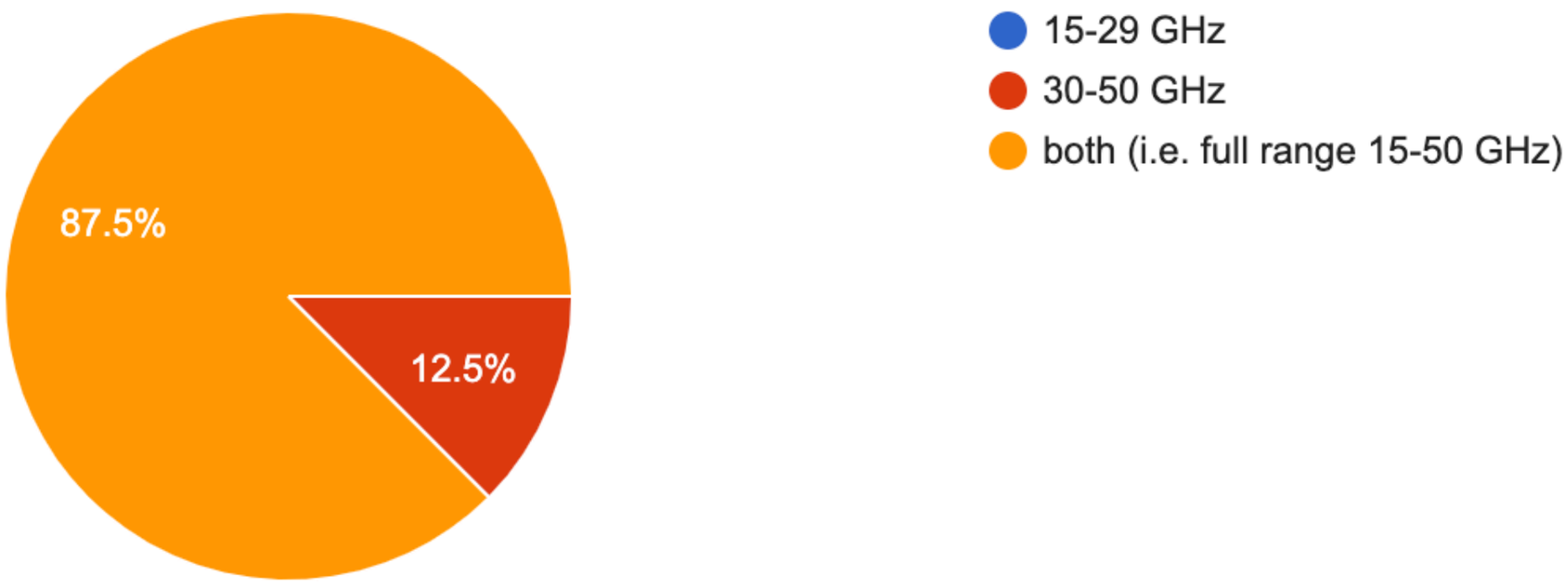
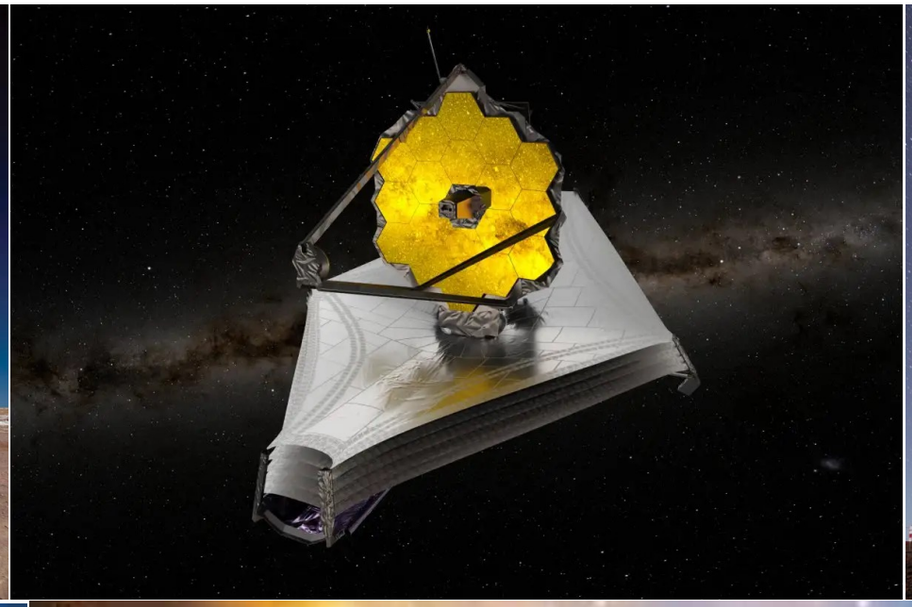
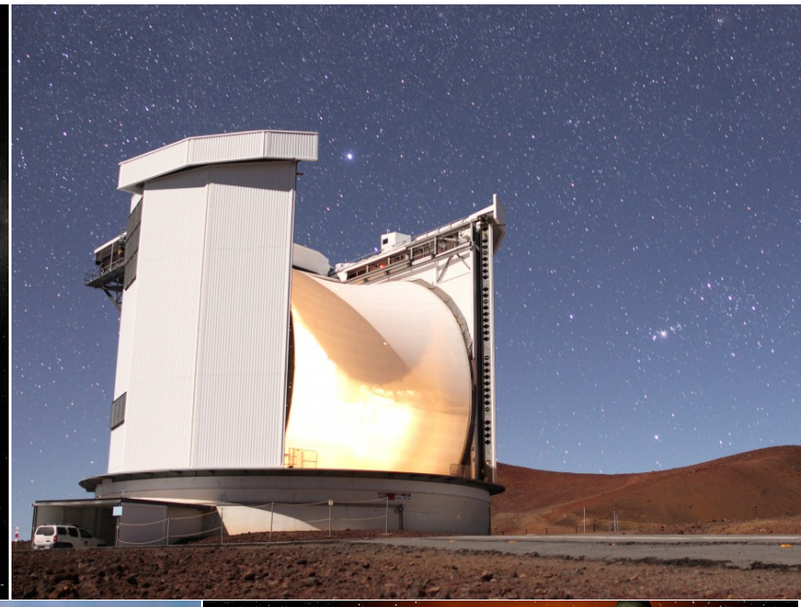
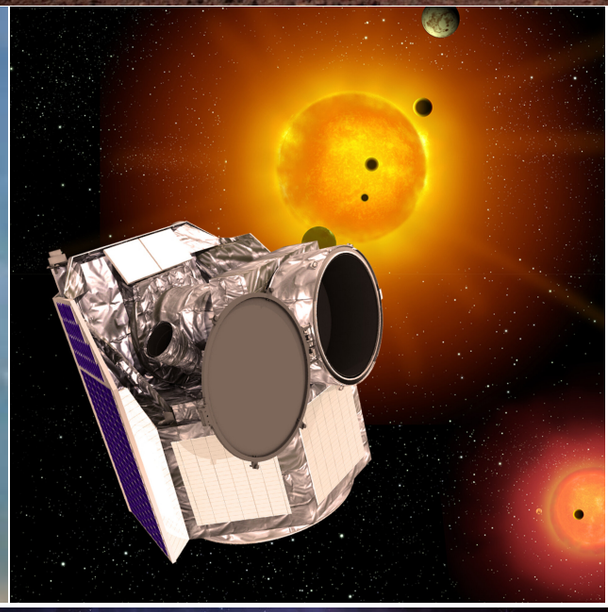
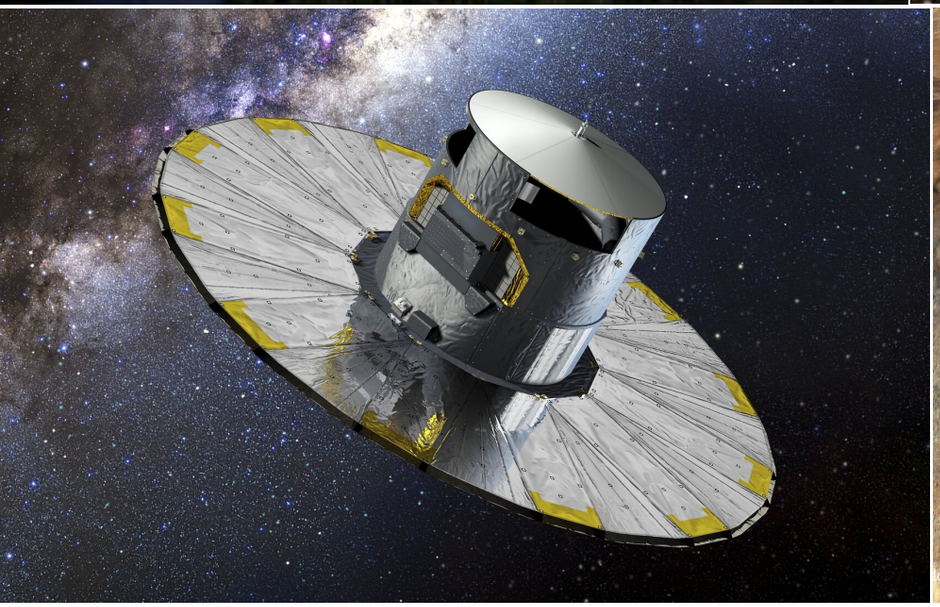
Band 6 science - SKACH community survey results

