The Centre of Mass Correction of LARES and LAGEOS for Single Photon Detection

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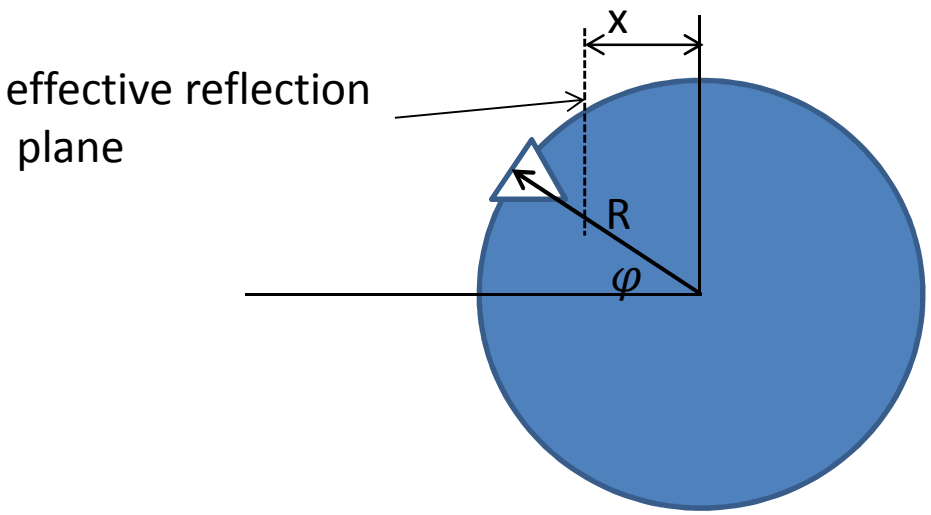
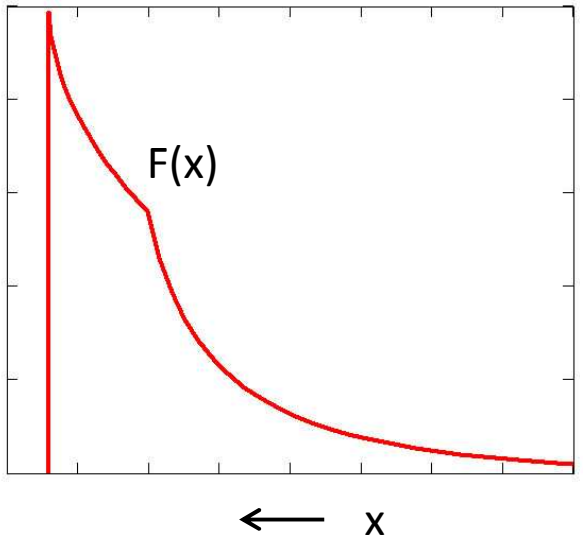
Motivation:
The advent of LARES supplementing the LAGEOS pair for the determination of the Thirring-Lense-precession

Method:
Fitting a signature model to the observed residual distribution
using data from stations Potsdam and Herstmonceux

- 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 pre-processing procedure (data filtering)

Estimating the Centre of Mass Correction (CoM)





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

$$Intens. = area^{p}(\varphi) \cdot Reflect.(\varphi,\alpha)$$

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

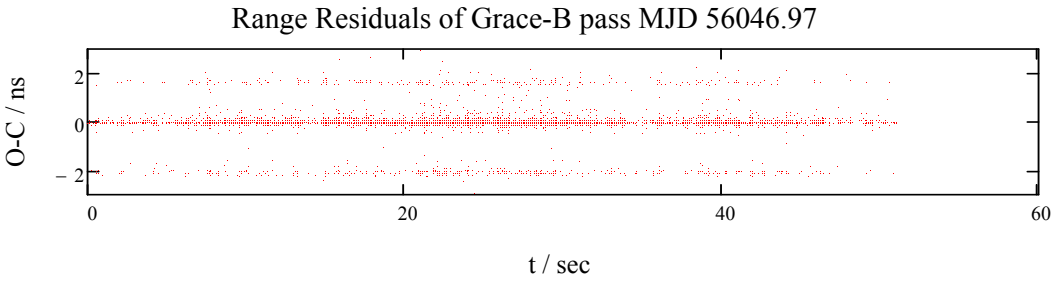
Satellite Response Function:

