

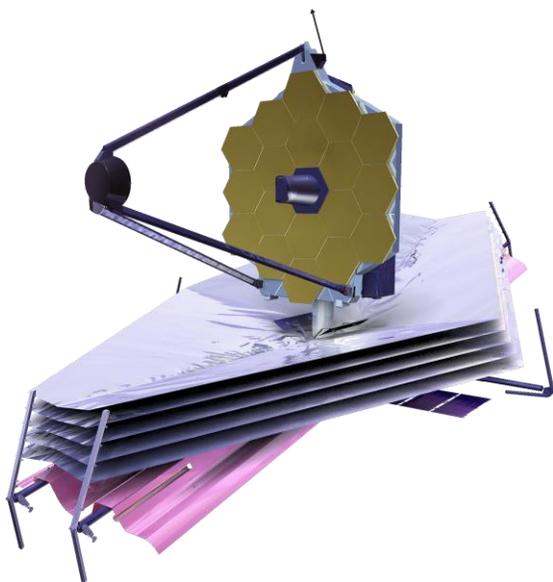
Vesmírný teleskop Jamesa Webba:

očekávání laické veřejnosti vs. reálné vědecké objevy

Petr Dvořák

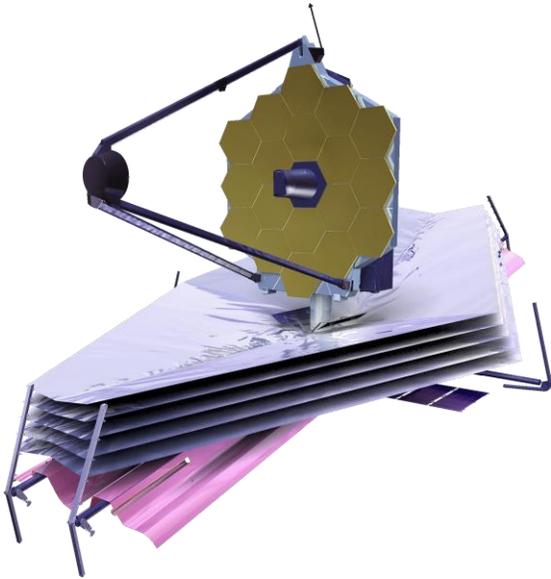
petr.dvorak@ceitec.vutbr.cz

MUNI Univerzita
třetího
věku
U3V



Dva základní pozorovací úkoly:

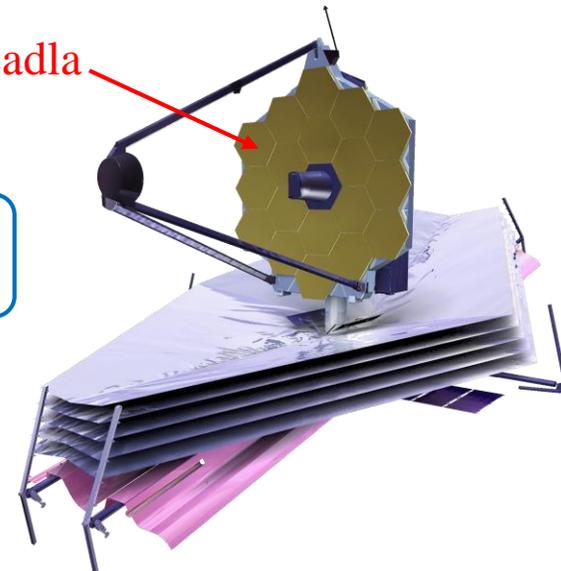
- Studovat objekty (galaxie a jejich zárodky) s vysokým červeným posuvem
- Studovat chladnější objekty než hvězdy: exoplanety a planetární disky, oblaka plynu, rodící se hvězdy



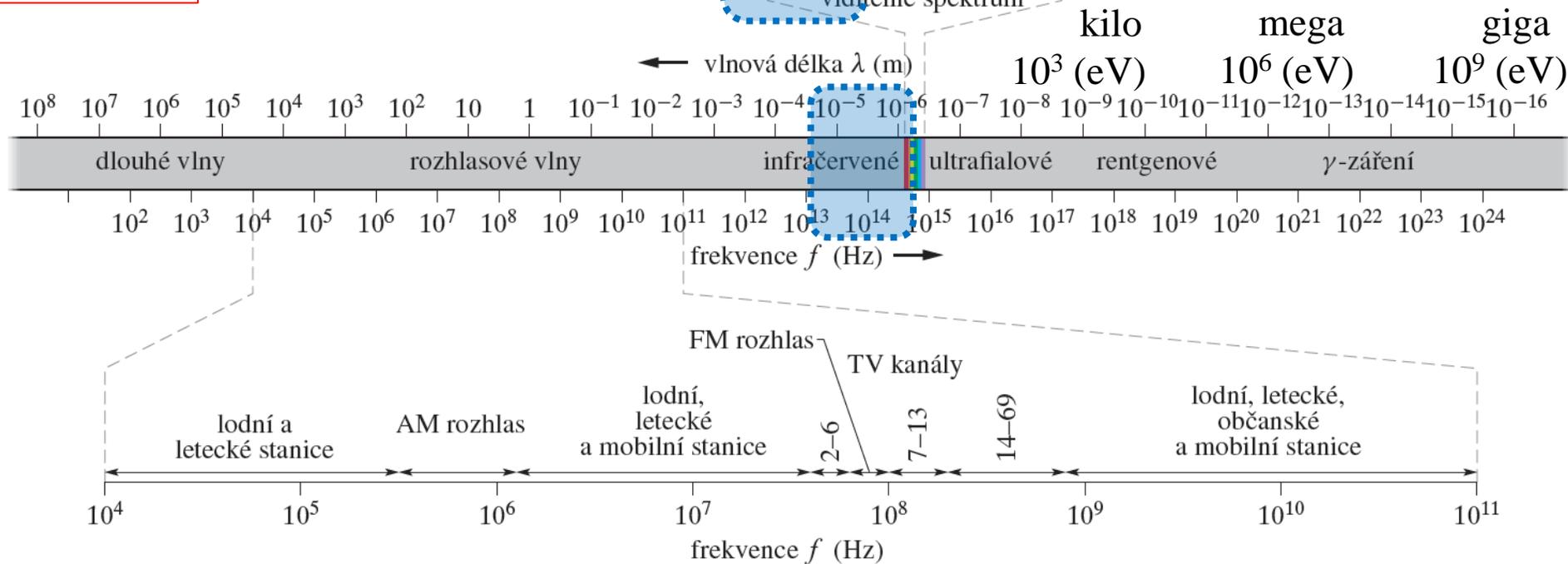
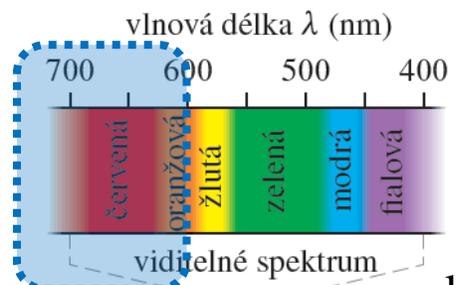
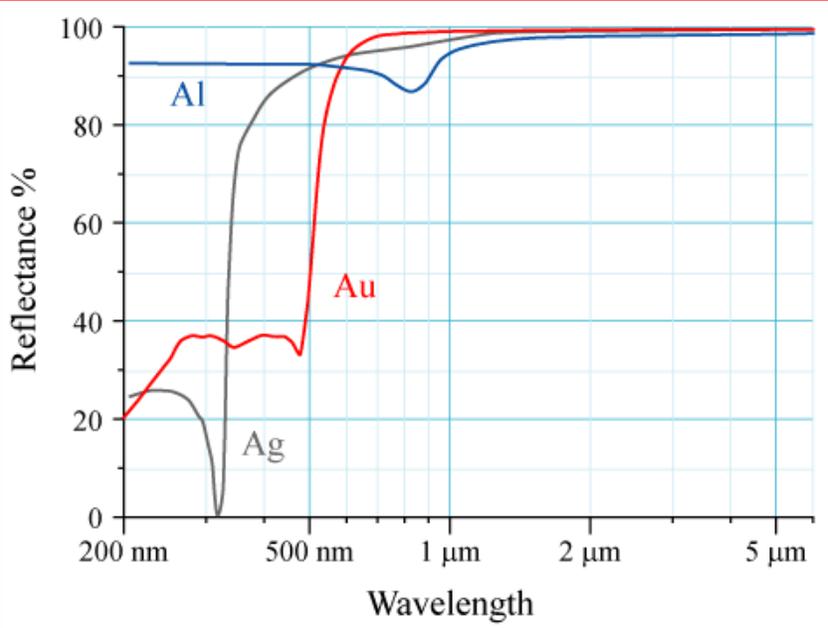
Nutnost sledovat velmi intenzitně slabé elektromagnetické signály s vysokou rozlišovací schopností v blízké a střední infračervené oblasti spektra

Blízká a střední infračervená oblast (NIR a MIR)

Au zrcadla



Pracovní rozsah vlnových délek JWST: 0,6-28,3 μm

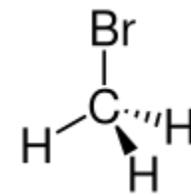


J. C. Maxwell (1865)

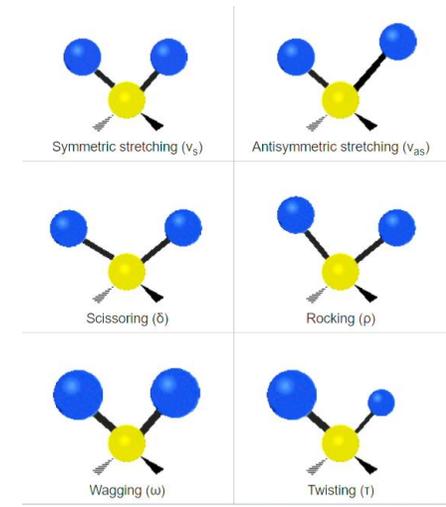
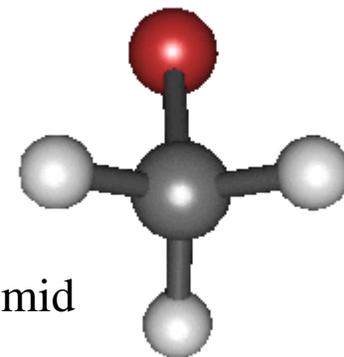
Blízka a střední infračervená oblast (NIR a MIR)

Vibrace molekul

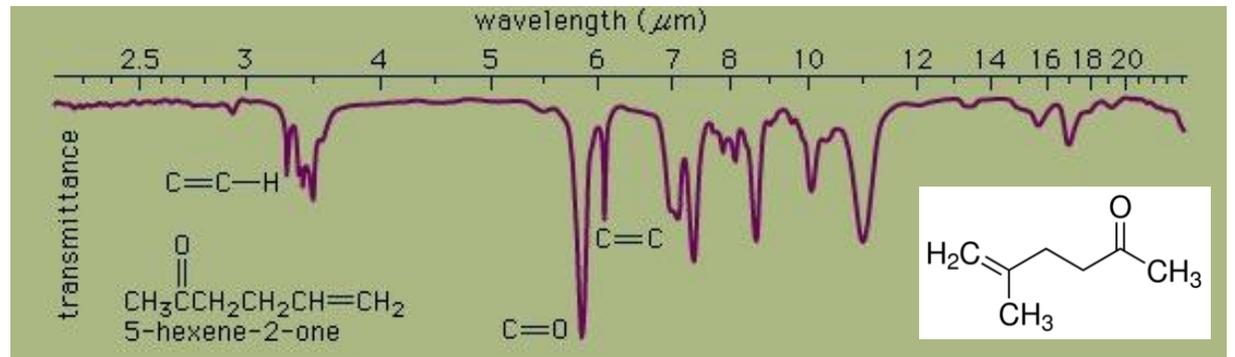
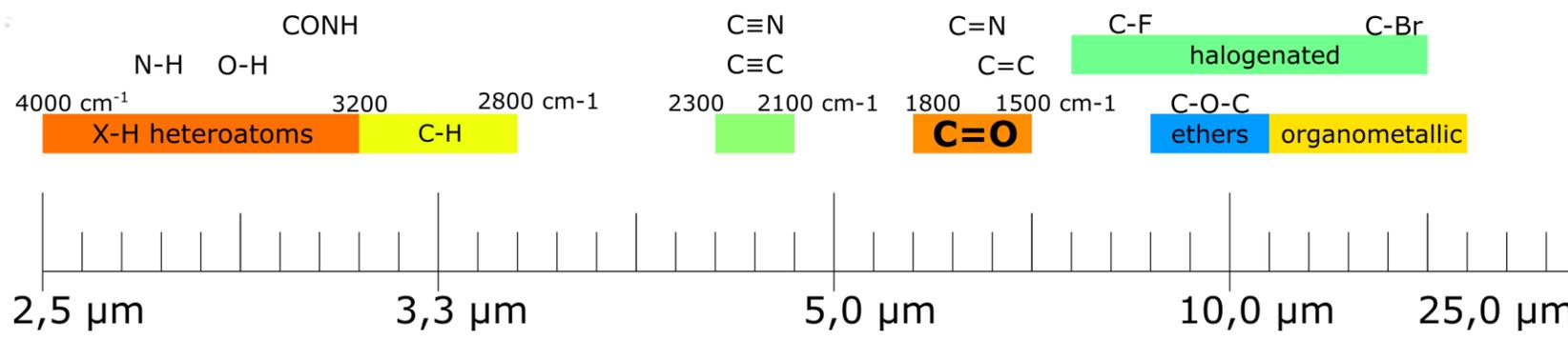
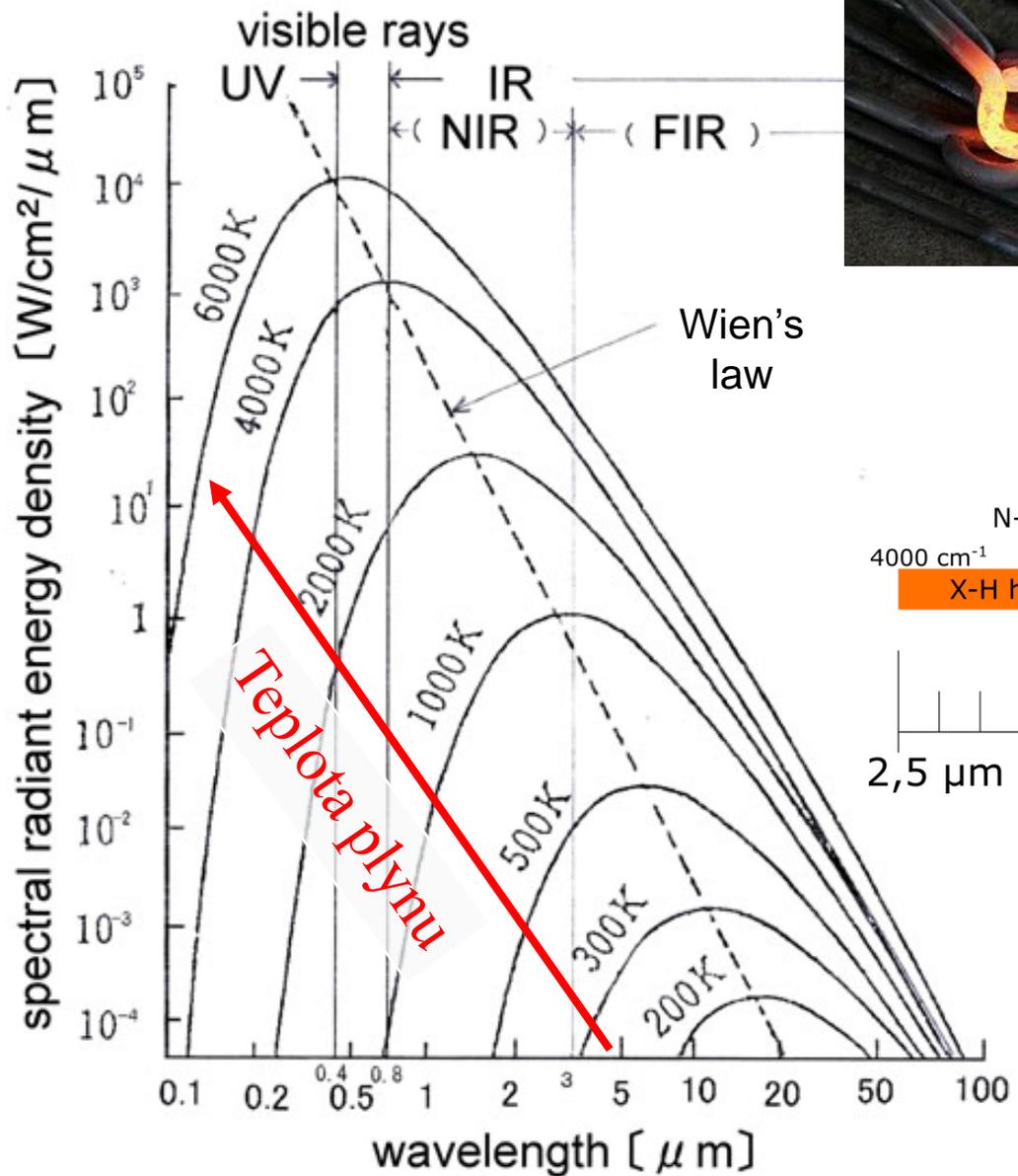
Termální záření



Methylbromid

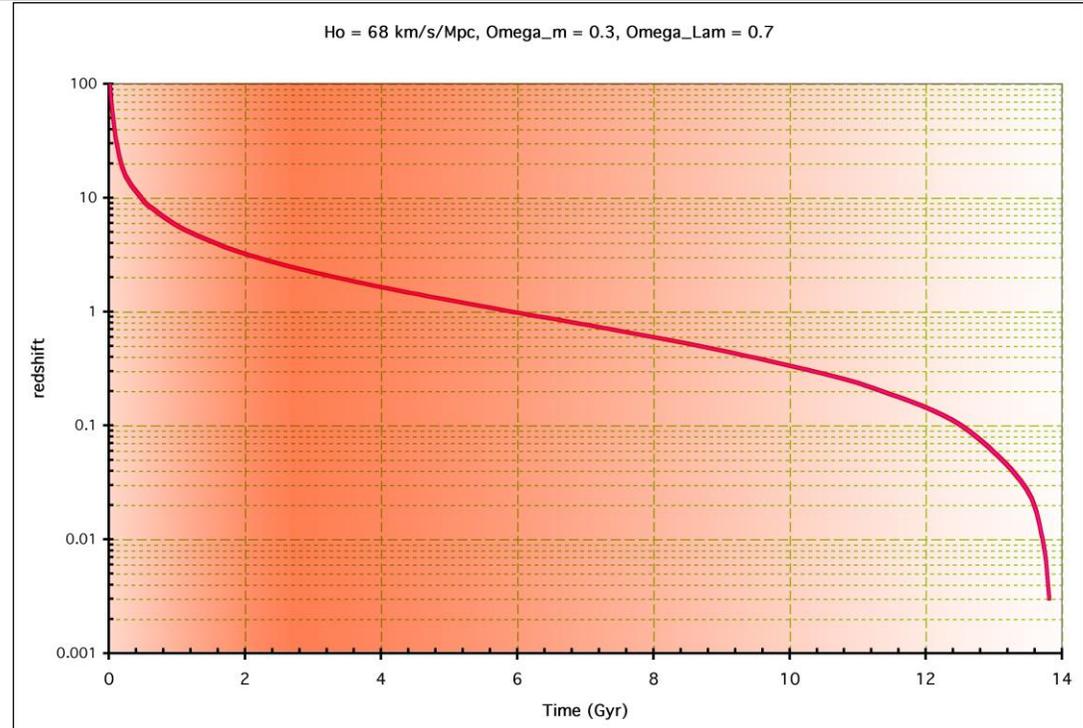
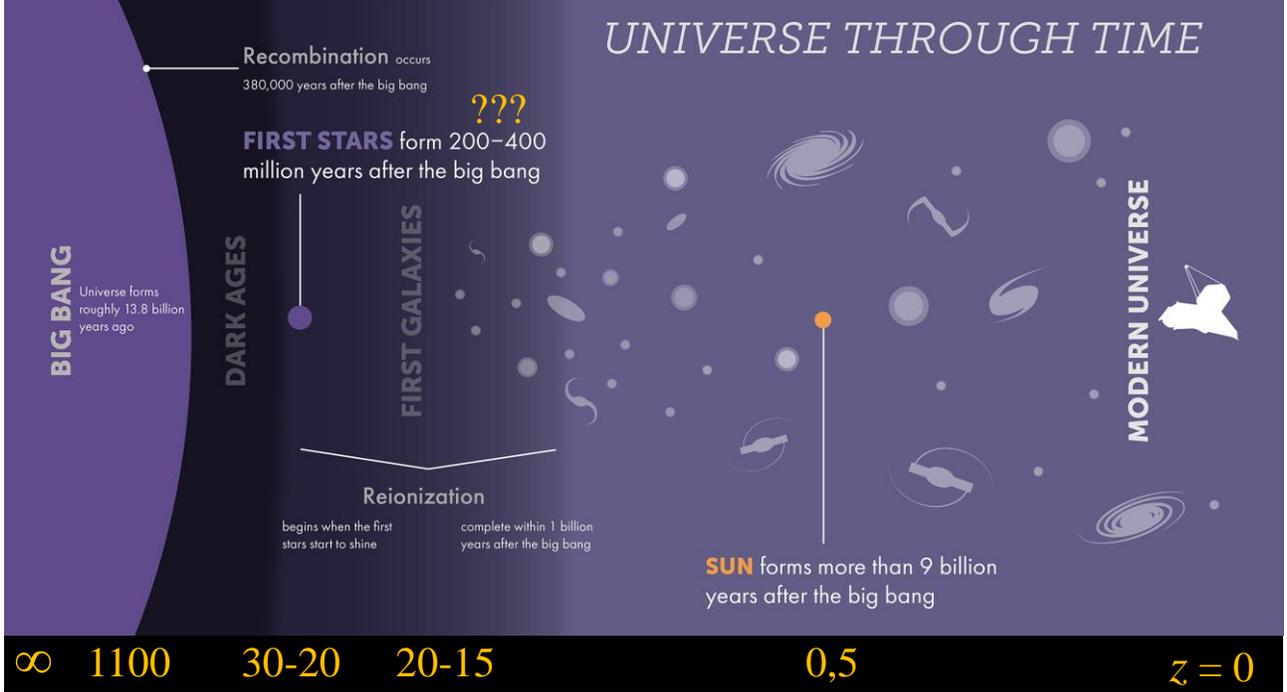
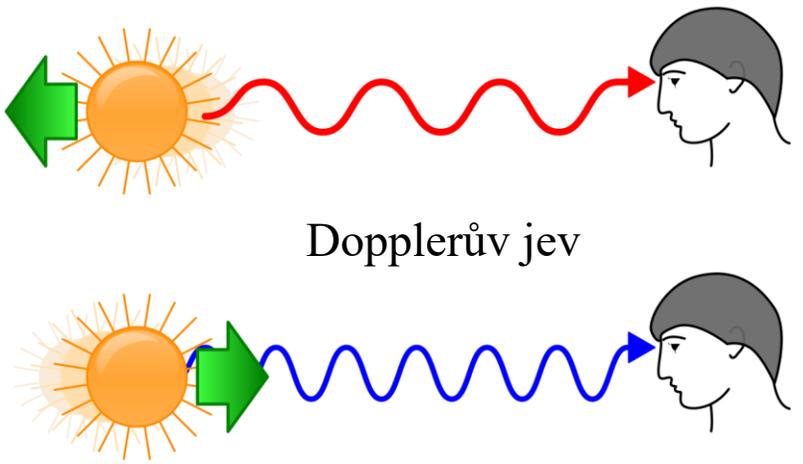
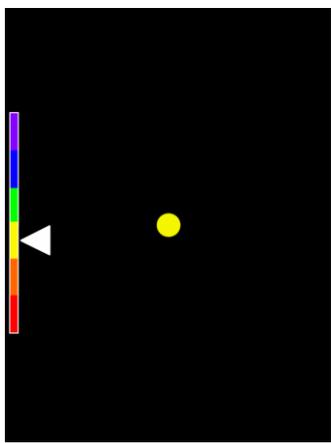
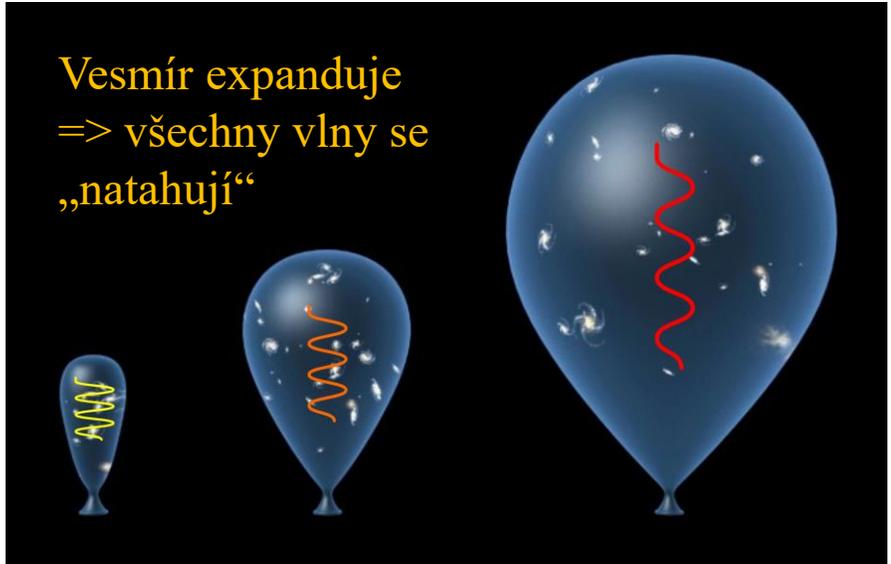


