

MOST
Microvariability and Oscillations of Stars



Dipl.Ing. Denis Frast
Allg. Astronomisches Seminar
19.04.2004

MOST – Das „Humble“ Space Telescope

S-Band Antenne

Solarzellen

Schutzkappe

**Apertur:
15 cm**

**Budget:
C\$10M**

CCD-Kamera

Teleskop

Umlenkspiegel

Apertur

60 cm

Most – Start am 30. Juni 2003



19.04.2004

Allg. Astron. Seminar - MOST

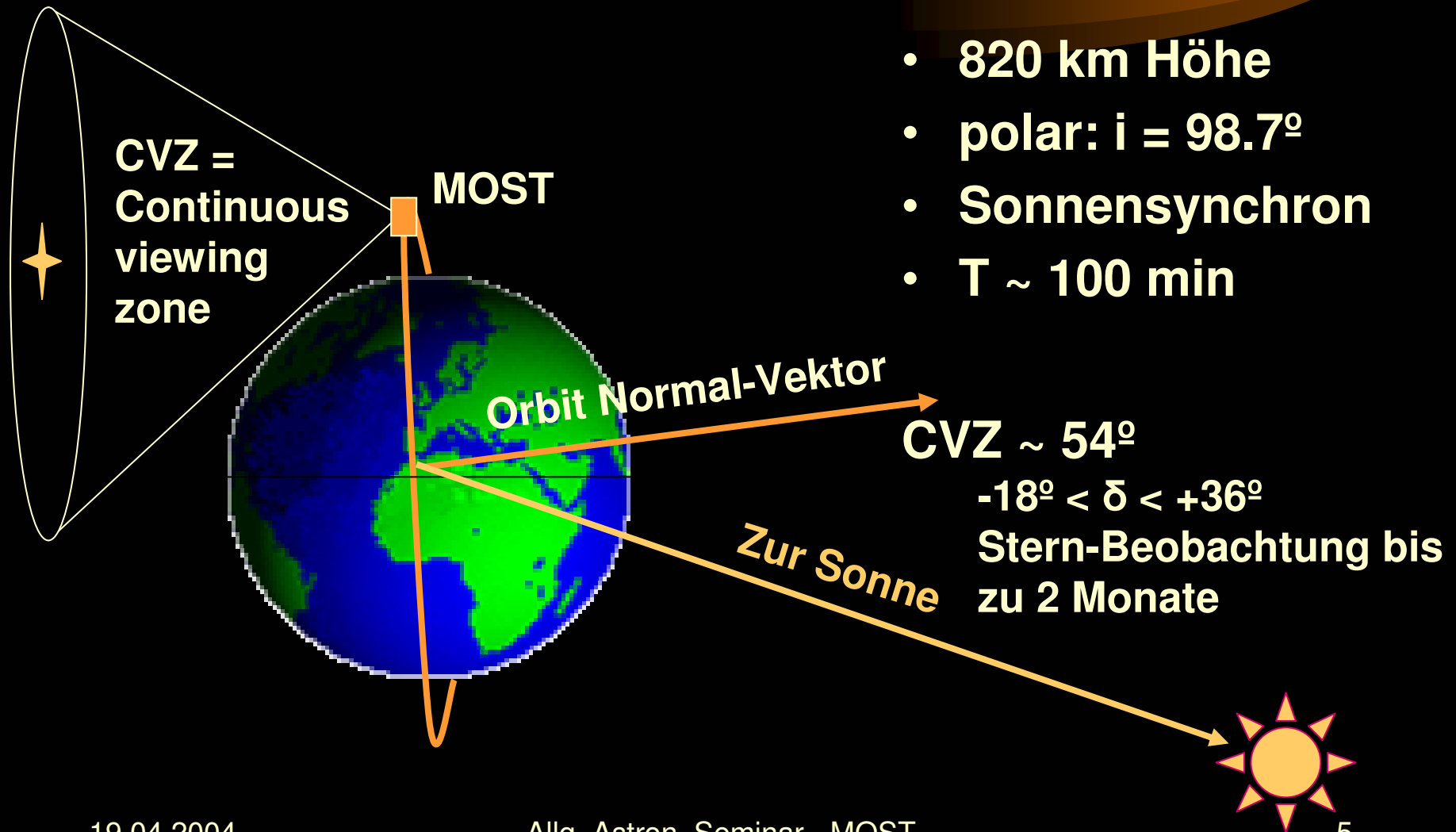
3

Technische Daten



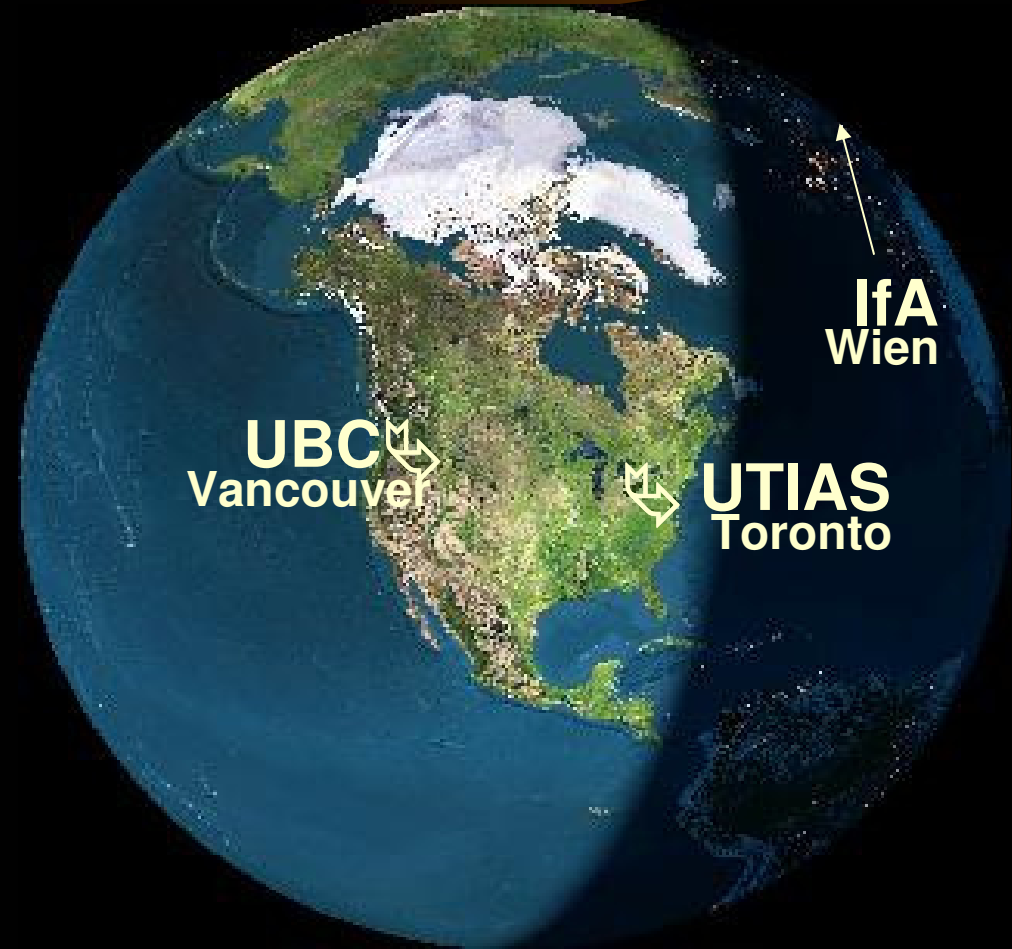
- Größe: 60x60x25 cm
- Maksutov Spiegelteleskop
 - 15 cm Apertur
 - 2° Bildfeld
- Über Umlenkspiegel belichtet
- athermale Struktur behält Fokus bei $-20^{\circ}\text{C} < T < +40^{\circ}\text{C}$
- Einzelner Breitbandfilter (350-700 nm)
- CCD Photometer
 - Science
 - Attitude control (ACS)
- zwei 1024x1024 Marconi frame-transfer CCDs
 - passive Kühlung $-40 \pm 0.1^{\circ}\text{C}$
 - “virtual shutter”
- 6x6 Fabry-Mikrolinsen
- Ausrichtungsgenauigkeit $\pm 10''$

Der Orbit von MOST



MOST Bodenstationen

- 3 Bodenstationen
 - Vancouver
 - Toronto
 - Wien
- Wien → mehr
 - Übertragungen
 - Aufnahmen

