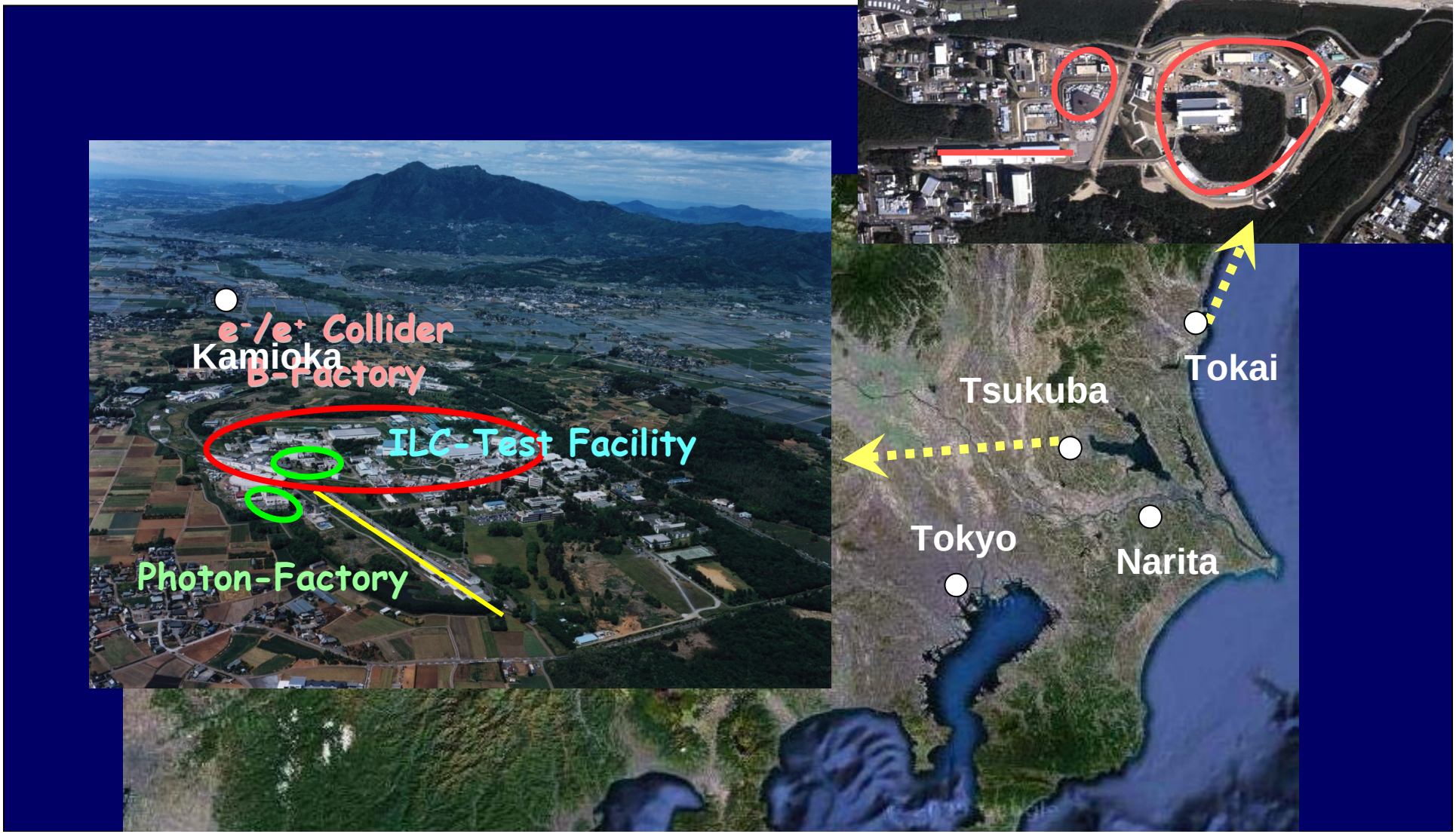
High Energy Physics in Japan

J-PARC
Super KEKB
R&D for ILC

Fermilab User's Meeting, June 2-3, 2010

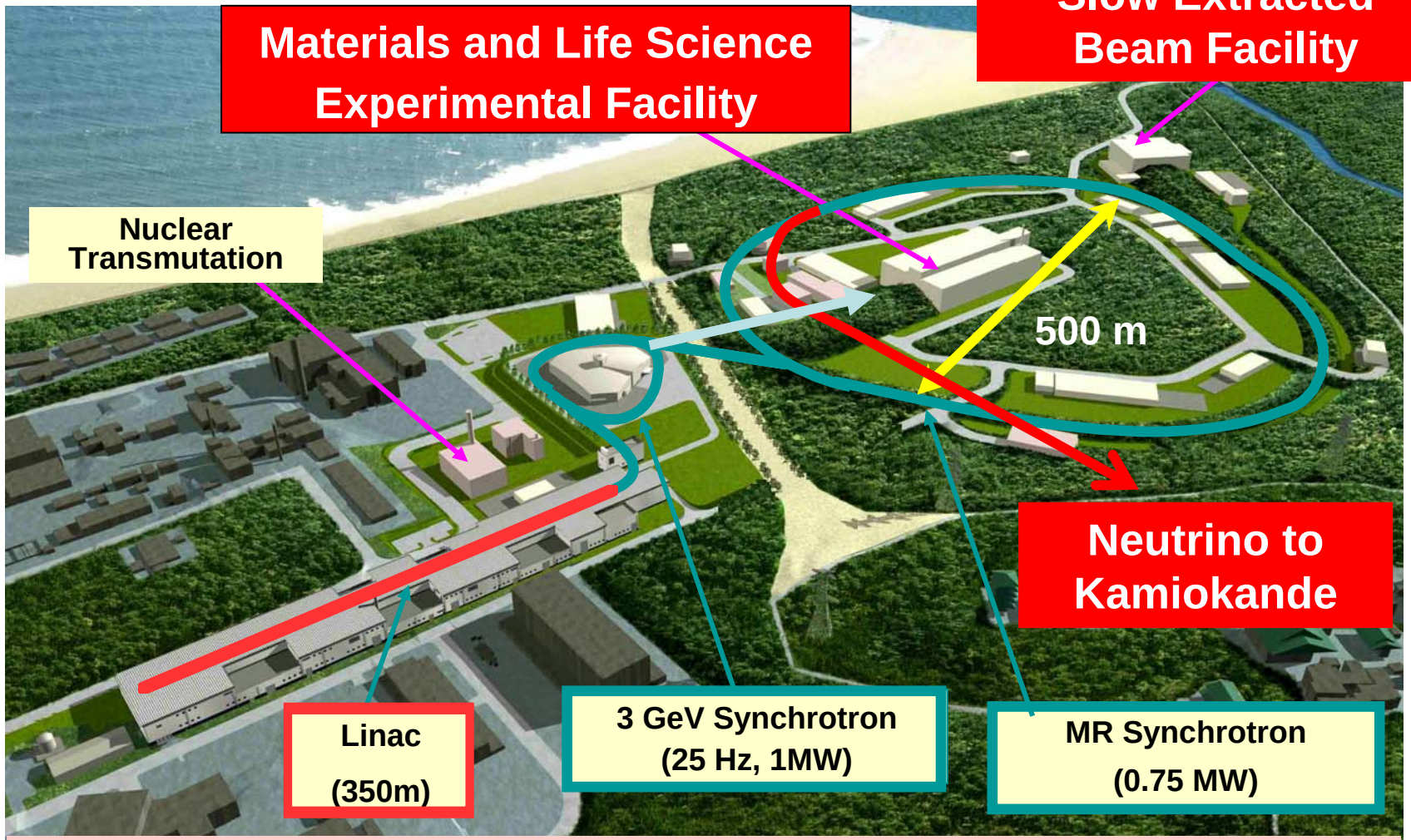
Koichiro Nishikawa
IPNS, KEK

KEK : Center for High Energy Accelerator / Science Researches



Particle Physics at J-PARC

J-PARC



J-PARC = Japan Proton Accelerator Research Complex

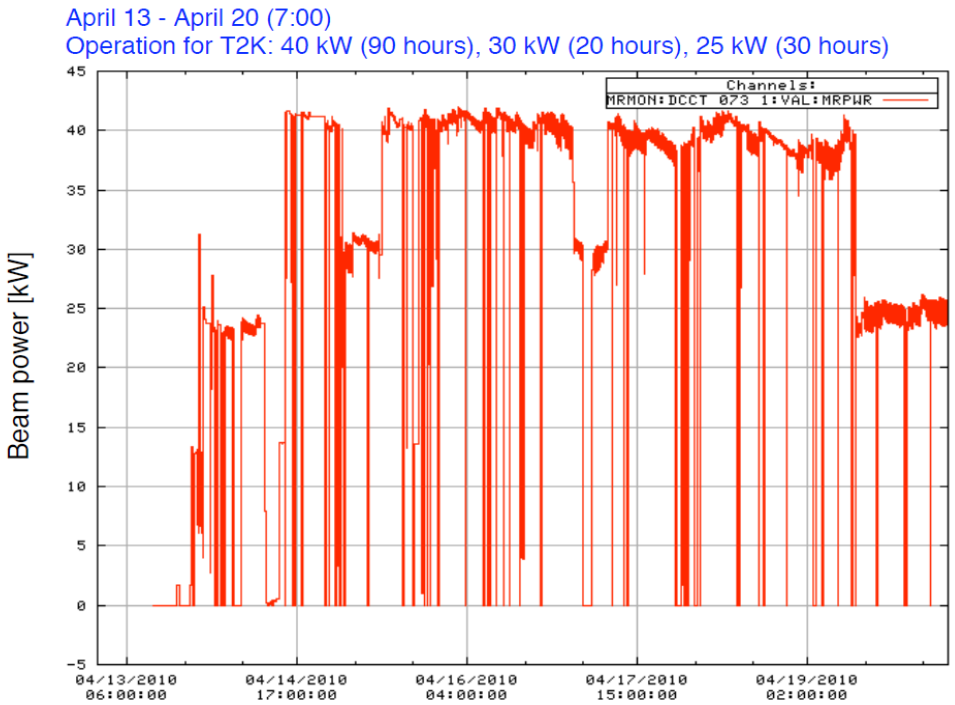
Joint Project between KEK and JAEA

Program Advisory Committee for Particle and Nuclear Physics

name	Affiliation	memo ○H20/4/1-H24/3/31 △H22/4/1-H26/3/31
Tadafumi Kishimoto	Research Center for Nuclear Physics	△
Susumu Shimoura	Center for Nuclear Study, University of Tokyo	○
Tomofumi Nagae	Kyoto University	△
Satoshi Nakamura	Tohoku University, Associate Professor	○
Yasuki Nagai	Japan Atomic Energy Agency	○
Toshinori Mori	International Center for Elementary Particle Physics	○
Hitoshi Yamamoto	Tohoku University	○
Avraham Gal,	The Hebrew University	○
Robert S Tschirhart	Fermi National Accelerator Laboratory	○
Matthias Gross-Perdekamp	University of Illinois	△
Konrad Kleinknecht	Mainz University	△
Shaevitz Michael	Columbia University	○
Shunzo Kumano	KEK	○
Katsuo Tokushuku	KEK	○
Ikaros I. Bigi	University of Notre Dame	△

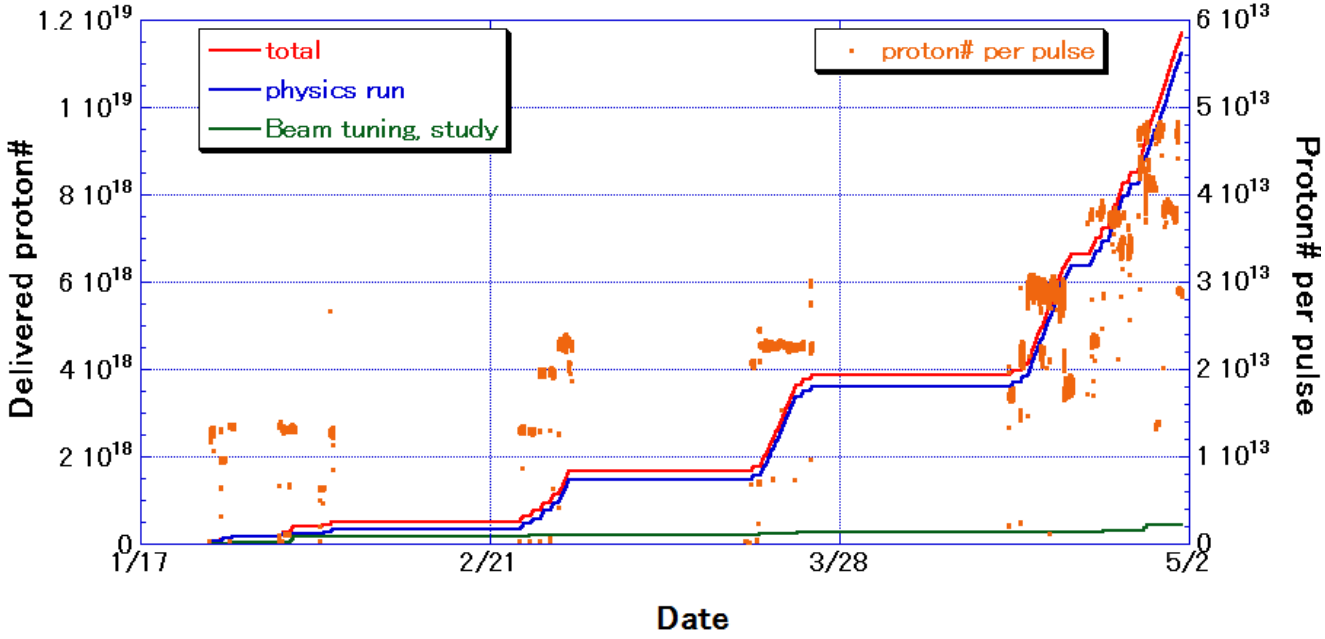
Accelerator status

Fast extraction beam in April



Beam loading in kicker
- to be replaced,
-Also for 8 bunches op.

Delivered # of protons
: 1.1 × 10^{19} (Jan.~Apr.)
Before summer shutdown
: 2~3 x 10^{19}



Accelerator status

Summary

T.Koseki
Apr.22

Fast extraction (FX) operation for neutrino of the main ring

-Continuous beam extraction of 50 kW in maximum to T2K experiment

-Start up high power beam operation

Demonstration of 100 kW operation in single shot mode.

