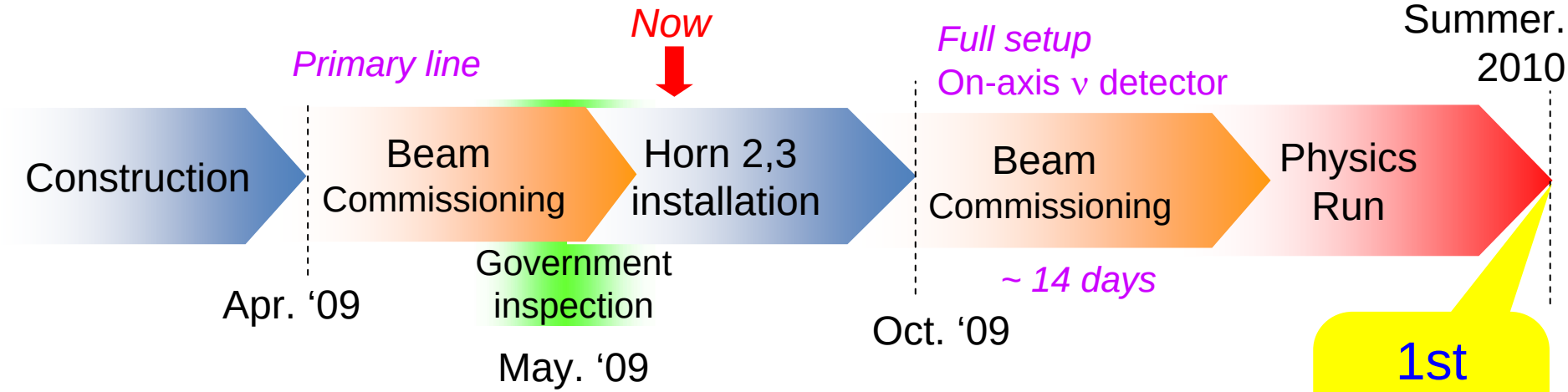
# E11 (T2K)
# Beam line

T. Nakadaira (KEK)
for
T2K collaboration

# Time-line of T2K / contents of this report




- Short time goal of T2K by 2010 summer.
  - Request on the beam from T2K
- Status report
  - ν beam line construction by 2009/3
  - Beam commissioning in Run 23 (April) & Run 24 (May)
  - Hardware work in 2009 summer
- Commissioning from October
- Summary

# Short term goal (Request)

- Unveil below CHOOZ limit within 2010.

30~50 [kW $10^7$ sec] : Reach CHOOZ limit

→ T2K requests <u>100kW $\times$ $10^7$ sec</u> by 2010 summer.

($10^7$ sec = 116 days)

# Expected output vs. POT

| Integrated power [kW $10^7$ sec] | SK events (FCFV 1-ring) $\nu\mu$ | $\sin^2 2\theta_{13}$ Sensitivity (90%CL) |
|---|---|---|
| Requested integrated power. | | |
| 100 | 39 | ~0.06 |
| To improve the current limit by CHOOZ | | |
| 50 | 20 | ~0.1 |
| | | *Limit by CHOOZ ~0.13* |
| 30 | 12 | ~0.15 |
| Check the SK signal (* including multi-ring events) | | |
| Near detector study (→ Dean's talk) | | |
| 6 (30kw x 30 day) | 10* | --- |

