Majorana Neutrino Searches at ILC

1. *Japanese HEP Roadmap*
2. *ILC Activity in KEK*
3. *ILC : First Priority for Next Lepton Collider*
4. *Majorana Neutrino Searches at ILC*
5. *Summary*

Atsuto Suzuki

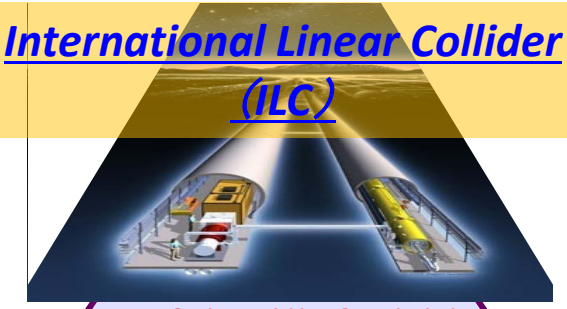
1. Japanese HEP Roadmap

in 2007

In 2008

Birth-Evolution of Universe

International Linear Collider (ILC)

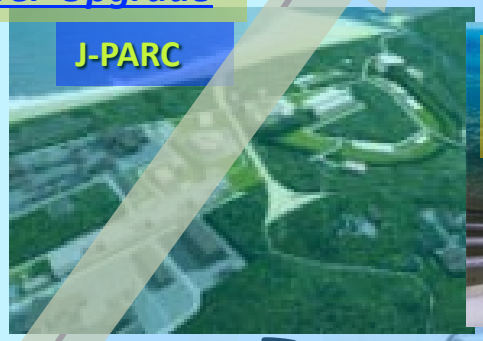


Quest for Unifying Matter and Force

Scientific Activities
Technology Innovation
Talented Human Resources

Lepton CP Asymmetry

Beam Power-Upgrade



Operation Power-Upgrade

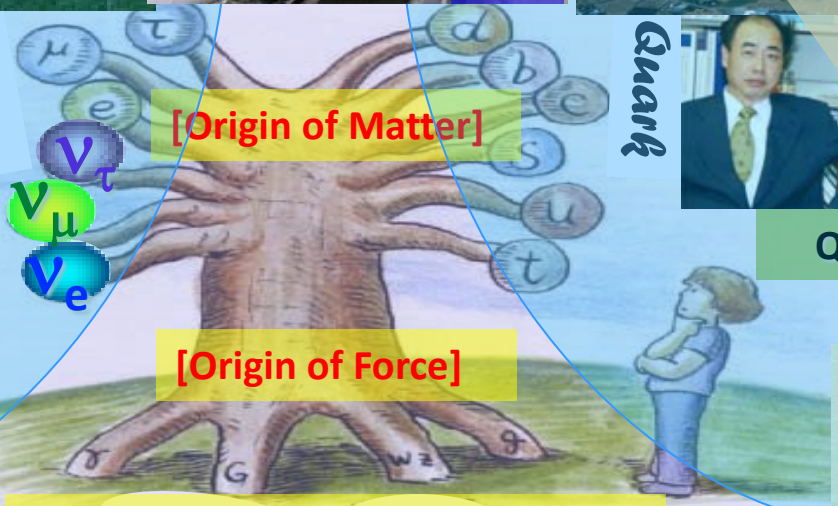
Beyond Standard Physics

SuperKEKB

Quark CP Asymmetry

Lepton

Quark



Quest for Neutrinos

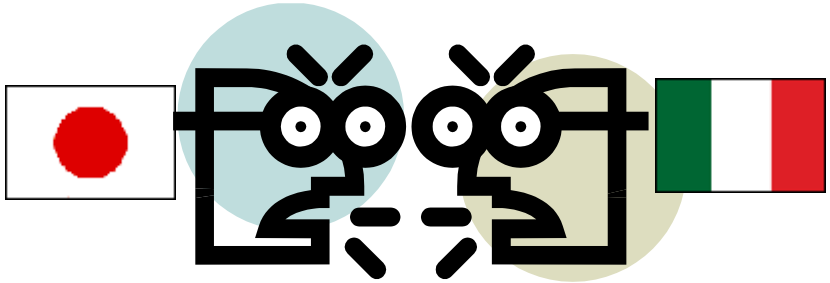
ν_τ ν_μ ν_e

Quest for 6 Quarks

Higgs Particle [Origin of Mass]

In 2009

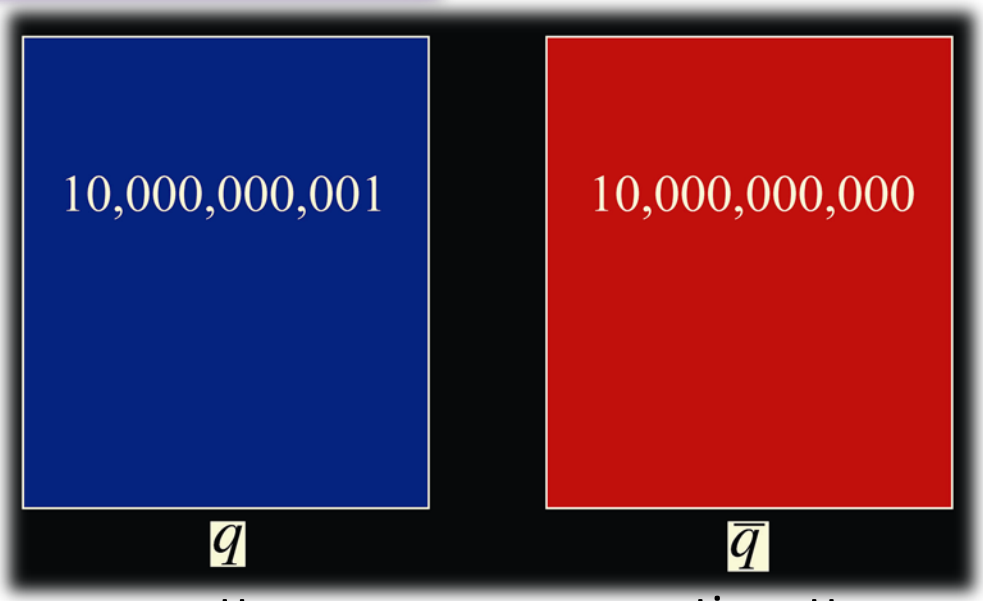
SuperKEKB vs. SuperB in Italy



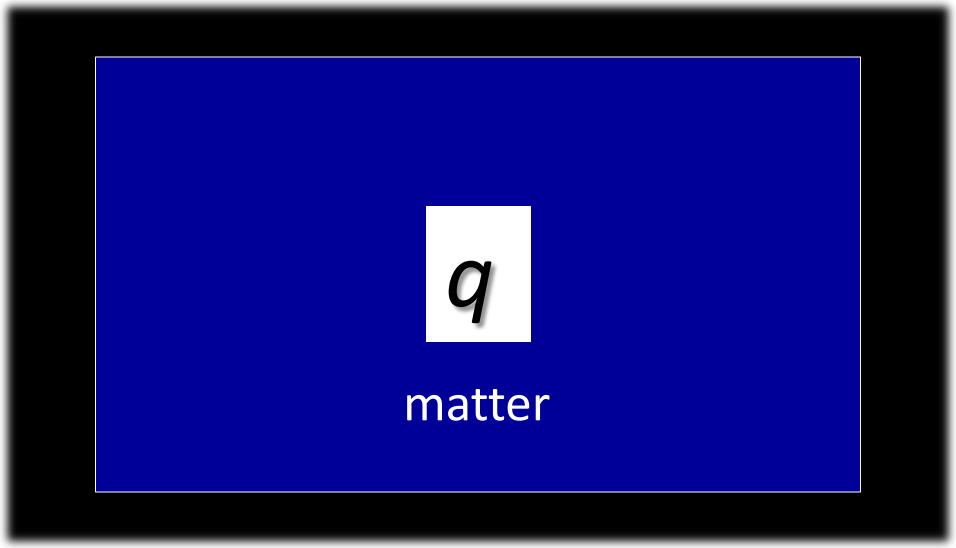
"matter-dominated universe plan"
or
"β vs. VHS plan"

"matter-dominated universe plan"

Early Universe

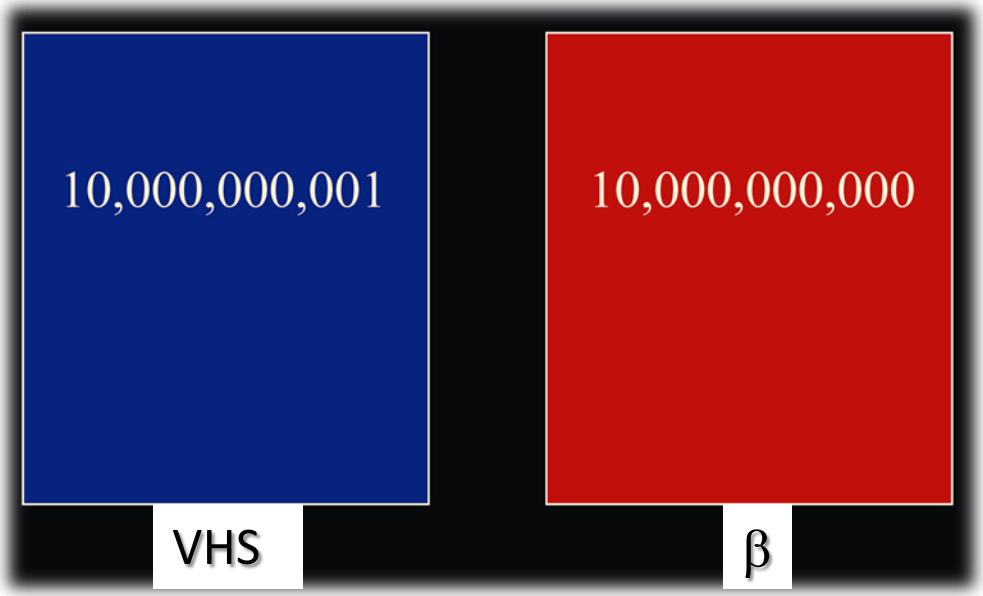


Present Universe

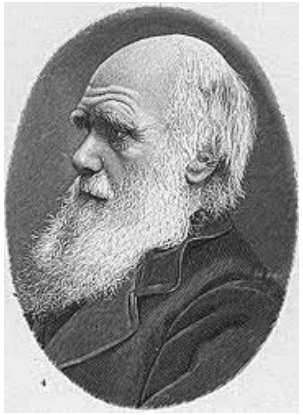


"β vs. VHS plan"

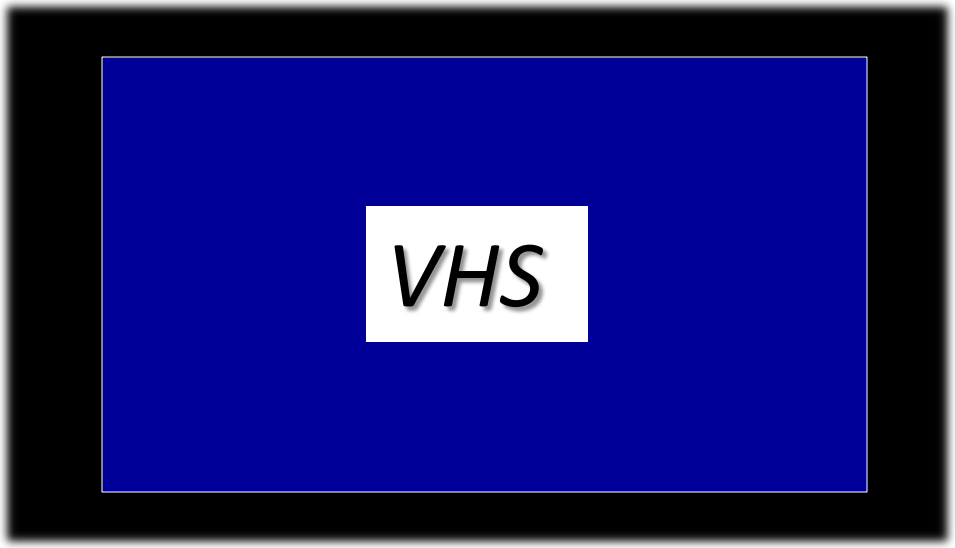
Early Stage of Market Share for Video-Tapes



