June 8, 2019 @ WIN2019 in Bari, Italy

What's next: Asia

T. Nakaya (Kyoto)

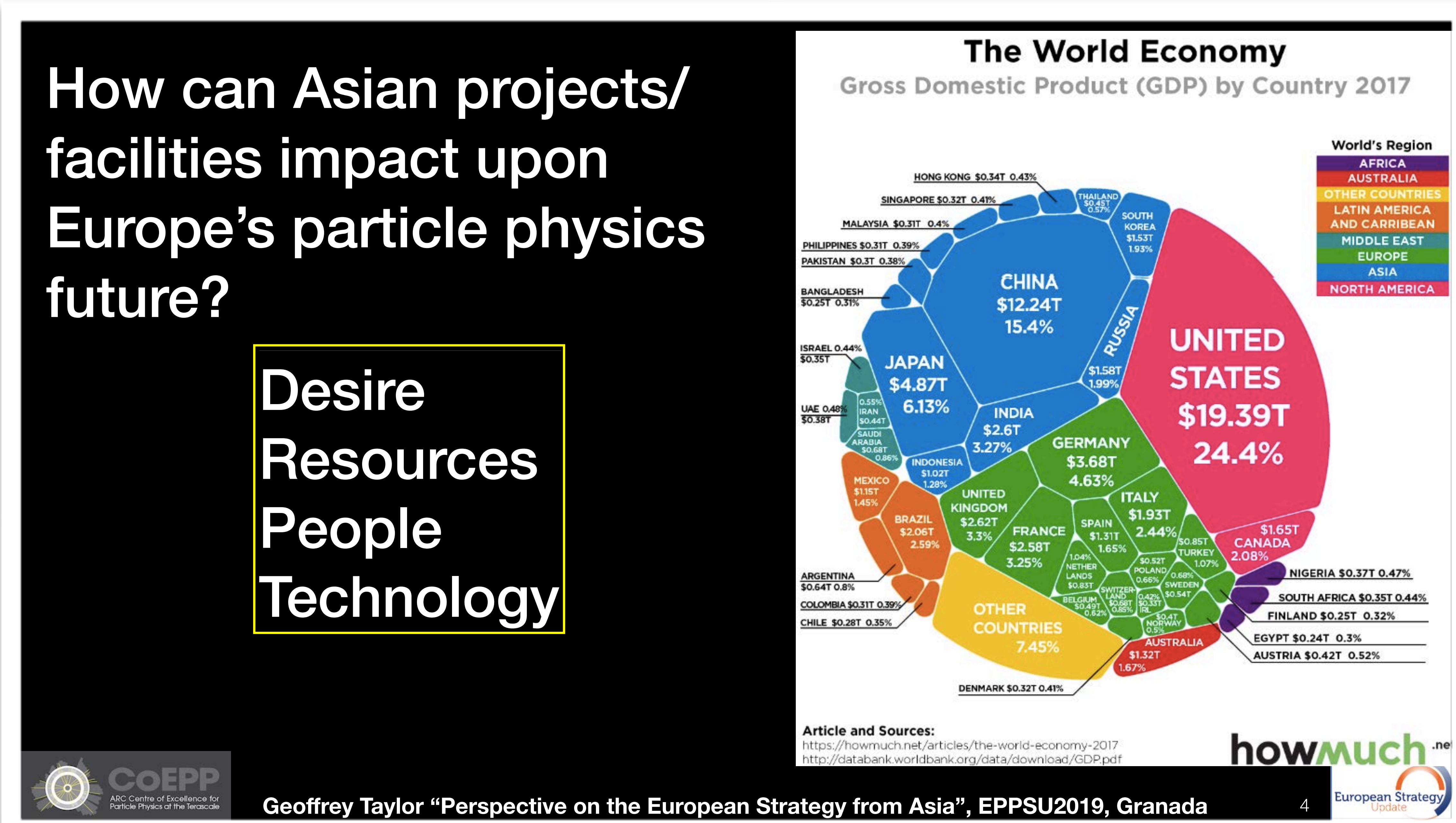
Physics (in WIN conferences)

- Higgs
- Neutrinos
- Flavor Physics
- Astroparticle Physics (w/ Dark Matters)
    - (Gravitational Wave and Cosmology)

<<What are the main contributions (concerning the physics of interest for WIN) we can expect from your region in the coming years? >>

This talk is based on my biased view to particle physics projects in Asia with my limited knowledge. It is NOT a fair review talk.

I listened to Geoff's talk in EPPSU2019.



- Characters of the Asian region in my view
  - Growth, Passion, Diversity and Curiosity!

Physics with projects in Asia (presented in WIN2019)

- Higgs
  - Many Asian scientists are working for ATLAS/CMS.
  - Higgs Factory [CepC, ILC]
- Neutrinos
  - Super-Kamiokande -> Hyper-Kamiokande
  - KamLAND -> KamLAND 2
  - Daya Bay -> JUNO
  - T2K w/ J-PARC and ND280 upgrade
  - INO
  - AMoRE
  - NEOS
  - JSNS^2
- Flavor Physics
  - BES III
  - Belle II/SuperKEKB
  - J-PARC: K0TO, COMET and μ g-2
- Astroparticle Physics (w/ Dark Matters)
  - CALET
  - DAMPE
  - HERD on CSS
  - GAPS
  - PANDA-X
  - COSINE
  - SABRE on SUPL (Australia)
  - CDEX
  - NEWAGE
- (Gravitational Wave & Cosmology)
  - KAGRA (Japan)
  - Ngari Observatory (China)
  - GroundBIRD, LightBIRD

Existing Facilities

- *Japan:*
  - *SuperKEKB/Belle II - high intensity B-factory*
  - *SuperKamiokande (T2K) (—> HyperK and Upgraded J-parc)*
  - *J-parc high intensity, low energy physics - COMET*
  - *Kamioka U/G Observatory - XMASS-I Direct Dark Matter Search*
  - *…*
- *China:*
  - *Daya Bay (—> JUNO) - Reactor Neutrino Physics*
  - *BEPC (Proposal: tau/charm factory)*
  - *LHAASO - Very high energy cosmic ray observatory*
  - *Jinpin - U/G laboratory - PANDA-X and CDEX Direct Dark Matter Searches*
  - *…*
- *Korea:*
  - *RENO - Reactor neutrino physics*
  - *…*

CoEPP ARC Centre of Excellence for Particle Physics at the Terascale

Geoffrey Taylor "Perspective on the European Strategy from Asia", EPPSU2019, Granada 7

European Strategy Update

from Geoff's talk in EPPSU2019

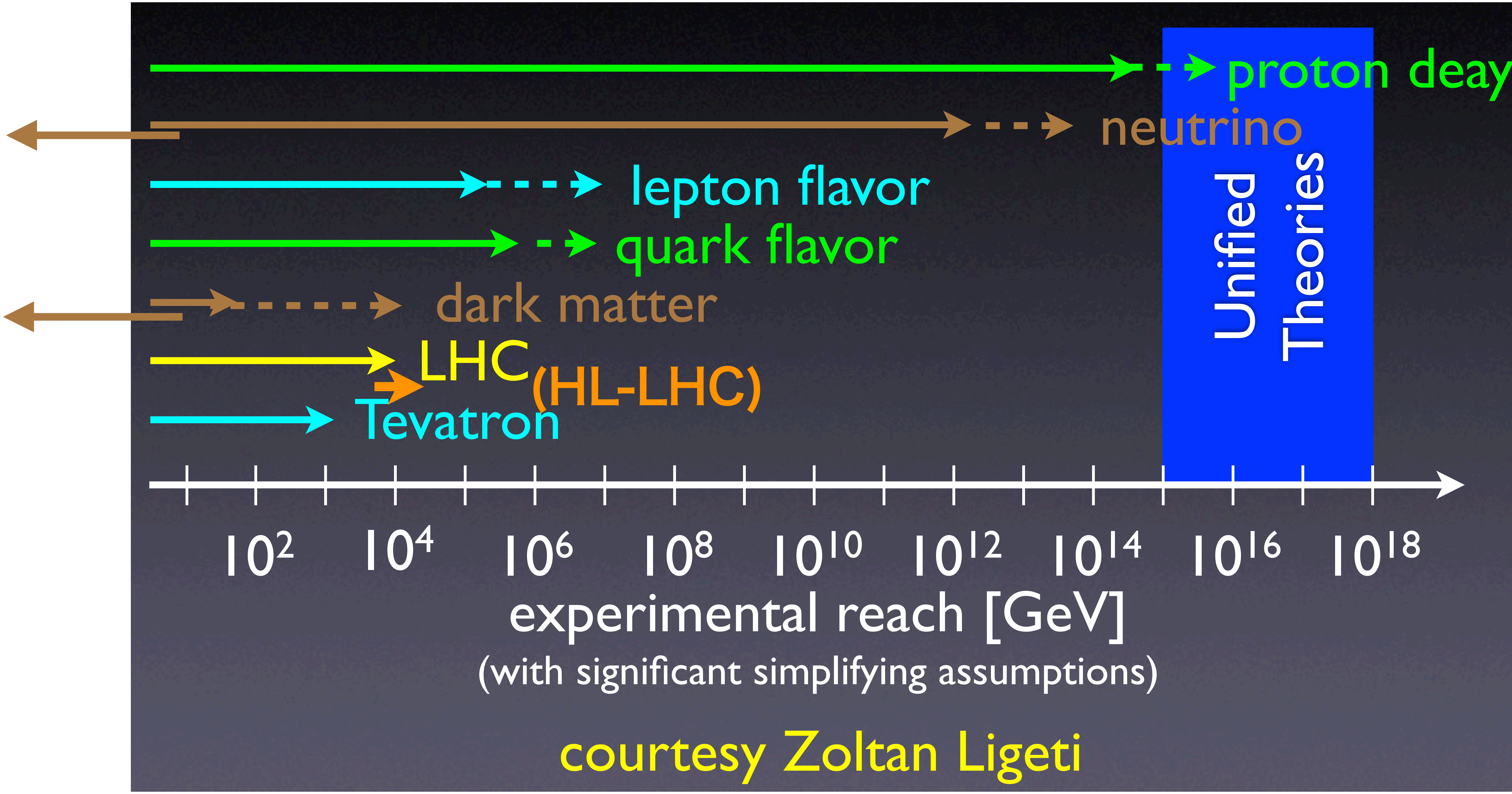
Fundamental Questions

Questions

- GUT: Unification of forces [and leptons and quarks]
- Origin of generations (family structure)
- Origin of neutrino mass
- Strong CP
- Baryon and anti-baryon asymmetry of our universe
- Dark Matter
- Accelerating universe
- Inflation

➡ We do not know the energy scale of New Physics

Should look for wider energy regions



Three arrows are added by TN (neutrino, dark matter and HL-LHC)

Questions

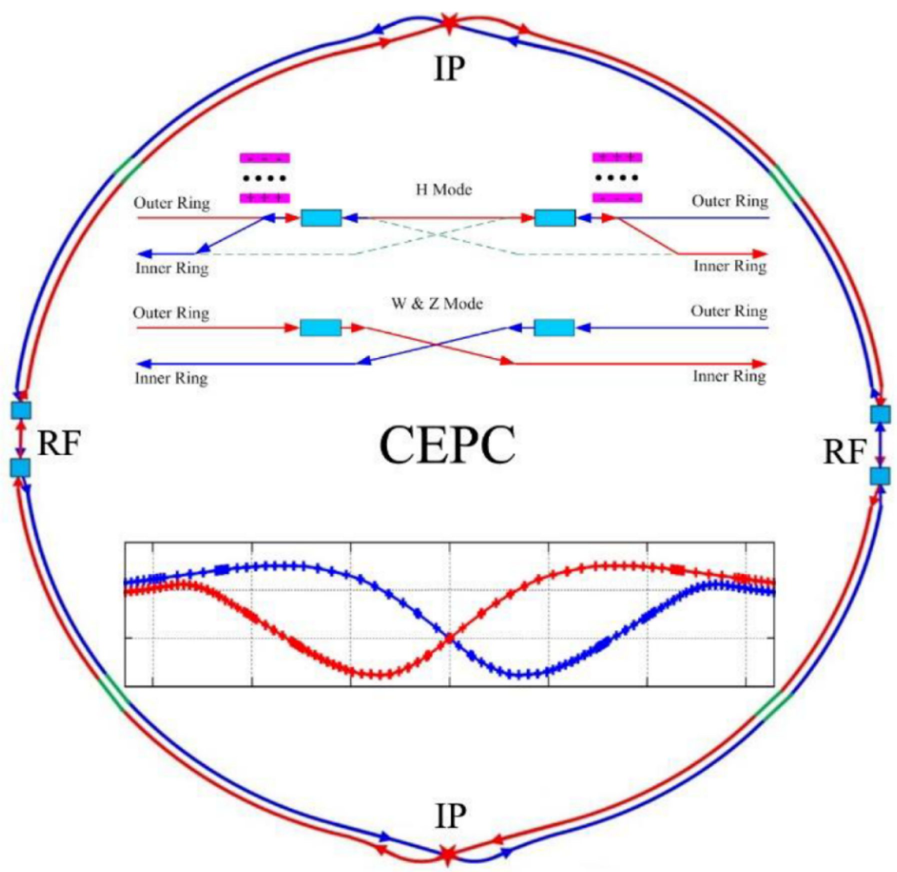
- GUT: Unification of forces [and leptons and quarks]
- Origin of generations (family structure)
- Origin of neutrino mass
- Strong CP
- Baryon and anti-baryon asymmetry of our universe
- Dark Matter
- Accelerating universe
- Inflation

➡ It is a good time to look over new physics with various ways in many aspects [as a purpose of WIN]

Higgs

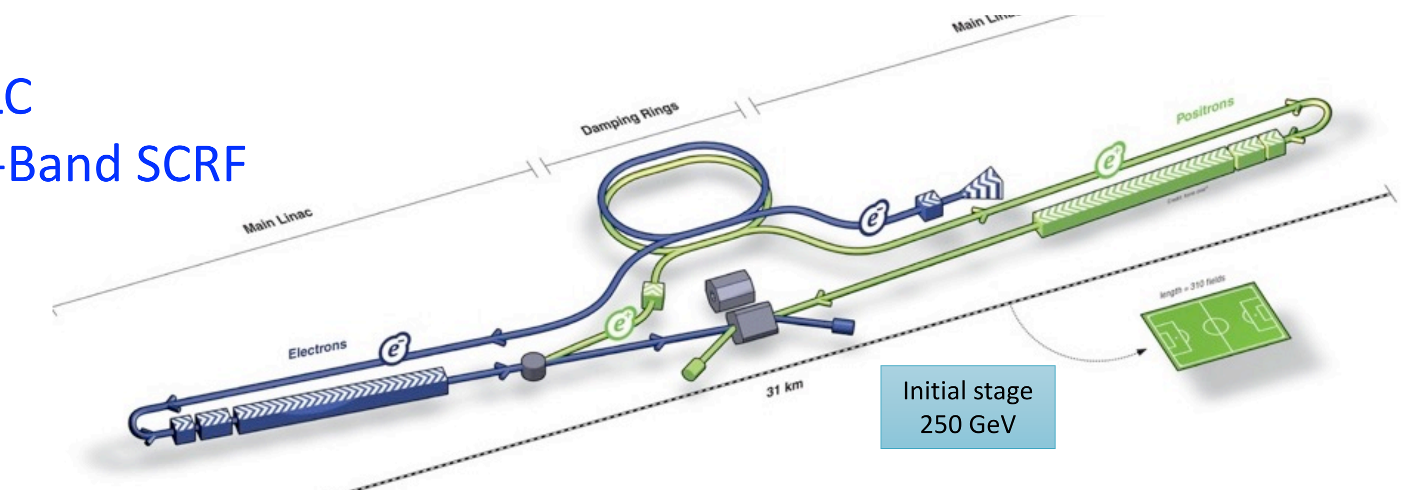
Higgs Factory

China and Japan propose a Higgs Factory as the future facility in Asia.



CEPC CDR https://arxiv.org/abs/1809.00285

ILC
L-Band SCRF



ILC TDR 2013 http://www.linearcollider.org/ILC/Publications/Technical-Design-Report

Strategy Documents:
https://ilchome.web.cern.ch/content/ilc-european-strategy-document
ILC Staging Report 2017
https://arxiv.org/abs/1711.00568

Prospect in Accelerators by S. Guiducci @ WIN2019

What else do we learn from Higgs?

Question	κ_V	κ_3	κ_g	κ_γ	λ_{hhh}	σ_{hZ}	$\mathrm{BR}_{\mathrm{inv}}$	$\mathrm{BR}_{\mathrm{und}}$	κ_ℓ	μ_{4f}	$\mathrm{BR}_{\tau\mu}$	Γ_h
Is h Alone?	+	+			+	+				+		+
Is h elementary?	+	+	+	+		+						
Why $m_h^2 \ll m_{\mathrm{Pl}}^2$?	+	+					+	+		+		+
1st order EWPT?			+	+	+	+				+		
CPV?		+(CP)										
Light singlets?							+	+	+	+		+
Flavor puzzles?		+							+		+	

BH, Y. Nir, arXiv:1905.00382

Many problems of particle physics today relate to Higgs observables

6

from “Summary: Electroweak Session” in EPPSU2019

- We all understand the importance of a Higgs factory in the world.
  - In addition, we also know it is an expensive (and very long-term) facility.
- I think that the support of the international community is essential to realize the Higgs factory.
  - It will be the international facility (not only Asia).

Neutrinos

Successful History (in Asia)

- Kamiokande, Super-Kamiokande, K2K/T2K, KamLAND, OPERA
- Daya Bay
- RENO

FUNDAMENTAL PHYSICS BREAKTHROUGH PRIZE

BOARD TROPHY EVENTS NOMINATIONS NEWS CONTACTS Search
COMMITTEE PRIZES LAUREATES RULES

For the fundamental discovery and exploration of neutrino oscillations, revealing a new frontier beyond, and possibly far beyond, the Standard Model of particle physics.

