

# SLR Calibration Issues – *Example: Graz*

Georg Kirchner, F. Koidl

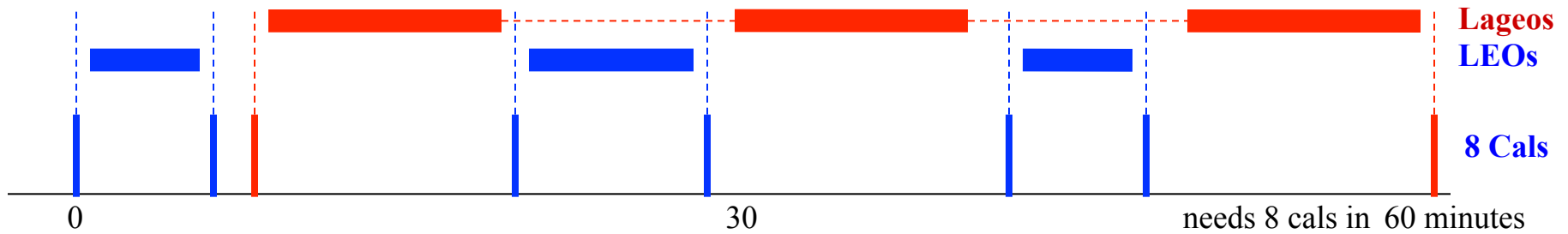
- Why talking about calibrations again?
- How we do calibrations in Graz SLR
- Some data, some results
- Some recommendations

Toshi checked CAL data of ILRS stations, and found some issues:

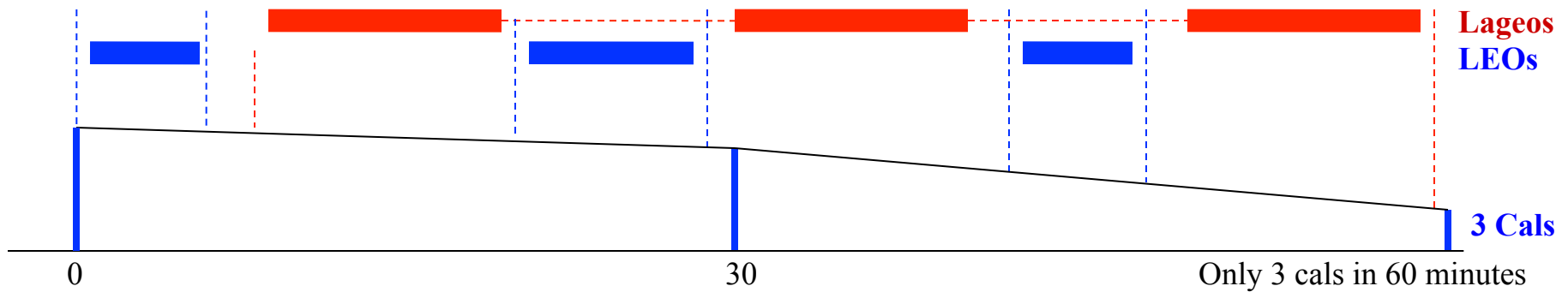
- A number of stations do not seem to provide the full info on their calibration
- A few stations do not calibrate often enough ...
- Epoch of calibration too close to first NP (15 secs); seems unlikely ...
- Large majority of stations has only pre-cal. True?
- Etc....

Improper calibration procedures will most likely introduce biases into the SLR data ☹

