MULTI-TECHNIQUE APPROACH FOR DERIVING A VLBI SIGNAL EXTRA-PATH VARIATION MODEL INDUCED BY GRAVITY: THE EXAMPLE OF MEDICINA

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Overview

- ***Discrepancies*** *between* ***Tie vectors and SG*** *solutions are found in TRF combinations.*
- Where do they originate from? (Deformations experienced by large VLBI antennas)
- How can these defs be modelled and handled?
- Application of a multi-technique procedure for estimating deformations parameters
- **Cross-check** of the results
- Formulation of a ***Signal Path Variation Model*** (valid for the Medicina VLBI telescope)

Inconsistencies between Ties & SG solutions

- Inter-technique Combinations of SG solutions and tie vectors at co-located sites often point out remarkable inconsistencies
- Examples (**CATREF** combination residuals)

Combination	*DOMES #*	*dN (mm)*	*dE (mm)*	*dU (mm)*	*Epoch*
1	12711	2.2	-2.3	1.8	01:174
2	12711	0.1	-1.1	1	02:252
3	12711	1.5	-3.5	6.7	02:253
4	12711	0.2	0.6	0.6	03:274
5	12711	-0.8	1.6	5.7	06:194

- The way we compute **Tie vectors**
- **Reference Point Definition**

Reference Point: one or more?

- A sort of **"trichotomy"** exists

1. ***Electronic RP:*** where the observable is detected and physically acquired (phase centres for GPS antenna and VLBI receivers)
2. ***Conventional RP:*** identified by the technique services according to a theoretical/geometrical definition (VLBI and SLR Invariant Point, GPS and DORIS Antenna Reference Point)
3. ***Stochastic RP:*** the outcome of an estimation procedure coming from either SG or terrestrial obs)

Local ties don't have access to ***Type No 1*** *of RP*

=> problem of **consistency** between the realization of RP with terrestrial and SG observable

The connection between the Electronic and Conventional RP

- ***Connection*** between
  Electronic & Conventional RP

  GPS technique => PCV files (Schmidt et al 2005, 2007)

  DORIS technique => (Willis et al 2007)

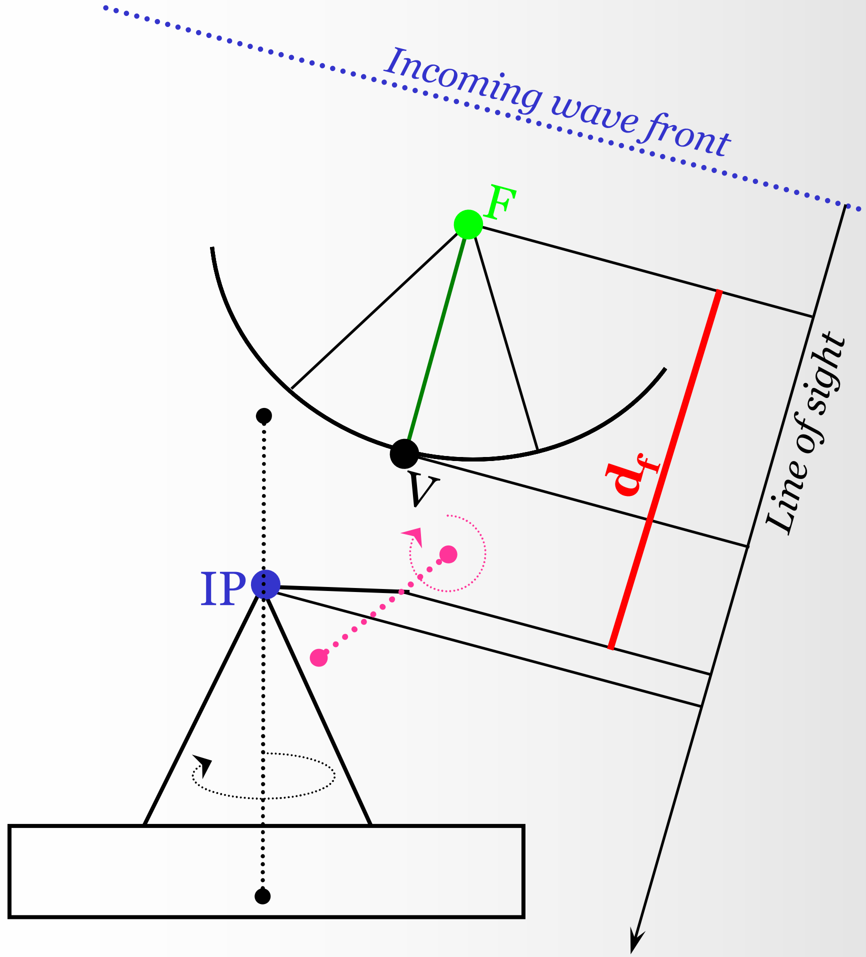
  VLBI technique => need to consider similar corrections, due to Grav. Deformations

