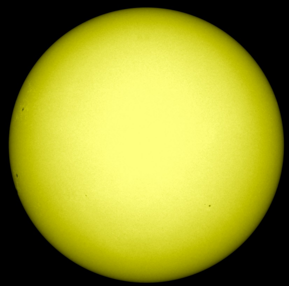
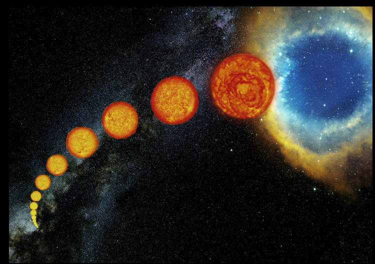
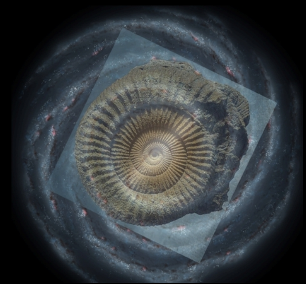
ASTROFISICA DELLE STRUTTURE COSMICHE BARIONICHE

FABRIZIO FIORE, FRANCESCO PALLA, ADRIANO FONTANA, MARCELLA MARCONI, LEONARDO TESTI

1.4-1.7 SOLE & EVOLUZIONE → DISTANZE → ASTROARCHEOLOGIA → FORMAZIONE STELLARE COSMICA







1.5 IL SOLE E L'EVOLUZIONE STELLARE

Si ringraziano per i contributi:

D. Spadaro (coord), F. Berrilli, I. Ermolli, F. Zuccarello, M.P. Di Mauro, G. Consolini…

S. Cassisi, A. Chieffi, S. Cristallo, S. Degl'Innocenti, M.P. Di Mauro, L. Girardi, M. Limongi, P. Marigo, A. Pietrinferni, E. Poretti, P.G. Prada Moroni, R. Silvotti, O. Straniero…

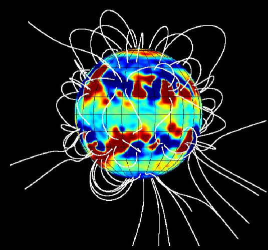
E. Antonello R. Ventura, G. Catanzaro, A. Buonanno, F. Leone, A. Frasca, V. Ripepi, C. Maceroni, R. Claudi, S. Benatti, M. Rainer, S. Pastori, F. Borsa, P. Ventura…

PLATO Team – stelle & evoluzione stellare

1.5 SUN AS A STAR: FRONTIERS

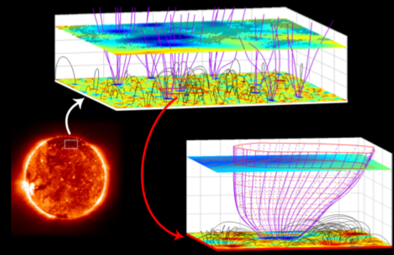
Sun as a laboratory for Basic Physics & Space Weather

I. Origin/Evolution of the Magnetic Field



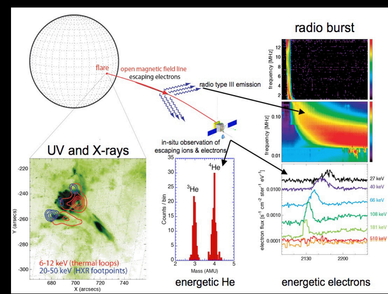
- → Emergence, diffusion & disappearance
- → Total magnetic budget & activity

II. Formation of a Hot Corona



- → Atmosphere's expansion
- → Winds & their sources

III. Energy Release & Particle Acceleration

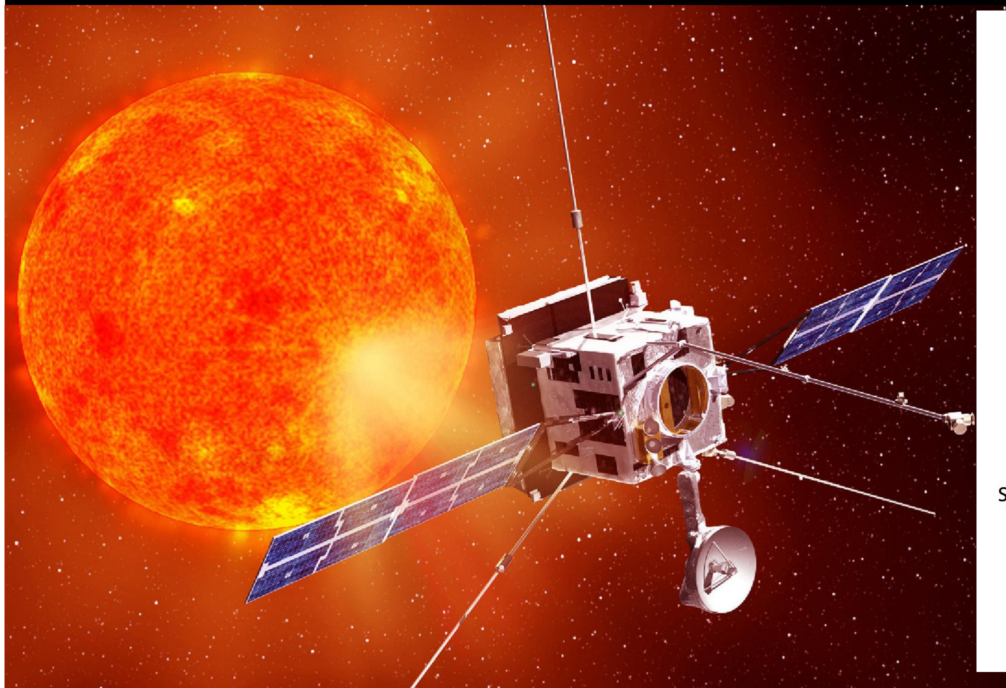


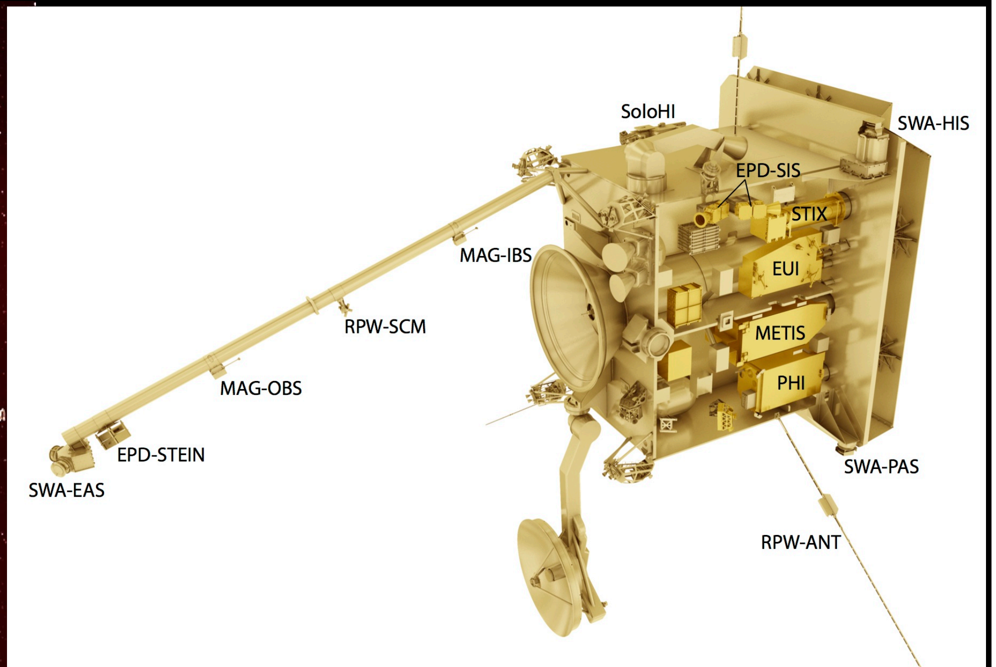
- → Onset of flares & CMEs
- → High energy particle acceleration:
  how and where?

1.5 SUN AS A STAR: INFRASTRUCTURES

Solar Orbiter (ESA-NASA) → 2018

→In-situ & remote-sensing instruments: corona & photos.
→Orbit: d~0.28 AU → inner heliosphere
~corotation for several days → time develpment
high inclination>30^0 → out of ecliptic measures





1.5 SUN AS A STAR: INFRASTRUCTURES

Solar Orbiter (ESA-NASA)* → 2018

Frontier I. Dynamo: FIRST observations of polar regions & whole meridional circulation

Frontier II. Hot Corona: regions responsible for solar wind
→ synergy in-situ & remote-sensing instruments
→ heating & acceleration solar wind at all latitudes

Frontier III. Particles: sources of energetic particle in impulsive events & their propagation in heliosphere

Solar Orbiter (ESA-NASA)* → 2018

Involvement

~80 researchers for three experiments: METIS, SWA, STIX

- 1 PI METIS: coronograph for remote sensing corona
  simultaneous EUV, UV, VIS emission 1.5-4 $R_\odot$
  link solar atmpshere → inner heliopshere

- 1 Co-PI SWA: in situ wind → ion, electron bulk properties
  from 0.3-1.4 AU + ion composition C N O Fe...

