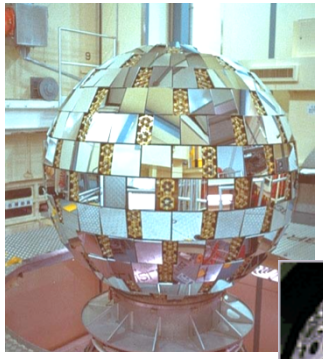
kHz Single Photon Ranging: A Precise Tool to Retrieve Optical Response of Satellites



Toshimichi Otsubo

Hitotsubashi University

Philip Gibbs

Graham M Appleby

NERC Space Geodesy Facility

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16th International Workshop on Laser Ranging, Poznan, 13-17 Oct, 2008.

kHz & Single Photon !

kHz System:

More shots, More returns (up to LAGEOS?)

Sharp pulse width (10 ps at Hx)

Single Photon System:

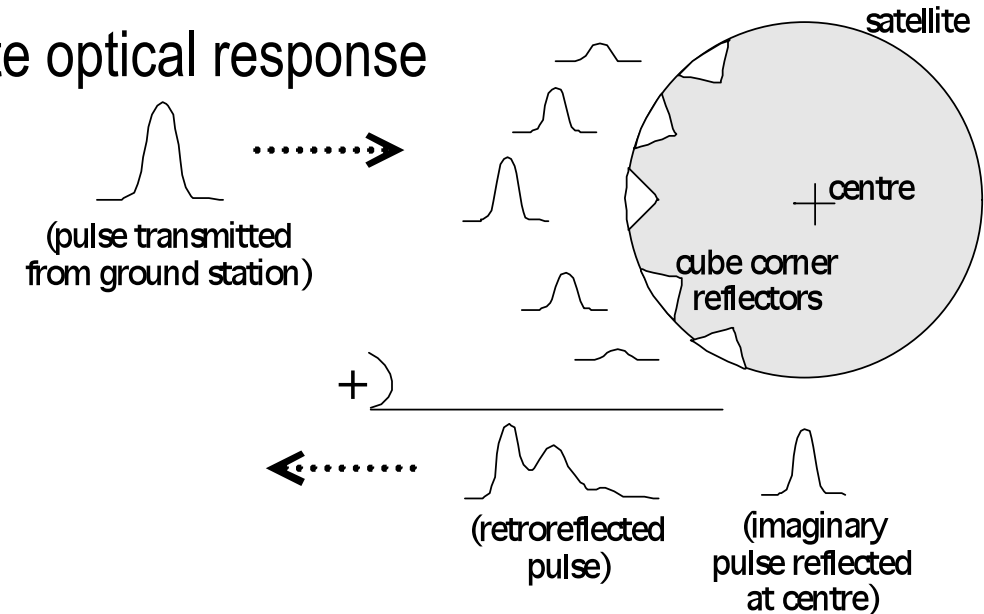
No intensity dependence → Systematic bias minimised

Large scatter, but the average profile of return pulse observable

kHz + Single Photon System:

Ideal tool for retrieving the satellite optical response

Works like a streak-camera



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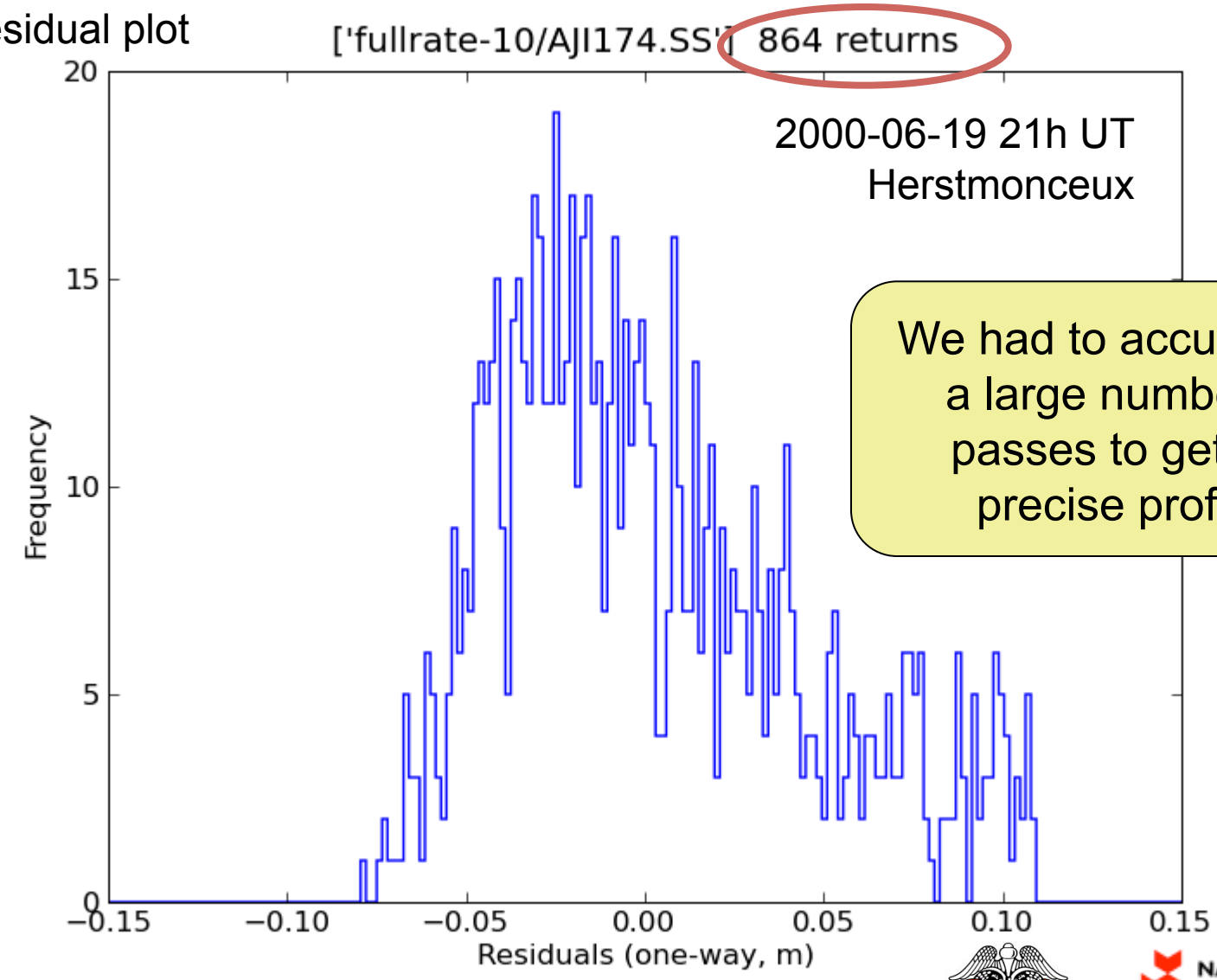
Single Photon + 10 Hz Laser