Indirect approach & Grav Deformations

- ***No unique way*** to conventional RP realization:

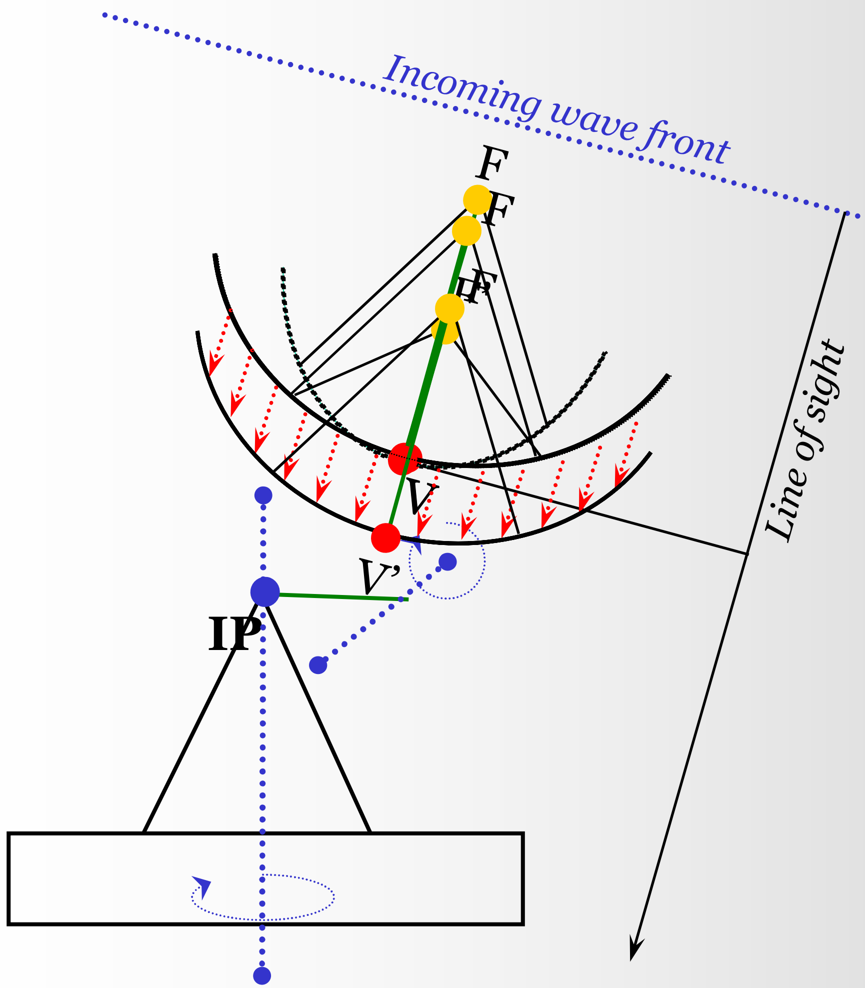
  *Direct, **Indirect**, Hybrid Approach (Sarti & Angermann, 2005)*
- ***Flexibility*** *of indirect approaches*
- *Possibility to reconstruct the geometry of VLBI systems (axes, axis offset, IP)*
- *Contribution to the **understanding** of the effects of grav deformations*
- *...but beware of indirect approaches! Handle with care!*

Grav Deformations & Electronic RP instability



- ***Grav deformations*** may induce Electronic RP **(F)** instabilities => reflect on the stability of **IP**
- In VLBI obs, ***d_f*** *(distance between **F** and moving axis)* is assumed to be ***constant***
- *But…any variation in the signal path modifies* ***d_f***
- If **unmodelled**, this variation corrupts the observable and affects the parameters' estimations

Insights on how an antenna can deform



- ***Grav deformations*** may induce:

1. Motion of the S/X Band **Receiver** (primary focus at Medicina)
2. **Deformation** Of the **Primary Reflector** (conveniently expressed by a *focal lenght variation*)
3. **Rigid Motion** of the **Primary Reflector** (vertex displacement)

Gravity dependent Signal Extra-path

- ΔL *signal path variation* (referred to the **L***ine* **o***f* **S***ight*)
- *Linear combination* of 3 contributions (Clark & Thomsen, 1988):

$$\Delta L = \alpha_f \Delta F + \alpha_V \Delta V + \alpha_R \Delta R$$

Focal Length Variation

Vertex displacement

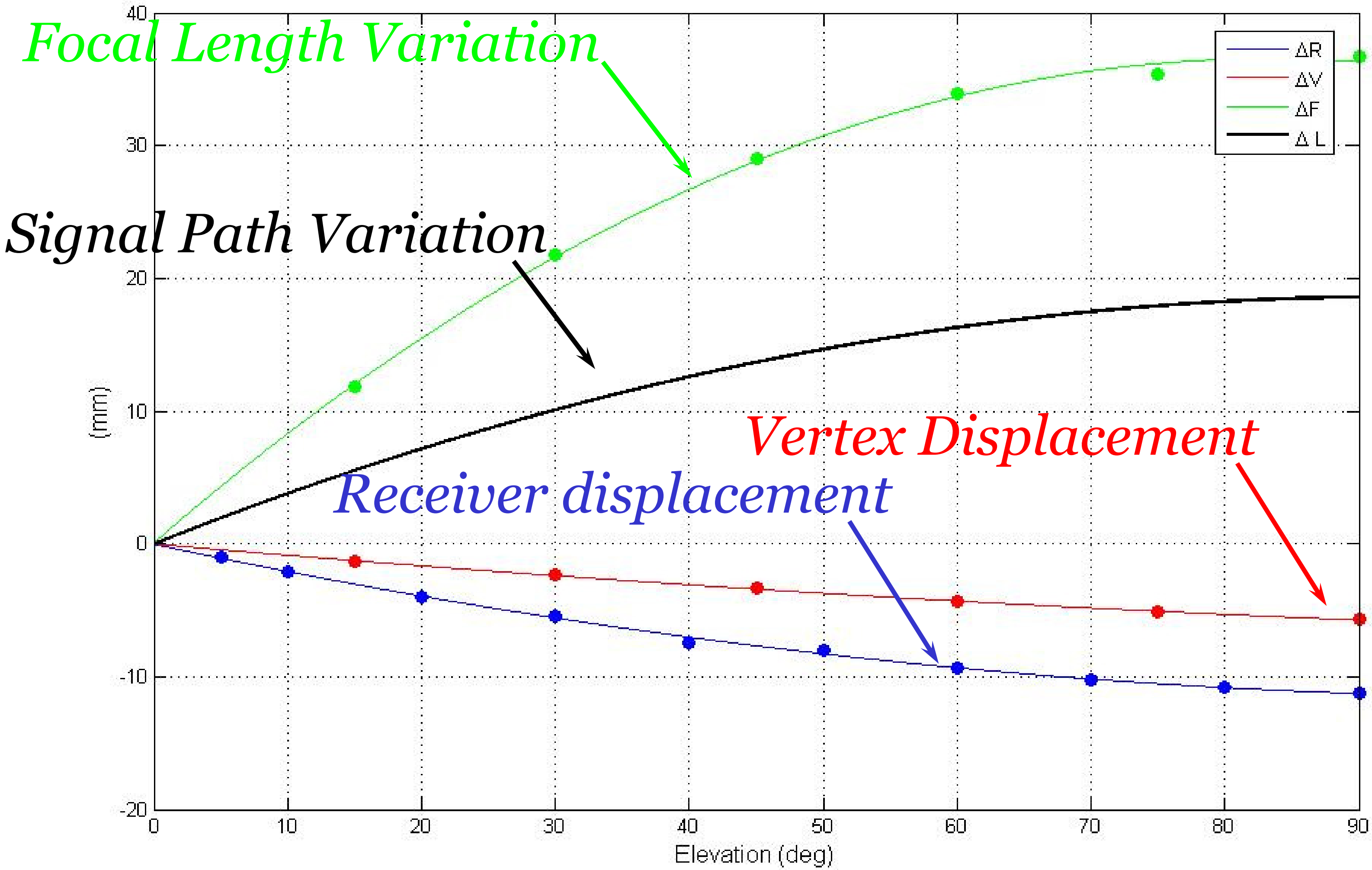
Receiver displacement

- the **3** α_i depend on the geometry of the VLBI telescope
- ΔL function of the antenna pointing elevation
- **Strictly peculiar** to the specific VLBI telescope

