GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

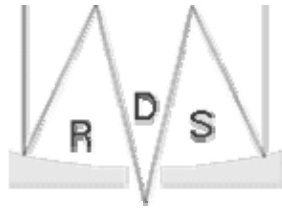
Astrophysik in Deutschland, Status, Probleme, Perspektiven

Günther Hasinger

MPE Garching & TU München

Vorsitzender des RDS

MAX-PLANCK-GESELLSCHAFT



Astroteilchenphysik in Deutschland: Status und Perspektiven 2005
4./5. Oktober 2005, DESY, Zeuthen

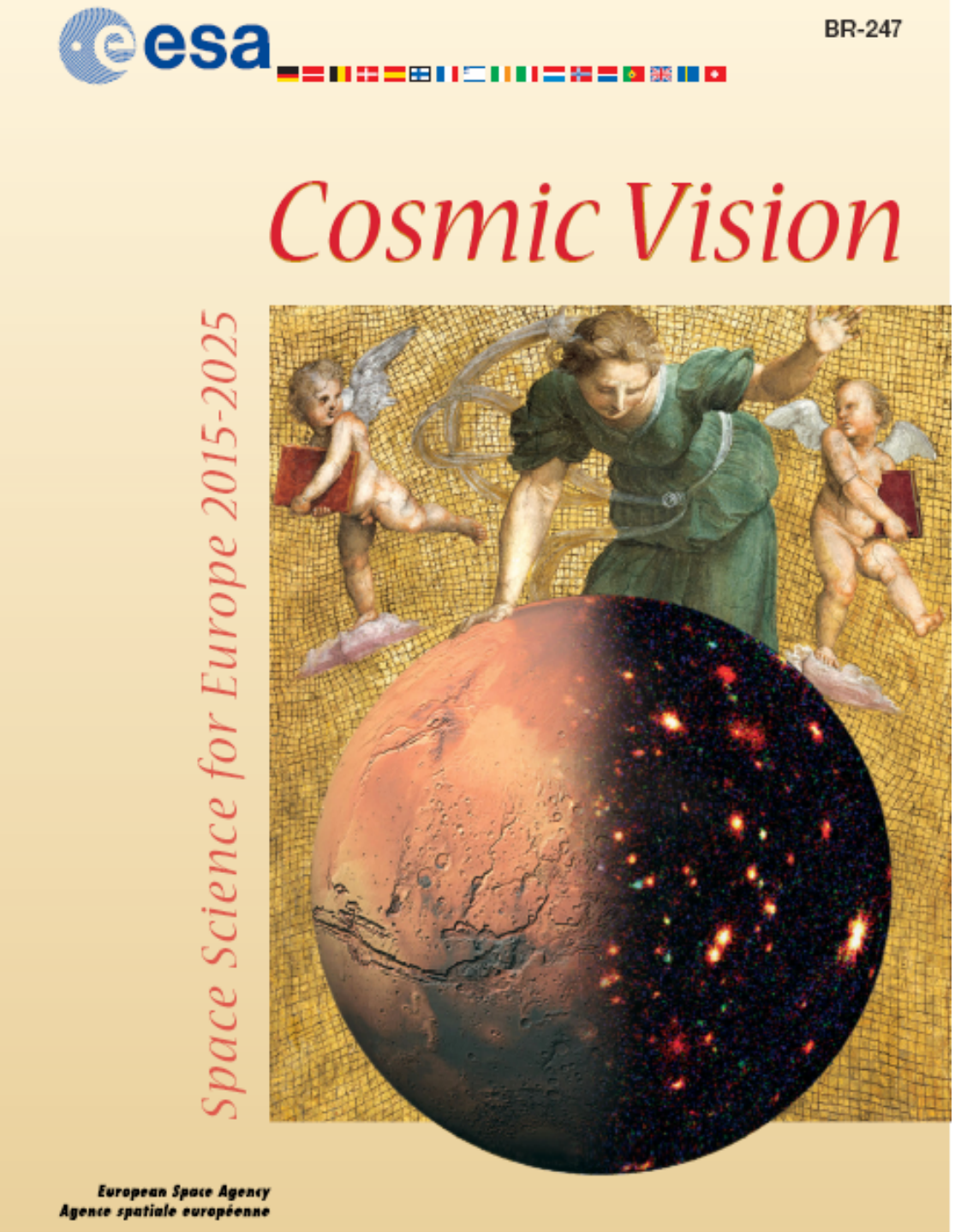
R D S

MAX-PLANCK-GESELLSCHAFT

Redaktionskommittee:

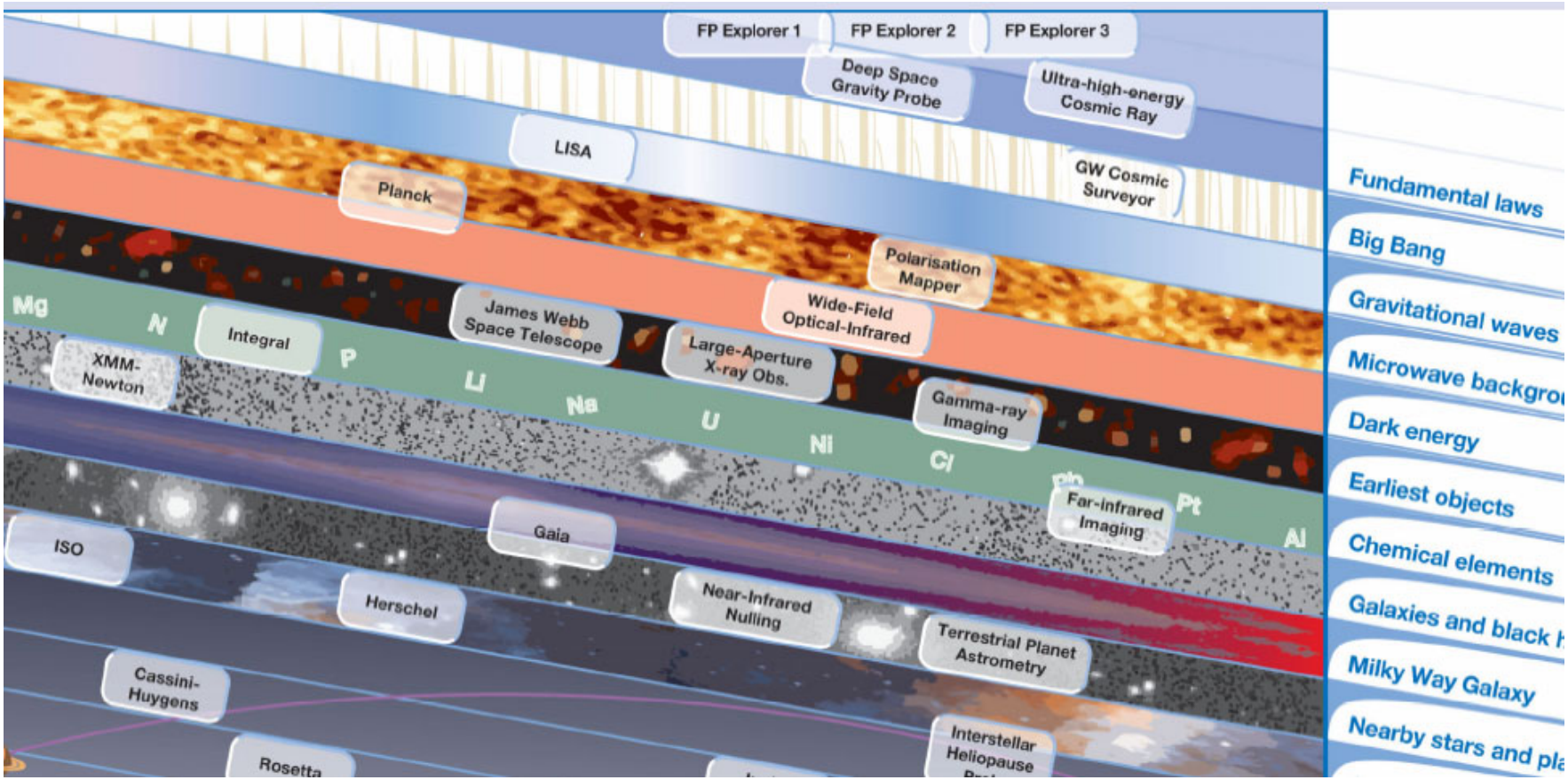
Andreas Burkert
Reinhard Genzel
Günther Hasinger
Gregor Morfill (Vorsitz)
Peter Schneider
Detlev Koester

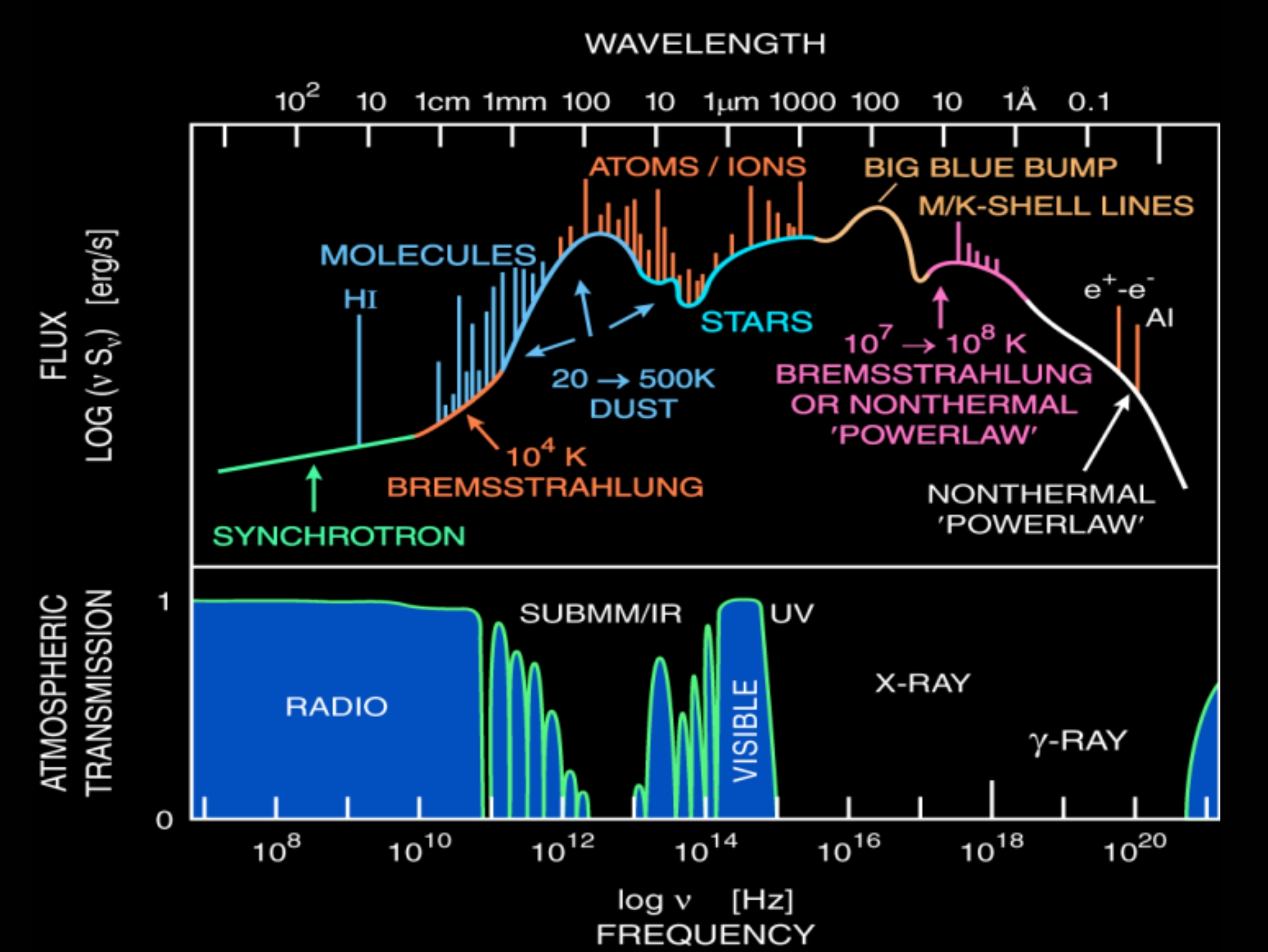
Erschienen Nov 2003



Title of the ESA-Brochure „Cosmic Vision 2015-2025“, summarising the most important scientific questions for future space research in Europe

ESA Cosmic Vision 2015-2025

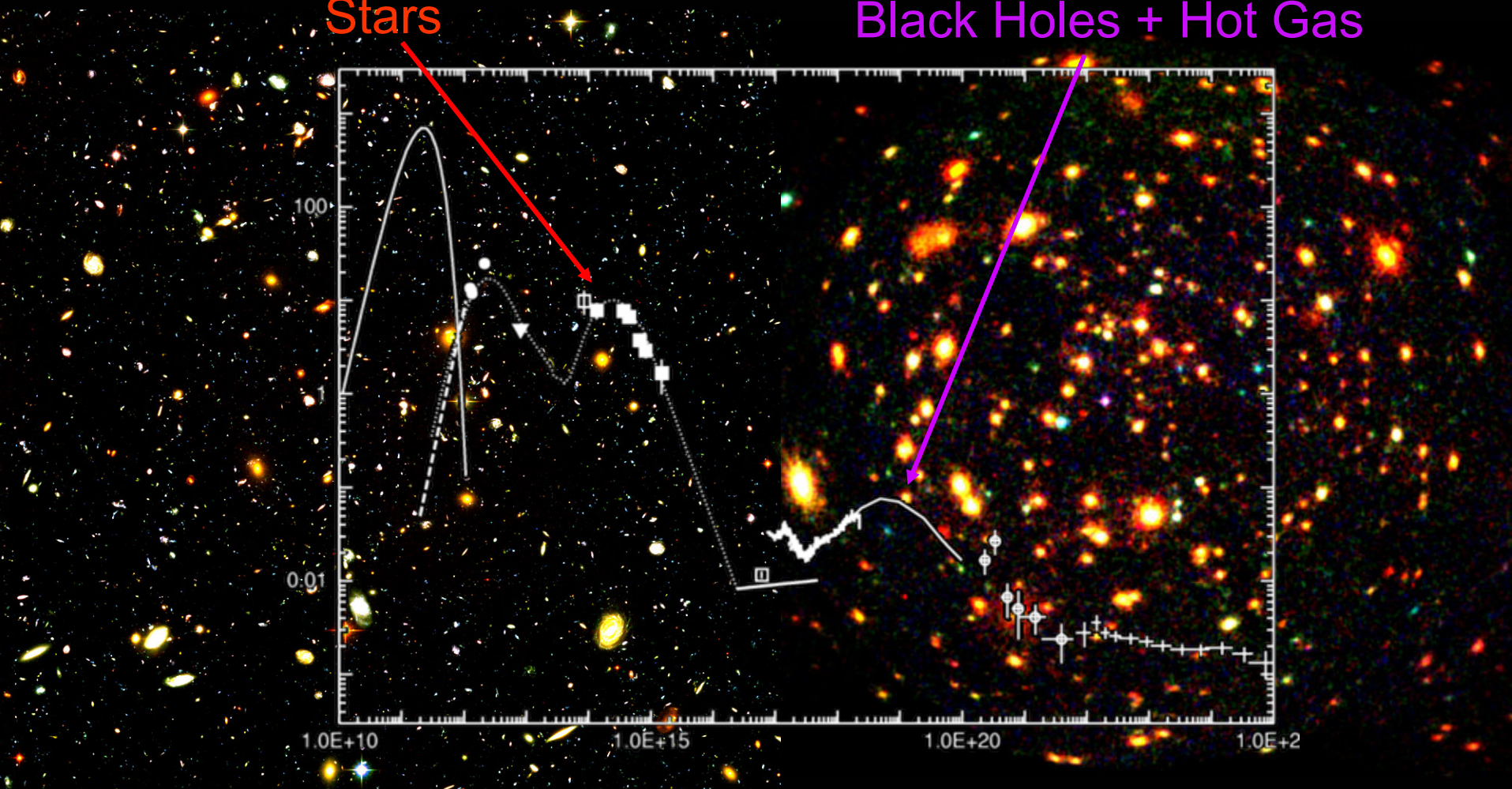



WAVELENGTH
10^2 10 1cm 1mm 100 10 1μm 1000 100 10 1Å 0.1
FLUX
LOG (νS_ν) [erg/s]
ATOMS / IONS
BIG BLUE BUMP
M/K-SHELL LINES
MOLECULES
HI
STARS
e^+-e^-
Al
$10^7 \rightarrow 10^8$ K
BREMSSTRAHLUNG
OR NONTHERMAL
'POWERLAW'
20 → 500K
DUST
10^4 K
BREMSSTRAHLUNG
SYNCHROTRON
NONTHERMAL
'POWERLAW'
ATMOSPHERIC
TRANSMISSION
1
0
SUBMM/IR
UV
RADIO
VISIBLE
X-RAY
γ-RAY
10^8 10^{10} 10^{12} 10^{14} 10^{16} 10^{18} 10^{20}
log ν [Hz]
FREQUENCY