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

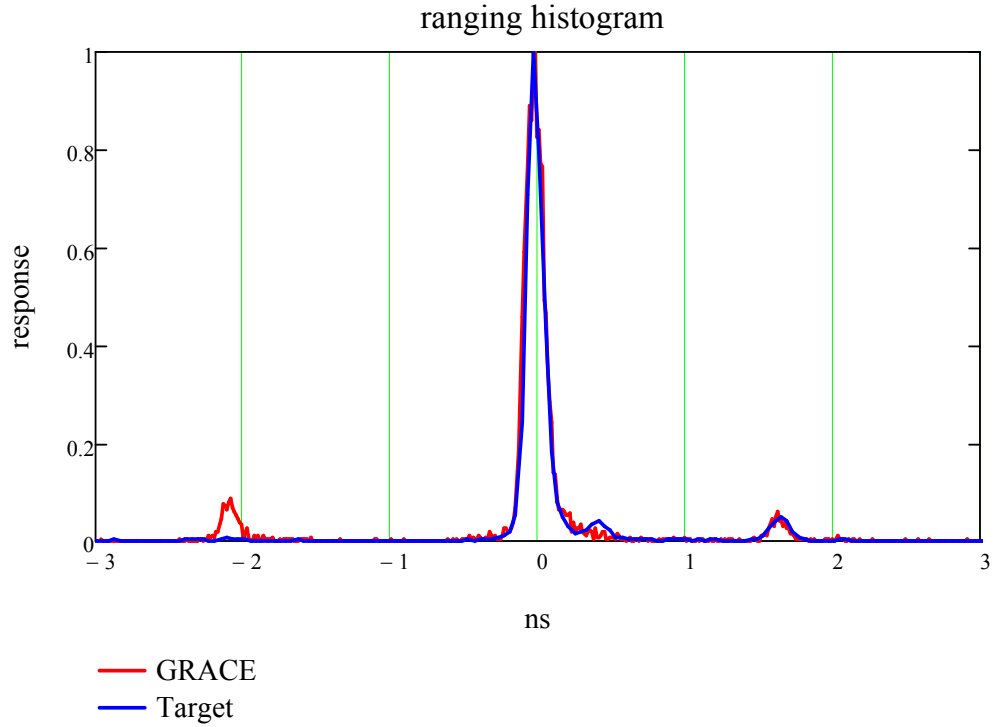
Centre of Mass Correction:

$$CoM = \int x \cdot F(x)dx$$

How to determine the system response?