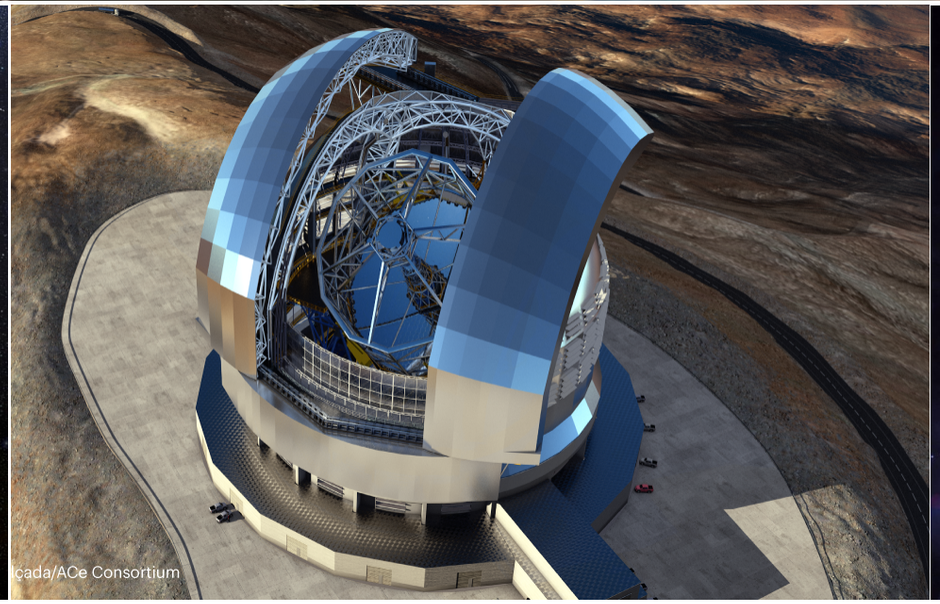








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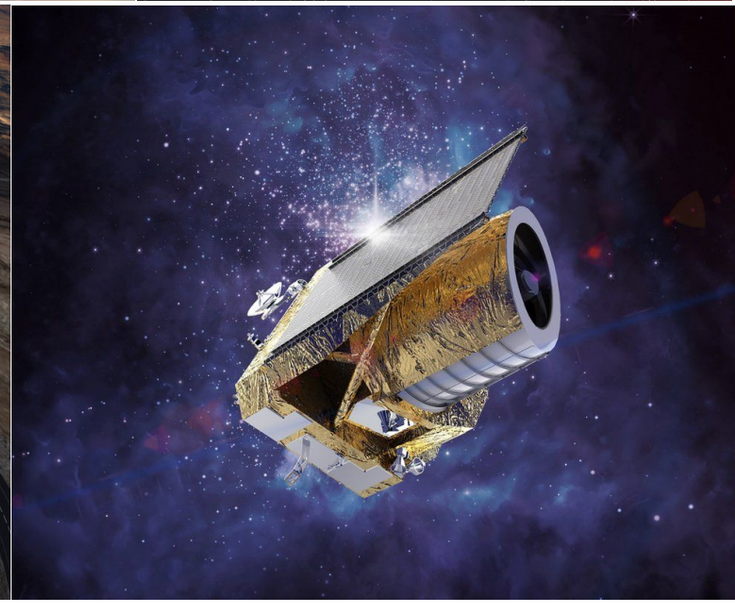

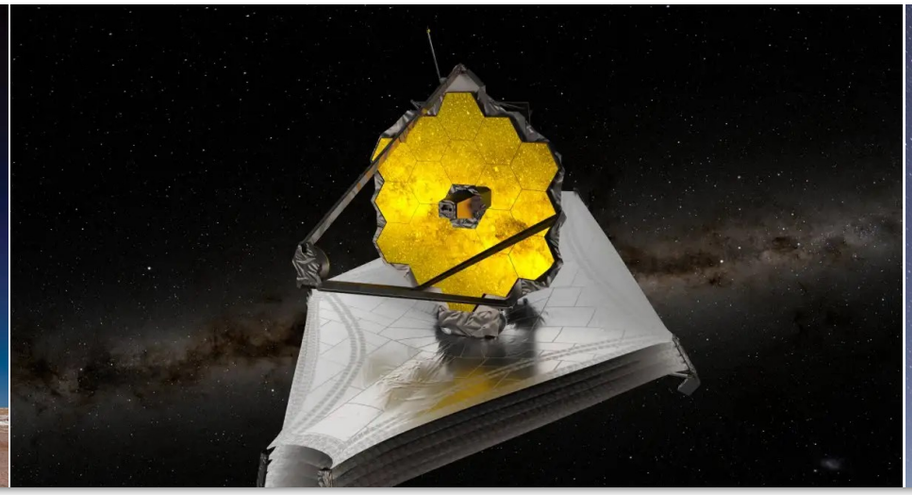

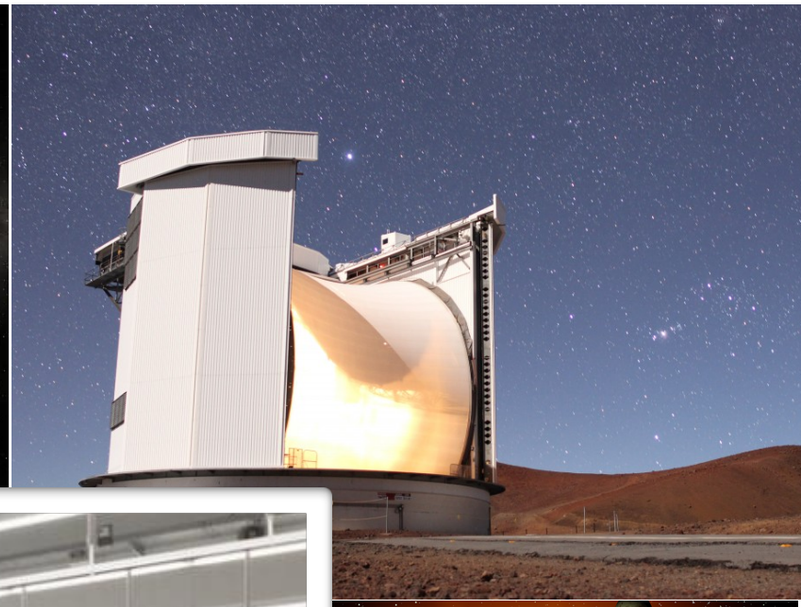

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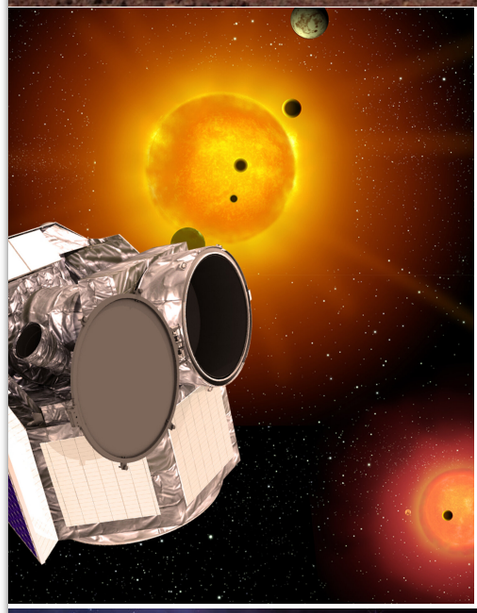

