Astronomy & Astrophysics: the next decade and beyond

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Research

- Stellar physics
- Galactic structure and evolution
- Interstellar medium
- Planetary / Extrasolar
- Solar physics
- High energy astrophysics

Stellar physics

- Stellar evolution
- Solar structure and evolution
- Stellar pulsation
- Nuclear astrophysics
- Explosive prcesses
- Helio / Asteroseismology
- Binary and multiple stellar systems

Galactic structure and evolution

- Chemical evolution and history of star formation
- Evolution of light elements
- Galactic model for star counts
- Open and Globular stellar clusters

Interstellar medium

- Large scale turbolence
- Star formation
- Dynamical processes

Planetary / Extrasolar

- Asteroids, comets
- Orbital and collisional dynamics
- Debris of star formation
- Extrasolar planetary formation
- Meteoroids and micrometeoroids
- Space weathering
- Astrobiology

Solar physics

- Corona structure
- Flare
- Turbolent dynamo

High energy astrophysics

- Novae and cataclysmic variables
- Pulsars
- Active Galactic Nuclei
- Acceleration processes

Main collaborations

- Many italian universities *(Bologna, Firenze, Roma, Padova …)*
- Many european universities *(Bonn, Chalmers, Heidelberg, Paris, Stockholm, Universitat Politècnica de Catalunya, …)*
- Many US universities *(Kennesaw State University, The Catholic University of America, University of Georgia, West Chester University, …)*
- INAF
- INFN
- NASA/STScI, ESO, ESA, Max-Planck Institüt fur Astronomie, Observatoire de la Côte d'Azur, …

Key open questions

- How do stars form?
- How do galaxies form?
- How do planetary systems form?
- What are the dark components?
- And then…

Collecting data…

The history of astronomy is a history of a continuing struggle against darkness

To achieve a deeper understanding of the Universe requires:

- peering deeper into the dark
- gathering ever larger samples
- obtaining ever higher precision

Origin and evolution of galaxies

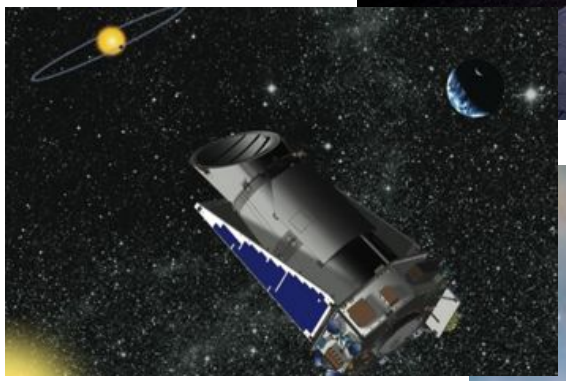
Complementary approaches:

- Detailed study of the local ancient stellar populations
- Observation of galaxies at different redshifts and thus evolutionary stages

Existing eyes on the Universe

- Radio: VLA, APEX
- IR: Herschel, Planck
- Optical/UV: HST, Kepler, VLT, Keck
- X-ray: Chandra, Swift
- Large Data Archives

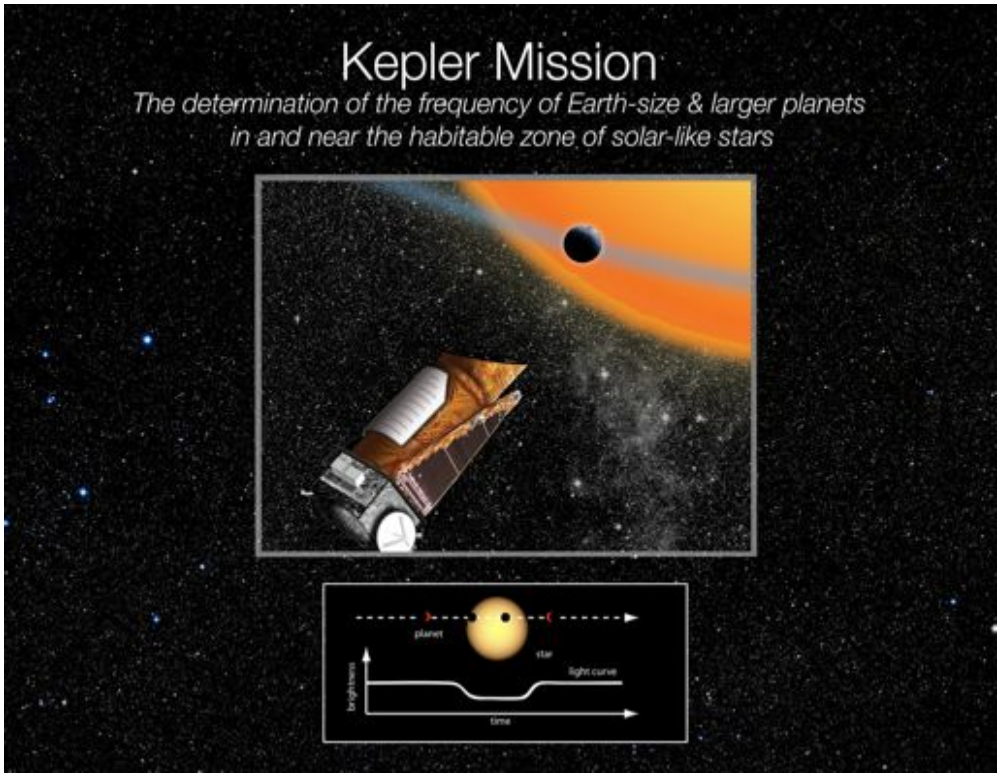





Kepler (2009)

