Japanese beam plan

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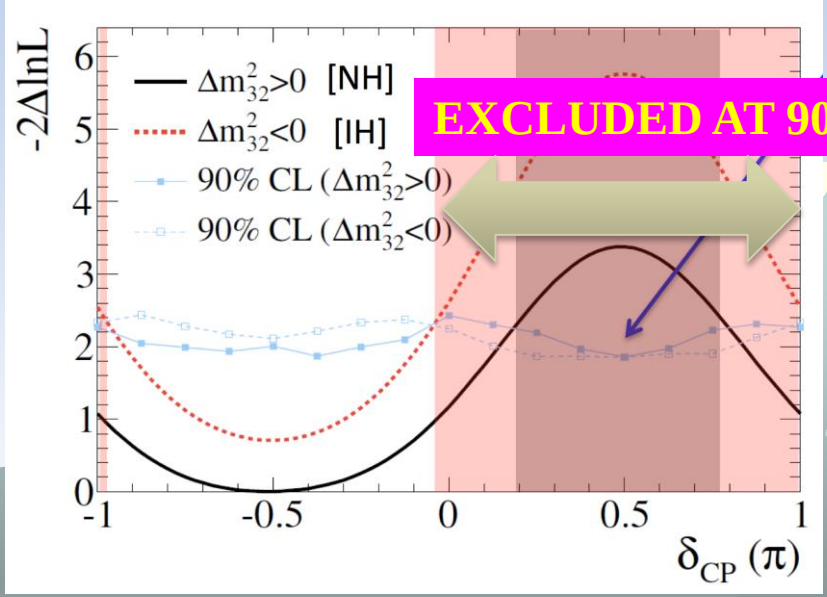
Contents

- Japanese neutrino beam = J-PARC neutrino beam facility
- Present status
- Future upgrade
- Ideas toward > MW under discussion

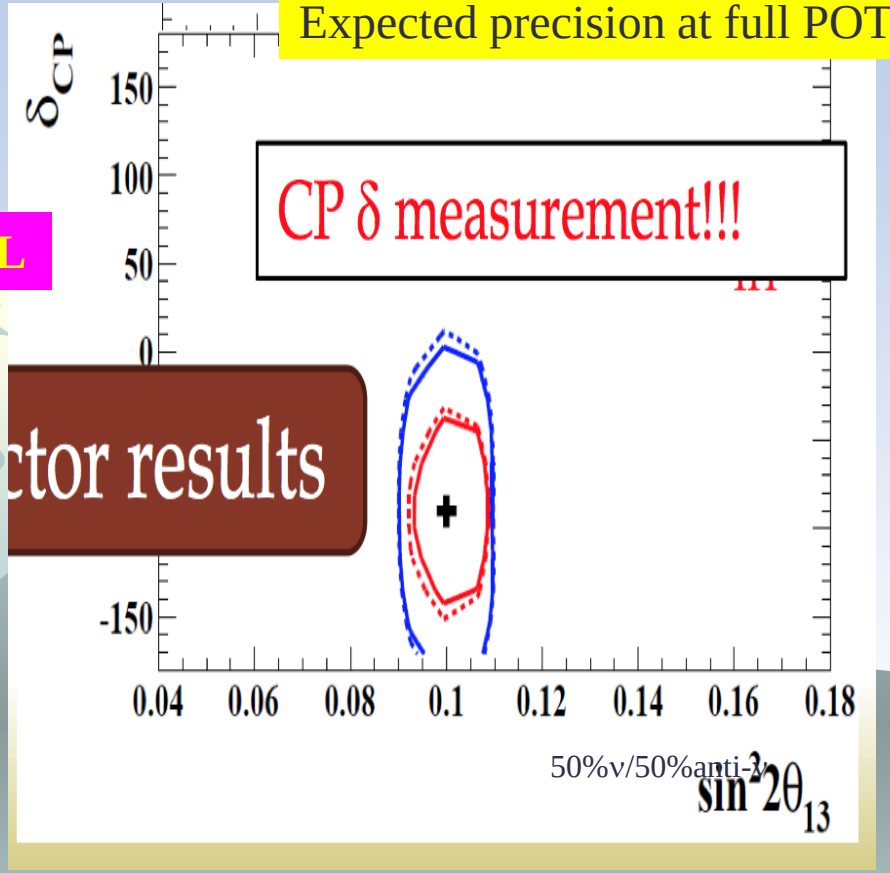
Present LBL experiment: T2K



EXCLUDED AT 90%CL

STARTED TO MEASURE CPV phase δ!!

