Von der Dunklen Energie bis zu kosmischen Neutrinos

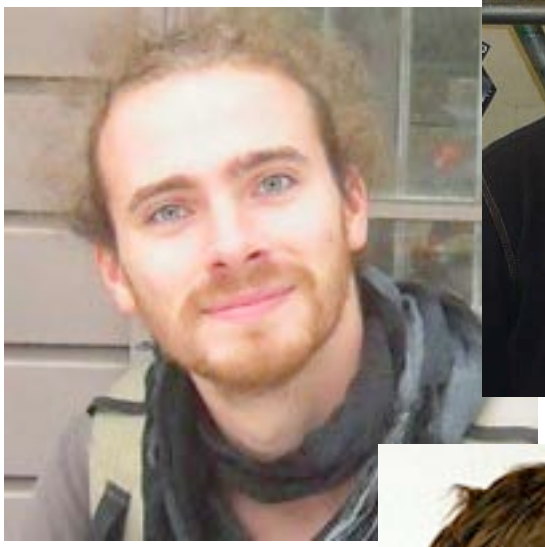
Marek Kowalski

Supernova 1994D

ZTF @ DESY & Humboldt-University

Daniel Küster

Simona Lombardo



Dr. Mickael Rigault

Dr. Jakob Nordin

Dr. Anna Franckowiak

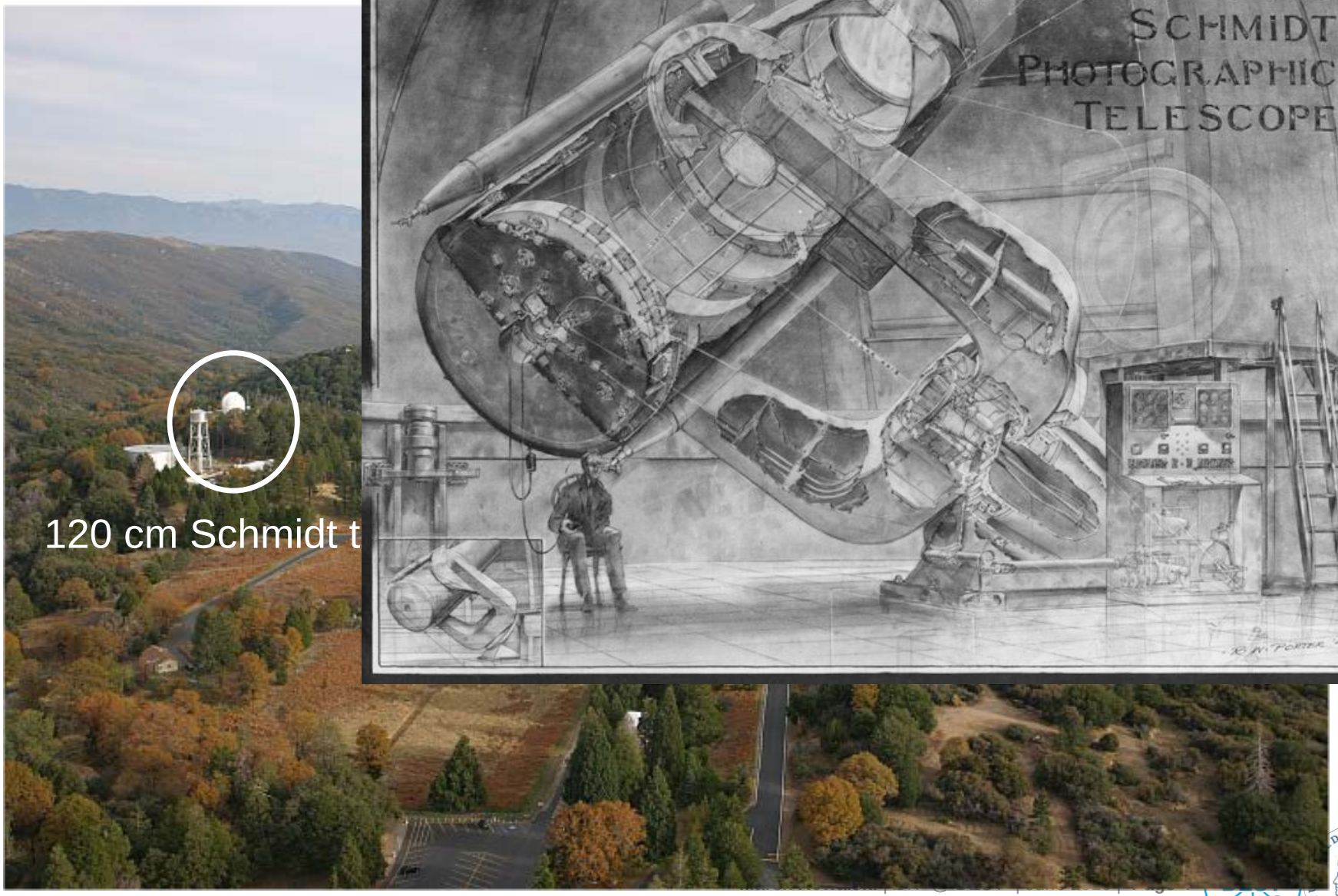
Nora Linn Strothjohann

und:

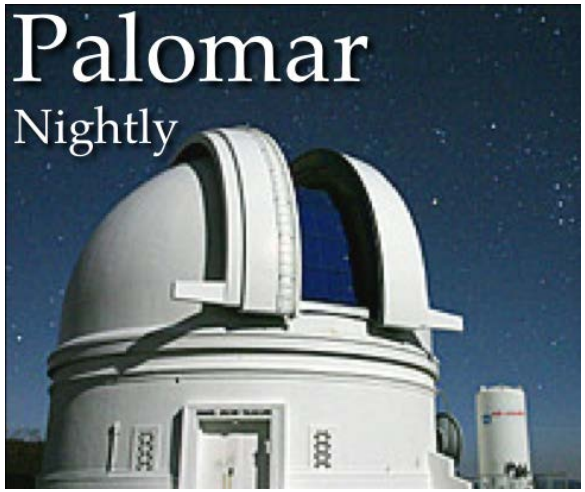
Alexander Donat
Lap Van Vu
Marek Kowalski

Mount Palomar Observatory

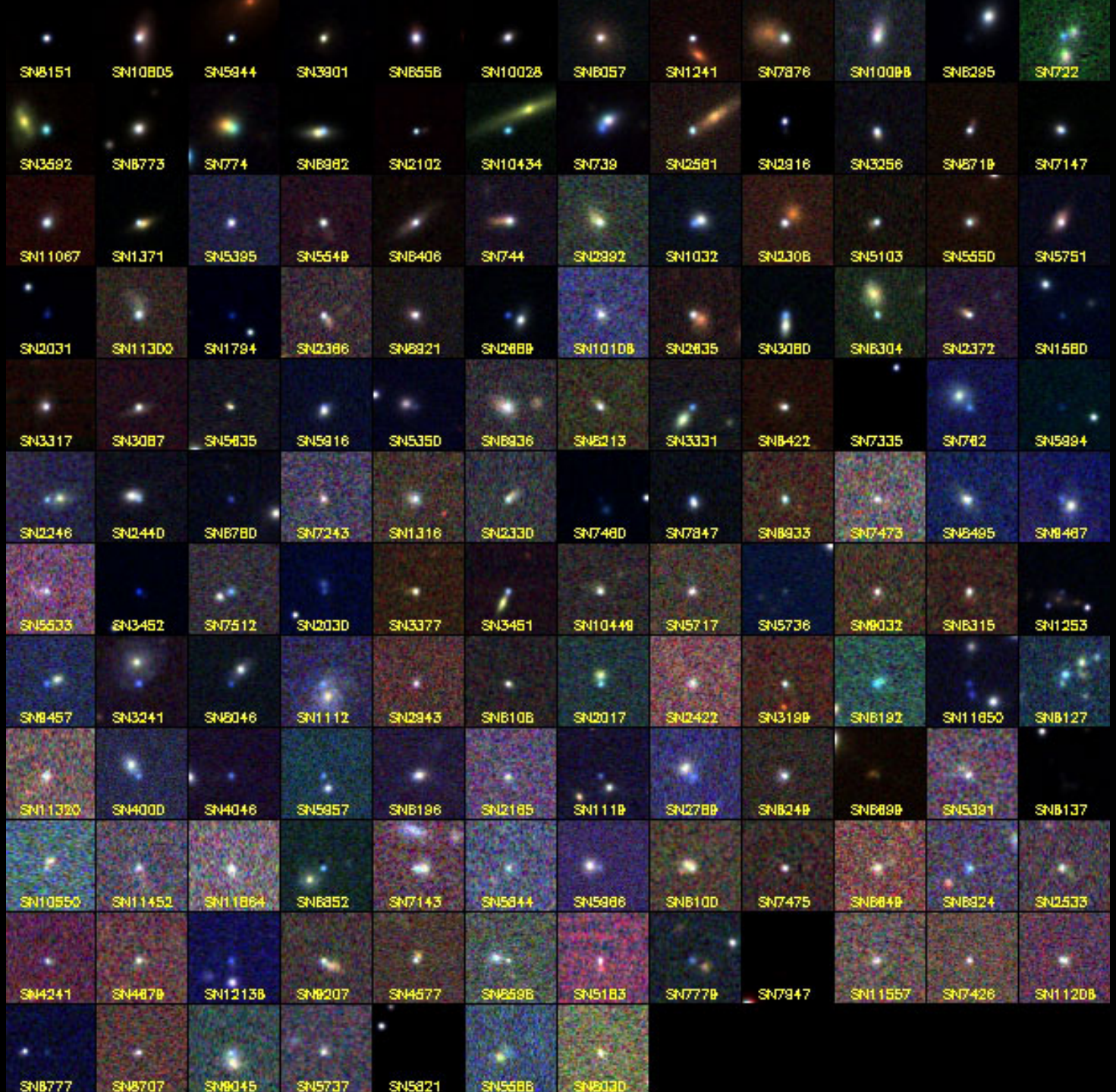
Mount Palomar Observatory



Supernovae: Explodierende Sterne



Beobachtung von Supernovae


SN8151
SN10805
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SN8295
SN722
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SN8773
SN774
SN8982
SN2102
SN10434
SN739
SN2581
SN2916
SN3256
SN5719
SN7147
SN11067
SN1371
SN5395
SN5549
SN8406
SN744
SN2992
SN1032
SN2308
SN5103
SN5550
SN5751
SN2031
SN11300
SN1794
SN2386
SN5921
SN2889
SN10108
SN2835
SN3080
SN8304
SN2372
SN1580
SN3317
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SN7335
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SN5994
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SN2440
SN8780
SN7243
SN1316
SN2330
SN7460
SN7847
SN8933
SN7473
SN8495
SN8467
SN5533
SN3452
SN7512
SN2030
SN3377
SN3451
SN10448
SN5717
SN5736
SN8032
SN8315
SN1253
SN8457
SN3241
SN5046
SN1112
SN2943
SN8108
SN2017
SN2422
SN3198
SN8192
SN11650
SN8127
SN11320
SN4000
SN4046
SN5957
SN8196
SN2185
SN1119
SN2788
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SN8137
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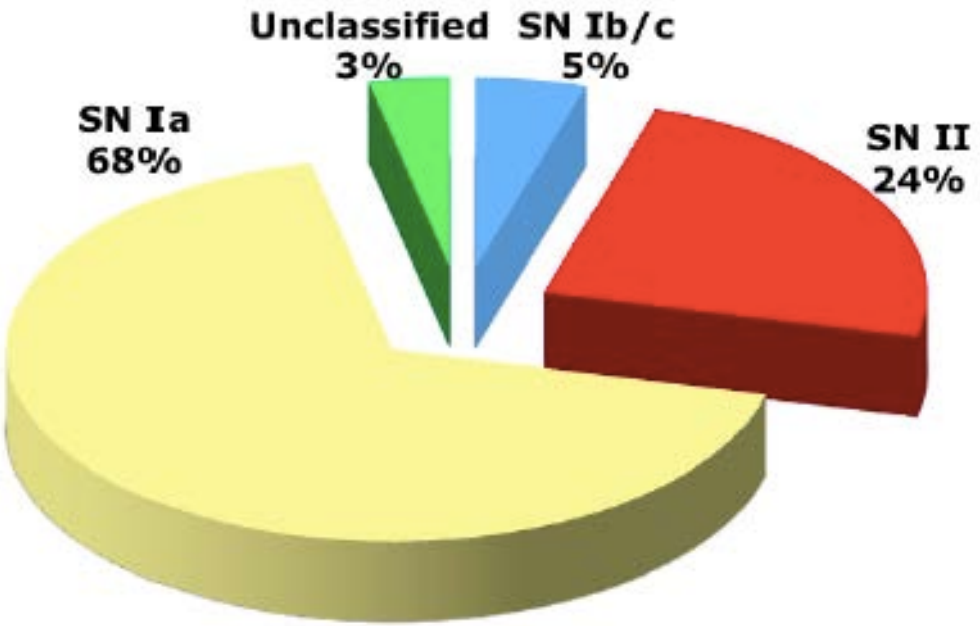
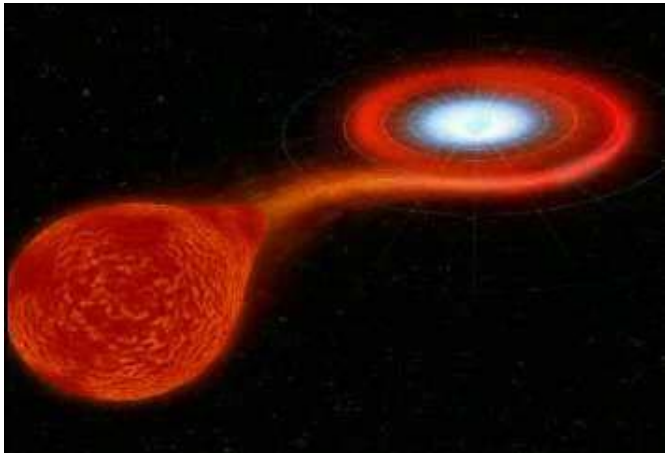
SN5588
SN8030