Planckův vyzařovací zákon



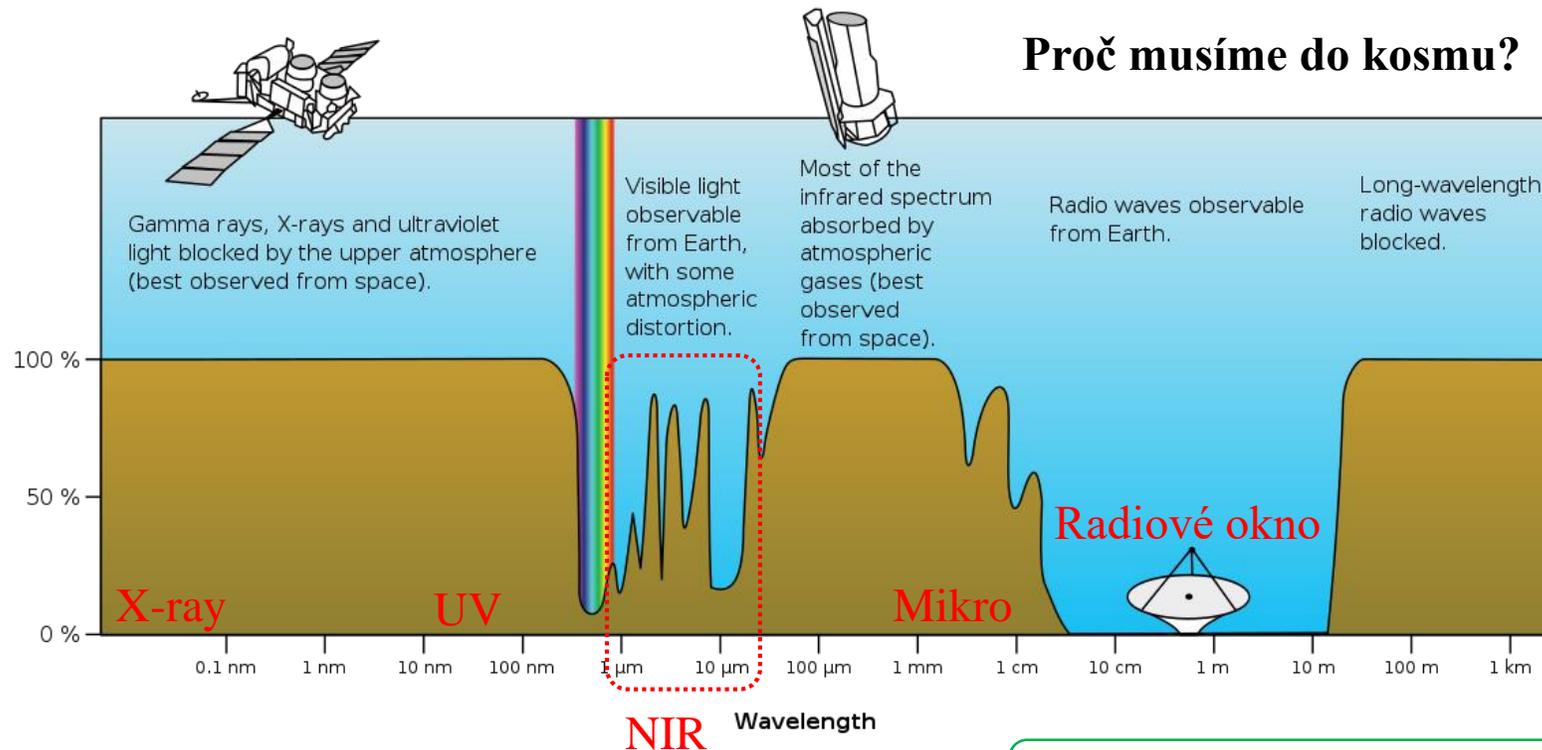
Objekty dalekého Vesmíru

- JWST rudý posuv až $z = 20$ (cca 180 mil. let po Velkém třesku)
- HST nejvíce $z = 10-11$ (cca 800-400 mil. let po VT)
- Vznik prvních hvězd $z = 20-30?$ (180-100 mil. let po VT)
- Vznik prvních galaxií $z = 15?$ (270 mil. let po VT)

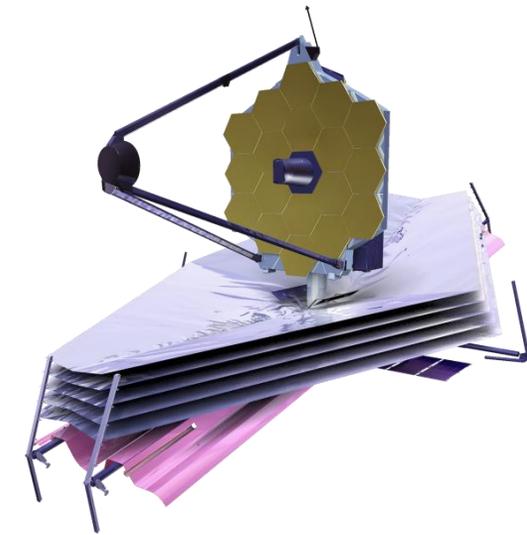




Proč musíme do kosmu?



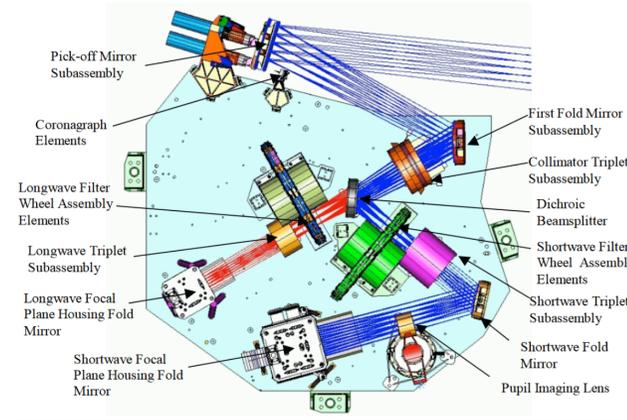
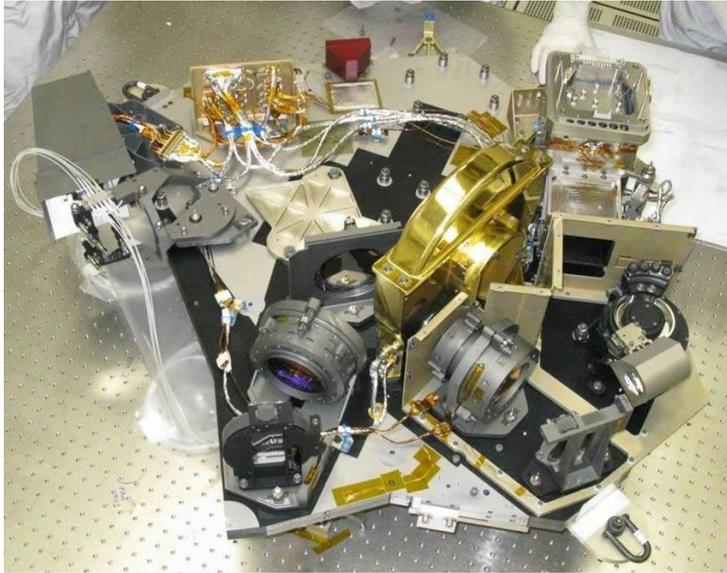
JWST
0,6-28,3 μm



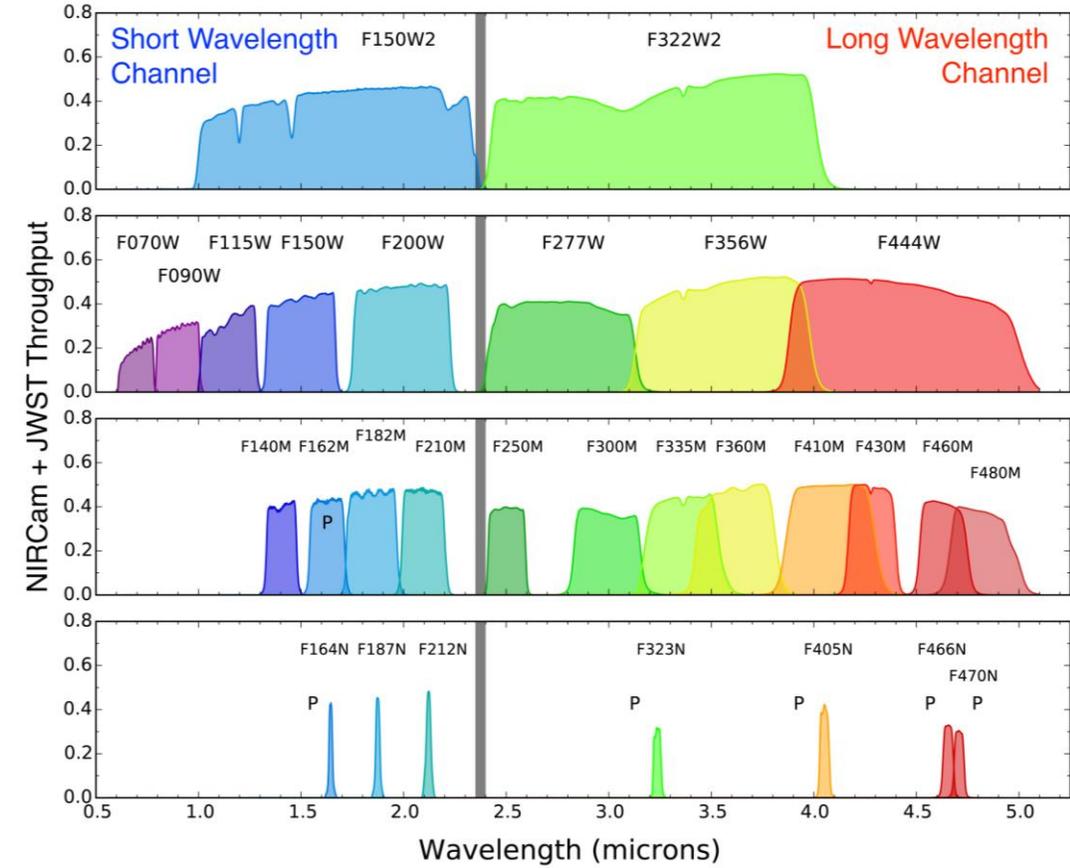
Pohyb molekul atmosféry a rozptyl v atmosféře výrazně zhoršuje obraz!

Detektory JWSR pro NIR a MIR

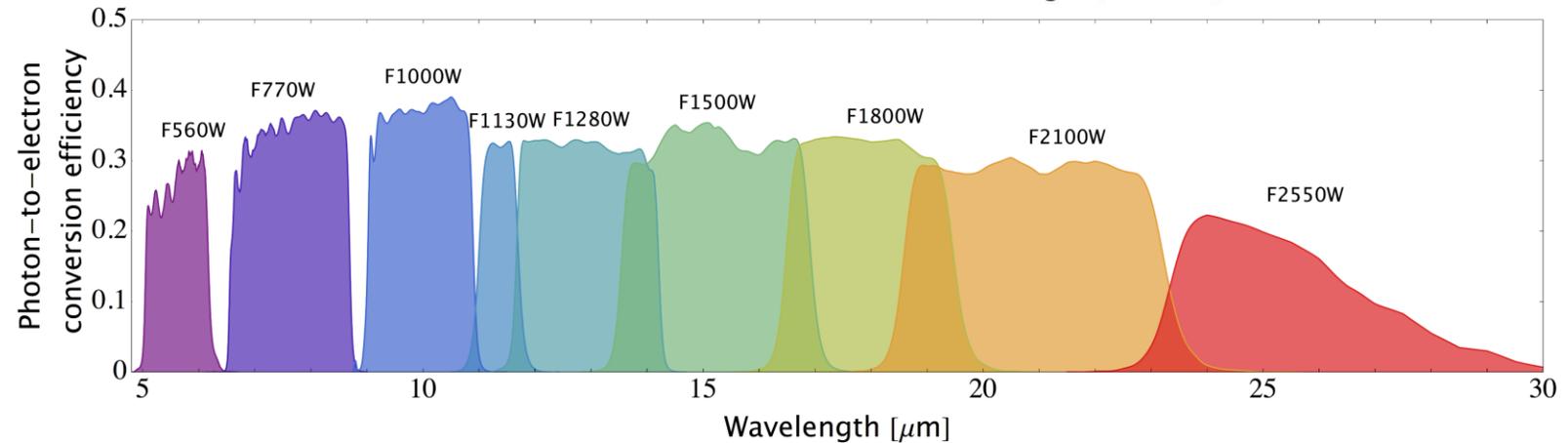
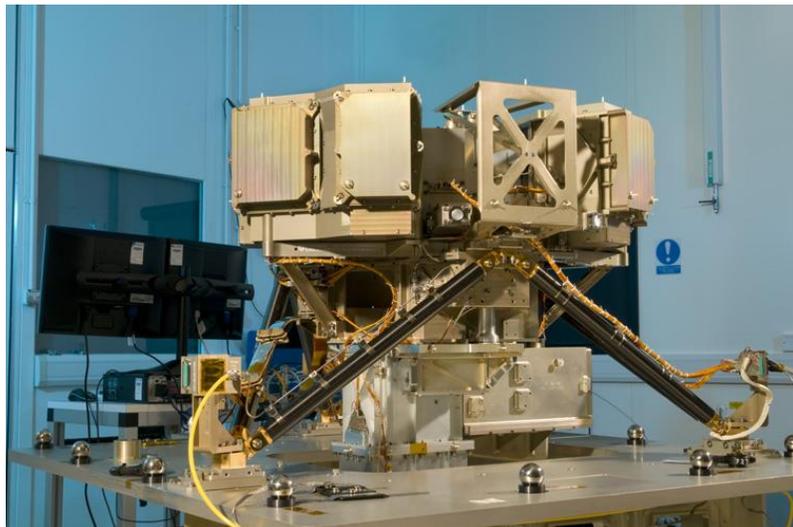
NIRcam 600 nm až 5 μm (i spektra), 2040 x 2040 px



NIRCam Filters

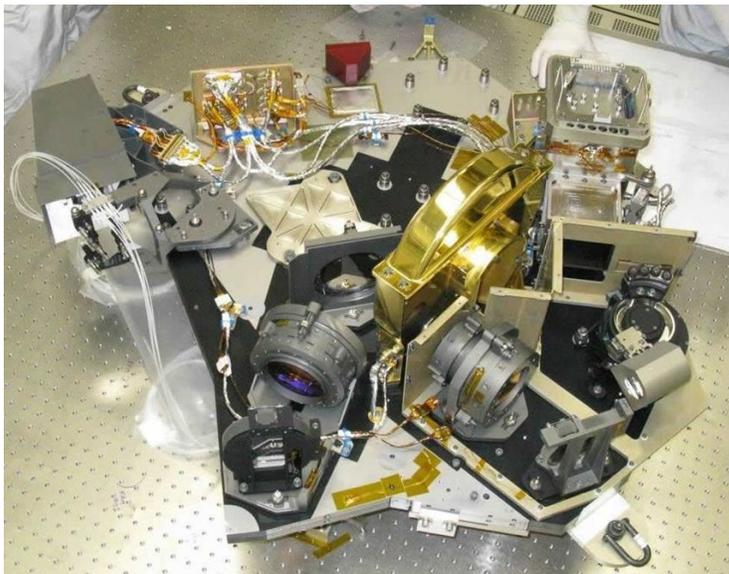


MIRI 4,9 μm až 28,3 μm (i spektra), až 1024 x 1024 px

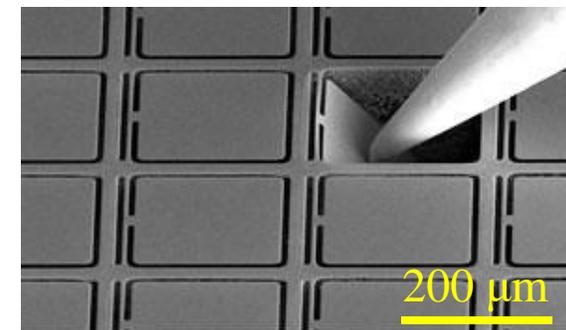
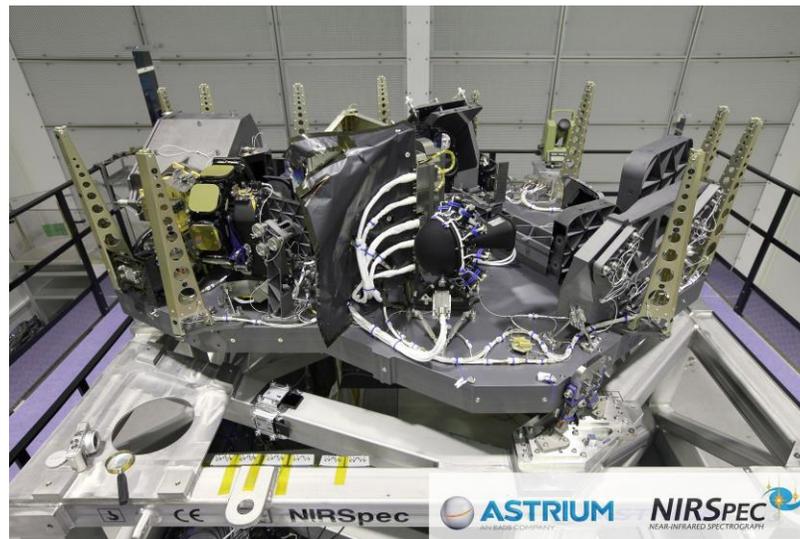


Detektory JWSR pro NIR a MIR

NIRcam 600 nm až 5 μm (i spektra), 2040 x 2040 px



NIRSpec 600 nm až 5 μm

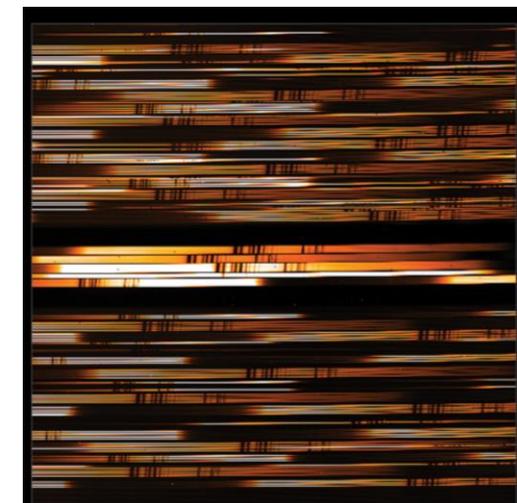
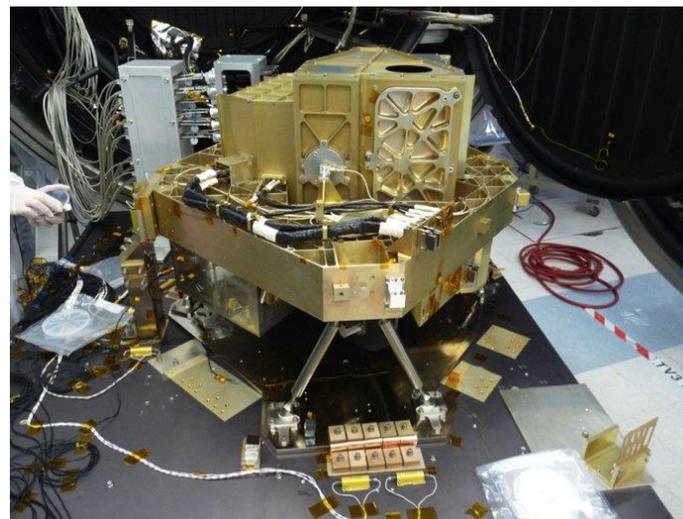


4 x 62 tis. okýnek

MIRI 4,9 μm až 28,3 μm (i spektra), až 1024 x 1024 px



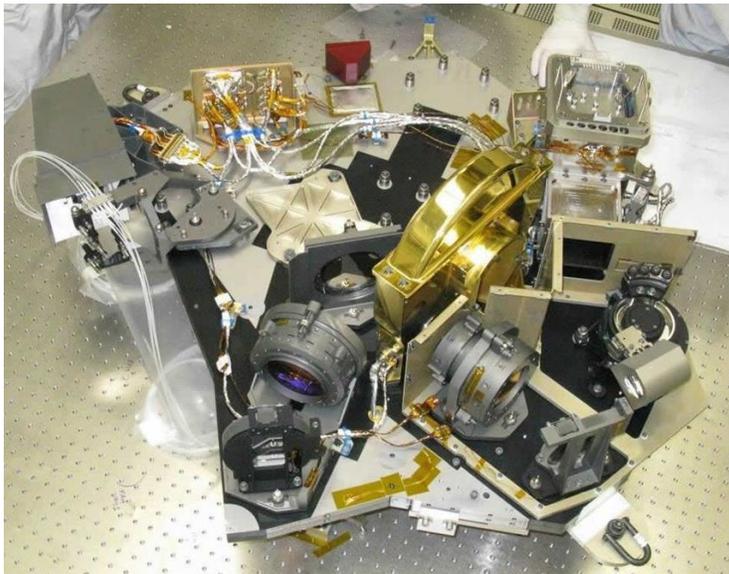
Fine Guidance Sensor and Near Infrared Imager and Slitless Spectrograph (FGS-NIRISS) 0,8 až 5 μm



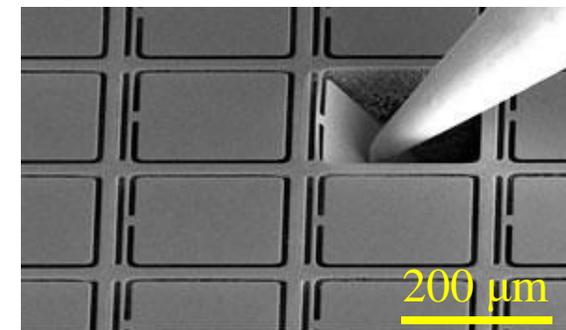
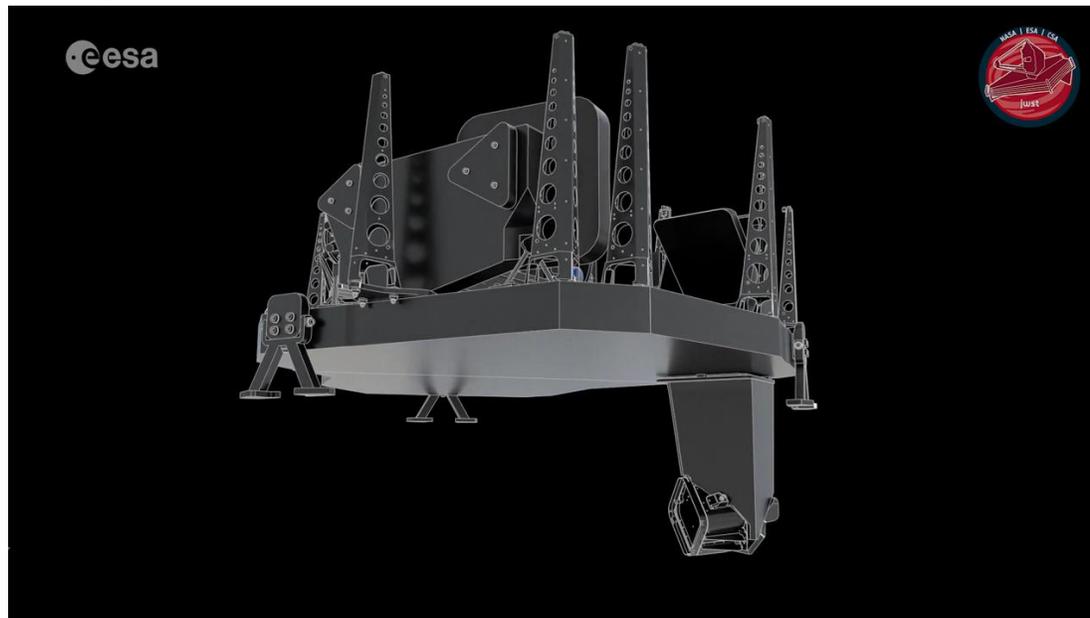
až 100 spekter v jednom zorném poli