LAUREATES

Breakthrough Prize Special Breakthrough Prize New Horizons Prize Physics Frontiers Prize

2016 2015 2014 2013 2012


Kam-Biu Luk and the Daya Bay Collaboration


Yifang Wang and the Daya Bay Collaboration

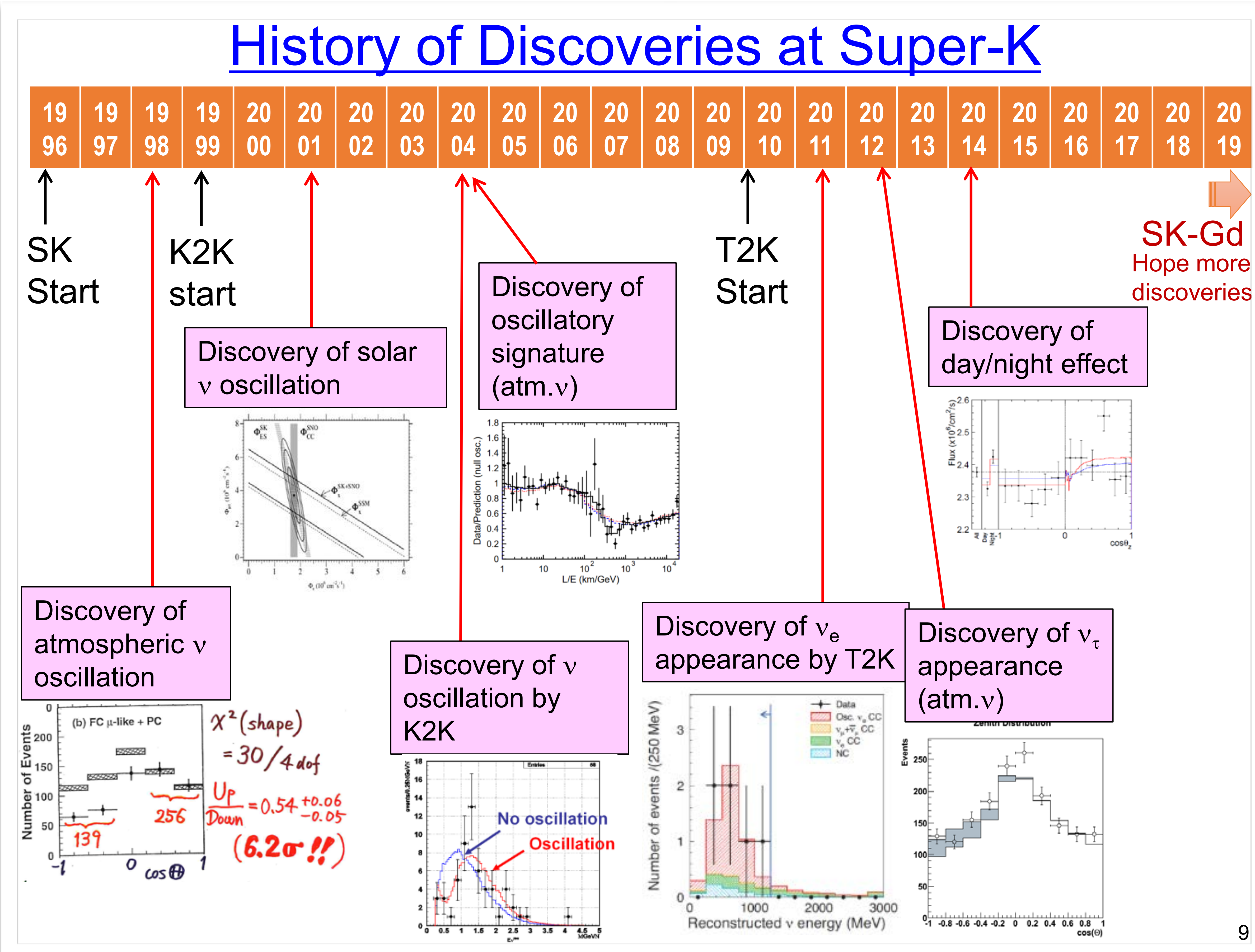

Koichiro Nishikawa and the K2K and T2K Collaboration


Atsuto Suzuki and the KamLAND Collaboration


Arthur B. McDonald and the SNO Collaboration


Takaaki Kajita and the Super K Collaboration

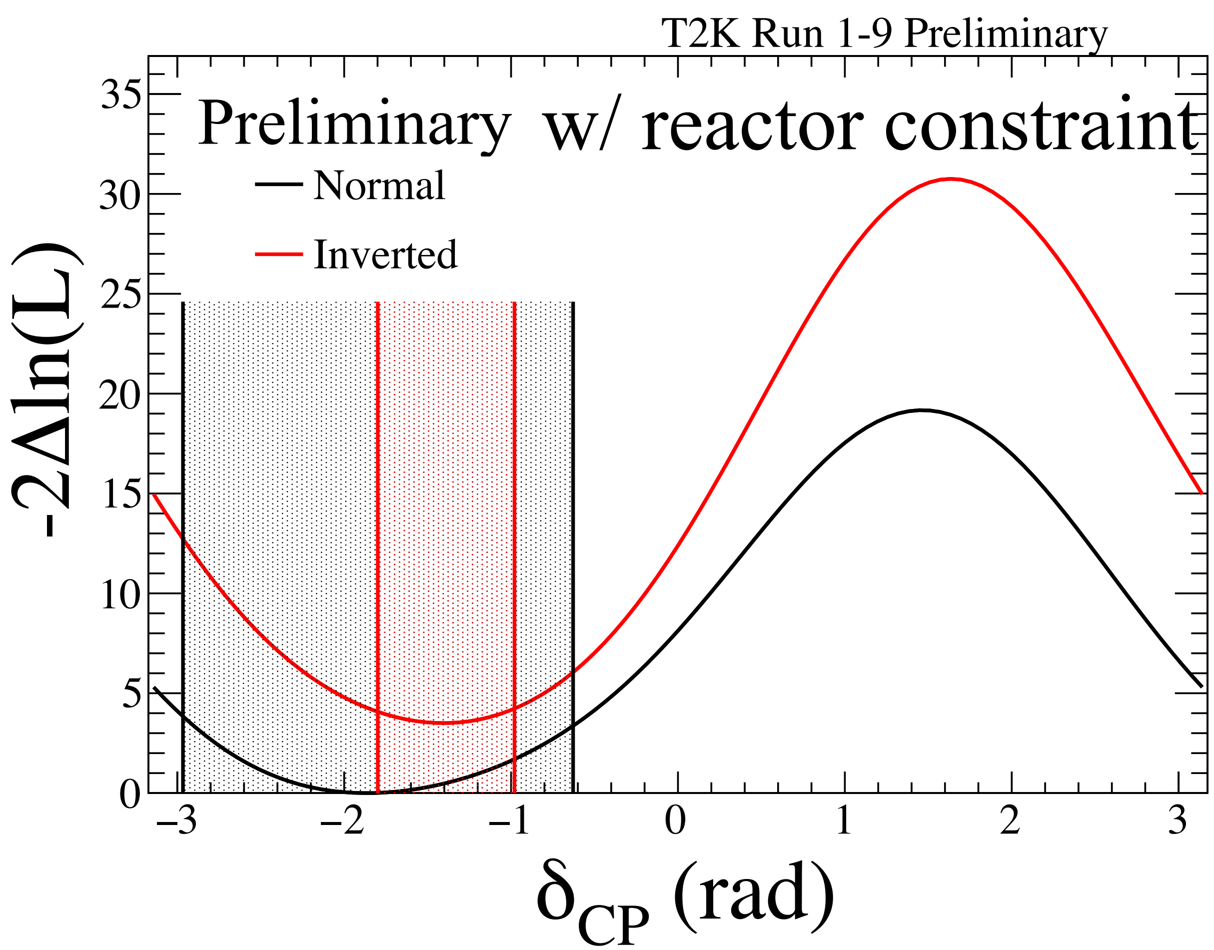

Yoichiro Suzuki and the Super K Collaboration



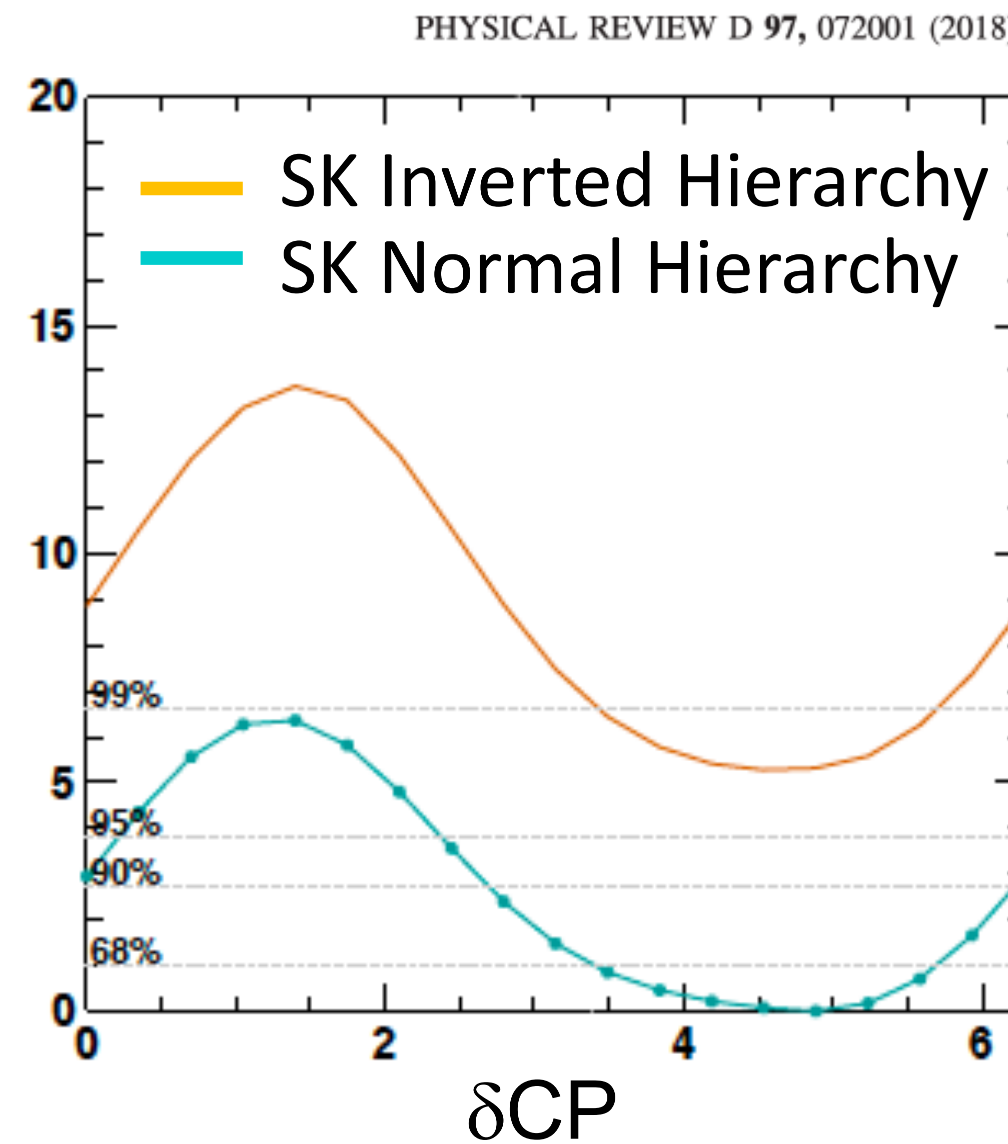
History of Discoveries at Super-K
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
SK Start
K2K start
T2K Start
SK-Gd
Hope more discoveries
Discovery of atmospheric ν oscillation
Discovery of solar ν oscillation
Discovery of oscillatory signature (atm.ν)
Discovery of ν oscillation by K2K
Discovery of ν_e appearance by T2K
Discovery of ν_τ appearance (atm.ν)
Discovery of day/night effect
(b) FC μ-like + PC
Number of Events
cos Θ
139
256
χ^2(shape) = 30/4 dof
Up/Down = 0.54 +0.06 −0.05
(6.2σ !!)
Data/Prediction (null osc.)
L/E (km/GeV)
No oscillation
Oscillation
Number of events /(250 MeV)
Reconstructed ν energy (MeV)
Data
NC
Events
cos(Θ)
9

Hints in neutrinos

- CPV and Mass Ordering!



$\delta_{CP} = 0, \pi$ fall outside 2σ interval



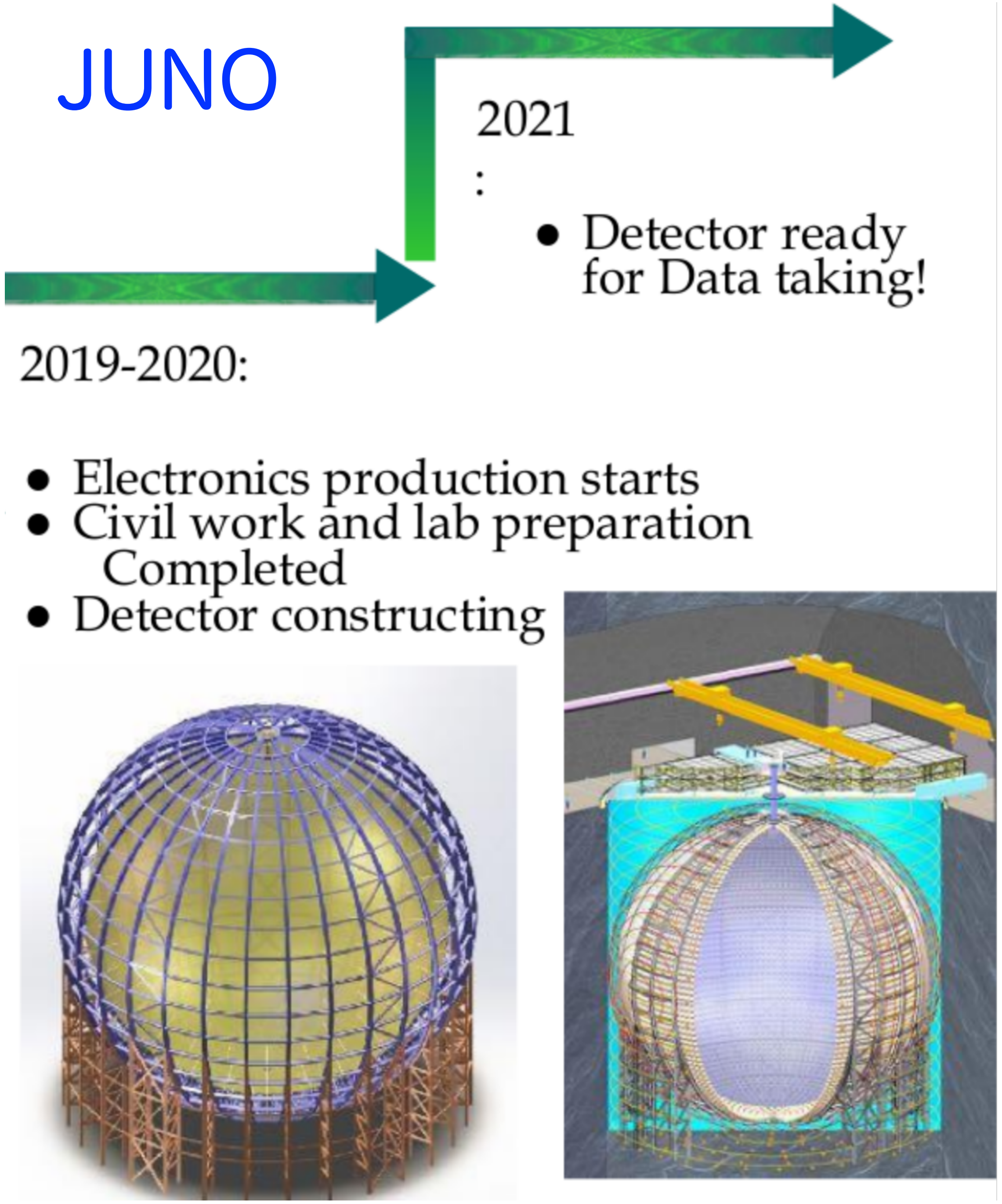
- *Normal hierarchy*(NH) is favored over *Inverted Hierarchy*(IH)
  - $\Delta\chi^2$ (NH – IH) = -5.27 (SK only: -4.33)
  - IH is rejected by between 91.9% and 94.5%.

