UNIVERSITY OF BIRMINGHAM

CoRoT

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Convection

rotation

planetary transits

developed and operated by CNES, with the contribution of Austria, Belgium, Brazil, ESA (RSSD and Science Programme), Germany and Spain

Goal 1

detection of exoplanets via transits

Goal 2

study the internal structure of stars using global, resonant oscillation modes

Goal 3

make use of oscillation modes to characterise stellar populations in the Milky Way

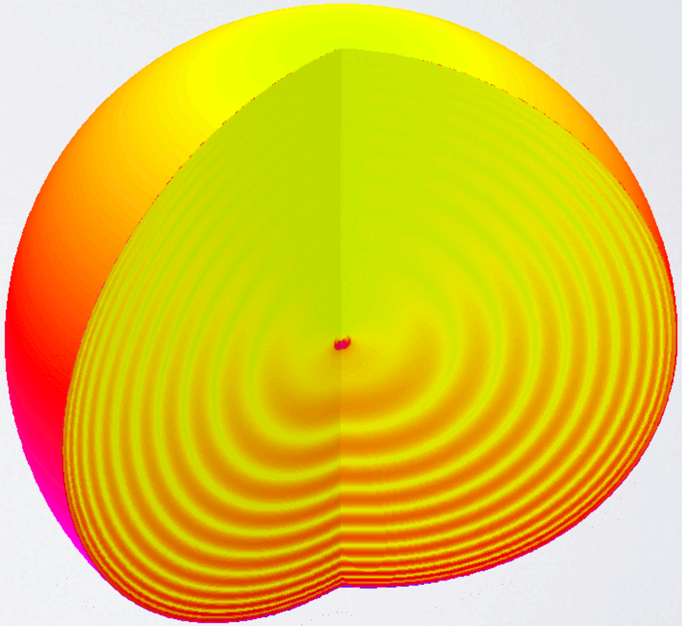
ASTEROSEISMOLOGY

Observations of stars:

- Information generally limited to the superficial layers
- No direct constraints on stellar interior

Study of stellar pulsation modes

Properties of the propagation cavity



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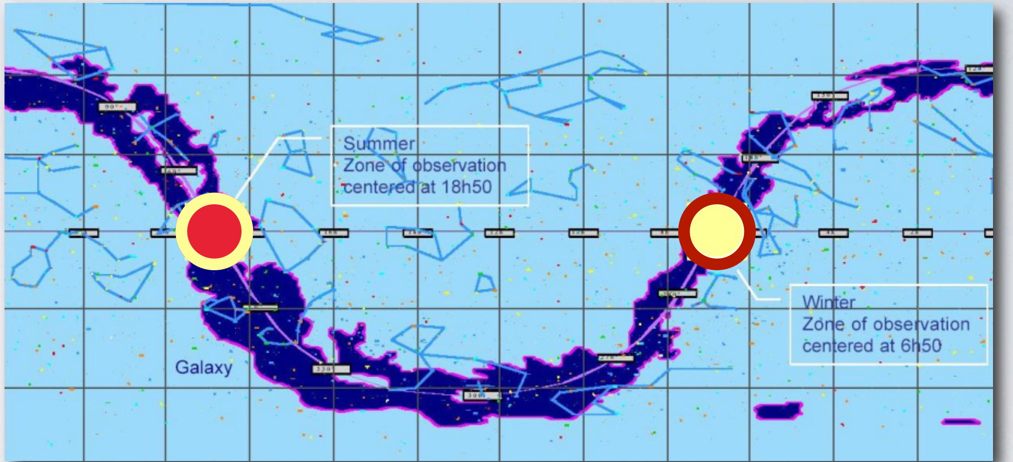
observations

