

Plans to study/model/commission ionospheric calibration (refraction and Faraday rotation)

(see also LSM 29-Oct-08 and 26-Nov-08)

Ger de Bruyn

for the Ionospheric/Polarization teams
and EoR/Magnetism/PSR KSP's

LOFAR Status meeting 8-Jul-09

Commissioning teams / working groups

The following list is slightly updated from the one presented by Michael. Membership is open for anyone that wants to seriously work on these issues over the next >6 months. Contact chairs !

Beam modeling: Johan Hamaker, Sarod Yatawatta, Stefan Wijnholds, Michiel Brentjens, Ronald Nijboer

Ionosphere: Jan Noordam, Ger de Bruyn, Bas van der Tol, James Anderson, Anna Scaife, Joris van Zwieten, Mamta Panday, (Maaijke Mevius), Huib Intema.

Polarization: Marijke Haverkorn, Ger de Bruyn, George Heald, James Anderson, Aris Noutsos, Anna Scaife, Enno Middelberg,...

GSM/LSM: John Swinbank, Niruj Mohan, Bart Scheers, Sarod Yatawatta, Ger van Diepen, Michael Wise

Data Quality & Monitoring: Pandey, Jason Hessels, Evert Rol, Fabien Batejat, Jan Noordam, Michael Wise

Long Baselines: John Conway, James Anderson, Jean-Mathias Griessmeijer, Hans-Rainer Kloeckner, Philippe Zarka, Annette Haas, Jan Noordam, Ger de Bruyn

More teams? e.g. imaging aspects ?

Ionospheric modeling approaches

Before 2000:

- Simple selfcalibration (single correction for whole uv-plane)
- Align (NEWSTAR/WSRT fitting for linear phase slopes - small arrays)
- Occasionally [peeling](#) brightest sources of the map (from 1990)

Since 2002:

- Field based calibration ([Cotton et al, 2004](#):VLA 74 MHz, Zernike polynomials)
- SPAM: modeling single/multiple screens ([Intema et al, 2008/09](#) VLA/GMRT)
- MIM /SPAM in BBS ([Mevius, 2009](#)): fitting in uv-plane, using known sources (1 --> more layers)
- MIM ([Noordam, 2004](#)): dealing with (differential integrated TEC/delays):
 - $\Delta\phi (X,Y,Z, l,m, t)$ where X,Y,Z are coordinates on earth. No layers, no piercing points...
 - + ionospheric simulations MeqTrees (Smirnov, Labropoulos/Yatawatta)
 - + ideas to constrain ionosphere (differential refraction, 'snapshot' calibration, pulsar RM(t))

(tomographic) inversion

MIM-model	$\Delta\phi (X,Y,Z, l,m, t)$	\rightarrow	$n_e (x,y,z, t)$	Ionospheric community
	holy trail	to the	holy grail ?	(x,y,z in ionosphere)

Some linearly polarized pulsars (pulse averaged !)

PSR1937+21 (P=1.6 ms)

$S_{150 \text{ MHz}} \sim 1\text{-}2 \text{ Jy}$ $\text{RM} = + 8 \text{ rad/m}^2$ 50-70% polarized

PSRJ0218+4232 (P= 2.2 ms)

$S_{150\text{MHz}} \sim 0.4 \text{ Jy}$ $\text{RM} = - 61 \text{ rad/m}^2$ 50-70% polarized

PSR0531+21 in the Crab Nebula (P=33 ms)

$S_{150 \text{ MHz}} \sim 10 - 20 \text{ Jy}$ $\text{RM} = - 42 \text{ rad/m}^2$? % polarized

NB: Using time-resolved observations ('gating') we can probably use many more pulsars for ionospheric RM and TEC monitoring ...

