



# Direct Detection of Cosmic Acceleration by TMT & High Dispersion Spectrograph

次世代超大型光学赤外線望遠鏡TMTと  
高分散分光器による宇宙の加速膨張の直接検証

## B04 Overview & Current Status of TMT

Tomo Usuda (TMT-J Director, NAOJ)

# B04 Members

◆ **PI (研究代表者) : Tomo Usuda (NAOJ)**

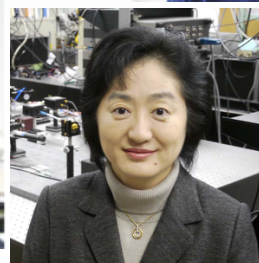


◆ **CoI (研究分担者)**

**Hajime Inaba (AIST)**



**Kaoru Minoshima (UEC)**



**Takeshi Chiba (Nihon U)**



**Toru Misawa (Shinshu U)**



◆ **Collaborator (連携研究者)**

**Feng-Lei Hong (Yokohama Nat. U)**

**Nobunari Kashikawa (NAOJ)**



**Wako Aoki (NAOJ)**



**Atsushi Onae (AIST)**



**Sho Okubo (AIST)**



◆ **Others**

**Malte Schramm (NAOJ)**



**Eiji Kambe (NAOJ)**



# Dr. Atushi Onae

- ◆ Dr. Atushi Onae, Chief Senior Researcher of AIST, passed away on June 12, 2017. He was 59 years old.



# B04 Objectives

## 3 pillars of science (theory)



4 approaches (expt, obs)

	[A01] Inflation Sasaki (Kyoto)	[A02] fluent. & struct. Takahashi (Tohoku)	[A03] Dark Energy Sugiyama (Nagoya)
[B01] CMB polariz. Hazumi (KEK)	$\zeta, r, n_s$ direct evidence	CMB lensing isocurv. $m_\nu, N_\nu$	cosmo. params CMB lensing
[B02] Subaru galaxy imaging Miyazaki(NAOJ)	Lensing $\rightarrow b(k)$ $\rightarrow P_{\text{primod}}(k)$	weak lensing $m_\nu$ non-std. DM	weak lensing SNe, $\gamma$
[B03] galaxy spectroscopy Takada(KIPMU)	primord. NG $\Omega_K, n_s, \alpha_s$	isocurv. DM in dSph gals. $P(k), m_\nu$	BAO, RSD $\Omega_{\text{de}}(z), \gamma$
[B04] TMT Usuda (NAOJ)	(2) QED coupling ( $\alpha$ ) space time variation <b>T.Chiba, Misawa</b>	(3) Lyman- $\alpha$ forests IGM <b>Misawa, Kashikawa</b>	(1) Direct detection of Cosmic Acceleration <b>T.Chiba</b>

**important observables at each intersection**

# A03 & B04 collaborations by T. Chiba

- ◆ We put the constraints on the scalar-tensor gravity theory by analyzing the CMB data power by Planck and BAO data. We find that the **variation of the gravitational constant between the recombination epoch and today is less than 0.19%**.

(J. Ooba, K. Ichiki, T. Chiba, N. Sugiyama, Prog.Theor.Exp.Phys., 2017, 043E03 (2017))

