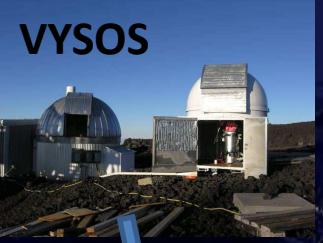
Since 2003 Danish 1.54m telescope at ESO La Silla has participated in the development of the microlensing technique and search for exoplanets; first as part of PLANET and since 2008 as MiNDSTEp with 5 months per year dedicated to microlensing and parallel projects.
The telescope was build in 1975 and scheduled for close down in 2006, but is now running for as long as spare parts and computers permit.

La Silla DK1.54m


observers

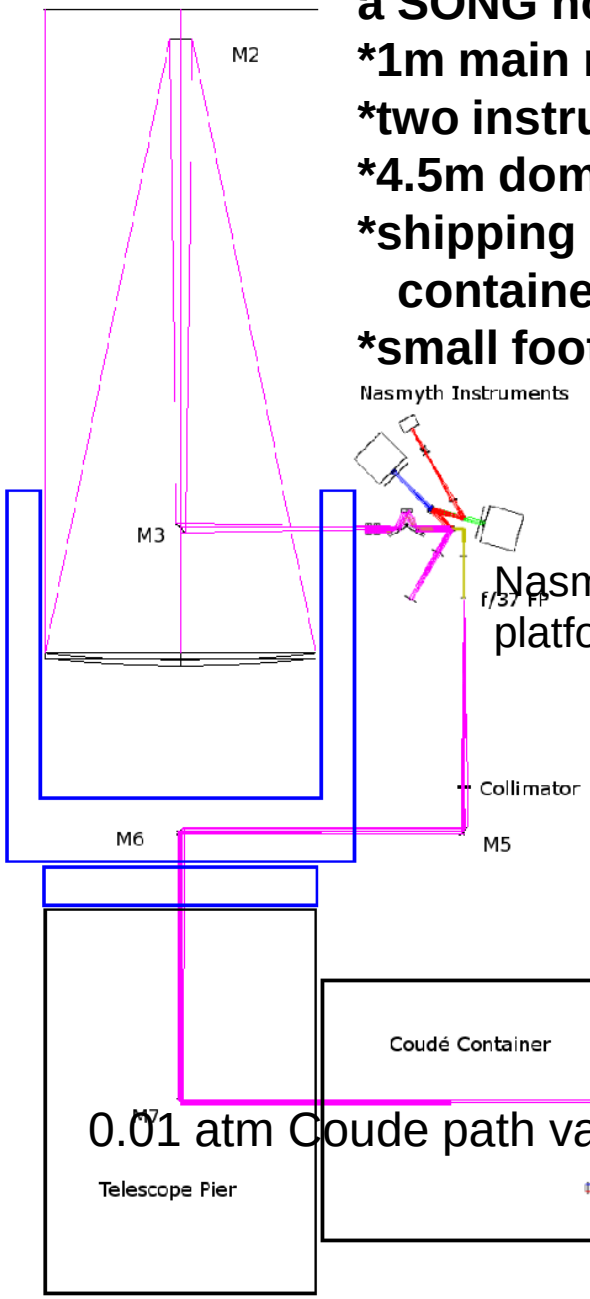

friends


telescope



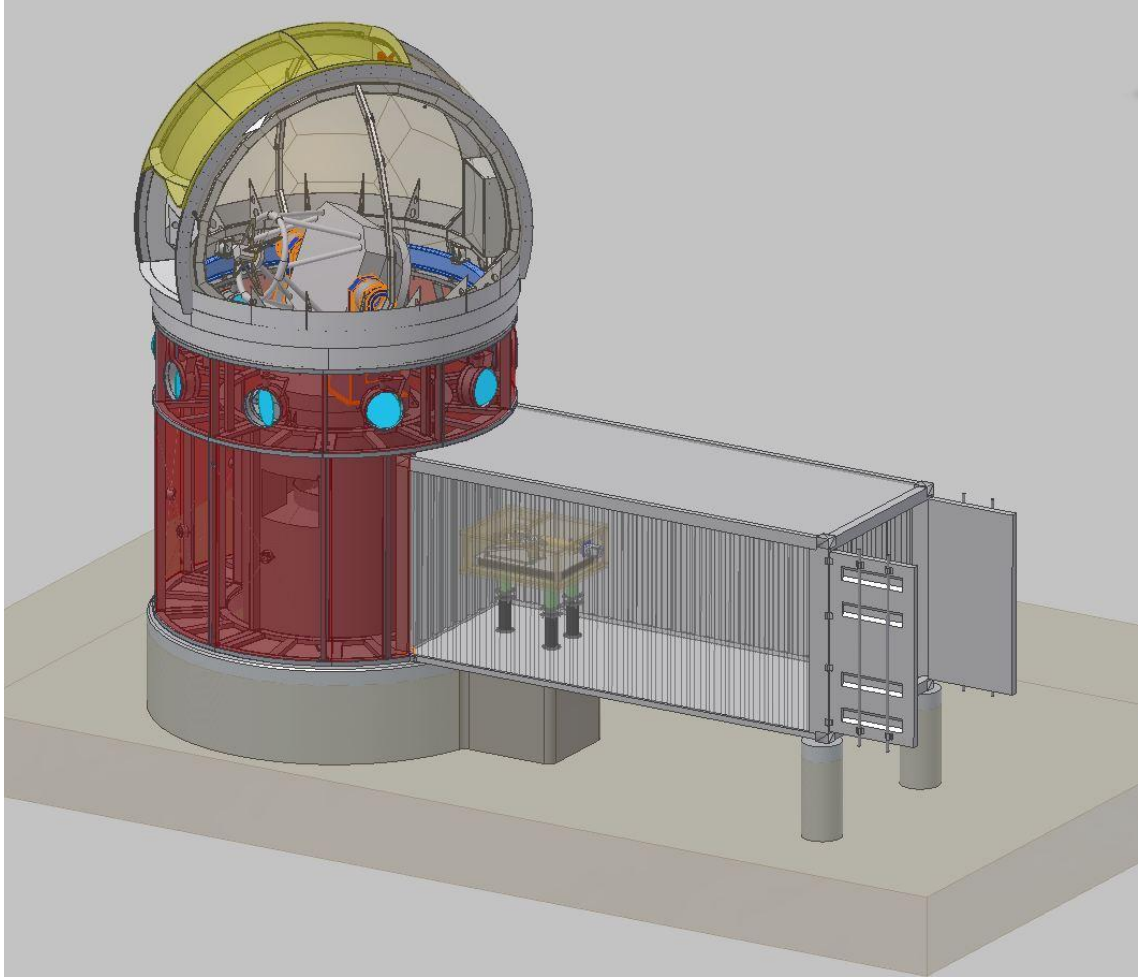
In 2011 and during following years, MiNDSTEp will be joined by several other telescopes