Anti-Darwinism Evolution

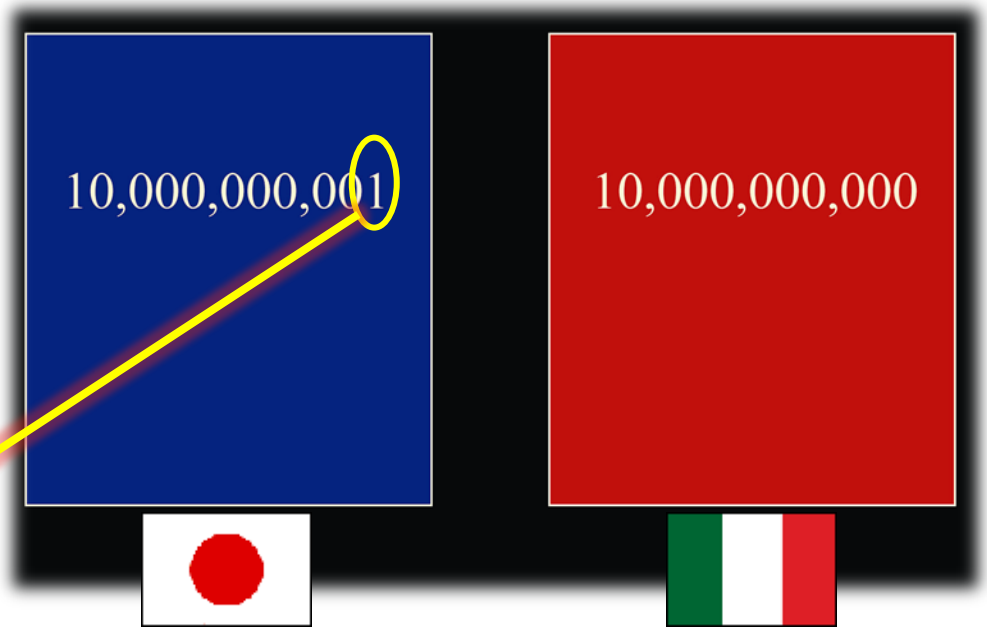


Final

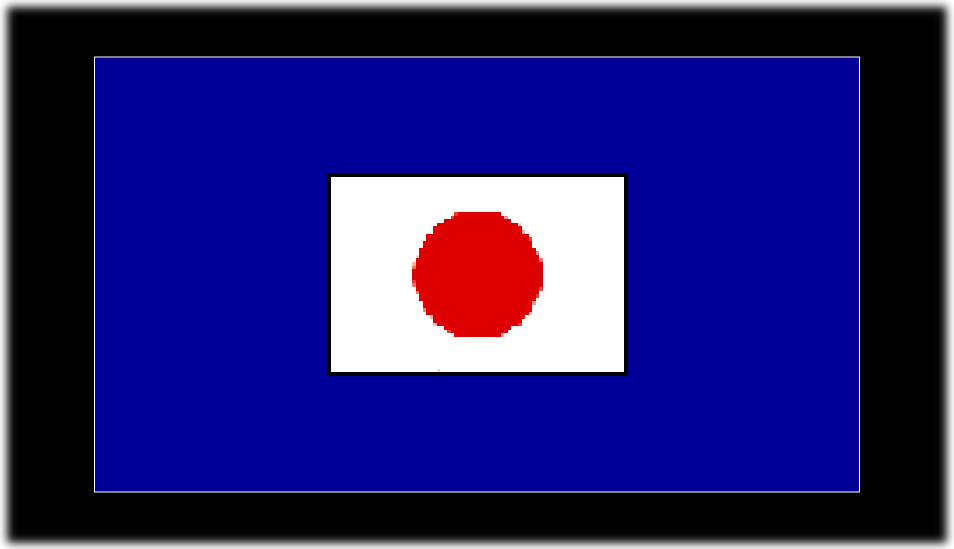


"SuperKEKB vs. Italian Super-B plan"

Present Super-B Factory



Early Approval of Budget



In 2010

KEKB to SuperKEKB : current status

- KEKB operation finished at 9:00 am June 30, 2010

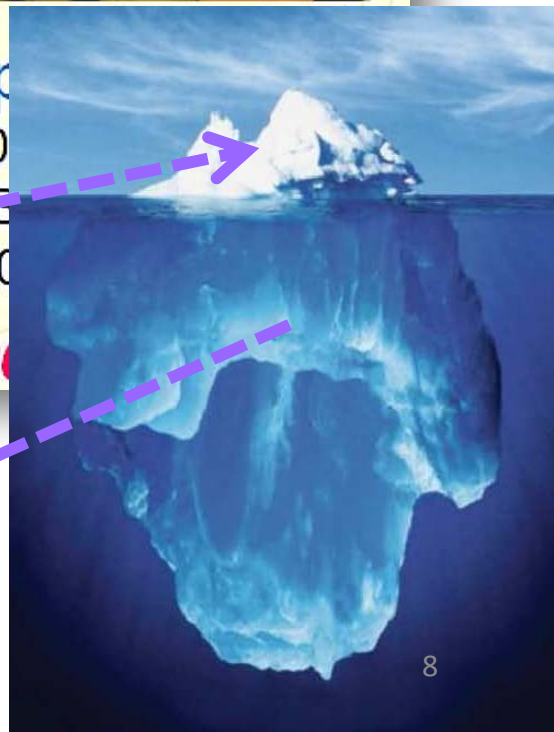
Partially funded (100 M$)

Almost fully funded

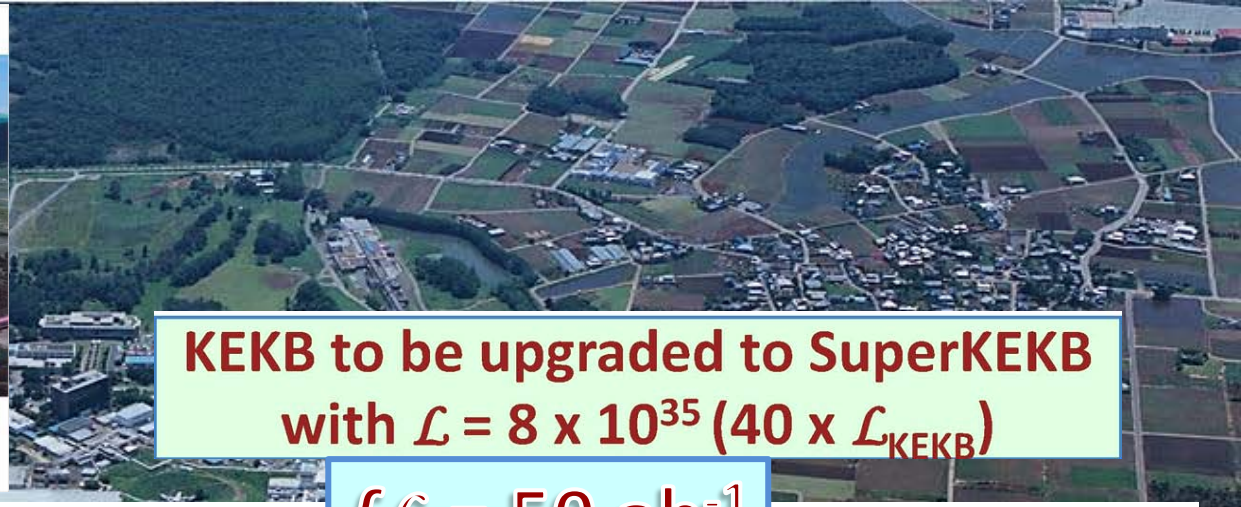
- SuperKEKB budget is partially app
  - Damping ring : 580M yen (~5.8M$) (FY2010
  - Special budget "Very Advanced Research
  - 1B yen (~100M$) (FY2010-2

350 M$

→Start construction (FY2010-2

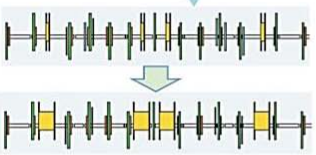


30 M$ (2009) + 50 M$ (2010,2011,2012) +
100 M$ (KEKB for 4 years) + 30 M$ (overseas) +
40 M$ (???) = 250 M$

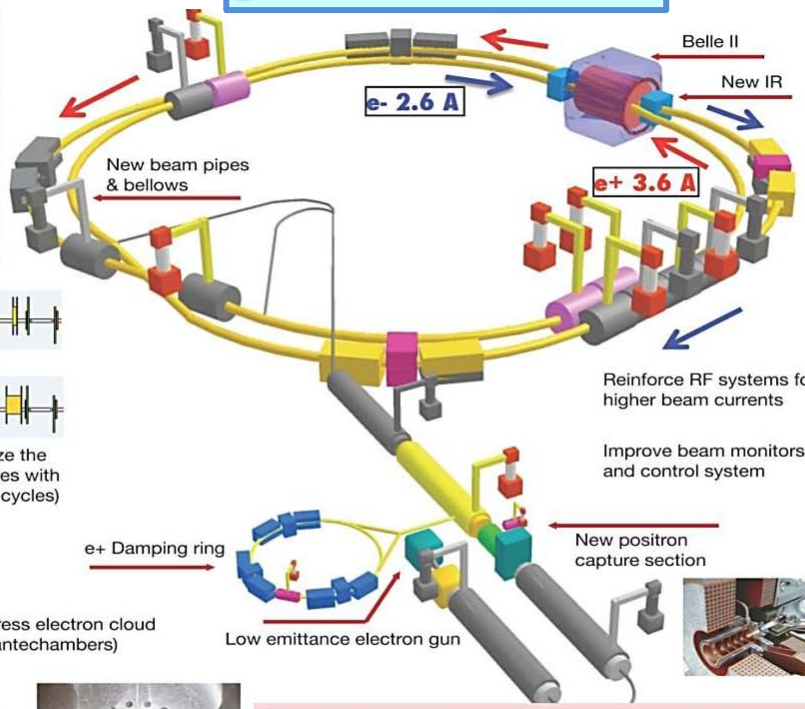


KEKB to be upgraded to SuperKEKB with $\mathcal{L} = 8 \times 10^{35}$ ($40 \times \mathcal{L}_{KEKB}$)

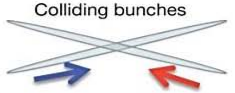
$\int \mathcal{L} = 50\ ab^{-1}$



Redesign the lattice to squeeze the emittance (replace short dipoles with longer ones, increase wiggler cycles)

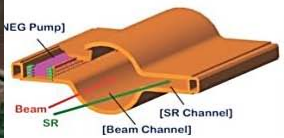


Colliding bunches



New superconducting final focusing magnets near the IP

Replace beam pipes to suppress electron cloud (TiN-coated beam pipe with antechambers)

