How Hitoshi Helped Me Become The Gdfather

(and also Father Christmas)

Mark Vagins

Kavli IPMU, University of Tokyo/UC Irvine

HitoshiFest @ Kavli IPMU

December 18, 2024

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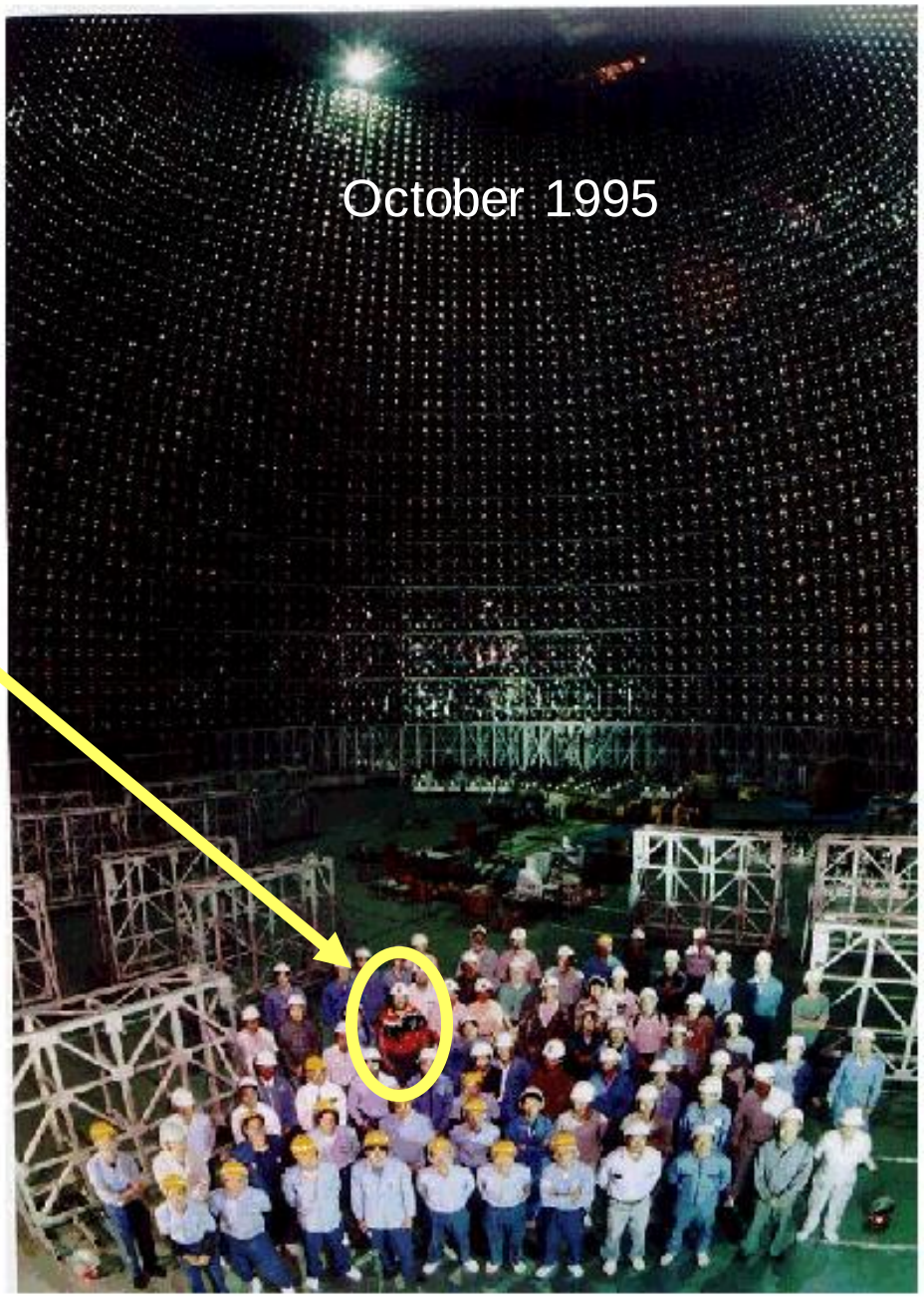
I've been a part of Super-Kamiokande (and wearing brightly-colored shirts) from its very early days…

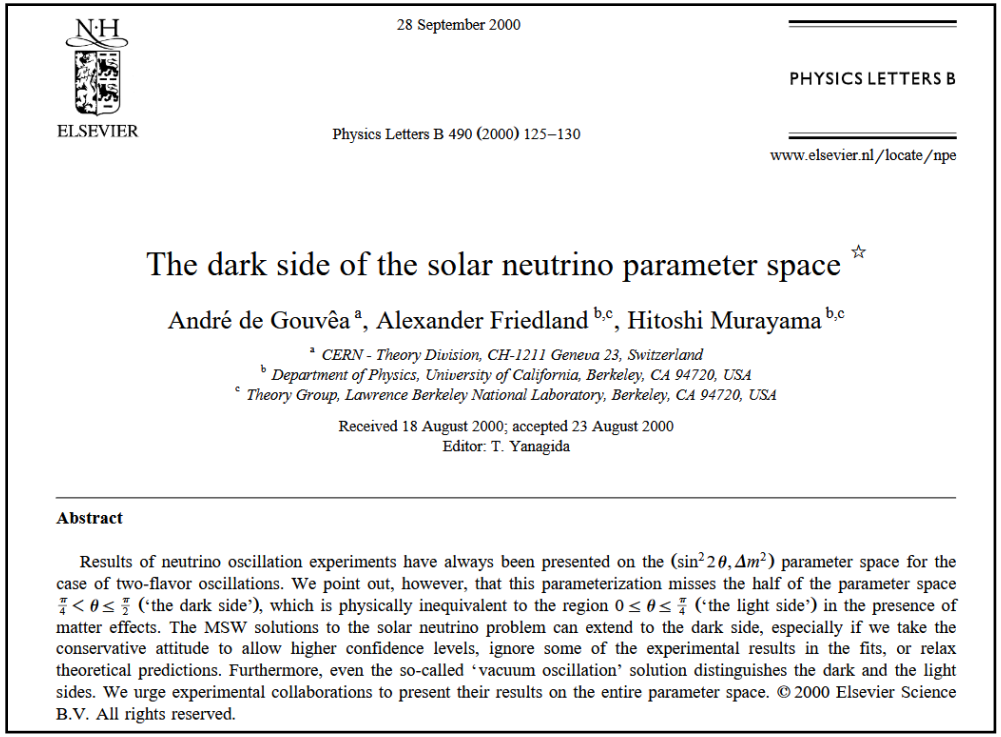
January 1996



Between 1998 and 2014 I served as a leader of Super-K's solar and supernova neutrino analysis group.

It was in this capacity that I first became aware of Hitoshi's work:

This paper, whose very abstract insisted (correctly) there was a better way to present solar neutrino data, caused quite a stir in the halls and meeting rooms of the Kamioka Observatory in the year 2000.



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28 September 2000

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Physics Letters B 490 (2000) 125–130

www.elsevier.nl/locate/npe

The dark side of the solar neutrino parameter space ☆

André de Gouvêa [a], Alexander Friedland [b,c], Hitoshi Murayama [b,c]

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[b] *Department of Physics, University of California, Berkeley, CA 94720, USA*
[c] *Theory Group, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA*

Received 18 August 2000; accepted 23 August 2000
Editor: T. Yanagida

Abstract

Results of neutrino oscillation experiments have always been presented on the $(\sin^2 2\theta, \Delta m^2)$ parameter space for the case of two-flavor oscillations. We point out, however, that this parameterization misses the half of the parameter space $\frac{\pi}{4} < \theta \leq \frac{\pi}{2}$ ('the dark side'), which is physically inequivalent to the region $0 \leq \theta \leq \frac{\pi}{4}$ ('the light side') in the presence of matter effects. The MSW solutions to the solar neutrino problem can extend to the dark side, especially if we take the conservative attitude to allow higher confidence levels, ignore some of the experimental results in the fits, or relax theoretical predictions. Furthermore, even the so-called 'vacuum oscillation' solution distinguishes the dark and the light sides. We urge experimental collaborations to present their results on the entire parameter space.

