



Ensquared Energy Budget

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Keck Next Generation Adaptive Optics
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Ensquared Energy Budget

- EE is an Important parameter for characterizing Integral Field Unit performance
- Is not necessarily tied to Strehl, for example the tip/tilt performance can be relaxed for large “spaxels”
- This presentation:
 - Ensquared energy as a function of
 - Number of actuators across (d/r_0)
 - Science wavelength λ
 - Strehl S
 - Wavefront Error σ_ϕ^2 in nm
 - Tip/Tilt variance σ_{TT}^2 in mas
 - Comments on Sky Coverage



PSF Modeling

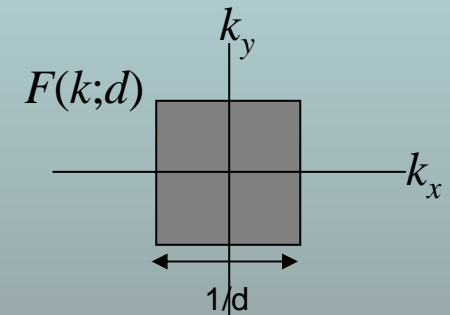
- Study is presently limited to fitting error and tip/tilt error
- Fitting error is modeled as filtered Kolmogorov turbulence:

$$S_{\tilde{\phi}}(k) = [1 - F(k; d)]^2 S_{\phi}(k)$$

$$S_{\phi}(k) = 0.027 r_0^{-5/3} k^{-11/3}$$

$$D_{\phi}(r) = FT \{ S_{\phi}(k) \}$$

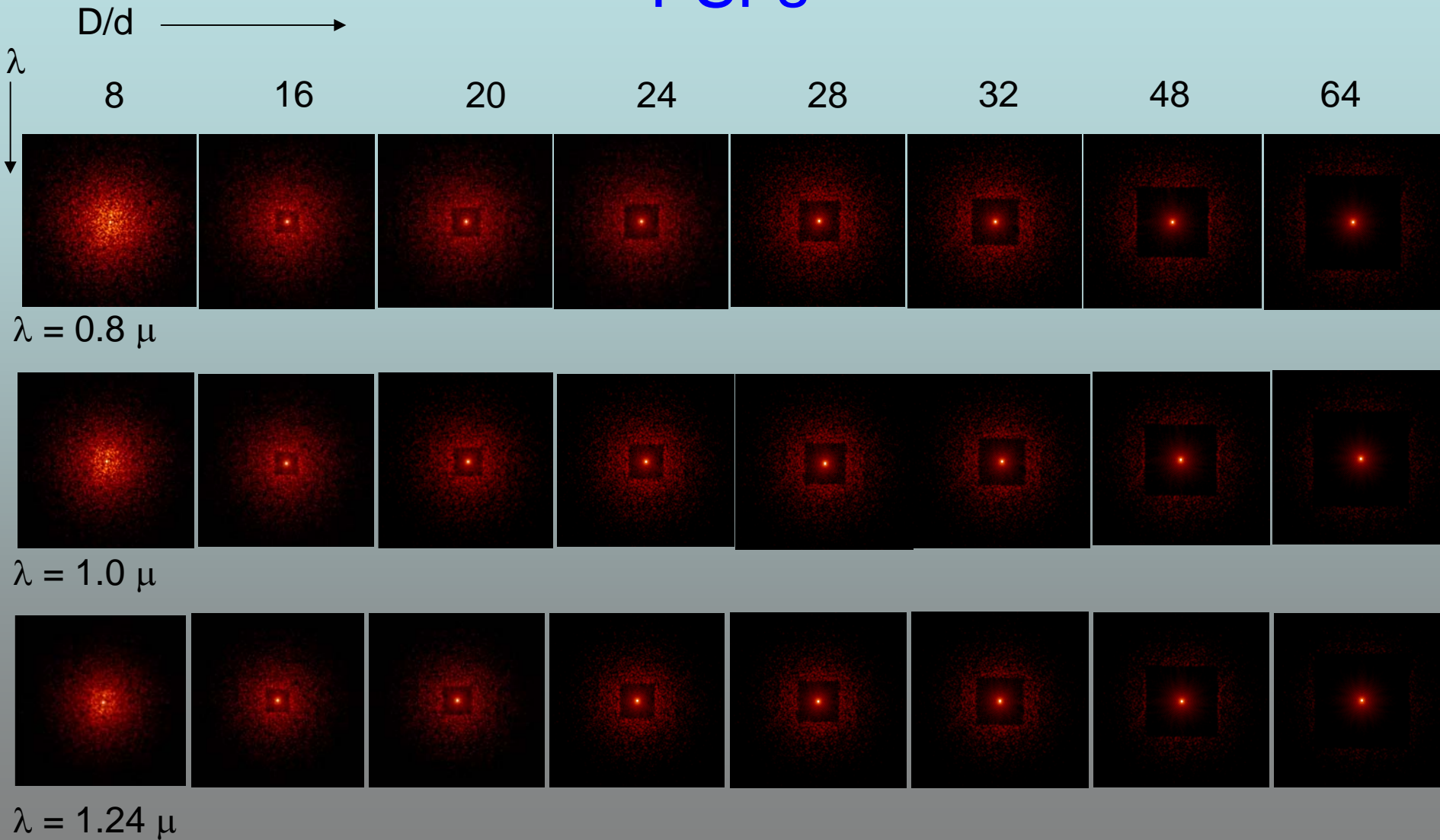
$$PSF(\theta) = \left[MTF(\text{telescope}) \times FT \left\{ e^{-\frac{1}{2} D_{\phi}(r)} \right\} \right]^2$$



