# SIBEX UV Spectrograph and Imager (SUSI)



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#### Michael Davis, on behalf of the SIBEX team 6 October 2022



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### **SIBEX Mission**

- Shock Interaction Breakout EXplorer (SIBEX) proposed to 2021 NASA MIDEX call
  - Not selected, but rated Category I
- Primary mission to observe shock breakout (SBO) explosions from supernovae and neutron star mergers (NSMs) in the X-ray and far-to-mid UV (136-300 nm)
  - Wide-field X-ray sensor detects shock breakout
  - S/C points UV imager to target within I minute of X-ray detection
  - Target position pinpointed with imager and UV spectrograph slit moved to target within I minute of initial pointing
  - UV spectroscopy continues on main target while surrounding field is imaged for reference
  - Ground can override pointing in case of special events, but not normal mode of operation



### **SIBEX Mission (continued)**

Science Goal 1: Characterize the early emission from SNe to both differentiate and probe the properties of stellar progenitors and supernova (SN) explosions, including inhomogeneities and asymmetries.

#### SN Science Objectives: SIBEX shall...

- 1) Determine density inhomogeneities in stars and their winds on short-timescale with 30% uncertainty.
- 2) Determine stellar radii with 33% uncertainty.
- 3) Determine density gradient of transition region between the star and stellar wind with 10% uncertainty.
- Distribute X-ray and UV brightness, position, and timing of SN SBOs to astronomical community in <1 minute.</li>
- Perform a population study of SNe discovered within one hour of SBO in X-ray and UV to 99% CL (sample accuracy of 10%).



SIBEX fills in the lifecycle gap of massive stars by providing the most direct probe of engines behind SBO explosions and their immediate surroundings.

Science Goal 2: Detect and localize NSMs and constrain properties of their jets, compact remnants, and ejecta.



Early time observations with SIBEX provide critical insights into the merged core surrounded by NSM disks.

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community in < 1 minute. (NASA's Swift mission has demonstrated similar distribution performance for gamma-ray bursts for over 17 years.)

4) Observe >20 NSMs in X-ray and UV within 1 hour after merger.

Constrain composition and mass of wind ejecta from NSMs.

1) Determine existence and lifetime of a magnetar in NSMs out to 330 Mpc.

Distribute X-ray and UV brightness, position, and timing of NSMs to astronomical

NSM Science Objectives: SIBEX shall...

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### **SIBEX Mission (continued)**

#### **Mission Science Motivations**

- Understanding SNe is fundamental to many areas of astrophysics (e.g., chemical enrichment of universe, galaxy evolution, star formation rate, stellar evolution, compact objects/remnants, circumstellar material/ composition, interstellar dust formation, cosmology).
- To understand the first stars in the universe (which are thought to be massive), we must understand ones in our backyard.

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- SNe enable detailed autopsies of stars (for which SIBEX provides a key missing step).
- 4) NSMs are thought to produce half of chemical elements heavier than Fe.
- 5) NSMs are prime multi-messenger sources and unique laboratories of gravity and extreme physics.

While searching for SN SBOs and NSMs, a large number of SSTs can be followed with SIBEX's unique instrumentation. SIBEX's science operations concept includes observations of these targets as part of a preplanned schedule which will automatically be interrupted by SIBEX detected SBOs and NSMs. These SSTs are also observed by the UV instrument when it is not observing primary science targets. *Some* of the SSTs to be observed by SIBEX include: active galactic nuclei (AGN), classical novae (CNe), exoplanet host stars (EHS), extragalactic X-ray binaries (EXBs), tidal disruption events (TDEs), and Type Ia SNe.



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### **SIBEX Science Requirement Flow**



#### SUSI Driving Requirements and Expected Performance

	Projected		
Instrument Functional Requireme	Performance	Margin	
UV Instrument 5 $\sigma$ -sensitivity in a 800-second exposure at 136 nm	$3.0E^{-14}$ erg/cm <sup>2</sup> /s	2.2E <sup>-14</sup> erg/cm <sup>2</sup> /s	36%
UV Instrument Wavelength Range for a QE > 1%	136-300 nm	136-300 nm	Compliant
UV Imaging Field-of-View	0.08 sq-deg	0.25 sq-deg	211%
UV Instrument Pointed Transient Resolution	1 s	0.3 s	233%
UV Instrument Localization Accuracy	2.0 "	1.0 "	100%
UV Instrument Spectral Resolution at 150 nm	100	230	130%
UV Spectral Field-of-View	20 sq-arcmin	30 sq-arcmin	50%



