High-precision VLBI astrometric measurements using SFPR observations of BLLAC.

Sol N. Molina

Instituto de Astrofísica de Andalucía. (IAA-CSIC)

José L. Gómez (IAA-CSIC)
Richard Dodson (ICRAR)
María Rioja (ICRAR, IGN)

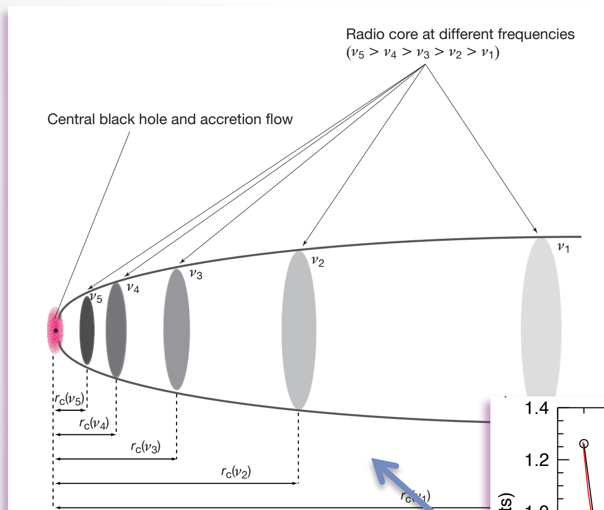
Outline of the talk

- Motivation: Determination of core shift.
- Sample of sources observed by VLBA.
- Astrometric Technique applied to BL Lac. Is a new approach to the Source Frequency Phase Transfer (SFPR).
- Preliminary results.

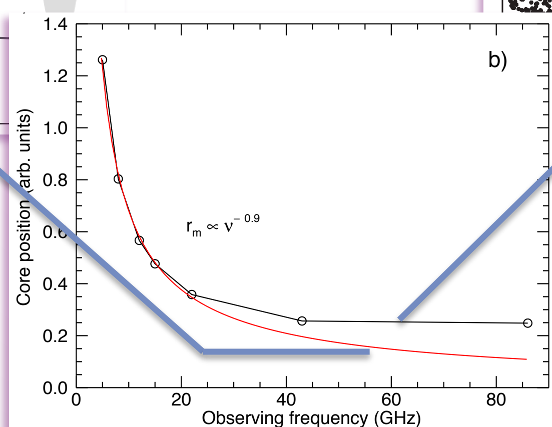
Motivation: Study the nature of core jets.

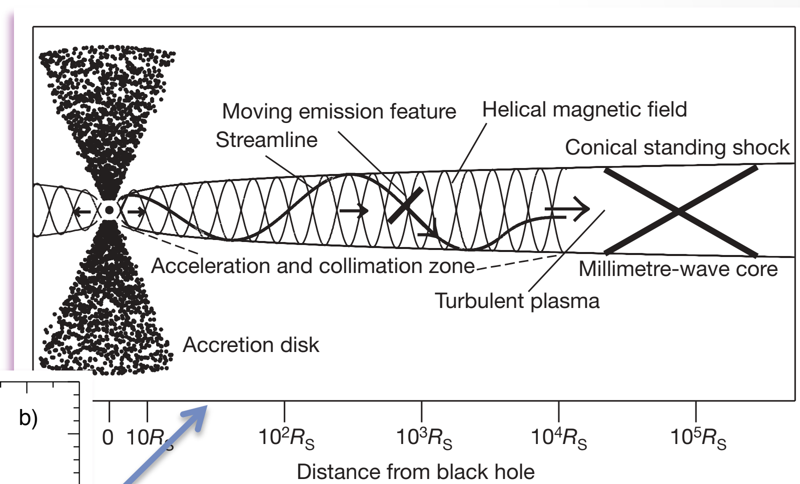
The location at which the jet becomes optically thin. Therefore its position shifts with observing frequency.

The radio core is a recollimation shock in the jet at a fixed location.



Hada et al. 2011.





Marscher et al. 2008.

It is necessary to have astrometric measurements at mm wavelength.

Sample of sources observed by VLBA.

BL Lac, 3C120, 3C273, CTA102, 0716+714, 3C111 and some other sources Mrk421, 4C+21.35, 1633+382, 3C279, and 3C454.3.

γ-ray emitting AGN at 1.3, 5, 8.4, 15, 22, 43 and 86 GHz.

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Observation Strategy

Usual phase-reference block →

Calibrator 1	50 sec
Target	30 sec
Calibrator 2	50 sec
Target	35 sec

Low freq.
5, 8, 15, 22 GHz

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Ionospheric block →

Target	1.3 GHz
Target	new C-band wide rec. { 4.3 GHz, 7.6 GHz }
Target	22 GHz

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Low freq. 5, 8, 15, 22 GHz

Ionospheric block →

Target	1.3 GHz	40 sec
Target	wide band at 5 GHz	40 sec
Target	22 GHz	40 sec

Frequency-phase-transfer block →

Target	22 GHz	30 sec
Target	→ 43 GHz	30 sec
Target	22 GHz	30 sec
Target	→ 86 GHz	30 sec

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Astrometric Technique applied to BL Lac.

Is a new approach to the Source Frequency Phase Transfer (SFPR) in which the ionospheric contribution is determined from the L (1.3 GHz), WC and K (22GHz) band.

$$\delta\tau(\nu,t) = \delta\tau_{trop}(t) + \delta\tau_{iono}(\nu,t) + \delta\tau_{struc}(\nu,t) + \delta\tau_{ast}(\nu,t) + \delta\tau_{inst}(\nu,t)$$

Rioja & Dodson (2011)

- $\delta\tau_{trop}(t)$ Tropospheric contribution
- $\delta\tau_{iono}(\nu,t)$ Ionospheric contribution
- $\delta\tau_{struc}(\nu,t)$ Source structure contribution
- $\delta\tau_{ast}(\nu,t)$ Astrometric contribution
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Includes the core shift

We have to calibrate

$\delta\tau_{inst}(\nu,t)$ $\delta\tau_{trop}(t)$ $\delta\tau_{iono}(\nu,t)$

Instrumental contributions

$$\delta\tau_{inst}(\nu,t)$$

Calculating instrumental contributions in a scan and using this to calibrate all the experiment.

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Ionospheric contributions

→ This is the novel part of this technique

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Ionospheric contributions → This is the novel part of this technique

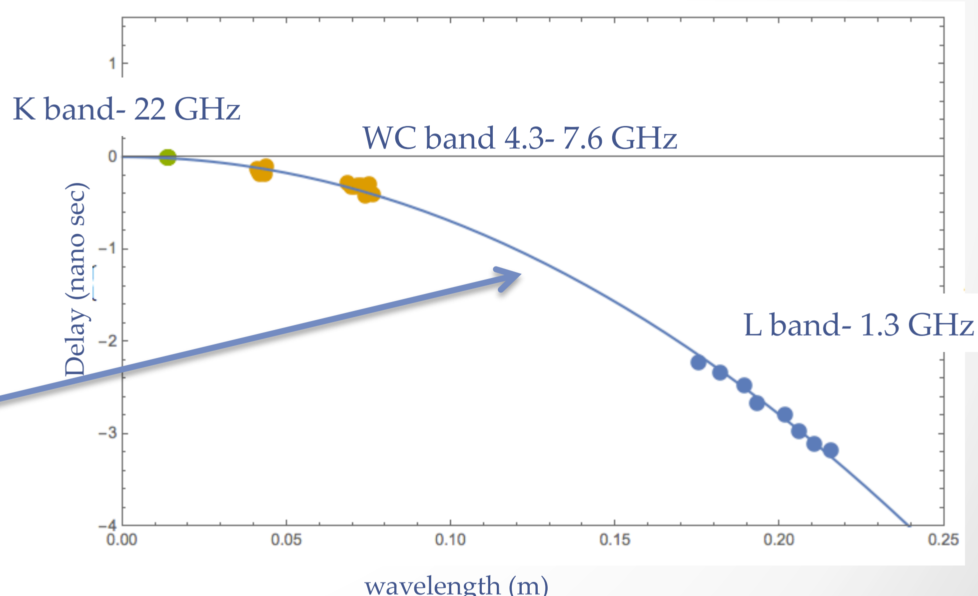
$\delta\tau_{iono}(\nu,t)$ → The delay varies with λ^2

