LOFAR self calibration

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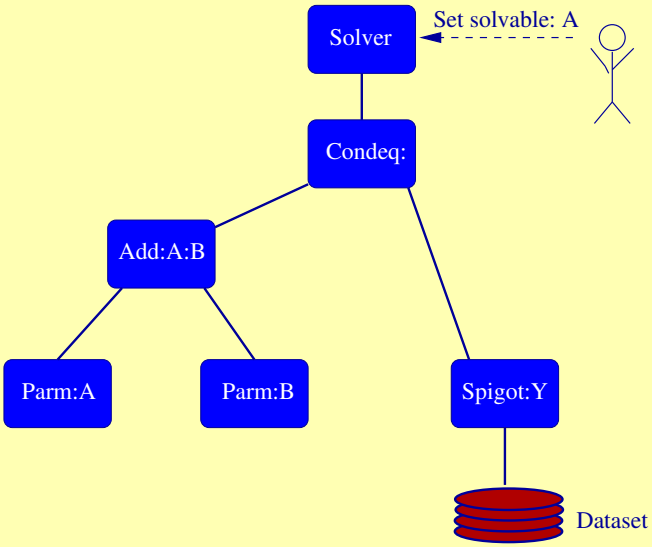
Operation 343

MeqTree/MeqTimba

- Meq = Measurement EQuation
- (Hamaker Bregman Sault 1995-6)
- Arbitrary expression trees
- Actually, graphs
- Example: $Y = A + B$