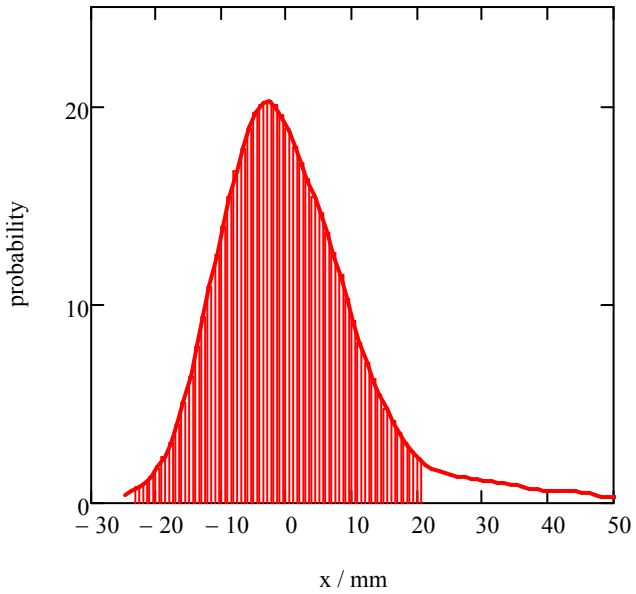


Range residuals of a GRACE pass

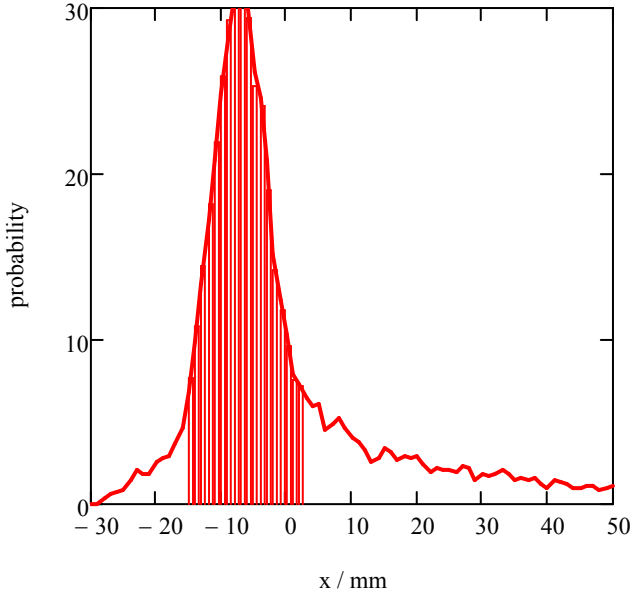


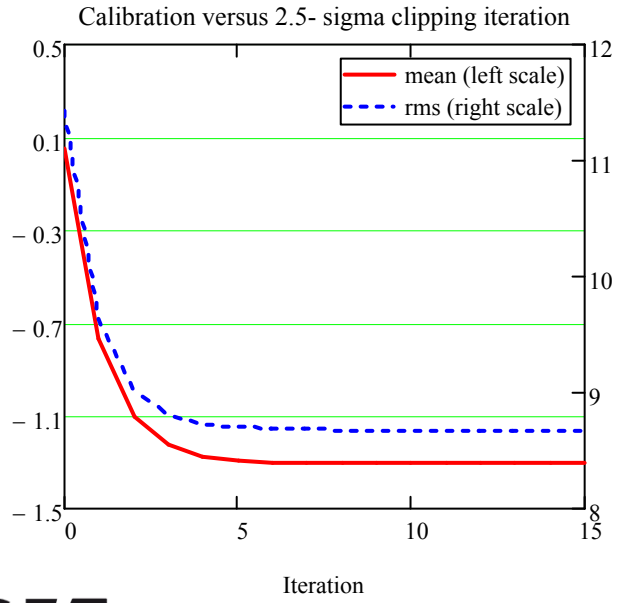
Comparison of the distribution of GRACE residuals with the calibration target
GRACE is almost free of signature (only one prism contributing)

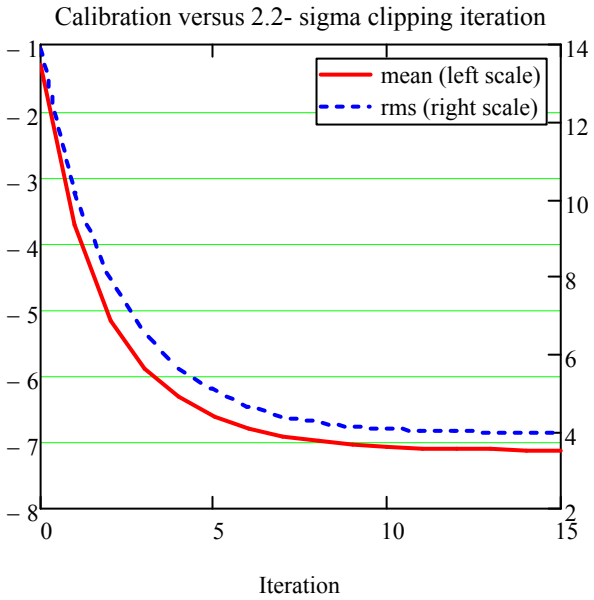
PMT, 2.5σ



SPAD, 2.2σ







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 clipping

Shift and RMS versus 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

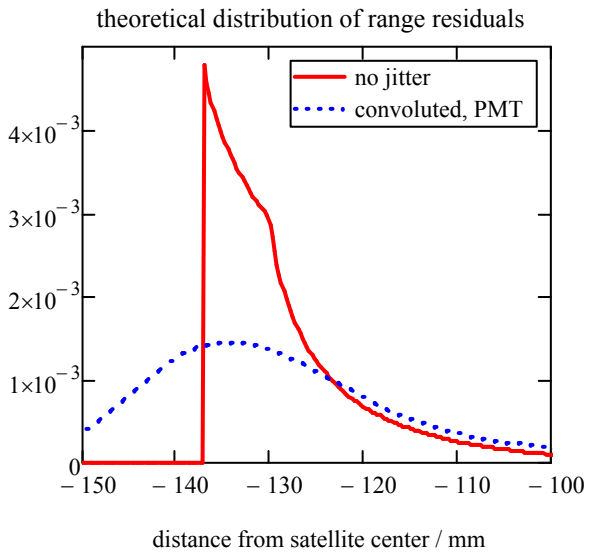
Fitting the Model to Potsdam Residuals: LARES, PMT