a SONG node has
***1m main mirror**
***two instruments**
***4.5m dome**
***shipping container**
***small footprint**



Nasmyth platform

0.01 atm Coude path vacum



SONG is a global network of robotic 1m telescopes, optimized to microlensing and asteroseismology

The price of a SONG node is 2 million Euro, which makes it affordable to be a partner in the project

How to make the network global

•1m modular 2MEuro 7/24 network telescopes with 2 specialized instruments

•diffraction limited camera (lucky imaging) for microlensing

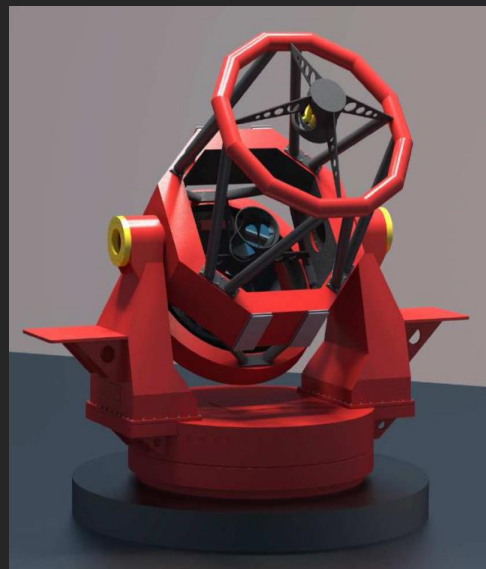
•high-resolution (R=120,000), high-stability (1 m/s for bright stars) I-cell spectrograph