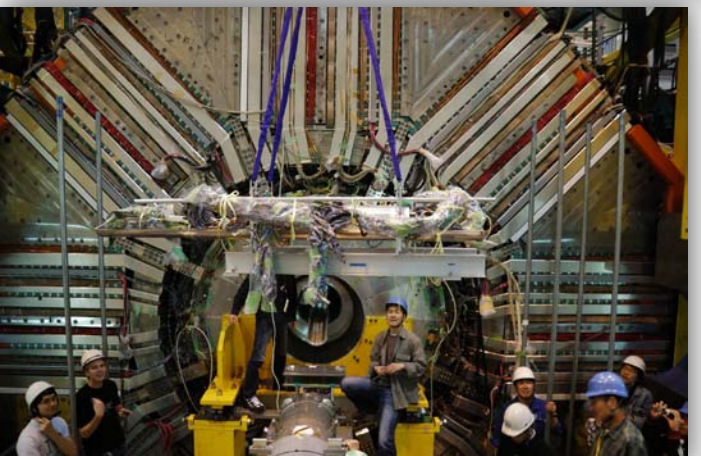
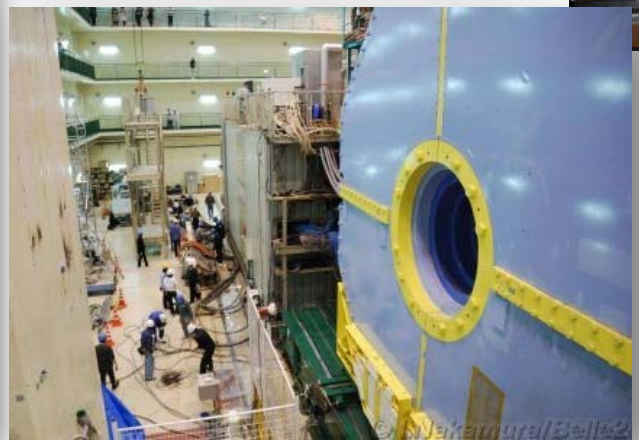
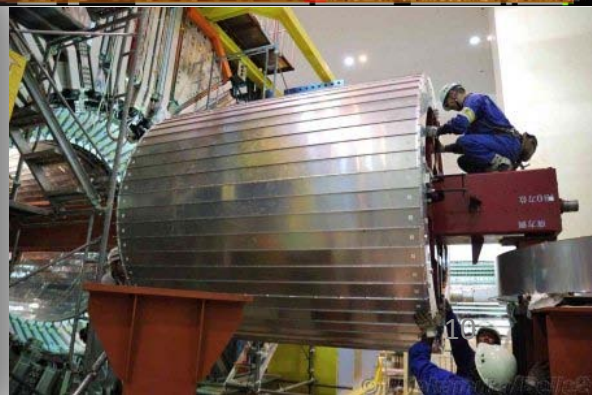


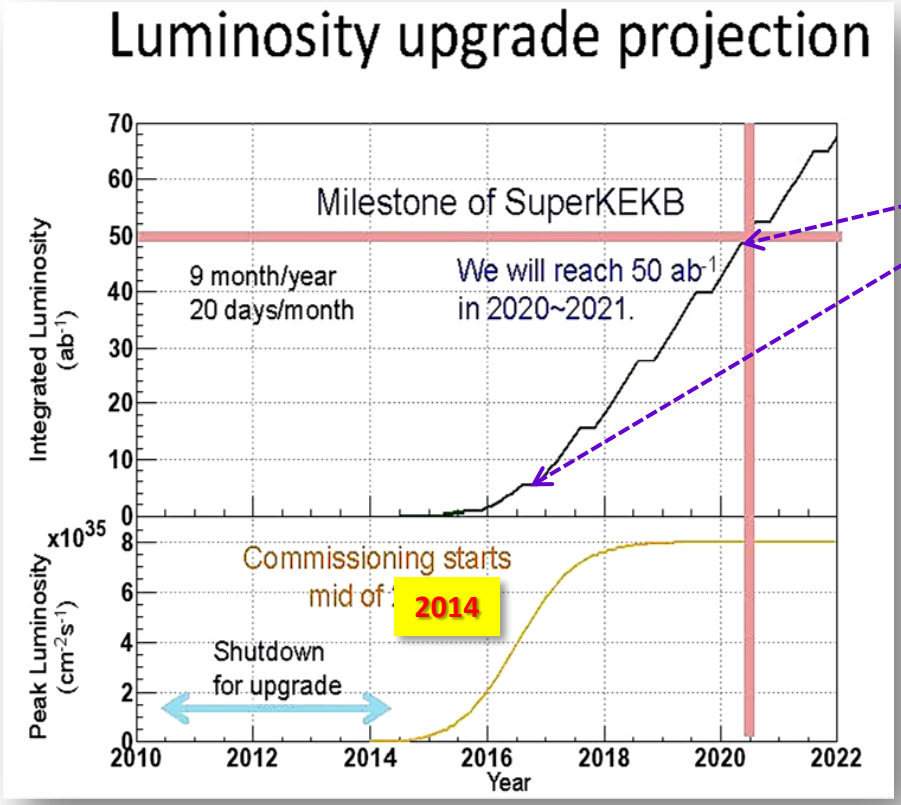
To get x40 higher luminosity

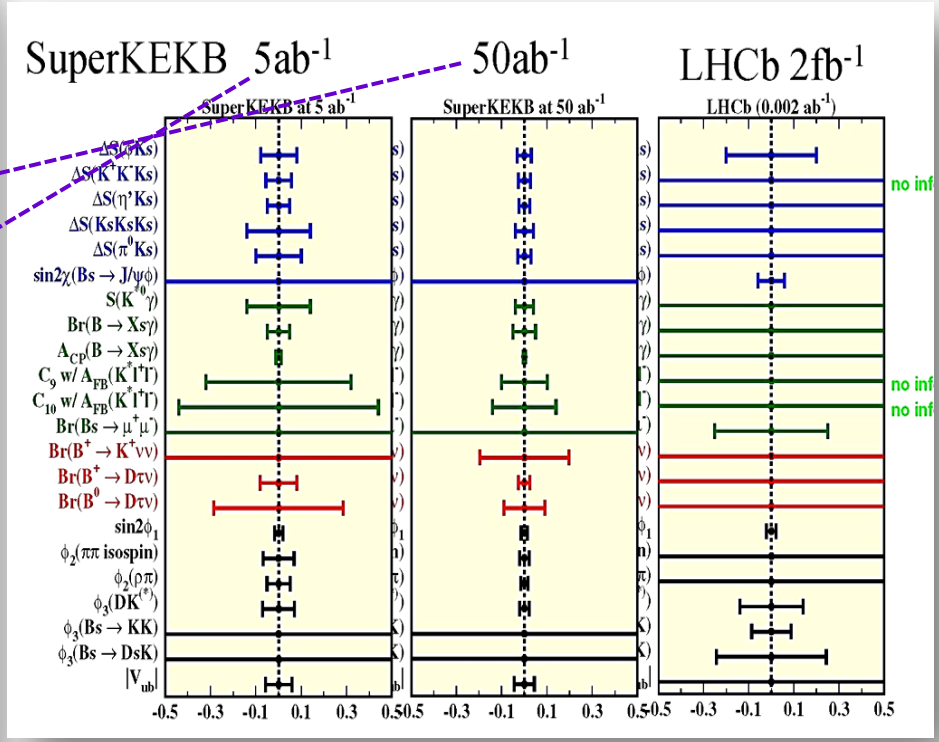




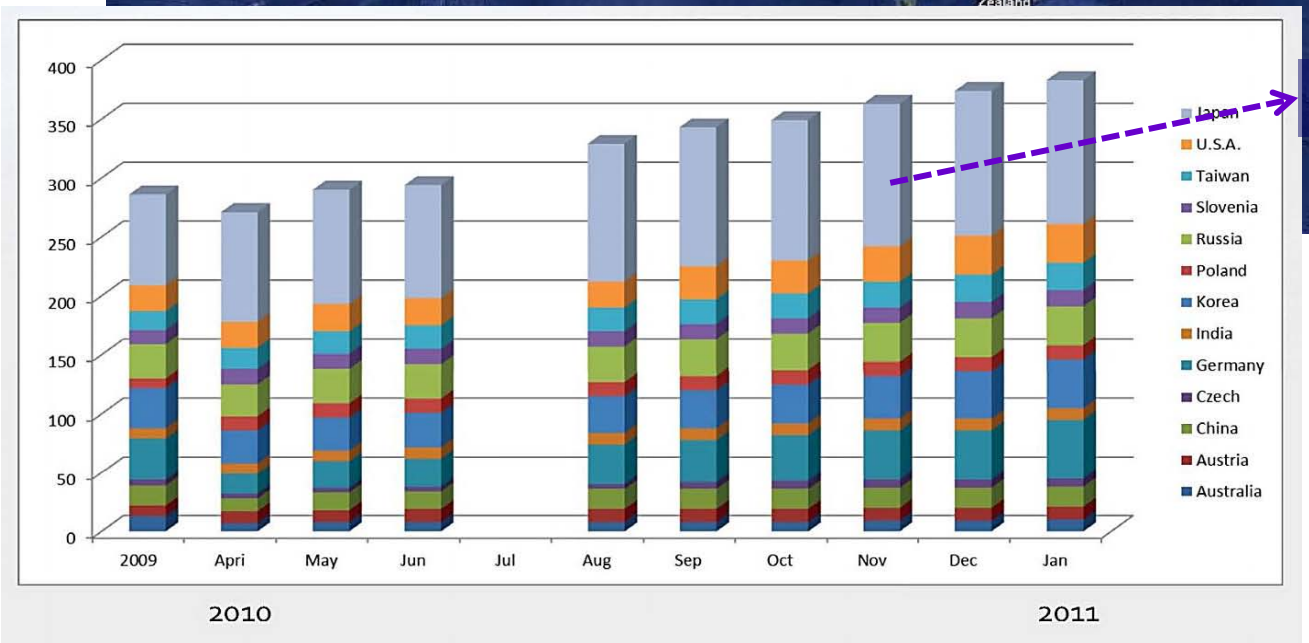


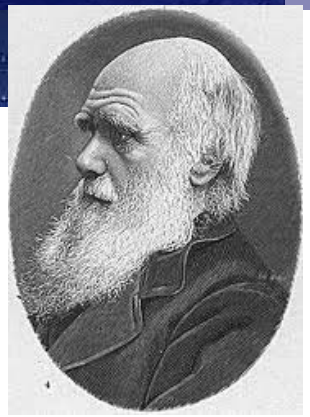

Luminosity upgrade projection
Integrated Luminosity (ab-1)
Milestone of SuperKEKB
9 month/year
20 days/month
We will reach 50 ab-1
in 2020~2021.
Peak Luminosity (cm-2s-1)
x1035
Commissioning starts
mid of
2014
Shutdown
for upgrade
Year


SuperKEKB 5ab-1
50ab-1
LHCb 2fb-1
SuperKEKB at 5 ab-1
SuperKEKB at 50 ab-1
LHCb (0.002 ab-1)
ΔS(η'Ks)
ΔS(K+K-Ks)
ΔS(η'Ks)
ΔS(KsKsKs)
ΔS(π0Ks)
sin2χ(Bs → J/ψφ)
S(K*0γ)
Br(B → Xsγ)
ACP(B → Xsγ)
C9 w/ AFB(K*l+l-)
C10 w/ AFB(K*l+l-)
Br(Bs → μ+μ-)
Br(B+ → K+νν)
Br(B+ → Dτν)
Br(B0 → Dτν)
sin2φ1
φ2(ππ isospin)
φ2(ρπ)
φ3(DK(*))
φ3(Bs → KK)
φ3(Bs → DsK)
|Vub|
no inf
no inf
no inf

