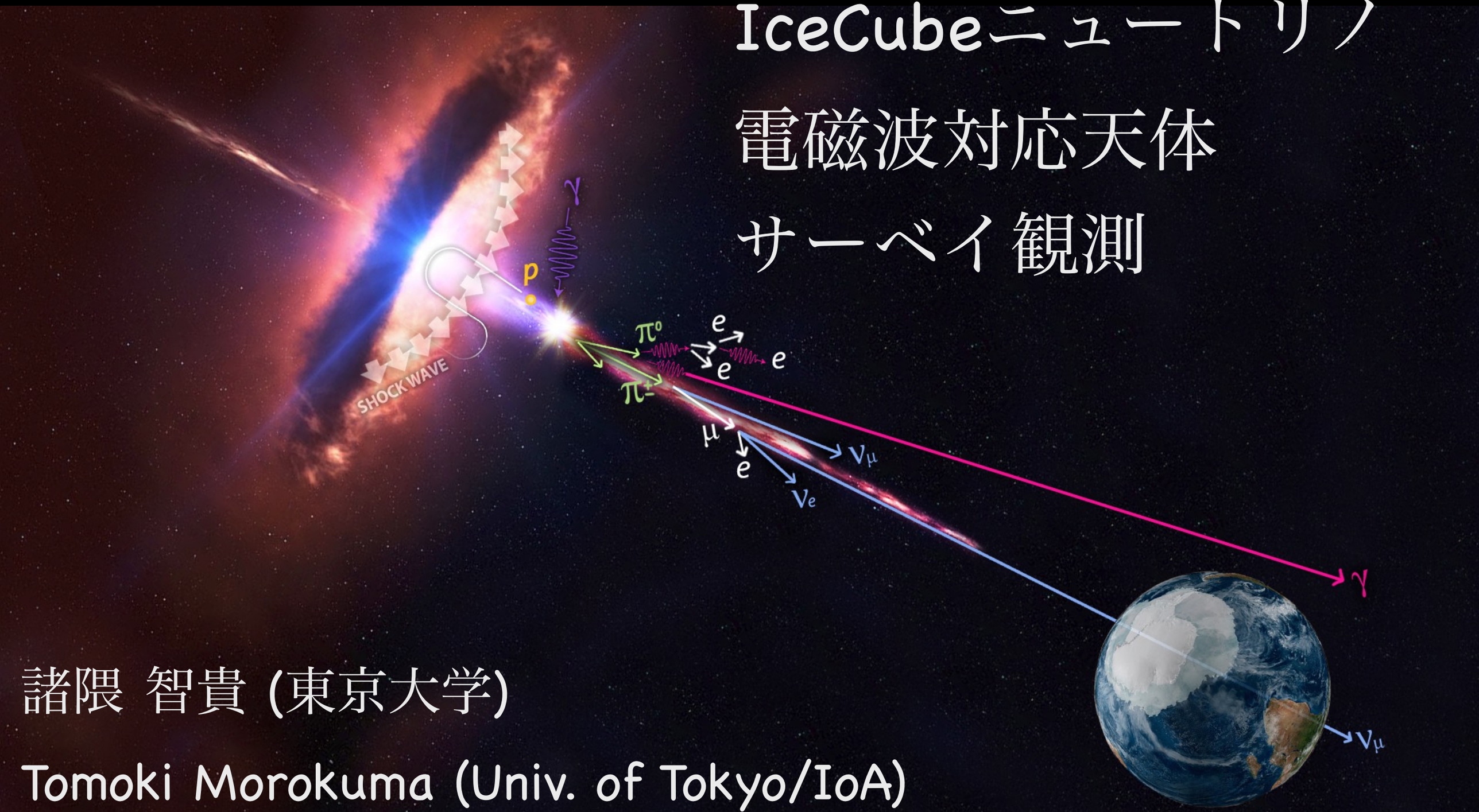
Tomo-e Gozenを用いた IceCubeニュートリノ電磁波対応天体サーベイ観測



諸隈 智貴 (東京大学)

Tomoki Morokuma (Univ. of Tokyo/IoA)

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木曽シュミットシンポジウム2017

ニュートリノフォローアップやTeVサーベイに向けた
TGSS, NVSS, PS1を用いた
新しいブレーザー候補カタログ BROS:
Blazar Radio and Optical Survey

田中康之（広島大学宇宙科学センター）
内海洋輔、井上芳幸 (ISAS/JAXA)、太田耕司(京大)

