

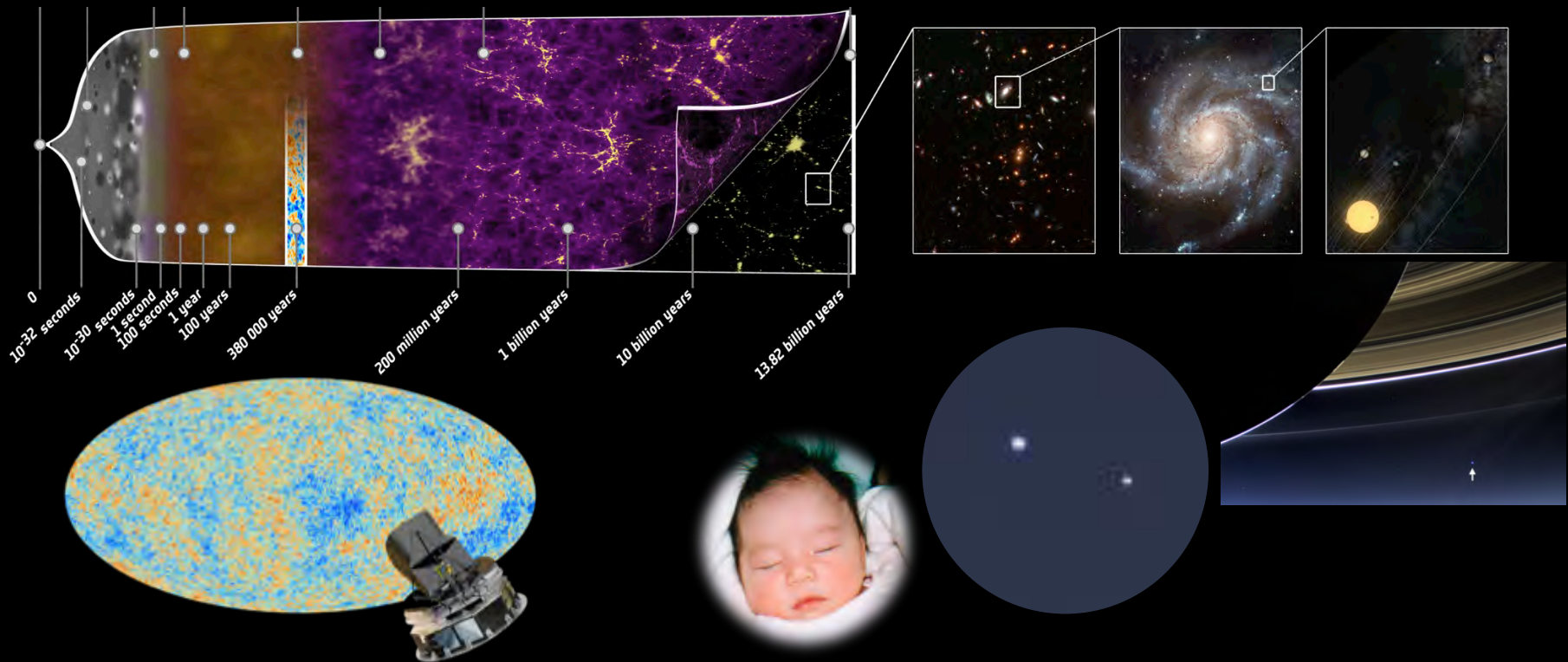
Theoretical Astrophysics Group in Department of Physics (2012-2019)

For the external visiting committee review

9:00-9:15 February 14, 2020

http://www-utap.phys.s.u-tokyo.ac.jp/~suto/mypresentation_2020e.html

Yasushi Suto (Department of Physics and RESCEU)