•Rapid re-pointing (20 deg/s), 5” precision

•2 Nasmyth foci (<60s switching); 15’/45” field

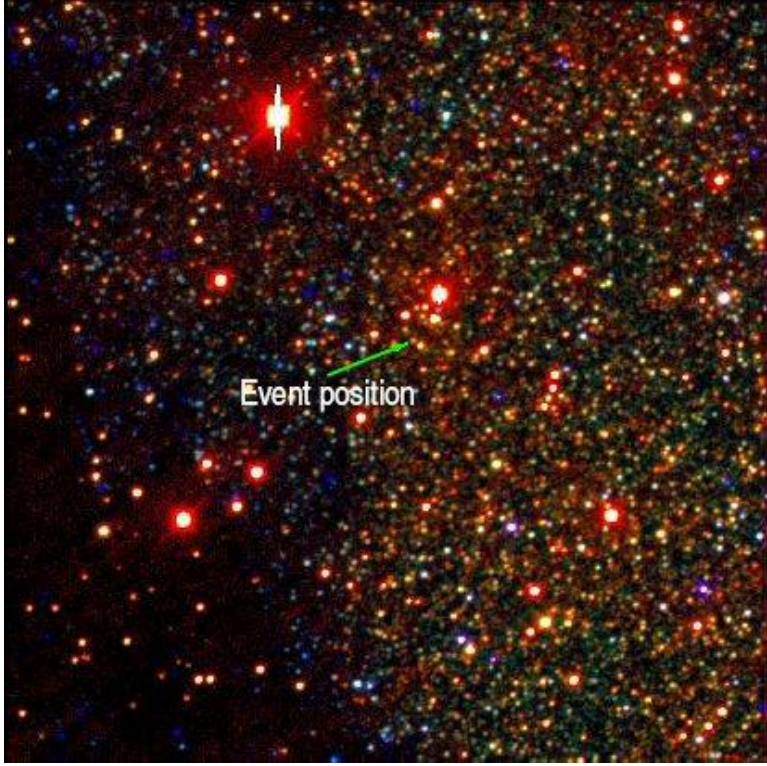
•Window allowing daytime observations

•Controllable mirror w. Shack-Hartmann WFS



$$A_{\max} = \frac{}{\sqrt{1+4(\Theta_E/\Theta_S)^2}}$$

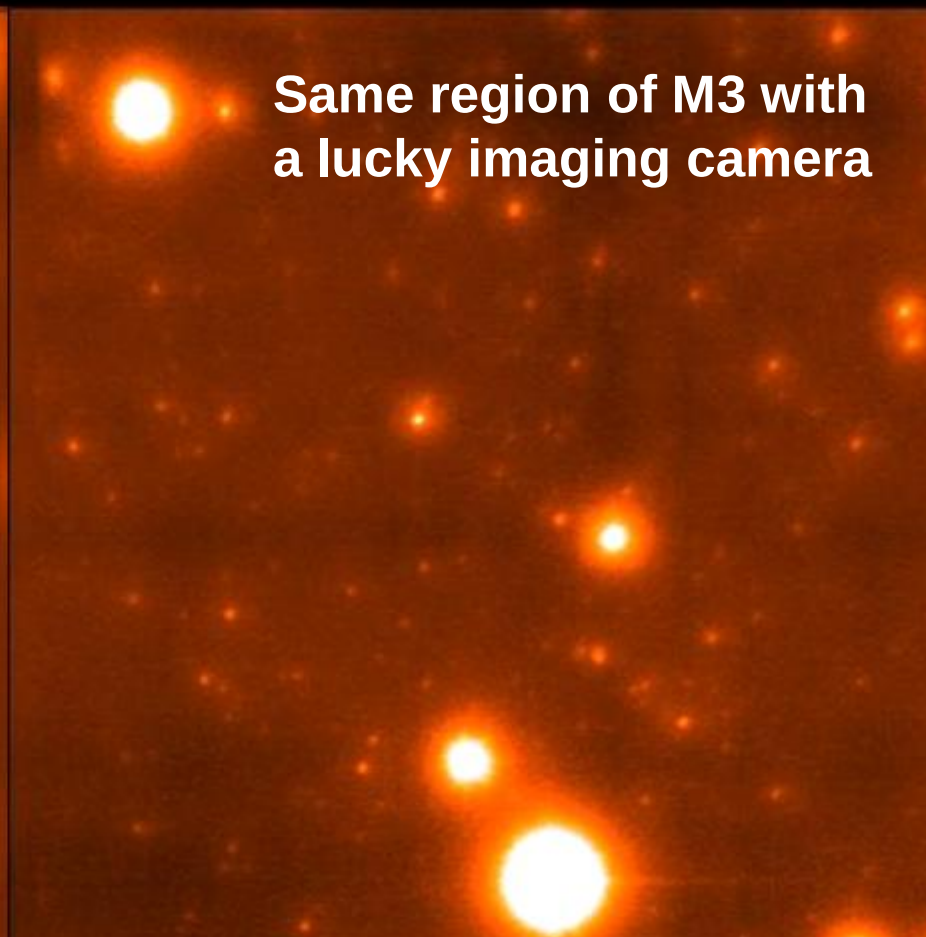
SONG is a follow-up survey able to find small planets