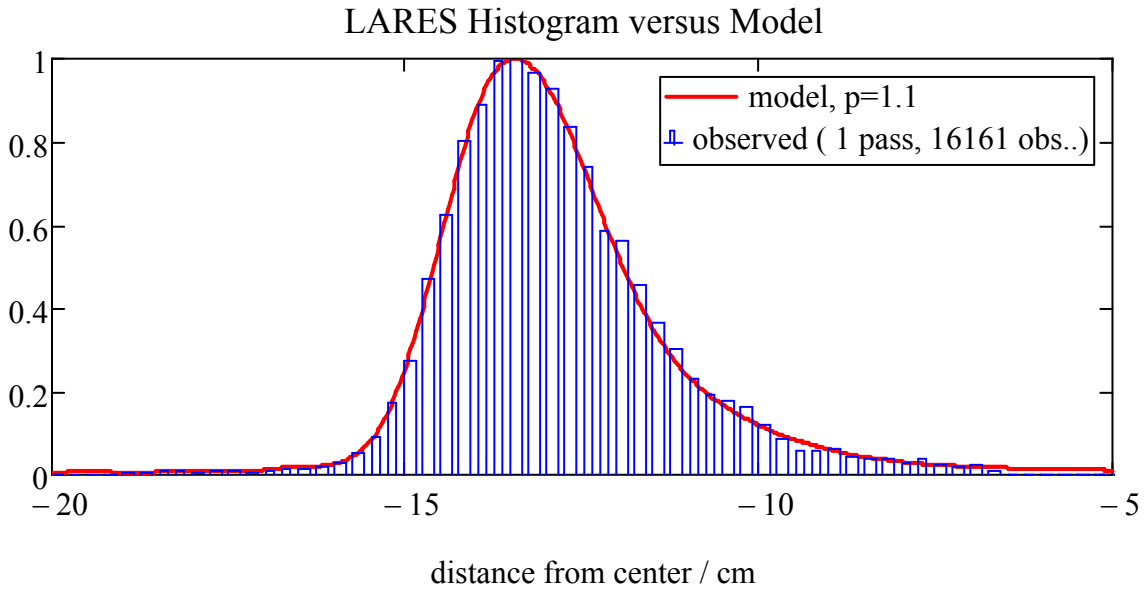
Fixed Parameters:

R=178.5 mm	satellite optical radius
L=27.84mm	vertex length
D=38.5 mm	free aperture diam.
d=1 mm	recess of the front face
ng = 1.4853	group refractive index