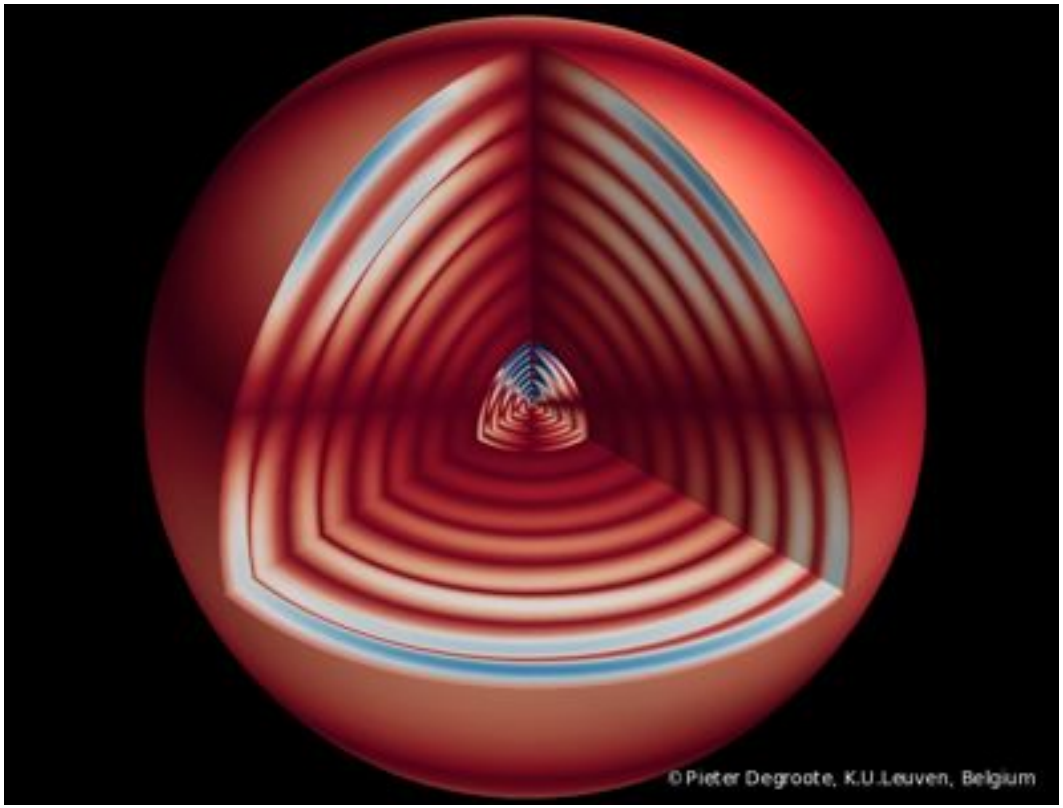
Science Objectives:

- Frequency of planets
- Terrestrial planets
- Properties of planet hosting stars
- Asteroseismology



Kepler

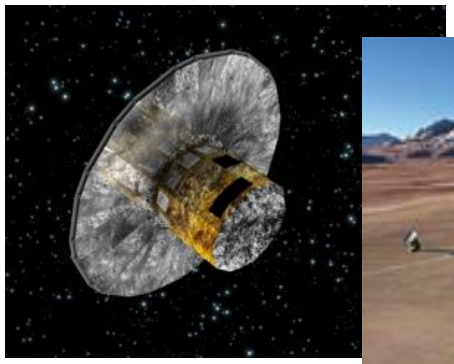
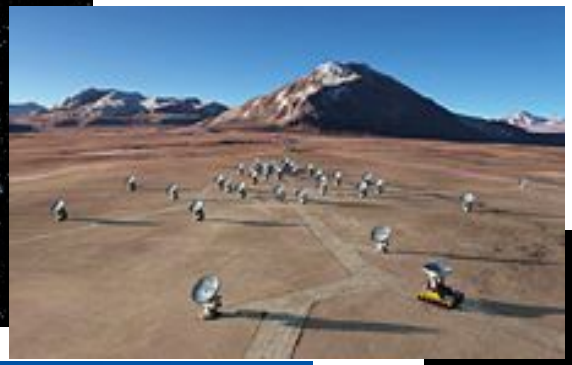
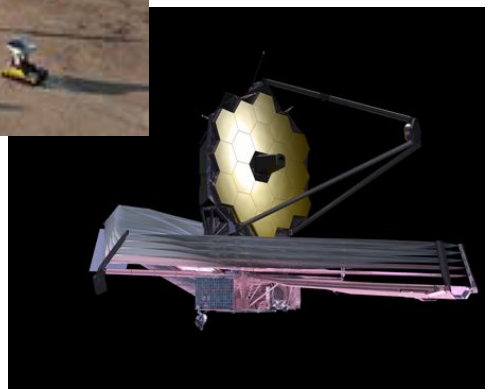
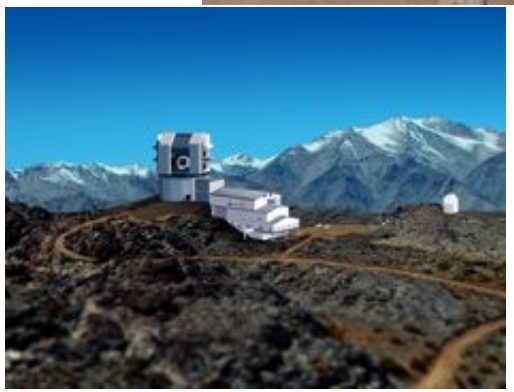
- The smallest extrasolar planet ever discovered: 1.4 Earth
- 1235 planets candidates
- Pulse of distant stars
- Echoes from the depth of a red giant star



Science (2011), 332, 205

New eyes on the Universe

- 2012: GAIA
- 2013: ALMA
- 2015: JWST
- 2018: LSST
  TMT
  E-ELT
- 2024: SKA

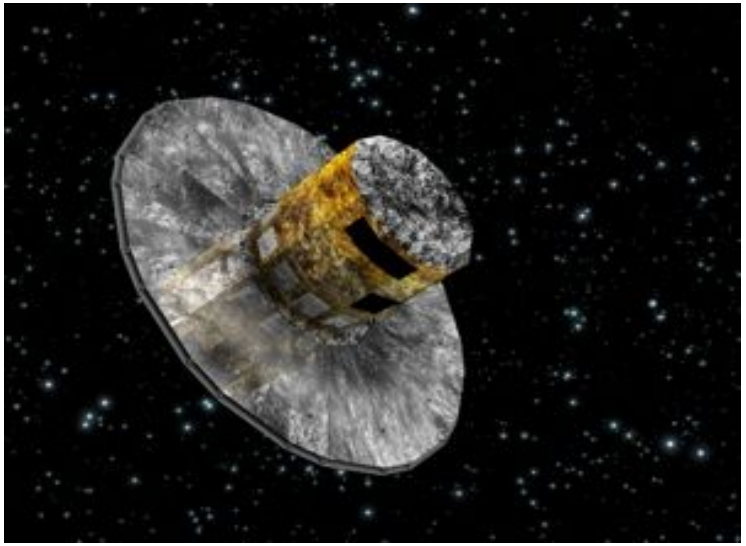





Global Astrometric Interferometer for Astrophysics (2012-2020)