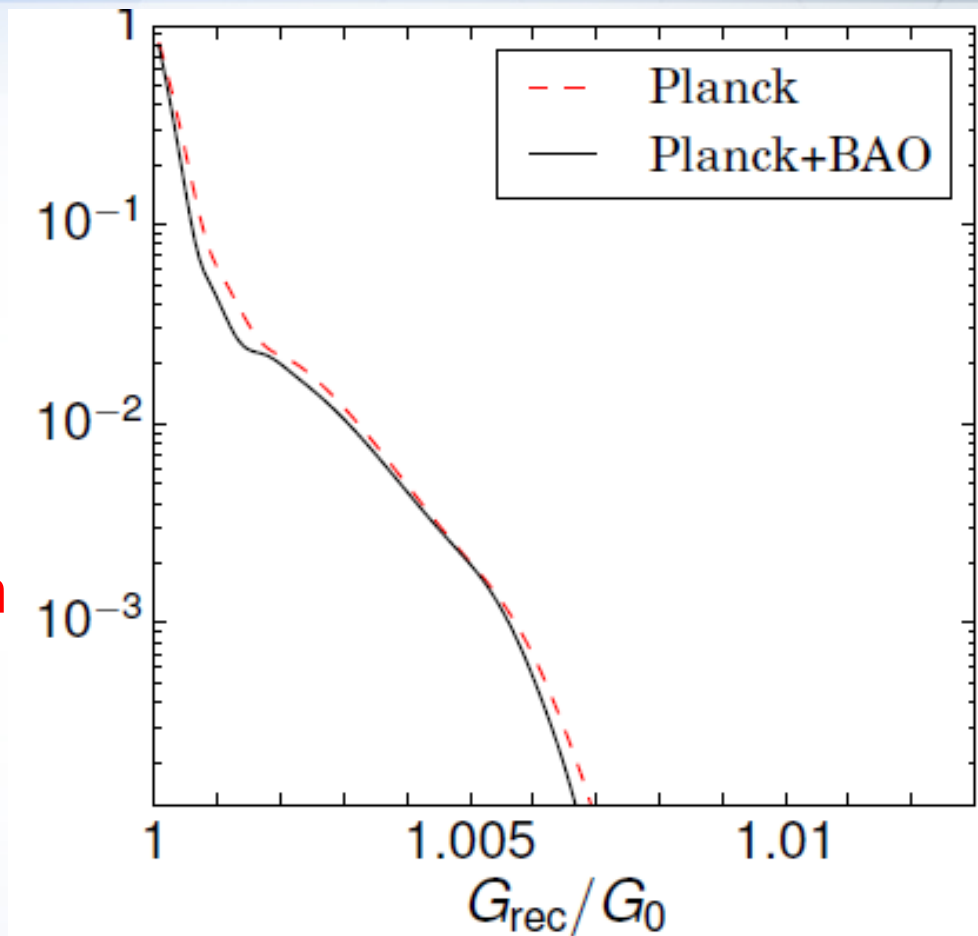
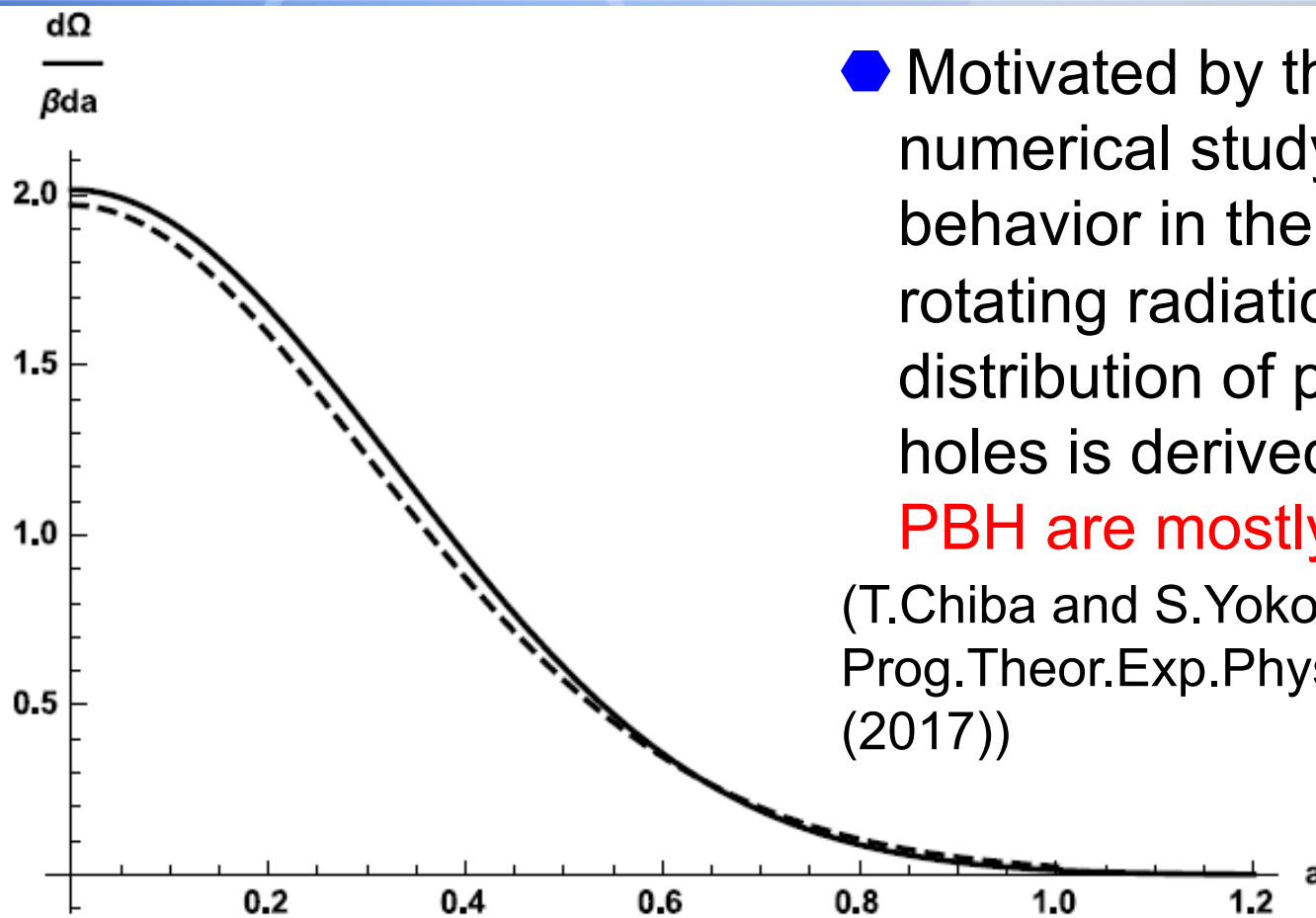


