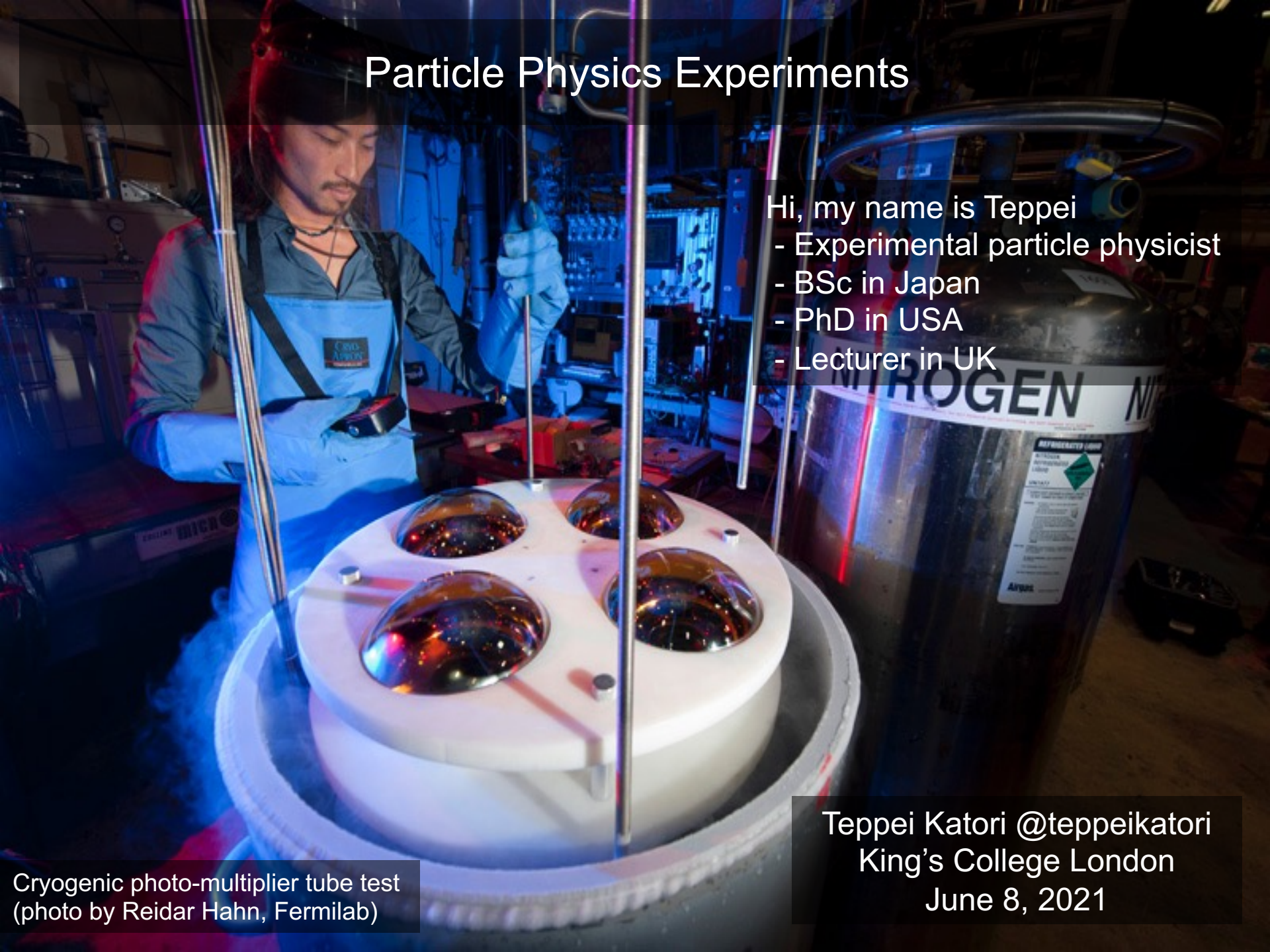
Particle Physics Experiments



Hi, my name is Teppei
- Experimental particle physicist
- BSc in Japan
- PhD in USA
- Lecturer in UK

Cryogenic photo-multiplier tube test
(photo by Reidar Hahn, Fermilab)

Teppei Katori @teppeikatori
King's College London
June 8, 2021

Particle Physics

Study matter, force, space-time with elementary particles

Origin of matter

Origin of space-time

Unification of matter, force, and space-time

etc

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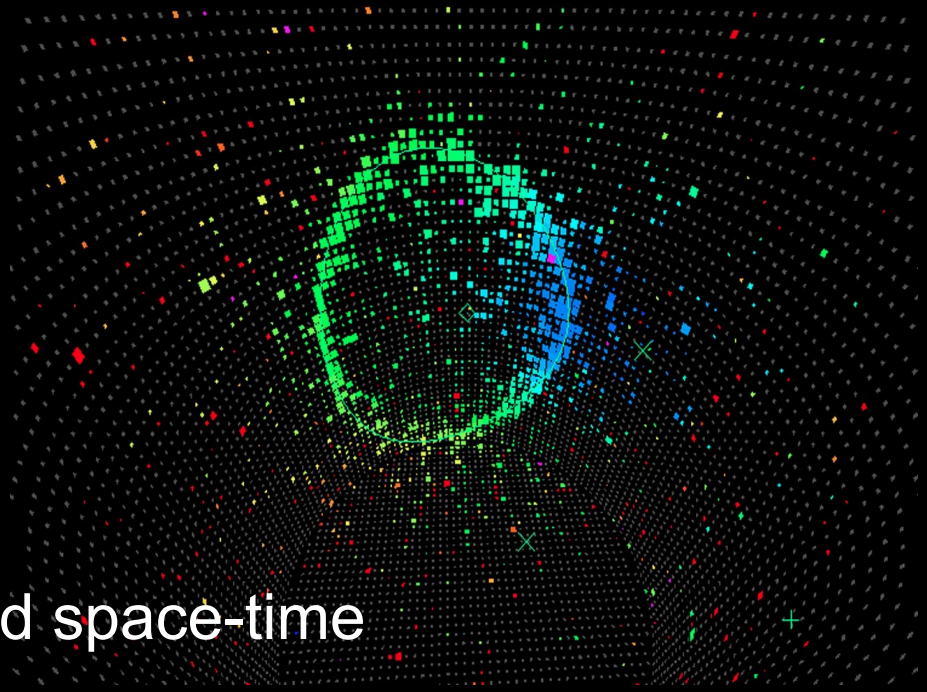
Particle Physics

