LOFAR Total Power Spectroscopy

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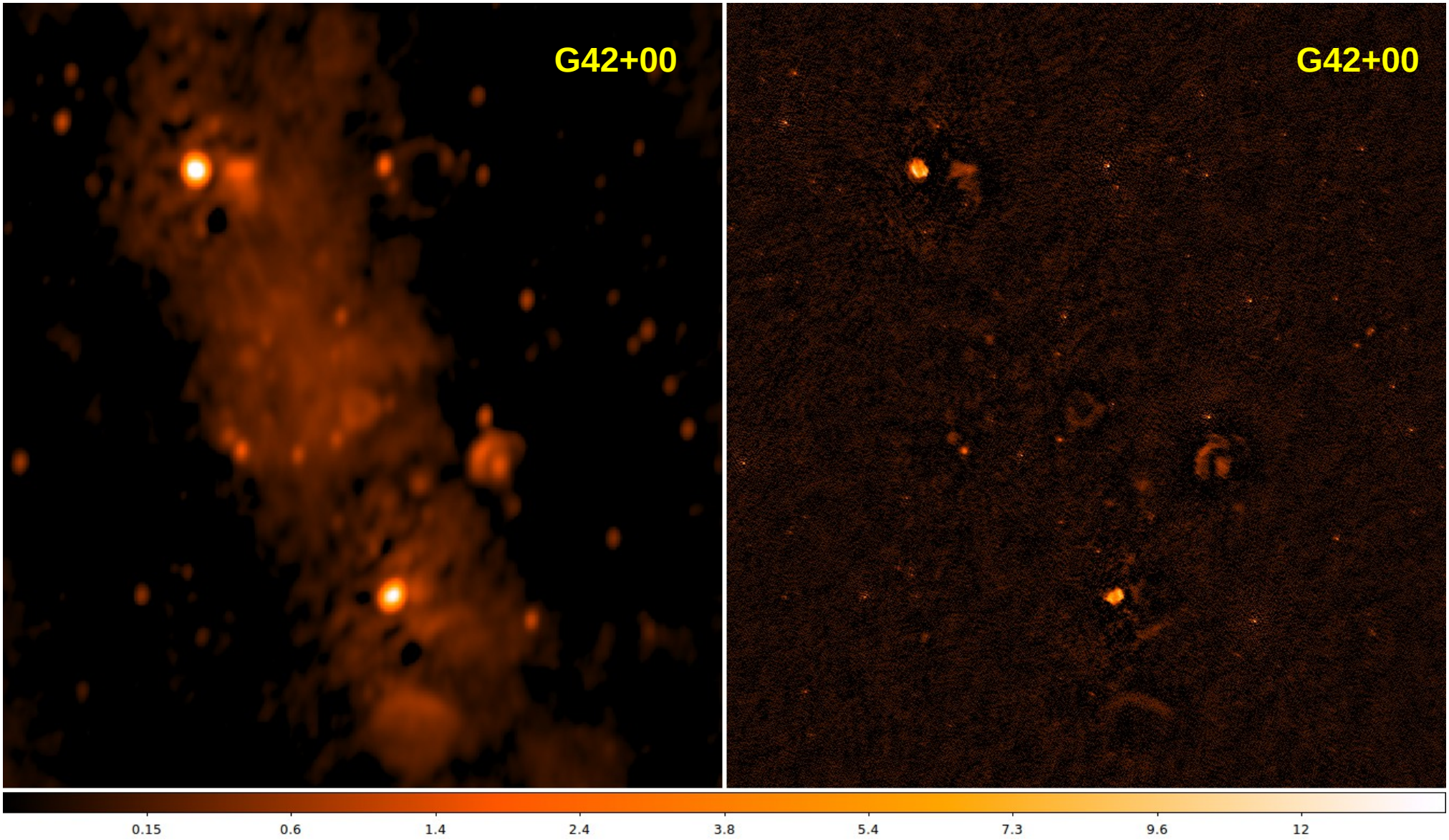


RRL Surveys

The Power of LOFAR:

Sensitivity , Resolution , FoV , BW

=> *"Survey speed"* *(α , δ , λ)*

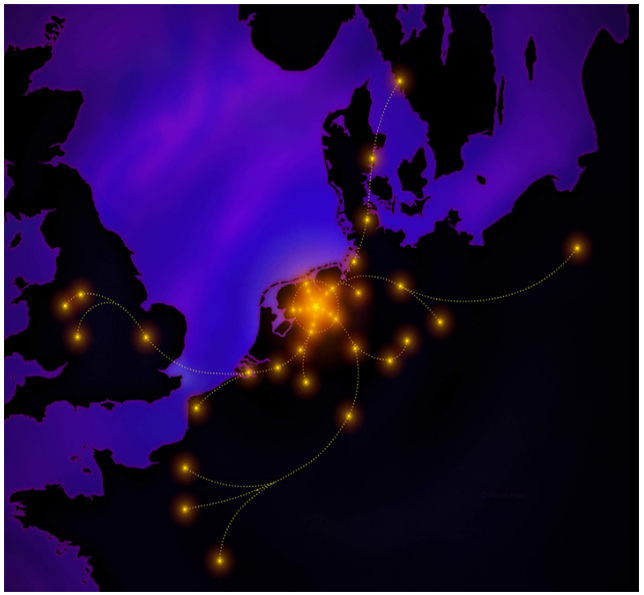
LBA 10 - 70 MHz : 400 RRL α-lines
HBA 105 - 250 MHz : 100 RRL α-lines

