

T2K Beam Operation Summary

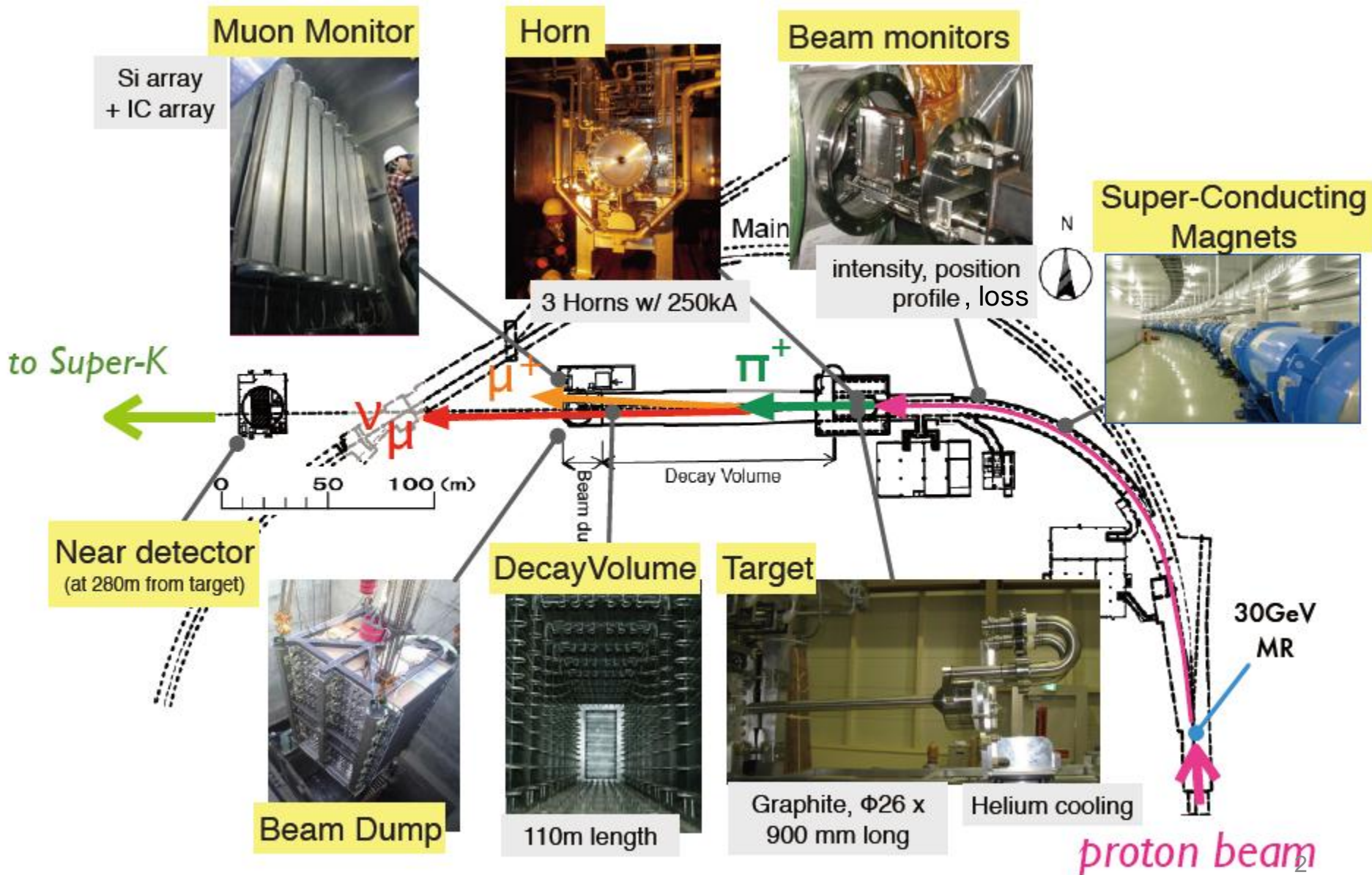
(earthquake recovery and beamline survey)