FIG. 7. Posterior distribution of  $G_{\text{rec}}/G_0$ , using the Planck data only (red dashed) or the Planck+BAO data (black).

# A0x & B04 collaborations by T. Chiba



- ◆ Motivated by the recent numerical study of the critical behavior in the collapse of a rotating radiation fluid, the spin distribution of primordial black holes is derived, finding that **PBH are mostly slowly rotating.**

(T.Chiba and S.Yokoyama,  
Prog.Theor.Exp.Phys., 2017, 083E01  
(2017))

Figure 2: The spin distribution function given by Eq. (17) is shown by a solid curve.

a dashed curve is obtained by performing the integration numerically.

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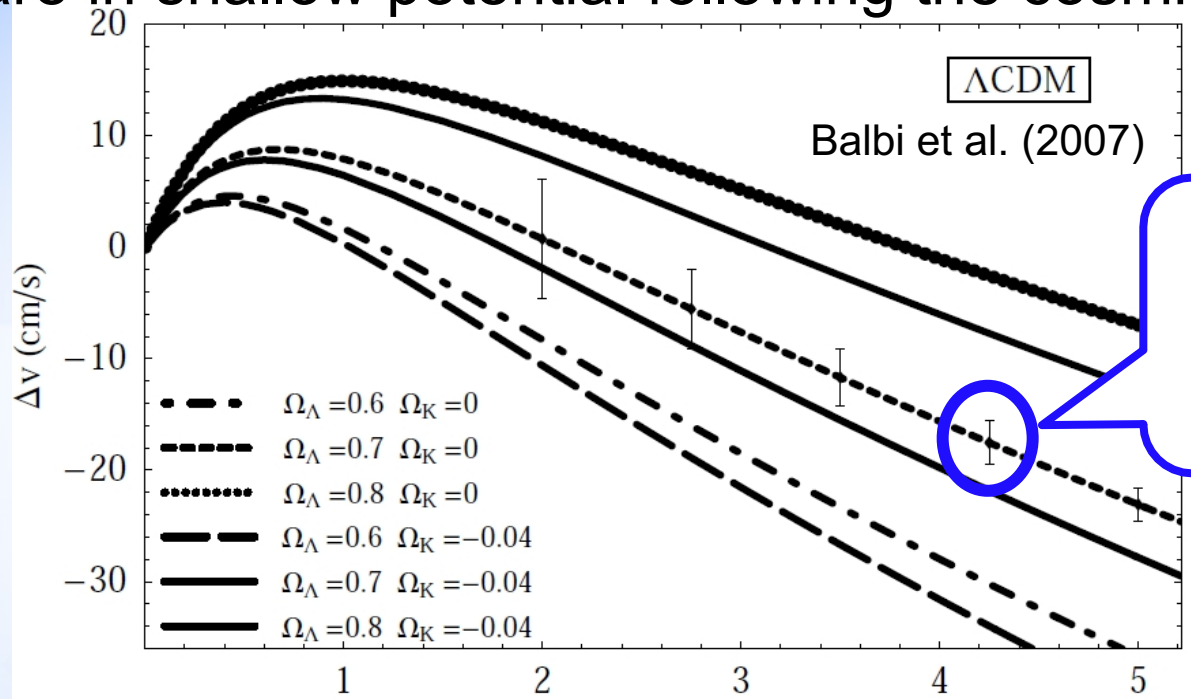
**important observables at each intersection**



