

T2K status 1

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Recovery

- Everything necessary for beam operation were recovered before the scheduled beam on Dec. 24
 - Ground drop around TS and BD were backfilled (paving remains)
 - All magnets in primary line including SC mags were realigned
 - Parts submerged under the water were repaired or replaced
 - 3rd horn was once extracted, visually inspected, alignment was confirmed and reinstalled
 - Target and 1st & 2nd horn were not extracted
 - Position was measured at horn supporting structures and realigned. The alignment was also checked by lowering laser marking device

Around target station



Repair around Beam Dump



Super conducting magnets

- Cryogenics system worked successfully in May.
- Excitation test was done successfully in May.
- Alignment Done in Aug. Re-survey performed.
- Corrector magnets already repaired.
(Additional heat anchor installed.)



Target

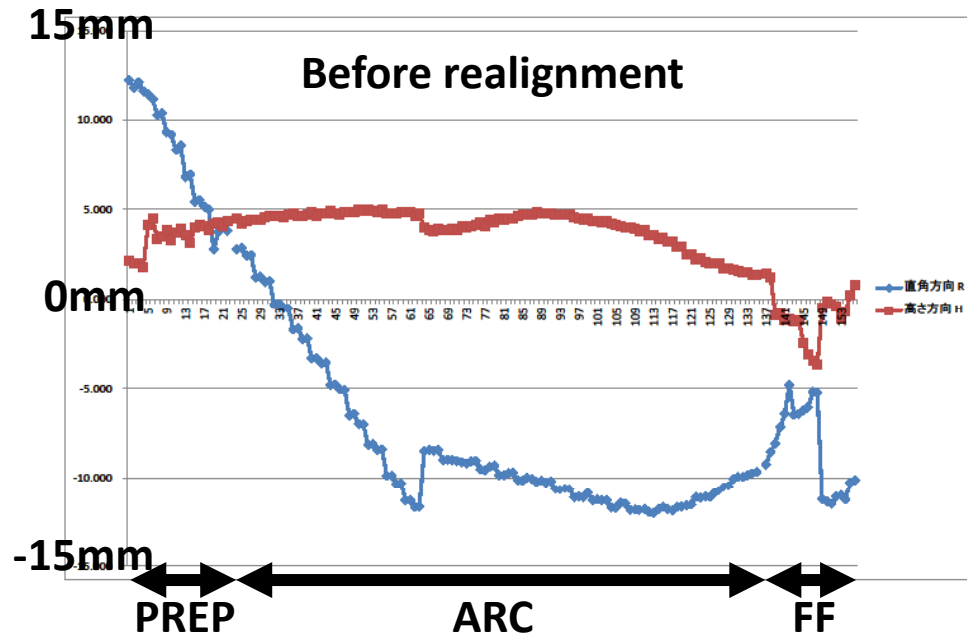
- Installed target
 - No clear change of He flow is found.
 - Spare target No.2(Toshiba) and No. 3(RAL)
 - No damage is found in the graphite parts in X-ray photo.
 - Spares were at TS ground floor at the earthquake.
 - They were also supported as cantilever.
- No indication of the damage of the installed target is found, though we have only circumstantial evidence.