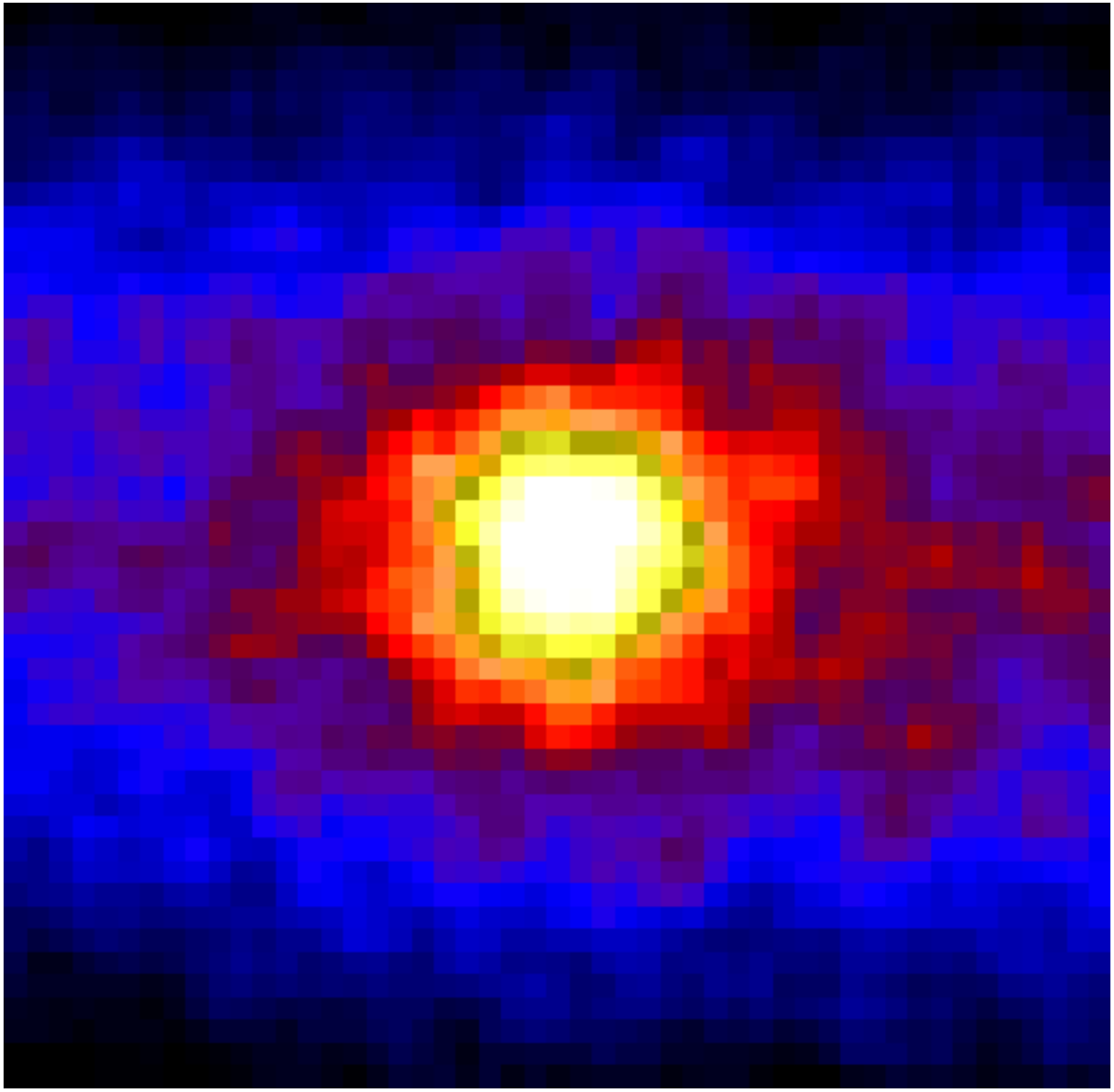
Two years later, I was drawn into a related squabble between Yoichiro Suzuki, who had just been promoted from being the Japanese leader of the solar and supernova group to the Spokesperson of Super-K, and Hitoshi, who was then a member of the Particle Data Group.

Hitoshi requested a certain plot to be created by Super-K for inclusion in the latest edition of the PDG handbook, and Yoichiro was not too pleased about it.

Such occasional drama aside, things were going well for our solar and supernova neutrino group.

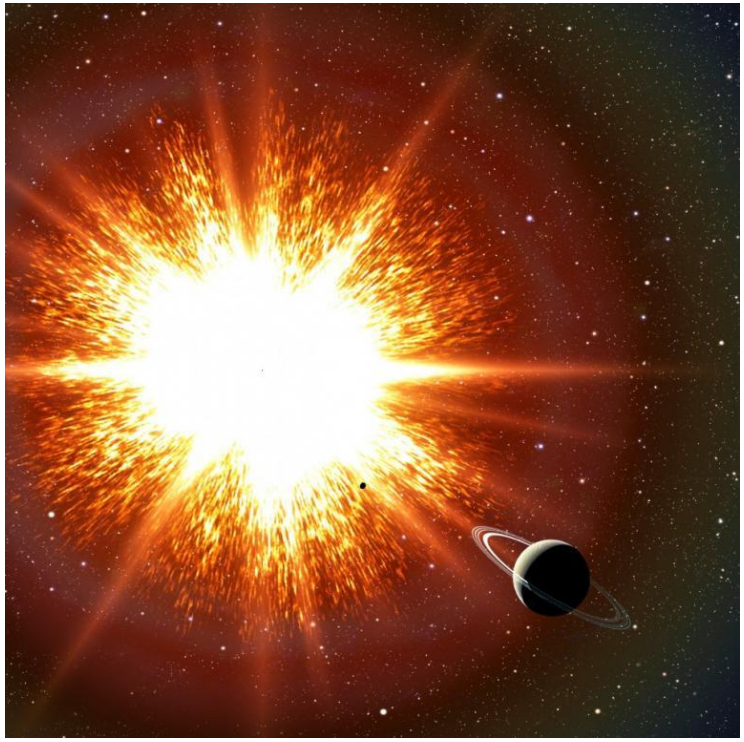
Here's a remarkable Super-K picture of the Sun imaged in MeV solar neutrino "light":

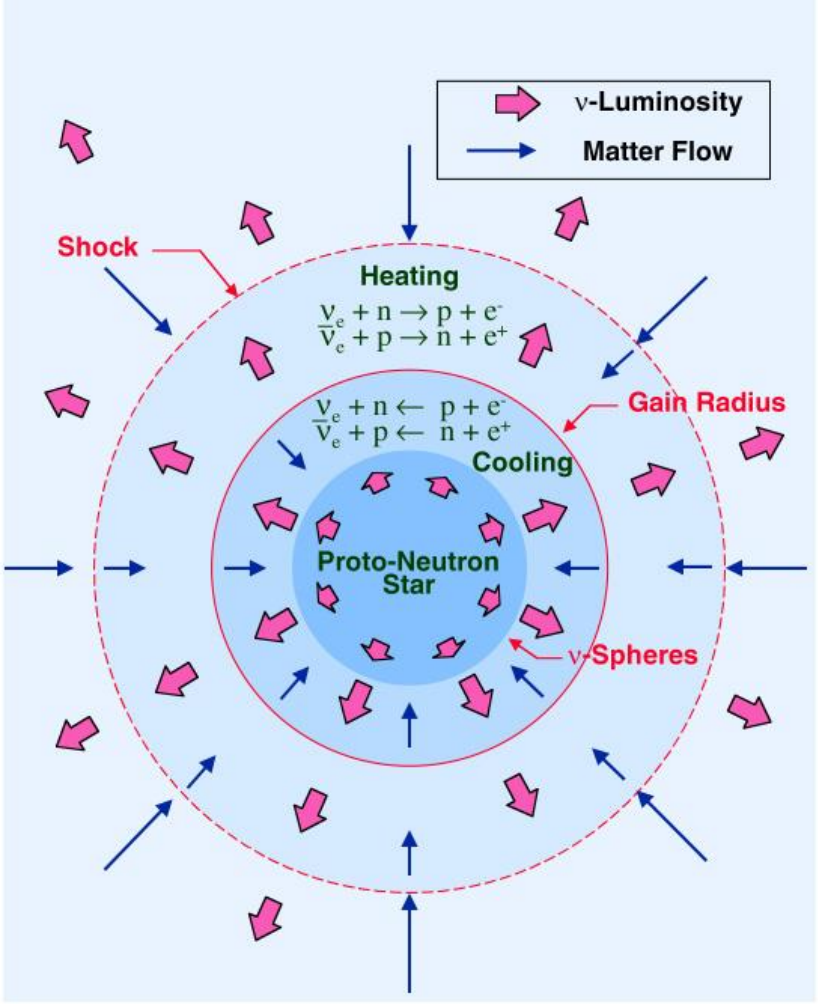
But what about supernova neutrinos?



