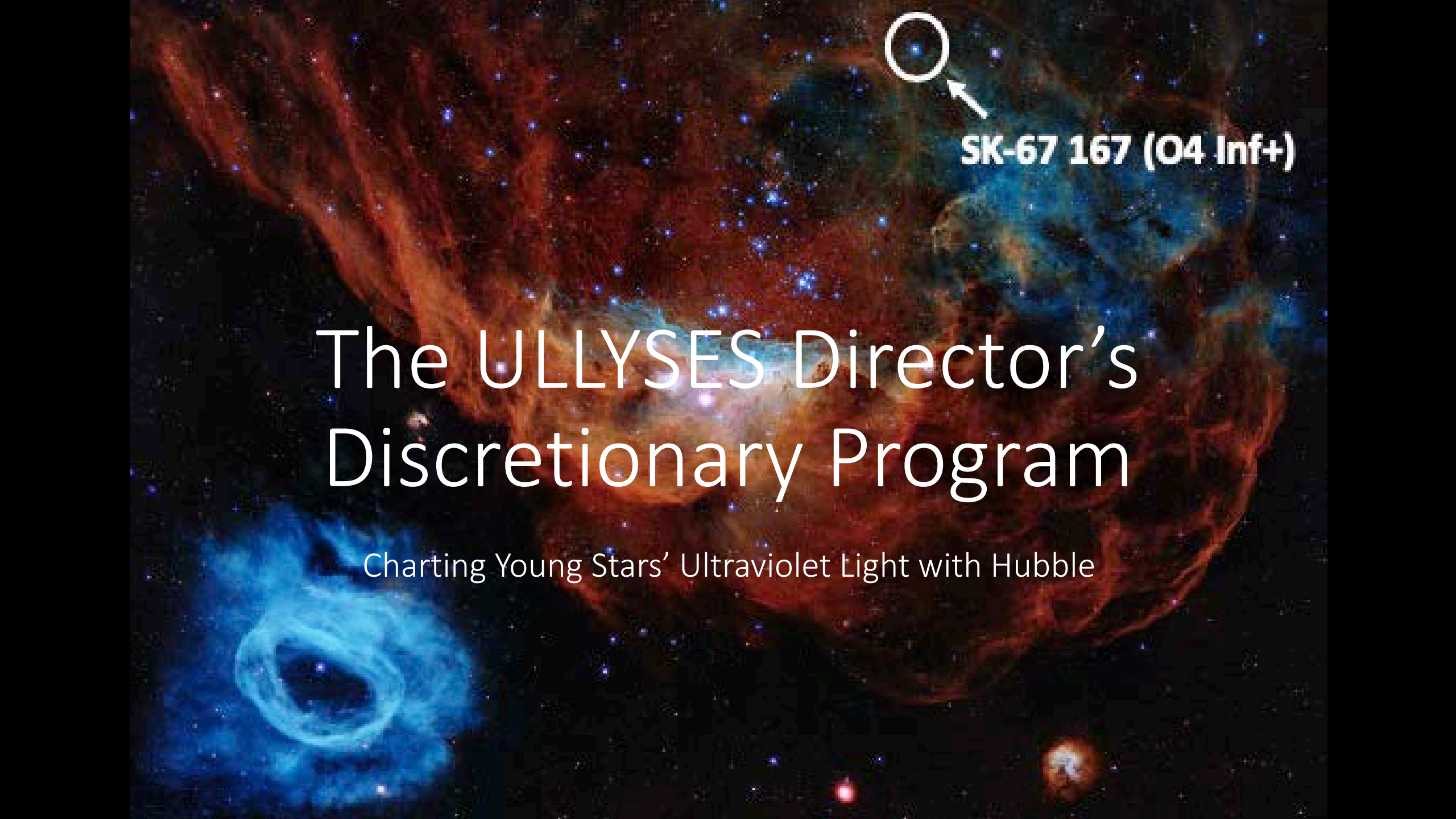
ULTRAVIOLET ASTRONOMY IN THE XXI CENTURY

e-Workshop 2020 – October 27-29

JcUVa

Downloaded from the JCUVA server hosting the workshop



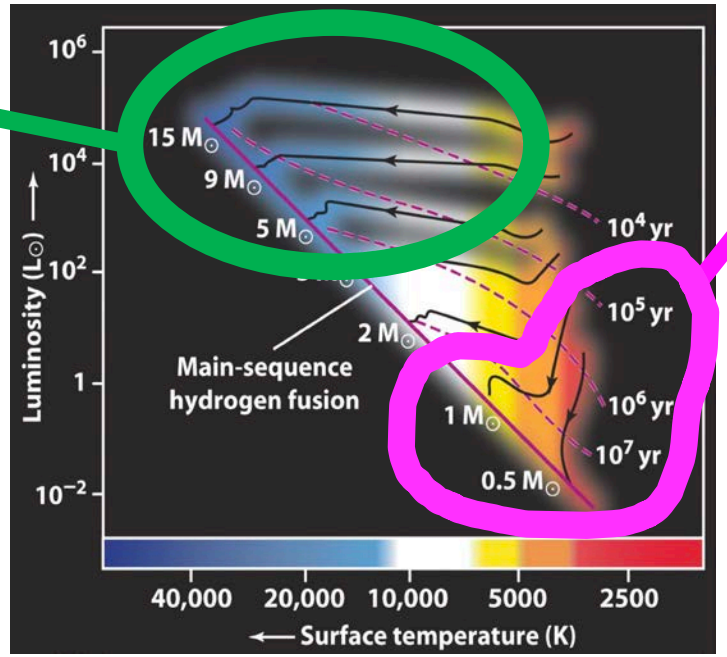
The ULLYSES Director's Discretionary Program

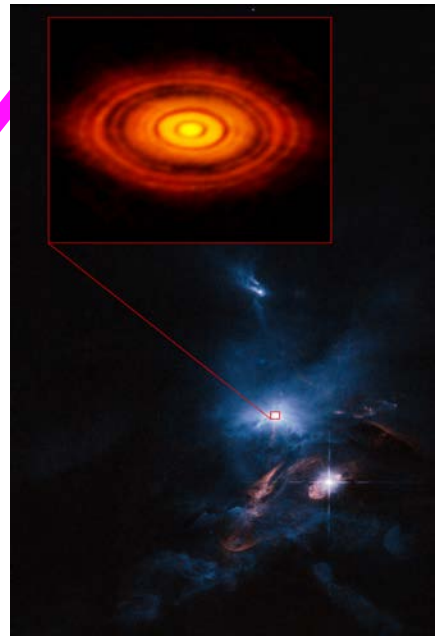
Charting Young Stars' Ultraviolet Light with Hubble

ULLYSES at a glance

- ULLYSES = **Ultraviolet Legacy Library of Young Stars as Essential Standards**
- **Director's Discretionary** Hubble program to obtain a **spectroscopic reference sample of young low and high mass stars – Largest HST program ever executed (~1000 orbits)**
- The scientific framework of the program was designed by the community, via a UV Legacy Working Group and the program is being implemented by a dedicated team at STScI

