Search for young transiting exoplanets within YETI project

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and
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Young Exoplanet Transit Initiative

World-wide monitoring of young open clusters

to find young transiting exoplanets

Cooperation of ~20 observatories and institutes since 2010

Project PI: Ralph Neuhäuser

Astrophysical Institute and University Observatory Jena (Germany)

Thanks to my Co-Is:
Markus Mugrauer, Stefanie Raetz, Ronnie Errmann (Jena/Germany),
Jan Janik (Brno/Czech Rep.), Waldek Ogłoza, Marek Dróżdż (Suhora/Poland),
Theo Pribulla, Zoltan Garai, Martin Vanko (Stara Lesna/Slovakia),
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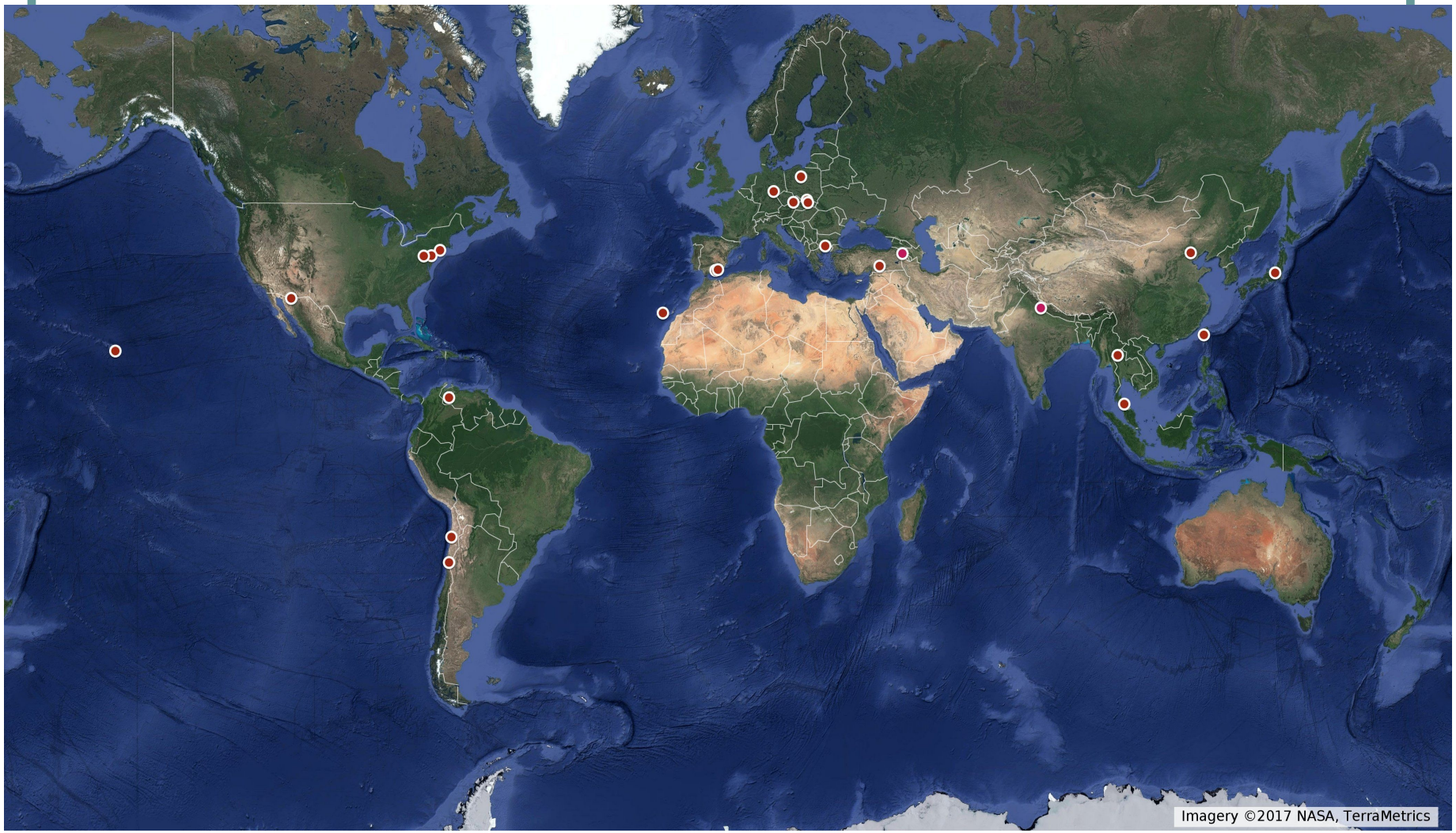
Santosh Joshi (ARIES Nainital/India),
Zhenyu Wu, Zhou Xu, Yonghao Wang (Xinglong/China),
Wen-Ping Chen (Lulin/Taiwan) and many others...

