Design of optical relay systems

Lens design Opti 517

Jose Sasian

College of Optical Sciences
University of Arizona
Tucson, Arizona 85721
USA

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Overview

- Introduction
- Relays for free-space photonic switching
- Relays for micro-lithography
- Relays for periscope systems
- Relays for photographic systems
- Conclusions

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Introduction

- Illustrate several optical relays
- Illustrate how ‘experience’ is gained
- Show a number of lens design insights

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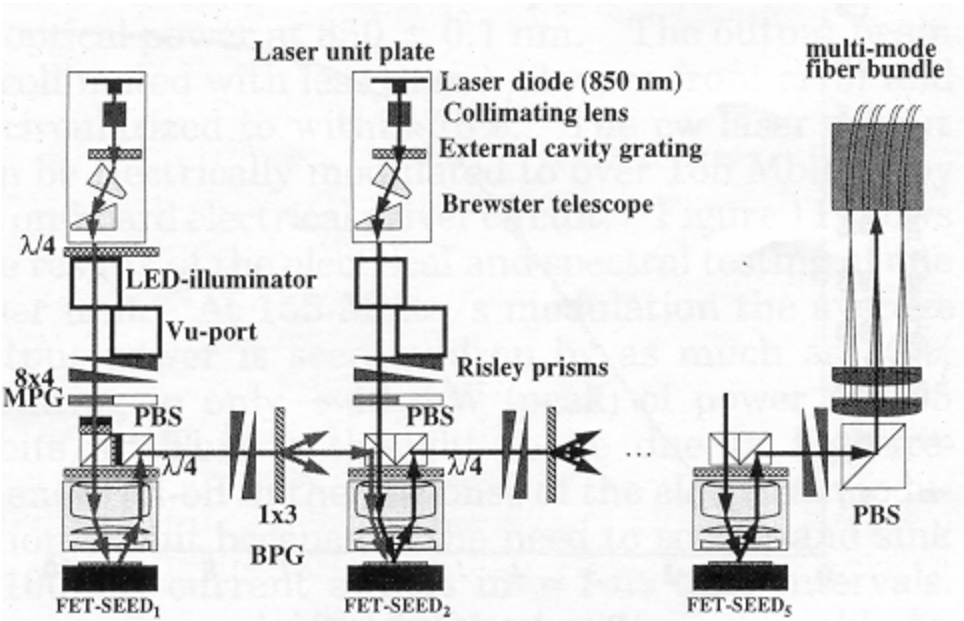
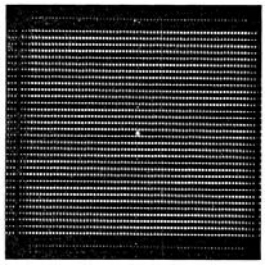
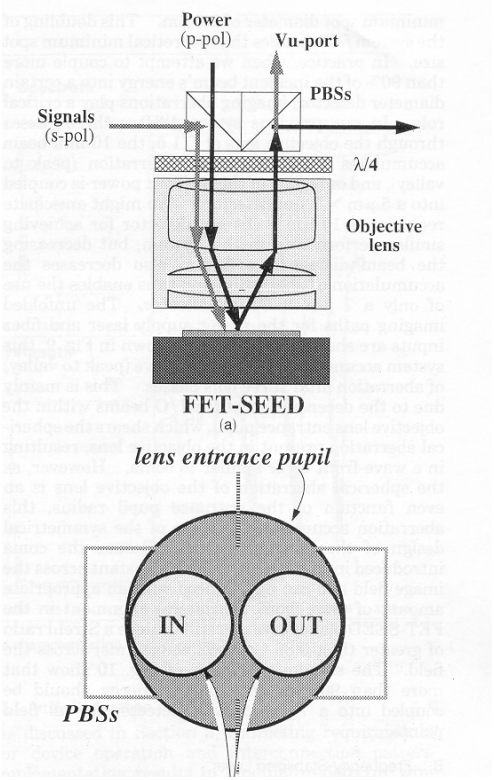
Photonic switching relay







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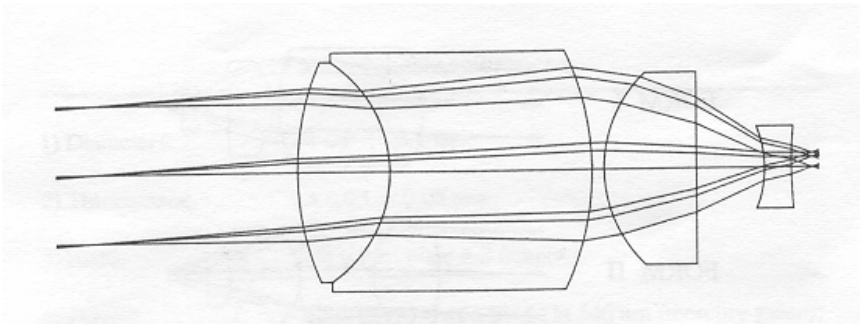
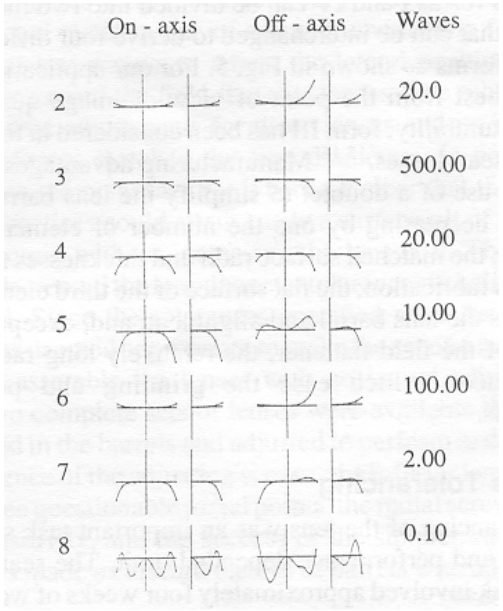
Objective

- External stop
- Telecentric
- F-sin(theta) mapping
- f/1.5
- F=15 mm
- Fov +/- 3.5 deg
- @ 850 nm





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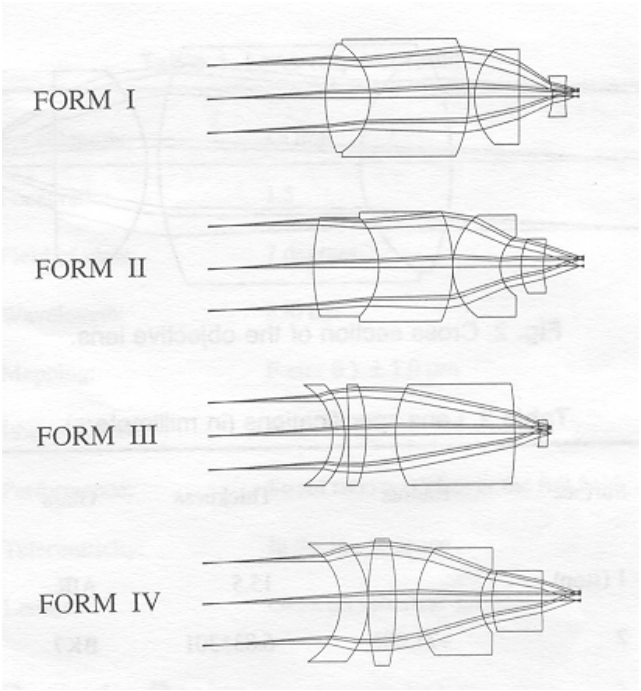
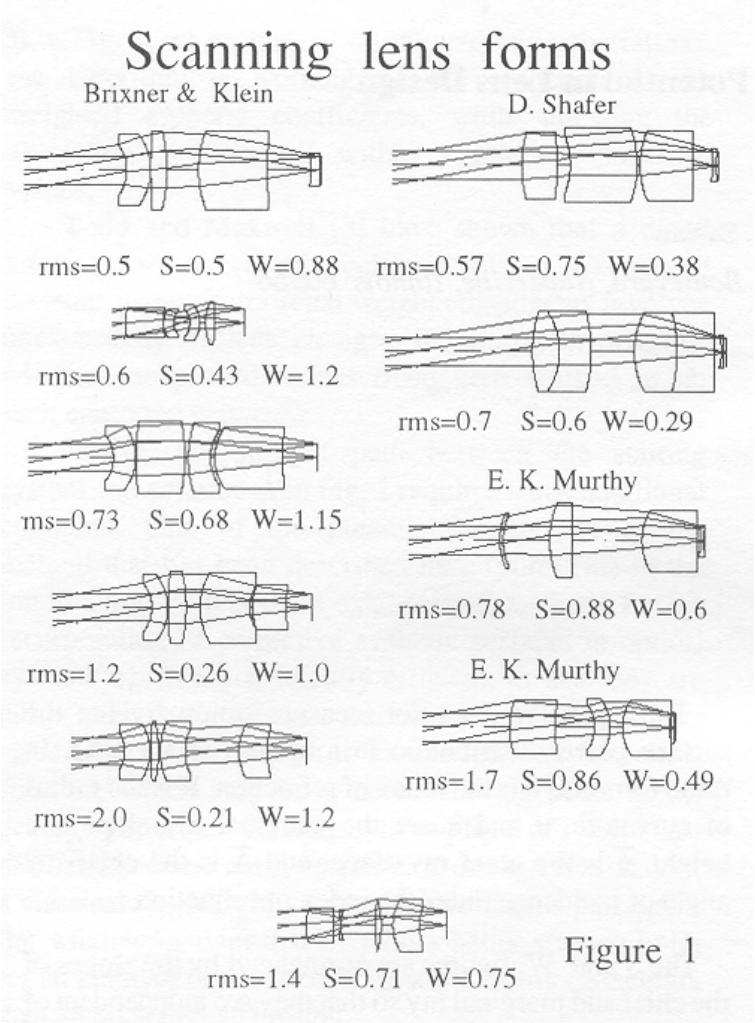
Lens forms