A) Medium resolution Galactic survey

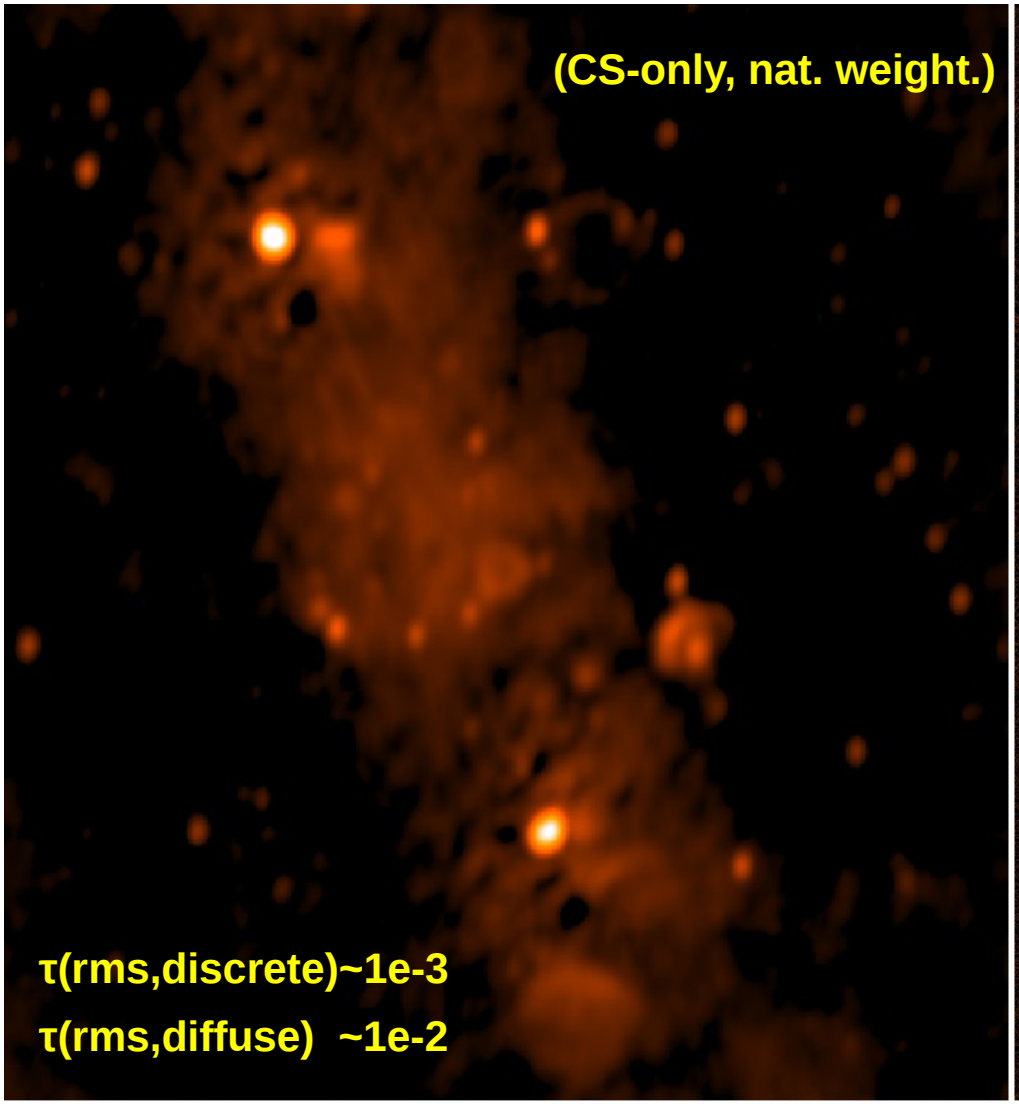
From degree-scales to >10'-scales

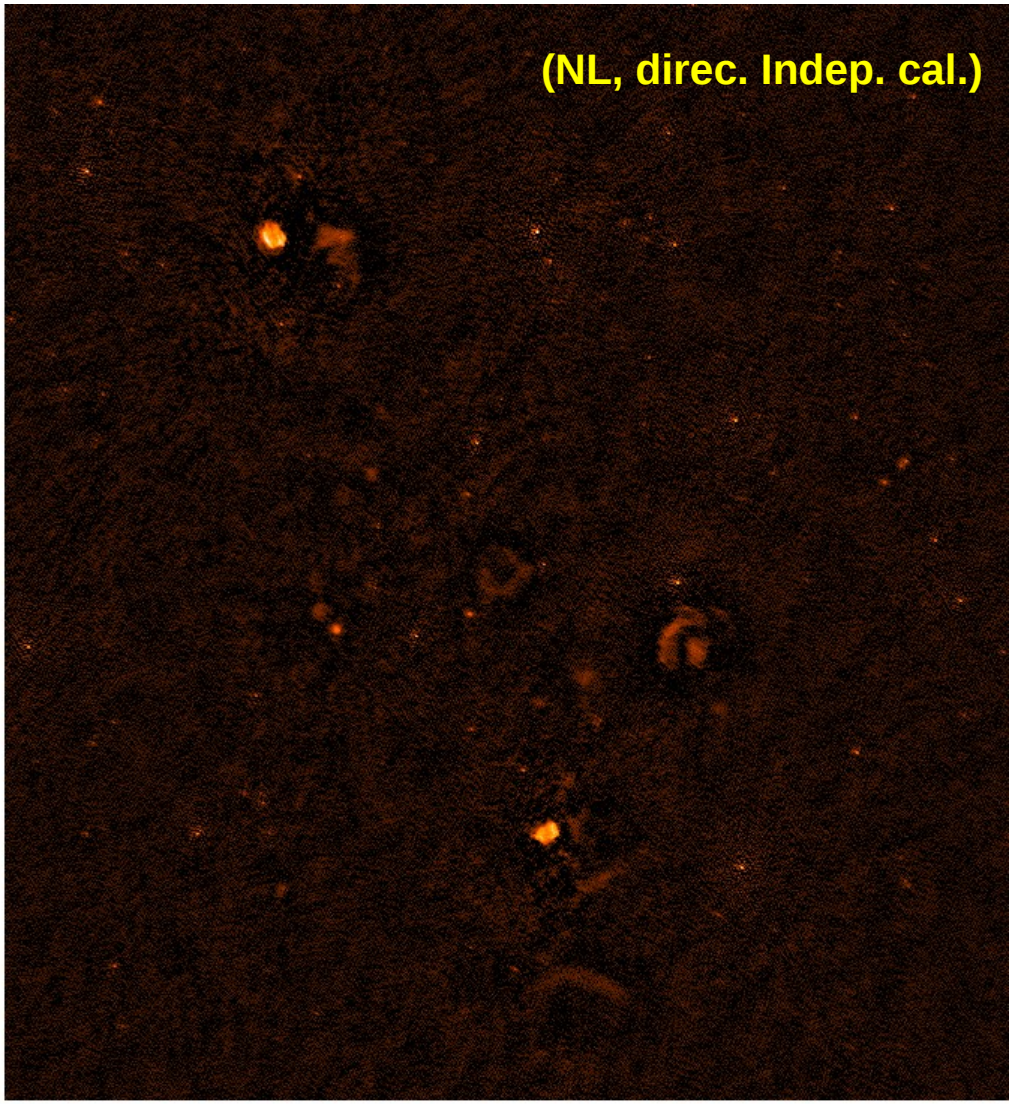
B) Galactic pinhole survey (<10')

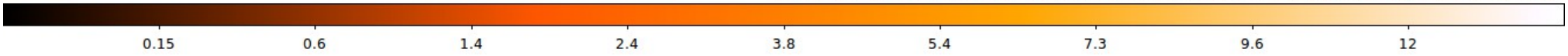
C) Extragalactic survey



G42+00 (150 MHz, 4 MHz, 4hr): Why we need total power



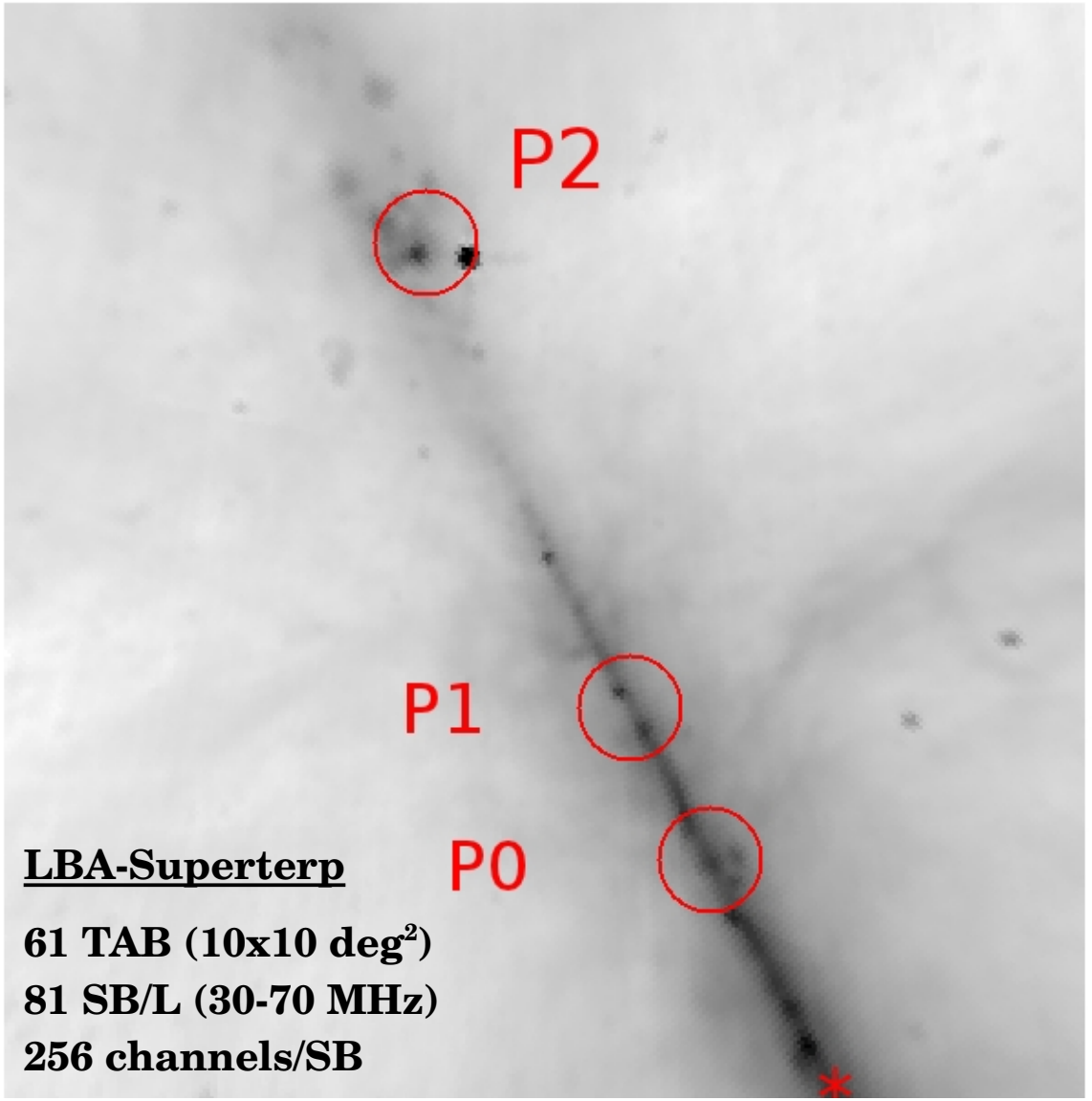




* CRRL basic quantity is optical depth, need to understand the continuum
  - only about 10-20% continuum recovered in HBA (Landecker+1970)
  - continuum scale (MW < 10 λ) is very different from gas scale (~arcmin)

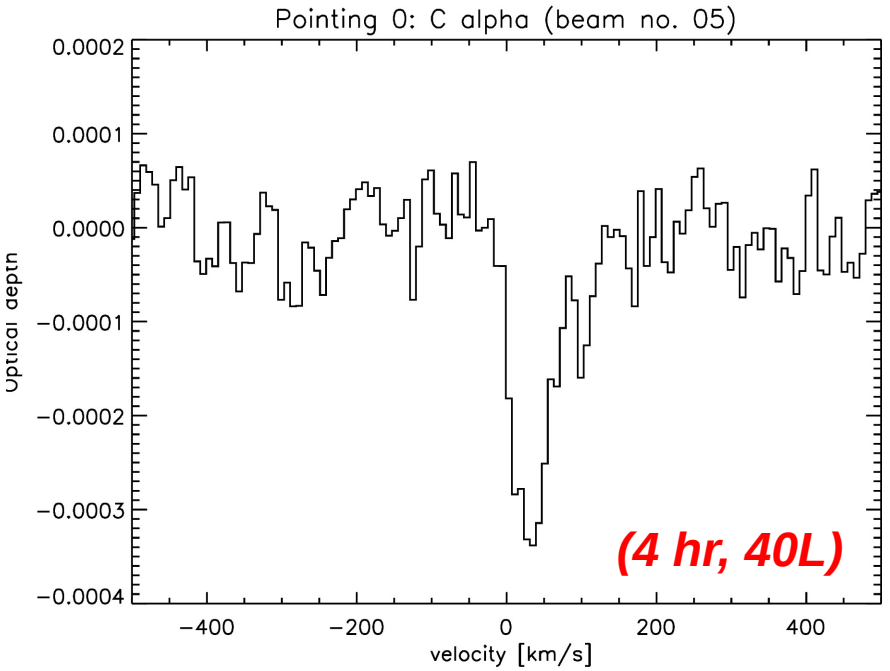
Galactic TA CRRL Survey: (BG results – LC 0 , 1)