Determination of the:

- distances
- dynamics

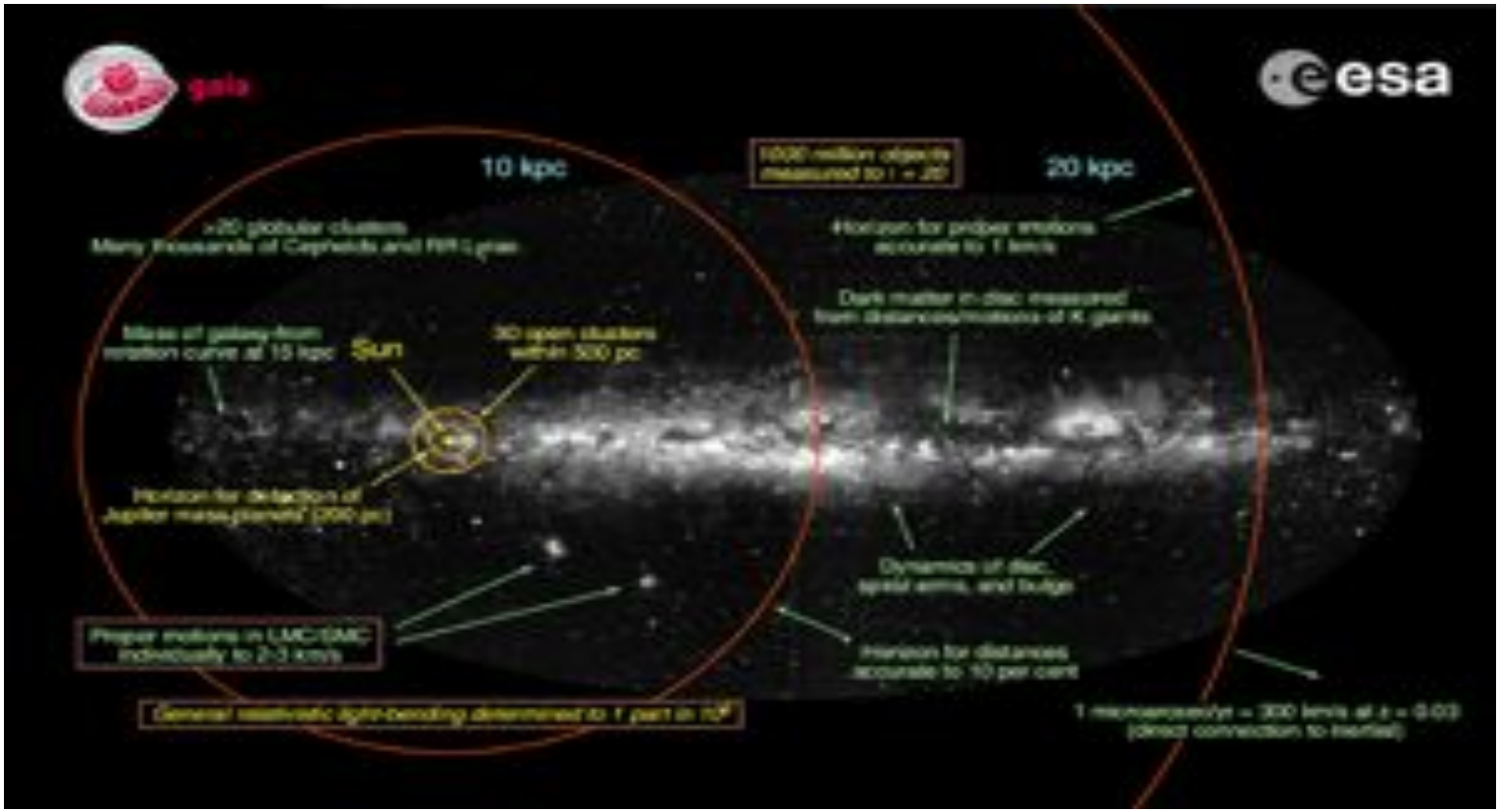
for 10^9 stars with very high precision



3D map of the Milky Way

Cost: 1 billion dollars

GAIA

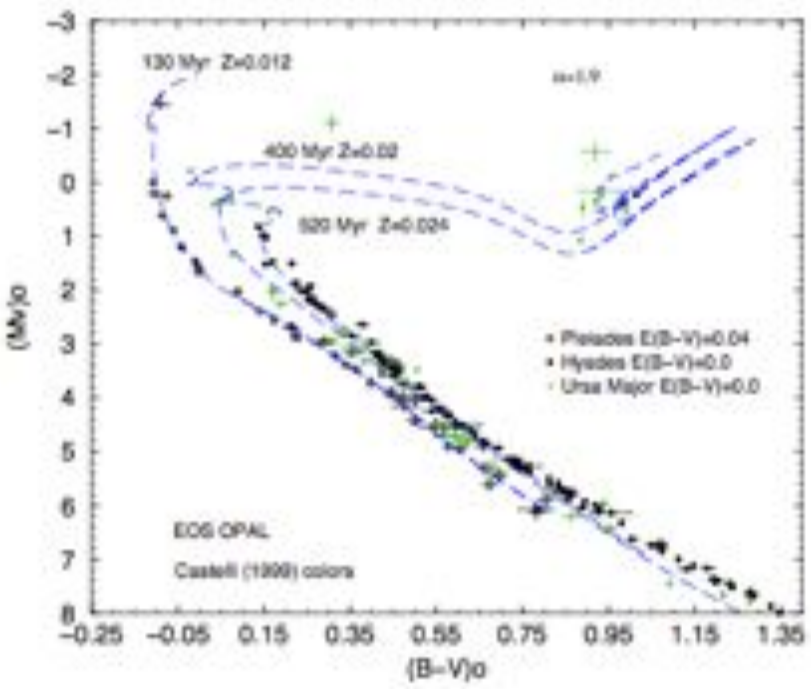

gaia
esa
10 kpc
20 kpc
Sun
Dynamics of disc, spiral arms, and bulge

HIPPARCOS (1989-1993)