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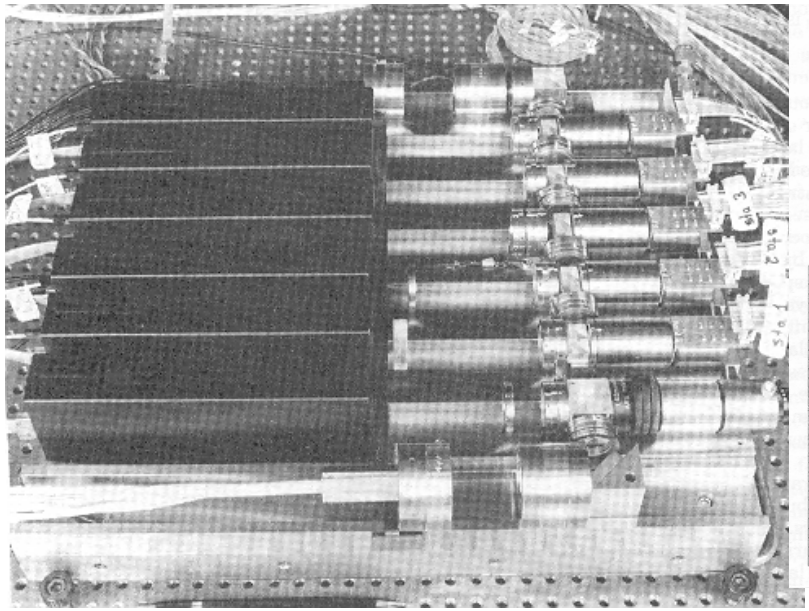
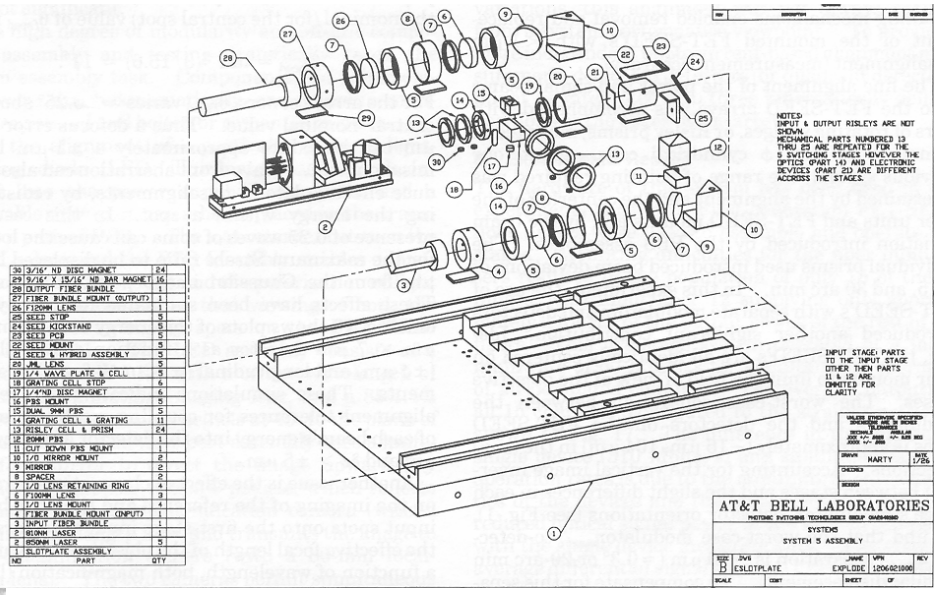
Photonic Switching system





NO	PART	QTY
30	3/16" ND DISC MAGNET	24
29	9/16" X 15/16" ND BAR MAGNET	16
28	OUTPUT FIBER BUNDLE	1
27	FIBER BUNDLE MOUNT (OUTPUT)	1
26	F120MM LENS	1
25	SEED STOP	5
24	SEED KICKSTAND	5
23	SEED PCB	5
22	SEED MOUNT	5
21	SEED & HYBRID ASSEMBLY	5
20	AML LENS	5
19	1/4 WAVE PLATE & CELL	5
18	GRATING CELL STOP	6
17	1/4"ND DISC MAGNET	6
16	PBS MOUNT	5
15	DUAL 9MM PBS	5
14	GRATING CELL & GRATING	11
13	RISLEY CELL & PRISM	24
12	20MM PBS	1
11	CUT DOWN PBS MOUNT	1
10	I/O MIRROR MOUNT	2
9	MIRROR	2
8	SPACER	2
7	I/O LENS RETAINING RING	4
6	F100MM LENS	3
5	I/O LENS MOUNT	4
4	FIBER BUNDLE MOUNT (INPUT)	1
3	INPUT FIBER BUNDLE	1
2	810NM LASER	1
1	850NM LASER	5
1	SLOTPLATE ASSEMBLY	1

NOTES:
INPUT & OUTPUT RISLEYS ARE NOT SHOWN.
MECHANICAL PARTS NUMBERED 13 THRU 23 ARE REPEATED FOR THE 5 SWITCHING STAGES HOWEVER THE OPTICS (PART 14) AND ELECTRONIC DEVICES (PART 21) ARE DIFFERENT ACCROSS THE STAGES.