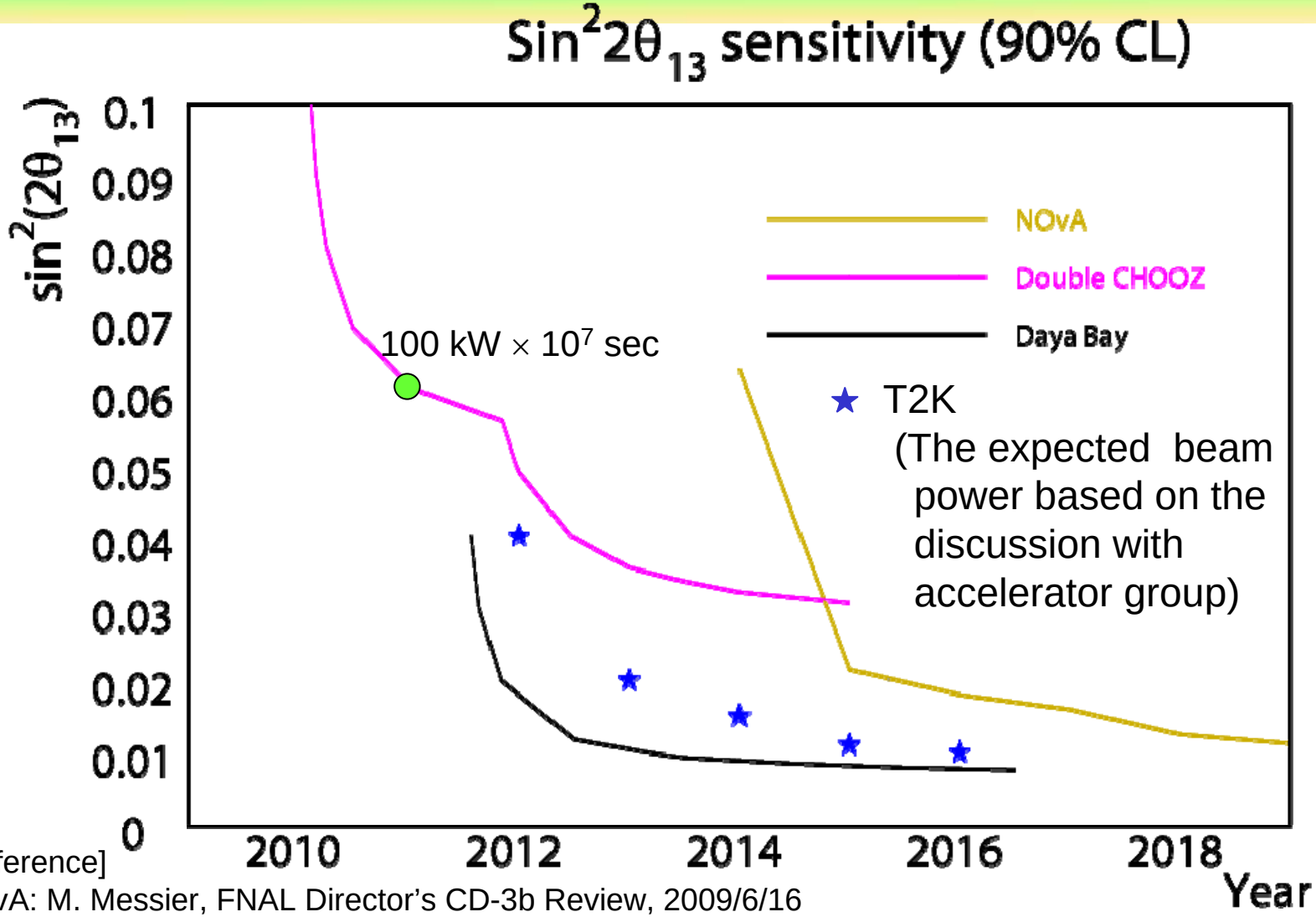
# Next Milestone (2011~)

- Accumulate 1~2×$10^7$ [MW sec] earlier than 2014.
  - To keep the international competitiveness