27cm telescope

polar circular orbit at 896km

launched December 27th 2006

observations



Camera with 4 detectors 2 for seismology, 2 for exoplanet search and seismology

"seismo" field

10 bright stars
V : 5.5 to 9.5
at 32s

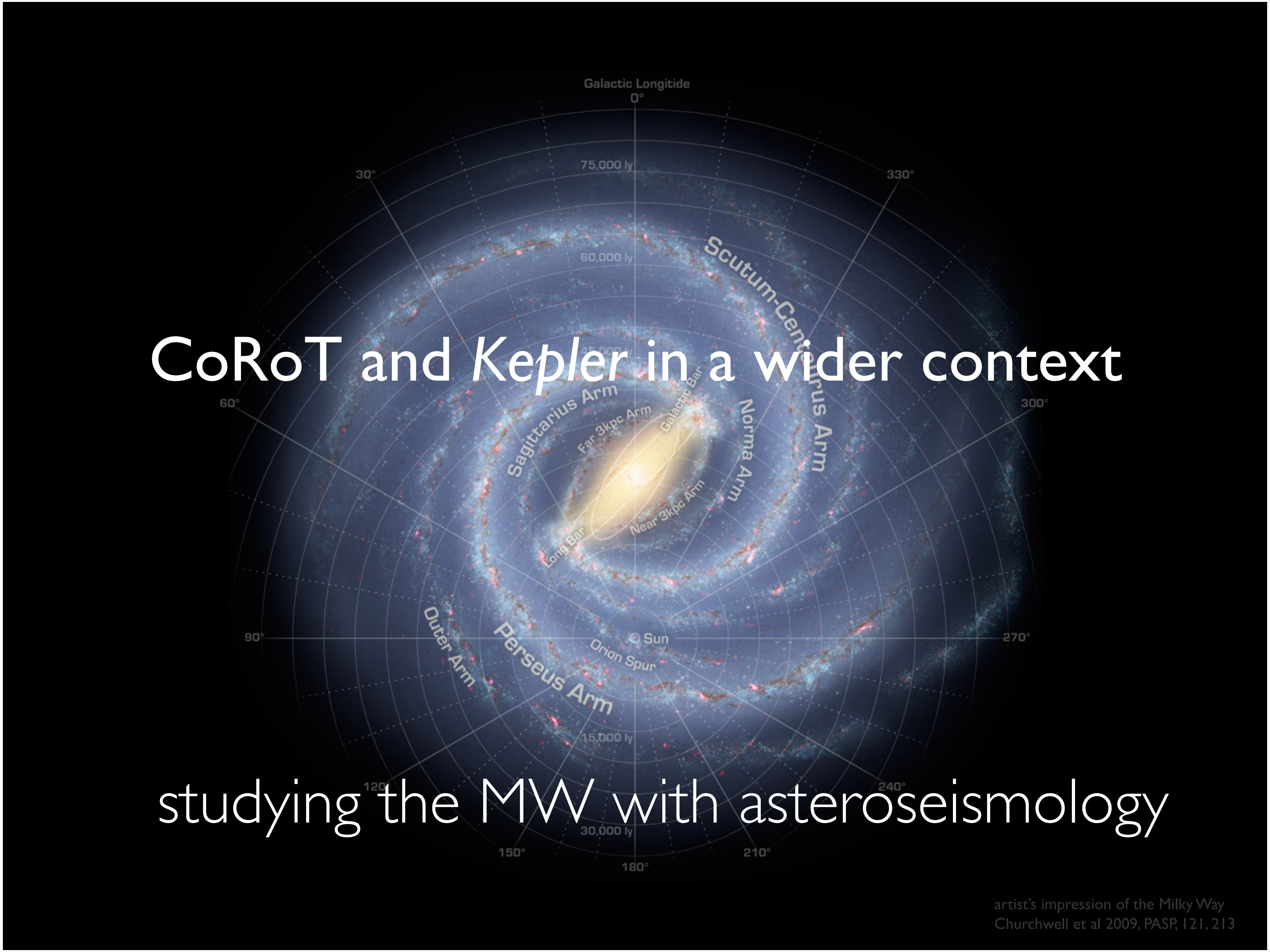
"exo" field

12 000
Faint stars
R : 10 to 16
at 32 or 512 s
FOV 4 deg^2

150-d long runs

ppm precision

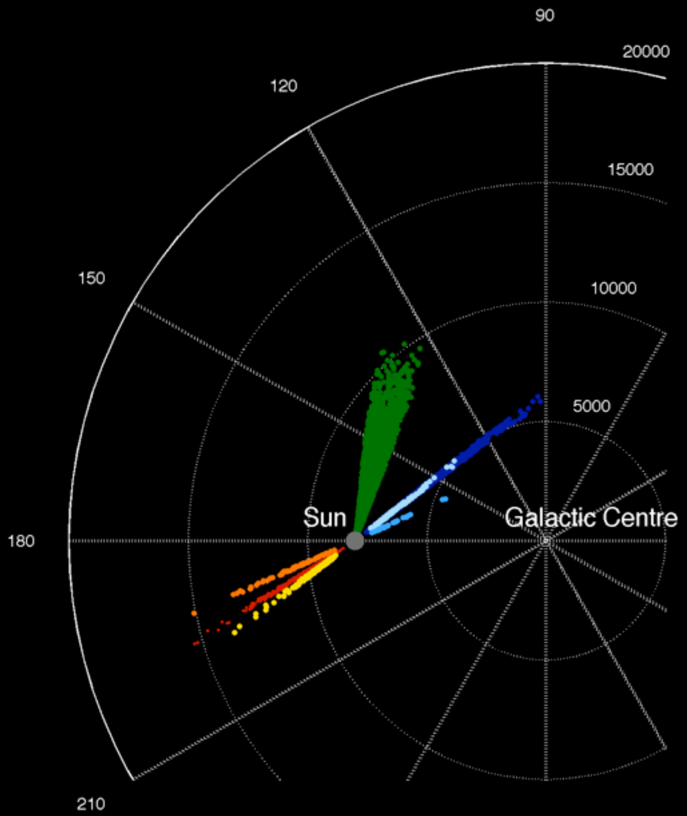