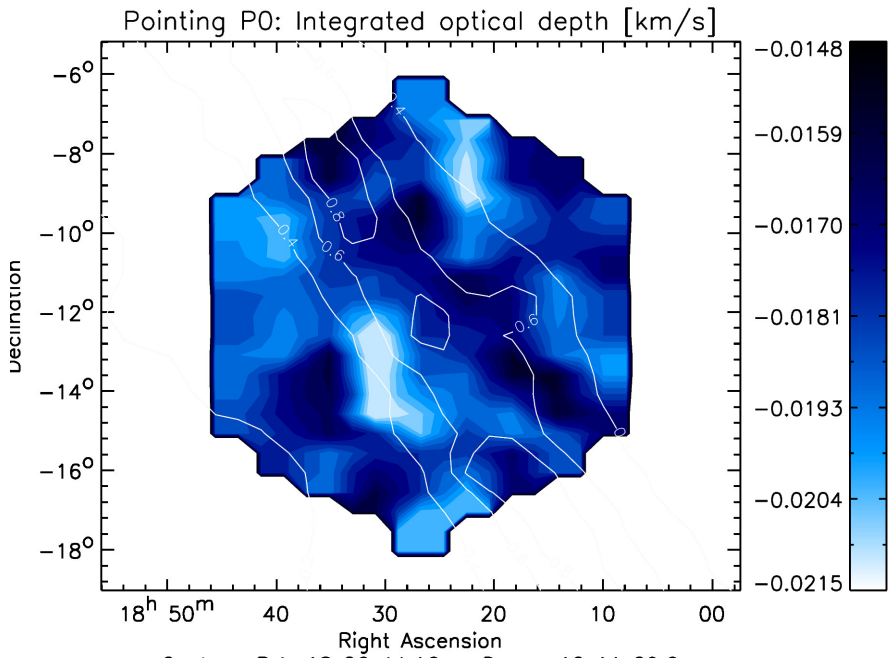
Haslam+1982 (408 MHz) map



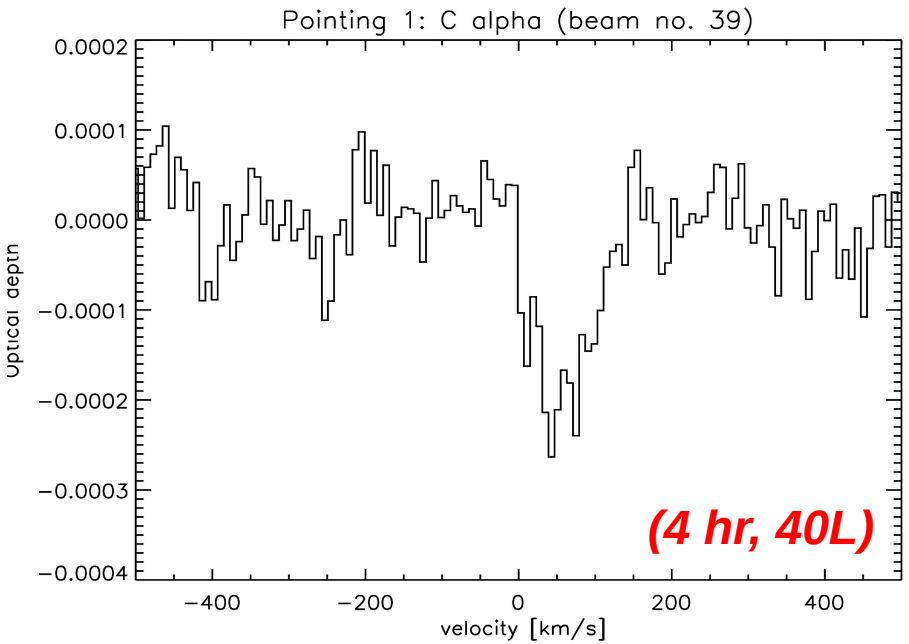
LBA-Superterp

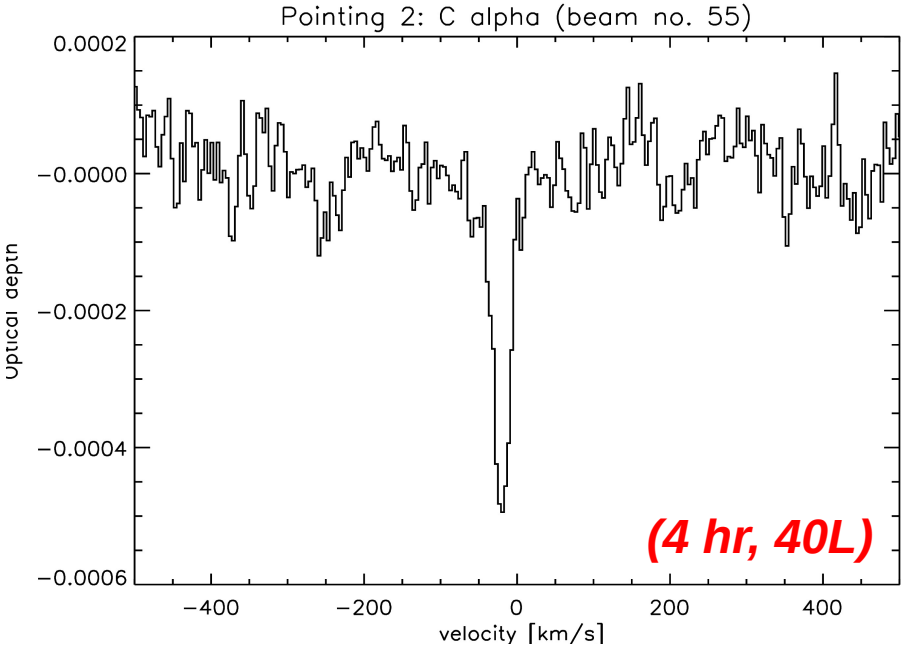
61 TAB (10x10 deg^2)
81 SB/L (30-70 MHz)
256 channels/SB

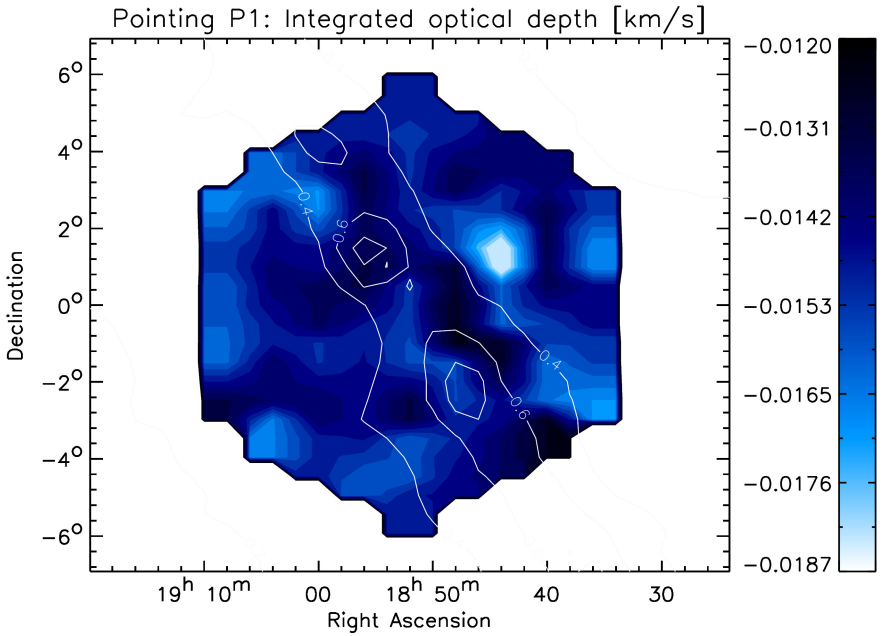


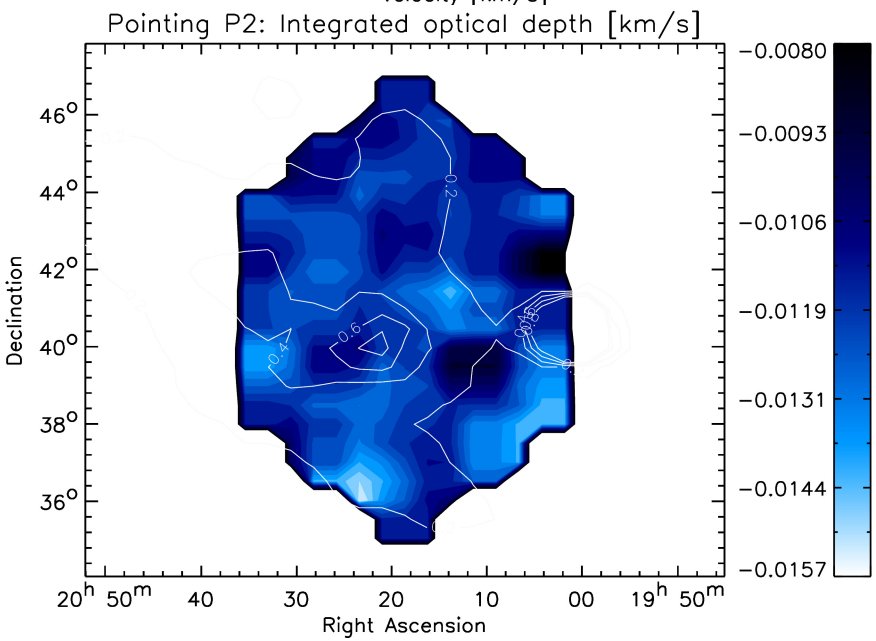


Galactic TA CRRL Survey: (BG results – LC 0 , 1)









Preliminary results:

→ **CRRL wide spread in MW plane**

→ **CRRL tau & FWHM decrease with Galactic longitude**

Galactic TA CRRL Survey: (BG results – summary)

LOFAR (50 MHz) results

P:	$\int \tau$	τ_{peak}	VEL*
0:	0.018	3.5e-4	+30
1:	0.015	2.5e-4	+55
2:	0.011	5.0e-4	+1

