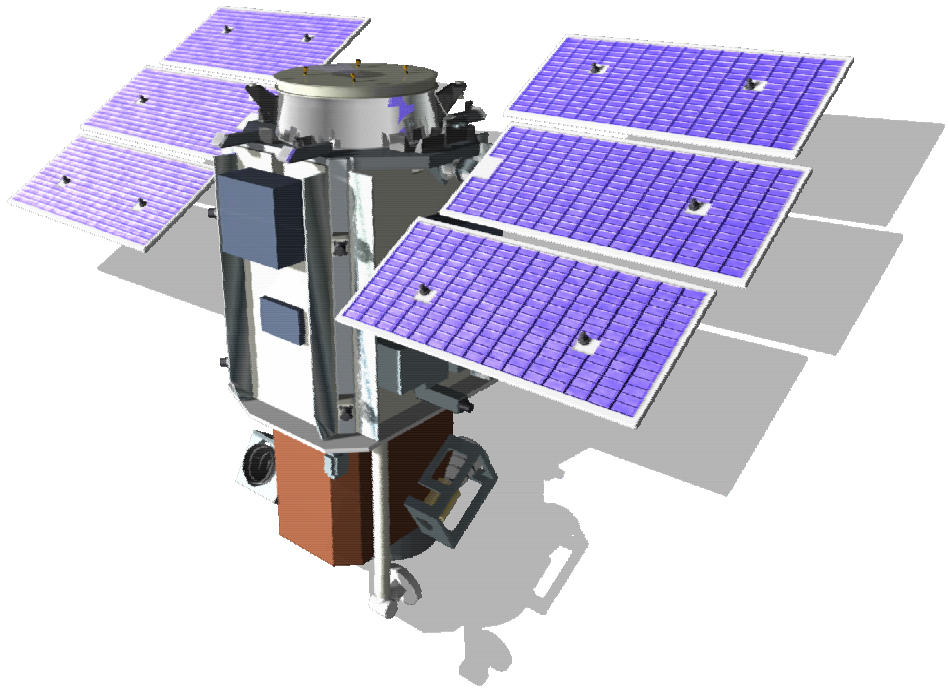
QuickBird On-Orbit Spatial Image Quality Assessment



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MTF Design Goal

- A key design Goal for QuickBird is System Modulation Transfer Function (MTF) > 0.1 at Nyquist frequency
  - MTF describes image contrast loss for a sinusoidal spatial variation in radiance as a function of spatial frequency.
  - Nyquist frequency is one cycle per two samples (pixels)
  - Compromise between too much blur and too much aliasing
- System MTF includes atmosphere, telescope, detector, electronics, and data compression/expansion.

Based on Measurements of Ground Edge Target

- Results presented based on a single painted edge target with roughly in-track and cross-track edges, slightly rotated from pixel direction.
- Results are consistent
  - Across the field of view
  - Over time
  - Along-track results slightly lower due to scanning blur
- 16 different images between 12/5/01 and 2/3/03.
- Two trials for each edge image to show consistency of process.

Resampling Effects on MTF

- Bilinear interpolated products will have significantly lower MTF.
- 8-Point Sinc interpolated products will have significantly higher MTF, with some “ringing”.
- MTF Corrected products will have highest MTF, with some overshoot on edges.
- Nearest neighbor resampling can create artifacts in products, but is generally neutral to MTF. (Non-shift-invariant process)
- Cubic Convolution can slightly increase or decrease MTF, depending on resampled GSD.
- **MTF results will vary based on the ratio between resampled GSD and native GSD.**
- **All results shown here use unresampled imagery.**

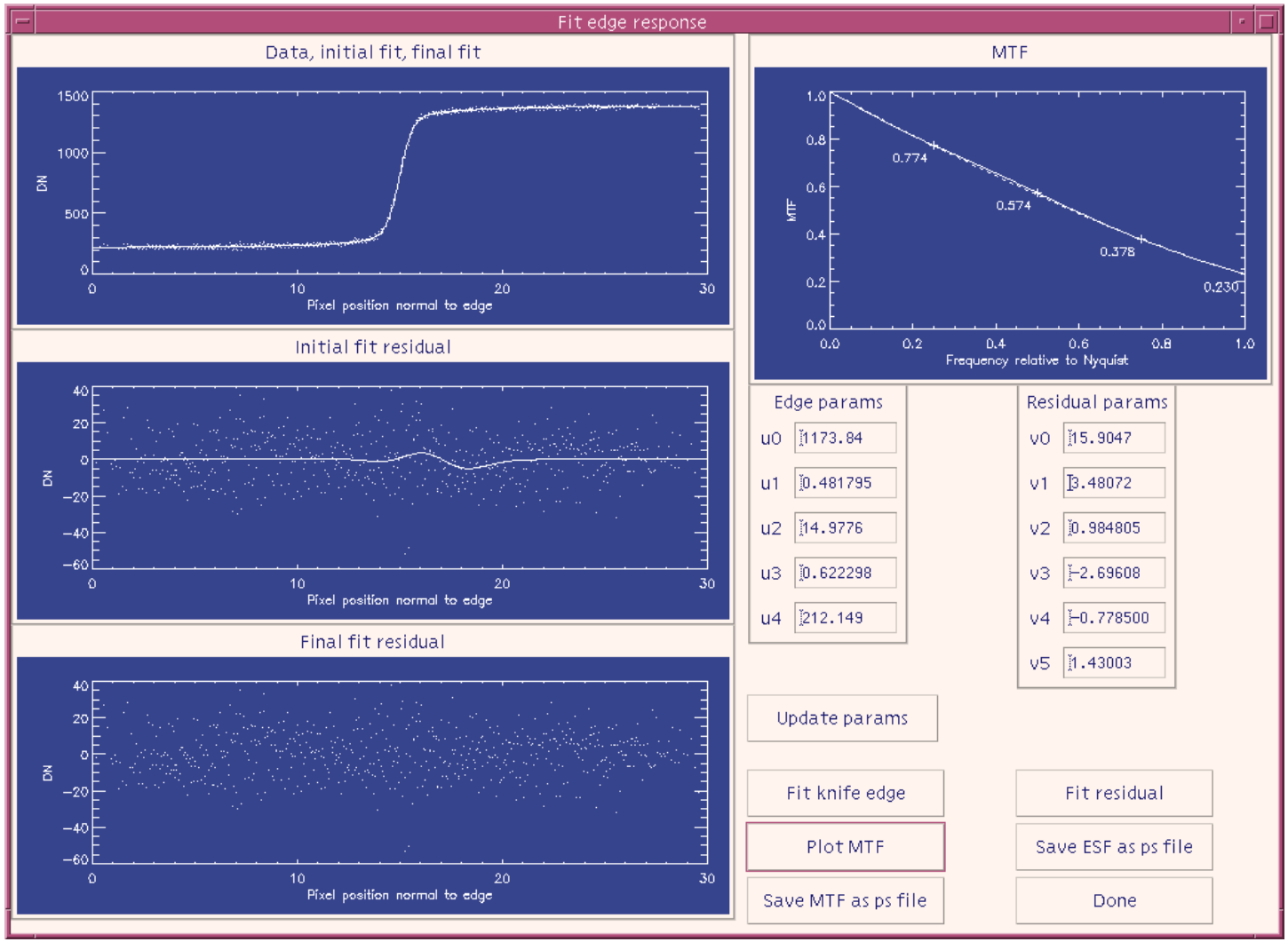
Focus Adjustments

- Focus was initially compensated thermally, using several edge targets as well as star targets.
- During 2002, we moved our focus mechanism to reduce the thermal compensation load.
- Some images whose results are shown here were taken during this process.
  - Images taken after settling of thermal transients.
  - Negligible degradation of image quality measured.