INPUT STAGE; PARTS TO THE INPUT STAGE OTHER THEN PARTS 11 & 12 ARE OMMITED FOR CLARITY

AT&T BELL LABORATORIES

SYSTEMS

SYSTEM 5 ASSEMBLY

SIZE	DWG	NAME	VPN	REV
B	SLOTPLATE	EXPLODE	1206021000	

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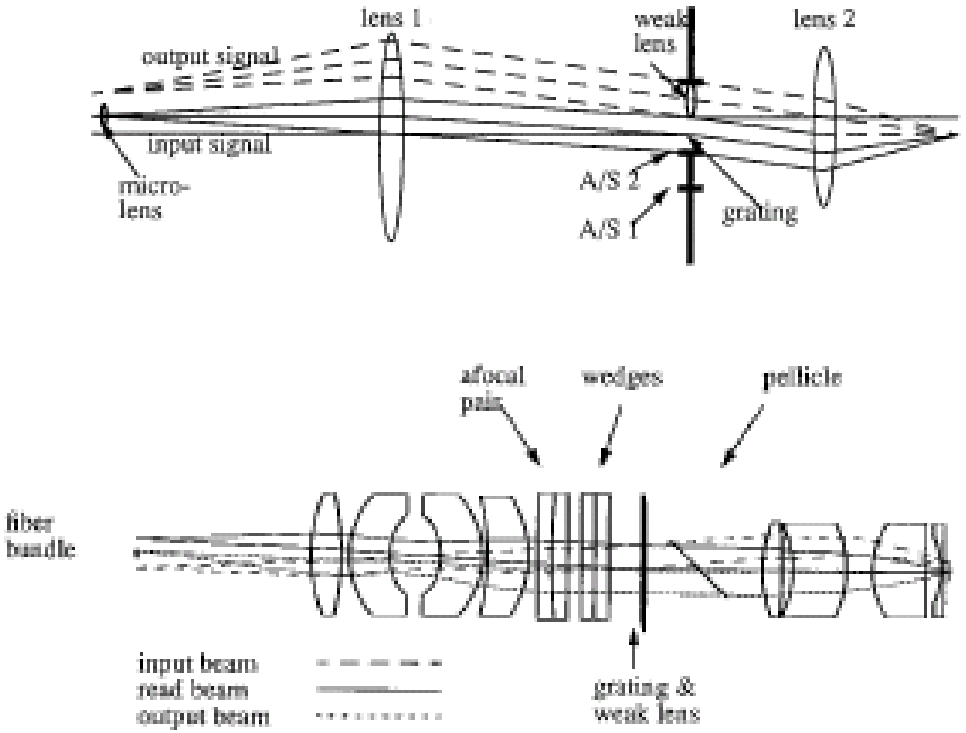
Single stage photonic switch



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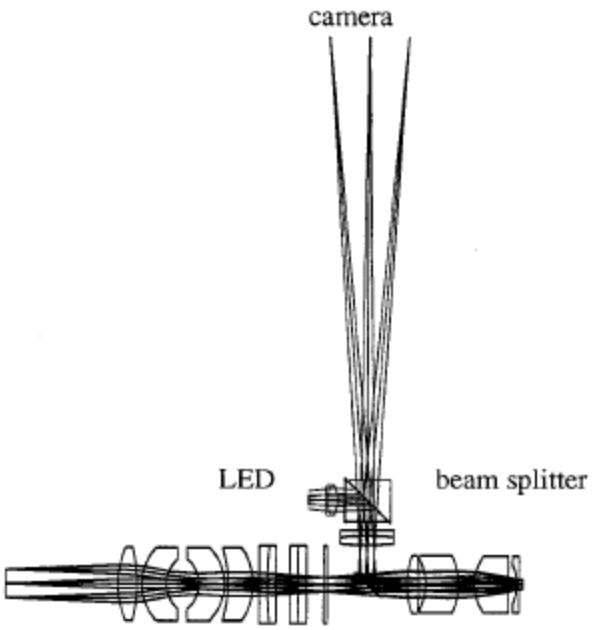
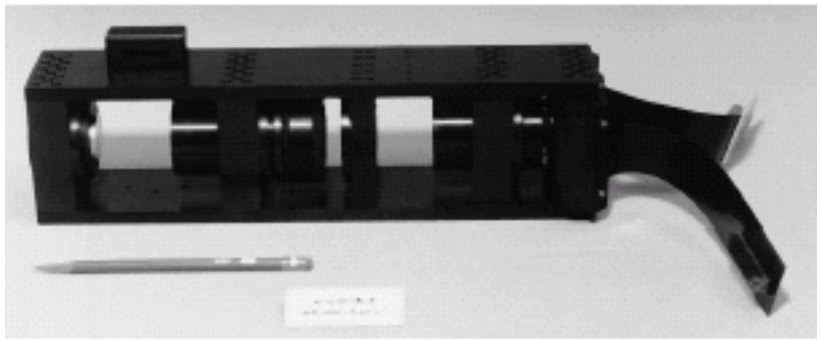
Single stage photonic switch





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Relays for periscope systems

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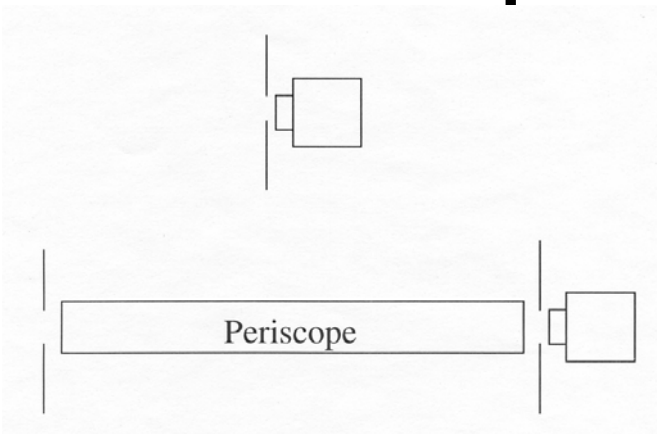
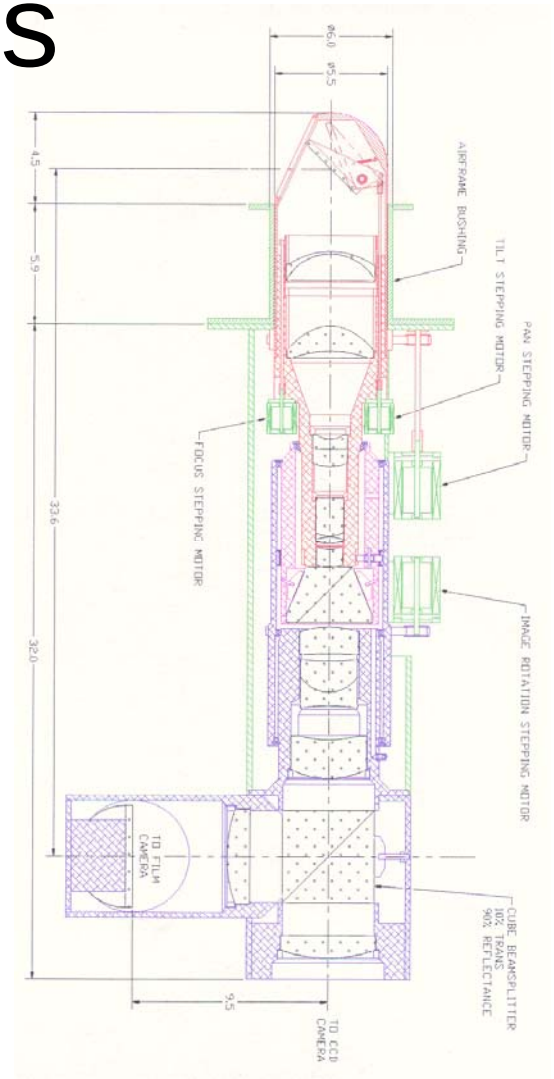
Requirements



Current	OSC design
• Field of view: 22 deg.	• Field of view: 43 deg.
• Speed: F/6.5	• Speed: F/4
• No image rotator	• Image rotator
• No lens interchangeability	• Lens interchangeability
• Image quality is questionable	• Excellent image quality