- Tip/Tilt error is modeled as a Gaussian blur of the AO-corrected PSF
- We use $D = 10$ m, $r_0 = 16$ cm



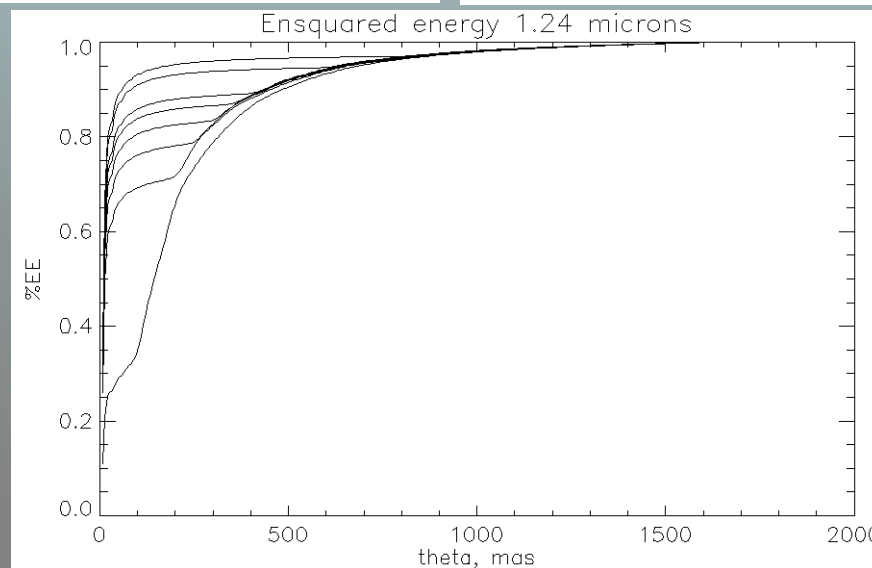
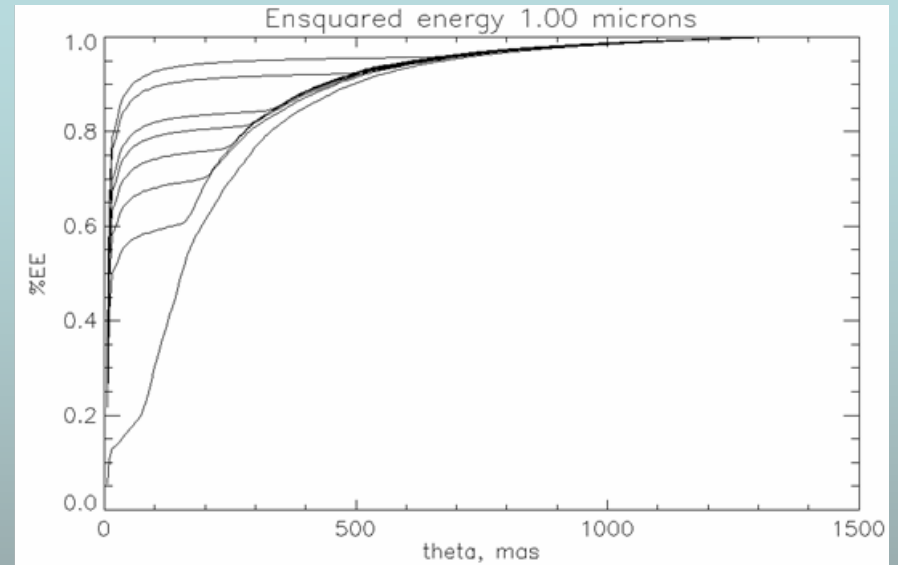
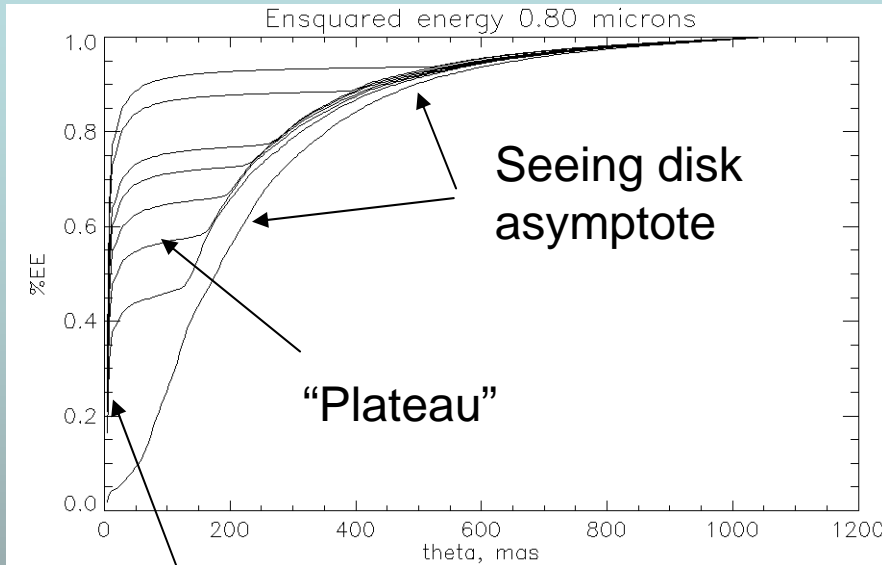
PSFs





