

A large radio telescope dish is the central focus, with several other smaller dishes visible in the foreground and background. The background is a dark sky filled with the Milky Way galaxy, showing its characteristic spiral arms and star fields. The overall scene is illuminated by a soft, ambient light, possibly from the setting or rising sun, creating a gradient from dark blue to a lighter, hazy glow near the horizon.

Milky Way SKA: the ISM, star formation and stellar evolution with the SKA

Mark Thompson, Grazia Umara, Naomi McClure-Griffiths, Laurent Loinard, Gary Fuller, Guillem Anglada, Sergio Molinari, Raymond Oonk and the Our Galaxy SWG

Our Galaxy SWG

First meeting at Leiden, May 2014
≈ 50 participants

Outcomes: The potential of SKA to make a tremendous impact on many key areas in the physics of the ISM, the early lives of stellar clusters, and stellar evolution.

Strong support to try and form a Galactic Science Working Group

Lorentz
center

Galactic Science with the SKA & Its Pathfinders

Workshop: 19 – 23 May 2014, Leiden, the Netherlands

Scientific Organizers

- Huib Van Langevelde, JIVE Dwingeloo / Leiden U
- Mark Thompson, U Hertfordshire

Scientific Advisory Committee

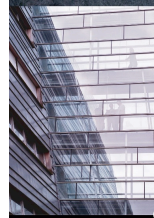
- Sharmila Goedhart, HartRAO / SKA-SA
- Melvin Hoare, U Leeds
- Steven Longmore, LJMU Liverpool
- Naomi McClure-Griffiths, CSIRO Sydney
- Floris van der Tak, SRON Groningen / U Groningen

Invited Speakers

- Tyler Bourke, SKA Organisation
- Andreas Brunthaler, MPIfR Bonn
- James Green, SKA Organisation
- Marijke Haverkorn, Radboud U / Leiden U
- Justin Jonas, SKA-SA/Rhodes U
- Laurent Loinard, UNAM Mexico
- Josh Peek, Columbia U
- Anna Scaife, U Southampton
- Grazia Umata, OaPD-INAF
- Wouter Vlemmings, Chalmers UT

The Lorentz Center is an international center in the sciences. Its aim is to organize workshops for scientists in an atmosphere that fosters collaborative work, discussions and interactions. For registration see: www.lorentzcenter.nl

Artist's Impression of the MeerKAT array.
Poster design: SuperNova Studios, NL



Our Galaxy SWG

Mark Thompson

Grazia Umata

John Dickey

Simon Ellingsen

Sandra Etoka

Jan Forbrich

Gary Fuller

Ciriaco Goddi

Lisa Harvey-Smith

Hiroshi Imai

Doug Johnstone

Gilles Joncas

Pamela Klaassen

Roland Kothes

Huib Jan van Langevelde

Francois Levrier

Bin Liu

Steve Longmore

Laurent Loinard

Naomi McClure-Griffiths

Sergio Molinari

Joseph Mottram

Hiroyuki Nakanishi

Raymond Oonk

Jill Rathborne

Michael Rupen

Kazi Rygl

Gregory Sivakoff

Ian Stevens

Jeroen Stil

Firoza Sutaria

Kengo Tachihara

Corrado Trigilio

Serena Viti

Wouter Vlemmings

Andrew Walsh

Albert Zijlstra

Good coverage in expertise as well as
In Nationality

Many of those people involved
in pathfinder projects

LOFAR, ASKAP and MeerKAT

Our Galaxy:

Wrap-up of the meeting

OUTCOMES:

The BIG PICTURE with several scientific outcomes

plus:

Several KSPs and Focus follow-up cases carried out by a team (TBD) consisting of people coming from different SWGs, some already defined, some in preparation, others just in the “*brain storming mode*”

Via:

Synergies/discussions/meeting with Cradle of Life

Magnetism

HI

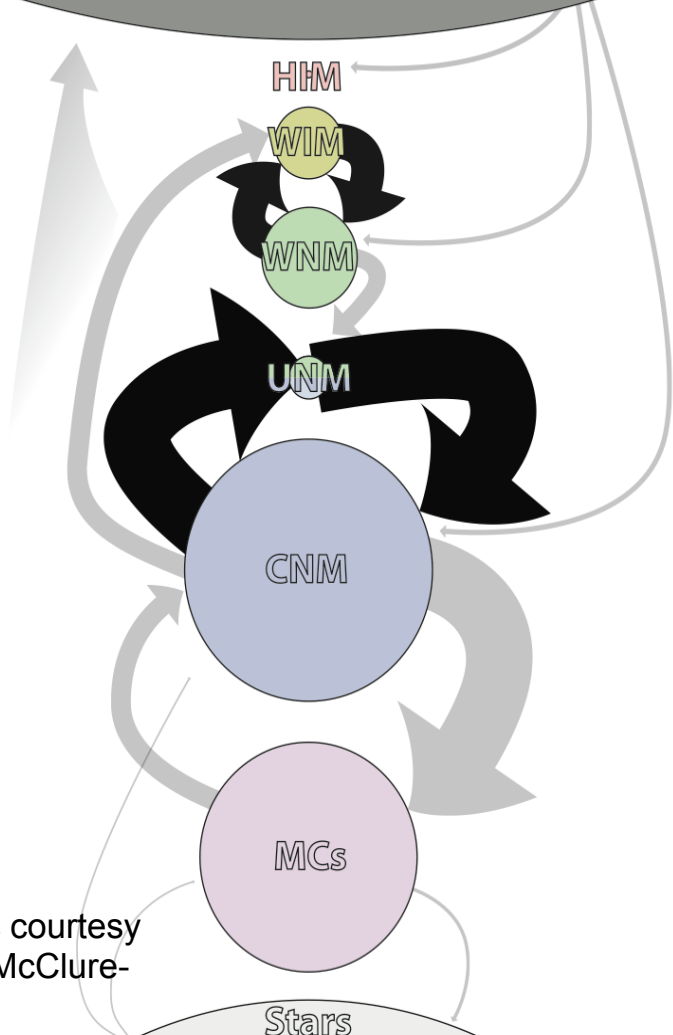
(non) HI spectral line

Continuum

Transients

The BIG PICTURE: Uncovering the ecology of baryons

Circum-Galactic Medium



How do galaxies work?

What is the flow of material from & to the Circum-Galactic Medium, the Interstellar Medium and stars?

What powers the ionisation of the Warm Ionised Medium?

How do molecular clouds form?

What is the relation between molecular clouds and star formation “laws”?

How do stars drive turbulence & energy into the ISM?

What can the structure of stellar clusters tell us about star formation?

What is the SNR/PNe formation rate in the Milky Way?

The SKA puts it all together

Circum-Galactic Medium

HIM

WIM

WNM

UNM

CNM

MCs

Stars

Thermal continuum from HII regions
Radio Recombination Lines

HI emission
HI absorption
HI tomography

H₂CO absorption
Thermal OH - CO dark gas

Thermal continuum from jets & winds
VLBI Tomography of young clusters
Stellar Radio HR diagram

THE BIG PICTURE: The planned Observations

Galactic Plane narrow spectral *

5–10 GHz & 10–15 GHz followup

0.1 K rms in 0.1 km/s (line)

~0.4 μ Jy rms continuum

-70 < l < +60 |b| < 1

Main science driver spectral line:

RRL+H₂CO

Molecular gas volume density

Kinematics ionised gas

Galactic Plane wide continuum

5–10 GHz, 3 μ Jy rms (continuum)

-70 < l < +60 with |b| < 5

Galactic Bulge |b| < 10?

Main science driver continuum:

Accretion

Stellar evolution

from Cradle (YSO) to Grave (PNs etc)

