

Aperture vs. Field of View Optimization – An Argument for Wider Field?

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Existing Design is Impressive!

- Large aperture, wide field
- Flat focal plane
- High throughput

- Can we perhaps do better?
- What is marginal gain vs. changes in aperture and field of view?

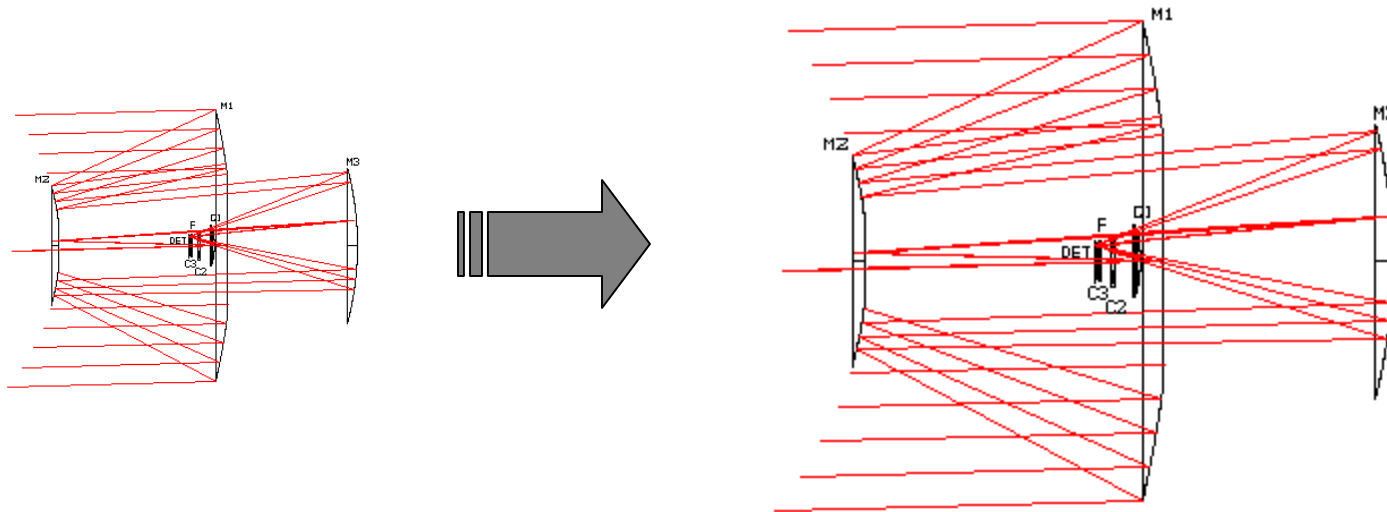
What are the optimal characteristics for LSST?

- Effective collecting area of $D \sim 6.5\text{m}$ constrained by streaking considerations for Near Earth Asteroids of interest, in $\sim 10\text{-}20$ sec integrations.
- For most surveys, can define Survey Figure of Merit, essentially number of sources/time

$$SFOM = \frac{\rho \phi_{source}^2}{SNR^2} \frac{\Omega D^2 \epsilon d}{\sigma^2 \phi_{sky}}$$

Scaling Arguments - Aperture

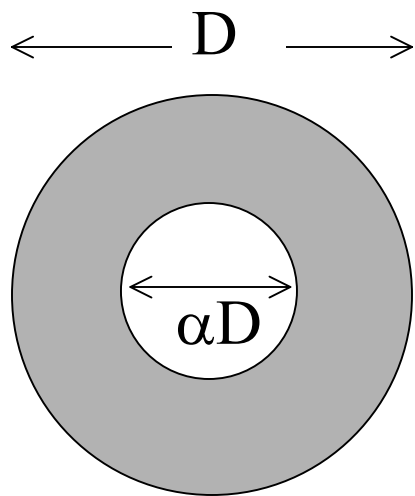
- In the limit of geometrical optics, encircled energy angles are invariant under rescaling system length scale, so optical performance at fixed FOV is independent of aperture! (Plate scale does change, of course...)



Scaling Arguments- Field of View

- Optical performance as FOV is varied is more complex.... We have considered marginal performance gain as FOV is varied, at fixed aperture.
- SFOM favors large collecting area, with wide FOV. At fixed aperture there is a tension between these.

