Nu 01 : R/D for neutrino beam production for future (Multi-) MW proton facility

- Continuation of Nu01
- Possible next R&D for future experiment with Multi-MW neutrino beam facilities

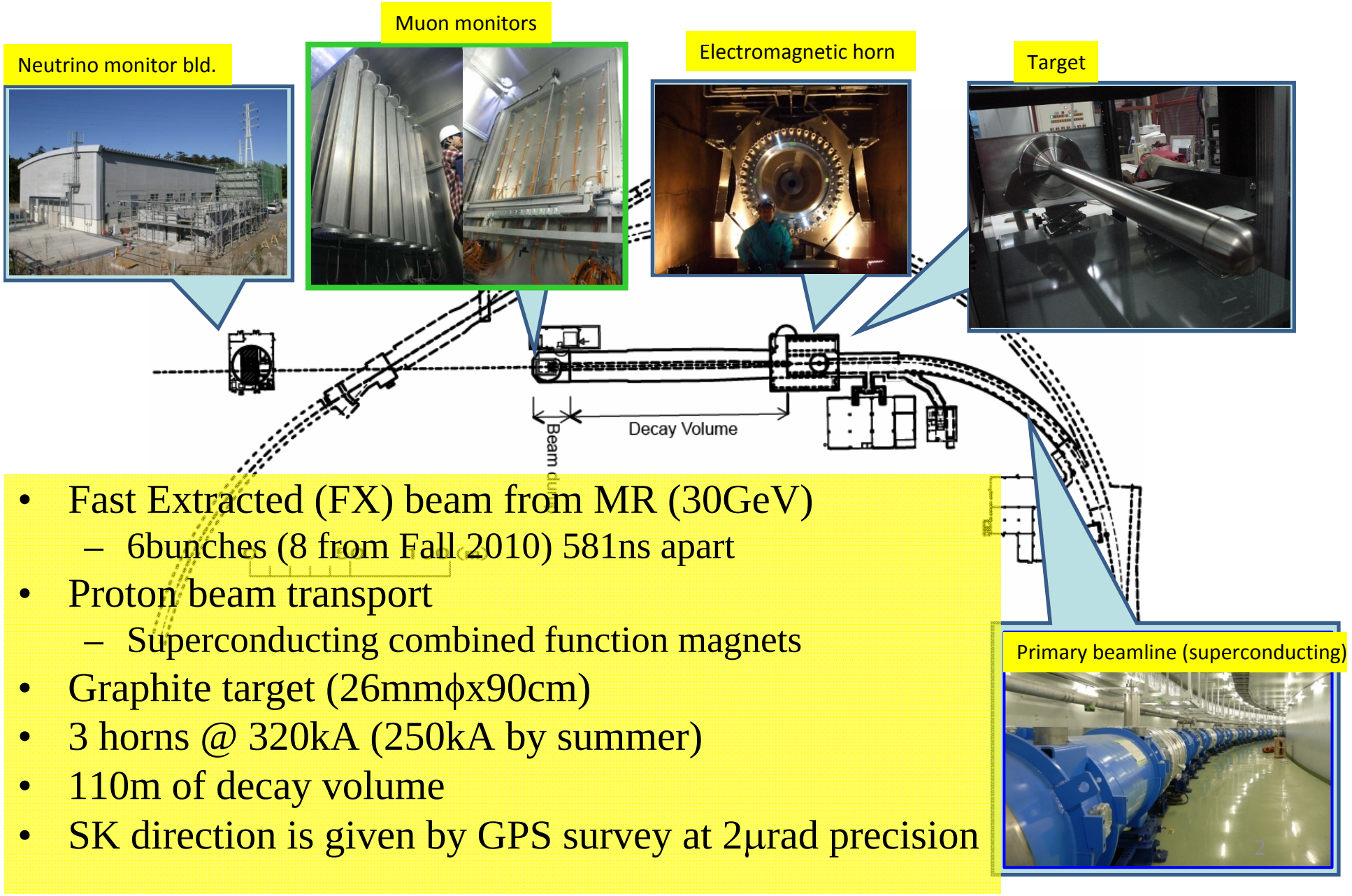
Workshop FJPPL10

LAPP, Annecy-Le-Vieux (France)

June 15, 2010

Koichiro Nishikawa (KEK)