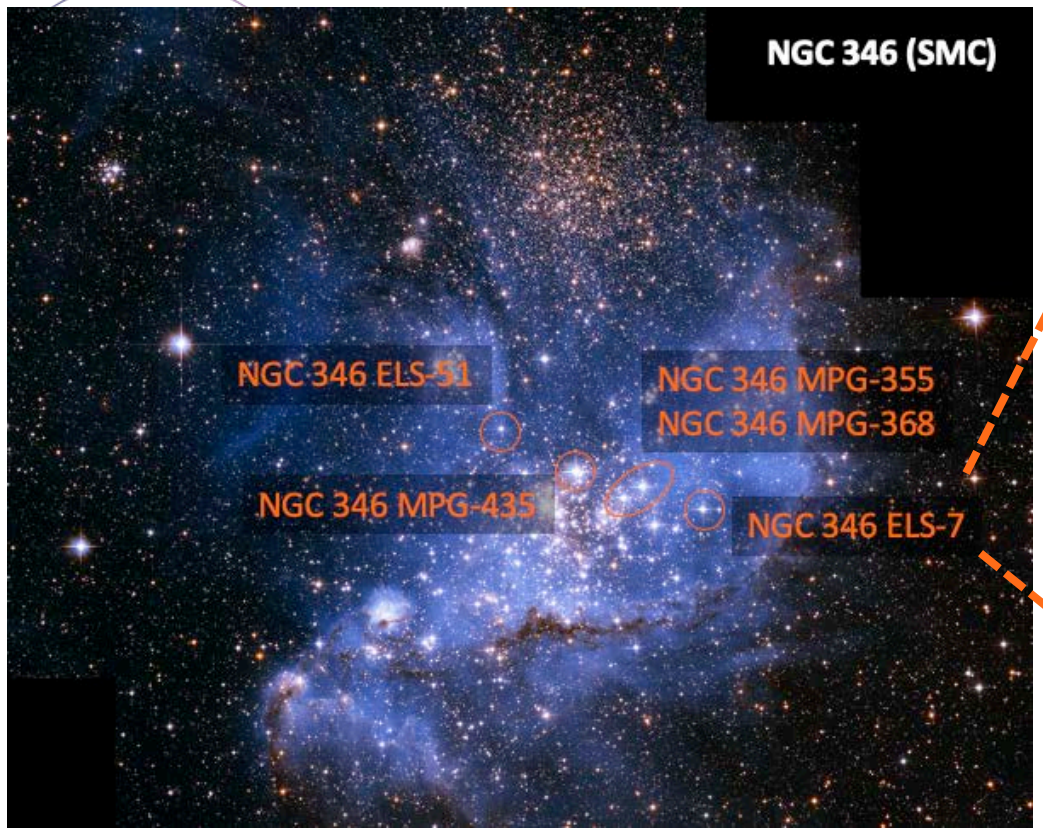
~500 orbits to extend the spectroscopic library of O and B stars to low metallicity (8-50% solar)

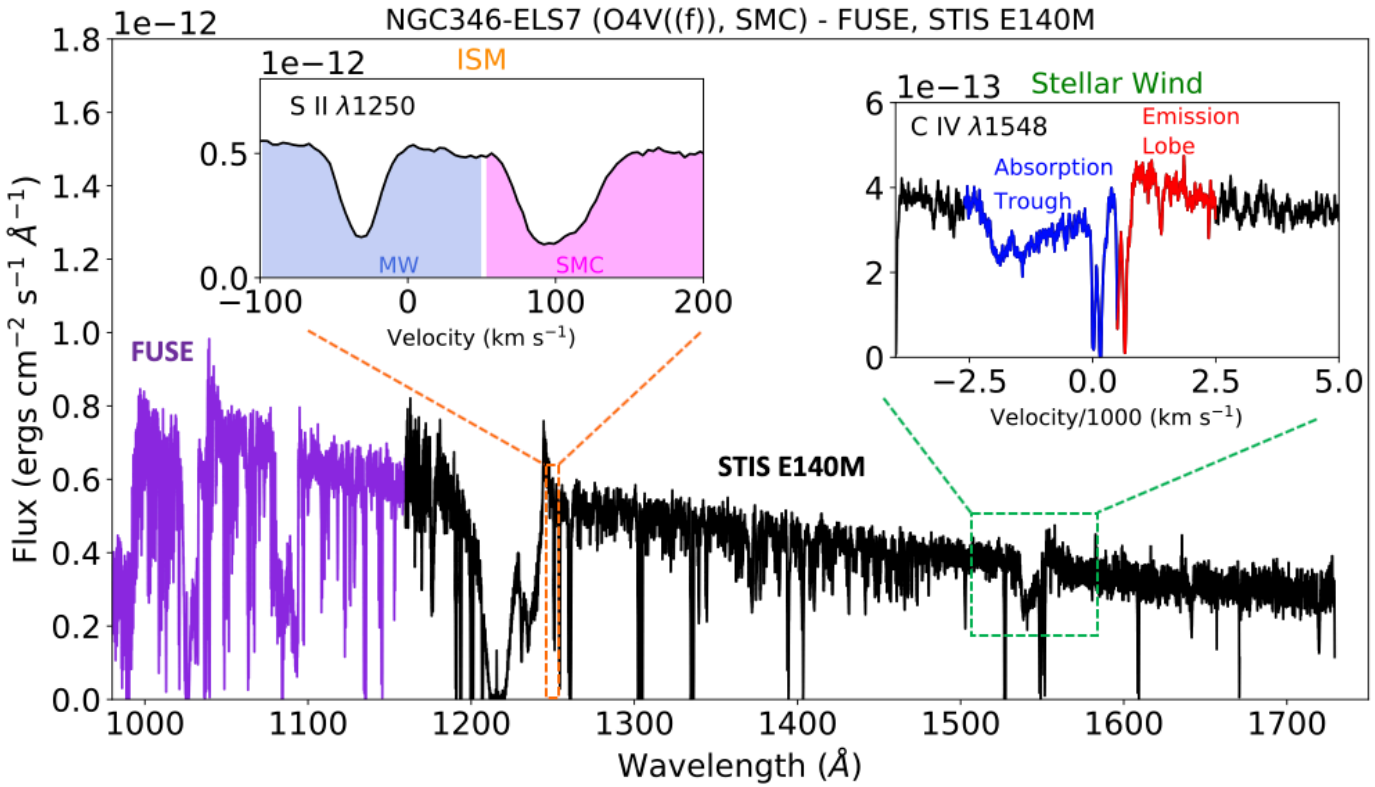




~500 orbits to obtain a spectroscopic library and time monitoring of T Tauri stars (younger than 10 Myr, mass < 1 M_o)

