

COMET Muon Task Force Report

18th June 2009

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.)

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New Members

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 (defined by ourselves)

- 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*

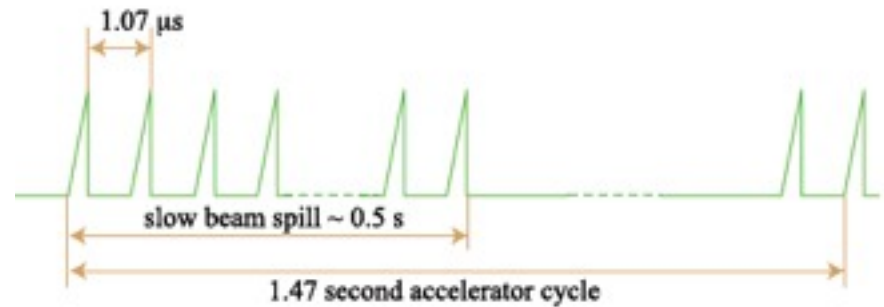
Contents

- Proton Acceleration
- Extinction
- Proton Transport/Extraction
- Experimental Space
- Solenoid Magnet
- Summary

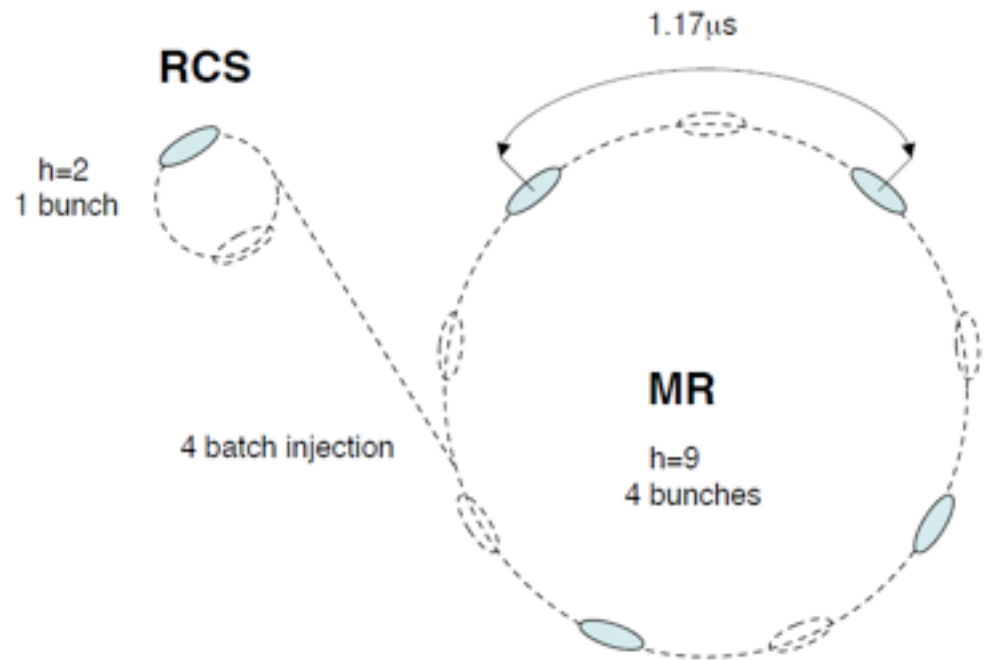
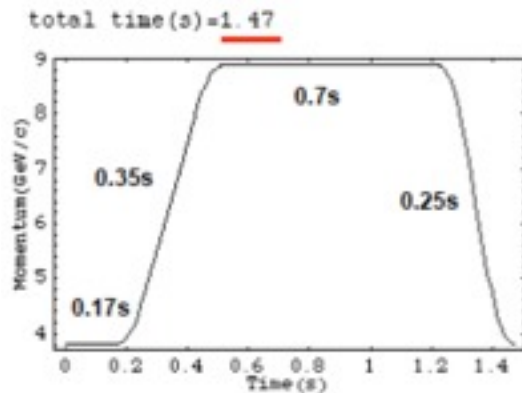
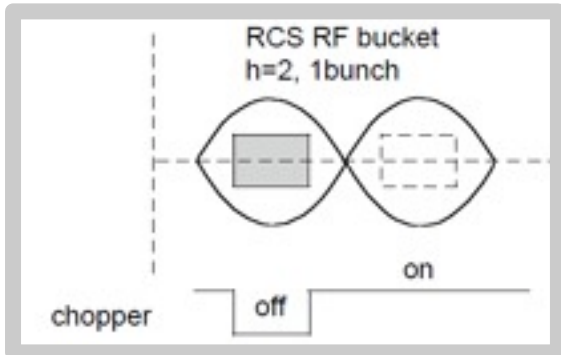
PROTON ACCELERATION

COMET Proton Acceleration

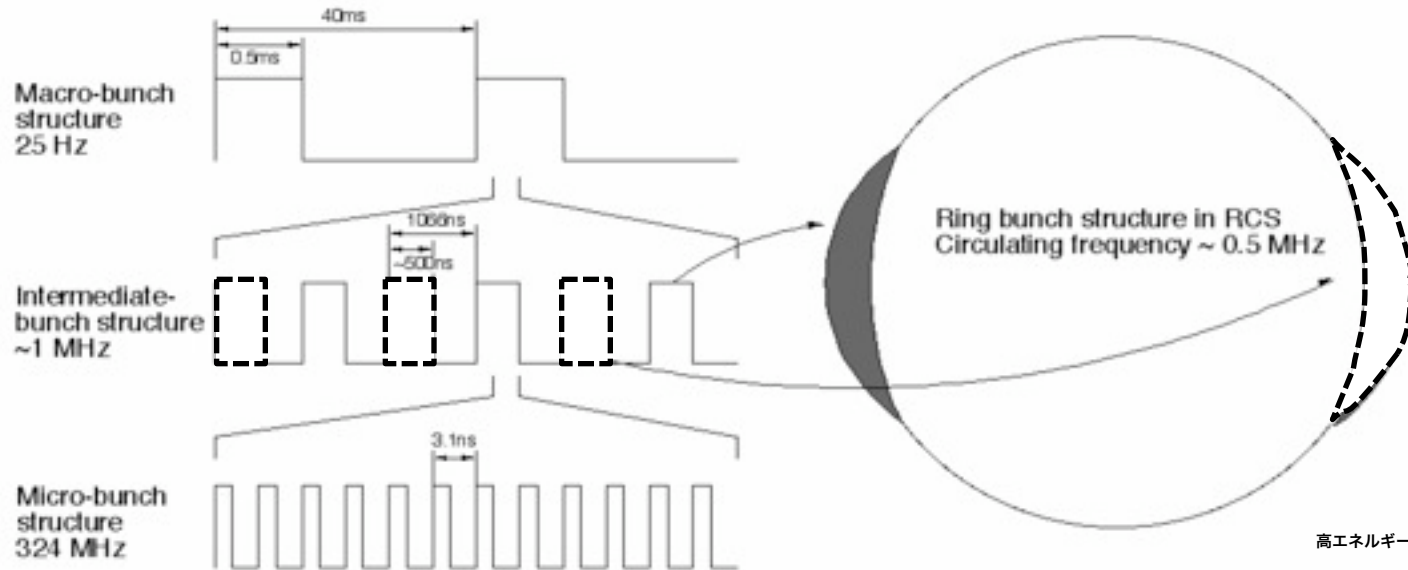
- RCS: $h=2$ with one empty bucket
- MR: $h=9$ with 5 empty buckets
- Bunched slow extraction
 - Slow extraction with RF cavity ON, 210kV



