ASTRON

UNIVERSITY OF OXFORD

RadioNet

SEVENTH FRAMEWORK PROGRAMME

StEFCal

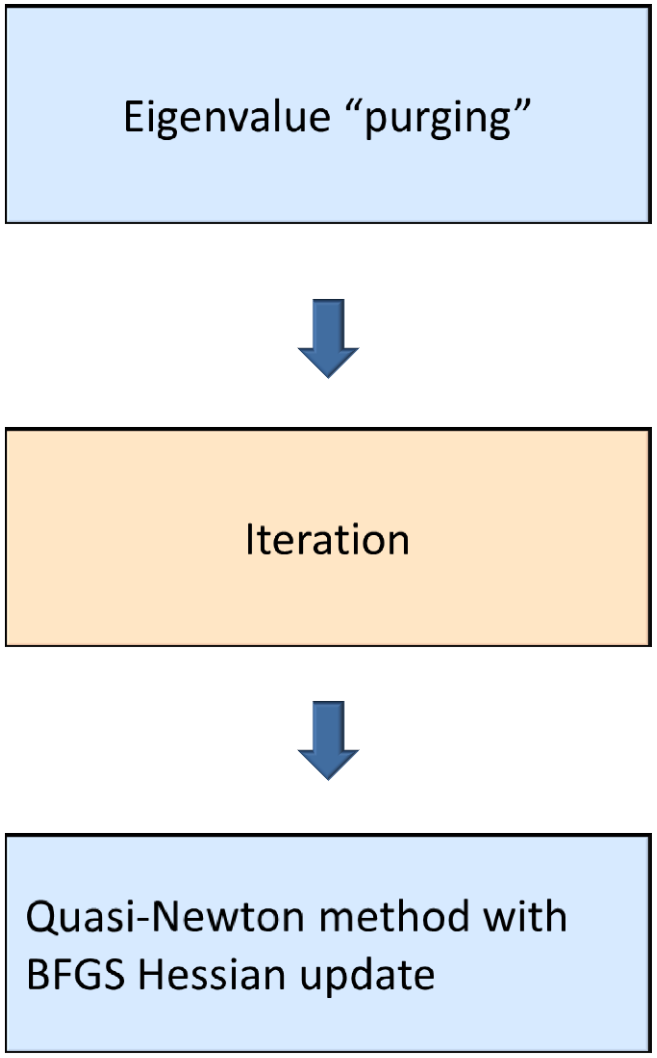
Stef Salvini, Stefan Wijnholds

Contract No: 283393

Basics

- StEFCal
  - O.Smirnov's nickname
  - Statistical Efficient & Fast Calibration (Stefan W's acronym)
- L_2 (least-squares) minimisation
- For minimizing $|| M – G D G^H ||_F$
  - M: model; D: data; G: diagonal or block-diagonal
  - G is
    - diagonal for unpolarised case
    - 2 x 2 block-diagonal for polarised case
  - Distance between model sky and calibrated observation
- $O(N^2)$ floating-point operations and memory footptrint throughout
- Accuracy and robustness
- Performance not dependent on the sky complexity

Components



Useful if n.sources << N
Otherwise can lead to bias
Using mixture of Lanczos & RR: $O(N^2)$

Iteration
Akin to ADI with dumping

Mostly for Polarization cases if the iteration fail to converge fast enough
Still $O(N^2)$

Iteration

- The iteration tries to find the stationary point (zeros) of the norm of the gradient of the Frobenius norm square:

