Key Science Project on

Cosmic Magnetism

Rainer Beck, MPIfR

LOFAR Key Science Projects

- Epoch of re-ionization – Groningen
- Extragalactic surveys – Leiden
- Transients and pulsars – Amsterdam/Manchester
- Cosmic rays – Nijmegen
- Solar radio emission – Potsdam
- *Cosmic magnetic fields – Bonn*

LOFAR MKSP

Management Team (4):

R. Beck (PI), J.A. Anderson (MPIfR Bonn),
G. Heald (ASTRON Dwingeloo),
A. Scaife (IAS Dublin)

Full members (19):

M. Kuniyoshi, A. Noutsos, W. Reich, C. Sobey (MPIfR Bonn)
R.J. Dettmar, E. Middelberg (Univ. Bochum)
M. Bell, T. Enßlin, Th. Riller (MPA Garching)
A. di Vincenzo (Tautenburg)
M. Brentjens, G. de Bruyn, M. Haverkorn (ASTRON Dwingeloo)
M. Iacobelli , C. Shneider (Leiden)
P. Alexander (MRAO Cambridge)
K. Chyzy (Cracow)
A. Fletcher (Newcastle)
J. Geisbüsch (Dominion Radio Obs.)

Associated members (38):

B. Adebahr (Bochum)
G. Arshakian (MPIfR Bonn)
G. Bernardi (CfA Cambridge/USA)
D. Bomans (Bochum)
J. Broderick (Southampton)
M. Brüggen (Jacobs Univ. Bremen)
E. Carretti (CISRO Sydney)
R. Drzazga (Cracow)
S. Duscha (ASTRON)
J. Eislöffel (Tautenburg)
L. Feretti (INAF Bologna)
K. Ferrière (Toulouse)
R. Gießübel (MPIfR Bonn)
D. Green (MRAO Cambridge)
V. Heesen (Hertfordshire)
M. Hoeft (Tautenburg)
M. Jamrozy (Cracow)
W. Jurusik (Cracow)
J. Kim (MRAO Cambridge)
U. Klein (Univ. Bonn)
M. Kramer (MPIfR Bonn)
M. Krause (MPE Garching)
R. Laing (ESO Garching)
E. Orru (Innsbruck)
K. Otmianowska-Mazur (Cracow)
R. Paladino (Innsbruck)
R. Pizzo (Groningen)
A. Purkayasta (Univ. Bonn)
J. Riley (MRAO Cambridge)
D. Schnitzeler (ATNF Sydney)
A. Shukurov (Newcastle)
M. Soida (Cracow)
B. Stappers (Manchester)
F. Tabatabaei (MPIfR Bonn)
M. Urbanik (Cracow)
C. Vogt-van Haarlem (ASTRON Dwingeloo)
M. Wezgowiec (Bochum)

MKSP working groups

- Milky Way (Chair: M. Haverkorn)
- Pulsar RMs (Chair: A. Noutsos)
- Nearby galaxies (Chair: C. Chyzy/R. Beck)
- Giant radio galaxies (Chair: G. de Bruyn)
- Intergalactic filaments (Chair: P. Alexander)
- Polarised stellar and AGN jets (Chair: J. Eislöffel)

MKSP Workshops

1. Kickoff meeting Bonn Sept 20 2007
2. Leiden Dec 12 2007
3. Bonn April 23 2008
4. Dwingeloo June 17 2008
5. Hamburg Sept 19 2008
6. Cambridge 25-26 March 2009
7. Garching 20-21 Oct 2009
8. Dwingeloo 19-20 April 2010
9. Dublin 26-27 Oct 2010
10. Newcastle April 2011

MKSP Documents

- Project Plan (Science Case) – on MKSP Website and GLOW WIKI
- Project Description for LOFAR Book – on GLOW WIKI
- MKSP Memo No. 1:
  Frequency Coverage Analysis
  – by George Heald
- MKSP Memo No. 2:
  Pulsar Studies of the Galactic Magnetic Field with LOFAR
  - by Aris Noutsos