Test of metal rich stellar models:

- *MNRAS (2001), 320, 66*
- *MNRAS (2002), 334, 193*

GAIA will revolutionize this kind of studies

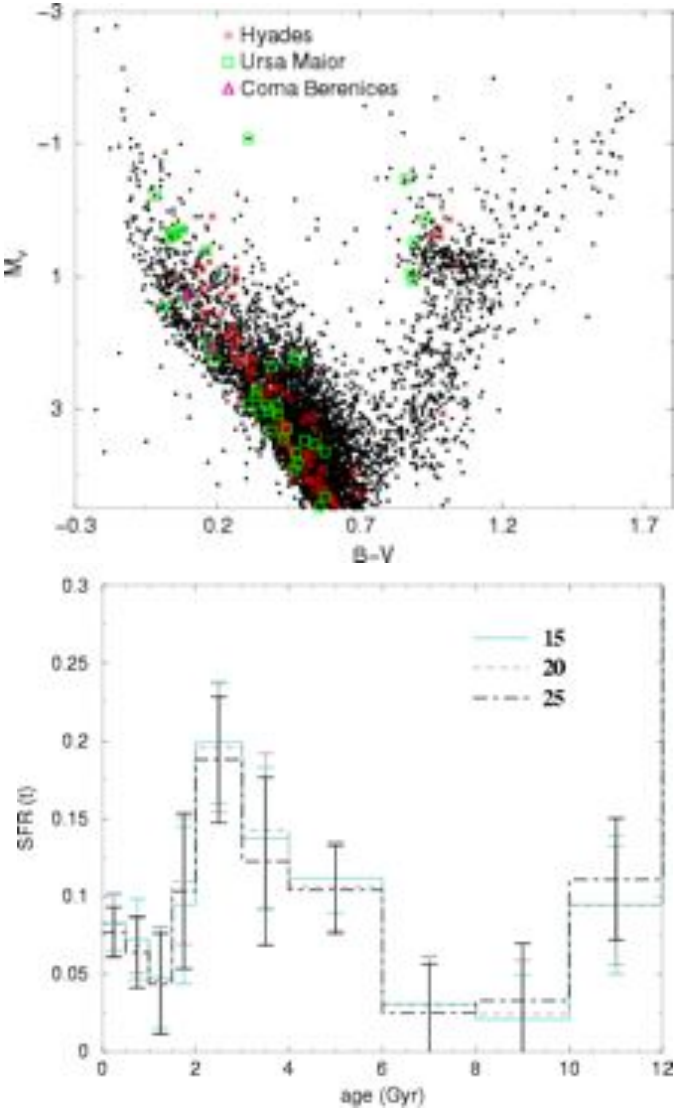


HIPPARCOS

- Solar neighbourhood star formation history
  A&A (2006) 459, 783

- Helium-to-metal enrichment ΔY/ΔZ
  A&A (2010) 518, 13

GAIA will dramatically increase both the dimension and the quality of the sample



GAIA

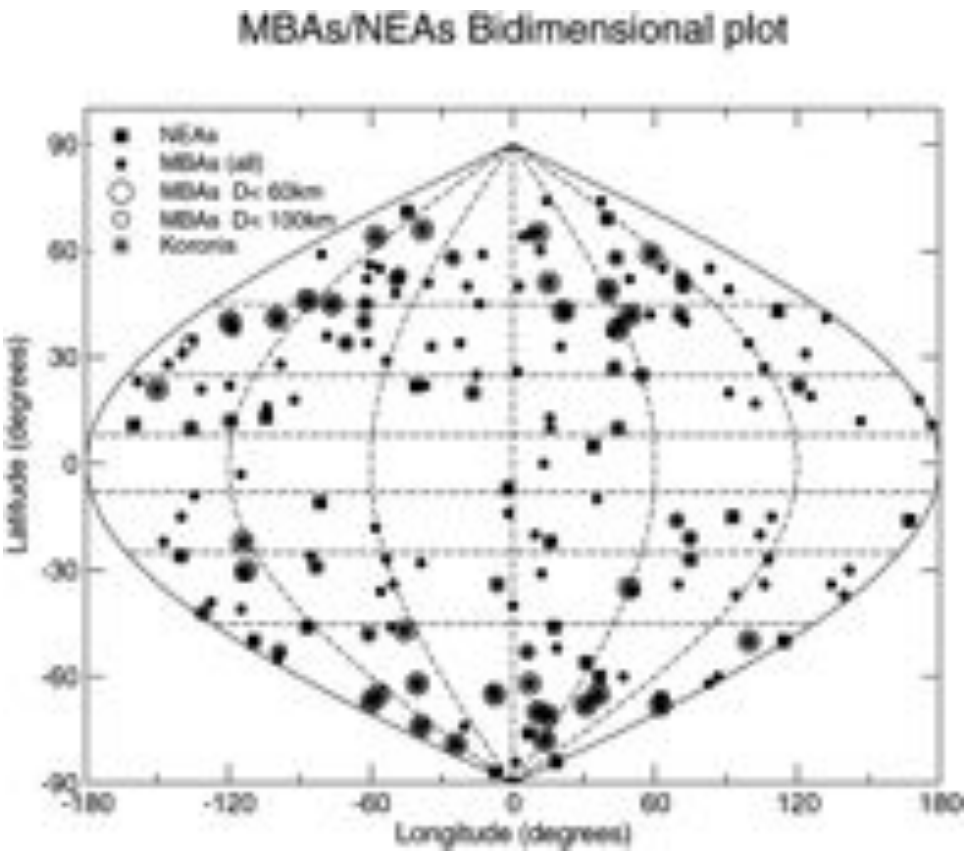
- Rotational properties of asteroids

  Nature (2004) 428, 400

  Icarus (2007) 192, 223

  A&A (2008) 490, 387

