Updated phase center corrections for satellite and receiver antennas

Ralf Schmid
Technische Universität München, Germany

Xavier Collilieux
Institut Géographique National, France

Florian Dilssner
European Space Operations Centre, Germany

Rolf Dach
University of Bern, Switzerland

Martin Schmitz
Geo++ GmbH, Germany

igs05.atx vs. igs08.atx

	igs05.atx	igs08.atx
GPS satellite antennas	11 years of data, 2 ACs	16 years of data, 4 ACs
	solutions aligned to IGb00 (based on relative phase center corr.)	solutions aligned to IGS08, i.e., full consistency with reference frame
	trend-correction due to error in mean vertical velocity of IGb00	no common *z*-offset trend
	radome calibrations not considered	available radome calibrations applied
	block mean values for satellites launched since 2006	satellite-specific estimates for 8 latest satellites
GLONASS sat. ant.	15 months of data, 1 AC	7/2.5 years of data, 2 ACs
Receiver antennas	robot calibrations for about 60% of the IGS stations	robot calibrations for about 70% of the IGS stations
	GPS-specific corrections only	GPS- and GLONASS-specific corrections

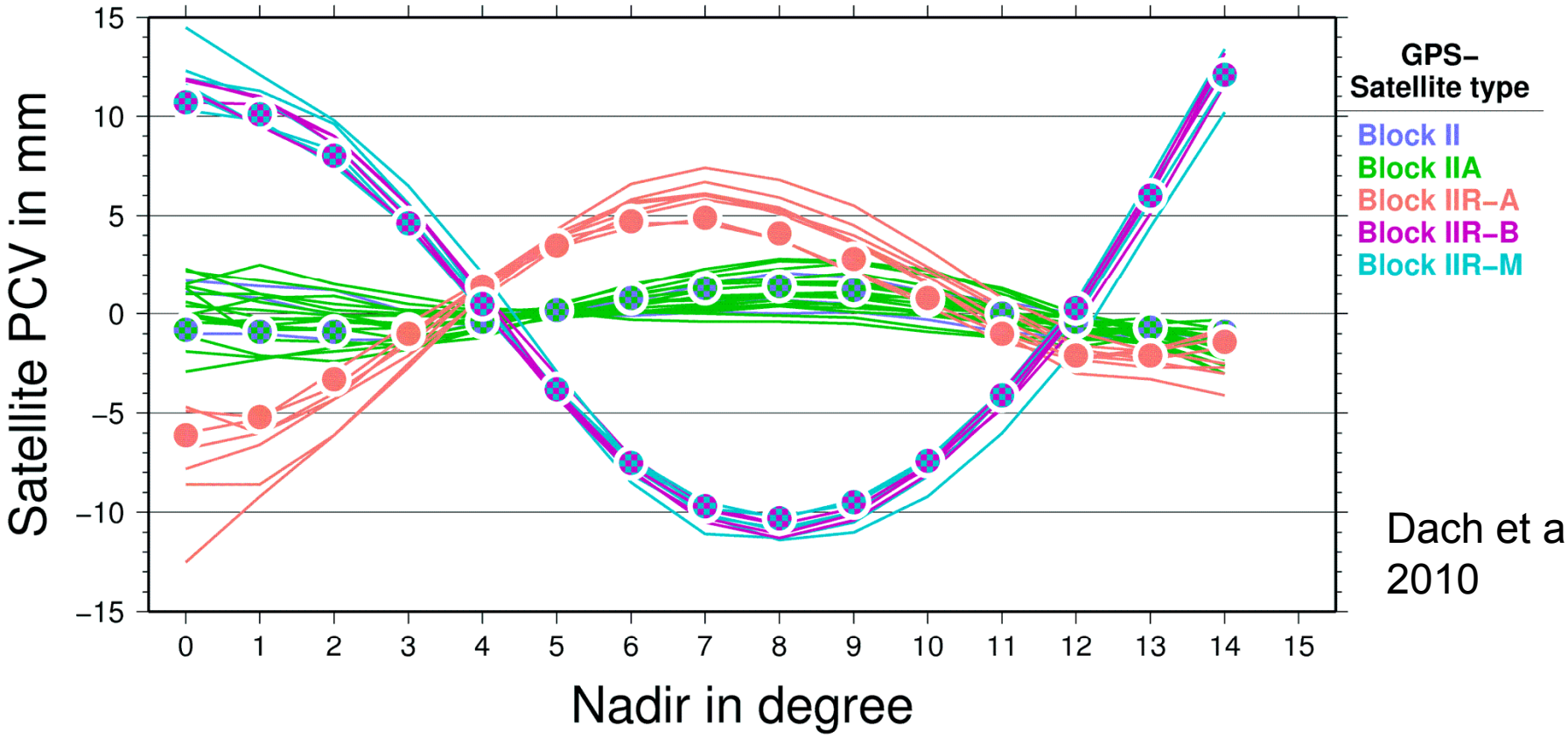
repro1 processing strategy

	CODE	GFZ	MIT	NRCan
Elevation cut-off	3°	7°	10°	10°
Weighting	$1/\cos^2(z)$	$1/2\sin(e)$ for $e < 30°$	$a^2+(b^2/\sin^2(e))$	none
Meteo data	GPT	GPT	GPT	ECMWF 6 h grids
Zenith delay	Saastamoinen dry	Saastamoinen dry + wet	Saastamoinen dry + wet	ECMWF dry + wet
Mapping function	GMF dry	GMF dry + wet	GMF dry + wet	NMF dry + wet
Zenith parameters	2 h continuous with GMF wet	1 h constants with GMF wet	2 h continuous with GMF wet	5 min stochastic ZTD
Gradient parameters	24 h NS + EW continuous	24 h NS + EW constants	NS + EW vary linearly	5 min stochastic

Griffiths et al., 2009

GPS satellite antenna PCVs

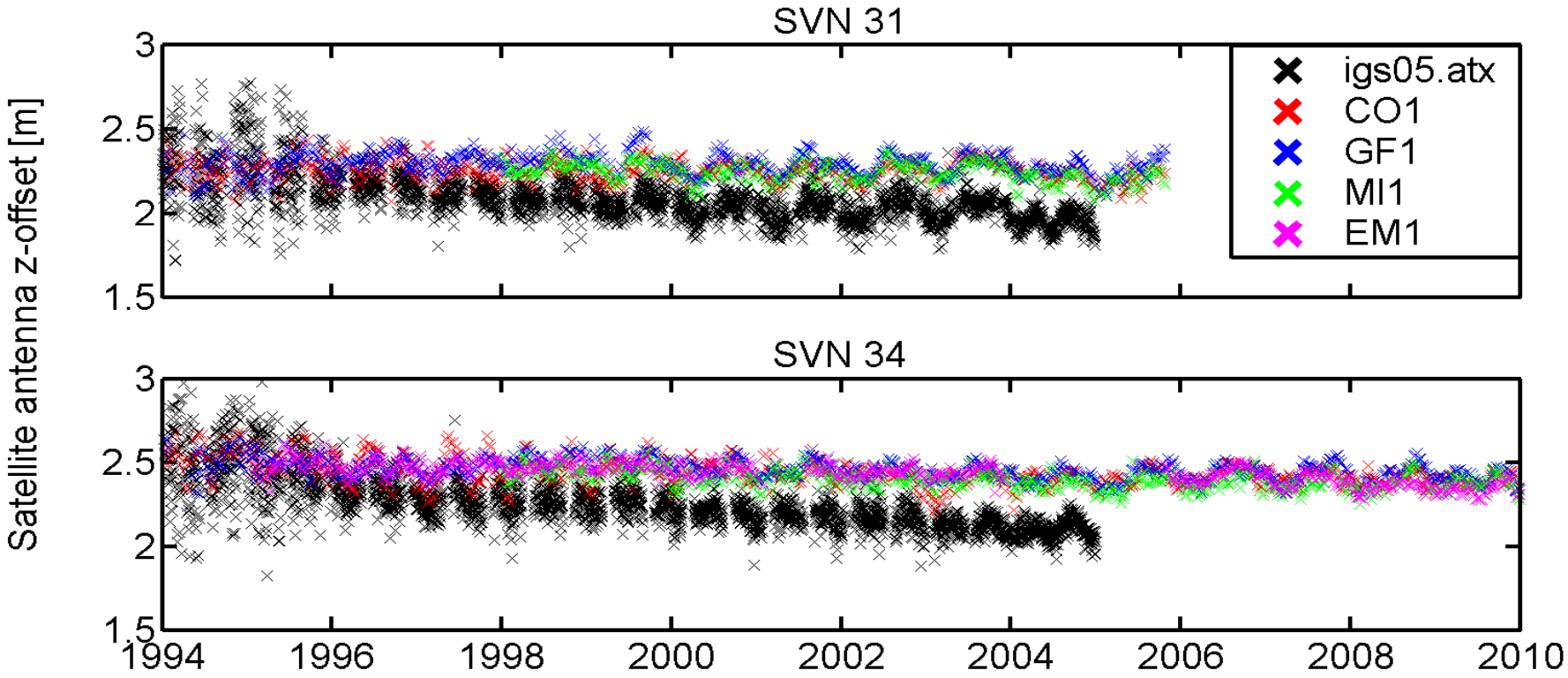
- SINEX format does not allow for antenna PCVs so far
- Impossible to derive PCVs consistent with *z*-offsets from SINEX files, i.e., **PCVs from igs05.atx will be kept**
- PCVs from current CODE solution still show good agreement