# CCF & CCCD Analysis for the AGN Outflow by Misawa



- Ly $\alpha$  forest is the most promising candidate for measuring small wavelength shift due to the cosmic expansion, because they are in shallow potential following the cosmic flow.



Velocity shift over a period of ~30 yrs is only  $\Delta v \sim 20 \text{ cm/s}$  at  $z \sim 4$ .

- Cross correlation function (CCF) & Cross correlation centroid distribution (CCCD) analysis (Grier et al. 2016) can be useful for the  $\Delta v$  measurement.



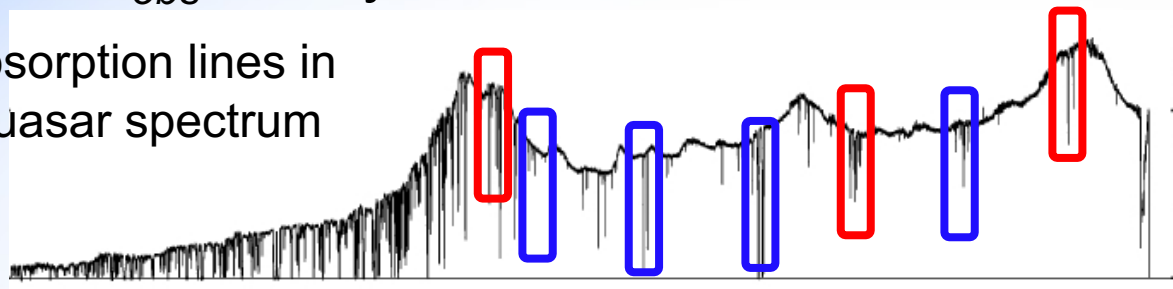


# CCF & CCCD Analysis for the AGN Outflow by Misawa

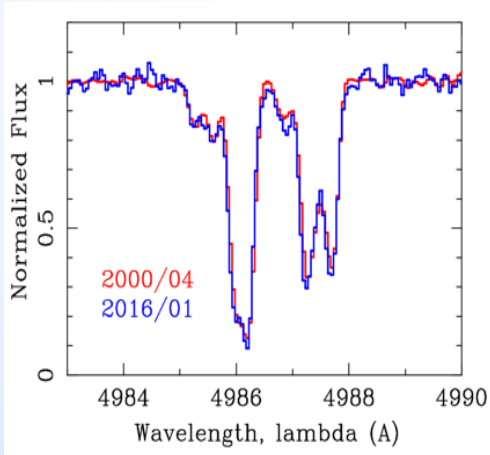


◆ We discovered a hint of acceleration of absorbers at the AGN outflow compared to the IGM, using spectra in two epochs with  $\Delta v_{obs} > 10$  yrs.