Cool vs. Hot

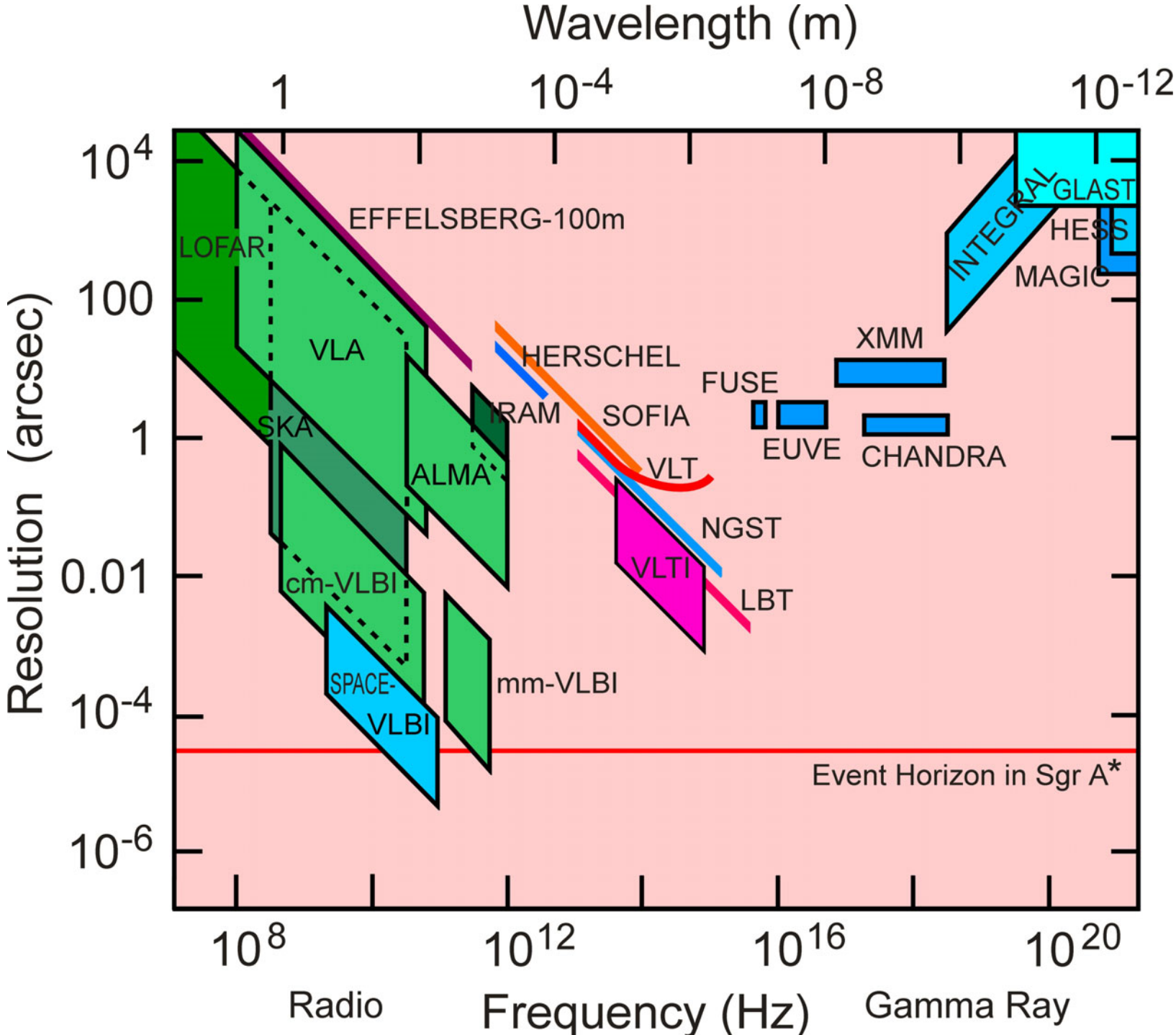
The 6,000 K Universe:
Stars

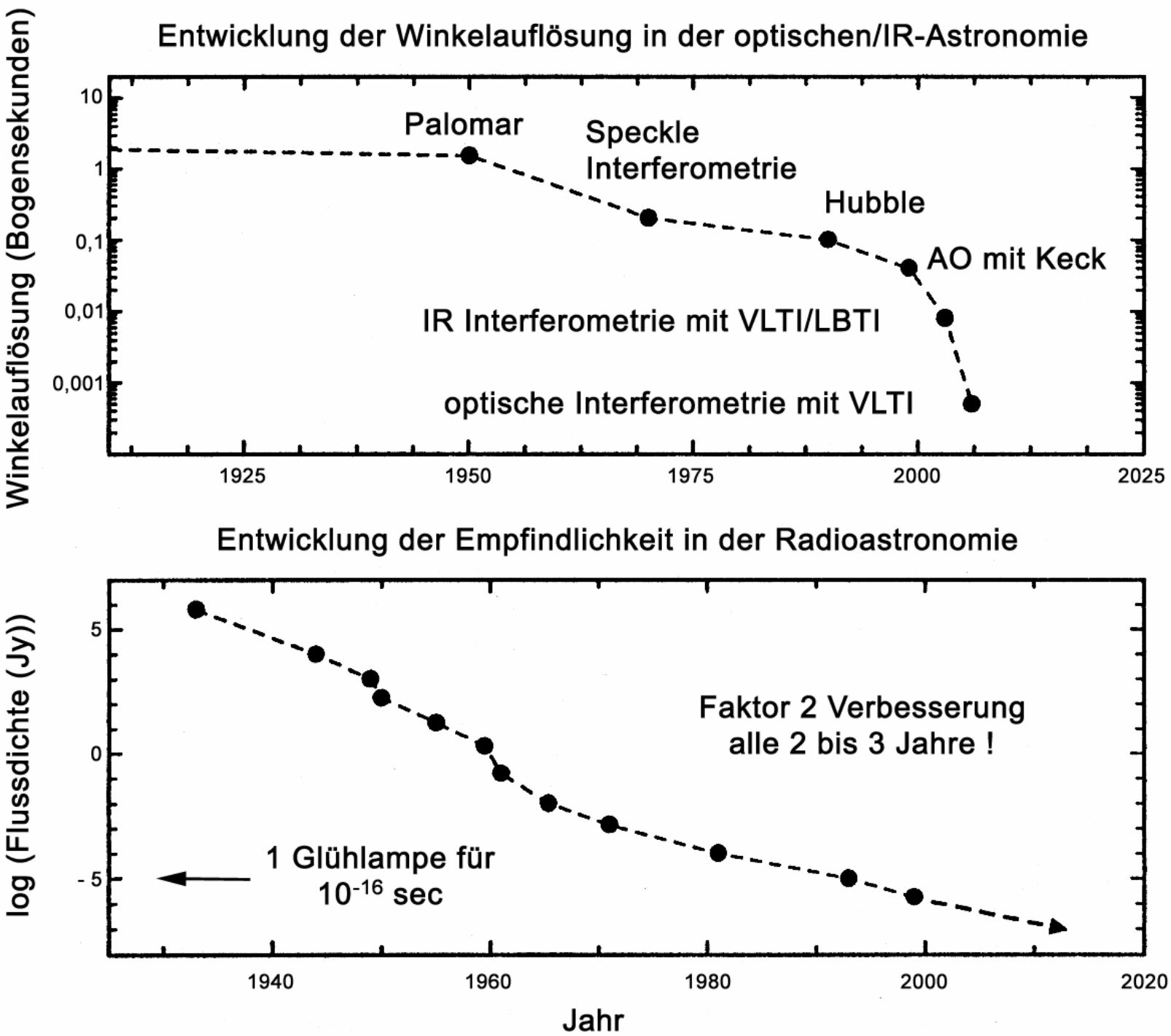
The 1,000,000 K Universe:
Black Holes + Hot Gas



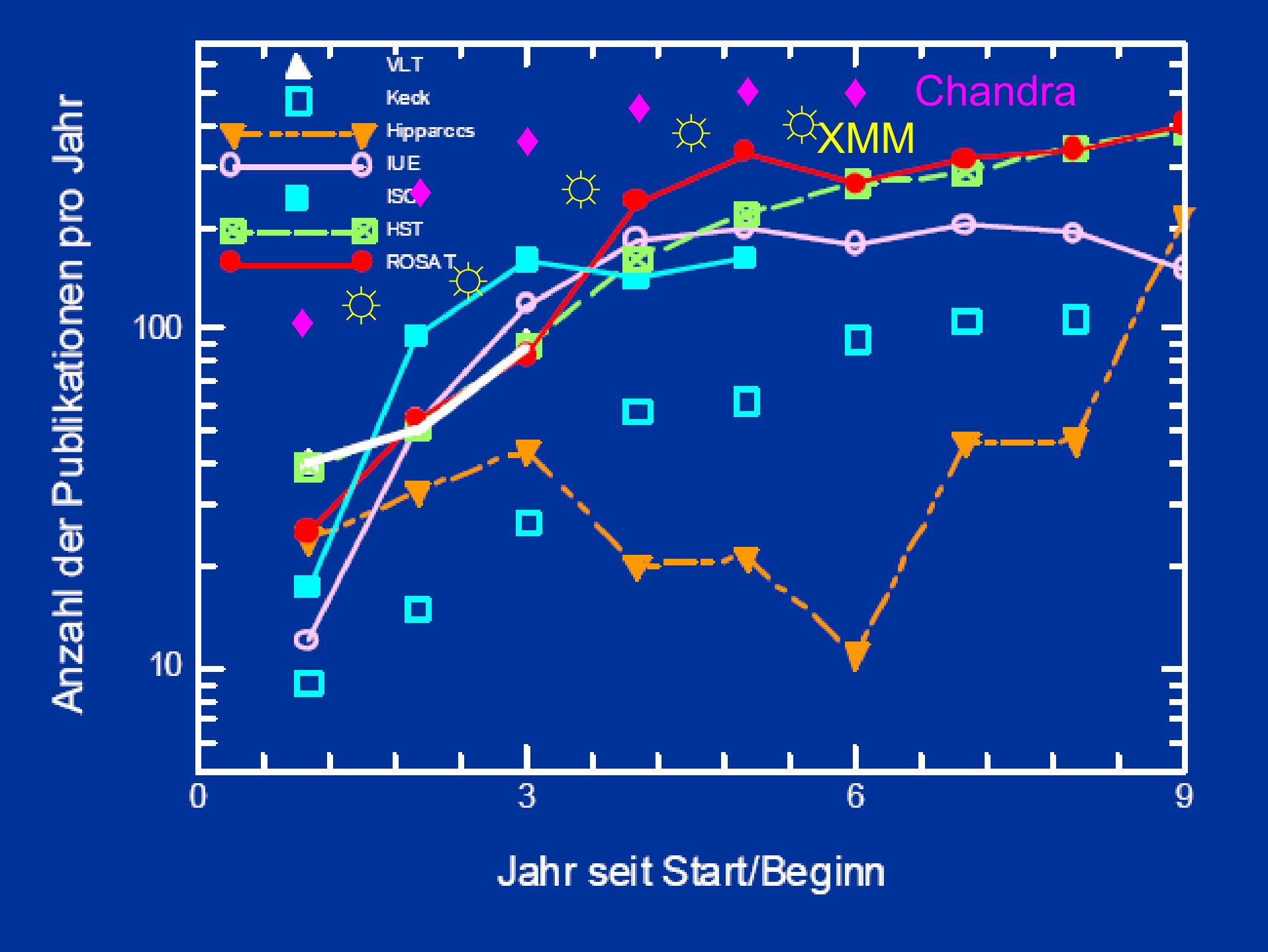
Hubble ACS Ultradeep Field

XMM-Newton 1 Msec Field

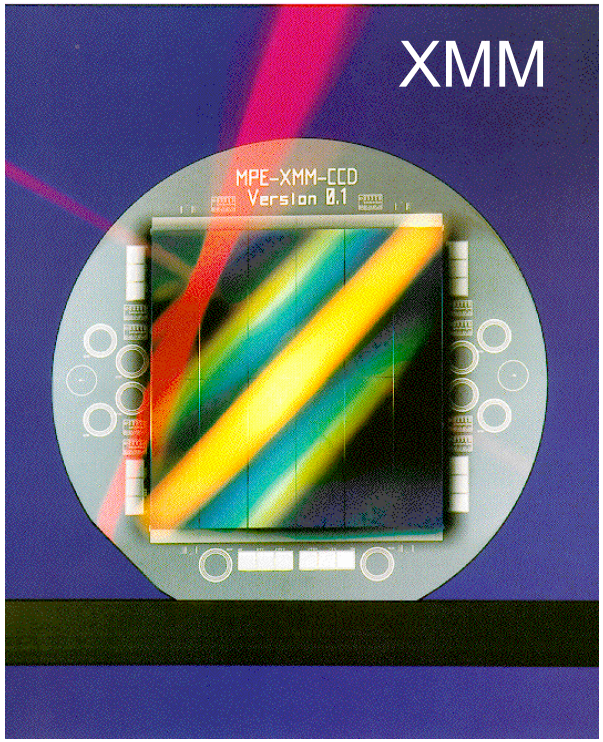

Wavelength (m)
1
10-4
10-8
10-12
Resolution (arcsec)
10^4
100
1
0.01
10-4
10-6
LOFAR
EFFELSBERG-100m
VLA
SKA
ALMA
cm-VLBI
SPACE-
VLBI
mm-VLBI
HERSCHEL
IRAM
SOFIA
VLT
NGST
VLTI
LBT
FUSE
XMM
EUVE
CHANDRA
INTEGRAL
GLAST
HESS
MAGIC
Event Horizon in Sgr A*
10^8
10^12
10^16
10^20
Radio
Frequency (Hz)
Gamma Ray

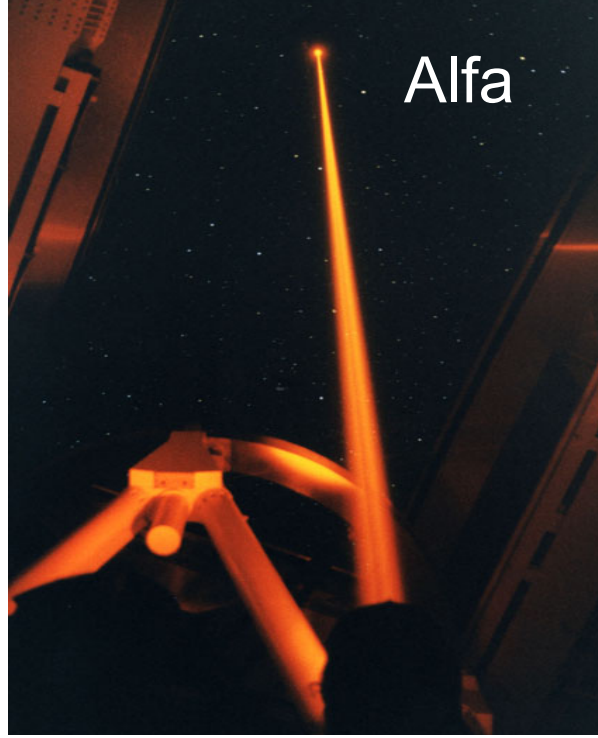

Entwicklung der Winkelauflösung in der optischen/IR-Astronomie
Winkelauflösung (Bogensekunden)
10
1
0,1
0,01
0,001
Palomar
Speckle
Interferometrie
Hubble
AO mit Keck
IR Interferometrie mit VLTI/LBTI
optische Interferometrie mit VLTI
1925
1950
1975
2000
2025
Entwicklung der Empfindlichkeit in der Radioastronomie
log (Flussdichte (Jy))
5
0
- 5
Faktor 2 Verbesserung
alle 2 bis 3 Jahre !
1 Glühlampe für
10-16 sec
1940
1960
1980
2000
2020
Jahr

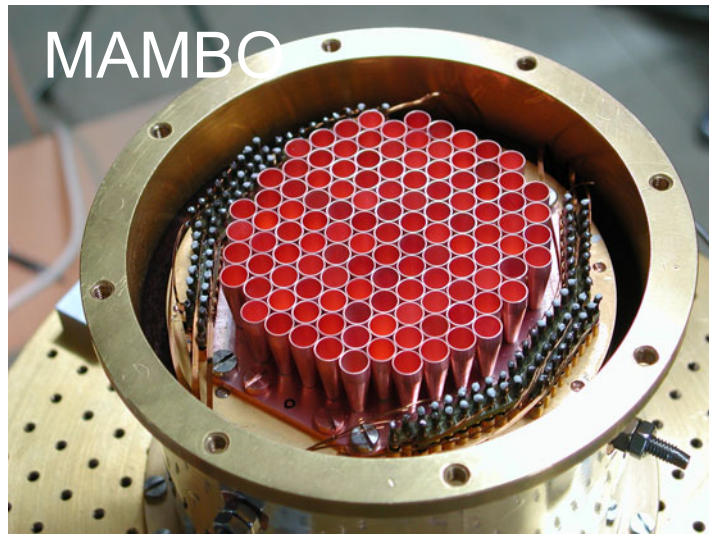
Observatorium	Bereich	Boden/ Welt-raum	Start	Ende	Träger	Deut-scher Anteil
Geo600	Gravitationswellen	B	2002		D	100 %
Effelsberg	Radio	B	1972		D	100 %
IRAM	Millimeter	B	1979		D/F/Sp	47 %
ISO	IR	W	1995	1998	ESA	25 %
La Silla	Optisch/NIR	B	1969		ESO	20 %
Calar Alto	Optisch/NIR	B	1973		D/Sp	90 %
VLT Paranal	Optisch/NIR	B	1998		ESO	20 %
SDSS	Optisch	B	1998		USA/NASA/D	5 %
HET	Optisch	B	1999		USA/D	9 %
Teneriffa	Optisch (Sonne)	B	1985		D/Sp	75 %
SOHO	UV/Optisch (Sonne)	W	1995		ESA/NASA	20 %
Hubble Space Telescope	UV/Optisch/NIR	W	1990		NASA/ESA	4 %
ROSAT	Röntgen	W	1990	1999	D/NASA/UK	60 %
Chandra	Röntgen	W	1990		NASA/NL/D	2 %
XMM-Newton	Röntgen	W	1999		ESA	25 %
Compton GRO	Gamma	W	1991	2000	NASA/ESA/D	25 %
Integral	Gamma	W	2002		ESA/Russ.	20 %
HEGRA	UHE-Gamma	B	1987		D/Sp/Armenien	80 %
GNO	Neutrinos	B	1990	1997	D/I/F/Polen/USA	50 %
AMANDA	Neutrinos	B	1996		USA/D/int.	15 %
CRESST/GENIUS	Dunkle Materie	B	1999		D/UK/I+Russ./USA	80 %


VLT
Keck
Hipparcos
IUE
ISO
HST
ROSAT
Chandra
XMM
100
10
0
3
6
9
Anzahl der Publikationen pro Jahr
Jahr seit Start/Beginn

Technologie-Entwicklung







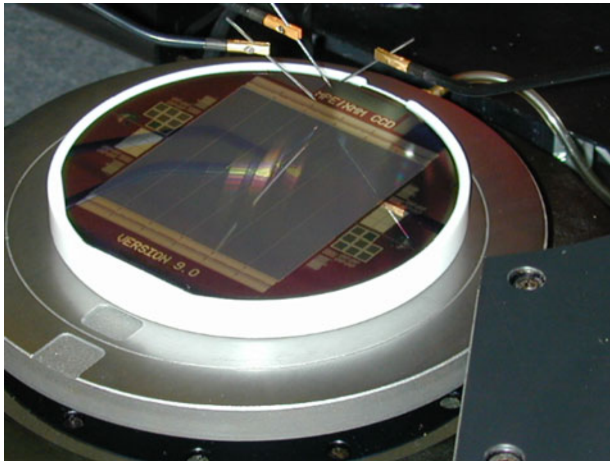
Halbleiterlabor des MPE und WHI

1200 m² Cleanroom up to class 1 …

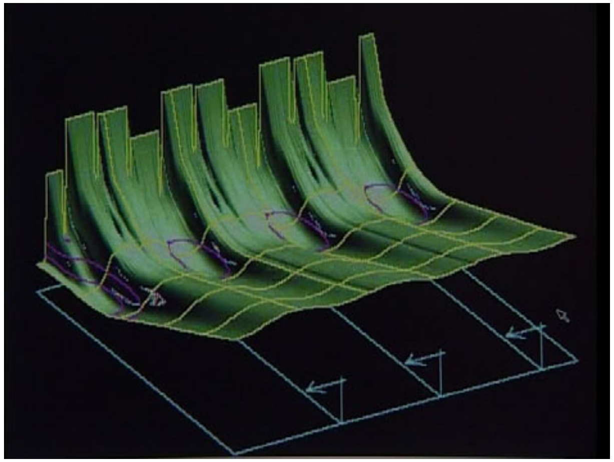
… with modern facilities

… for a complete 6“ silicon waver production

mounting and bonding



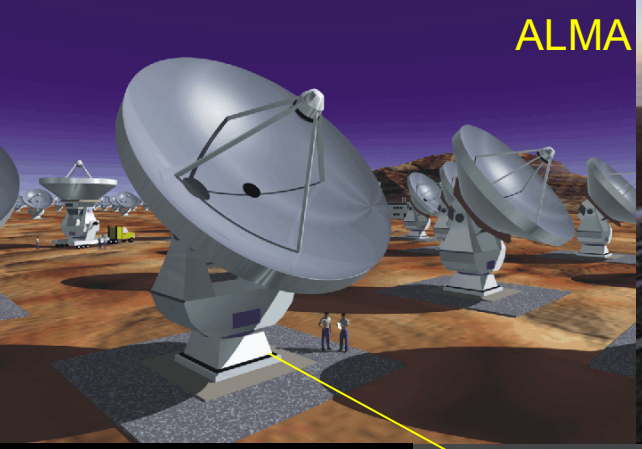
test and qualification



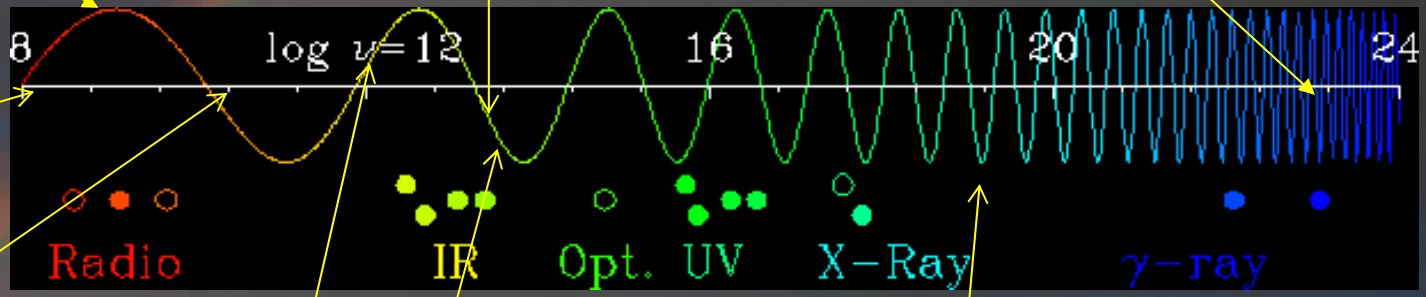
Computer network for simulation, layout and analysis

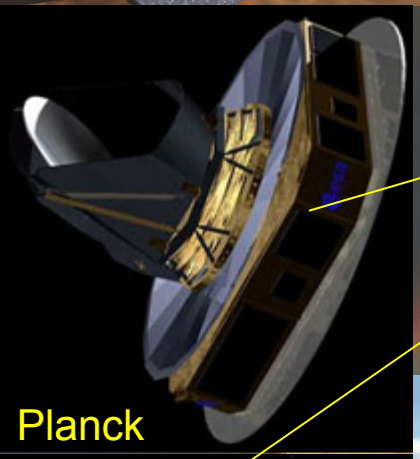
„Großgerät“ der MPG: Kosten 4 Mio €/J. Wird von >15 Unis genutzt

Sensoren für die Mars-Rover Spirit und Opportunity!



