Two-Color Calibration of the Zimmerwald SLR System

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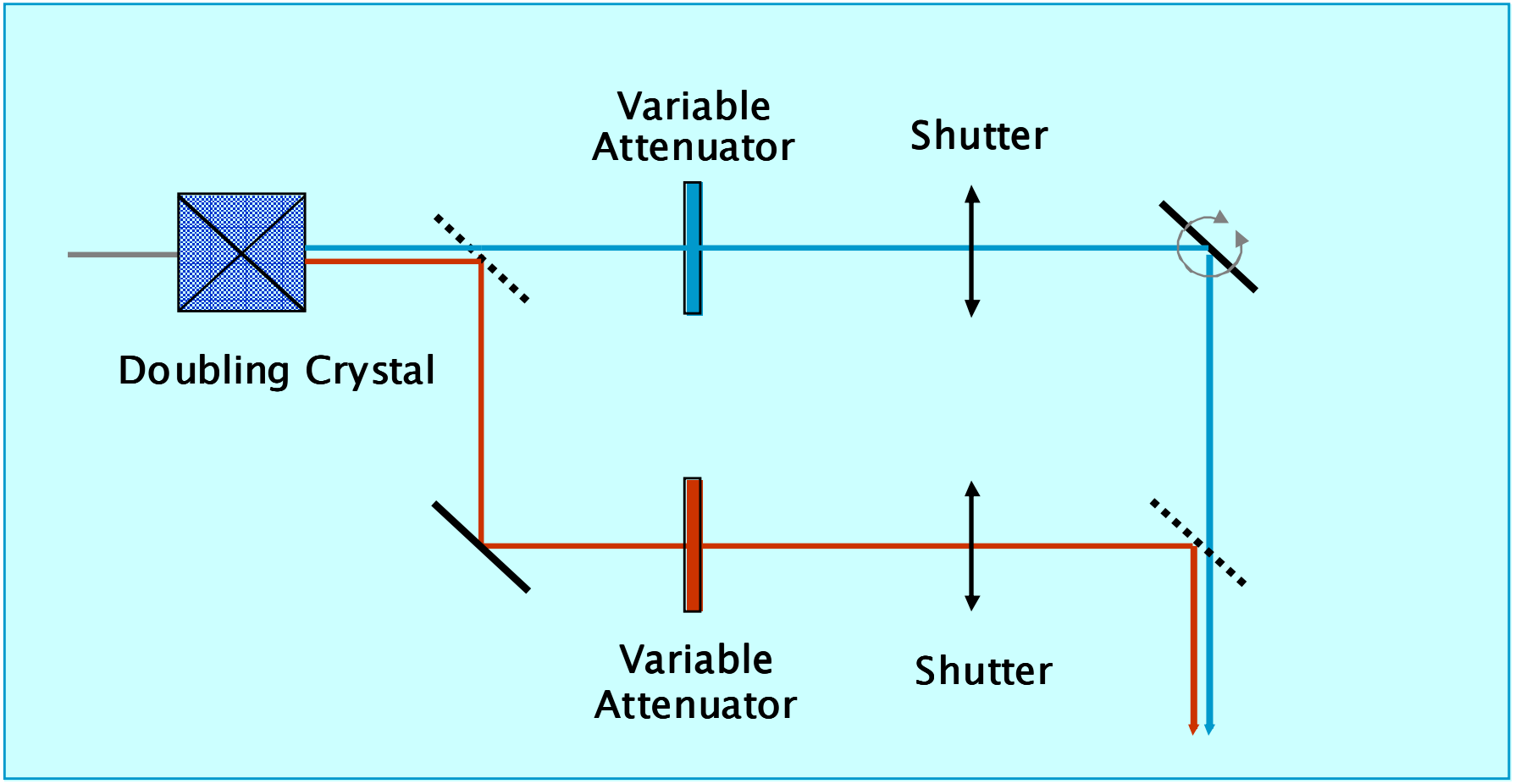
Contents

- Design of the two-color system
- Systematic biases between blue and infrared
- Source of biases
- Measures taken
- Ready for improvement of refraction correction?