NBI 2012

T. Ishii (KEK)

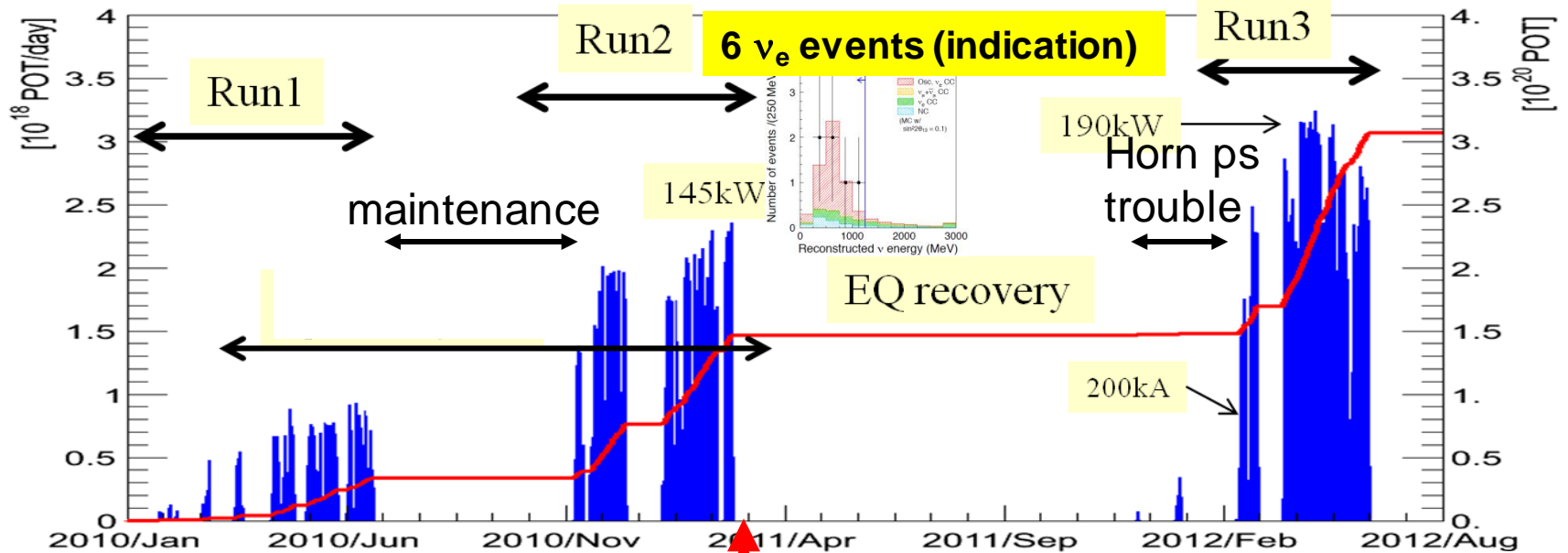
for the T2K beam group

J-PARC Neutrino Beam Facility



Data accumulation

Delivered POT to Neutrino Beam line (MR-FX)



Earthquake

- Apr. 2009 First beam
- Jan. 2010 Physics run (Run1) started including the near detectors
- July-Oct.2010 Summer maintenance period
- Nov.2010 Run2 started
- Mar.2011 Stop due to the earthquake, 1.43×10^{20} POT for physics accumulated by then
- Apr.-Dec.2011 Recovery from the earthquake
- Dec.2011 Horn power supply broken
- Mar.2012 Run3 started using old PS (with lower horn current in March)
- Apr.-Jun.2012 Run3 with nominal horn current, 3.01×10^{20} POT for physics accumulated so far (8×10^{21} POT approved)
- Oct.2012 Run4 started and 200kW continuous operation achieved

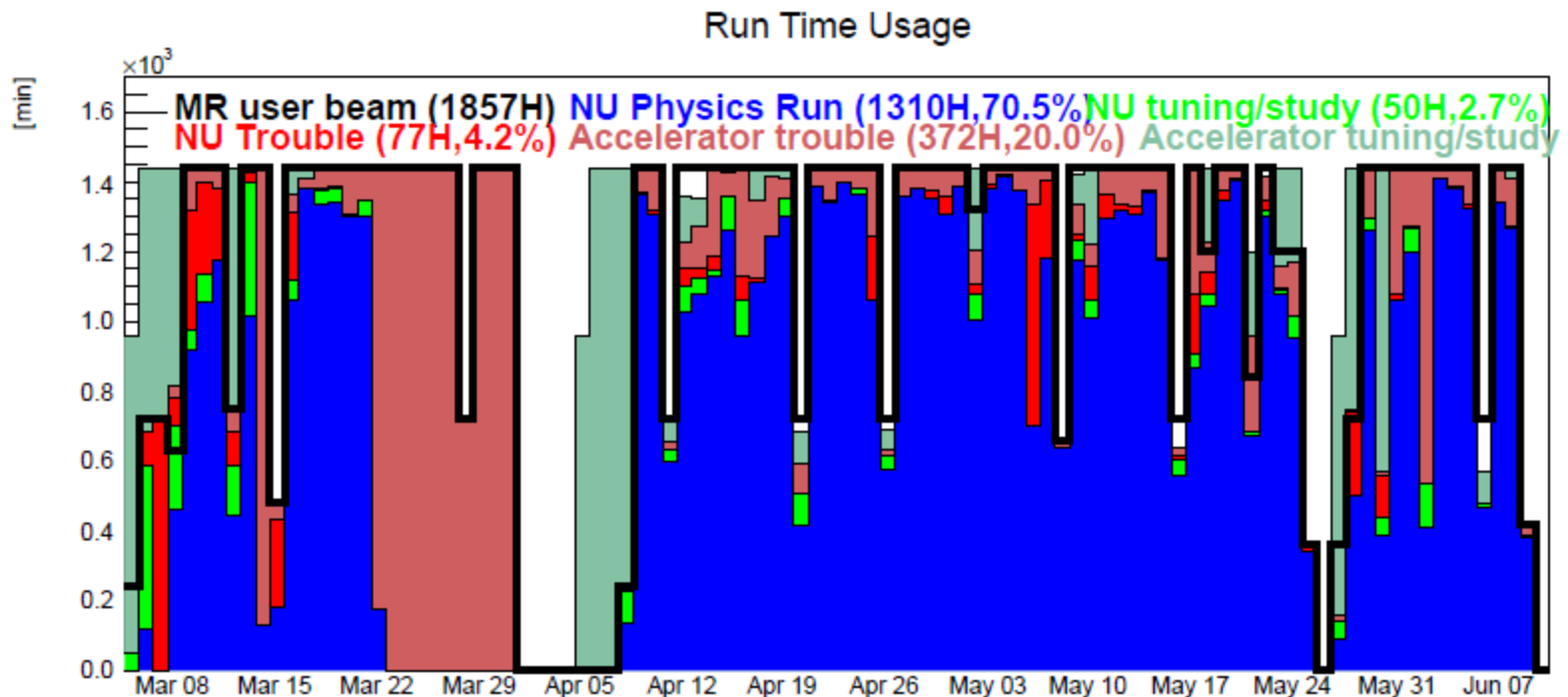
11 ν_e events (evidence)

Beam-line Problems & Main Works

- 2010
 - Radiation in exhaust at NU3/TS restricted the beam power. → Ishida's talk
 - Relocation of underground control panels of air ventilation / water circulation at TS to avoid attack of fast neutrons to PLCs
- 2011
 - **Earthquake (Mar.11, 2011)**
 - Realignment of the primary-beamline magnets → This talk
 - Repair of submerged components of the primary beamline
 - The first operation of remote maintenance of irradiated Horn-3 → Sekiguchi's talk
 - Realignment of horns in the vessel → Sekiguchi's talk
 - New horn power supply damaged during test operation (Dec.22, 2011) → Sekiguchi's talk
- 2012
 - Rapid re-installation of old horn PS → Sekiguchi's talk
 - Upgrade of TS air ventilation to reduce radiation in the exhaust. → Ishida's talk