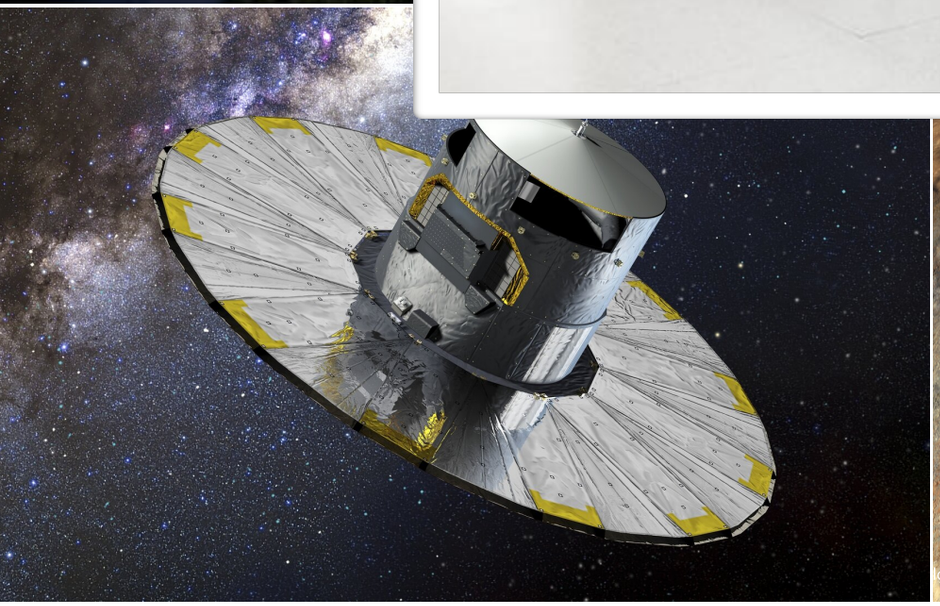

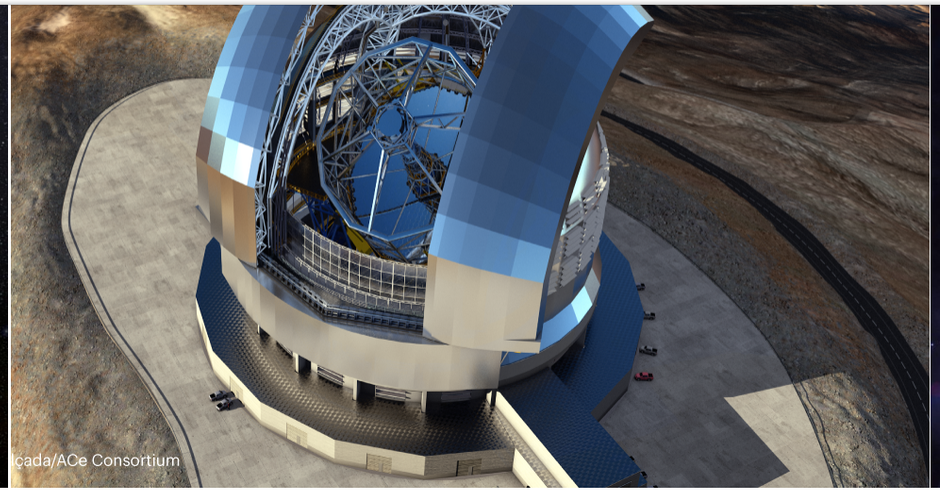
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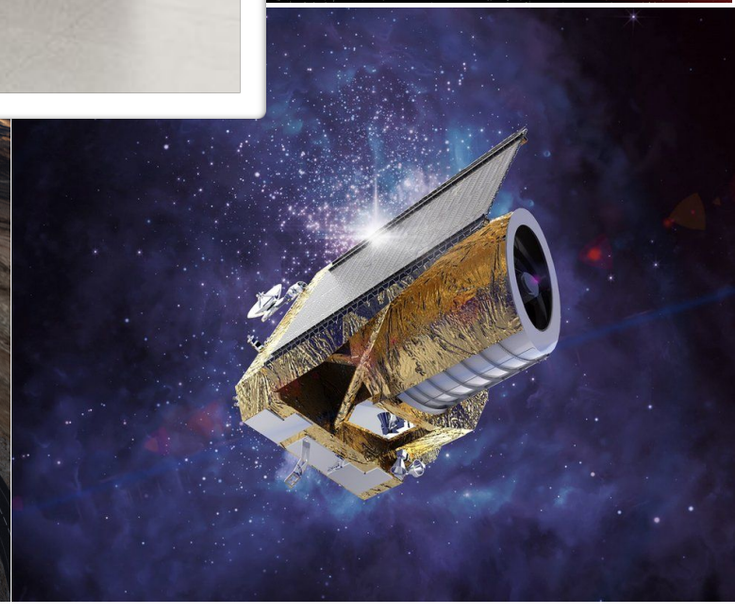
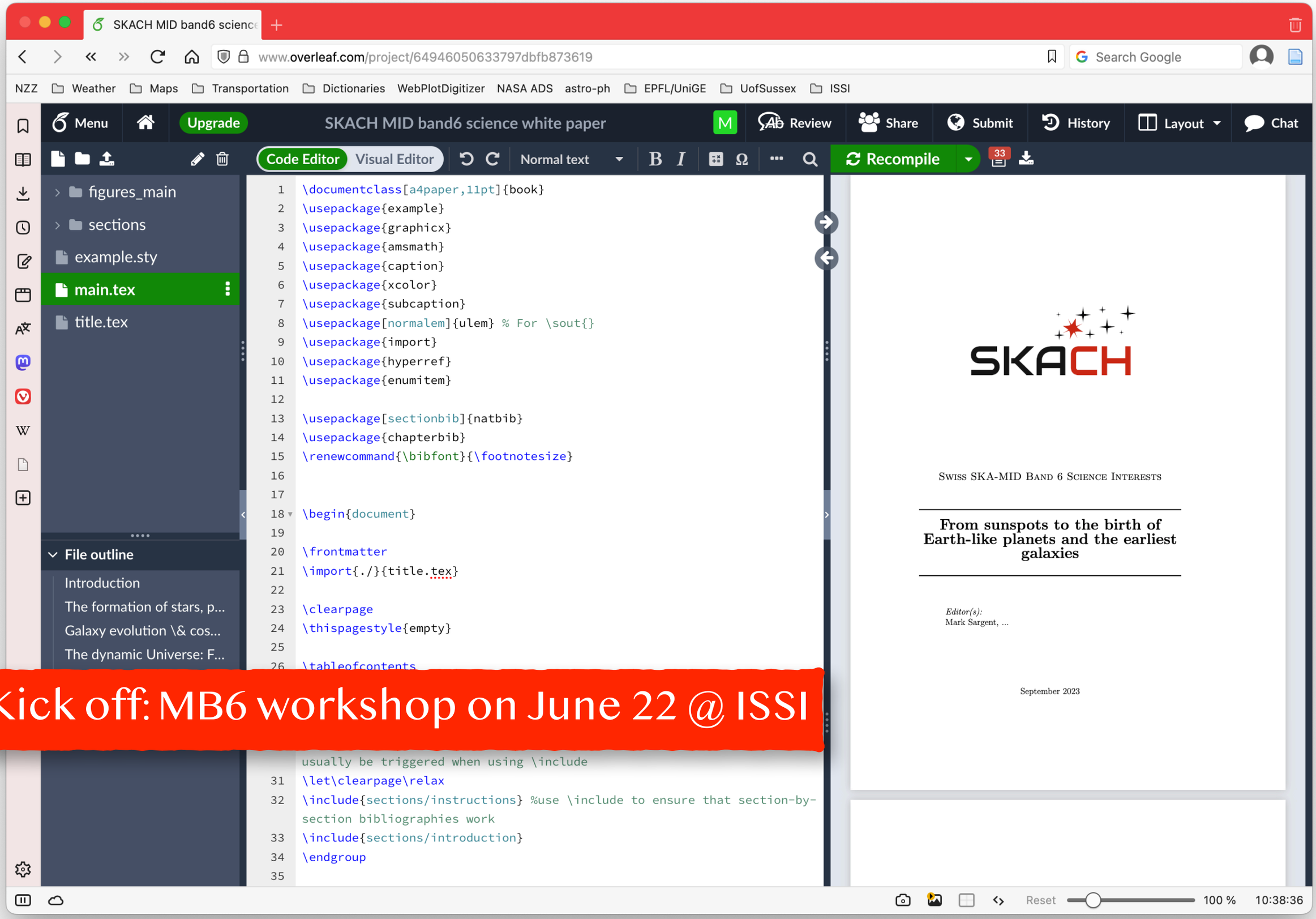


