

# Balloon-borne Imaging Telescope: 40 days and 45 nights in space



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Durham University



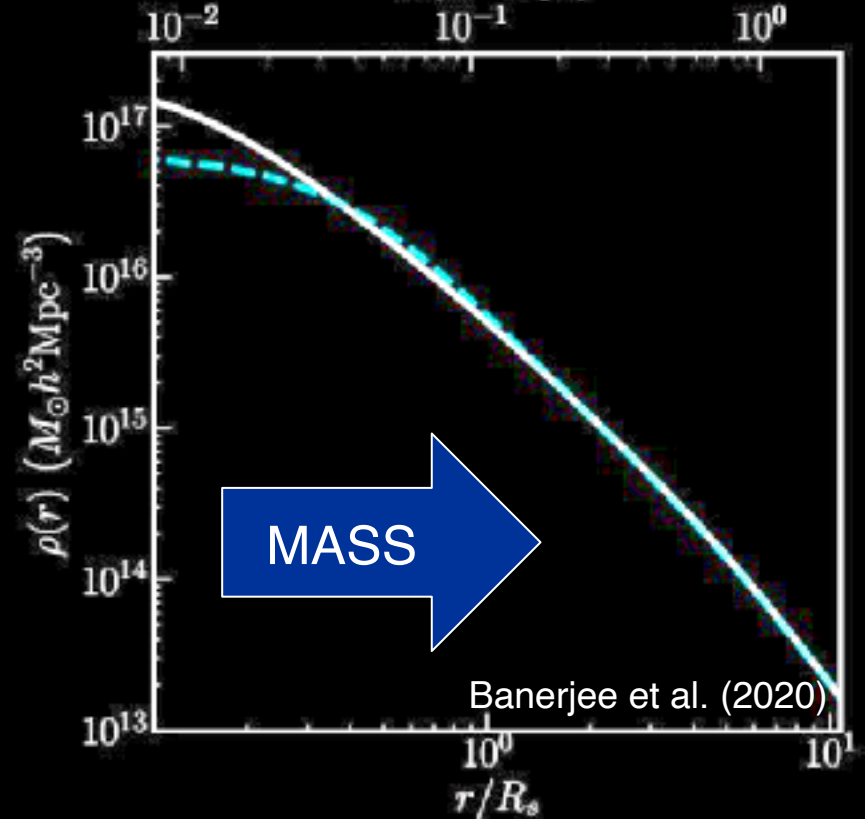
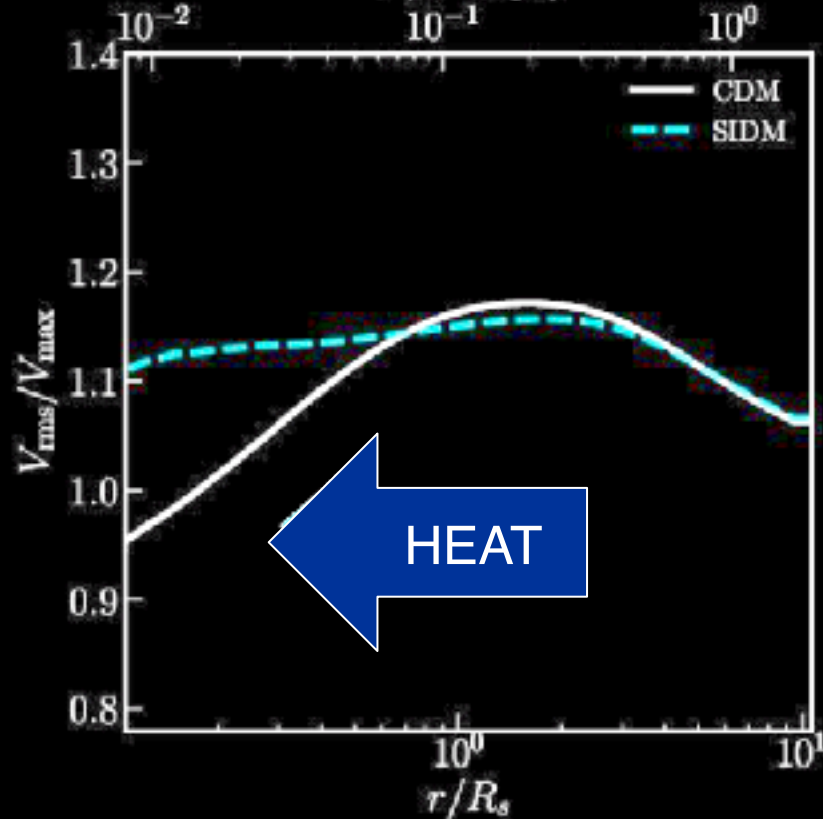
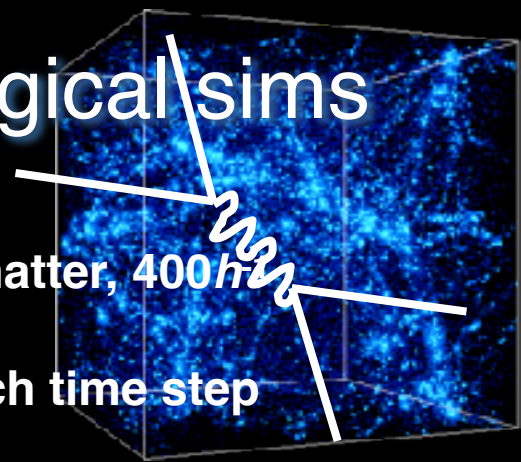
# Self-Interacting Dark Matter cosmological sims

Robertson et al. (2017,  
2020)

**Fully hydro, cosmological simulations: stars, gas, dark matter,  $400h^{-1}$  Mpc**

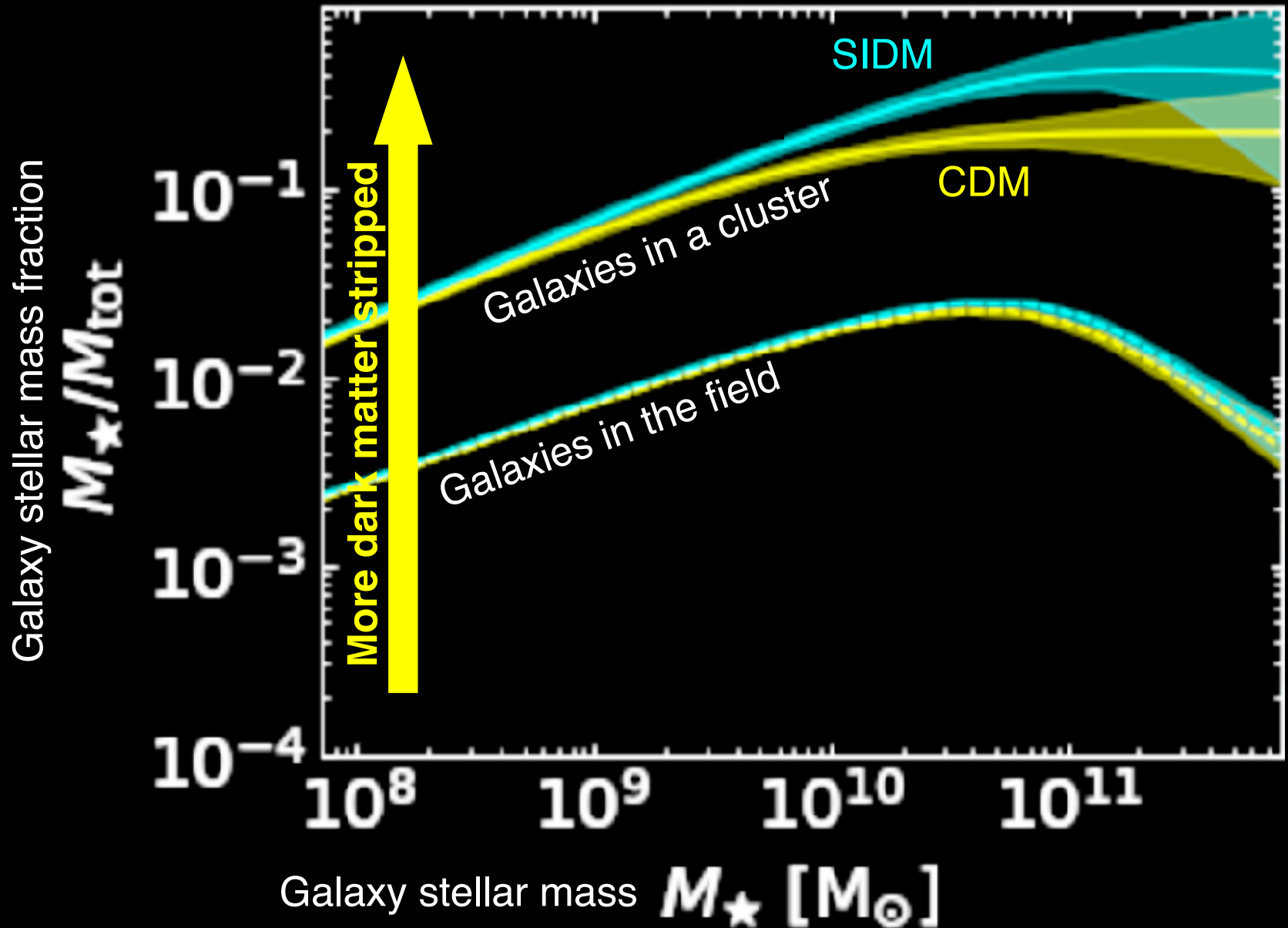
**Allow DM particles to interact with neighbours during each time step**

- **Probability of DM-DM scattering ( $\sigma_{\text{DM}} / m_{\text{DM}}$ )**
- **Relative velocity of scattering DM articles ( $m_{\text{mediator}}$ )**
- **Scattering physics (frequent, low  $\Delta p$  vs rare, high  $\Delta p$ ) ( $h^{-1}\text{Mpc}$ )**



# Stripping of galaxies as they fall into clusters

Sirks et al. (2022)





# The largest particle collider in the universe

Clowe et al. (2006)