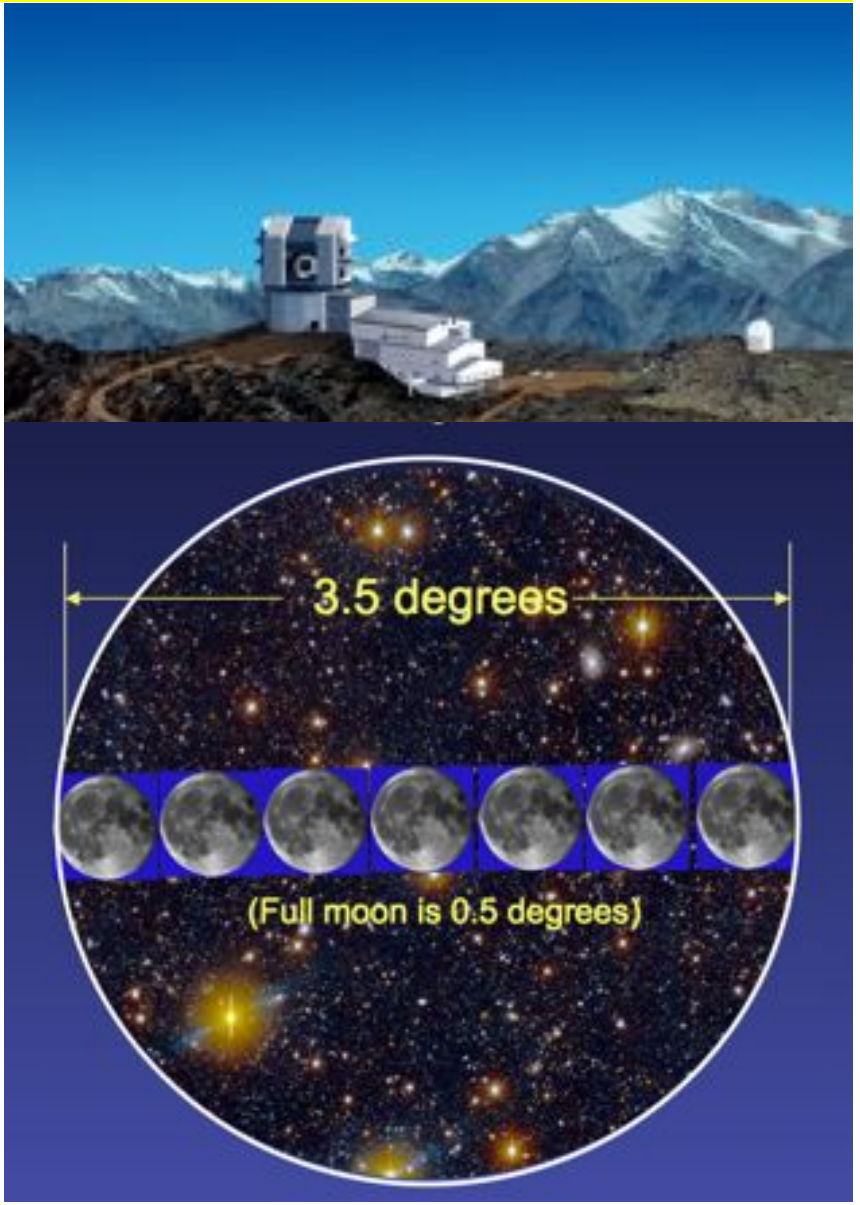
GAIA will increase the database by **two orders** of magnitude



"Scienza asteroidale prima e dopo Gaia" (Pisa 4-6/5/2011)

Large Synoptic Survey Telescope

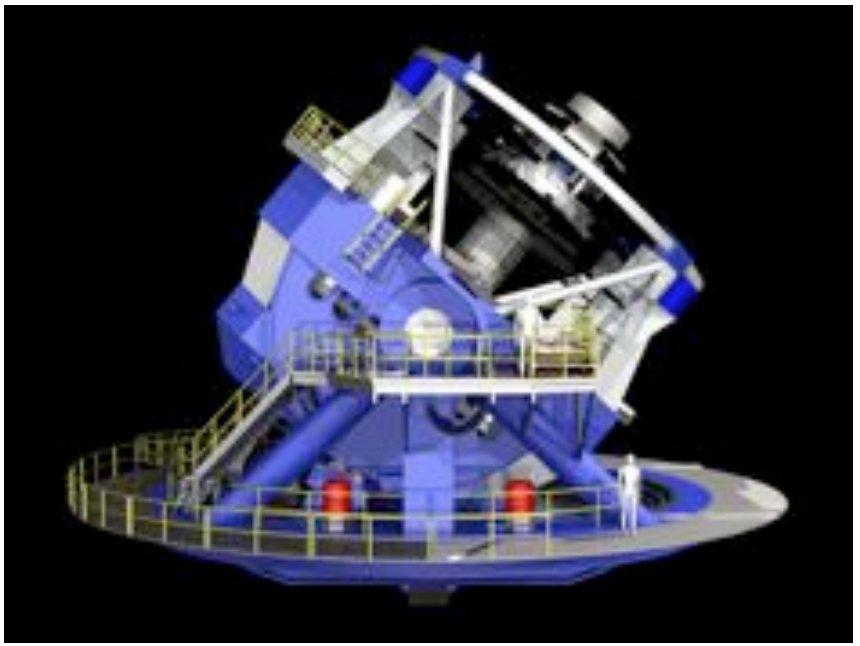
- First light 2019
- Camera: 3.2 Gigapixel
- Primary diameter: 8.4 m
- Field of view: 3.5^{o}
- 30 Tb /night
- 6 filters (ugrizy)
- Construction cost: 500 million dollars



LSST

Science Objectives:

- Solar System
- Optical Transients
- Galactic Stucture
- Dark Matter



LSST

Huge and **immediately free** archive with:

- 10^{10} MS stars
- RR Lyrae and Classical Novae within 400 Kpc
- Sizeable fraction of galactic VLMS, BDs, WDs
- Spatial and dynamical map of the MW
- Rare/Transient events: Novae, SN, …
- 10^{10} galaxies

A new temporal scale will be accessible…

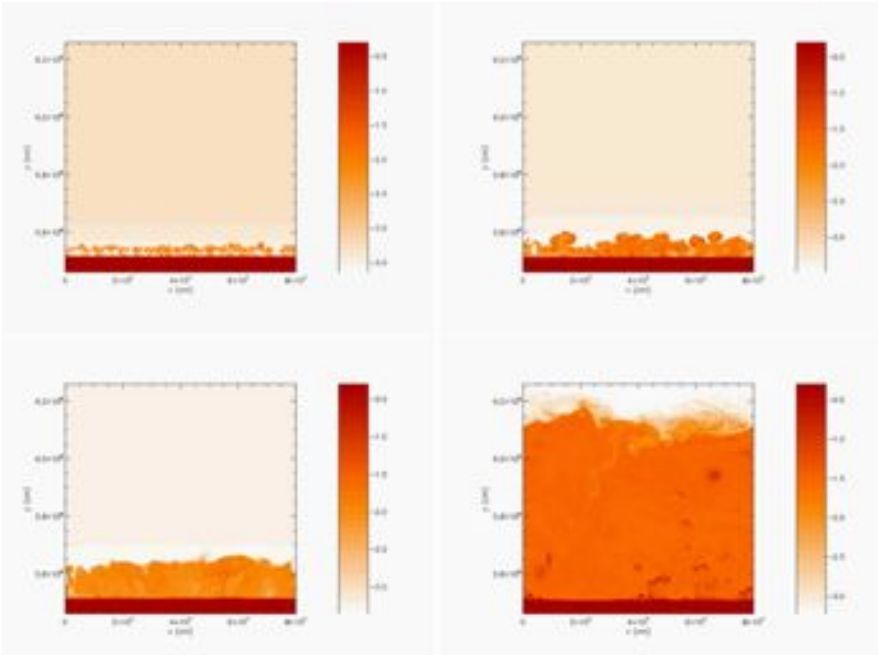
Novae

- Mixing in Classical Novae

  A&A (2011) 527 , 5

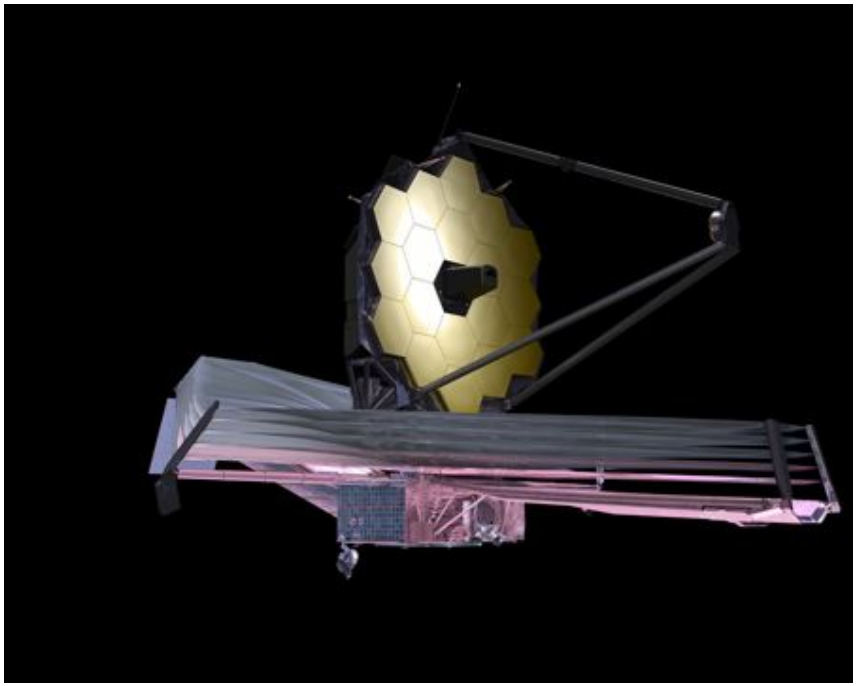
  A&A (2010) 513L, 5

  A&A , in preparation



James Webb Space Telescope

- First light 2015
- Primary diameter: 6.5 m
- Optical resolution: ≈0.1 arcsec
- It will detect objects 10 to 100 times fainter than HST limit
- 0.6-27 μm
- Project cost: 4.5 billion dollars

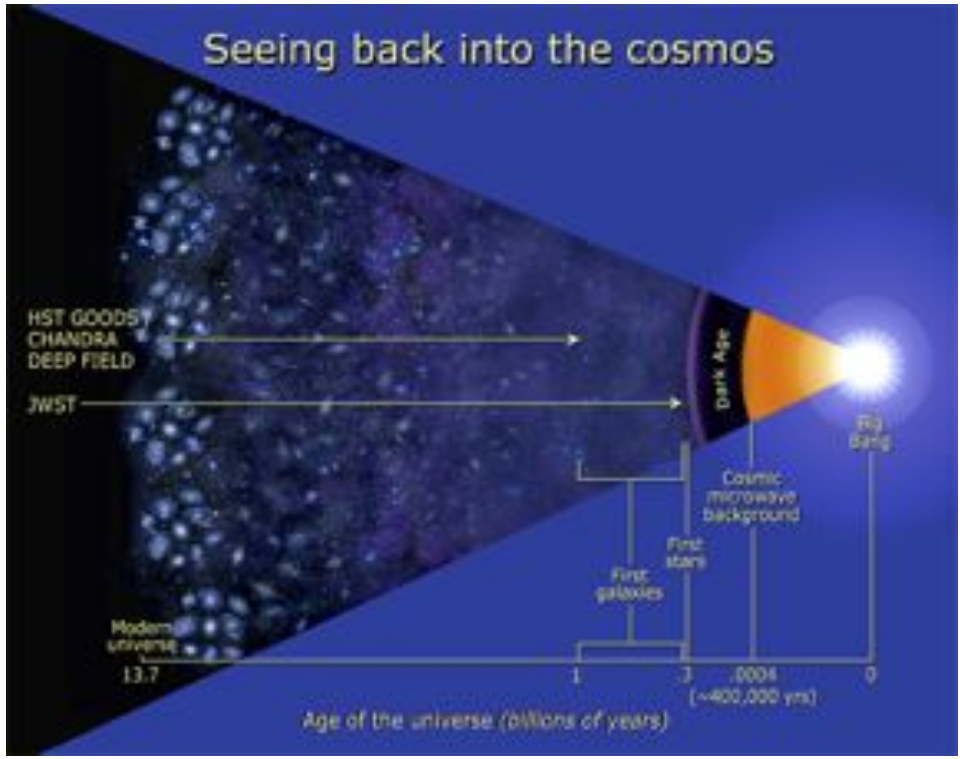


JWST

Science Objectives:

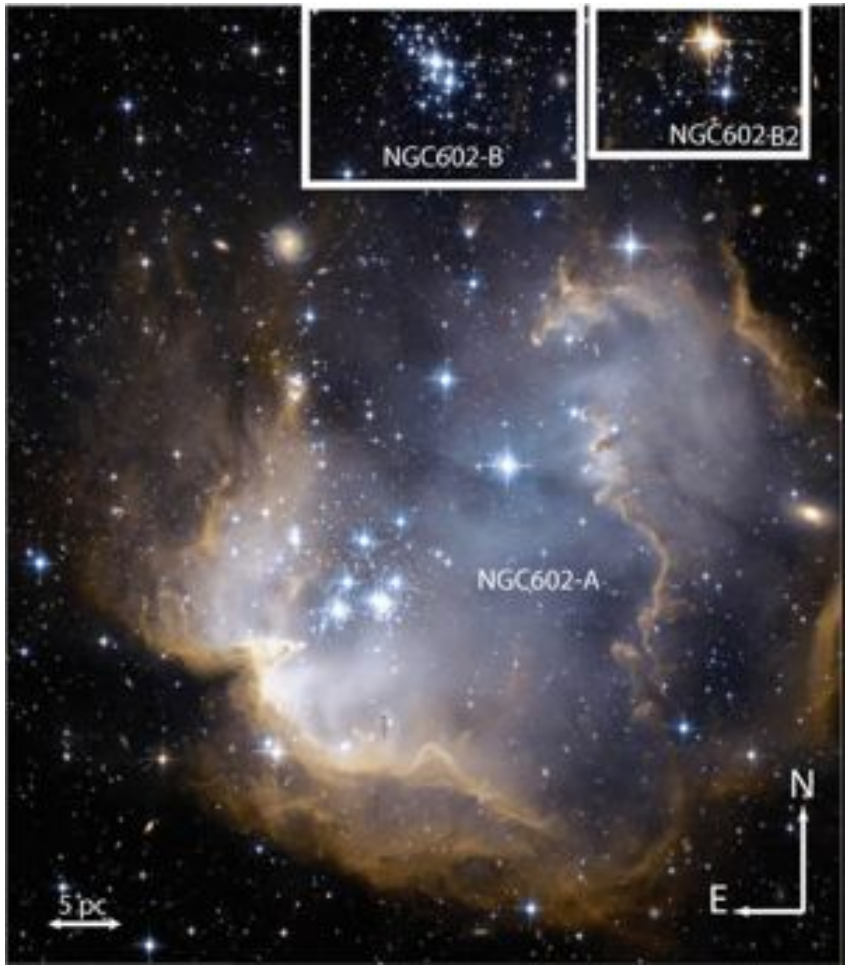
- First light

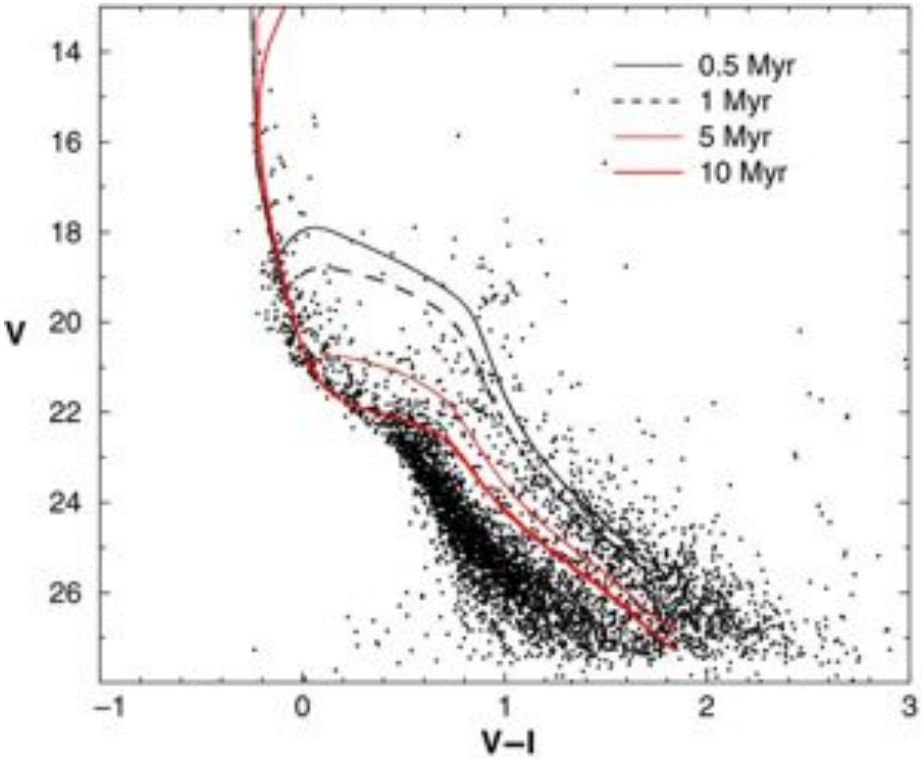
- Birth of stars and protoplanetary systems