Optimization of Optics to Maximize SFOM



Collecting Area $A \sim D^2(1-\alpha^2)$

Instrument Area $\Omega \sim (D\alpha)^2$

Vignetting $\varepsilon \sim 1/\alpha$

Overall goal is to optimize $SFOM \sim A\Omega\varepsilon$

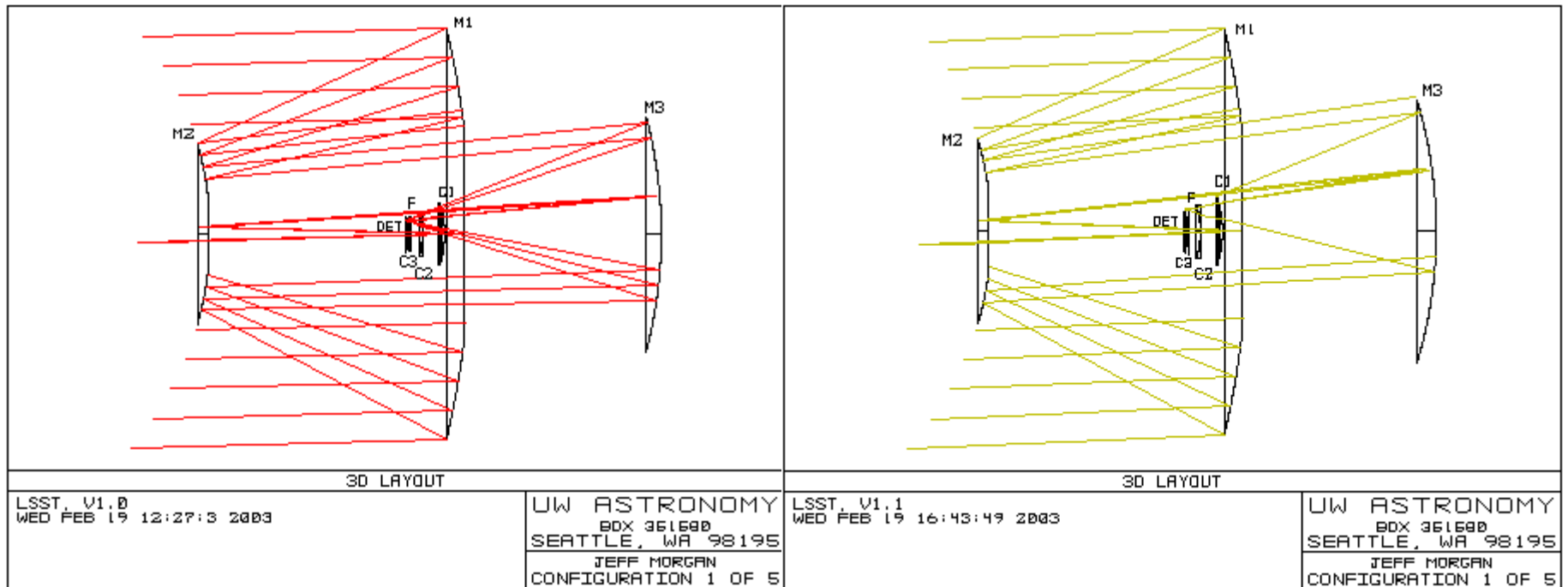
$A\Omega\varepsilon \sim [D^2 (1-\alpha^2)] \alpha D^2 = D^4(\alpha-\alpha^3)$

$d(A\omega\varepsilon)/d\alpha = 0 \Rightarrow \alpha^2 = 1/3$

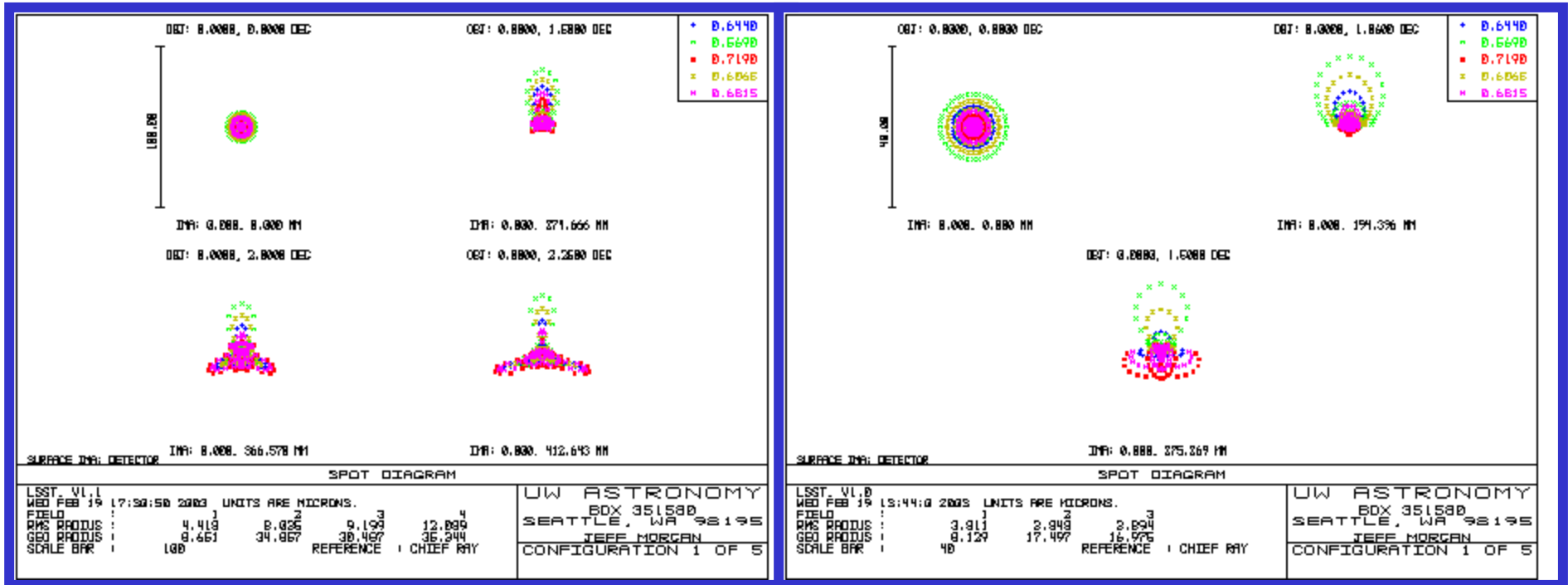
Should we consider wider field?

