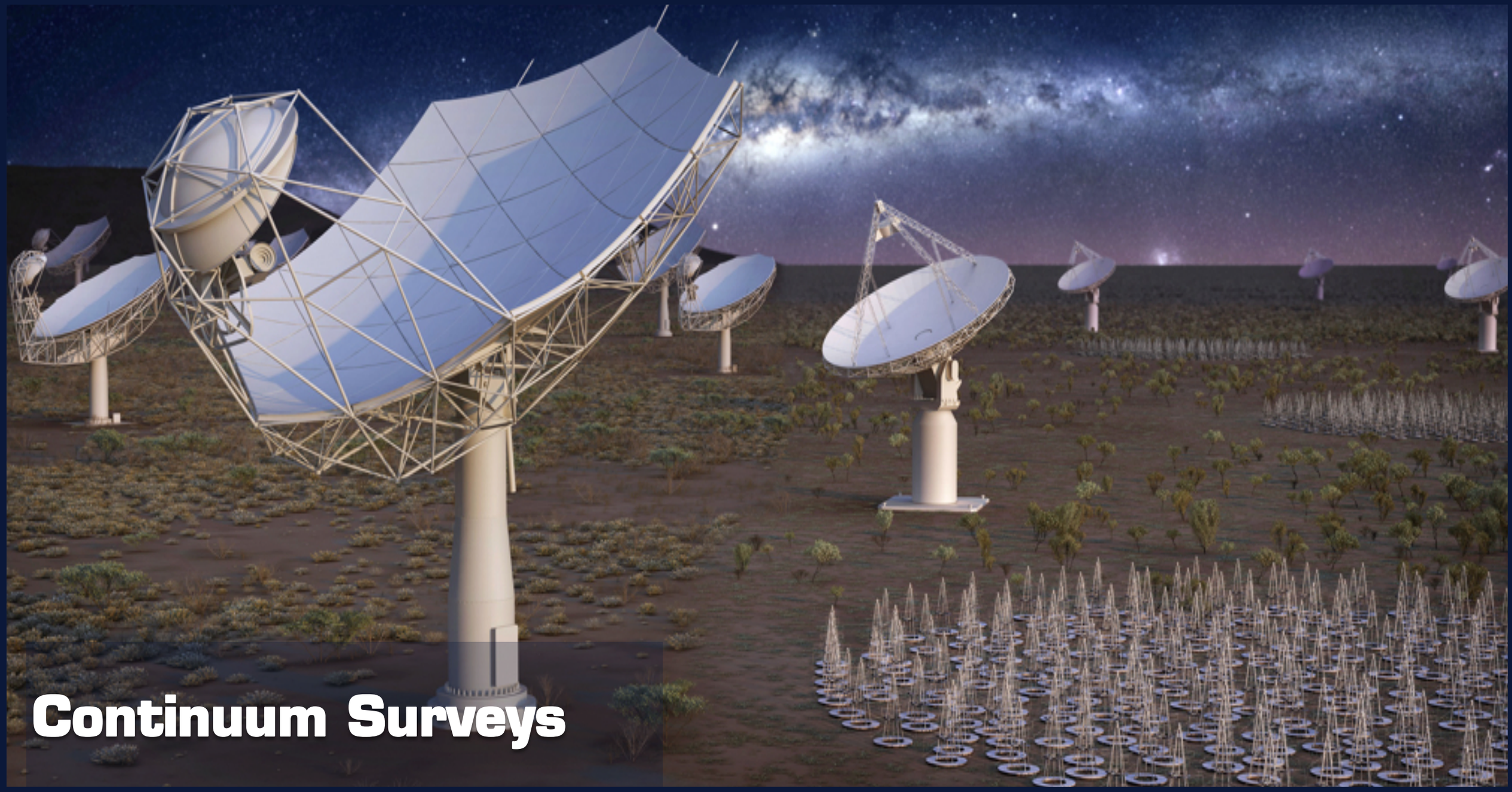


Continuum Surveys

C. Ferrari

on behalf of the SKA Extragalactic Continuum SWG

The Extragalactic Continuum SWG

- ~110 scientists (15 core group) from 20+ countries (SWG chairs: N. Hurley-Walker, M. Sargent)

  Full list: https://astronomers.skatelescope.org/science-working-groups/galaxy-evolution-continuum

- 5 scientific focus groups:
  A. Star formation history of the Universe (coordinators: M. Jarvis, M. Sargent)
  B. Active Galactic Nuclei and Their Role in Galaxy Evolution (coordinators: I. Prandoni, D. V. Lal)
  C. Galaxy Clusters and Large Scale Structure (coordinators: R. Cassano, C. Ferrari)
  D. Detailed Astrophysics of Star Formation and Accretion in Local Galaxies (coordinators: A. Alberdi, R. Beswick)
  E. Strong Lensing (coordinator: J. McKean)