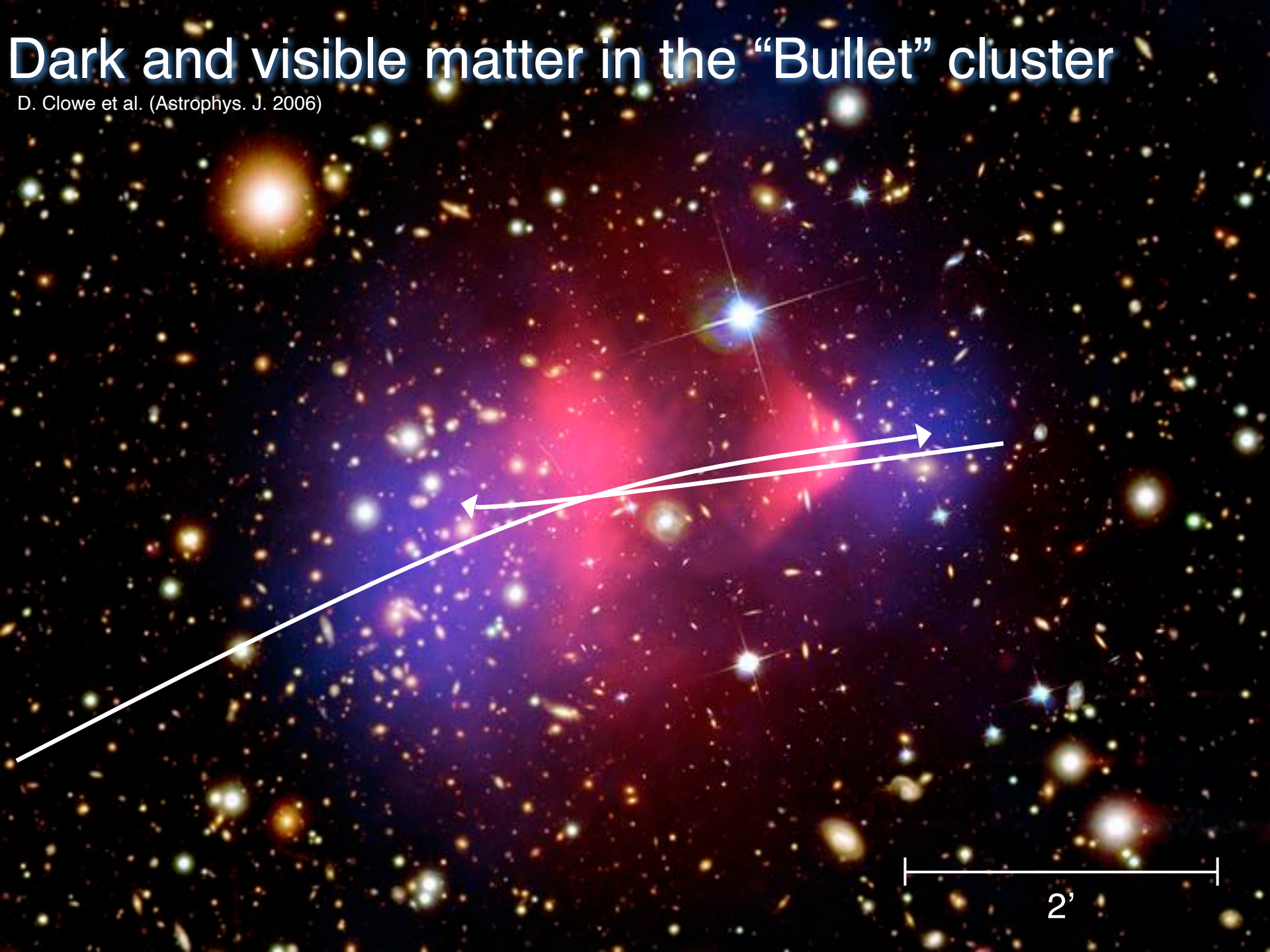
Robertson et al. (2018)



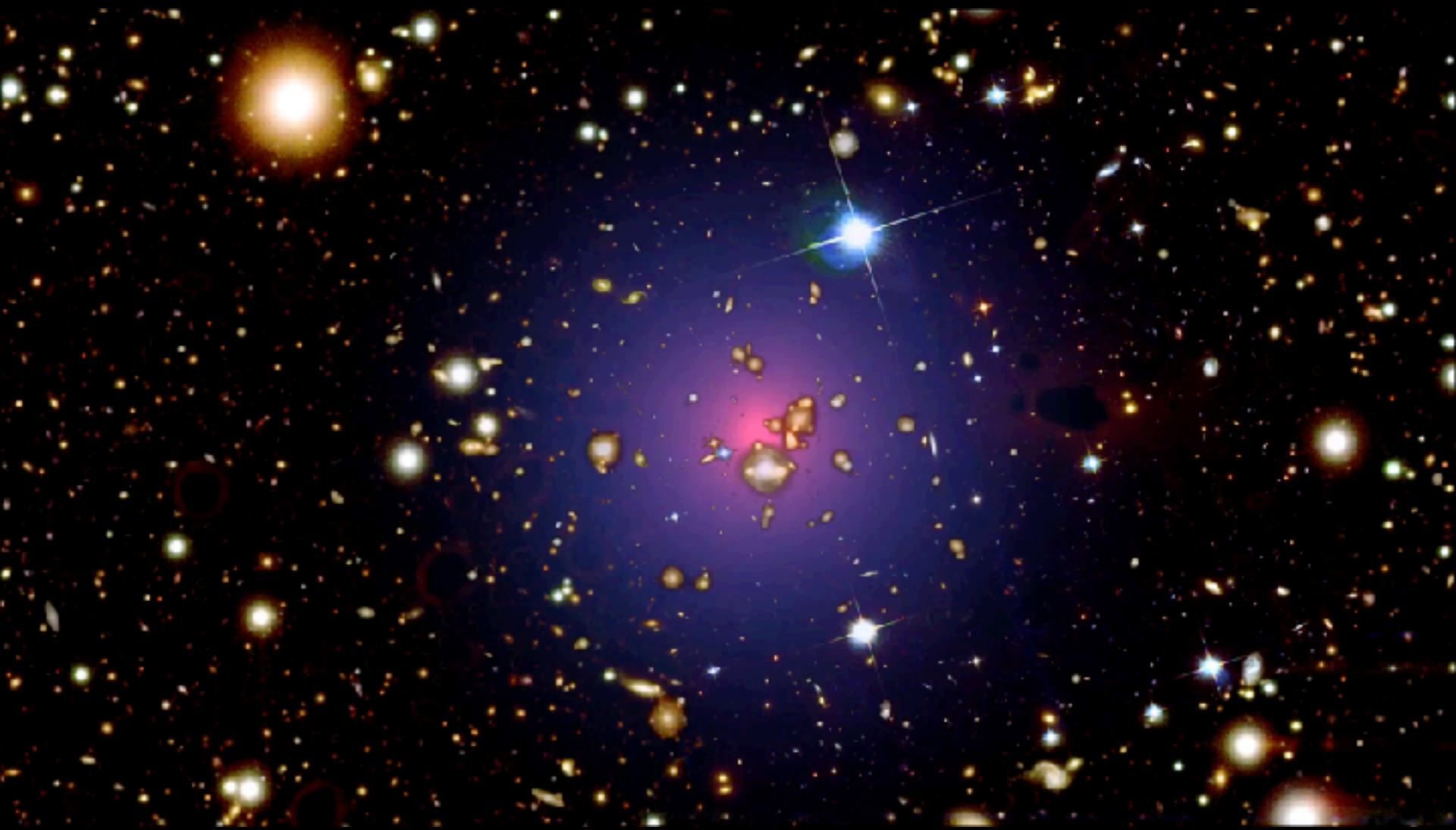


# Dark and visible matter in the “Bullet” cluster

D. Clowe et al. (Astrophys. J. 2006)



If dark matter doesn't interact with anything (CDM)



Robertson et al. (2018)

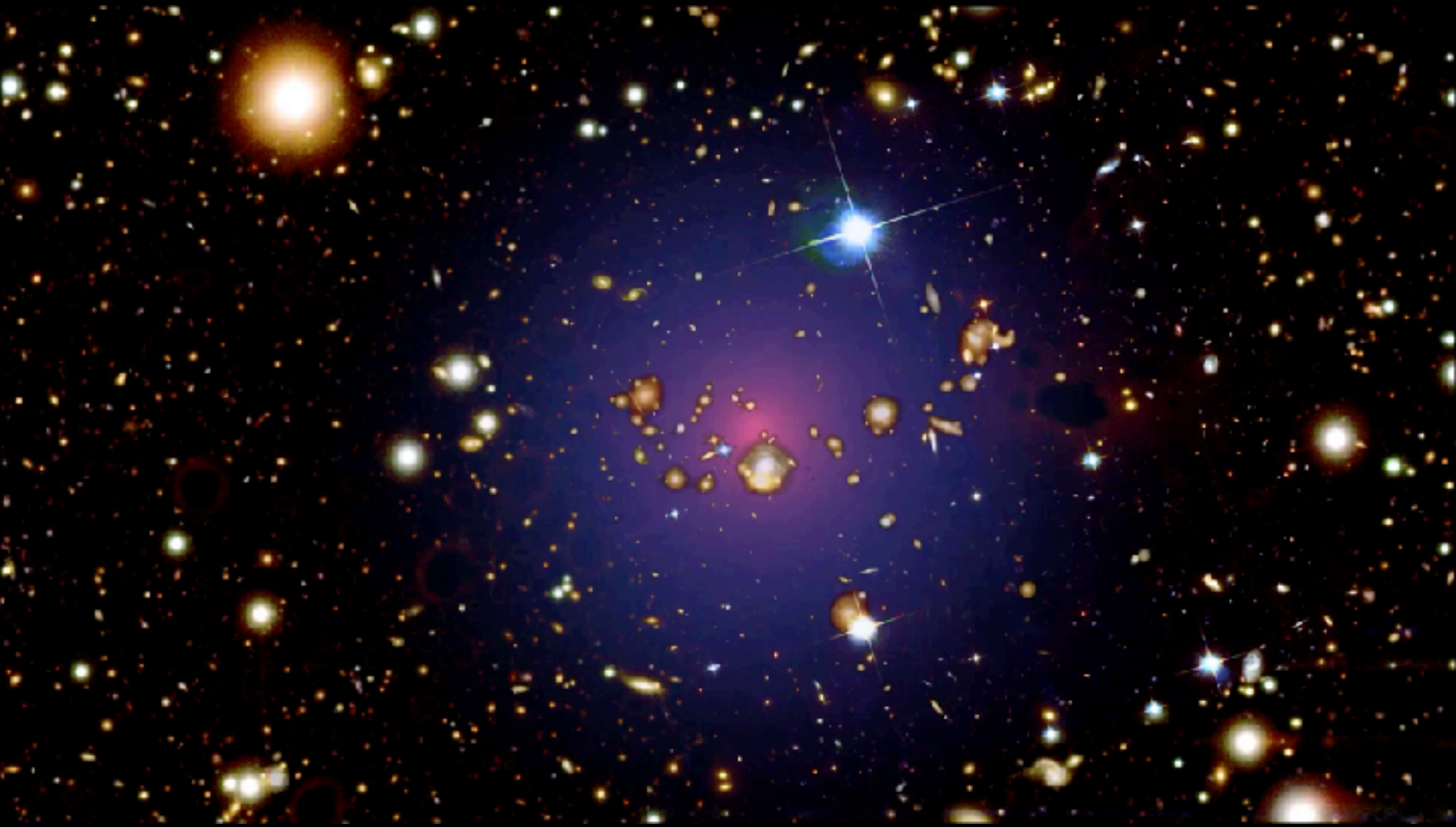


# The LHC doesn't stop after just one collision





If dark matter were like hydrogen (strong SIDM)



Robertson et al. (2018)