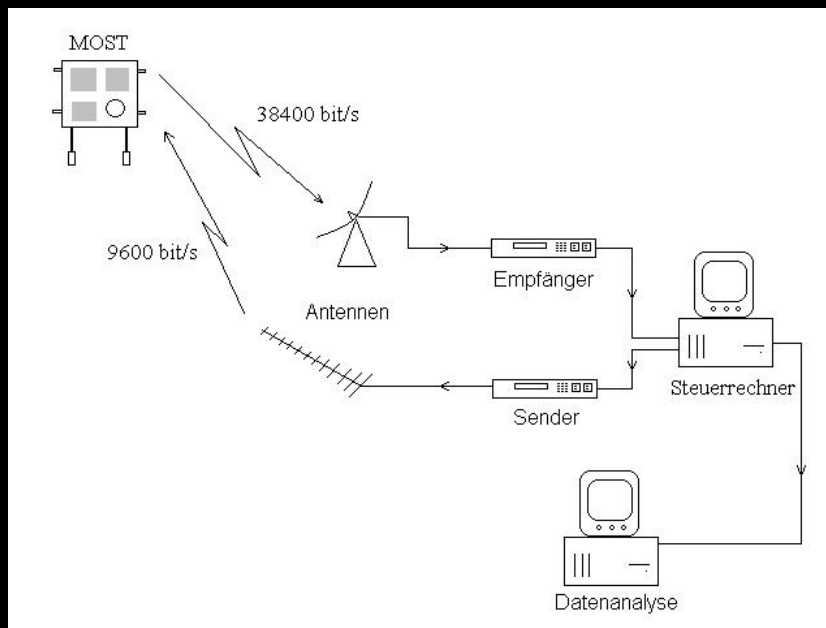


MOST Downlink

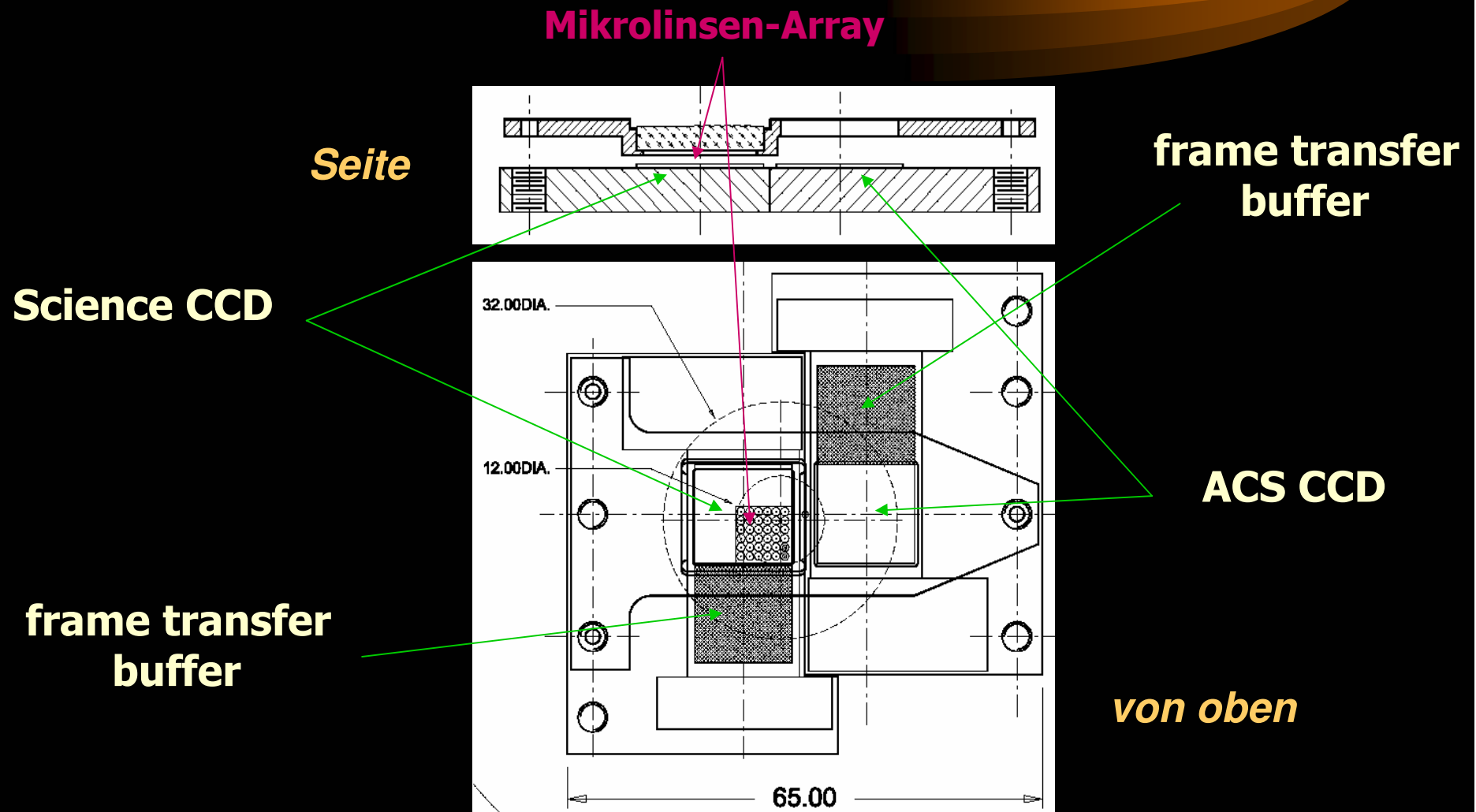


Bodenstation Wien

- Am Dach der Sternwarte
- autonomer Betrieb
- 6 Durchläufe pro Tag

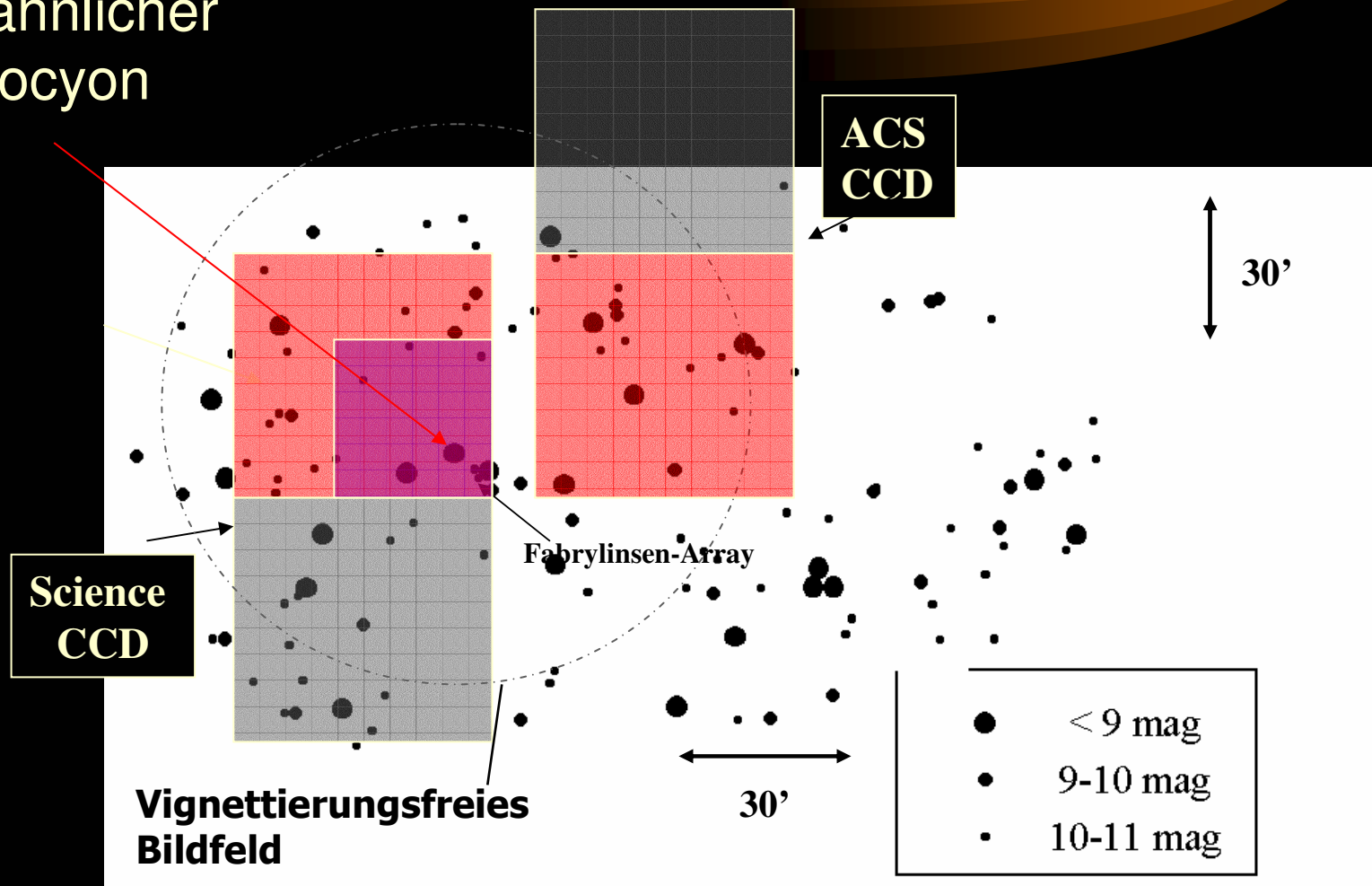


MOST-Fokalebene



Target und ACS

Sonnenähnlicher
Stern Procyon



Fabry Imaging und Direct Imaging

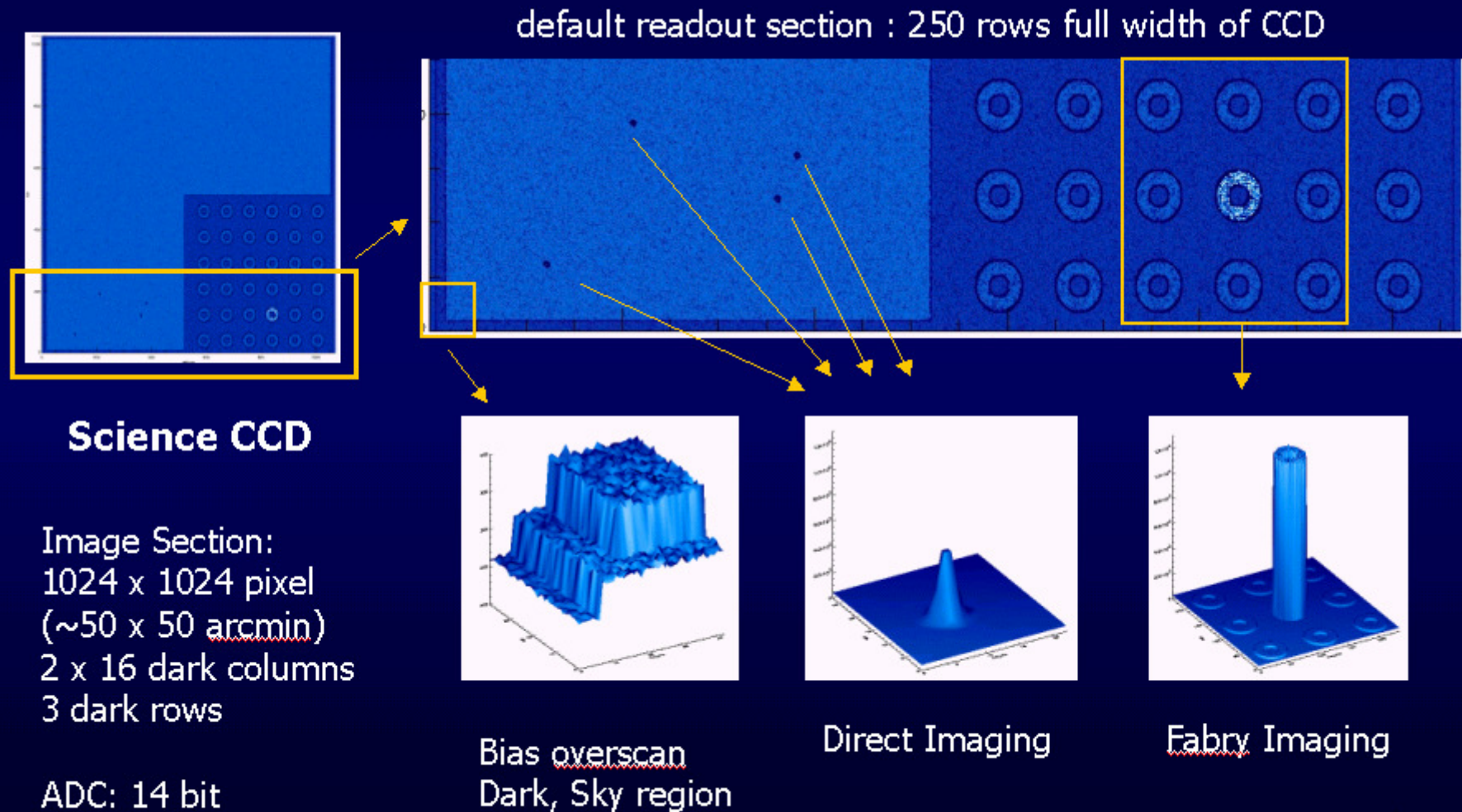
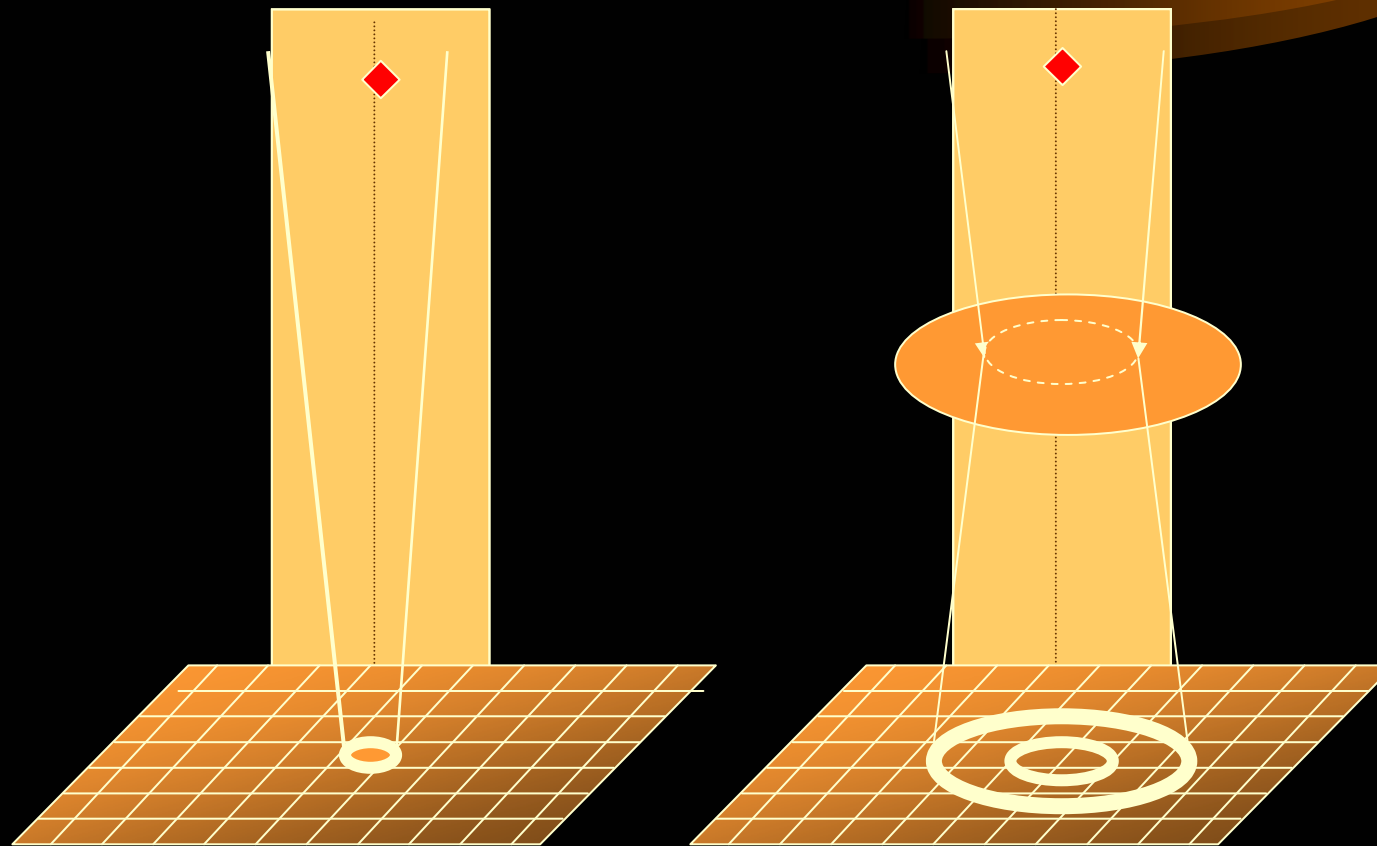