Detektory JWSR pro NIR a MIR

NIRcam 600 nm až 5 μm (i spektra), 2040 x 2040 px

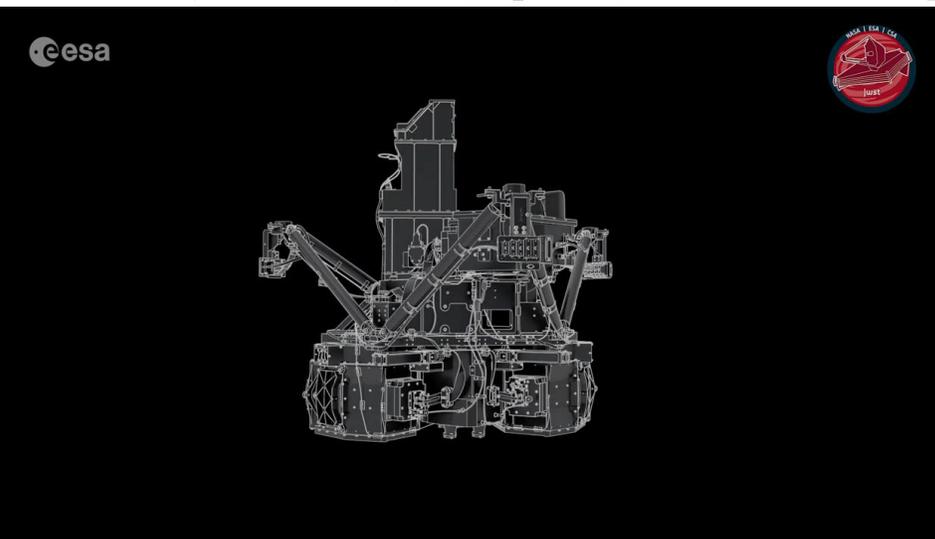


NIRSpec 600 nm až 5 μm

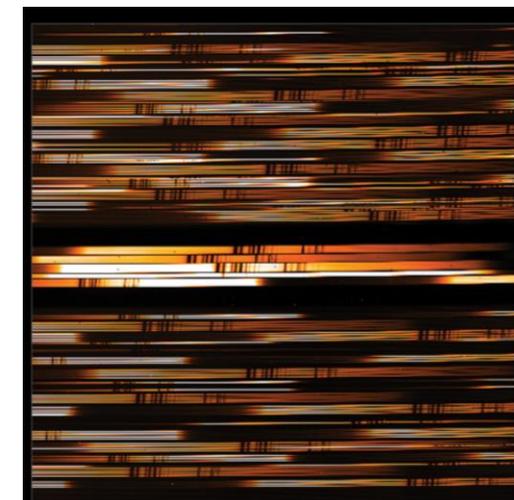
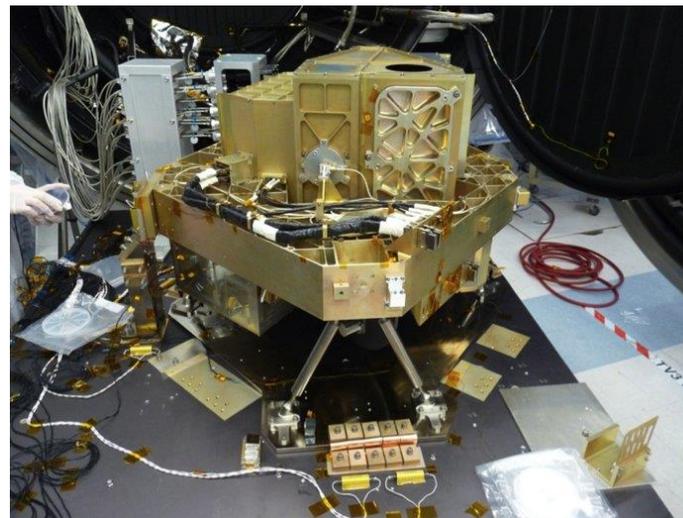


4 x 62 tis. okýnek

MIRI 4,9 μm až 28,3 μm (i spektra), až 1024 x 1024 px

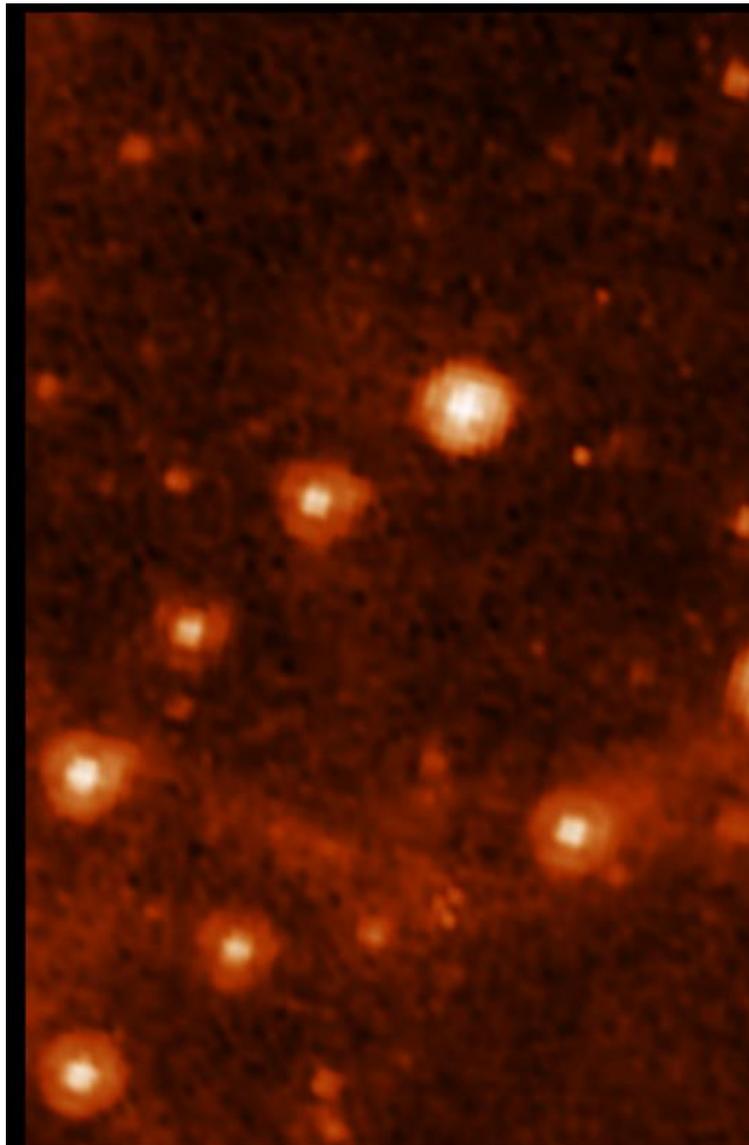
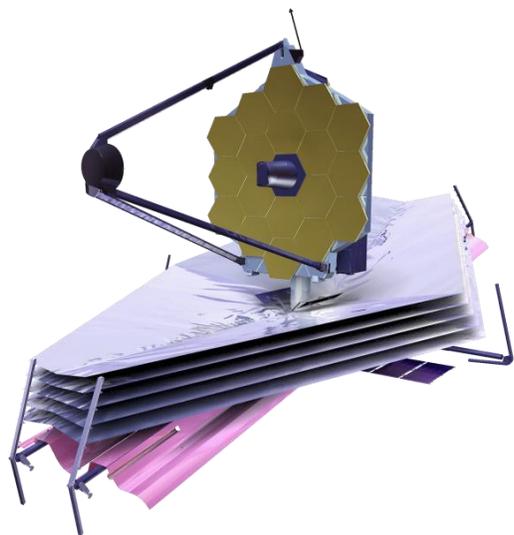
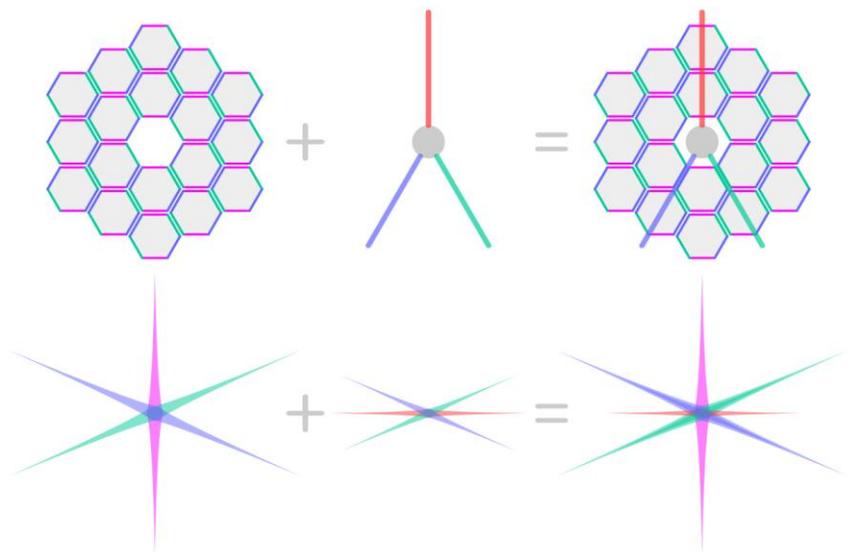


Fine Guidance Sensor and Near Infrared Imager and Slitless Spectrograph (FGS-NIRISS) 0,8 až 5 μm



až 100 spekter v jednom zorném poli

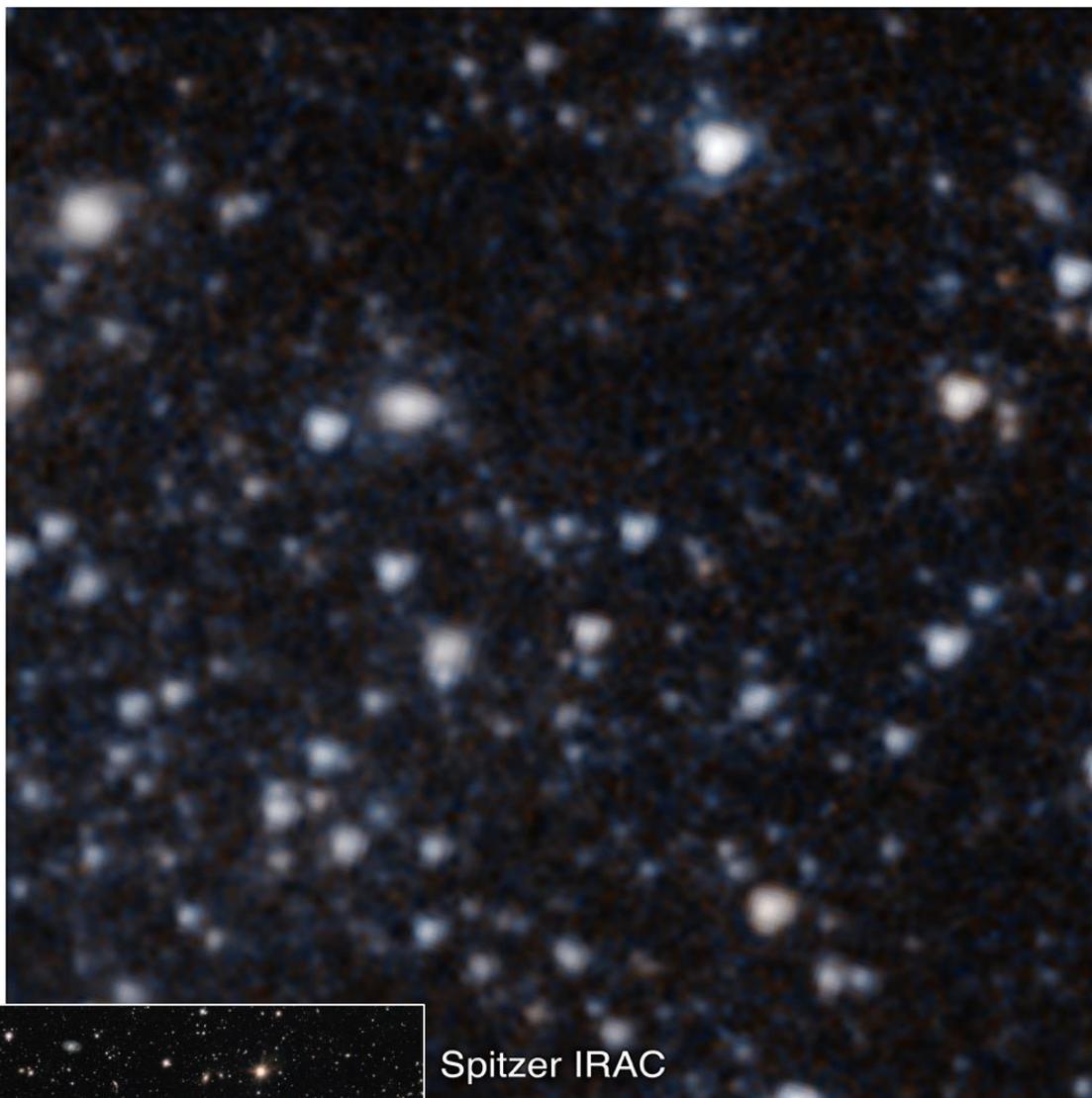
Difrakce bodových zdrojů světla



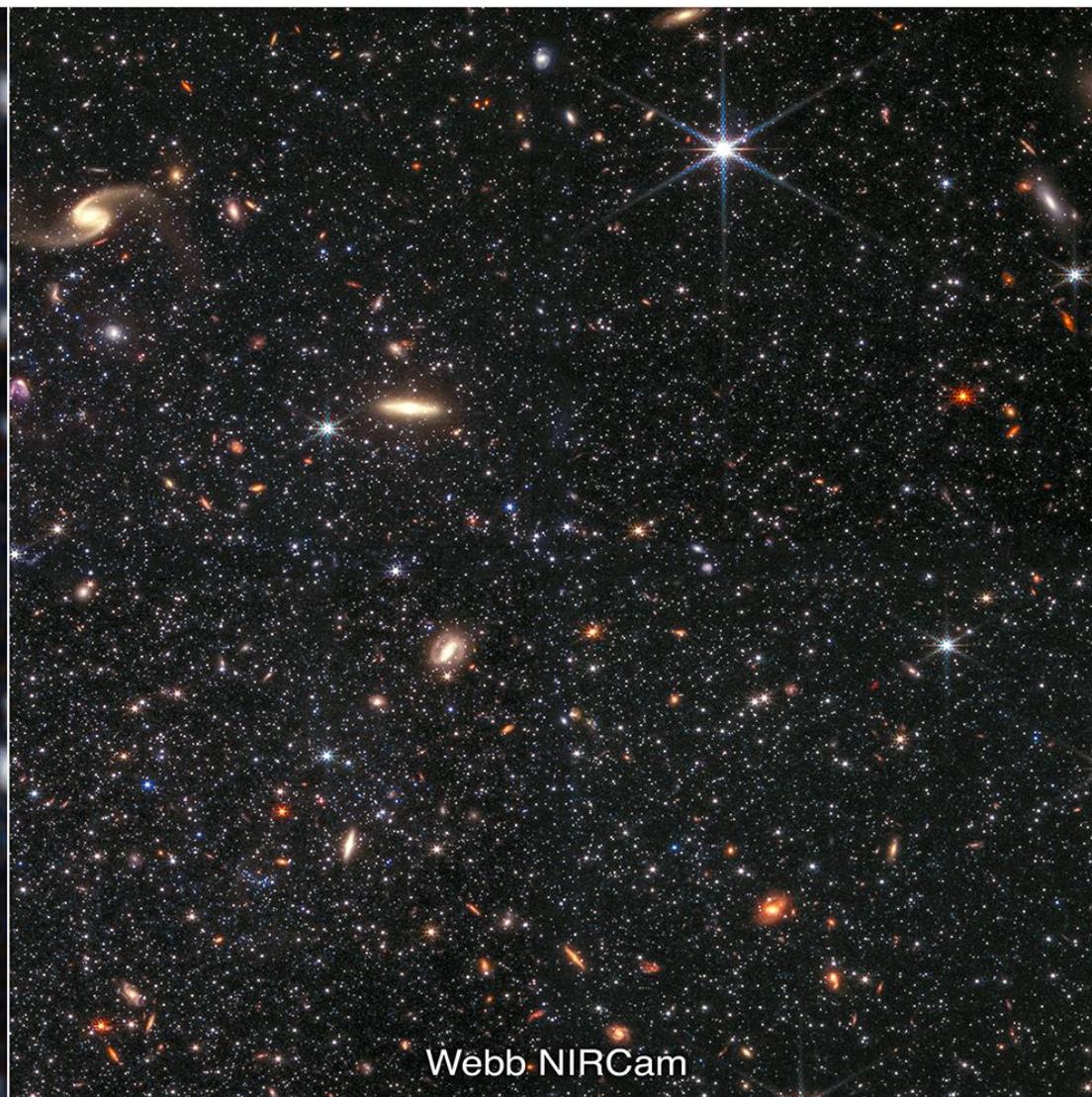
SPITZER IRAC 8.0μ



WEBB MIRI 7.7μ



Spitzer IRAC



Webb NIRC2

Část trpasličí galaxie Wolf-Lundmark-Melotte (WLM) zachycená infračervenou kamerou Spitzerova vesmírného dalekohledu (vlevo) a blízkou infračervenou kamerou vesmírného dalekohledu Jamese Webba (vpravo). Snímky demonstrují pozoruhodnou schopnost Webbova dalekohledu rozlišit slabé hvězdy mimo Mléčnou dráhu. Na snímku ze Spitzera je 3,6mikronové světlo vyznačeno modře a 4,5mikronové oranžově (IRAC1 a IRAC2). Webbův snímek zahrnuje 0,9mikronové světlo zobrazené modře, 1,5mikronové modře, 2,5mikronové žlutě a 4,3mikronové červeně (filtry F090W, F150W, F250M a F430M).

Vzdálenost: $3,04 \pm 0,11$ Mly (930 ± 30 kpc)

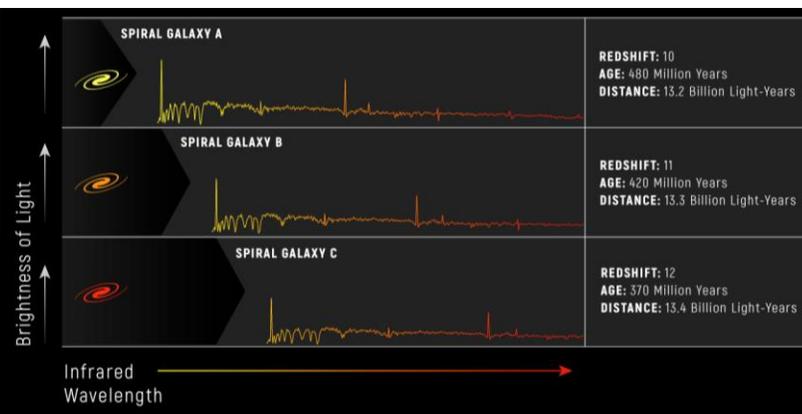


Vzdálenost: přibližně 4 Gly

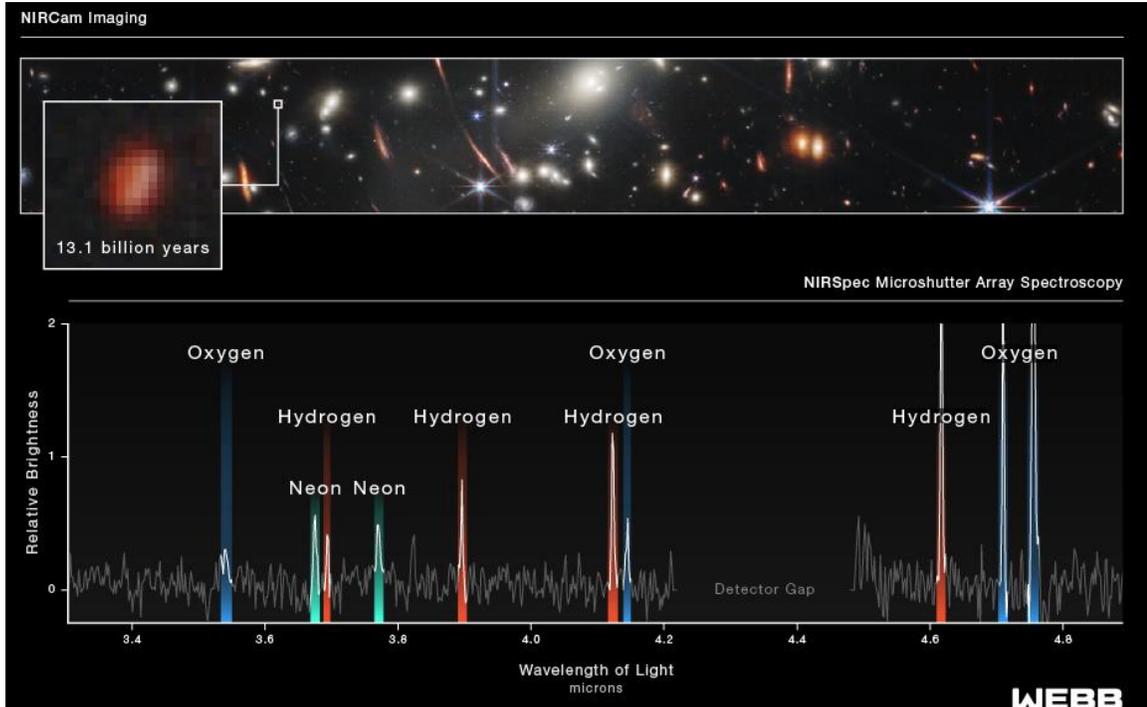
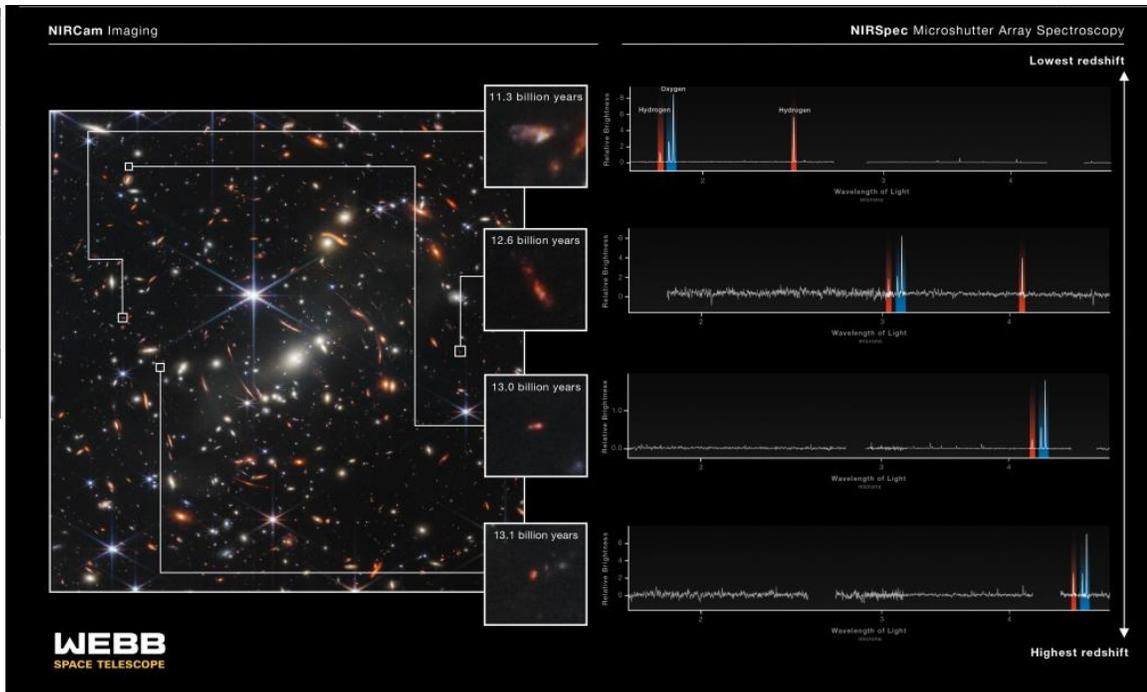
Hubblův vesmírný teleskop (HST)

Vesmírný teleskop Jamese Webbe (JWST)

