JWST-extragalactic surveys

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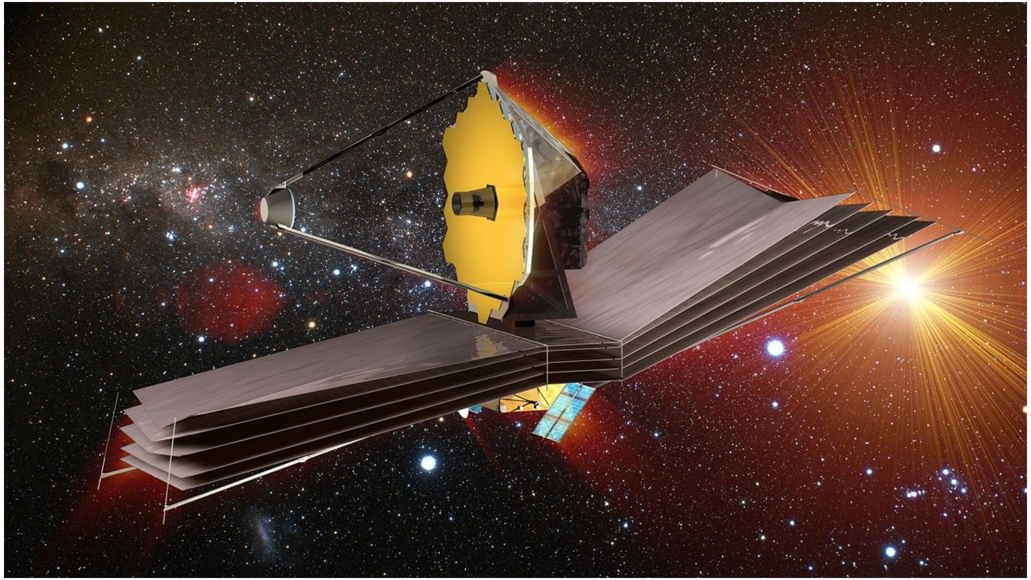
L.Pentericci- INAF OAR on behalf of the collaboration

