RUMOBSERVATORIER

Version II

Jørgen Valentin Enkelund

RUMOBSERVATORIER - HUBBLE

RUMOBSERVATORIER

- Hubble opsendelse og konstruktion
- Instrumenter
- Billeddannelse
- Reparationer og forbedringer
- Resultater med kommentarer
- GOODS
- JWST
- Resume

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Opsendt den 24. April 1990 med rumfærgen Discovery

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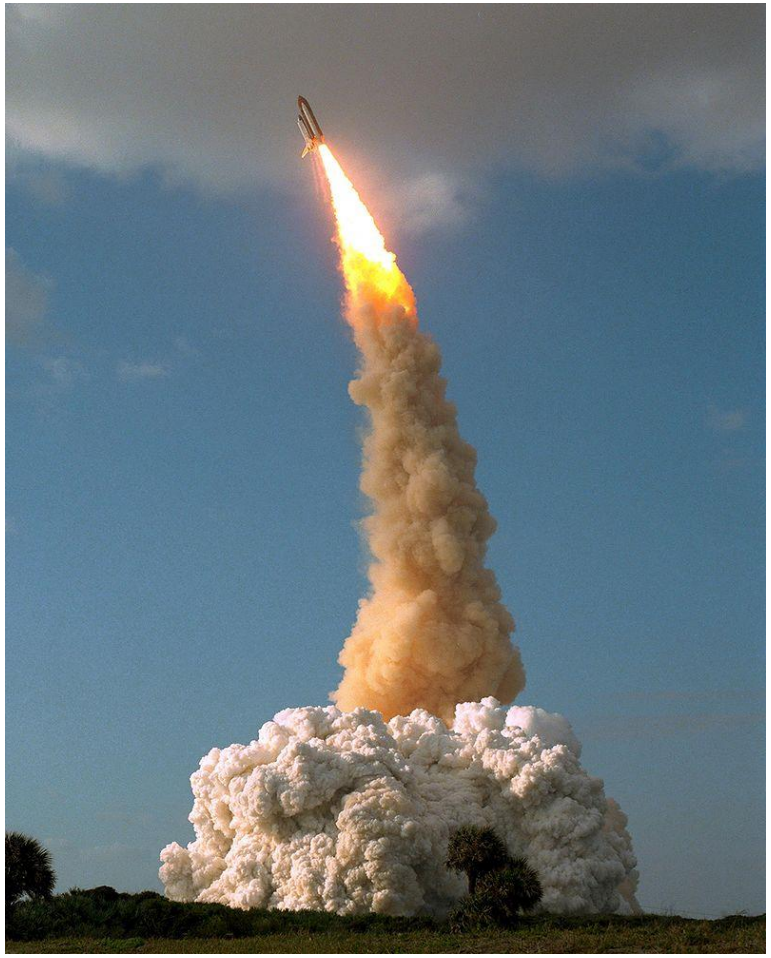

Omkostninger frem til afsendelsestidspunkt: 1,5 milliarder USD

Oprindelige budget i 1972 var 300 millioner USD

Omkostningerne efter servicebesøg og nye instrumenter var i 2009 ca. 9 milliarder USD

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Frigivet fra lastrummet den
25. April 1990

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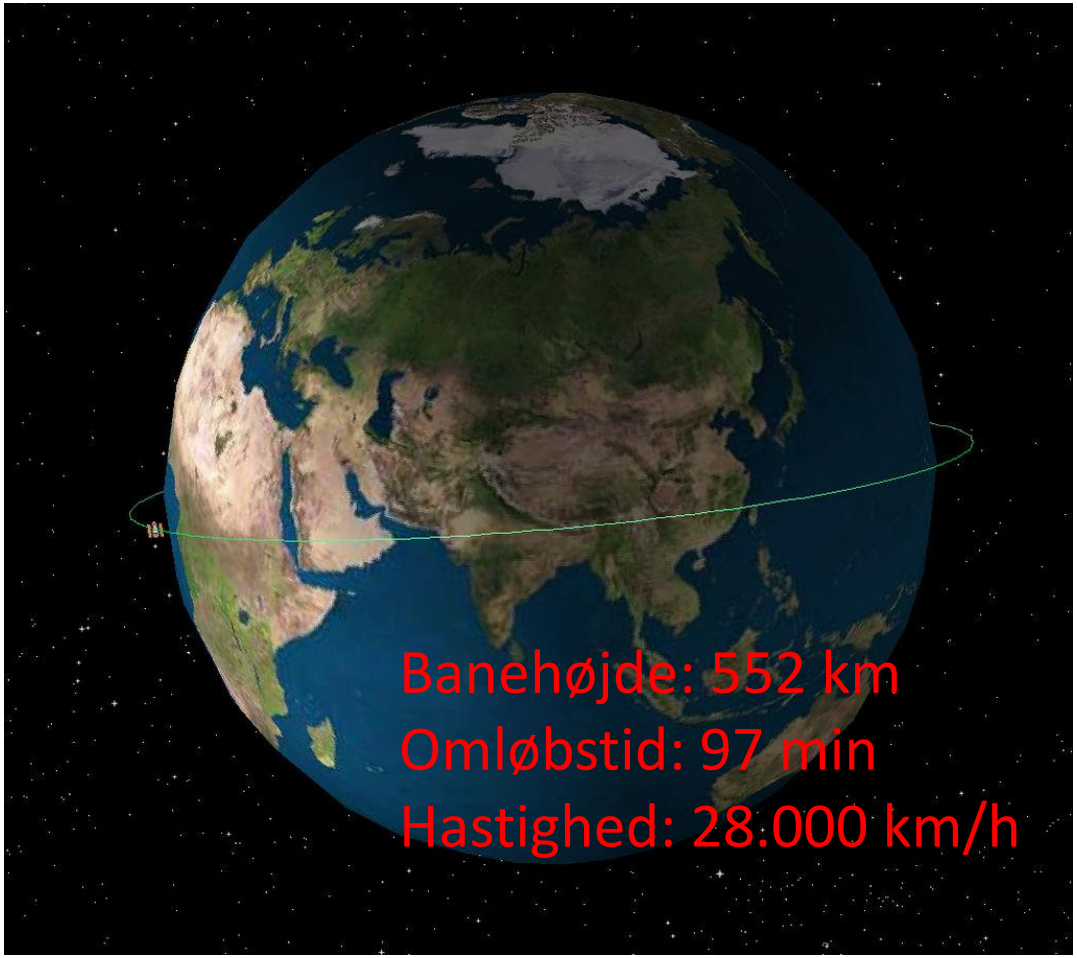

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Længde: 13,2 m
Vægt: 11.110 kg
Max. diameter: 4,2 m
Strømforbrug: 2.800 W
Tracking præcision: 7/1000 buesekund
Udvendig temperatur: -101 til +93°C

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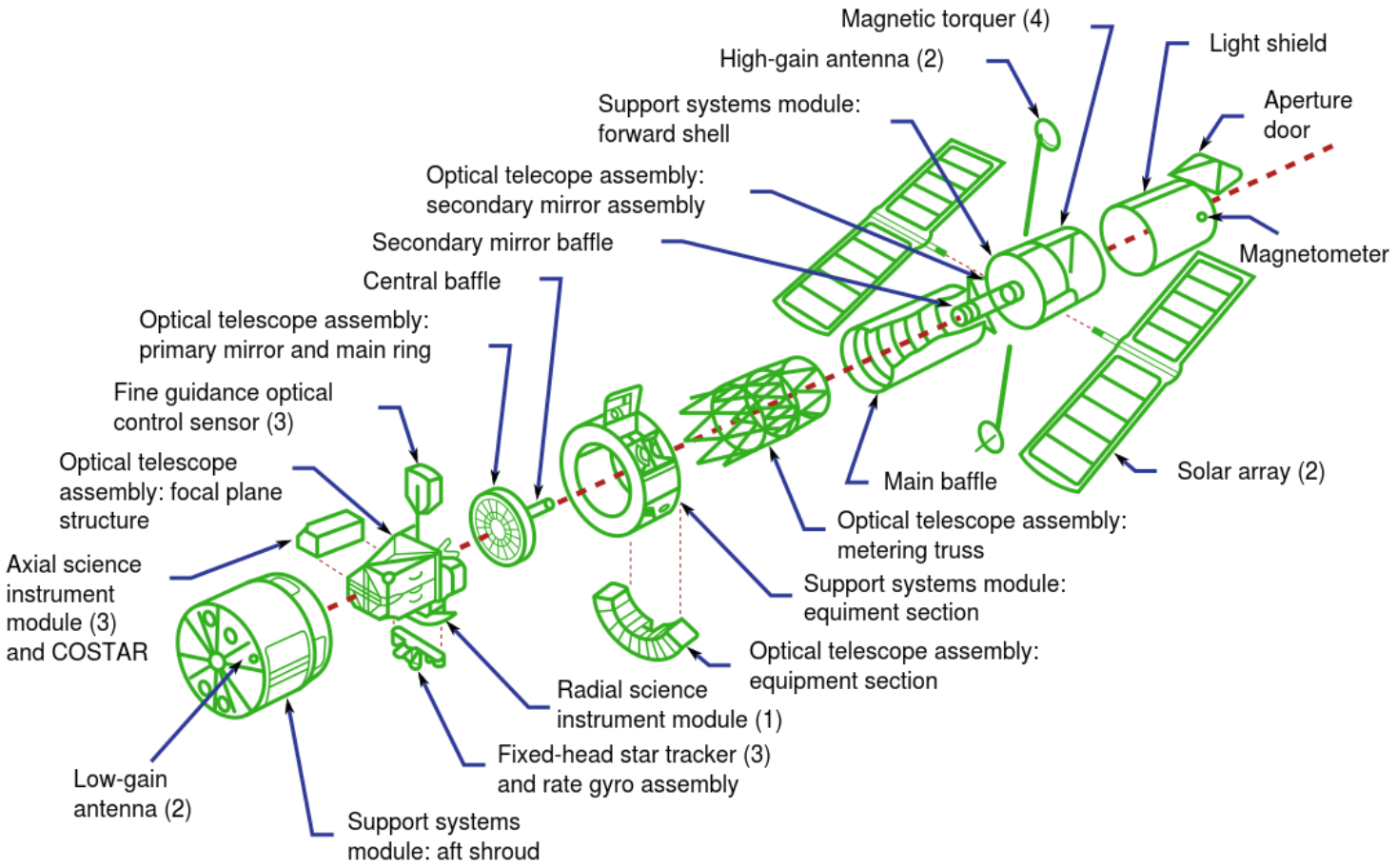
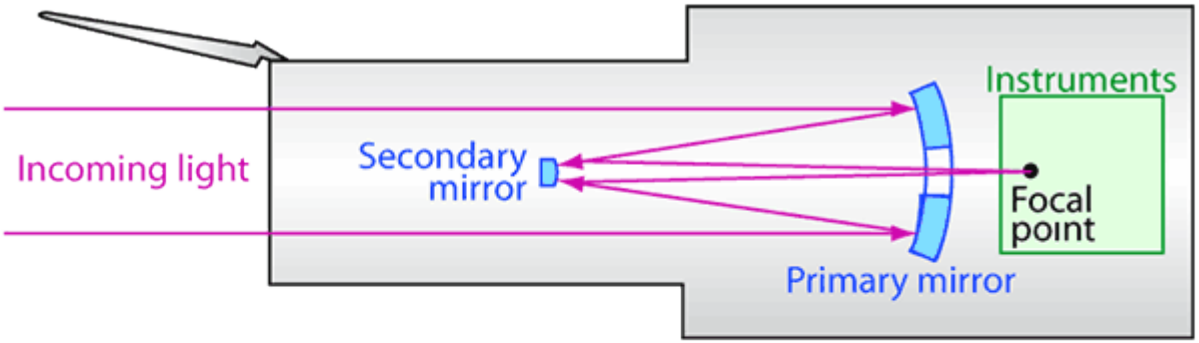
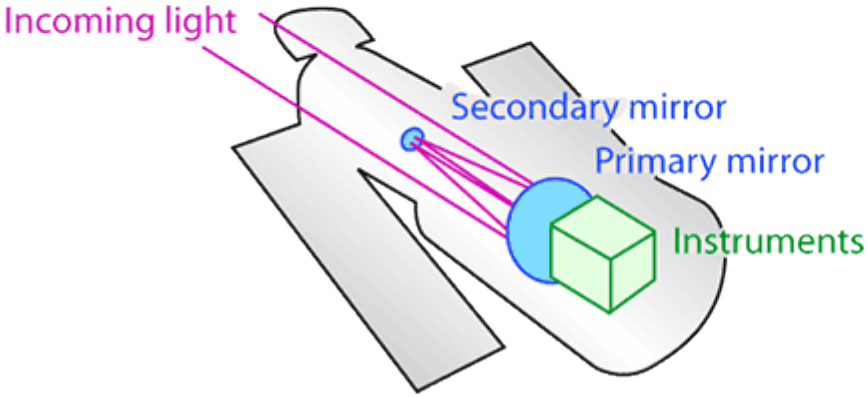


RUMOBSERVATORIER - HUBBLE





Teleskopet er af Ritchie-Crétien Cassegrain typen
Fokal længde 57,6m
F-forhold = 24

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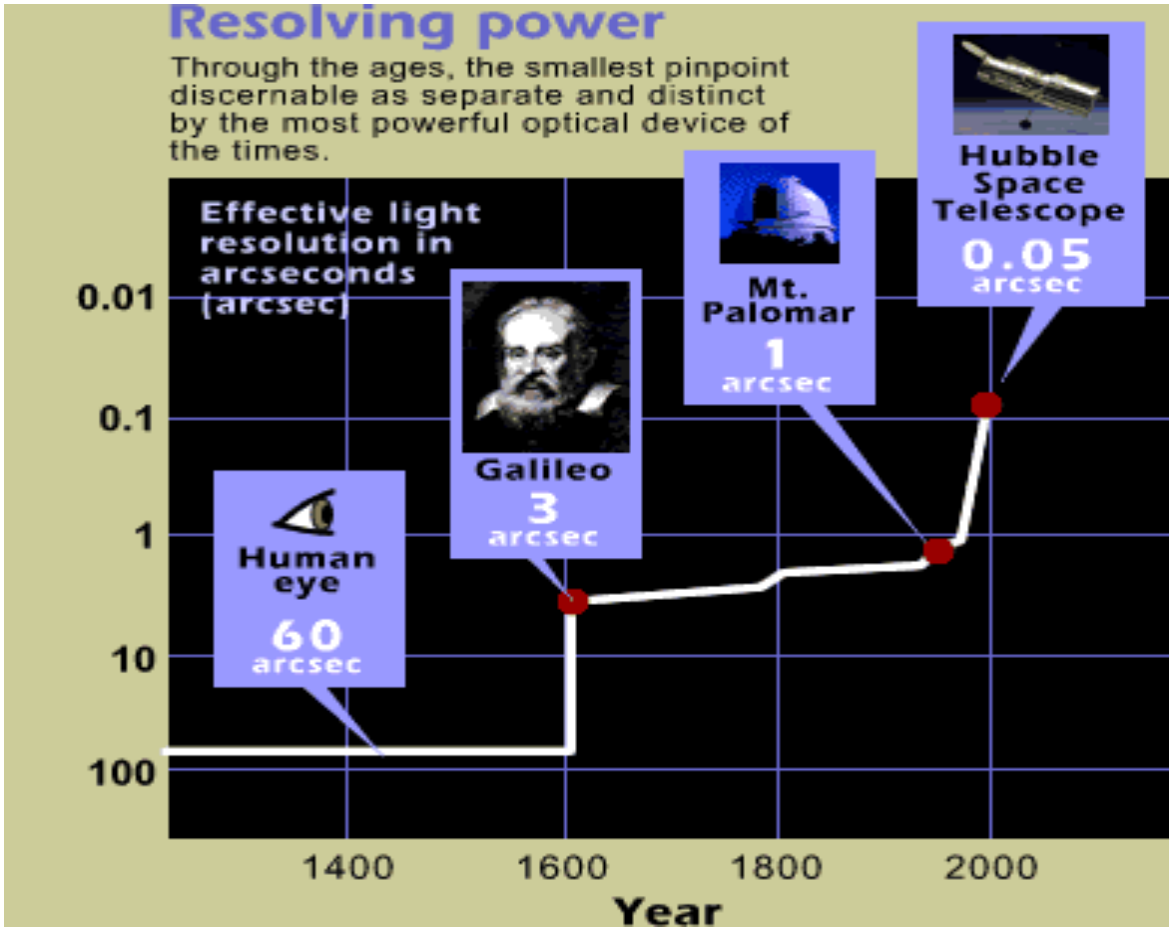
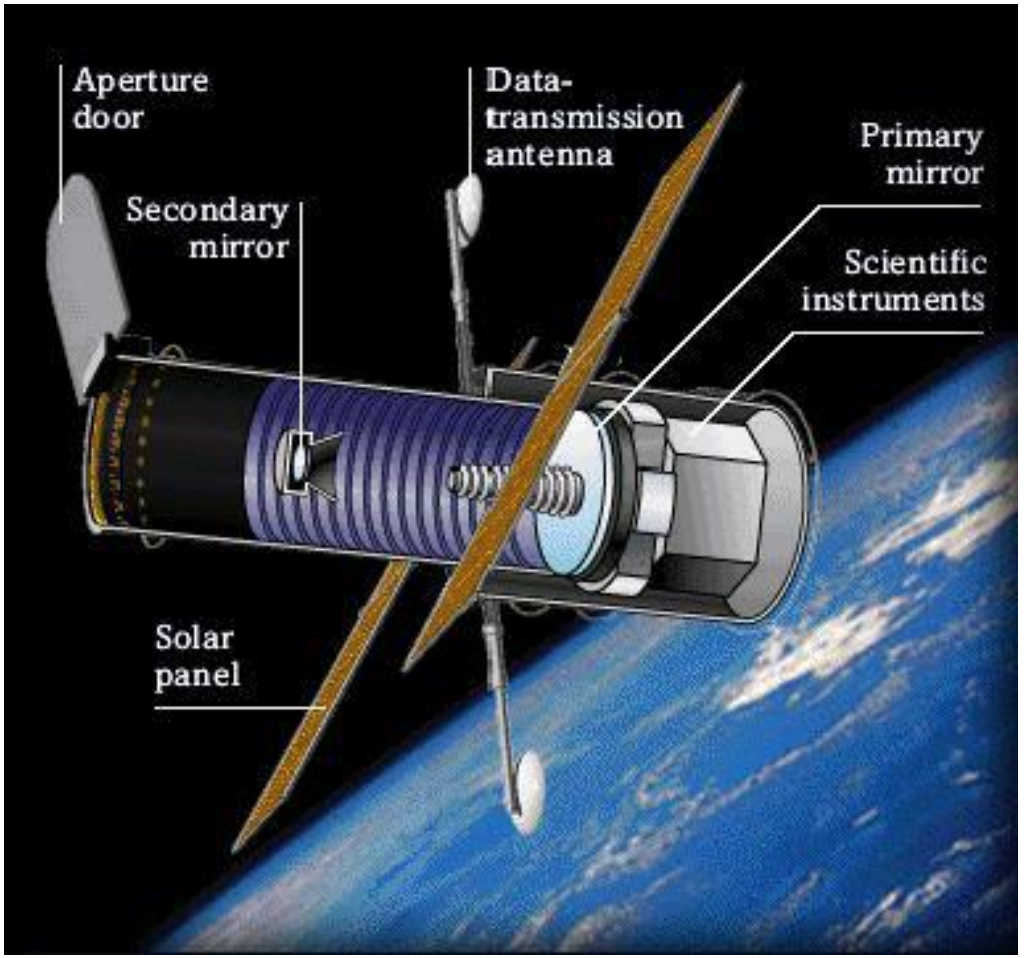


