Interim report from Cosmic ray Researchers Congress (CRC) for Japanese strategy on astroparticle physics.

Contents:

1. What is CRC?
2. Master Plan
3. CRC future plan committee, “Town meeting”
4. History: Discussions and results on Master Plan 2014, 2017
5. Discussions for Master Plan 2020, rating by CRC

I am going to talk about “LARGE” projects.
LARGE = more than 10 billion yen ~ 100 M$

Chief executive of the CRC
Graduate school of science, Osaka City University
Shoichi OGIO

What is CRC?

CRC = Cosmic ray Researchers Congress (established in 1953)
= Community of the researchers who are working/interested in cosmic ray physics, astroparticle physics and astrophysics in Japan.

Purpose: Contributing to the development of cosmic ray physics through encouraging cooperations and interactions among researchers.

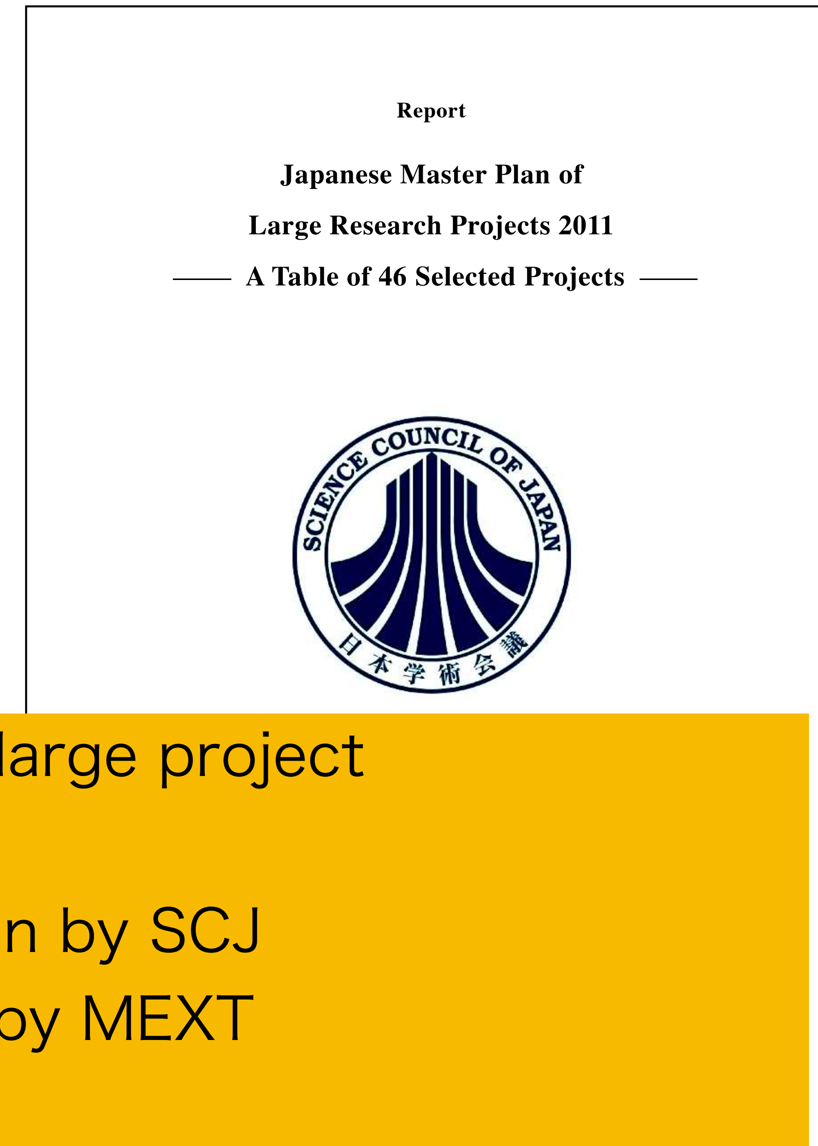
Activity: Planning and management of conferences/workshops for related studies and future plans.

Organization: General meeting twice a year.
Executive board by 13 elected board members

Number of members: 408 @ March 2019

What is Master Plan?

Recommendation prepared by Science Council of Japan (SCJ) including large research projects selected from the proposals from all field of science based on discussions and selection in wide communities of scientists. (<u>CRC is one of the communities</u>)


Report

Japanese Master Plan of

Large Research Projects 2011

—— A Table of 46 Selected Projects ——

Definition of "large" project: more than about 10 billion yen ~ 100 M$

Two categories:

*High priority

*Selected

Renewed every three years (2011, 2014, 2017, 2020)

Steps for a formal approved large project

1: Selected on the Master Plan by SCJ

2: Selected on the Roadmap by MEXT

3: Budget approved by MOF

*MEXT: Ministry of Education, Culture, Sports, Science and Technology-Japan

*MOF: Ministry of Finances

CRC future plan committee

A permanent standing committee for continued discussions of future plans.

Established in 2011

Members: about 13 including non-CRC members invited
from other communities(Astronomy, Particle physics, etc.)
Selected by the CRC executive board
Currently, 4th term (Apr. 2018 - Mar. 2021)

Activity: Planning and management of the conferences called "CRC town meeting for future plans". Moreover, discussing and priority rating of proposed future plans for the most recent Master Plan based on the discussions in the town meetings.

Town meeting: about twice per year, ~60 participants. In total 15 meetings.

http://www.icrr.u-tokyo.ac.jp/CRC/

History: discussions and results on Master Plan 2014 (1st term)

6 CRC town meetings for Master Plan 2014 in Jul. 2011 to Nov. 2012

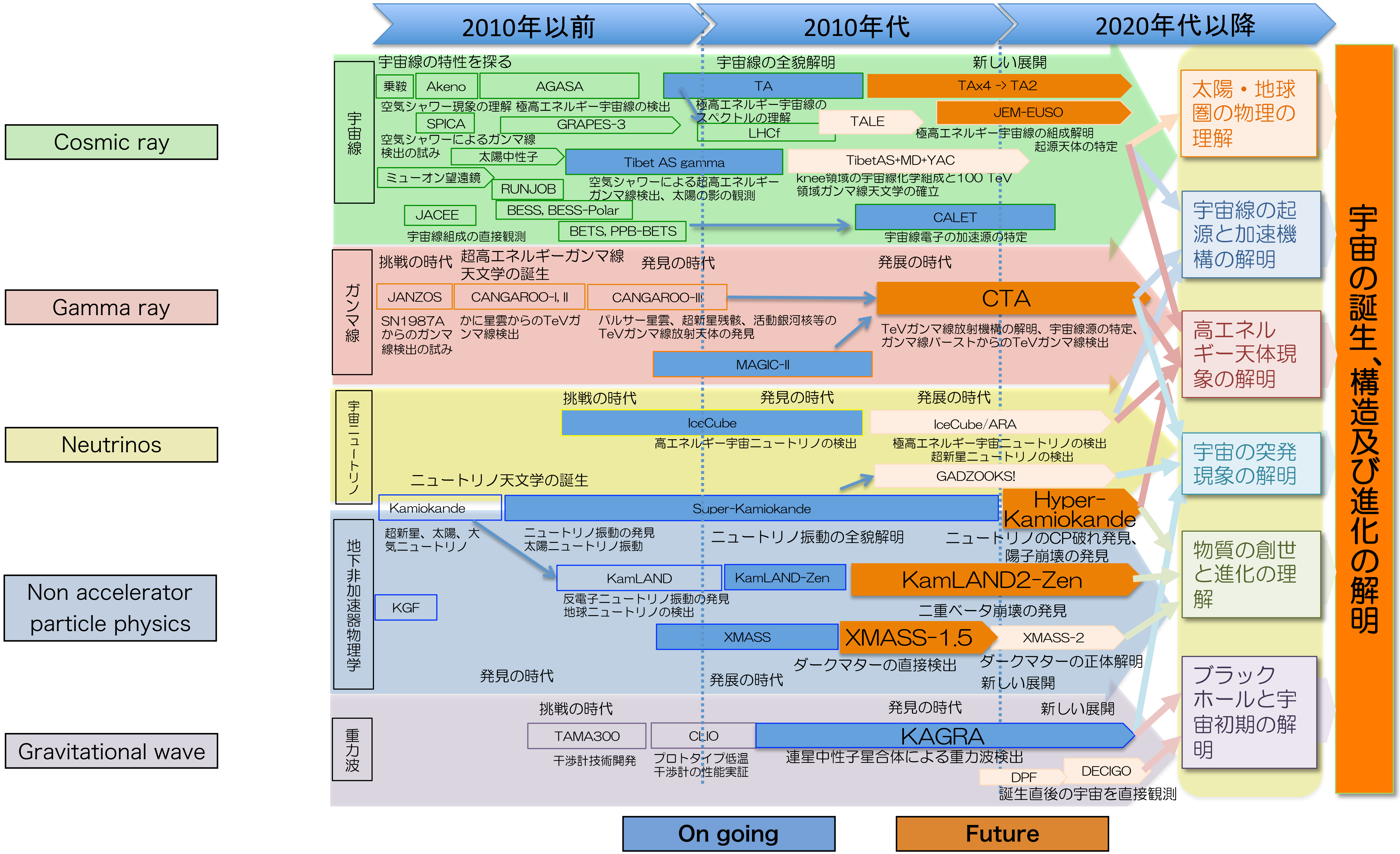
Rating and recommendation by CRC:
Top priority: CTA, KamLAND2-Zen, (Hyper Kamiokande (HK))
Second priority: TA2, JEM-EUSO, XMASS1.5
Encouraged to be early realization with KAKEN-HI (Grant-in-Aid for Scientific research): TibetAS gamma, GAZOOKS!(SK-Gd), IceCube/ARA

On Mater Plan 2014:
High priority: HK
Selected: CTA, KamLAND2-Zen, JEM-EUSO, XMASS1.5, (KAGRA as on "going")

→ Results:

* CTA was funded and started the construction of LST (2015-)
* More realistic (feasible) extensions of TA → TALE and TAx4 were funded with KAKEN-HI (2015-)

History: CRC Roadmap (2013, 2nd term)



History: discussions and results on Master Plan 2017 (3rd term)

2 CRC town meetings for Master Plan 2017 in Dec. 2015 to Feb. 2016

Recommendation by CRC:
HK, CTA, KamLAND2-Zen, JEM-EUSO, XMASS1.5, IceCube-Gen2, Pre-DECIGO

On Mater Plan 2017:
High priority: HK (→ **Selected on Roadmap 2017 by MEXT***)
Selected: KamLAND2-Zen, XMASS1.5, IceCube-Gen2, (CTA & KAGRA as on “going”)

* MEXT: Ministry of Education, Culture, Sports, Science and Technology-Japan

History: Other topics discussed in the town meetings (3rd term)

◆Multi-messenger astrophysics
◆Large (larger) scale future plans on the neutrino/dark matter physics
◆Challenging/exploratory future plans based on a long-term perspective

Schedule for Master Plan 2020 (4th term)

Jul. 2018: Deadline to submit Letter of Intent (LOI) to SCJ
Aug. 2018: SCJ released the LOI list to the public
Oct. 20, 2018: First town meeting: discussions for CRC related candidates on the LOI list
Nov. 18, 2018: Second town meeting: discussions and rating for CRC related LOI candidates
Nov. 30, 2018: Submit a recommendation letter with rating by CRC to SCJ
Mar. 2019: Submit a proposal by each candidate collaboration
Summer 2019: Selected candidates will be interviewed by SCJ
Spring 2020: SCJ will release the Master Plan 2020

LOI candidates and rating by CRC

Project	CRC rating for MP2020
SK	Top priority on-going projects
KAGRA	
CTA	
HK	
KamLAND2-Zen	Top priority new projects
IceCube-Gen2	
B-DECIGO	Selected new projects
LISA	
ALPACA	Endorse early realization with KAKEN-HI
POEMMA	Postpone endorsement. Carried over to next

http://www.icrr.u-tokyo.ac.jp/CRC/

LOI candidates

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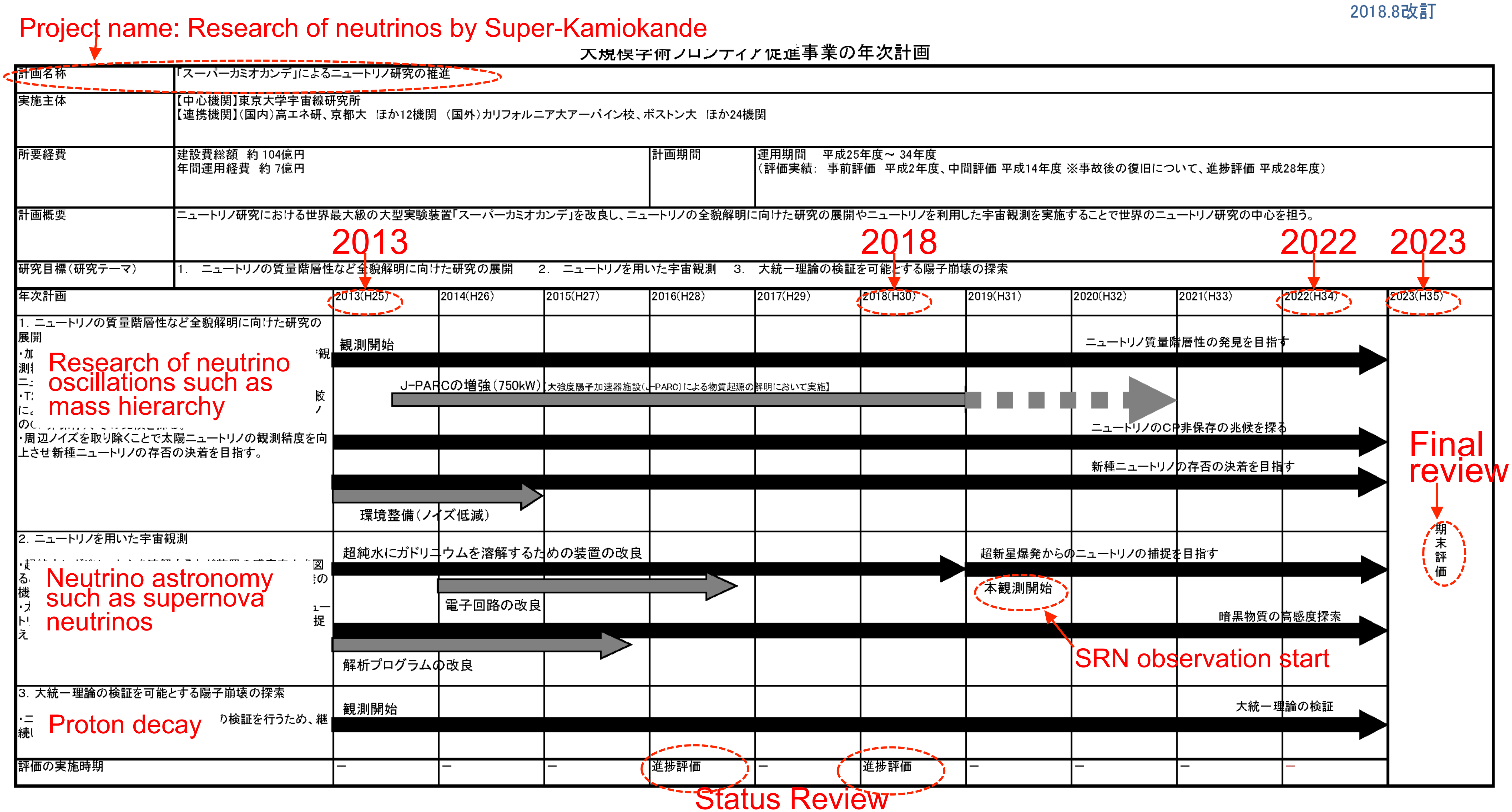
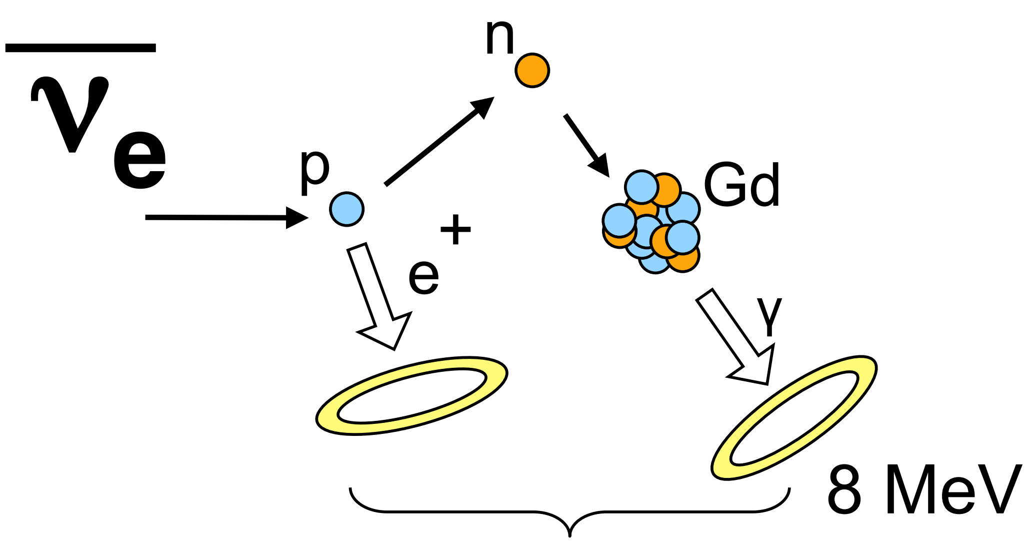
Super-Kamiokande in the current big-frontier project



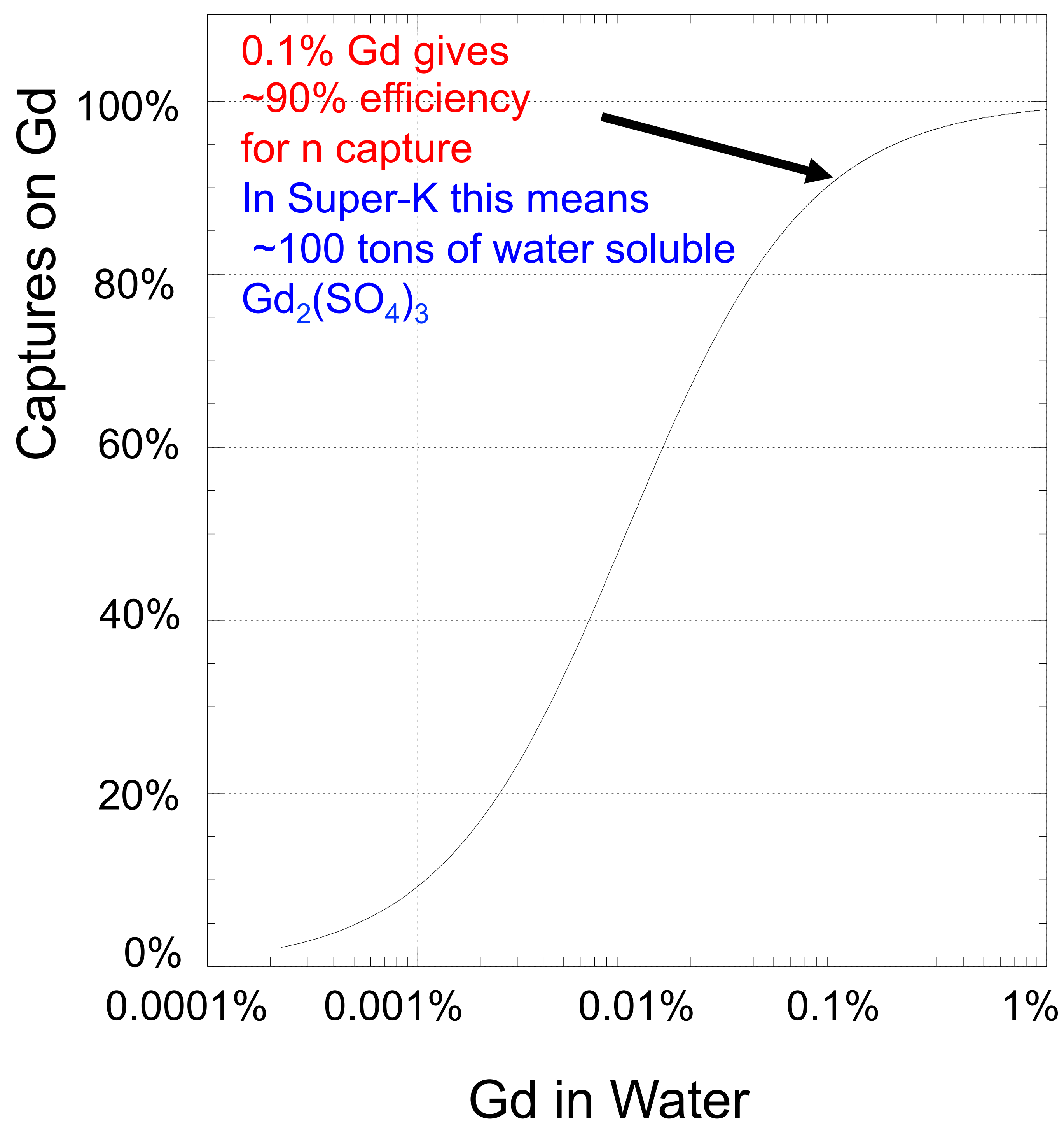
In the current big-frontier project in MEXT, Super-Kamiokande(SK) is terminated in 2022. However, SK can still improve a lot of neutrino physics including supernova neutrino observations. So, we would like to continue SK with new developments at least until Hyper-Kamiokande will start stable data taking.

Neutron tagging with Gadolinium

Gd has a large neutron capture cross section(^{157}Gd: 254,000 barn, ^{155}Gd: 60,900 barn) and emits gamma ray cascade of ~8MeV.



ΔT~30μs
Vertices within 50cm



Neutron tagging will reduce background and enable highly sensitive measurement of $\bar{\nu}_e$. In addition, it will enable neutrino/anti-neutrino identification.