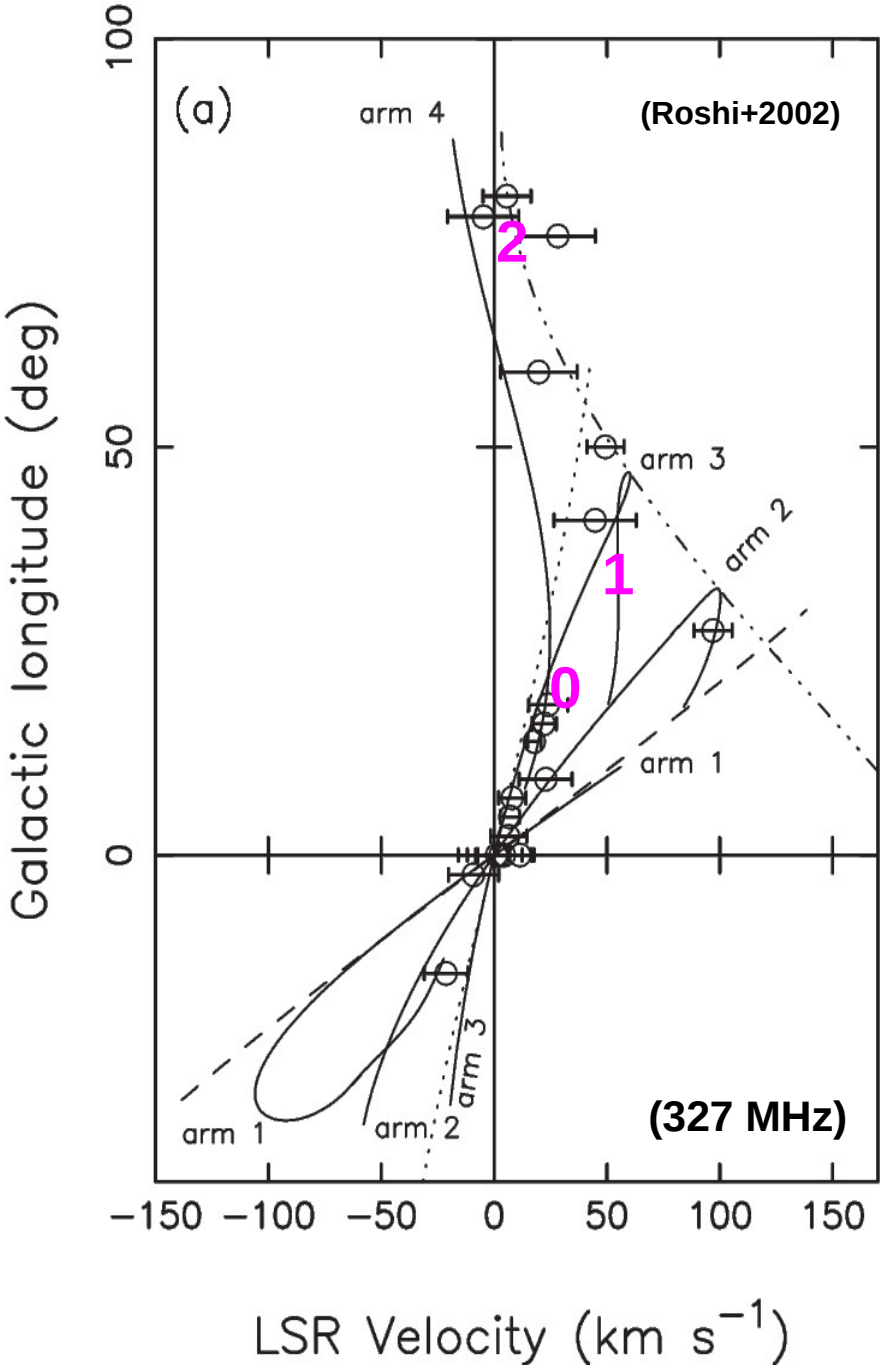
* after correcting for doppler (matches Roshi+2002)

Comparing surveys τ_{peak}

Ro00	(327 MHz, 2º)	(3 - 6)e-4
Er95	(76 MHz, 4º)	(5-10)e-4
Lofar*	(50 MHz, 1º)	(3 - 5)e-4

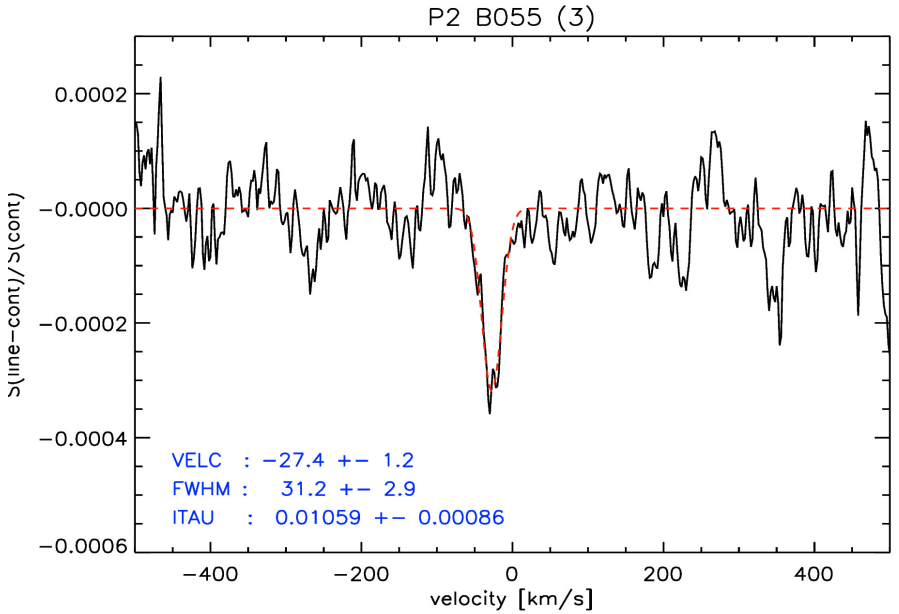
* LOFAR TA dilution: non-physical instrumental noise ?

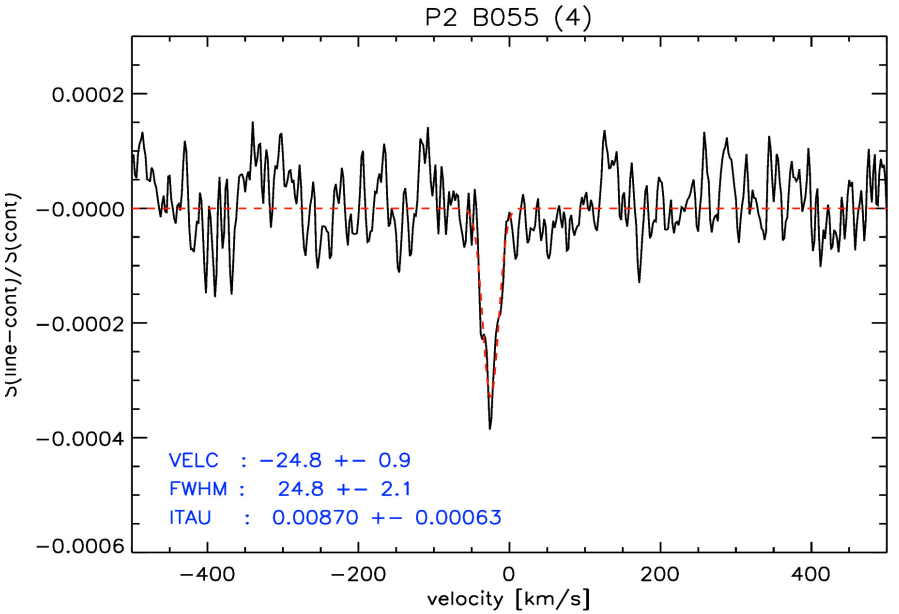
* Physical dilution of the surveys (gas vs. continuum) ?

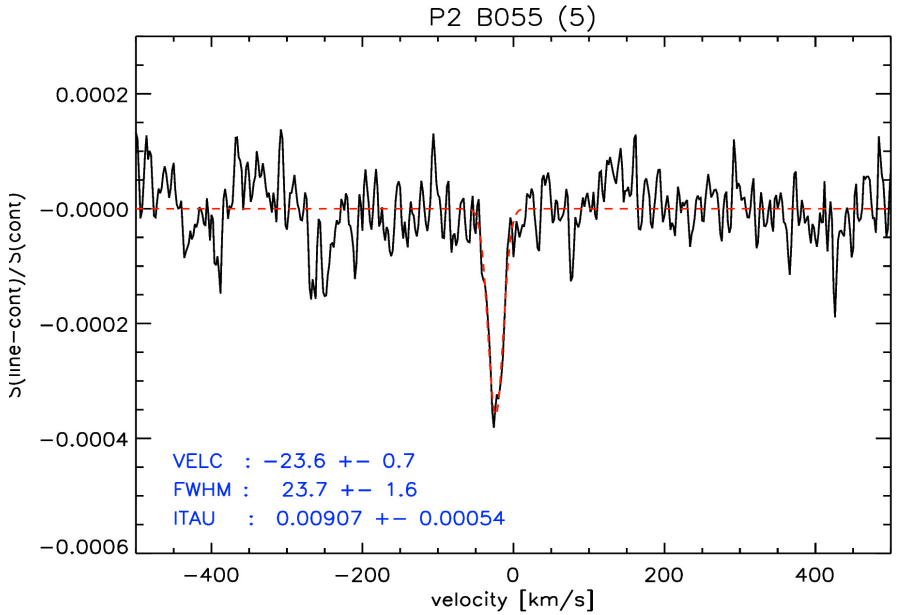


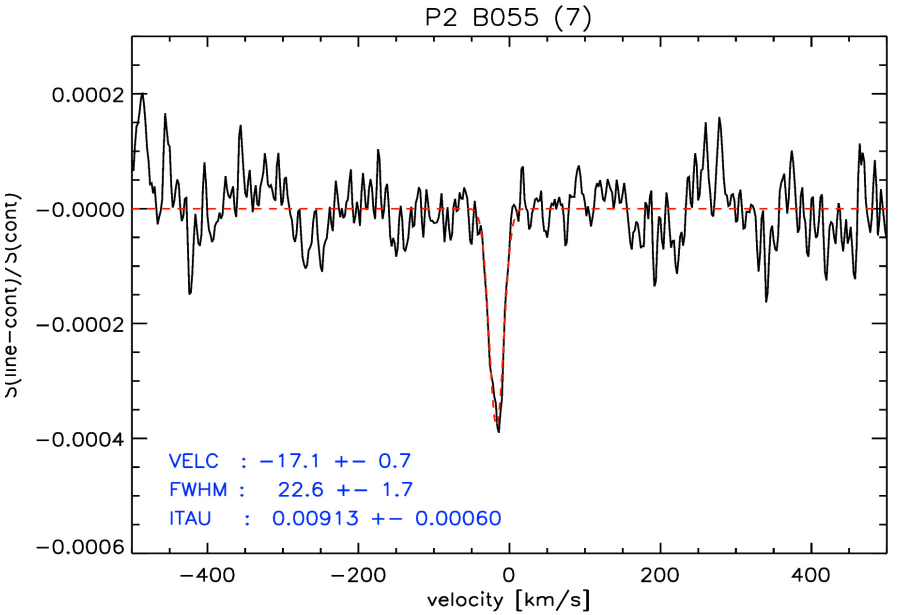
LBA TA CRRL: BG Stability , Quality & Instrument noise