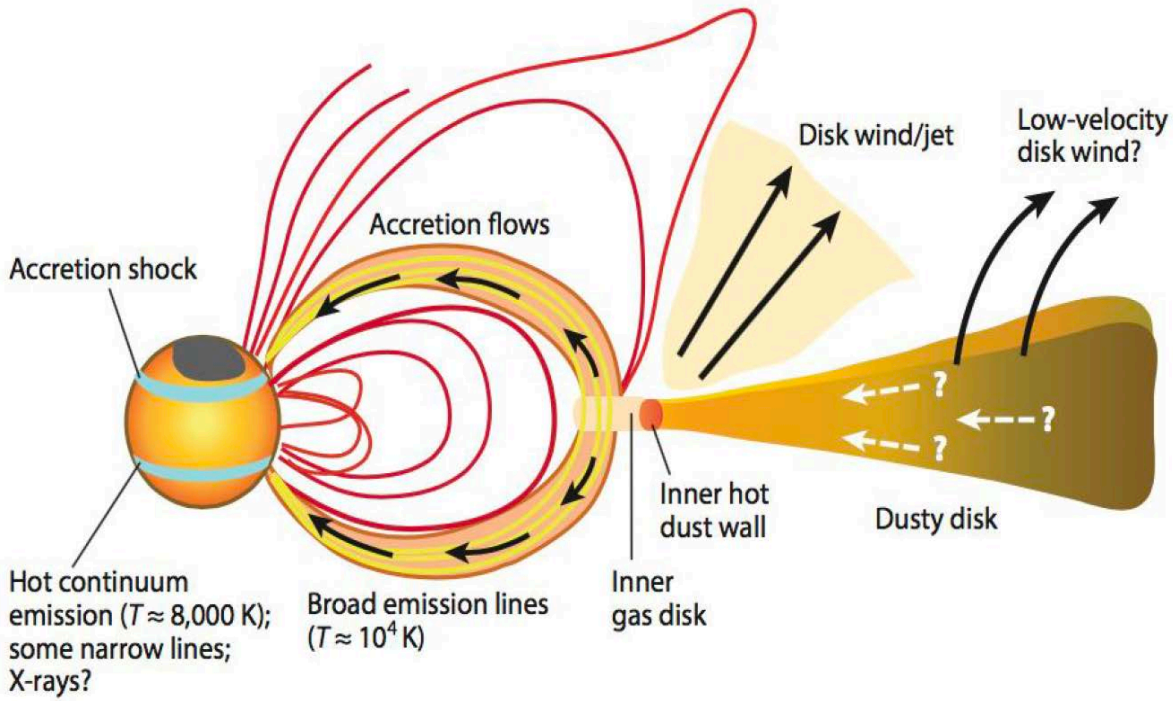
A Spectroscopic Survey of High Mass Stars

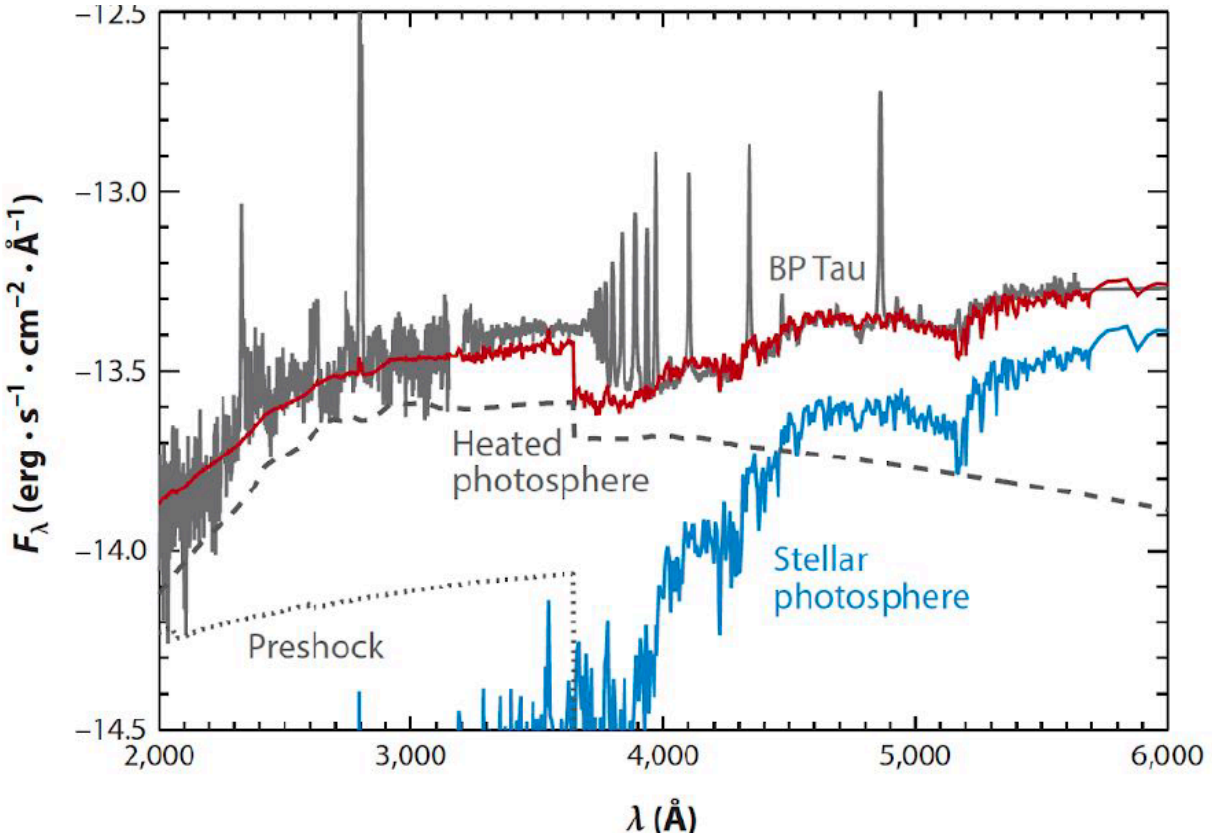




- ✓ Massive Stars
  - o Stellar winds and abundances
  - o Ionizing radiation
  - o Spectral templates for population synthesis
- ✓ ISM
  - o Chemical abundances
  - o Depletions on dust
- ✓ CGM
  - o Kinematics
  - o Metallicity
  - o Spatial distribution

A Spectroscopic Survey of Young Low Mass Stars





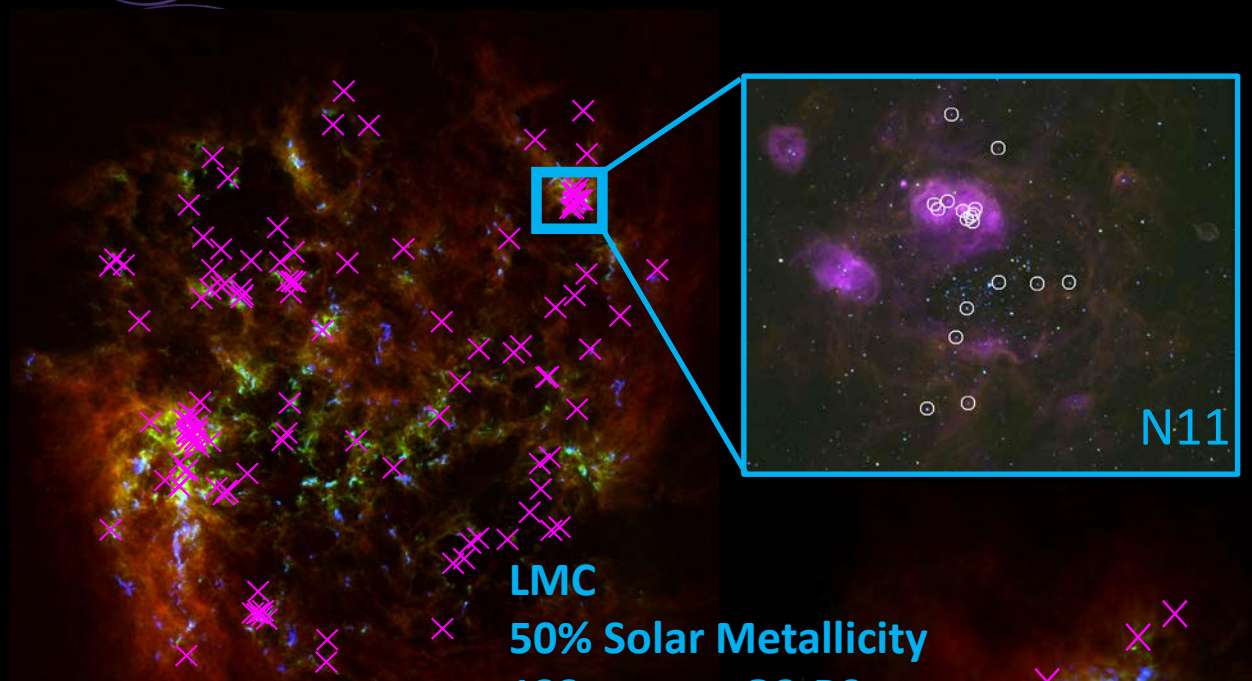
- ✓ T Tauri Stars
  - o Accretion physics
  - o UV radiation and impact on disk evolution and planet composition and atmospheric escape
  - o Time monitoring component for 4 targets (100 orbits) to study accretion variability