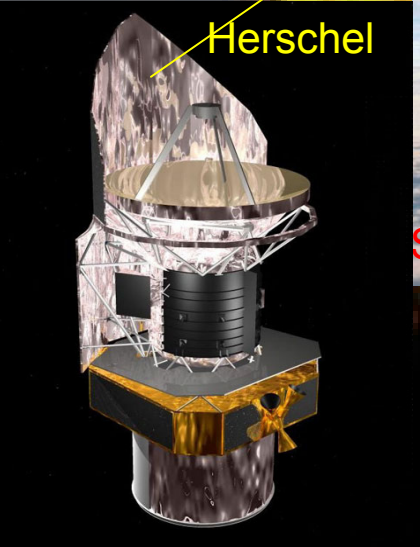
1 Oktave





56 Oktaven (7 „Grand Pianos")

SOFIA



Observatorium	Bereich	Boden/ Welt- raum	Start	Träger	Deut- scher Anteil
LISA	Gravitationswellen	W	2011	NASA/ESA	13 %
SKA*	Radio	B	>2010	US/international	
Planck	Mikrowellen	W	2007	ESA	25 %
APEX	Millimeter	B	2004	D/ESO/Sweden	60 %
ALMA	Millimeter	B	2011	USA/Europa	10 %
Herschel	IR	W	2007	ESA	25 %
SOFIA	IR	Flugzeug	2004	USA/D	20 %
DARWIN/TPF*	IR	W	>2012	NASA/ESA	13 %
JWST	NIR/IR	W	2010	NASA/ESA	4 %
PRIME*	NIR	W		USA/D	10 %
LBT	Optisch/NIR	B	2004	USA/I/D	25 %
STELLA	Optisch	B	2003	D/Sp	80 %
MONET	Optisch	B	2003	D/USA/Südafrika	80 %
SALT	Optisch	B	2005	Südafrika/USA/D	5 %
Eddington	Optisch	W	>2007	ESA	25 %
OWL*	Optisch	B	>2012	ESO	20 %
GAIA	Optisch (Astrometrie)	W	<2012	ESA	25 %
Sunrise*	Optisch (Sonne)	Ballon	2004	D/US/Sp	50 %
Gregor	Optisch (Sonne)	B	2005	D/Sp	75 %
Solar Orbiter	Optisch (Sonne)	W	2011	ESA	25 %
WSO/UV*	UV	W	>2007	Russl./D/int.	10 %
ROSITA*	Röntgen	W/ISS	2008	D/ESA	80 %
XEUS*	Röntgen	W/ISS	>2012	ESA/J	20 %
MEGA*	Gamma	Ballon	2003	D/Sp/I	50 %
GLAST	Gamma	W	2006	NASA/F/D/I/J	2 %
H.E.S.S.	UHE-Gamma	B	2002	D/F/UK/Namibia	70 %
MAGIC	UHE-Gamma	B	2003	D/Sp/int.	60 %
BOREXINO/LENS	Neutrinos	B	2003	I/D/int.	10 %
ICECUBE	Neutrinos	B	2008	USA/D/int.	15 %
Pierre Auger	Kosmische Strahlung	B	2003	USA/D/int.	20 %

Tabelle 5.4: Mittlere Projekte (10 bis 25 M€ in mindestens einer der Perioden)

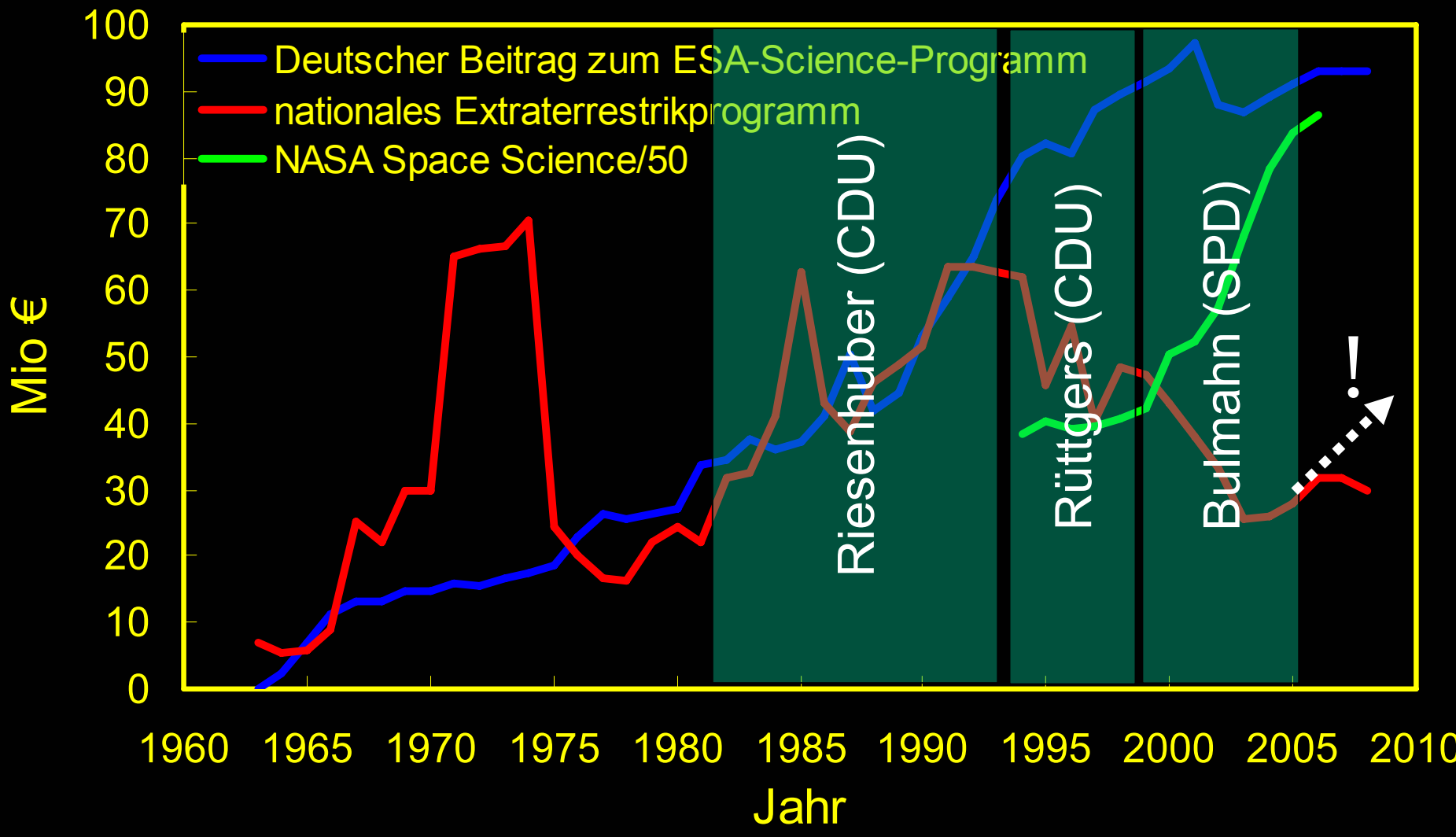
					2003–2009 (M€)			
B/W	Projekt	Art	P	Länder	BMBF	DLR	DFG	MPG z.
W	LISA	Instr.	*			10,0		
W	Solar Orbiter	Instr.	*			10,0		
W	Weltraumteleskope	Nutzung	*			13,0		
W	Solar Orbiter	Instr./Nutzung				3,0		1,0
B	VLT(I)/LBT	Instr.	*		11,0			2,5
B	Innovationsfond	Techn./Instr.	*	5,0	5,0			5,0
B	H.E.S.S./MAGIC	Bau/Nutzung	*		9,2			2,5
B	Astroteilchen	Bau/Nutzung	*		8,8			2,0
B	ICECUBE	Bau/Nutzung	*		8,8			
B	VLT(I)/LBT	Instr.						5,0
	Summe Priorität 1			5,0	42,8	33,0		12,0
	Summe Priorität 2					3,0		6,0

					2010–2016 (M€)			
B/W	Projekt	Art	P	Länder	BMBF	DLR	DFG	MPG z.
W	LISA	Instr.	*			10,0		
W	Solar Orbiter	Instr.	*			10,0		
W	Weltraumteleskope	Nutzung	*			15,0		
W	Solar Orbiter	Instr./Nutzung				2,0		
B	VLT(I)/LBT	Instr.	*		3,0			2,0
B	Innovationsfond	Techn./Instr.	*	5,0	5,0			5,0
B	H.E.S.S./MAGIC	Bau/Nutzung	*		10,5			1,5
B	Astroteilchen	Bau/Nutzung	*		2,5			2,0
B	SKA	Techn./Instr.			10,0			5,0
B	Ausbau Astroteilchen	Instr.	*		13,0			
B	VLT(I)/LBT	Instr.			5,0			2,0
	Summe Priorität 1			5,0	34,0	35,0		10,5
	Summe Priorität 2				15,0	2,0		7,0

Tabelle 5.5: Kleine Projekte (≤ 10 M€ in beiden Perioden)

				2003–2009 (M€)			
B/W	Projekt	Art	P	Länder	BMBF	DLR	DFG	MPG z.
W	Planck	Nutzung	•			2,0		
W	GAIA	Instr./Nutzung	•	5,0		5,0		
W	NGST	Instr.: MIRI				10,0		
W	UV (WSO)	Techn.+Instr.				5,0		
W	GLAST	Instr.+Nutzung				2,5		
B	Zugang Rechenzentren	Instr.	•	5,0				
B	Virtual Observatory	Instr.	•		2,5			2,0
B	Adaptive Optik/ Detektoren	Technologie	•		3,5			
B	GREGOR	Bau	•	4,0				
B	LIGO II/ Gravitationswellen	Instr.+Techn.			5,0			
B	Robotische Teleskope	Instr.+Nutzung		2,0	2,0			
B	D.M.:CRESST/GENIUS	Techn.+Nutzung			2,5			
B	Adaptive Optik/ Detektoren	Technologie			3,5			
B	HET/SALT	Instr.+Nutzung			1,0			
	Summe Priorität 1			14,0	6,0	2,0		2,0
	Summe Priorität 2			2,0	14,0	22,5		

Schwarze (rot/grüne) Löcher bei der nationalen Grundlagenforschung im Weltraum



CV 2015-2025 Planning

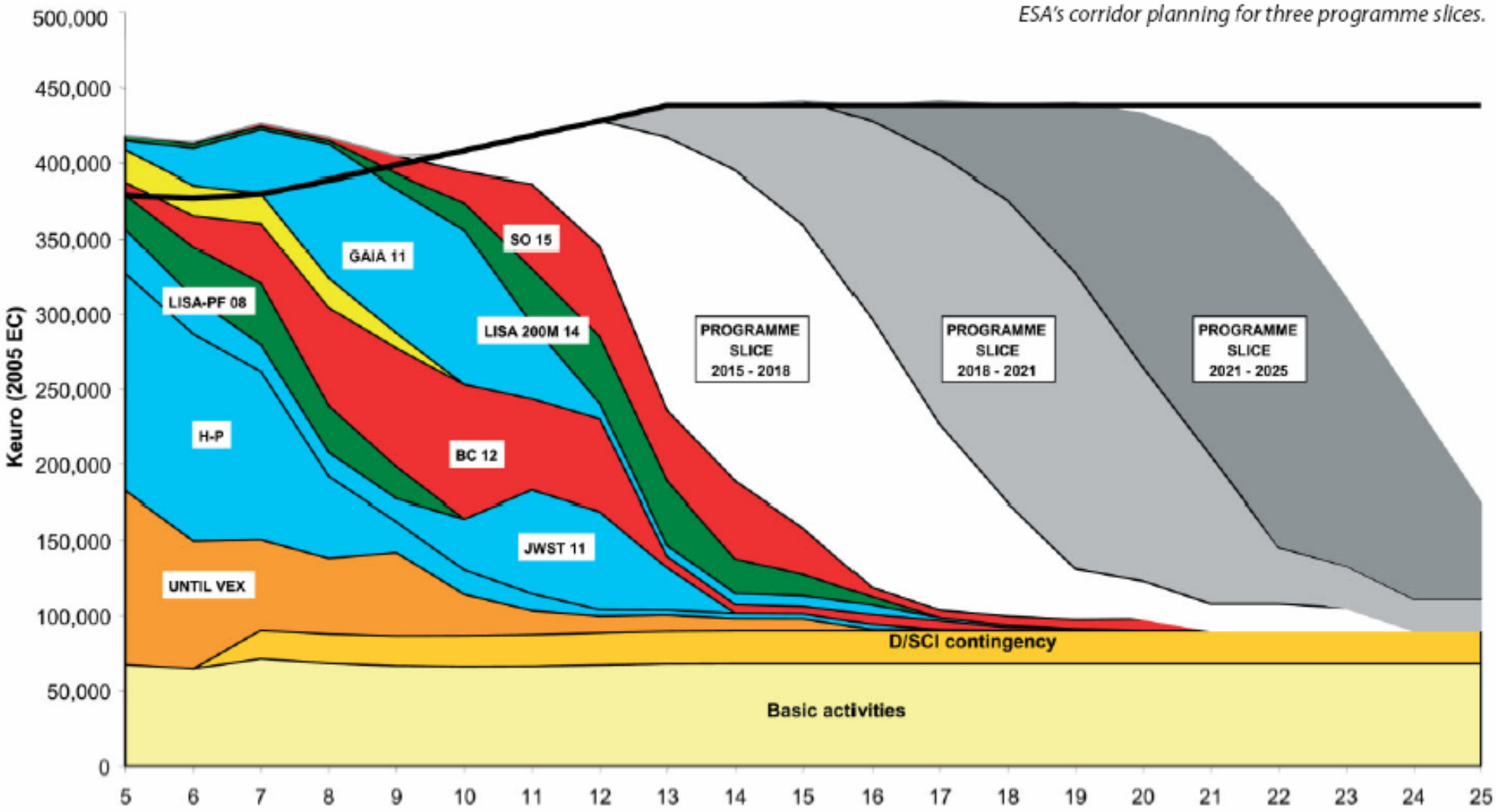


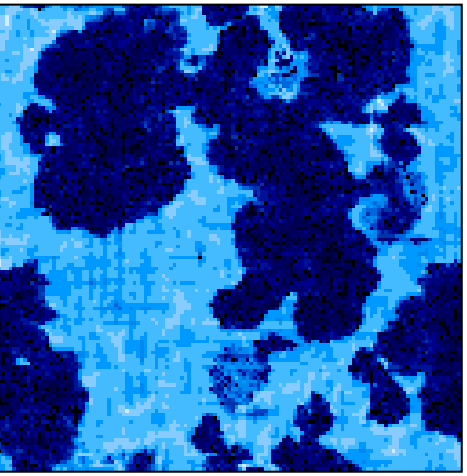
Tabelle 6.2: Wissenschaftliches Personal an deutschen Instituten

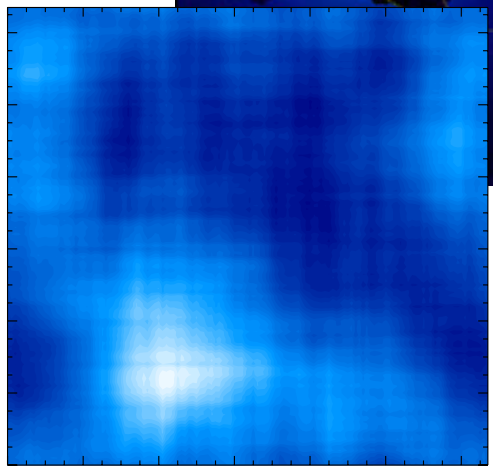
Personal	Insgesamt	Universitäts-institute	Außeruniversitäre Institute (inkl. MPG)
C4	50	27	23
C3	47	19	28
Planstellen	375	94.5	280.5
C2, C1, A/BAT			
Drittmittel	202	83	119
Gesamt	674	223.5	450.5
Doktoranden			
Planstellen	147	31	116
Drittmittel	262	215	47
Gesamt	409	246	163
Diplomanden	215	163	52

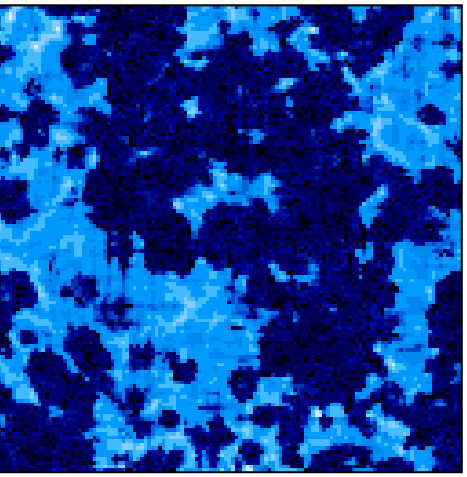
	Anzahl IAU-Mitglieder	Einwohnerzahl (Millionen)	Bruttosozialprodukt (Billionen US$)	IAU-Mitglieder pro Million Einwohner
Schweden	100	8,9	0,23	11,2
Schweiz	80	7,3	0,29	11,0
Niederlande	172	15,7	0,39	11,0
Frankreich	643	58,9	1,43	10,9
Belgien	101	10,2	0,26	9,9
Dänemark	52	5,3	0,18	9,8
Großbritannien	561	58,7	1,26	9,6
Griechenland	99	10,6	0,12	9,3
USA	2300	276,2	8,08	8,3
Italien	437	57,3	1,15	7,6
Deutschland	455	82,1	2,18	5,5
Spanien	218	39,6	0,56	5,5
Österreich	32	8,1	0,22	4,0
Japan	471	126,5	4,09	3,7
Polen	121	38,7	0,15	3,1