# If there were no dark matter

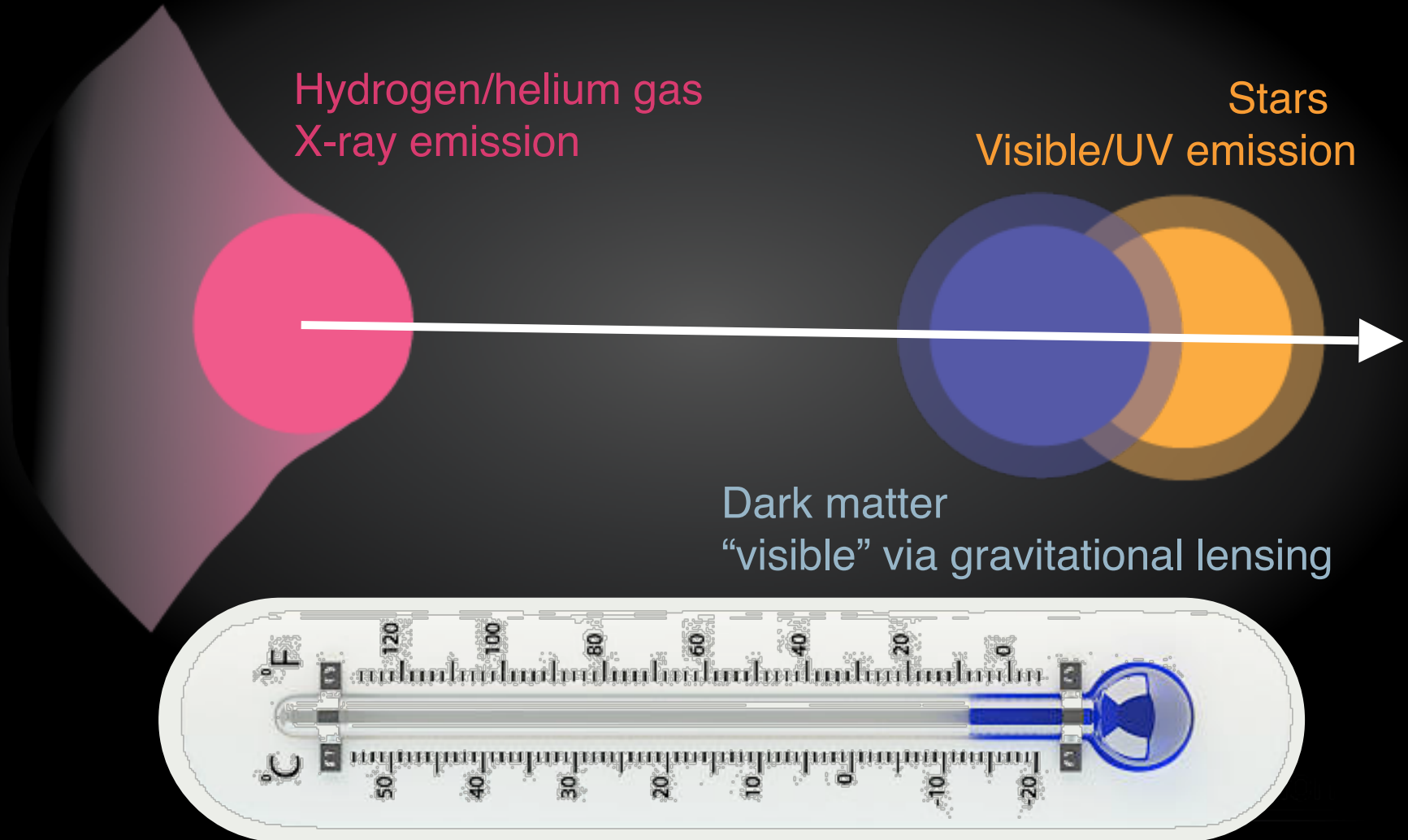


Robertson et al. (2018)

# Bookending dark matter's behaviour

Harvey et al. 2014, MNRAS 441, 404

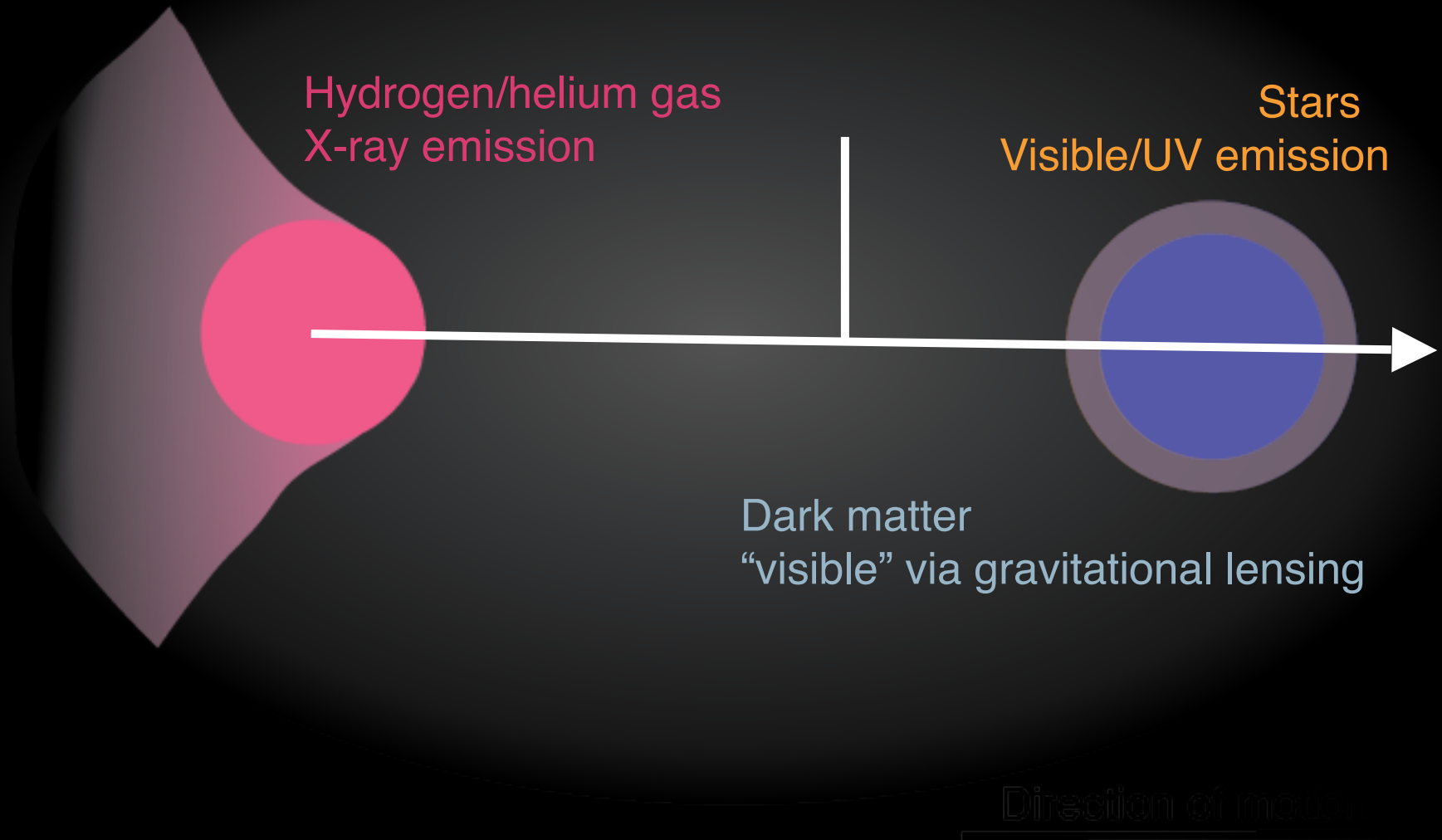
Kahlhoefer et al. 2014, MNRAS 437, 2865





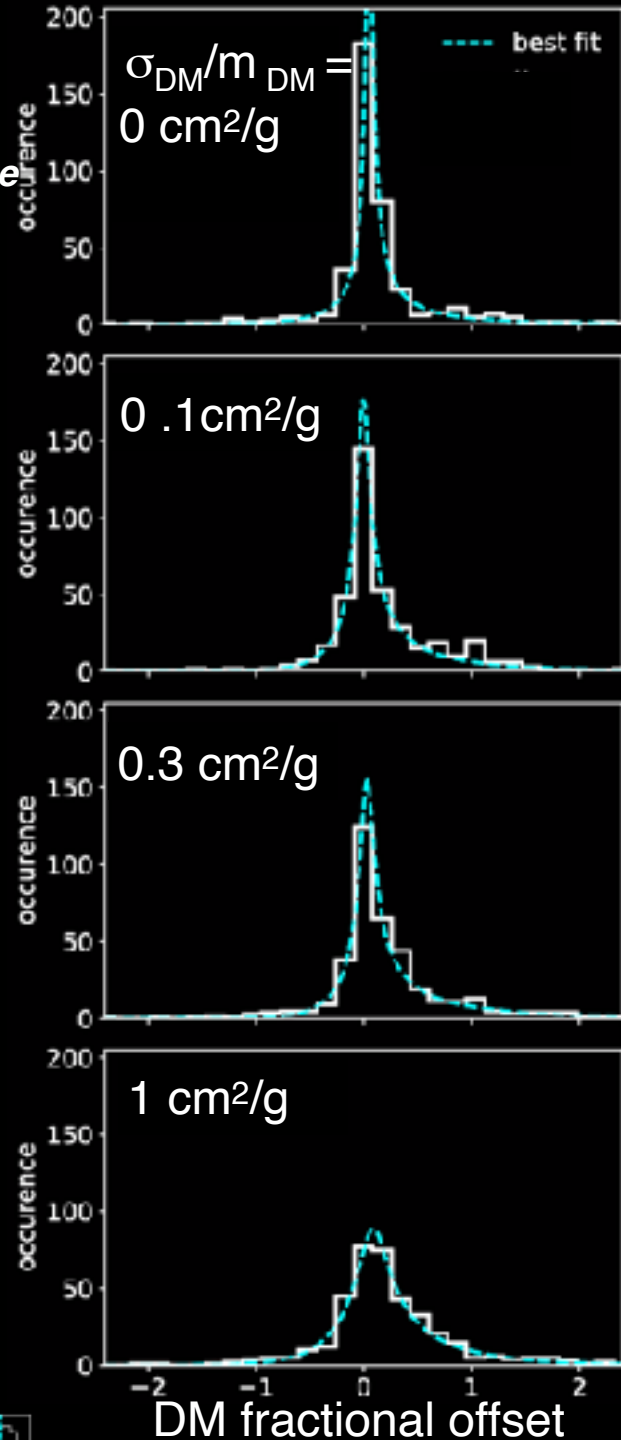
# Bookending dark matter's behaviour – null tests

