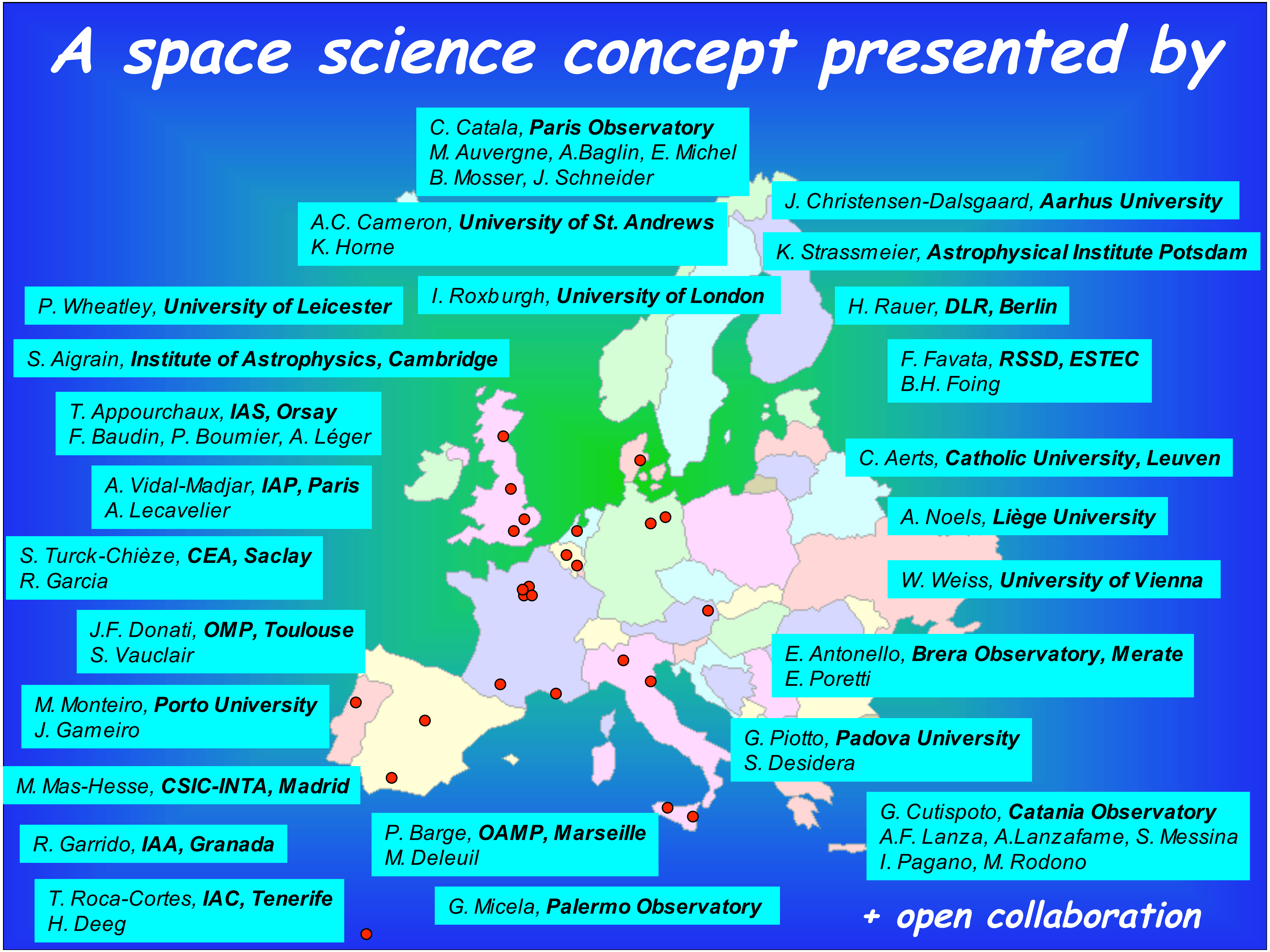
The life of stars & their planets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We need a better knowledge of formation & evolution of stars and planets

stellar formation & evolution theory is essential for:

- *measuring ages in the universe*
- *understanding chemical evolution of the universe*

planet formation & evolution theory is essential for:

- *understanding the origin of earth and life*
- *determining whether life is likely to exist elsewhere in the universe*

We don't have a solid understanding of formation & evolution of stars and planetary systems

stellar ages are model dependent and often unreliable:

- ages of globular clusters > age of the universe ?
- ages of brown dwarfs in clusters ≠ ages of clusters (turn-off) ?
- etc…

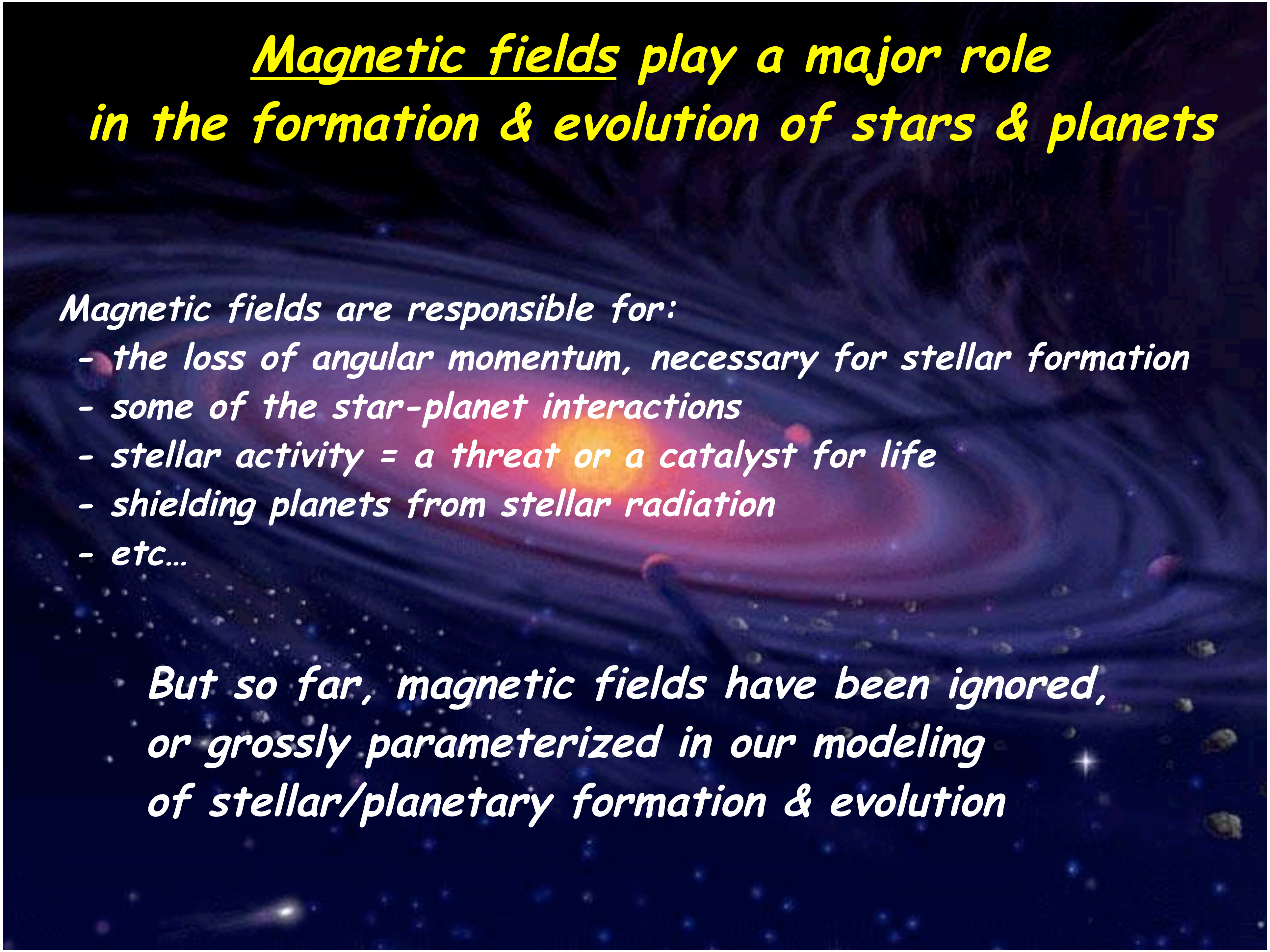
although WMAP/Planck provide an estimate of the age of the universe