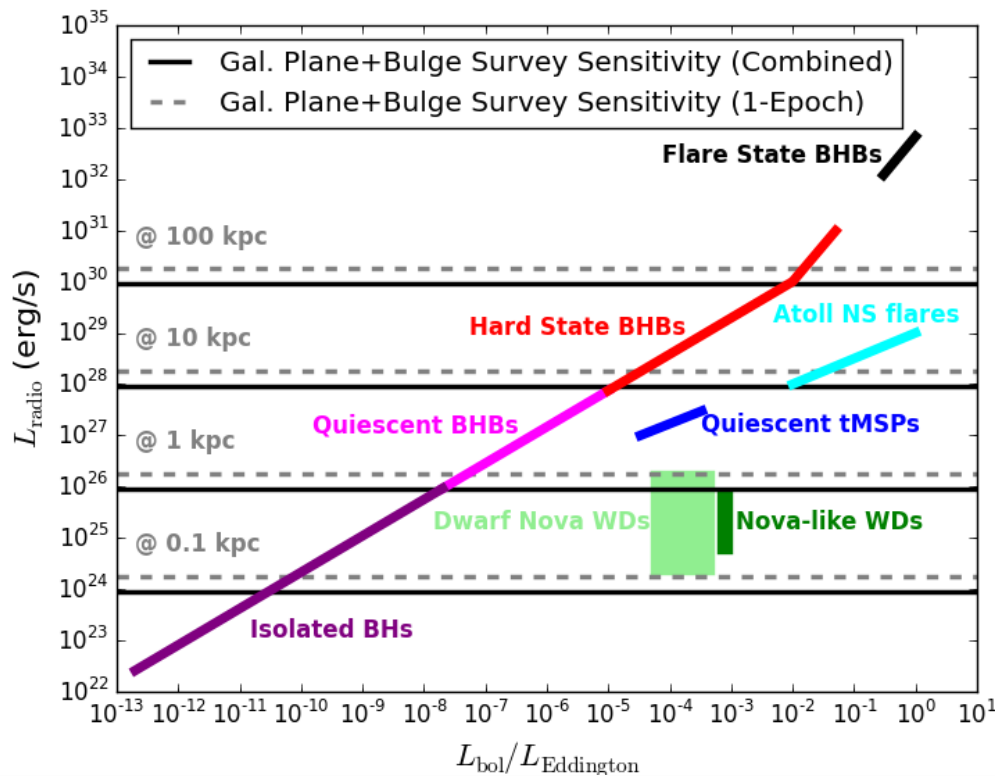


Narrow spectral ~ 1000 hrs

Wide continuum ~3300 hrs

* See Mark's Use Case on H₂CO

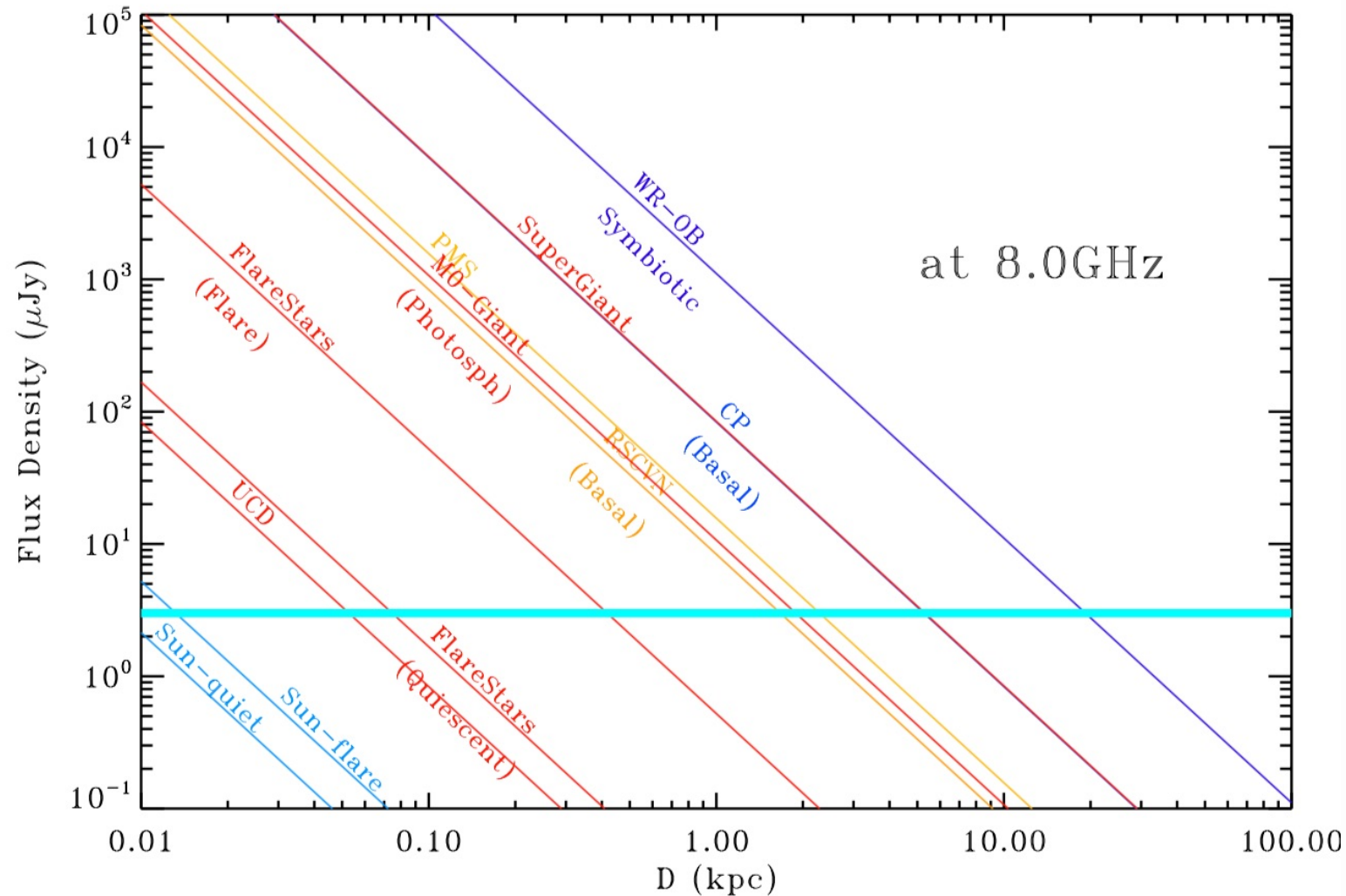
Tier 2 Accreting Compact Objects



Detect large numbers of accreting compact objects across wide ranges of mass accretion rate and compact object.

Wide implications for understanding the connected physics of accretion and outflow, as well as the evolution of binary systems.

Tier 2 Detections forecast: Radio Stars



Flaring Sun @ 10pc

OB-WRs @GC

KSP: Stars, planets and civilization

Synergies between Our Galaxy & Cradle of Life

-Magnetospheric emission from sample of nearby exoplanets with SKA1-Low (imaging, V & I or 4 Stokes)

12 hours per target, multi-epoch TBD
=> max sensitivity 50 (50–87.5 MHz) &
10 (300–337.5 MHz) microJy

- merge with a wider study of star-object interactions such as sample of all nearby stars/ brown dwarfs/ low-mass stars/ white dwarfs/ etc. (Our Galaxy)

Survey on stars with known planets (hot Jupiter?)

- Check the presence of aurorae due to star-object interaction
- Possibly also MID (band 1 and/or 2) as frequency of emission is function of Stellar B
- Need high temporal resolution (1min)

Exoplanets:

Synergies between Our Galaxy & Cradle of Life



While searching for signature of a planet...

- ✓ Study the radio coronae
- ✓ Radio flares (multi-epoch observations, high temporal resolution)
typical behaviour (occurrence rate, duration..)
- ✓ Comparison with solar-type magnetic activity
- ✓ Evidences for rotational modulation of radio emission

Need: **full census of stars with planets**; infos on B of host stars if available
full census of nearby stars (test completeness of samples, spectral type,
mass distribution infos at other wavelenghts)

KSP: Nearby young stellar clusters

Nearby clusters Band 5:

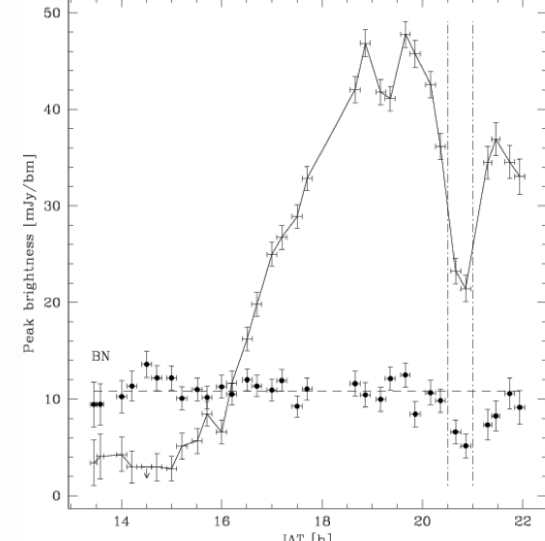
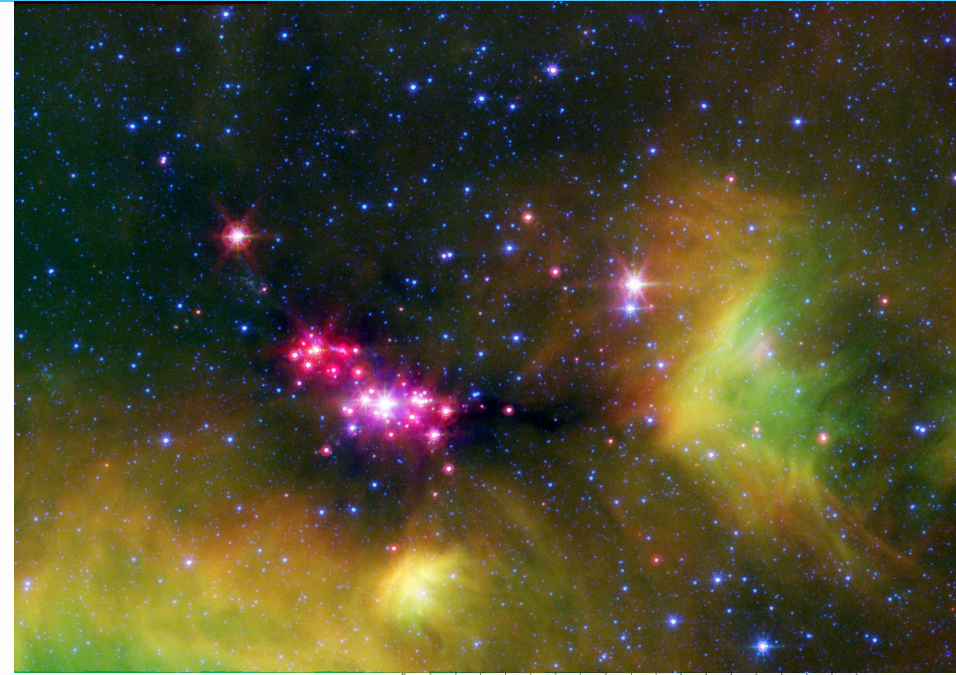
5 GHz continuum variability study
over ~1 yr