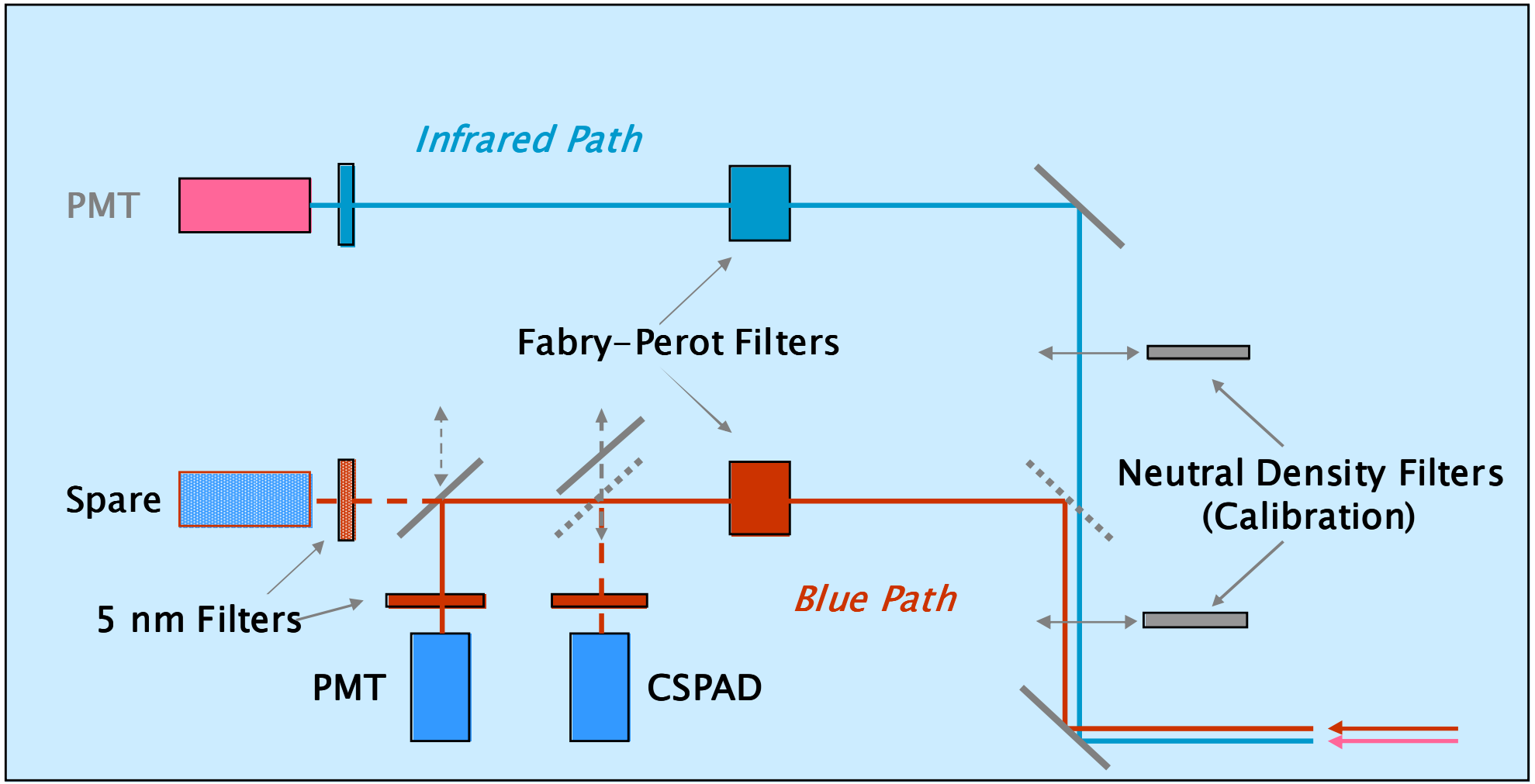
Two-Wavelengths Design

- Coudé path optics designed for two wavelengths: 423 nm and 846 nm
- Mirror coatings in telescope optimized for the two wavelengths
- Transmit and receive paths designed for separate beam control (shutters, attenuators, filters)
- Receivers
  - Blue (423 nm): CSPAD (and Hamamatsu PMT)
  - IR (846 nm): Hamamatsu PMT

Transmit Path



Receiving Path



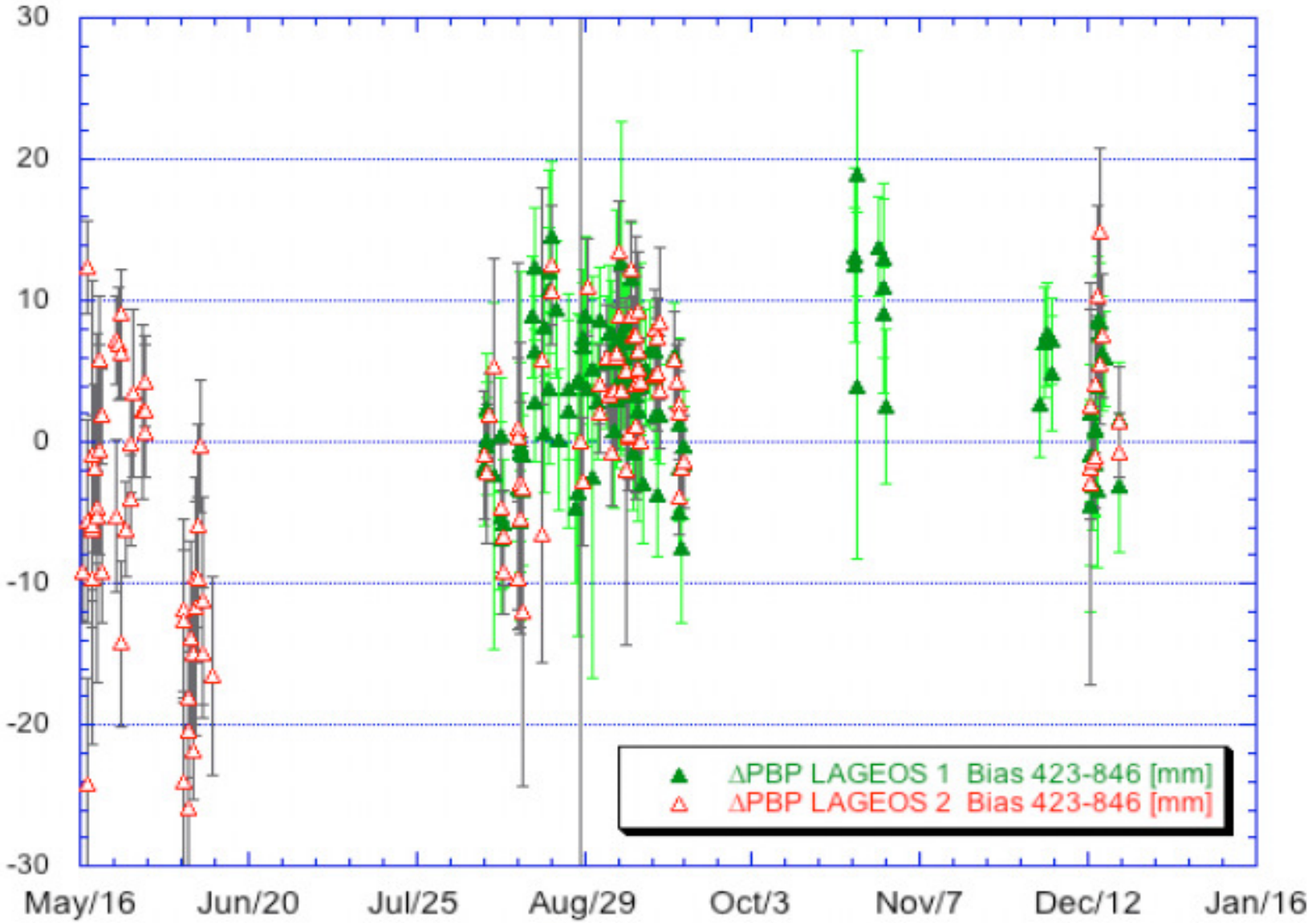
Conclusions reported 2002

- Range biases between the two reception channels could still be in the system (a few millimeters?)
- *No systematic behavior detectable till now*
- Differences of the Marini–Murray refraction corrections at 423 and 846 nm obviously better than < 8 mm
- Is accuracy of the two wavelengths good enough for mapping function improvement?

