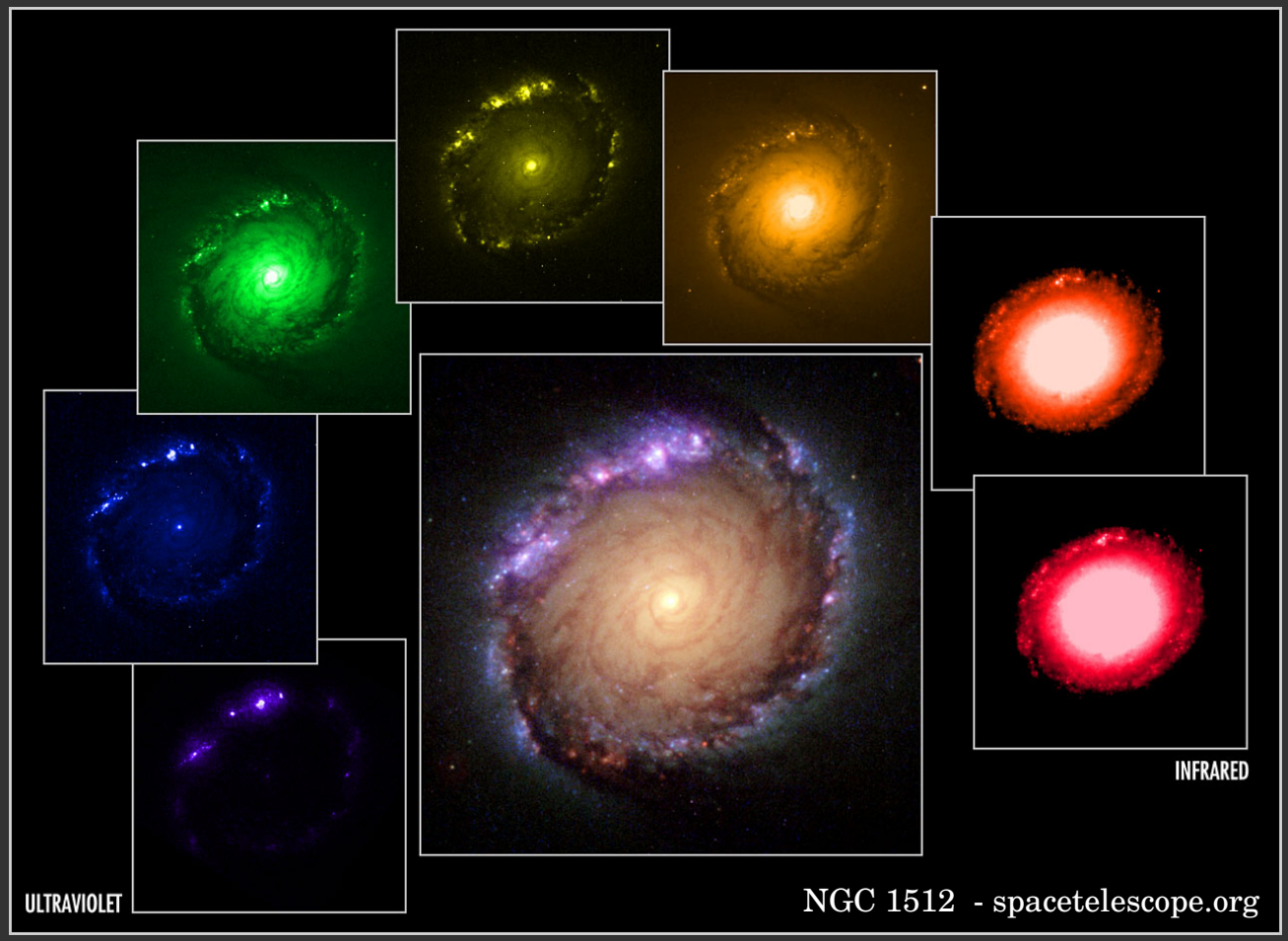
A Luz e a Astrofísica

Imageamento, Fotometria e Espectroscopia



Fabricio Ferrari

IMEF – FURG

2015 – Ano Internacional da Luz

Astronomia

Laboratório é o Universo

Observacionais, não experimentais*

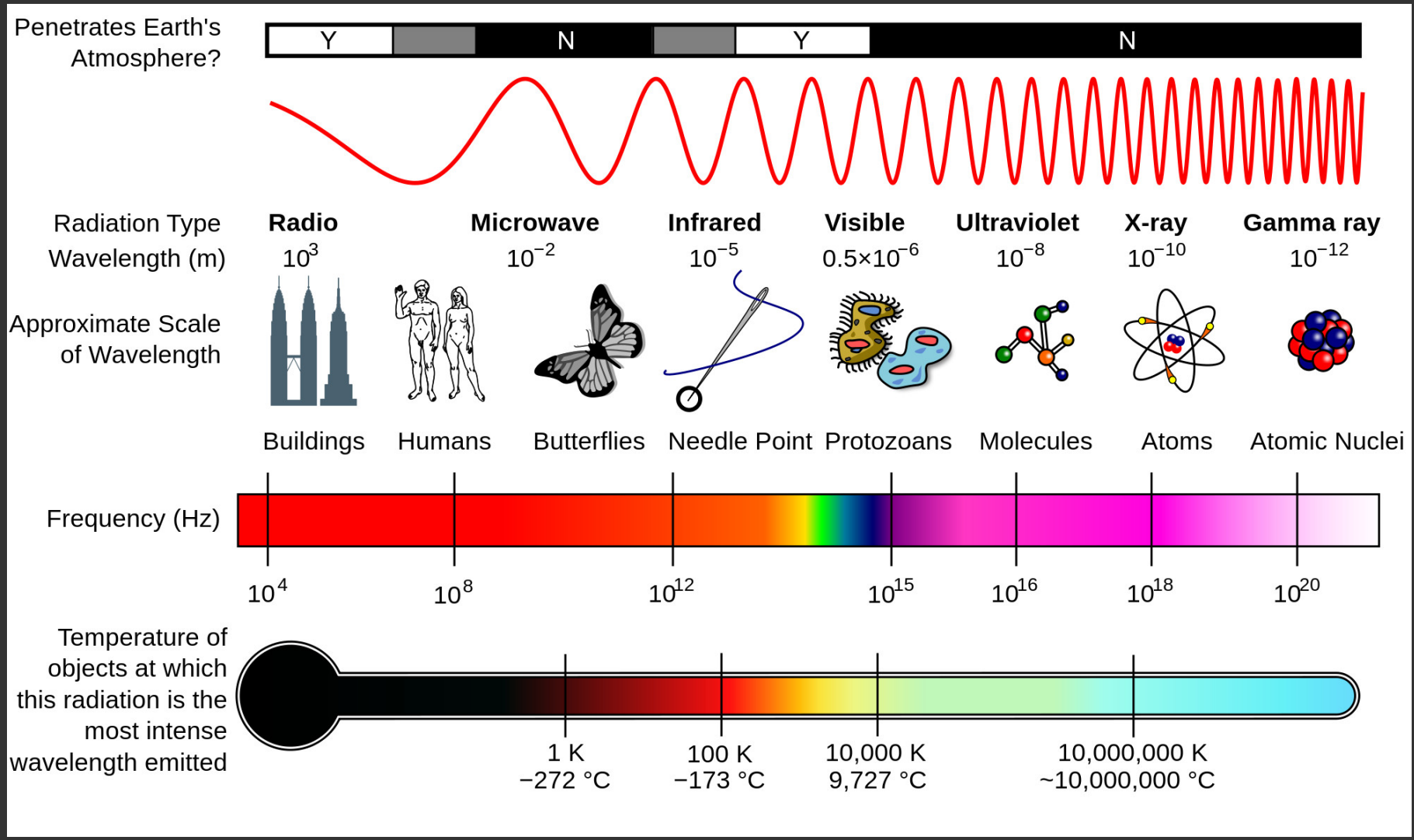
Fenômenos ocorridos no passado

Medidas limitadas às propriedades da luz*

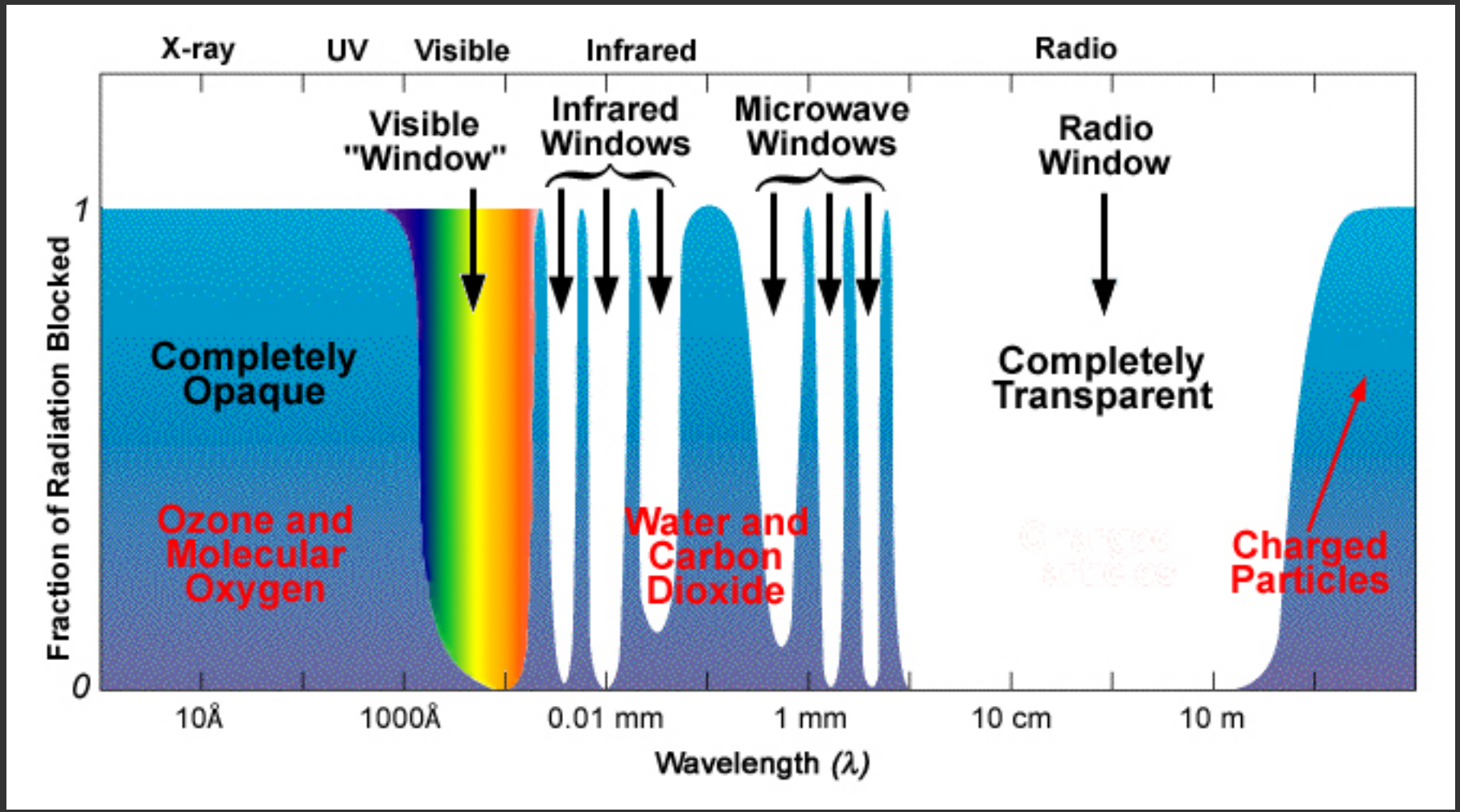
Propriedades da Luz

- Intensidade, fluxo, irradiância, amplitude
- Ângulo de entrada, posição, imagem
- comprimento de onda, frequência
- momentum angular, spin, polarização
- variação temporal
- fase

Espectro Eletromagnético



Absorção Atmosférica



Informação Espectral – M51

Instrumentos

Telescópios

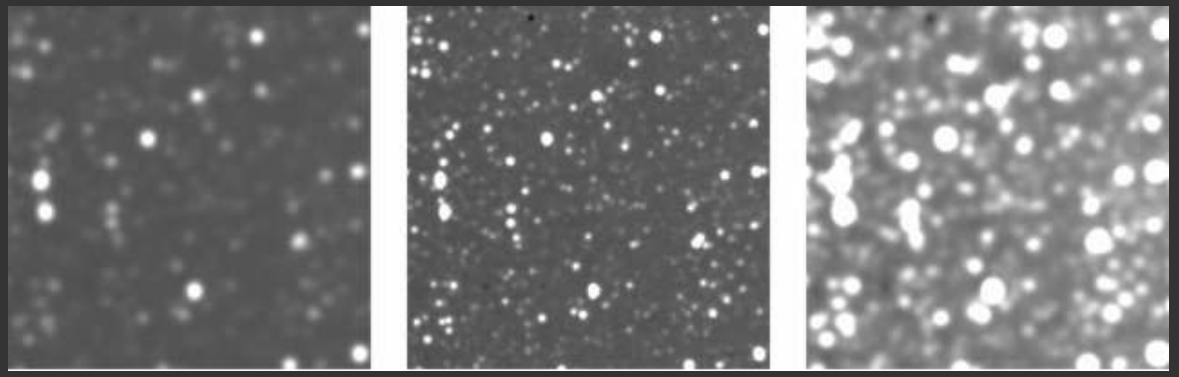
Coletar a maior quantidade de energia (luz)

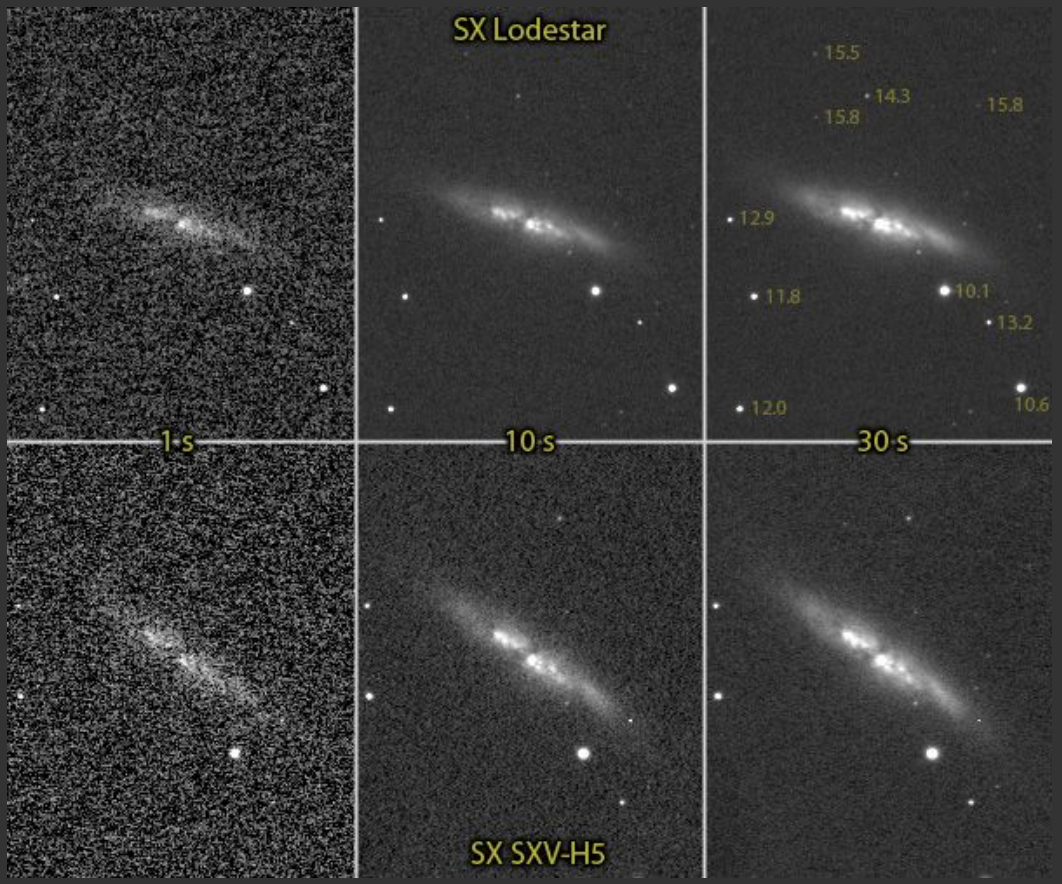
Maxima resolução espacial

Minimo ruído (termico, eletrônico, urbano, zodiacal,...)