→ the age ladder of the universe is still unreliable (climb at your own risk!)

we do not have a sufficient understanding of:

- the mechanisms controlling orbital eccentricities
- the mechanisms controlling migration
- the planet / star metallicity connection
- the distribution of planets and their characteristics

→ we lack statistical knowledge of planet and parent star properties


Magnetic fields play a major role
in the formation & evolution of stars & planets
Magnetic fields are responsible for:
- the loss of angular momentum, necessary for stellar formation
- some of the star-planet interactions
- stellar activity = a threat or a catalyst for life
- shielding planets from stellar radiation
- etc…
But so far, magnetic fields have been ignored,
or grossly parameterized in our modeling
of stellar/planetary formation & evolution

The formation and evolution of stars, their planets, and their magnetic fields are <u>intrically related and must be studied jointly</u>

- stars and planets are born together from the same material
- stars affect their planets (radiation, particles, etc…)
- planets affect the evolution of their parent stars
    . angular momentum,
    . enrichment by collision,
    . magnetic interaction, etc…
- magnetic fields play a major role in this common history
    . coupling the star with the accretion disk,
    . controlling stellar winds in crucial phases,
    . transporting angular momentum inside stars,
    . protecting planets from particle bombardment,
    . possibly halting planet inward migration, etc…

We lack sufficient <u>observational constraints</u> for these three fundamental problems

Proposed concept: *study these three issues simultaneously by three complementary approaches on the same stars*

- *select a very large sample of stars (>100,000) of all ages and masses*

- *detect and study planets around these stars, via planetary transit observations*

- *study internal structure and internal rotation of the same stars, via asteroseismology*

- *detect, characterize and map magnetic fields in these stars, via UV monitoring and tomographic techniques*

Observational concept

- observe a large number of relatively bright stars ($m_V \leq 11$)

  maximize field of view: 140 $m_V \leq 11$ stars per sq. deg.

  → **30° x 30° : ≥ 120,000 stars**

  unbiased stellar sample in terms of mass, age, metallicity, etc…

  include open clusters of various ages, old pop II stars, etc…

- perform very long-term, high precision, visible light monitoring

  maximize monitoring duration (5 yrs?): 1-2 yr planetary orbits,
  very high precision seismology