Full-rate residual plot



We had to accumulate a large number of passes to get the precise profile.

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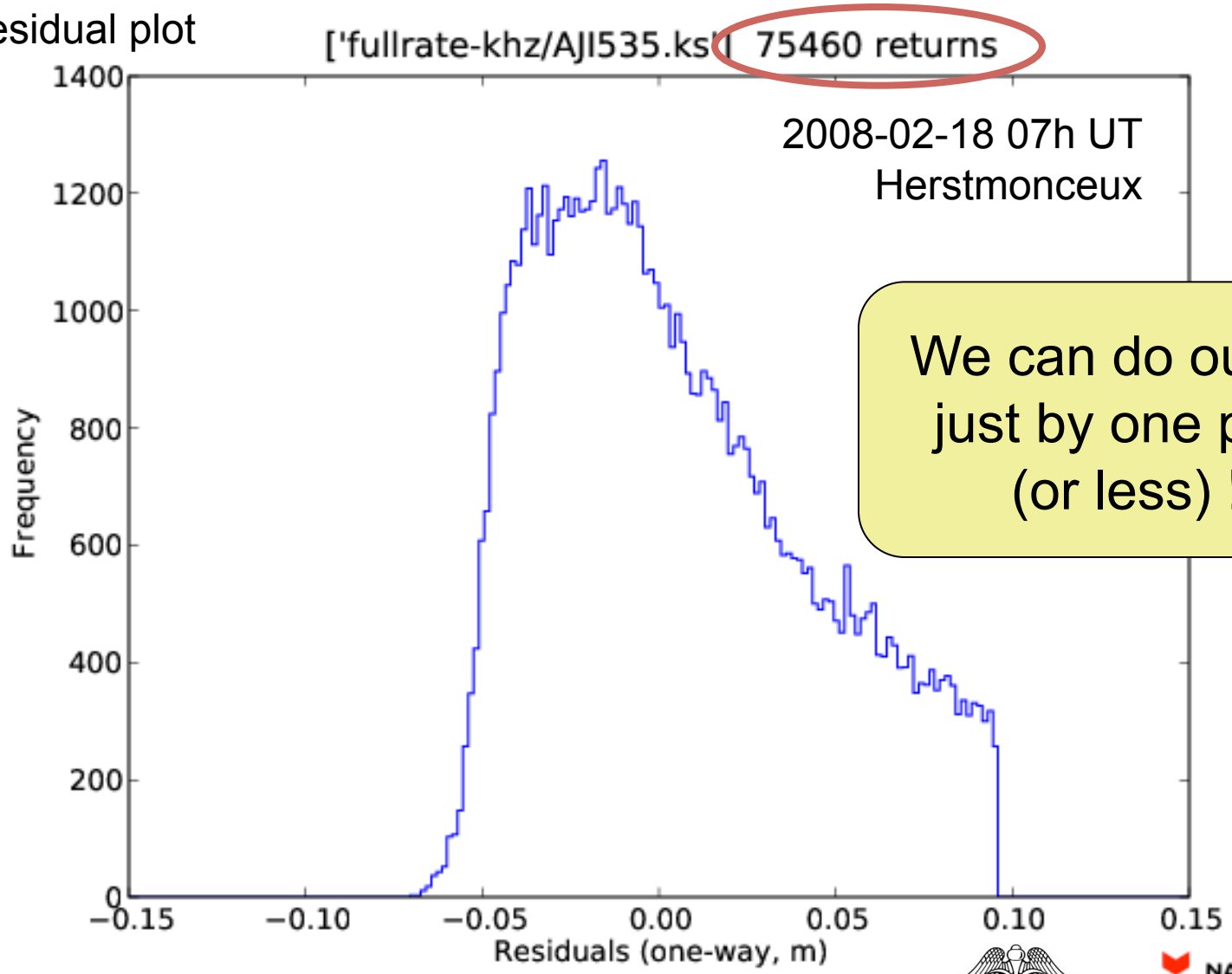
Single Photon + kHz Laser

Full-rate residual plot



We can do our job just by one pass (or less) !!