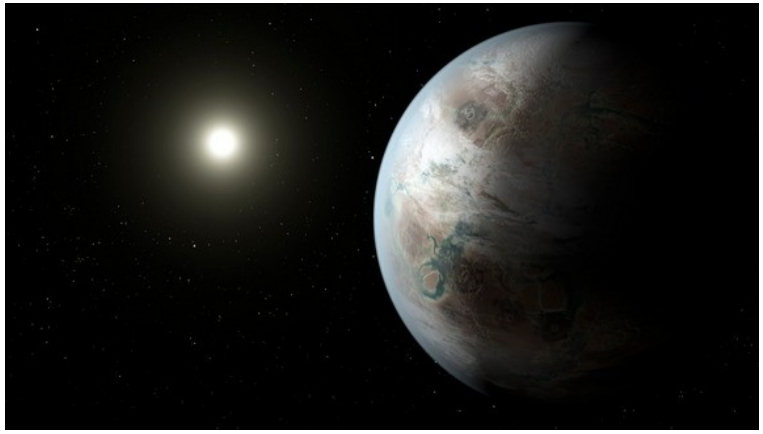
Young Exoplanet Transit Initiative



Young Exoplanet Transit Initiative

Goals of YETI network

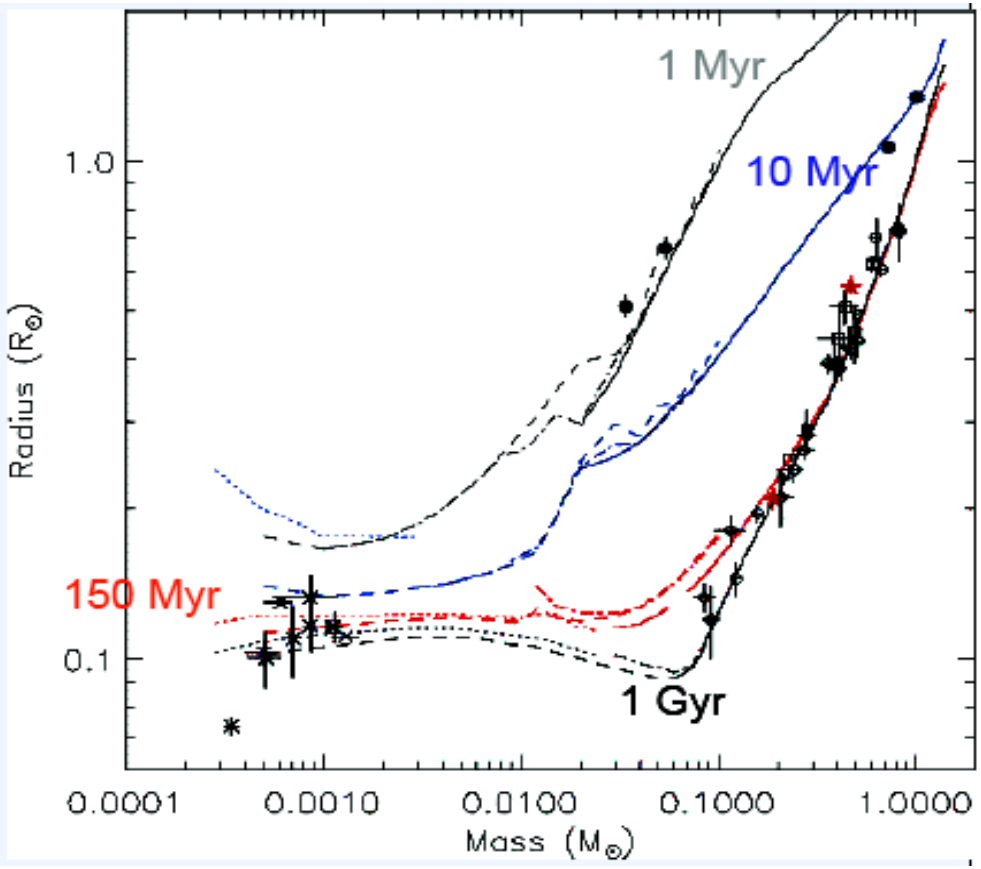
- The main aim is to find young transiting extrasolar planets



Credit: NASA Ames/JPL-Caltech/T. Pyle

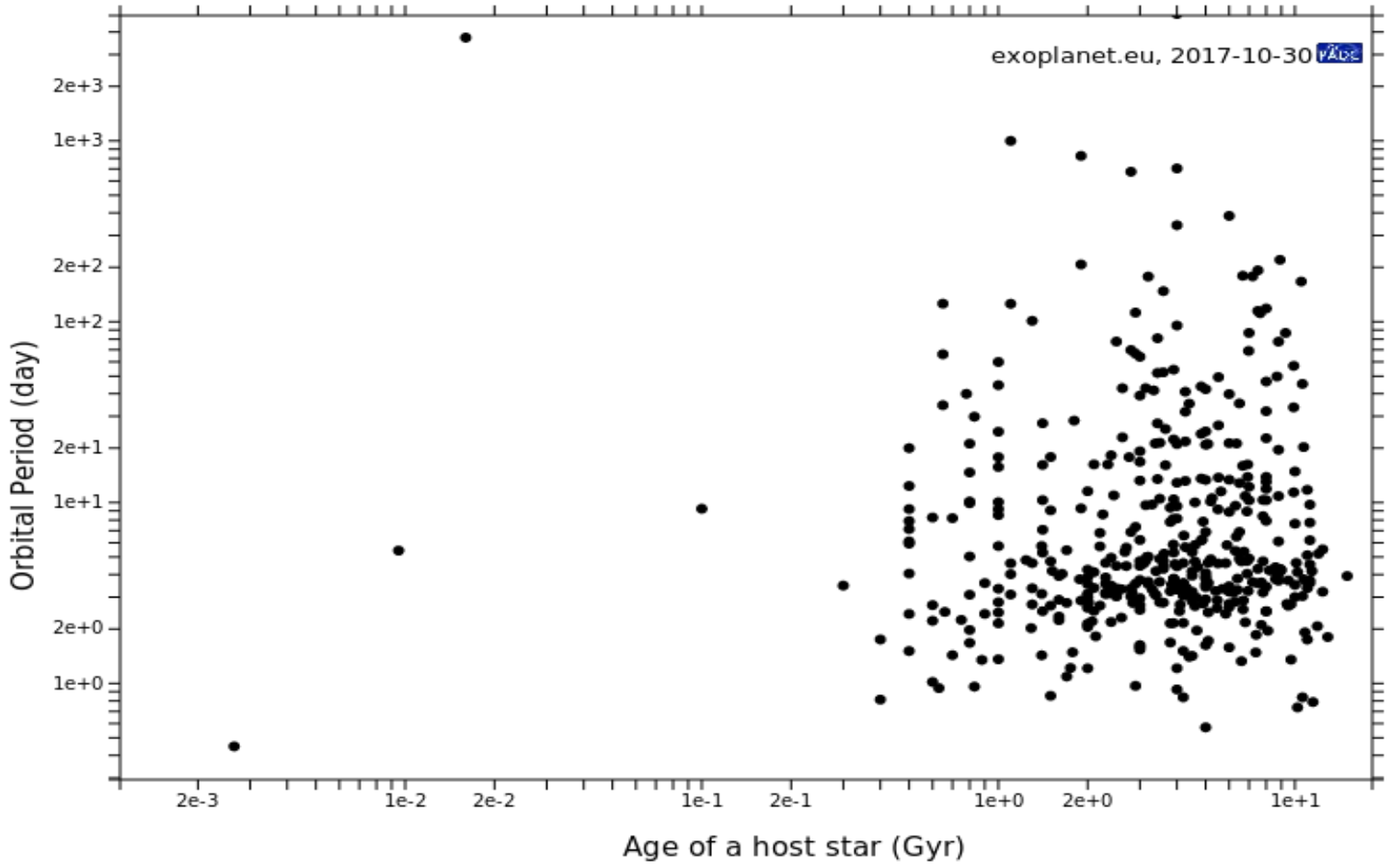
- Detailed study of selected eclipsing binaries, determination of the orbital and physical parameters of companions (exoplanets, brown-dwarfs, low-mass stars of late spectral types)
- Investigation of other variability phenomena in selected stars on different time-scales
- Long-term goal is to test star and planet formation scenarios