RUMOBSERVATORIER - HUBBLE



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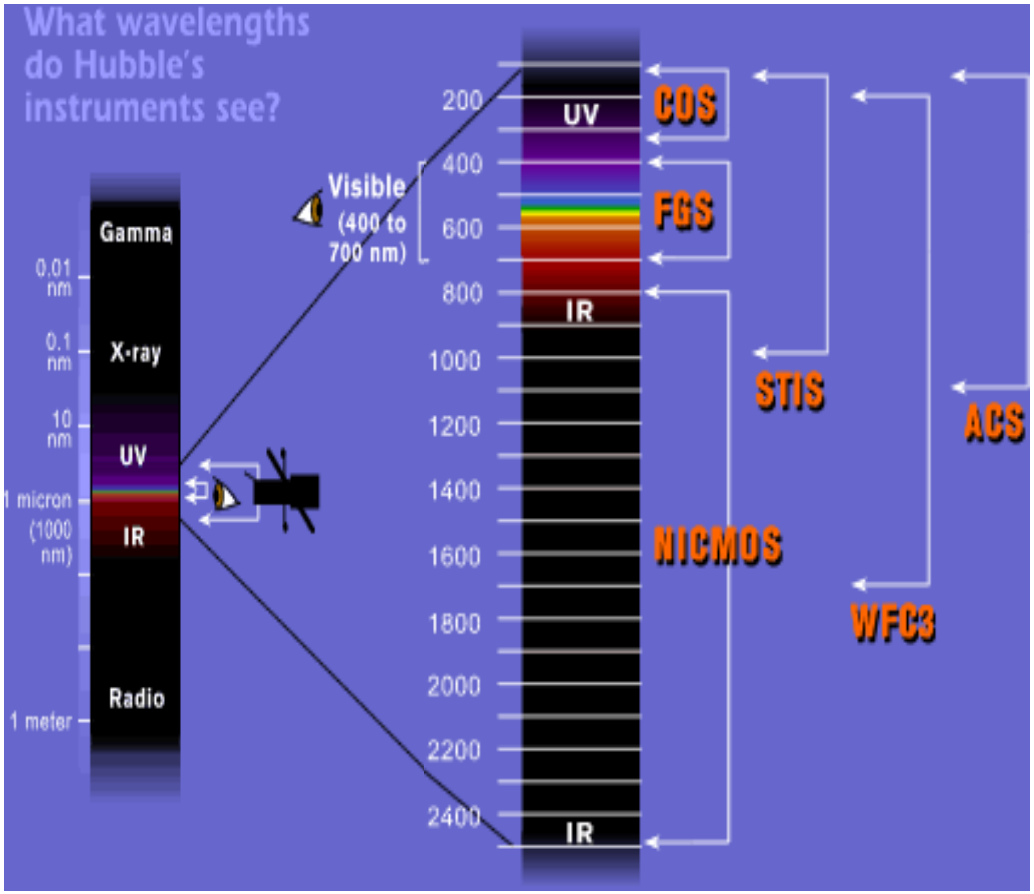
- Instrumenterne dækker fra UV til infrarødt (115 – 2500 nm)



COS – Cosmic Origin Spectrograph

FGS – Fine Guidance Sensors

NICMOS – Near Infrared Camera and Multi Object Spectrometer

STIS – Space Telescope Imging Spectrograph

WFC3 – Wide Field Camera 3

ACS – Advanced Camera for Survey

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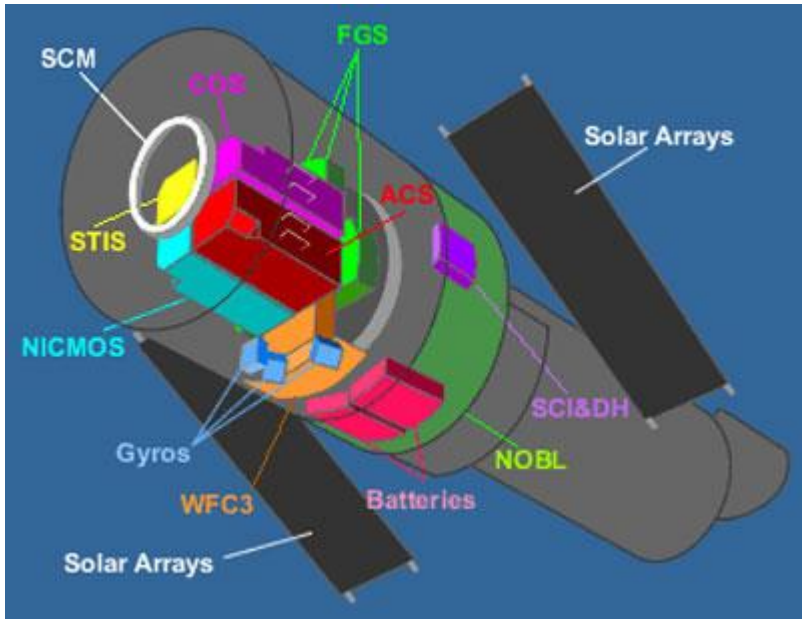
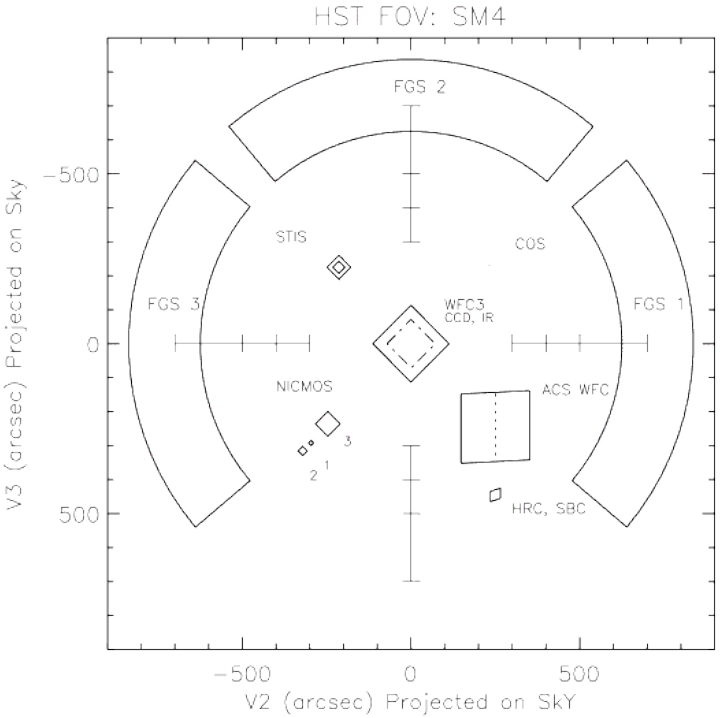


Videnskabelige instrumenter og tilbehør

Fokusplan med instrument udtag



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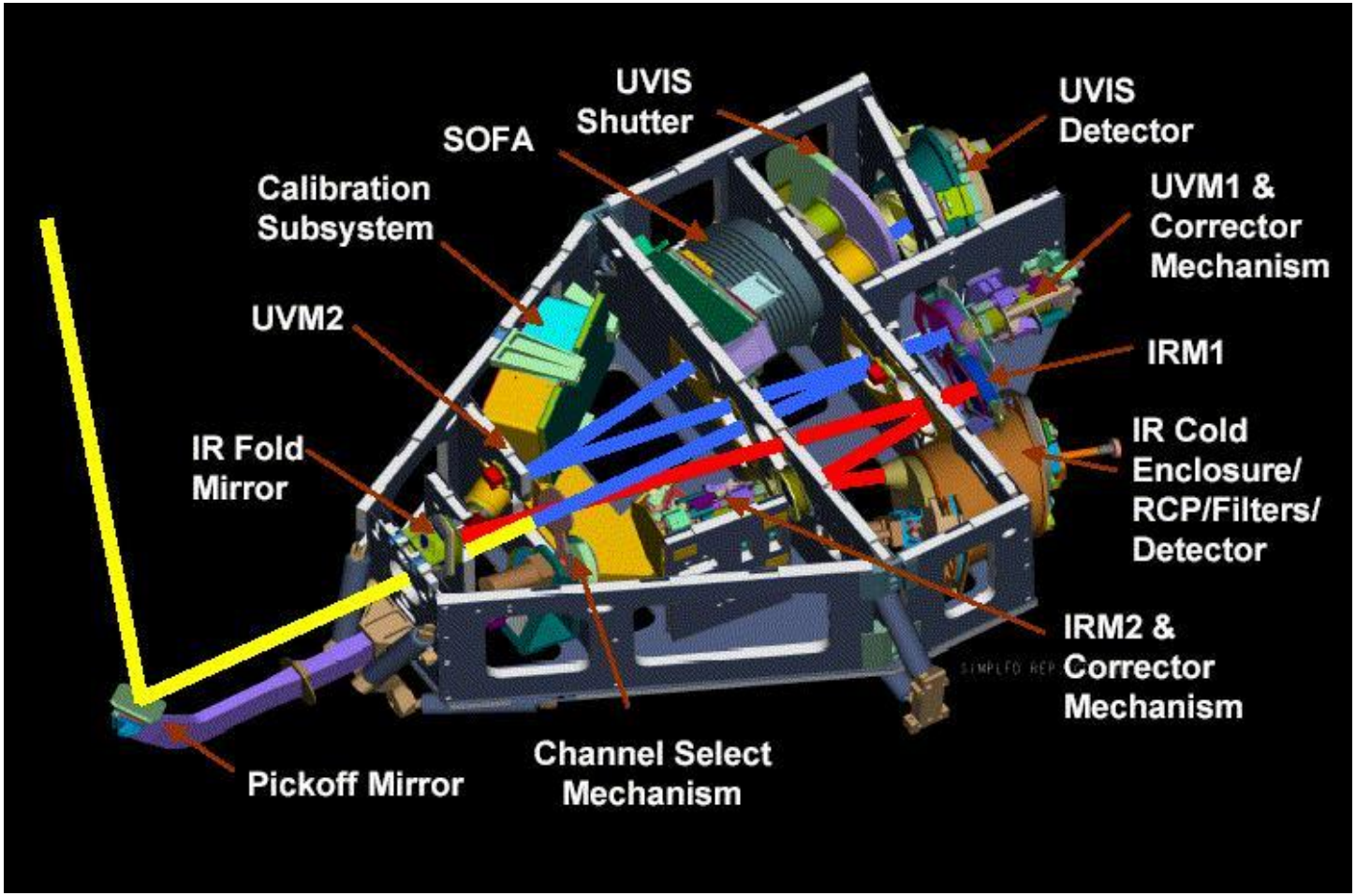
- WFC3 – skematisk



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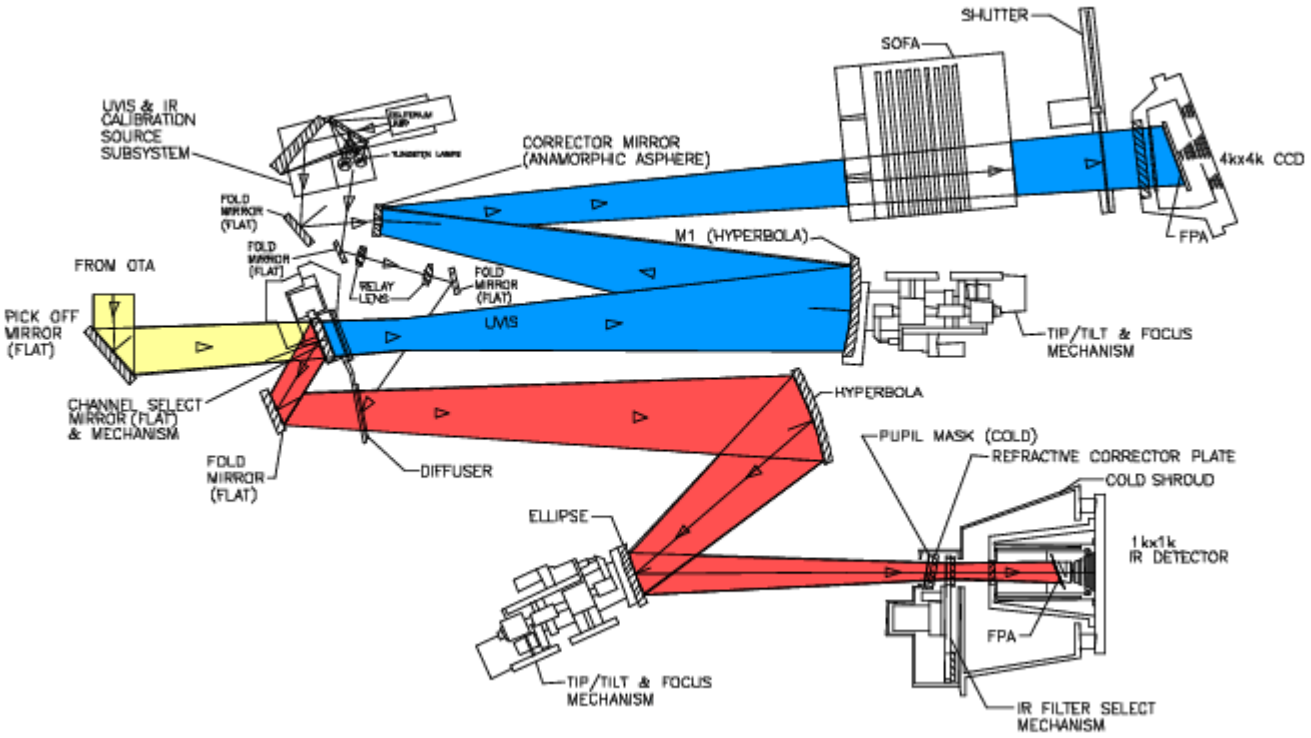
- WFC3 – dobbelt lysvej med fokusenheder og filtre



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- WFC3 -Filterenheder

UVVIS – 48 filtre fra SOFA
(Selectable Optical Filter Assembly)

IR – filterhjul med 17 filtre + 1 tom

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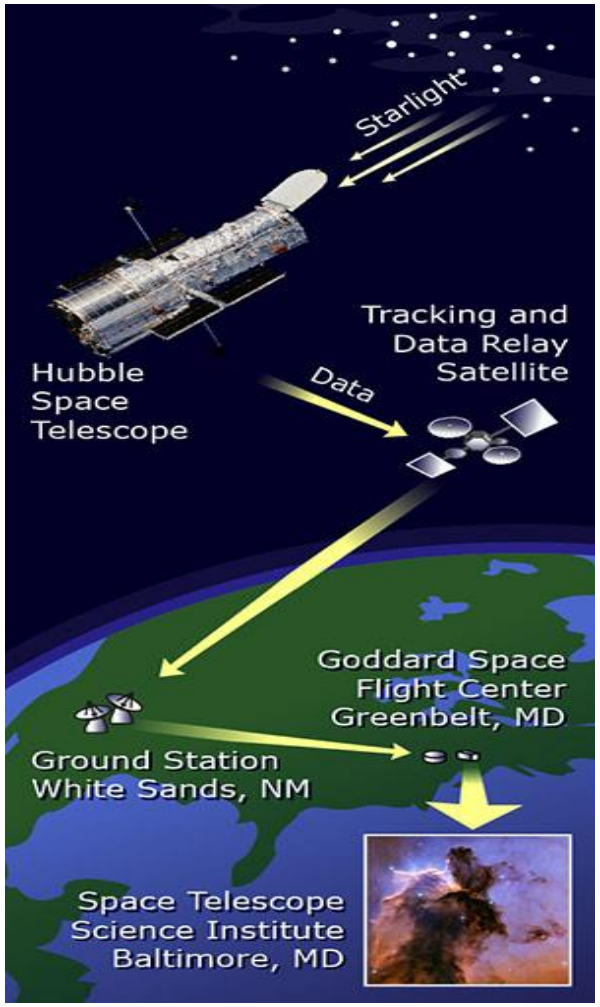

Datamængde pr. måned
ca. 600 gigabytes

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- Billeddannelse – en kombination af videnskab og billedkunst