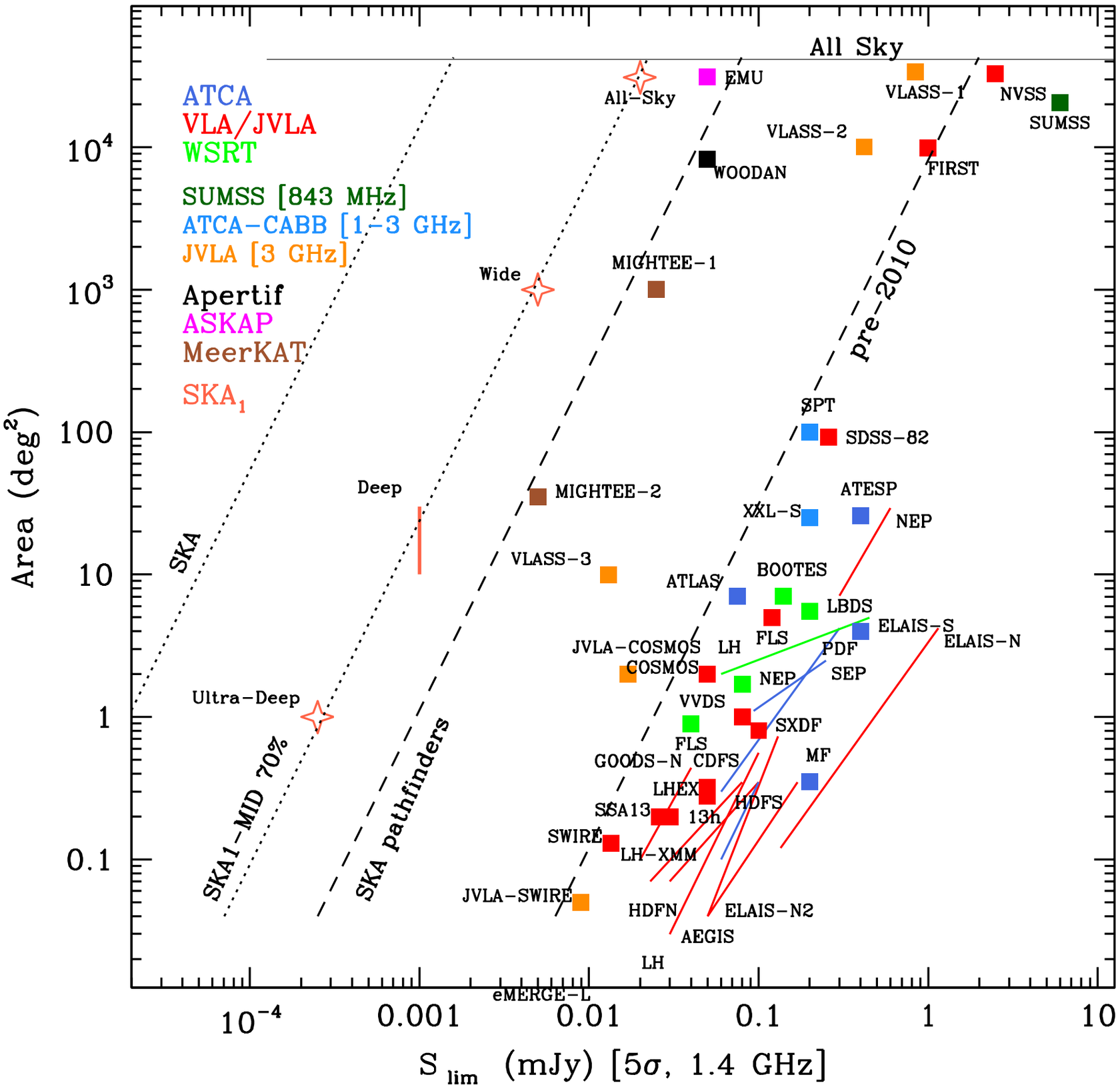
- 3 technical focus groups:
  F. Simulations (coordinator: A. Bonaldi)
  G. Source Extraction & Characterisation
  H. SKA1-LOW Data Analysis & Calibration

Slide courtesy: M. Sargent

Vacancies/potential new roles

- SDP contact
- Commensality champion?
- SRC champion?