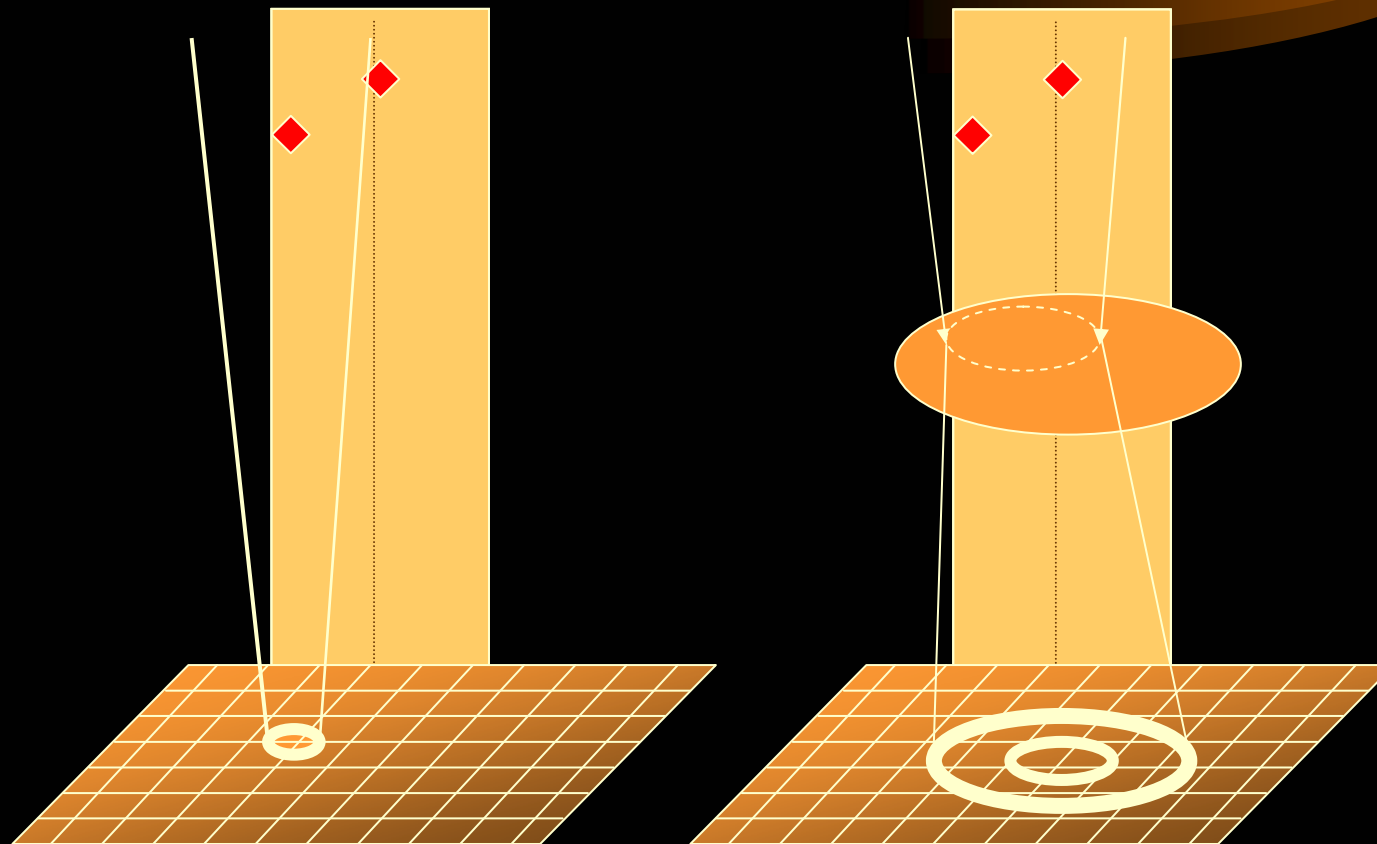
Abbildung über Fabry-Linse



Im Fokus

Fabry-Bild

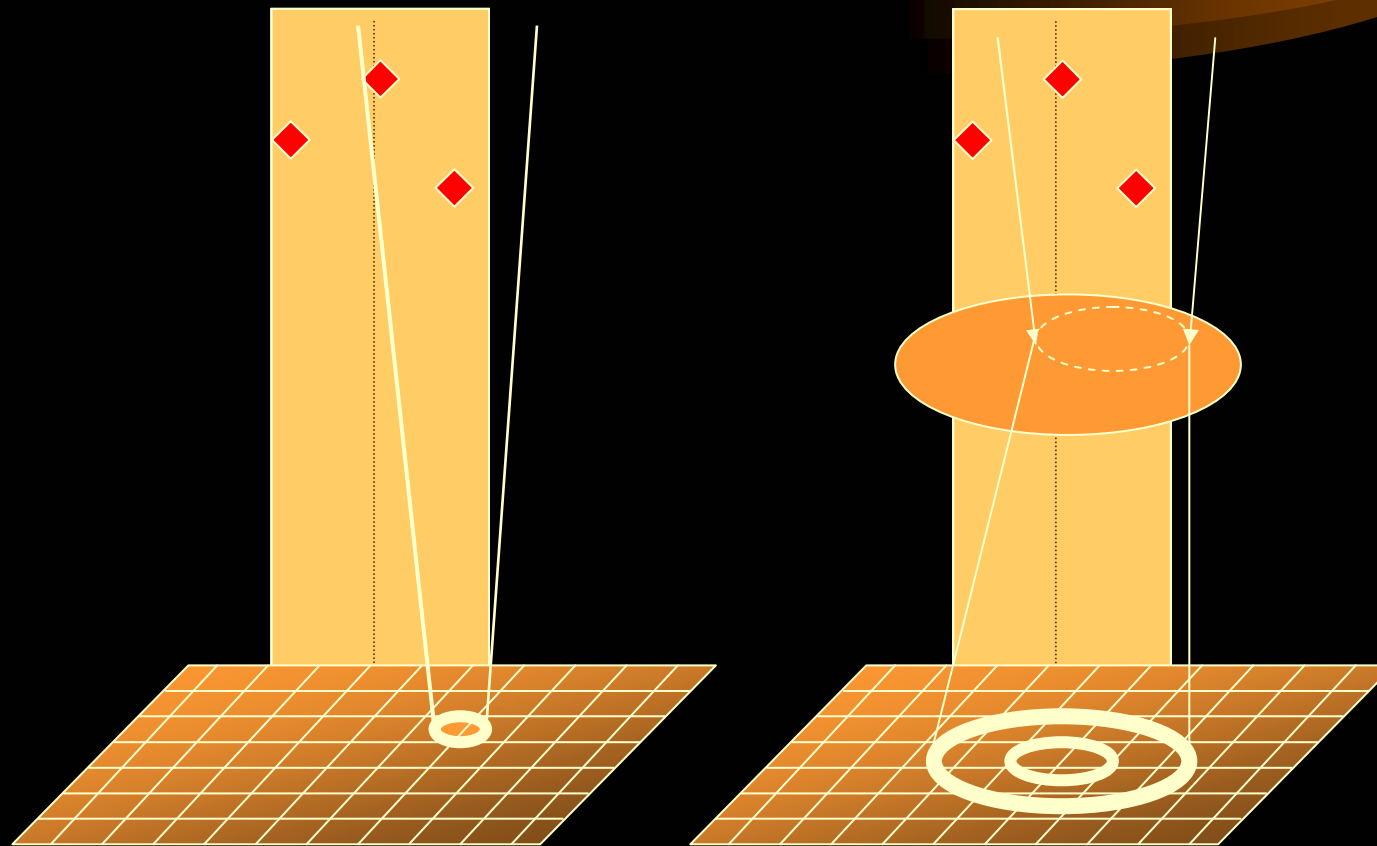
Abbildung über Fabry-Linse



Im Fokus

Fabry-Bild

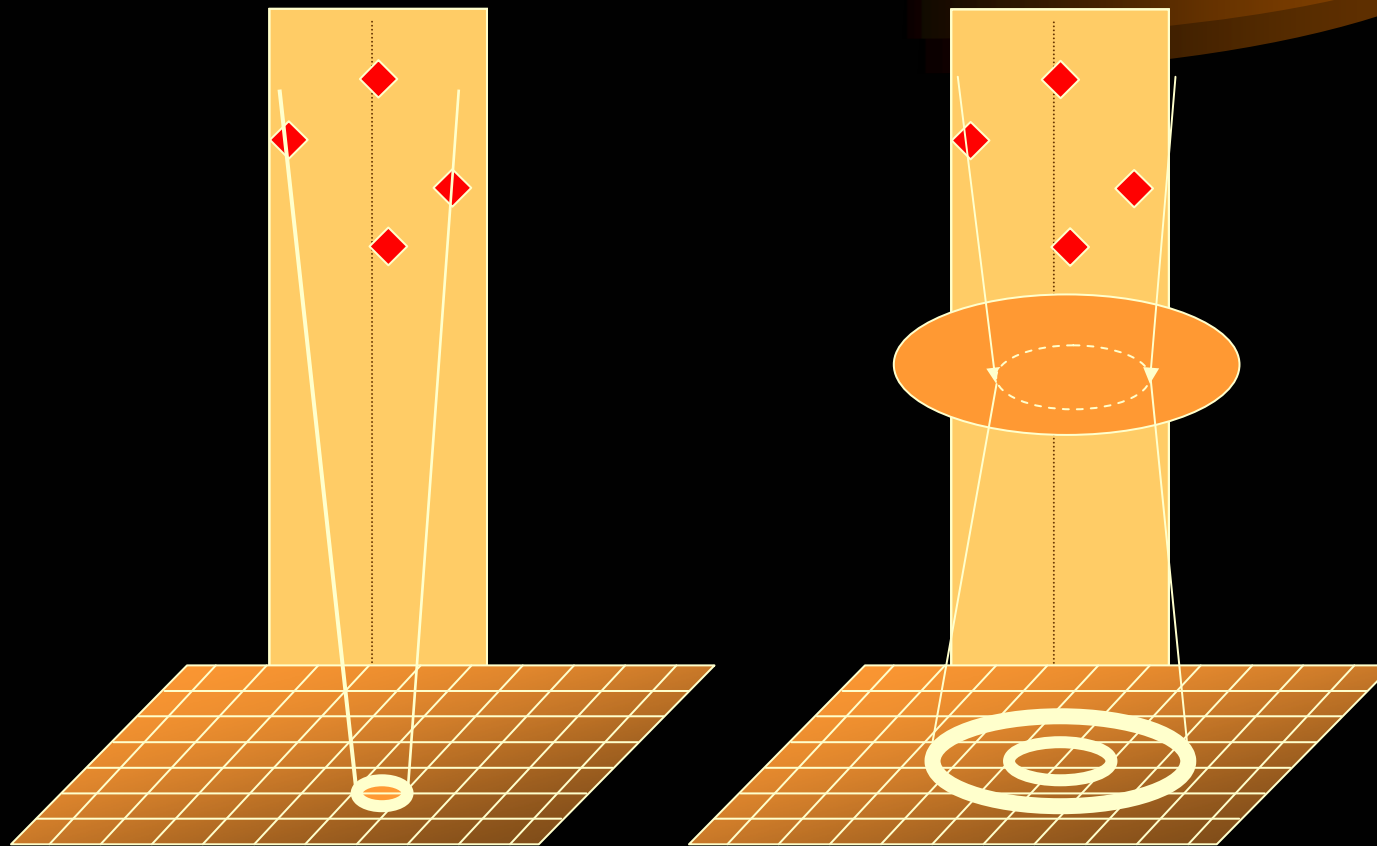
Abbildung über Fabry-Linse



Im Fokus

Fabry-Bild

Abbildung über Fabry-Linse



Im Fokus

Fabry-Bild

Abbildung über Fabry-Linse

pupil image

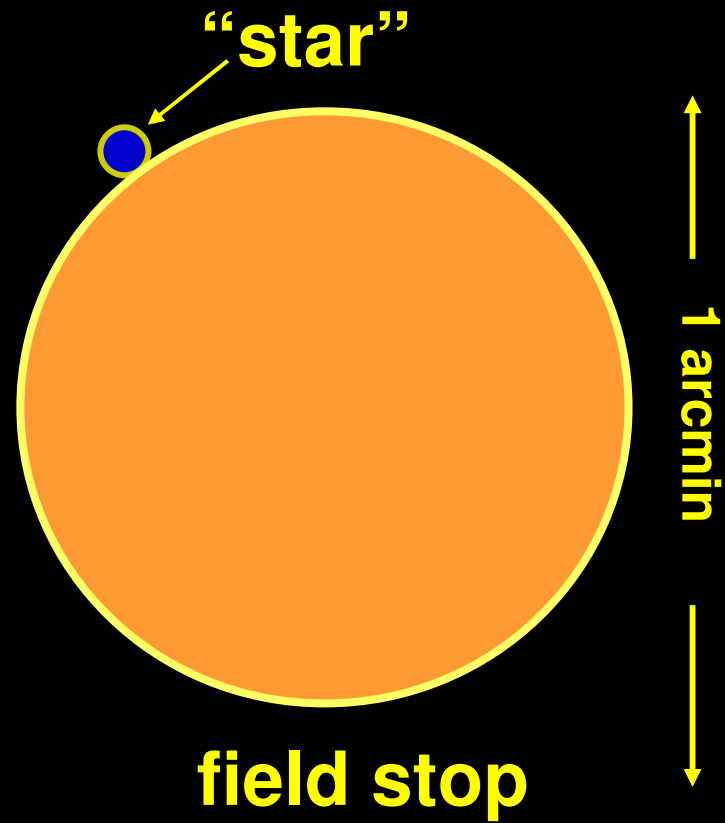
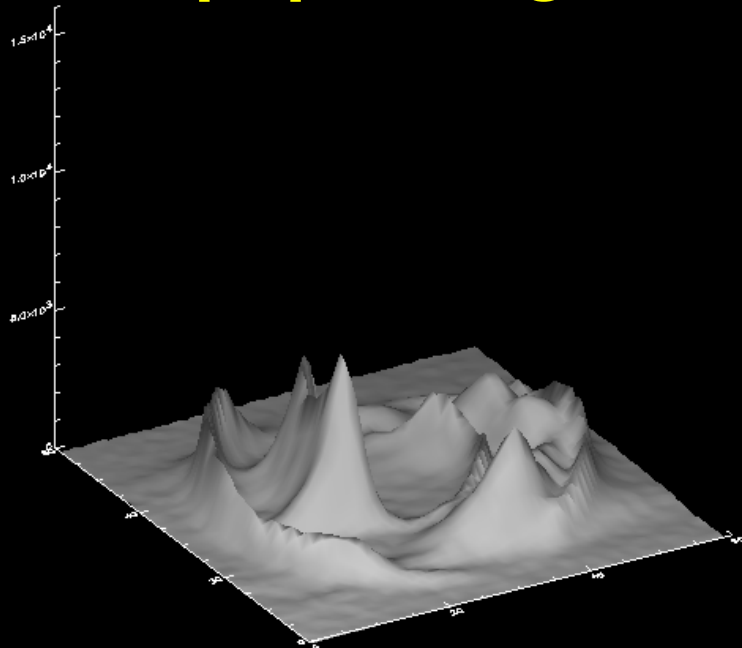
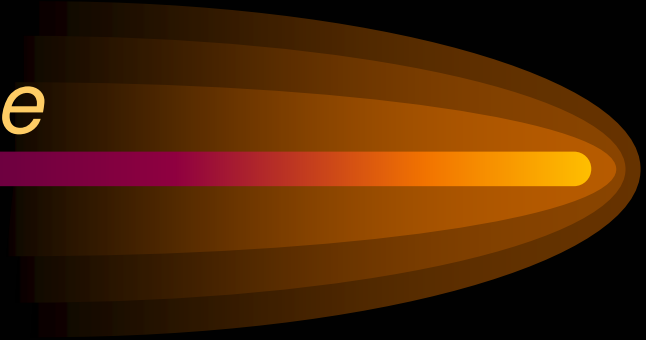
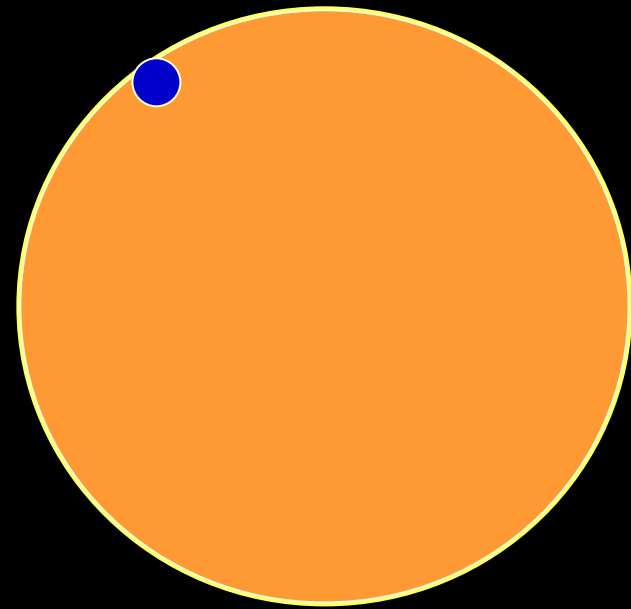
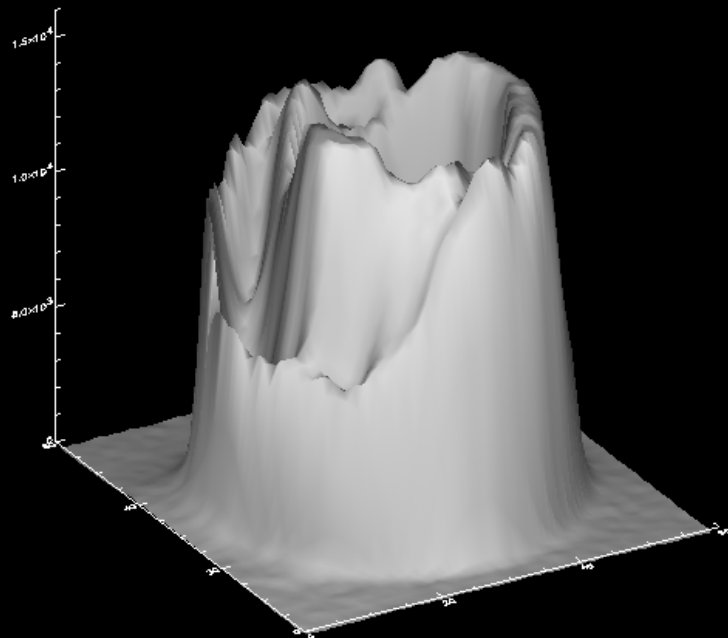