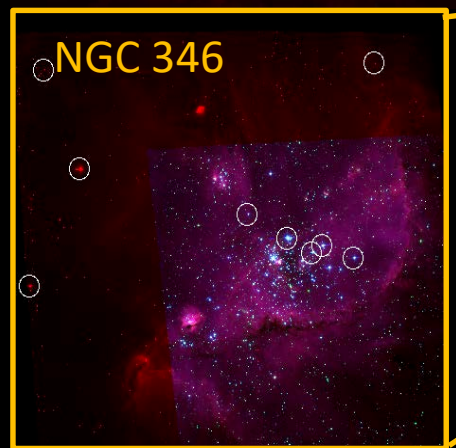
Overview of ULLYSES target sample

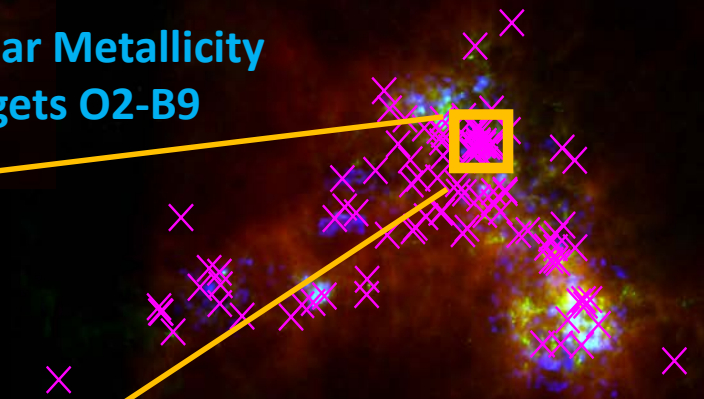
- Targets were released to the community in early 2020
- ~330 (including 90 archival) targets will be included in the ULLYSES database
- Numerous coordinated and follow-up observations planned by community (see C. Espaillat's talk):
  - Massive stars: VLT X-Shooter
  - T Tauri stars:
    - ✓ VLT X-Shooter
    - ✓ XMM-Newton and ISS/NICER
    - ✓ Magnetic mapping with spectro-polarimetry (CFHT)
    - ✓ IR spectroscopy (IRTF)
    - ✓ Photometric monitoring with LCOGT and other ground-based observatories
    - ✓ TESS

Region	# ULLYSES targets	# AR targets	# ULLYSES orbits
LMC	98	34	225
SMC	65	41	220
Sextans-A	3	6	~37
NGC 3109	3	0	~15
Lupus	27	4	142
Cha I	16	3	97
ε Cha	2	1	22
η Cha	5	3	20
Orion	10	0	45
σ Ori	3	0	13
CrA	2	0	10
TW Hydrae	1	0	2
Monitoring T Tauri Stars	4	0	100
TOTAL	241	92	948

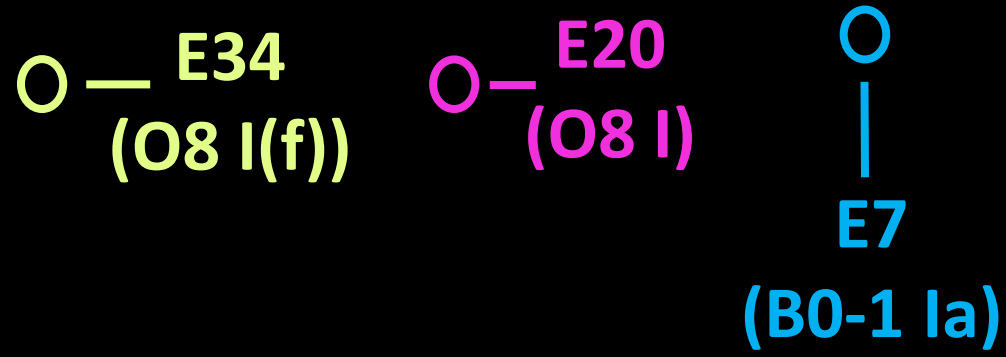
Overview of massive stars



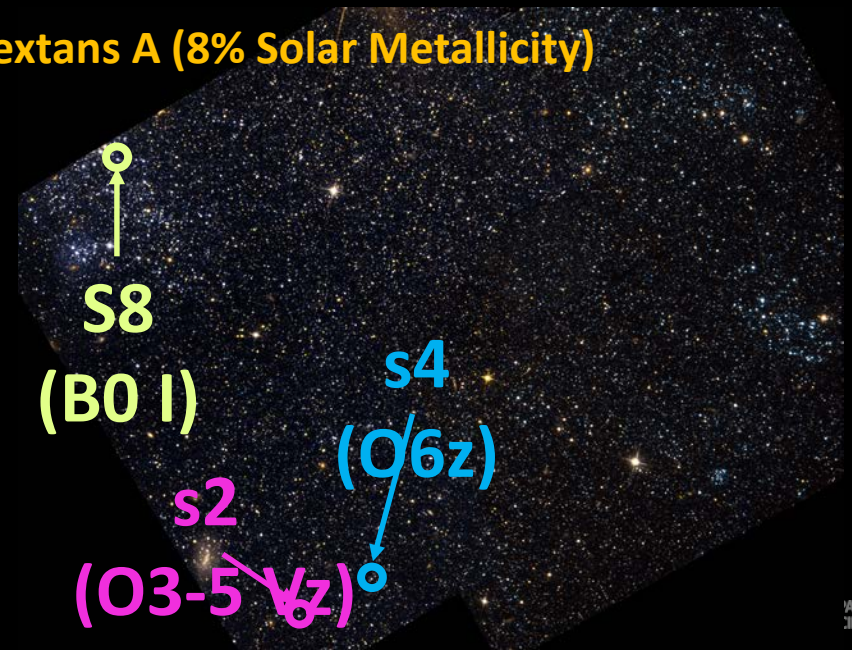




NGC3109 (15% Solar Metallicity)