$$\delta\tau_{iono} = c + m\lambda^2$$

↓

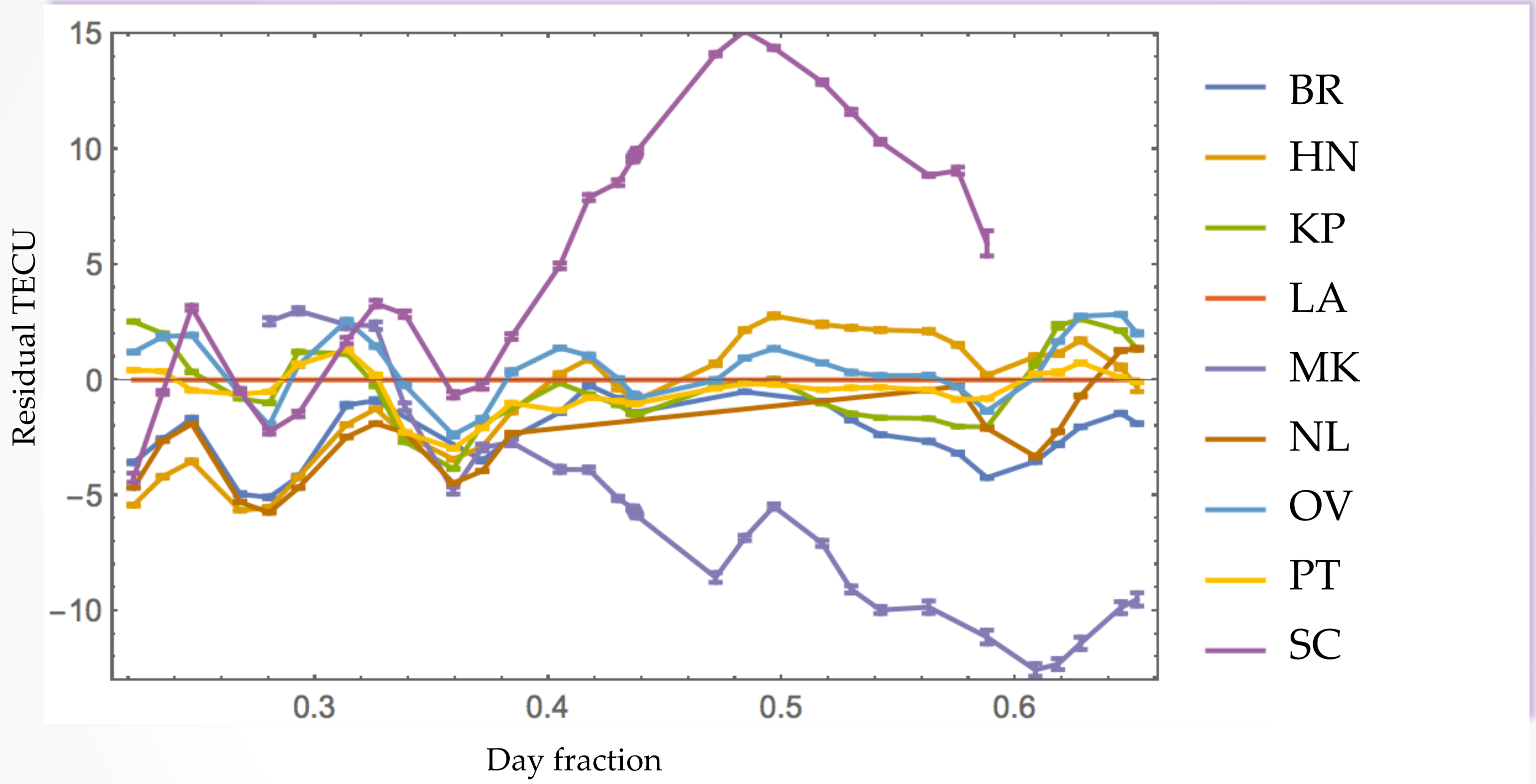
Tec (Total electron content)

We have developed a program to fit the data.



Example for HN antenna

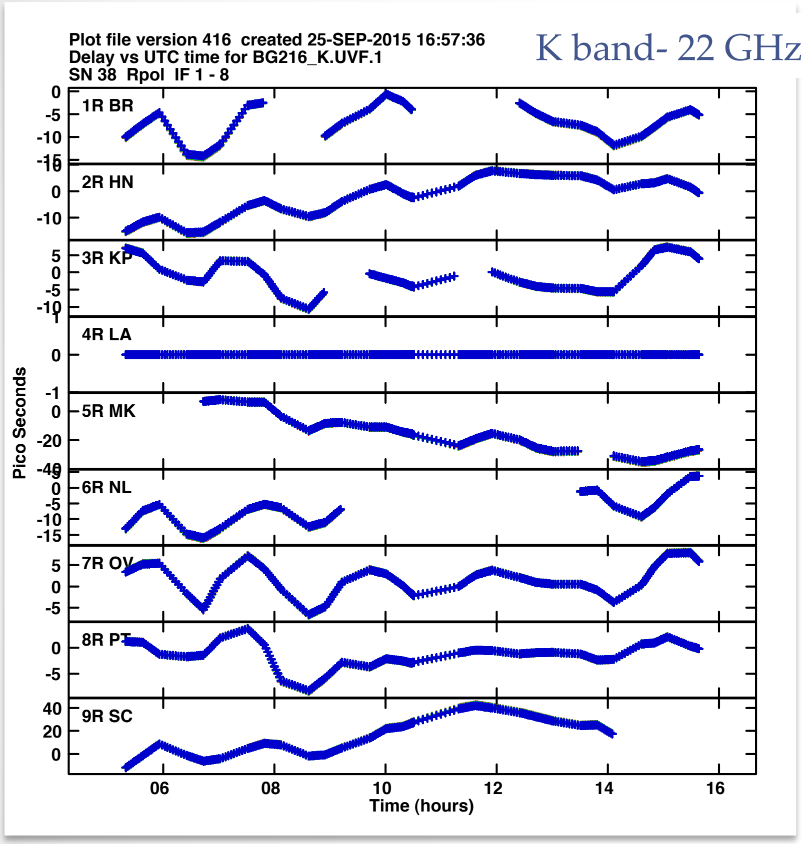
Tec (Total electron content) values



We have obtained TEC values.

We have calculated a new table at each frequency that contain the ionospheric corrections.

SN Tables with ionospheric corrections



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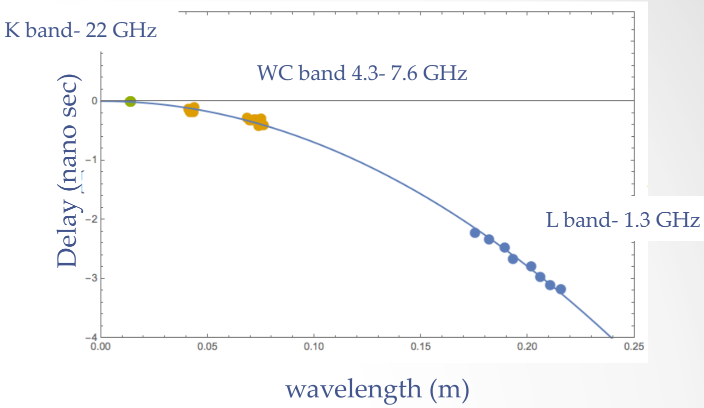

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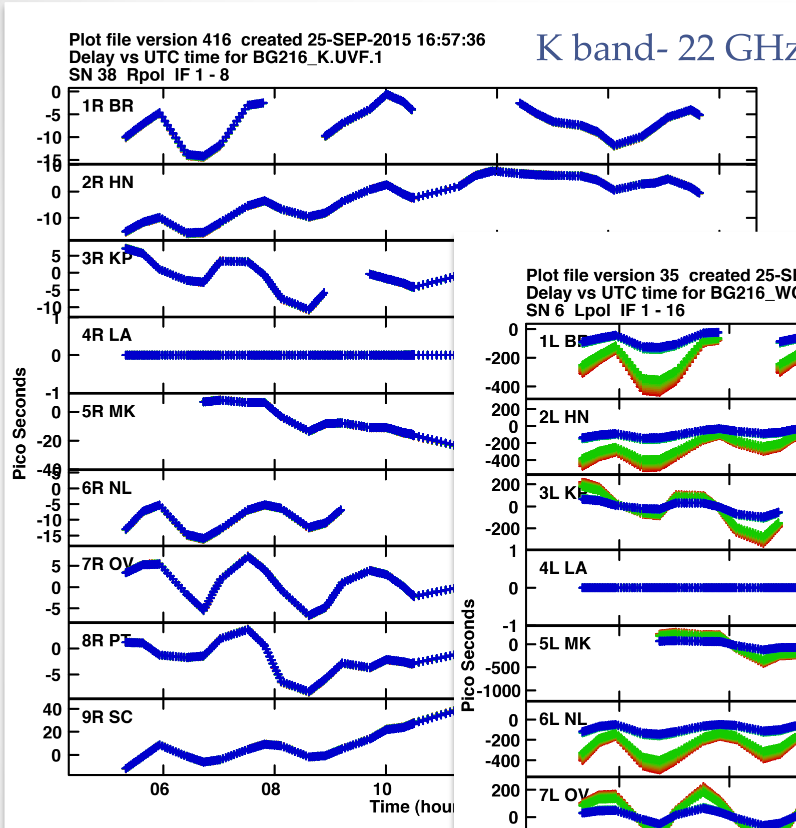

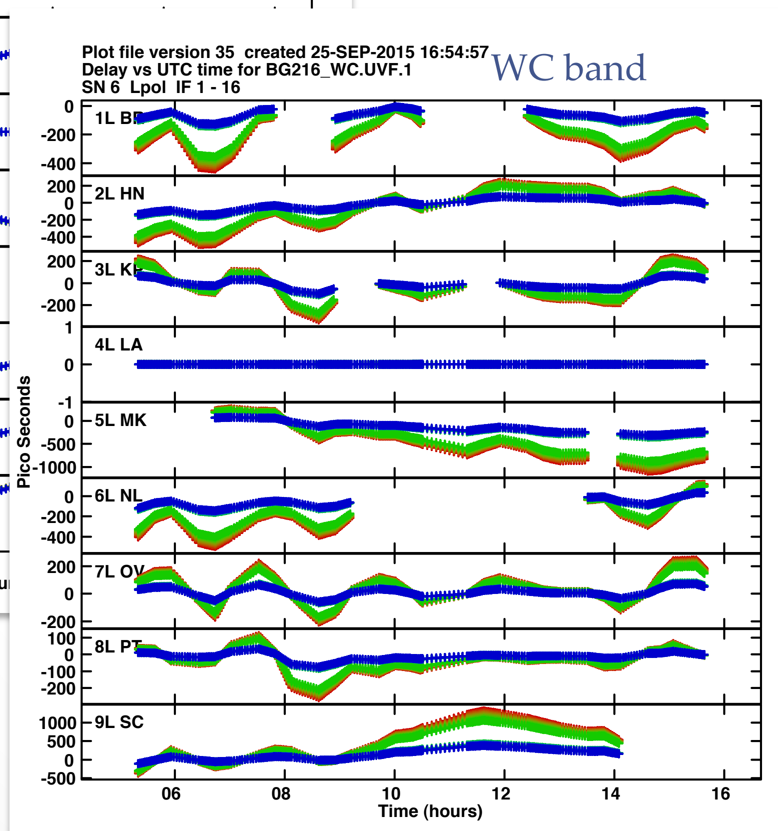

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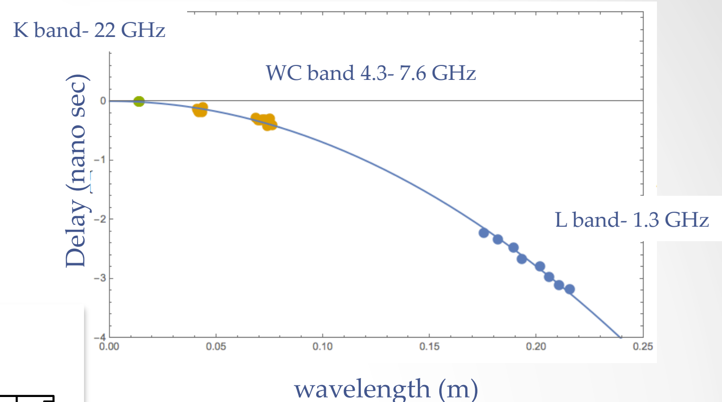