* **Results from 4 observing runs: Instrumental noise level 'constant'**









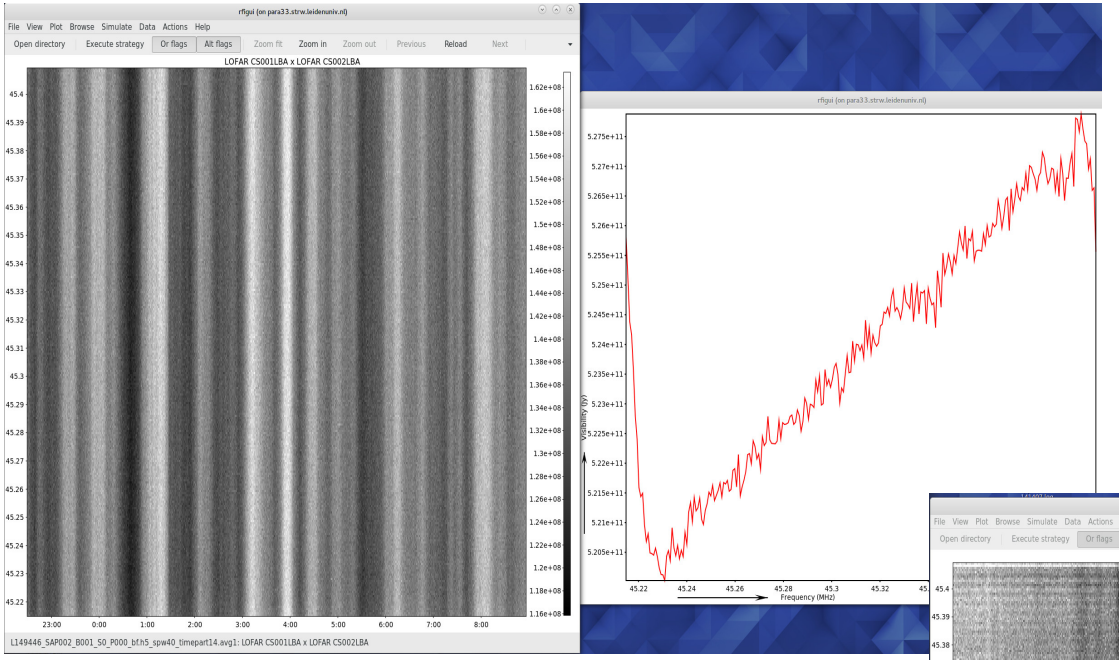
BG changed to Cobalt (LC1++)

- high spectral resolution
- subband bandpass

BG vs. Cobalt I: high frequency resolution

Commissioning: (zerolevel determination, Cobalt commissioning of TA-spec)

Project 1 (LBA 256chn): BG vs. Cobalt, bandpass and zerolevel determination

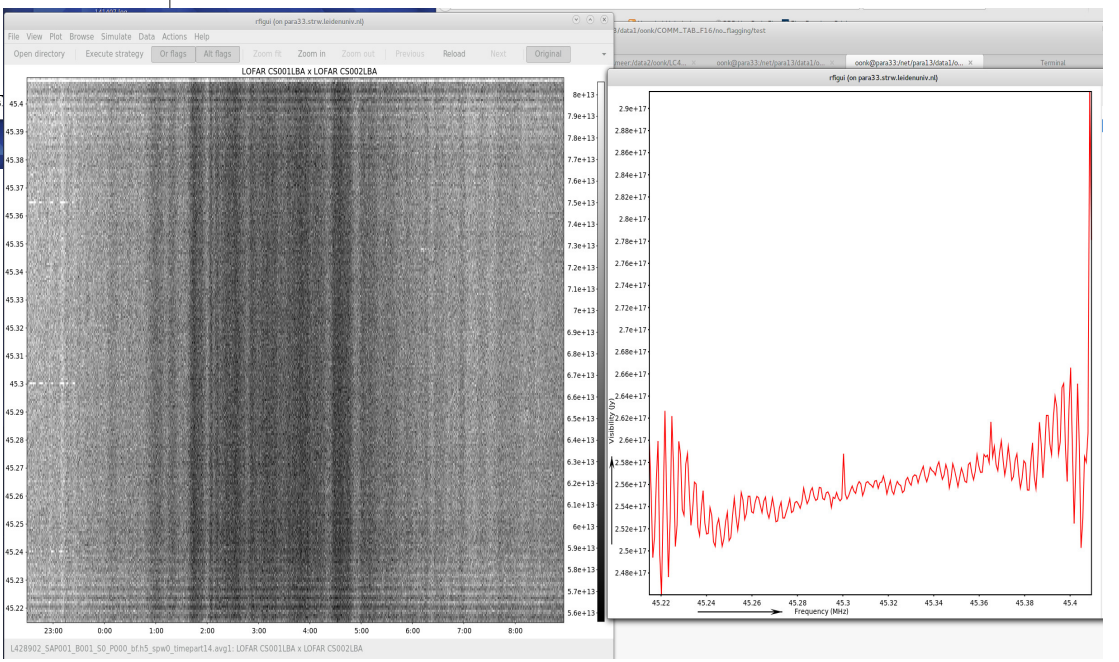


Cycle 5: Cobalt (bad bandpass)
τ(rms,chn) > 1e-2
systemic noise (bps)
can not detect RRL

↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

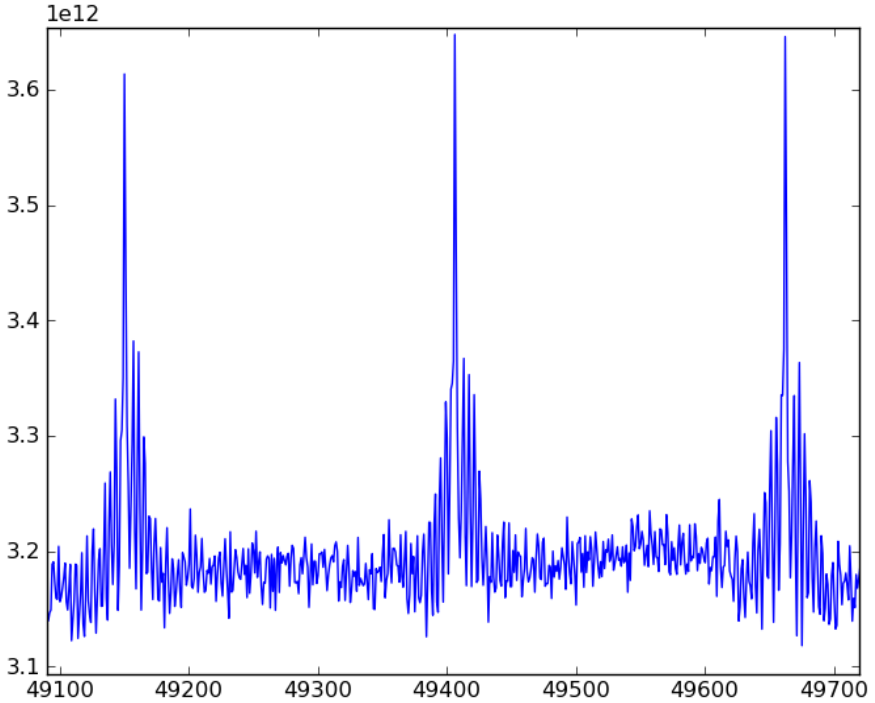
↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑

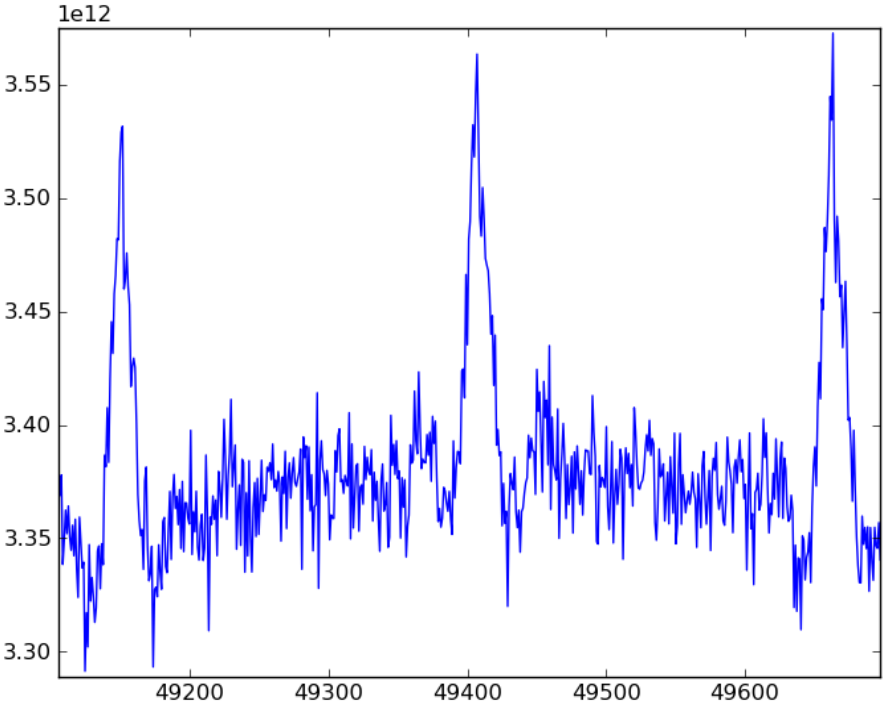
Cycle 1: Bluegene (good data)
τ(rms,chn) ~ 1e-3
gaussian noise
RRL easily detected



LBA TA CRRL Survey: Commissioning & Future

256 channel correction test march 2016: (*plots courtesy R. Fallows*)





*** Improved Cobalt bandpass correction looks encouraging, but needs to quantified**

- new LBA 256 chn Cobalt commissioning observations are done

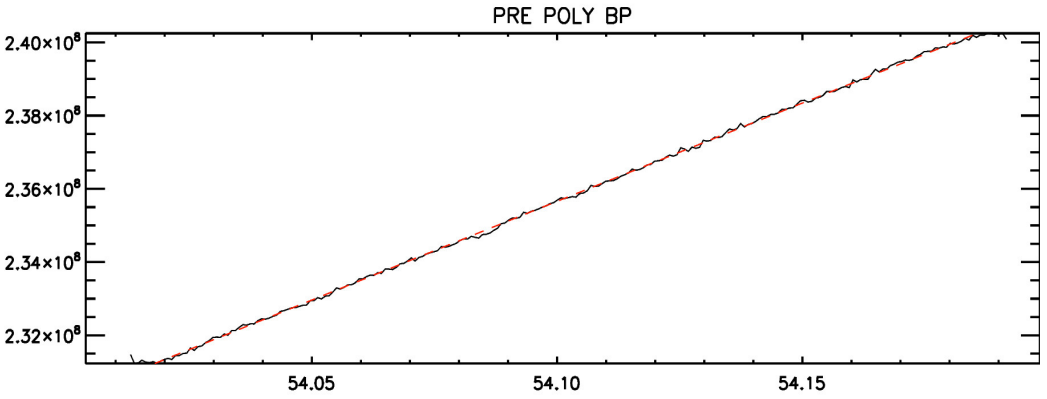
- HBA and HBA-HIGH need commissioning observations are planned