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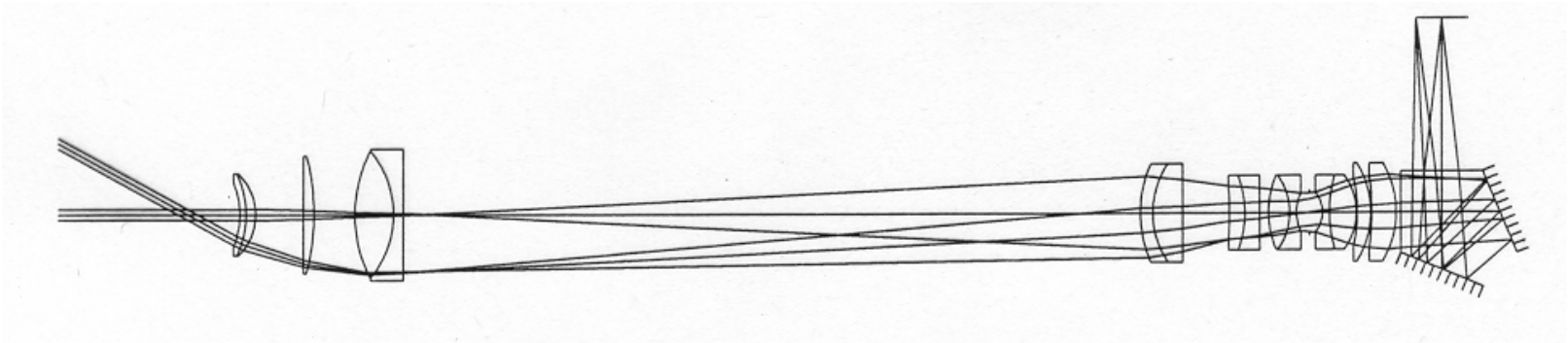
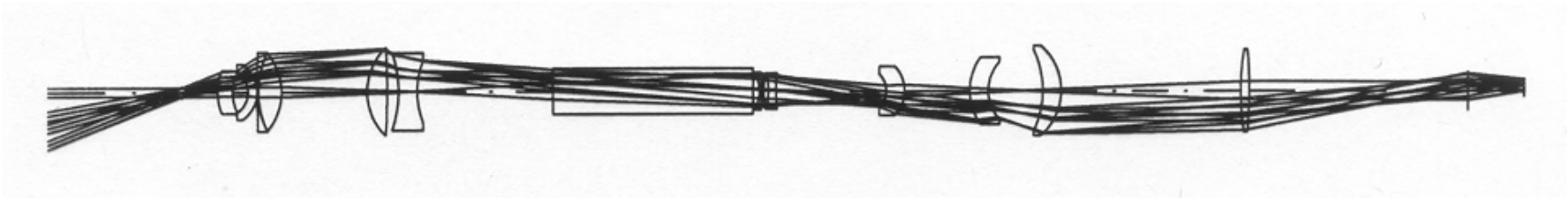
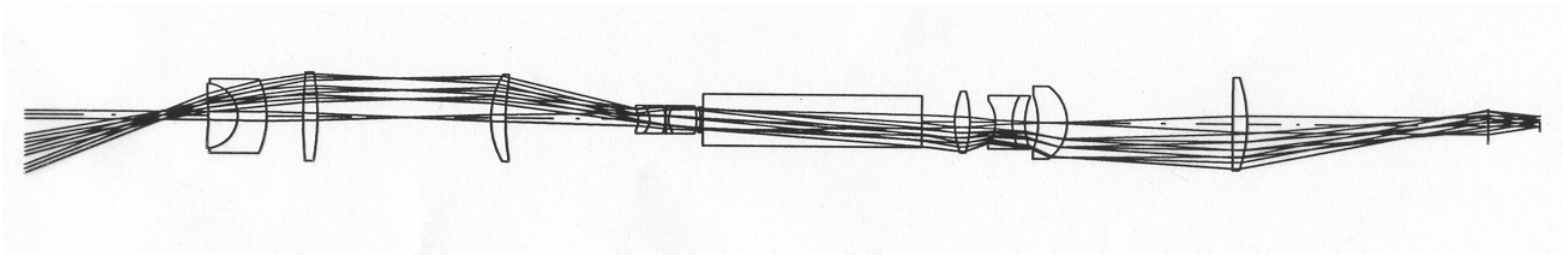
Periscope designs







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Design results

U of A periscopes	design 1	design 2	design 3
Field of view:	43.0 deg.	36.0 deg.	43.0 deg
Window diameter:	10 mm	12.5 mm	15 mm
Magnification:	2	2	2
Speed:			
80-200 zoom lens: (35 mm full .98 x .735)	4 - 10 (8)	4 - 10 (8) (100-250 zoom)	2.8 - 6.5
4.5 X 6 still (200 / 240 mm)	10	10	6.5
6 X 7 IMAX (240 / 290 mm)	12	12	8
Image rotator:	yes	yes	yes
Lens interchangeability:	yes	yes	yes
Image quality:	excellent	excellent	excellent (good at corners)
Distortion:	1%	1%	1%
Number of Lenses:	14	14	18 - 22
Comments:	6" lenses	Desirable	larger system head & pechan
Close objects:	yes	yes	yes
Tilt mirror: (at least -2 to 45 deg)	yes	yes	yes
Filters:	yes	yes	yes

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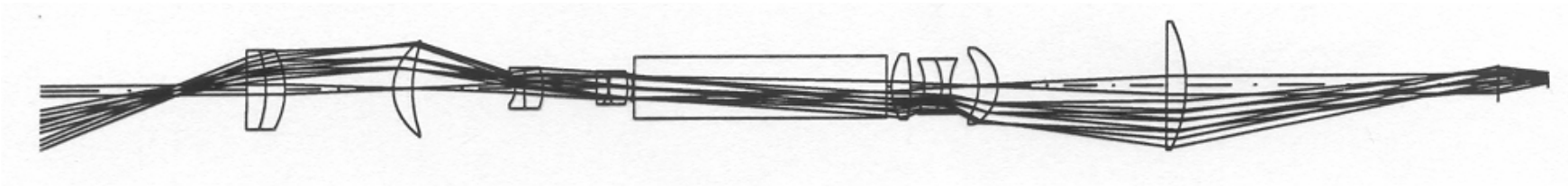
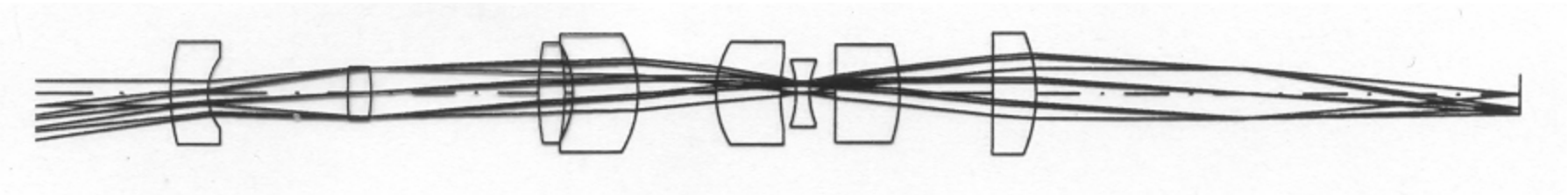
Periscope designs





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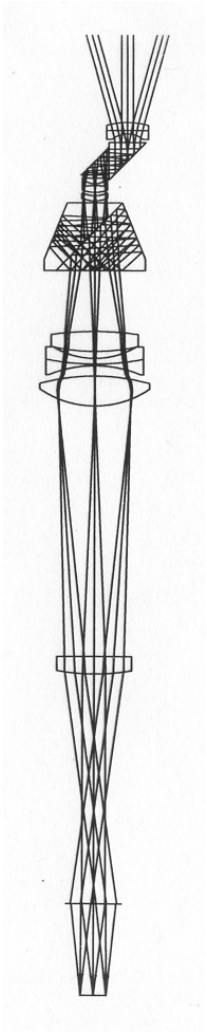
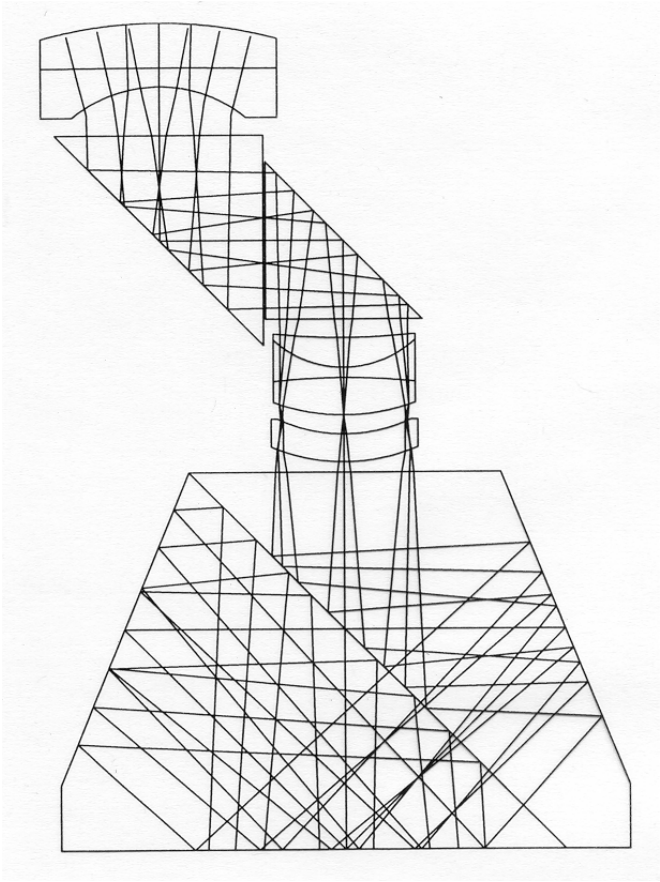
Final solution





