

COMET Muon Task Force Report

16th January 2010
Satoshi MIHARA, KEK

Task Force

- Members

- S.Mihara, N.Saito, K.Yoshimura (KEK)
- M.Ieiri, K.Tanaka (KEK, Beam line experts)
- T.Ogitsu (KEK, SC magnet expert)
- A.Ando, K.Oide, M.Tomizawa, T.Koseki, M.Kinsho, M.Ikegami, Y.Hashimoto (KEK, Acc experts)
- M.Aoki, A.Sato, Y.Kuno, M.Yoshida (Osaka Uni.)

If possible a task force should be set up to consider the special demands of the required beam structure, energy, and intensity. Reports from these committees should be made to the PAC in upcoming meetings....

Minutes of the 4th PAC meeting

- Goal

- In order to realize an experiment that can provide significant physics result, the task force aims at **showing a realistic solution(s) for the experiment** under discussions among experts from accelerator, beam channel, and physics groups.

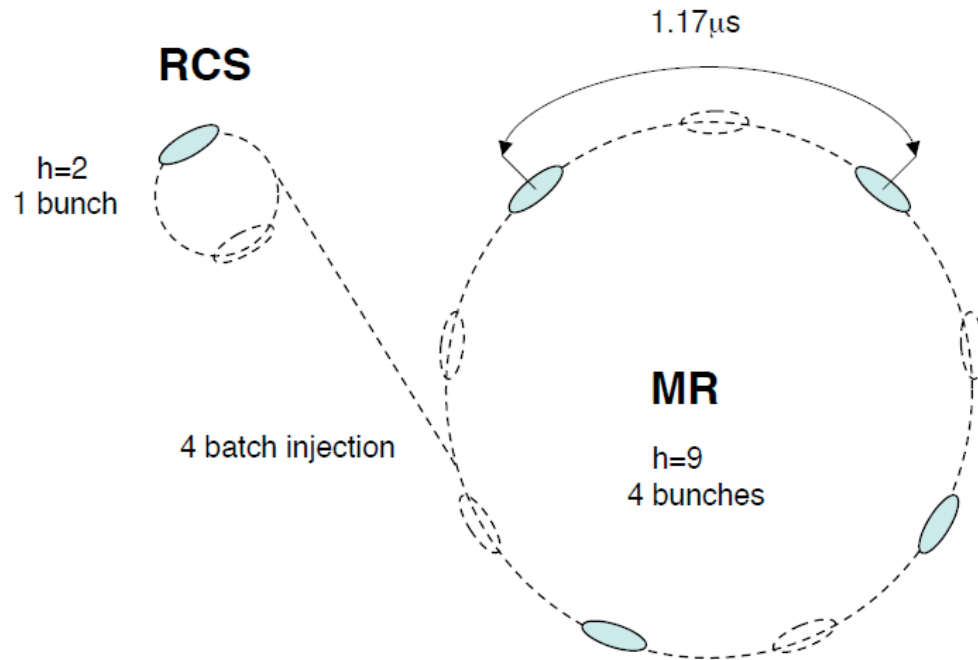
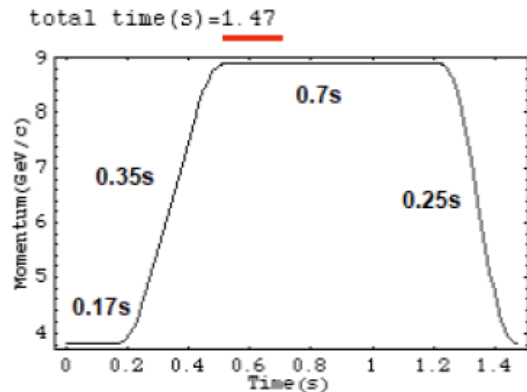
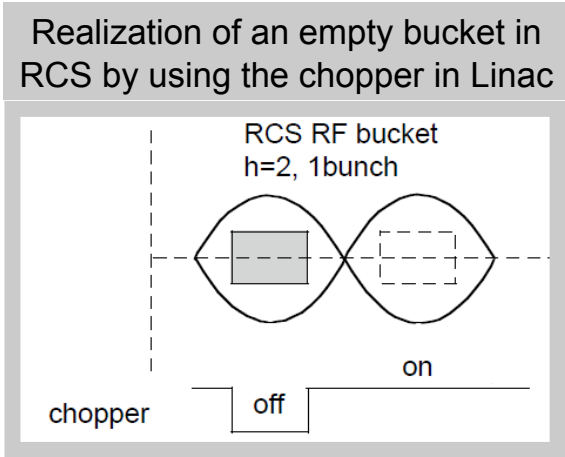
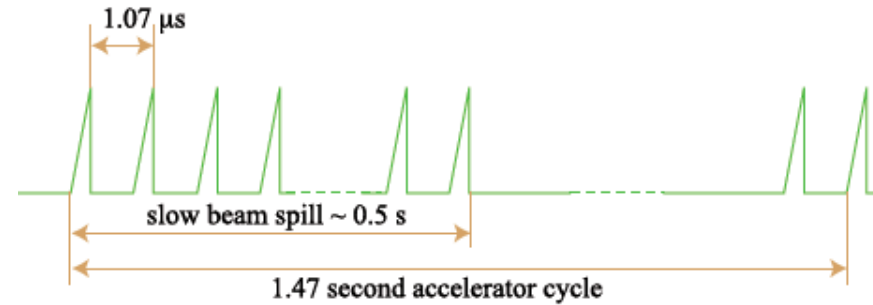
Tasks

- Proton beam acceleration
 - Investigation of the method described in the proposal
 - Other possibilities to produce required proton beam structure
- Extinction
 - 10^{-9} level necessary to reach 10^{-16} sensitivity
 - Development of measurement technique
- Proton beam extraction/transport
 - Proton beam transport to the target
 - Radiation shield around the target
 - Beam dump
- Experimental space
 - Possible location(s)
 - In the current experimental hall
 - Extension of the current hall
- Solenoid Magnet