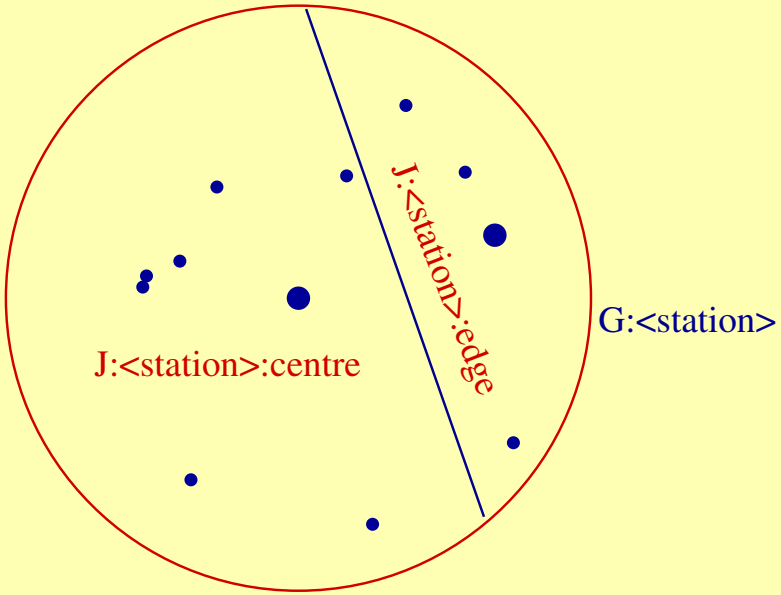


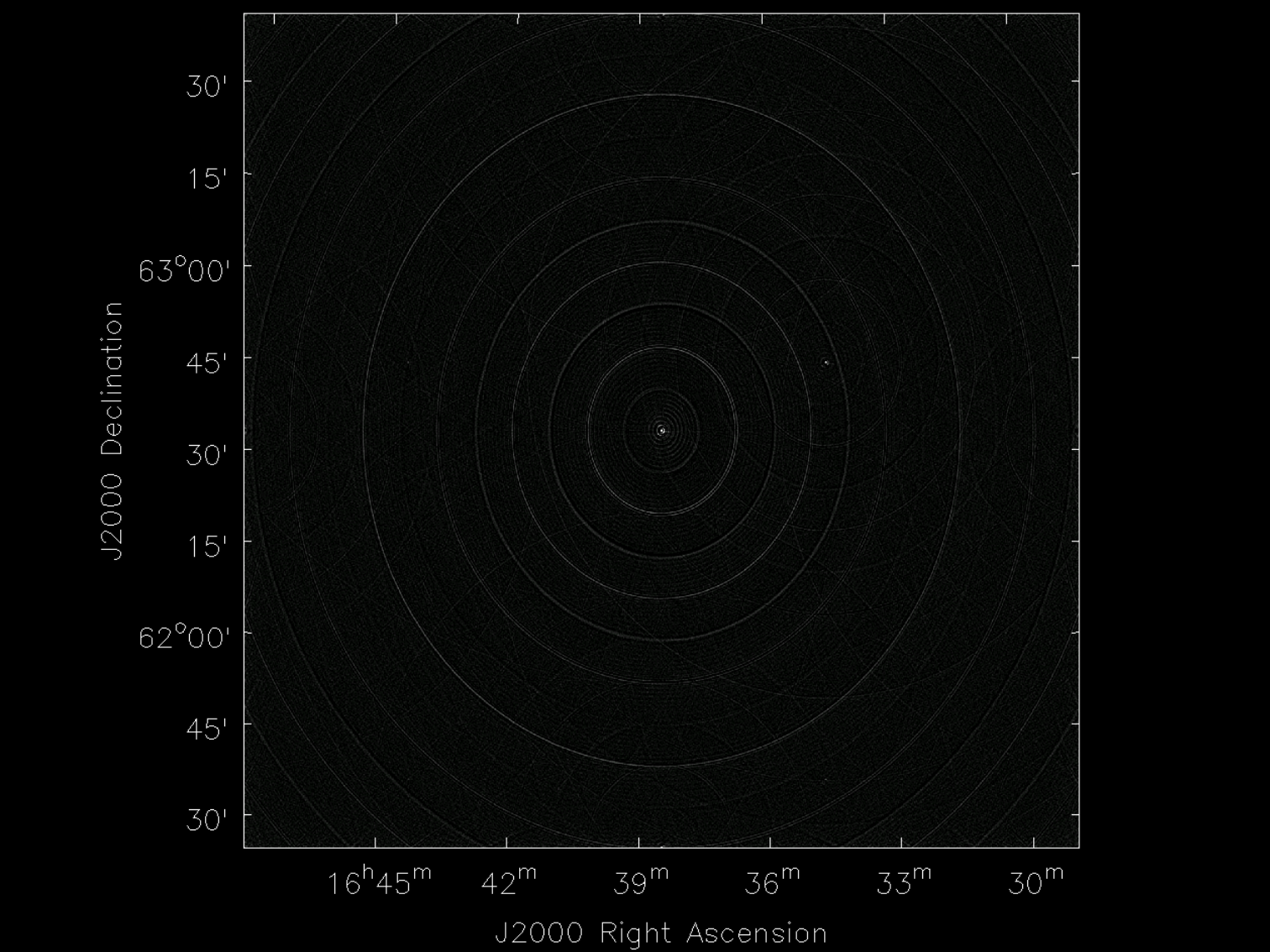
Simple dataset

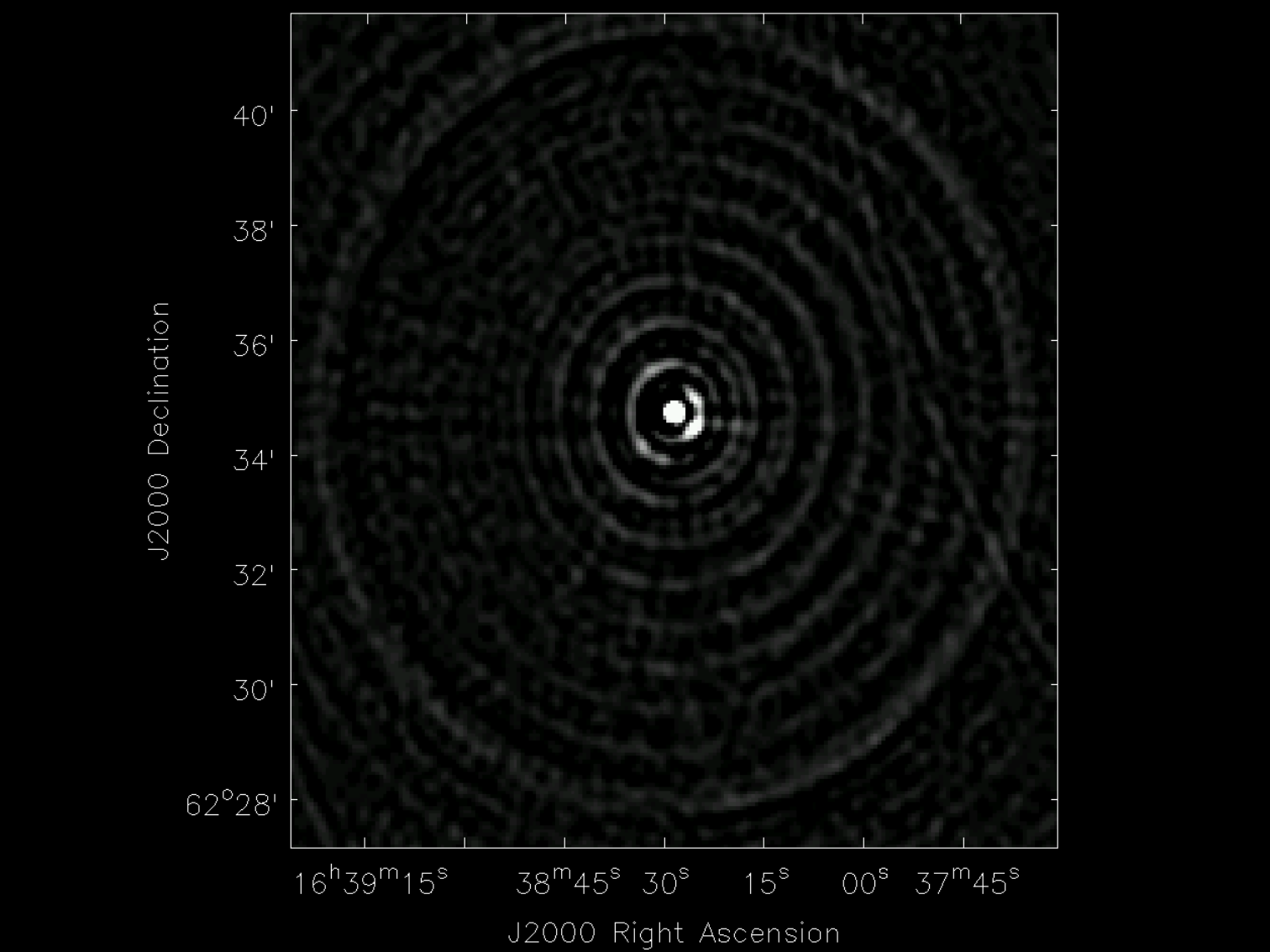
- WSRT dataset
- 20 MHz around 1175 MHz
- Bright (6 Jy) pointsource at phase centre (3C 343.1)
- Bright (1.8 Jy apparent) pointsource at flank of beam (3C 343)
- Thermal noise level in single channel: 0.3 mJy/beam

Measurement Equation

$$\tilde{\mathrm{V}}_{ij} = \mathrm{G}_i \left(\sum_p \mathrm{J}_{ip} \left[\sum_k K_{ipk} \mathrm{E}_{ijp} K^*_{jpk} \right] \mathrm{J}^\dagger_{jp} \right) \mathrm{G}^\dagger_j \qquad (1)$$




30'
15'
63°00'
45'
30'
15'
62°00'
45'
30'
J2000 Declination
16h45m
42m
39m
36m
33m
30m
J2000 Right Ascension


40'
38'
36'
34'
32'
30'
62°28'
J2000 Declination
16h39m15s
38m45s
30s
15s
00s
37m45s
J2000 Right Ascension