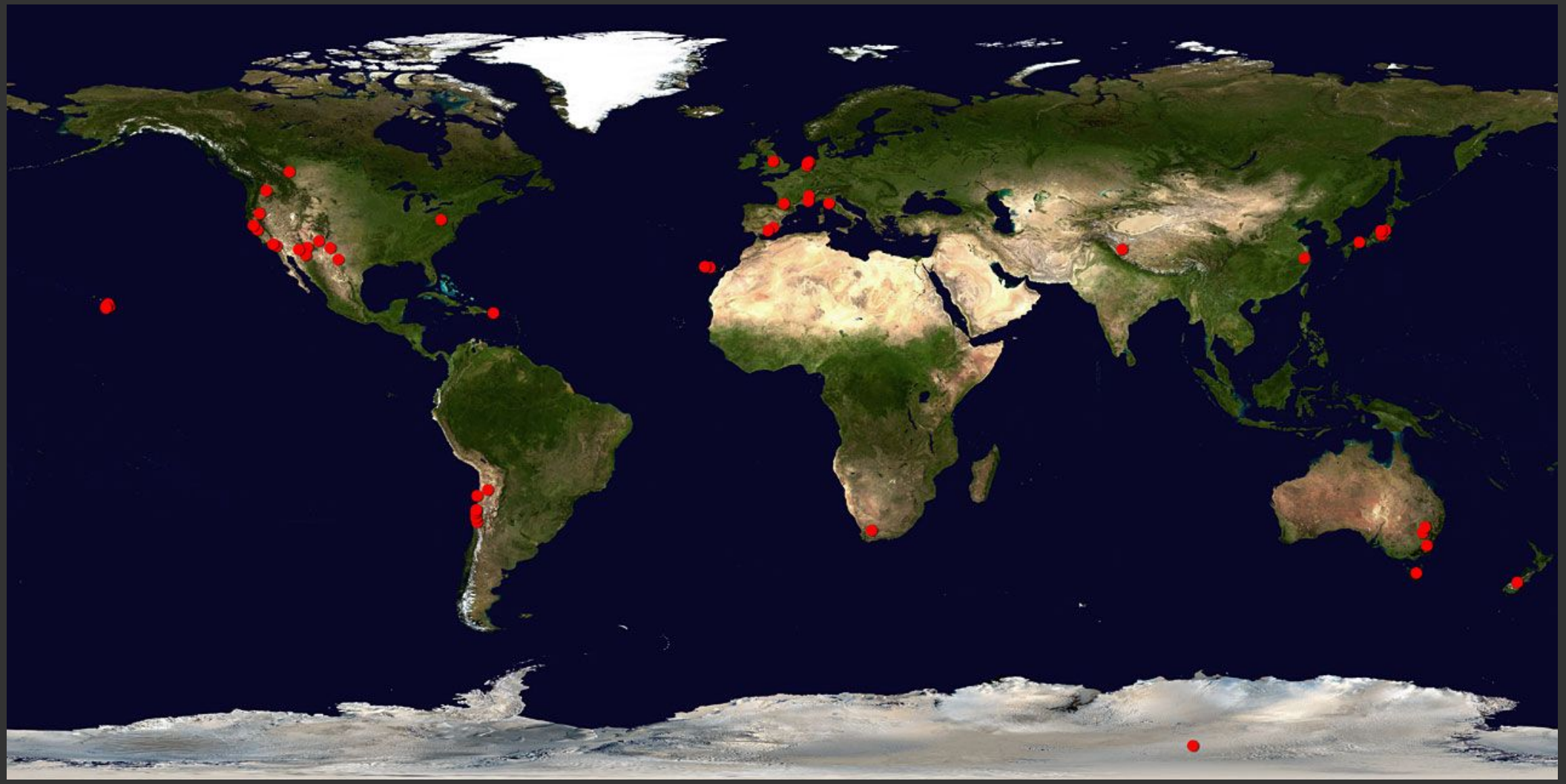
- Imageamento
- Espectroscopia
- Polarimetria

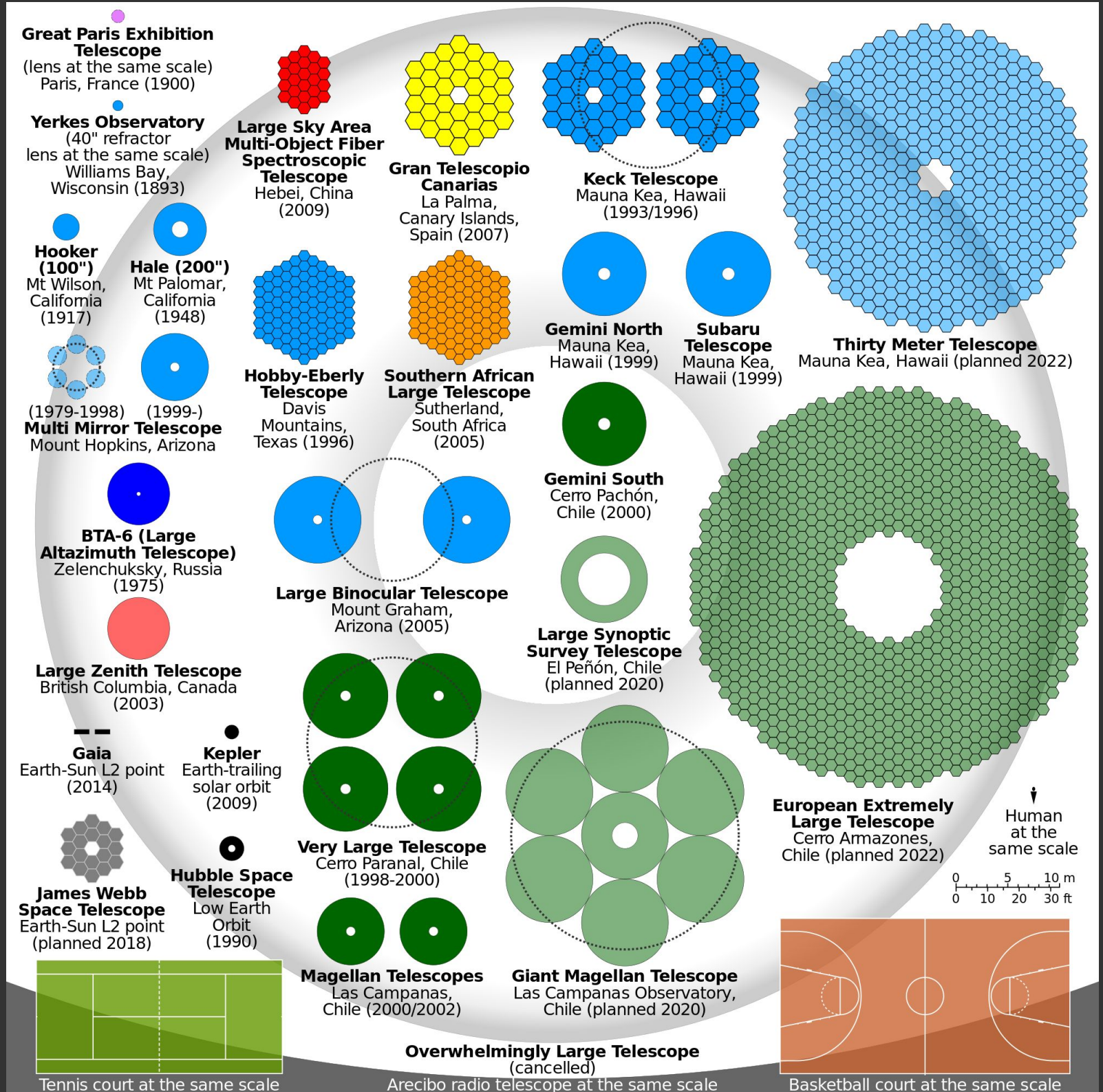
Exposição, ruido e *seeing*



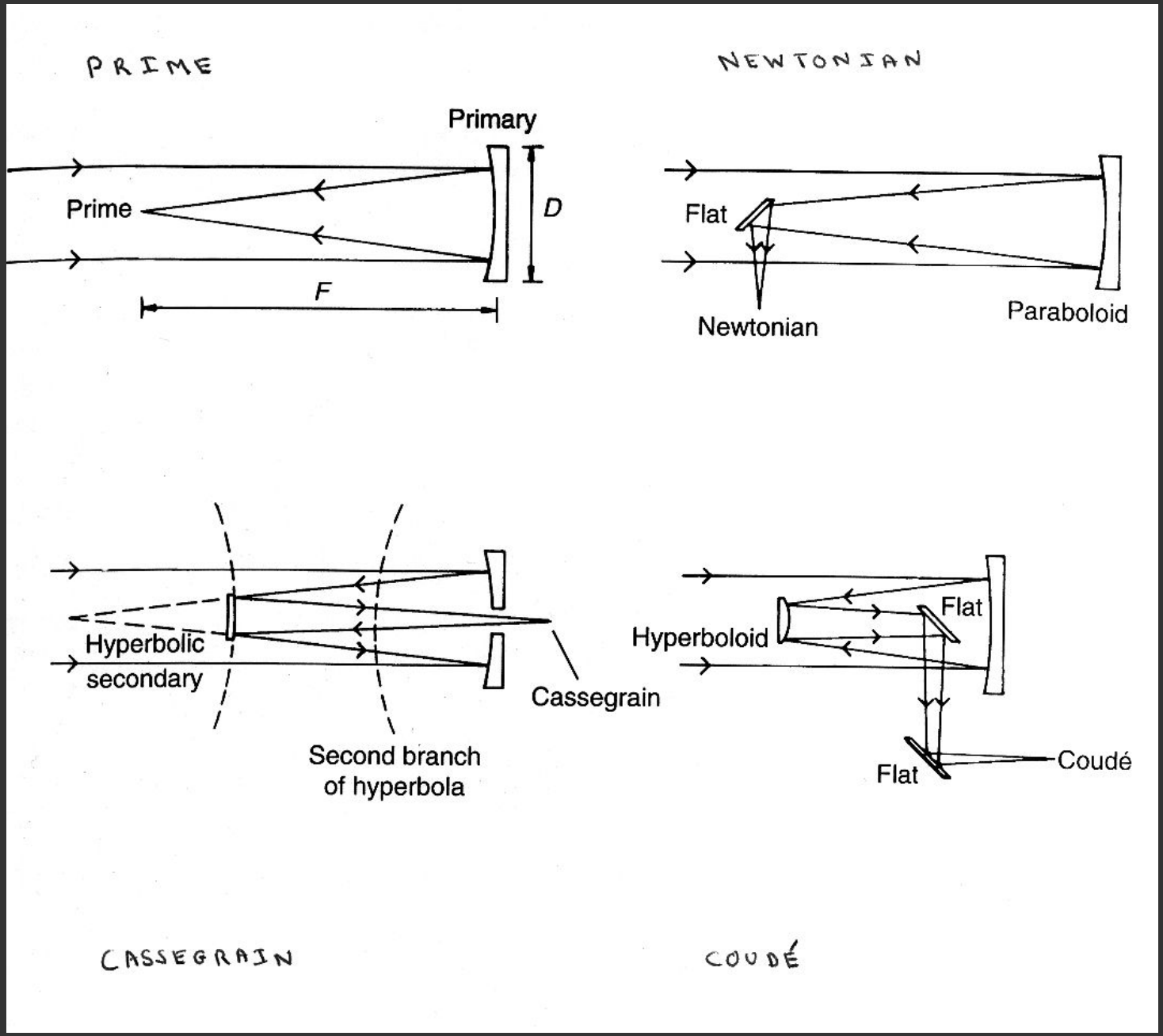


Sítios Astronômicos




Great Paris Exhibition Telescope
(lens at the same scale)
Paris, France (1900)
Yerkes Observatory
(40" refractor
lens at the same scale)
Williams Bay,
Wisconsin (1893)
Hooker (100")
Mt Wilson,
California
(1917)
Hale (200")
Mt Palomar,
California
(1948)
(1979-1998)
(1999-)
Multi Mirror Telescope
Mount Hopkins, Arizona
BTA-6 (Large Altazimuth Telescope)
Zelenchuksky, Russia
(1975)
Large Zenith Telescope
British Columbia, Canada
(2003)
Gaia
Earth-Sun L2 point
(2014)
Kepler
Earth-trailing
solar orbit
(2009)
James Webb Space Telescope
Earth-Sun L2 point
(planned 2018)
Hubble Space Telescope
Low Earth
Orbit
(1990)
Large Sky Area Multi-Object Fiber Spectroscopic Telescope
Hebei, China
(2009)
Gran Telescopio Canarias
La Palma,
Canary Islands,
Spain (2007)
Keck Telescope
Mauna Kea, Hawaii
(1993/1996)
Hobby-Eberly Telescope
Davis
Mountains,
Texas (1996)
Southern African Large Telescope
Sutherland,
South Africa
(2005)
Gemini North
Mauna Kea,
Hawaii (1999)
Subaru Telescope
Mauna Kea,
Hawaii (1999)
Thirty Meter Telescope
Mauna Kea, Hawaii (planned 2022)
Large Binocular Telescope
Mount Graham,
Arizona (2005)
Gemini South
Cerro Pachón,
Chile (2000)
Large Synoptic Survey Telescope
El Peñón, Chile
(planned 2020)
Very Large Telescope
Cerro Paranal, Chile
(1998-2000)
Magellan Telescopes
Las Campanas,
Chile (2000/2002)
Giant Magellan Telescope
Las Campanas Observatory,
Chile (planned 2020)
European Extremely Large Telescope
Cerro Armazones,
Chile (planned 2022)
Human at the same scale
0 5 10 m
0 10 20 30 ft
Tennis court at the same scale
Overwhelmingly Large Telescope
(cancelled)
Arecibo radio telescope at the same scale
Basketball court at the same scale