Study matter, force, space-time with elementary particles



Origin of matter
→ Artificial beam experiment

Origin of space-time
→ Cosmic ray measurement

Unification of matter, force, and space-time
→ Proton decay search

etc

Experimental evidence of the world beyond our world

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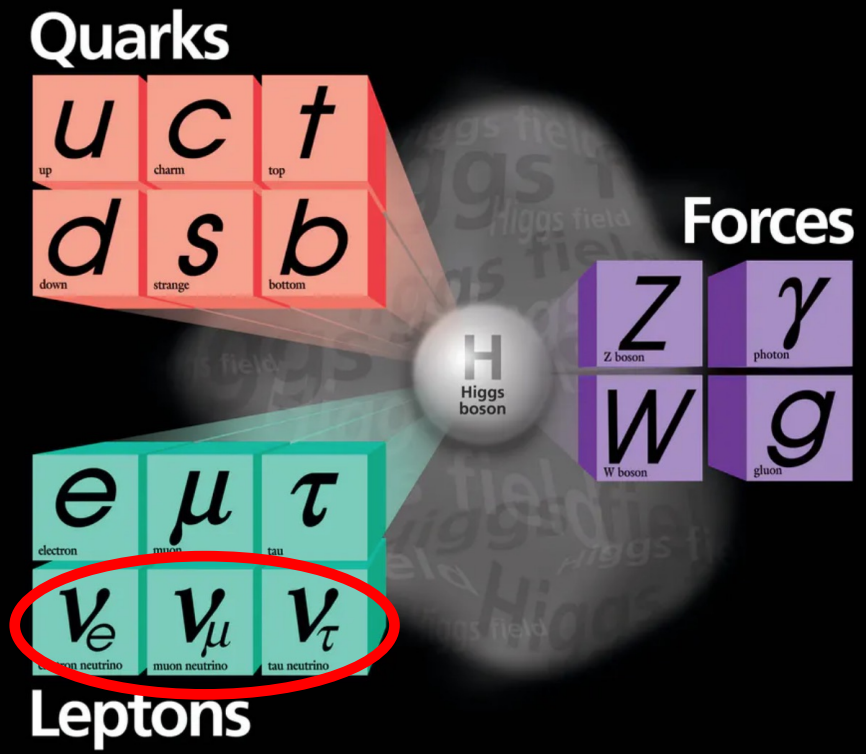
The Standard Model, Elementary Particles of the Universe

- 6 Quarks

- 6 Leptons
  - 3 neutrinos

- 3 Force carries

- The Higgs boson



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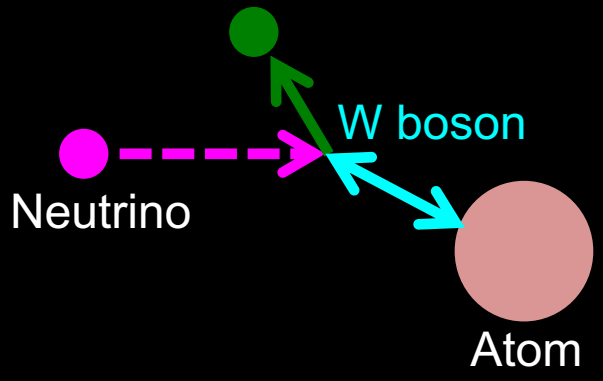
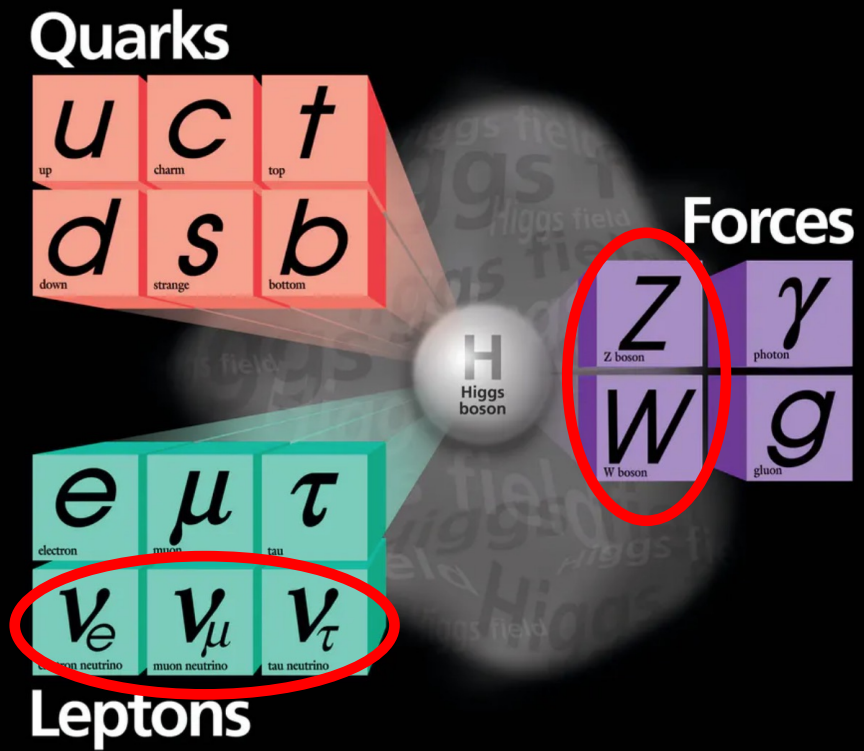
Neutrinos, Ghost particles

Neutrinos are everywhere, but very difficult to observe
→ You need extremely large detector

Neutrinos can exchange only W and Z bosons (Weak interaction)





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Neutrinos, Ghost particles

Neutrinos are everywhere, but very difficult to observe
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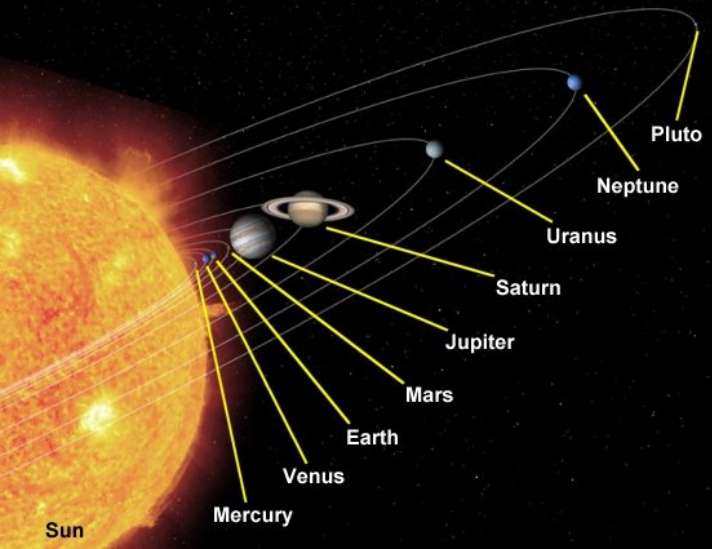
Neutrinos are produced by nuclear fusion in the Sun.