  - 3$\sigma$ discovery

    1 MW × $10^7$ sec → $\sin^2 2\theta_{13} = 0.05$

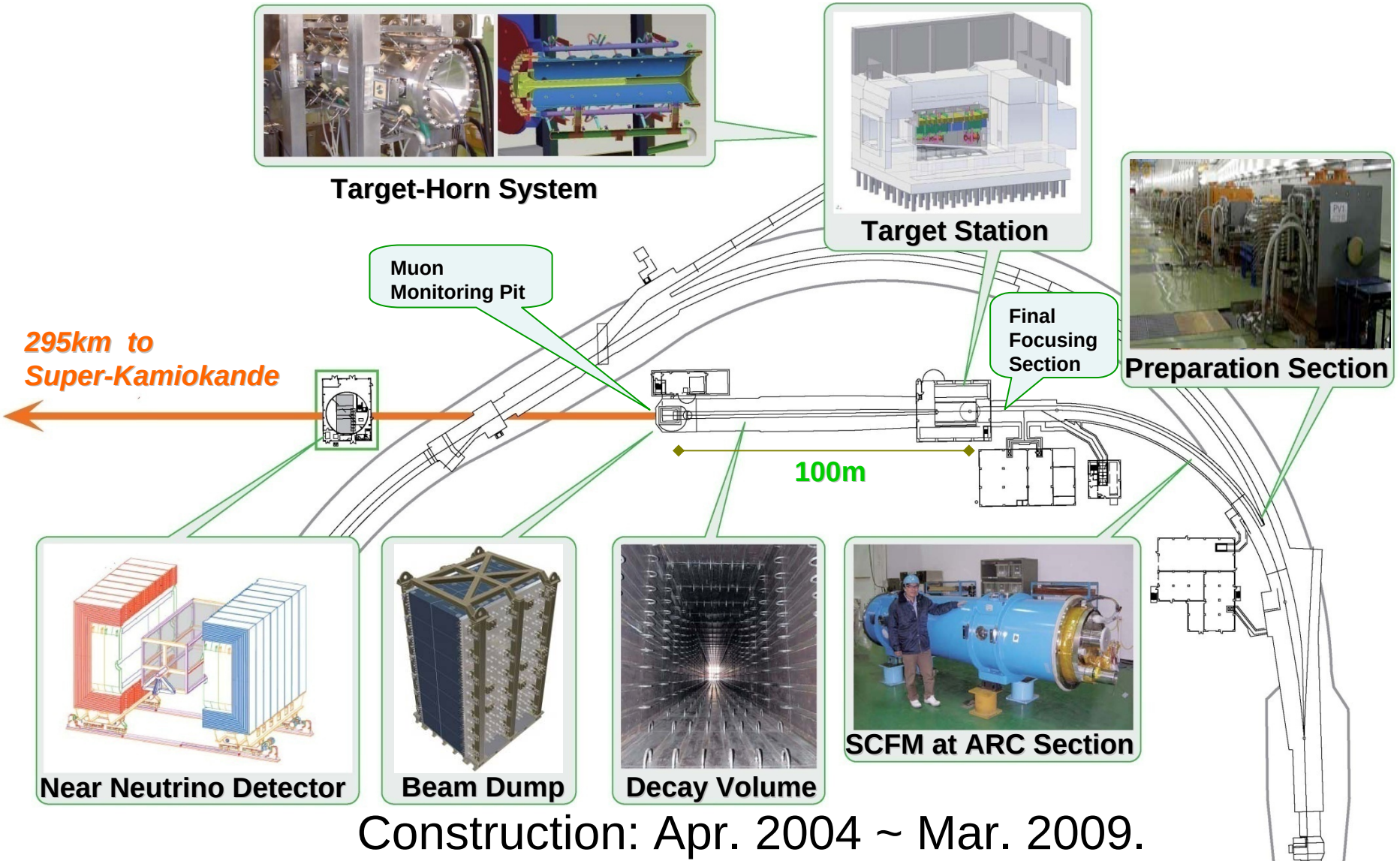
    2 MW × $10^7$ sec → $\sin^2 2\theta_{13} = 0.03$