Ensquared Energy

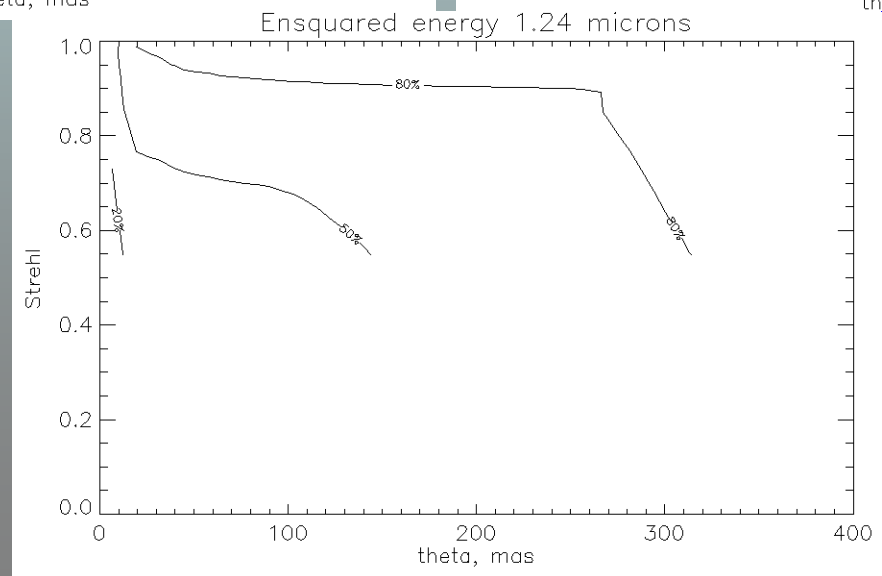
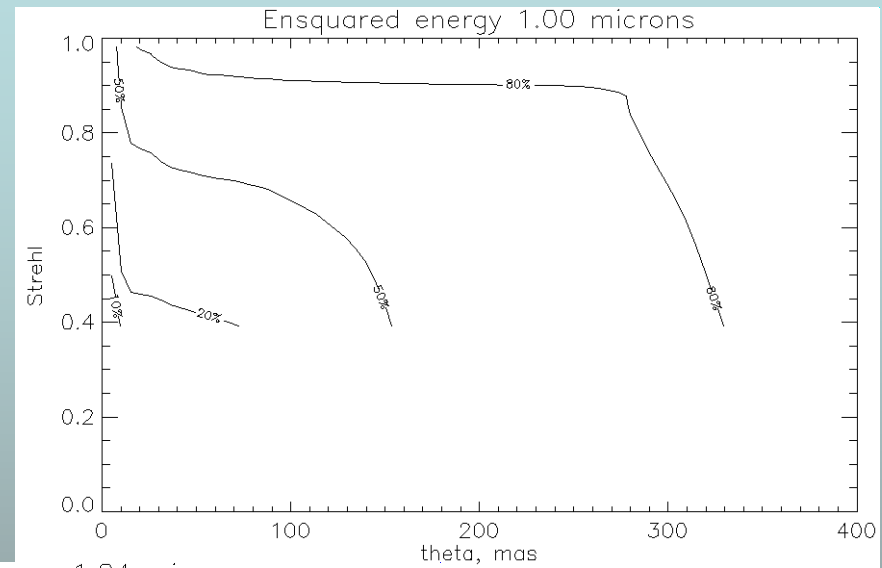
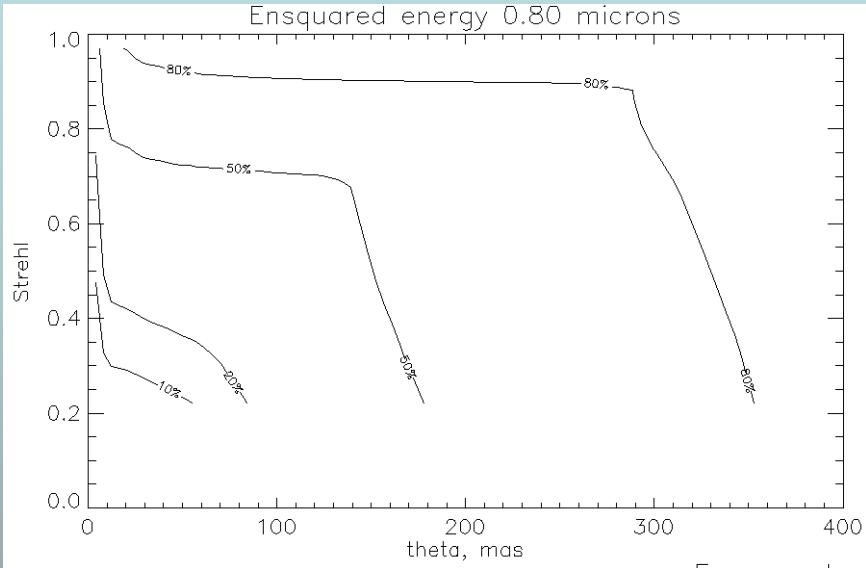
Dominated by core, plateau, and then seeing disk





