Astronomical Probes to Cosmology: Distance Indicators Edition

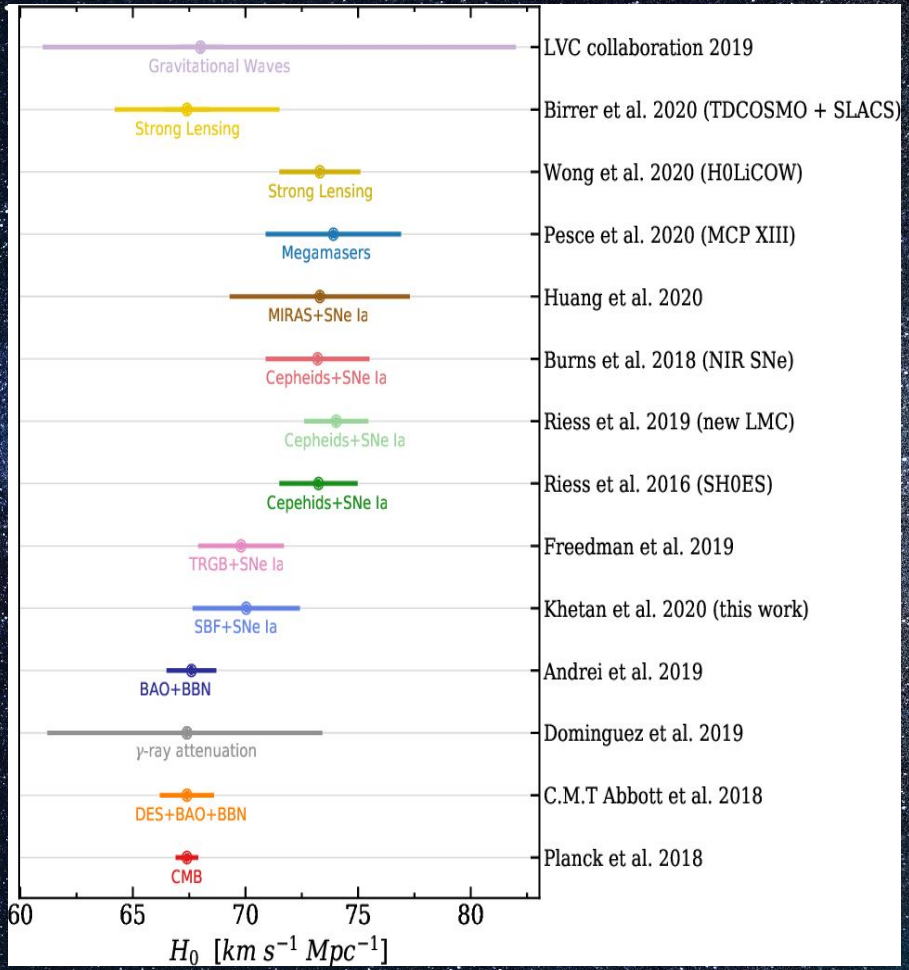
Nandini Hazra
(4th Year)

Advisors: Marica Branchesi, Michele Cantiello
Collaborators: J.P. Blakeslee, G. Raimondo, M. Mirabile, E. Brocato, U. Dupletsa, E. Loffredo, B. Banerjee

- Why do we need precise distances?

- What is a standard candle?

- **Why do we need precise distances?**
  - Calibrate astronomical quantities: fluxes, masses, ages etc.
  - Hubble Tension: values of the Hubble constant diverge as we move from low-z to high-z probes



