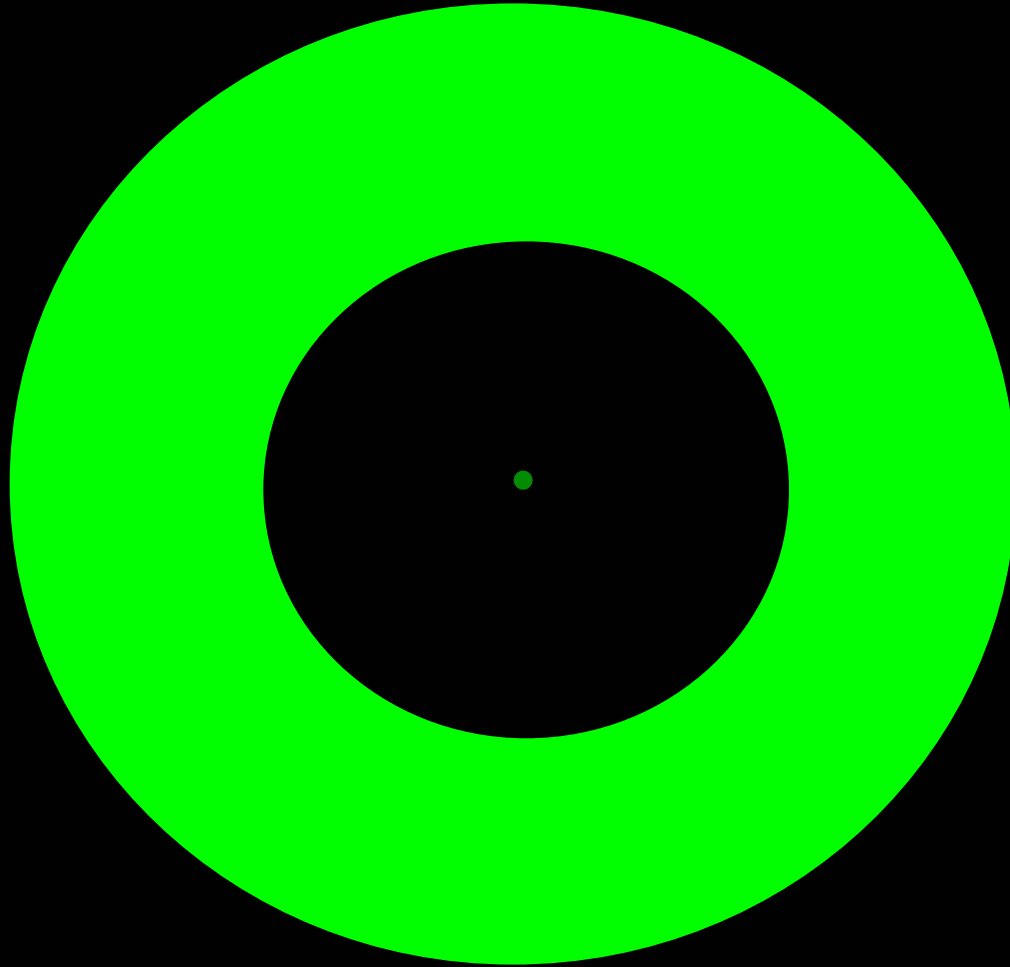


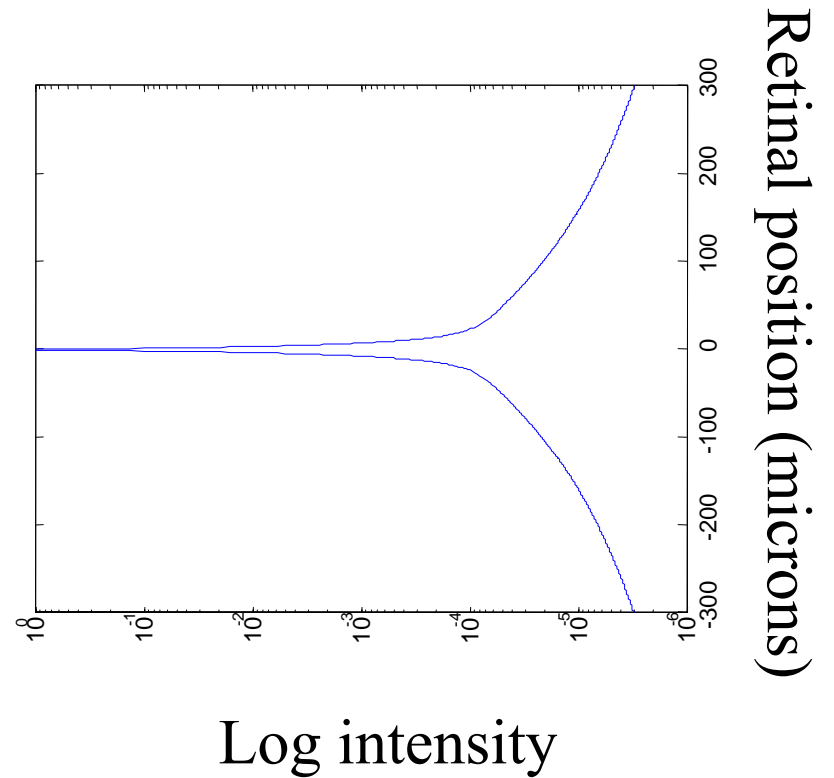
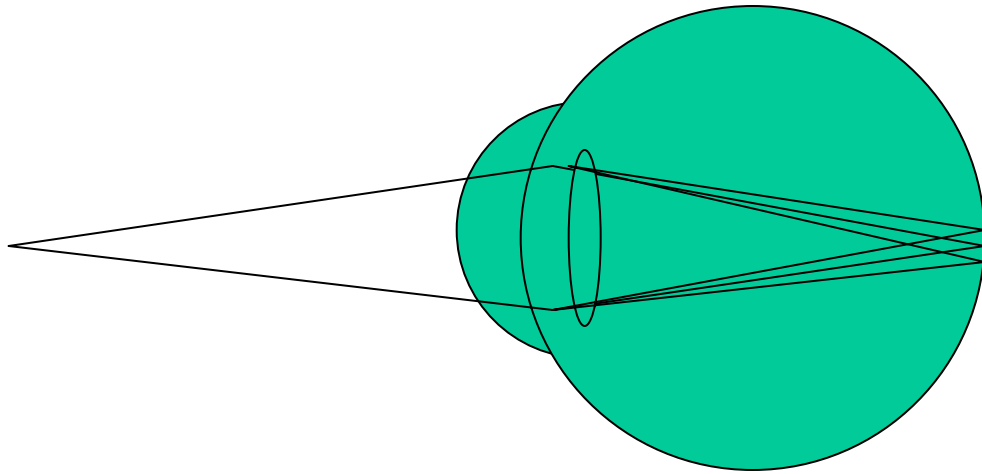
The black hole glare test for retinal light spread



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Point-spread function

Amount that the image of a point of light is spread by the eye's optics (cornea, lens, vitreous)



Physical measurements of point-spread function

- **Wavefront aberration** – measure distortion in wavefront reflected from the retina.
- **Double pass imaging** – view image of a point reflected from the retina.

Limitations:

- Reflections are not a direct measure of visually significant glare (they do not occur exclusively at the photoreceptors).
- Scattering behind the retina inflates the double-pass light spread at intermediate and large angles (several arcmin and up)
- Fail in the tails of the spread function where image intensity is low.

Psychophysical measurements

- **Interferometric contrast sensitivity** – compare sensitivity to undistorted (interferometric) gratings to normally viewed gratings (LeGrand; Campbell and Green; Williams; etc.)
- **Increment thresholds** – Only large visual angles can be assessed (Holladay and Stiles).

Limitations:

These techniques have not been shown to be valid in measuring light spread at intermediate angles.