A core-collapse supernova is a nearly perfect "neutrino bomb".

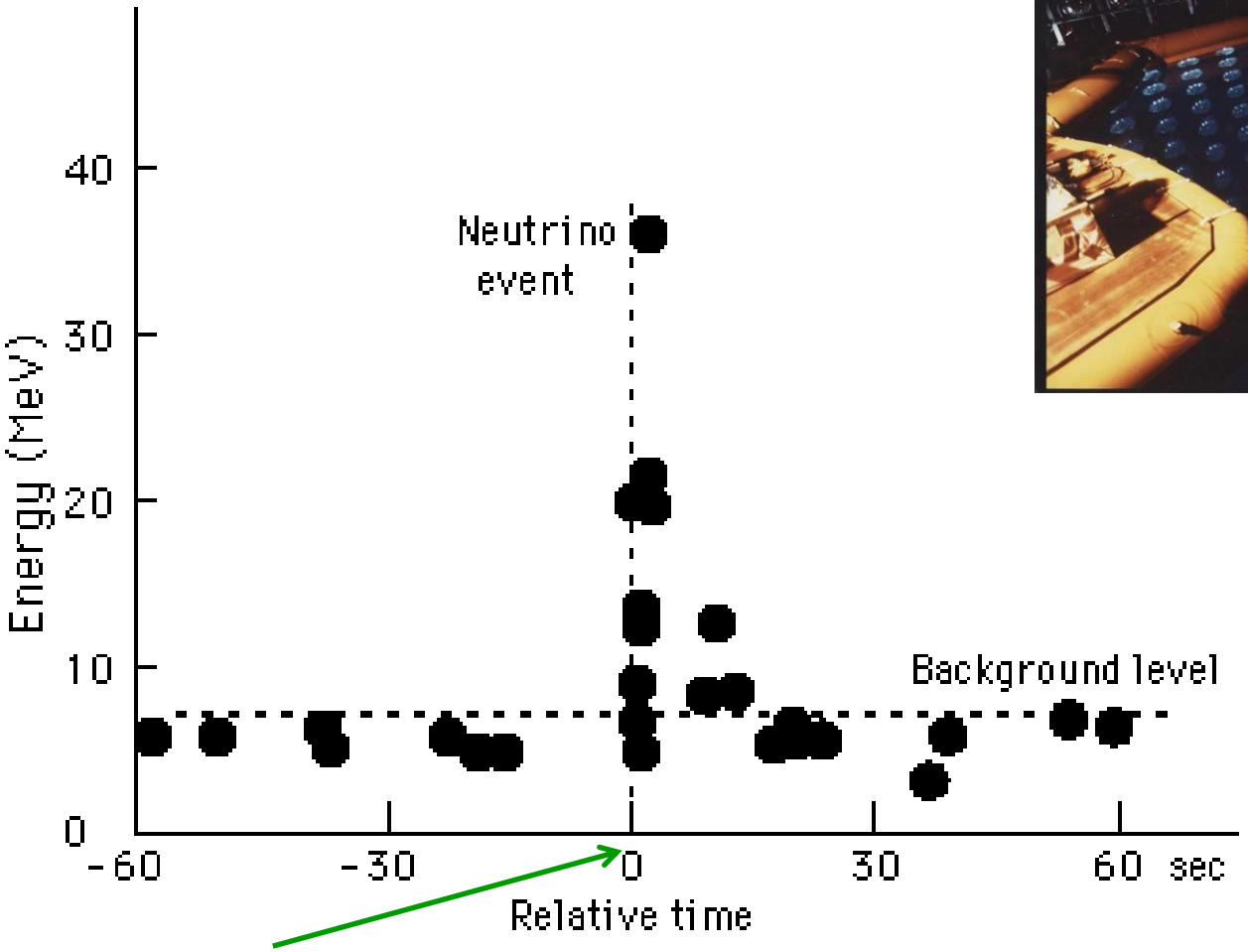
Within ten seconds of collapse it releases >98% of its huge energy (equal to 10^{12}, hydrogen bombs exploding every second since the beginning of the universe!) as neutrinos.

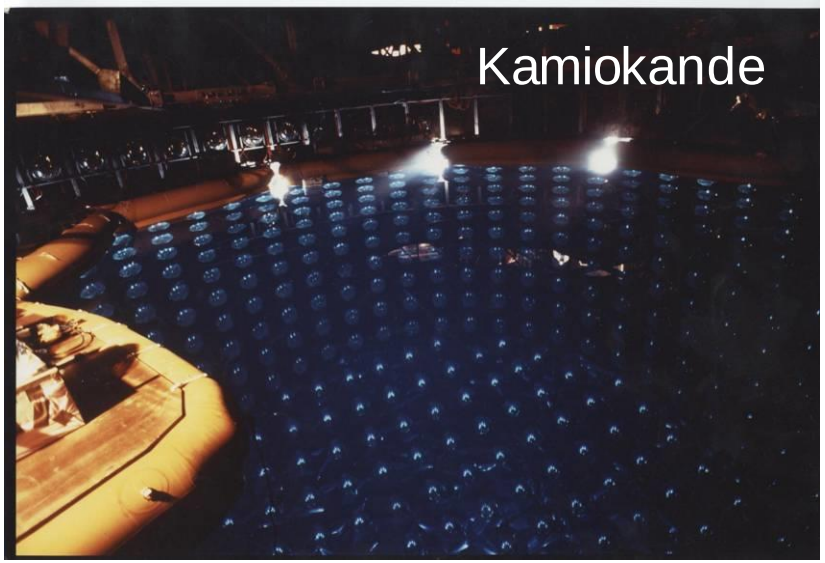


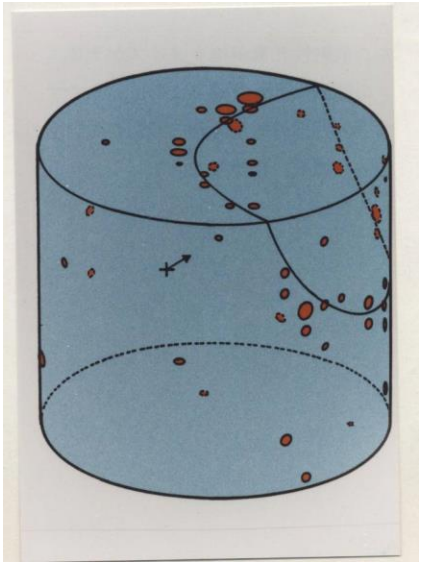


Neutrinos, along with gravitational waves, provide the only possible windows into core collapses' inner dynamics.