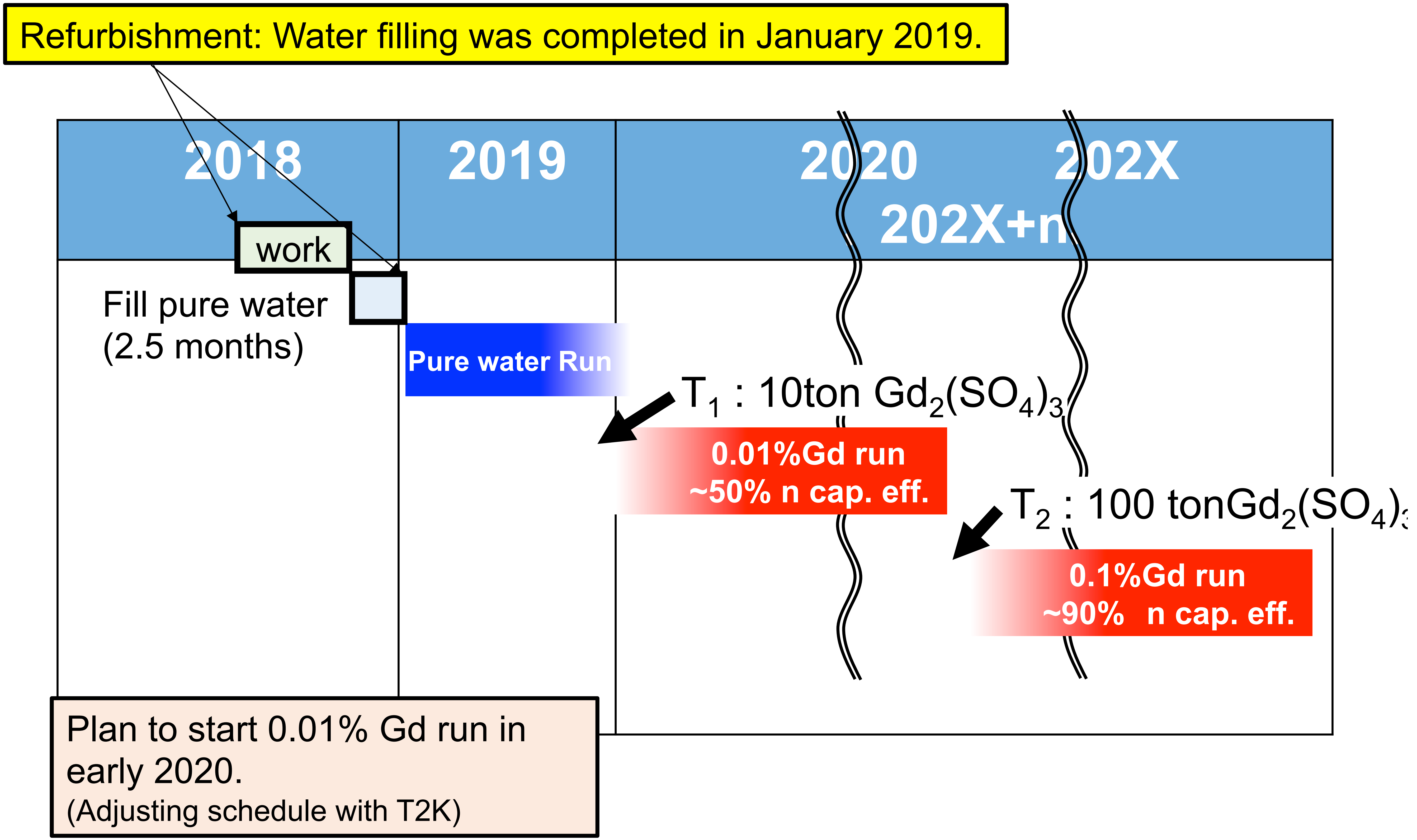
Summary of physics in the SK-Gd phase

- In the SK-Gd phase, low energy anti-neutrinos will be detected with neutron tagging information with quite low background.
- The main physics target will be Supernova Relic Neutrinos (SRN). We plan to observe SRN with 5~10 years' live time for the first time in the world.
- Pointing accuracy for galactic supernova will be improved to 3°and it would contribute to electromagnetic follow-up.
- SK-Gd will be an important detector for supernova physics and it should continuously take data until Hyper-K starts.
- Neutron tagging will reduce background for nucleon decay searches and it would improve significance if a true nucleon decay is observed.
- For T2K and atmospheric neutrinos, SK-Gd will contribute to neutrino/anti-neutrino identification and improve CP phase measurement and mass hierarchy determination.

Contents of “New developments in neutrino physics at Super-Kamiokande”

- Observation of Supernova Relic Neutrinos (SRN)
  - (also called Diffuse Supernova Neutrino Background (DSNB))
  - First observation is expected at SK-Gd
- Improve observation of supernova burst neutrinos
  - Improve pointing accuracy
  - $\nu_e(+\nu_x)$ spectrum measurement
  - Possible detection of neutrinos from Si burning.
- Reduce neutrino background for nucleon decays
  - Anti-tag neutrons to reduce atmospheric neutrino background
- Discriminate neutrino and anti-neutrino events for T2K
  - Using neutron multiplicity
- Reactor neutrinos
  - precise determination of θ_{12} and Δm^2_{12} with high statistics measurement, if Japanese reactors restart

Schedule of SK-Gd



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General outline of KAGRA Project

KAGRA is 3km L-shaped underground laser interferometer with cryogenic mirrors

Project framework

- ICRR hosts this project, and KEK and NAOJ co-host it to construct KAGRA for gravitational wave astronomy. Univ. of Toyama also supports it.

Purpose of this project

- To understand astronomical phenomena like supernova explosion and coalescence of binary compact stars with gravitational waves

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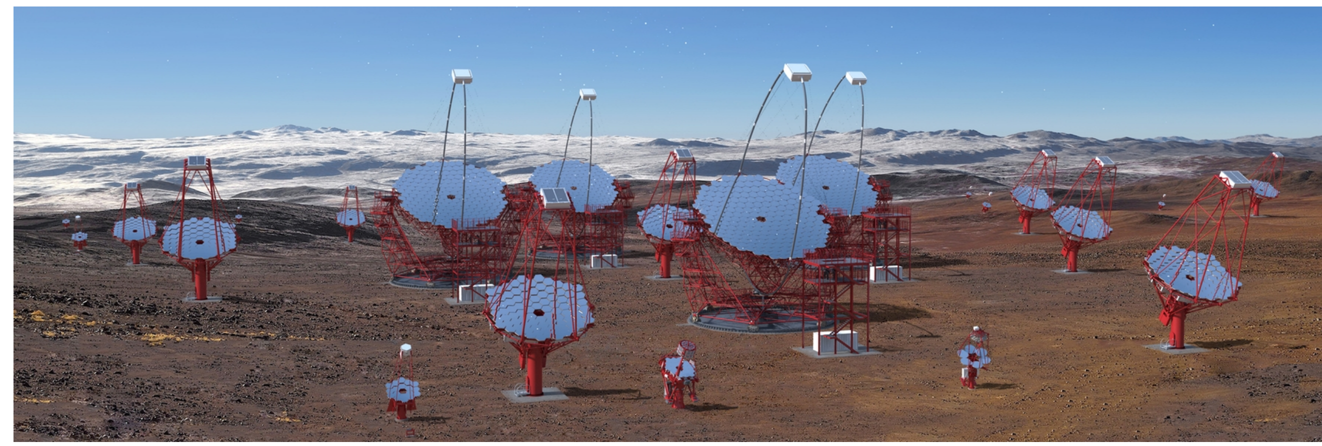
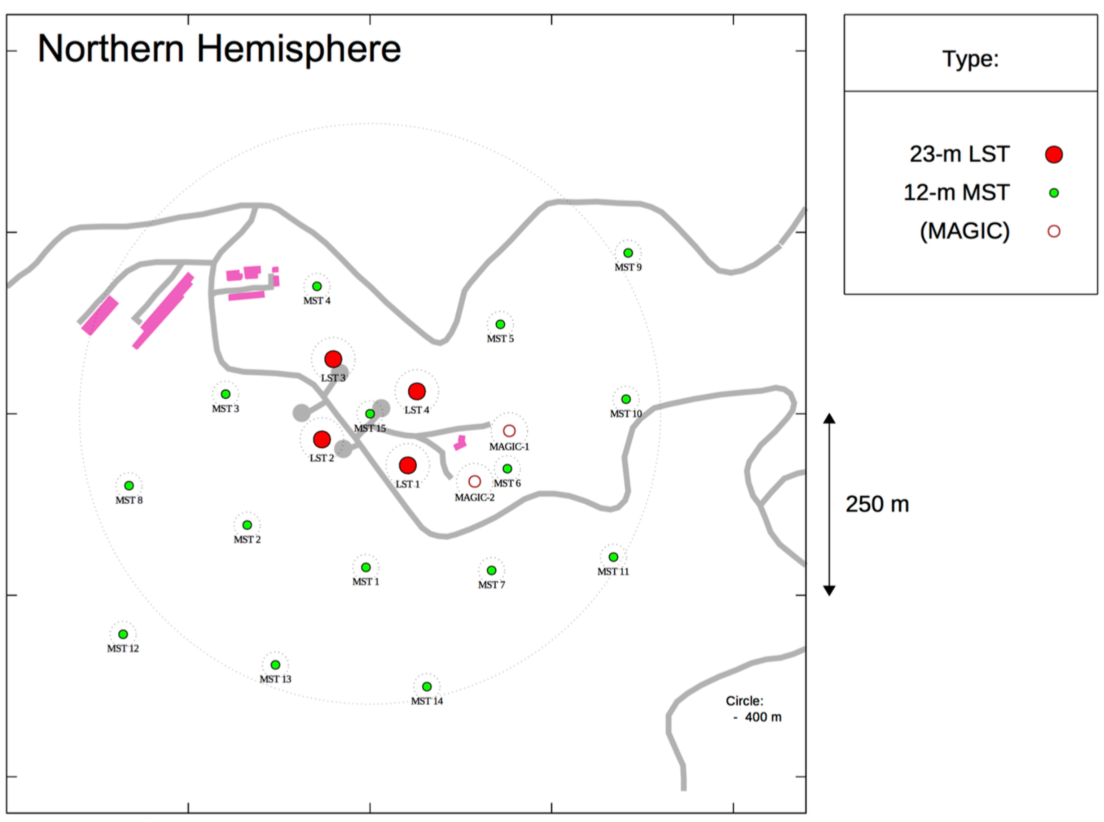
cherenkov telescope array

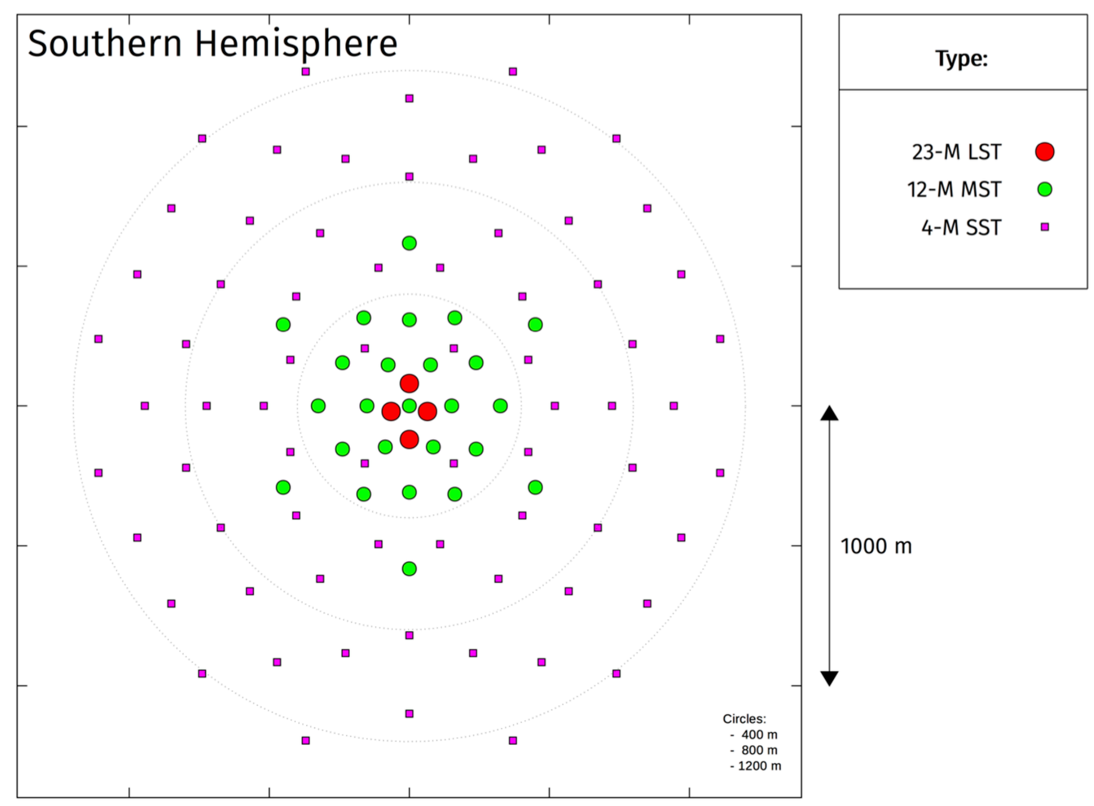
Two sites for all sky observatory

Roque de los Muchachos Observatory
La Palma, Spain

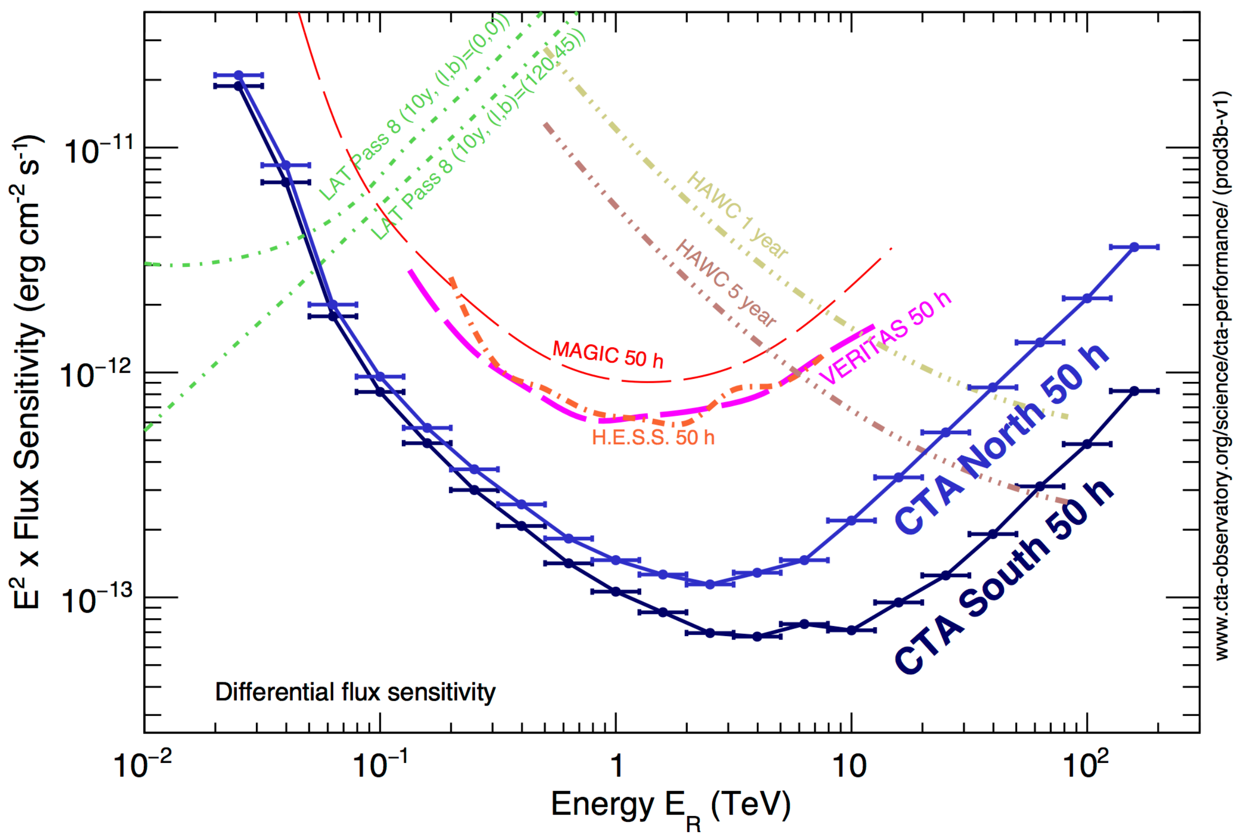
Paranal, Chile

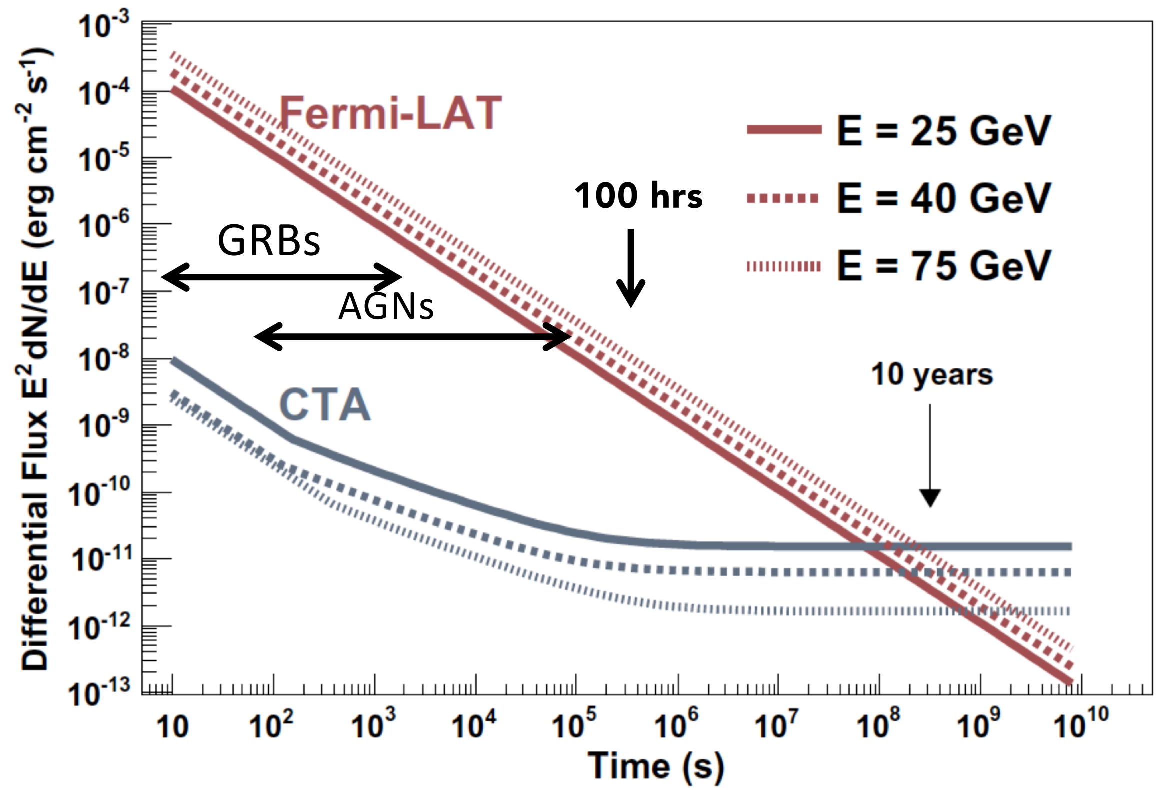






CTAN-LST Array
Sensitivity x3, Angular Resolution x2
Energy Range 20GeV~200TeV

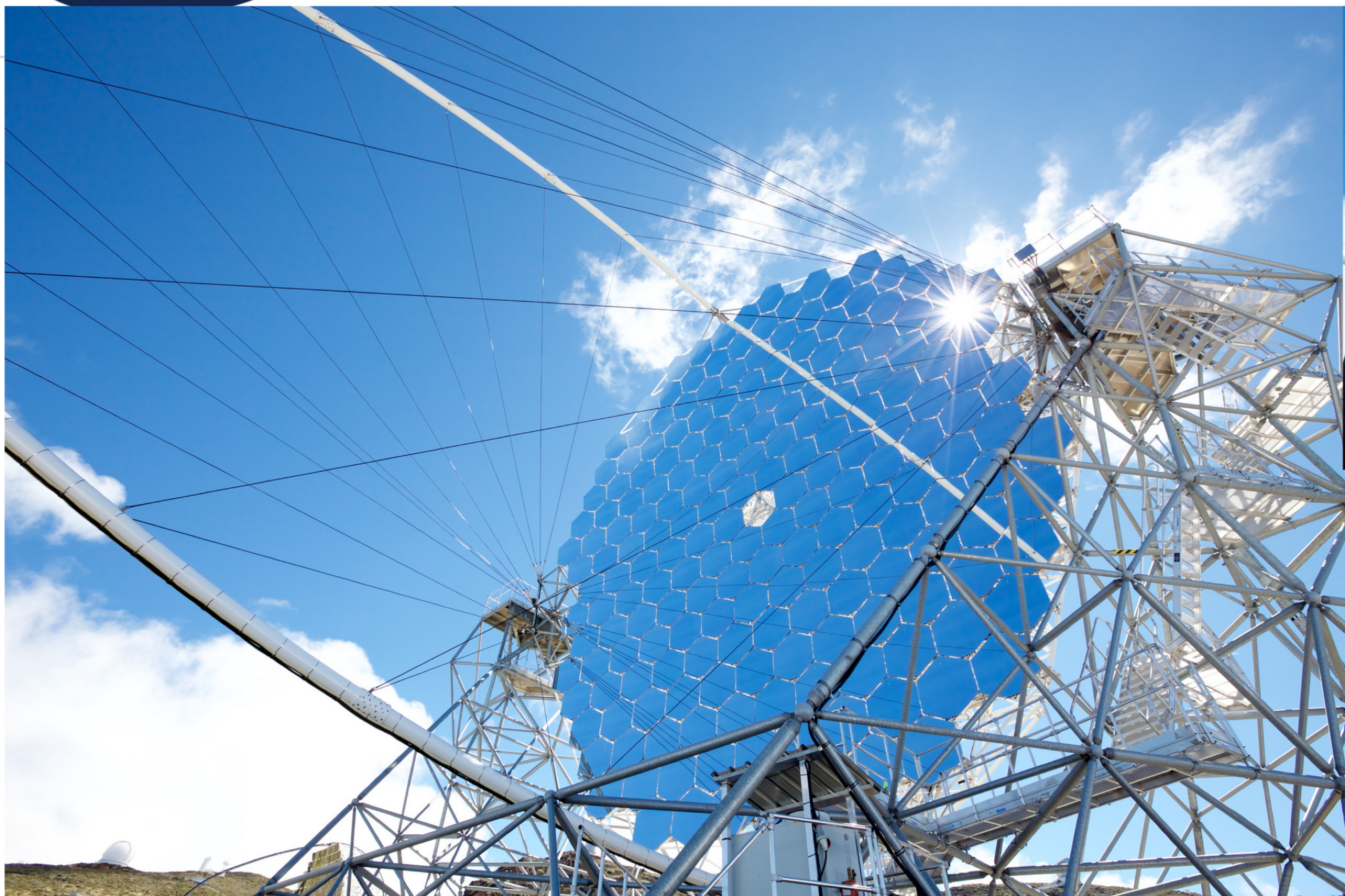


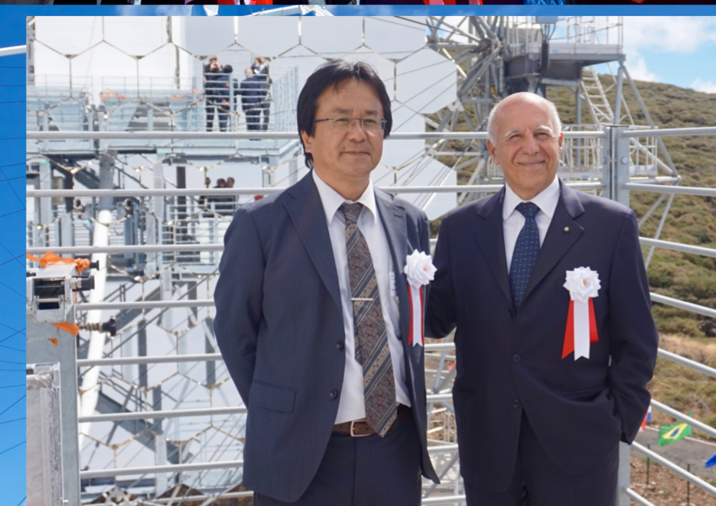


- CTA-LST array contributes to the sensitivity in low energies
- >20GeV Threshold Energy
- Distant AGNs are observable up to z=2, and GRBs up to z=4
- X10000 sensitivity for GRBs and AGN flares than Fermi
- First observation of GRBs from ground