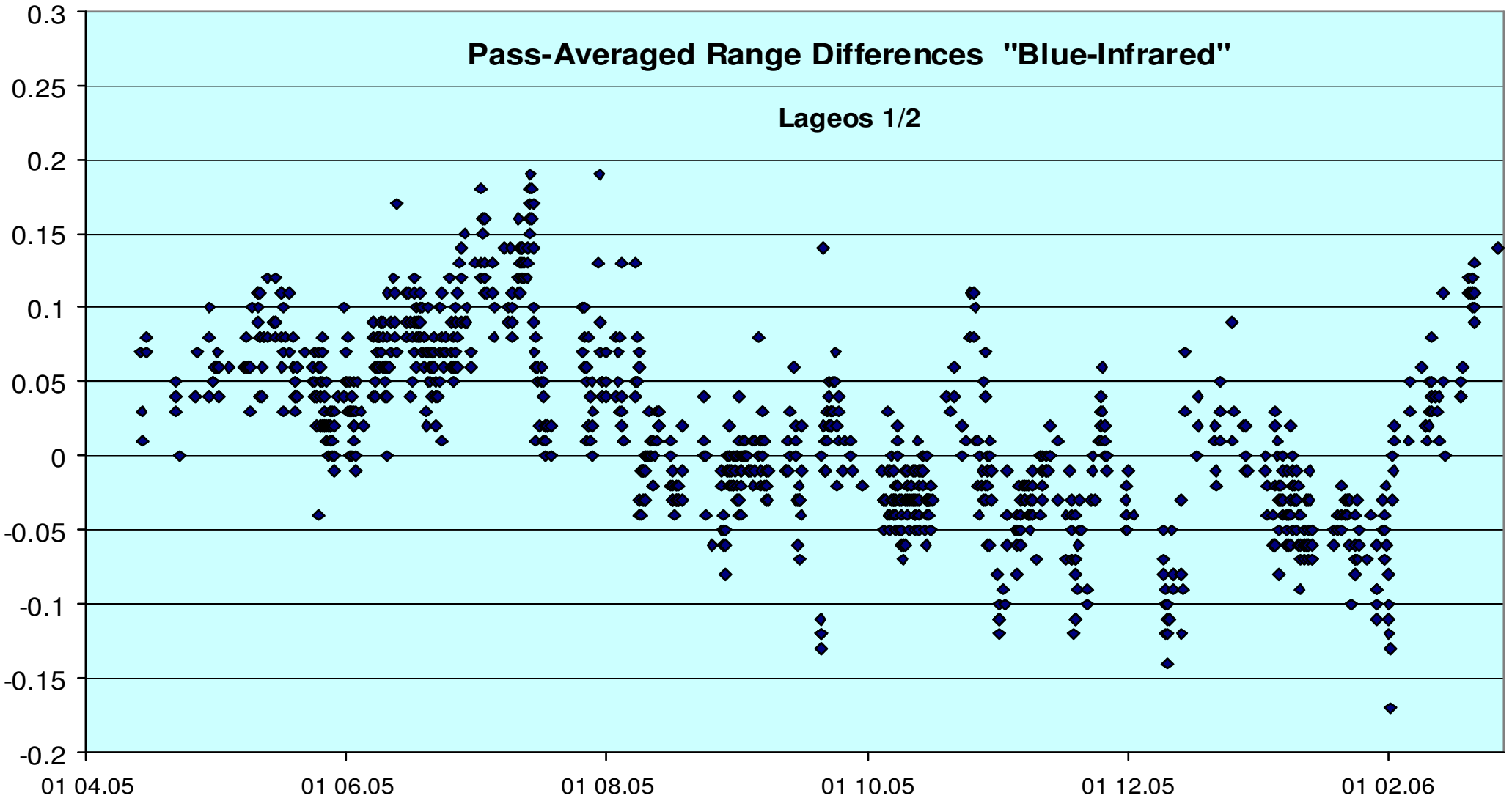
But ...

- Systematic and slowly (weeks - months) changing differences between calibrated ranges in blue and infrared (Marini-Murray applied)
- Up to +- 2 cm
- Pass per pass averages of pass residuals (generated during onsite np computation)
- Confirmed by analysis centers

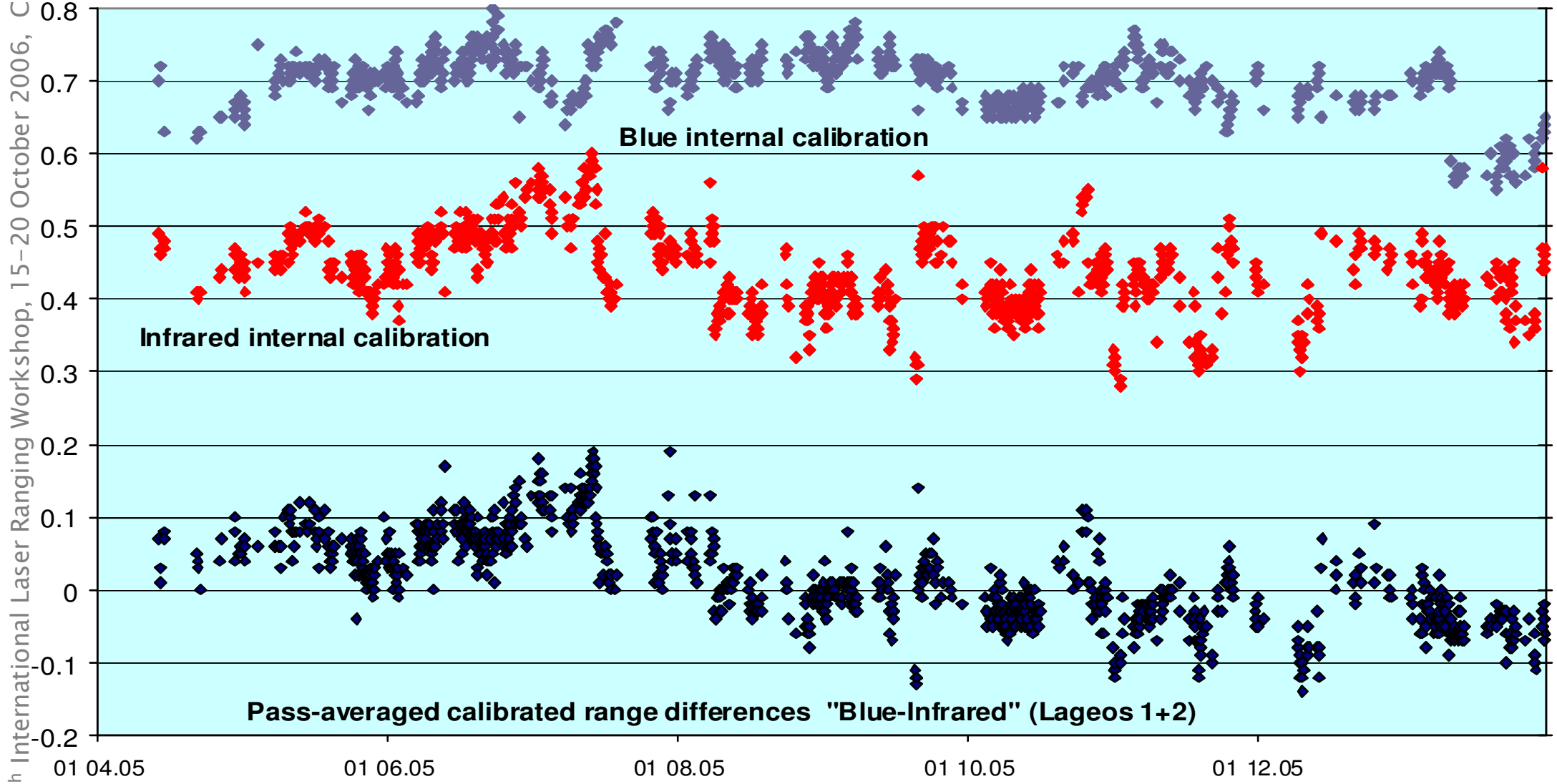
Pass-per-pass bias differences Blue-IR
(JCET 2004)