An exquisite instrument for surveying the sky



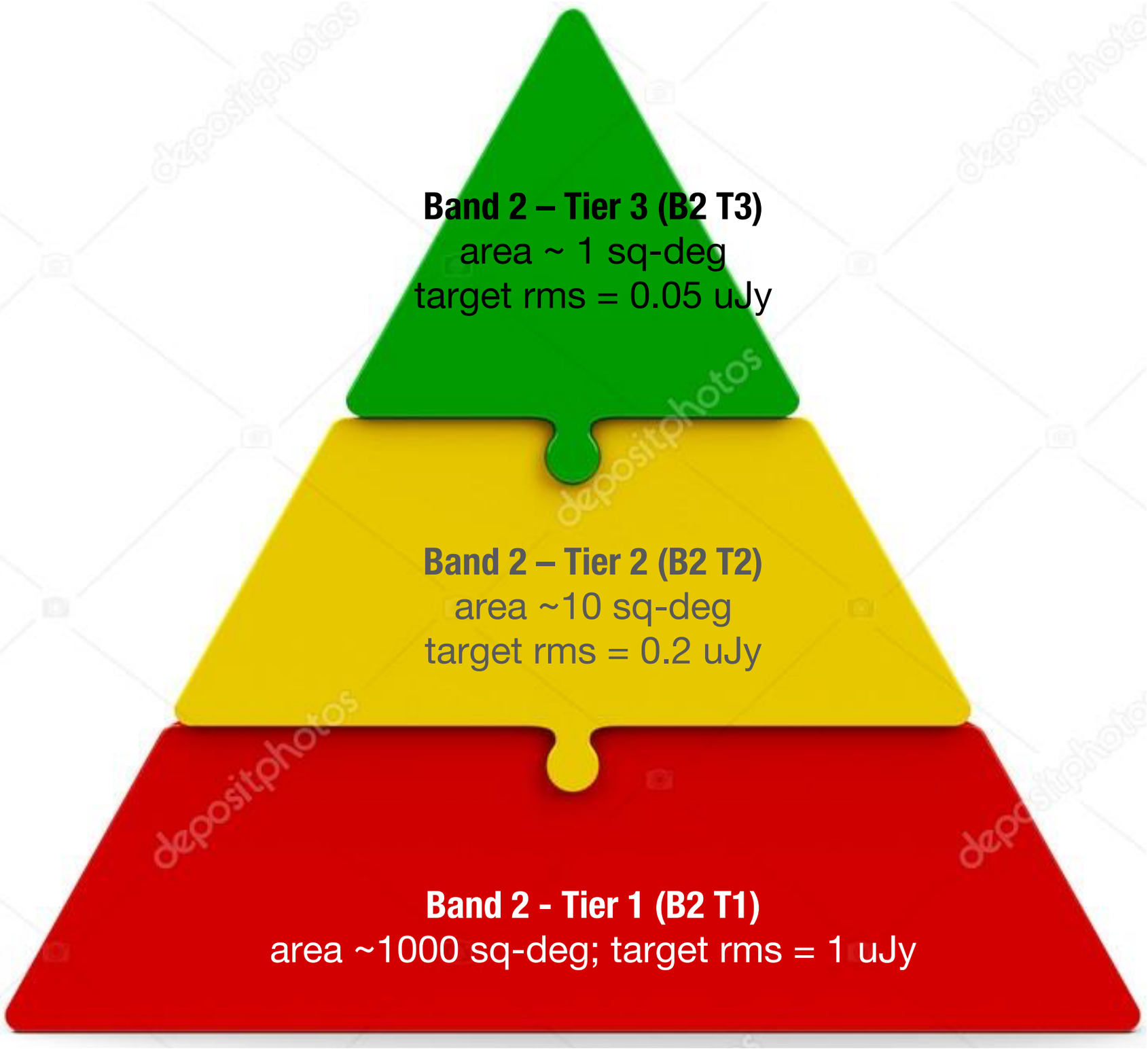
Prandoni & Seymour 2015

Continuum Surveys within SKA HPSO

Science Objective	SWG	High Priority Science Objective Number	Mode	Frequency	Observing Area		Integration		HPC					
				Range Low - High	Total Area	Angular Resolution Min:Max	Total (hr)	Per Pointing	B_Max (km)	sub-bands	Depth	PFlops	Fraction'	PF*Frac'
EoR - Imaging AASKA14:001	CD/EoR	1	**Imaging**	**50 - 200 MHz**	100 deg2	10:1000 arcsec	5000	2000 hr	65/40	Low 1-4	xl	648/ 336	0.156	101/52
EoR - Power Spectra AASKA14:001	CD/EoR	2	**imaging/Power Spectrum**	**50 - 200 MHz**	1000 deg2	10:1000 arcsec	5000	200 hr	65/40	Low 1-4	l	231/113	0.156	36/18
			imaging/Power Spectrum	**50 - 200 MHz**	10000 deg2	10:1000 arcsec	5000	20 hr	65/40	Low 1-4	m/l	175/88	0.156	28/14
Pulsar Searching AASKA14:040	Pulsars	4	**Non-Imaging**	**150 - 350 MHz**	30000 deg2	320 arcsec	12750	40 mn	1	Low 4-6	s/m	1	0.398	0.40
			Non-Imaging	**650 - 950 MHz**	2400 deg2	105 arcsec	800	10 mn	1	Mid 3	s	1	0.009	0.01
			Non-Imaging	1250 - 1550 MHz	2400 deg2	60 arcsec	2400	10 mn	1	Mid 5	s	1	0.028	0.03
Pulsar Timing AASKA14:037	Pulsars	5	**Non-Imaging**	**150 - 350 MHz**	0.9 arcmin2	8 arcsec	4300	40 mn	1	Low 4-6	s/m	1	0.134	0.13
			Non-Imaging	**950 - 1760 MHz**	0.7 arcmin2	7 arcsec	1600	15 mn	1	Mid 4-5	s	1	0.019	0.02
HI - High z AASKA14:128	HI	13	**Imaging**	790 - 950 MHz	5.4 deg2	3:5 arcsec	5000	1000 hr	50	Mid 3	xl	247	0.058	14.29
HI - Low z AASKA14:129	HI	14	**Imaging**	1300 - 1400 MHz	3.8 deg2	3:5 arcsec	2000	200 hr	50	Mid 5	l	63	0.023	1.46
HI - Galaxy AASKA14:130	HI	15	**Imaging**	1415 - 1425 MHz	1080 deg2	5:60 arcsec	12600	4.4 hr	50	Mid 5	m	17	0.146	2.48
Transients - FRB AASKA14:055	Transients	18	**Non-imaging/ Commensal**	650 - 950 MHz	30000 deg2	105 arcsec	10000	2 msec	1/150	Mid 3	s	36	0.116	4.17
CoL - Planet formation AASKA14:117	Cradle of Life	22	**Imaging**	**8 - 12 GHz**	0.05 deg2	0.04:1 arcsec	6000	600 hr	150	Mid 11-12	xl	42	0.069	2.92
Magnetism - RM-grid AASKA14:092	Magnetism	27	**Imaging**	1000 - 1700 MHz	31000 deg2	2 arcsec	10000	7.4 mn	100	Mid 4 -5	s	59	0.116	6.83
Cosmology - High z IM AASKA14:019	Cosmology	32	**Auto-Correl/ Commensal**	**350 - 1050 MHz**	30000 deg2	1.7 deg	10000	2.2 hr @ 190 Dishes	1/50	Mid 1-3	m	98	0.116	11.34
Cosmology - ISW, Dipole AASKA14:018, 032	Cosmology	33	**Imaging**	1000 - 1700 MHz	31000 deg2	2 arcsec	10000	7.4 mn	100	Mid 4-5	s	59	0.116	6.83
Continuum - SFR(z) AASKA14:067	Continuum	37 + 38	**Imaging**	1000 - 1700 MHz	1000 deg2	0.5:1 arcsec	10000	3.8 hr	150	Mid 4-5	m	149	0.116	17.25
			Imaging	1000 - 1700 MHz	7.8 deg2	0.5:1 arcsec	2000	95 hr	150	Mid 4-5	l	496	0.023	11.48
			Imaging	1000 - 1700 MHz	0.38 deg2	0.5:1 arcsec	2000	2000 hr	150	Mid 4-5	xl	1438	0.023	33.29
			Imaging	**7 - 11 GHz**	0.5 deg2	0.05:1 arcsec	1000	16.4 hr	150	Mid 11-12	m/l	18	0.012	0.21
			Imaging	**7 - 11 GHz**	30 arcmin2	0.05:1 arcsec	1000	1000 hr	150	Mid 11-12	xl	42	0.012	0.49