Overview

Sub-course A5 (general physics theory) in graduate school of physics

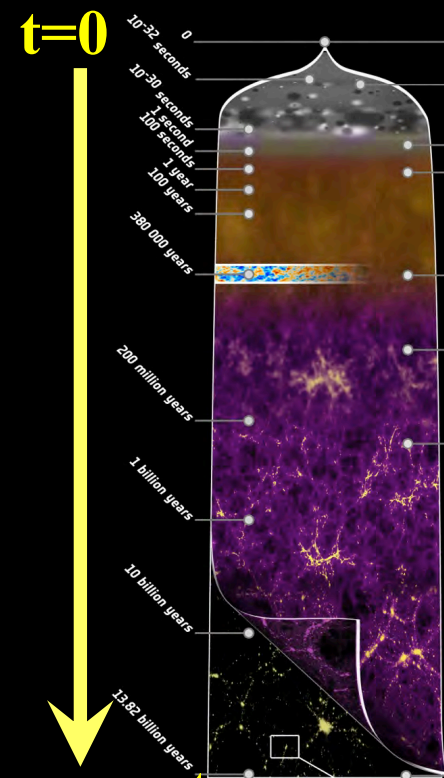
Member	affiliation	Research area
Yasushi Suto	Department of physics	Observational cosmology & exoplanet
Naoki Yoshida	Department of physics & IPMU	Computational cosmology & statistical methods in astrophysics
Jun'ichi Yokoyama	RESCEU	Early-universe cosmology & Gravitational wave
Kipp Cannon	RESCEU	Gravitational-wave astrophysics
Masahiro Kawasaki	Institute of Cosmic-ray Research	Early-universe cosmology
Hideyuki Tagoshi	Institute of Cosmic-ray Research	Gravitational-wave data analysis
Katsuaki Asano	Institute of Cosmic-ray Research	High-energy astrophysics
Fujihiro Hamba	Institute of Industrial Science	Fluid dynamics

* Toshikazu Shigeyama joins department of astronomy

Group members

Member	Position	Research area
Yasushi Suto	Professor	Observational cosmology, exoplanet, asteroseismology
Masamune Oguri	Assistant Prof.	Observational cosmology, gravitational lens
Naoki Yoshida	Professor	Computational cosmology, formation of first stars and blackholes, astrostatistics
Kazumi Kashiyama	Assistant Prof.	High-energy astrophysics, multi-messenger astronomy
Tilman Hartwig	Assistant Prof.	Galactic archeology, machine-learning

- Closely working together with RESCEU (Yokoyama, Cannon, and Shigeyama) and IPMU.

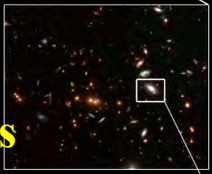


Birth of the universe
Cosmic inflation Yokoyama
Big-bang nucleosynthesis
Cosmic microwave background Yokoyama
Formation of 1st objects Yoshida
Formation of galaxies and stars
Stellar nucleosynthesis Shigeyama
Development of large-scale structure Suto, Yoshida

**Research
area
coverage**

present

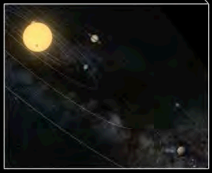
**clusters
of galaxies**



galaxies



**stars and
planets**



X-ray/radio survey Suto
Optical/infrared survey
Observational cosmology Suto, Yoshida
Gravitational-wave astrophysics Cannon
Time-domain astronomy Yoshida Shigeyama
Milky Way (Galactic archaeology) Shigeyama
Exoplanet survey/astrobiology Suto