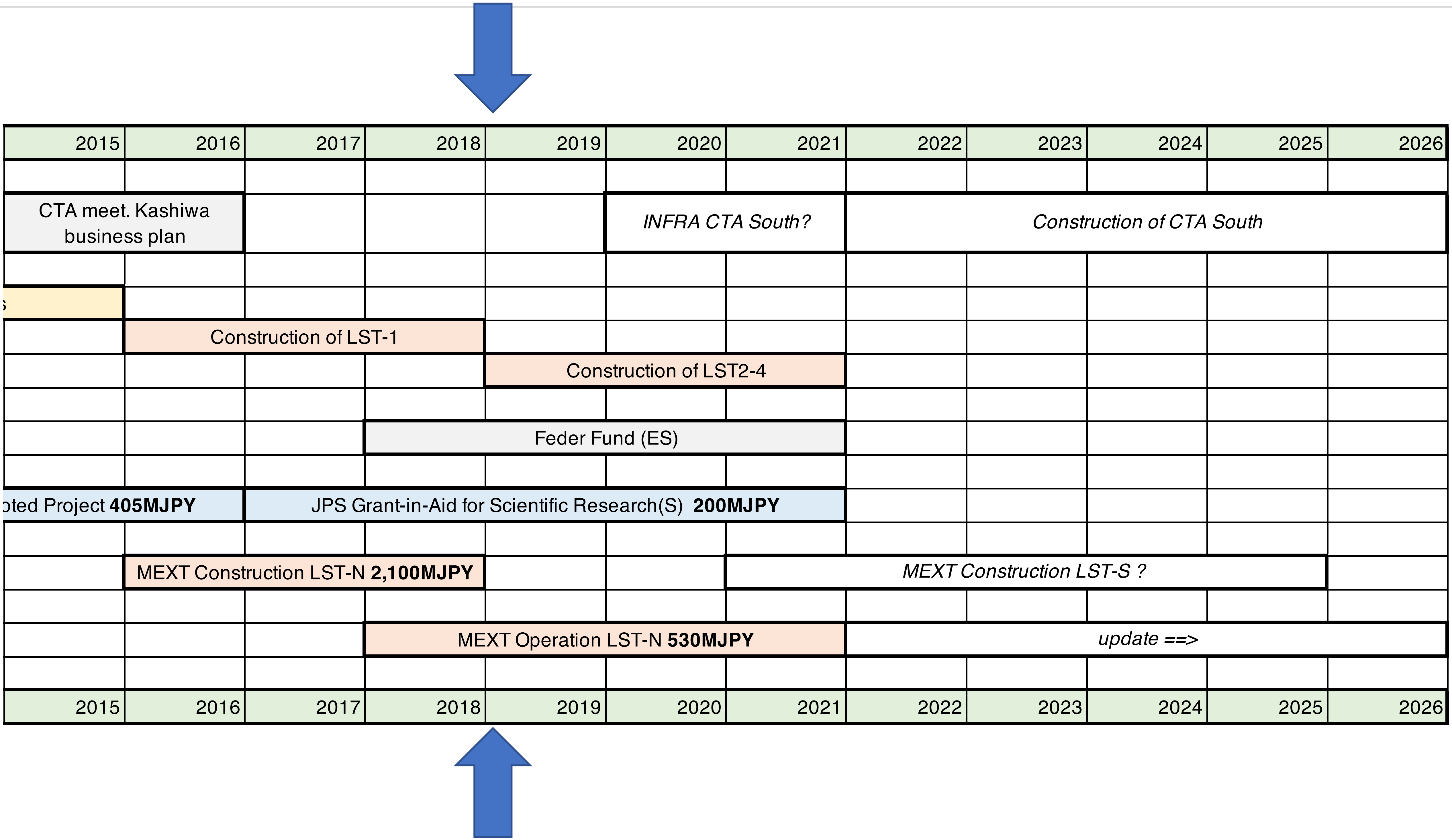
cta cherenkov telescope array

LST1: inaugurated on Oct.10 by more than 200 people





Timeline and Budgets



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Hyper-Kamiokanded project

✓Gigantic detector for nucleon decay search and neutrino detection

- ✓8.4 times larger fiducial mass (190 kiloton) than Super-K

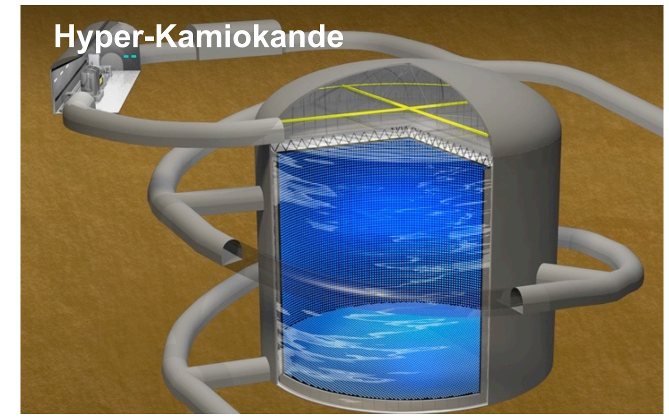
✓Mega-Watt J-PARC ν beam and Near detector system

✓International project

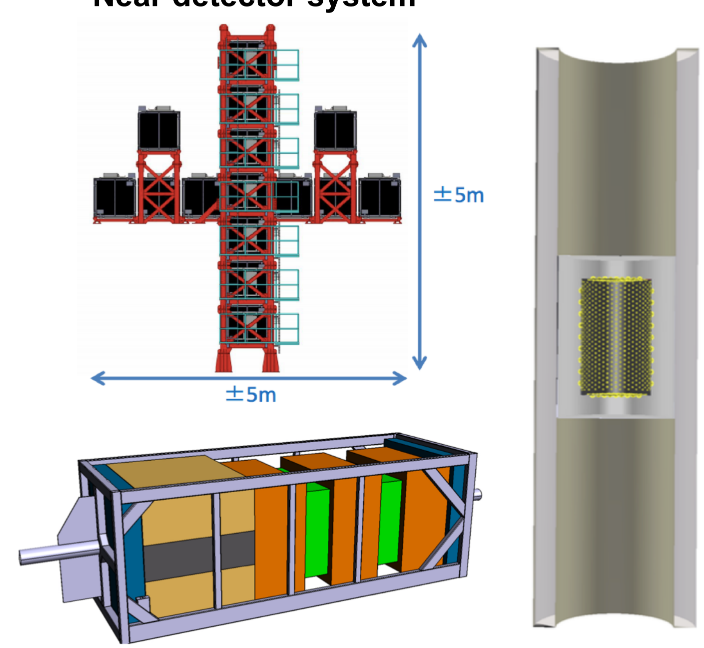
- ✓17 countries, ~300 researchers (¾ from oversea) as of 2018/4

✓Funding prospect

- ✓**Listed in MEXT-Roadmap2017:** project urgency and importance is recognized by Japanese government
- ✓Seed funding has been allocated for FY2019
- ✓**Preparing to start construction in 2020, Operation will start ~2027**



Near detector system



Broad Science and Discovery potential by unprecedented statistics and precision

✓Complehensive ν oscillation study

✓By accelerator, atmospheric, and solar ν
✓CP violation discovery and measurement→best bet to understand the origin of matter-antimatter asymmetry in the universe
✓Explore the origin of the unique neutrino properties

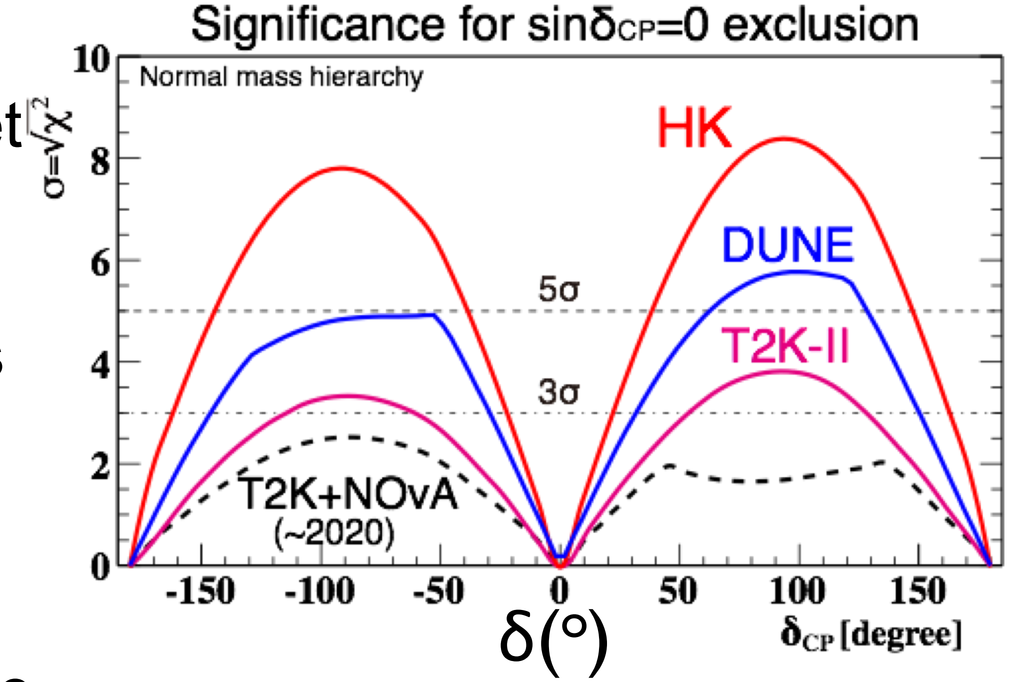
✓Neutrino Astronomy to explore

- Solar ν_e : ~2σ tension in Dm221 w/ reactor, Hep ν
- Supernova ν burst w/ reach to ~Mpc
  - Explosion mechanism: ν plays key role to achieve explosion
  - Instance of birth of Black holes and Neutron stars
  - ~1° pointing accuracy → Alert to telescopes
- SN diffuse ν
  - History of start formation and heavy nucleus

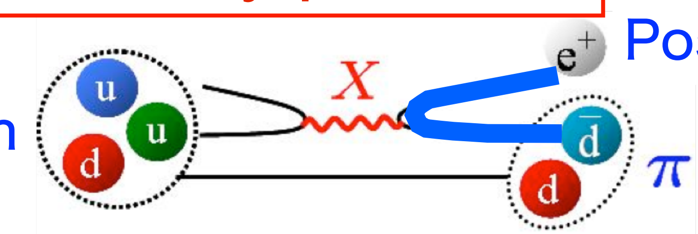
✓Proton Decay discovery

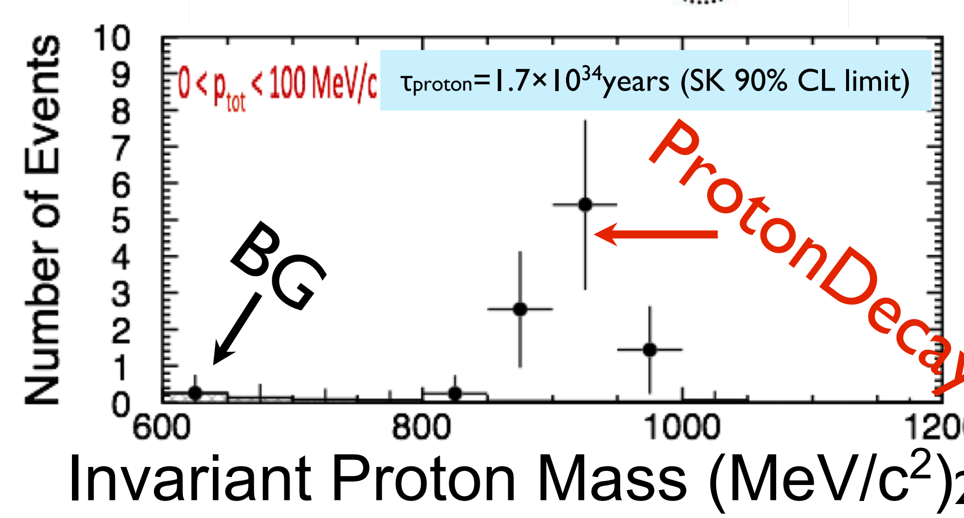
✓Unification of elementary particles and forces to establish new paradigm of particle physics
✓Aim to extract unification scale, gauge group etc

Competition



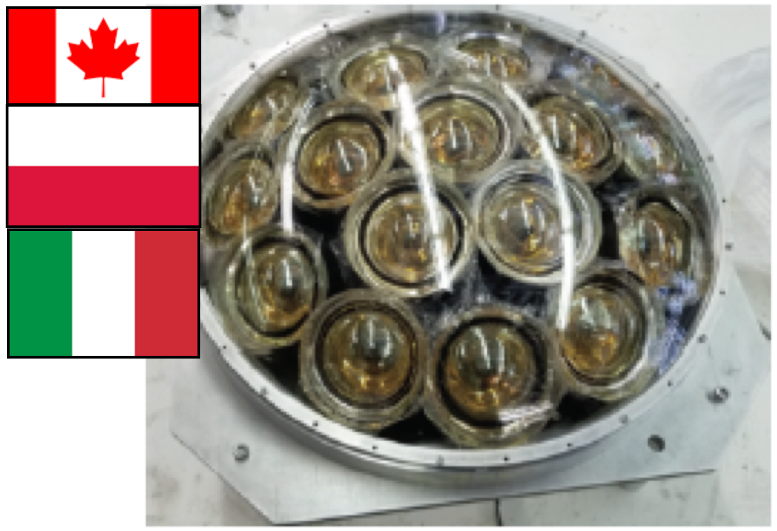
Discovery potential



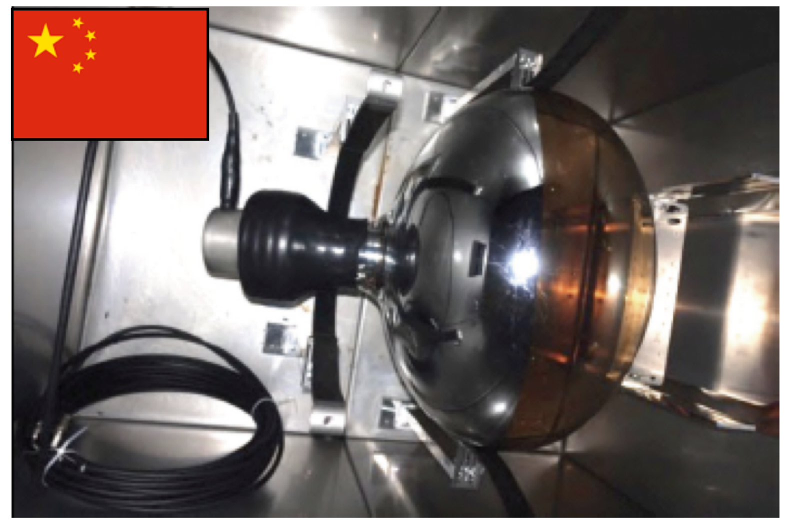


International Cooperation

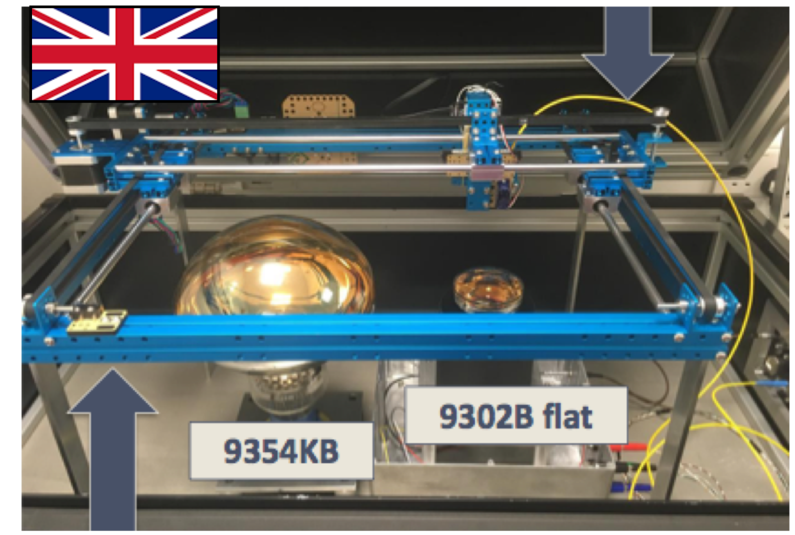
Multi-PMT module



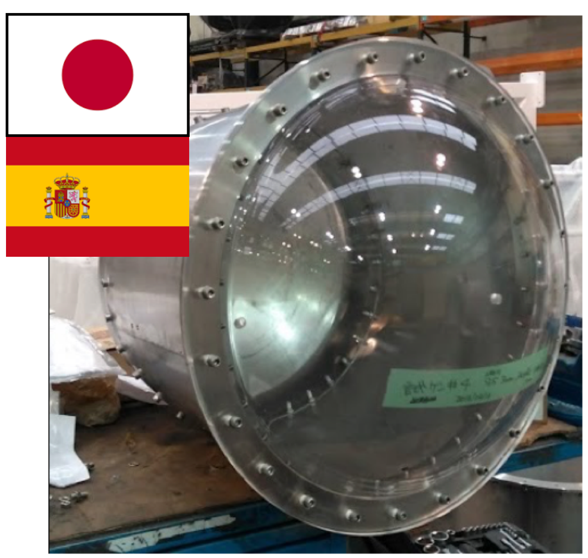
MCP-PMT



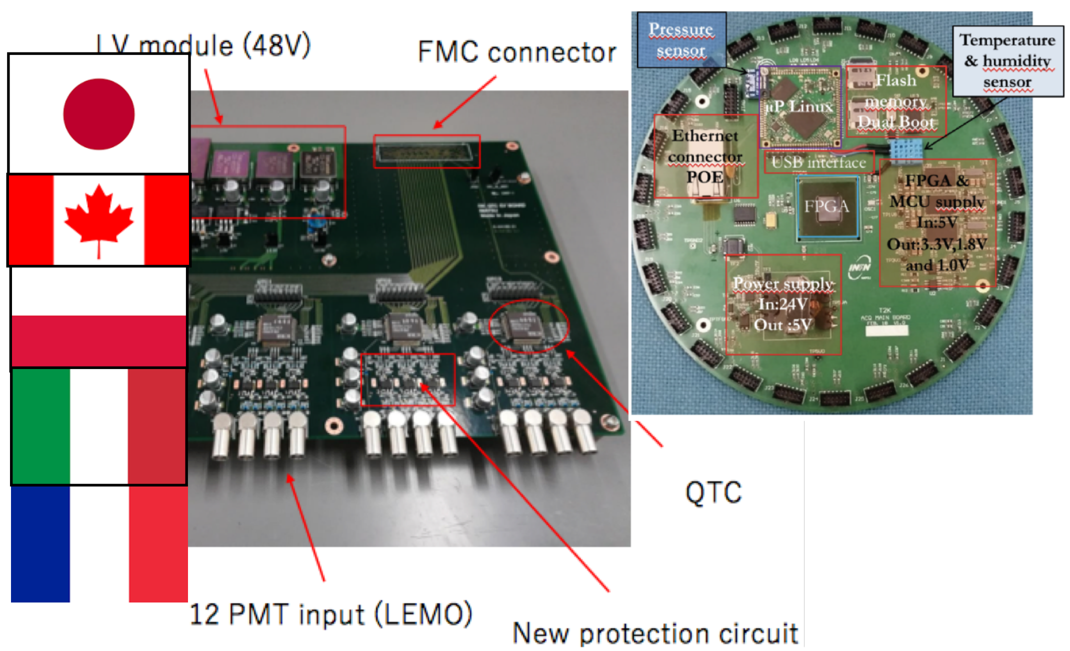
OuterDetector



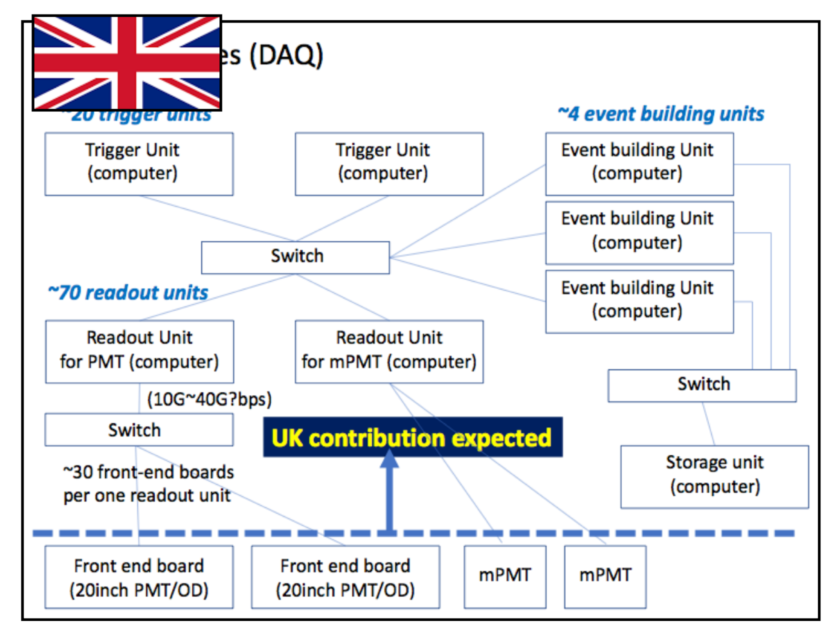
PMT cover



Electronics



DAQ



- Ongoing discussions to decide international contributions.
- Technical Report version2 to be completed soon

LOI candidates and rating

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Summary

We multi-purposely propel ultra-low background researches including following two major subjects.