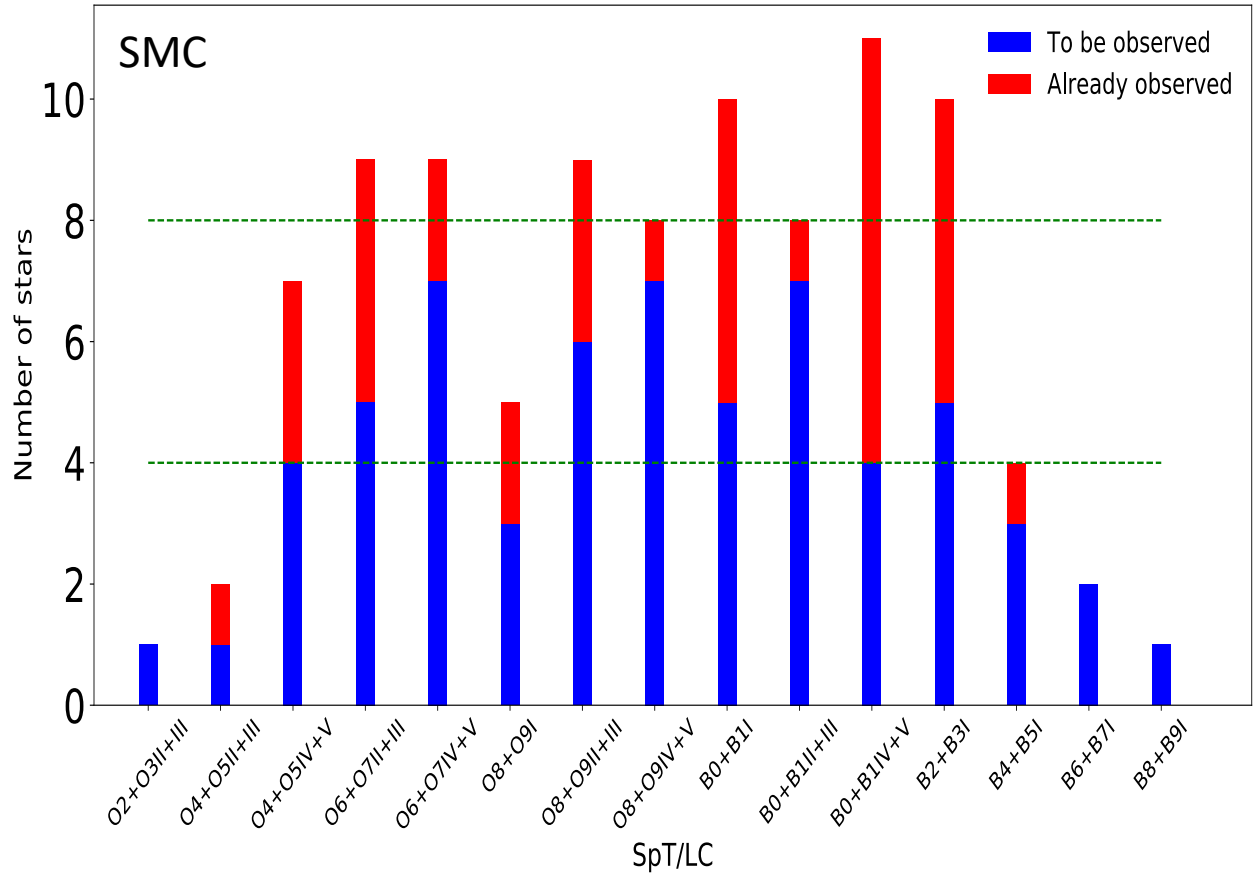


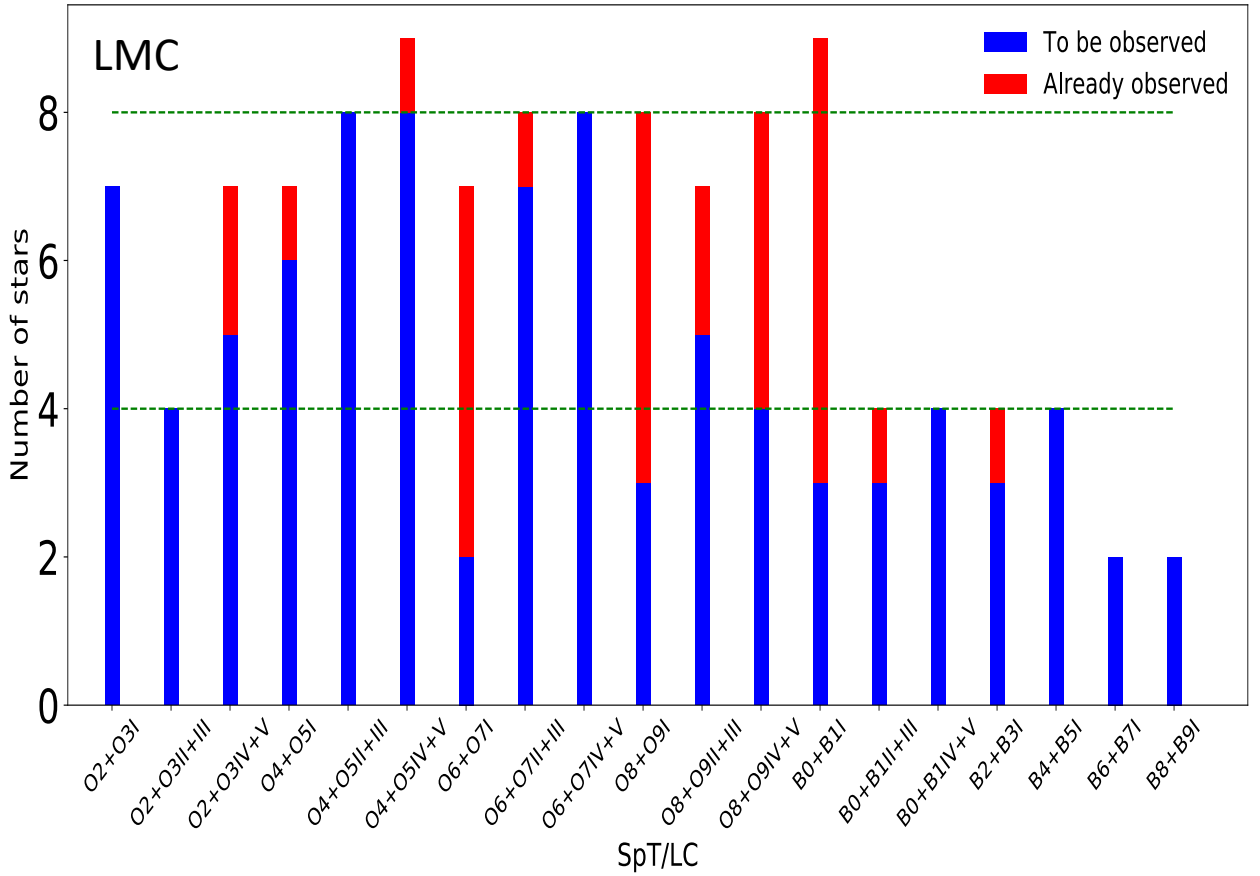
Sextans A (8% Solar Metallicity)



Target Selection – Sampling of SpT/LC

- 4-5 O I-V per SpT/LC bin
- 2-4 B0-B1 I-V stars per bin
- 2-4 B2-B4 I per bin
- 1-2 B5-9 I per bin

