The Centre of Mass Correction of LARES for Single Photon Detection

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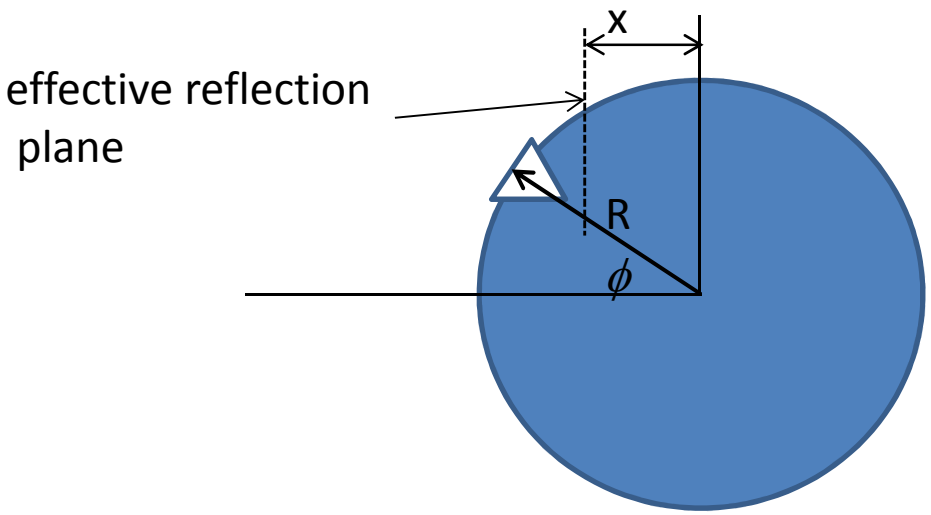
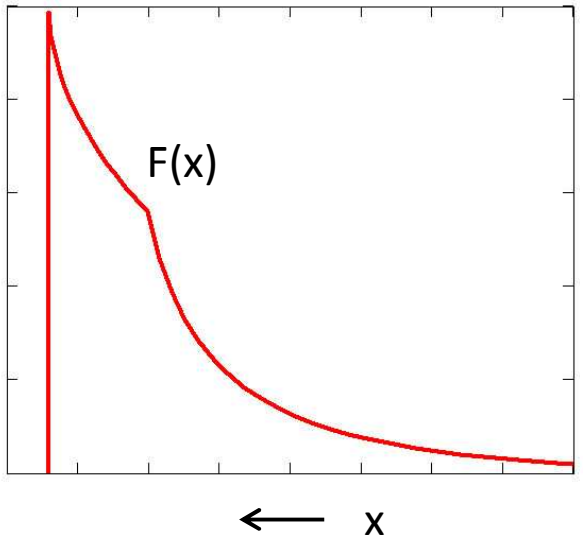
Method: Fitting a signature model to the observed residual distribution
using data from station Potsdam

- The LARES range correction was not measured prior to launch
- Ranging data to the satellite in orbit image all the disturbing effects
  (temperature gradients)
- kHz stations are well suited for this study (data from a single pass sufficient)
- The range correction is significantly depending on the system response and
  the preprocessing (data filtering) procedure (poor standardization)

Estimating the Centre of Mass Correction (CoM)





$$X(\phi) = R \cdot \cos(\phi) - L \cdot \sqrt{{n_g}^2 - sin^2(\phi)}$$

$$Int = Area^{\boldsymbol{p}} \cdot Reflectivity$$

$\boldsymbol{p}$: ***free parameter*** **(Otsubo 2003)**

Satellite Response Function:

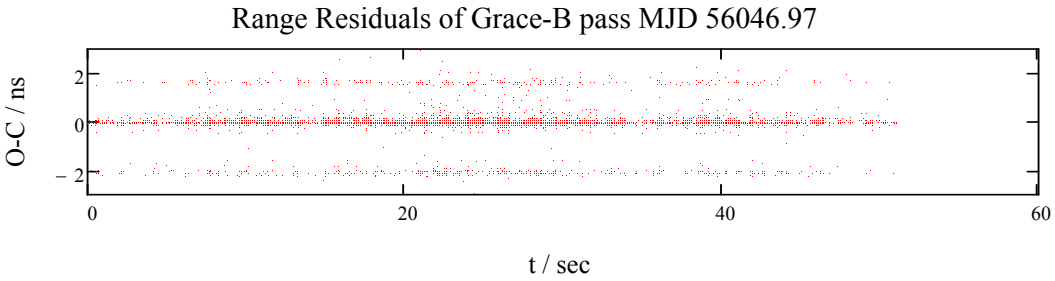
$$F(x) \qquad \int F(x)dx = 1$$

Centre of Mass Correction:

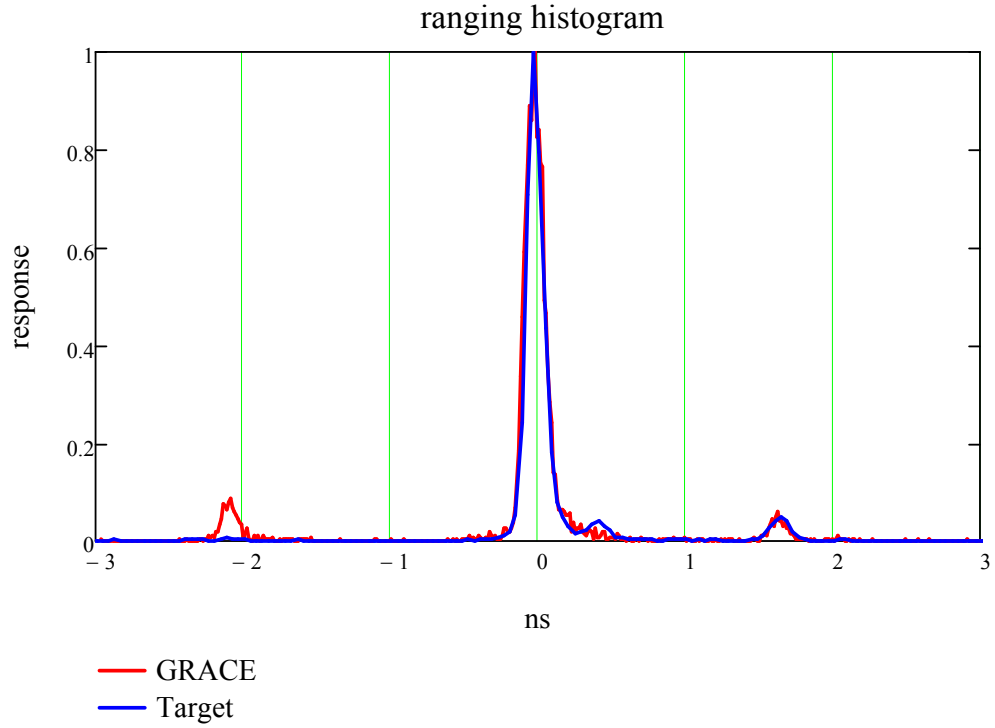
$$\text{CoM} = \int x \cdot F(x)dx$$

Matera 2000 http://cddis.gsfc.nasa.gov/lw12/docs/neubert_COM.pdf

How to determine the system response?



