International Astronomical Union Symposium 395

“Stellar populations in the Milky Way and beyond”

Paraty, Brazil — 17-22 November 2024

Dreaming the next generation Galactic plane survey with the Roman Space Telescope

Dante Minniti

Universidad Andrés Bello

Centro de Astrofísica y Tecnologías Afines

Specola Vaticana

Thank you Beatriz!

IAU 395 Paraty 2024

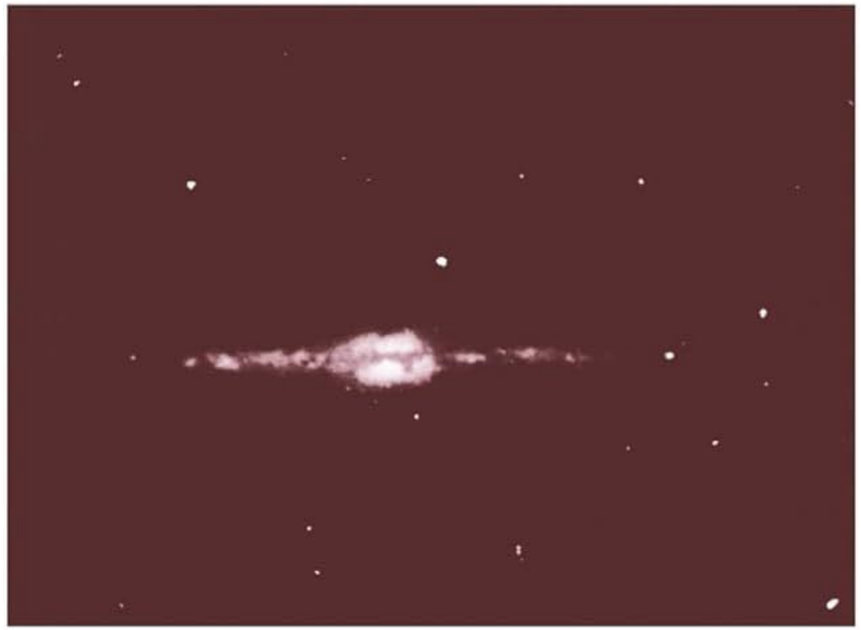
INTERNATIONAL ASTRONOMICAL UNION

SYMPOSIUM No. 149

IAUS 149 Angra dos Reis

THE STELLAR POPULATIONS OF GALAXIES

Edited by B. BARBUY and A. RENZINI



INTERNATIONAL ASTRONOMICAL UNION

KLUWER ACADEMIC PUBLISHERS

ESO ASTROPHYSICS SYMPOSIA

D. Minnitti · H.-W. Rix
Editors

European Southern Observatory

SPIRAL GALAXIES IN THE NEAR-IR

Garching 1995

Springer

Extragalactic Star Clusters
IAU Symposium Series, Vol. 207, 2002
Doug Geisler, Eva K. Grebel, and Dante Minniti, eds.

IAUS 207 Pucón 2002

Memorable Quotes

What you call old open clusters are young clusters!

When you reach the plate limit you always have a Horizontal Branch.

Powerpoint was invented so you could blink CMDs.

There are NO globular clusters at the peak of the luminosity function!

We don't know how many globular clusters there are in the Milky Way.

Since globular clusters don't bounce, NGC 3201 (with a retrograde orbit at 250 km/s) had to have come in that way (and been captured).

If you are missing 10-20% (of the Galactic GCs), then you are only doing 80-90% science.

It's worth getting up at 8:30 on Wednesday morning (for my talk).

The Milky Way is doing the best it can to form massive clusters with the material that it has.

You just have to take my word for it.

The evidence for them being in circular orbits is circular.

You don't see the age gap in those diagrams because those ages are wrong.

The question is whether or not we are going to believe this.

The PSF (of the NICMOS data on 30 Doradus) looks like a Tarantula.

I'll tell you some numbers but you mustn't write them down.

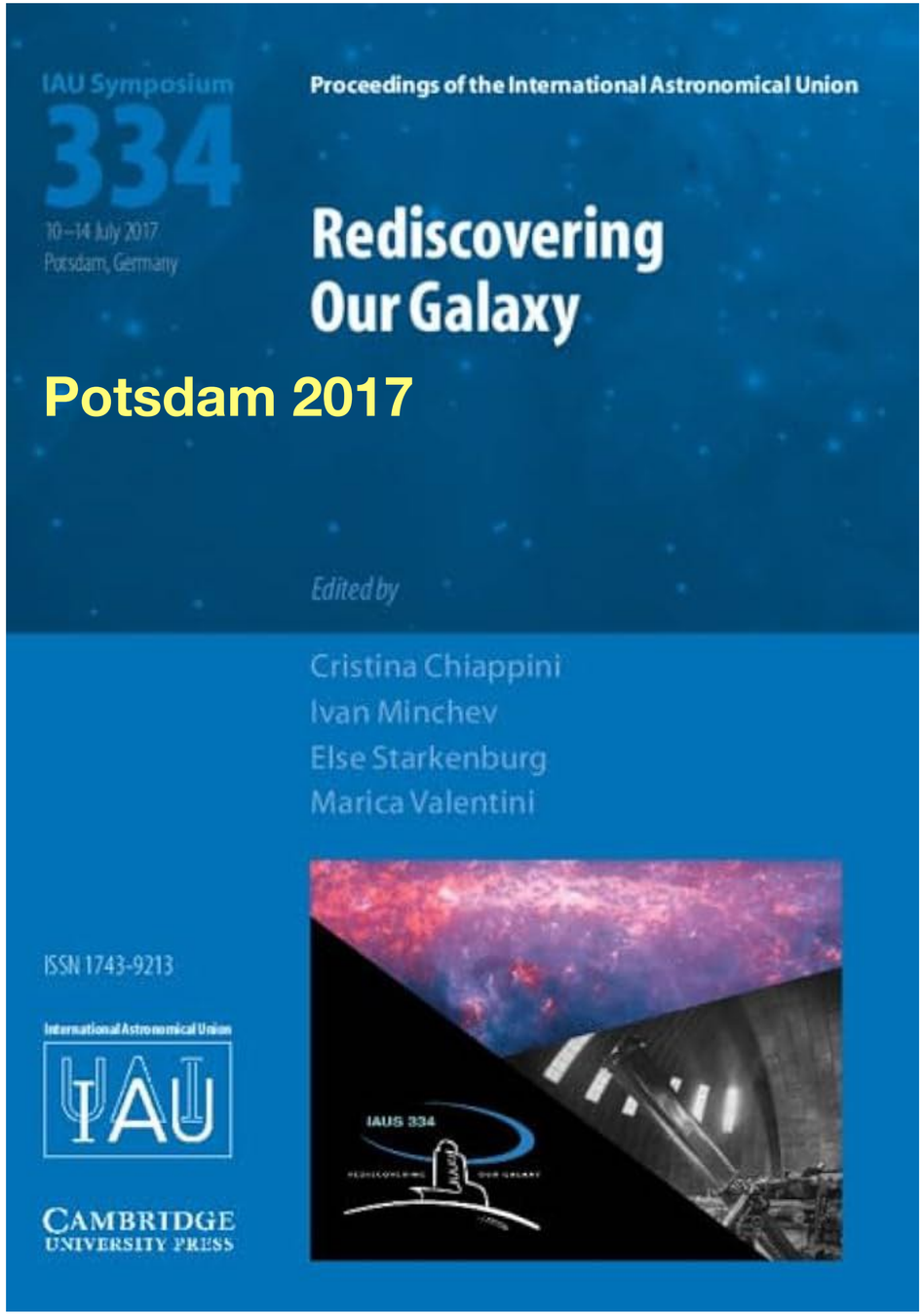
I have 2 posters so please don't scream at me if I go over the 2 minute limit.