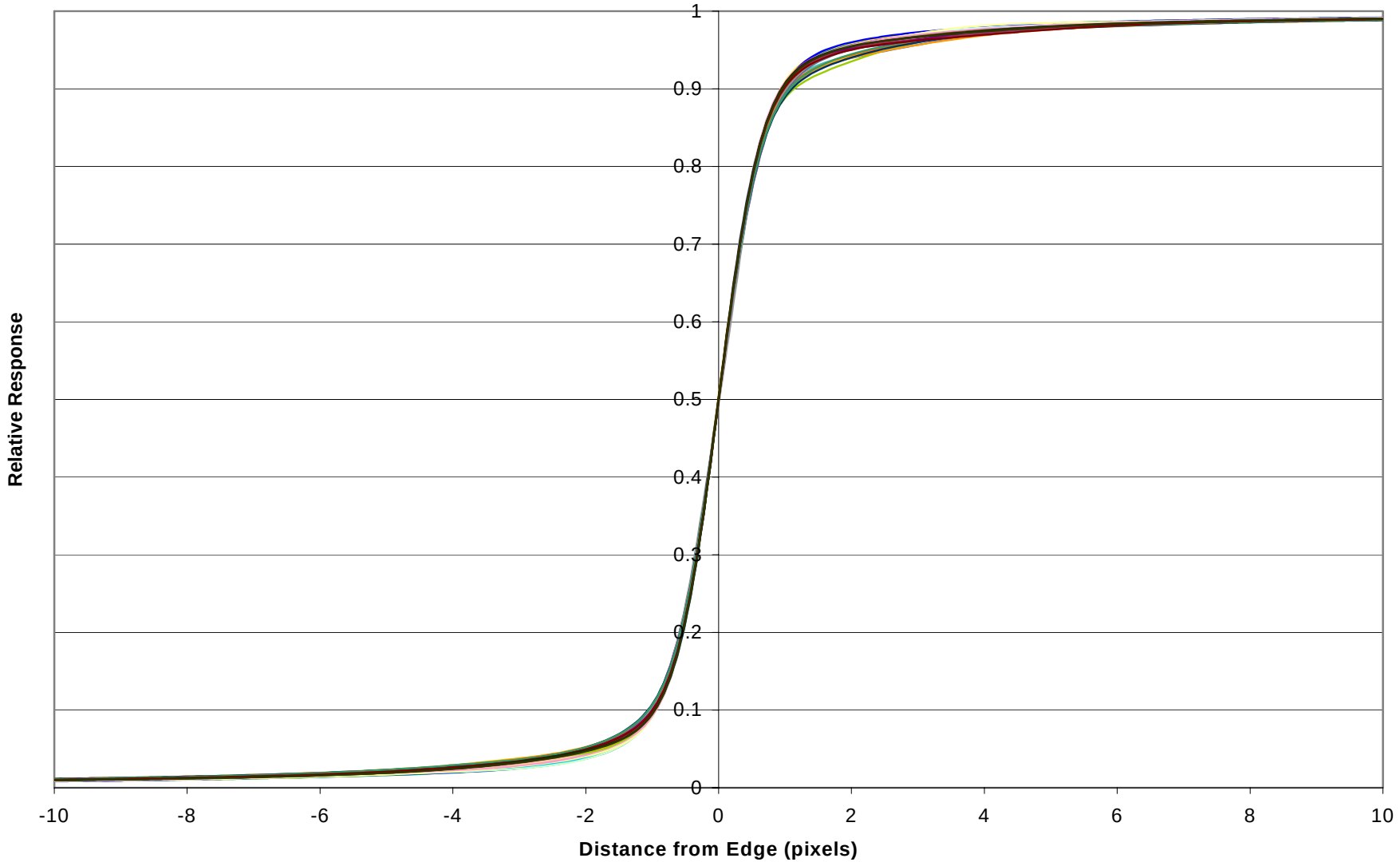
Edge/MTF Measurement Process

- Select an image chip within target, spanning edge.
- Approximate location of edge.
- Treat each pixel as response vs. distance from edge.
- Fit data with flexible fitting function (Canova, et al., Proc. SPIE, Vol. 3750, pp. 368-375)
- Normalize edge response and calculate line response and MTF.