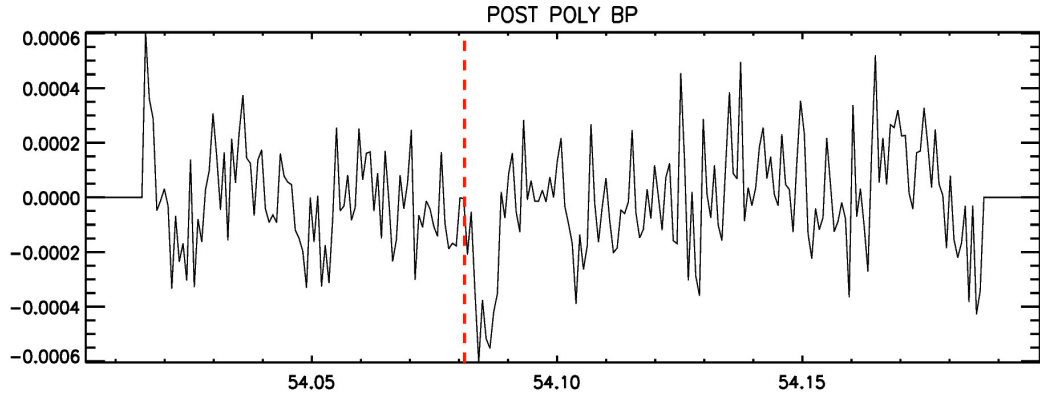
<u>Future</u>: 6 arcmin scale TA mapping of CRRLs in Cyg X and G42+00 (<u>cycle 6</u>)

directly compare the interferometry with total power spectroscopy

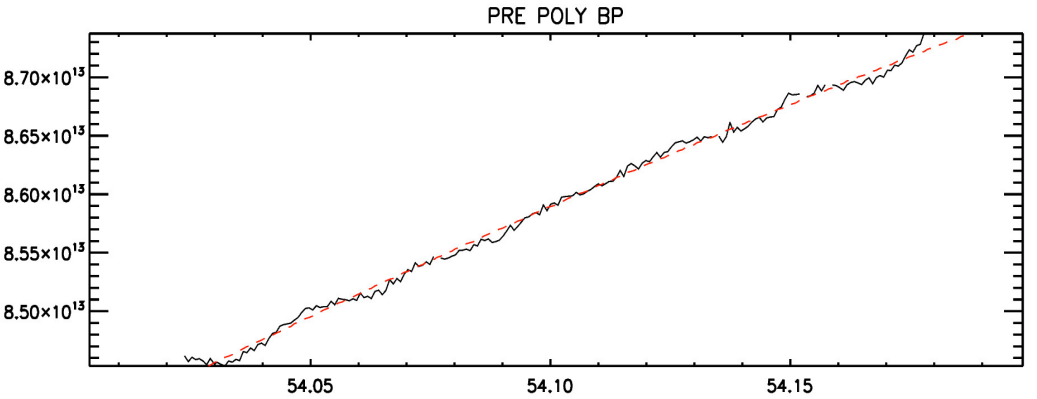
BG vs. Cobalt: TA spectra BG vs. Cobalt (w. correction)

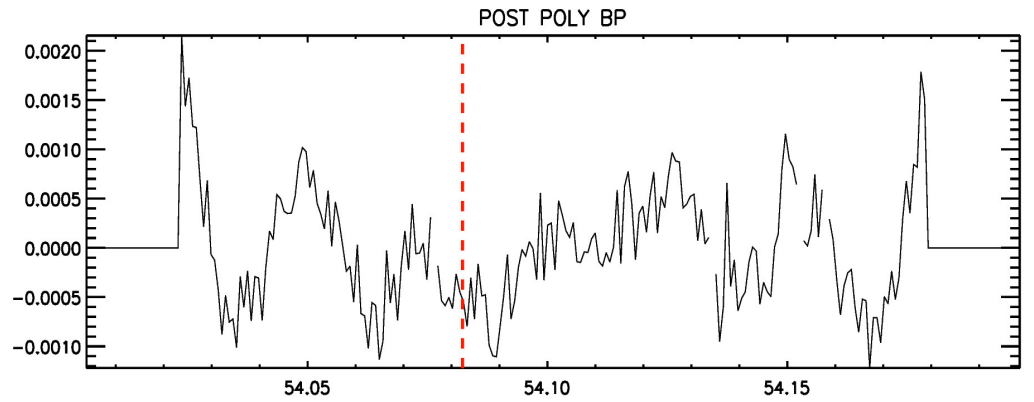
BG: Flagging & Averaging only





C: Flagging, Averaging, 256chn corr

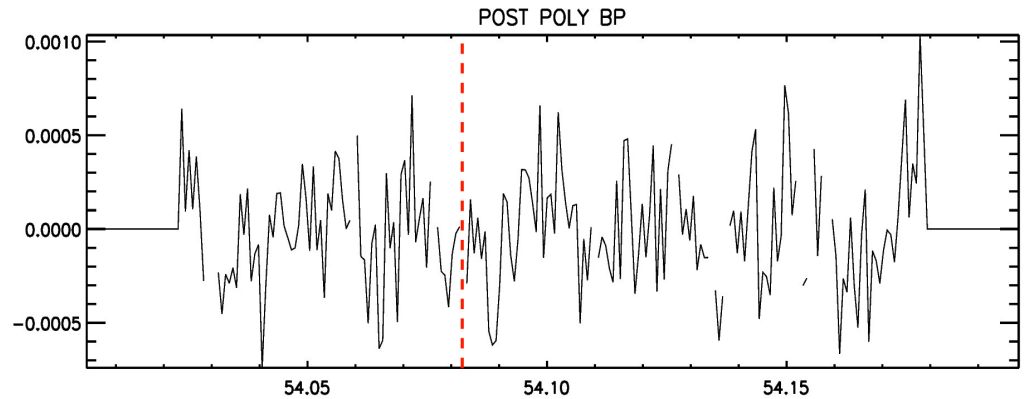




1 SB (NEW Cobalt w. correction)

Cobalt Bandpass ('off') corrected =>

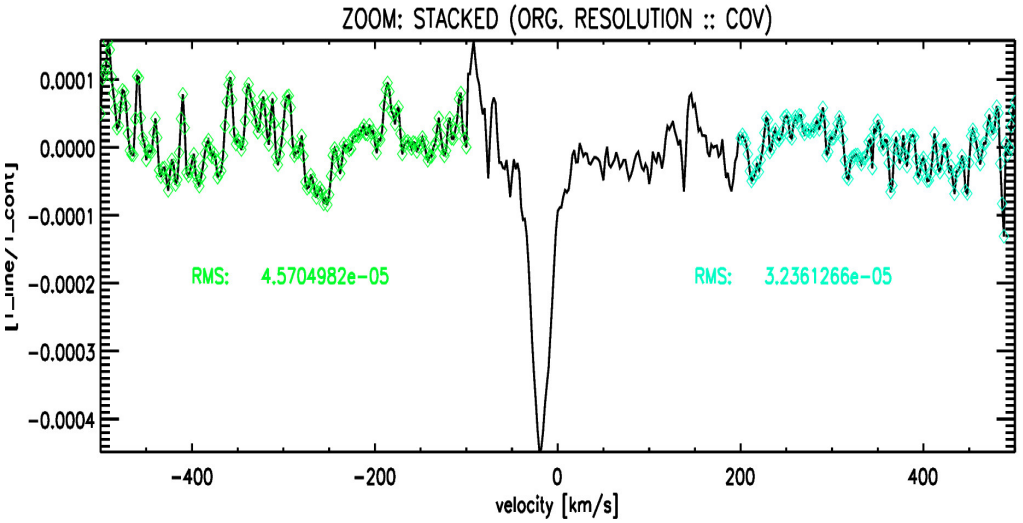
- **spectral rms factor ~2 worse**
- **bandpass adds sqrt(2) noise**



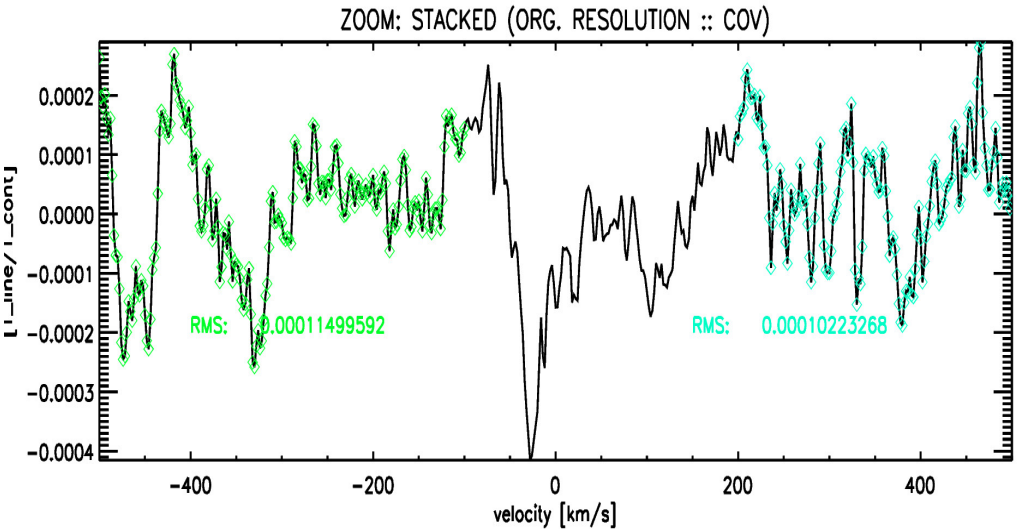
BG vs. Cobalt: TA spectra BG vs. Cobalt (w. correction)