1. Data kalibreres, så man fjerner digitale fejl, og spor fra kosmisk stråling fjernes ved at kombinere to identiske optagelser og fjerne differencen
2. Billeder fra samme bølgelængdeområde sammenstykkes og stakkes, så der opnås et 8-bits billede (2^8 = 256 farvenuancer)
3. Mindst tre 8-bits billeder (RGB) samles til et 24-bits billede (2^{24} = 16,7 mio. farvenuancer)

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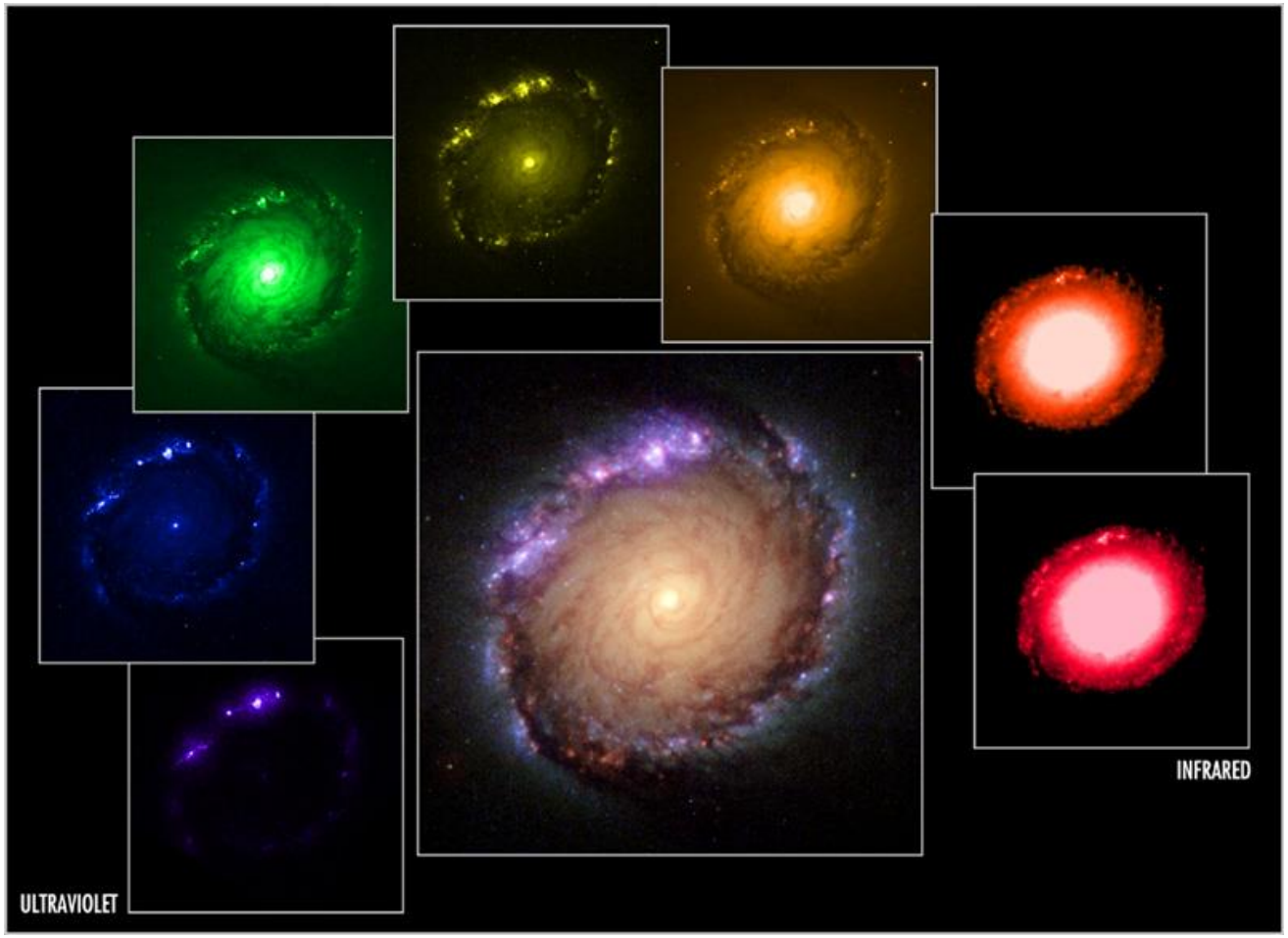

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- Video - Sådan foregår det i praksis

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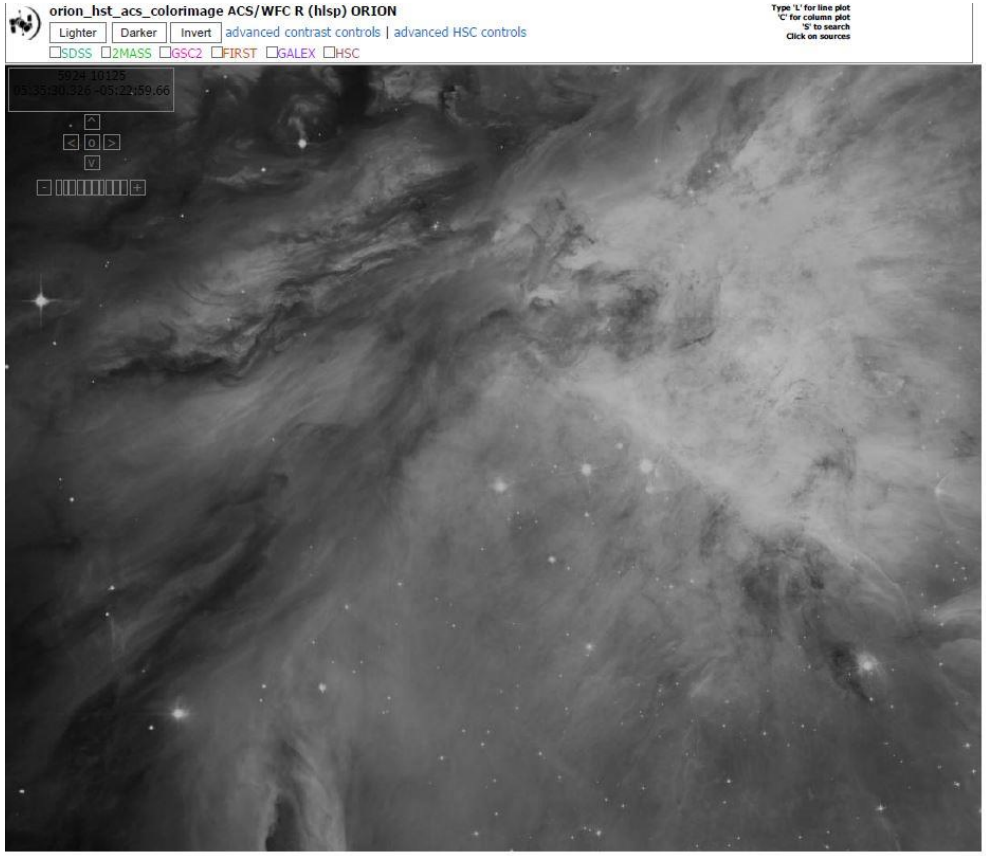
- Her kan du selv prøve det med data fra Hubble

http://hla.stsci.edu/hlaview.html

Et eksempel på et downloadet billede af M42 i rødt lys vises her



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Forskellige typer af fejl er blevet rettet under missionen
Der har været 5 service besøg fra 1993 til 2009

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- Servicebesøg

1993 – SM 1:
Wide Field Planetarium Camera 2 (WFPC 2) installeres
Corrective Optics Space Telescope Axial Replacement (COSTAR) installeres
Gyroer, solfangere og magnetometer repareres

1997 – SM 2:
Fine Guidance Sensors (FSG)
Space Telescope Imaging Spectograph (STIS)
Near Infrared Camera and Multi Object Spectrometer (NICMOS)
Solid State Recorder (SSR)

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Reparation af elforsyning

Udskiftning af wide field camera

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- Servicebesøg

1999 – SM 3a:
Gyroer og FGS serviceres
Computer udskiftes
S-band transmitter
SSR

2002 – SM 3b:
Advanced Camera for Surveys (ACS) erstatter WFPC 2
Solpaneler skiftes
Ny strøm kontrol enhed installeres
Nyt kølesystem til NICMOS til opretholdelse af - 196°C

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- Video af SM 3b

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- Servicebesøg

2009 – SM 4:

Wide Field Camera 3 installeres
Cosmic Origins Spectograph (COS) som er UV følsomt installeres
Batterier, FGS, STIS og ACS repareres
Nyt styresystem til instrument og datahåndtering installeres

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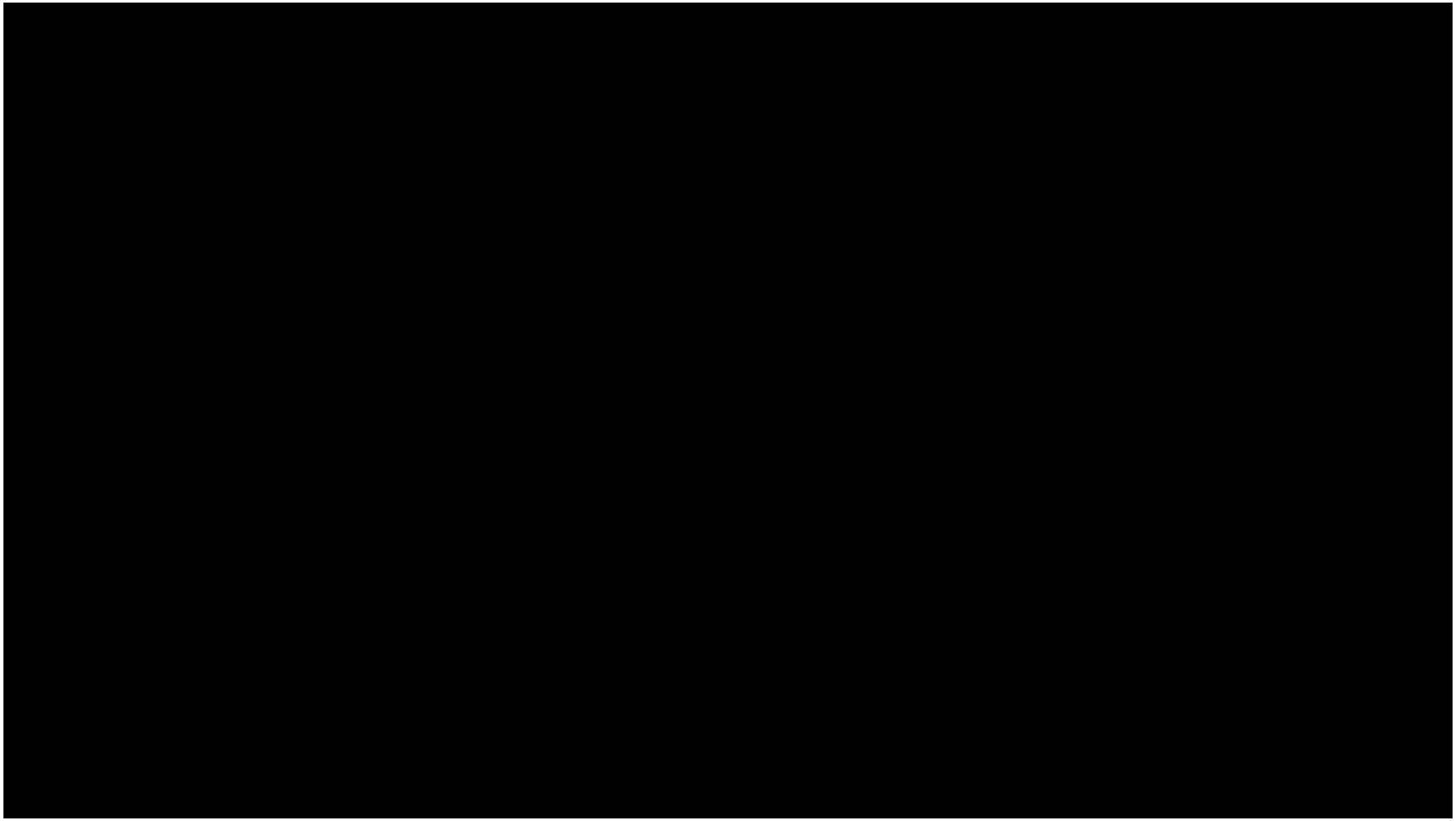
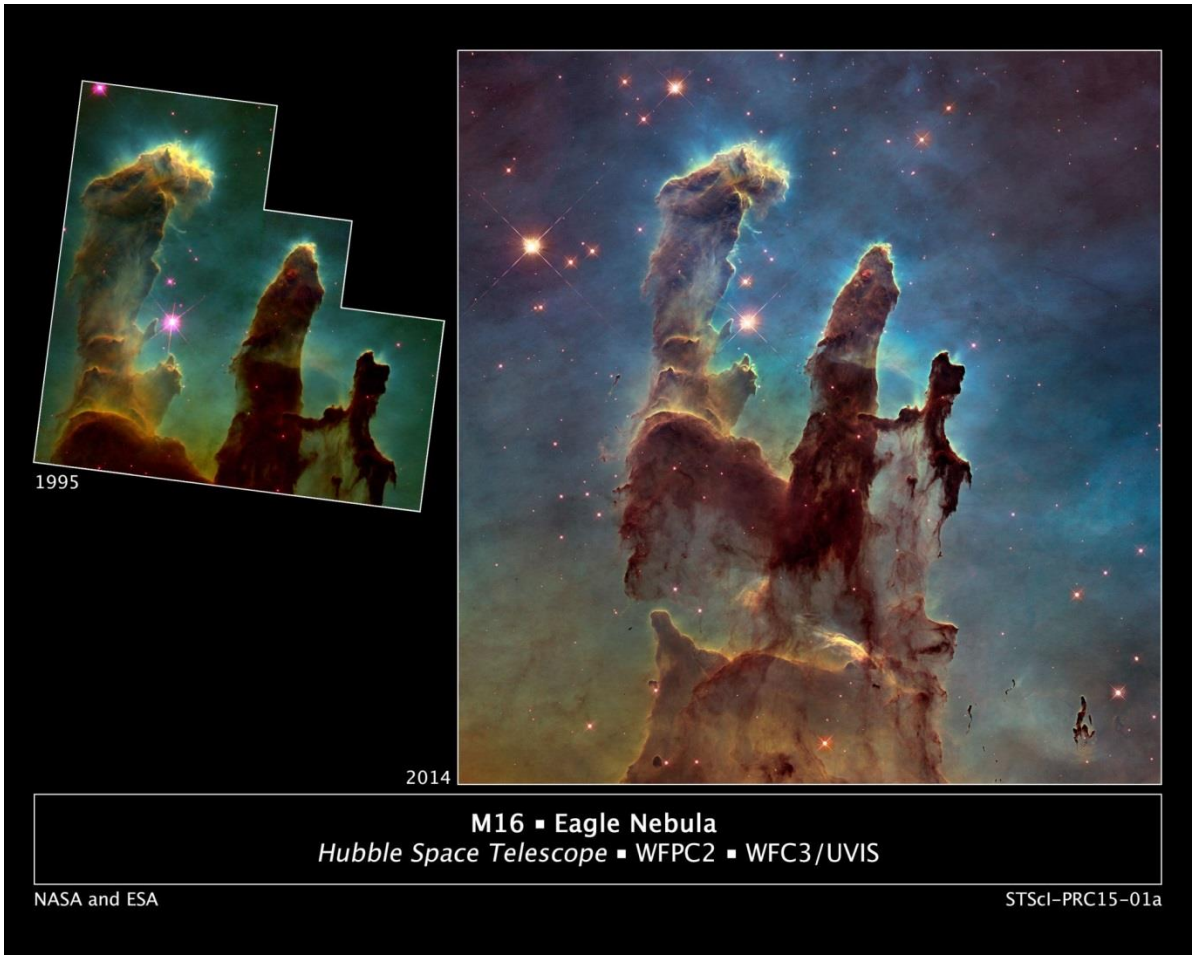
- Video af SM 4



RUMOBSERVATORIER - HUBBLE



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- ARBEJDSOPGAVER

1. Afstandsmåling i rummet
2. Planeter og måner i vort solsystem
3. Stjernedannelse og planetdannelse
4. Stjernespektre
5. Stjernedød
6. Observationer ved forskellige bølgelængder
7. Galakser i alle stadier
8. Universet - alder og udvidelse

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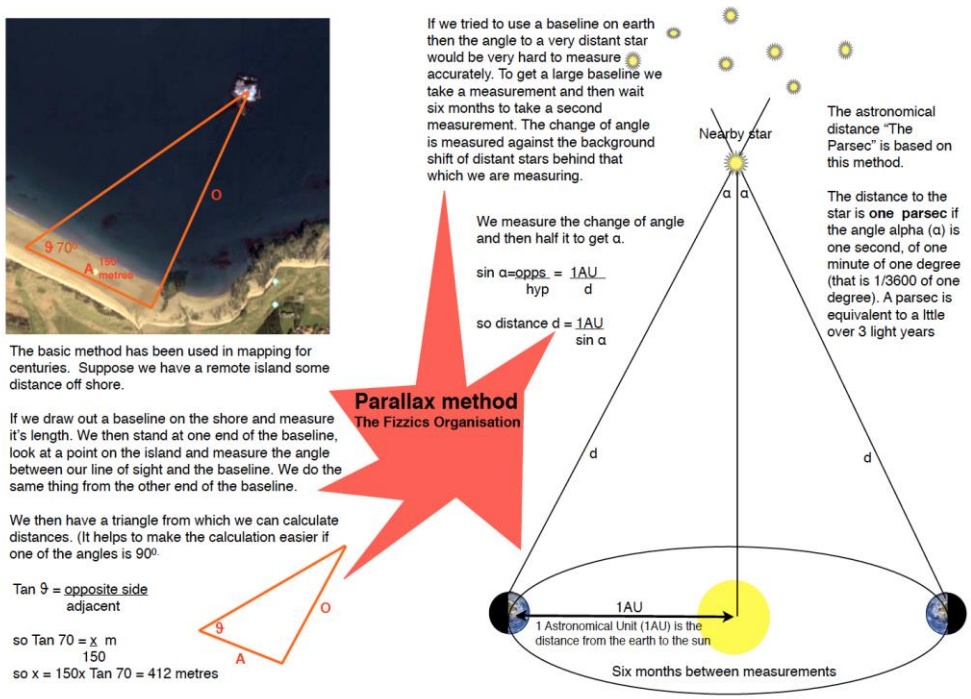
1. Afstandsmåling i rummet

- Parallakse metoden



Det nye WFC 3 kamera kan arbejde med en præcision på 20-40 mikro buesekunder.