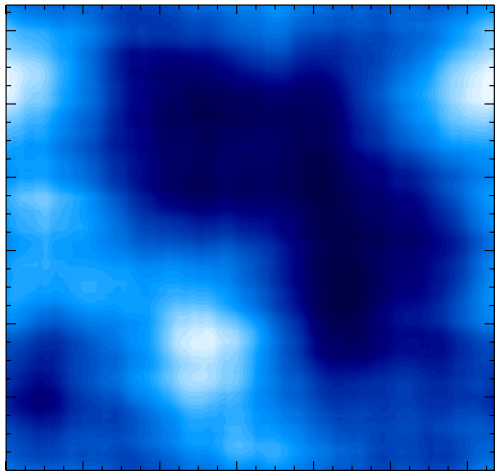
LOFAR

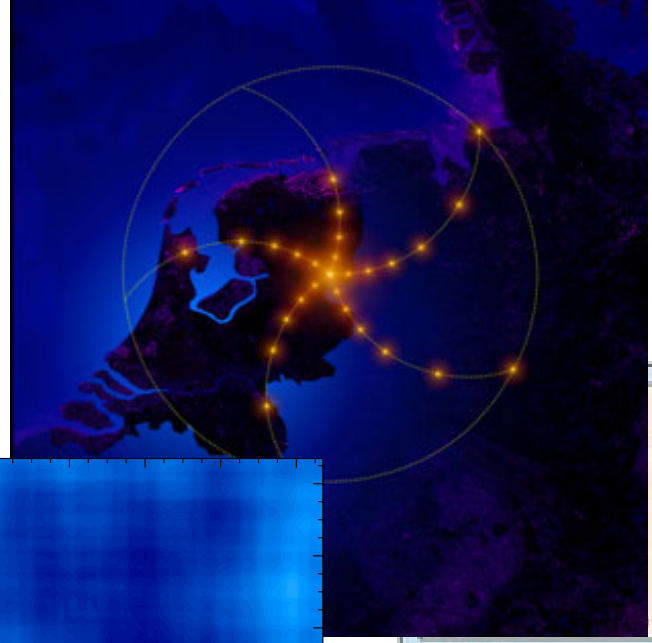
Reionization @z> 10





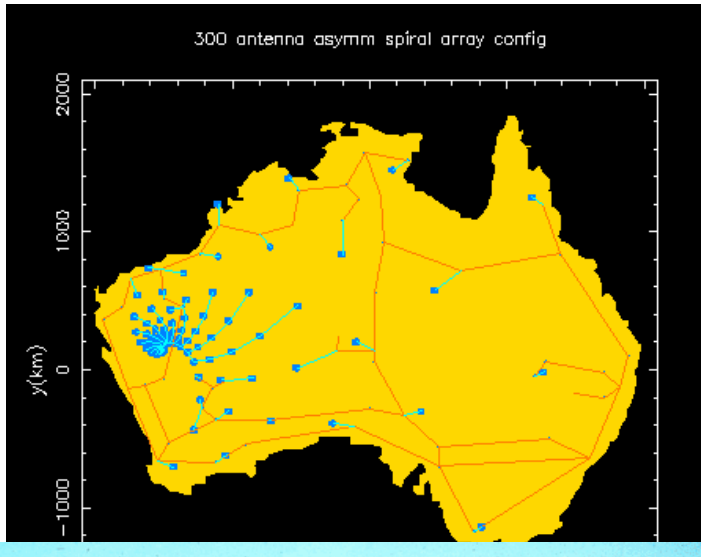






Square Kilometer Array

- Radioastronomie – next-generation global facility
- Status: Planung / Laufzeit 2015+
- Standort Australien oder Süd-Africa,
- MPG Akteur: MPIfR
- MPG Inst./Abtlg. Nutzer: mehrere
- LOFAR als Vorstufe (deutsch/holländische Kooperation?)

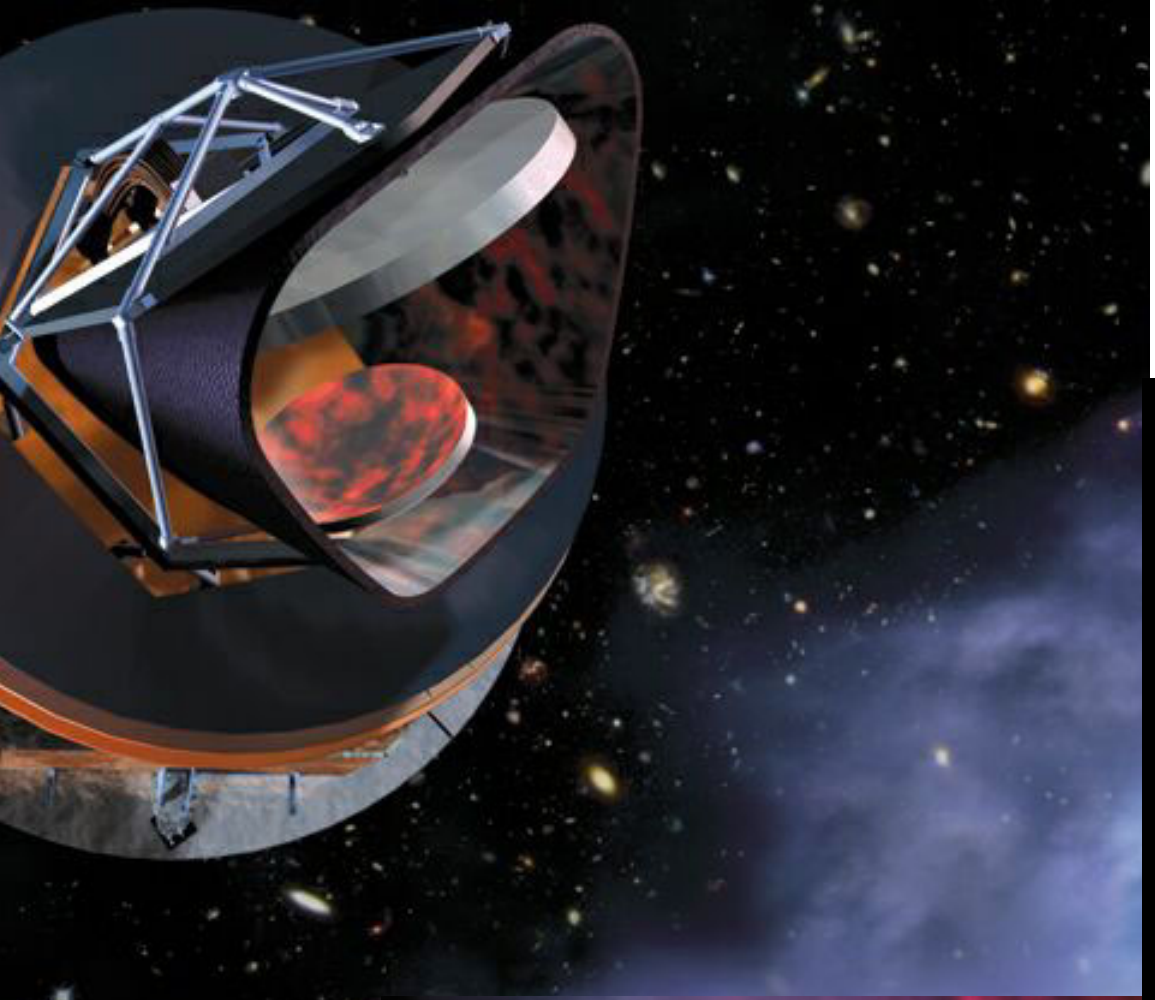


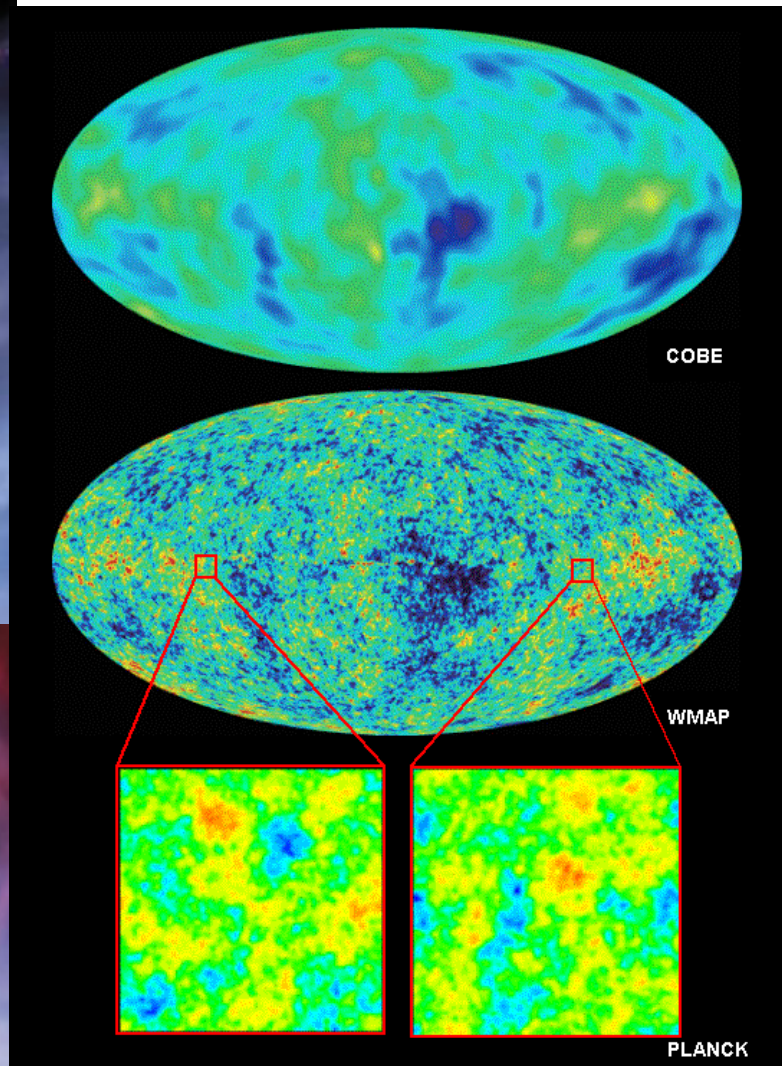
Planck

ESA

Start 2007

Mikrowellen

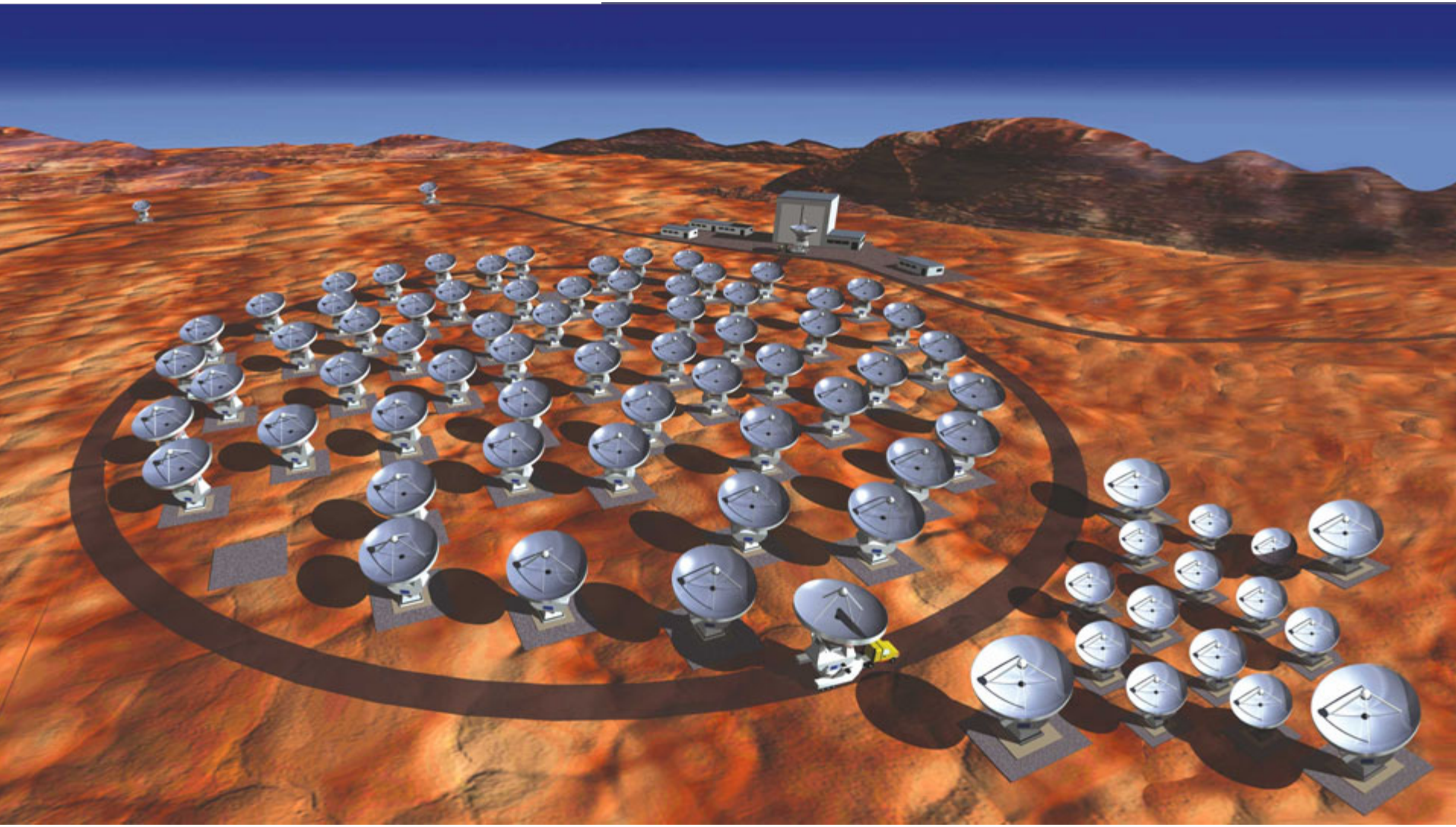




Atacama Pathfinder Experiment

- *Submillimeterastronomie:*
- *A – Langfristige Beteiligung*
  - *Status: im Bau*
  - *Laufzeit 2004-2010*
- *Standort: Chile*
- *Akteur: MPIfR*
- *MPG Inst./Abtlg. Nutzer*
  - *MPIfR, MPE, MPA*

Atacama Large Millimeter Array



HERSCHEL

ESA

Start 2007

IR(80-670λ)

3.5m Telescope

passively cooled

L2 orbit

Instruments:

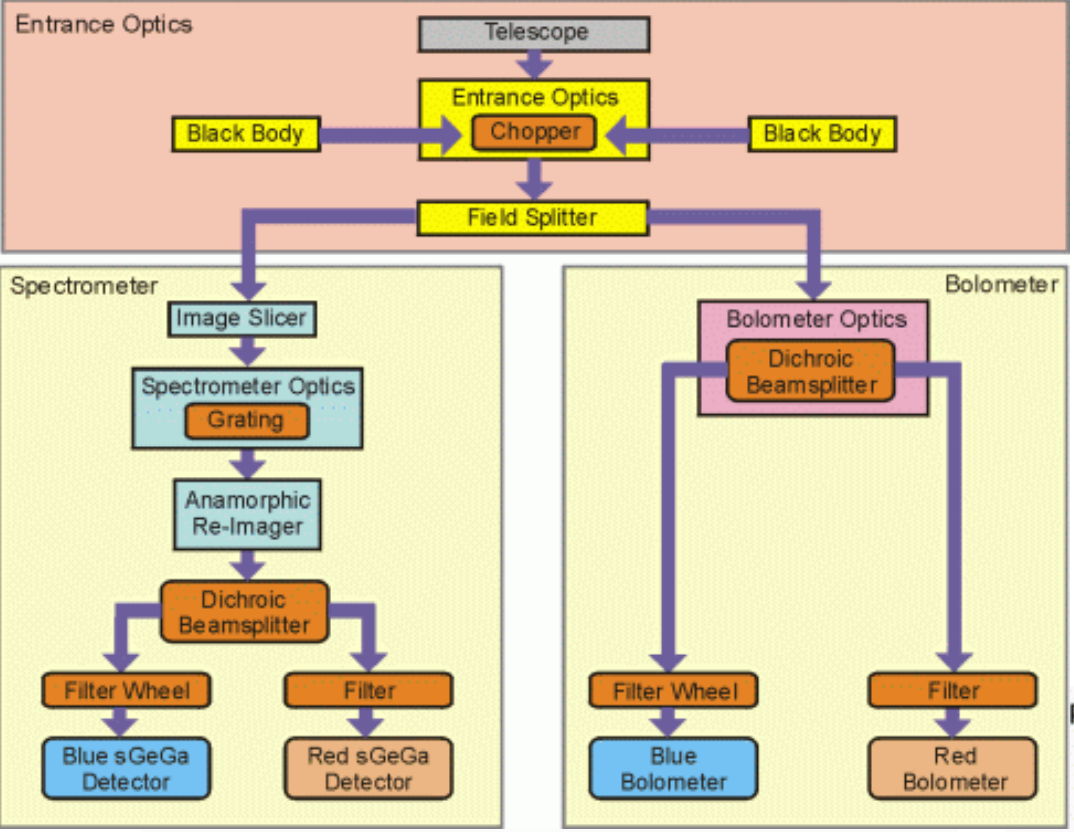
PACS (MPE)