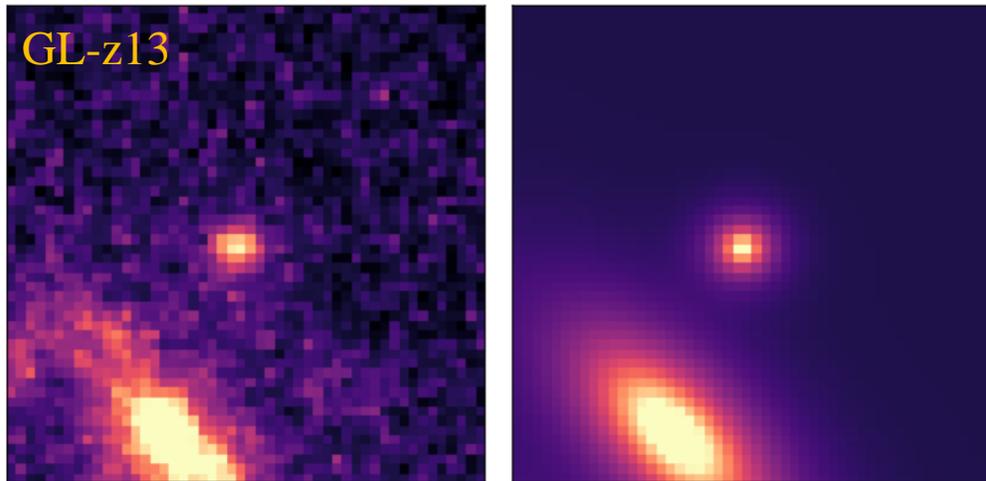
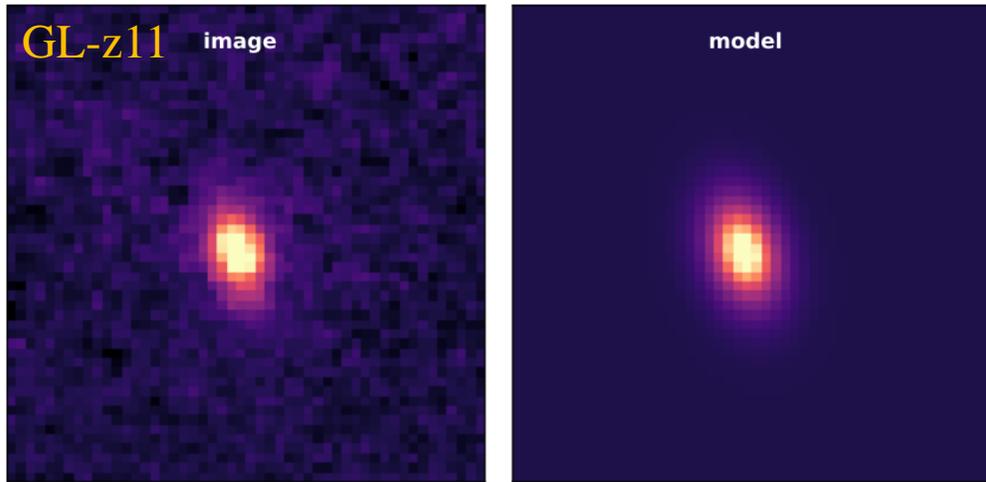
JAMES WEBB SPACE TELESCOPE DEEP FIELD | SMACS 0723



MIRI Filters: F770W, F1000W, F1500W, F1800W
 NIRCam Filters: F090W, F150W, F200W, F277W, F356W, F444W



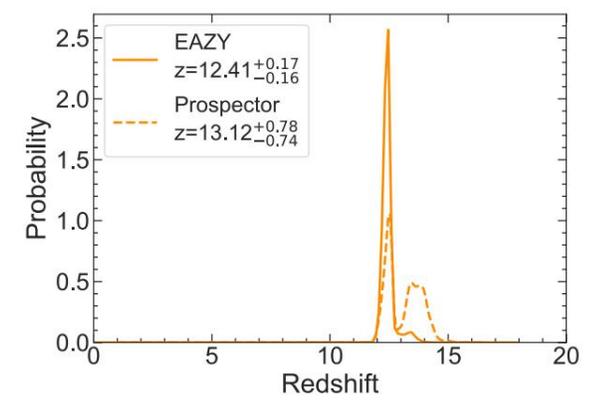
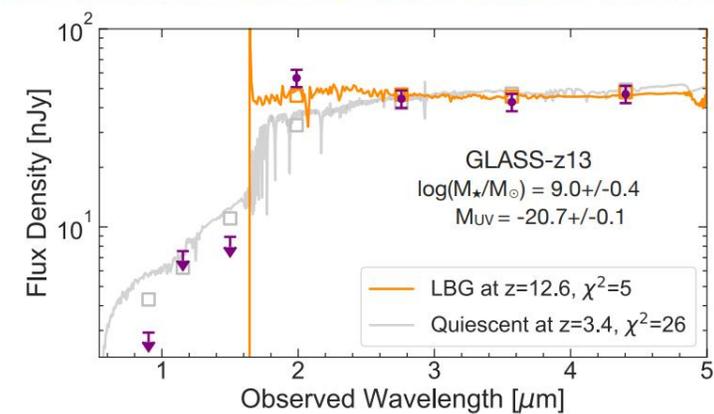
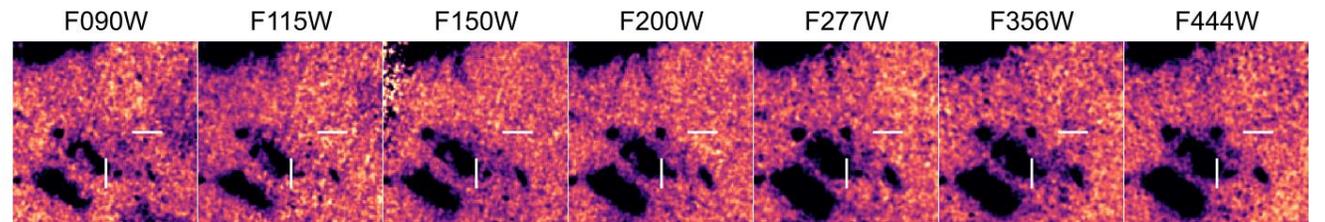
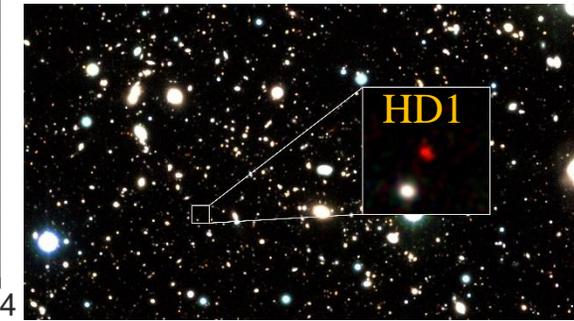
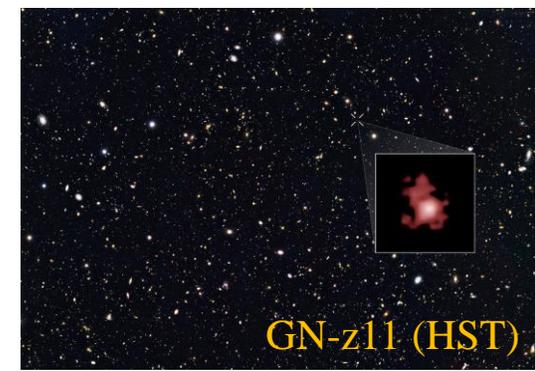
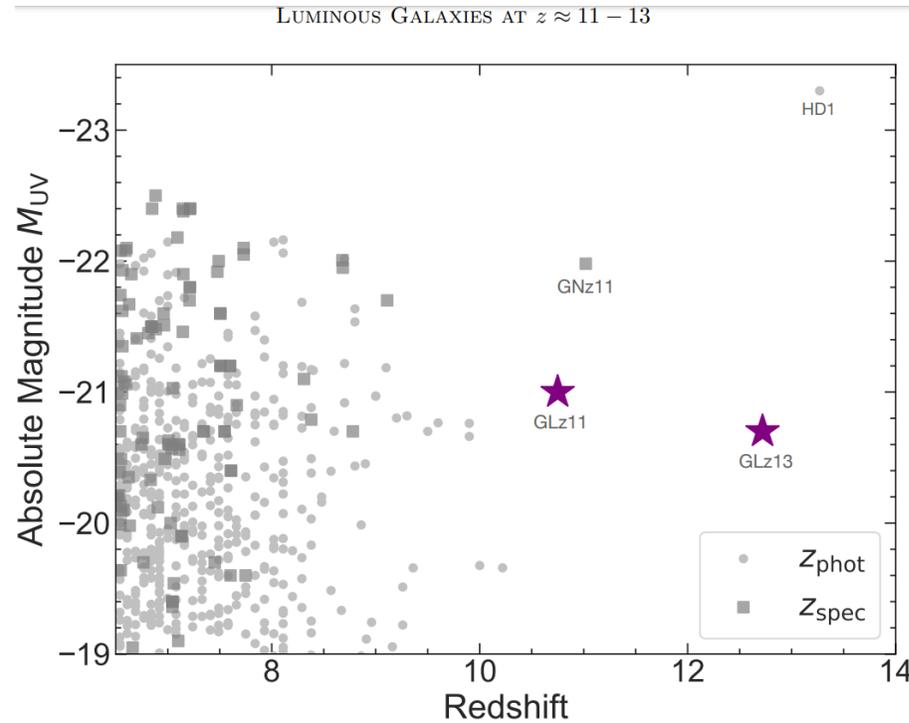
Pozorování dalekého Vesmíru



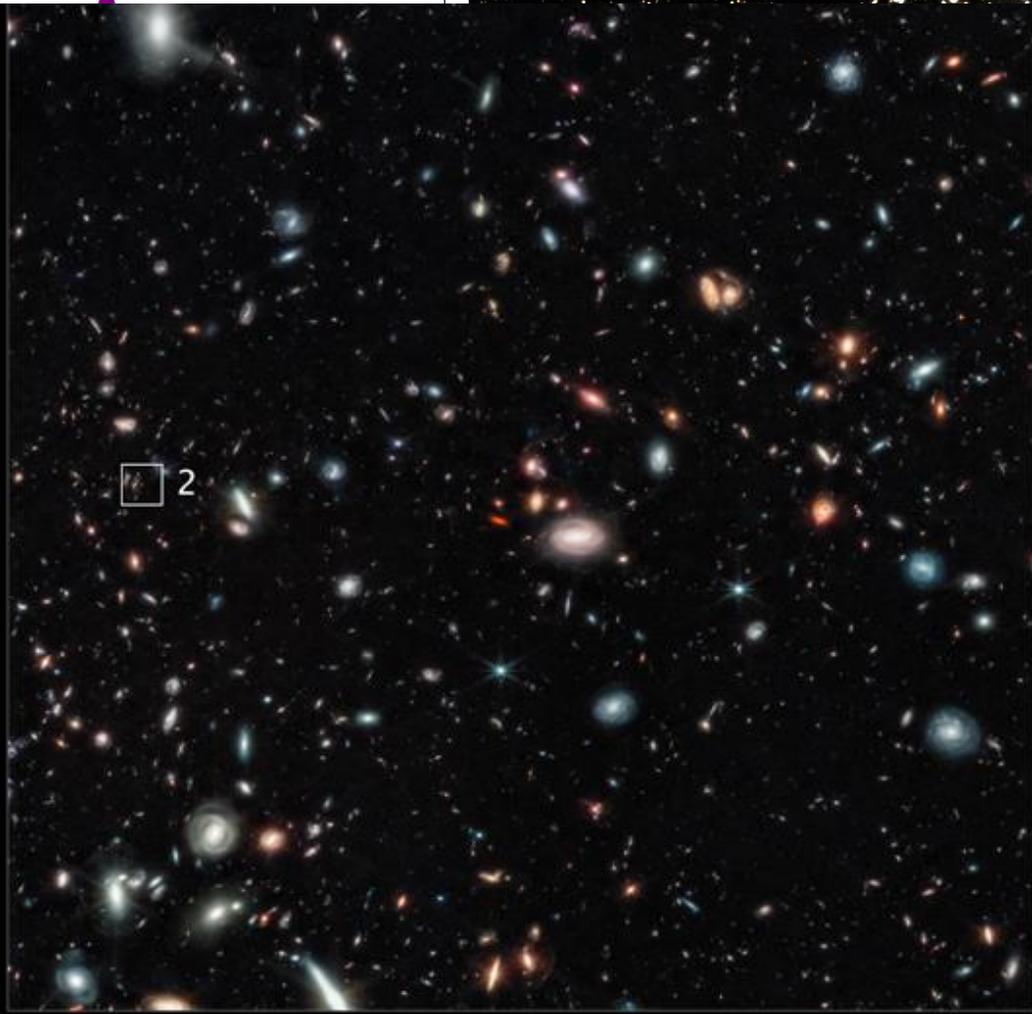
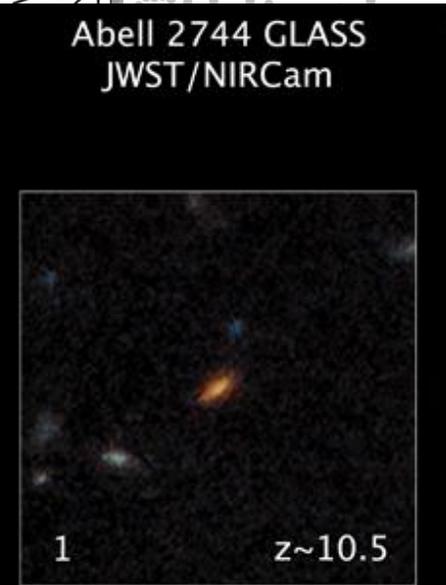
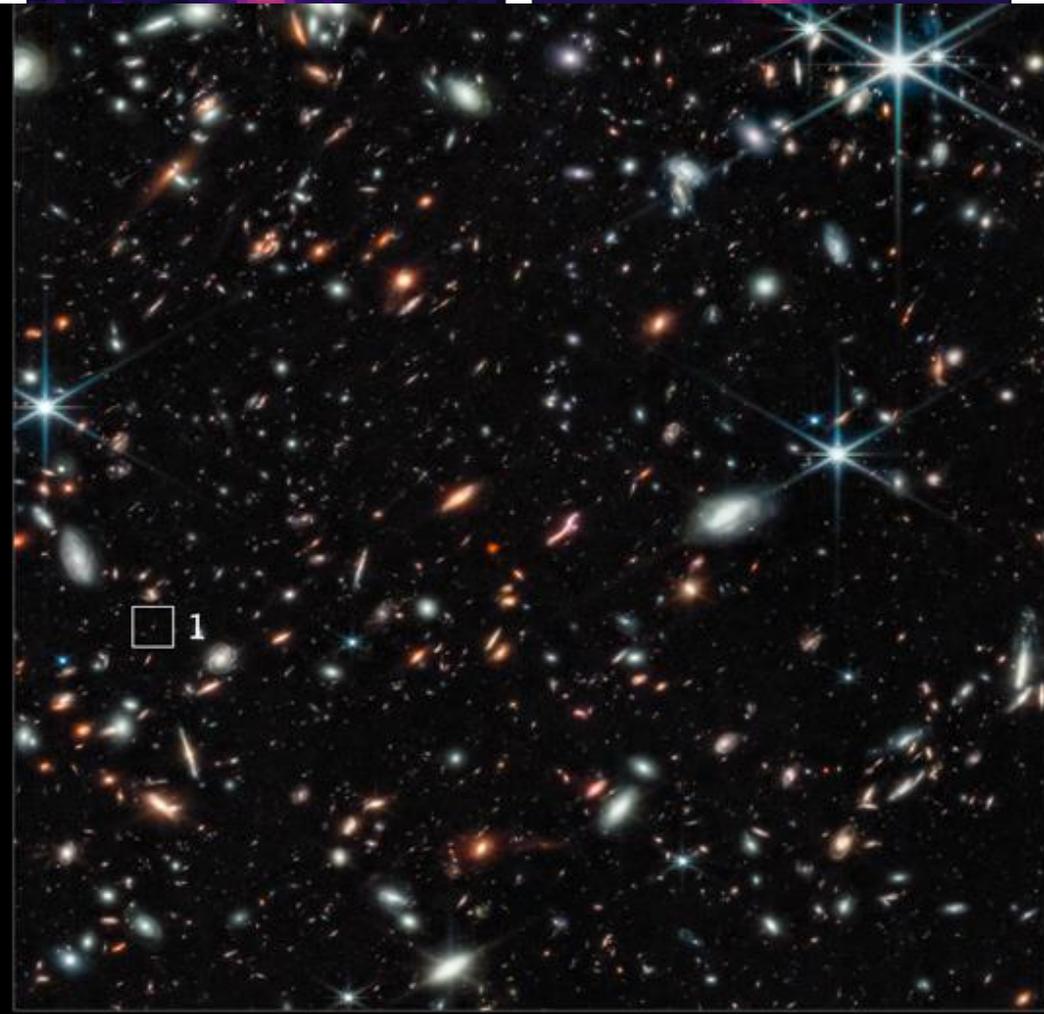
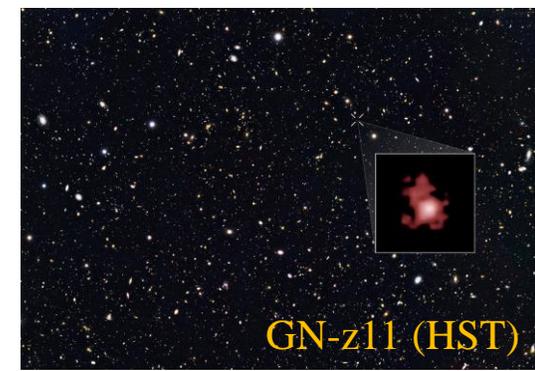
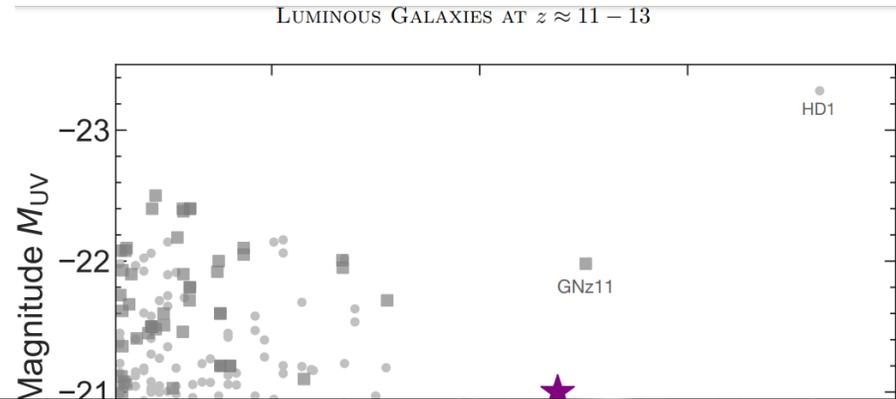
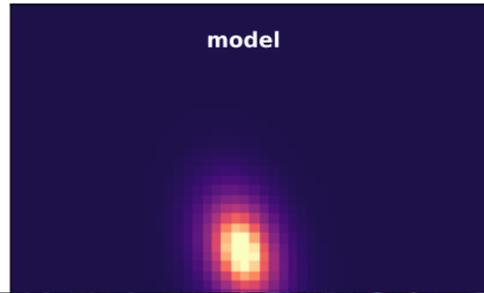
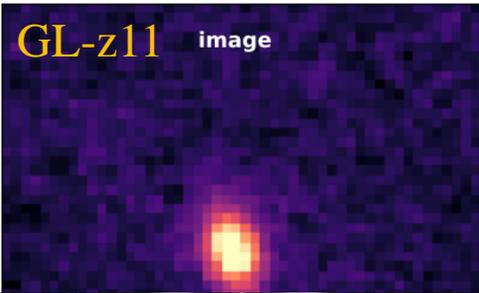
$z = 13,1$ odpovídá stáří Vesmíru **329,8 mil. let**

Vzdálenost \approx **33,205 mld. ly**

<https://doi.org/10.48550/arXiv.2207.09434>

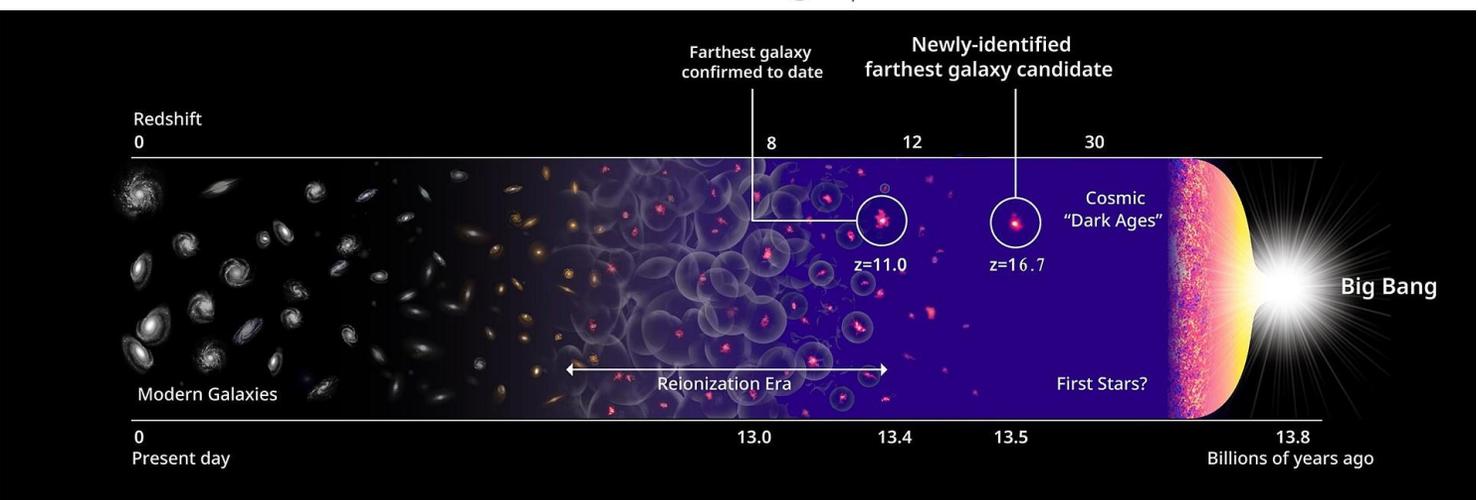
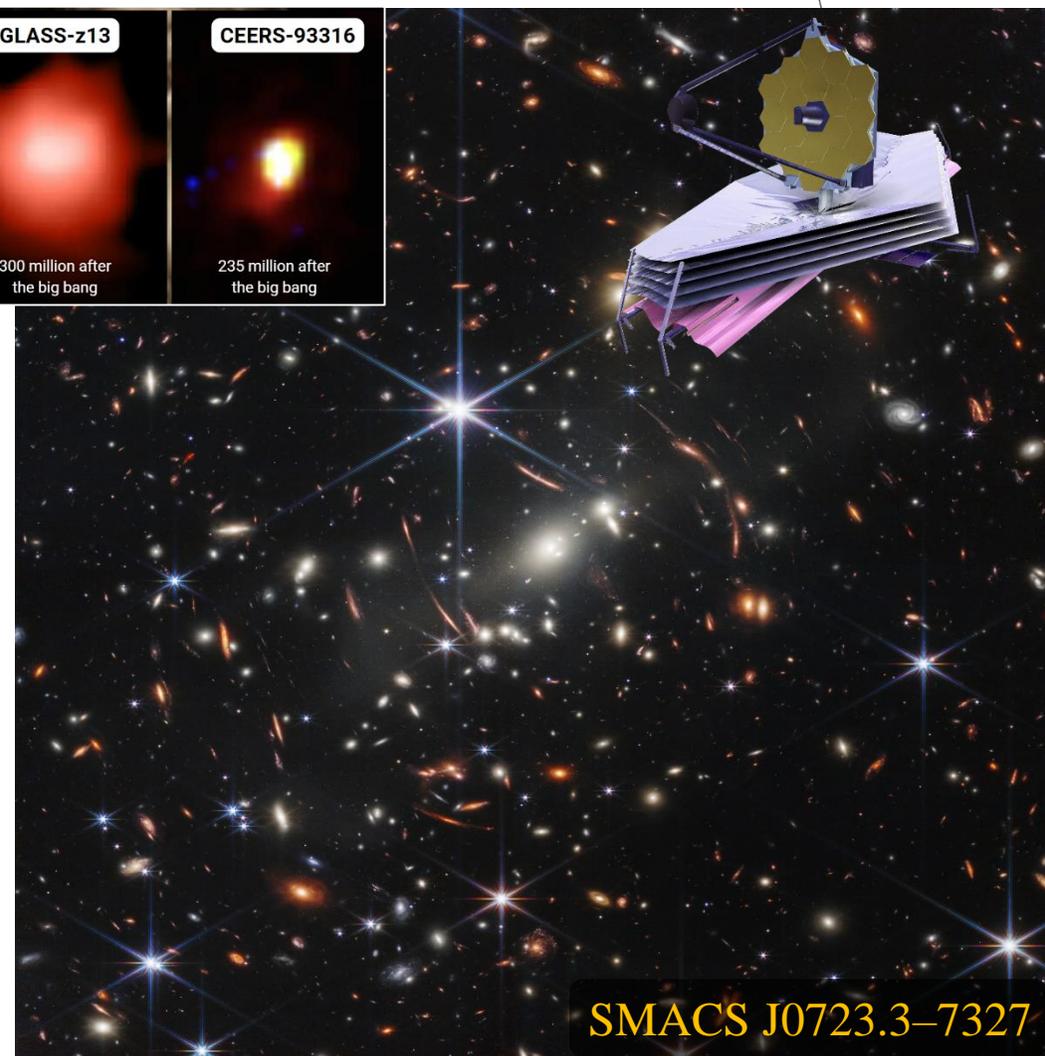
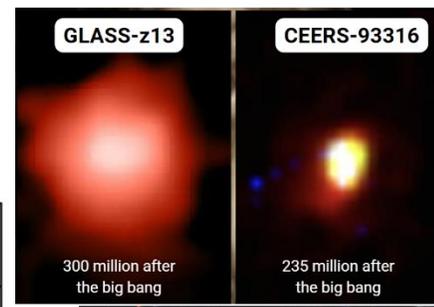
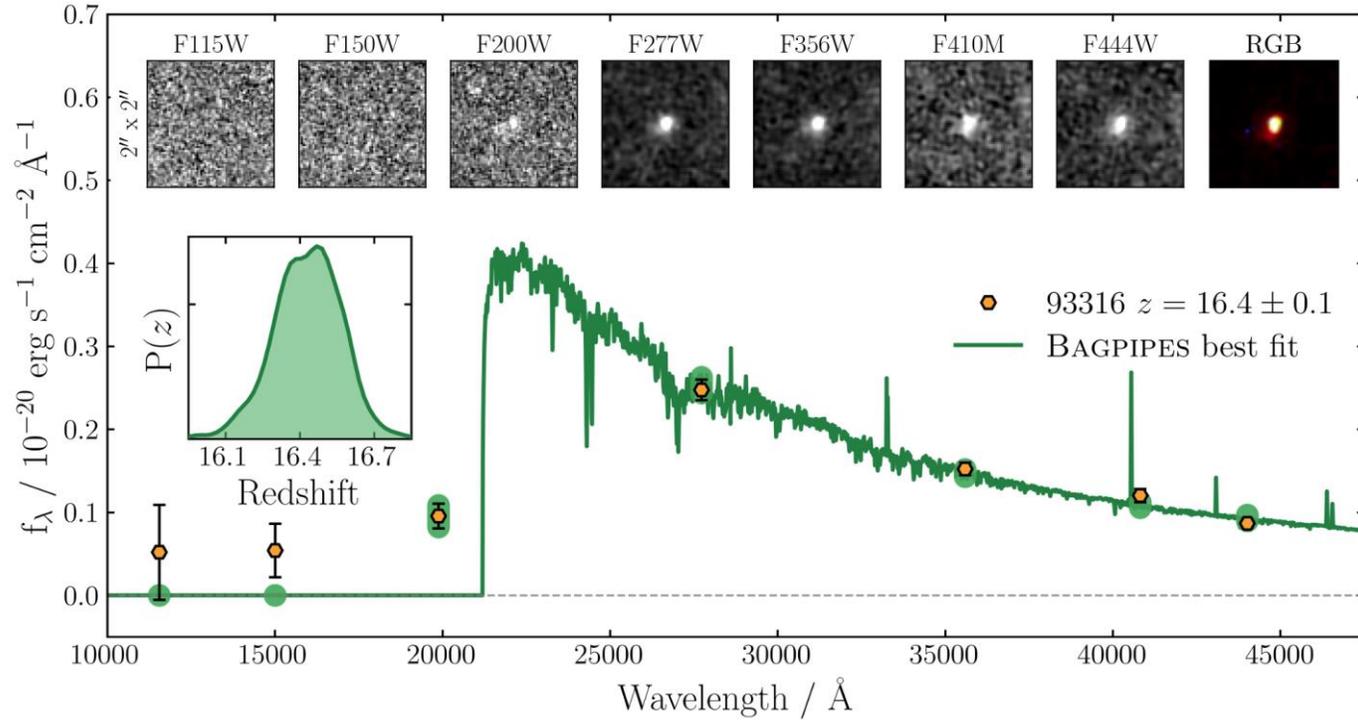