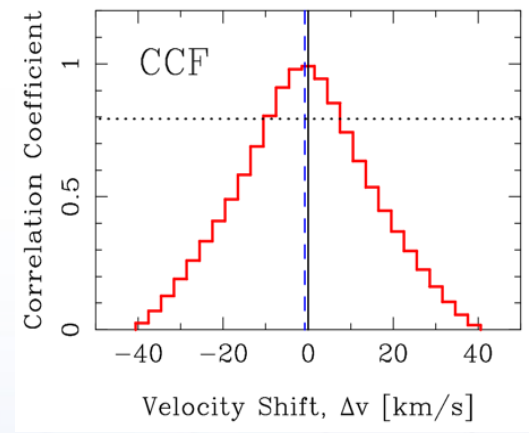
absorption lines in quasar spectrum



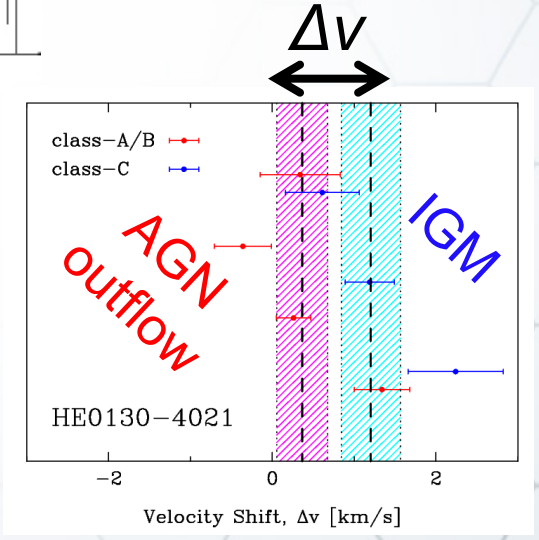
1. Classify them into AGN outflow (accelerated) and IGM (stable).



2. Compare “narrow” absorption lines in two epochs.



3. Measure the centroid of CCF 10,000 times using artificial spectra (CCCD).



4. Compare CCCDs of AGN outflow and IGM (Misawa et al. in prep.)

# B04 Objectives

## 3 pillars of science (theory)



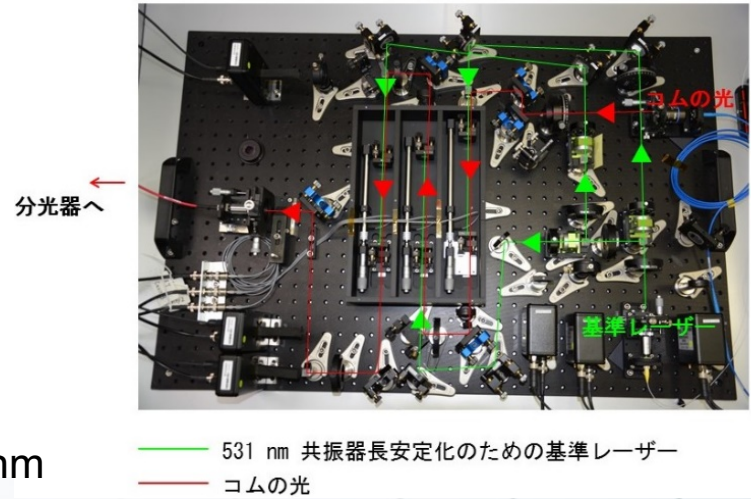
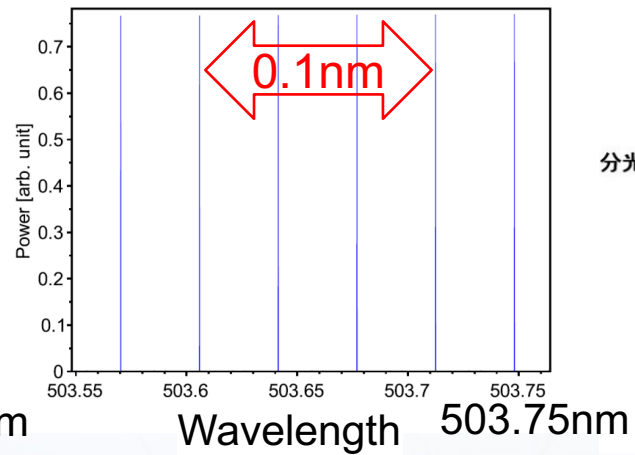
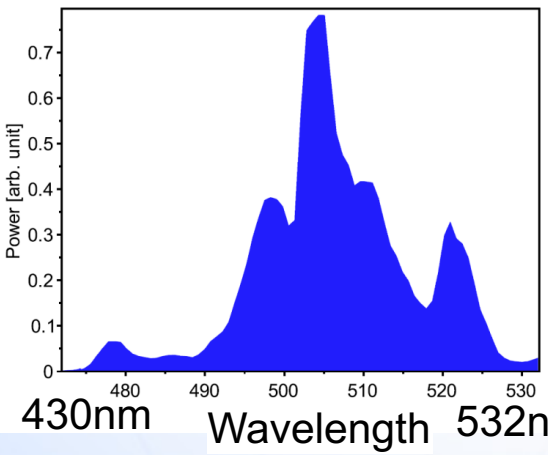
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**Optical Laser Frequency Comb is a key component.** 10/20