Characterization of architecture of planetary systems towards astrobiology

Yasushi Suto

Department of Physics and RESCEU

■ Research topics

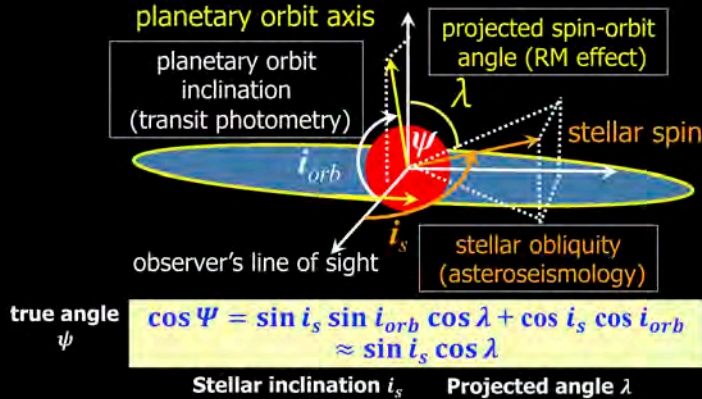
- Observational determination of spin-orbit architecture of exoplanetary systems with the Rossiter-McLaughlin effect and asteroseismology
- Search for icy and rocky rings in exoplanetary systems
- Orbital dynamics of multi-planets and black holes
- Global climate model simulations of Earth-twins for biosignature detection in future direct imaging missions

■ Contribution to community and public

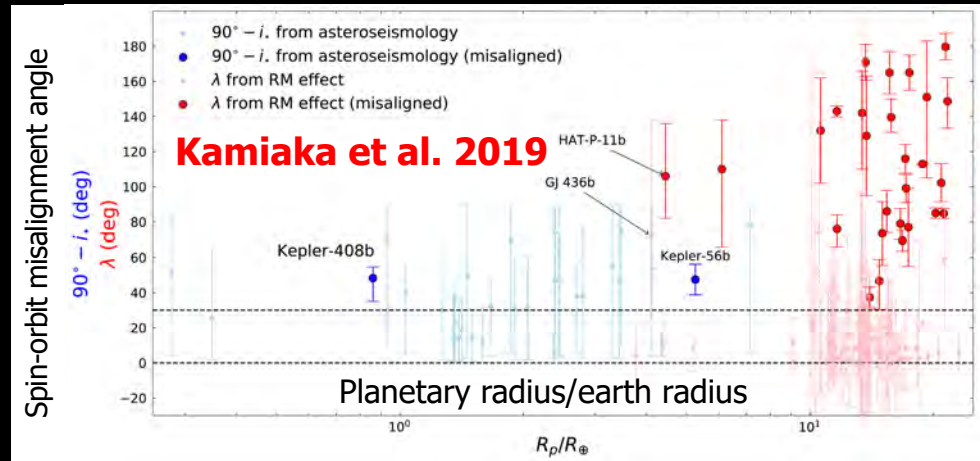
- Member of Science Council of Japan (2011-2017)
- Global scholar (visiting professorship) at Princeton University (2009-2013)
- Executive Board member of Japan Astronomical Society (2017-2023)
- Subaru Hyper-Suprime Cam collaboration executive board (2012-), chair (2018-)
- Bi-weekly book reviewer for *The Yomiuri* newspaper (讀賣新聞) (2012-2014)
- Invited regular contributor for Ronza (論座) in asahi.com (2010-)

Research highlights

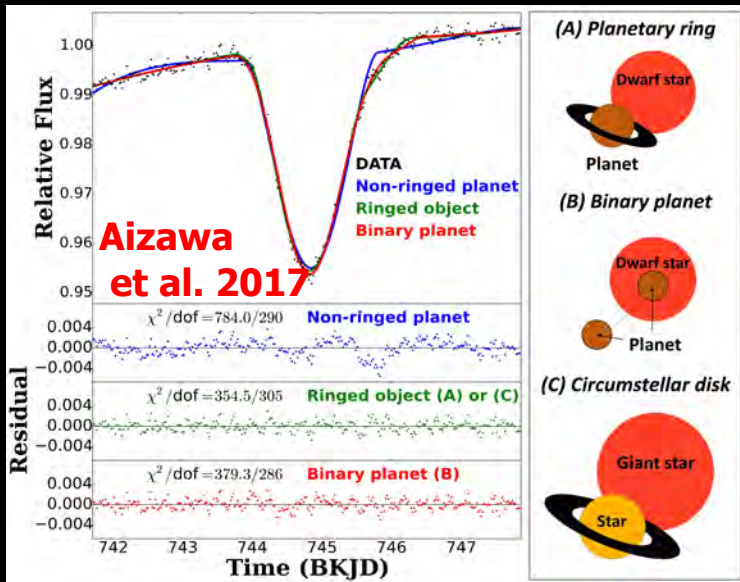
Spin-orbit architecture of a planetary system