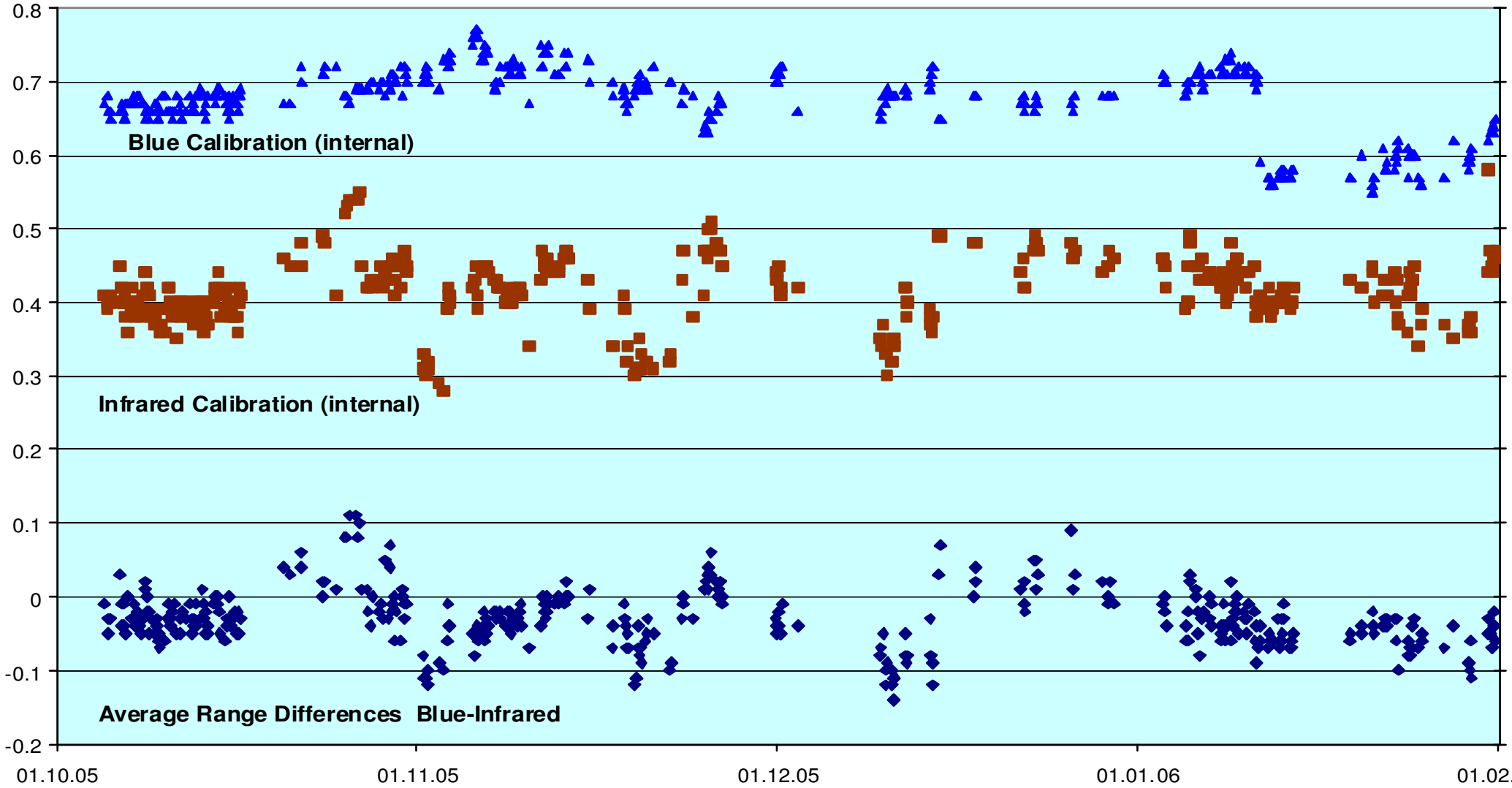
Time Series of Differences (on-site)
04.2005-03.2006



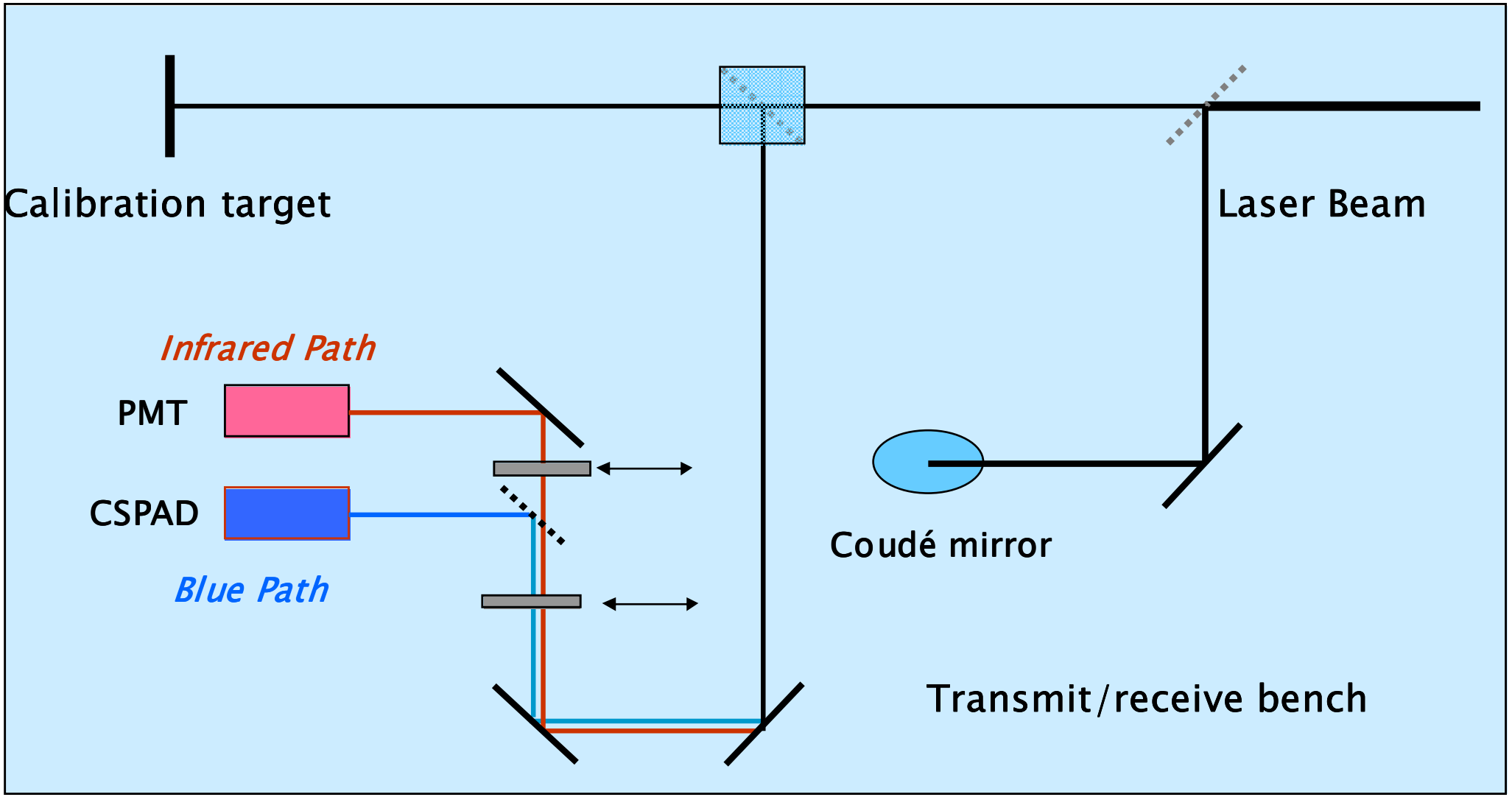
Comparison of Calibrations with Range Differences