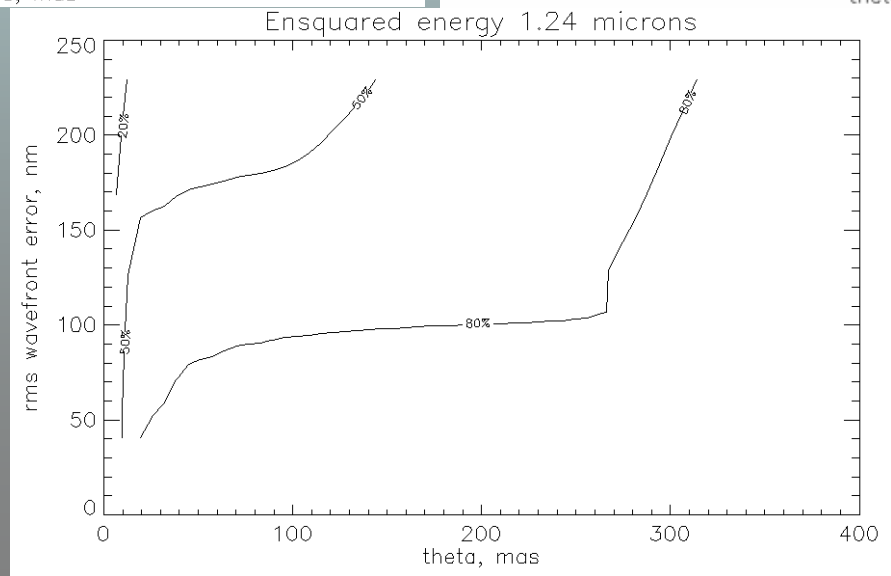
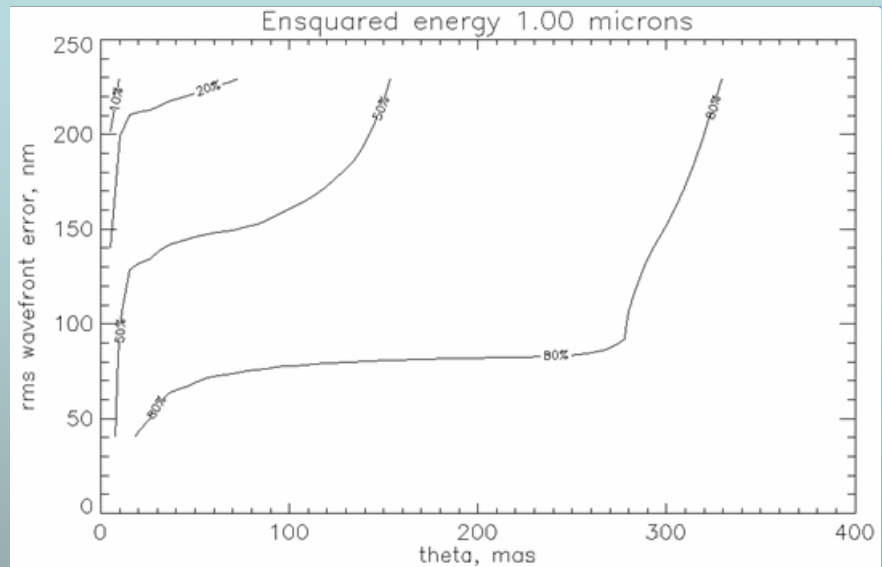
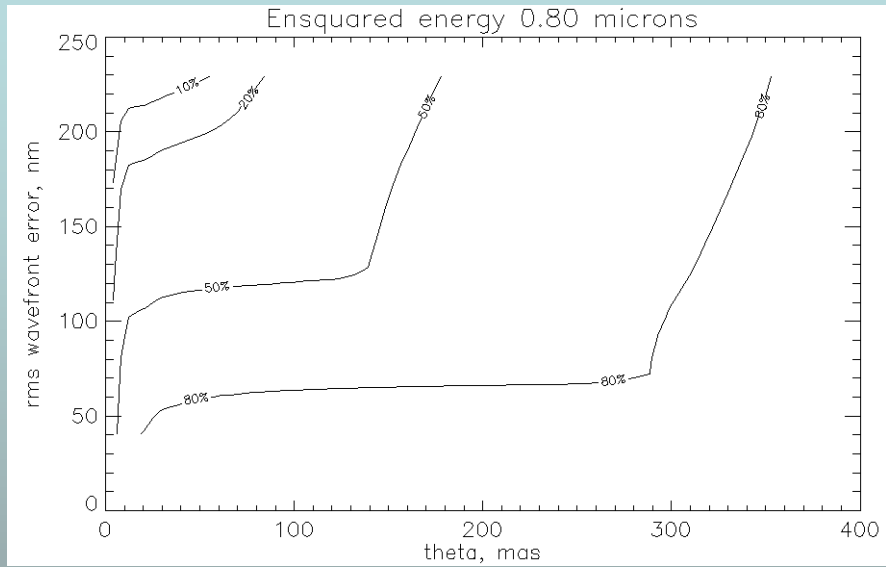
Contours of Ensquared Energy