Kan således ved parallakse metoden måle afstande op til 5.000 pc, svarende til ca. 17.000 lysår

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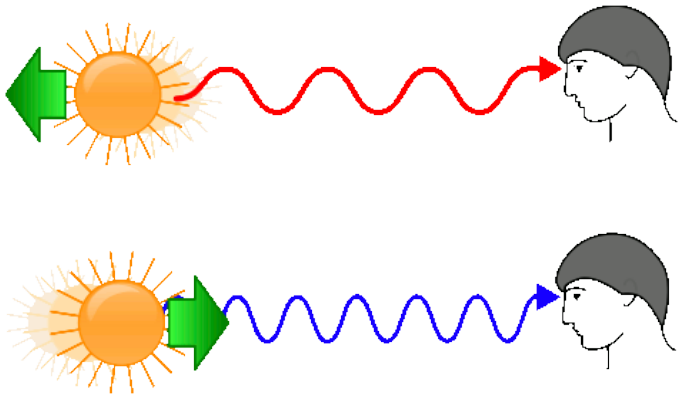
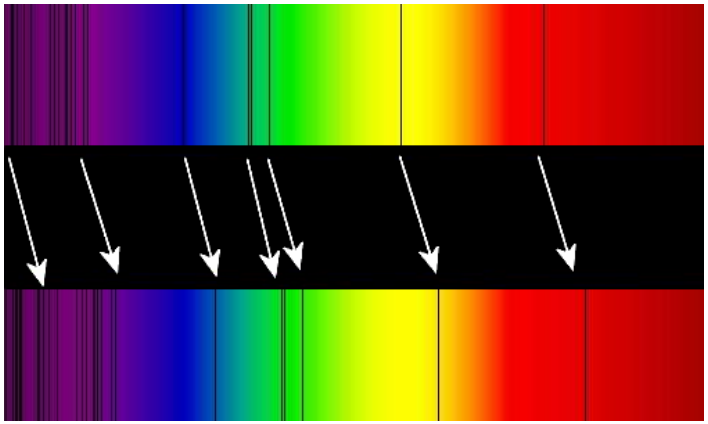
- Rødforskydning





Rødforskydningen $Z = \lambda_{obs} - \lambda_o / \lambda_o = \Delta\lambda / \lambda_o$

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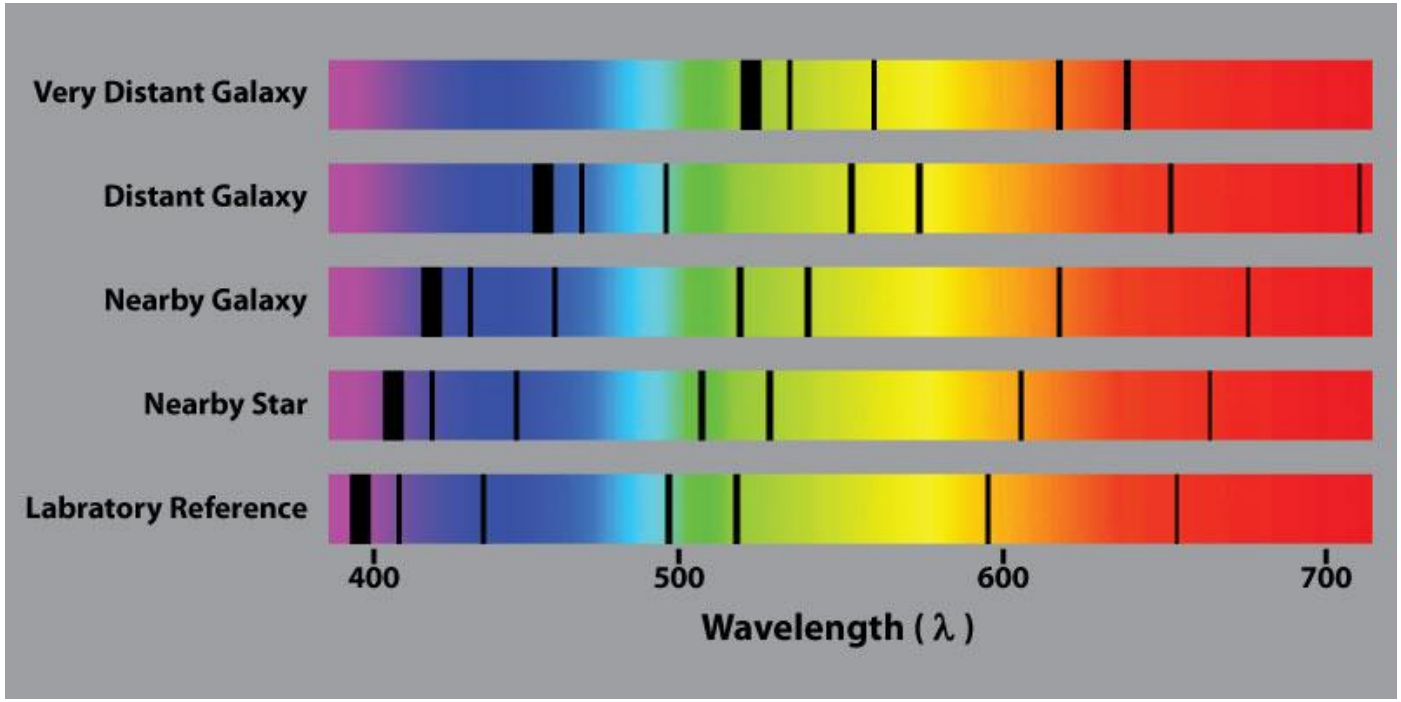
- Rødforskydning



Rødforskydningen $Z = \lambda_{obs} - \lambda_o / \lambda_o = \Delta\lambda / \lambda_o$

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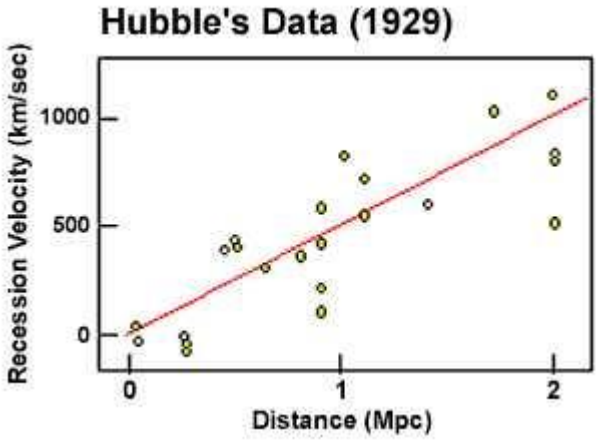
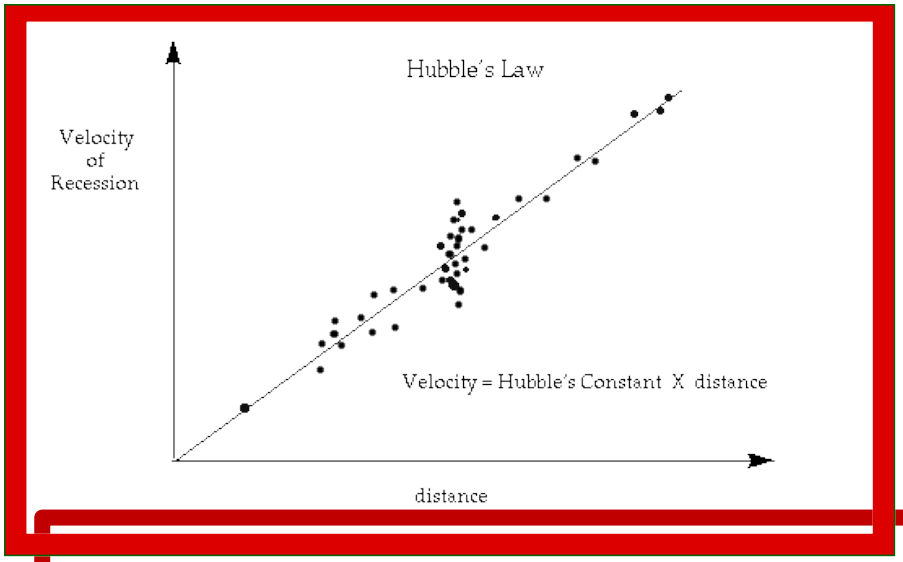
- Hubbles lov

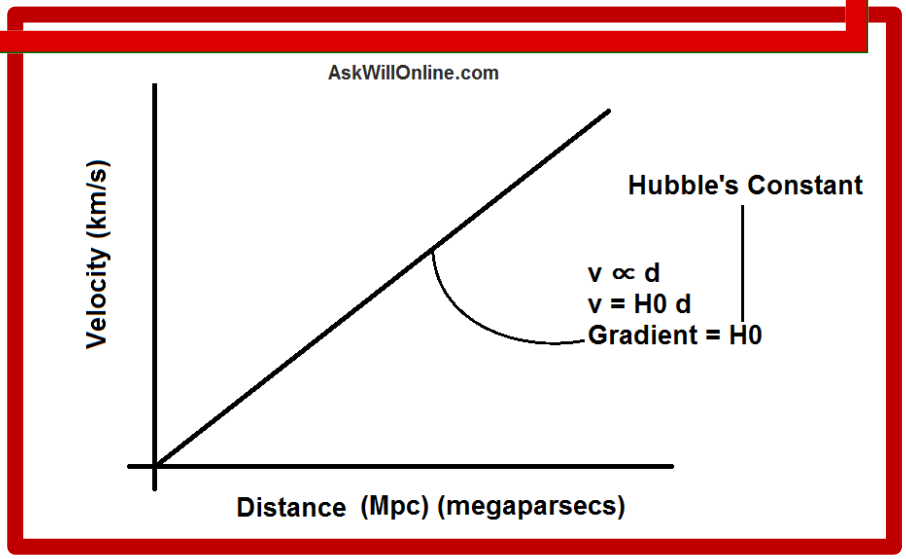
$$\underline{v = H * d}$$

v = Hastighed – km/sec
H = Hubble parameter – (km/sec)/Mpc
d = Afstand - Mpc



RUMOBSERVATORIER - HUBBLE





<u>Hubble parameteren gennem tiden</u>

1929 (Hubble) – 500

2010 målinger – 70,8 ± 1,6

2011 (Hubble) – 72,8 ± 2,2

<u>For kosmologisk, ikke relativistisk rødforskydning gælder:</u>

$z = v / c = H * d / c \leftrightarrow$
$d = z * c / H$
hvor c er lysets hastighed

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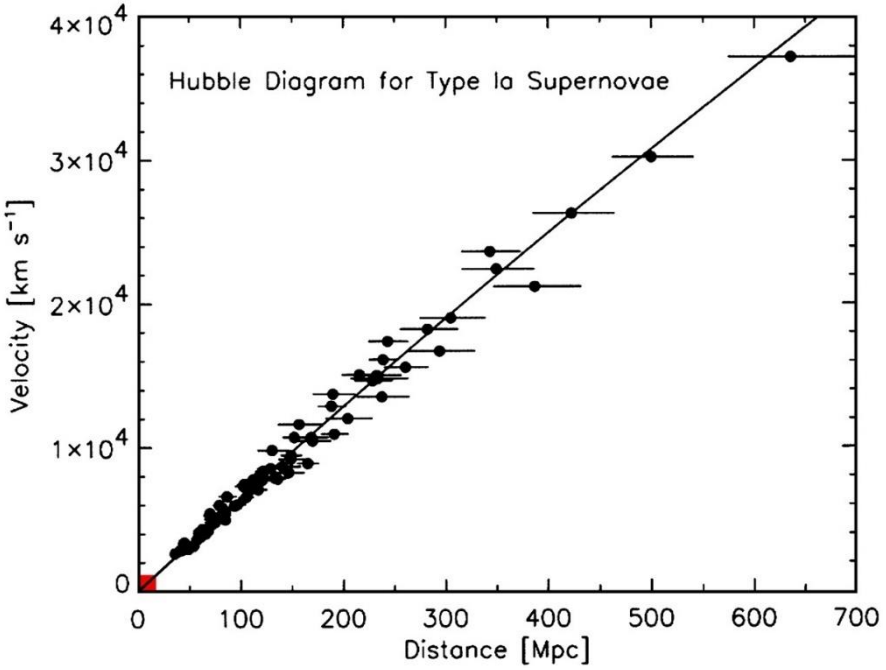
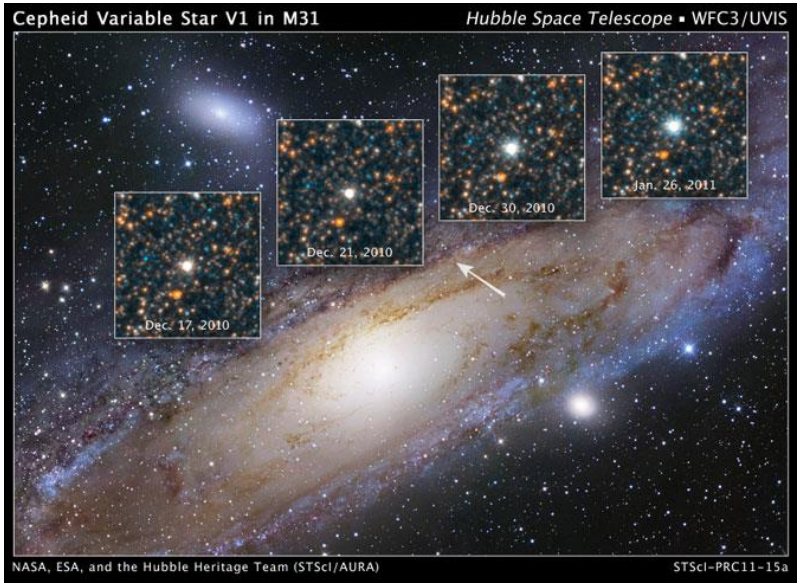
- Afstandsmåling med standard candle





Afstands kvadrat loven: $l = L / 4 \pi d^2 \leftrightarrow d = \sqrt{\frac{L}{4 \pi l}}$ hvor d = afstand, L = udsendt og l = målt flux

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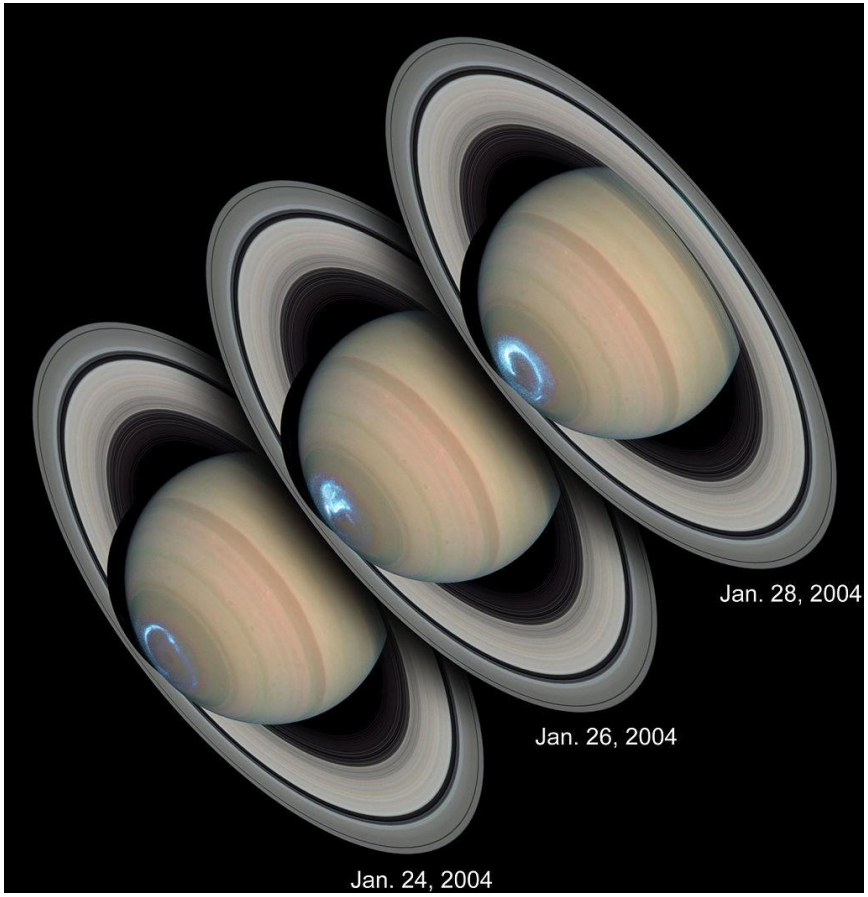
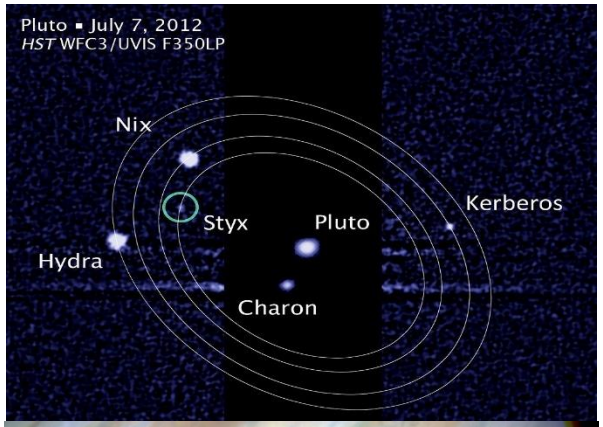
2. Optagelser fra vort solsystem