「巴御前」で探して「晴明」で追究する
超新星・ニュートリノ源・重力波源

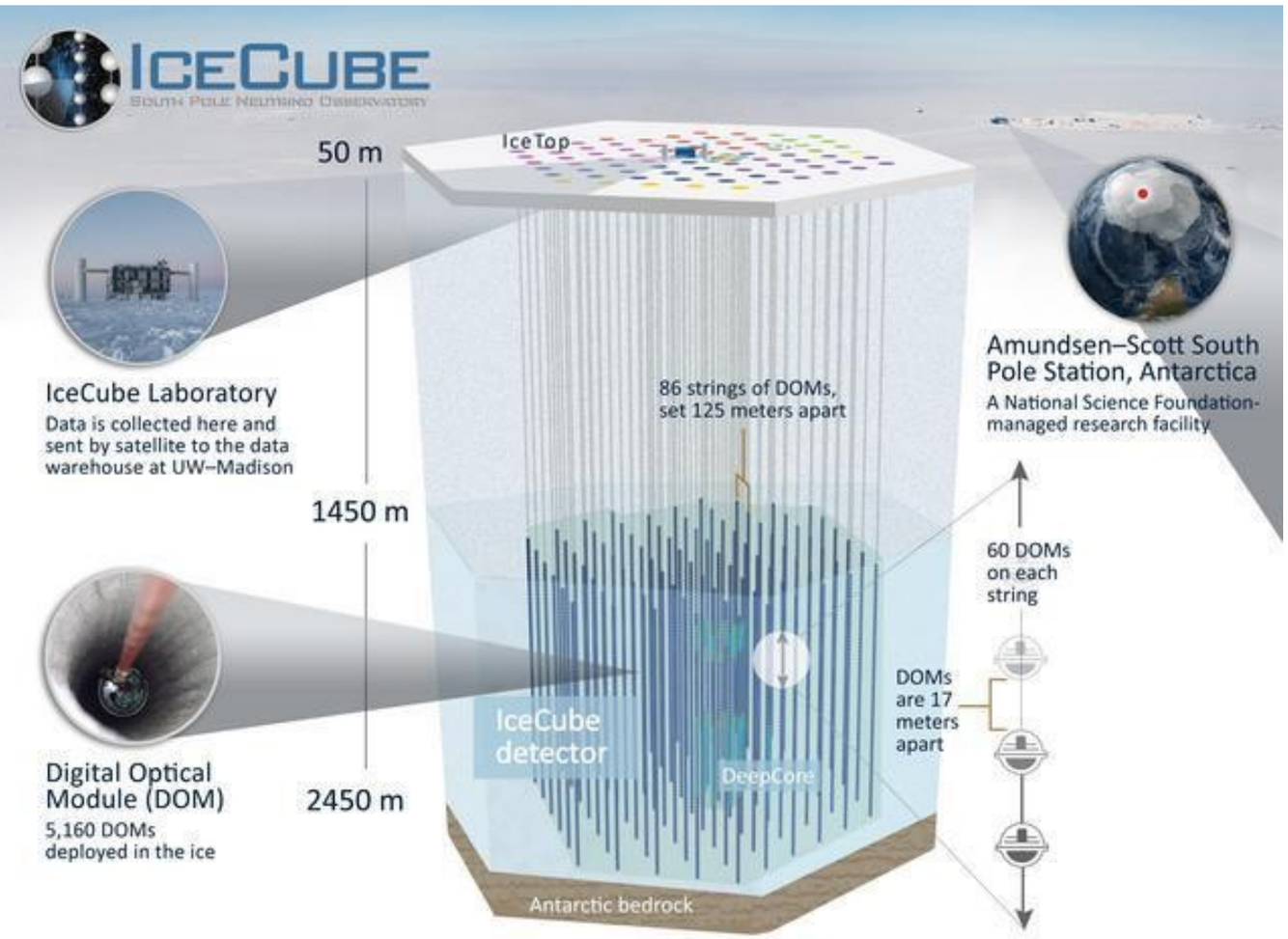
太田耕司(京大理)

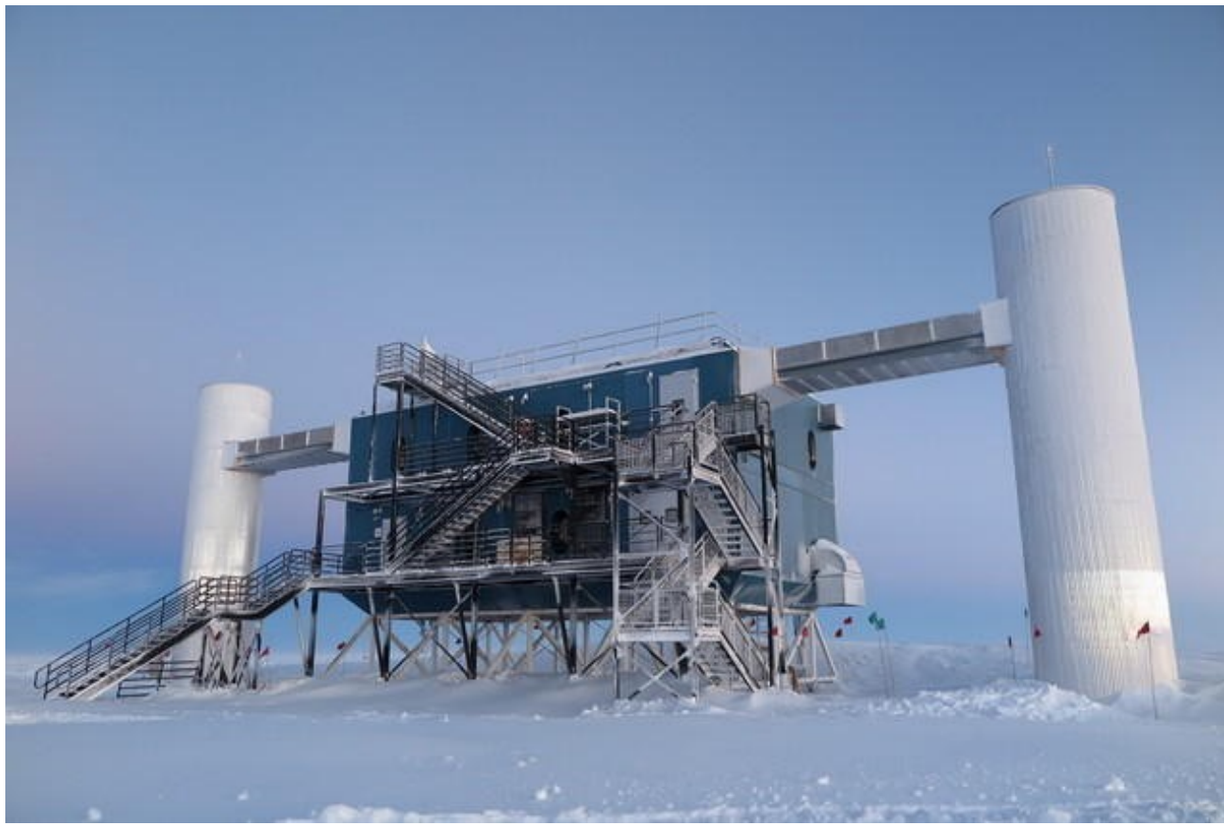
共同研究者：
前田啓一、松林和也、木野勝、他（京大理）
土居守、酒向重行、他（東大理）