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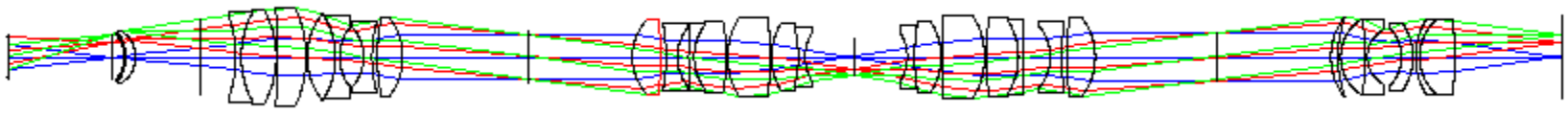
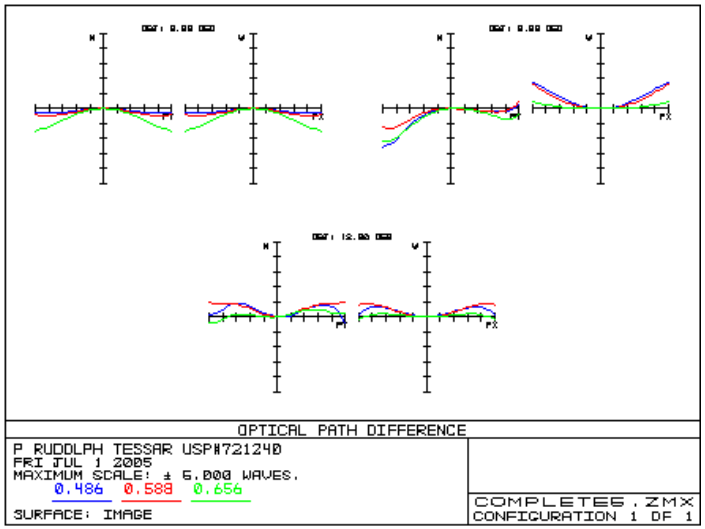
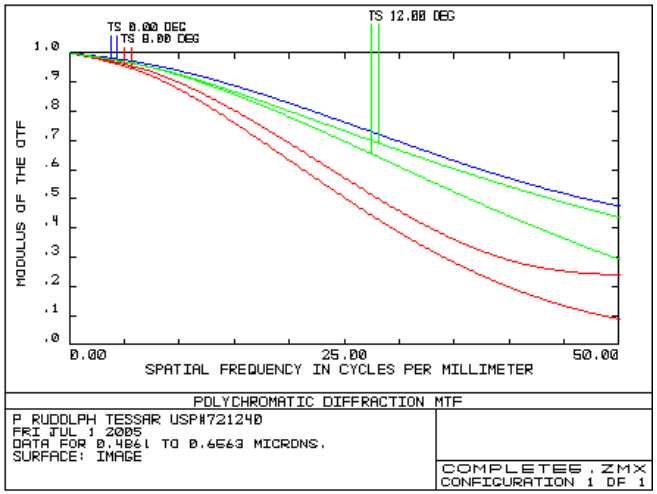
Relays for photography







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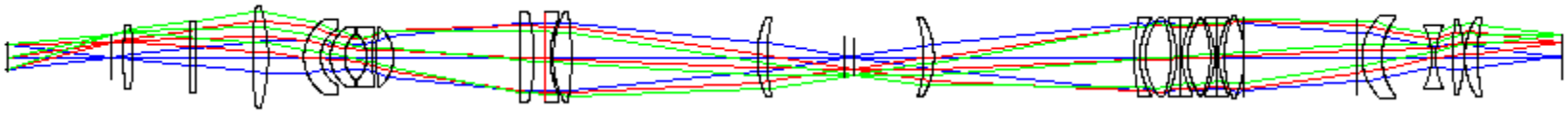
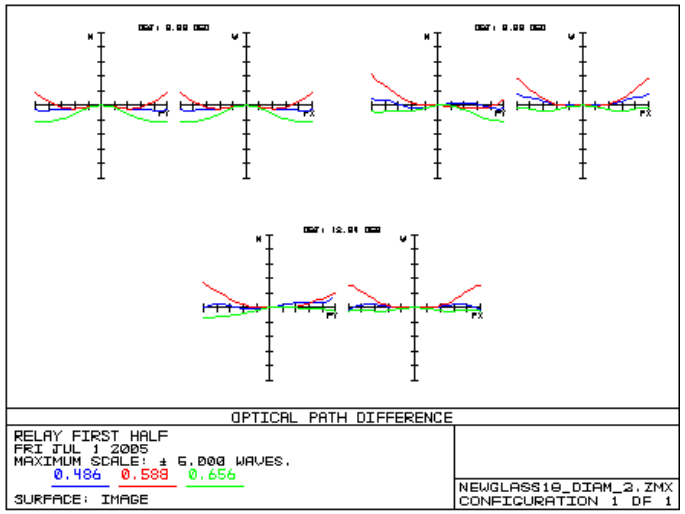
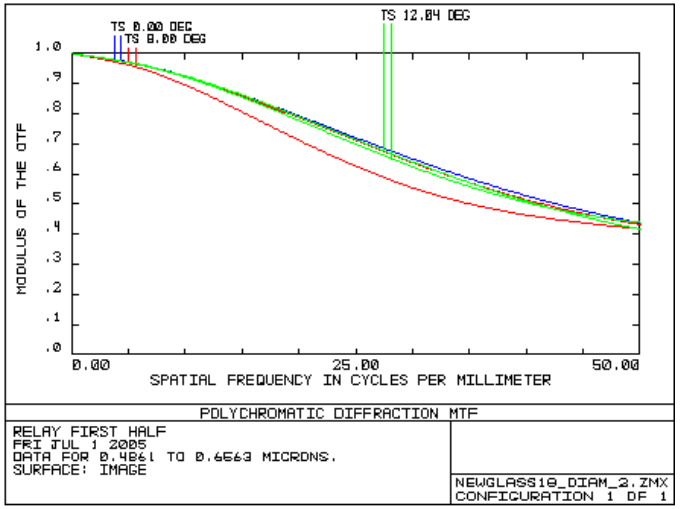
Relays for photography







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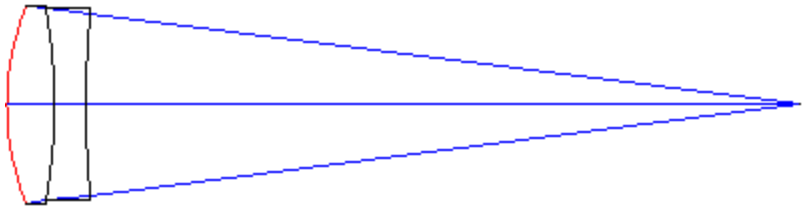
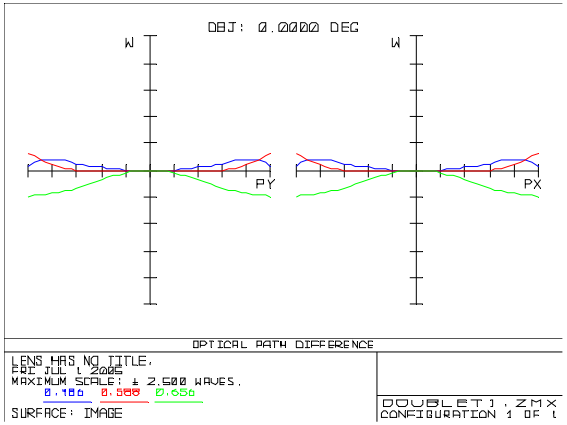
Chromatic correction