Kamiokande's Burst Time Structure

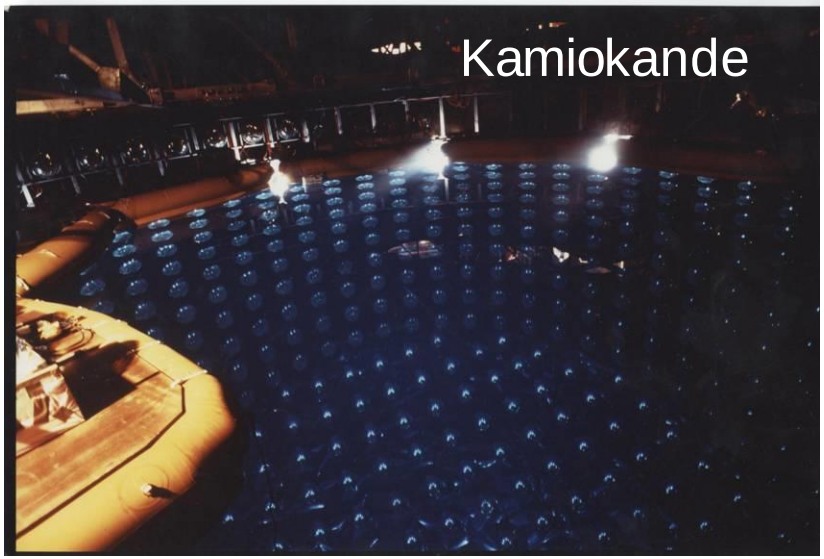


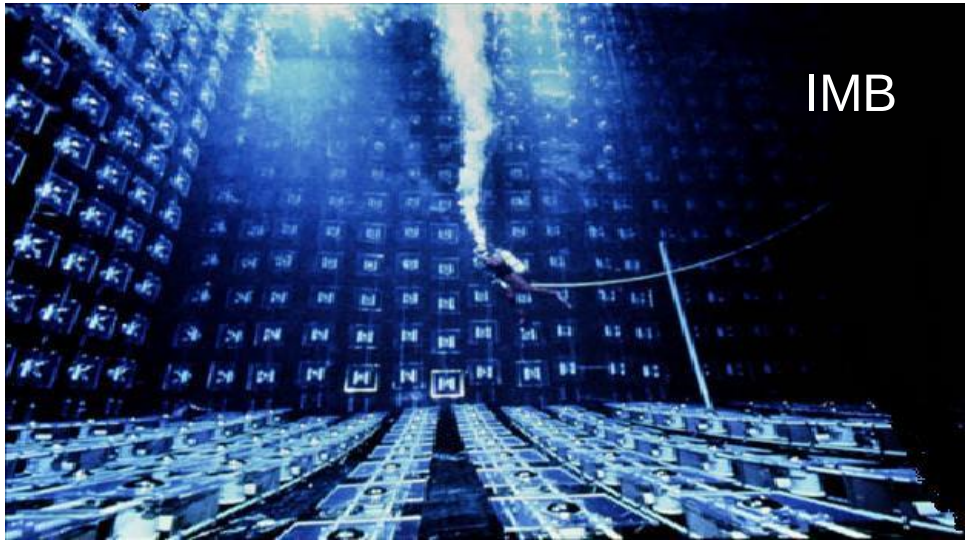


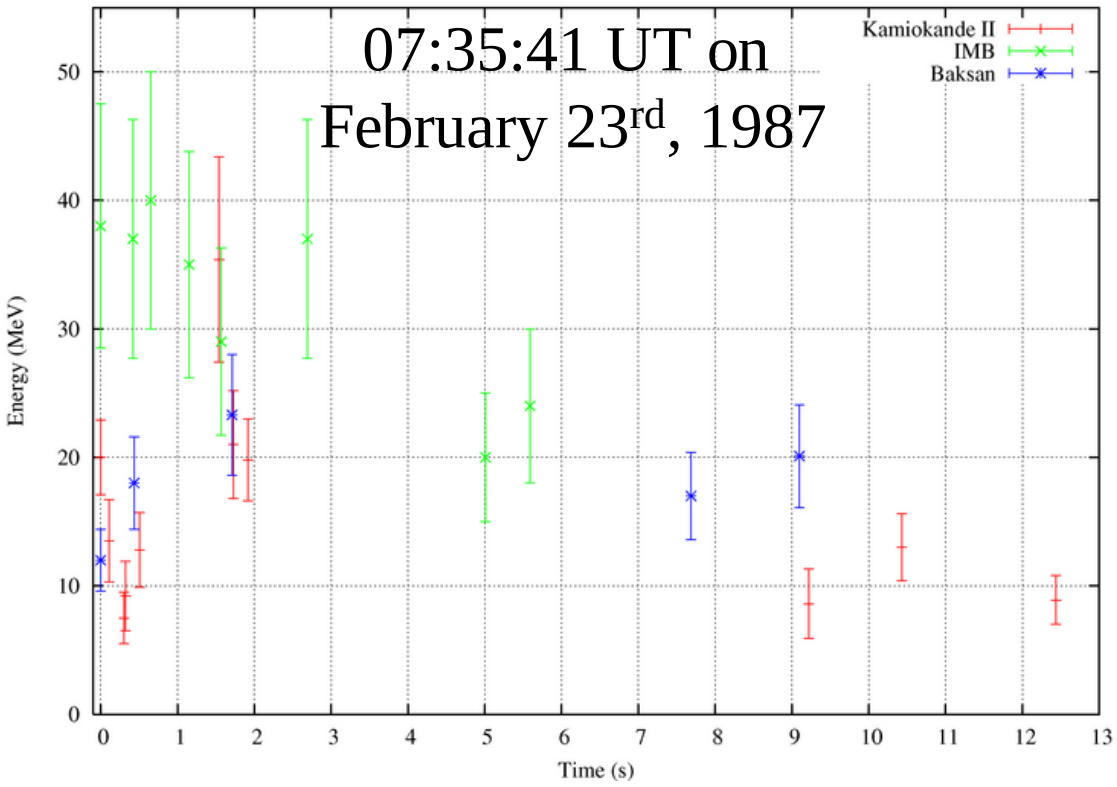


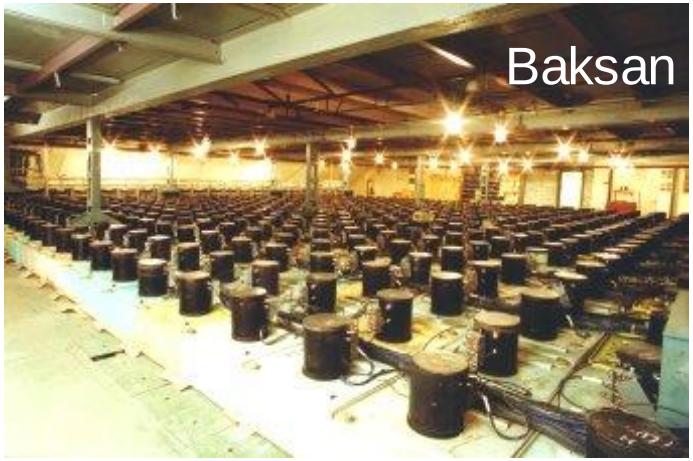
16:35:41 JST on February 23rd, 1987

SN1987A's neutrinos also seen simultaneously by IMB (in the US) and Baksan (in the Soviet Union)







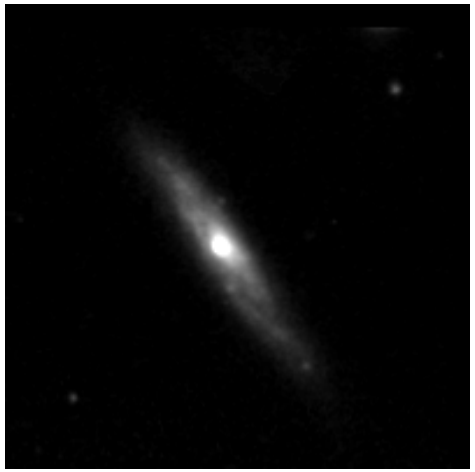


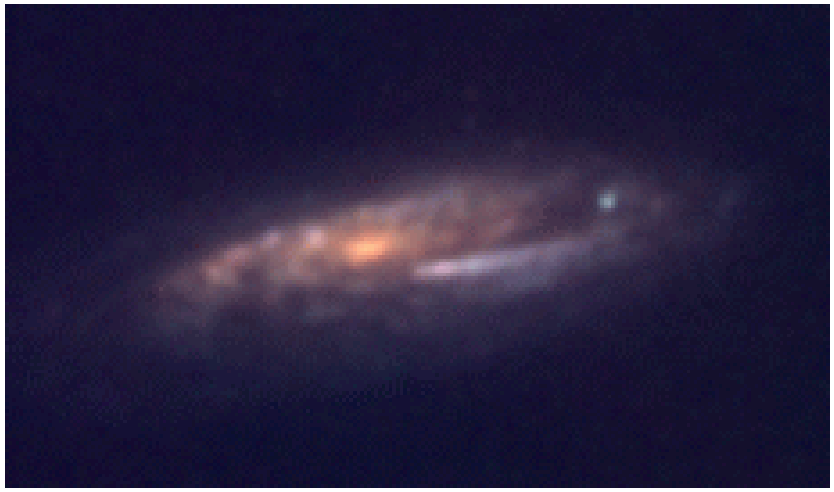
These 24 supernova neutrinos remain the only ones observed.

So, how can we be certain to see more supernova neutrinos without having to wait too long?

This is not the typical view of a supernova! Which, of course… is good.

Yes, nearby supernova explosions may be rare, but supernova explosions are extremely common.





Here's how most supernovas look to us (video is looped).

There is about ***one SN explosion per second*** in the universe as a whole.

These produce the as-yet unobserved diffuse supernova neutrino background [DSNB], also known as the supernova relic neutrinos [SRN].