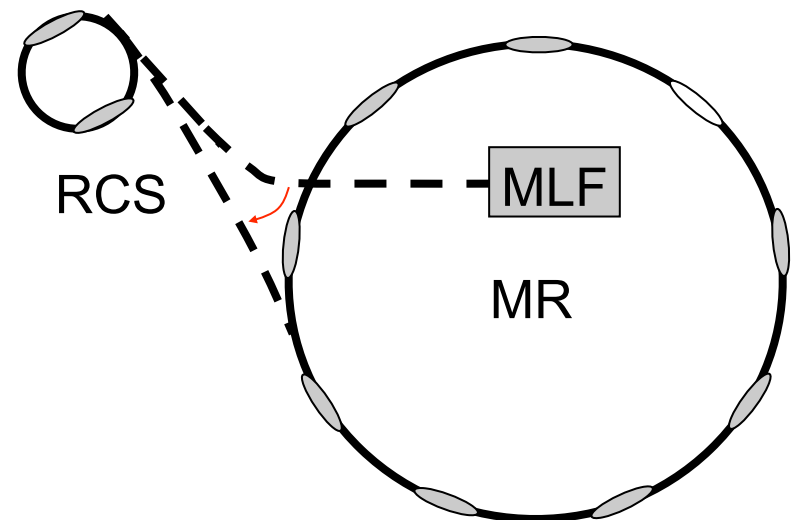
Realization of an empty bucket in RCS by using the chopper in Linac



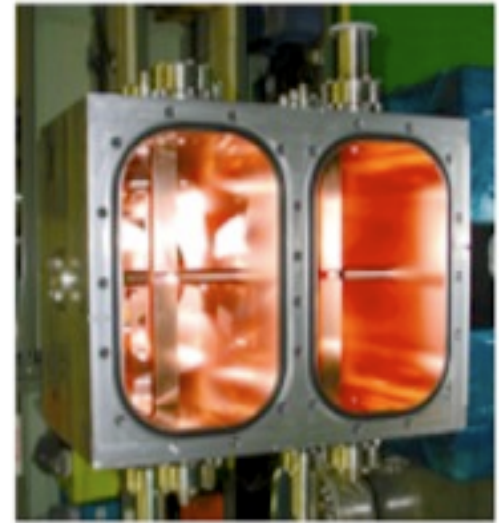
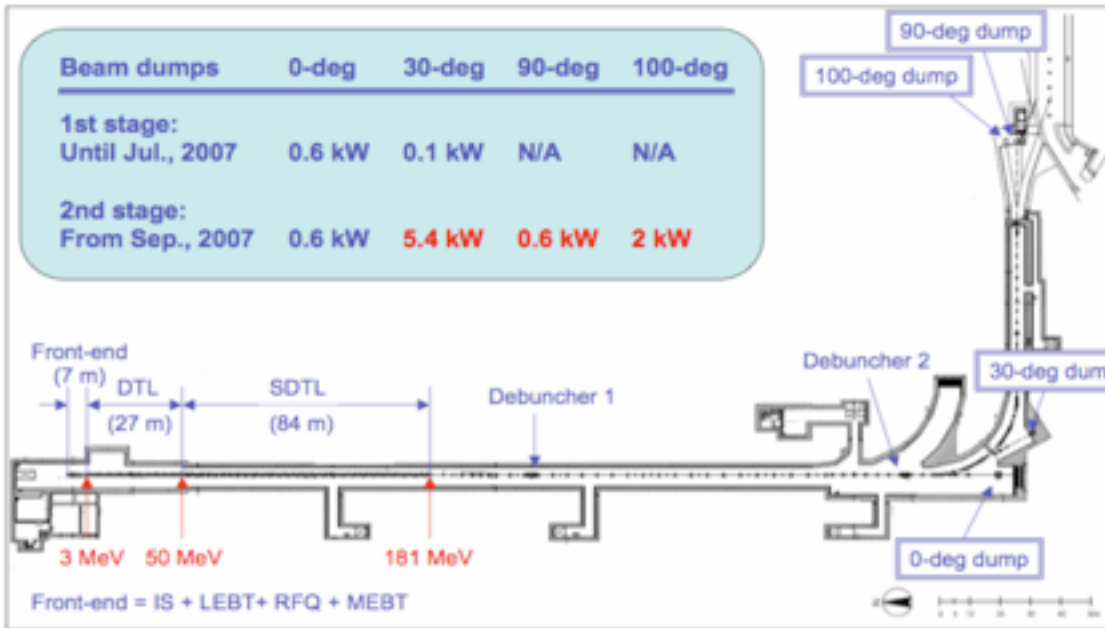
RCS, MR Injection



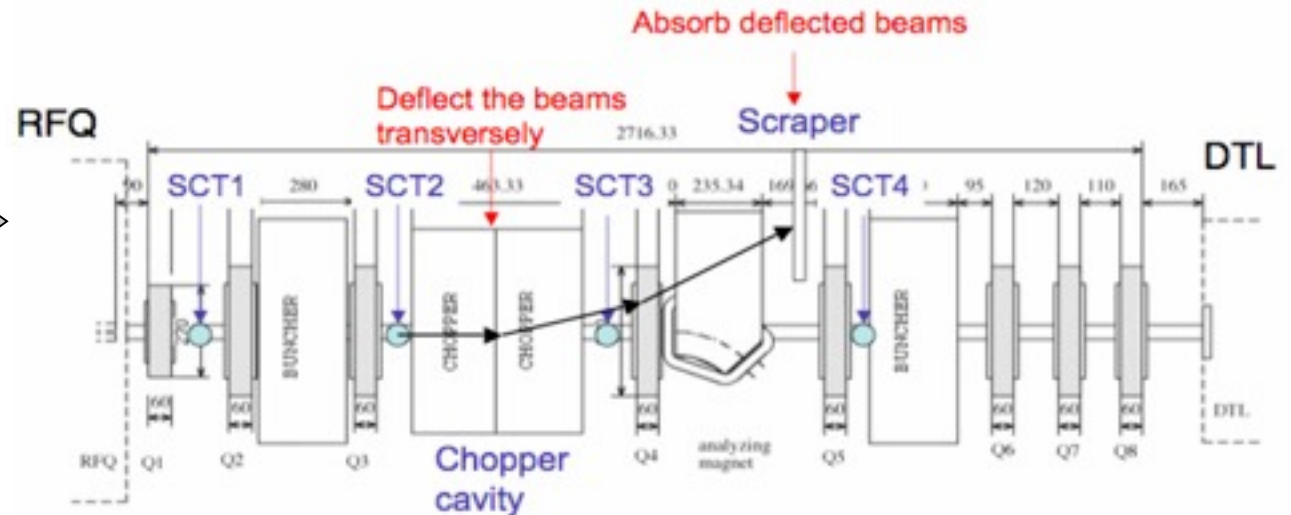
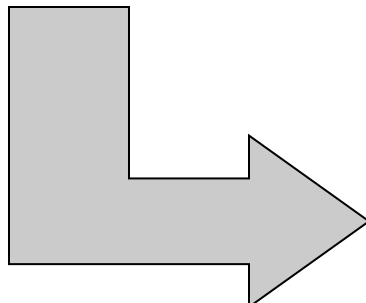
- Acceleration and extraction in 20msec
- Bunch configurations
 - Micro bunch 324 MHz LINAC
 - Intermediate bunch ~1MHz Chopper
 - Macro bunch 25Hz RCS