  aim at a relative photometric precision better than

  2\. 10^{-5} in 1 hr for $m_V=11$: transits of sub-earth sized planets

  1\. 10^{-6} in 2 weeks for $m_V=11$: seismology of solar-like oscillations

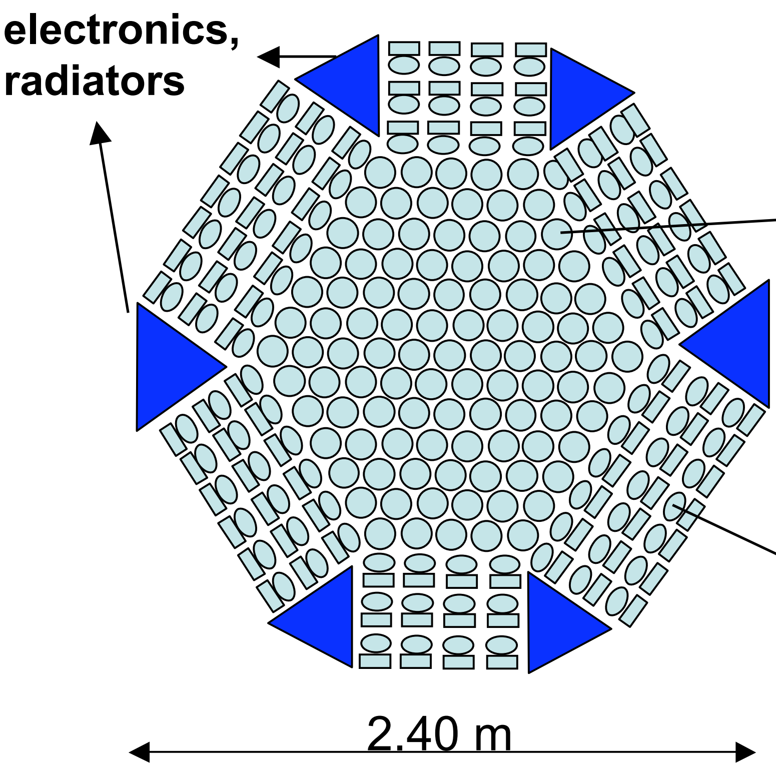
  → **collecting area ≥ 1 m^2**

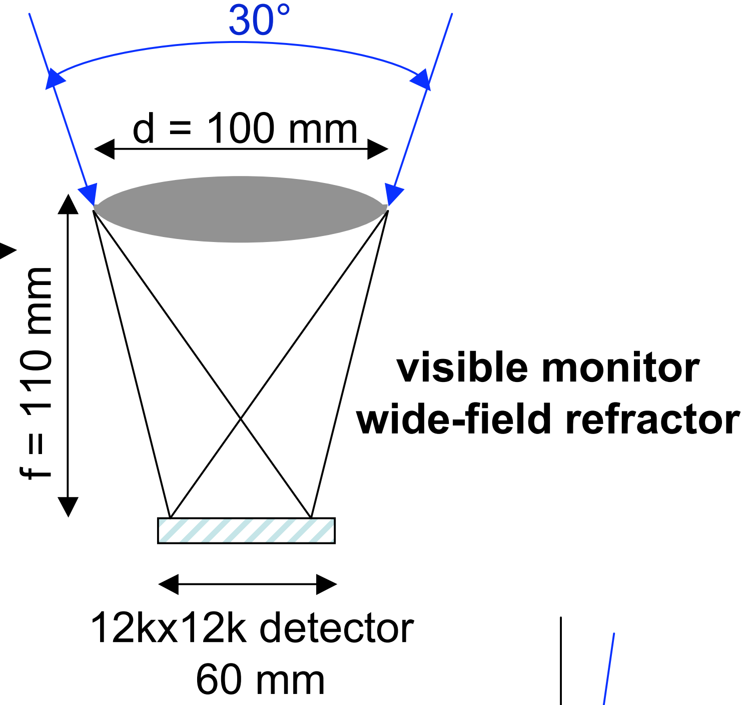
- perform at the same time very long-term UV monitoring

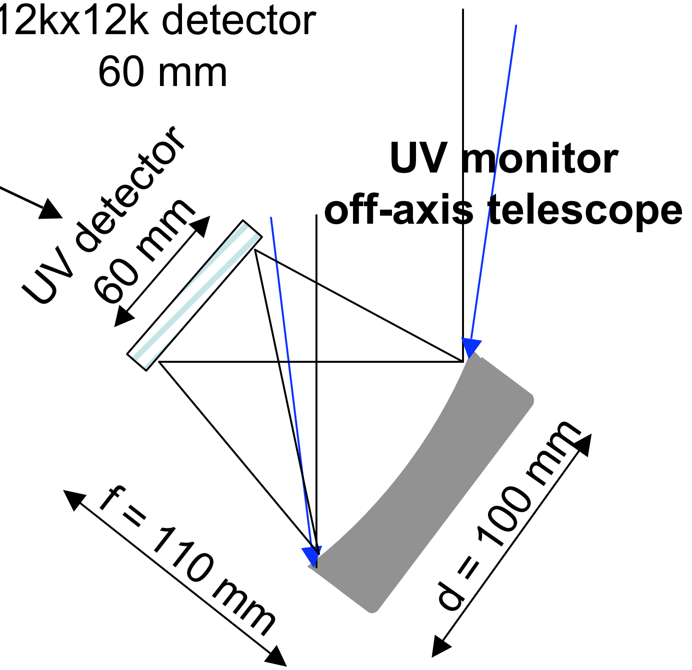
  several wide and narrow UV bands sensitive to stellar activity