$$\text{Trace}\{(G^{+}V)\,[M-(G^{+}V)^{+}G]\}=0$$

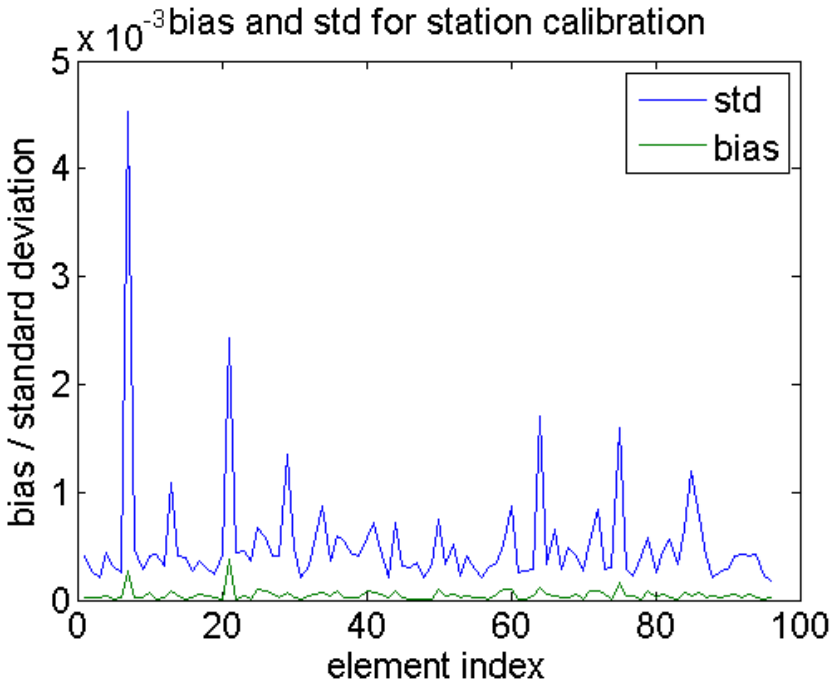
- ADI iteration does not converge
- “Damping” very effective
  - Get $G^{[2j+1]}$
  - Get $G^{[2j+2]}$
  - Set $G^{[2j+2]} = (G^{[2j+2]} + G^{[2j+2]}) / 2$
- Relaxation approach available
  - Faster but less reliable

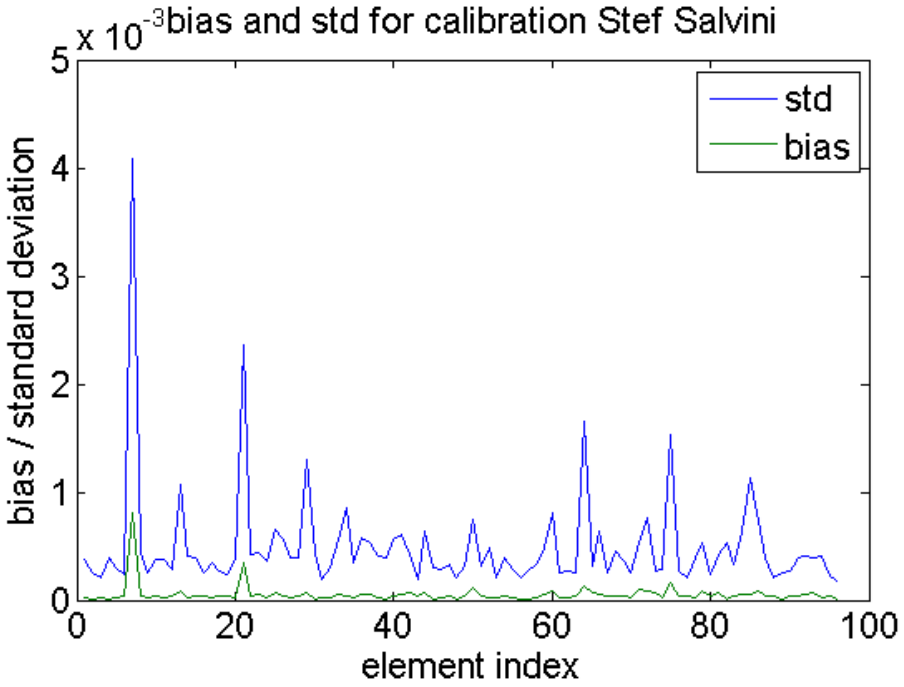
Some performance figures

N. Antennas	Old		StEFCal	
	Time (sec)	Normwise error in G	Time (sec)	Normwise error in G
96 (LOFAR)	0.403	0.204	0.015	0.240
351 (~ SuperTerp)	11.58	0.110	0.058	0.103
1,000 (~ SKA1 station)	273.74	0.069	0.381	0.034