# International competition




[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

# Beam line status report




Construction: Apr. 2004 ~ Mar. 2009.

Completed except for Horn 2, 3.

# Goal in April / May beam commissioning

- Main goal:
  - Pass the inspection for the radiation safety by the government.
  - Establish the operation of the primary proton beam-line.
  - Confirm the neutrino production by observing the muons.
  - Confirm the pion focusing by the electromagnetic horn.
- Constraint:
  - The installation of 2nd and 3rd horns is scheduled in this summer.

    → The number of the beam spill should be minimized in order to reduce the radio activation.
  - The # of shots for the beam line tuning << 1000.

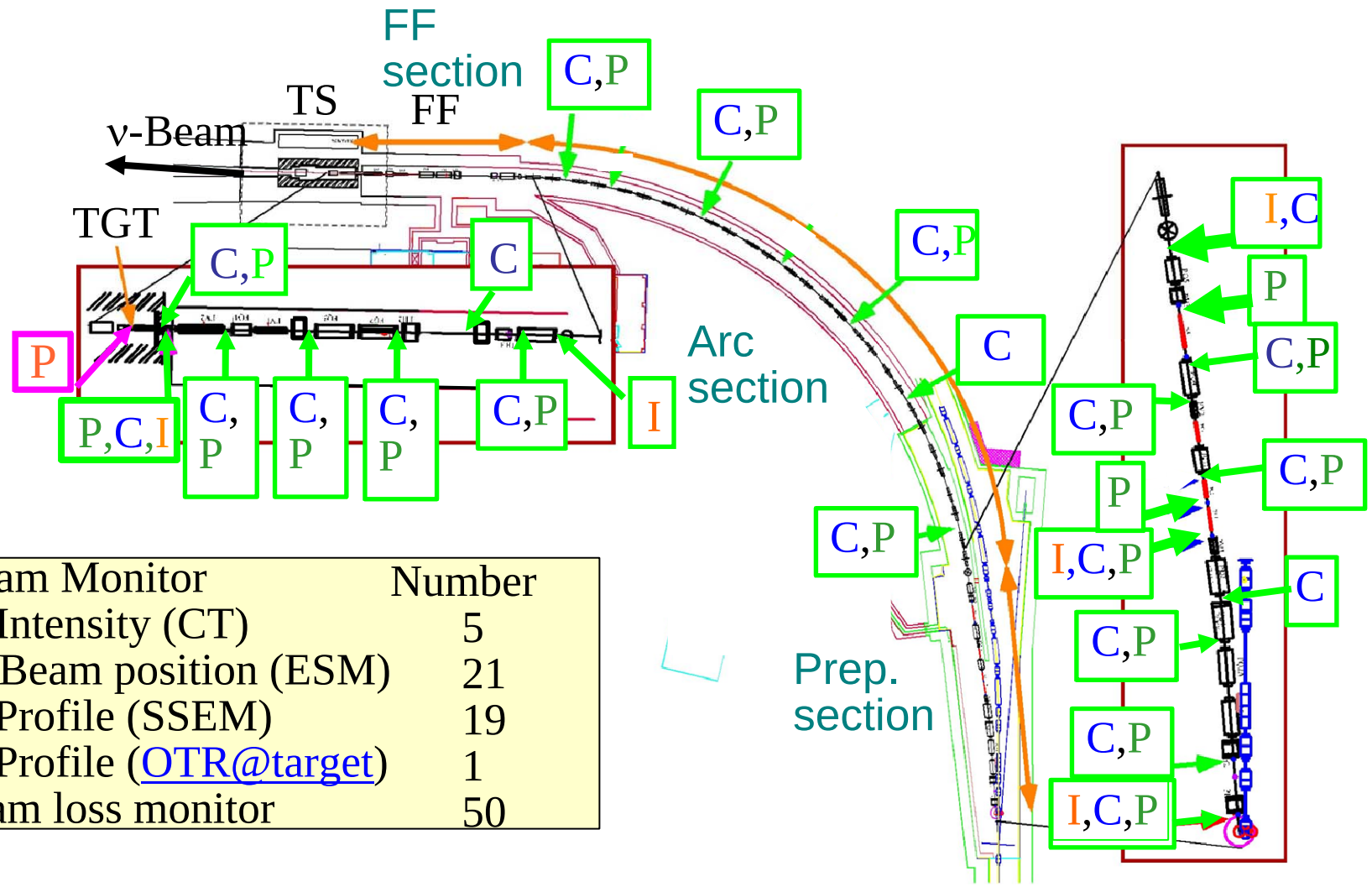
# Condition @ Apr./May. commissioning

- Beam condition:
  - ~4x$10^{11}$ p/bunch, 1 bunch / spill
    - 2 bunches operation, doubled intensity (~7x$10^{11}$ p/bunch) are also tested.
  - Single shot operation / Rep. period: 6 sec.
  - Beam size, bunch width is smaller than design.
- 1$^{st}$ Horn Only: 270kA
- TS : Filled by Air instead of Helium.

# Achievement the commissioning.

- Beam orbit from MR is stable.
  - Difference from the design: 0.3mm(position),0.04mrad(direction)
- Primary beam line tuning
  - The superconducting combined-function magnets are working well.
  - Beam orbit is roughly tuned in ~ 3mm level.
  - Operation check of beam monitors
- The effect of the electromagnetic horn is confirmed.
  - Secondary muons are observed behind the beam dump.
- Successfully passed the government inspection.

# Primary beam-line & monitors

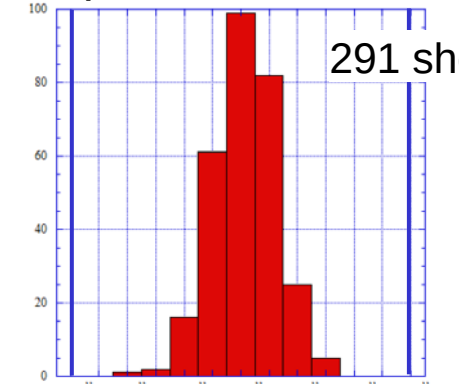



| Beam Monitor | Number |
|---|---|
| I : Intensity (CT) | 5 |
| C: Beam position (ESM) | 21 |
| P: Profile (SSEM) | 19 |
| P: Profile (OTR@target) | 1 |
| beam loss monitor | 50 |

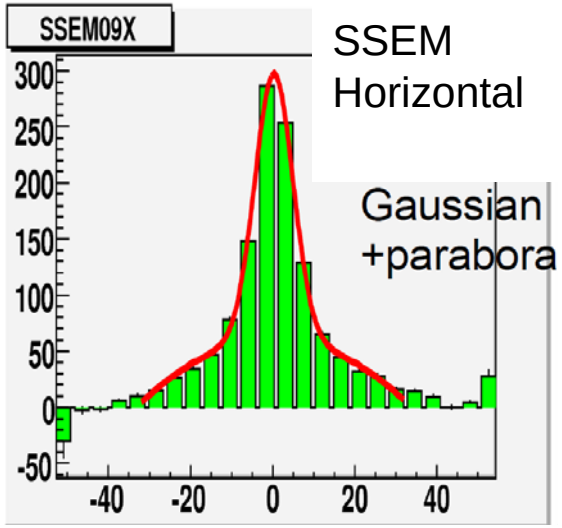
# Proton beam monitors

- Intensity monitor (CT)
  - Spill by spill stability: 1.9%
  - Beam timing stability: 4ns
- Profile (SSEM)
  - Resolution
    - Position: ~0.1mm(H), ~0.2mm(V)
    - Beam size: ~0.2mm
  - Board component in the horizontal beam profile is observed.
    ← consistent with the measurement by MR-profile monitor
- Position (ESM)
  - Resolution: ~0.6mm
    - *Bunch width in Apr/May is narrower than design.*