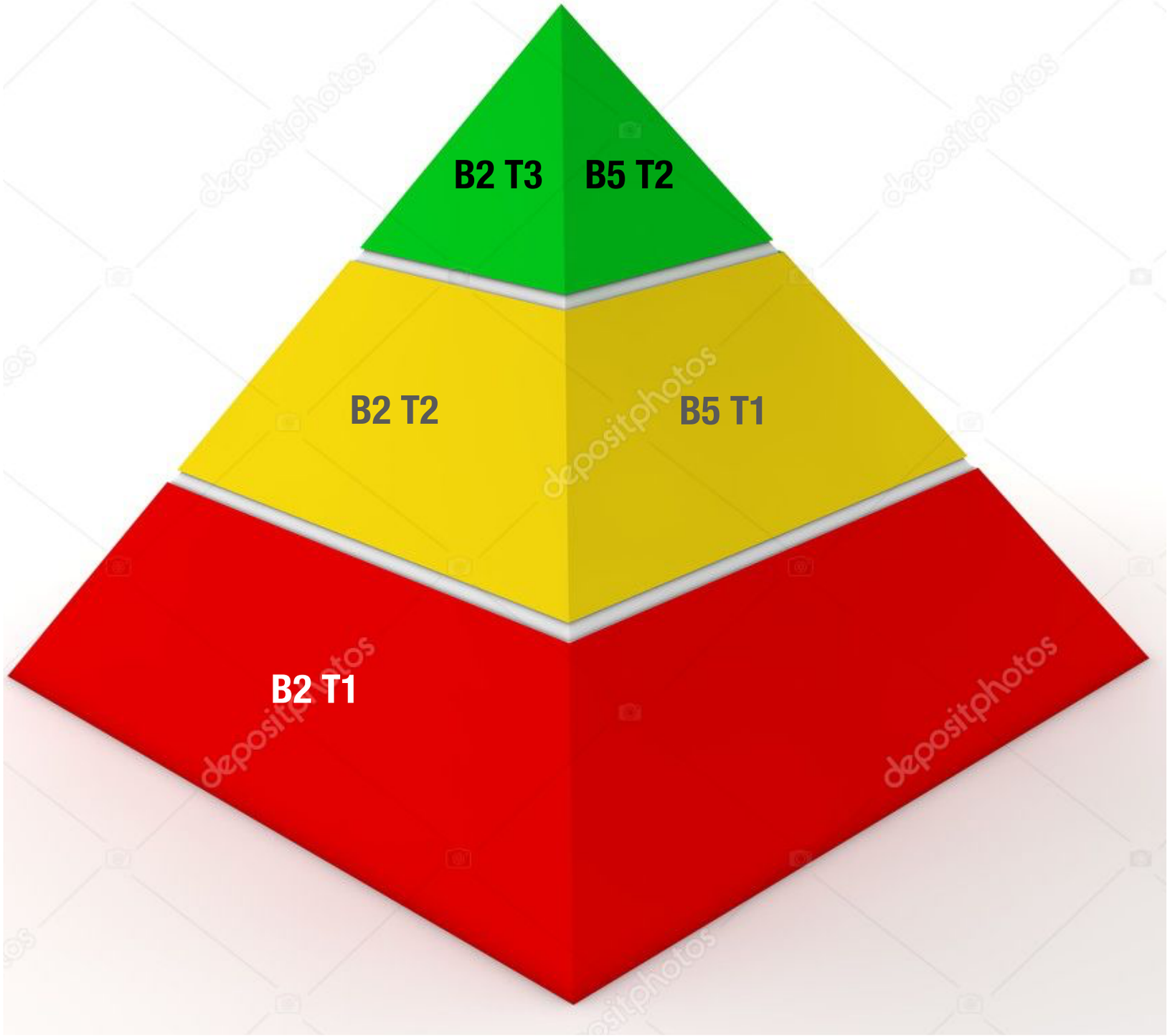
"Anticipated SKA1 HPC Requirement"
May 2018
SKA-TEL-SKO-0000941

Three Tier Surveys



Measuring the star formation history of the Universe - non-thermal processes (HPSO #37)	Active Galactic Nuclei and their role in galaxy evolution (commensally with HPSO #37)
SFR>10 M⊙/yr galaxies up to z~3-4, and SFR>50 M⊙/yr galaxies up to z~6	RQ and low-power RL AGNs down to L~1. E+22 W/Hz at z~3-4
SFR>10 M⊙/yr galaxies at z~1-2	RQ and low-power RL AGNs down to L~1.E+22 W/Hz at z~1-2
Bulk of the SFG population (down to SFR~0.5 M⊙/yr at z~0.1; and to SFR~5 M⊙/yr at z~0.5)	Bulk of the AGN population (RQ and low-power RL AGNs down to L~1.E+21 W/Hz at z~0.1 and to L~1.E +22 W/Hz at z~0.5)