SMC: NGC602

Star formation history of young clusters…





AJ (2009) 137, 3668

ApJ (2010) 712L, 63

ApJ, submitted

A&A, submitted

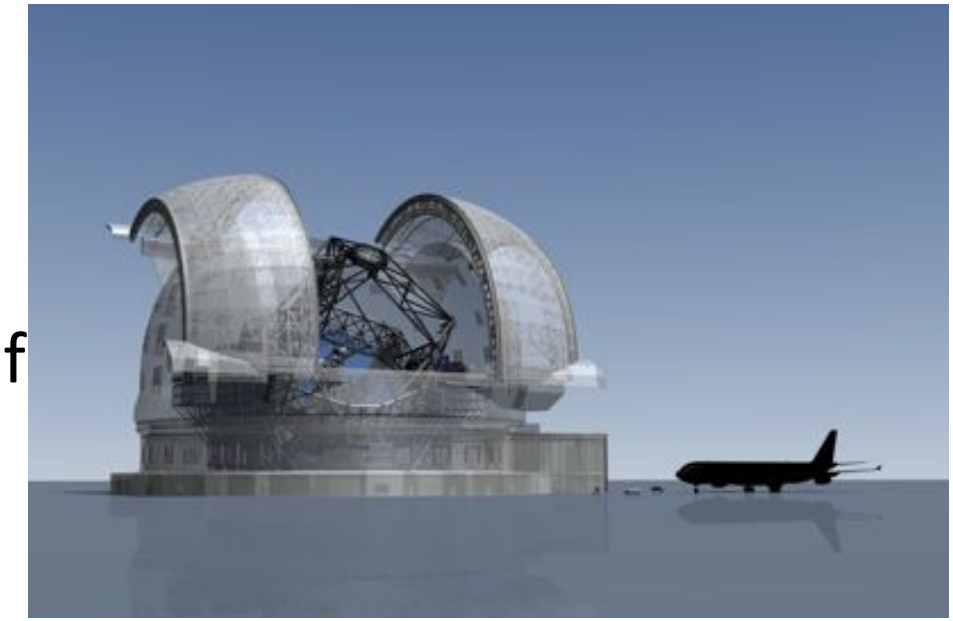
European Extremely Large Telescope

- First light 2018
- Primary diameter: 42 m
- **>100** more sensitive than Keck *(2x10m)* and VLT *(4x8.2m)*
- Precision photometry
- High angular resolution
- High Resolution Spectra
- Construction cost: 1.5 billion dollars

E-ELT

Science Objectives:

- Extra-solar planets
- Resolved stellar populations in a representative sample of the Universe
- Physics of high redshift galaxies
- Comsology



Atacama Large Millimiter/ submillimiter Array

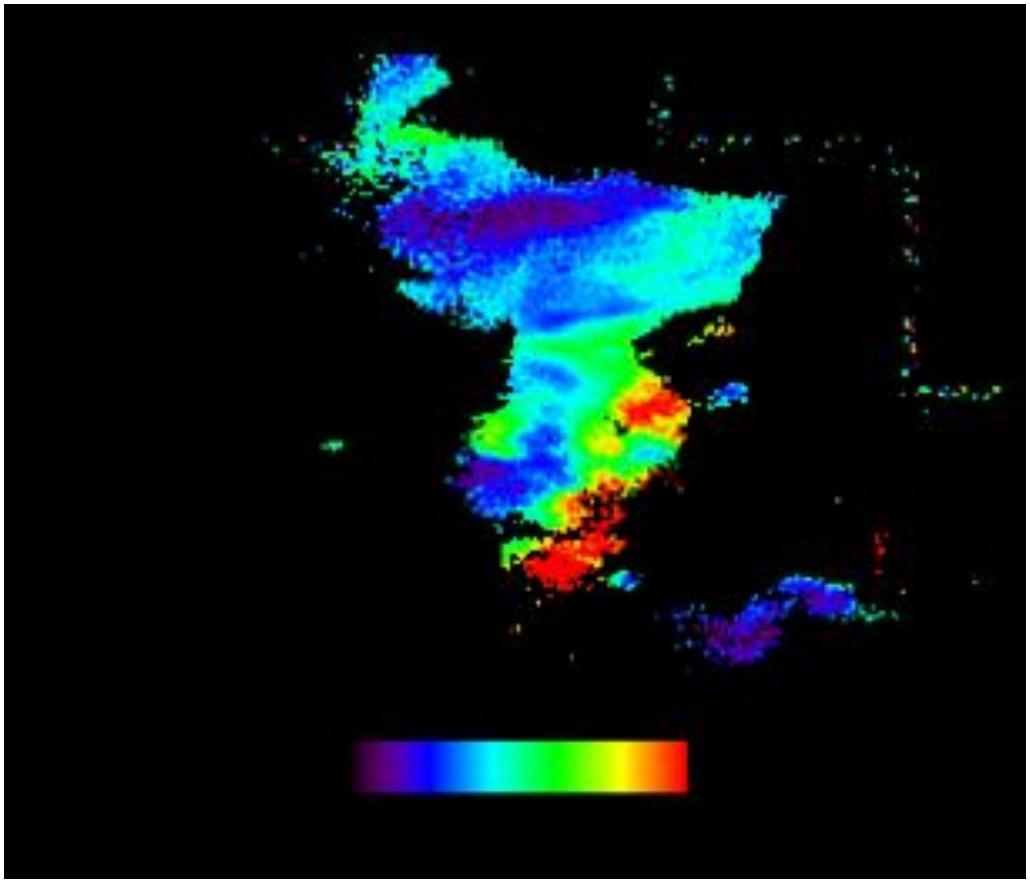
- Completed in 2013
- The most powerful telescope at submillimeter/ millimeter wavelengths
- 66 antennas
- Baselines: 150 m – 16 Km
- Max resolution: 6 mas at 675 GHz
- Cost: 1.3 billion dollars

ALMA

Science Objectives:

- First stars
- Star and planet formation
- Chemistry of giant clouds

ALMA



- Random flows and diagnostics of turbulence in the high latitude cirrus

  A&A (2006) 457, 197

This is a nearby (100 ly) Galactic cloud, **ALMA** will be able to do the same thing for all galaxies in the Local Group, to ≈ **10 Mly**, with almost the same velocity resolution.

“The history of astronomy is a history of receding horizons” (E. Hubble)