Summary of beam operation in Spring 2012

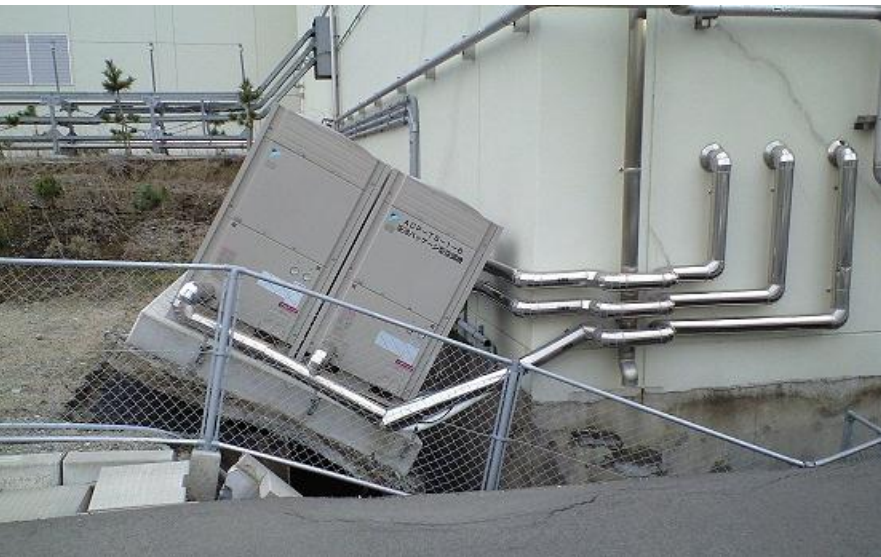
- Allocated beam to MR user : 1853hrs~80% of total time 97days
- Running efficiency : ~70%=physics run(1310h)/allocated(1853h)
- Acc. trouble ~20% : LINAC klystron PS down, MR injection kicker down, MR BM down, FX kicker down, high radiation in MR machine room limited the beam power
- Nu trouble ~4.2% : horn PS down, cryo. of magnet stopped due to a thunder storm, horn cooling water's quality deteriorated due to air contamination and intense beam → performed ion exchange of the cooling water



Earthquake damage and recovery

- The earthquake occurred on Mar. 11, 2011
- Large displacement everywhere in J-PARC
 - Beam-line components were displaced
- Ground collapse at some places
- Cracks in buildings and tunnels
 - Cracks in the MR tunnel resulted in a water leak and some of cables and monitors were submerged
- Electricity, network, cranes, air conditioning, ventilation, cooling water and drainage stopped or got damaged
- Everything necessary for beam operation were recovered before the scheduled beam on Dec. 24, 2011

Recovery around Target Station



Displacement data due to the earthquake by GSI

(geospatial information authority of Japan)

Most concern was the direction and baseline change.

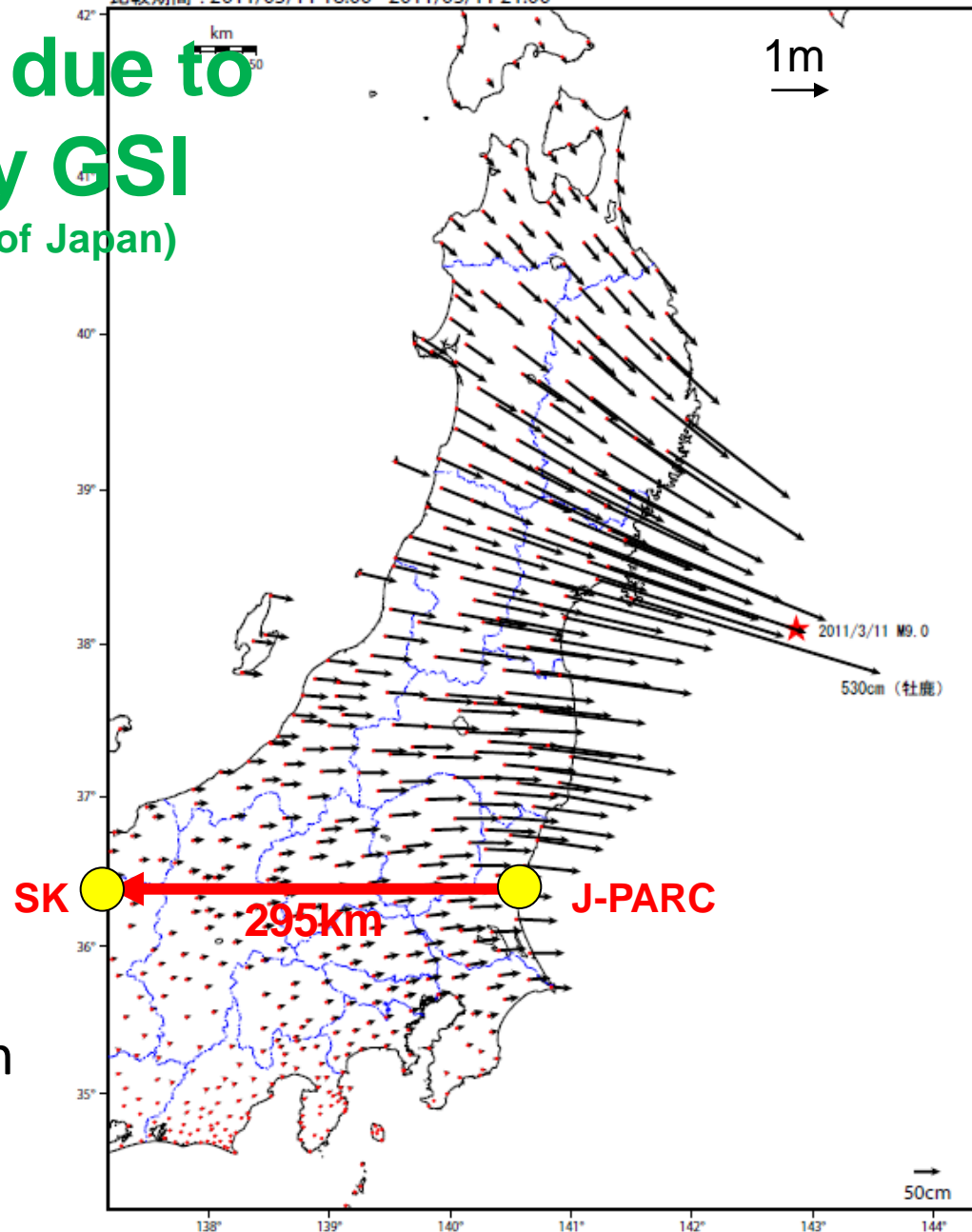
We performed a long-baseline GPS survey.