# of protons @ FF exit



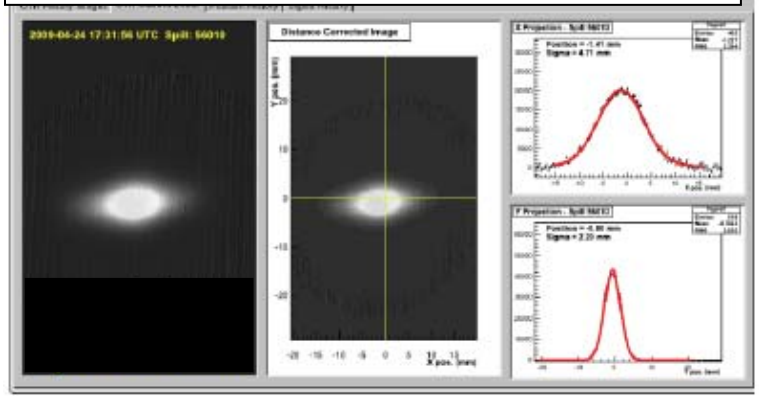

$1.56\times10^{11}$ $1.80\times10^{11}$

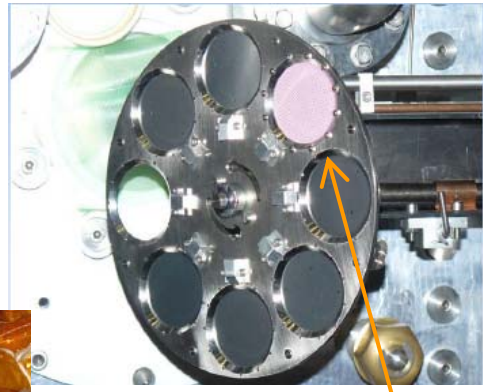


# Proton beam monitors (Cont'd)

- Beam Profile @ target
  (OTR: Optical Transition Radiation)
  - Fluorescence plate is used instead of Al/Ti foils.
  - Functionality of the optical equipment (Mirrors, Camera, etc…) is confirmed.
- Beam loss monitor (BLM)
  - Beam loss due to SSEM detected: 16mW / 1SSEM (calculation).
  - Beam loss other than SSEM loss is much smaller.

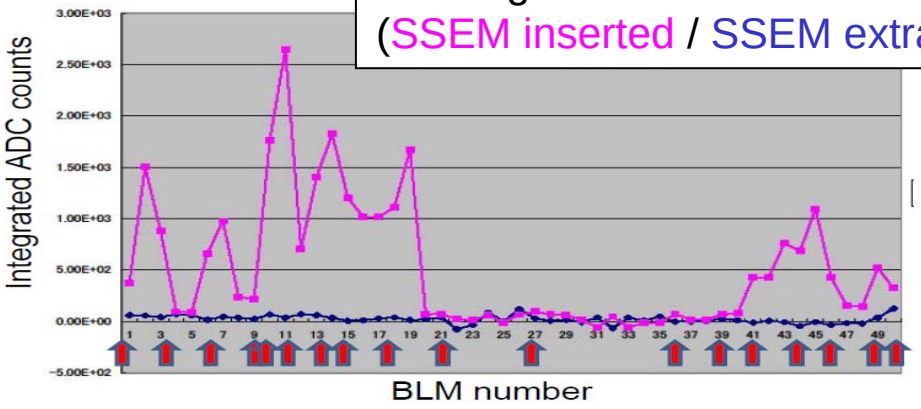
Beam profile from fluorescence plate
(Observed by OTR system)