1. Verification of Majorana nature of neutrinos in connection with a big mystery of the universe and particle physics

The question whether neutrinos are Dirac particles or Majorana ones became critically important after the discovery of neutrino oscillations. Majorana nature is a key of the See-saw mechanism and the Leptogenesis theory those can explain "why neutrinos are light" and "how matter particles dominated in the universe."

The only realistic way of verifying Majorana nature is "search for neutrino-less double beta decay," and KamLAND-Zen is largely leading the world competition in the research.

We investigate the whole inverted hierarchy region aiming at the discovery. Consequently, multiple theoretical models and neutrino mass hierarchy can be verified.

2. Neutrino geoscience with geo-neutrino observation

KamLAND pioneered neutrino geoscience and is accumulating high quality data as the world leading detector after the suspension of domestic nuclear power plants. It is about to provide new important knowledges on earth's dynamics and primordial meteorite.

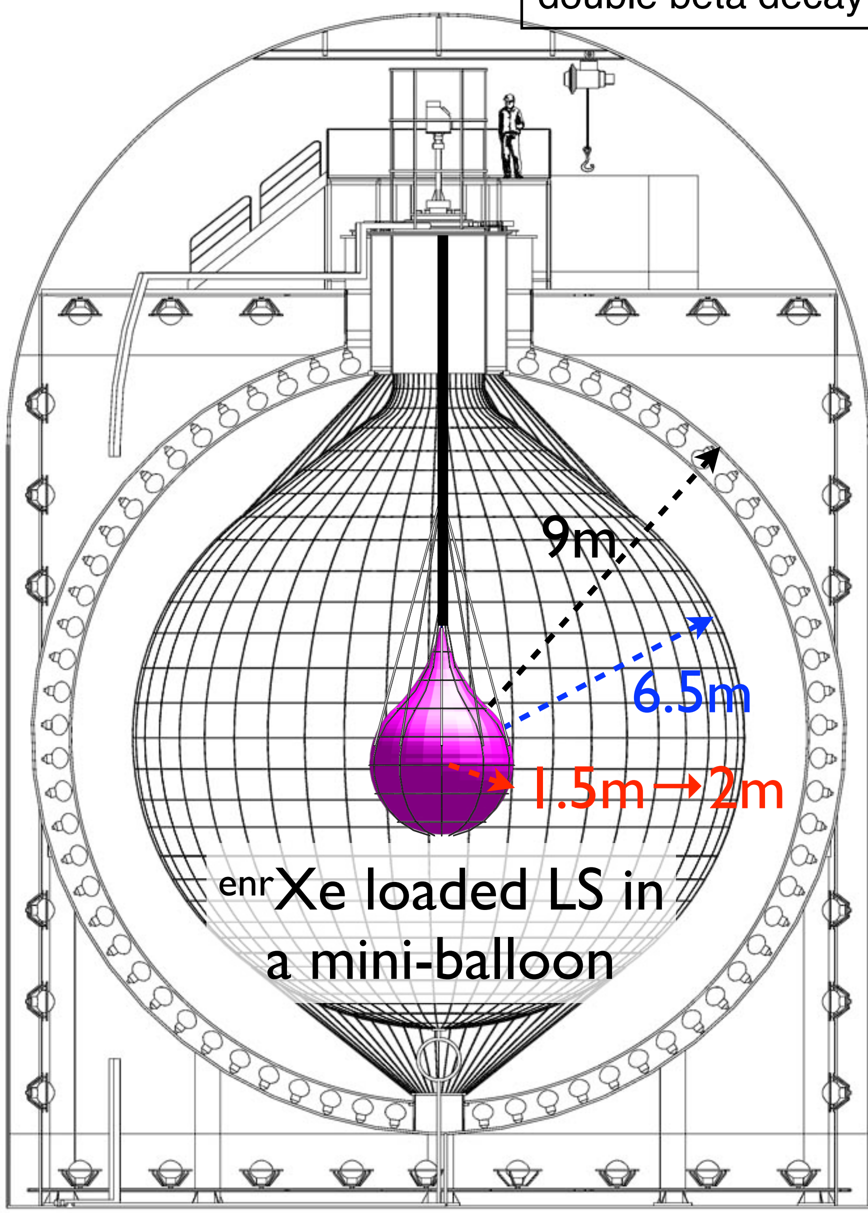
The continuous observation and an improvement of KamLAND detector will effectively develop neutrino geoscience and deepen the understanding of the formation and dynamics of the earth.

Thank you very much for your continuous support!

Current world best limit from

KamLAND-Zen

Zero Neutrino
double beta decay search



90% enriched ^{136}Xe
320kg for phase-I
380kg for phase-II
745kg for Zen 800 (started in January)

largest amount so far

^{136}Xe

Noble gas

Centrifugal enrichment possible

$Q_{\beta\beta}$=2459 keV

(below ^{208}Tl 3198-5001 keV)

Advantages of using KamLAND

⓪ low cost and quick start
(running detector)

① BG can be identified
(full active thick shielding)

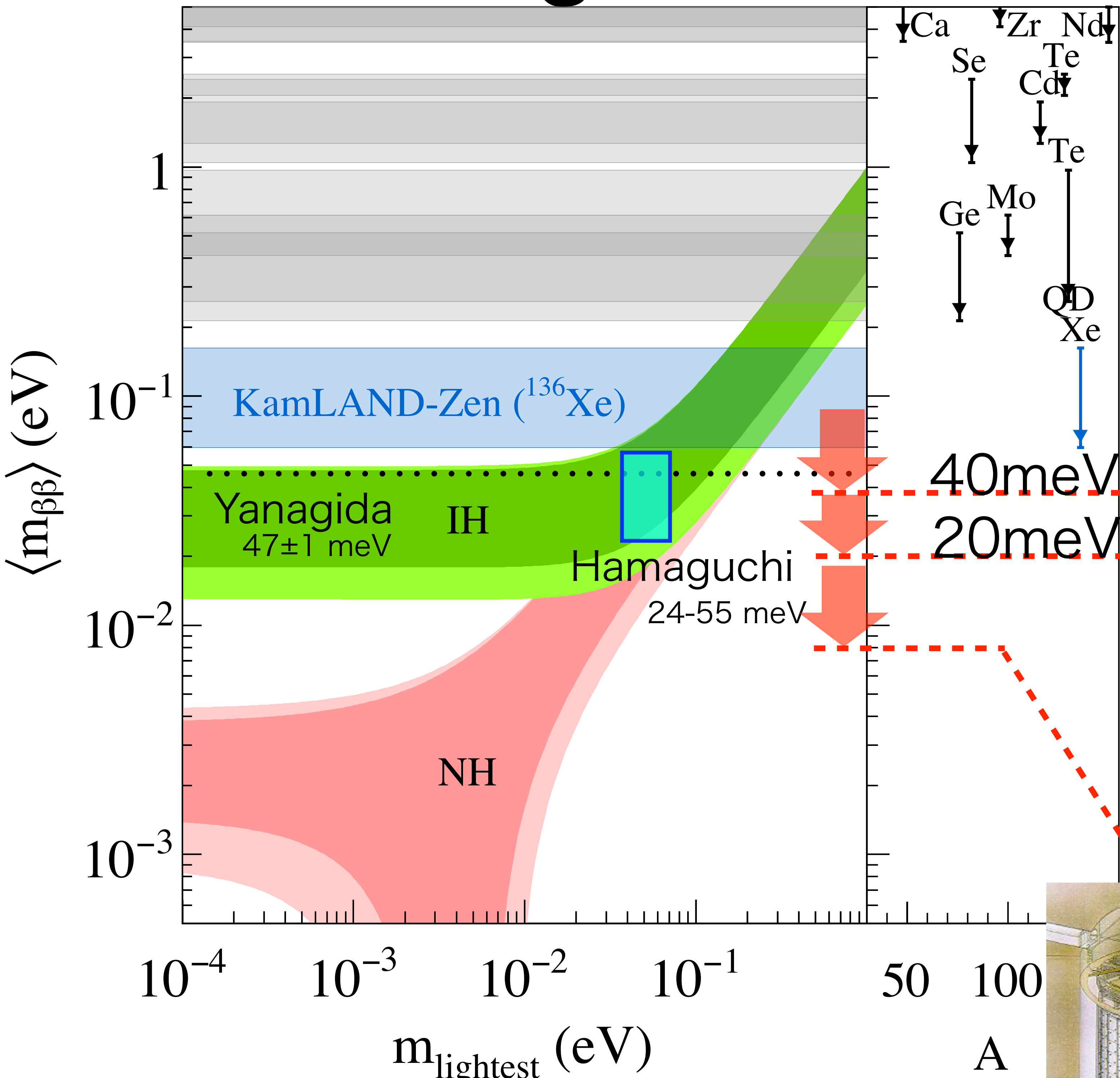
② In-situ purification possible
(liquid media)

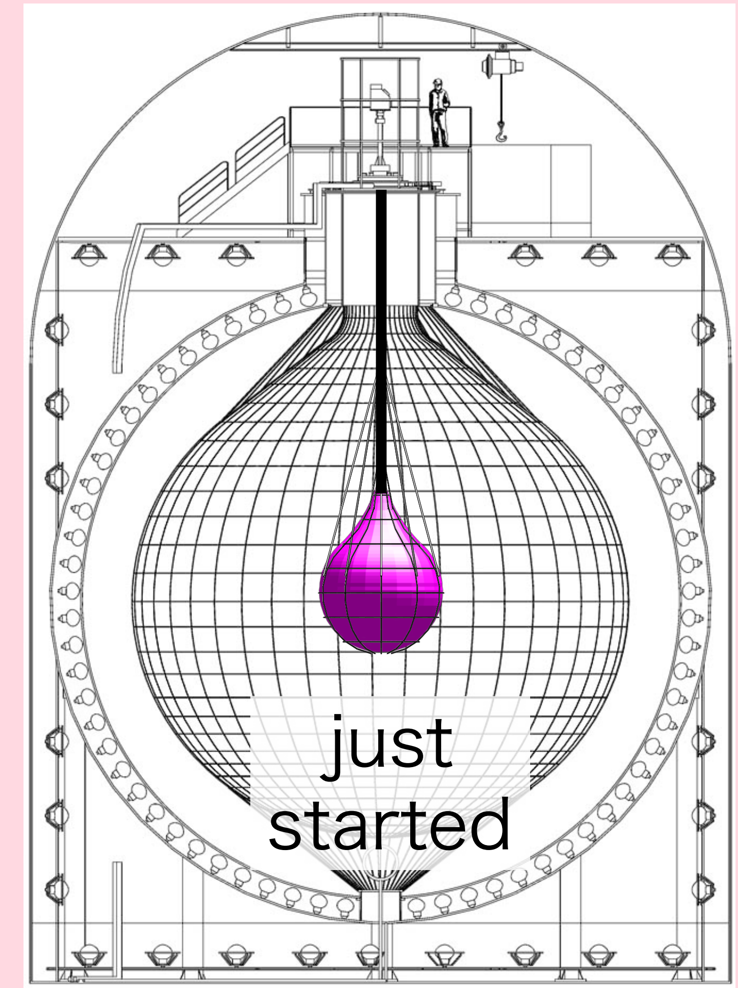
③ On/Off measurements possible
(xenon is removable)

④ multi-purpose
(geo-neutrino)

⑤ easily scalable
(mini-balloon)

World-leading KamLAND-Zen

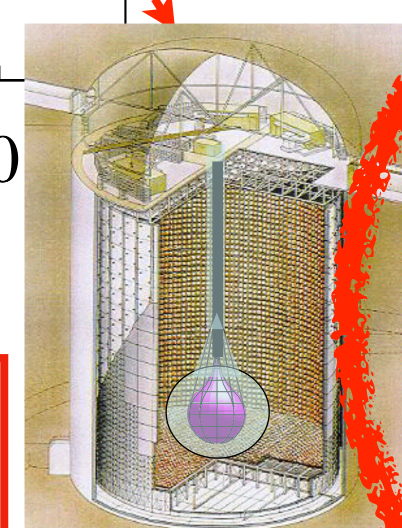


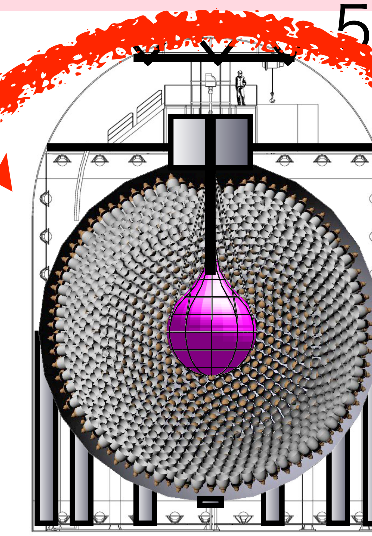


low BG film, 750 kg xenon

KamLAND-Zen 800

$5x10^{26}$y (5y)





better resolution

scintillating film

KamLAND2-Zen

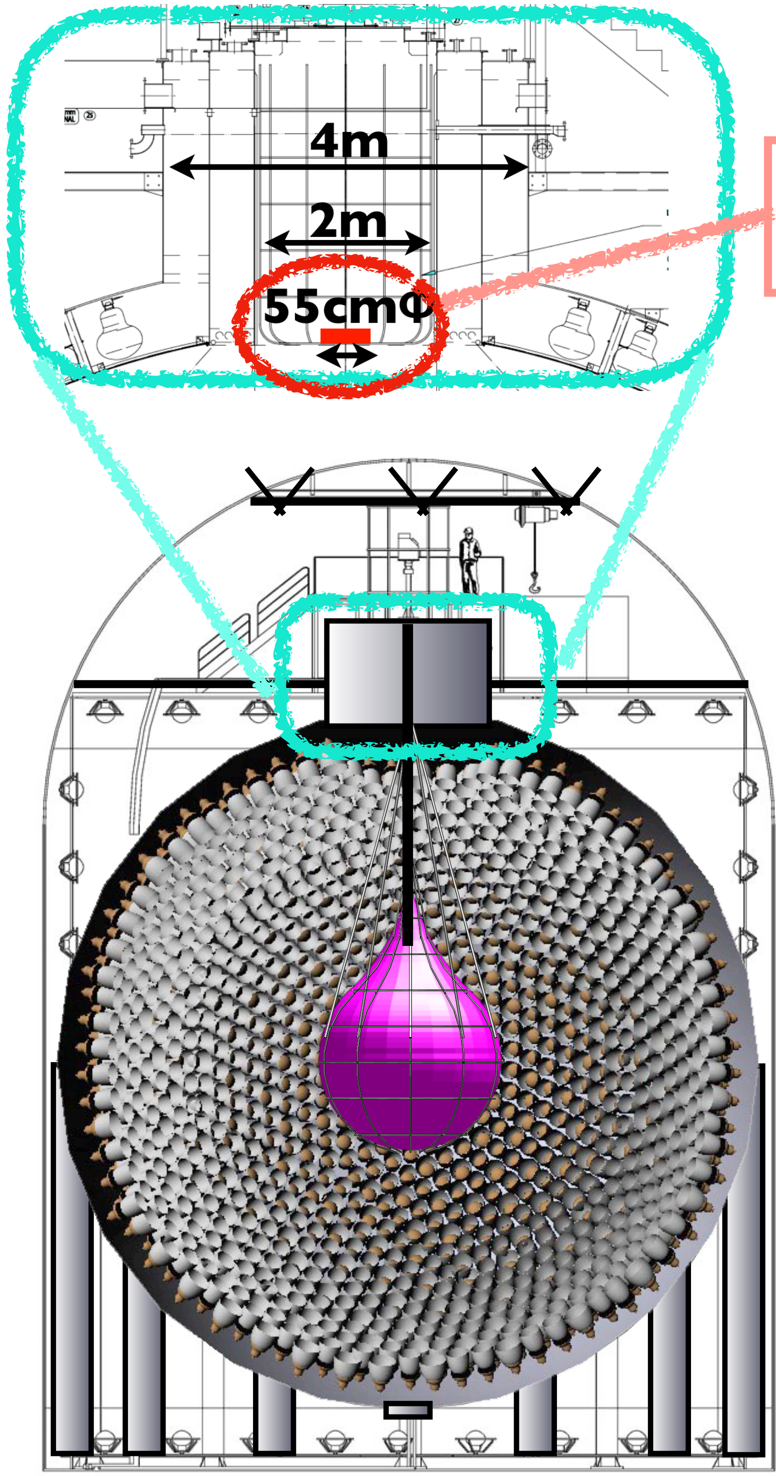
$2x10^{27}$y (5y)

The discovery may be just around the corner.

KamLAND-Zen is closest !!!

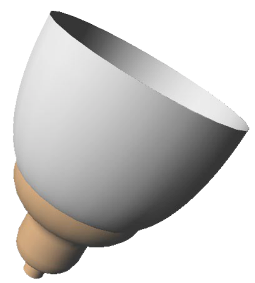
And more future plans!

Higher energy resolution for reducing 2ν BG



1000+ kg xenon

⇒ KamLAND2-Zen

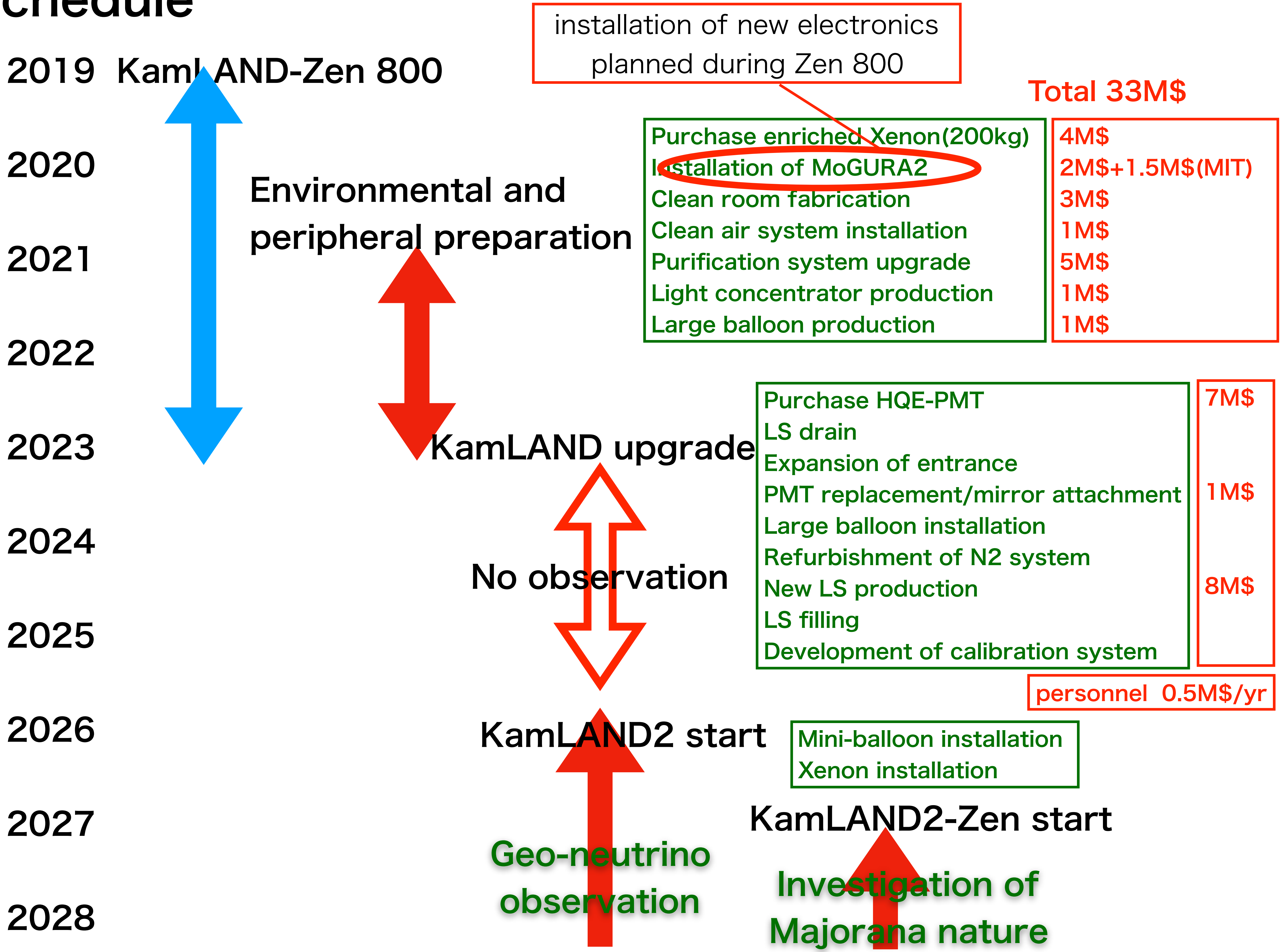


Winston cone	light collection ×1.8
high q.e. PMT 17”ϕ→20”ϕ ε=22→30+%	light collection ×1.9
New LAB LS (better transparency)	light collection ×1.4

expected σ(2.6MeV)= 4% → ~2%

target sensitivity 20 meV

Schedule



2019 KamLAND-Zen 800
2020
2021
2022
2023
2024
2025
2026
2027
2028
installation of new electronics planned during Zen 800
Total 33M$
Environmental and peripheral preparation
Purchase enriched Xenon(200kg)
Installation of MoGURA2
Clean room fabrication
Clean air system installation
Purification system upgrade
Light concentrator production
Large balloon production
4M$
2M$+1.5M$(MIT)
3M$
1M$
5M$
1M$
1M$
KamLAND upgrade
Purchase HQE-PMT
LS drain
Expansion of entrance
PMT replacement/mirror attachment
Large balloon installation
Refurbishment of N2 system
New LS production
LS filling
Development of calibration system
7M$
1M$
8M$
No observation
personnel 0.5M$/yr
KamLAND2 start
Mini-balloon installation
Xenon installation
KamLAND2-Zen start
Geo-neutrino observation
Investigation of Majorana nature