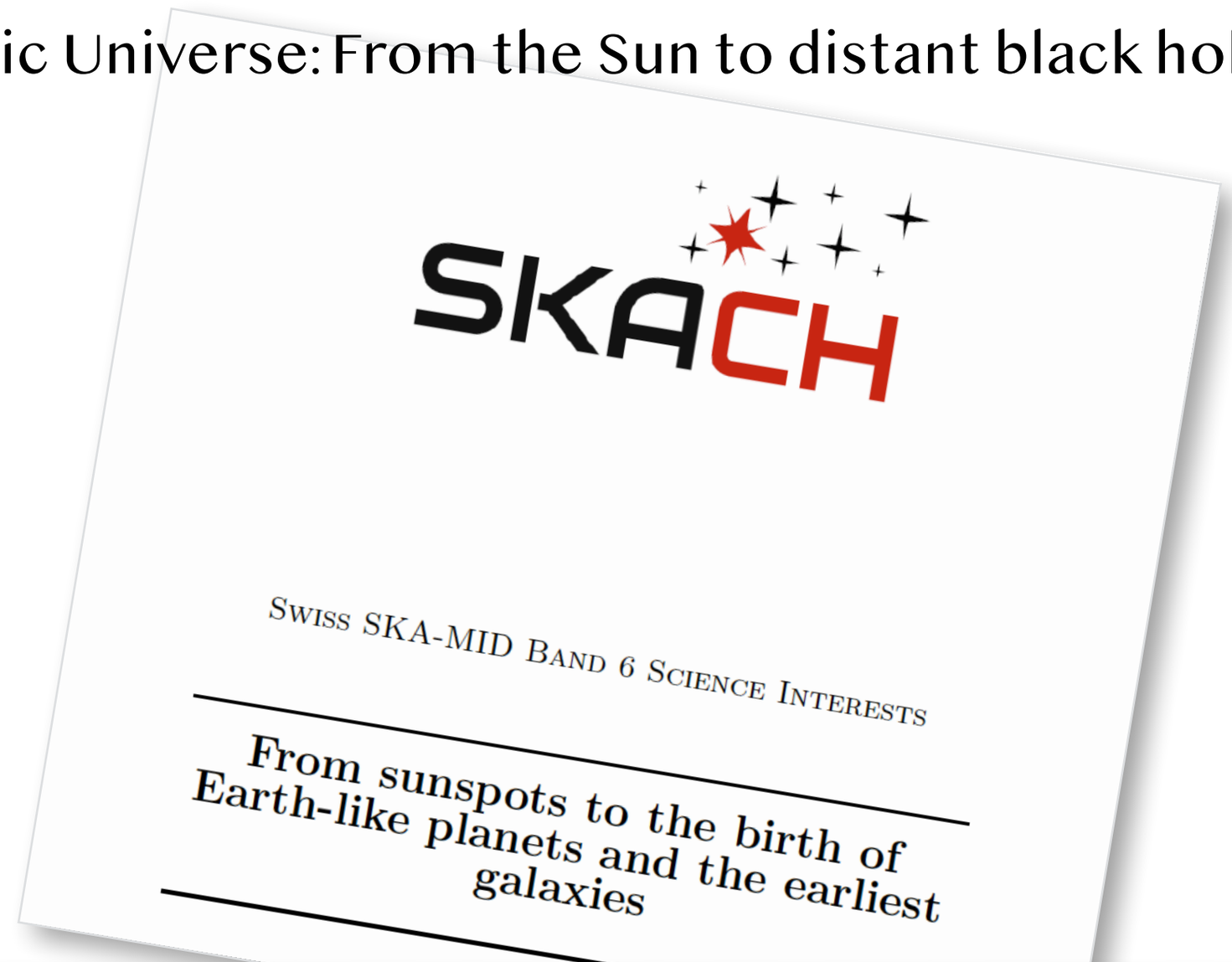
SKACH band 6 science white paper



Kick off: MB6 workshop on June 22 @ ISSI

SKACH band 6 science white paper

1. The formation of stars, planets and the building blocks for life
2. Galaxy evolution & Cosmology
3. The dynamic Universe: From the Sun to distant black hole mergers



currently 20+ science cases/topics proposed for inclusion

SKACH band 6 science white paper

1. The formation of stars, planets and the building blocks for life
   - Galactic star and planet formation
   - Exoplanets
   - Astrochemistry (➜ talk by Susanne Wampfler)
   - Morphology of asteroids & comets with bistatic radar
2. Galaxy evolution & Cosmology
3. The dynamic Universe: From the Sun to distant black hole mergers

