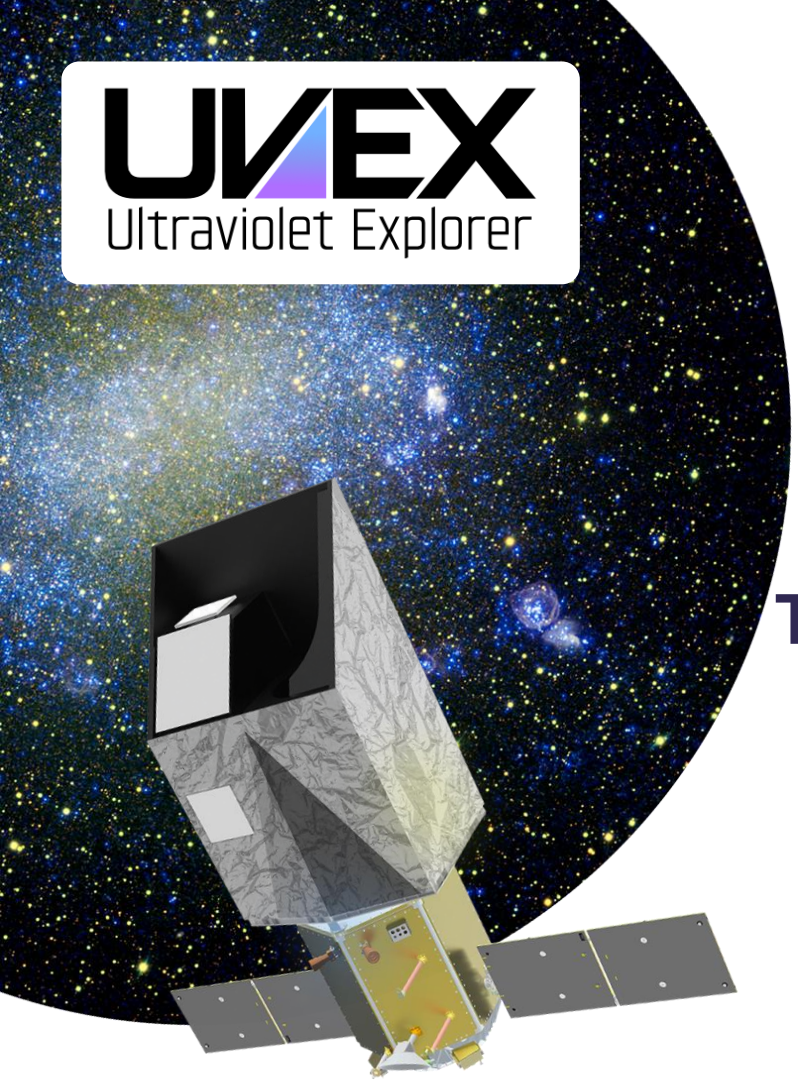
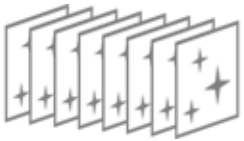
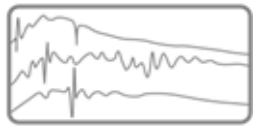


All-Sky


Time Domain


Spectroscopy

The Ultraviolet Explorer (UVEX) Mission

Dan Weisz

UC Berkeley

UVEX Project Scientist

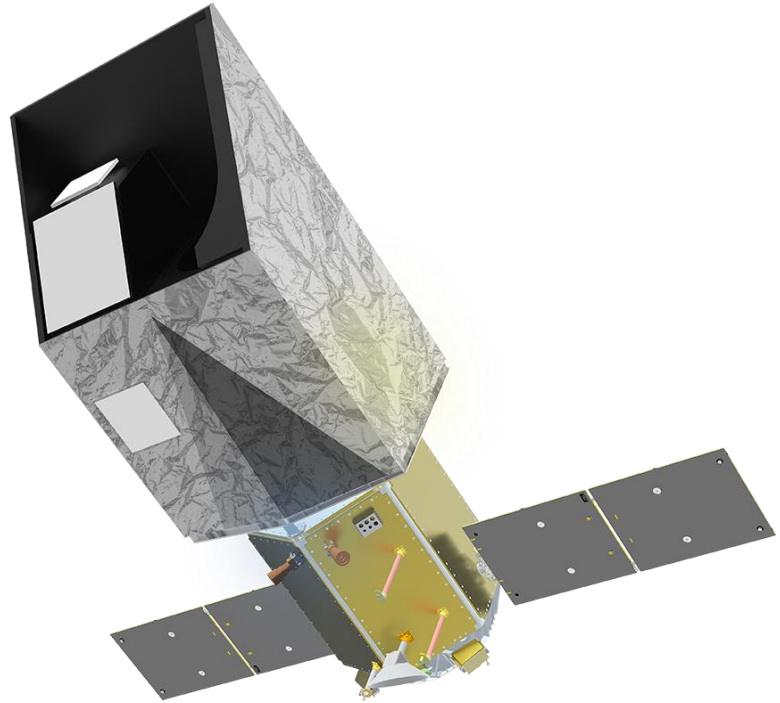
September 23, 2026

UVEX Concept paper: Kulkarni+ (2021)
UVEX Mission paper: Harrison+ (submitted)

UVEX at a Glance

UVEX Ultraviolet Explorer

- **NASA Medium-Class Explorer (MIDEX).** Selected 2024, launch in 2030
- **Two-year baseline science mission** run by the Science Team; all data public immediately
- **Cadenced, All-sky imaging** in FUV + NUV, ~50-100× deeper than GALEX, including the Galactic Plane
- **Long-slit UV spectroscopy** 1150–2800 Å at R ≈ 2000–4600, with HST/COS-like sensitivity
- **Rapid response:** on target < 6 hr after a trigger; 8% of time reserved for community ToOs



UVEX observatory: 75 cm three-mirror telescope feeding two imagers and a spectrograph.

Who Builds and Operates UVEX

UVEX Ultraviolet Explorer

Caltech

PI institution: focal plane, science operations, Science Data Center

UC Berkeley / SSL

Project implementation, telescope, mission operations

Northrop Grumman

Spacecraft, observatory integration & test, launch

IPAC / IRSA

Data pipeline and the public archive

Leadership

Principal Investigator
Fiona Harrison (Caltech)

Project Scientist
Dan Weisz (UC Berkeley)