T2K Neutrino Oscillation Results by C. Riccio @ WIN2019

20 Years of Super-Kamiokande and Gd New Era by M. Nakahata @ WIN2019

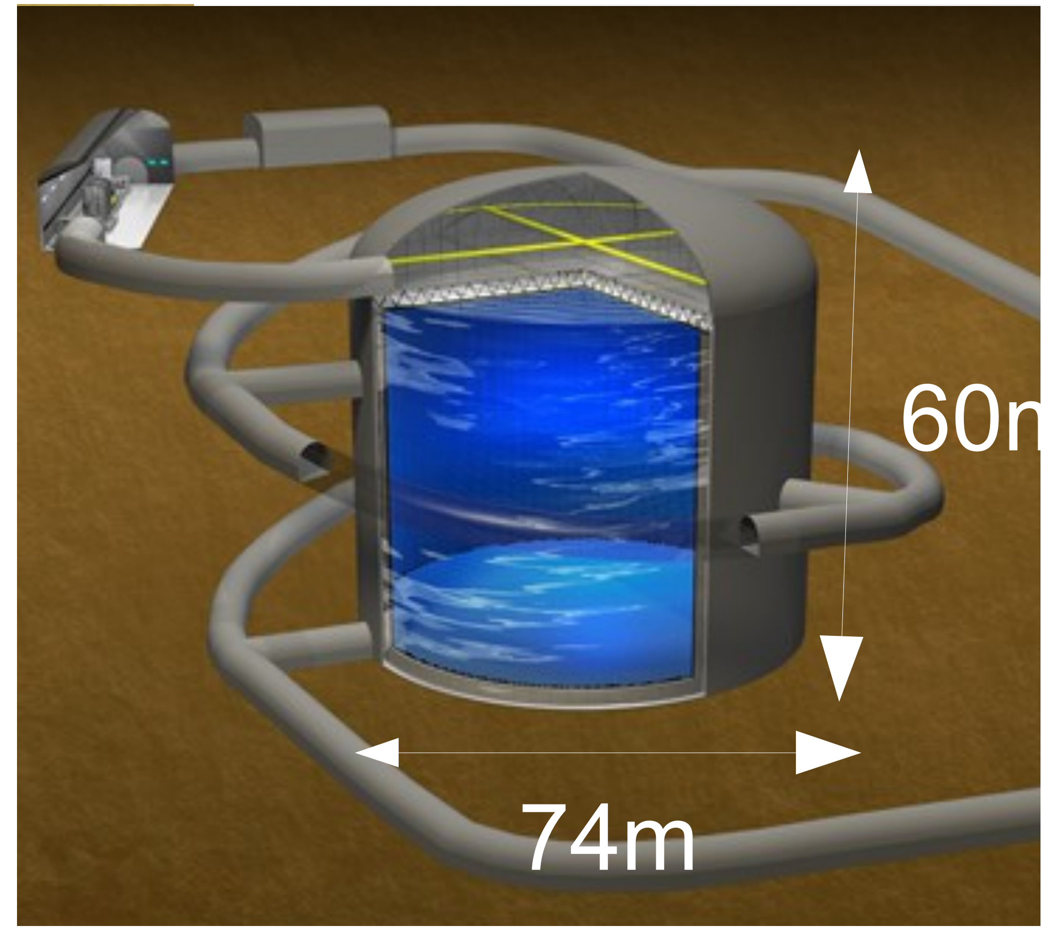
Next Step

JUNO

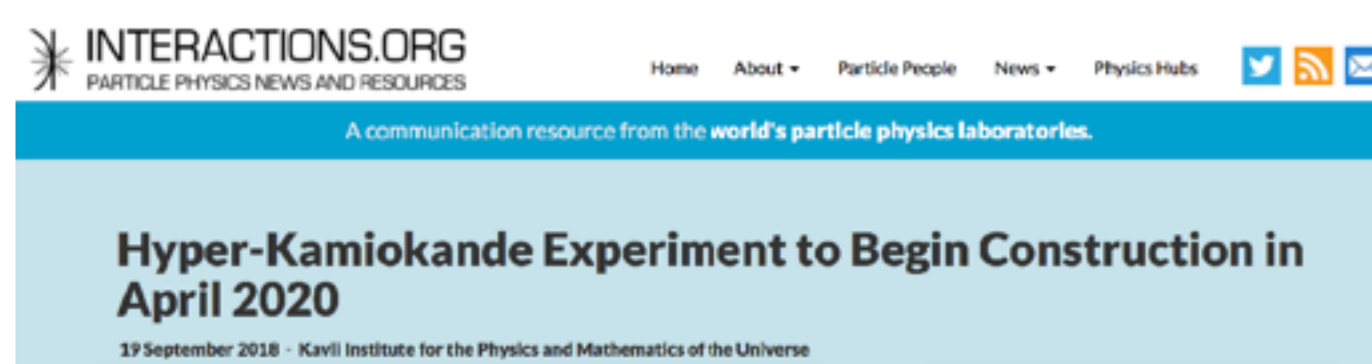


Physics prospects of JUNO by J. P. A. M. André @WIN2019

Hyper-Kamiokande



Hyper-Kamiokande by J. Łagoda @WIN2019



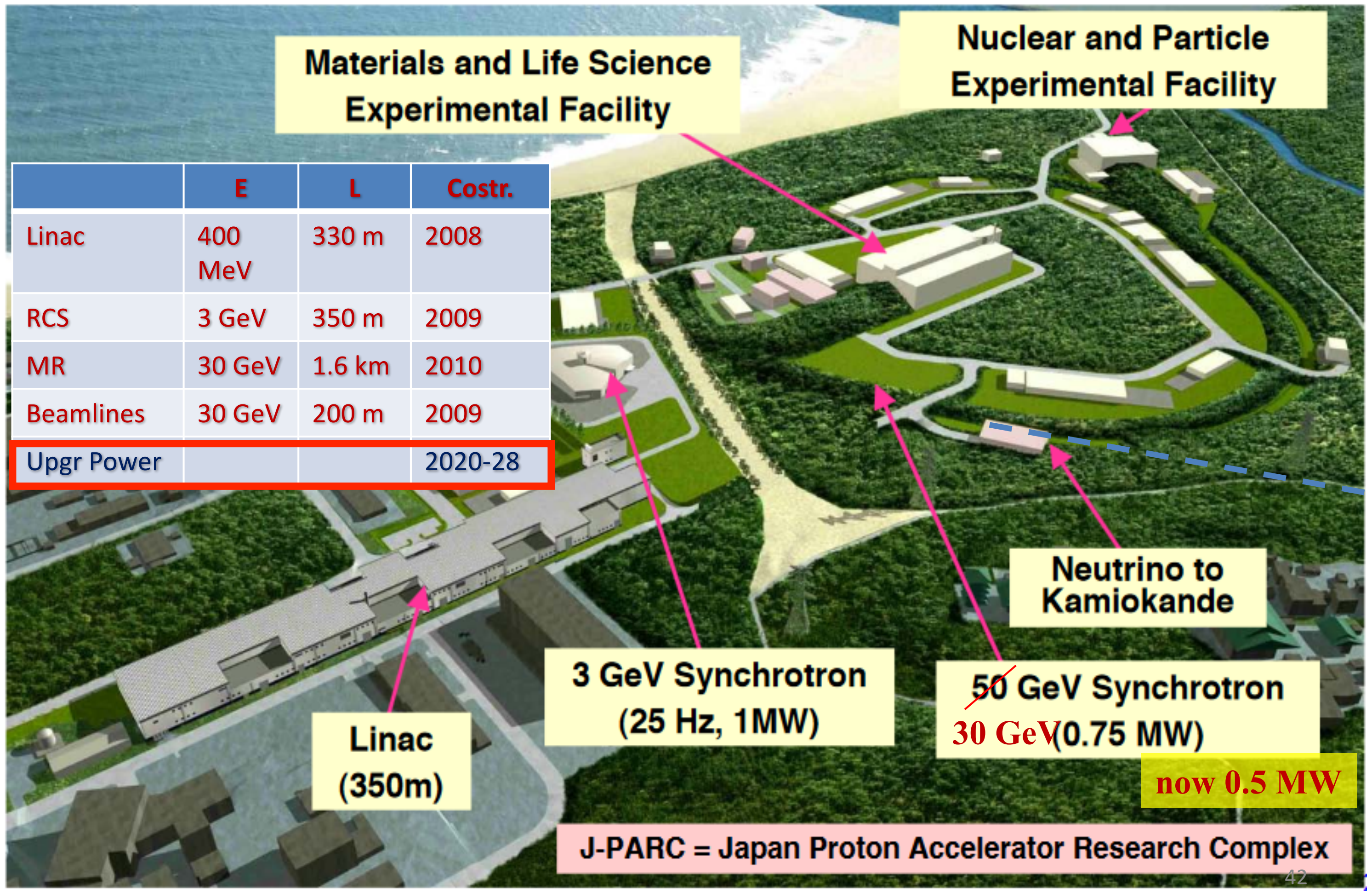
A communication resource from the world's particle physics laboratories.

Hyper-Kamiokande Experiment to Begin Construction in April 2020

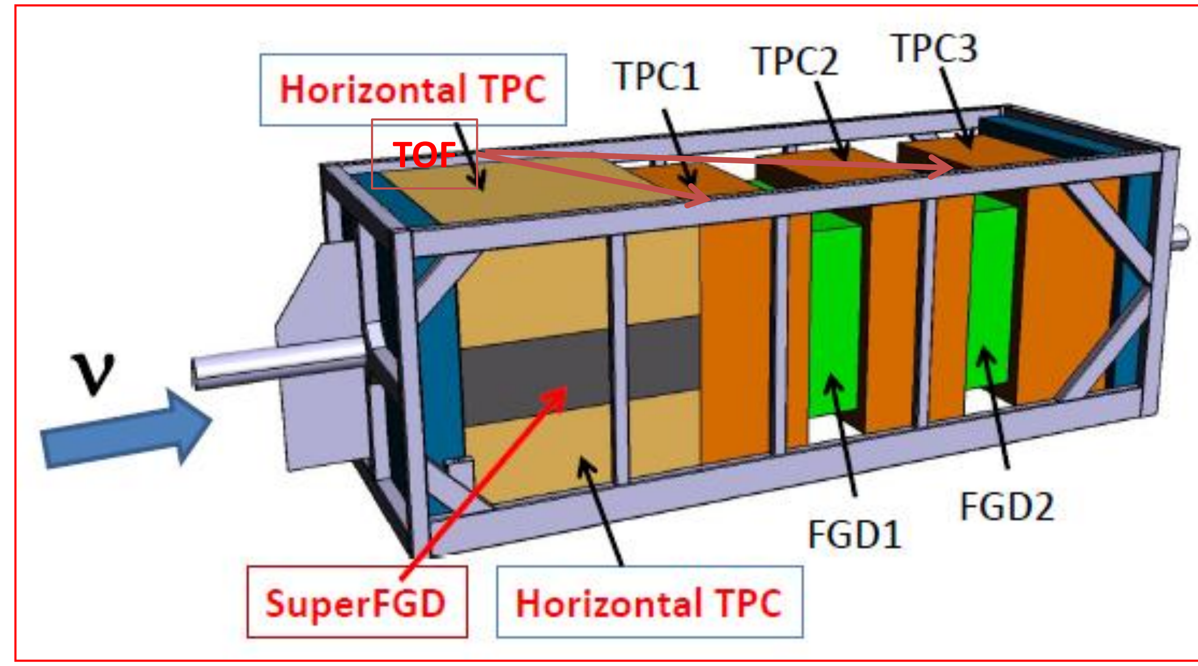
19 September 2018 - Kavli Institute for the Physics and Mathematics of the Universe

Next Step

J-PARC sends neutrinos to Super-K (Hyper K)



	E	L	Costr.
Linac	400 MeV	330 m	2008
RCS	3 GeV	350 m	2009
MR	30 GeV	1.6 km	2010
Beamlines	30 GeV	200 m	2009
Upgr Power			2020-28



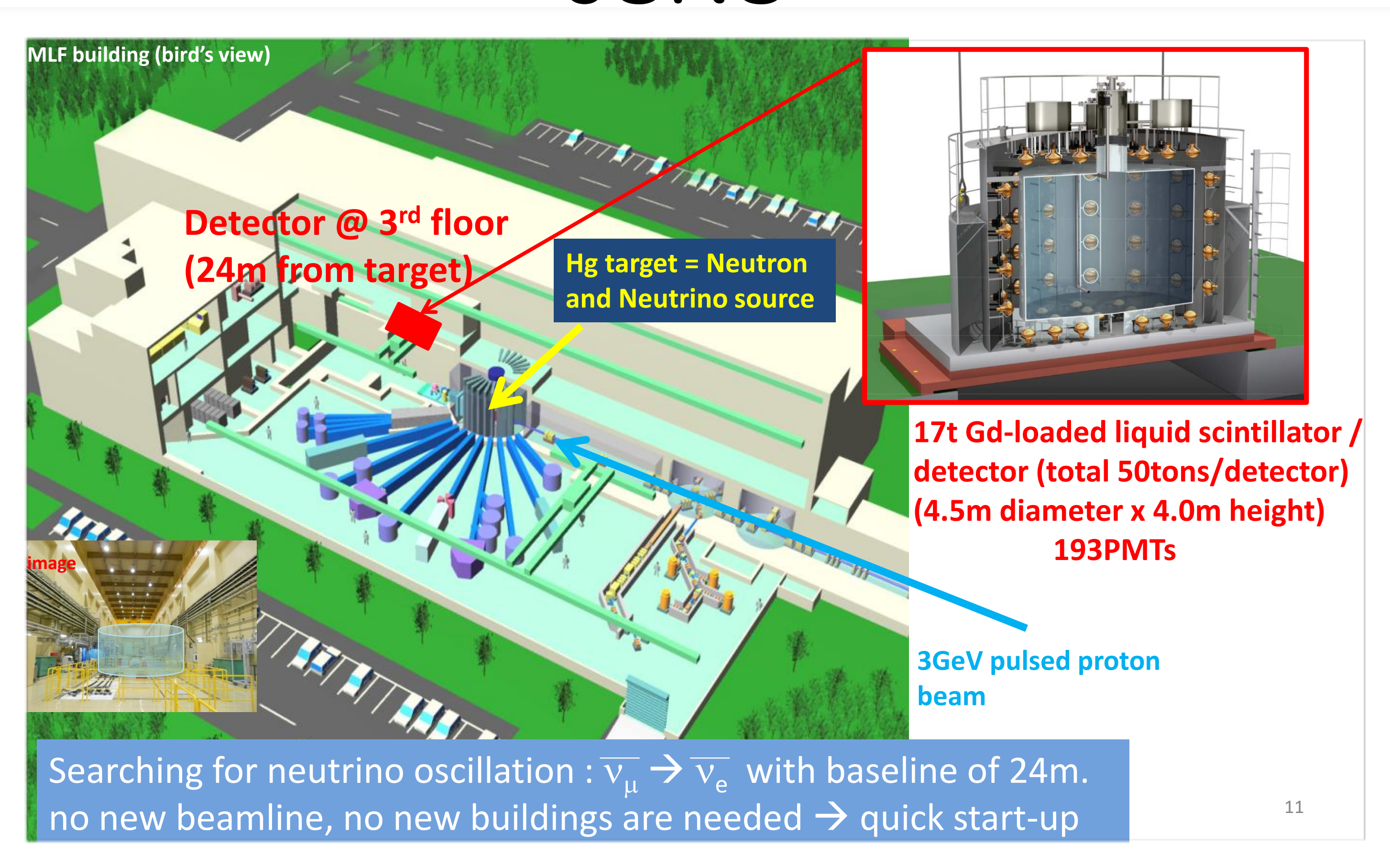
Upgrade of T2K Near Detector ND280 by Y. Kudenko @ WIN2019

”Power Upgrade in 2020-2028”

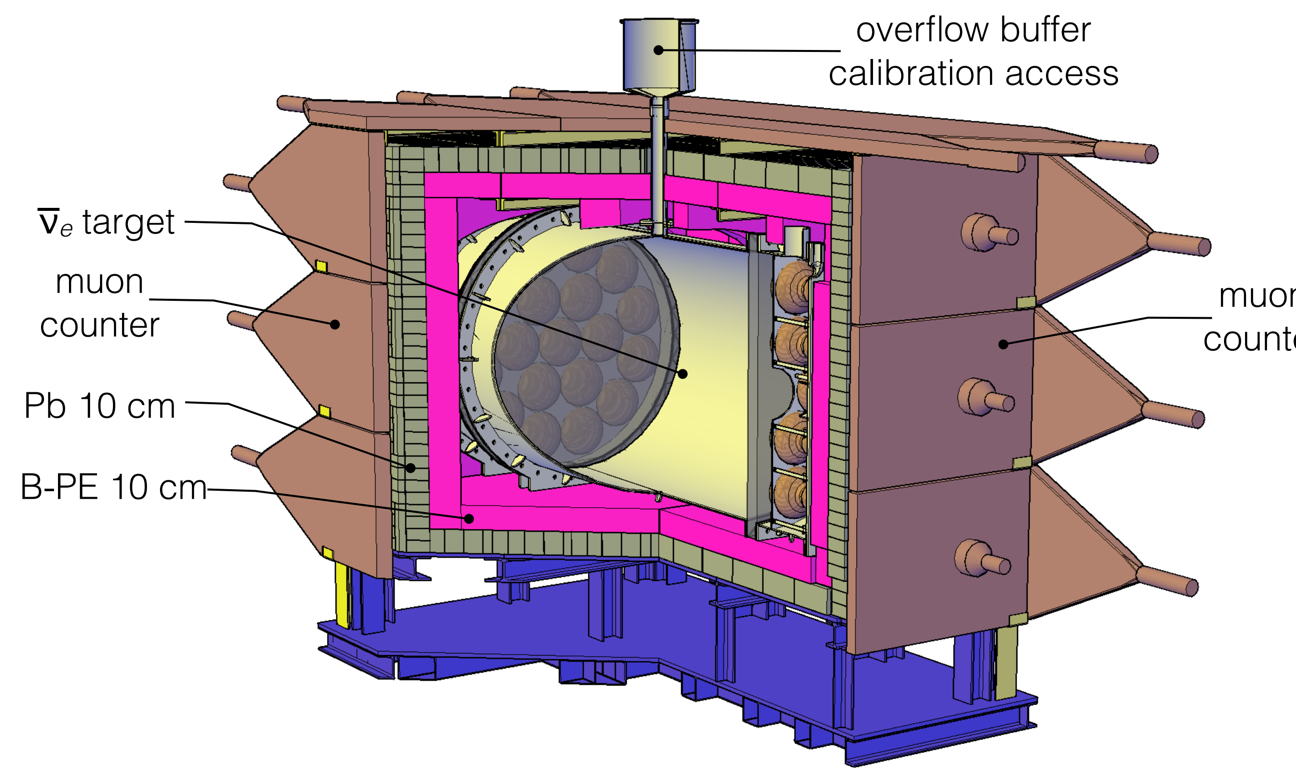
Prospect in Accelerators by S. Guiducci @ WIN2019

Check anomalies (eV sterile neutrinos)!

JSNS²

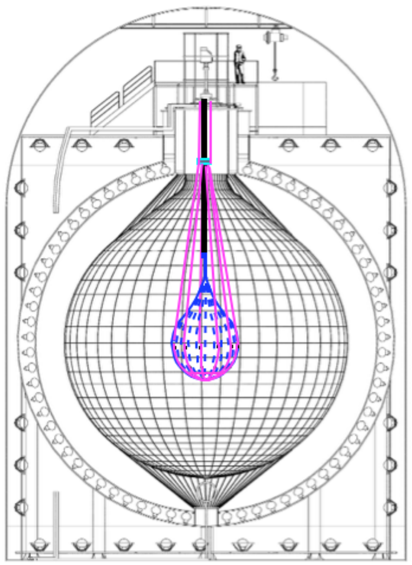


NEOS



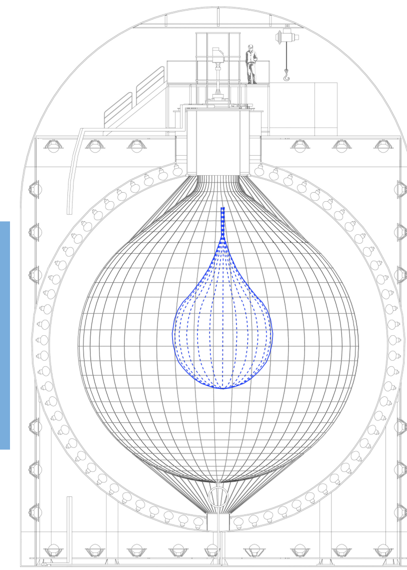
- JSNS²: Data taking will start in 2019.
- NEOS: Under data taking toward the new results in 2020.