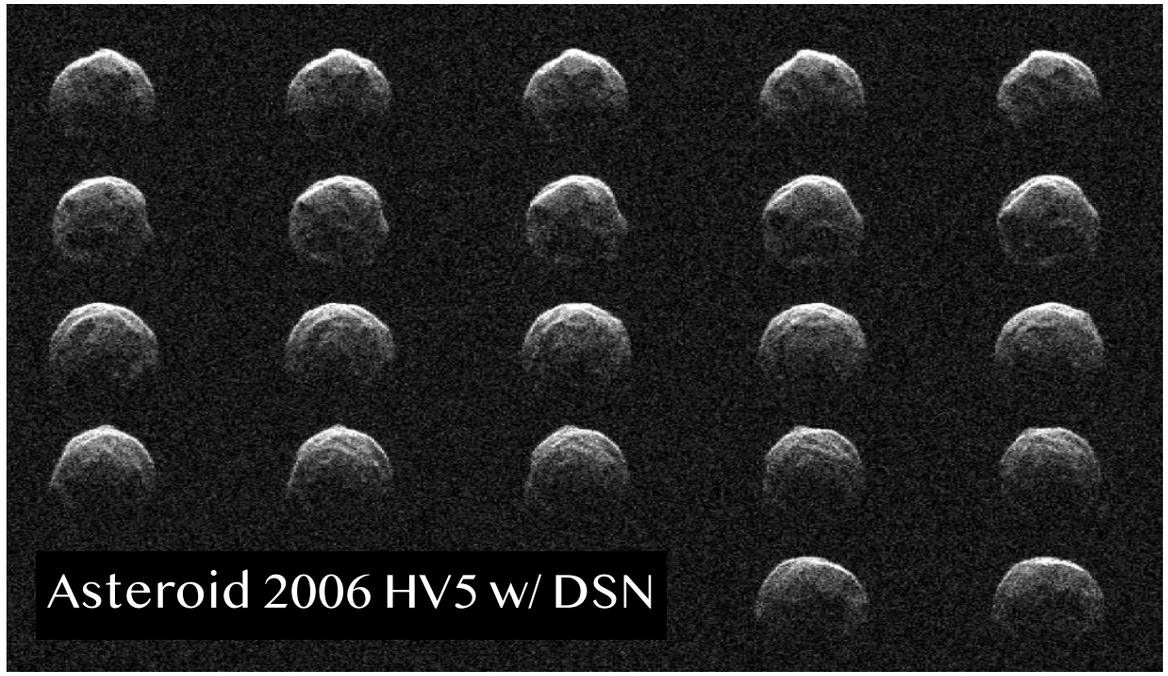
SKACH band 6 science white paper

1. The formation of stars, planets and the building blocks for life
2. Galaxy evolution & Cosmology
   - Star clusters in the Galactic Centre
   - Constraining feedback models with resolved molecular gas maps of galaxies at cosmic noon
   - Leveraging SKA sensitivity to overcome CMB contrast issues and trace cold gas in normal galaxies into the EoR
   - Redshift evolution of cold gas content in quiescent galaxies
   - Cosmological evolution of the H_2 mass density - a key constraint for galaxy formation theory
   - Are starbursts powered by high star-formation efficiency or simply gas-rich? Lessons from CO luminosity function evolution
   - The interstellar medium of galaxies and quasars in the first billion years
   - Radio SEDs as a tool for constraining galaxy astrophysics
   - Predictions for early-Universe galaxy continuum emission based on low-z EOR galaxy analogues
   - CO intensity mapping
   - Gravitational lensing
3. The dynamic Universe: From the Sun to distant black hole mergers

SKACH band 6 science white paper

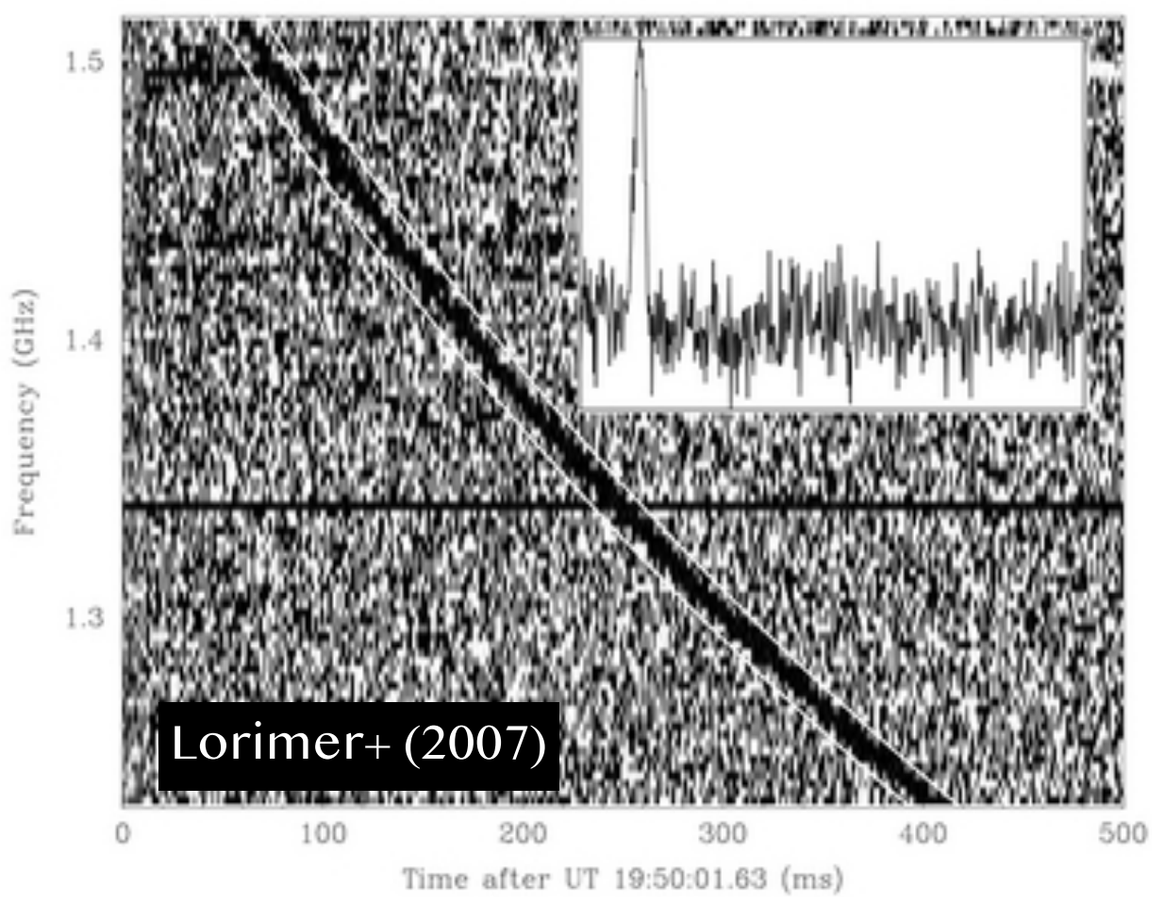
1. The formation of stars, planets and the building blocks for life
2. Galaxy evolution & Cosmology
3. The dynamic Universe: From the Sun to distant black hole mergers
   - The band 6 view of solar flares
   - Synergies between hard X-ray and high radio frequency observations of the Sun
   - Transients
   - Microlensing of FRBs
   - Gravitational wave detection via a ranging-to-Uranus-mission (➜ talk by Prasenjit Saha)
   - Gravitational wave to EM wave conversion in pulsar magnetospheres

Recent potential additions to SKACH white paper



Planetary radar

Jones (MSSL/ISSI) & Sargent (ISSI)



FRB microlensing

Saha (UniZH) & Denzel (ZHAW)

Aims for this session

- Observatory viewpoints/updates (➜ talks by Tyler Bourke, Tony Mroczkowski)
- Give visibility to further B6 science cases (➜ talks by Susanne Wampfler, Prasenjit Saha)
- Identify new science cases
- Explore joint science interests with extra-CH community
- Gauge community desire for a WSPF vs. “standard” SPF Conceptual and quantitative input to MB6 instrument development (➜ MB6 instrumentation session this afternoon)

Summary

- Swiss scientists have a strong track record in many of the astrophysics fields where a B6 observing capability would add value (e.g.: astrochemistry, gravitational lensing, gravitational wave physics, planet formation, solar physics, star-formation in high-z galaxies)

- SKACH B6 science white book aims to expand/quantify relevant science cases outlined in SKAO memo 20-01, and outline new use cases inspired by specific Swiss science interests.

- Write-up of science cases on-going, with aim to conclude by end of 2023. Continuing engagement with further potentially interested parts of the CH science community. (More contributions welcome!)

- Effort is based on most recent performance estimates and aims to provide direct input for instrumentation needs/development.