Expected precision at full POT

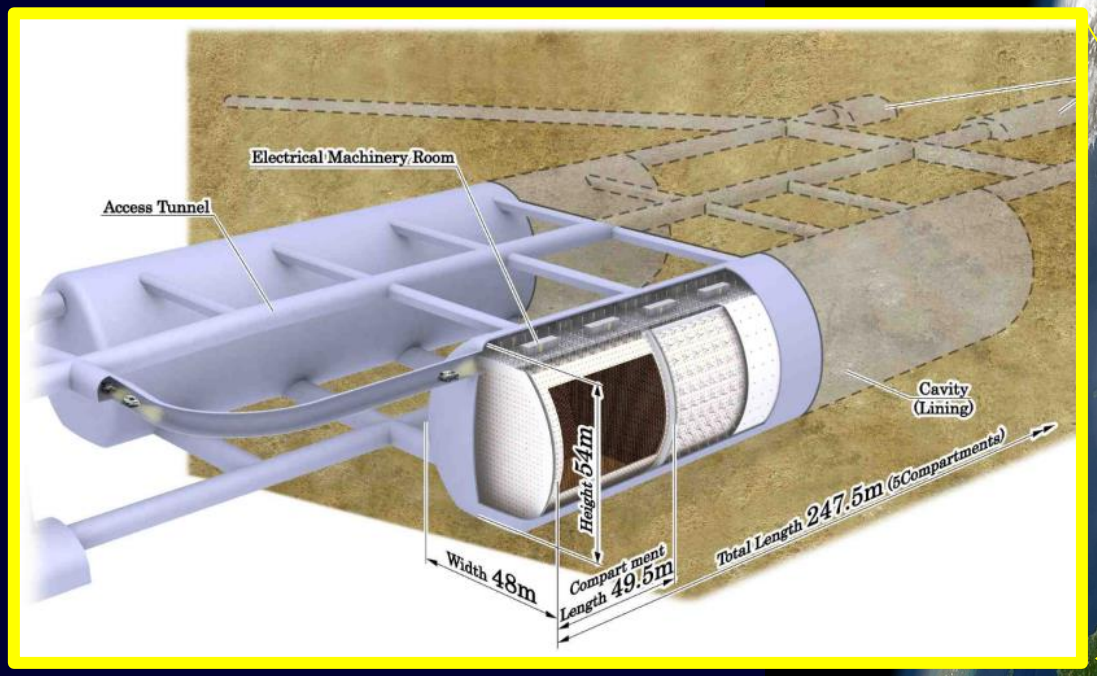


Plan to accumulate 7.8×10^{21}POT

Future LBL plan in Japan

J-PARC+HK @ Kamioka
L=295km OA=2.5deg

➔ Shiozawa-san's talk



LoI: The Hyper-Kamiokande Experiment arXiv:1109.3262v1

The beam is from J-PARC

Japan Proton Accelerator Research Complex : J-PARC

Design : 750kW (x100 KEK-PS)

xp facility

質・生命科学実験施設

施設

500m！

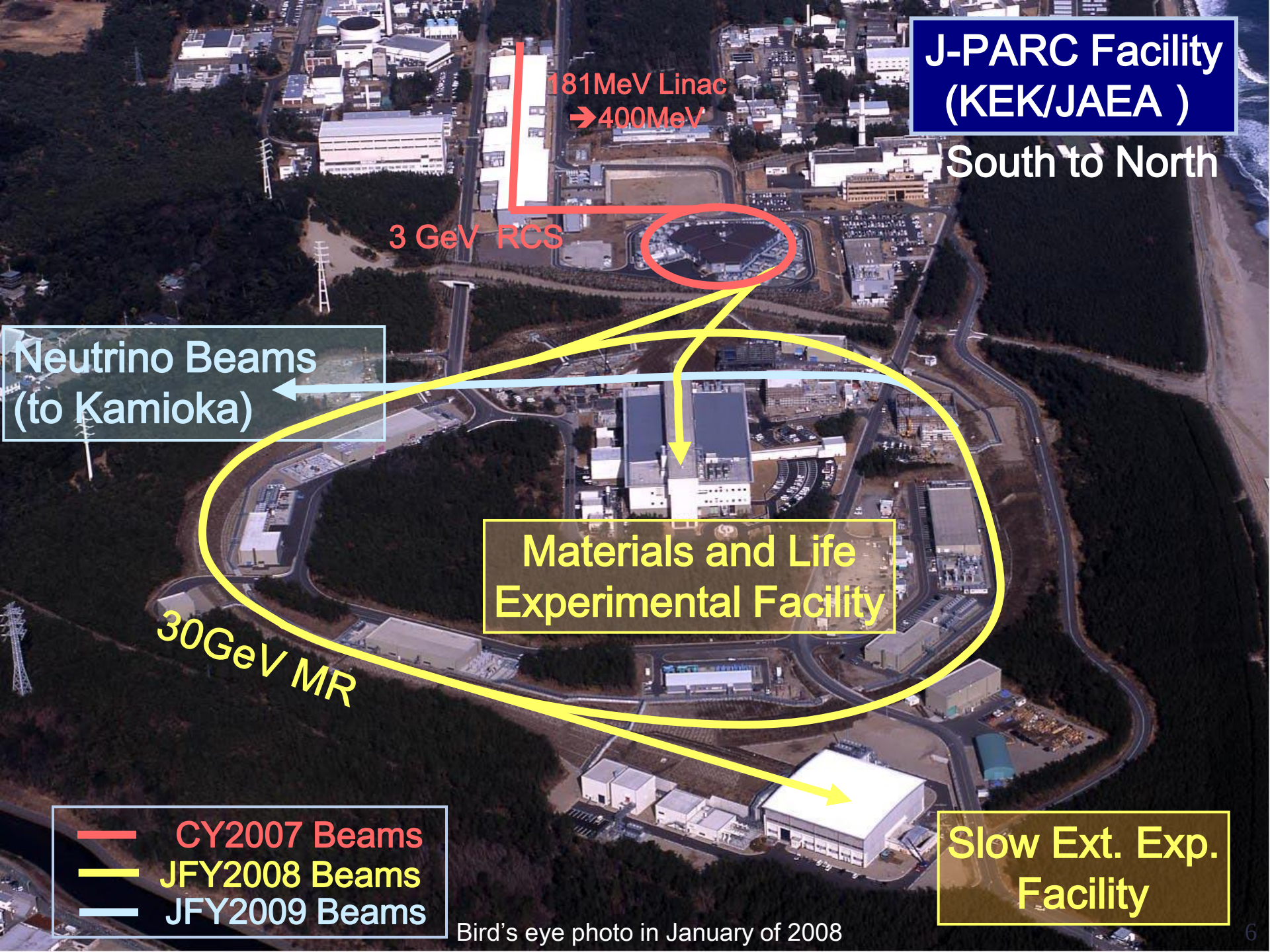
Neutrino facility

LINAC
(350m)

3GeV RCS
(25Hz, 1MW)

Main ring
(0.75MW)