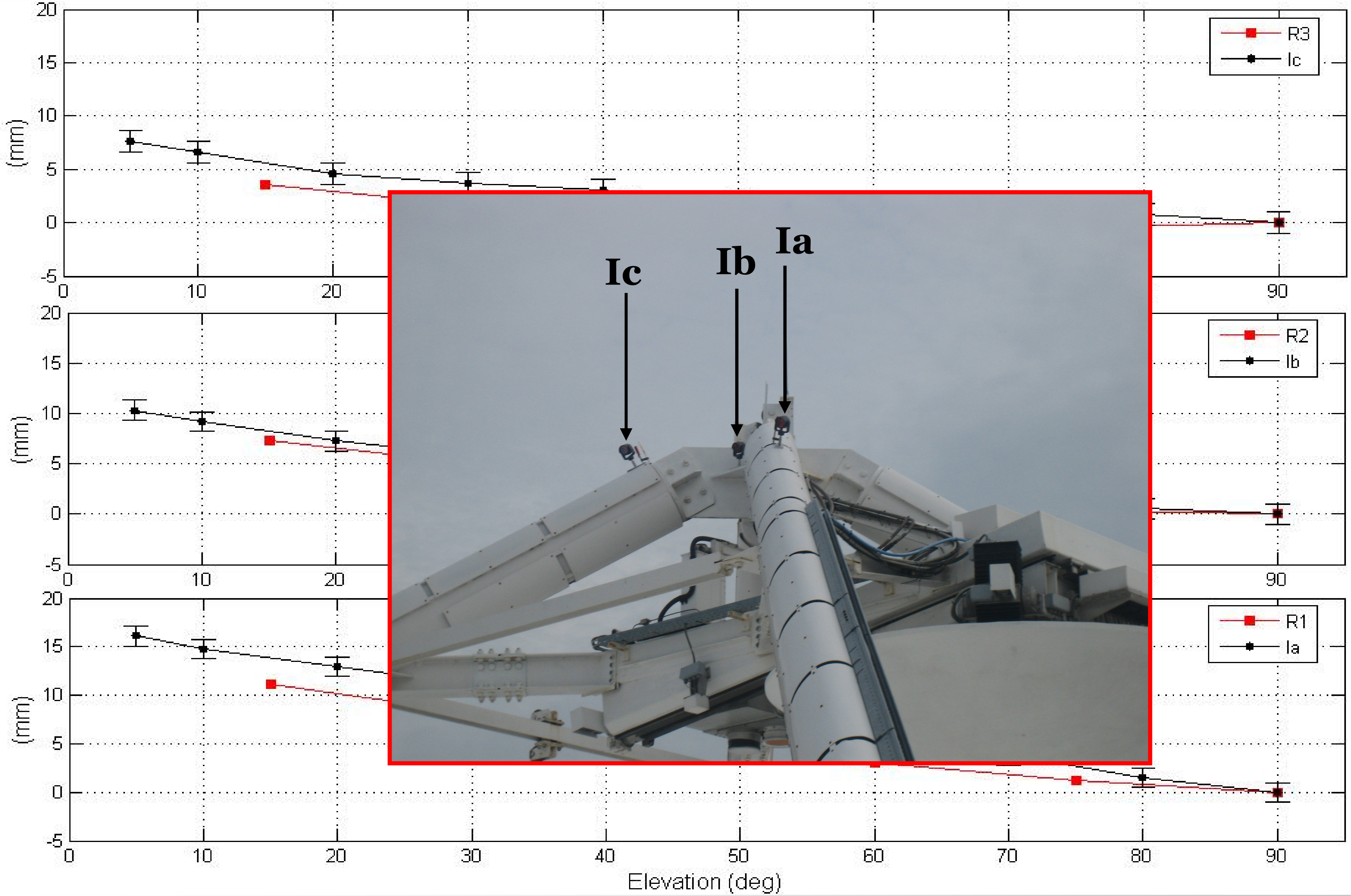
Quantifying the three effects

- ***Combination*** of 3 methods *(Sarti et al. Submitted to JoG)*:
- **T***errestrial* **L***aser* **S***canning* on the primary reflector **(ΔF)** *(Sarti et al. 2009 in press JSE)*
- **T***errestrial* **T***riangulation* and **T***rilaterations* **(ΔR)**
- **F***inite* **E***lement* **M***odelling* **(ΔV)**