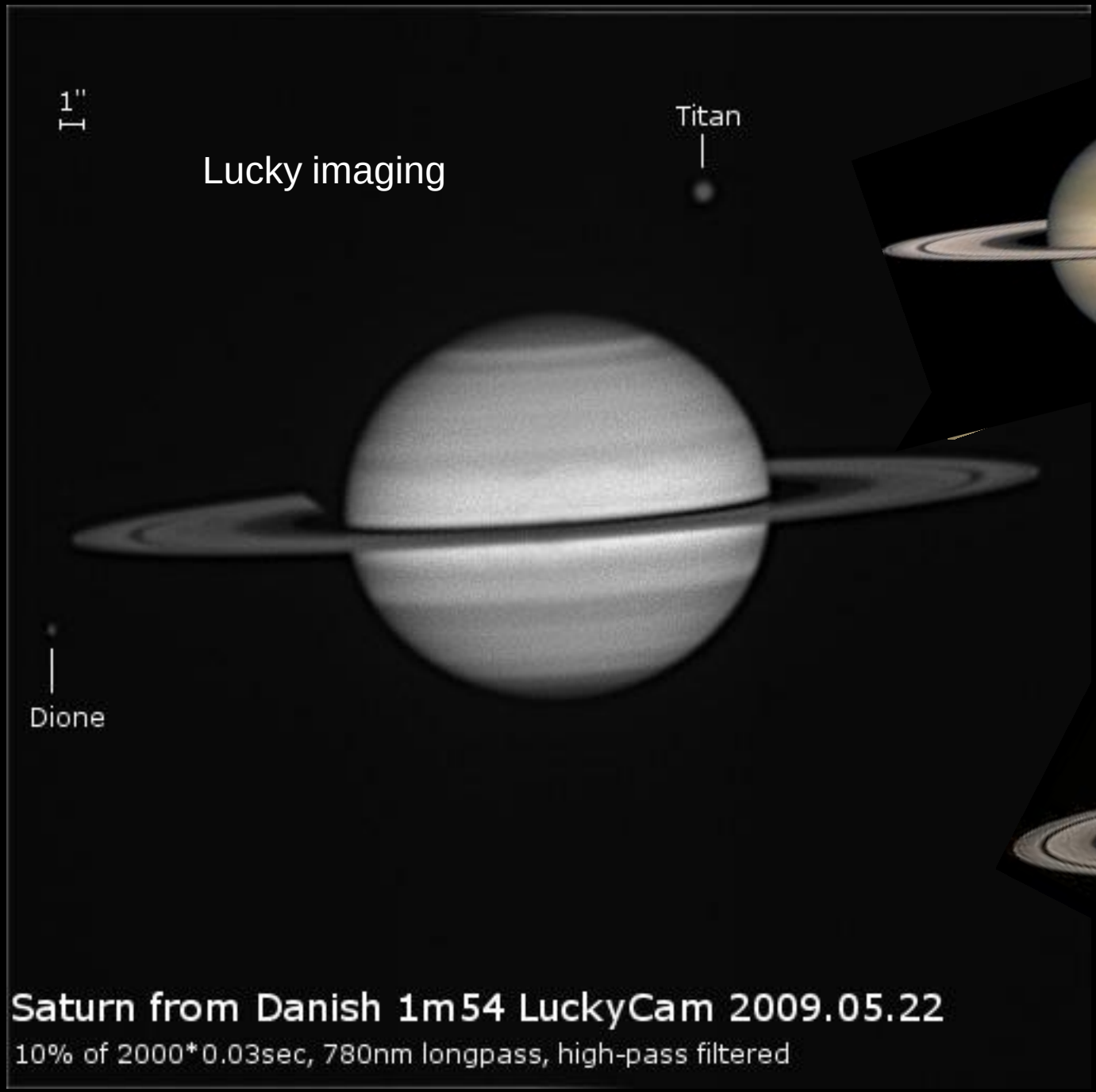


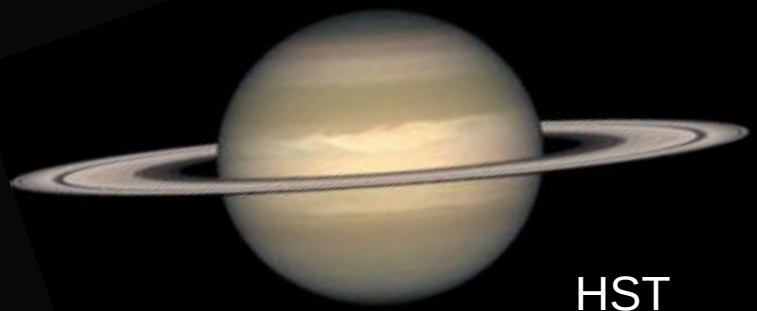
To observe smaller mass planets, requires to be able to resolve smaller source stars (i.e Lucky Imaging if fields are crowded), and observe more events (i.e. faster telescopes, observing a larger fraction of the year and night).

In order to routinely discover terrestrial-like exoplanets in terrestrial-like orbits, SONG telescopes are developed for diffraction limited Lucky Imaging for microlensing .