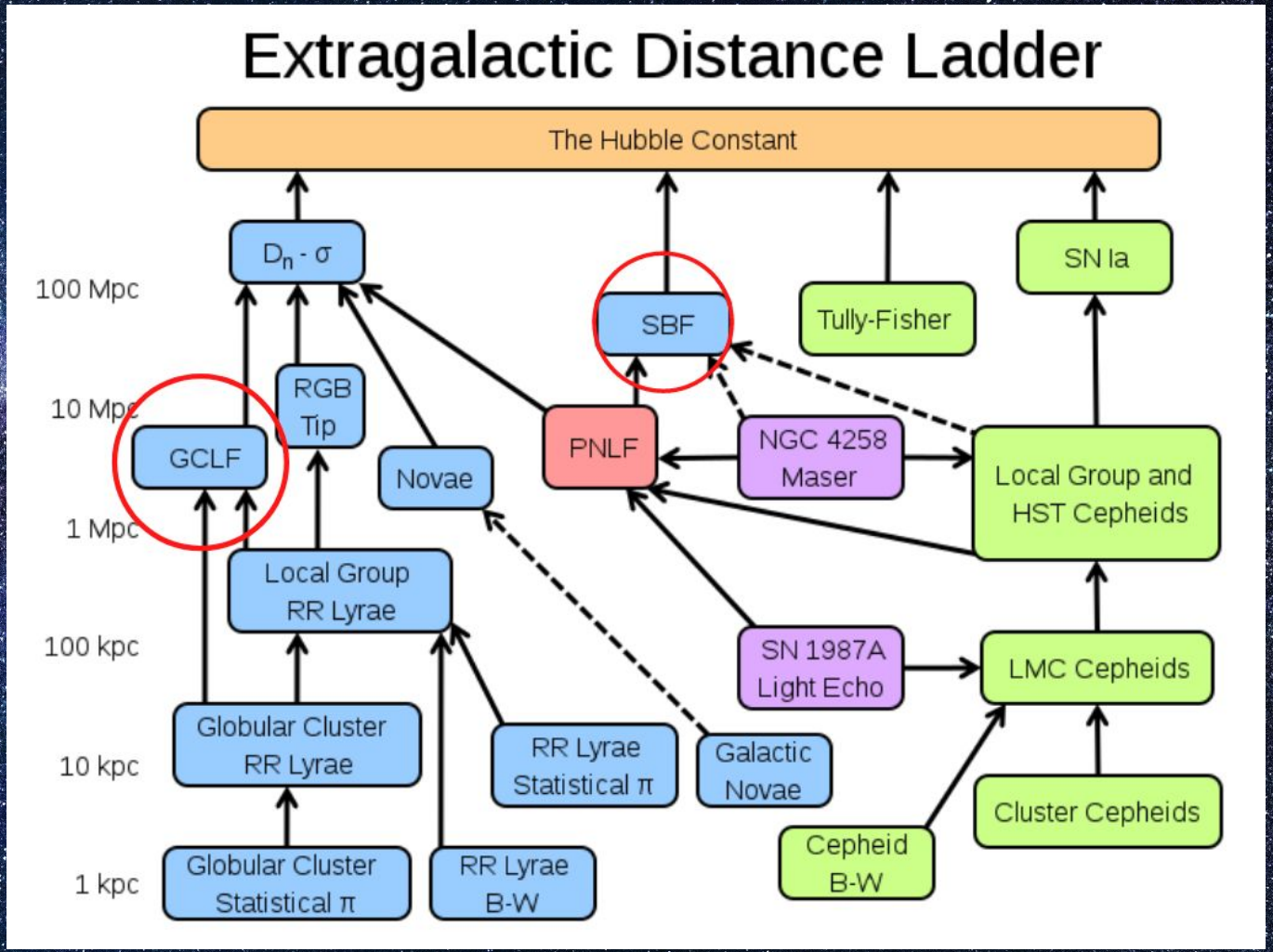
What is a standard candle?