Harvey et al. 2014, MNRAS 441, 404  
Kahlhoefer et al. 2014, MNRAS 437, 2865

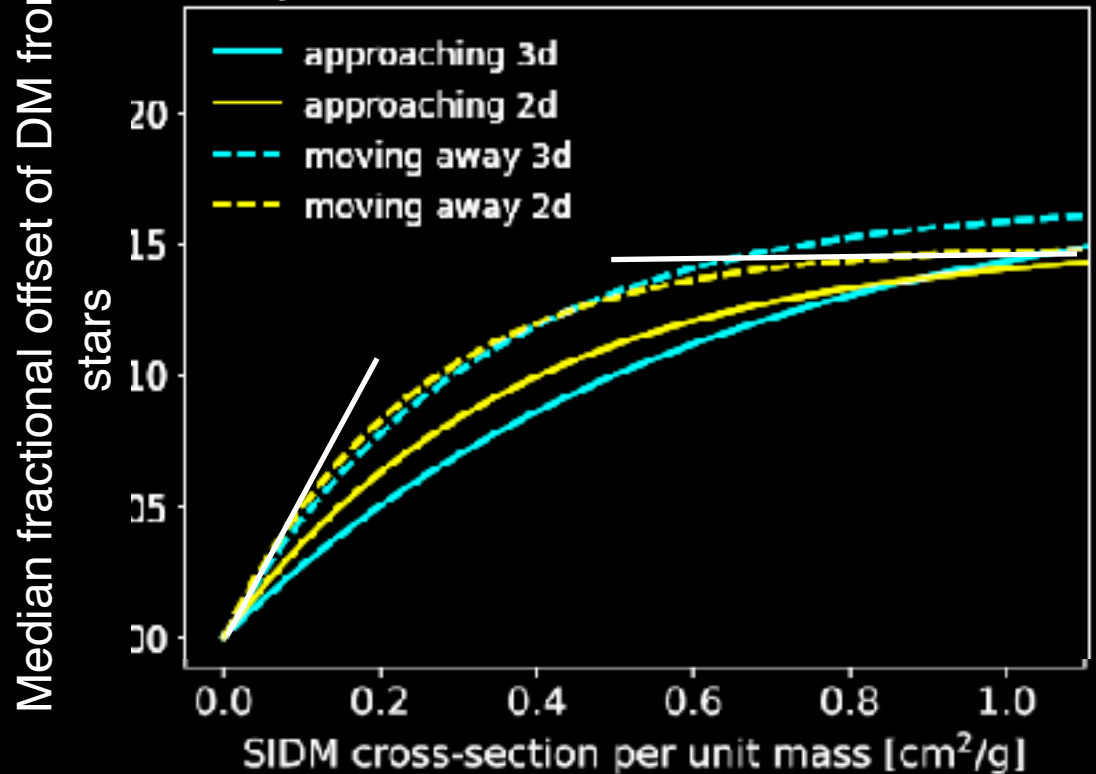


# Statistics of many collisions

Sirks et al. (2024)

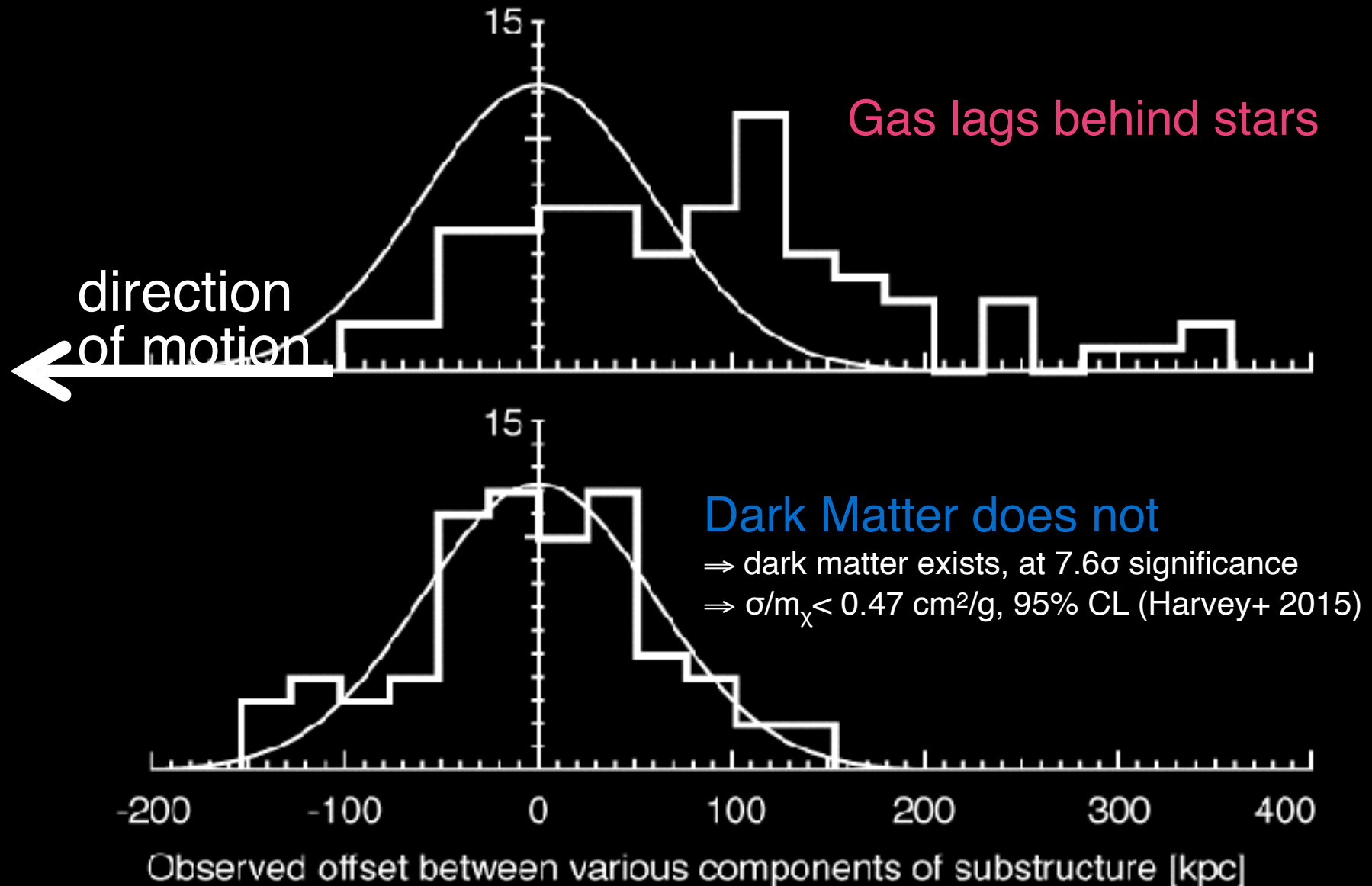


## Subject to selection effects



# Inconclusive constraints with HST archive

Harvey et al. (2015)

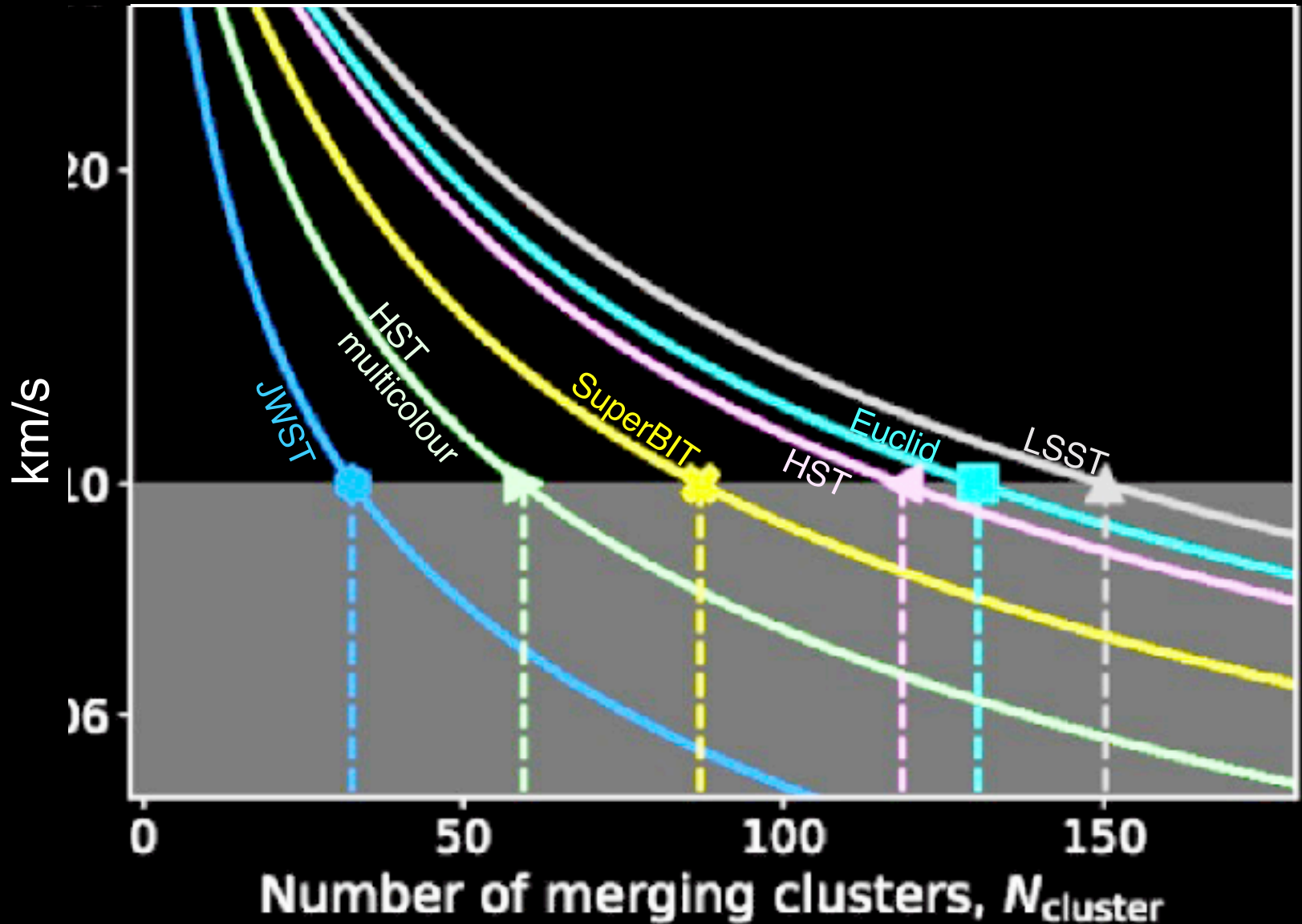




# Predicted constraints from future observations

Sirks et al. (2024)