Linac Chopper



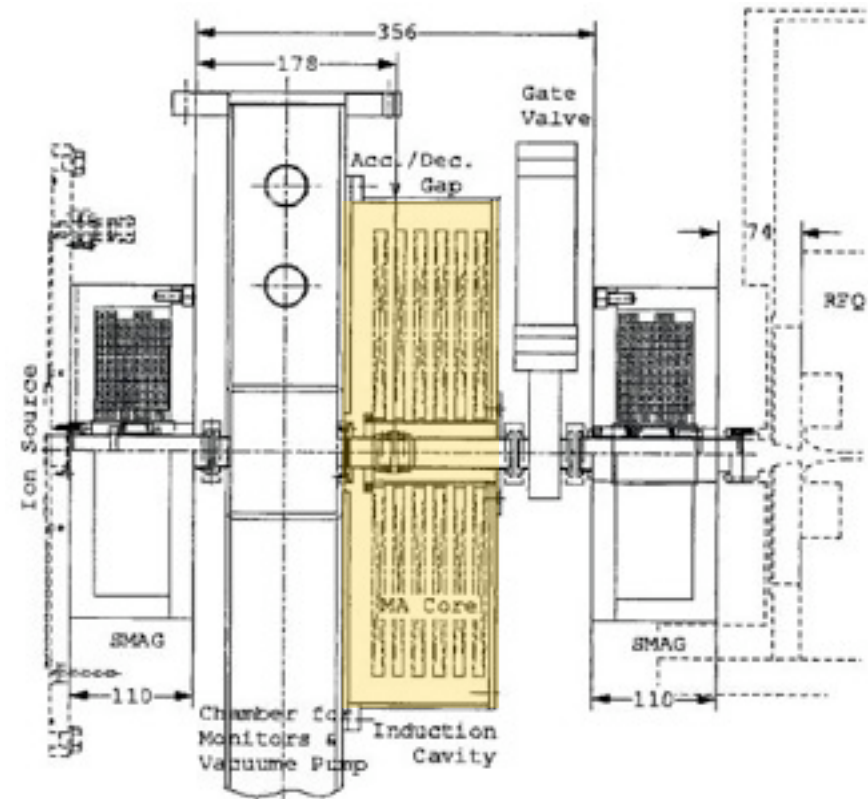
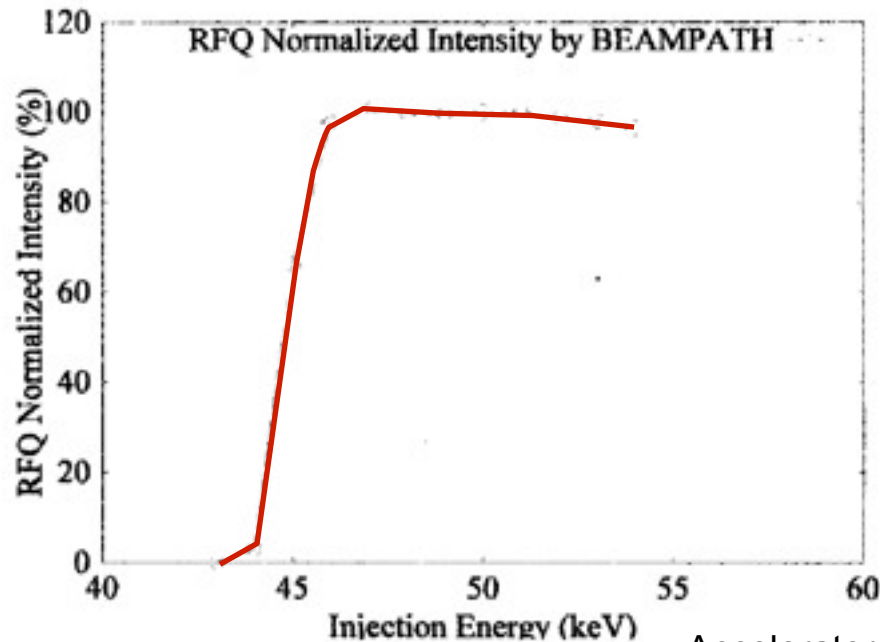
Two Cavities



池上雅紀

Pre-Chopper

- Linac Chopper efficiency is found not to be sufficient for COMET (reported later)
- Pre-Chopper, installed between the ion source and RFQ but not used due to the noise from the device, will certainly be effective to improve
 - Energy modulation type chopper
 - Necessary anyway for high rate operation above 50mA

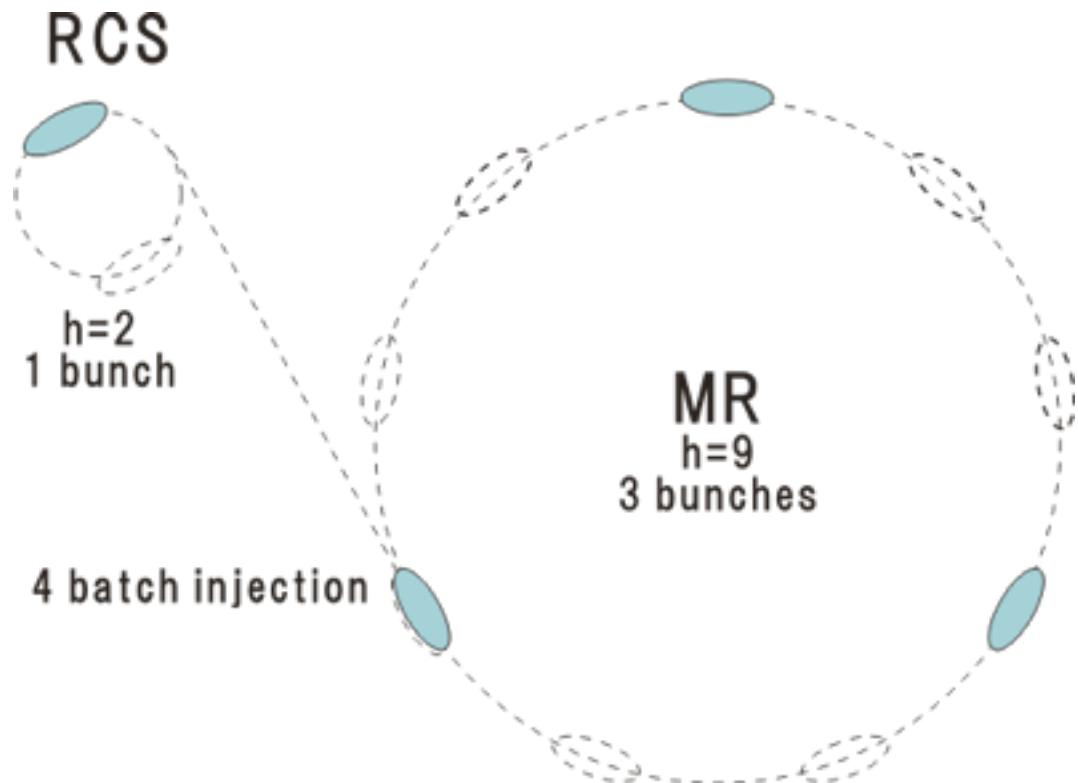


Request (to the accelerator group)

- Settle down the noise and make it operational
- Test effectiveness even before by decreasing the ion source voltage

New Bunch Configuration

- Wider bunch-bunch separation \rightarrow 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