Projetos Óticos

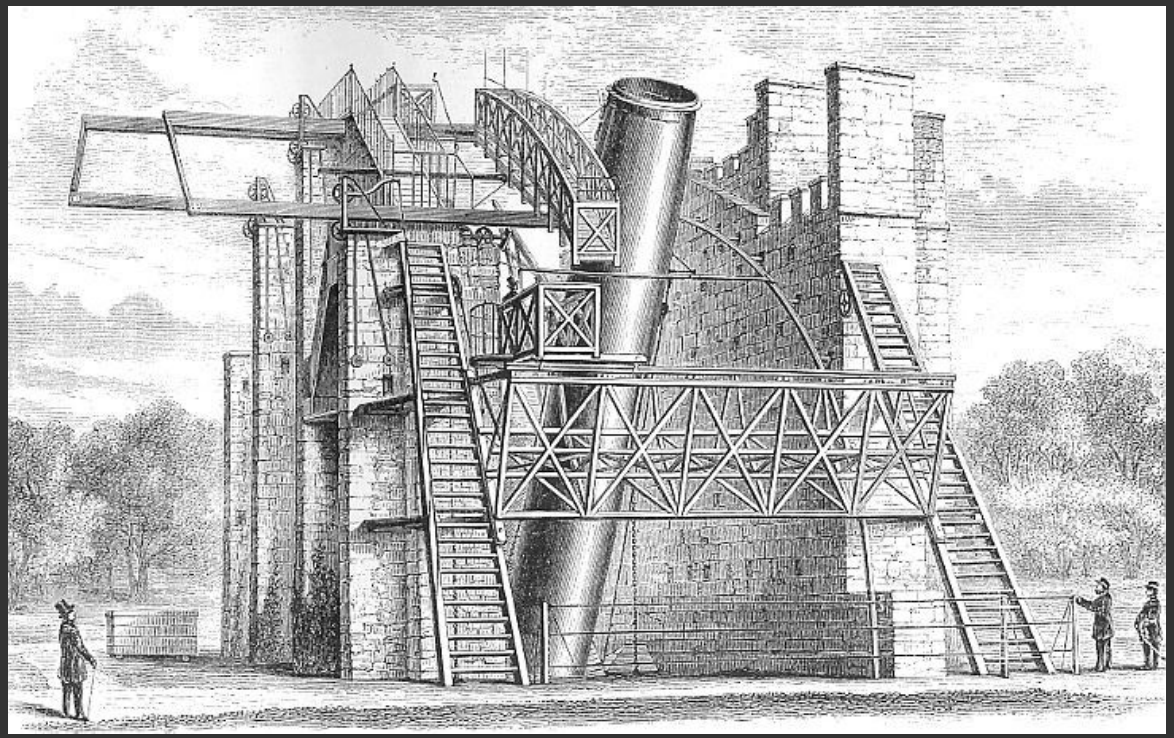


História

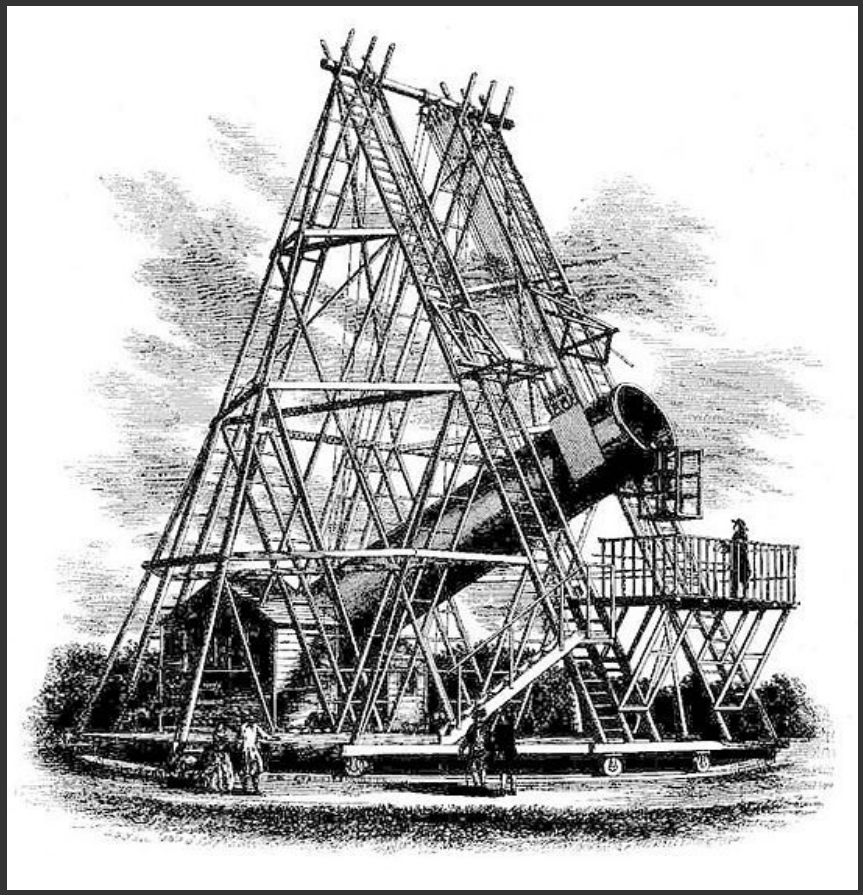
Johannes Hevelius

1673

Isaac Newton



Leviathan of Parsonstown
William Parsons 1845

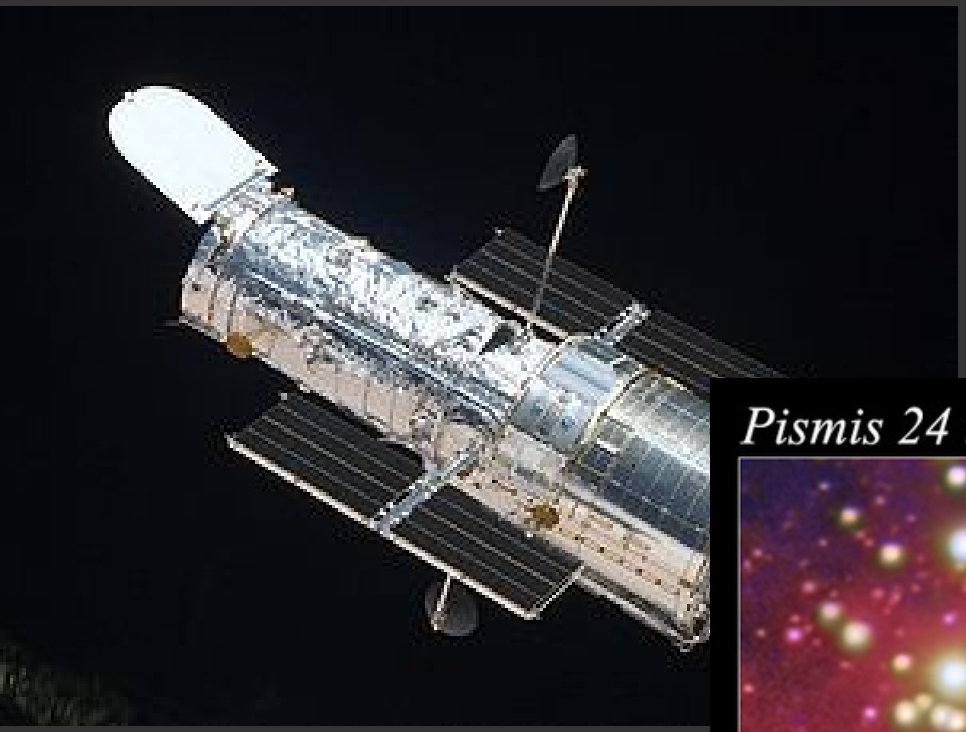


William Herschel
Telescópio de 40”
(1m) 1785

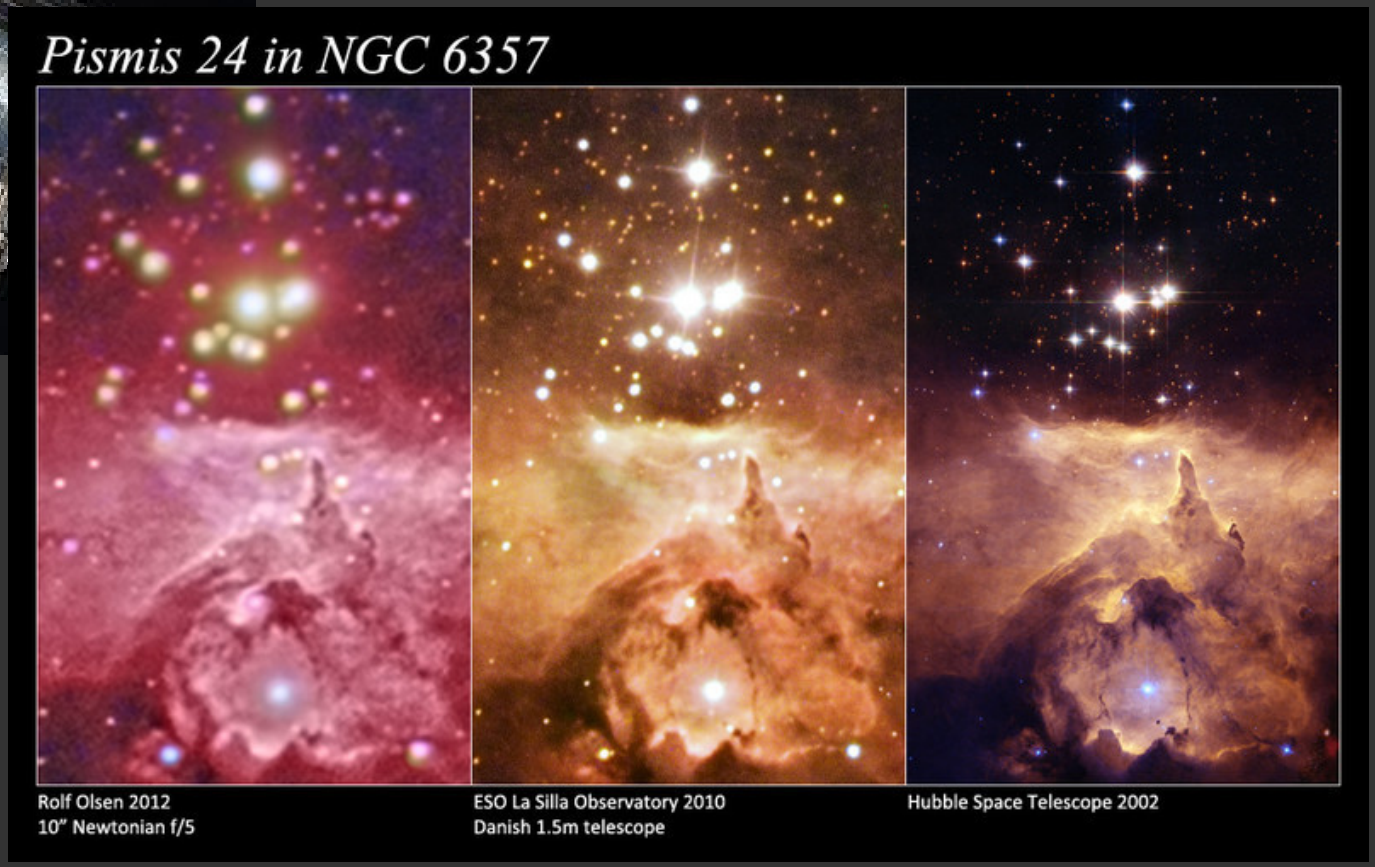
Mount Wilson Observatory
Los Angeles
100” = 2.54 m
1927

Monte Palomar, CA, 1948

Telescópio Espacial Hubble

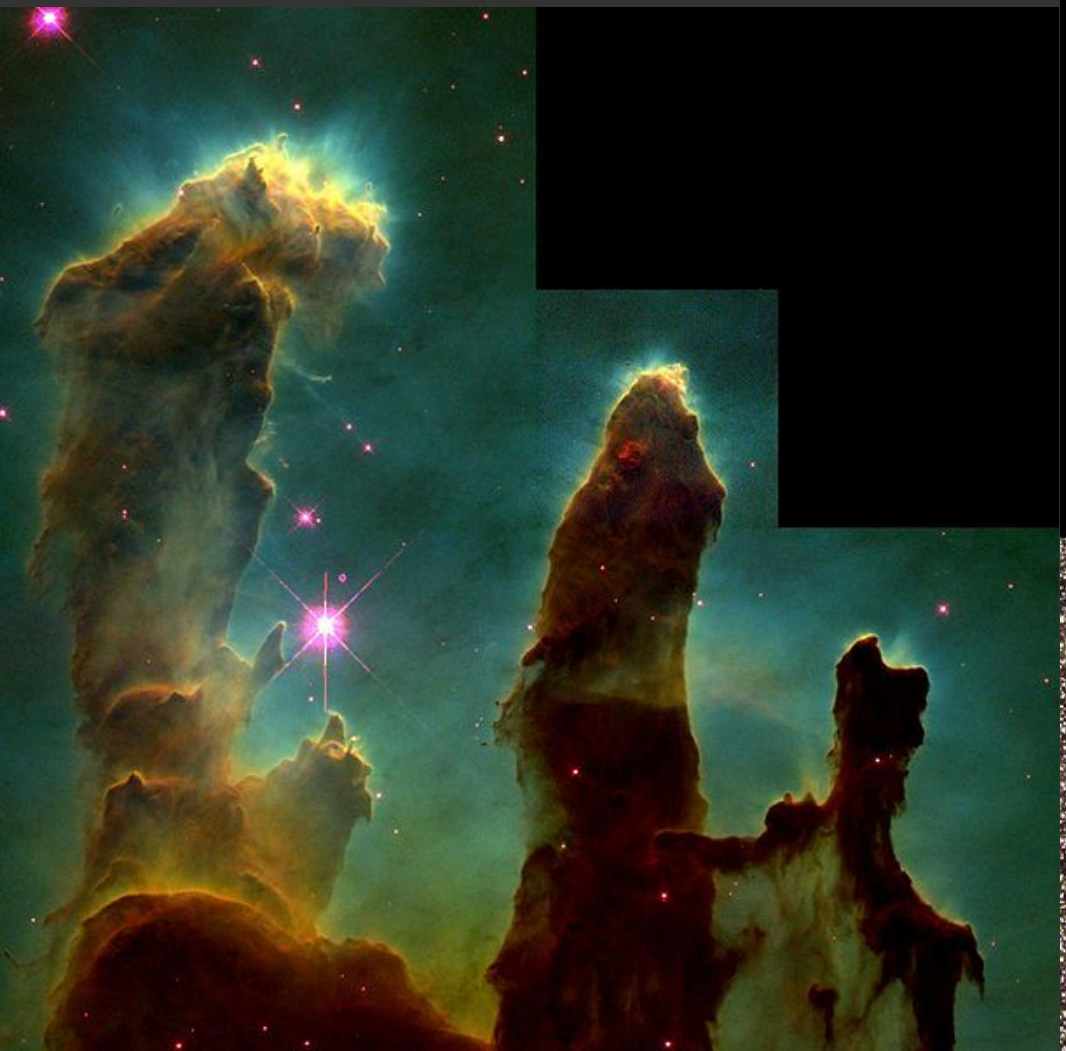


Espelho 2.4 m
US$ 5 billion

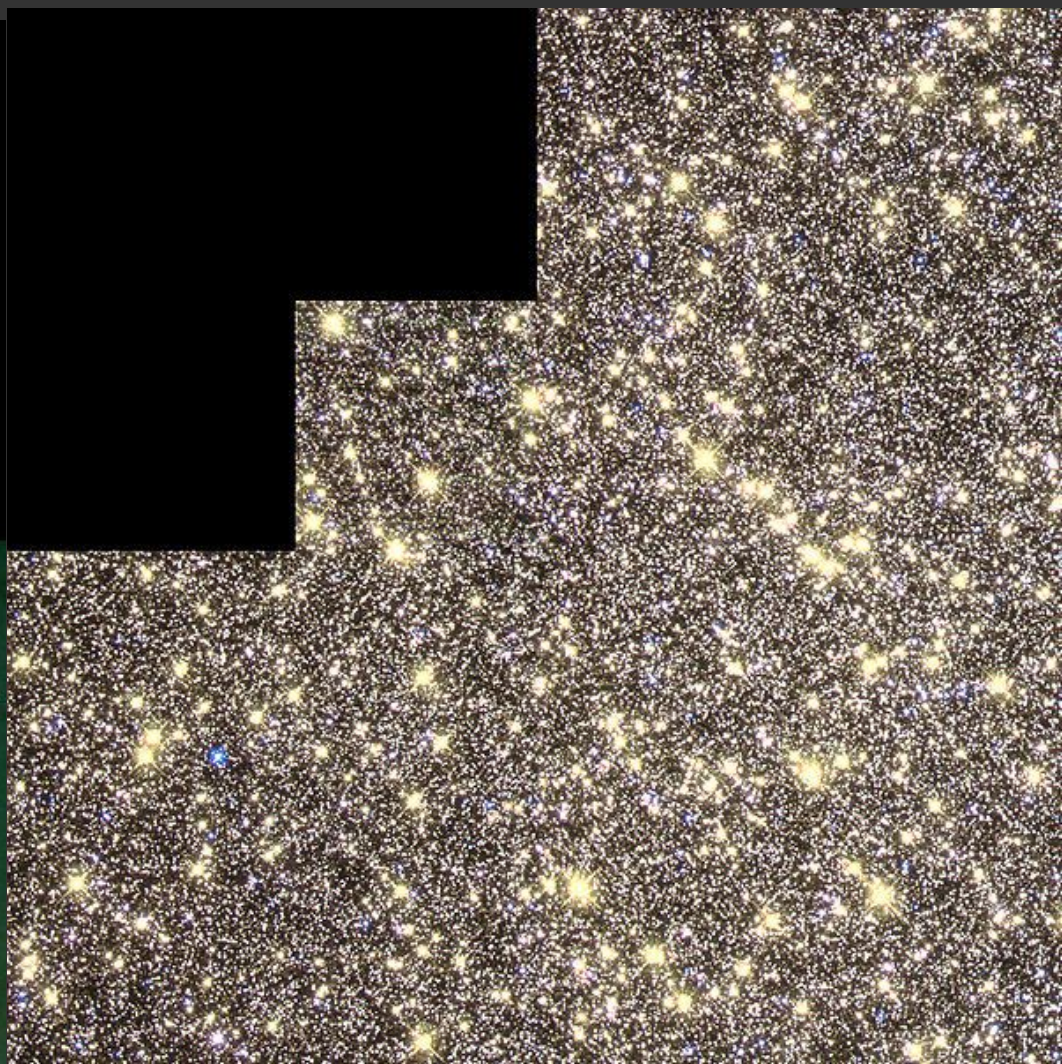


Imagens HST

Nebulosa da Águia (HST)



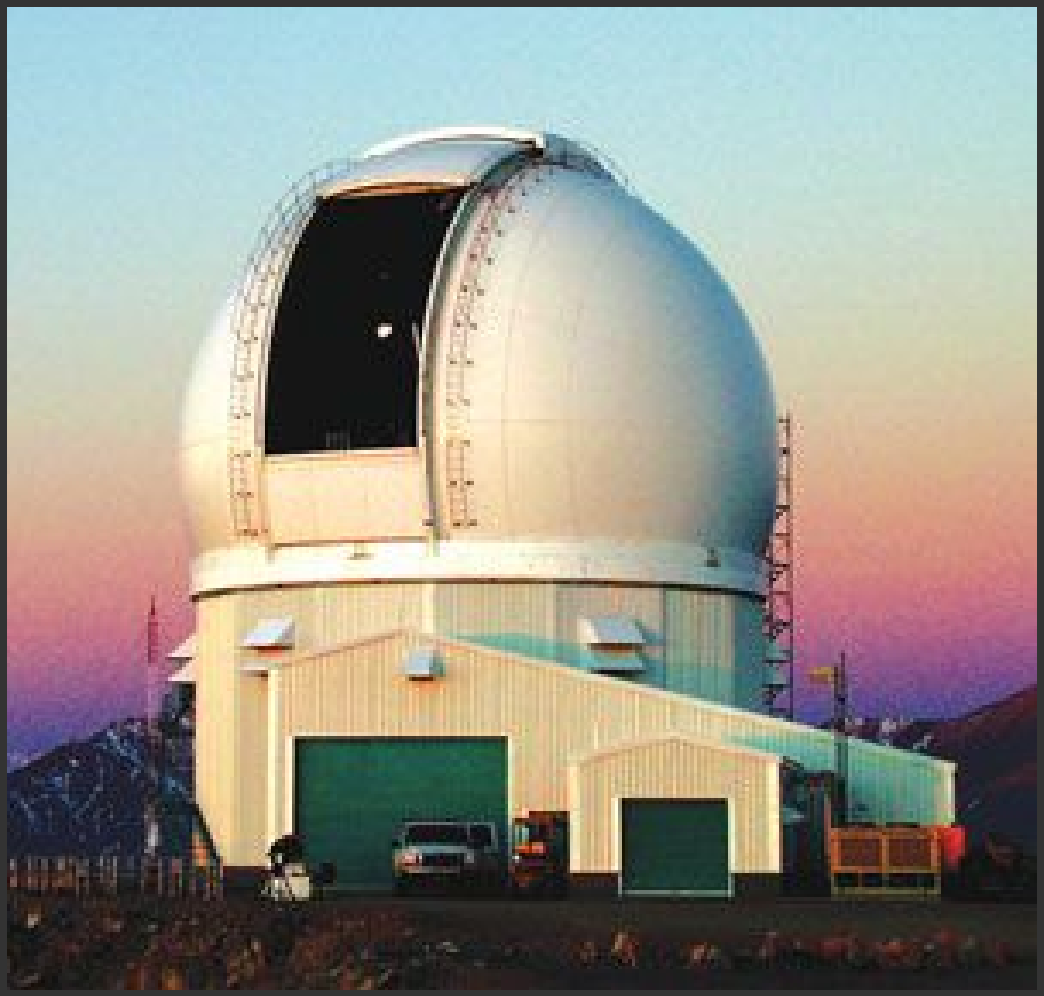
Omega Centauri (HST)