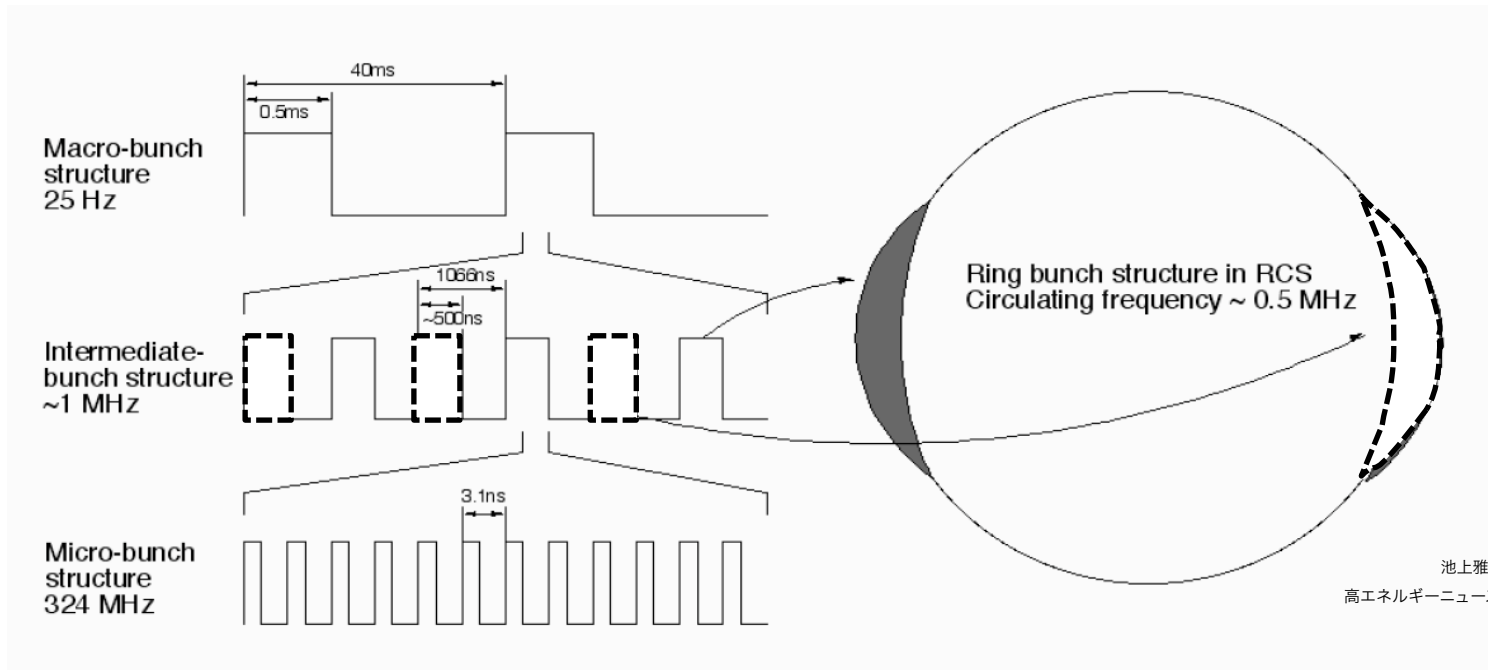
PROTON ACCELERATION

COMET Proton Acceleration

- RCS: $h=2$ with one empty bucket
- MR: $h=8(9)$ with 4(5) empty buckets
- Bunched slow extraction
 - Slow extraction with RF cavity ON, 210kV

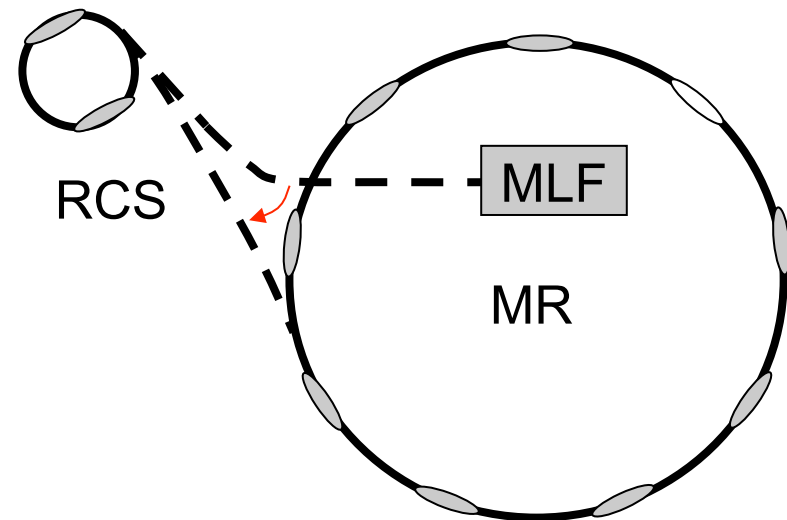


RCS, MR Injection



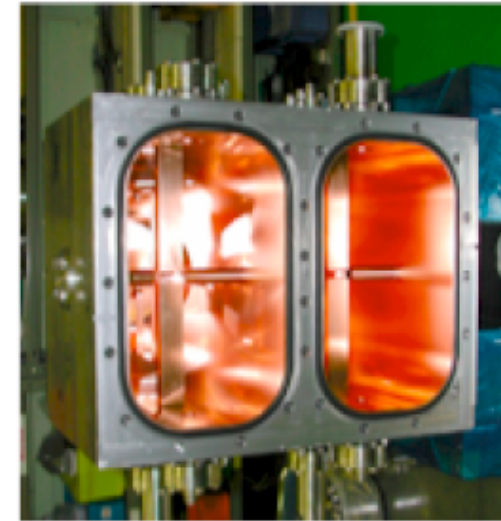
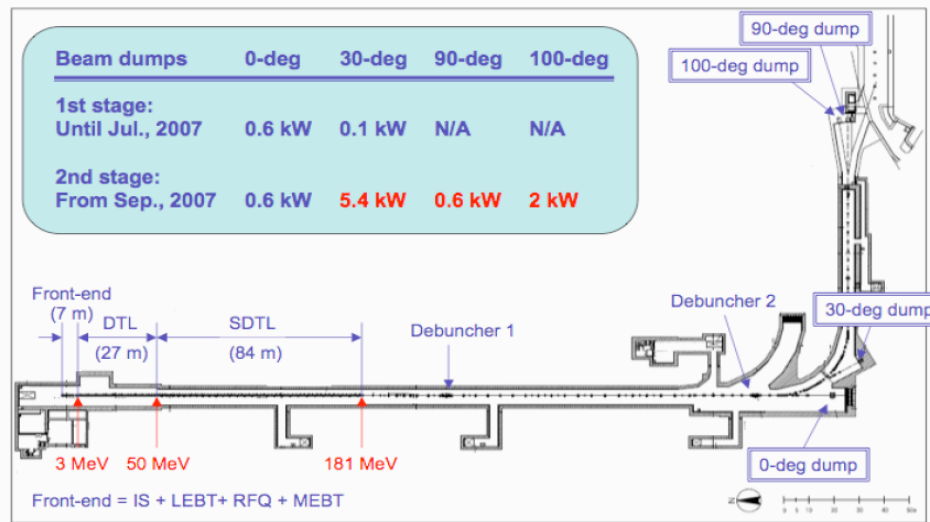
池上雅紀
高エネルギーニュース vol.25 No.4

- Acceleration and extraction in 20msec
- Bunch configurations
 - Micro bunch 324 MHz LINAC
 - Intermediate bunch ~1MHz Chopper
 - Macro bunch 25Hz RCS

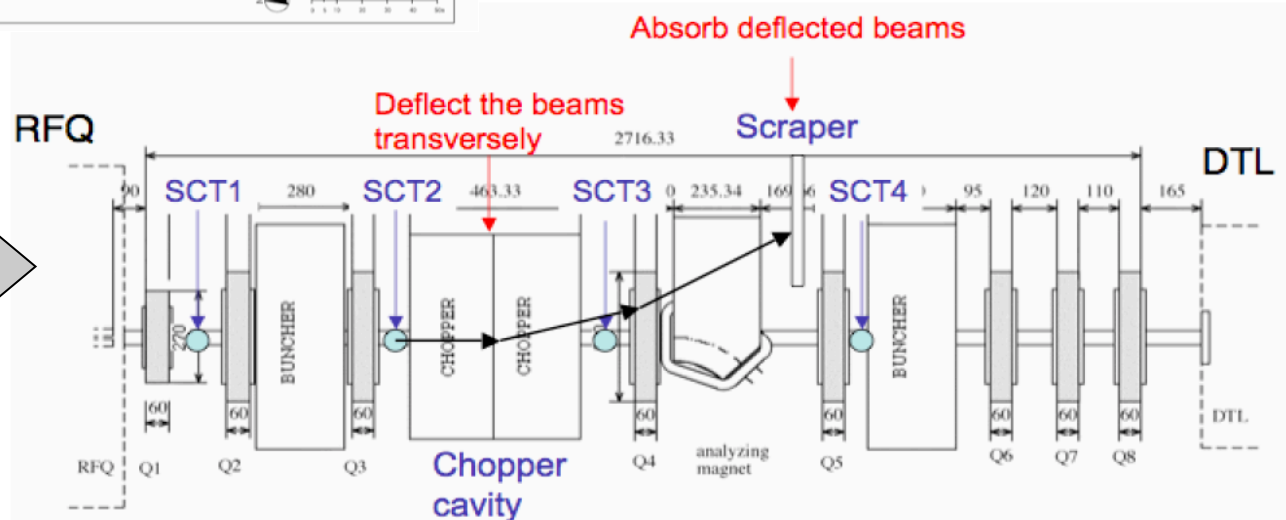
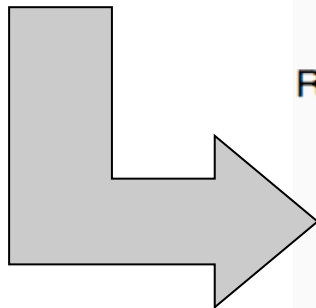