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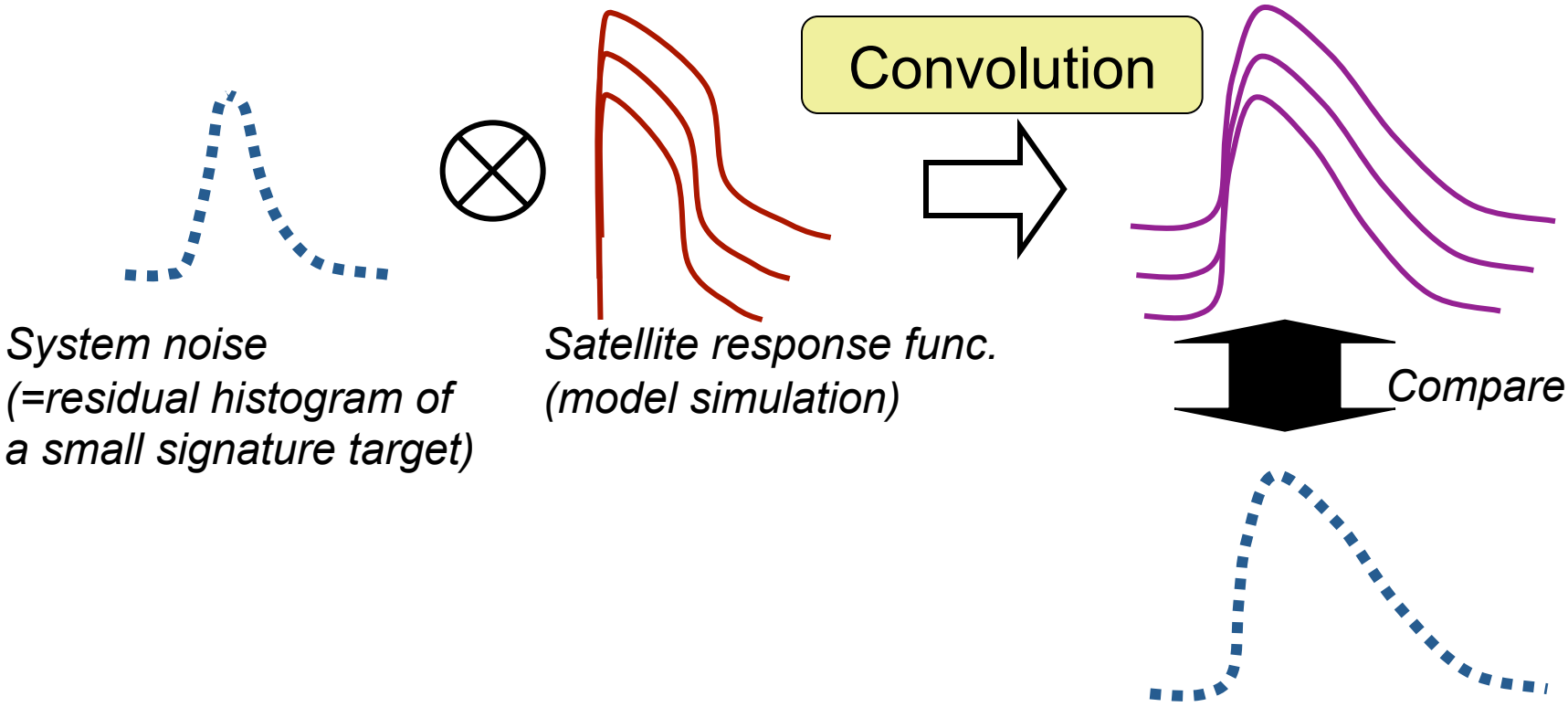
Convolution Approach

Otsubo and Appleby (2003, JGR)

Convolution: System noise ⊗ Satellite response function

The result compared with Residual scatter



System noise (=residual histogram of a small signature target)

Satellite response func. (model simulation)

Residual histogram of satellite returns.

Deconvolution Approach, possible?

This study (2008-, ongoing)

The result can be compared with satellite response function

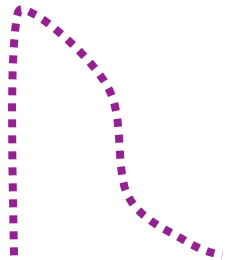
System noise (=residual histogram of a small signature target)

Freq domain: F

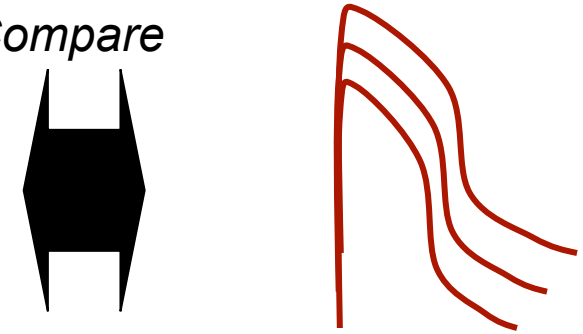
Deconvolution
"G / F" w/ LPF
→ Time domain

Residual histogram of satellite returns.