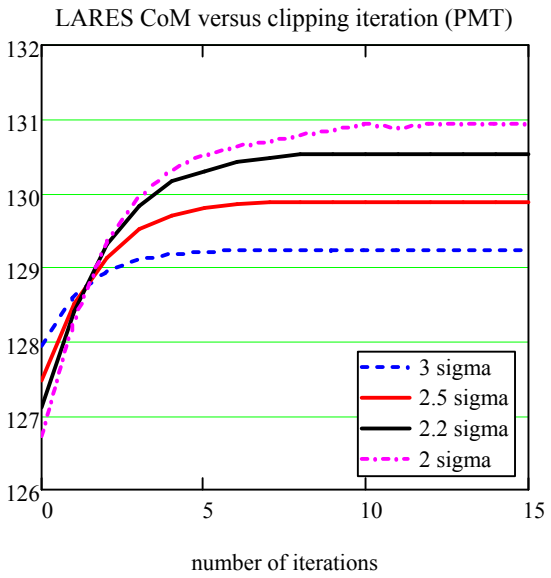
Free Parameter

P=1.1

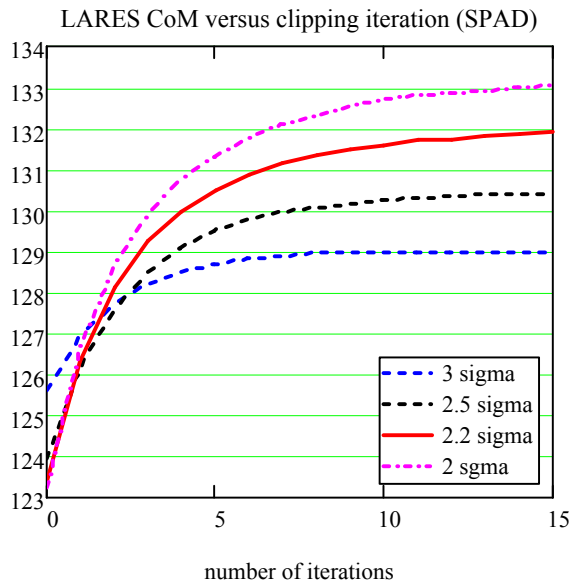


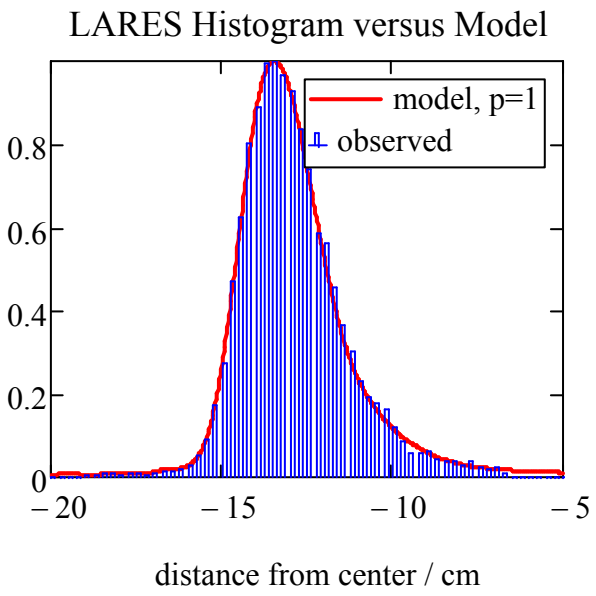


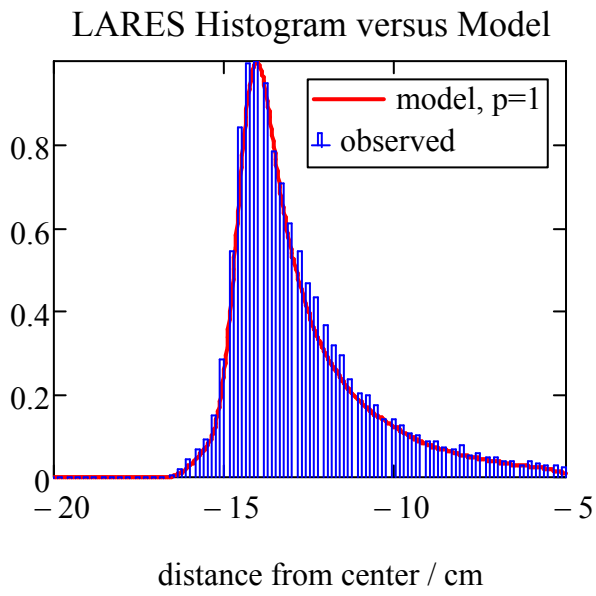
PMT



SPAD