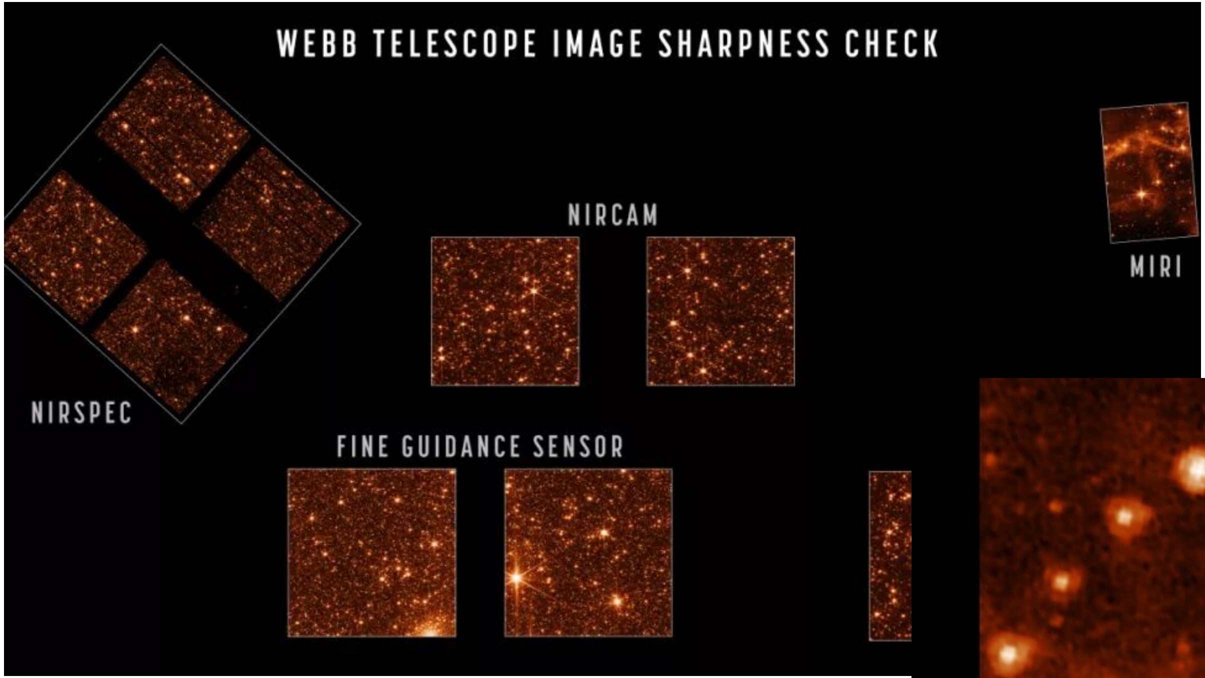


JWST-launch and deployment

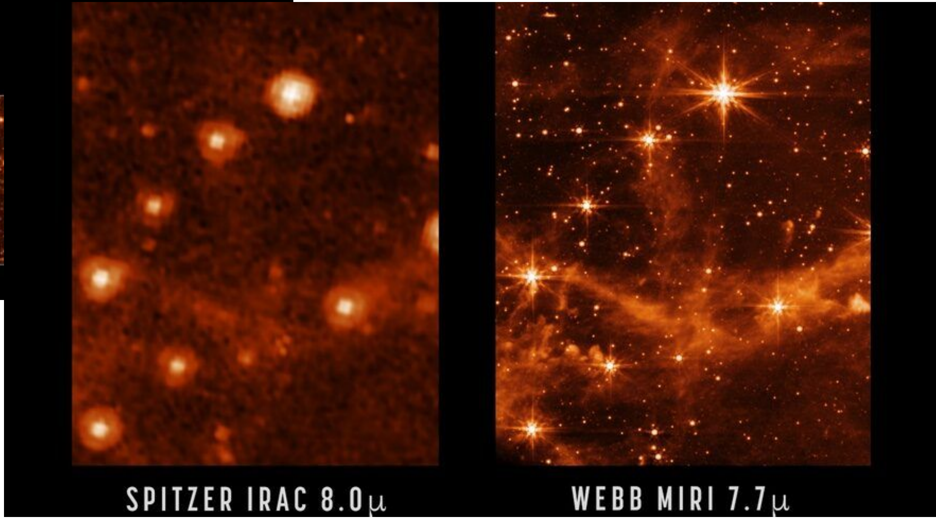
25-December 2021: liftoff
Launch+10 days: sunshield deployment and tensioning complete
Launch+11 days : secondary mirror deployment completed
Launch+28 days: mirror segment deployments completed
Launch+30 days: Webb is orbiting in L2
Launch+31 days: NIRCAM cooling completed
Launch+3 months Telescope alignment over all instruments completed
Launch +3.5 months: final cooling of MIRI completed
Launch+4 months: iterate alignment for final correction completed!
Launch+4 months: Instrument commissioning: ongoing

https://jwst.nasa.gov/content/webbLaunch/deploymentExplorer.html

JWST-so far so good!!



Engineering images of sharply focused stars in the field of view of each instrument demonstrate that the telescope is fully aligned and in focus. For this test, Webb pointed at part of the Large Magellanic Cloud



Extragalactic survey: why join forces?

Our team includes key members of the international collaborations that will conduct 6 extragalactic surveys:

- 2 are ERS program (Early Release Science) and will be amongst the very first programs to obtain data from JWST
- 4 are GO1 programs of which 2 have a <u>treasury status</u> i.e. are designed to create a dataset of lasting scientific value

Why join forces in a unique “scheda”?

- Many of us are co-Is of more than one program
- The scientific topics addressed by the surveys are common and there are many overlaps and possible synergies between programs
- The technical challenges to reduce and analyse the data will be similar: it therefore makes sense to collaborate and coordinate all efforts
- Finally we could disseminate to the italian community all the expertise gained in the analysis of the very first data also in view of future Cycles

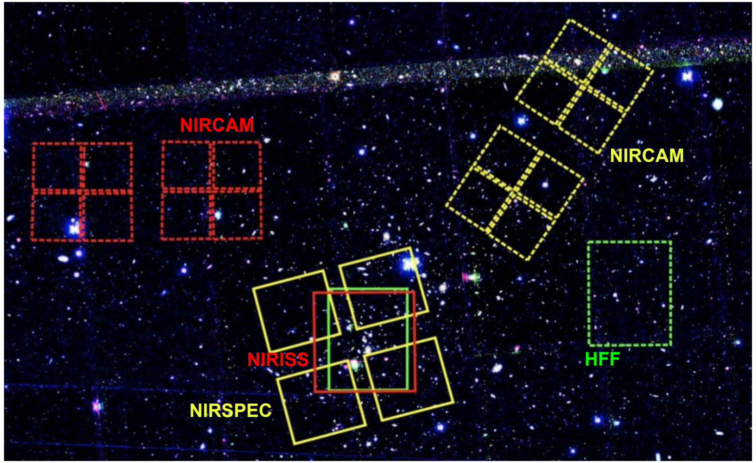
many related “schede”: higzgal, RELIGHT, MetEvol etc etc

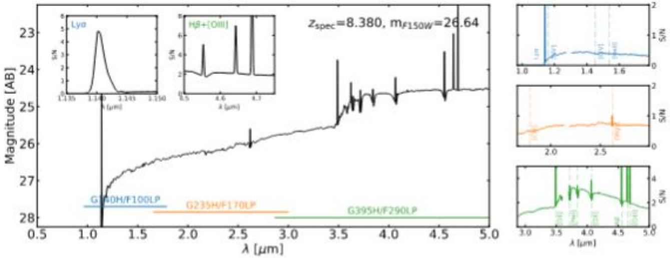
Extragalactic surveys - GLASS (ERS)