木曽シュミットシンポジウム2018

IceCube Experiment@South Pole

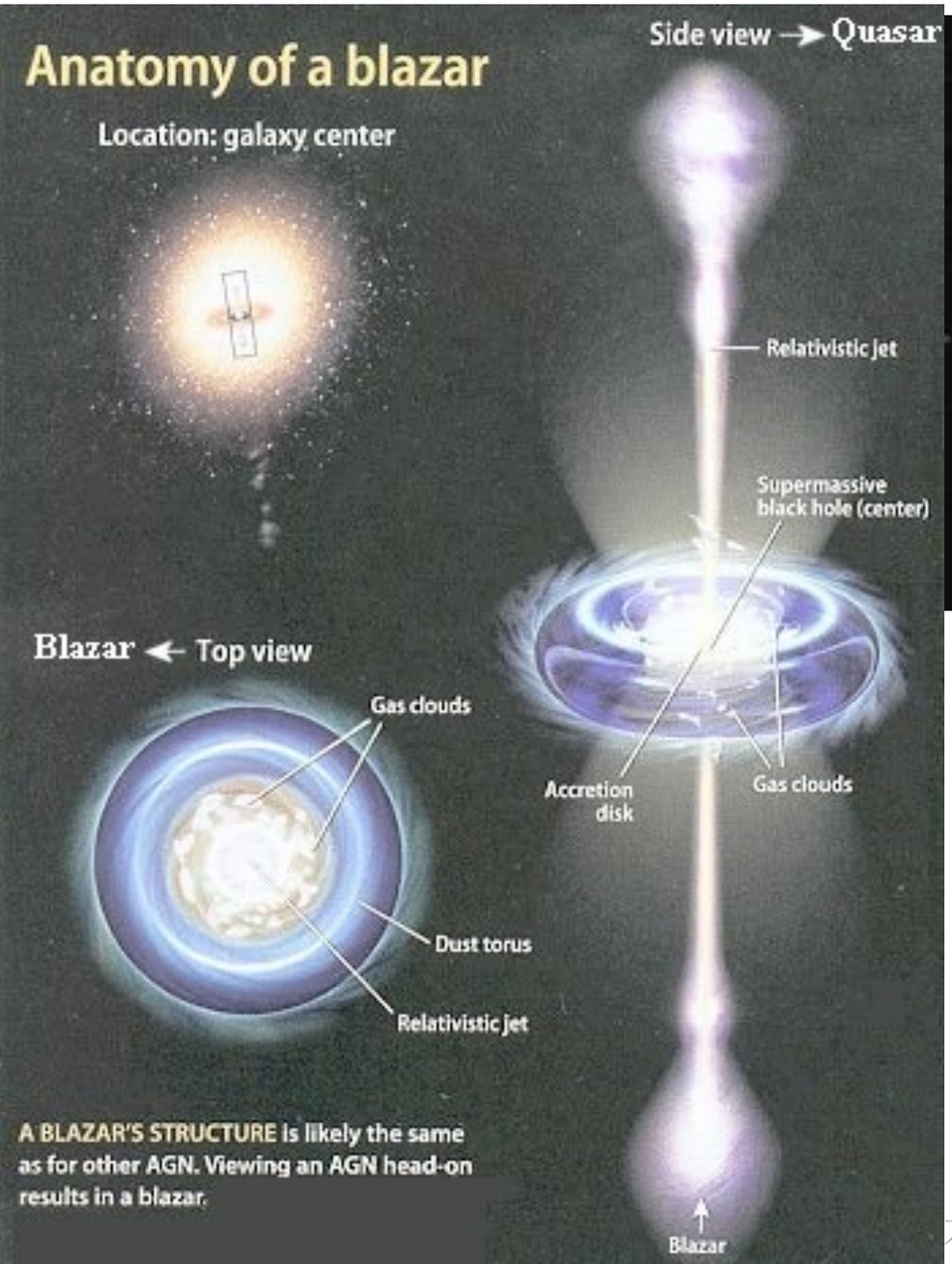
- Location: Amundsen-Scott South Pole Station
- Coordinates: 89:59:24S 63:27:11W (from wikipedia)
- 5160 optical sensors
- 1G tons water (ice)
- public alert from April 2016