**Standard** Calibration Scheme: Pre- & Post Cal for *each* pass ...



**Graz / kHz**: 1 Cal each 30 – 60 minutes; interpolated for pre-/post pass calibrations



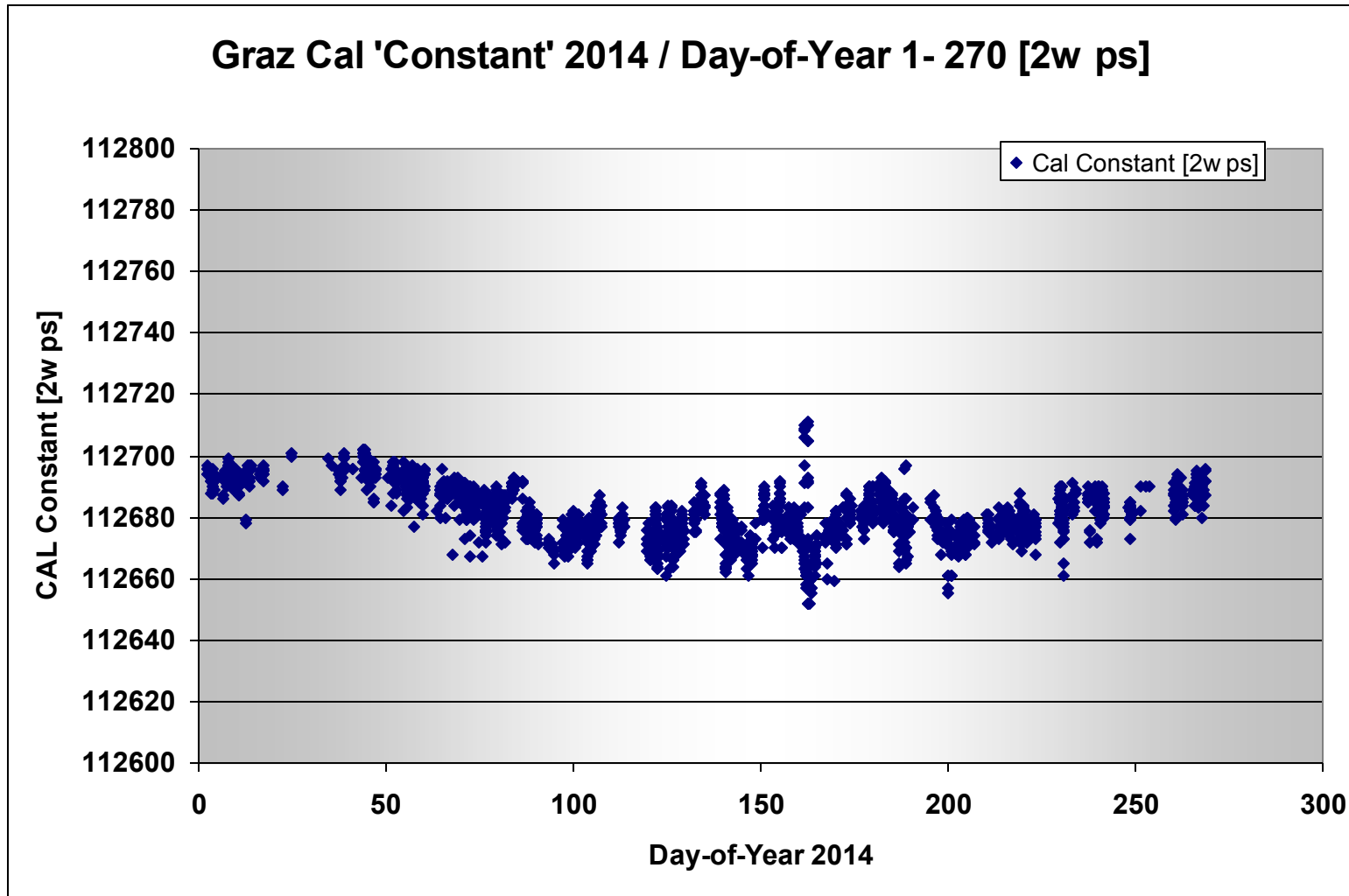
Graz / kHz: 10.000 returns from near target (within dome); return quote: 10% -20%; < 1 minute  
 Each cal: 1 line appended to main CAL file: CAL values / Epoch time / statistics / Met vals etc.  
 Linear interpolation between CALs; max drift between CALs: Few ps only...