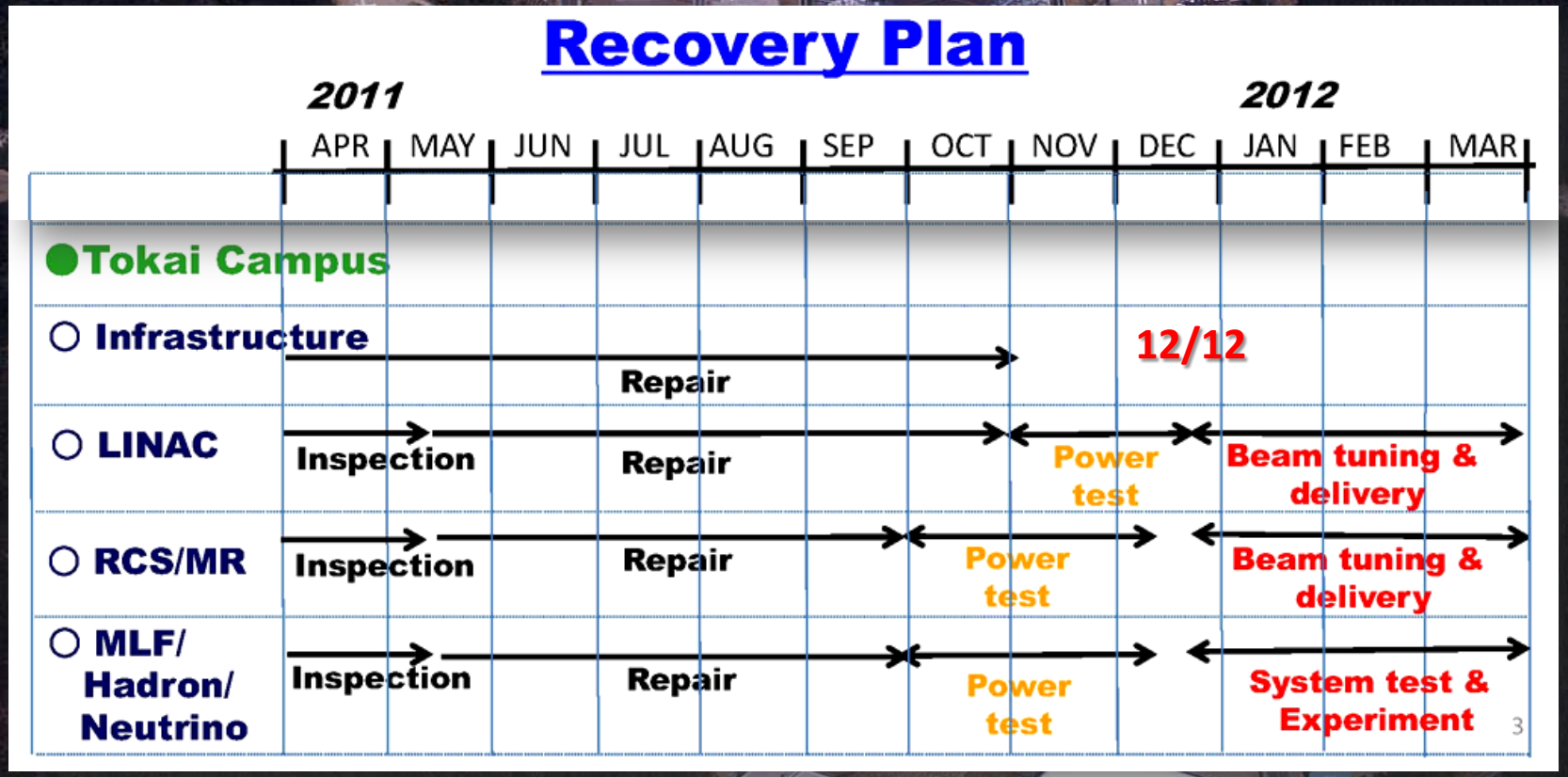
SuperKEKB : International Collaboration



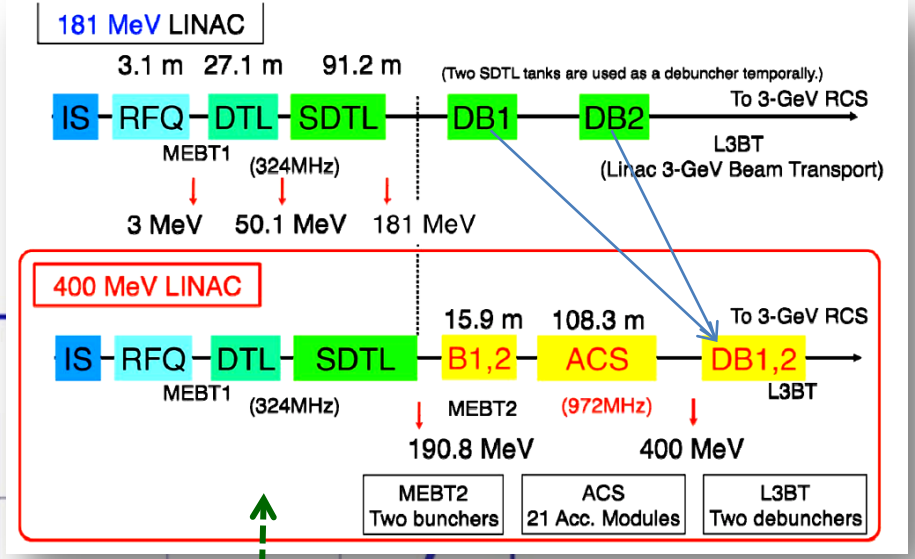
Anti-Darwinism Evolution

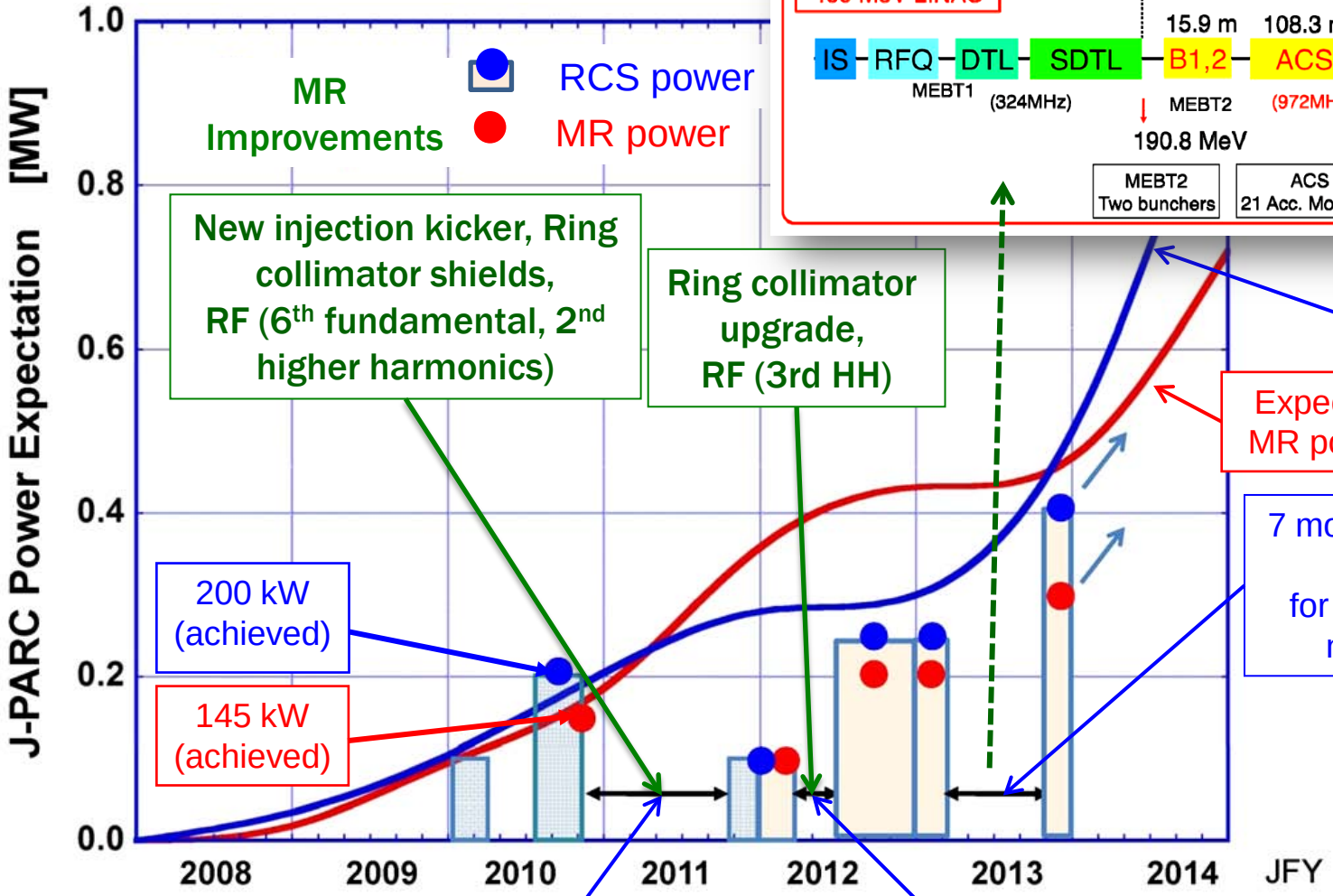


J-PARC Power-Upgrade



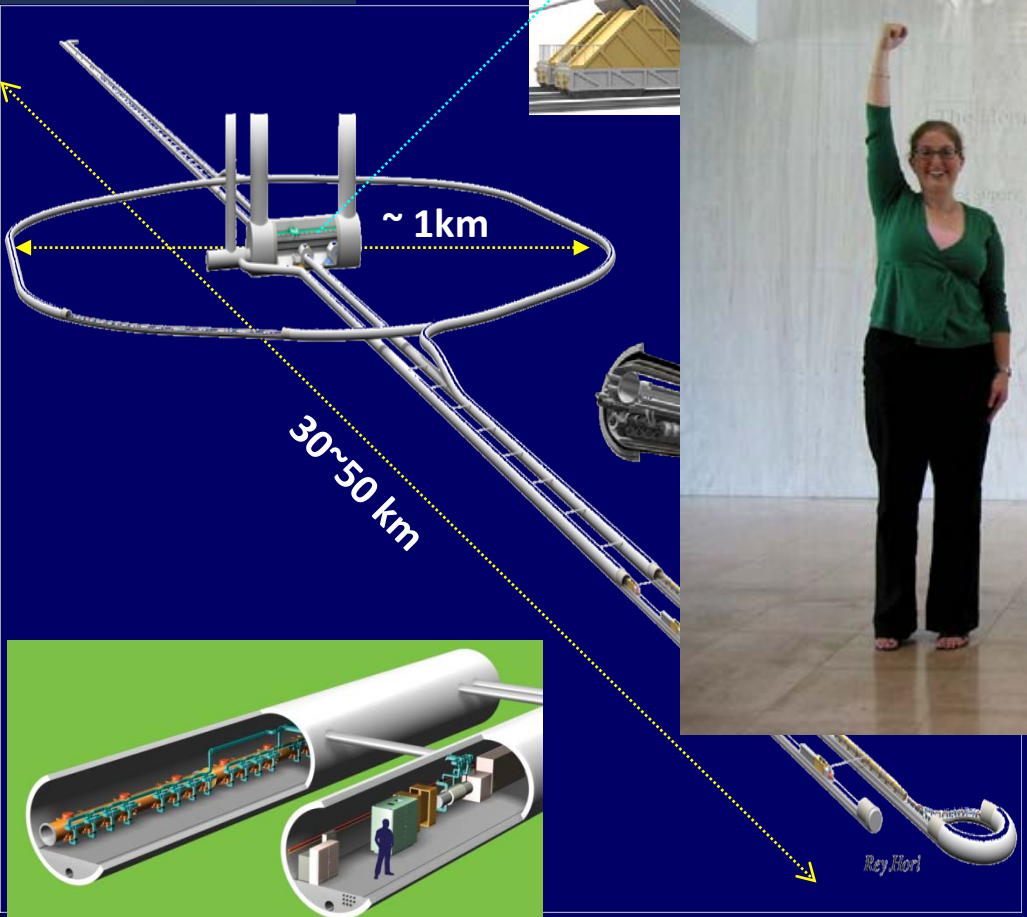
Power Upgrade Plan of RCS/MR





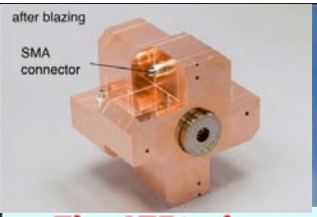
2. ILC Activity in KEK

International Linear Collider



ATF: Accelerator Test Facility for ILC

- Generate Low Emittance Beams
- Handle Nano-Size Beams

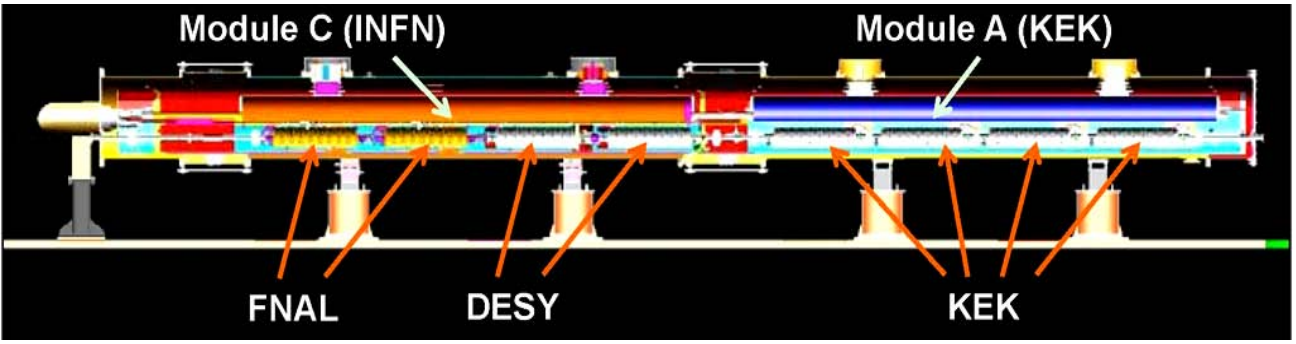


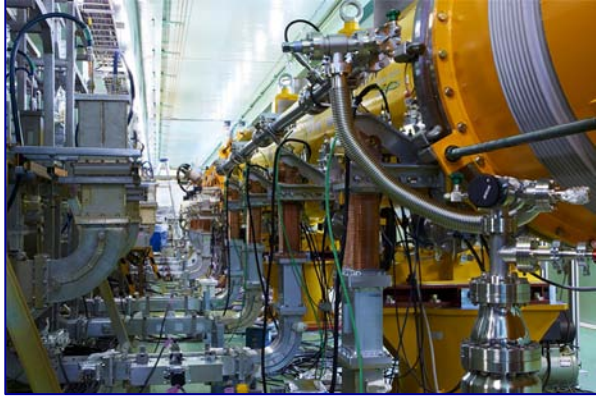
STF: Super-Conducting RF Test Facility