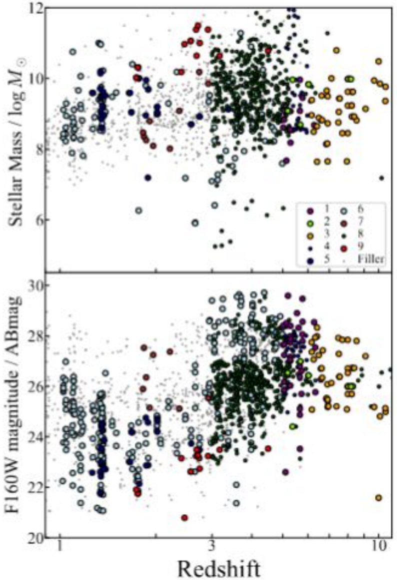
The GLASS-JWST-ERS Program (P.I. Treu) will obtain the deepest extragalactic data of the ERS campaign

- Two key science questions: 1) “What sources ionized the universe and when?” 2) “How do baryons cycle through galaxies?”
- NIRISS and NIRSpec spectroscopy of galaxies in a field centered on the lensing Hubble Frontier Field cluster Abell 2744
- In parallel, NIRCam will observe two black fields that are offset from the cluster center

With NIRSPEC: Lyα systemic velocity offsets at z > 6; Lyα and UV continuum spatial offsets; Rest-frame optical line redshifts,; UV emission line fluxes; for high intermediate redshift galaxies: spectrally resolved key diagnostic lines ([N II] + Hα, the auroral [O III] line at 4363 Å and Hγ, [Ne III] + He I + Balmer lines, and doublets such as [S II] and [O II]), metallicity, dust attenuation, and SFR in z ≳ 4 galaxies
With NIRCAM: rest-frame UV/optical photometry and sizes for ~100-200 LBGs at z ≳ 7
With NIRISS: ionized gas metallicity, dust extinction, and SFR maps for ~50 z ≲ 3.5, log M∗ ≳ 6 galaxies;







Figures from Treu et al., submitted to ApJ

Extragalactic surveys - CEERS (ERS)

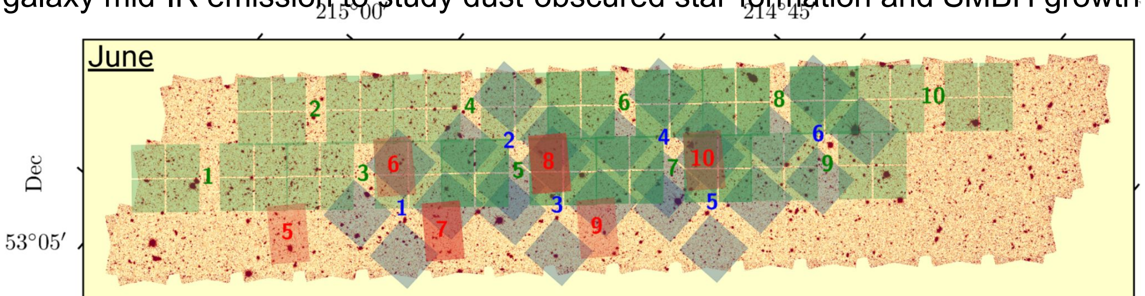
CEERS (PI S. Finkelstein) is an ERS program focused on the evolution of high redshift galaxies.

CEERS <u>will test (nearly) all instrumental modes for extragalactic surveys:</u>

- NIRCAM 7 bands imaging on 10 pointings (maglim~29-28.5)
- NIRSPEC MSA Pointings R=1000 on 6 pointings
- NIRSPEC MSA Pointings R=100 on 4 pointings
- MIRI 2-bands (F560W,F770W) on 3 pointings (maglim~26)
- MIRI 6-bands (F770W … F2100W) on 3 pointings (maglim~25.5-22)

CEERS will address key JWST science goals, including:

- constraining the abundance and physical nature of galaxies at z~9-13;
- constraining the physical conditions of star-formation and black hole growth via line diagnostics of galaxies at z>3;
- quantifying the first bulge and disk structures at z>3; and
- characterizing galaxy mid-IR emission to study dust-obscured star-formation and SMBH growth at z~1-3



light green=NIRCAM
red=MIRI
grey =NIRSPEC

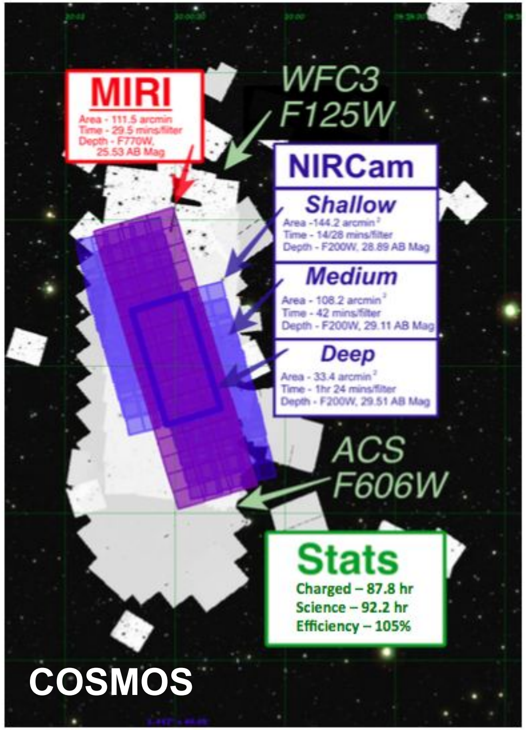
Extragalactic surveys- PRIMER (Treasury)