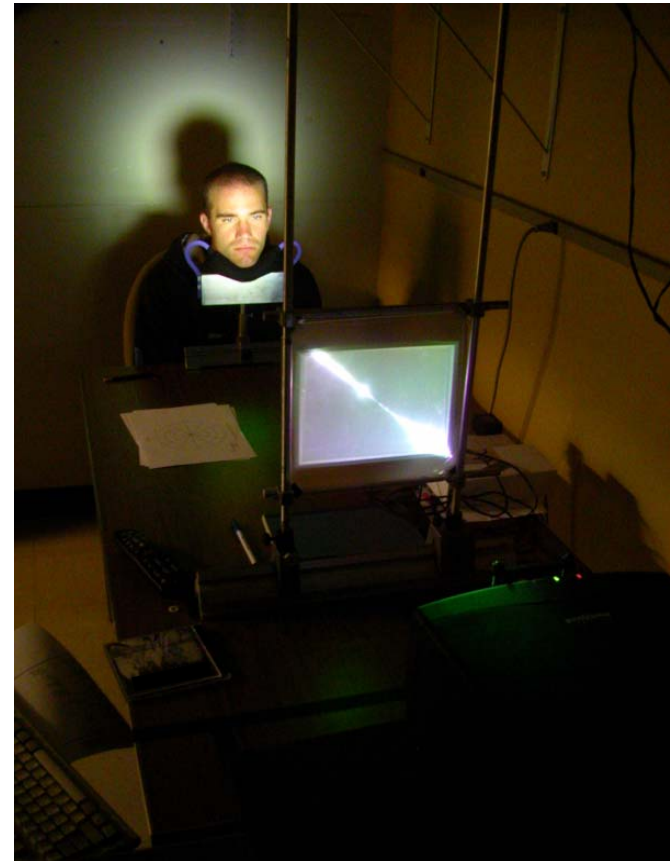
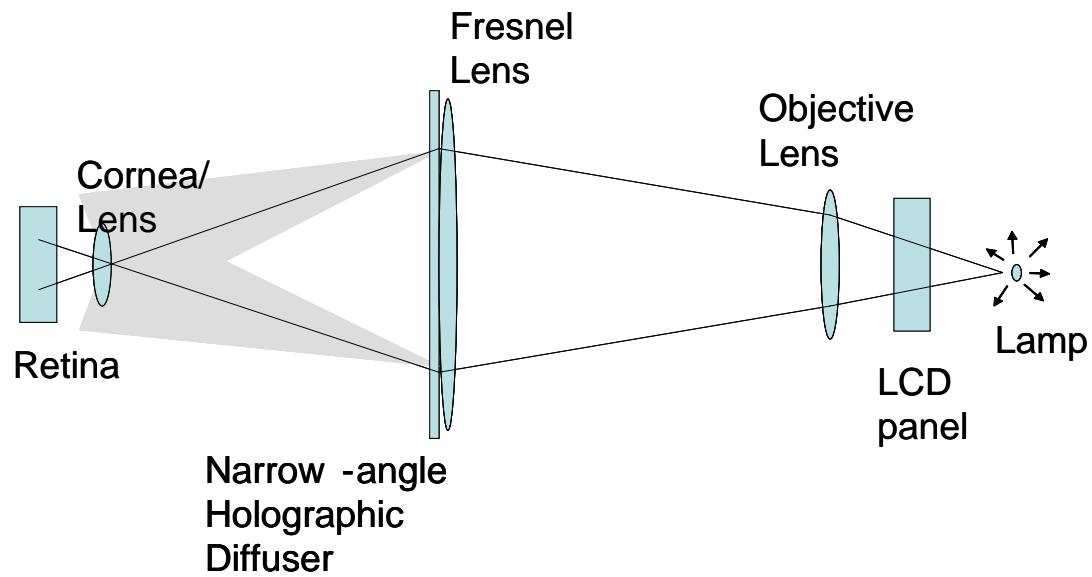
Motivation:

- Practical method valid over few arcmin to few degrees
- Relate to visual problems consistently reported by some percentage of patient (lens replacement, corneal)
- PG radiologist w/ cataracts, lens implant
 - * surgery considered successful (improved acuity)
 - * reported that his job (seeing bright features in a dark surround) was more difficult
 - halos
 - starburst patterns
- similar problems reported by patients after corneal ablation surgeries (night driving)