Linac Chopper

- We found in the previous measurement that the chopping efficiency is not 100%
 - We observed particles remaining in an empty bucket

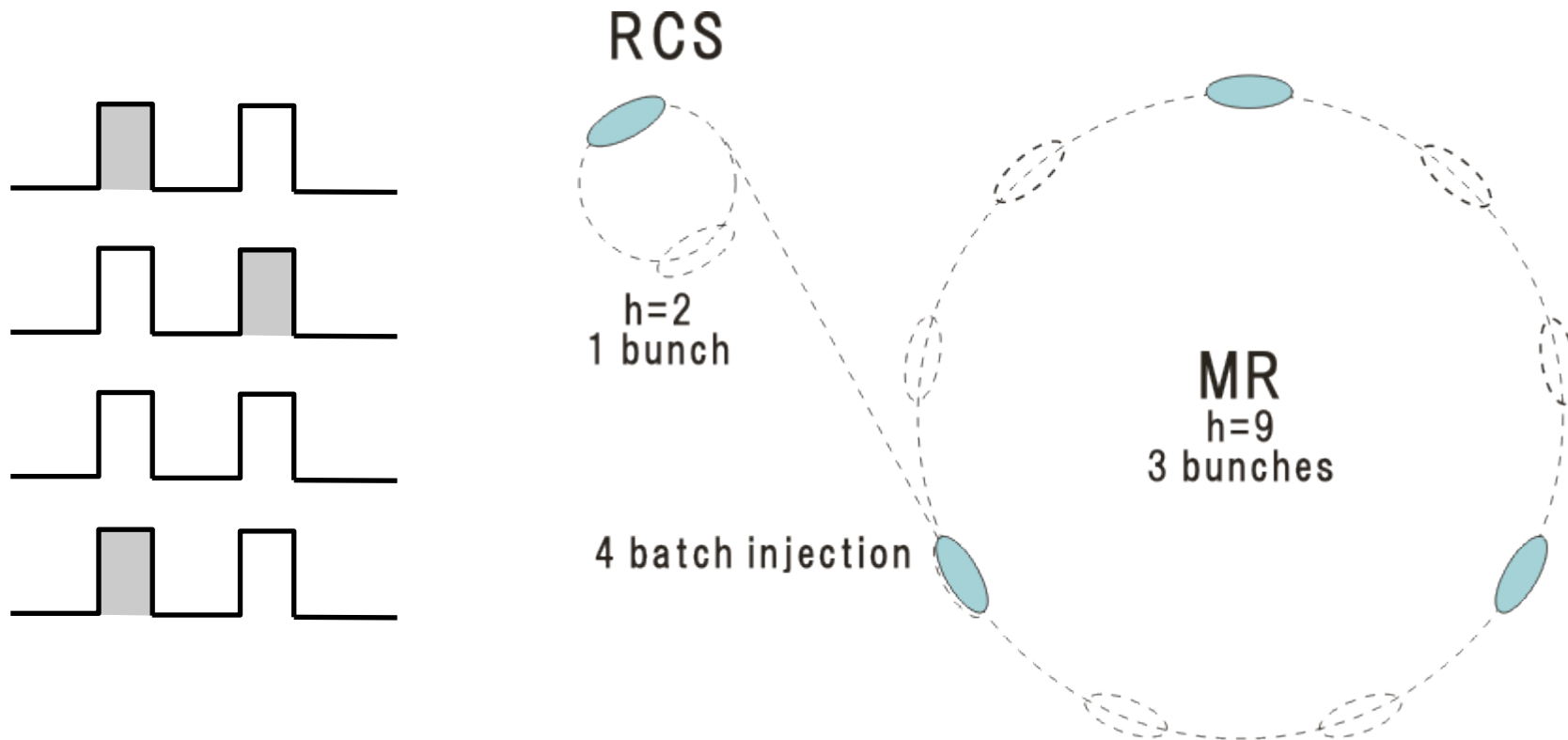


Two Cavities



New Bunch Configuration

- Wider bunch-bunch separation → Longer measurement time per bunch
 - $\sim 1.2\mu\text{sec} \rightarrow \sim 1.8\mu\text{sec}$
 - Less effect of the prompt background
- Beam power is $\frac{3}{4}$ of the nominal scheme
- Need further investigation by the experiment group



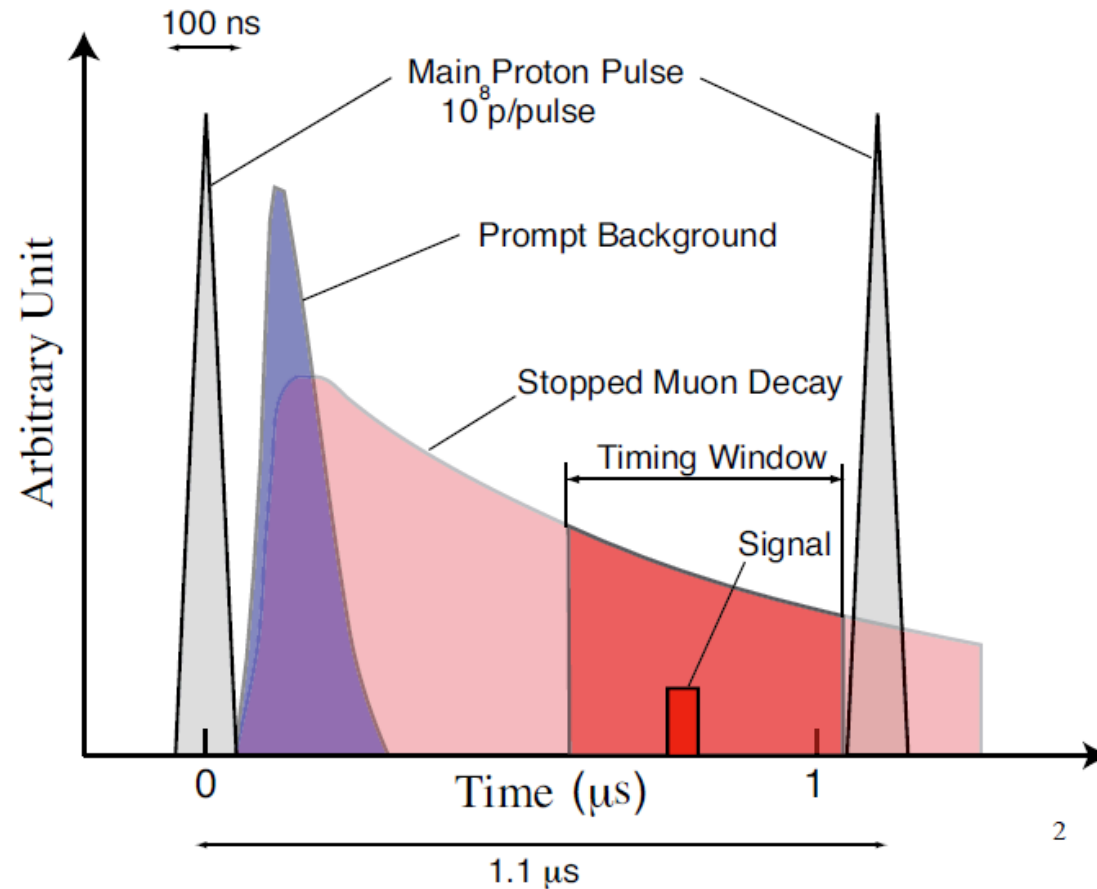
Summary of Proton Acceleration for COMET