Search for the Majorana particle



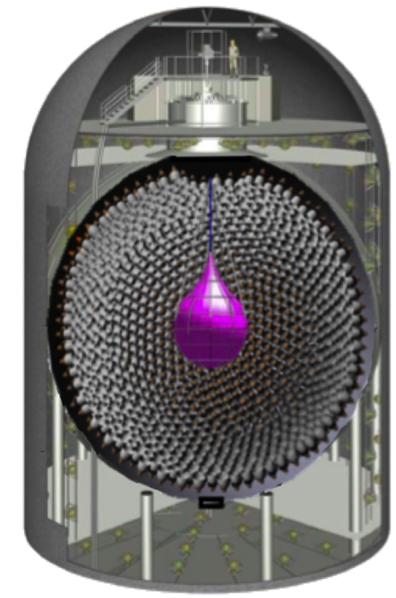
Zen400
380 kg_{Xe}
'11—'15

KamLAND-Zen 400



Zen800
750 kg_{Xe}
NOW

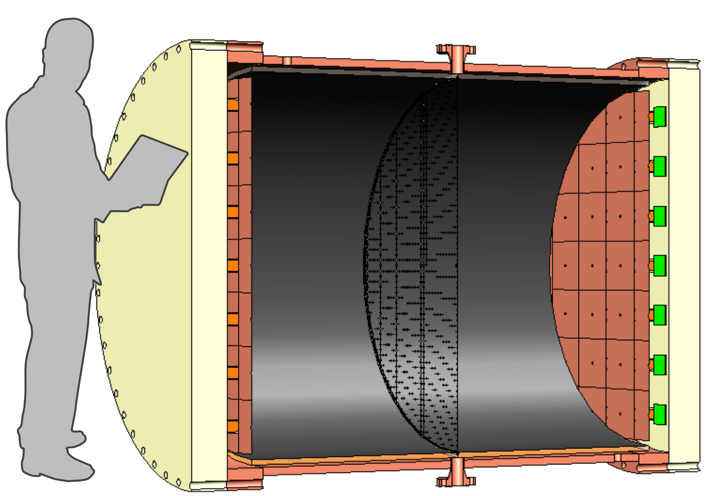
KamLAND-Zen 800



2-Zen
1000 kg_{Xe}
Future

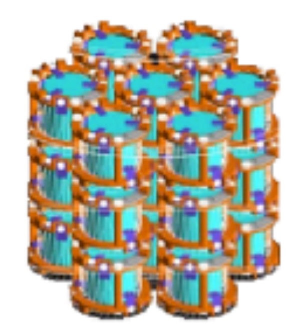
KamLAND2-Zen

PANDA X
PARTICLE AND ASTROPHYSICAL XENON TPC



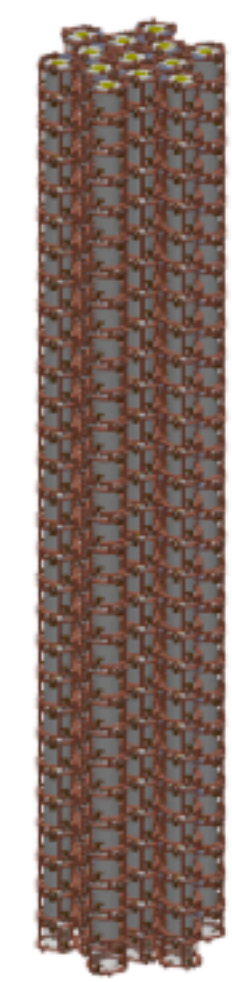
arXiv:1610.08883

$^{40}Ca^{100}MoO_4$
~ 1.5 kg
AMoRE Pilot

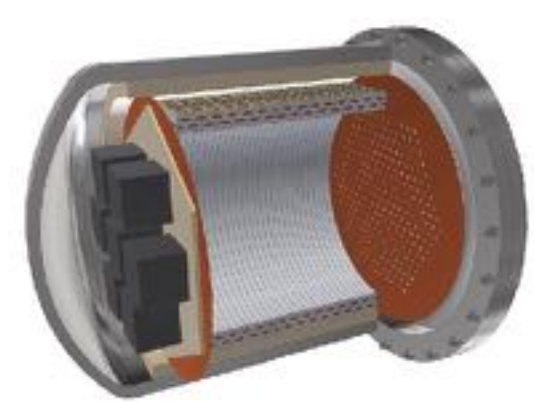


$^{40}Ca^{100}MoO_4$
~ 5 kg
AMoRE-I

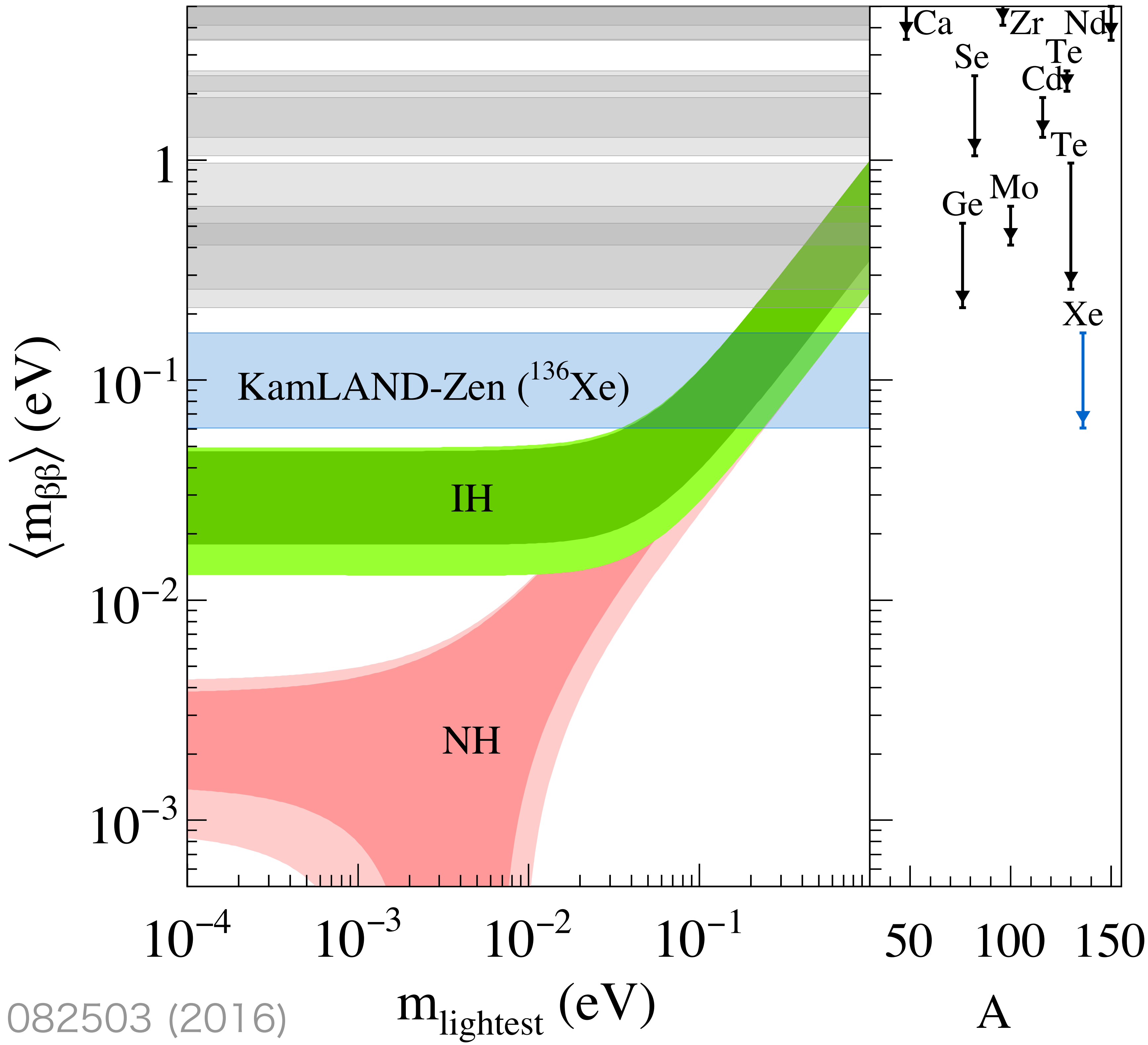
$X^{100}MoO_4$
200 kg
AMoRE-II



AXEL

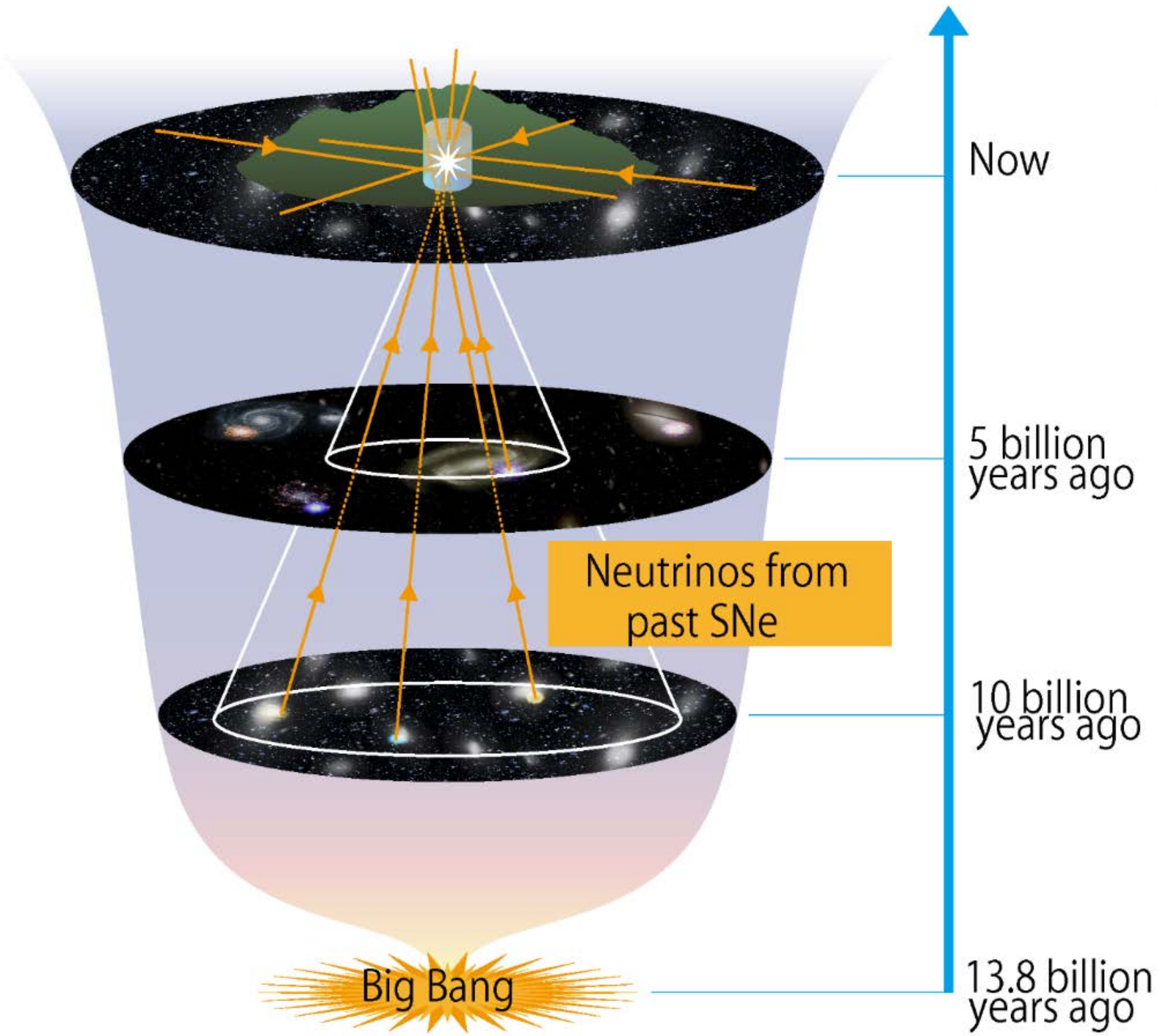


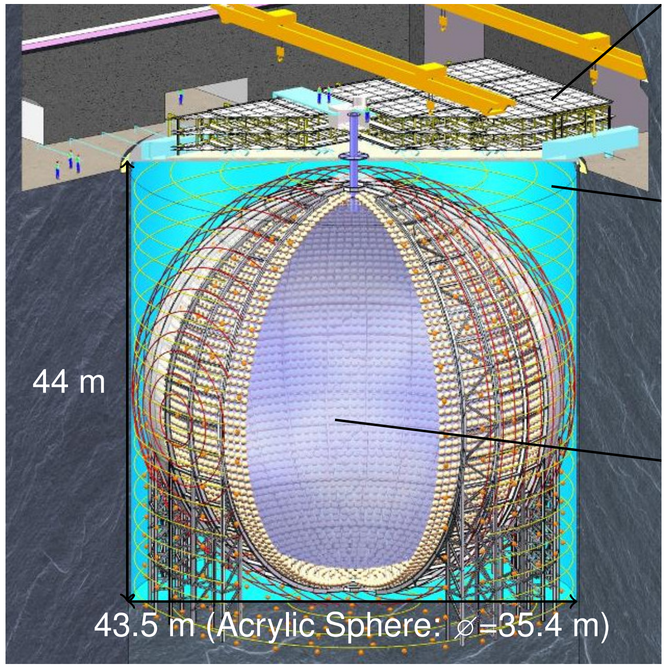
Limit on Majorana eff. mass



PRL **117**, 082503 (2016)

Supernova Relic Neutrinos



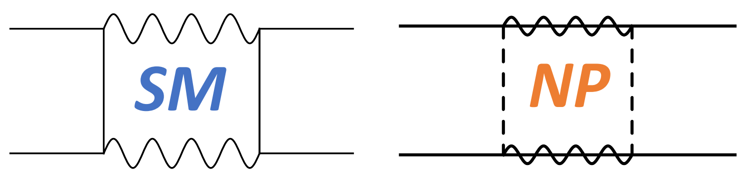


Flavor Physics

Hints of New Physics!

K (ε'/ε) : 2.8 σ deviation from SM

c.f. meson mixing



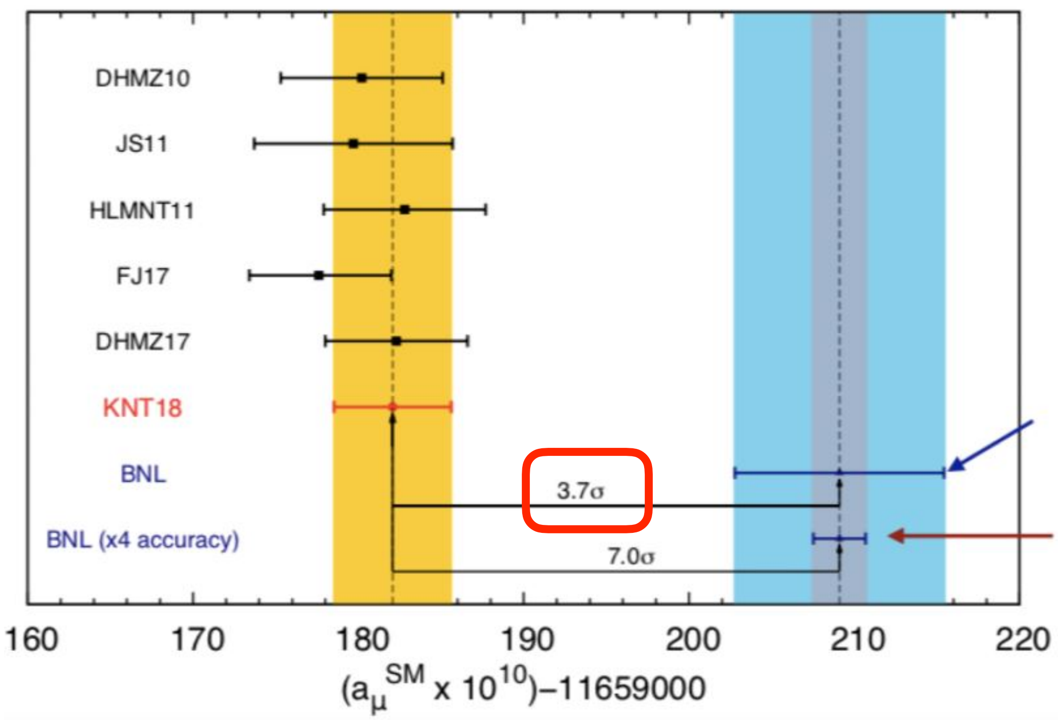
$$\mathcal{L}_{eff} = \mathcal{L}^{SM} + \frac{1}{\Lambda_{NP}^2}\sum_i C_i \mathcal{O}_i^{\rm dim6}$$

If $|C_{\rm NP}| \sim 1$

$$\Lambda_{\rm NP} \sim \begin{cases} \mathcal{O}(10^5 {\rm TeV}) & : K^0 \\ \mathcal{O}(10^4 {\rm TeV}) & : D^0 \\ \mathcal{O}(10^3 {\rm TeV}) & : B_{d,s} \end{cases}$$