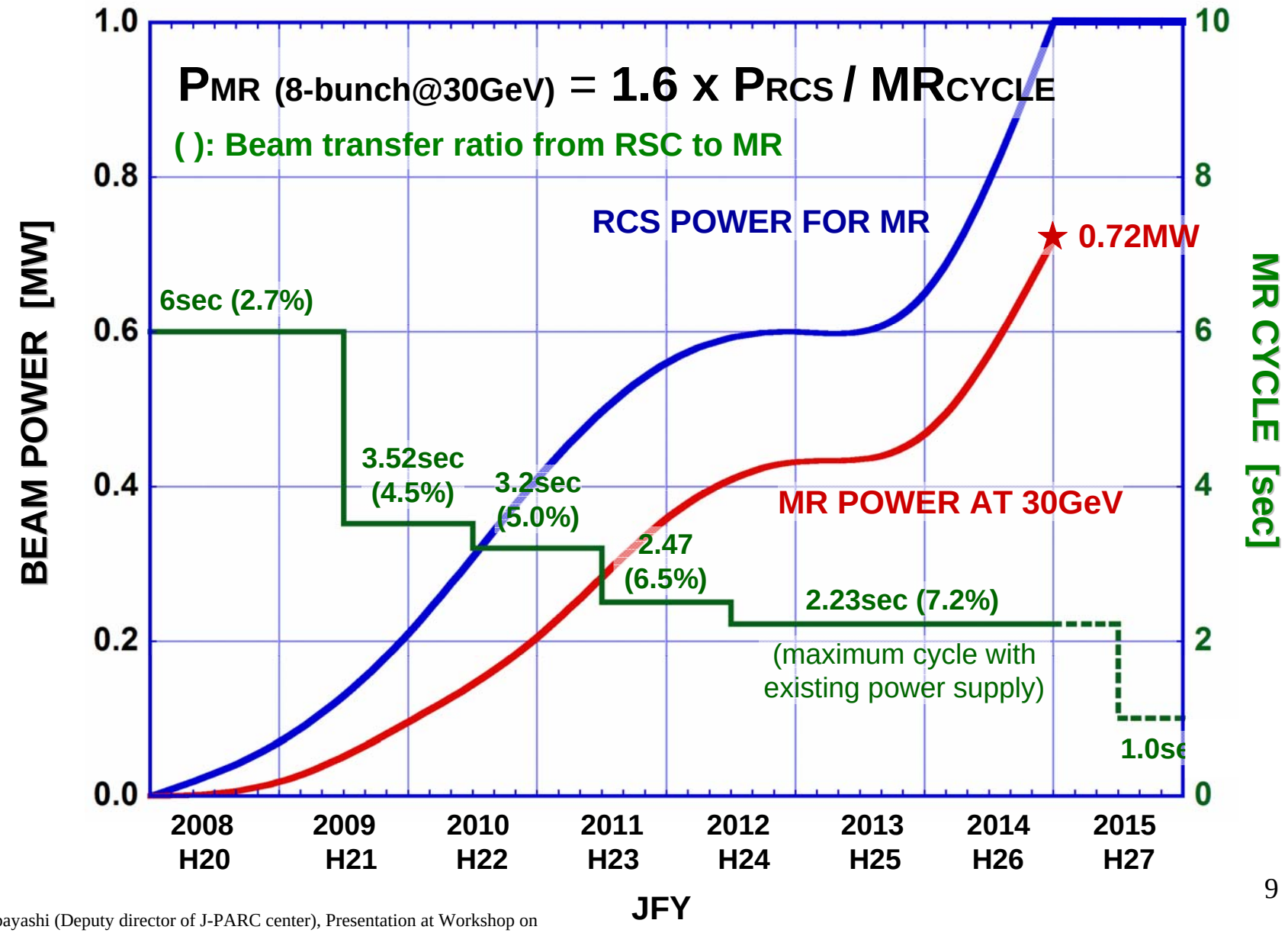
Plan for JFY2010:

- Beam delivery of 50 - 100 kW (or higher) to T2K experiment
- Detailed comparison between measurements and simulation for 100 kW intensity

In the 2010 summer shutdown:

- Increase shielding of 3-50BT (beam transport from 3GeV-RCS to MR)
- Replacement FX kickers to realize the operation with eight bunches
- Installation one 2nd harmonics cavity to reduce the effects of space charge force

AN EXPECTED BEAM POWER CURVES FOR RCS AND MR FAST BEAM EXTRACTION



H.Kobayashi (Deputy director of J-PARC center), Presentation at Workshop on Applications of High Intensity Proton Accelerators, Oct.19-21, 2009, FNAL

T2K experiment

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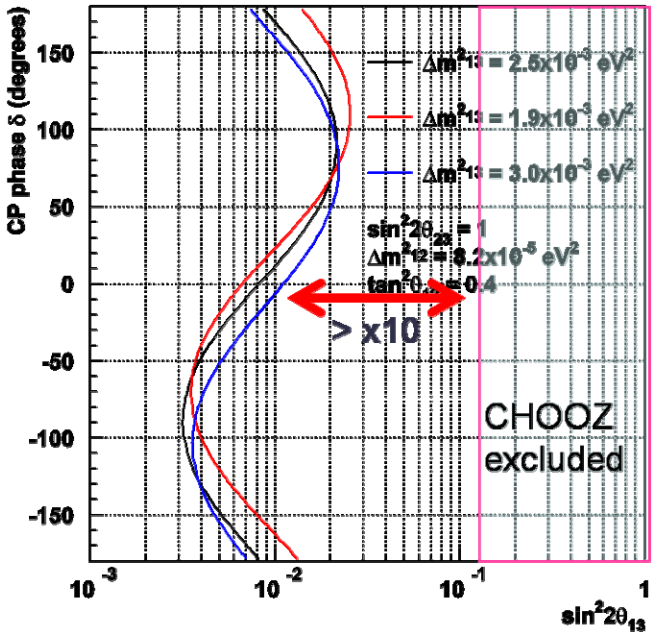
Tokai-to-Kamioka (T2K) long baseline neutrino oscillation experiment

Super-Kamiokande
(ICRR, Univ. Tokyo)

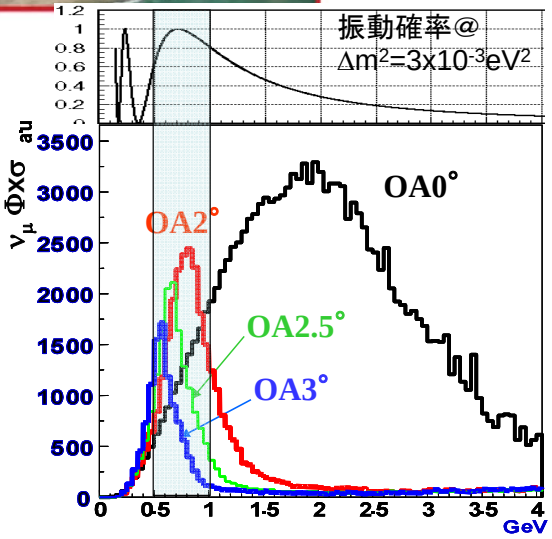
Now Running!

J-PARC Main Ring
(KEK-JAEA, Tokai)

ν_e appearance (θ_{13})

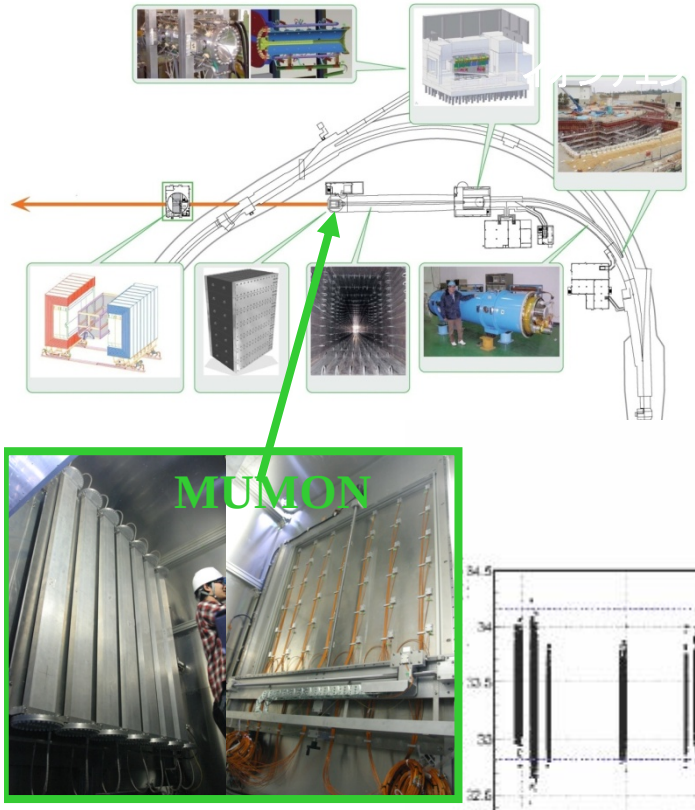


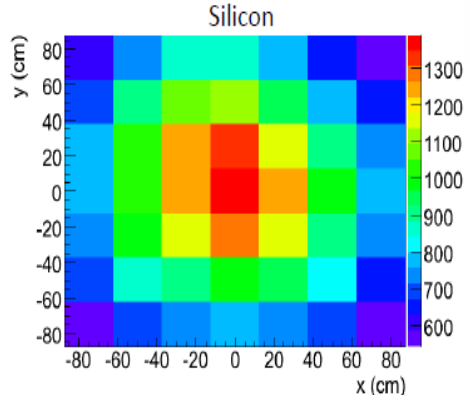
- Goal
  - **Discover νμ →νe app.**
  - νμ disapp. meas.
- Intense narrow spectrum νμ beam
  - Off-axis w/ 2~2.5deg
  - Tuned at osci. max.
- Near detector
- Super Kamiokande



1600ν_μCC/yr/22.5kt

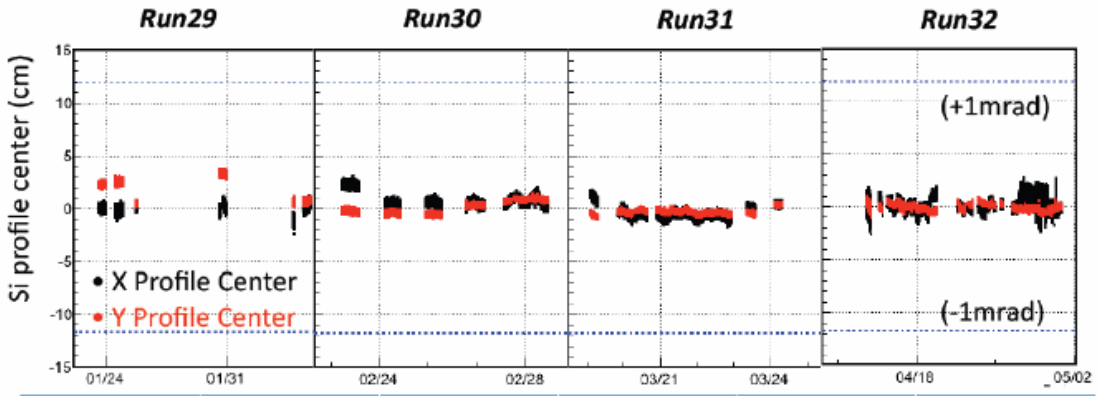
Beam direction & intensity stability

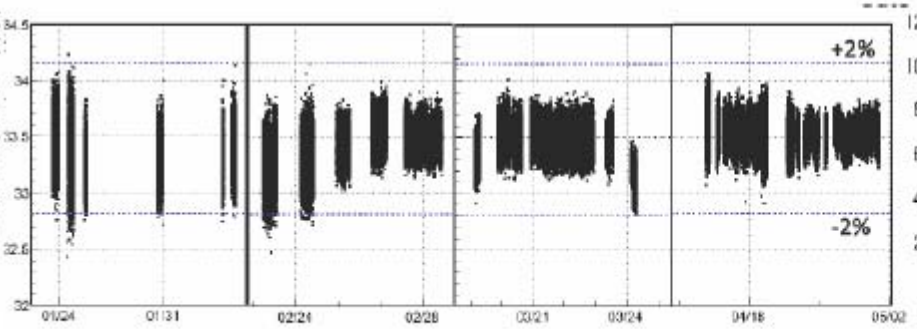


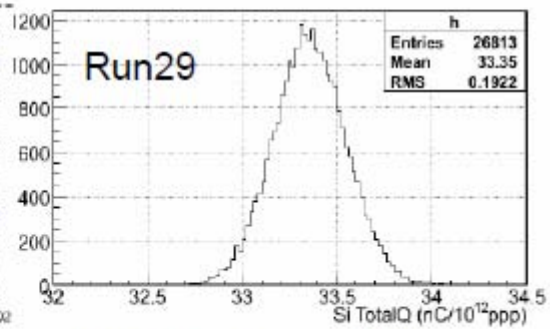


Muon direction

K. Suzuki







RMS / Mean = 0.58%

Very stable well within our physics requirements.

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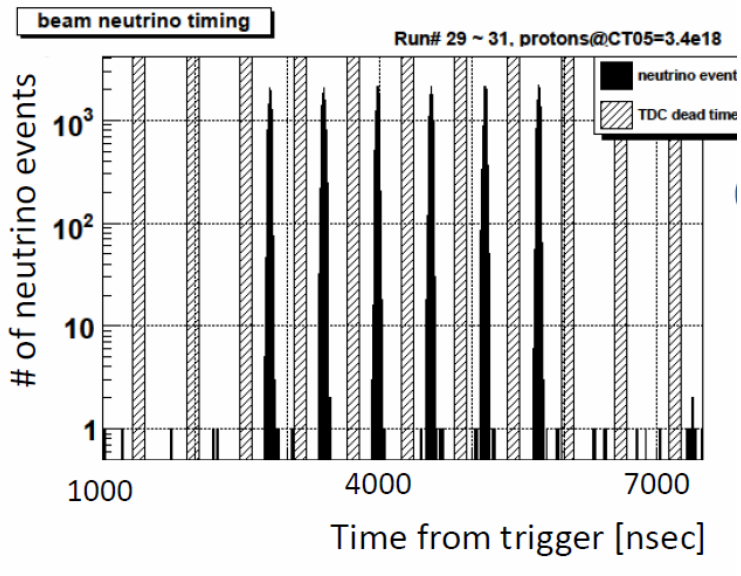
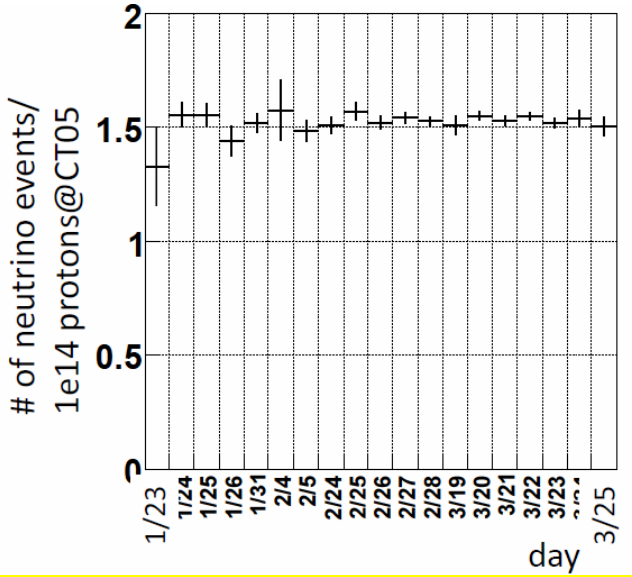
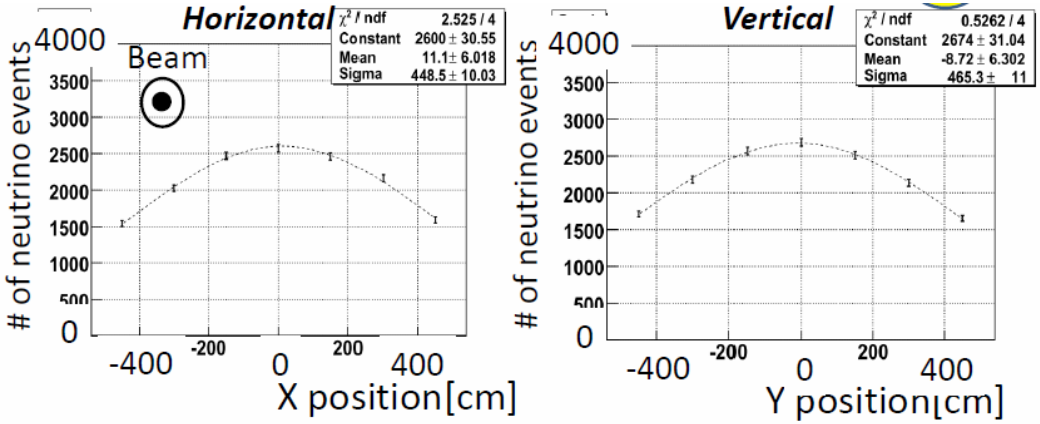
Neutrino profile measurements@280m