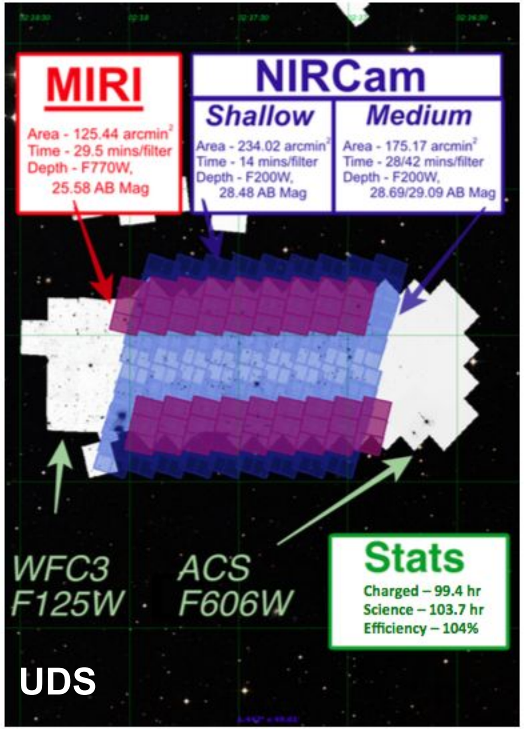
PRIMER (PI J. Dunlop) is a Cycle 1 public Treasury Program focused on galaxy and black-hole formation and evolution

- COSMOS + UDS fields
- NIRCAM 8 bands imaging on 695 sq. arcmin (maglim~29.5-27.6)
- MIRI 2 bands (F770W, F1800W) on 237 sq. arcmin (maglim~25.5, ~23)

Major science goals:

- abundance and physical properties of z~7-12 galaxies;
- robust stellar mass estimates in high-z galaxies;
- complete census of dust-obscured star formation and AGN growth at cosmic noon;
- morphology and spatially resolved SED fitting of high-z galaxies through high-resolution (~0.1'') rest-frame optical imaging.





Extragalactic surveys- COSMOS-WEBB (Treasury)

COSMOS-WEB (PI: J. Kartaltepe and C. Casey) is the largest Cycle 1 public Treasury Program with 280.6 observing hours to observe **half a million galaxies** with **NIRCam** and **32,000 galaxies** with **MIRI**

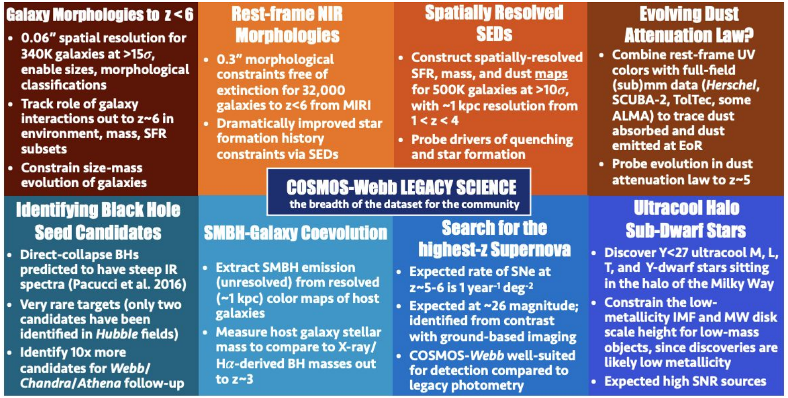
Scientific Goals:

I) thousands of galaxies in the EoR: understand the **reionization's spatial distribution, environments** (from 6<z<10) and **drivers at** early stages (8<z<11)

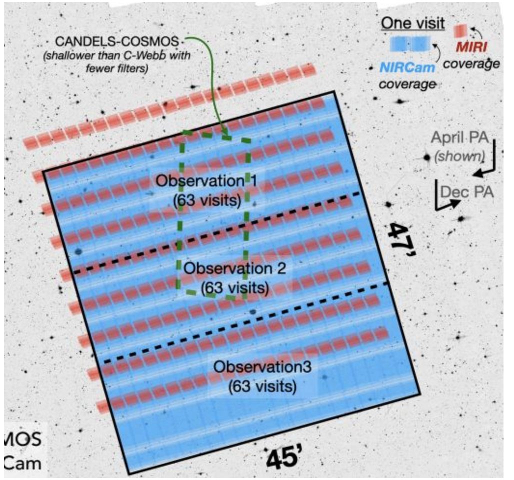
II) Quiescent Galaxies from EoR to the peak of galaxy assembly: constrain the **masses and star formation histories of the earliest quiescent galaxies**;

III) directly measure the evolution of **the stellar mass to halo mass relation (SMHR) out to z~2.5** to recalibrate cosmological simulations of galaxy formation.