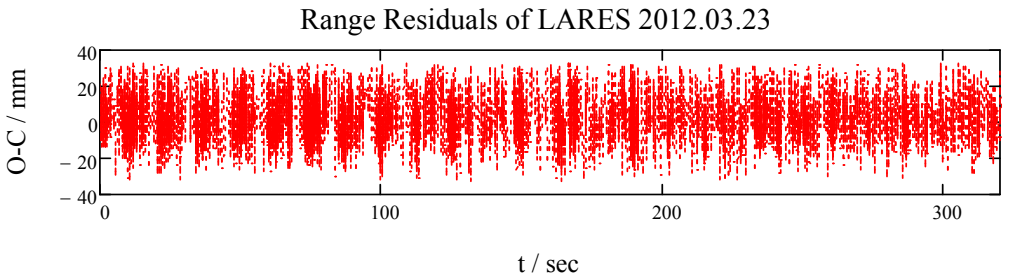
Range residuals of a GRACE pass



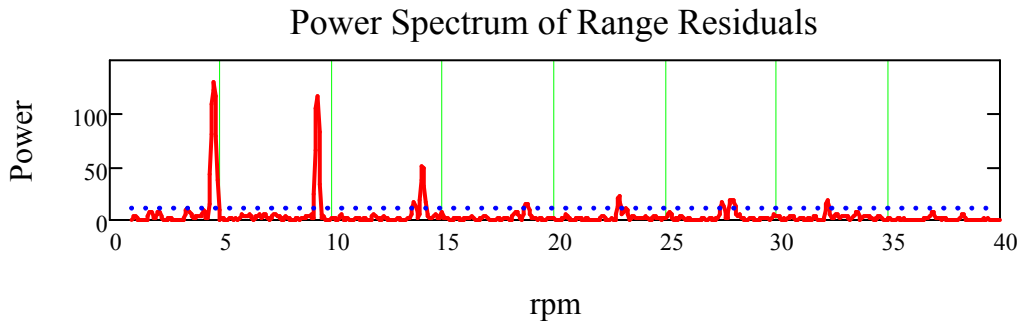
Comparison of the distribution of GRACE residuals with the calibration target

GRACE is almost free of signature (only one prism contributing)

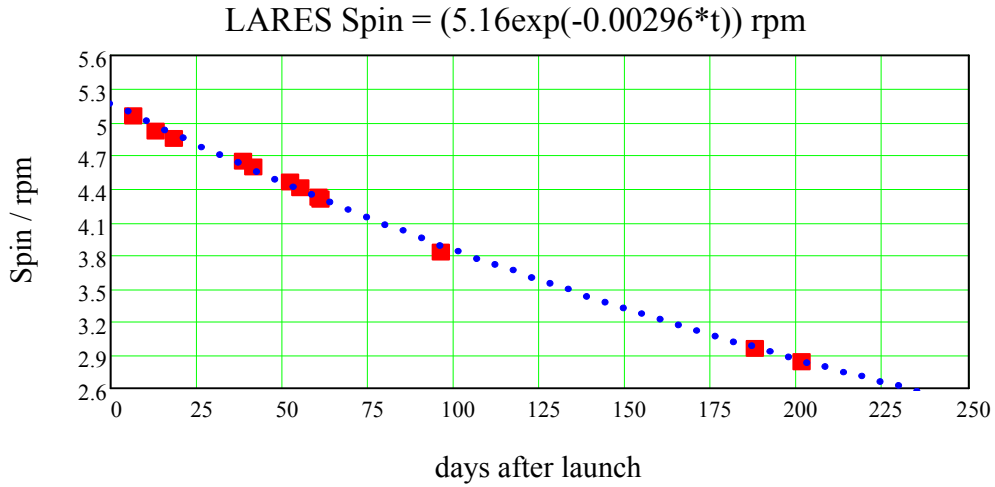
LARES Spin by Spectral Analysis of the Range Residuals



Range residuals of a LARES pass 40 days after launch
The return rate is modulated with a period of about 12 sec.



Power spectrum of the residuals using the method of Lomb (Numerical Recipes 3rd Ed. 2007, p.685)



Apparent Spin rate of LARES versus time
The blue dots indicate an exponential decay fitted to the data. The spin imediately after launch is estimated to be 5.16 rpm.
(Corrected spin and axis orientation to be published by D.Kucharski)

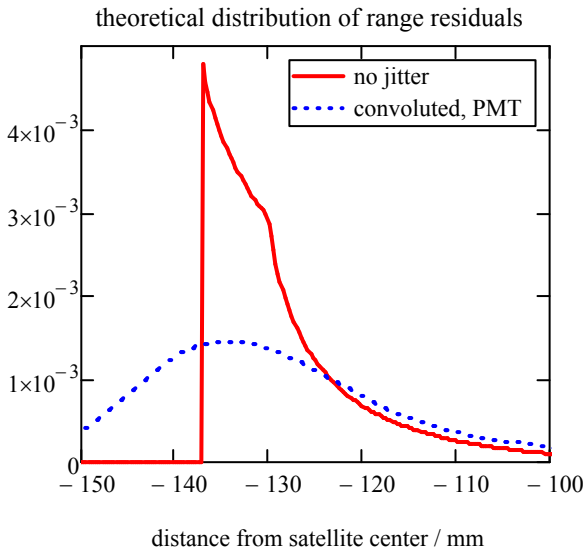
Fitting the Model to the Observed Residual Distribution