X-ray photograph of No. 2 target

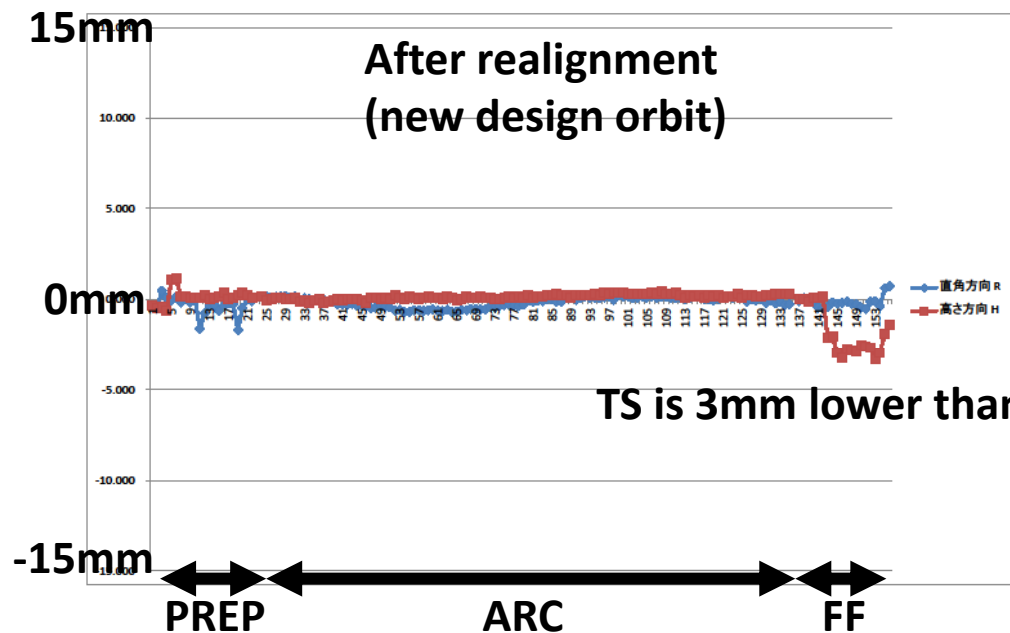
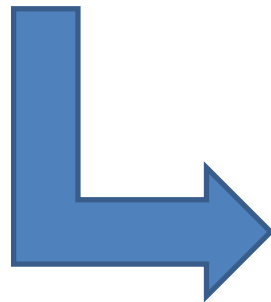
Realignment

Magnet location [measured – design]