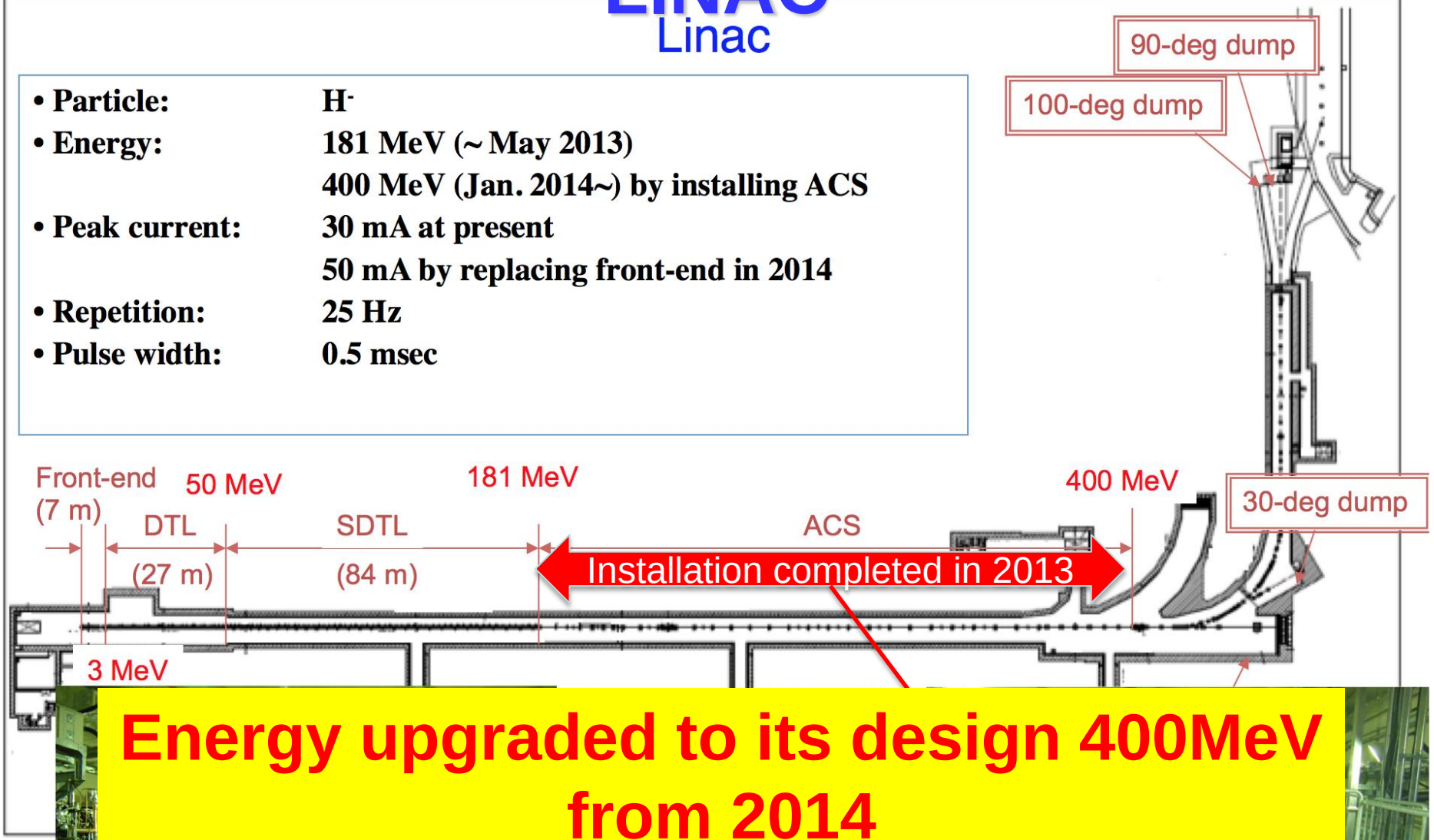
J-PARC = Japan Proton Accelerator Research Complex



Bird's eye photo in January of 2008

LINAC
Linac

- **Particle:** H^-
- **Energy:** 181 MeV (~ May 2013)
  400 MeV (Jan. 2014~) by installing ACS
- **Peak current:** 30 mA at present
  50 mA by replacing front-end in 2014
- **Repetition:** 25 Hz
- **Pulse width:** 0.5 msec