New Physics implication from Kaon physics by K. Yamamoto @WIN2019

μ g-2: 3.7 σ deviation from SM

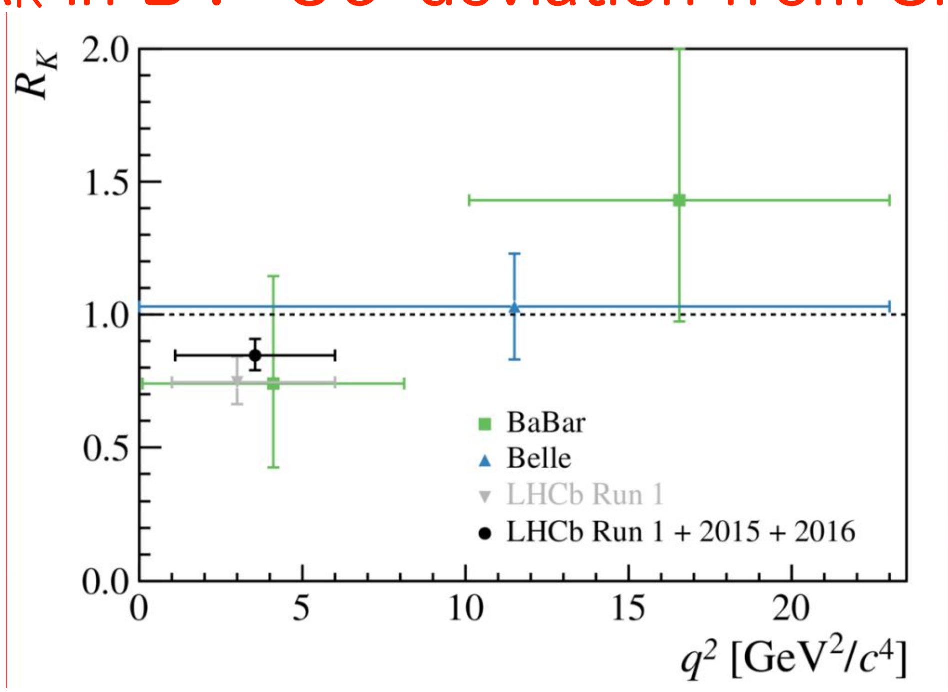


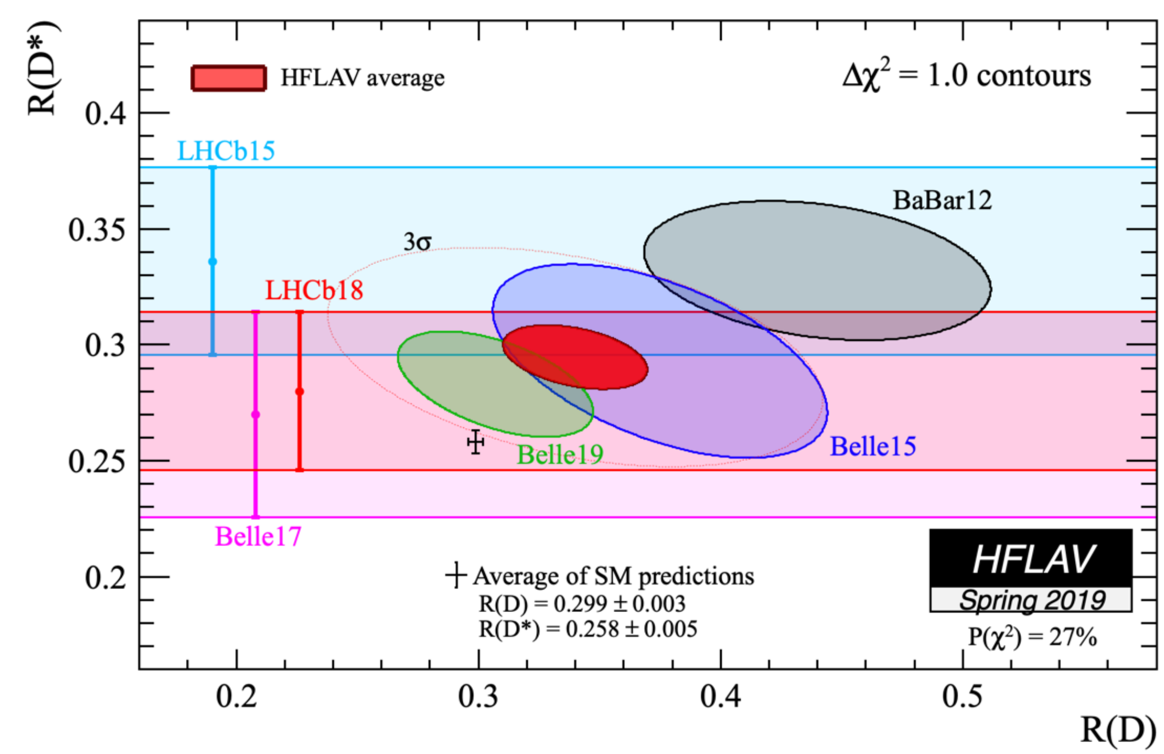
CPV in D : 5.3 σ

$\Delta A_{CP} = (-15.4 \pm 2.9) \cdot 10^{-4}$

$R_{D^{(*)}}$ in B : 3.1 σ deviation from SM

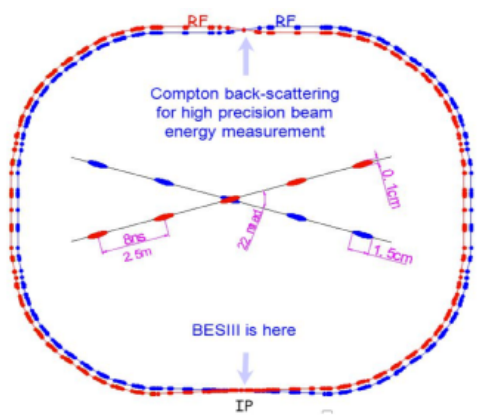
R_K in B : ~3 σ deviation from SM

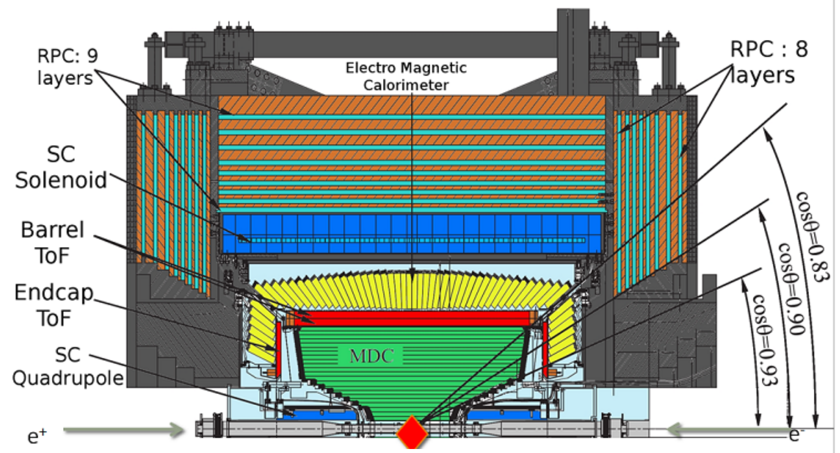




BESIII

BESIII experiment





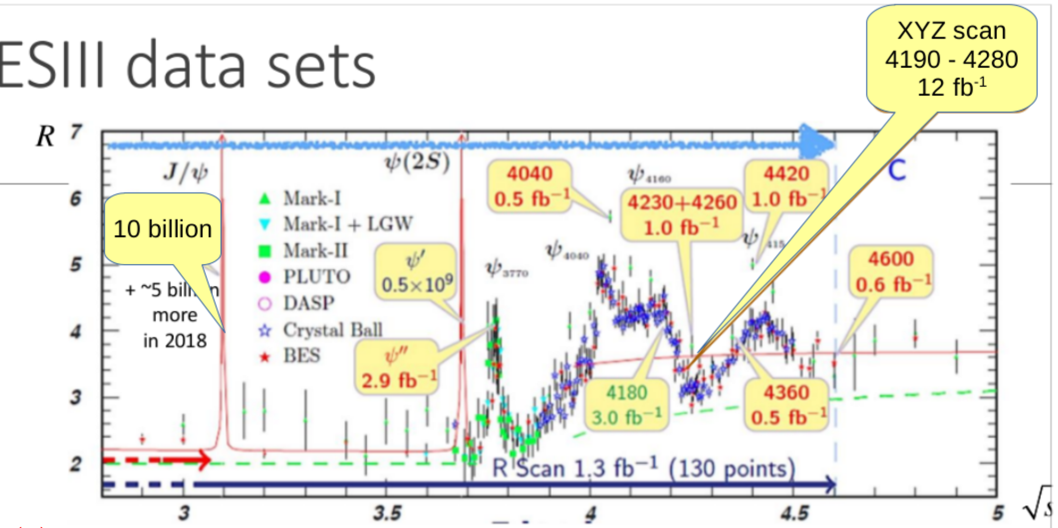
BEPCII

- Two ring symmetric e^+e^- collider; circumference: 240 m and with a design instantaneous luminosity of $1\times10^{33}\text{cm}^{-2}\text{s}^{-1}$.
- $\sqrt{s}$: 2 - 4.6 GeV.
- Beam crossing angle 22 mrad.

BESIII

- Hermeticity 93% of 4π
- MDC: σ_p/p= 0.5% at 1 GeV
- ToF system: σ = 80 ps (110 ps) in barrel (endcap)
- ECL: σ_E/E = 2.5 % at 1 GeV
- Superconducting solenoid (SSM): ⇒ 1 T

BESIII data sets



$D^{0(+)}$ data

- $e^+e^- \to \psi(3770) \to D^0\bar{D}^0(D^+D^-)$.
- $\int \mathcal{L}dt = 2.93\ \text{fb}^{-1}$ at $\sqrt{s} = 3.774$ GeV.
- $N_{D^0\bar{D}^0}$: 10M, $N_{D^+D^-}$: 8M

D_s^+ data

- $e^+e^- \to D_S D_S^{*-}, D_S^{*-} \to D_S^-\gamma$.
- $\int \mathcal{L}dt = 3.19\ \text{fb}^{-1}$ at $\sqrt{s} = 4.178$ GeV.
- $N_{D_s^+D_s^{*-}}$: 3M

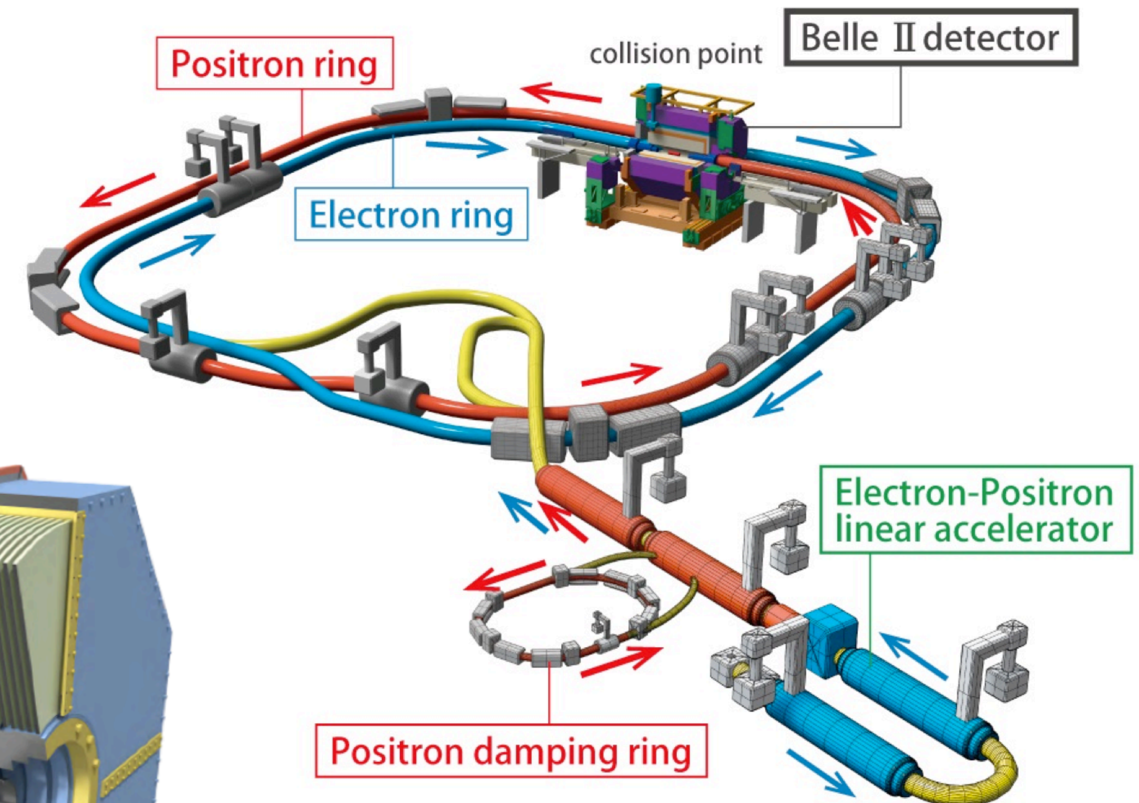
$\Lambda_c^+\Lambda_c^-$ data

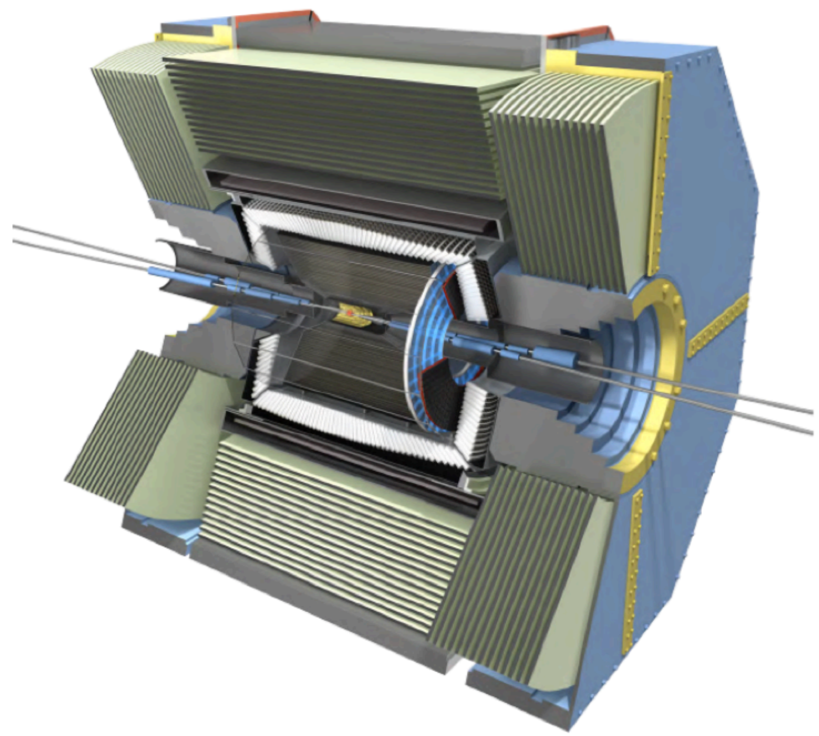
- $e^+e^- \to \Lambda_c^+\Lambda_c^-$.
- $\int \mathcal{L}dt = 0.57\ \text{fb}^{-1}$ at $\sqrt{s} = 4.6$ GeV.

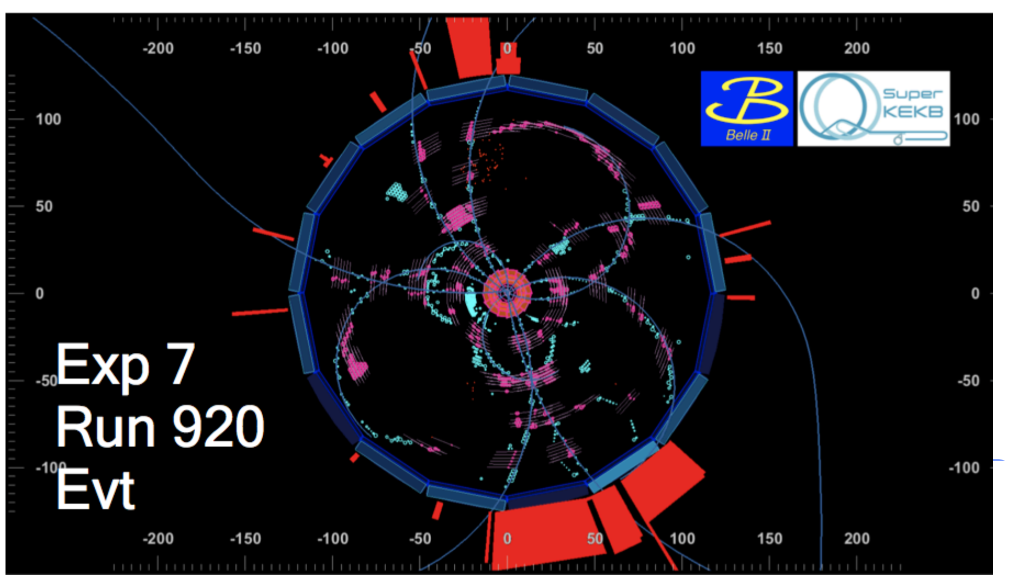
Recent BESIII results in open charm by K. Ravindran + other BESIII talks @WIN2019