- $\sim 1\mu\text{sec}$ bunch-to-bunch width
 - 4(5) empty buckets with $h=8(9)$
 - 6 empty buckets with $h=9$
- $< \sim 100\text{nsec}$ bunch length
- Bunched slow extraction to deliver the proton beam to the pion production target
- $\sim 50\text{kW}$ operation at 8GeV (1.47sec cycle) is supposed to reach the target sensitivity in “two years”.
- Investigation of particle leakage
 - Direct/indirect measurements of the extinction level
 - Simulation

EXTINCTION
10⁻⁹ IS OUR GOAL

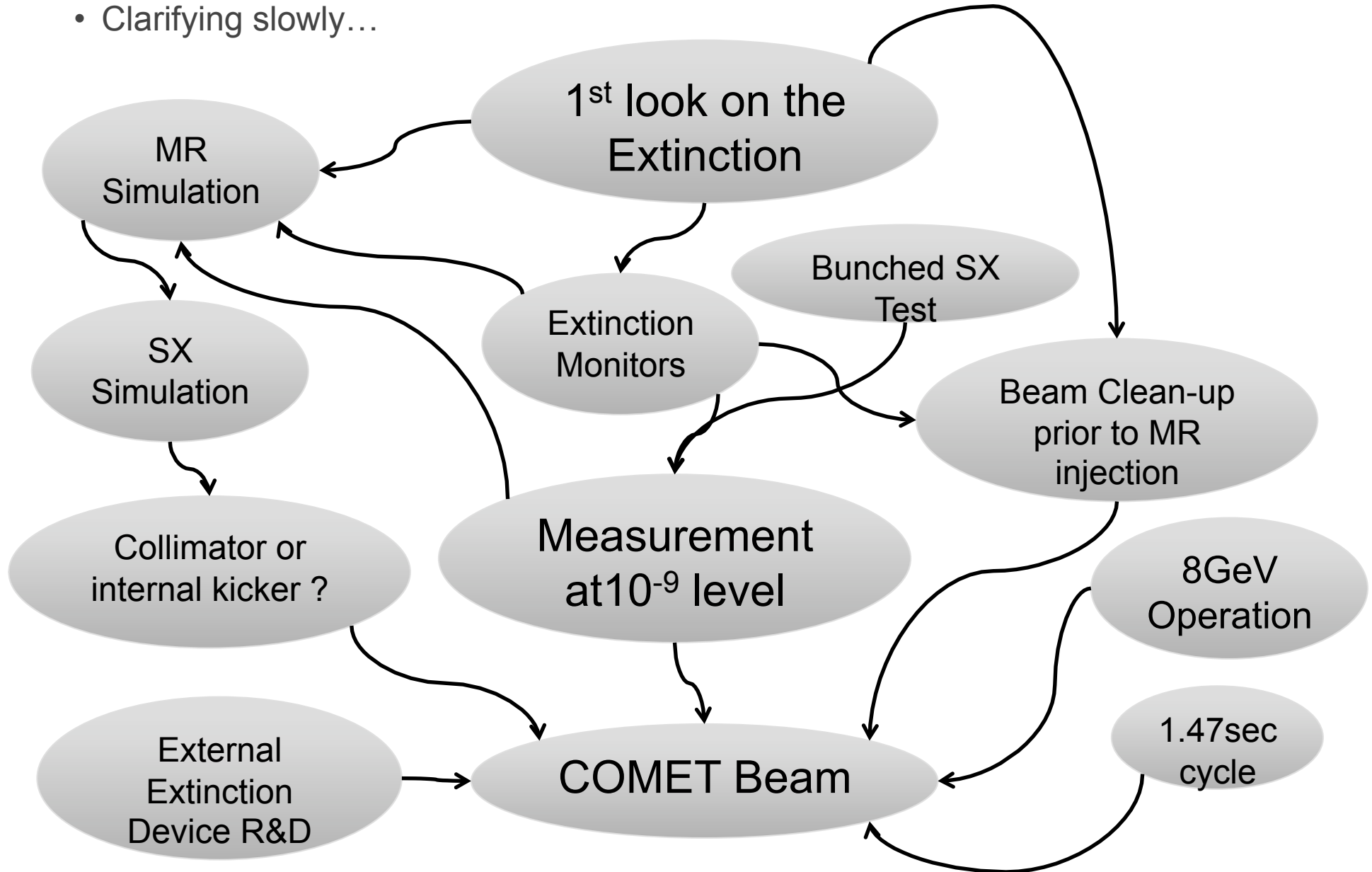
COMET Requirement on Proton Beam

- $\pi^- + p \rightarrow \pi^0 + n$
- $\pi^0 \rightarrow \gamma\gamma, \gamma \rightarrow e^+e^-$
- Necessary to reduce below 10^{-9} to reach 10^{-16} sensitivity