CoRoT and *Kepler* in a wider context



studying the MW with asteroseismology

artist's impression of the Milky Way
Churchwell et al 2009, PASP, 121, 213

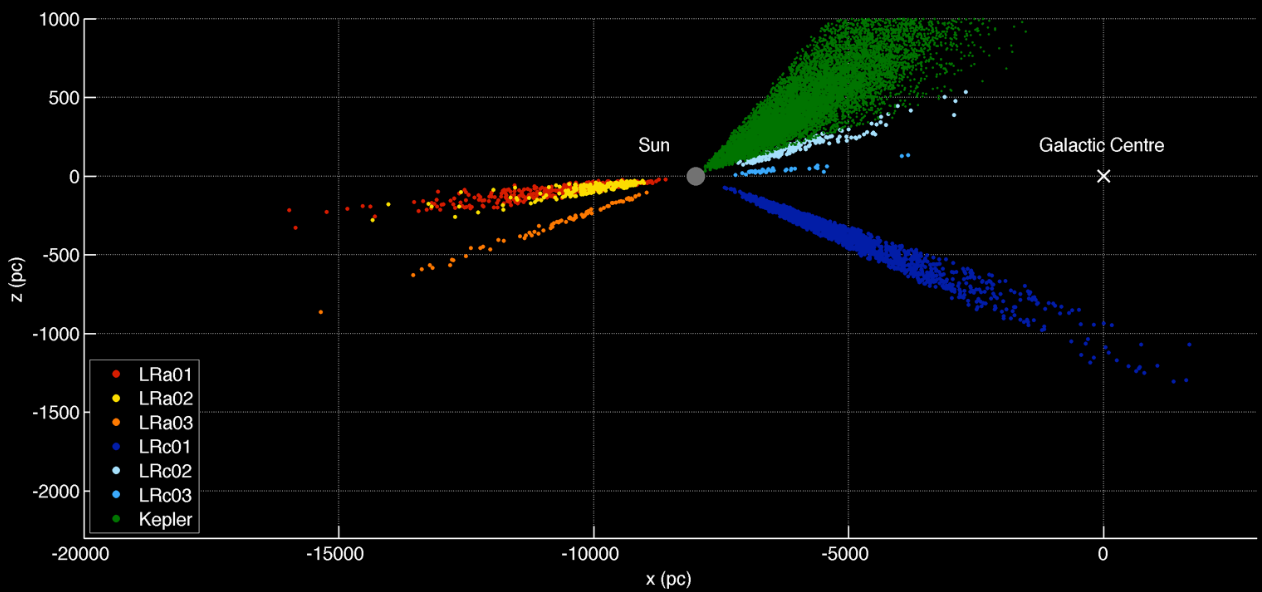
Sun
Orion Spur
LRa01
LRa02
LRa03
LRc01
LRc02
LRc03
Kepler



Distance and age

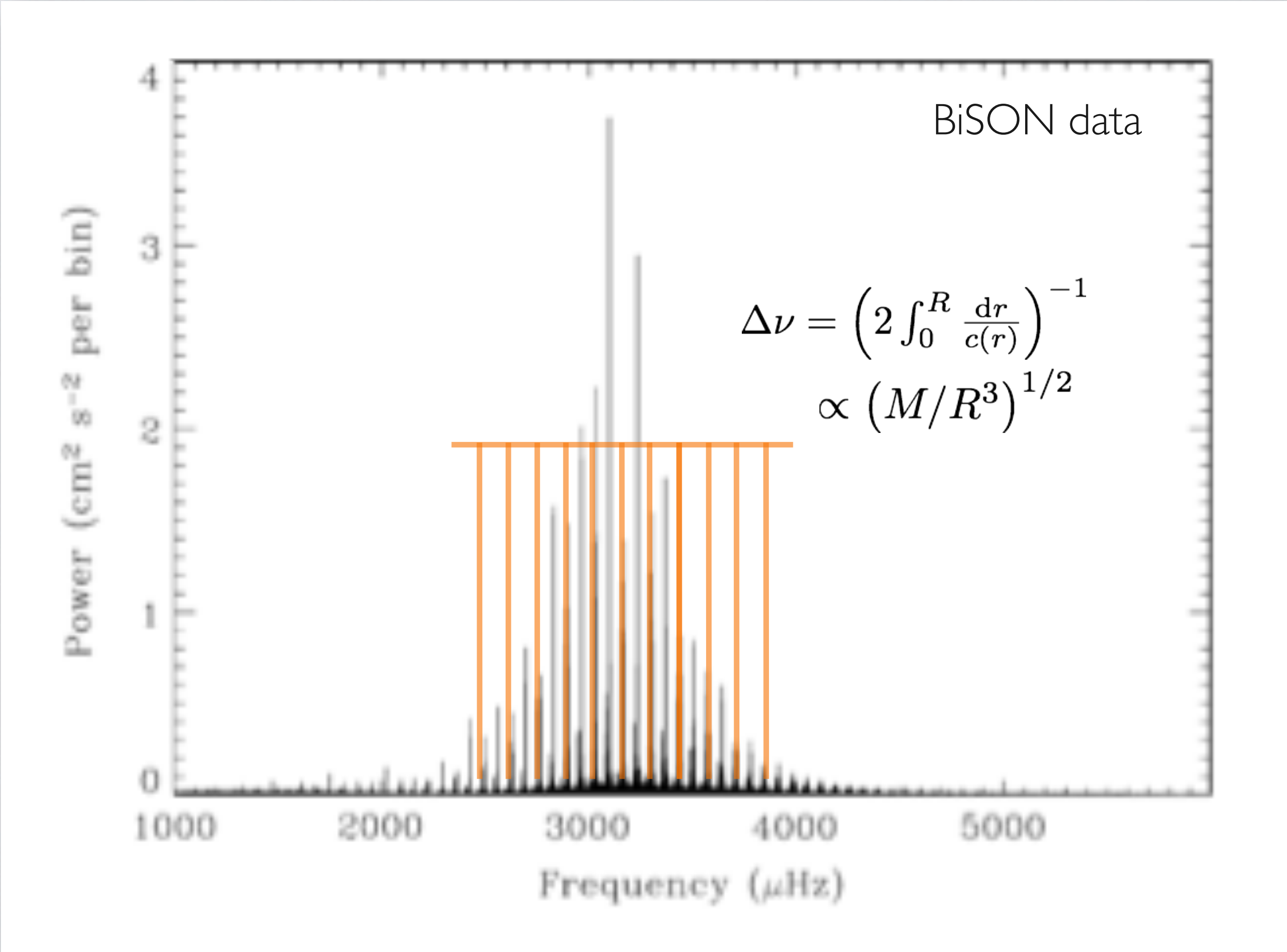
spectroscopic constraints needed to complete chemo-dynamical picture