Freq domain: G



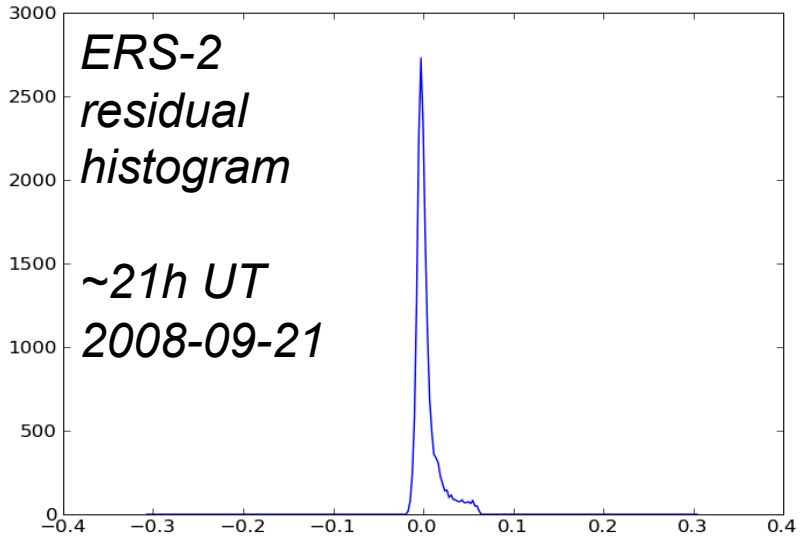
Compare



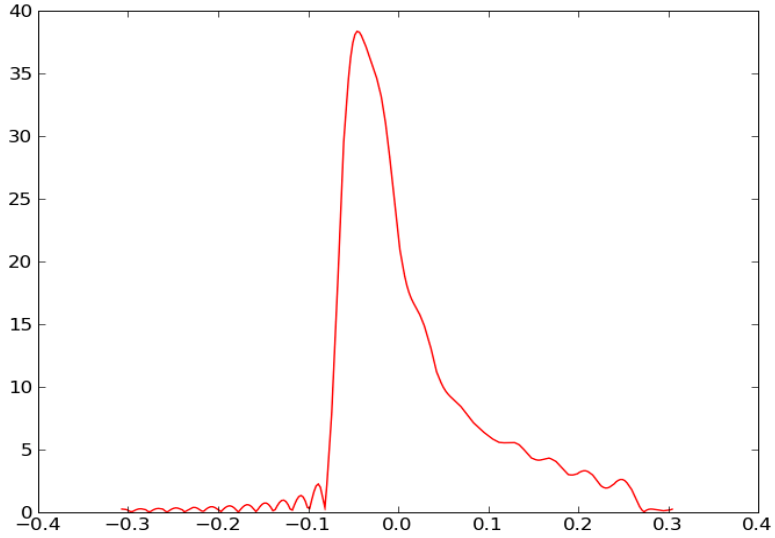
Satellite response func. (model simulation)

Deconvolution Test [1] AJISAI

Special postprocess: Loose (10σ) rejection



⊗



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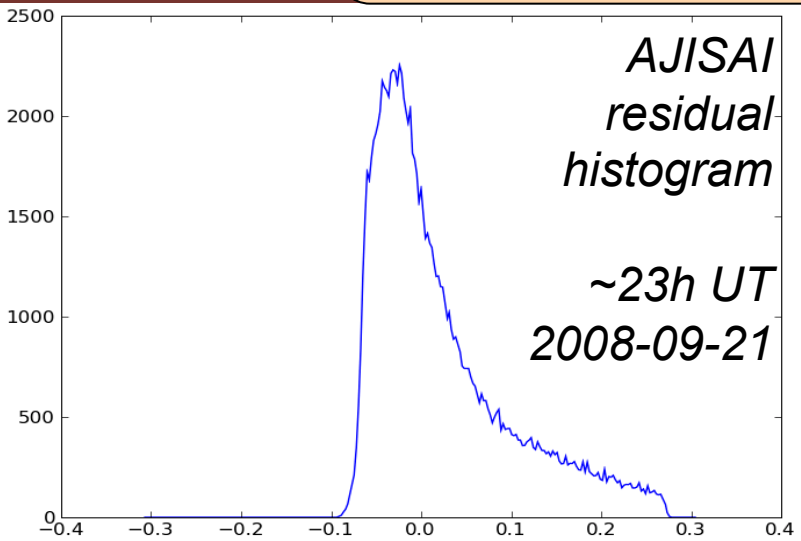
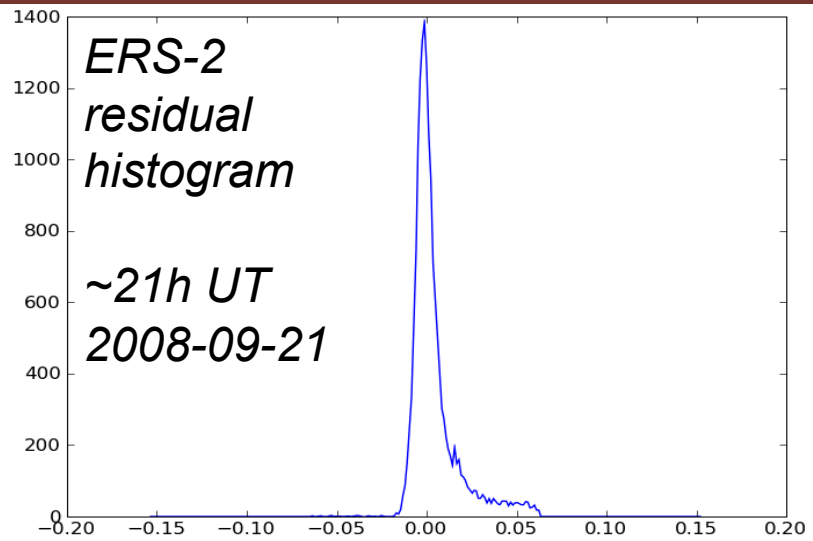