One distance formula to rule them all

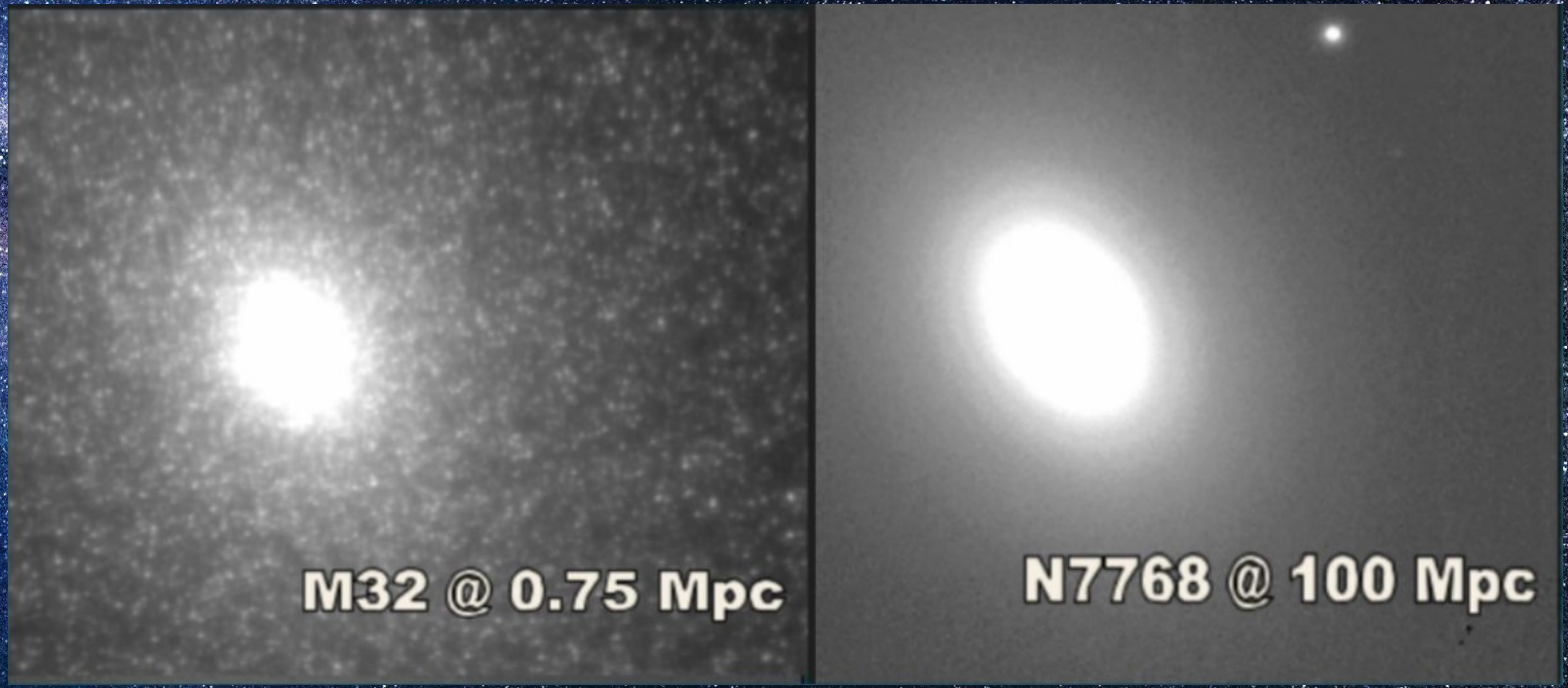
$$m - M = D$$

Where: m = Apparent magnitude
M = Absolute magnitude
D = Distance modulus

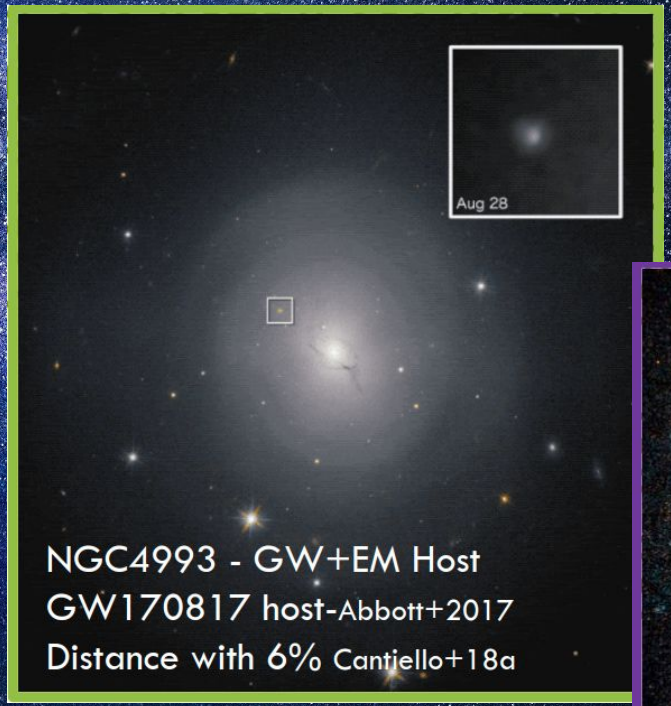
"A standard candle is an astronomical object for which the absolute magnitude is known, or can be inferred"