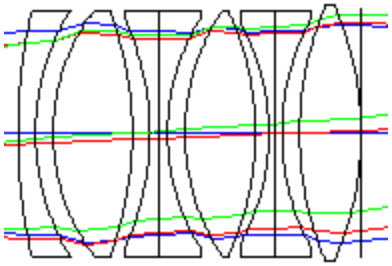
f/4, f=100 mm

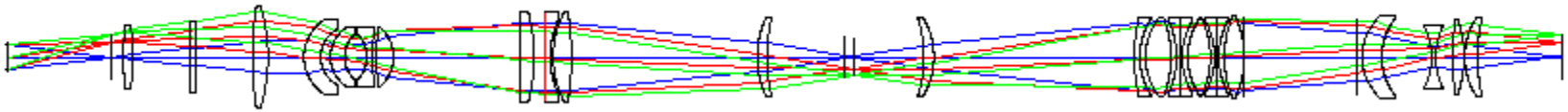


BK7 & F2



KZFS1
TIF6
PSK53A
FPL53





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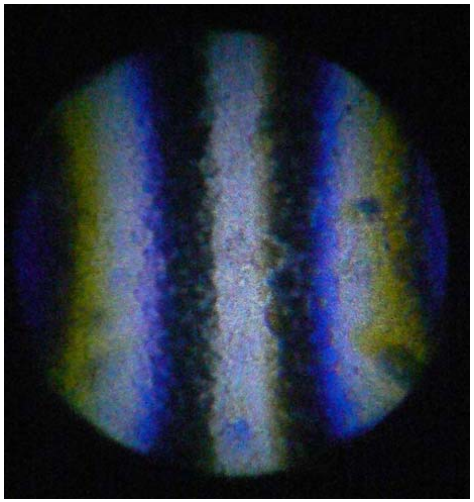
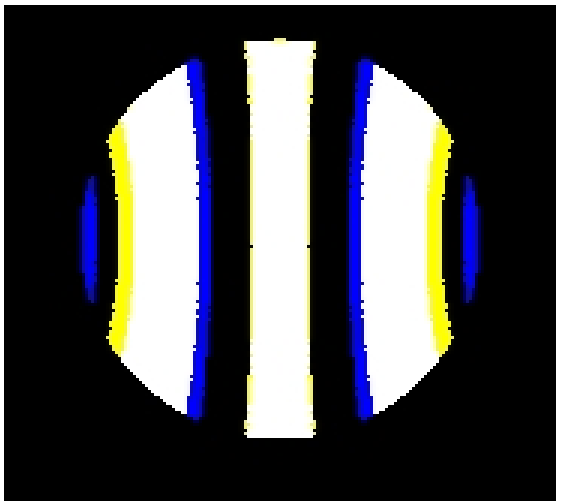
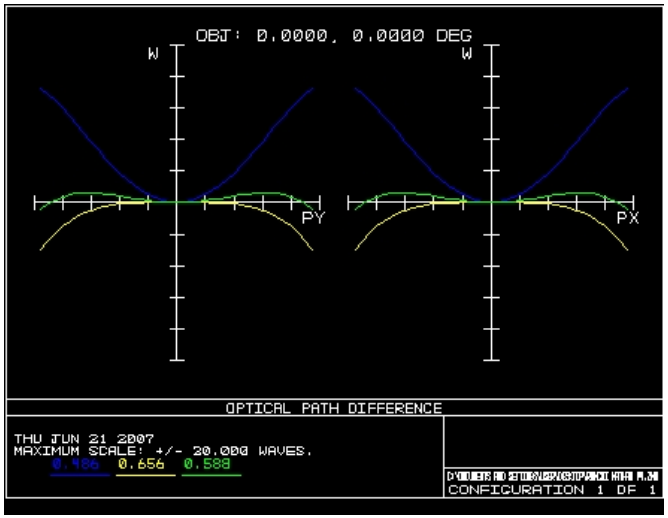
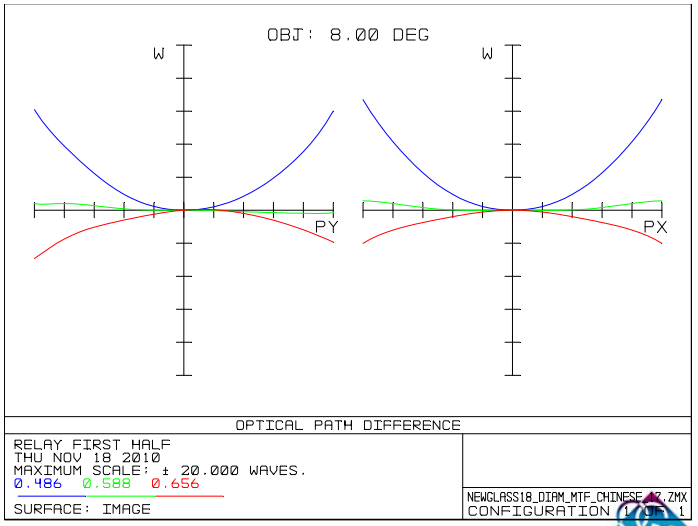
Actual system









From Ronchigram simulation

From changing the Abbe number by 3

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Relays for telescope systems

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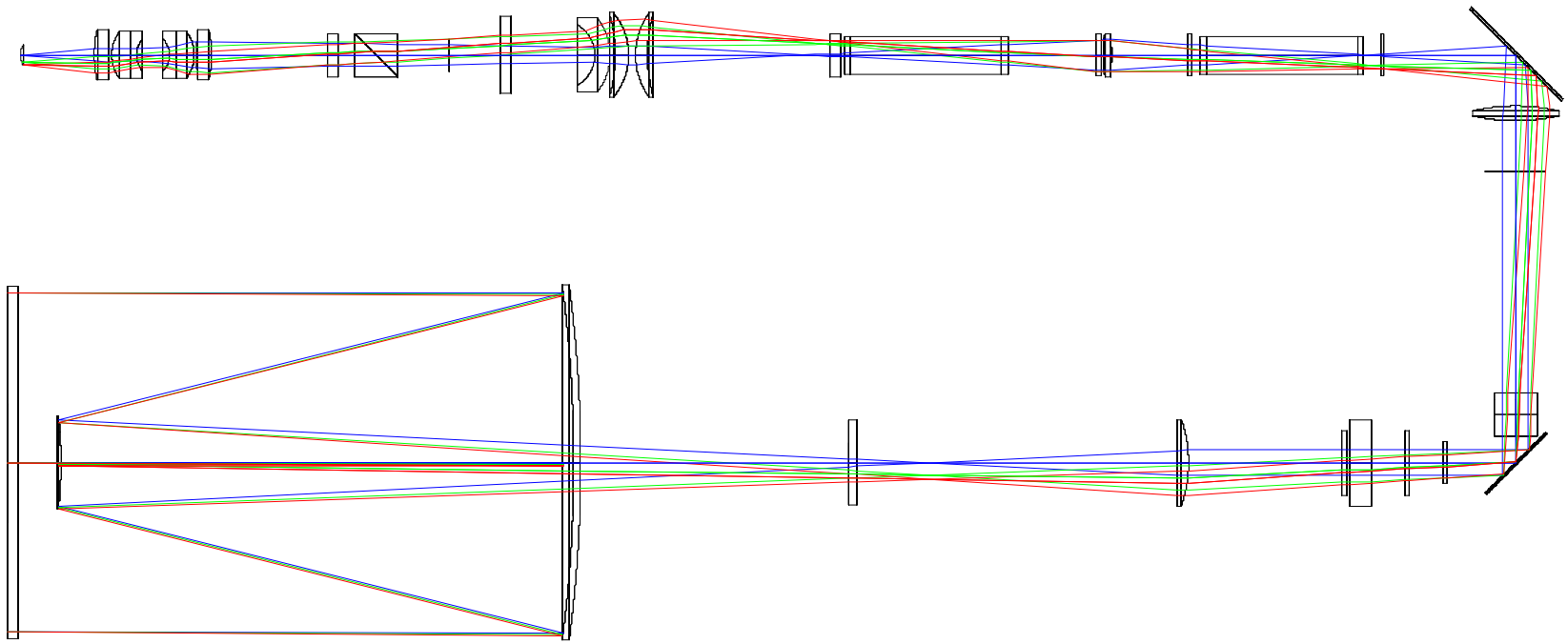
Layout of Original System