- Simulated sky (GSM – 25,000 sources) + receiver noise
- 200 sources used for calibration
- MATLAB code
- My own laptop (Intel Core 2 i7, 2.0 GHz, Windows

Bias & STD compared to Stefan W

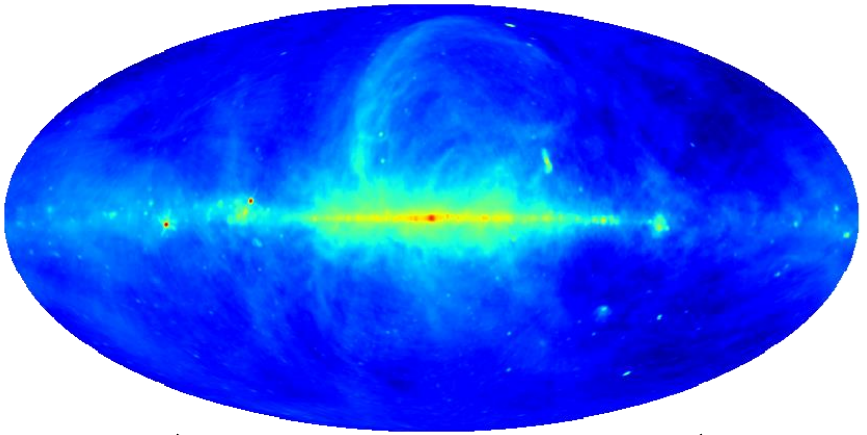




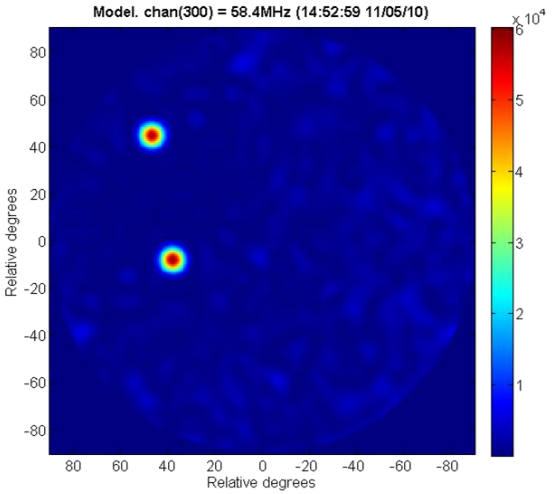
Chilbolton LBA LOFAR Station

- Chilbolton LBA LOFAR station data
  - Thanks to Griffin Foster (OU)!
- Channel 300: 58.4 MHz
  - Other channels also available
  - Sequence of snapshots
  - Observations spaced by ~520 seconds
- Model sky of increasing complexity
  - 2 sources
  - 500 sources
  - 5,000 sources