Pozorování dalekého Vesmíru



Pozorování dalekého Vesmíru

Kandidát na nejvzdálenější vesmírný objekt: **CEERS-93316**



$z = 16,4$ odpovídá stáří Vesmíru **240 mil. let**

Vzdálenost \approx **34,7 mld. ly**

<https://doi.org/10.48550/arXiv.2207.12356>



JD 1

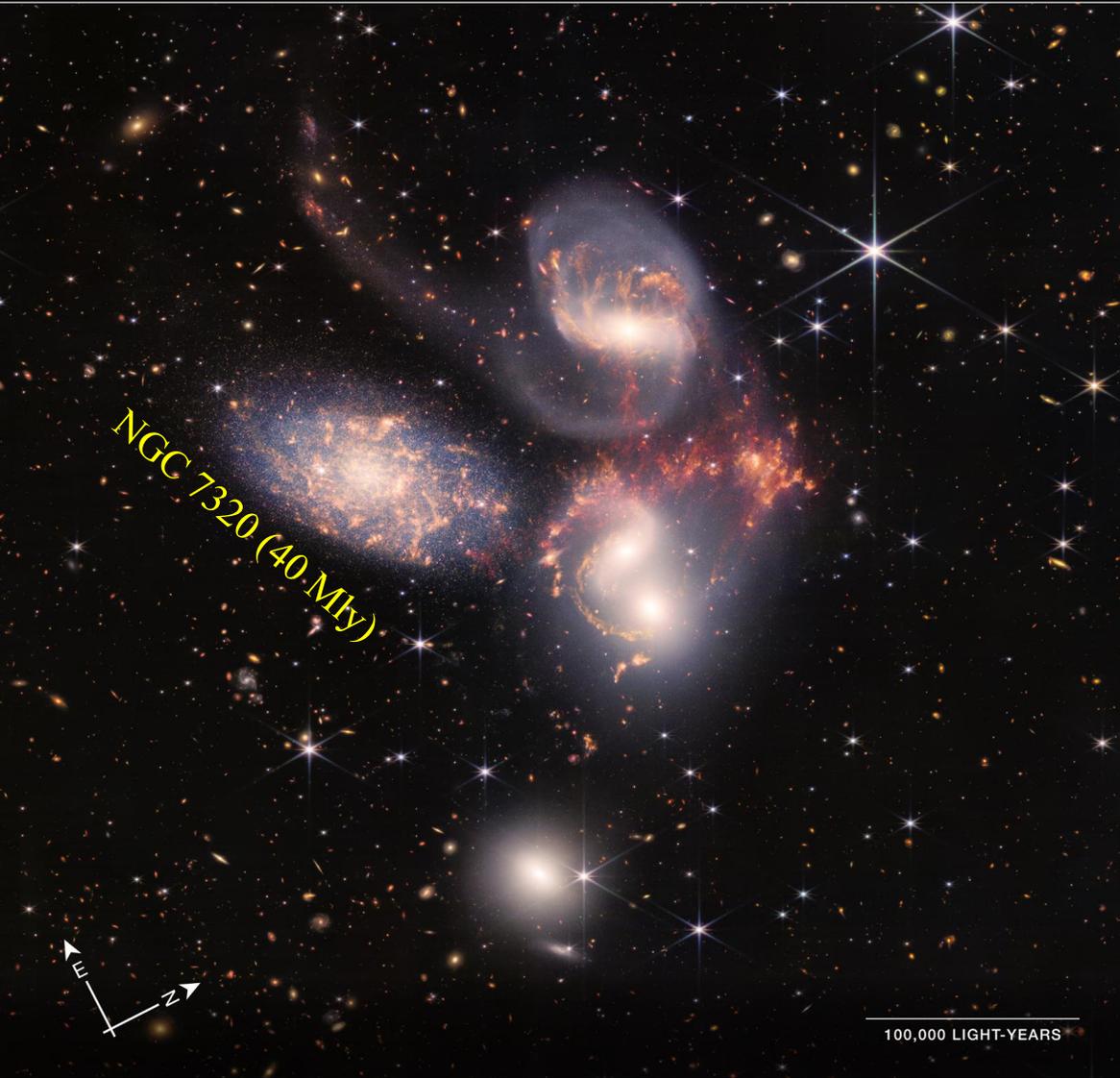
JD 2

JD 3

Gravitační čočkování

Masivní gravitace kupy galaxií MACS0647 působí jako kosmická čočka, která ohýbá a zvětšuje světlo ze vzdálenějšího systému MACS0647-JD. Rovněž trojnásobně čočkuje systém JD, což způsobuje, že se jeho obraz objevuje na třech oddělených místech. Tyto obrazy, které jsou zvýrazněny bílými rámečky, jsou označeny JD1, JD2 a JD3; zvětšené pohledy jsou zobrazeny na panelech vpravo. Na tomto snímku z Webbova přístroje NIRCам (Near Infrared Camera) byla modrá barva přiřazena vlnovým délkám 1,15 a 1,5 mikronu (F115W, F150W), zelená vlnovým délkám 2,0 a 2,77 mikronu (F200W, F277W) a červená vlnovým délkám 3,65 a 4,44 mikronu (F365W, F444W).

Vzdálenost: 290 Mly

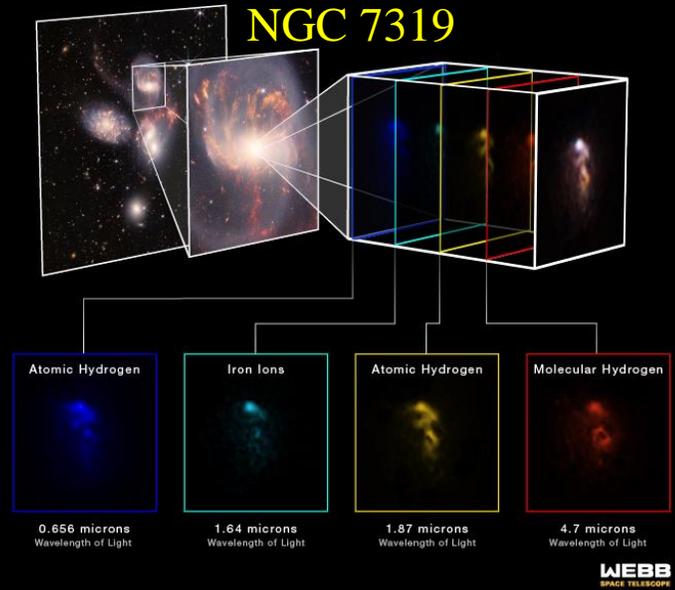


NIRCam Filters | F090W F150W F200W F277W F356W F444W

MIRI Filters | F770W F1000W

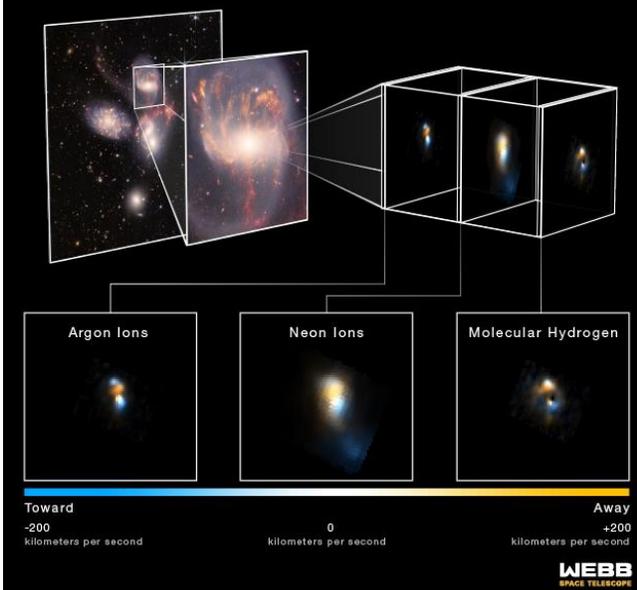
INTERACTING GALAXIES | STEPHAN'S QUINTET
COMPOSITION OF GAS AROUND ACTIVE BLACK HOLE

NIRCam and MIRI Imaging | NIRSpec IFU Spectroscopy

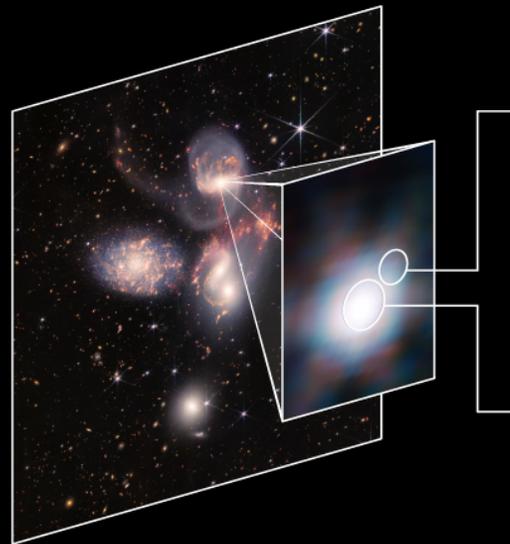


INTERACTING GALAXIES | STEPHAN'S QUINTET
VELOCITY OF GAS NEAR ACTIVE BLACK HOLE

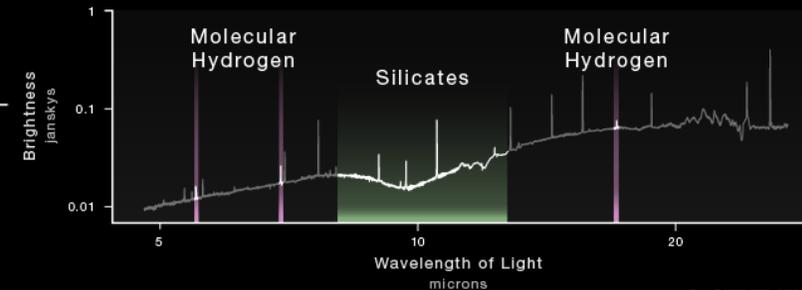
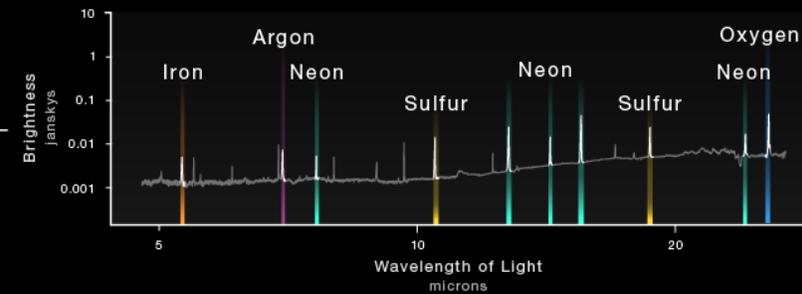
NIRCam and MIRI Imaging | MIRI IFU Medium Resolution Spectroscopy

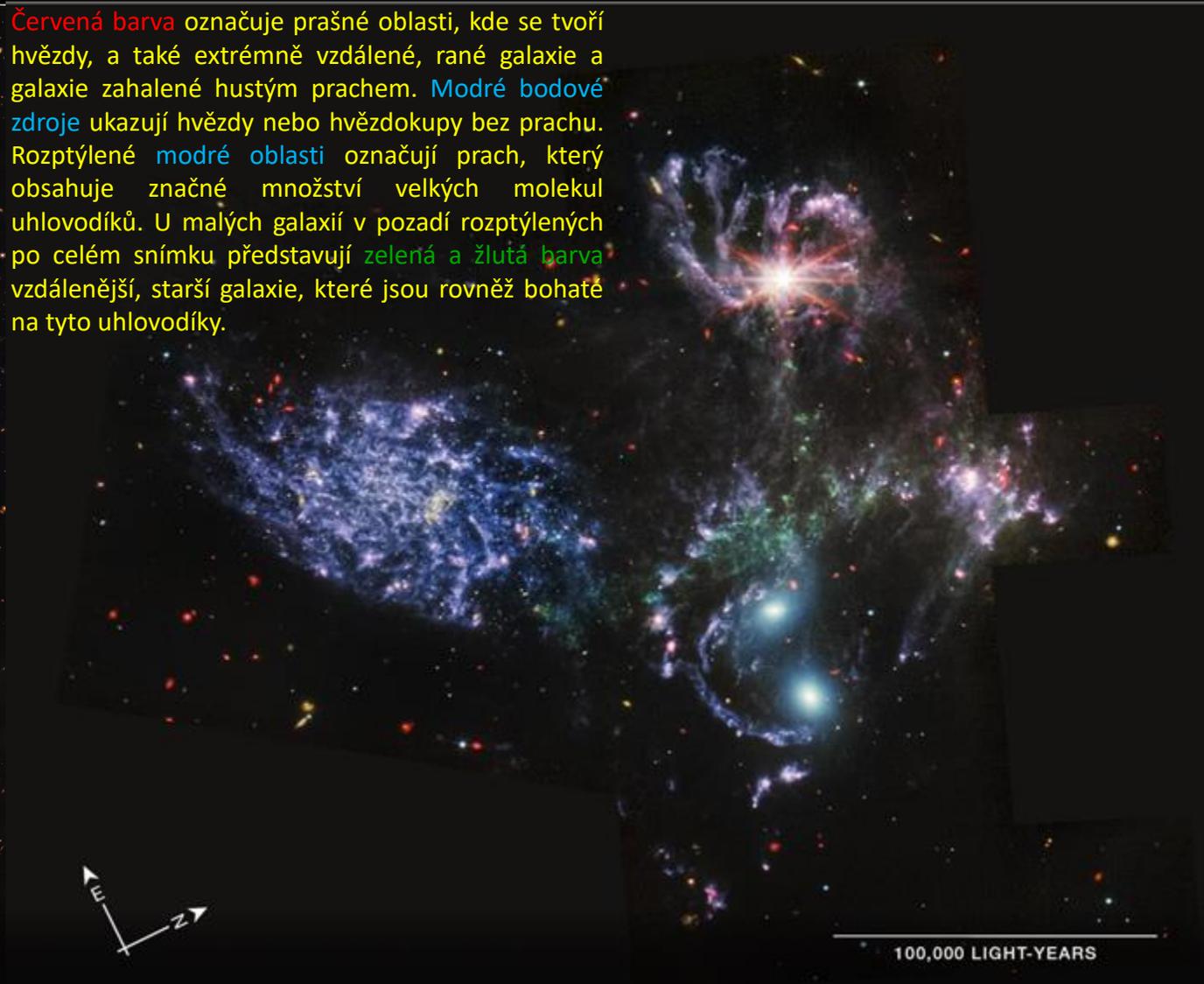
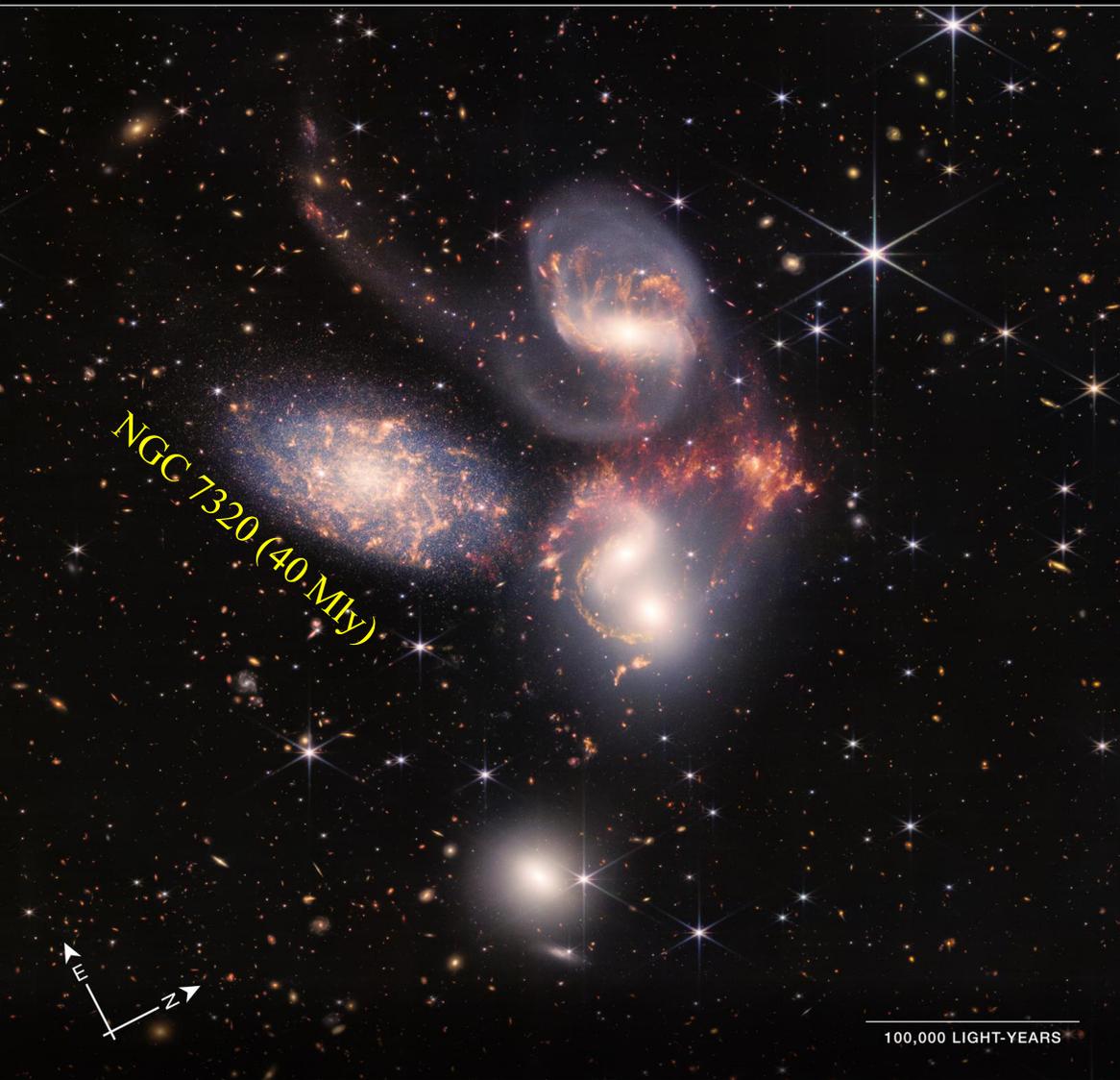


NIRCam and MIRI Imaging



MIRI IFU Medium Resolution Spectroscopy





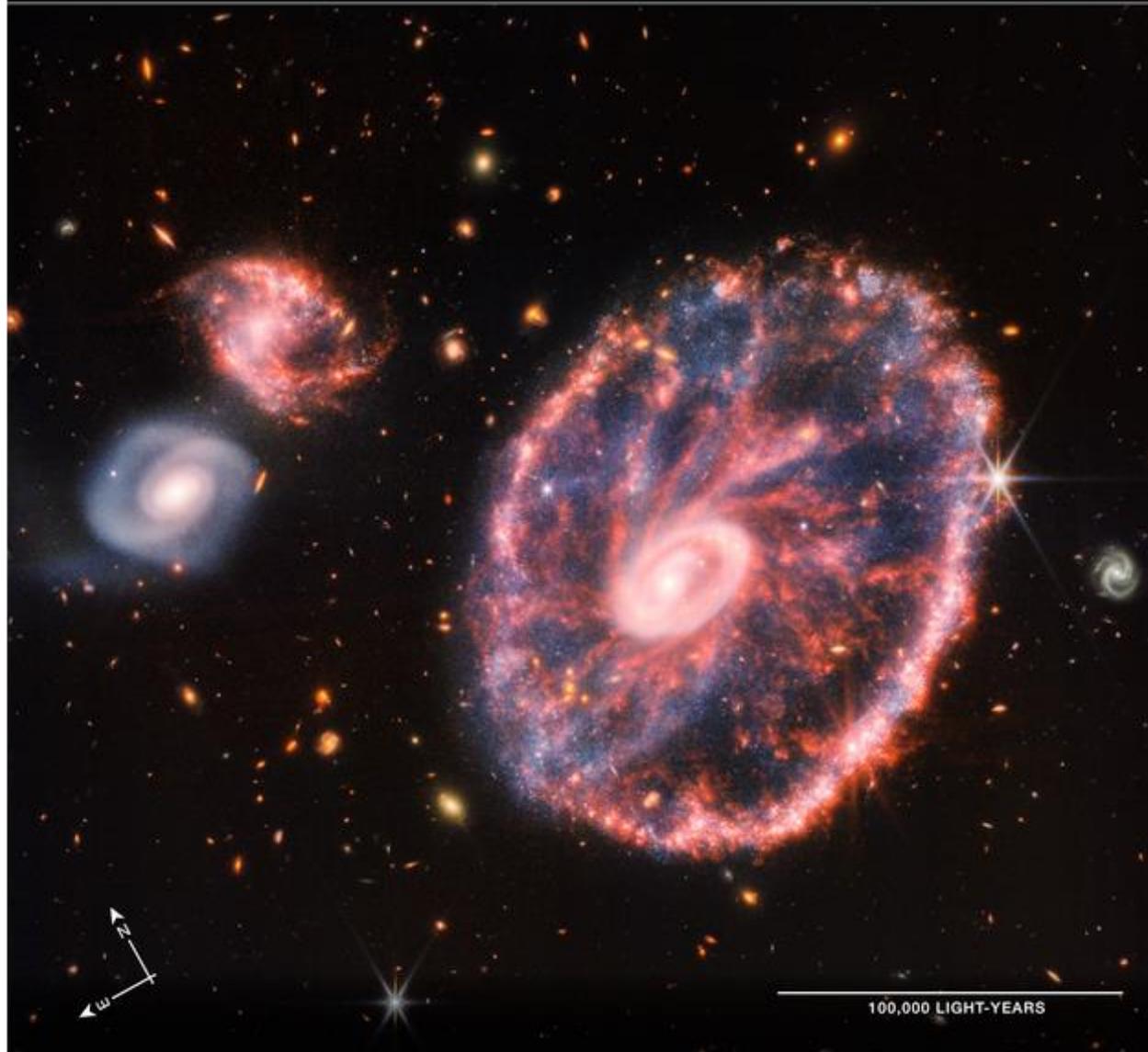
Červená barva označuje prашné oblasti, kde se tvoří hvězdy, a také extrémně vzdálené, rané galaxie a galaxie zahalené hustým prachem. Modré bodové zdroje ukazují hvězdy nebo hvězdokupy bez prachu. Rozptýlené modré oblasti označují prach, který obsahuje značné množství velkých molekul uhlovodíků. U malých galaxií v pozadí rozptýlených po celém snímku představují zelená a žlutá barva vzdálenější, starší galaxie, které jsou rovněž bohaté na tyto uhlovodíky.