Time of CAL	Start	TARGETID	Distanc	Rets	Rets	Sig	RQot	Raw Cal	Cal0	RMS	Skew	Kurto	P-M	Press	T ext	Tint	HUMI	HUMI	Las	
YYYY DDD HH mm ss			lway mm	meas	rem.	ma	%	2way ps	2w ps	ps			ps	hPa	°C	°C	ext%	int%	µJ	
.....	.....	.....																		
.....	.....	.....																		
2014 272 05 16 28	TARGET	03	1742	10000	7877	2.2	11.0	124315	112689	13	0.022	2.339	-1	969.1	10.2	24.4	91.0	16.8	251	
2014 272 06 49 48	TARGET	03	1742	10000	8586	2.2	37.9	124315	112689	17	-0.048	2.310	1	969.7	10.4	24.4	92.5	16.3	320	
2014 272 08 07 32	TARGET	03	1742	10000	8408	2.2	33.6	124317	112691	16	-0.023	2.314	1	970.0	12.0	24.4	93.7	16.4	321	
2014 272 09 06 41	TARGET	03	1742	10000	7896	2.2	19.3	124319	112693	13	-0.020	2.351	0	970.1	13.3	24.4	93.3	16.7	321	
2014 272 10 11 49	TARGET	03	1742	10000	7996	2.2	19.5	124317	112691	14	0.019	2.339	0	969.8	15.5	24.5	89.8	18.2	321	
2014 272 11 05 10	TARGET	03	1742	10000	7995	2.2	22.5	124314	112688	14	-0.036	2.341	0	969.5	17.1	24.5	88.1	18.6	320	
2014 272 12 12 19	TARGET	03	1742	10000	7855	2.2	15.3	124317	112691	13	-0.025	2.359	0	969.1	18.3	24.6	80.3	17.0	321	
2014 272 13 24 20	TARGET	03	1742	10000	7948	2.2	17.4	124316	112690	14	0.003	2.335	0	968.6	19.0	24.7	74.8	16.8	317	
2014 272 14 23 54	TARGET	03	1742	10000	7846	2.2	16.7	124314	112689	14	0.014	2.319	0	968.3	19.3	24.7	71.6	16.6	316	
2014 272 14 42 00	TARGET	03	1742	10000	7884	2.2	16.3	124315	112690	14	-0.015	2.331	0	968.3	19.3	24.7	71.1	16.5	317	
2014 272 15 46 00	TARGET	03	1742	10000	7883	2.2	16.6	124313	112687	13	-0.009	2.345	0	968.3	18.6	24.7	70.3	17.6	318	
2014 272 16 39 01	TARGET	03	1742	10000	7918	2.2	18.3	124314	112688	14	0.022	2.335	0	968.4	17.6	24.6	73.1	17.2	318	
2014 272 17 12 51	TARGET	03	1742	10000	8063	2.2	24.1	124311	112685	14	-0.051	2.349	2	968.4	16.6	24.7	77.4	16.7	319	
2014 272 17 50 04	TARGET	03	1742	10000	8878	2.2	46.9	124299	112674	18	0.020	2.220	-1	968.3	15.7	24.7	81.6	16.8	318	
2014 272 18 43 17	TARGET	03	1742	10000	8572	2.2	44.8	124308	112682	16	-0.035	2.278	3	968.4	15.6	24.6	83.8	16.7	315	
2014 272 19 44 31	TARGET	03	1742	10000	9082	2.2	52.1	124301	112675	18	0.048	2.278	-3	968.2	15.3	24.7	82.9	18.3	318	
2014 272 20 44 57	TARGET	03	1742	10000	8443	2.2	42.8	124309	112683	16	-0.014	2.292	1	968.0	14.8	24.7	83.9	16.8	318	
2014 272 21 47 28	TARGET	03	1742	10000	8219	2.2	29.3	124313	112687	15	-0.047	2.332	0	967.6	14.2	24.7	84.6	18.6	318	
2014 272 22 33 31	TARGET	03	1742	10000	8802	2.2	45.6	124306	112680	17	-0.018	2.253	2	967.3	14.0	24.7	86.3	18.6	317	
2014 272 23 37 23	TARGET	03	1742	10000	8388	2.2	38.0	124312	112686	16	-0.045	2.306	1	967.0	13.5	24.7	88.3	18.0	315	
.....	.....	.....																		