Extended Maxwellian View

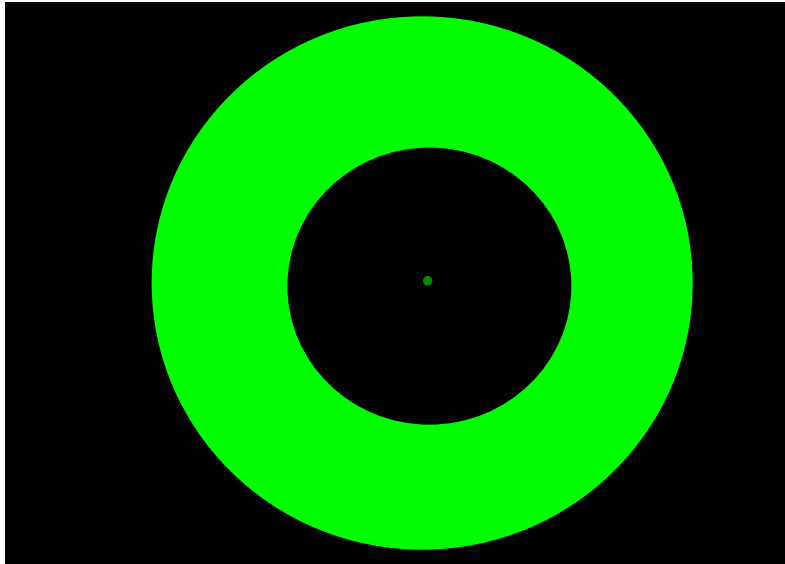
BIGMAX™

10^5 cd/m^2

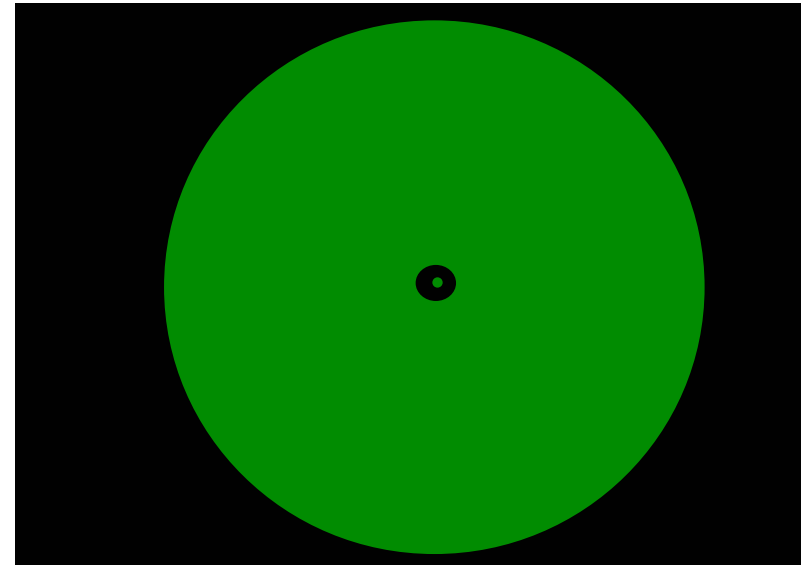


MacLeod & Beer, VSS 2003

Method



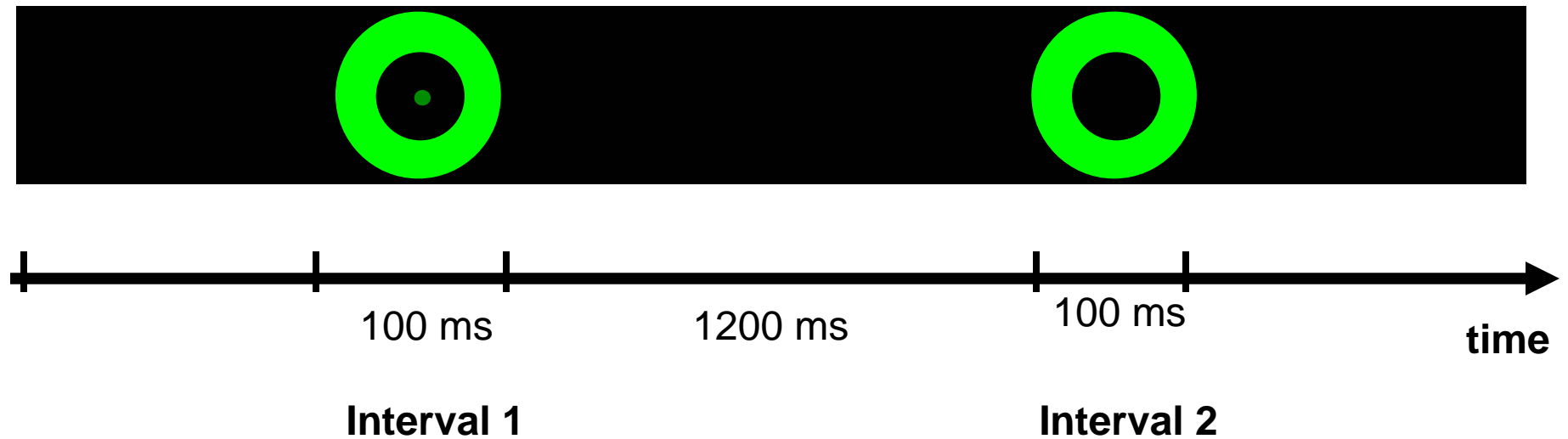
Large hole diameter -
high needed surround intensity



Small hole diameter –
small needed surround intensity

- stimuli similar to Westheimer & Liang
- threshold for test spot set by light falling on retina at test flash location
- measure the amount of light scattered to that location from surround by finding the surround intensity needed for a criterion elevation of threshold.