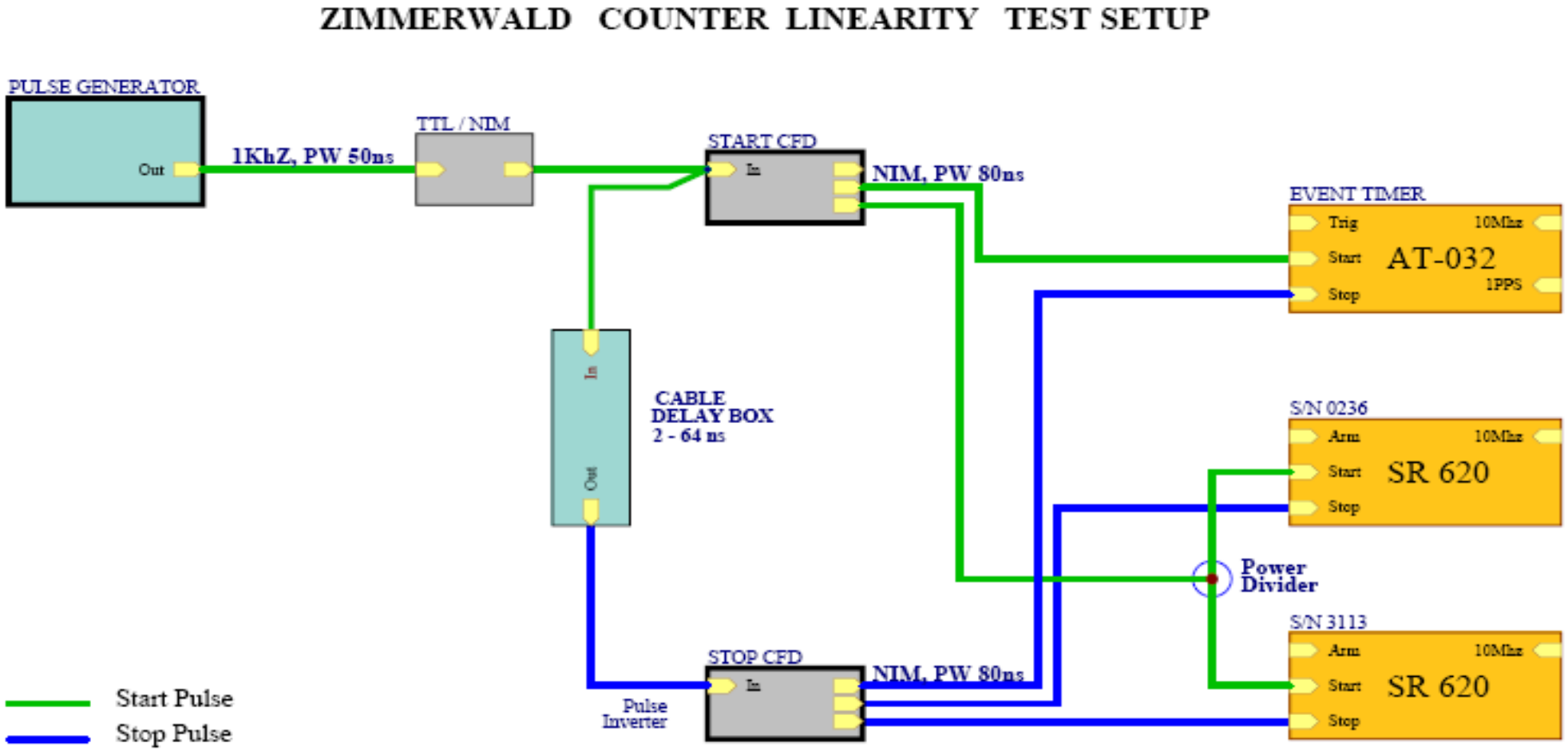
Zoom (4 months)