Supernovae: Explodierende Sterne



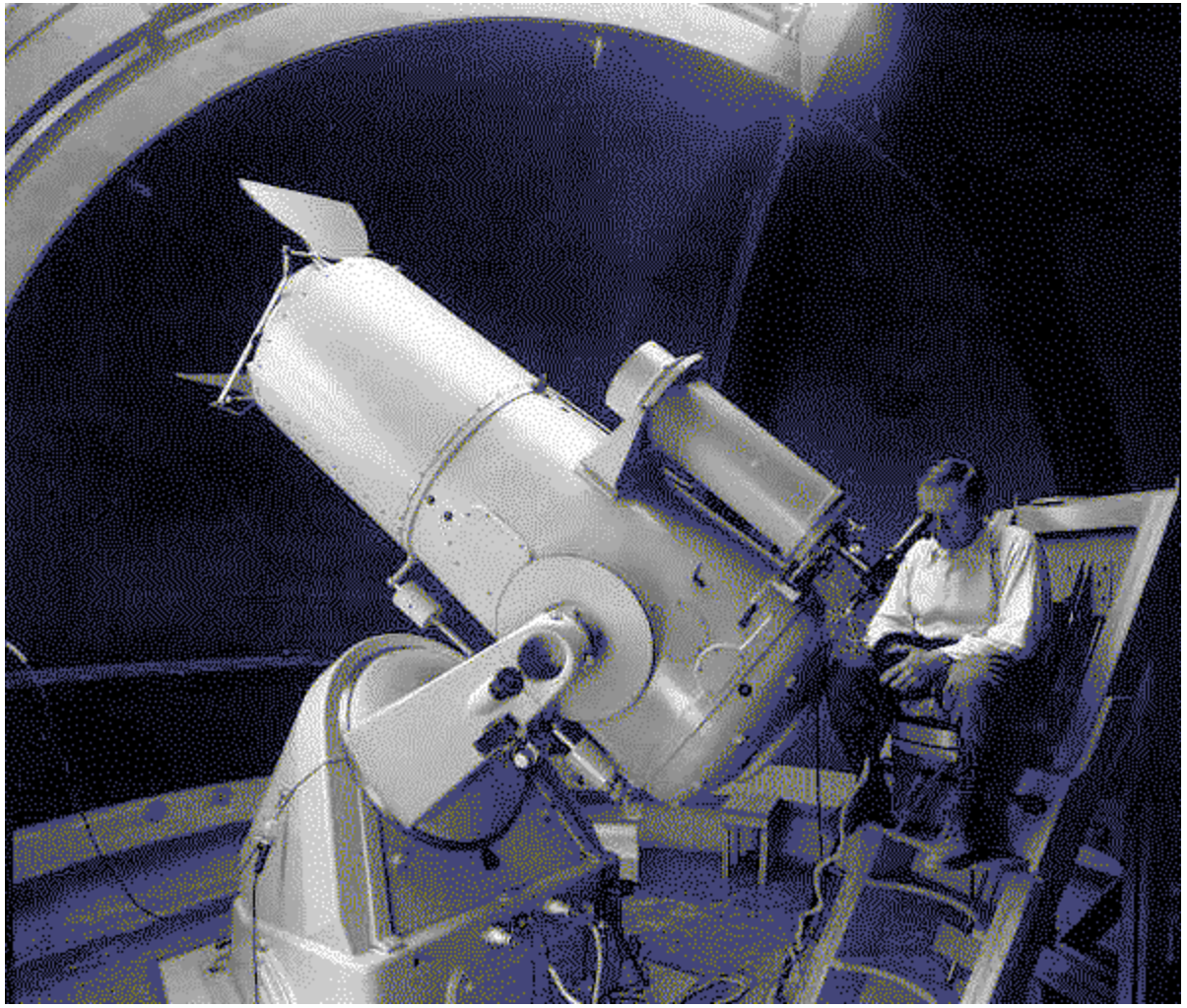
gravitativer Kollaps

Supernova Ia

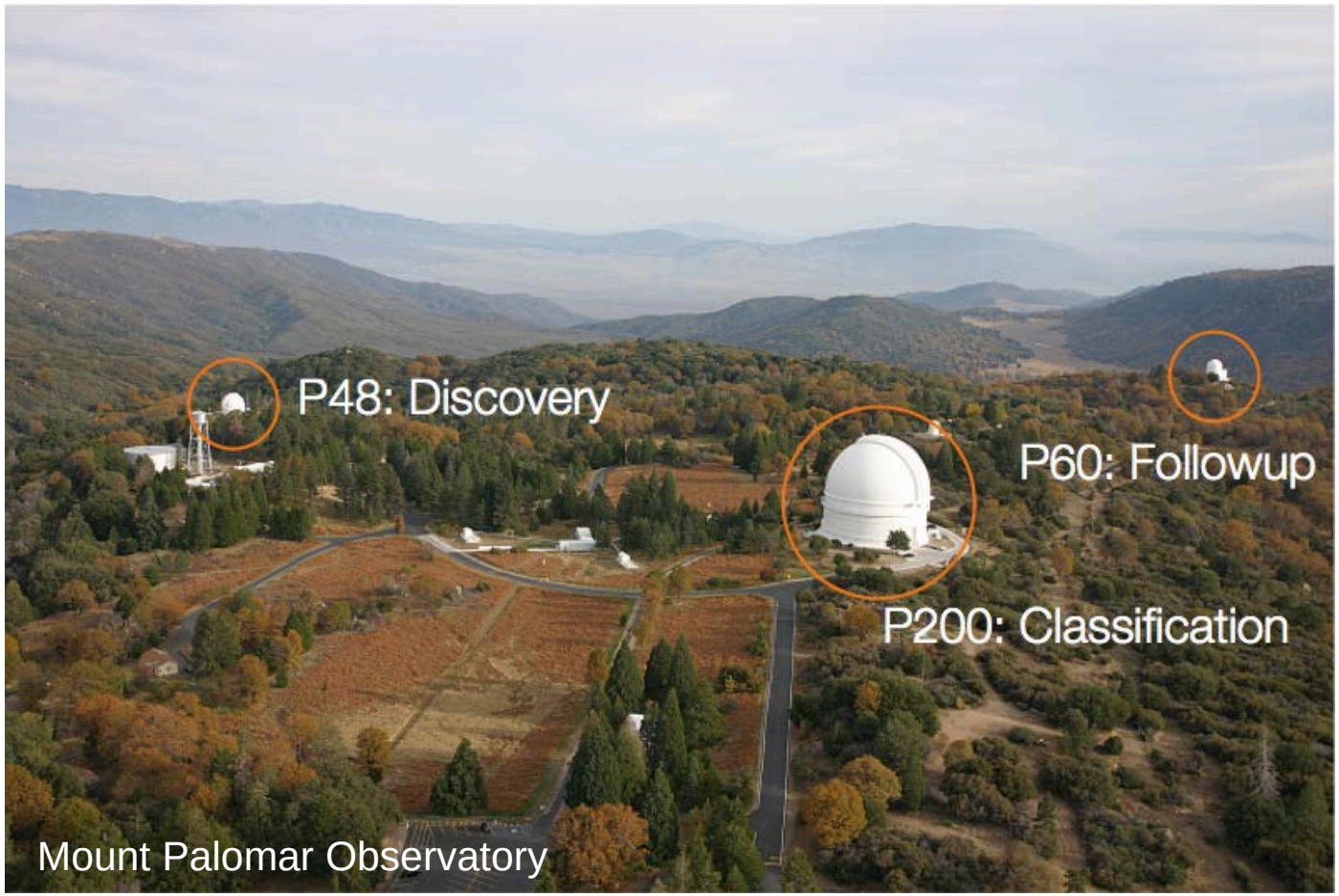


~3000 SNe in total so far from Palomar Transient Factory and the Supernova Factory

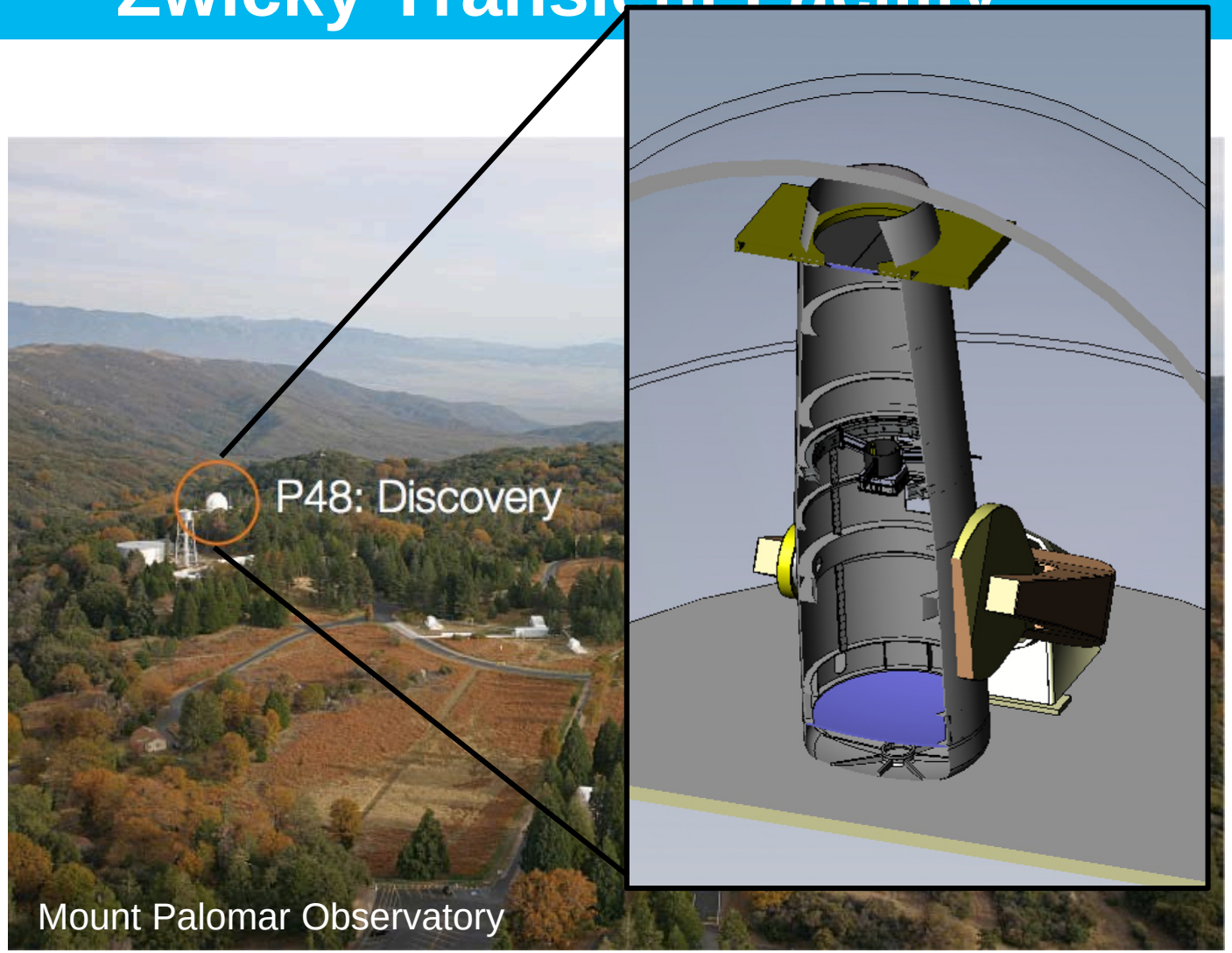
Fritz Zwicky (1898-1974)



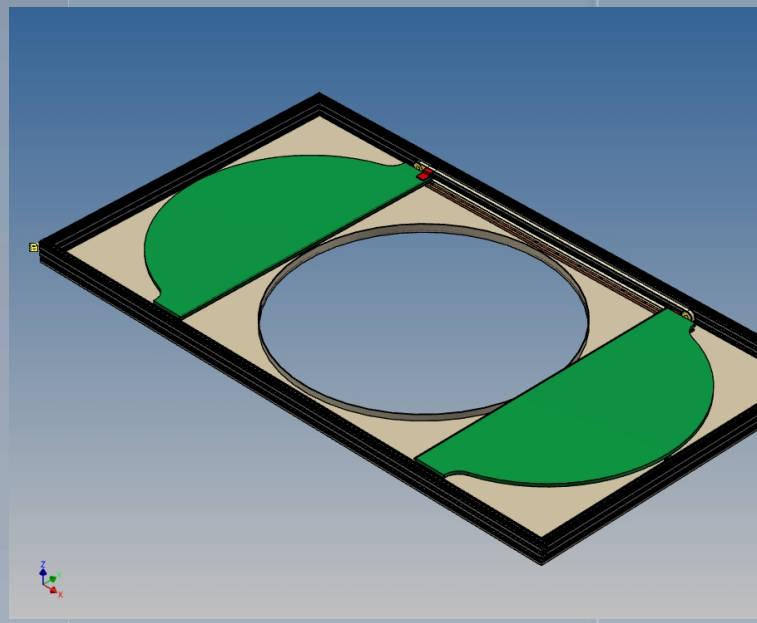
Zwicky Transient Facility

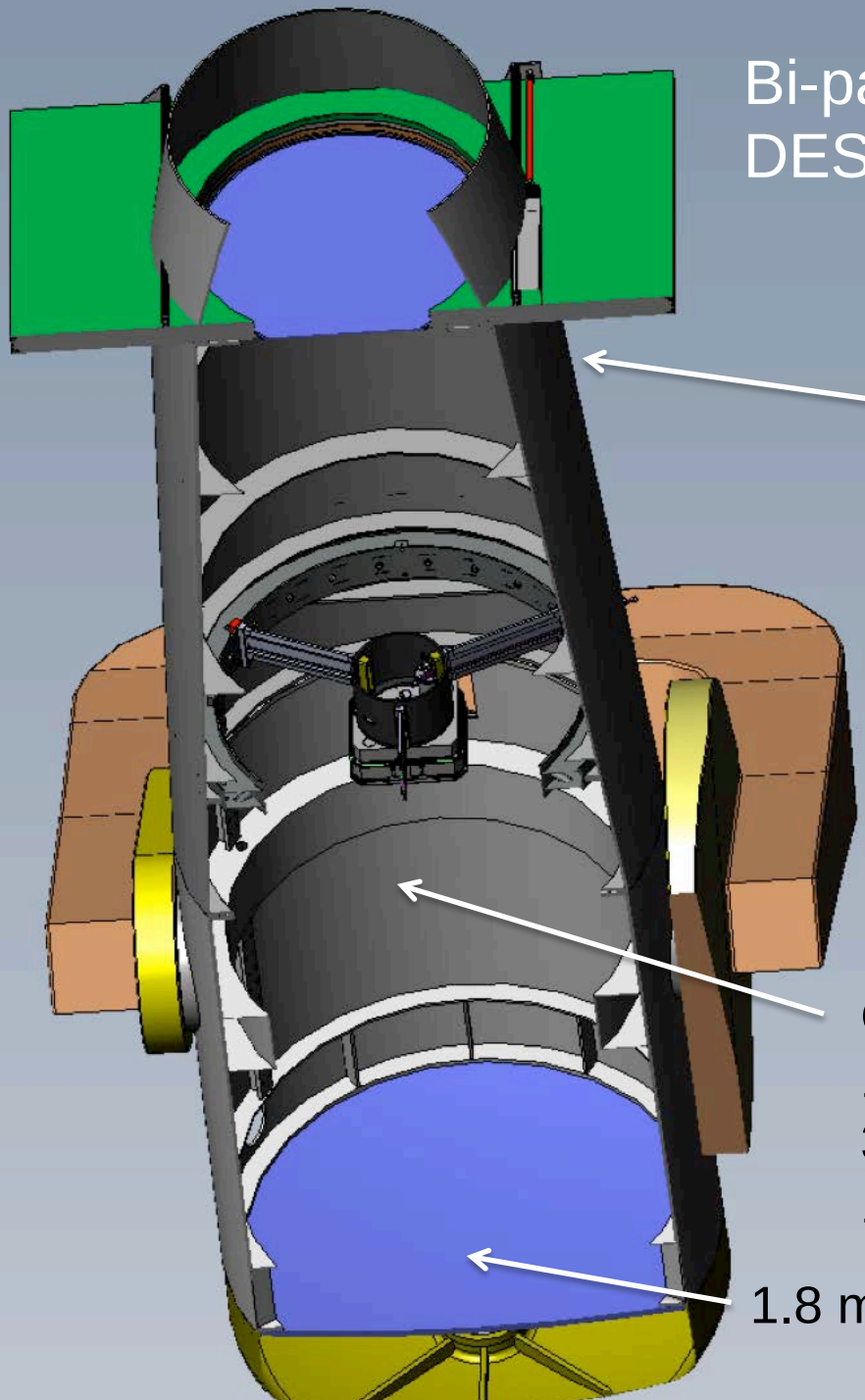


Zwicky Transient Facility



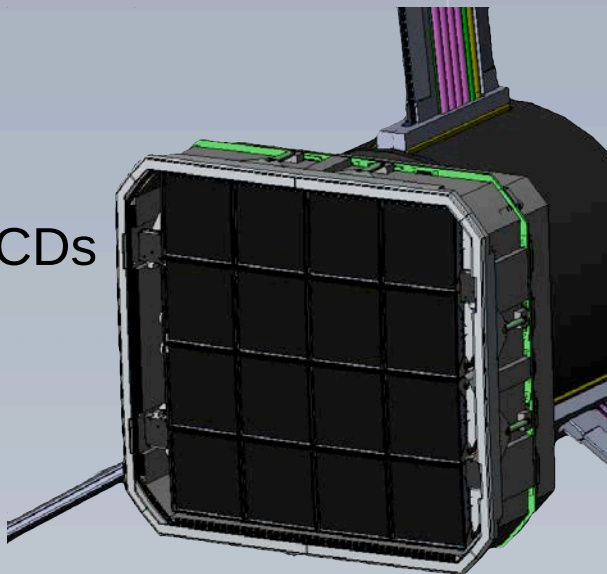
Bi-parting shutter constructed by DESY/Bonn



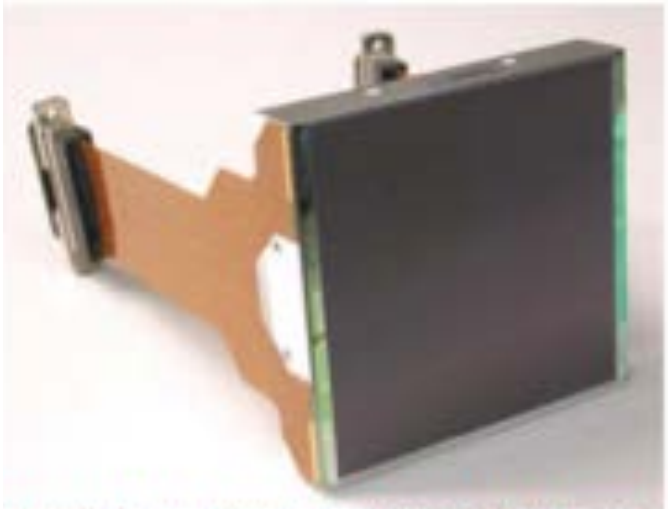


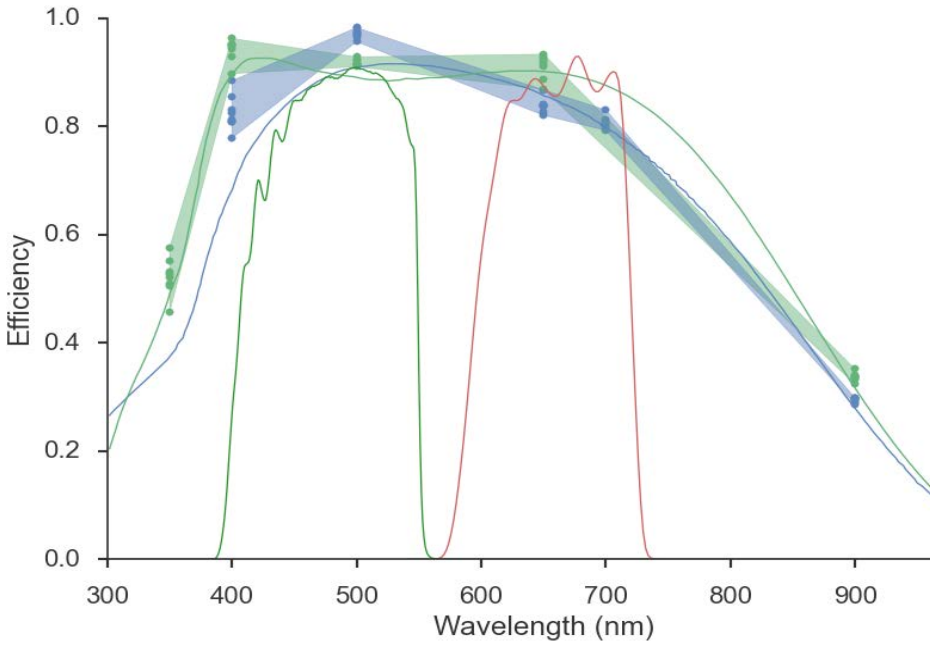
Camera:
16 6k x 6k e2v CCDs
30 s exposure
15 s readout