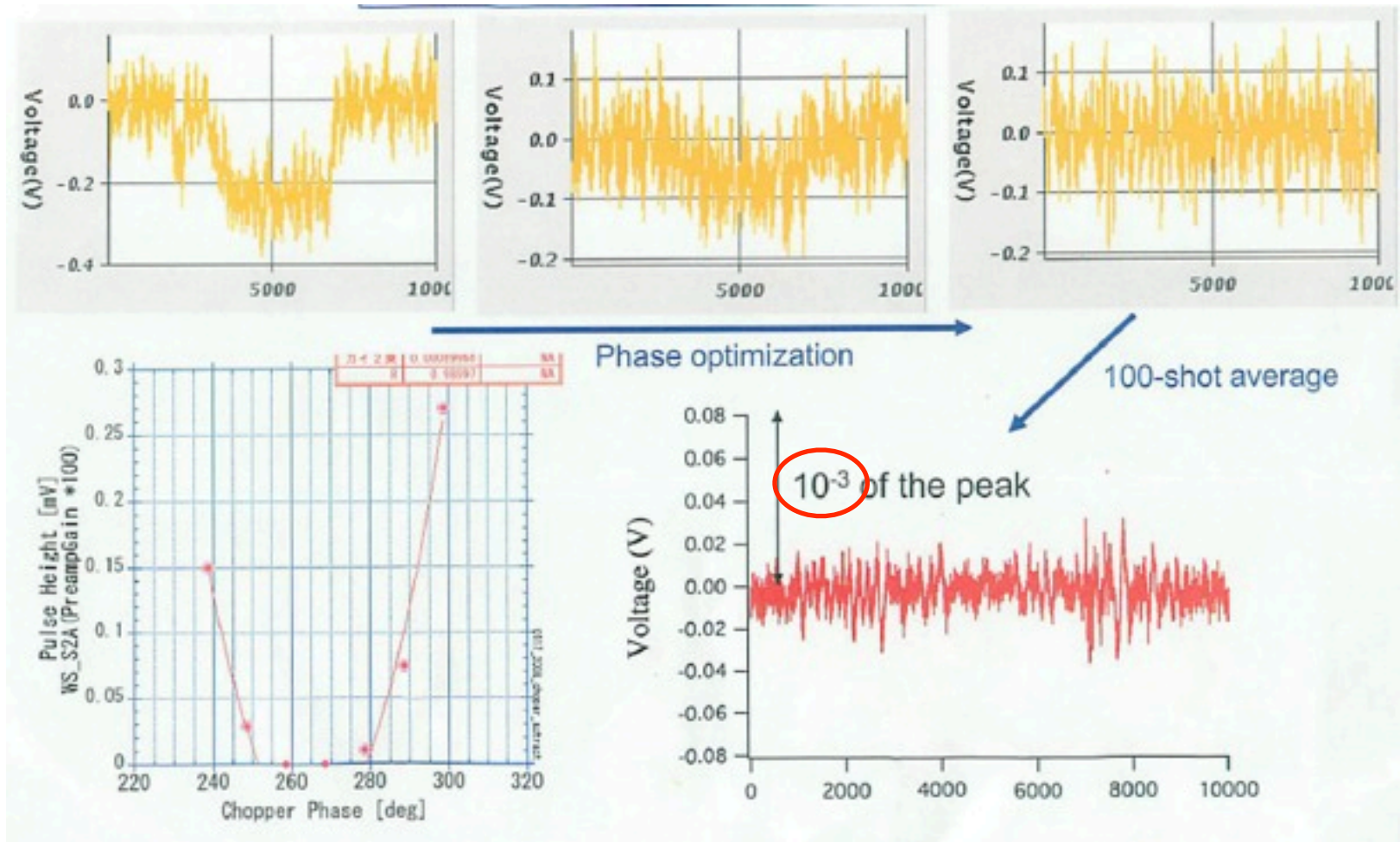
EXTINCTION

Extinction Measurements

- Precedent measurement by the accelerator group
- Extinction measurement using secondary beam
 - Not performed yet
- Extinction measurement using a newly-installed abort line monitor
 - 1st measurement was done in Jun 2009
 - We appreciate understanding of the importance of this measurement by the accelerator group
 - Especially support by the vacuum group is invaluable

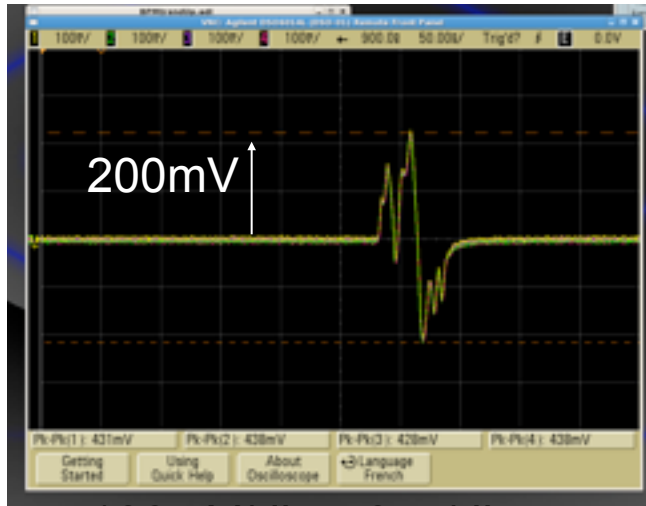
Precedent Measurement by the Acc. Group

- Chopper phase optimization using a LINAC wire scanner monitor

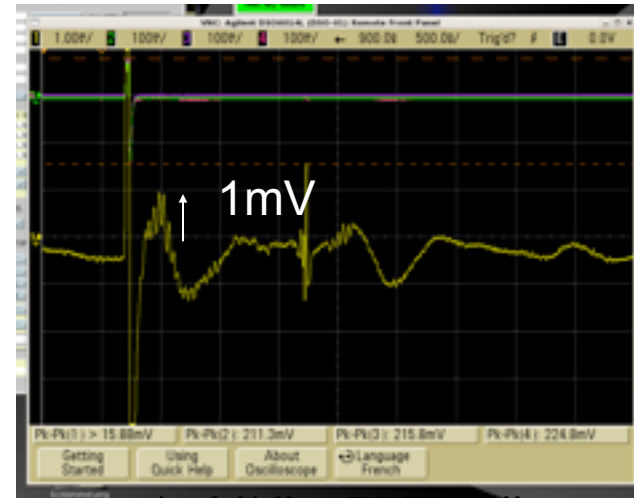


Precedent Measurement con'd

- RCS Beam Profile Monitor Extinction better than 1/200

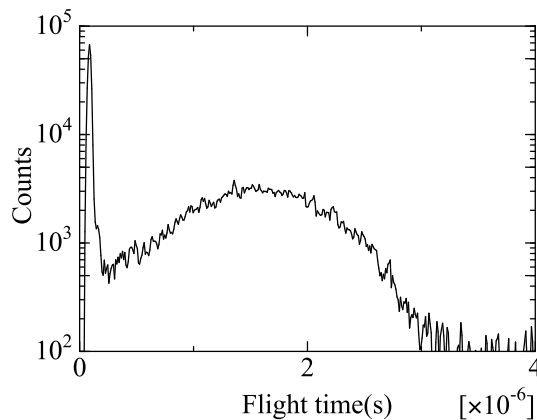


100mV/div, 50ns/div



1mV/div, 500ns/div

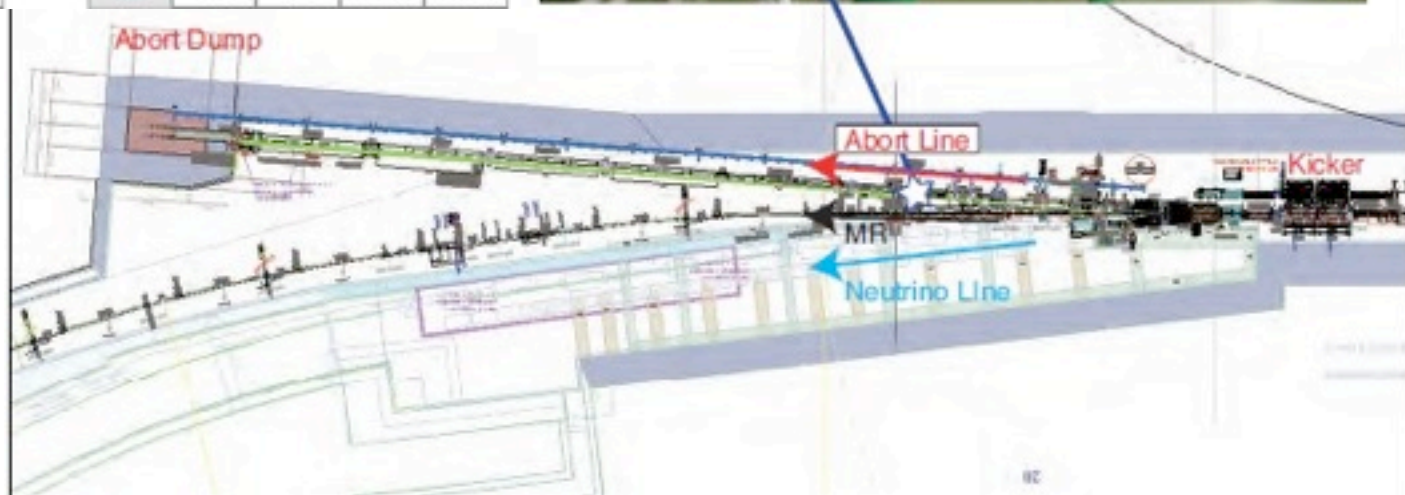
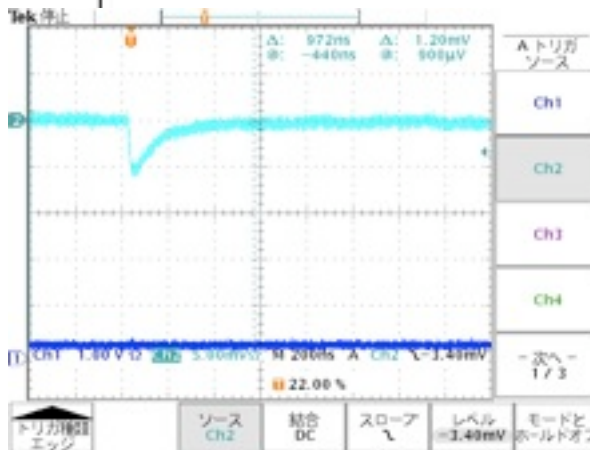
- TOF measurement of neutron at MLF BL-8, 26 m flight length