"Everyone complains about the (supernova neutrino) weather, but no one *does* anything about it…"

So, after one of the sessions at Neutrino 2002 in Munich, theorist John Beacom and I spent a couple of hours sitting in a subway station, brainstorming ideas.

arXiv > hep-ph > arXiv:hep-ph/0309300

Search... Help

High Energy Physics - Phenomenology

[Submitted on 26 Sep 2003]

GADZOOKS! Antineutrino Spectroscopy with Large Water Cerenkov Detectors

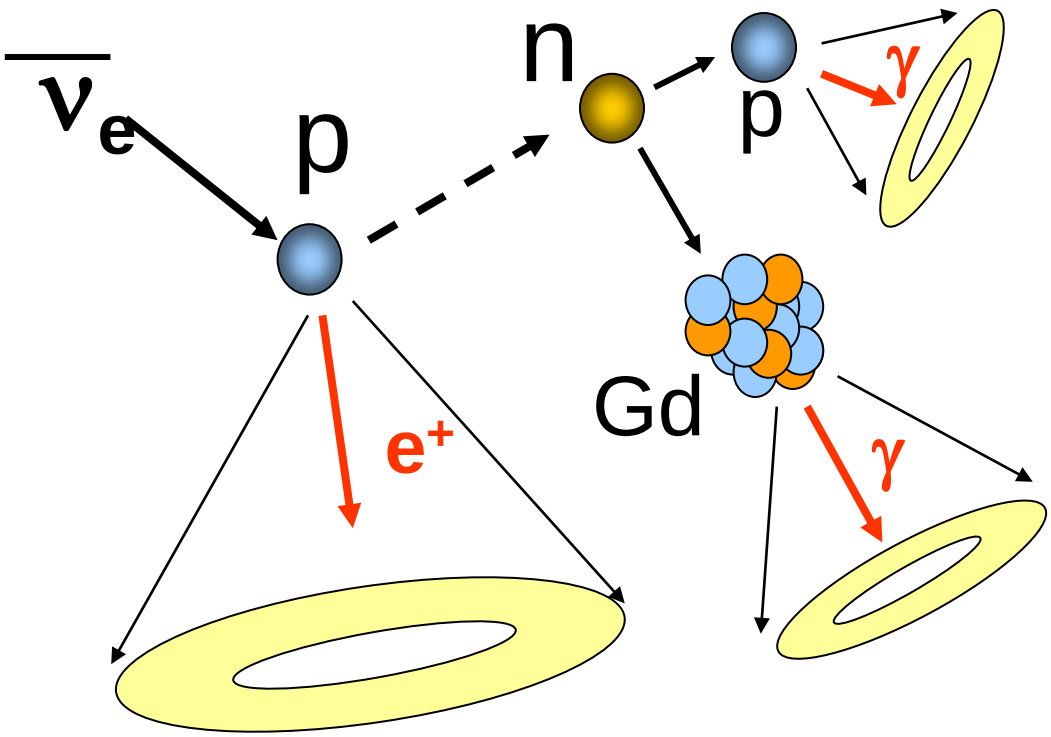
John F. Beacom, Mark R. Vagins

We propose modifying large water Čerenkov detectors by the addition of 0.2% gadolinium trichloride, which is highly soluble, newly inexpensive, and transparent in solution. Since Gd has an enormous cross section for radiative neutron capture, with $\sum E_\gamma = 8$ MeV, this would make neutrons visible for the first time in such detectors, allowing antineutrino tagging by the coincidence detection reaction $\bar{\nu}_e + p \to e^+ + n$ (similarly for $\bar{\nu}_\mu$). Taking Super-Kamiokande as a working example, dramatic consequences for reactor neutrino measurements, first observation of the diffuse supernova neutrino background, Galactic supernova detection, and other topics are discussed.

Comments: 4 pages, 1 figure, submitted to Phys. Rev Lett. Correspondence to beacom@fnal.gov, mvagins@uci.edu
Subjects: **High Energy Physics - Phenomenology (hep-ph)**; Astrophysics (astro-ph); High Energy Physics - Experiment (hep-ex); Nuclear Experiment (nucl-ex); Nuclear Theory (nucl-th)
Report number: FERMILAB-Pub-03/249-A
Cite as: arXiv:hep-ph/0309300
(or arXiv:hep-ph/0309300v1 for this version)
https://doi.org/10.48550/arXiv.hep-ph/0309300
Journal reference: Phys.Rev.Lett. 93 (2004) 171101
Related DOI: https://doi.org/10.1103/PhysRevLett.93.171101

[*Phys. Rev. Lett.* 93 (2004) 171101 has exactly 591 citations!]

Basically, we said, "Let's add 0.2% of a water soluble gadolinium compound to Super-K!"



Positron and gamma ray vertices are within ~50 cm.

Possibility 1: 10% or less

$n+p \rightarrow d + \gamma$

2.2 MeV γ-ray

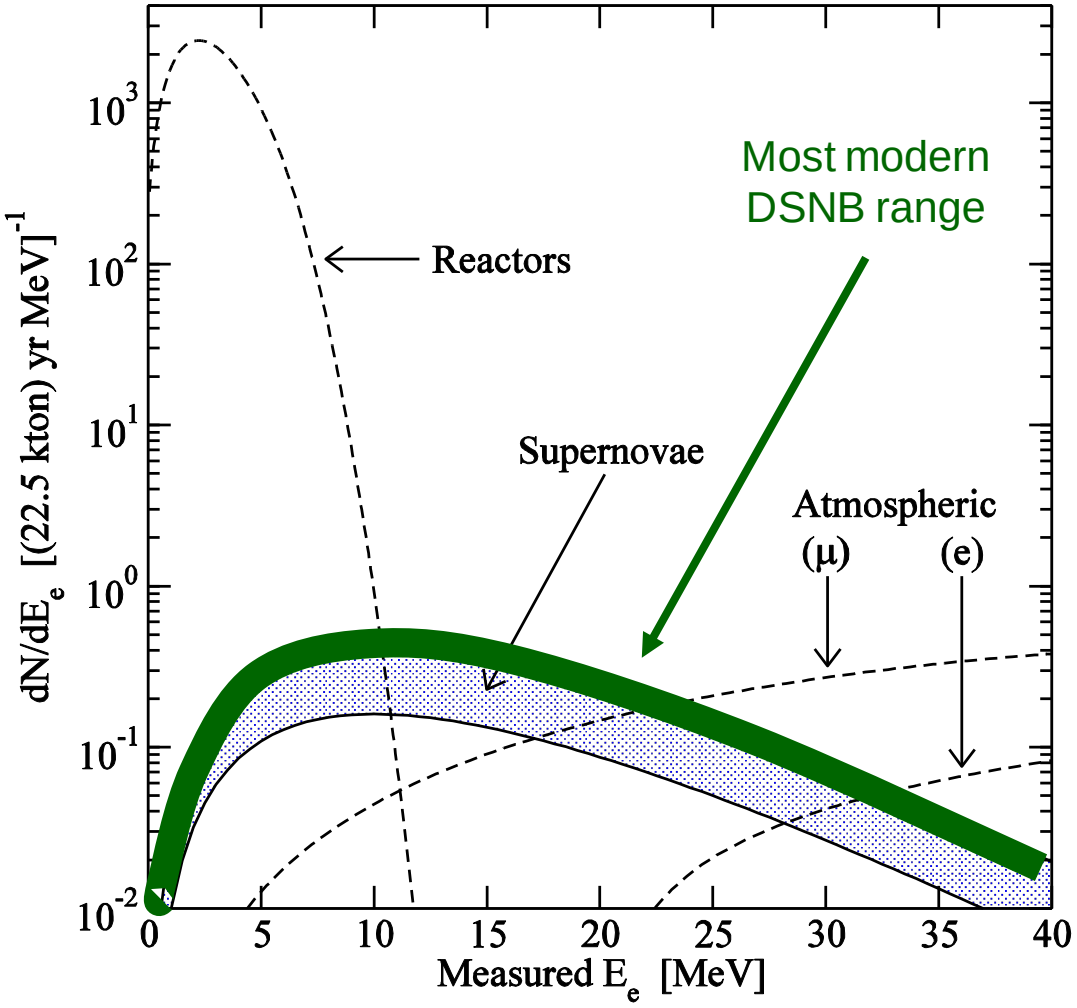
Possibility 2: 90% or more

$n+Gd \rightarrow$ ~8MeV γ

ΔT = ~30 μsec

$\overline{\nu}_e$ can be identified by delayed coincidence.