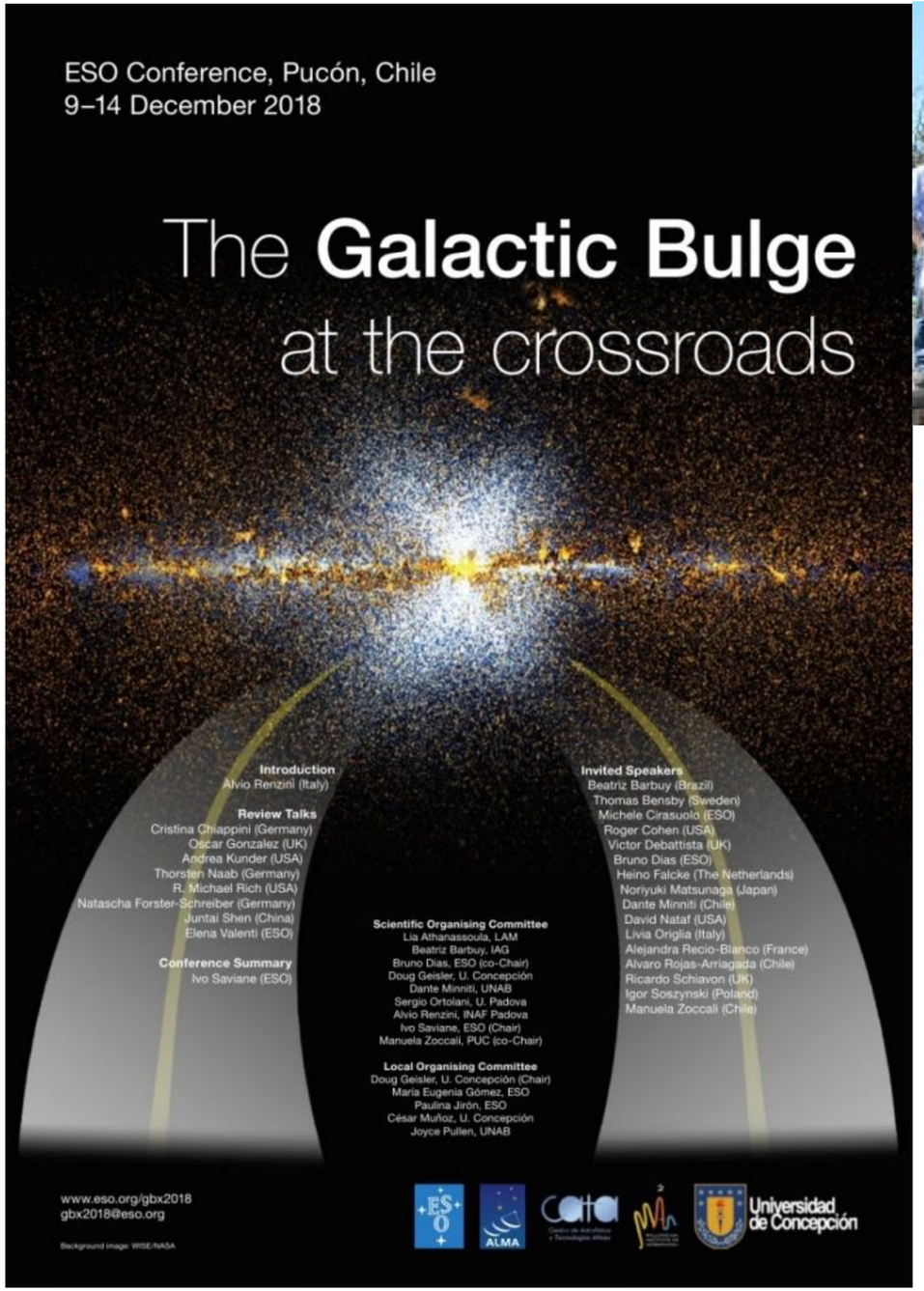
Is the evidence for dark matter in dwarf galaxies evaporating with the stars?

This is a mild-mannered but slightly eccentric galaxy. But beneath its bland exterior this galaxy is a raging psycopath.

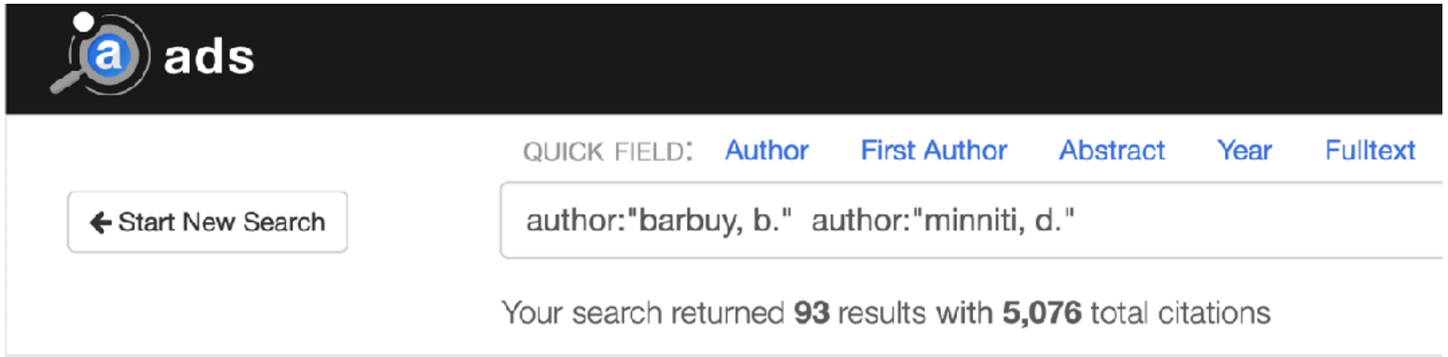
I'm an optimistic person and I don't like bad news.

If we saw a lot of big H II regions in an Sa galaxy we would call it an Sc.





then the pandemic hit…

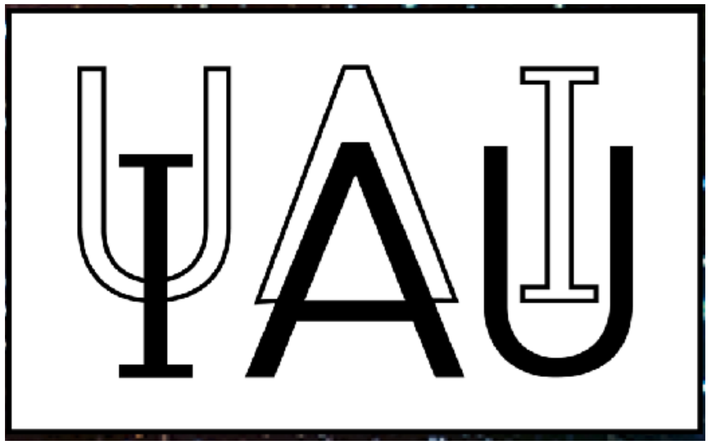


IAU 395 Paraty 2024

Thank you very much
Jorge, Cristina, et al. !!!

The International Astronomical Union

https://iau.org/



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Specola Vaticana

- **~few 10^12**: total MW mass
- **~few 10^11**: total number of stars in the MW

In spite of much recent progress, we have only measured ~1% of the MW stars so far!

How far can we see in the presence of extinction?

The extinction horizon

Using different distance indicators to trace the extinction horizon along the Galactic plane.