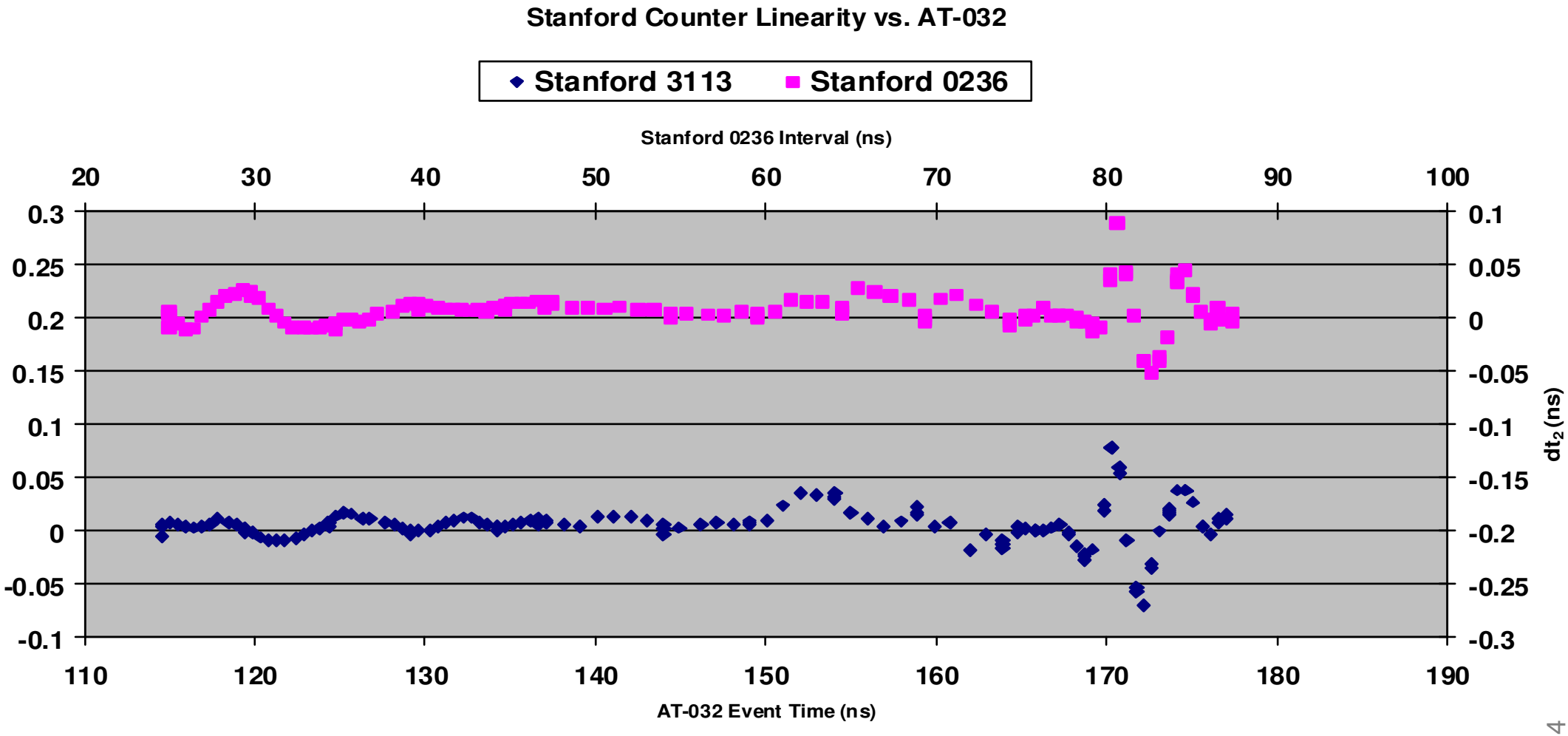
Internal Calibration



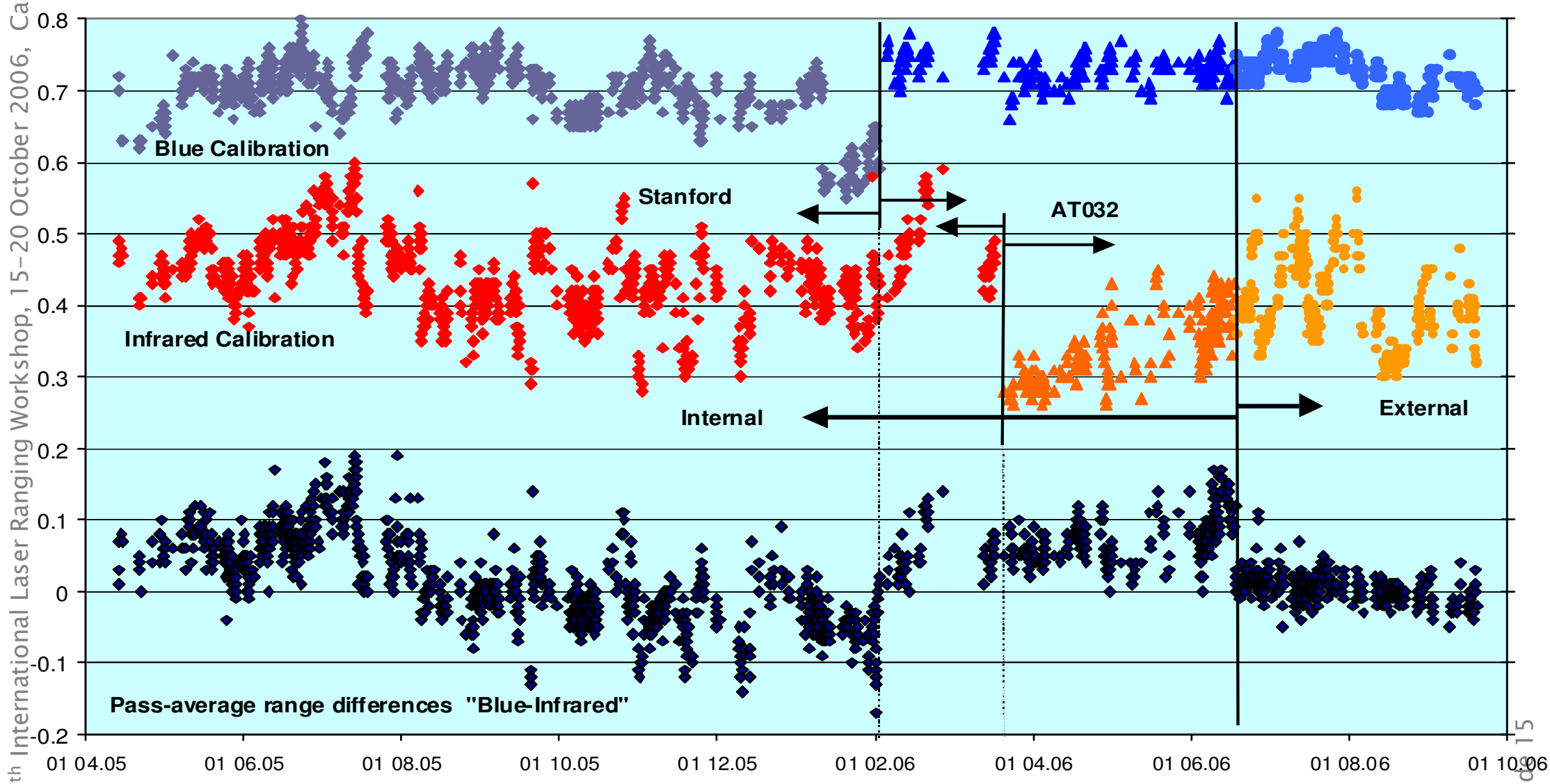