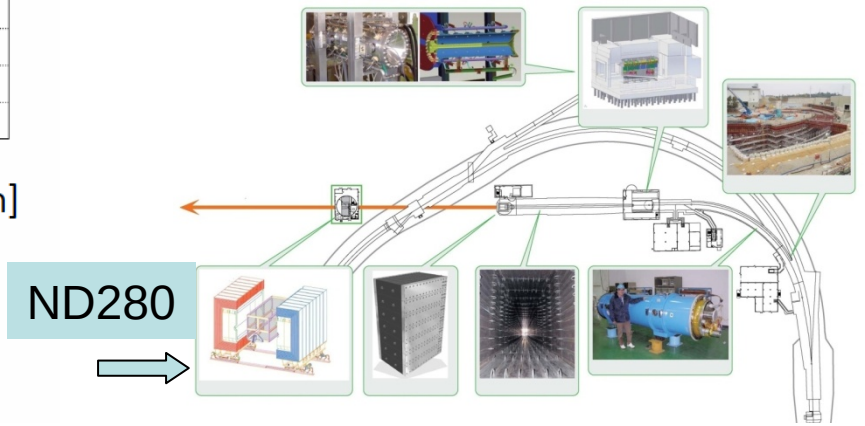
Center: 11.1 +- 6.0 cm (to south)
σ : 449 +- 10 cm

Center: -6.8 +- 6.3 cm
σ : 465 +- 11 cm

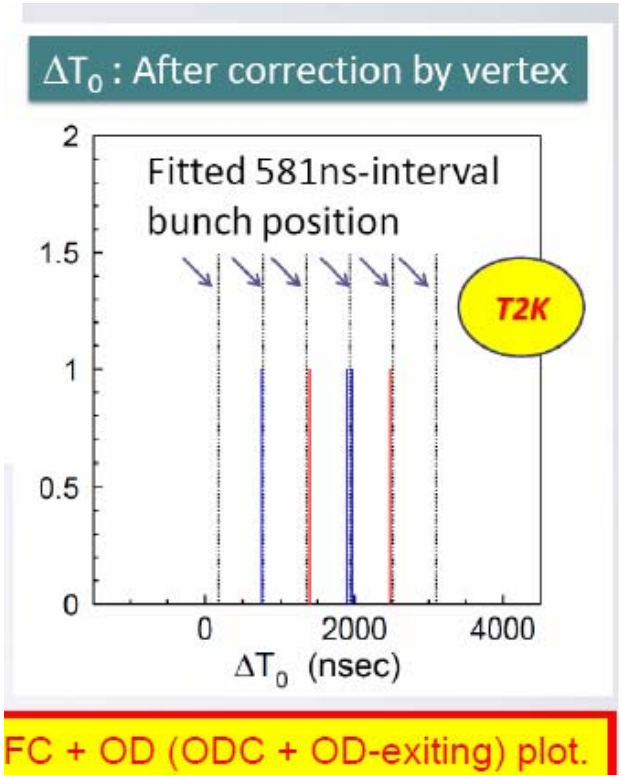
(※)Error include only stat. error.

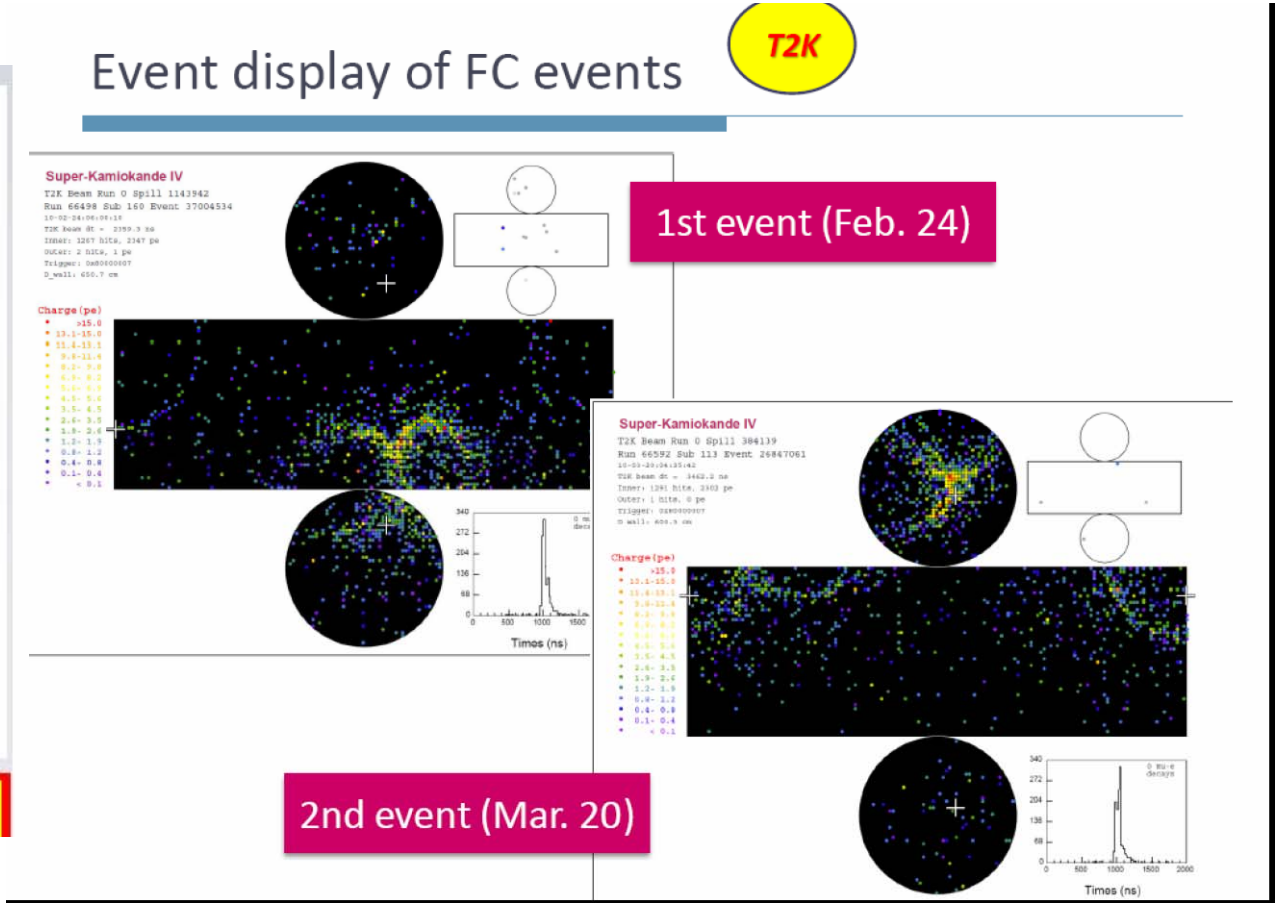
Neutrino direction is within 1mrad(28cm)(※)

- Bunch structure clearly seen
- Event rate is stable
- Beam direction is within 1mrad



Observed SK event sample before the end of March
Now more events





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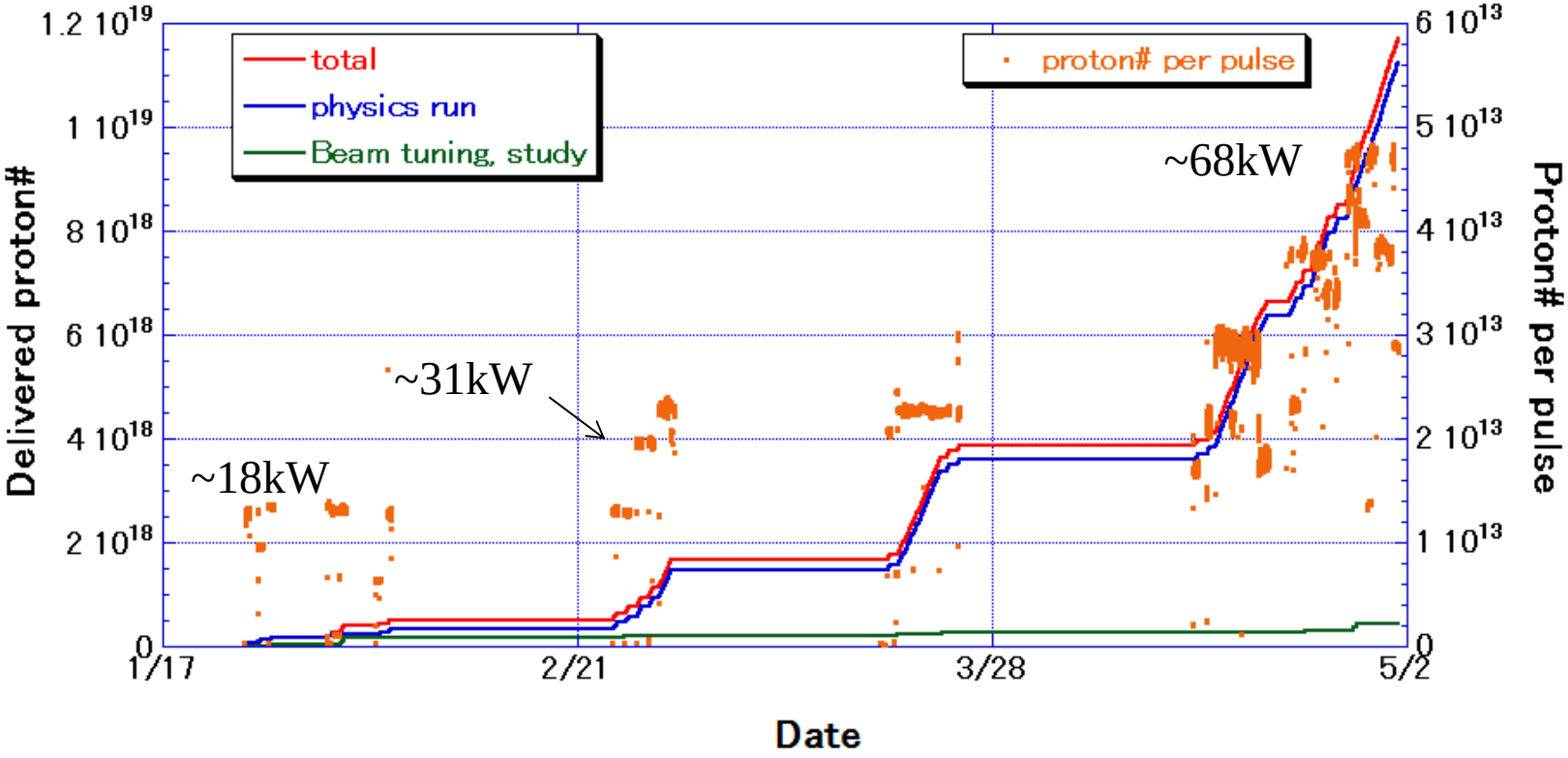
Started physics data taking!

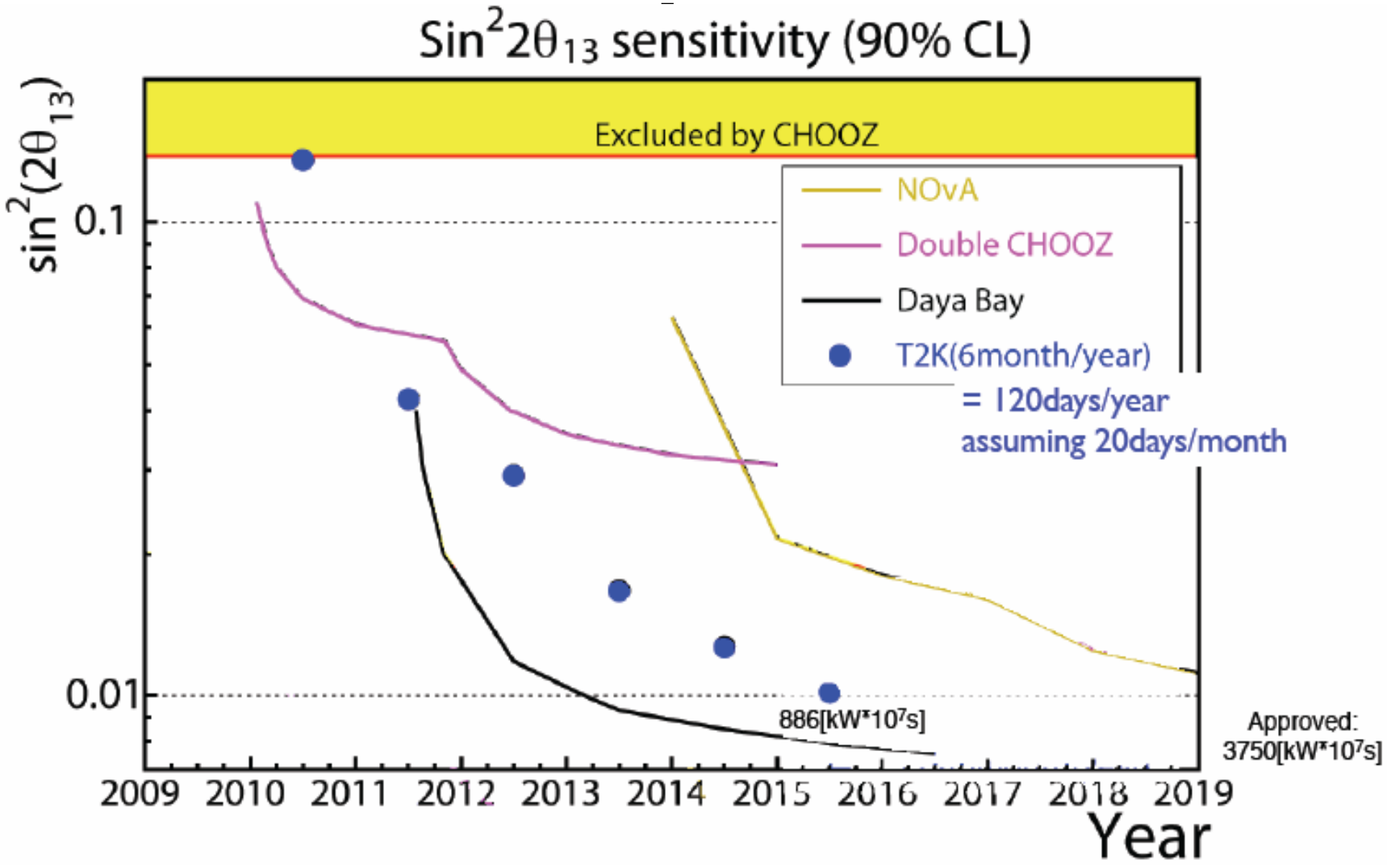


Delivered # of protons : 1.1×10^{19} (Jan.~Apr.)