e.g. [Fe/H], [α/H], v_{rad}



ENSEMBLE SEISMOLOGY OF G-K GIANTS

$\Delta\nu$: large frequency separation



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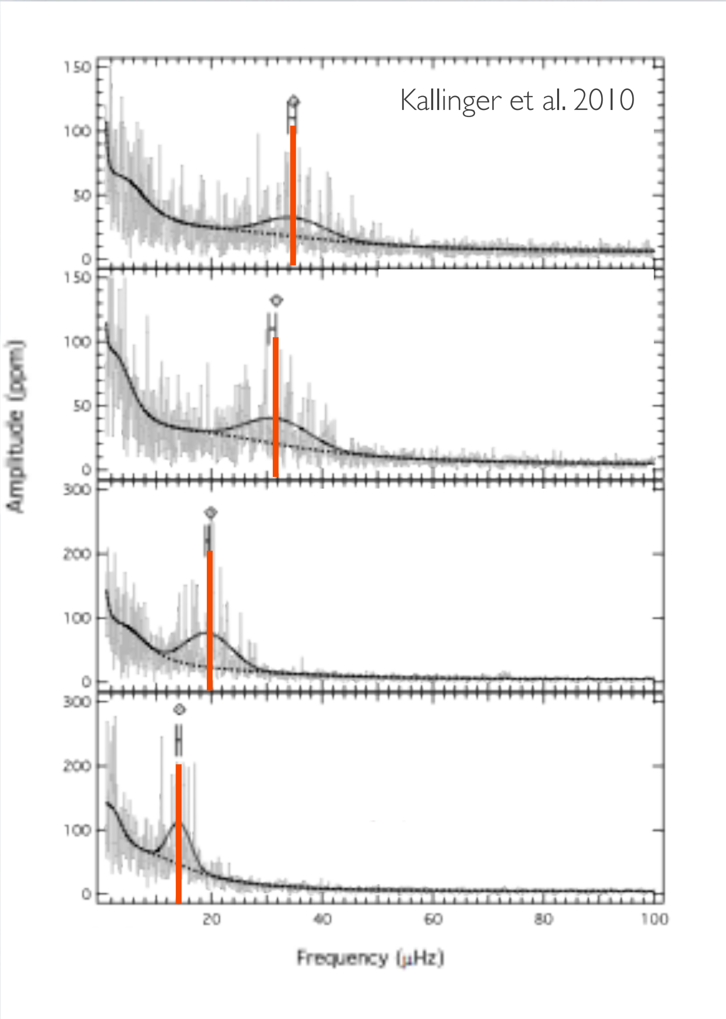
ENSEMBLE SEISMOLOGY OF G-K GIANTS

ν_{max}



$$\nu_{max} \simeq \frac{M/M_{\odot}}{(R/R_{\odot})^2 \sqrt{T_{eff}/T_{eff,\odot}}} \nu_{max,\odot}$$

Brown et al. 1991
Kjeldsen&Bedding 1995
Belkacem et al. 2011

ENSEMBLE SEISMOLOGY OF G-K GIANTS

average seismic parameters:

$$\Delta\nu \simeq \sqrt{\frac{M/\mathrm{M}_\odot}{(R/\mathrm{R}_\odot)^3}}\,\Delta\nu_\odot$$

$$\nu_{\max} \simeq \frac{M/\mathrm{M}_\odot}{(R/\mathrm{R}_\odot)^2\sqrt{T_{\mathrm{eff}}/T_{\mathrm{eff},\odot}}}\,\nu_{\max,\odot}$$

radius and mass estimates:

$$\left(\frac{R}{\mathrm{R}_\odot}\right) = \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)\left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-2}\left(\frac{T_{\mathrm{eff}}}{\mathrm{T}_{\mathrm{eff},\odot}}\right)^{0.5}$$

$$\left(\frac{M}{\mathrm{M}_\odot}\right) = \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)^{3}\left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-4}\left(\frac{T_{\mathrm{eff}}}{\mathrm{T}_{\mathrm{eff},\odot}}\right)^{1.5}$$

? impact on study of stellar populations

ENSEMBLE SEISMOLOGY OF G-K GIANTS

- Radius $\Rightarrow$ distance

Pulsating stars as distance indicators:

RR Lyrae, Cepheids: $P \propto (M/R^3)^{-1/2}$

$$\log(P)=a \log(L) + b \log(M) + c \log(T_{eff}) + d$$

ENSEMBLE SEISMOLOGY OF G-K GIANTS

- Radius ➡ distance

Pulsating stars as distance indicators:

Solar-like oscillations

- Radius + T_{eff} ➡ L
- apparent mag + BC ➡ ℓ

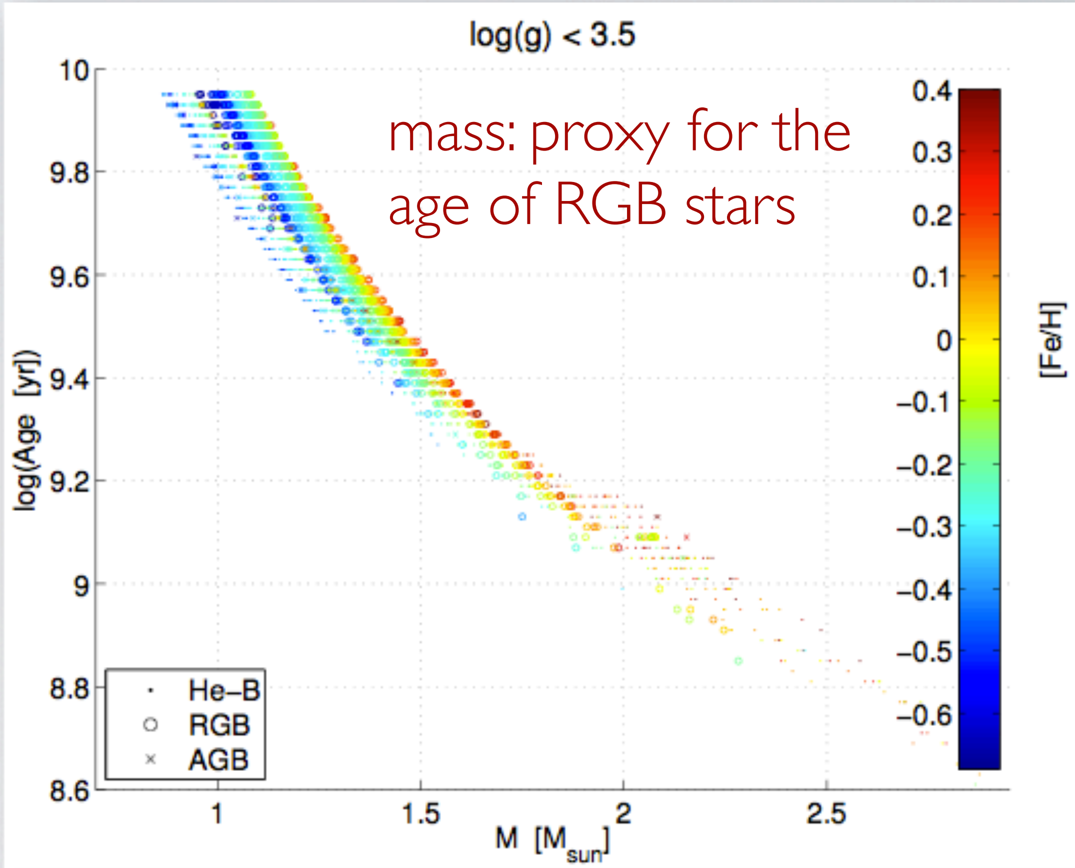
➡ $d^2 \propto L/\ell$

ENSEMBLE SEISMOLOGY OF G-K GIANTS

- Mass ➡ age

Age-mass relation

GIANTS



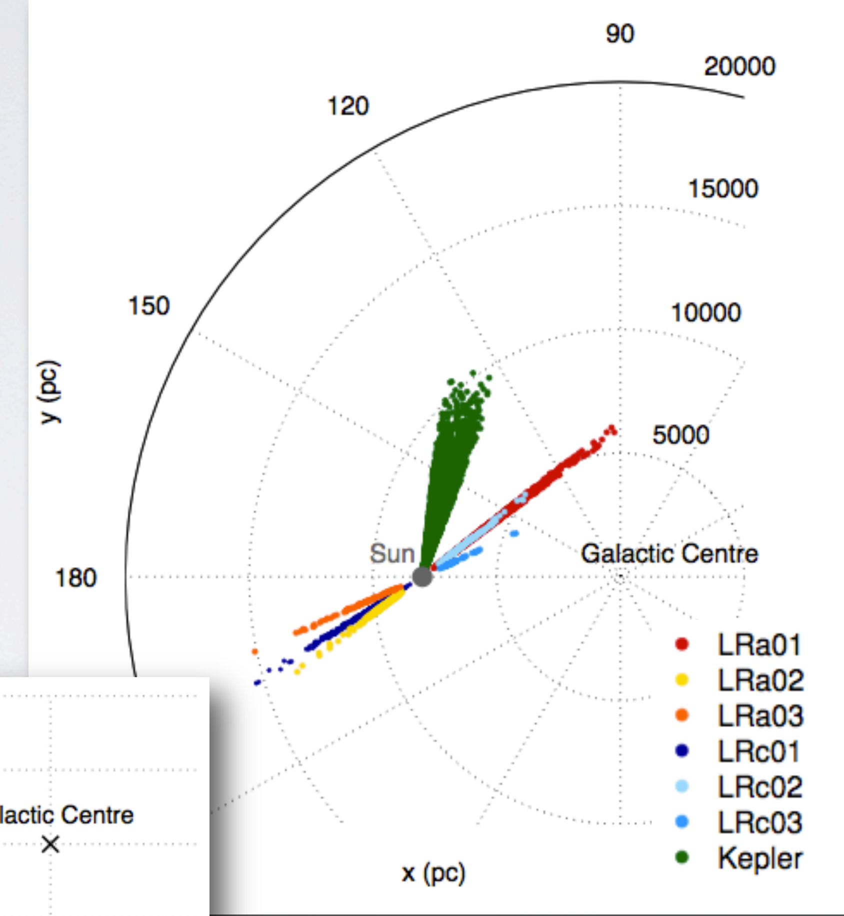
M+[Fe/H]: "chronometer" for evolved stars