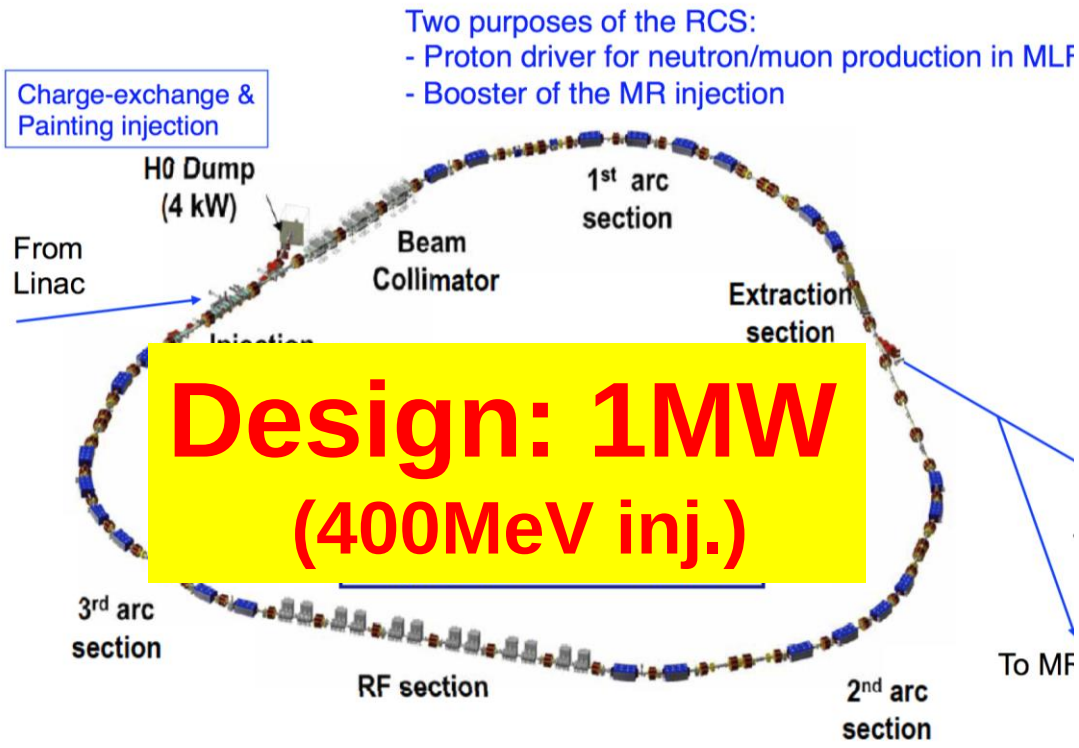


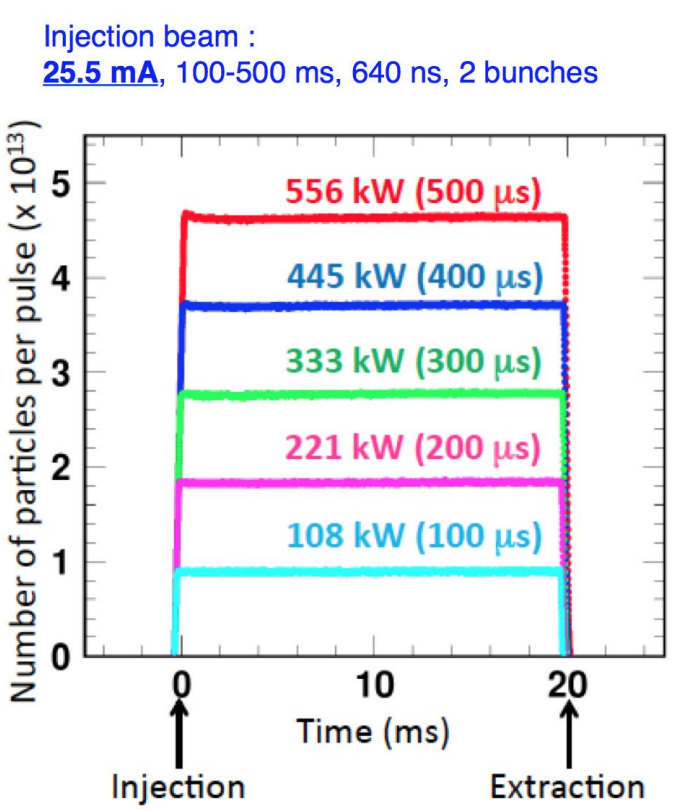
Energy upgraded to its design 400MeV from 2014

Energy upgrade of the linac with the ACS system

400 MeV acceleration was achieved
(Jan. 17, 2014)

RCS (Rapid Cycling Synchrotoron)

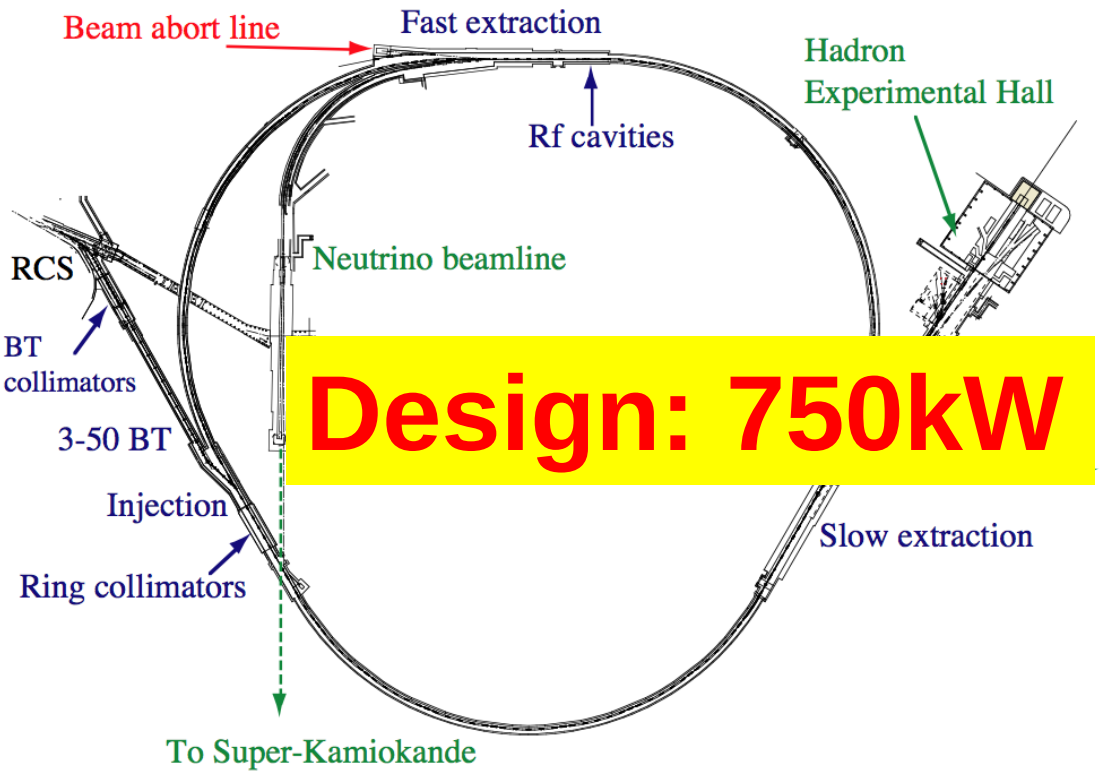




- ~600kW demonstration succeeded with 180MeV inj. (2013)
- 300kW stable operation to MLF
- High power test w/ 400MeV inj soon