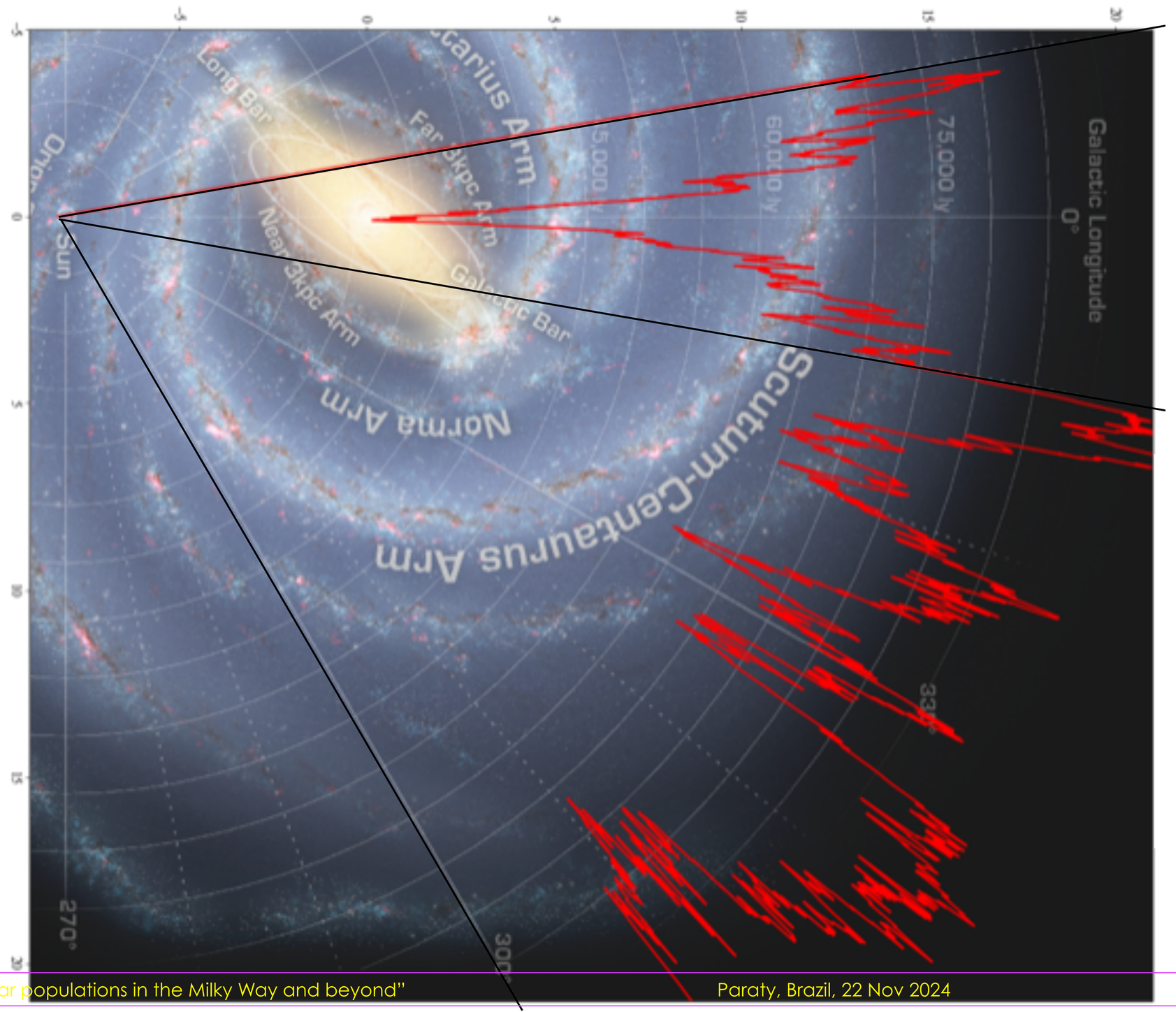
- **Field stars**: (the Gaia revolution): very numerous, excellent distances locally
- **Open clusters**: poor: acceptable distances, rare, moderately bright
- **Globular clusters**: poor: good distances, rare, bright
- **RR Lyrae**: poor: excellent distance indicators, numerous, blue
- **Cepheids**: poor: excellent distance indicators, luminous, rare, blue
- **Miras/LPVs**: reasonable: good distance indicators, numerous, bright, red
- **RC giants**: good: very numerous, bright, red, poor distance indicators
- **Masers**: poor: excellent distances, bright in radio, rare

We got the Galactic plane covered with the RC giants.

Some dips may be due to the spiral arm tangents.

Note void due to crowding towards the Galactic centre. That is a very special place…

Red Clump Giants as Distance Indicators

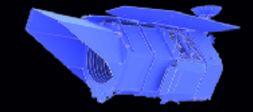


Galactic Plane Extinction Horizon using RC Giants from the VVV Survey

Image credit: Jason Sanders (2022)

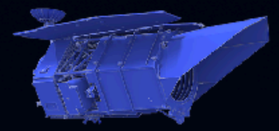
ROMAN SPACE TELESCOPE

https://roman.gsfc.nasa.gov/



Right

Front



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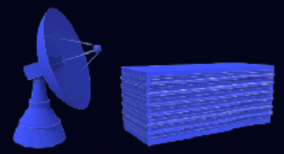
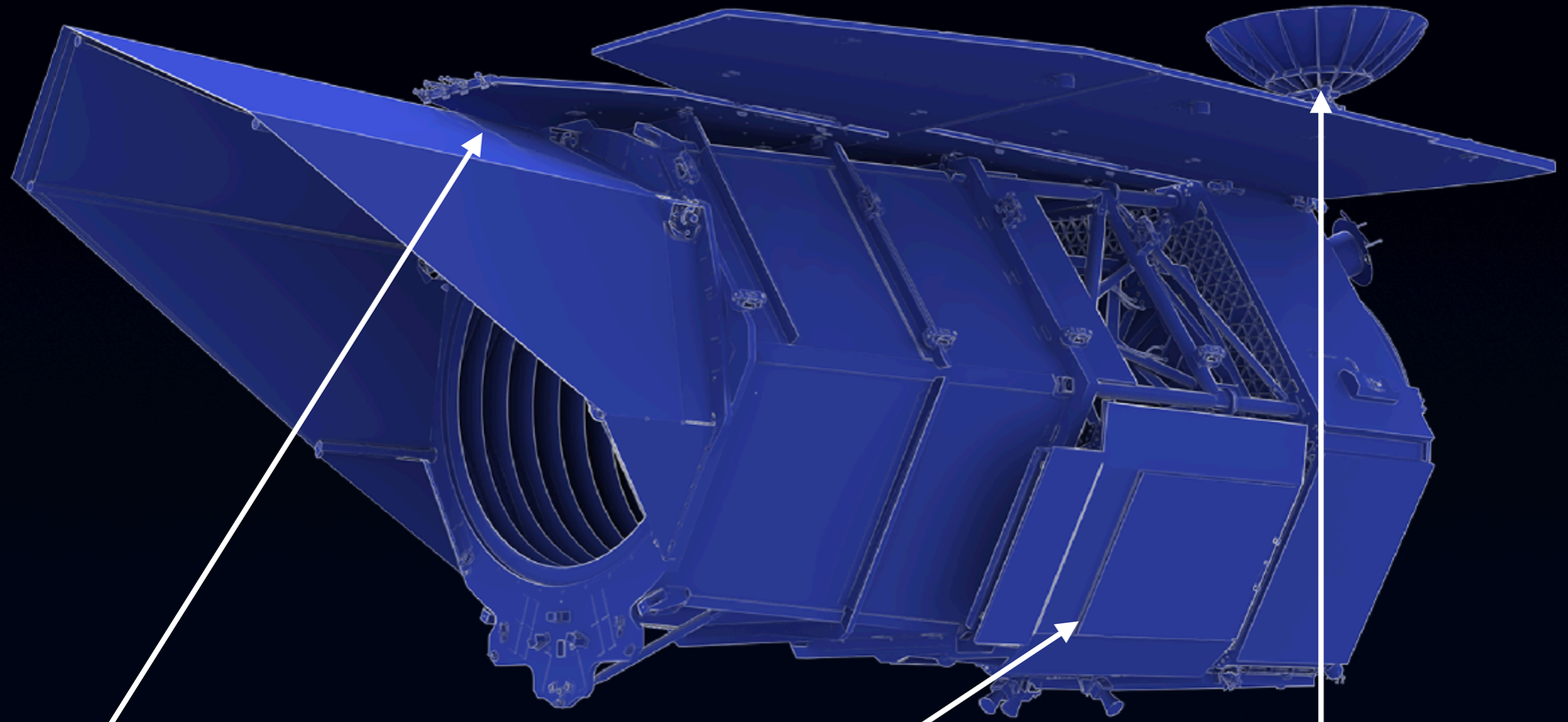
Back



Ground



Wide Field Instrument • Communications •
Solar Array Sun Shield • Observatory Support Systems •
Telescope