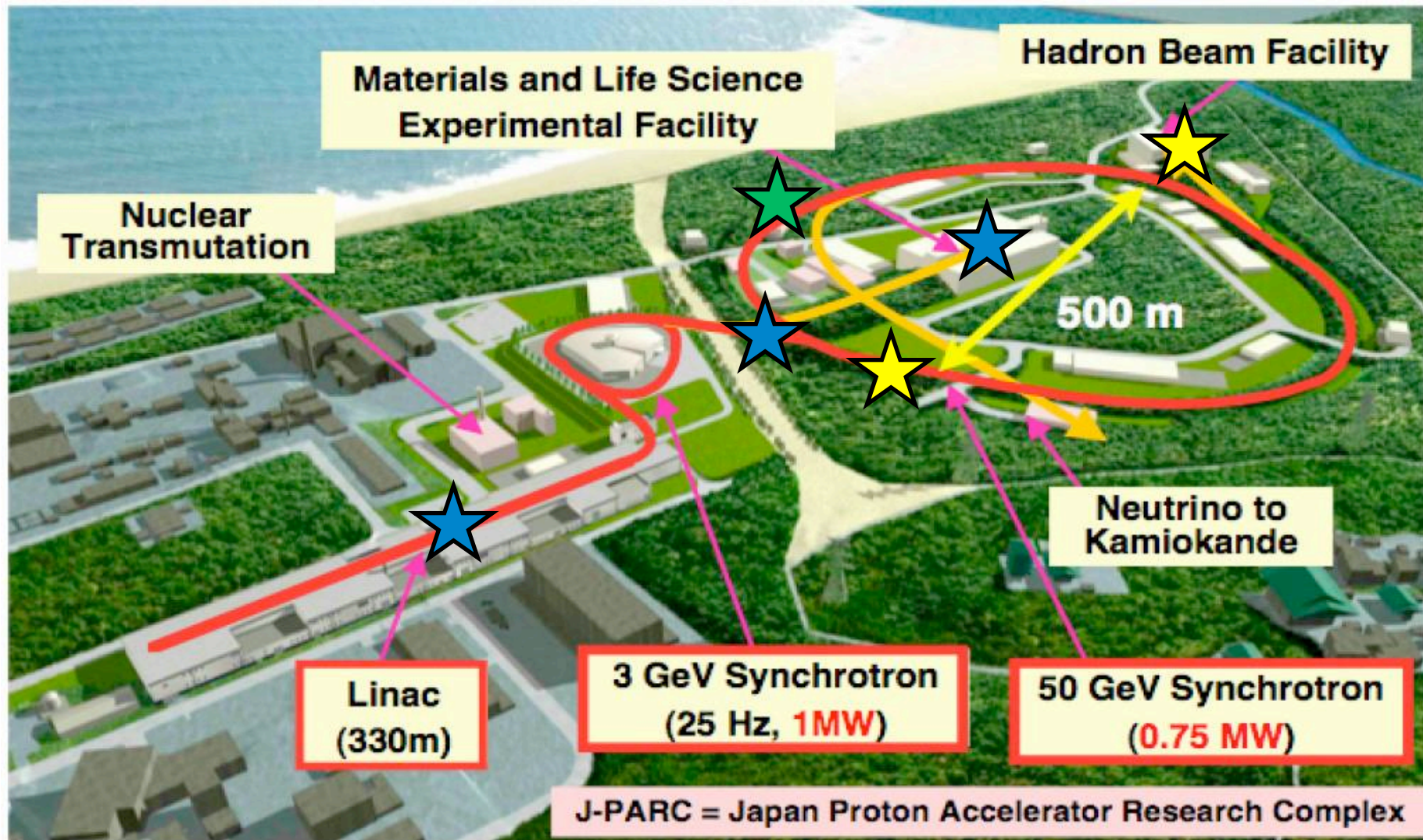
Strategy to realize the COMET beam

- Clarifying slowly...



Current Status of Extinction R&D

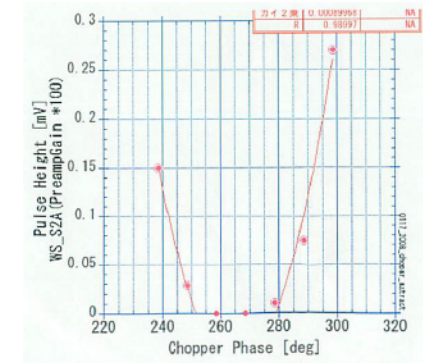
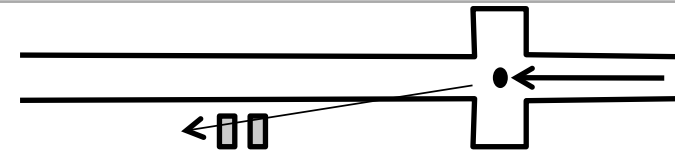
★ Study in progress ★ Monitor upgrade ★ In preparation



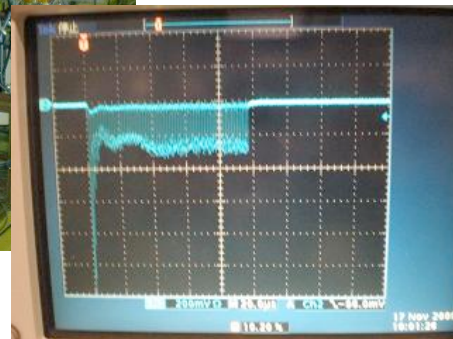
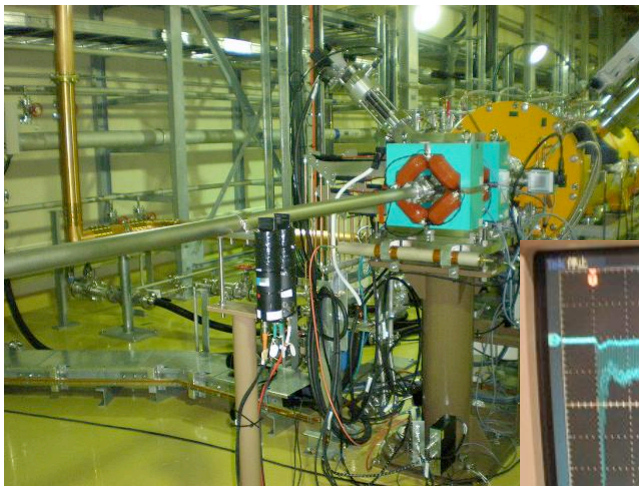
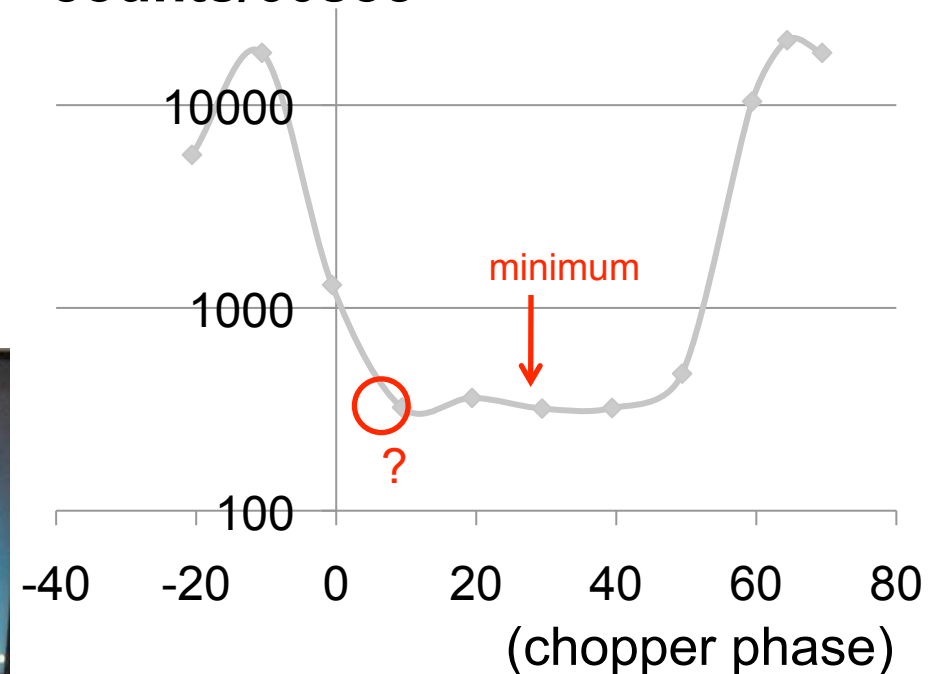
Measurement at LINAC

SM, M. IKEGAM and LINAC Monitor Group

- Investigate LINAC chopper performance
 - Aim at achieving better sensitivity than reading induced charge on the wire
- Plastic scintillation/Cerenkov counters
 - Behind a wire scanner monitor
- 1st test in December
 - Not significant improvement
- Further study foreseen