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

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

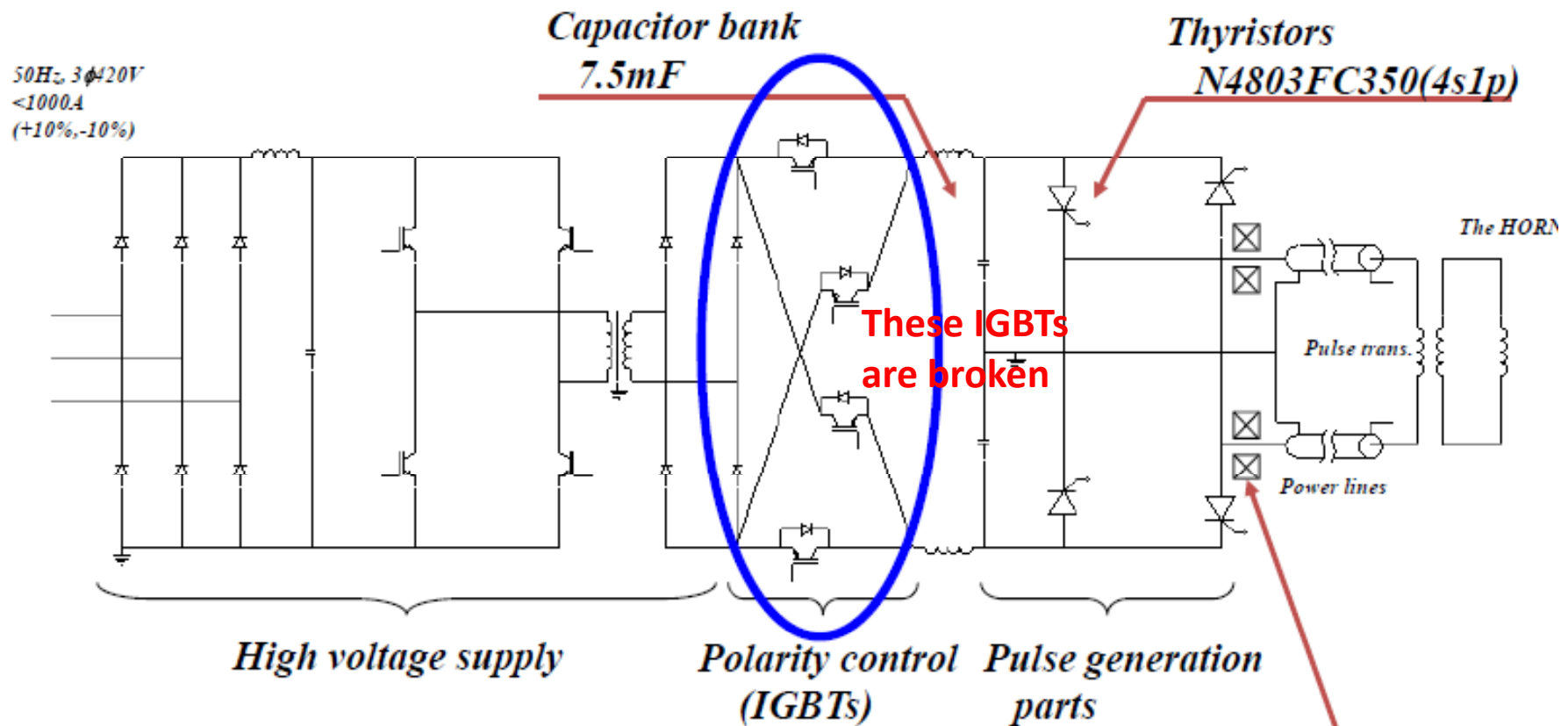


TS is 3mm lower than FF.

Horn power supply failure

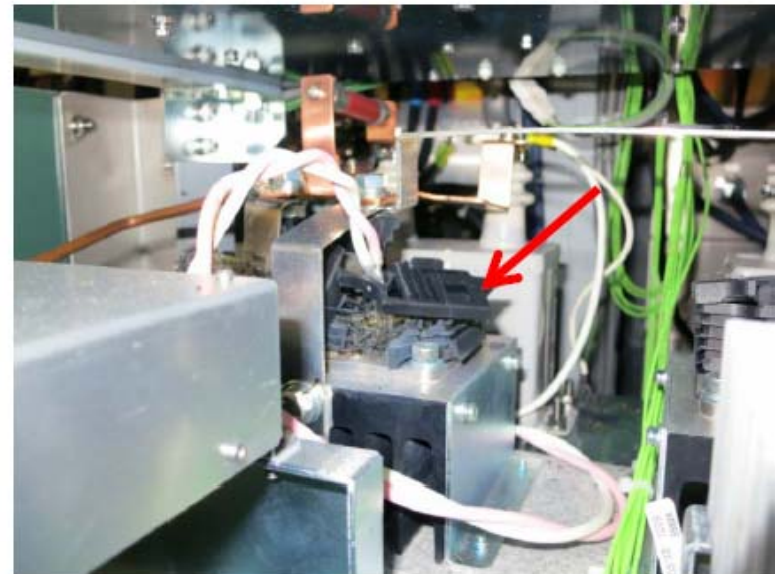
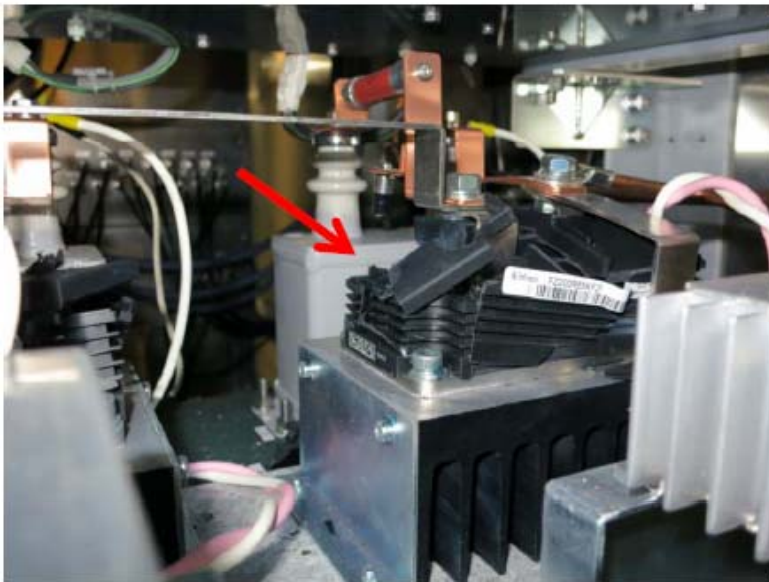
- On Dec. 22, during final operation test, horn power supply was broken
- Several IGBTs to switch charging capacitors were burst
- From visual inspection,
 - Several out of 12 IGBTs are apparently broken
 - It is natural to consider that remaining IGBT are also damaged
 - Choke coil next in serial to IGBTs are also damaged
 - Unexpected huge current went through IGBT
- The reason why such huge current was drawn is now under investigation
 - Control circuits confused by some electrical (spike?) noise issued “switch on” signal to IGBTs at the timing when huge charge is stored in Capacitor bank?
 - Deterioration of IGBTs?