# Optical Laser Frequency Comb for very accurate $\lambda$ calibrations

◆ Design & test works are on going @AIST using Yb (Ytterbium)-fiber-based astro-comb around  $\lambda \sim 530\text{nm}$  to calibrate a high dispersion spectrograph for radial-velocity measurements. AIST developed Er-fiber astro-comb for HIDES spectrograph at Okayama Astrophysical Observatory.



(left) Computer simulated Astro-comb Spectrum at 470~532 nm  
(middle) Enlarged view @503.6nm

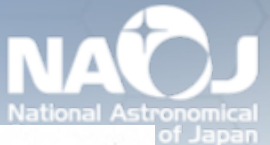
See talk by Okubo & Kambe



# Current Status of TMT



# CDUP Approved (Sep. 28<sup>th</sup>)



TMT  
Thirty

ALOHA FRIDAY 9/29/17  
Partly sunny. High 89, low 75 >> A18

HONOLULU  
**Advertiser**  
ER.COM >> \$1 Oahu, \$1.25 neighbor islands >> The Pulse of Paradise

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## TELESCOPE FOES VOW FIGHT IN COURT, ON THE MOUNTAIN



**5-2**

FOR AGAINST

A state board authorizes a building permit for the \$1.4 billion Mauna Kea observatory

By Timothy Hurley  
thurley@stacadvertiser.com

- Suzanne D. Case, BLNR chairwoman
- Stanley H. Roehrig
- Keith "Keone" Downing

Opponents of the Thirty Meter Telescope

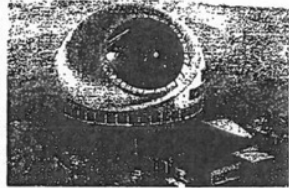
Just as in the

### ハワイ望遠鏡 再許可

#### 世界最大級 工事再開へ

州委員会

米ハワイ島マウナケア山頂で建設が計画されている世界最大級の望遠鏡「TMT」について、土地利用の再審査手続きをしていたハワイ州土地・天然資源委員会は29日、利用を許可することを決定し、日米中など5カ国でつくる「TMT国際天文台」は、来年4月の工事再開を目指し、地元当局と協議しながら準備を進める方針。TMTは口径30メートルの光学望遠鏡で、宇宙初期に誕生した銀河や星の解明や太陽系外の惑星の探索などで成果が期待されている。2015年3月に建設工事が本格的に始まったが、地元住民が「山頂



末、州土地・天然資源

口径30メートルの望遠鏡「TMT」の完成予想図。TMT国際天文台提供

委による許可を不適切とする判決を出し、審議を差し戻していた。再審査では、関係者から意見を聞く公聴会のとりまとめをした審査官が今年7月、土地利用を認めることが望ましいとする意見を提出。20日に最終口頭

弁論が開催されていた。計画に参画する国立天文台の白田知史TMT推進室長は「委員会の慎重かつ迅速な判断に感謝している。速断りはしたがこの間、地元の支援者との関係も強固になった。住民の意見を聞きながら、工事再開を目指したい」と話している。

【須田桃子】

# Status of the CDUP Reapproval for TMT

- ◆ Dec 2 2015: The Supreme Court of Hawaii decision on CDUP issued.
- ◆ Feb 2016: The Third Circuit Court further remands the permit application to the Board of Land and Natural Resources (BLNR) in Hawaii, and as a result, the contested case hearing process is reopened by BLNR.
- ◆ May 2016: Hearing Officer to preside over the BLNR hearing is selected and actual preparations for the hearing is initiated.
- ◆ Prehearing conferences (May 16, June 17, Aug 5, 12, & 29) & Oct. 3
- ◆ Sep 26 2016: Site Visit
- ◆ Testimony concluded in the Contested Case Hearing (Oct 20 to March 2, total 44 days)
- ◆ July 27: very Positive Recommendation from the Hearing Officer (Ms. Riki M. Amano)
- ◆ **Sep 28: Decision by BLNR → Approved!**