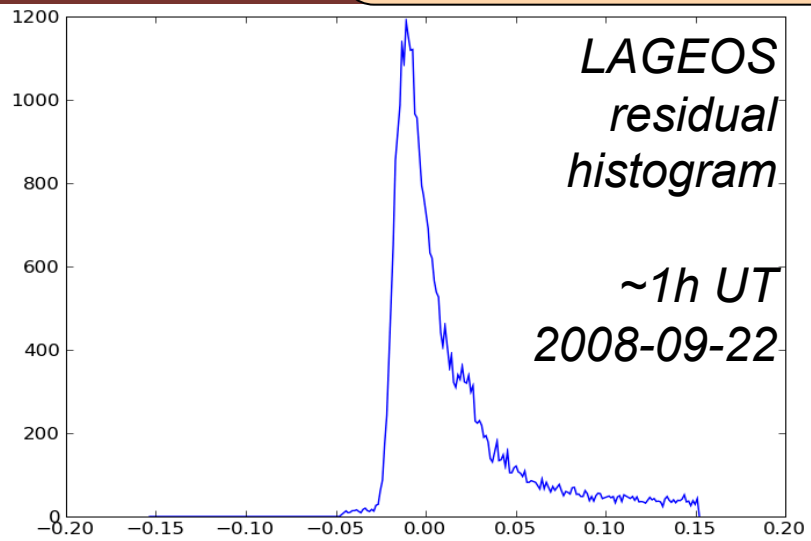
X axis:
residuals
(one-way, m)

Y axis:
counts

Deconvolution Test [2] LAGEOS

Special postprocess: Loose (10σ) rejection





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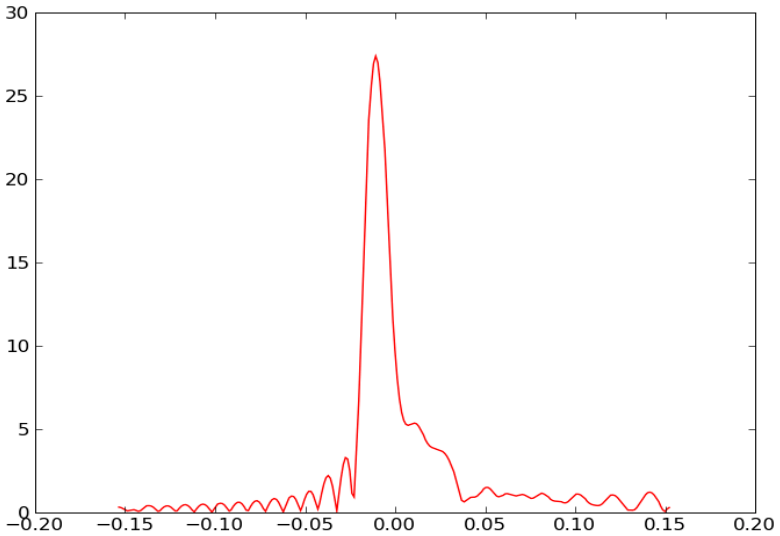
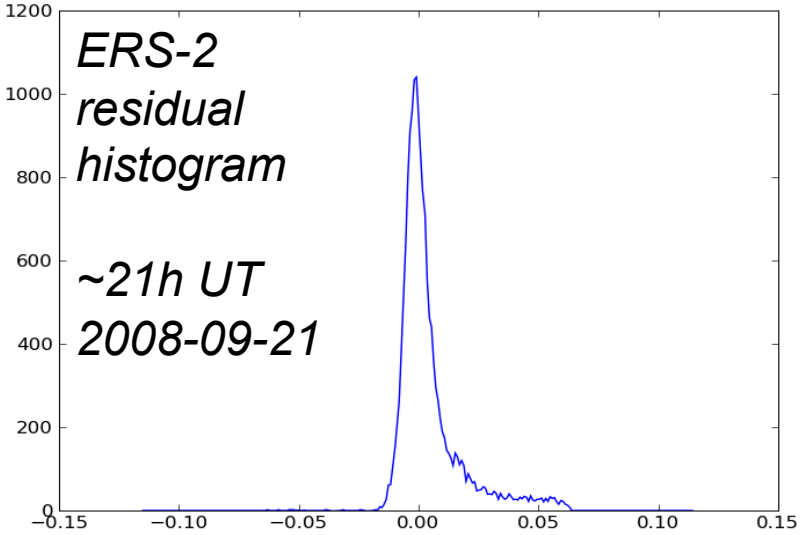