Use (linearly) polarized pulsars

WSRT LFFE data

138 - 143 MHz

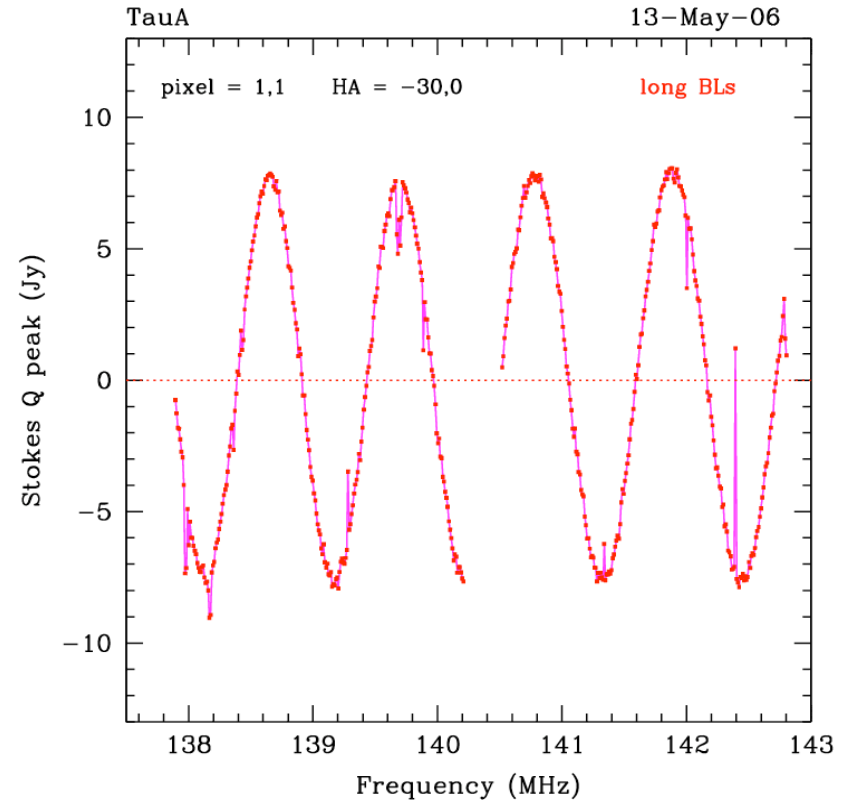
(two adjacent 2.5 MHz bands)

PSR0531+21 had **> 8 Jy**
polarized flux in May 2006 !!!

PSR spectral index $\nu^{-2.5}$

→ **60 Jy at 60 MHz** !?

The period of the sinusoid (in MHz) increases as ν^{-3} hence there would be 2 periods per subband at 60 MHz !!