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### **SIBEX Spacecraft and Payload**

- Two sets of XRF modules act a widefield X-ray finders
  - 12 telescopes per module for a total of 24 identical telescopes
  - Each X-Ray telescope has 6°×6° FOV, separated by 5.25°; 5 arcmin resolution
  - Two telescopes are co-aligned with SUSI boresight for redundancy

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 Most instrument mass & power allocated to XRF



- A. Orbit/Launch Vehicle
  - Baseline orbit: 30° inclination, 600 km altitude
- AO LV: compatible with Scenario 2 AO LV
- Launch mass: 716.4 kg out of worst case 950 kg possible
- B. Observatory
- 1 Observatory in LEO orbit
- Hosting 1 UV Telescope and 1 X-ray Instrument (with 24 telescopes)
- C. Instrument Accommodations
- Instrument Mass (MEV): 292.9 kg
- Instrument Power (MEV): 307.2 W
- Average Total Science Data Rate: 640 kb/s
- · Pointing: Inertial pointed, 3 axis stabilized, 1 arc-sec control

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### **Instrument Design Considerations**

- Optical:
  - Aperture size driven by sensitivity requirement
  - F/number and spatial resolution driven by sensitivity requirement
  - I 36nm 300nm wavelength range and sensitivity requirement drive AI+MgF2 mirror coatings and detector "filter" window
  - Contamination driven by sensitivity requirement
  - Imager shares UV spectrograph optical path
  - FWHM PSF requirement drives optical design
  - Optical alignment tolerances drive metering structure and mirror materials

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- Electronics:
  - Temperature sensors
  - Cover deployment actuators
- Mechanical:
  - Launch Environments
     & Modal/Frequency
     Requirements
- Thermal:
  - Optical alignment
     tolerances drive
     thermal requirements



## **Design Overview**

- Telescope is Ritchey-Chrétien design with 40 cm primary aperture and 320 cm focal length (f/8)
- Spectrograph is Rowland circle design with toroidal grating and cylindrically curved MCP detector
  - Heavily influenced by SwRI's planetary Alice/UVS design
- Imager is modified Offner with flat MCP detector
  - FUV requires all-reflective re-imager

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Detector is sealed-tube with BaF<sub>2</sub>
 window to block geocoronal oxygen

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## **SUSI Spectrograph**



- F/8 Rowland Circle (slower than Alice F/3)
- Grating: 200 mm radius, 1000 lines/mm

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 Detector: Borosilicate MPC z-stack, 100 mm radius

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### SUSI Spectrograph (cont.)





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ABOBATOBY

#### SUSI Spectrograph Resolution

- Resolution varies slightly across the Rowland Circle
  - Peak R~800 @ 250 nm
  - Requirement is R>150 at 150 nm
    - Expected R~230 at 150 nm



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### **SUSI Imager**



- FOV is 0.5° per side, for 0.25 sq. deg.
- Max spot size is 1.5 arcsec; Nyquist sampling improves positioning to better than 1 arcsec
- Detector is flat borosilicate MCP stack



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IMA: 14.079. -14.389 mm

IMA: -13.975, 14.134 mm

OBJ: 0.2500, 0.0000 (deg)

IMA: 14.017. -0.036 mm

OBJ: 0.2500, 0.2500 (deg)

IMA: 13.975, 14.134 mm

OBJ: -0.2500, -0.2500 (deg)

IMA: -14.079. -14.389 mm

#### A few words on detectors

- Spectrograph and Imager have slightly different shapes (cylindrically curved vs. flat), but otherwise share identical properties
  - Borosilicate MCP z-stack (Europa Clipper and SPRITE heritage)
  - Sealed tube with  $BaF_2$  window to block Ly-alpha & oxygen geocorona
    - Sealed tube allows easier ground testing and fewer handling restraints
- Detector features bi-alkali cathode for simultaneous FUV & NUV response on same detector
- Cross-delay-line readout electronics
  - Heritage going back to GALEX & COS
  - SwRI heritage includes Juno- (in flight 10+ years), JUICE-, and Europa Clipper-UVS
- Data taken in time-tagged mode but can be co-added to form an image histogram
  - JUICE- and Europa-UVS provide experience with programmable histograms with 1/s cadence