Example of instrumental concept

very wide field + large collecting area





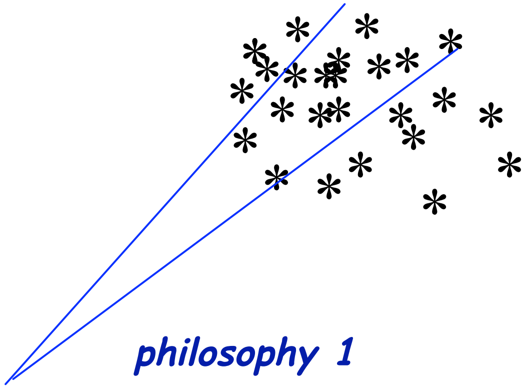


~ 100 x 10cm telescopes and refractors looking in the same direction at the same 30°x30° field

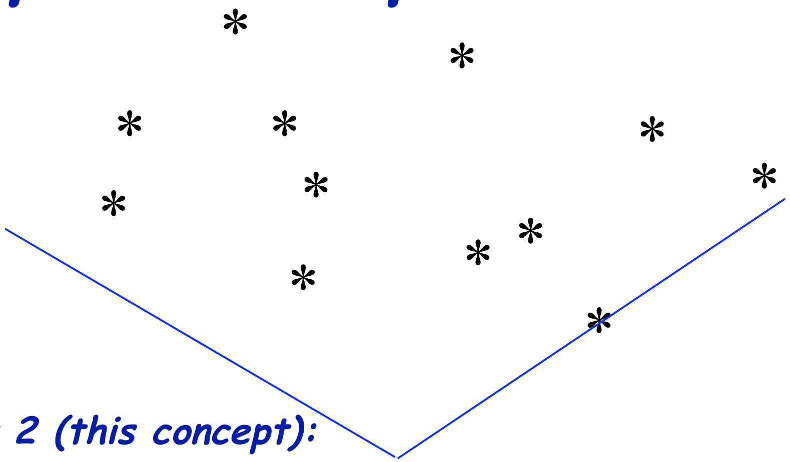
<u>needed developments</u> : large format, small pixel optical detectors, large format UV detectors, miniaturized electronics, onboard computing, etc… , but <u>heritage from previous developments</u>

alternative concepts are considered

Interest of this concept for exoplanets



philosophy 1
(COROT, Kepler, Eddington):
distant, faint stars (m_V=15-17)



philosophy 2 (this concept):
nearby, bright stars (m_V=10-11)

when we focus on bright stars (but with unbiased sample), we have:

- simultaneous seismology (interior, age) and UV-monitoring (activity)
- high signal-to-noise ratio: smaller planets, higher precision, etc…
- better rejection of false events (background EB, confusion, etc…)
- bright & nearby stars: opportunity for further studies (spectroscopic and astrometric follow-up, interferometric imaging, etc…)

. very wide field: gigantic star sample when fainter stars are included (cf talk by S. Desidera: 900,000 GK dwarfs $m_V \leq 14.3$)

. UV monitoring: some characterization of planet atmospheres

Interest of this concept for stellar interiors

Seismology down to solar-like oscillation level for ≥ 120,000 stars !

- 1200 times COROT, 5 times Eddington
- 5 year duration: very high precision on frequencies, and therefore
on internal structure & rotation + detection of internal B
- all types of stars, all masses, all ages
- 120,000 stars = significant fraction of Gaia/RVS targets
provide the age of these stars = time coordinate
(the missing observable)

Interest of this concept for stellar activity

Activity monitoring for ≥ 120,000 stars, of all types !

- first ever gigantic survey for stellar activity
- ~ 100 times Mount Wilson survey
- 5 year duration: study of activity cycles
- assess the level of « noise » induced by activity on optical light curves and correct for it in planetary transit and seismology studies

Conclusion: a european roadmap

- *the proposed concept will study* — *at the same time*, *on the same targets*
  - *planet characterization*
  - *stellar formation and evolution*
  - *stellar magnetic activity and its role in the evolution of stars and planets.*

- *needs:* (visible + UV)
  - *very wide-field for ≥120,000 stars $m_V \leq 11$*
  - *very high precision photometric monitoring*
  - *very long duration monitoring*

- *will open the road for further studies*
  - *high resolution spectroscopy*
  - *interferometric imaging of planetary surfaces*
  - *high degree oscillation modes in nearby stars*

European roadmap