Neutrino facility for T2K at J-PARC



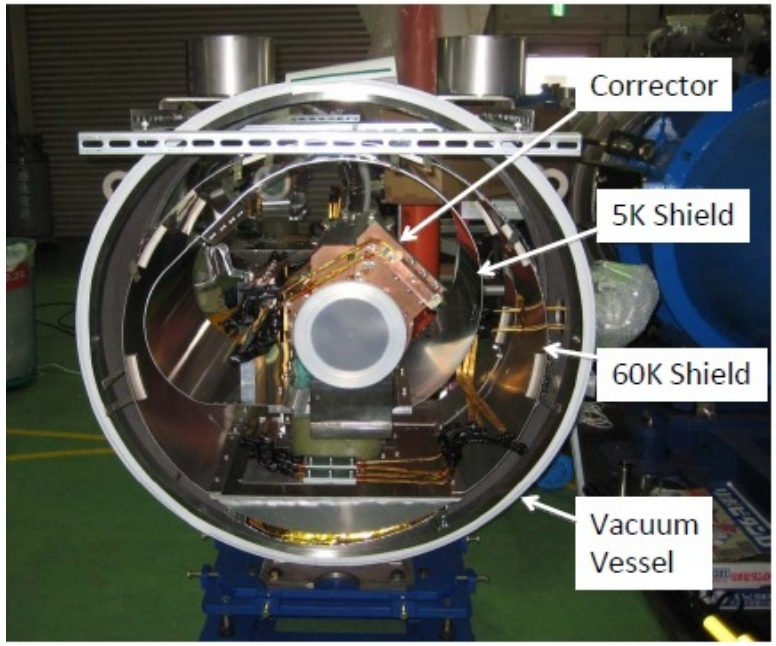
- Fast Extracted (FX) beam from MR (30GeV)
  - 6bunches (8 from Fall 2010) 581ns apart
- Proton beam transport
  - Superconducting combined function magnets
- Graphite target (26mmϕx90cm)
- 3 horns @ 320kA (250kA by summer)
- 110m of decay volume
- SK direction is given by GPS survey at 2μrad precision

Superconducting magnet system

- Superconducting combined function magnets
  （Cryogenic science center at KEK &
  Cryogenic group at IPNS）
- Magnet safety system (MSS) (Saclay)
- Corrector coils (BNL, US)

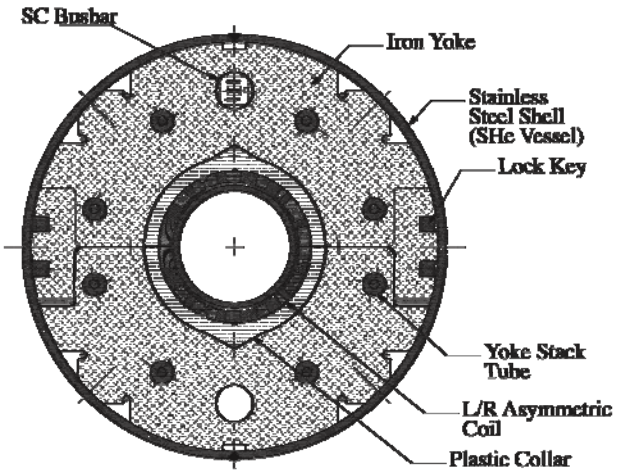
MSS (from Saclay)

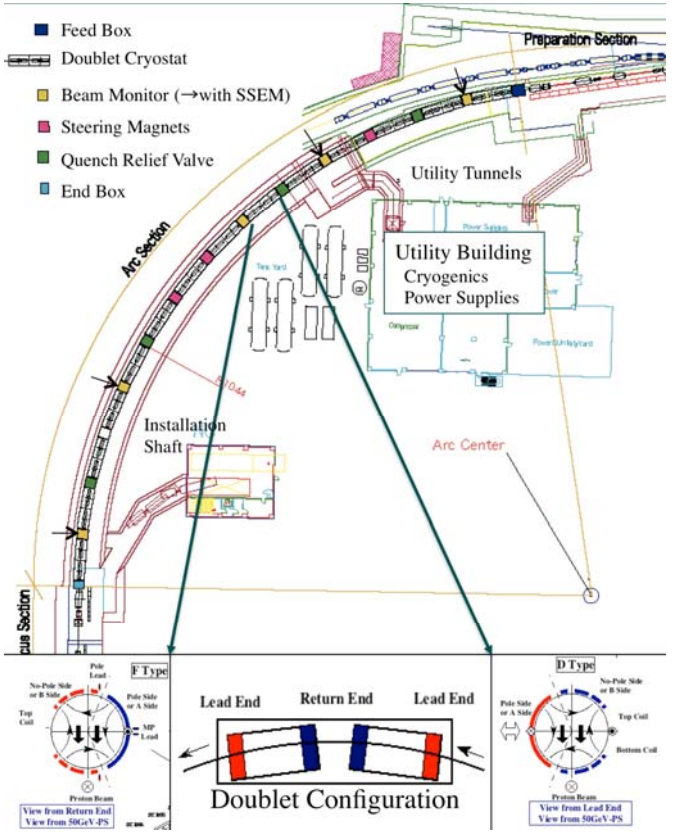
Assembled Corrector Inter-Connect (from BNL)