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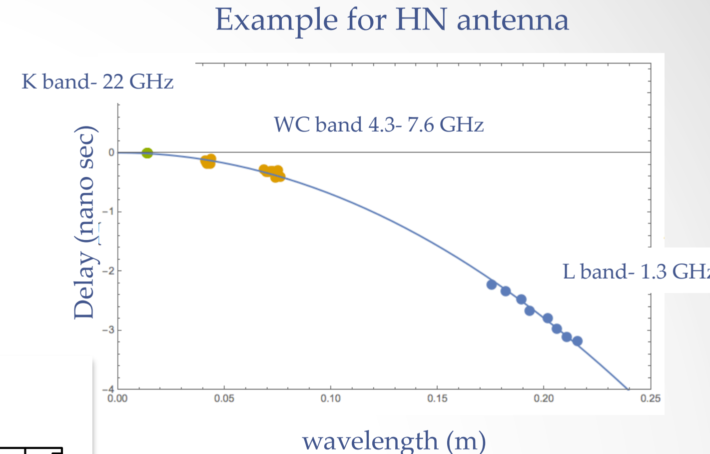

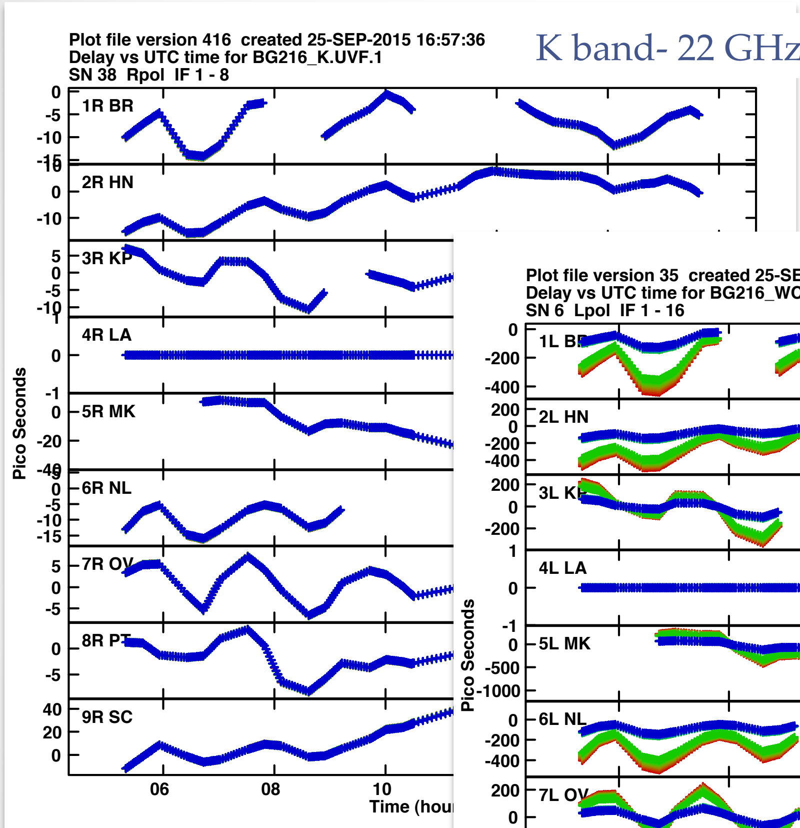

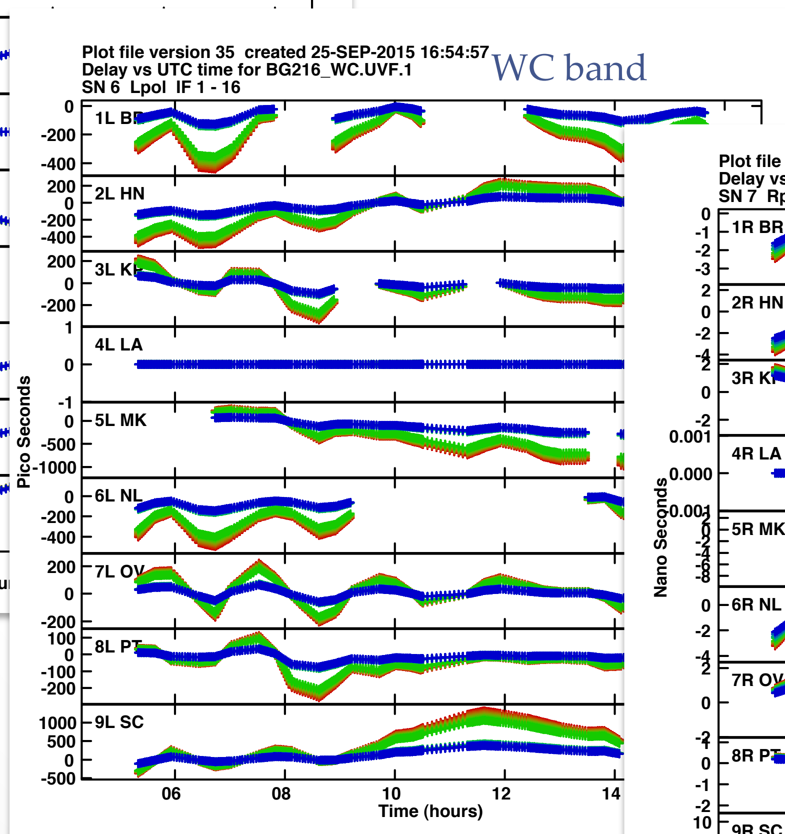

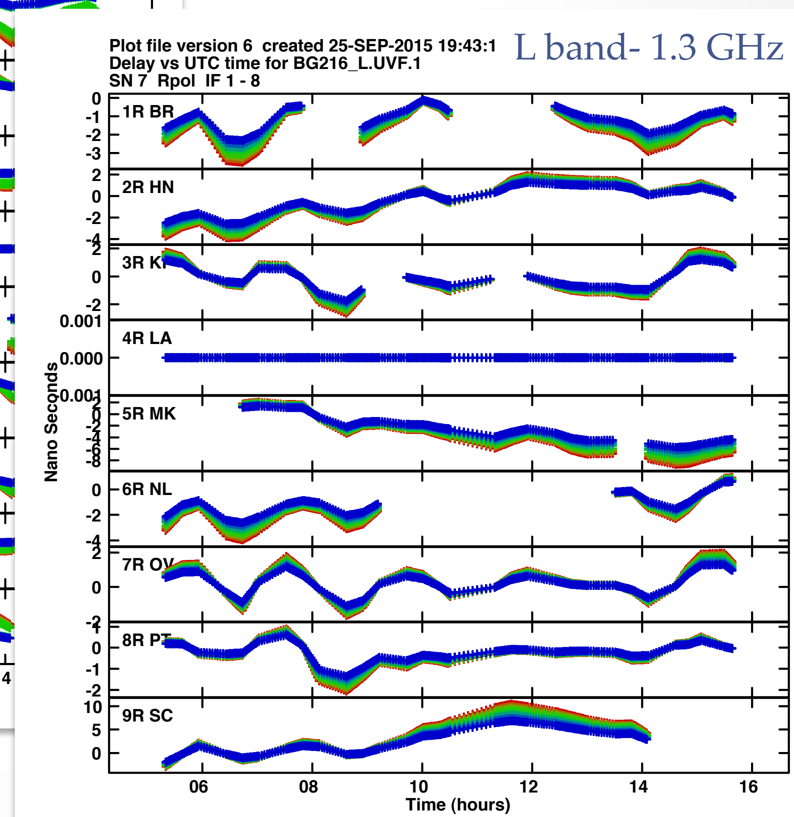

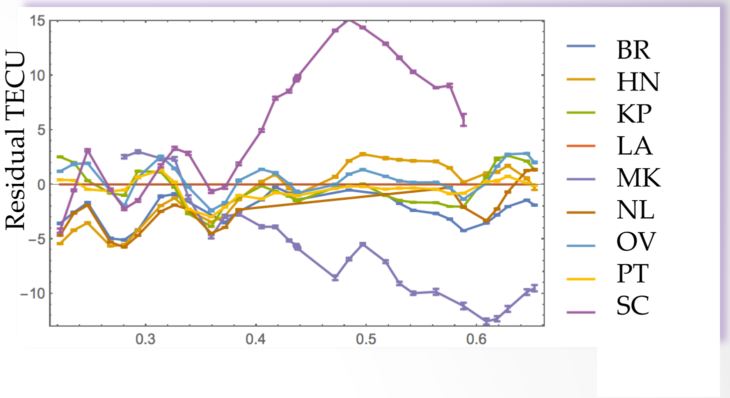

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We want to test if these corrections have removed the ionospheric terms.