Goals of YETI network

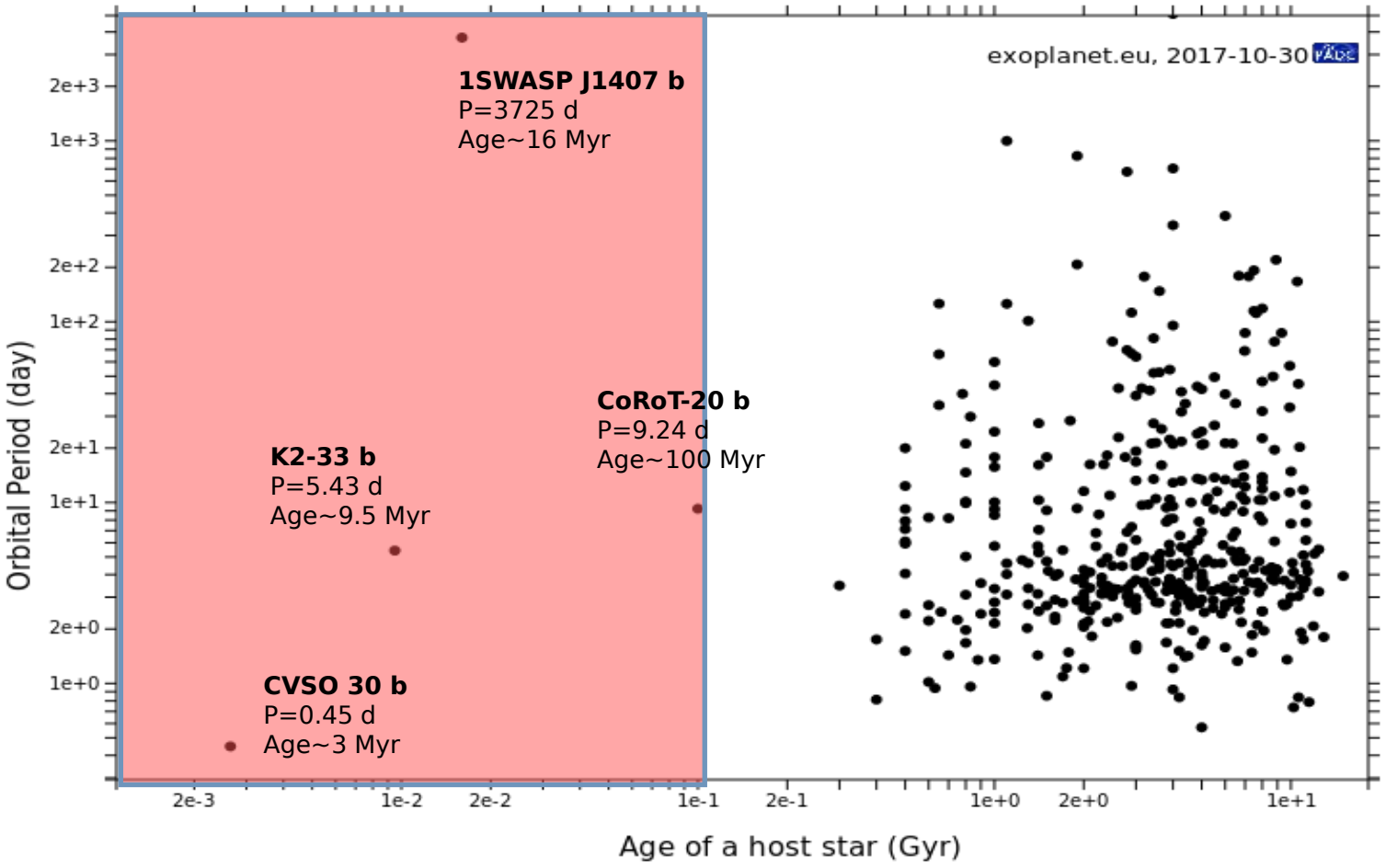


Source: invited talk of E. Moraux on JENAM 2010 mini-symposium *Star clusters in the era of large surveys*