Abbildung über Fabry-Linse



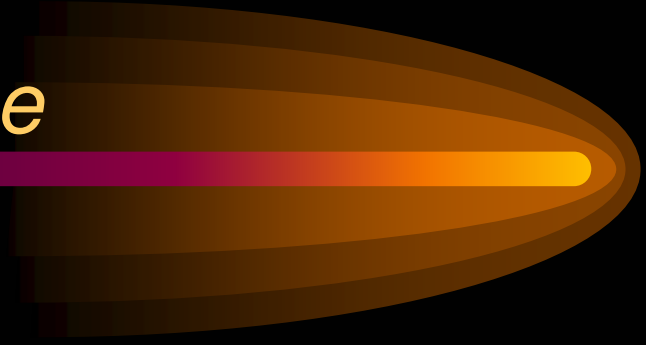
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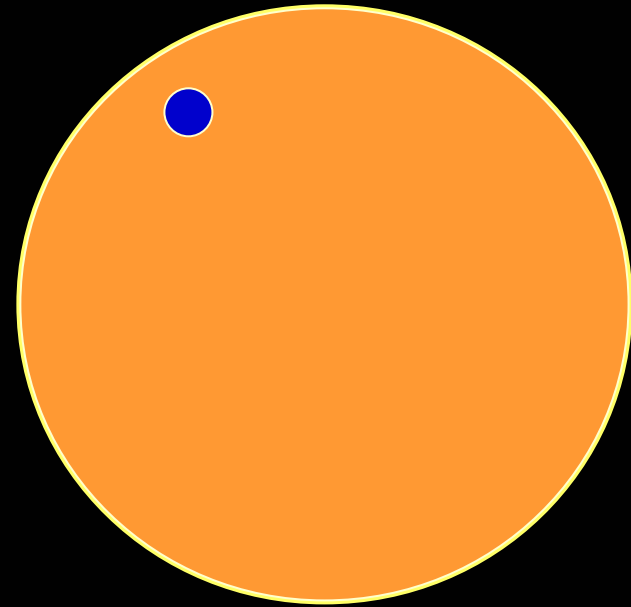
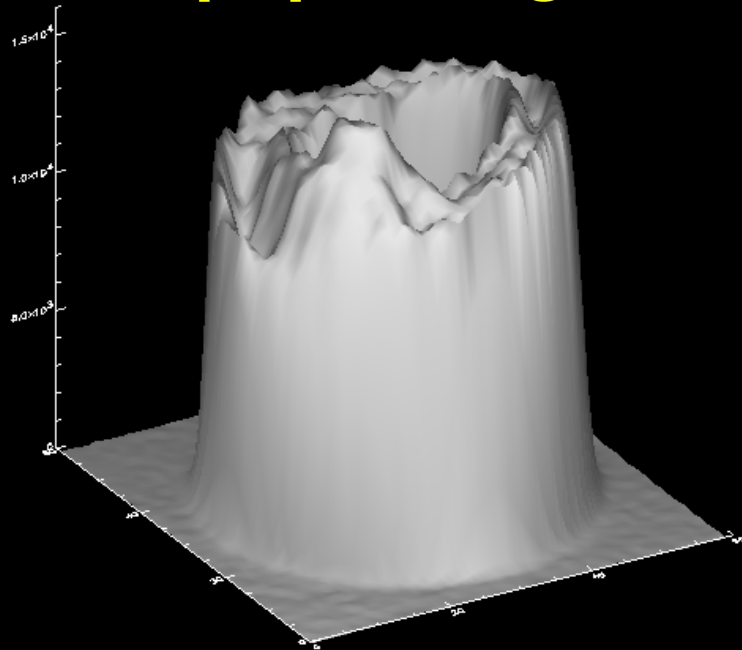
1 arcmin

field stop

Abbildung über Fabry-Linse



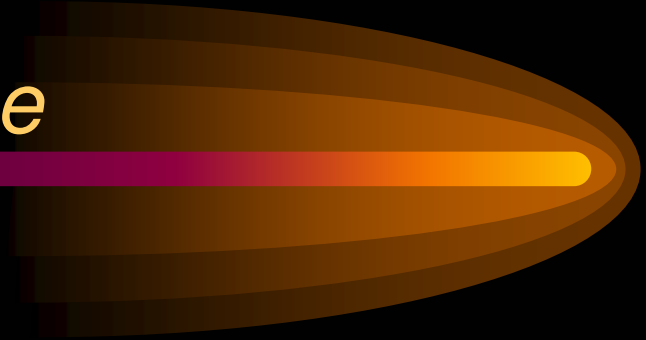
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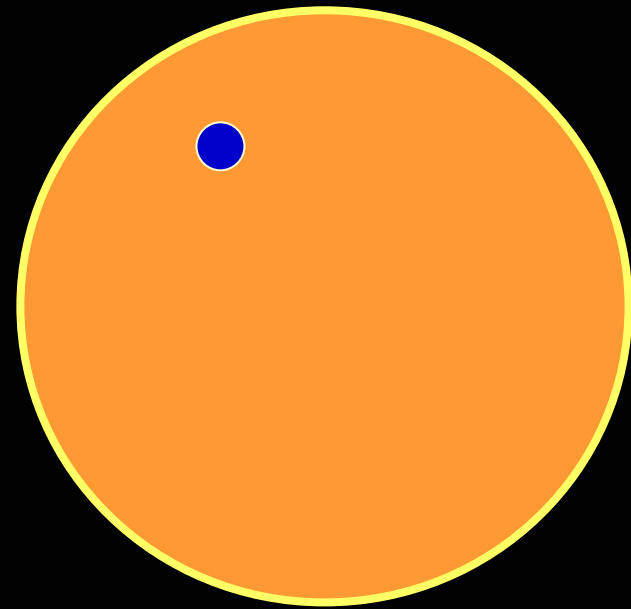
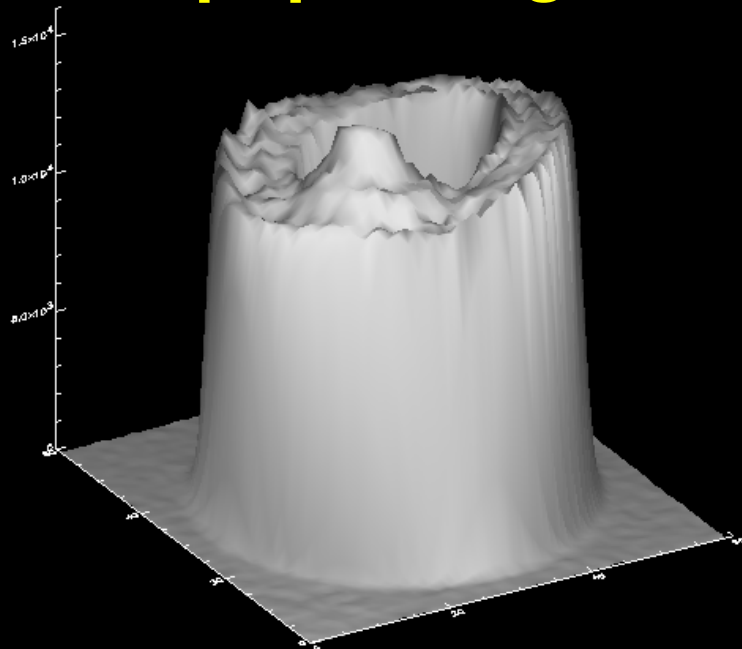
↑ 1 arcmin ↓

field stop

Abbildung über Fabry-Linse



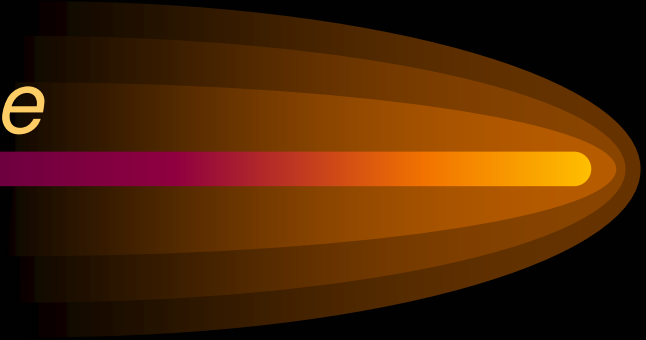
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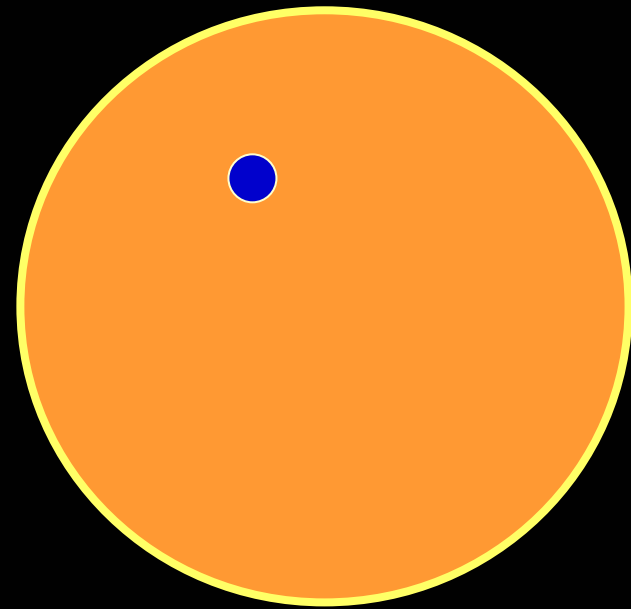
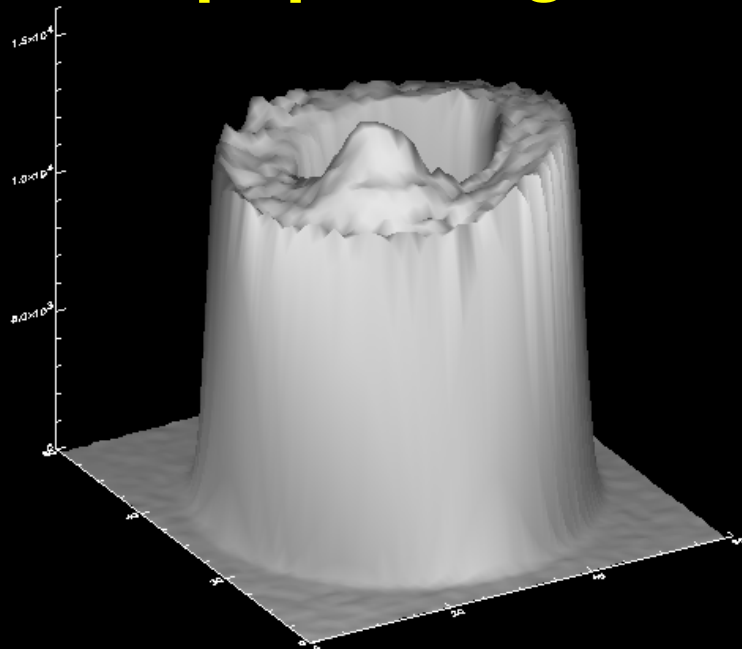
↑
1 arcmin
↓

field stop

Abbildung über Fabry-Linse



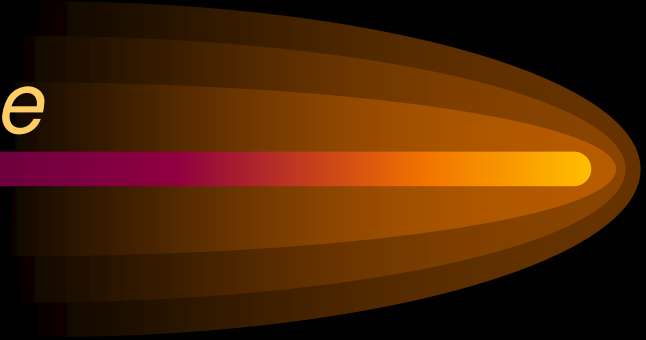
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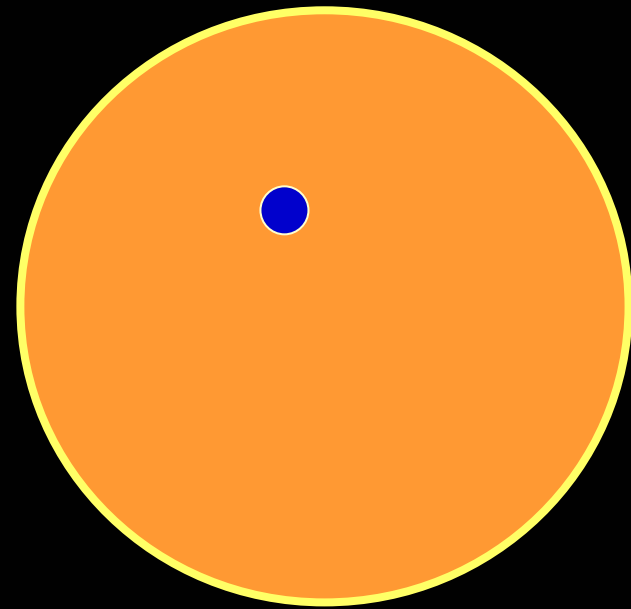
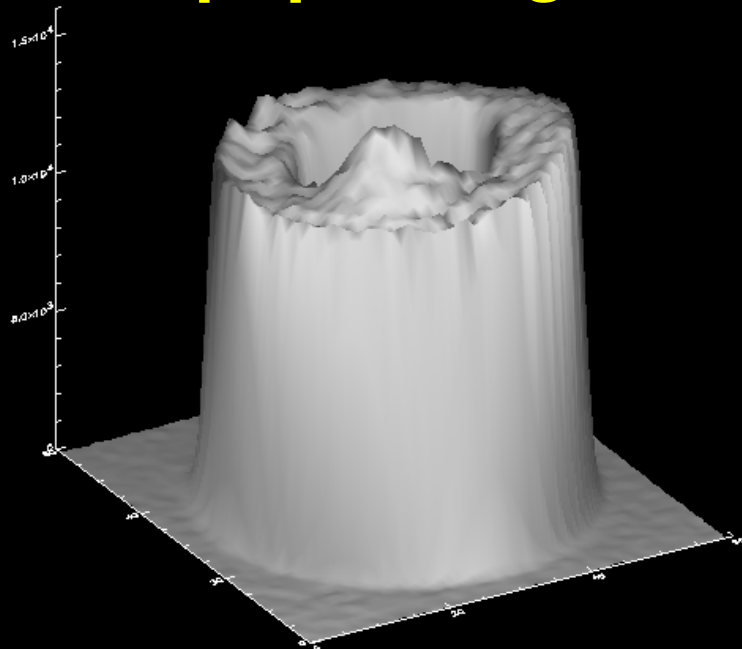
field stop