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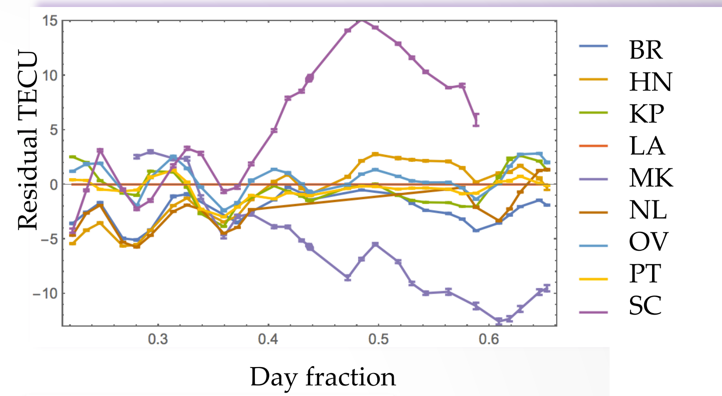
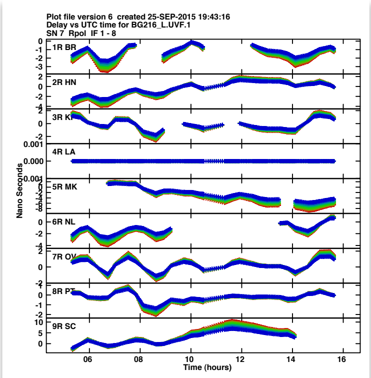
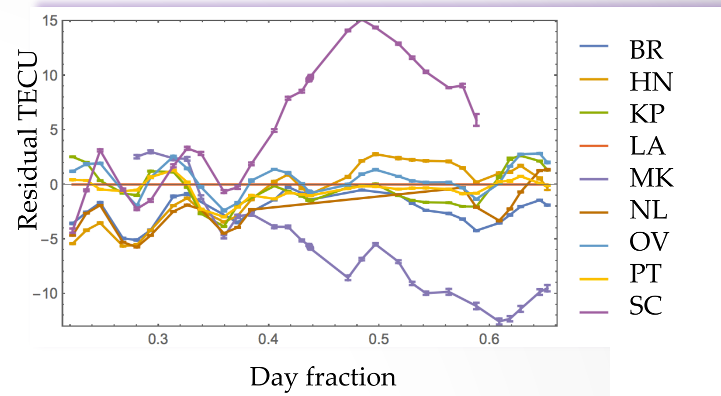


We have applied the solution tables obtained to the data

Recalculate TEC values





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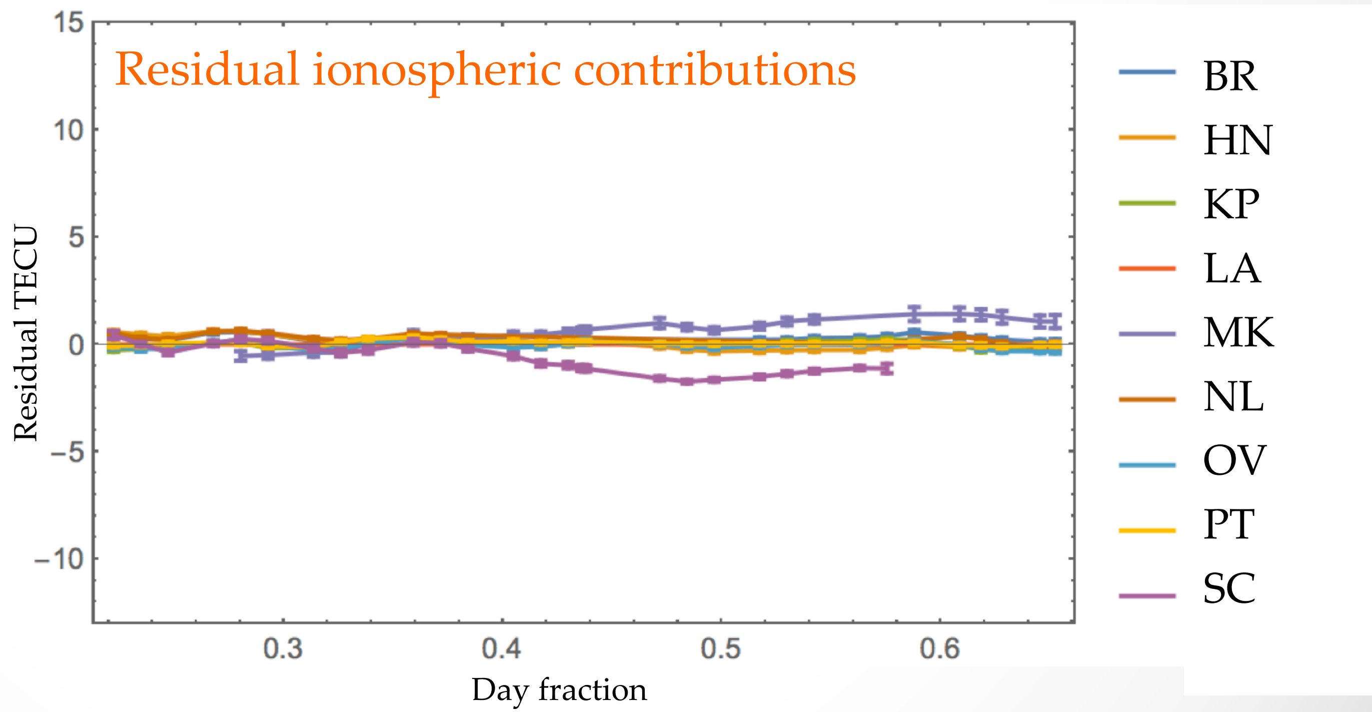
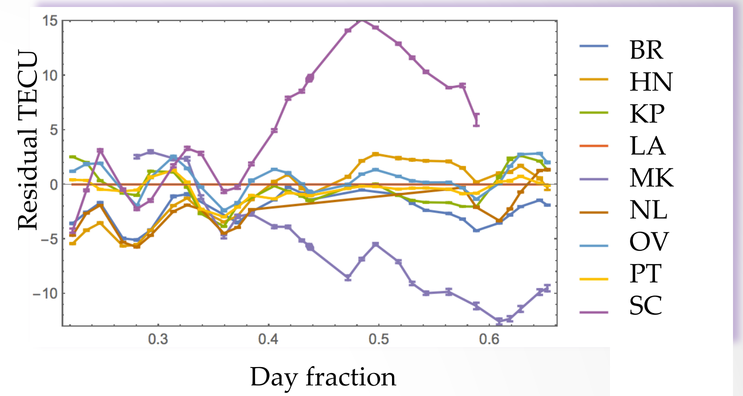
Tec Residual are
~ 0.2 TECU

Except for MK and SC





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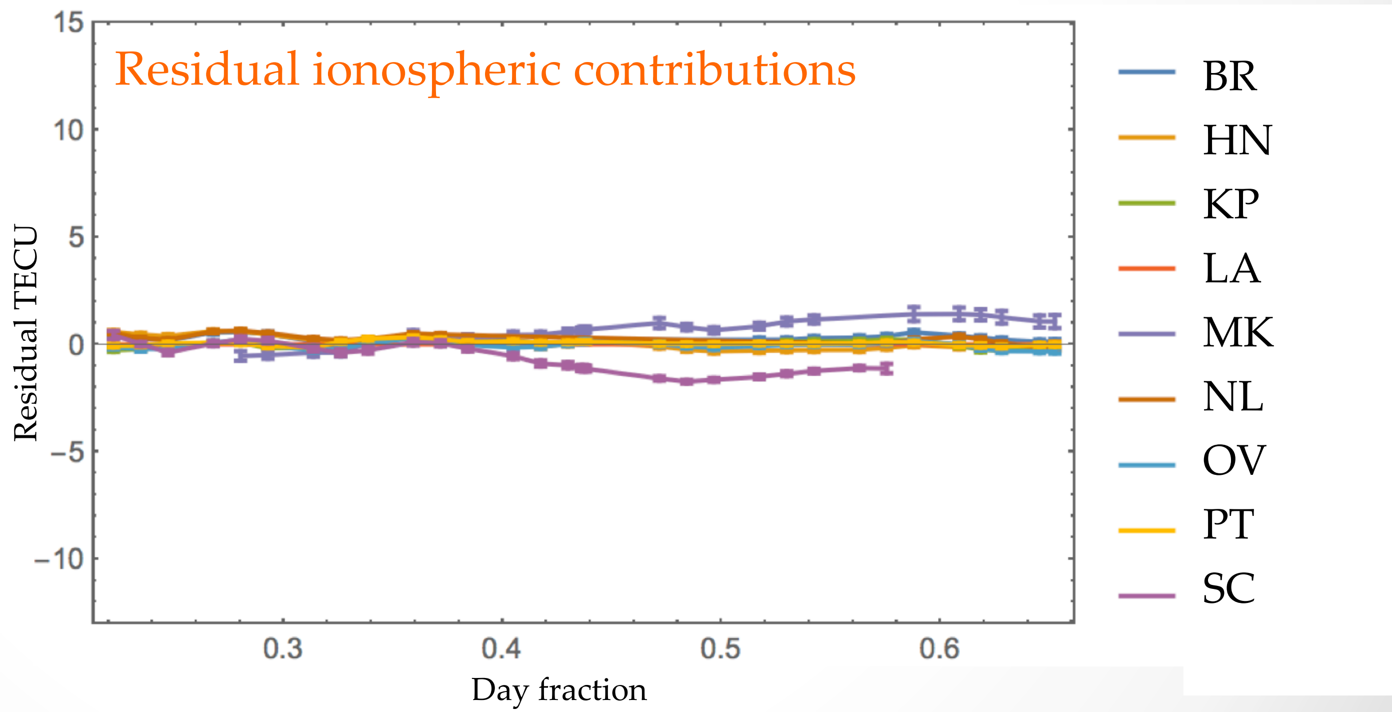

Doing more iterations could improve this calibration.

