Particle Physics Experiments

Hi, my name is Teppei

- Experimental particle physicist
- BSc in Japan
- PhD in USA
- Lecturer in UK

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



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

The Standard Model, Elementary Particles of the Universe

- 6 Quarks
- 6 Leptons - <mark>3 neutrinos</mark>
- 3 Force carries
- The Higgs boson





Neutrinos, Ghost particles

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



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



Neutrinos, Ghost particles

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

Super-Kamiokande detector

<u> 72K</u>

Niigata

Awa shima

T2K (Tokai to Kamioka) experiment

Kanagawa

Kawasaki 👝

Yokohama

Neutrino beam

Viigata

95km

20066A 2AUG

Strong artificial neutrino beam is sent over 300km underground

Chib

Tokyo

Tokyo

Funabashi

Pointer 36" 23'41 59" N 139" 11'54.71" E elev 665 m

fima

Image 0 2007 TerraNeries 0 2007 ZENRIN 41

Mito

Streaming 100

Saitama

Ceck Synchrotron

Nuclear and Particle Physics Experimental Hall

J-PARC

Asimo Pacifity

J-PARC neutrino beam

Neutrino beam

proton accelerator





Neutrino production target





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



Share this: f 📴 🗾 🕂 🔤 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 The Nobel Prize in Physics Kajita and Arthur B. McDo 2002







Super-Kamiokande detector

40m

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



Super-Kamiokande detector

neutrino

photons (light)

40m

Photo-multiplier tubes (PMTs)

In bright room, 1,000,000,000,000,000 (10¹⁸) 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





Super-Kamiokande detector



Hyper-Kamiokande detector

We are building a new bigger water tank

- Detect more neutrinos from artificial beam, Sun, nuclear reactors, supernova, galaxies, etc





Daily life of particle physicists

Operation shift



lab work





🗅 🗁 🚍 🗶 🔚 🥱 🐰 🖬 🖺 🔍 Programming TTree * geni = dynamic cast <TTree *> (inpfile.Get("gst")); gStyle->SetOptStat(0000): int nbs=100: int nbg=30:int nlg=0.0:int nhg=3.0: int nhn=30; int nln=0.0; int nhn=3.0; JUDYTET moon Last Checkpoint: 22/01/2015 (unsaved changes) int nbw=30; int nlw=0.0; int nhw=3.0; File Edit View Insert Cell Kernel Widgets Held TH1F *h1q2 = new TH1F("h1q2","h1q2",nbq,nlq,nhc TH1F *h1nu = new TH1F("h1nu","h1nu",nbn,nln,nhr 🖻 + • = if (hashifter[x-1]-23)detia[x-1]-8:# Within trajectary of Moon Head:___append(His[x-1]) Metral__append(His[x-1]) Moral__append(His[x-1]) Moral__append(His[x-1]) Moral__append(His[x-1]) Matchan_astray[Mid2_1]) Head: History_astray[Mid2_1]) Head: Middam_astray[Mid2_1]) Accover List to array History Status History History History Status History History History Status History if (abs(HEdc[x-1])<=25)&HEid[x-1]>0:# Within trajectory of Moon HIZF whiten = new HIZF("hrqn", "hrqn", hbs,nlq,nhc HIZF whiten = new HIZF("hrqn", "hrqn", nbs,nlq,nhc HIZF whiten = new HIZF("htqn", "htqn", nbs,nlq,nhc HIZF whiten = new HIZF("htqn", "htqn", nbs,nlq,nhc HIZF whiten = new HIZF("htqn", "htqn", nbs,nlq,nhc #include "sktq.h" #include "skpdst.h" #include "skbadc.h" #include "geopmt.h" #include "geotnk.h" #include "skroot_lowe.h" h1q2->SetLineWidth(1);h1q2->SetLineColor(1); h1nu->SetLineWidth(1);h1nu->SetLineColor(1); h1ww->SetLineWidth(1):h1ww->SetLineColor(1): h2qn->SetLineWidth(1);h2qn->SetLineColor(1); #include "nncluster.h' hqqn->SetLineWidth(1);hqqn->SetMarkerColor(2); HESE distribution hrgn->SetLineWidth(1):hrgn->SetMarkerColor(4): integer lun_thru, lun_stop parameter (lun_thru=21) parameter (lun_stop=22) hdgn->SetLineWidth(1);hdgn->SetMarkerColor(8); htqn->SetLineWidth(1);htqn->SetMarkerColor(6); h1q2->GetXaxis()->SetTitle("#nu (GeV)"); integer vlun_thru, vlun_stop, vlun_log, vlun parameter (vlun_thru = 31) h1nu->GetXaxis()->SetTitle("Q^{2} (GeV^{2})"); h1ww->GetXaxis()->SetTitle("W (GeV)"): parameter (vlun_stop = 32) parameter (vlun_log = 33) hbox->GetXaxis()->SetTitle("#nu (GeV)");hbox-> integer iargc, narg character#200 fname_in character#200 fname_thru character#200 fname_stop h2qn->GetXaxis()->SetTitle("#nu (GeV)");h2qn-> h2gn->GetXaxis()->SetTitleOffset(2.0);h2gn->Ge mubov variables In [6]: #Plots declinention distribution bdc = np.arange(-1.0,1.2,0.2) #arangw doesn't include integer j real mbentry(4), mm_entry(9*4) integer n lef nncluster variables integer ngood, flag integer goodtube(maxtubes) integer maxnseed parameter (maxnseed = 80) integer nseed integer seed(maxnseed) Writing real seedinfo(mayneeed 6) & Menu 1 Ab Review 🏻 🍟 Share Submit 🕲 History 🗅 🖿 🕹 Source Rich Text 🧈 😂 Recompile 🕞 😁 🛃 95 - \institute{ ■ figures 96 Dept of Physics, University of epj.bs Alberta, Edmonton, Alberta, T6G 2E1, inst Canada PUBLISHED BY IOP PUBLISHING FOR SISSA MEDIALAB IceCube.bib 97 \and RECEIVED: December 24, 2019 98 Dept.~of Physics, King's College IceCube.tex REVISED: March 3 2020 London, WC2R 2LS London, UK ACCEPTED: April 2, 2020 99 \and snhasic hst 100 Dept.-of Physics and Wisconsin IceCube PUBLISHED: May 0 2020 svepjST.ck Particle Astrophysics Center. TECHNICAL REPORT University of Wisconsin, Madison, WI sviour.cls 53706 1154 101 } Pulse shape particle identification by a single large 102 103 - \abstract{ 104 Test hemispherical photomultiplier tube 105 } %end of abstract 106 107 \maketitle 108 % File outline S. Samani,^{a,1} S. Mandalia,^a C. Argüelles,^b S. Axani,^b Y. Li,^c M.H. Moulai,^b B. Ty,^{d,e} Z. Xie,^c Introduction (blue Juan 110 - \section(Introduction {\color(blue)]uan J. Conrad.^b T. Katori^{a,2} and P. Sandstrom⁴ The data of the IceCub Pablo 0.5}} ^aSchool of Physics and Astronomy, Queen Mary University of London, The IceCube Neut 112 {\color{blue}JP: The introduction is London EI 4NS, U.K. Kinematics and e too long and misses citations, but it b Department of Physics, Massachusetts Institute of Technology, has the overall idea of what I'd like Cambridge MA 02139 U.S.A. to write. Feel free to comment on the eutrino interaction idea and whether parts can be removed. CSchool of Physics, Sun Yat-sen University, Guangzhou, Guangdong, 510275 P. R. China ^dDepartment of Physics, University of Wisconsin,