SOAR

Brazil, Chile, USA

2002



Telescópios Gemini (Sul, Norte)
2 x 8m

USA, UK, Canada, Chile, Australia, Argentina, Brasil

Telescópios Keck
2x10m

VLT

ESO+Chile

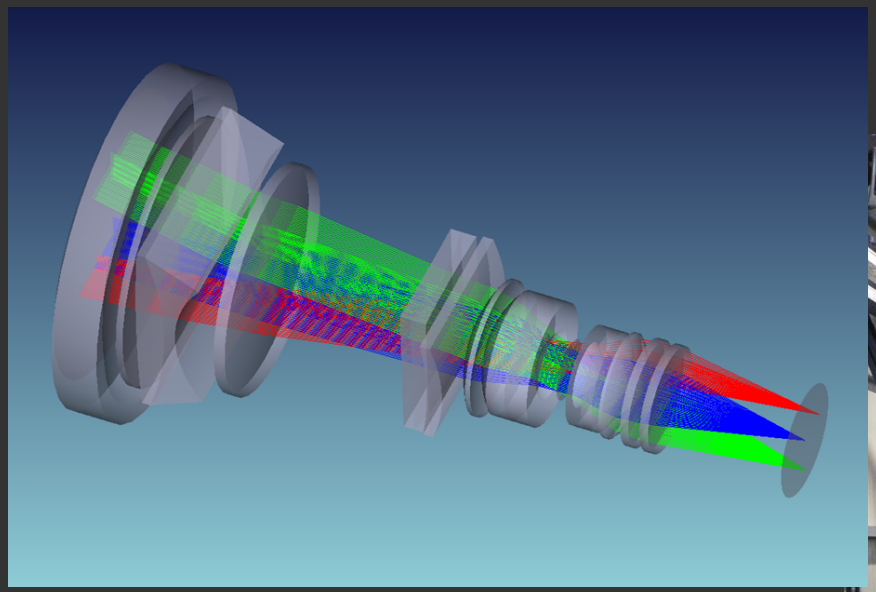
4 x 8.2 m ~2000

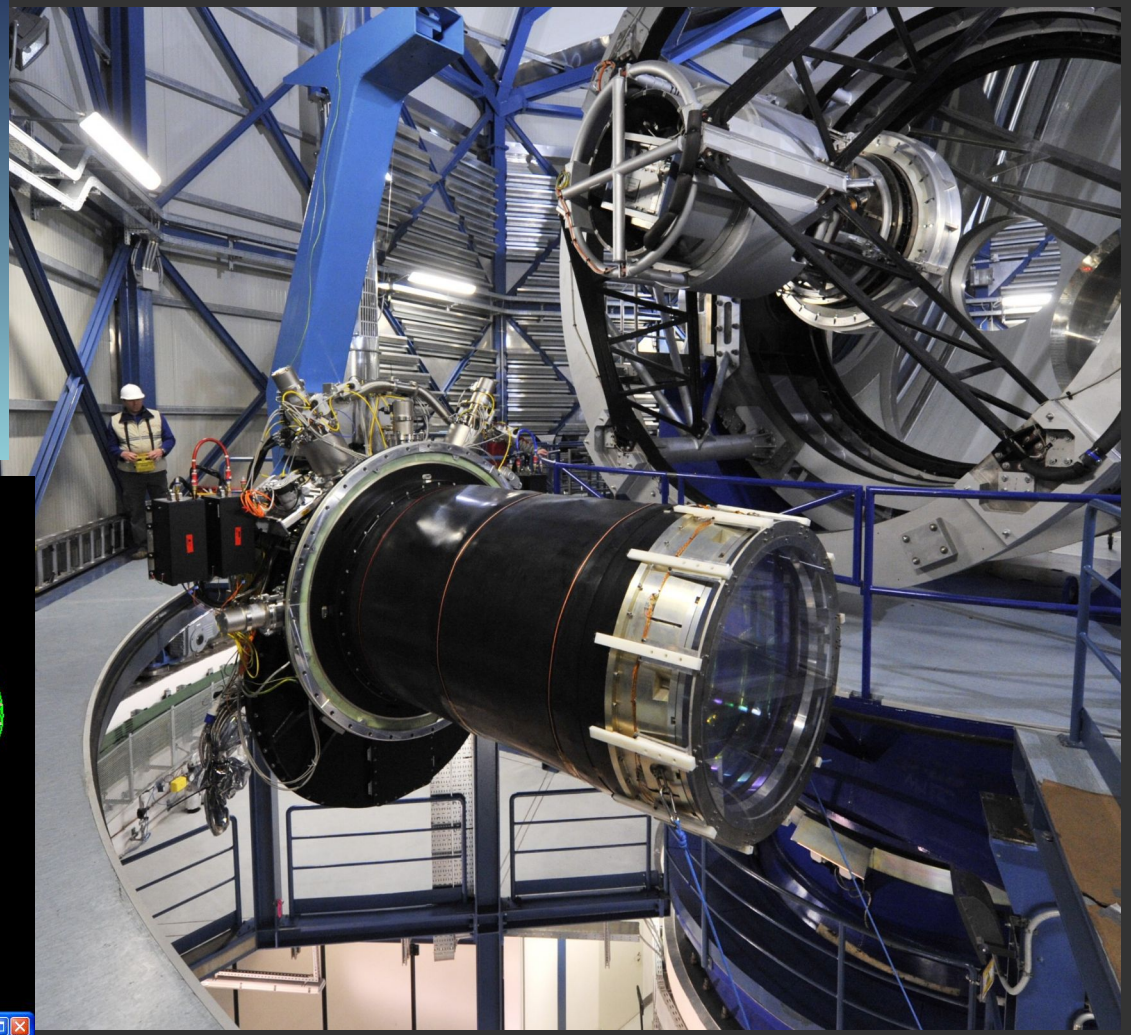
Instrumentação

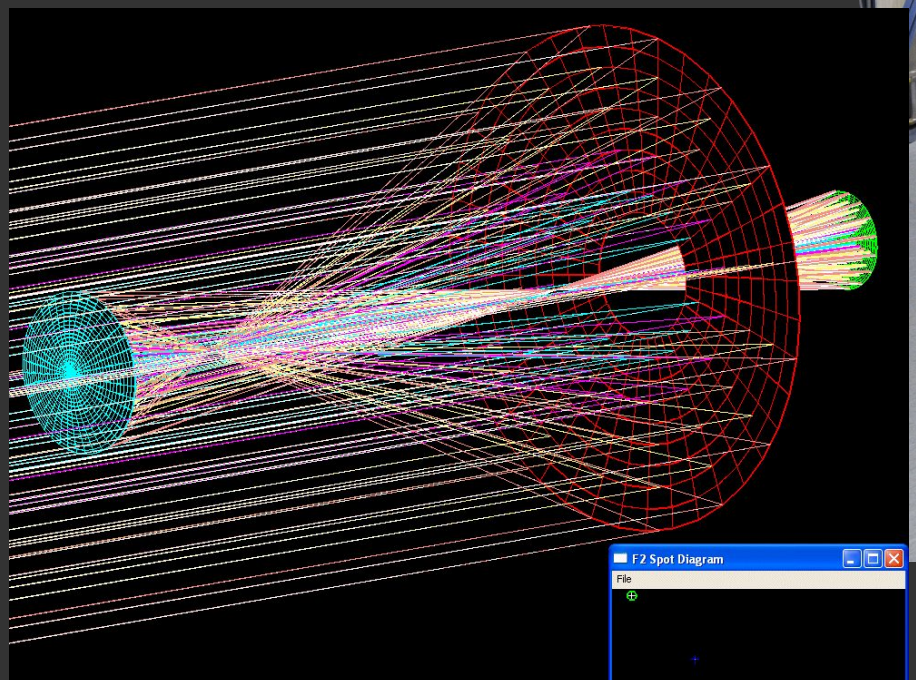
Cameras – imageamento

Espectrógrafos – espectroscopia

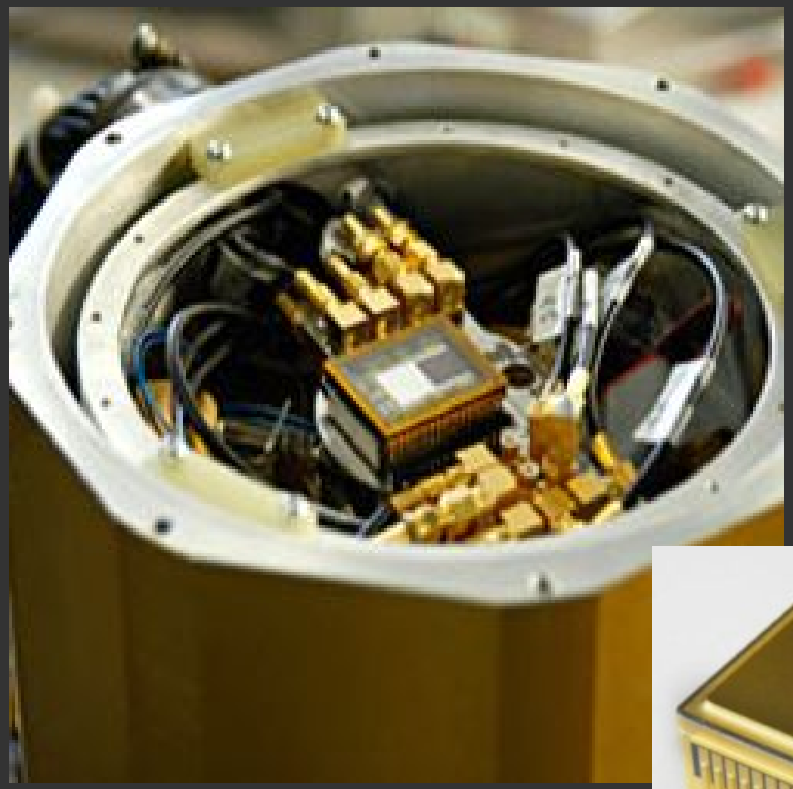
Cameras

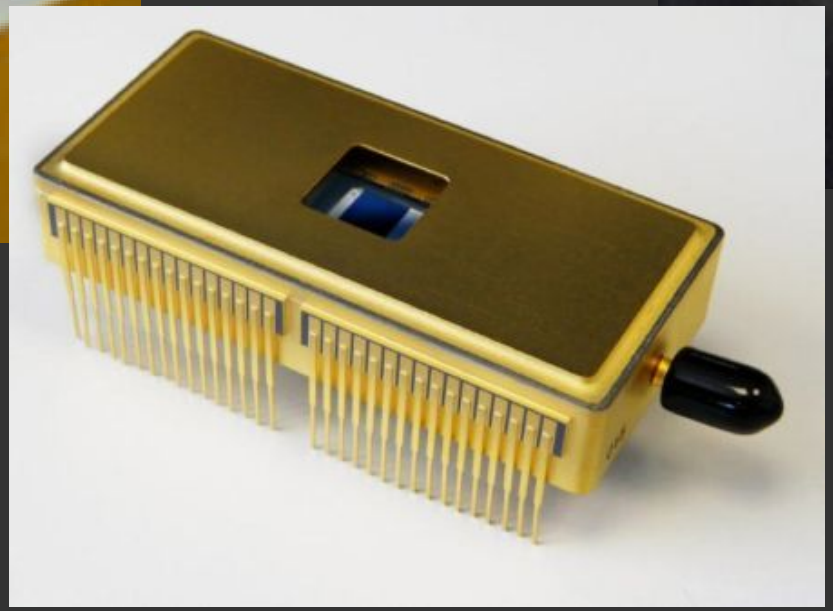




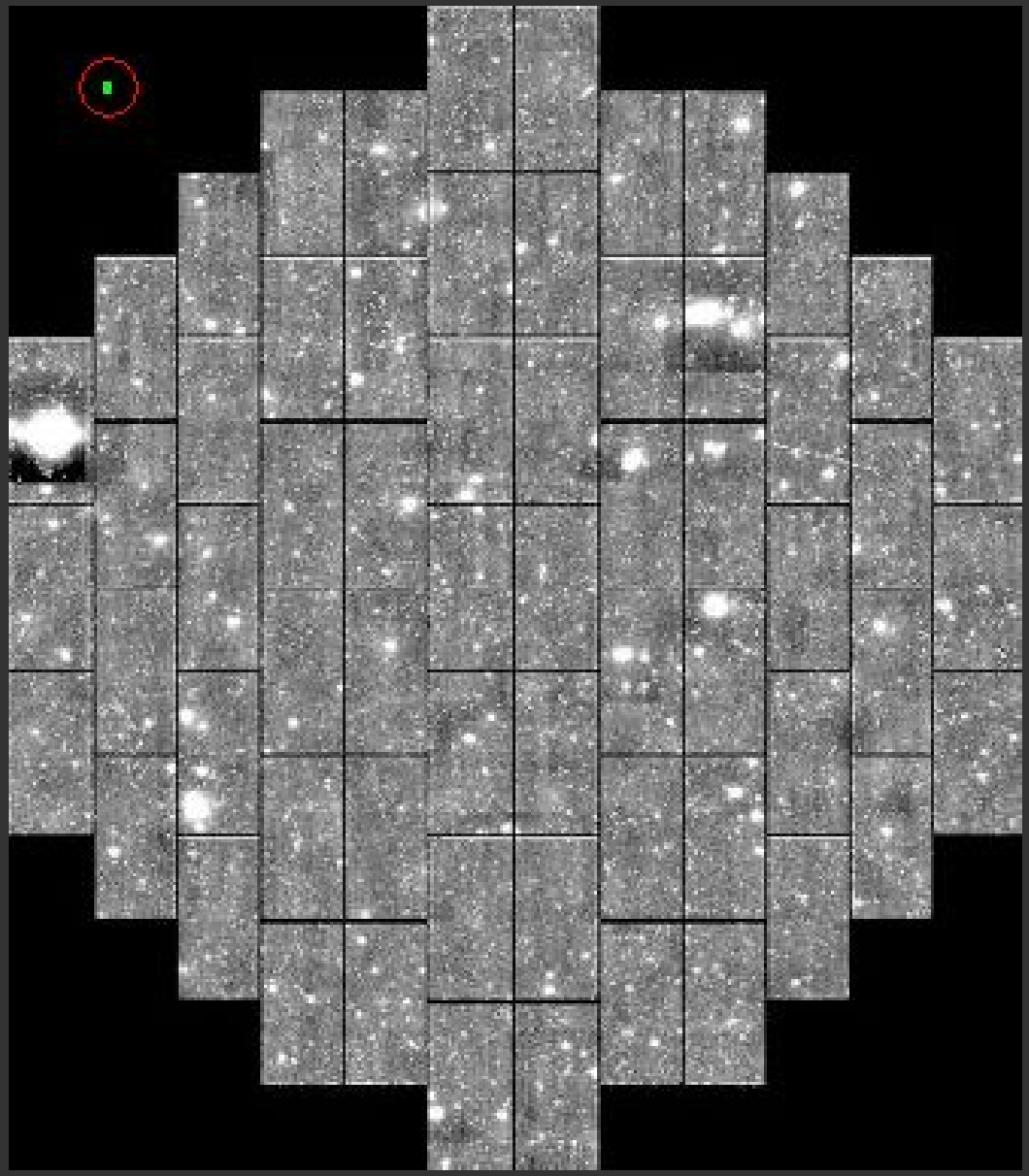


CCDs





DECam – Dark Energy Survey



Sensibilidade

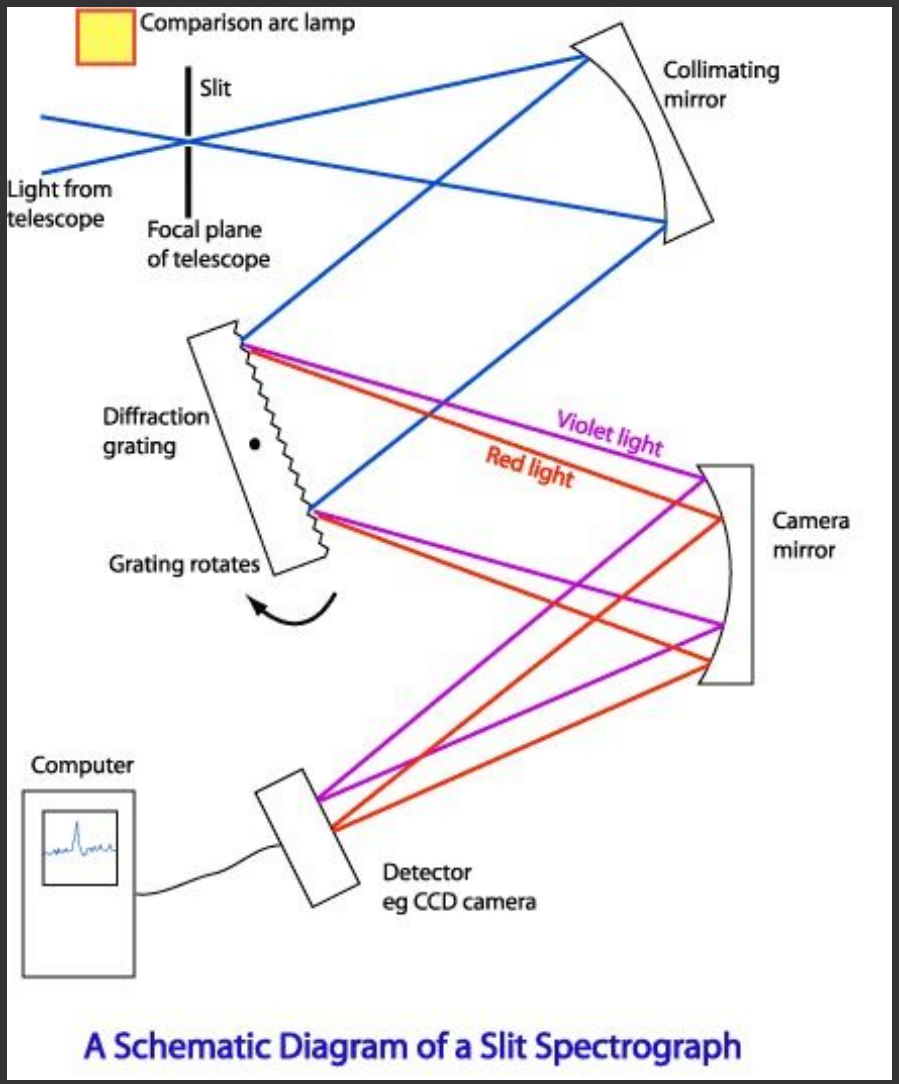
1 Jy = 1.5 10^7 fótons/s/m²
1 Jy = 10^{-26} Watts/m²/Hz