- 42 Italian Co-Is, including 7 members of Project Office of METIS

* Solar Probe + (NASA: 2018) → d=9 $R_\odot$ - probe outer corona

1.5 SUN AS A STAR: INFRASTRUCTURES

EST – European Solar Telescope

→2011: end design study → construction?
→Budget of ~25 (12) M€ from FP7 & H2020
→ASTRONET high priority for medium-sized project
→ 50% Total cost from Spain & Germany – rest TBF
→ESFRI Letter of Support from INAF + 3 Univ. :
help to raise €

I. Characteristics

- Optical design & instruments optimised for NUV-NIR spectropolarimetric obs of photosph/chromosph/low corona

- Focal plane Instr.: Broad Band Imager & Spectropolarimetrs

- Use of MCAO for all instruments

EST – European Solar Telescope

II. Science Goals

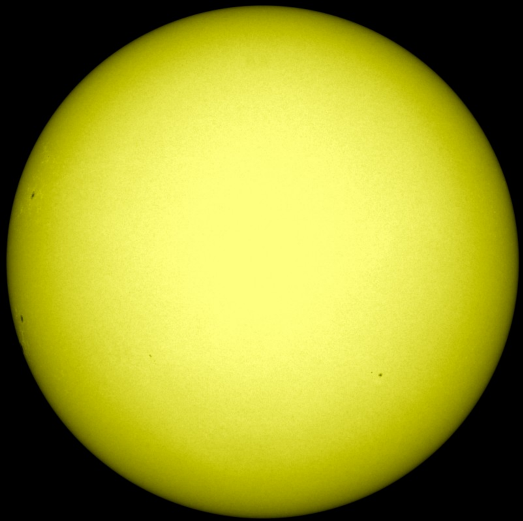
→ same Frontiers as SolOrb, different probes

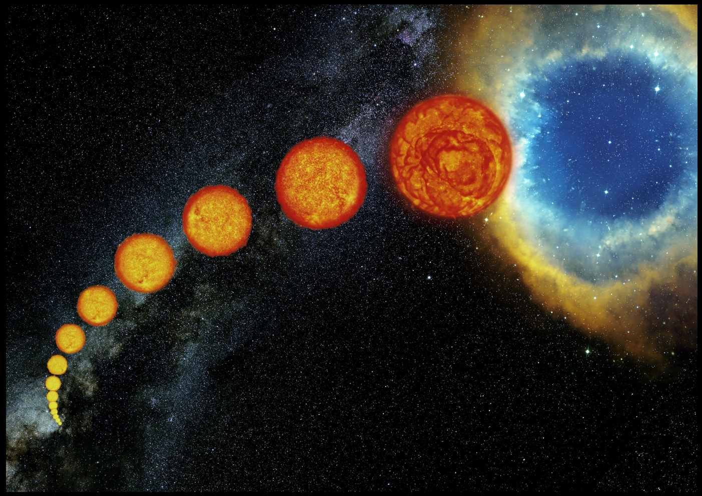
III. Involvement

- ~80 researchers including INAF, University, CNR & SME
- involved in science requirements, broad-band imager, protoptypes, telescope control, deformable mirrors, AO, detectors, site characterisation

IV. Sinergy with DKIST (ATST): complementary instruments different time coverage… but timing: 2019 x DKIST

1.5 SOLE & EVOLUZIONE STELLARE





Huge amount of high quality observational data (CoRoT, Kepler, Gaia, ...) requires progress in models & statistical methods for comparison with observations

1.5 EVOLUTION - FRONTIERS

Treatment of mixing processes

→ Turbulent convection in 3D
→ Overshooting/semiconvection
→ Rotation induced and thermohaline mixings

→ Need for 3D models; computing & expertise

Non-canonical physical processes

→Rotation and related mixing phenomena
→Magnetic field (observational and structural effects...)
→Mass-Loss in various evolutionary stage

→Need for new physics in models

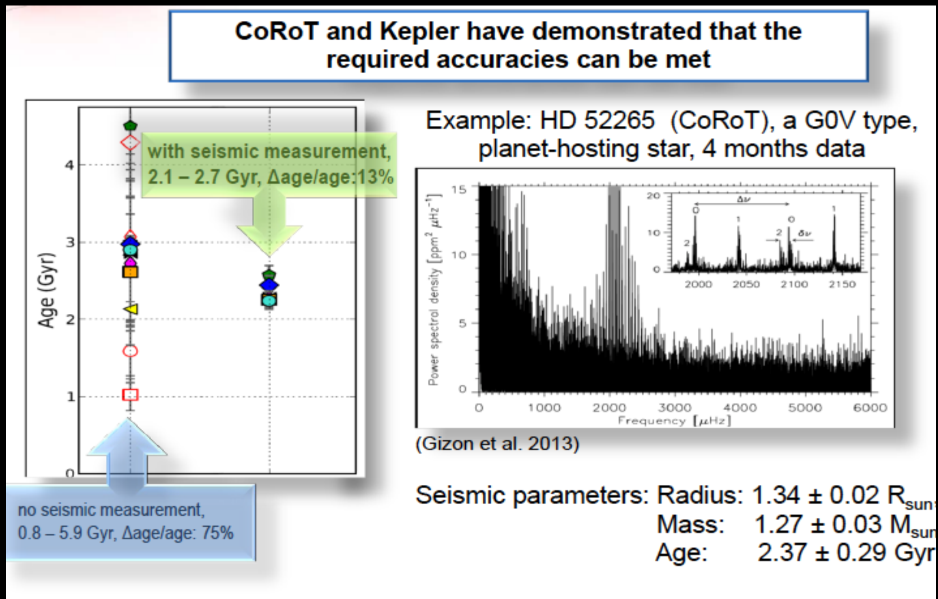
Constraints from stellar pulsation models

1.5 EVOLUTION - ASTEROSEISMOLOGY FRONTIERS

Breakthrough : Obtain for STARS same results obtained for the SUN from helioseismology

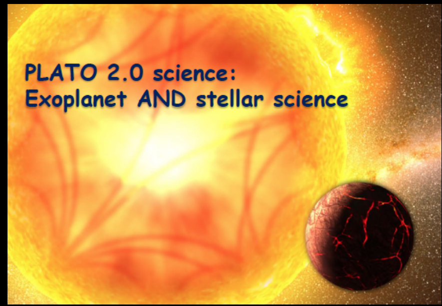
Characterization of exoplanets…
- Mass + Radius → mean density
- Orbital distance, atmosphere
- Age

needs characterization of stars
- Stellar Mass & Radius
- Stellar type, L, activity
- Stellar Age



	Solar-type stars		
	R	M	Age
Only with frequency separation	2.2%	4%	35%
With individual frequencies	0.3%	0.8%	3.7%

1.5 EVOLUTION - ASTEROSEISMOLOGY INFRASTRUCTURES: PLATO (2024)



- Seismology of 85000 stars: → $R_\star$ $M_\star$ ~2% - $t_\star$~10%
- Identify missing physics in stellar models
- 50% sky coverage + stellar ages: stellar population studies, chemical and dynamical evolution of the galaxy
- Large samples of, e.g., pulsating stars in multiple systems, pulsating eclipsing binaries, hybrid pulsators, etc. etc.
- 18 INAF researchers (4 leaders WP on Stellar Physics)

Complementary ground-based robotic network
→high order l-modes ... italian participation?
Site: 2 M€ // less € for Steering Committee

SONG
STELLAR OBSERVATIONS NETWORK GROUP

1.5 EVOLUTION - FRONTIERS
NUCLEAR ASTROPHYSICS

$C^{12}+\alpha \rightarrow {}^{16}O$: accurate measurements Cross Sections crucial for several problems

→ how much C/O is produced by stars?
→ synthesis & light curves SN Ia &IIp

Mg/Al & Ne/Na cycles : relevant for

→ AGB nucleosynthesis in the context of GC pollution & multipopulations
→ neutron capture phenomena
→ all elements heavier than iron

→ Support synergy with nuclear physics teams (e.g. LUNA)
→ Accurate spectroscopy with HARMONI@E-ELT
→ Constraints on stellar chemistry: dust and molecules in AGB

1.5 EVOLUTION - FRONTIERS
NUCLEAR ASTROPHYSICS

C^{12}+C … ections

?

Mg/A … t of GC

Facilities for dust and molecule detection in AGB winds

	SKA	SRT	ALMA	JWST
sky	south	north	south	space
Wavelength coverage	3 - 400 cm	0.3 - 100 cm	0.3 - 10 mm	0.6 - 28 µm
Availability	2023	now	now	2018

MOLECULES

DUST

→ Support…
→ Accurat…
→ Constraints on stellar chemistry: dust and molecules in AGB

1.7 LA SCALA DI DISTANZA COSMICA, DALL'UNIVERSO LOCALE AGLI INDICATORI DELL'ESPANSIONE

Si ringraziano per i contributi:

M. Cantiello, S. Benetti, E. Cappellaro, A. Pastorello, M. Turatto, G. Bono, E. Brocato, G. Clementini, M. Dall'Ora, S. Leccia, M. Marconi, I. Musella, V. Ripepi, M. Della Valle, R. Buonanno, G. Fiorentino, M. Lattanzi, G. Raimondo, C. Cacciari, G. Altavilla, ...

Primary calibrators: Cepheids & RR Lyr

Secondary Calibrators: SBF, SN Ia & IIp

SCIENTIFIC FRONTIERS IN THE DISTANCE SCALE CALIBRATION : CEPHEIDS AS PRIMARY INDICATORS

State-of-Art

- Zero point based on LMC distance
- The PL is not universal ← chemical composition effects on both the slope & zero point (galactic & extragalactic environments)
- ULP variables: verify if massive Cepheids → direct estimate of H_0

Breakthrough ⇒

GAIA will provide accurate distances (typically few tens of μas for about 9000 Cepheids → final calibration of the zero point and the slope

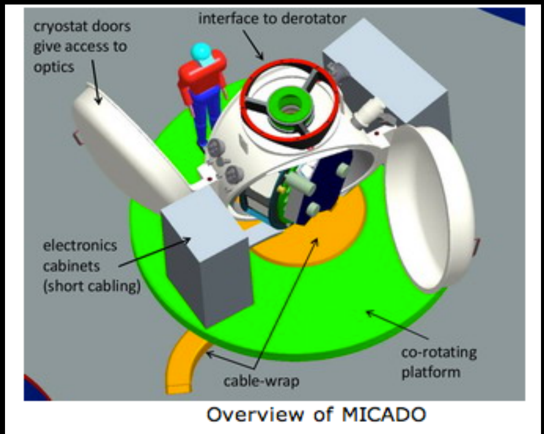
GAIA & VLT → metallicity effect on PL quantified in the MW

GAIA → measure of the parallax of Cepheids in the LMC (lower accuracy: direct distance to the LMC

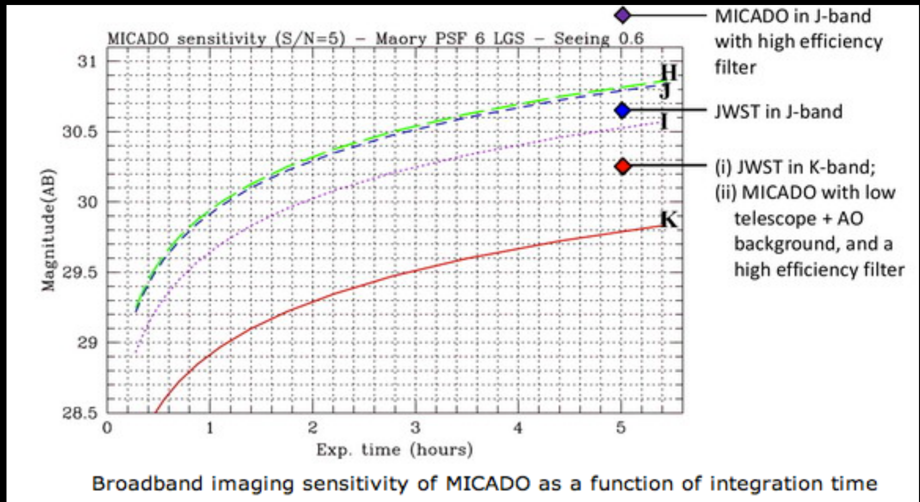
SCIENTIFIC FRONTIERS IN THE DISTANCE SCALE CALIBRATION : CEPHEIDS AS PRIMARY INDICATORS

Infrastructure — JWST → NIR and MIR PL relations: better than optical

Infrastructure — E-ELT CAM (MICADO) → classical Cepheids in the Coma Cluster: estimate of H_0 only using primary distance indicators!!