No sign of extinction
larger than 1/100

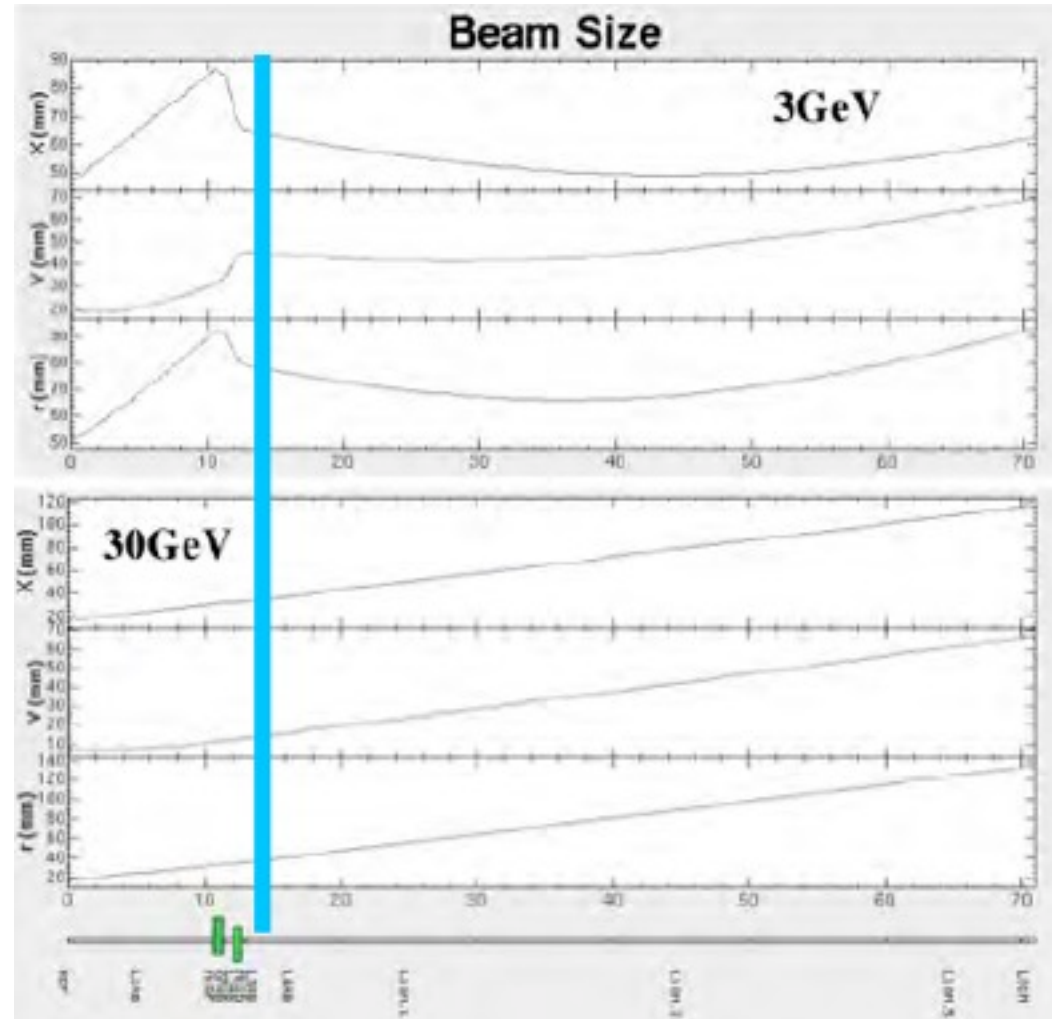
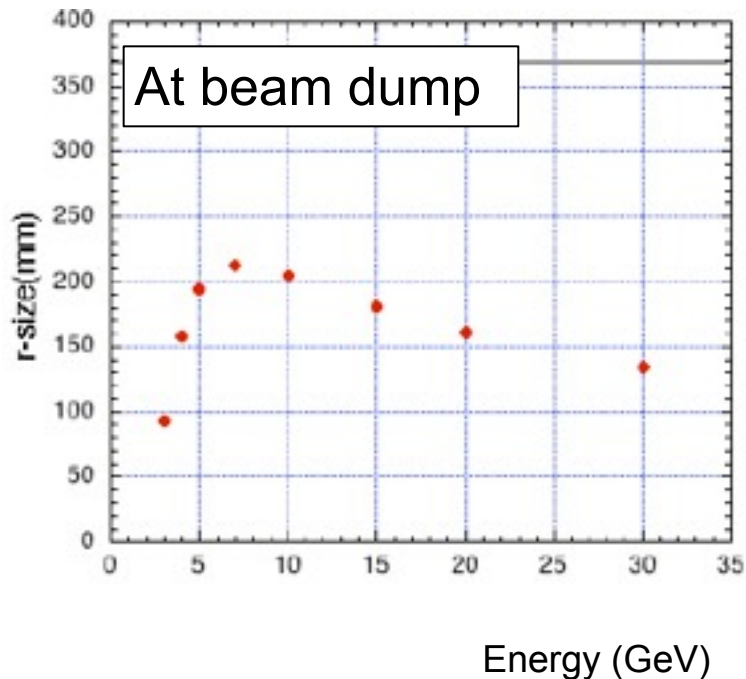
Abort Line Measurement Layout

- Need to transfer PMT signal
 - from the abort line to the counting room
 - through 300m long cable
 - Very special cable