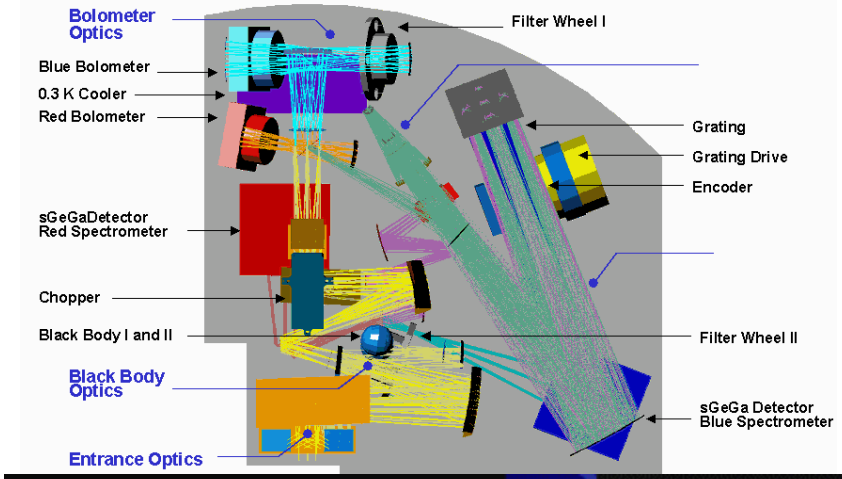
SPIRE

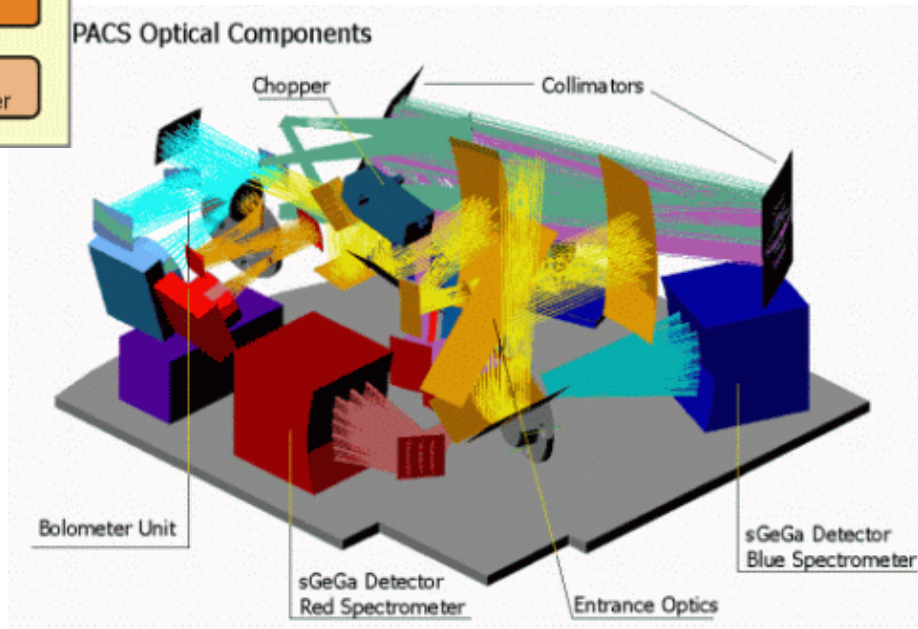
HIFI

PACS

Photodetector Array Camera & Spectrometer







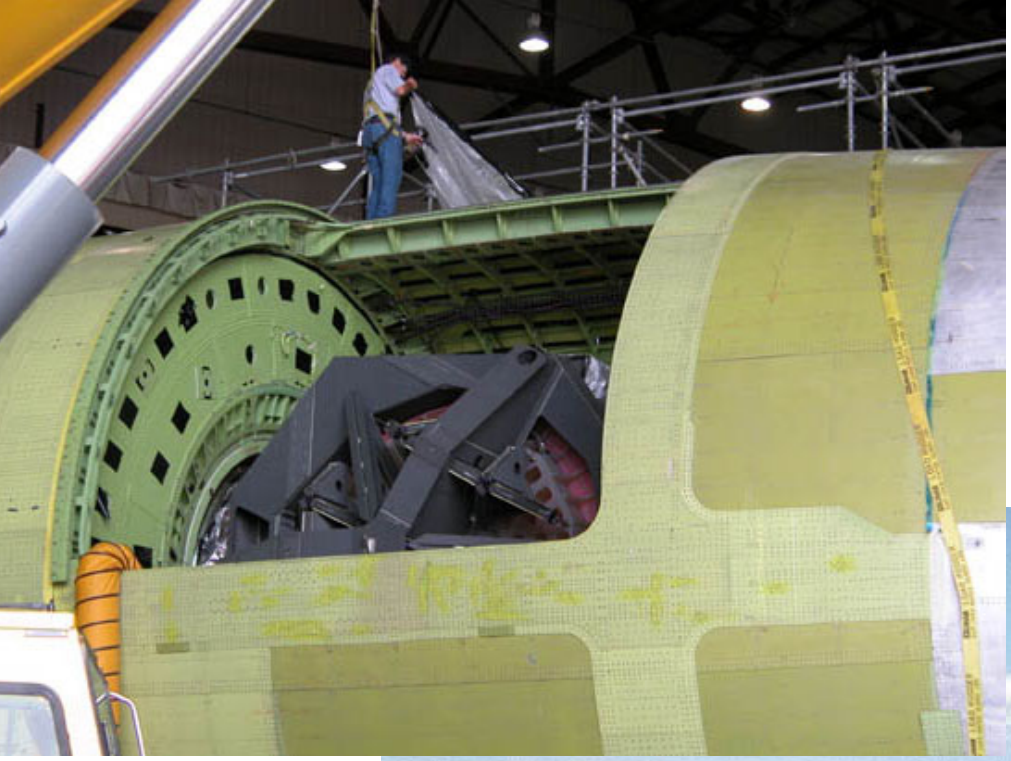
SOFIA

NASA/D

Start: 2006

IR (5-600λ)

2.5m Telescope



German Instruments:

FIFI-LS (MPE)

GREAT (MPIfR)

JWST

NASA/ESA

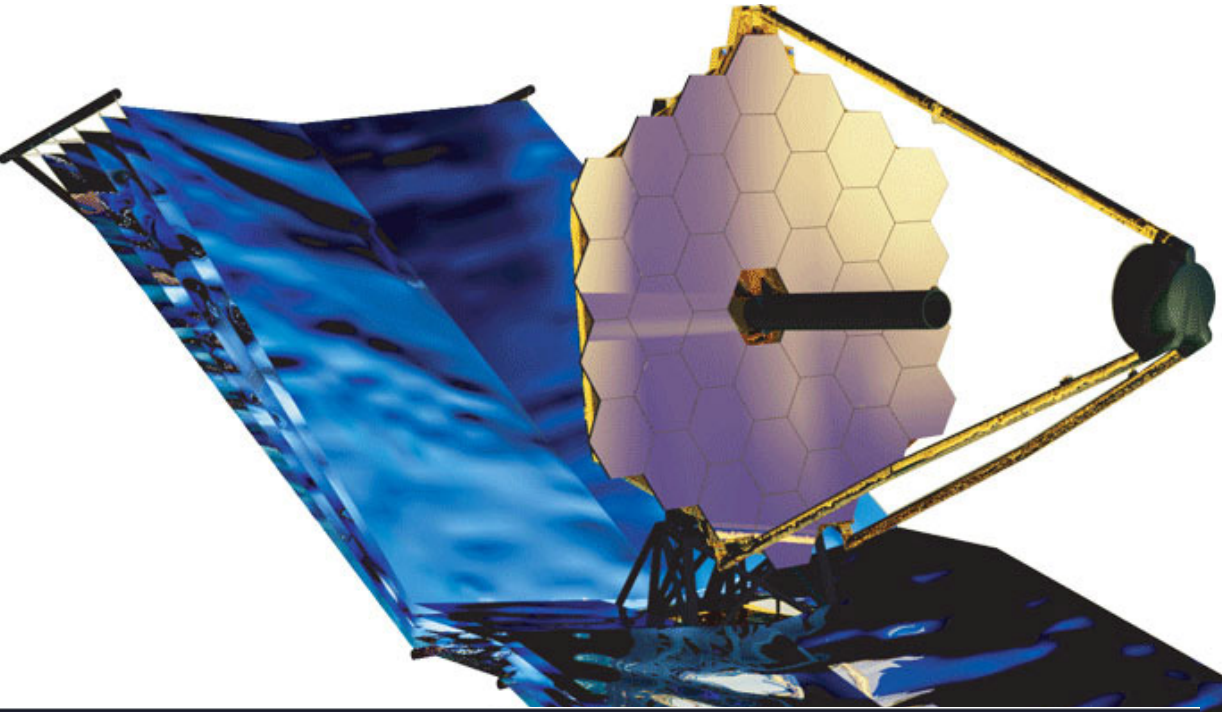
Start >2012

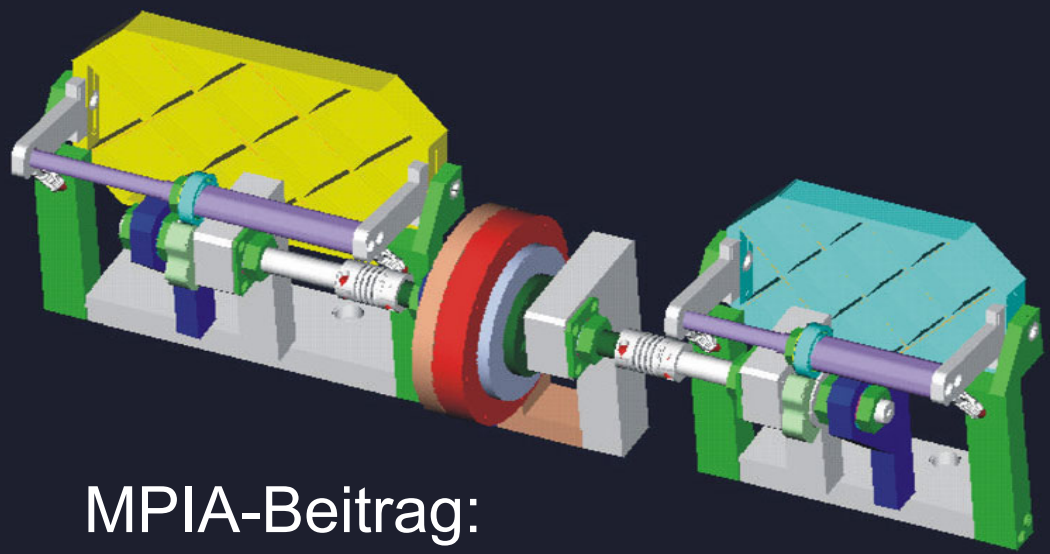
NIR/MIR

4m Teleskop

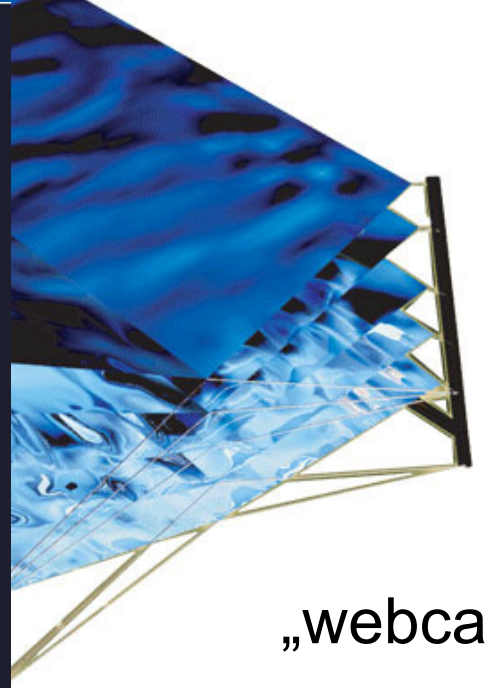
passiv gekühlt

L2 Orbit





MPIA-Beitrag:
Kryomechanismen etc.



„webcam“

Darwin/TPF*

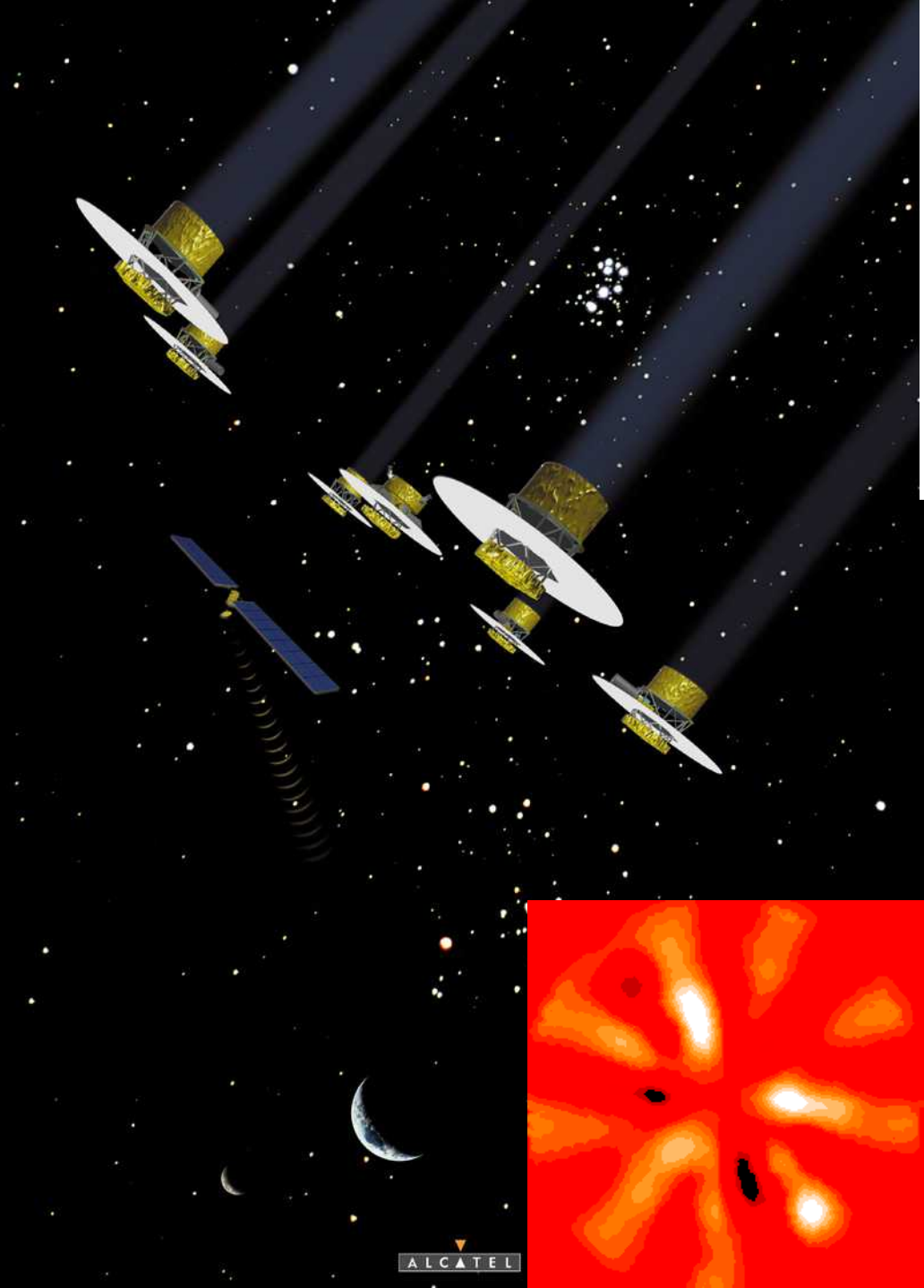
NASA/ESA

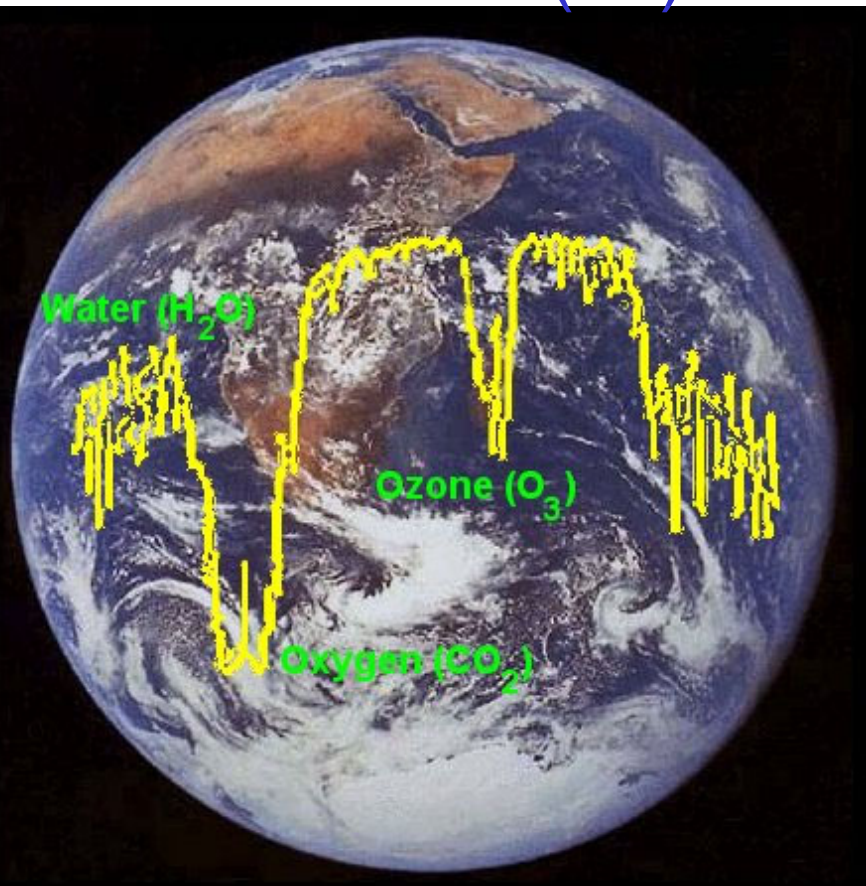
Launch > 2017

IR interferometer

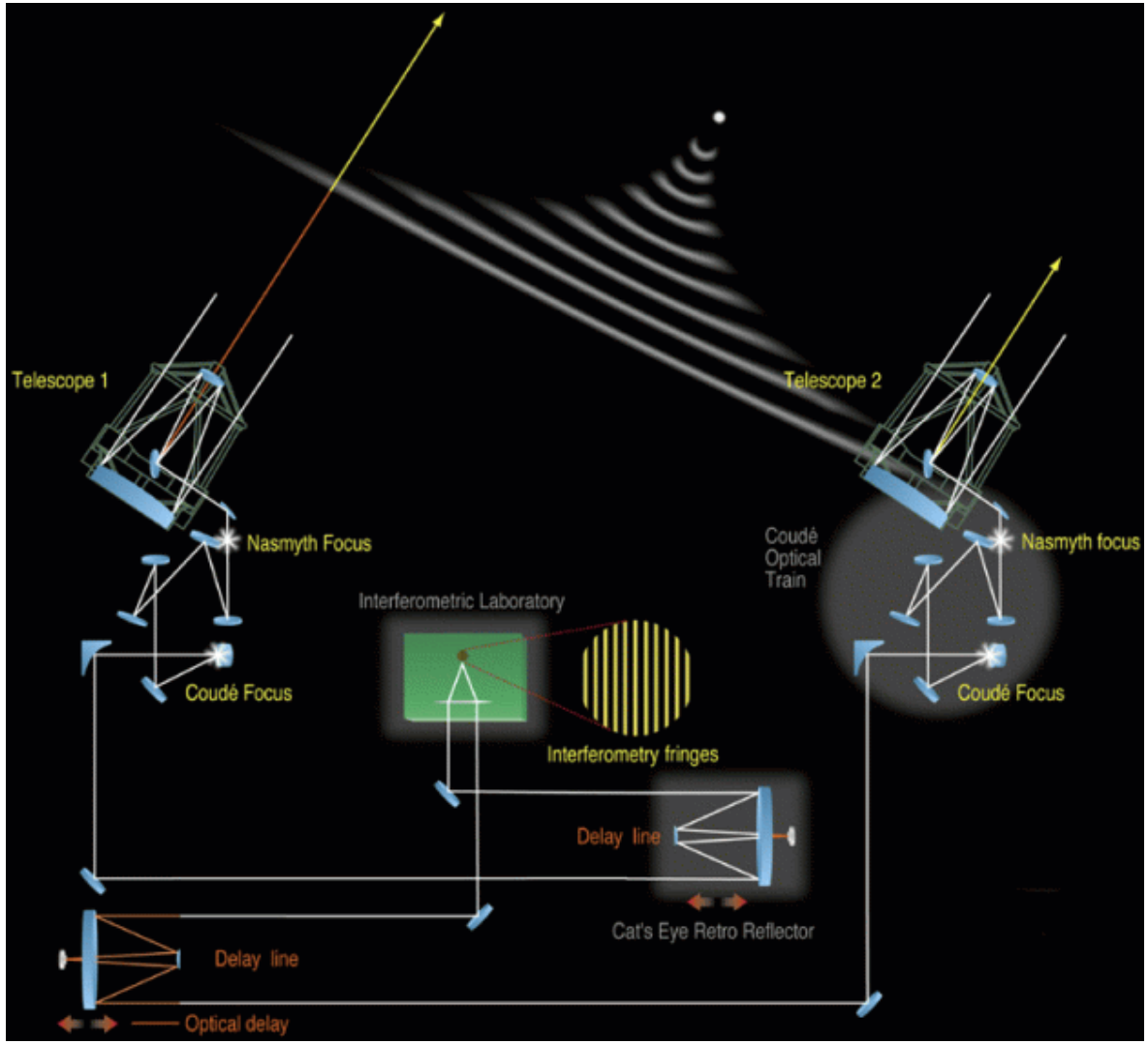
3 Teleskope 3m?