1.8 m primary mirror



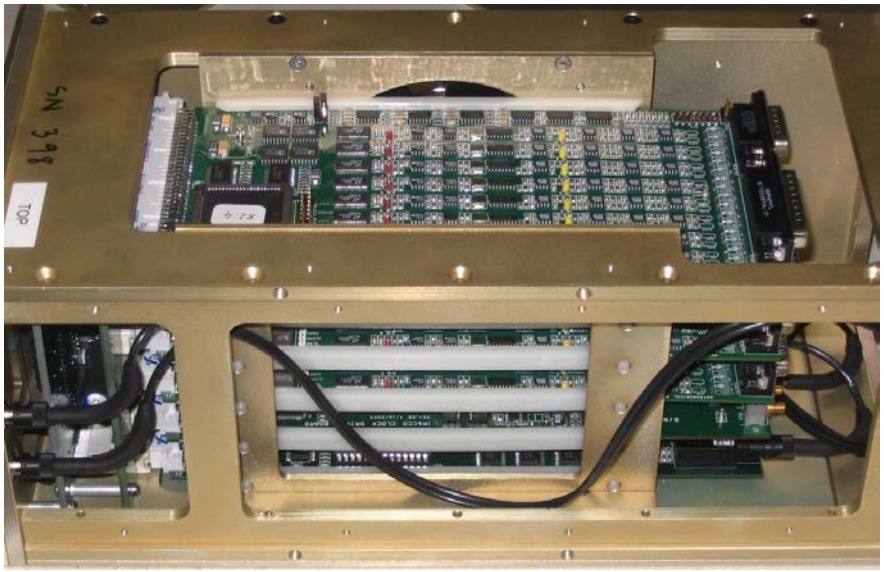
Affordable wafer-scale CCDs make ZTF possible.





e2v	
dimension	9.2 x 9.2 cm
pixels	6.1k x 6.1k
pixel size	15 micron
pixel scale	1”/pixel
outputs	4

Moore's Law reduziert auch die Auslesezeit

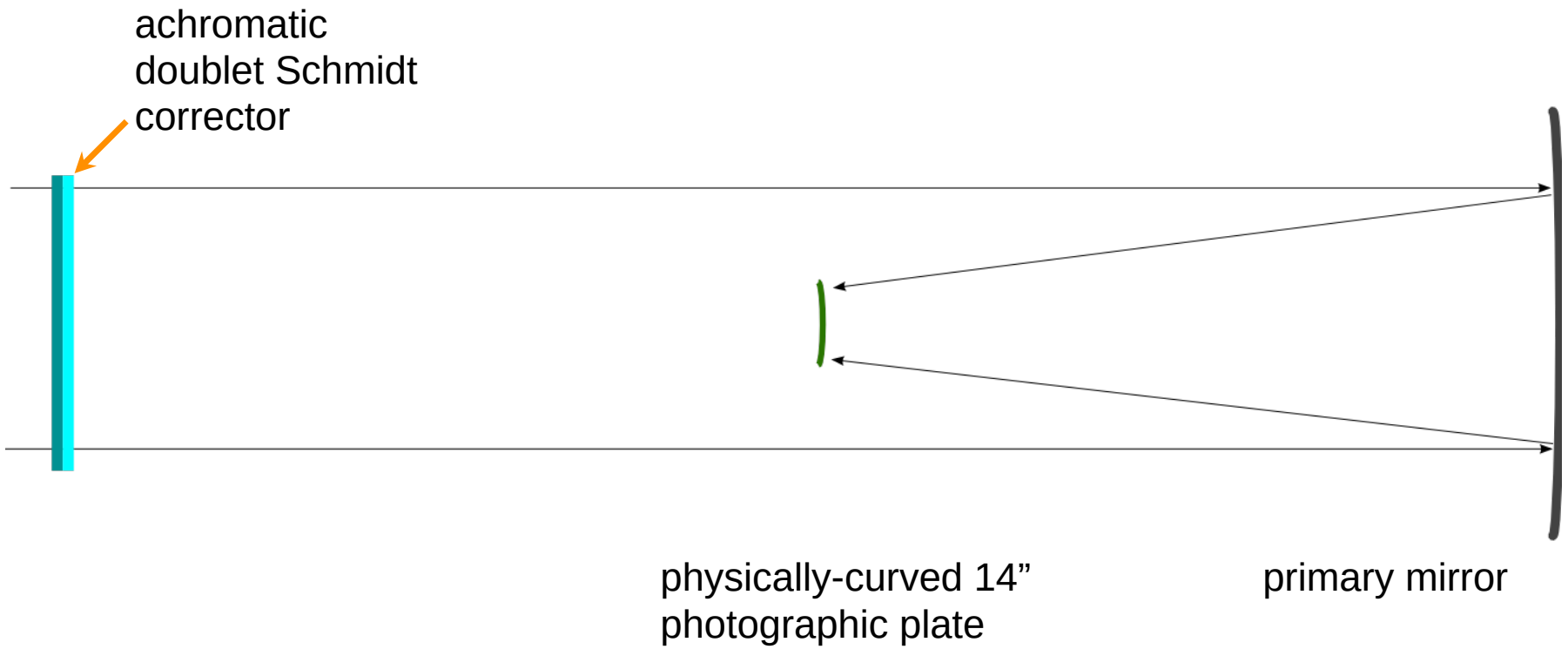


PTF
2000-era Leach Gen-II controller
36 s Auslese von 96 Mpx

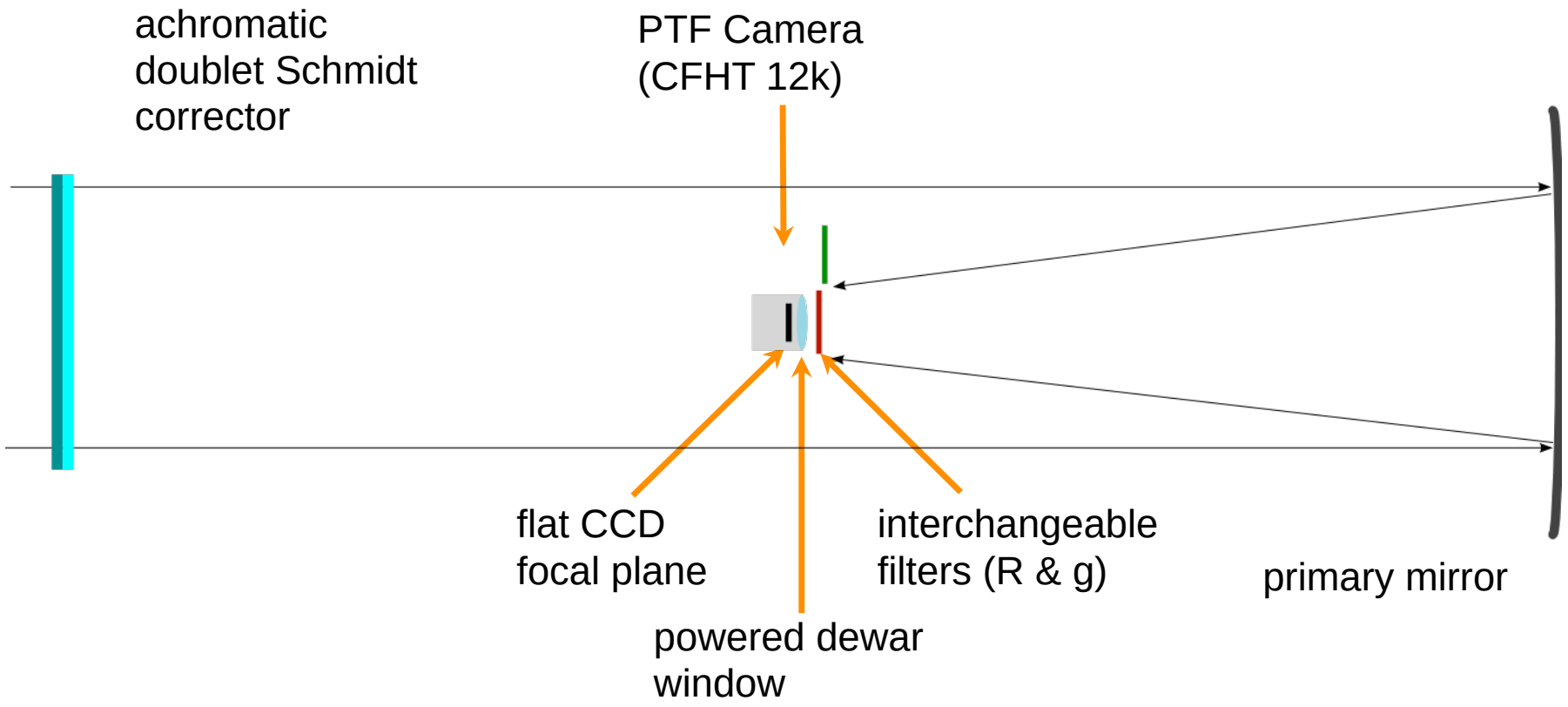
ZTF
STA Archon controller
10 s Auslese von 576 Mpx

bench testing in progress

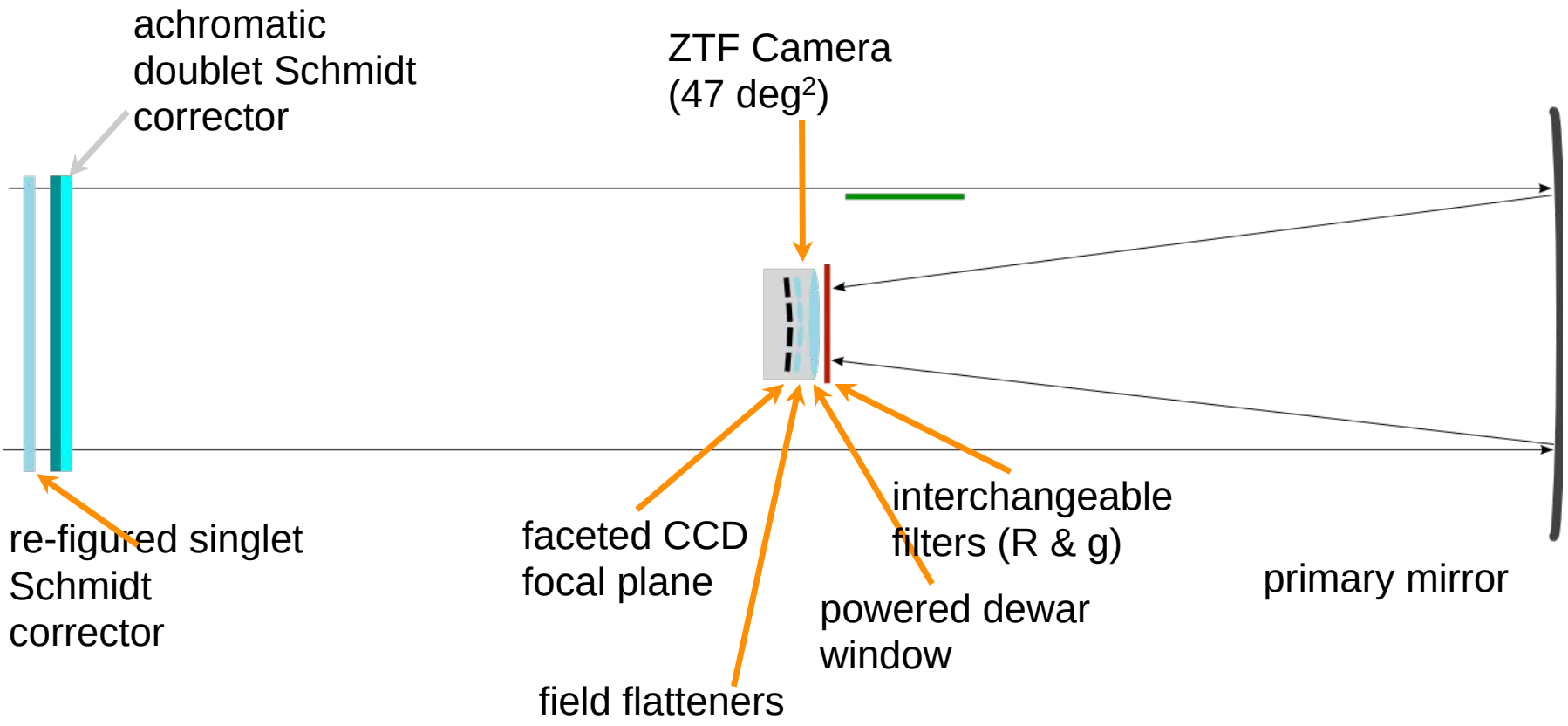
Palomar Sky Survey with photographic plates



PTF replaced the plates with a CCD camera.

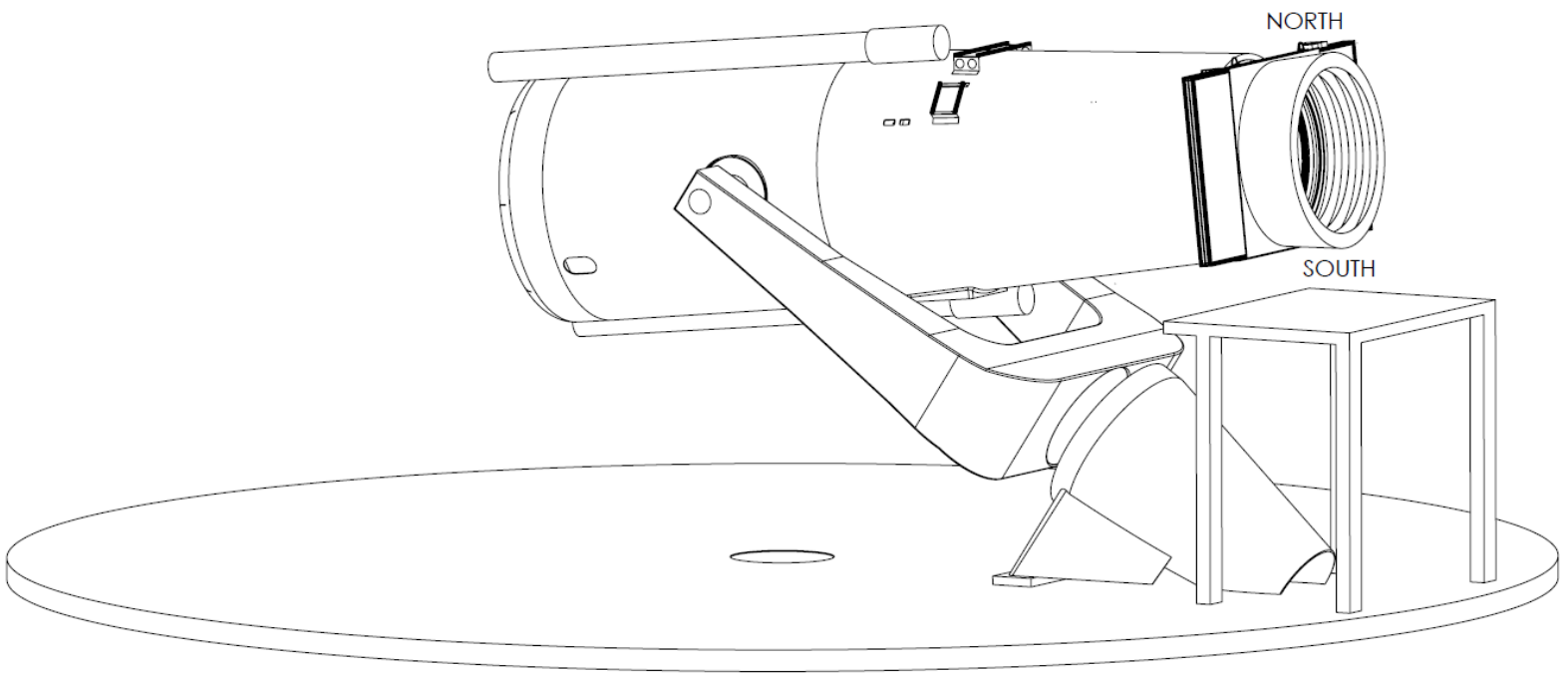


New optics enable ZTF's unprecedented field of view.