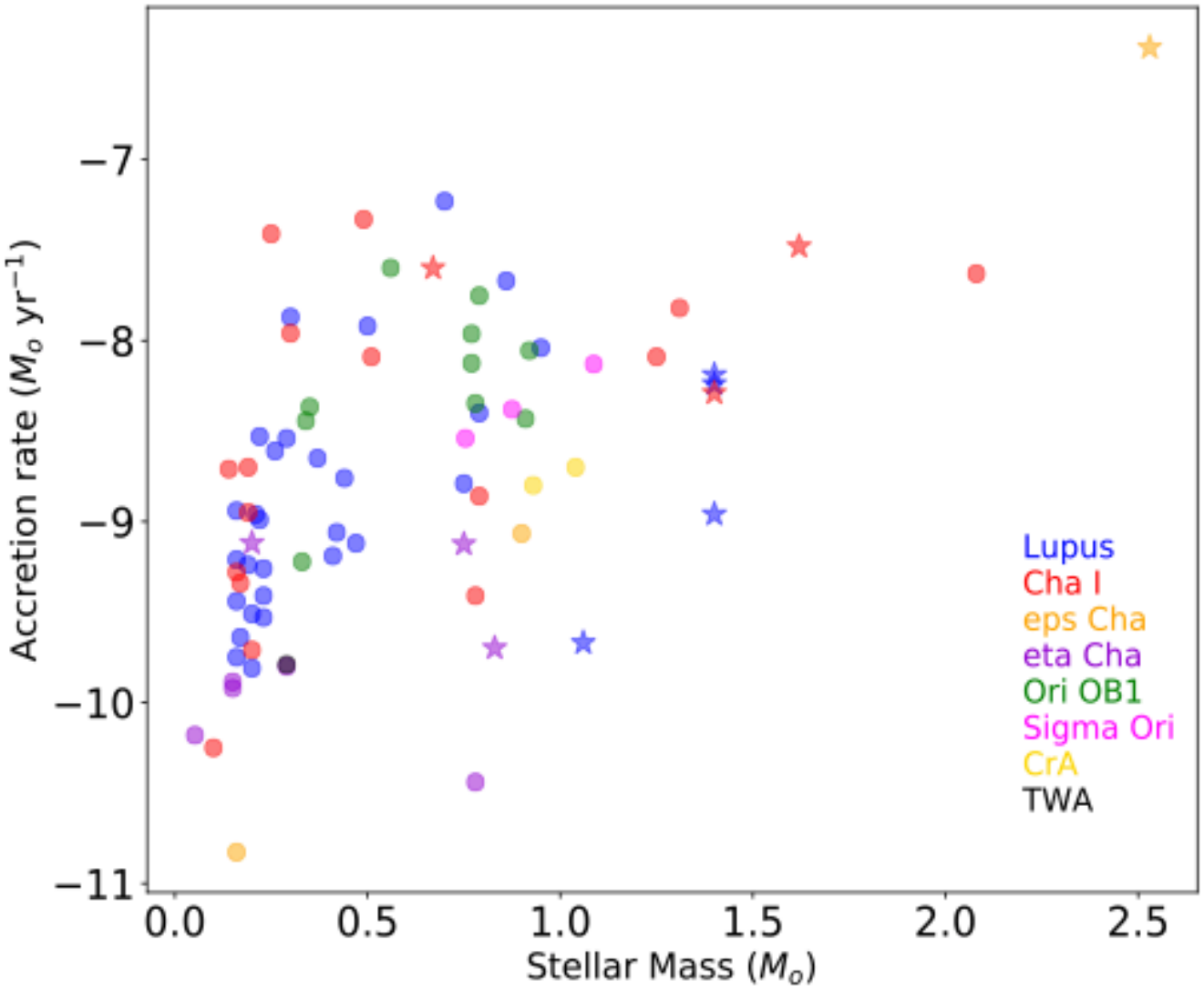




Target Selection – T Tauri Star Sample

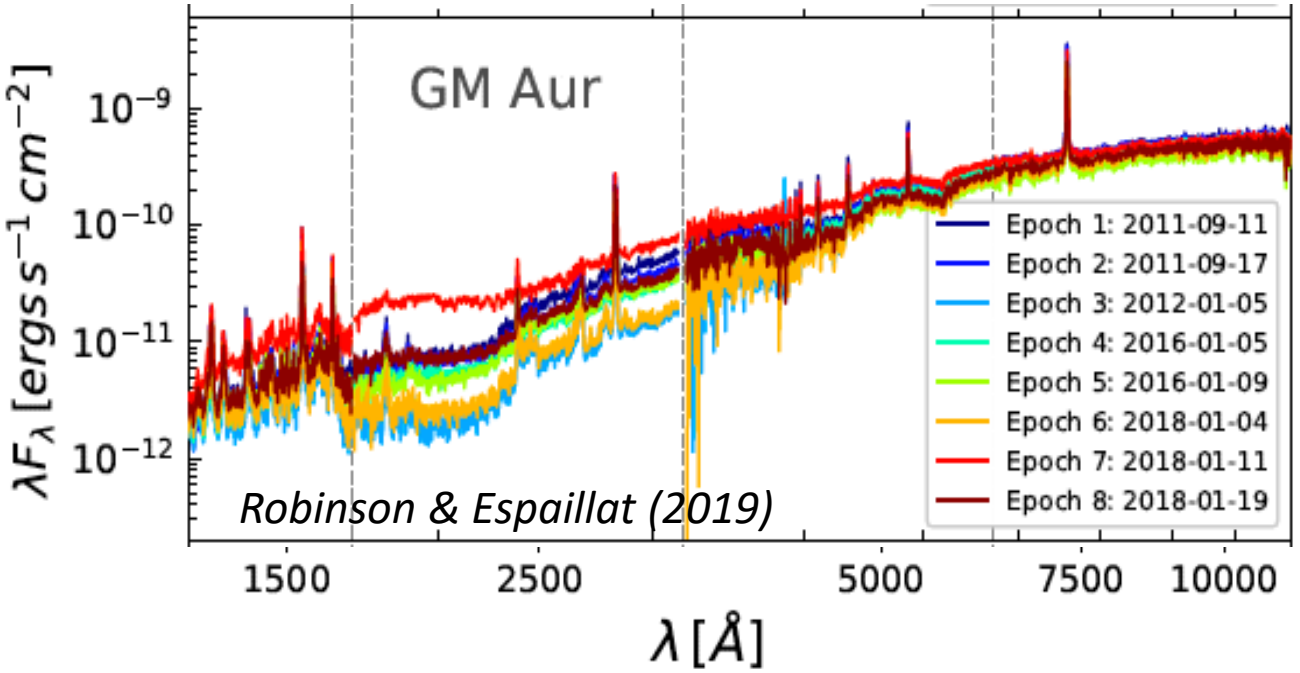
- 67 targets in 8 star-forming regions
- 355 orbits
- Complete sampling of mass and accretion rate

SF region	# of targets
Lupus	27
Cha I	16
ε Cha	2
η Cha	5
Orion	10
σ Ori	3
CrA	2
TWA	1