- Considerations:
 - Aberrations vs. FOV.
 - Baffling, stray light issues
 - System implications
 - Camera gets more ambitious!
- Our tentative conclusion: much to be gained from considering wider field of view!

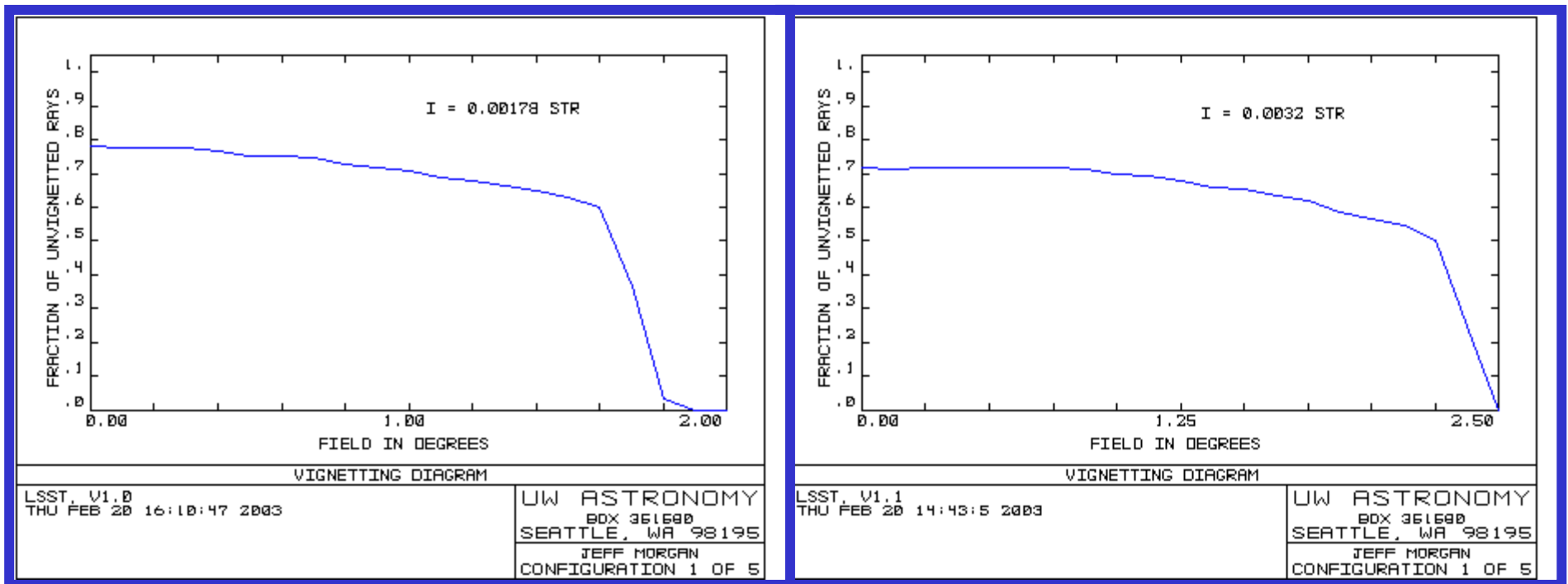
An existence proof of a wider field design



Spot diagram comparison – still subdominant under most conditions



Throughput vs. Field Angle comparison



Big potential gain in Survey Relative Figure of Merit!

$$RM = \frac{(1 - \alpha_2^2) I_2}{(1 - \alpha_1^2) I_1} \sim 1.7$$

Aperture effect

2-d Angle-integrated throughput

Summary

- Existing design is powerful- can we do better?
- Potential system-level gains for wider field are large, and probably merit further consideration.
- Such work would need to address:
 - Baffling, stray and scattered light
 - Camera gets more ambitious
 - Cost-optimized design vs. performance optimized
 - Tradeoffs/benefits for different science goals
(needs more input from LSST Science Working Group, though!)
- Many thanks to the entire LSST team for their input and support for this effort.