(40 SB stacked)

BG: Flagging & Averaging only

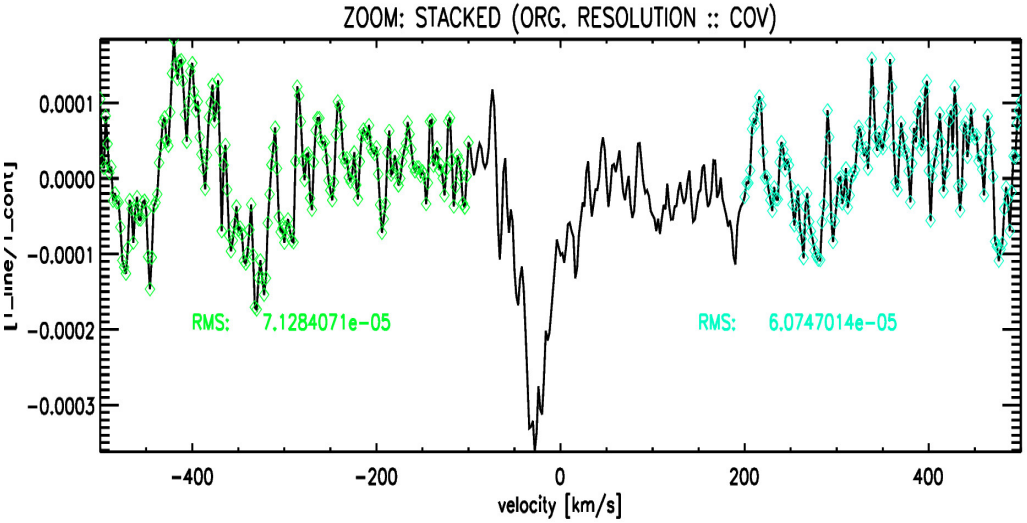


C: Flagging, Averaging, 256chn corr



<u>40 SB</u> (NEW Cobalt w. correction) =>

C: Flagging, Averaging, 256chn corr
+ bandpass correction from 'off'



Flux calibration of TA (Cobalt)

- TA self-generated noise (zerolevel)
- superterp flux calibration

BG vs. Cobalt: **zerolevel and flux calibration**

1. Observe a well-known region (superterp obsv)

- target region (e.g. RRL field)

- nearby absolute flux calibrator (e.g. Cyg A, Vir A)

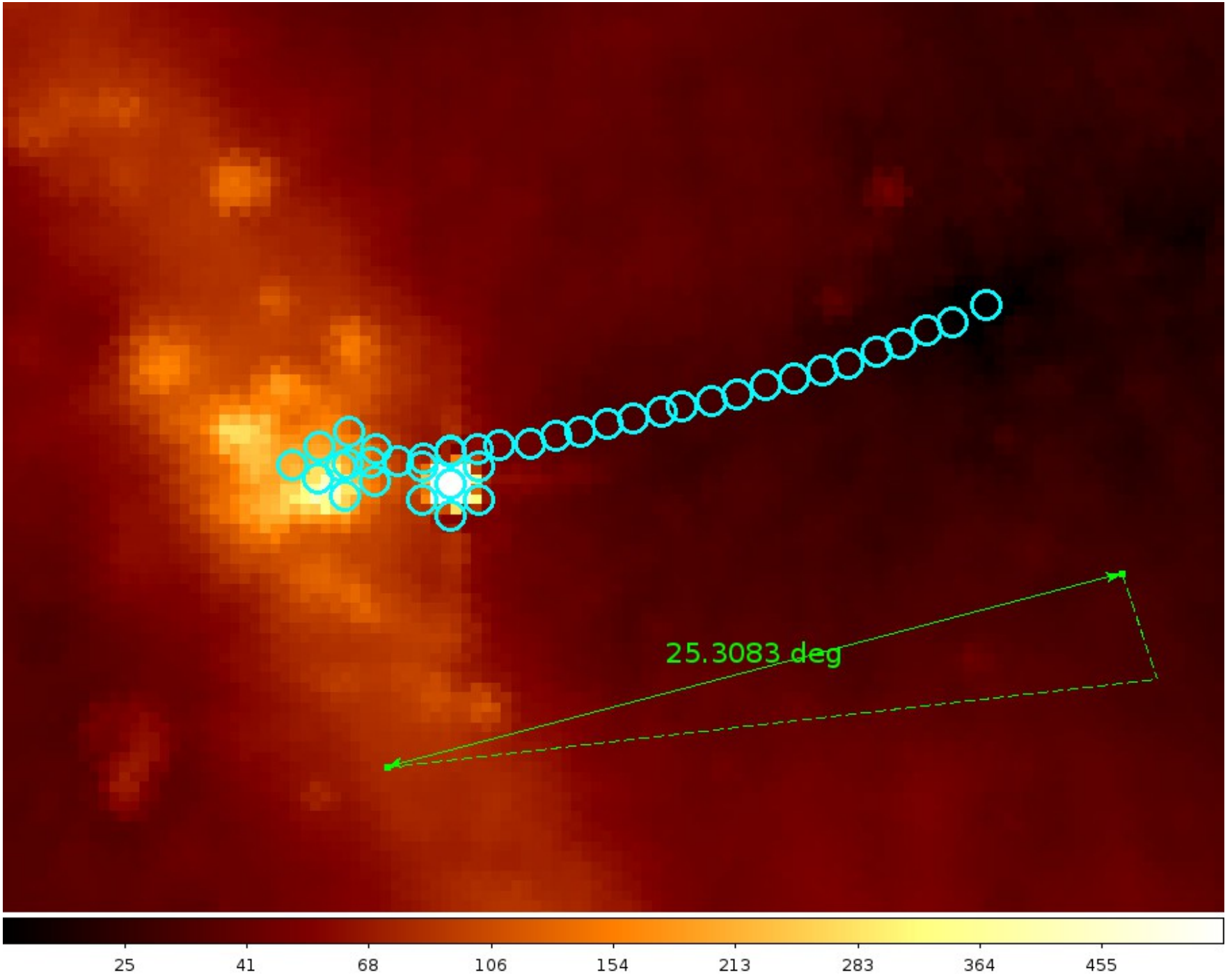
- zerolevel field(s) (use MW GSM)

2. additionally check LBA inner vs. LBA outer

- not done before

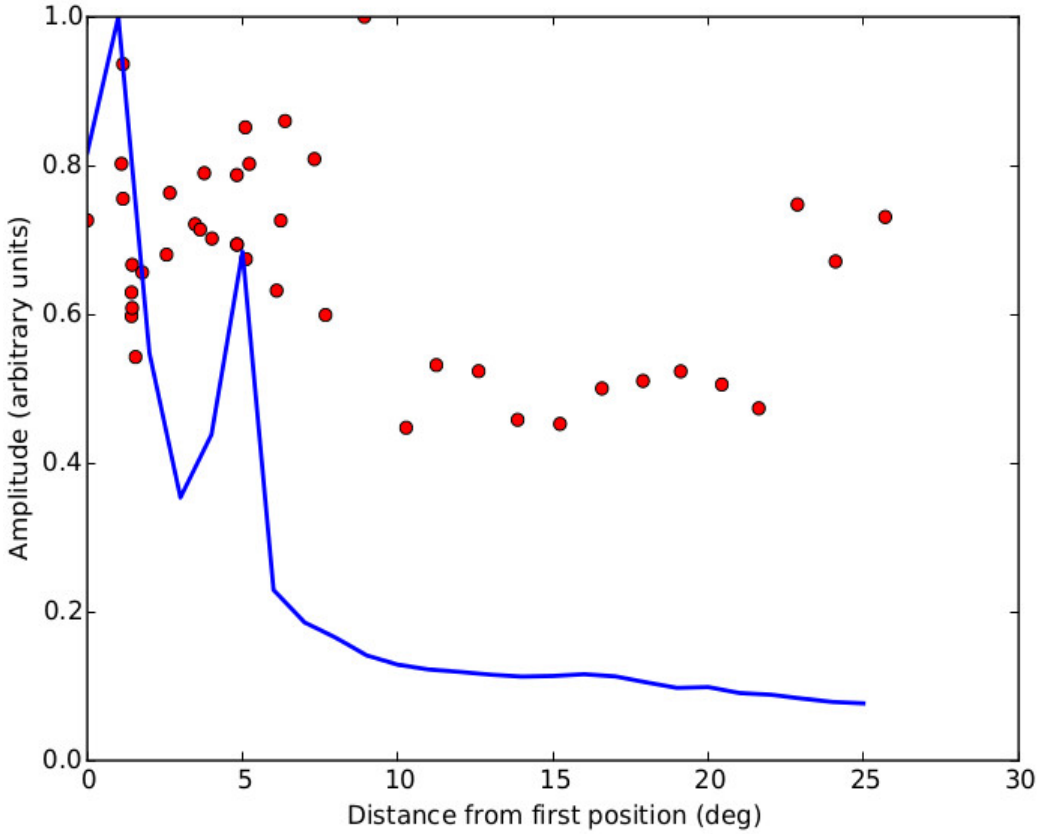
**** see also S. Wijnholts (LSM 25/05/2016)***