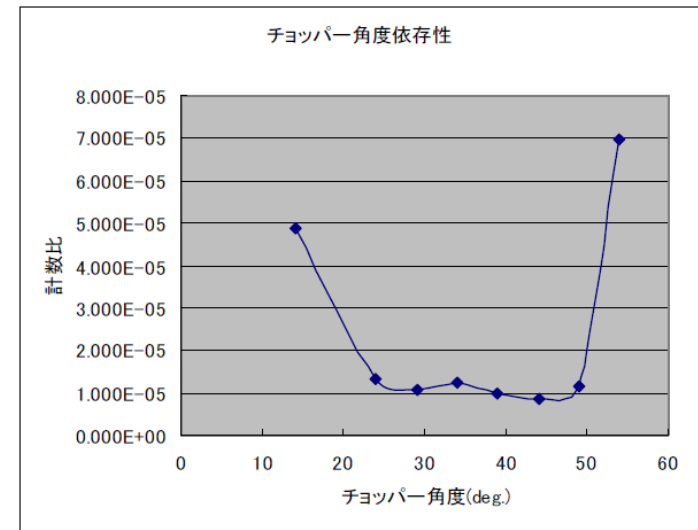
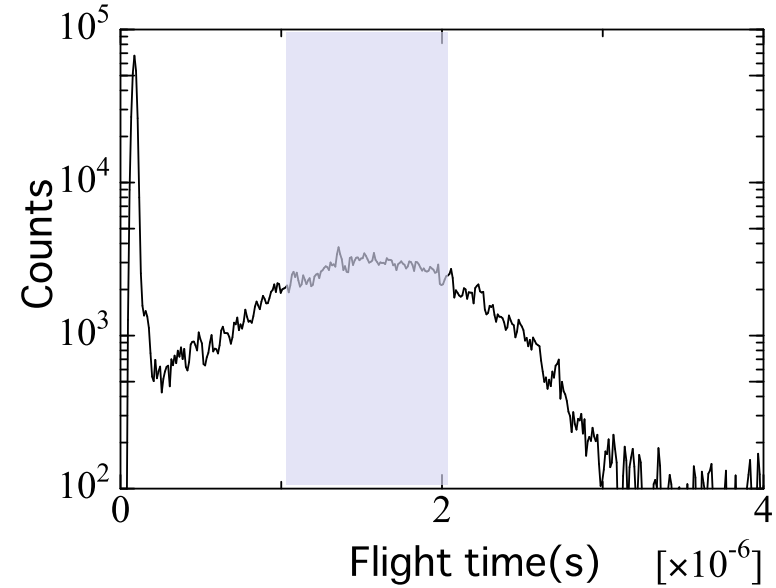


counts/60sec



Measurement at MLF using neutron s.MEIGO and M.Harada

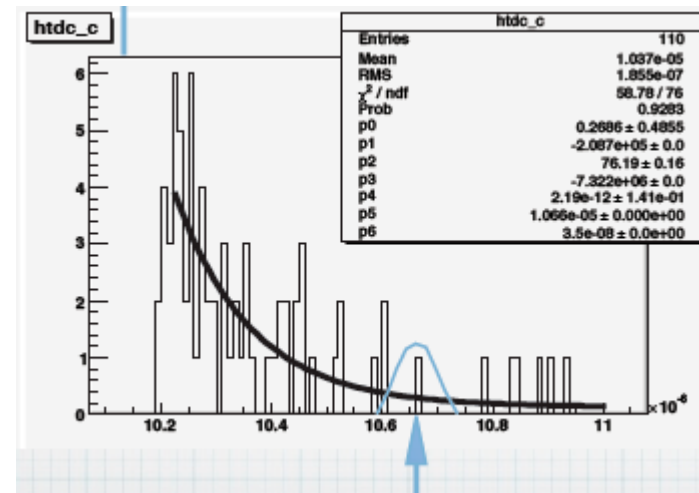
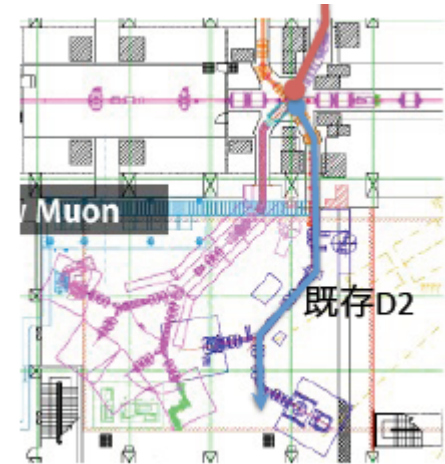
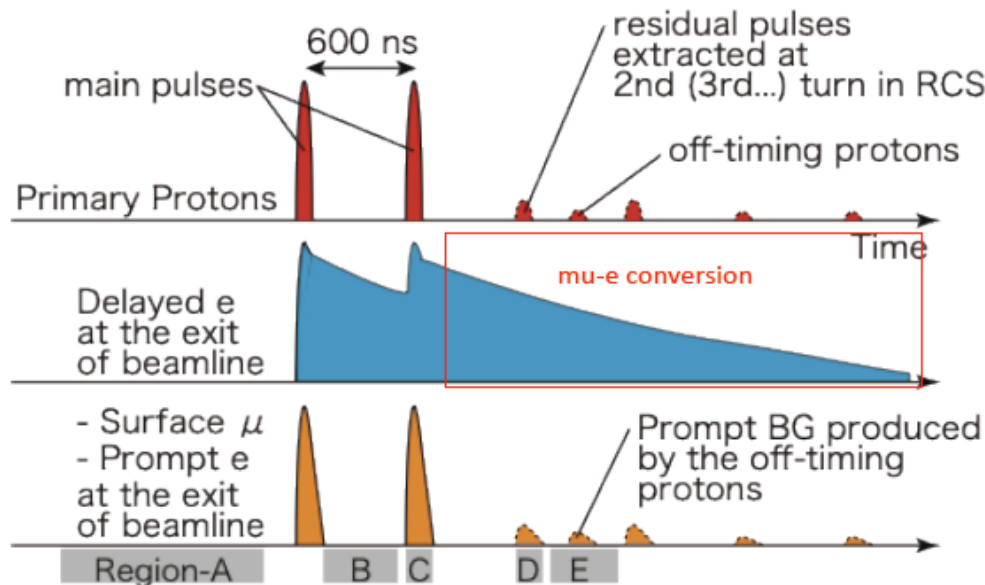
- TOF measurement of neutron at MLF BL-10
 - ³He counter
 - 26 m flight length
- Compare the number of delayed neutrons
 - Between No chop / fully chopped
 - No chop : normal operation
 - Fully chopped: “Empty buckets” operation
- Linac current=5mA
 - $N(\text{fully chopped})/N(\text{No chop}) = 1.2 \times 10^{-5}$
- Linac current=15mA
 - Improved to **1.13×10^{-7}**
 - Not fully understood
 - Chopper efficiency may depend on the beam current



Energy	181MeV	181MeV	3GeV	3GeV
	Ref	Chopped	Ref	Chopped
Cnt/10min	611887	13	35840900	439
ratio	1	2.118×10^{-5}	1	1.225×10^{-5}
No. proton	2.08×10^{12}	4.404×10^7	2.08×10^{12}	2.548×10^7

Another possible method using muon... M.AOKI et al

- e⁻ from Muon decay
- Estimation of residual pulse level after RCS beam extraction