- Rich physics as a tau&charm factory
- Various interesting results coming

B-Factory: Belle II/SuperKEKB

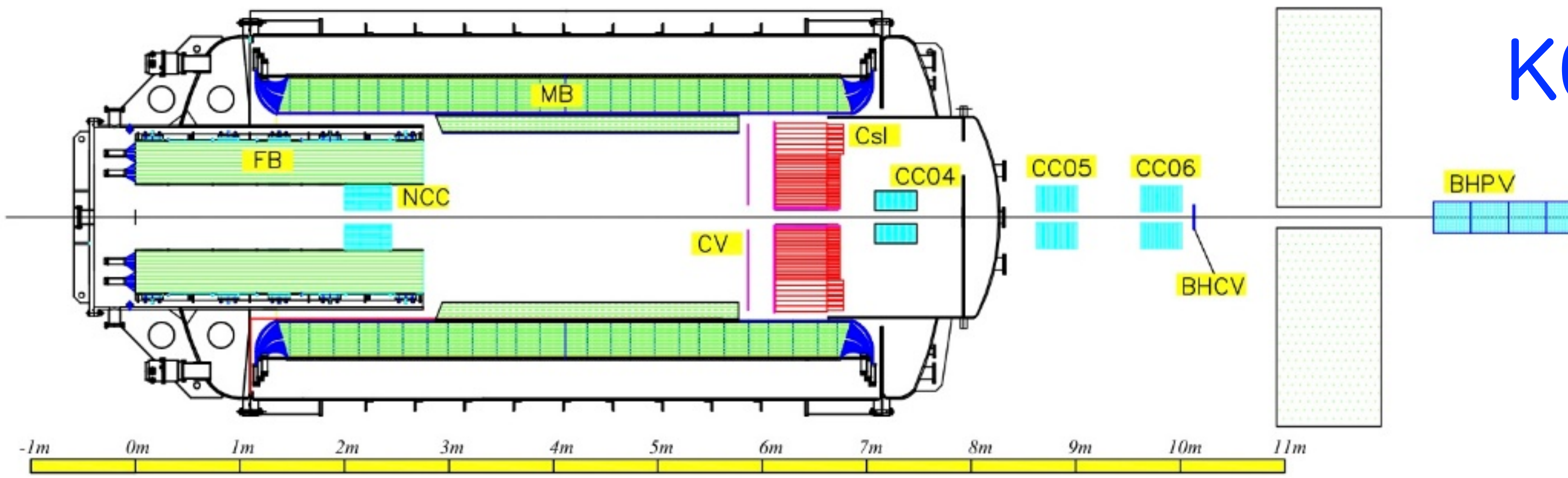






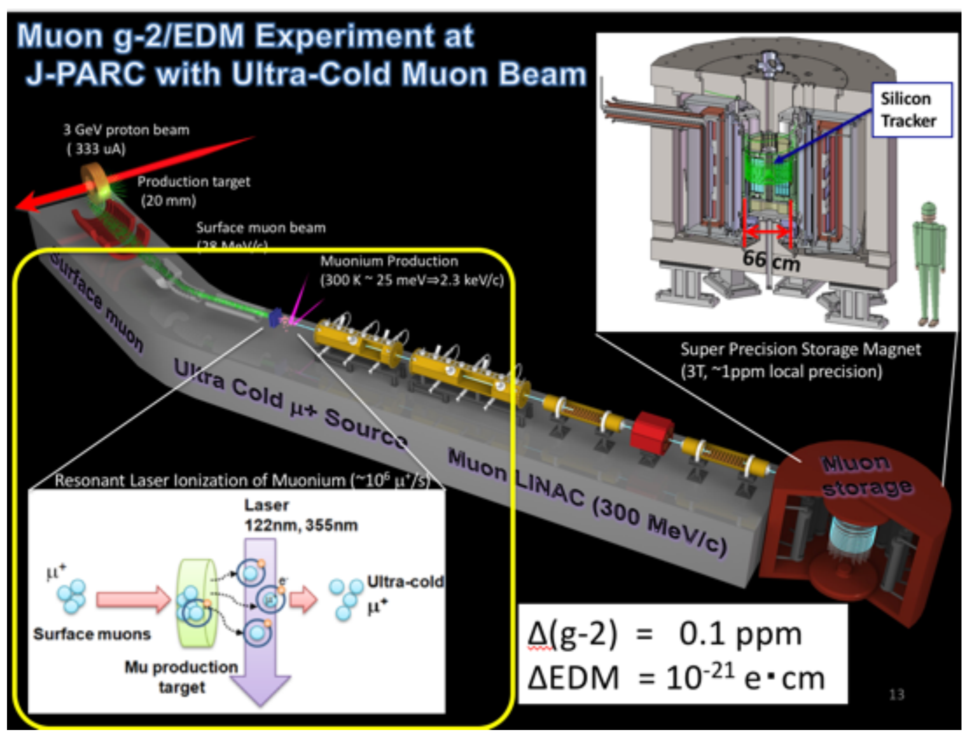
- Physics data taking with the full detector just started in March 2019.
  - Many interesting results are expected in the coming years.

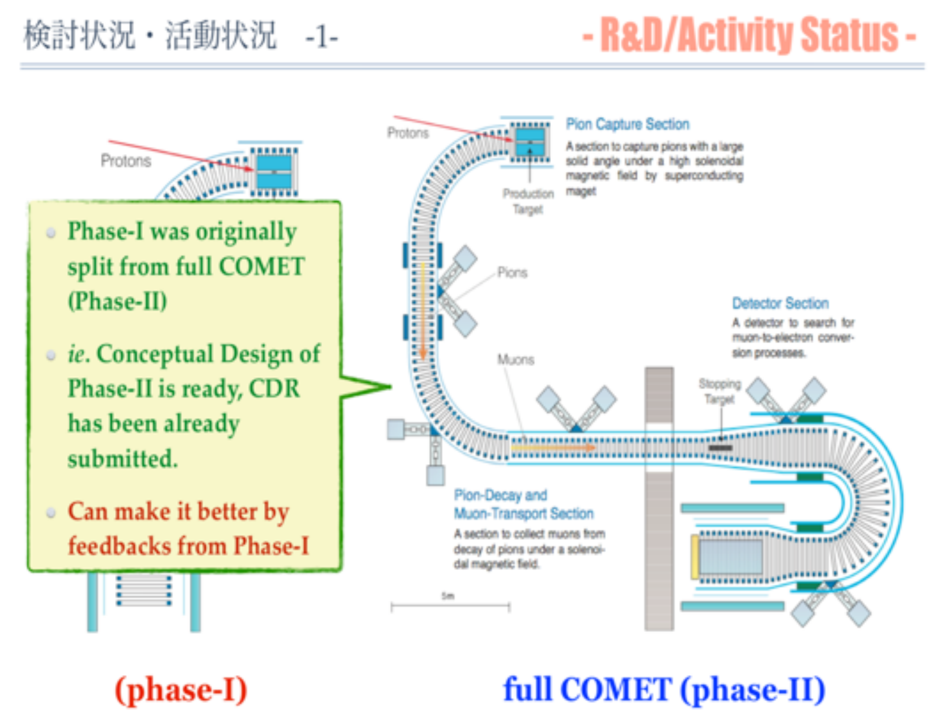
J-PARC: K and μ



KOTO

μ g-2





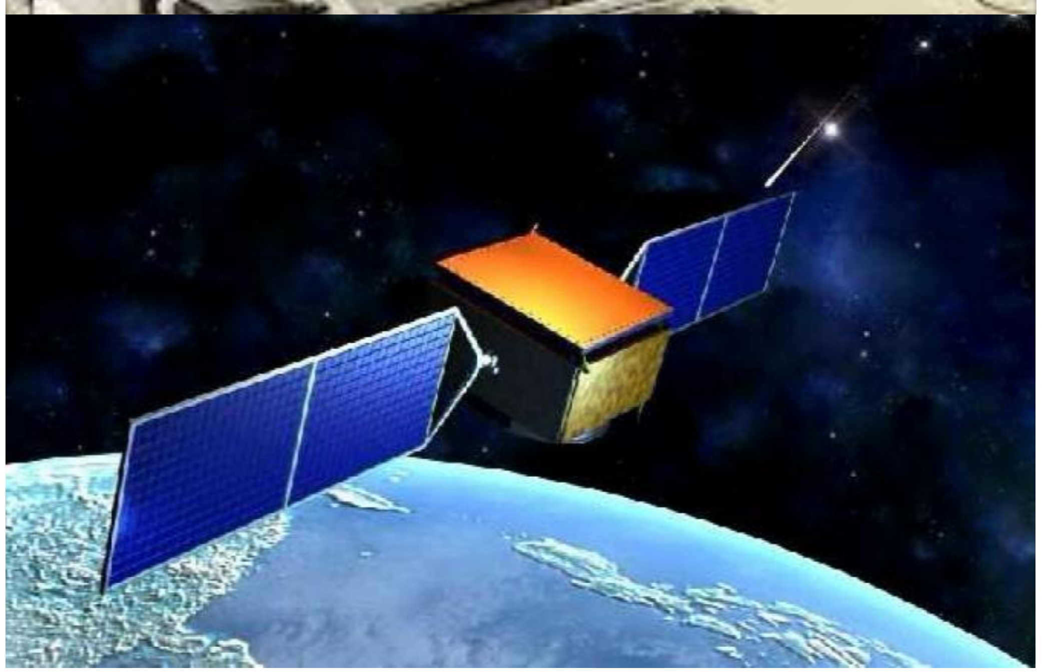
COMET
($\mu \rightarrow$e)

- KOTO ($K_L \rightarrow \pi^0 \nu \nu$) experiment starts new data taking after the upgrade.
- COMET ($\mu \rightarrow$e conversion) and muon g-2 experiments are under preparation.

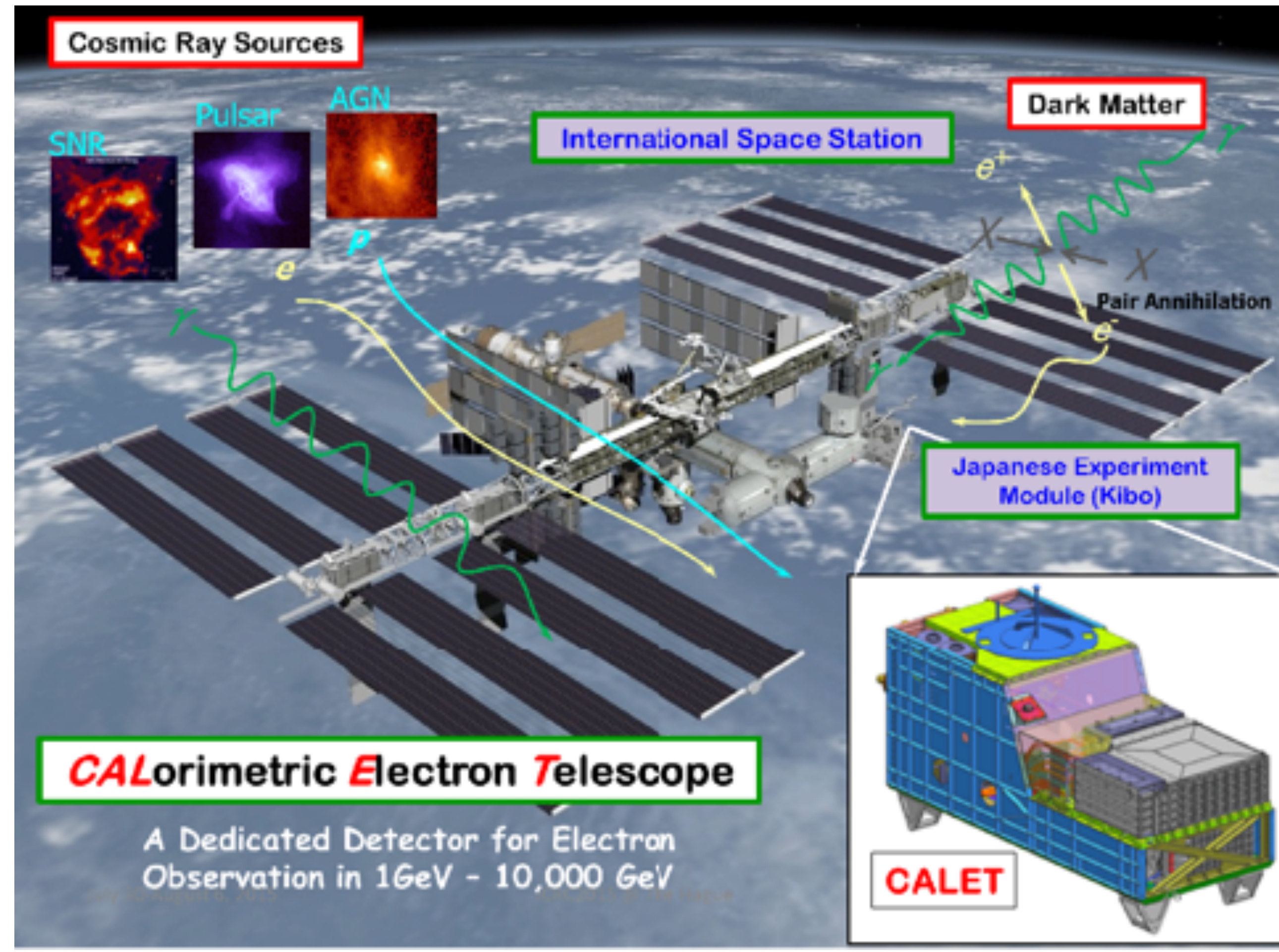
Astroparticle Physics (and Dark Matter)

Search for Dark Matters annihilation in Space

DAMPE

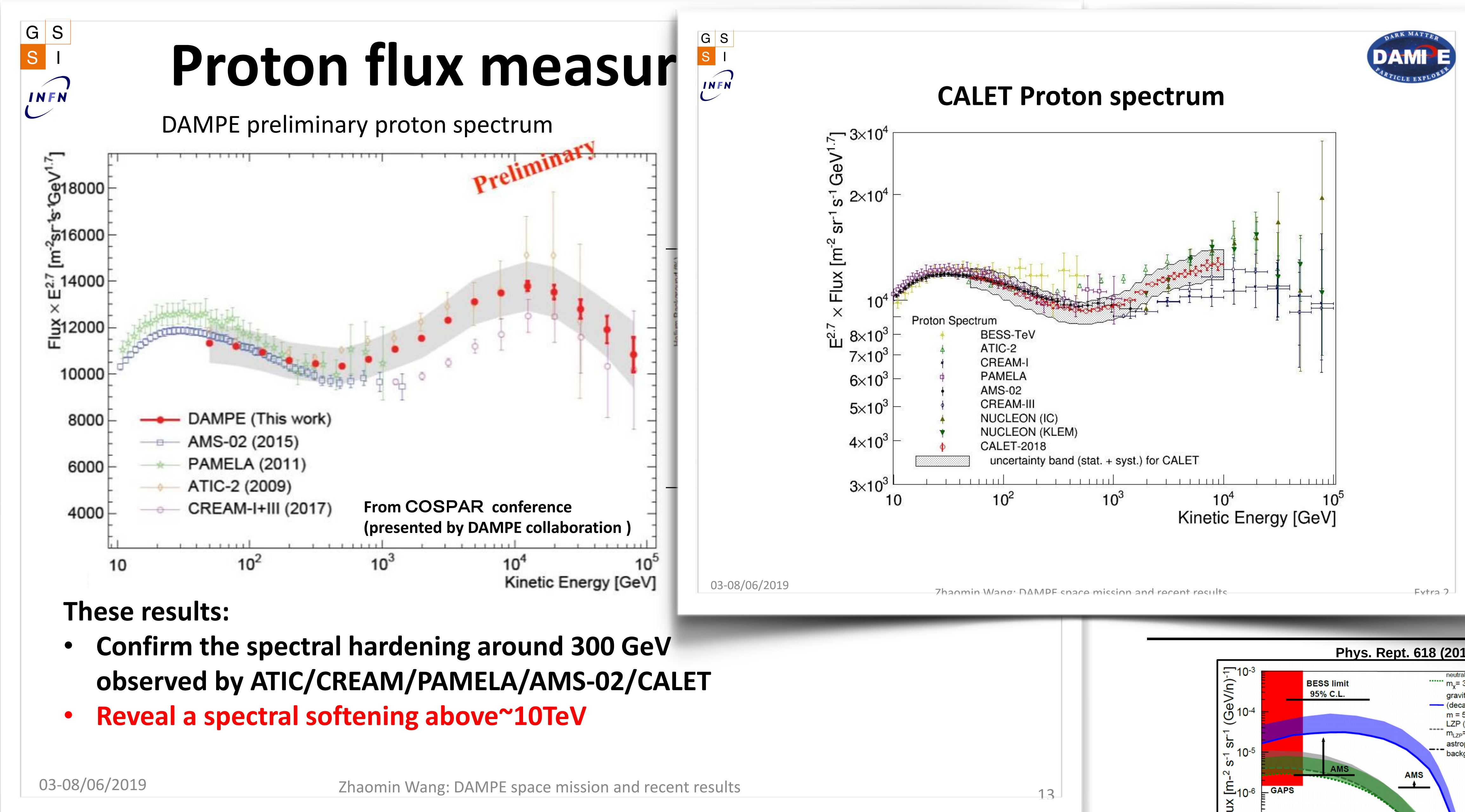


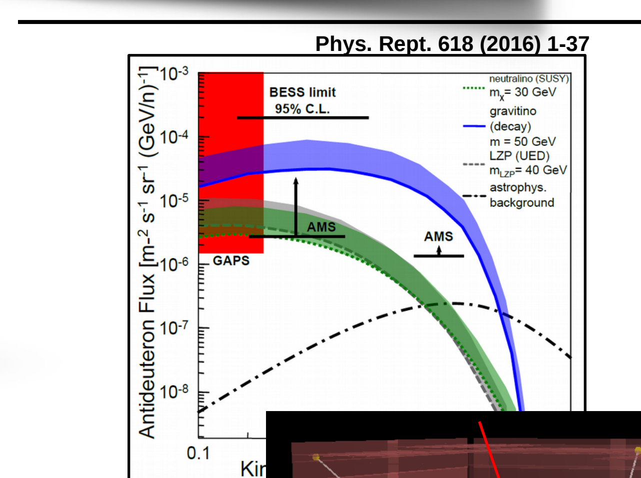
CALET

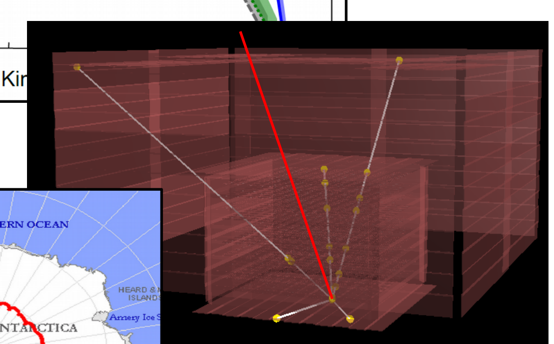


- AMS is a pioneer to search for Dark Matter annihilation in Space and to observe the positron and antiproton excess.
- There are more observations coming from DAMPE and CALET.