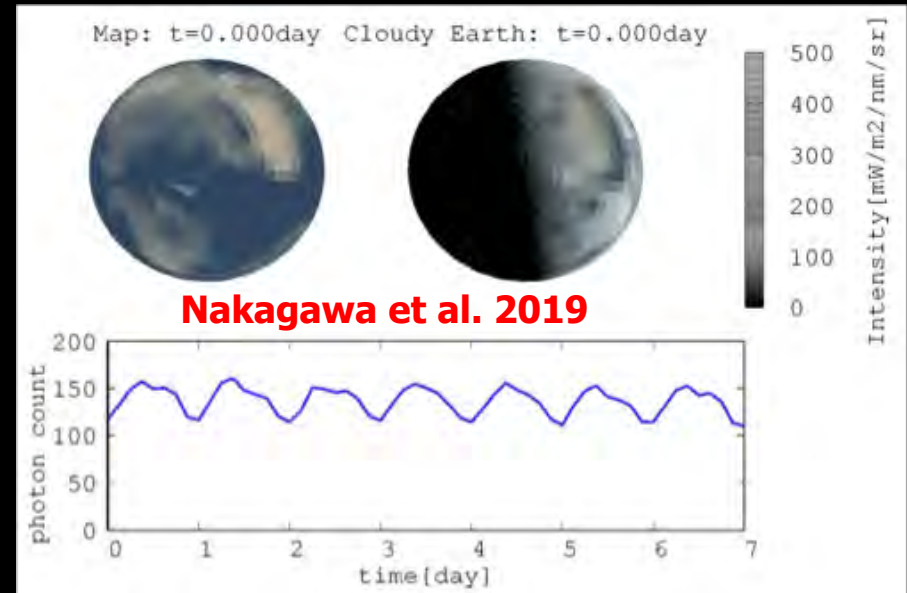
stellar spin obliquities from asteroseismology



a possible candidate of an icy ring (?)



GCM simulation of an oblique earth



Titles of Ph.D thesis (2013-2019)

Year	Title	Current position
2019	Stellar Inclinations from Asteroseismology and its Implications for Spin-Orbit Angles in Exoplanetary Systems	Private company
2017	Formation of hot Jupiters and their spin-orbit evolution	Private company Chinese
2016	Evolution and Statistics of Non-sphericity of Galaxy Clusters from Cosmological Simulations	Japan meteorological agency
2016	Exploring the Architecture of Transiting Exoplanetary Systems with High-Precision Photometry	Postdoc at IAS Princeton ->Assistant Prof. at Osaka Univ. (March 2020-)
2014	Stacking image analysis of SDSS galaxies in far-infrared and its implications for the Galactic extinction map	Private company
2013	An Improved Method for CMB Lensing Reconstruction and Its Cosmological Applications	Postdoc at Cambridge Univ.
2013	Measurements of Spin-Orbit Angles for Transiting Systems: Toward an Understanding of the Migration History of Exoplanets	Assistant Prof. at Tokyo Inst. Technology
2013	Exploring the landscape of habitable exoplanets via their disk-integrated colors and spectra: Indications for future direct imaging observations	Associate Prof. at National Astron. Obs. (April 2020-) Female

- Current students (no new student from 2019 due to my retirement age)
 - 5 doctor course students (1 Chinese)
 - 1 master course student (Chinese female)

Awards for previous students (2012-2019)