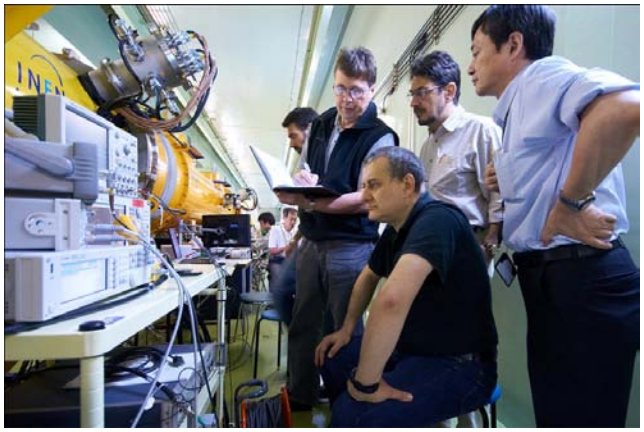
S1-Global

first step of ILC

2009 ~ 2011.2.25

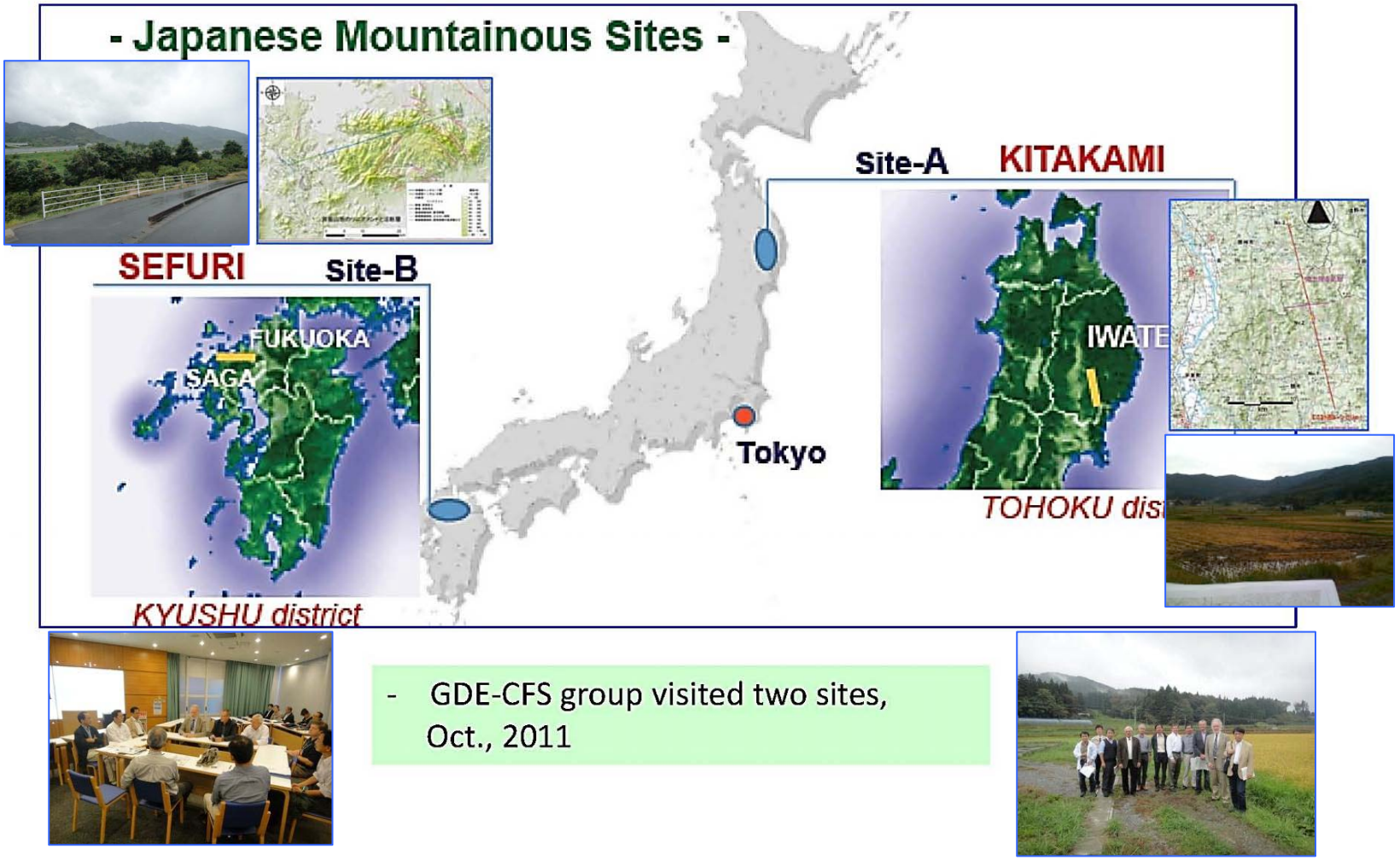






Plug compatibility of SCRF system was successfully demonstrated by international collaboration.

Two Candidate Sites in Asia/Japan



- GDE-CFS group visited two sites, Oct., 2011

3. ILC : First Priority for Next Lepton Collider

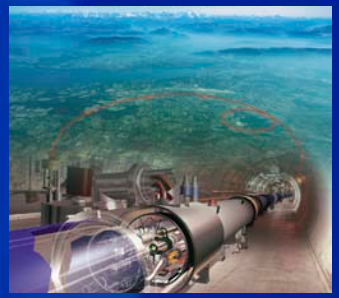
ICFA Point of View of Situation and Plans for Period 2011-2012-Post for ILC

Atsuto Suzuki

(KEK: High Energy Accelerator Research Organization)

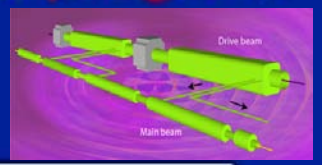
Biggest decision of the decade !