Main parameters of MR

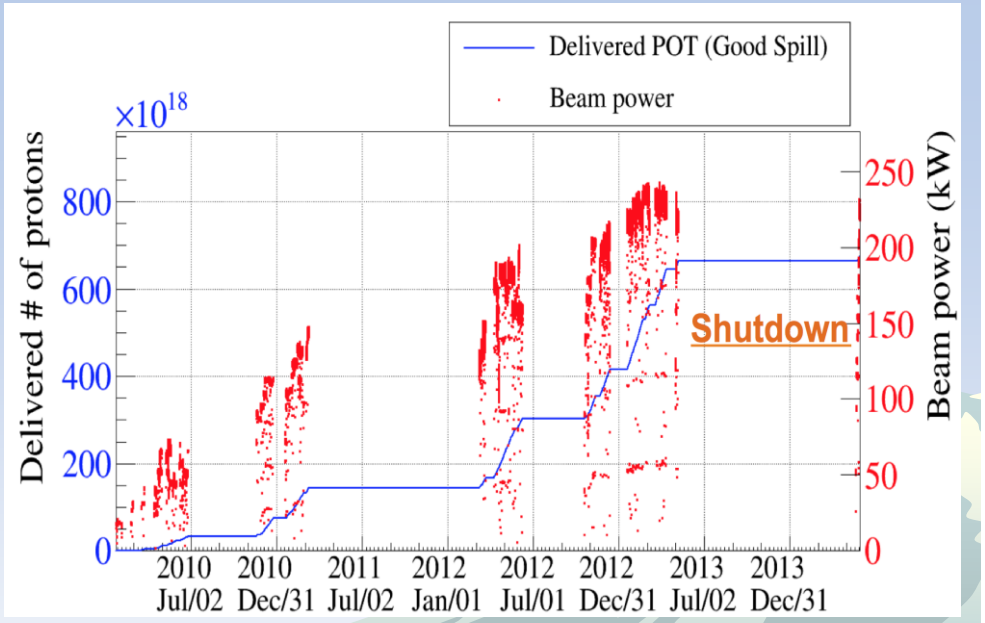
Circumference	**1567.5 m**
Cycle time	**6 s for SX**
	2.48 s for FX
Injection energy	**3 GeV**
Extraction energy	**30 GeV**
Superperiodicity	**3**
h	**9**
Number of bunches	**8**
Rf frequency	**1.67 - 1.72 MHz**
Transition γ	**j 31.7 (typical)**
Physical Aperture	
3-50 BT Collimator	**54-65 π.mm.mrad**
3-50 BT physical ap.	**> 120 π.mm.mrad**
Ring Collimator	**54-65 π.mm.mrad**
Ring physical ap.	**> 81 π.mm.mrad**

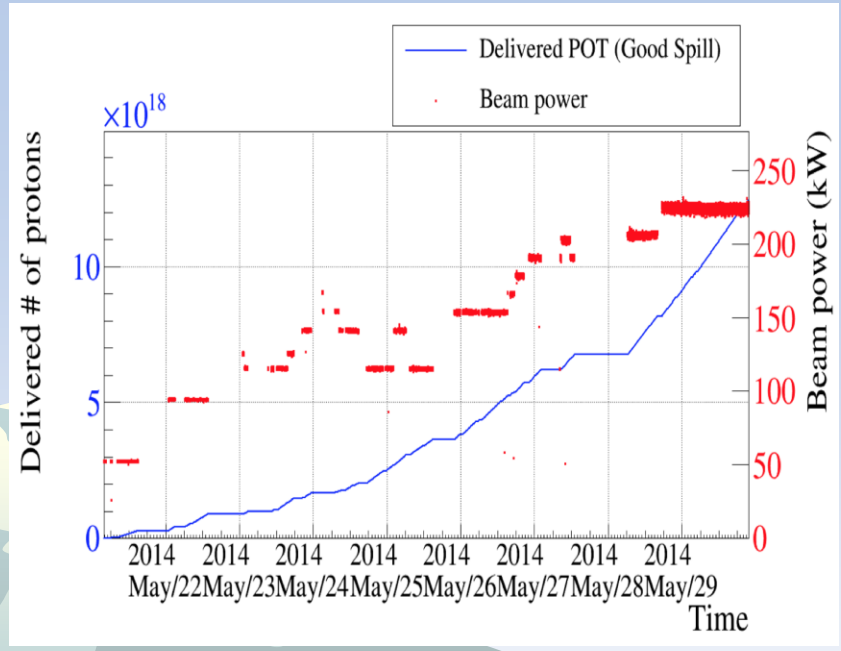


Three dispersion free straight sections of 116-m long:

- **Injection and collimator systems**
- **Slow extraction (SX)**
  to Hadron experimental Hall
- **MA loaded rf cavities and Fast extraction(FX) (beam is extracted inside/outside of the ring)**
  outside: Beam abort line
  inside: Neutrino beamline (intense ν beam is send to SK)

MR status





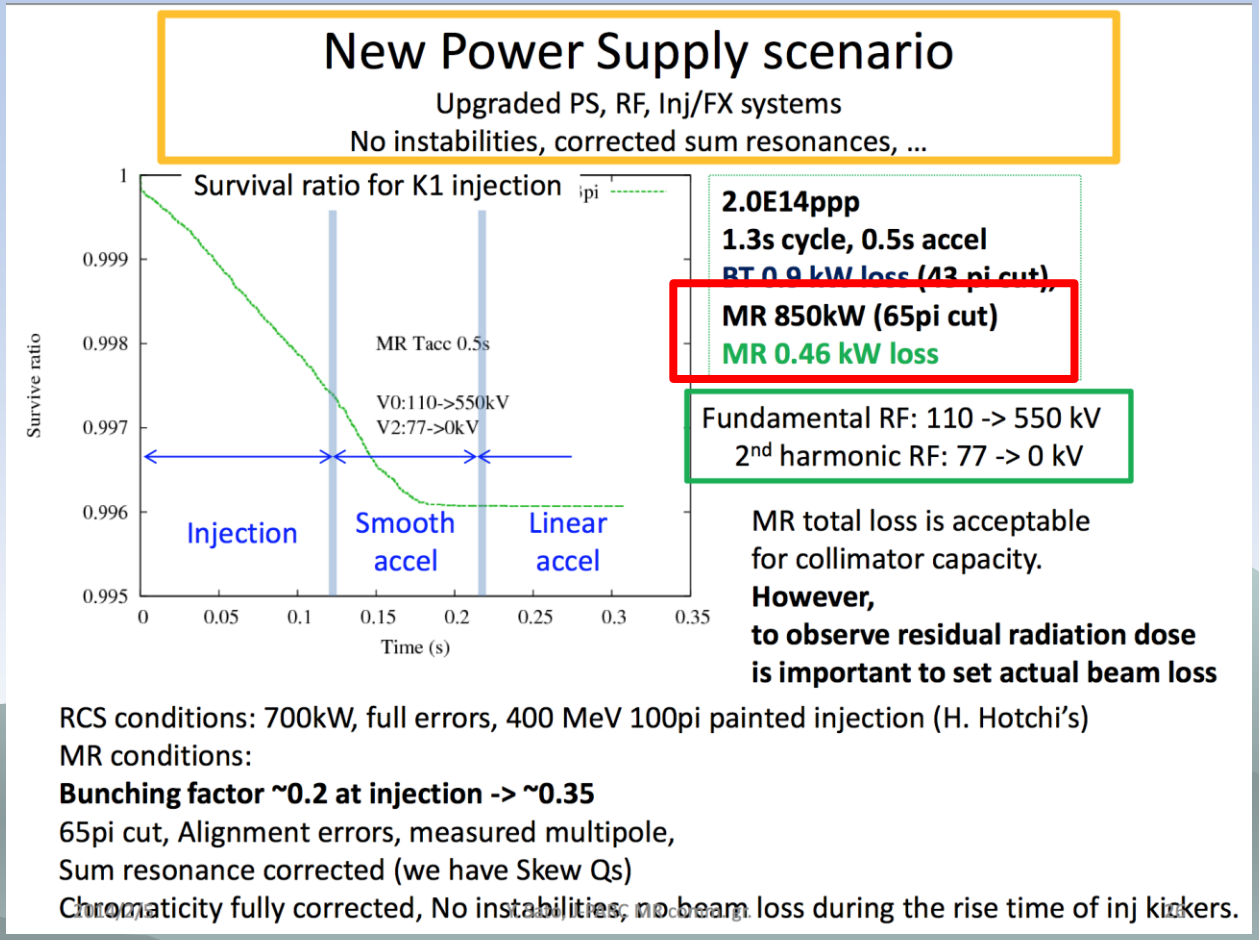
- Operation resumed in May 2014 after long shutdown for LINAC upgrade&HD hall accident since May 2013
- Stable operation at **~230kW** achieved
  - ~120T(1.2e14) p/pulse (8bunchs) ~ 1.5e13 p/bunch
- Present limitation for higher power
  - Beam loss around injection (period&area) to MR
  - LINAC current limited by Ion source & RFQ capacity which results in limited #p/bunch in RCS = MR