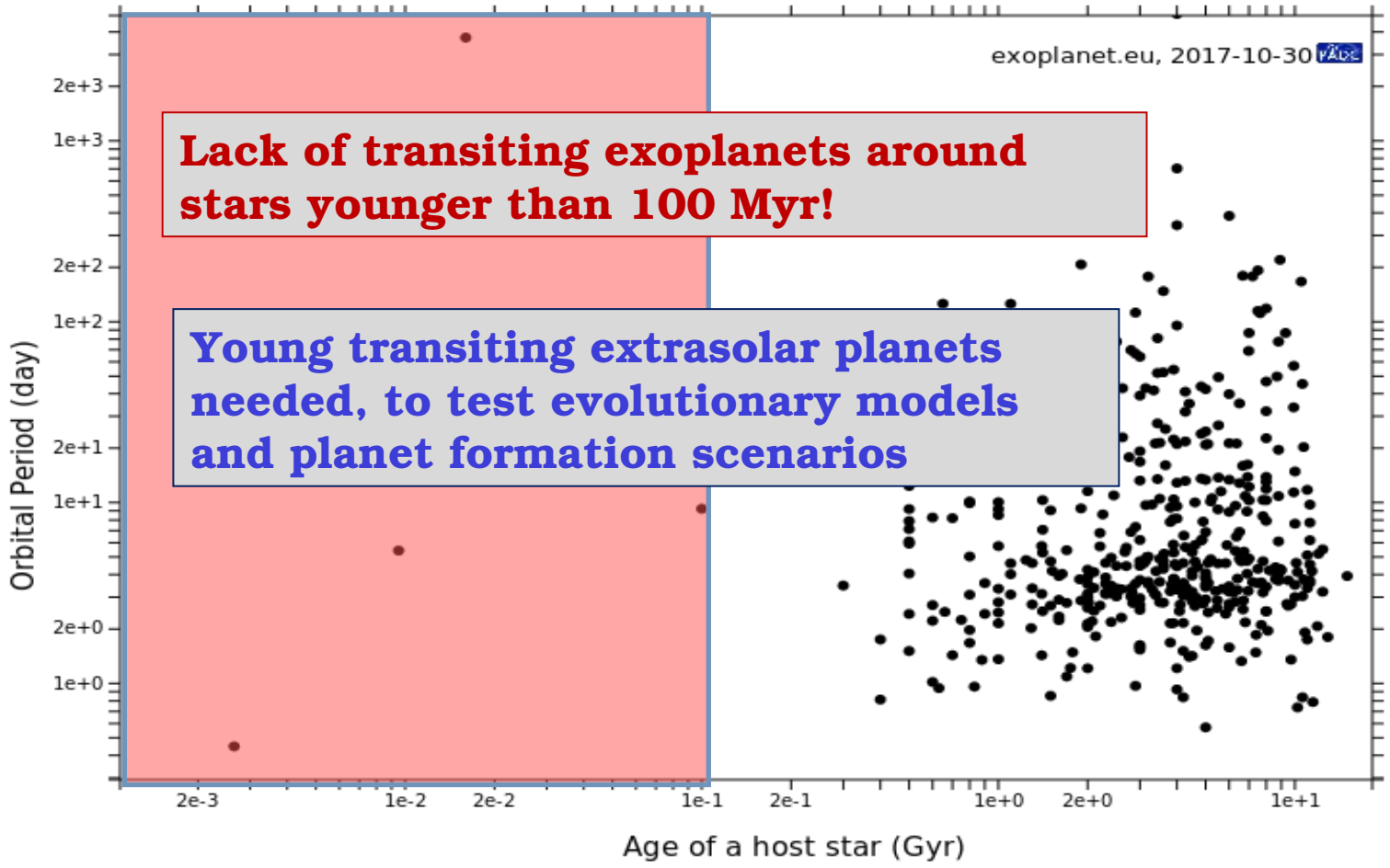
Extrasolar planets today…



Extrasolar planets today…



Extrasolar planets today…



List of YETI clusters

Open cluster	RA [h:m:s]	Dec [° : ’ : ”]	Monitoring dates (start - end)	Age [Myr]	D [pc]
Trumpler 37	21:39:00	57:29:24	2009 Aug - 2011 Sep	~4	870
25 Ori	05:24:45	01:50:47	2010 Oct - 2013 Feb	7-10	323
IC 348	03:44:34	32:09:48	2012 Sep - 2014 Nov	~2	316
Collinder 69	05:35:06	09:56:00	2012 Nov - 2015 Feb	~5	400
NGC 1980	05:35:24	-05:54:54	2013 Feb - 2015 Feb	4-5	400
NGC 7243	22:15:08	49:53:54	2013 Aug - 2015 Nov	~76	750
NGC 869	02:19:00	57:07:42	2016 Oct - ongoing	12	2079
NGC 884	02:22:18	57:08:12	2016 Nov - ongoing	11	2345
IC 4665	17:46:18	05:43:00	2017 May - ongoing	43	352

Selected targets

Open cluster name	Central coordinates J2000.0 RA [h : m : s]	Dec [° : ’ : ”]	Age [Myr]	Distance [pc]	V [mag]	Angular radius of the cluster [deg]	No. of member stars
h Per (NGC 869)	02:19:00	+57:07:42	12	2079	4.9	1.75	~3000
χ Per (NGC 884)	02:22:18	+57:08:12	11	2345	5.7	1.75	~2300
IC 4665	17:46:18	+05:43:00	43	352	4.2	1.00	382

Credit: V. Wendel, J. Popsel, S. Binnewies

DSS

What can we observe?