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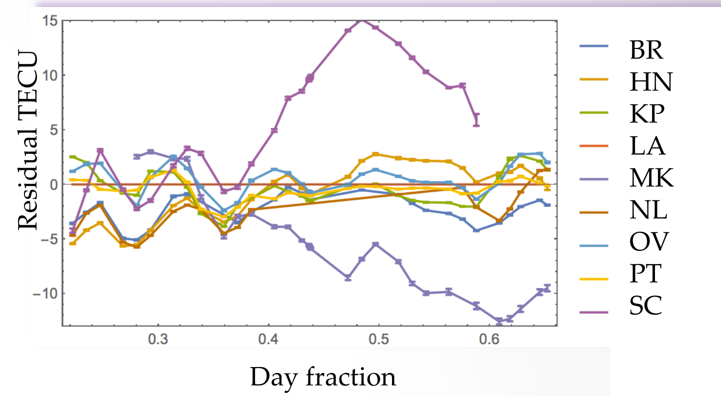

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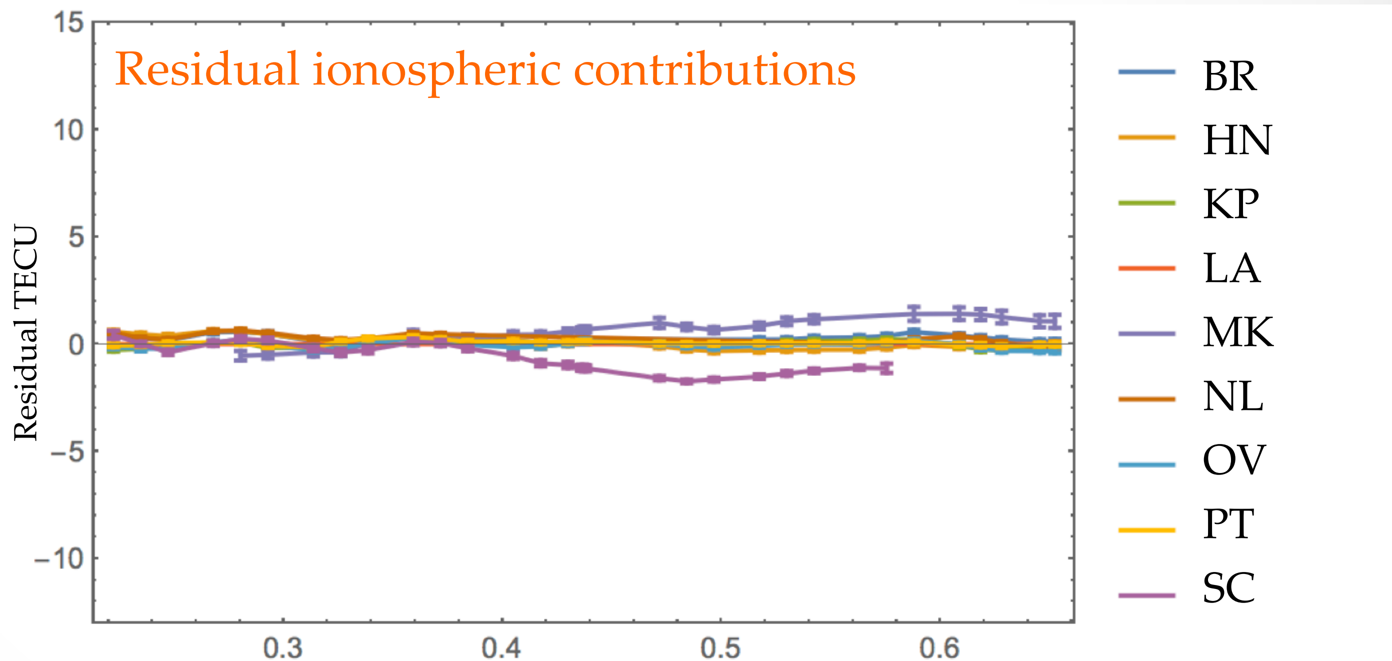


Doing more iterations could improve this calibration.

Most of the ionospheric contribution has been removed.

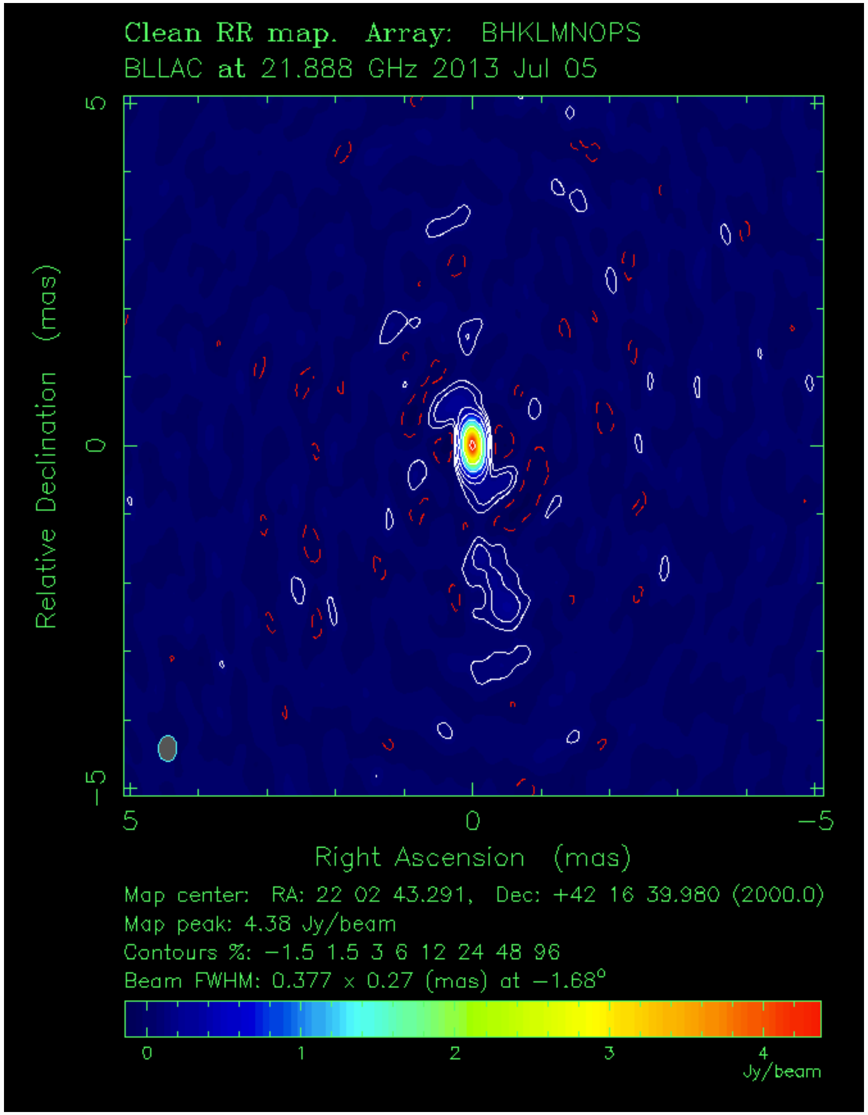
Tropospheric contributions

$\delta\tau_{iono}(\nu, t)$ → We have to calculated the tropospheric contribution with a GFF in Aips.

We have removed all the contributions

$$\delta\tau_{inst}(\nu, t) \quad \delta\tau_{trop}(t) \quad \delta\tau_{iono}(\nu, t)$$

Map obtained at 22 GHz

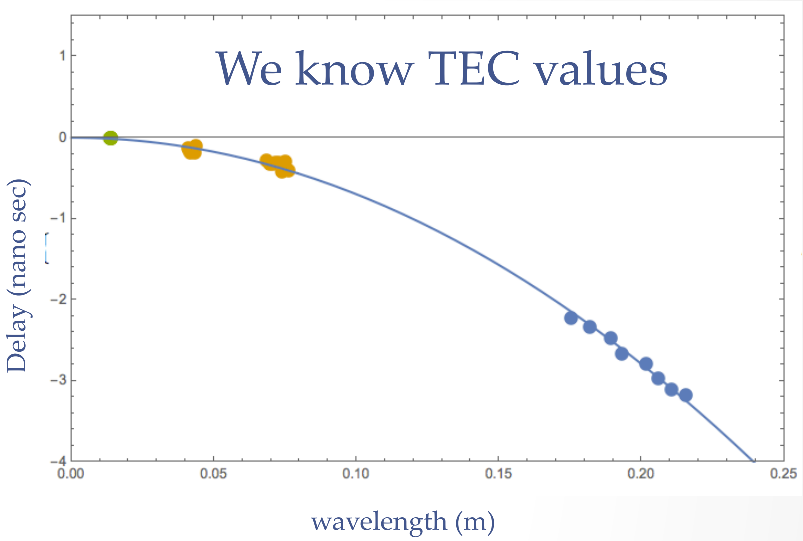


Map without autocalibration steps.