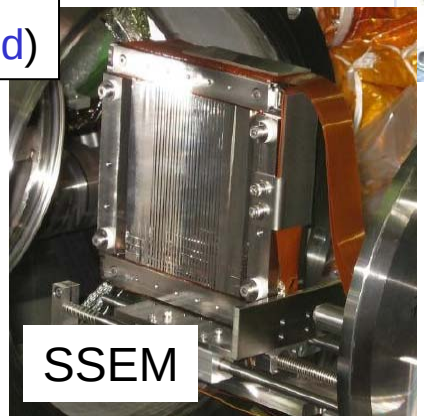




OTR foils
fluorescence plate

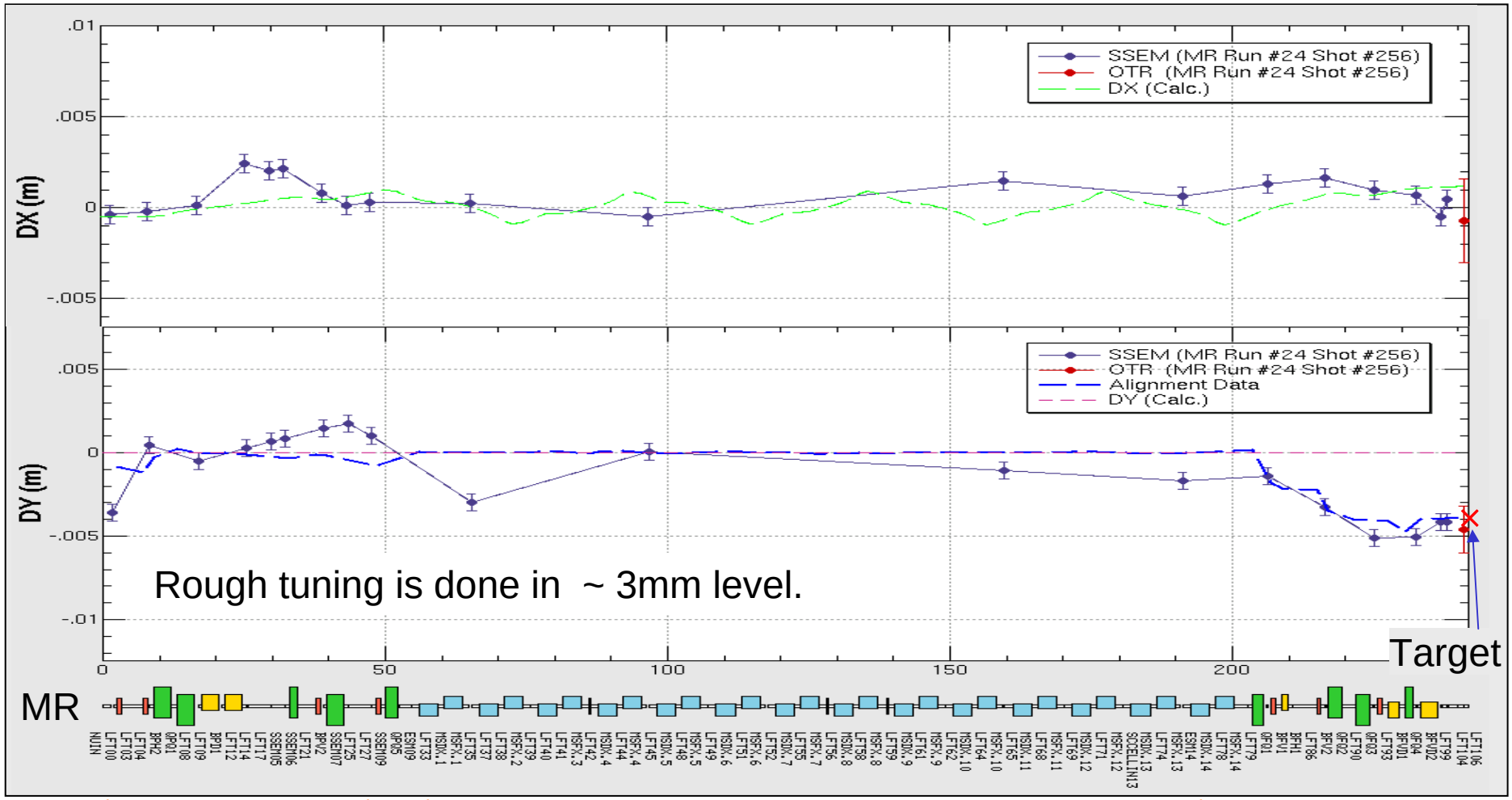
BLM signal distribution
(SSEM inserted / SSEM extracted)