Target Selection – T Tauri Stars Monitored Over Time

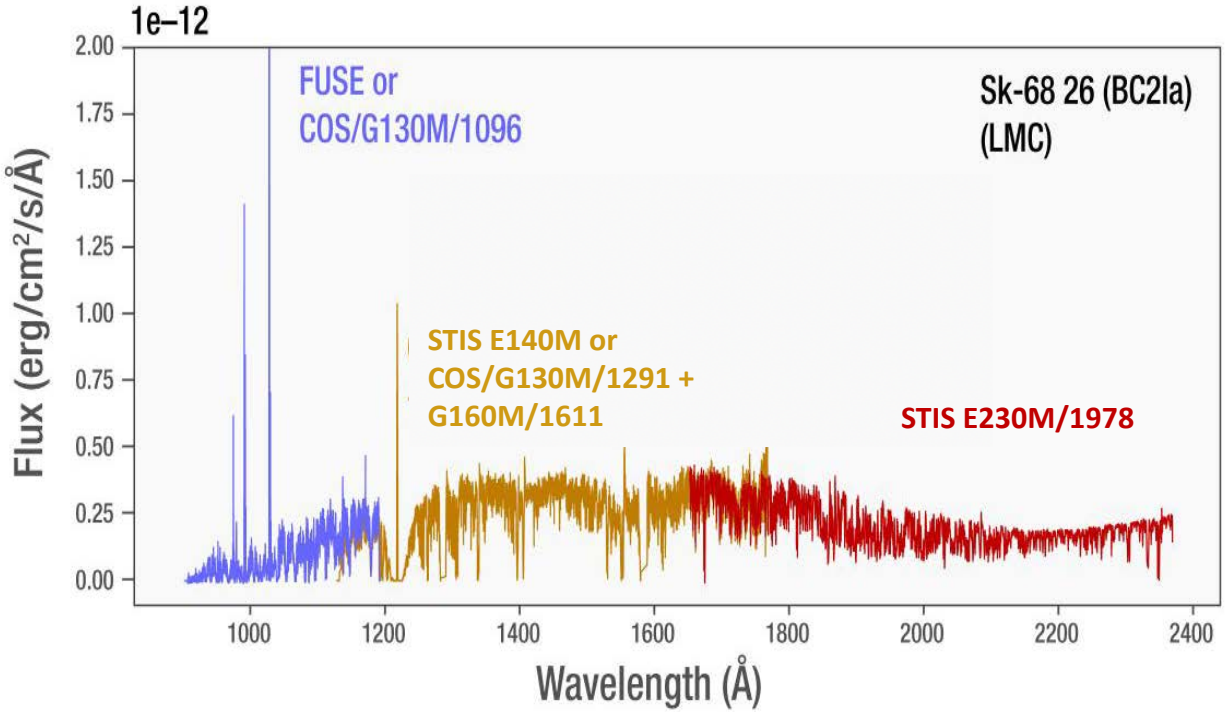
- 4 T Tauri stars selected from time monitoring with HST
- Two epochs spaced out by 9-12 months, with 4 observations per rotation period for 3 periods during each epoch
- UV coverage 1400-3000 Å



Target	RA(J2000)	DEC(J2000)	Mass (M_{sun})	Radius (R_{sun})	Mass Accretion Rate (M_{sun}/yr)	Rotational Period (days)	A_V (mag)
BP Tau	04h19m15.86s	+29d06m27.2s	0.70	2.00	2.9E-08	8.19	0.51
GM Aur	04h55m10.98s	+30d21m59.1s	1.36	1.75	5.0e-9	6.10	0.60
TW Hya	11h01m51.95s	-34d42m17.7s	0.70	1.00	2.0E-09	3.57	0.00
RU Lup	15h56m42.31s	-37d49m15.47s	0.70	1.64	5.0E-08	3.71	0.07

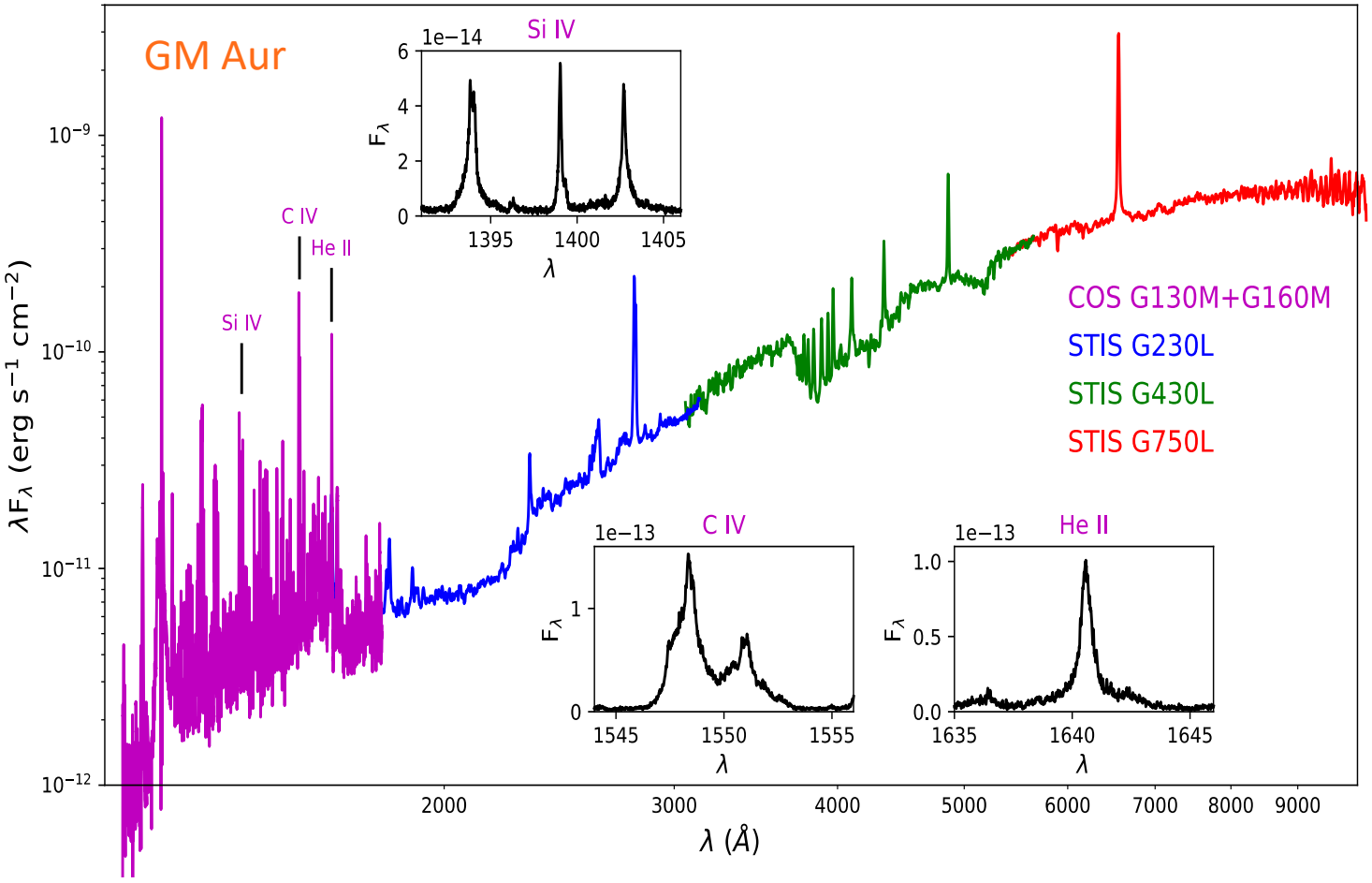
Observing Strategy – LMC/SMC Massive stars