Very Preliminary

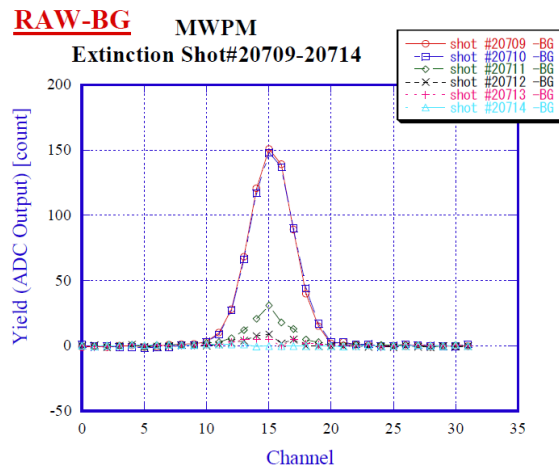
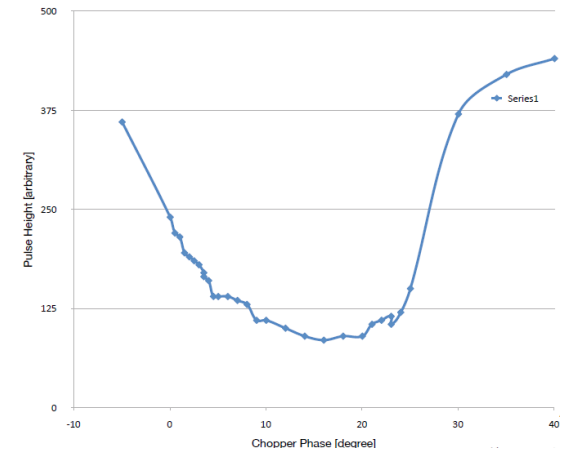
$$N[\text{prompt}] = 100\text{k} * 40389 = 4e9 \text{ total}$$

$$R[\text{extinction}] < 1.2 / 4e9 = 3e-10$$

Measurements at MR

Koji YOSHIMURA and Yoshinori HASHIMOTO

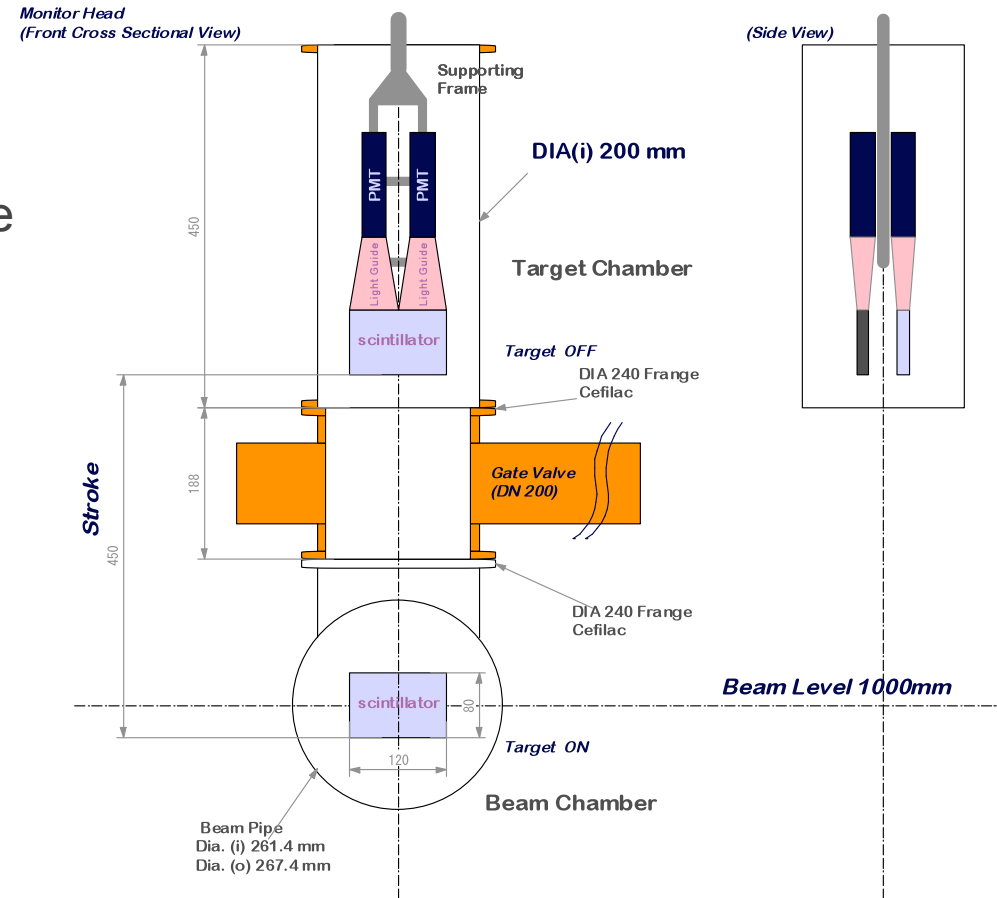
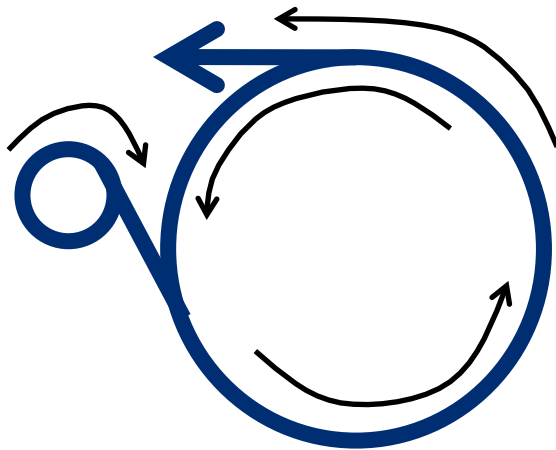
- 1st measurement using the abort-line monitor
 - Chopper phase optimization
 - Extinction $< 2 \times 10^{-5}$ as reported in the previous PAC meeting
- More monitors at different locations to diagnose the beam
 - Plastic scintillation/Cerenkov counters outside the beam pipe
 - End of the transport line from RCS to MR
 - Behind the MWPM
 - After the injection kicker
 - Behind the flying wire profile monitor
 - Profile monitors as a “target”
- New monitors tested in November
 - Sensitivity was found to be not sufficient
 - (MWPM itself is possible to measure $\sim 10^{-5}$)
 - Need geometry optimization