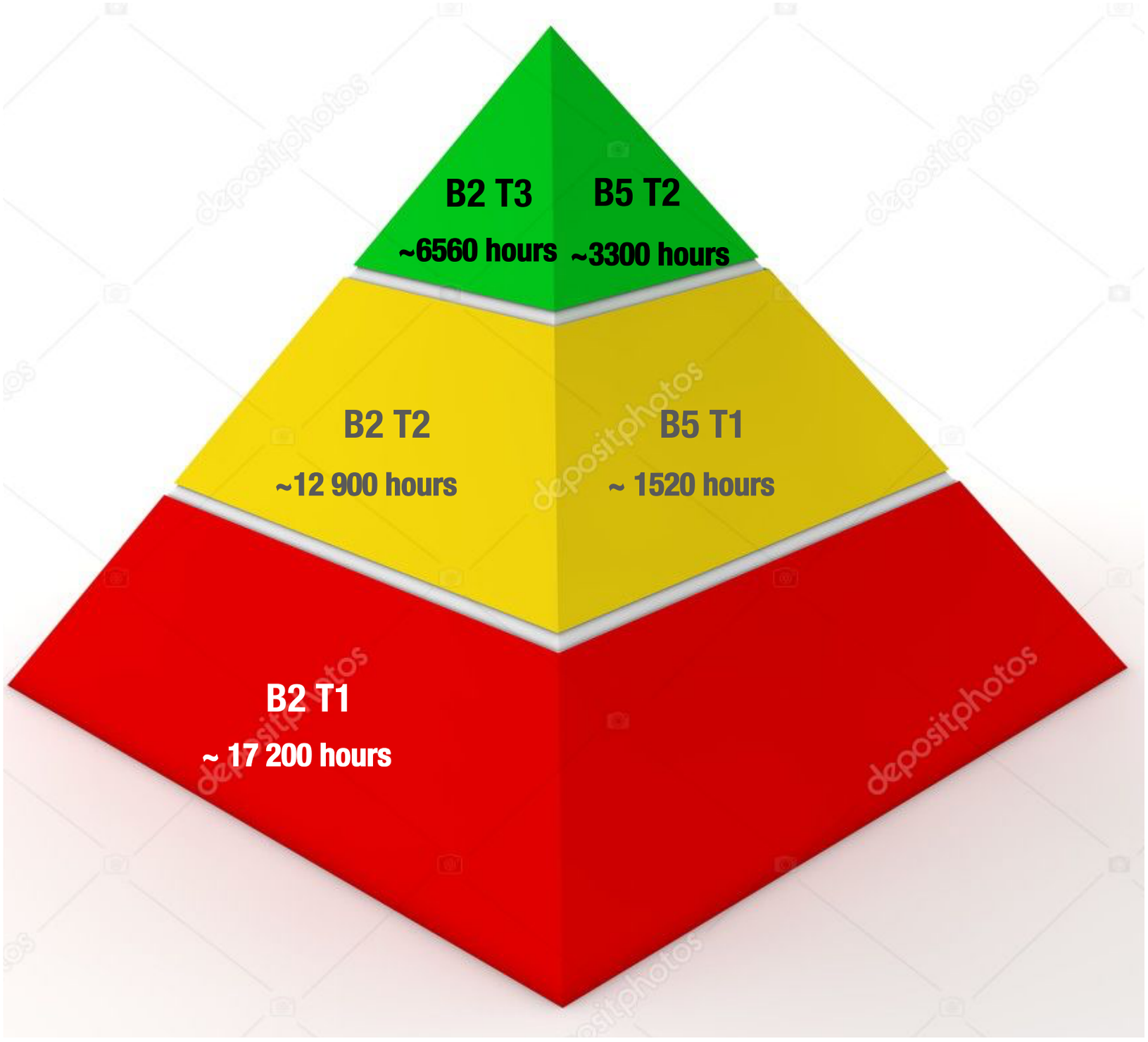
Three Tier Surveys



Measuring the star formation history of the Universe - non-thermal processes (HPSO #37)	Active Galactic Nuclei and their role in galaxy evolution (commensally with HPSO #37)
SFR ~50 M⊙/yr galaxies out to z~6 Will resolve SFR>100 M⊙/yr galaxies on sub-kpc scales out to z~1; SFR>100 M⊙/yr galaxies on kpc z~2	Will resolve sub-kpc scales up to z~1
SFR ~100 M⊙/yr galaxies out to z≲3 Will resolve SFR>100 M⊙/yr galaxies on sub- kpc (≲0.1") scales out to z~0.5	Will resolve sub-kpc scales out to z~0.5

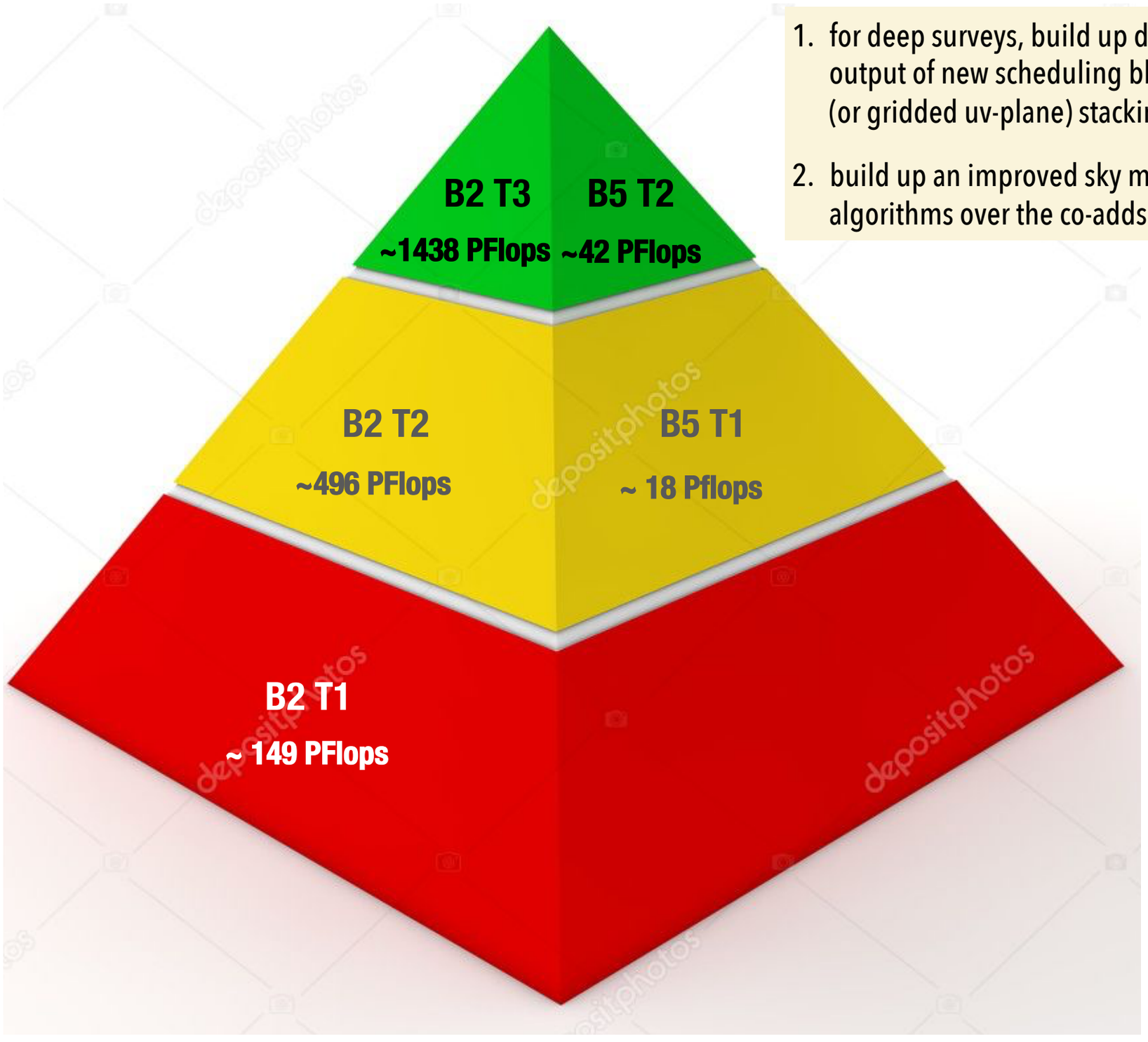
Sargent & Hurley-Walker - For the Continuum SWG

Three Tier Surveys



Sargent & Hurley-Walker - For the Continuum SWG

Three Tier Surveys



1. for deep surveys, build up deep image over time by continuously adding the output of new scheduling blocks do the coadded deep image via image plane (or gridded uv-plane) stacking
2. build up an improved sky model over time by regularly running cataloguing algorithms over the co-adds from #1 above