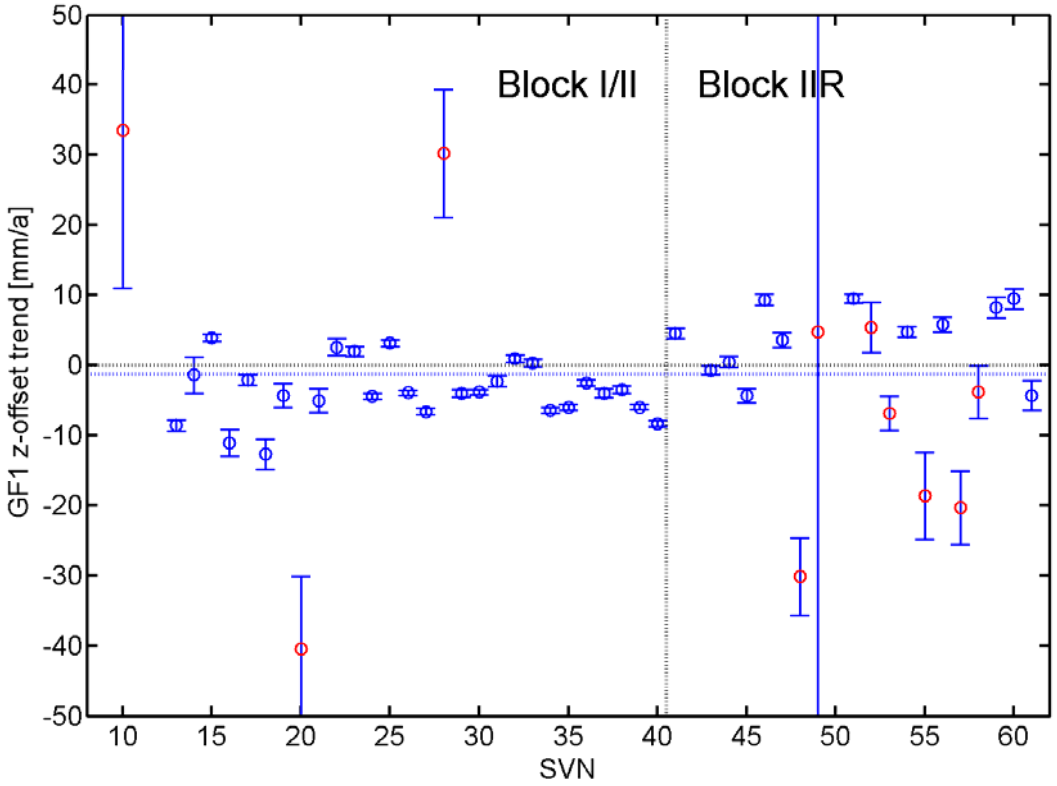
Dach et al., 2010

GPS satellite antenna PCOs

- Different scatter: daily (igs05.atx) vs. weekly estimates (repro1)
- **Trend** due to error in mean vertical velocity of IGb00 has more or less **disappeared**
- Certain **satellites fixed** in MIT and NRCan solutions (e.g., SVN 31)
- Preliminary results with **ITRF2008P** kept fixed