NASA/Roman Large Imaging Surveys

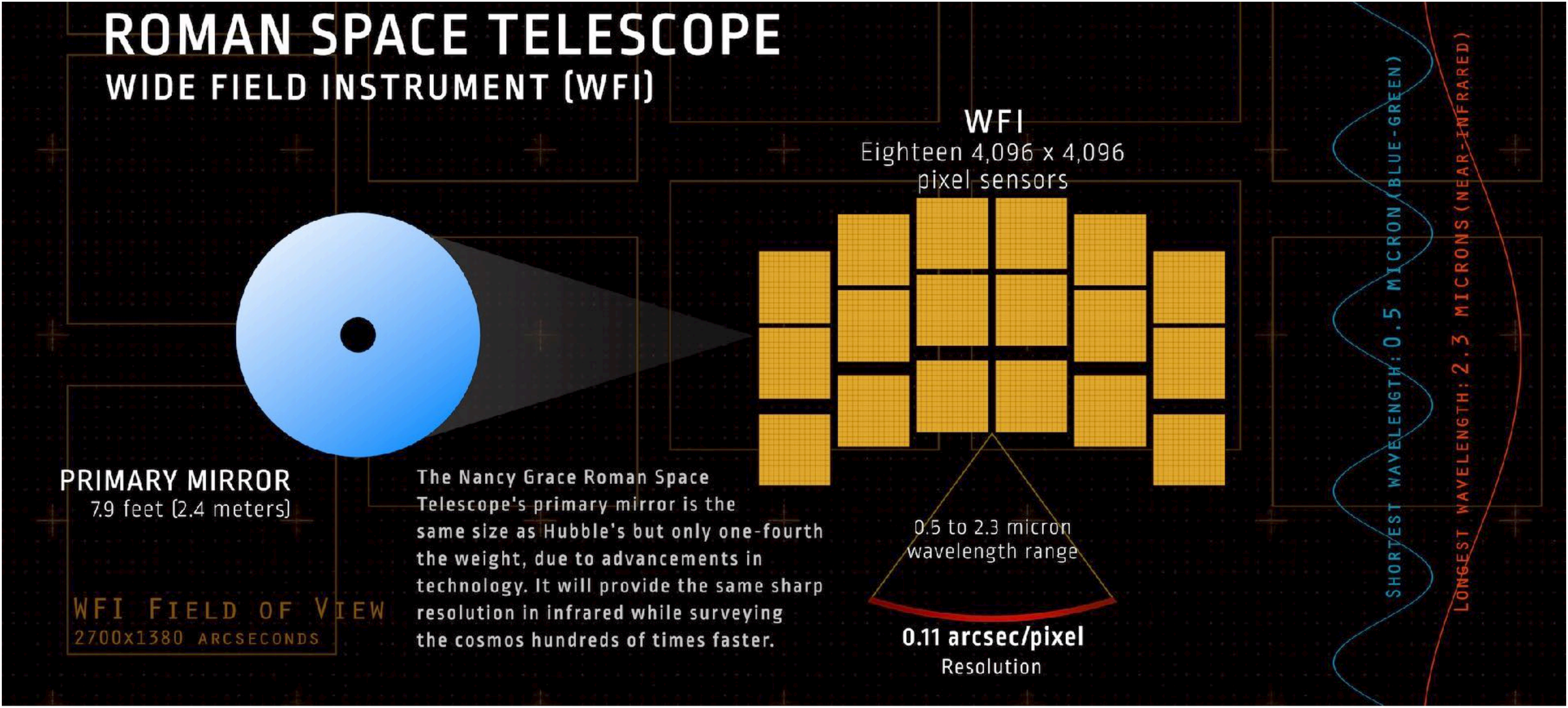
Great science

Large teams

Big Problems

The Roman WFI would be a very efficient survey machine in space

Expected performance ~8 sqdeg/hr (contiguous, in one filter)



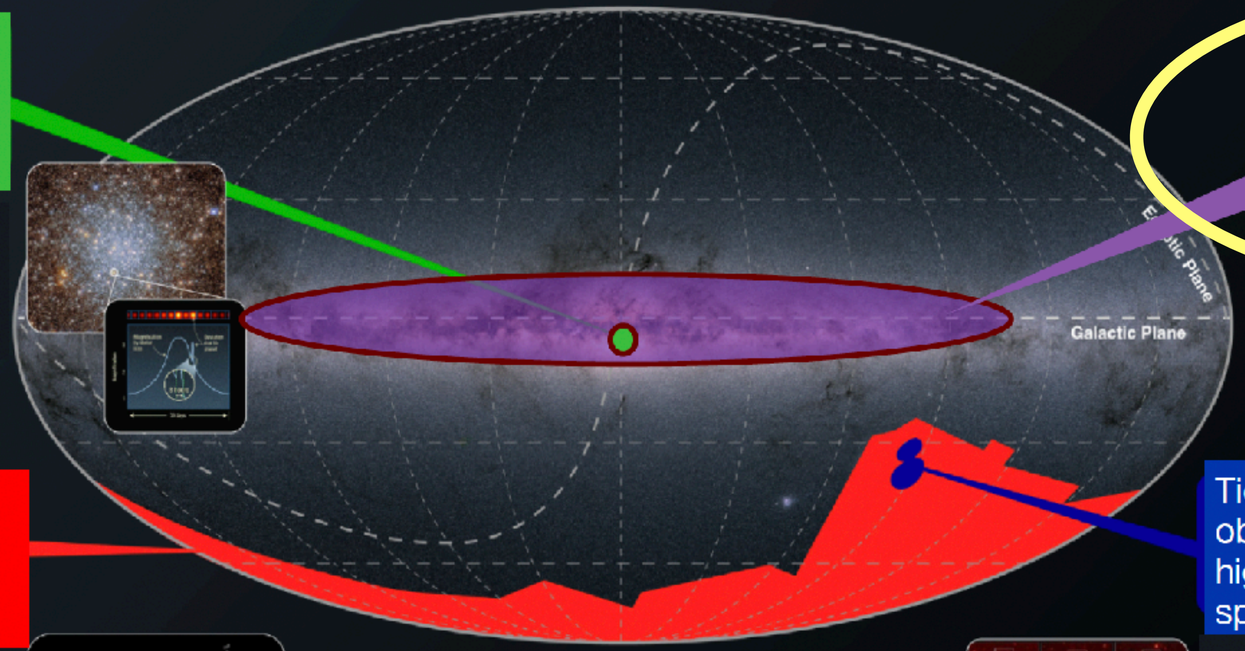
45’

Roman Core Community Surveys (CCS)

Example implementation:

~< 15 min cadence observations over few deg² towards Galactic bulge

Galactic Bulge Time Domain Survey

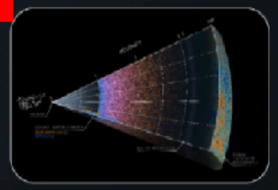


Galactic Plane Survey

~1000 deg² in three bands (~JHK)

Wide area (thousands of deg²) survey including multiband imaging and slitless spectroscopy

High Latitude Wide Area Survey



Tiered, multiband time domain observations of ~10s of deg² at high latitudes with slitless spectroscopy

High Latitude Time Domain Survey

ROMAN SPACE TELESCOPE

Core Surveys

Roman Space Telescope's larger view and fast survey speeds will unveil the evolving universe in ways that have never been possible before.

Slide credit: Roman ST (2024)

A Roman Galactic Plane Survey

Scientific drivers

Total Area

Configuration

Filters

Cadence for variability

Epochs for PMs

Compromises

A Roman Galactic Plane Survey

Galactic Plane Survey Definition Committee

Rachael Beaton *STScI*	Thomas Kupfer *Universität Hamburg*
Bob Benjamin* *U Wisconsin-Whitewater*	Dante Minniti *Universidad Andrés Bello*
Sean Carey *Caltech/IPAC*	Roberta Paladini *Caltech/IPAC*
Kishalay De *MIT → Columbia*	Rachel Street* *Las Cumbres Observatory*
Janet Drew *University College London*	Eddie Schlafly *STScI*
Matthew De Furio *U of Texas at Austin*	Catherine Zucker *CfA | Harvard & Smithsonian*

*Co-chair

Oct 22, 2021	Request for Information on Early Definition
Jan 10, 2024	Recommendation for Galactic Plane Survey
May 20, 2024	Request for Self-Nominations, White Papers, Science Pitches
Sept 11, 2024	First meeting of Definition Committee
Oct 9, 2024	Completed Review of Contributions
	<Working groups, survey design>
Jan 2025	Preliminary Design Complete
Feb 2025	Town Hall, on-line meetings…
Apr 2025	Final Design to ROTAC (with some iterations afterward)

Slide credit: Bob Benjamin (2024)

Roman Galactic Plane Survey

What would you do?

Fast call, fast reactions

Scientific drivers

Many science pitches received

Inputs for the GPS

https://roman.gsfc.nasa.gov/science/galactic_plane_survey_definition.html

Roman Galactic Plane Survey

What do you prefer?
What is best?