Method (cont.)

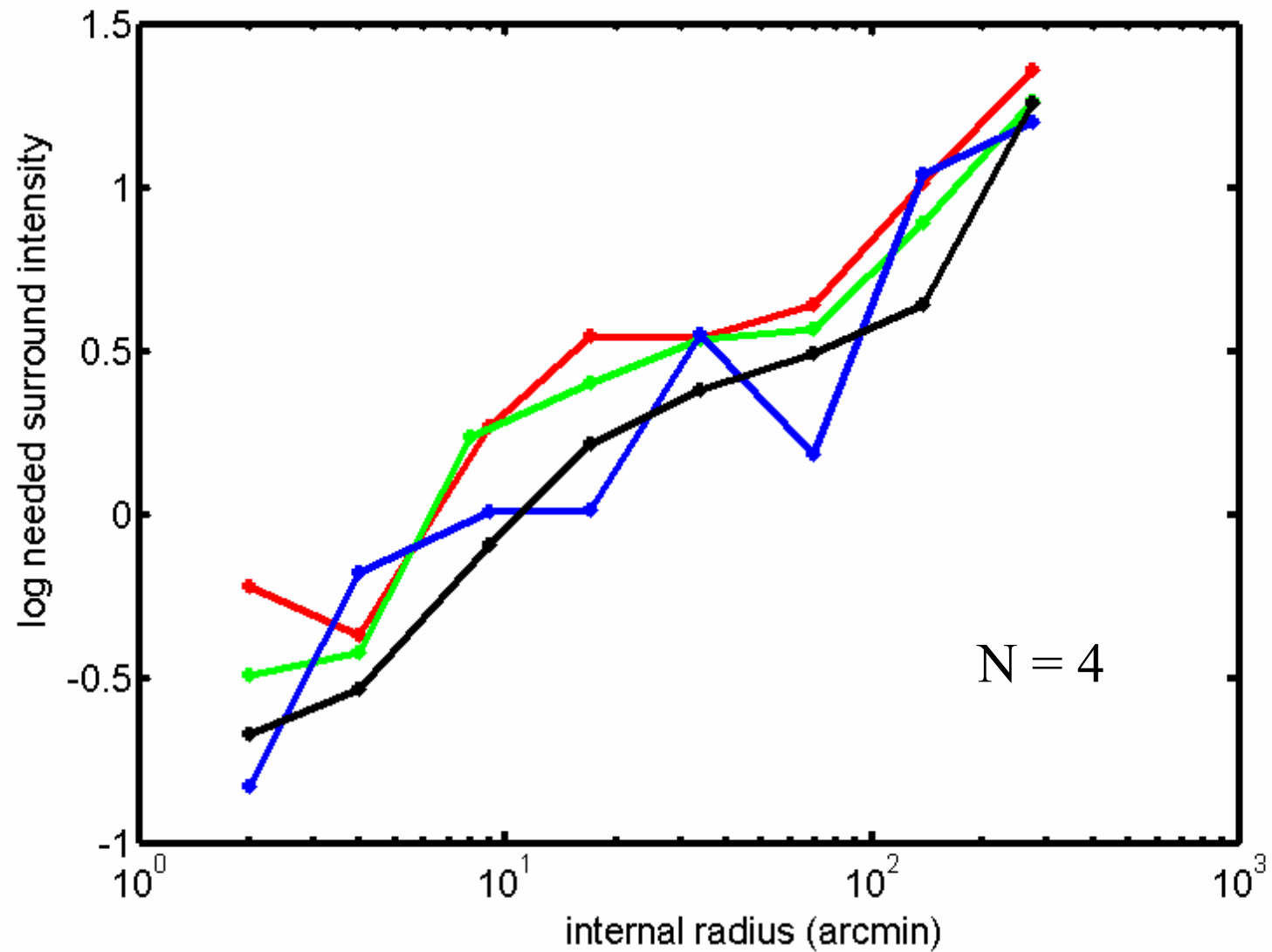


2AFC

flashed surround, unlike W&L

QUEST varied surround intensity, 9 randomly interleaved conditions