Keep running till June and restart in Nov. hopefully

>100 kW for 7-8 months before June 2011

Search ν_e appearnce well below CHOOZ limit


Sin²2θ13 sensitivity (90% CL)
sin²(2θ13)
0.1
0.01
Excluded by CHOOZ
NOvA
Double CHOOZ
Daya Bay
T2K(6month/year)
= 120days/year
assuming 20days/month
886[kW*10⁷s]
Approved:
3750[kW*10⁷s]
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year

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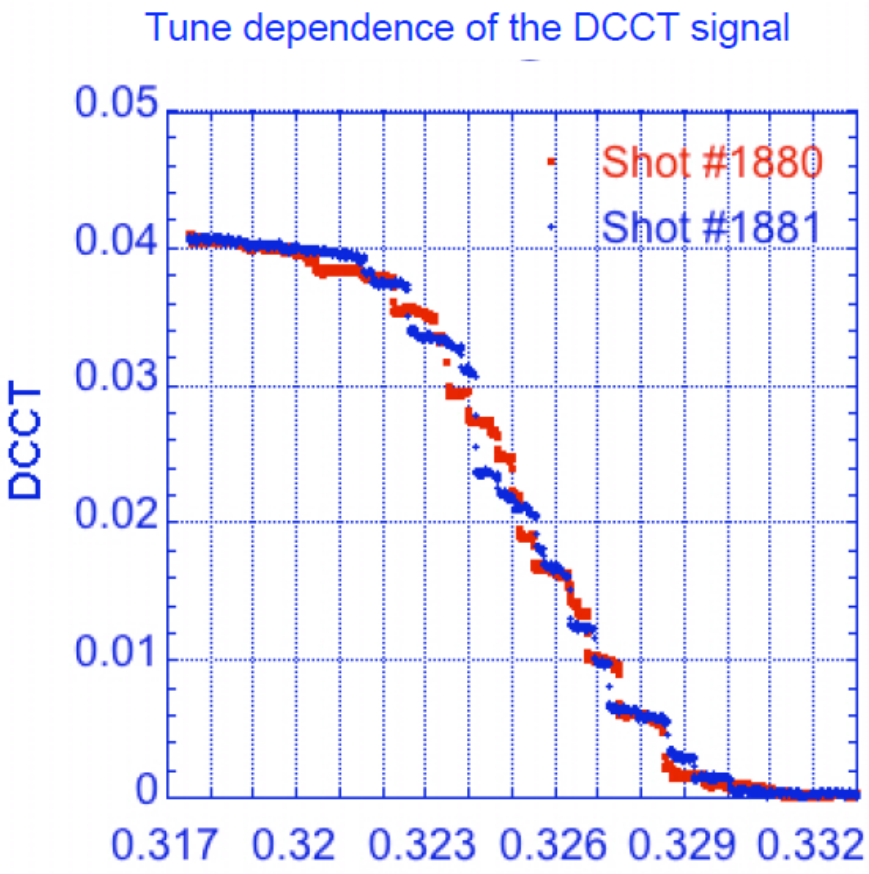
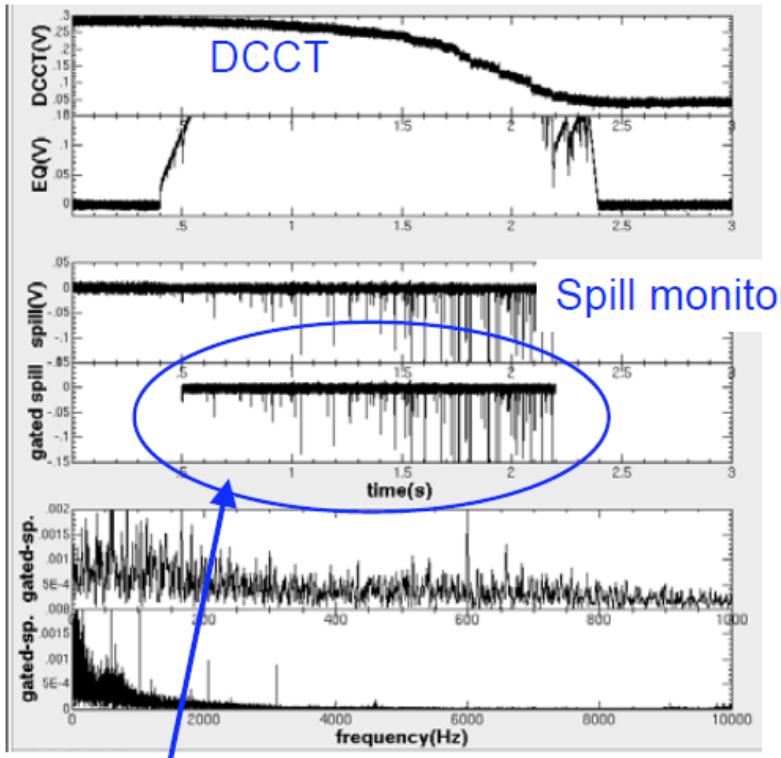
Slow extraction

Slow Extraction

Spill structure &Radioactivity by beam loss



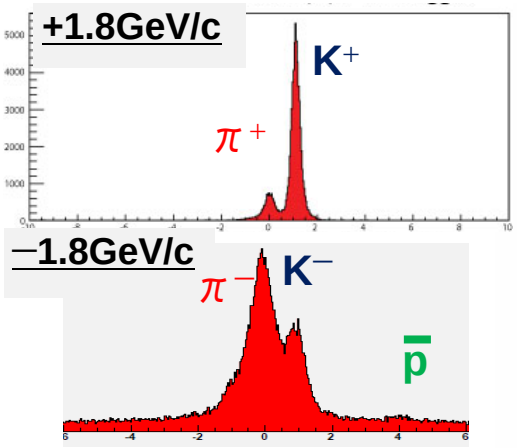
Because of the tune fluctuation, the circulating beam decreases in the step-like shape

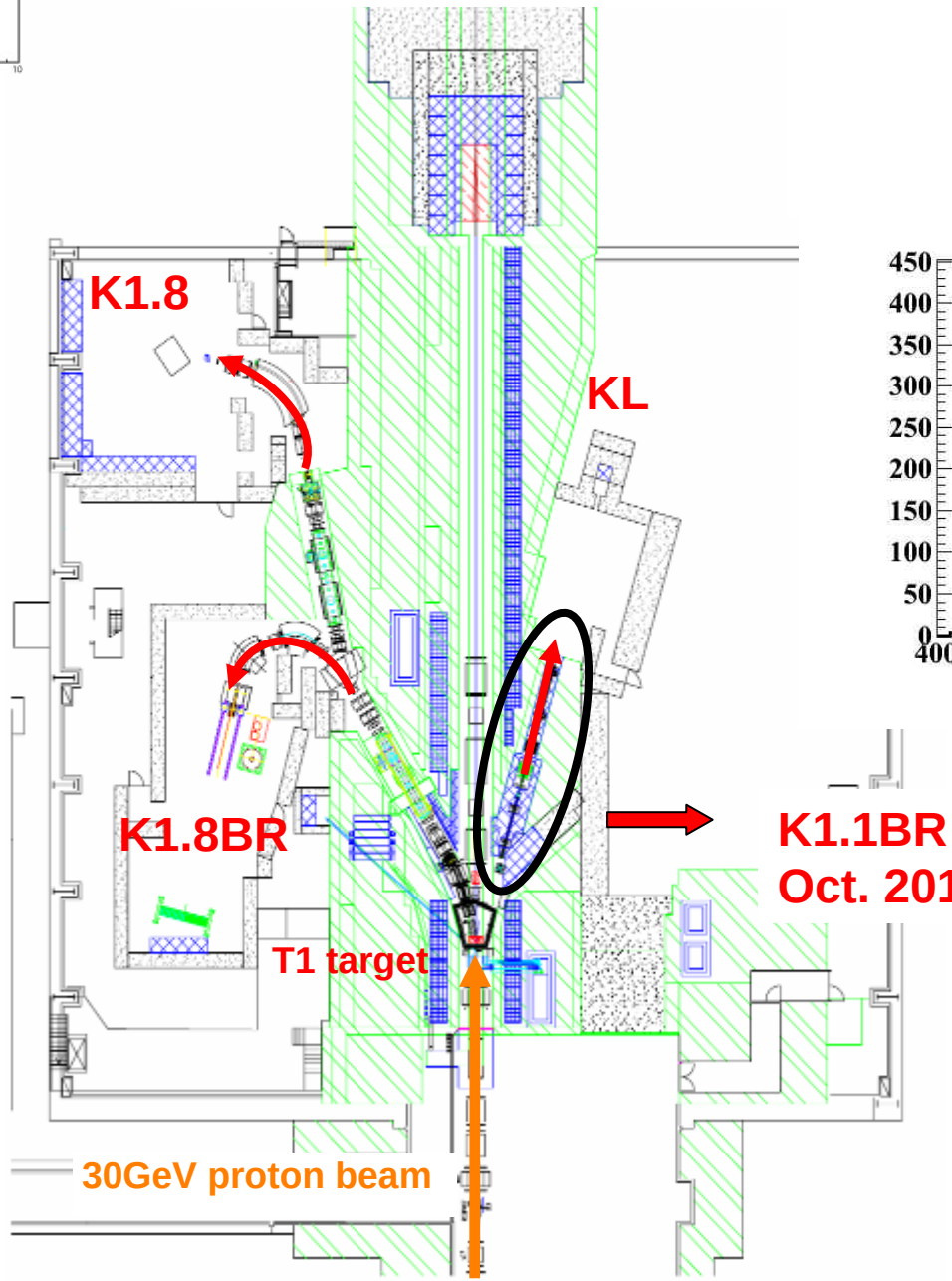


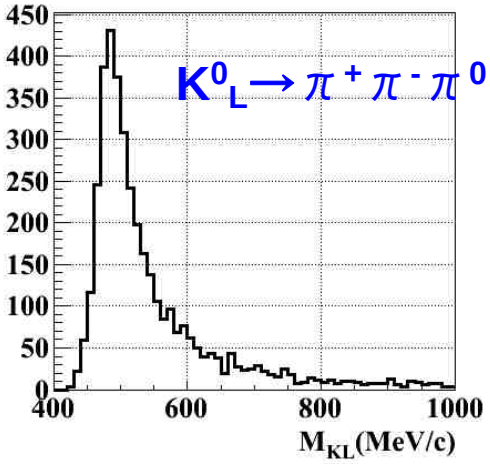
Extracted beam has many sharp peaks.

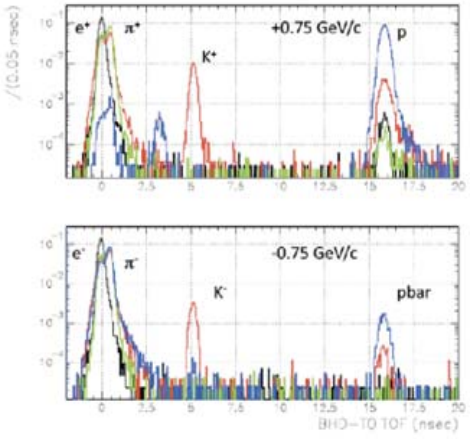
$$Duty = \frac{\left(\int_0^T Idt\right)^2}{\int_0^T dt \int_0^T I^2 dt} \qquad \sim 1\ \%$$

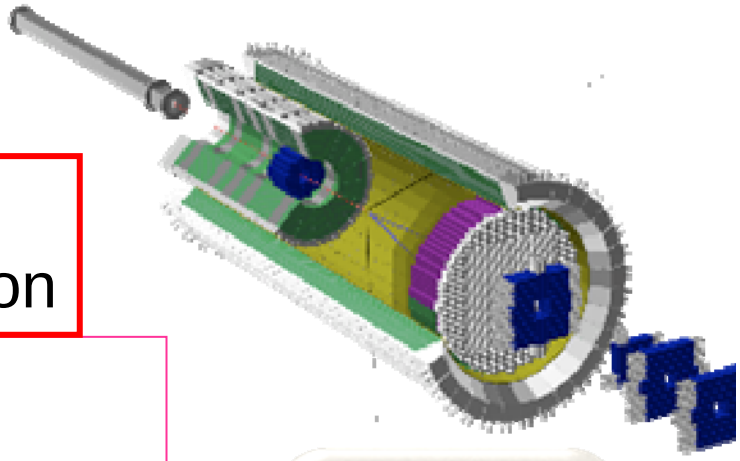
Slow extracted beam facility









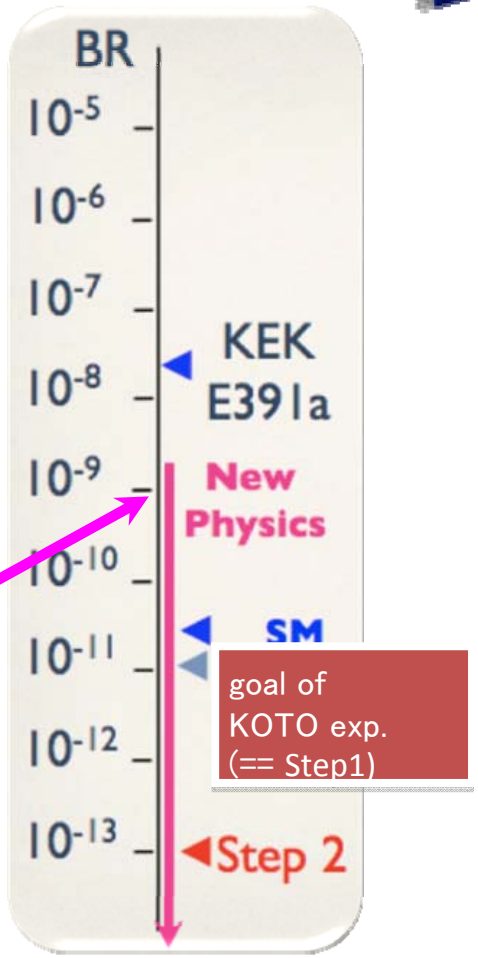


Search for CP violation sources in KL above the second order weak interaction

- 2009: beamline construction
  - ⇒ beam survey (KL flux)
- 2010: CsI calorimeter construction
  - ⇒ engineering run
    - beam properties with calorimeter
    - Beam test at Tohoku U. with electron beam
    - Integration of calorimeter components:
      - CsI crystal, PMT, PMT holding structure, CW base, HV circuit, 125MHz FADC, cables, ...
- 2011: detector installation
  - ⇒ full engineering run, start physics run