Remaining *z*-offset trends

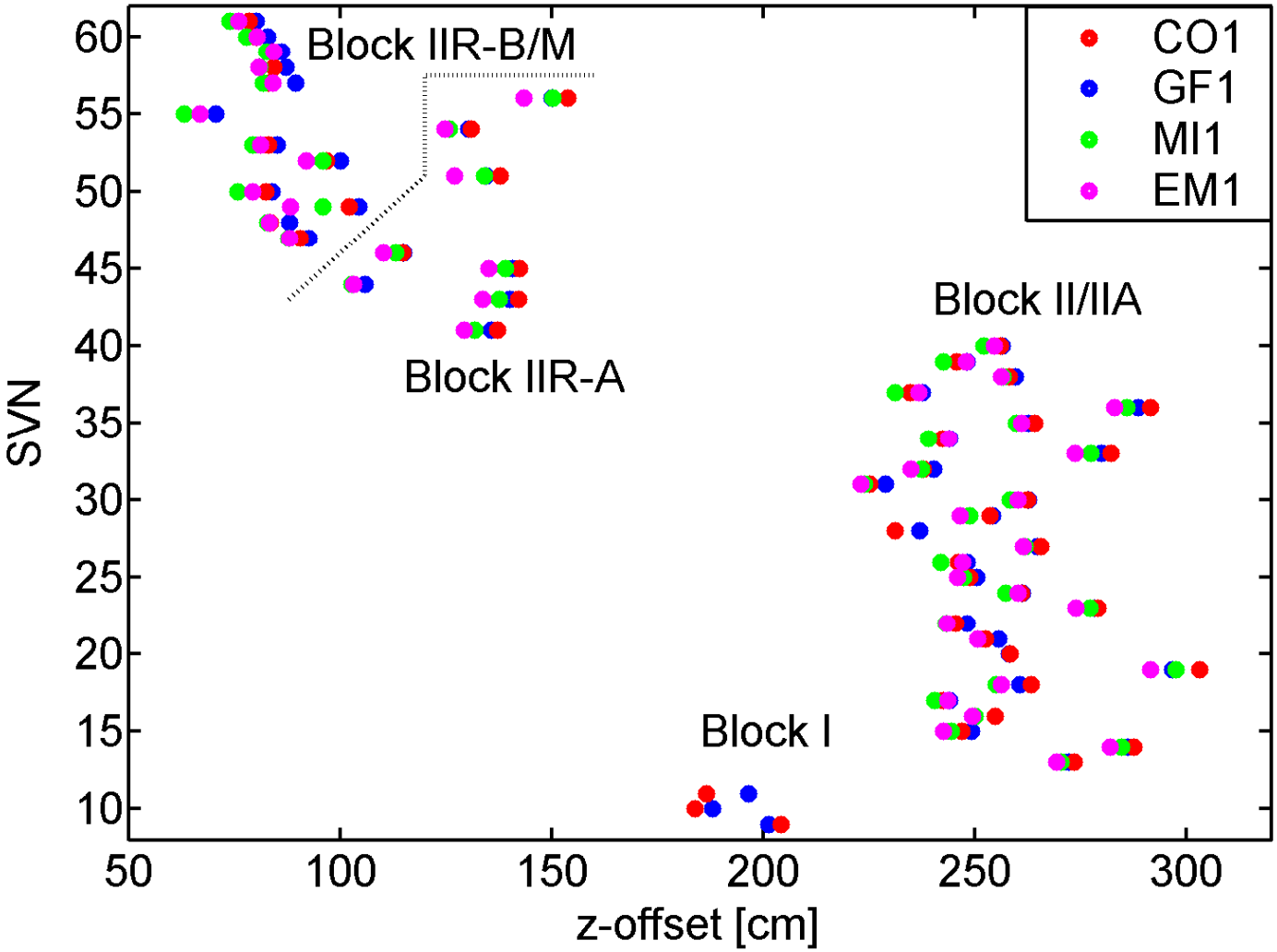


Trends [mm/a]	igs05.atx (Schmid et al., 2007)	igs08.atx
CODE/ TUM	**-24.8**	**-4.9**
GFZ	**-22.0**	**-1.3**
MIT	----	**-1.9**
NRCan	----	**-3.9**

Altamimi et al. (AGU 2009):
Scale rate agreement between VLBI and SLR: 0.06 ppb/a