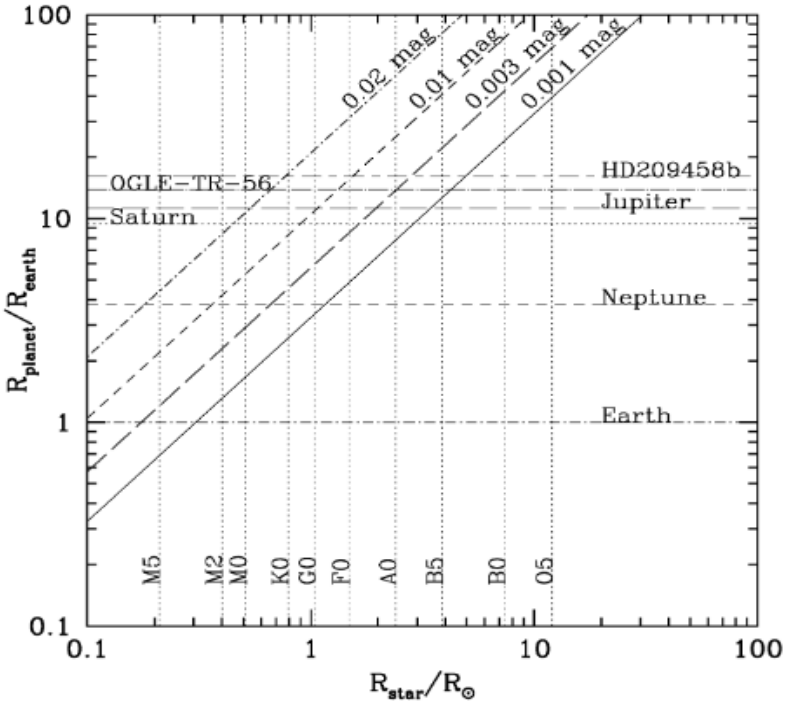


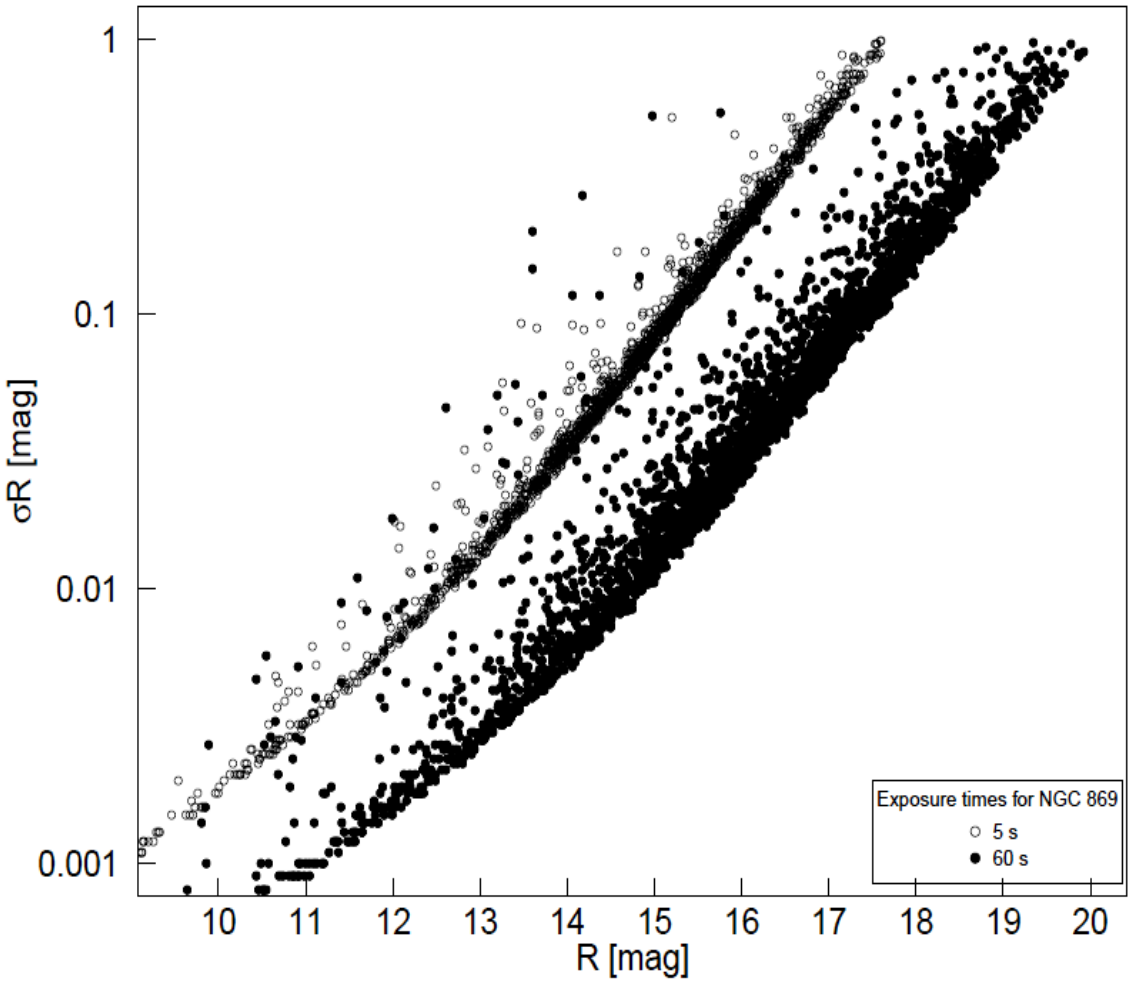
FIG. 1.—Depth of transit signal for transiting planets with different radii as a function of MK spectral type and corresponding stellar sizes (from Cox 2000) based on geometric arguments only. The diagonal lines indicate the amplitude of the transit signal in the light curve of a given planet-star combination. For instance, a Jupiter-sized planet would cause a 0.01 mag dip in the light curve of a G0 star, but only a 0.003 mag dip in the light curve of an A0 star.