DAMPE space mission and recent results by Z. Wang @ WIN2019





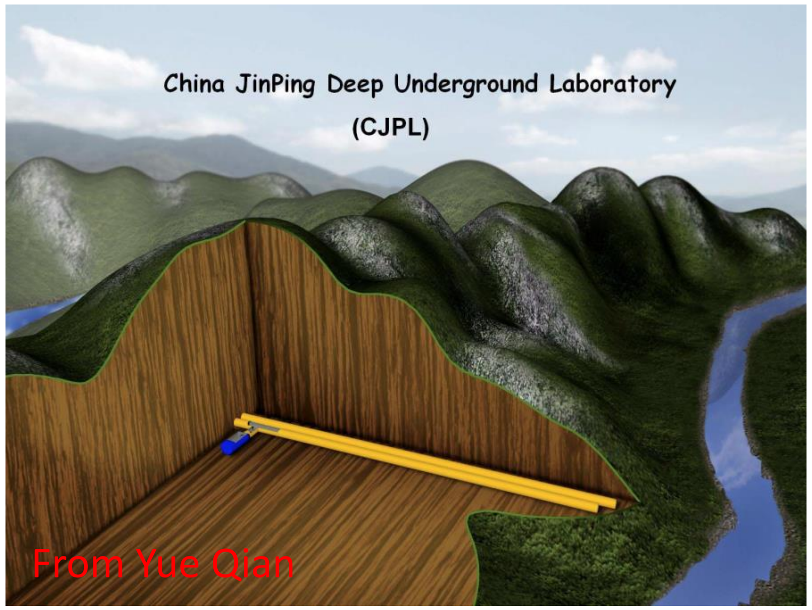


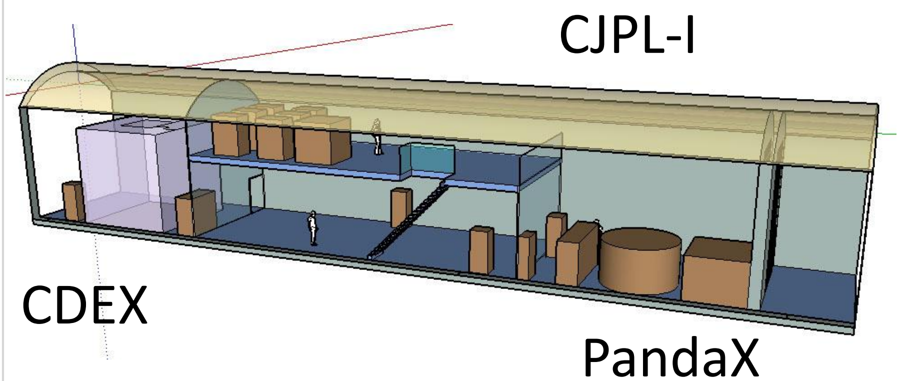
The first flight will be late 2021

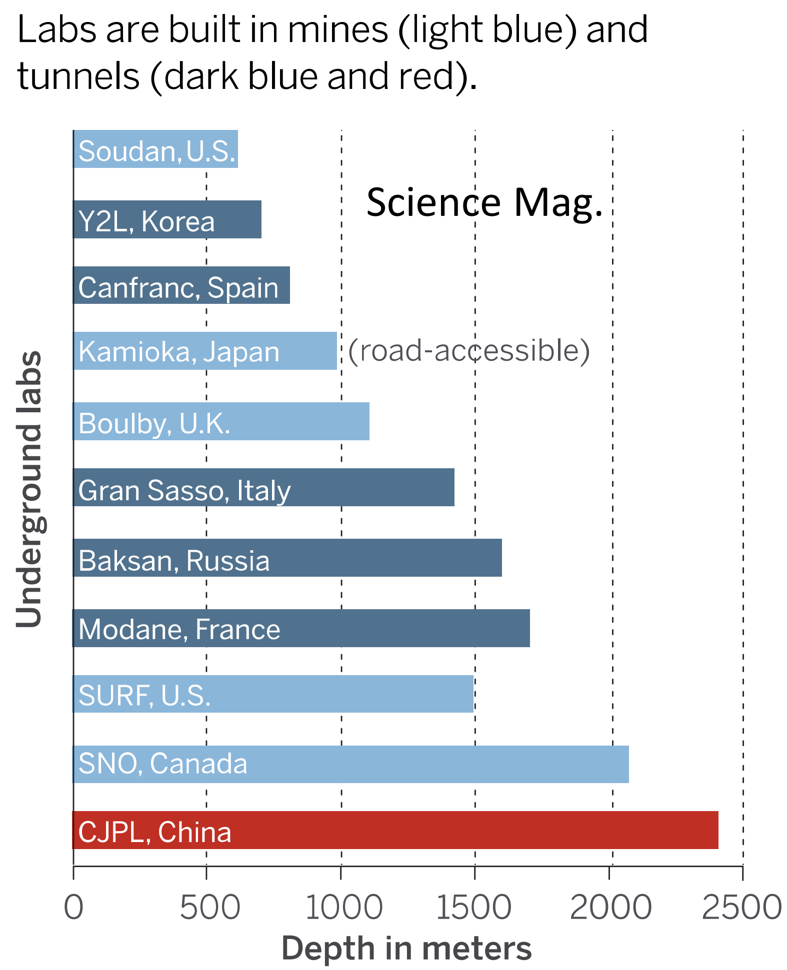
GAPS - antideuteron search by R. Munin @WIN2019

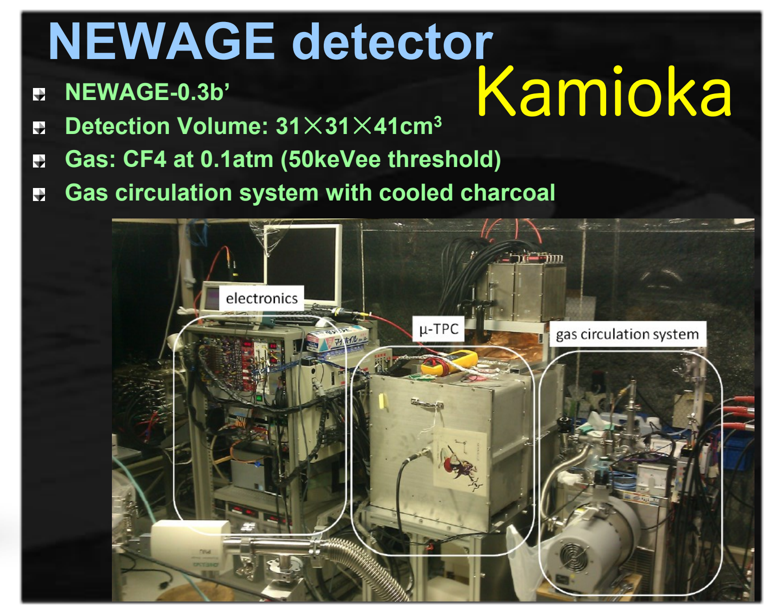
Underground lab in Asia for Dark Matter Search

CJPL – Deepest underground lab in the world







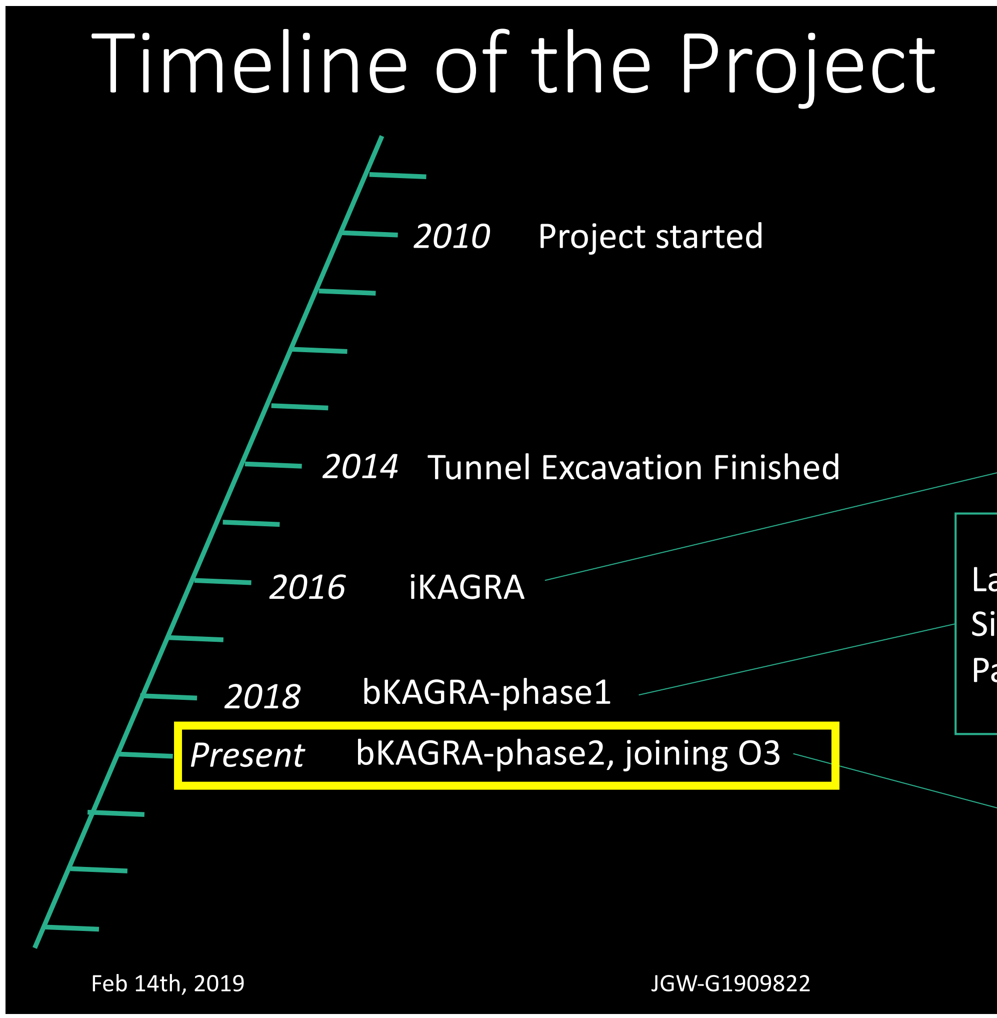


Panda X Dark Matter and Neutrinoless Double Beta Decay Programs by HAN Ke @14th Rencontres Du Vietnam "International Symposium on Neutrino Frontiers" in 2018

There are activities of underground lab in India and Australia

(Gravitational Waves & Cosmology)

KAGRA in Kamioka



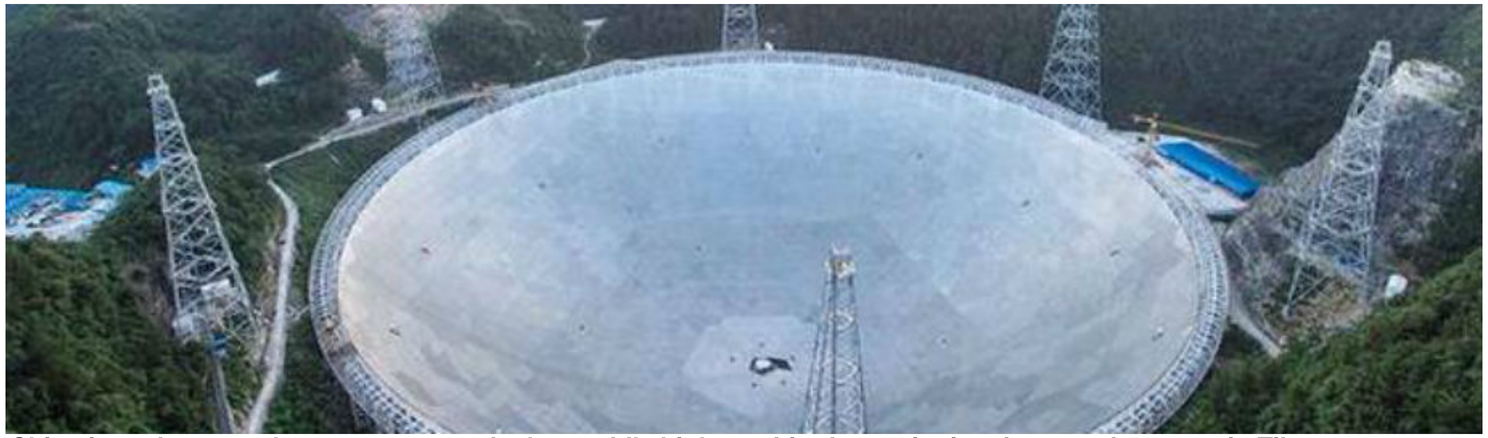
- "Status of KAGRA: the underground- and cryogenic gravitational-wave detectors" by K. Kokeyama at the 5th Kagara International Workshop/ The 1st Kagra-Virgo-3G Detectors Workshop in Perugia, Italy.
  - Almost ready to join O3!

Gravitational Wave Telescope in China

- We hear the big investment on the Gravitational Wave Telescope in China.
- It is very interesting to follow how the project is going.
  - I am not the expert of this subject, and I just find the following news on the web.

#NgariObservatory: Construction of gravitational wave telescopes in #Tibet under way

People's Daily | March 15, 2018



***China is under smooth progress towards the world's highest altitude gravitational wave telescopes in Tibet Autonomous Region to detect the faintest echoes resonating from the universe, a project insider disclosed,* writes Bai Yang of People's Daily.**

CMB

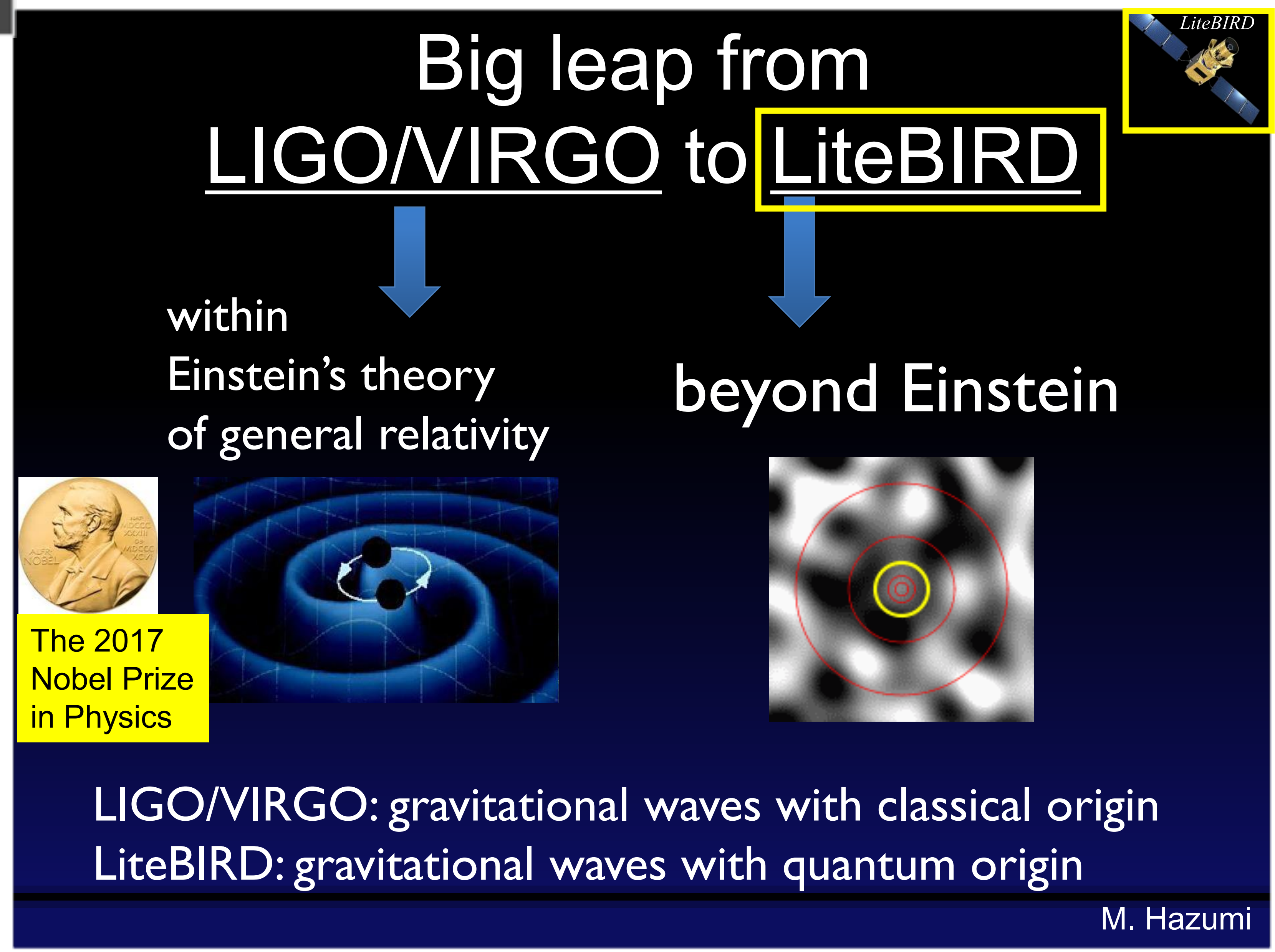
http://litebird.jp/eng/

News & Topics

ISAS selects LiteBIRD as the strategic large mission #2!