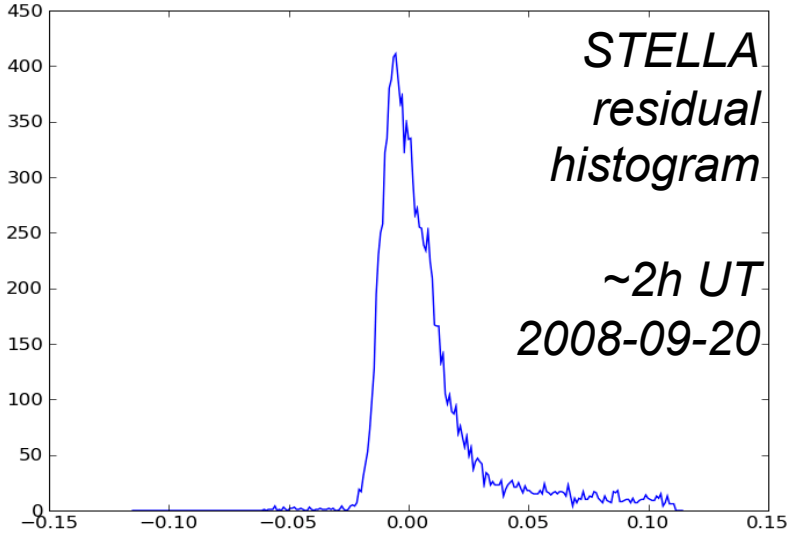
X axis:
residuals (one-way, m)

Y axis:
counts

Deconvolution Test [3] STELLA

Special postprocess: Loose (10σ) rejection





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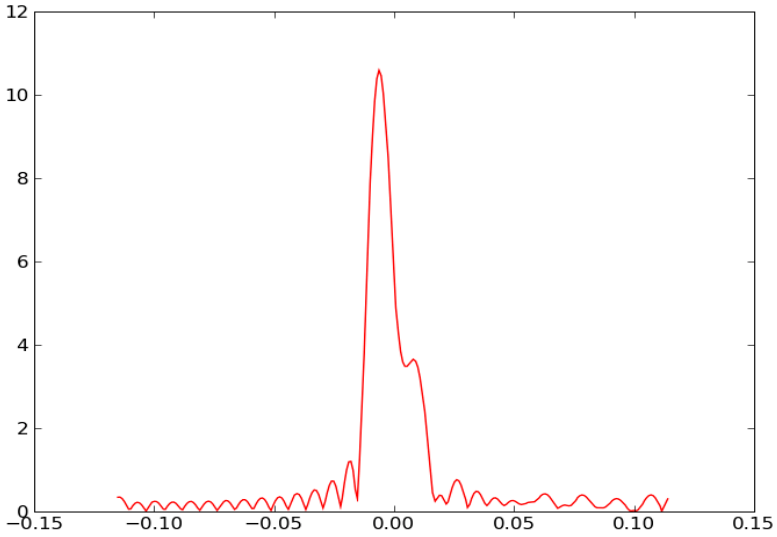


X axis:
residuals (one-way, m)

Y axis:
counts

4-D Simulation of CCR Response

4-Dimensional Function:

Angle of incidence and azimuth (2-D)

Velocity aberration (2-D)

My talk in Session 13 gives more details

Software development at Hitotsubashi University for Single CCR Response (ongoing)

Language: C#

Input:

CCR Shape, Optical Index, Coat, Size, Recession, Dihedral angle

Laser wavelength, Polarisation

Output:

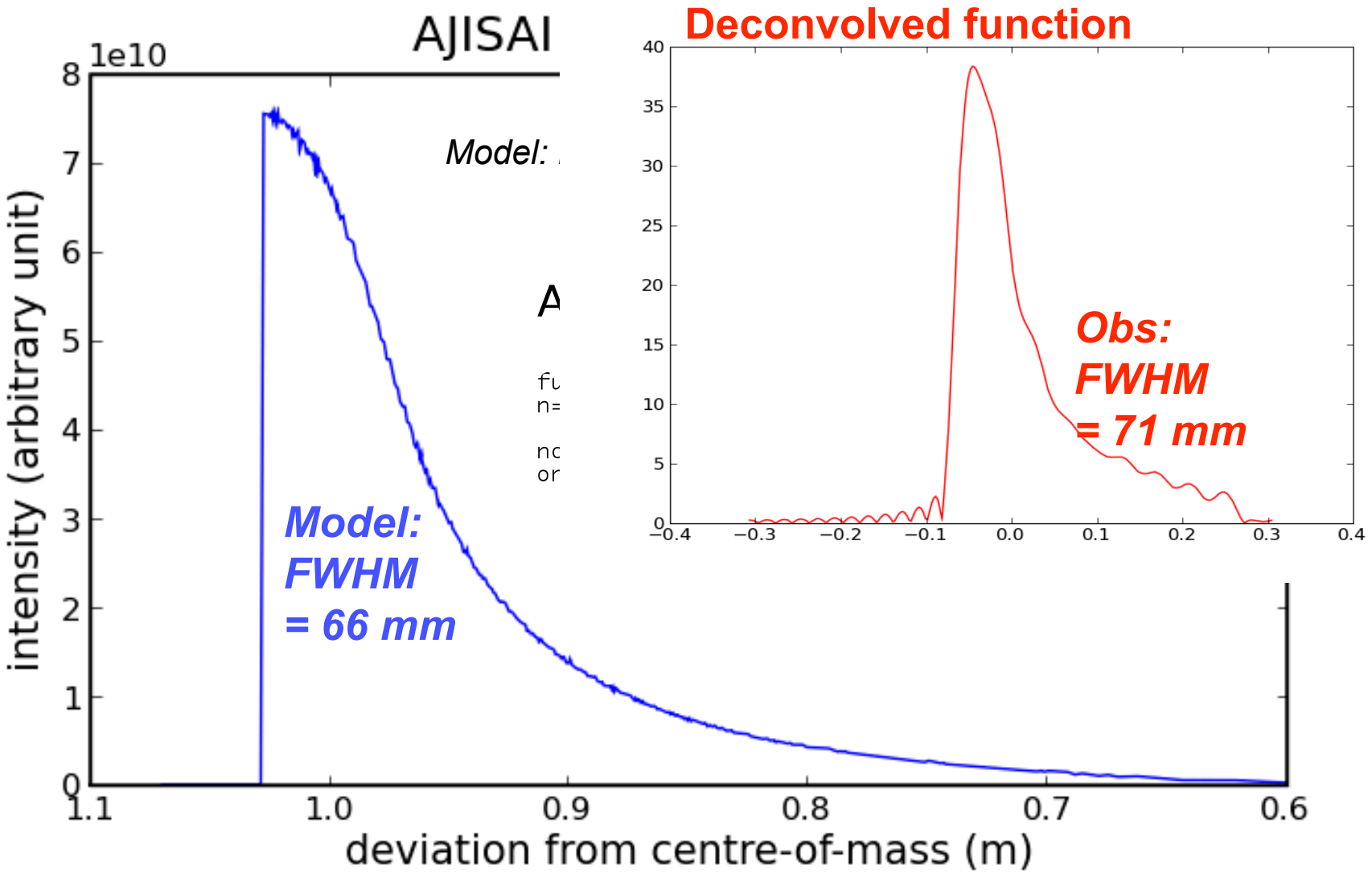
Far-field amplitude

Grid size: 2-deg for angle of incidence, 2-μrad for velocity aberration

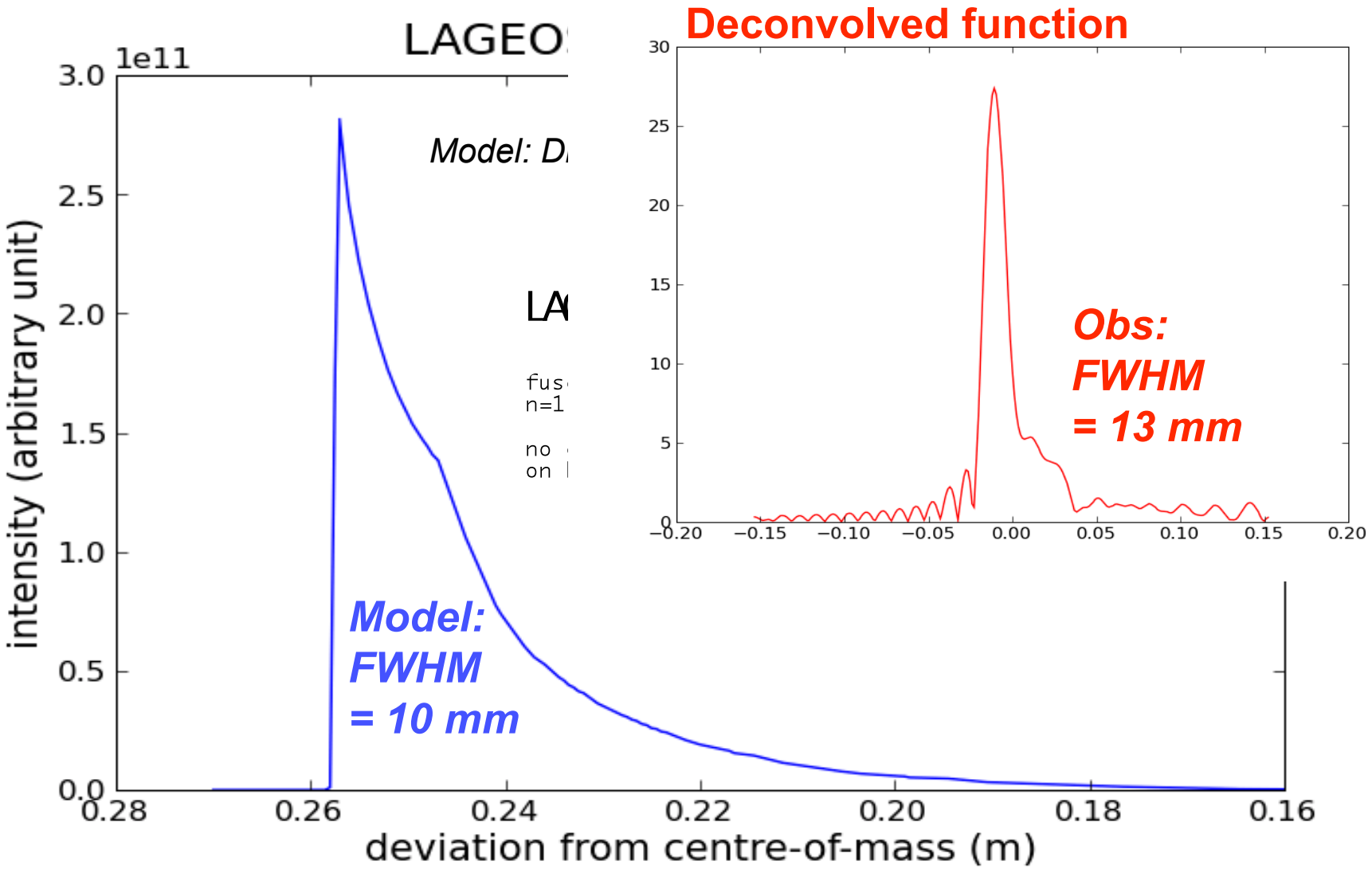
> 2 GB in ASCII Text, > 100 MB in Binary (NetCDF) file