plotted vs (Strehl, θ) – they're essentially insensitive to wavelength



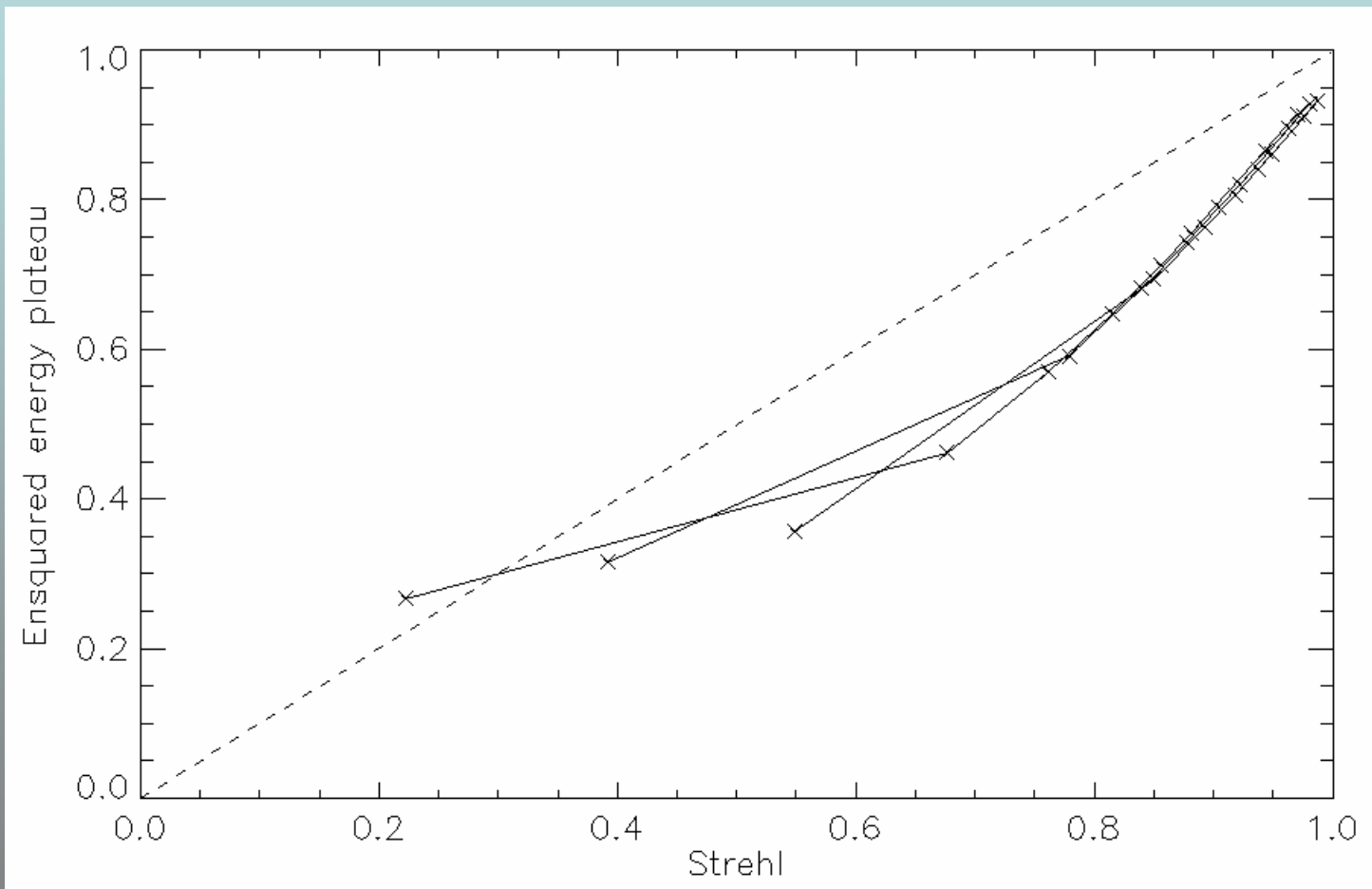


Contours of Ensquared Energy plotted vs (wfe, θ)