Around 1,000,000,000,000 (1 trillion) neutrinos from the Sun pass through your body every second.



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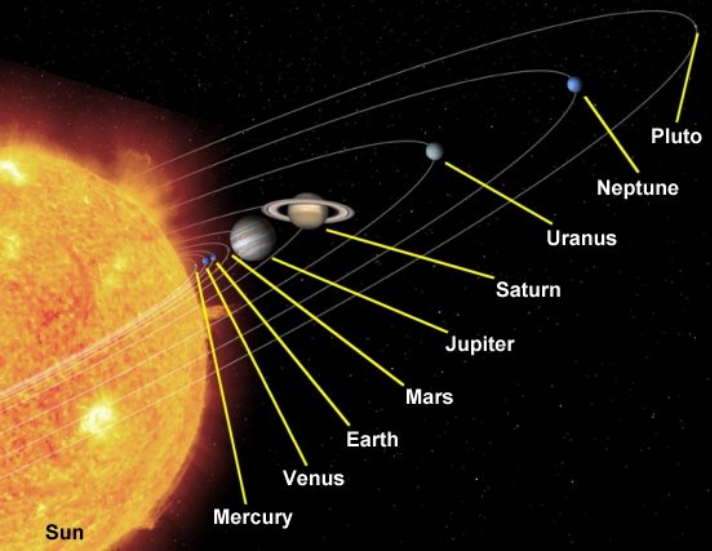
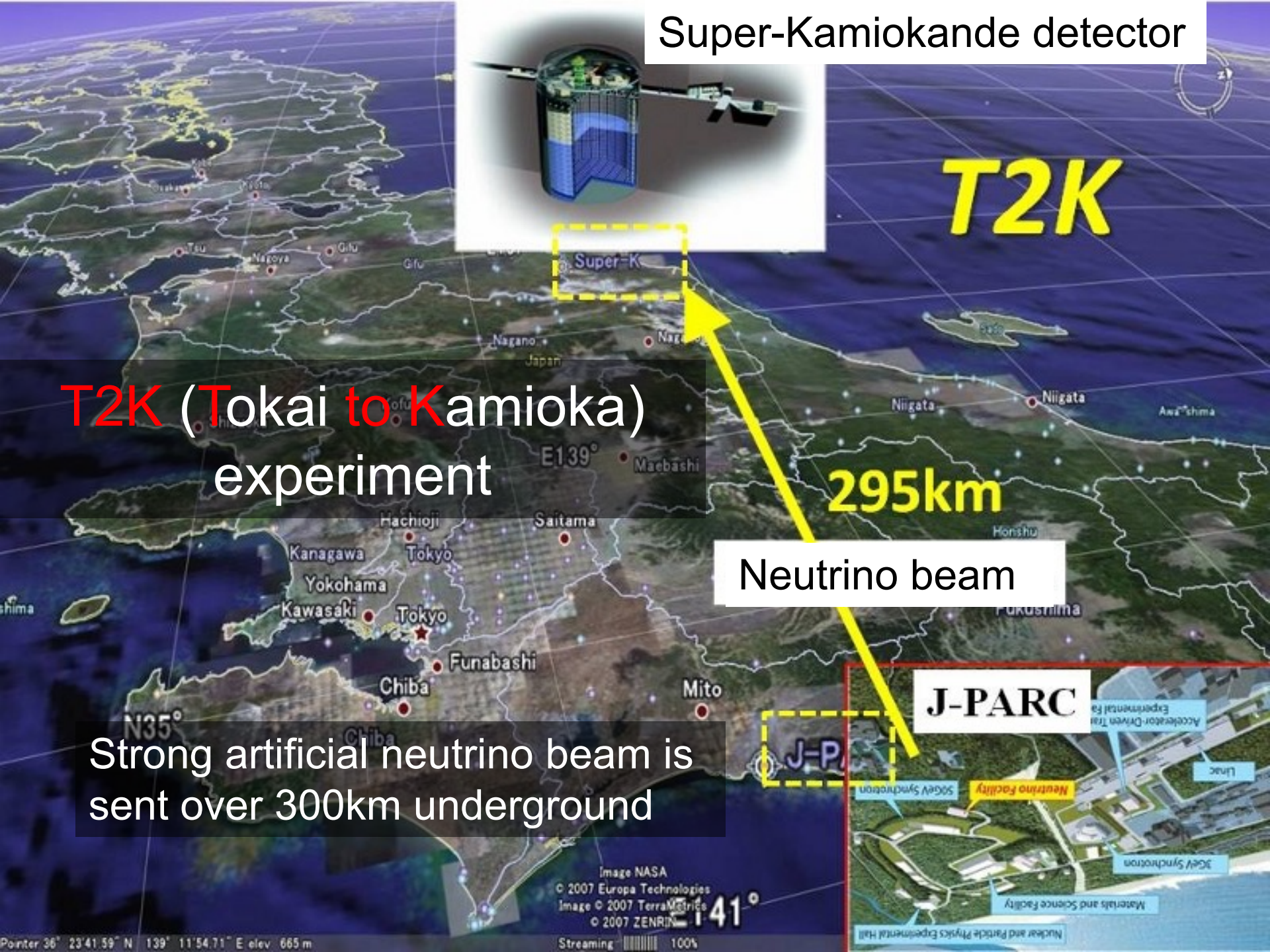