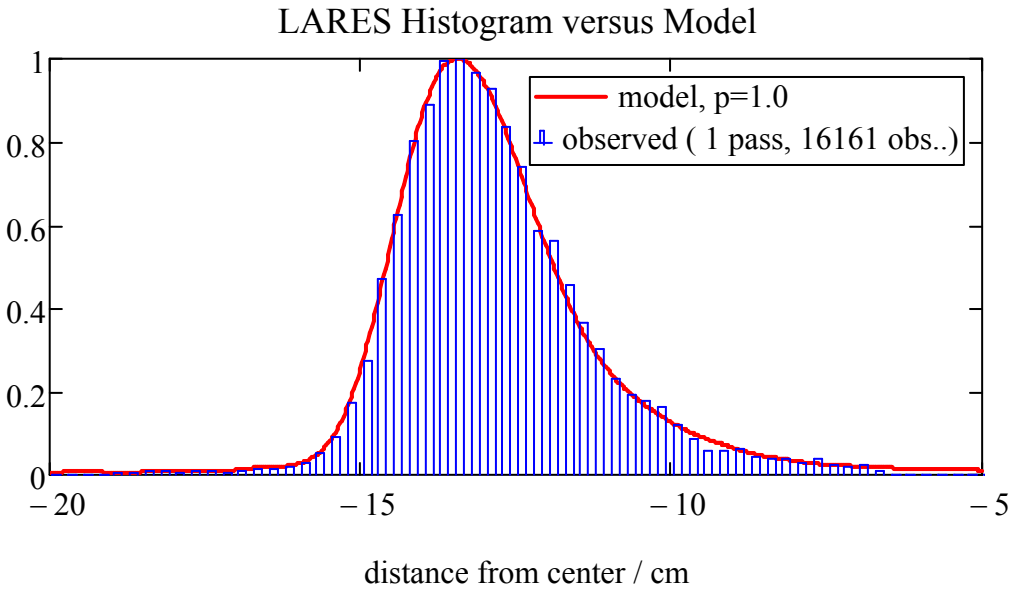
Fixed Parameters:

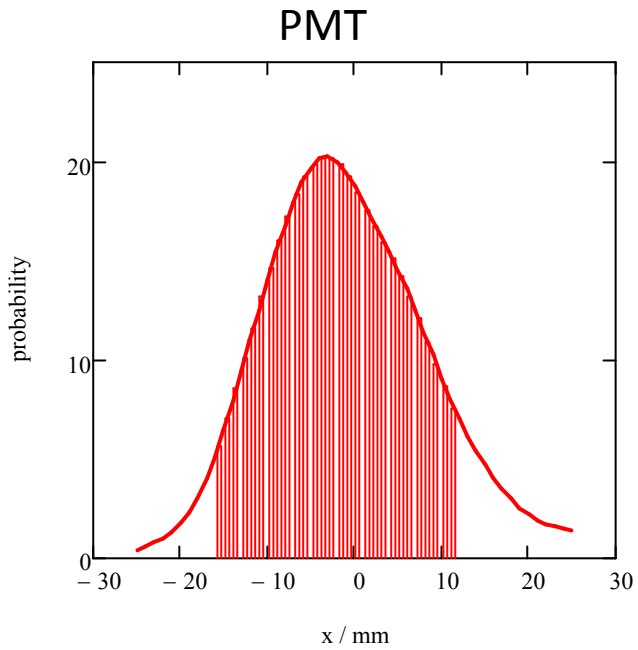
R=178.5 mm	satellite optical radius
L=27.84mm	vertex length
D=38.1 mm	free apertur diam.
d=1 mm	recess of the front face
ng = 1.4853	group refractive index