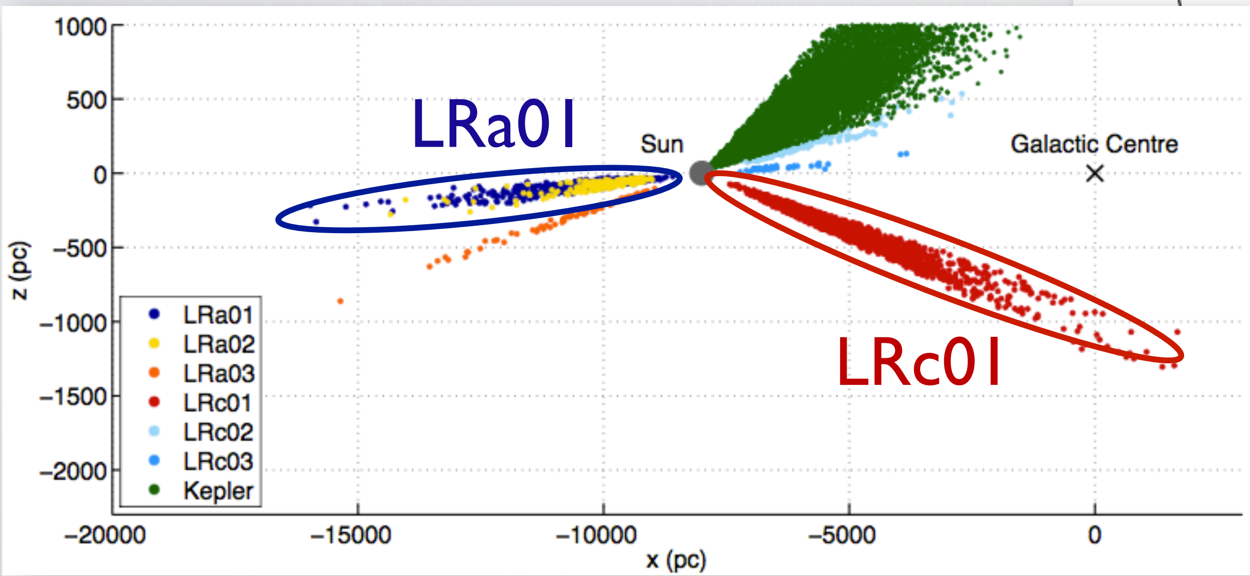
EARLY RESULTS: DISTANCES

CoRoT LRs: ~ 3000 stars
Mosser et al. 2010

Kepler data: ~ 10000 stars Hekker et al. 2011, Stello et al.