Path to design MR power (750kW)

- **Higher #p/bunch**
  - **LINAC upgrade** → Enable RCS operation upto 1MW
    - 400MeV (2013)
    - Frontend (Ion source, RFQ) (2014)
  - **Reduce beam loss in MR**
    - MR RF higher harmonic (2013-2017)
    - Intra bunch feedback (installed)
    - Injection kicker pulse shape correction (2014)
  - **Increase MR collimator capability**
    - → 3.5kW loss

- **Higher rep late (2.48 → ~1s, x2)**
  - **Replace MR magnet PS** : Budget requested (plan 2015-2017)
  - **High gradient RF core** (2013-2017):R&D

MR power expectation w higher rep rate



Simulation result with realistic assumptions & actual observations
By Y.Sato, Feb.2014

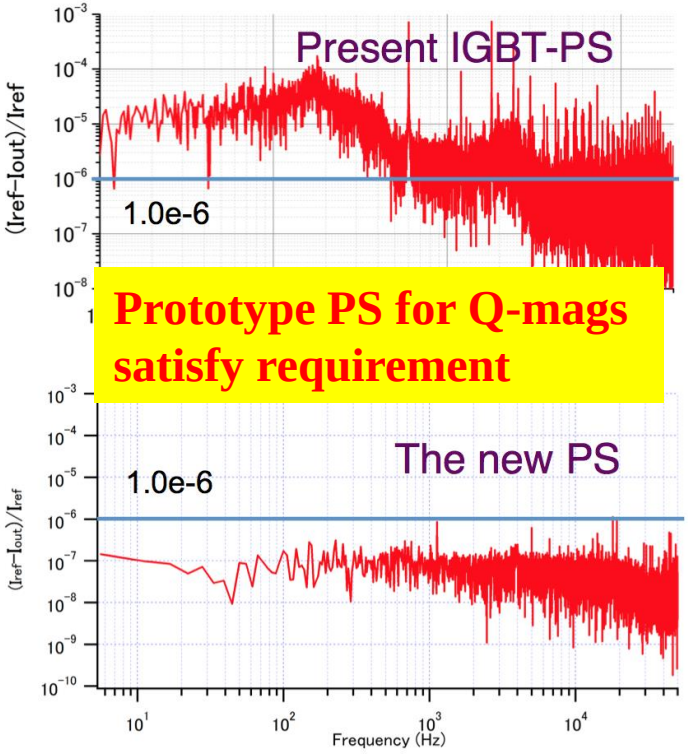
- **~750kW can be achieved**
  - (~ 850kW could be in reach)
  - Yet better operation parameters for higher power will be sought in June/Oct 2014

New power supply

Developments going well

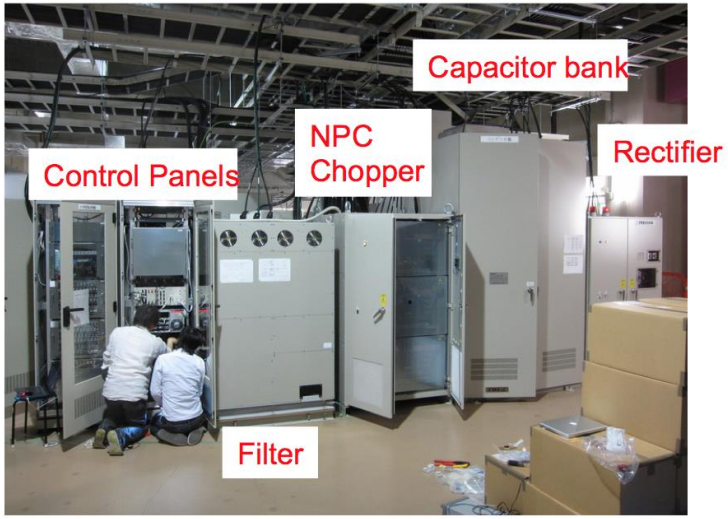
The small scale PS

Current ripple at 30 GeV



Prototype PS for Q-mags satisfy requirement

The large scale PS



Schedule

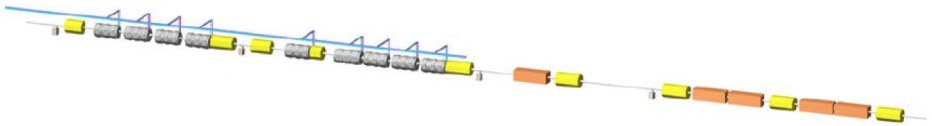
	JFY 2013	JFY 2014	JFY 2015
Controller	Manufacturing	Controller Test	Selecting chopper design
Prototype	Manufacturing	Factory Test	
Mass Production		combine	

The new PS requires additional budget of ~ 60 oku-Yen. The budget request will be submitted to the government in 2015-2017.