Main circuitry of pulsed power supply



Saturable inductor to suppress inrush current

So called **“Full-Bridge Circuit”** enables us to re-use magnetic energy in Horn at next cycle (stored energy in the Horn during excitation is 120kJ)



Plan and status of horn PS recovery

- Recovery: 2 methods in parallel
 - 1.Repair present power supply
 - We have no spare IGBTs with same spec
 - It takes several month to procure
 - We use lower HV rating IGBTs (3.3kV instead of 6.5kV)
 - J-PARC MR group has enough stocks. So immediately available
 - May limit current < 250kA (need to check with test operation)
 - 2.Revive old power supply
 - Had been disassembled and stored at Tsukuba for ~yr
 - Need to check healthiness
 - Have never driven 3 horns with 1 power supply
 - May limit current <250kA or rep rate (simulation says OK)
- Present status
 - Old power supply has been already moved from Tsukuba and being assembled
 - Design work of repair and protection improvements has been started
- Schedule
 - With either methods, the recovery work will take 2 month at least
 - We aim to be ready for full data taking w/ horn recovered from March 1st
 - We plan to take scheduled beam in January with the horn off in order to make beam studies for high power operation and various systematic studies using near neutrino detectors

Status of spare horns

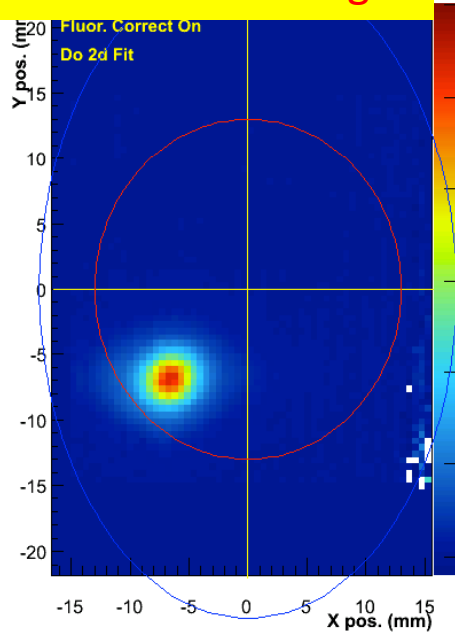
- Current spare horns:
 - Only horn1 and its support module exist.
- For horn2 and horn3, we already have some parts
 - Horn2: inner conductor, large ceramic ring
 - Horn3: inner conductor, large ceramic ring, large sealing parts
 - Support modules need to be produced.
- Plan to prepare spare horns
 - Time-consuming parts will be made in this fiscal year.
 - Outer conductors for horn2 and horn3
 - Several types of ceramic insulators
 - Other parts
 - Assembly will be done in next fiscal year.