↑ 1 arcmin ↓

Abbildung über Fabry-Linse



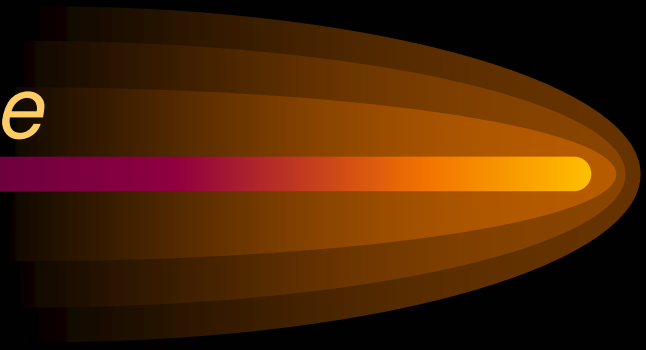
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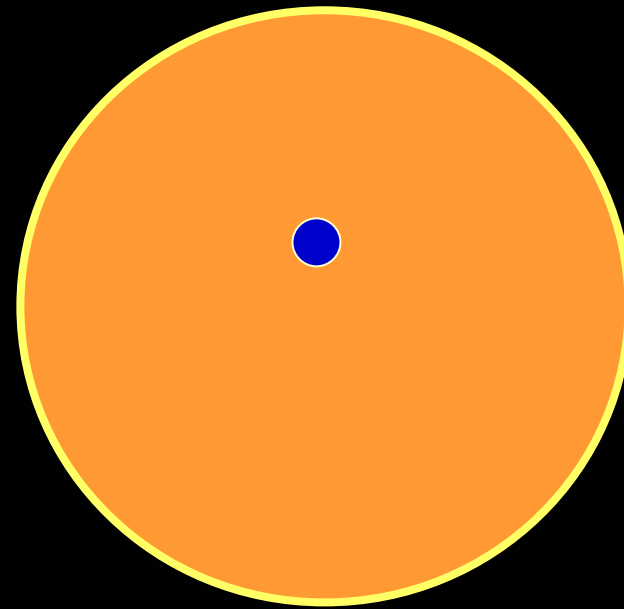
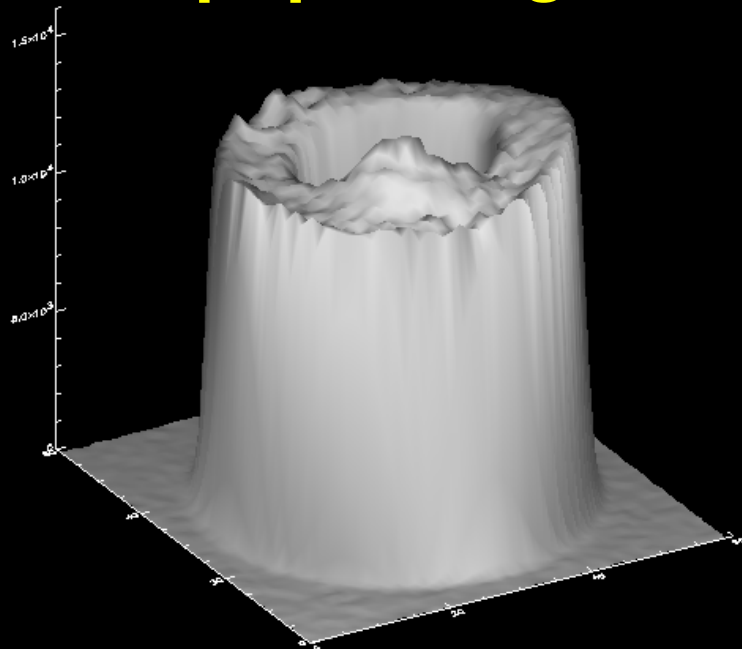
1 arcmin

field stop

Abbildung über Fabry-Linse



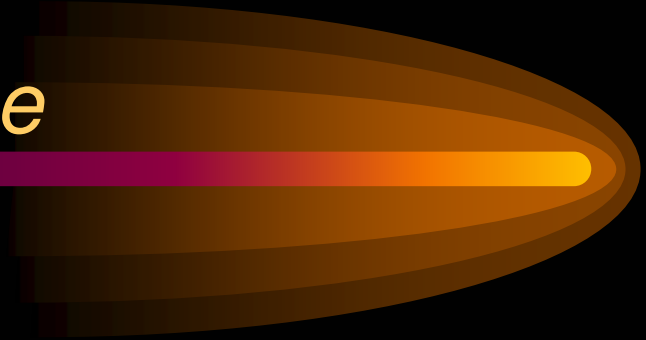
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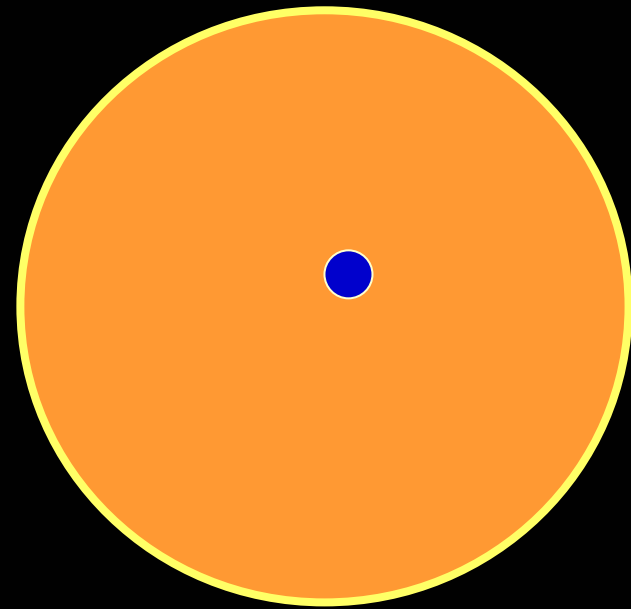
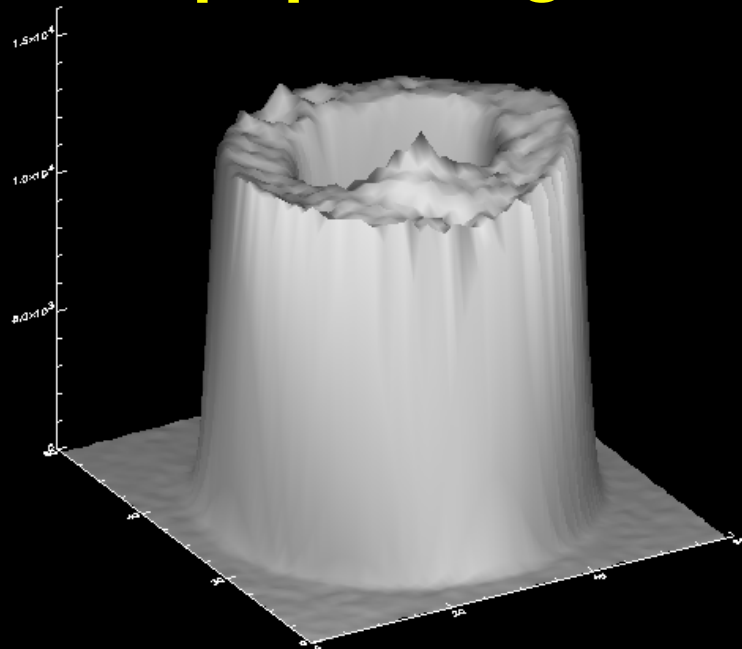
↑ 1 arcmin ↓

field stop

Abbildung über Fabry-Linse



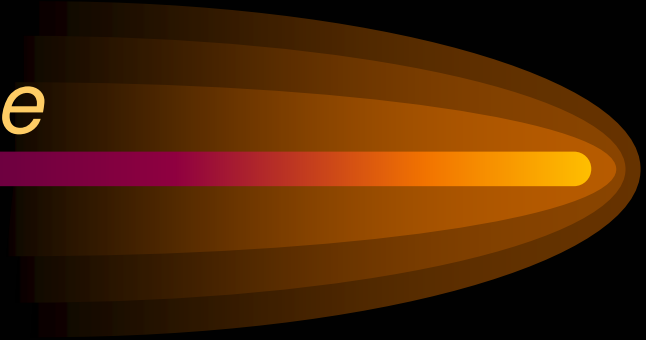
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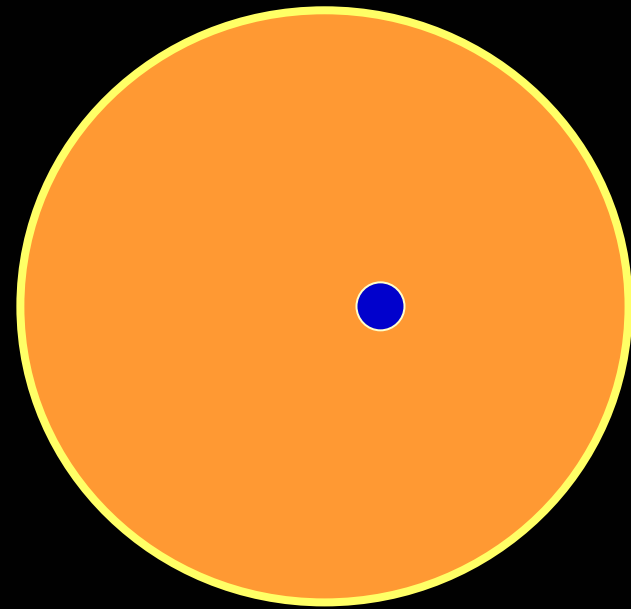
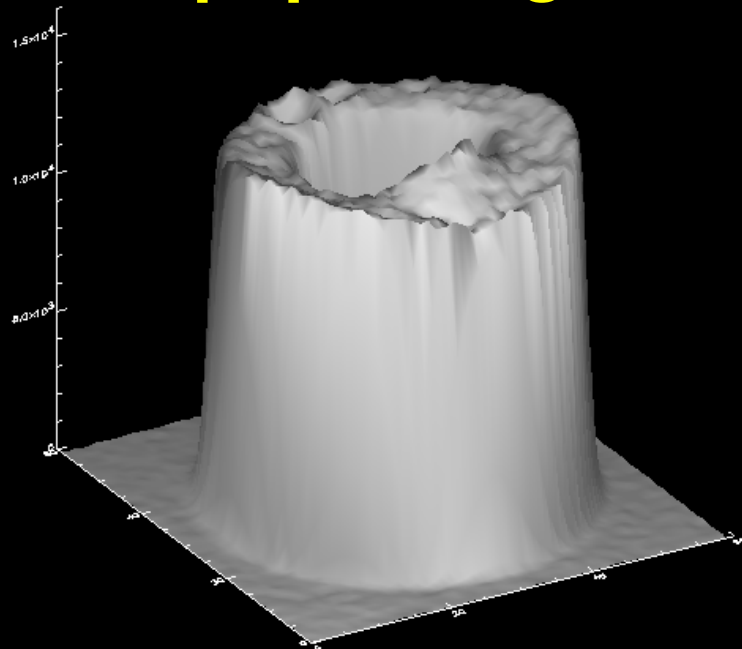
1 arcmin

field stop

Abbildung über Fabry-Linse



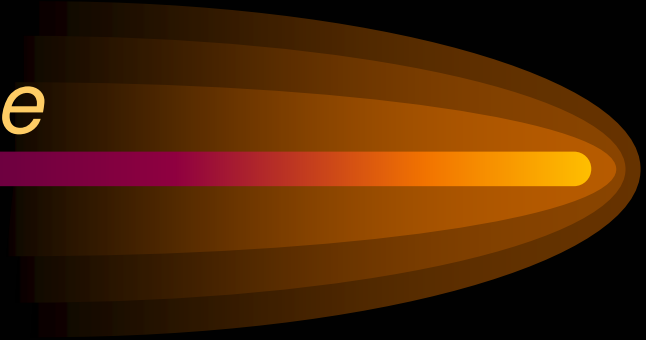
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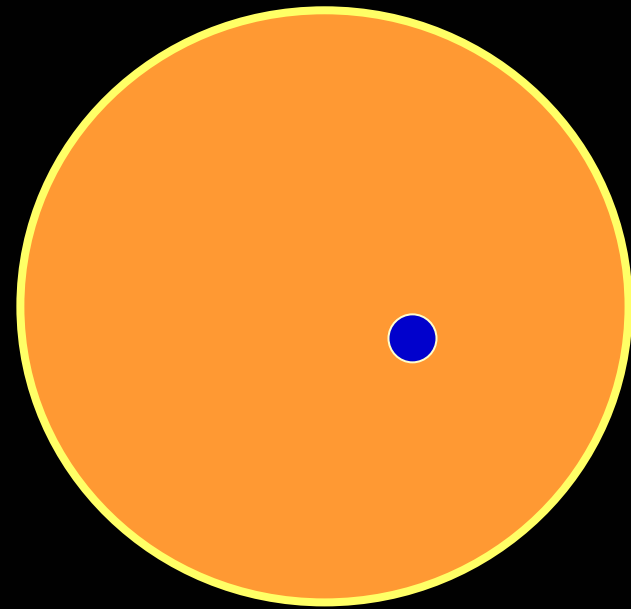
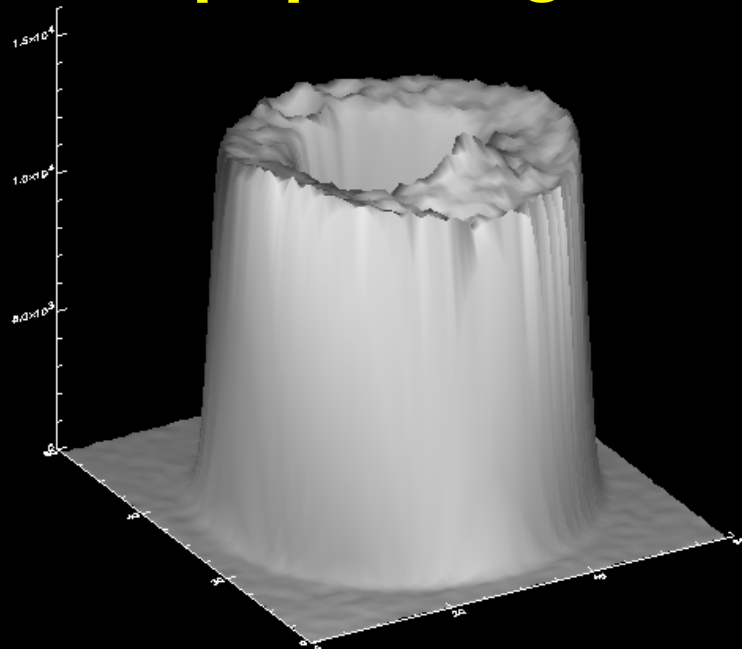
1 arcmin