MKSP webpages

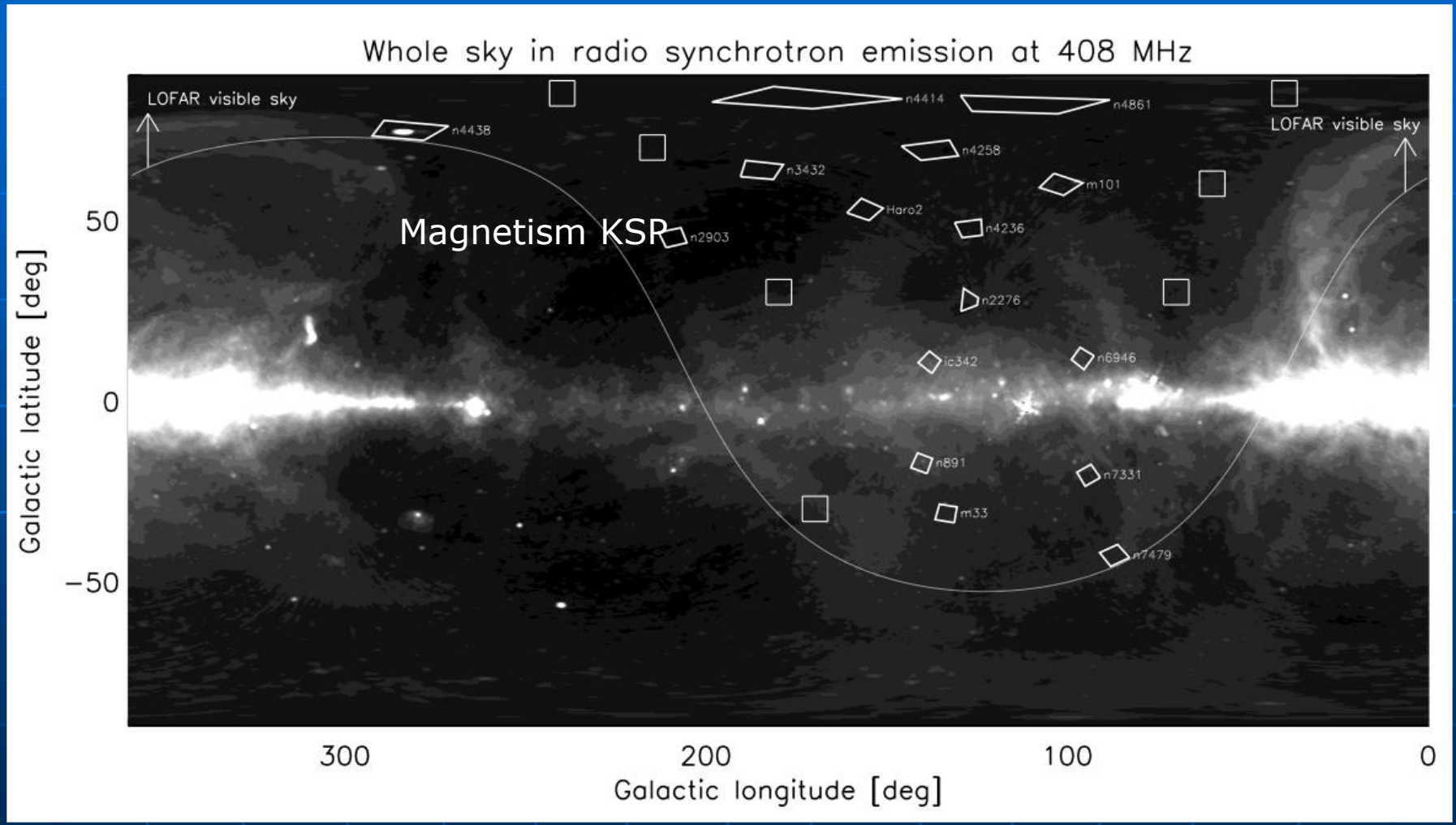
Public webpage:
http://www.mpifr-bonn.mpg.de/staff/rbeck/mksp.html
(Webmaster: Rainer Beck)

WIKI page (internal):
http://blogger.astro-rub.de/airubblog
(Webmaster: Enno Middelberg)

MKSP observation plan

- Survey of ≈60 galaxies
  180-210 MHz, 9h per galaxy, together with Surveys KSP
- **Deep galaxy survey**
  10-20 galaxies, 120-180 MHz, 100h per galaxy
- Milky Way fields
  piggyback with deep extragalactic fields
- Radio galaxies
  10 galaxies, 3 frequency bands, 5h per galaxy and band
- Stellar jets
  5 objects, 120-180 MHz, 20h per object