Beam (re)commissioning in Dec.2011

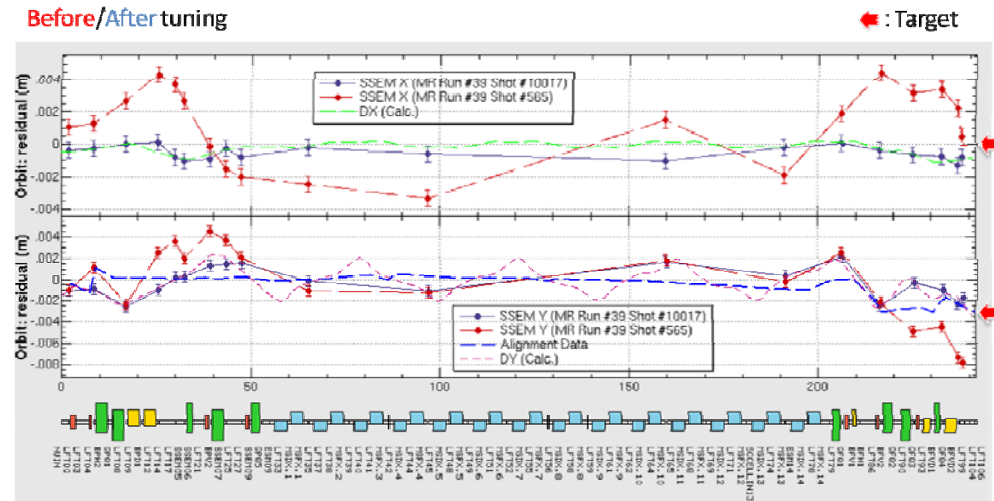
- Goal
 - Confirm functionality & reproducibility of beam line components & detectors with low intensity
 - Rough tuning of primary beam transport with new magnet alignment
- Summary of results
 - **Functionality and reproducibility of all beam line equipments (except horns) are confirmed**
 - All beam monitors worked well
 - At this moment, proton orbit is tuned as good as 3mm displacement from design orbit
 - Beam loss is also confirmed to be the same level as before
 - Took data for ~3hrs at 28kW w/o any trouble
 - Delivered POT in Dec.: $7.6e+16$
 - **Reproducibility of muon and neutrino yield (normalized by N_p) was confirmed**

Beam (re-)commissioning

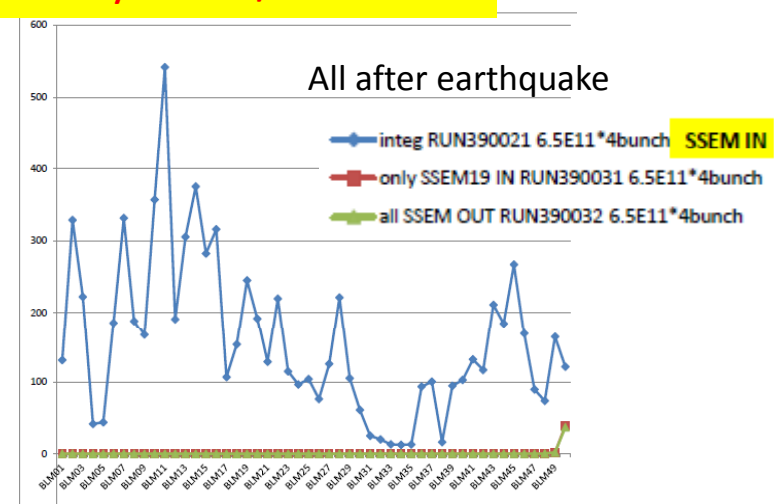
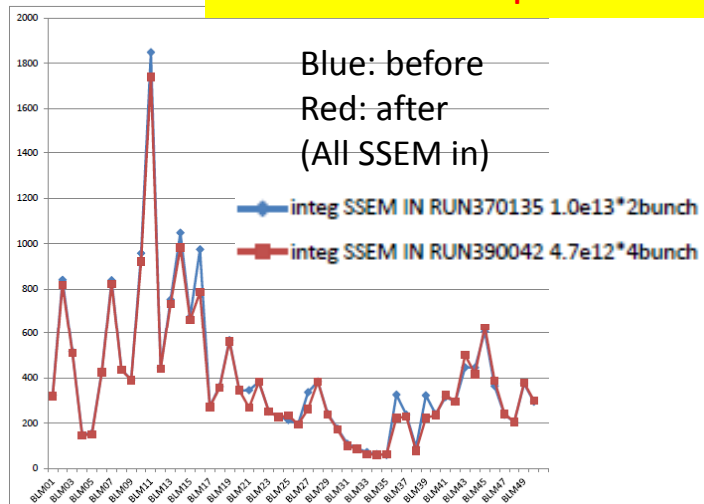
First shot hit the target