field stop

Abbildung über Fabry-Linse



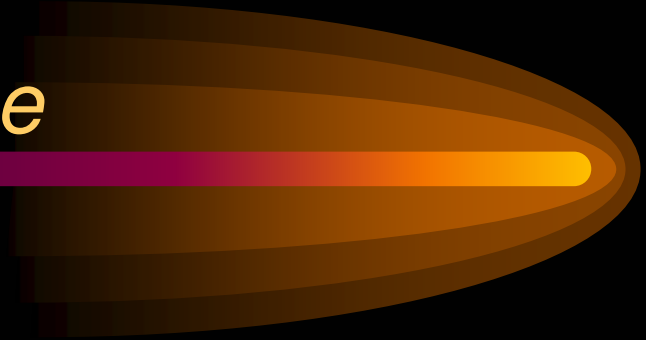
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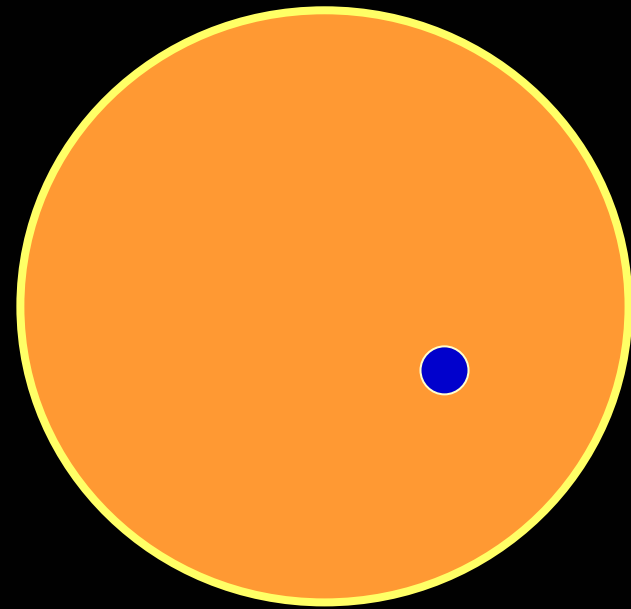
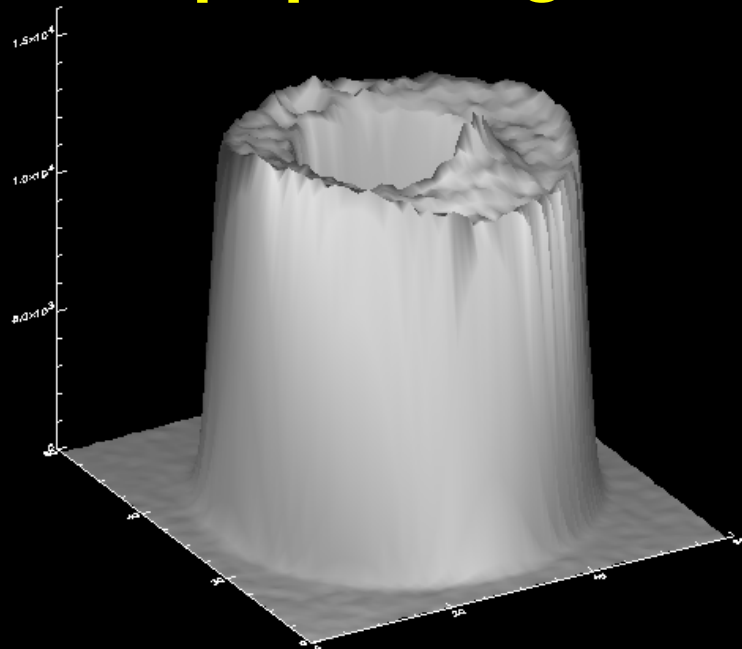
1 arcmin

field stop

Abbildung über Fabry-Linse



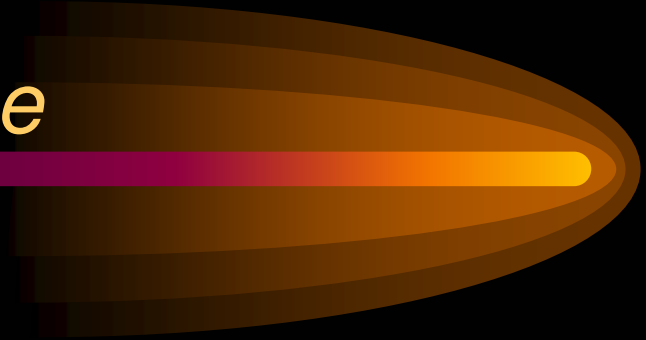
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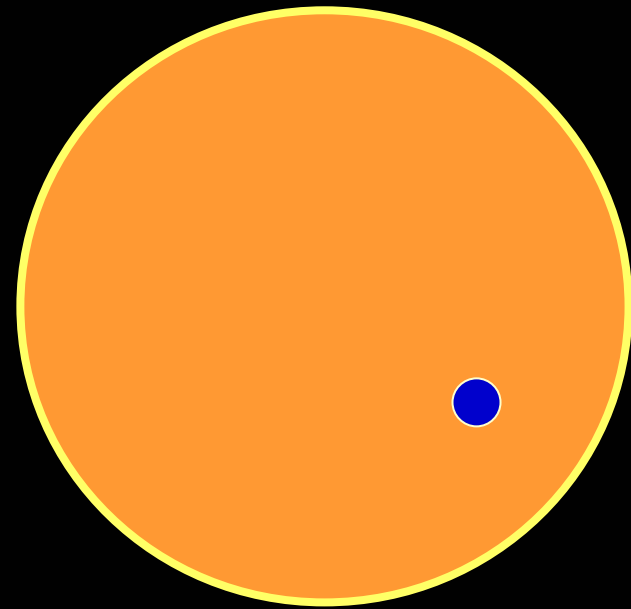
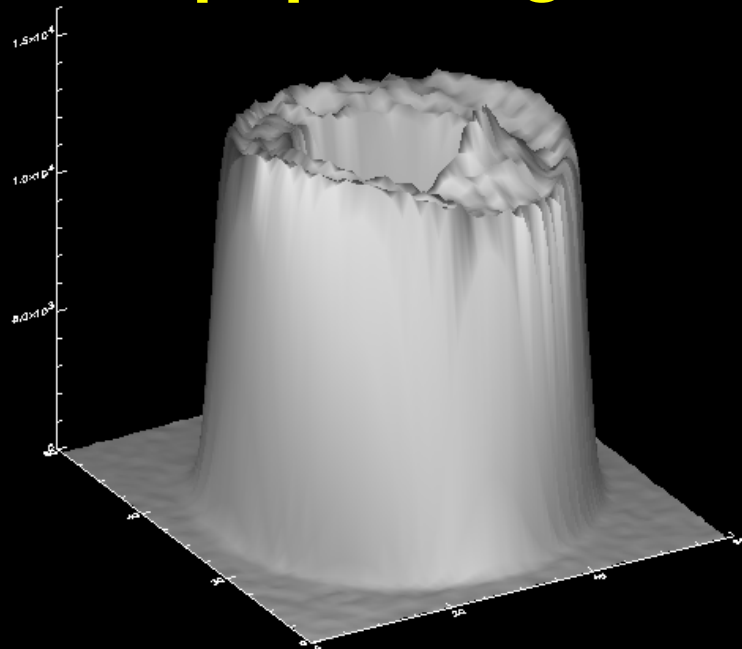
1 arcmin

field stop

Abbildung über Fabry-Linse



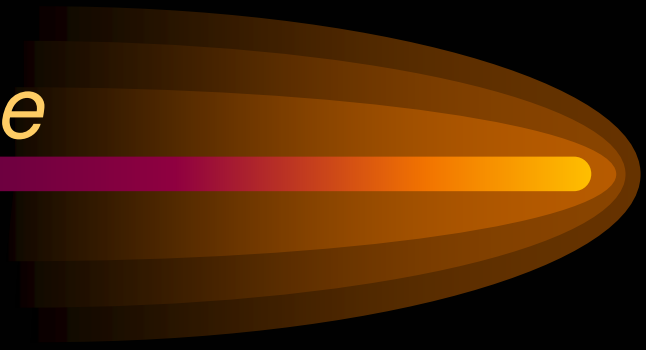
pupil image



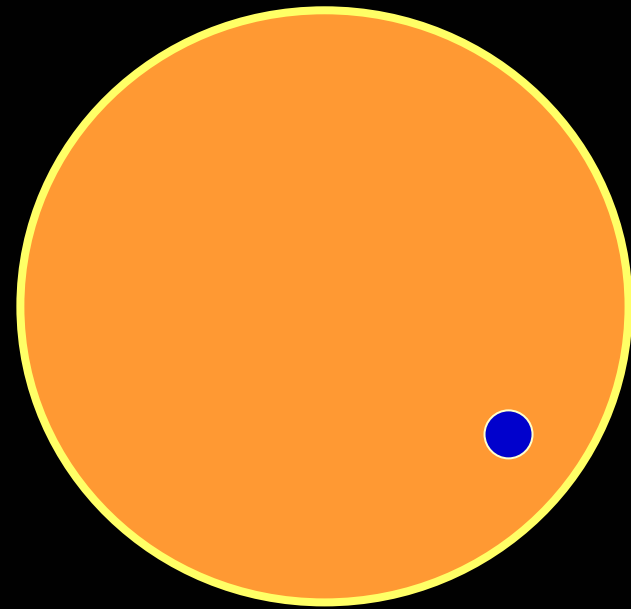
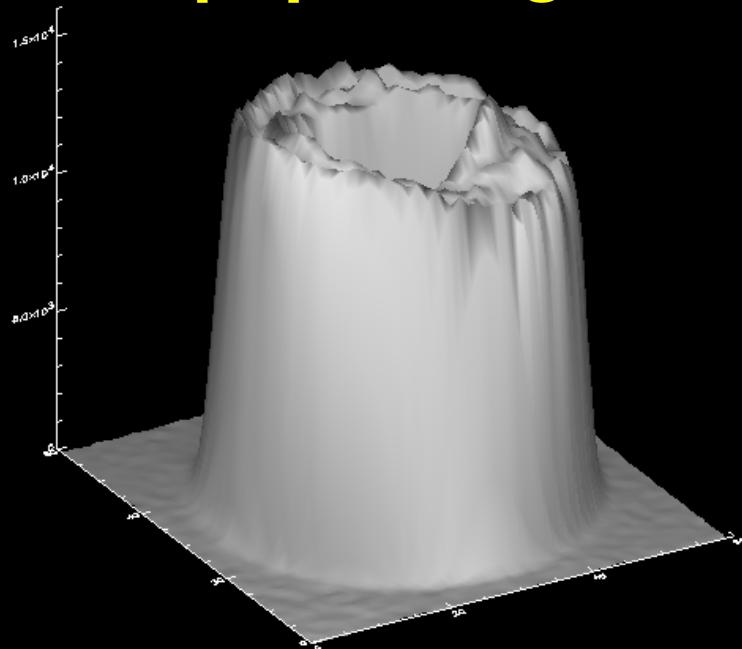
1 arcmin

field stop

Abbildung über Fabry-Linse



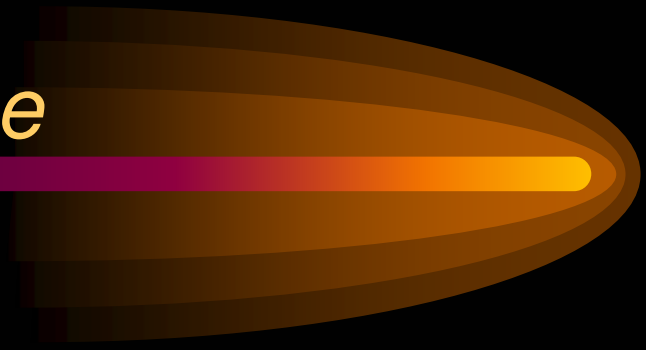
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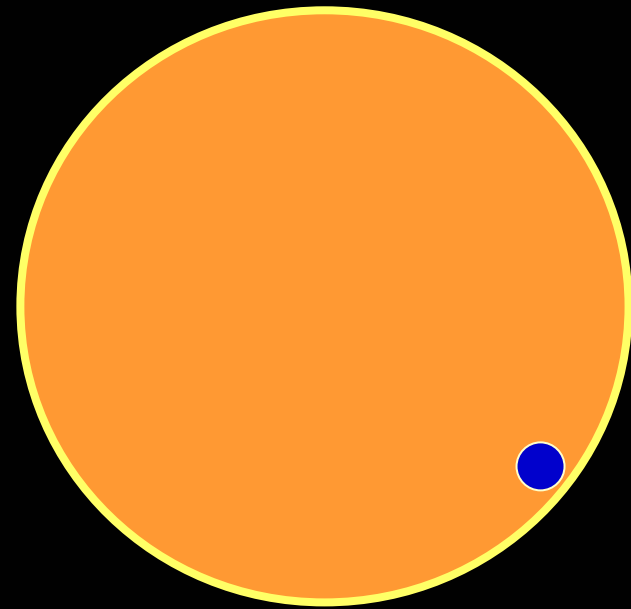
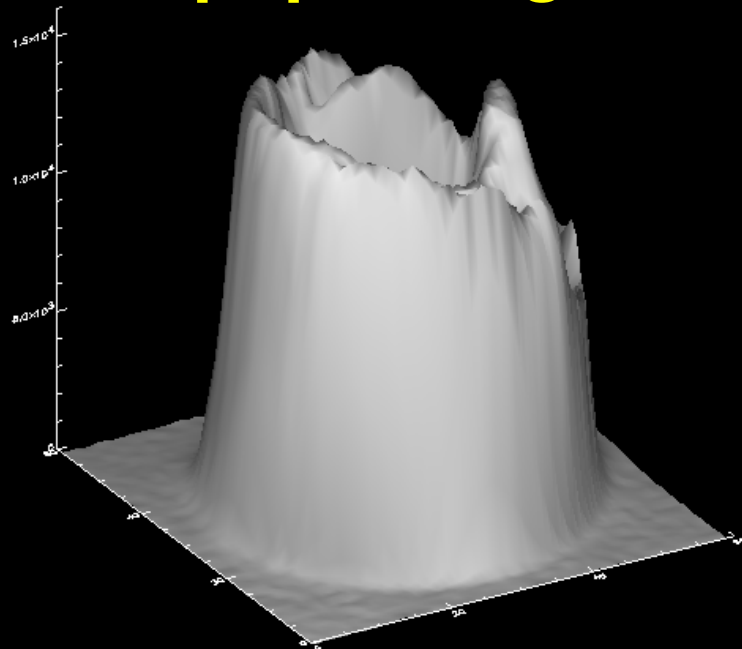
1 arcmin