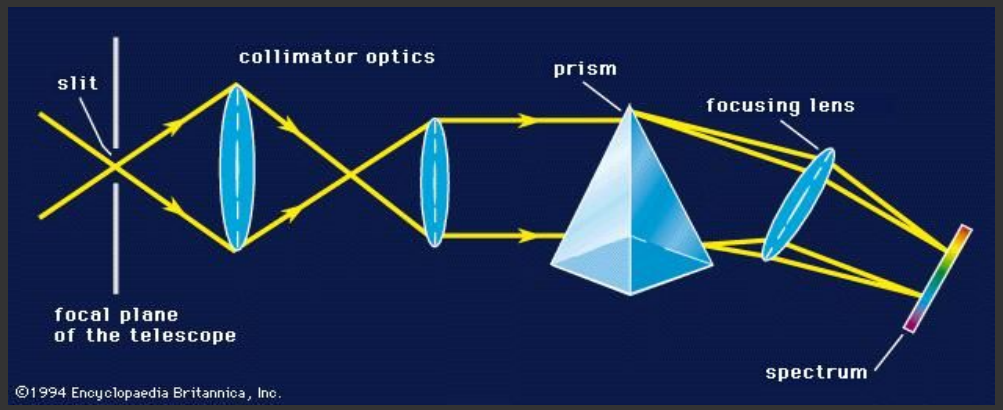
Limite de detecção:

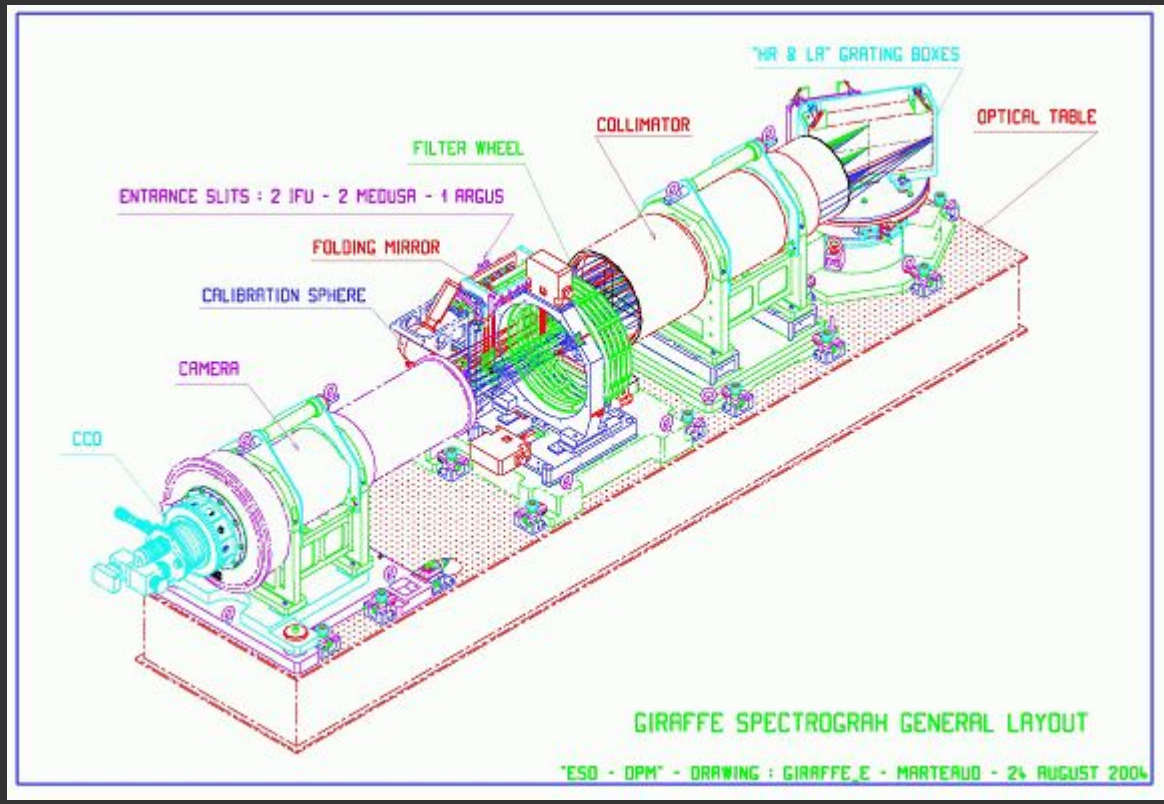
24 mag ~ 10^{-7} Jy ~ 1 fóton/s/m²

1 vela ~ 10^{15} fótons/s
(detectável a 10^7m)