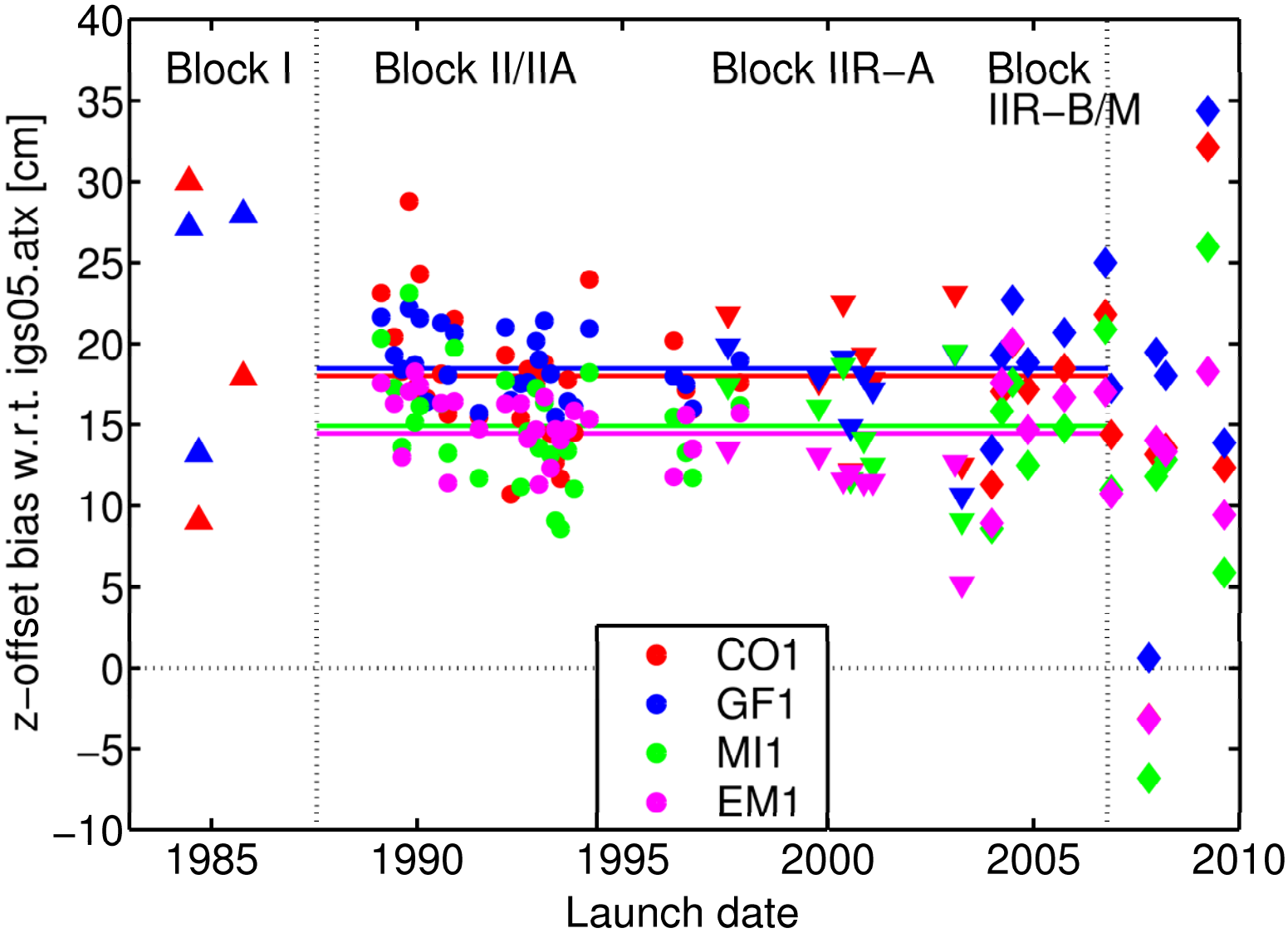
→ **± 0.03 ppb/a** correspond to a *z*-offset trend of about **± 4 mm/a**
→ GPS tends to support the SLR scale rate

Absolute GPS *z*-offsets by SVN



Differences between ACs are much **smaller than satellite-to-satellite differences** within each block

z-offset bias w.r.t. igs05.atx (I)