IV) Legacy science:



Observing Strategy



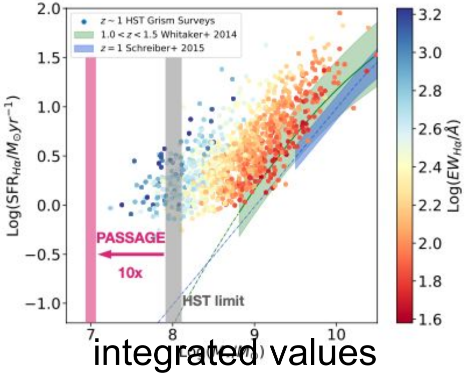
0.6 deg^2 deep NIRCam
0.2 deg^2 deep MIRI

Extragalactic surveys- PASSAGE

The Parallel Application of Slitless Spectroscopy to Analyze Galaxy Evolution (PASSAGE, PI Malkann) is a pure-parallel survey of emission-line galaxies at 1<z<8, with the NIRISS grism

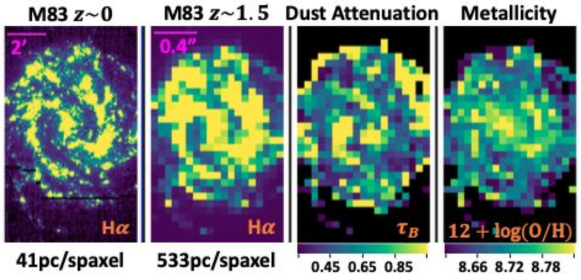
- PASSAGE will measure spatially resolved extinction-corrected SFRs, gas ionization properties, and metallicities across "Cosmic Noon" (z=1-3.5), down to M* = 1e7 Msun.
- At z>7 it will spectroscopically discover many dozens of the brightest Lyα line emitters in the reionization epoch, and detect Ly-break galaxies independent of their Lyα lines to provide the first unbiased determination of the EW(Ly-a) distribution, and potentially evidence for ionized bubbles.
- PASSAGE will observe 80 shallow, 33 medium and 11 deep independent fields, detecting several thousand galaxies (with line SNR > 5) reaching SFRs down to <1 Msun/yr. Wide and continuous spectral coverage (1.0-2.2um) will secure rest-frame optical emission line ratios in the medium/deep fields. The all-sky coverage will remove cosmic variance,

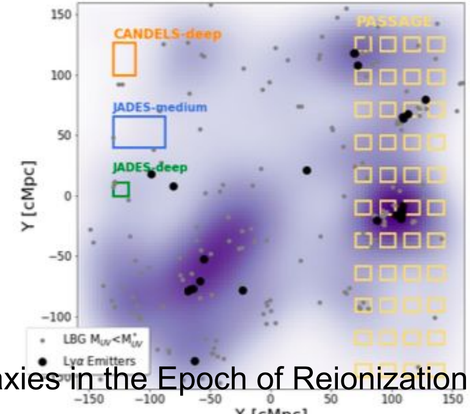
To maximize benefit to the community and JWST follow-up,, we will rapidly release fully- reduced spectra and images in user-friendly formats, as well as catalogs of redshifts, SFRs, reddenings, metallicities, and 2-D maps of resolved line emission.