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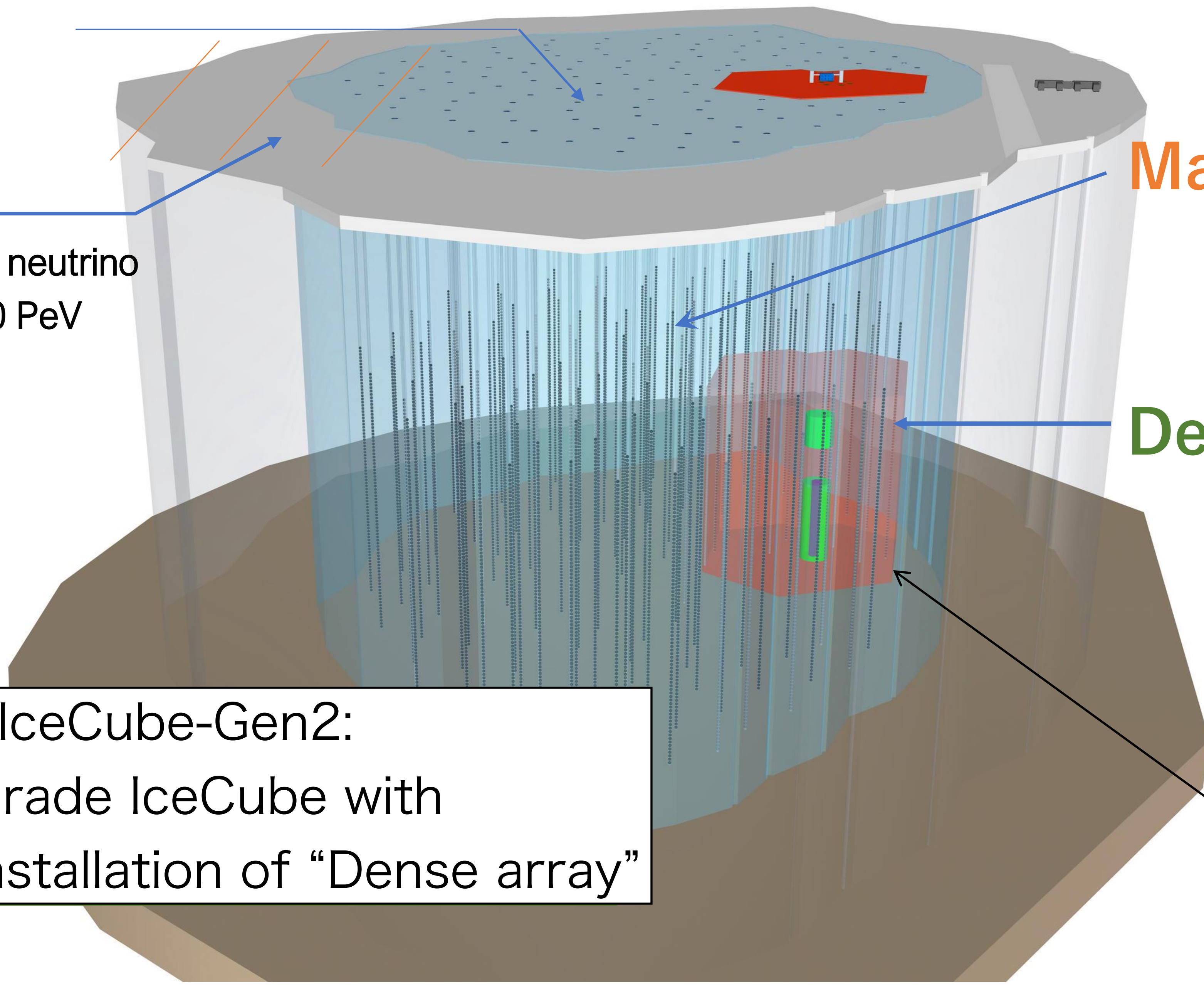
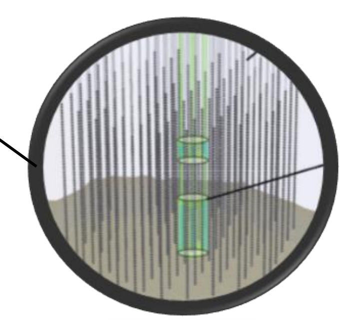
IceCube-Gen2

- Surface array
  - muon veto
  - CR physics
- Radio array
  - cosmogenic neutrino
  - neutrino >10 PeV



Main array
- ≈100 strings
- ≈100 sensors/string
- ≈240m distance

Dense array
- 26 strings
- 125-192 sensors/string
- ≈25m distance

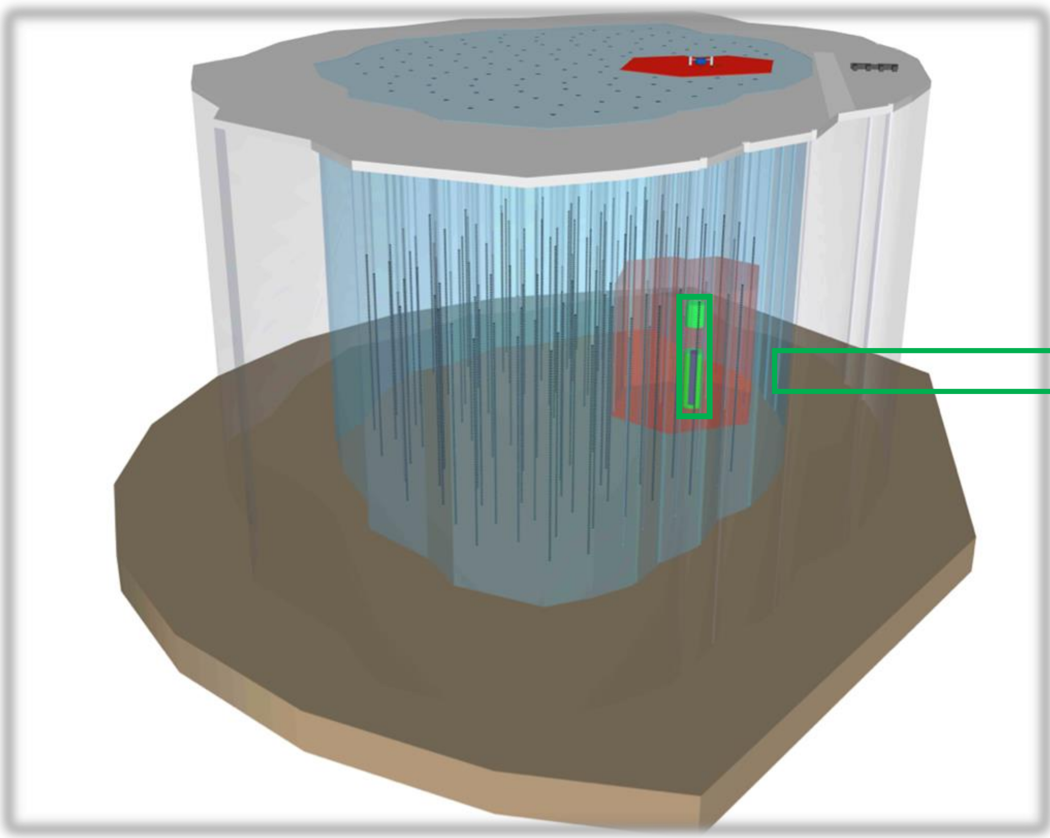


IceCube-Gen2:
upgrade IceCube with
additional installation of “Dense array”

13

IceCube Gen2 in-ice detectors

IceCube-Gen2 main phase

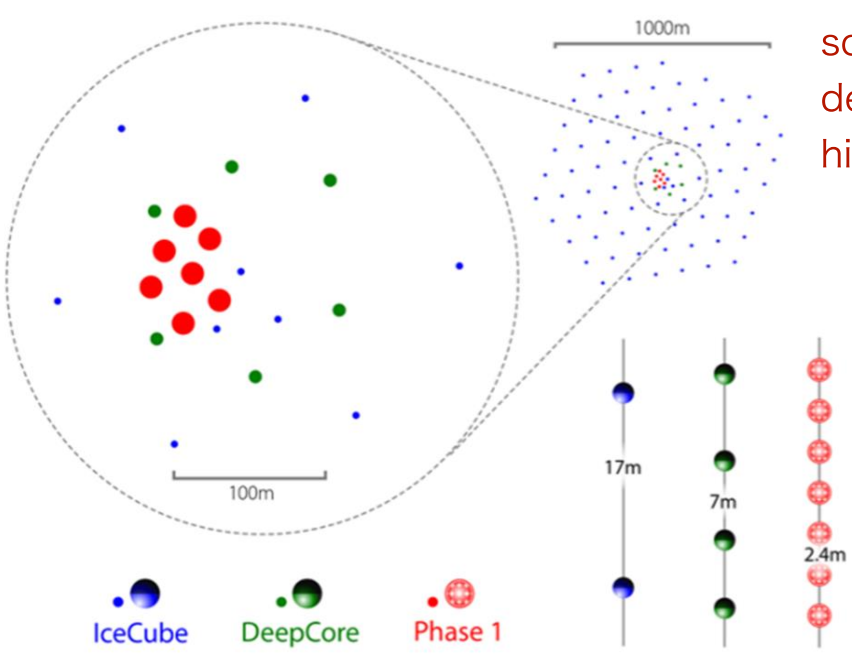


Expect to be approved in 2021

IceCube-Gen2 phase1

Started in 2018. Total cost is 30M$. Installation will be in 2021-22

In order to precisely understand the scattering length and scattering angles in the ice with densely arrayed high sensitivity photo-sensors



Japanese team contributes 3 strings with KAKEN-HI budget.

High sensitivity photo-sensor
"D-Egg"
developed in Chiba U.

Target of Phase 1 upgrade:

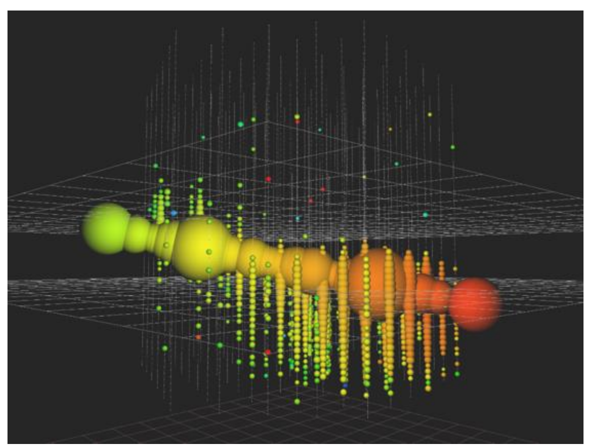
twofold increase of astrophysical neutrino events

Track event

$\nu_\mu \rightarrow \mu$

angular resolution:

0.5°



Currently, only this type of events are used for Multi-messenger studies

Cascade event

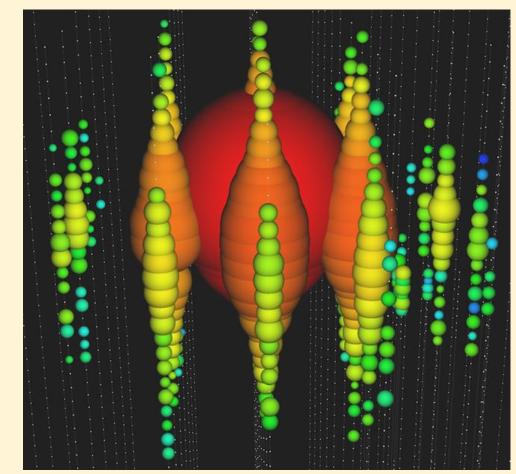
$\nu_e \rightarrow e + X$

angular resolution:

15°

better energy resolution (~15%)

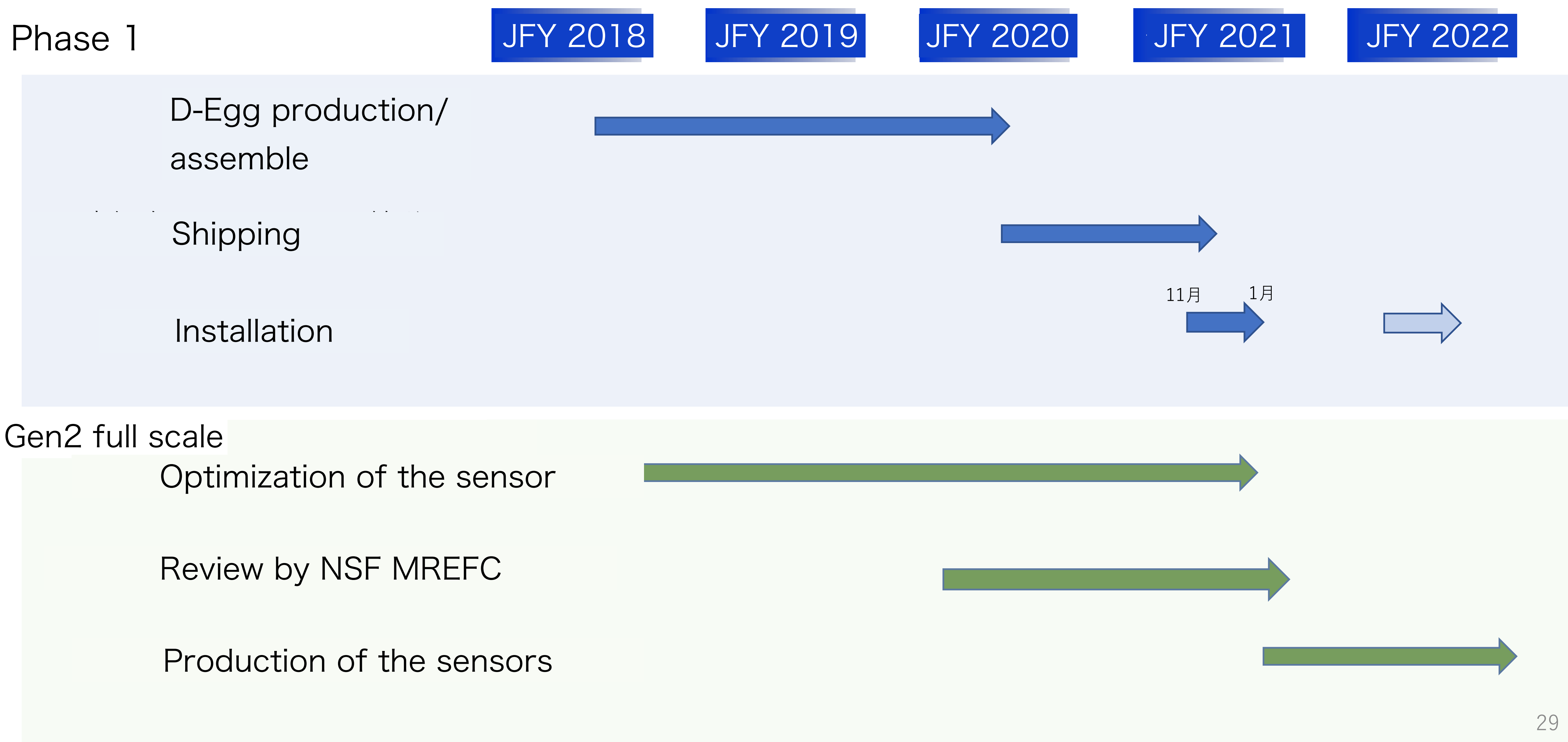
lower atmospheric ν BG



To improve this angular resolution with Phase 1 upgrade

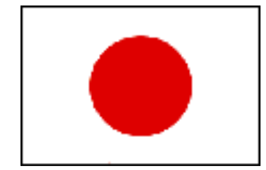
15

Schedule


Phase 1
JFY 2018
JFY 2019
JFY 2020
JFY 2021
JFY 2022
D-Egg production/
assemble
Shipping
11月
1月
Installation
Gen2 full scale
Optimization of the sensor
Review by NSF MREFC
Production of the sensors

29

IceCube-Gen2 Schedule and Budget



科研費

新学術

基盤S

	Phase 1	R&D
2015-2017		
2018	approved PDR	
2019	PRR (readiness review)	Full scale
2020		MREFC panel
2021	PFR	
2022	installation	FDR
2023-2030		installation
2030		full science run

2.5 B yen (25M$) from MEXT

KAKEN-HI 0.5 B yen (5M$)

30

LOI candidates and rating

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HK	
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LISA	
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Space GW telescope: B-DECIGO

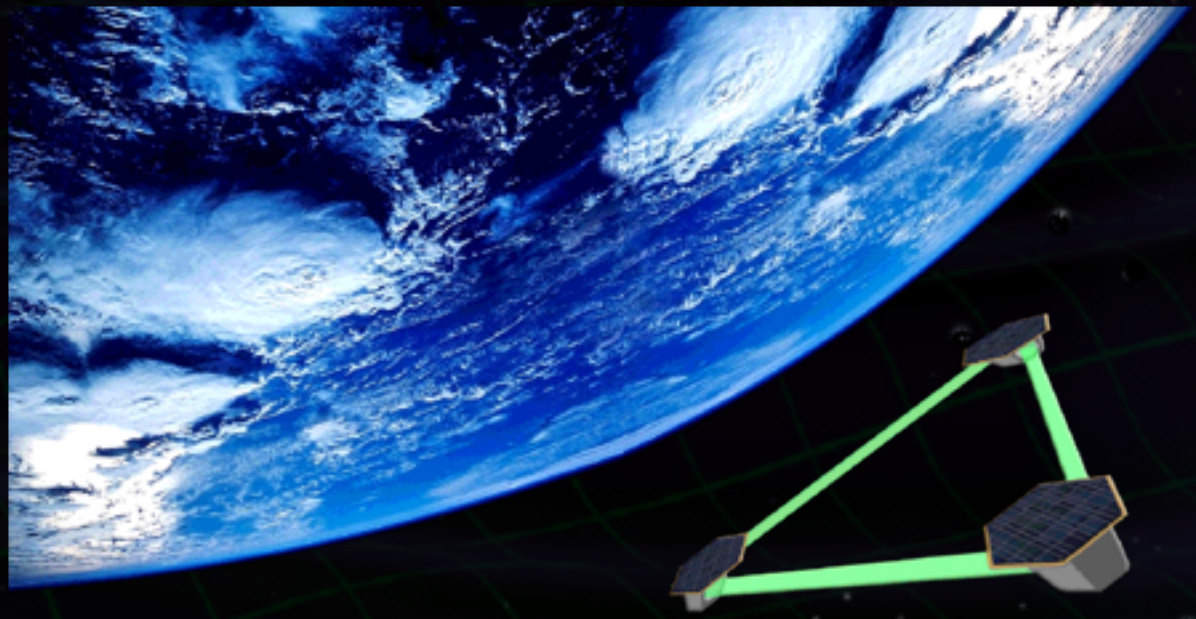
DECIGO

former “Pre-DECIGO”

- B-DECIGO

 - 3 space crafts constitute Space GW telescope
 - Sensitivity: 2×10^{-23} $Hz^{-1/2}$ at 0.1Hz.

絵: 佐藤修一



- Targets

 (1)compact binary mergers
 (2) Middle size BH binary
 (3) Understand the foreground GW emmission

Expected to be launched in 2030

summary of B-DECIGO science

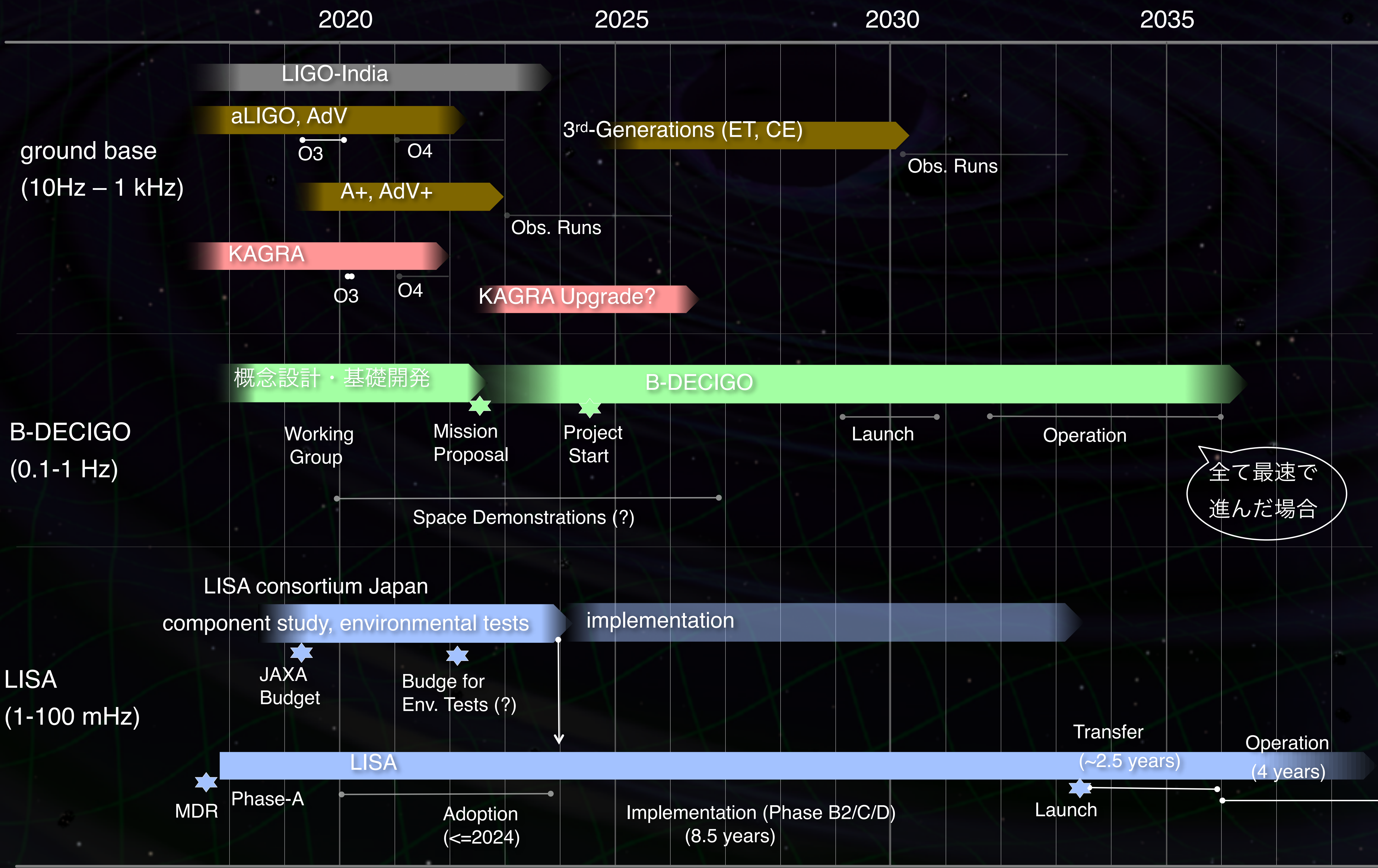
- B-DECIGO opens new window

  - frequency 0.1-1Hz: not covered by ground-based GW telescopes nor LISA
  - expect high event rate:
    NS mergers ~100 yr^{-1}, BH mergers ~10^5 yr^{-1}
  - forecast mergers to other observatories (1 sec before, 0.1deg^2 resolution for an event @ z=1)
  - prepare for DECIGO