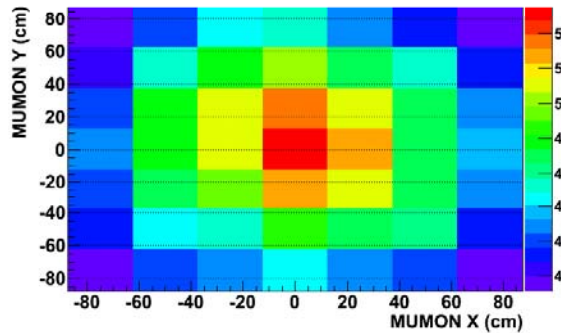
Orbit tuning done to <3mm level



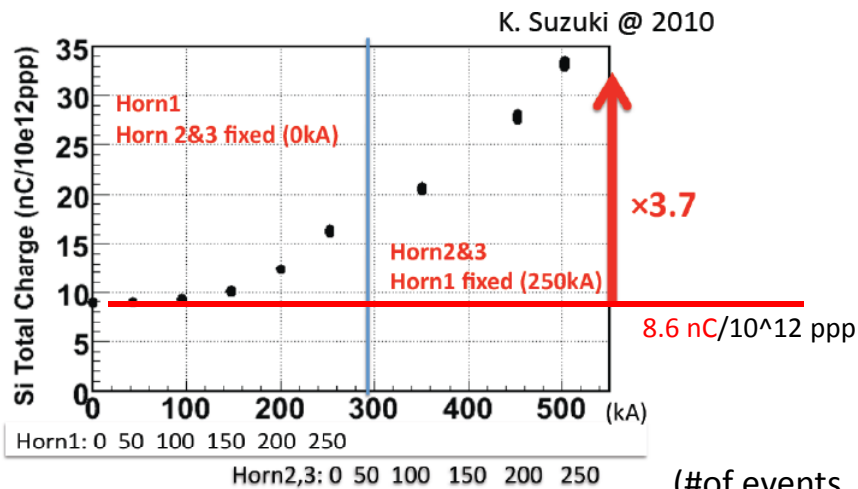
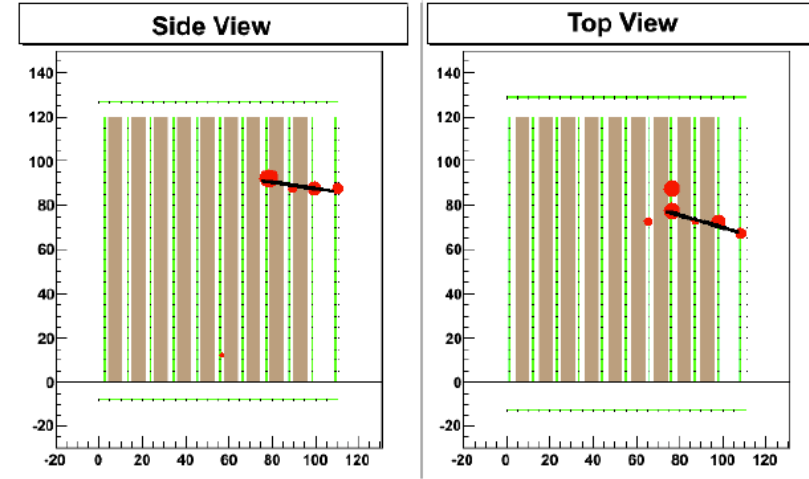
Beam loss is reproduced and very low w/o SSEM in