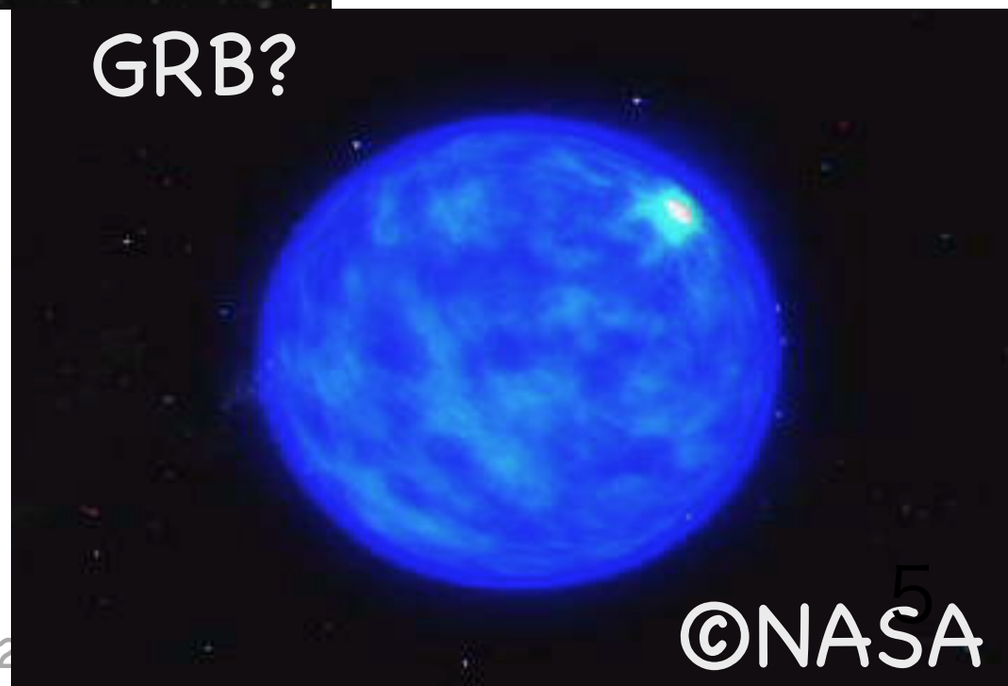


Origin of High-E neutrinos?

- origin of high-E cosmic rays
- not observationally identified until 2017
  - e.g., Kadler+2016



AGN jet?