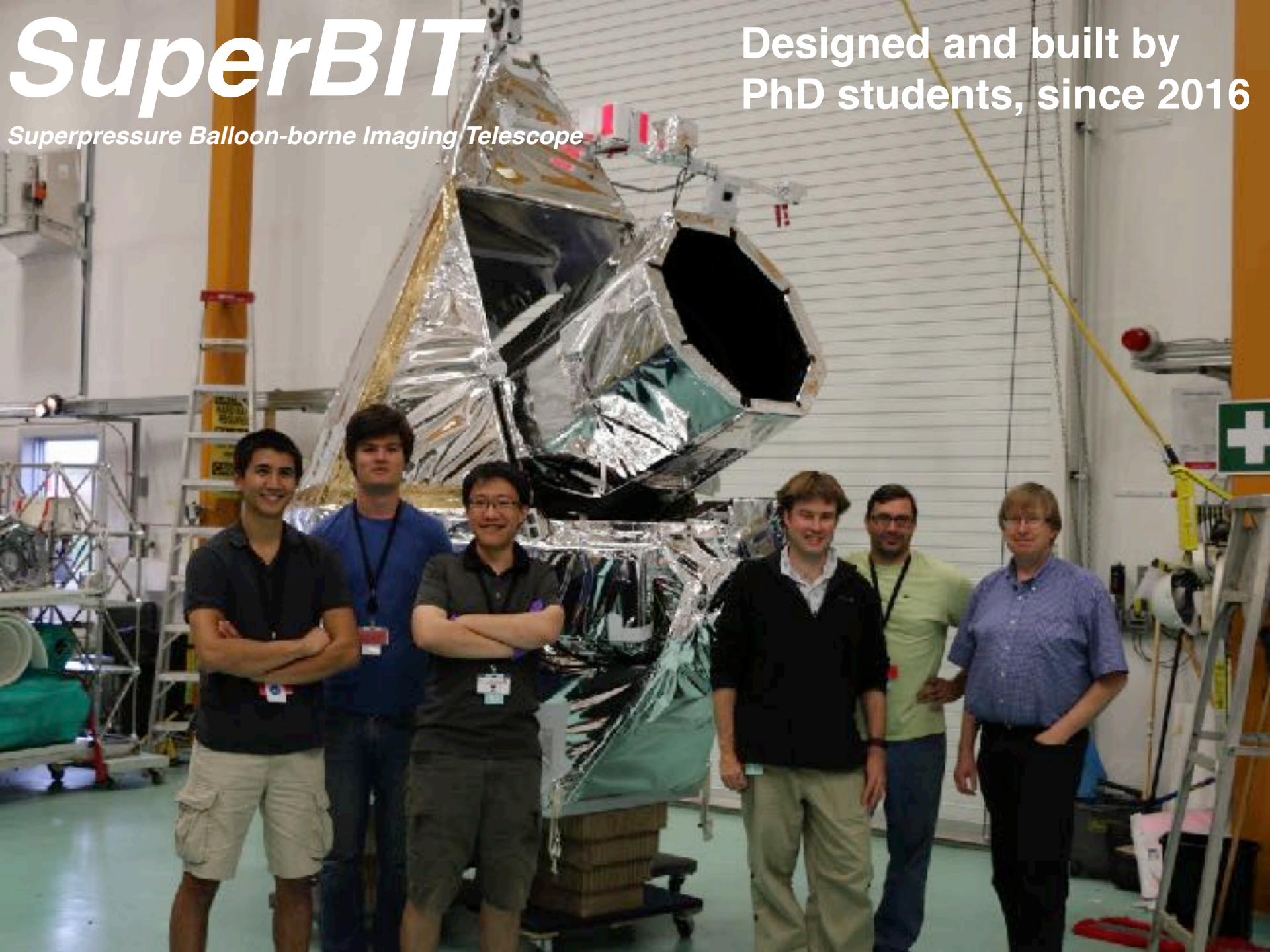
95% confidence limit [ $\text{cm}^2/\text{g}$ ] on  
SIDM cross-section  $\sigma/m$  at  $\sim 1000$



# *SuperBIT*

*Superpressure Balloon-borne Imaging Telescope*

Designed and built by  
PhD students, since 2016

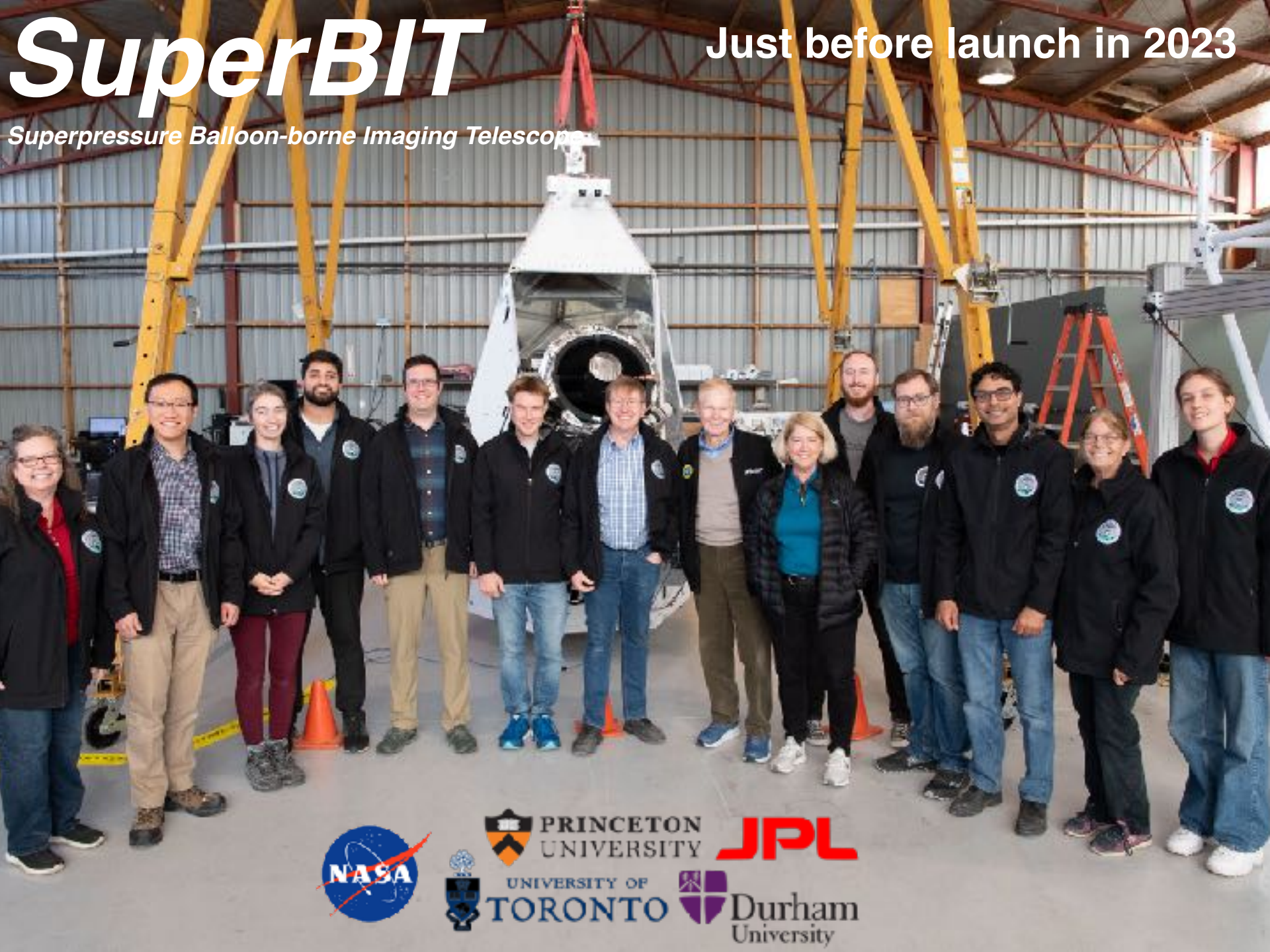




# SuperBIT

*Superpressure Balloon-borne Imaging Telescope*

Just before launch in 2023



PRINCETON  
UNIVERSITY

UNIVERSITY OF  
TORONTO

JPL

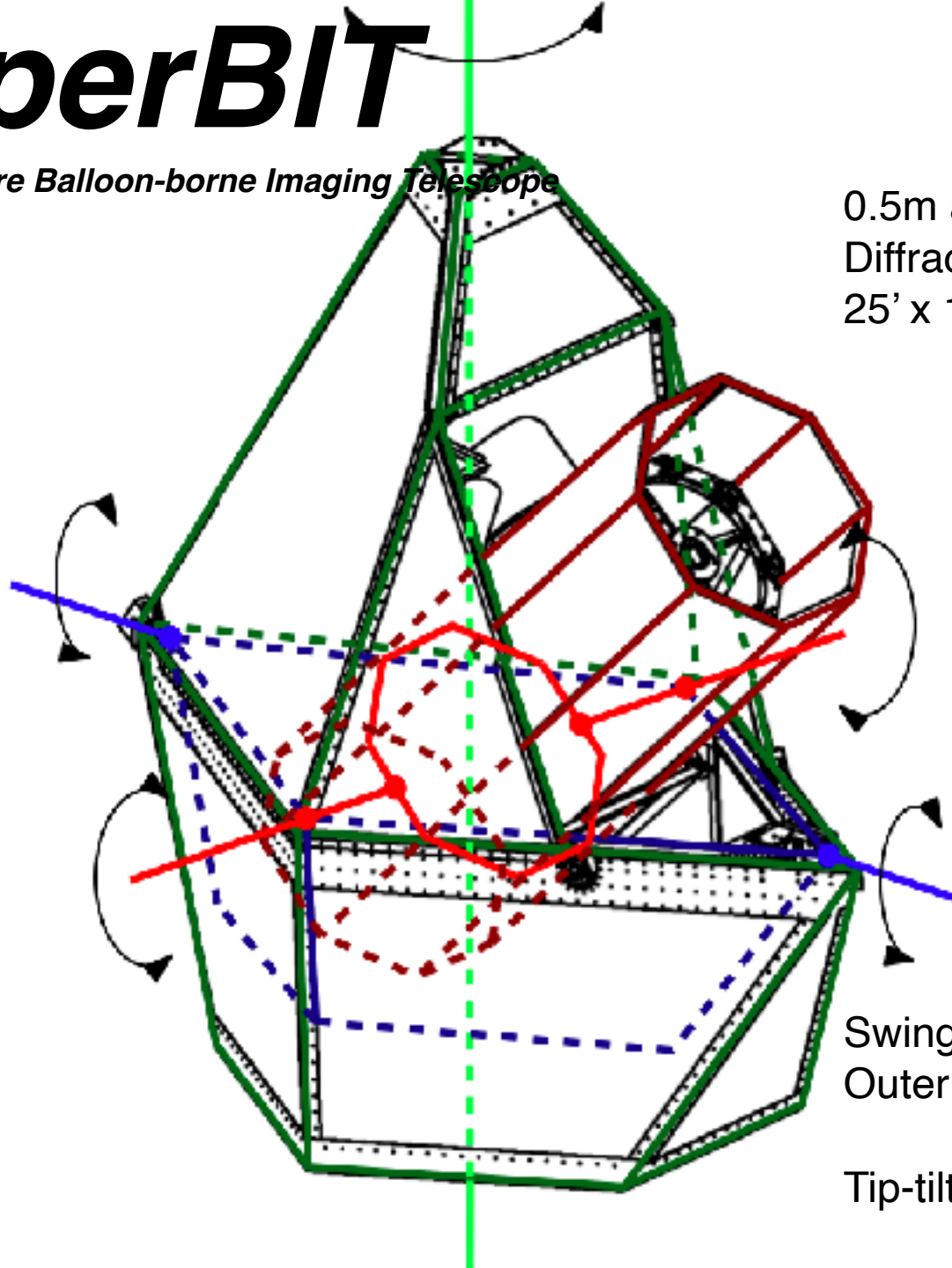


Durham  
University



# ***SuperBIT***

*Superpressure Balloon-borne Imaging Telescope*



0.5m alt/az telescope

Diffraction-limited 0.3" FWHM (b/u)

25' x 17' field of view

Swings on rope up to 2 degrees!

