



# Validation of GNSS-SLR local ties by using space ties

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- Problematic evaluation of Local Ties in „classical“ combination approach
- Alternative combination methods
- GNSS-SLR combination using GNSS satellites as co-location
- Discrepancies between resulting space-geodetic coordinates and Local Ties



## „Local Tie“:

3D vector between reference points of space geodetic instruments (GNSS antenna or SLR telescope or ...) at co-located sites

From terrestrial measurements



**Discrepancies !**

## Station coordinates from space techniques:

3D position of reference points of space geodetic instruments (GNSS antenna or SLR telescope or ...)

From space-geodetic measurements



## If discrepancies between Local Ties and space techniques exist:

How to evaluate which Local Ties can be used within the combination?

### Problem in «classical» combination approach:

Only ERPs and station coordinates are common parameters

- Station coordinates have to be combined
- At least some Local Ties have to be used to connect the techniques
- An independent validation is NOT possible



# Alternatives for connecting the space techniques?

## Troposphere parameters:

- Common parameters for microwave techniques (GNSS, VLBI, DORIS)

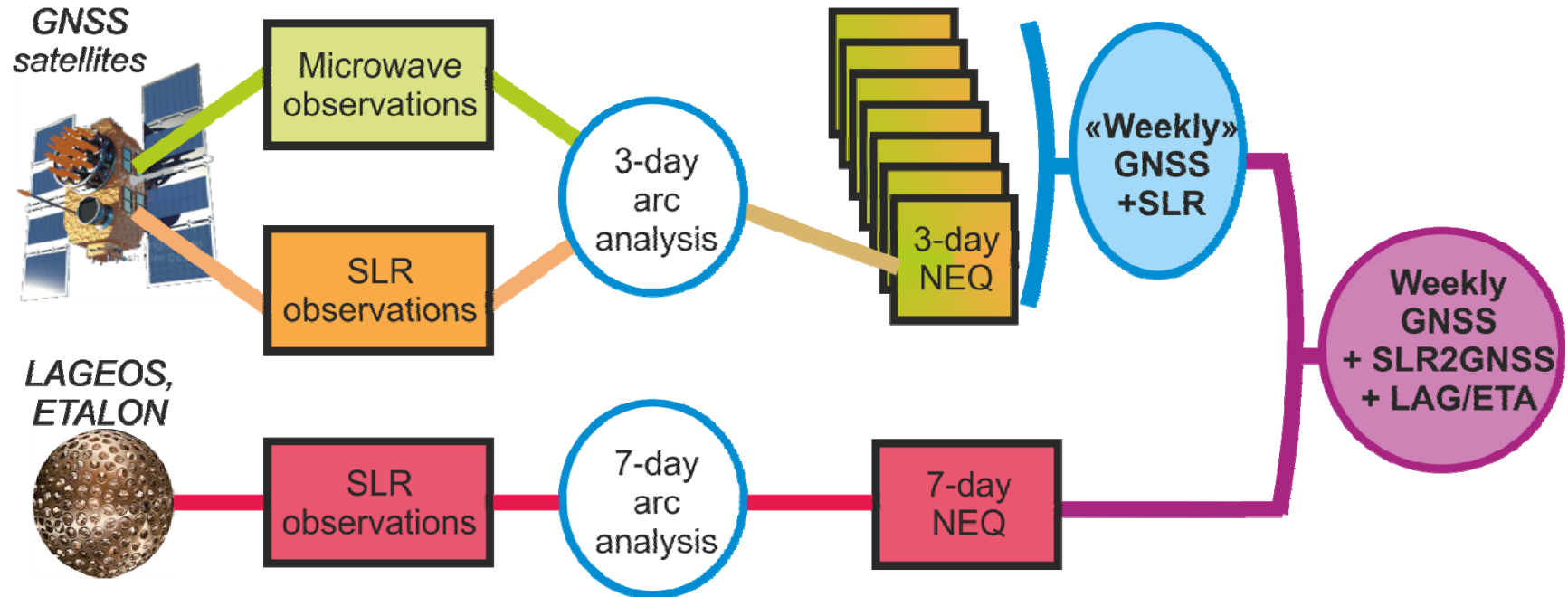
*already studied: Krügel et al. (2007), JoG, Special Issue «VLBI»*