Computation time: 6 to 14 hours per reflector … needs optimisation

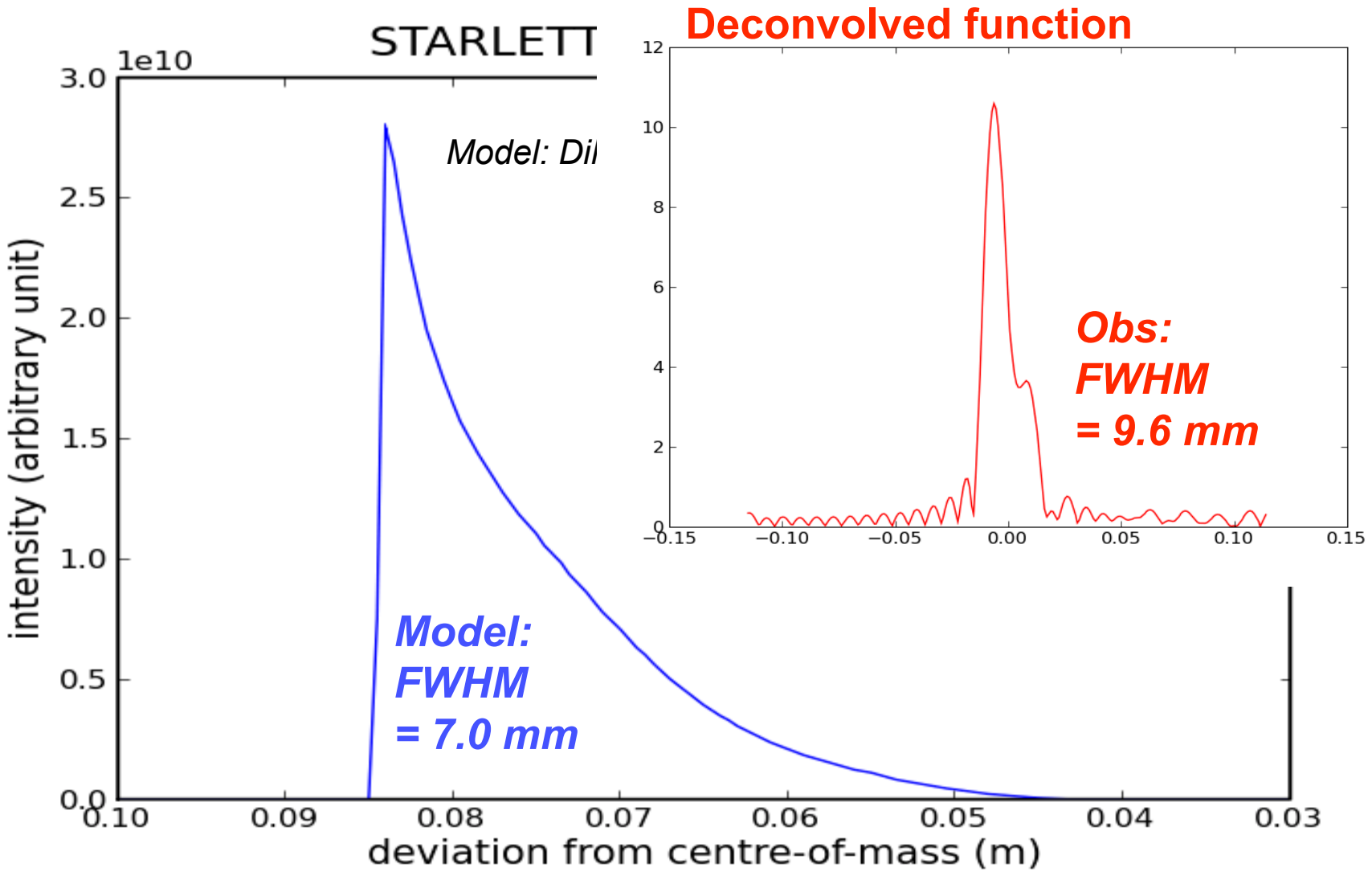
Optical Response Function (AJISAI)



Optical Response Function (LAGEOS)



Optical Response Function (STARLT.)



Conclusions & Future works

Nothing conclusive yet…

kHz Single Photon data being obtained at Herstmonceux:

- Ideal to retrieve the satellite response function.
- NOT requires hundreds of passes.

Testing a new data handling procedure - Deconvolution

- Targeting direct comparison between 'observed response function' and 'modeled response function'.
- Sensitive to noise data. Sensitive to LPF settings.
- More tests required.

HIT-U developing software for simulating 4D optical pattern

- This is also on-going development.

Many thanks to Herstmonceux crews.

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