Compare B-DECIGO w LISA Japan

	B-DECIGO	LISA Japan
Taget	compact object mergers Middle mass BH	WD, NS mergers High mass BH
Frequency band	0.1 Hz	10 mHz
Host	Japan(next to KAGRA)	ESA
Financial resource, estimates	JAXA, 30 B yen (0.3B$)	JAXA, 1 B yen (1M$)
Activities in following 5 years	mission study, make a proposal, R&D TRL 4-5	component study, environmental tests, production TRL 6-9

重力波分野の見通し



2020
2025
2030
2035
ground base
(10Hz – 1 kHz)
LIGO-India
aLIGO, AdV
O3
O4
3rd-Generations (ET, CE)
Obs. Runs
A+, AdV+
Obs. Runs
KAGRA
O3
O4
KAGRA Upgrade?
B-DECIGO
(0.1-1 Hz)
概念設計・基礎開発
B-DECIGO
Working Group
Mission Proposal
Project Start
Launch
Operation
全て最速で進んだ場合
Space Demonstrations (?)
LISA
(1-100 mHz)
LISA consortium Japan
component study, environmental tests
implementation
JAXA Budget
Budge for Env. Tests (?)
Transfer
(~2.5 years)
Operation
(4 years)
LISA
MDR
Phase-A
Adoption
(<=2024)
Implementation (Phase B2/C/D)
(8.5 years)
Launch

Space GW telescopes

B-DECIGO

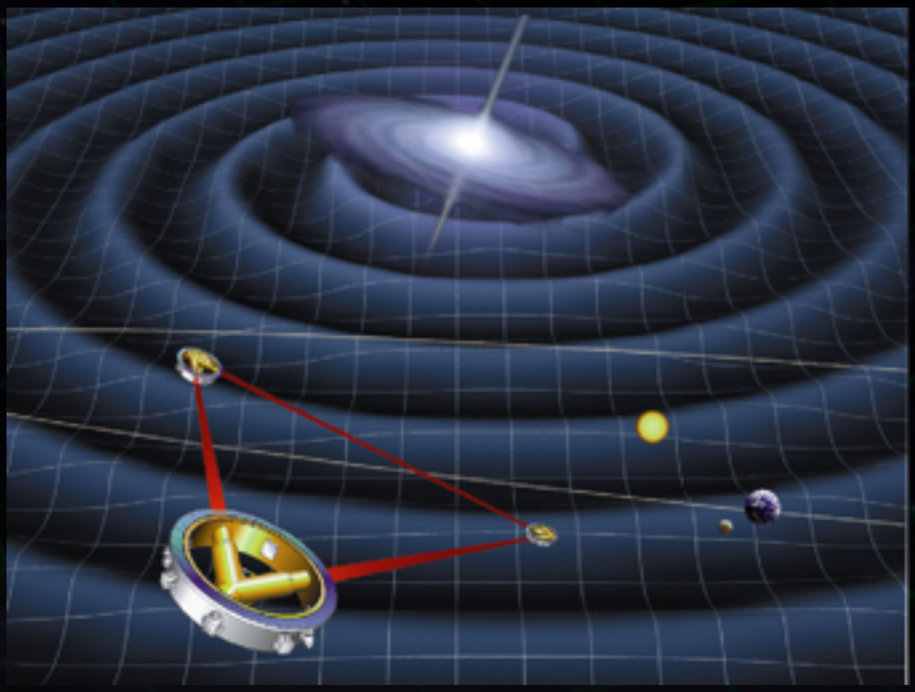
(Deci-hertz Interferometer
Gravitational Wave Observatory)

- Early universe, cosmological study @ 0.1Hz
- geocentric orbit, baseline=100km, 3 S/C, formation flight
- FP interferometer

LISA

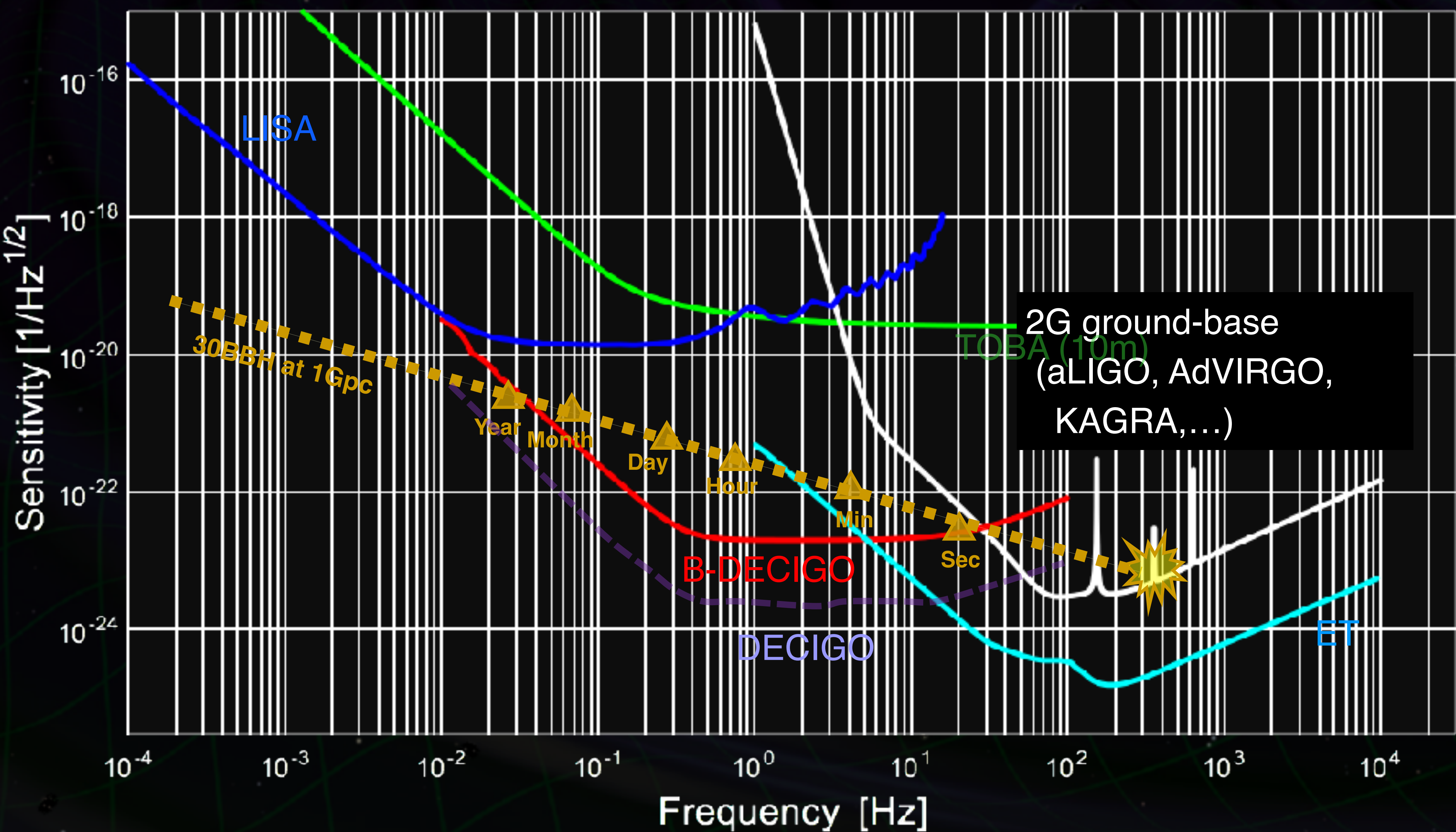
(Laser Interferometer Space Antenna)

- HM BH, binaries @ 1mHz
- heliocentric orbit, baseline= 2,500,000km, 3 S/C
- optical transponder technique



Sensitivity

T. Nakamura et al., Prog. Theor. Exp. Phys. 093E01 (2016)



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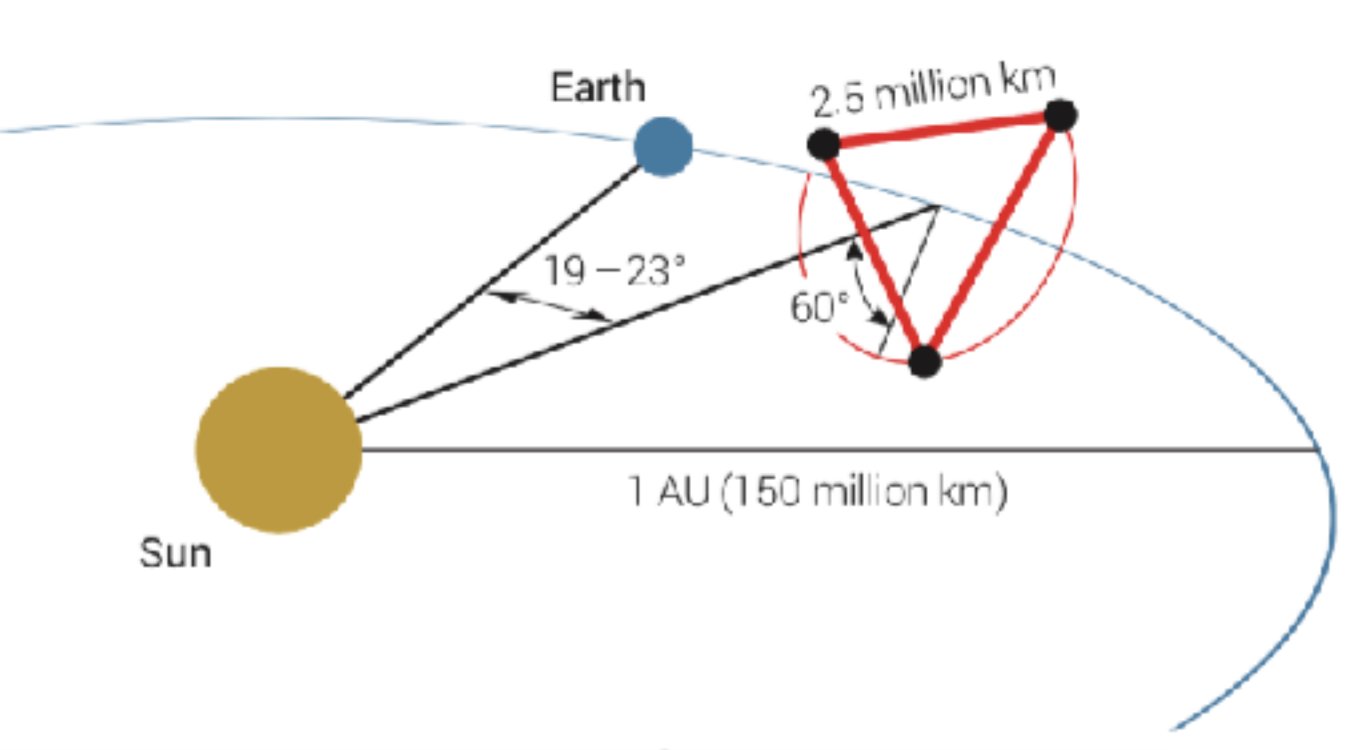
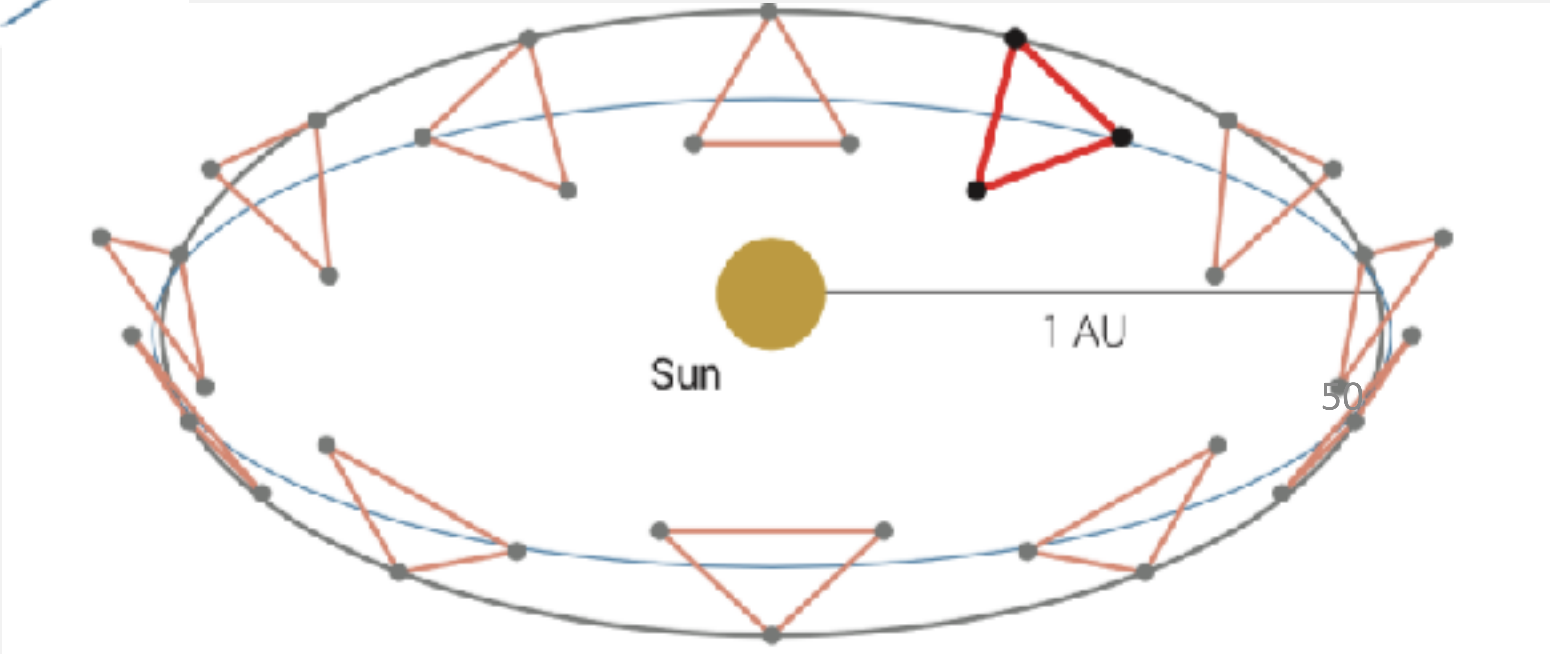
What is LISA?

- LISA: **L**aser **I**nterferometer **S**pace **A**ntenna
- A gravitational wave observatory in space
- An ESA-led ongoing project
  - Selected as L3 mission in the ESA cosmic vision program (2017).
- Targeting low-freq. gravitational waves in 1mHz -100mHz
- To be launched in 2034
- Three spacecrafts form an almost equilateral triangle
  - A laser interferometer with six laser inks, 2.5×10^6 km each
  - Drag-free control for achieving extremely low acceleration noise
  - Every laser link phase-locked to another by the optical transponder technique
- Demonstration of low acceleration noise and other key technologies done by LISA path finder (launched in 2015)

Constellation orbit



- Heliocentric orbit
- Retarded by 20 deg from the Earth
- 10 years max. due to the propellant
- Minimizing the thermal variation from the solar radiation



Schedule

Event	From	To	Status
Phase 0 instrument contributions	2017-JUL	2017-NOV	Done
Mission Definition Review (MDR)	2017-NOV-27		Done
Phase A (mission & instruments)	2018-APR	2019-DEC	
Mission Consolidation Review (MCR)	2019-FEB	2019-MAR	
Mission Formulation Review (MFR)	2019-OCT	2019-DEC	
Adoption	<=2024		
Implementation (Phase B2/C/D)	8.5 years		
Launch	2034		
Transfer & Commissioning	2.5 years		
Operations	4 years		
Extension (TBD)	6 years		10 years of total science

Envisaged budget

* Total cost ~ 1200 M€
* NASA's contribution to it ~200 M € (guessed)
  to cover the telescopes, thrusters, lasers and others.
* Previous Japan's envisaged contribution ~ 2 M€ (~ 2 Oku-JPY)
* Currently attempting to improve the accuracy of the cost estimation
  =>A high chance that the necessary amount increases (~ 10 Oku-JPY)
* Planning to use small budget from the Science advisory committee of ISAS for
  hardware studies covering the first three years.

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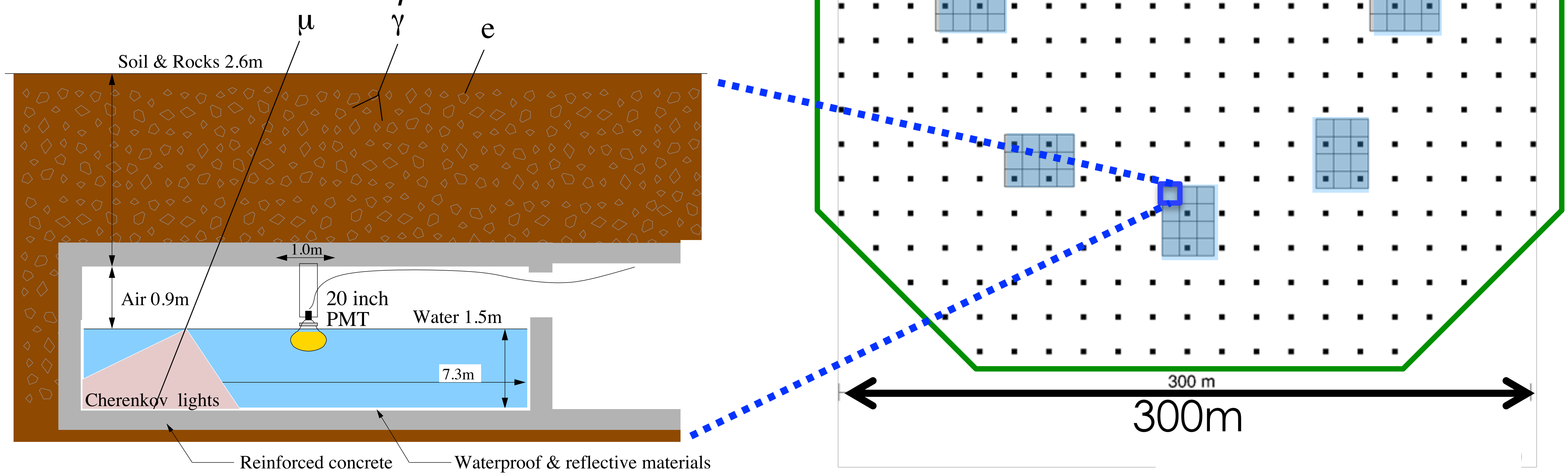
ALPACA Project

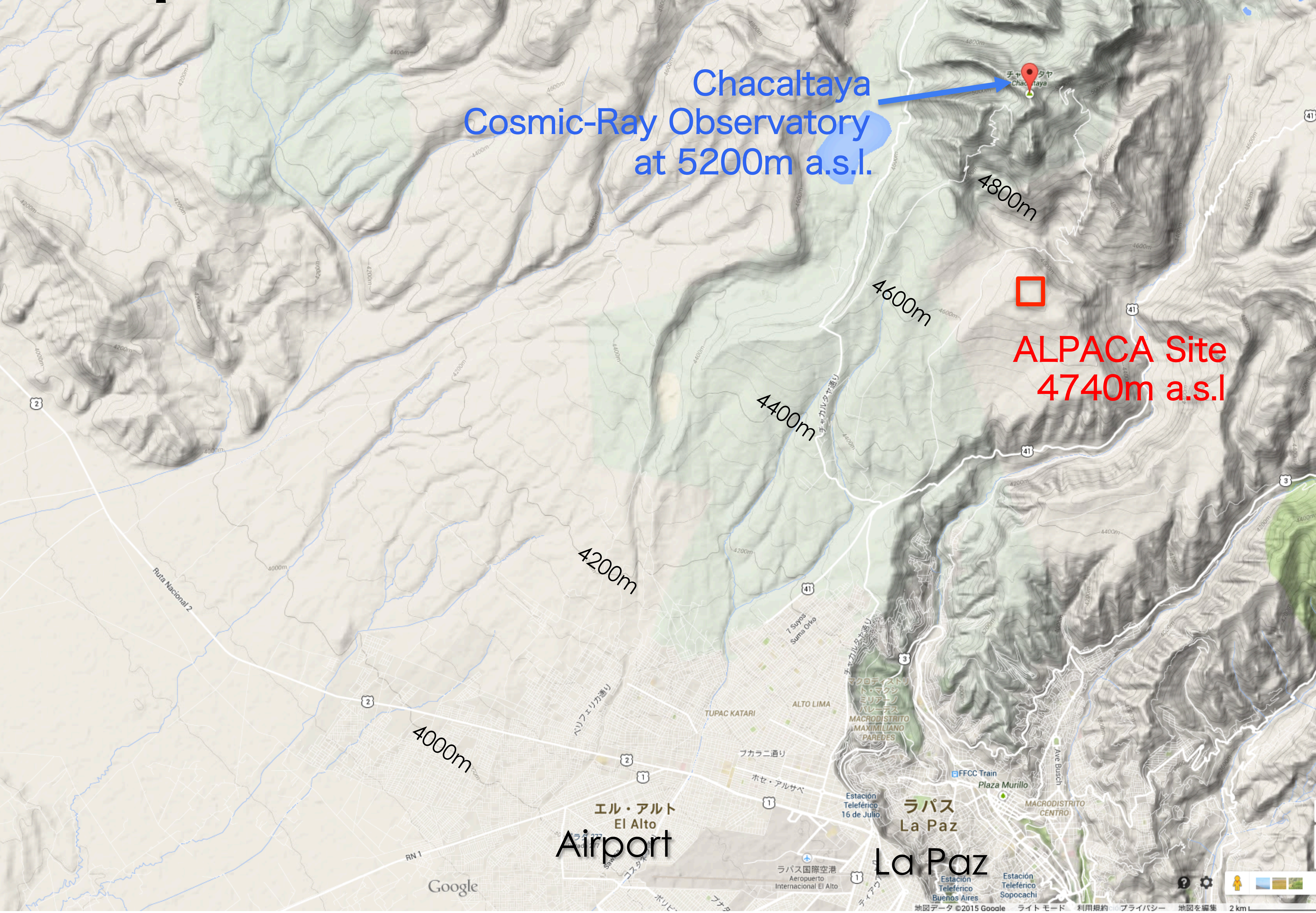
1. **Air shower array ~83,000m²**
   = 401 x 1m² scintillation detectors