Superconducting Magnet System

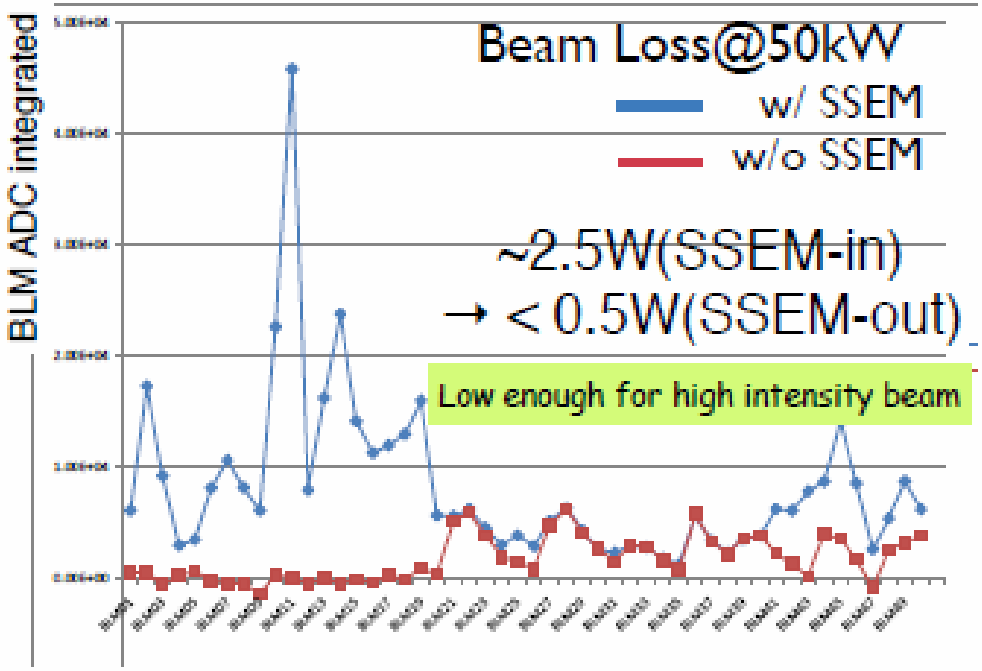
- Construction Completed in Dec. 2008.
- Hardware Commissioning till Mar. 2009.
- Beam Operation started in April 2009.

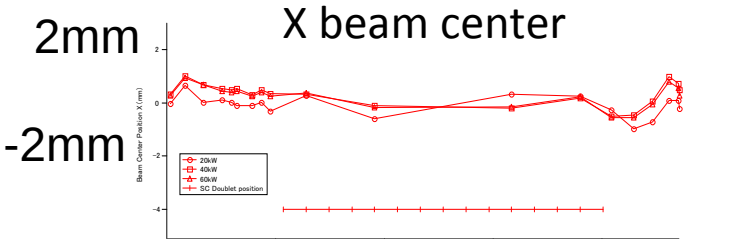


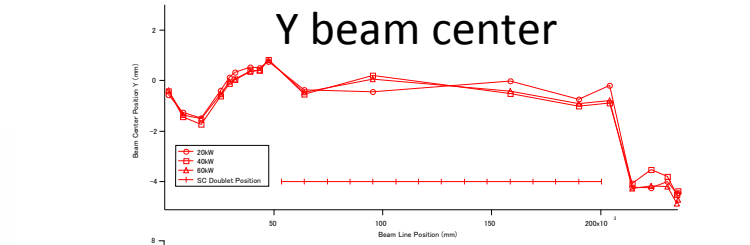


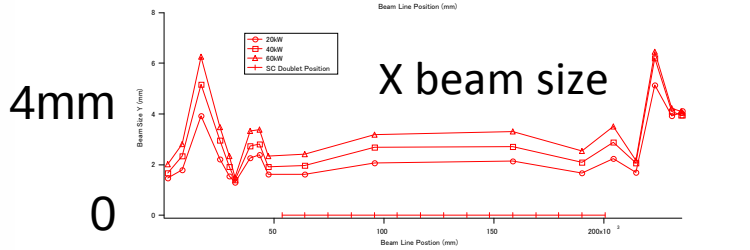
Operation Status

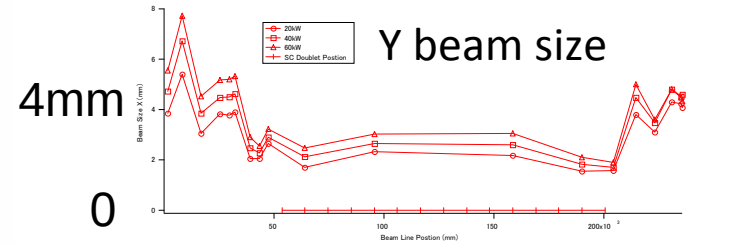
- Up to 100 kW beam has been transferred.
- No quench so far.
- No major trouble.
- MSS & Quench Acquisition work stably.
- Routine maintenance during summer shut down.