#### **SUSI Overview – Ray Trace**



Spectrograph structure and rear close-out cover not shown



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#### **SUSI Section View – Front**



Spectrograph structure and rear close-out cover not shown



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### **Design Overview**



**Front View** 

**Rear View** 

Spectrograph structure and rear close-out cover not shown



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#### **SUSI Detector Package (i.e. imager and spectrograph)**





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### **SUSI I/F Electrical Requirements**

- HV connections between detector and HVPS
  - Heritage from multiple previous instruments
- High-speed interface prefers spacewire, but heritage has included LVDS
  - Proposed spacewire, but future S/C may desire something different
- Power heritage assumes "standard" 28V S/C bus, but can be adjusted for other reasonable voltage values
- Total operational instrument power is ~32 W during decontamination, ~16 W for nominal science ops (essentially 2x Europa Clipper power)



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#### **Power Budget**

- Current CBE is 15.6 W for nominal operations
  - Detector Electronics 4W
  - HVPS 0.5 W
  - LVPS 1.5 W
  - C&DH I.8W
  - Based on as-built values for Europa-UVS, 7.8 W per instrument head
- Assumes no operational heaters needed, just decontamination heaters
  - Depending on thermal analysis, trim heaters may be necessary to maintain temperature during operations, raising operational power to ~32 W



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#### SUSI I/F Mechanical & Thermal Requirements

- Mechanical:
  - SUSI Instrument mechanical interface to SC bipods bolted to top of SC payload bench
- Thermal
  - Thermal isolation between Telescope and SC provided by bi-pods
- Spectrograph interfaces with telescope on optical bench behind MI
- Spectrograph is glass optics w/composite structure

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- Detector housings are AI per heritage, electronics dump
   4 W each
- Total instrument mass (Telescope + SDP + bipods): 66 kg after ~18% contingency





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### **SUSI** Thermal Design – Overview

- Telescope thermally isolated from bus by titanium/fiberglass bipod mounts
  - MLI around housing to further isolate from S/C
- Sunshade can be used as a radiator to pull heat from electronics as needed
  - Use heritage pyrolytic graphite sheet (PGS) thermal straps for

radiator thermal bus

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- Telescope metering structure made of M55J / cyanate ester composite system with near-zero CTE layup to maximize thermal stability
  - Trim heaters and MLI used as needed to maintain stable temperature
  - Temperature sensors on the barrel will provide monitoring to calibrate readings



#### **SUSI** Thermal Design – S/C Bus Isolation

- Instruments thermally isolated from bus by low conductivity titanium/fiberglass bipod mounts
- MLI blanketing will provide further radiative isolation from bus and radiators









### **Pointing Budget/FOV**

- Imager sees 0.5° FOV with multiple guide stars
  - Guide star positions are read out with 100 ms cadence and fed to S/C pointing system
    - Guide stars taken from Vincent Hue's Juno-UVS catalog of thousands of UV stars
- Spectrograph has 3 arcsec x 10 arcsec slit
  - Telescope PSF is 0.5 arcsec at slit-jaw interface, so 1 arcsec stability needed to keep PSF in slit without vignetting



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### High Level Test/Calibration Req'ts/Plan

- OTA will be assembled and calibrated by SDL
  - Calibration includes alignment, focus, and throughput tests
- Imager and Spectrograph subystems will be assembled and calibrated by SwRI
  - Imager calibration includes alignment, focus, effective area, and FOV tests
  - Spectrograph calibration includes alignment, focus, effective area, spectral characterization (bandpass, resolution, position), stray/scattered light rejection
- Integrated SUSI (OTA+Imager+Spectrograph) will be assembled and calibrated by SDL
  - Final Calibration includes alignment, focus, effective area, simultaneous imaging/spectroscopy check, and wavelength resolution



### Heritage/TRL by Subsystem

- Orbital Environments
  - Orbit is ~600km LEO and
     30° inclination
  - Pointing ≥45° off from sun
- All electronics have heritage in Jupiter orbit, much harsher than LEO
- Mechanical components have launch heritage ranging from Delta II to Atlas V 55 I