EM identification of IceCube-170922A

差出人 Shigeru Yoshida <syoshida@hepburn.s.chiba-u.ac.jp>

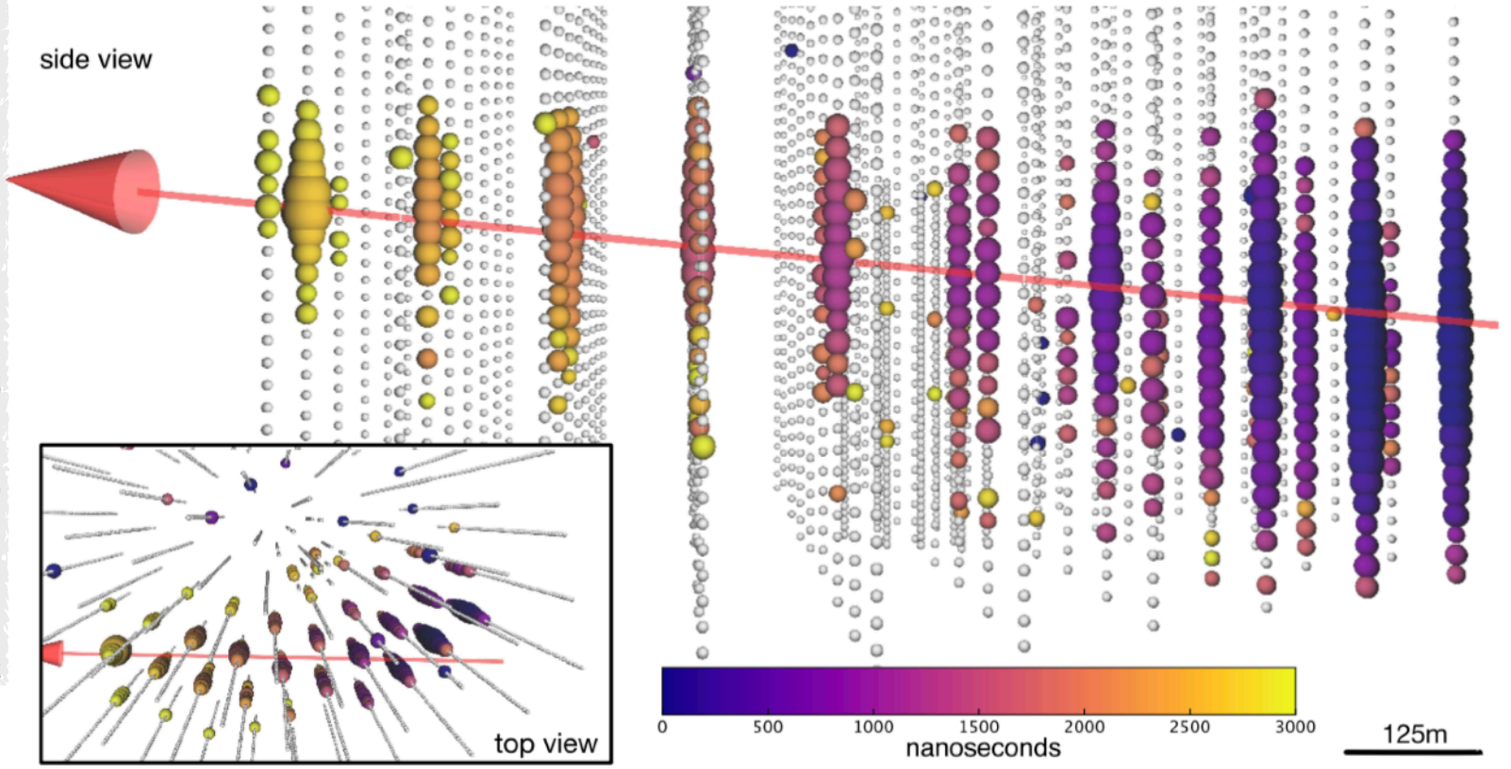
件名 **an EHE alert**

宛先 Yasuyuki Tanaka <ytanaka@astro.hiroshima-u.ac.jp>, Kou

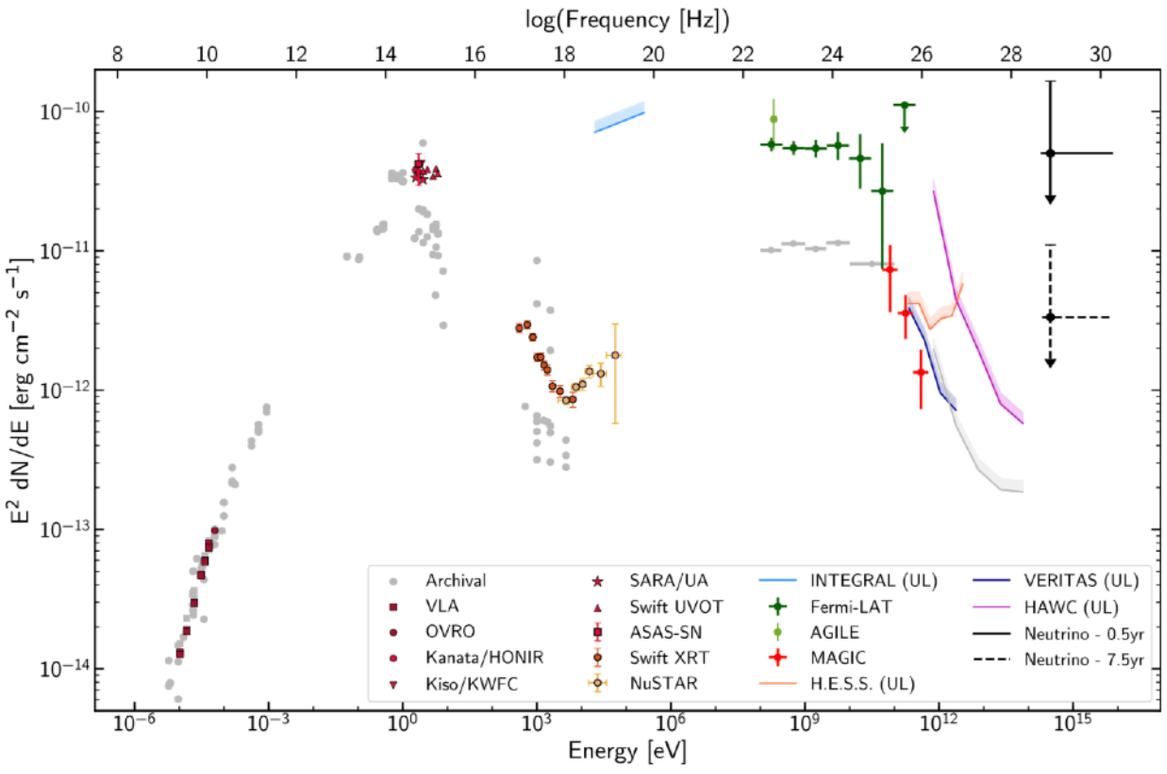
Cc Shigeru Yoshida <syoshida@hepburn.s.chiba-u.ac.jp>

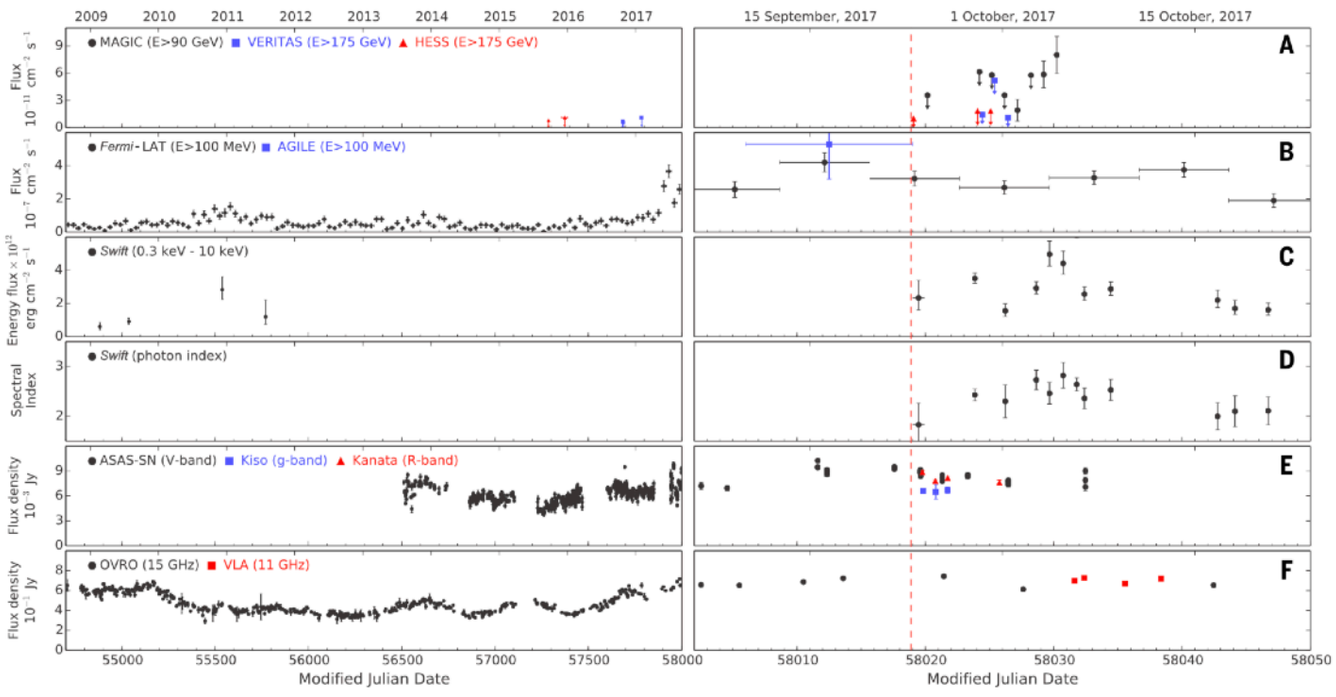
FYI.
これは、かなり信号くさいイベントです。
GCN に送りました。
https://gcn.gsfc.nasa.gov/gcn/notices_amon/50579430_130033.amon
VERITAS が follow-up する、ということは Hawaii でもみれないですか
可能ならSubaru で follow-up すべき high quality event です。
IceCube side での解析は続行中で、角度精度をあげた情報が
随時 GCN に流れます。