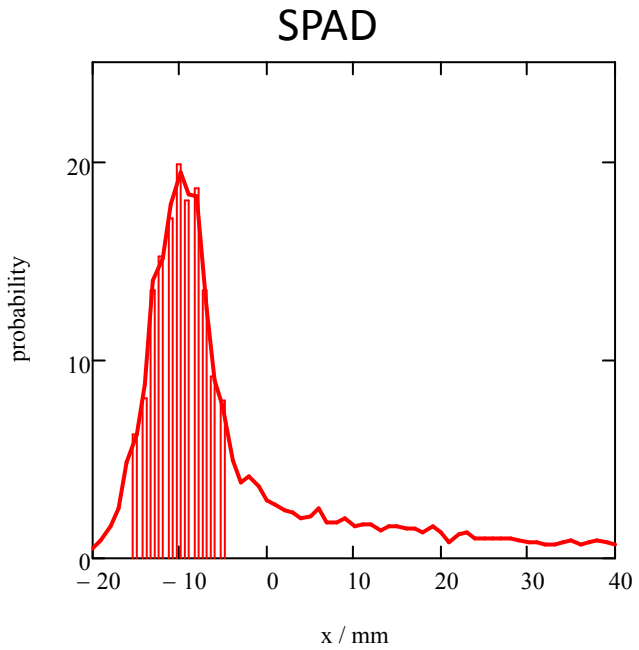
Free Parameter

P=1.0





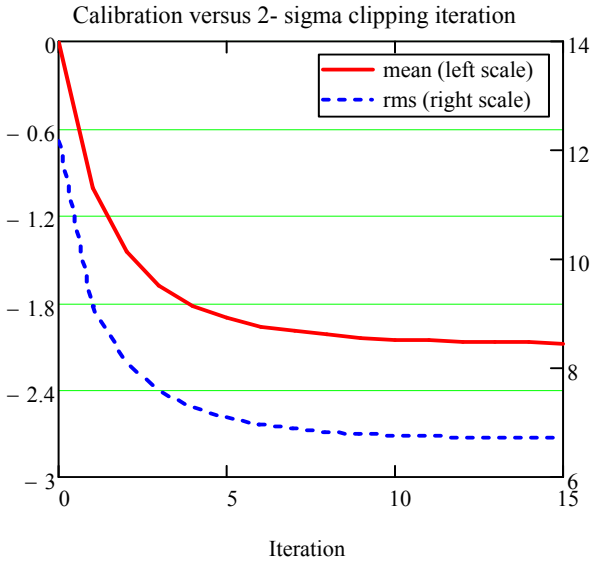


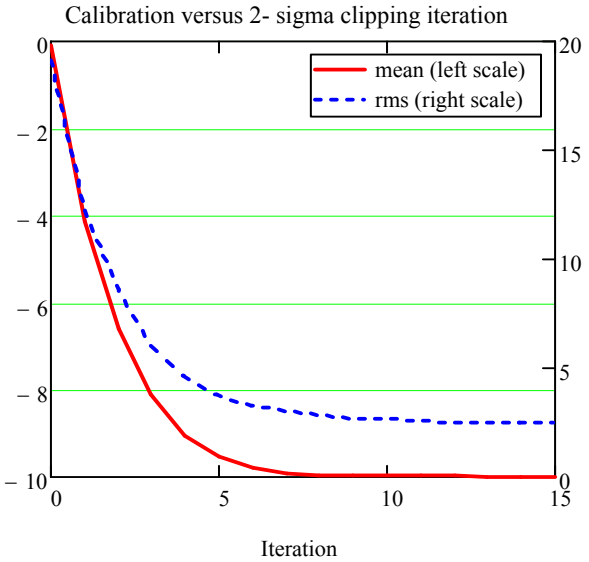


Clipping of Calibration

Zero point of the x-scale corresponds to the mean of the unclipped distribution

Shaded is the part of the distribution which is used after iterative 2-σ– clipping