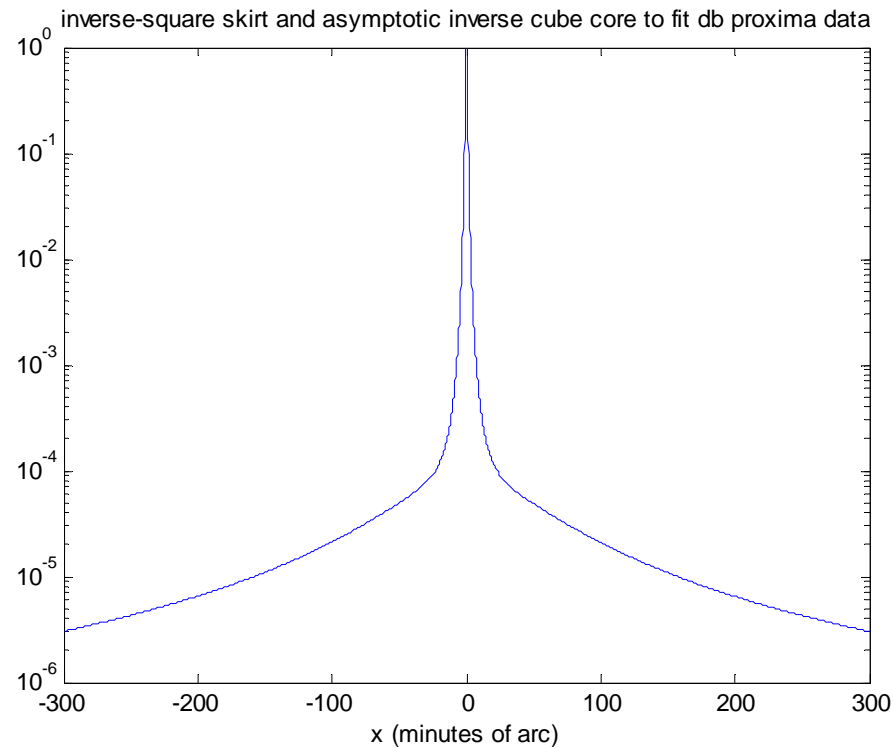
Results (normal subjects):



Model

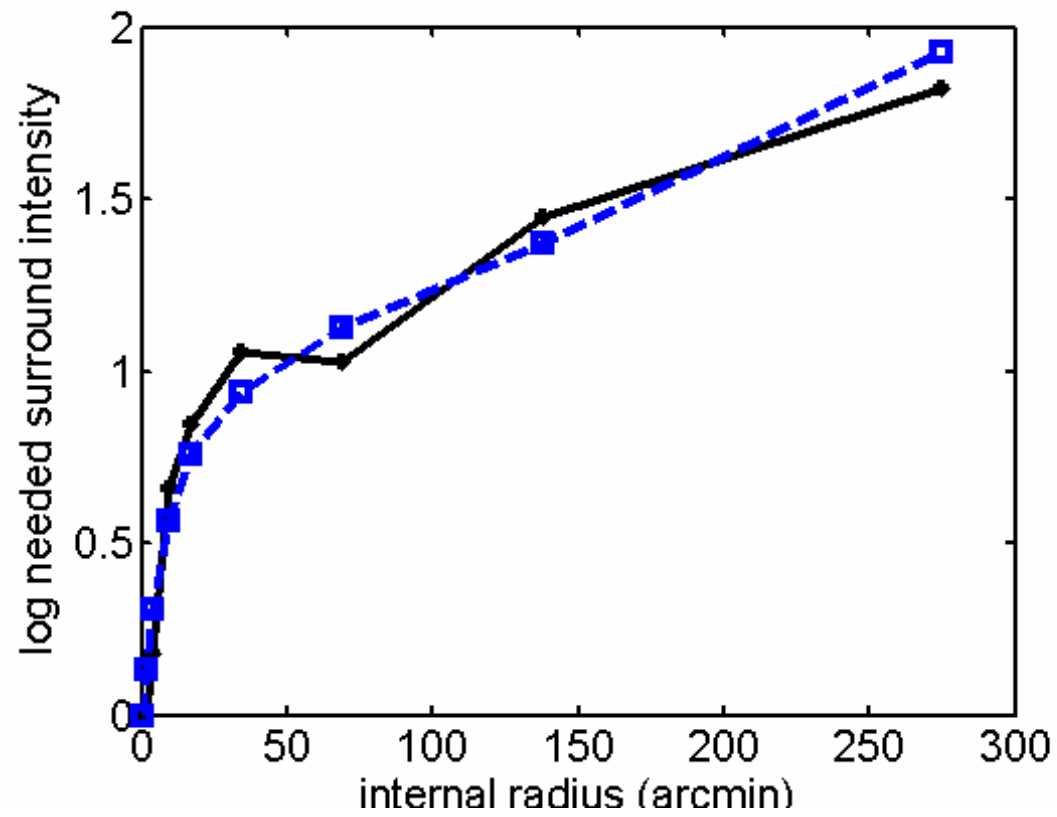
$$\text{NSI} = 1 / \int r * \text{psf}(r) \, dr$$