However, you have a small chance to hit 1 neutrino in your lifetime


Super-Kamiokande detector
T2K
Super-K
T2K (Tokai to Kamioka) experiment
295km
Neutrino beam
Strong artificial neutrino beam is sent over 300km underground
J-PARC
Nagano
Niigata
Hachioji
Saitama
Kanagawa
Tokyo
Yokohama
Kawasaki
Funabashi
Chiba
Mito
Honshu
Fukushima
E139°
E141°
N35°
Maebashi
Image NASA
© 2007 Europa Technologies
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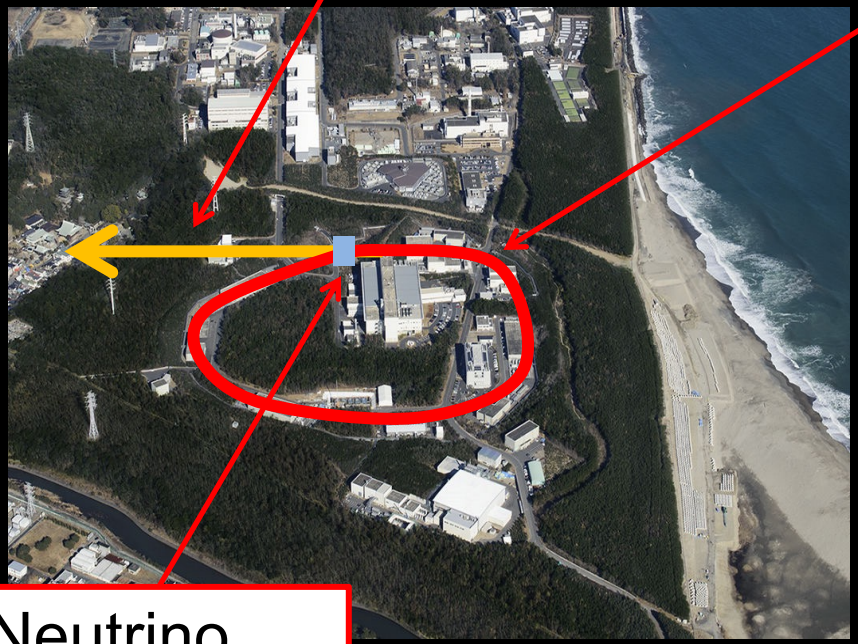
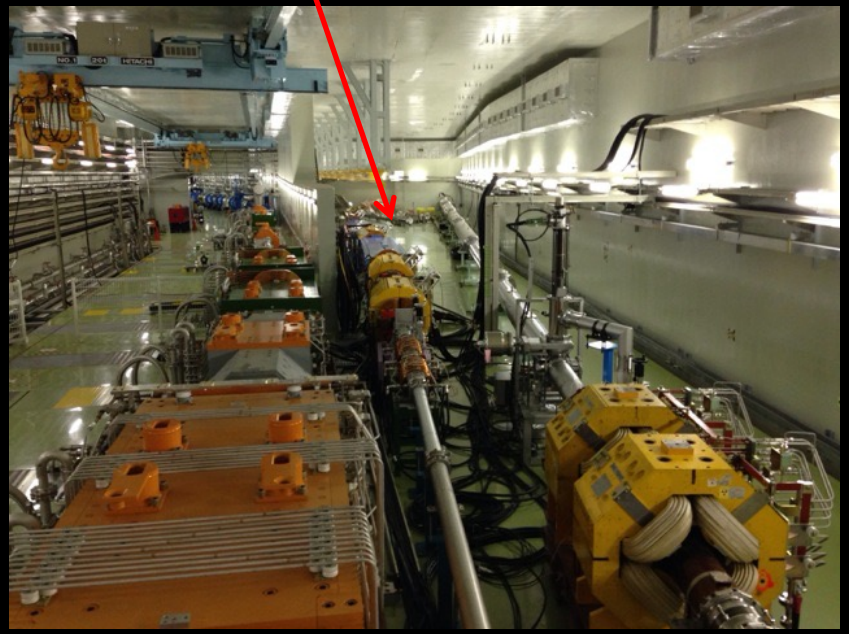
Streaming 100%