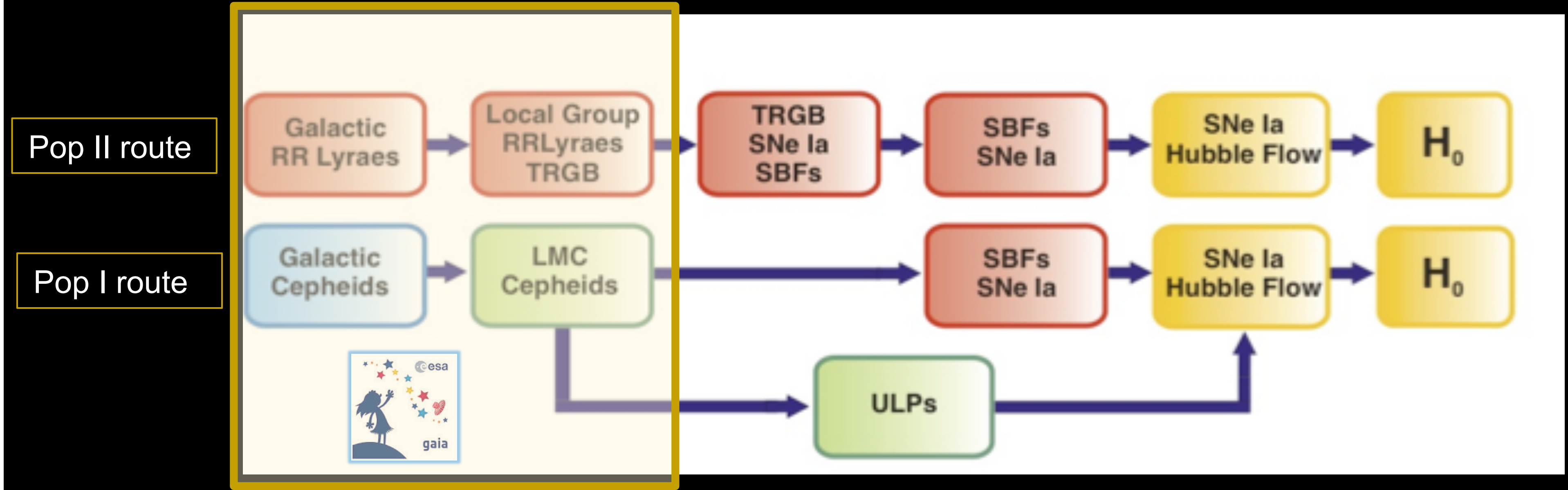
Overview of MICADO



Broadband imaging sensitivity of MICADO as a function of integration time

Infrastructure — VLT and ELT high resolution MOS → abundances of large extragalactic Cepheid samples → Z-effect on the PL outside MW

Need for an accurate Pop. II distance scale → RR Lyr: alternative route to H_0



GAIA+JWST+ELT→ obtain the absolute calibration of the extragalactic distance scale via Cepheids (<1%) and RR Lyr (few %)

Stellar Physics → obtain critical constraints from comparison with predictions of nonlinear pulsation models

SCIENTIFIC FRONTIERS IN THE DISTANCE SCALE
SECONDARY INDICATORS: SBF

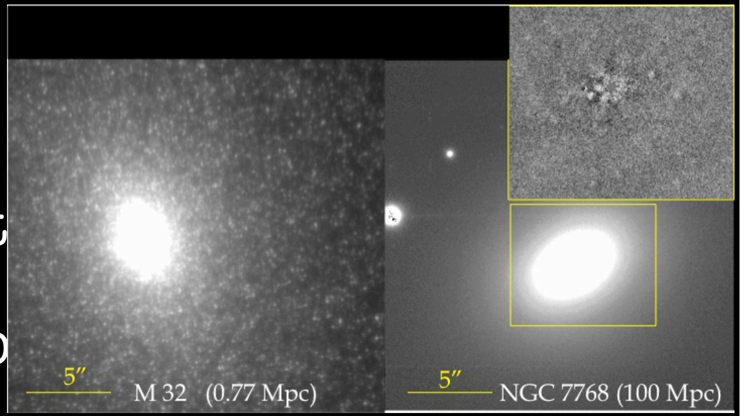
Now → SBF intrinsic accuracy on distance ~3%.

Challenge → reduce uncertainty by ~2-3 with an updated calibration approach: with Gaia (eg Cepheids)

Key goal → SBF surveys to secure at 3% the 'bridge' from local to cosmological distances (10-150 Mpc): HST, CFHT

Future

- JWST: stable PSF, large collecting area, efficient in NIR bands → factor of ~2-3 more than present distance limit
- E-ELT: better resolution JWST and much larger collecting area → factor ~3-5 more than present distance limit
- SKA: maser direct distance ~500 Mp



FRONTIERS IN THE DISTANCE SCALE
SUPERNOVAE IA → H_0 @ 1%

H_0 da SN Ia → 73±2 Riess+
H_0 da CMB → 68±1 Planck+BAO
→ formally inconsistent

If so, CMB value implies change in cosmological model

→ Are SN Ia solid?

FRONTIERS IN THE DISTANCE SCALE
SUPERNOVAE IA → H_0 @ 1%

GOAL: accurate event selection to reduce systematics

- Only normal SN Ia (deflagration of a ~1 M_{CH} WD) follow *Phillips rule* which is OK for distance ladder!
- Physics of diversity is the key to control evolution with Z