cryostat window fabricated; quotes out for other elements

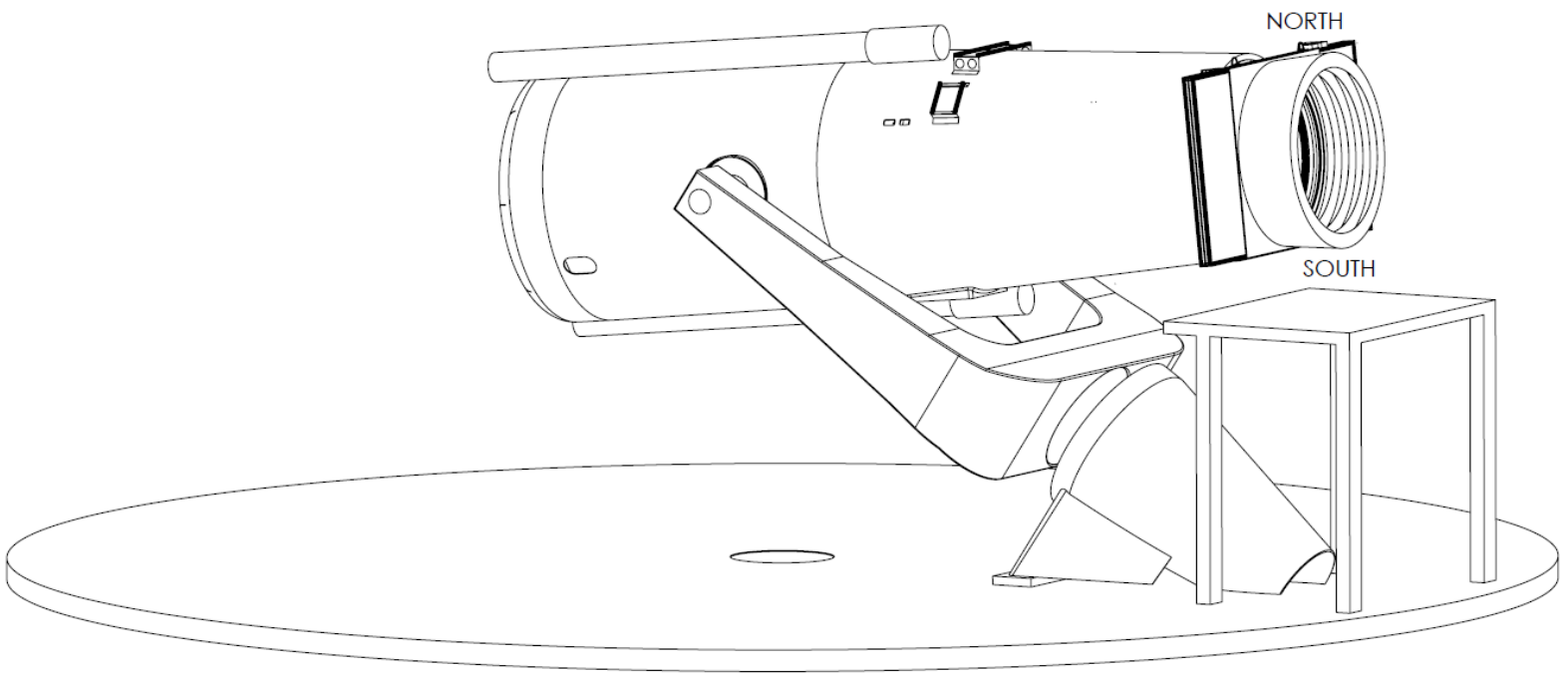
Optischer Verschluss – der Shutter



DESY

Bonn Shutter

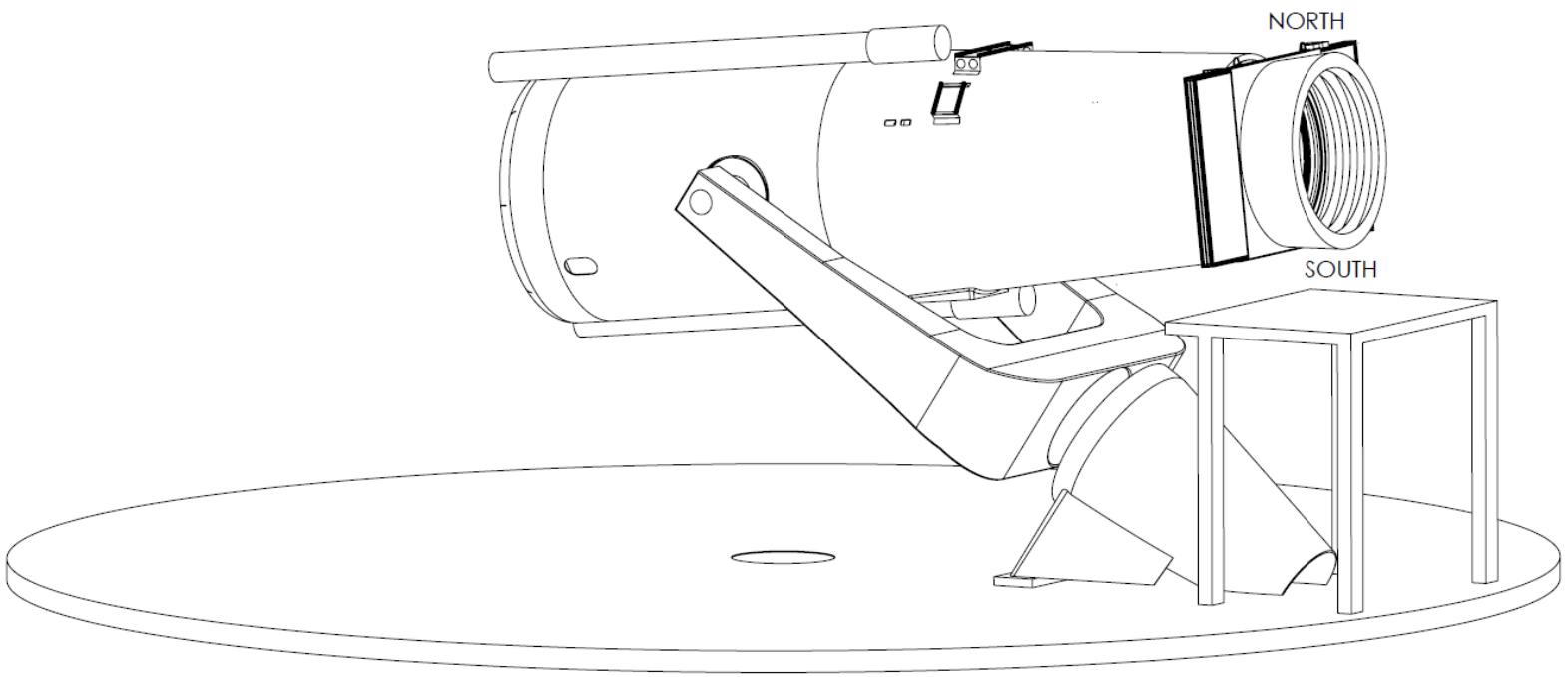
Optischer Verschluss – der Shutter



DESY

Bonn Shutter

Optischer Verschluss – der Shutter



In Zeuthen: Untersuchung, dass die sich bewegenden Verschlussplatten keine störenden Schwingungen auf das optische Teleskop übertragen, um die hohe optische Abbildungsqualität des Teleskops zu erhalten & Test der Lichtdichtigkeit.