Here's what the coincident signals in Super-K with $GdCl_3$ or $Gd_2(SO_4)_3$ will look like (energy resolution is applied):



$\bar{\nu}_e + p \rightarrow e^+ + n$

spatial and temporal separation between prompt e^+ Cherenkov light and delayed Gd neutron capture gamma cascade:

λ=~4 cm, τ=~30 μs

→ Up to a few events/yr in Super-K with Gd

Gadzooks!

[A Serious SK Upgrade Suggestion]

Mark Vagins
University of California, Irvine

Osawano
November 11, 2002

Here's the very first transparency (i.e., what we older folks used before PowerPoint but after glass slides) I ever showed on the topic…
over twenty-two years ago.

Please note the subtitle:

"A Serious SK Upgrade Suggestion"

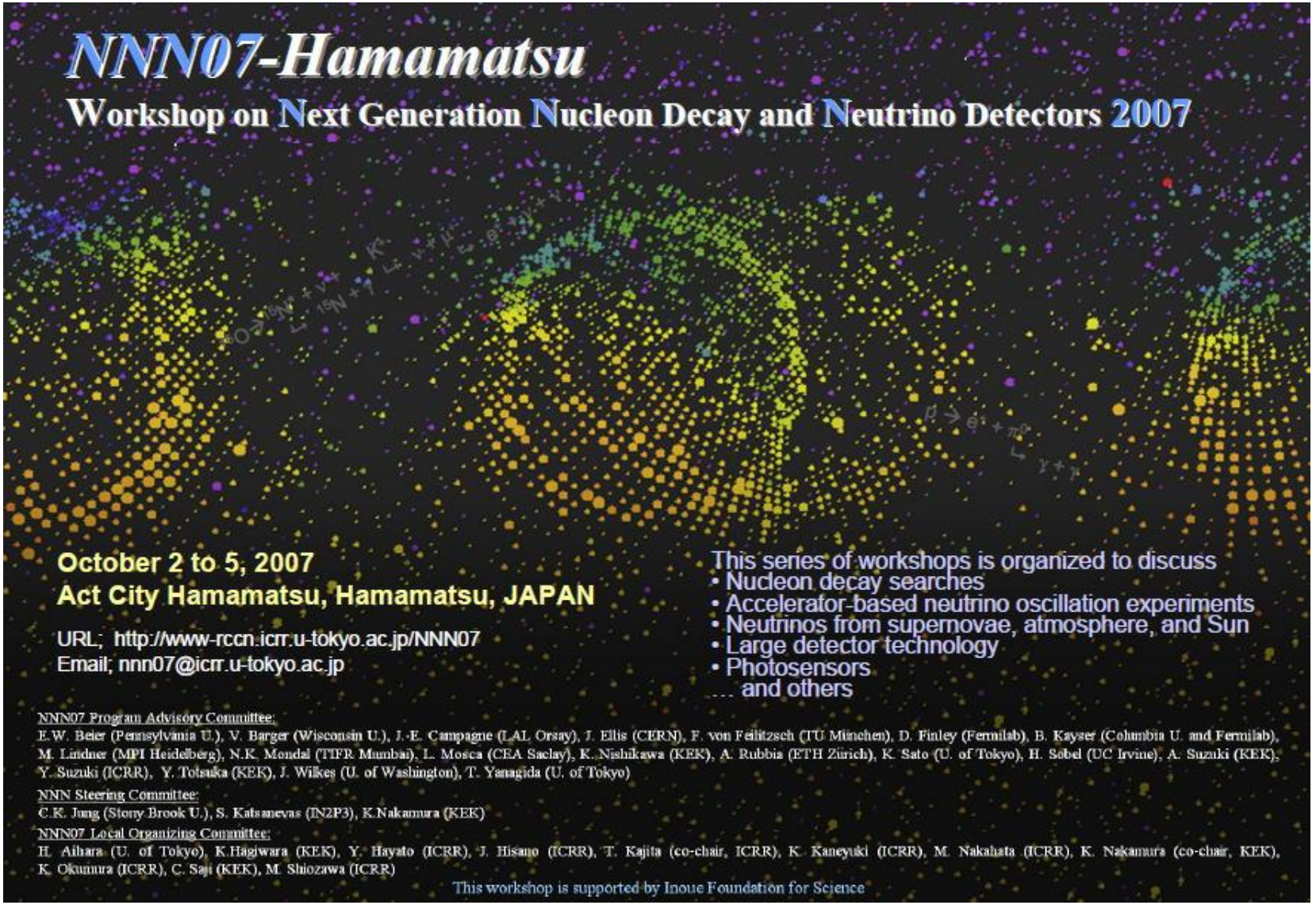
Now, John and I never wanted to merely propose a new technique – we wanted to make it work!

[Snowbird photo by A. Kusenko]

Suggesting a major modification of one of the world's leading neutrino detectors is indeed not the easiest route…

…so began many years of experimental and theoretical studies.

And then Hitoshi re-entered the story.



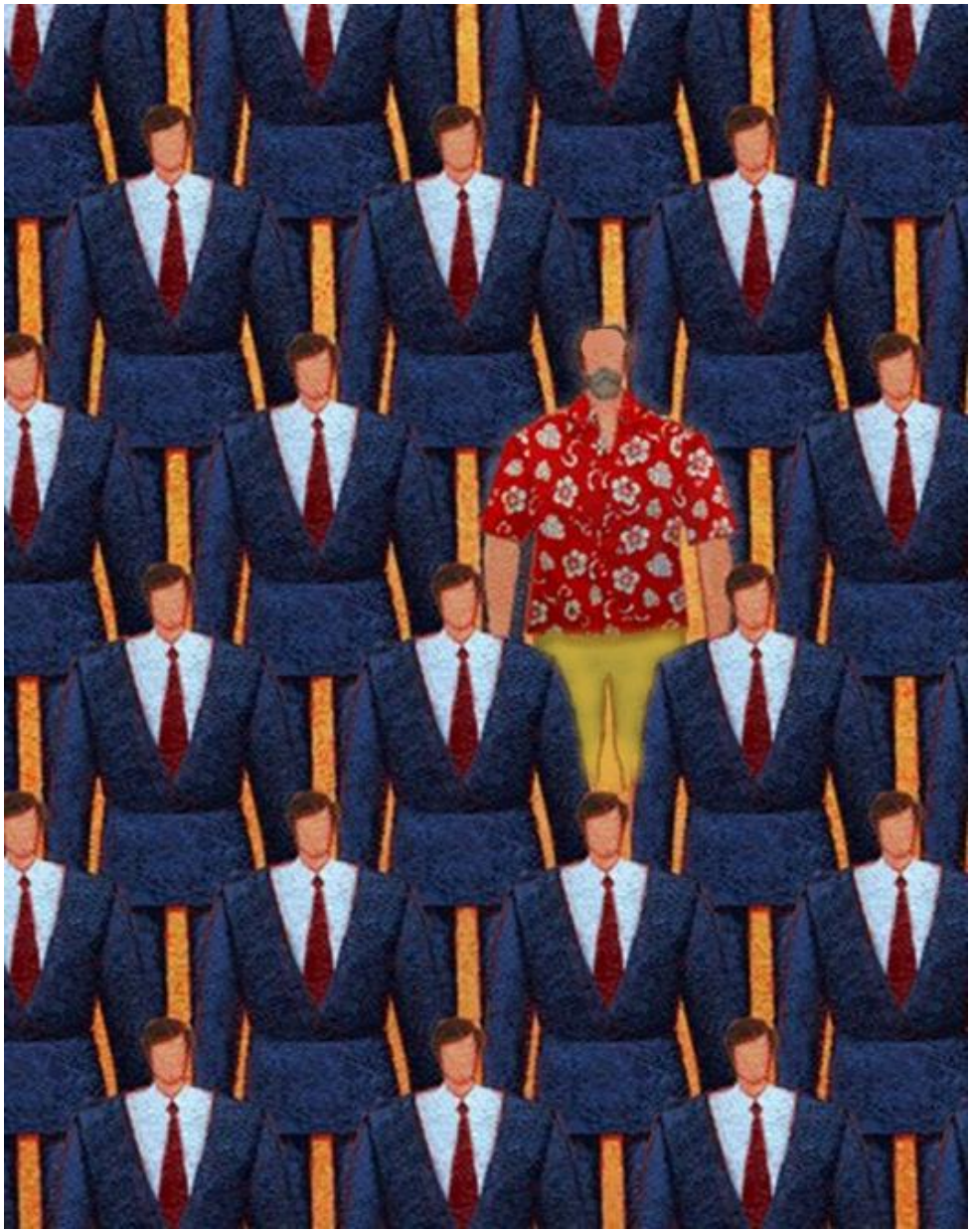
Hitoshi and I were both presenting talks here, and on October 4th, 2007, exactly one month after the press conference announcing the establishment of IPMU, he invited me to apply for a job.