*Thaller (2008), PhD thesis, GFZ STR 08/15*

## Satellite orbits:

- LEO satellites: GNSS, SLR, DORIS
- **GNSS satellites: GNSS, SLR**

# GNSS-SLR combination: Satellite co-location



- Using co-locations at GNSS satellites for connecting both techniques
- Local Ties are not necessary as additional constraint!
- Allowing for an independent comparison



## GNSS analysis:

- combined GPS-GLONASS analysis (since June 2003)
- similar to IGS processing at CODE

## SLR analysis (spherical satellites):

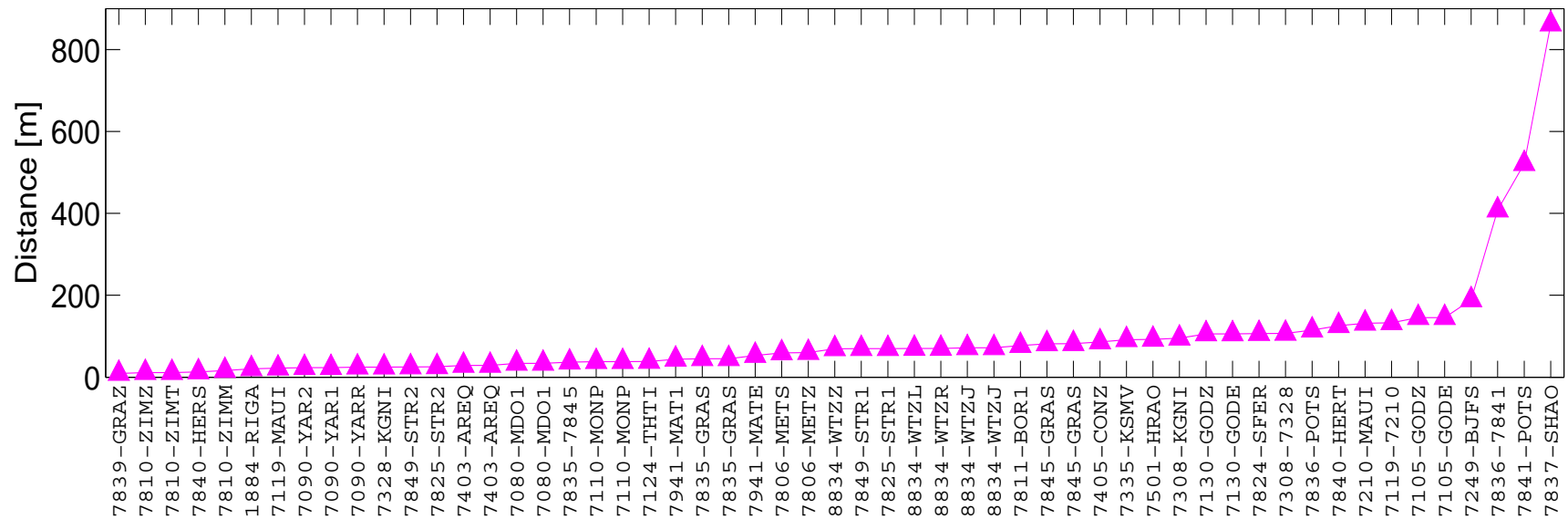
- combined LAGEOS-Etalon analysis
- similar to ILRS processing at BKG