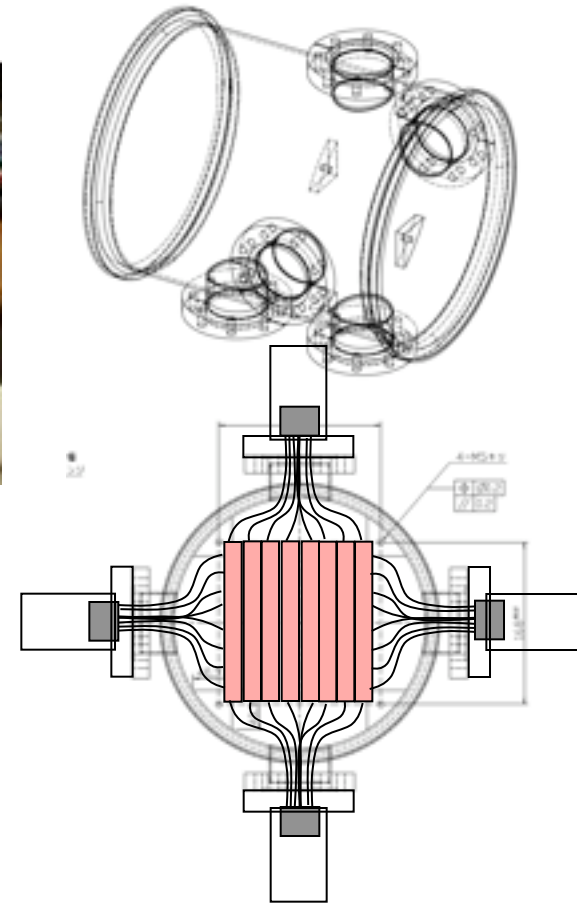
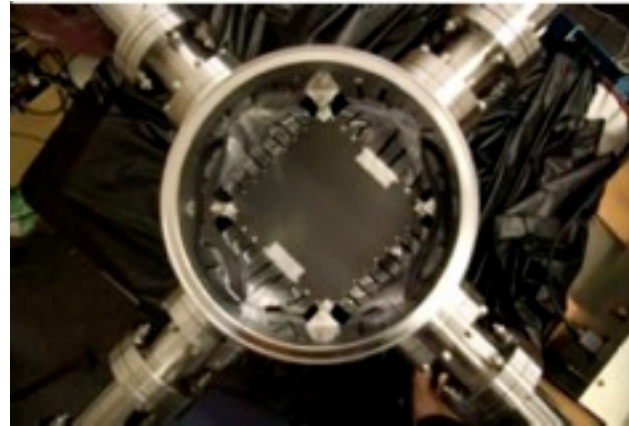
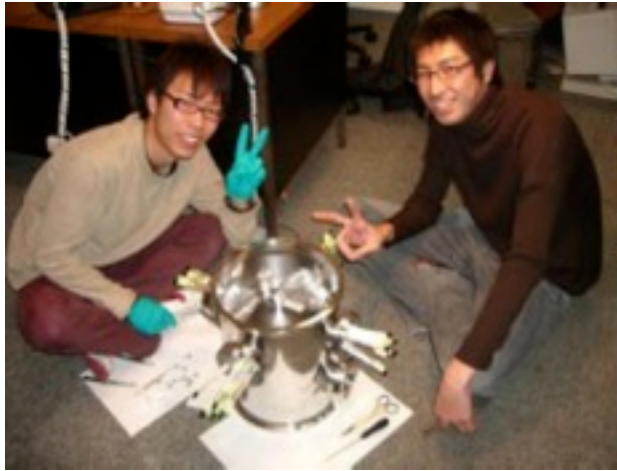
Expected Beam Profile at the Monitor

- Just behind the Q doublet
 - 160mm diam. at 3GeV
 - 80mm diam. at 30GeV
- → 150mm diam. at 8GeV
- In reality smaller than this thanks to the dedicated tuning for this study