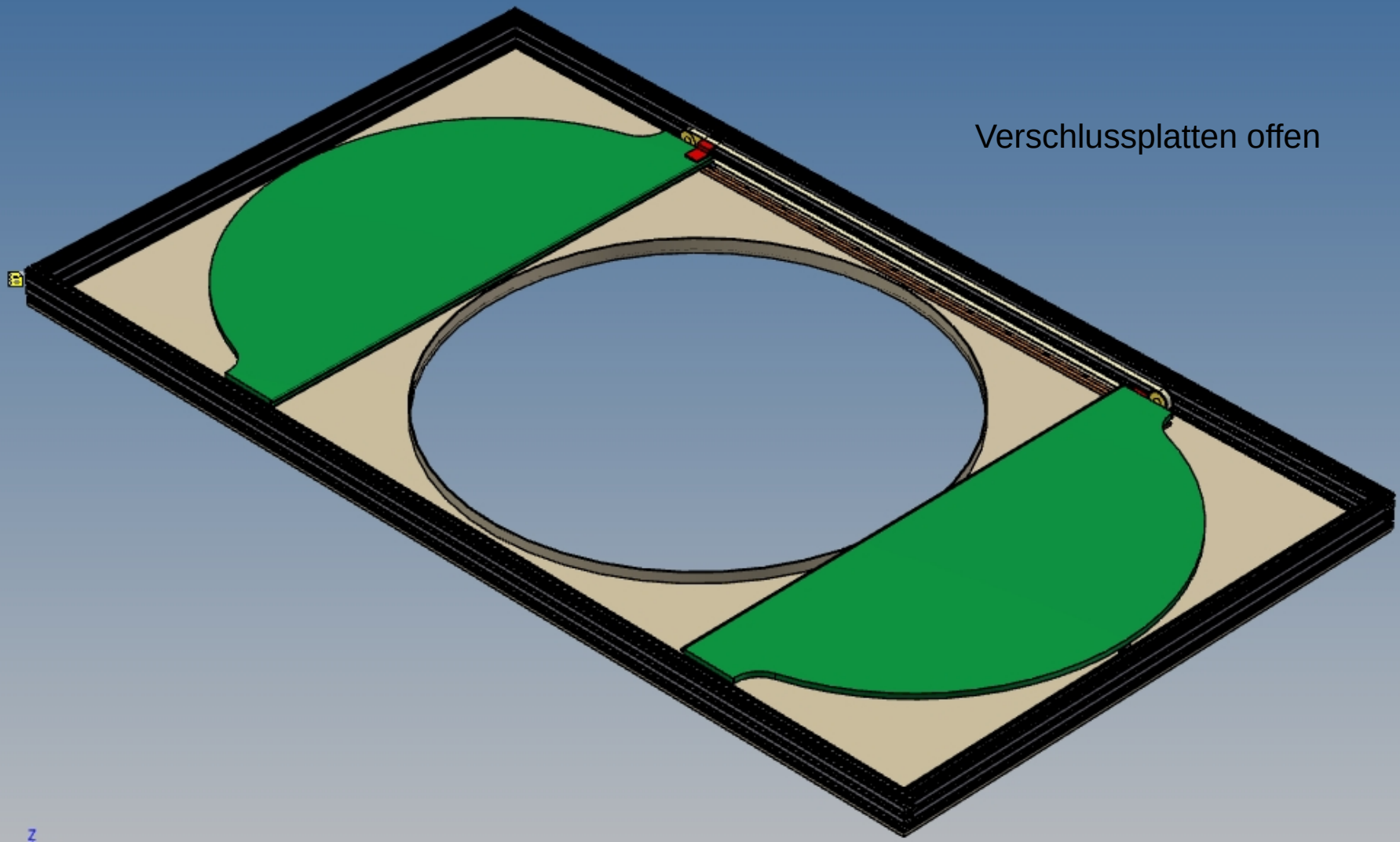
Breite: 1,5 m

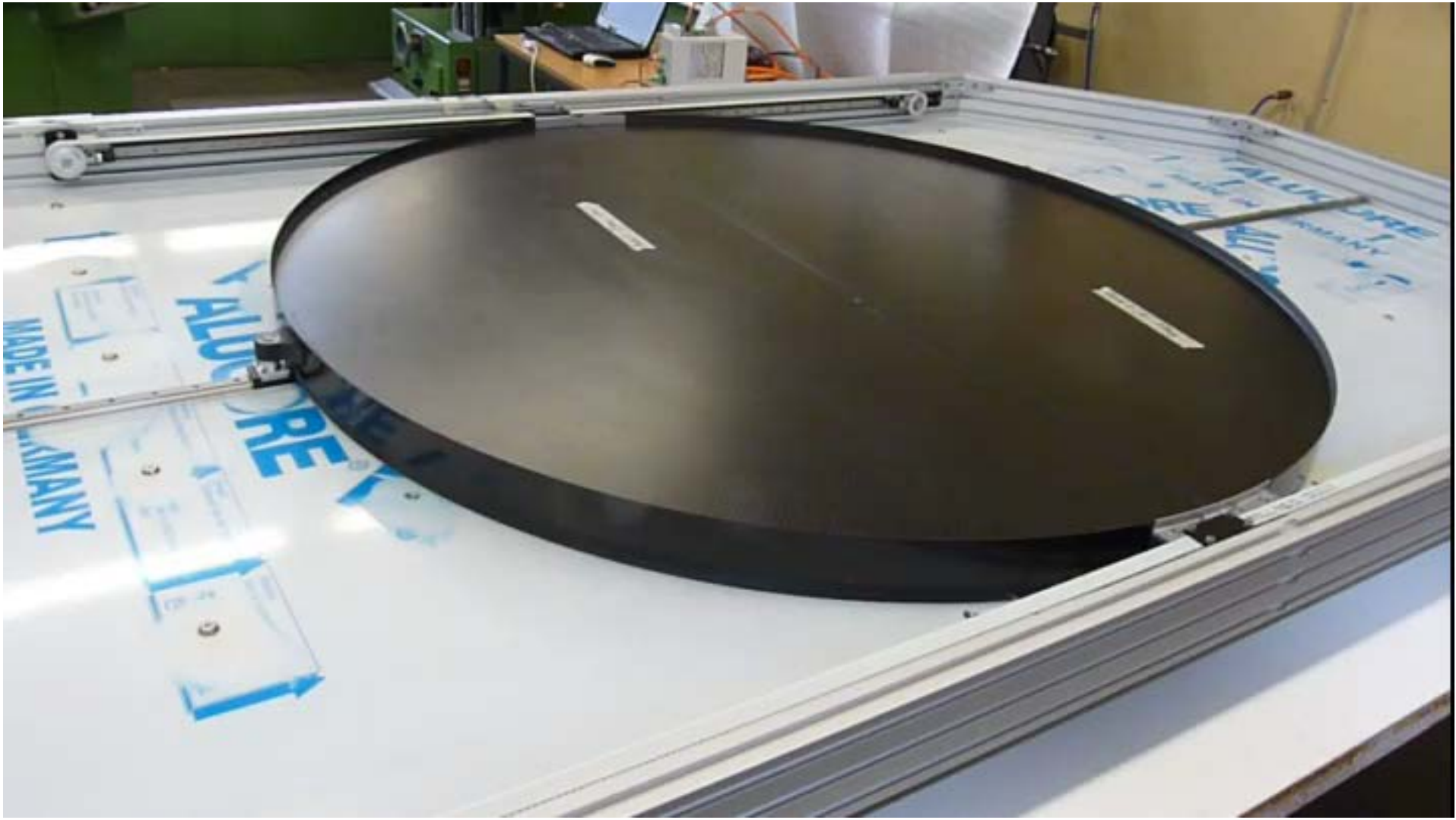
Länge: 2,8 m

Öffnungsdurchmesser: 1,35 m

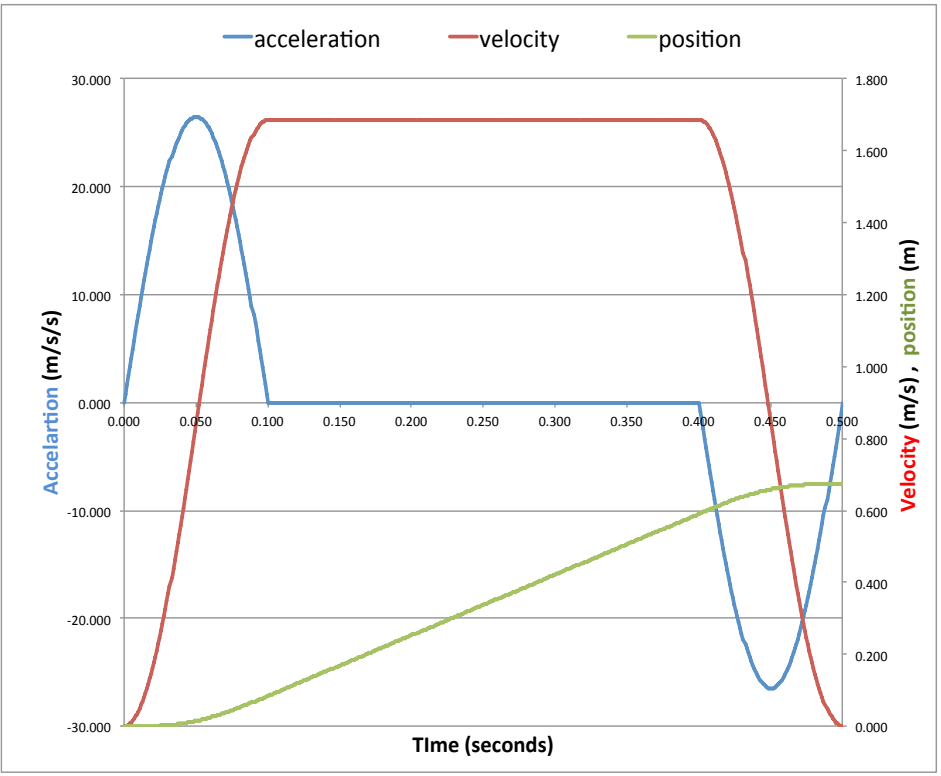
Zum Vergleich: Tischtennisplatte

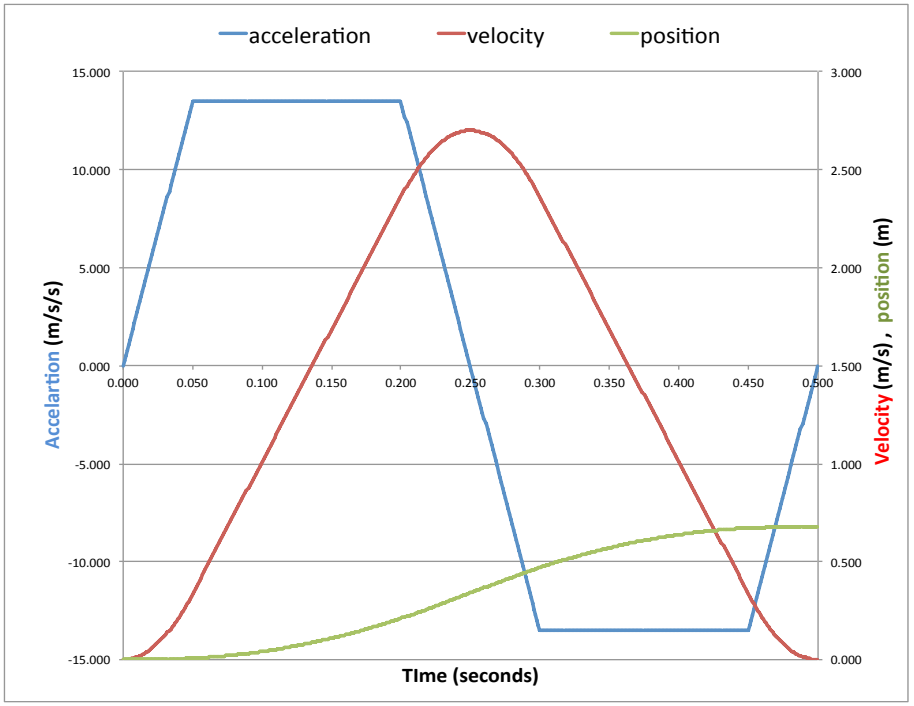
Verschlussplatten offen



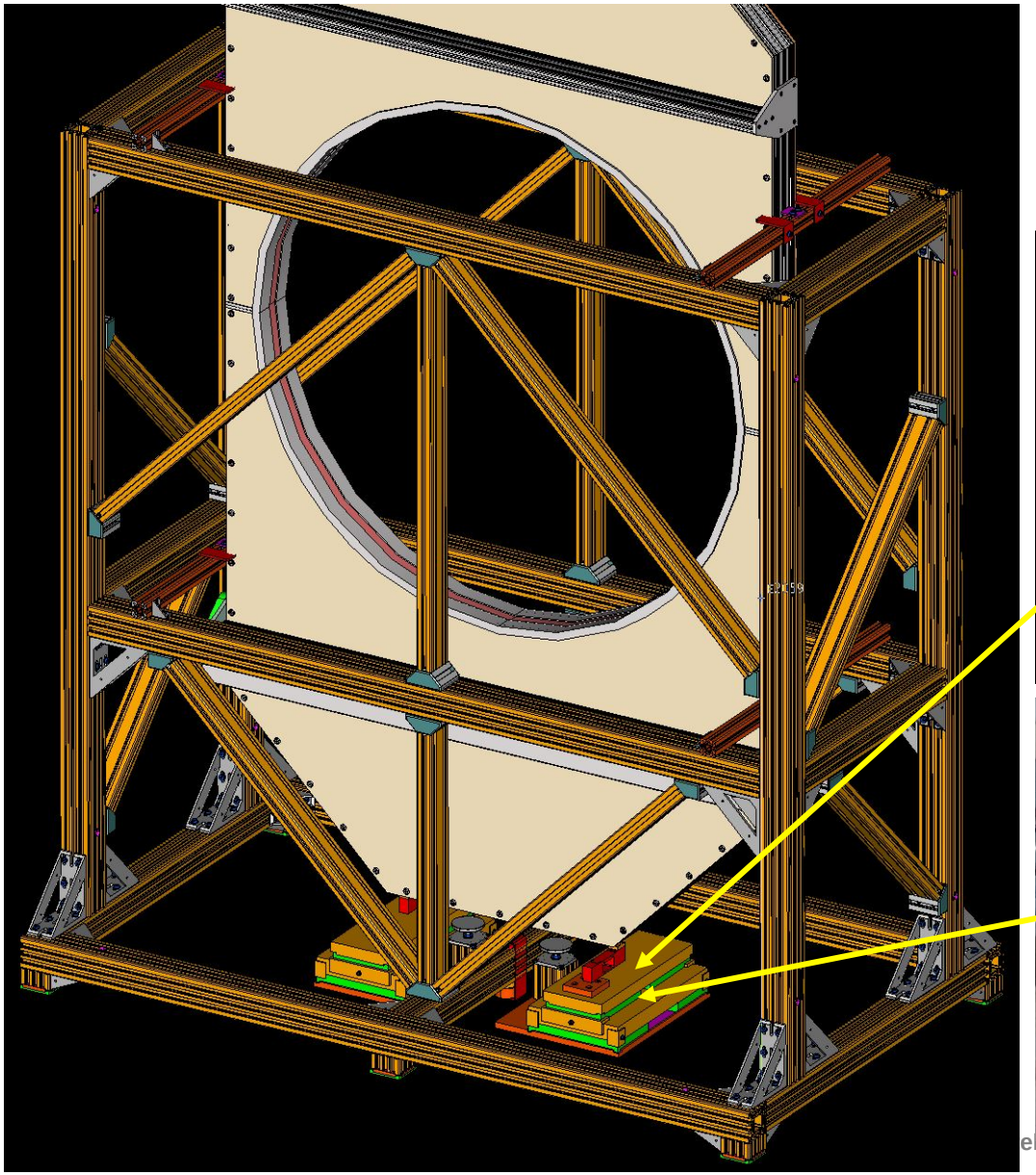

ALUMOTE
MADE IN GERMANY

Fahrprofile





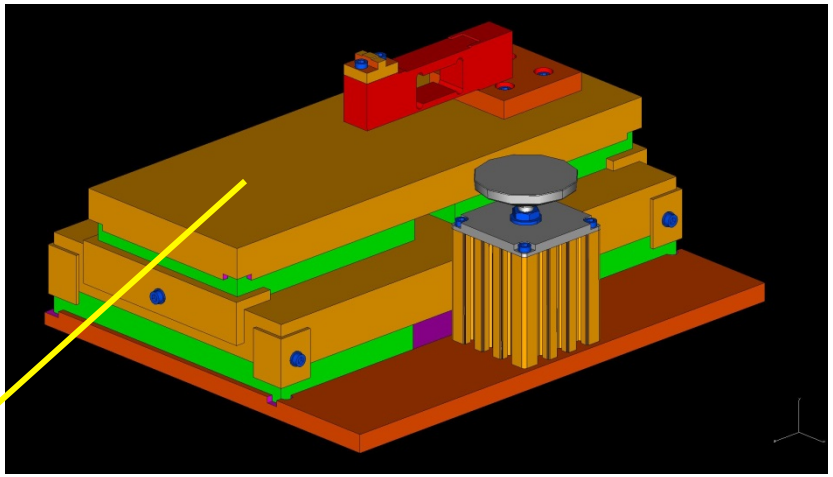
Schwingungsmessplatz

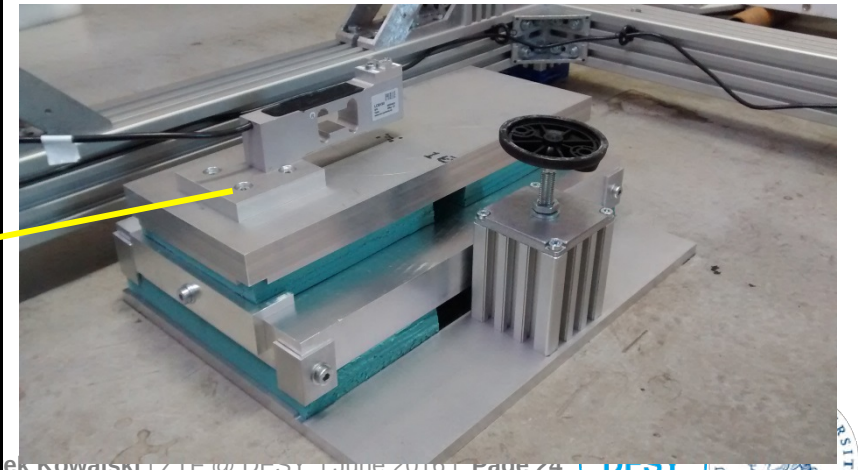


Requirements:

Reaktionskraft < 3N

Messgenauigkeit<0.5N





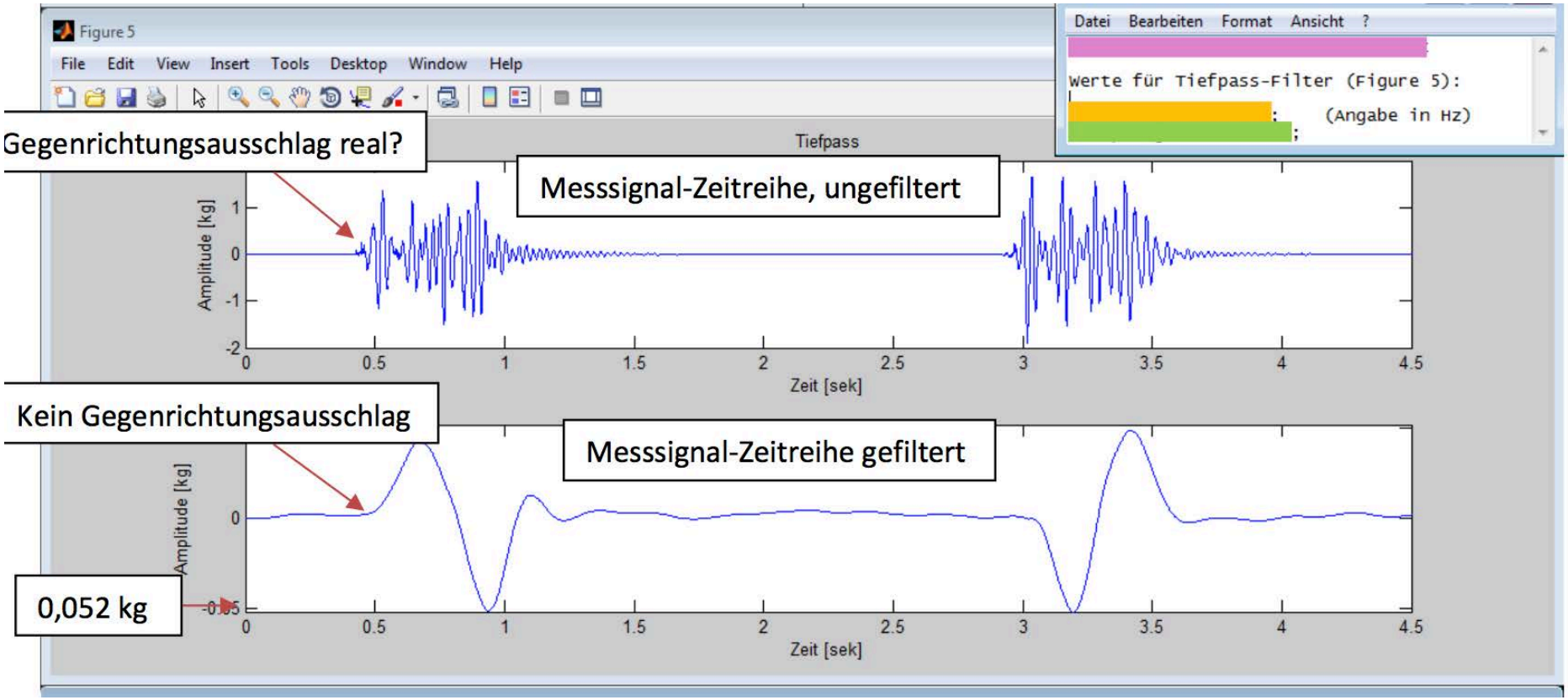
Messung am Prototype (ohne Blades)

Messung am Prototype (ohne Blades)

Stange A+23 gr, Gewichtsunterschied 0,025 kg.

F= m*a = 0,025 kg * 20,3 m/s² = 0,501 N → Gewichtsänderung 0,052 kg

Finden der Filterparameter, bis - 0,052 kg angezeigt wird in Messignal-Zeitreihe gefiltert



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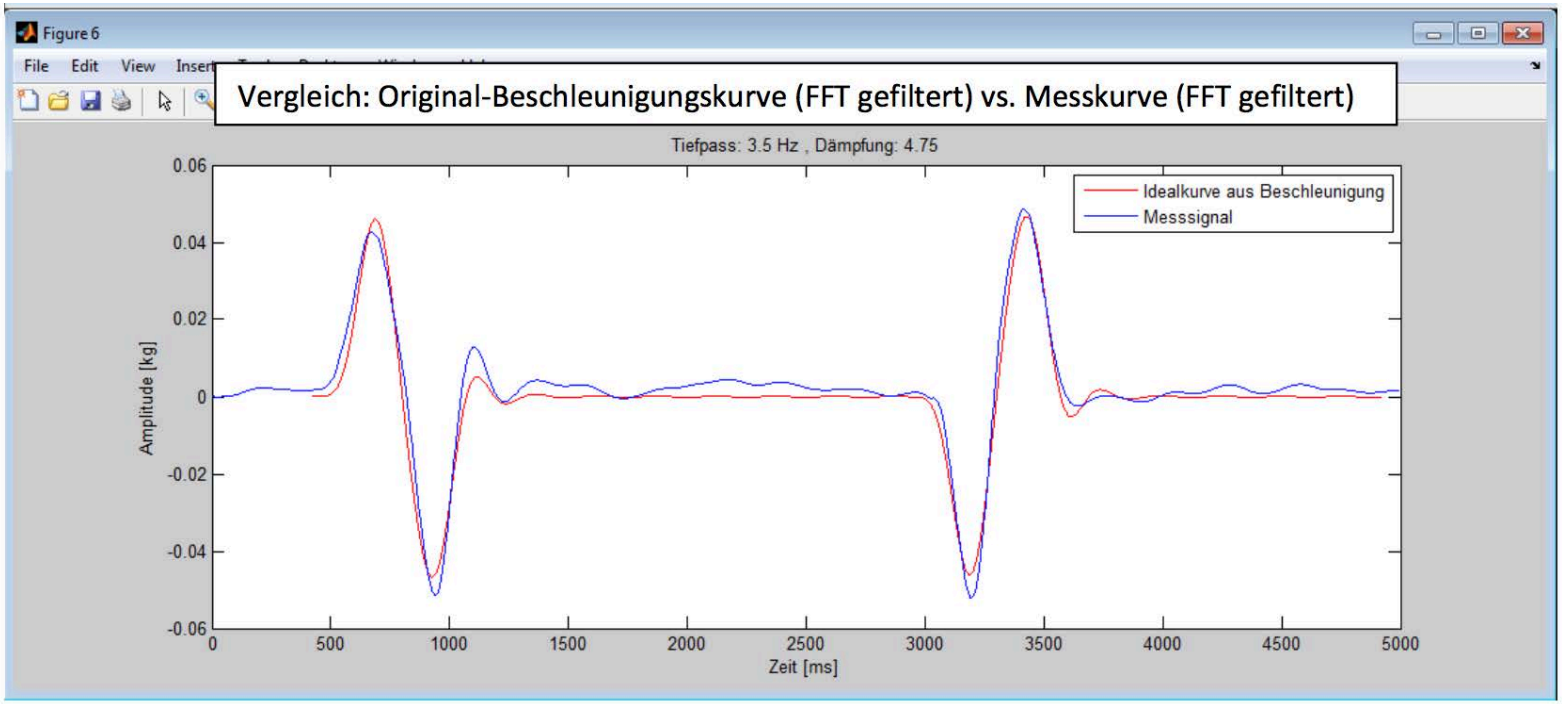
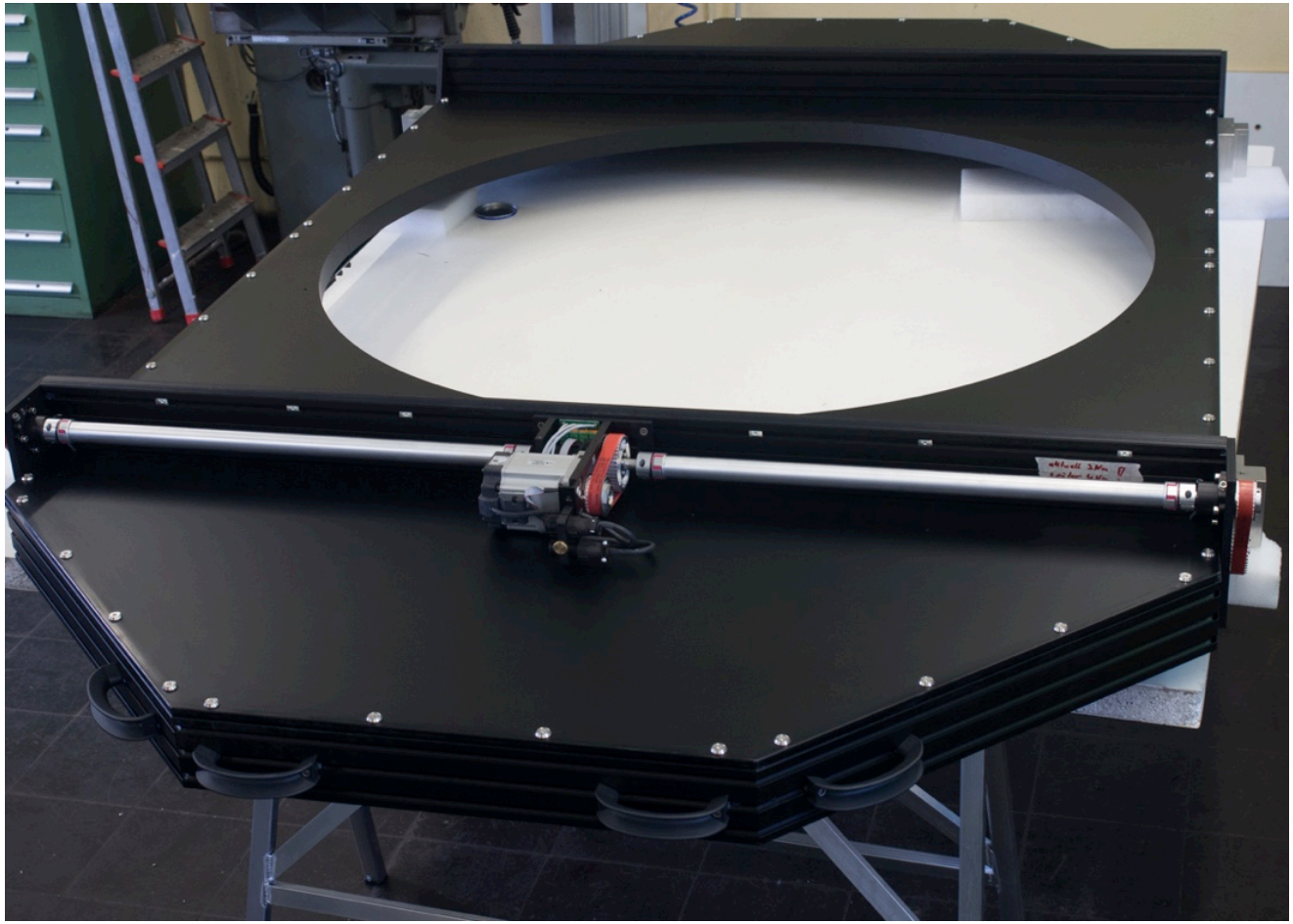
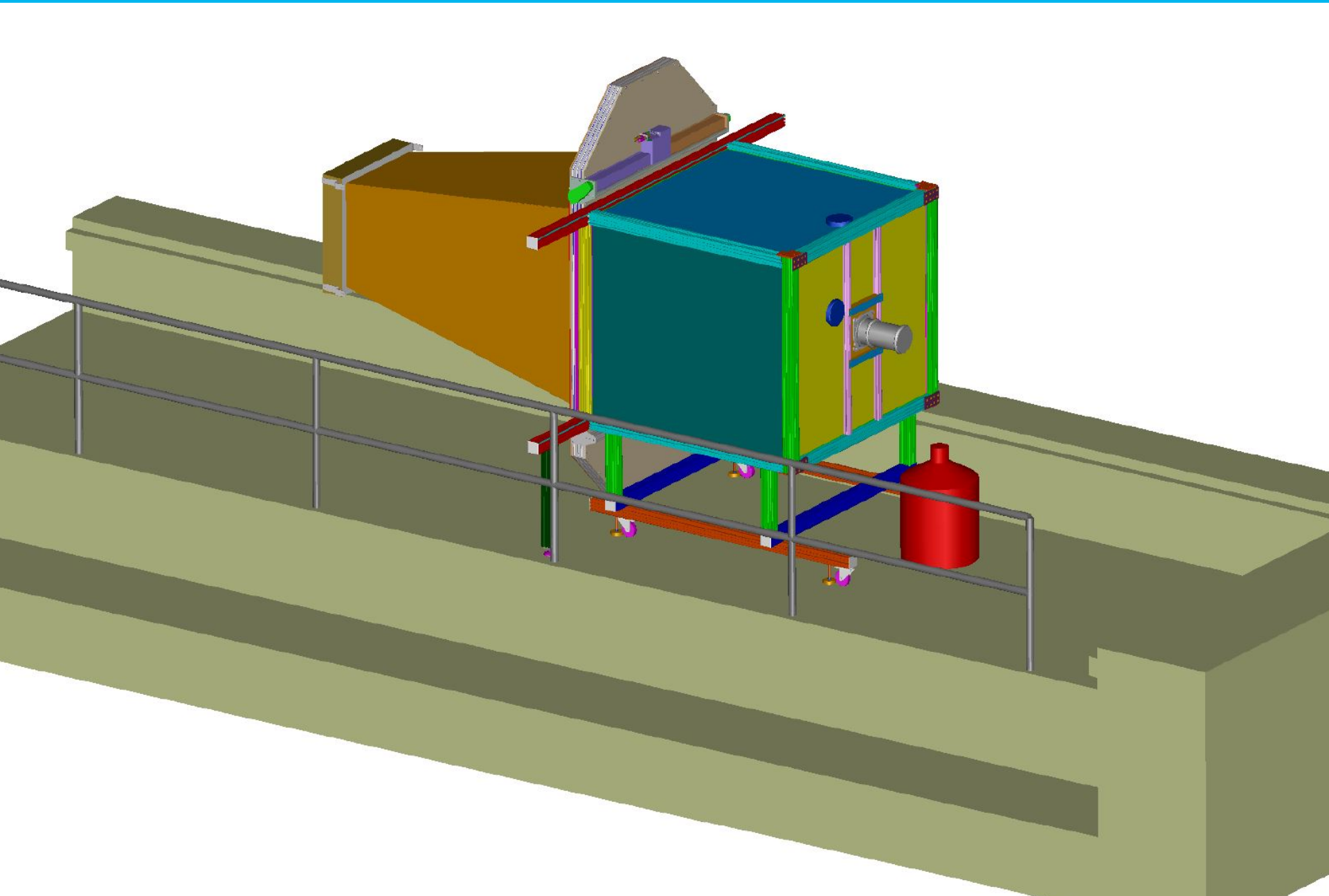