吉田



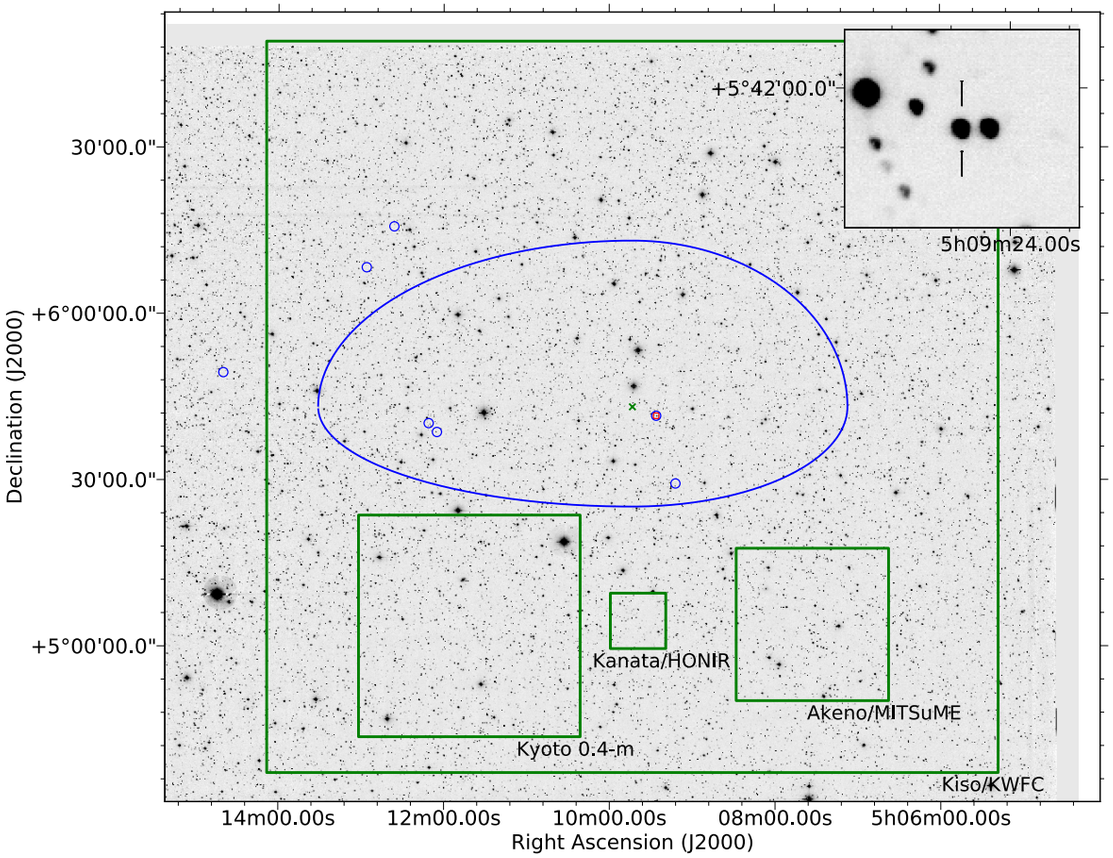
IceCube Collaboration 2018



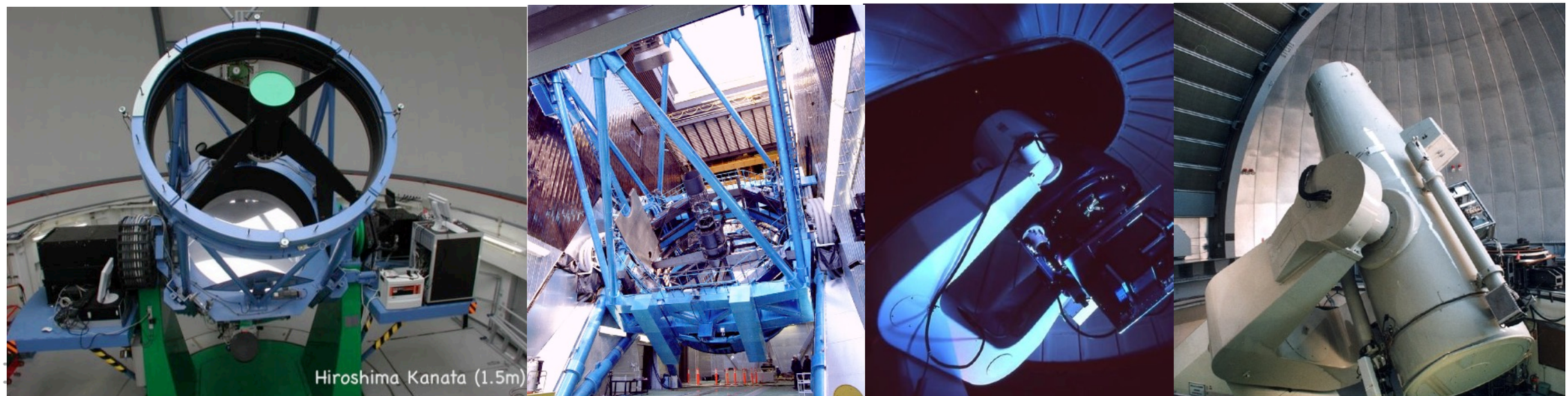


EM identification of IceCube-170922A

rapid variability detection (Kanata/HONIR) ==> "noticed" Fermi/LAT variability (Tanaka+2017)
==> EM follow-up ==> identification



TM in prep.