Extragalactic Distance Ladder
The Hubble Constant
100 Mpc
10 Mpc
1 Mpc
100 kpc
10 kpc
1 kpc
D_n - σ
SBF
Tully-Fisher
SN Ia
RGB Tip
GCLF
Novae
PNLF
NGC 4258 Maser
Local Group and HST Cepheids
Local Group RR Lyrae
SN 1987A Light Echo
LMC Cepheids
Globular Cluster RR Lyrae
RR Lyrae Statistical π
Galactic Novae
Cluster Cepheids
Cepheid B-W
Globular Cluster Statistical π
RR Lyrae B-W

Surface Brightness Fluctuations (SBF) as a Standard Candle



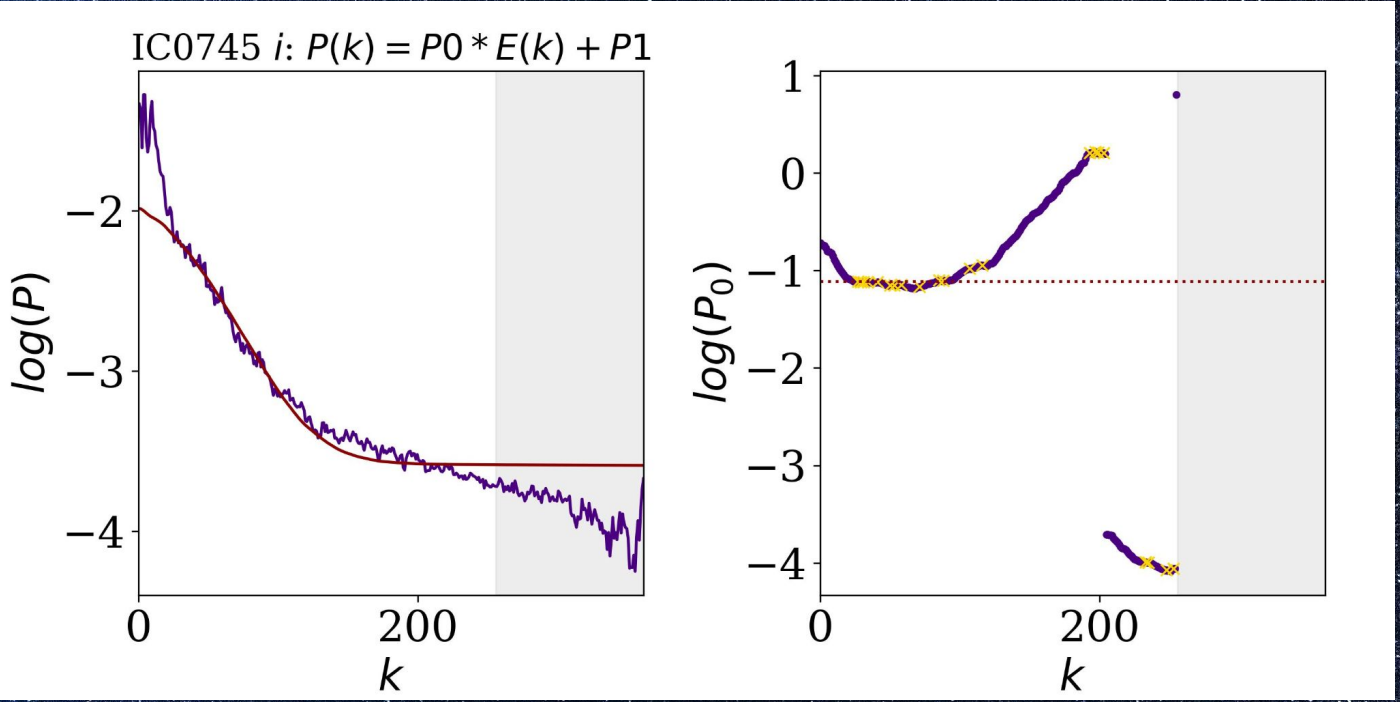
Surface Brightness Fluctuations (SBF) as a Standard Candle