Links

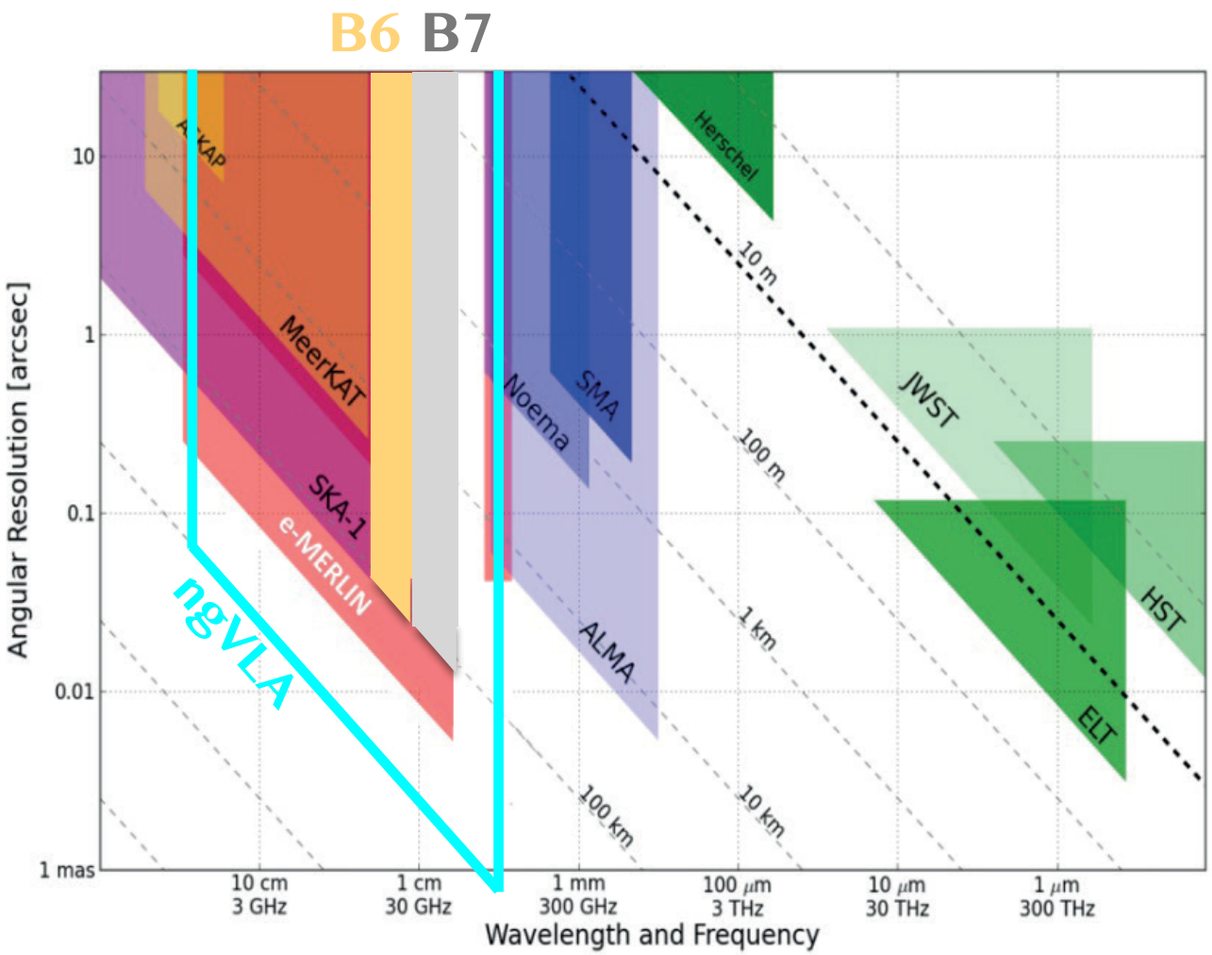
- White book "SKA1 Beyond 15GHz: The Science case for Band 6" (SKA memo 20-01)
- ngVLA science book: https://ngvla.nrao.edu/page/scibook

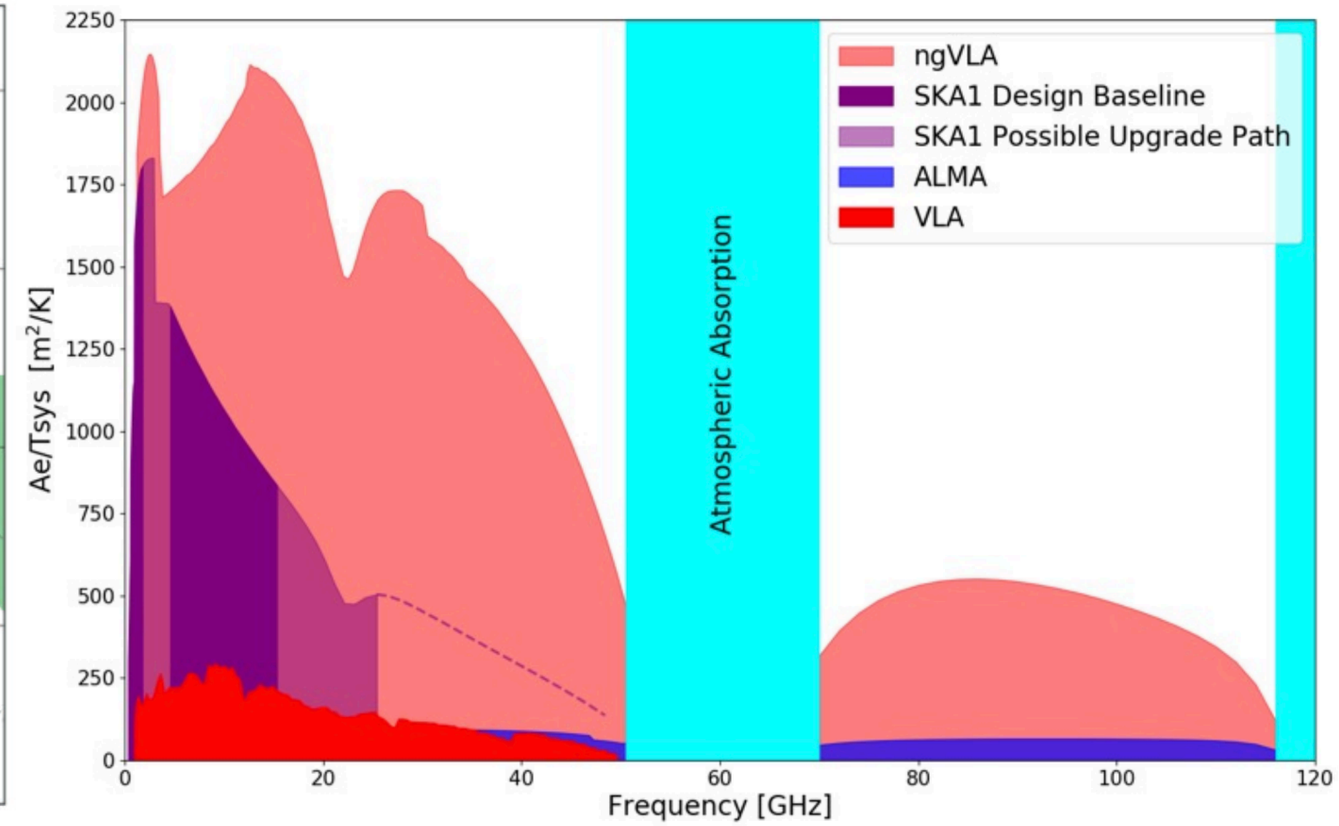
- Swiss SKA white book
- SKACH slack channel: #mb6-receiver-science-cases

- B6a/b sensitivity primer (see QR code ➜)

Back-up

Other show in town: ngVLA





- 1.2-116 GHz
- Hardware optimised for ~30 GHz, higher elevation
- Northern hemisphere
- Full science ~3037?