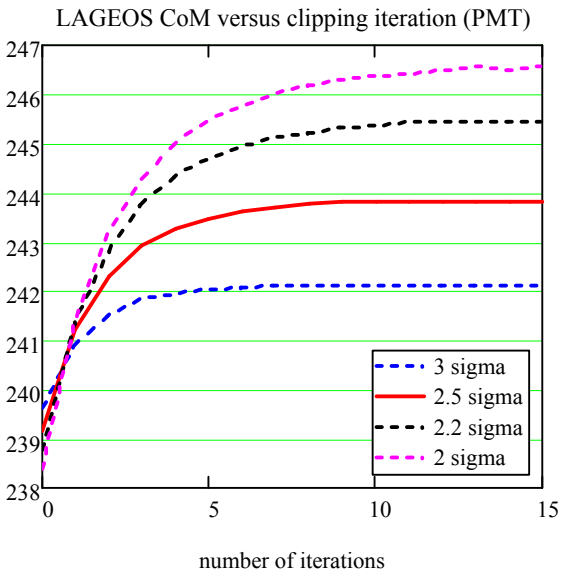
LARES CoM versus clipping iteration

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

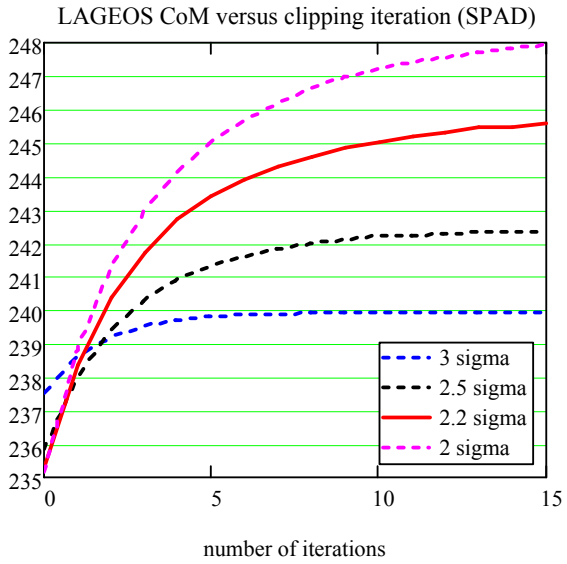
Comparison of the model with the residual histograms.