## SLR analysis (GNSS satellites):

Using identical models as for GNSS and SLR-LAGEOS



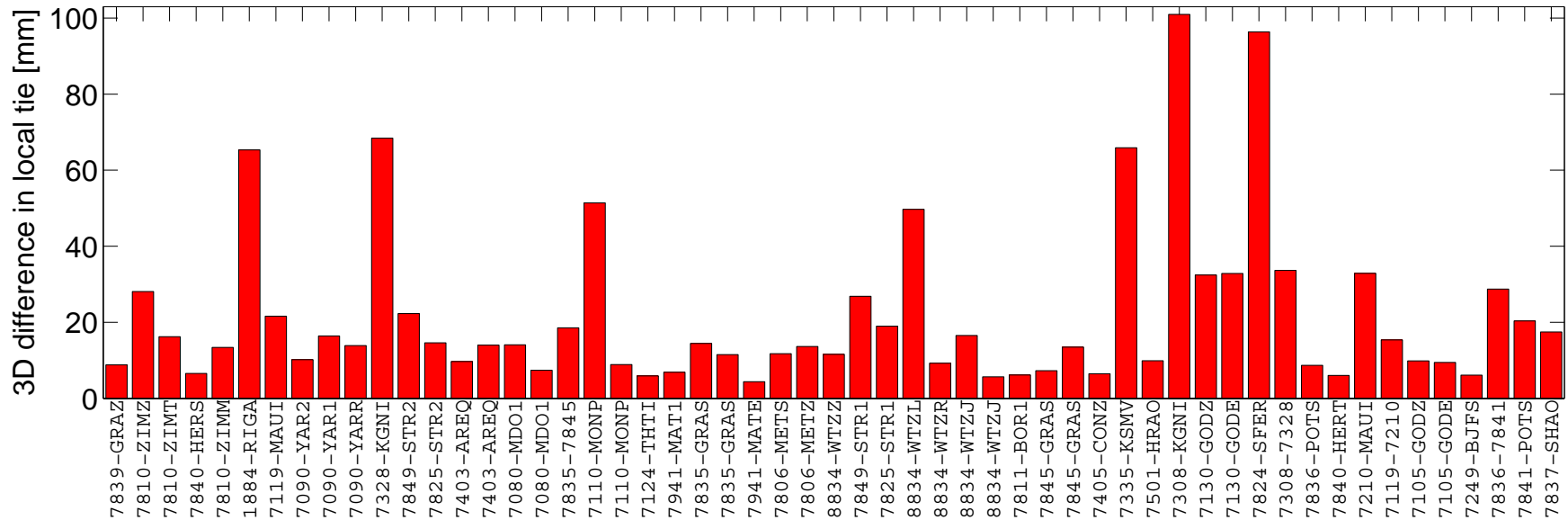
- Distances of co-located instruments:







# Discrepancies at co-locations

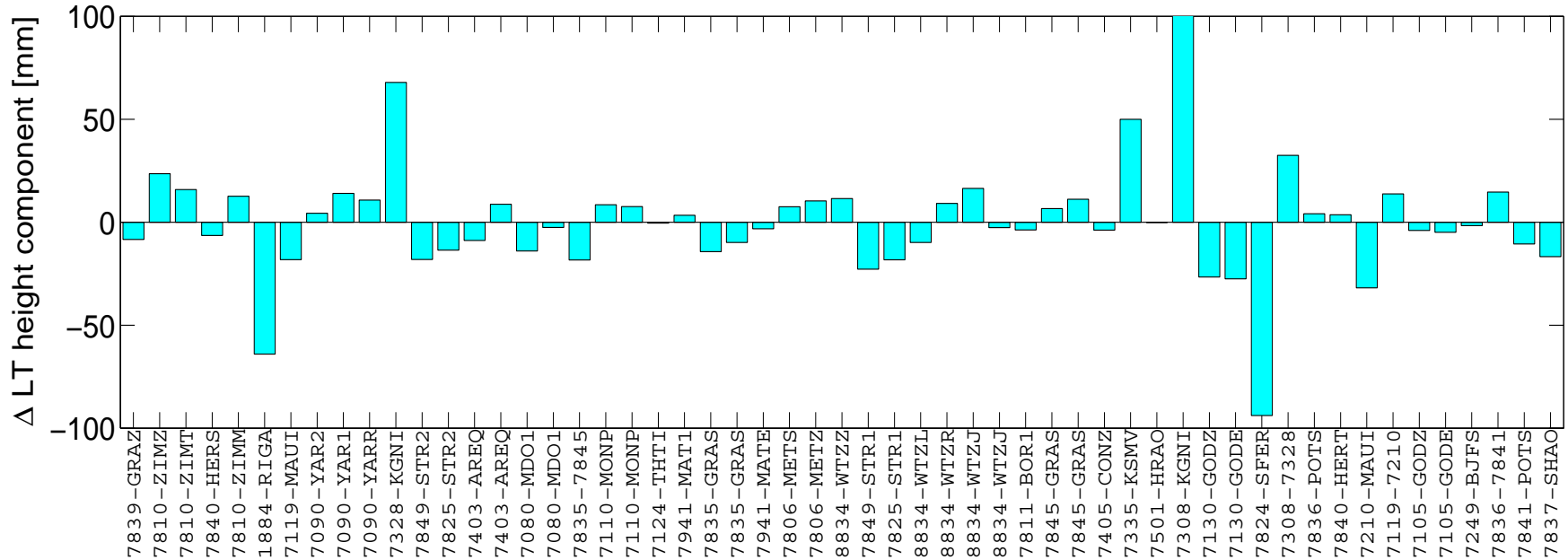


## 3-D agreement:

$0 \text{ mm} < \Delta \leq 10 \text{ mm}$	17 co-locations
$10 \text{ mm} < \Delta \leq 20 \text{ mm}$	13 co-locations
$20 \text{ mm} < \Delta \leq 30 \text{ mm}$	5 co-locations
$30 \text{ mm} < \Delta$	15 co-locations