Calibrating data at 43 GHz

$\delta\tau_{inst}(\nu,t)$ → Fring in Aips

$\delta\tau_{iono}(\nu,t)$ →



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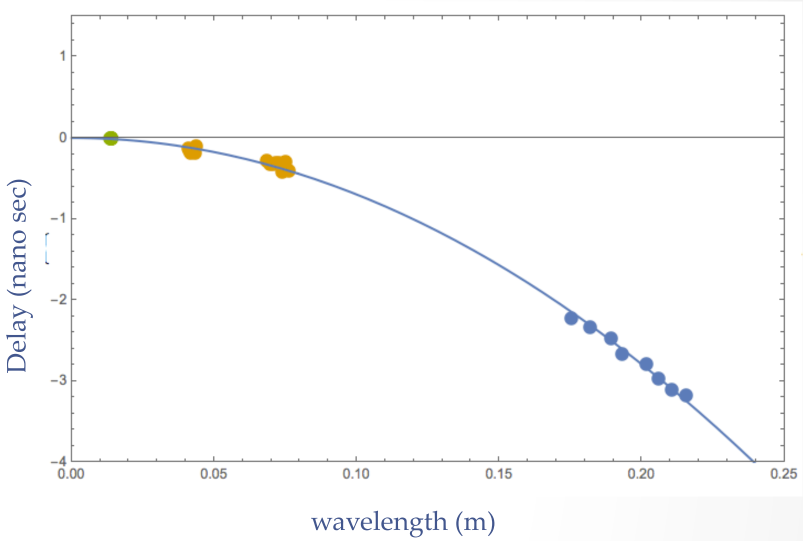
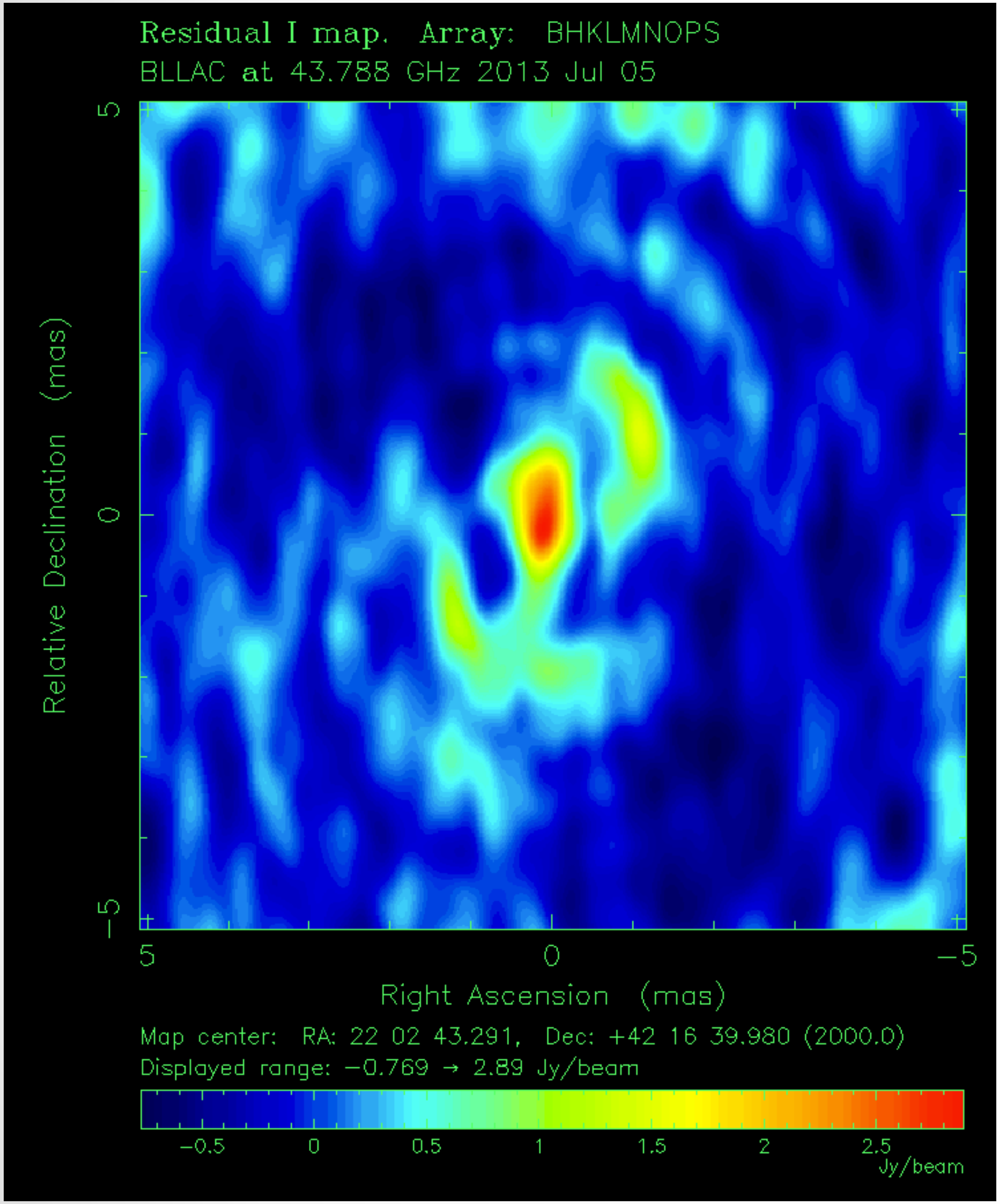


$\delta\tau_{trop}(t)$ The tropospheric phase contributions are proportional to the observing frequency

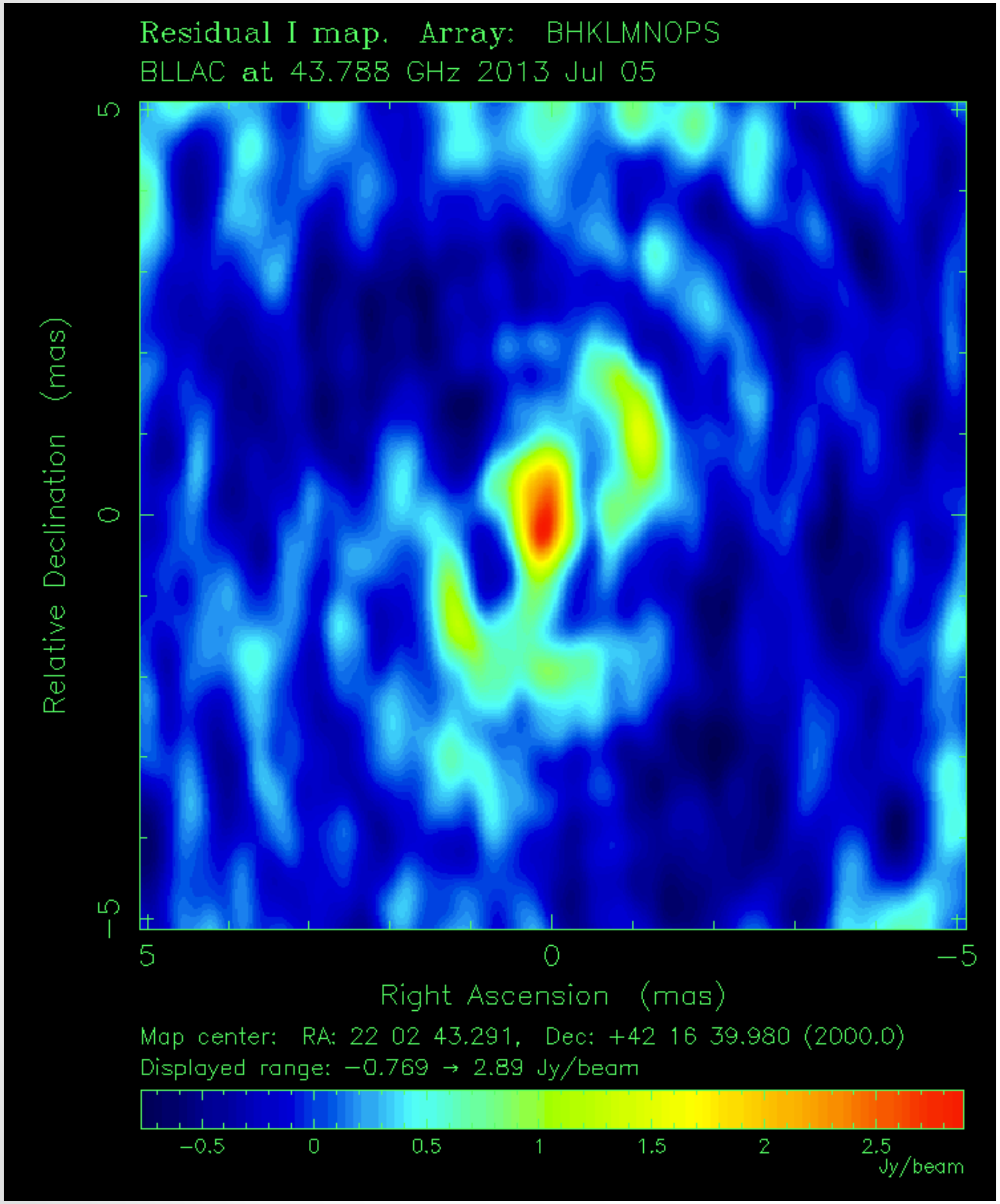
Frequency-phase-transfer $\phi\tau_{trop}(\nu_1)\bullet R = \phi\tau_{trop}(\nu_2)$ $R = \frac{\nu^{high}}{\nu^{low}}$

→ $\phi\tau_{trop}(22GHz)\bullet R = \phi\tau_{trop}(43GHz)$



- Instrumental contribution obtained from a Fring for 43 GHz data.
- Ionospheric contributions obtained from TEC calculations from the fit of the data at L (1.3 GHz), WC and K (22 GHz) band.
- Tropospheric contribution calculated from 22 GHz data.

This map is obtained without any autocalibration.



This is work in progress

We have to improve some points:

- Iterations to obtain a better ionospheric determination.
- Better tropospheric calibrations using autocalibrated solutions at low frequency.

We have a detection at 43 GHz !!!

That implies that we have successfully remove at a first order term the ionospheric and tropospheric contributions.

This is a 43 GHz image referred to 22 GHz image.

We can measure the core shift between the two frequencies.

We didn't use an external calibrator to do this calibration.

Summary

- Multiwavelength observations suggest that at mm wavelength the core may correspond to a recollimation shock.

- To test this we are performing astrometric observations of a sample of γ-ray emitting AGN at 1.3, 5, 8.4, 15, 22, 43 and 86 GHz with VLBA.

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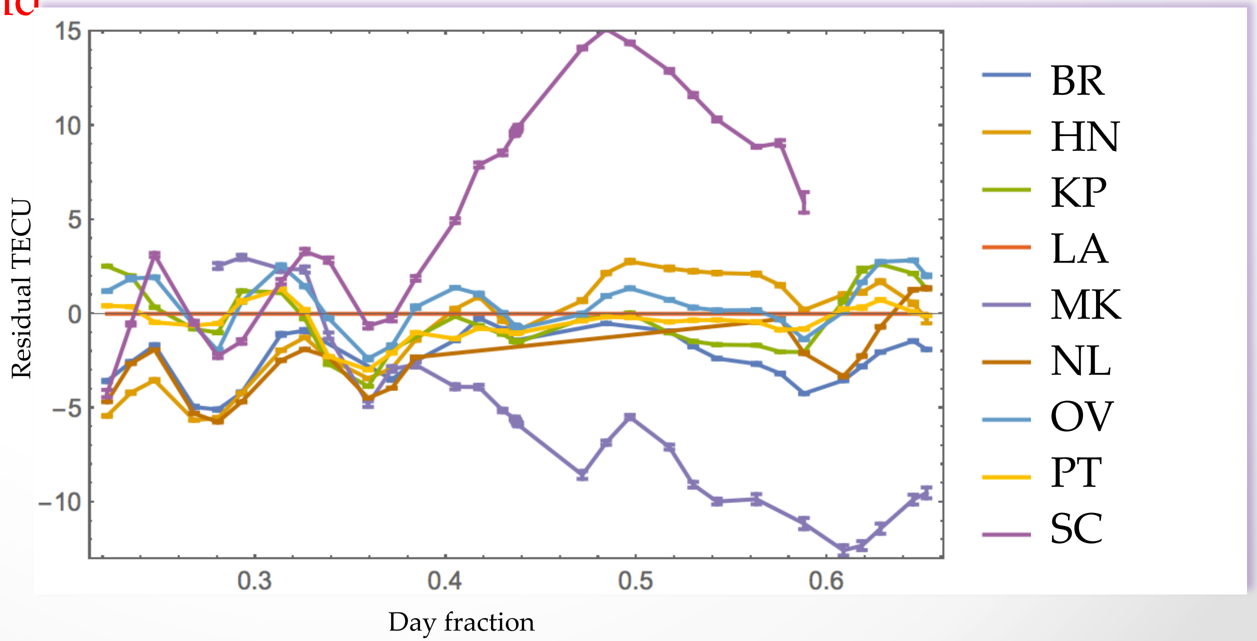

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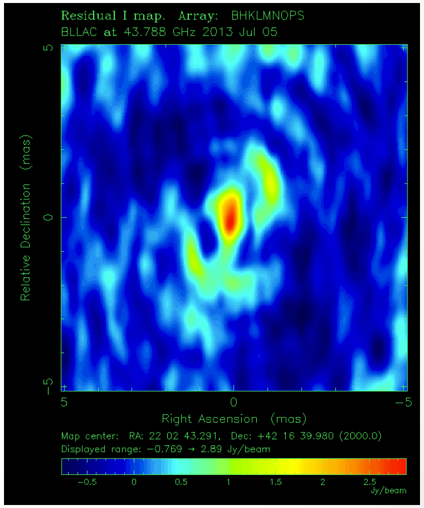
- Combine this with frequency phase transfer at higher frequencies allow us to obtain a reliable calibration of the 43 GHz data.