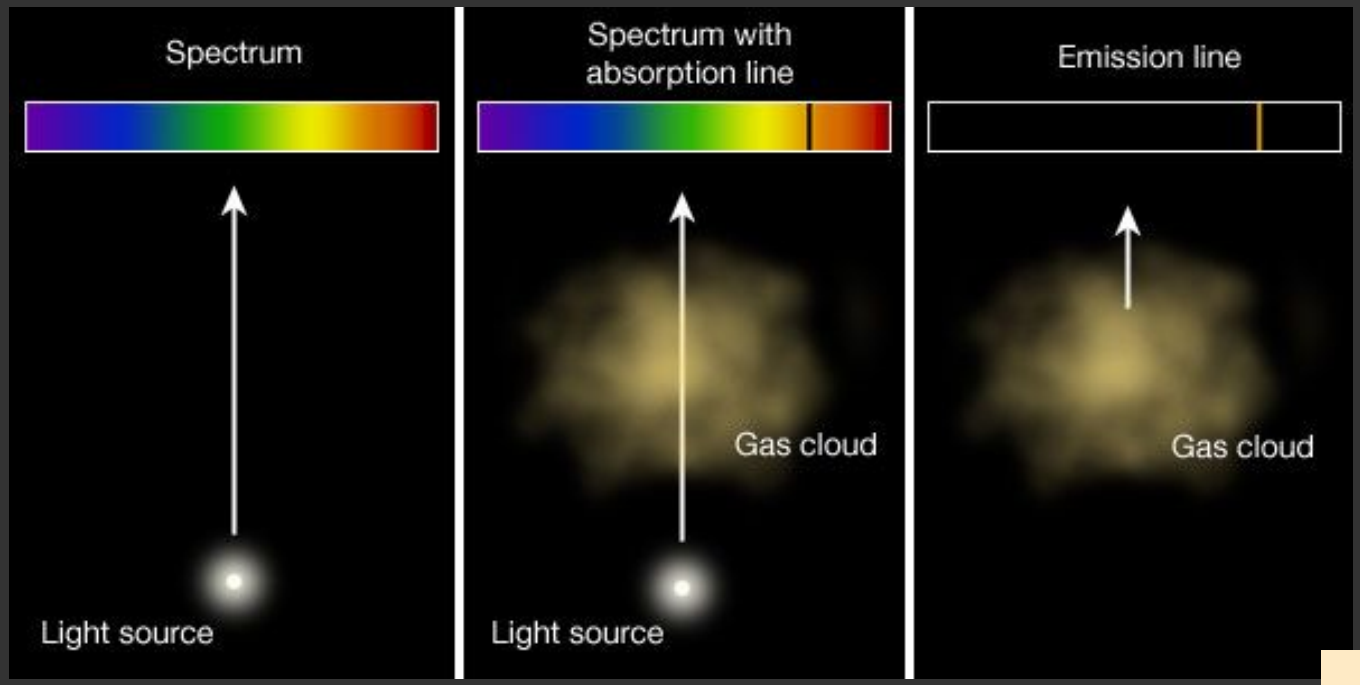
Espectrógrafo



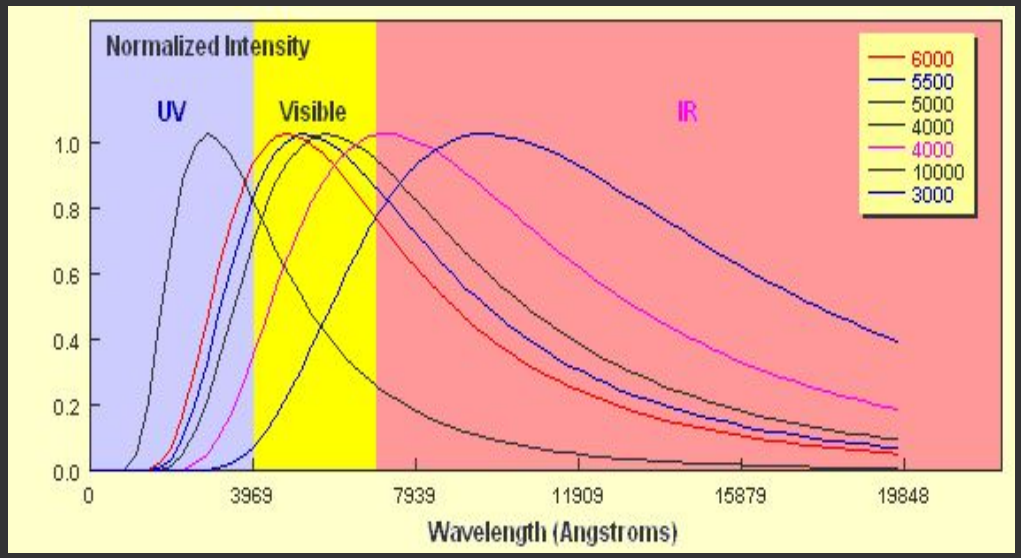


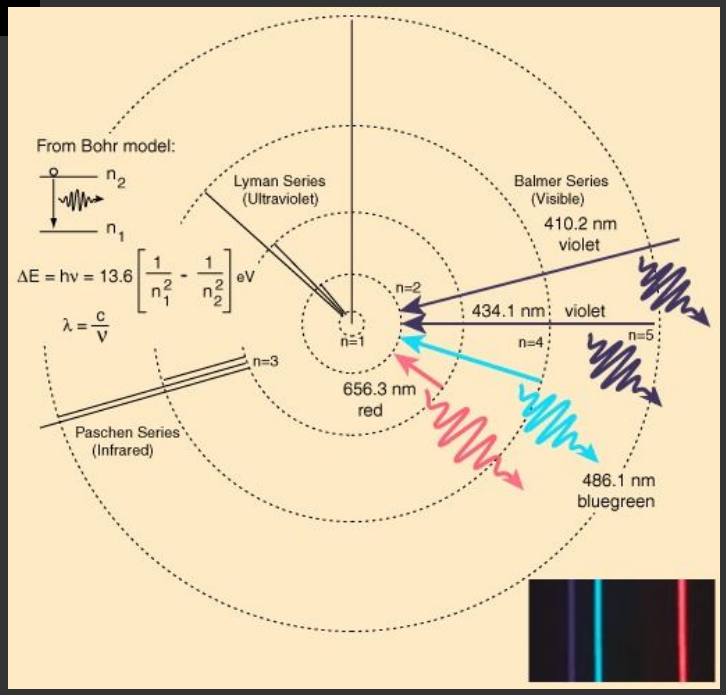


Linhas Espectrais

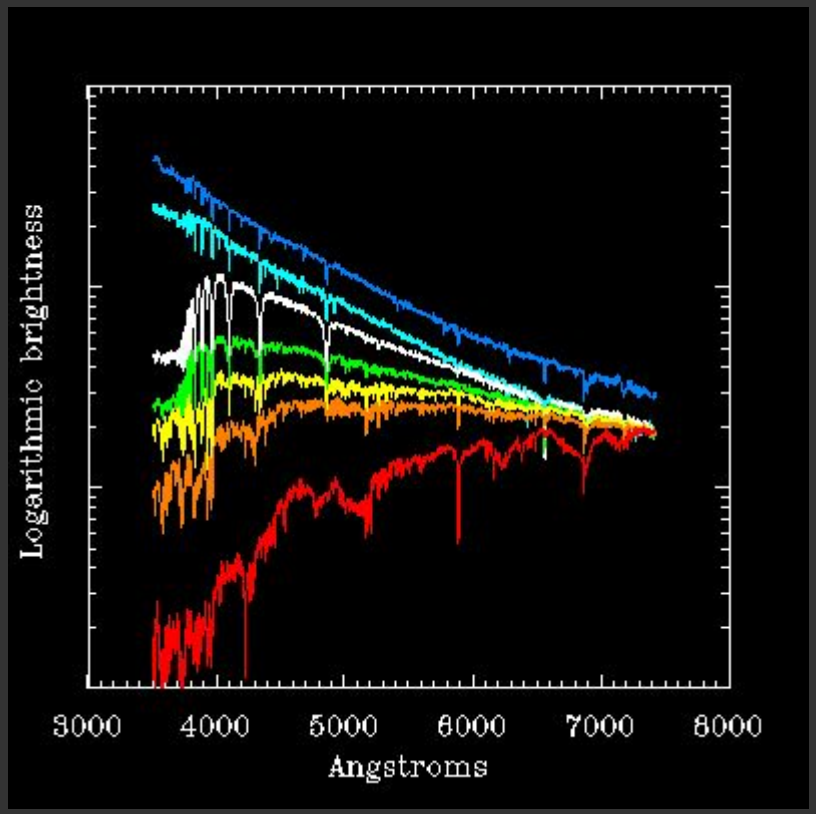


Leis de Kirchoff

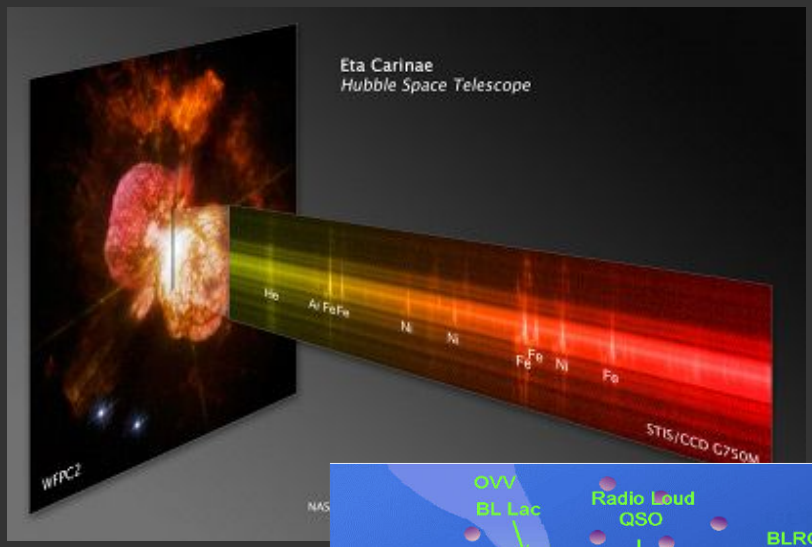




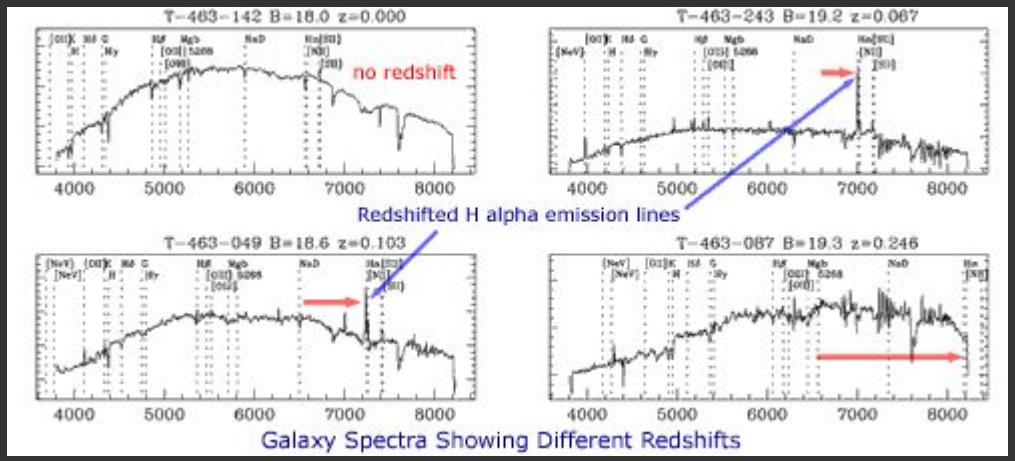
Informações do Espectro



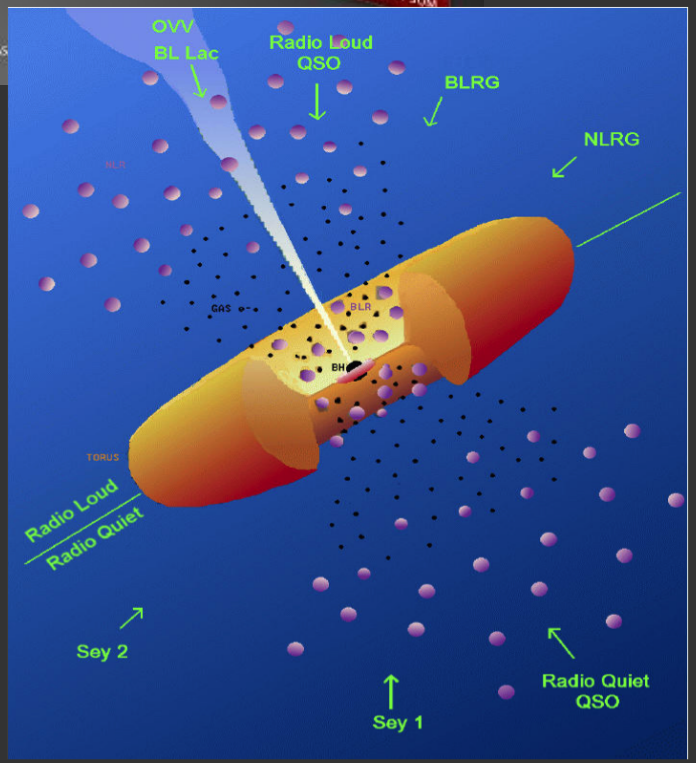
estrelas



estrela



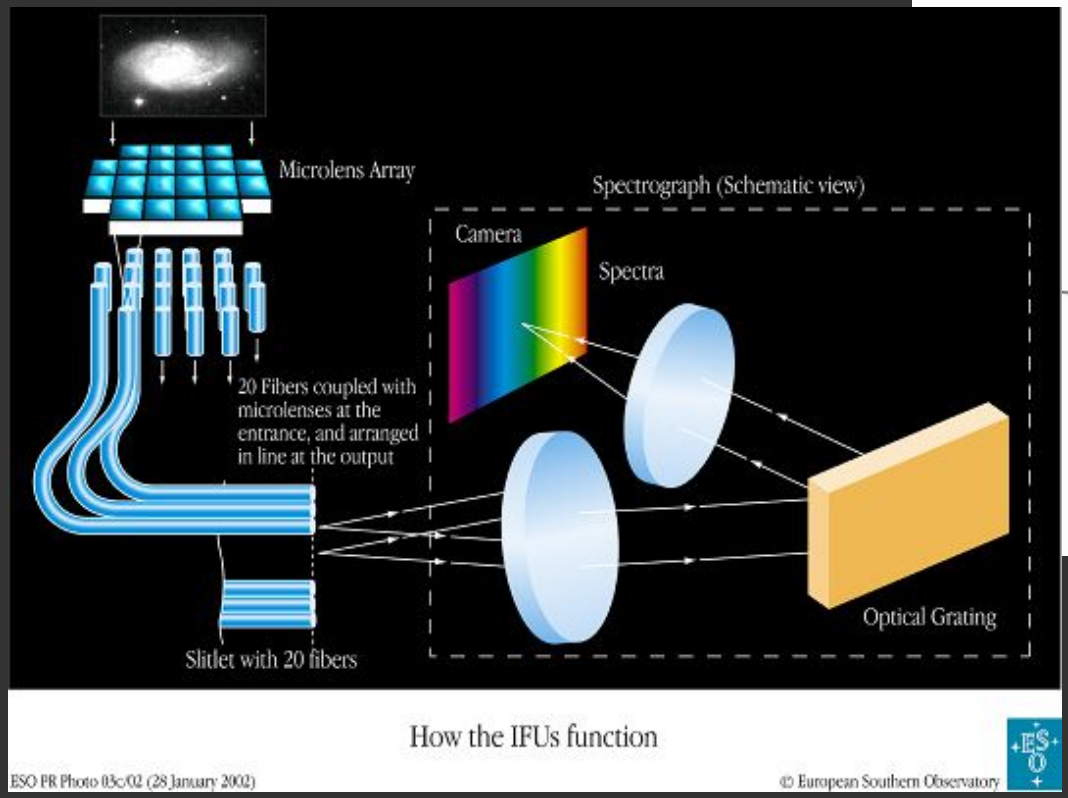
galáxias
e redshift

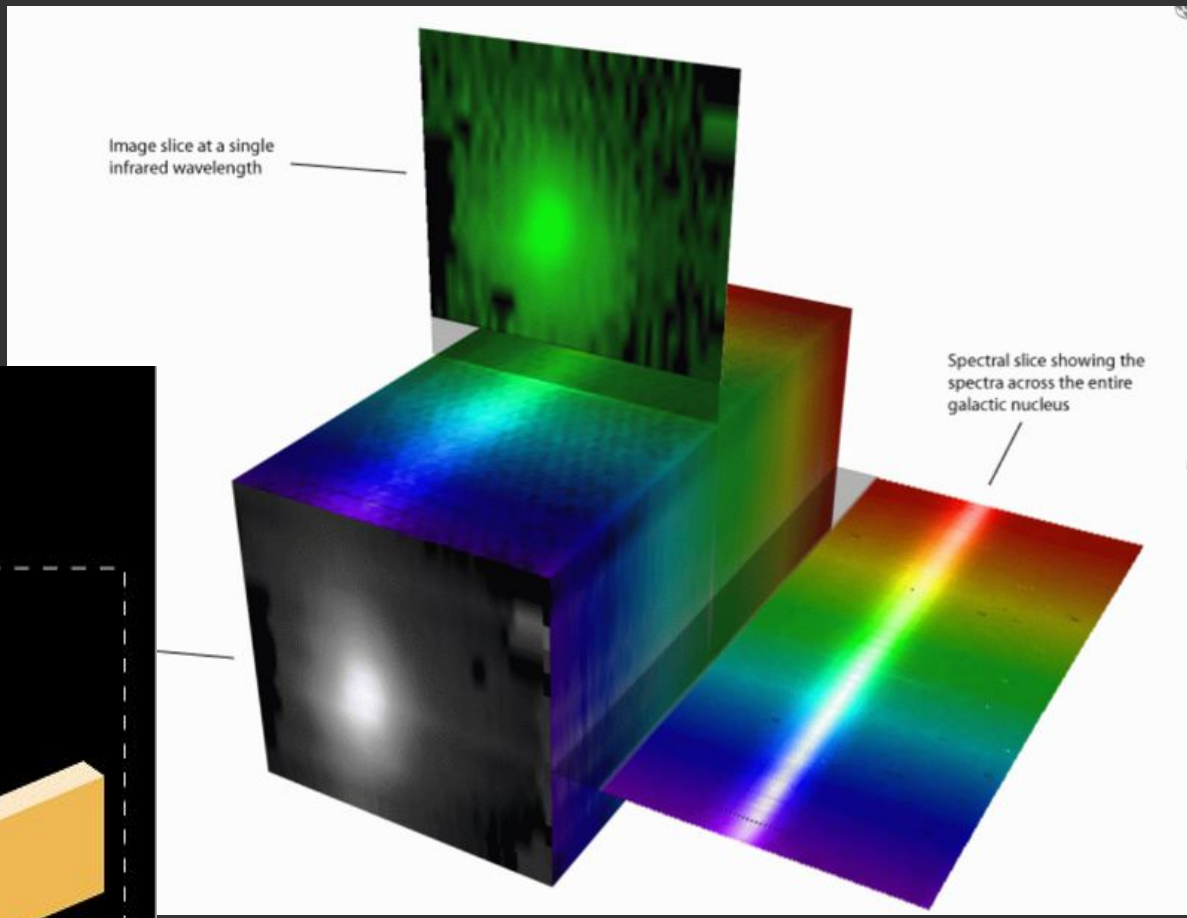


AGN

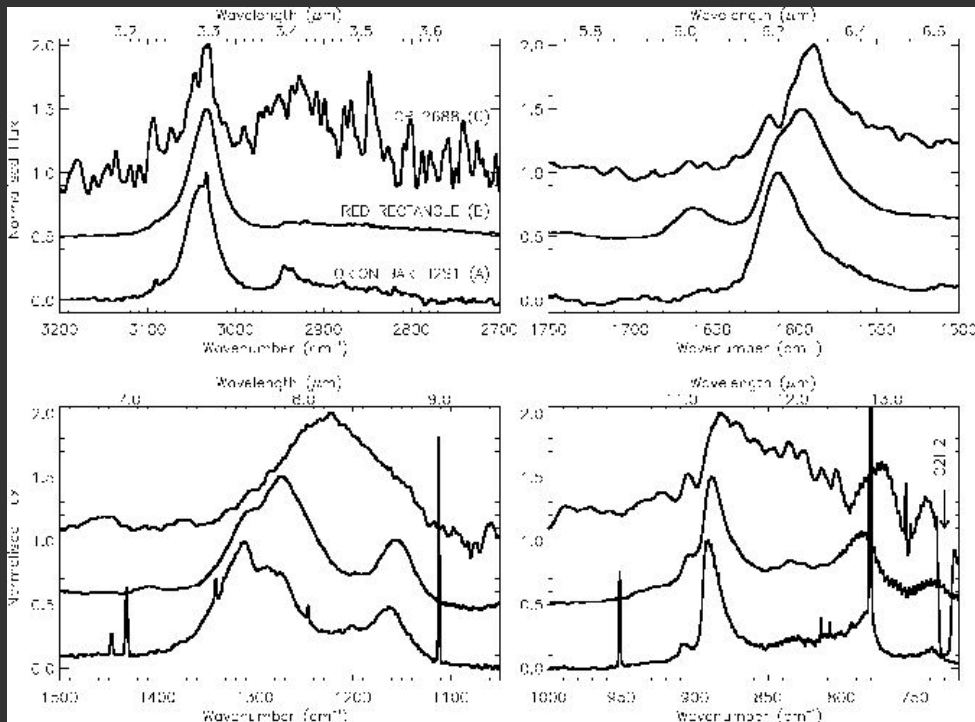
Instrumentos – IFU

unidades de campo integral

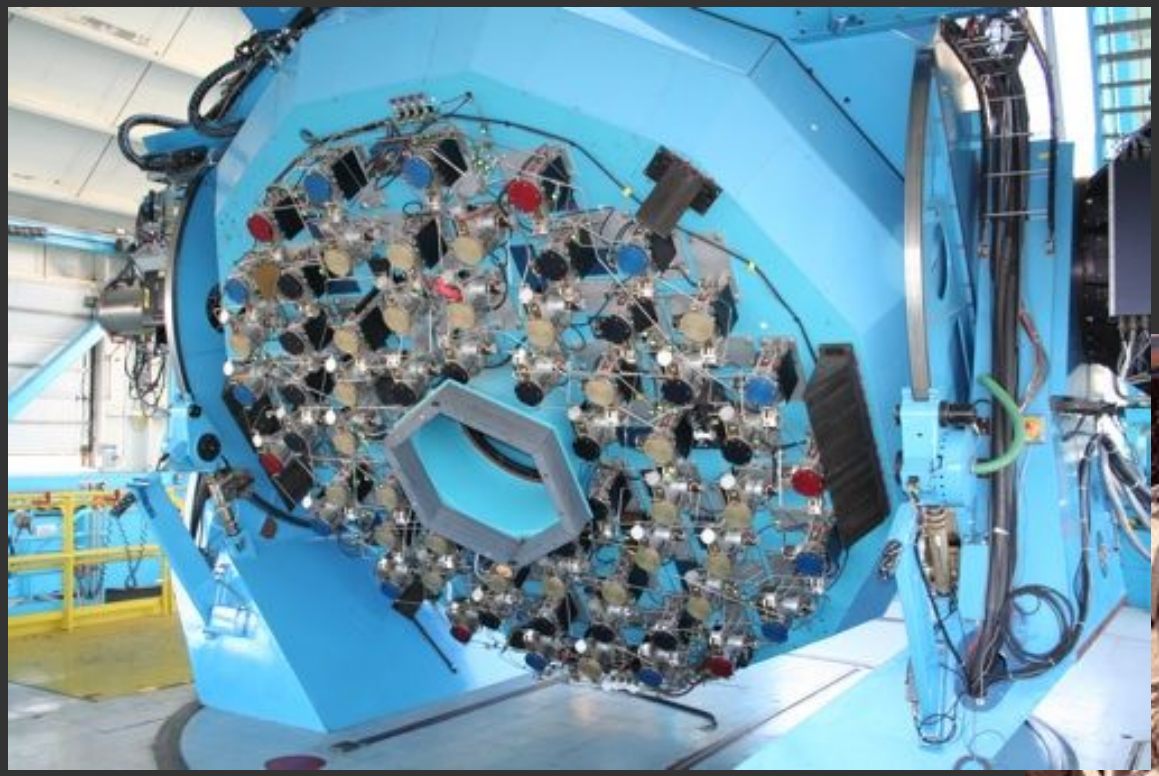


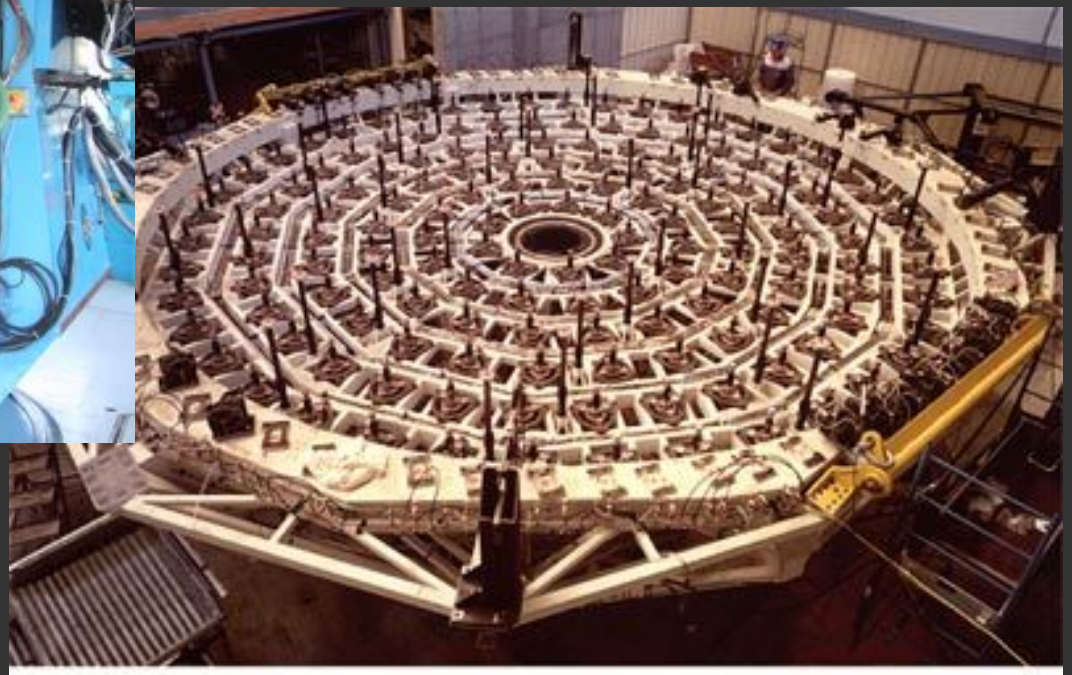


Espectrógrafos de campo integral



Ótica Ativa
1990...

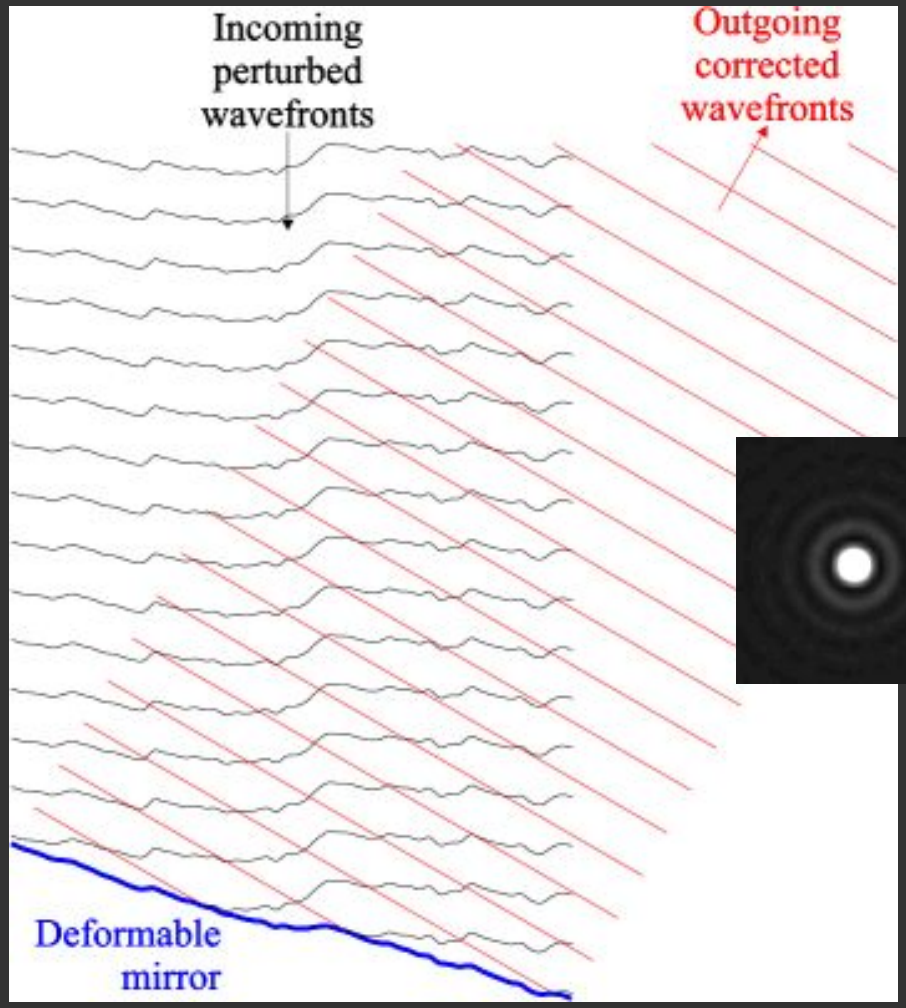




Active Mirror Supports in VLT M1 Cell

ESO PR Photo 34a/99 (13 August 1999)

Ótica Adaptativa 2000...