LOFAR:
Structure of the magnetized Galactic halo



M. Haverkorn

MKSP long-term proposals

- LOFAR MKSP Project Proposal (PI R. Beck):
  Milky Way, nearby galaxies, intergalactic filaments, giant radio galaxies
- Polarisation from stellar jets (PI A. Scaife):
  5 known YSOs
- Broadband imaging of the Galactic plane (PI M. Haverkorn)
- Low frequency properties of the magnetized ISM in M33 (PI F. Tabatabaei)

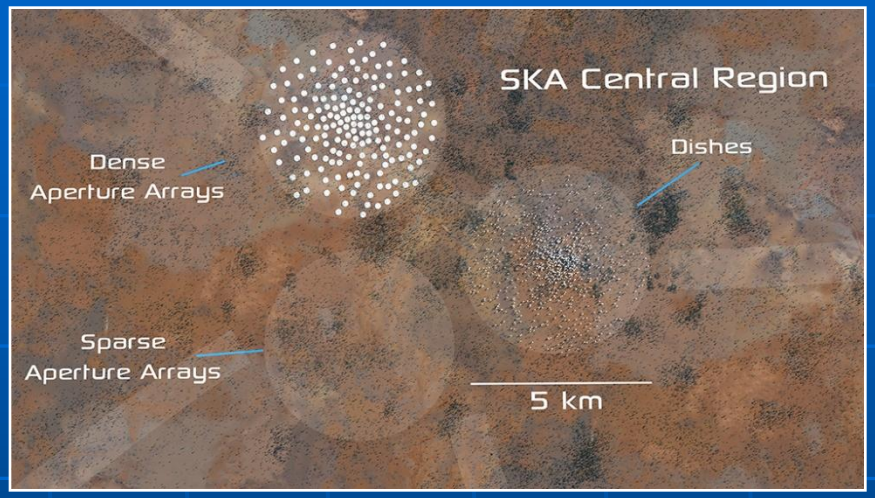
Time allocation plans
(NL, D, UK, F, S + open time)

Signup fraction per consortium 2% of total & NL cap 70% of reserved access

Year1	0.58	0.17	0.05	0.05	0.05	0.10
Year2	0.51	0.15	0.05	0.05	0.05	0.19
Year3	0.41	0.12	0.04	0.04	0.04	0.35
Year4	0.30	0.10	0.04	0.04	0.04	0.48
Year5	0.20	0.07	0.03	0.03	0.03	0.64

- Total observation time for GLOW in 5 years (assuming 50% efficiency): ≈2600 h
- The MKSP needs ≈1500 h
- Massive support by GLOW & significant support by the other international consortia needed