2. **Underground Water-Cherenkov-type muon detectors ~5400m²**
   Underground 2.5m (~19X_0)
   = 56m² with 20”ϕ PMT x 96 cells

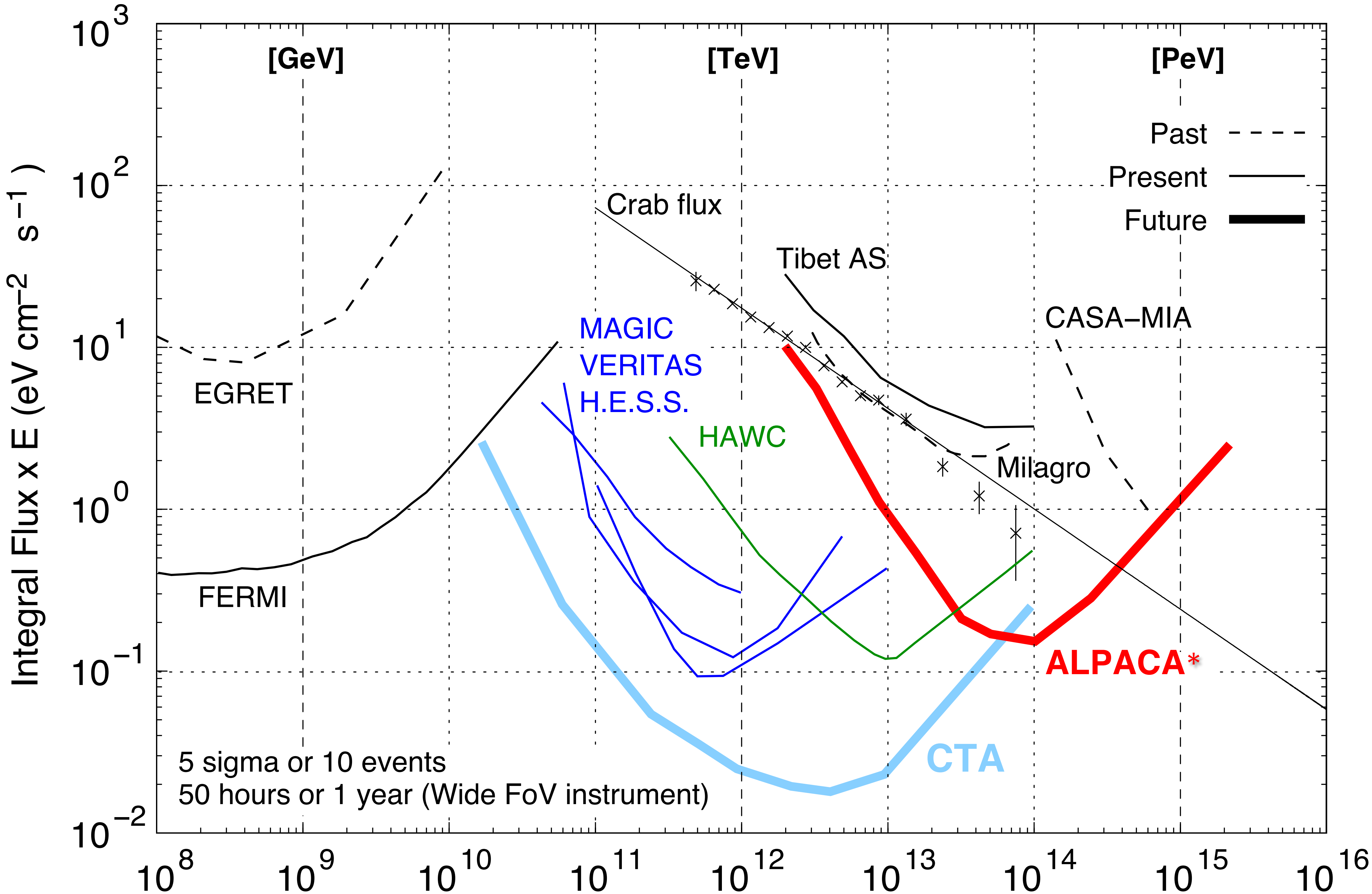


- ✓ Gamma-ray induced air shower has much less muons.
  Cosmic-ray background rejection >99.9% @100TeV.
- ✓ Observation with wide FoV(~2sr) & regardless day/night & weather
  Angular resolution ~0.2° @100TeV Energy resolution ~20%@100TeV

Experimental Site



Sensitivity for Gamma-Ray Point Source



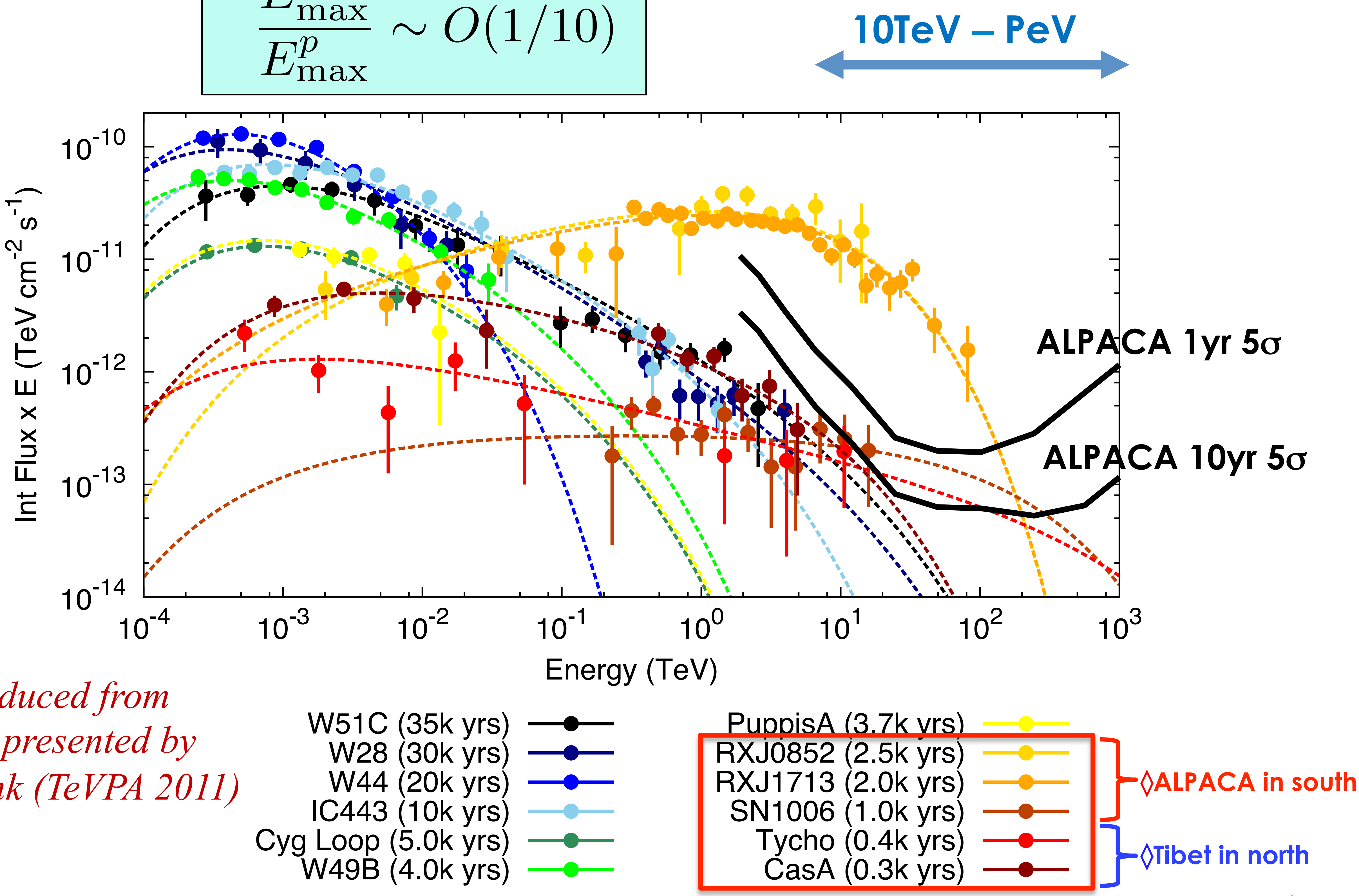
AS arrays → Wide FoV & continuous observation

*Based on MC Simulation For the Tibet AS+MD

Gamma-Ray Observation : SNRs

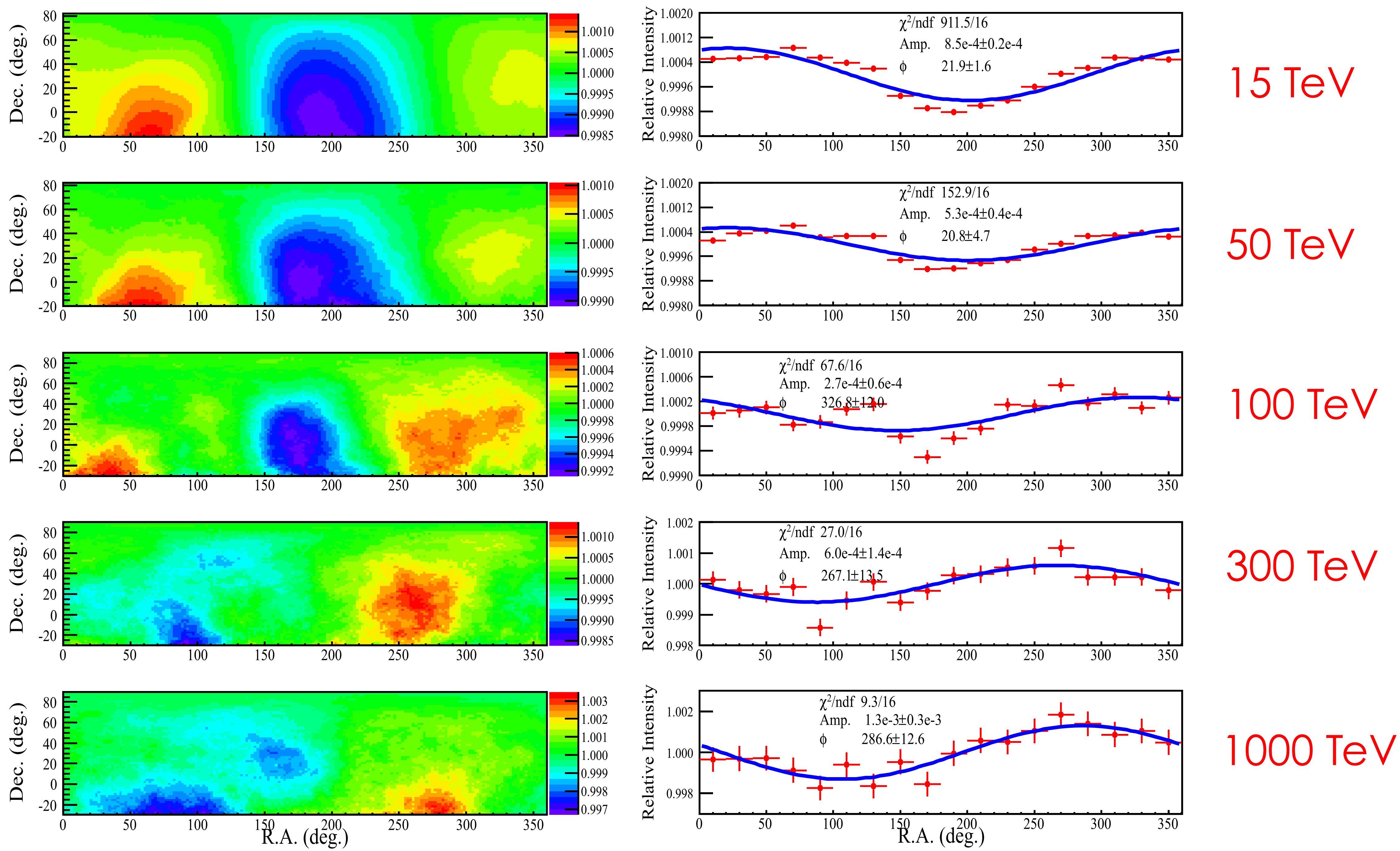
$$\frac{E^{\gamma}_{\max}}{E^{p}_{\max}} \sim O(1/10)$$

Probe of PeVatrons



Reproduced from slides presented by S. Funk (TeVPA 2011)

Cosmic Ray Anisotropy (Tibet AS)



Amenomori+, ApJ, 836, 153 (2017)

What is the origin of ~0.1% anisotropy?
→ Wide energy range observations in both hemispheres are important.

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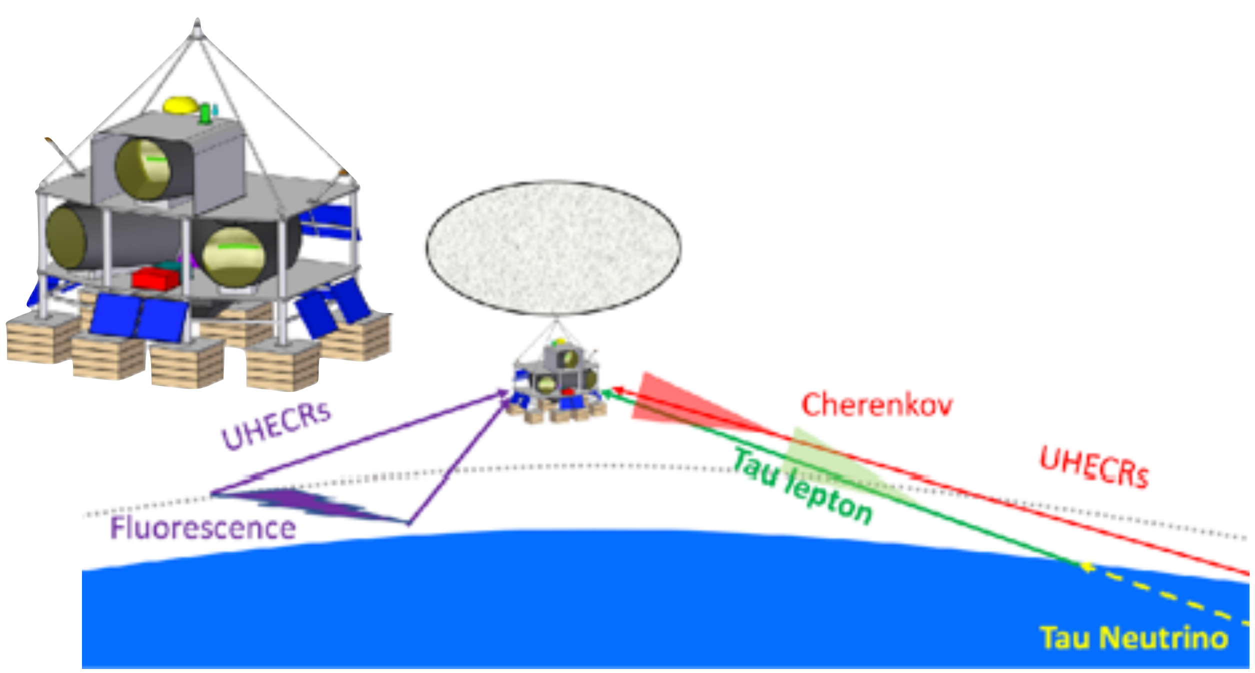
POEMMA and EUSO-SPB2 mission

POEMMA mission is designed to observe UHECRs and neutrinos from space by using stereo observation technique. POEMMA is comprised of two identical satellites flying in formation. POEMMA uses Schmidt type optics, which will be tested by EUSO-SPB2.

EUSO-SPB2 (EUSO-Super Pressure Balloon 2)

PI: prof. Angela V. Olinto (Chicago univ.)

Over-all budget: 5 Billion yen
2021 April: Flight (max 3 months)



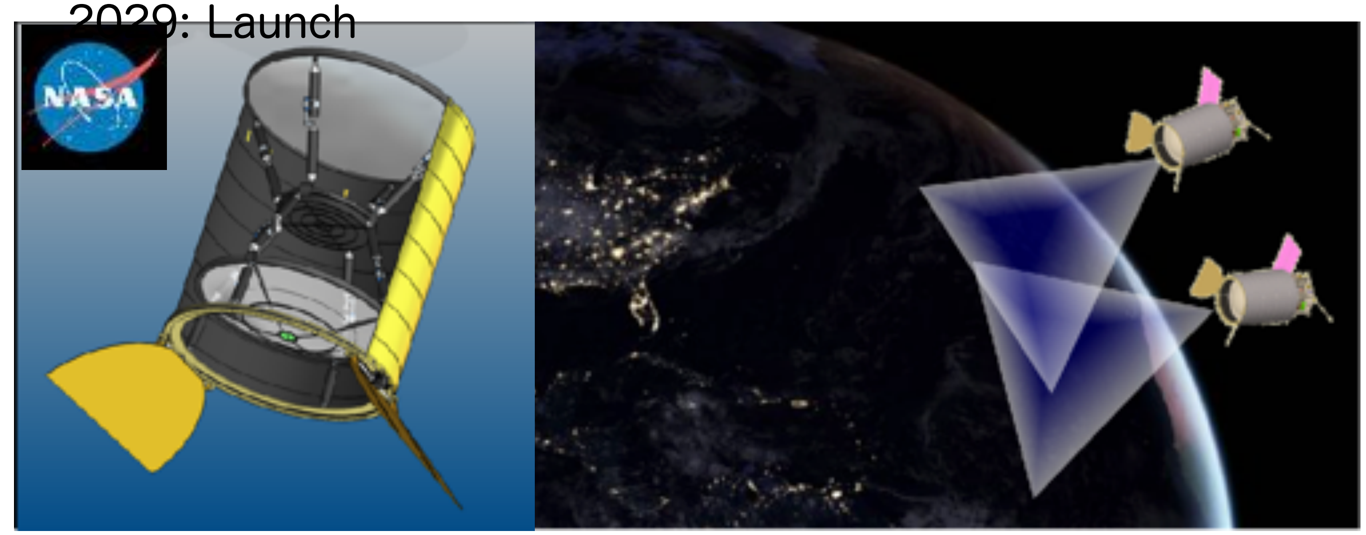
POEMMA (Probe Of Extreme Multi-Messenger Astrophysics)

PI: prof. Angela V. Olinto (Chicago univ.)

2017: POEMMA is selected “NASA probe studies for 2020 decadal survey (1B$ class)“

2019 March: Conceptual study has been reported to NASA.

2024: System Requirement Review
2025: Preliminary Design Review
2026: Critical Design Review
2029: Launch

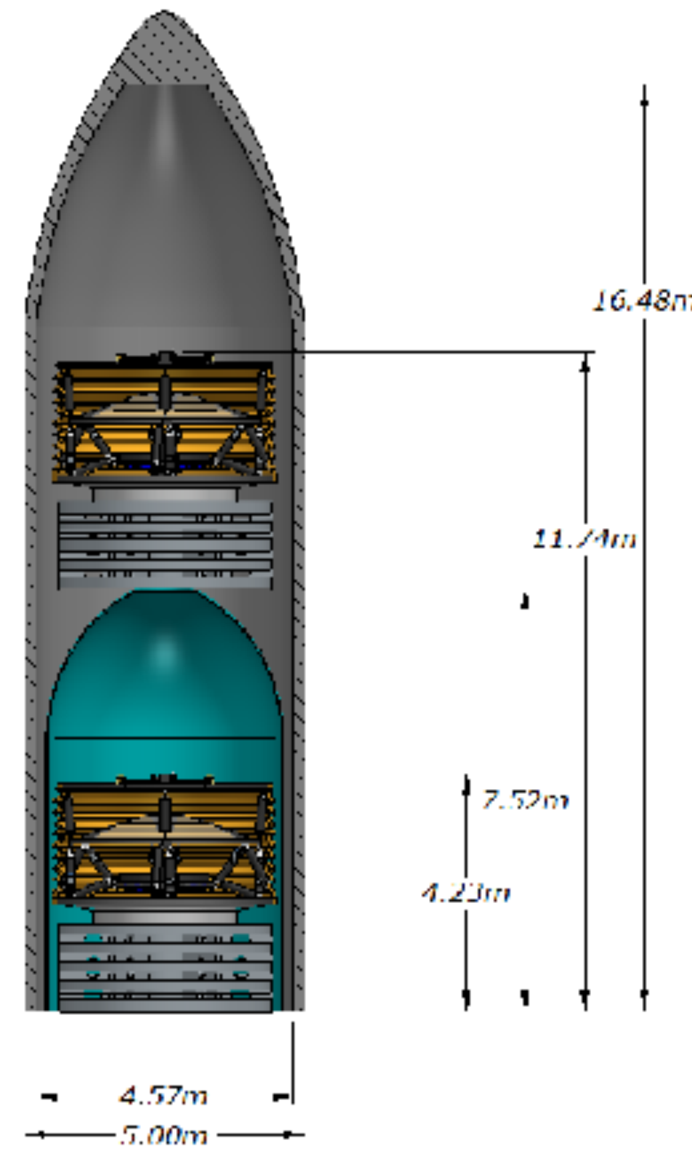


POEMMA mission

Mission Lifetime: 3 years (5 year goal)
Orbits: 525 km, 28.5° Inc
Orbit Period: 95 min
Satellite Separation: ~25 km – 1000+ km
Satellite Position: 1 m (knowledge)
Pointing Resolution: 0.1°
Pointing Knowledge: 0.01°
Slew Rate: 8 min for 90°
Satellite Wet Mass: 3860 kg
Power: 2030 W
Data: 1 GB/day
Data Storage: 7 days
Communication: S-band (X-band if needed)
Clock synch (timing): 10 nsec

Operations:

- Each satellite collects data autonomously
- Coincidences analyzed on the ground
- View the Earth at near-moonless nights, charge in day and telemeter data to ground