field stop

Abbildung über Fabry-Linse



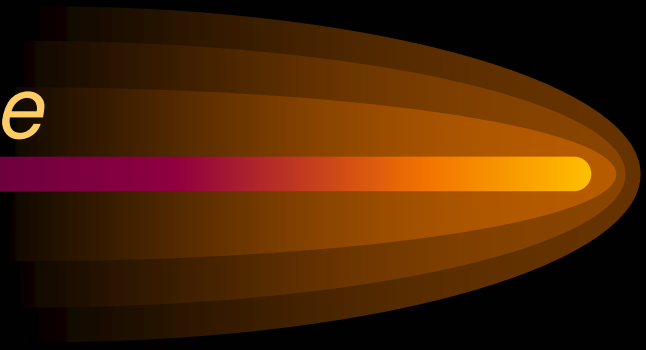
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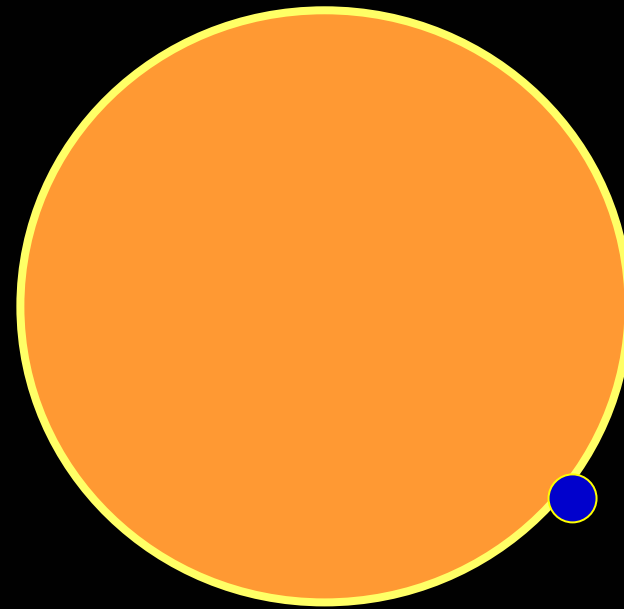
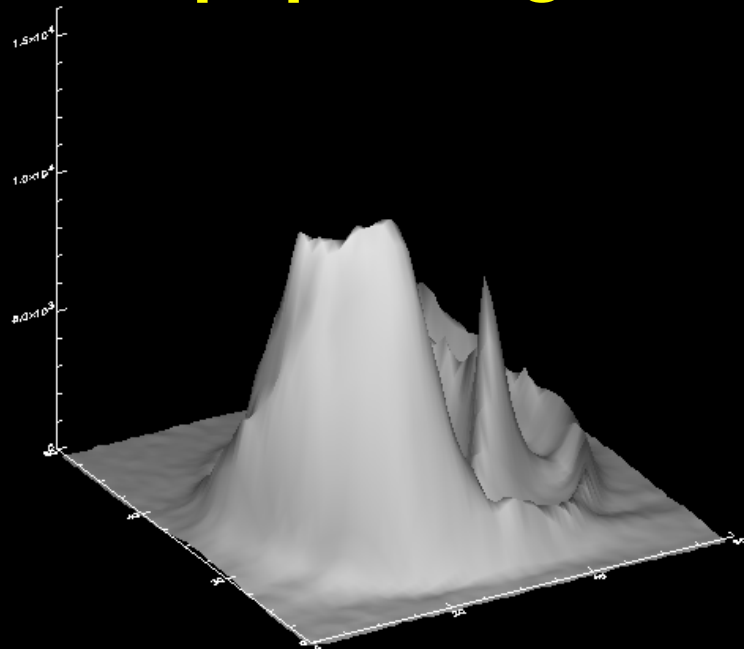
↑ 1 arcmin ↓

field stop

Abbildung über Fabry-Linse



pupil image

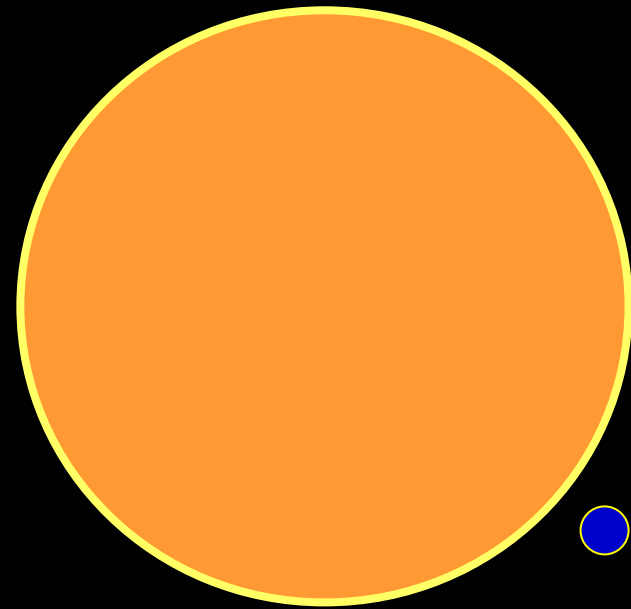
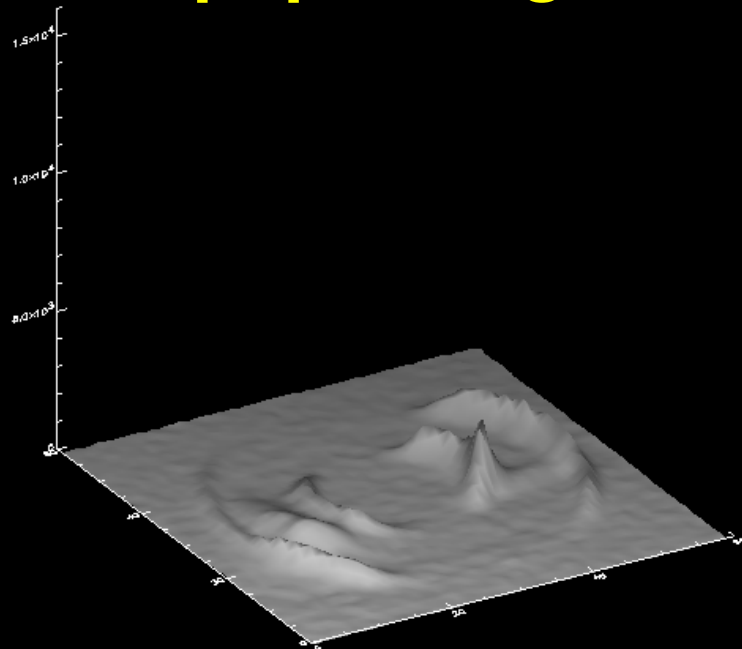


1 arcmin

field stop

Abbildung über Fabry-Linse

pupil image



field stop

1 arcmin

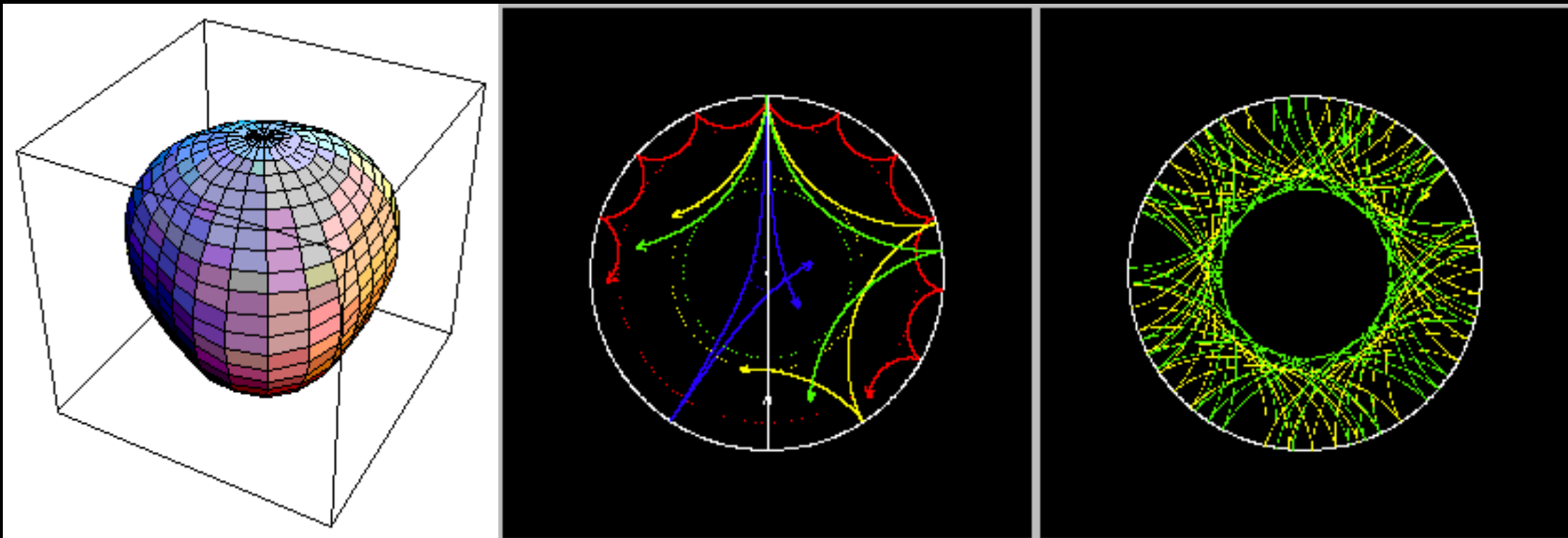
Photometrie auf der Erde und im All



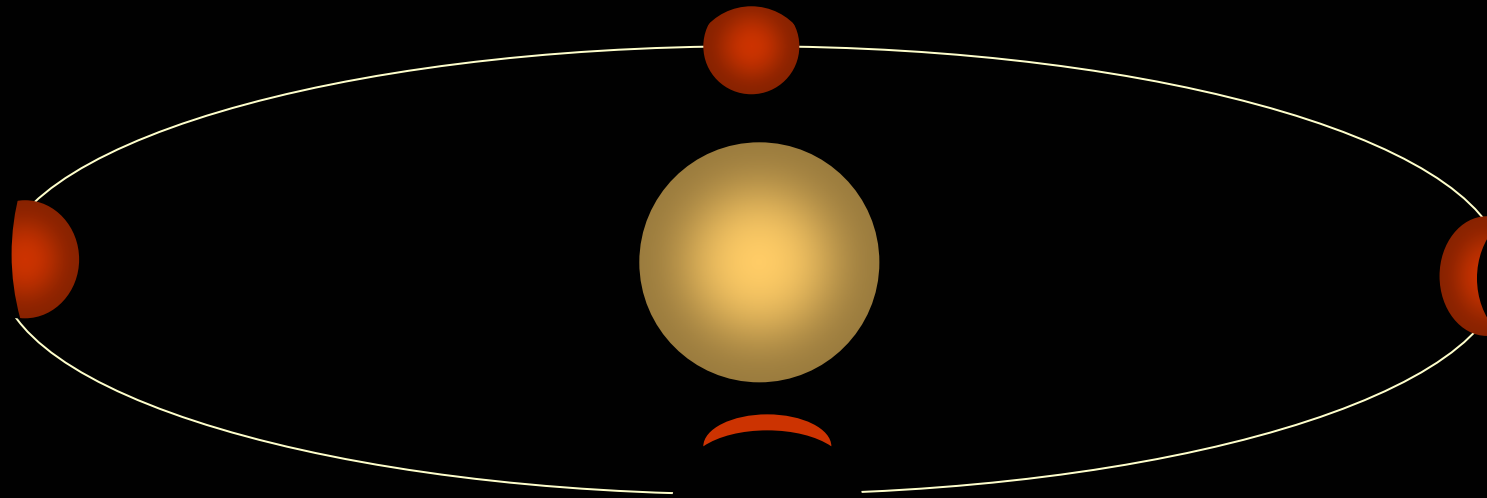
- Erde
 - Beobachtungen nur in der Nacht → Beobachtungslücken
 - Szintillation
 - Genauigkeit im Bereich von mmag
- All
 - Kontinuierliche Beobachtungen
 - wenig atmosphärische Störungen
 - Genauigkeit im Bereich von μmag

Astroseismologie

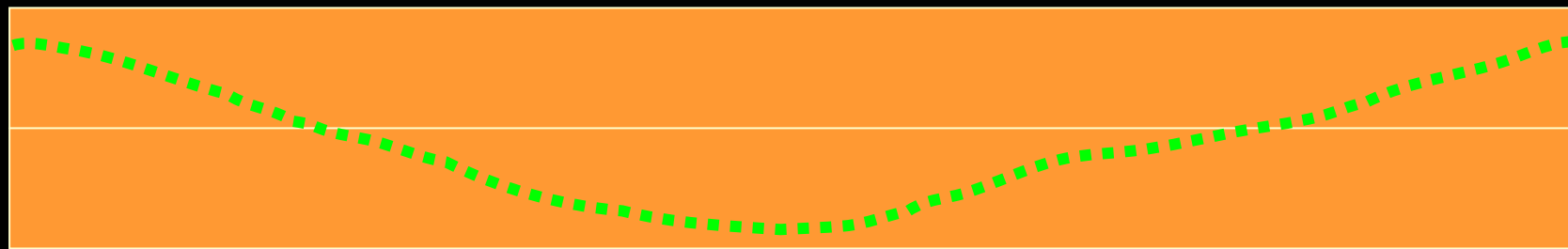
- MOST: Messung der Frequenzen radialer und nicht-radialer akustischer Oszillationen (p-Moden)
 - Sternradien
 - Struktur der Atmosphären-Schichtung, Konvektion
 - Sternentwicklung