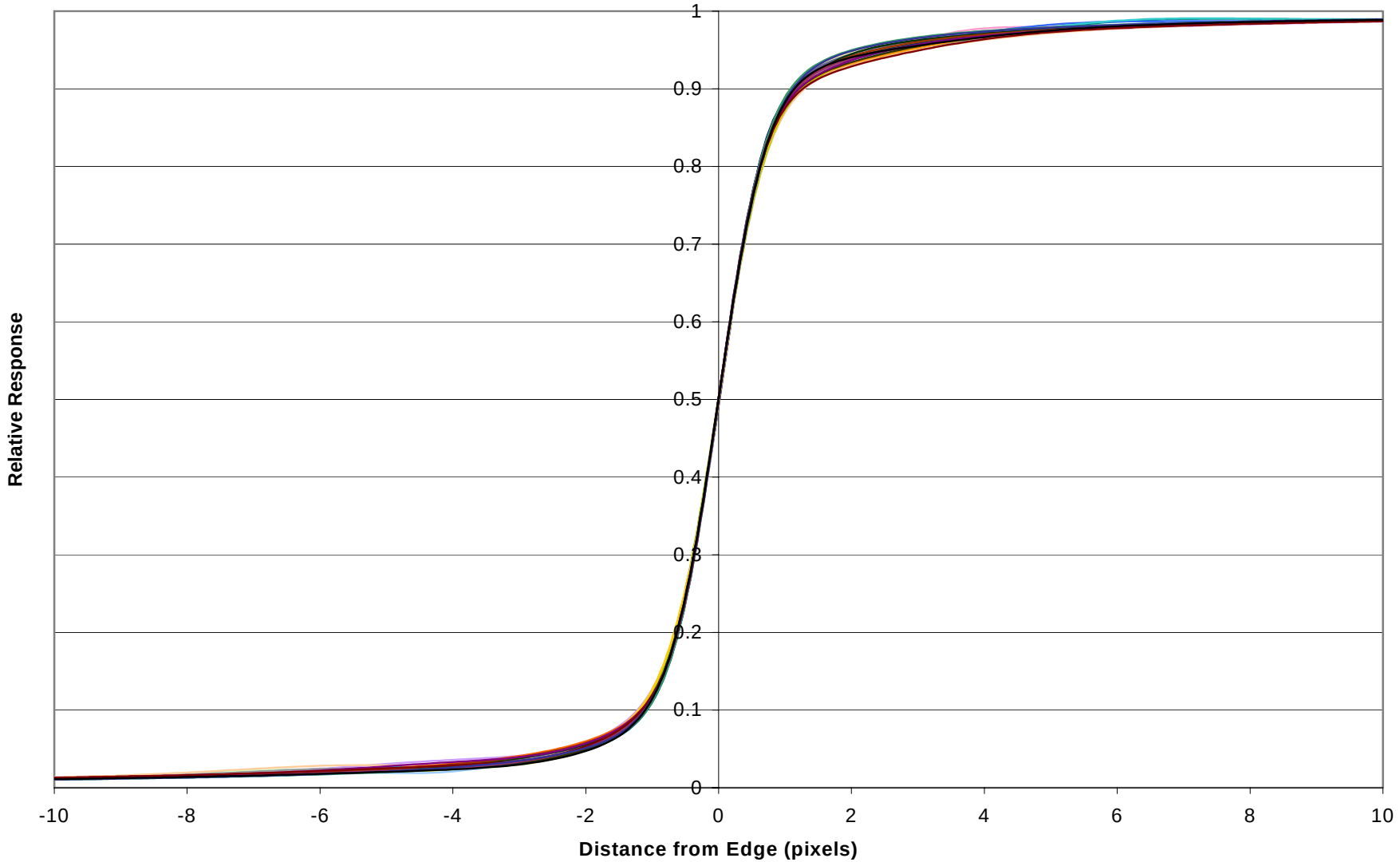
Example of Edge Fit



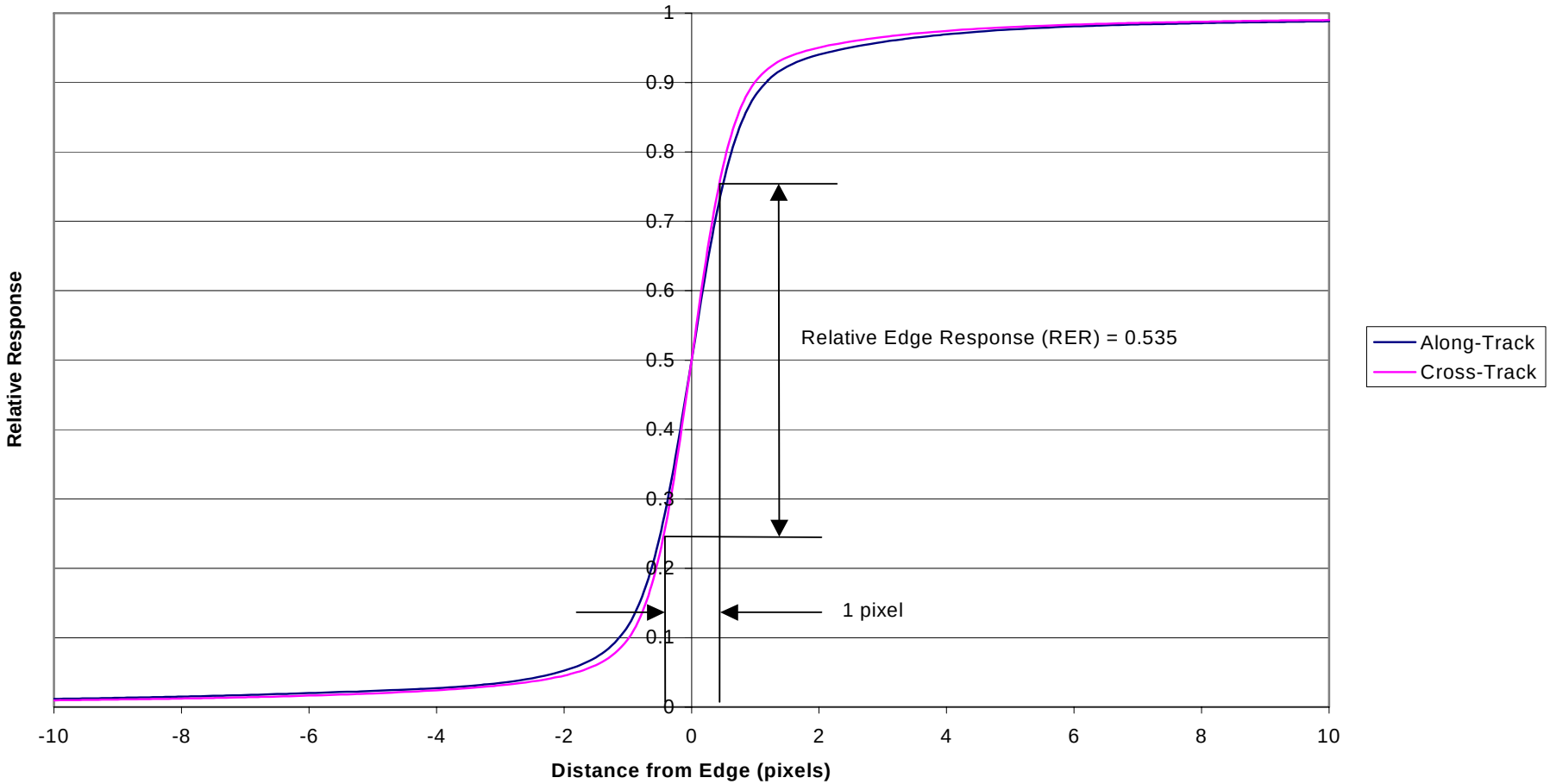
Cross-Track Edge Measurements



Along-Track Edge Measurements