Finder Plutos fire nye måner



Fotograferer Jupiter efter kollisionen med kometen Shoemaker – Levy 9 i 1994

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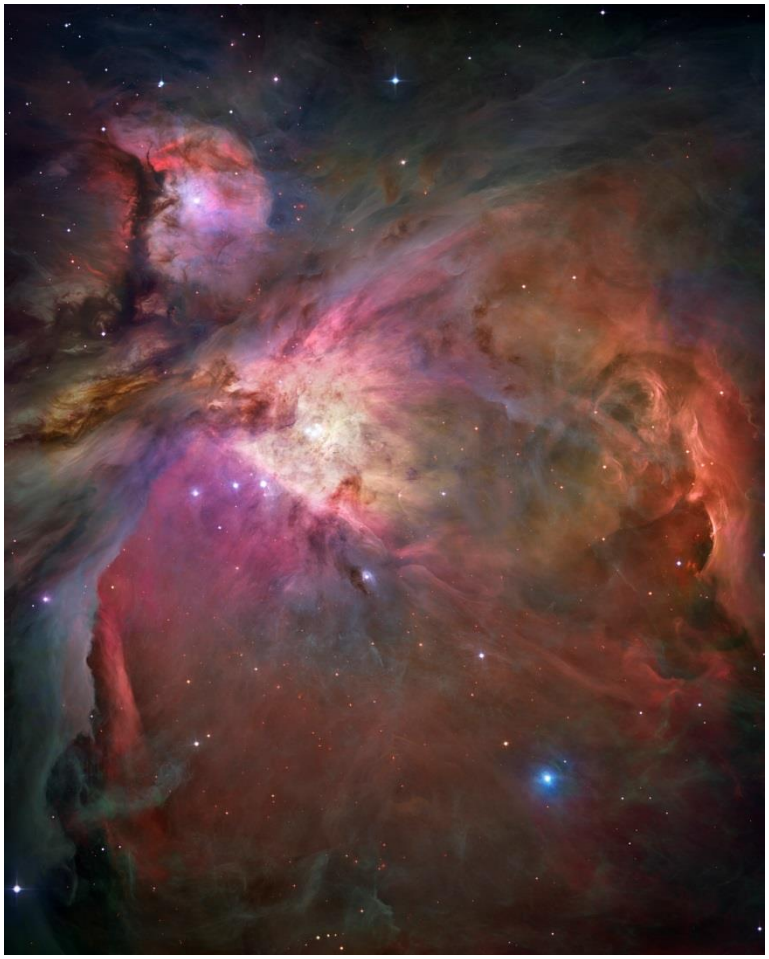
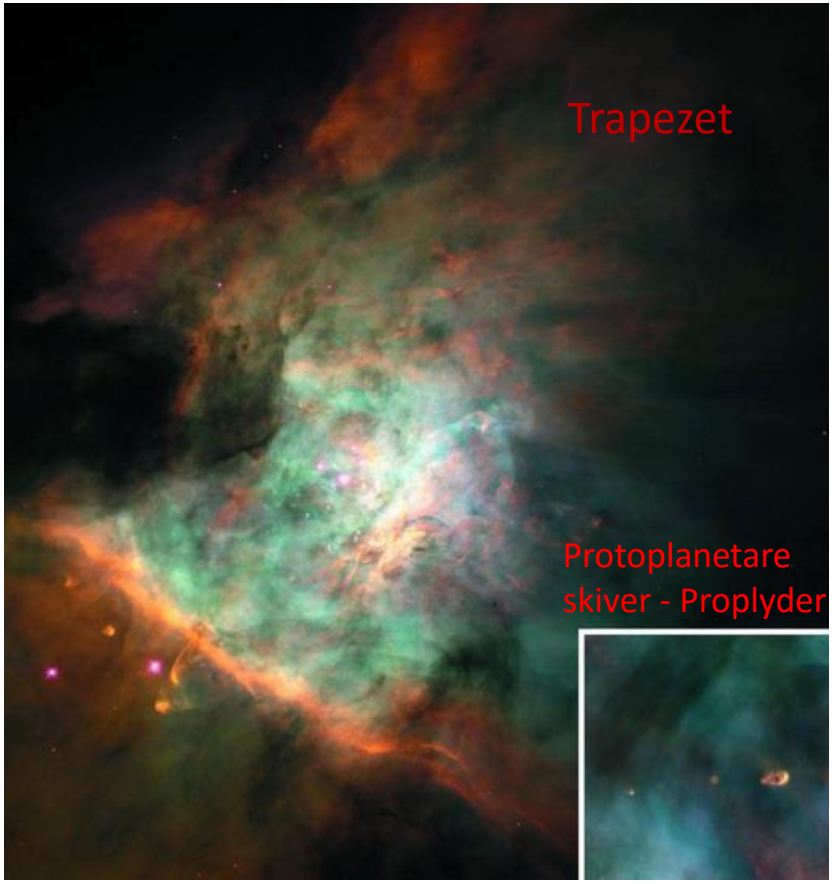
3. Stjernedannelse



Oriontågen M 42 i “Orion”

Emissionståge - molekylesky



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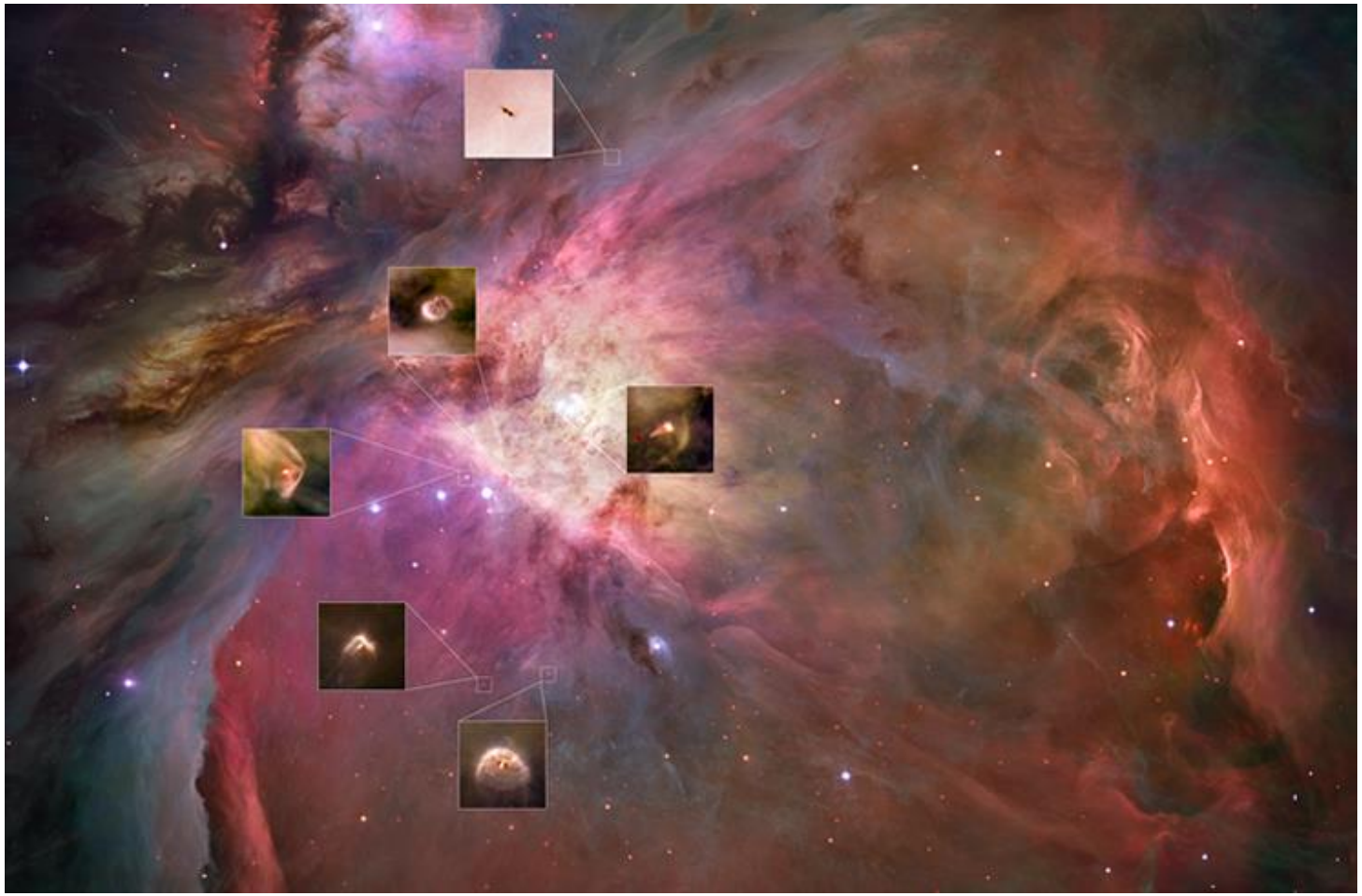

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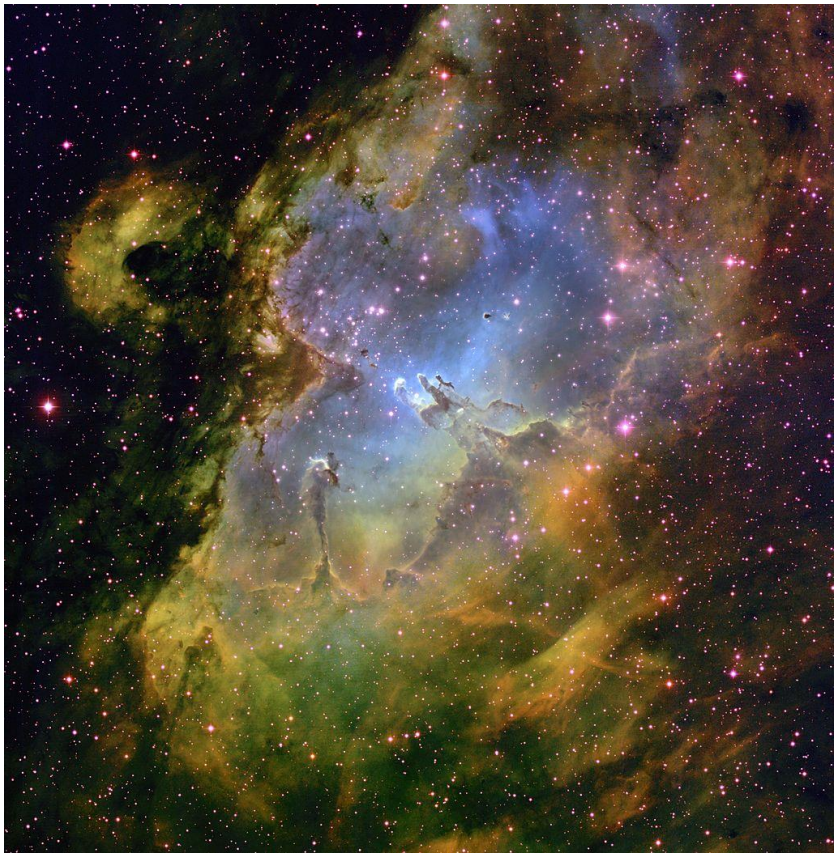
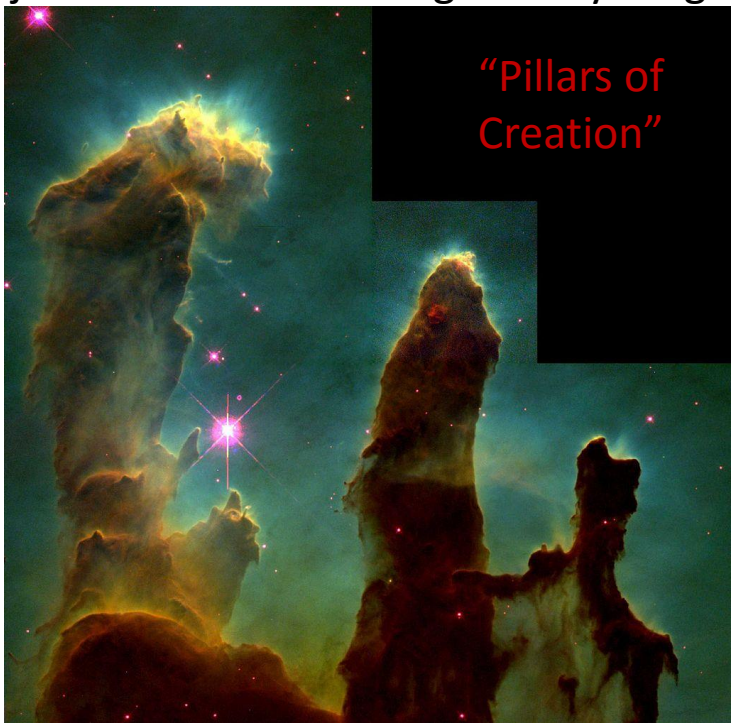
Ørnetågen

Emissionståge i “Slangen”



Søjlerne består af støv og molekylær gas



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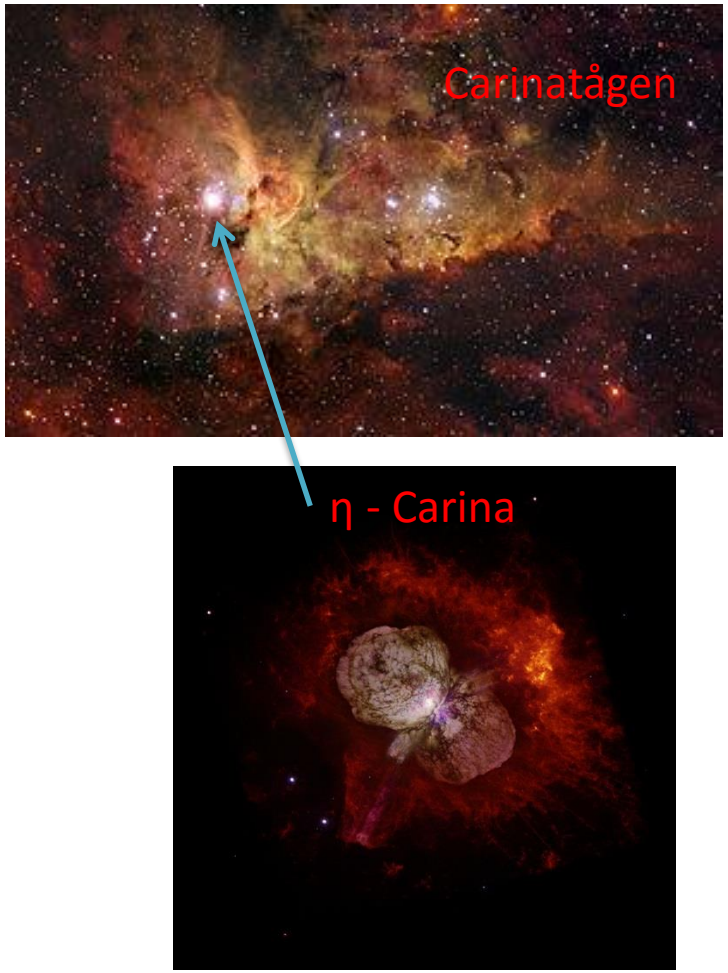
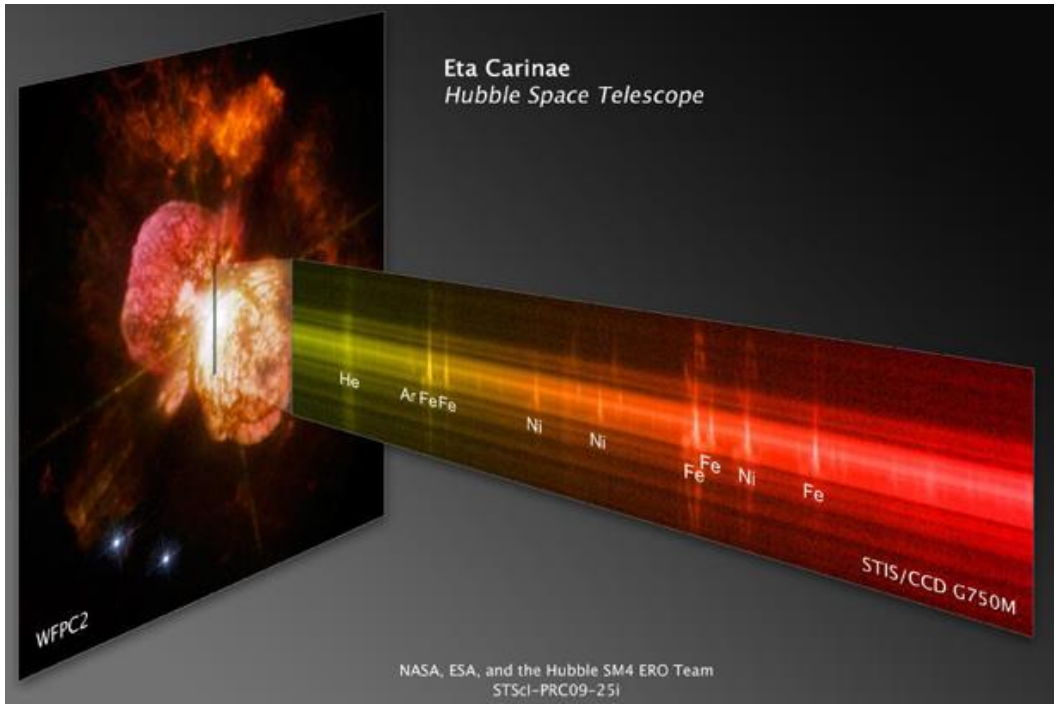
4. Stjernespektre