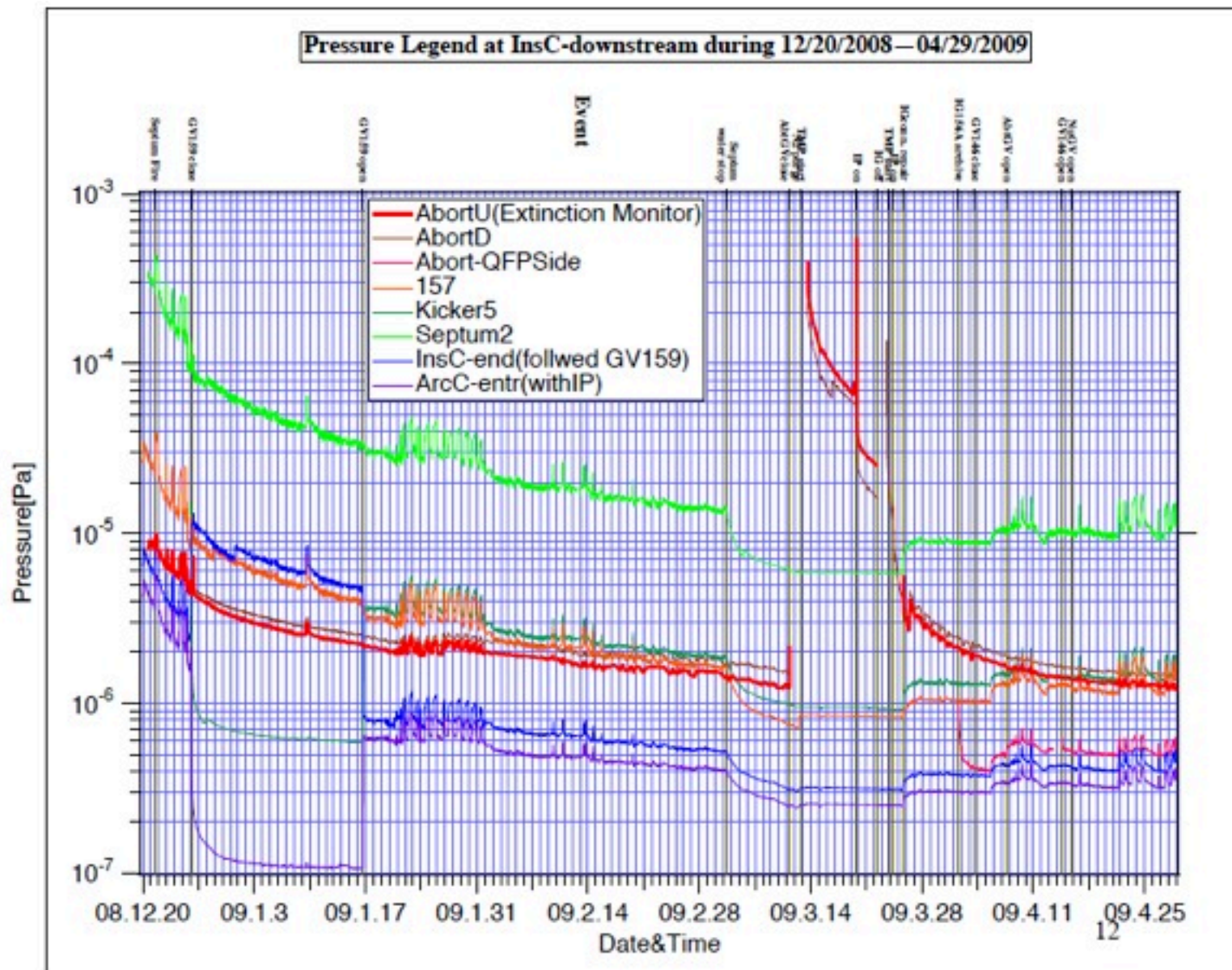


Preparation and Installation of the Monitor

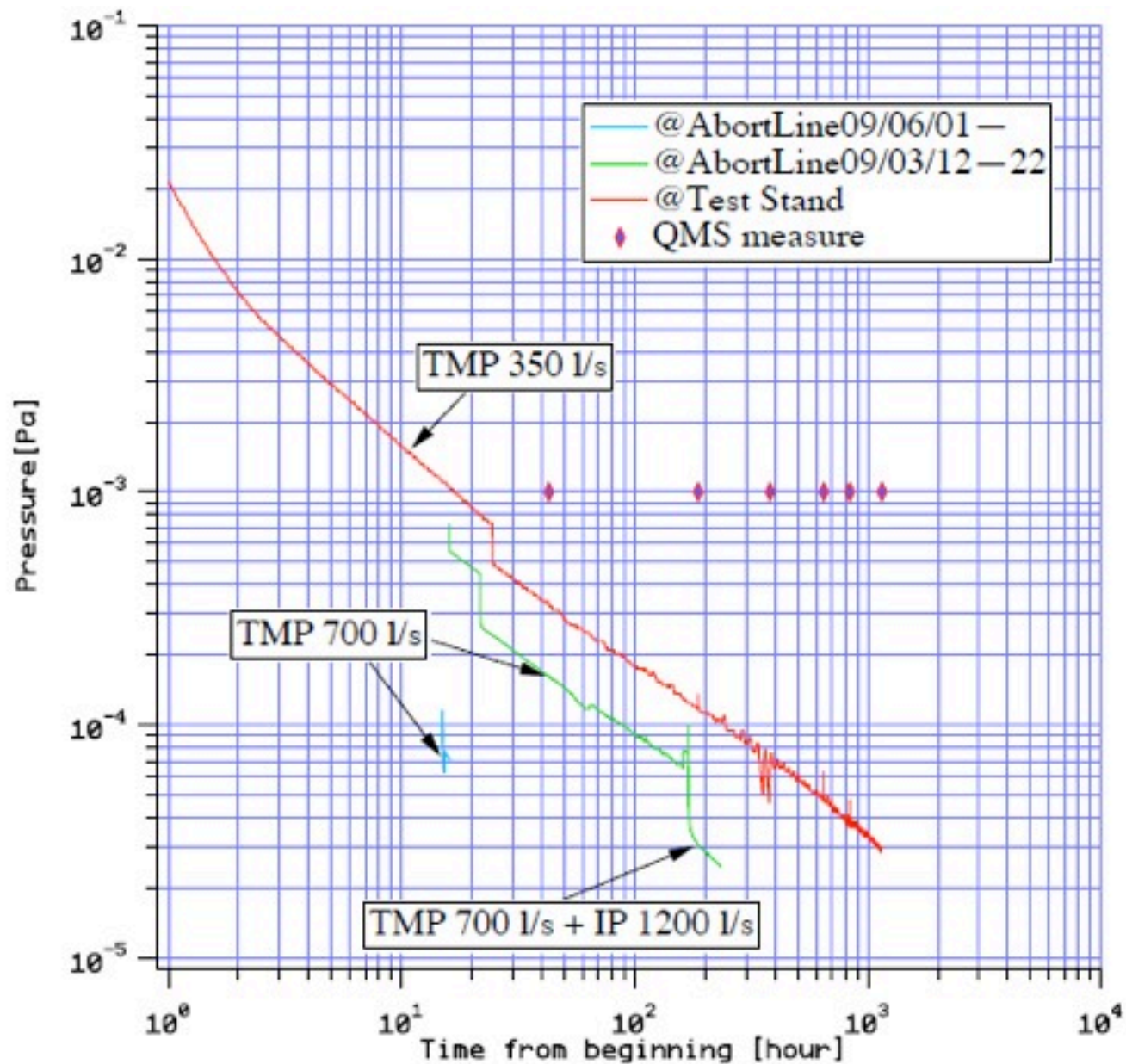
- Thanks to
 - Nakadohzone, Tachimoto Osaka U. Students
 - Accelerator Vacuum Group



Installed in March but...

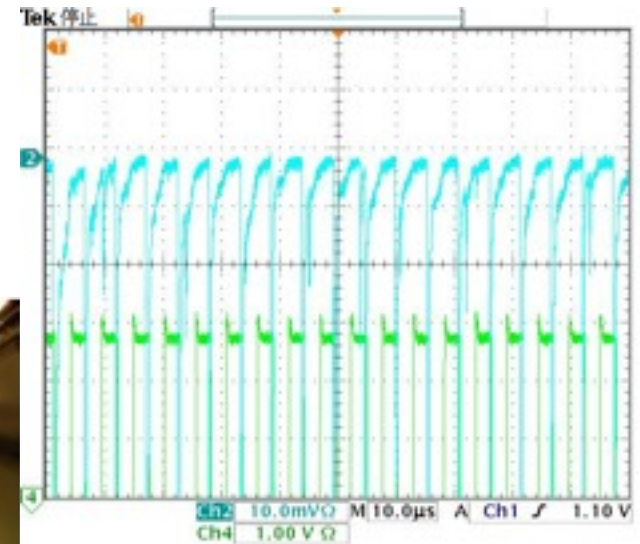


Da capo al fine



Another counter outside the duct

- Prepared for signal study previously
- Has been staying for electronics test
- Found to be very useful for study



- Scattered proton on the monitor can be viewed by the counter
No other material in the beam duct than the monitor

First Shot !

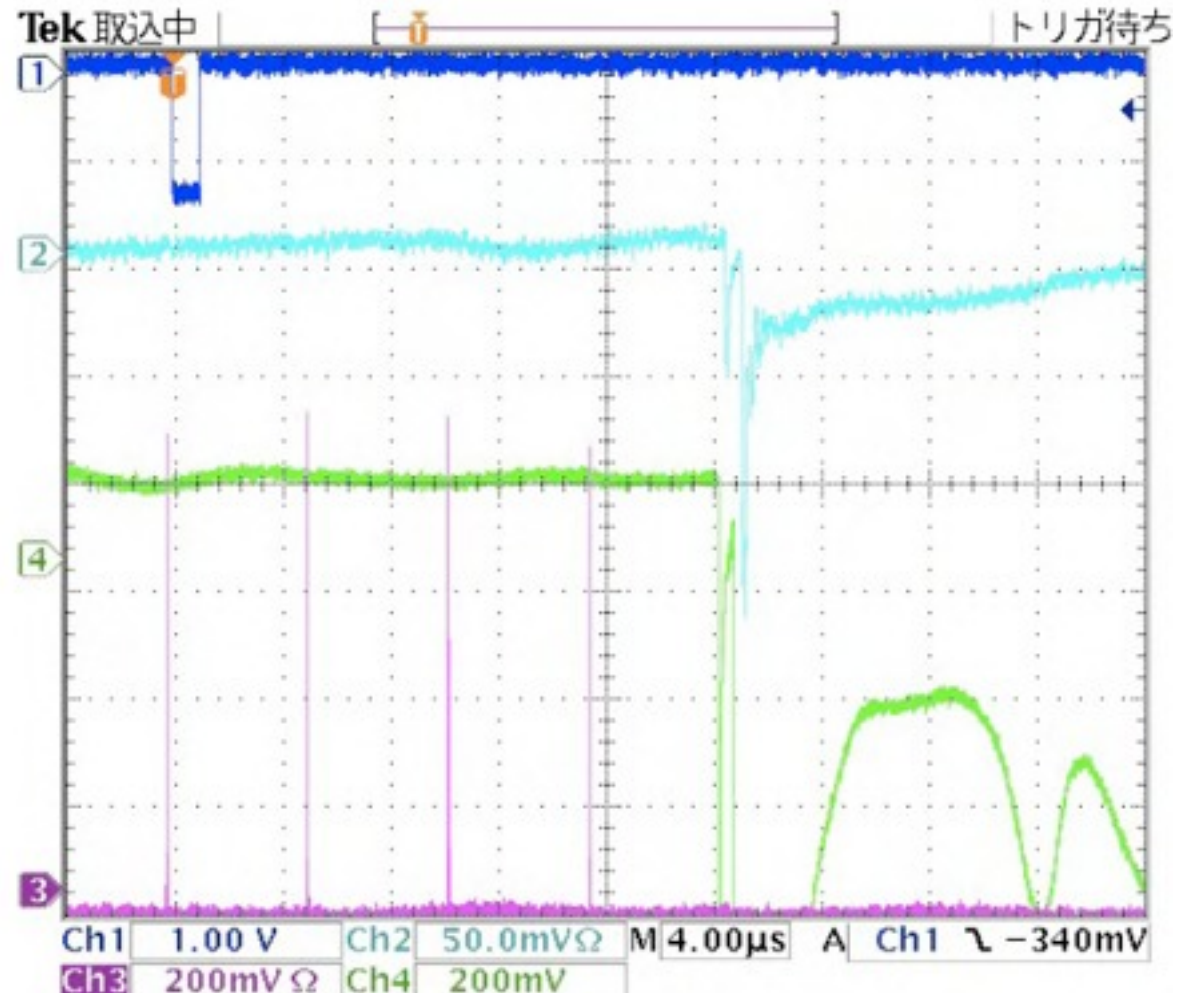
- RCS single bunch operation
- Fast extraction to the abort line, First the empty bucket and then filled bucket