Direction change < 0.001 mrad

Distance change = +0.9m

Effect of these changes on the oscillation analysis is negligible.

More concern is the rotation of the J-PARC area. (next page)



Movement of the J-PARC GPS Primary Reference Points

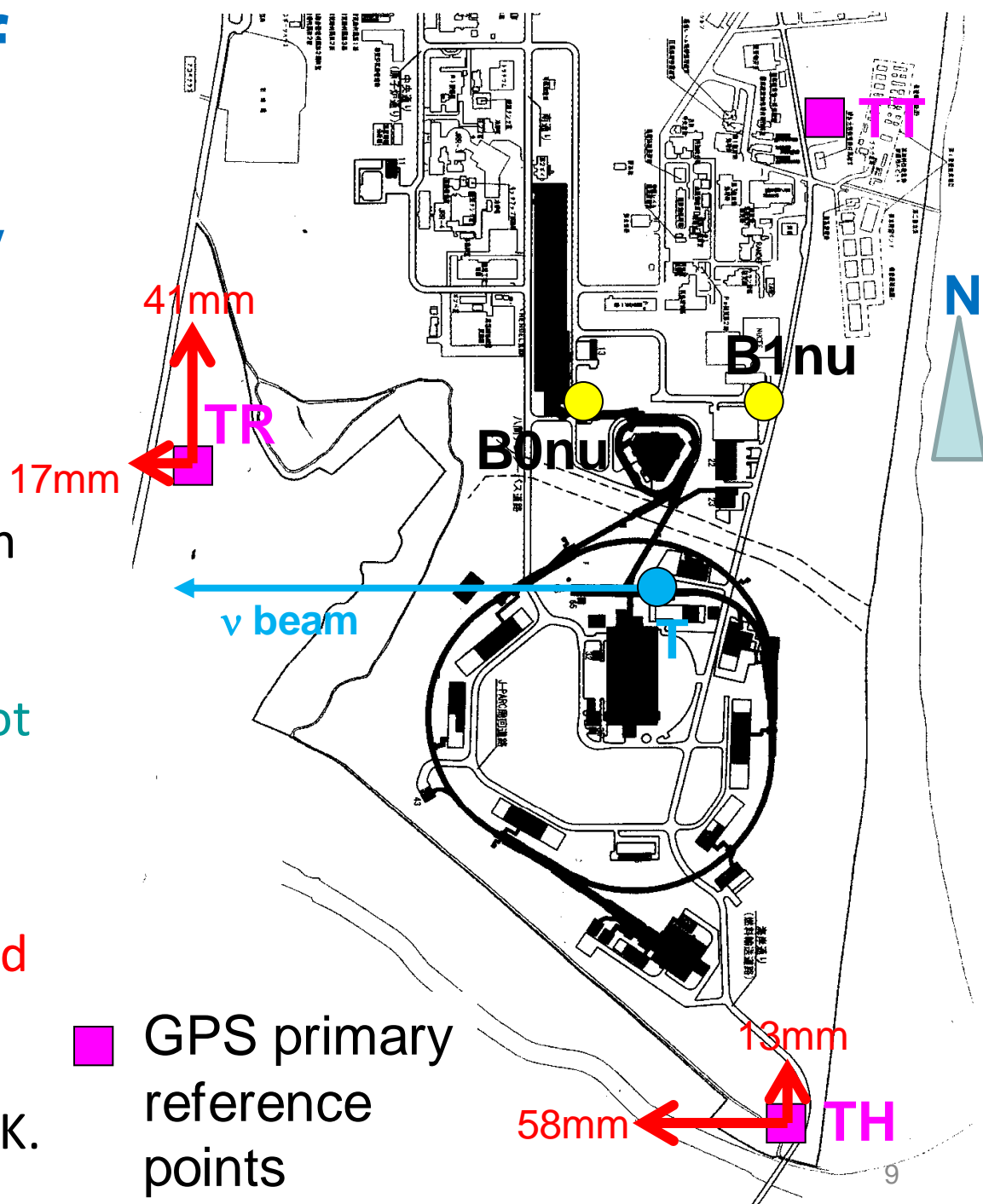
GPS gives a vector between two points. Hence it gives the direction angle.

Here, we assume **TT** has not moved.