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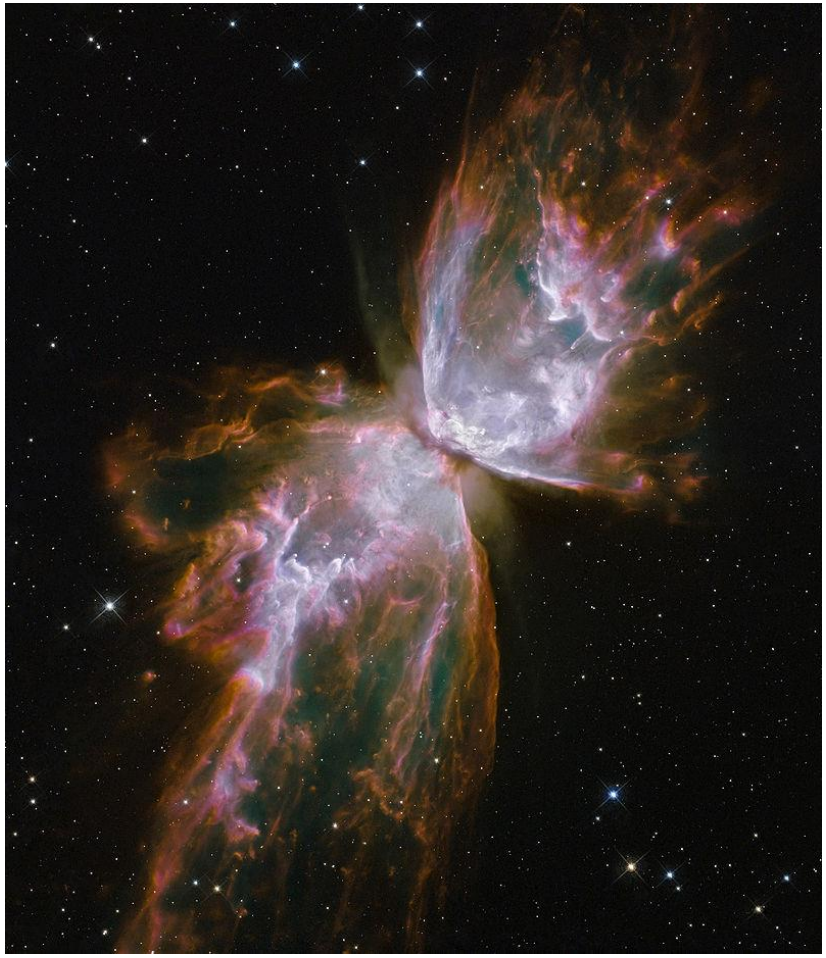
5. Stjernedød



Sommerfugletågen

Planetarisk tåge i “Skorpionen”
Centrum – hvid dværg 220.000 °C
Vinger – plasma 20.000 °C

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6. Observationer ved forskellige bølgelængder

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- Hestehoved tågen

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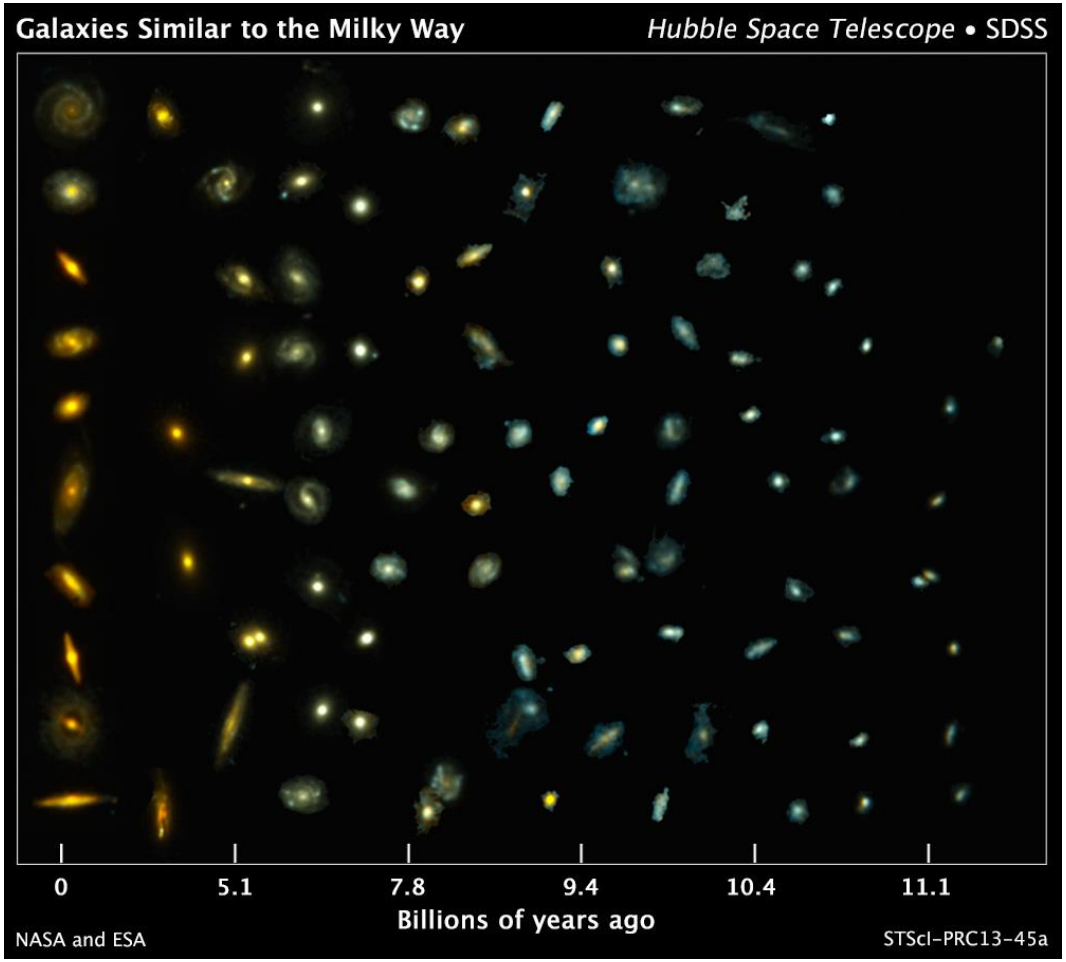
7. Galakser i alle stadier



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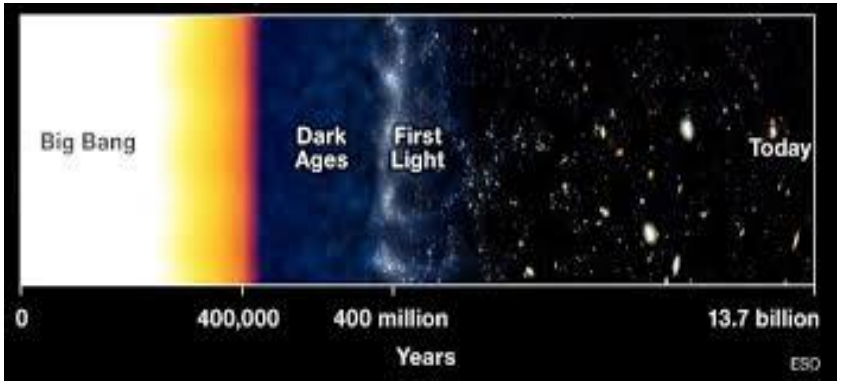
8. Universet – alder og udvidelse



<u>Givet resultater der bidrager til forståelsen af:</u>

- Mørk energi
- Mørkt stof
- Universets udvidelse
- Universets alder

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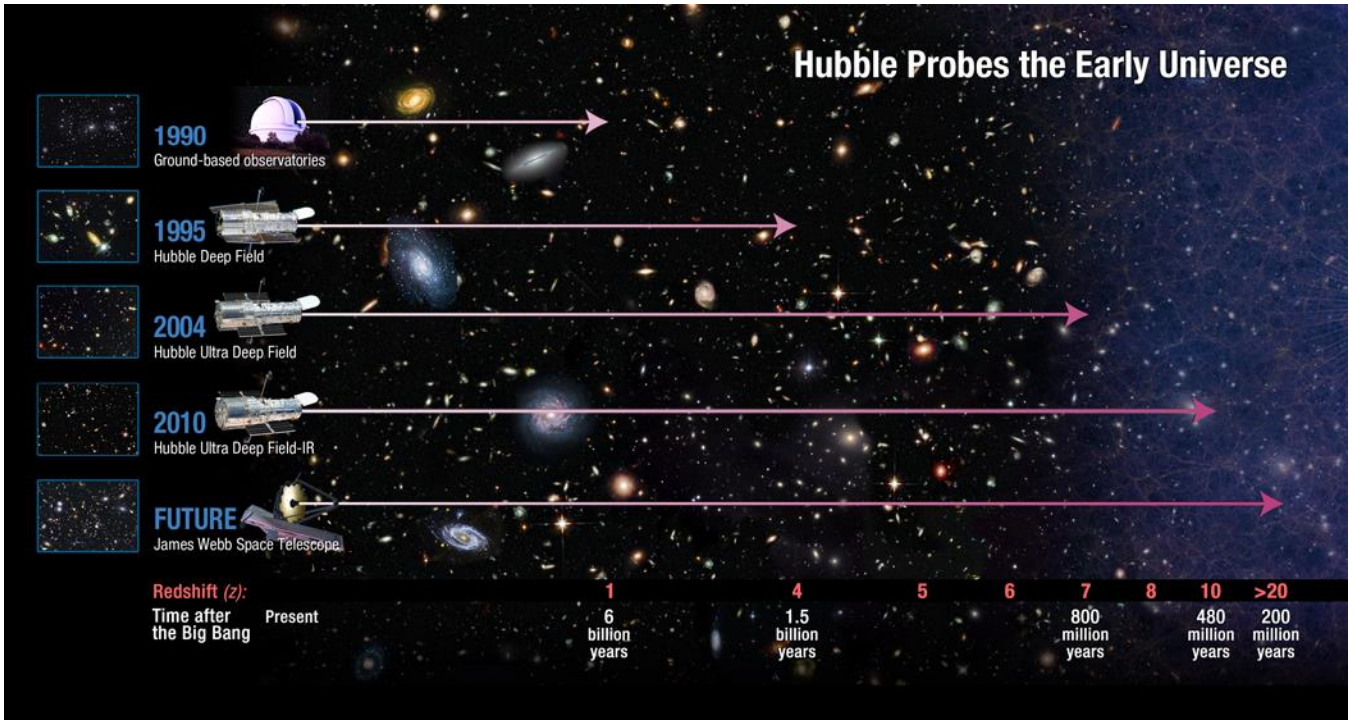

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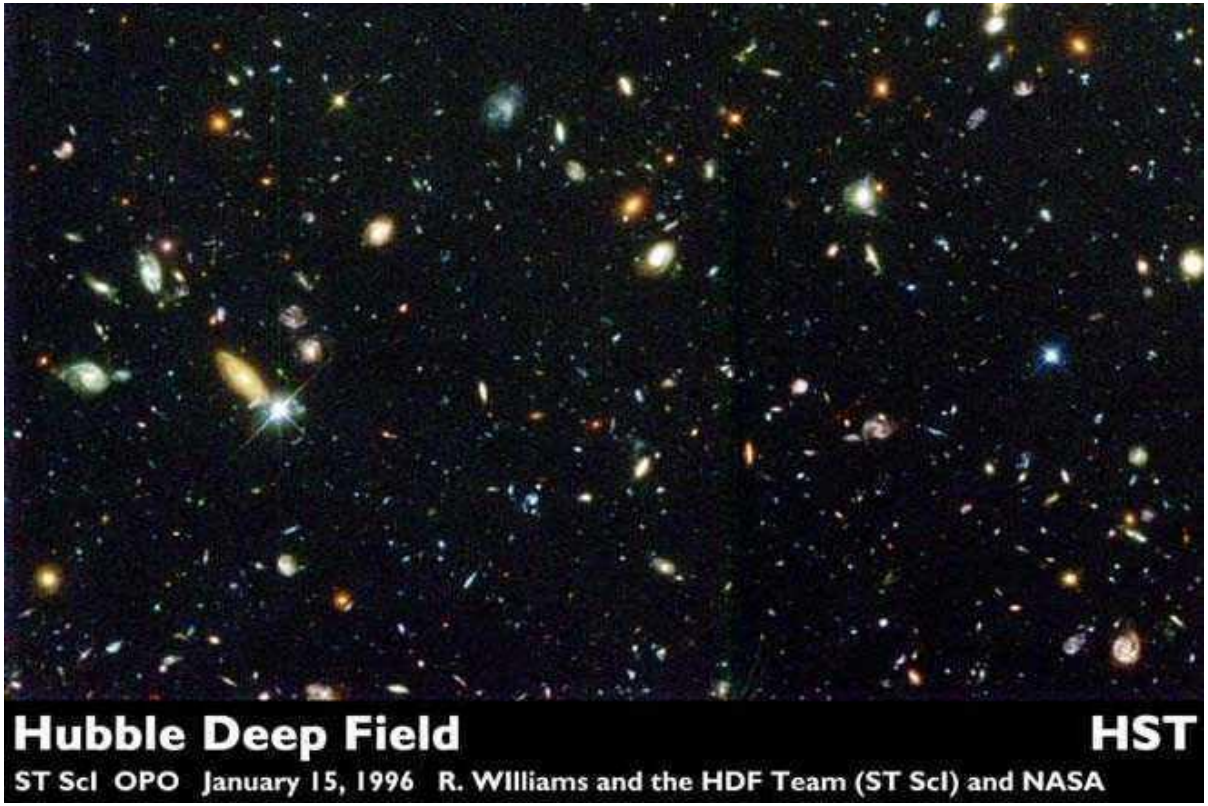
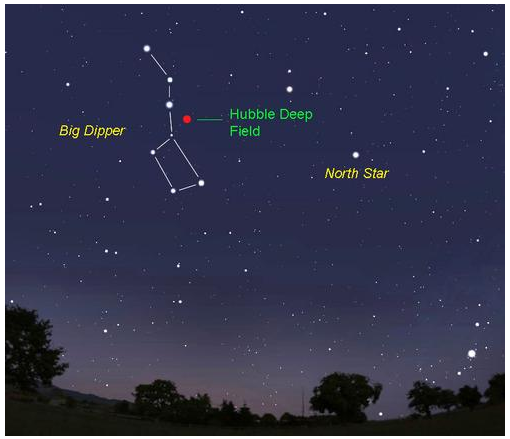


Hubble deep field billede fra 342 enkeltoptagelser med ACS og NICMOS fra d. 18 – 28/12 1995



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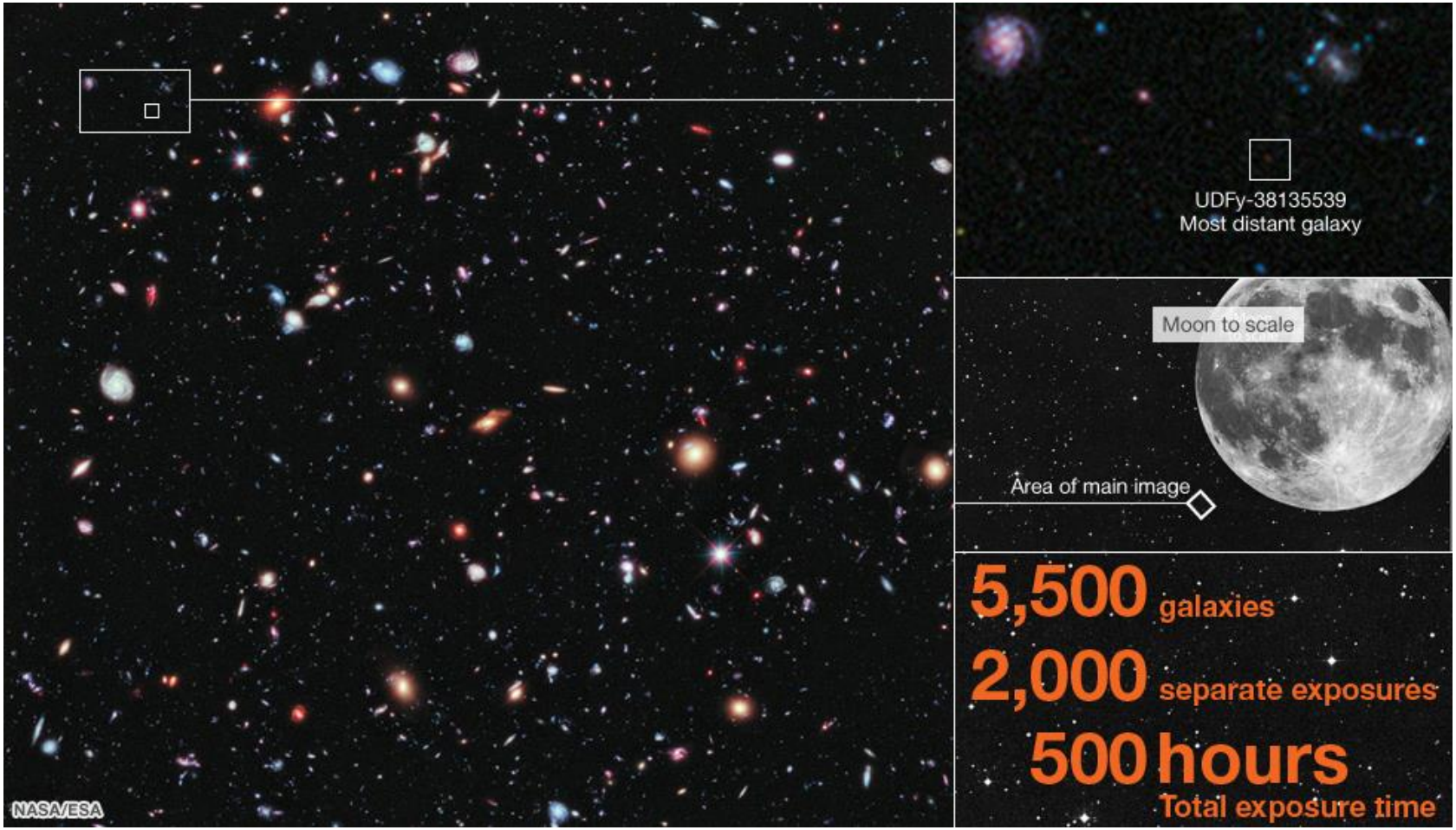
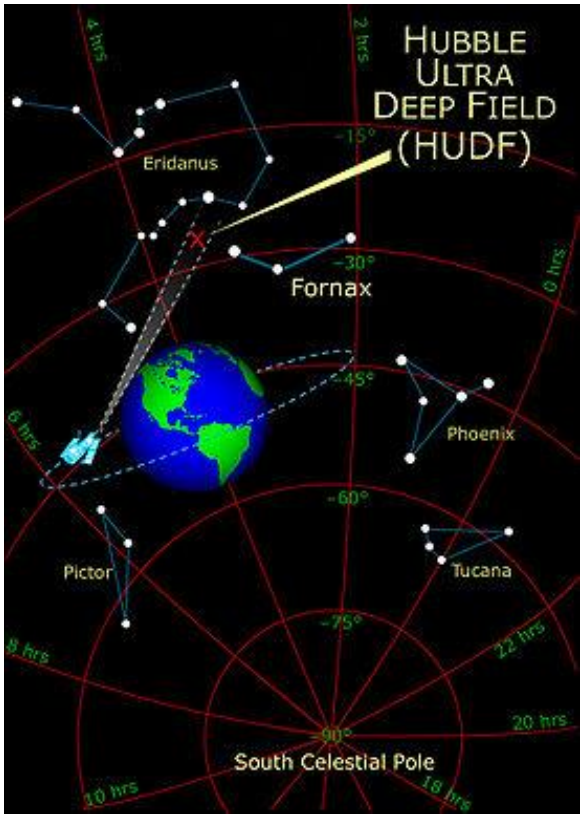
- Hubble ultra deep field billede fra 28 dages optagelser