J-PARC neutrino beam

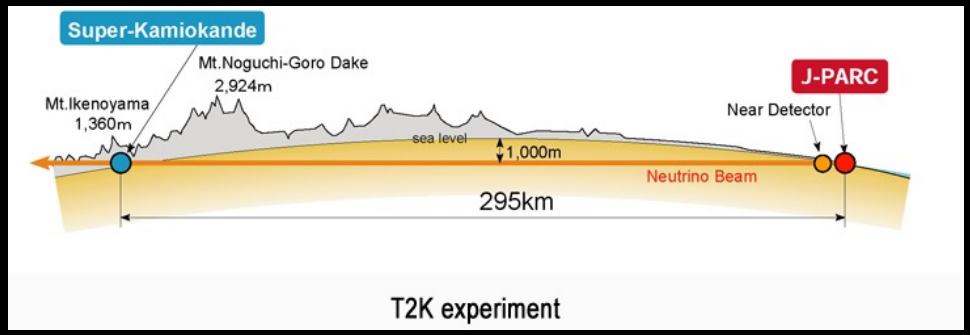
Neutrino beam

proton accelerator





Neutrino production target



T2K experiment

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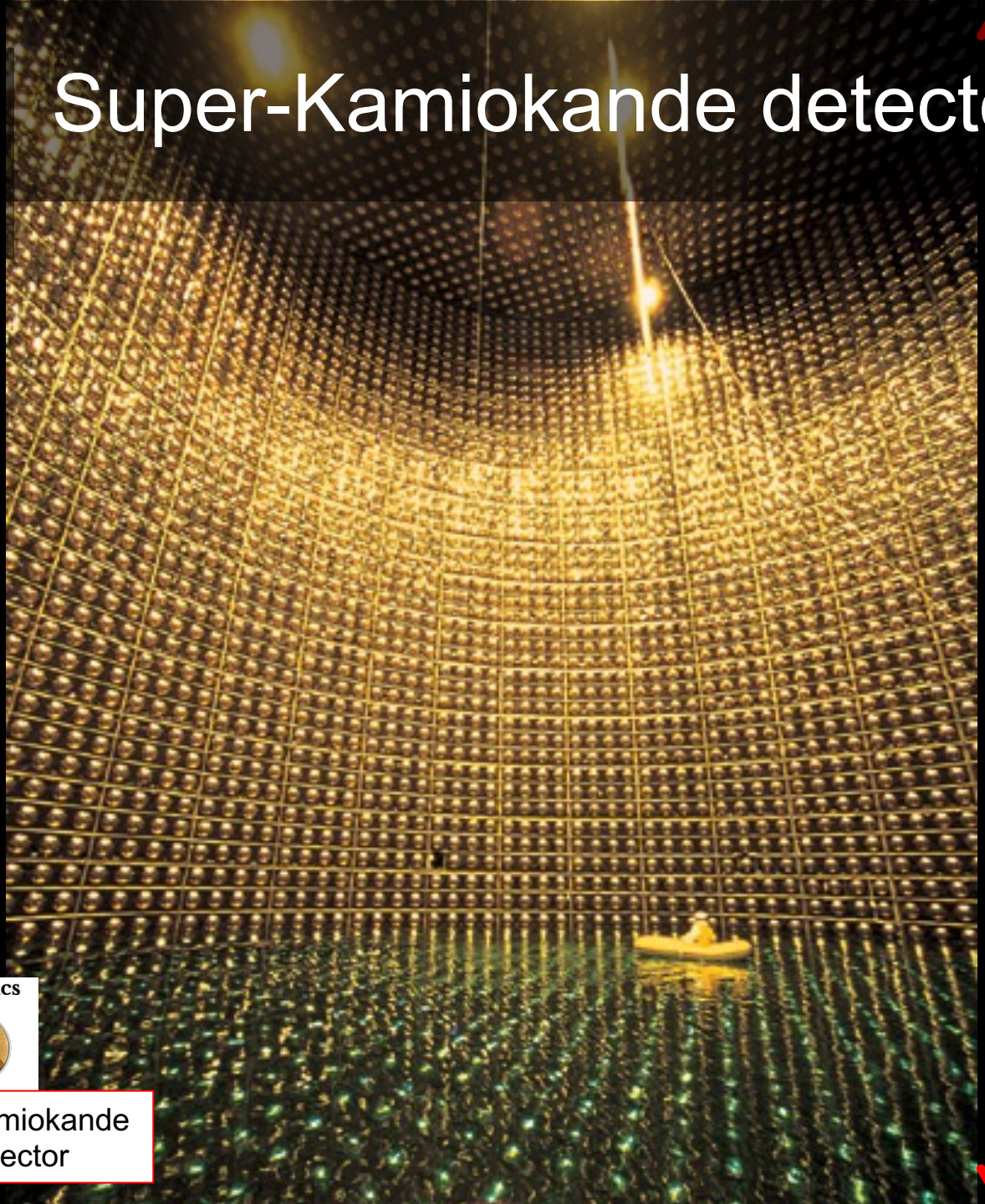
Super-Kamiokande detector

40m height, 50k ton of pure water to observe neutrinos



e Nobel Prize in Physics 2015

Takaaki Kajita, Arthur B. McDonald

Share this: 1.6K

The Nobel Prize in Physics 2015

Photo © Takaaki Kajita

Takaaki Kajita

Prize share: 1/2

Photo: K. McFarlane. Queen's University /SNOLAB

Arthur B. McDonald

Prize share: 1/2

The Nobel Prize in Physics
Kajita and Arthur B. McDo
oscillations, which shows

The Nobel Prize in Physics 2002

Raymond Davis Jr.
Prize share: 1/4

Masatoshi Koshiba
Prize share: 1/4

Kamiokande detector

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Super-Kamiokande detector

40m height, 50k ton of pure water to observe neutrinos

Neutrinos hit with water atom, and produce photons

Photo-multiplier tubes (PMTs) covered on the wall to identify neutrinos

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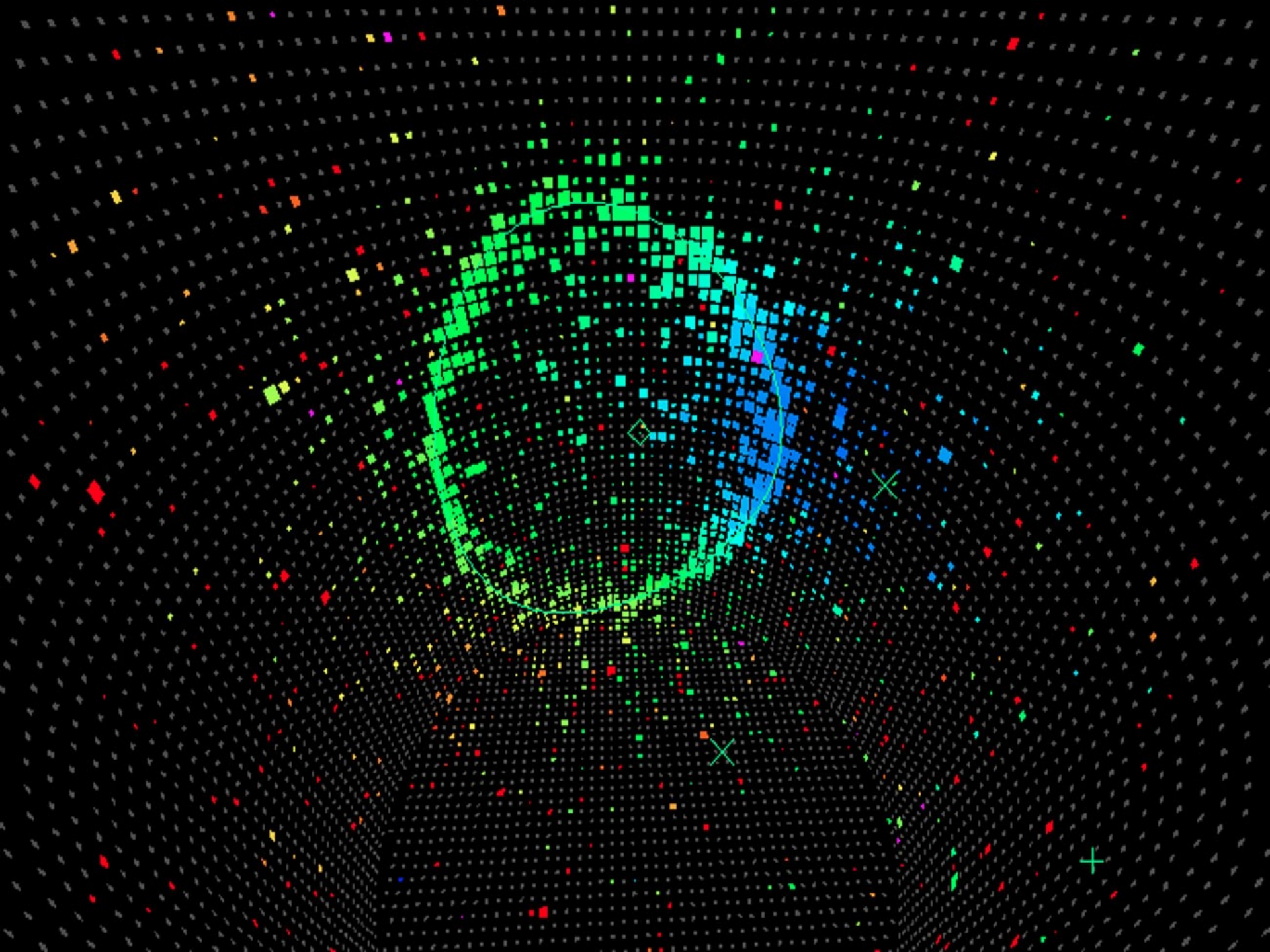
Photo-multiplier tubes (PMTs)