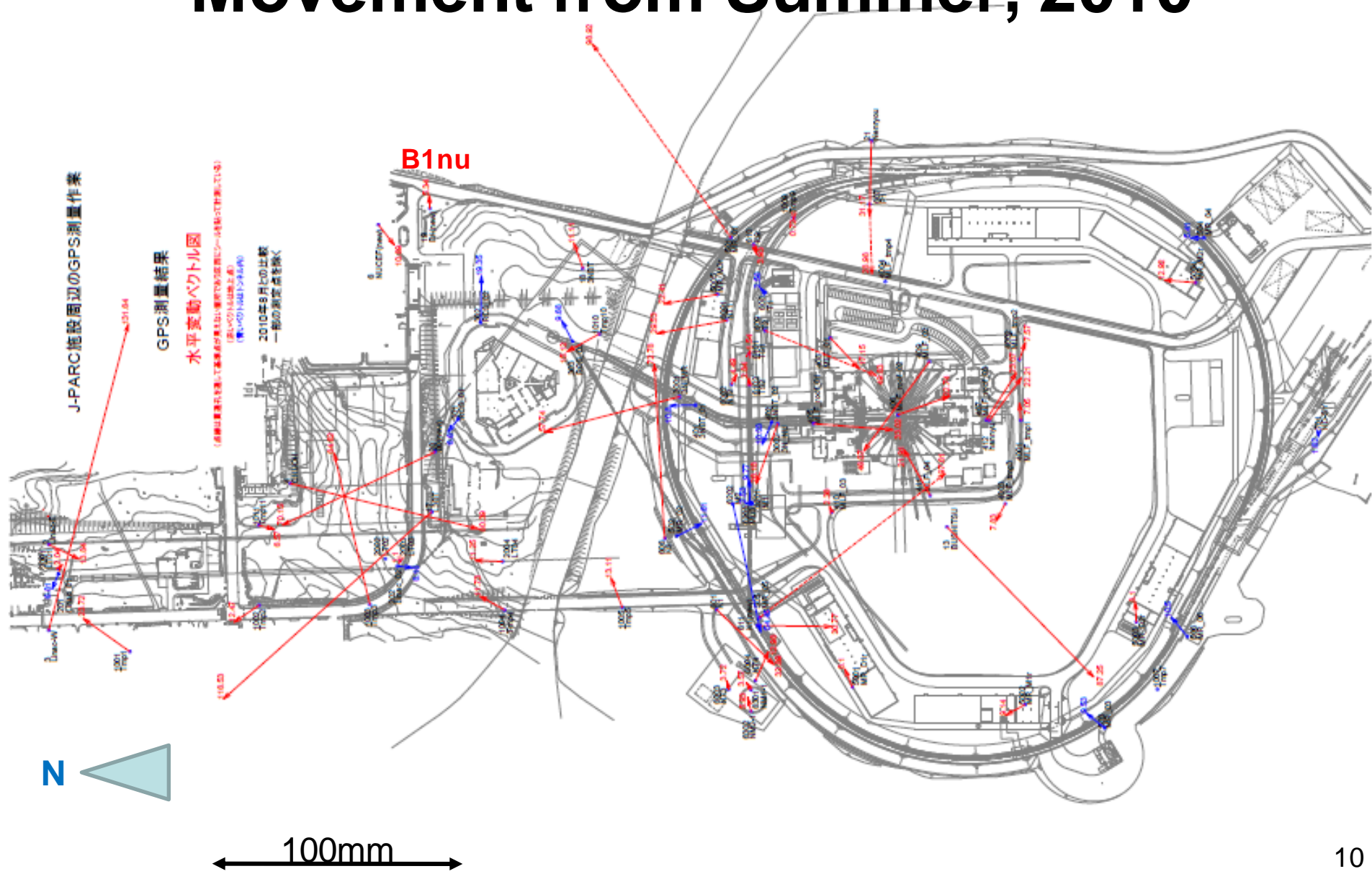
Survey result

The GPS primary reference points seem to have rotated clockwise by 0.04mrad (accuracy $\sim 0.005\text{mrad}$).

This is still negligible for T2K.



GPS-based survey result in April, 2011 Movement from Summer, 2010

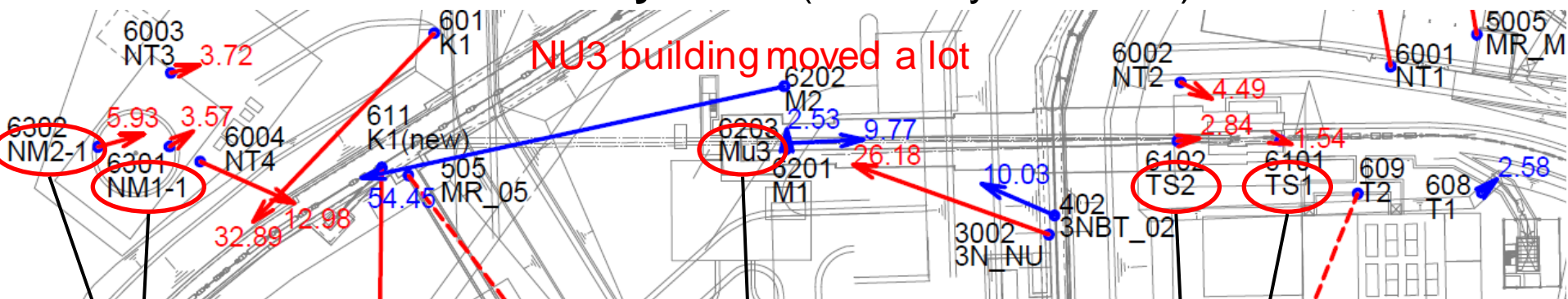


Movement from Summer, 2010 around the neutrino beam line



GPS-survey result (accuracy is $\pm 5\text{mm}$)