Year	Name	Award	Current position
2019	Masamune Oguri	23 rd Hayashi Chushiro Prize (Astronomical Society of Japan)	Assistant Prof. at RESCEU
2019	C.Hikage, A.Taruya, T.Matsubara, T. Nishimichi	23 rd Publication of Astronomical Society of Japan Excellent Paper Award	Project AP at IPMU, AP at Yukawa Inst. Prof. at KEK, Project AP at Yukawa Inst.
2018	Hajime Kawahara	22 nd Publication of Astronomical Society of Japan Excellent Paper Award	Assistant Prof. at Earth & Planetary Science Dept. Univ. of Tokyo
2018	Kento Masuda	34 th Inoue Research Award for Young Scientists	Assistant Prof. at Osaka Univ.
2017	Kento Masuda	7 th Ikushi Prize (Japan Society of Promotion of Science)	Assistant Prof. at Osaka Univ.
2017	Atsushi Taruya	10 th Kimura Prize in Theoretical Physics (Yukawa Foundation)	Associate Prof. at Yukawa Inst.
2016	Yuka Fujii	32 nd Inoue Research Award for Young Scientists	Associate Prof at National Astron. Obs.
2014	Norio Narita	25 th Young Astronomer Award (Astronomical Society of Japan)	Project Associate Prof. at AstroBiology Center
2014	Teruyuki Hirano	30 th Inoue Research Award for Young Scientists	Assistant Prof. at Tokyo Inst. Technology
2014	Norio Narita, Teruyuki Hirano	18 th Publication of Astronomical Society of Japan Excellent Paper Award	Project AP at ABC, Assistant Prof. at TiTech
2013	Takahiko Matsubara	17 th Hayashi Chushiro Prize (Astronomical Society of Japan)	Prof. at KEK

+ 5 Deans Awards for excellent graduate students

Computational Cosmology and Astrophysics

Naoki Yoshida (Physics/RESCEU/IPI/Kavli IPMU)

Formation of stars, blackholes and galaxies

Large-scale structure and dark matter

Supercomputer simulations

Time-domain astronomy

Machine-learning application to cosmology

Ph.D thesis (2015-2020)

Year	Title	Current position
2020	Probing Cosmic Star-Formation History with Blind Millimeter Searches for Galaxy Emission Lines	Graduating in March 2020
2019	Cosmology and Cluster Astrophysics with Weak Gravitational Lensing and the Sunyaev-Zel'dovich Effect	IAP Paris, JSPS Foreign Fellow
2019	Photoevaporation of Protoplanetary Disks and Molecular Cloud Cores in Star-Forming Regions	RIKEN SPD
2019	Numerical Investigations on Explosion Mechanisms of Core-collapse Supernovae	Postdoc at ICRR, U-Tokyo
2018	Formation of supermassive stars and black holes via direct gravitational collapse of primordial gas clouds	JSPS Fellow at Tohoku-U
2018	Formation and growth of massive black holes in the early universe	Kavli Fellow at IPMU/KIAA
2016	Chemo-thermal evolution of collapsing gas clouds and the formation of metal-poor stars	Postdoc at Georgia Tech, US
2015	Probing Cosmic Dark Matter and Dark Energy with Weak Gravitational Lensing Statistics	Project Assist. Prof at NAOJ/ NASA Jet Propulsion Lab.

- Current students
 - 4 doctor course students (2 from foreign countries)
 - 3 master course student (1 from foreign country)

Awards (2014-2020)

Year	Name	Prize/Award	Title
2017.3	Connor Omand	Dean's Award, Faculty of Science	Radio, Submillimetre, and Infrared Signals from Embryonic Supernova Remnants
2017.3	Kana Moriwaki	Dean's Award, Faculty of Science	Chemodynamics of proto-planetary systems
2016.3	Ken Osato	Dean's Award, Faculty of Science	Cosmology with Weak Gravitational Lensing and SZ Effect
2015.2	Masato Shirasaki	Inoue Research Award for Young Scientists	Probing Cosmic Dark Matter and Dark Energy with Weak Gravitational Lensing Statistics
2014.3	Masato Shirasaki	Dean's Award, Faculty of Science	Probing Cosmic Dark Matter and Dark Energy with Weak Gravitational Lensing Statistics
2017.2	Naoki Yoshida	JSPS Prize	Numerical simulations of structure formation in the early universe
2017.2	Naoki Yoshida	Japan Academy Medal	Numerical simulations of structure formation in the early universe