Total Area

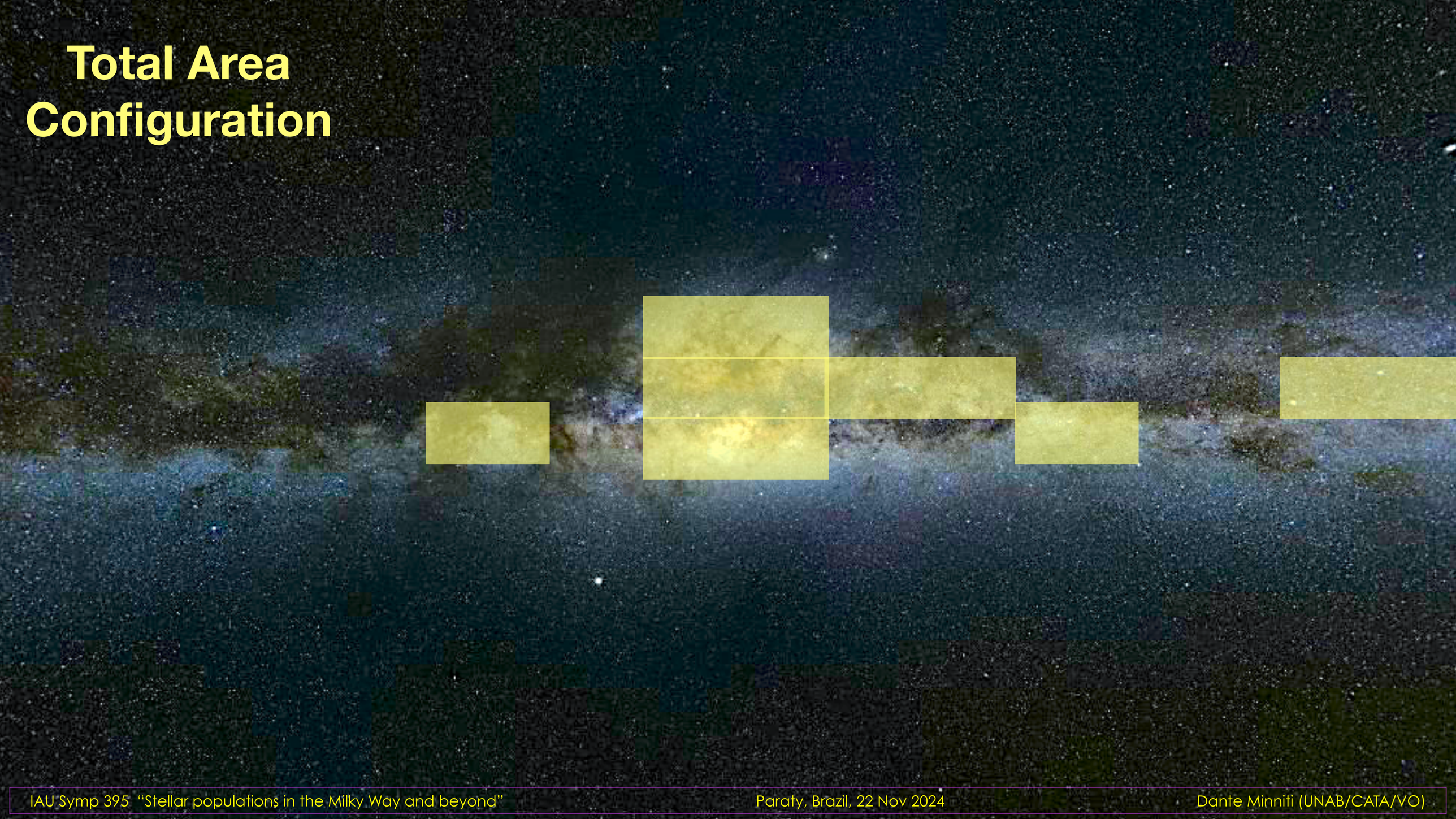
Configuration

Filters

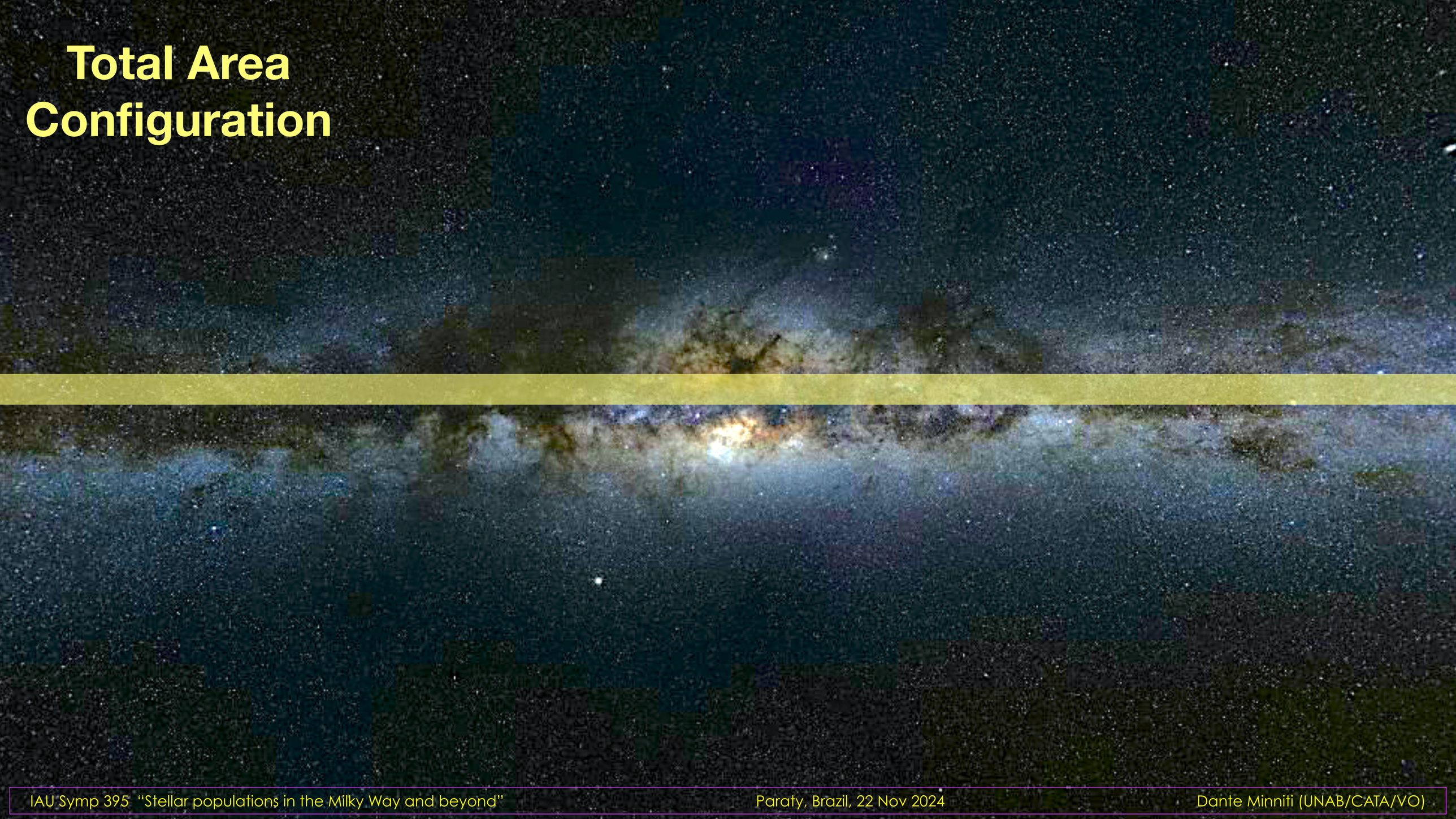
Cadence for variability

Epochs for PMs

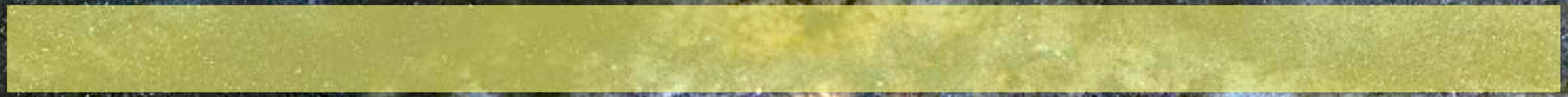
Total Area Configuration



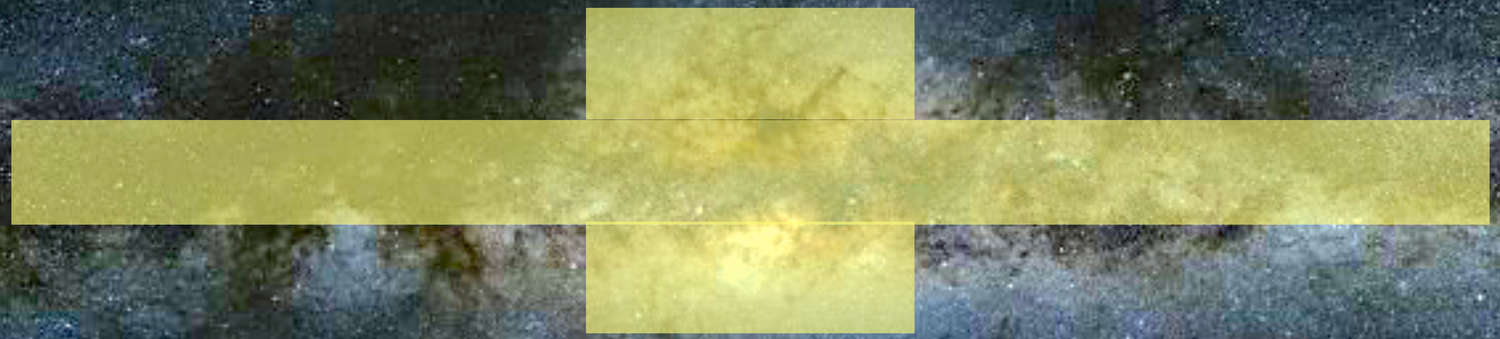
Total Area Configuration



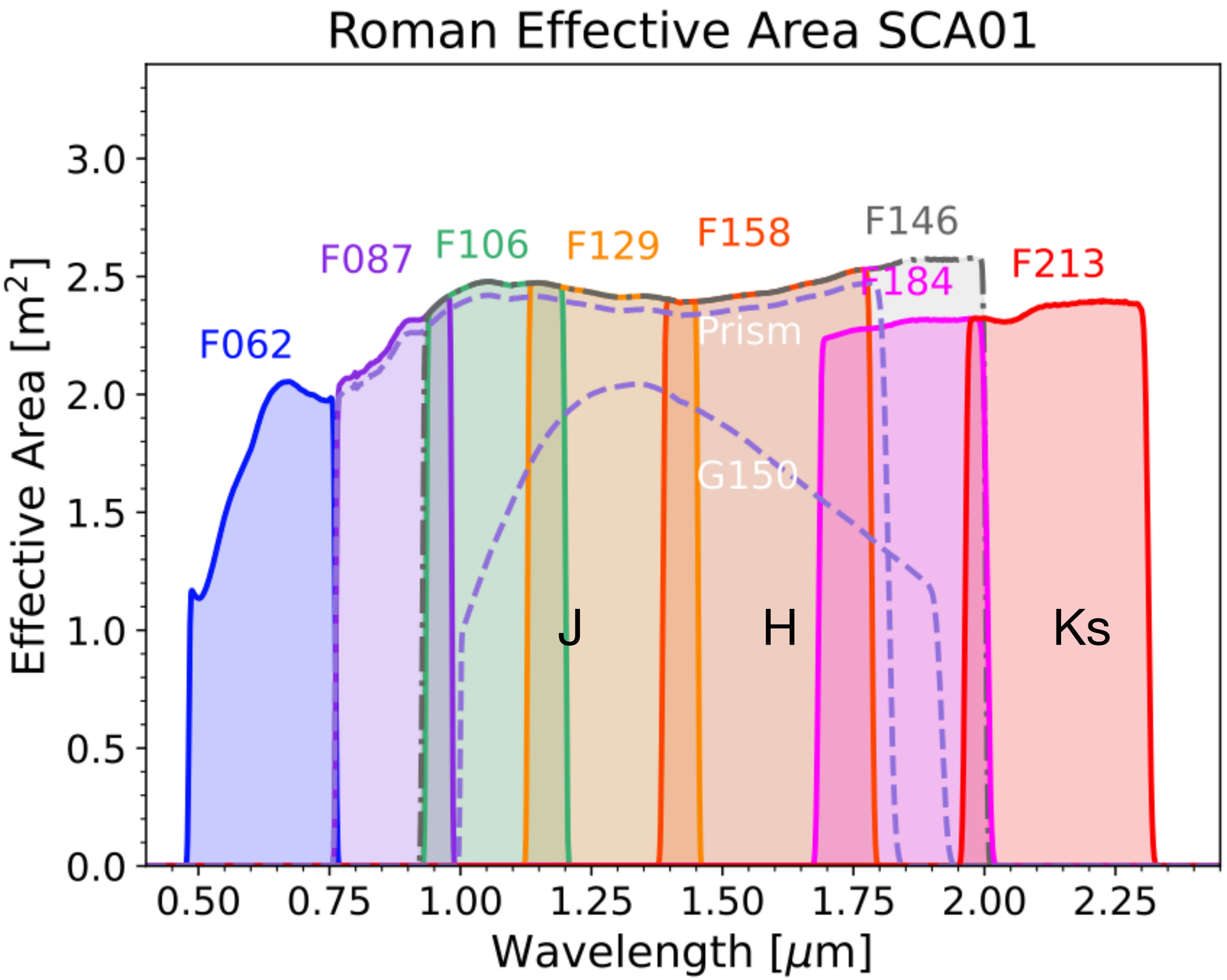
Total Area Configuration



Total Area Configuration



WFI Filters



https://roman.gsfc.nasa.gov/science/WFI_technical.html

We need a Ks-band filter for WFIRST!

THE SCIENCE ADVANTAGE OF A REDDER FILTER FOR WFIRST

JOHN STAUFFER[1], GEORGE HELOU[2], ROBERT A. BENJAMIN[3], MASSIMO MARENGO[4], J. DAVY KIRKPATRICK[2], PETER CAPAK[2], MANSI KASLIWAL[5], JAMES M. BAUER[6], DANTE MINNITI[10,11,12], JOHN BALLY[13], NICOLAS LODIEU[7], BRENDAN BOWLER[8], ZENGHUA ZHANG[9], SEAN J. CAREY[1], STEFANIE MILAM[14], BRYAN HOLLER[15]