New high gradient RF sytem

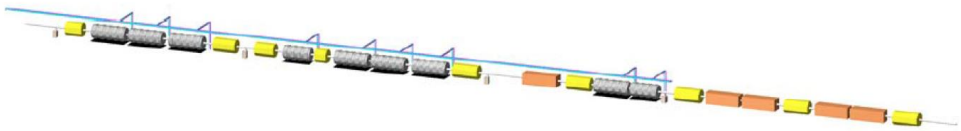
High impedance rf system

The rf cavities will be replaced with the higher impedance system using FT3L.



Current situation : 3gap X 9 = 27 gaps

Total rf voltage ~ 270 kV



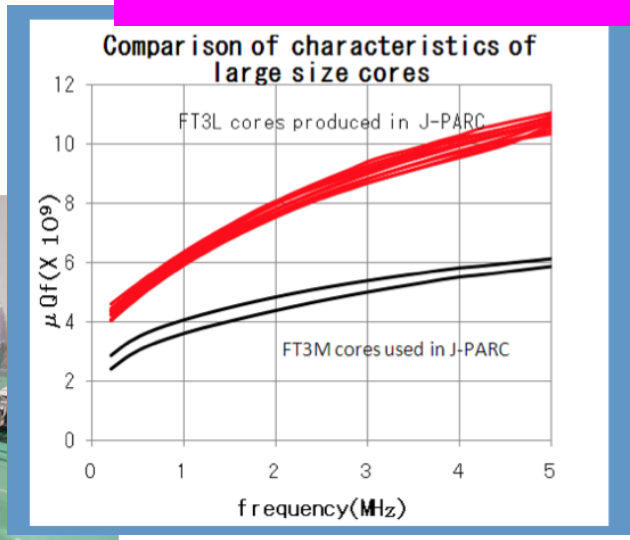
After replacement : 4gap X 2 + 5gap X 7 = 43 gaps **& 2nd Harmonic Cavity**

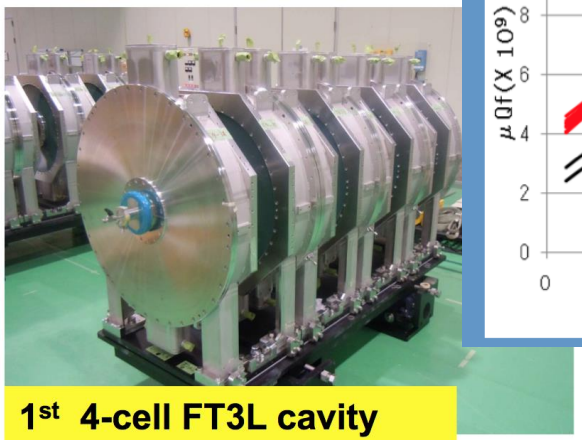
Total rf voltage ~ 450 kV+20%margin

FT3L cell impedance is 40% higher than present one.

5-cell cavity can be driven by same PS and AMP.

Development succeeded





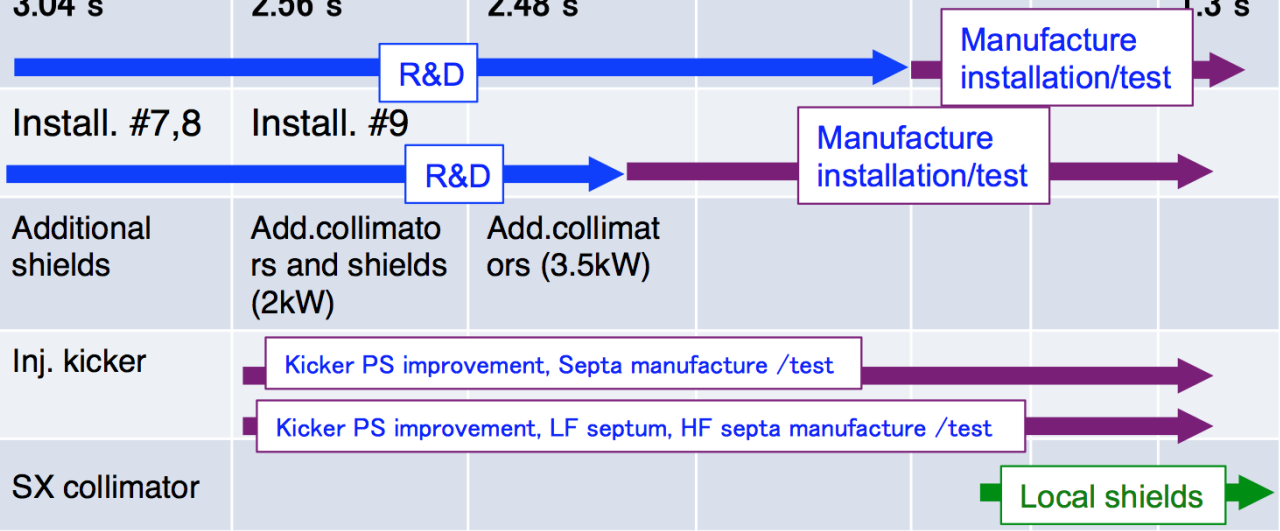
1st 4-cell FT3L cavity

Budget for the new rf cavities is mostly secured by supplementary budgets in JFY2011 and 2012.
All the cavities will be ready to install in JFY2015.

Mid-term plan of MR

FX: The high repetition rate scheme is adopted to achieve the design beam intensity, 750 kW. Rep. rate will be increased from ~ 0.4 Hz to ~1 Hz by replacing magnet PS's and RF cavities.
SX: After replacement of stainless steel ducts to titanium ducts to reduce residual radiation dose, 50 kW operation for users will be started. Beam power will be gradually increased toward 100 kW carefully watching the residual activity. Local shields will also be installed if necessary.