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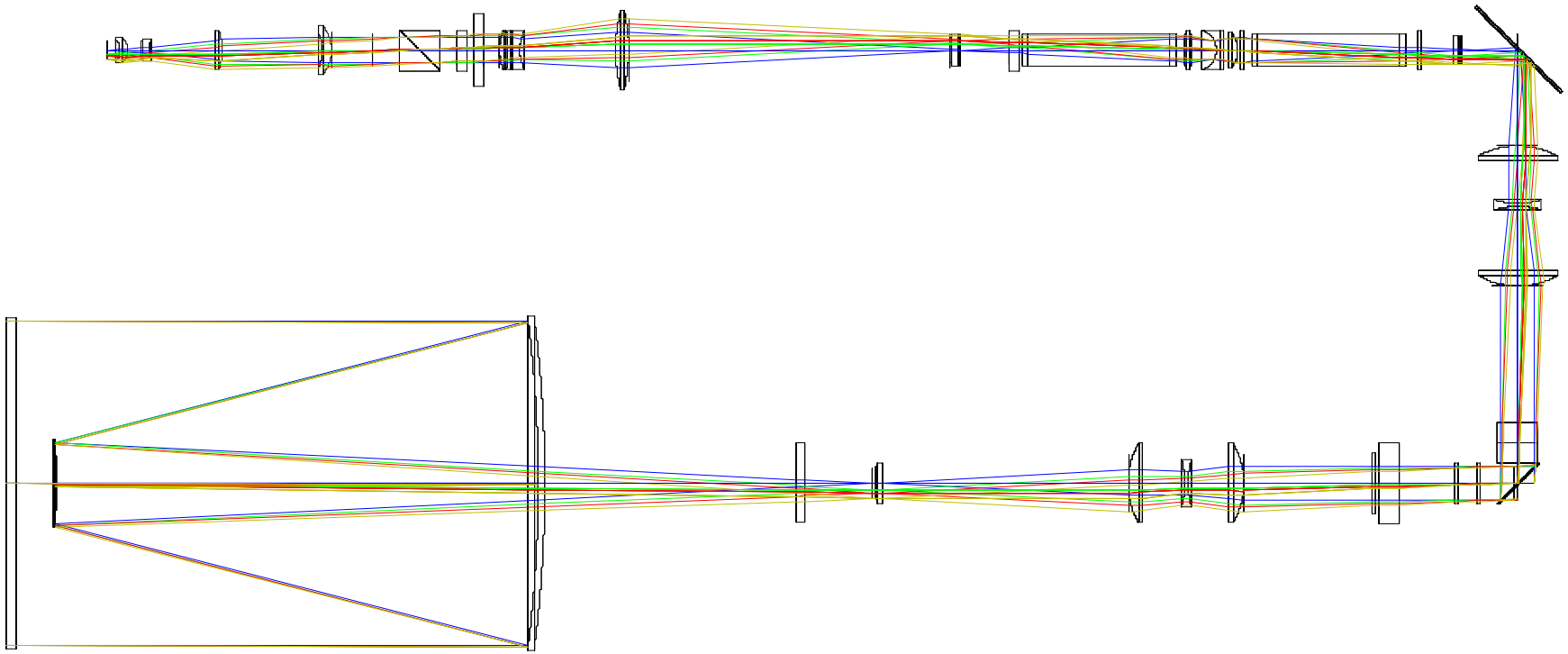
Re-designed system



All off-the-shelf optics

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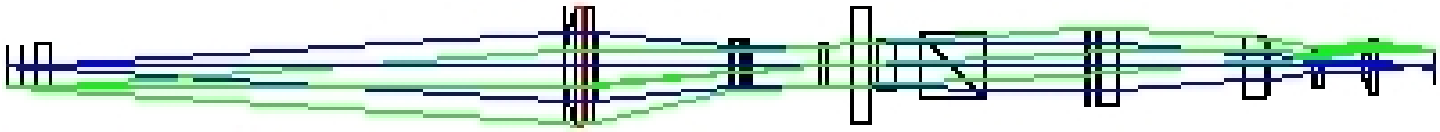
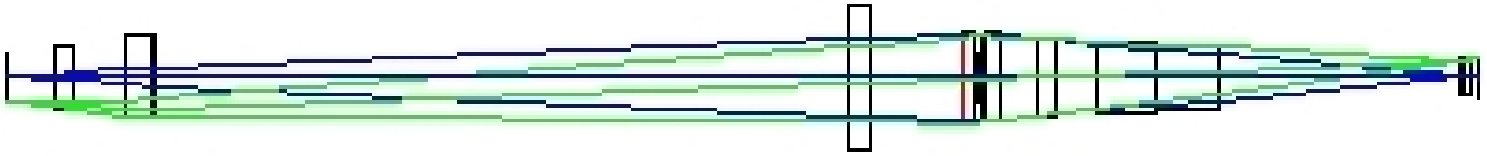
Actual tough and easy designs (specs understanding)

Coma sensitivity 0.54
Astigmatism sensitivity 0.78



Coma sensitivity 0.14
Astigmatism sensitivity 0.21



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Alignment Challenge

- All off-the-shelf components ~70 surfaces
- Laser to establish optical axis
- Point sources at wavelength
- Ronchi grating
- CCD images and then projected images

- Obtain near diffraction limited spots at about 1.7 to 2 pixels. (DF ~ 1 pixel)

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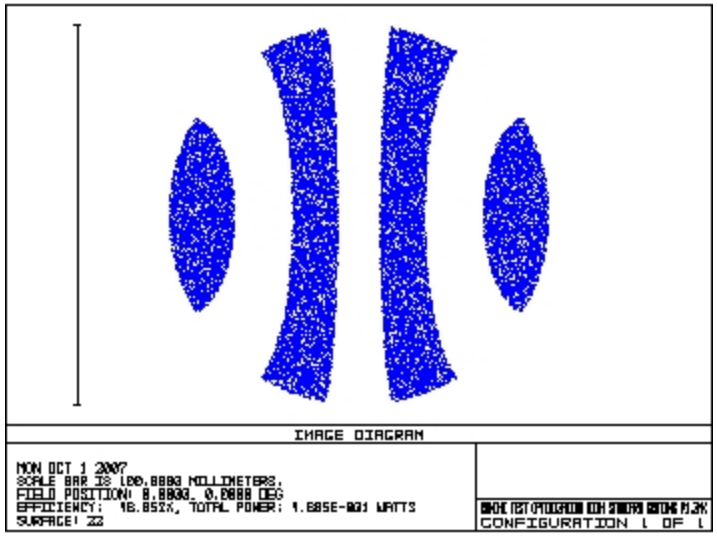
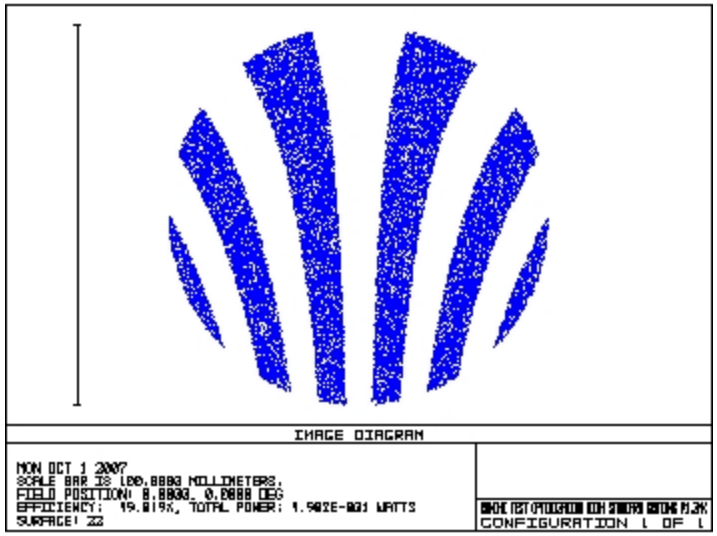
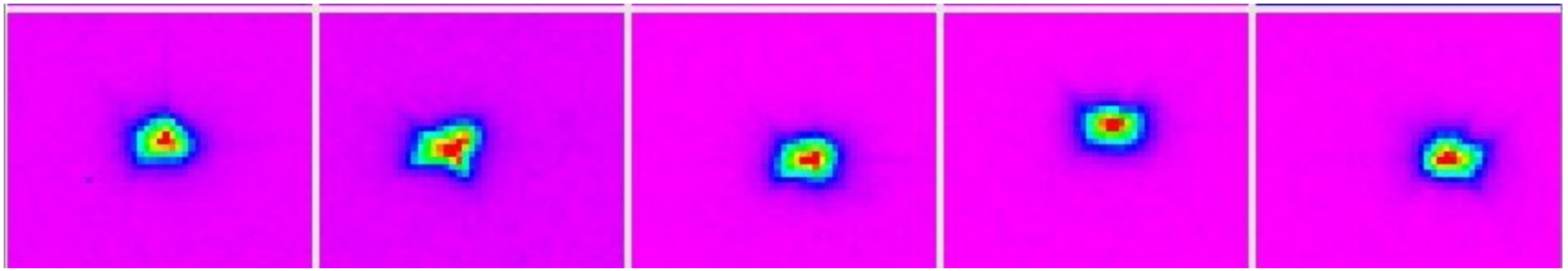
Alignment