Counter linearity: Short time intervals



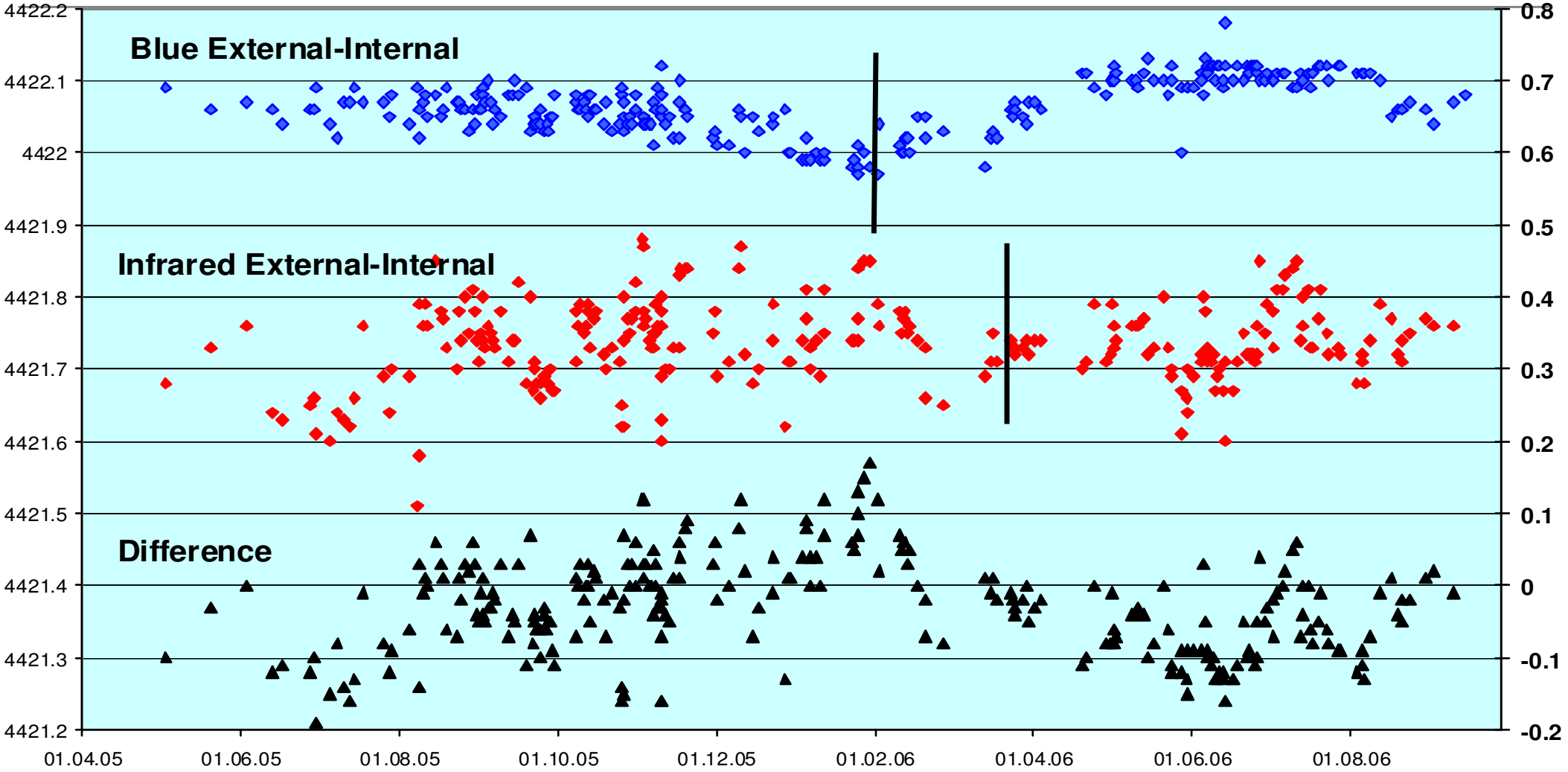
Counter linearity at very short flight times