Shutter bereit!

Versand nach Zeuthen in KW25

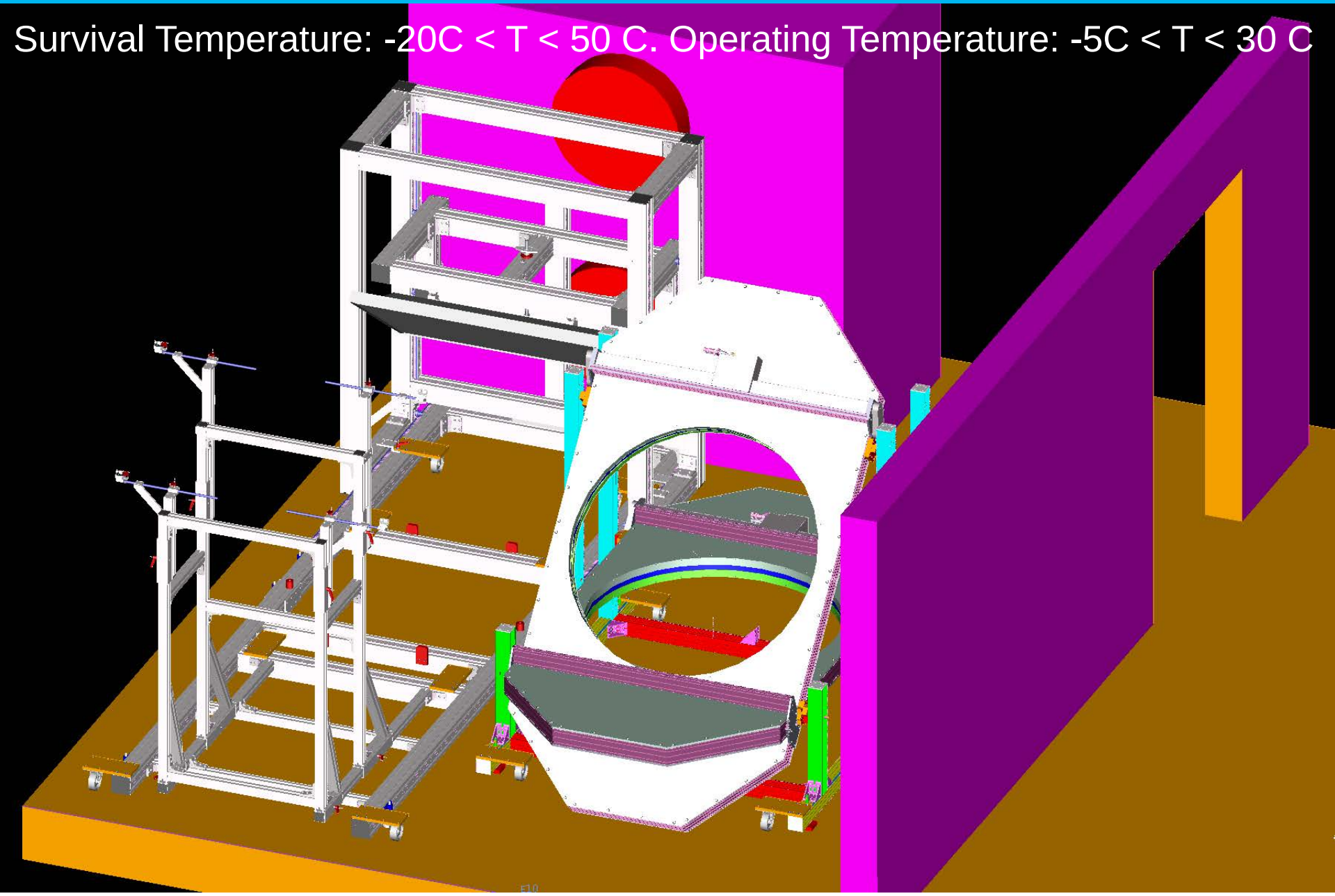


Lichtdichtigkeit <0.1 photons / 15µm pixel / sec



Fahrtests in der Kältekammer

Survival Temperature: -20C < T < 50 C. Operating Temperature: -5C < T < 30 C



From the user manual

IMPORTANT:

After power on or reset the shutter is ready for operation.

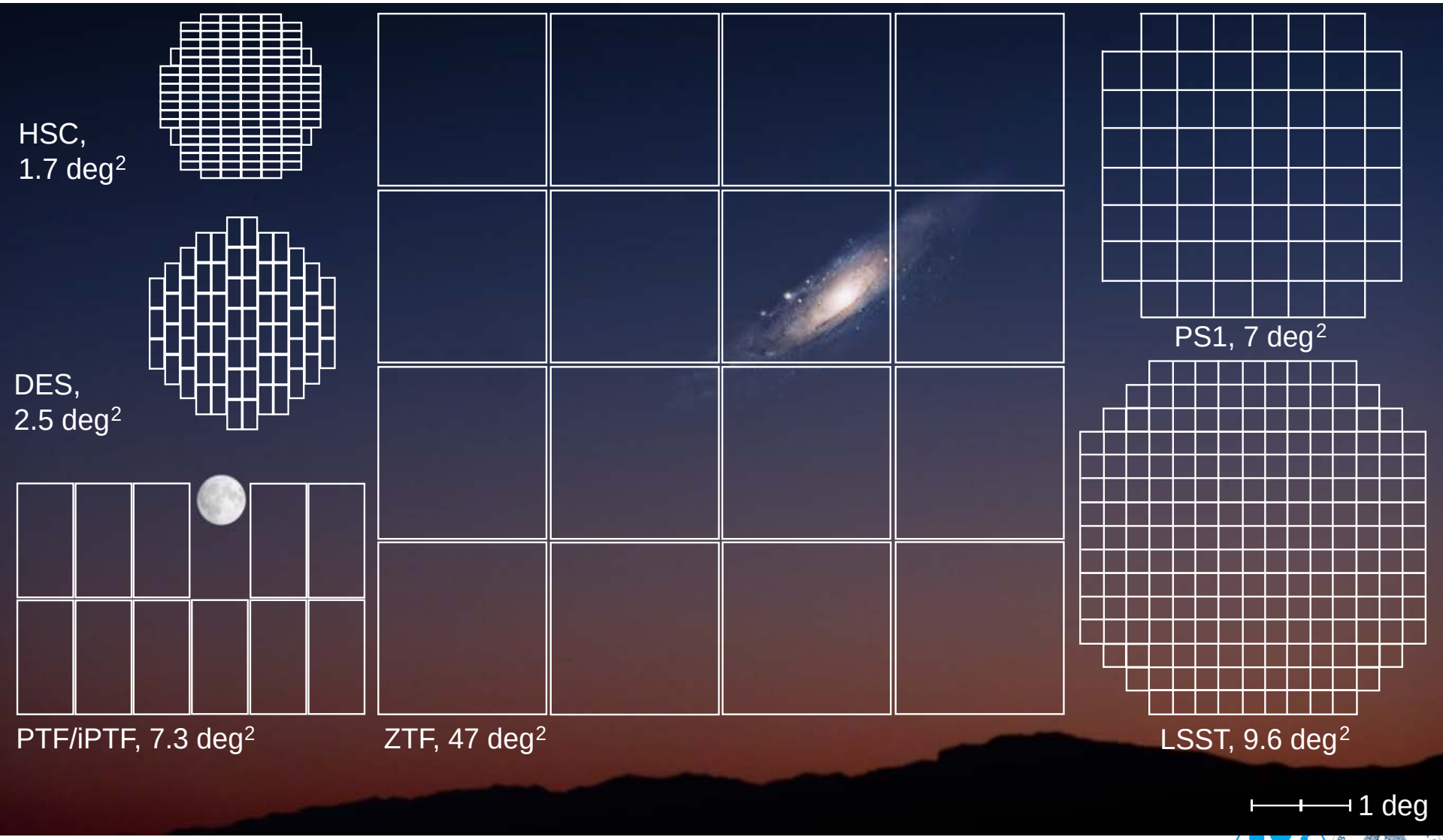
Now the blades move with high speed and much more torque.

Nobody should try to stop the blades by hand arm or finger.

Nobody should work next to the aperture to avoid any accident.

Only trained stuff should have access to the shutter.

ZTF & other wide field Imagers



ZTF versus PTF

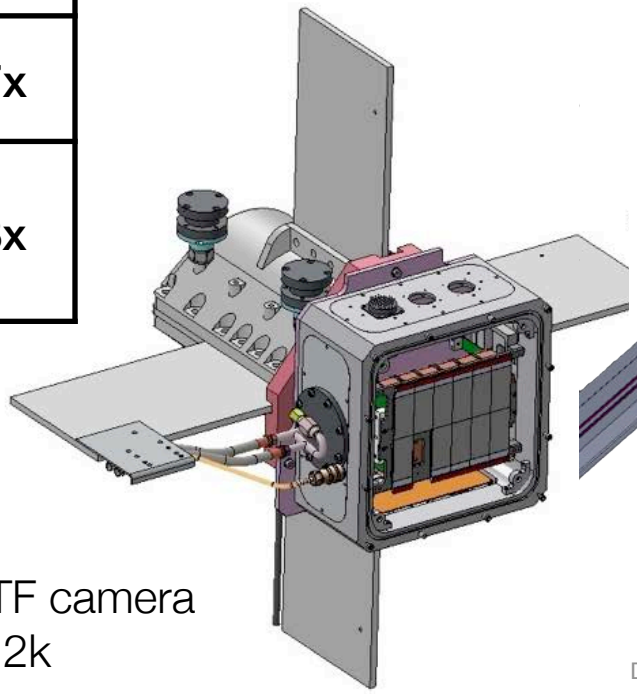
	PTF	ZTF
Active Area	7.26 deg^2	47 deg^2
Overhead Time	46 sec	<15 sec
Optimal Exposure Time	60 sec	30 sec
Relative Areal Survey Rate	1x	**14.7x**
Relative Volumetric Survey Rate	1x	**12.3x**

3750 deg^2/hour

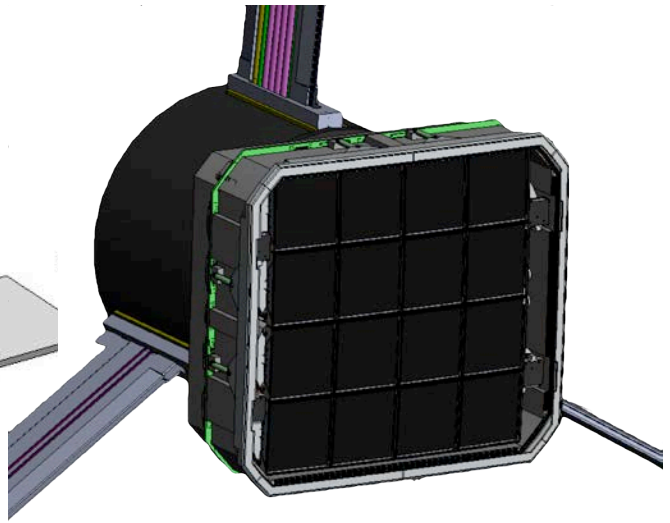
⇒ 3π survey in 8 hours

>250 observations/field/year

for uniform survey



Existing PTF camera
MOSAIC 12k



New ZTF camera:
16 6k x 6k e2v CCDs

ZTF versus other surveys

3750 deg²/hour

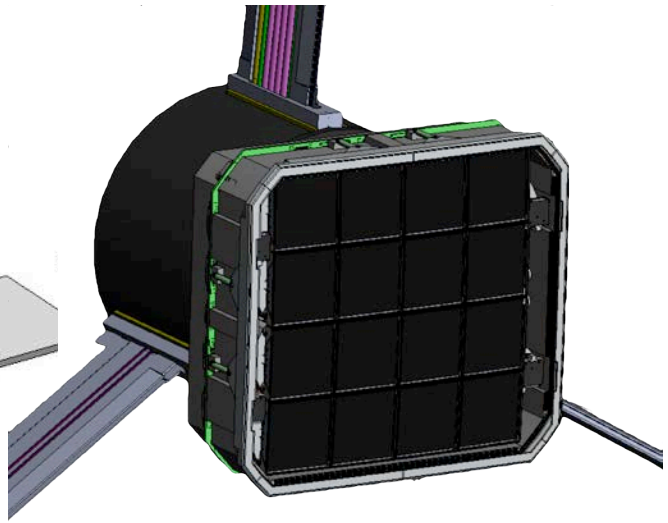
⇒ 3π survey in 8 hours

>250 observations/field/year

for uniform survey

Survey Camera	D (m)	Ω_{FoV} (deg²)	Etendue (m²deg²)
PTF	1.2	7.3	8.2
DECam	4.0	7.0	37.7
PS1	1.8	3.0	17.8
ZTF	**1.2**	**47**	**53.1**

Existing PTF camera
MOSAIC 12k

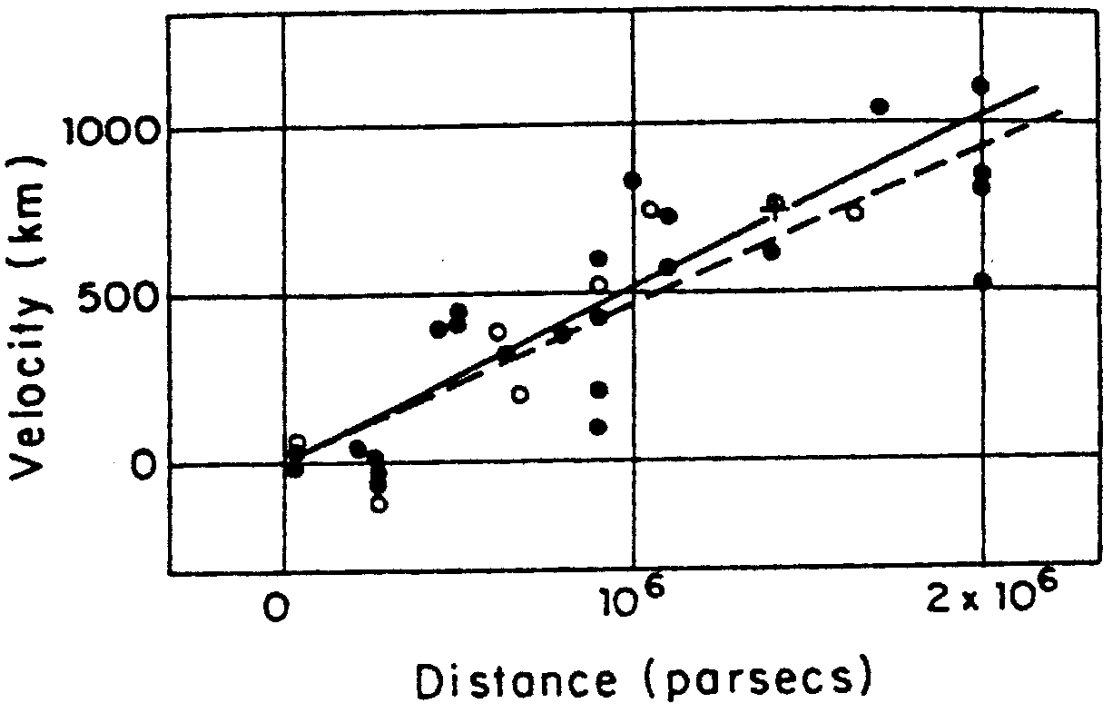


New ZTF camera:
16 6k x 6k e2v CCDs

ZTF-Forschung am DESY & HU

Edwin Hubble (1929)