He said his intent was to create “an island of America in Japan.”

I was naturally skeptical if such a thing was even possible.

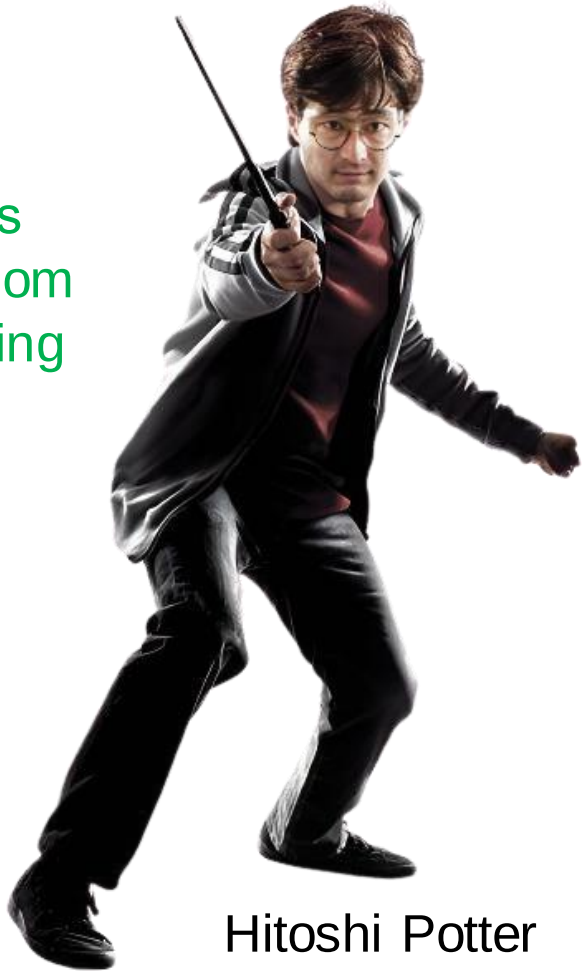
During my 13 years working in Japan up to that point, I had often seen an old-fashioned **愛の鞭** leadership style applied, especially in Kamioka.
But this is NOT my style!

This is my style!



I figured it would take some kind of magical wizard to create a place where *I* would feel at home in Japan.

But that's *exactly* whom I was dealing with!



Hitoshi Potter

On March 15th, 2008, after visiting the temporary basement headquarters of IPMU, I received an official job offer from Hitoshi. It read, in part:

"In this position, you will be able to continue your research program in the Super-Kamiokande experiment and play a leadership role in its future program to dope it with a Gadolinium compound to enhance its neutron detection capability, which may well lead to the first detection of relic supernova neutrinos."

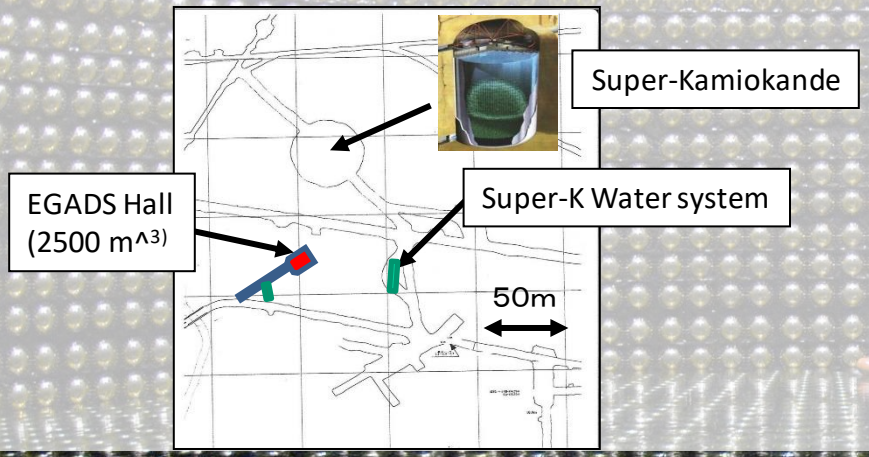
By now I could see Hitoshi's vision taking shape, so this was like getting a letter of invitation to attend Hogwarts!

I then promptly joined IPMU - as its first full-time foreign professor.

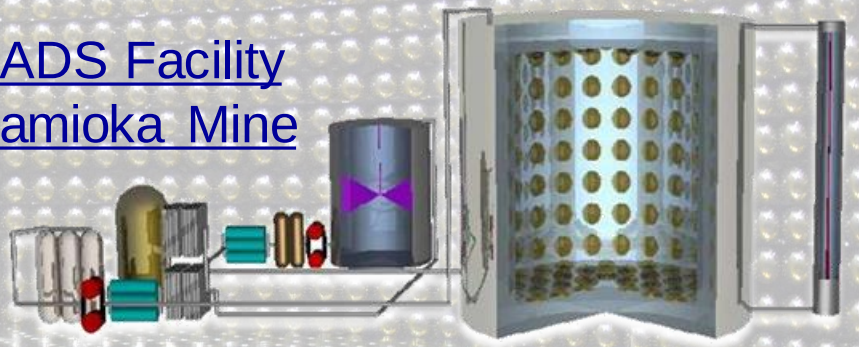
IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

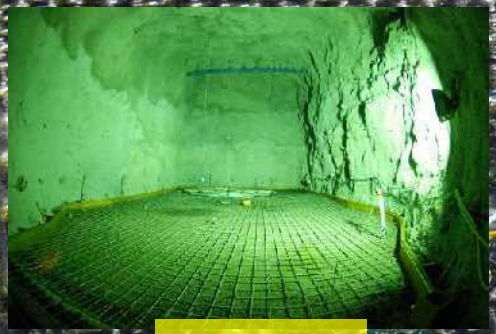
EGADS → Gd-loaded Super-K

Now that I was part of the home team, IPMU/ICRR built **EGADS** (Evaluating Gadolinium's Action on Detector Systems), a dedicated Gd demonstrator which includes a working 200-ton scale model of SK, under my direction.



EGADS Facility
in Kamioka Mine

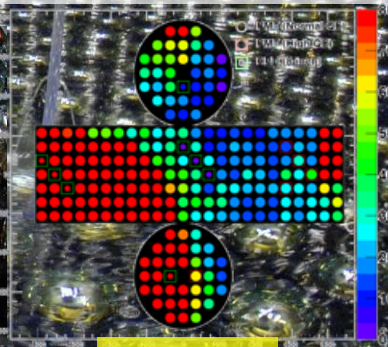




12/2009

11/2011

8/2013



6/2015

In 2014 I was made the leader of Super-K's newly formed gadolinium group, a position I continue to hold. In 2015, based on the EGADS results, it was decided to move forward and load SK with Gd.

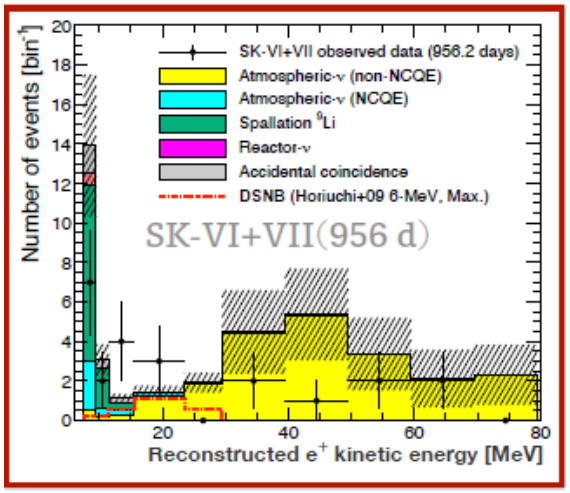
Well over $10,000,000 (1.5B yen) - not counting salaries - has been spent developing and proving the viability of the Gd-in-water concept.

In 2020, the first 13 tons of gadolinium sulfate went into Super-K (SK-VI), and in 2022, with IPMU's help, the $Gd_2(SO_4)_3$ in SK was tripled (SK-VII).

Oh, and another thing Hitoshi helped me (and IPMU) with…

My wonderful UTokyo graduate student, Saki Fujita, was explicitly inspired to apply for graduate school here as a result of reading Hitoshi's bestselling 2010 book, which was a junior high school gift from her mother.