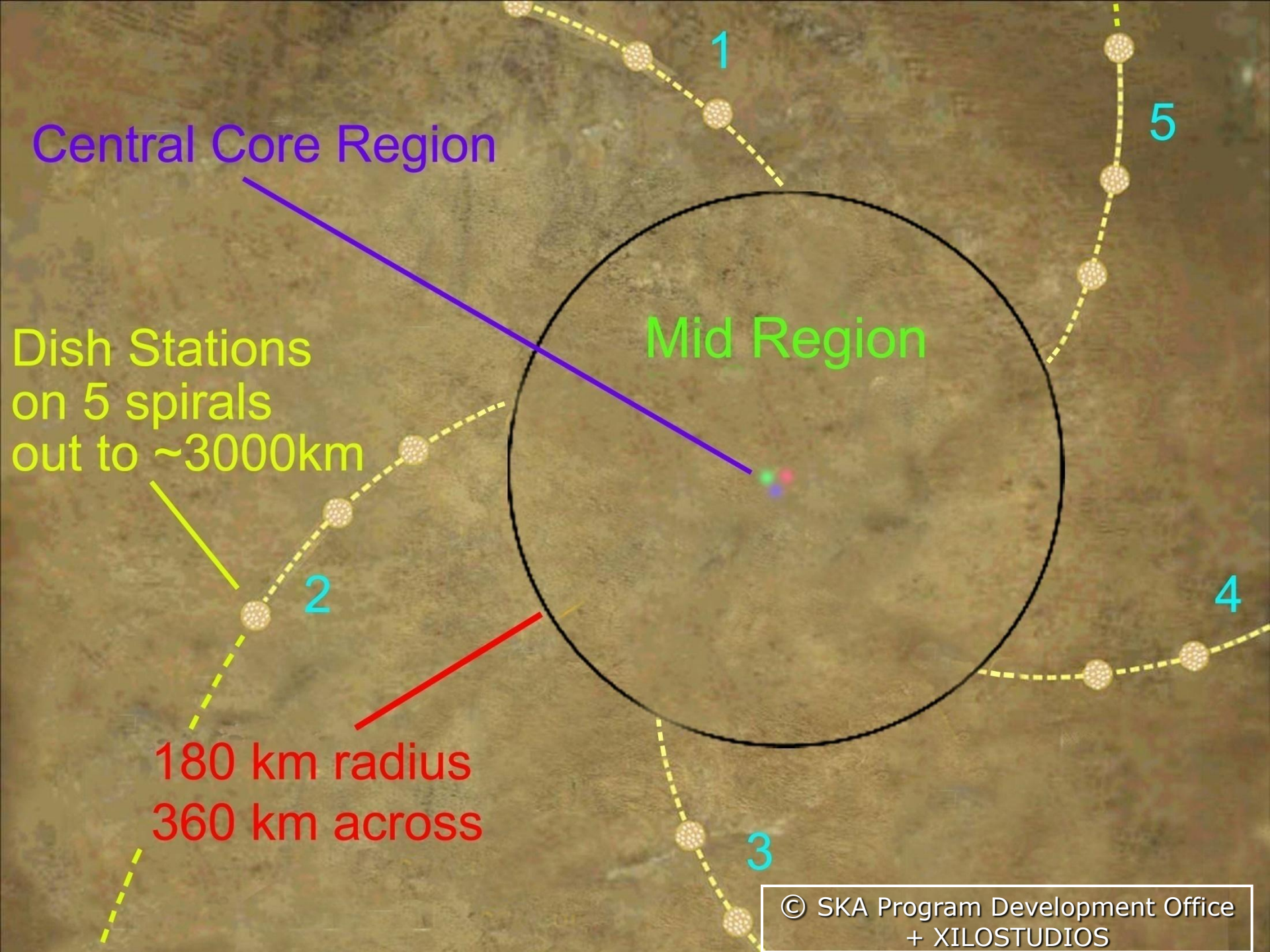
SKA


SKA Central Region
Dishes
Dense
Aperture Arrays
Sparse
Aperture Arrays
5 km


Swinburne Astronomy Productions


Swinburne Astronomy Productions


Swinburne Astronomy Productions


Central Core Region
Mid Region
Dish Stations
on 5 spirals
out to ~3000km
180 km radius
360 km across
1
2
3
4
5
© SKA Program Development Office
+ XILOSTUDIOS

SKA sparse Aperture Array (70-450 MHz)

SKA Project Office
+ Swinburne Astr. Prod.

SKA dishes (450 MHz–3 GHz)

SKA Project Office
+ Swinburne Astr. Prod.

SKA Key Science Projects

- The Dark Ages & Dark Energy
- Galaxy evolution & large-scale structures
- Testing theories of gravitation
- Cosmic magnetism
- The Cradle of Life
- Exploration of the Unknown

Faraday rotation grids with the SKA

Deep fields (12h integration) with the full SKA:

- ≈ 8000 10-σ polarized sources per deg^2
  (≈ 2 RMs per arcmin^2)

All-sky survey (1h per field):

- ≈ 2000 10-σ polarized sources per deg^2
  (≈ 0.5 RMs per arcmin^2)
- **Total number of RMs: ≈ 8 10^7 !**

- ASKAP: ≈ 80 RM per deg^2 within 12h (large field of view)
- MeerKAT: ≈ 400 RM per deg^2 (small field of view)
- Phase-1 SKA: ≈ 800 RM per deg^2 (large field of view)