Grossman-Nir limit

10% intensity(30kW) one month



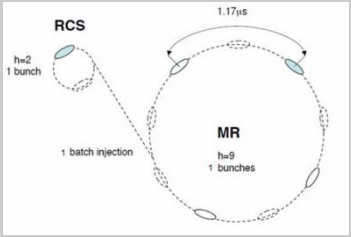
R&D for future

Muon experiments R/D

g-2, μ–e conversion

COMET (μ–e conversion search@J-PARC)

- **Beam Extinction Study**
  - Abort line measurement



•Single bunch, single shot operation of MR

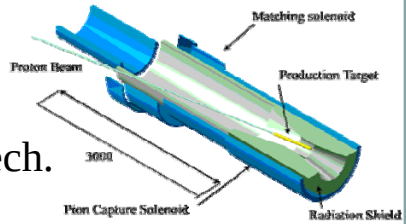
~ 10^{-7} level has been measured

  - Secondary beam line measurement

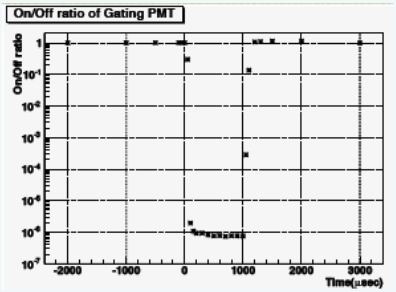
•Measure secondary particle time structure relative to a reference signal from the MR

•Bunched slow extraction to be done

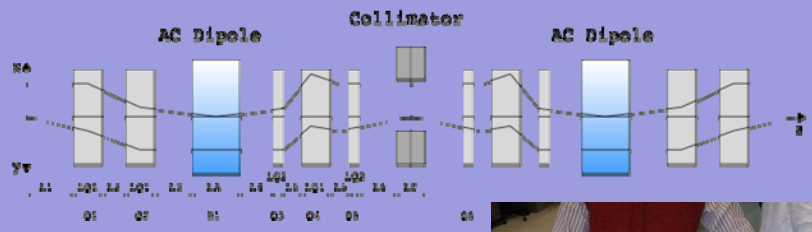
- **Super-conducting solenoid**
  - Pion capture solenoid
- B=5T
- Radiation transparent
- Technology
  - Detector Solenoid Tech.
  - NbTi+Al conductor
  - Indirect pipe cooling
  - Conductor development
  - Test coil construction and test



- **Extinction monitoring device development**
  - Gating PMT developed (10^{-6} level)



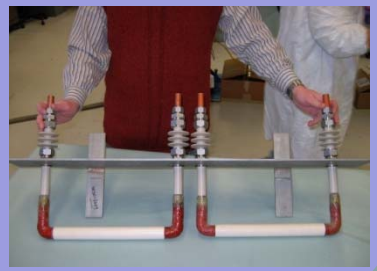
- **AC-dipole development**



- Collaboration with FNAL

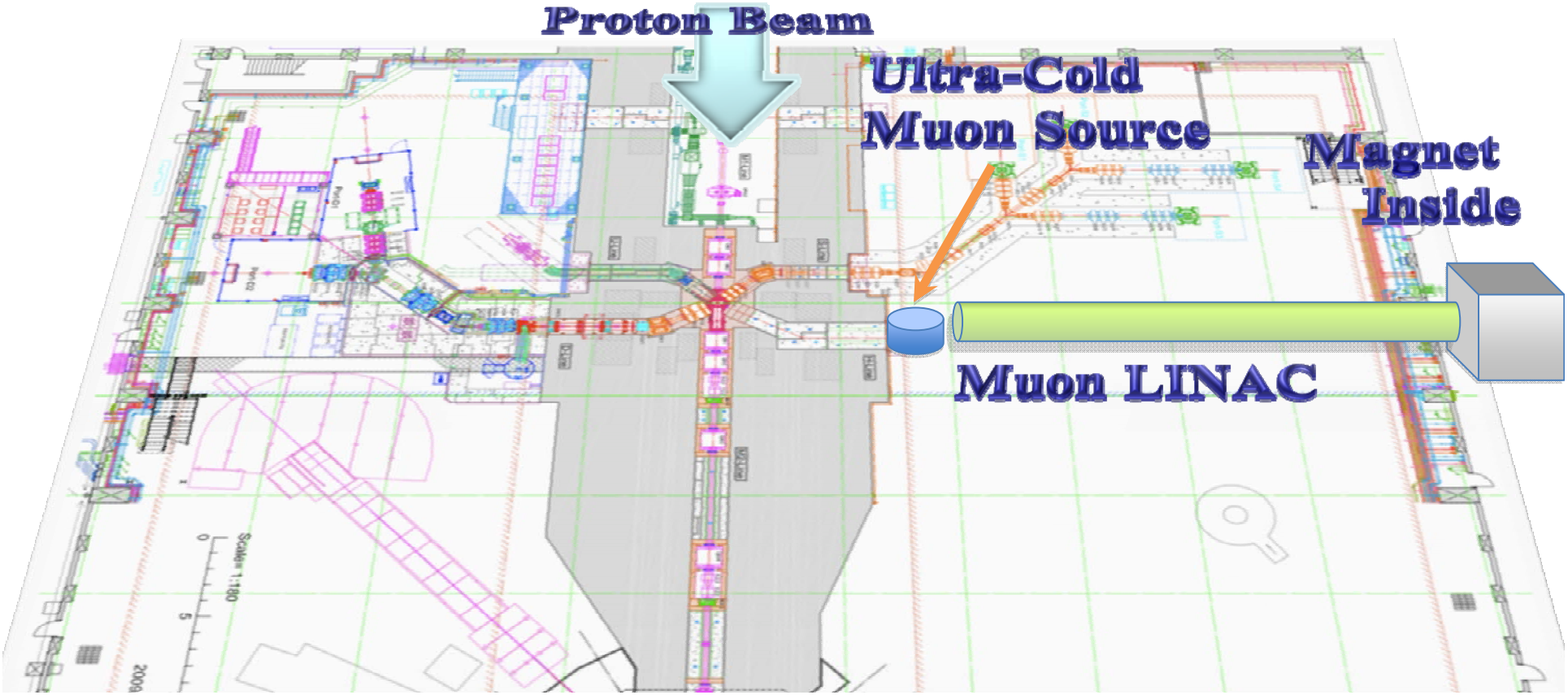
•1st version corona-tested

•2nd version built



Muon g-2/EDM proposal at 3GeV RCS facility

- Proposal submitted to J-PARC PAC
  - Many homework! R&D
  - Muonium production
  - Ionization by high power laser
  - Acceleration while keeping small emittance to allow expt at non-magic momentum
  - Precision magnet



Future neutrino program

Beyond T2K

- Lepton Sector CP Violation
  - Search for CP violation in Neutrino Oscillation Process
    - Comparison with Reactor data
    - Neutrino & anti-neutrino comparison （ν, $\bar{\nu}$ cross section)
    - ➢ 1st and 2nd oscillation maximum comparison （wide E_ν ）
- Proton Decay
  - $p \rightarrow \nu K$
  - $p \rightarrow e \pi^0$
  - SK has accumulated about 200kton･year and continuing

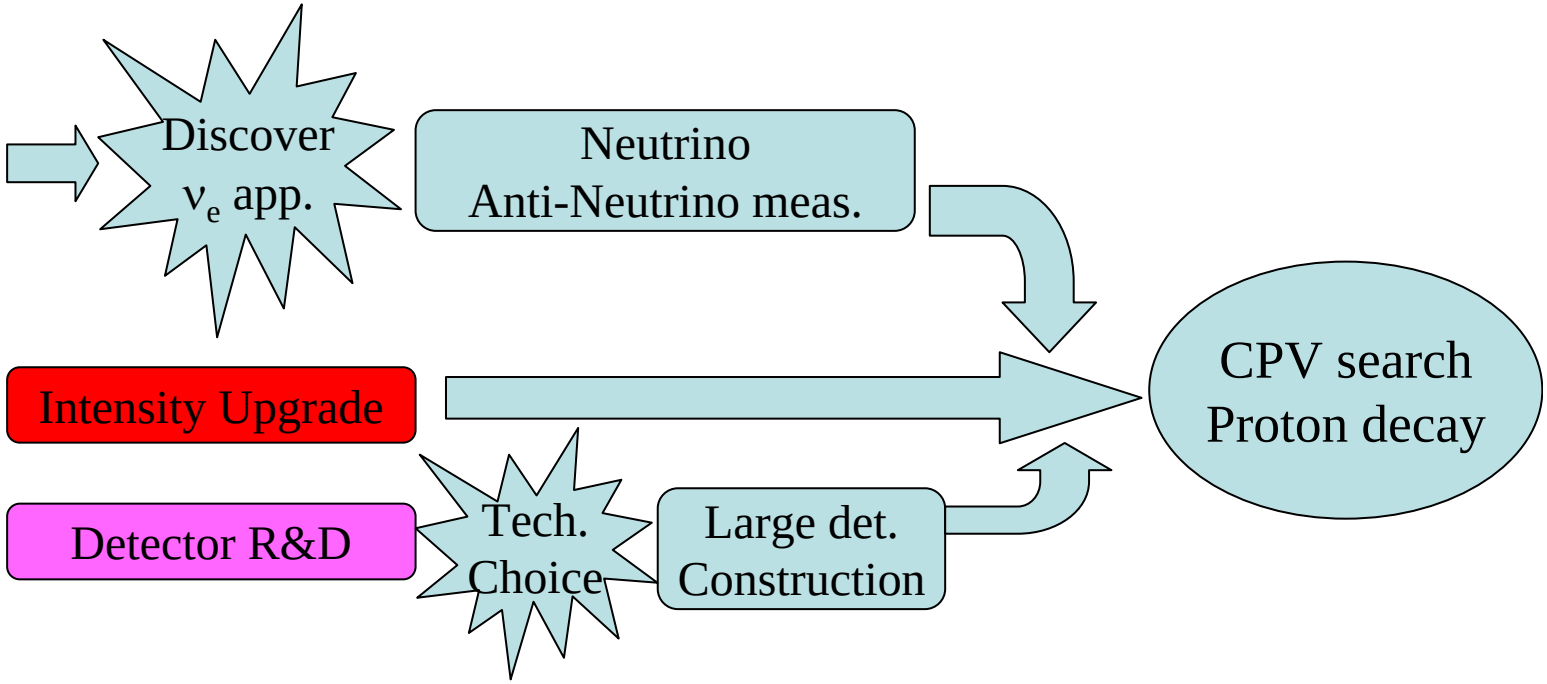
Required

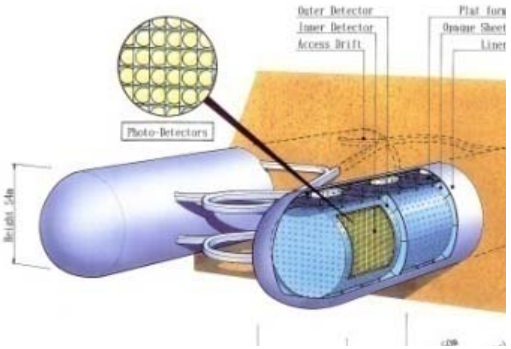
1. **Higher beam power**
2. **New detector concept, new way of looking for the phenomena**

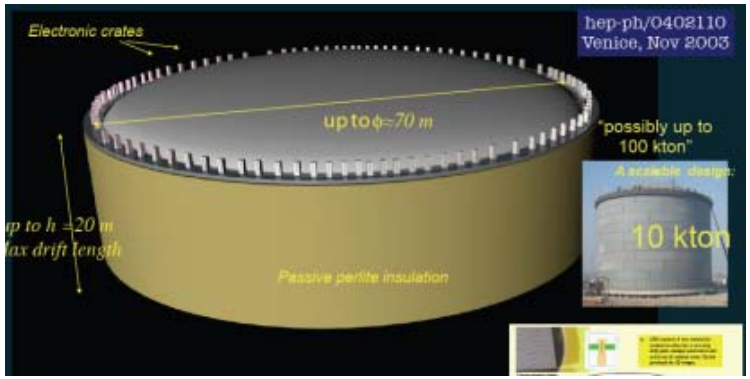
Beyond T2K

Quest for the Origin of Matter Dominated Universe

T2K (2009~)