uncertainty ~10-15%



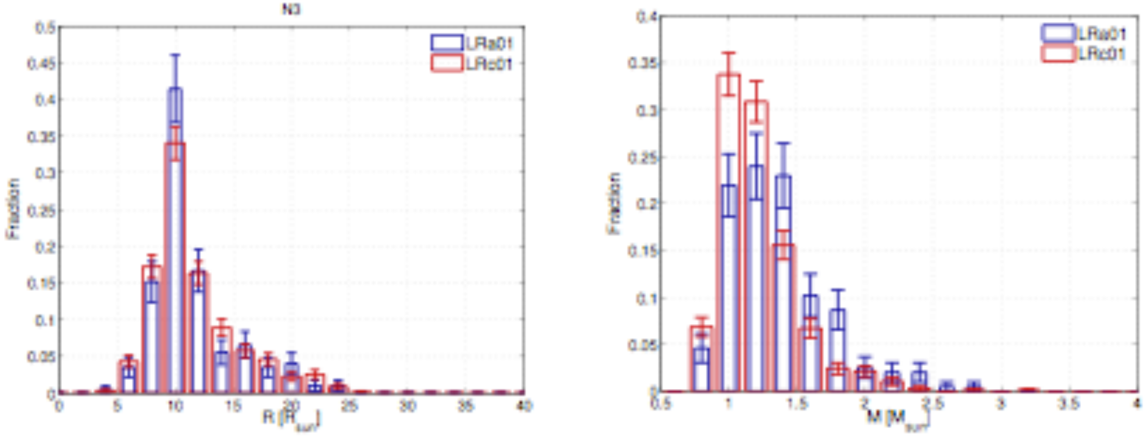


Miglio et al. 2012 ApSS

Miglio, Chiappini, Morel et al. MNRAS in press
http://arxiv.org/abs/1211.0146

early results: differential population studies

observed



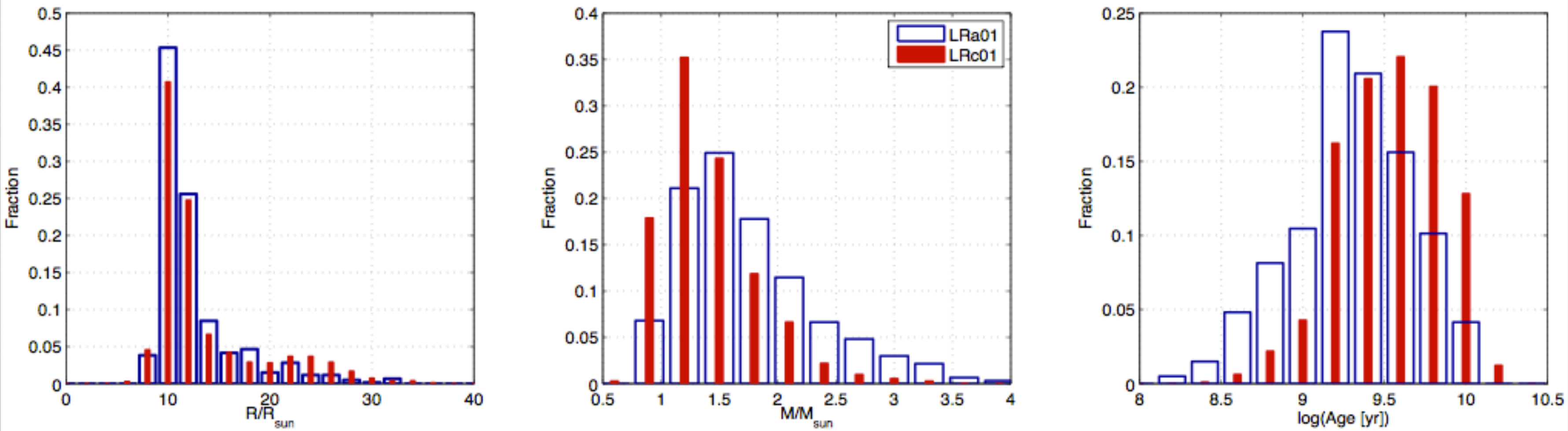
$\bar{Z}_{LRa01} < \bar{Z}_{LRc01}$

Miglio, Chiappini, Morel et al. MNRAS in press

http://arxiv.org/abs/1211.0146

synthetic

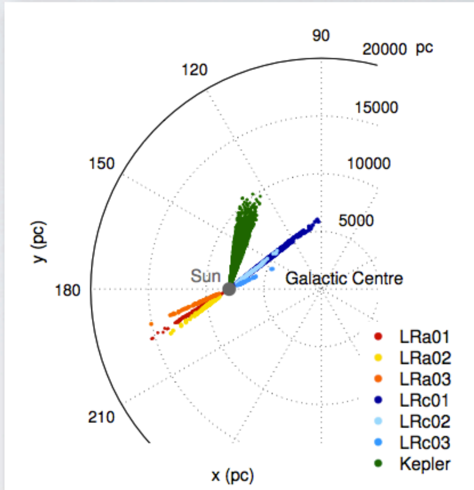
TRILEGAL



Summary

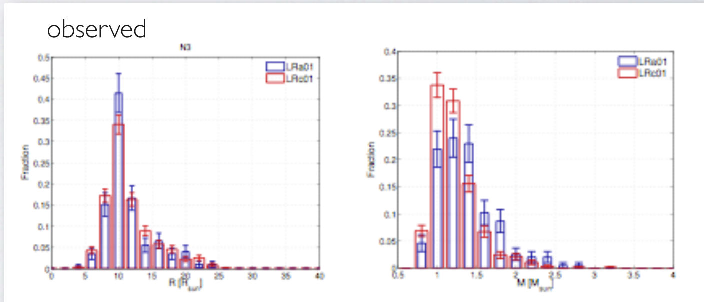
solar-like oscillating G-K giants are novel tracers of the MW

- large number: ~ 10-15,000 observed by CoRoT and *Kepler*



- accurate distance indicators

- we can map regions ~10 kpc away from the Sun, at different z and R



- we can explore with a homogeneous sample a wide age interval sampling look-back times as long as the age of the Galaxy.

SPECTROSCOPIC CONSTRAINTS NEEDED!

seismology of giants in
CoRoT and *Kepler* fields
(age, distance)

+

chemo-dynamical constraints
from spectroscopic analyses

→

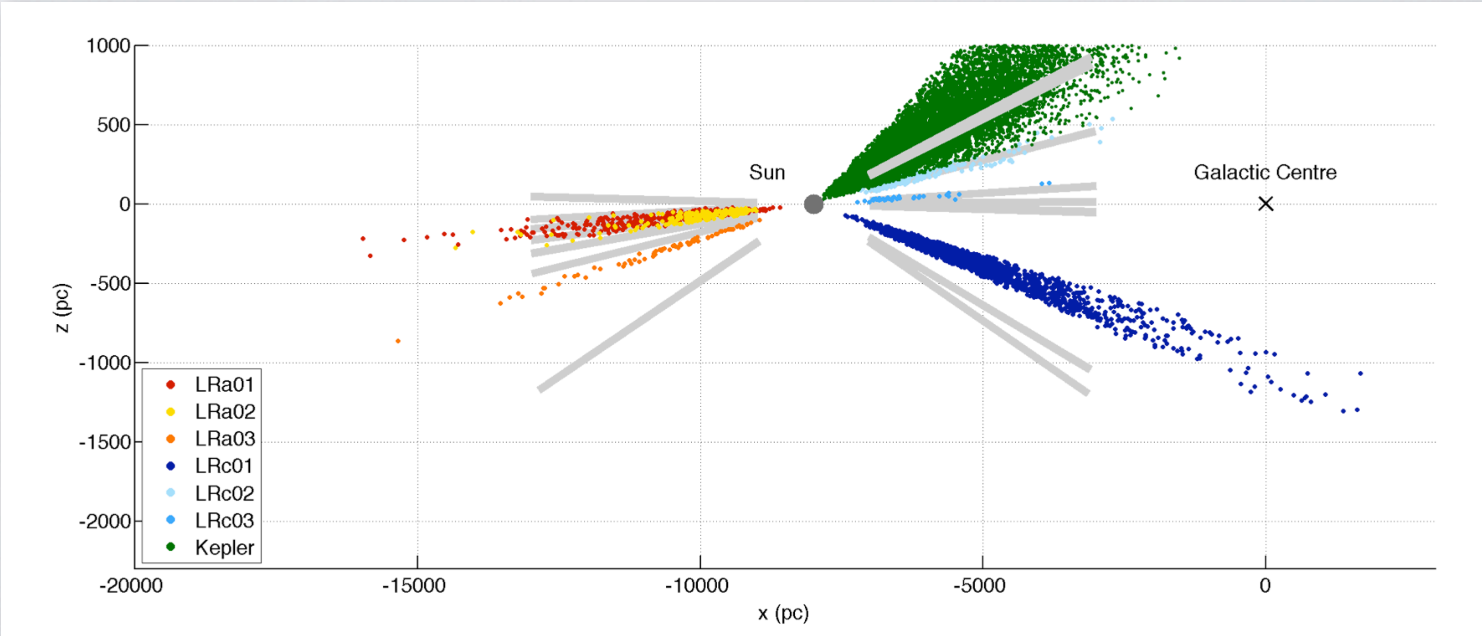
gold standard for current
and future surveys of the
Milky Way