4 Satelliten (L2)

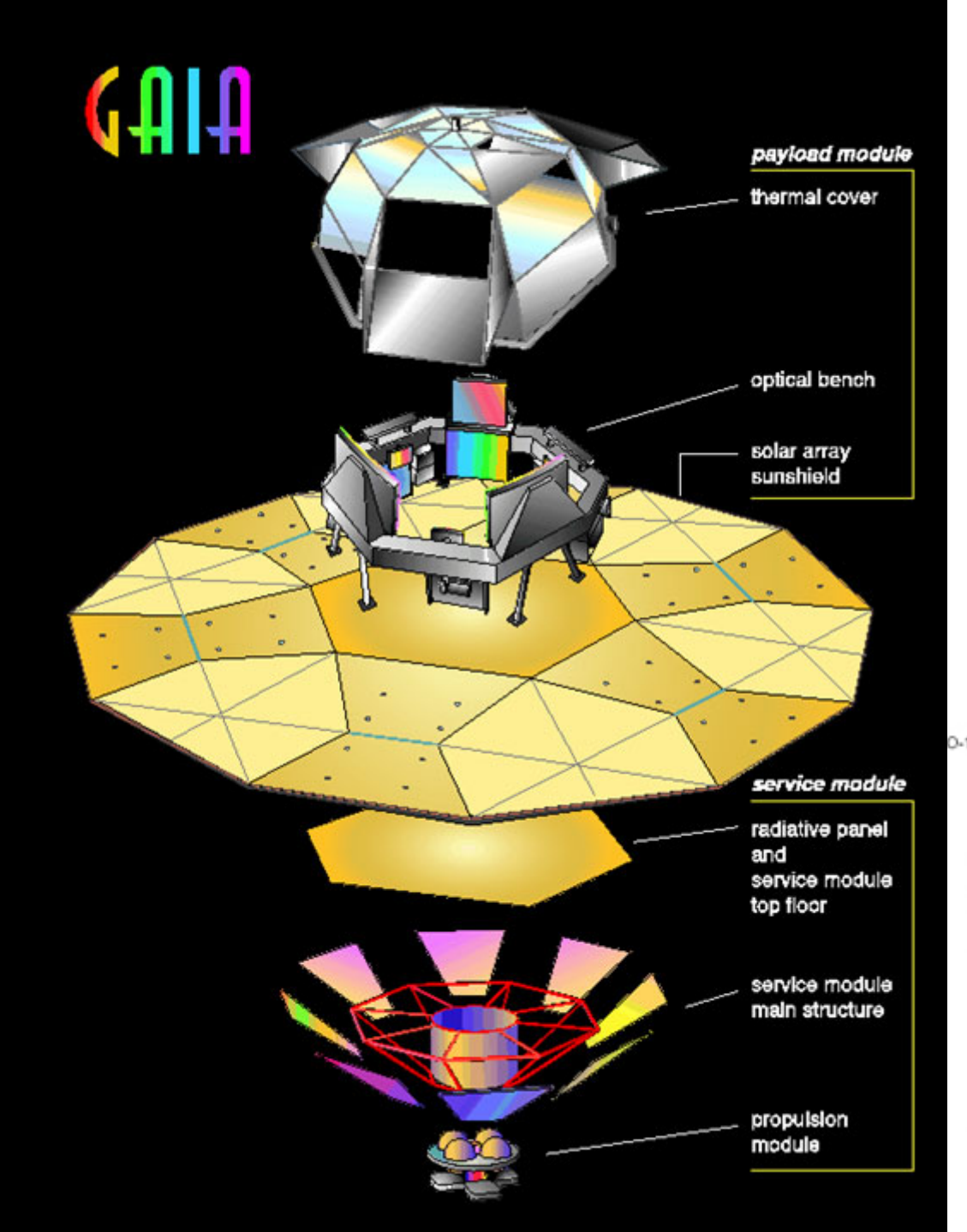




VLT/VLTI



VLT ist inzwischen DAS weltweit führende Observatorium !

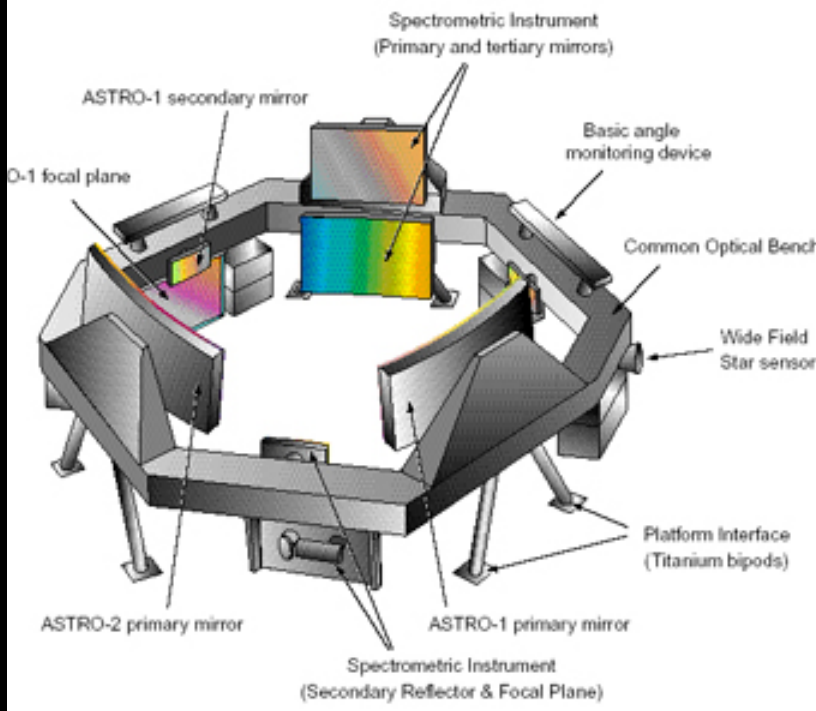


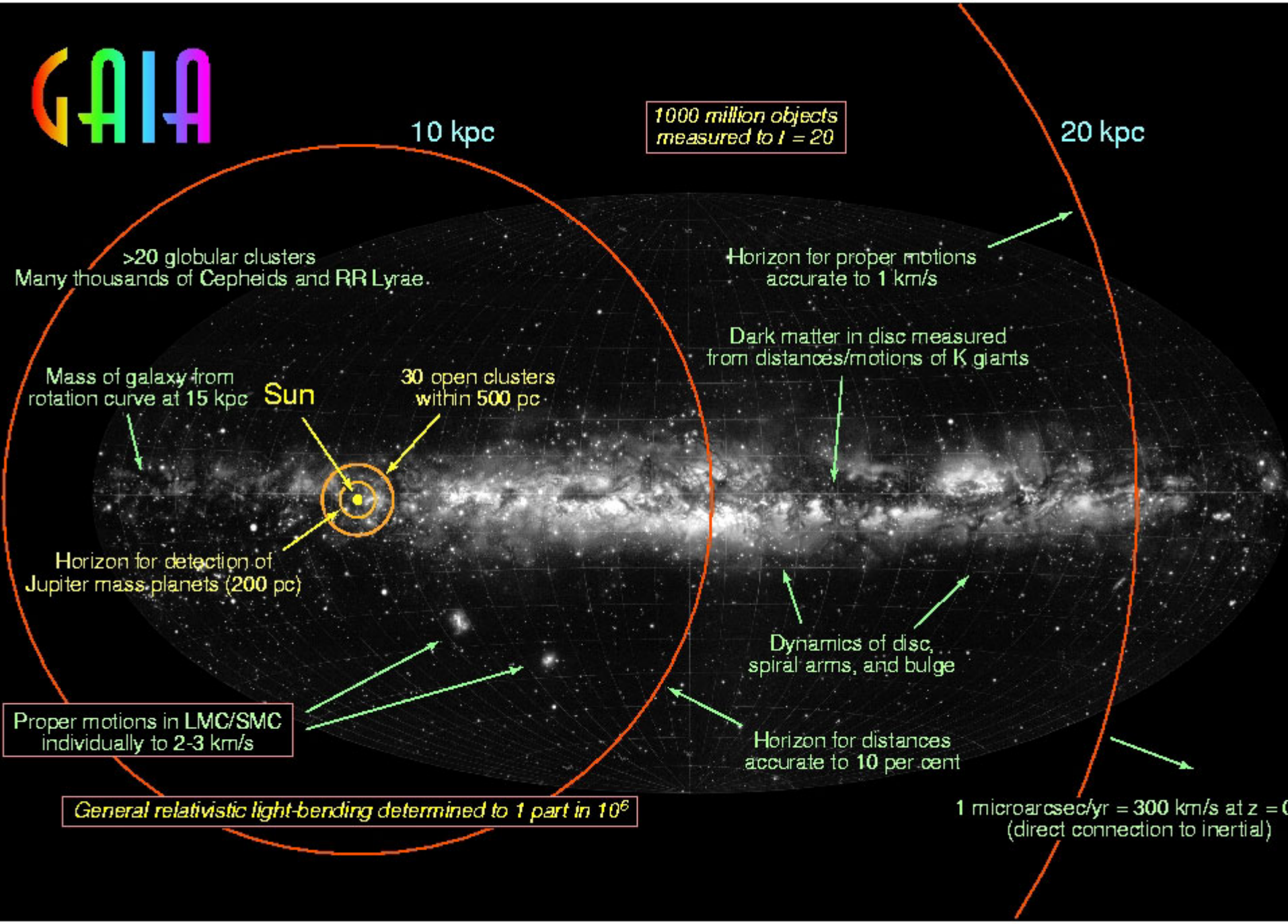
GAIA

ESA

Start < 2012

opt. Astrometrie

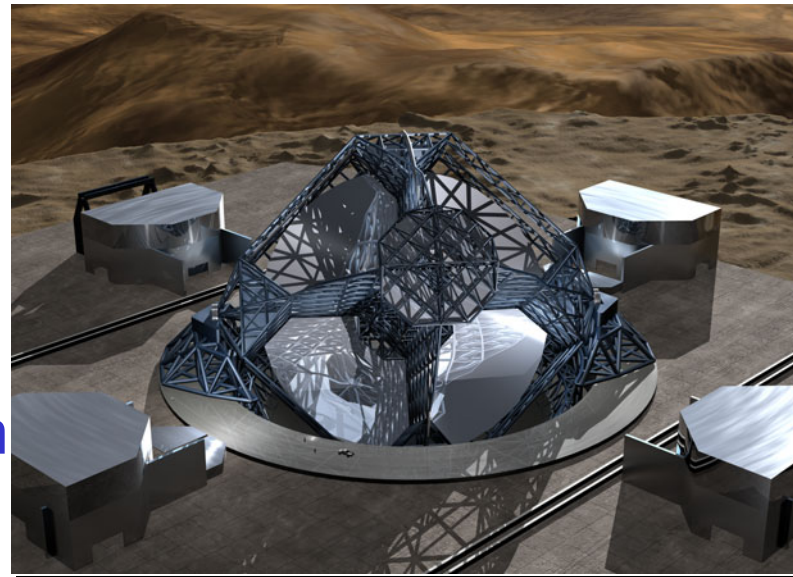



GAIA
10 kpc
1000 million objects
measured to I = 20
20 kpc
>20 globular clusters
Many thousands of Cepheids and RR Lyrae.
Horizon for proper motions
accurate to 1 km/s
Dark matter in disc measured
from distances/motions of K giants
Mass of galaxy from
rotation curve at 15 kpc
Sun
30 open clusters
within 500 pc
Horizon for detection of
Jupiter mass planets (200 pc)
Dynamics of disc,
spiral arms, and bulge
Proper motions in LMC/SMC
individually to 2-3 km/s
Horizon for distances
accurate to 10 per cent
General relativistic light-bending determined to 1 part in 10^6
1 microarcsec/yr = 300 km/s at z =
(direct connection to inertial)

Extremely Large Telescopes

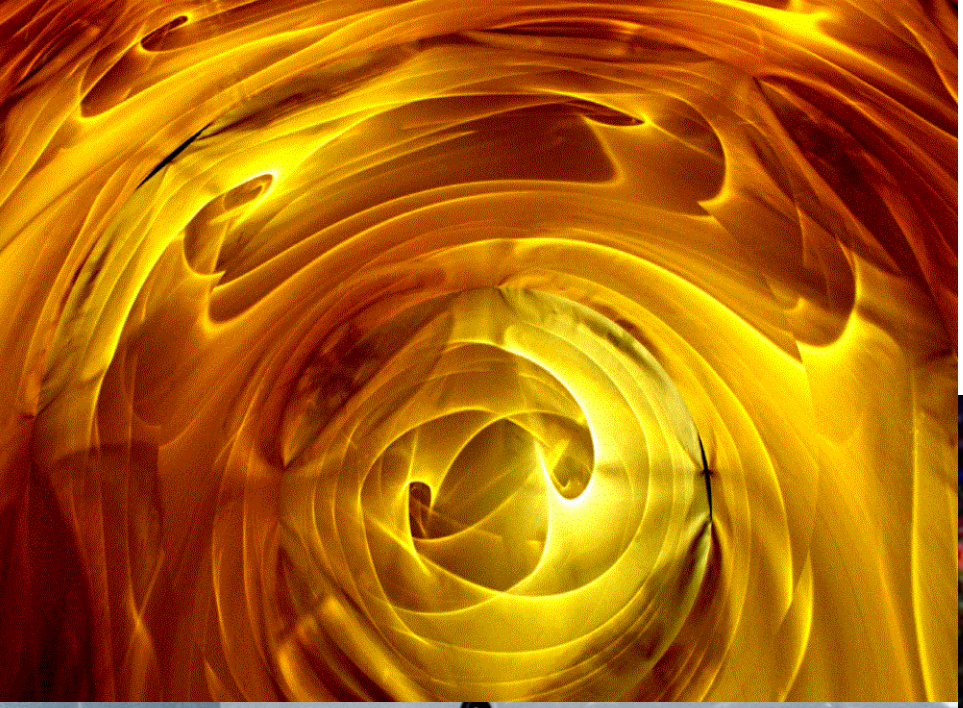
Bildung erster Galaxien und Sterne, Abbildung von Exoplaneten und Spektroskopie ihrer Atmosphären

OWL-Projekt der Europäischen Südsternwarte (ca. 2015; Projekt in Planung, Standort: nicht entschieden



Max-Planck-Institute – Technologieentwicklung

- Multi-Conjugate Adaptive Optics (MPIA, MPE)
- Laser Guide Stars (MPE, MPIA)
- Integrierte Instrumentenkonzepte (MPIA, MPE)