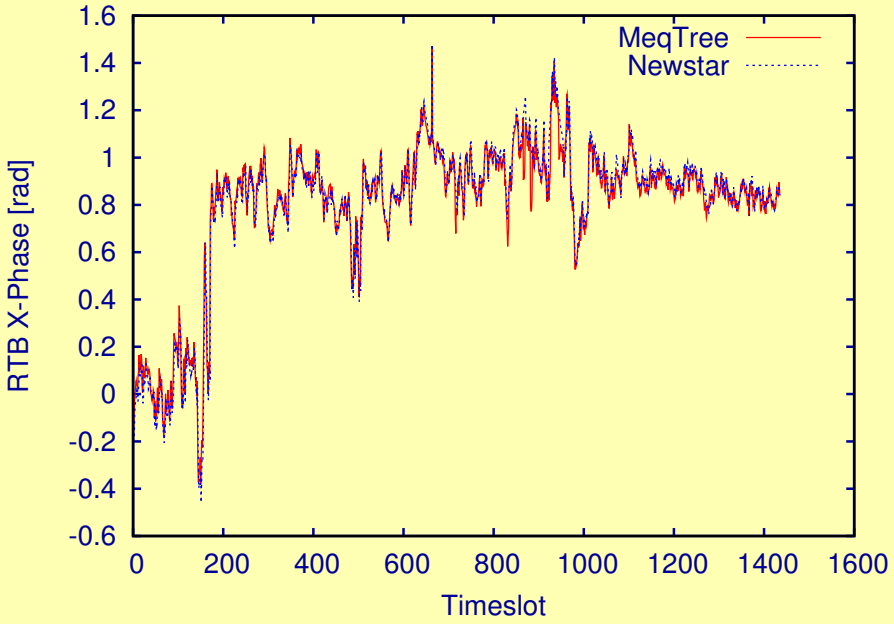
Reduction procedure - preprocessing

- Coarse flagging (Aips++ autoflag tool)
- Flagged on time- and frequency median filter on abs XY and YX
- Bandpass, gain, pol.leakage calibration using 3C 295 (Aips++)

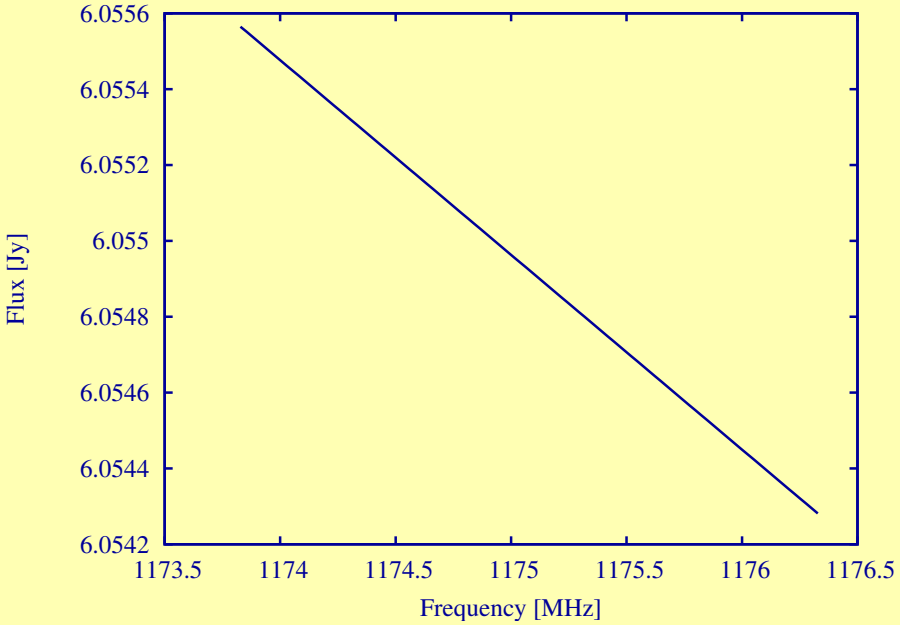
Reduction procedure - selfcal

- Polynomial source flux fit (I and Q) in uvplane (MEQ)
- Fit for one phase *G* (30s) (MEQ)
- Flux fit (full domain) (MEQ)
- Flagging on amplitude of residuals (Aips++)
- Phase fit *G* (30s)(MEQ)
- Gain fit (15 min, linear polynomial in time)(MEQ): both sources independently: *J*