EE does not track Strehl as closely as it did for a 30m aperture

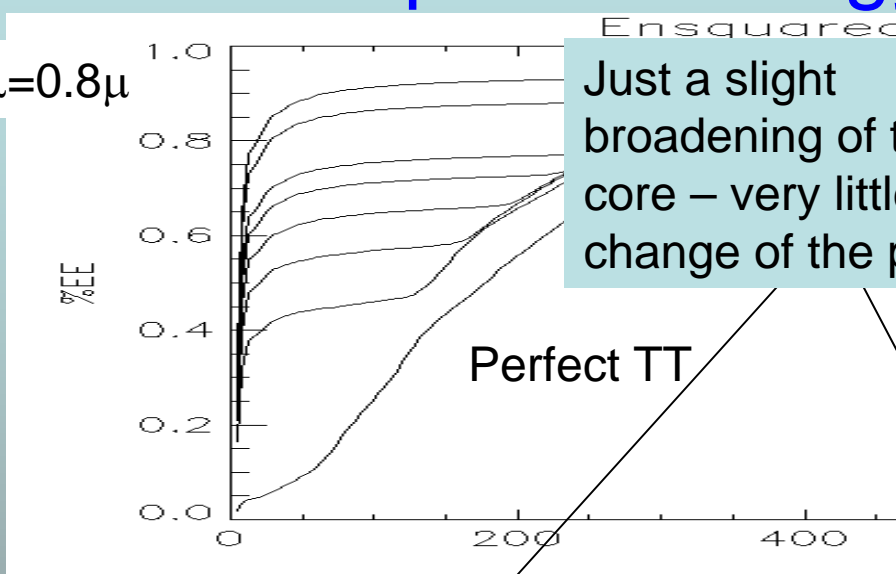




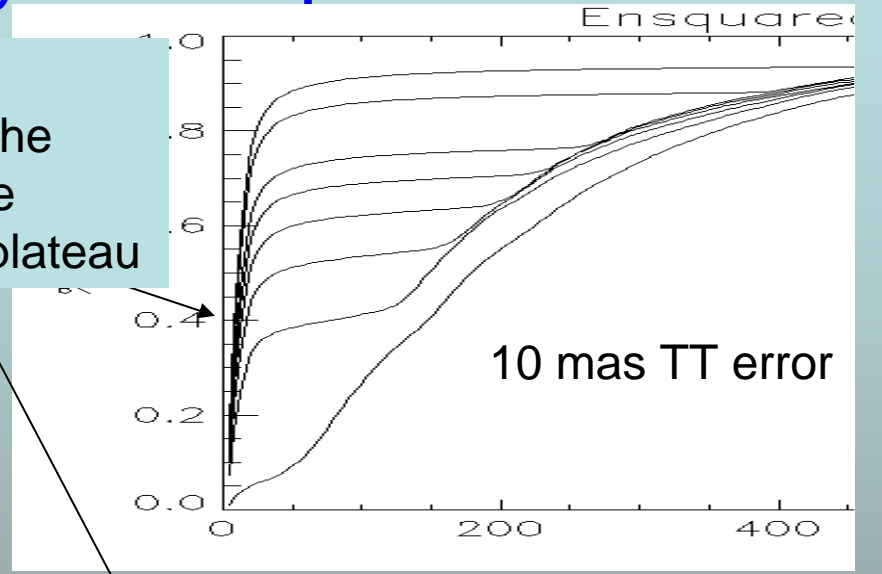
Ensquared Energy with Tip/Tilt Blur

$\lambda=0.8\mu$

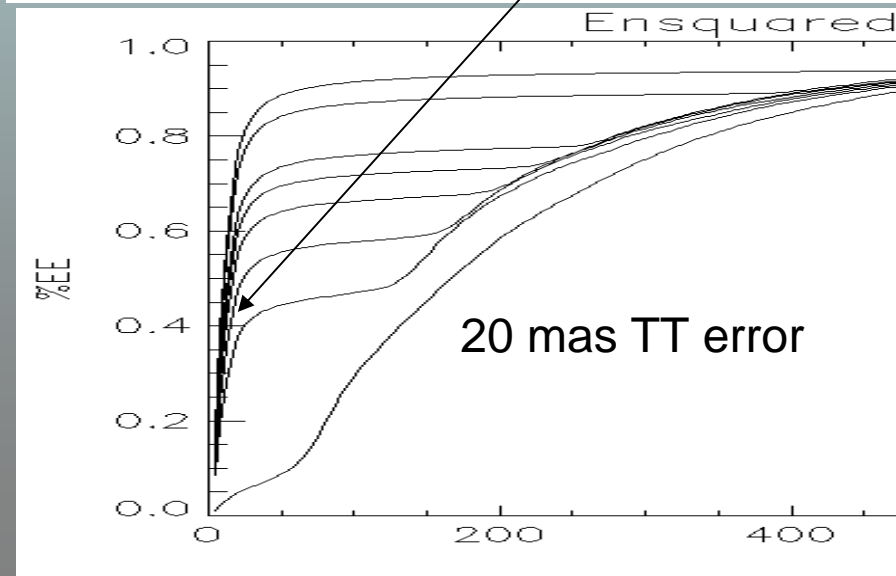
Just a slight broadening of the core – very little change of the plateau