chemo-dynamical constraints are
the limiting factor now

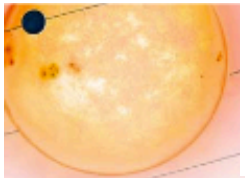
A LOOK AT THE FUTURE

- *Kepler*: fixed FOV in the extended mission, but exquisite data for seismology

- CoRoT: future runs in the extended mission

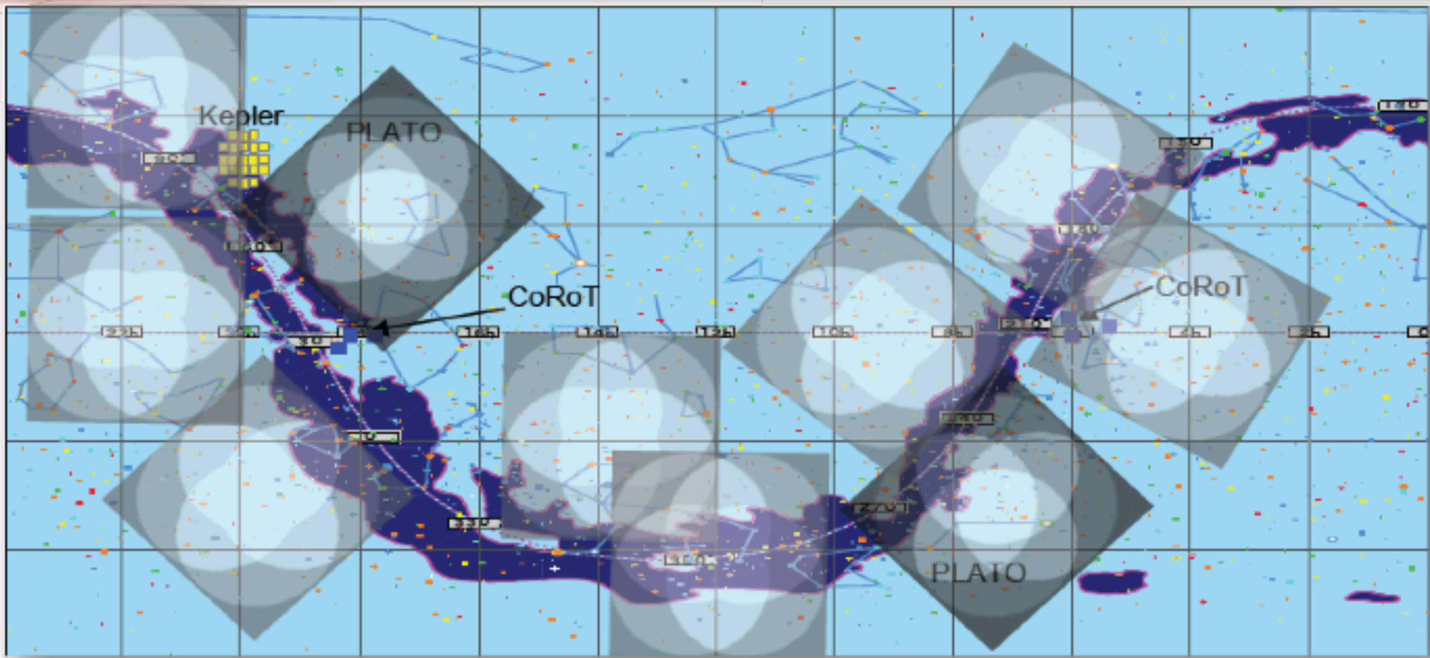


A LOOK AT THE FUTURE



PLATO: FIELD OF VIEW

esa



The M2 baseline assumed 2 long pointing + step-and-stare phase

For M3: Other observing other strategies are possible, e.g.:

- Start with step-and-stare phase for large coverage in the early phase → > 50% coverage
- Start at regions with interesting objects

courtesy of H. Rauer (DLR)