Extrasolare Planeten

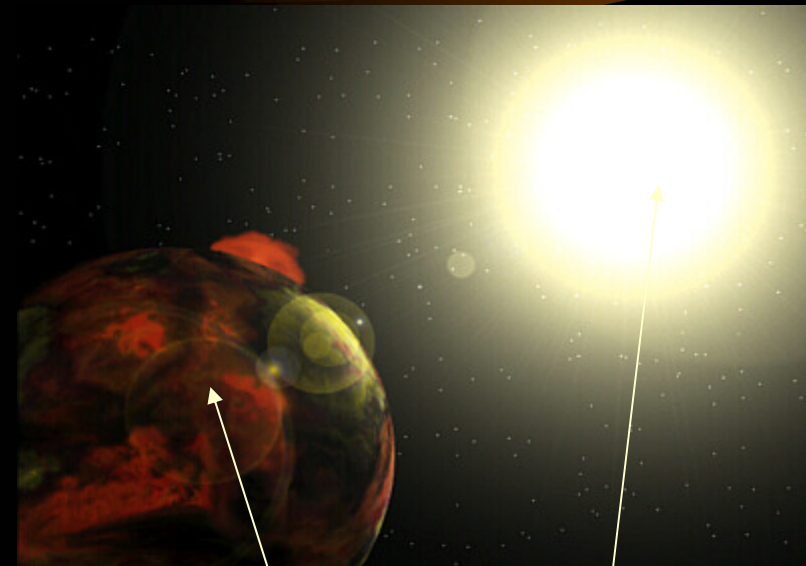


Lichtkurve



MOST science targets

- Sonnenähnliche Sterne
- Metallarme Sub-Zwerg
- Pulsierende magnetische Sterne (*roAp*)
- Wolf-Rayet Sterne
- Nahe extrasolare Riesenplaneten



51 Peg b

51 Peg a

MOST - Target Stars - Mission Year 1 (2003)

release date (yyyy-mm-dd): 2002-4-11

Star	mag(V)	Target Type	Spec. Class.	Additional Information
Procyon	0.38	Solar-like Oscillations	F5V	reported-p-mode-detection
eta Boo^{mt}	2.68	Solar-like Oscillations	G0IV	reported-p-mode-detection
tau Ceti^{mt}	3.5	Solar-like Oscillations	G8V	
delta Vir^{mt}	3.61	Solar-like Oscillations	F9V	
gamma Ser^{mt}	3.85	Solar-like Oscillations	F6IV	
iota Leo^{mt}	4.00	Solar-like Oscillations	F4IV	
HD224930	5.73	Metal Poor Subdwarf	G3V	low-chromospheric-activity
HD76932	5.80	Metal Poor Subdwarf	F9V	near-main-sequence-turnoff
gamma Equ	4.68	Rapid Oscillating Ap Star	F0p	4-periods-detected
10 Aql	5.89	Rapid Oscillating Ap Star	F0spe	multi-periodic
HR1217	6.00	Rapid Oscillating Ap Star	Ap...	6-periods-detected
51 Peg	5.49	Exo-Solar Planetary System **	G2.5IVa	M=0.47; P=4.23
HD38529	5.93	Exo-Solar Planetary System **	G4V	M=0.81; P=14.41
WR 134	8.23	Wolf-Rayet Star	WN6	
WR 135	8.36	Wolf-Rayet Star	WC8	
WR 123	11.26	Wolf-Rayet Star	WN8	multi-periodic
zeta Oph	2.56	Massive Non-Radial Pulsator	O9.5Vn	non-radial-pulsation

HR 1217

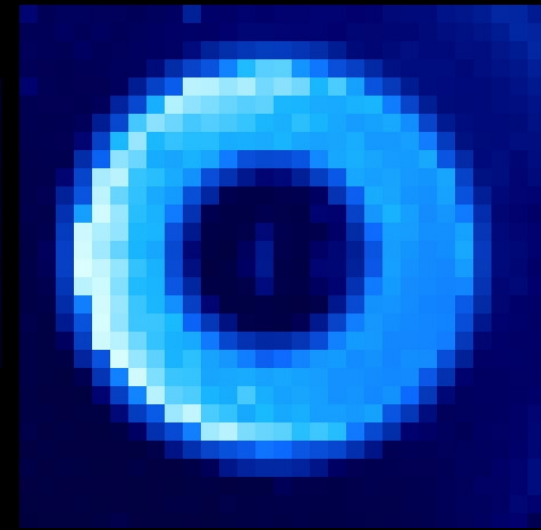
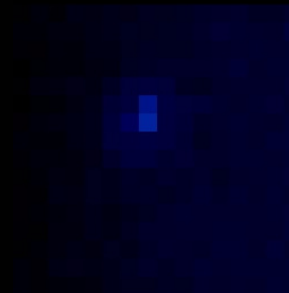
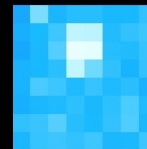
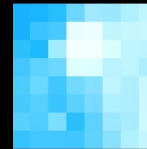
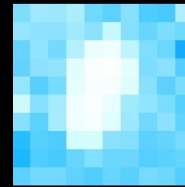
Science Frames



- Eine Aufnahme je 10 bis 30 Sekunden
- Aufnahmen werden gespeichert und bei jedem Pass zu einer Bodenstation gesendet
- Übertragungsformate
 - SDS1: gebinntes FITS-Frame des Primary Targets (Zeilen- und Spaltensummen)
 - SDS2: FITS-Frame mit Primary und Secondary Targets
 - SDS 1 zur kompakteren, weniger detaillierten Übertragung

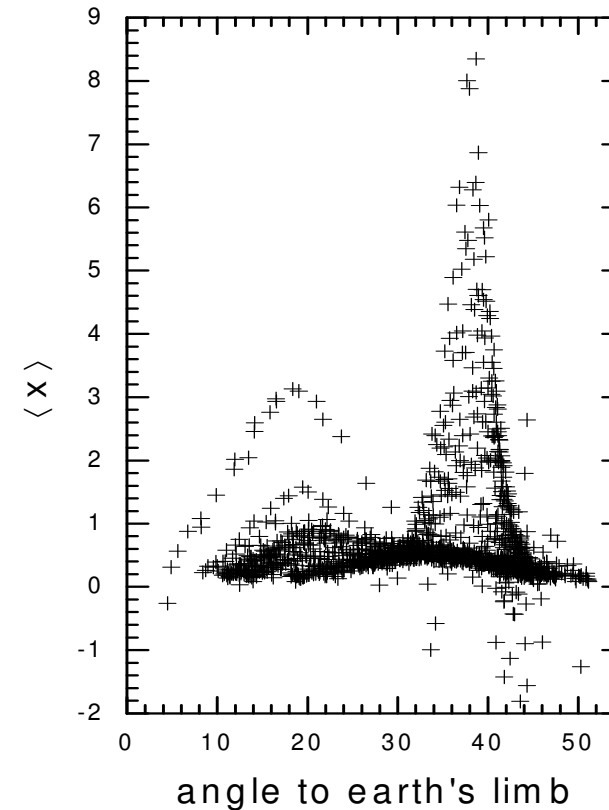
SDS2 Datenformat

- Primary Target
 - Fabry-Bild („Doughnut“)
 - Größe 29x29 Pixel
- Secondary Targets
 - Direct imaging
 - Größe variabel: mehrere Pixel
 - Bis zu 7 Secondaries

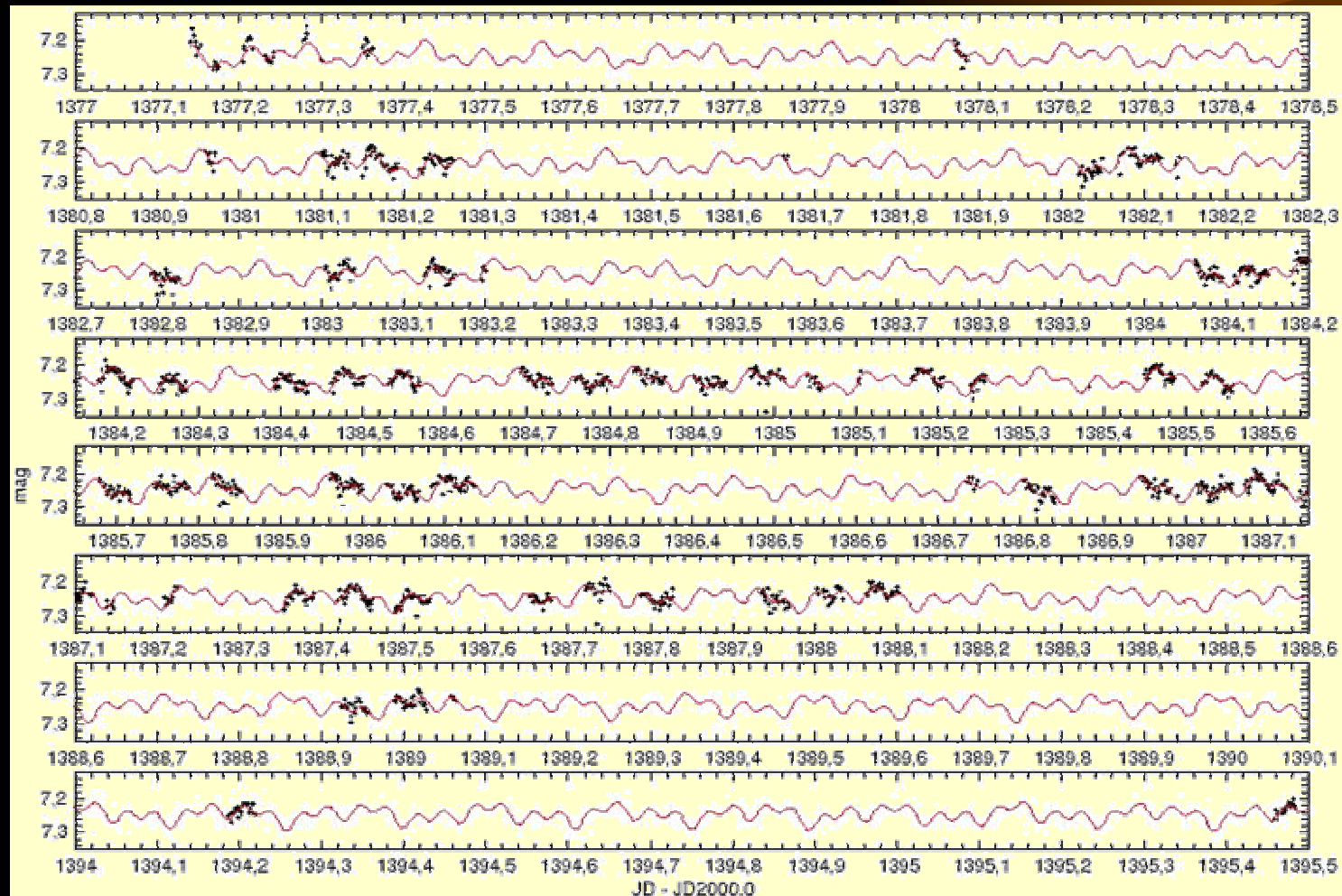


Vom Frame zur Lichtkurve

- Reduktion jedes Bildes auf einen Helligkeitswert
 - Bestimmung einer Apertur für die gesamte Messreihe
 - Korrektur von Hintergrundtrends (Taylor-Reihe)
 - Bad-Pixel-Korrektur ($k \cdot \sigma$)
 - Modellierung des Hintergrunds im Bereich des Targets
- größtes Problem: Streulicht



Lichtkurve von Delta Ceti

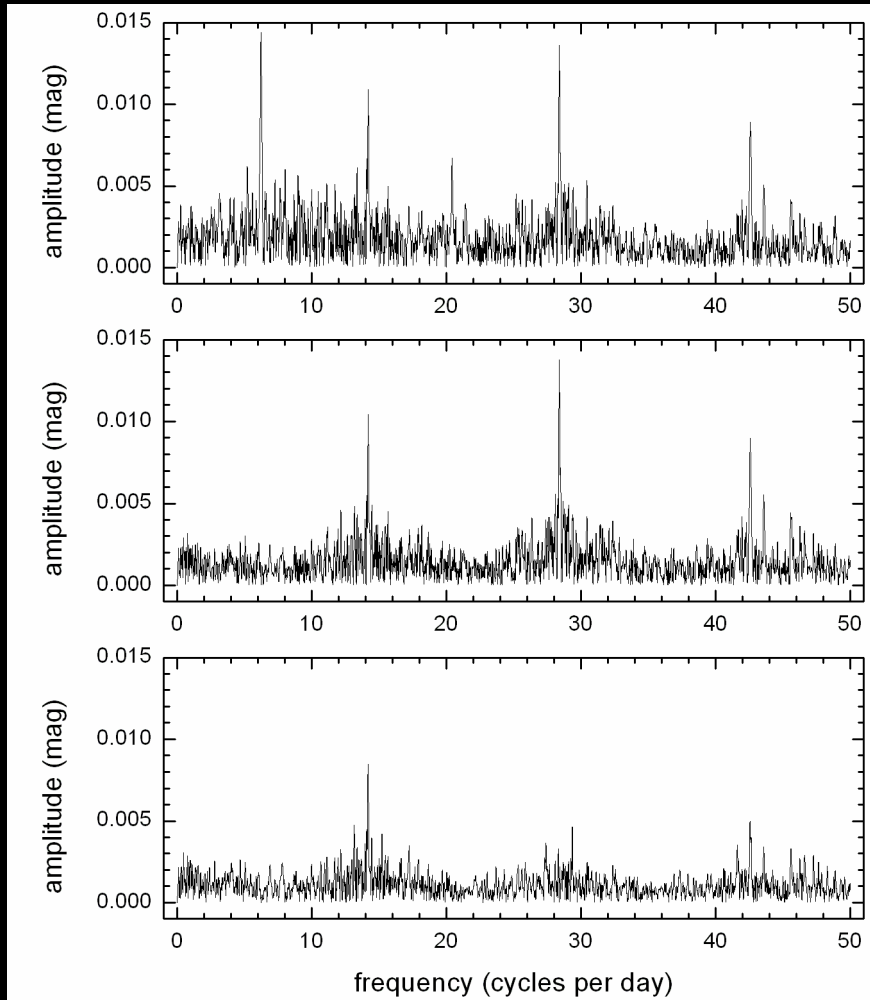


Von der Lichtkurve zu Frequenzen



- Fourier-Analyse der Lichtkurve, z.B. über Period (Breger)
- S/N im Spektrum
- Spektrales Fenster
- Alias-Frequenzen

Fourier-Analyse



$$f_1 = 6.205 \text{ c/d}$$
$$a_1 = 15.2 \text{ mmag}$$

$$f_2 = 28.371 \text{ c/d}$$
$$a_2 = 16.5 \text{ mmag}$$

$$f_3 = 14.168 \text{ c/d}$$
$$a_3 = 15.1 \text{ mmag}$$

**Residuen: spectral noise = 0.78
mmag**

Danke für die Aufmerksamkeit!



- Fragen?