integrated values

dust, metallicity maps





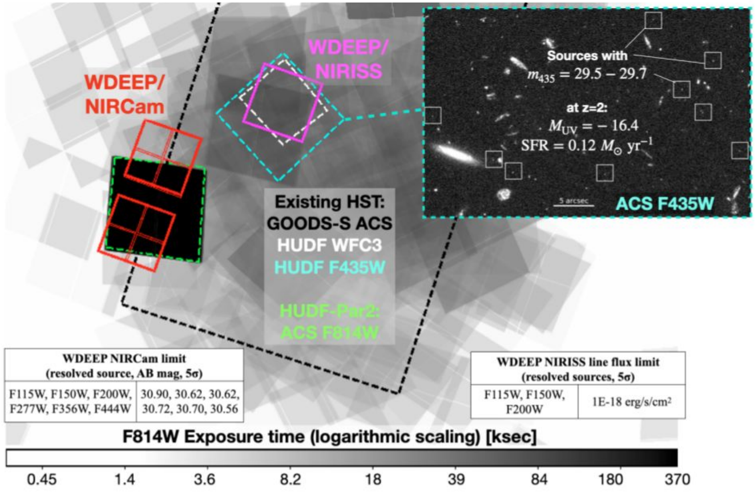
Galaxies in the Epoch of Reionization

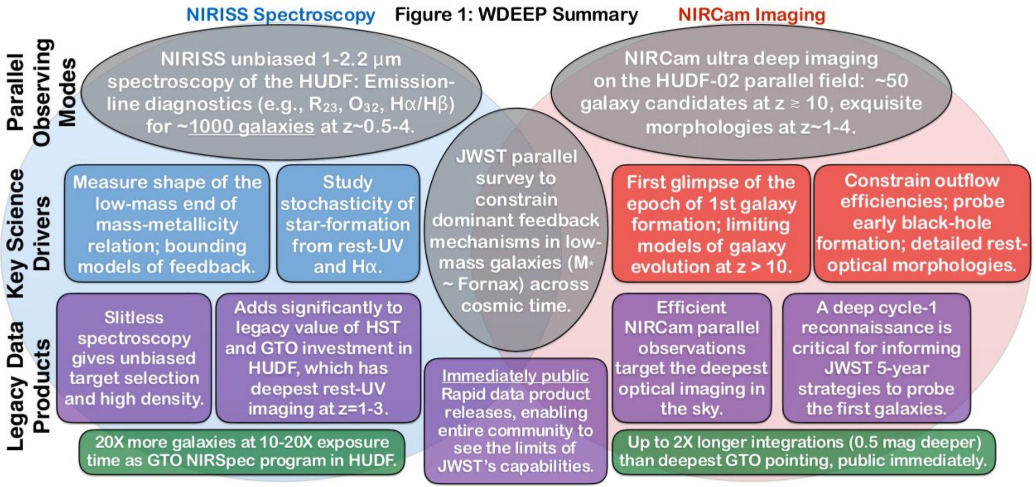
Extragalactic surveys - NGDEEP (aka WDEEP)

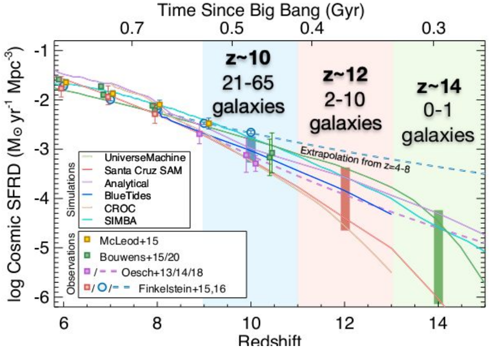
NGDEEP co-PIs: Finkelstein, Papovich, Pirzkal;

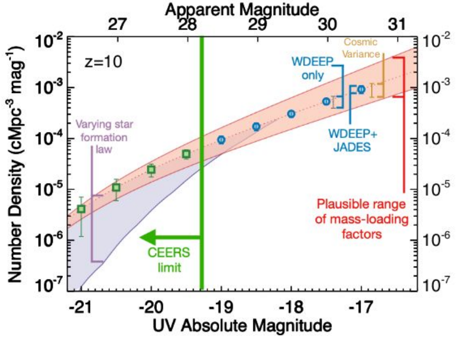
- **Deep NIRISS to detect faint emission lines** (*>1e-18 cgs*) in faint, low mass galaxies
- The **deepest 6-band Cycle 1 NIRCam imaging** (*~31AB*) to probe z>12

121.7 hr NIRISS (HUDF) and NIRCam (HUDF-Par2)









Extragalactic surveys

	NIRCAM	NIRSpec	MIRI	NIRISS	Main characteristics	Technical aspects
GLASS ERS	✅	✅		✅	Lensing cluster A2744, NIRISS/NIRSpec combination	-NIRISS: Wide Field Slitless Spectroscopy, R~150 (F115, F150W, F200W) -NIRSpec: Multi-Object Spectroscopy, R~2700 (F100LP, F170LP, F290LP) -NIRCam: Parallel Imaging (F090W, F115W, F150W, F277W, F200W, F356W, F444W)
CEERS ERS	✅	✅	✅		Deep spectroscopy and imaging of EGS- field	-NIRCam: Imaging (F115W, F150W, F200W, F277W,F356W,F410W, F444W) -MIRI: Imaging (F560W,F770W,F1000W,F1280W, F1500W,F1800W, F2100W) -NIRSpec R=1000, R=100
PRIMER GO1 Treasury	✅		✅		Large area, homogeneous coverage	-MIRI: Imaging (F770W,F1800W) -NIRCam: Imaging (F090W, F115W, F150W, F200W, F277W,F356W,F444W)
NGDEEP GO1	✅			✅	Ultra deep field, single pointing, spectroscopy of everything	NIRISS- Wide Field Slitless spectroscopy R=150 (F115W, F150W, F200W) -NIRCam: Imaging (F115W, F150W, F200W, F277W,F356W,F410W, F444W)
PASSAGE GO1				✅	Pure parallel program, 80+30 pointings	-NIRISS: Wide Field Slitless Spectroscopy, R~150 (F115, F150W, F200W)
COSMOS-WEB GO1 Treasury	✅		✅		Ultra large area (0.6sq) COSMOS field	-NIRCam: Imaging (F115W, F150W, , F277W, F444W) -MIRI: Imaging (F770W))

The programs are clearly connected since they:

1. exploit common instrumental set ups
2. address scientific issues that are equal or very similar