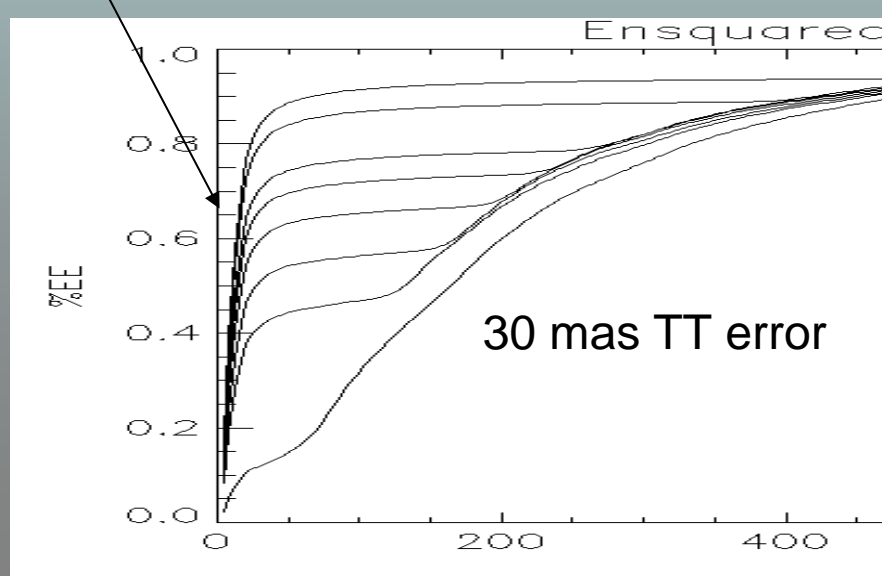
Perfect TT



10 mas TT error



20 mas TT error



30 mas TT error

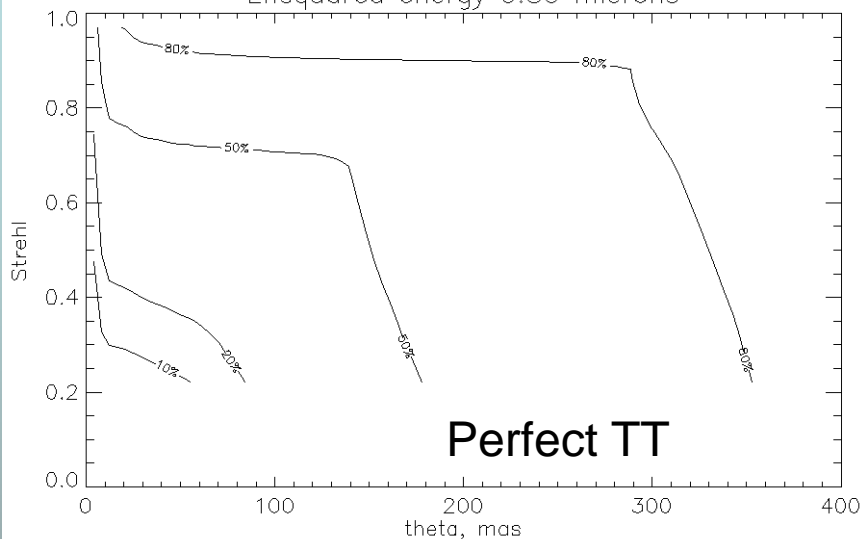


Ensquared Energy Contours

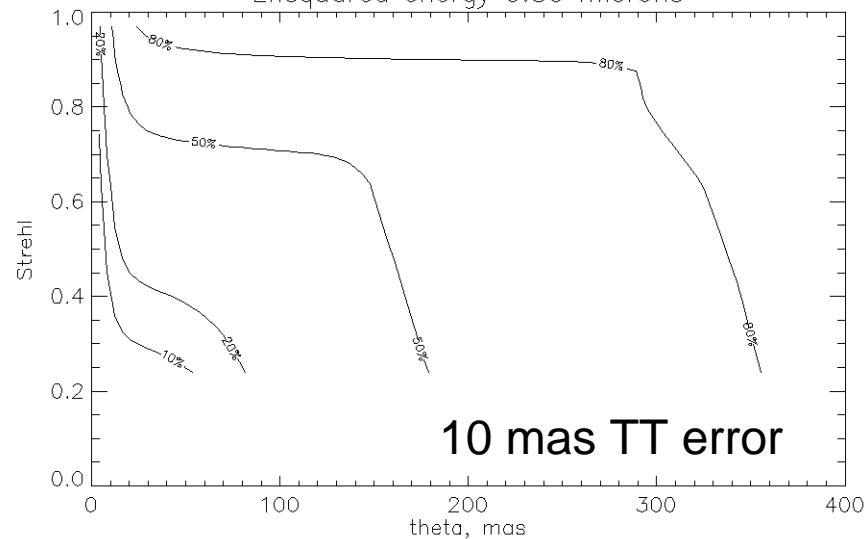
with Tip/Tilt Blur – hardly any effect in the plateau region

$\lambda=0.8\mu$

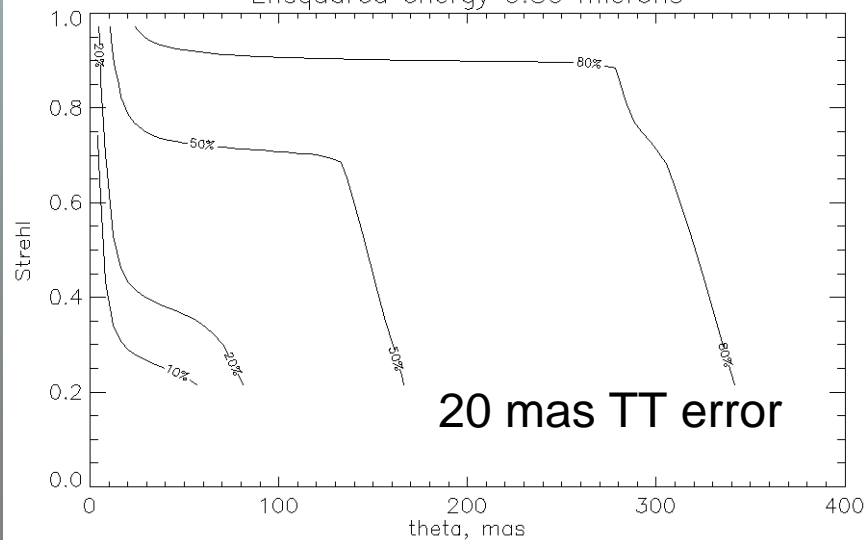
Ensquared energy 0.80 microns



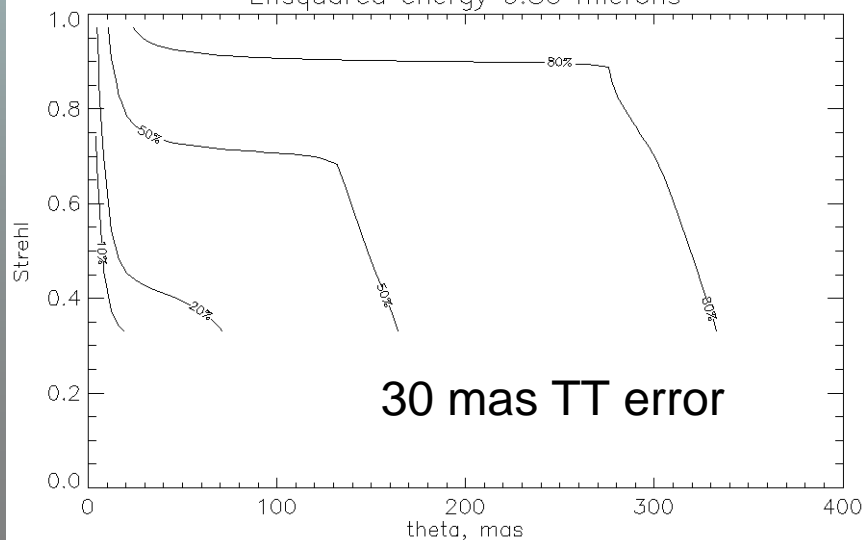
Ensquared energy 0.80 microns



Ensquared energy 0.80 microns



Ensquared energy 0.80 microns





Sky Coverage and Conclusions

- How do we condense all this information into a viable “ensquared energy budget”
- Sky coverage:
 - If we are interested in 2 x DL spatial resolution of the IFU, then 30 mas tip/tilt is tolerable
 - From TT star statistics, this is about 40% sky coverage (if I’ve used Rich’s spreadsheet correctly) compared to 5% in a 142 nm [high-order] / 184 nm [High order + Tip/Tilt] error budget