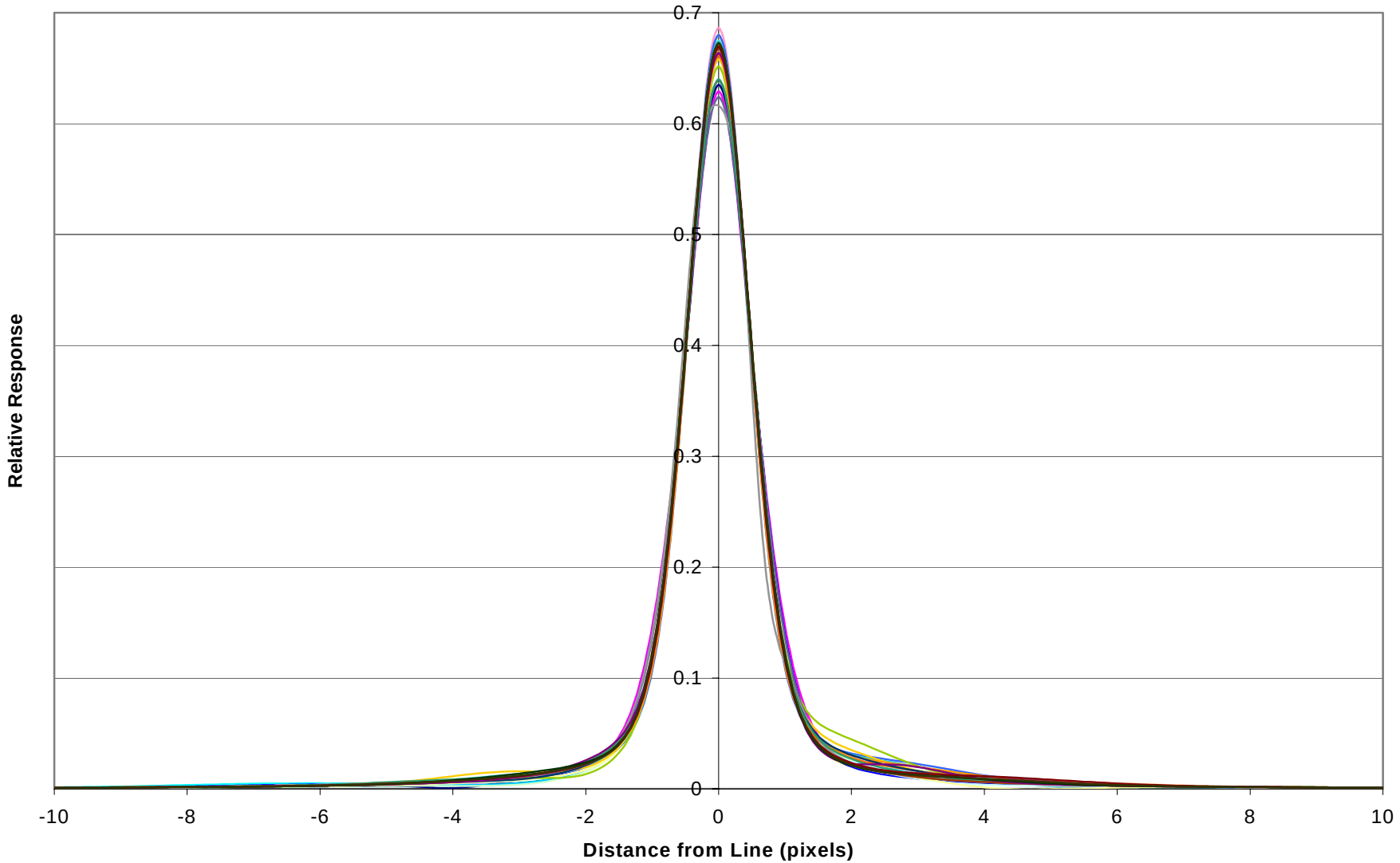


Average Edge Response

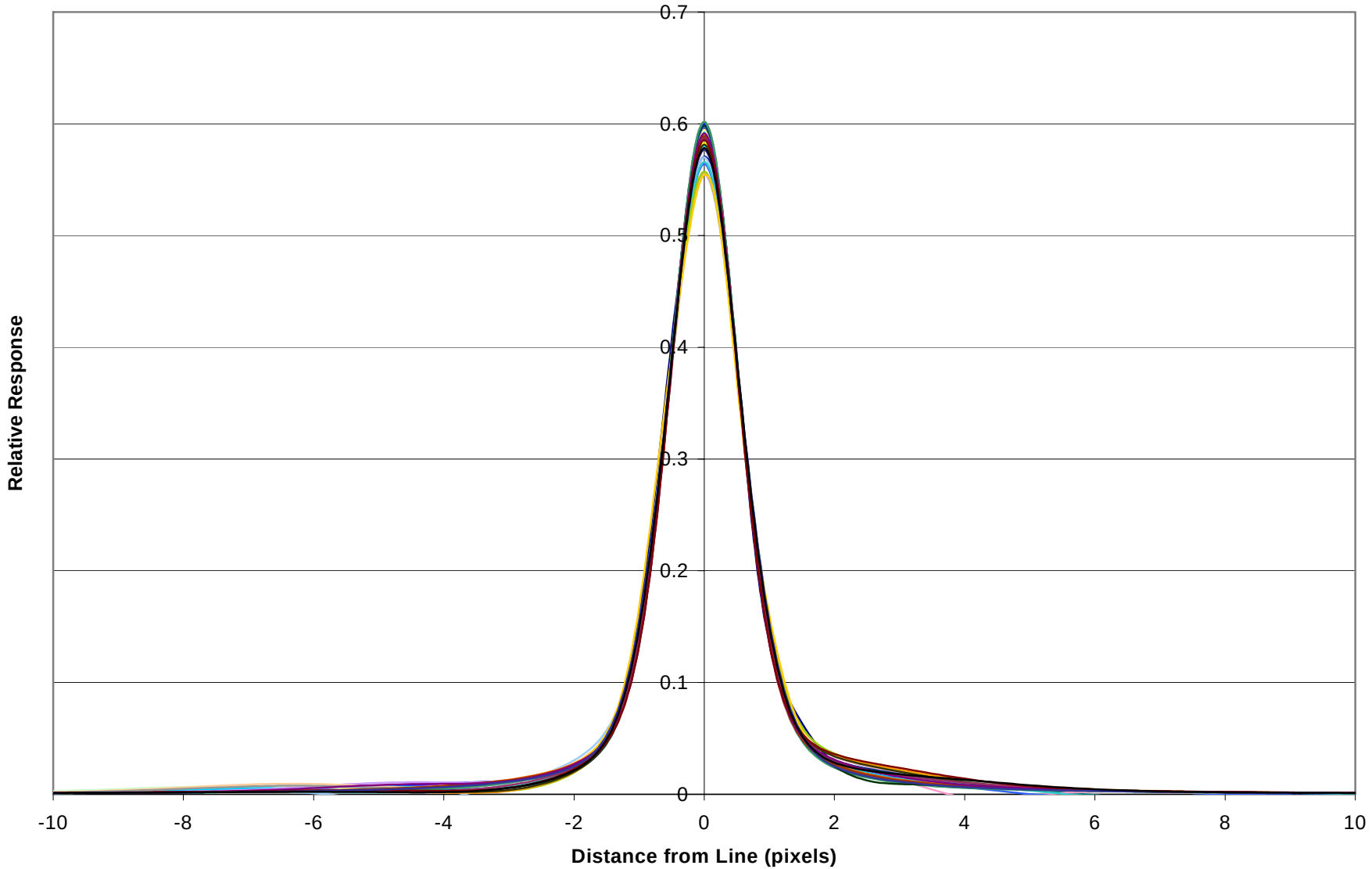


Relative edge response used to predict NIIRS.