JAMES WEBB SPACE TELESCOPE

CARTWHEEL GALAXY

ESO 350-40

Vzdálenost: 500 Mly

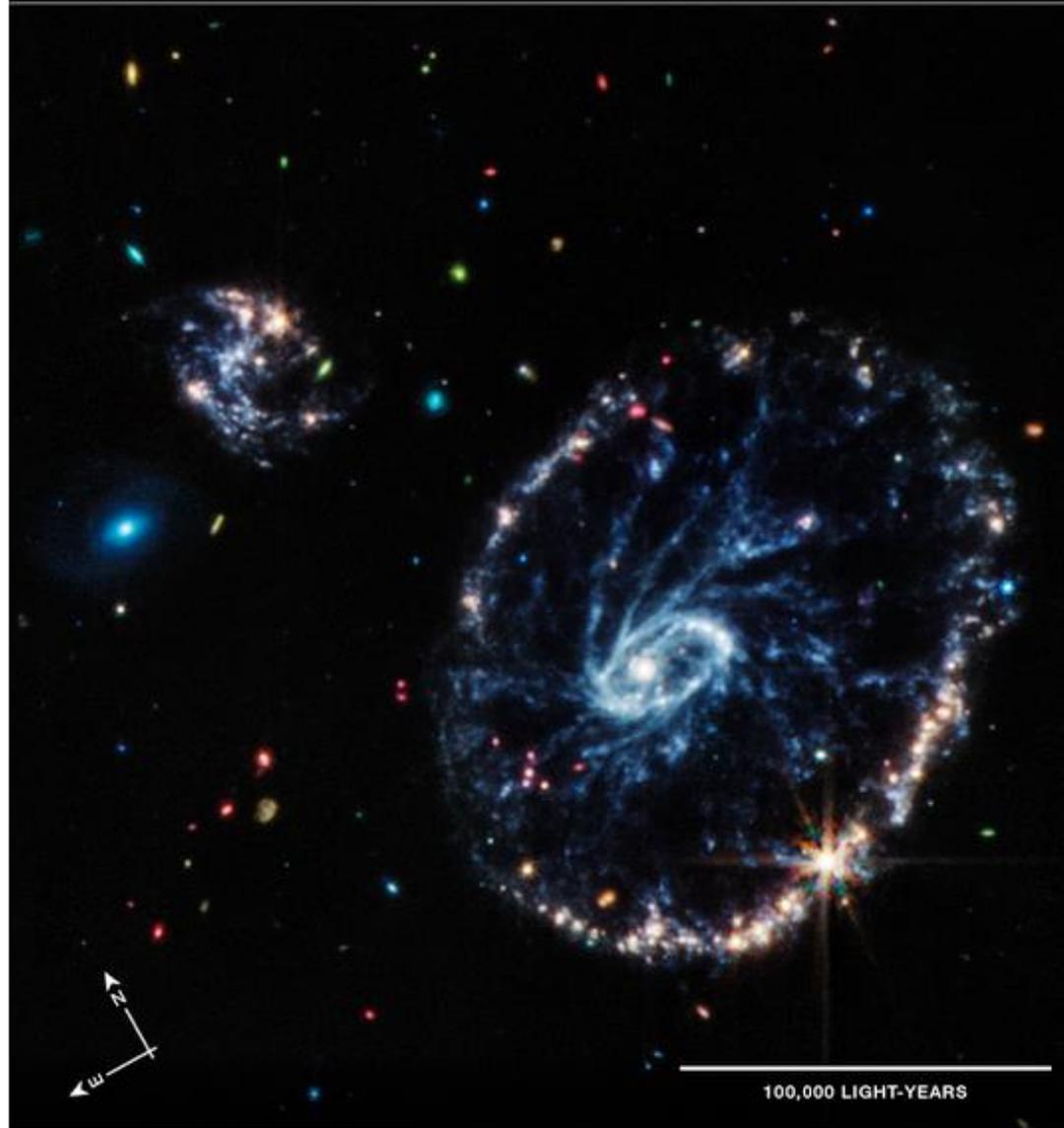


NIRCam Filters | F090W F158W F200W F277W F356W F444W

MIRI Filters | F770W F1000W F1280W F1800W

JAMES WEBB SPACE TELESCOPE

CARTWHEEL GALAXY | ESO 350-40



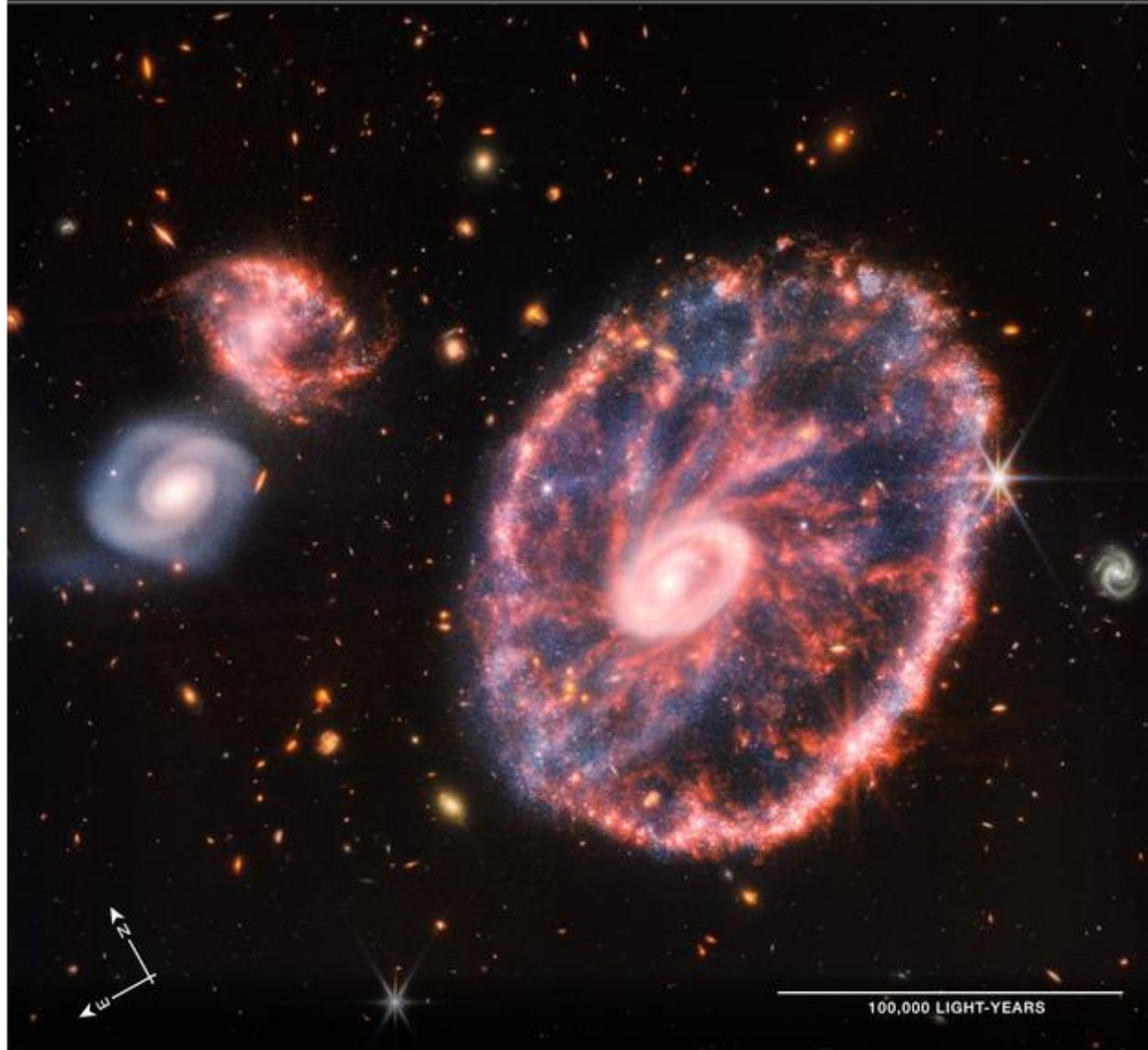
MIRI Filters | F770W F1000W F1280W F1800W

JAMES WEBB SPACE TELESCOPE

CARTWHEEL GALAXY

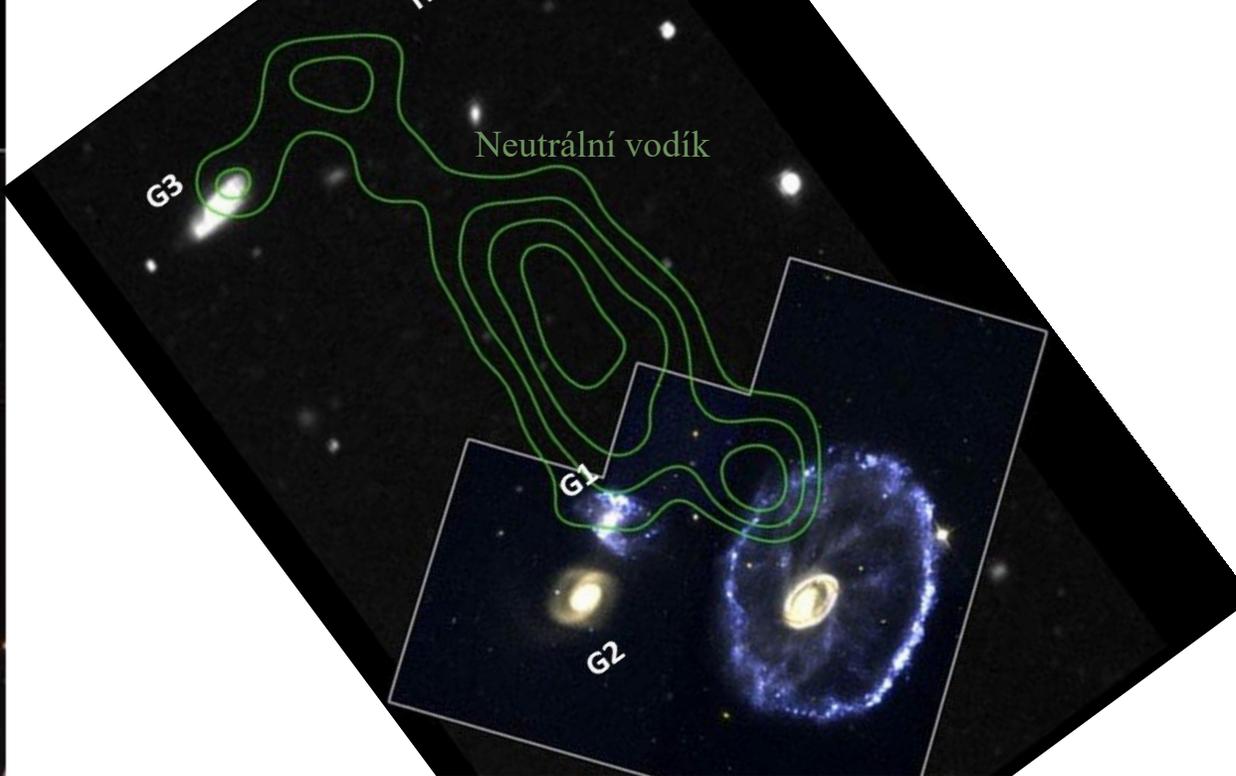
ESO 350-40

Vzdálenost: 500 Mly



NIRCam Filters | F090W F158W F200W F277W F356W F444W

MIRI Filters | F770W F1000W F1280W F1800W



Numerické simulace



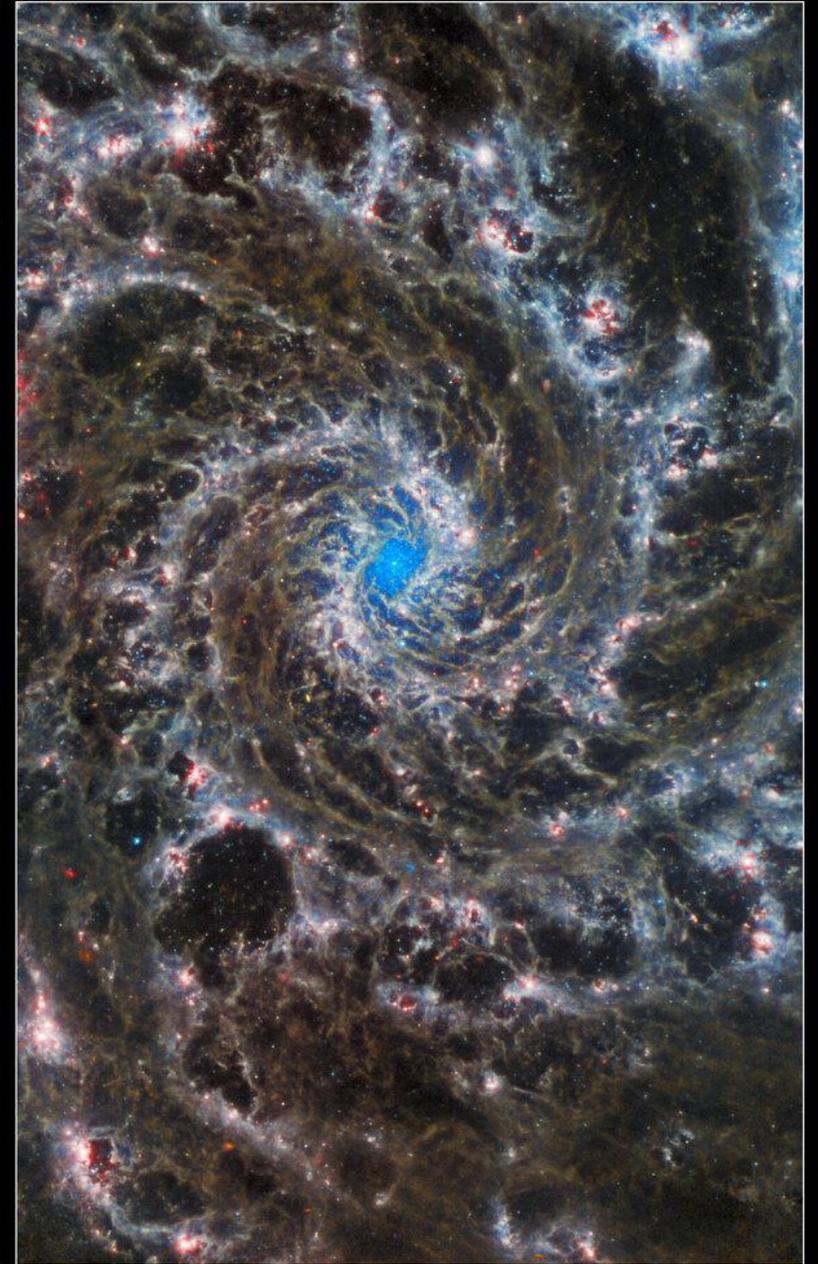
M74 (HST a JWST), 32 Mly: **Červené barvy** označují prach protkaný rameny galaxie, **světlejší oranžové** jsou oblasti s horkým prachem. **Modře** jsou vyznačeny mladé hvězdy v ramenech a jaderné jádro. Těžší, starší hvězdy směrem ke středu galaxie jsou zobrazeny **azurovou a zelenou**. **Růžovou barvou** jsou v ramenech vidět také bubliny vznikajících hvězd.



Hubble / Optical



Hubble & Webb



Webb / Infrared (MIRI)



TARANTULA NEBULA
STAR FORMATION REVEALED

NIRCam Imaging

Vzdálenost: 179 kly

Atomic Hydrogen

1.87 microns
Wavelength of Light

Molecular Hydrogen

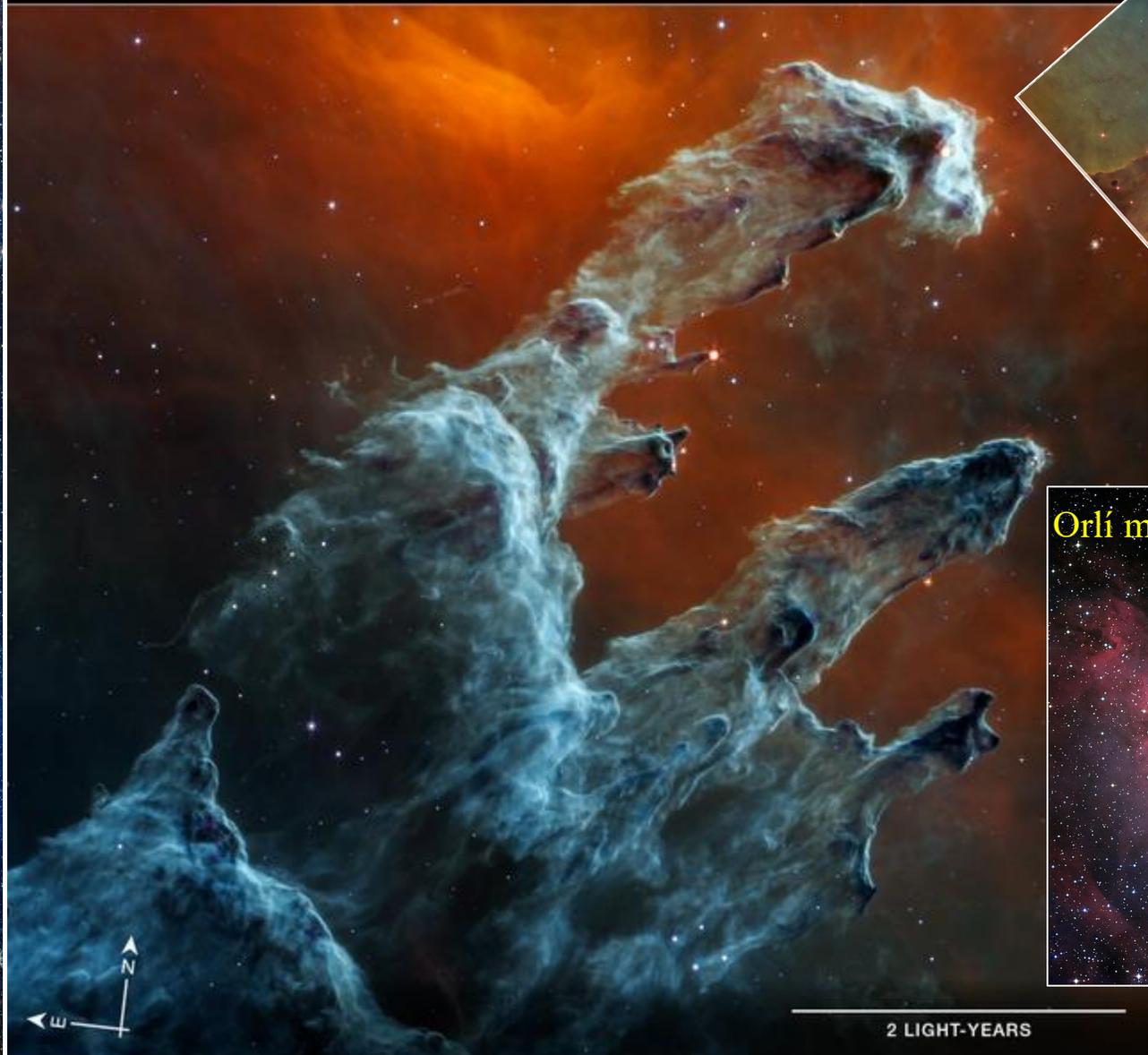
2.12 microns
Wavelength of Light

Hydrocarbon Dust

3.3 microns
Wavelength of Light



JAMES WEBB SPACE TELESCOPE
PILLARS OF CREATION | M16



MIRI Filters | F770W F1130W F1500W

Vzdálenost: 6500-7000 ly

JAMES WEBB SPACE TELESCOPE

CARINA NEBULA | NGC 3324



NIRCam Filters | F090W F200W F444W
MIRI Filters | F770W F1130W F1280W F1800W

NIRCam Filters | F090W F187N F200W F470N F335M F444W

JAMES WEBB SPACE TELESCOPE
L1527 IRS | IRAS 04368+2557

Protohvězda (460 ly)