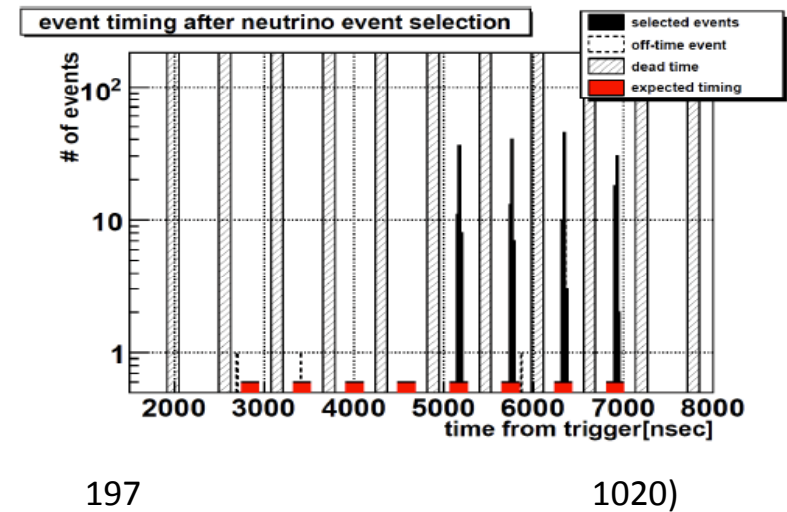
Muon/Neutrino yield



Si/CT5 = 8.6 nC/10¹² ppp (beam at target center)



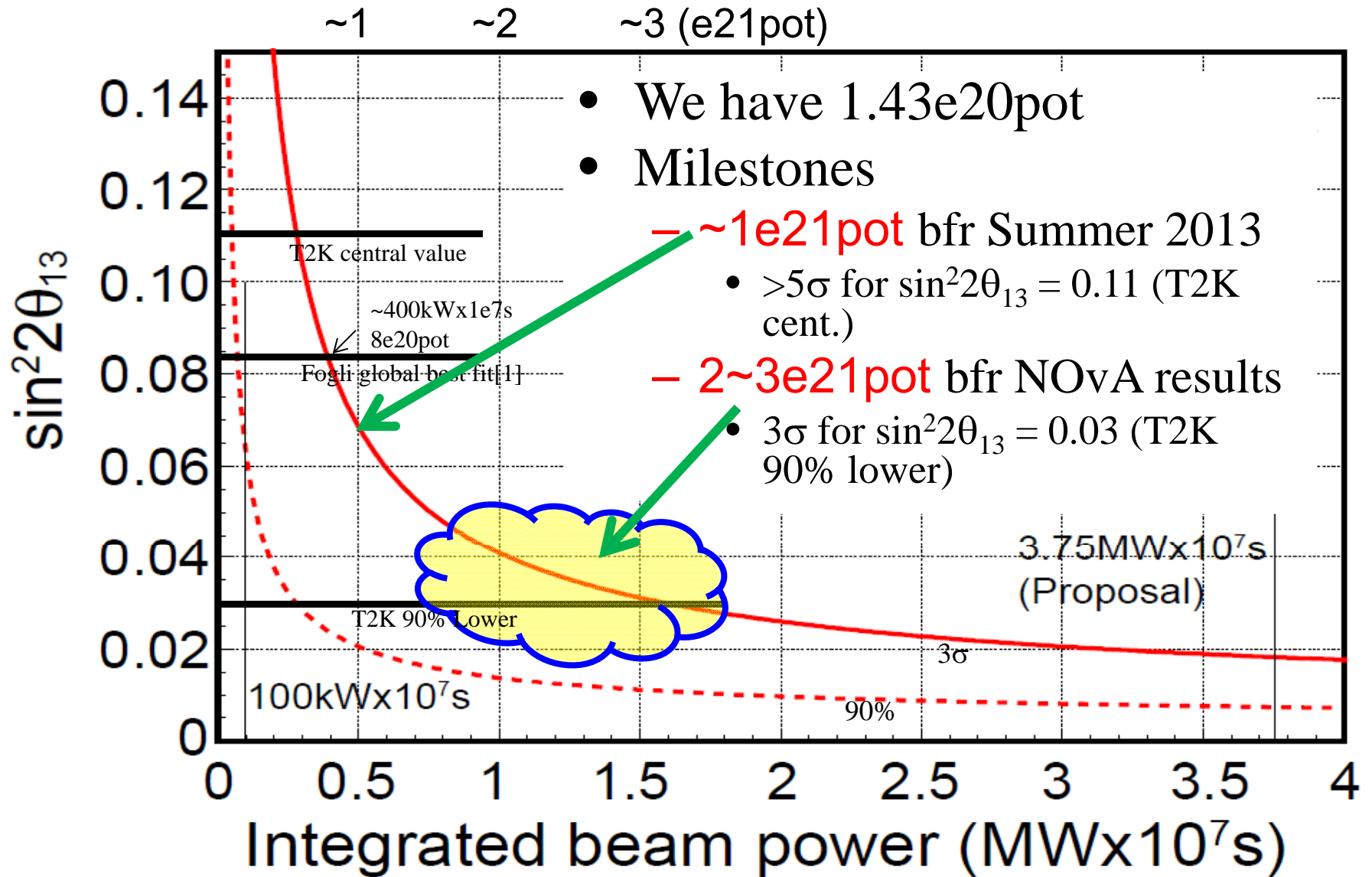
- Run29 (run#290173)
- All horns off → All horns on (250kA)
- Confirmed muon yields increased by 3.7 times