In bright room, 1,000,000,000,000,000,000 (10^{18}) photons are constantly hitting your hand

Neutrinos produce a few photons

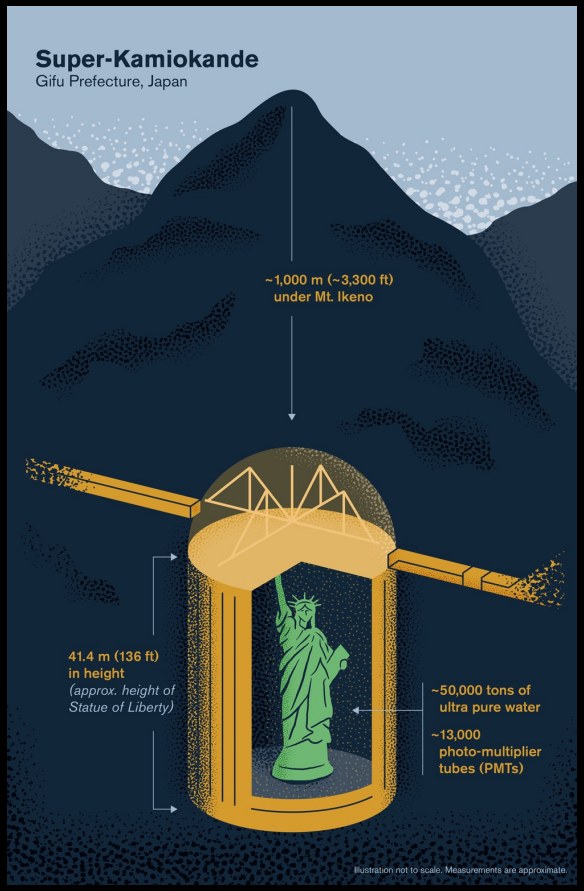
PMT can detect one photon



Super-Kamiokande detector

Kamioka (神岡), Japan

Deep mountain area, and the detector is located inside of a mountain



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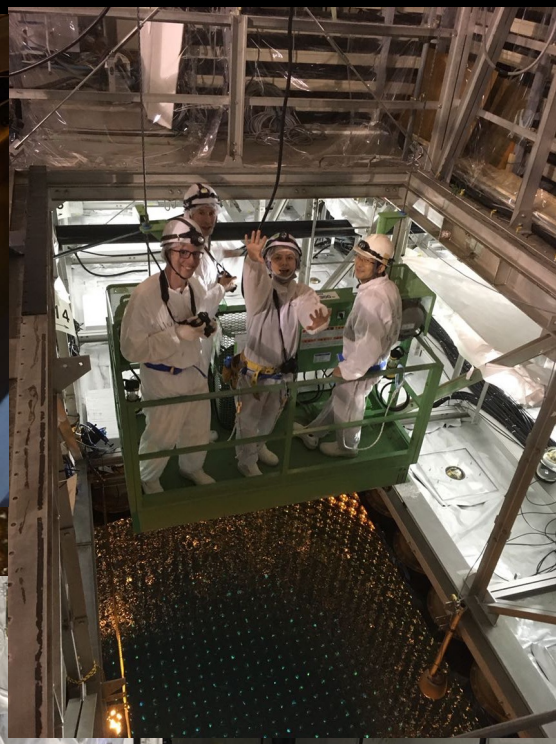
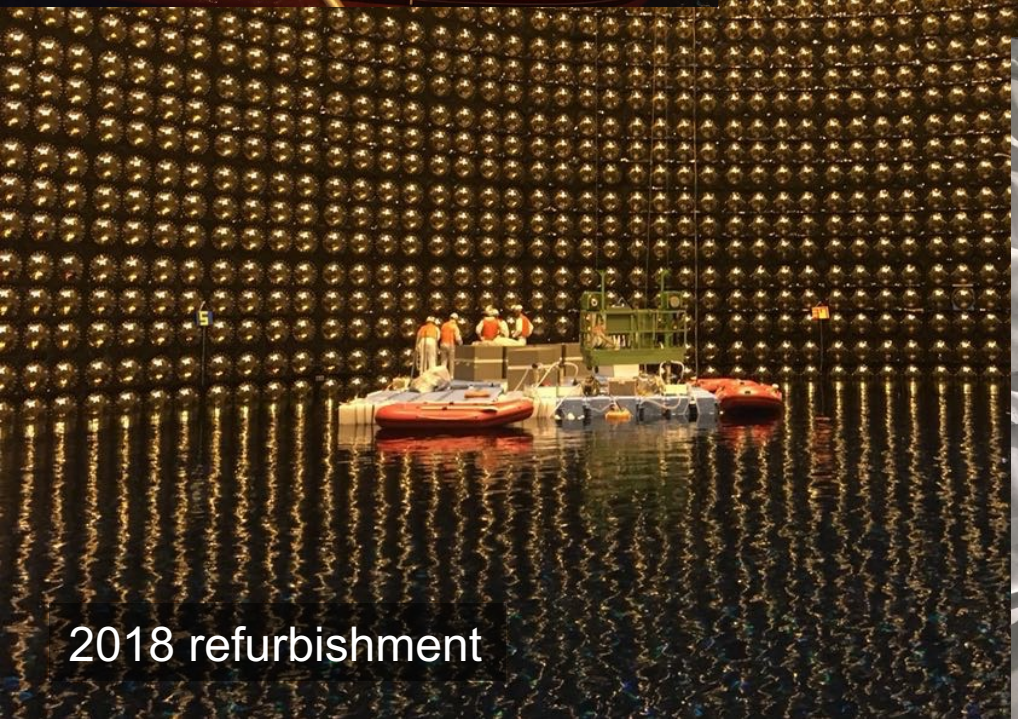
Super-Kamiokande detector