LHC Results



or

ILC Enough — By far the easiest! A Global program



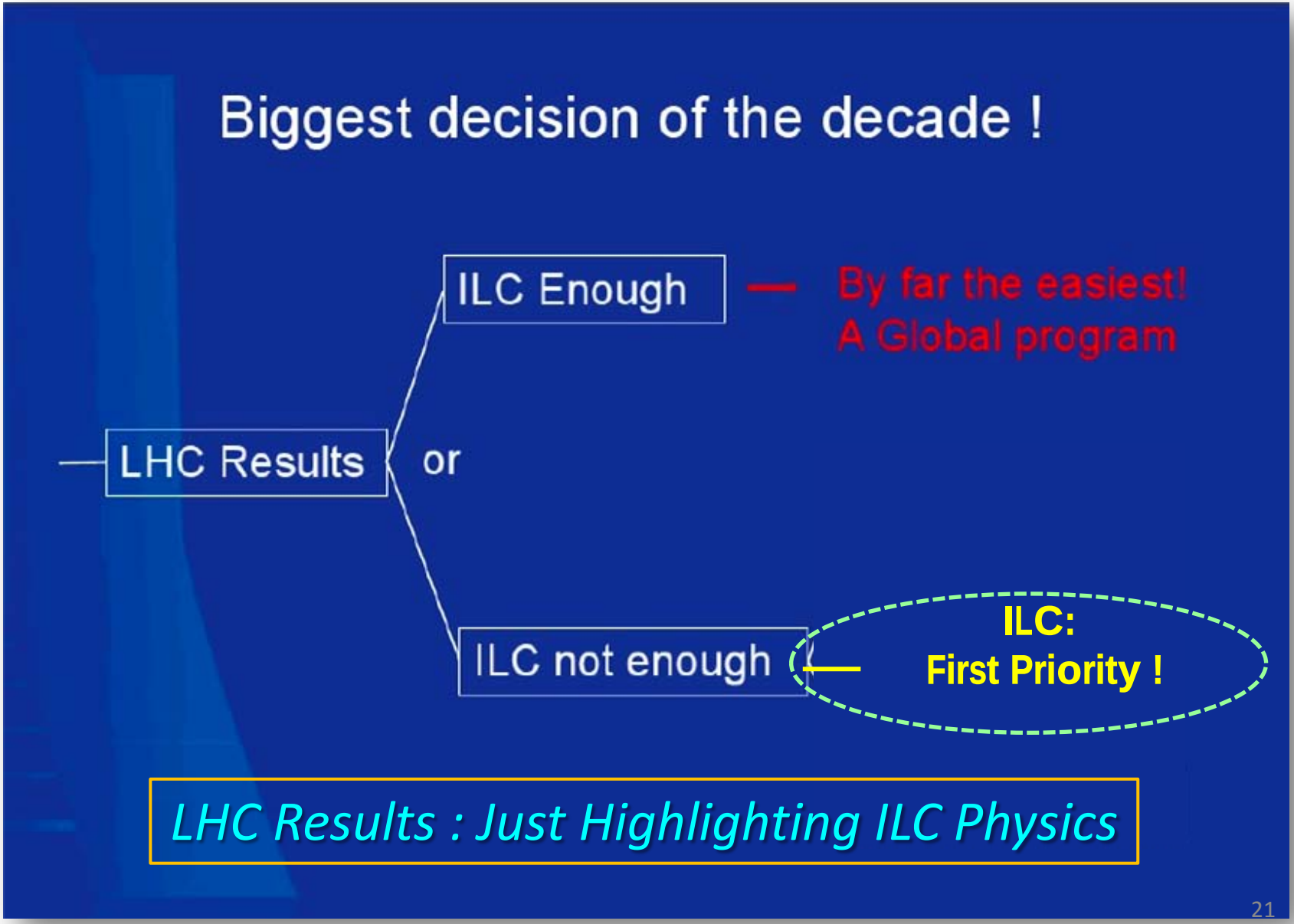
ILC not enough

or

CLIC

Muon collider

My Understanding



World Particle Theorists

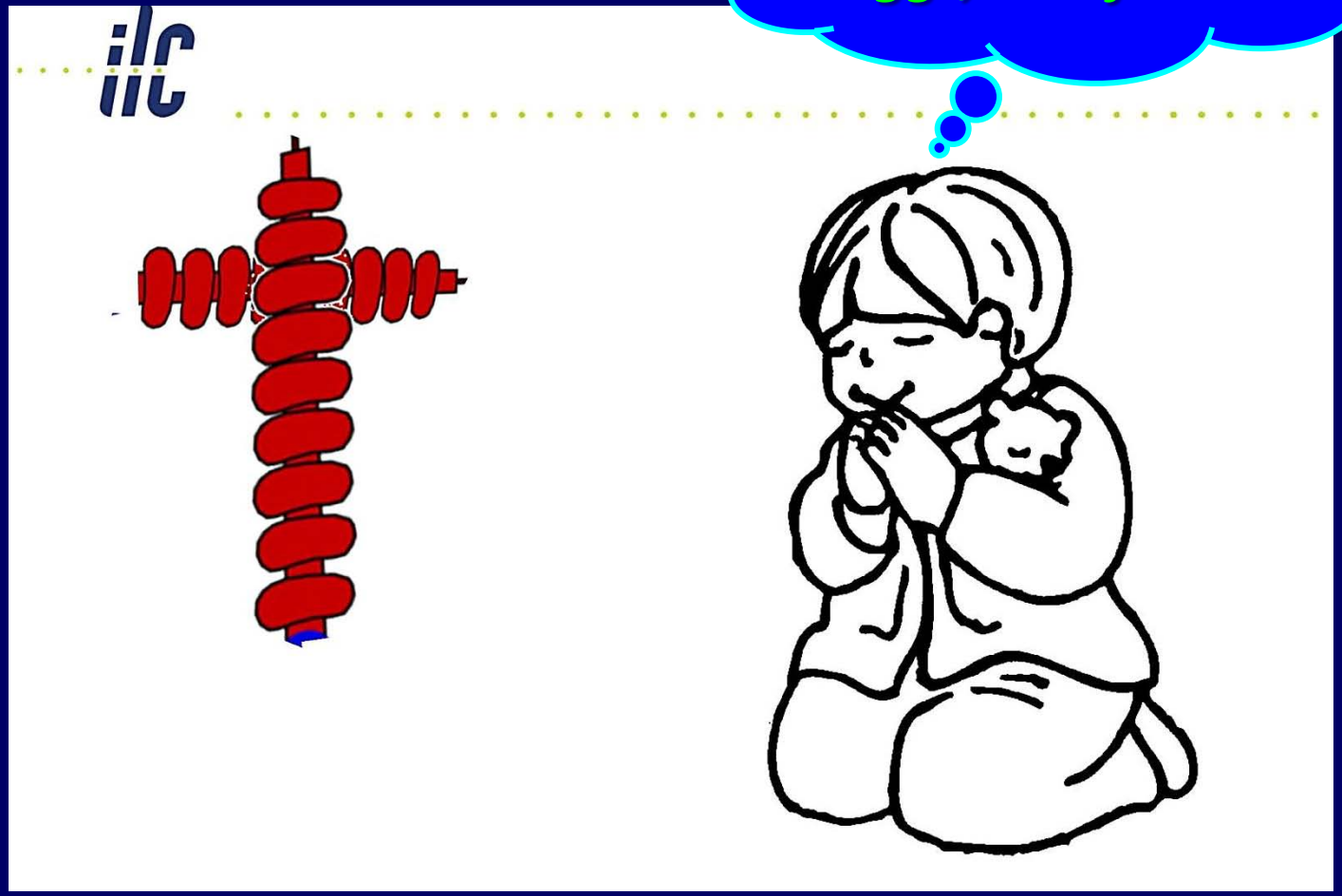
Discoveries :
Higgs, ……..from LHC

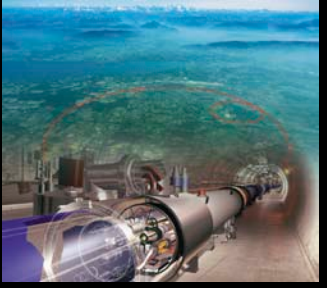
There is luck in leisure.