At Neutrino 2024 the SK Collaboration released its latest Gd-enhanced results:



They were highlighted in *both* the experimental (Mark Chen) and theoretical (Eligio Lisi) summary talks at the conclusion of the conference.

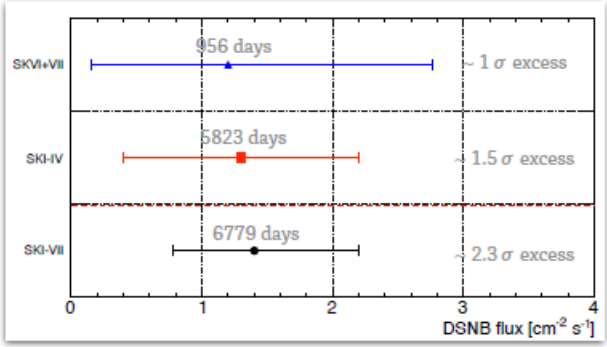
(UC Irvine will host Neutrino 2026)

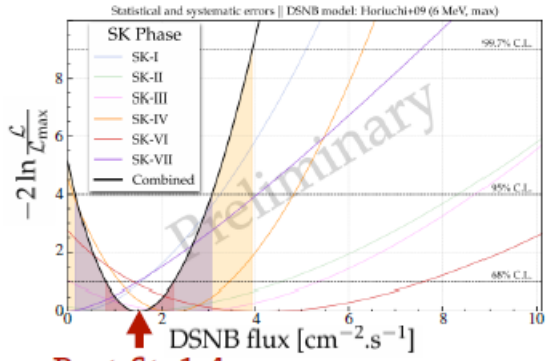
Tension from zero assumption

Spectral-fitting analysis

Spectrum fitting analysis to extract significance

- Total 6779 days of SK (5823 d pure-water and 956 d Gd-water) combined
- Analysis threshold: $E_\nu > 17.3$ MeV
- Suppress uncertainty of background prediction by fitting both $N_n=1$, $N_n \neq 1$





Best fit: 1.4

Highlight:

- Sensitivity of SK-Gd ~1000 days exposure is already comparable level it with ~6000 days of pure-water SK
- Best fit of whole SK observation is $1.4^{+0.8}_{-0.6}$ cm^{-2} s^{-1} for $E_\nu > 17.3$ MeV

➡ exhibit ~2.3 σ excess!!

[Masayuki Harada]

I currently control more gadolinium than any other private citizen in the world, and I readily share it and my Gd-enabling filtration technology with all who ask.

So, now you know how Hitoshi helped me become the Gdfather.

Gd-H_2O: Everybody's Doing It, Man…

Name	Location	Main Goal	Water Volume	$Gd_2(SO_4)_3$ Loaded
EGADS	Kamioka	Gd R&D, SN Watch	200 tons	Since 2013
ANNIE	Fermilab	High-E Neutron Multiplicity	26 tons	Since 2019
Super-K-VI/VII	Kamioka	DSNB, SN Burst, PDK, ATM/Sol/LB ν	50 ktons	Since 2020/2
XENONnT Water Shield	Gran Sasso	Dark Matter Detection	700 tons	Since 2023
WCTE	CERN	IWCD/mPMT Demonstrator	50 tons	Early 2025 (planned)
30-ton Test Tank	BNL	Nuclear Non-Proliferation Demonstrator	30 tons	Early- to mid-2025 (planned)
BUTTON	Boulby	Underground Demonstrator	30 tons	2025(?)
Hyper-K-II(?)	Kamioka	DSNB, SN Burst, PDK, ATM/Sol/LB ν	258 ktons	203X(?)

But what about Father Christmas?

In November of 2009, during my second holiday season at IPMU, a call went out on the Kashiwa campus for someone who met the following three criteria (I quote directly):

"someone who has a bouncy tummy,
looks good on beard,
and has happy smiling face"

Proving to be a good fit to these parameters, I quickly got an annual gig playing Santa Claus for the children of the Donguri nursery school on campus and did this for many years, often encountering other IPMU parents whose young kids were attending the school.

But one year I attended a big Christmas show near Tokyo called "Pure White Christmas, A Salute To Santa" which had no Santa in it!

Upon exiting the theater I was spotted by the show's director, who exclaimed, "My Santa!" And so I was discovered: I've been in the cast for over a decade.

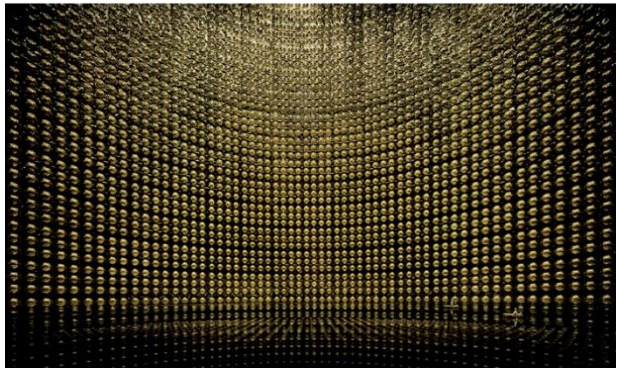

0歳からのファミリーコンサート
ピュアホワイト
クリスマスコンサート15
～サンタさんの魔法～
鈴やタンバリンなど
おもちゃの楽器を
持ってきてね♪
イラスト：いいつかじゅんこ
2024年12月15日（日）
浦安市文化会館 大ホール
〒279-0004 千葉県浦安市猫実1-1-2（浦安市役所 隣）
【全席指定】〈一 般〉 前売2,000円/当日2,500円
〈さくらメイト〉 前売1,500円/当日2,000円
〈小学生以下〉 700円
①開場10：15 開演11：00
②開場14：15 開演15：00 （約1時間予定）
《さくらメイト先行発売》
10/17（木）10時～Web販売
《一般発売》
10/19（土）10時～窓口・Web販売
販売先所
浦安市文化会館 047-353-1121（第2・4木曜休館日）
浦安市民プラザ 047-350-3101（第1・3水曜休館日）
うらやす財団オンラインチケットサービス
チケット購入はこちら
♪大人1名につき3歳未満のお子様1名膝上鑑賞無料。お座席必要な場合は有料。
♪車いす席をご希望の場合は、文化会館までお問い合わせください。
♪専用駐車場はございません。ご来場の際は公共交通機関をご利用ください。
主催◆公益財団法人うらやす財団（浦安市文化会館） 後援◆NPO法人文化交流サポート浦安 協力◆TSUTAYA 浦安さくら通り店・CREATION ・株式会社木田屋商店

You may have noticed that I am a pretty happy guy…

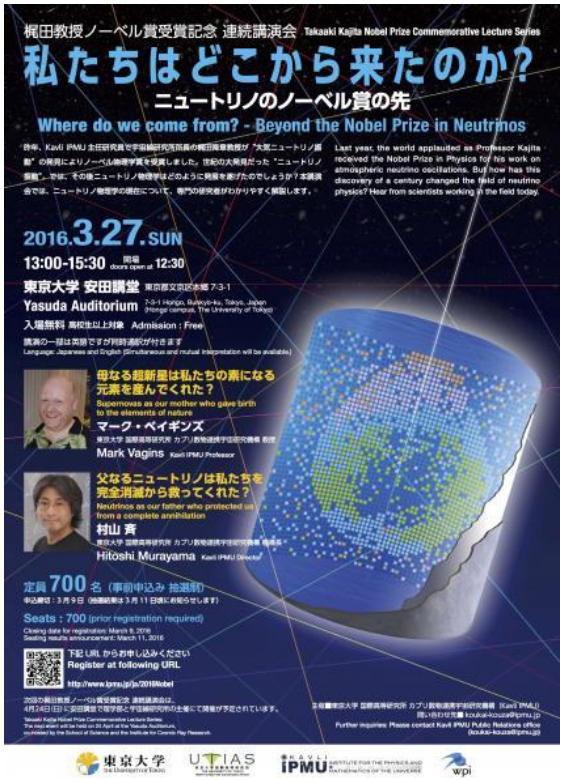
THE SECRET OF HAPPINESS

What is the secret of (career) happiness?

- Imagine that you had enough money to live comfortably.
- What in the world would you spend all your free time doing?
- Now, find someone who wants to pay you for doing exactly that!



Thank you, Hitoshi, for all you've done for me, for Kavli IPMU, for the science world, and for the world in general. We are all truly better off for knowing you!



Happy 60th birthday!