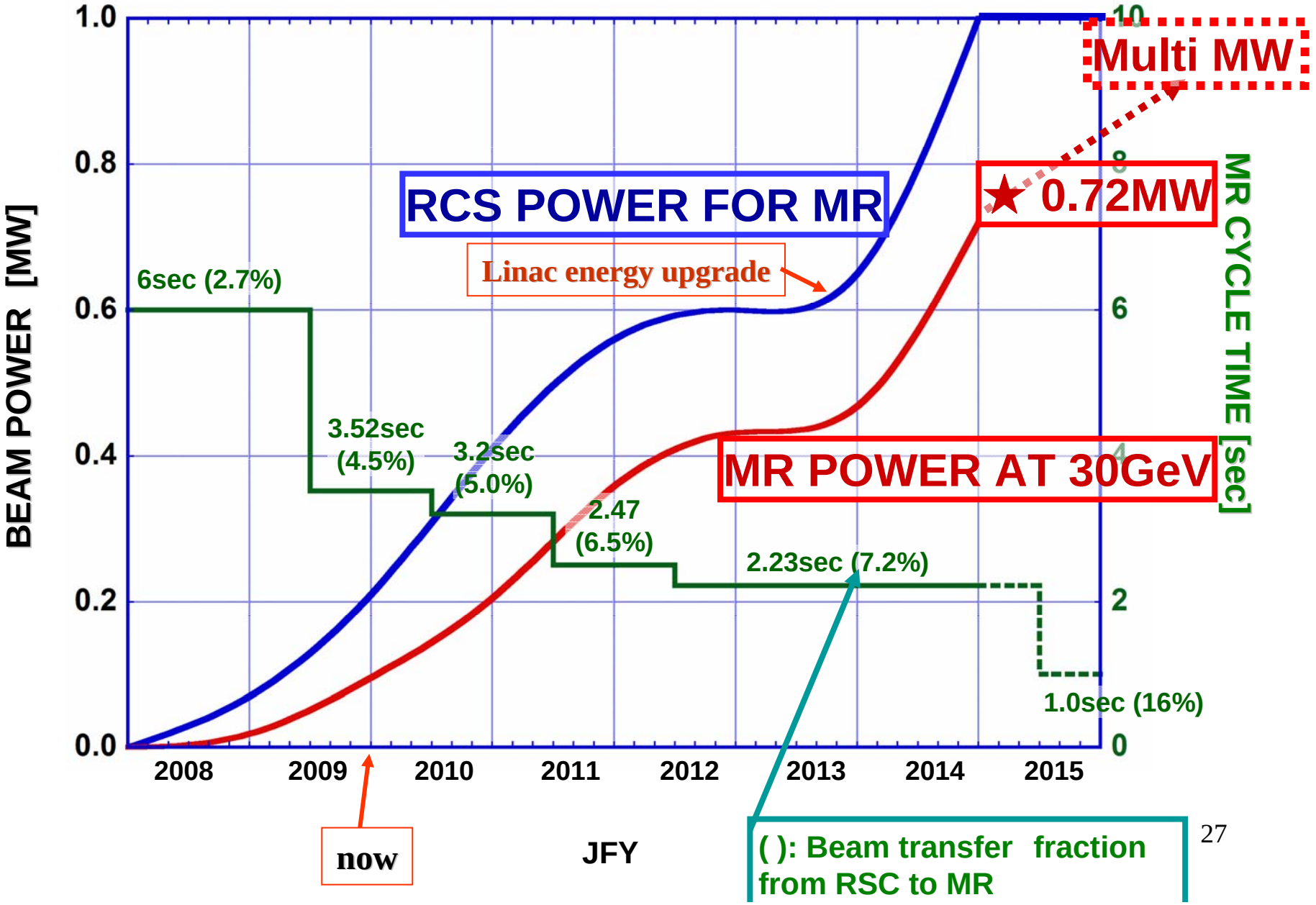






AN EXPECTED BEAM POWER CURVES for FX

Rapid cycling PS (>1Hz) RF technology, power supply

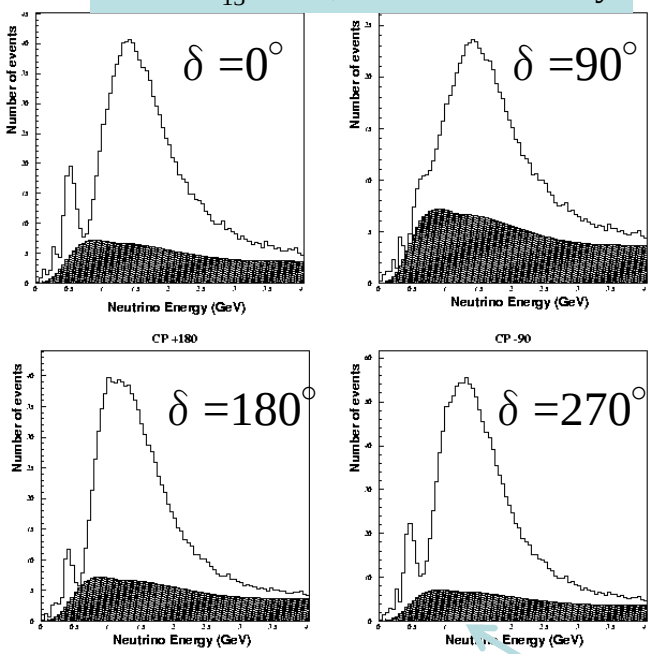


A Scenario

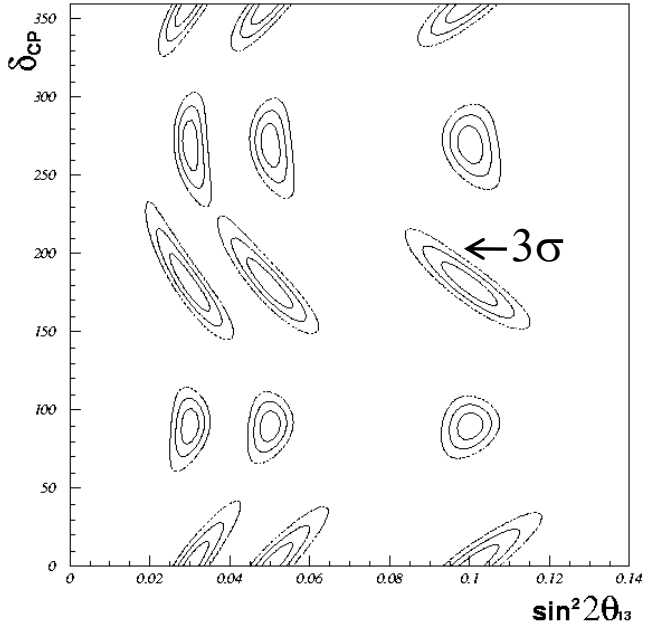
- Cover 1st and 2nd Maximum
- Neutrino Run Only 5Years × 1.66MW
- 100kt Liq. Ar TPC
  - Good e/π^0 discrimination
  - Good multi-track measurement
  - →Reconstruction of wide energy range

ν_e Spectrum

$\sin^2 2\theta_{13}$=0.03,Normal Hierarchy



CP Measurement Potential



Super KEKB

Major achievements at Belle

Belle collaboration
15 countries ~400 collaborators
As of March 2010
# of papers : 315
# of citations: 13,309

Evidence for D^0 mixing

Observation of direct CP violation in $B \to \pi^+\pi^-$

Evidence for $B \to \tau\nu$

Observation of $b \to d\gamma$

Evidence for direct CP violation in $B \to K^+\pi^-$

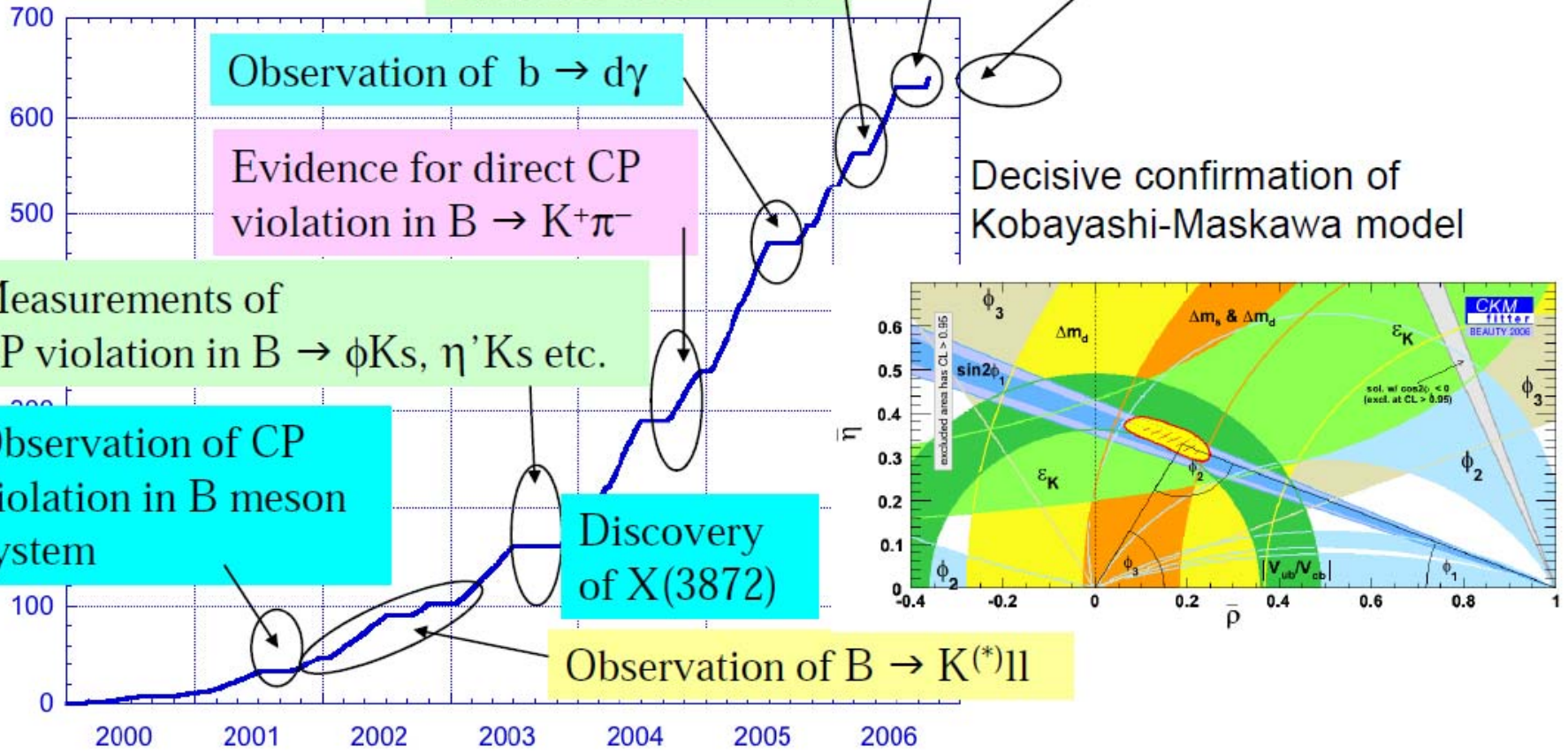
Measurements of CP violation in $B \to \phi Ks$, $\eta' Ks$ etc.

Observation of CP violation in B meson system

Discovery of X(3872)

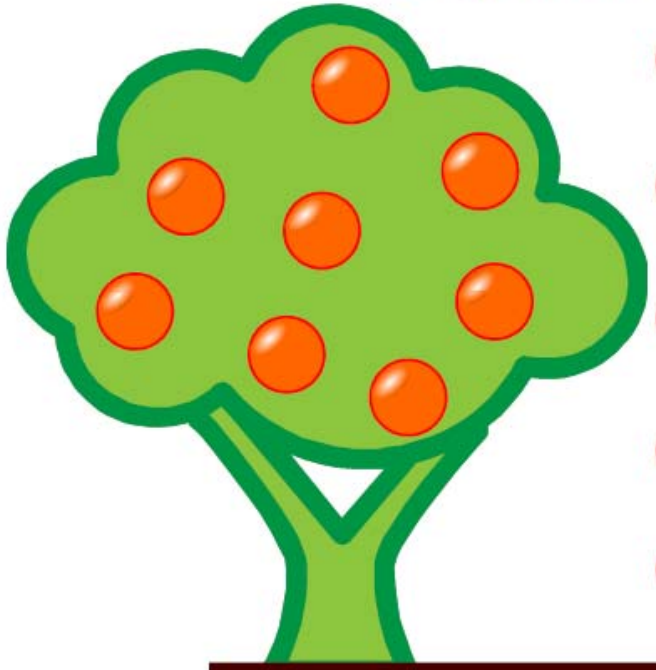
Observation of $B \to K^{(*)}ll$

Decisive confirmation of Kobayashi-Maskawa model



New Hints from B-Factories

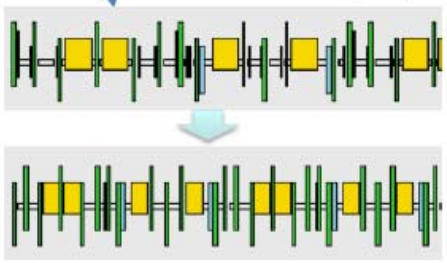
Several phenomenological hints beyond the SM from B-factories



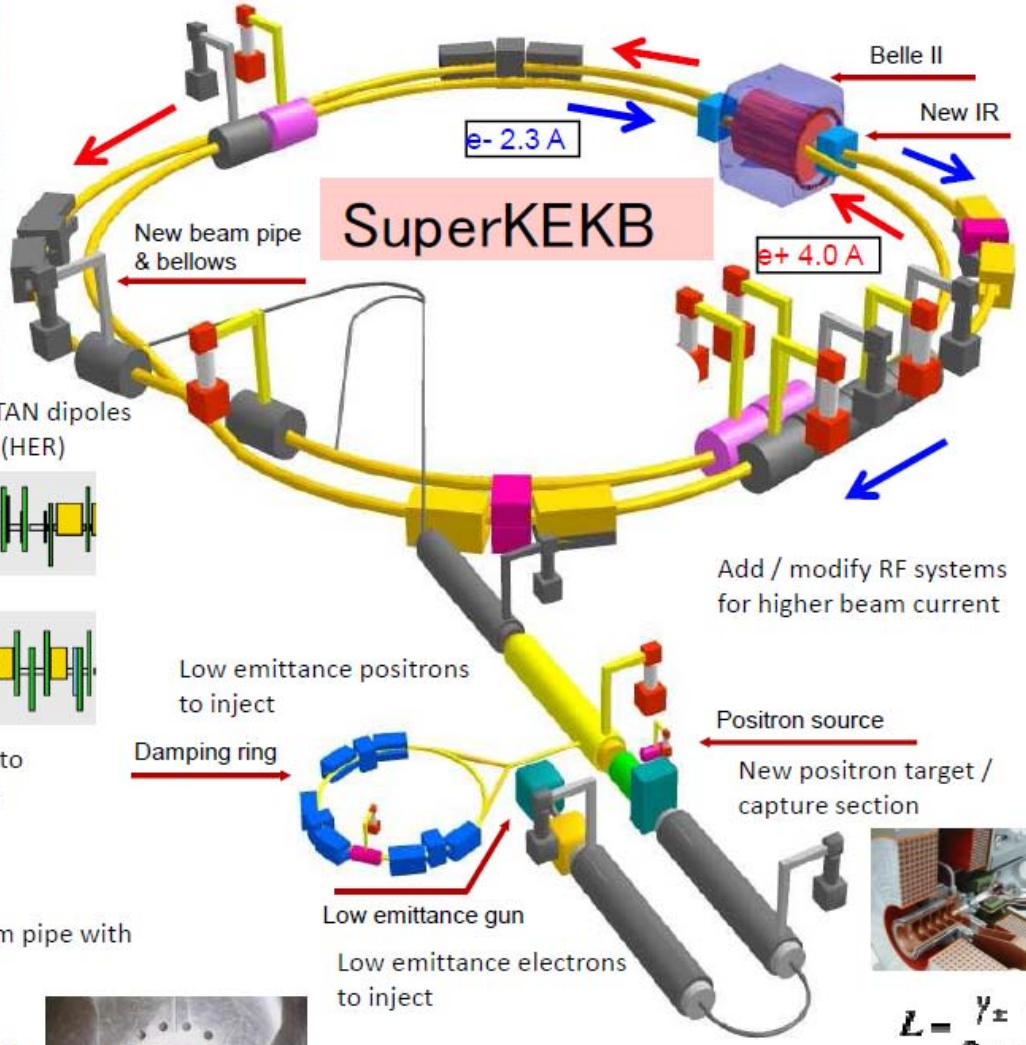
- Difference in *CP* violation btw B^0 and B^+
- First observation of pure leptonic *B* decay
- Unexpectedly large D^0-$\bar{D}^0$ mixing
- New particles like *X*(3872)
- and many other hints

Verification of the KM theory.
Establishment of the SM.