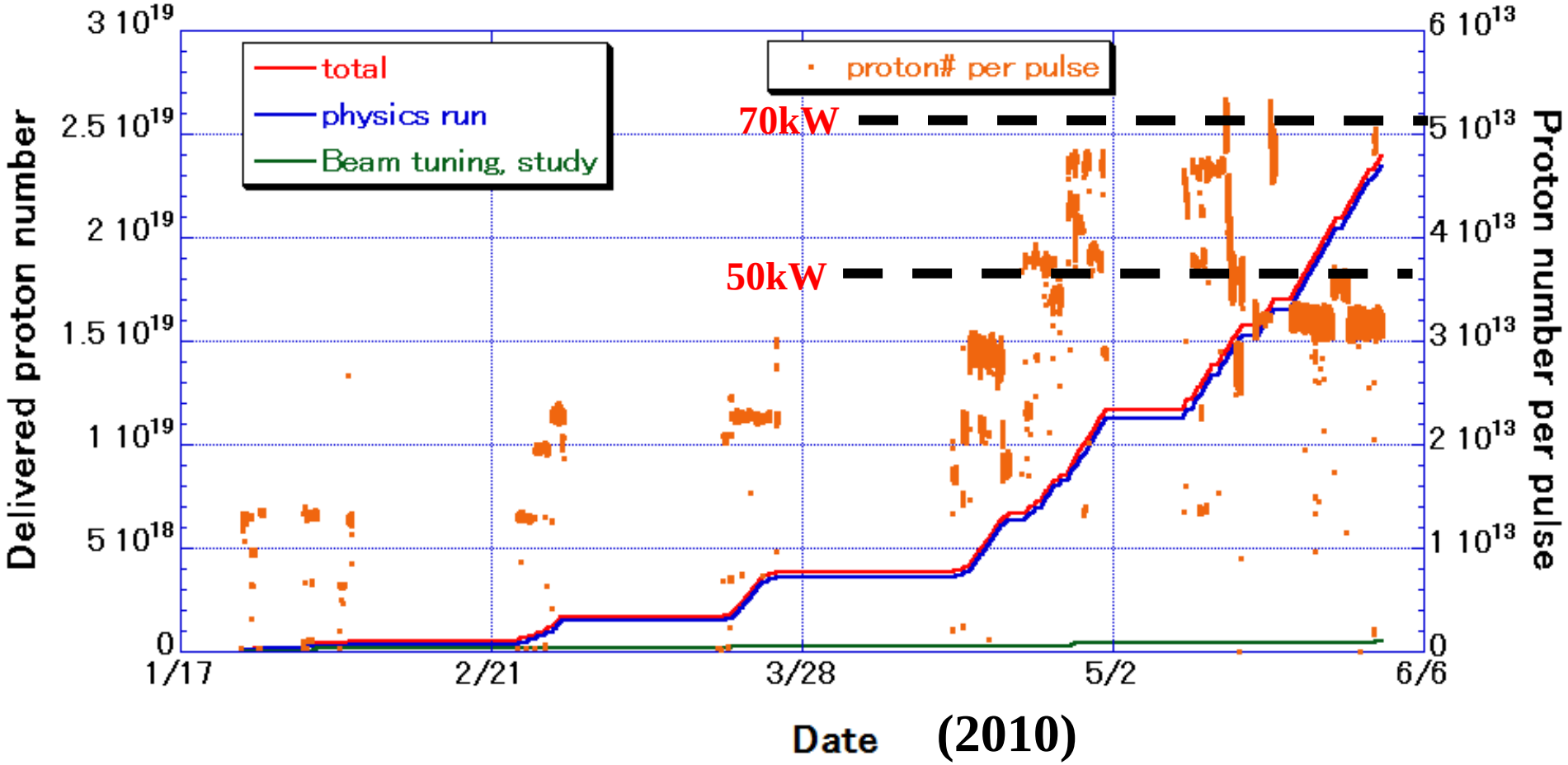




Budget

- Travel Budget Only
  - In case of trouble in MSS or Quench Acquisition,
  - Saclay Engineer can travel to J-PARC to FIX.
  - For 1~2 weeks * 4 person.
  - Routine check up will be performed by KEK during summer shut down.
  - If a problem that need to be FIXED by Saclay engineer we need to arrange travel.