JFY	2011	2012	2013	2014	2015	2016	2017
			Li. energy upgrade	Li. current upgrade			
FX power [kW] (study/trial)	150	200	200 - 240	200 –300 (400)			750
SX power [kW] (study/trial)	3 (10)	10 (20)	25 (30)	20-50			100
Cycle time of main magnet PS New magnet PS for high rep.	3.04 s	2.56 s	2.48 s				1.3 s
Present RF system New high gradient rf system	Install. #7,8	Install. #9					
Ring collimators	Additional shields	Add.collimators and shields (2kW)	Add.collimators (3.5kW)				
Injection system FX system	Inj. kicker						
SX collimator / Local shields	SX collimator						
Ti ducts and SX devices with Ti chamber		SX septum endplate	Beam ducts	Beam ducts ESS			



Possibilities for further upgrade

Under discussion

- Idea of 8GeV second booster between 3-GeV RCS & MR
  - Conceptual design & simulation are done for the beam power of up to RCS 2 MW equivalent.
  - MR Power 3.2 MW for 1 s cycle H=9
  - MR Power 5.5 MW for 1.16 s cycle H=18

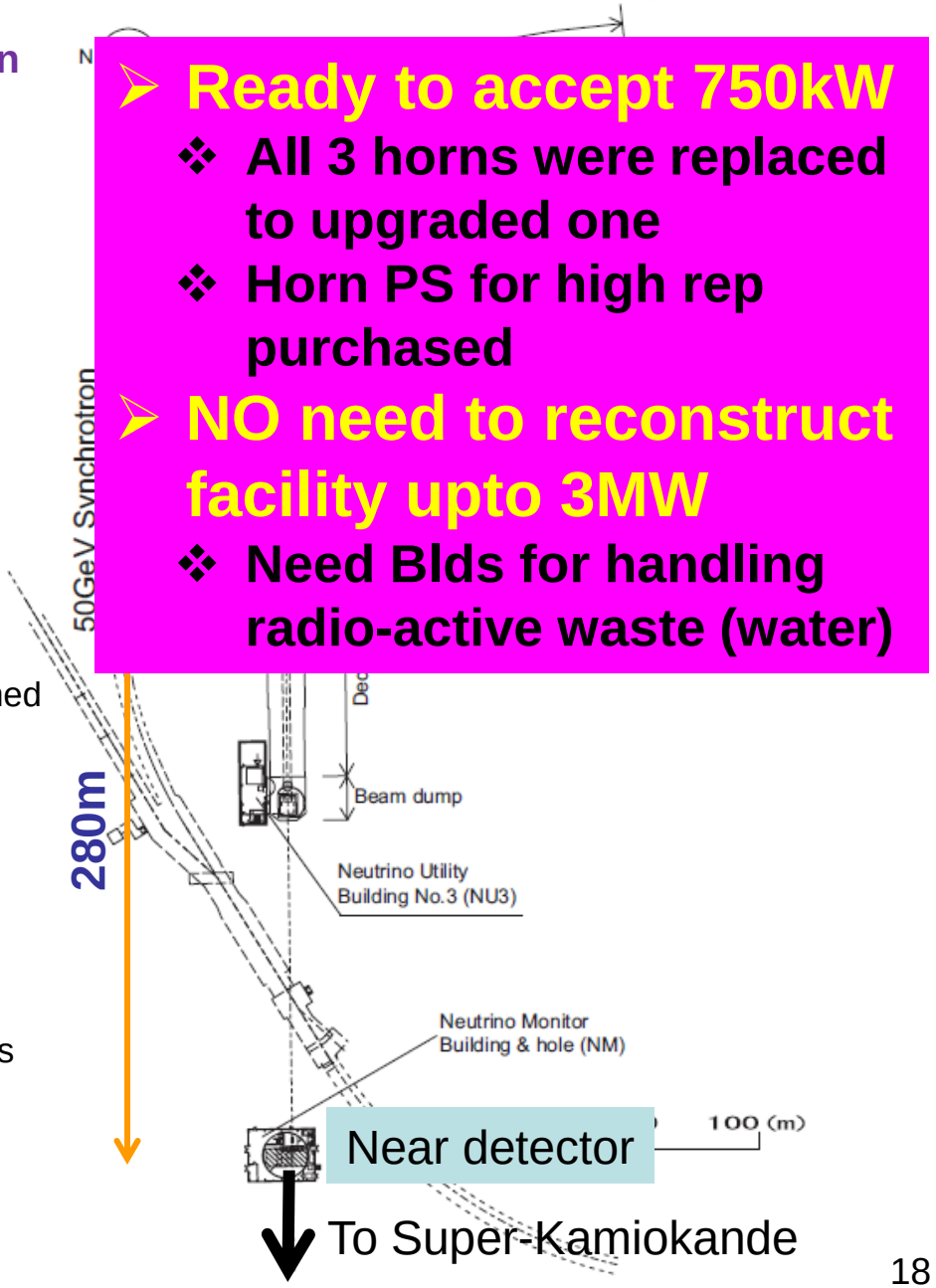
- Idea of New proton linac for neutrino beam production
  - ~9MW linac with an beam energy > 9 GeV
  - (Construction site may not be the Tokai campus)

- etc

Still in researcher's voluntary study level

J-PARC Neutrino Beam facility

- **Superconducting combined function magnet in proton beamline**
- **Conventional horn focused beam**
- **Off-axis beam**
  - Adjustable off-axis angle 2~2.5deg.
  - 2.5 deg at Day1
- **MW-capable beamline**
  - Design intensity is 750kW with safety factor
  - Parts which can never be upgraded later are designed for Multi-MW (3~4MW)
    - Shielding and cooling capacity of target station, decay volume, beam dump
- Key issues
  - Beam loss
  - Remote/quick maintenance of activated components
  - Radio active waste



Conclusion (1)

- Next generation LBL experiment in Japan will use neutrino beam from J-PARC
- J-PARC neutrino beam achieved 230kW stable operation
- There is clear concrete plan to achieve design power of 750kW
  - ~850kW could be in reach, keep trying to find yet better operation parameters
- Based on ~5yrs of operation experience, Neutrino beam facility is ready to accept 750kW
- Neutrino beam facility can accept upto 3MW
  - w/ target/horn/window upgrade
  - w/ additional system/blds for handling radio-active waste
- Possibilities of further upgrade are being discussed

Conclusion (2)

We pursue the realization of next generation INTERNATIONAL long baseline neutrino experiment based **in Japan with J-PARC**