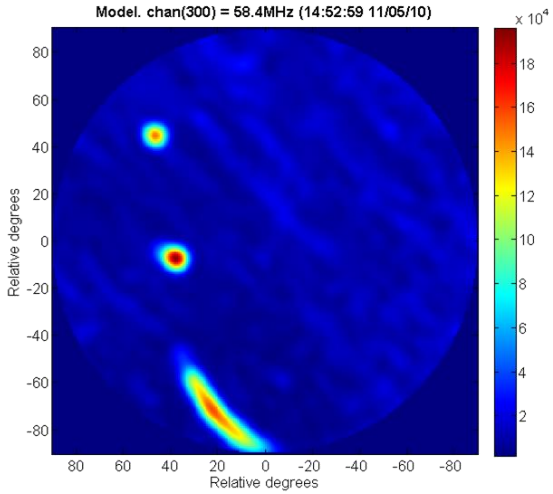
Model Sky



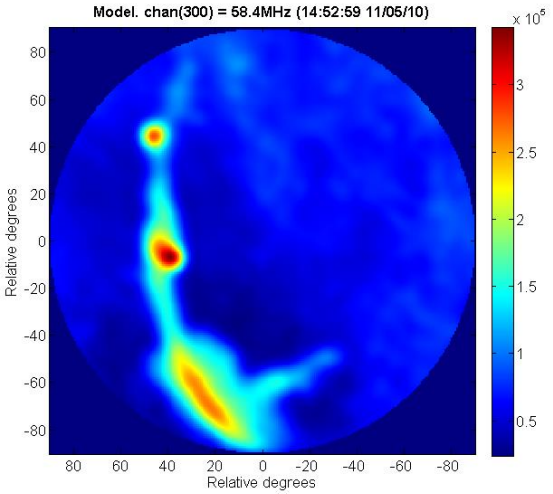
2 sources



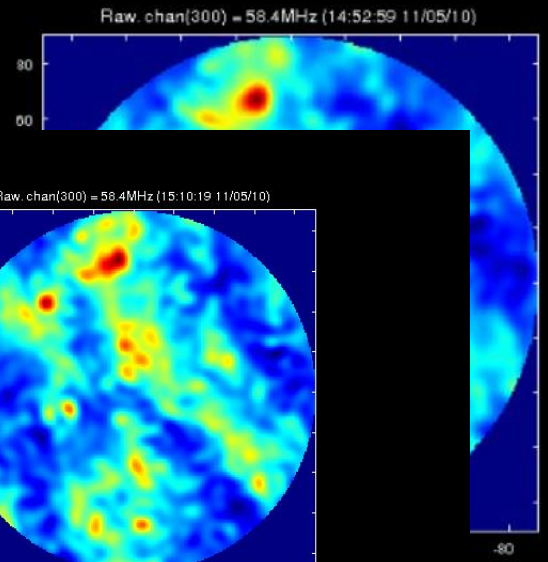
500 sources

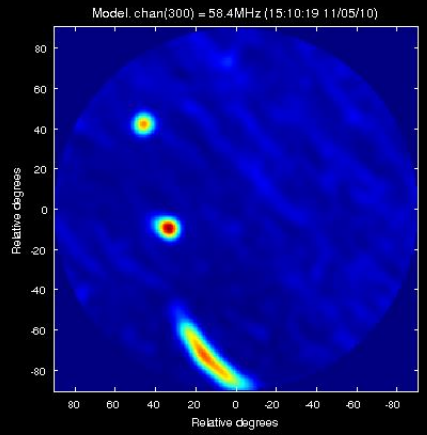


5000 sources

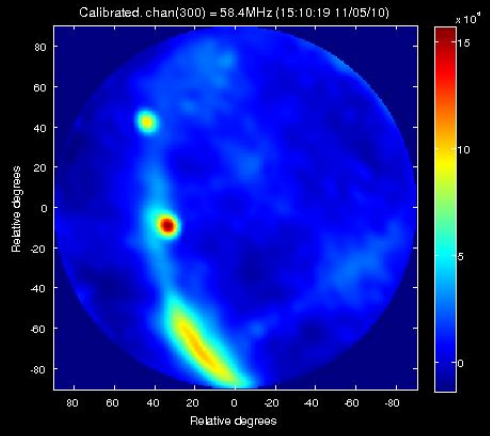



Model. chan(300) = 58.4MHz (14:52:59 11/05/10)
80
60


Raw. chan(300) = 58.4MHz (14:52:59 11/05/10)
80
60
-80


Model. chan(300) = 58.4MHz (15:10:19 11/05/10)
Relative degrees
80 60 40 20 0 -20 -40 -60 -80
Relative degrees

Raw. chan(300) = 58.4MHz (15:10:19 11/05/10)
Relative degrees
80 60 40 20 0 -20 -40 -60 -80
Relative degrees


Calibrated. chan(300) = 58.4MHz (15:10:19 11/05/10)
x 10^4
15
10
5
0
Relative degrees
80 60 40 20 0 -20 -40 -60 -80
Relative degrees


80 60 40 20 0 -20 -40 -60 -80
Relative degrees