RESEARCH HIGHLIGHT

Statistical Computational Cosmology with Big Astronomical Data

Machine-learning applications to

- **Distribution of matter in the Universe**
- **Multi-label classification of supernovae**
- **Emulation and fast statistical analysis**



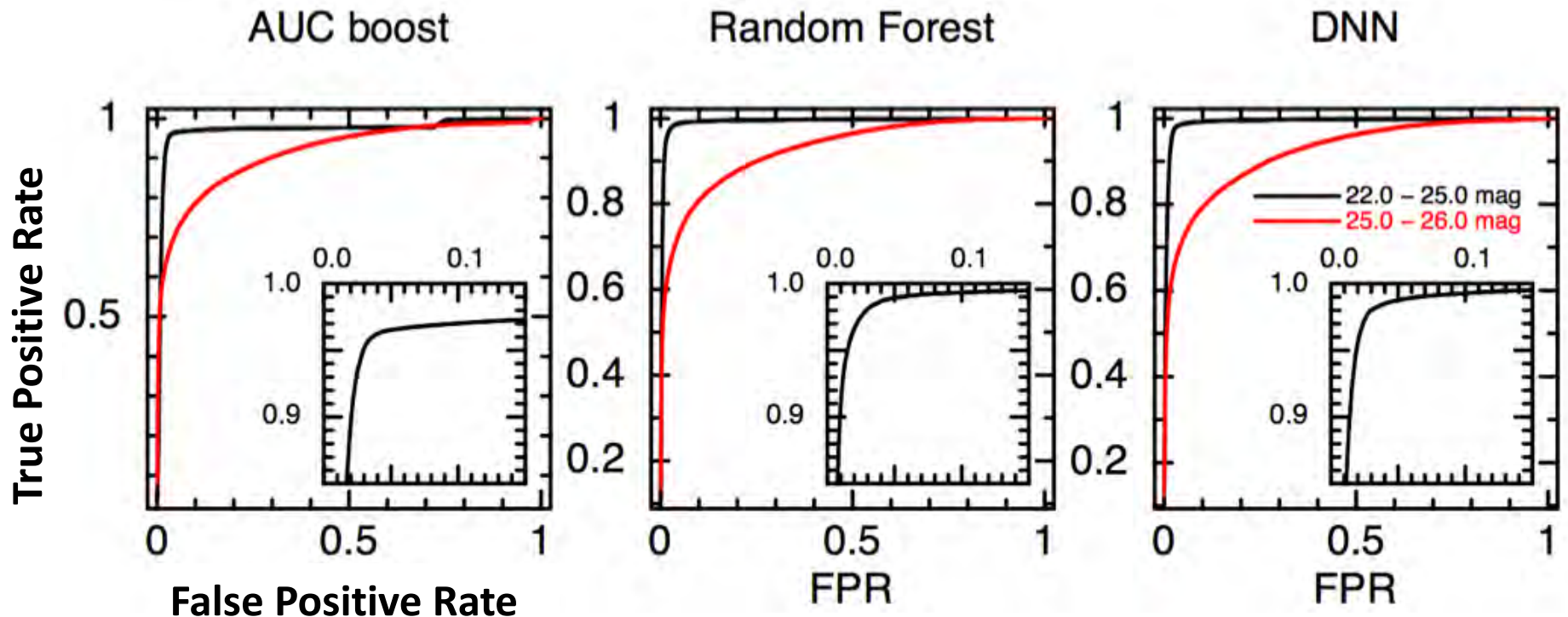
before / after 2014



Since 2014, HSC has been collecting 300 Giga byte images EVERY NIGHT.