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

PMT

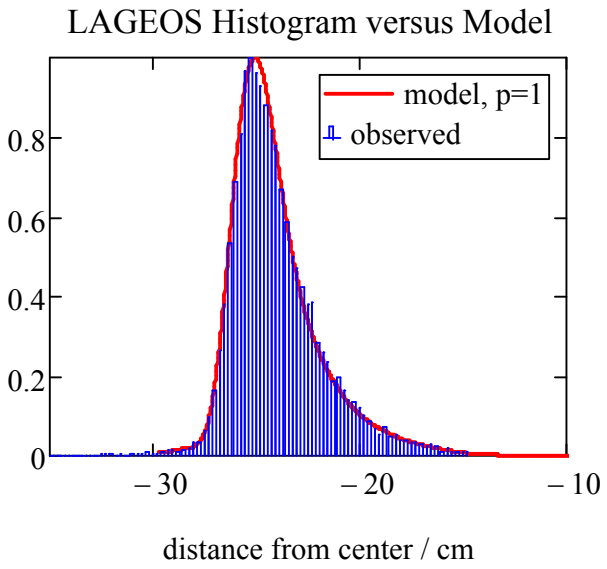


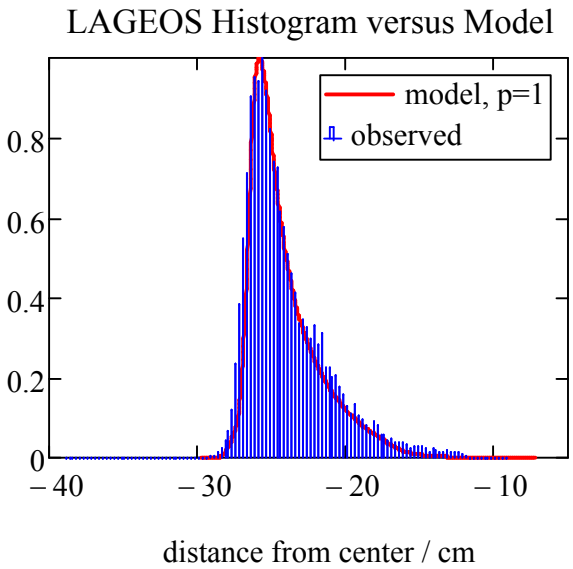
SPAD



LAGEOS 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
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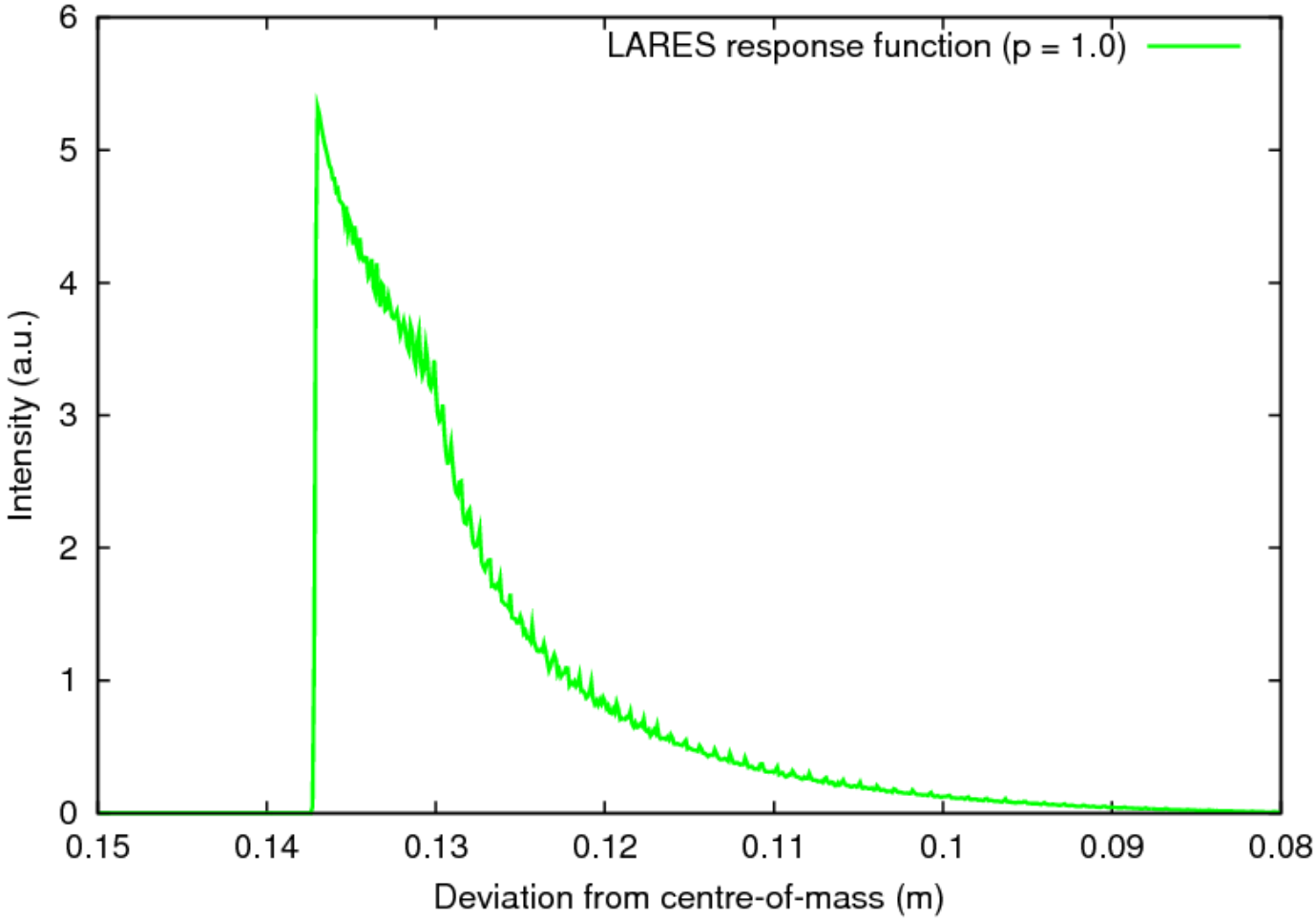
LARES Response Function by Simulation