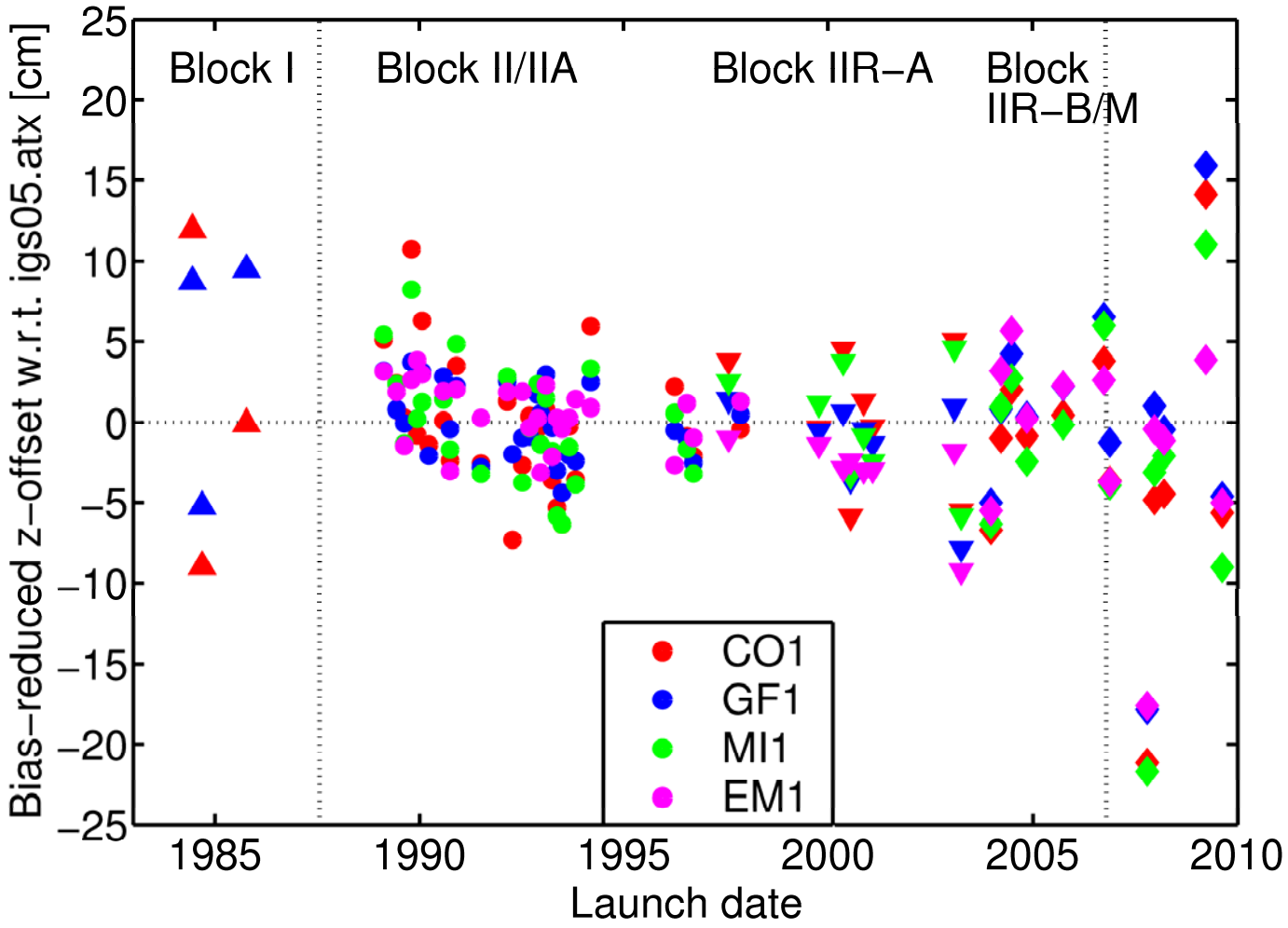


18.5 cm
18.0 cm
14.9 cm
14.4 cm

z-offset bias w.r.t. igs05.atx (II)

- Bias w.r.t. igs05.atx:
  - CODE: **18.0 cm** ± 3.9 cm
  - GFZ: **18.5 cm** ± 2.7 cm
  - MIT: **14.9 cm** ± 3.5 cm
  - NRCan: **14.4 cm** ± 2.8 cm
- Bias between GFZ and CODE/TUM:
  - igs05.atx (Schmid et al., 2007): **about 4 cm**
  - igs08.atx: **0.5 cm**
- Altamimi et al. (2010):
  Scale difference between ITRF2005 and ITRF2008**P**: -1.13 ppb
- Zhu et al. (2003): **-1.13 ppb** correspond to about **+14.5 cm**
- Part of the bias between CODE/GFZ and MIT/NRCan possibly due to certain fixed satellite offsets in the MIT/NRCan solutions

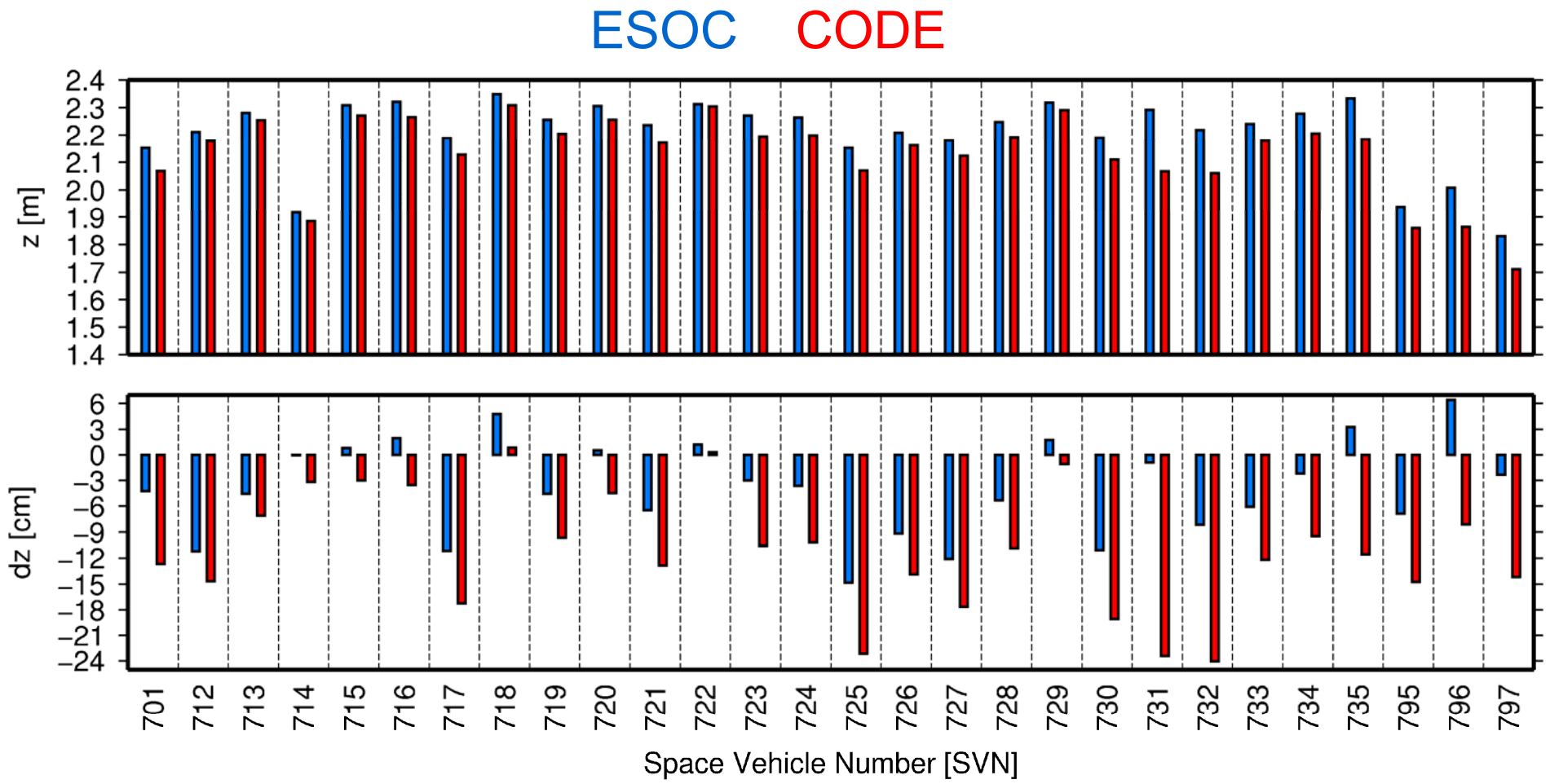
Bias-reduced *z*-offsets w.r.t. igs05.atx