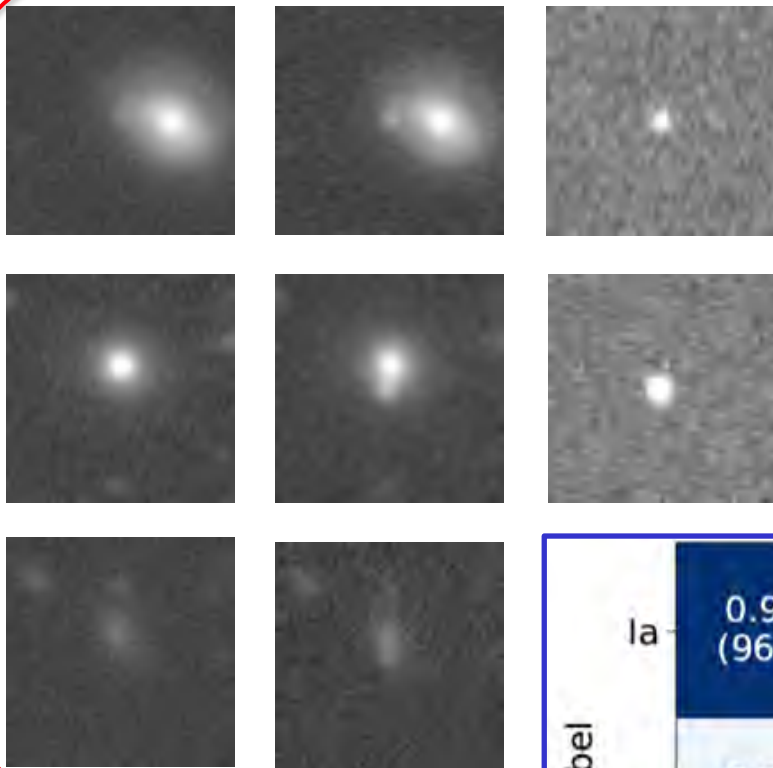
Supernova detection with machine learning

- Training data: 24000 transients including supernovae.
Real and artificial sources and use data augmentation
- ↑ Peculiar feature of our task: “1 positive out of 1000 negatives”
- New machines: Random Forest, DNN, Boosting by AUC
- 23 features and/or 2-D images