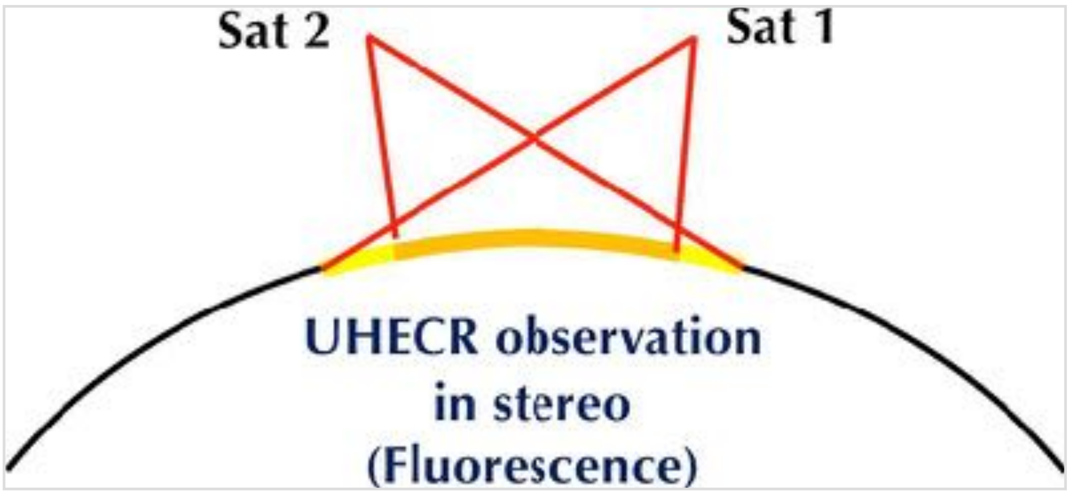


Dual Manifest Atlas V

John Krizmanic, UHECR2018

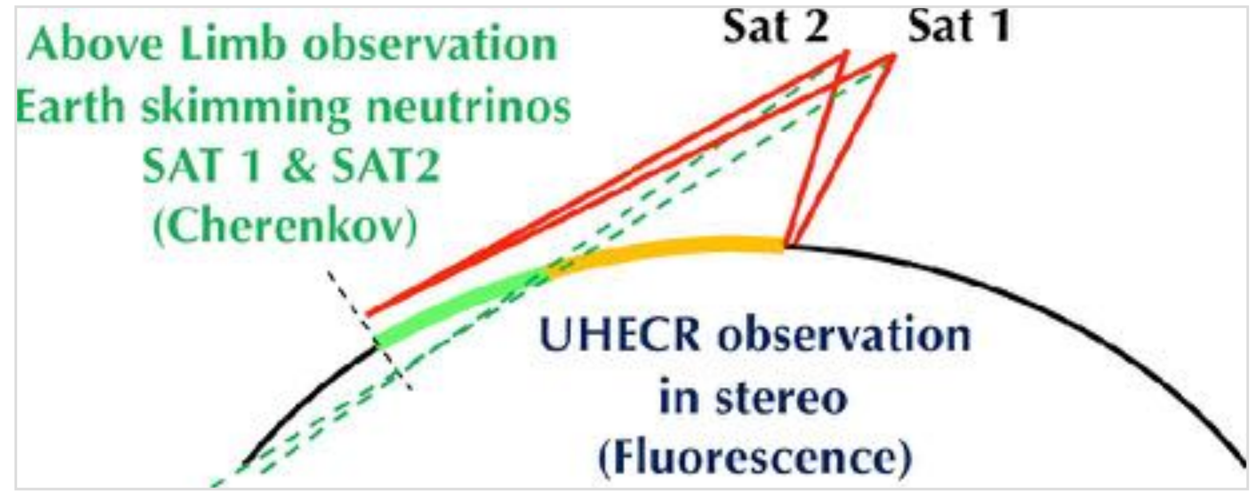
POEMMA observation modes

Stereo mode (UHECR)

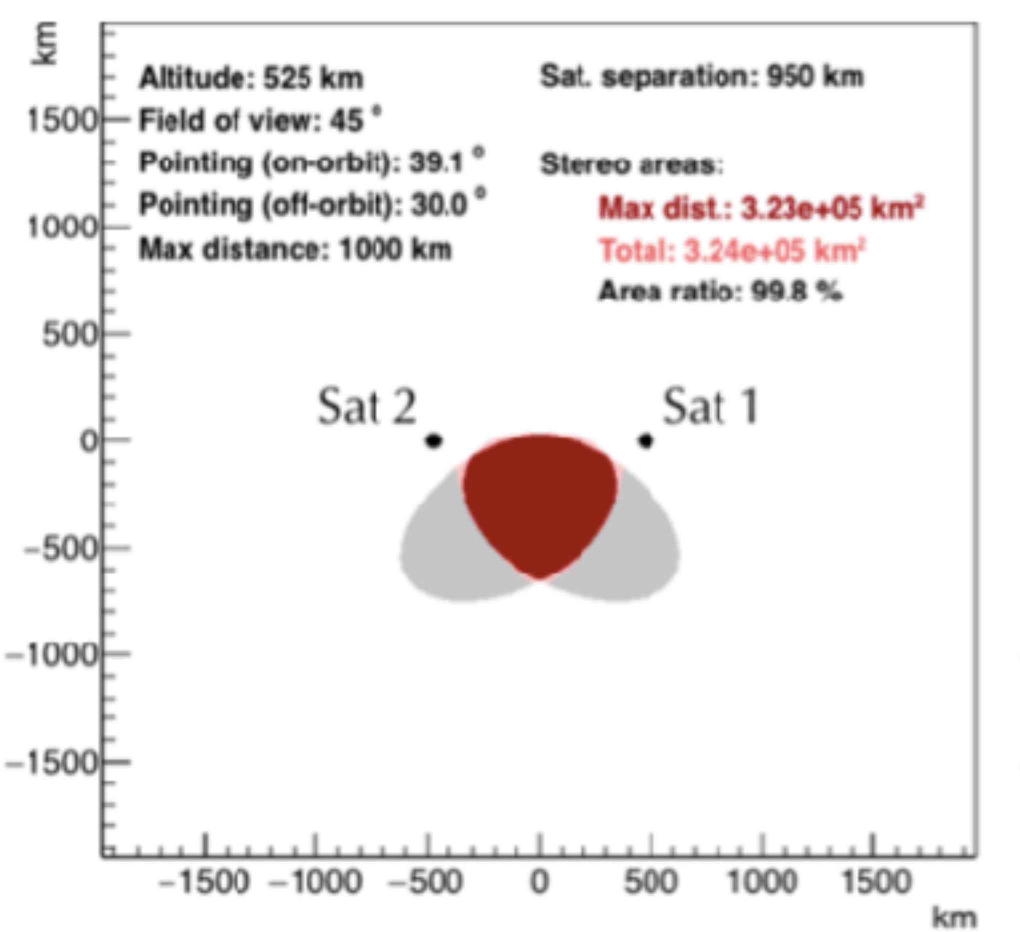


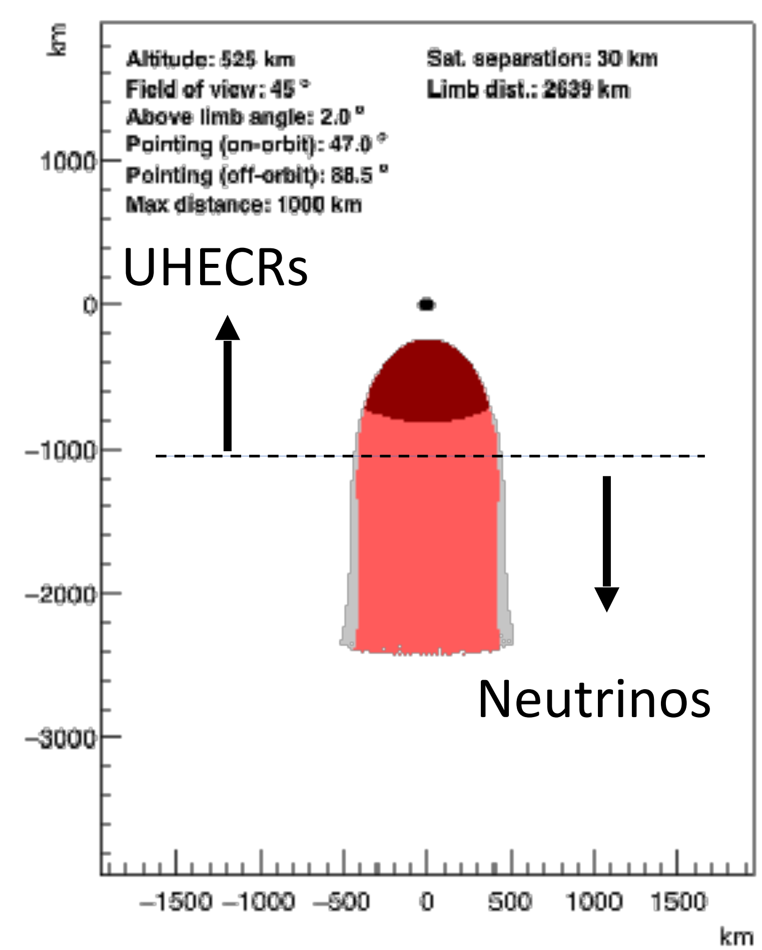
Satellite Separation ~300 km

Limb-viewing mode (UHECR + neutrino)

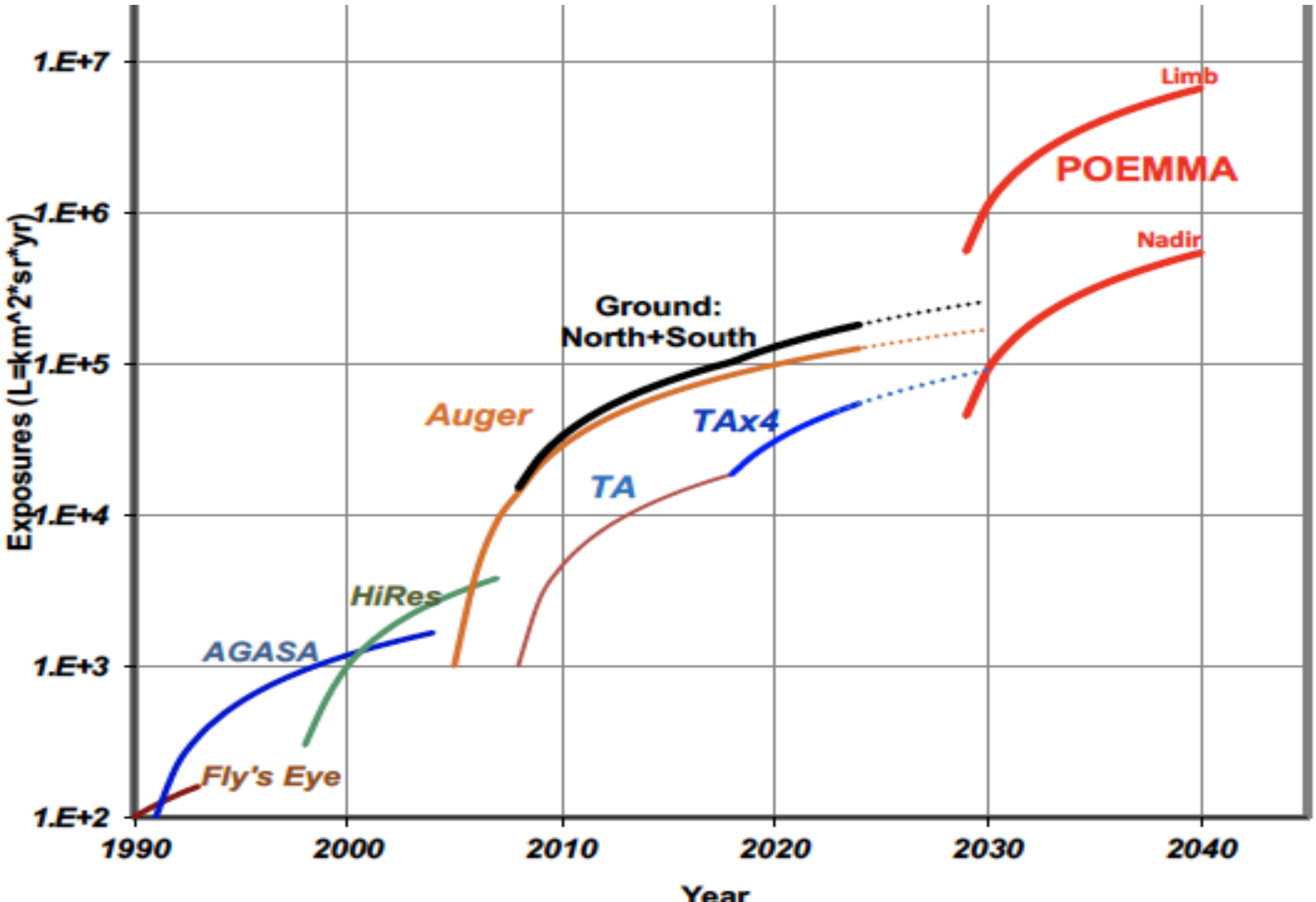


Satellite Separation ~30 km



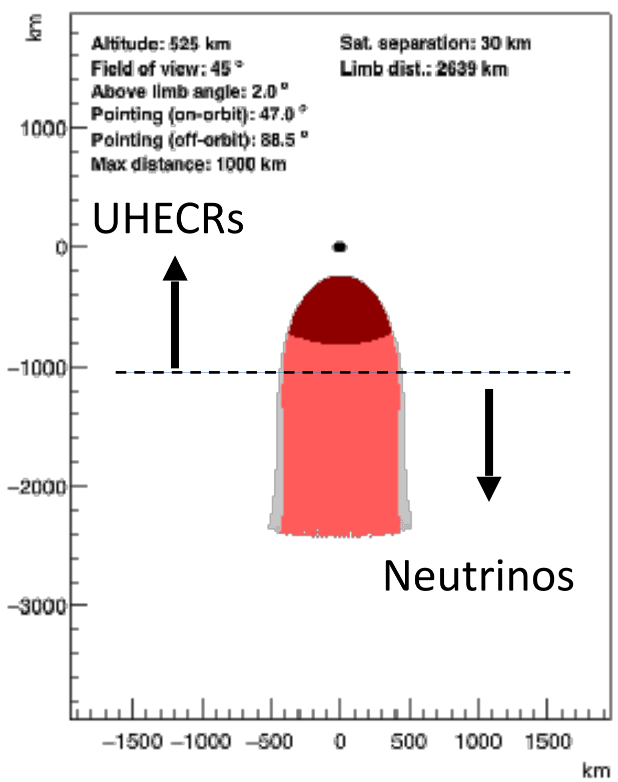


Integrated exposures comparison

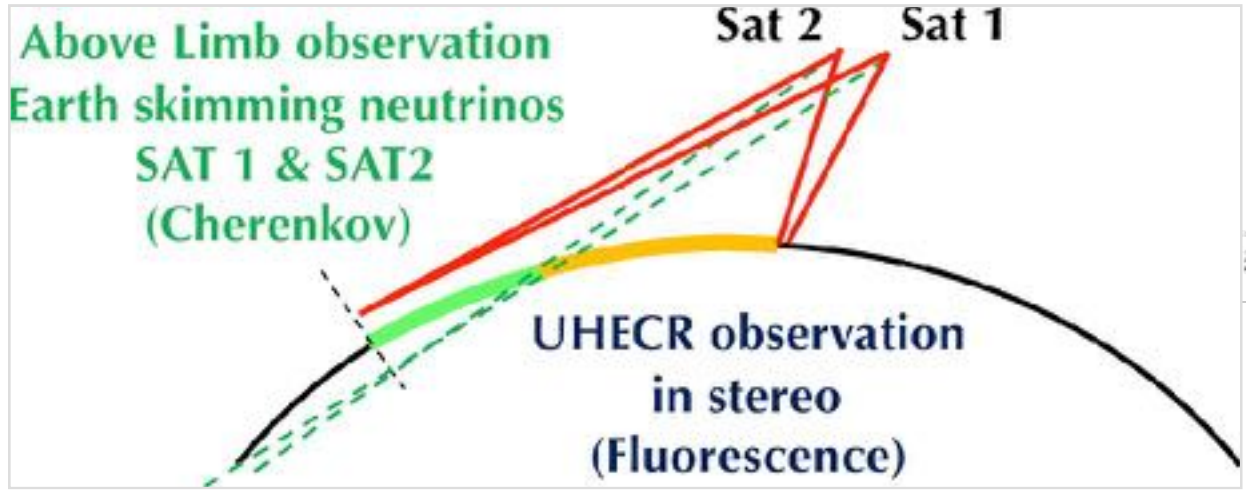


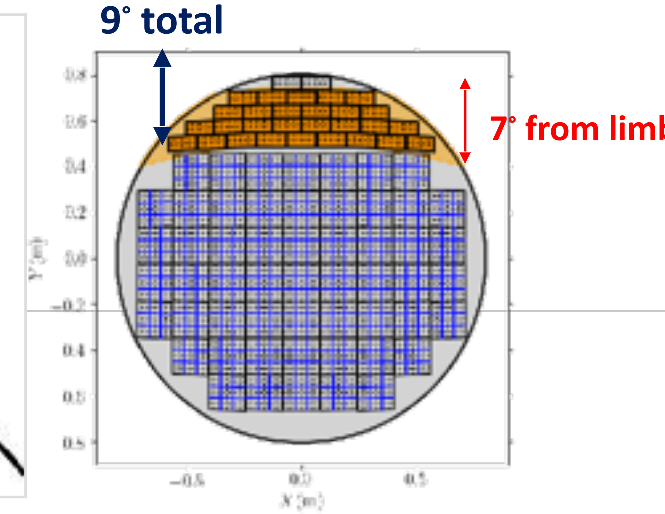
John Krizmanic, UHECR2018

POEMMA neutrino observation



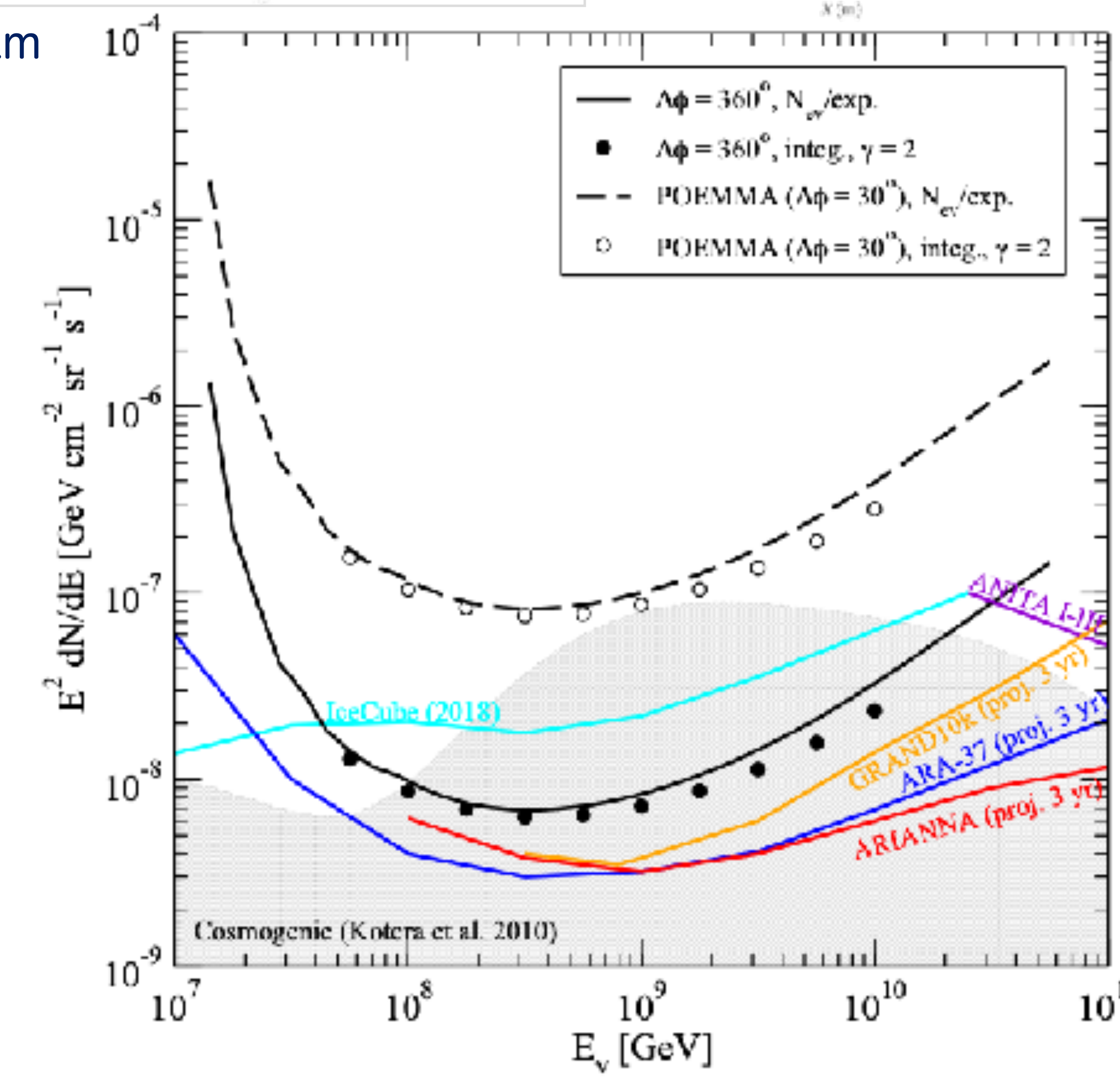
Limb-viewing mode (UHECR + neutrino)





Satellite Separation ~30 km

- 5 year
- 20% duty cycle
- 10 PE threshold with time coincidence to reduce air glow background 'false positives'
- Viewing to 7° away from Limb



John Krizmanic, UHECR2018

Japanese contribution

- EUSO-SPB2
  - Corrector lens (1.0m diameter) development
    - Two flight lenses
- POEMMA
  - Corrector lens (3.3m diameter) development
    - Two flight lenses, two backup lenses
    - Lens frame
  - Multi-anode photomultiplier tubes

EUSO-SPB1

Extreme Universe Space Observatory on a Super Pressure Balloon

- SPB1 system worked normally.
- We are analyzing observation data.
    - We do not confirm a signal of UHECR shower event.
        - Expected event number of 12 days observation is 1.6. No signal is statistically consistent.

<u>Regarding the EUSO SPB balloon short flight,</u>
because some debris from the pyrotechnic cutters on the reefing collar had been found to penetrate the 3 mill thick reefing sleeve, it has been assumed by NASA that the balloon (which is thinner) was also penetrated and this started the tear that became a big hole by day 3 of the flight.