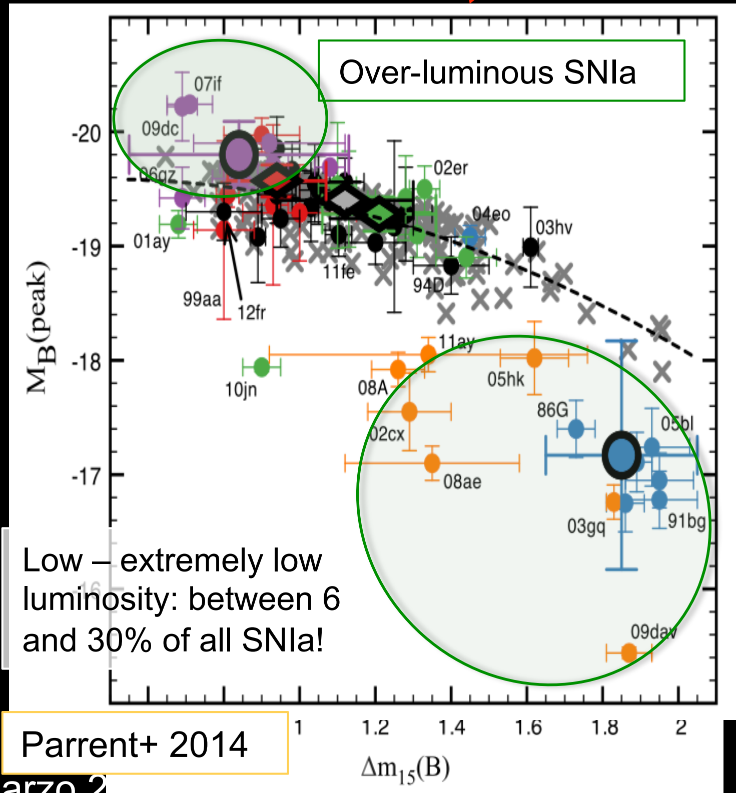
→ Need for better statistics → LSST

→ Reduce systematics : calibration & extinction

→ Need to explore a homogeneous and nearby SNIa sample from UV to NIR

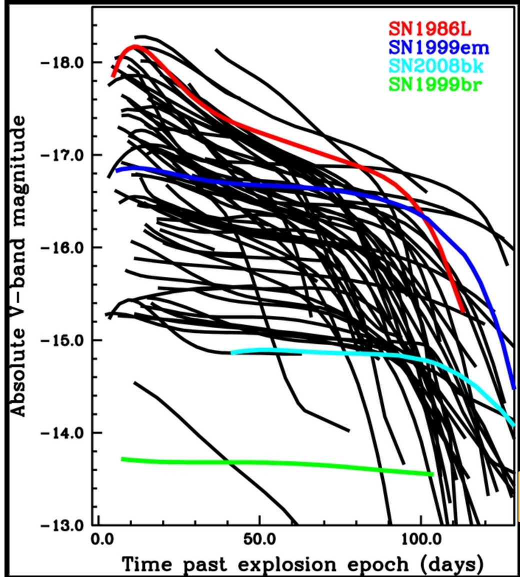
→ Missing spectroscopic follow-up

SOXS@NTT would be perfect



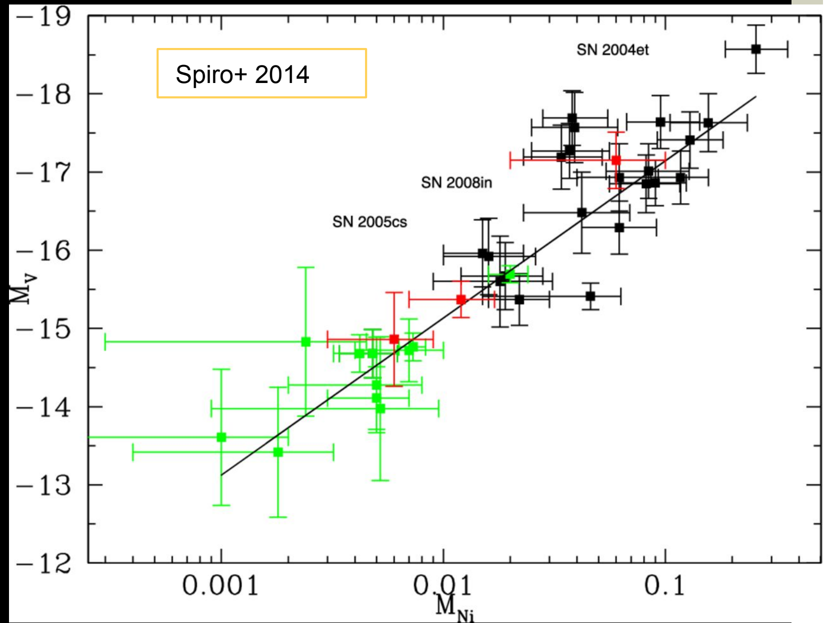
Parrent+ 2014

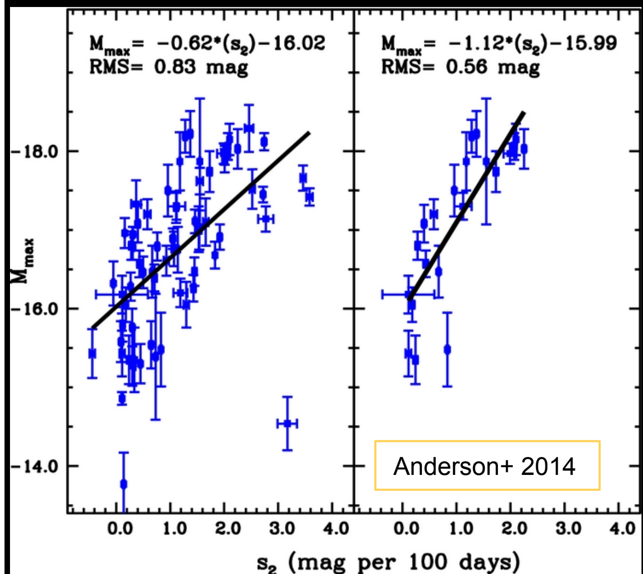
SCIENTIFIC FRONTIERS IN THE DISTANCE SCALE: SUPERNOVAE IIP



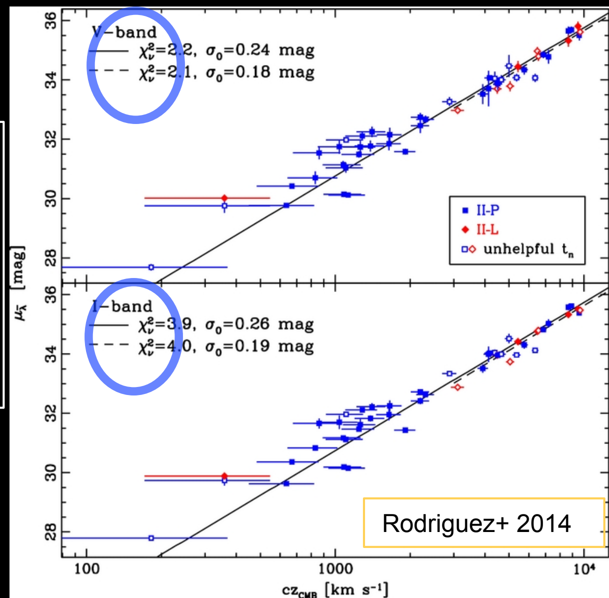
Anderson+ 2014

Wide heterogeneity… But with promising correlations!





JWST, ELT ➔ probe the geometry of the Universe up to z~5, independently of SN Ia!



1.6 L'ASTRO-ARCHEOLOGIA DELLA GALASSIA E DELLE GALASSIE VICINE

Si ringraziano per i contributi:

F. Ferraro, G. Fiorentino, G. Piotto, M. Bellazzini, G. Bono, A. Bragaglia, B. Bucciarelli, E. Carretta, M. Crosta, A. Curir, R. Drimmel, E. Franciosini, M. Franchini, E. Held, M. G. Lattanzi, L. Magrini, F. Matteucci, P. Molaro, C. Morossi, E. Pancino, S. Randich, D. Romano, R. Smart, R. Sordo, A. Spagna, M. Tosi, A. Vallenari, S. Zaggia, G. Clementini, L. Federici, I. Musella, V. Ripepi, F. Calura, D. Romano, R. Capuzzo Dolcetta…

I. Galactic archeology: Milky Way
II. Near field cosmology: dSphs/UFDs
III. Beyond LG → resolving galaxies to Virgo

GALACTIC ARCHEOLOGY

The most important event in the next 10 yr is the progressive release of Gaia data:

2017: first astrometric → 2022: final

Photometry & astrometry for 10^9 sources to V=20

Radial velocity for all stars with V<17.0

An extreme data analysis challenge:

data mining resources badly needed:

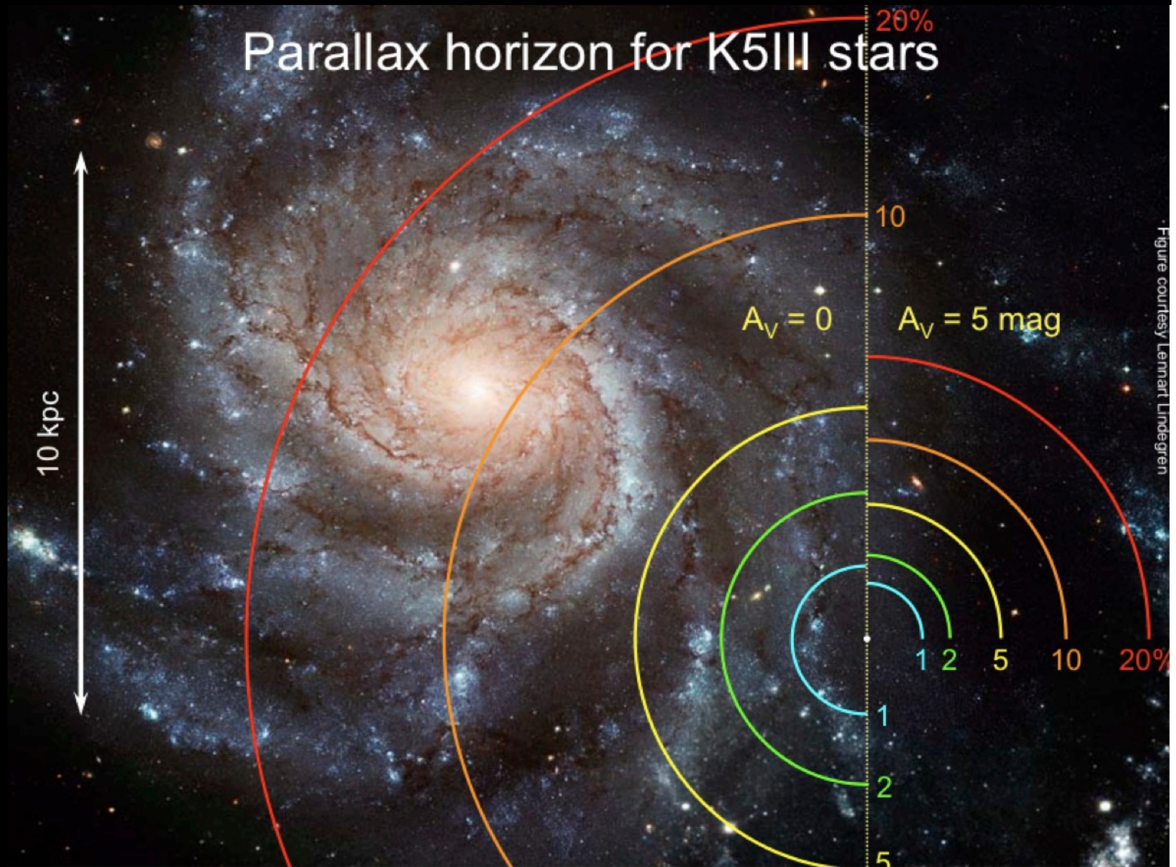
a) Software & hardware

b) Database design & operation

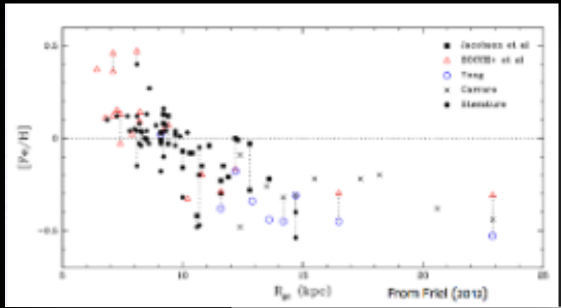
c) Expertise and training

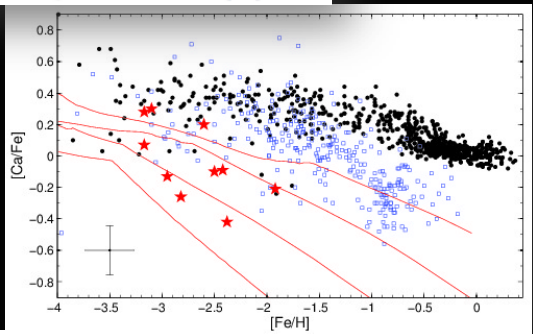
d) People & Money

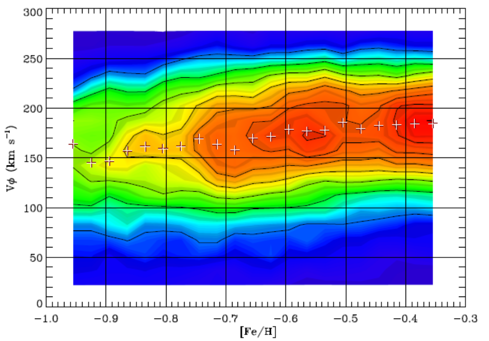
…or loose years of work by tens by Italian scientists. Exploitation of Gaia data would remain at the craftsman level.

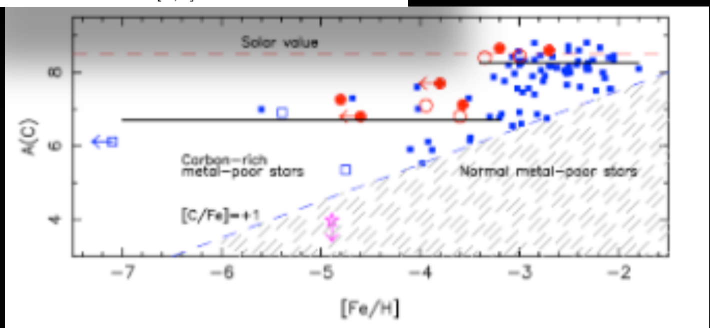


Galactic Archaelogy→ Surveys









Chemistry + kinematics and dynamics + very large homogeneous samples

- Formation of the thin disc – role of migration
- Is the thick disk of the Milky Way a “fossil” remnant of the formation of the disk? Or the product of secular processes?
- Is the warp of the Milky Way long-lived or transient? What is the mechanism that has formed this structure?
- Are halo substructures in the Milky Way consistent with CDM formation scenarios?
- Classical bulge or pseudo-bulge
- What was the nature of the first objects to shine through the Universe?