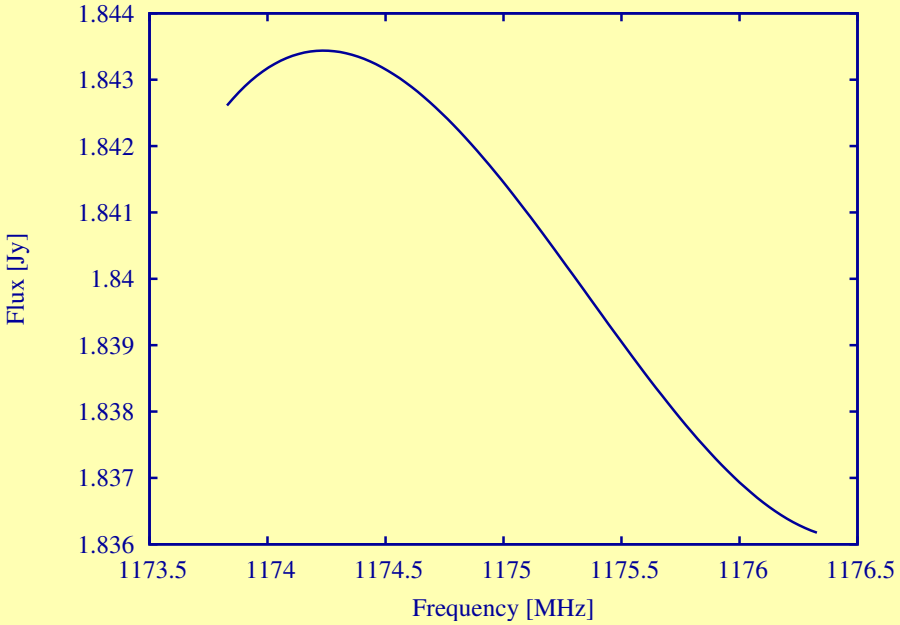
Phase solution comparison (approximate fluxes)