Replace long TRISTAN dipoles with shorter ones (HER)



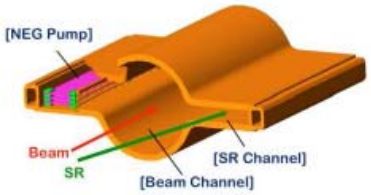
Redesign the HER arcs to squeeze the emittance

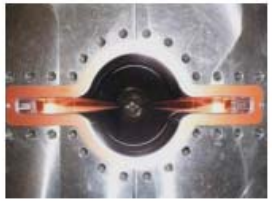


Colliding bunches

New superconducting /permanent final focusing quads near the IP

TiN-coated beam pipe with antechambers





$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

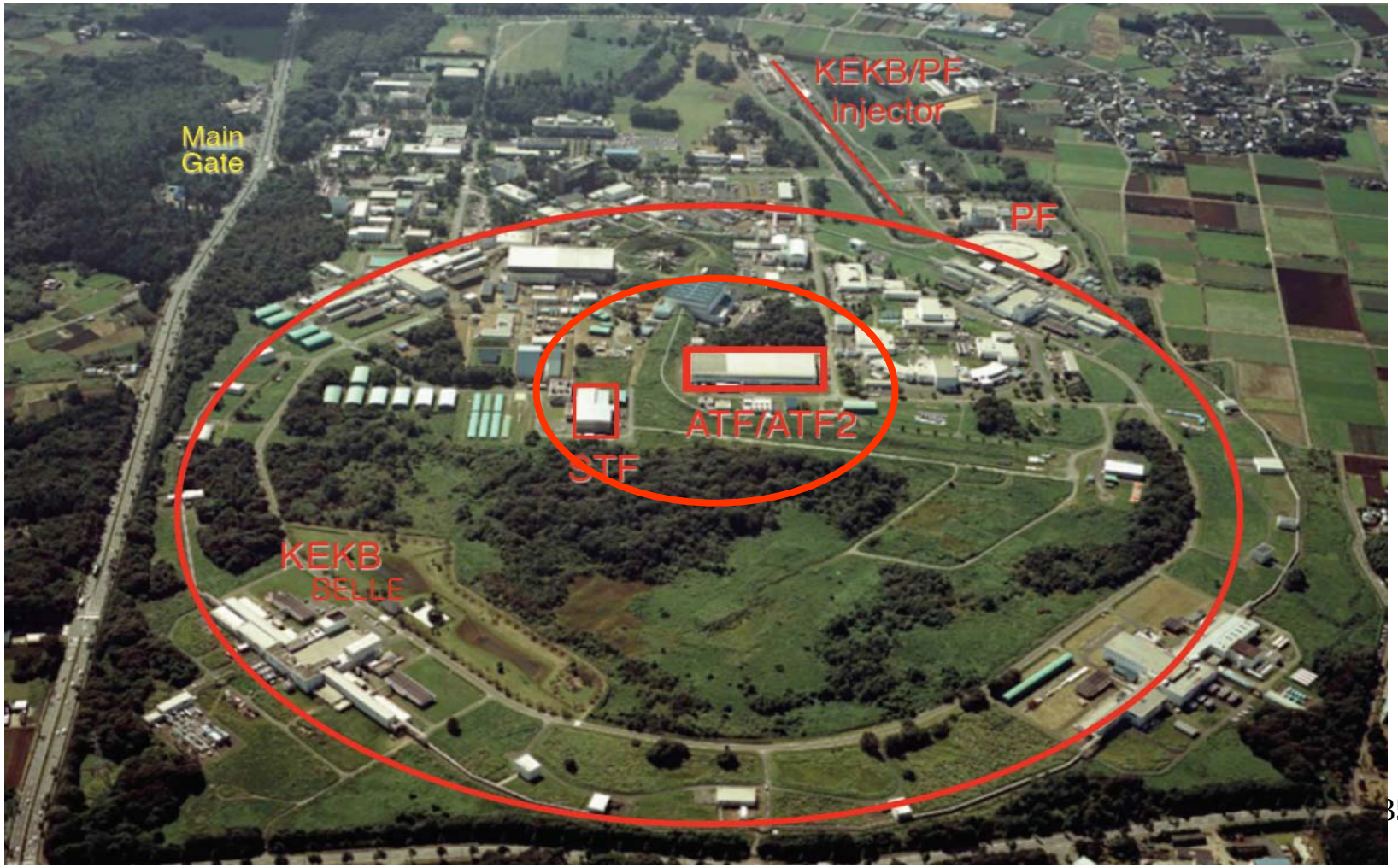
x 40 Gain in Luminosity

New collaboration ‘Belle-2’ has been formed
Intense negotiation with MEXT now

R&D for ILC
Projects at KEK site
by international collaborators

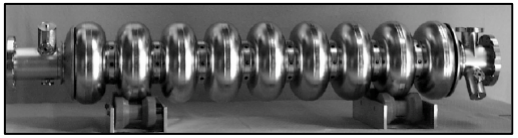
R&D activities for ILC in Japan

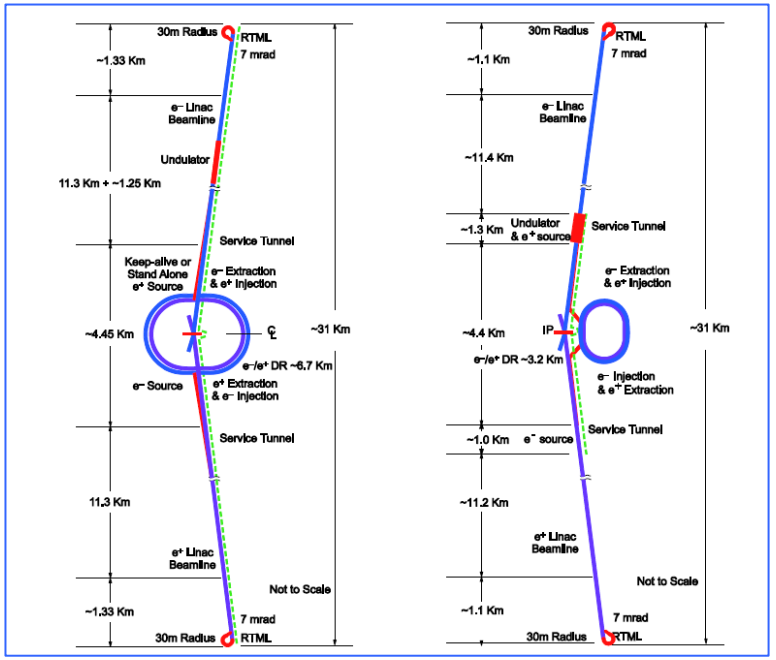
- ❑Cavity and cryo-module development at STF
- ❑ATF2: Final focus test facility
- ❑Design Study of the ILC conventional facility in mountain regions



SCRF Technology Required

Parameter	Value
C.M. Energy	500 GeV
Peak luminosity	$2x10^{34}$ $cm^{-2}s^{-1}$
Beam Rep. rate	5 Hz
Pulse time duration	1 ms
Average beam current	9 mA (in pulse)
Av. field gradient	**31.5 MV/m**
# 9-cell cavity	**14,560**
# cryomodule	**1,680**
# RF units	**560**





RDR SB09

Global Plan for SCRF R&D

Year	07	2008	2009	2010	2011	2012
Phase	TDP-1			TDP-2		
Cavity Gradient in v. test to reach 35 MV/m	→ Yield 50%			→ Yield 90%		
Cavity-string to reach 31.5 MV/m, with one-cryomodule		Global effort for string assembly and test (DESY, FNAL, INFN, KEK)				
System Test with beam acceleration			FLASH (DESY) , NML (FNAL) STF2 (KEK, test start in 2013)			
Preparation for Industrialization				Production Technology R&D		

ILC-type (1.3 GHz) Cavity Venders and Laboratories in 2010

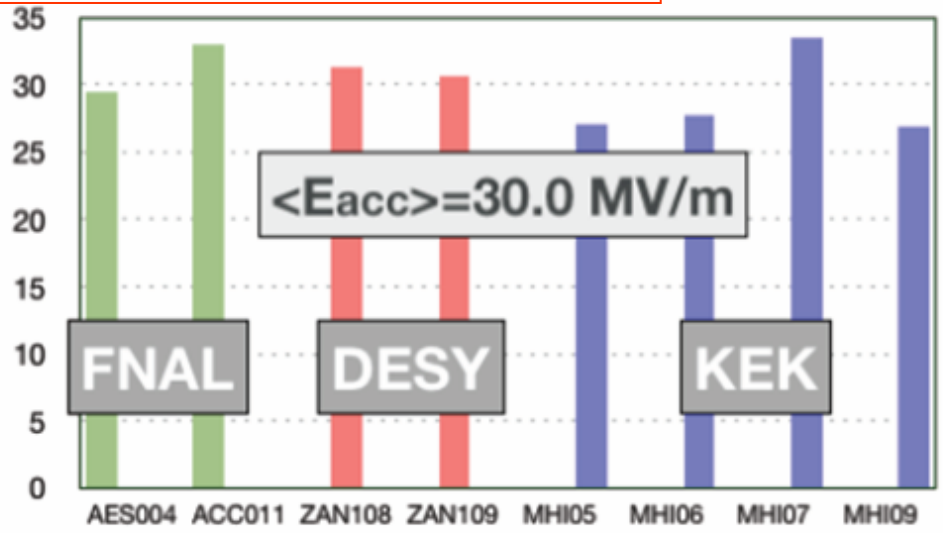
	Venders	**Laboratories**
Europe	**RI/ACCEL*** **Zanon***	DESY, CEA/Saclay, INFN, (CI)
Americas	**AES*** Niowave/Roark PAVAC	FNAL/ANL, JLab, Cornell, (TRIUMF, LANL)
Asia	MHI (Hitachi) (Toshiba)	KEK, IHEP, PKU, (Tsinghua-U), RRCAT/IUAC (in coop. w/ FNAL, KEK)
	* Established venders in the yield statistics (as of March, 2010)	

Multiple venders per region being realized

- High gradient acc. module development as a project S-1-Global

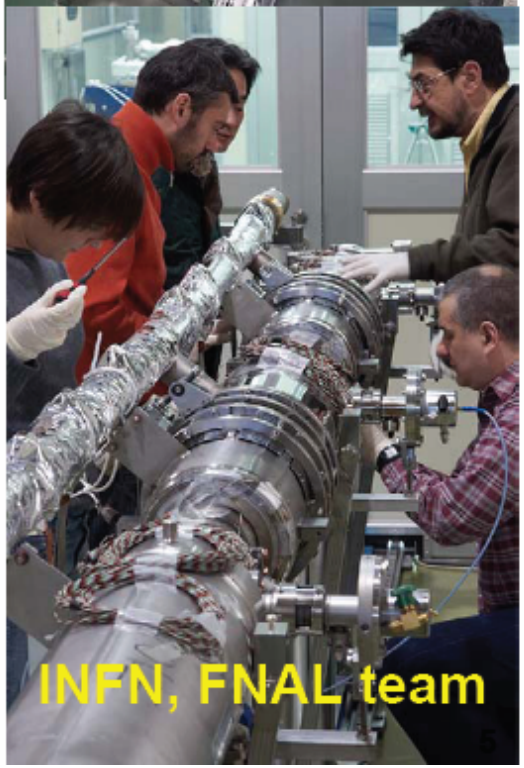
  Two cavities from FNAL,
  two cavities from DESY,
  KEK supplies 4 cavities
  to achieve average 31.5MV/m RF operation, in KEK-STF.

S1-Global;
A symbolic project of the world-wide collaboration



2 cavities from FNAL:
AES004(27MV/m) ACC011(33MV/m)

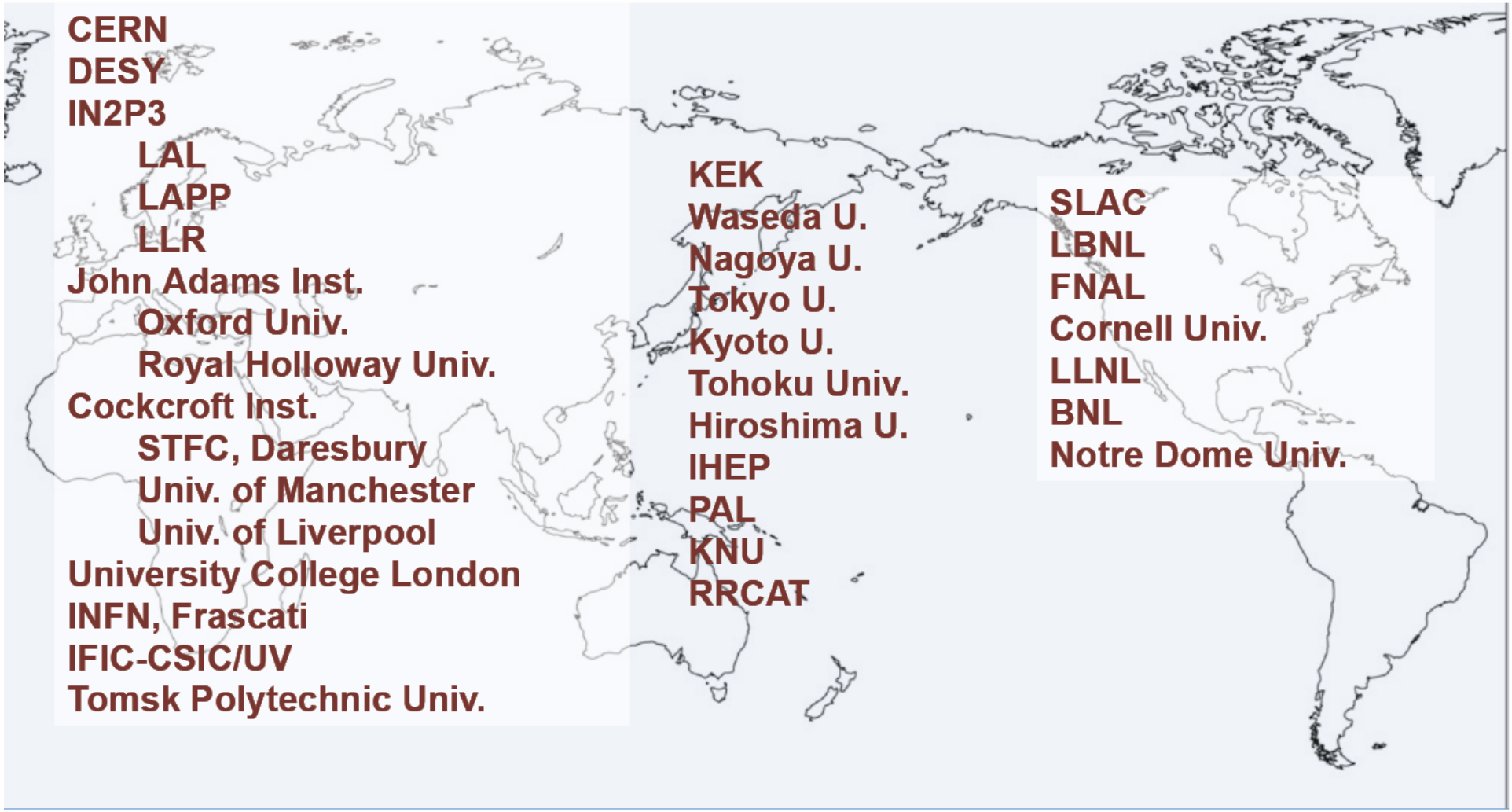
cavity connection in clean room for module installation