10mm

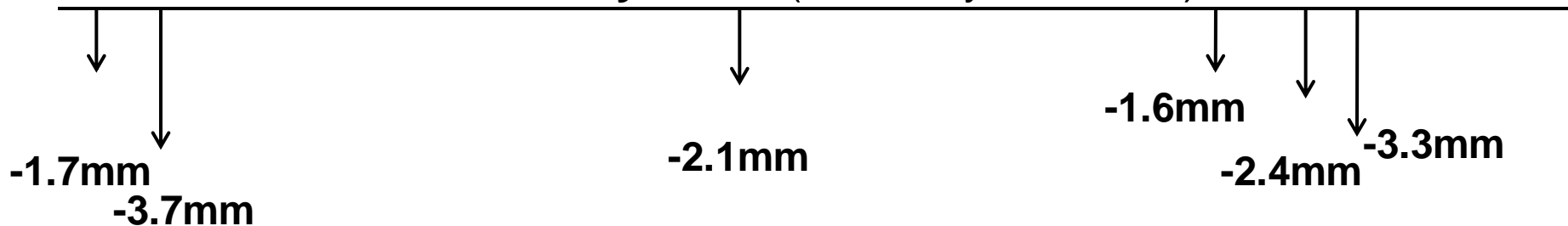


Neutrino-monitor building 1F

Muon pit underground

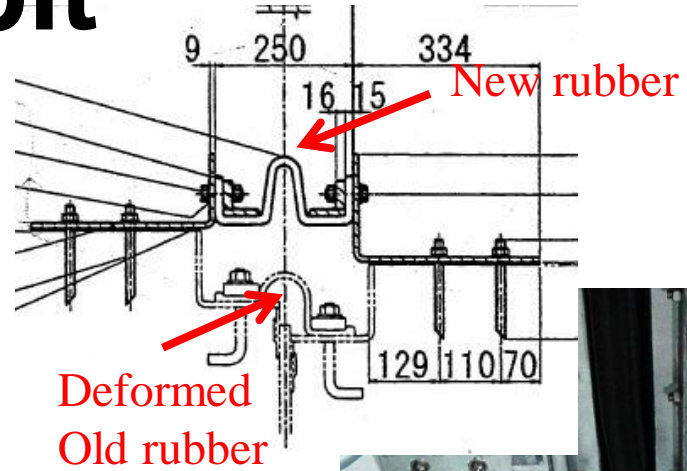
Target-station building 1F

Level-survey result (accuracy is $\pm 1\text{mm}$)

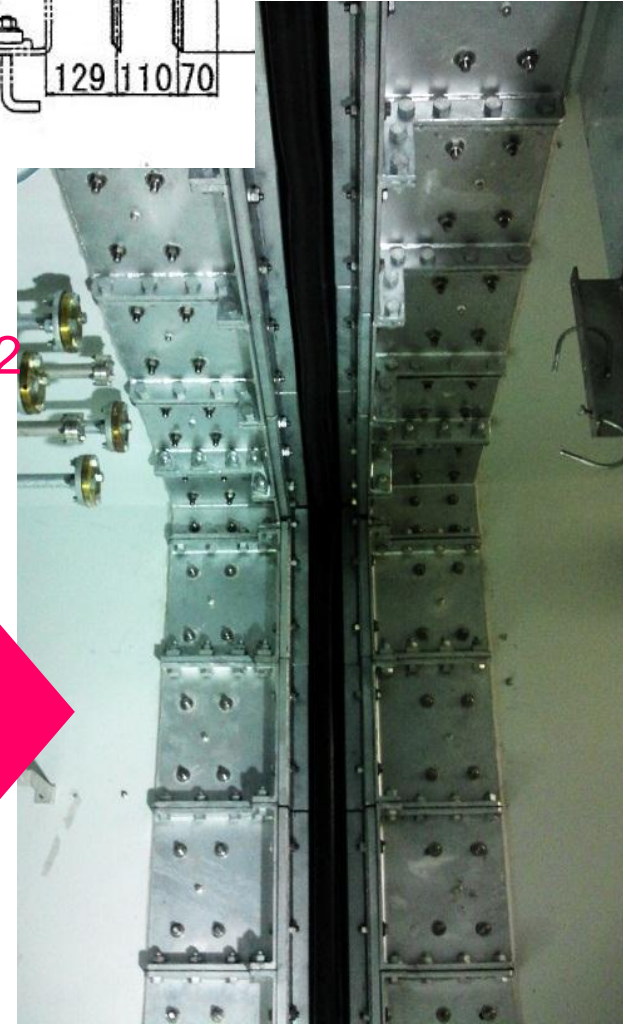
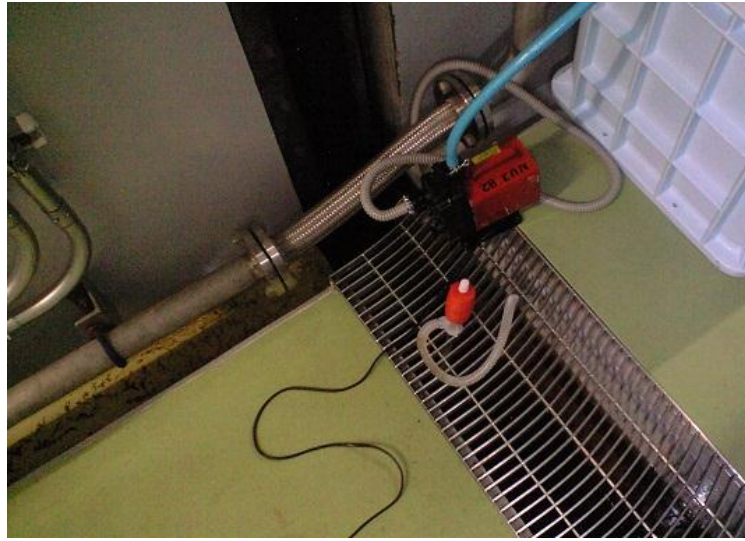