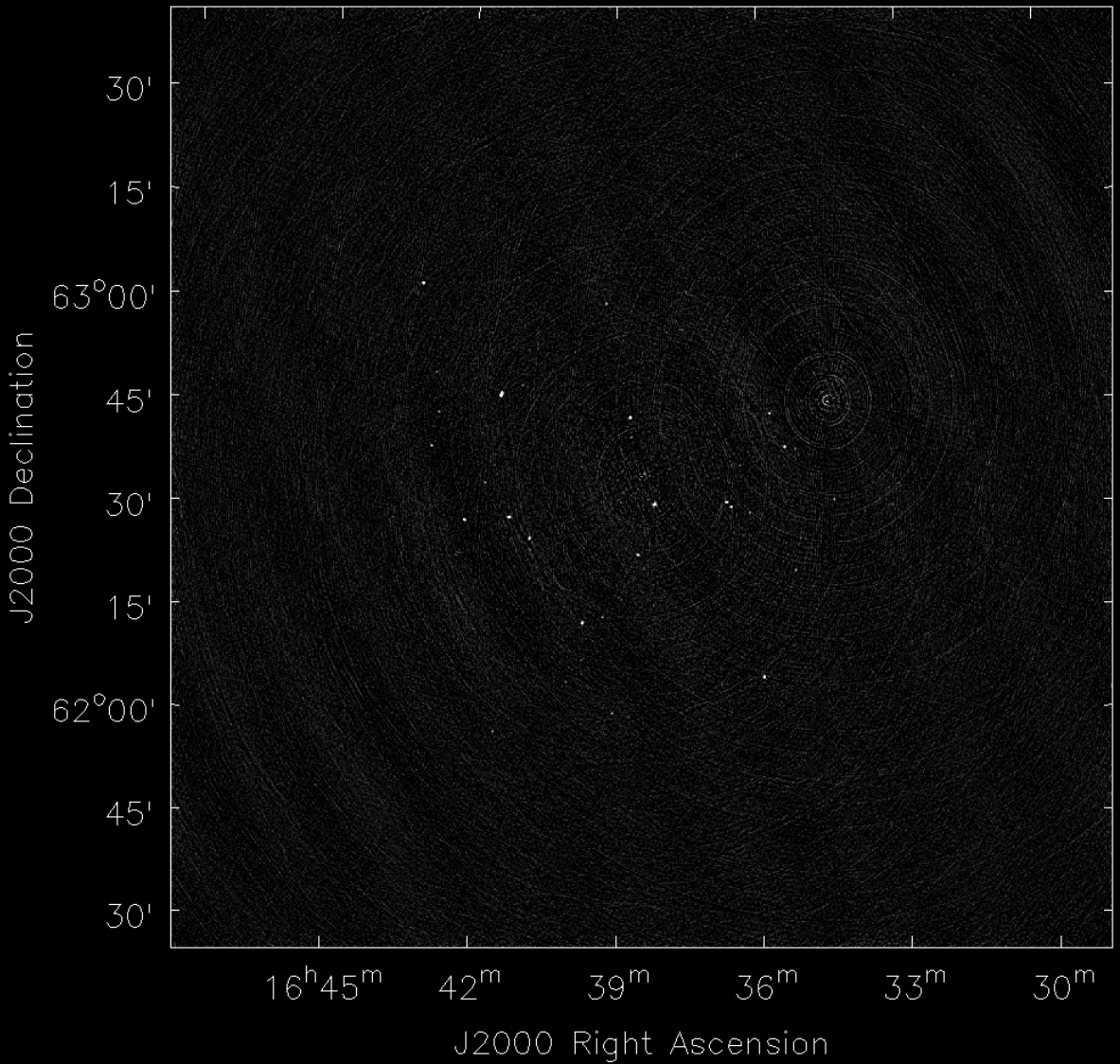


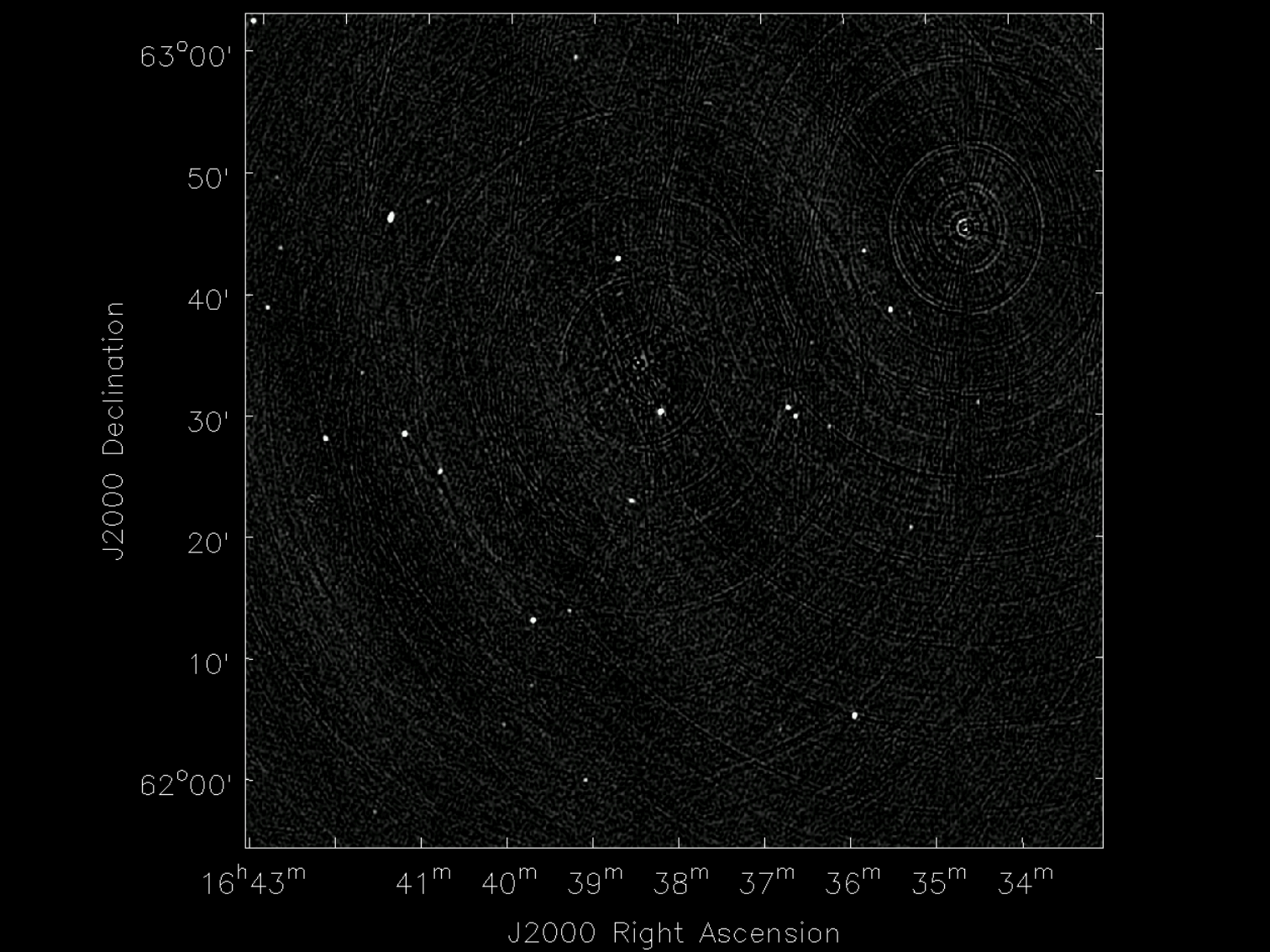
3C 343.1 flux


6.0556
6.0554
6.0552
6.055
6.0548
6.0546
6.0544
6.0542
Flux [Jy]
1173.5
1174
1174.5
1175
1175.5
1176