	Neutrino event rate in FV	Sand muon event rate
RUN39	2.94 ± 0.21(stat.) events / 10 ¹⁵ POT	1.23 ± 0.04(stat.) events / 10 ¹⁴ POT
RUN34 w/o horn	2.85 ± 0.19(stat.) events / 10 ¹⁵ POT	1.20 ± 0.04(stat.) events / 10 ¹⁴ POT

Very good agreement with before the earthquake!

Expected sensitivities & milestones



To realize the milestones

A case study (1mon = $1e7s/6 = 19.3days$)

Nu12(DC, RENO results?)

DayaBay →

← NOVA first results?

CY	2012				2013				2014				2015			
	1	4	7	10	1	4	7	10	1	4	7	10	1	4	7	10
Acc/Nu		NU			NU	LINAC			NU				NU			
MR Power	200				300				350				450			
Mon/yr	3				6				3				6			
Integ. Power	169				469				644				1094 (kW.1e7s)			
Integ. POT	3.5E+20				9.8E+20				1.3E+21				2.3E+21			

Milestones: $\sim 1e21$

$2\sim 3e21$

◆ Need

- ❖ Higher rep rate & Higher PPP & control loss → Higher power
- ❖ Beam time as long as possible

◆ Critical items:

❖ Short term

- ◆ Replacement of inj. Kicker before next beam: Done!
- ◆ Addition of RF for higher rep&ppb: (Partly) Done!
- ◆ Higher capacity for beam loss (collimator): being done
- ◆ Improve rep rate even before whole power supply replacement
- ◆ High power beam study (How much ppb can be stacked?)

❖ Longer term (few yrs) toward design intensity and beyond

- ◆ R&D of high gradient RF core
- ◆ Complete R&D of high rep rate MR power supply & budget request ($\sim 1Hz$ or more)

Summary

- ◆ All components necessary for beam operation were recovered after damages by the earthquake
- ◆ Succeeded to take beam from Dec. 24 as scheduled
- ◆ Functionality and reproducibility of all components except horns were confirmed
 - ❖ Muon&neutrino yield are consistent with before the earthquake
- ◆ Horn power supply was broken
 - ❖ We aim to recover the horn power supply by the end of Feb. and restart full experiment from March 1st
- ◆ Highest priority is to establish non-zero θ_{13} and precise measurement of θ_{13} as soon as possible
- ◆ Milestones
 - ❖ ~ 1e21pot : Summer 2013
 - ◆ Conclude non-zero θ_{13} for presently estimated best fit values
 - ❖ 2~ 3e21pot : Before NOvA first results (in 2014~2015?)
- ◆ We need beam power and time as much as possible
 - ❖ Scenario to improve beam power before PS replacement
 - ❖ High power beam study
 - ❖ Power supply & RF R&D for higher rep rate