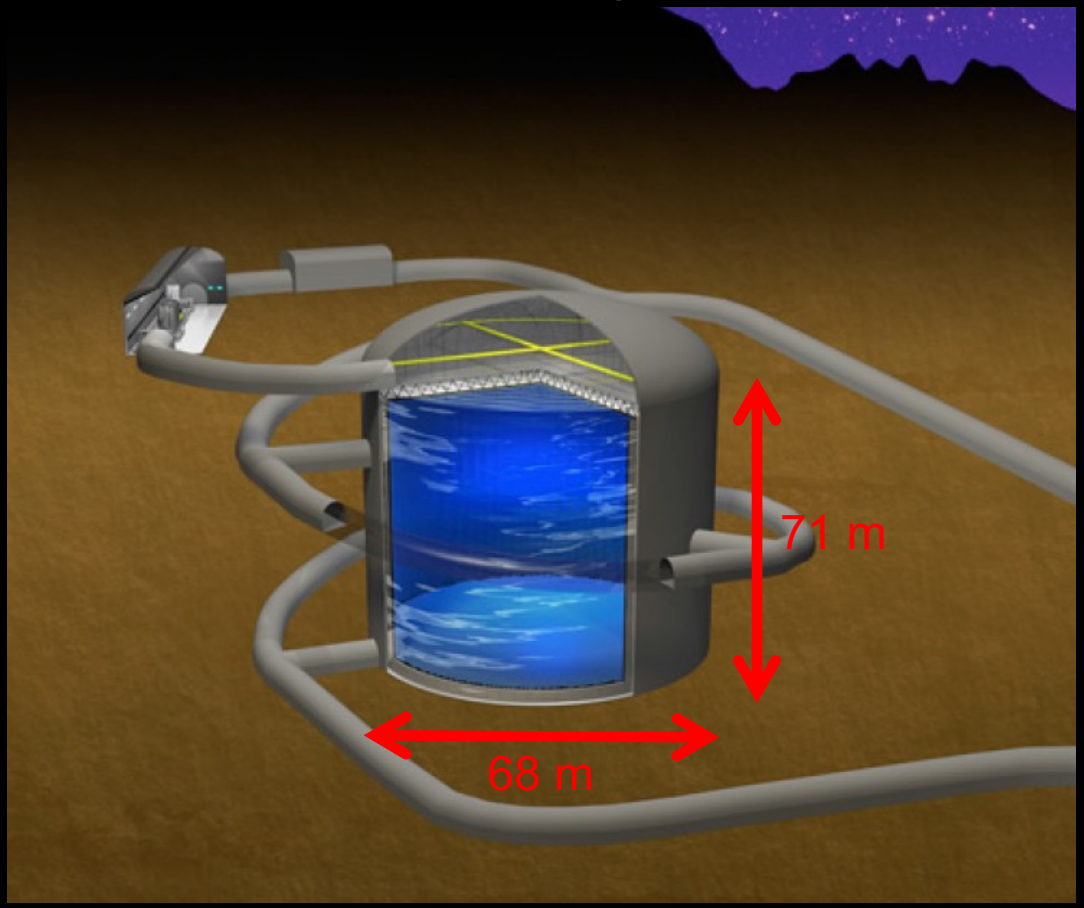




2018 refurbishment

Hyper-Kamiokande detector

We are building a new bigger water tank
- Detect more neutrinos from artificial beam, Sun, nuclear reactors, supernova, galaxies, etc



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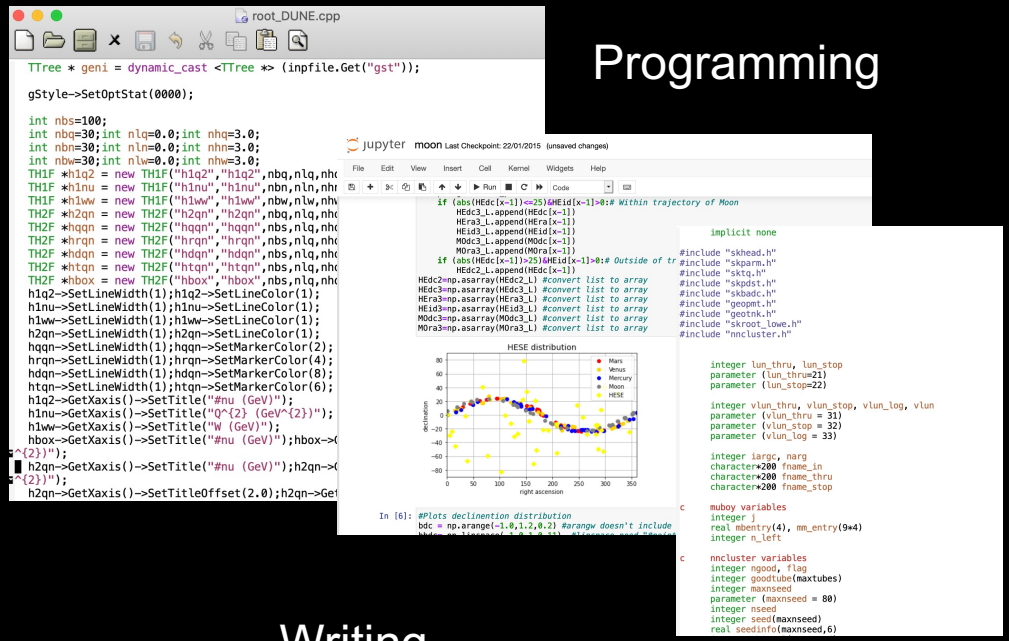
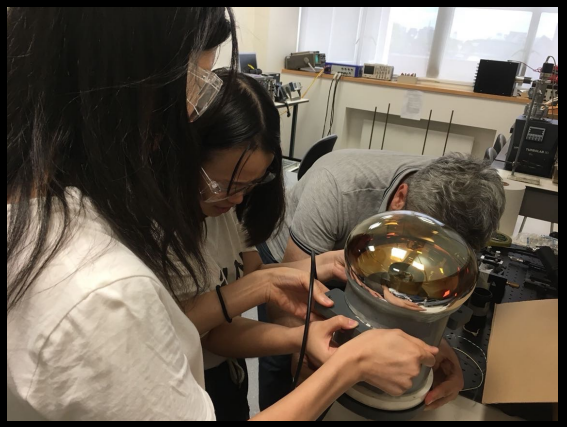
Daily life of particle physicists