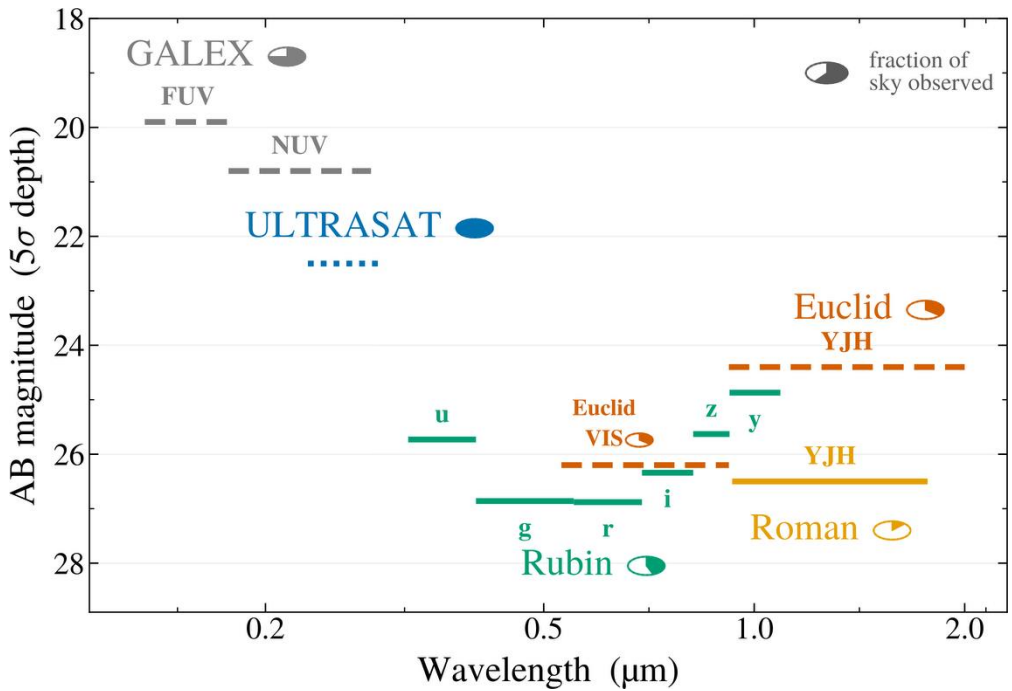
Science leadership

Low-mass galaxies: Dan Weisz (UC Berkeley)
Dynamic universe: Suvi Gezari (Maryland)
Survey legacy: Keivan Stassun (Vanderbilt)
Nebular emission: Danielle Berg (UT Austin)
Magellanic Clouds: Hugues Sana (KU Leuven)
Gravitational waves: Mansi Kasliwal (Caltech)
Supernovae: Raffaella Margutti (UC Berkeley)
UV time domain: Matthew Graham (Caltech)

Science team: ~90 scientists at ~40 institutions, including

The 2030s Survey Landscape

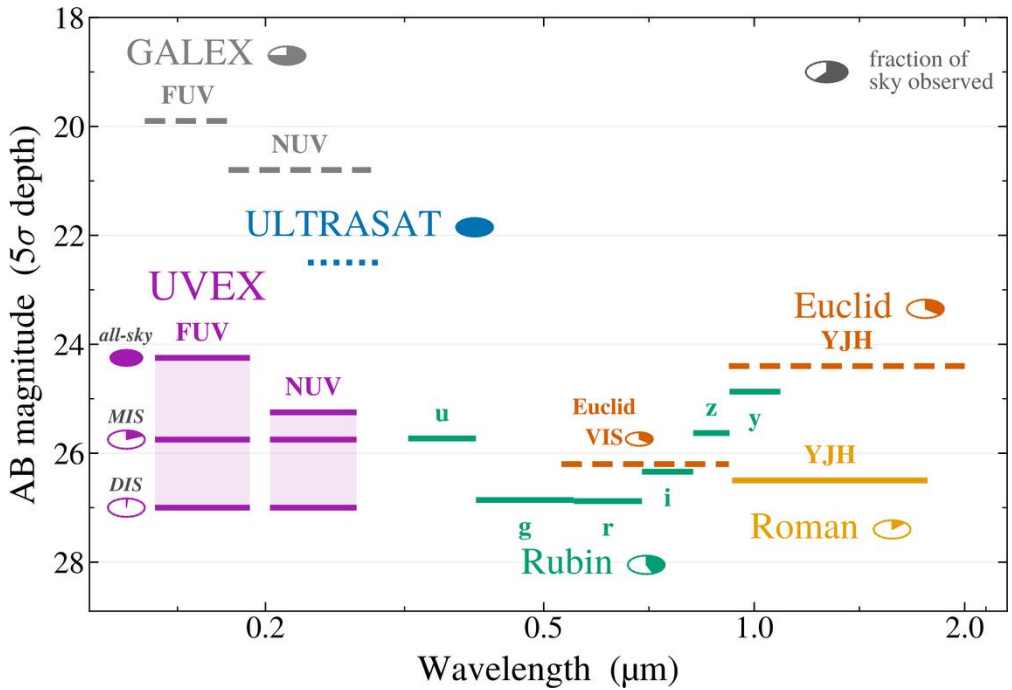
- **Optical and infrared:** Rubin, Euclid and Roman will map the sky to 25–28 AB mag
- **Time domain and multi-messenger:** Rubin alerts, LIGO/Virgo/KAGRA O5, DSA-2000, ULTRASAT
- **JWST** continues to deliver rest-frame UV spectra of galaxies at z > 6, with few local UV comparison samples
- **Ultraviolet surveys:** GALEX's all-sky survey reaches only ~20 AB mag; ULTRASAT is NUV-only at ~22.5 AB mag; HST is deep but narrow, with limited ToO response time



5σ survey depths of GALEX, ULTRASAT, Rubin, Euclid and Roman.

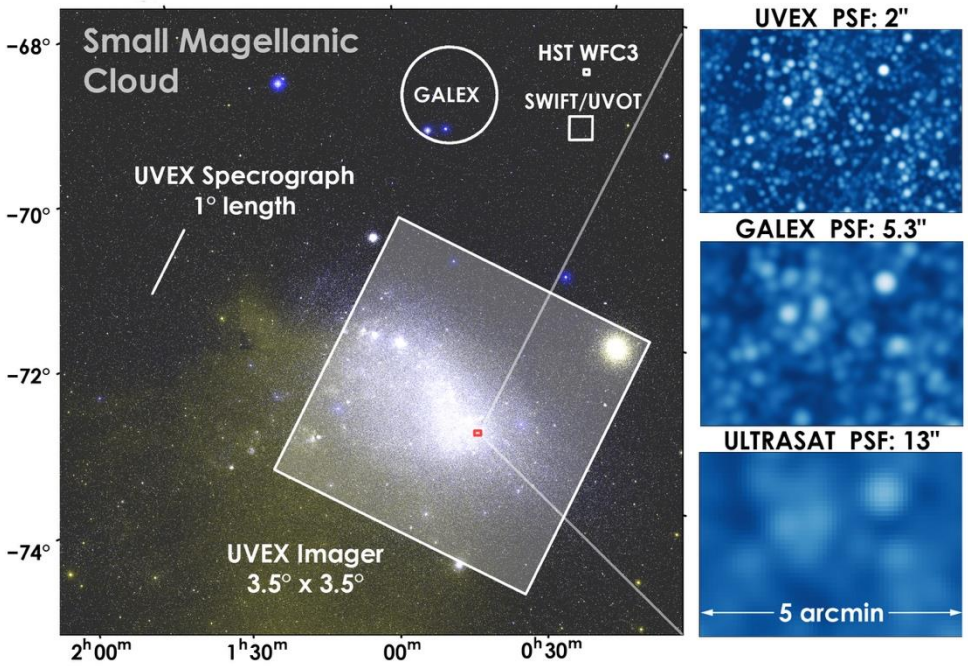
Why the UV, and Why Now: UVEX Fills the Gap