Paradigma moderno

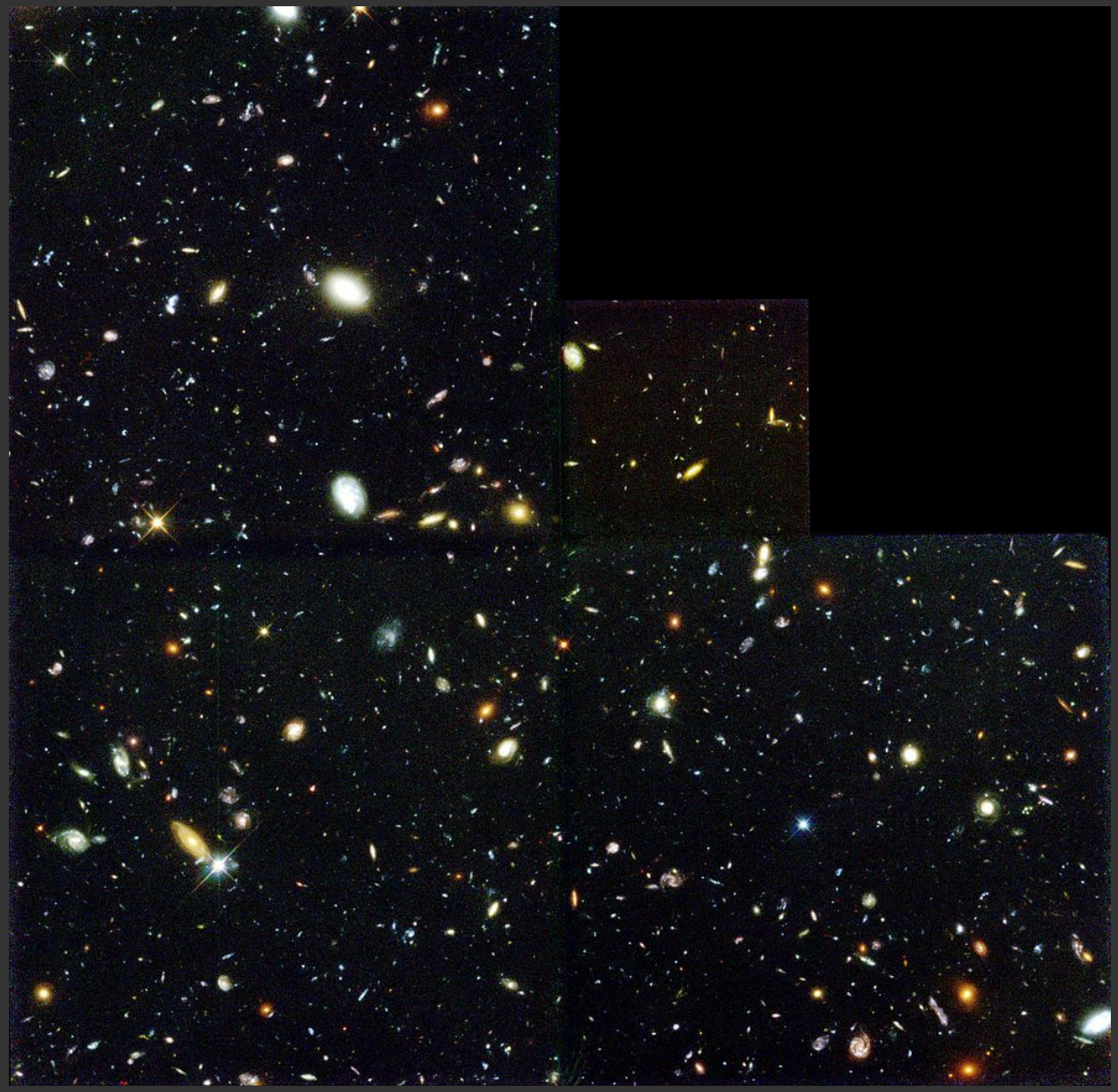
Telescópio Enormes (~30 m)

- poucos alvos (~10)
- altíssima resolução
- Excelente razão sinal-ruído
- Estudos de processos físicos detalhados
- Buracos Negros, Exoplanetas, Formação Estelar

Telescópios Médios (2 - 4 m)

- Número enorme de alvos (10^6 - 10^9)
- Boa razão sinal-ruido
- Mapeamento do Universo em larga escala
- Cosmologia Observacional, Evolução de Galáxias

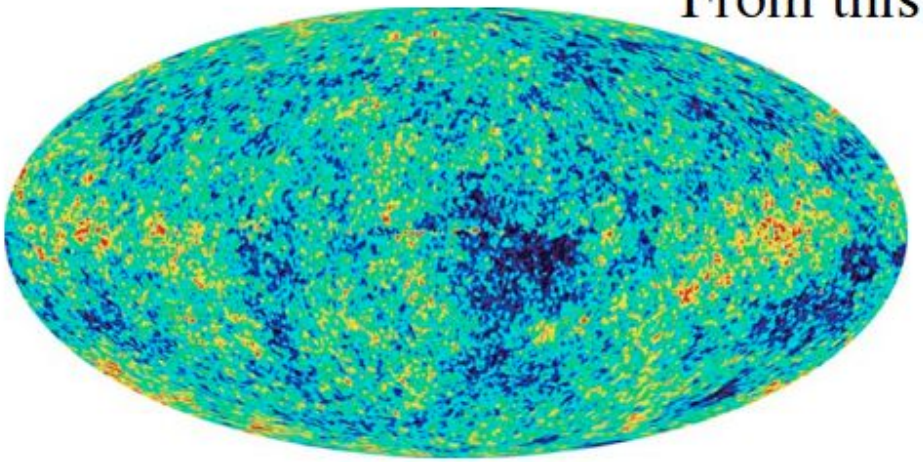
Deep Fields (HDF, HUDF)



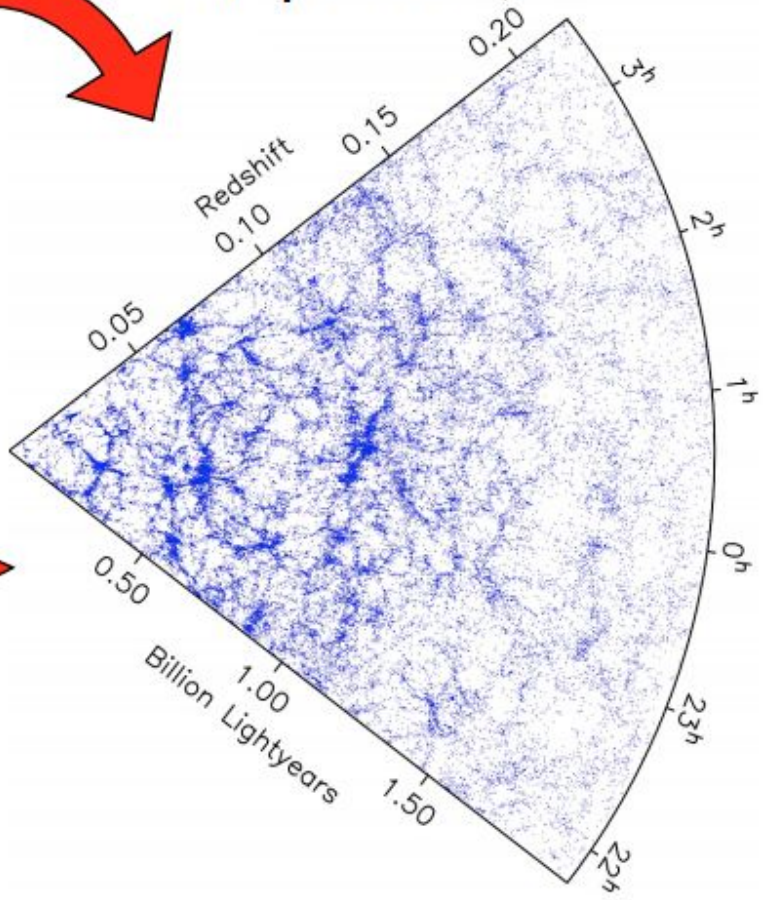
Exposicao de 10dias
3000 galaxias
2.5 arcsec

Cosmologia Observacional

From this ($\Delta\rho/\rho \sim 10^{-6}$)

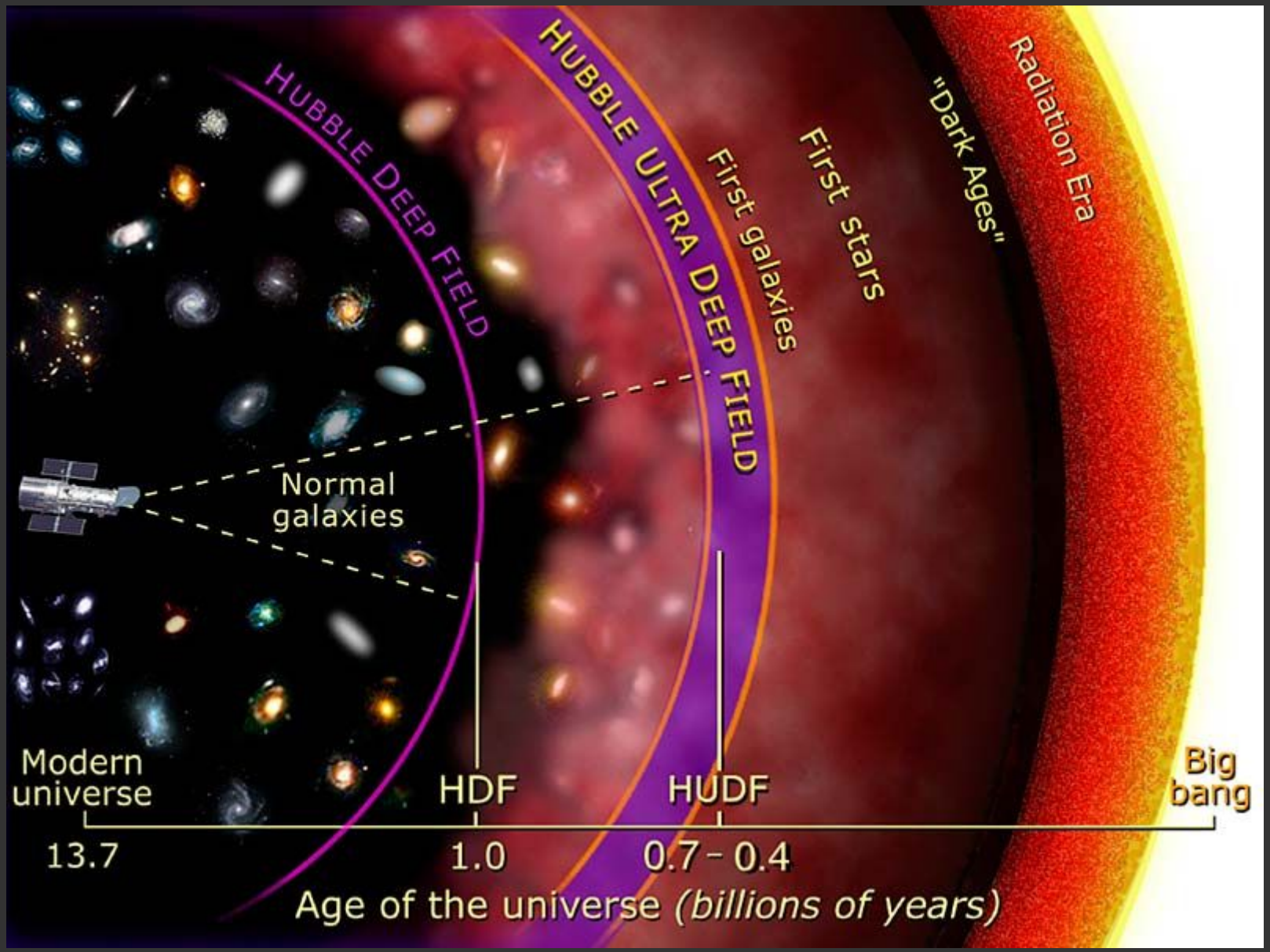


to this
($\Delta\rho/\rho \sim 10^{+2}$)



to this
($\Delta\rho/\rho \sim 10^{+6}$)