– in I-band r0 is 20cm at seeing of 1”, giving D/r0=5, => optimal Lucky Imaging, with ”space-like” resolution of 0.2”

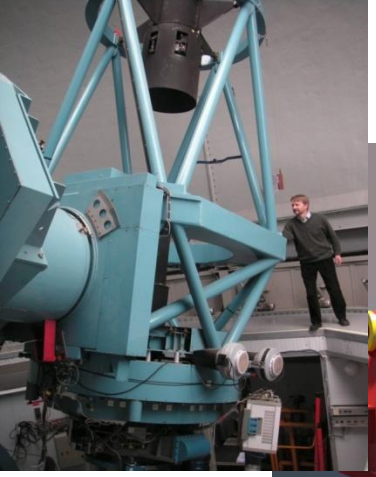



1''
Titan
Lucky imaging
Dione
Saturn from Danish 1m54 LuckyCam 2009.05.22
10% of 2000*0.03sec, 780nm longpass, high-pass filtered



HST

Voyager



Compared to older telescopes, SONG has:

3X smaller PSF (factor 10)
Better throughput (factor 1.5)
Faster slew and pointing (factor 2)
Broader filters (factor 4)
Better use of the year (factor 2)

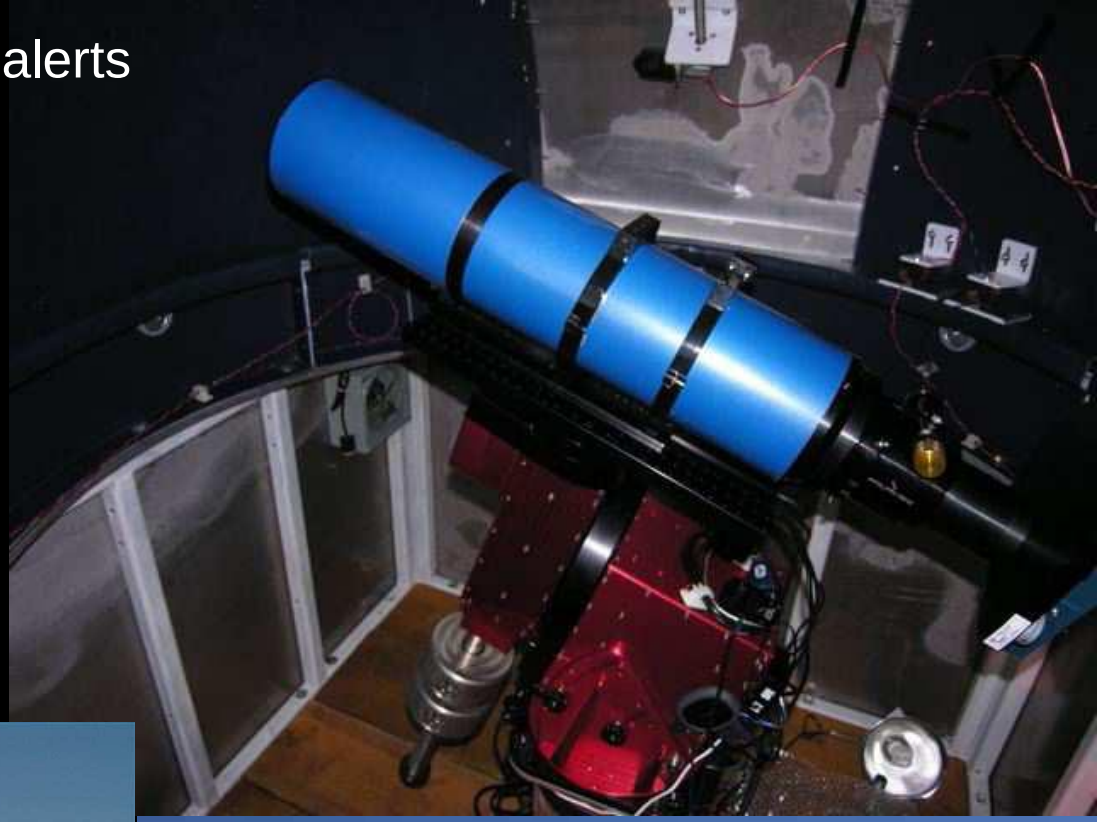
i.e. a SONG telescope obtains >100 times more science photons per background photon per time unit