果報は寝て待て
Luck comes during sleeping

Sleeping

ILC Volk





Nothing from LHC

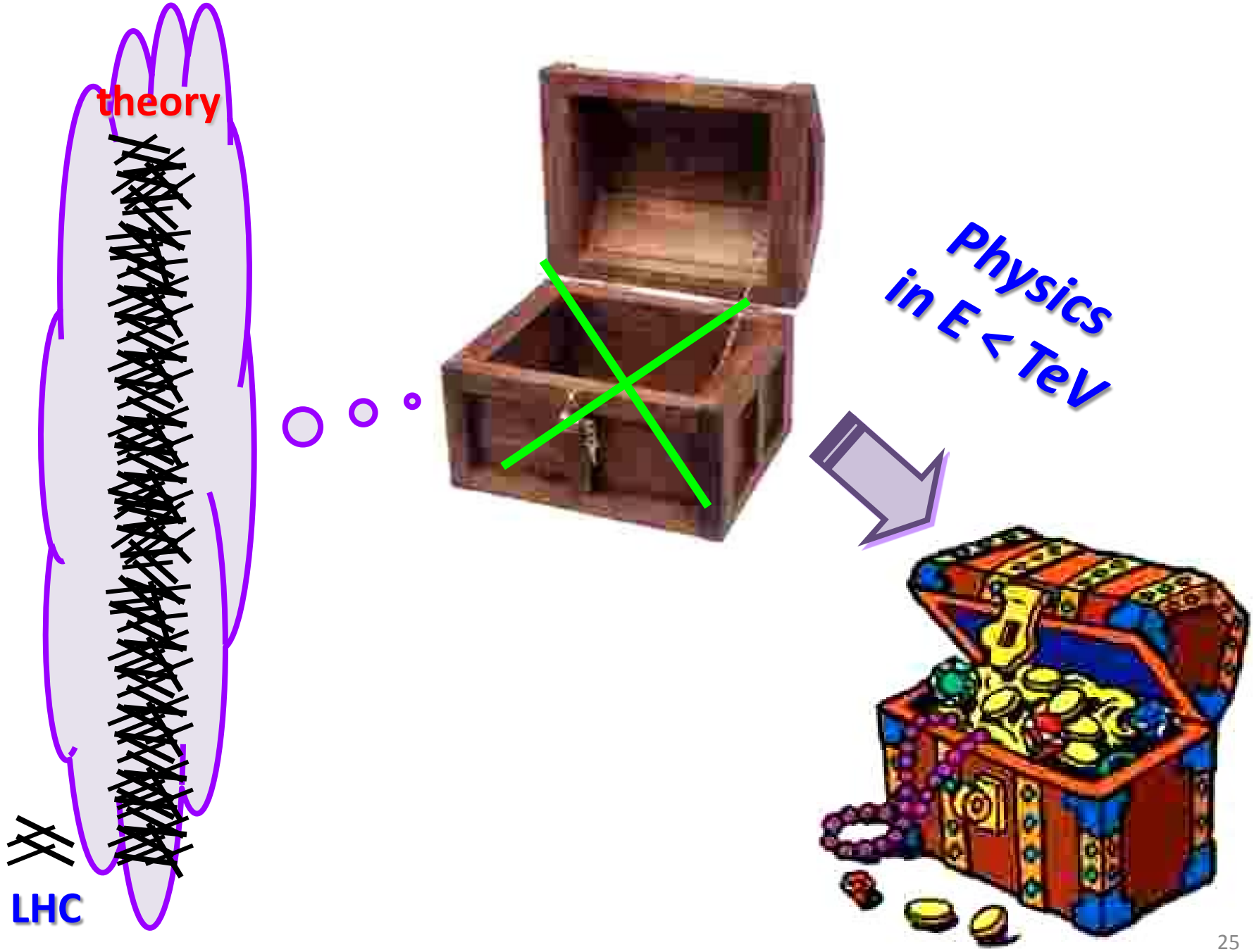
World Theorists

theory

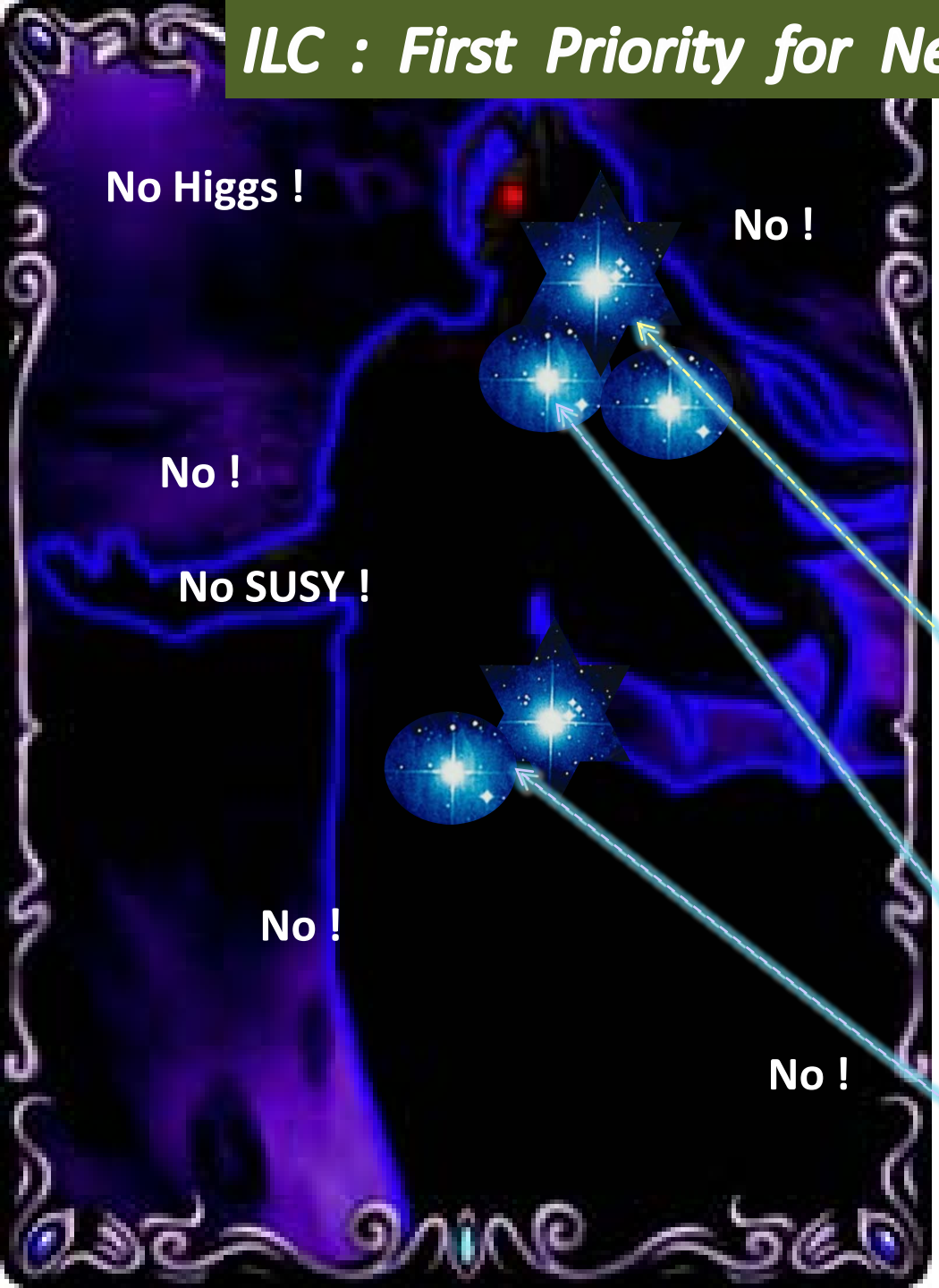
No New Physics from LHC

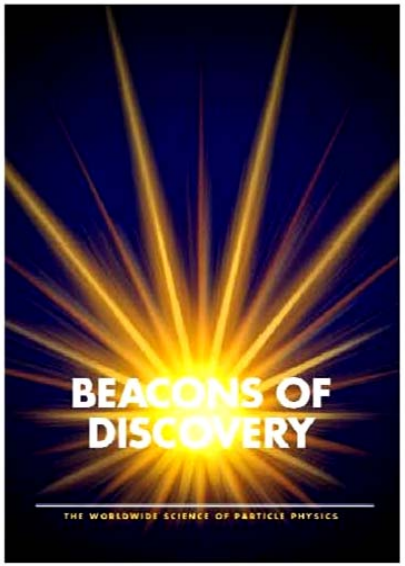
rush heading at

LHC


theory
LHC
Physics
in E < TeV

ILC : First Priority for Next Lepton Collider



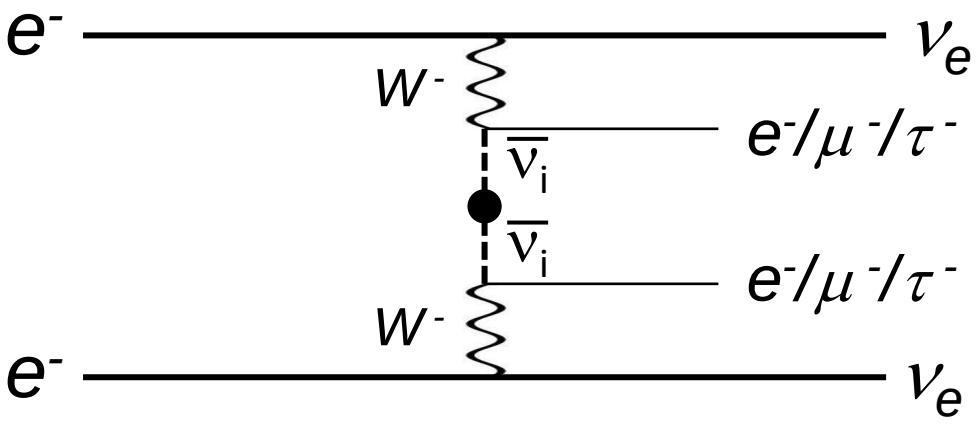


ILC : Indirect option

ILC : Z_o factory (GigaZ option)

ILC : Top factory

4. Majorana Neutrino Searches at ILC



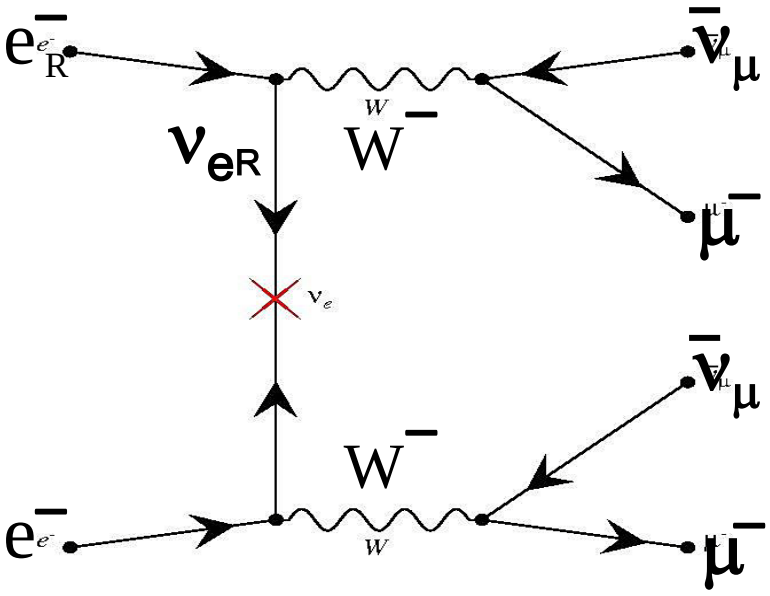
Monte Carlo Program : GRACE

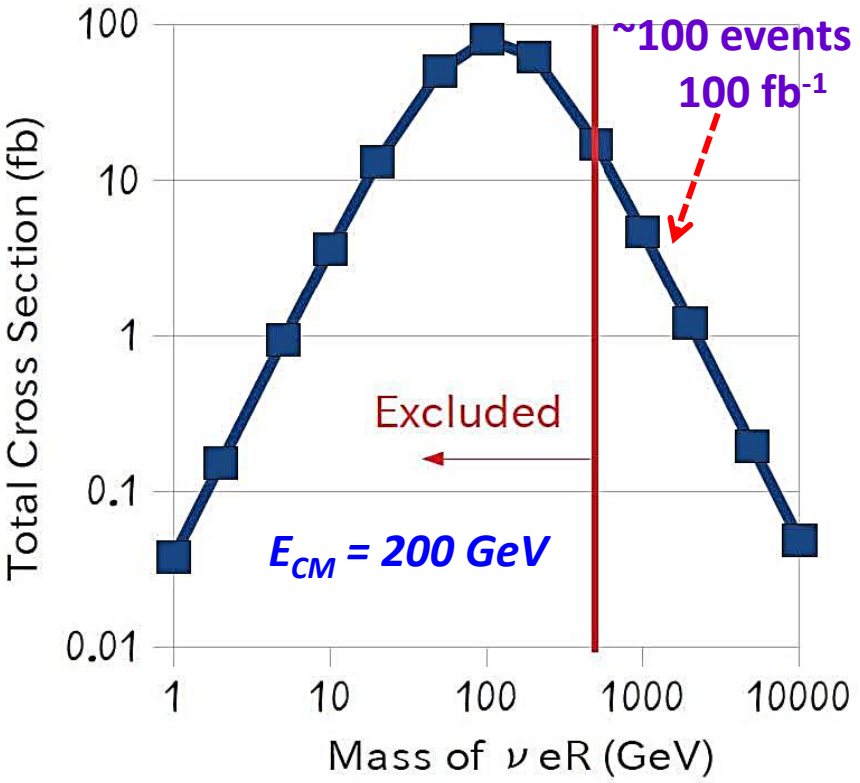
∈

Majorana Neutrinos

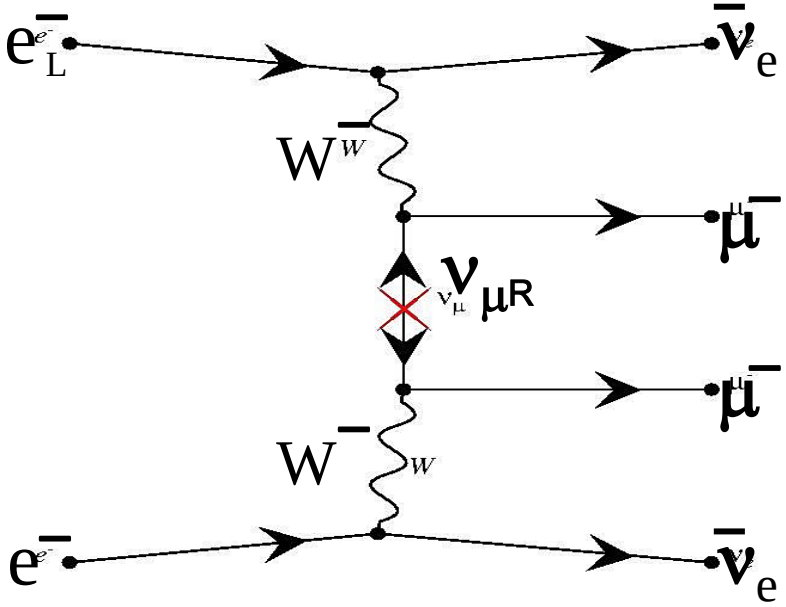
1 Model

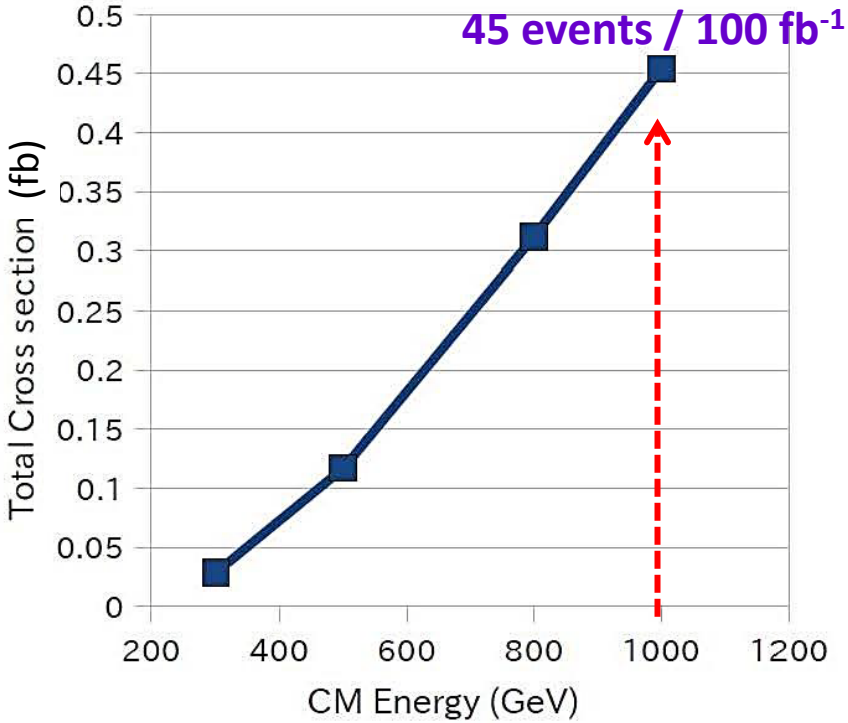
- $SU(2)_L \times SU(2)_R \times U(1)_{B-L}$
- Gauge boson masses on $SU(2)_L \times SU(2)_R$ are degenerated: $m_{W_L^\pm} = m_{W_R^\pm}$.
- Neutrinos are Majorana particles.
- A mass of left-handed neutrino is light: $m_{\nu_L} \ll \mathcal{O}(\text{eV})$.
- A mass of right-handed neutrino is heavy: $m_{\nu_R} \geq \mathcal{O}(\text{weak scale})$.





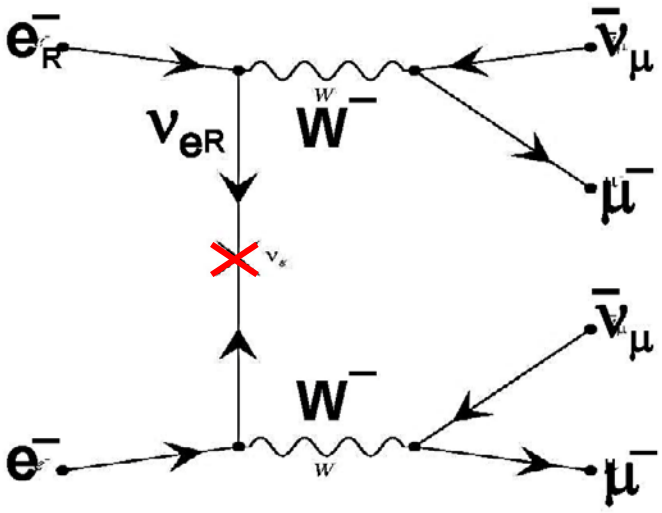
- A W^- pair-production occurs through a right-hand electron-neutrino.
- A CM-energy is 200 GeV.
- Cut:$30^\circ < \theta_\mu < 150^\circ$, $E_\mu > 10$ GeV
- We assume a signal is background-free.
- Total cross sections in fb are shown in Figure .
- We can expect about 100 events for 1 TeV ν_{eR}-mass after accumulating 100 fb^{-1}.