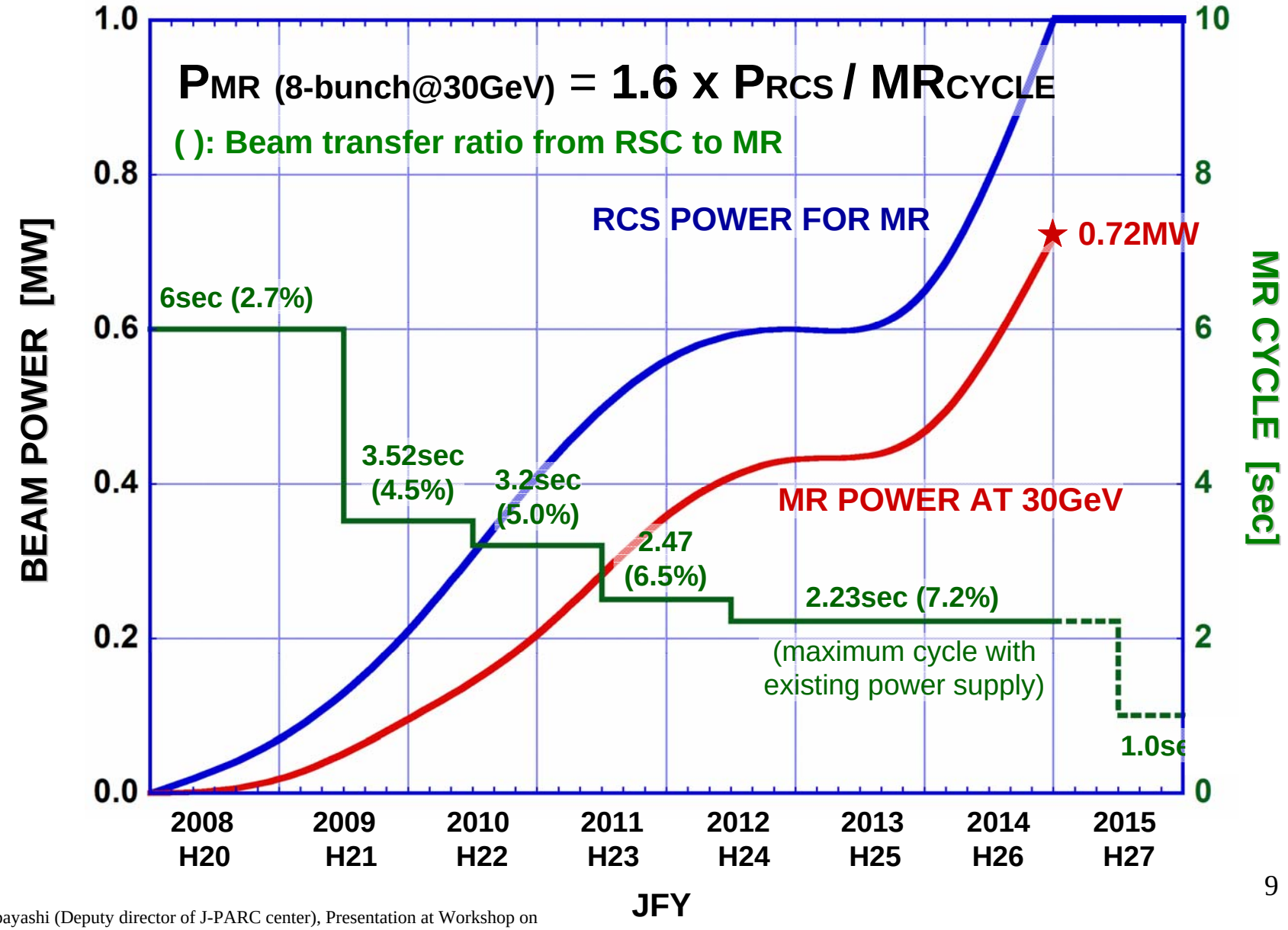
Started data taking for oscillation!



- **Delivered # of protons: 2.34×10^{19} (Jan-May)**
- **Continuous run @ ~50kW level**
- **Trial upto 70kW done**

Work continue

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

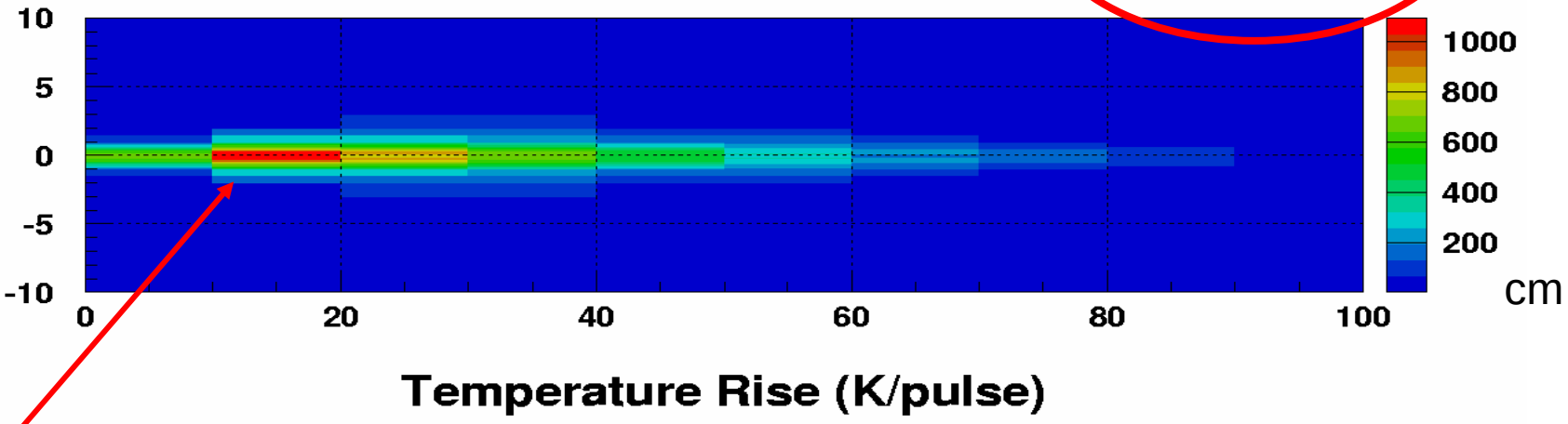
First high energy MW fast-ext'ed beam ! Real challenge !