Baseline Design SDP HPC deployment: ~ 260 PFlops

"Anticipated SKA1 HPC Requirement" – May 2018

SKA-TEL-SKO-0000941

Largest fractional bandwidth request

ν_{min} (GHz)	ν_c (GHz)	ν_{max} (GHz)	Sub-band	Band	σ_c (μJy/Bm)	θ'_{min} (“)	θ_{min} (“)	θ_{max} (“)	θ'_{max} (“)
0.050	**0.060**	**0.069**	Low sb1		163	16.4	23.5	1175	3290
0.069	**0.082**	**0.096**	Low sb2		47	11.9	17.0	850	2379
0.096	**0.114**	**0.132**	Low sb3		26	8.6	12.3	614	1719
0.132	**0.158**	**0.183**	Low sb4		18	6.2	8.9	444	1244
0.183	**0.218**	**0.253**	Low sb5		14	4.5	6.4	321	899
0.253	**0.302**	**0.350**	Low sb6		11	3.3	4.6	232	650
0.35	**0.41**	**0.48**	Mid sb1	B1	16.8	1.015	2.031	270.8	541.6
0.48	**0.56**	**0.65**	Mid sb2	B1	8.1	0.745	1.489	198.6	397.2
0.65	**0.77**	**0.89**	Mid sb3	B1	4.4	0.546	1.092	145.6	291.2
0.89	**1.05**	**1.21**	Mid sb4	B2	2.7	0.400	0.801	106.8	213.5
1.21	**1.43**	**1.65**	Mid sb5	B2	2.0	0.294	0.587	78.3	156.6
1.65	**1.95**	**2.25**	Mid sb6		1.6	0.215	0.431	57.4	114.9
2.25	**2.66**	**3.07**	Mid sb7		1.4	0.158	0.316	42.1	84.2
3.07	**3.63**	**4.18**	Mid sb8		1.6	0.116	0.232	30.9	61.8
4.18	**4.94**	**5.70**	Mid sb9	B5a	1.4	0.085	0.170	22.7	45.3
5.70	**6.74**	**7.78**	Mid sb10	B5a	1.3	0.062	0.125	16.6	33.2
7.78	**9.19**	**10.61**	Mid sb11	B5b	1.2	0.046	0.091	12.2	24.4
10.61	**12.53**	**14.46**	Mid sb12	B5b	1.2	0.034	0.067	8.9	17.9

“Anticipated SKA1 HPC Requirement” – May 2018

SKA-TEL-SKO-0000941

Largest fractional bandwidth $(\nu_{Max} - \nu_{Min})/\nu_C$

less than about 0.3

This means that to construct an image using the full design bandwidth of band 2 (as we would like to, in order to maximise sensitivity) we will have to stack **a posteriori in the image plane** images of individual sub-bands

Note that these sub-bands can still be observed simultaneously, but the final broad-band image will apparently not be delivered by SDP

This will have implications for the creation of deep, high-resolution mosaics reaching the required dynamic range and sensitivity which we will have to explore going forward

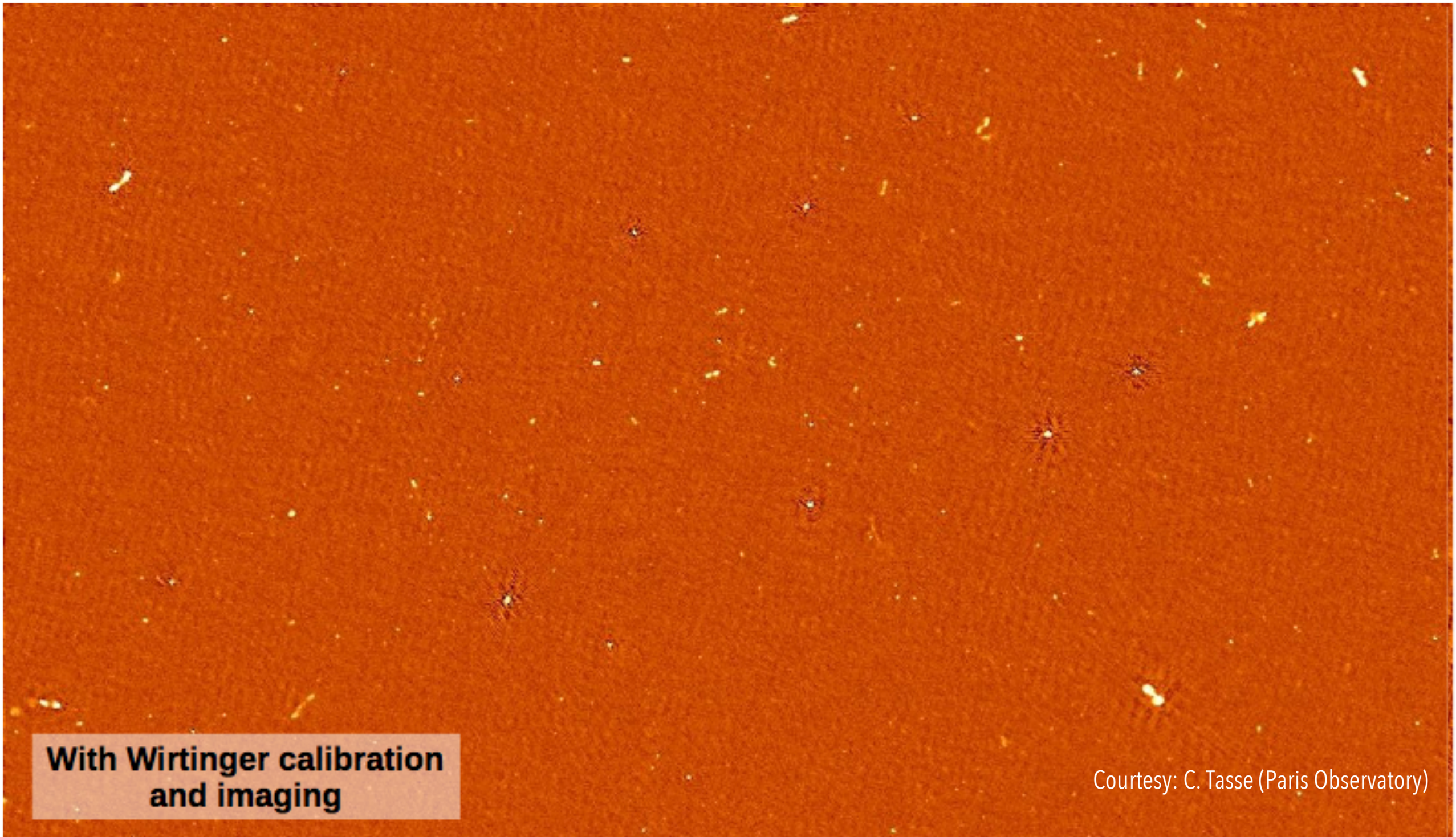
For the time being however, on the purely operational level, it is clear that an important role of the SRCs will be to carry out the final steps in producing wide-band, deep images

Direction Dependent Effects

"Although only limited support for Direction Dependent (DD) rather than Direction Independent (DI) calibration methods is currently implemented within the SDP parametric model, there is the ability to specify the number of Ionospheric patches for which gain solutions will be determined as well as the associated timescale"