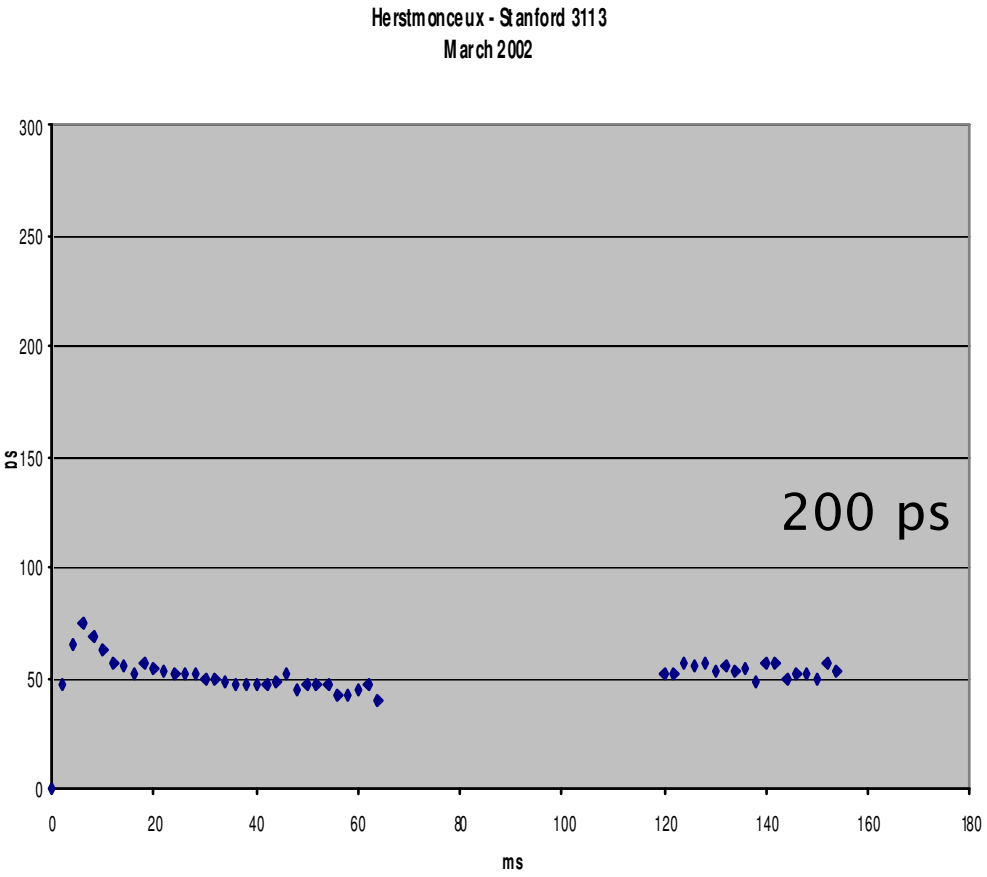
Event timer, External Calibration



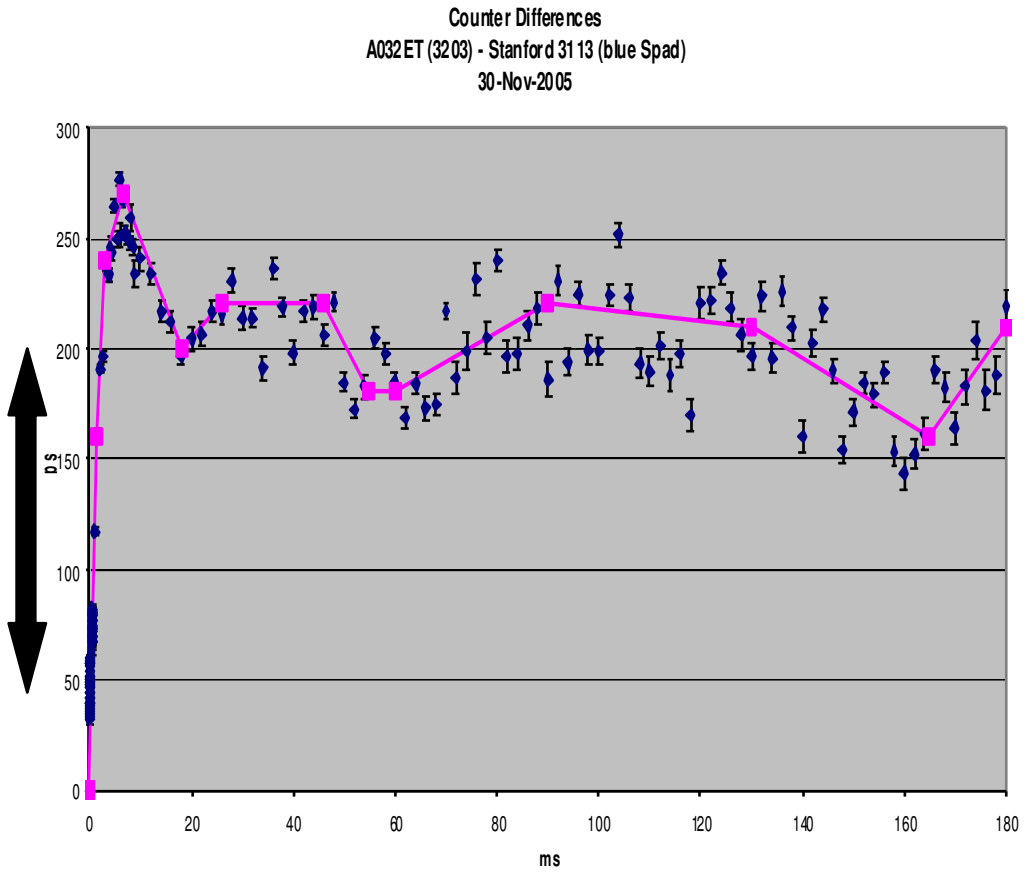
External – Internal Calibration



Reference minus Stanford #3113

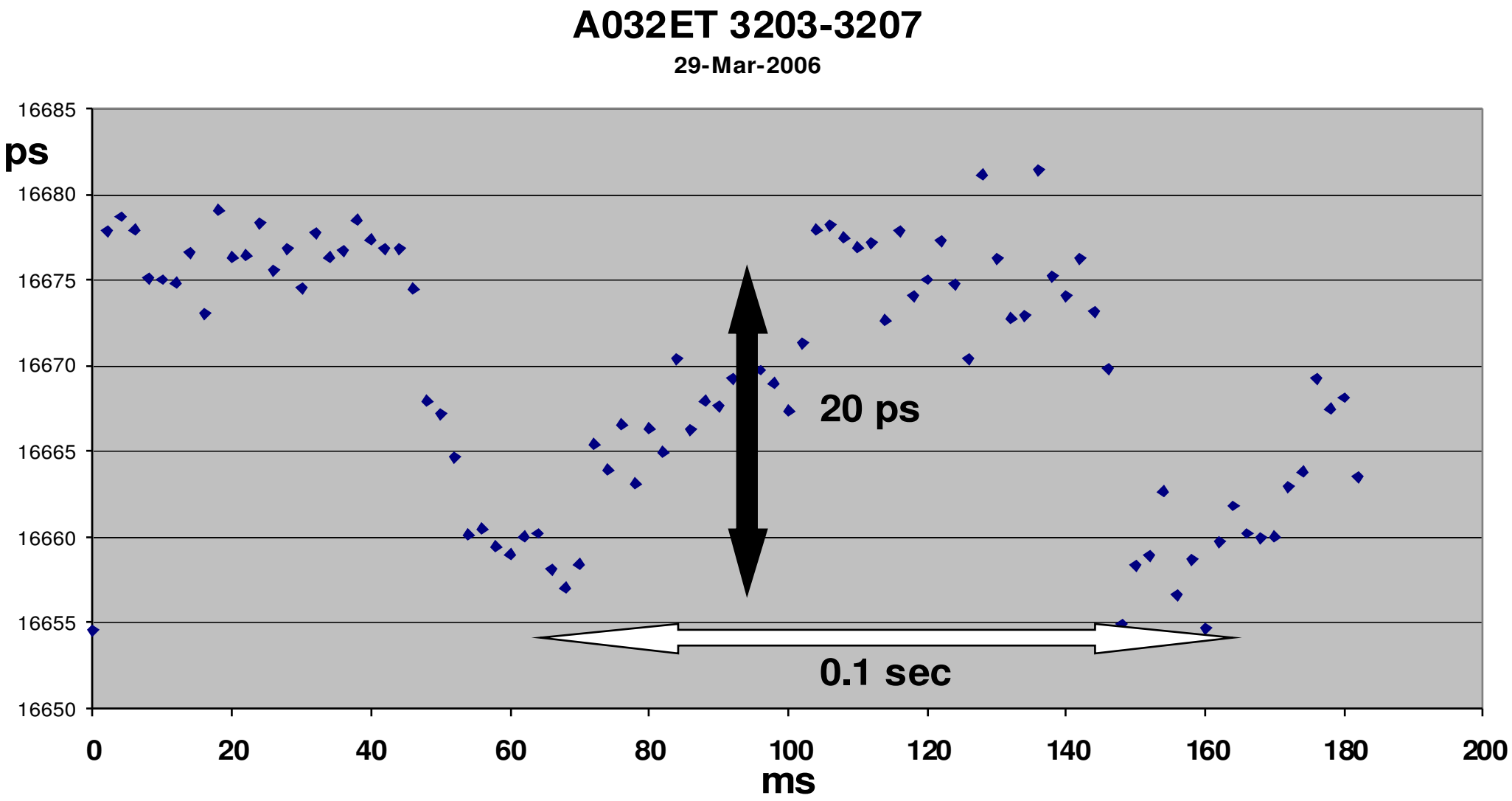


Herstmonceux



A032ET Event timer

A032ET Counter Comparison



Improving the tropospheric refraction?

$$m_{\Delta R} = f(\lambda_i) / [f(\lambda_2) - f(\lambda_1)]\, m_{R2-R1}$$

Amplifying factor $f(\lambda_i) / [f(\lambda_2) - f(\lambda_1)]$:

14 for $\lambda_1 = 423$ nm, $\lambda_2 = 846$ nm

$$m_{R2-R1} = \mathrm{sqrt}(m_{R1}^2 + m_{R2}^2 + m_{Cal1}^2 + m_{Cal2}^2)$$

Goal: 1 mm

Calibrated range difference bias-free to 0.08 mm = 0.5 ps!

$\rightarrow m_{R_i}$ and $m_{Cal_i} < 1/14/2\text{mm} = 0.04$ mm!!