Revolution in the next few years thanks to Gaia plus GB spectroscopic **surveys**: Gaia-ESO and X-shooter (now), WEAVE, MOONS, 4MOST –(at European level- > 2017)

Galactic Archaelogy→ Surveys

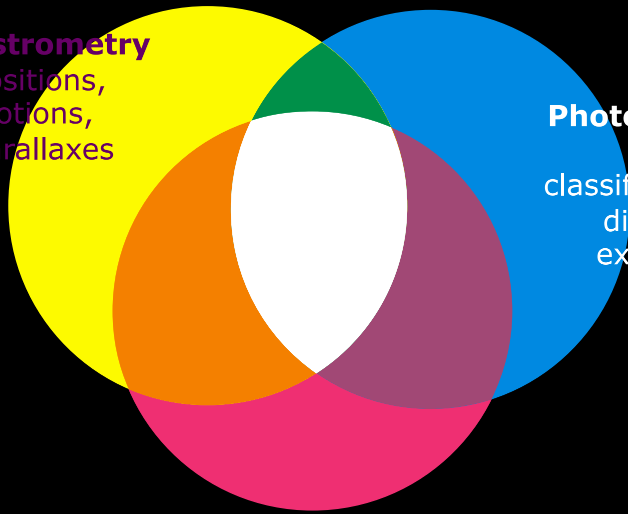
Space Missions:

- *HST*
- *Gaia*
- *Kepler*
- *CoRoT*
- *Euclid*
- *Plato*
- *JWST*
- *Gaia+*

Ground-based telescopes:

- LBT, VLT, VST, VISTA, TNG
- New WF multi-fiber spectrograph (WEAVE, 4MOST, MOONs)
- MUSE
- E-ELT → HIRES, MOS, MICADO,HARMONI, METIS

Optical and near-infrared



Infrastructures:

– Data Centers for analysis, storage, data access:
  - ASDC
  - Gaia Data Processing Center (host copy of the mission Data Base)
- **Computing capabilities** (e.g., CINECA, DPCT)
- Archival data mining

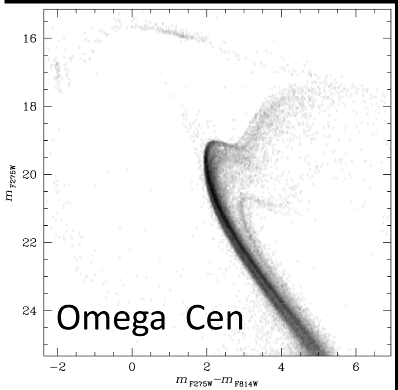
Large Surveys:

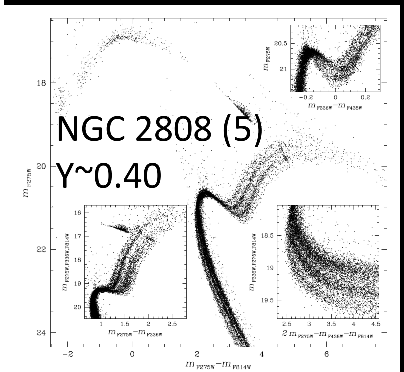
- **Gaia-ESO Survey**
- SDSS
- APOGEE, GALAH, LAMOST
- **WEAVE**, 4MOST, **MOONS**
- And E-ELT?

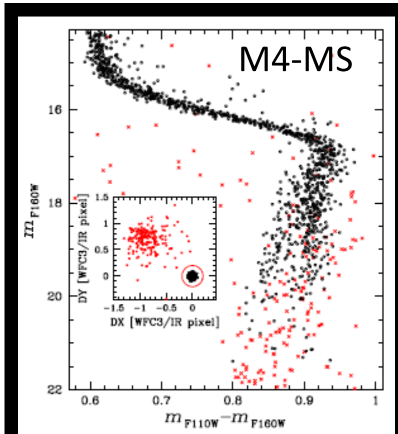
Models, simulations, tools:

- New generation of models in a fully cosmological context including chemical and relativistic dynamical evolution
- Synergy with stellar evolution and nucleosynthesis
- Improvement in NLTE, 3D, model atmospheres, spectral analysis, calibrations→ building up from Gaia-ESO

Galactic Archaelogy→ Globular Clusters and their multiple populations







No consensus on the processes leading to them →

- Mass must have been much higher (>x10) than now
- To reconcile spectroscopic & photometric observations need to assume a population enriched in He (Y<~0.40)
- Development of a strong blue/near-UV HB → new SED

Frontiers

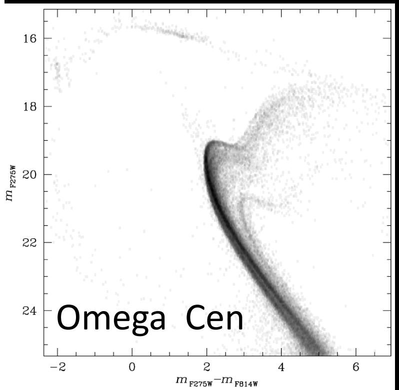
Globular Clusters formation

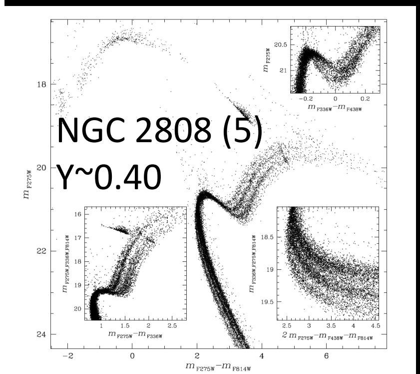
- Rrigin of the multiple populations
- Chemical enrichment processes, polluters and time-scales

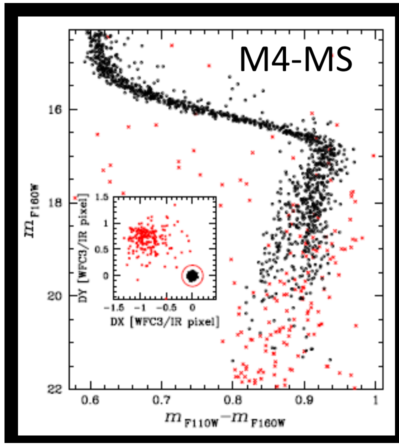
Dynamical evolution of stellar systems

- Star density and velocity dispersion profiles
- Dynamical age of stellar systems
- Formation of exotic objects (Blue Stragglers/msPulsars)

Galactic Archaelogy→ Globular Clusters and their multiple populations







Breakthroughs:

- Extend observations of multiple pops to low-mass stars → locally and at least to the Local Group (JWST)
- The universality of star cluster formation process
- Discovery of IMBH governing their dynamics
- Dark matter in galactic sub-structures
- Detection of massive neutron stars → EOS
- Coupling stellar evolution with dynamics simulations: expertise Nbody, SPH… → TEAM !!

Galactic/Extragal Archeaology: Science Top Level requirements

- High resolution, high sensitivity spectroscopy in opt & IR
  detailed chemistry and nucleosynthesis down to the TO in the Galaxy & Local Group
  VLT-Espresso + CRIRES+ ➔ EELT-HIRES

Medium resolution, high sensitivity multi-object spectrosc
  metallicity and kinematics in the Galaxy & Local Group
  VLT-MOONS, WEAVE, VISTA-4MOST ➔ EELT-MOS

- Medium spectral, high spatial resolution integral field spectroscopy
  metallicity and kinematics of dense stellar fields
  VLT+AO SINFONI+MUSE, JWST ➔ EELT-IFU

Galactic/Extragal Archeaology: Science Top Level requirements

High spatial resolution & sensitivityNIR imaging

accurate photometry down to the TO and below of the stellar populations in the inner Galaxy in other bulges with high extinction

JWST → EELT- MICADO+MAORI

- **High spatial resolution & sensitivity MIR & sub-mm obs**

  tracing circumstellar envelopes of pop I and II giants for mass loss

  JWST → EELT-METIS, ALMA

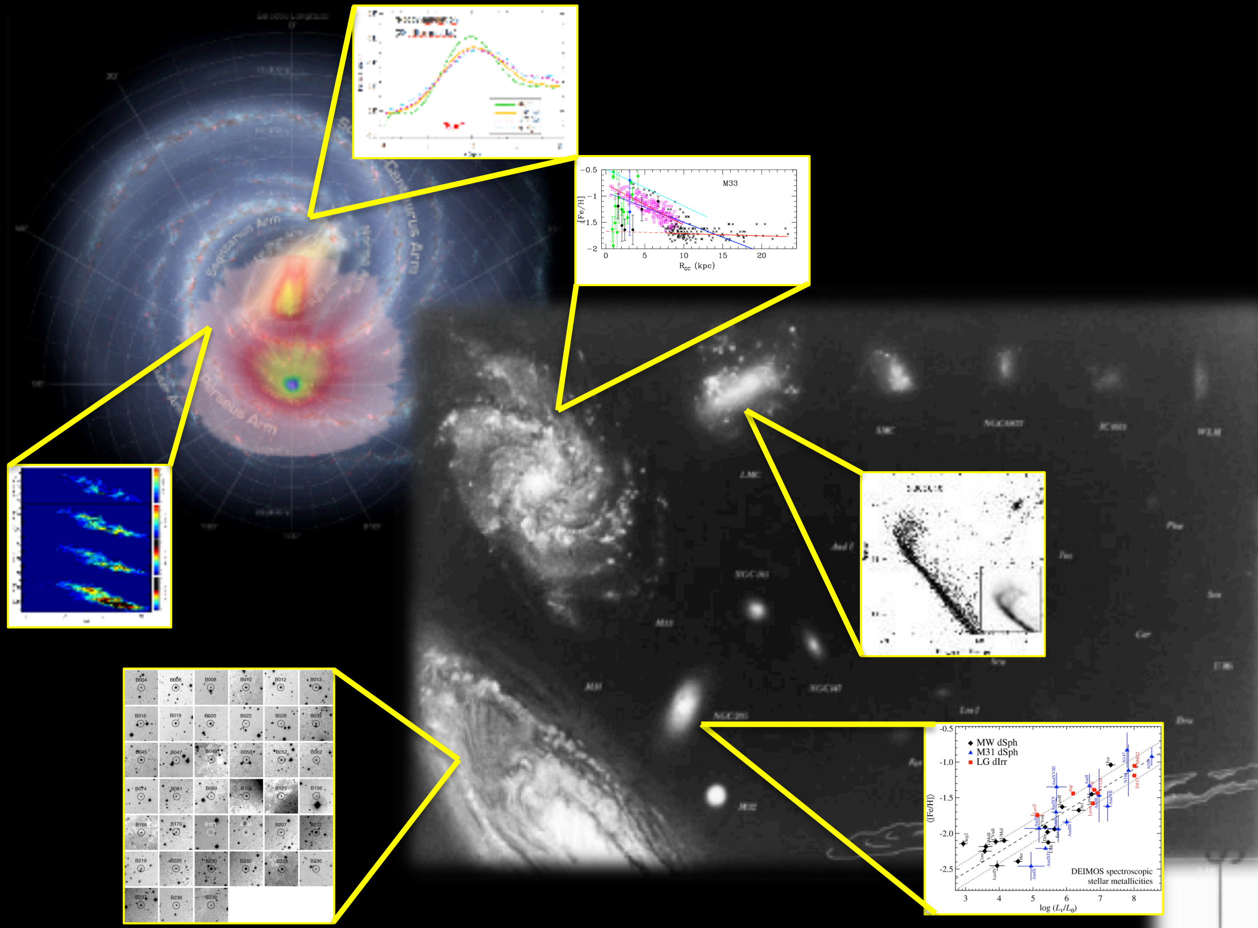
- **GAIA + multi-epoch imaging in the optical and IR**