BG vs. Cobalt: target

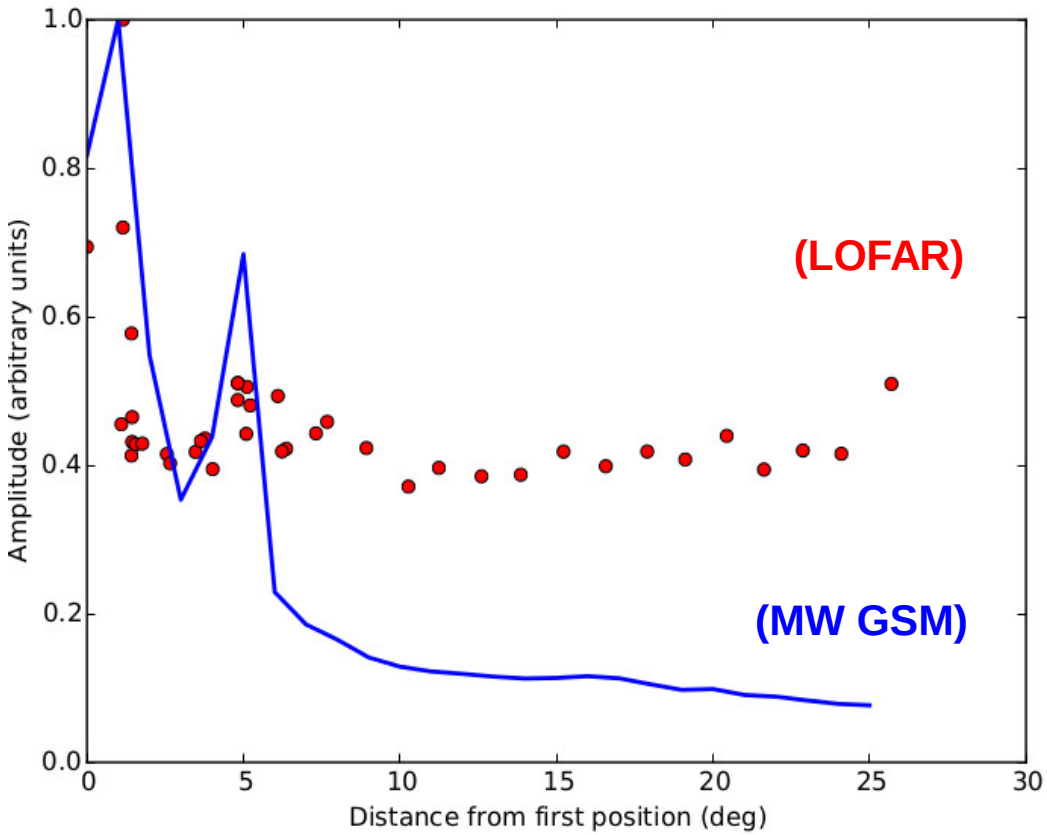


Cobalt: continuum flux profiles (10m obsv; 1°)

LBA inner (58 MHz)



LBA outer (58 MHz)



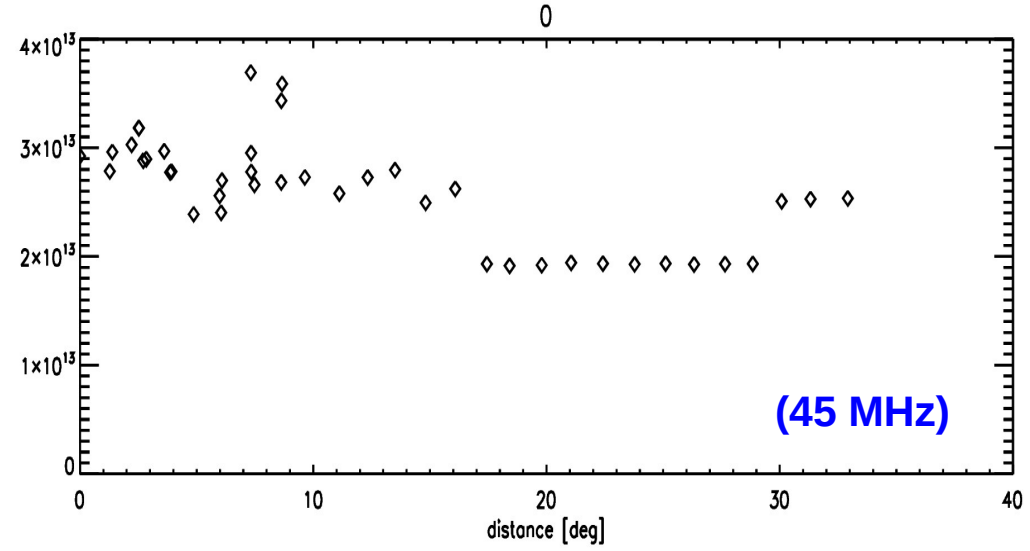
Work in progress:

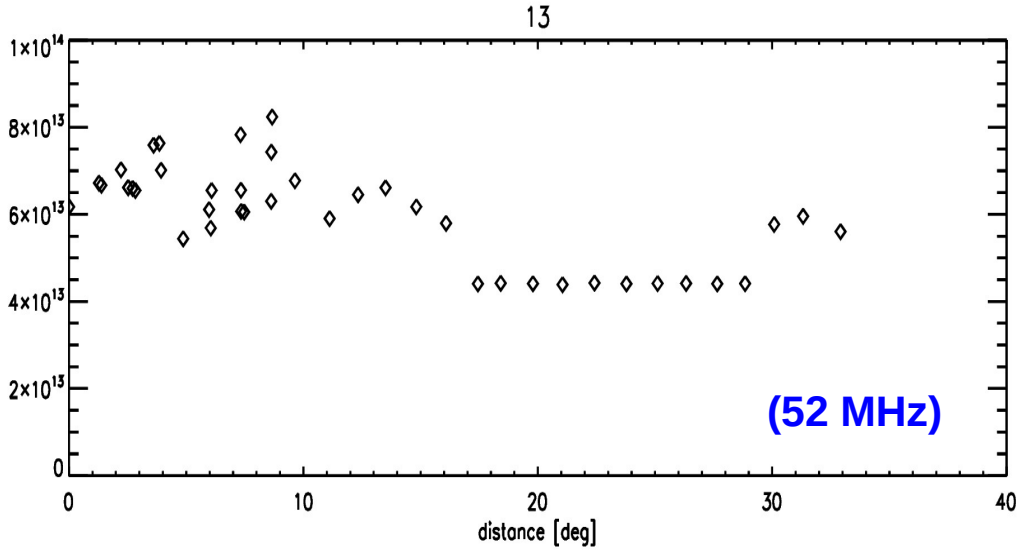
*** Peak continuum to non-physical zerolevel (p/z) is similar for inner and outer**

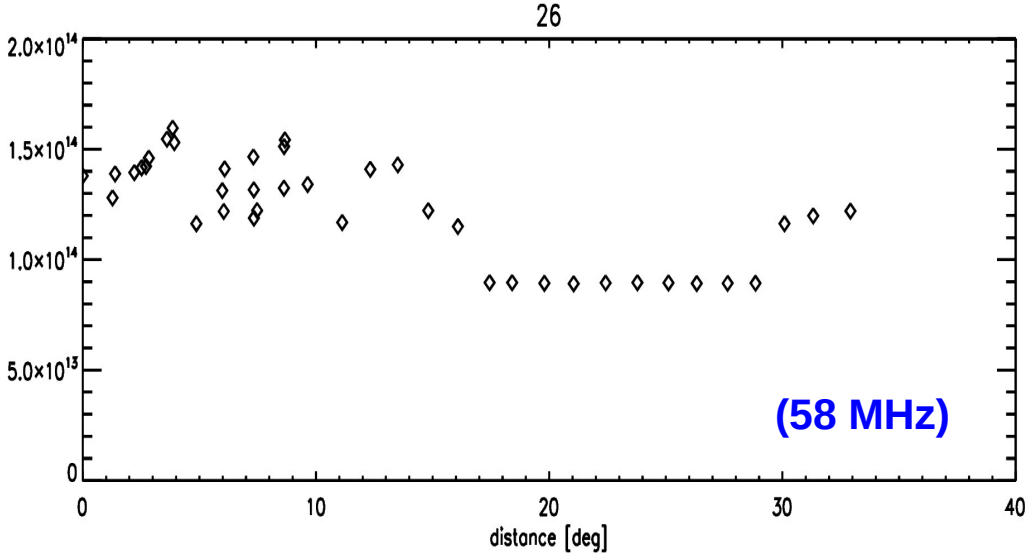
*** LBA inner has significant reduced continuum contrast and increased scatter**

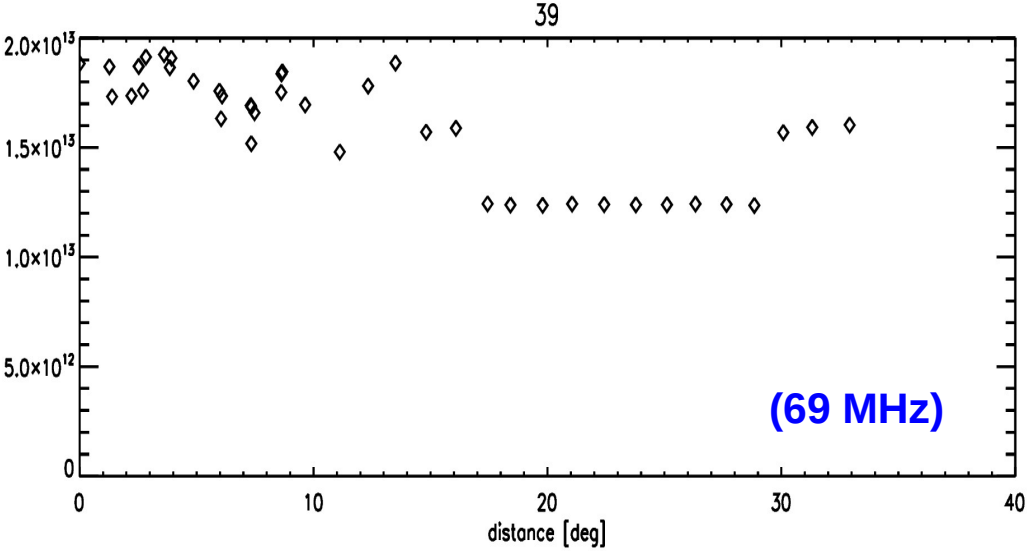
*** MW GSM extraction (blue curve) needs to be corrected for LOFAR beam**

Cobalt: continuum flux profiles (LBA inner)









*** LBA inner : flux smearing does not show strong frequency dependence (p/z ~ 1.5)**

*** LBA outer : not investigated yet**

Conclusions:

1. Total power TA spectroscopy works and provides Information on the most diffuse RRL component

2. Flux calibration of TA is possible (with limited accuracy)

- ***LBA inner 'smearing' independent of frequency***
- ***Should we even try to calibrate LBA inner ?***
- ***How can we improve the calibration (a.o. beam model) ?***

3. Cobalt subband bandpass not nearly as good as BG

4. Focused on LBA (HBA and HBA-HIGH is coming)

Recommendation:

* ***Given the above issues with LBA inner, we should switch to LBA outer.***