- **The UV uniquely traces:**
  - hot young stars → star formation rates, stellar evolution, binarity, dust
  - hot evolved stars: white dwarfs and stripped stars
  - the earliest (< 1 day) phases of supernovae, neutron-star mergers, other transients (e.g., tidal disruption)
- **UVEX:** three imaging tiers matched to Rubin, Euclid and Roman — all-sky to 24–25 AB, Medium to 25.75, Deep to 27 — ~100× deeper than GALEX with a 2× sharper PSF
- **Plus** HST/COS-like long-slit spectroscopy and rapid response to transients
- **With ULTRASAT and HST,** the UV side of the 2030s landscape and a bridge to the Habitable Worlds Observatory



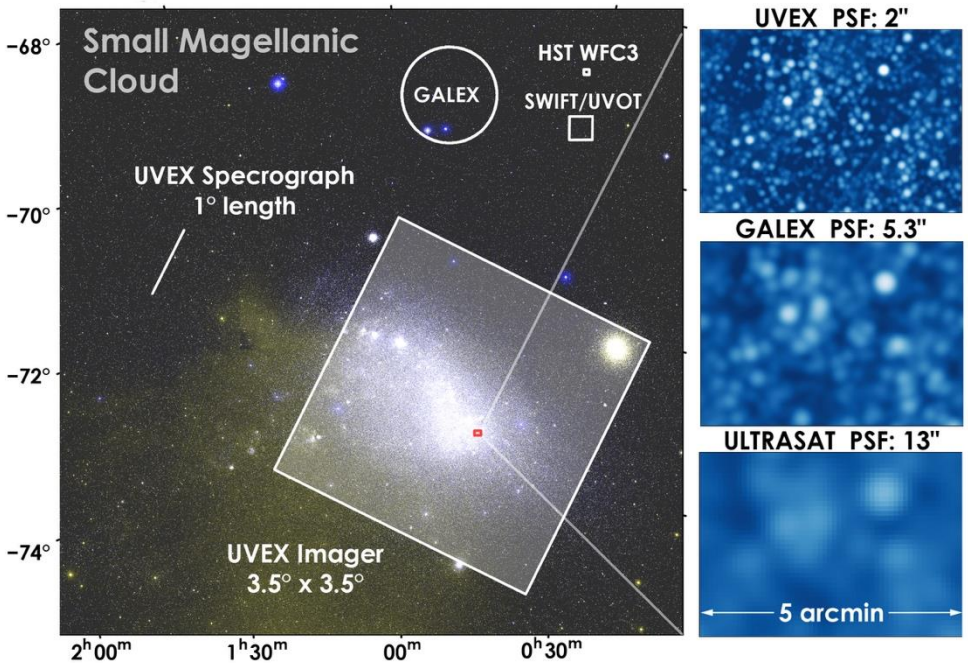
5σ depths of UVEX survey tiers (all-sky, Medium, Deep) vs. GALEX, ULTRASAT, Rubin, Euclid and Roman.

Wide-field Imaging

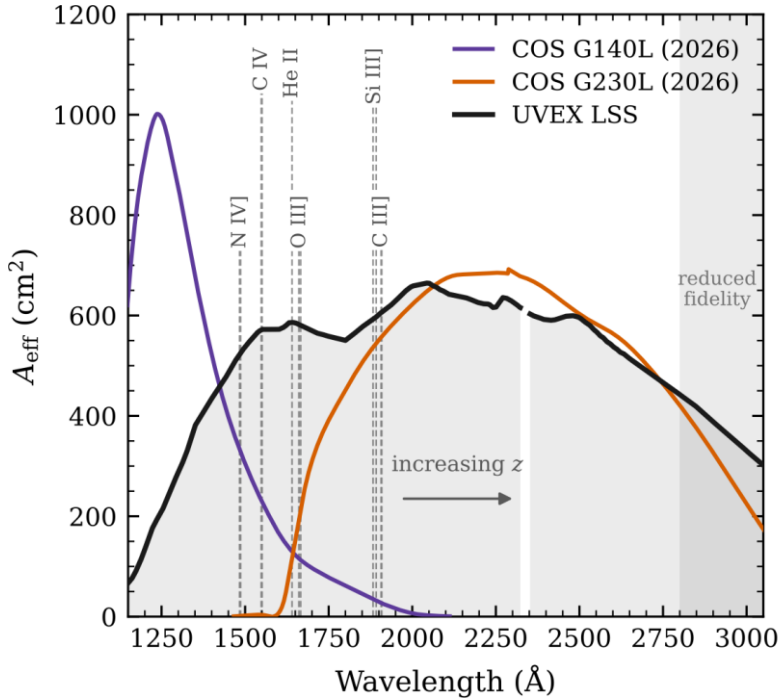


One 12 deg² pointing covers most of the SMC; the ~2″ PSF resolves stars outside the densest clusters (compare GALEX 5.3″, ULTRASAT 13″).

Wide-field Imaging and COS-like Spectroscopy



One 12 deg² pointing covers most of the SMC; the ~2″ PSF resolves stars outside the densest clusters (compare GALEX 5.3″, ULTRASAT 13″).



Spectrograph effective area vs. HST/COS G140L and G230L (2026 sensitivities). UVEX covers the full range in one exposure and exceeds G140L by 2–20× over 1490–1900 Å.

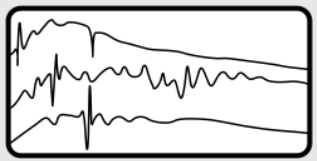
Three Science Goals for the Baseline Mission

UVEX Ultraviolet Explorer

The Low-Mass Galaxy Frontier

- Find and characterize local ($z \lesssim 0.3$) galaxies with $M_\star \sim 10^6$–10^9 $M_\odot$ over 8000 deg²
- Rest-UV spectra of the most metal-poor galaxies (C/O, nebular diagnostics)
- Stripped stars and massive-star winds in the Magellanic Clouds

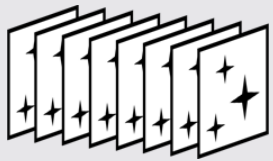
Goal 1



The Dynamic Universe

- Rapid UV tiling of LIGO O5 neutron-star merger sky maps
- First UV spectral sequences of supernovae at < 1 day
- 8% of time for a community-driven ToO & time-domain program