2019-05-21

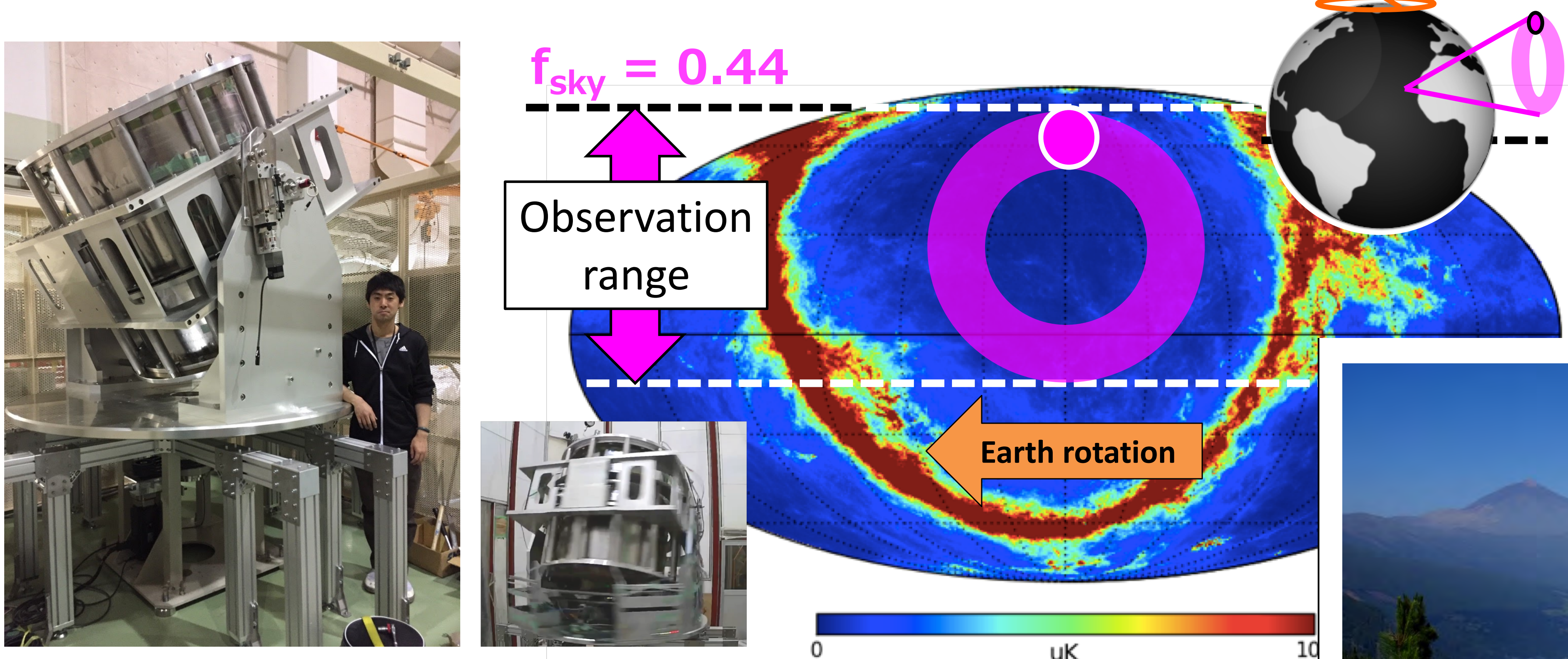
ISAS has confirmed that LiteBIRD completed activities planned during Prephase-A2 (previously called as Phase-A1) and has selected LiteBIRD as the strategic large mission #2.



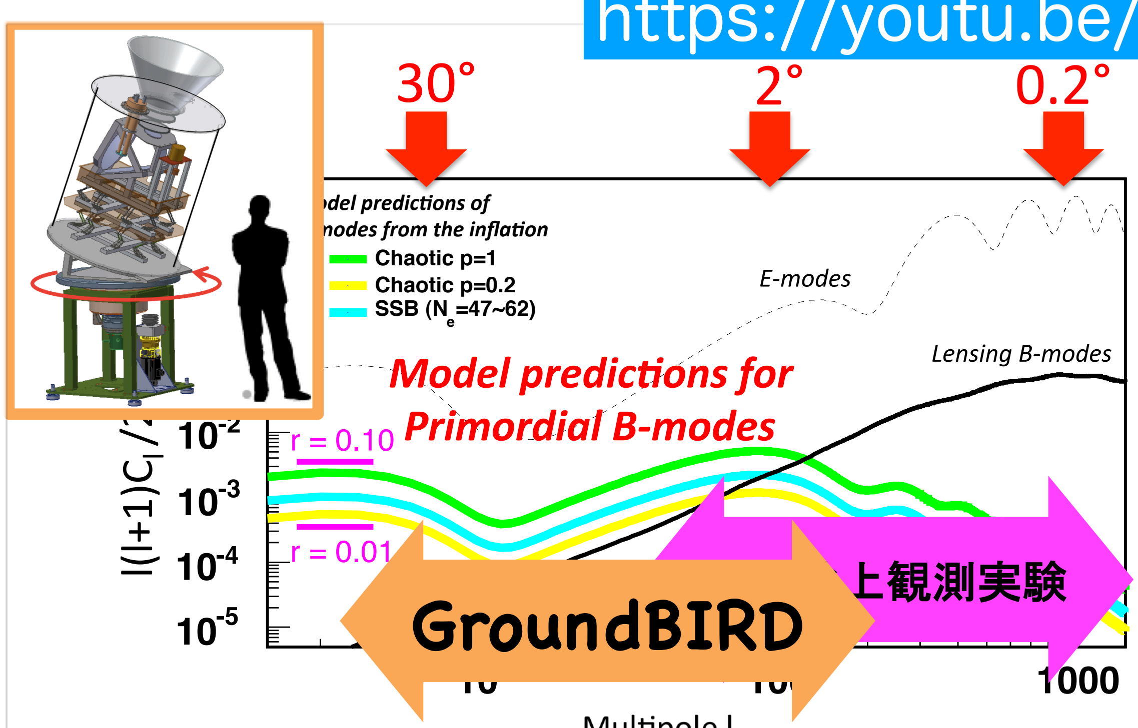
Cosmology
Present and Future
by P. de Bernardis @WIN2019

CMB -GroundBIRD-

Large sky coverage with high-speed rotation scan @ Canary island, soon



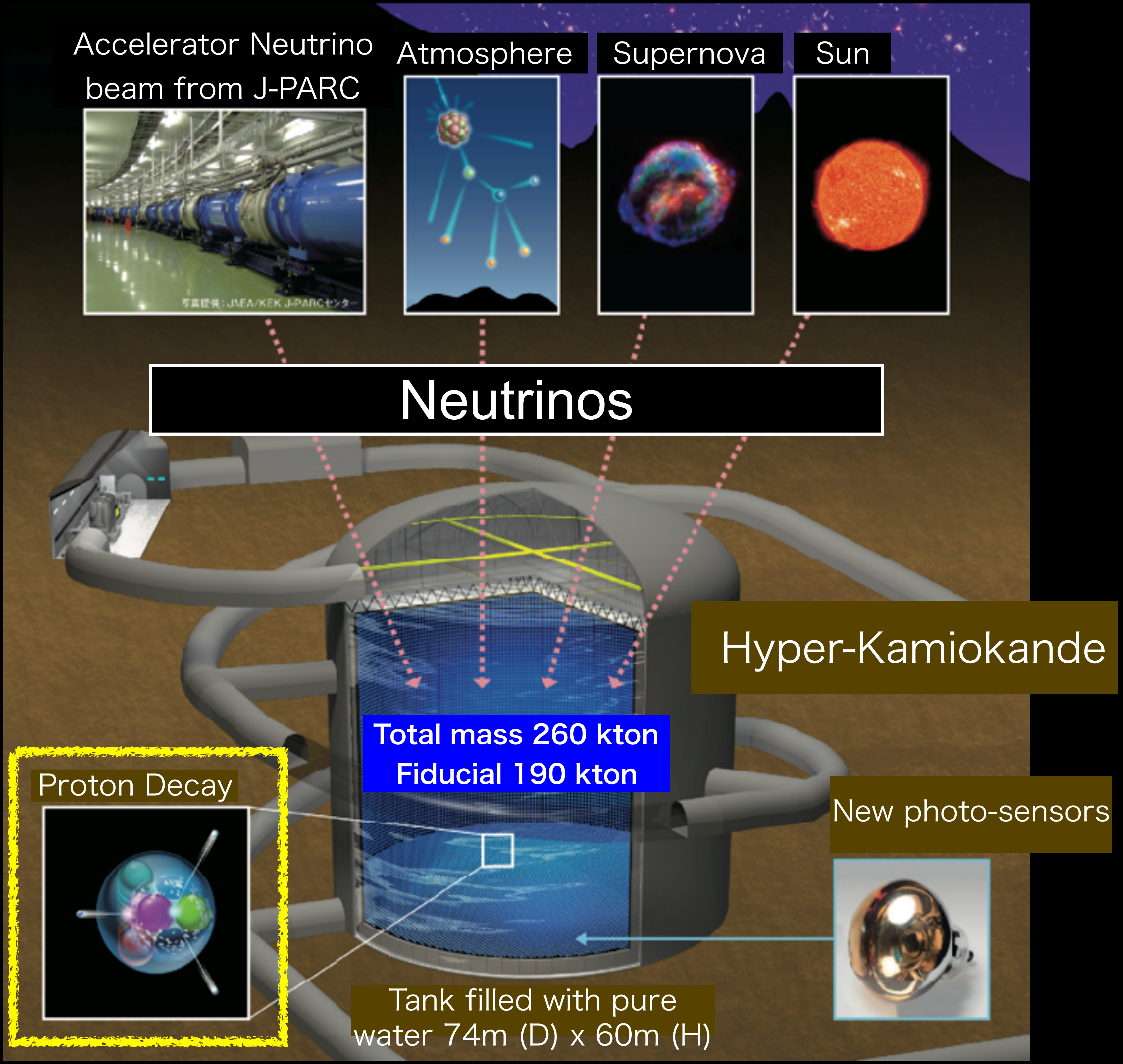
https://youtu.be/MQX4mM-fXhE



Th

Proton Decay

Hyper-Kamiokande program



People from Asia

Participation from Asia

Participation in HEP

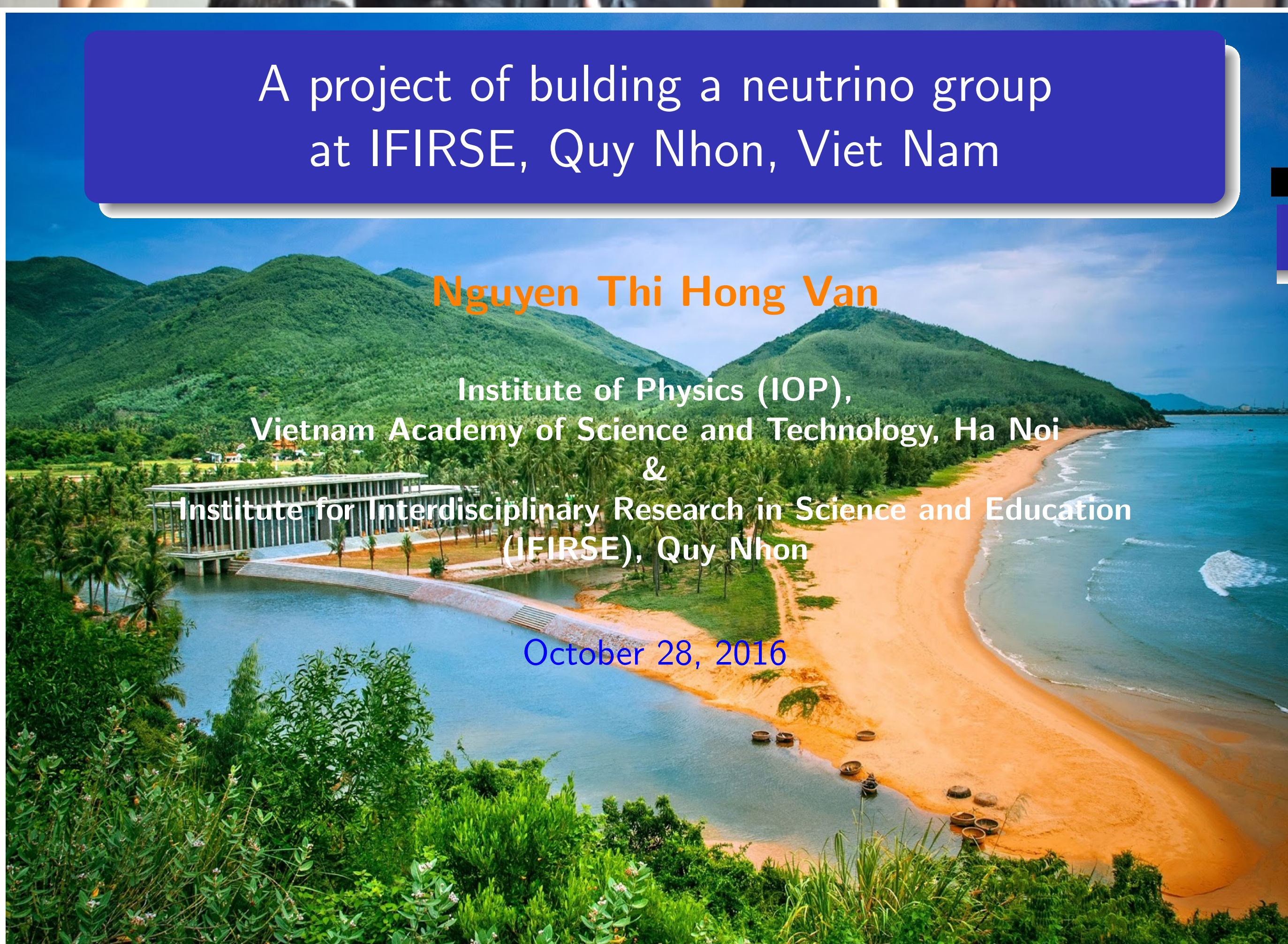
- Japan
- China
- India
- Korea
- Taiwan
- Hong Kong
- Australia
- Thailand, Vietnam, Indonesia …

Considerable contributions to European and US programs

CoEPP ARC Centre of Excellence for Particle Physics at the Terascale

Geoffrey Taylor "Perspective on the European Strategy from Asia", EPPSU2019, Granada 8

European Strategy Update



A project of bulding a neutrino group at IFIRSE, Quy Nhon, Viet Nam

Nguyen Thi Hong Van

Institute of Physics (IOP),
Vietnam Academy of Science and Technology, Ha Noi
&
Institute for Interdisciplinary Research in Science and Education (IFIRSE), Quy Nhon

October 28, 2016

Where to build the group?

ICISE - International Center for Interdisciplinary Science and Education

- **Location**: Quy Nhon, Binh Dinh, Vietnam (20 hectares site between mountains and sea),
- **Founders**: Tran Thanh Van and Le Kim Ngoc
- **Activities**: → 10-12 high level international scientific conferences a year → welcome more than 1000 scientists over the world every year.
  → International schools on specific subjects.

Where to build the group? (2)

- **IFIRSE**, beside ICISE, is created to promote scientific research and education in Quy Nhon and Vietnam.
- IFIRSE is surposed to become an Institute of high level with an international environment and collaboration.
- Director: Tran Thanh Van

IFIRSE - Institute For Interdisciplinary Research in Science and Education

Theoretical Physics Group

- Le Duc Ninh (*got PhD in France, spent postdoc in Germany*)
- Dao Thi Nhung (*got PhD in Germany, spent postdoc in Germany*)
- more people are welcome

Experimental Physics Group

- Tsuyoshi Nakaya (*Prof. at Kyoto univ., Japan*)
- Cao Van Son (*got PhD in US, postdoc at Kyoto univ. & KEK, Japan*)
- N. T. Hong Van (*got PhD in France, working at IOP*)

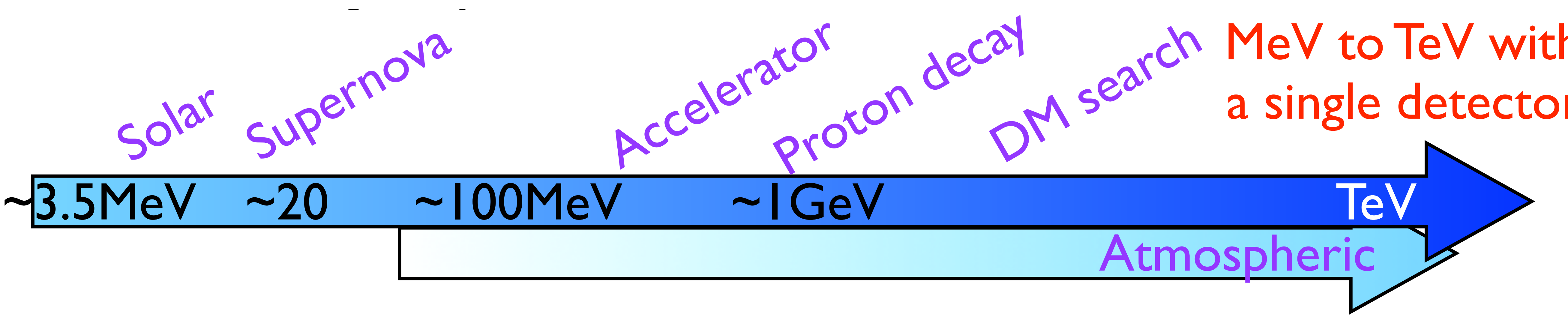
Summary

- Many new results are coming in the next few years.
- Several new experiments will be online. The decision on the new facility will occur in the near future.

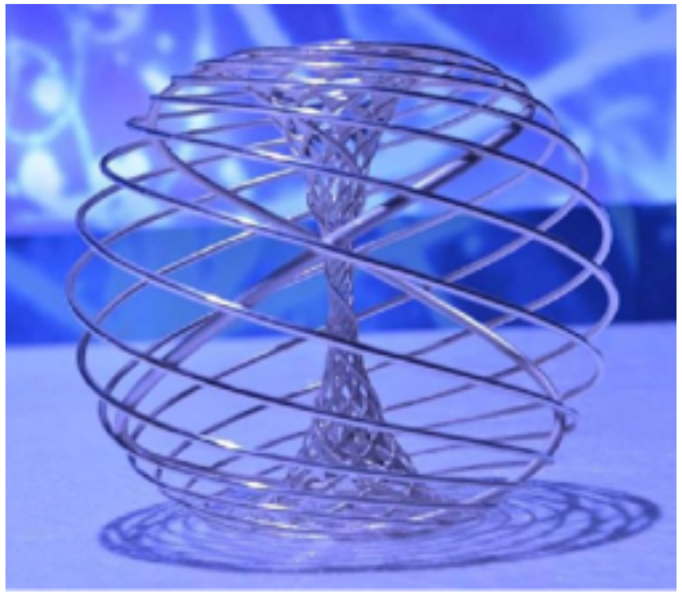
- The WIN conferences will grow including more projects in Asia.
- We pursue particle physics research with
  - Growth, Passion, Diversity and Curiosity!

Backup

Various Physics subjects



- The **mass** of the detector with the **wide energy coverage** is the Key to probe new physics.
- It is an only unique choice to search for the proton decay up to 10^{35} years.




BREAKTHROUGH
INITIATIVES