$\text{psf} = 1 / r^3$ for small radii
 $\text{psf} = 1 / r^2$ for larger radii



core radius
skirt radius (fixed)
skirt weight

Model fit



Comparison to other estimates:

Our data:

* core radius = 2.1 arcmin

* proportion of light at 1 deg = $0.85 \times 10^{-6} / \text{arcmin}^2$

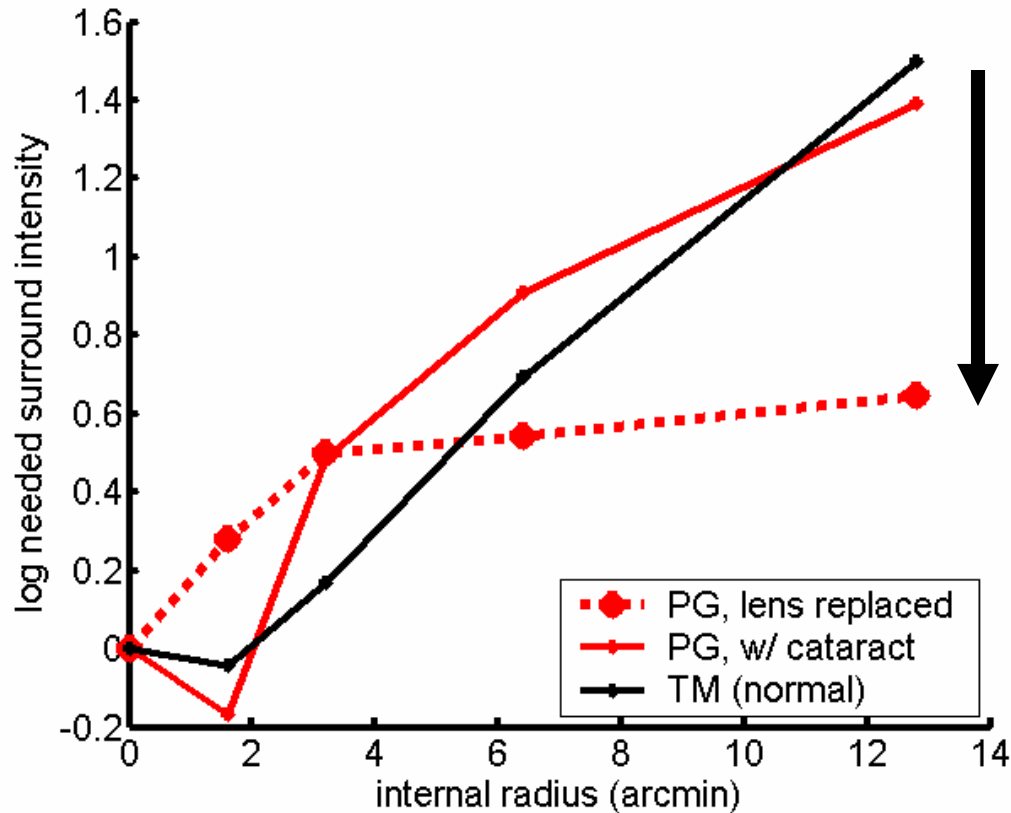
Williams, Brainard, McMahan, Navarro (interferometric):

* core = 0.7 arcmin

Vos, Holiday & Stiles estimates (large angles):

* proportion at 1 deg = $1.6 \times 10^{-6} / \text{arcmin}^2$

Results - PG compared to normal subject



roughly 10-fold
more glare in
operated eye

	<u>TM (normal)</u>	<u>PG (cataract)</u>	<u>PG (lens proth.)</u>
core	1.8 arcmin	1.5 arcmin	2.7 arcmin
skirt wt.	0	0	115x