Individual distances upto 3% accuracy Up to ~100 Mpc

Data from observing campaigns with diverse science cases

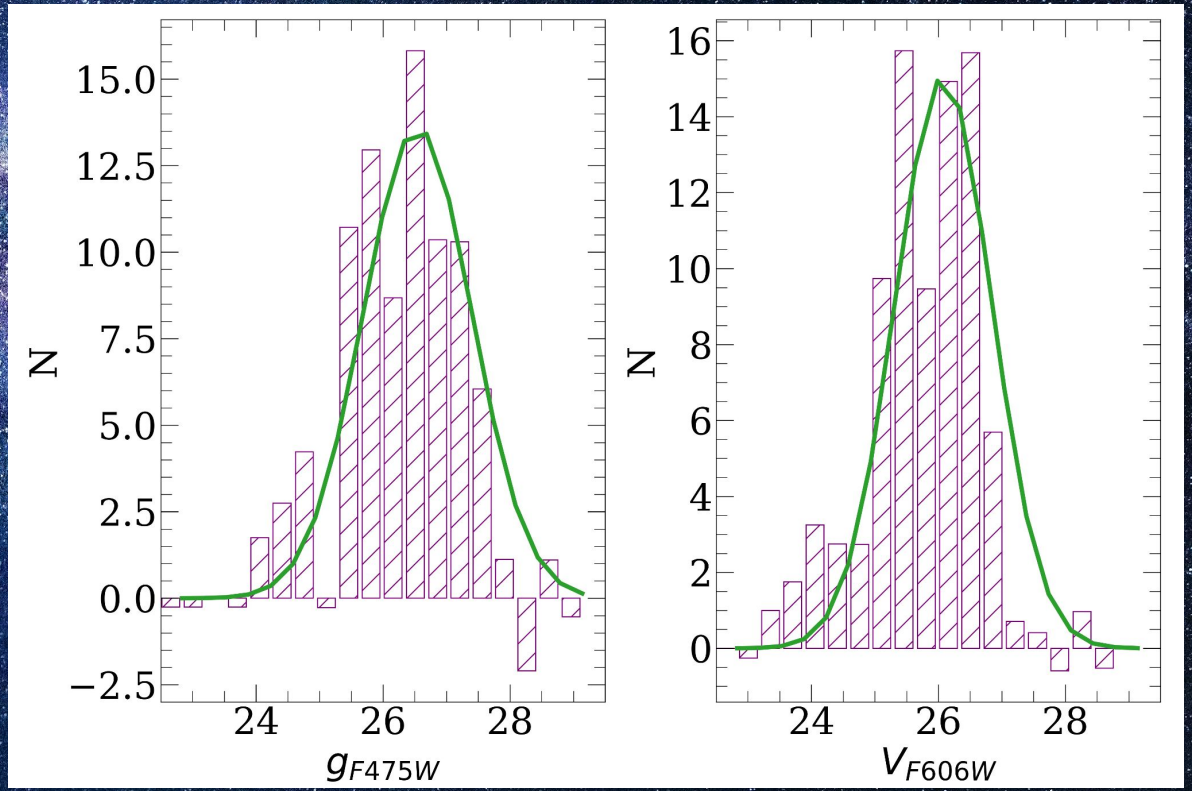
Surface Brightness Fluctuations (SBF) as a Standard Candle