von Braun et al. 2005, PASP 117, 141

Observational strategy

- **Photometric monitoring:**
- By using YETI network facility – 1 meter-class telescopes (enough observing time guaranteed)
- ~3 runs per year per cluster, typically two weeks long
- CCD observations only with R filter, also in UBVI bands outside campaigns
- Alternating short and long exposures to accommodate bright and faint stars in the clusters
- Aperture and differential photometry
- Analysis of variable objects – we are able to detect of any transit with a depth of at least ~5 mmag rms down to R = 14 mag, and ~50 mmag rms down to R = 16 mag stars

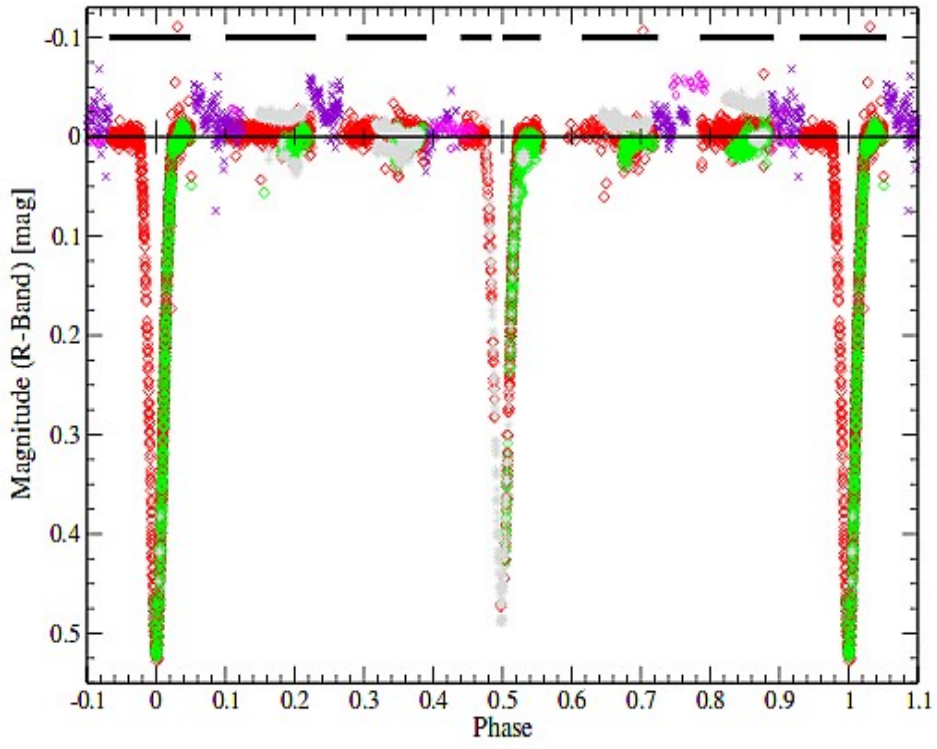
Photometric precision



Data from
0.6 m telescope
at Mt. Suhora
Observatory

Importance of networking

eclipsing star (V =11.94 mag, P = 6 d) detected in Trumpler 37
(Errmann et al. 2014, AN 335, 345)

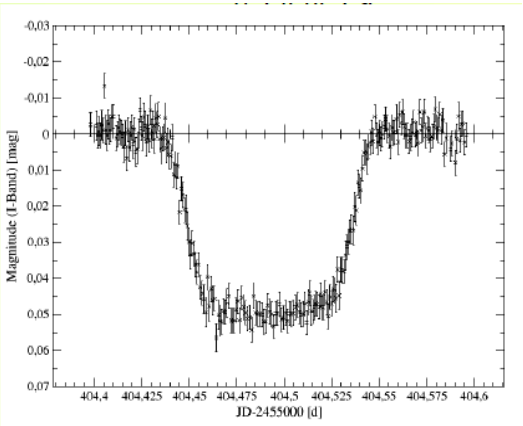


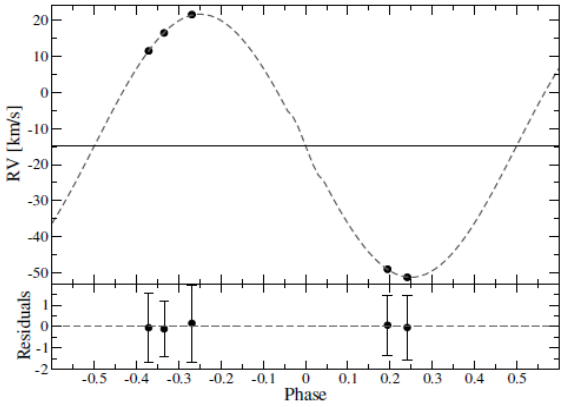
no gaps in LC important, but careful analysis of data from different telescopes is needed