Je größer die Distanz einer Galaxie, desto schneller entfernt sie sich von

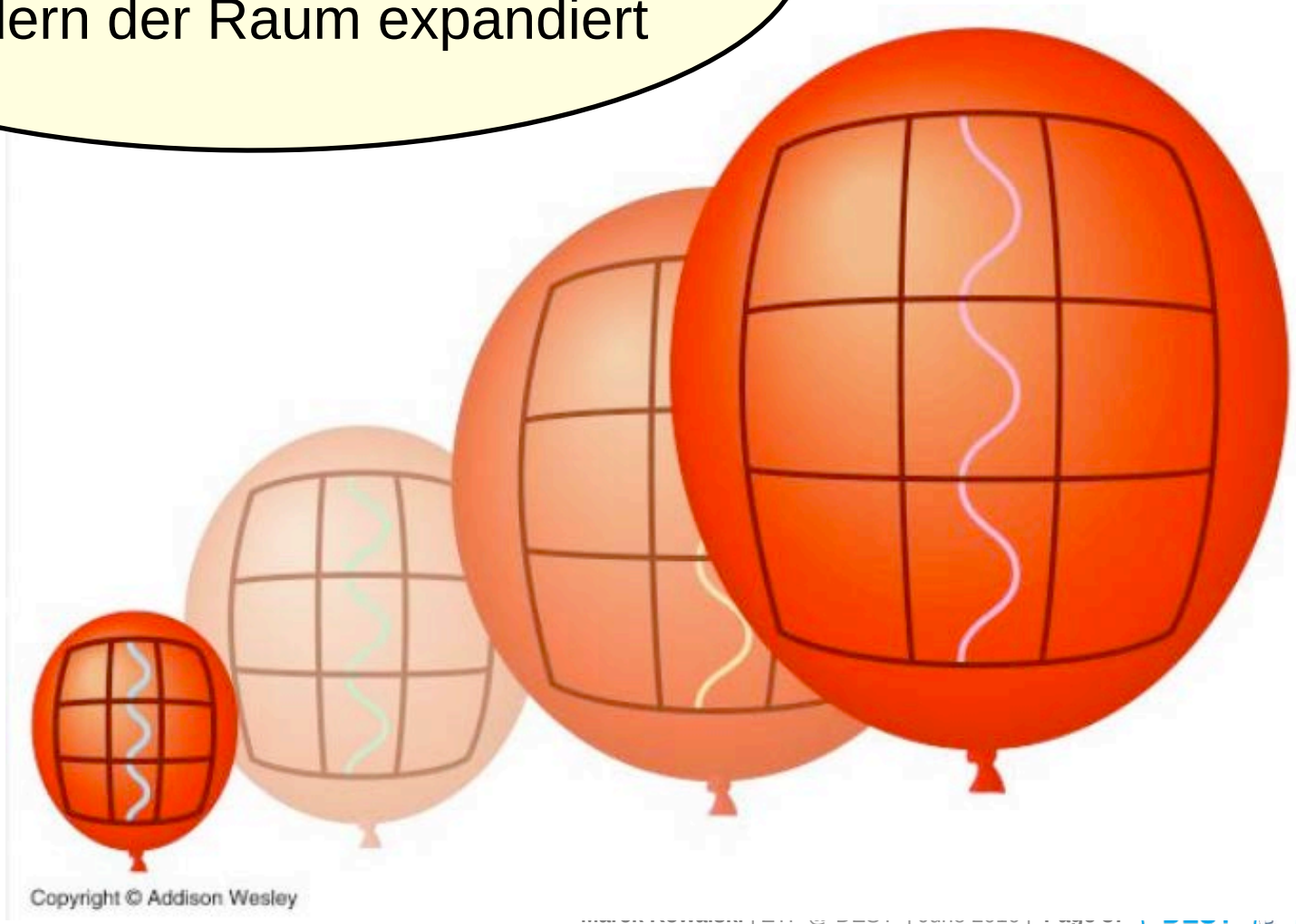


Rotverschiebung der Spektren:

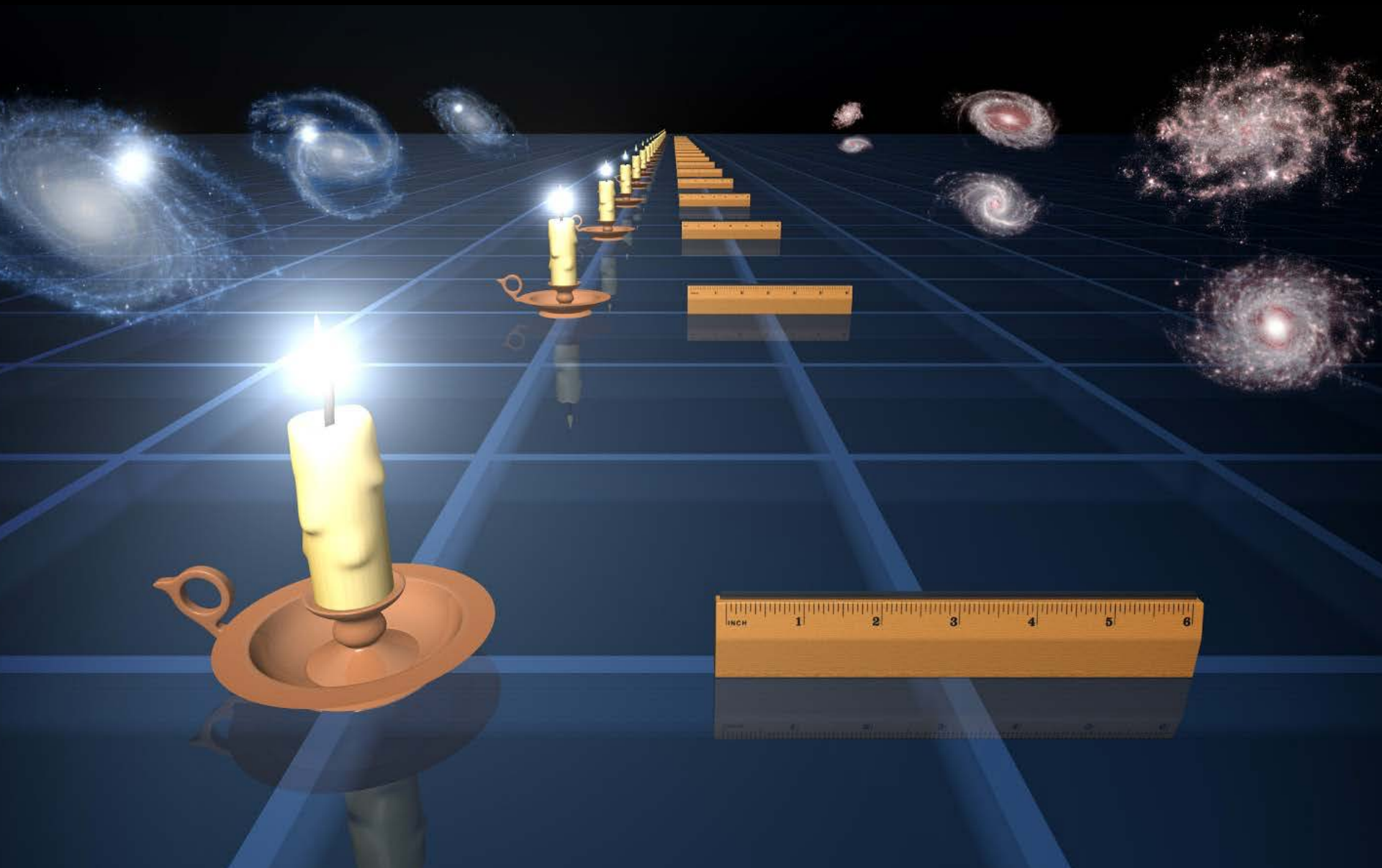
$$z = \frac{\lambda_{obs} - \lambda_{emit}}{\lambda_{emit}}$$

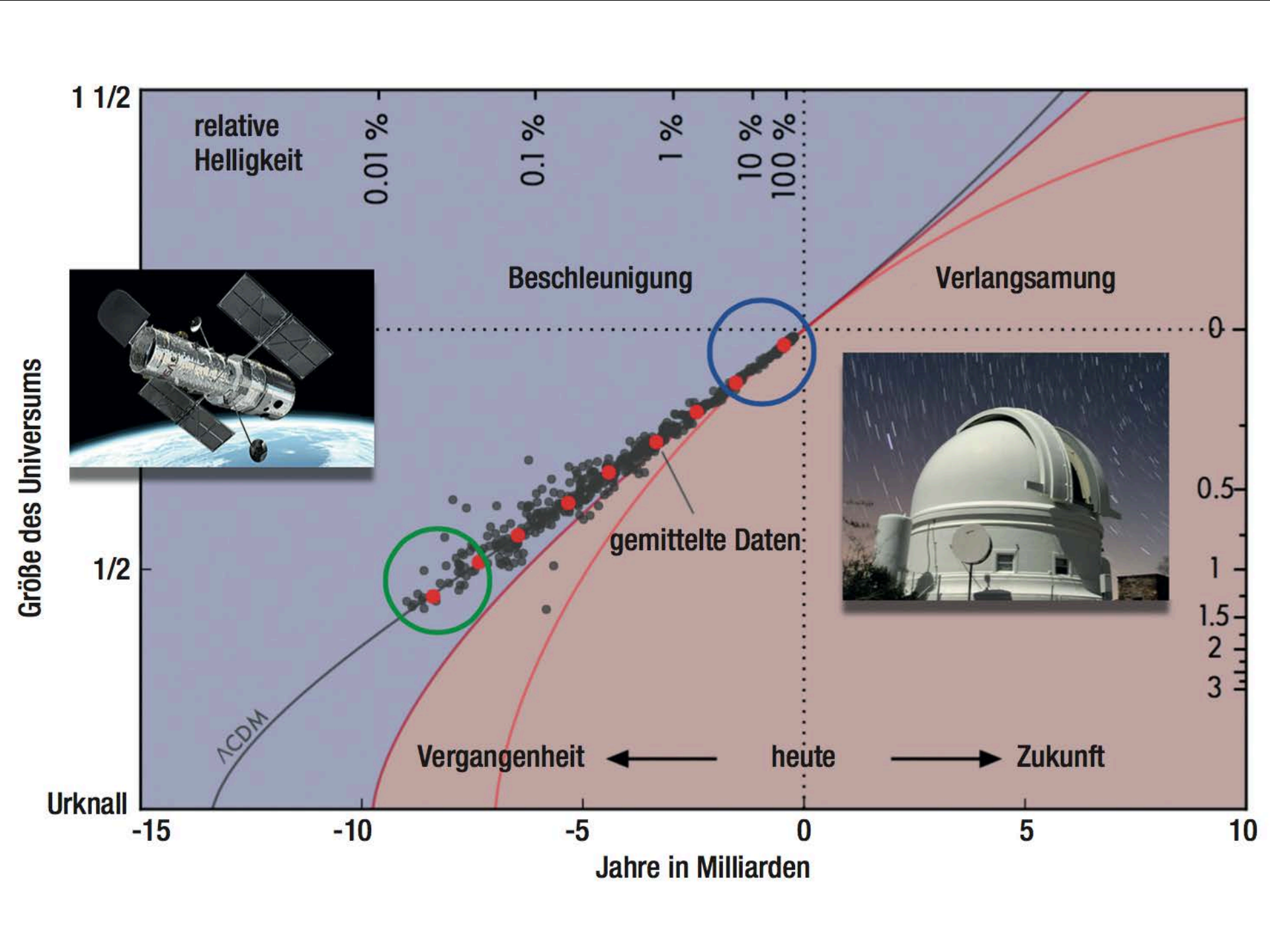
„Doppler-Effekt"

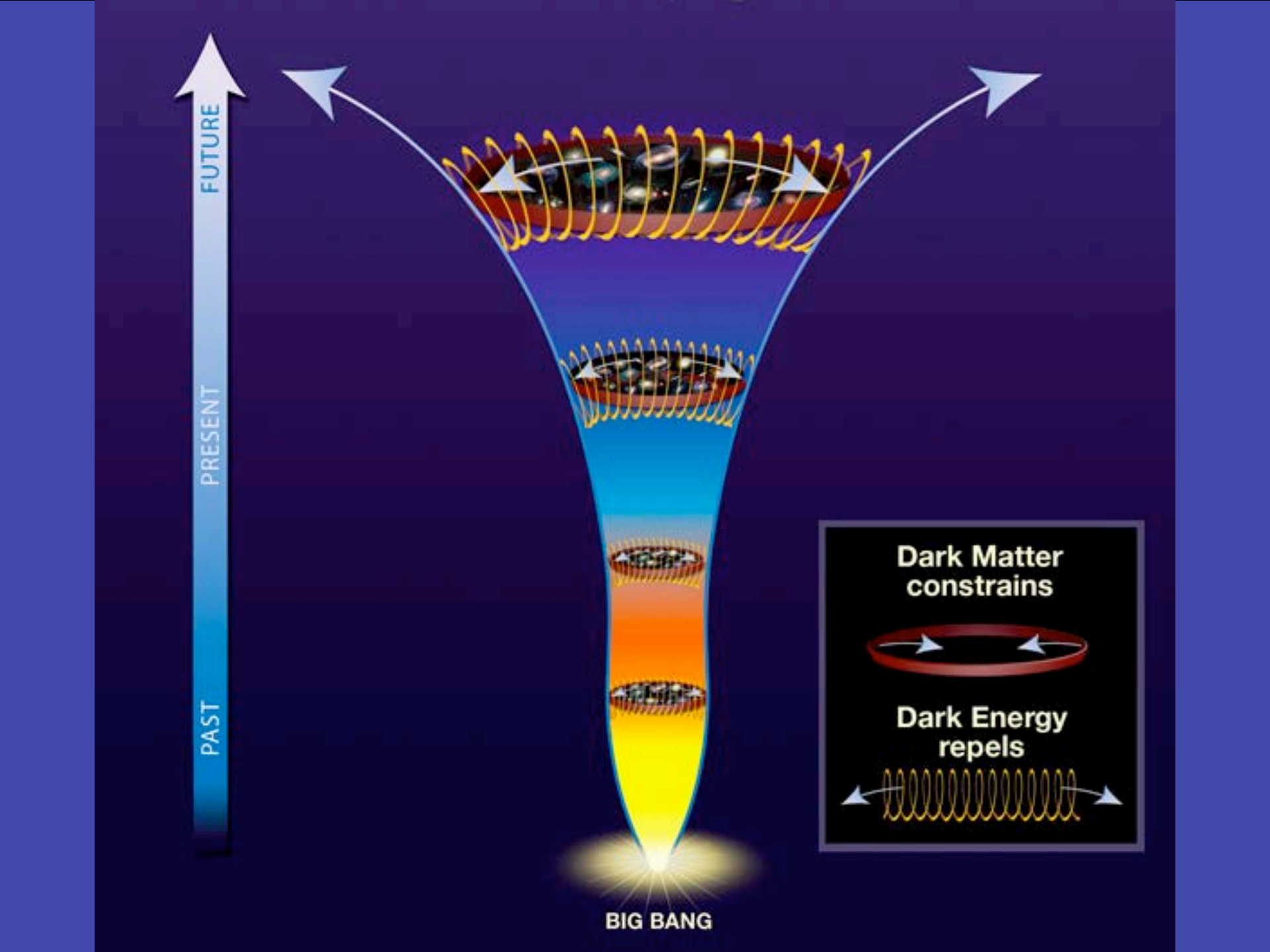
Moderne Interpretation:
Die Galaxien fliegen nicht weg
sondern der Raum expandiert