3.3E14 ppp w/ 5μs pulse

When this beam hits an iron block,

Residual radiation

> 1000Sv/h



1100°

(cf. melting point 1536°)

✓ Material heavier than iron would melt.

✓ Thermal shock stress $\approx E\alpha\Delta T \approx 3GPa$

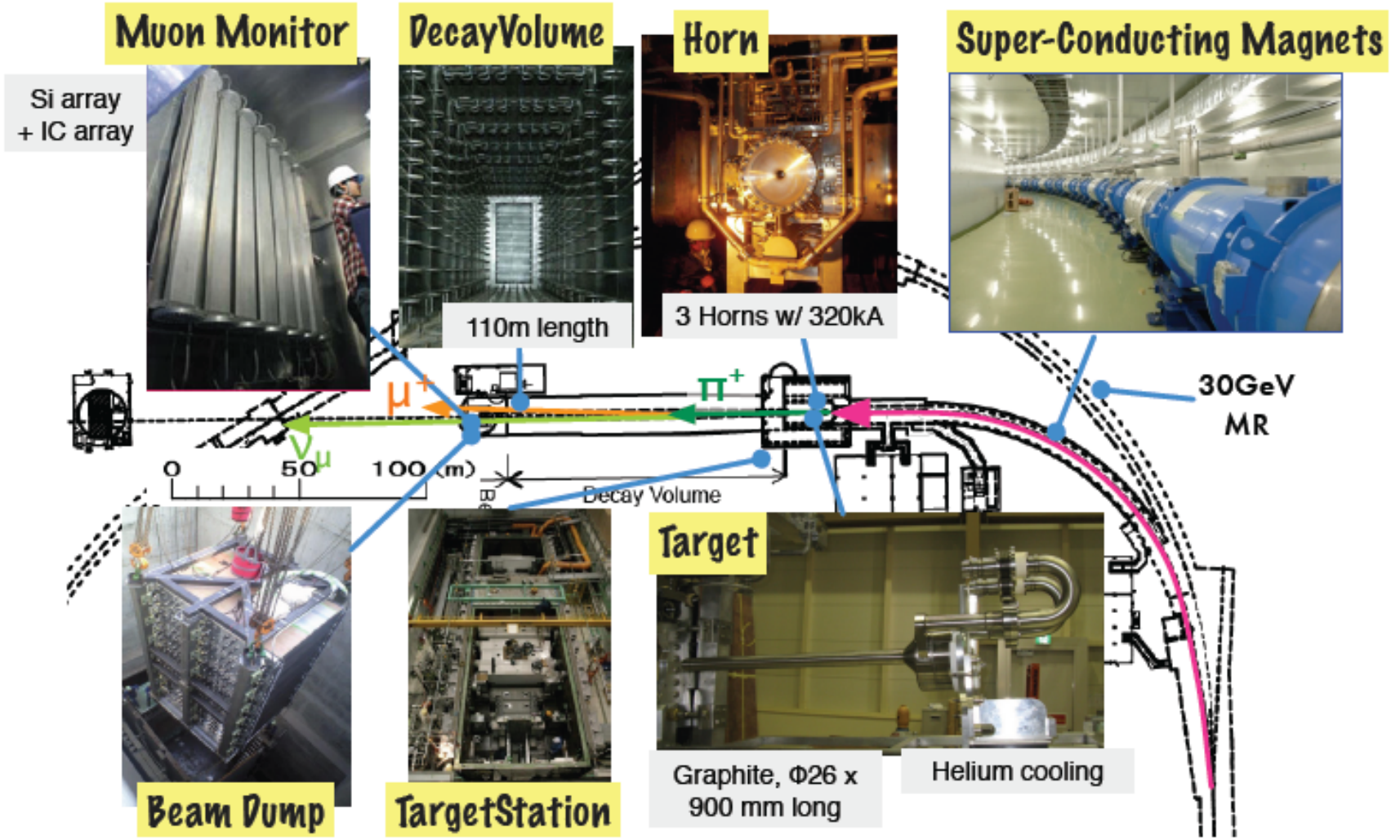
(max stress ~300 MPa)

Material heavier than Ti might be destroyed.