Hazra et al. 2023, in prep: SBF distances using Subaru data

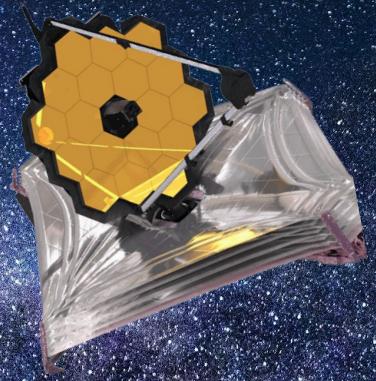
Globular clusters as a Standard Candle

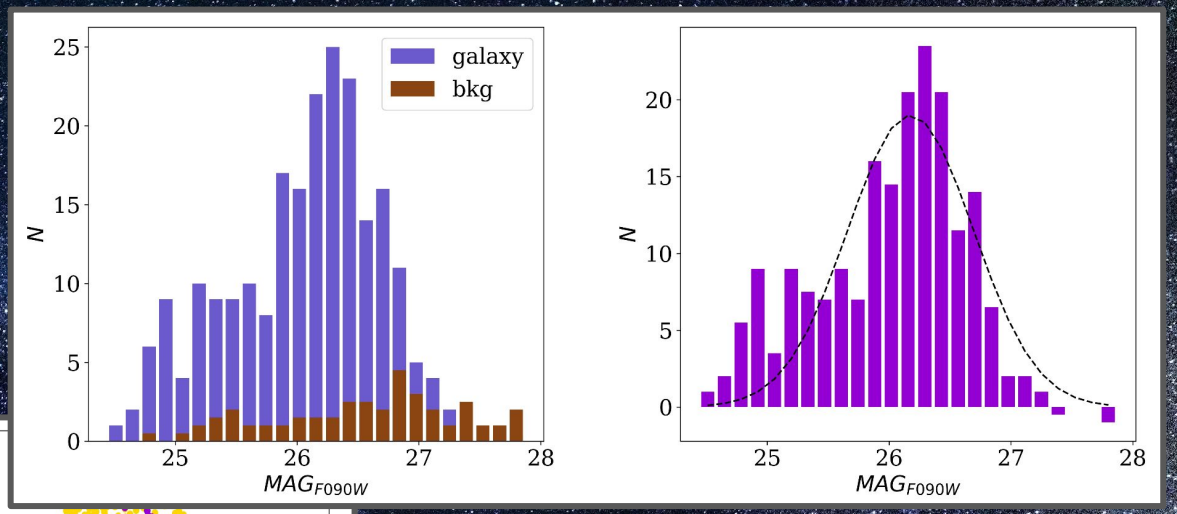
Dense, old systems of stars. Tracers of galaxy properties: evolution, mergers, distance