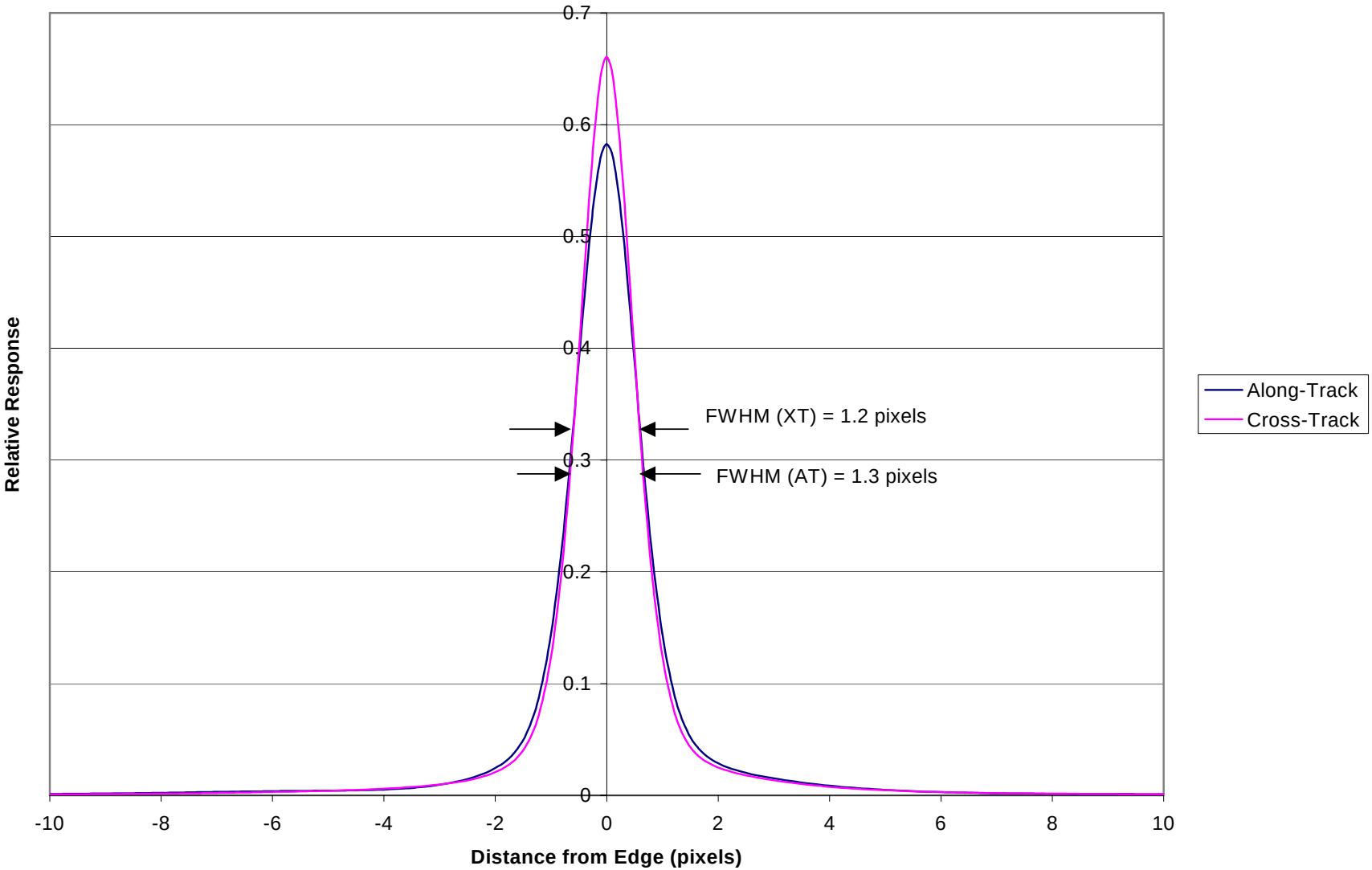
Cross-Track LSF Measurements



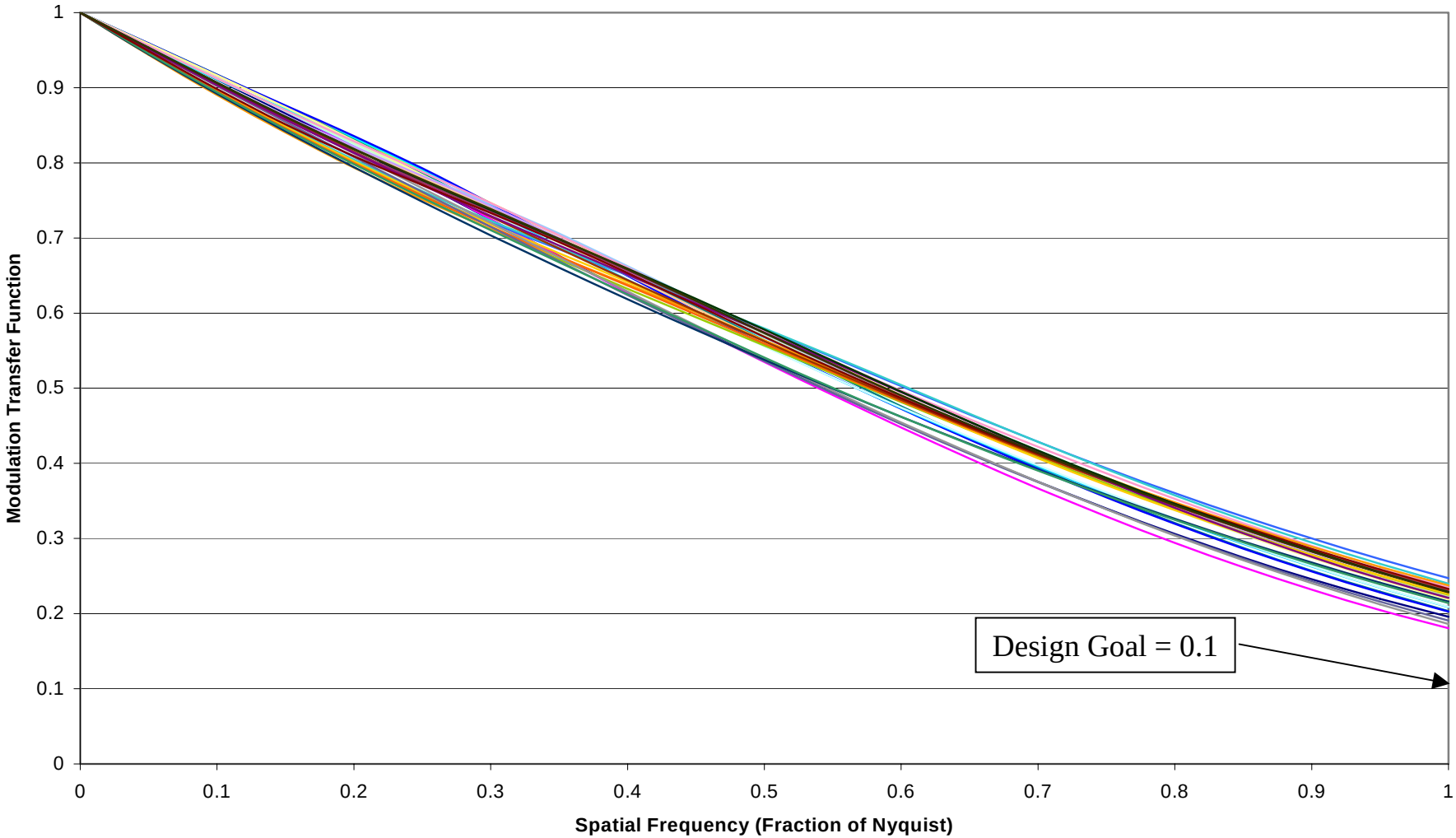
Along-Track LSF Measurements



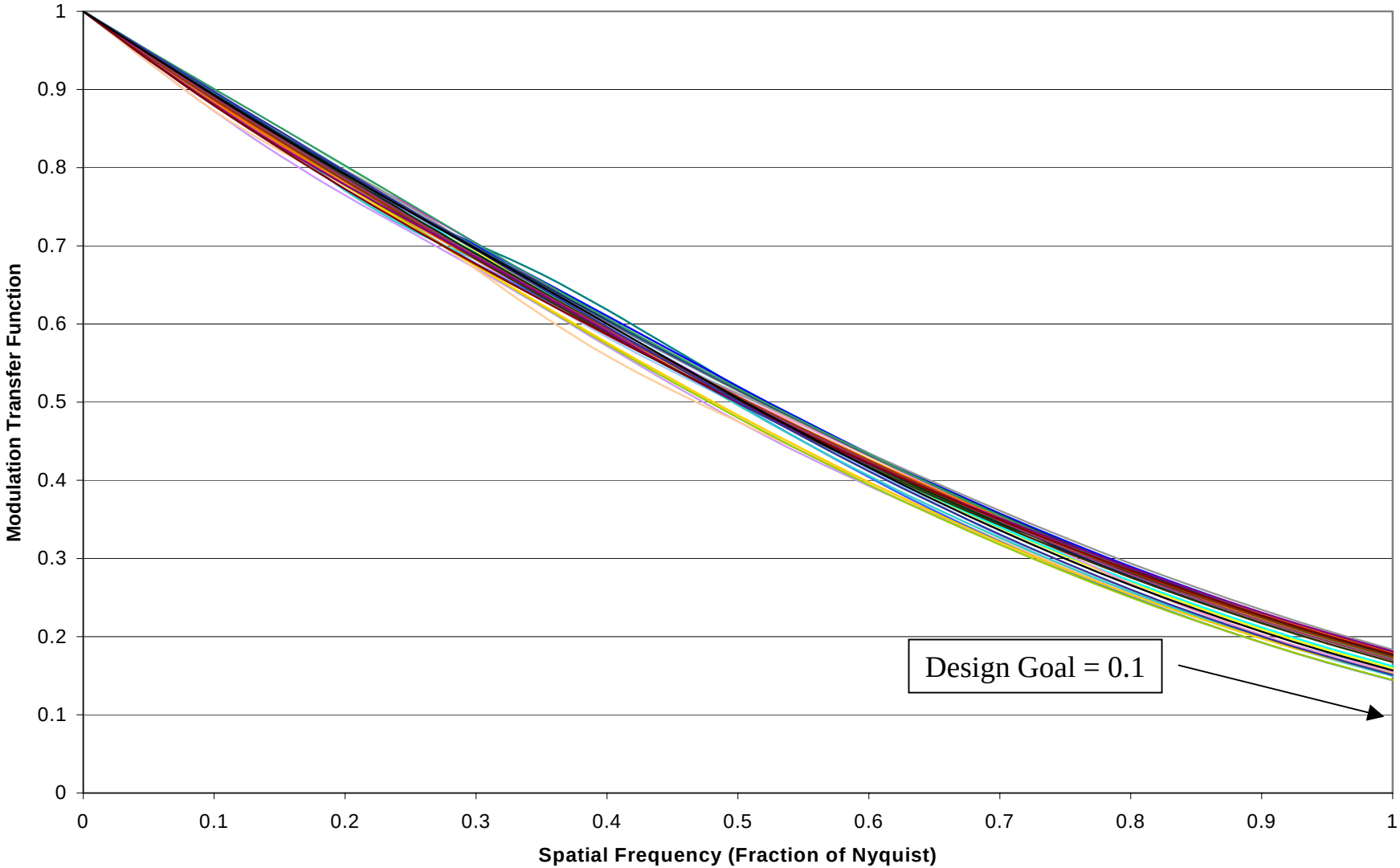
Average Line Spread Functions



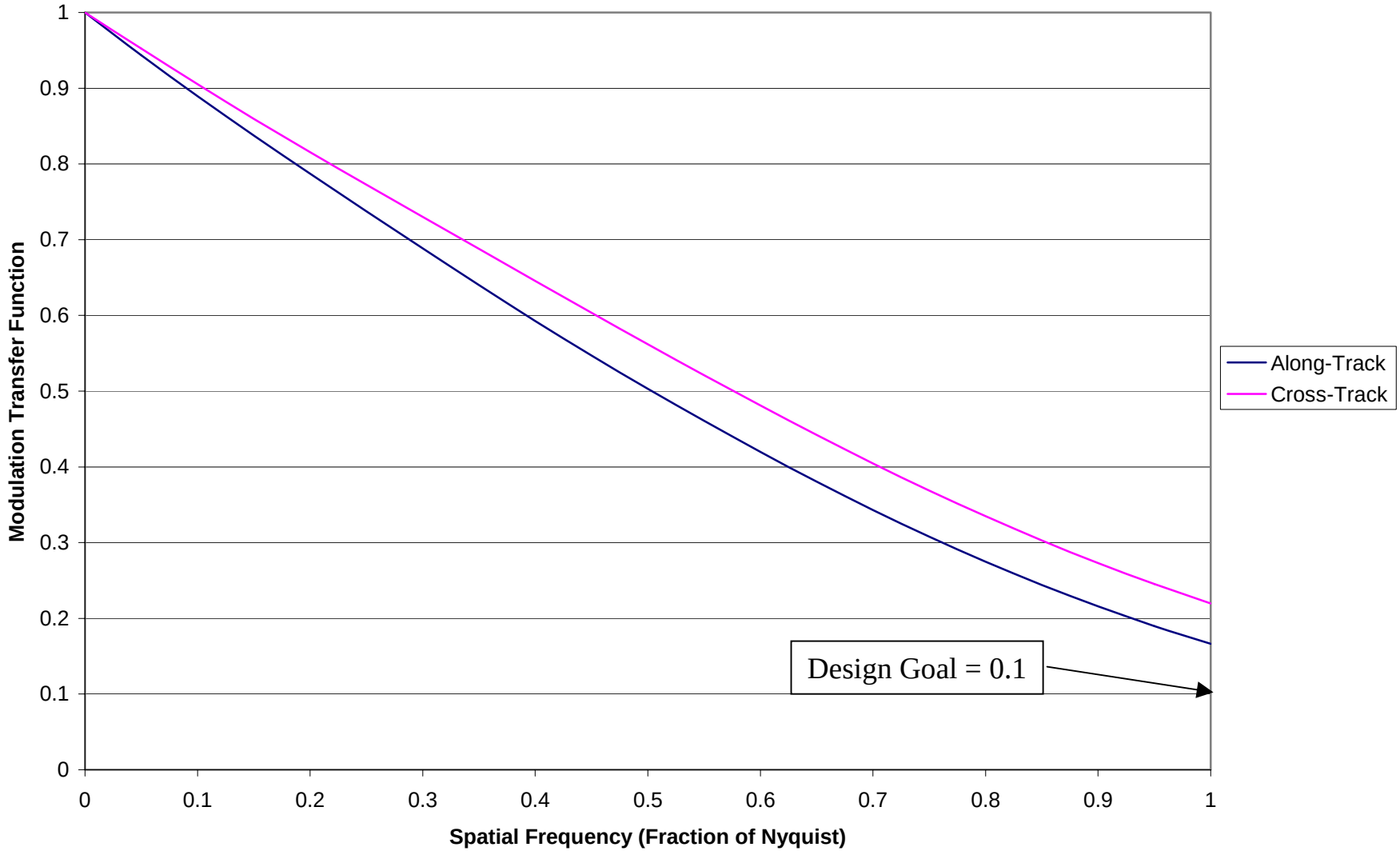
Cross-Track MTF Measurements