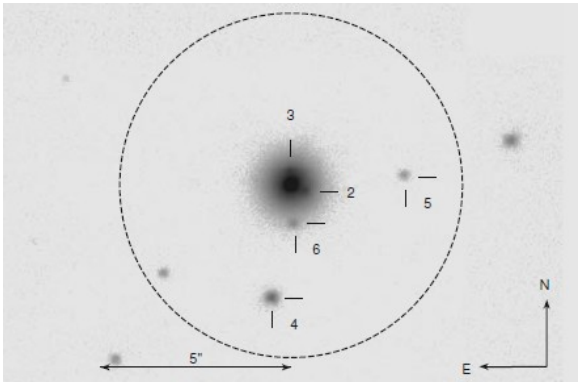
colored data points from:
Jena/Germany,
Byurakan/Armenia,
Xinglong/China,
Swarthmore/USA,
Lulin/Taiwan

Observational strategy

- **Follow-up observations for targets with periodic transit-like signals:**
- By using larger telescopes (proposals to TAC)
- High-quality photometry (to improve transit light curve)
- Low- and high-resolution spectroscopy (to ensure that the star is young and confirm the nature of substellar-mass companion, e.g. by RV variation analysis)
- Adaptive optics IR images (to exclude other bright eclipsing stars in the larger PSF)