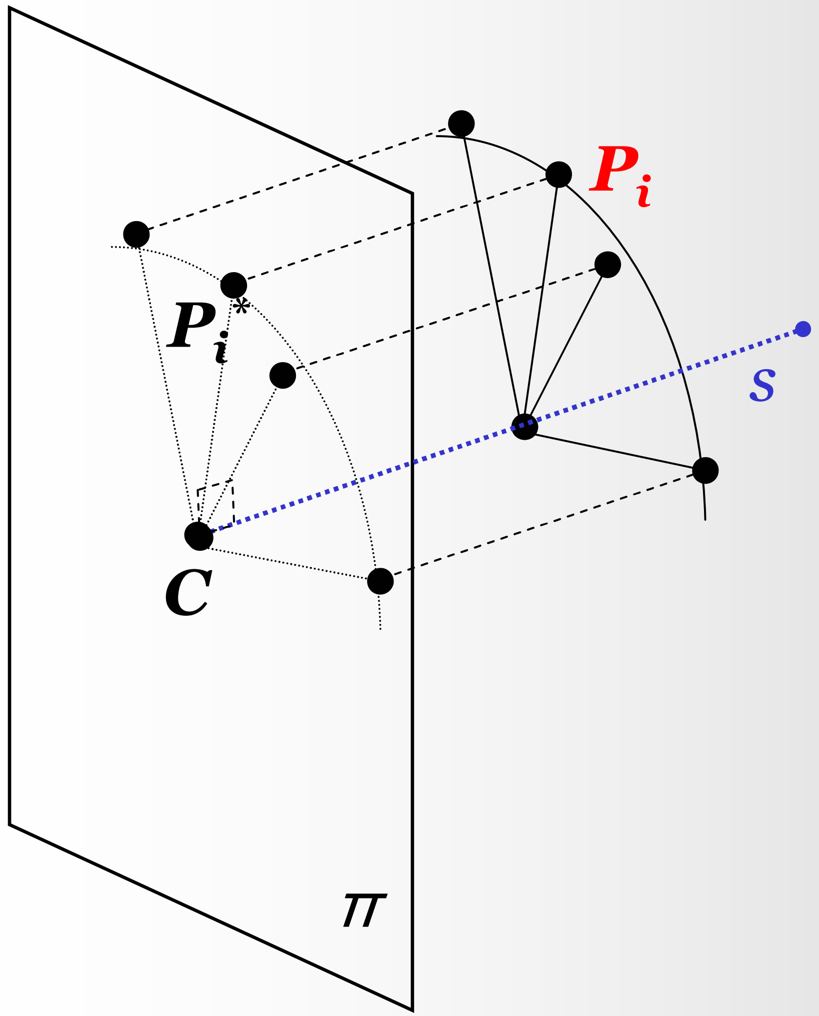
Signal Path Variation



Cross Check (1): The Receiver Motion (1)