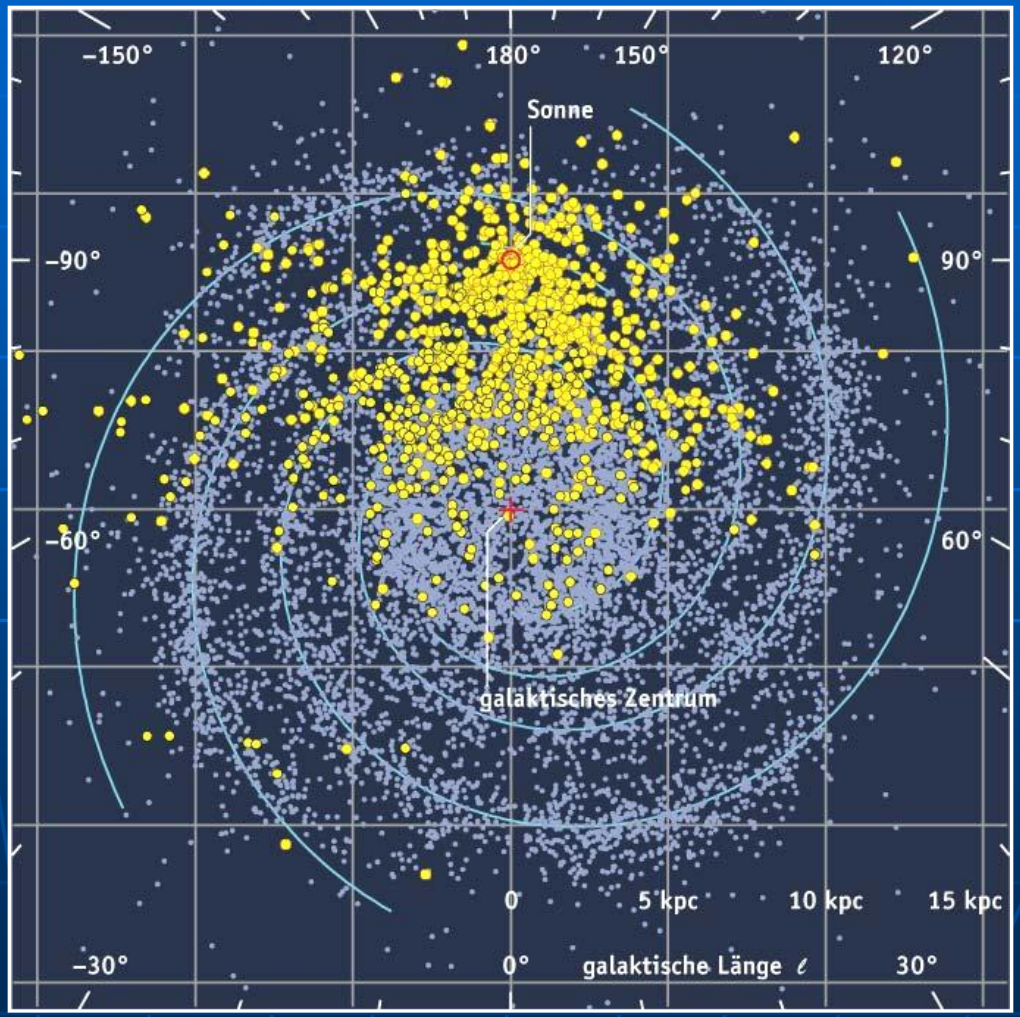
RM grids with the SKA and its pathfinders

- RMs from pulsars:
  3-D *reconstruction* of the detailed field structure of the Milky Way
  (Noutsos et al. 2008)

- RMs towards background sources behind galaxies:
  3-D *reconstruction* of field patterns from nearby galaxies, *recognition* of field patterns for galaxies out to ≈ 100 Mpc
  (Stepanov et al. 2008)