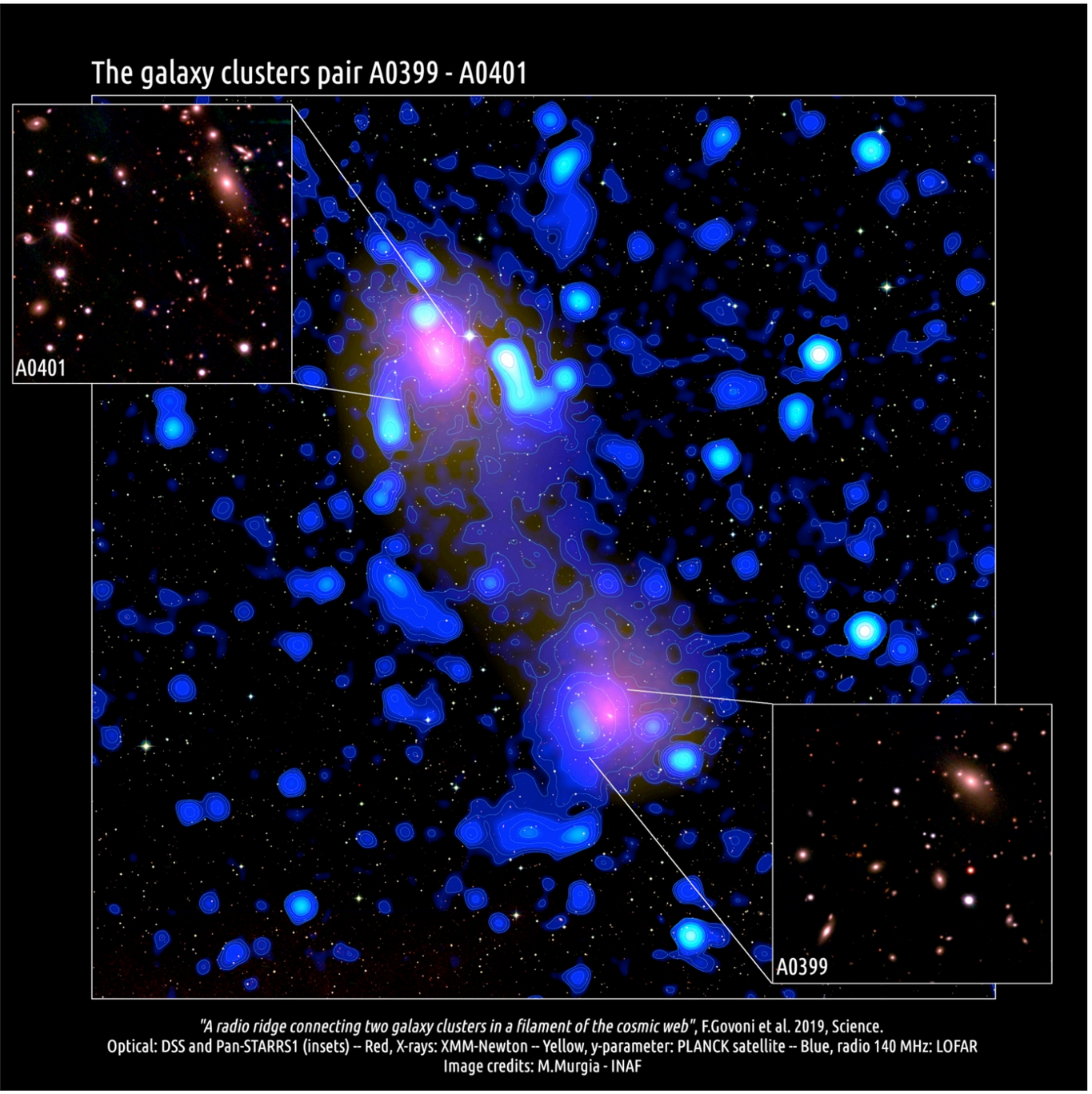
"Anticipated SKA1 HPC Requirement" – May 2018

SKA-TEL-SKO-0000941



Courtesy: C. Tasse (Paris Observatory)