- **FUV coverage from 1140 Å to 1800 Å** with COS/G130M/1291 + COS/G160M/1611, or STIS/E140M for brighter stars
- Coverage below 1150 Å with archival **FUSE** data or COS/G130M/1096 for O stars if cost is reasonable
- STIS/E230M/1978 for 09-B9 I
- STIS/E230M/2707 or COS/G185M/1953+1986 for B5-9 I



	I	II-III	IV - V
O2-08	• COS/G130M/1291 + G160M/1611 or STIS/E140M • FUSE or COS/G130M/1096	• COS/G130M/1291 + G160M/1611 or STIS/E140M • FUSE or COS/G130M/1096	• COS/G130M/1291 + G160M/1611 or STIS/E140M • FUSE or COS/G130M/1096
O9	• COS/G130M/1291 + G160M/1611 or STIS/E140M • FUSE or COS/G130M/1096 • STIS/E230M/1978	• COS/G130M/1291 + G160M/1611 or E140M • FUSE or COS/G130M/1096	• COS/G130M/1291 + G160M/1611 or STIS/E140M • FUSE or COS/G130M/1096
B0-B1.5	• COS/G130M/1291 + G160M/1611 or E140M • STIS/E230M/1978	• COS/G130M/1291 + G160M/1611 or STIS/E140M	• COS/G130M/1291 + G160M/1611 or STIS/E140M
B2-B4	• COS/G130M/1291 + G160M/1611 or STIS/E140M • STIS/E230M/1978 or COS/G185M/1921+1953+1986	X	X
B5-B9	• COS/G130M/1291 + G160M/1611 or STIS/E140M • STIS/E230M/1978 or COS/G185M/1921+1953+1986 • STIS/E230M/2707	X	X

Observing Strategy – T Tauri Stars



- Survey stars:
  - Medium-resolution UV coverage 1140-1780 Å with COS/G130M/1291 + COS/G160M/1611
  - NUV coverage at low resolution with STIS/G230L
  - Optical-NIR with STIS G430L and G750L
- Monitoring stars:
  - COS G160M/1611
  - COS G230L/2635 + 2950

Observing Status

- Massive stars:
  - LMC: 13 targets observed and 10 more will be observed by 10/31/2020
  - SMC: 25 targets observed
  - 65 fully archival targets in LMC+SMC combined
  - Remainder of LMC/SMC and low metallicity targets will observed over Cycles 28 and 29
  - HST/WFC3 pre-imaging scheduled for October-November 2020 (NGC 3109) and March 2021 (Sextans A) – F225W, F275W, F336W, F475W, F814W – Spectroscopy with COS/G140L/800 will follow
- T Tauri stars:
  - 13 Orion T Tauri stars to be observed in November-December 2020 in coordination with TESS
  - A fraction of T Tauri stars will be observed in coordination with TESS in March-June 2021 (the remainder will be observed at later dates)
  - 4 monitoring T Tauri stars will be observed in spring-summer 2021 (epoch 1) and 2022 (epoch 2)
- Observing status and scheduled can be checked at https://ullyses.stsci.edu

Data Products – Overview

- **High-Level Science Products (HLSPs)**:
  - ✓ STIS and COS calibrated pipeline products and acquisition images
  - ✓ Co-added spectra for each grating setting
  - ✓ Spliced spectra (multiple grating settings, multiple instruments, e.g., FUSE + COS/STIS)
- **Database**
  - ✓ Repository of meta data that describes
    - **New ULLYSES Data:** coordinates, instrumental configurations, exposure times, etc.
    - **Archival/Ancillary Data:** archival HST and FUSE spectra; links to spectra from other facilities (e.g., VLT, LCOGT, XMM etc)
    - **Targets:** fundamental stellar parameters (with references)
  - ✓ Used to construct web interfaces and enable queries
    - Search form, filtering to refine queries, visual selection from interactive plots, API
- **Quick-look tools:** interactive plots of spectra with interactive S/N calculations
- **Jupyter notebooks:** demonstrate data handling and analysis techniques
- **Website** (https://ullyses.stsci.edu)

Data Products – Overview

- DR1 planned for November 5, 2020:
  - LMC/SMC targets observed up to October 15, 2020 (including archival targets)
  - Tabular search for targets
  - Link to tar-ball for download
  - No database yet
- DR2 planned for spring 2021
  - Database with UI (form + table)
  - All LMC/SMC targets observed to that point
  - NGC 3109 Images and photometry
  - HST spectra and LCOGT photometry for Orion T Tauri stars
- Quarterly data releases

Back-up slides

ULLYSES Core Implementation Team (CIT)


Julia Roman-Duval
(CIT Lead)


Jo Taylor
(DP Lead)


Travis Fischer
(DP Deputy Lead)

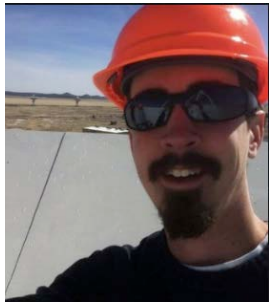

Charles Proffitt
(Observing Lead)


TalaWanda Monroe
(Observing Deputy Lead)


Will Fischer
(T Tauri Star Lead Expert)


Alex Fullerton
(Massive Star Lead Expert)


Alessandra Aloisi
(Pre-imaging)


Chris Britt
(Public Outreach)


Ivo Busko
(DP/software)


Svea Hernandez
(DP)


Robert Jedrzejewski
(DP, software)


Sean Lockwood
(ETC, Obs)


Elaine Mae Frazer
(DP)


Rachel Plesha
(Targets, Obs, DP)


Adric Riedel
(Targets, DP)


Allyssa Riley
(DP)


David Sahnow
(Observing)


Richard Shaw
(DP)


Ravi Sankrit
(Observing)


Linda Smith
(Targets)


Tony Sohn
(Observing)


Debopam Som
(Observing)


Leonardo Ubeda
(Website)


Dan Welty
(Targets, Obs, DP)

Science Advisory Committee (SAC)

- SAC composition (Massive stars / T Tauri stars)
  - Jean-Claude Bouret (Laboratoire d'Astrophysique de Marseille)
  - Catherine Espaillat (Boston University)
  - Chris Evans (UK Astronomy Technology Centre)
  - Kevin France (University of Colorado Boulder)
  - Miriam García (Centro de Astrobiología (CSIC-INTA))
  - Chris Johns-Krull (Rice University)
  - Derck Massa (Space Science Institute)
  - Joan Najita (National Optical Astronomy Observatory)

Timeline and Milestones up to now

- June 2019: CIT and SAC assembled
- September 2019: Request for input from the community regarding target selection
- November 2019: T Tauri stars to be monitored over time and low-metallicity massive stars selected for observations released to the community
- **February 18, 2020: Release of full target samples**
- **June 2020: First observations of LMC/SMC stars**
- July 2020: Launch of website (ullyses.stsci.edu)
- **August 2020: Beginning of LCOGT monitoring observations of Orion T Tauri stars**

Timeline and Milestones

- November 5, 2020: First data release (LMC/SMC only)
- November-December 2020: HST observations of Orion T Tauri stars (with TESS, LCOGT)
- Spring 2021: DR2 (includes functional database and user interface – this is a working goal)
- Spring-summer 2021: Epoch 1 of monitoring stars, and more survey CTTS
- Quarterly data releases through the end of the program