→ igs08.atx and igs05.atx agree at the **±5 cm** level

→ **Preliminary values** for Block IIR-B/M were not too bad

GLONASS satellite antenna corrections



Mean bias between ESOC and CODE: 7.3 cm

Receiver antenna calibrations

GPS:

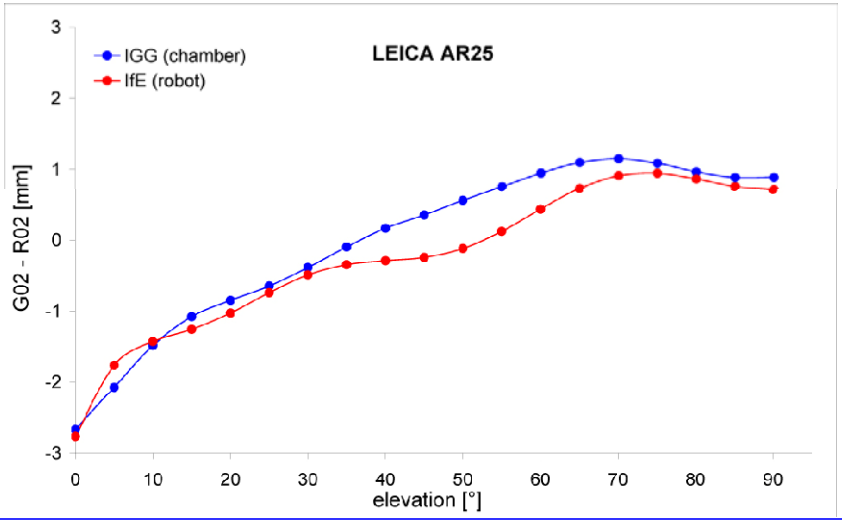
- 15 additional robot calibrations (e.g., for **TPSCR3_GGD**)
- update for 61 existing robot calibrations

Statistics for stations in the IGS network (December 2009):