Diffuse sources & Cosmic Web



Govoni et al. 2019, Science

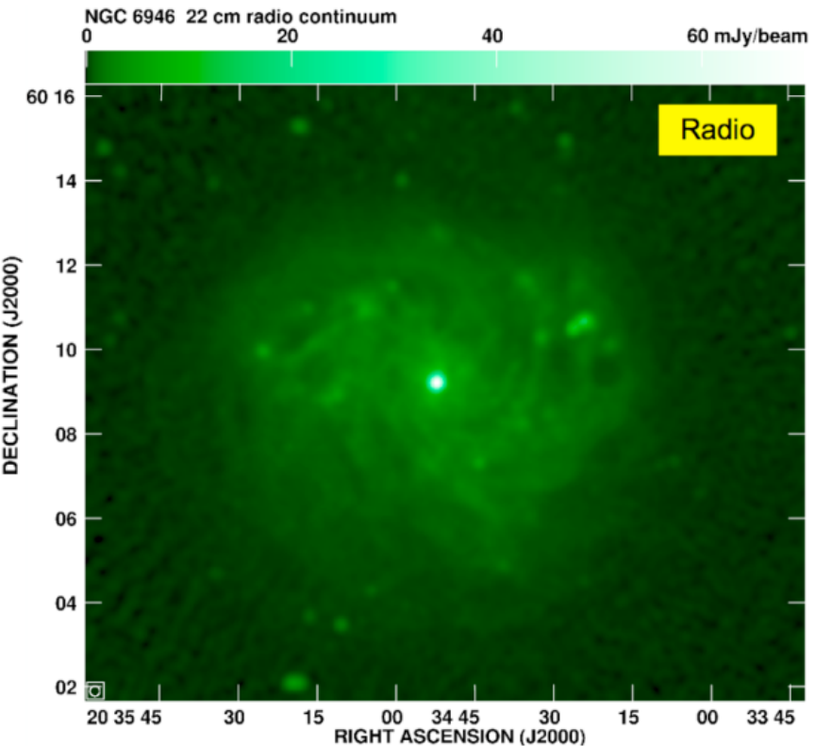
Van Weeren et al. 2016, ApJ

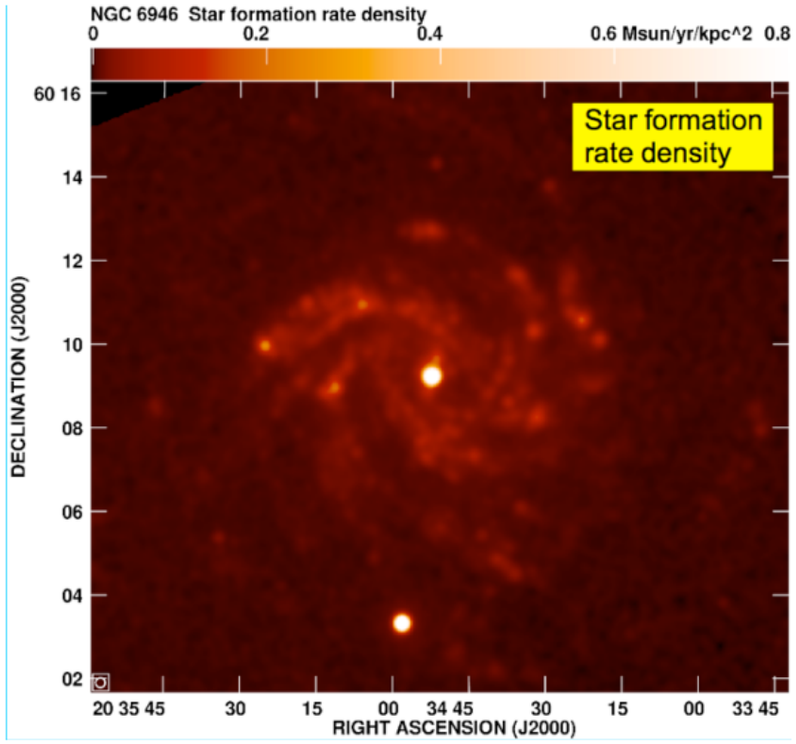
Best possible DD calibration and imaging scheme, not necessarily the same as for point/compact sources

Need of point source subtraction and, at least, tapering

Need of spectral maps

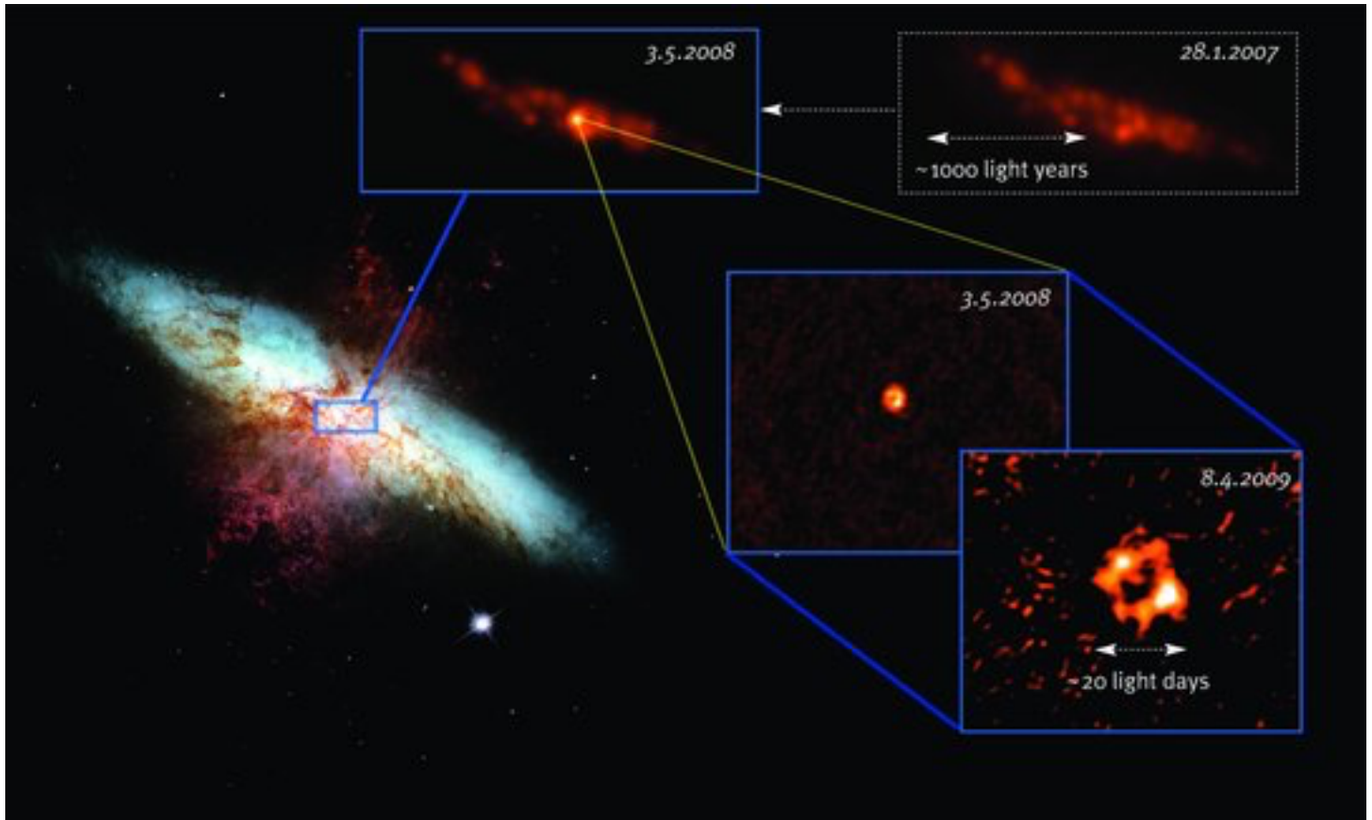
Nearby galaxies & Supernovae





Line	Rest freq (MHz)
HCN $v_2 = 1, \Delta J = 0, J = 2$	1346.765
HCN $v_2 = 1, \Delta J = 0, J = 4$	4488.4718
H_2CO	4829
N_2H+	5009.8278
H_2CNH $1_{10} - 1_{11}, \Delta F = 0, \pm 1$	5289.813
HCO+	6350.908
HNC	6484.497
CH_3OH $5_1 - 6_0 A^+$	6668.5192
HCN $v_2 = 1, \Delta J = 0, J = 5$	6731.9098
HCO+	8890.452
HCN $v_2 = 1, \Delta J = 0, J = 6$	9423.3338
HNC	9724.644

Beswick et al. 2015



Graphics: Milde Science Communication, HST Image: /NASA, ESA, and The Hubble Heritage Team (STScI/AURA); Radio Images: A. Brunthaler, MPIfR.