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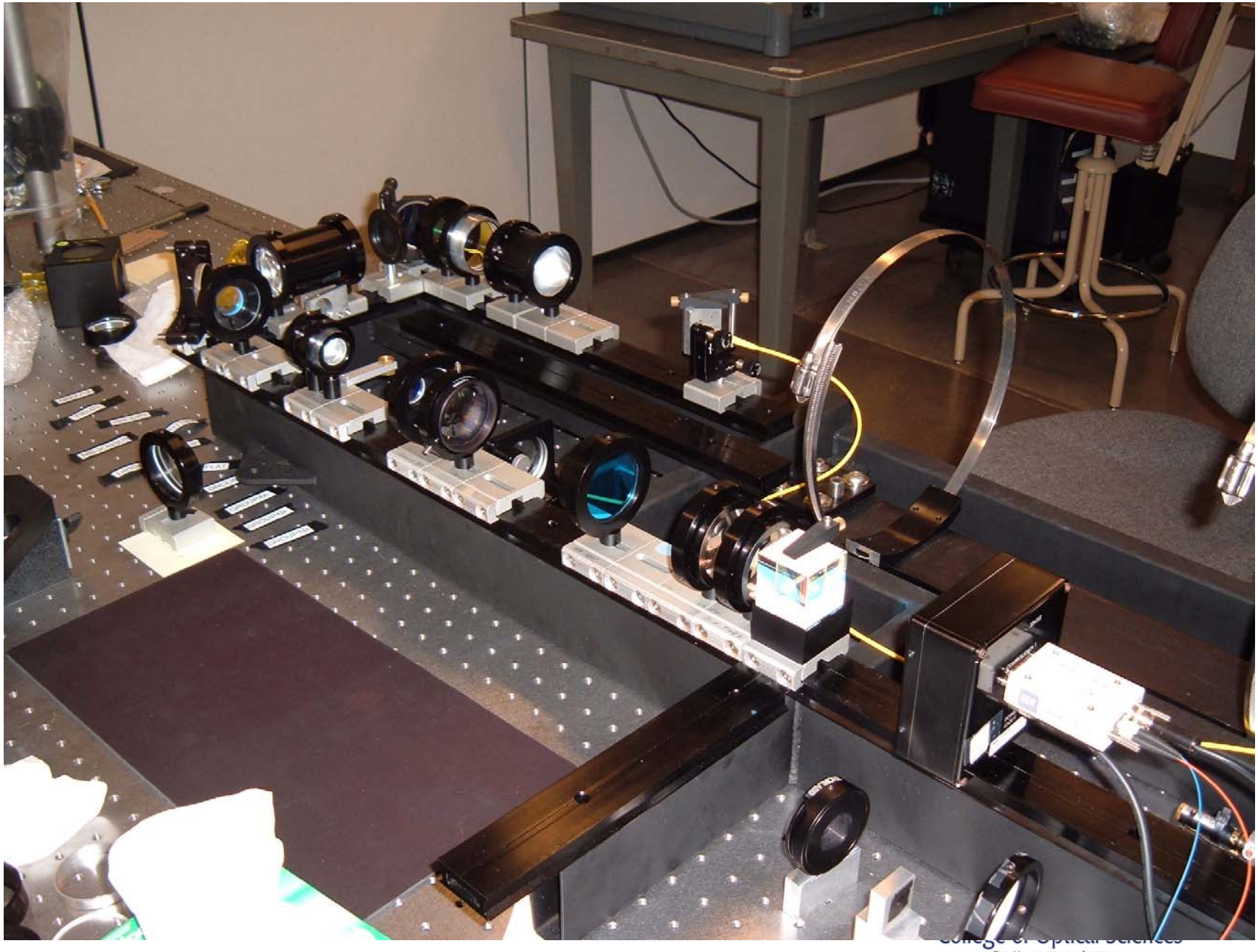

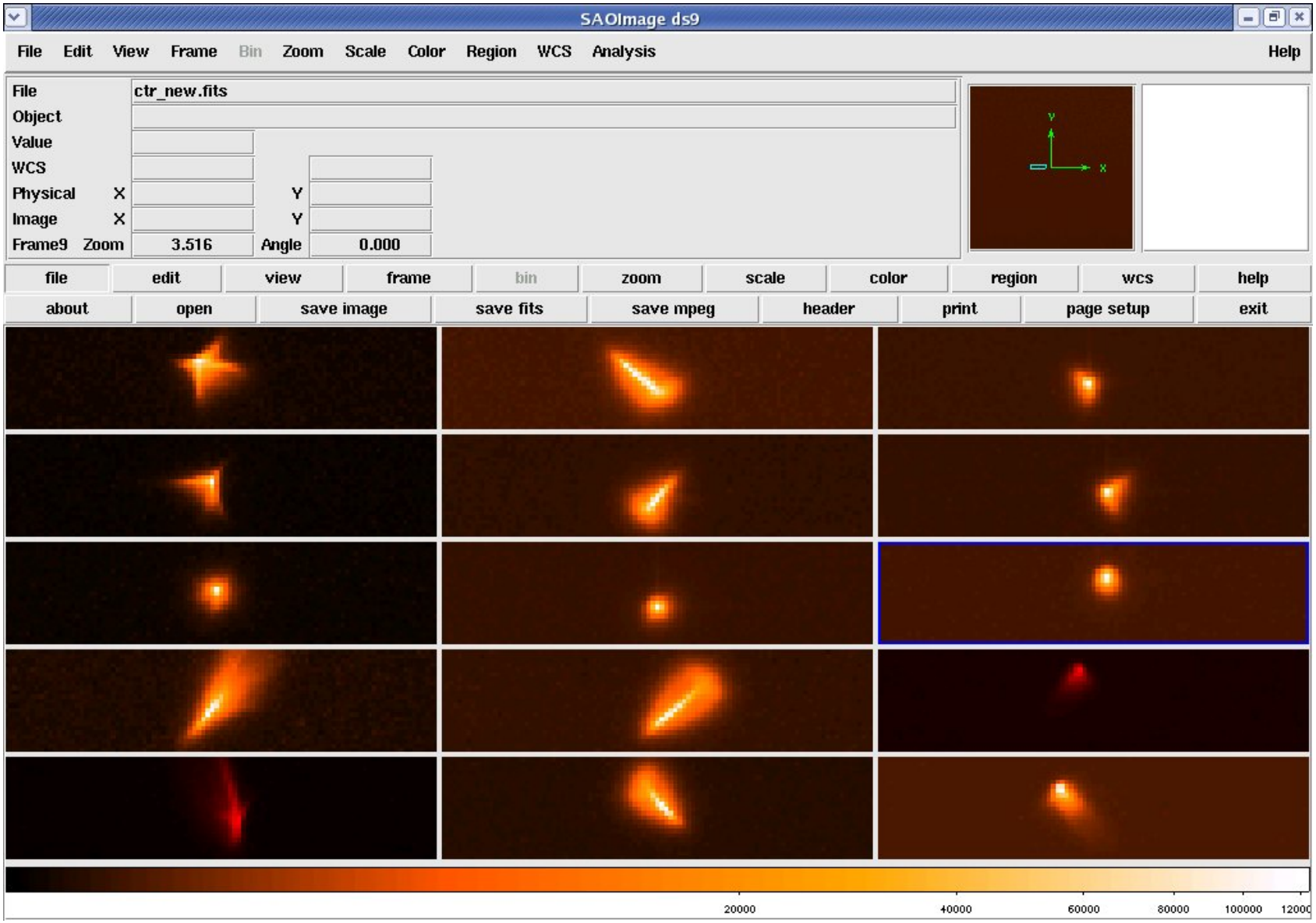

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Conclusion

- Several relay systems and a number of insights:
- Best form for four element lens
- Clever use of prisms
- Clever use of glass location
- Use of off-the-shelf lenses

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