Automatic classification by our machine

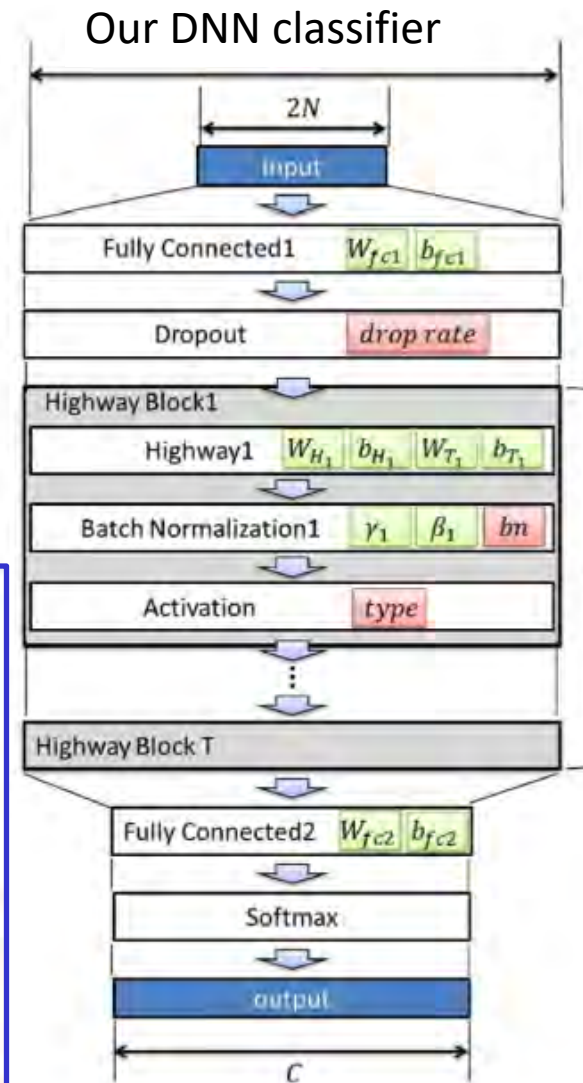
Oct. Dec. difference



Classification performance

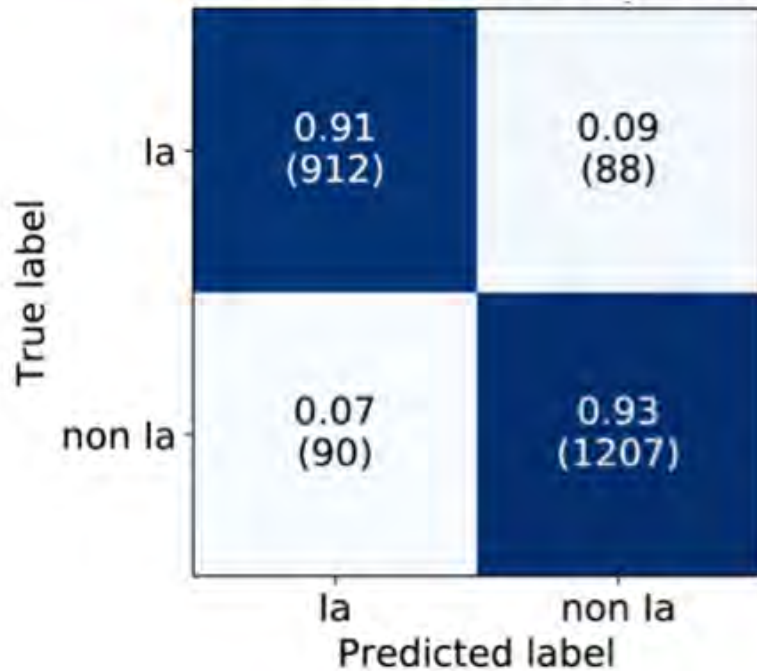
True label	la	0.96 (964)	0.01 (8)	0.03 (28)
	lbc	0.06 (9)	0.74 (119)	0.20 (32)
	ll	0.02 (21)	0.01 (9)	0.97 (1107)
		la	lbc	ll
		Predicted label		

Small number statistics can be improved by using a larger set of data from ongoing Observations ↑

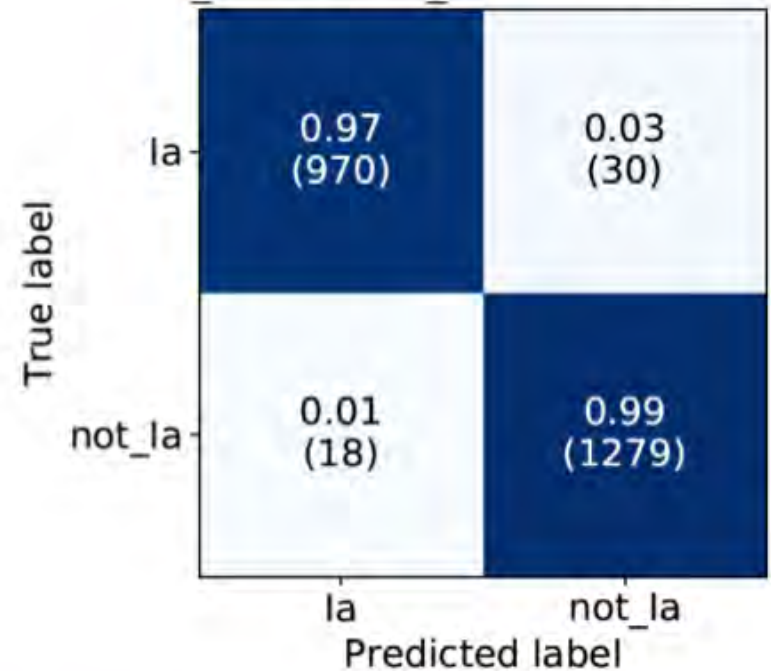


Ongoing observation: More supernovae

The best classifier that won the PLAsTiCC competition (2019)



Our DNN classifier



I. Takahashi et al., to be submitted to Publication of the Astro. Soc. Japan

can be improved by using a larger set of data from ongoing observations