Operation shift

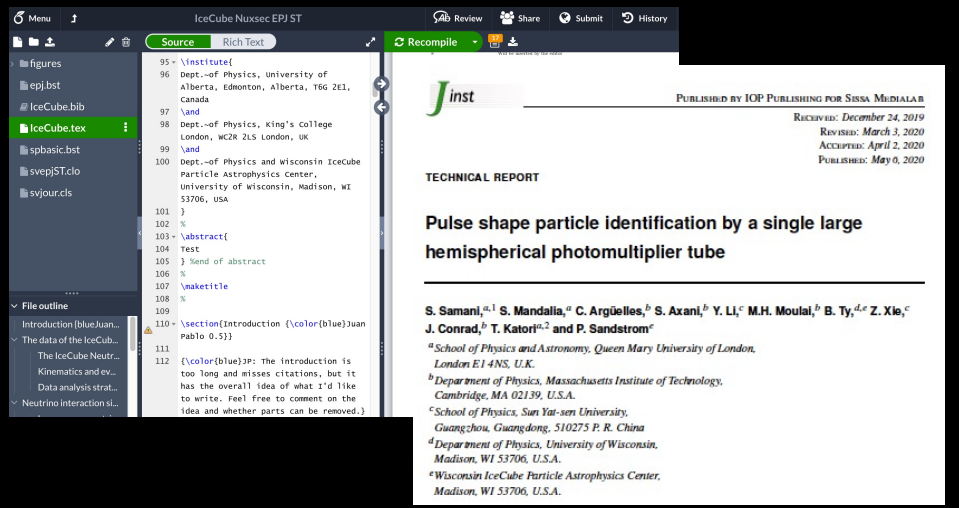
Programming



lab work



Writing



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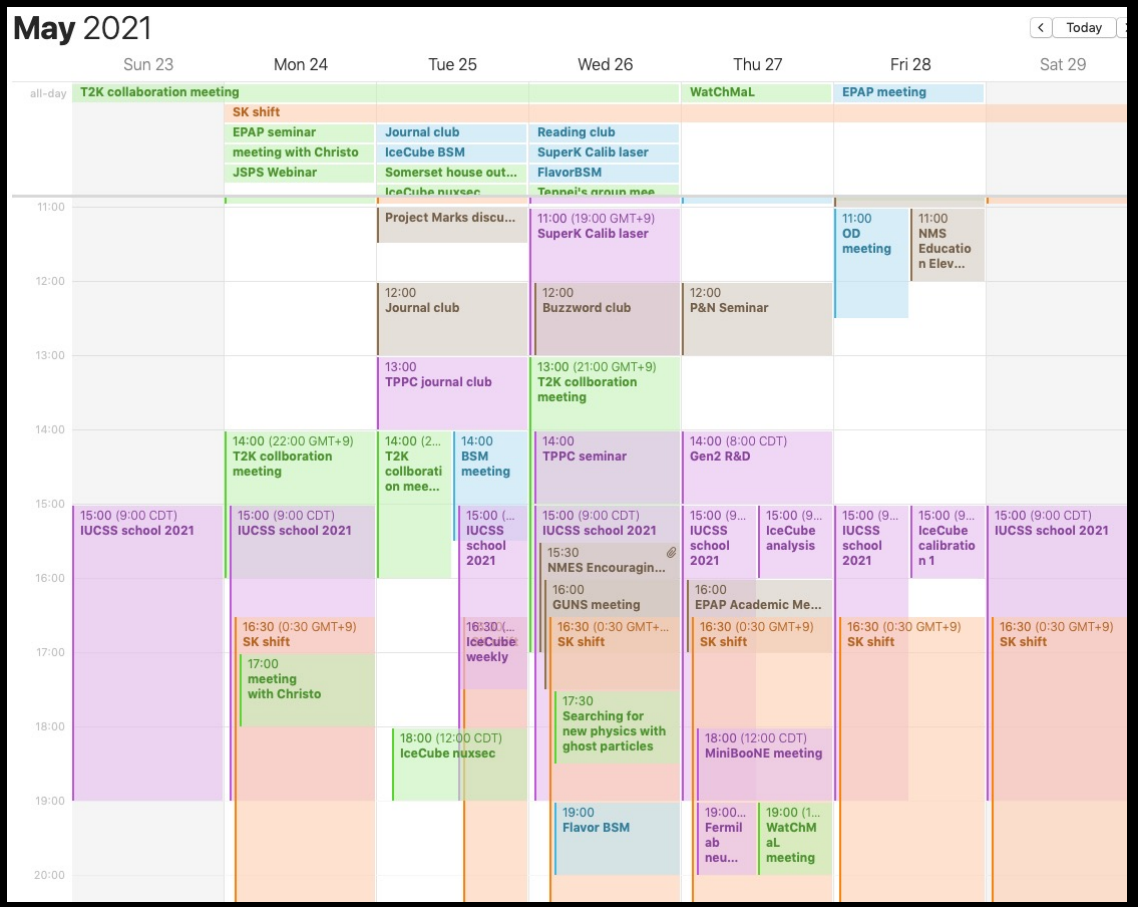
Daily life of particle physicists

Many meetings
- double, triple bookings
- unusual time (1am,etc), almost all meetings are international



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Daily life of particle physicists

IceCube Neutrino Observatory (Antarctica)
- 2 winter over operators at the South Pole right now

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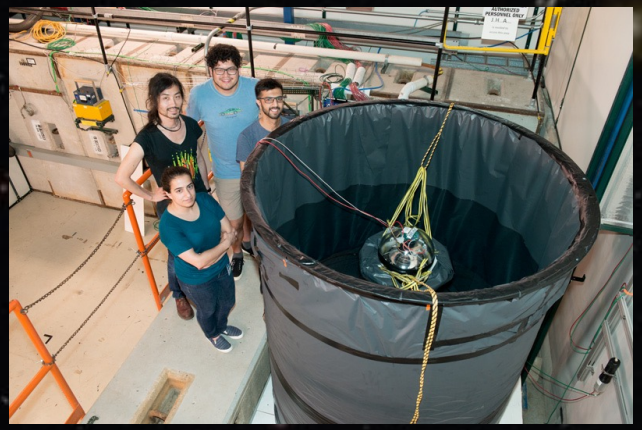

End

Particle physics is the subject to study matter, force, space-time with elementary particles.

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