Rotation measures of pulsars in the Milky Way with the SKA

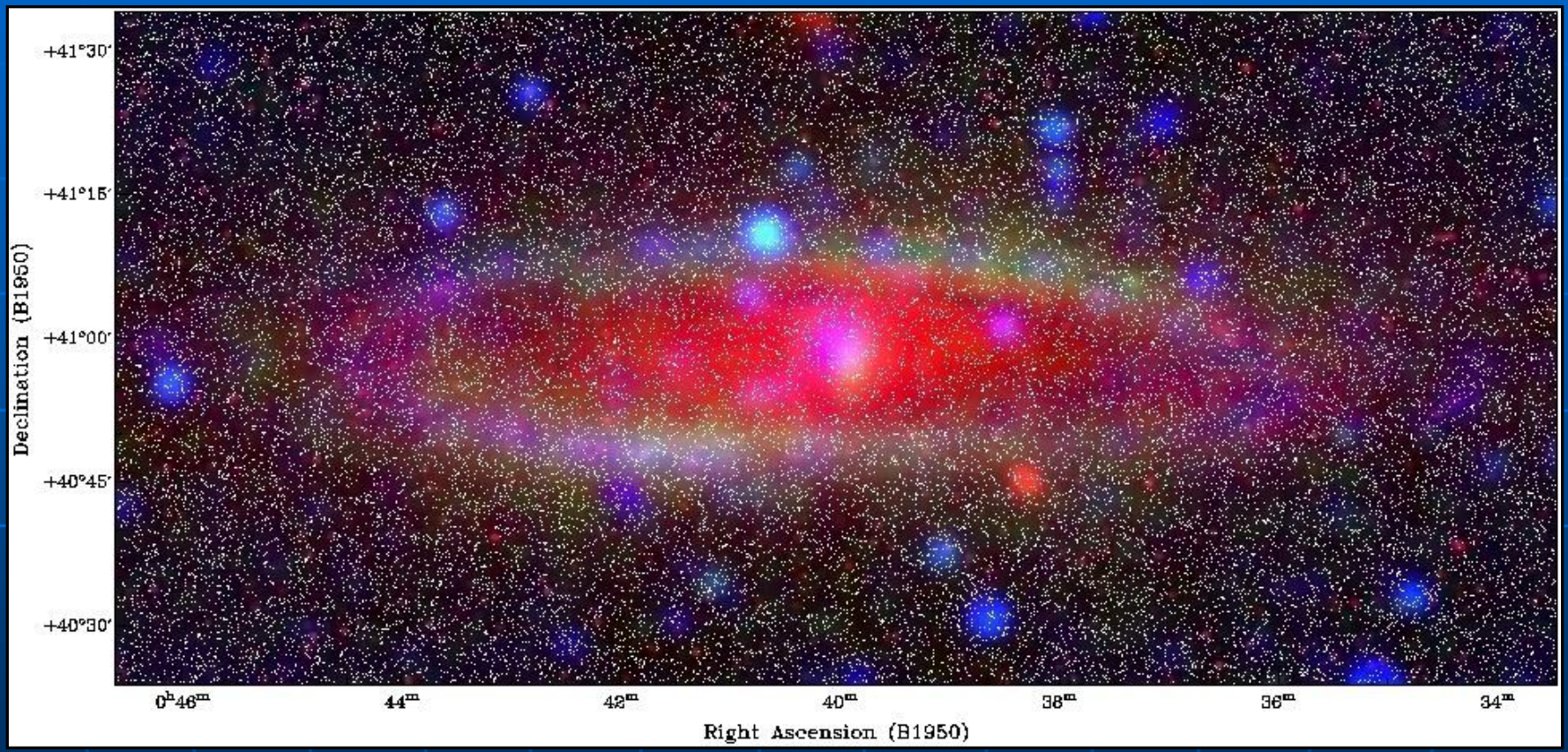
Known pulsars and pulsars to be detected with the SKA (≈30000)