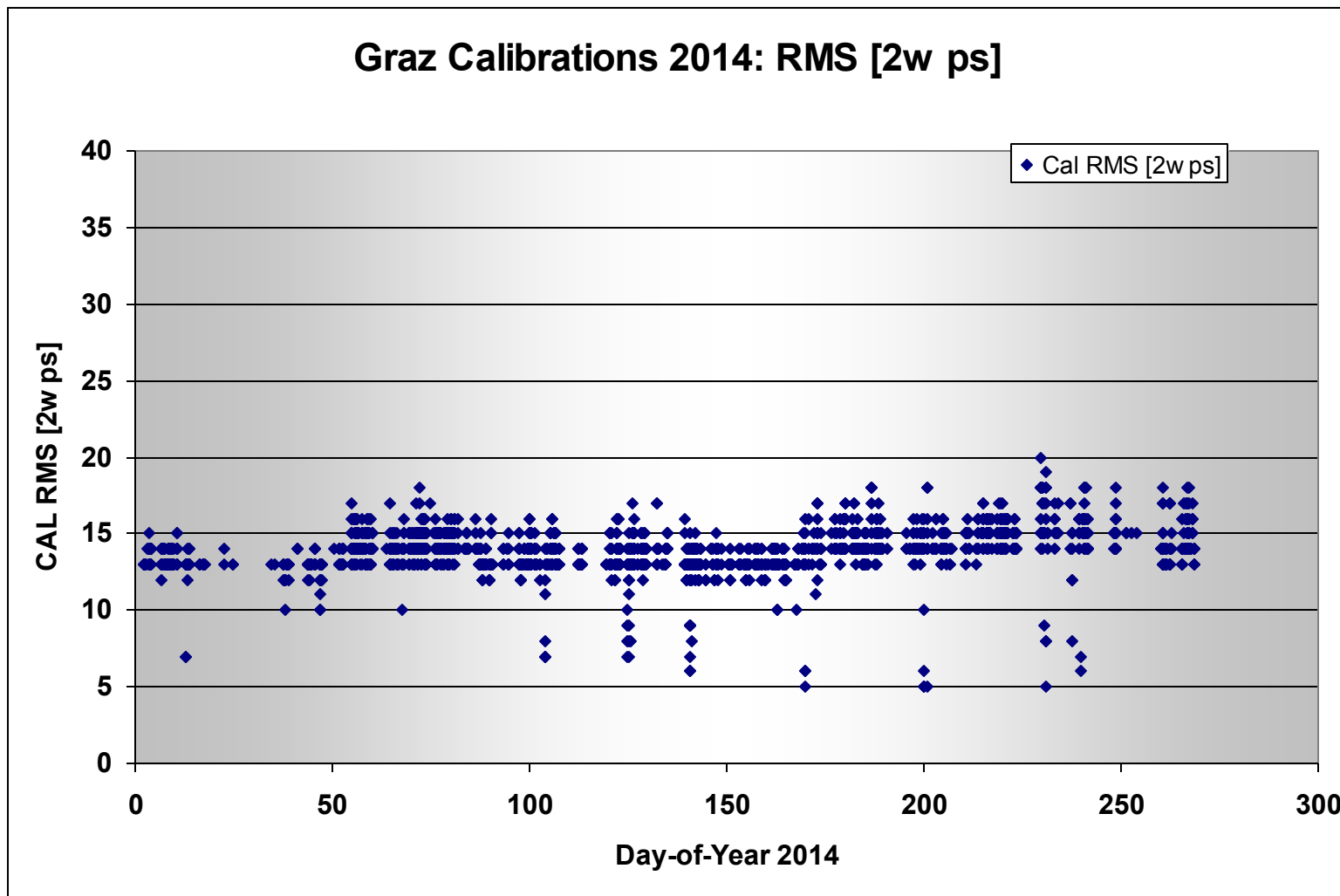
The Graz main CAL file: Simple ASCII records; 20 cal in 18 hours

ONE line per Calibration: Date, CAL values, statistics, met values etc.