Tuner installation for FNAL cavities at outside of clean room

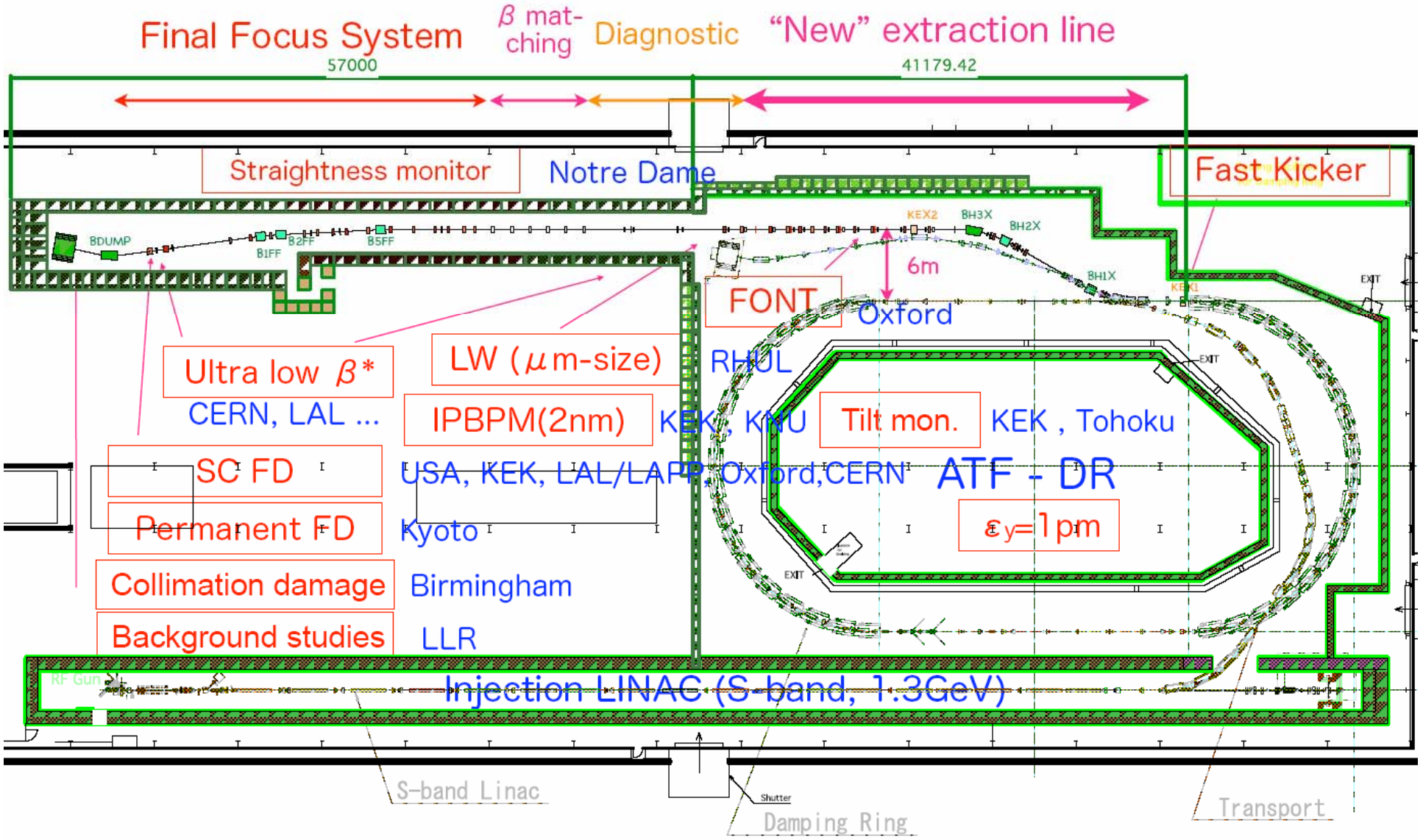
ATF International Collaboration

(*ATF*:Accelerator Test Facility)



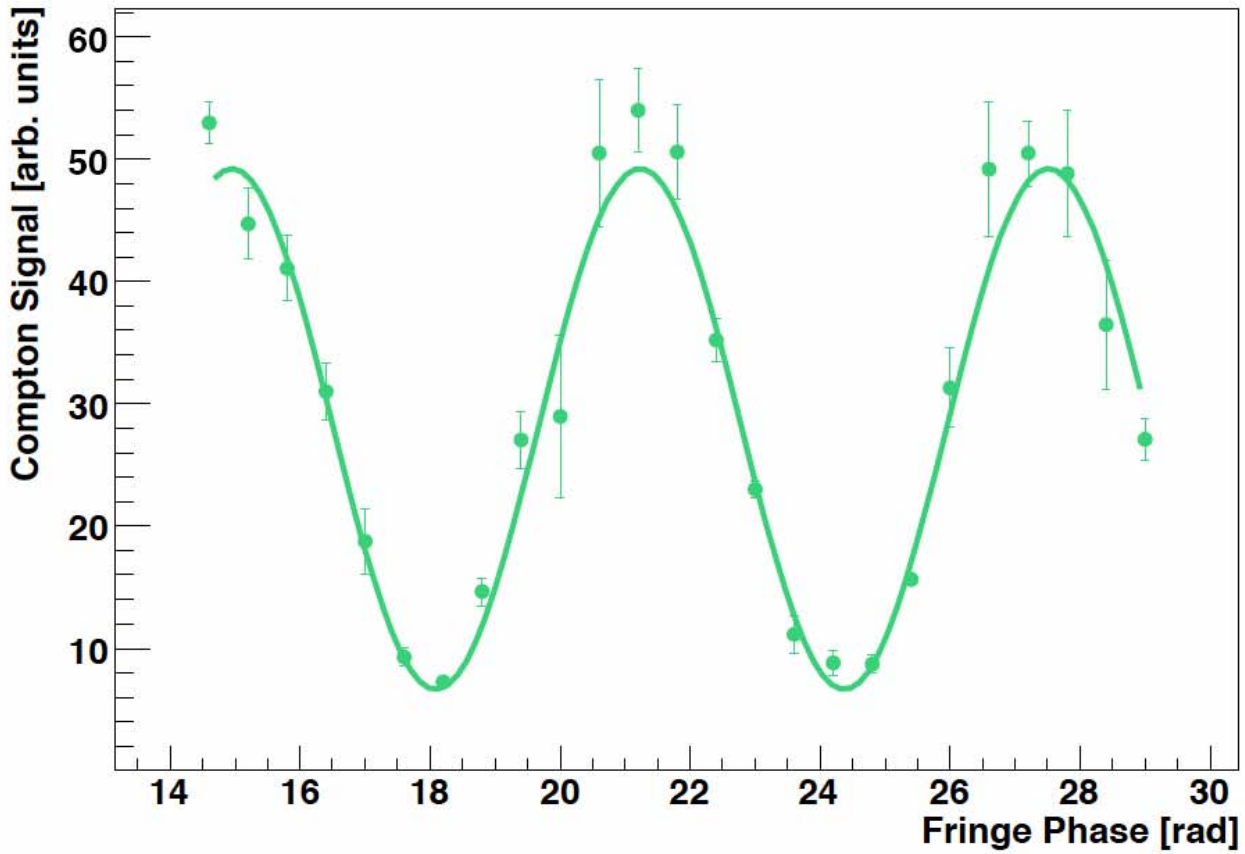
ATF2 beam line and planned/proposed R&Ds

2008 - 2010 - 2012 (- 2014 - ?)



Fringe Scan

Beam size measurement with Shintake-monitor



Crossing angle :4.12 [deg]
Average of 4 bunches/point
Scan range 13.2[rad]
with a step of 600mrad

Fringe Pitch 7.4um

Modulation = 0.767± 0.020

σy = 855 ± 42 nm

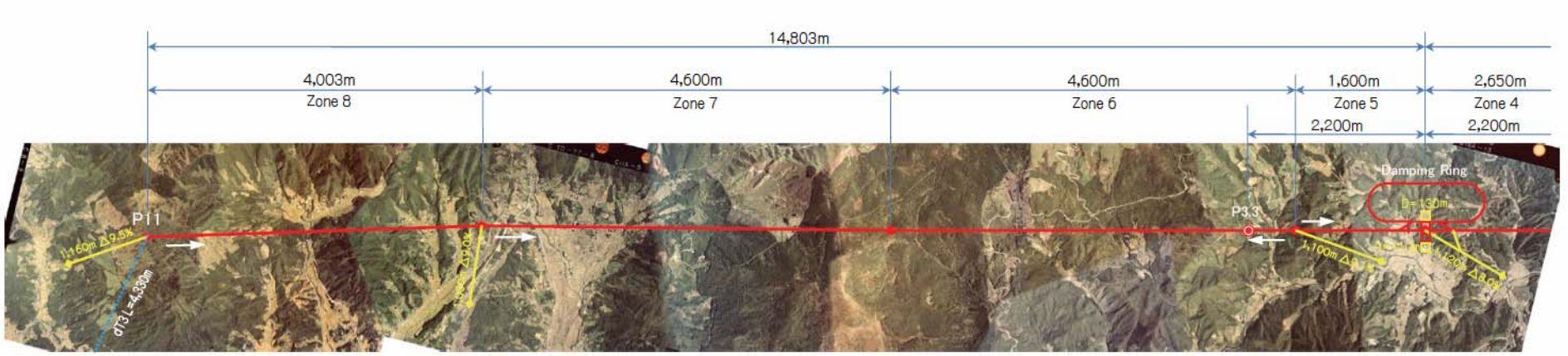
ATF2 - 37nm by end of December, 2010

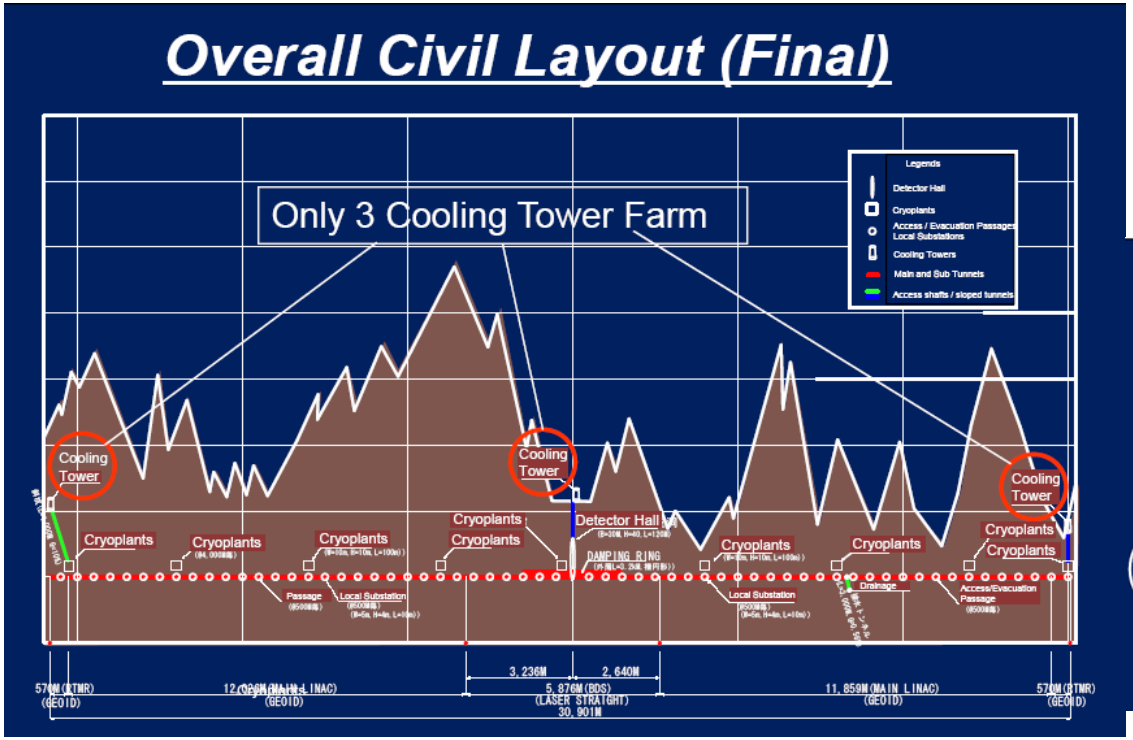
(1) All the instruments have been commissioned; i.e. BPMs, IPBSM etc.

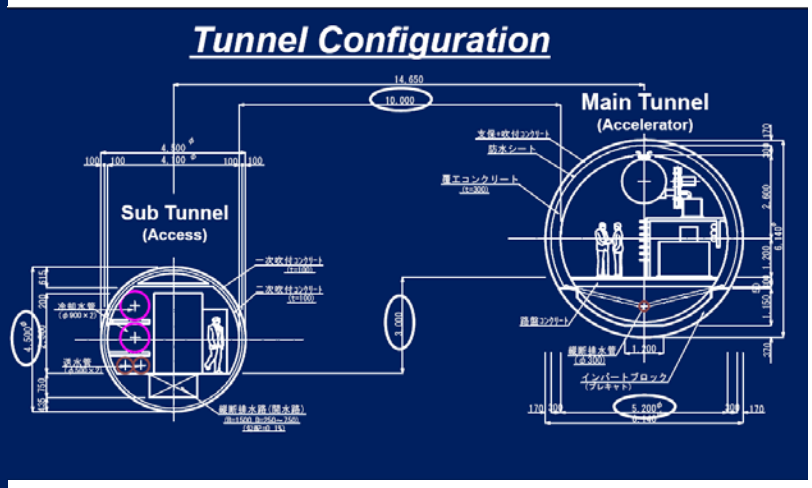
(2) Beam tuning knobs have been developed and were also commissioned.

(3) The pre-continuos run successfully completed with IP X-mismatched issue;
to be ready for the continuous run towards 100nm beam size in May, 2010.

Design Study of the ILC conventional facility in mountain regions







- The Japan High Energy Physics community's master plan
  - Highest priority is given to ILC
  - Before ILC, promote flavor physics at KEKB and J-PARC
    - Continuous improvements of J-PARC
    - Upgrade of KEKB/Belle
  - Energy frontier
    - Collaboration in LHC/ATLAS
    - ILC R&D

Keep Producing Physics Results

high precision physics in leptons and hadrons
energy frontier physics at LHC/ATLAS

Technology Developments

Low temperature technologies
Accelerator/Beam technologies (high power, low emittance…)

Human Resources