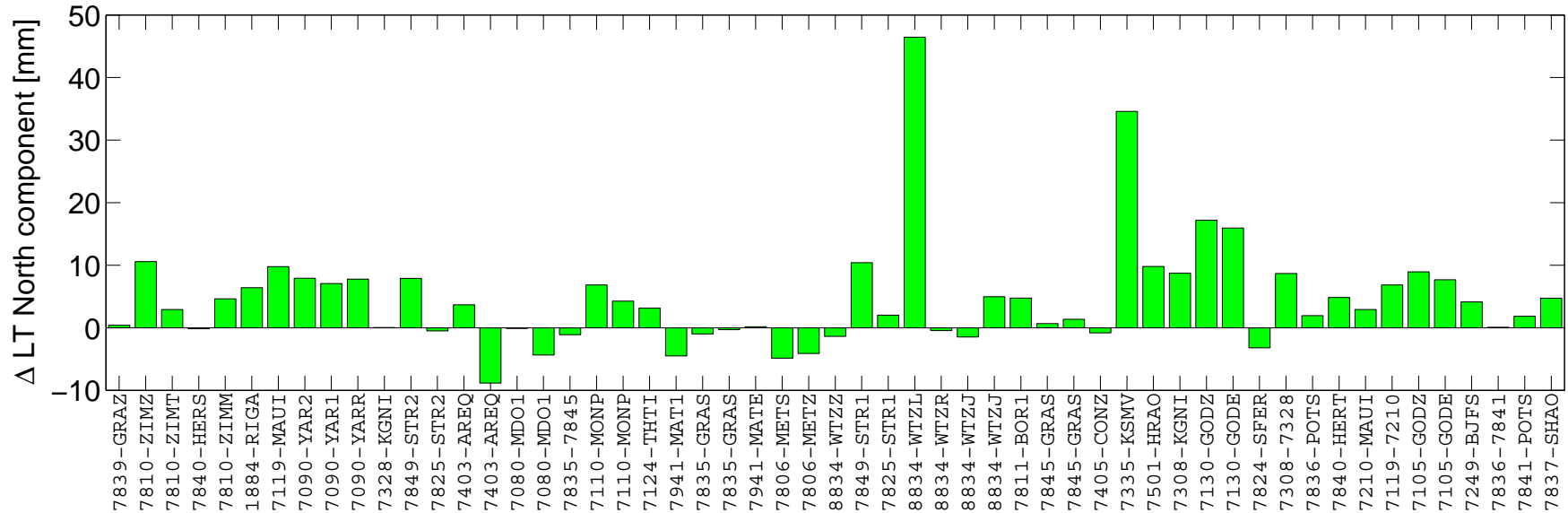


# Discrepancies at co-locations



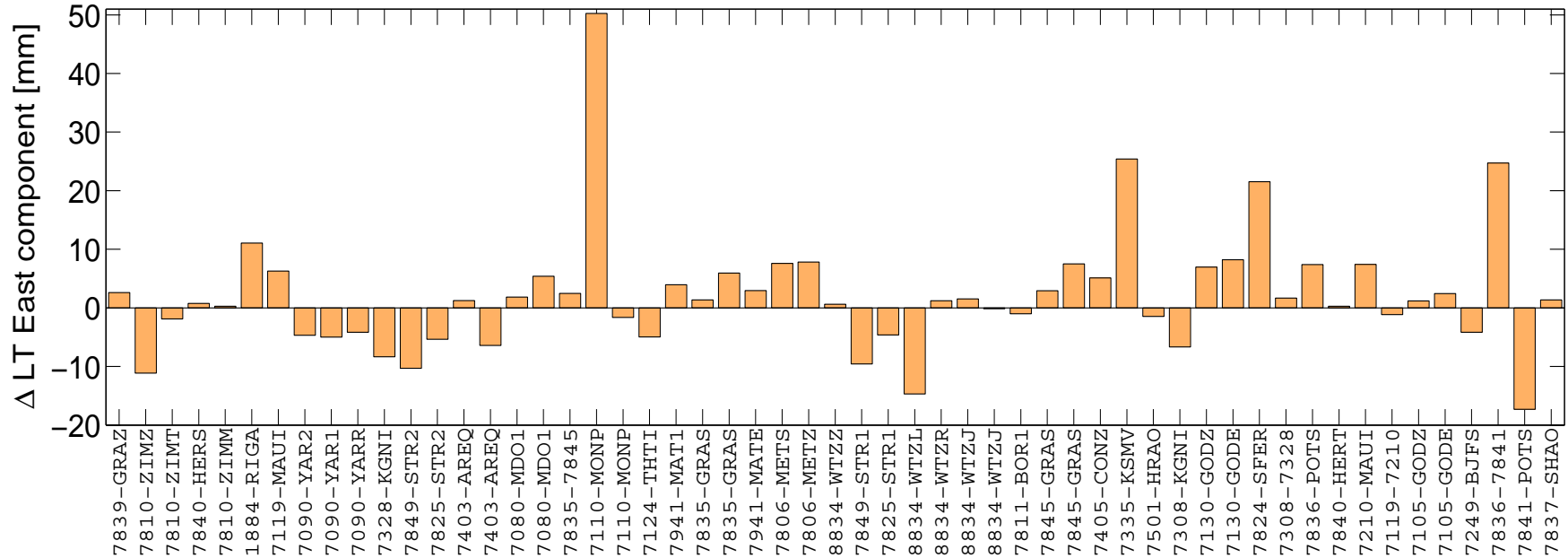
## Height agreement:

$0 \text{ mm} < \Delta H \leq 3 \text{ mm}$	5 co-locations
$3 \text{ mm} < \Delta H \leq 5 \text{ mm}$	10 co-locations
$5 \text{ mm} < \Delta H \leq 10 \text{ mm}$	12 co-locations
$10 \text{ mm} < \Delta H \leq 20 \text{ mm}$	20 co-locations
$20 \text{ mm} < \Delta H \leq 30 \text{ mm}$	4 co-locations
$30 \text{ mm} < \Delta H$	10 co-locations



**Horizontal agreement:**

$0 \text{ mm} < \Delta H_z \leq 3 \text{ mm}$	10 co-locations
$3 \text{ mm} < \Delta H_z \leq 5 \text{ mm}$	8 co-locations
$5 \text{ mm} < \Delta H_z \leq 10 \text{ mm}$	23 co-locations
$10 \text{ mm} < \Delta H_z \leq 20 \text{ mm}$	10 co-locations
$20 \text{ mm} < \Delta H_z \leq 30 \text{ mm}$	2 co-locations
$30 \text{ mm} < \Delta H_z$	8 co-locations



**Horizontal agreement:**

$0 \text{ mm} < \Delta H_z \leq 3 \text{ mm}$	10 co-locations
$3 \text{ mm} < \Delta H_z \leq 5 \text{ mm}$	8 co-locations
$5 \text{ mm} < \Delta H_z \leq 10 \text{ mm}$	23 co-locations
$10 \text{ mm} < \Delta H_z \leq 20 \text{ mm}$	10 co-locations
$20 \text{ mm} < \Delta H_z \leq 30 \text{ mm}$	2 co-locations
$30 \text{ mm} < \Delta H_z$	8 co-locations



- Alternative combination methods exist:
  - GNSS-SLR combination via satellite co-location
- Useful for **independent** validation of Local Ties
- Horizontal agreement is better than height agreement (**41 vs. 27 co-locations better than 1 cm**)
- To be improved:
  - Extend for 2011,2012... (more SLR tracking of GLONASS)
  - Check for epoch of Local Ties
- **Reason for discrepancies** have to be identified by other methods!