Goal 2



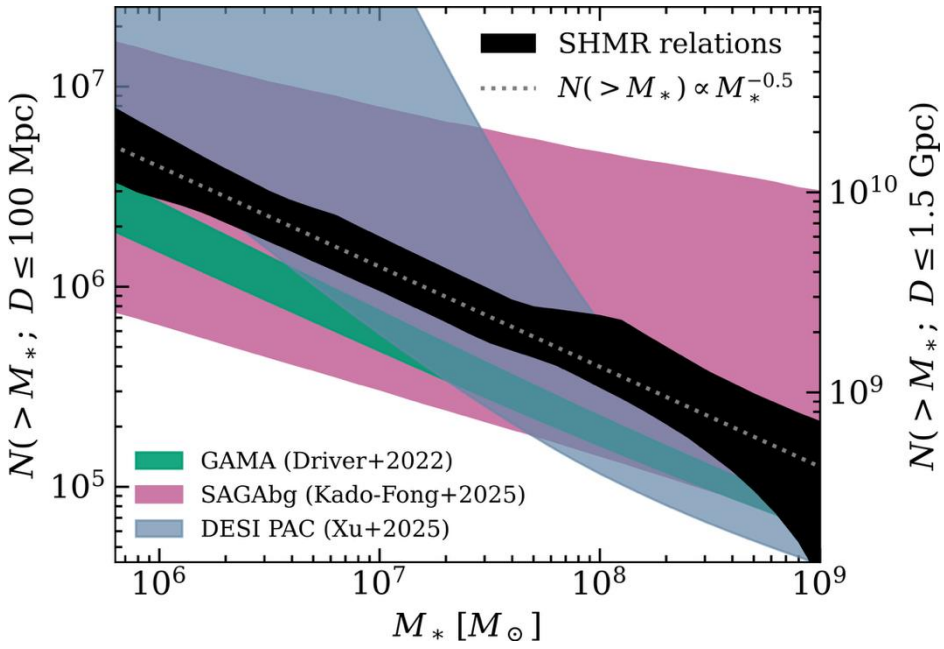
Deep Synoptic Surveys

- Cadenced FUV + NUV survey of the whole sky, over 100× deeper than GALEX
- 3–10 visits per field on cadences from days to months
- Public transient alerts; parallel spectra across the whole sky

Goal 3

Goal 1: The Low-Mass Galaxy Frontier

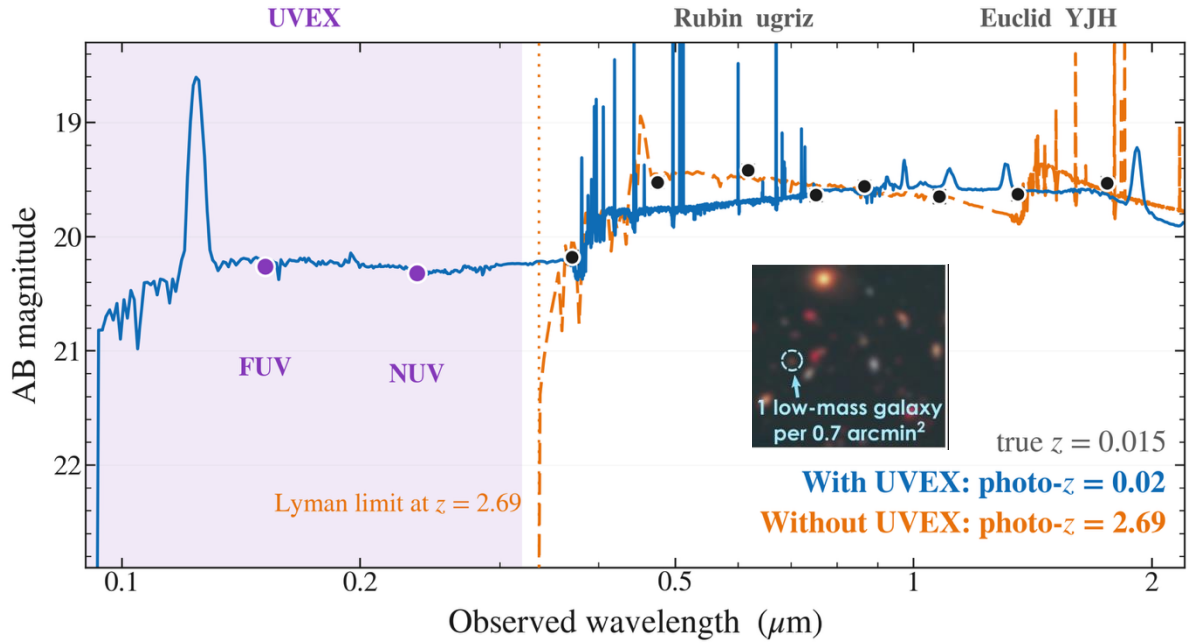
- **Why:** Galaxies with $M_\star \sim 10^6$–$10^9\ M_\odot$ (1–50% $Z_\odot$) should dominate local galaxy counts and are the analogs of JWST's early galaxies, yet only a tiny fraction is known; counts are uncertain by ~20×
- **UV breaks the degeneracy:** Local dwarfs and $z \gtrsim 1$ galaxies look alike in optical/IR colors; adding FUV/NUV separates them and improves photo-z's
- **Medium Imaging Survey:** 7500 deg² to 25.75 AB in FUV and NUV, detecting a ~$10^6\ M_\odot$ star-forming dwarf at 100 Mpc
- **Deep Imaging Survey:** 500 deg² to 27.0 AB, overlapping Rubin, Euclid and Roman deep fields



Predicted vs. measured number of low-mass galaxies within 100 Mpc (left axis) and 1.5 Gpc (right). Existing constraints differ by more than 10×.