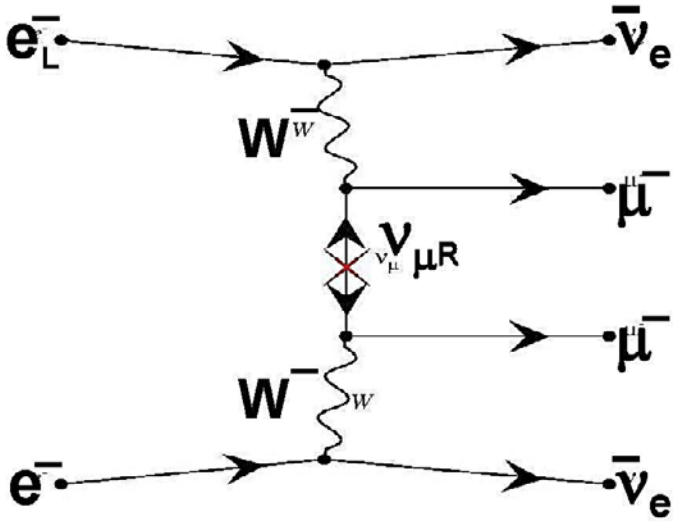




- A W^- pair-production occurs through a right-hand muon-neutrino
- A mass of a right-hand muon-neutrino is set to be the same as a W-boson mass.
- Cut:$30^o < \theta_\mu < 150^o$, $E_\mu > 10$ GeV
- We assume a signal is background-free.
- Total cross sections in fb as a function of a CM-energy are shown in Figure
- We can expect about 45 events at a CM-energy of 1 TeV after accumulating 100 fb^{-1}.

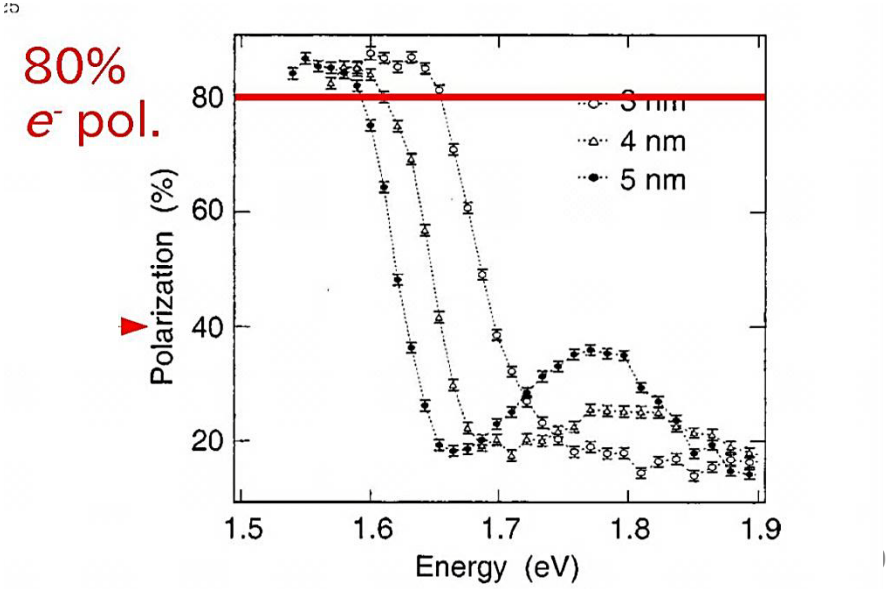
Beam Polarization : Discriminate 2 Reactions





Recent achievement at SLAC

T. Maruyama et al., App.Phys. Lett., 85 (2004) 2640



PHYSICAL REVIEW D VOLUME 53, NUMBER 11 1 JUNE 1996

Inverse neutrinoless double β decay reexamined

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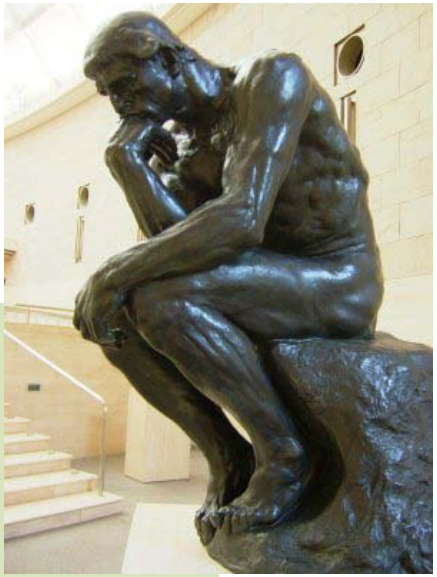
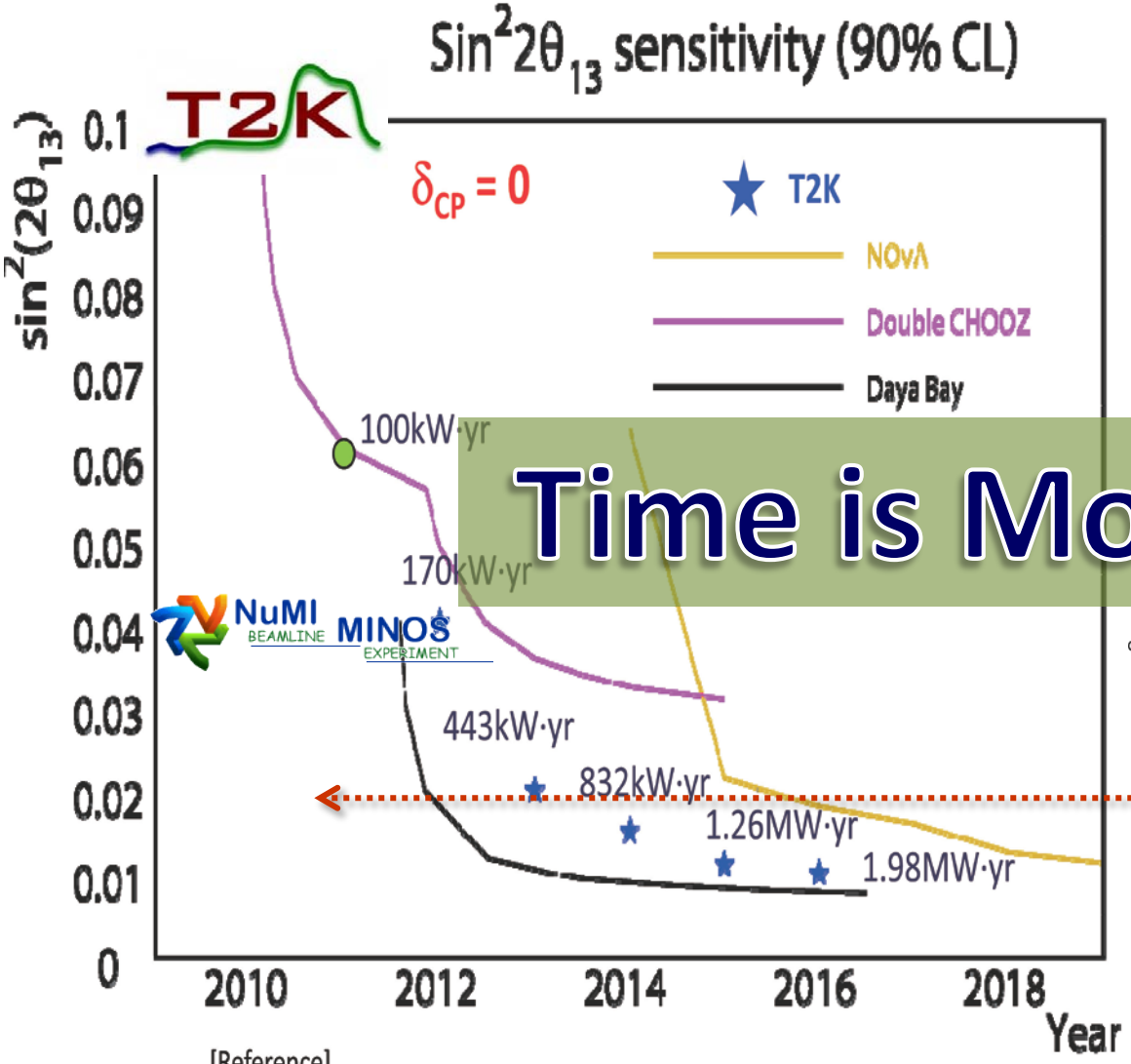
We critically reexamine the prospects for the observation of the $\Delta L=2$ lepton-number-violating process $e^-e^-\to W^-W^-$ using the e^-e^- option of a high-energy e^+e^- collider (NLC). We find that, except in the most contrived scenarios, constraints from neutrinoless double β decay render the process unobservable at an NLC of $\sqrt{s}<2$ TeV. Other $\Delta L=2$ processes such as $\gamma\gamma\to\ell^+\ell^+W^-W^-$, $e^-\gamma\to\nu_e\ell^-\ell^-W^+$, $e^-e^-\to\nu_e\nu_e\ell^-\ell^-$ ($\ell=\mu,\tau$), and $e^-\gamma\to e^+W^-W^-$, which use various options of the NLC, require a $\sqrt{s}$ of at least 4 TeV for observability. [S0556-2821(96)00611-X]

5. Summary

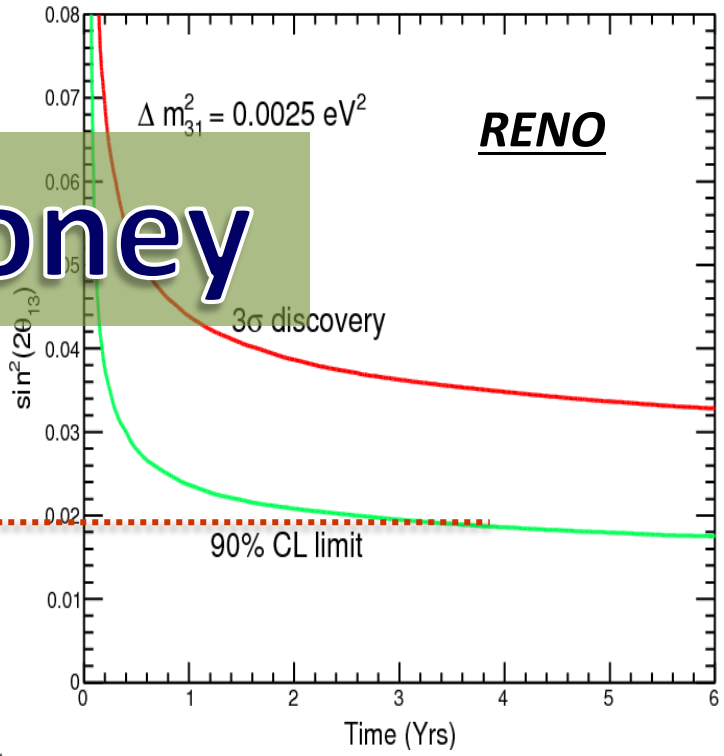


Thinking, Thinking,,,,
Neutrino Physics at ILC
:
ILC is the next lepton collider option

World θ_{13} Race : Overheating !



Time is Money



[Reference]
NOvA: M. Messier, FNAL Director's CD-3b Review, 2009/6/16
Double CHOOZ: A. Porta, Rencontres de Moriond EW 2009, 2009/3/13
Daya Bay: P. Rubin, ibid