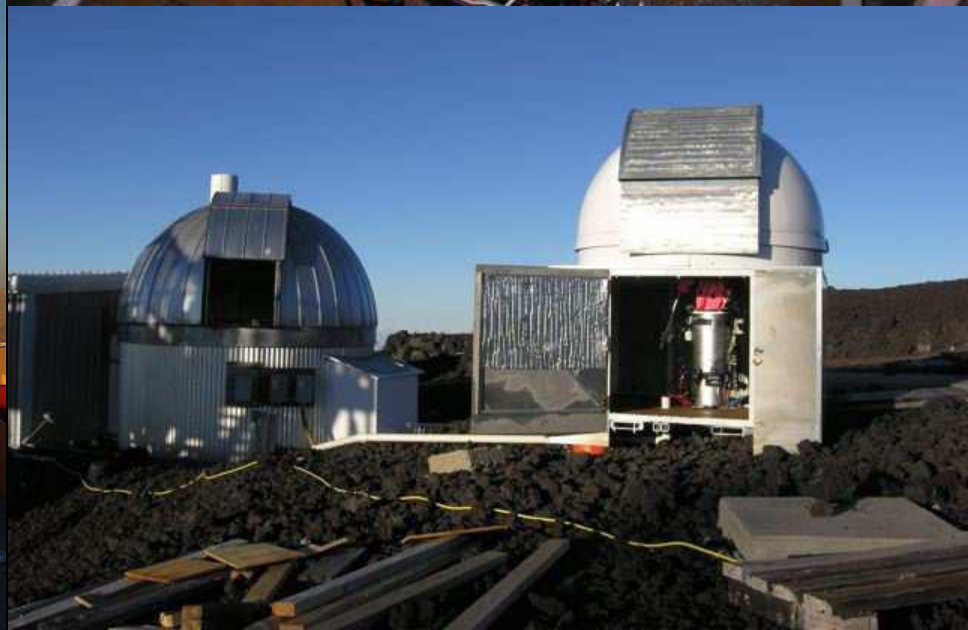
=>SONG can reach 10 times smaller planets with 10 times higher efficiency. The source crossing probability decreases only with $\sqrt{M_{pl}}$. If there are 5-50 times more 1-10 M_E planets than 10-300 M_E planets, as most planet formation models predict, we will expect at least 10, and up to a few hundreds, terrestrial like planets per year with SONG, and reach good statistics on terrestrial planets after a few years of operation.

Tests with bright microlensing alerts in the whole Galactic plane are now being performed at

VYSOS-5” (right) and Mauna Loa Observatory in Hawaii

and
VYSOS-6” (below) at Cerro Armazones Observatory in Atacama, Chile.