Outer gimbals (gyros+guide star):

<1" rms stability

Tip-tilt mirror (guide star):

0.03-0.1" rms stability



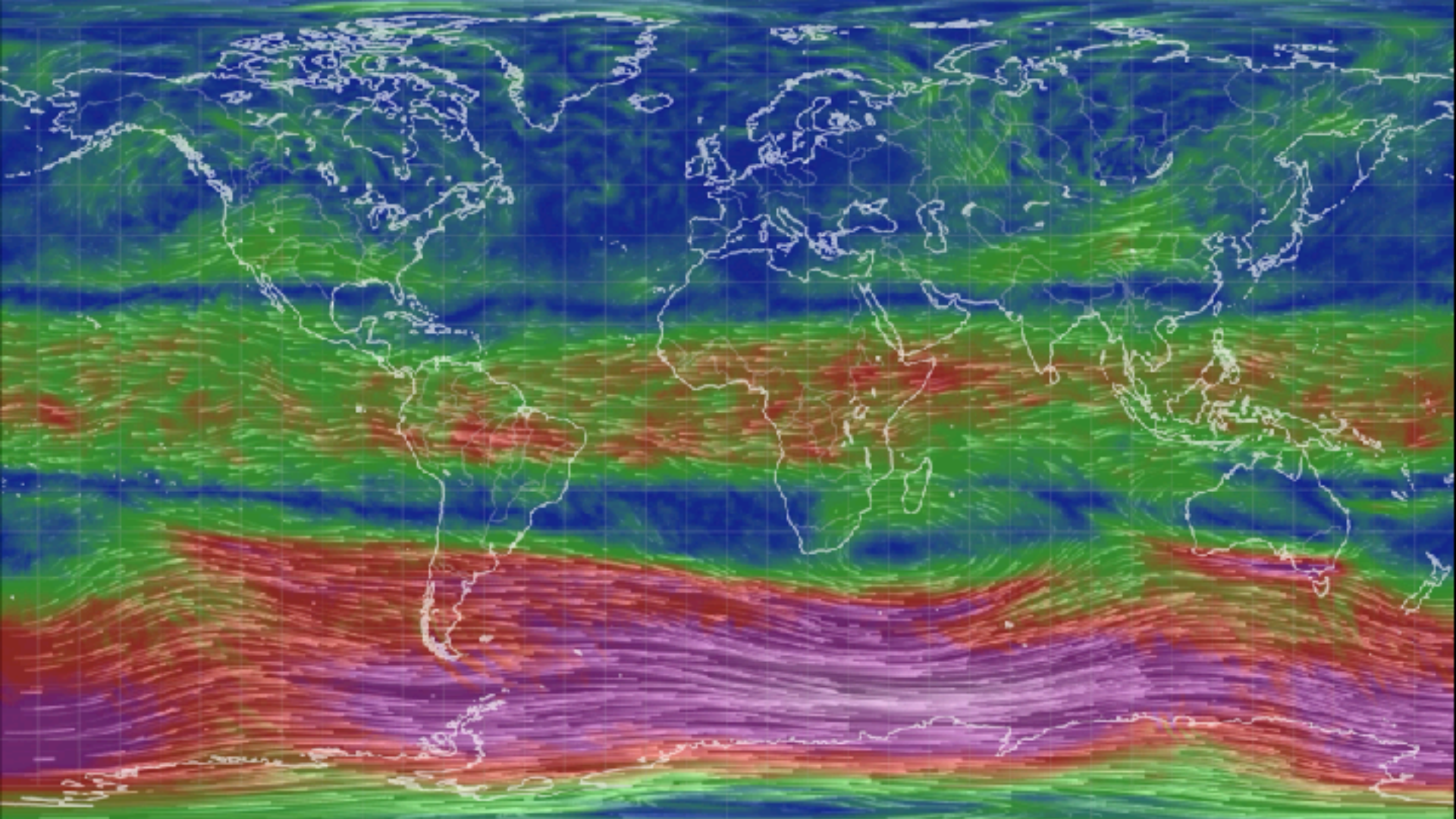
# ***SuperBIT***

*Superpressure Balloon-borne Imaging Telescope*



Video courtesy Bill Rodman



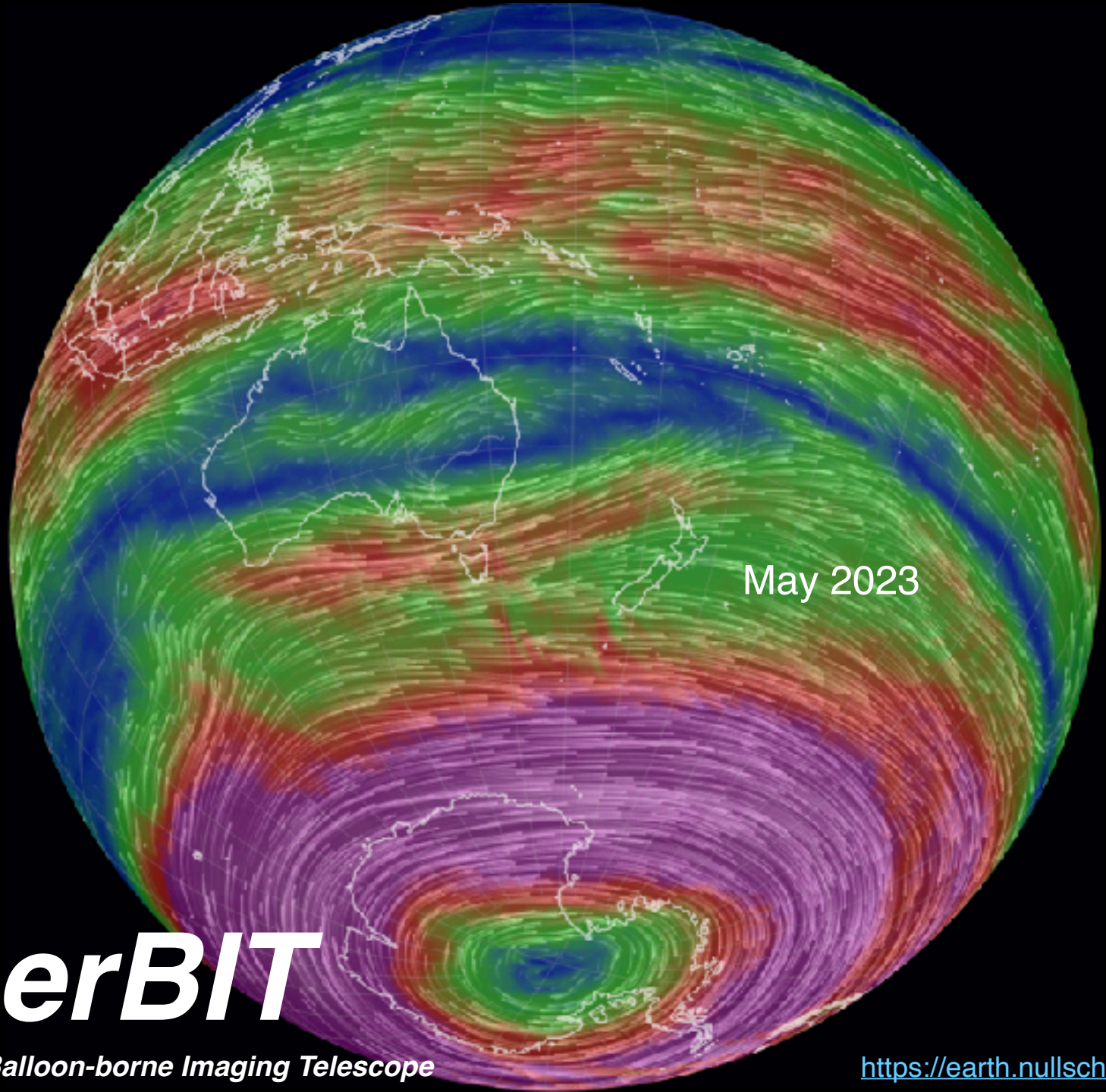


Stratospheric polar vortex winds, May 2023

<https://earth.nullschool.net>

***SuperBIT***  
*Superpressure Balloon-borne Imaging Telescope*





May 2023

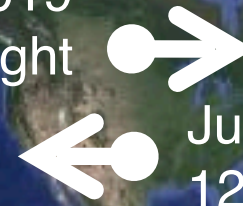
***SuperBIT***  
*Superpressure Balloon-borne Imaging Telescope*