# 1) Hawaii's Public Opinion: CDUP for TMT



Big Q (October 2, 2017)

## Will the Thirty Meter Telescope be built, now that it has cleared a significant permit hurdle?

A. Yes, good chance (900 Votes)



B. 50-50 (182 Votes)



C. No, seriously doubt it (95 Votes)



*This is not a scientific poll — results reflect only the opinions of those voting*

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- ◆ **Sep 28: Decision by BLNR**
- ◆ **Oct 17: Appeal to Hawaii Supreme Court → may take ~1 year**
- ◆ Onsite construction expected to resume in 6 months following CDUP approval. **Preparation to resume onsite construction from April 2018**



- ◆ TMT 5<sup>th</sup> annual Science Forum was held in Nov 7~9, 2017 @ Infosys campus (Mysore, India)  
<https://www.youtube.com/watch?v=DQ5Zn8WFFavE>
- ◆ 2<sup>nd</sup> Generation Science instruments' concepts were discussed.  
→ Call for TMT Instrumentation White Papers (Mar 21<sup>st</sup>)



**TMT** BEYOND FIRST LIGHT  
तीस मीटर दूरबीन NEXT-GENERATION INSTRUMENT STUDIES  
तीस मीटर दूरबीन

CONTENT:  
INTERNATIONAL SCIENCE DEVELOPMENT TEAM (ISDT) SESSIONS ON INSTRUMENT STUDIES  
KICKING OFF NEXT-GENERATION INSTRUMENT STUDIES  
BIG SCIENCE QUESTIONS FOR TMT NEXT-GENERATION INSTRUMENTS  
LESSONS LEARNED FROM 1ST GENERATION INSTRUMENTS

SCIENCE ORGANIZING COMMITTEE:  
(CO-CHAIR) CHRISTOPHE DUMAS (INM)  
(CO-CHAIR) SRINAND RAGURATHAN (ISU/CA) | ANSHU S. S. DIA  
JUDY COHEN (CALTECH) | IAN DELL (ANTONIO DE BRUNO UNIV.)  
MARK BICKINGSON (INDAC) | RAO LEE (SHANGHAI OBS.)  
JESSICA LU (UC BERKELEY) | CHRISTIAN MAROIS (NIC HERZBERG)  
CHI NAGISA (TOKYO UNIV. OF SCIENCE) | LIUC SHAOBO (INDAC)  
SHIBANI THIRUPATHI (IAI) | BIN YANG (YUNNAN OBS., NAOC & IAO)

NOVEMBER 7-9, 2017 - INFOSYS CAMPUS, MYSORE, INDIA  
REGISTRATION DEADLINE: SEPTEMBER 18, 2017  
[HTTPS://CONFERENCE.IPAC.CALTECH.EDU/TMTSF2017](https://conference.ipac.caltech.edu/tmts2017)

TMT | IAO | ISU/CA | ARIES | 7/20

◆ 5 splinter sessions:

- (1) High resolution spectroscopy (photo)
- (2) Near-IR multi-object spectroscopy
- (3) Thermal IR (MIR) instrumentation (partially joint w/ High Contrast)
- (4) High contrast / ex-AO instrumentation (partially joint w/ MIR)
- (5) Broad spectral coverage spectrophotometry/polarimetry (e.g., for time domain follow-up)



## Shedding Light on the Dark Universe with Extremely Large Telescopes

Asia/Australia meeting in Lanzhou, China from Aug 30-Sept 2, 2017

Americas meeting at UCLA, April 2-6, 2018

Trieste Italy, hosted by ICTP (International Center for Theoretical Physics), July 2-6 2018

# Summary

- ◆ Developing Optical Laser Frequency Comb is going well at AIST.
- ◆ Feasibility study for future scientific observations is also on going.

TMT status:

- ◆ CDUP re-approved in September 28
- ◆ Onsite construction expected to resume in April 2018
- ◆ 5th TMT Science Forum @India in Nov 7~9
- ◆ Call for White Paper 2<sup>nd</sup> Generation Science Instrumentation White Paper (due March 21<sup>st</sup> )