ONE calibration per hour

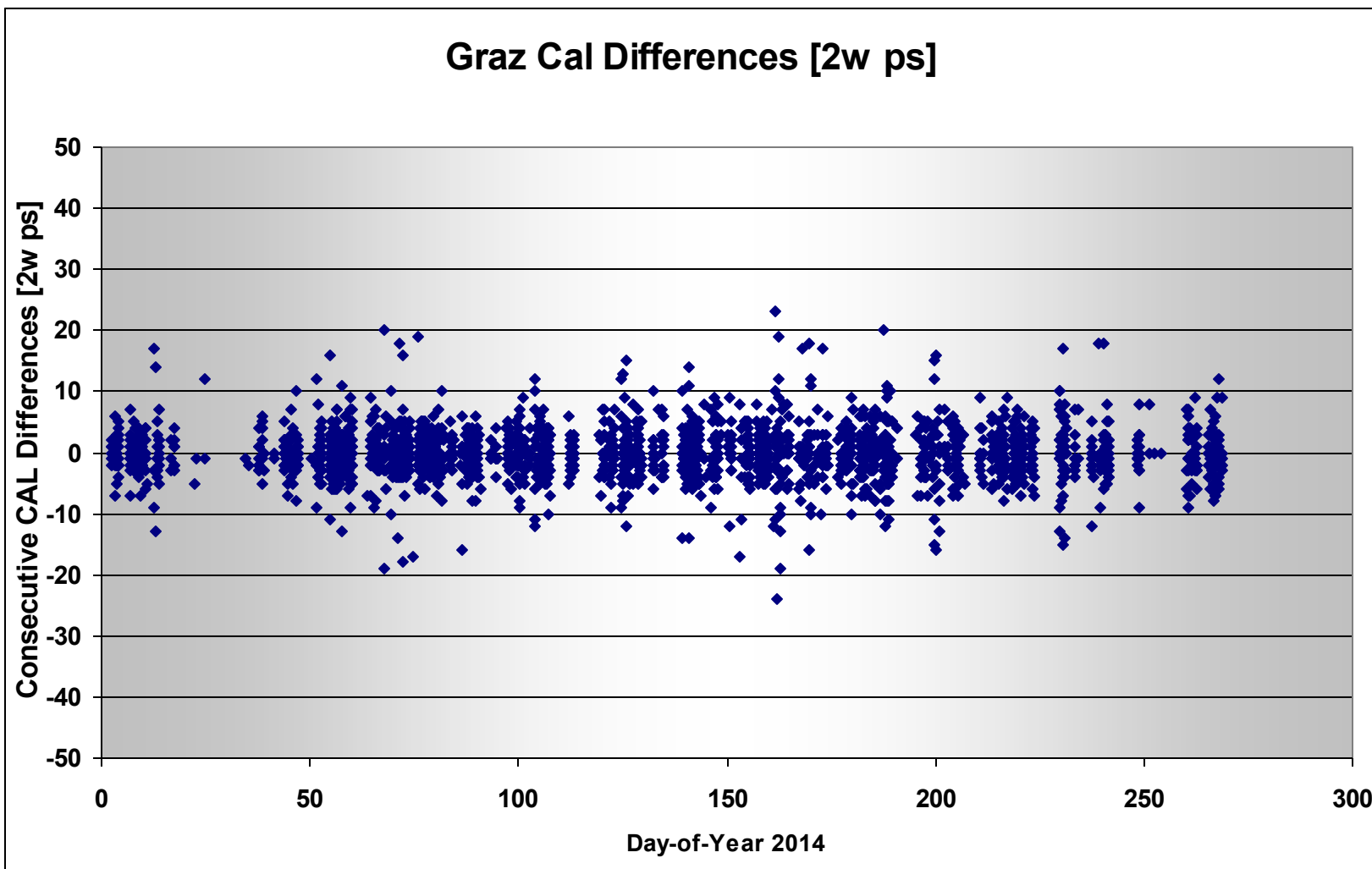


- ⇒ Graz CAL ,Constant ' : Usually remaining within a  $\pm 10$  ps band for some period
- ⇒ Slowly changing with seasonal outside air temperature (cable temperature drift)



=> RMS usually around 15 ps (2-way); that is  $\approx 2.5$  mm (1-way);