Emission mechanisms/sources underpinning B6 science

Lines

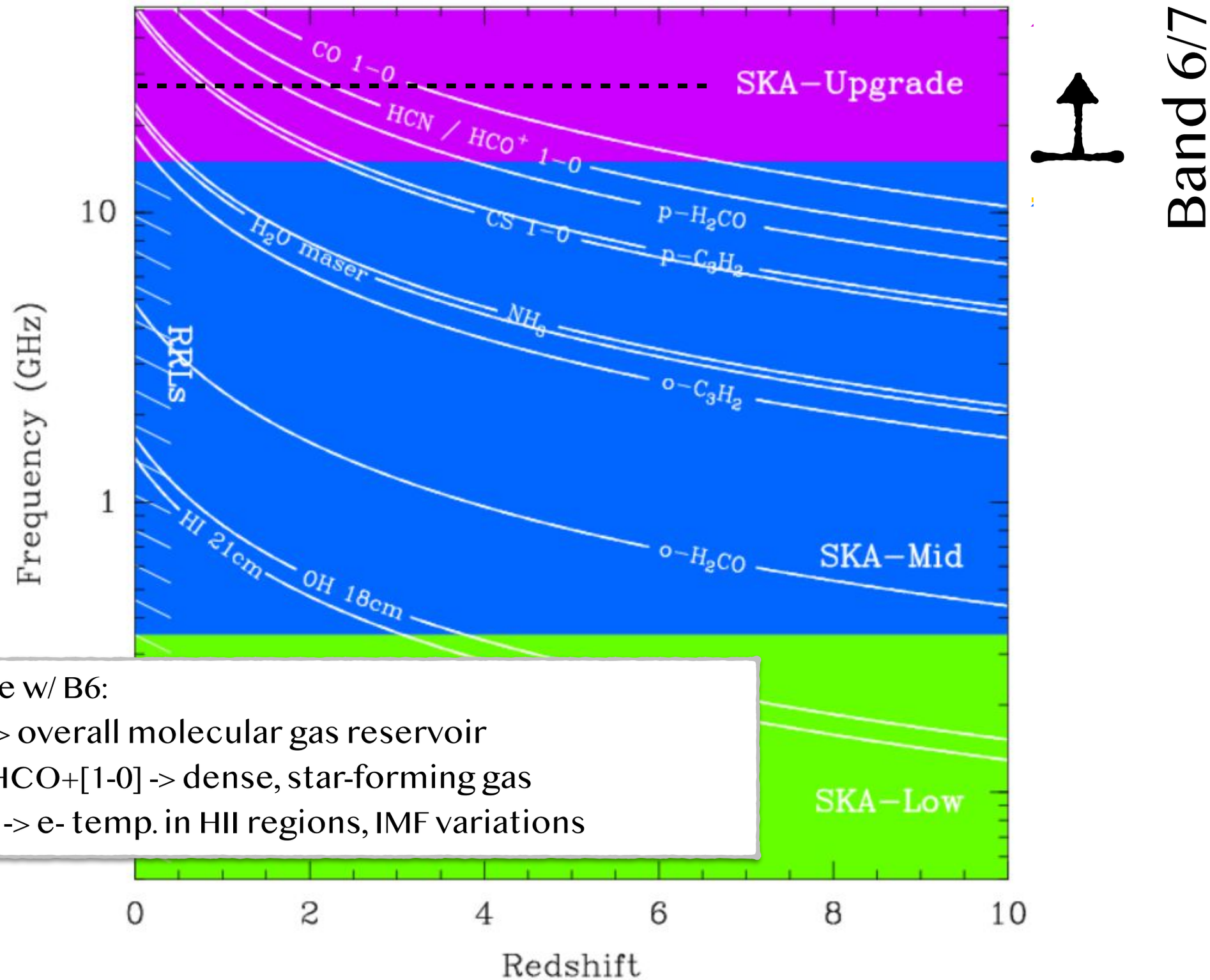
- Exgal.:
  - redshifted cold/dense molecular lines
  - (mega-)masers
  - …
- Galactic:
  - masers
  - organic/prebiotic molecules
  - dense gas tracers
  - …

Continuum

Exgal.:
- Star-formation (HII regions): thermal emission
- Spinning Dust: anomalous microwave emission
- AGN
- clusters (S-Z effect)
- …

Galactic:
- proto-planetary disks (cm-sized and smaller particles)
- …

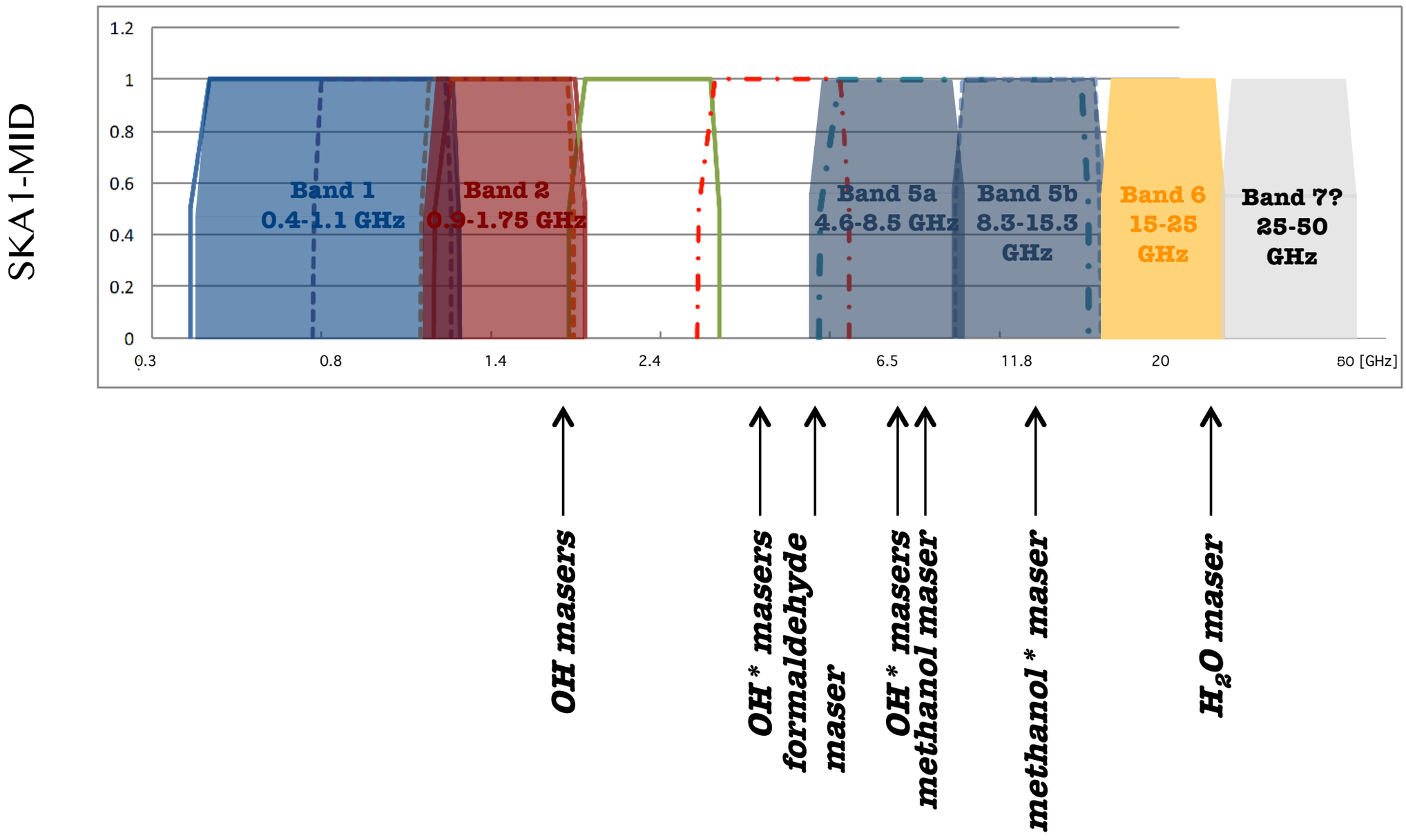
Did you know? - Cosmic star-formation history