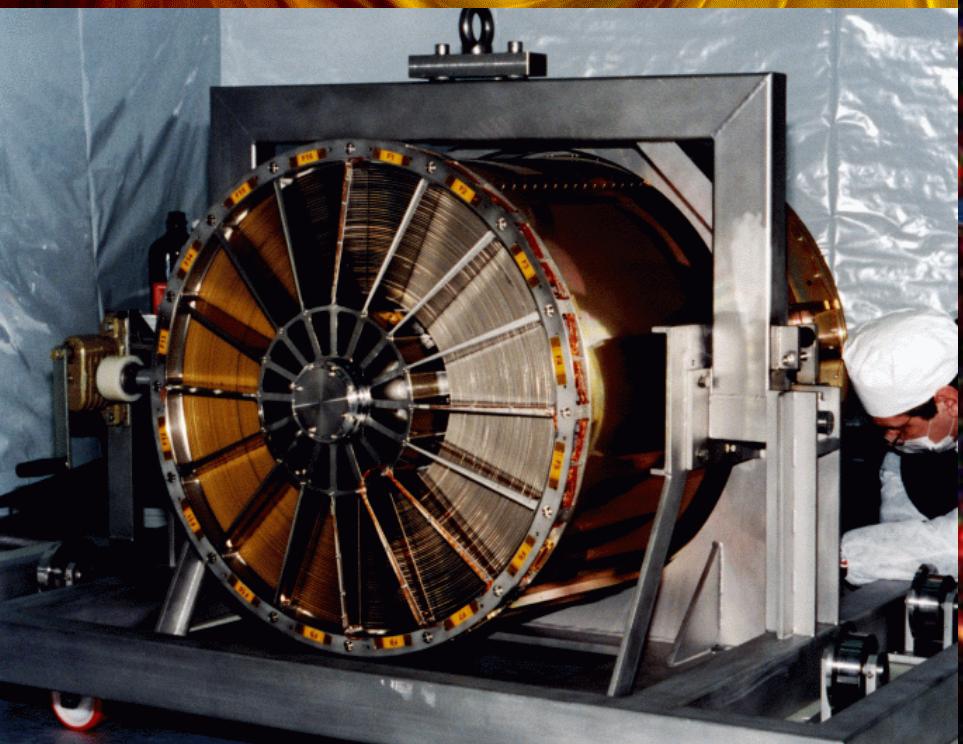


XMM-Newton

ESA

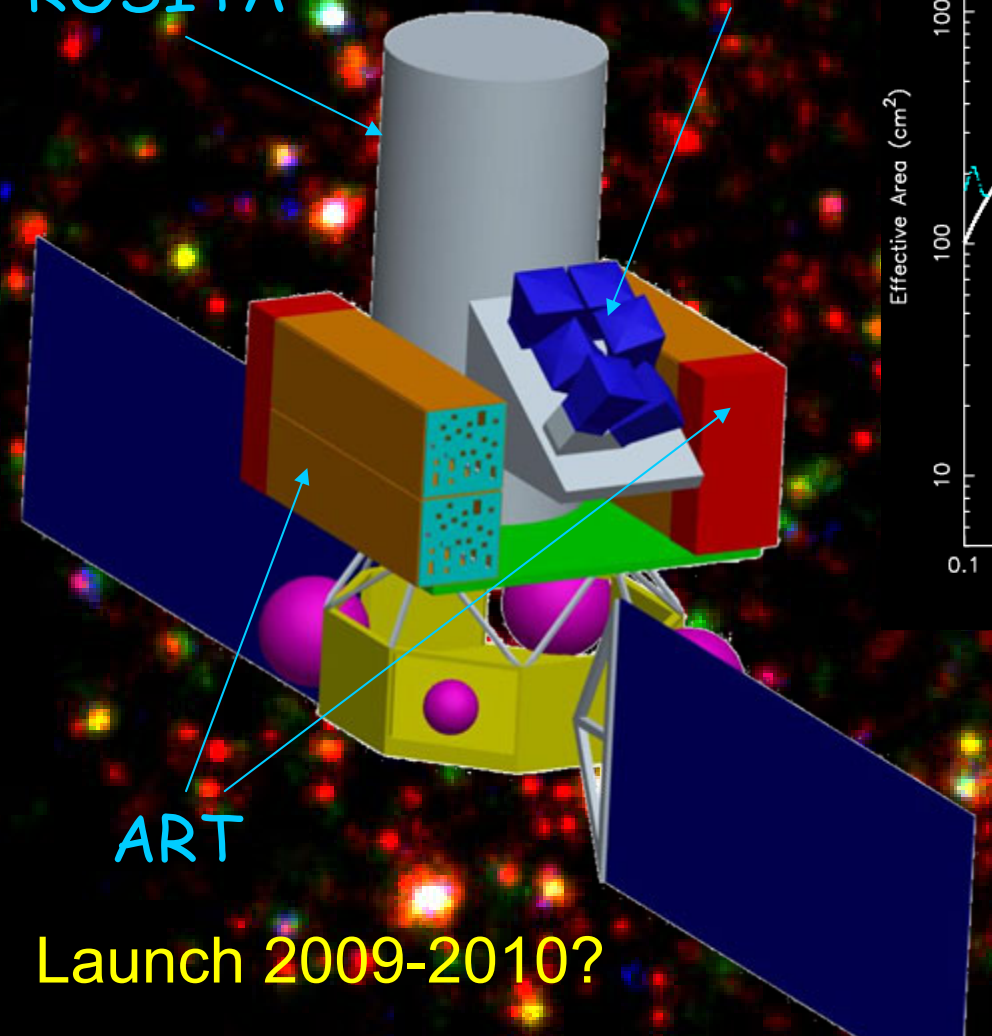
Launch: Dec. 1999

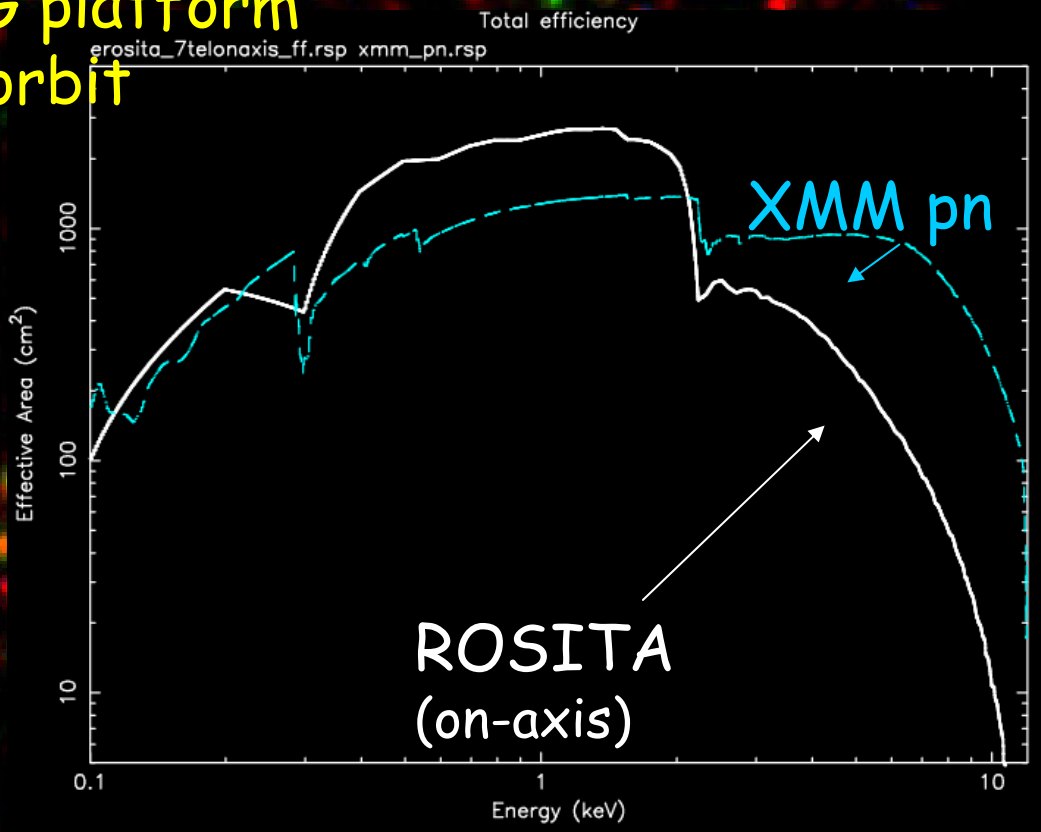
X-ray (0.1-10 keV)

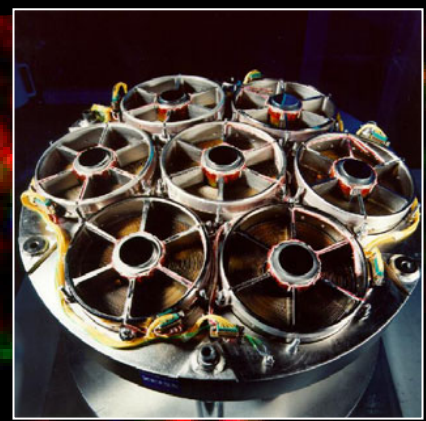


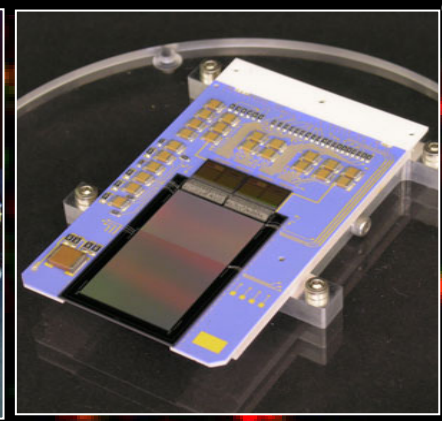
eROSITA

Study: launch on Russian SRG platform from Kourou into equatorial orbit









Launch 2009-2010?

XEUS*

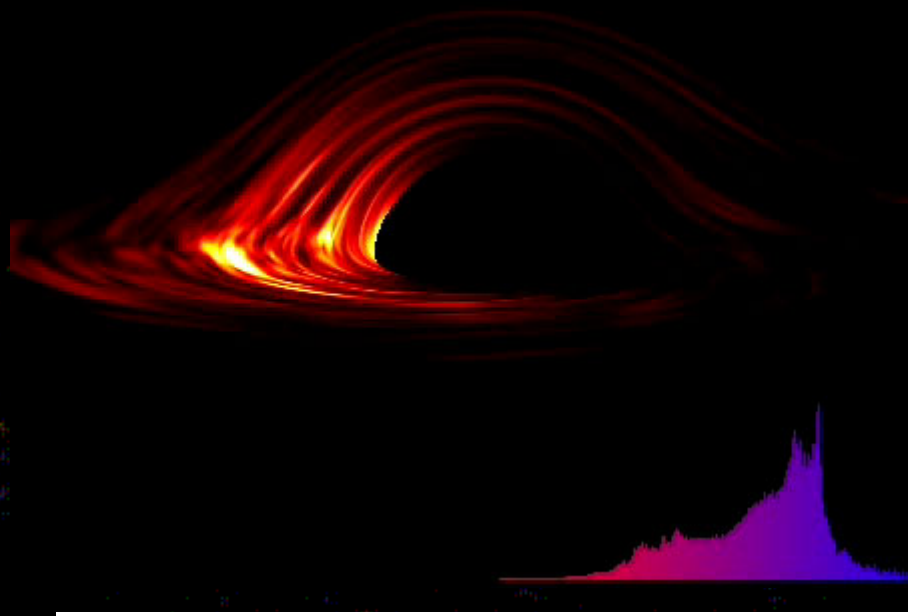
ESA/J

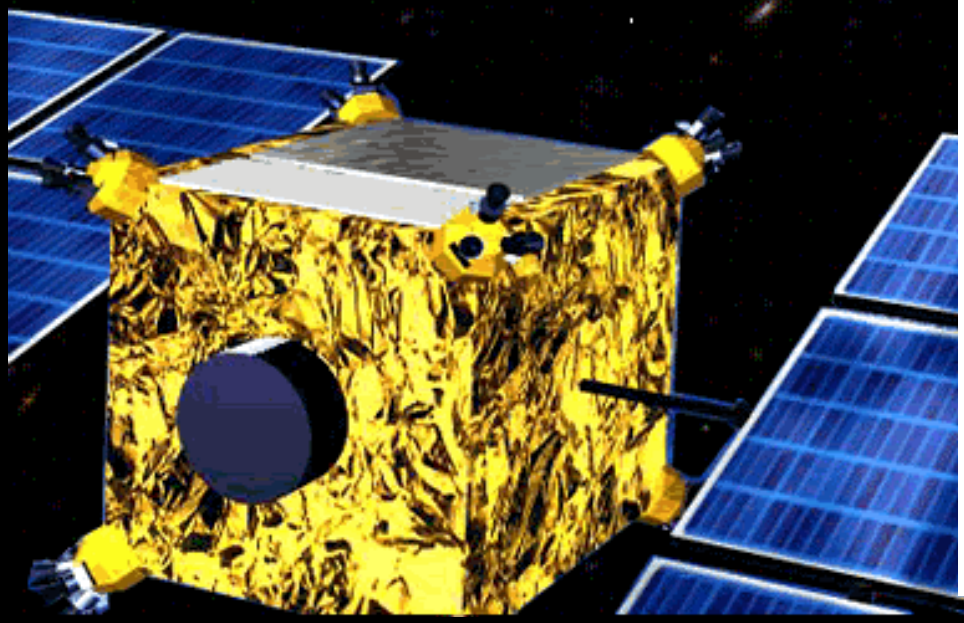
Start >2016

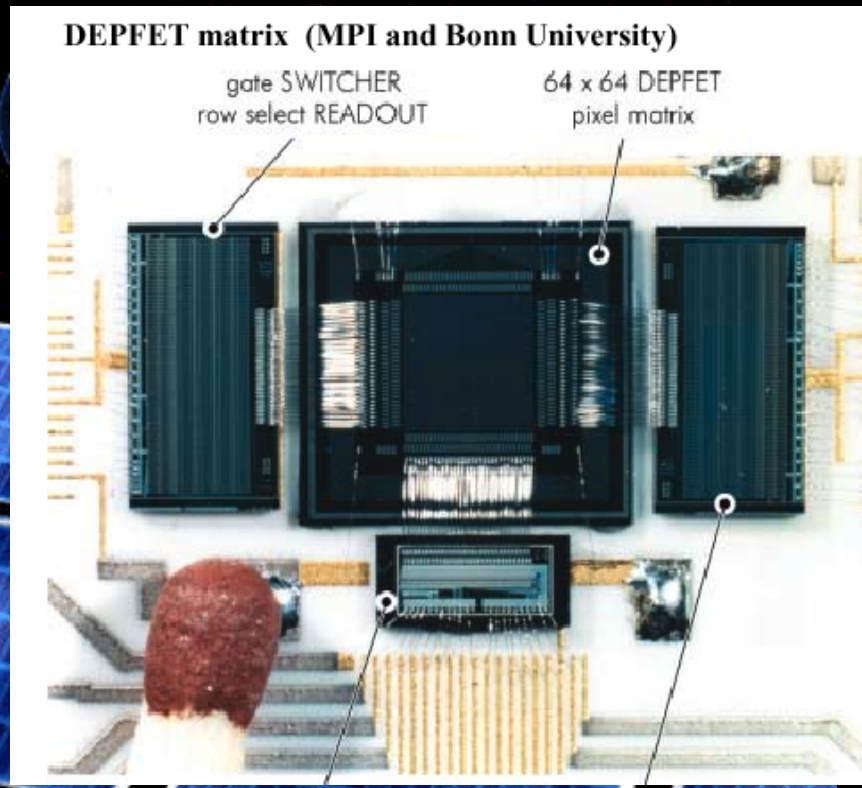
Röntgen (0.1-60 keV)

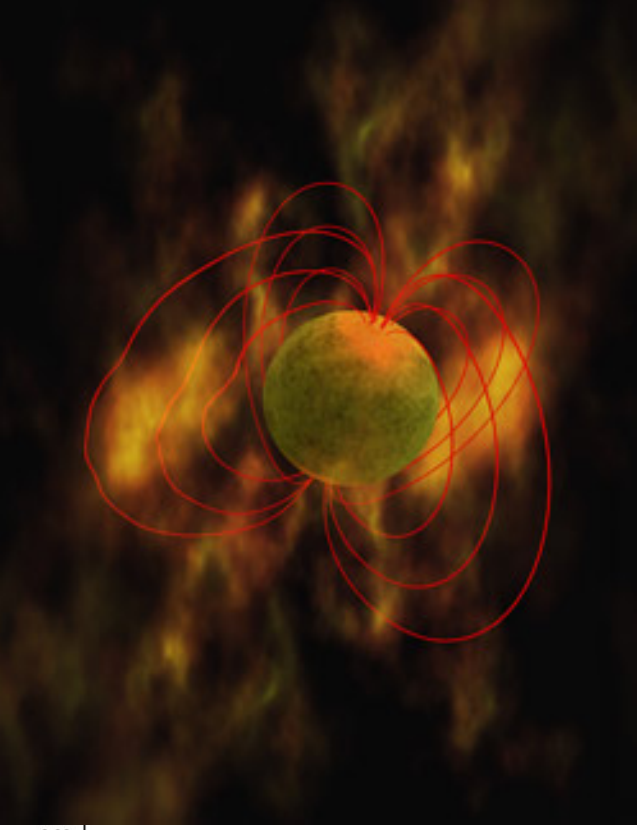
5m Teleskop

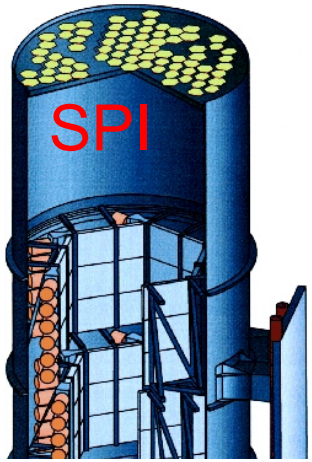
L2 orbit











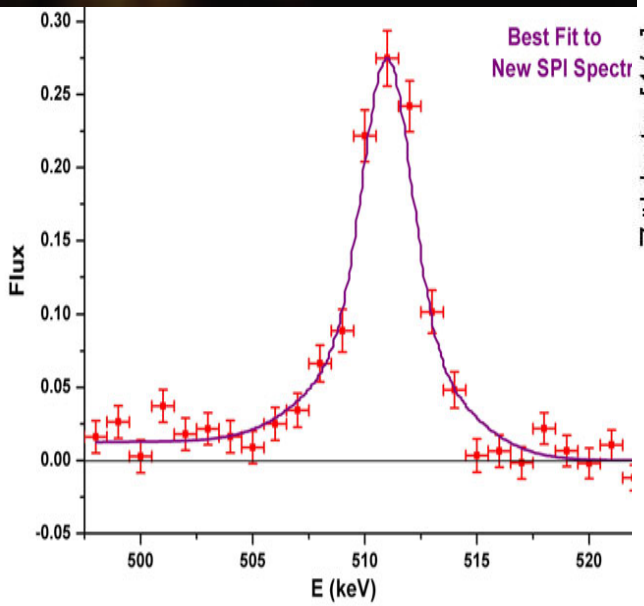
Integral

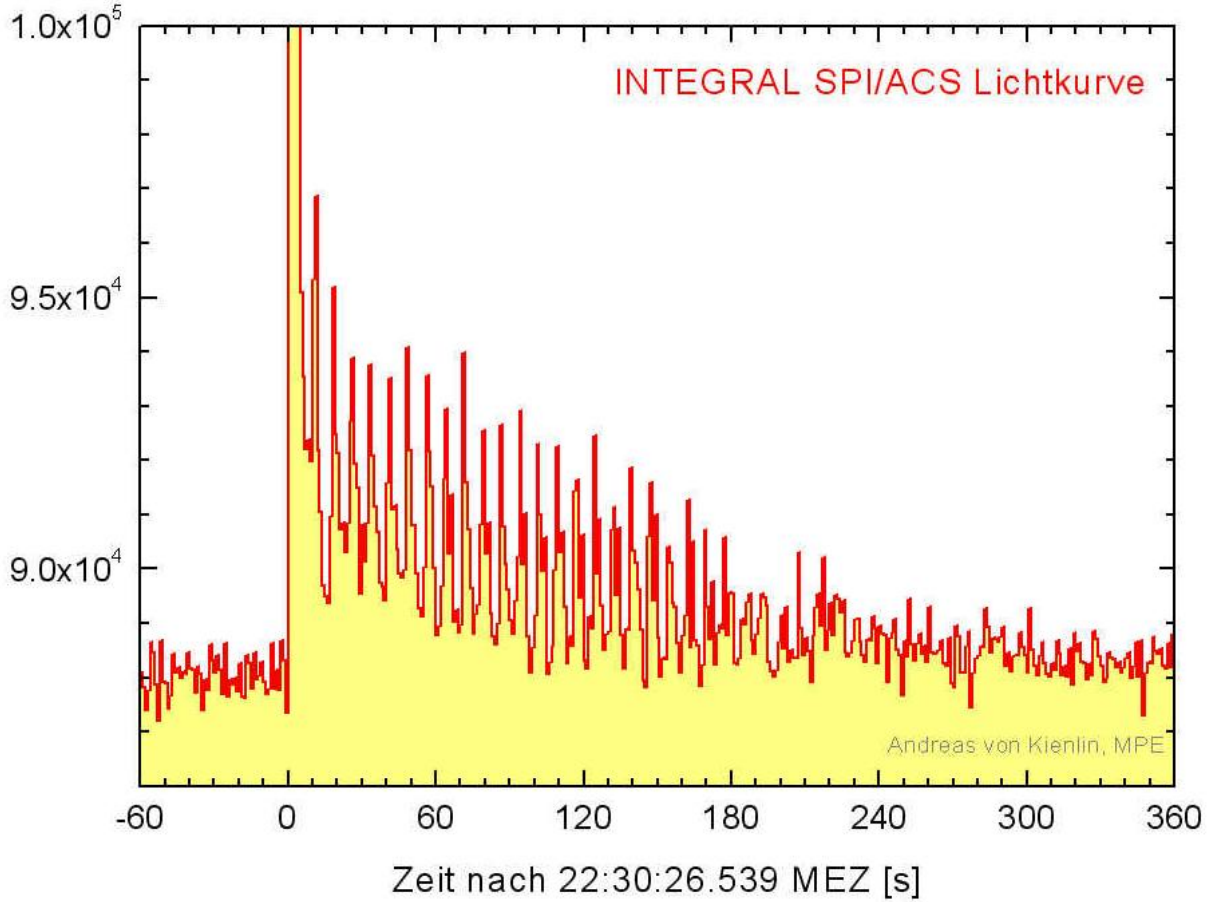
ESA/RU

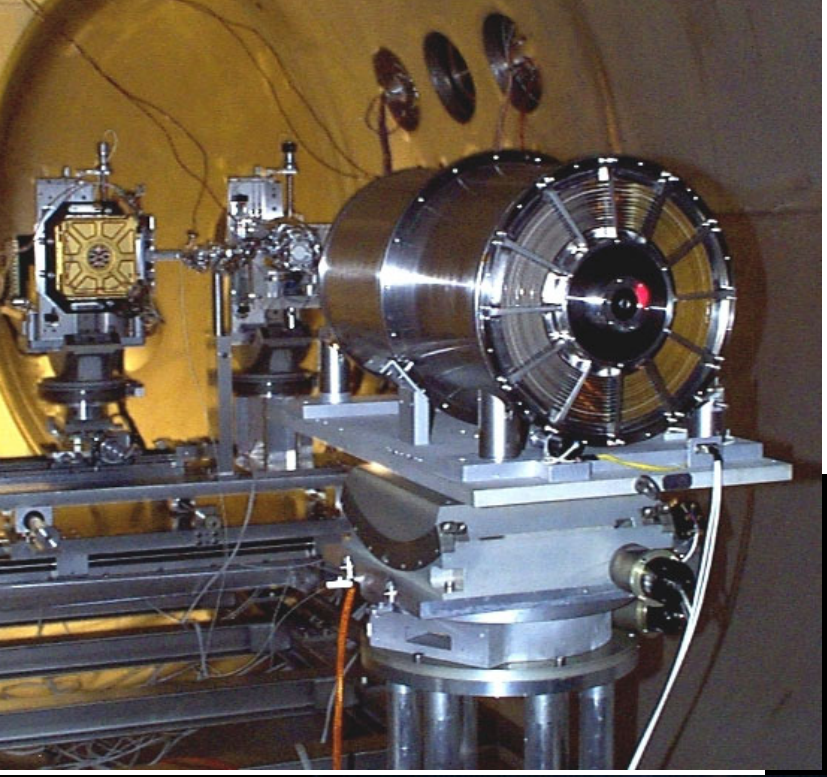
Launch: 17.10.2002

Gamma (3 keV-10 MeV)