1176.5
Frequency [MHz]

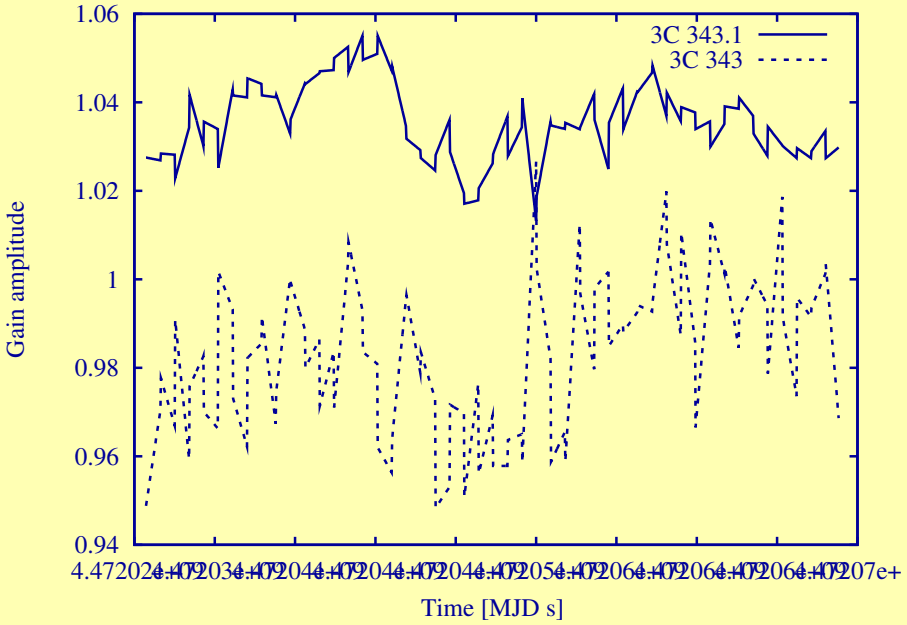
3C 343 flux


1.844
1.843
1.842
1.841
1.84
1.839
1.838
1.837
1.836
Flux [Jy]
1173.5
1174
1174.5
1175
1175.5
1176
1176.5
Frequency [MHz]