Abort line monitor

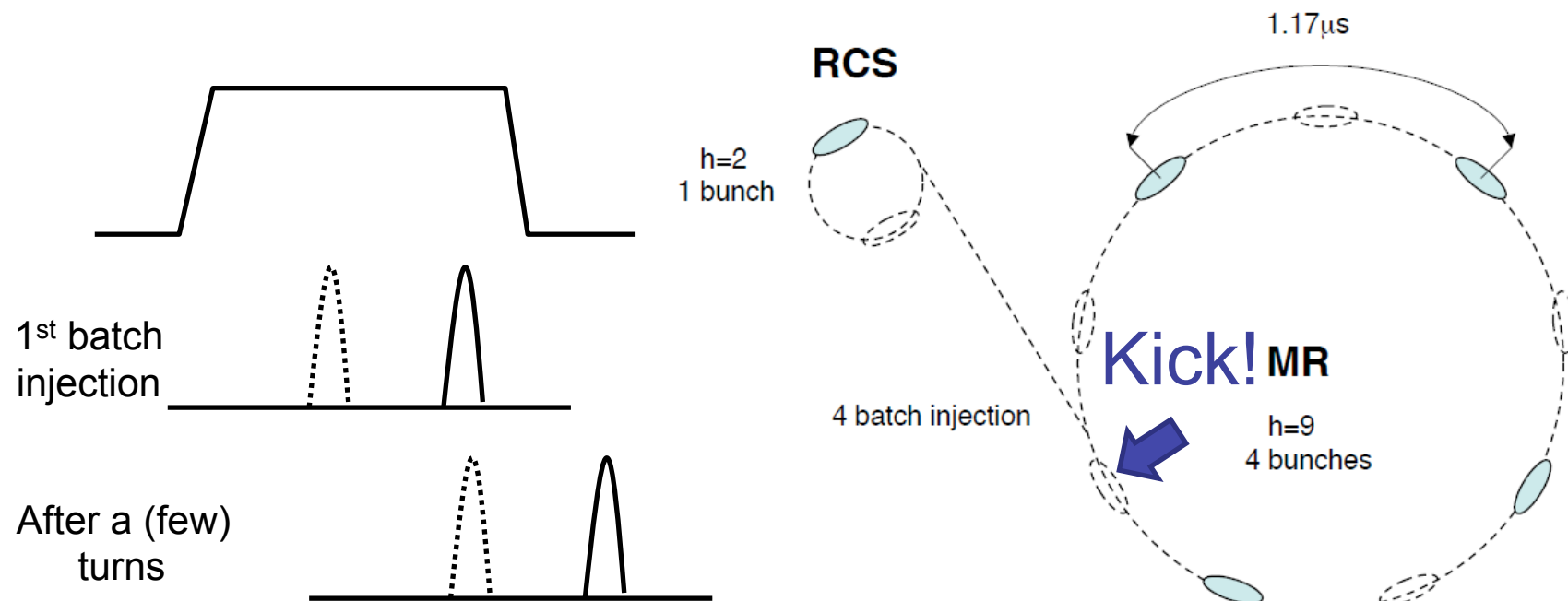
New Abort-line Monitor

- Aiming at highest sensitivity by directly looking at the MR beam
- Remotely controllable
- Vacuum separation by the gate valve when not in use
- Diagnose the beam before and after acceleration in the Main Ring



Clean Up the Beam Before Injection

- Possible method by using the injection kicker
- Empty buckets will be completely cleaned before acceleration
- Need longer injection time



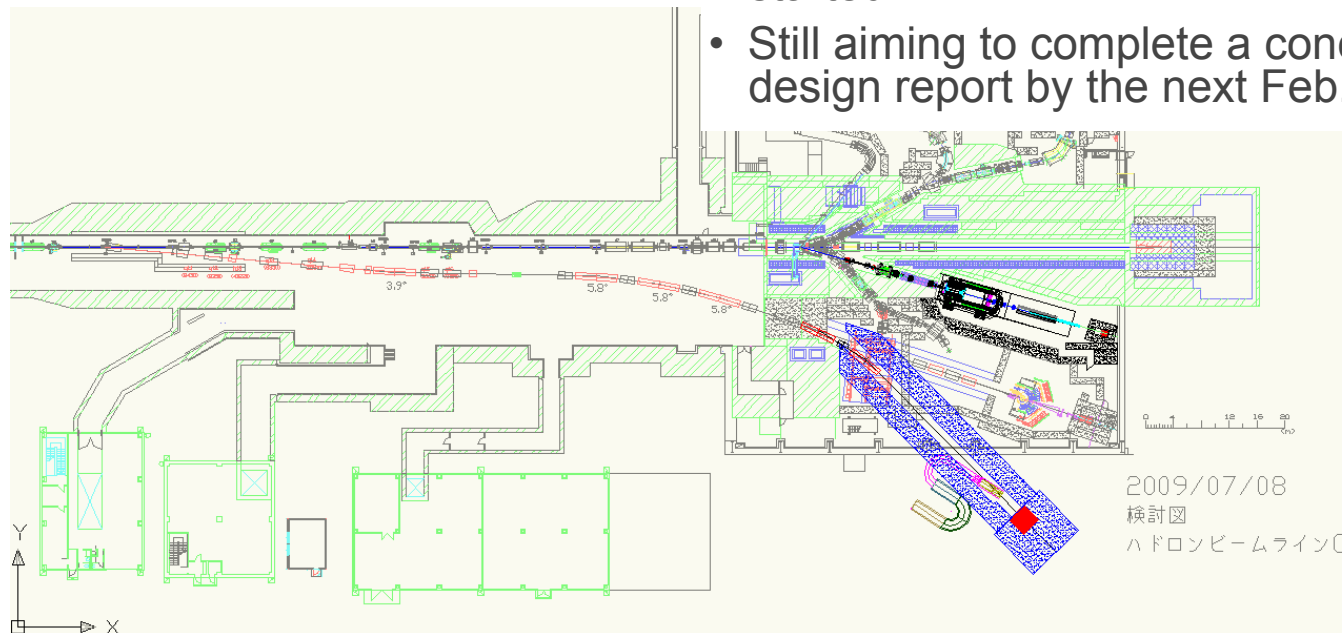
Extra Extinction Device R&D (US-Japan collaboration program) M.Aoki and M.Yoshii

Japan

- MA(Magnetic Alloy) core based design work was initiated.
- Collaboration with J-PARC RF group.
- Considering a system with MA-core kicker(s) plus a septum magnet.

US

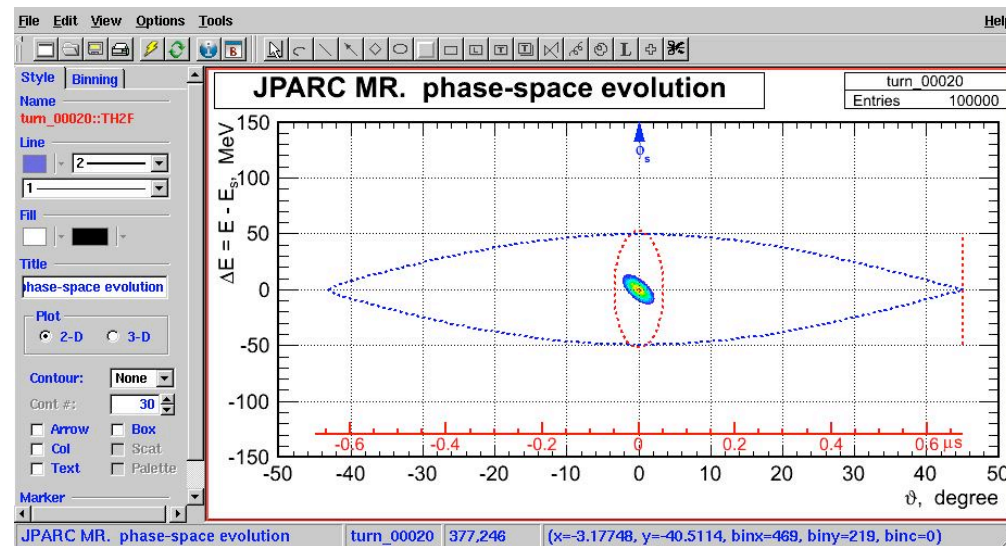
- MnZn Ferrite: high power ferrite test performed.
- Eddy-Current power loss was a bit higher.
- Re-evaluation of the conceptual design started.
- Still aiming to complete a conceptual design report by the next Feb.



Main Ring Simulation

Gogi Macharashvili

- New attempt to investigate particle leakage at the level of 10^{-9}
 - Simplification
 - How the particle phase space develops during acceleration ?
 - Ignore the core (stable) part of the beam for speeding up
 - Calculate the probability of particle reaching to the edge of the separatrix
 - Estimate the probability of particle leakage due to RF noise



- Particle interaction with a septum foil
- Time structure of the extracted beam

Summary

- There are still lots of things to be done
- Various kinds of work are in progress in parallel with the collaboration
 - With (great) help of the accelerator group
- MR study
 - Simulation
- Extinction
 - New monitors to optimize accelerator parameters
 - External extinction device R&D is in progress
 - Secondary beam line measurement with bunched slow extraction
- SC magnet R&D
 - Next presentation..