- Missions
  - New Horizons: Kuiper Belt, 16+ years of operation
  - OCI PACE: LEO ~ 700km, space qualified, not launched
  - WISE: Sun-synch ~ 500km
  - SABER: LEO ~ 600km
  - LRO-LAMP: Lunar orbit, 13 years of continuous HV operations
  - Juno: Jupiter orbit, 10 years of operation (6 at Jupiter)
  - ICON MIGHTI: LEO ~ 600km
  - Roman Space Telescope: LI, space qualified, not launched
  - JUICE: Jupiter, space qualified, not launched
  - Europa Clipper: Jupiter, space qualified, not launched



### **SUSI Contamination Control**

- Contamination control efforts, specifically managing moisture absorption, particulate accumulation, and controlling molecular contamination will be critical to meet the SUSI performance requirements.
- All assembly, alignment, and testing will be performed in a Class 1000 or better cleanroom or a verified clean vacuum chamber.
- SDL and SwRI use best practices to prevent, clean, monitor, and protect the sensitive SUSI hardware from contamination. SDL and SwRI both have significant experience in the application of contamination control theory and practice, modeling, materials characterization, cleaning and cleanliness certification. Test facilities support continuous GN2 purge; bake-out; particulate (tape lifts, rinses, or direct microscope imaging) and NVR (DRIFTS or GC/GC) contamination control monitoring, sampling; and analysis to IEST-STD-CC1246D (sample analysis), ASTM E595 (%TML & %CVCM), and ASTM E1559 (outgassing kinetics).
- T-0 filtered GN<sub>2</sub> purge

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### **SUSI Contamination Control**

- Standard procedures for UV instruments include:
  - Particulates
    - Cleaning (GN<sub>2</sub> and/or swab)
    - CO<sub>2</sub> snow cleaning after installation (if necessary)
  - Molecular
    - Bakeouts with RGA and QCM monitoring
    - NVR analysis of surfaces and scavenger plate collection
    - UV ozone scrub of mirrors after coating (if necessary)
    - CO<sub>2</sub> snow cleaning after installation (if necessary)
  - Inspections
    - White light and UV/black light with magnification
  - Monitoring
    - Witness mirrors
- SwRI has delivered six UV spectrographs and three UV sounding rockets (multiple launches each) without contamination degradation



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#### **Future trades/improvements for next round**

- MCP vs. CMOS for imager
- Improve imager optical design
  - Is Offner best option?
- Drop mid-UV and go solely FUV
  - A possible descope listed in proposal
  - Else split spectrograph into two detectors or two photocathodes
    - Rosetta- and New Horizons-Alice both featured split photocathodes with a Lyman-alpha gap
- Any need for higher resolution spectroscopy?
- All of these are internal discussions only one (irrelevant) SUSI PMW returned by reviewers
  - A question about SUSI grism
    - SUSI does not feature a grism, and the word never appears in the proposal. Draw your own conclusions. <sup>(2)</sup>



#### **SIBEX Mission Team**

- Southwest Research Institute
  - Mission PI (Pete Roming), PM (Michael McLelland), MOC, SOC
  - SUSI PM, I&T, imaging channel, spectrograph, electronics, & calibration
- Space Dynamics Laboratory
  - XRF instrument build & management
  - SUSI telescope build under SwRI guidance
- Millennium Space Systems
  - Spacecraft build, I&T, and management

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- University of Miami
  - XRF PI (Masimiliano Galeazzi)
- University of Texas
  - SUSI PI (Cyndi Froning)

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### **Summary**

SIBEX proposed to latest (2021) MIDEX call

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- Category I, but not selected for further study
- SIBEX answers many key questions in UV time-delay astrophysics
- SIBEX Ultraviolet Spectrograph and Imager designed from systems with extensive spaceflight heritage
  - Key personnel have decades of experience supporting UV instrumentation across multiple disciplines and mission categories
- Hopefully we can propose some form of SIBEX and/or SUSI to a future opportunity
  - SUSI itself could fit in a SMEX-class mission if the science is right
  - Easy to scale up to a future PROBE if an opportunity arises



# **Backup Slides**



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#### Science Traceability Matrix (aka Eye Chart)