SSEM

# Beam Orbit



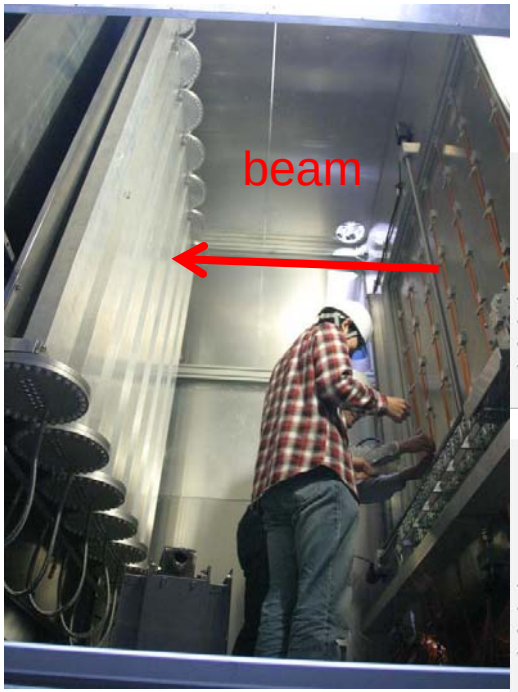

Preparation Section

Arc-section
Superconducting combined-function Magnets

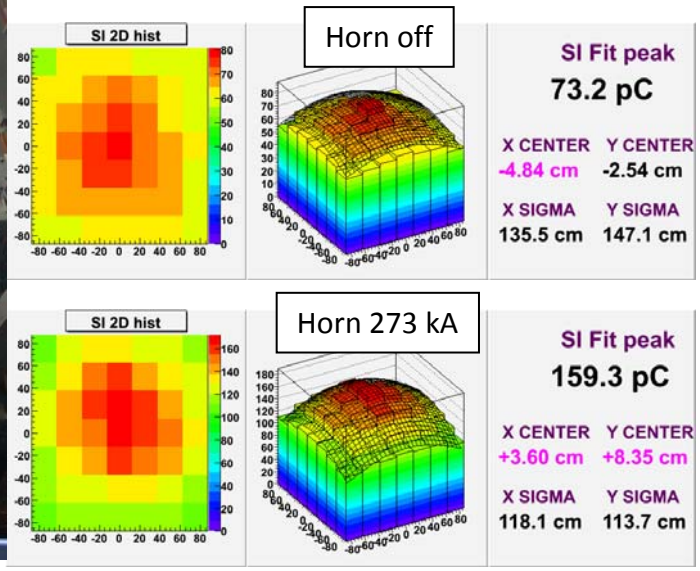
Final-Focusing section

# Horn & secondary beam-line

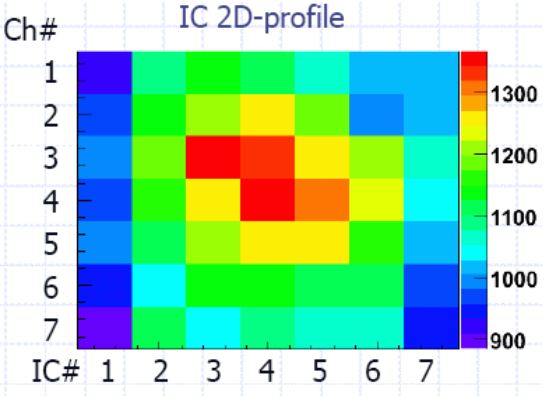
- 1st horn is operated in ~270kA without no fatal trouble.
- Muon yied measured by Si become twice due to the 1st horn excitation.
  - Ionization chamber also measured the profile by integrating spills.




Muon profile by Si detector

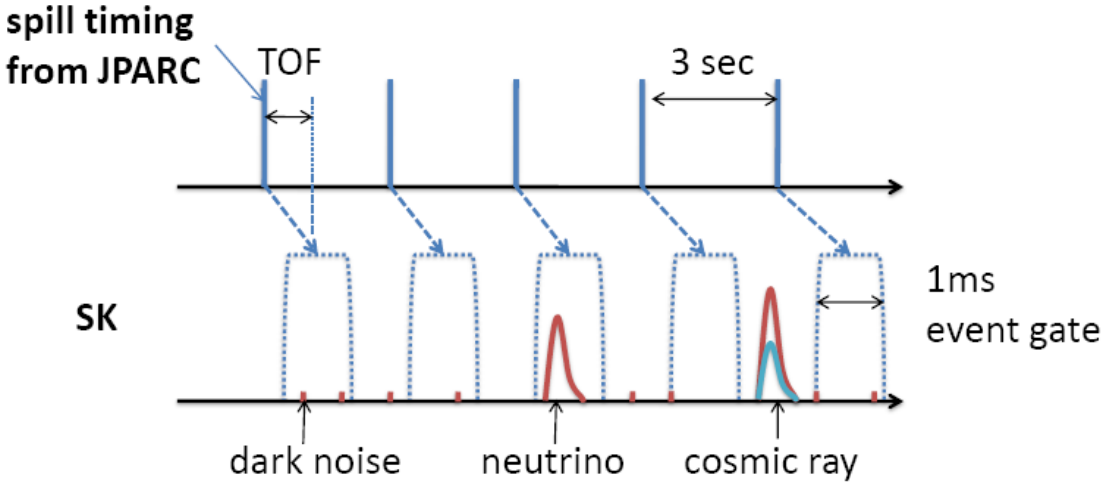



Muon profile by Ionization chamber (Integration of 365 spills)

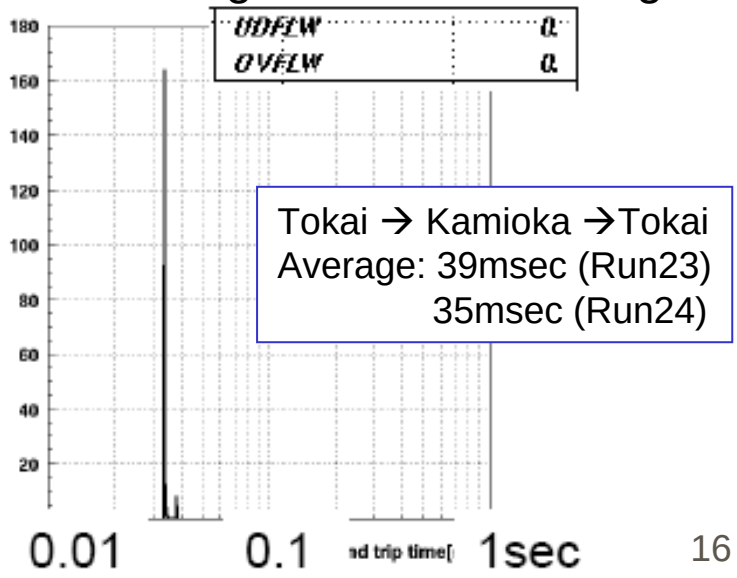


# First beam to SK

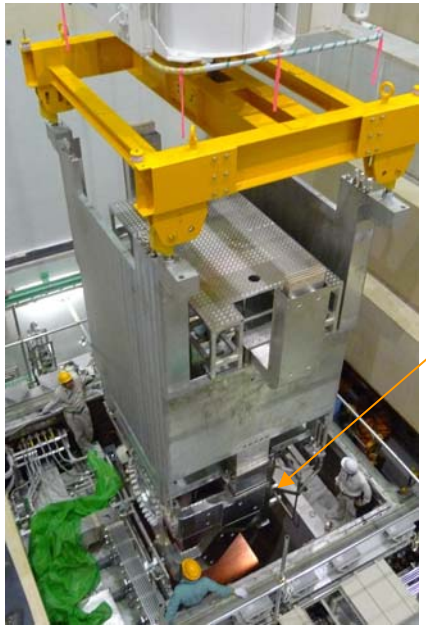
- SK was stably taking the data during beam.
- Spill timing based on GPS is successfully sent to Kamioka site.
  - No fatal delay of the data transfer during commissioning date is happened.
- Online data selection for T2K is working well.