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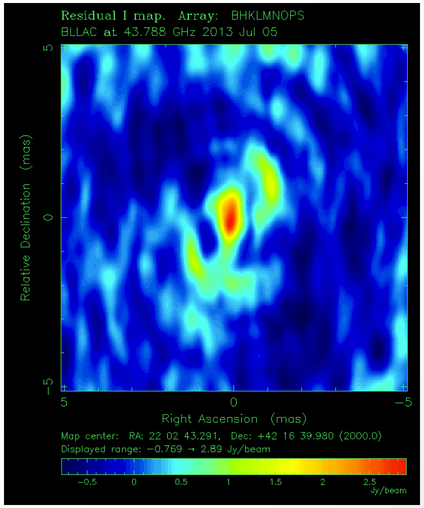
- This map is related at 22 GHz data so it is possible to measure a core shift between images at these frequencies.
- In this new implementation we didn't use an external calibrator.



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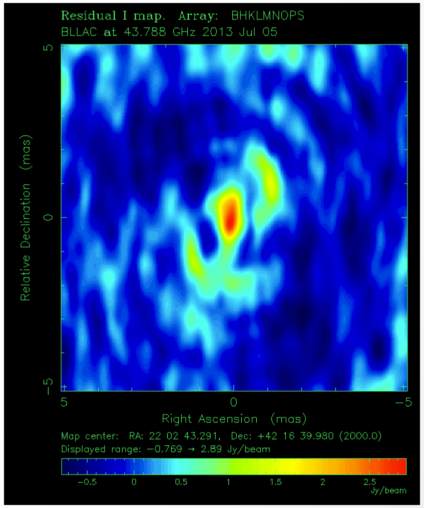

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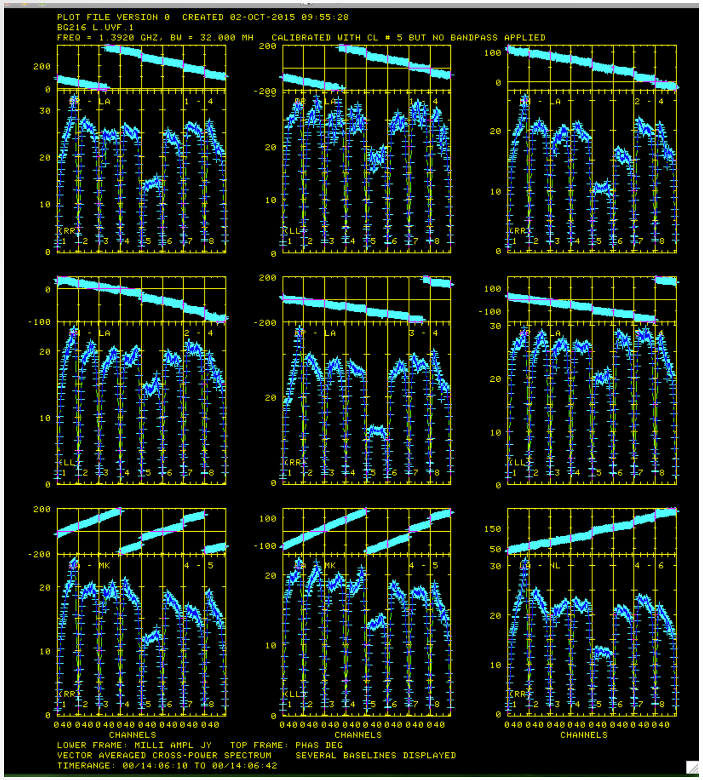
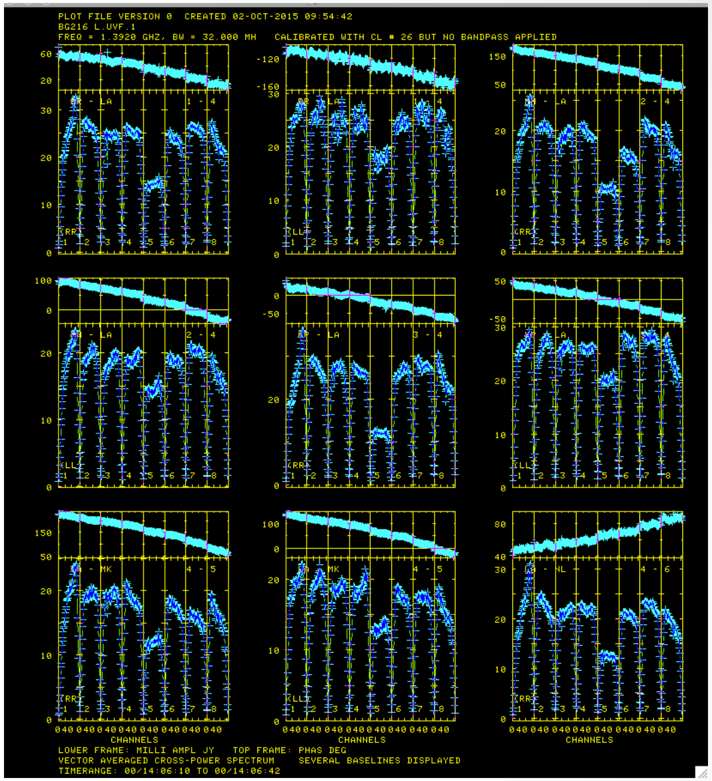
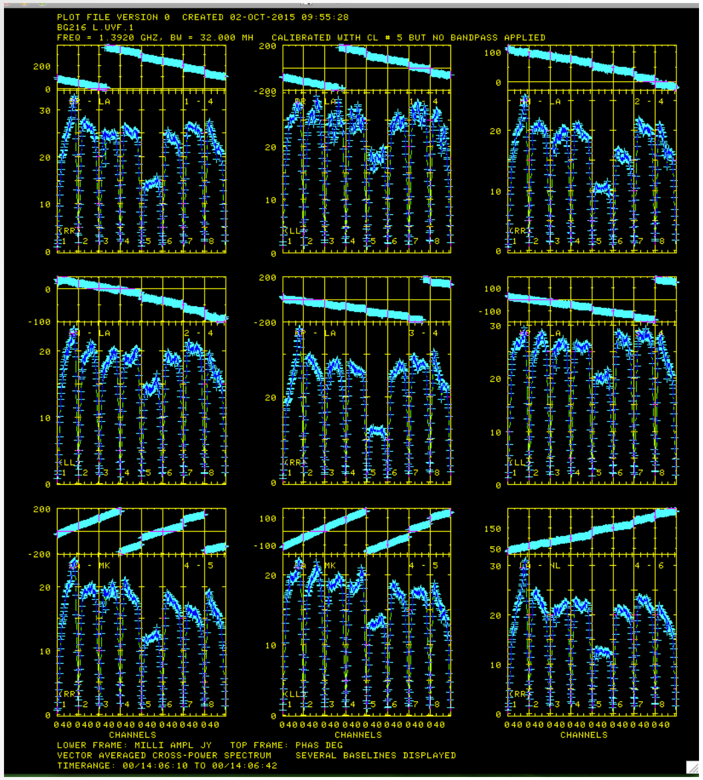
- This work is in progress and we expect to obtain astrometric solutions at 86 GHz.