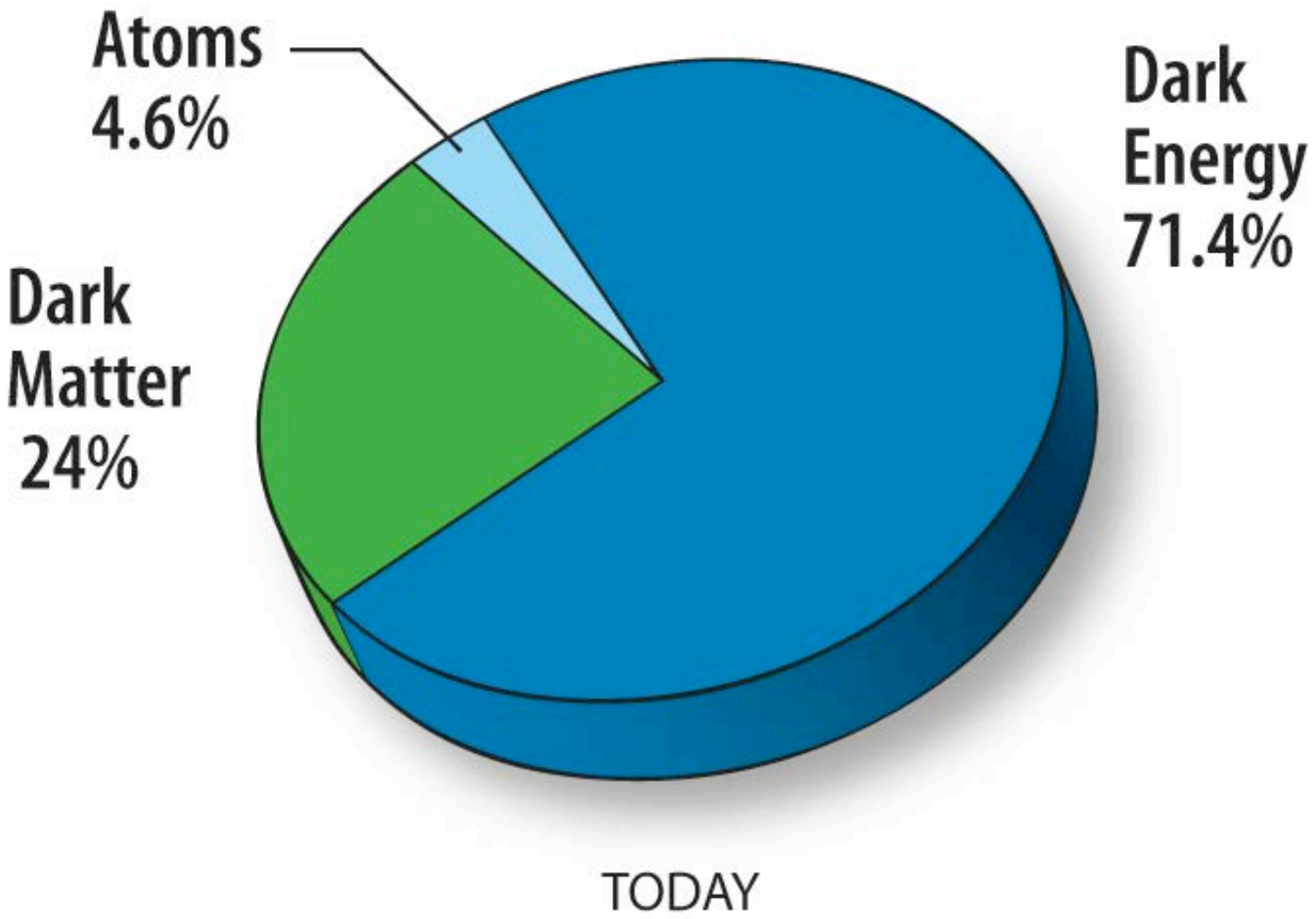
SNe Ia als Standardkerzen




1 1/2
relative Helligkeit
0.01 %
0.1 %
1 %
10 %
100 %
Beschleunigung
Verlangsamung
0
0.5
1
1.5
2
3
1/2
Größe des Universums
gemittelte Daten
ΛCDM
Vergangenheit
heute
Zukunft
Urknall
-15
-10
-5
0
5
10
Jahre in Milliarden


FUTURE
PRESENT
PAST
BIG BANG
Dark Matter constrains
Dark Energy repels

Heutige Zusammensetzung des Kosmos

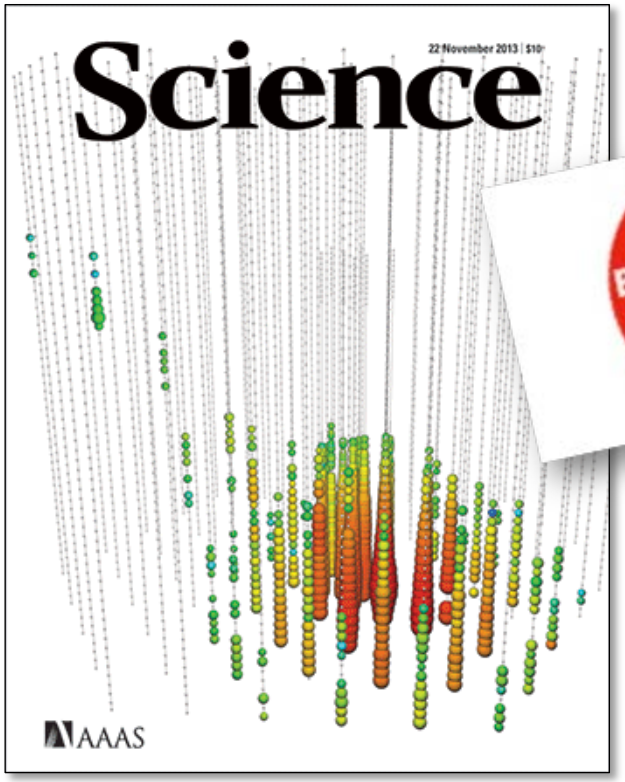


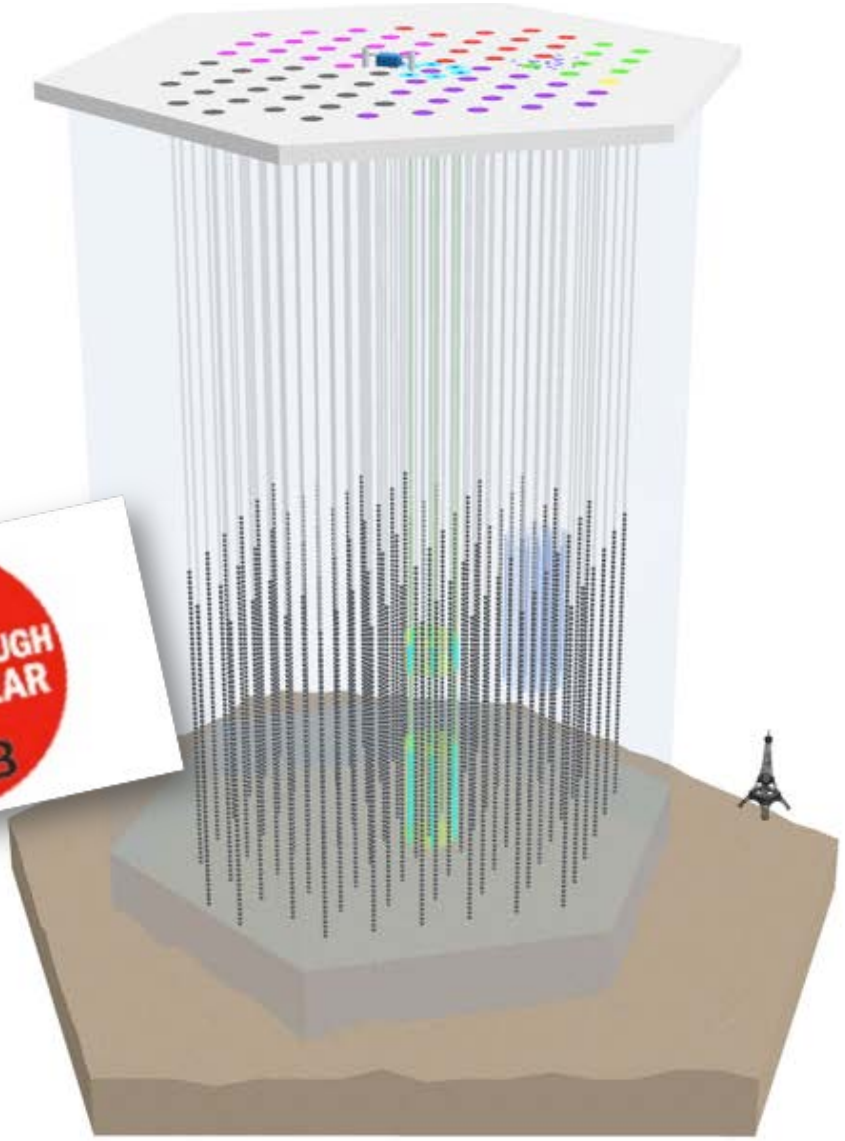
Das IceCube Observatorium

IceCube

- 86 Strings, 5360 DOMs
- E_{thresh} ~ 100 GeV

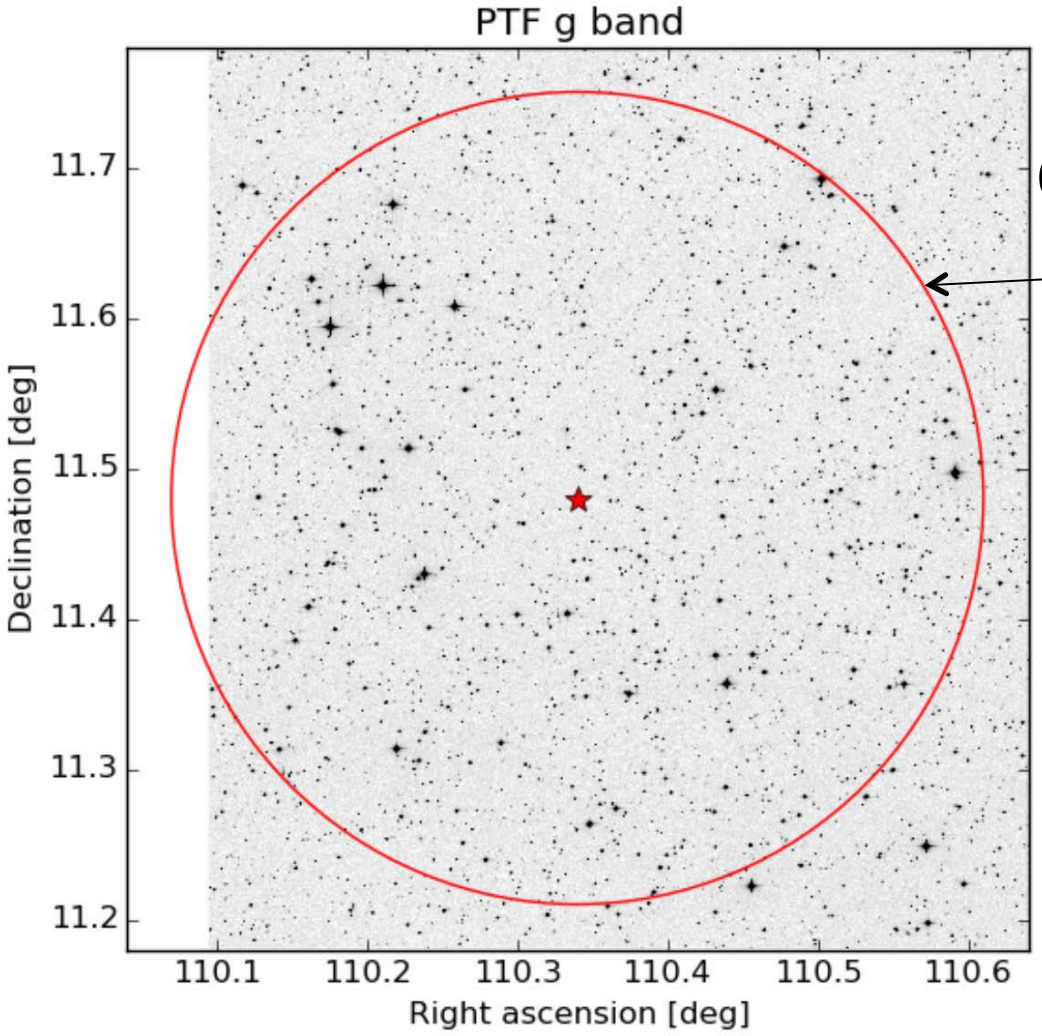
➔ astrophysical neutrinos



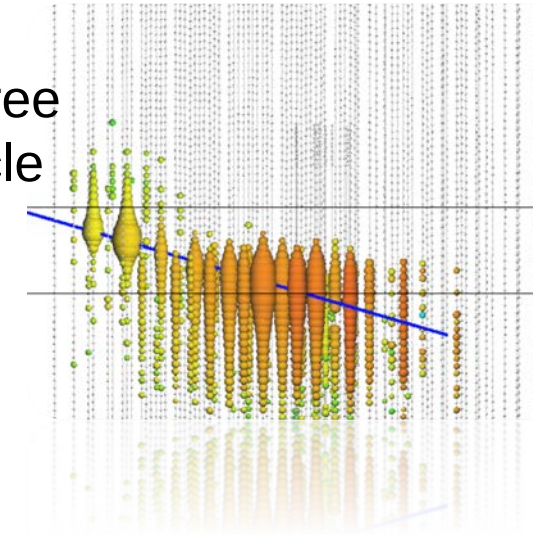


Quellen hochenergetischer Neutrinos?

Viele Kandidaten!



0.27 degree error circle



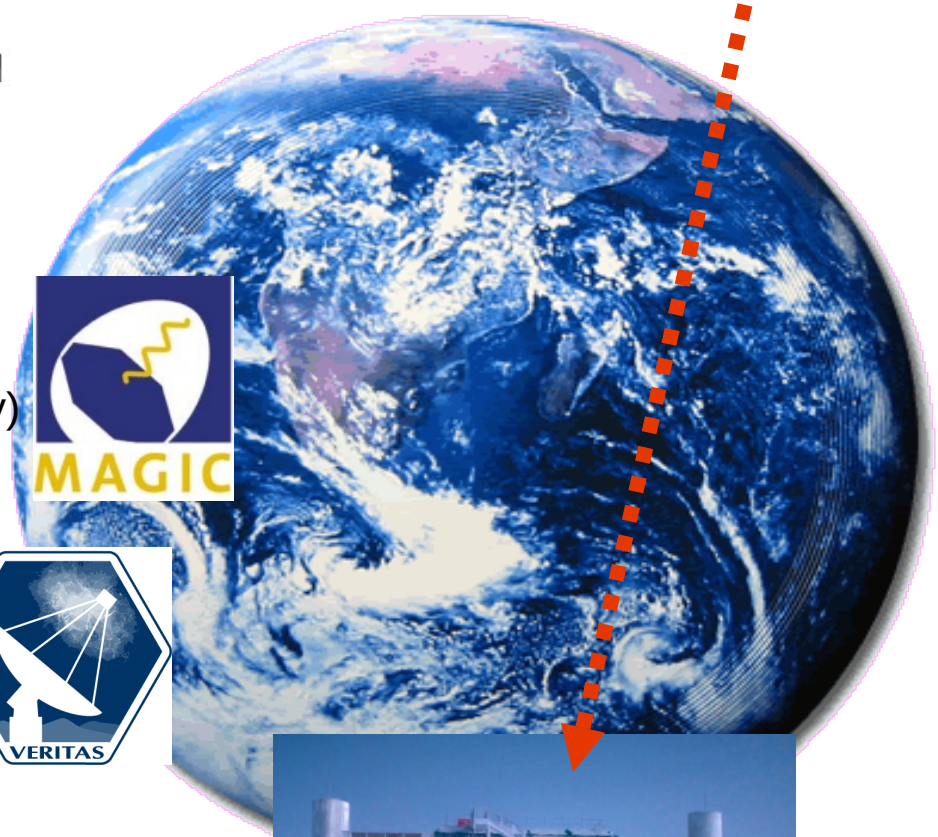
IceCube Neutrino-Nachbeobachtungen

AGN/SN/GRB

Swift (X-Ray)

PTF (optical)

PALOMAR TRANSIENT FACTORY



MAGIC

(Gamma-Ray)

MAGIC

DESY

VERITAS

(Gamma-Ray)

VERITAS

iridium

IceCube

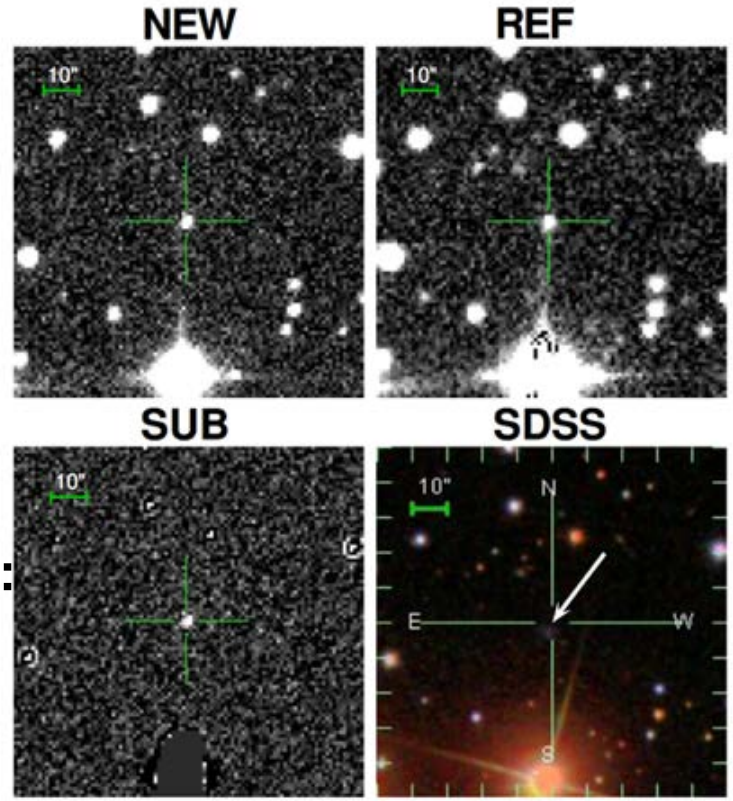
SOUTH POLE NEUTRINO OBSERVATORY

IceCube Neutrino-Nachbeobachtungen

Swift (X-Ray)

PTF (optical)

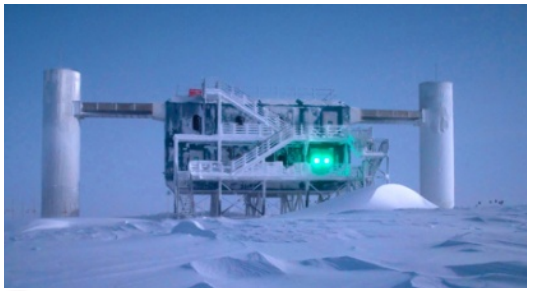
PALOMAR TRANSIENT FACTORY



DESY

Nachweis einer Supernova IIN:
PTF12csy; chance coin. ~2%
Voge et al., Astrophys. J. (2015)

iridium



IceCube
SOUTH POLE NEUTRINO OBSERVATORY

Ausblick:

- Shutter Tests in DESY bis August
- Shutter Installation am Palomar Obs. im Oktober
- Kamera Installation Dez-Feb 2017
- First Light: Frühjahr 2017
- Himmelsdurchmusterung ab Sommer 2017 - 2020