Goal 1: Why UV imaging is Needed to find Local Dwarfs

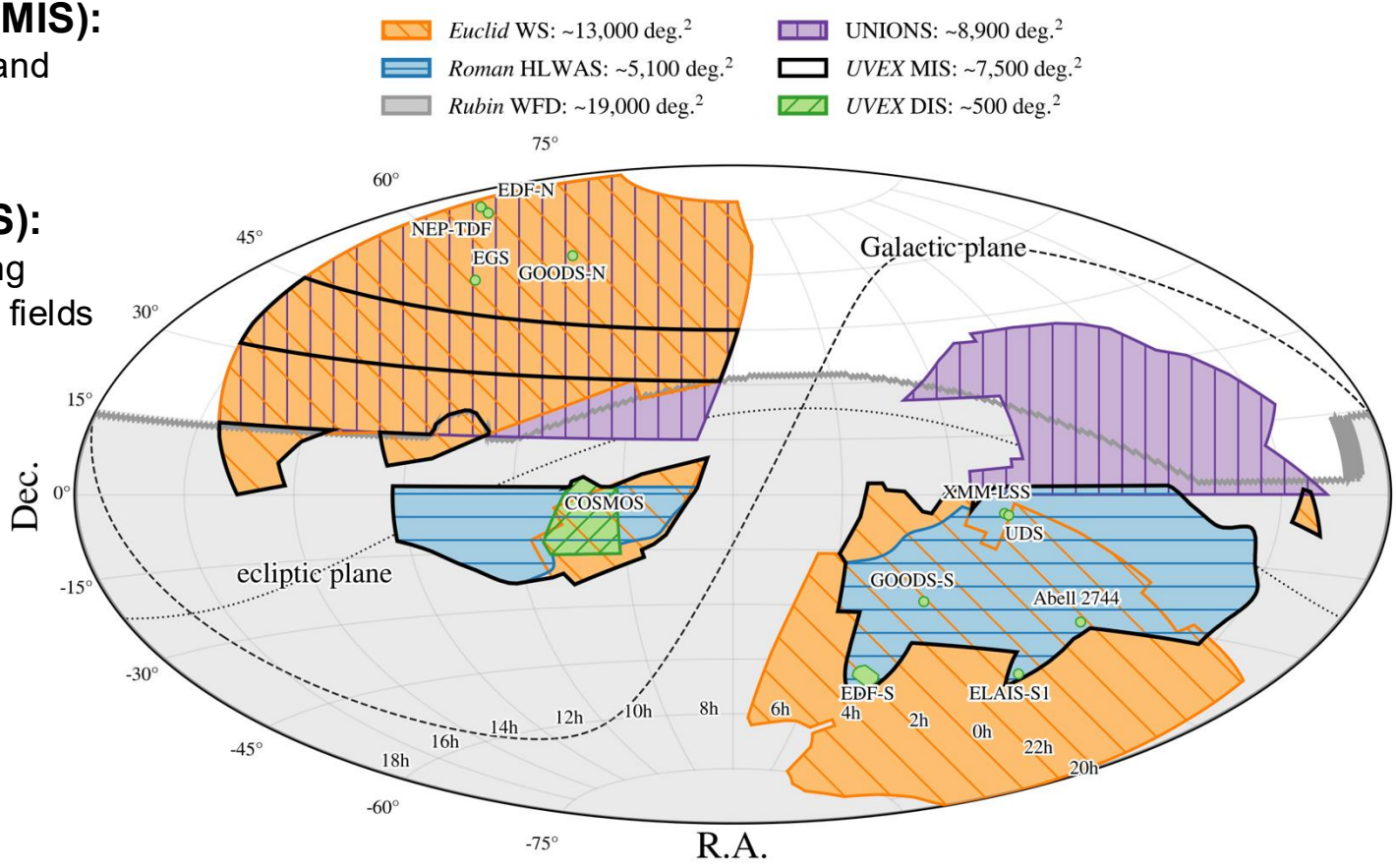
- **In optical/IR colors alone, a nearby dwarf and a massive z ≳ 1 galaxy look the same.** The rest-frame UV of the distant galaxy is redshifted out of the UVEX bands. FUV/NUV photometry breaks the degeneracy
- **Result:** Photometric redshifts good enough to select local ($z < 0.3$) star-forming low-mass galaxies over the whole extragalactic sky, with 50% fewer interlopers when UVEX is combined with Rubin and Euclid



A real galaxy at z = 0.02: with UVEX the photo-z is right; without it, z ≈ 2.7.

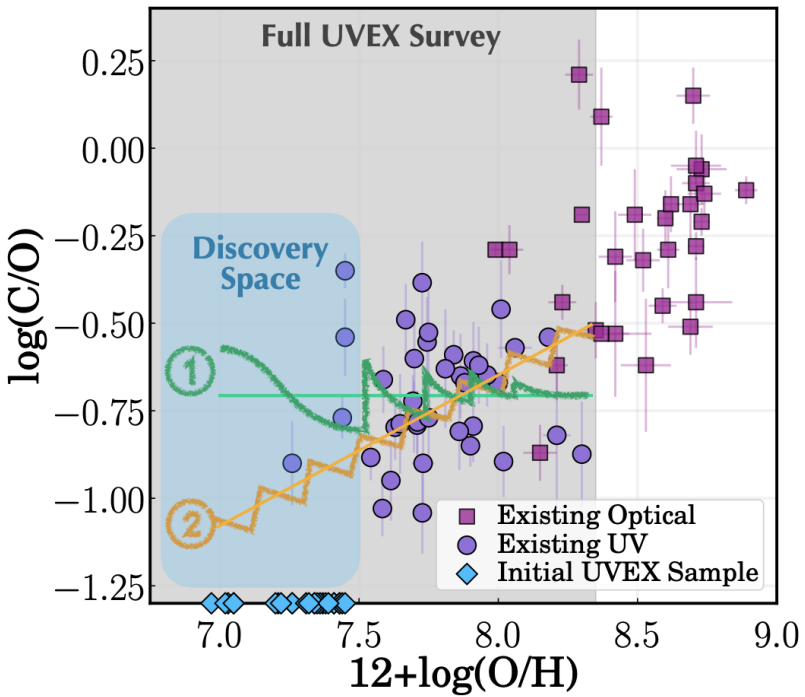
Goal 1: UVEX MIS and DIS Footprints

- **Medium Imaging Survey (MIS):** 7500 deg² to 25.75 AB in FUV and NUV, detecting a ~10^6 $M_\odot$ star-forming dwarf at 100 Mpc
- **Deep Imaging Survey (DIS):** 500 deg² to 27.0 AB, overlapping Rubin, Euclid and Roman deep fields



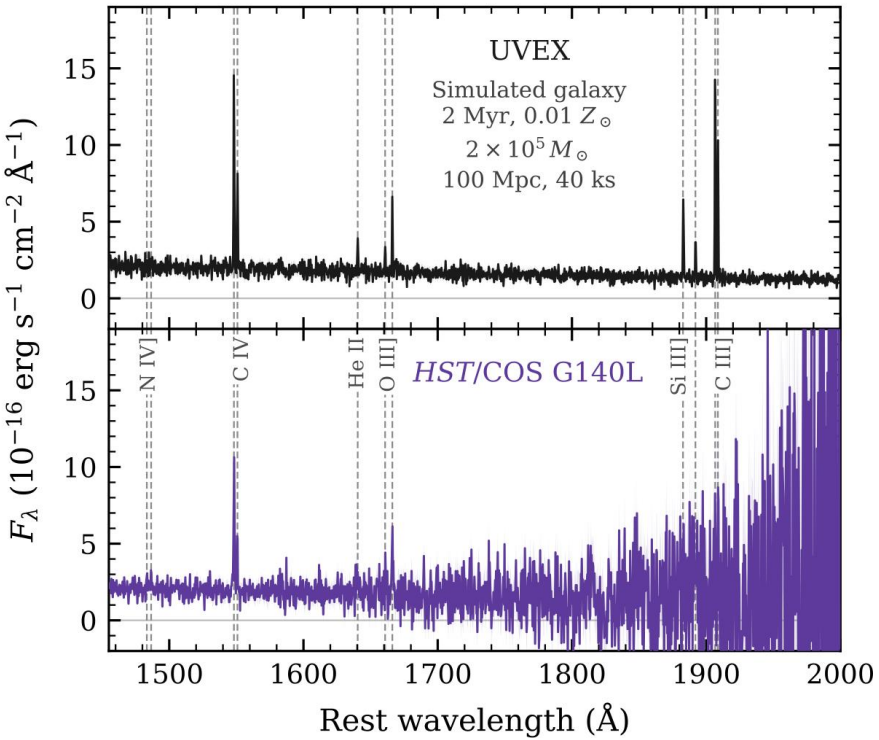
Goal 1: UV Spectroscopy of the Most Metal-poor Galaxies