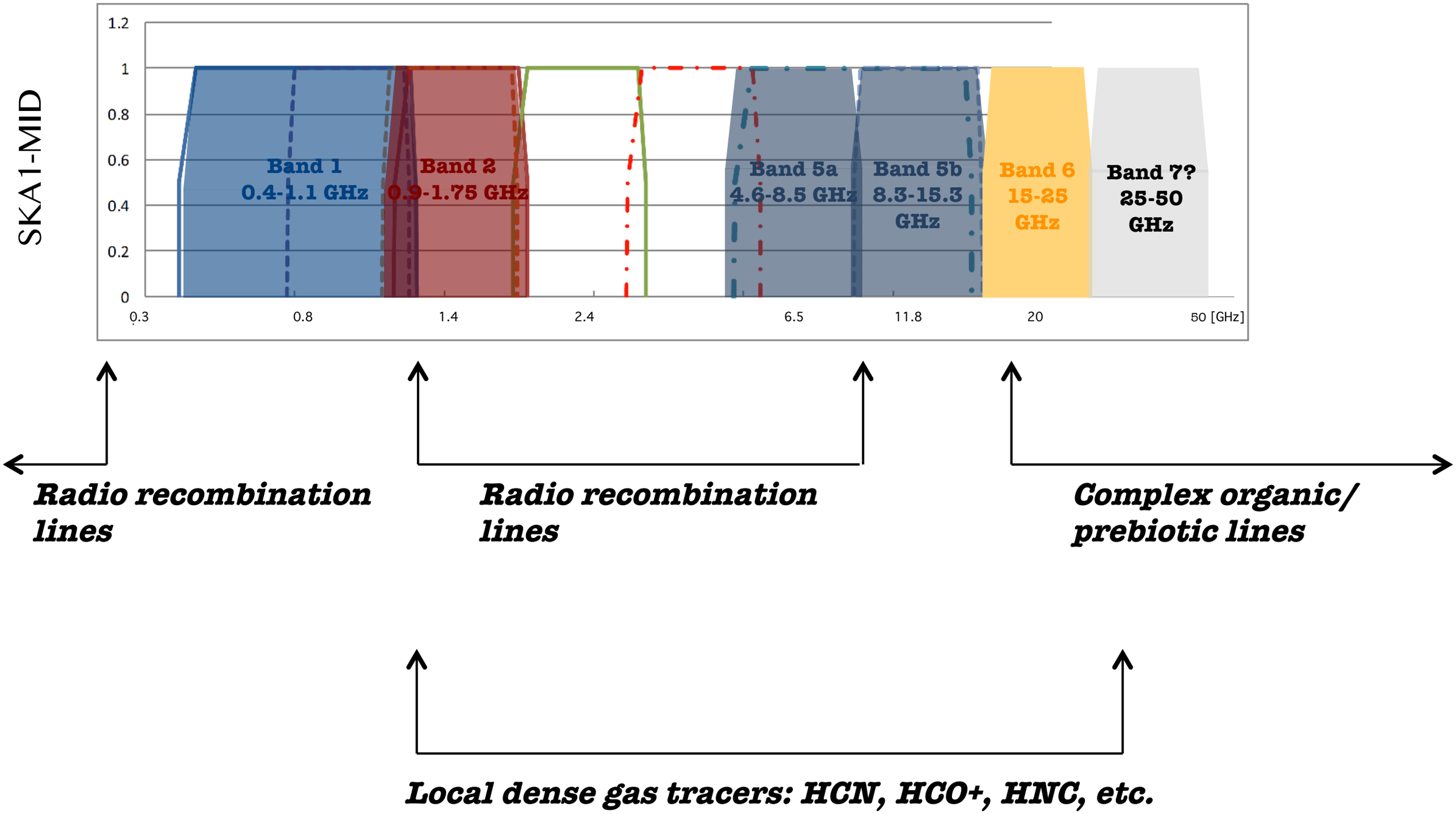
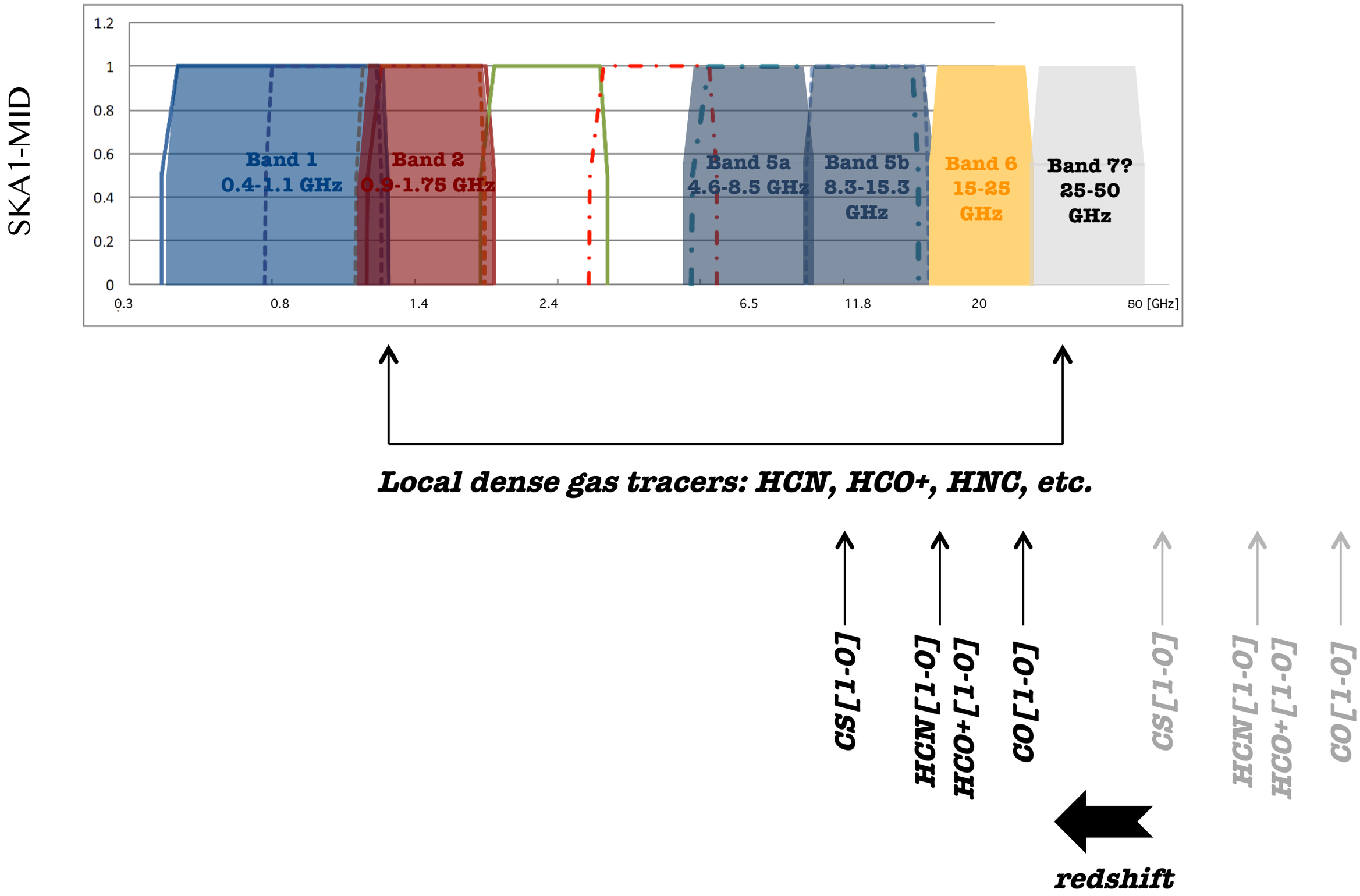
CSFH science w/ B6:

- ^{12}CO[1-0] -> overall molecular gas reservoir
- HCN[1-0], HCO+[1-0] -> dense, star-forming gas
- ^{12}CO/^{13}CO -> e- temp. in HII regions, IMF variations

Emission mechanisms/sources underpinning B6 science



Emission mechanisms/sources underpinning B6 science



Emission mechanisms/sources underpinning B6 science