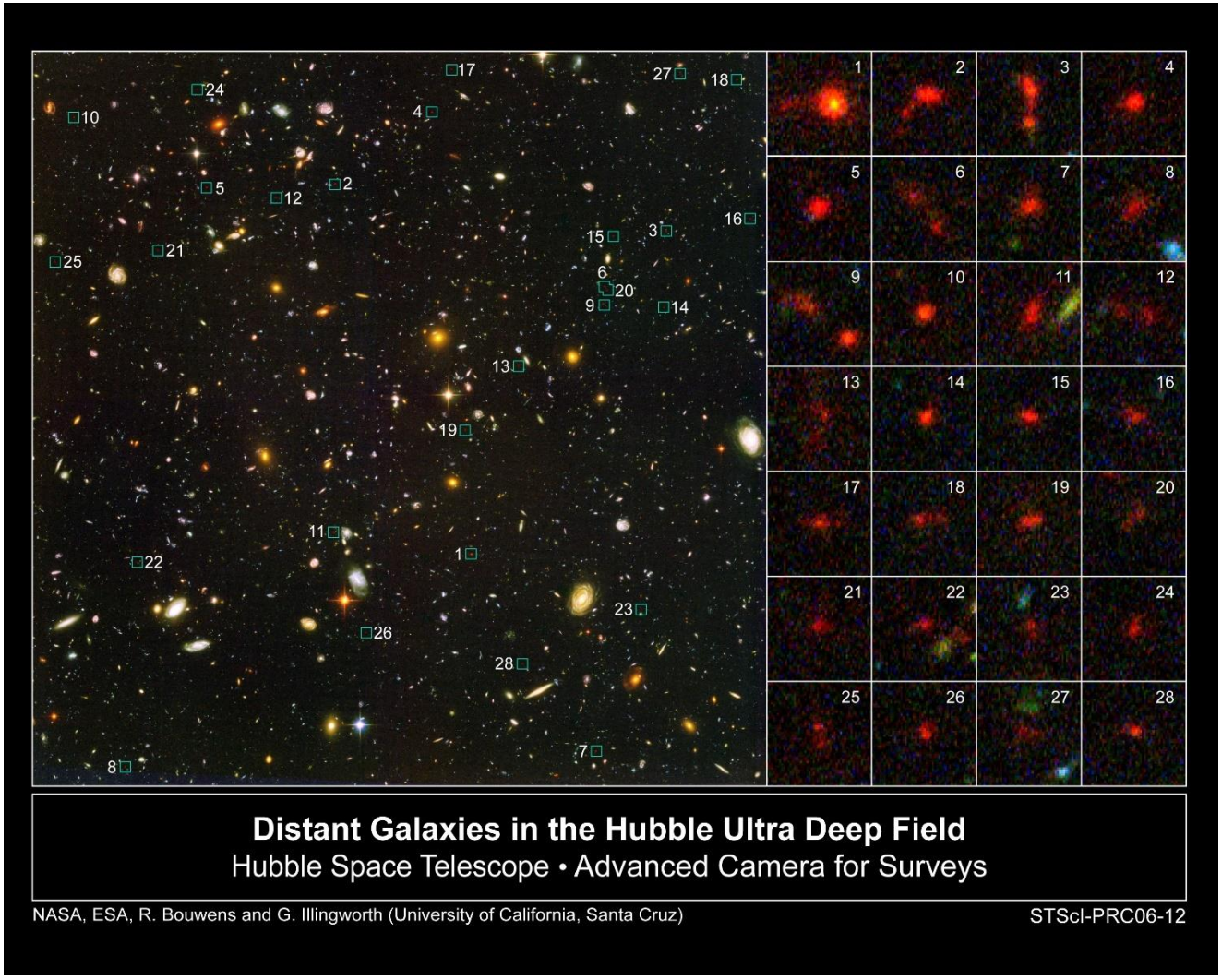


RUMOBSERVATORIER - HUBBLE

- Ultra deep field placering



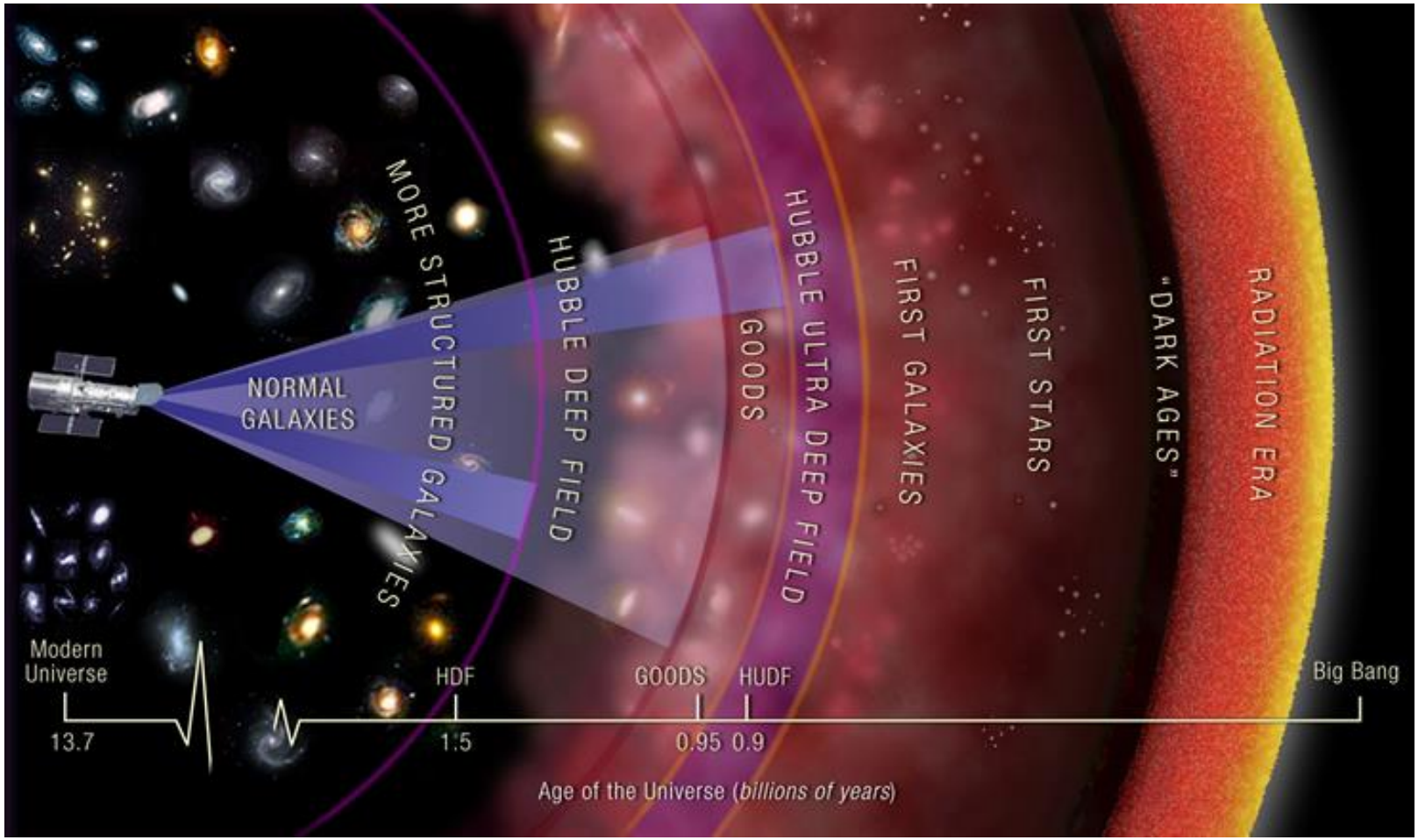
RUMOBSERVATORIER - HUBBLE



RUMOBSERVATORIER - HUBBLE

- Video om Hubble ultra deep field

RUMOBSERVATORIER - GOODS



RUMOBSERVATORIER - GOODS

Spitzer
IR 3,6 - 160 µm
2003 - 2015

Hubble
150 – 2500 nm

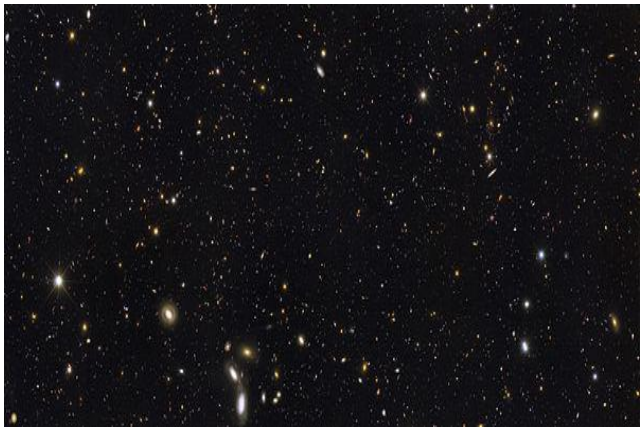
ESO – VLT
300nm – 20 µm

Chandra
X-Ray 0,1-10 keV
1999 - 2015

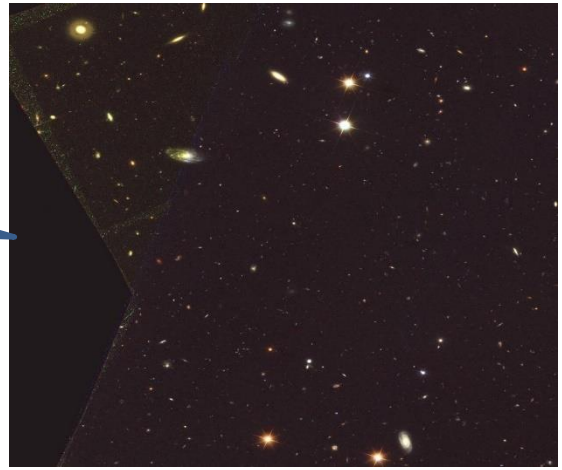
RUMOBSERVATORIER - GOODS

GOODS syd felt

GOODS nord felt



Her kan man hente billeder - eksempel

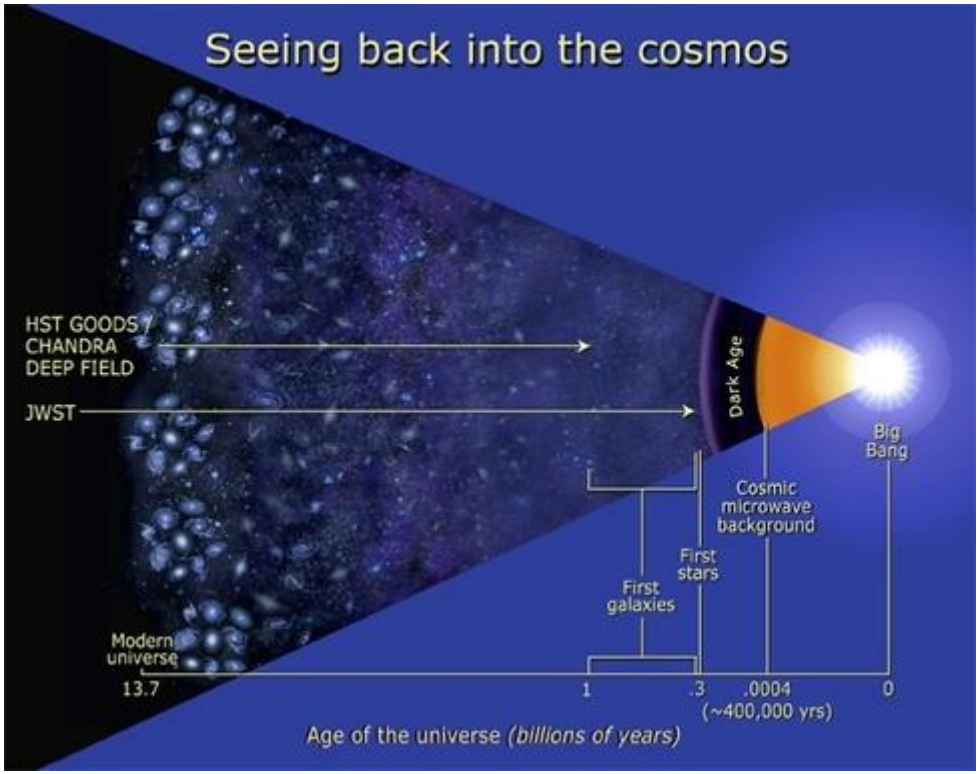


https://archive.stsci.edu/prepds/goods/

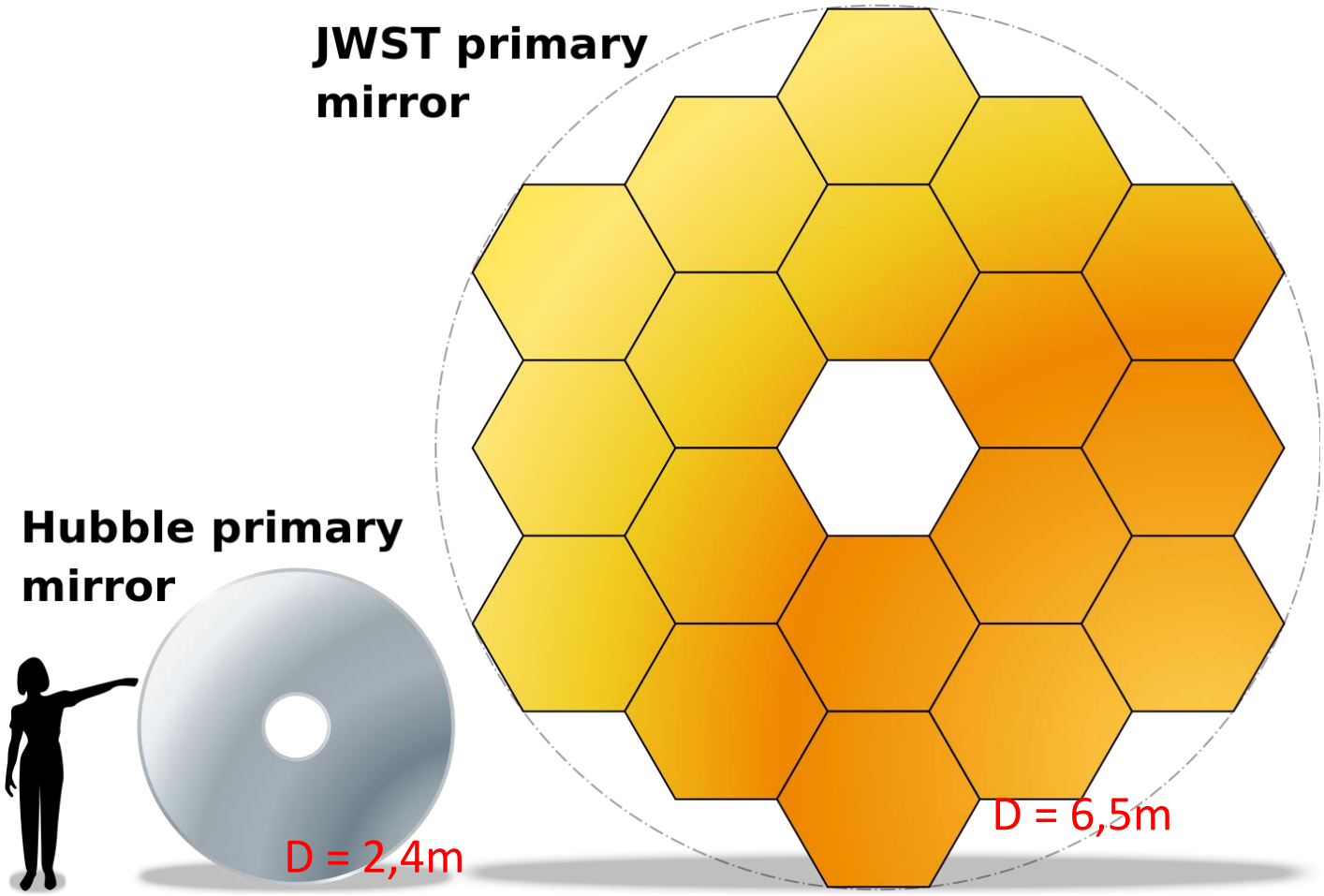
RUMOBSERVATORIER - GOODS