<https://earth.nullschool.net>





Sep 2015 & 2019  
12hr test flight & 36hr test flight



June 2016 & 2018  
12hr test flight

Kelvin-Helmholtz

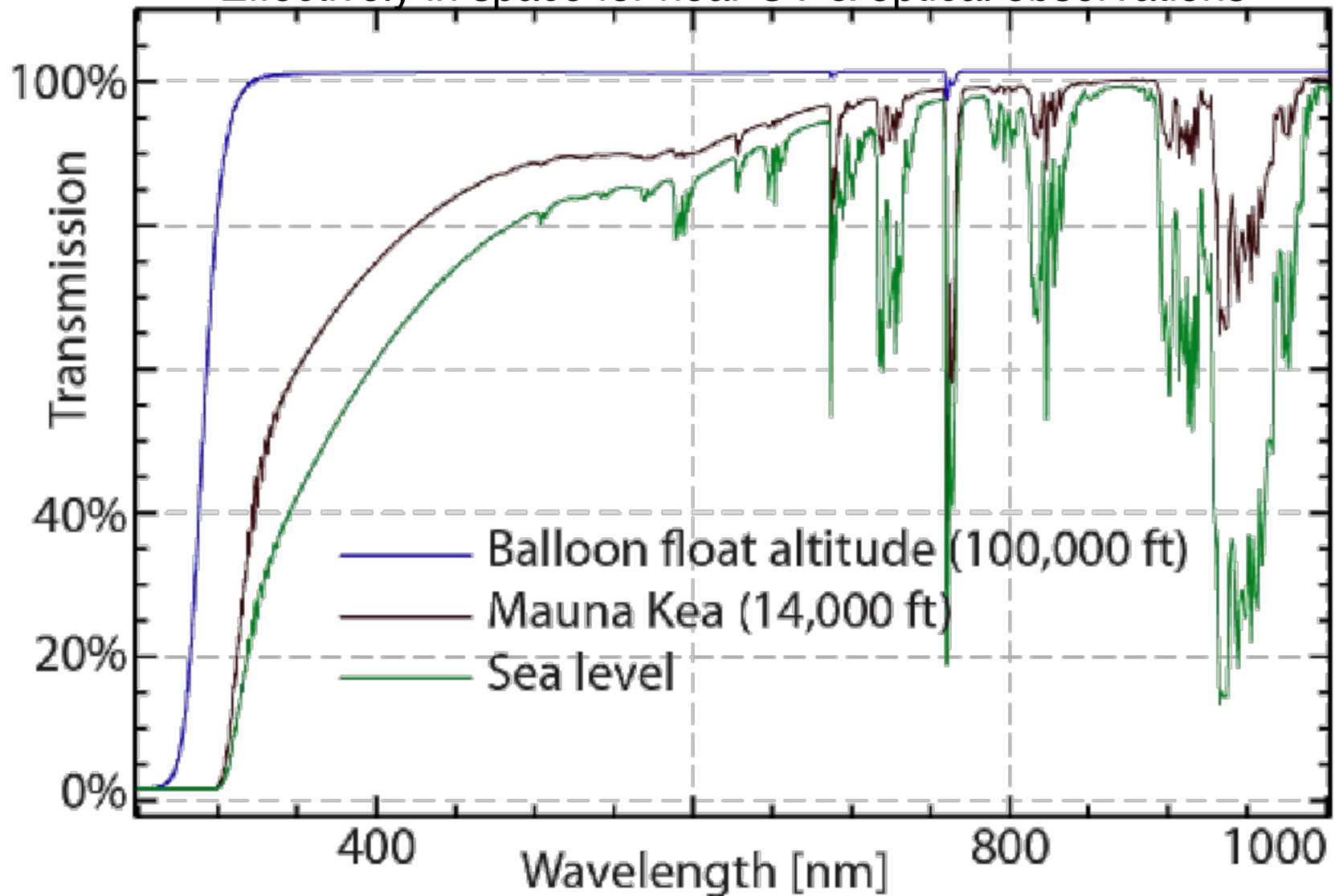
2023: 40 days and 46 nights at the edge of space

Thank your TO on your next observing run!

# ***SuperBIT***

***Superpressure Balloon-borne Imaging Telescope***

Effectively in space for near UV & optical observations



# ***SuperBIT***

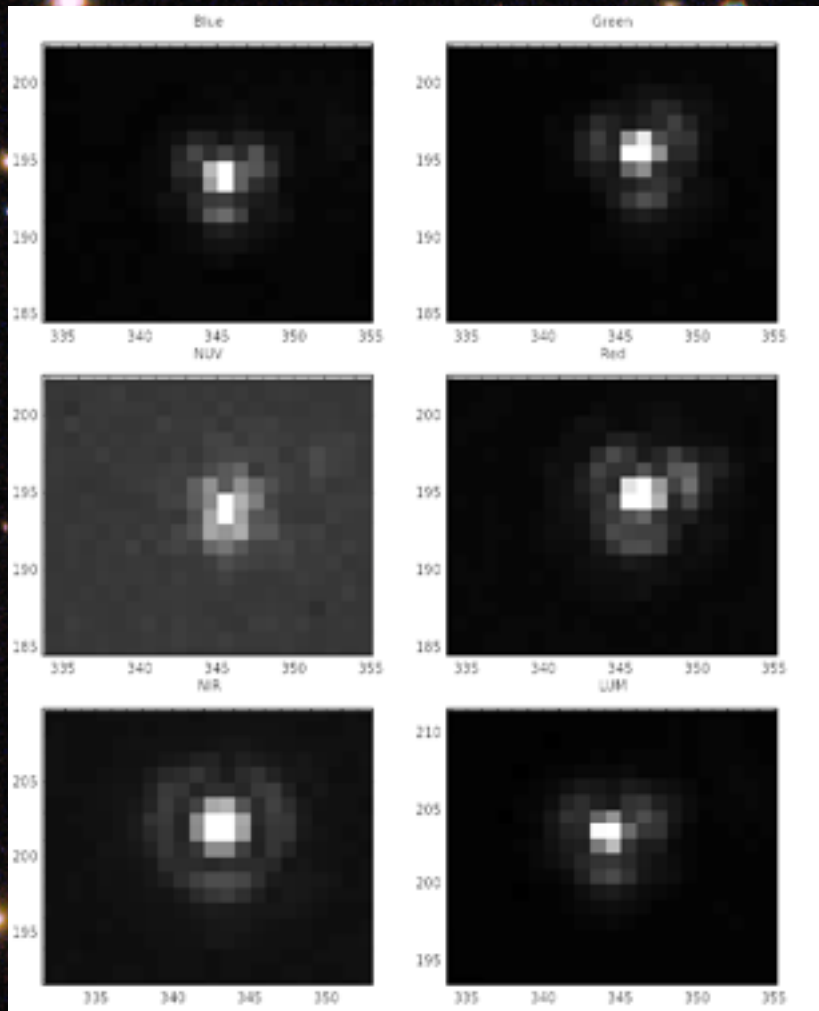
*Superpressure Balloon-borne Imaging Telescope*