Breakthrough of the Year 2018 (Science)

Science

2018 BREAKTHROUGH OF THE YEAR

Development cell by cell

RUNNERS-UP

Messengers from a far-off galaxy

Molecular structures made simple

Ice age impact

#MeToo makes a difference

An archaic human 'hybrid'

Forensic genealogy comes of age

Gene-silencing drug approved

Molecular windows into primeval worlds

How cells marshal their contents

• PEOPLE'S CHOICE •

Visitors to *Science*'s website are in agreement with the magazine's reporters and editors: Development cell by cell is the Breakthrough of the Year. We invited online readers to vote on a dozen candidates for the breakthrough. The first round of voting narrowed the choices to four, and a second round, in which more than 12,000 votes were cast, determined the top People's Choice. The results are:

https://vis.sciencemag.org/breakthrough2018/index.html

https://science.sciencemag.org/content/361/6398

Tomo-e photometry of known blazars

- Bright (~<18 mag) known blazars are automatically monitored in our High-Cadence Supernova Survey
- Many unknown (un-IDed) blazar candidates
  - identification of Fermi unID sources
    - Tomo-e & KWFC rapid variability ==> Morita-kun's talk (next)
    - VLBI searches: Fujinaga+2016 (w/ Yamaguchi 32m radio telescopes)
  - BROS: Blazar Radio and Optical Survey (Itoh, R. et al.)
    - Search for flat-spectrum radio sources + PS1 optical counterparts
      - TGSS (150 MHz) + NVSS (1.4 GHz)
    - > x5 sources than previous catalogs (CRATES etc.)
    - Discovery of elliptical galaxy sequence

Tomo-e Gozen light curves
for TXS 0506+056

Join AMON?

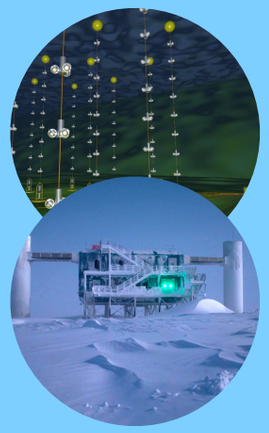
- The Astrophysical Multimessenger Observatory Network
  - The Pennsylvania State University
  - https://www.amon.psu.edu
- AMON seeks to perform a real-time correlation analysis of the high-energy signals across all known astronomical messengers
  - photons, neutrinos, cosmic rays, gravitational waves
  - 1. Enhance the combined sensitivity of collaborating observatories to astrophysical transients by searching for coincidences in their sub-threshold data; and
  - 2. Enable rapid follow-up imaging or archival analysis of the putative astrophysical sources.
- AMON participants can be characterized as "triggering", "follow-up", or both.
  - Follow-up for IceCube, GW, etc. sources
  - Trigger for "Tomo-e flash"??
- MoU between AMON & Japanese Consortium

AMON members and prospective* members.