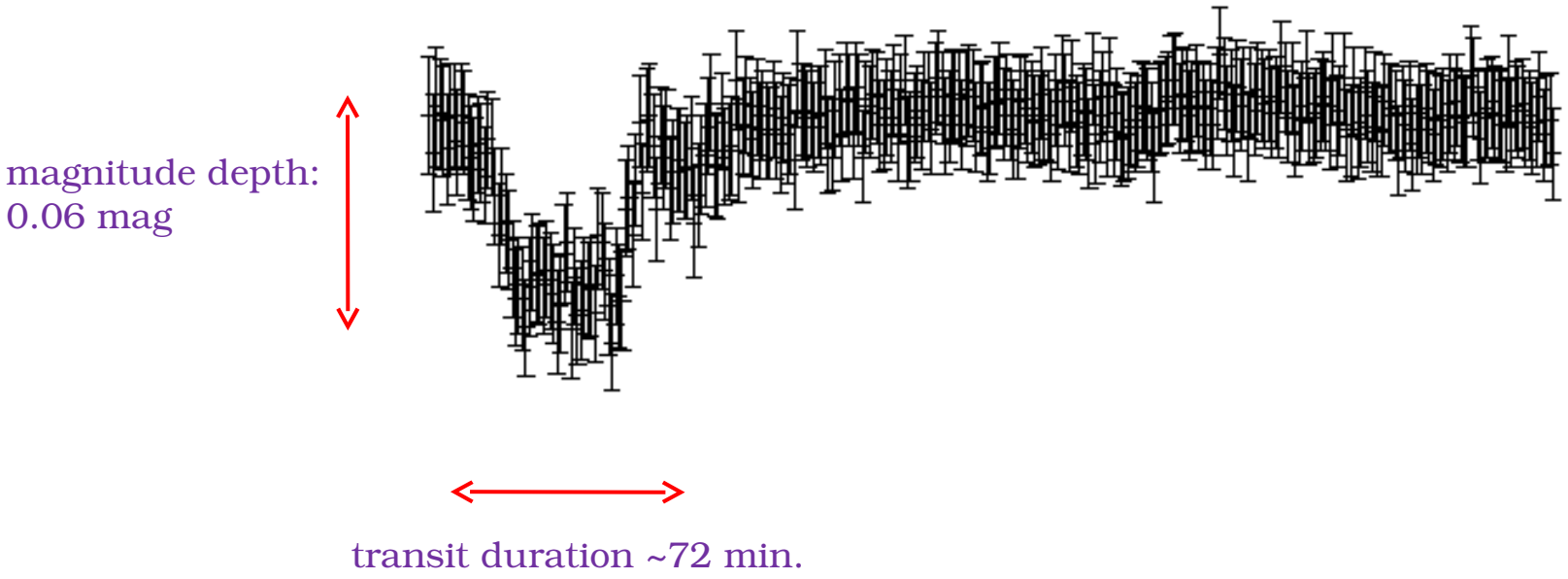


Please contact me if you are able to help with this!
pzielinski@astrouw.edu.pl

Promising candidates

Data from 0.6 m telescope at Stara Lesna Observatory

σR ~0.01 mag



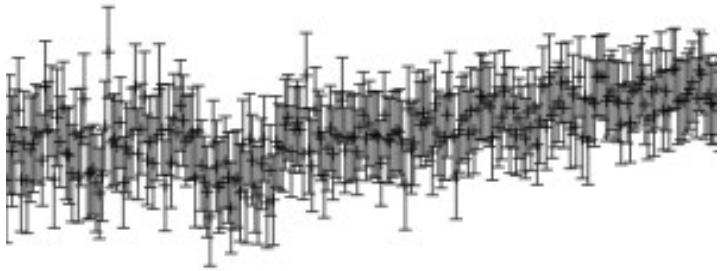
Star 197 in NGC 869

Promising candidates

Data from 0.6 m telescope at Stara Lesna Observatory

σR ~0.015 mag

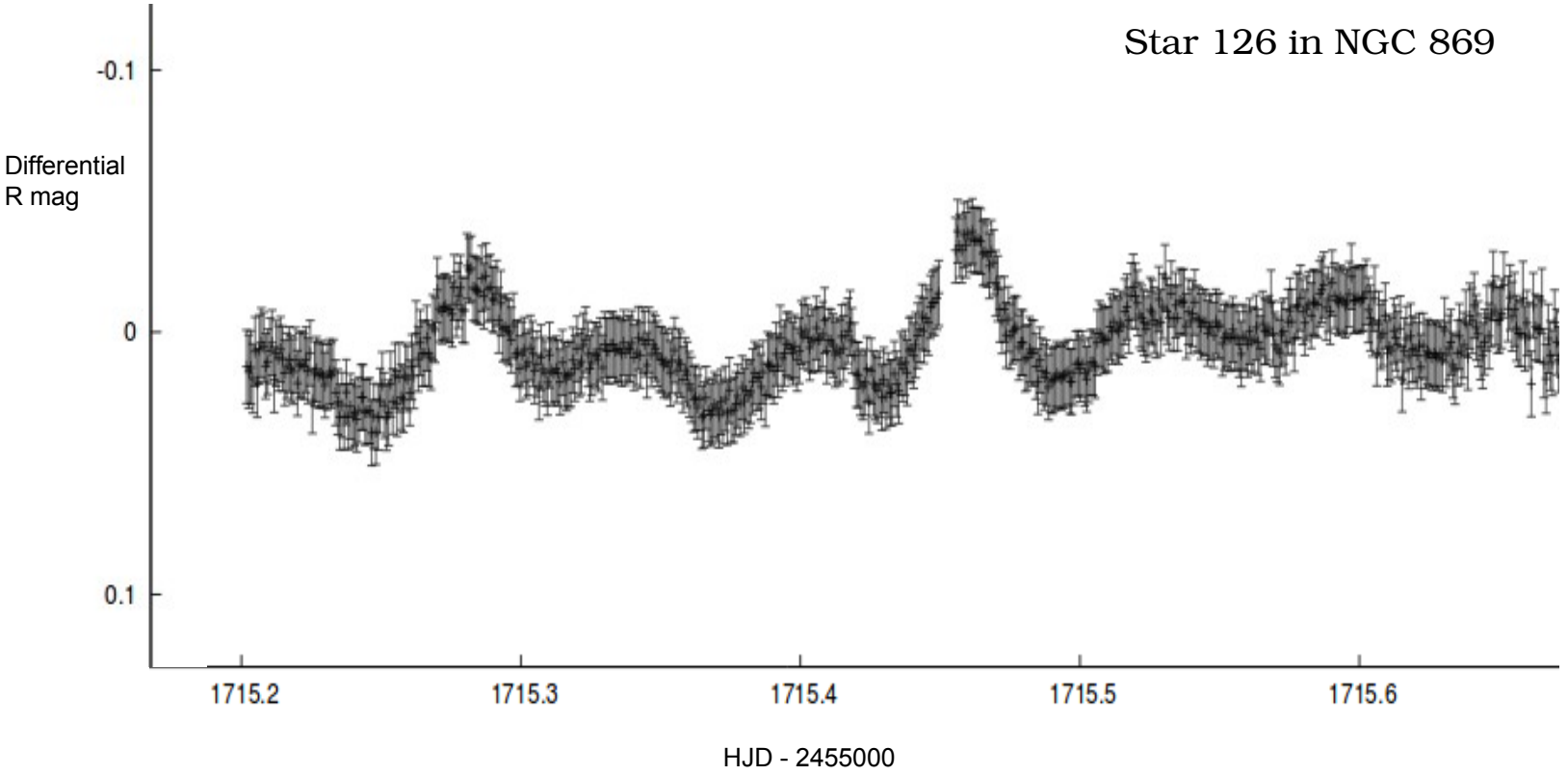
magnitude depth:
0.03 mag



transit duration ~58 min.

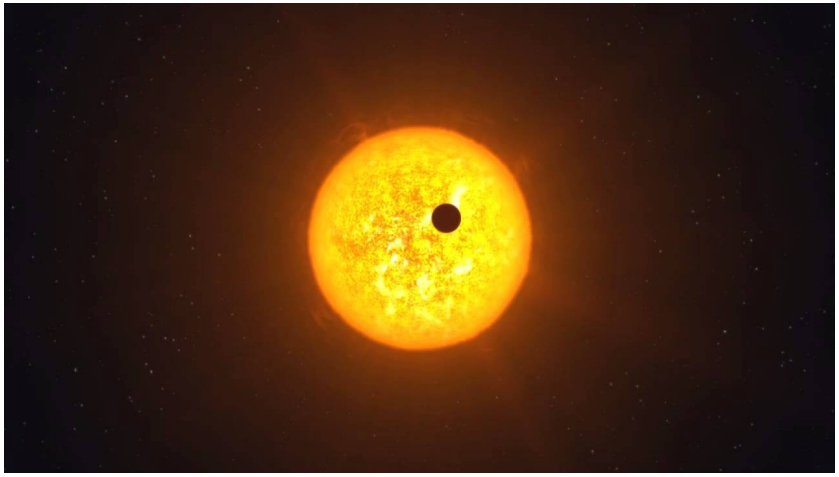
Star 223 in NGC 869

Promising candidates



Data from 0.6 m telescope at Stara Lesna Observatory

Expected results



Credit: ESO/L. Calçada

✓ **at least 3 new young transiting planet candidates**
(Neuhäuser et al. 2011, AN 332, 547)

✓ **several eclipsing brown dwarf or low-mass star candidates in each cluster**
✓ photometric precision for the typical 1 meter-class telescope of the YETI network allows for transit detection of Jupiter-size planets at close-in orbits with periods up to ~30 days

✓ **hundreds of new variable and active stars, study of rotation periods distribution**
✓ only for Trumpler 37: ~50 eclipsing binaries, ~30 flares, tens of rotating and pulsating stars with periods between 1h – 300 d, many T Tauri stars, irregular variables, etc. (Errmann et al. 2014, AN 335, 345)

Thank you!