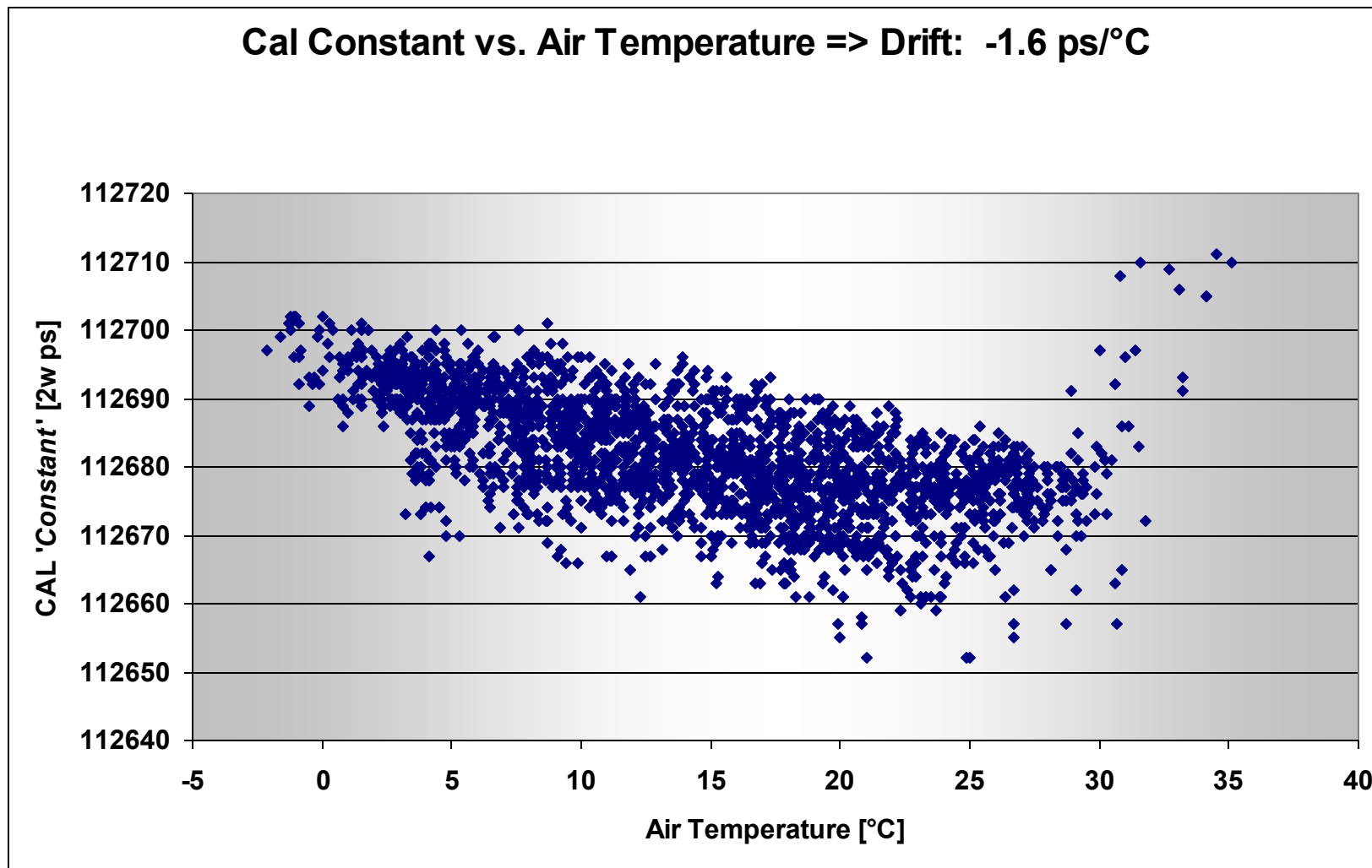
=> Outliers below about 10 ps are due to too strong return signal (tests, observer sleeping ☺)