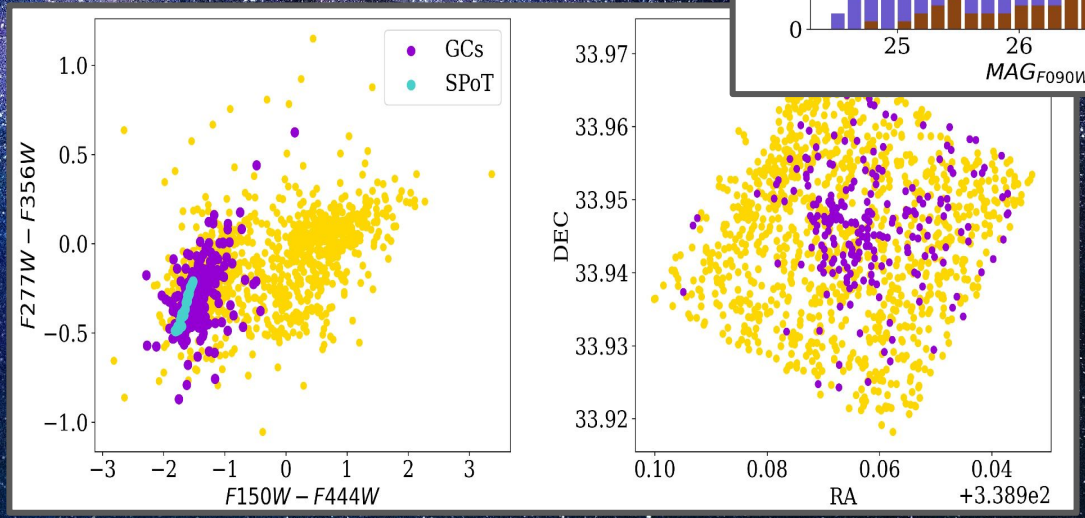


Hazra et al. 2022,
Using archival data from
Hubble Space Telescope

Globular clusters as a Standard Candle







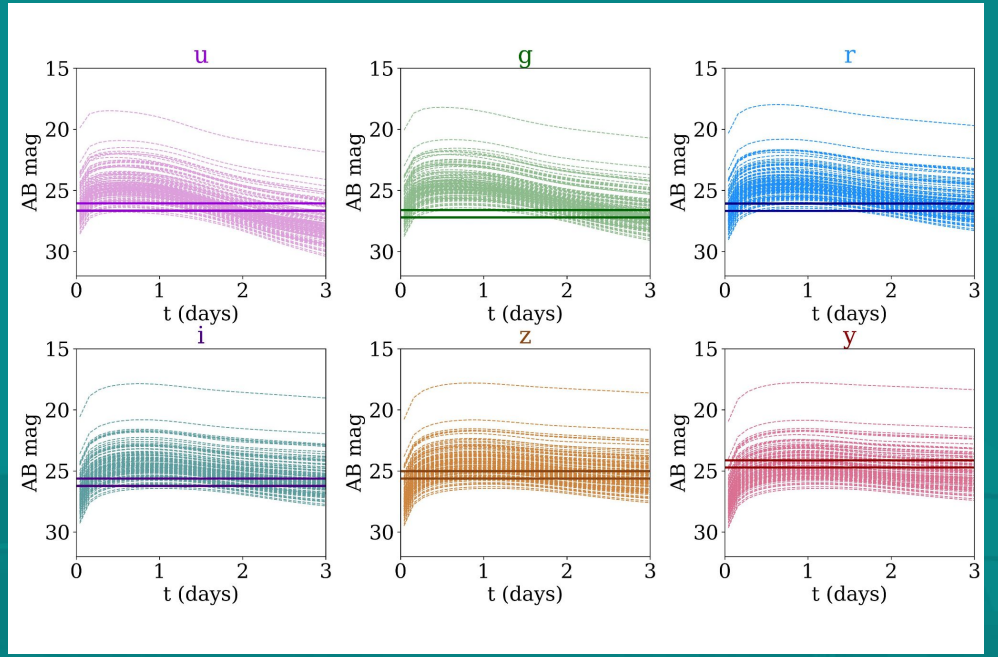
Hazra et al. 2023, in prep.:
Globular clusters using JWST

Joint detection strategies: Vera Rubin Observatory and Einstein Telescope

VERA C. RUBIN OBSERVATORY

3rd gen GW observatories like the Einstein Telescope (ET) will detect 100,000 binary neutron star (BNS) mergers each year, a fraction of which are expected to have detectable EM counterparts

We are developing observational strategies to follow-up BNS mergers and detect optical signals from kilonova transients using the Vera Rubin Observatory:
8 metre-class Optical Telescope in Chile



NSF NOIR Lab AURA SLAC U.S. DEPARTMENT OF ENERGY

With: Marica Branchesi, Eleonora Loffredo, Ulyana Dupletsa

Summary

Two-pronged approach to resolve the Hubble Tension:

- Reduce error bars on distance measurements from standard candles
- Calibrate new probes: gravitational waves, Observational strategies for EM+GW joint detections