CR

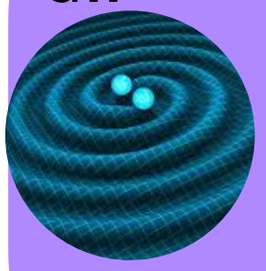
Pierre Auger

ν

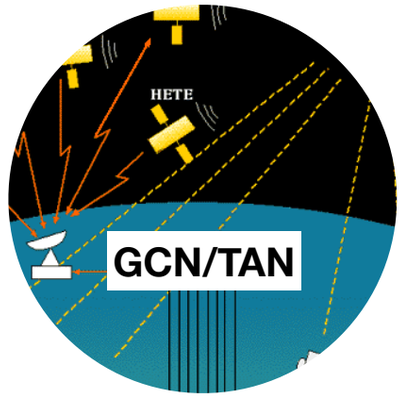


IceCube
ANTARES

GW



*LIGO-Virgo



γ

SWIFT
VERITAS
HESS
MAGIC

FACT
Fermi
HAWC

γ

LMT
Palomar Transient Factory
MASTER

23

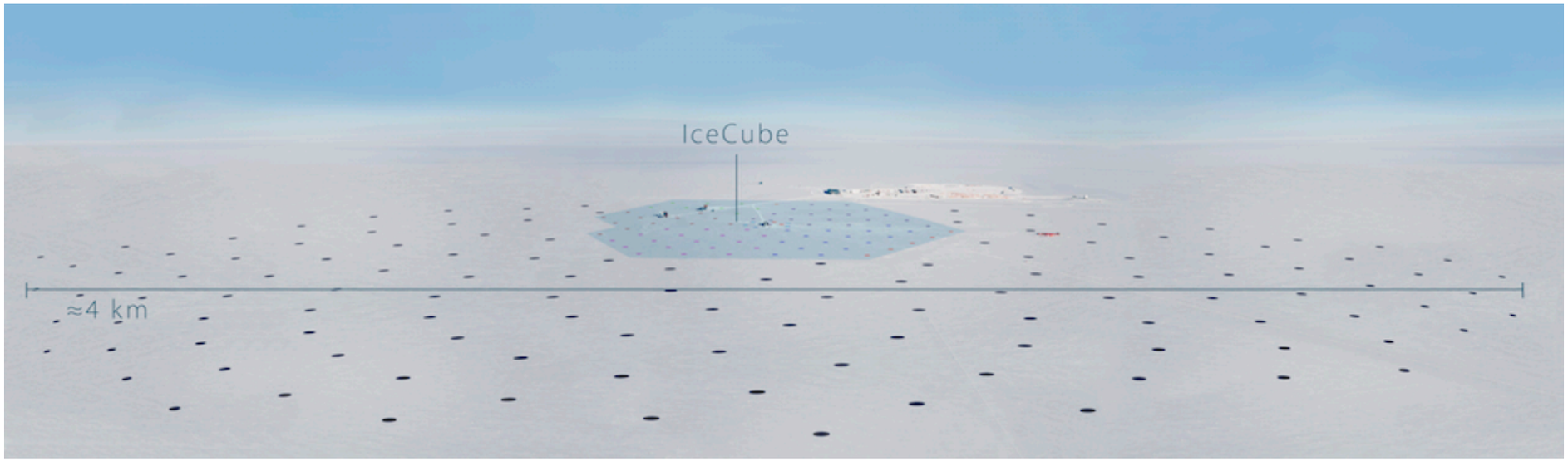
from H. Ayala's slides@AMON WS 2019

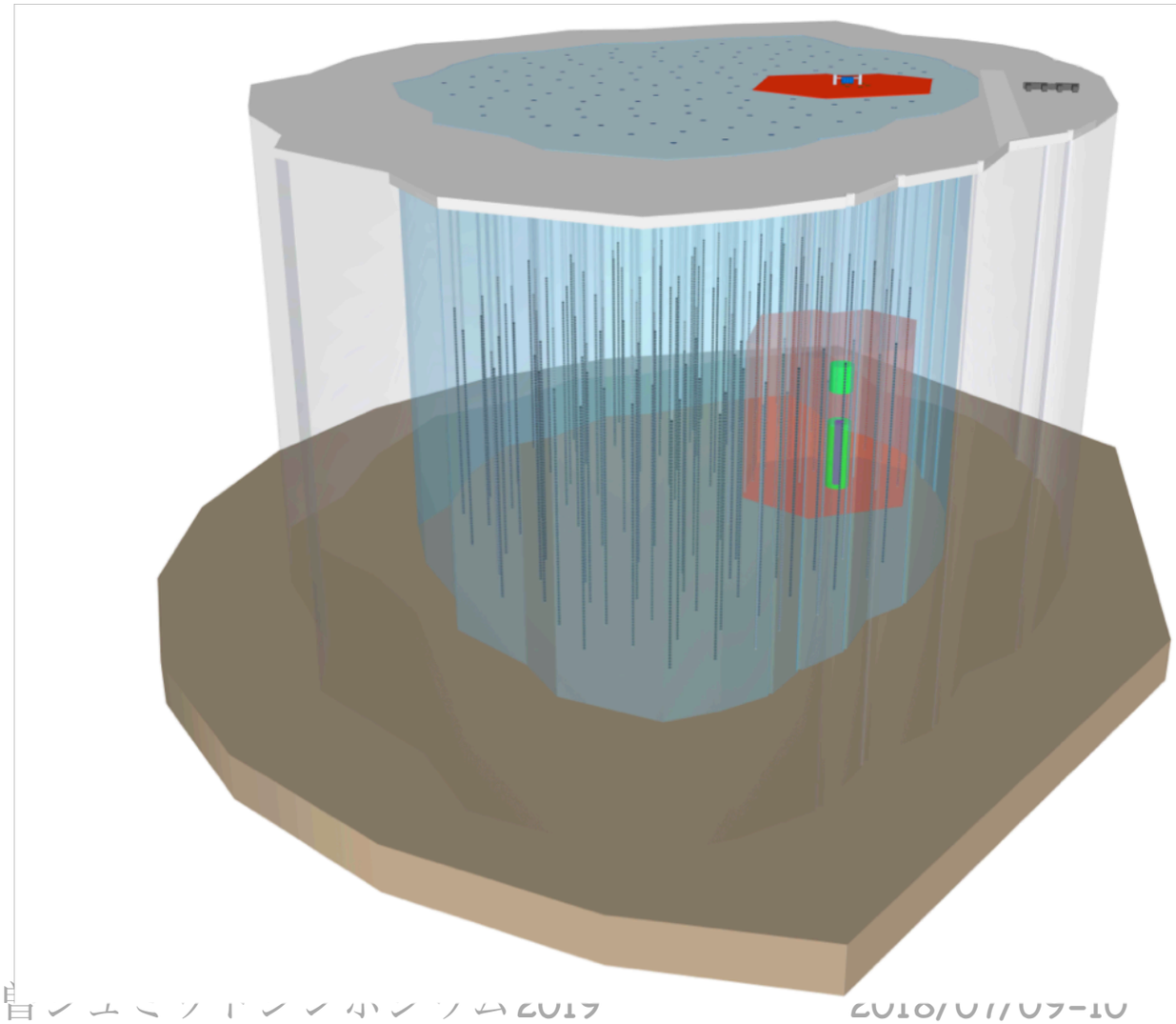
MoU between AMON & Japanese Consortium?

- Member:
  - Kiso/Tomo-e: 諸隈 (PI), 冨永, 田中雅
  - Kyoto/Seimei: 太田, 山中
  - Hiroshima/Kanata+Hinotori(+Fermi): 川端, 笹田, 深沢, 大野
  - Subaru: 内海 (SLAC), 冨永, 田中雅, 諸隈
  - RIKEN: 井上(芳)

IceCube upgrade: Gen2

https://icecube.wisc.edu/science/beyond





Summary

- IceCube neutrinos are key to understanding high-energy cosmic ray acceleration mechanisms, high-energy laboratory in the universe.
- First electromagnetic identification (BL Lac, TXS 0506+056 @z=0.33) was achieved for IceCube-170922A.
  - Contributions from optical/NIR Japanese telescopes (Kanata, Kiso, MITSuME, Subaru) were critical for this identification and follow-ups.
- Further systematic follow-up observations are desired.
  - Optical/NIR observations are critical to pin down the source.
- IceCube public alerts (since April 2016) are limited to high signalness sources w/ good localization (~< 1 deg).
  - More alerts?
- AMON is managing coincidence of sub-threshold events of multiple messengers and realtime alerts based on it.
- Japanese Consortium (PI: Morokuma) will make an MoU w/ AMON?
  - How about "triggering" for Tomo-e flashes to AMON observing facilities (after we understand frequency of the flashes and contamination rates)?