Relative alignment is OK for the experiment

NU3 and Muon pit

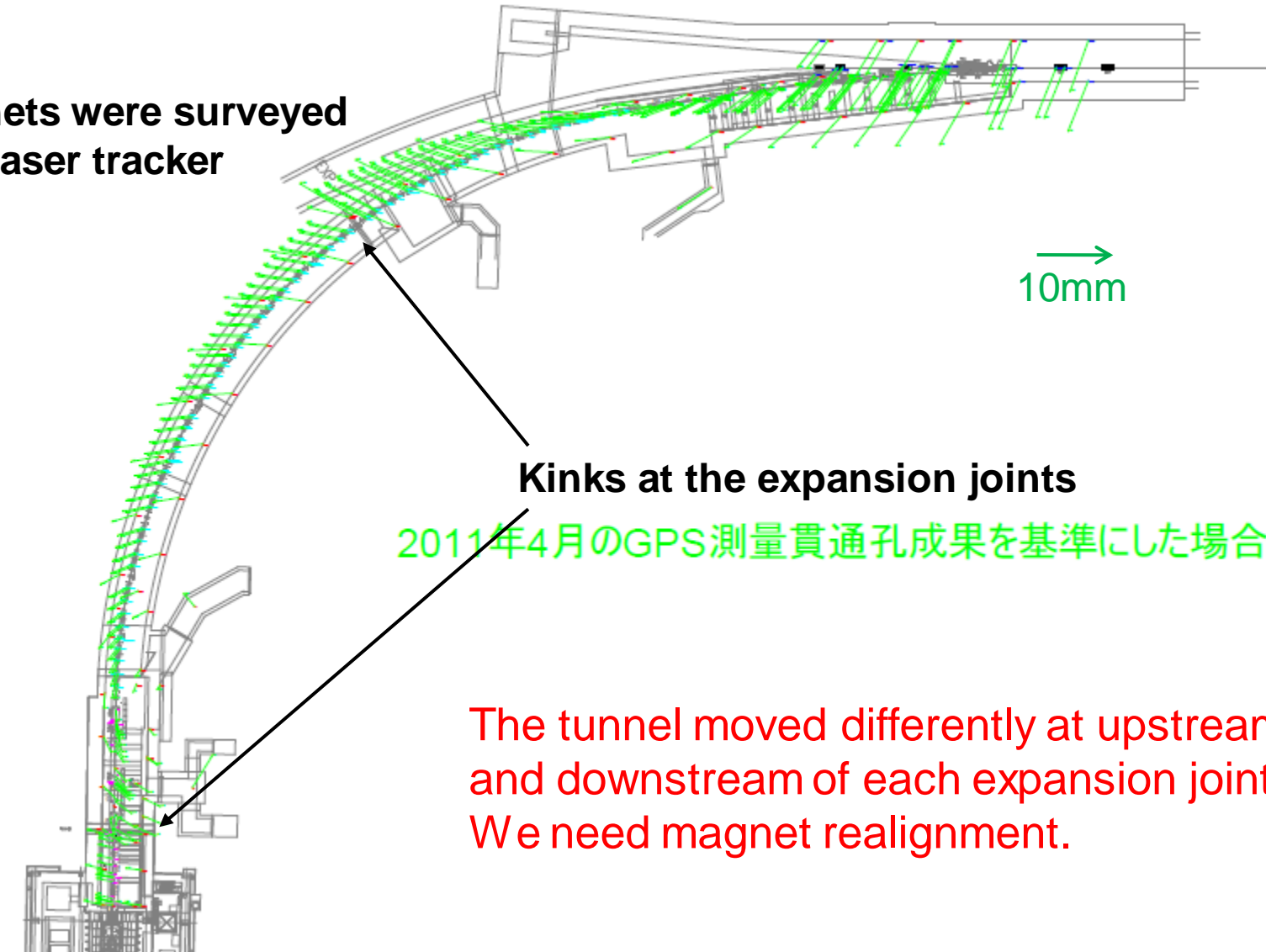


Joint was repaired in Summer 2012

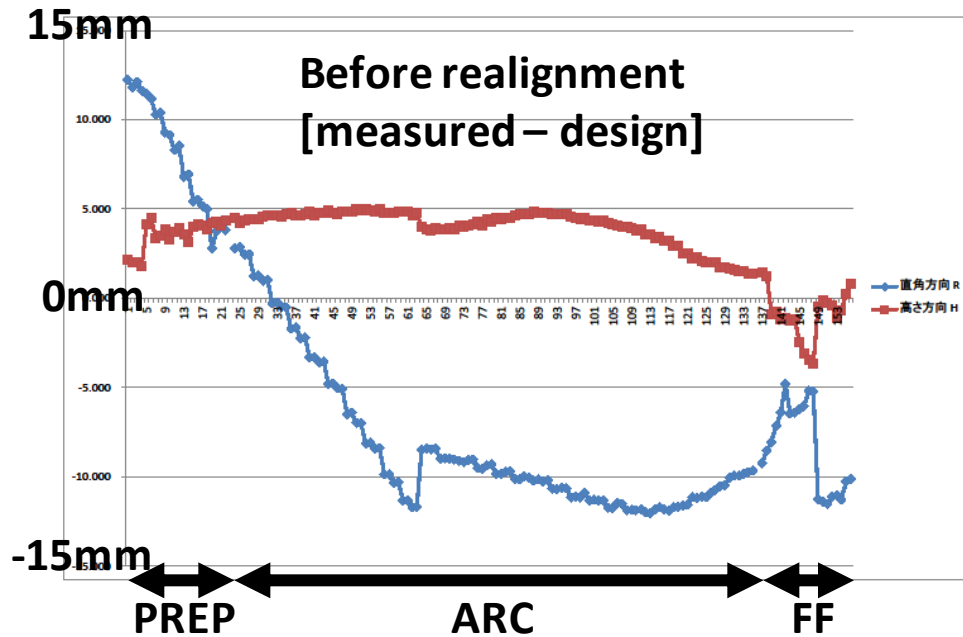


Displacement of the primary beamline magnets

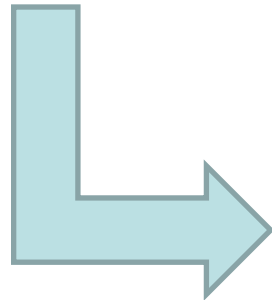
Magnets were surveyed by a laser tracker