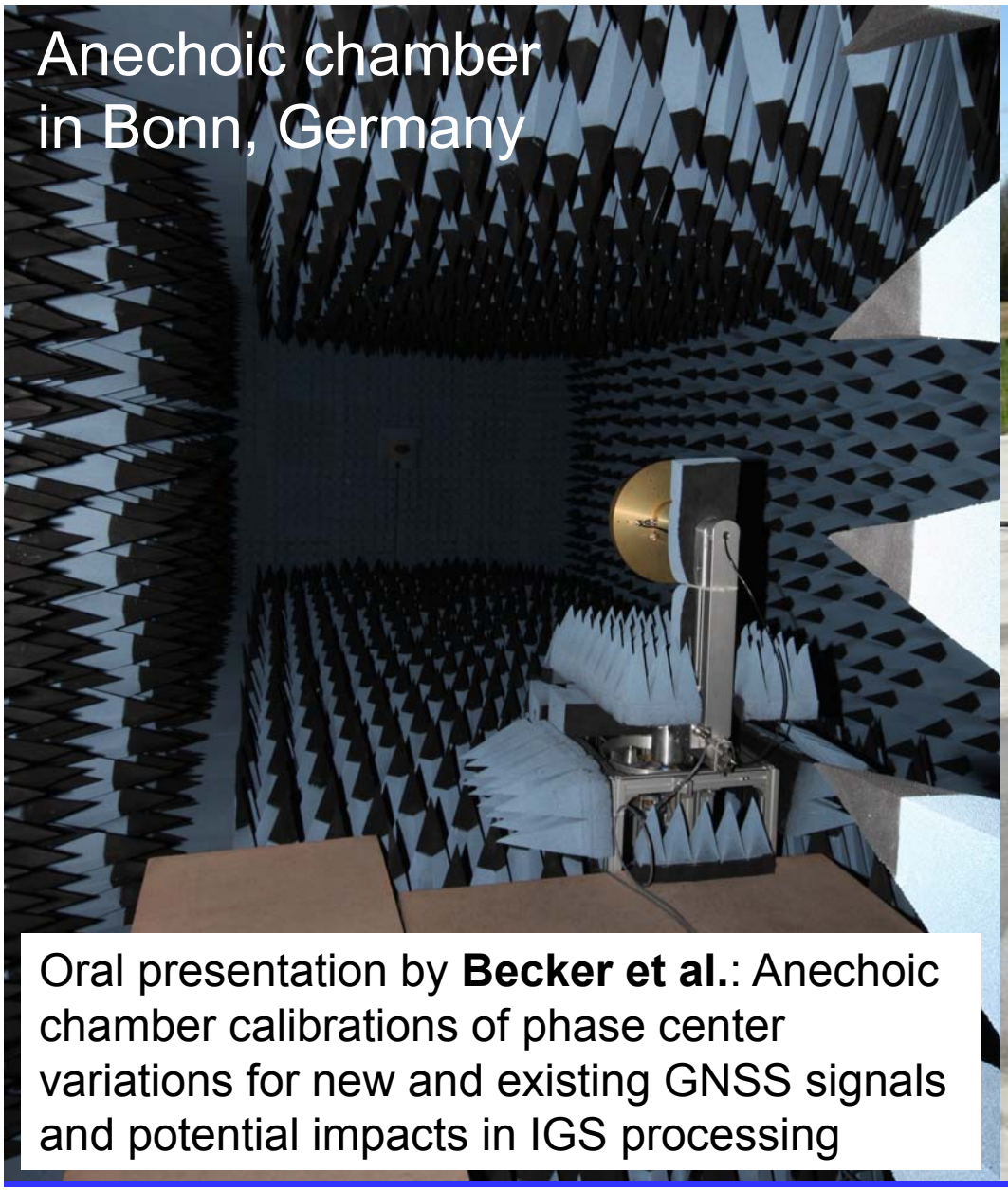
Model	**absolute** calibration	**converted** field calibration	**uncalibrated** antenna/ radome combination
igs05.atx	62%	18%	20%
igs08.atx	**69%**	**11%**	**20%**

GLONASS:

- GLONASS-specific calibrations not considered so far
- available for about **60%** of the GPS/GLONASS stations



New absolute calibration institutions



Oral presentation by **Becker et al.**: Anechoic chamber calibrations of phase center variations for new and existing GNSS signals and potential impacts in IGS processing

Poster presentation by **Bilich et al.**: GNSS absolute antenna calibrations at the National Geodetic Survey

Antenna format updates

ANTEX:

- Allow for **frequency-specific GLONASS** calibrations?
- How to store receiver-dependent **carrier-to-noise patterns** CN0?
- Necessary to store **near-** and/or **far-field effects**?
- Header of a single antenna type does not allow for calibrations from different institutions/antenna samples/etc.

SINEX:

- Add GLONASS-specific receiver antenna corrections (additional **`SITE/GLO_PHASE_CENTER`** block)
- Allow for **satellite antenna phase center variations**?

antenna.gra:

- Define **antenna northing**

Conclusions

- **Consistency between ITRF2008/IGS08 and igs08.atx** will be far better than between IGS05 and igs05.atx
- Remaining GPS satellite antenna ***z*-offset trends** are within the uncertainty of the ITRF2008 scale rate; GPS closer to SLR
- ***z*-offset bias w.r.t. igs05.atx** can mainly be explained by scale change of about 1.1 ppb
- ***z*-offset biases between ACs** are small and probably caused by single fixed offset values in certain AC solutions
- Highly improved **GLONASS satellite antenna corrections** (more satellites/tracking stations/analysis centers)
- **Uncalibrated equipment** is still a big problem
- Reference Frame Working Group has to check the impact of **updated receiver antenna calibrations** on IGS08


Thanks for
your attention!
Leica
MUEJ, Munich