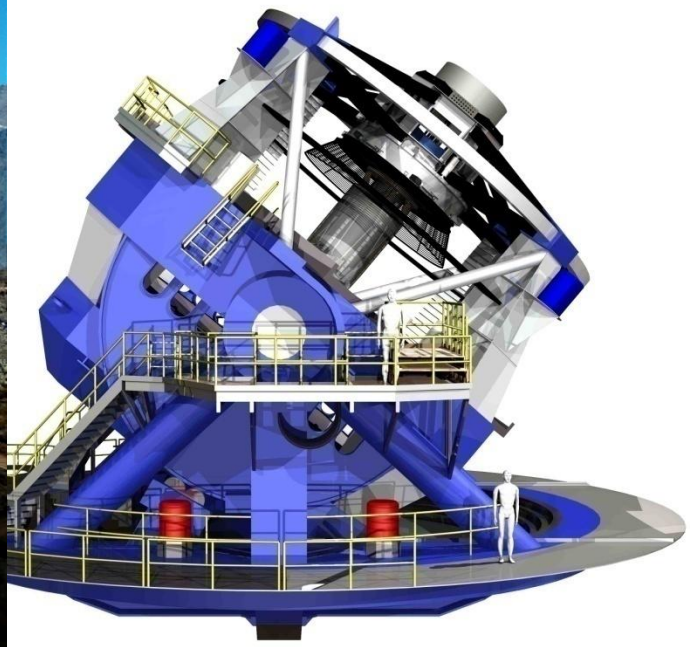


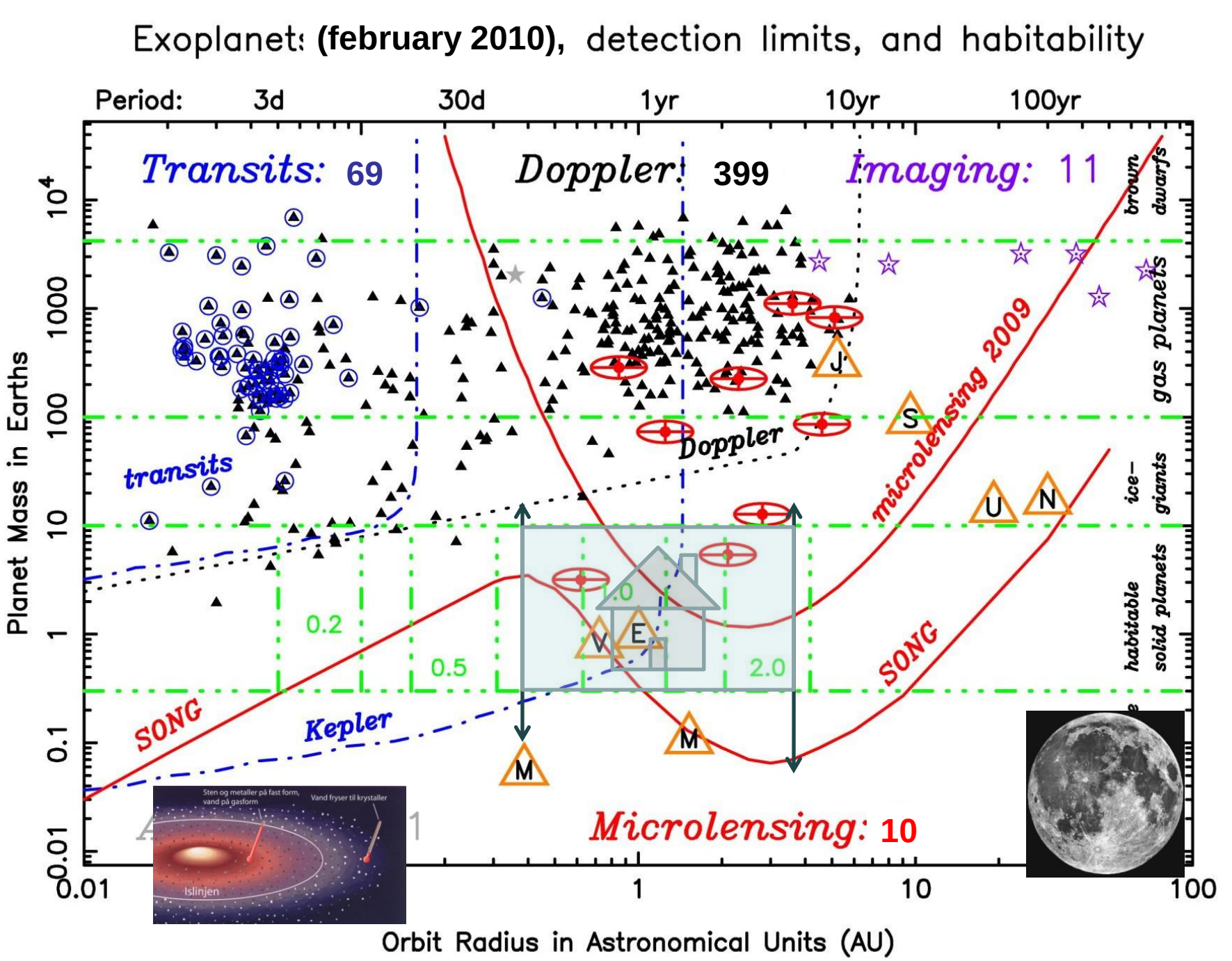


Large Synoptic Survey Telescope
LSST will detect NEOs to 100 m diam.

One 8.4 m mirror, 3 Gpixel CCD, Vlim = 27
full sky cover every 3 nights from 2014; 30 TB/night
10 sqr.deg. in each 15 sec exposure
at 0.2”resolution in 5 bands, 4000Å-1.06mu