J-PARC Neutrino beam facility

2MW is tolerable for J-PARC ν beam-line without any major upgrade

step by step toward high power beam (radiation, cooling, beam-loss control etc..)



MR improvement Scenario toward multi-MW power frontier machine
— KEK Roadmap —

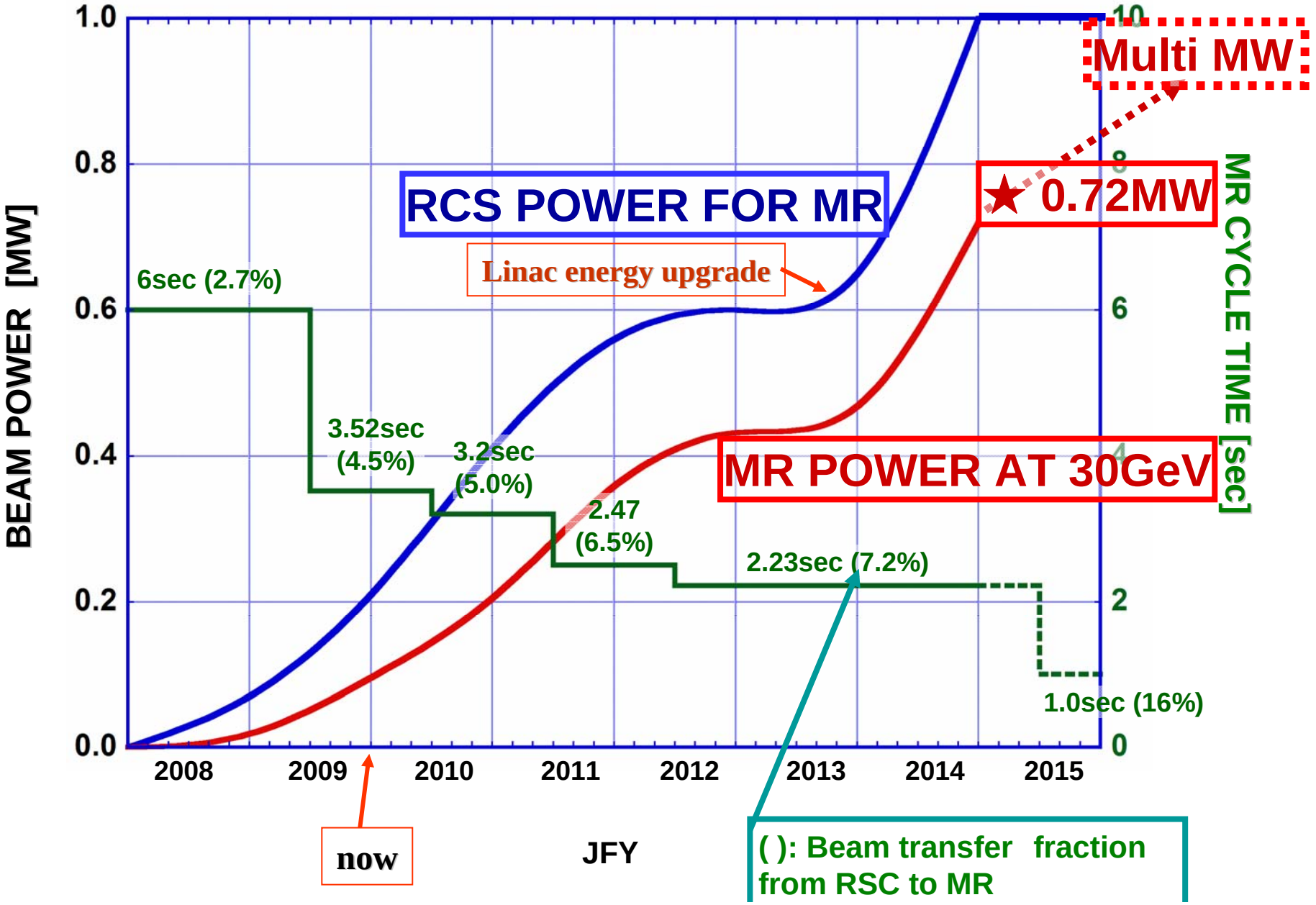
	Day1 (now trying)	Next Step	KEK Roadmap
Power(MW)	0.1	0.45	1.66
Energy(GeV)	30	30	30
Rep Cycle(sec)	3.5	3 ~ 2	1.92 (→ 0.5 ?)
No. of Bunch	6	8	8
Particle/Bunch	1.2×10^{13}	$<4.1 \times 10^{13}$	8.3×10^{13}
Particle/Ring	7.2×10^{13}	$<3.3 \times 10^{14}$	6.7×10^{14}
LINAC(MeV)	181	181	400
RCS	h=2	h=2 or 1	h=1 ?