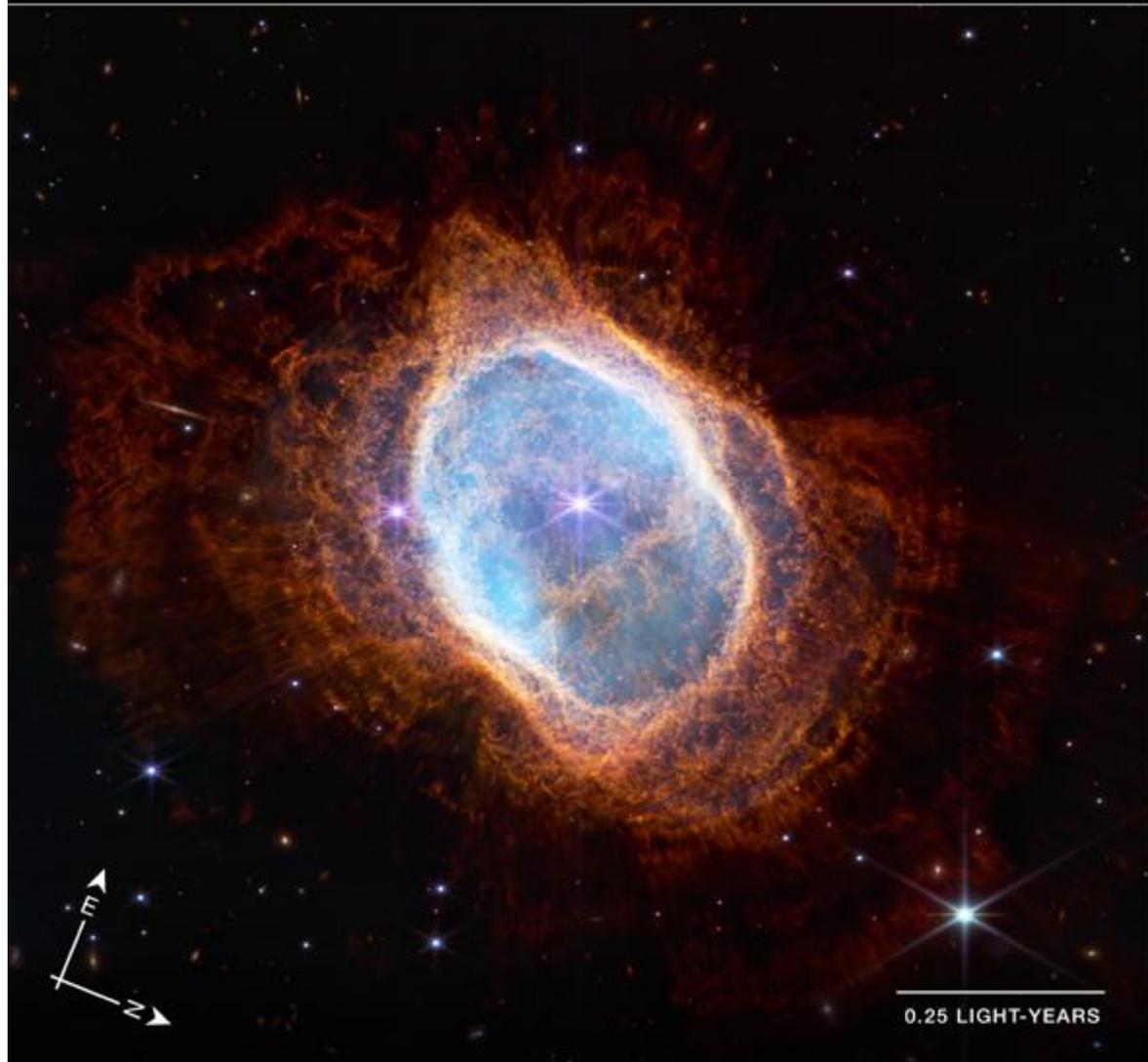


NIRCam Filters | F090W F335M F444W F470N

JAMES WEBB SPACE TELESCOPE

SOUTHERN RING | NGC 3132

Vzdálenost: 2000 ly



NIRCam Filters

F090W

F187N

F212N

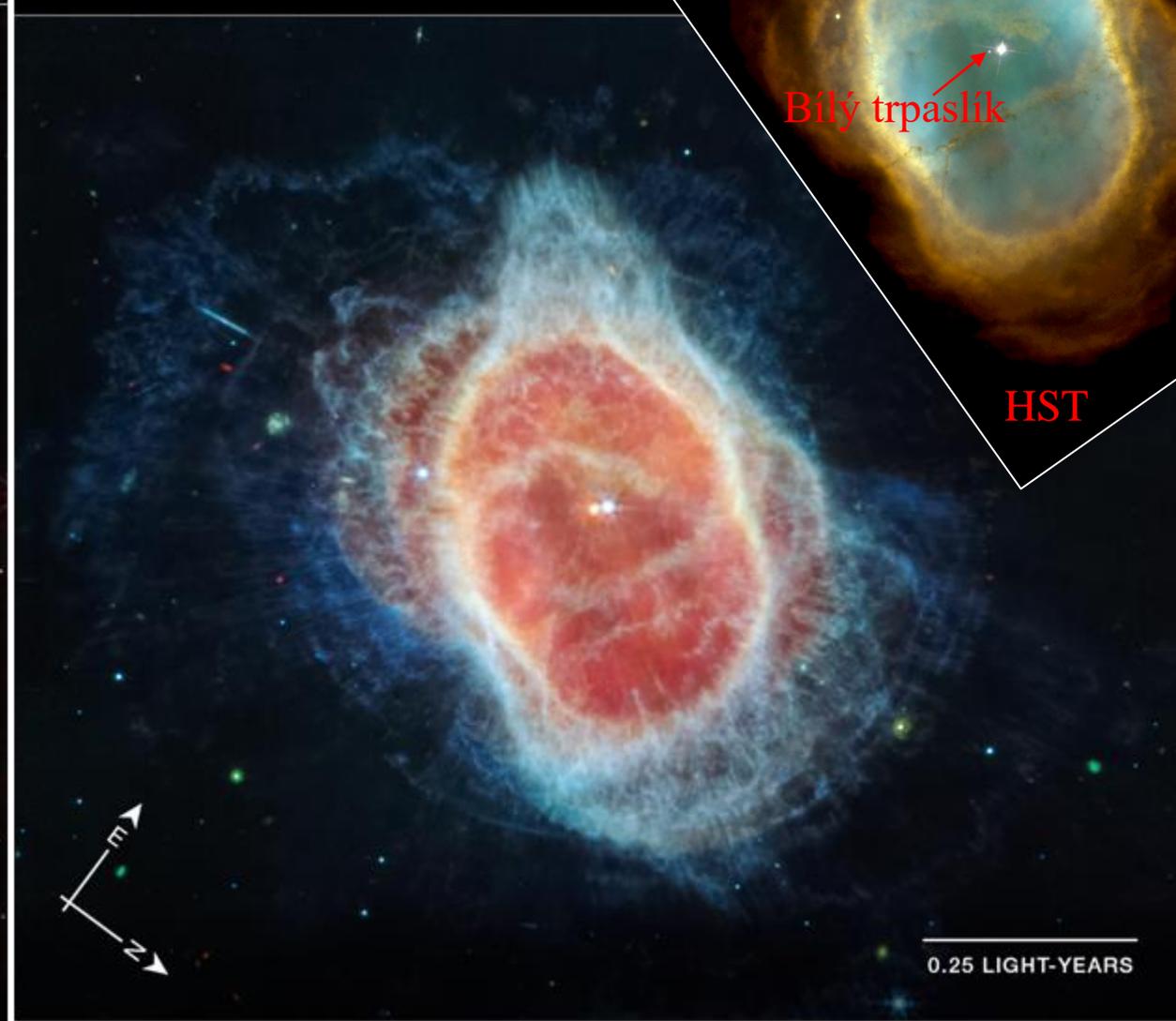
F356W

F405N

F470N

JAMES WEBB SPACE TELESCOPE

SOUTHERN RING | NGC 3132



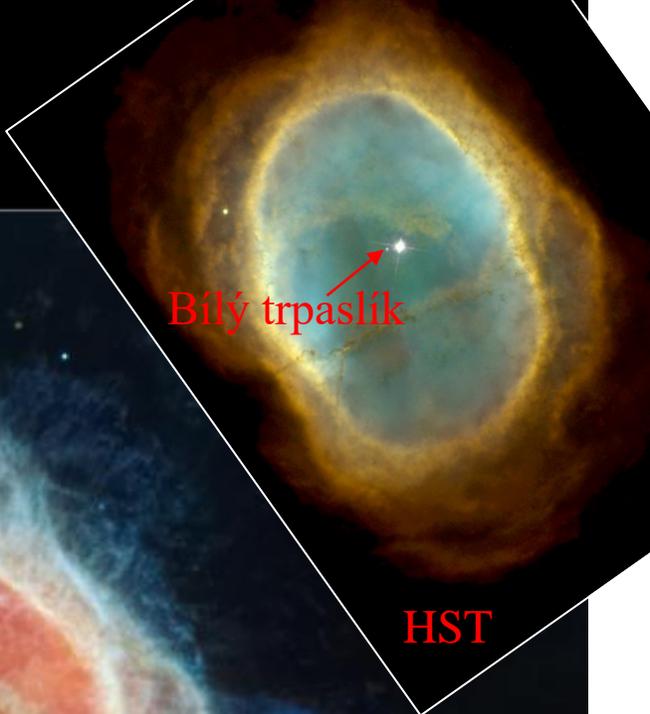
MIRI Filters

F770W

F1130W

F1280W

F1600W

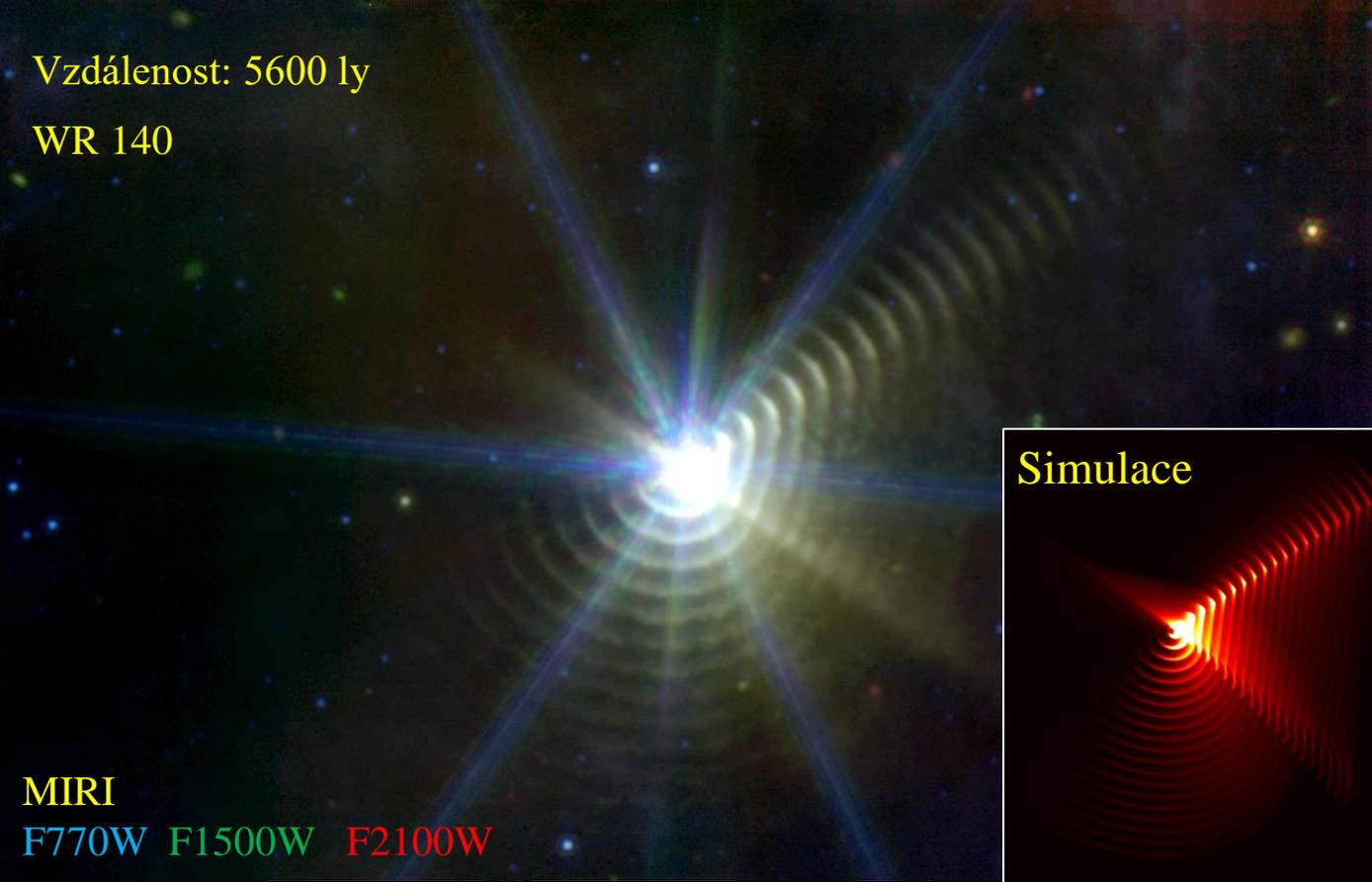


Bílý trpaslík

HST

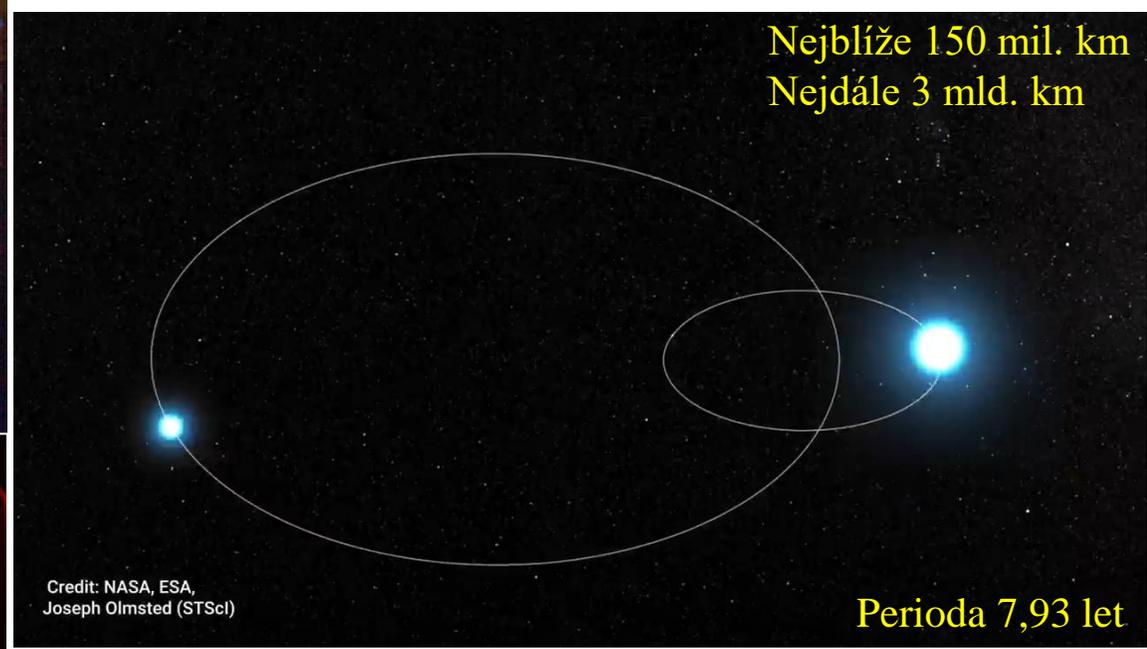
Vzdálenost: 5600 ly

WR 140



Simulace

Nejblíže 150 mil. km
Nejdále 3 mld. km



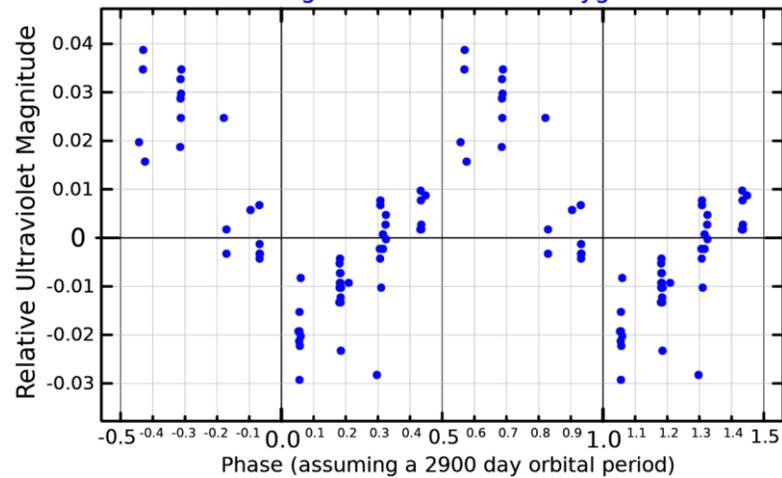
Credit: NASA, ESA,
Joseph Olmsted (STScI)

Perioda 7,93 let

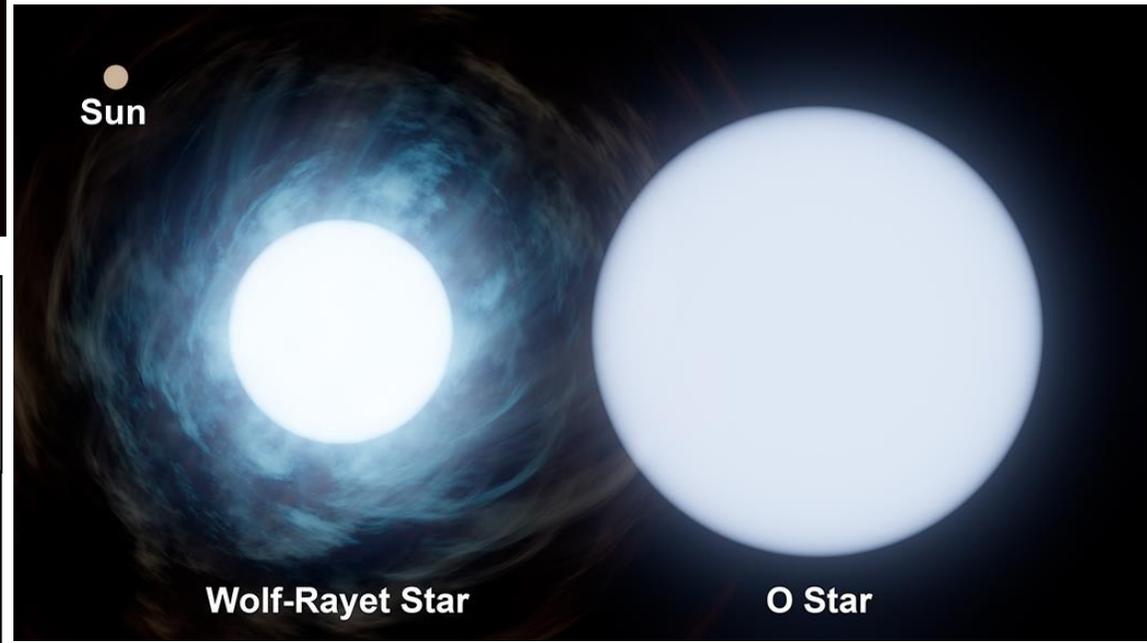
MIRI

F770W F1500W F2100W

A Light Curve for V1687 Cygni



WR	
Mass	$8.4^{[11]} M_{\odot}$
Luminosity	$537,000^{[12]} L_{\odot}$
Temperature	$70,000^{[12]} K$
O	
Mass	$20.5^{[11]} M_{\odot}$
Radius	$35^{[12]} R_{\odot}$
Luminosity	$1,600,000^{[12]} L_{\odot}$
Temperature	$35,000^{[12]} K$