- **UV spectra** have the same lines JWST sees at z > 4 — C IV, He II, O III], N IV], C III] — plus wind, photospheric and ISM absorption features
- **Goal:** C/O and nebular diagnostics for ≥ 25 star-forming LMLZ galaxies at z ≤ 0.47, reaching extremely metal-poor (≤ 5% $Z_{\odot}$) systems too faint for HST/COS
- **Why it matters:** Local calibrators for densities, temperatures and abundances inferred from high-z UV line ratios; templates for the first galaxies
- **Advantages over COS:** 2″ × 1° long slit captures extended emission; sensitivity extends to 2800 Å, so C III] is measurable well beyond z ~ 0.05



C/O vs. metallicity: existing optical (squares) and UV (circles) measurements and the initial UVEX sample (diamonds). UVEX opens the low-metallicity regime where models diverge.

Goal 1: UVEX vs. HST/COS on the Same Metal-Poor Galaxy



Simulated 1% $Z_\odot$, 2×10⁵ $M_\odot$ star-forming galaxy at 100 Mpc, 40 ks with UVEX (top) and COS G140L (bottom), both run through current ETCs.

- **Same resolution** (0.58 Å vs. 0.59–0.62 Å per pixel), but UVEX is far more sensitive redward of 1500 Å
- **Continuum S/N:** 6.0 vs. 5.4 (1500 Å); 5.5 vs. 1.0 (1800 Å)
- **One exposure** covers 1150–2800 Å where COS needs two gratings; C III] λ1909 measurable to z ≈ 0.47 (vs. z ≲ 0.05 with COS)
- **2″ × 1° long slit** captures extended emission that COS's 2.5″ aperture misses

~30×
COS requires more exposure time at 1800 Å

2–20×
the COS G140L effective area at 1490–1900 Å

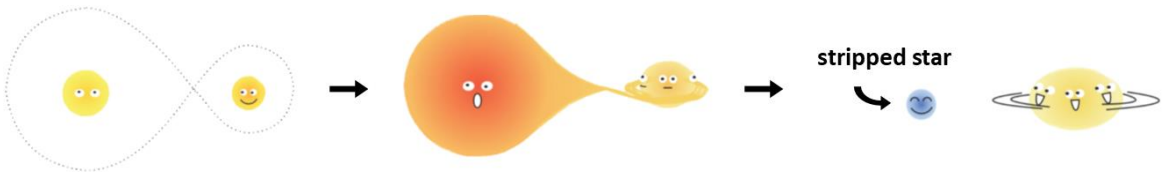
≥ 25
LMLZ galaxies with C/O in the baseline mission

Goal 1: Massive and Stripped Stars in the Magellanic Clouds

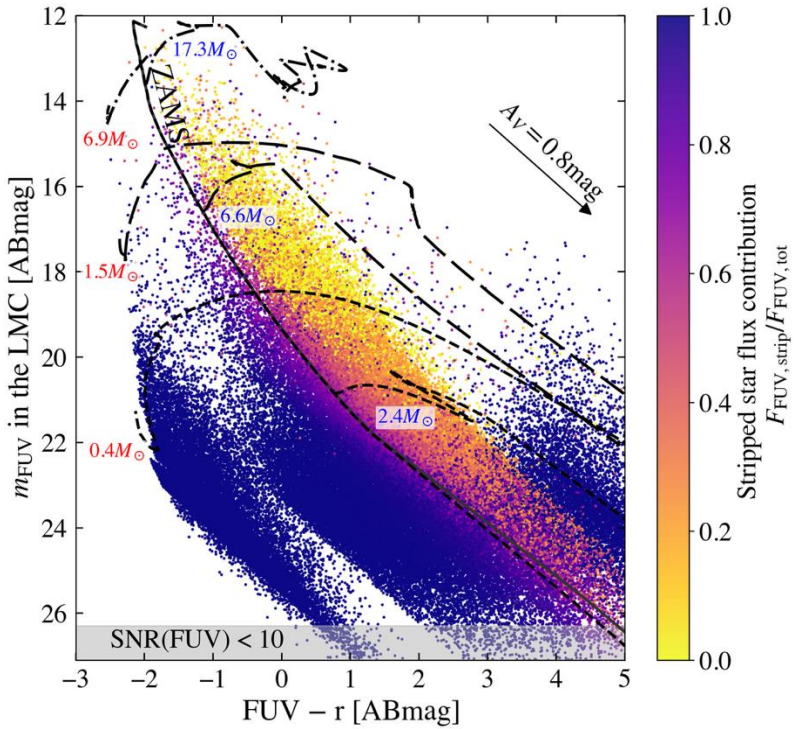
UVEX Ultraviolet Explorer

Formation of a Stripped star

(credit: Ylva Götberg)



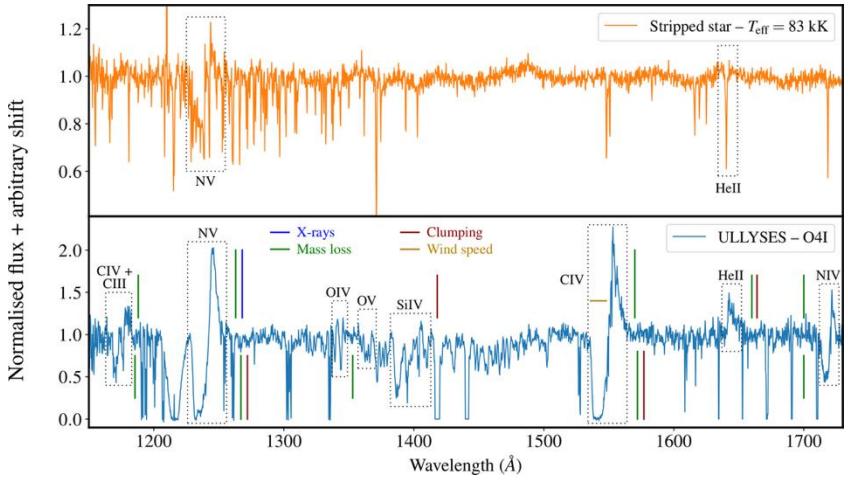
- **Cadenced imaging** of ≥ 50 deg² (LMC) and 18 deg² (SMC) to ~27 mag (FUV and NUV) in ~80 epochs
- **Stripped stars:** binary-stripped stars are hot, UV-bright and optically-faint; UVEX will identify a population spanning ~0.35–8.5 $M_\odot$ via FUV excess and eclipsing UV light curves
- **Science Impacts:** progenitors of stripped-envelope SNe, X-ray binaries and GW mergers; the ionizing budget of binaries