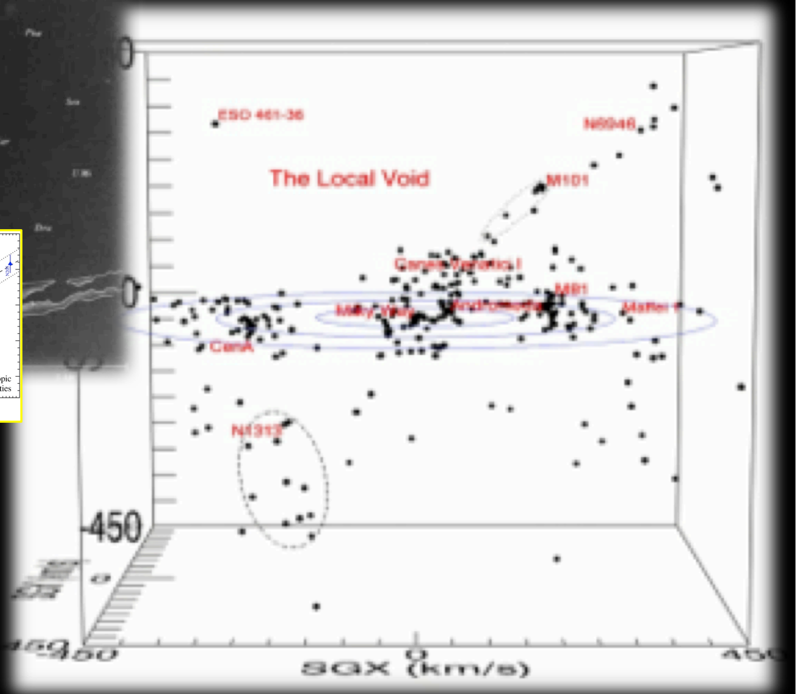
  proper motions, variability

  JWST + wide-field imagers, e.g. VST, VISTA, LBC, LSS

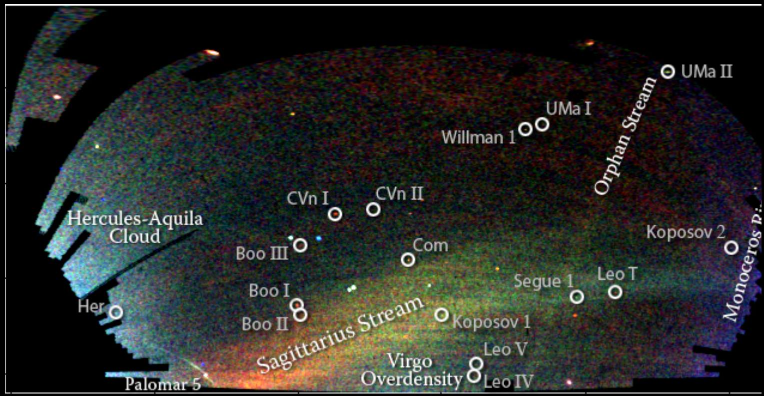
Near-field Cosmology: MCs, dSph & UFDs

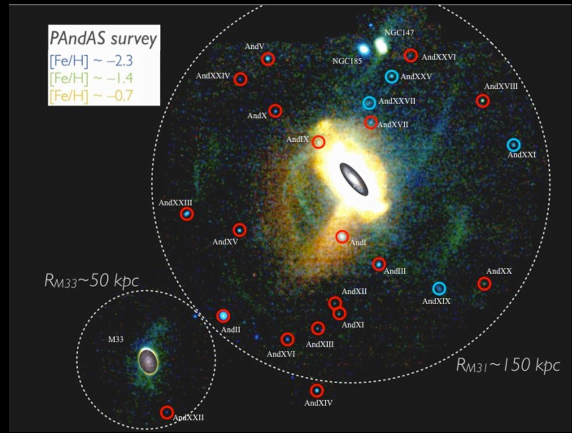
- Many morphological types
- Star formation histories
- Disentangling nature vs nurture, role of mergers, etc.
- Individual star spectroscopy





- Progress in our understanding of structure formation in the Universe
- E.g., did the galaxies form from early primordial gas or from partially enriched gas?





MW satellites, 21 (9), & M31 26 (14) new "faint" system >2005

dSphs

✓Most numerous...

✓ Most DM dominated...

✓Complex and unique SFH

but...

- Missing Satellites
- Metallicity Problem
- Variable Stars Problem

dSphs/UFDs as "building blocks"

→ see remnants eg @CTIO, CFHT, VST, SUBARU

→ MW & M31 halo's properties homogeneous to those of their satellites eg @ESO, LBT,HST,Spitzer...

→ UFDs as missing satellites? eg SDSS, DESS, LBT

Resolved stellar populations:

CMDs → star formation history

Pulsating variable stars:

standard candles → distances, stellar overdensities (streams)

stellar pop tracers → spatial distribution, structure & galaxy assembling

→ ESO facilities, TNG, LBT, GTC, HST, Spitzer ... Gaia, JWST, ELT, LSST

Resolving Stellar Populations in Galaxies up to Virgo…

Breakthrough

reconstruct SFH in compact galaxies up to18-20 Mpc

- reduce/no uncertainties on past histories of different galaxy types
  - → bursting vs gasping SF; nature vs nurture; mergers vs accretion; feedback
- youngest & oldest populations
  - → complete evolution here & now and there & then

Coupling EELT & JWST:

- High spatial resolution of MICADO (3, 1.5 mas) → accurate/deep photom
  J~31-32, K~30-31 mag
  & spectroscopy (MOS/HIRES)

- Observe HB stars (t>10 Gyr)

1.4 EVOLUZIONE COSMICA FORMAZIONE STELLARE: LOCALE & GLOBALE

Si ringraziano per i contributi:

L. Testi, D. Galli, J. Alcala, B. Nisini, C. Codella, G. Sacco, S. Molinari, D. Elia, F. Strafella, J. Brand, R. Cesaroni, L. Olmi, E. Flaccomio, L.Prisinzano, G. Umana, E. Corbelli, L. Hunt… + Fil Rouge su ISM

Molecular Clouds & Dense Gas → SFR

Protostars: disks, jets, feedback (v. 2.2)