Combined with VLBI epochs for
parallax & proper motion

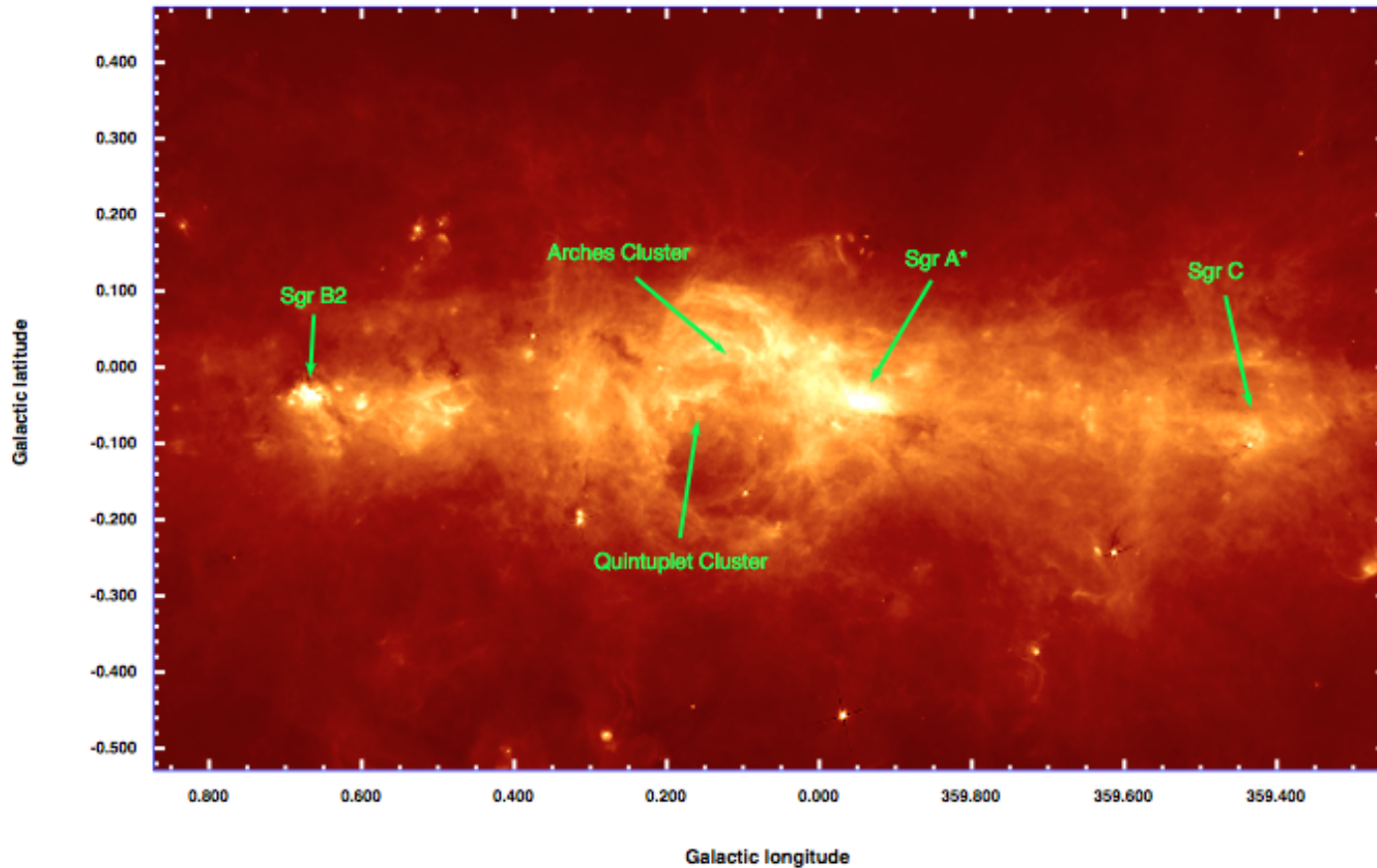
~10 clusters, ~100 hr per cluster

Reveal YSO flaring mechanism,
proper motions constrain star formation models

Commensal with Cradle of Life KSP
on grain growth evolution



KSP: The Galactic Centre



Galactic Centre Bands 2&5:

- Thermal/non-thermal continuum from Galactic Centre clusters
- Recombination lines
- Possible synergy with CTA?

Synergies between Our Galaxy and Magnetism

All-sky Survey Band-2

Legacy Strong Lensing (rare populations)	~1 GHz Band 2	All-sky	4 uJy	31000 deg ²	~2" 0.5"	Magnetism Cosmology tests Transients (beam forming) HI surveys Our Galaxy
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The all-sky will include the GP and it will be a complementary survey @band 2 for:

-spectral index infos

to disentangle between thermal and non-thermal Galactic sources

-Full stokes information

B and for picking up coherent events and gyrosynchrotron flaring stars
(strong V polarization)

NOT exhaustive list....

Discussion already started

CONTACT POINTS –already individuated

KSPs: To be discussed...

Expertise not at this meeting/commensality yet to be explored...

Band 2 survey of the Galactic Plane:

Wide view of Plane required for HI and RRLs (~10 degrees in latitude?)

Required for the big picture!

Non-thermal continuum – synergy with Band 5 survey

Thermal OH for CO-dark gas?

Could be done commensally with pulsar Galactic Plane survey...?

Carbon Recombination lines with SKA-Low

Tracer of diffuse ISM (density, electron temperature, pressure, WNM/CNM fraction...)

Galactic Plane survey? High latitudes?

Commensality/complementarity with EoR?

Open issues for discussion that we identified

- Zoom modes and underlying continuum resolution
 - not more channels but more wisely placed for narrow & broad-band spectroscopy
- Commensality between imaging & non-imaging modes?
 - Zoom modes?
- “All-Sky” Band 2 surveys – how commensal can they be?
 - Depth, resolution, zoom modes, etc?