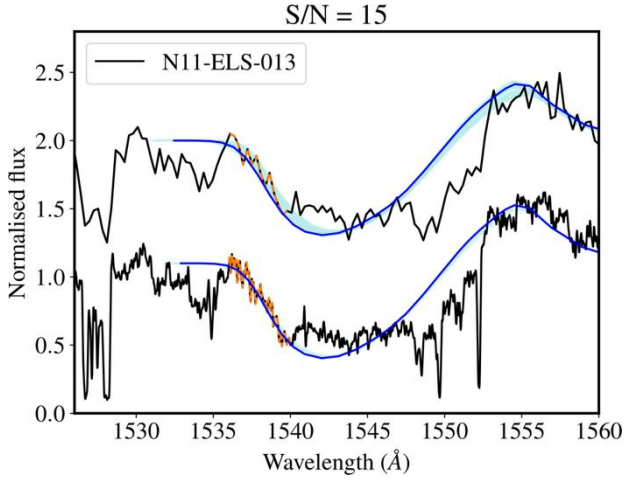
Simulated FUV − r color–magnitude diagram of the LMC; color shows the stripped-star contribution to the FUV light. About half of stripped-star binaries sit > 5σ bluer than the main sequence.

Goal 1: UV Spectra of OB and Stripped Stars in the Clouds

- **Winds live in the FUV:** N V λ1240 and C IV λ1548 P-Cygni profiles give terminal speeds (v∞ to 25%)
- **Sample:** S/N > 15 spectra of > 500 OB stars and > 50 stripped stars at 1/2 and 1/5 $Z_\odot$ — the largest FUV library of massive stars and their binary products at sub-Solar metallicity; builds on HST/ULLYSES (233 mostly single hot stars and no stripped stars); Only 7 LMC/SMC stripped stars have UV spectra



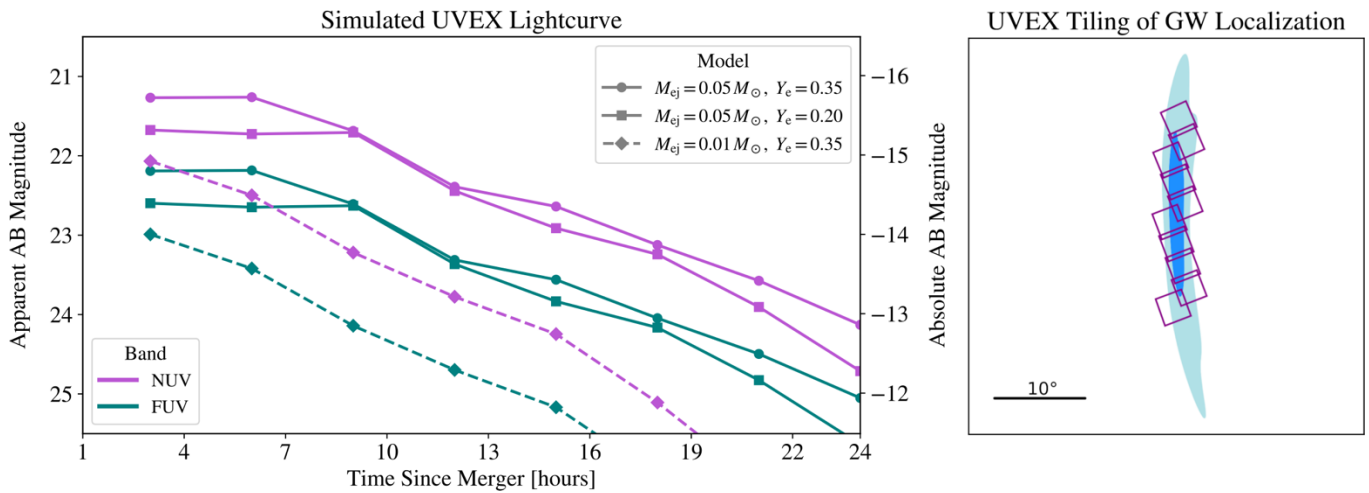
Simulated UVEX spectra of an O4 supergiant (1800 s; blue) and a 4.4 $M_\odot$ stripped star (10 ks; orange), with the main wind diagnostics indicated.



C IV λ1548 in an LMC O8 V star at HST/STIS (bottom) and UVEX (top) resolution with wind fits overlaid.

Goal 2: Neutron Star Mergers in the UV

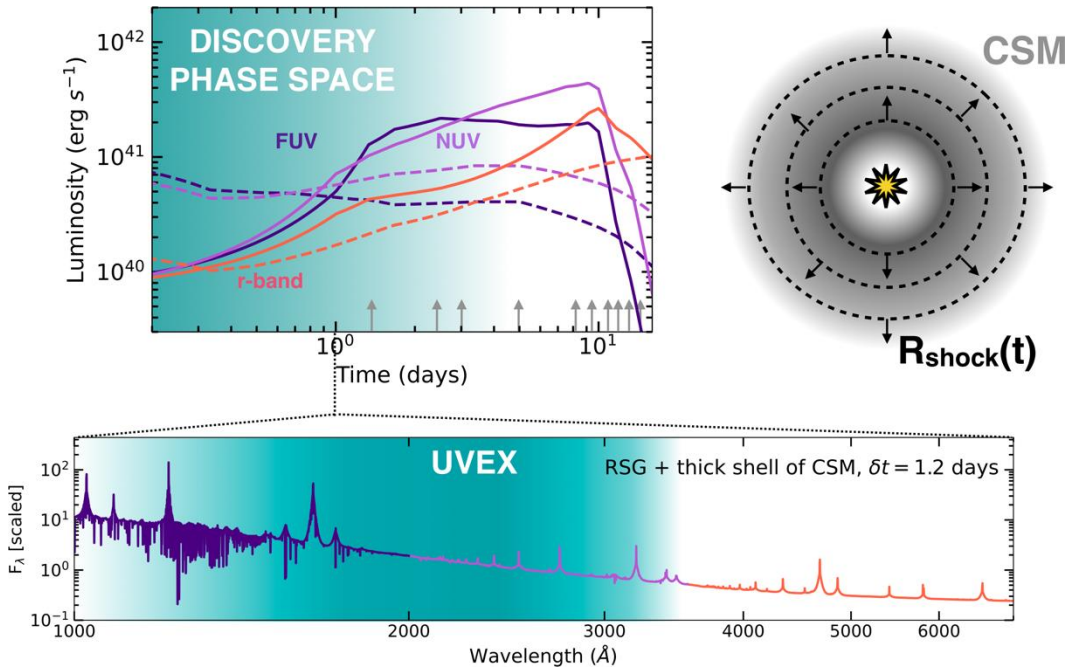
- **Rapid two-band tiling** of LIGO/Virgo/KAGRA O5 BNS and NSBH localizations starting < 6 hr post-merger
- **Spectroscopic sequences** over the first day if a counterpart is found (by UVEX, ULTRASAT or others) at < 12 hr
- **Expected yield:** ~15 events followed up; ~6–9 kilonova detections — early UV distinguishes shock-powered from radioactively powered ejecta and constrains the fast, blue component



Left: predicted NUV/FUV kilonova light curves at 250 Mpc for different ejecta masses and lanthanide fractions.
Right: an optimized UVEX tiling of a GW skymap.