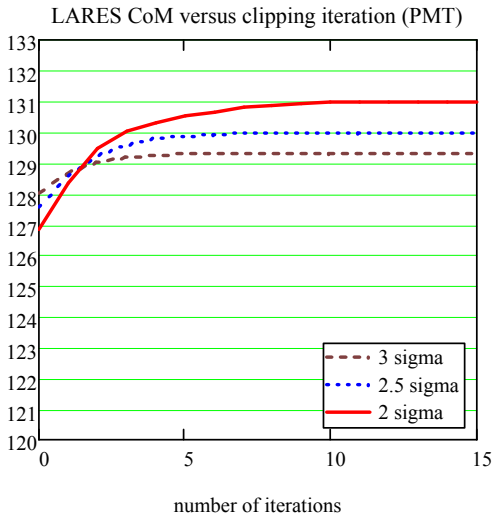




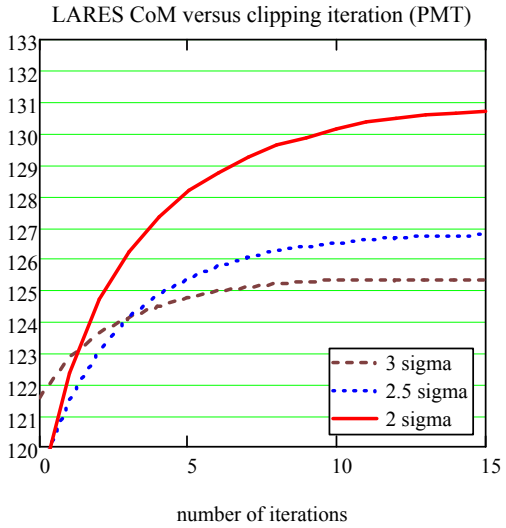
Shift and RMS versus 2-σ-Clipping Iteration

The shift is small for the PMT but 5 times greater for The SPAD detector. It depends On the asymmetry of the distribution

PMT

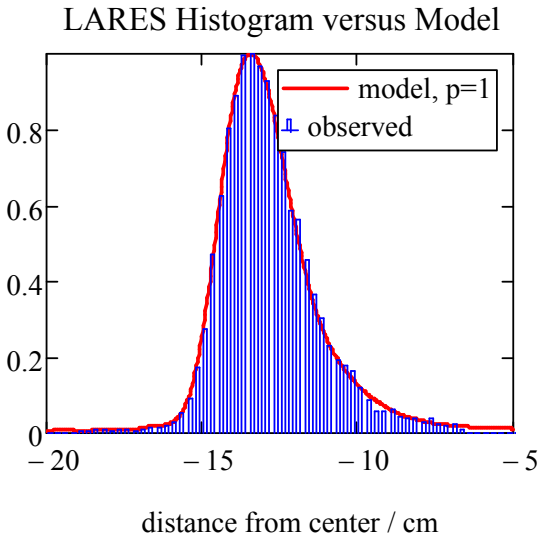


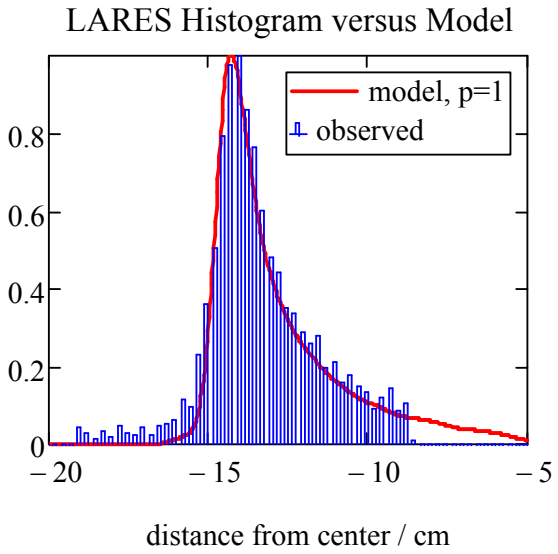
SPAD



LARES CoM versus clipping iteration

The asymptotic value of the calibration is subtracted for each curve.





Comparison of the model with the residual histograms.

Data from a single pass have been used in both cases.

Conclusion

- LARES CoM for Potsdam $(130 \pm 1)\ mm$ (PMT, 2.5-sigma editing)
  $(131 \pm 1)\ mm$ (SPAD, 2-sigma editing)

Future plan:

- Apply the analysis in the frame of the ILRS Signal Processing Working Group to data of other stations starting with all Europaean kHz systems
- Update LAGEOS range corrections to millimeter precision