Stellar Clusters → IMF, SFH

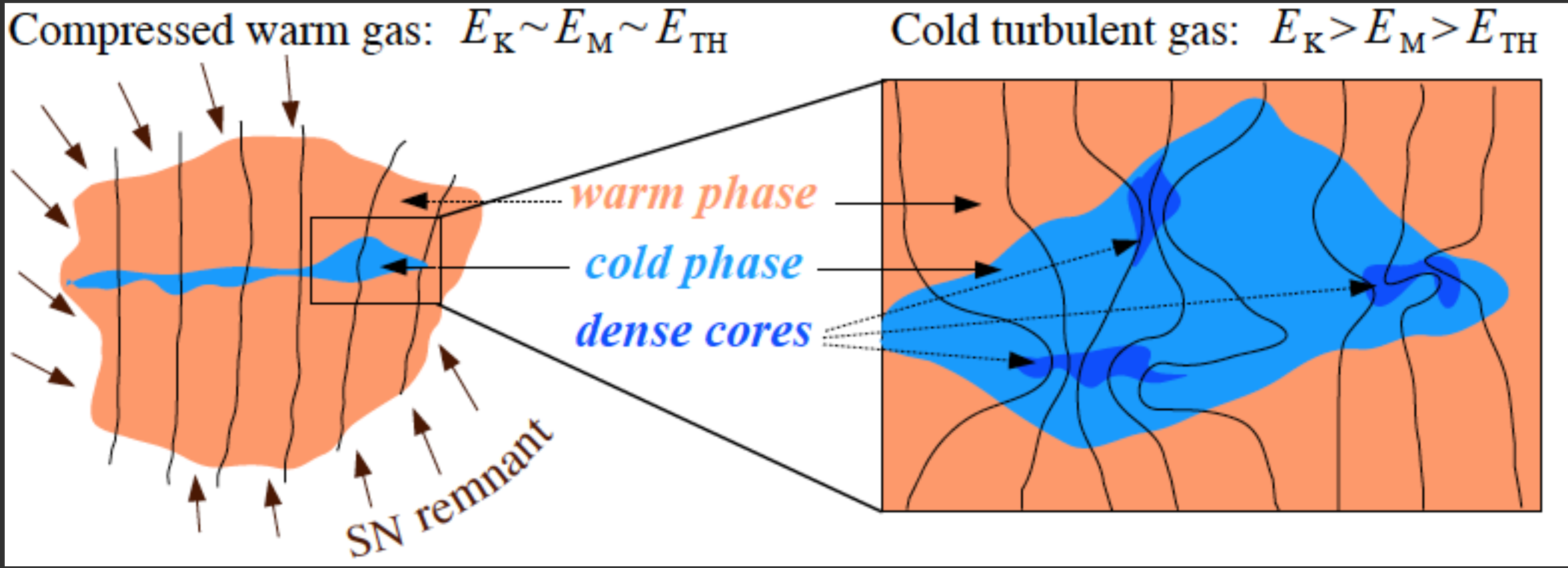
From Milky Way to Global → bridge

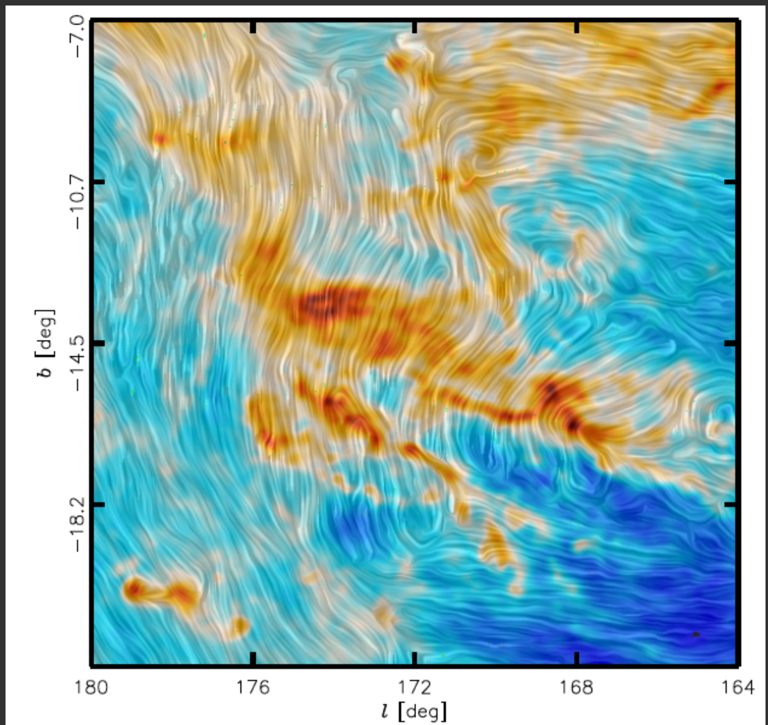
1.4 FORMAZIONE STELLARE: CLOUDS: BREAKTHROUGHS

Molecular Clouds: SFR ~ 3-5% → Why?
Very cold (~few K), not in free-fall

Competition of gravity, turbulence, magnetic field

- $E_G \sim E_M \sim E_K >> E_{th}$ → B is important; ~equilibrium → dense cores
- $E_G \sim E_K > E_M >> E_{th}$ → SuperAlfvenic turbulence → shocks → dense cores
- $E_G \sim E_M > E_K >> E_{th}$ → Subalfvenic turbulence → fragmentation → grav. instab.

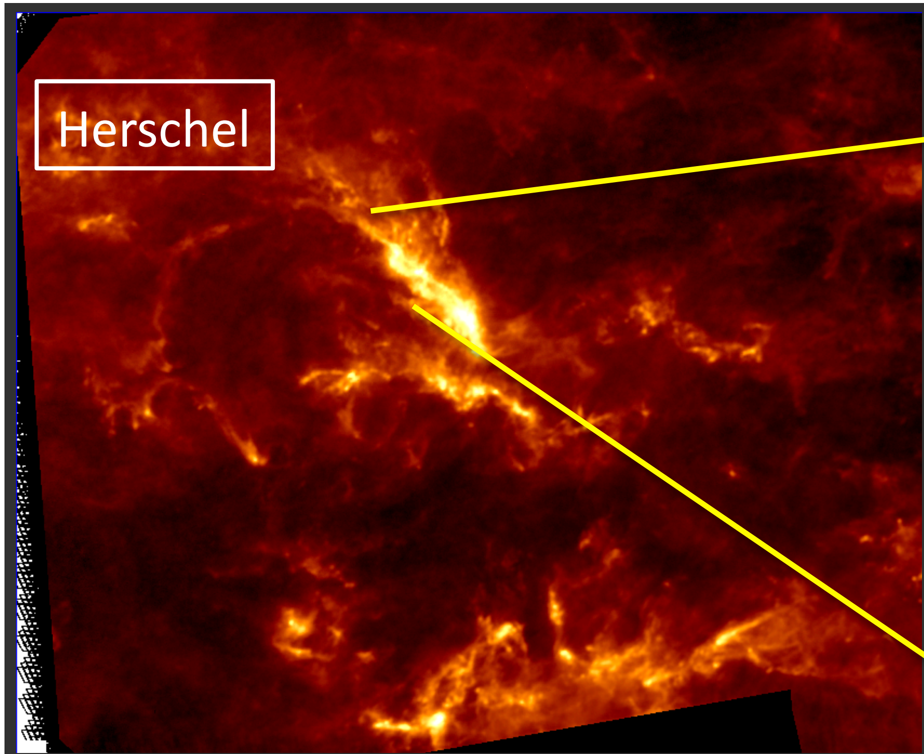




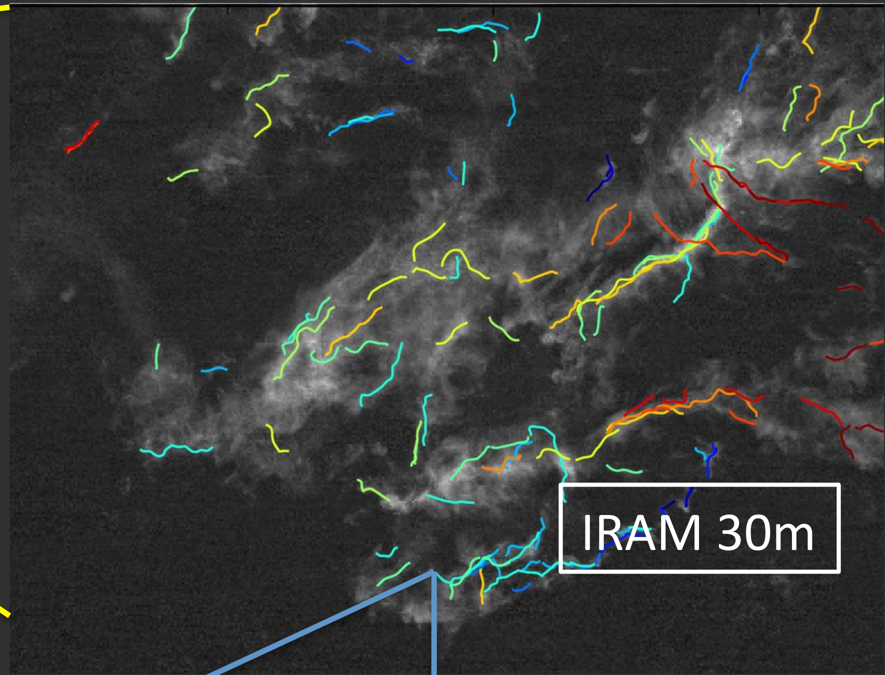
Polarization map Planck 2015 –

Well Ordered Field → $E_G \sim E_M > \sim E_K >> E_{th}$

Magnetic field is IMPORTANT both on the large and small scal

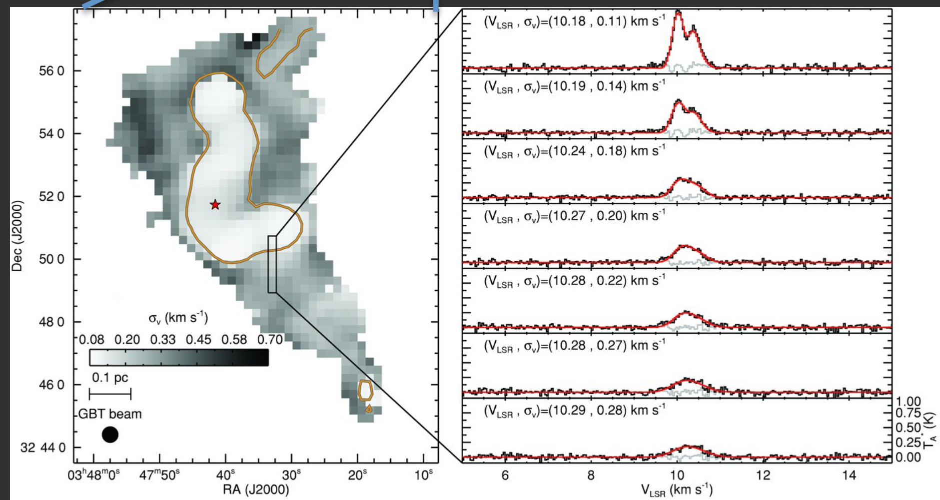


Filaments, bundles, clumps: few pc



Molecular cloud complex: 10x pc

Scales & Complexity of Star Formation: Surveys & Interferometers



Dense gas in cores: ~0.1 pc

no evidence for shocks → protostellar sites

IRAM PdB

1.4 FORMAZIONE STELLARE: INFRASTRUCTURES: IR & (SUB)MM

Clouds, Clumps, Cores & Filaments: SFR

- Large-scale Galactic Plane surveys: x10^3 clouds and filaments + Deeper surveys: 10^2-sized filaments target samples

  → FIR from space: OK limited spatial resolution (1-2m w/ heterodyne)
  → (sub)mm: >10-30m class JCMT, IRAM, APEX, ARO, CCAT

- Individual Clumps/Cores

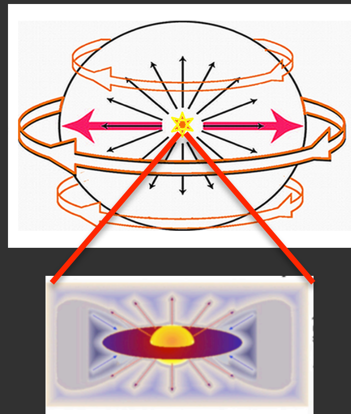
  - Kinematic mapping @ resol'n<1 km/s →ALMA, JVLA, MeerKAT, SKA

  - 1 → 20 μm imaging for YSOs Mass Function → 4/8m telescopes for large-scale surveys; JWST and E-ELT for deep surveys

  - 1cm → 21cm continuum and spectroscopy for first signals of star-birth: large surveys with JVLA, MeerKAT, ASKAP, SKA

1.4 FORMAZIONE STELLARE COSMICA
PROTOSTARS/DISKS: BREAKTHROUGHS

Solving the angular momentum problem



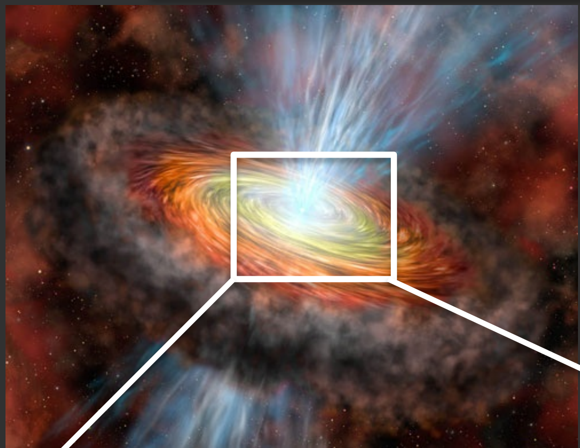
Solar System's angular momentum is concentrated in the Jovian planets