Extragalactic surveys

	NIRCAM	NIRSpec	MIRI	NIRISS	Main characteristics	Technical aspects
GLASS ERS	✅	✅		✅	Lensing cluster A2744, NIRISS/NIRSpec combination	-NIRISS: Wide Field Slitless Spectroscopy, R~150 (F115, F150W, F200W) -NIRSpec: Multi-Object Spectroscopy, R~2700 (F100LP, F170LP, F290LP) -NIRCam: Parallel Imaging (F090W, F115W, F150W, F277W, F200W, F356W, F444W)
CEERS ERS	✅	✅	✅		Deep spectroscopy and imaging of EGS- field	-NIRCam: Imaging (F115W, F150W, F200W, F277W,F356W,F410W, F444W) -MIRI: Imaging (F560W,F770W,F1000W,F1280W, F1500W,F1800W, F2100W) -NIRSpec R=1000, R=100
PRIMER GO1 Treasury	✅		✅		Large area, homogeneous coverage	-MIRI: Imaging (F770W,F1800W) -NIRCam: Imaging (F090W, F115W, F150W, F200W, F277W,F356W,F444W)
NGDEEP GO1	✅			✅	Ultra deep field, single pointing, spectroscopy of everything	NIRISS- Wide Field Slitless spectroscopy R=150 (F115W, F150W, F200W) -NIRCam: Imaging (F115W, F150W, F200W, F277W,F356W,F410W, F444W)
PASSAGE GO1				✅	Pure parallel program, 80+30 pointings	-NIRISS: Wide Field Slitless Spectroscopy, R~150 (F115, F150W, F200W)
COSMOS-WEB GO1 Treasury	✅		✅		Ultra large area (0.6sq) COSMOS field	-NIRCam: Imaging (F115W, F150W, , F277W, F444W) -MIRI: Imaging (F770W))

Many of the data analysis tools that will be developed for the ERS data will then be used for the much larger samples obtained by the GO programs

e.g.:

- GLASS will develop the NIRISS pipeline and tools that will be used by PASSAGE (which has a similar set up)

  PASSAGE will give a much larger statistics for the spatially resolved studies e.g. SFR -mass t

Extragalactic surveys

	NIRCAM	NIRSpec	MIRI	NIRISS	Main characteristics	Technical aspects
GLASS ERS	✅	✅		✅	Lensing cluster A2744, NIRISS/NIRSpec combination	-NIRISS: Wide Field Slitless Spectroscopy, R~150 (F115, F150W, F200W) -NIRSpec: Multi-Object Spectroscopy, R~2700 (F100LP, F170LP, F290LP) -NIRCam: Parallel Imaging (F090W, F115W, F150W, F277W, F200W, F356W, F444W)
CEERS ERS	✅	✅	✅		Deep spectroscopy and imaging of EGS- field	-NIRCam: Imaging (F115W, F150W, F200W, F277W,F356W,F410W, F444W) -MIRI: Imaging (F560W,F770W,F1000W,F1280W, F1500W,F1800W, F2100W) -NIRSpec R=1000, R=100
PRIMER GO1 Treasury	✅		✅		Large area, homogeneous coverage	-MIRI: Imaging (F770W,F1800W) -NIRCam: Imaging (F090W, F115W, F150W, F200W, F277W,F356W,F444W)
NGDEEP GO1	✅			✅	Ultra deep field, single pointing, spectroscopy of everything	NIRISS- Wide Field Slitless spectroscopy R=150 (F115W, F150W, F200W) -NIRCam: Imaging (F115W, F150W, F200W, F277W,F356W,F410W, F444W)
PASSAGE GO1				✅	Pure parallel program, 80+30 pointings	-NIRISS: Wide Field Slitless Spectroscopy, R~150 (F115, F150W, F200W)
COSMOS-WEB GO1 Treasury	✅		✅		Ultra large area (0.6sq) COSMOS field	-NIRCam: Imaging (F115W, F150W, , F277W, F444W) -MIRI: Imaging (F770W))

The programs are also largely complementary to each other e.g.

- PRIMER and COSMOS-WEB will obtain shallower near-IR imaging on large areas while CEERS and GLASS will observe small pointing but to greater depth
→ Galaxies LF at bright and faint end

- NGDEEP will obtain a superdeep pointing with NIRISS / PASSAGE will obtain >100 NIRISS pointings in parallel mode
→ bright and faint Lya emitters for EoR topology studies

- GLASS will observe a lensign field compared to CEERS' "blank" field

Observations Schedule

critical months!!!

Program	Jul 22	Aug 22	Sep 22	Oct 22	Nov 22	Dec 22	Jan 23	Feb 23	Mar 23	Apr 23	May 23	Jun 23	Jul 23	Aug 23	Sep 23	Oct 23	Nov 23	Dec 23	Jan 24
GLASS	✅				✅														
PRIMER					✅	✅	✅			✅	✅		✅	✅					
CEERS						✅													
COSMOS-WEBB							✅			✅	✅							✅	✅
NGDEEP							✅												

Autumn will be a critical time for data acquisition for all programs

NB: PASSAGE being a purely parallel survey does not have an implementation schedule yet.