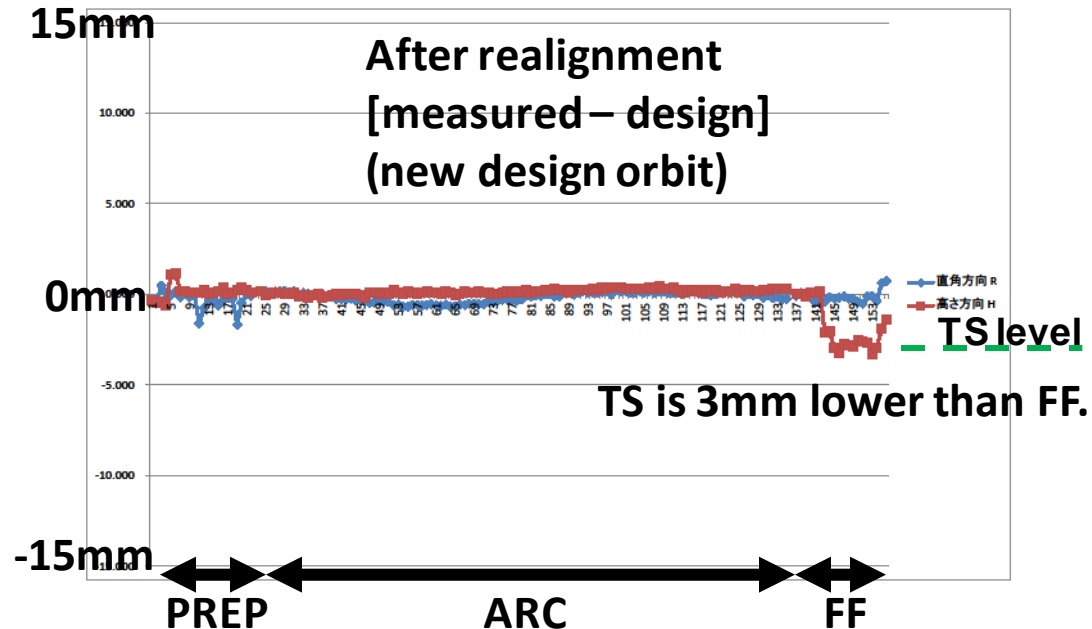
Primary-beamline magnets were realigned



Realignment was done based on the May 2011 survey results. The beam orbit was also redesigned.

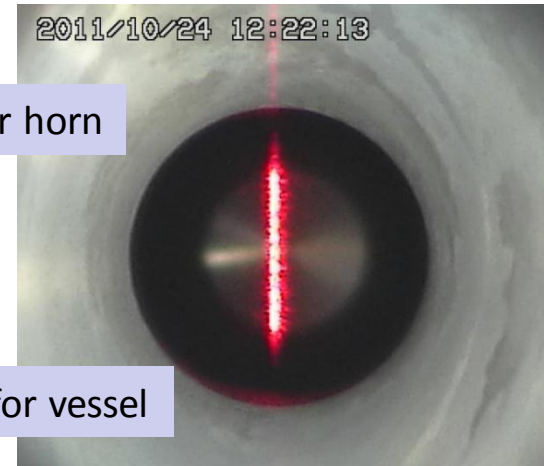
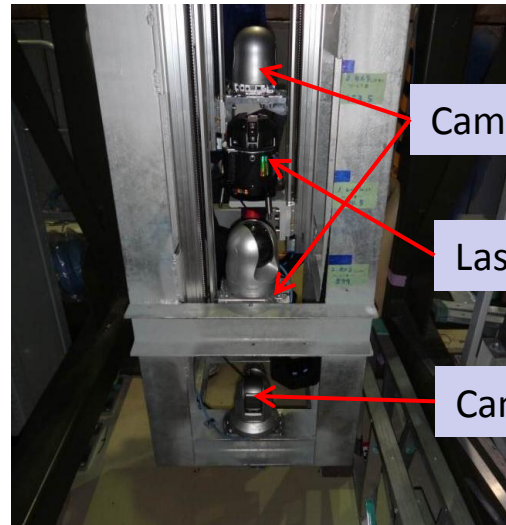
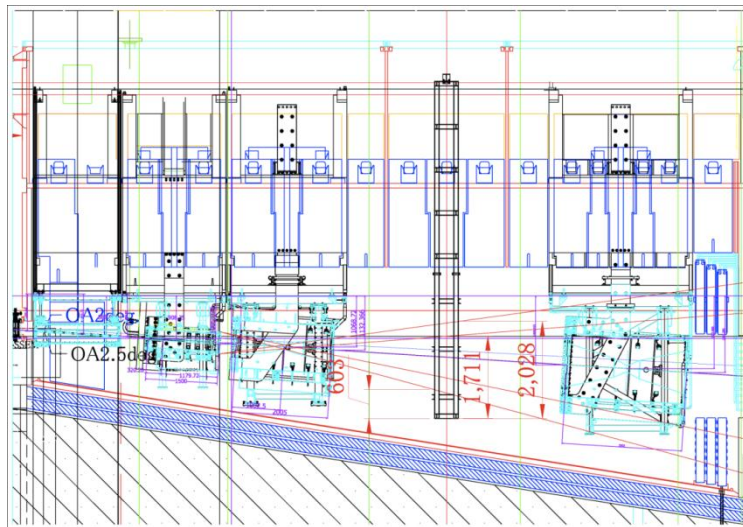


--- ΔR :horizontal direction
--- ΔH :height



Horns and target

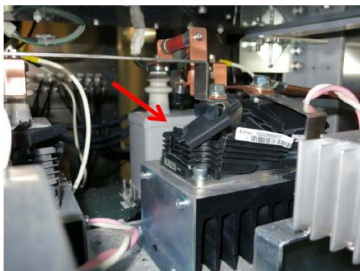
- Horns were realigned at the markers on the support module.
- The alignment was confirmed remotely by using a laser and cameras.



Rear face of 1st horn and target



Broken IGBTs



- On Dec. 22, during final operation test, horn power supply was broken
- Several IGBTs to switch charging capacitors were burst
- We changed to the old power supply, which had been used for K2K and at beginning of T2K

→ Sekiguchi-san's talk for detail

Summary

- The T2K neutrino beam line suffered serious damage from the earthquake in March 2011
- Long-baseline and local surveys were done to confirm the beam direction and alignment of the beam line components
- Everything necessary for beam operation were recovered before the beam resumed in Dec. 2011
- The new horn PS was broken and we ran with the old PS in Spring 2012
- We achieved the beam power of 190kW and ~70% running efficiency in Spring 2012
- 200kW continuous operation was achieved in this month and we are trying to increase the power and efficiency