Busy week from 6-10 July 2009

Local: Michiel Brentjens, Marijke Haverkorn, Ger de Bruyn, Goerge Heald

? Bas van der Tol,

Visitors: Anna Scaife, Enno Middelberg, James Anderson

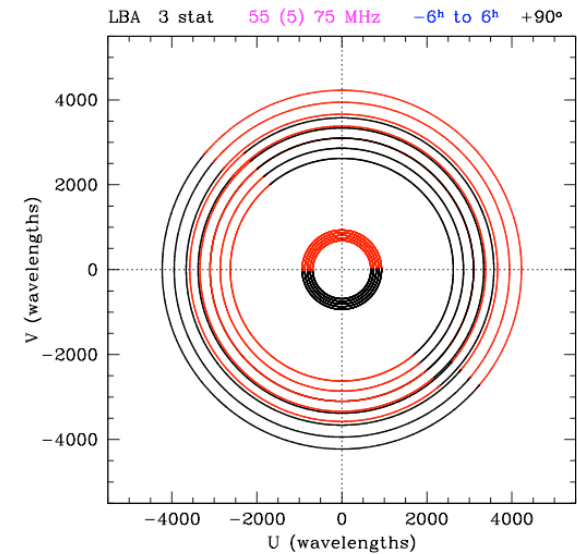
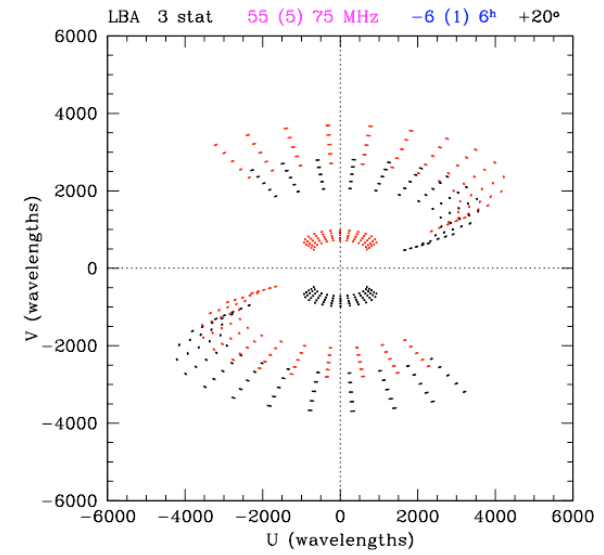
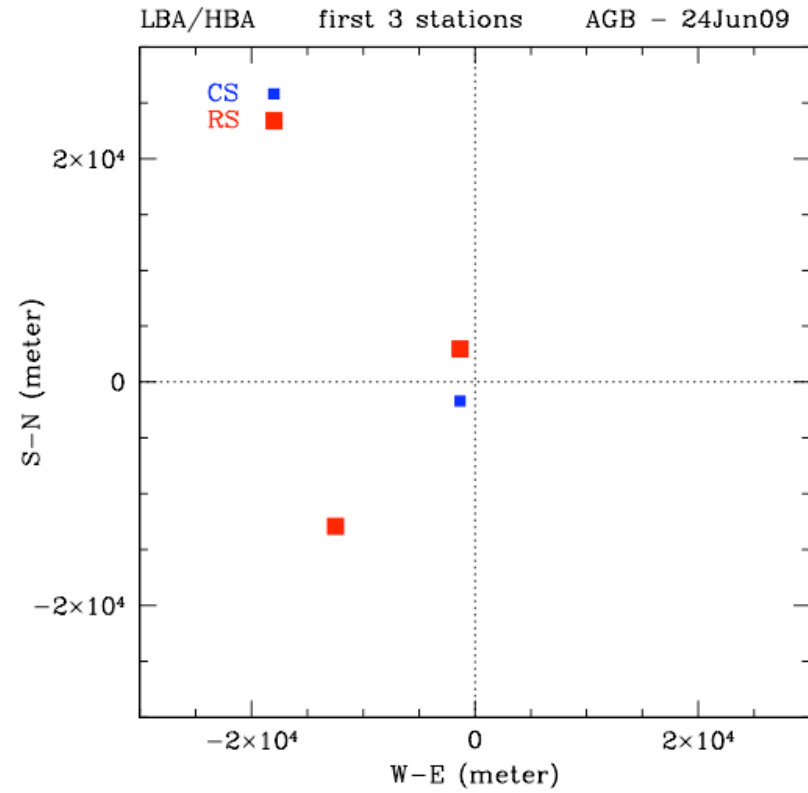
? Aris Noutsos,

Summerstudents: Louise Ker, Francesco de Gasperin

Some ideas for activities (in preparation...)

- observations with LBA and HBA
- pulsars and discrete sources
- differential refraction, Faraday rotation, multi-beam tests
- 'mozaicing' over frequency / sources ? SAS/MAC/CEP overhead
- closure phase (check on instrument and discrete nature of source!)
- discussions on short/medium/long term efforts
- planning& coordinating commissioning/modeling efforts over the summer

uv-coverages for a 3-station array in July 2009



Differential Ionospheric Refraction on 15 km baselines ?

'Fringe spacing' at 120(30) MHz on a ~ 15 km baseline is 35" - 120"

CasA, TauA heavily resolved. CygA and VirA still OK but complex

Other sources needed! E.g.

- 3C123 250 Jy at 120 MHz 'isolated' fields
- 3C196 90 Jy (5 ~ 6 Jy sources in 6° field)
- 3C295 100 Jy
- 3C409 100 Jy
- 3C61 50 Jy (dec +87 !!) initial imaging near NCP (~ constant elevation)
- 3C348 500 Jy (Hercules A, flux calibrator ?)

Note that in (200s, 180 kHz) --> $Bt = 10^8$ < 1-3 Jy noise in HBA

Estimated sensitivity for a 24-tile to 48-tile baseline

Assume SEFD (1 pol) for a 24-48tile baseline at 120 MHz : ~ 2000 Jy

Thermal noise in (200s , 180 kHz) $\sim 2000 / 5800 \sim 0.35$ Jy

Fluxes for the polarized flux of the 3 pulsars at 120 MHz are 1 Jy, 3 Jy, 10 Jy .

--> even in a single subband we can start to see these (integrated polarized signals of) pulsars in 200s integration !

Conduct 12h tracks with 2-3 stations on PSR0531 followed by PSR1937 (day and night coverage at dec +21 !)

Note that on a 15-20 km baselines the Crab nebula (1500 Jy !) is almost completely resolve --> no gain issues

High resolution VLA images of TauA at 74 / 327 MHz

Note how the pulsar shows up strongly at 74 MHz !