Madison, WI 53706, U.S.A. Wisconsin IceCube Particle Astrophysics Center, Madison, WI 53706, U.S.A.

Daily life of particle physicists

Many meetings

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

May 2021												< Today
	Sun 23 Mon 24		Tue 25		Wed 26		Thu 27		Fri 28		Sat 29	
all-day	T2K collaboration meeting							WatChMaL		EPAP meeting		
	SK shift											
	EPAP seminar		Journal club		R	eading club	ding club					
	meeting with Christo		IceCube BSM		SuperK Calib laser							
	JSPS Webinar		Somerset house out		F	FlavorBSM						
			IceCube nuxsec		Tennei's aroun mee		_					
11:00 -			Project Marks discu		11:00 (19:00 GMT+9) SuperK Calib laser					11:00 OD meeting	11:00 NMS Educatio n Elev	
12:00 -			12:00 Journal club		1 E	12:00 Buzzword club		12:00 P&N Seminar				
13:00 -				13:00 TPPC journal club		13:00 (21:00 GMT+9) T2K collboration meeting						
14:00 -		14:00 (22:00 GMT+9) T2K collboration meeting	14:00 (2 T2K collborati on mee	14:00 BSM meeting	1	4:00 PPC seminar	1	14:00 (8:00 0 Gen2 R&D	CDT)			
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16:00		16:30 (0:30 GMT+9)		16:30)(16:00 GUNS meeting 16:30 (0:30 GMT+		16:00 EPAP Acade	emic Me	16:30 (0:30) GMT+9)	16:30 (0:30 GMT+9)
17:00		SK shift 17:00 meeting with Christo		IceCube weekly		SK shift 17:30		SK shift		SK shift		SK shift
18:00			18:00 (12: IceCube r	00 CDT) nuxsec		searching for new physics with ghost particles		18:00 (12:0 MiniBooN	DO CDT) E meeting			
19:00						19:00 Flavor BSM		19:00 Fermil ab neu	19:00 (1 WatChM aL meeting			
20:00												



Daily life of particle physicists

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









Particle physics is the subject to study matter, force, spacetime with elementary particles.

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