Cordes 2001

SKA RM survey

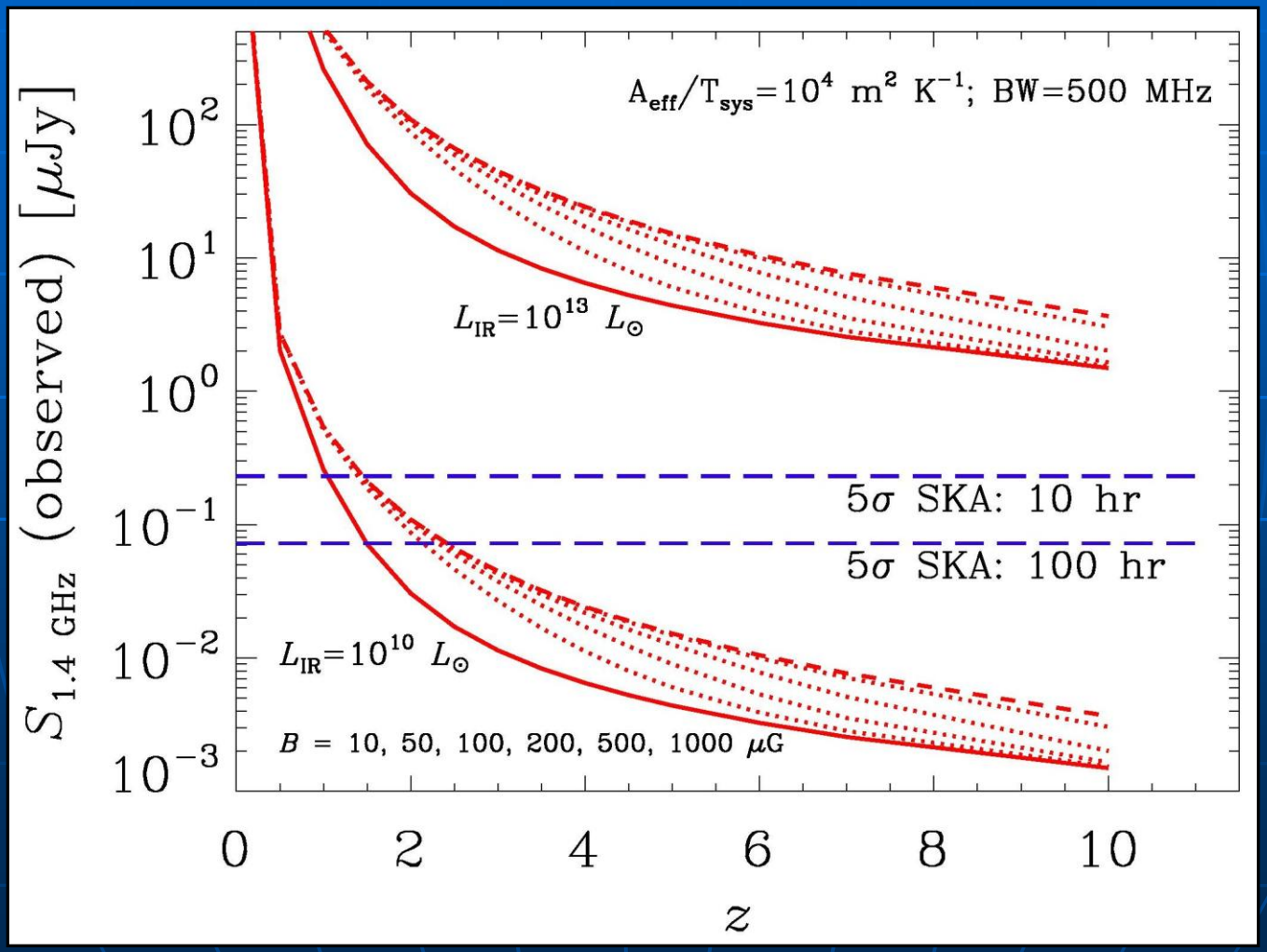
(simulation by Bryan Gaensler)



≈10000 polarized sources shining through M31

Observation of distant galaxies with the SKA

Murphy 2009



ASKAP
(Australian SKA Pathfinder)

36 antennas of 12m diameter, max. baseline 6km, frequency range 0.7 -1.8 GHz

POSSUM: *POlarization Survey of the Universe's Magnetism*

- All-sky polarized continuum at 1.4 GHz
- Rotation measures for ≈ 1.5 million sources (≈ 50 RMs/deg^2)
- Recognize large-scale fields in Milky Way, nearby galaxies and clusters

MeerKAT (proposed)

80 antennas of 12m diameter, max. baseline 60km, frequency range 0.6 - 14.5 GHz

MeerQUITTENS: *MeerKAT QU Investigation To Trace Extragalactic Nonthermal Sources*

- Mapping and RM grids of nearby spiral and dwarf galaxies, galaxy groups and clusters
- Frequency bands 900-1750 MHz and 8-10 GHz
- Ideal complement to LOFAR and POSSUM

APERTIF (proposed)

12 Westerbork antennas of 25m diameter, max. baseline 1.6km, frequency range 1000 - 1750 MHz

FRIGG: *Faraday Rotation Investigation of Galaxies and Groups* (PI: R. Beck)

- Mapping and RM grids of 4 galaxiex and 5 galaxy groups
- Frequency bands 1050-1350 and 1350-1650 MHz

BEOWULF: *B-field Estimation and Observational Wide-field Understanding of Large-scale Faraday-structure* (PI: A. Scaife)

- Mapping and RM grid of the Perseus-Pisces supercluster
- Frequency bands 1050-1350 and 1350-1650 MHz

WODAN: *Westerbork Observations of the DeepAPERTIF Northern-Sky* (PI: H. Röttgering)

- Continuum survey at 1130-1430 MHz