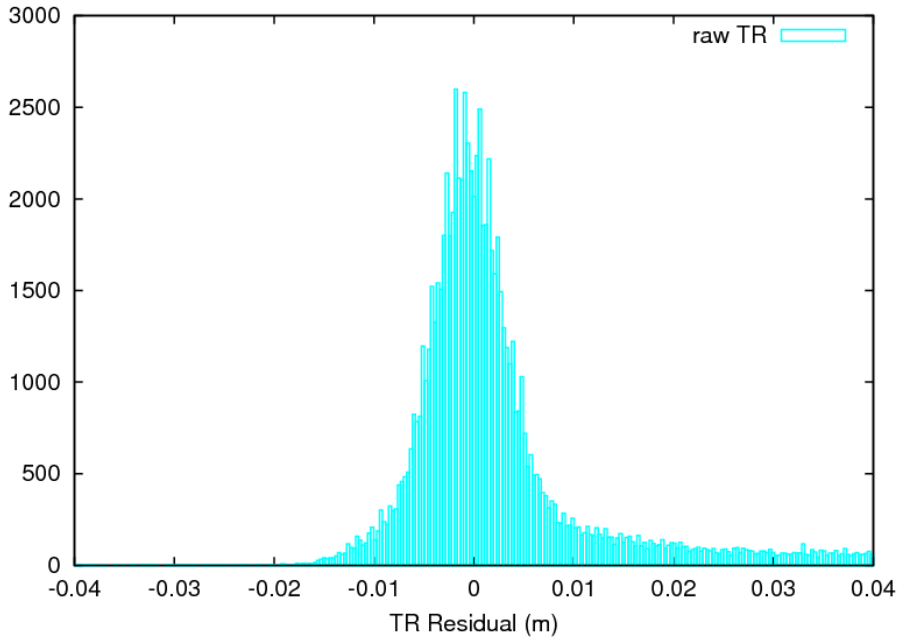
GFZ's and HIT-U's agreed very well



Results from Herstmonceux Data (cSPAD–Detector)

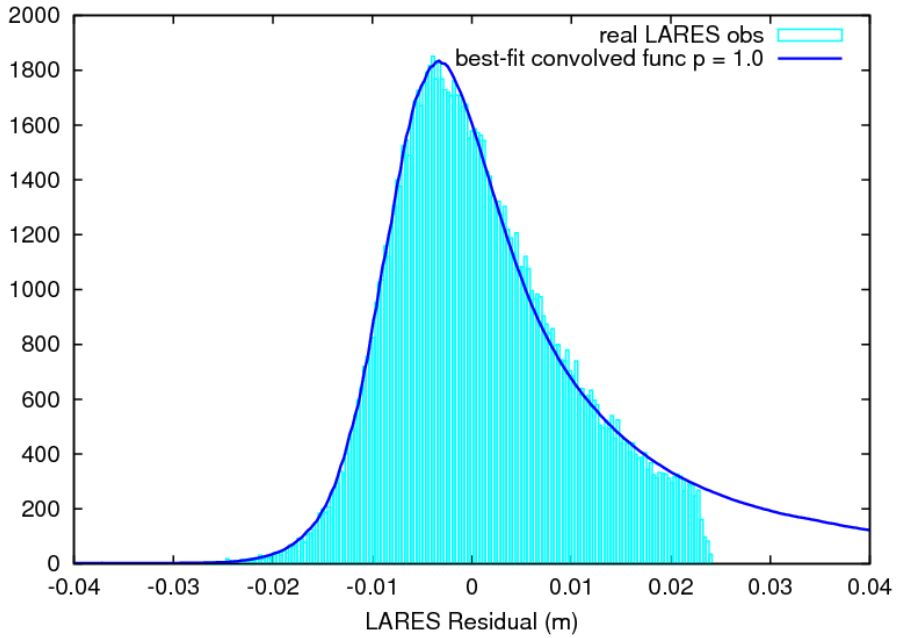
LARES fullrate data (coutesy of R A Sherwood, NERC)
single photon detection (low return rate)
5 passes in May 2012, > 200,000 returns in total

System Response (TR)



Model Fit to LARES Residuals

p = 1.0



Summary of Results

Satellite	Potsdam			Herstmonceux		
	CoM/mm	Detc./edit	ILRS	CoM	Detc./edit	ILRS
LARES	130	PMT/2.5σ	131 *)			
	132	SPAD/2.2σ		130	cSPAD/3σ	131 *
LAGEOS	244	PMT/2.5σ	251 **)			
	246	SPAD/2.2σ		TBD	cSPAD/3σ	245 **)

*) http://geo.science.hit-u.ac.jp/research-en/memo-en/lares-centre-of-mass-correction

**) http://ilrs.gsfc.nasa.gov/network/site_information/nsgf_iCoM_LAGEOScorrections.html