SIE	BEX.		-	Scienc	e Tracea	b	ilii	ty Matrix				1	FO1		
A NASA Strategio Goals	SIBEX Science Goals	Soience Objectives (SO) <sup>4</sup>	Baientifio Measurement Requirements     Physical Parameters (PP) <sup>4</sup> Observables				Instrument Functional Requirements (IFR)				Projected Performance	Margin	Mission Functional Requirements (MFR; Top Level)		
		SOL1 1) SIREY shall determine		PP-1.1.1) SIBEX shall detect in X-rays > 40 (21) Sile with 1 hour after SBO *	880 of 8Ne in X-rays	Π	IF	FR-1.1.1) XRF Energy Range		0.3-5 keV	0.1-10 keV	Compliant			
S) (Shaar ladar Ba pada	density inhomogeneities in stars		PP-1.1.2) SIBEX shall determine the	Count Date of V-my Shie		IF IF	FR-1.1.2) XRF Field-of-View"		0.18 (0.09) sr	0.20 (0.10) sr	11%	Science Countries lands > 26			
		with 30% uncertainty.		X-ray brightness of SNe with 20% uncertainty.	Pholons		lF kr	(FR-1.1.8) XRF 50-sensitivity in 24-s et keV band for transient searches (assur	sposure <sup>#</sup> in 0.3-5 ming $\beta = -1$ )	1.6x10 <sup>-to</sup> erg/cm <sup>2</sup> /s	1.2x10 <sup>-tit</sup> ergioni/is	33%	months to discover ≥40 (21) 8Ne flowed from IER-1.1.1 & 1.1.3).		
				PP-1.1.3) SIBEX shall determine velocity of expanding SNe shells (x <sub>i</sub> ) to <0.05c (0: 1 keV.	X-ray Emission Lines		IF	FR-1.1.4) XRF FWHM Energy Resolut	ton @ 1 keV <sup>+</sup>	500 eV	150 eV*	233%	Permit viewing of any part of the celestral schere outside Sun, Moon,		
	80-1.2) SIBEX shall determine siellar radii with 33% uncertainty.	I.2) SIBEX shall determine ar radii with 33% uncertainty.	ne inty. PP-1.1.4) BIBEX shall determine BNe positions < 1 arcmin on the sky from X-rays.	Localize on Year Delectronic	111	IF C	(FR-1.1.5) XRF Localization Accuracy exposure for a source of 1.6x10 <sup>-10</sup> erg/s	(90% CL) in 24-s cm <sup>3</sup> /s	5 arcmin	3.1 arcmin	01%	and Earth (moving around sky at one revolution per orbit) 45° half-an-			
	1) Characterize the early			positions < 1 arcmin on the sky from X-rays.	SNe	Ш	li in	IFR-1.1.8) XRF Temporal Cadence (TC ing for bansients?	) while search-	30 s	24 s	25%	gie keep-out zones (flowed from 80-2.4, PP-1.1.1, IFR-1.1.3, 1.2.3,		
<sup>4</sup> Expand human knowledge through new scientific discoveries. <sup>3</sup>	emission from supernovae (SNe) to both differentiate	80-1.8) SIBEX shall determine the		PP-1.1.5) SIBEX shall determine	Arrival Time of X-ray Skie	Ш	F	FR-1.1.7) XRF TC for pointed transien	t observations <sup>‡</sup>	10 5	85	25%	2.1.8 & 2.2.8).		
(NASA 2018 Strelegic Plan)	and probe the properties of siellar progenitors and	density gradient of the bansition region between the star and the		absolute timing of SBO from X-ray photons with an accuracy of ±5 ms.	Photons	Ш	E R	FR-1.1.8) XRF Absolute Timing Accure readout relative to UTC	acy per CCD	10 ms	5 ms	100%	Orbit selected to reduce non-cosmic background on XRF CCDs to less		
0	SNe explosions, including inhomogenetics and asym-	stellar wind with 10% uncertainty.		PP-1.2.1) SIBEX shall detect in UV ≥ 40 (21) SNe win 1 hour after SSO."	SBO of SNe in UV	╉	IF IF	FR-1.2.1) SUSI Wavelength Range for	ra QE > 1%	136-300 nm	136-300 nm	Compliant	than 2 events/cm <sup>2</sup> /s 90% of the time (fowed from IFR-1.1.8 & 2.1.8).		