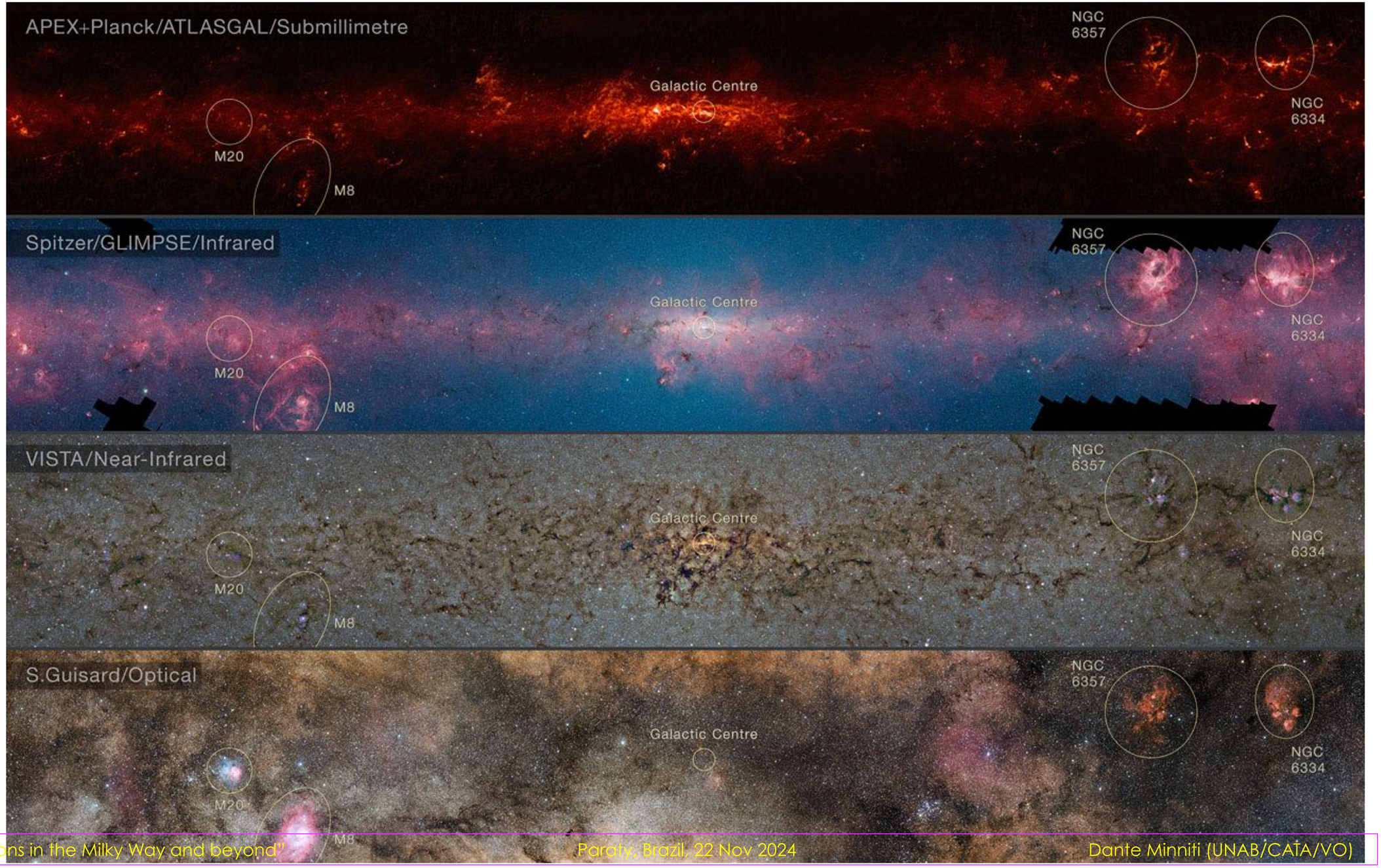
ABSTRACT

WFIRST will be capable of providing Hubble-quality imaging performance over several thousand square degrees of the sky. The wide-area, high spatial resolution survey data from WFIRST will be unsurpassed for many decades into the future. With the current baseline design, the WFIRST filter complement will extend from the bluest wavelength allowed by the optical design to a reddest filter (F184W) that has a red cutoff at 2.0 microns. In this white paper, we outline some of the science advantages for adding a K_s filter ($\lambda_c \sim 2.15$ μm) in order to extend the wavelength coverage for WFIRST as far to the red as the possible given the thermal performance of the observatory and the sensitivity of the detectors.

J. Stauffer et at. 2018 (arXiv:1806.00554)

The Galactic Plane/Bulge at different wavelengths

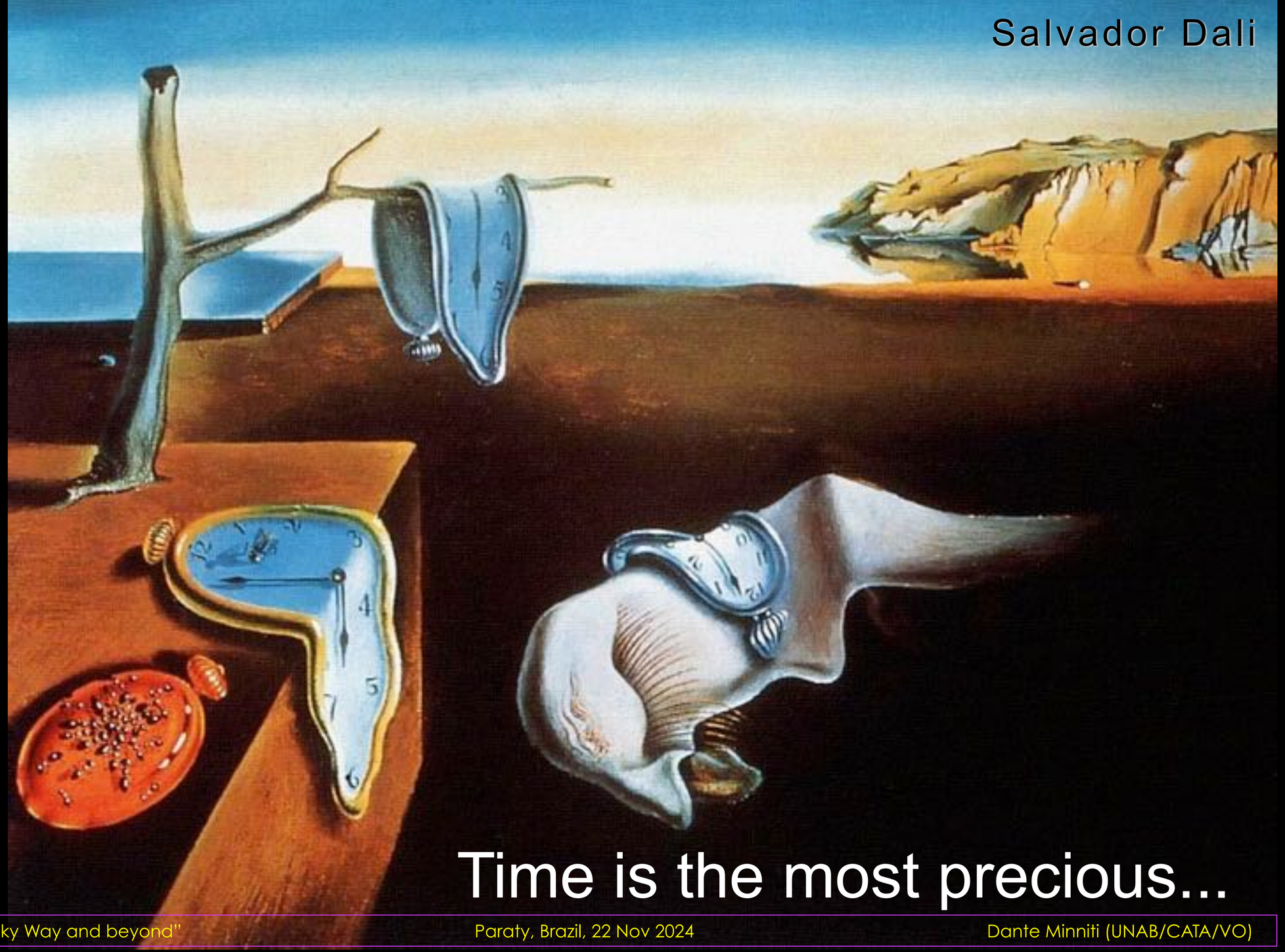
ESO PR 1606
Image credit:
Carlos De Breuck
July 2016



Compromises

“only” 700 h available for the Galactic Plane Survey

What would you sacrifice?



Example of one possible concept…

Roman Early-Definition Astrophysics Survey Opportunity

Galactic Roman Infrared Plane Survey (GRIPS)

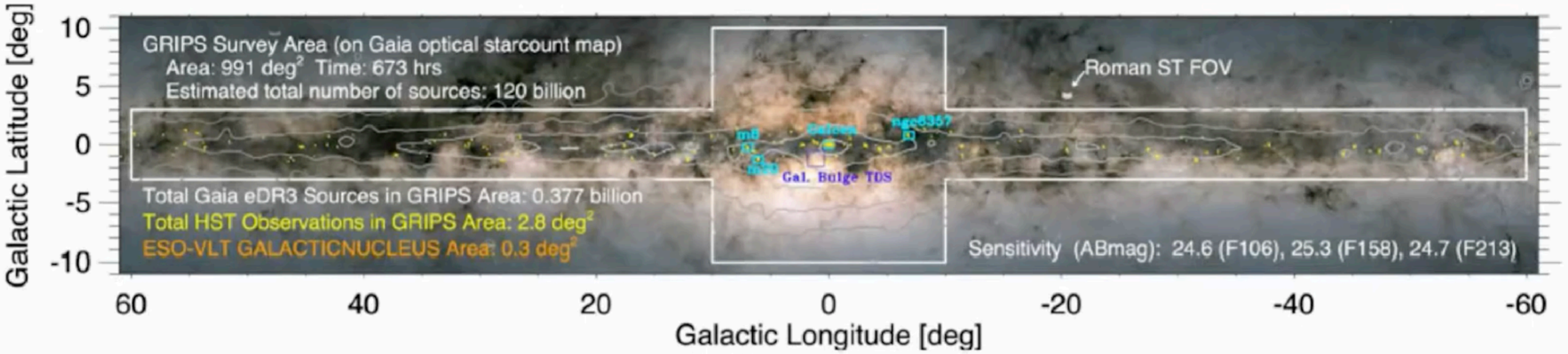
Roberta Paladini (Caltech-IPAC) on behalf of:

Catherine Zucker (STScI), Robert Benjamin (Wisconsin), David Nataf (JHU), Dante Minniti (Univ Andres Bello), Gail Zasowski (Univ. of Utah), Joshua Peek (STScI), Sean Carey (Caltech-IPAC), Lori Allen (NOIRLab), Javier Alonso-García (U. Antofagasta), João Alves (University of Vienna), Friedrich Anders (Universitat de Barcelona), E. Athanassoula (LAM), Timothy C. Beers (Notre Dame), Jonathan Bird (Vanderbilt), Joss Bland-Hawthorn (USyd), Anthony Brown (Leiden), Sven Buder (ANU), Luca Casagrande (ANU), Andrew Casey (Monash), Santi Cassisi (INAF), Marcio Catelan (PUC), Ranga-Ram Chary (Caltech-IPAC), Andre-Nicolas Chene (Gemini), David Ciardi (Caltech-IPAC), Fernando Comeron (ESO), Roger Cohen (STScI), Thomas Dame (SAO), Ronald Drimmel (INAF), Jose Fernandez-Trincado (UCN), Douglas Finkbeiner (Harvard), Douglas Geisler (Universidad de Concepción), Mario Gennaro (STScI), Alyssa Goodman (Harvard), Eva Grebel (U. Heidelberg), Gregory Green (MPIA), Gergely Hajdu (CAMK), Calen Henderson (Caltech-IPAC), Joseph Hora (CfA), Valentin D. Ivanov (ESO), Davy Kirkpatrick (Caltech-IPAC), Michael Kuhn (Caltech), Andreas Kunder (Saint Martin's University), Jessica Lu (UC Berkeley), Philip W. Lucas (Hertfordshire), Daniel Majaess (MSVU), Ted Mackereth (U. Toronto), S. Thomas Megeath (U. Toledo), Aaron Meisner (NOIRLab), Sergio Molinari (INAF), Przemek Mroz (Warsaw), Melissa Ness (Columbia), Nadine Neumayer (MPIA), Francisco Nogueras-Lara (MPIA), Alberto Noriega-Crespo (STScI), Radek Poleski (Warsaw), Hans-Walter Rix (MPIA), Luisa Rebull (Caltech-IPAC), Henrique Reggiani (Carnegie), Marina Rejkuba (ESO), Roberto K. Saito (UFSC), Ralph Schoenrich (University College London), Andrew Saydjari (Harvard), Ricardo Schiavon (Liverpool John Moore University), Eugenio Schisano (INAF), Edward Schlafly (LLNL), Kevin Schlaufman (JHU), Leigh Smith (Cambridge), Joshua Speagle (U. Toronto), Yuan Sen Ting (ANU), Dan Weisz (UC Berkeley), Rosemary Wyse (JHU), Nadia Zakamska (JHU)

Slide credit: Roberta Paladini (2021)

Galactic Roman Infrared Plane Survey (GRIPS)

Possible Observational Outline



- **Coverage:** $-60 < l < +60$ deg, $|b| < 3$ deg (inner Galaxy + bulge) - ~1000 deg² total
- **Filters:** F106, F158, F213 (roughly, JHK)
- **Integration Time:** 55 sec / filter → minimum depth: 25.5 mag, 25.3 mag, 24.7 mag (F106, F158, F213, respectively)
- **Dithers:** one primary dither (filling detectors gaps + cosmic-ray removal) and two secondary dithers (F213, accurate astrometry)

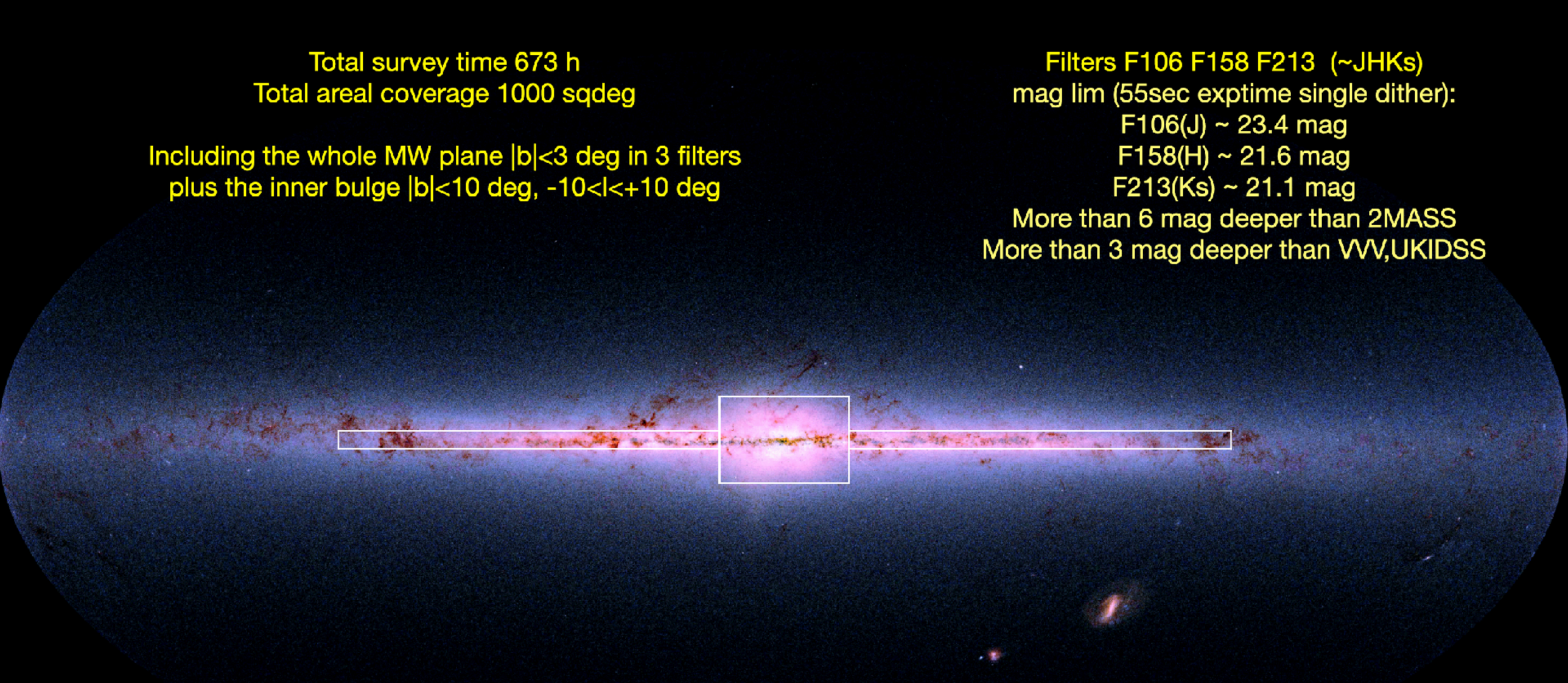
Slide credit: Roberta Paladini (2021)

Total: 673 hrs (single epoch)

Total survey time 673 h
Total areal coverage 1000 sqdeg

Including the whole MW plane |b|<3 deg in 3 filters
plus the inner bulge |b|<10 deg, -10<l<+10 deg

Filters F106 F158 F213 (~JHKs)
mag lim (55sec exptime single dither):
F106(J) ~ 23.4 mag
F158(H) ~ 21.6 mag
F213(Ks) ~ 21.1 mag
More than 6 mag deeper than 2MASS
More than 3 mag deeper than VVV,UKIDSS



Galactic Roman Infrared Plane Survey (GRIPS)

Image credit: 2MASS/IPAC
Slide credit: Dante Minniti (2021)

Some Questions

Where are most of the stars in the MW?

Where are most of the planets in the MW?

Where is most of the gas and dust in the MW?

Where are most of the heavy remnants (NS/BH)?

Where will the next Galactic SN blow up?

Where will the next Galactic GW event occur?

etc…

Summary

So far we have only measured ~1% of the Milky Way Stars. Because of extinction in the Galactic plane, we need higher resolution and deeper observations in the near-Infrared.

The Roman WFI would be a very efficient optical and near-IR survey machine in space. The Galactic Plane Survey with the Roman Space Telescope will map the Galactic plane to unprecedented depth, allowing us to measure a significant fraction of the MW stars.

How to get involved:
An overview of the Roman Galactic Plane Survey
https://roman.gsfc.nasa.gov/science/galactic_plane_survey_definition.html

To monitor the Roman Community Forum and sign up for Roman news
https://asd.gsfc.nasa.gov/roman/comm_forum

To join or monitor the Roman Science Forum or join working groups
https://outerspace.stsci.edu/site/ruf