- Kompositbillede fra Hubble, Spitzer og Chandra af Krabbetågen

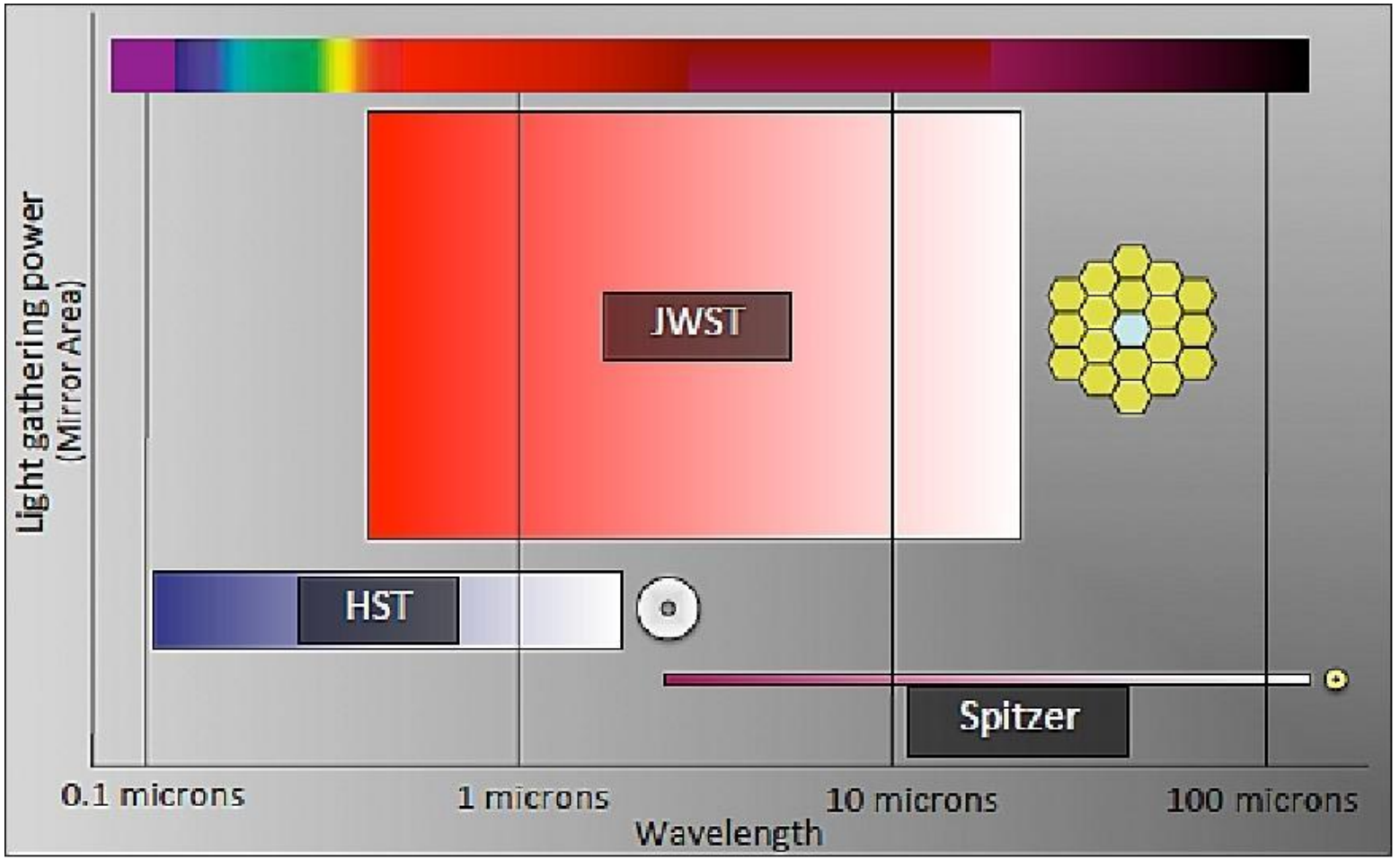
RUMOBSERVATORIER –James Webb



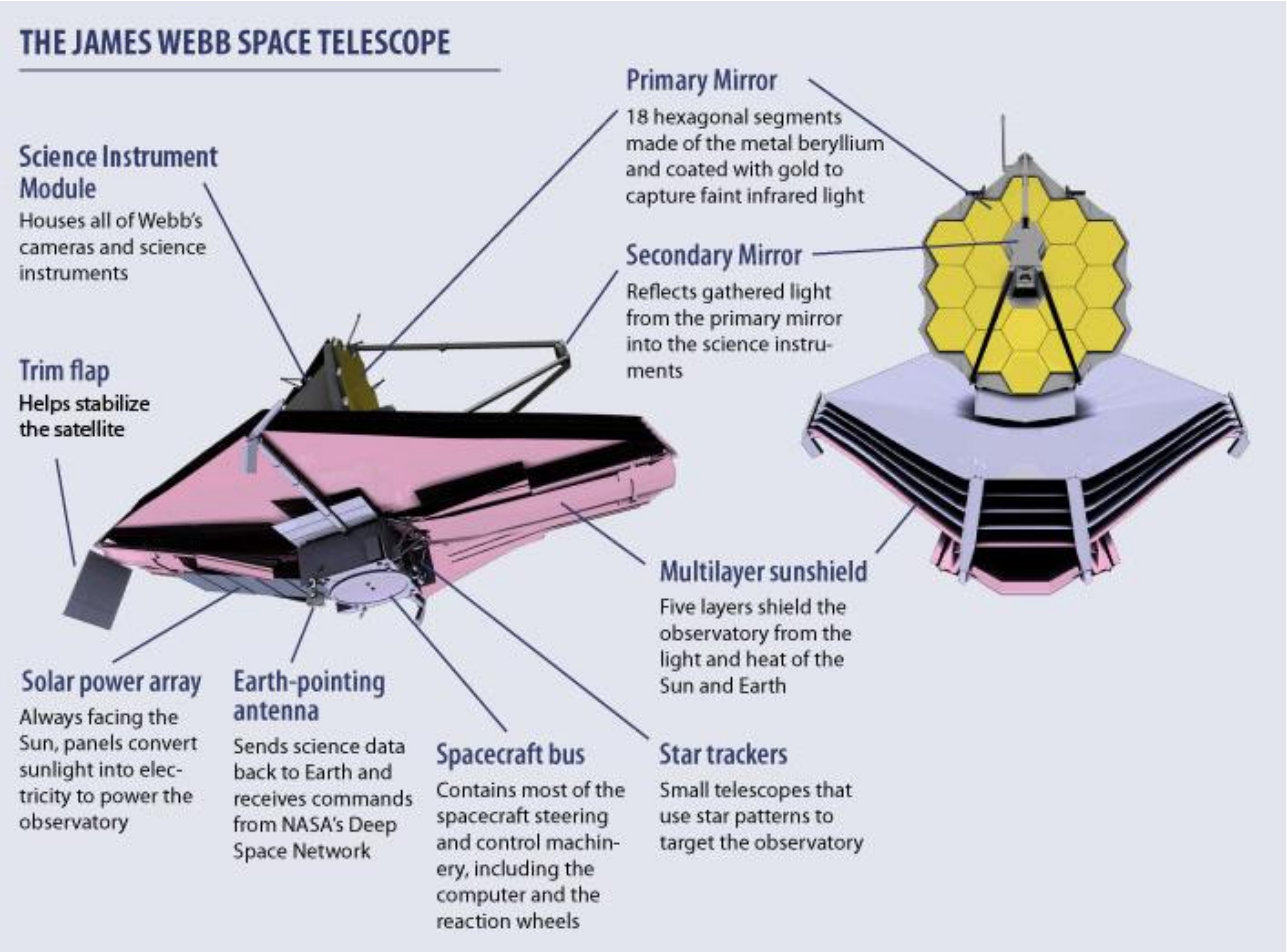
RUMOBSERVATORIER – James Webb



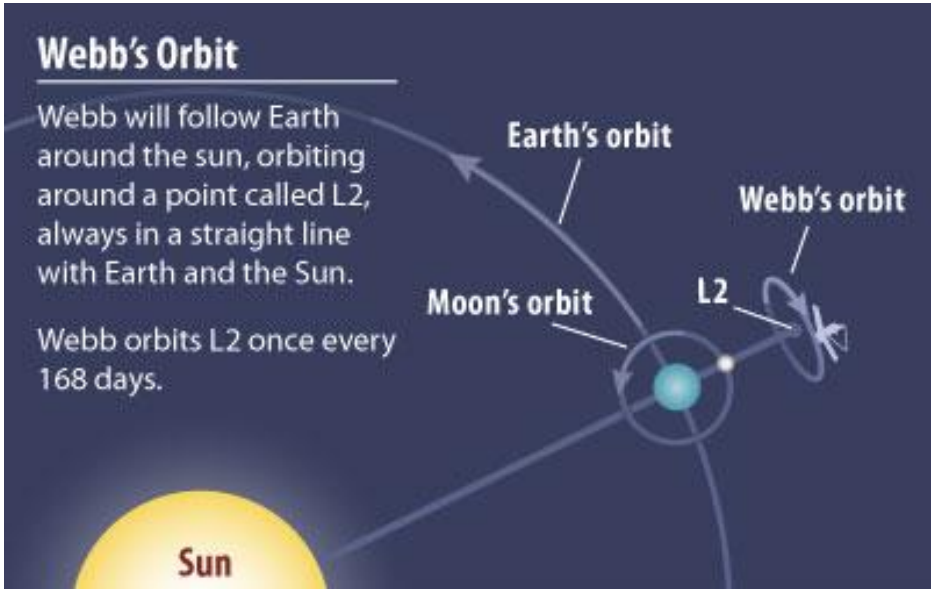
RUMOBSERVATORIER – James Webb



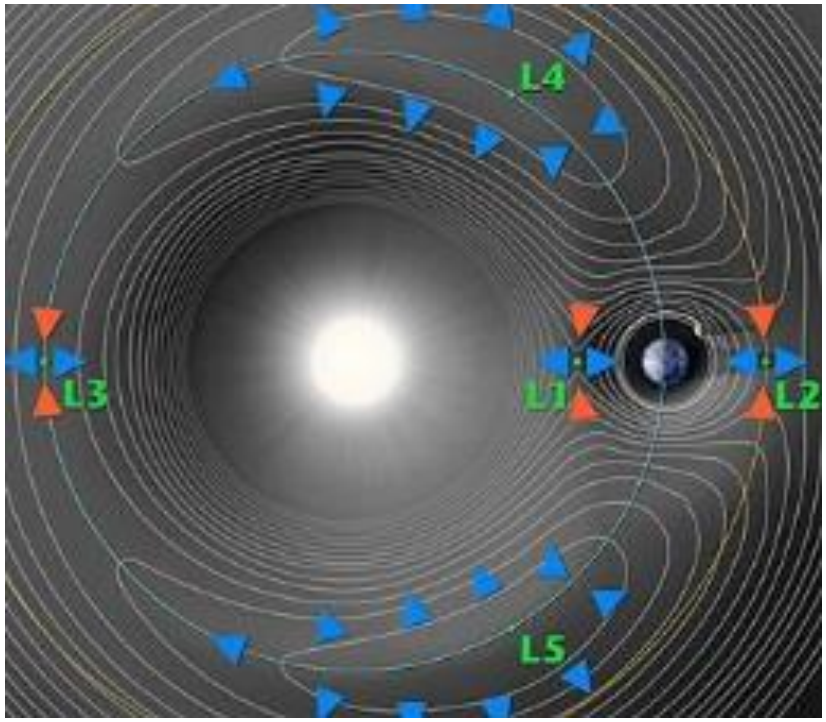
RUMOBSERVATORIER – James Webb



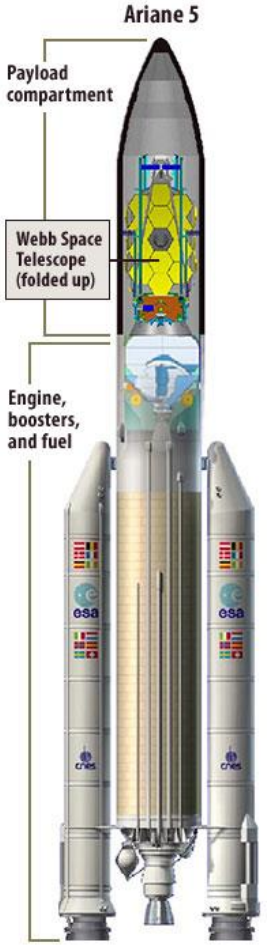
RUMOBSERVATORIER – James Webb

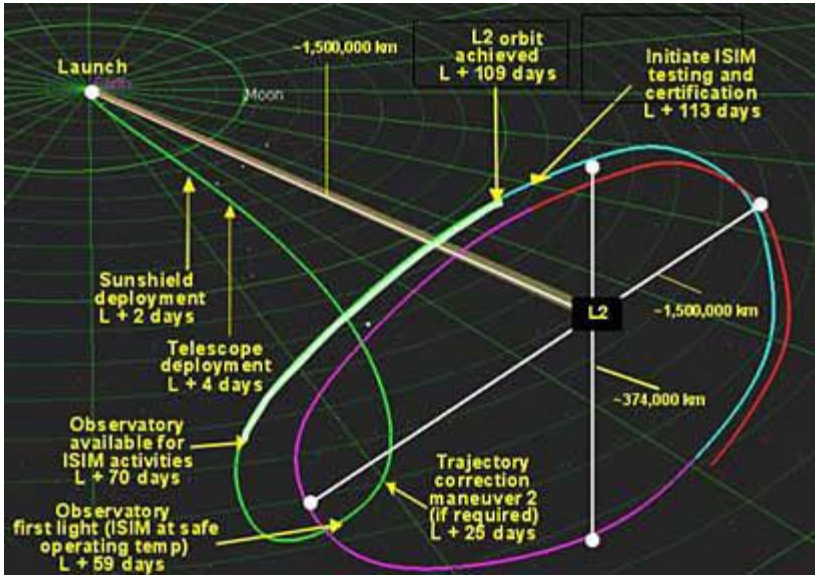


RUMOBSERVATORIER – James Webb



RUMOBSERVATORIER – James Webb

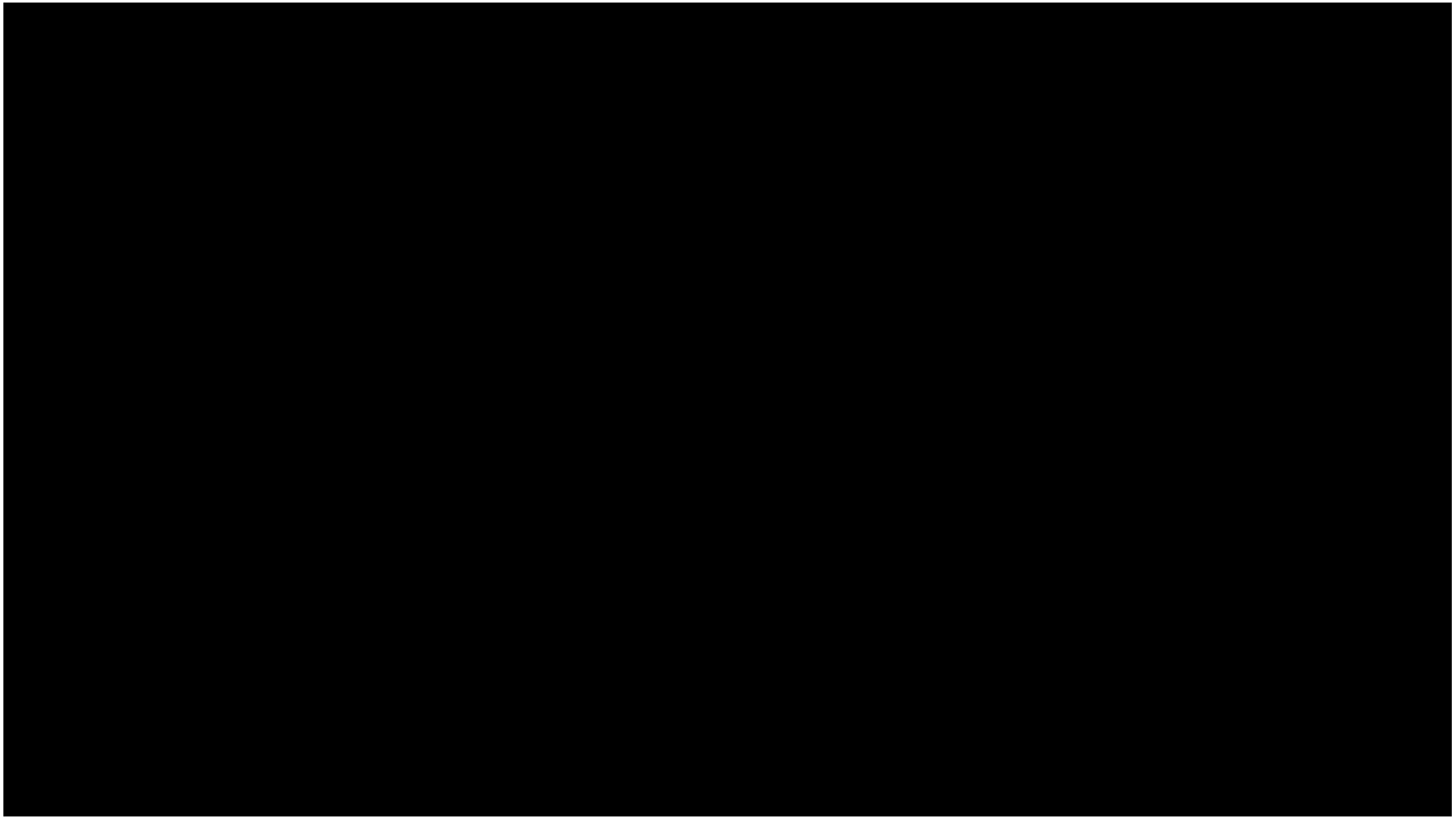




Opsendelse planlagt til 2011 med et budget på 3 milliarder USD (oprindeligt 1,6)

Opsendelse forventes i 2018 med et budget På 8,8 milliarder USD

RUMOBSERVATORIER - RESUME



RUMOBSERVATORIER

VELKOMMEN HJEM