work(s)? Probe the origin and	metries.			PP-1.2.2) SIBEX shall determine the UV brightness of SNe with 10%	Count Rate of UV SNe Photons			FR-1.2.2) SUSI imaging Field-of-view FR-1.2.3) SUSI Sc-sensibility in a 800-	-s exposure at	289 SQ-84Cmin 3.0x10-14	2.2x10 <sup>-14</sup>	211%	8/C pointing, litter, and drift < 1		
the nature of black holesand		X-rey and UV brightness, position,		uncertainty.			ĩ	136 nm		erg/cm/inm/s	ergicni/inm/s <sup>a</sup>	df 01.	arcsec over 800s (flowed from IFR- 1.2.5. 1.2.8. & 2.2.4).		
Address Show, we didi here?		(SBC) to the astronomical commu-		velocity of 8Ne expanding shells to	UVLines	Ш		IFR-1.2.4) SUSI Resolving Power @ 1	50 nm	100	230	130%	Accommodale Pavload Deck, XRF.		
Explore the origin and evolution of stars, that make up our uni-		nay n < 1 mma.		PR.1.2 (1) SIREX shall determine		łII	I IF	IFR-1.2.5) SUSI Spectral Field-of-View	r	20 sq-arcsec	30 sq-excsec	50%	SUBI, and surshield flowed from SO-2.4 & PP-1.1.1.		
verse.* (NASA 2020 Science Plan - Science 2020-2024: A Vision for		SO-1.6) SIBEX shall perform a population study of Sile within one		SNe positions on the sky from UV < 2 arcsec.	Location on UV Delector of SNe	Ш	F	FR-1.2.8) SUSI Localization Accuracy		2.0 arcsec	1.0 arcsec	100%	see FO4).		
Scientific Excertance]		hour of SBO in X-rey and UV to 99% (90%) CL (sample accuracy		PP-1.2.5) SIBEX shall determine ab- volute timine of SPD from LM retrieves	Arrivel Time of UV SNe	Ш	IF IF	FR-1.2.7) SUSI TC for pointed transler	nt observations	15	0.3 5	233%	Autonomously detect and prioritize new events in XRF and SUBI imag-		
0		of 10%)."		with accuracy of ±5 ms.	Pholons		R	relative to UTC	racy per riceau	10 ms	Sms	100%	ing data via comparison to catalogs of known sources (flowed from		
*Probe the origin and destiny of our universe, including the nature		80-2.1) SIBEX shall determine the existence and lifetime of a magne- tarin the NBM out to 330 Mpc.           80-2.2) SIBEX shall constrain the composition and mass of the wind elects from NBM.           d their source of the state of the state norm of the state norm cal community in <1 minute.		PP-2.1.1) SIBEX shall determine the X-ray brightness of NSM with 20%	Count Rate of X-ray NSM	╉		FR-2.1.1) XRF Energy Range FR-2.1.2) XRF Elektrof-View*		0.3-5 keV	0.1-10 keV	Compliant 11%	80-2.4, PP-1.1.1 & 1.2.1).		
of black hölesand gravity." "Explore the origin and evolution				uncértairity. PP-2,1.2) BIBEX shall determine NBM	Location on X-ray Delector of		IF S	IFR-2.1.8) XRF So-sensitivity to a NSN sure <sup>#</sup> In the 0.3-5 keV band	l in a 24-s expo-	1.0x10 <sup>+0</sup> erg/cm <sup>2</sup> /s	6.3x10 <sup>+1</sup> ergicmPis	59%	Change observation pointing (XRF, SUSI spectrometer) from current target to a newly detected or com-		
verse. <sup>3</sup> [Explorer Program Science Objective]				positions to < 1 ercmin on the sky from X-reys.	NSM	Ш	IF et	FR-2.1.4) XRF Localization Accuracy ( exposure for a source of 1.0x10 <sup>+0</sup> erg	(90% CL) in 24-s (cm?)s	5 arcmin	3.1 arcmin	61%	manded event ≤ 21.5" away wifn 60s (flowed from IFR-1.1.2 & 2.1.2)		
	2) Detect and localize			PP-2.1.3) SIBEX shall determine should a timing of X-ray photons from	Anival Time of X-ray NSM	Ħ	F	FR-2.1.5) XRF TC for pointed transien	t observations	10 min	85	74a	Disseminate Information (brightness,		