SGR 1806-20 Ausbruch am 27. Dezember 2004





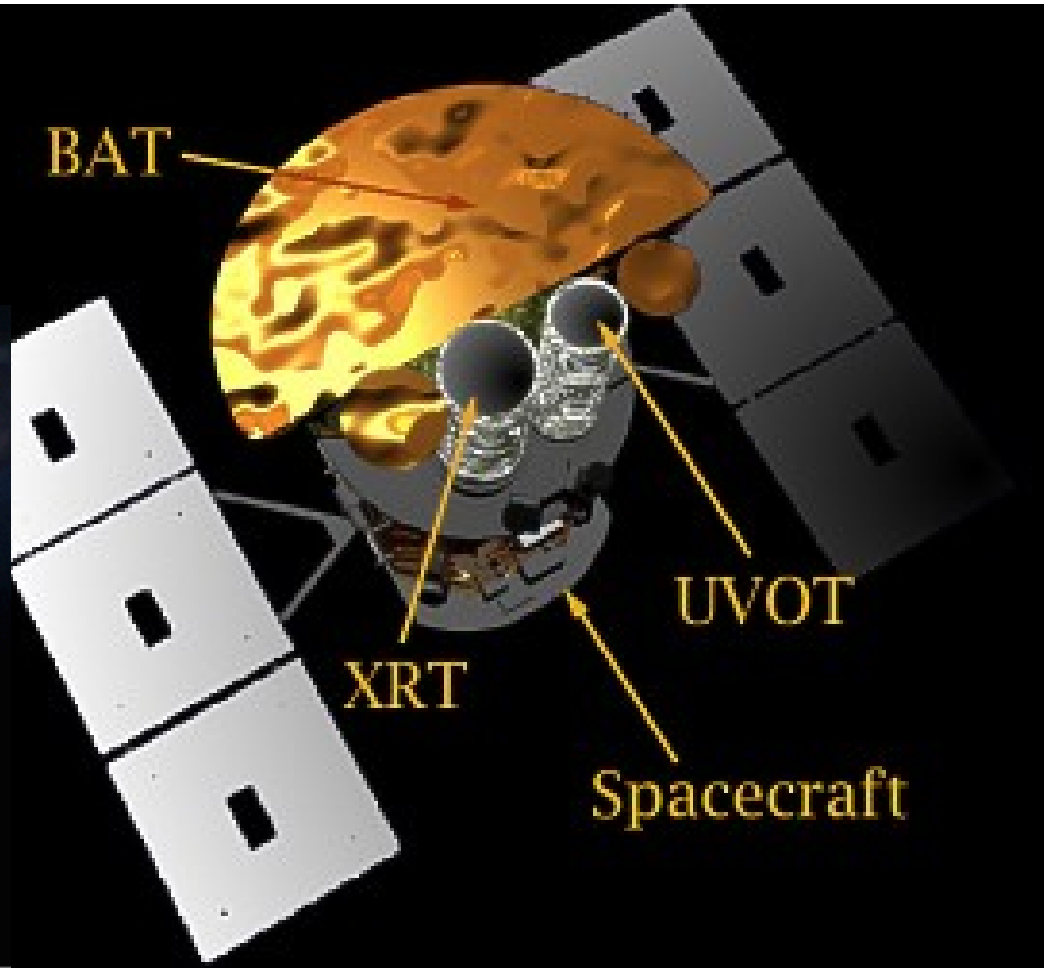


Swift

NASA/UK/I/D

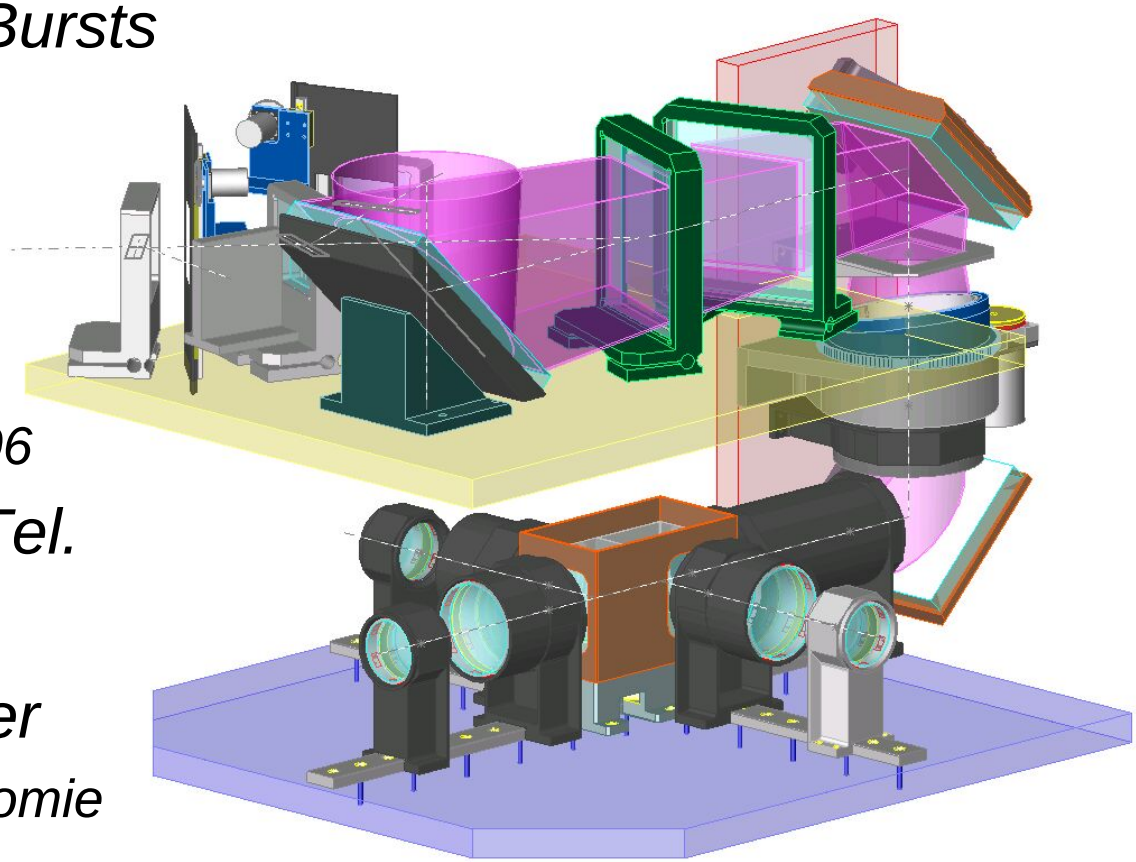
Start 11.2004

Gamma (Burst)



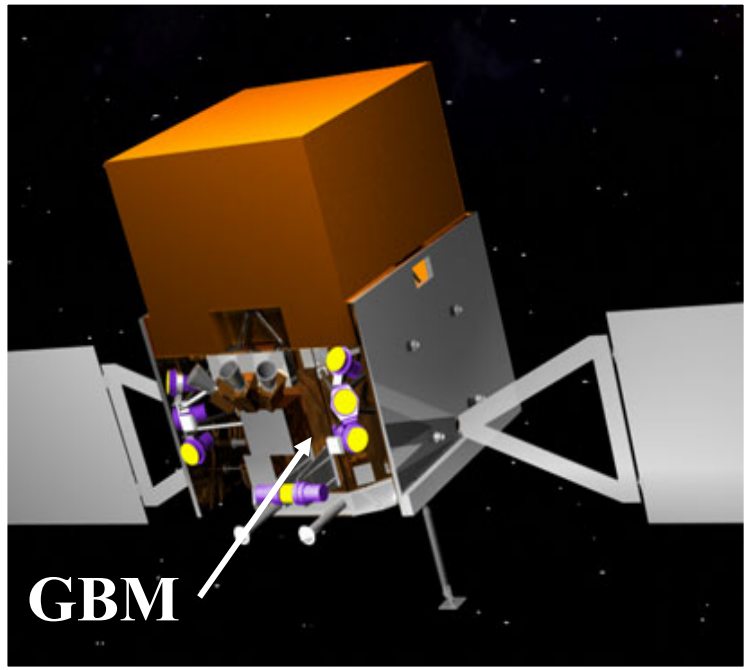
Gamma Ray Burst Optical/NIR Detector

- *Gamma-Astronomie: Bursts*
- *Status*
  - *im Bau*
  - *Laufzeit 2001 – 2007*
  - *First Light Frühjahr 2006*
- *Standort: Chile 2.2m-Tel.*
- *Akteur: MPE*
- *MPG Inst./Abtlg. Nutzer*
  - *MPE X-/Gammaastronomie*
  - *LSW Tautenburg*
  - *MPIA/ESO*



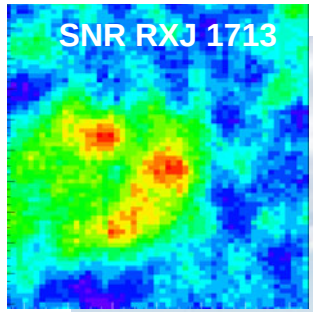
GLAST Gamma Burst Monitor

- *Gamma-Astronomie: Bursts*
- *Status*
  - *im Bau*
  - *Laufzeit 2001 – 2010*
  - *Start 2007*
- *Weltraum*
- *Akteur: NASA/DLR*
- *MPG Inst./Abtlg. Nutzer*
  - *MPE Gammaastronomie*



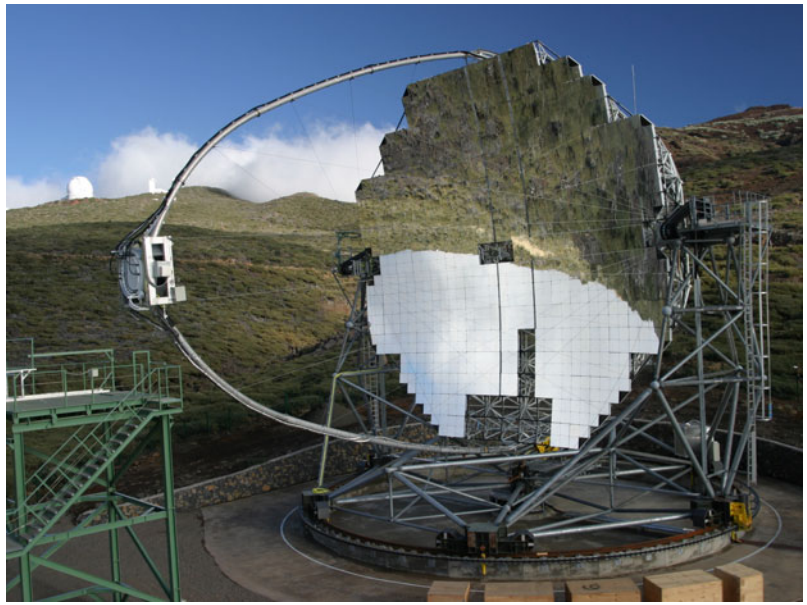
High Energy Stereoscopic System

- *Hochenergie-Gamma-Astronomie: kosmische Beschleuniger*
- *A – langfristige Bindung*
- *Status:*
  - *Phase I: Betrieb*
  - *Phase II genehmigt*
  - *Laufzeit 2004 – ca. 2015*
- *Standort: Namibia*
- *Akteur: MPIK*
- *MPG Inst./Abtlg. Nutzer*
  - *MPIK*

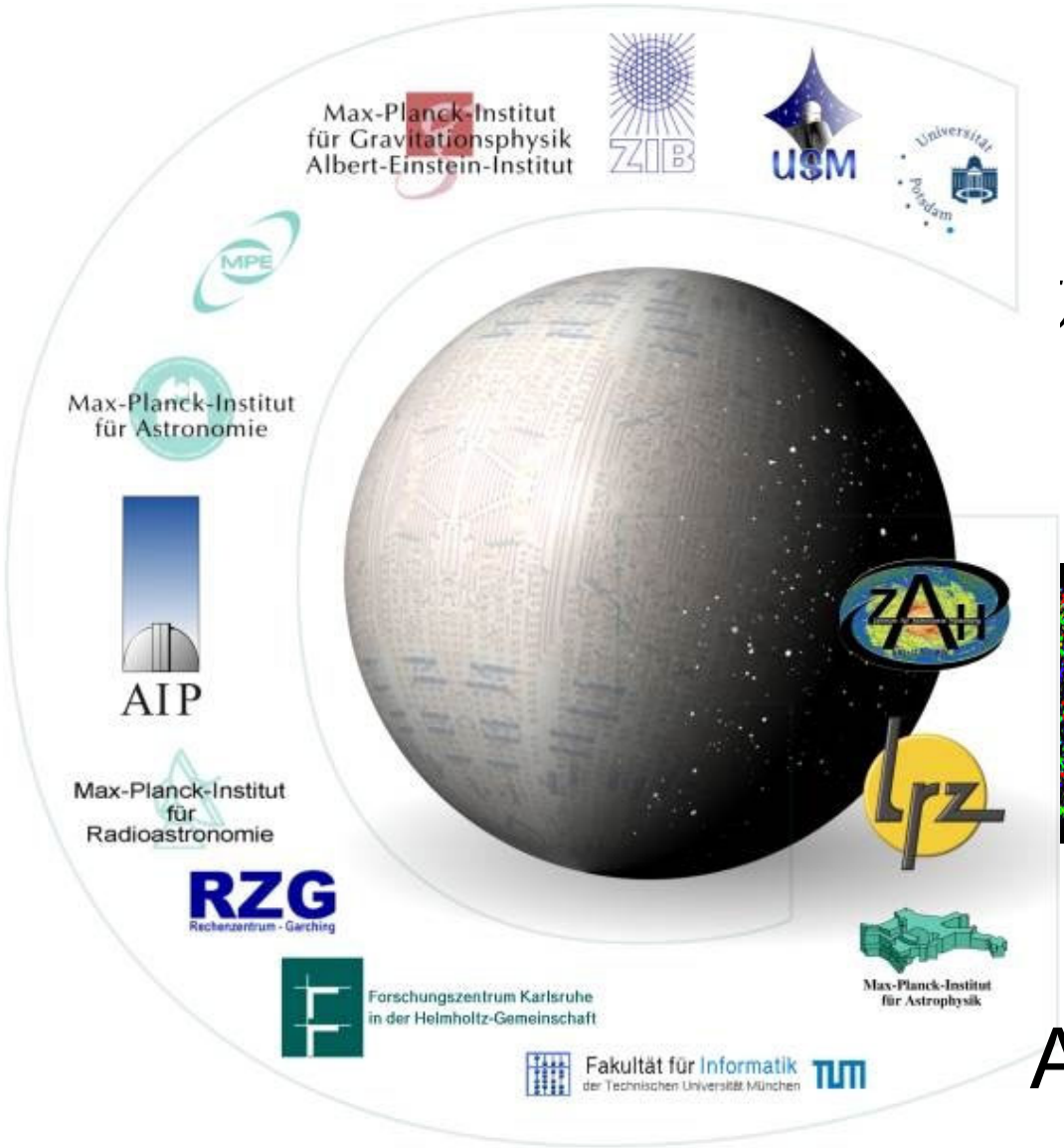


Major Atmospheric Gamma Ray Imaging Cherenkov Telescope

- *Hochenergie-Gamma-Astronomie*
- *Status:*
  - *I. Teleskop in Betrieb*
  - *II. Teleskop im Bau*
  - *Laufzeit 2004 – ca. 2015*
- *Standort: LaPalma*
- *Akteur: MPP(WHI)*
- *MPG Inst./Abtlg. Nutzer*
  - *MPP (WHI)*



Global Virtual Observatory
German Astrophysical Virtual Observatory



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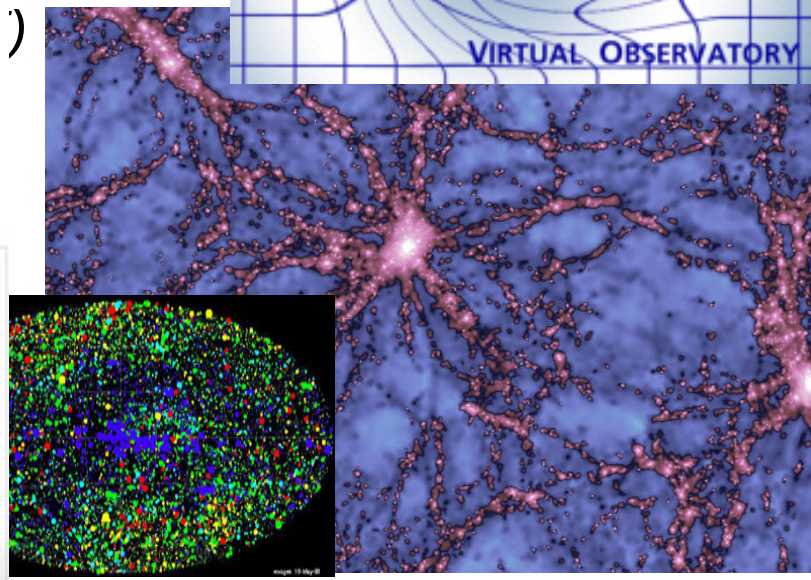

Astro-Grid