Rapid cycling
- High power RF
- Magnet P.S.

Key technologies to develop

AN EXPECTED BEAM POWER CURVES for FX

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



δ : CP Violation in Lepton Sector

Two approaches

$$P_{\alpha\beta} = \delta_{\alpha\beta} - 4\sum_{j>i} \mathrm{Re}(U^*_{\alpha i}U_{\beta i}U_{\alpha j}U^*_{\beta j}) \sin^2 \frac{(m_j^2 - m_i^2)L}{4E_\nu}$$

$$\mp 2\sum_{j>i} \mathrm{Im}(U^*_{\alpha i}U_{\beta i}U_{\alpha j}U^*_{\beta j}) \sin \frac{(m_j^2 - m_i^2)L}{2E_\nu}$$

Second Max.

CPV $\propto \sin\theta_{12} \sin\theta_{23} \sin\theta_{13} \Delta m^2_{12}$ (L/E) $\sin\delta$

Solar and Atmospheric ν

$$A_{CP} = \frac{P(\nu_\mu \to \nu_e) - P(\overline{\nu_\mu} \to \overline{\nu_e})}{P(\nu_\mu \to \nu_e) + P(\overline{\nu_\mu} \to \overline{\nu_e})} \approx \frac{\Delta m^2_{12}}{4E_\nu} \cdot \frac{\sin 2\theta_{12}}{\sin\theta_{13}} \cdot \sin\delta$$

Beyond T2K

- Lepton Sector CP Violation
  - Search for CP violation in Neutrino Oscillation Process
    - Comparison with Reactor data –
    - Neutrino & anti-neutrino comparison （ν, ν cross section)
    - ➢ 1^{st} and 2^{nd} 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

<u>Required developments</u>

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

Beyond T2K

Quest for the Origin of Matter Dominated Universe

T2K
(2009~)

Discover
ν_e app.

Neutrino
Anti-Neutrino meas.

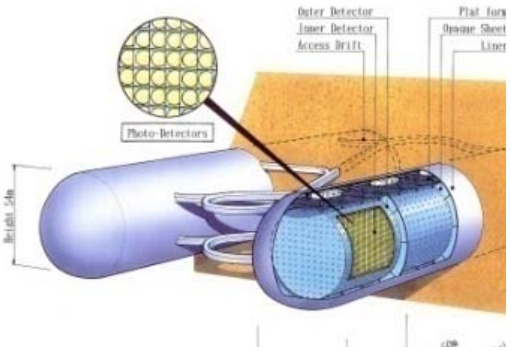
Intensity Upgrade

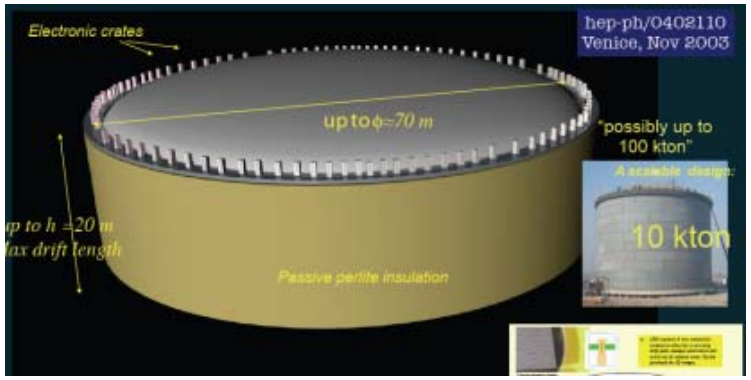
Detector R&D

Tech.
Choice

Large det.
Construction

CPV search
Proton decay





J-PARC PAC recommendation

Beam test of LAr
Charged particle beam

6. PROPOSAL EVALUATIONS

1. **P32:** (Towards a Long Baseline Neutrino and Nucleon Decay Experiment with a next-generation 100 kton Liquid Argon TPC detector)

The PAC acknowledges the high scientific merit of a neutrino oscillation experiment with a baseline longer than T2K. The measurements of the mixing angle θ_{13} and a possible CP violation in the lepton sector are of highest significance.

The specific P32 proposal is to set up and test a 250 Liter LAr prototype TPC in a low-energy charged particle beam at J-PARC, preferentially with kaons from the K1.1BR beamline. **The PAC encourages the team to proceed with this development work and recommends the allocation of beam time of a low intensity charged particle beam at J-PARC for this test.**

KEK's first step toward LAr !

A physics defined-site independent R&D effort on LAr TPC detector

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

R&D towards a Giant LAr Charge Imaging ExpeRiment (GLACIER)

André Rubbia (ETHZ)

EuroNU week in Strasbourg
June 1-4th, 2010, Strasbourg, France

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Looking forward an exciting new collaboration to come