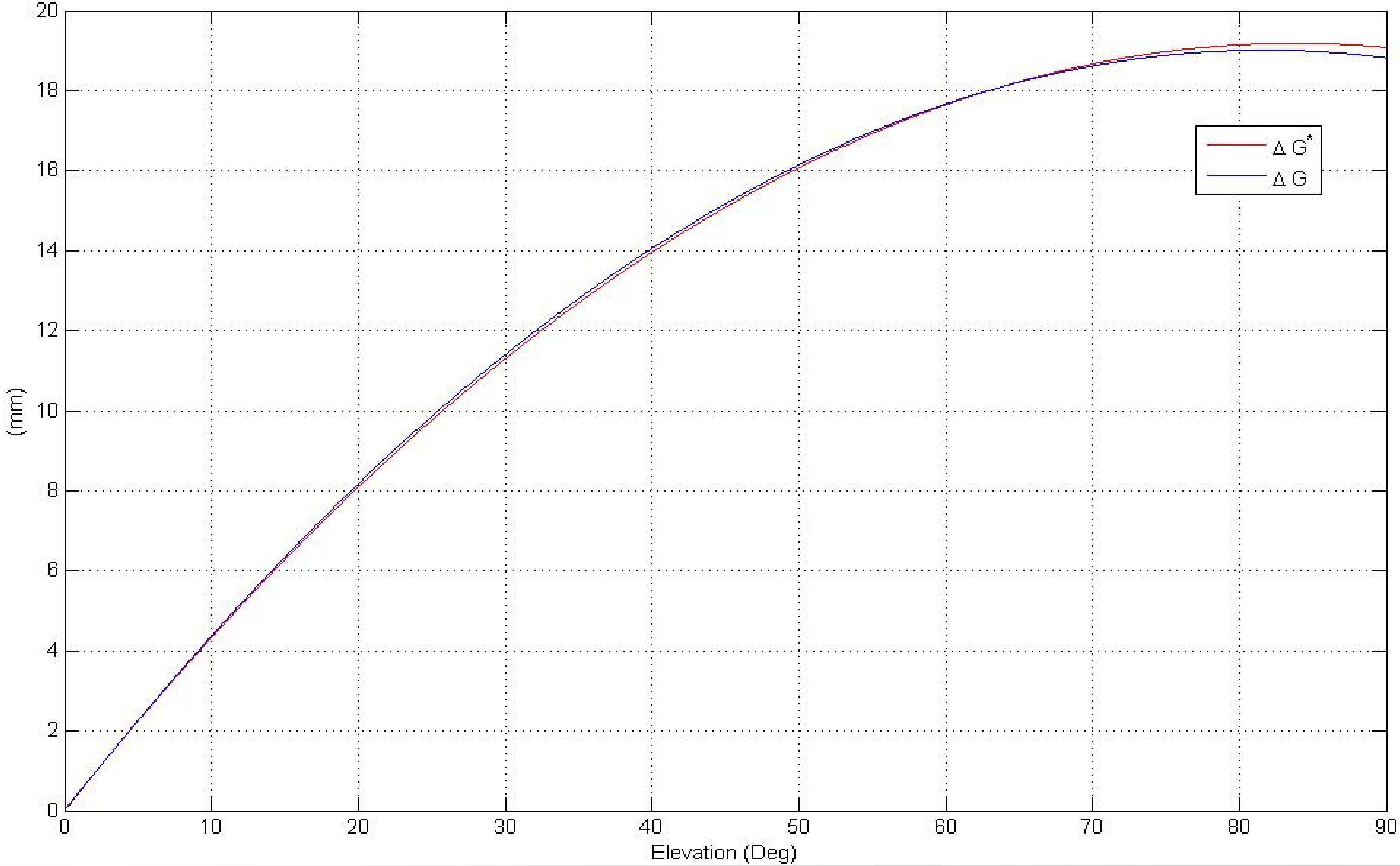


Cross Check (1): The Receiver Motion (2)



- The graphs showed
- ***Variations of radial distances*** between
- ***the elevation axis (s)*** and the **targets** P_i
- Suitably projected onto a ***reference plane*** which is **orthogonal** to the **elevation axis** and contains the **Line of Sight**.

Cross check (2): Signal path variation



Possible consequences

- The signal path variation may introduce a non-negligible ***error*** in the VLBI obs equ
- Such a variation sin(e) (R^2=0.99)
- Likewise the sensitivity of height on an error on the obs equation behaves as a sin function (Ray et al. 2005)
- => The 2 effects are **highly correlated.** What does this imply? .... *More investigations…*
- Carter et al. (1980) compared the tie vector *Westford-Haystack* VLBI antennas with SG solution
- and observed a discrepancy in the *height component* of the *baseline Westford-Haystack* of **13 sin(e)** mm

Conclusions

- It might be necessary to introduce ad-hoc ***PCV-like models*** accounting for ***VLBI IP motion*** induced by gravity deformations (on *large antennas*)
- ***More*** *efforts must be done* for evaluating the impacts of deformations ***within the VLBI data processing***
- ***Cross-checking*** *of results proved to be valuable*
- Modest impact of gravitational deformations for the next generation of (smaller) VLBI antennas

Thank You
for
the attention