Team role and leadership

The team (20 people) is mostly based in two units, the Astronomical Observatory of Rome (including ASDC) and the Astronomical Observatory of Padova, with external collaborators at University of la Sapienza (theory group) and University of Bologna

Roles: in all collaborations we have or will have key roles.
For example in GLASS we (OAR+ASDC) are committed to reduce the NIRSPEC data and release them both to the collaboration and to the general public
We will also give essential contribution to the NIRSPEC reduction and NIRISS/NIRSPEC comparison (OAR+OAPD)

We expect to give substantial contributions also to the GO programs data analysis

Leadership:
All members of our team have a recognized leadership in several of the proposed science topics (first galaxies, spatially resolved studies, Luminosity-Function evolution, environmental effects etc)
For example in the GLASS collaboration we have already decided to lead several “first papers” i.e. papers that will exploit the very first data coming in July/August
In the GO teams this phase (working groups creation and publication plans) is still partially ongoing but we expect to have an important role

Challenges

Table 1: Distinct JWST Observing Modes

Observing Mode	Instrument	Wavelength (microns)	Pixel Scale / Resolving Power	Field of View
Imaging	NIRCam	0.6 - 2.3	0.032 arcsec	2.2 x 2.2 arcmin
	NIRCam	2.4 - 5.0	0.065 arcsec	2.2 x 2.2 arcmin
	NIRISS	0.9 - 5.0	0.065 arcsec	2.2 x 2.2 arcmin
	MIRI	5.0 - 28	0.11 arcsec	1.23 x 1.88 arcmin
Slitless Spectroscopy	NIRISS	1.0 - 2.5	150 (λ/Δλ)	2.2 x 2.2 arcmin
	NIRISS	0.6 - 2.5	700 (λ/Δλ)	single object
	NIRCam	2.4 - 5.0	2000 (λ/Δλ)	2.2 x 2.2 arcmin
Multi-Object Spectroscopy	NIRSpec	0.6 - 5.0	100, 1000, 2700 (λ/Δλ)	3.4 x 3.4 arcmin with 250k 0.2 x 0.5 arcsec micro shutters
Single Slit Spectroscopy	NIRSpec	0.6 - 5.0	100, 1000, 2700 (λ/Δλ)	Slits of 0.4 x 3.8, 0.2 x 3.3, and 1.6 x 1.6 arcsec
	MIRI	5.0 - ~14.0	~100 @ 7.5 microns (λ/Δλ)	0.6 x 5.5 arcsec slit
IFU Spectroscopy	NIRSpec	0.6 - 5.0	100, 1000, 2700 (λ/Δλ)	3.0 x 3.0 arcsec
	MIRI	5.0 - 7.7	3500 (λ/Δλ)	3.0 x 3.9 arcsec
	MIRI	7.7 - 11.9	2800 (λ/Δλ)	3.5 x 4.4 arcsec
	MIRI	11.9 - 18.3	2700 (λ/Δλ)	5.2 x 6.2 arcsec
	MIRI	18.3 - 28.8	2200 (λ/Δλ)	6.7 x 7.7 arcsec
Aperture Mask Interferometry	NIRISS	3.8 - 4.8	0.065 arcsec	-
Coronagraphy	NIRCam	0.6 - 2.3	0.032 arcsec	20 x 20 arcsec
	NIRCam	2.4 - 5.0	0.065 arcsec	20 x 20 arcsec
	MIRI	10.65	0.11 arcsec	24 x 24 arcsec
	MIRI	11.4	0.11 arcsec	24 x 24 arcsec
	MIRI	15.5	0.11 arcsec	24 x 24 arcsec
	MIRI	23	0.11 arcsec	30 x 30 arcsec

JWST IS COMPLEX!!

many different observing modes for each instrument

Challenges

JWST is a completely new telescope with complex instruments and many different modes

*e.g .NIRSPEC has the first MOS capabilities in space: MSA planning and data reduction will be non trivial

*data analysis tools will also complex: a substantial effort will be needed to go from data to scientific results

→ <u>it is very important for the italian community to collaborate in this effort to facilitate the scientific exploitation of data</u>
→ <u>it is essential to find ways to share and disseminate the knowledge that will be acquired with the very first scientific programs</u>

The Scheda has the aim of coordinating the efforts of the various teams supporting and coordinating their participation to the surveys

Challenges- 2

Competitivity will be really high to achieve science results in time. ERS data will be public immediately

To keep our visibility within the (large) collaborations and maintain the lead on several science topics, participation to collaboration meetings (also in person) and visits will be essential.

Cycle 2 deadline is not so far, January 2023: by that time there will be little public data (possibly only the ERS program) where we can train our tools.Same is true for most of the italia community

Criticalities & Fundings

Main criticality is the lack of fundings to:

1. Hire highly motivated postdocs to work on the science exploitation
of data (the team has very few postdocs/PhD students!!)

2. Participate to collaboration meetings given that most collaborations (all but one) are USA-based.

3. Support ways to share analysis tools developed

A funding request has therefore been submitted in the Large Program channel to hire:
1 postdoc for Rome to mainly work on NIRSPEC data and science
1 postdoc for Padova to mainly work on NIRISS data and science

A PRIN-MIUR request was submitted more focused on theory-observations comparison

Criticalities & Fundings

Analytic budget description (numbers in Euro)

Item	Year 2022	Year 2023
Postdoc1 OAR	35000Euro	35000 Euro
Postdoc2 OAPD	35000Euro	35000Euro
PC- Hardware	5000Euro	2500Euro
Travel	25000 Euro	27500Euro