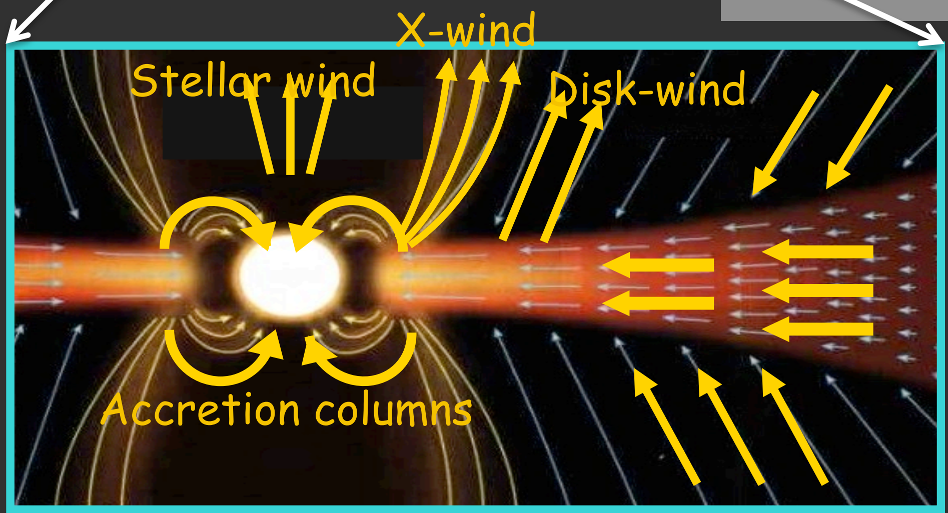
Formation of a keplerian disk and high-velocity jet/outflow

1. Understand kinematics of accretion/ejection at d~1-10 AU → IRAM- PdB, ALMA,
2. solving jet launching, properties of pristine disks, fragmentation → ALMA, HST, JWST, EELT

1.4 FORMAZIONE STELLARE COSMICA
PROTOSTARS/DISKS: BREAKTHROUGHS

Disk-Star interactions during PMS evolution: the initial conditions for planet formation (cf.2.2)





Main issue:
properties and evolution of gas in the inner disk critical for future formation of planets in HZ
Main processes evolving and interacting together:

→ young-stellar photosphere
→ disk accretion physiccs
→ jets/winds origin

Main observational tools:
→ optical/IR spectroscopy
→ High contrast/high resolution imaging

1.4 FORMAZIONE STELLARE COSMICA
PROTOSTARS/DISKS: INFRASTRUCTURESS

Who is working on that and what we need…

Large number (10) of ALMA proposals approved as top priority in the first 3 cycles of ALMA observations;

Angular momentum problem

Involvement
- 8 staff @ OAA, OAR, IAPS
- 4 post-docs, 2 PhD students

Funding: PRIN-JEDI; Premiale iALMA; ASI-Herschel;

Observing facilities needed
ESO-ALMA, IRAM-NOEMA; SKA

A Far-IR interferometer (space) to trace embedded high-mass stars.

Numerical simulations: needed.

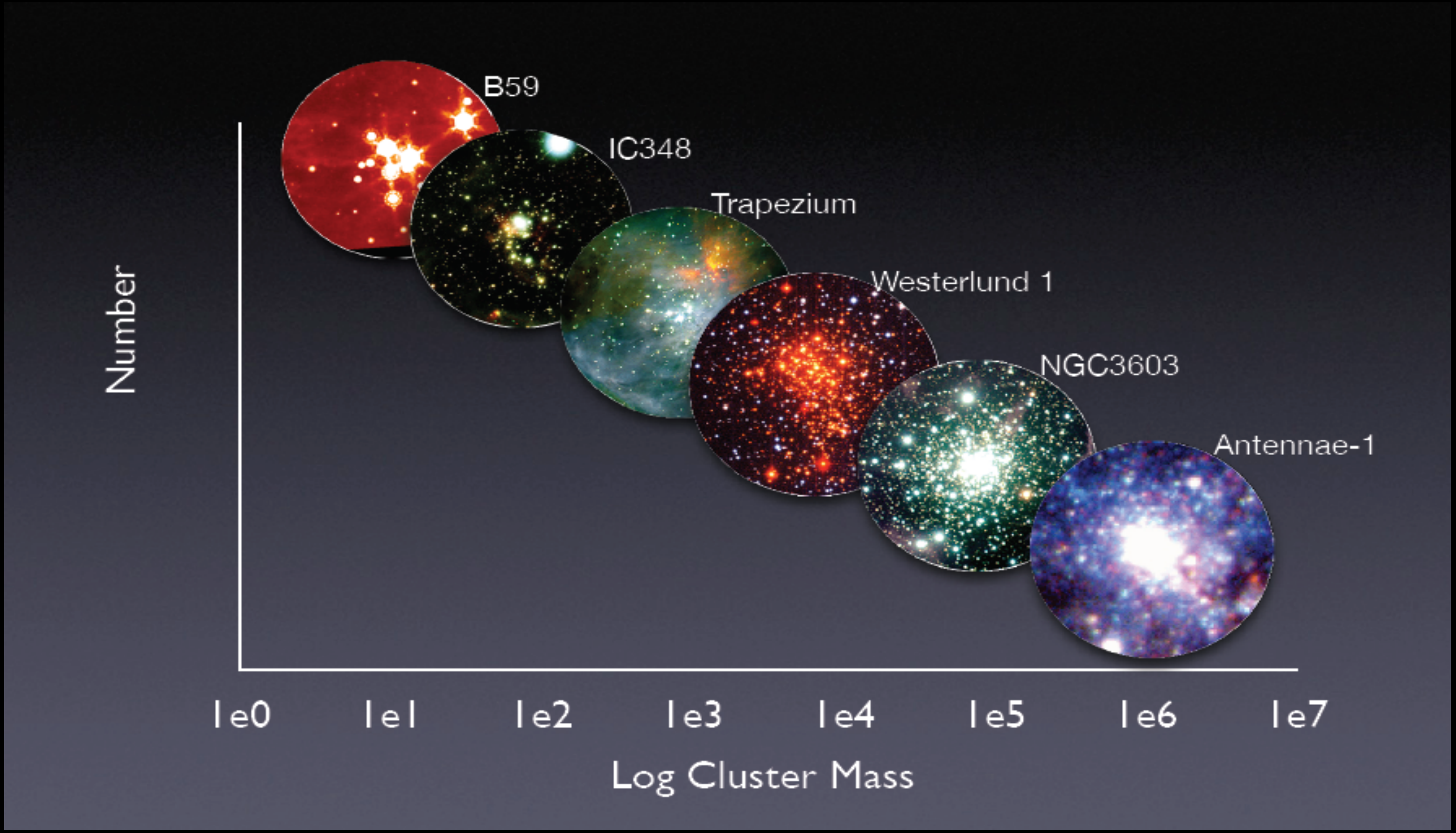
Disk-star interaction

Involvement
- 12 staff @ OAR, OAA, OANa, OAPa, OAC
- 1 TD, 2 post-doc from JEDI

Forefront Instrumentation
→VLT-X-shooter in sinergy w/ ALMA, TNG-GIANO
→nearfuture: VLT-SPHERE, LBT-SHARK, LBT-LN-MCAO
→far future: E-ELT HIRES, MIDIR, JWST

1.4 FORMAZIONE STELLARE COSMICA
STELLAR CLUSTERS: BREAKTHROUGHS

Clusters: IMF → universal?
SFH → slow vs rapid



1.4 FORMAZIONE STELLARE COSMICA
STELLAR CLUSTERS: BREAKTHROUGHS

Clusters: IMF → universal?
SFH → slow vs rapid

- Origin & Evolution → Herschel, ALMA, IRAM

  Initial conditions in molecular clouds
  Gas removal & dispersion: SFH

- Stellar mass distribution → Opt/IR surveys,JWST

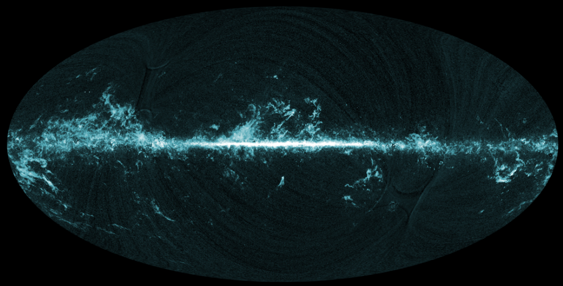
  Clump/Core MF → Stellar IMF
  IMF: from small (10^3) to large (10^5) clusters

- Effects on disks & planets→ ALMA, GAIA & GES

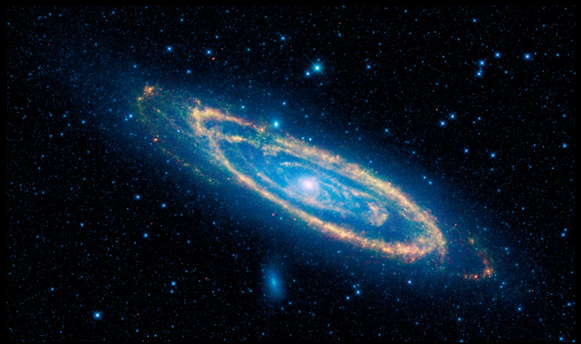
  Photoevaporation & Dynamical Interactions
  Orbital evolution vs Planet expulsion

1.4 FORMAZIONE STELLARE COMSICA

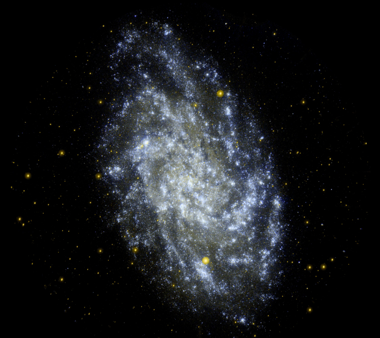
1.4 FORMAZIONE STELLARE COSMICA: FROM LOCAL TO GLOBAL



- MW as an engine for star formation
- An "unicum": lots of H_2
- Gas-rich satellites → infall & replenishment



- SF in a ring @ 10kpc (1/2 r_{opt})
- No/little H_2
- Gas-poor satellites → quenching SF



- SFR~0.5 M/yr → >M31 but <MW
- Intermediate H_2
- No satellites, unperturbed → gas form web

F i n e