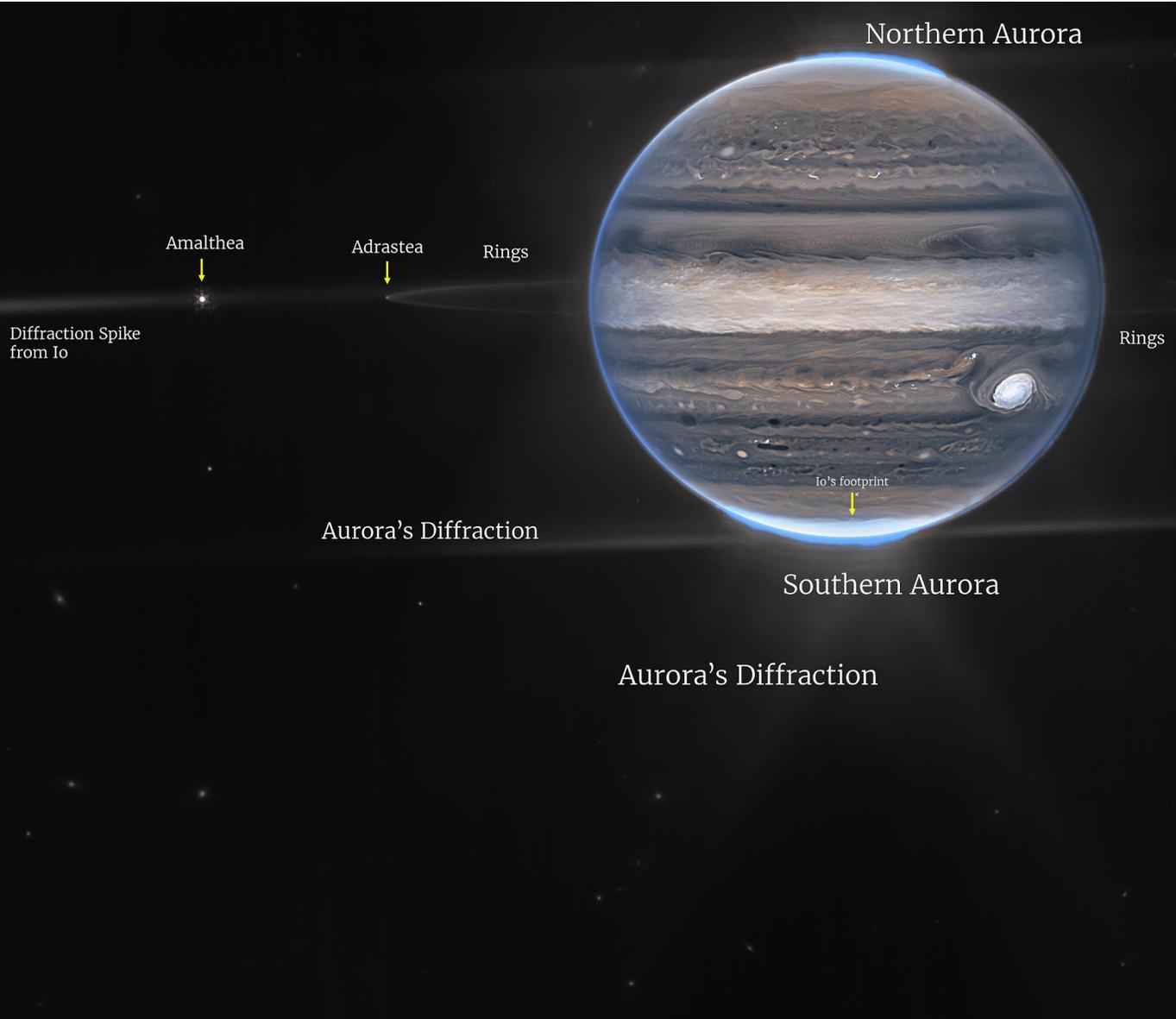


Sun

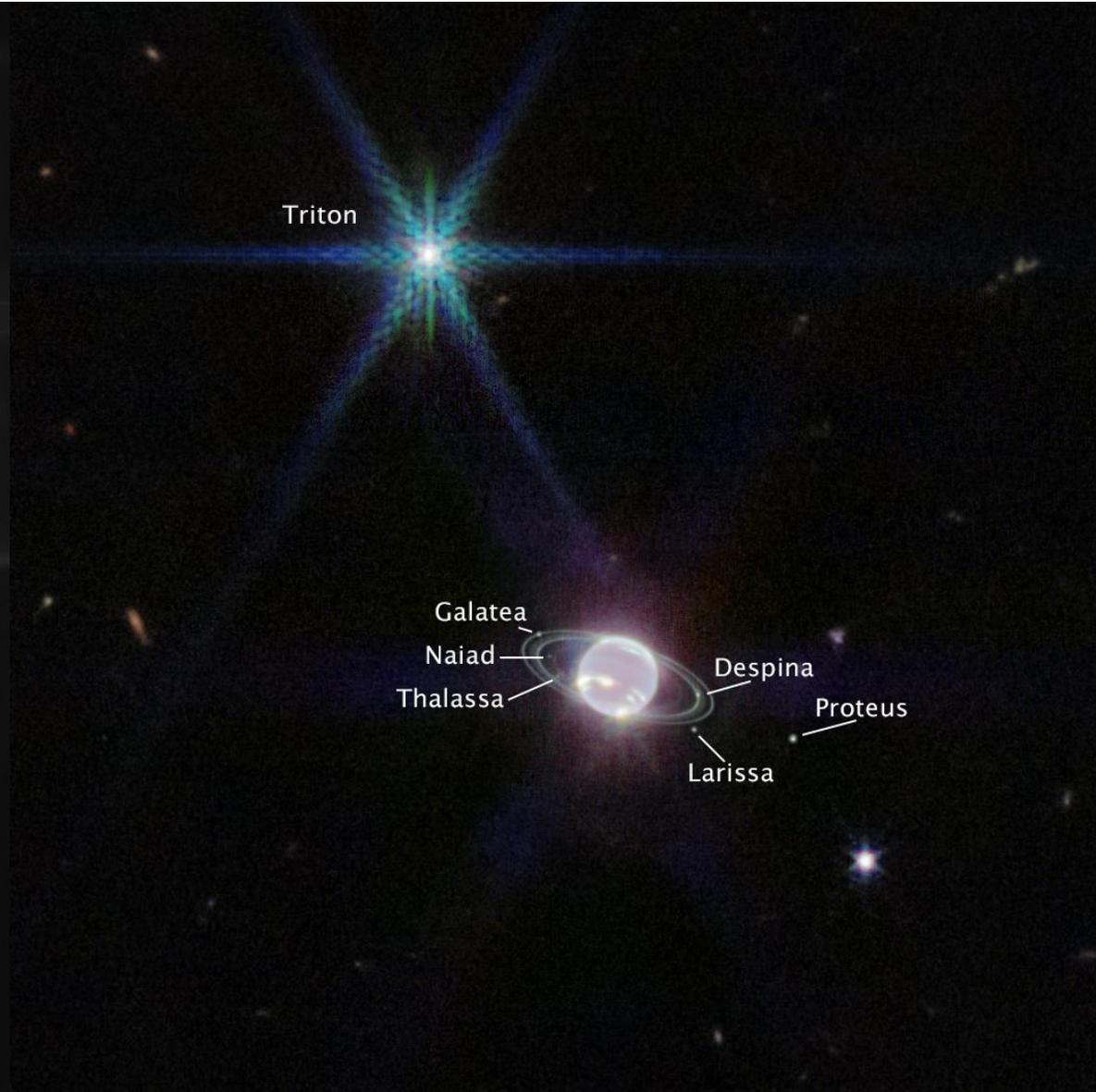
Wolf-Rayet Star

O Star

Jupiter

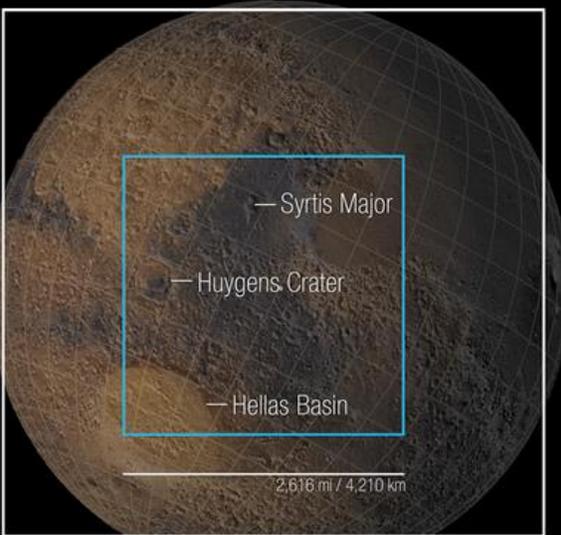


Neptun



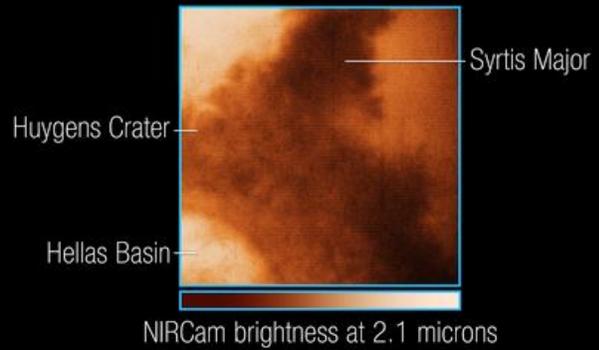
Mars

James Webb Space Telescope
NIRCam - September 5, 2022

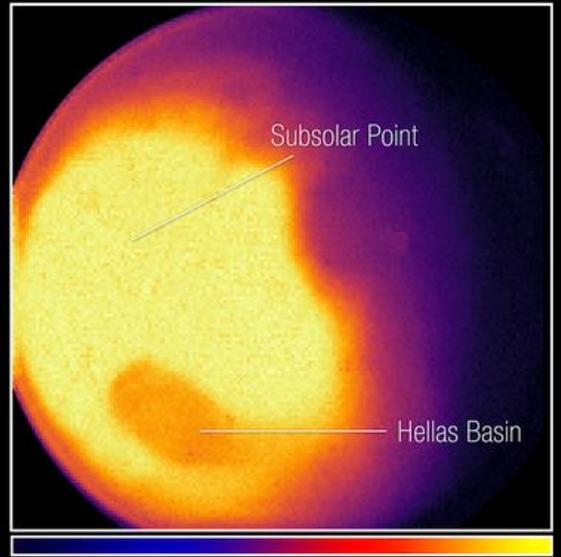


Simulated Mars image with base maps from NASA and MOLA data

NASA, ESA, CSA, STScI, MARS JWST/GTO team



NIRCam brightness at 2.1 microns

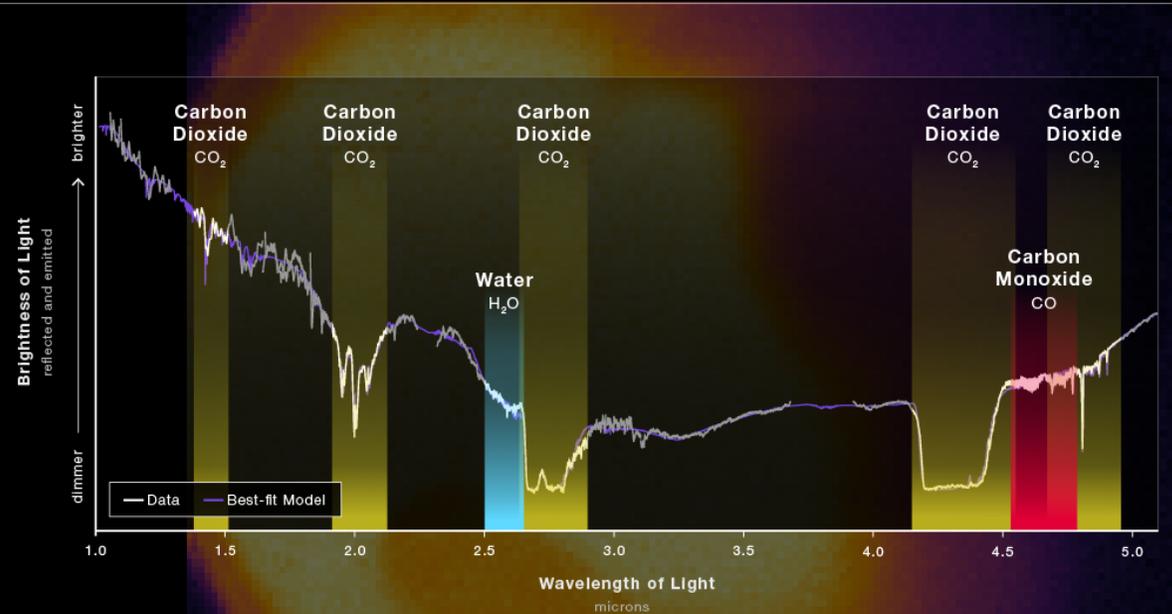


NIRCam brightness at 4.3 microns

Tepelná mapa

MARS ATMOSPHERE COMPOSITION

NIRSpec | Fixed Slit Spectroscopy

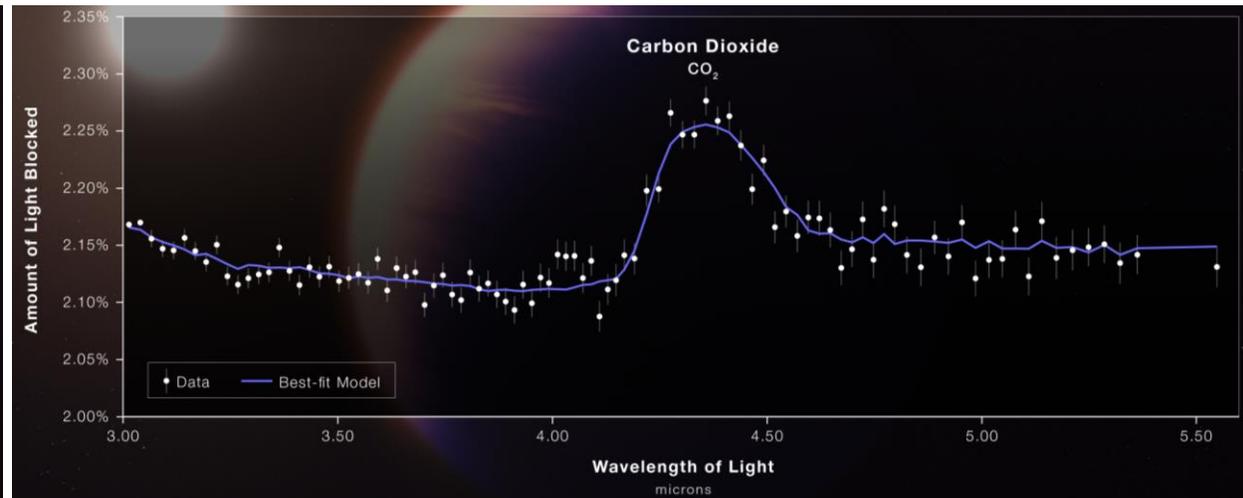
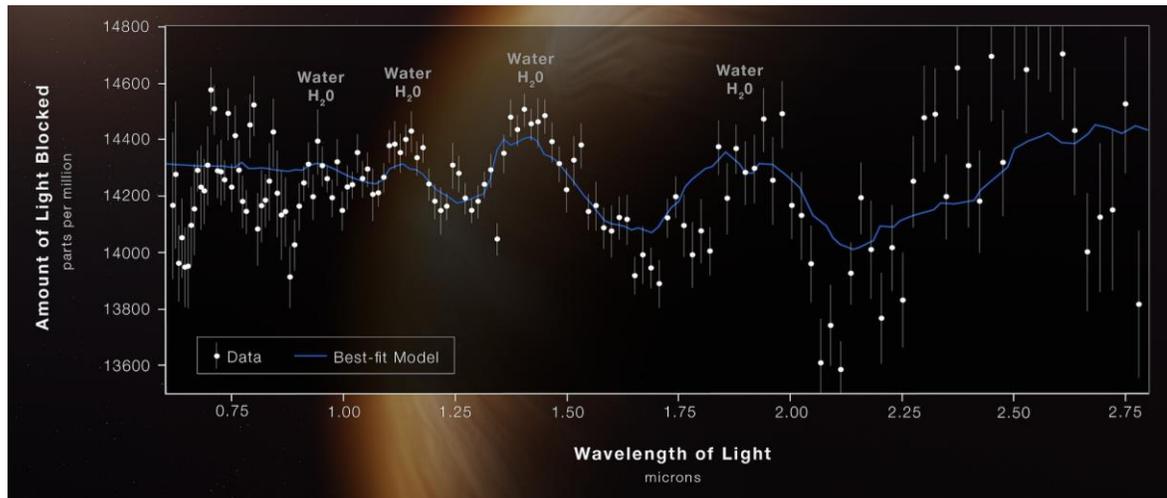
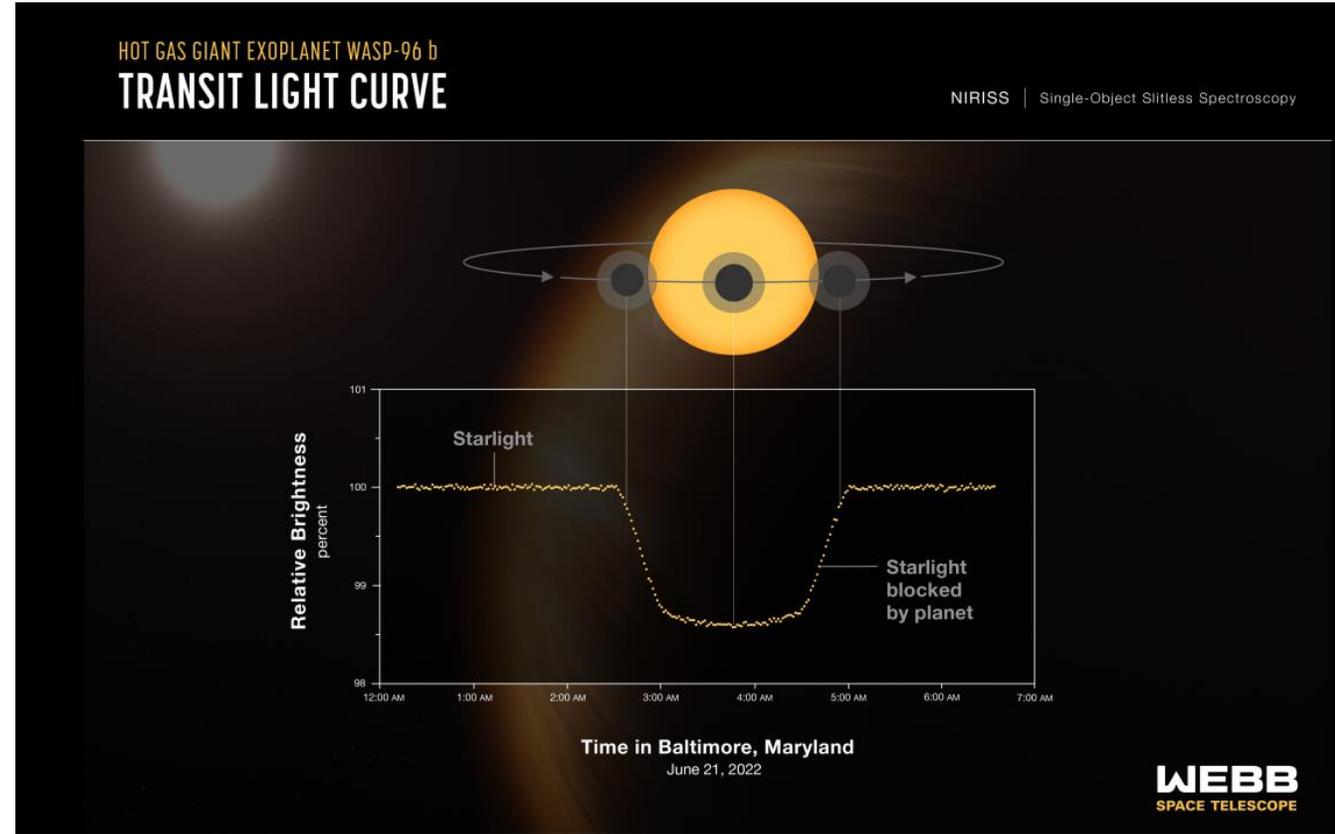
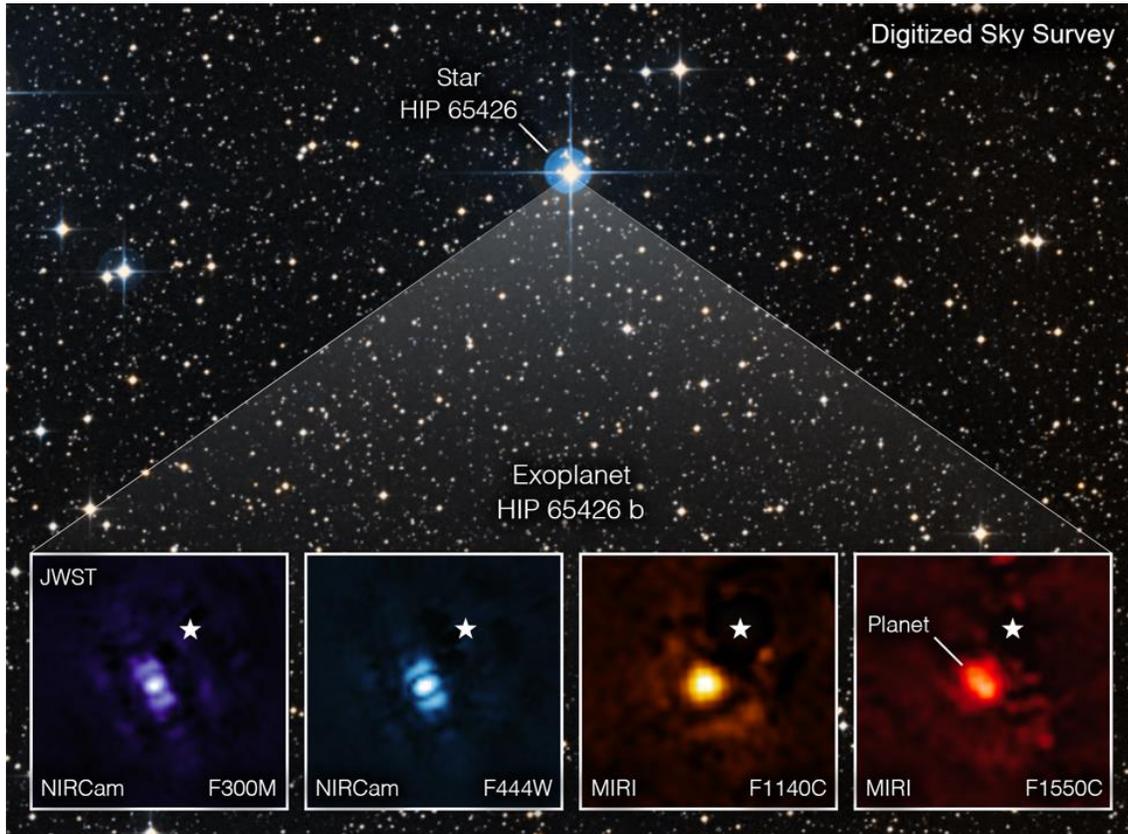


WEBB
SPACE TELESCOPE

Složení (celé) atmosféry



Exoplanety



První data z JWST: 12. července 2022

1. měřicí cyklus = 1 rok
(mimořádné události)

VISIT ID	PCS MODE	VISIT TYPE	SCHEDULED START TIME	DURATION	SCIENCE INSTRUMENT AND MODE	TARGET NAME	CATEGORY	KEYWORDS
1189:15:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-21T01:06:43Z	00/01:13:13	MIRI Medium Resolution Spectroscopy	J045853-89+643452.0	Star	Brown dwarfs
2586:467:1	FINEGUIDE	PRIME WFC ROUTINE	2022-11-21T02:32:03Z	00/01:32:08	WFC NIRCcam Fine Phasing	2MASS-05352161+6715458	Star	Focus test
1335:2:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-21T04:36:46Z	00/01:29:19	MIRI Medium Resolution Spectroscopy	F2M1106-MIRI	Galaxy	Active galactic nuclei, Emission line galaxies,
Quasars								
1495:99:1	NONE	PARALLEL DARK CALIBRATION	^ATTACHED TO PRIME^		NIRSpec Dark			
1335:11:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-21T06:22:44Z	00/00:28:43	MIRI Medium Resolution Spectroscopy	F2M1106-BG	Unidentified	Blank field
1490:30:1	NONE	PARALLEL SLEW CALIBRATION	^ATTACHED TO PRIME^		NIRSpec Internal Lamp			
1947:4:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-21T07:32:44Z	00/01:03:55	MIRI Medium Resolution Spectroscopy	CASSIOPEIA-A-KNOT1	ISM	Supernova remnants
1947:5:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-21T08:43:36Z	00/01:03:55	MIRI Medium Resolution Spectroscopy	CASSIOPEIA-A-KNOT2	ISM	Supernova remnants
1947:6:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-21T09:53:42Z	00/01:01:10	MIRI Medium Resolution Spectroscopy	CASSIOPEIA-A-KNOT3	ISM	Supernova remnants
1947:7:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-21T11:02:45Z	00/01:03:55	MIRI Medium Resolution Spectroscopy	BACKGROUND-RETURN	Calibration	Telescope/sky background
1549:5:1	MOVING	PRIME TARGETED MOVING	2022-11-21T12:47:08Z	00/01:37:25	MIRI Medium Resolution Spectroscopy	526-JENA	Solar System	Asteroid
2574:5:1	MOVING	PRIME TARGETED MOVING	2022-11-21T15:32:55Z	00/01:51:36	NIRSpec IFU Spectroscopy	POLYMELE	Solar System	Asteroid
1279:6:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-21T18:31:05Z	00/04:01:35	MIRI Imaging	TRAPPIST-1B	Star	Exoplanet Systems, Exoplanets, M dwarfs, M stars
2654:5:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-21T23:42:16Z	00/02:42:53	MIRI Medium Resolution Spectroscopy	SDSSJ0749-MIRI	Galaxy	Active galactic nuclei, Emission line galaxies,
Quasar-galaxy pairs								
1497:19:1	NONE	PARALLEL DARK CALIBRATION	^ATTACHED TO PRIME^		NIRISS Dark			
2777:146:1	NONE	PARALLEL SLEW CALIBRATION	^ATTACHED TO PRIME^		NIRSpec Internal Lamp			
2654:6:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T02:28:30Z	00/00:43:56	MIRI Medium Resolution Spectroscopy	SDSSJ0749-BG	Unidentified	Blank field
1495:32:1	NONE	PARALLEL DARK CALIBRATION	^ATTACHED TO PRIME^		NIRSpec Dark			
1893:1:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T04:19:13Z	00/04:39:41	NIRSpec IFU Spectroscopy	BDF3299	Galaxy	High-redshift galaxies, Lyman-alpha galaxies
1497:20:1	NONE	PARALLEL DARK CALIBRATION	^ATTACHED TO PRIME^		NIRISS Dark			
1520:22:1	NONE	PARALLEL SLEW CALIBRATION	^ATTACHED TO PRIME^		MIRI Anneal			
1893:2:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T09:05:48Z	00/00:38:43	NIRSpec IFU Spectroscopy	BDF3299-BACKGROUND	Galaxy	High-redshift galaxies
2107:7:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T10:20:55Z	00/00:51:06	MIRI Imaging	NGC-1566	Galaxy	Spiral galaxies
2777:121:1	NONE	PARALLEL SLEW CALIBRATION	^ATTACHED TO PRIME^		NIRSpec Internal Lamp			
2107:7:2	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T11:16:45Z	00/00:48:21	MIRI Imaging	NGC-1566	Galaxy	Spiral galaxies
2107:7:3	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T12:09:17Z	00/00:48:21	MIRI Imaging	NGC-1566	Galaxy	Spiral galaxies
2107:7:4	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T13:02:22Z	00/00:48:21	MIRI Imaging	NGC-1566	Galaxy	Spiral galaxies
2107:25:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T14:00:19Z	00/01:00:50	NIRCcam Imaging	NGC-1566	Galaxy	Spiral galaxies
2107:25:2	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T15:06:06Z	00/00:58:05	NIRCcam Imaging	NGC-1566	Galaxy	Spiral galaxies
2516:9:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T16:31:22Z	00/00:43:44	MIRI Imaging	MIRI-PT-5	Galaxy	High-redshift galaxies, Starburst galaxies,
Ultraluminous infrared galaxies								
1495:33:1	NONE	PARALLEL DARK CALIBRATION	^ATTACHED TO PRIME^		NIRSpec Dark			
2418:43:1	MOVING	PRIME TARGETED MOVING	2022-11-22T18:07:44Z	00/00:59:36	NIRSpec IFU Spectroscopy	SILA-NUMAN	Solar System	Asteroid
2777:161:1	NONE	PRIME UNTARGETED	2022-11-22T19:08:13Z	00/00:03:53	NIRSpec Internal Lamp			
2078:11:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-22T19:31:28Z	00/01:41:29	NIRCcam Wide Field Slitless Spectroscopy	J0910P1656	Galaxy	High-redshift galaxies, Quasars
2745:5:1	NONE	PRIME UNTARGETED	2022-11-22T21:38:57Z	00/03:00:00	Realtime Commanding			
2084:3:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-23T00:57:59Z	00/04:53:03	NIRCcam Grism Time Series	55CNC	Star	Exoplanet Systems, Exoplanets, G subdwarfs
1250:1:1	MOVING	PRIME TARGETED MOVING	2022-11-23T06:57:04Z	00/00:35:19	NIRCcam Imaging	EUROPA	Solar System	Satellite
1250:2:1	MOVING	PRIME TARGETED MOVING	2022-11-23T07:40:07Z	00/01:01:02	NIRSpec IFU Spectroscopy	EUROPA	Solar System	Satellite
1250:4:1	MOVING	PRIME TARGETED MOVING	2022-11-23T08:49:56Z	00/00:17:40	MIRI Imaging	EUROPA	Solar System	Satellite
2726:479:1	FINEGUIDE	PRIME WFC ROUTINE	2022-11-23T09:19:08Z	00/01:32:08	WFC NIRCcam Fine Phasing	2MASS-23425655+0014229	Calibration	Focus test
2418:37:1	MOVING	PRIME TARGETED MOVING	2022-11-23T11:59:13Z	00/00:43:04	NIRSpec IFU Spectroscopy	2003WL7	Solar System	Asteroid
2418:51:1	MOVING	PRIME TARGETED MOVING	2022-11-23T13:51:29Z	00/01:03:28	NIRSpec IFU Spectroscopy	2000K67	Solar System	Asteroid
2418:40:1	MOVING	PRIME TARGETED MOVING	2022-11-23T15:10:24Z	00/00:59:36	NIRSpec IFU Spectroscopy	2005PU21	Solar System	Asteroid
2457:1:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-23T16:39:31Z	00/02:58:35	NIRSpec IFU Spectroscopy	SDSS-3221524.00-005643.8	Galaxy	Quasars
1483:79:1	NONE	PARALLEL DARK CALIBRATION	^ATTACHED TO PRIME^		NIRCcam Dark			
2654:7:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-23T20:46:23Z	00/02:53:53	NIRSpec IFU Spectroscopy	SDSSJ0749-NIRSPEC-REPEAT	Galaxy	Active galactic nuclei, Emission line galaxies,
Quasar-galaxy pairs								
1483:124:1	NONE	PARALLEL DARK CALIBRATION	^ATTACHED TO PRIME^		NIRCcam Dark			
1264:1:1	FINEGUIDE	PRIME TARGETED FIXED	2022-11-24T00:18:51Z	00/02:34:04	MIRI Medium Resolution Spectroscopy	GN20-MRS	Galaxy	Active galactic nuclei
1483:75:1	NONE	PARALLEL DARK CALIBRATION	^ATTACHED TO PRIME^		NIRCcam Dark			

Conferences

First Science Results from JWST

MON 12 DEC 2022 - THU 15 DEC 2022

Location

Space Telescope Science Institute (STScI)
3700 San Martin Drive
Baltimore, MD 21218

Contact Information

Have questions? Please contact STScI.



Děkuji Vám za pozornost!

petr.dvorak@ceitec.vutbr.cz