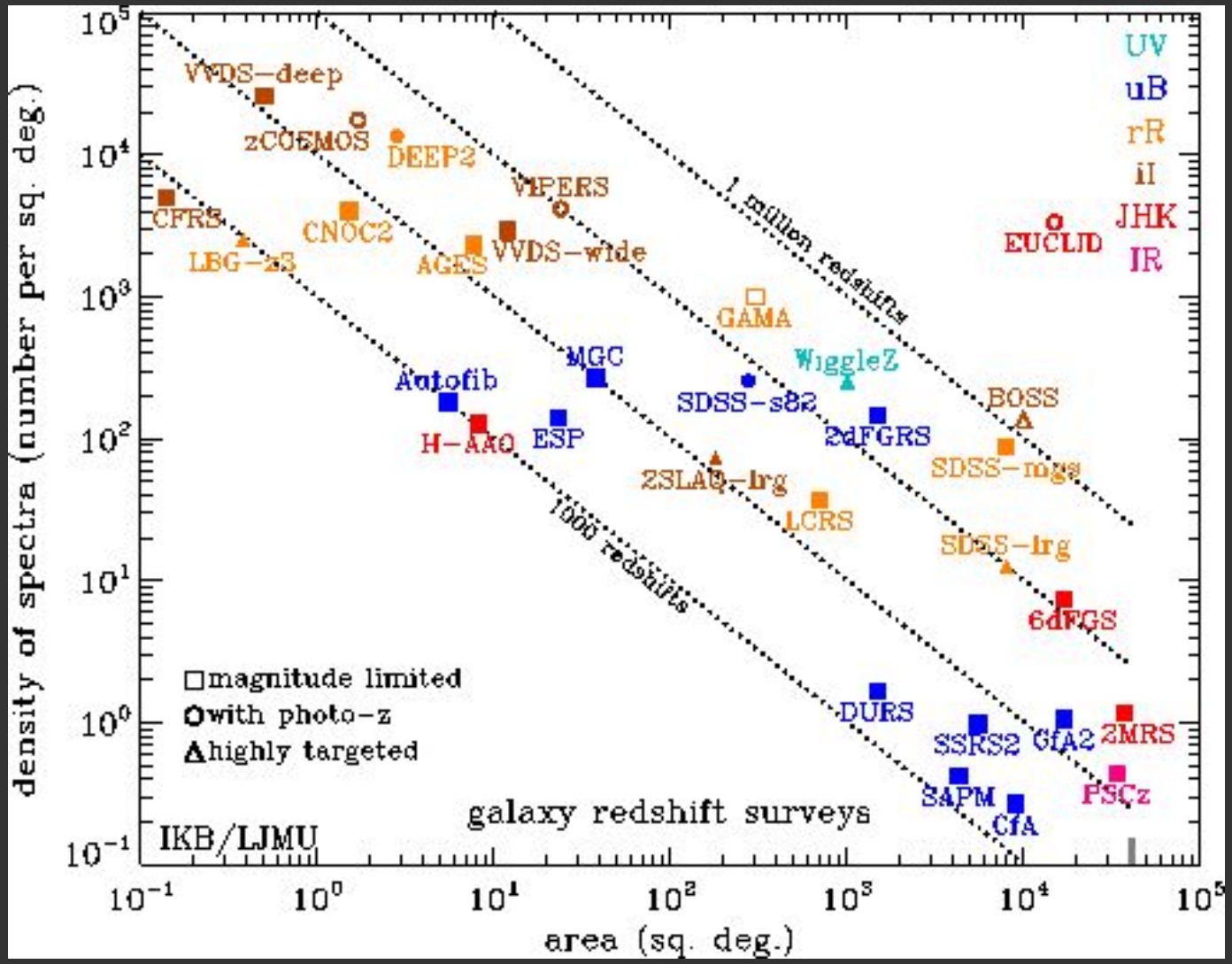
Cosmologia Observacional



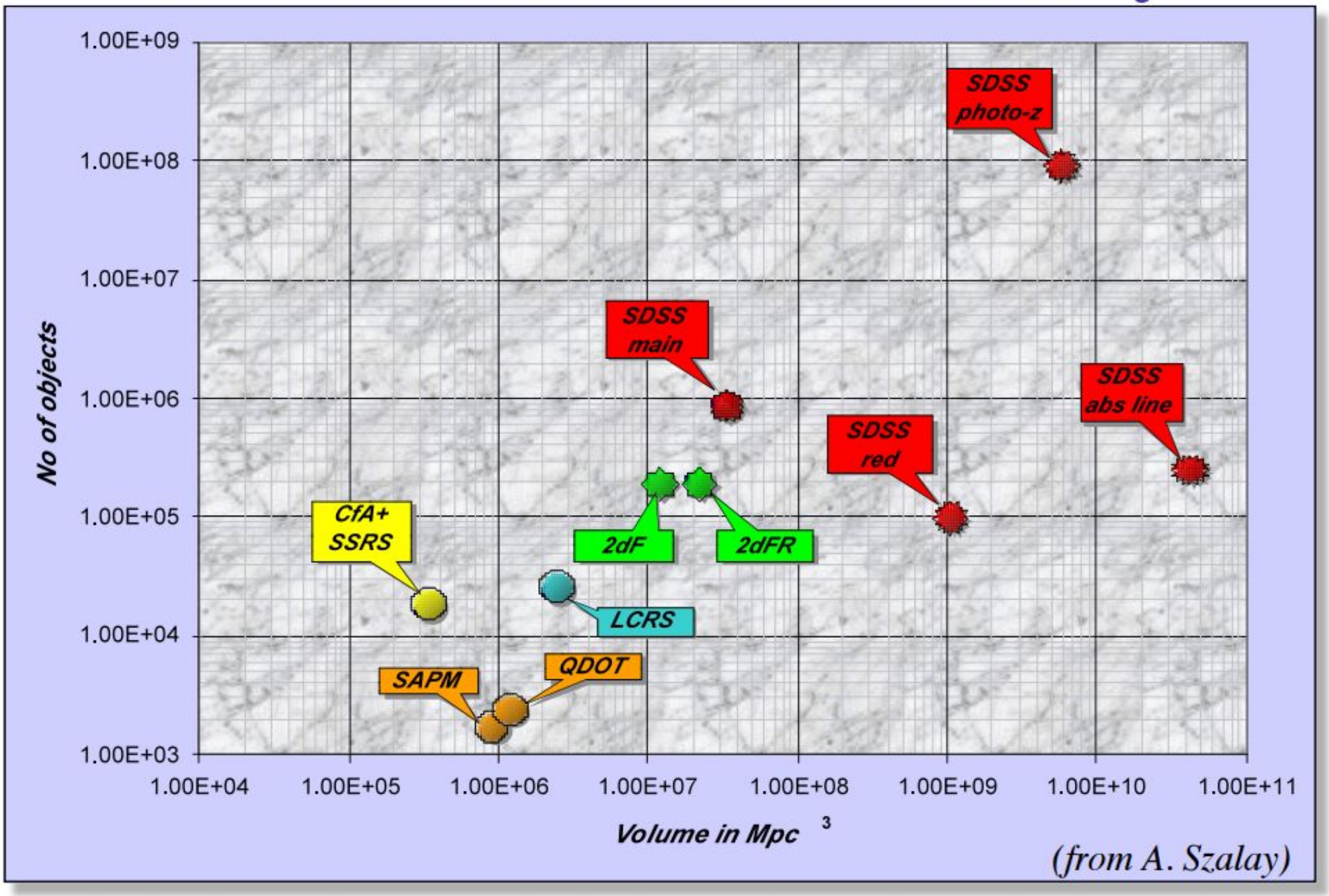
Levantamentos

CfA1	N=1100	600 sq.deg.	(1985)
Las Campanas	N=26 000	700 sq.deg., R < 17.5	(1996).
CfA2	N=18 000	17000 sq.deg., B < 15.5	(1999).
DEEP2	N=38 000	2.8 sq.deg., R < 24.1	(2003).
GAMA	N=300 000	300 sq.deg., R < 19.8	(2010).
SDSS	**N=700 000**	**8000 sq.deg., r < 17.77**	**(2002)**
2dF (2dFGRS):	N=220000	1500 sq.deg., b < 19.45	(2001)
DES	**N>2 000 000**	**5000 sq.deg.**	(2013)

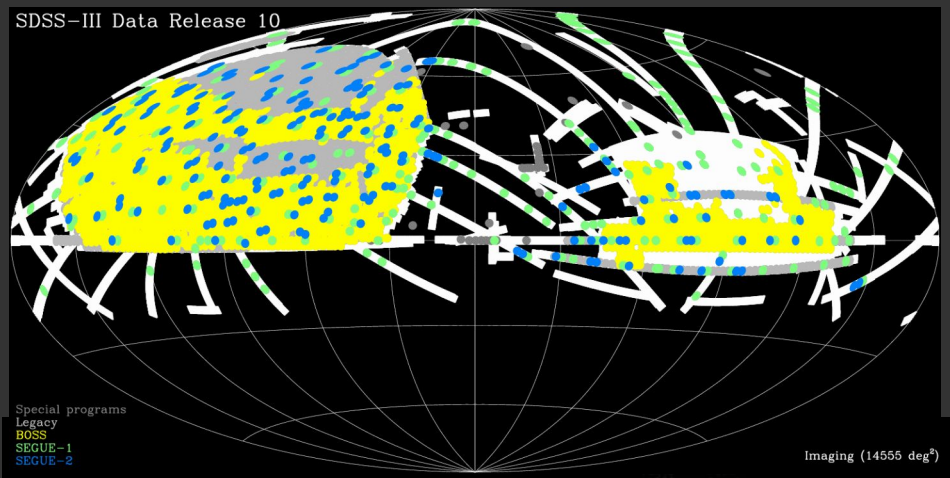
Levantamentos

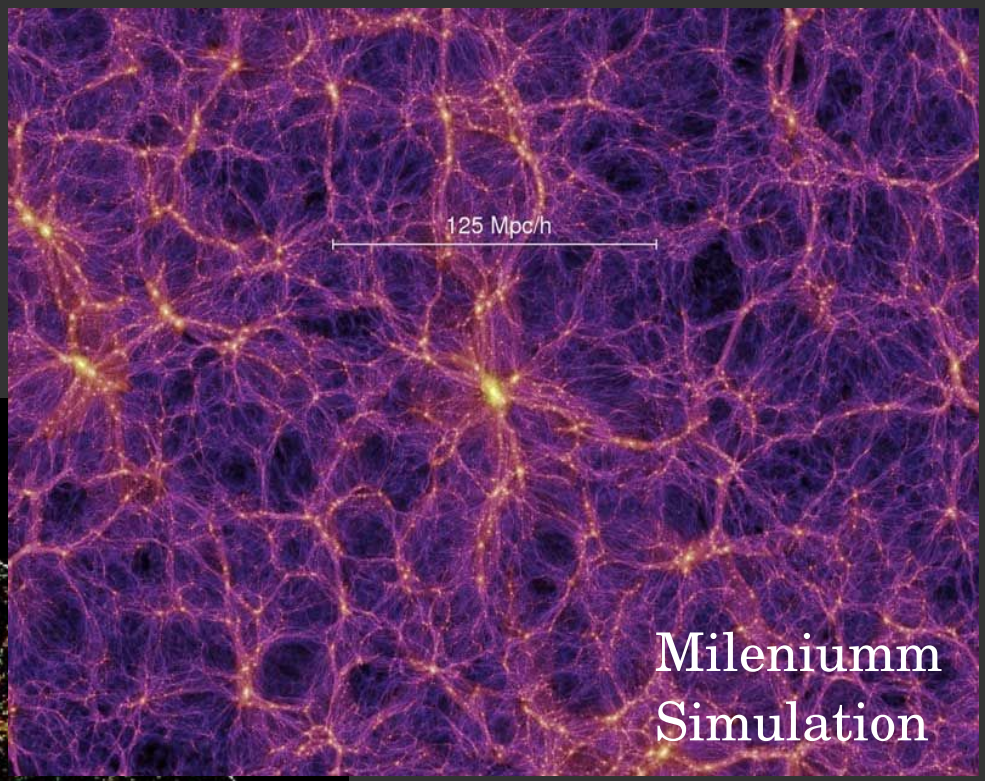


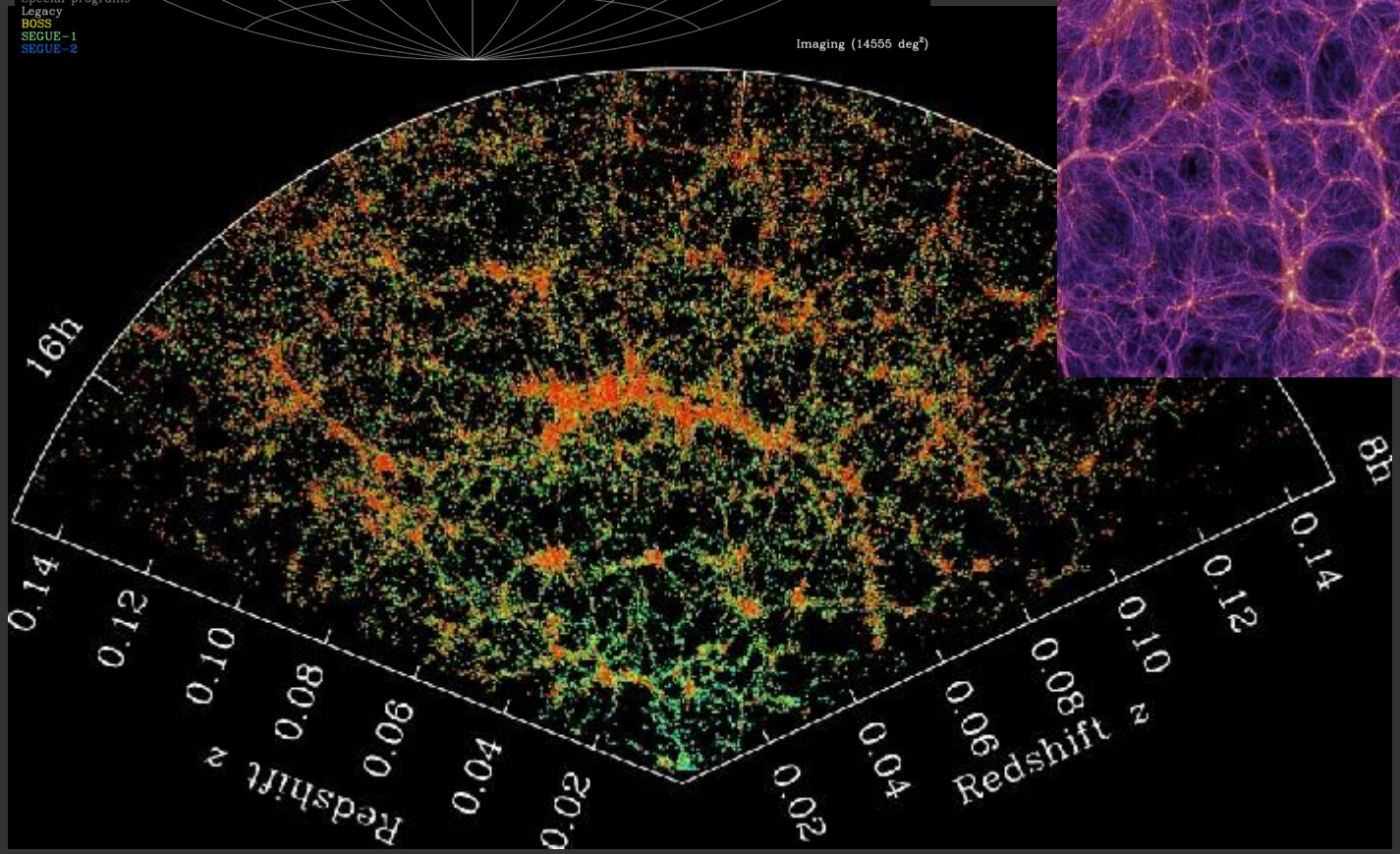
Area and Size of Redshift Surveys



SDSS Sload Digital Sky Survey

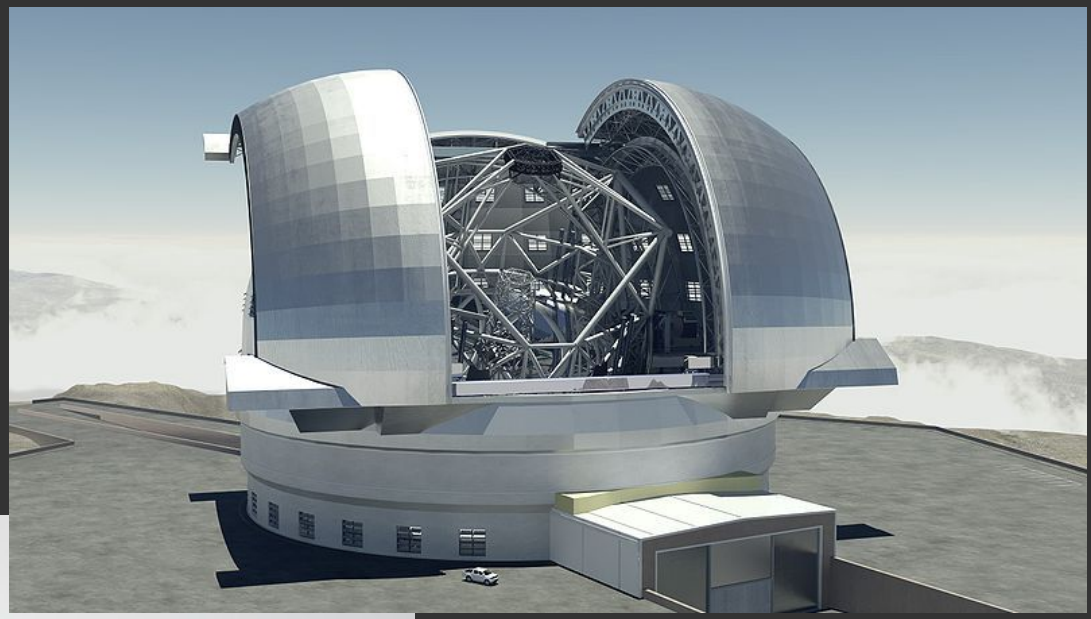






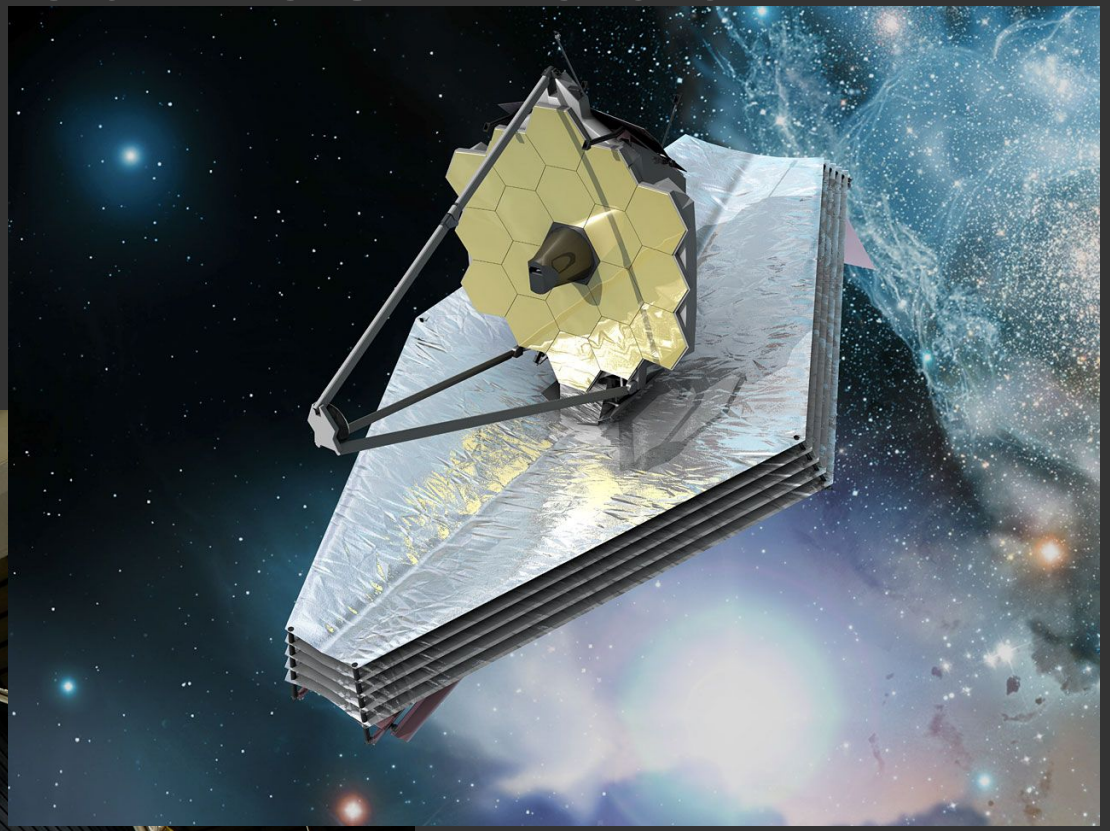
ELT (ESO)

42m



TMT Telescope

Telescópio James Webb



www.wikipedia.org
www.eso.org
www.nasa.gov
www.stsci.edu
www.sdss.org

http://newt.phys.unsw.edu.au/~mgb
http://www.darkenergysurvey.org/
http://vigitek.biz/advanced-optical-design/
http://hyperphysics.phy-astr.gsu.edu/
http://www.astro.caltech.edu/~george/ay127/Ay127_LSS.pdf
http://ecuip.lib.uchicago.edu/multiwavelength-astronomy/astrophysics/05.html