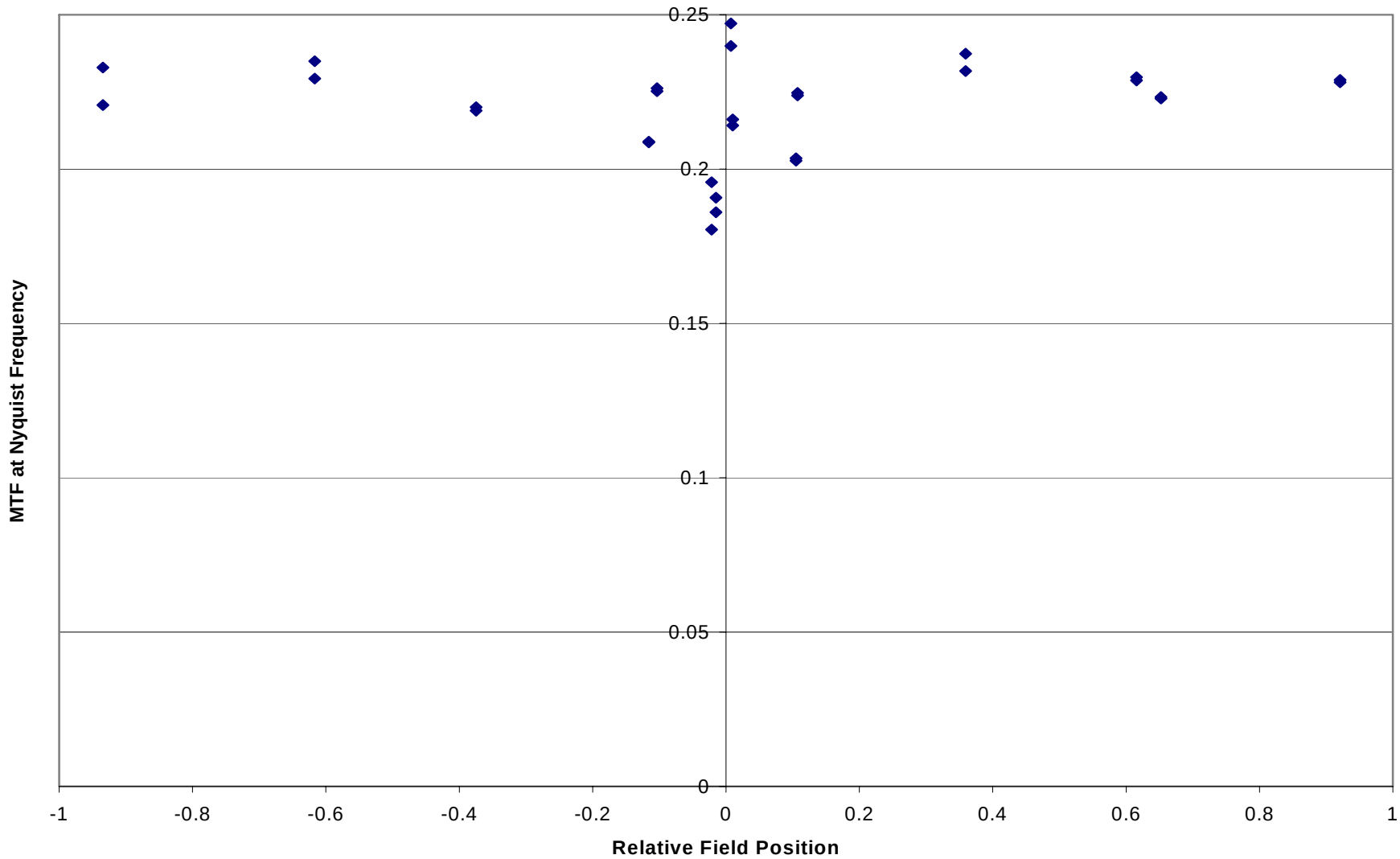
Along-Track MTF Measurements



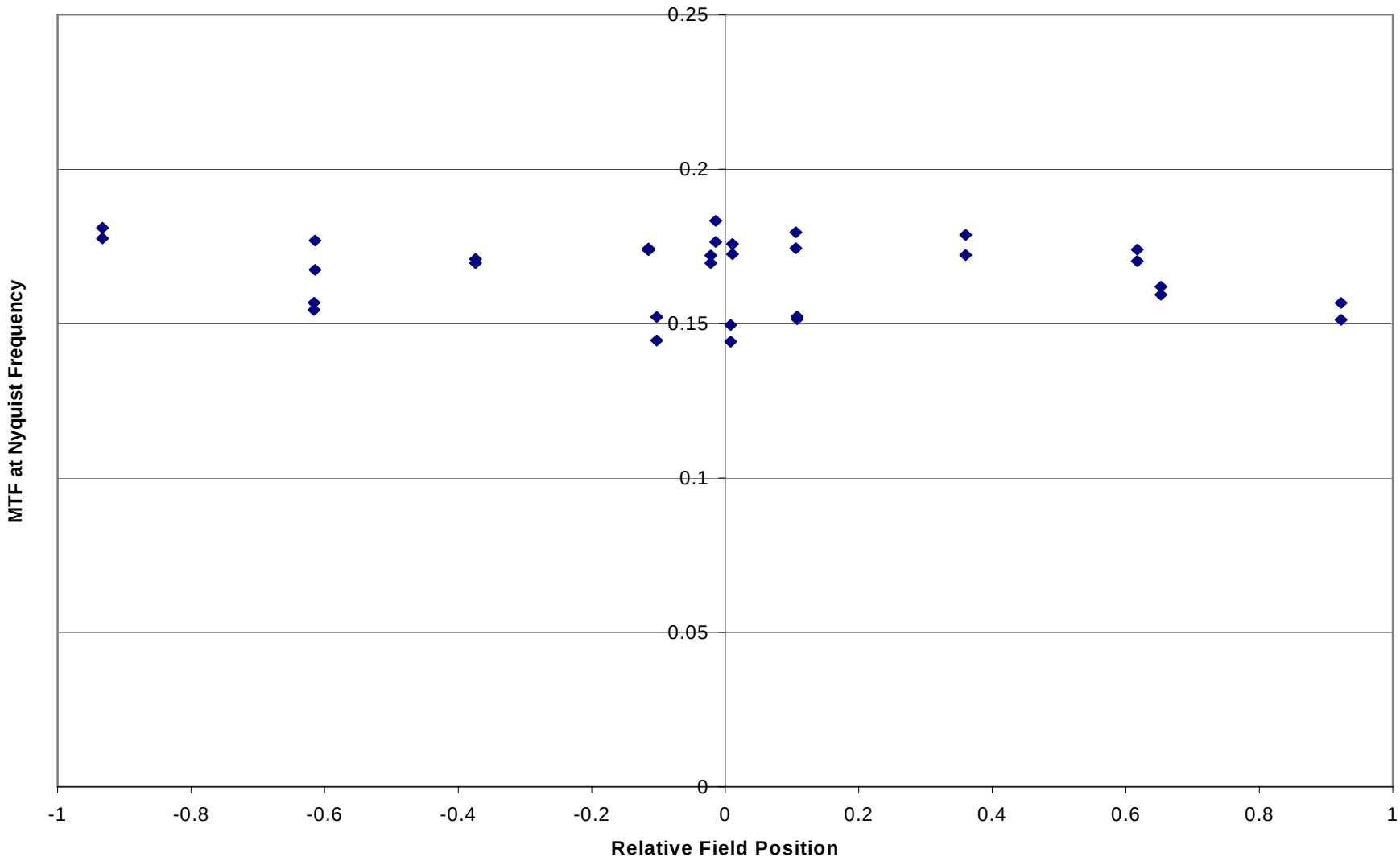
Average MTF Measurements



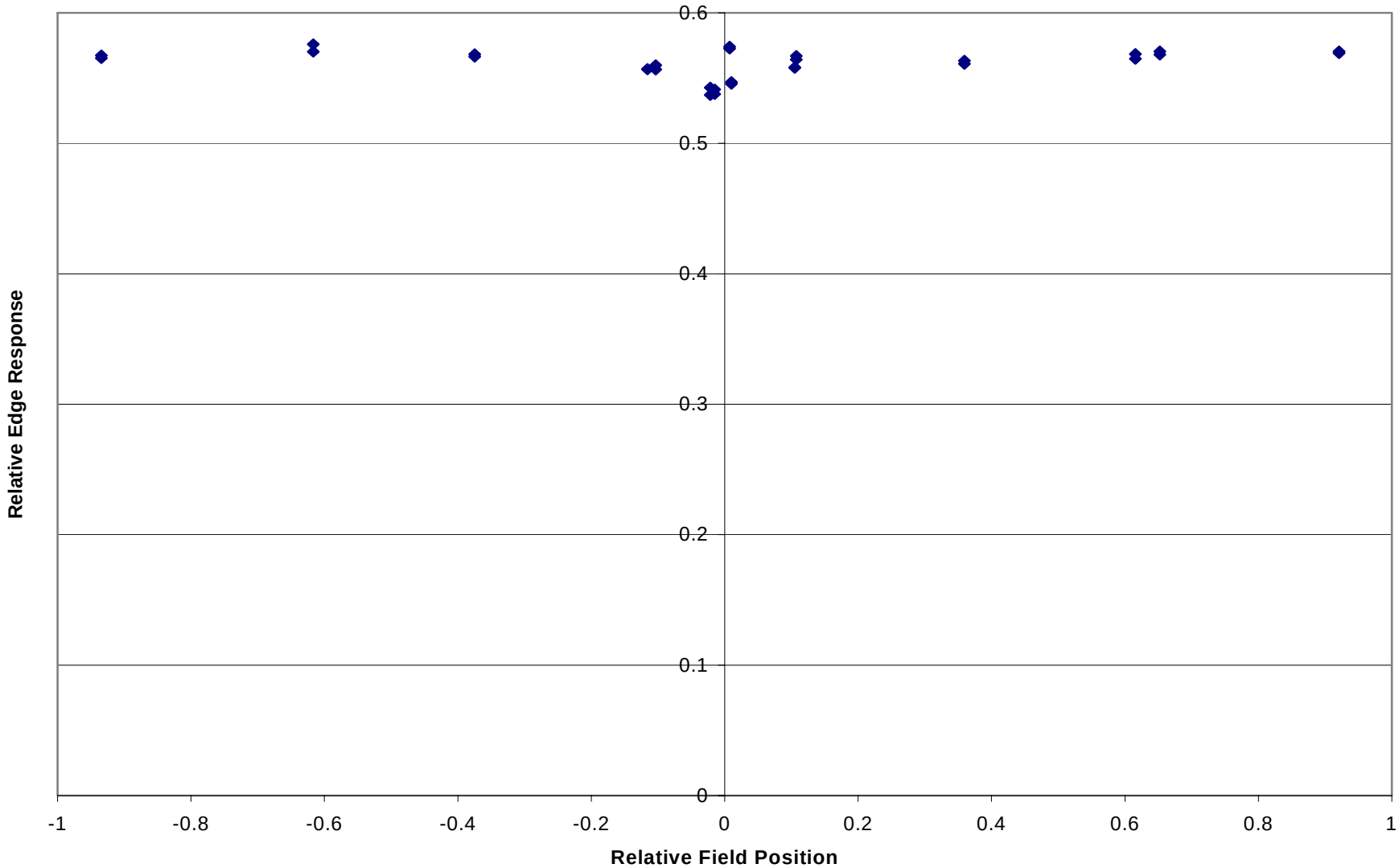
Cross-Track MTF at Nyquist Is Consistent Across Field of View



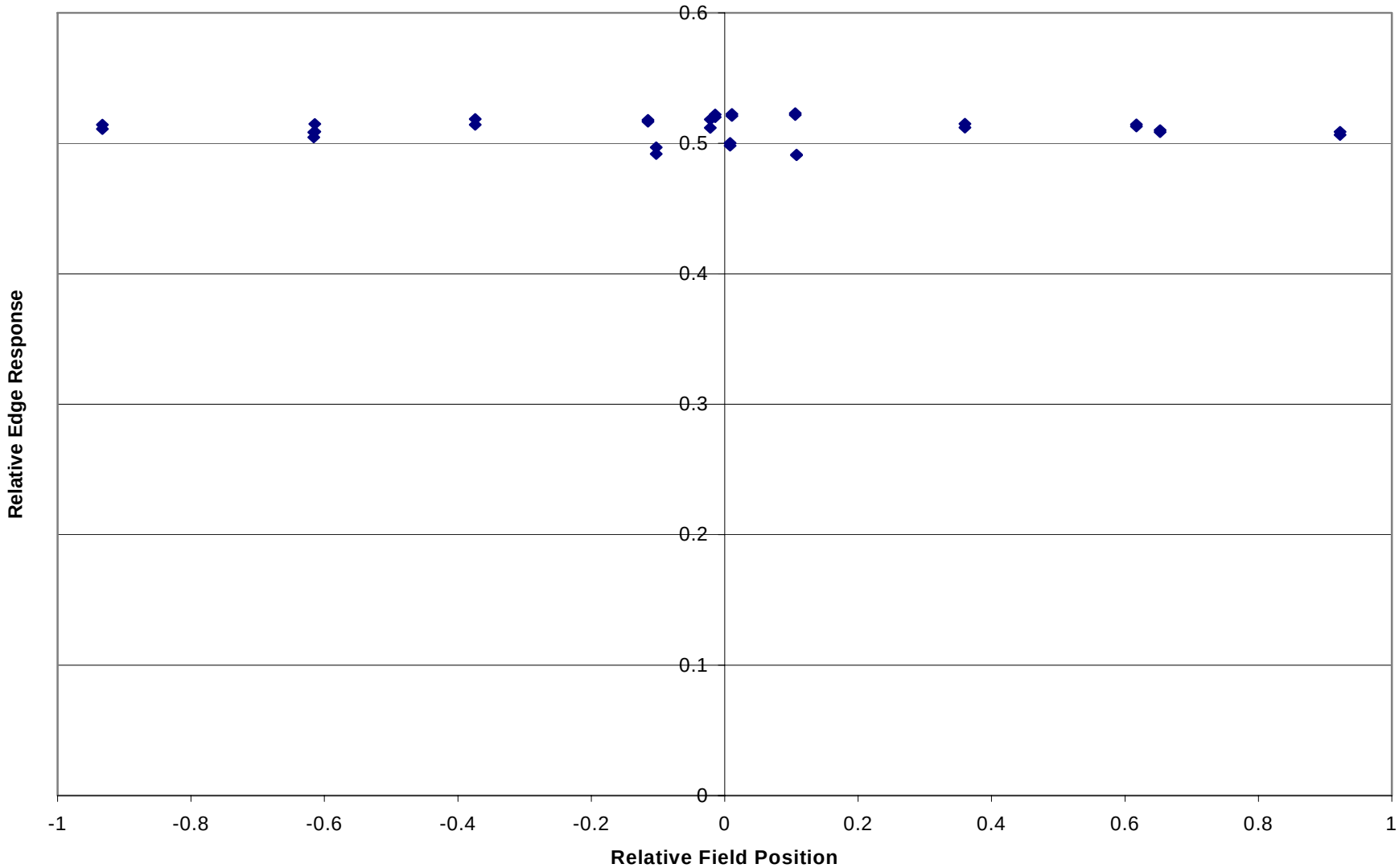
Along-Track MTF at Nyquist Is Consistent Across Field of View



Cross-Track RER Is Consistent Across Field of View



Along-Track RER
Is Consistent Across Field of View



Summary of Results

- Average MTF at Nyquist Frequency
  - 0.219 ± 0.016 Cross-Track
  - 0.166 ± 0.012 Along-Track
  - 0.191 Geometric Mean
  - Design goal of > 0.1 MTF at Nyquist exceeded
- Relative Edge Response
  - 0.561 ± 0.011 Cross-Track
  - 0.511 ± 0.009 Along-Track
  - 0.535 Geometric Mean
- Line Spread Function FWHM
  - 1.2 pixels Cross-Track
  - 1.3 pixels Along-Track
- Results consistent over time and across field of view.
- Plan to monitor annually