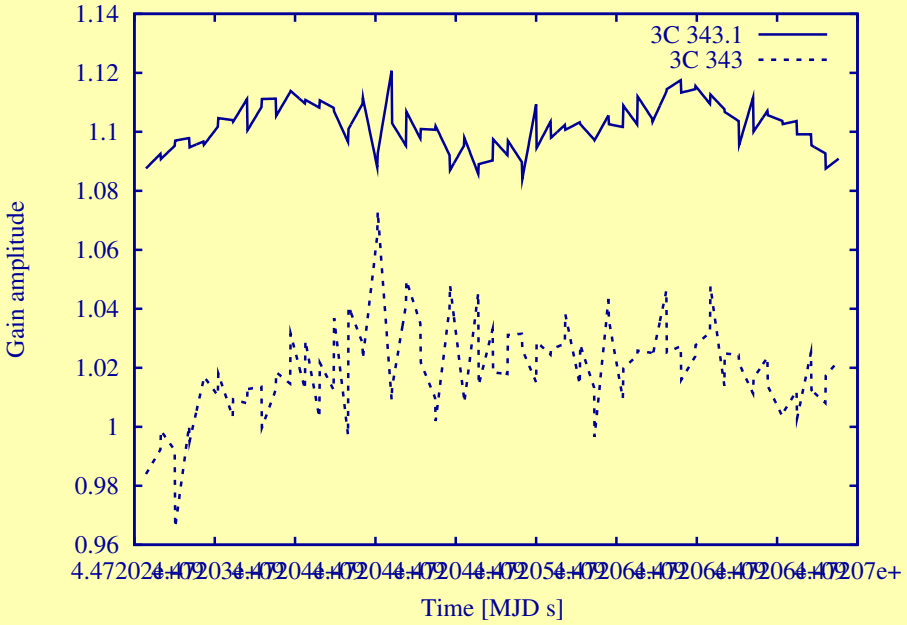

30'
15'
63°00'
45'
30'
15'
62°00'
45'
30'
J2000 Declination
16h45m
42m
39m
36m
33m
30m
J2000 Right Ascension


63°00'
50'
40'
30'
20'
10'
62°00'
J2000 Declination
16h43m
41m
40m
39m
38m
37m
36m
35m
34m
J2000 Right Ascension

RT7 gain amplitude



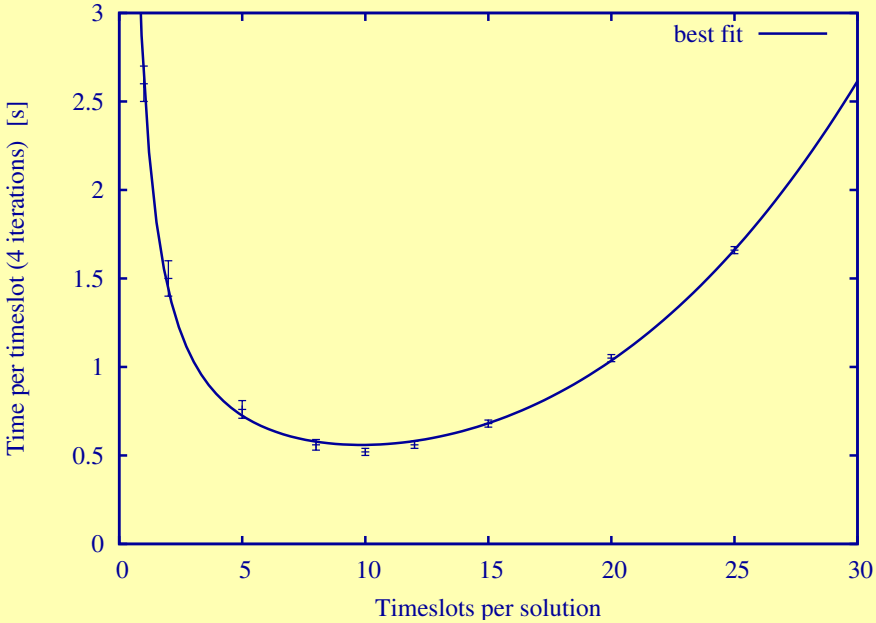
RTD gain amplitude



Properties of image

- 6 channels
- thermal noise: 0.12 mJy/beam, max DR≈ 50 000:1
- actual map noise: 0.4 mJy/beam, DR ≈ 15 000:1

Execution time



$$t = (\frac{a}{x} + bx^3 + c)n_{\text{iter}} \qquad (2)$$

$a = 0.60 \pm 0.03$, $b = 2.13 \pm 0.05 \times 10^{-5}$, $c = 0.059 \pm 0.004$

Conclusions/future

- IT WORKS !!!
- Ability to modify ME easily in MeqTree system is very powerful
- For large domains, MeqTree is about twice as fast as Newstar
- For domains smaller than about 600 datapoints, overhead dominates run-time currently in our unoptimized system
- Add other sources to predict
- either make G timescale longer or shorter...