	constrain properties of their			NSM with an accuracy of ±6s.	Pholons	Ш	Ű	UTC	acy redeve to	125	5 ms	2300x	sky coordinates, and timing) on newly detected targets to the ground		
	ejecta.			PP-2.2.1) BIBEX shall determine the UV brightness of NBM with 10%	Count Rate of UV NSM Photons	╉╂	E B	IFR-2.2.1) SUSI Wavelength Range for IFR-2.2.2) SUSI Imaging Field-of-View	18 QE > 1%	135-300 nm 299 sp-excmin	136-300 nm 900 se-axcmin	211%	win ≤50 s (80-1.4 & 2.3, IFR-1.1.8, 1.1.5, 1.1.8, 2.1.8, 2.1.4, 2.1.8).		
				PP-2.2.2) BIBEX shall determine NBM	Location on LN Delectre of		F F	FR-2.2.8) SUBI So-sensitivity in a 800	-s exposure at	3.6x10-14	2.2x10 <sup>14</sup>	64%	Return science data of 55.3 Gbits/		
			20	positions to < 2 arcsec on the sky from UV.	NSM	┍╇╄	1.	136 nm IFR-2.2.4) SUSI Localization Accuracy		2.0 arcsec	ergicm/inm/s <sup>a</sup> 1.0 arcsec	100%	day (average) to SOC (see Table D-1).		
				PP-2.2.3) SIBEX shall determine absolute timing of LM absolutes from	Arrival Time of UV NBM		F F	IFR-2.2.5) SUSI TC for pointed transient observations		10 min	0.3 5	1999x	-		
		Nese within one hour ener merger.		NSM with an accuracy of ±6s.	Photons	Ш	<u> </u>	UTC	rocy relative to	125	5 ms	2300x			
Notes: **Color-coding next to requi and n = number of pholons (5 is co side and at longer wavelengths. Th	rements is provided to follow f risidered low and is used to cal e performance on the dark side	owdown. "Requirements in bold boxes - culate the IFRI; "Transient searches are of the orbit is 1.1x1014 erg/cm/inm/s at	ere impe e while b t 136 nm	icted by descopes to the TSM. Requirement re XRF is looking for translents. Pointed tro 1. For XRF telescopes co-aligned with SU	its for the TSM are provided in { insient observations are those th SI, the performance is 100 eV.	∑"XR at beg	Fexpasi n after t	sure time for finding new transferits; "The the observatory has settled 8081 on a	he FWHM is relate target; <sup>o</sup> This is the	ed to velocity (v,) is e performance of 8	ty the following: FW 3USI on the daylit s	HM = E <sub>4</sub> (11-w,)/ de of the orbit. P	$1+v_i$ ] $e^{-1}$ $1^{-2}$ .35" $\pi^{i0}$ where $E_0 = 1$ keV enformance improves on the night		
B NSM Science Flo	B NSM Science Flow Detect and localize NS mergers (NSM) and constrain properties of their jets, compact remnants and ejecta														
Model Model Assumption										ssumption	X-ray UV*				
Lepend liter Panel B only of a magnetar in NBM out to of a magnetar in NBM out to of a magnetar in NBM out to of wind evola from NBM as							an	nd UV within 1 hr after	SNe-High SNe Nominal	Bright & dim UV d	ata extrapolated to	a extrepolated to X-ray but durations are longer [ba[21] 64 58 calibrate model free: 10] 54 48			
Observables	30	0 Mpo.	a nana eje	to asl	astro community in <1 min.	Stin 1		merger.	SNe-Low	Swift late-time UV	UV data extrapolated to X-ray [bs[21] k, magnetar driven out to 330 Mpc [M/21]		49 44		
Physical Parameters Science Objective	V con bein	binary ad 2014	LINE	inhtnerr und			+	acition SBO UV firming and	NSMHigh	Off-axis/tsotropic,			21] 30 30		
Science Goals	un	voertain	10%	unoertain <1 aromin	w/±8 s accuracy	Ch	<2 ares	±8 s accuracy	NSM-Nominal	On-axis jet out to	600 Mpo [lvk21]		28 28		



**Space Dynamics** 

Utah State University

ABORATORY

#### SPACE SCIENCE & ENGINEERING