# SuperBIT

*Superpressure Balloon-borne Imaging Telescope*

early look at data: Abell 3827

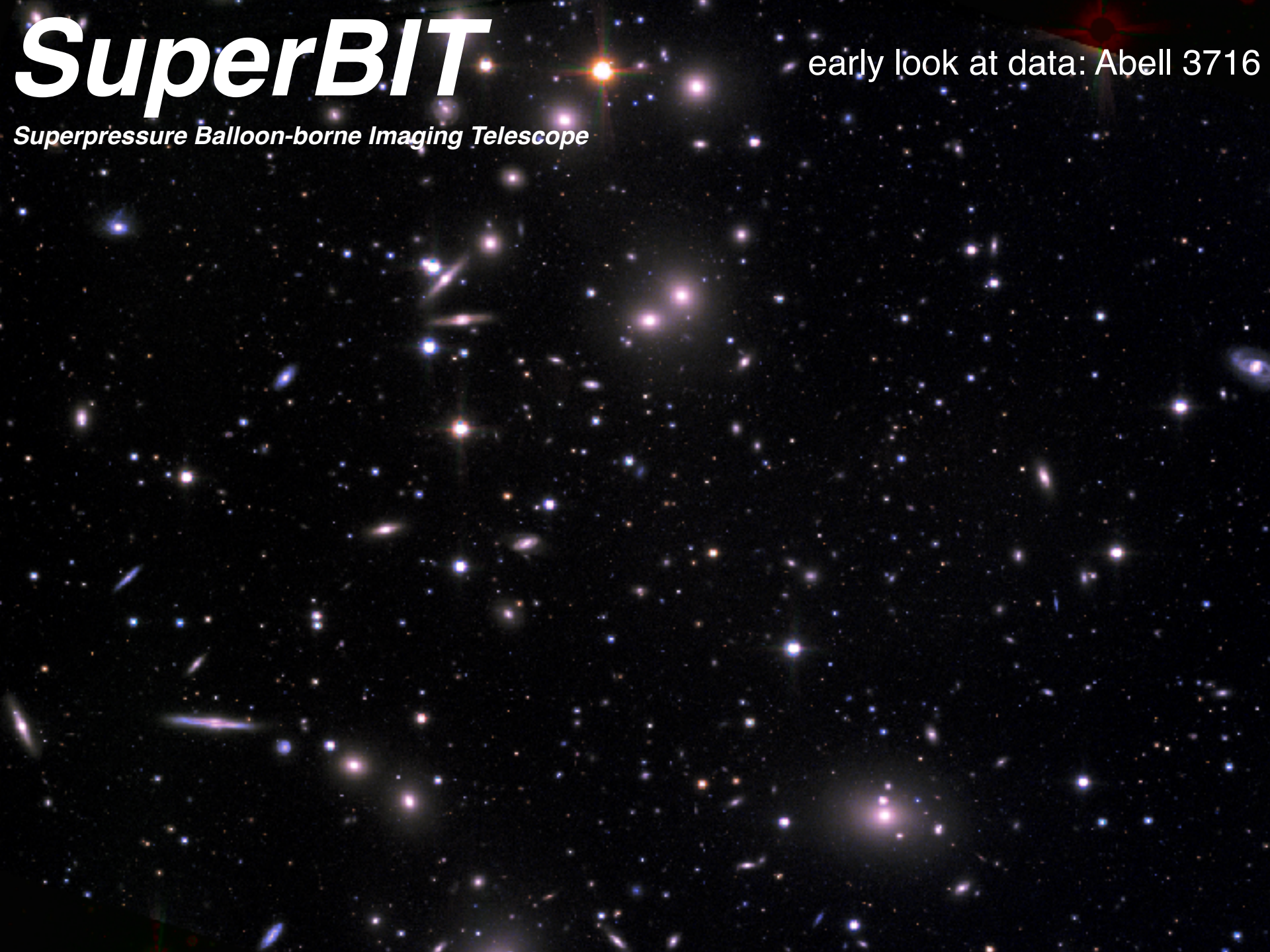




# ***SuperBIT***

*Superpressure Balloon-borne Imaging Telescope*

early look at data: Abell 3716





# ***SuperBIT***

*Superpressure Balloon-borne Imaging Telescope*

early look at data: Abell 1689

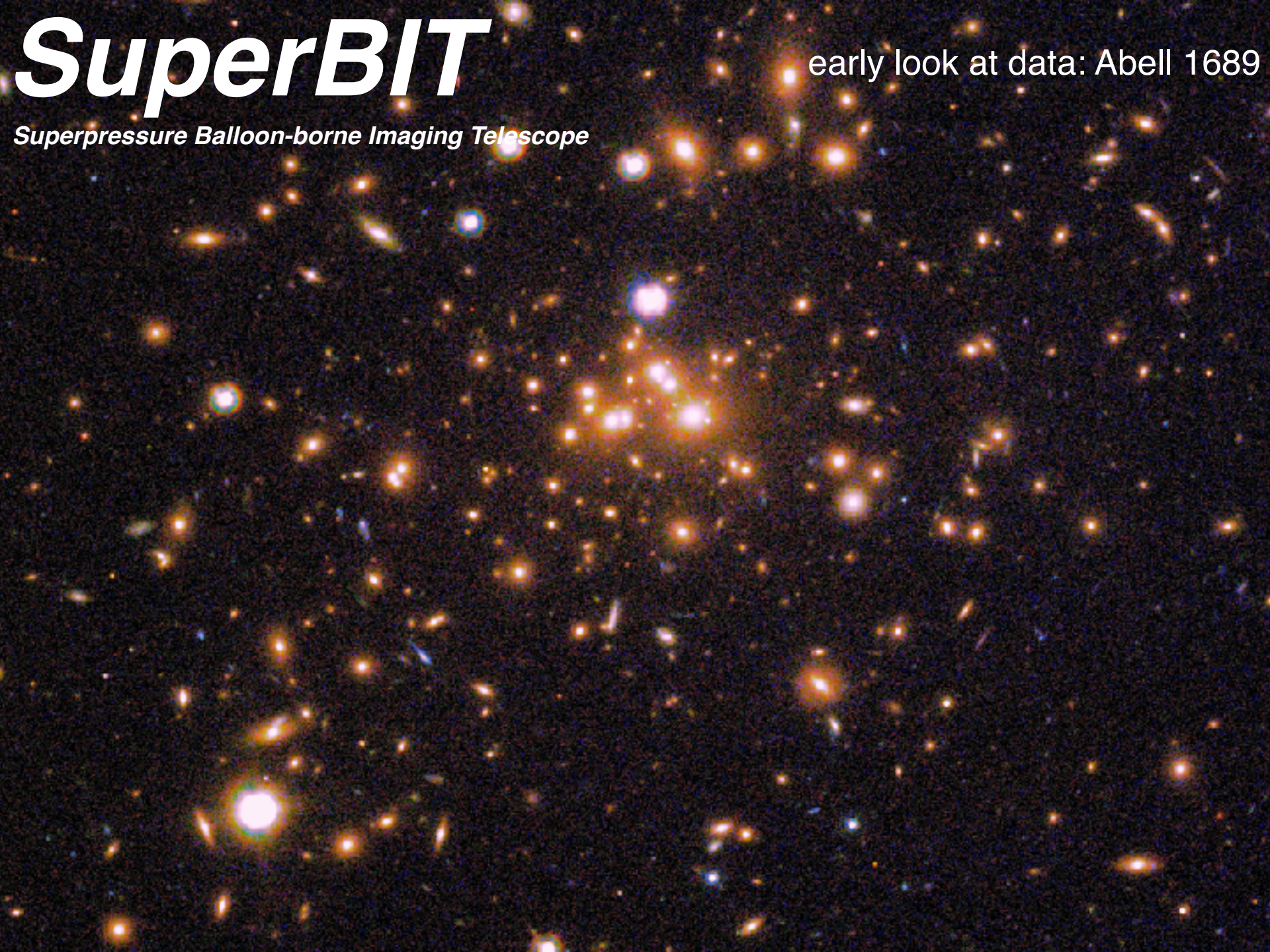




# ***SuperBIT***

*Superpressure Balloon-borne Imaging Telescope*

early look at data: Abell 1689

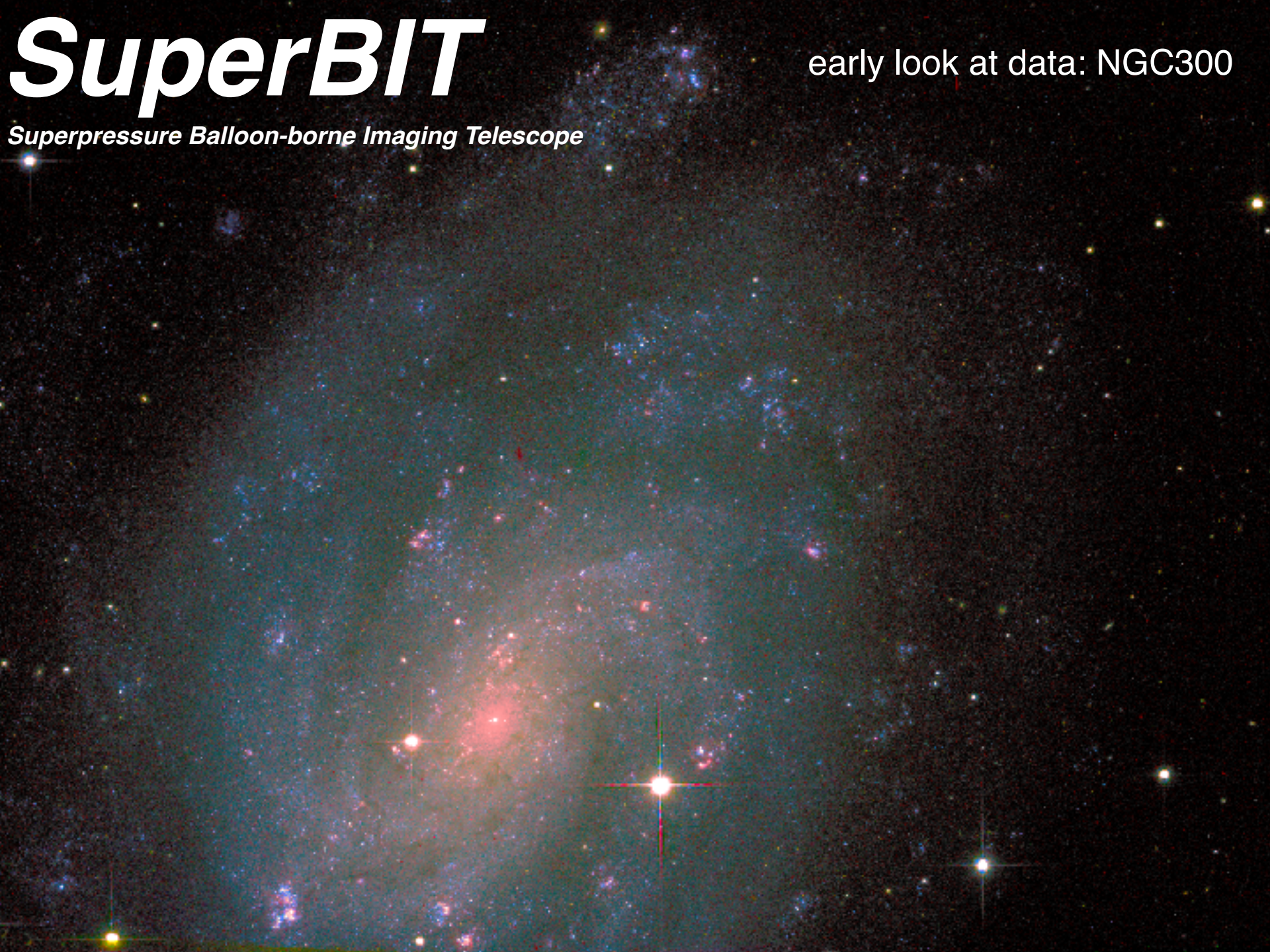




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early look at data: NGC300





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Aurora Australis, from camera on top of balloon

# *SuperBIT*

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# Data **download**, by parachute

Sirks et al. (2020, 2023)





# ***SuperBIT***

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Telescope also  
comes down by parachute





# SuperBIT

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Westmost Debris

GPS Coordinates

SIP Cage + Hat

Innes/Middle Frame



# SuperBIT

Superpressure Balloon-borne Imaging Telescope





# SuperBIT

*Superpressure Balloon-borne Imaging Telescope*

**Success for \$5m + launch!**

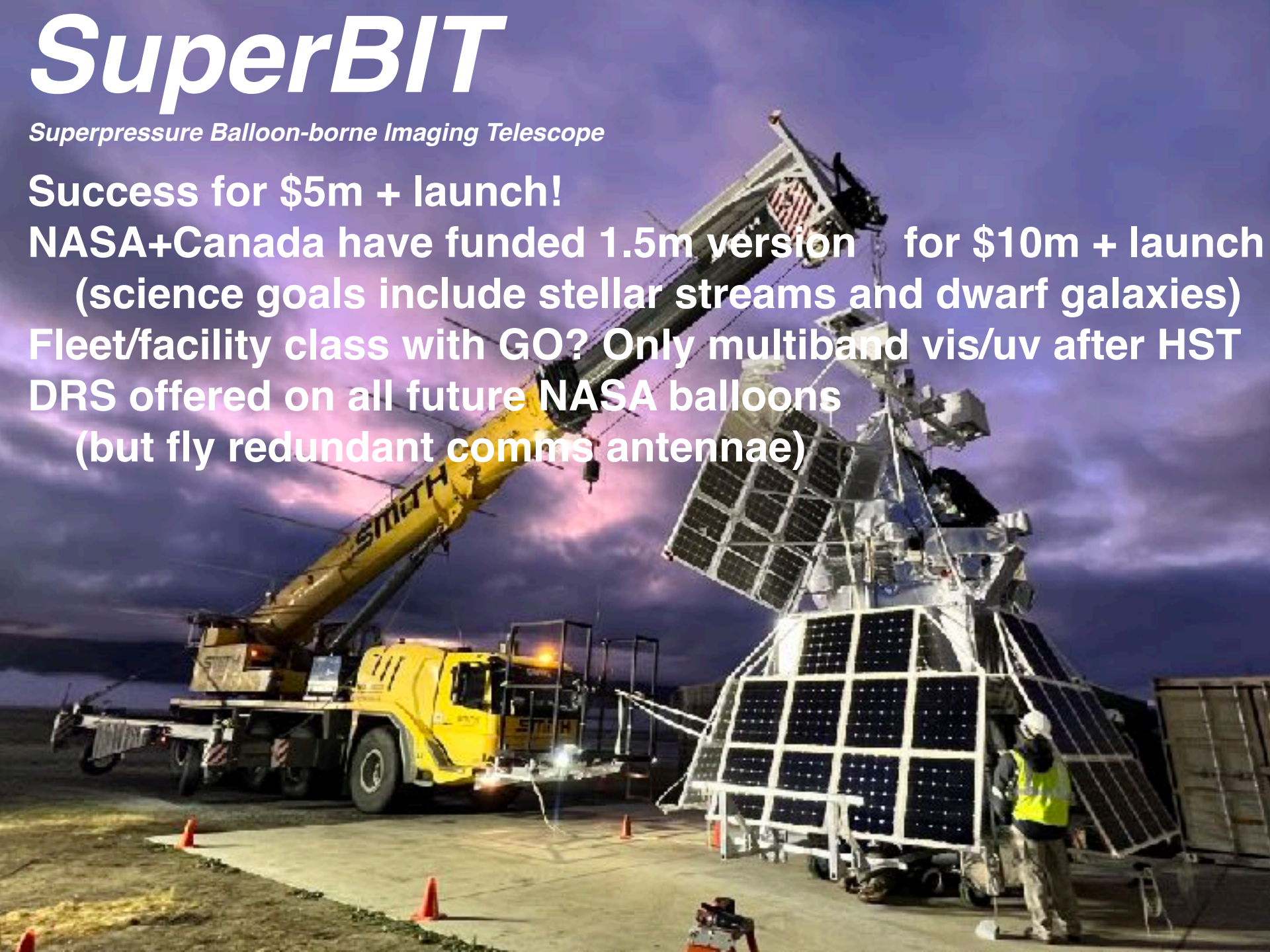
**NASA+Canada have funded 1.5m version for \$10m + launch**

**(science goals include stellar streams and dwarf galaxies)**

**Fleet/facility class with GO? Only multiband vis/uv after HST**

**DRS offered on all future NASA balloons**

**(but fly redundant comms antennae)**



Fin