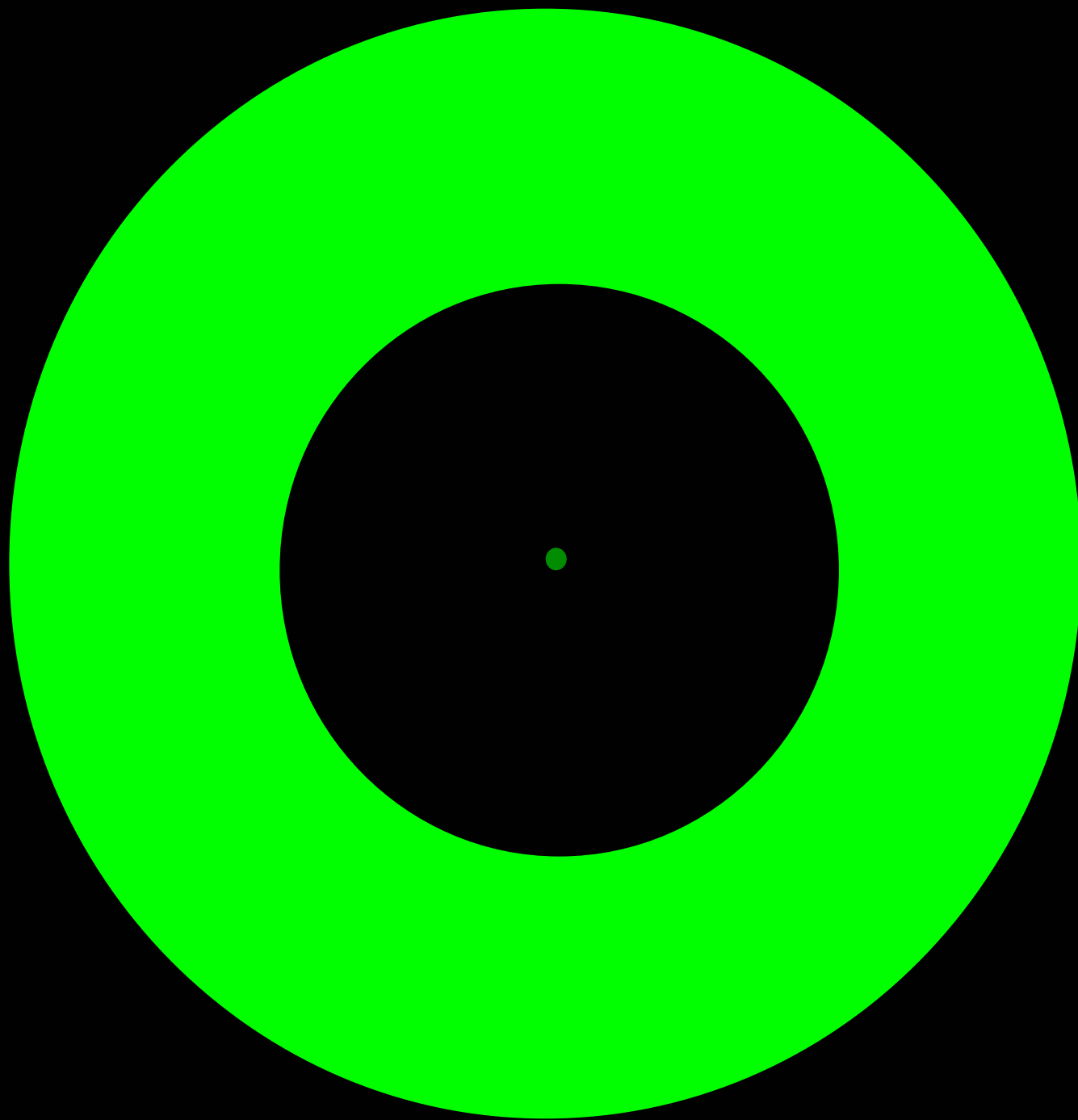
Conclusions

- We were able to make measurements of the point spread function over intermediate scatter angles. Our inferred point-spread function is:
 - broader than some estimates of the point spread function at small scatter angles.
 - roughly consistent with accepted estimates for light glare at larger angles (~ 1 deg).

Caveat: Neural, as opposed to optical, factors may play a role in thresholds, and need to be better accounted for.

- PG's post-operative complaints of glare, were substantiated in an objective way.
 - 2AFC test, randomized conditions
 - ten-fold increase in light spread compared to a normal subject.
- The BIGMAX display provides the light levels and control needed for measurement of the point spread function.
 - high intensity without head restraint or careful alignment
 - high-resolution, easily controlled stimuli allowing randomized presentation of stimuli changed on the fly
 - inexpensive

Thank you!



test threshold

possible neural effect