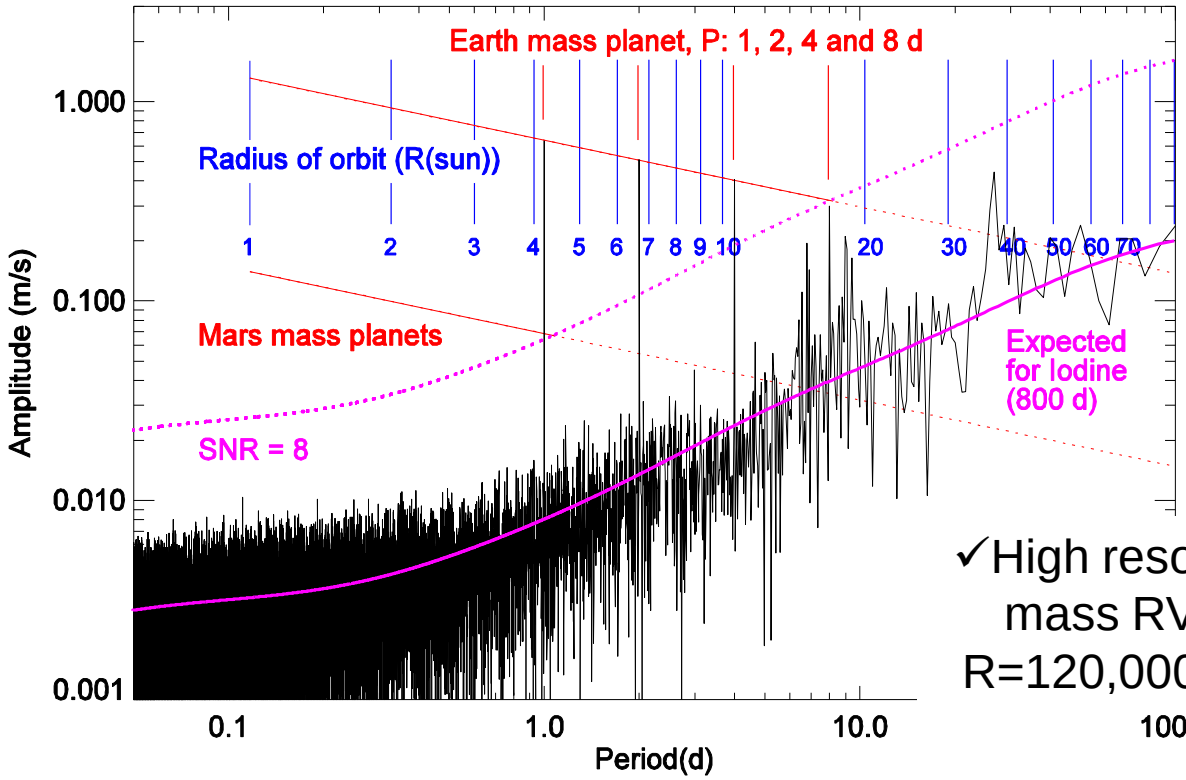
2.7km high Cerro Pachon in North Chile




Exoplanets (february 2010), detection limits, and habitability
Period: 3d 30d 1yr 10yr 100yr
Transits: 69
Doppler: 399
Imaging: 11
Microlensing: 10
transits
Doppler
microlensing 2009
SONG
Kepler
SONG
0.2
0.5
1.0
2.0
J
S
U
N
V
E
M
M
brown dwarfs
gas planets
ice–giants
habitable solid planets
Planet Mass in Earths
Orbit Radius in Astronomical Units (AU)
0.01
0.1
1
10
100
1000
10^4
0.01
1
10
100
Sten og metaller på fast form, vand på gasform
Vand fryser til krystaller
Islinjen

SONG (Stellar Observations Network Group): A global network of 1m telescopes for long time series observations

✓High resolution imaging for microlensing at ”summer time”



SONG radial velocity capability:

- **Mars-mass planets with P < 1 day**
- **Earth-mass planets with P < 8 days**
- **4-Earth-mass planets with P < 30 days**

✓High resolution spectrograph for low mass RV observations in ”winter” R=120,000; dV=1m/s for bright stars

StarPlan is a so-called Centre of Excellence in Copenhagen

The central theme of StarPlan: is our solar system normal?

* observations and models of solar systems under formation
*studies of the oldest material in our own solar system
*studies of extrasolar planets with SONG

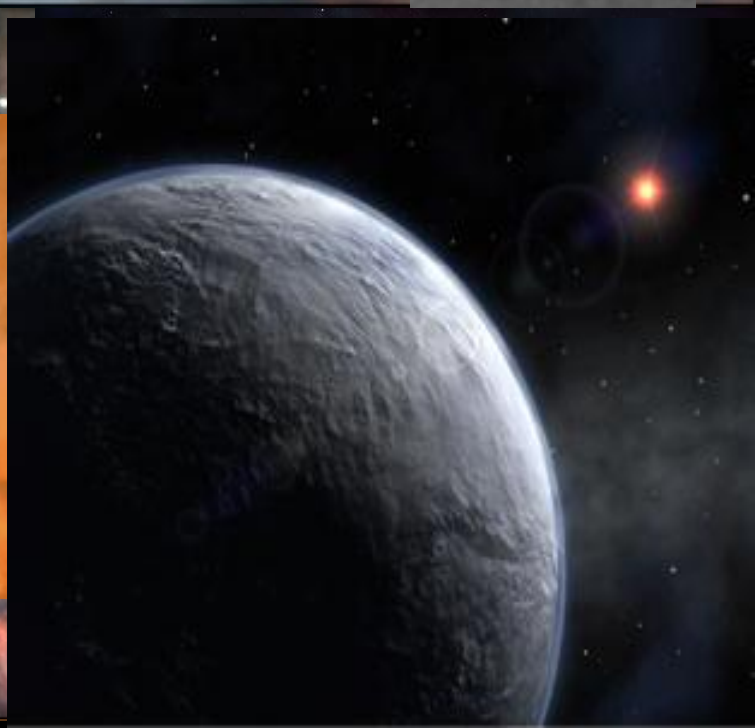
proplyd

Protostellar disk?

New solar systems in the Orion nebula

20.000 AU

There are special NSF fellowships available in USA for PhD studies at StarPlan



Did we develop here because the solar system is unique?
(or) is it because the solar system is unique we are here?

StarPlan and exoplanets:

StarPlan is developing a camera that will use the microlensing theory to help revealing the abundance of exoplanetary systems similar to our own – including truly exo-Earths. The camera will be placed on all the SONG telescopes in a global network.

The exoplanet group at StarPlan (starplan.net) is participating in the global networks:

* SONG,
  song.phys.au.dk, a global network of 1m telescopes,
* MiNDSTEp,
  mindstep-science.org , searching for exoplanets.