Round trip time of GPS data transfer during the commissioning

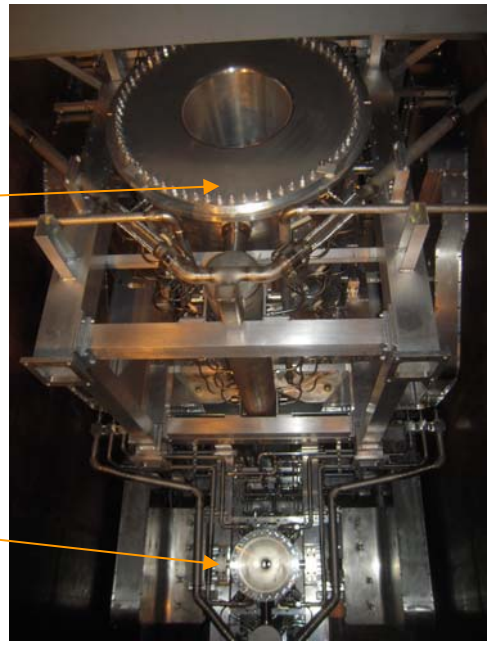


# Schedule of summer work.



2nd horn installation

Installed 1st horn



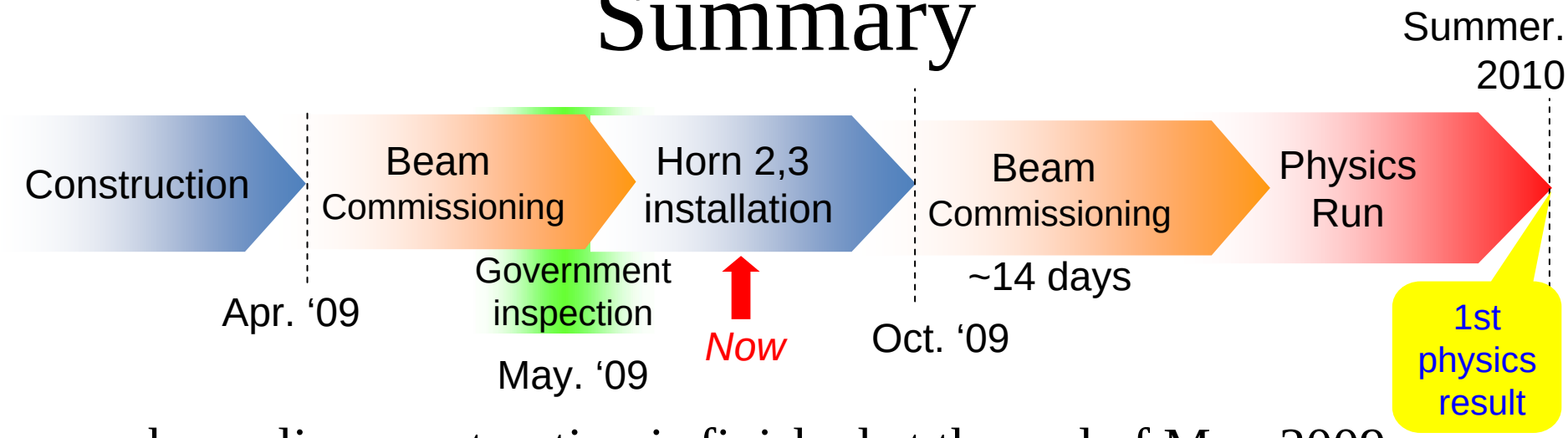
- Primary beam line work: ~ Early September.
  → Start vacuuming from Sep. 10th.
- Secondary line
  - 2nd horn installation: 7/10 Successfully finished!
  - 3rd horn installation: Early August:
  - Fill TS Vessel-DV-BD with Helium gas in late September
- Become ready for beam operation in 2nd week in October.

# Commissioning plan towards physics run.

- Total: ~ 14 days

1. Newly installed hardware commissioning (1 day)
2. Remaining beam-orbit tuning (~1 day)
3. Beam line stability check  (~24 hours)
4. Reproducibility check / orbit tuning in response to MR beam condition change (~1 day x n times)
5. Study to understand the focusing by Horns (1 day)
6. Beam based alignment for target & horn, beam monitors (2 days)
7. Proton beam-monitor study (1 day)
8. MUMON study including emulsion (2 days)
9. INGRID (Near detector on axis) (~1 day + 24 hours)

# Summary




- ν beam line construction is finished at the end of Mar. 2009.
  - Exception: Horn 2, 3 installed in summer 2009.
- 1st ν beam is generated in Apr. 2009.
  - Muon signal @ beam dump is confirmed.
  - Passed the government inspection. Got license to operation.
- Horn 2, 3 installation is in progress.
- Beam commissioning with full horn setup is planed from Oct.
  After ~2 week beam study, ν beam line become ready for physics run.

→ 1st physics result in summer 2010.