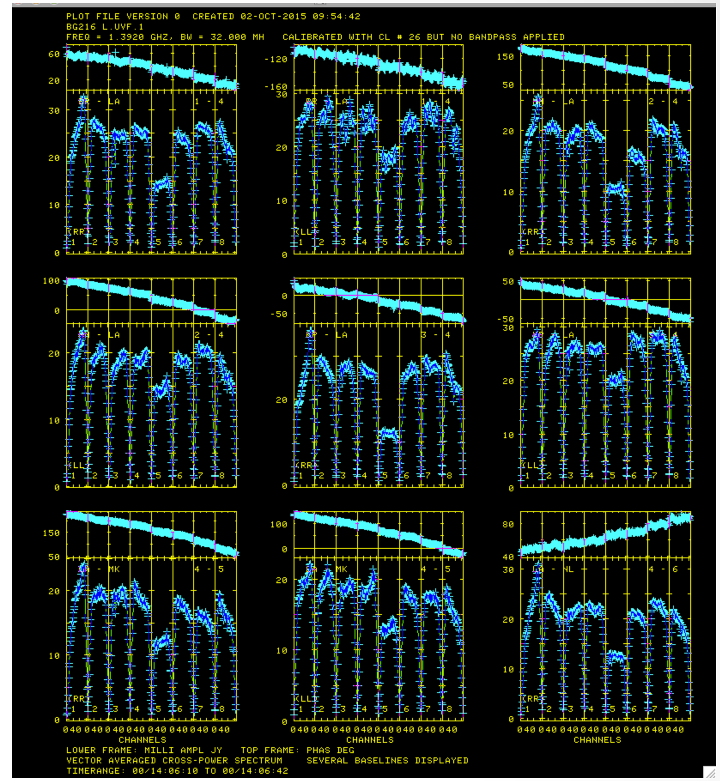


L-band (1.3 GHz) instrumental delays calibrated



L-band (1.3 GHz), ionospheric contribution calibrated

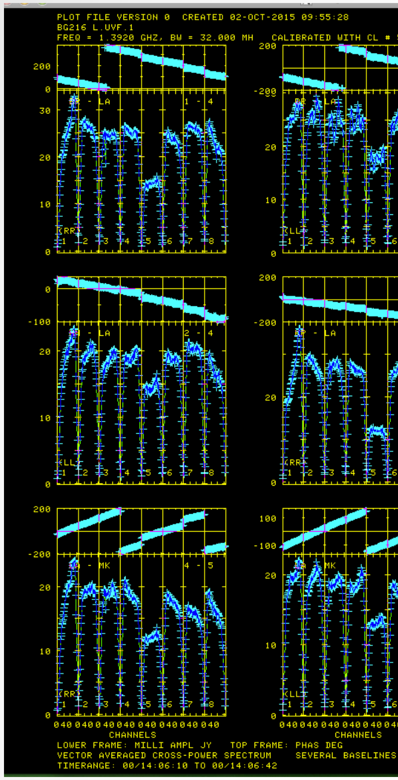


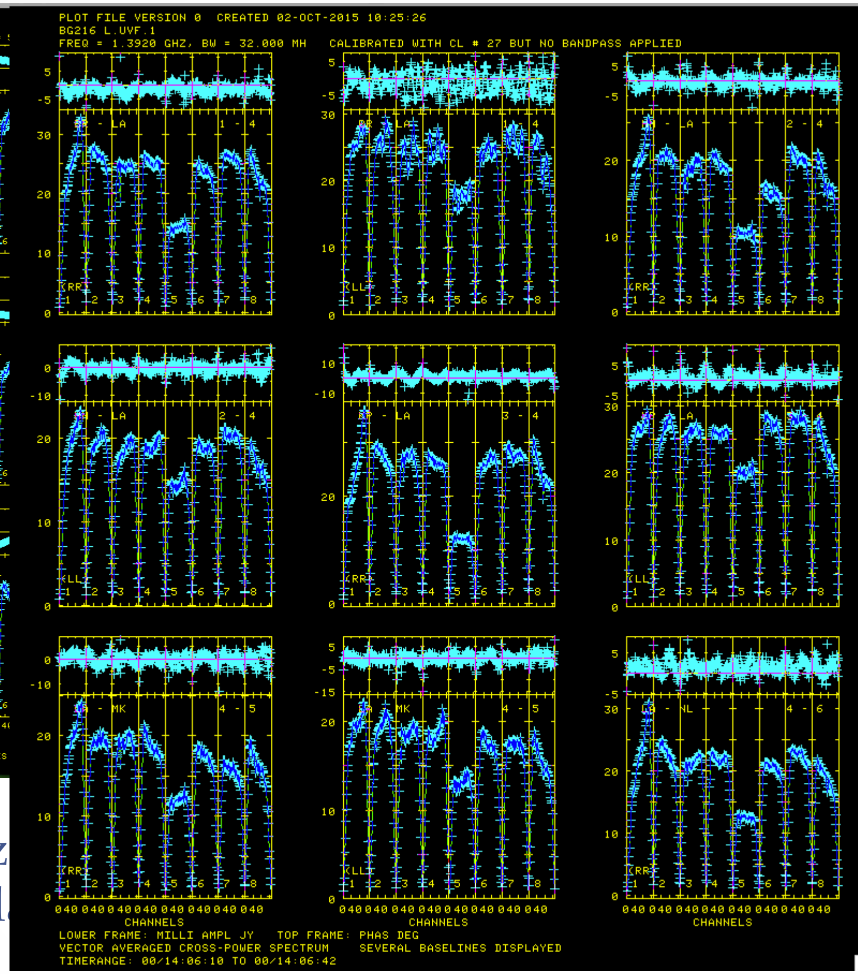


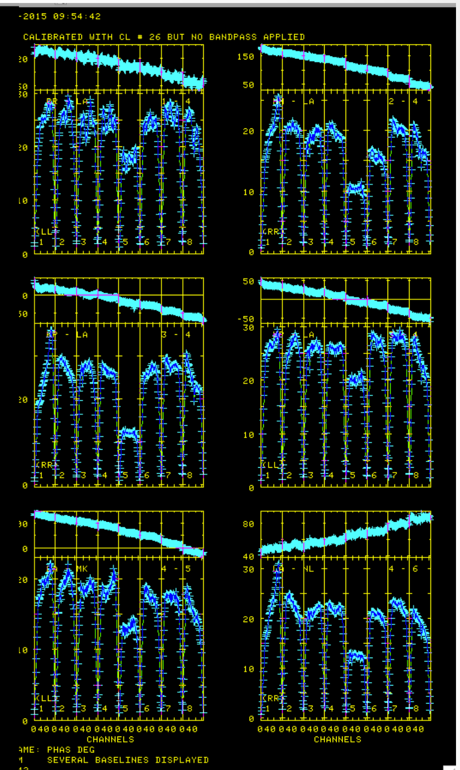
L-band (1.3 GHz) instrumental delays calibrated

L-band (1.3 GHz), ionospheric contribution calibrated

We have to calculated the tropospheric contribution with a GFF







L-band (1.3 GHz
instrumental del
calibrated

GHz), ionospheric
n calibrated

L-band, instrumental, ionospheric and trophospheric contribution calibrated

Calibrating data at 43 GHz

$\delta\tau_{inst}(\nu,t)$ → Fring in Aips

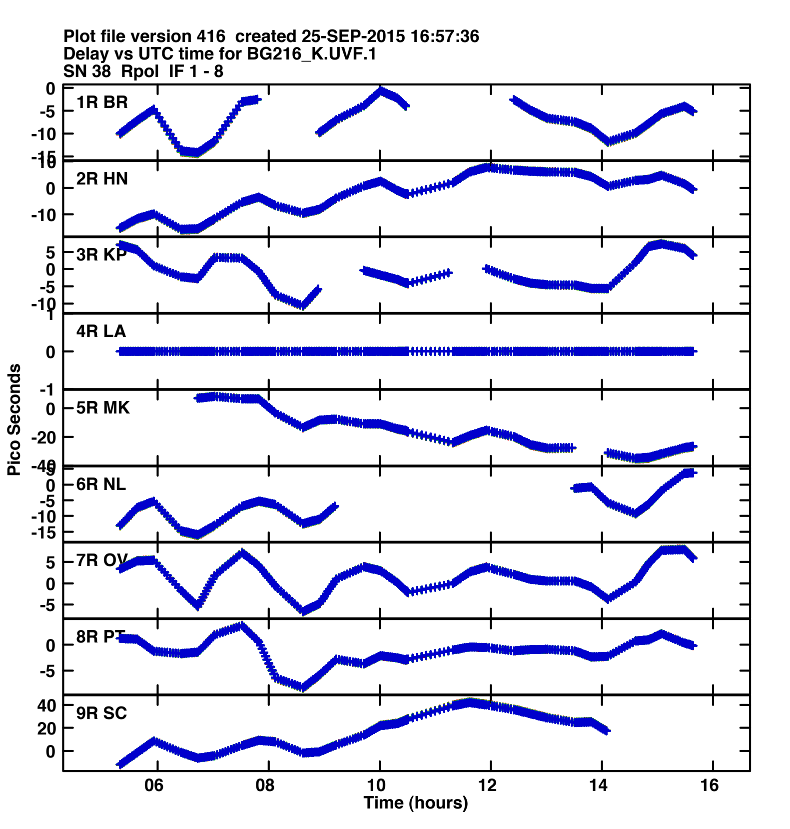


Table with ionospheric calibration at 22 GHz

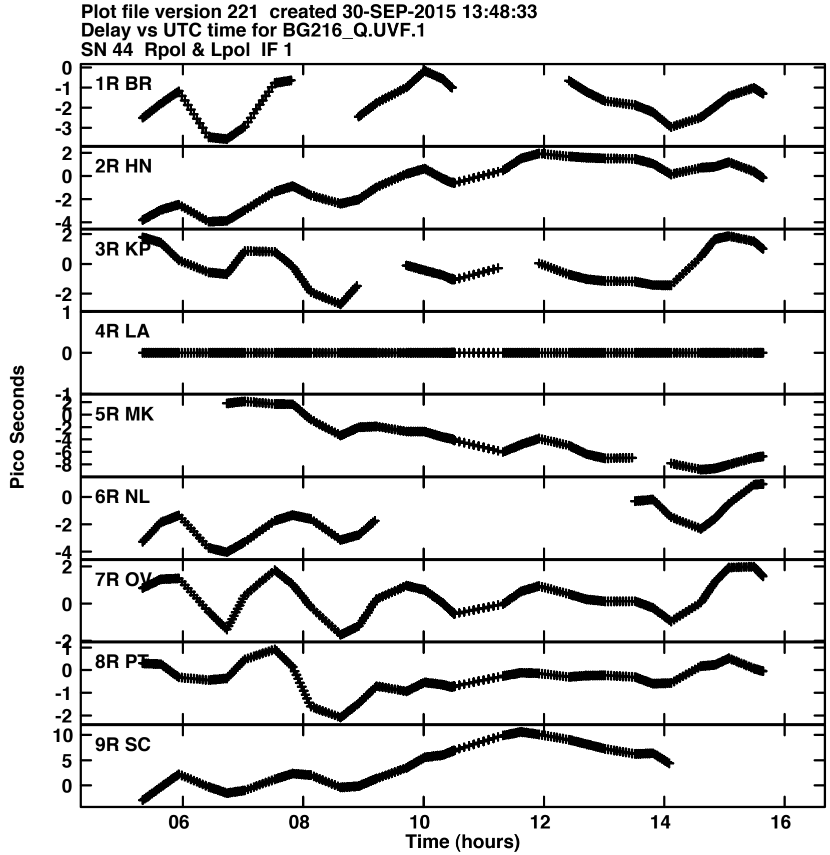


Table with ionospheric calibration at 43 GHz