Goal 2: The First UV Spectra of Infant Supernovae

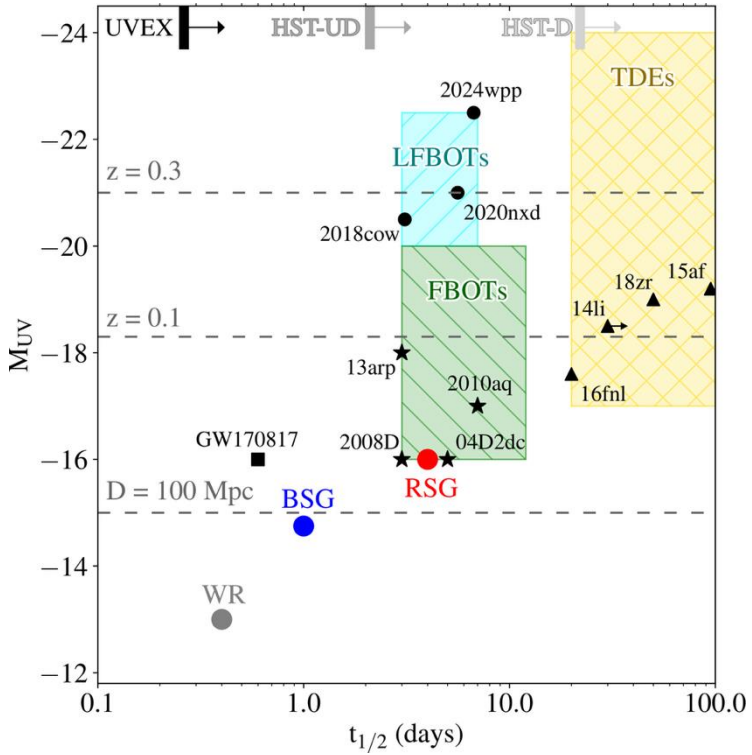
- **The first day of most explosions peaks in the UV** — no UV spectrum exists before ~1.5 days
- **Plan:** Spectral sequences starting < 6 hr after trigger for ≥ 10 supernovae within ~100 Mpc
- **Science:** The progenitor's final mass loss (confined CSM) and the composition and structure of the exploding star, read from rapidly evolving UV lines
- **Triggers** from Rubin, ULTRASAT, ground-based surveys, and UVEX's own all-sky survey



Top: FUV/NUV/r light curves of a red-supergiant explosion with (solid) and without (dashed) a dense CSM shell; arrows mark all existing early UV spectra. Bottom: simulated UVEX spectrum at 1.2 days.

Goal 2: The Community ToO & Time Domain Program

- **8% of the mission** (58 days) for community-identified ToOs and time-domain spectroscopy — vs. ~2% of HST for UV spectroscopic ToOs and < 1% for disruptive (< 21 d) ones
- **Response** as fast as < 6 hr when needed (average < 3 hr to target); ~20 rapid ToOs per year
- **Targets:** TDEs (only 5 UV spectra exist), FBOTs and luminous FBOTs (one UV spectrum exists), shock-cooling emission from young SNe, novae, stellar flares, CVs…
- **Triggers from UVEX itself:** The all-sky survey should find ~20 TDEs, up to 10 LFBOTs and ~50 SLSNe per year bright enough (m < 20) for spectroscopy



UV transient phase space (peak NUV magnitude vs. time above half-max). Ticks compare UVEX response to HST disruptive (D) and ultra-disruptive (UD) ToOs.

Goal 2: The Community ToO & Time Domain Process

UVEX Ultraviolet Explorer

1. White papers

Community submits science cases with trigger criteria, event rates and response times

2. SOC review

A Scientific Organizing Committee reads the white papers and drafts a nominal priority plan

3. Workshop

A community workshop in summer 2027 sets the trigger categories and the pre-approved observing plans for the first year

4. Triggering

Candidates come in via the ToO interface or API and are auto-vetted against the agreed criteria; ~10% of the time is kept for the unexpected

5. Execution

UVEX observes; quick-look spectra are posted promptly and all data are public at once, whoever triggered

Allocation is programmatic — time goes to categories of sources, not to individual PIs.

More details at the AAS winter meeting: UVEX Town Hall --- Tuesday January 12, 2027.

Goal 3: A Deep, Cadenced All-Sky UV Survey

UVEX Ultraviolet Explorer

- **Coverage:** The entire sky, including the Galactic Plane, in FUV and NUV simultaneously
- **Depth:** ~23.5–24.5 AB per visit; stacked ≥ 24.25 (FUV) / 25.25 (NUV) AB outside the Plane
- **Cadence:** 3–10 visits per field spanning hours to months to years — sensitive to flares, novae, TDEs, SNe, AGN variability, …
- **Bonus:** The spectrograph exposes in parallel, yielding the largest UV spectral dataset ever
- **Alerts:** Transients found by difference imaging, broadcast to everyone within 1 hr of data receipt

>50-100×

deeper than the GALEX all-sky survey in the FUV and NUV

2×

sharper PSF than GALEX

+14,000 deg²

of new sky coverage, including the Galactic Plane

0 days

proprietary period; images released daily

Data Products

UVEX Ultraviolet Explorer

Calibrated images

Level 2 single-epoch FUV + NUV images, delivered daily to IRSA

Difference images & alerts

Subtractions against the first-pass all-sky reference; alert packets to brokers and the public within 1 hr

Spectra

2D long-slit frames from every dwell — targeted and parallel — plus 1D extraction tool; quick-look ToO spectra posted promptly

All-sky maps

Stacked FUV + NUV mosaics after the first all-sky pass; final maps after full reprocessing

Catalogs

All-sky source catalog with multi-epoch photometry and light curves; LMLZ galaxies with UV–optical–IR photo-z's

High-level products

Science-team Level 4 products (e.g. stripped-star candidates, ToO spectral sequences, LMLZ catalogs) and documentation, all at IRSA

No proprietary period. Archive, tools and documentation at IRSA (IPAC) · alerts and quick-look spectra via the Science Operations Center · triggers via the Community ToO interface / API

Summary

- **UVEX launches in 2030:** Wide-field FUV + NUV imaging, sensitive long-slit UV spectroscopy, and rapid response
- **Two-year baseline science:** The low-mass galaxy frontier, the dynamic UV universe, and a cadenced all-sky survey > 100× deeper than GALEX
- **The UV complement** to Rubin, Euclid, Roman, JWST, LIGO O5 and ULTRASAT — and a bridge to HWO
- **For the community:** 8% of time for ToOs and time-domain shaped by your white papers; public alerts; daily data releases; no proprietary period
- **Learn more:** UVEX Town Hall at the AAS winter meeting, January 12, 2027

UVEX Concept paper: Kulkarni+ (2021)
UVEX Mission paper: Harrison+ (submitted)