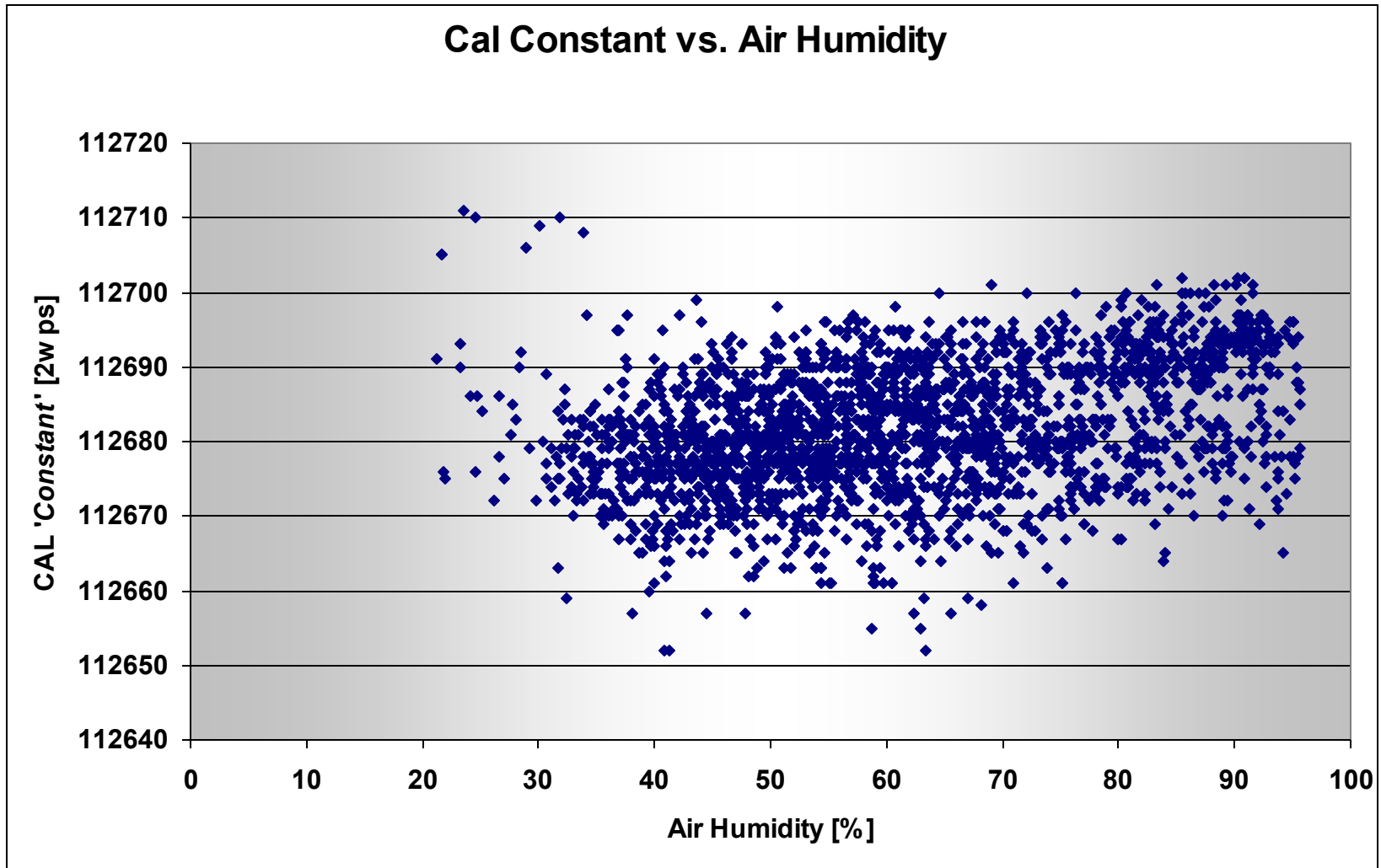
⇒ Usually  $< 6$  ps (1 mm) between 2 calibrations;

⇒ Outliers: Mainly due to drifts in cables (opening of dome etc.)





Drift:  $-1.6 \text{ ps} / ^\circ\text{C}$ ; above  $30^\circ$ : Detector package heat problem (no cooling...)  
Drift caused by outside cables; drift completely compensated by ,pre-/post cal '



Slight dependence: Mainly due to air temperature / humidity correlation ...

- Make it simple to do a CAL (Graz: Press ,c ‘ on keyboard, no other action)
  - If more action needed, observers try to avoid / minimize the work load 😊
- Switch from Pre-/Post-Cal schemes to interval scheme (e.g. at least once/hour)
  - Issue clear signals / warnings to operators if CAL interval is getting too long
- Automatically check actual CAL values against cal history;
  - Inform / warn operators clearly if deviations / offset etc. occur
- Automatically check all CAL data (statistics, cal values, met etc.)
  - Inform / warn operators if one parameter is outside some limits
- Use of Graz short cal target (in front of telescope, within dome - see Shanghai proceedings 1996) has contributed a lot to Graz data stability:
  - No atmosphere problems anymore (too short, no fog, no cloud, no rain)
  - Extremely stable => inside dome, protected from animals, people, nature ...
  - Easy to (re-) measure with sub-mm accuracy

Thank you !