Kicker excitation signal

Abort line monitor HV 300V

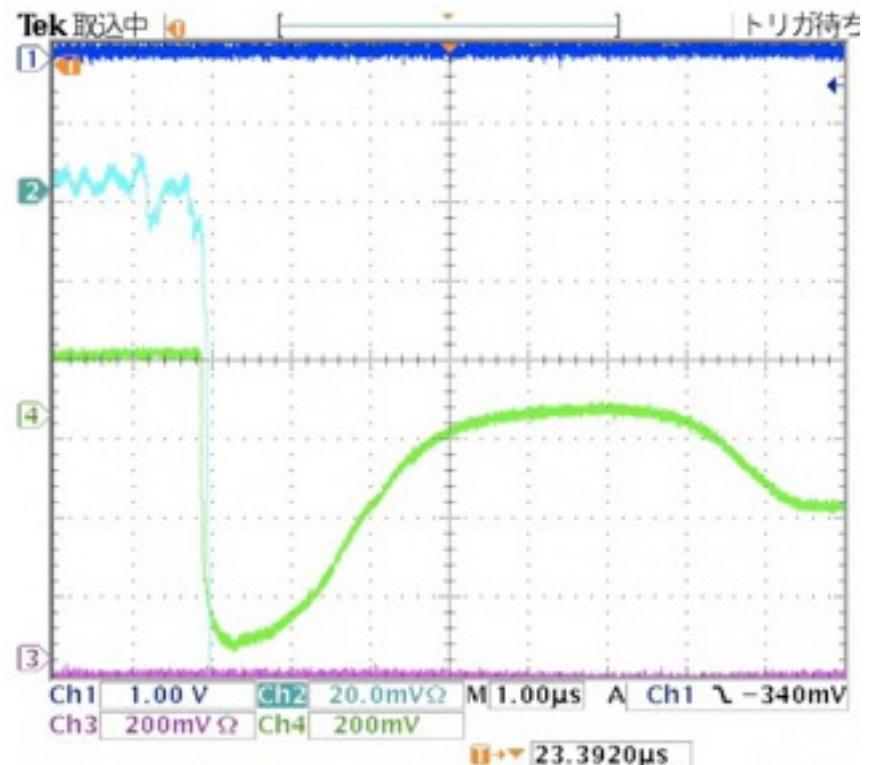
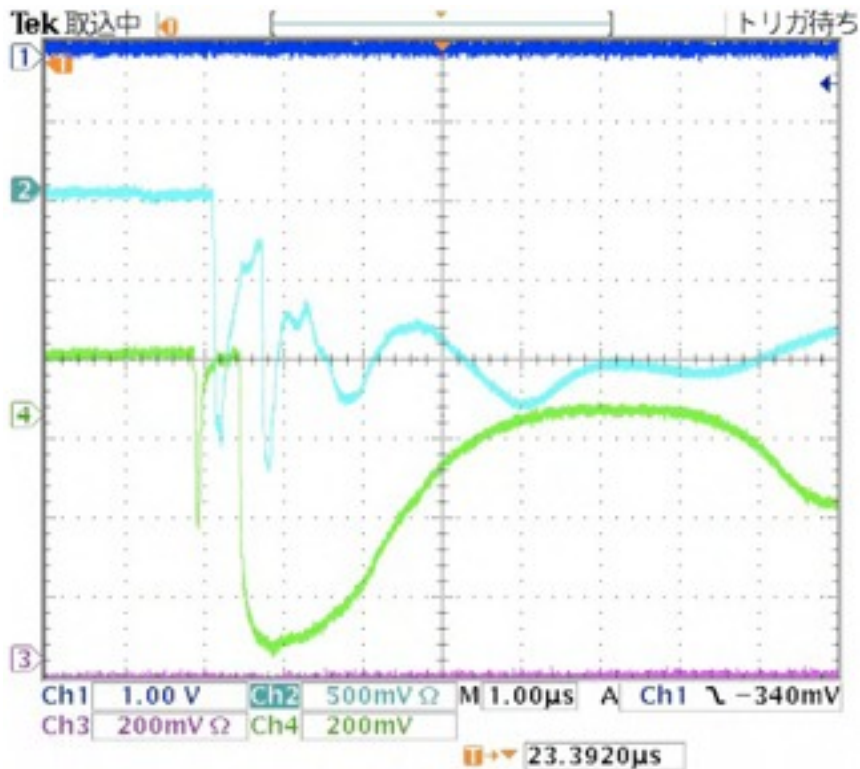
Outside counter normal gain

Beam intensity monitor



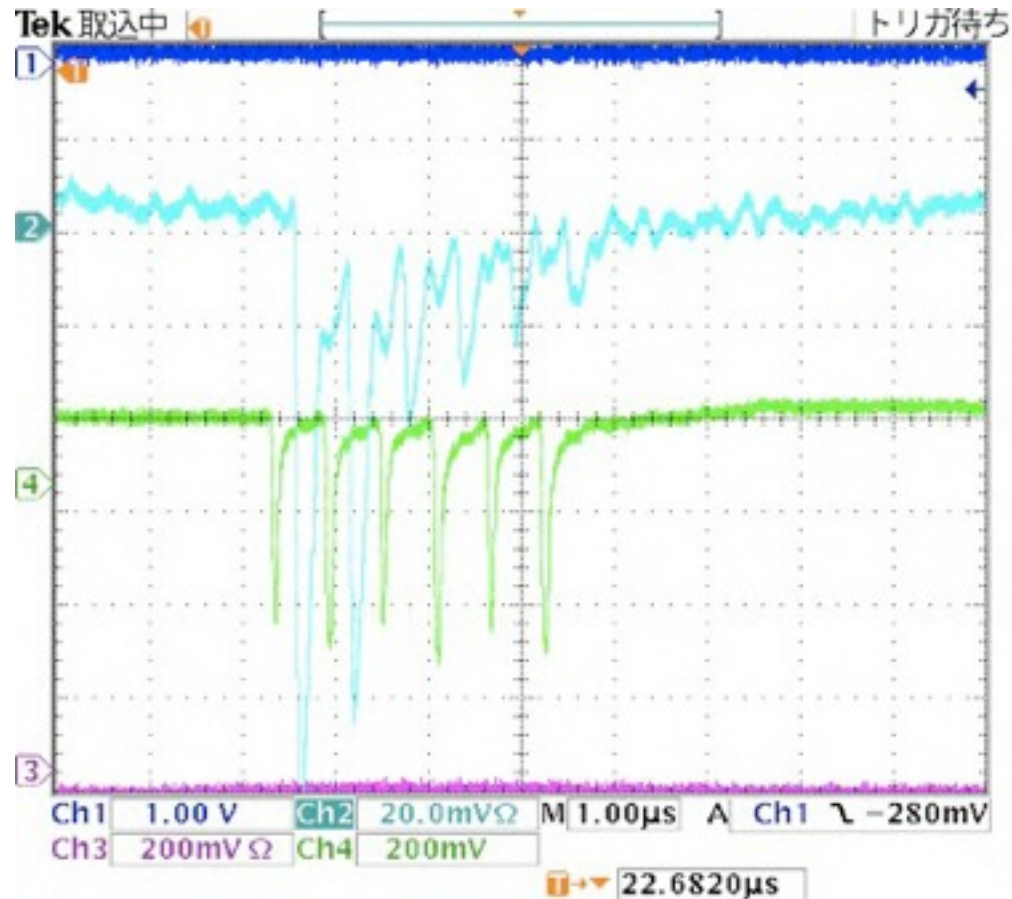
Study on Empty Buckets

- Two different extraction (MR bunch filling configuration)
 - Empty – Filled
 - Filled – Empty
- It looks that protons certainly remain in the empty bucket
 - not small amount...



Confirmation

- 6 empty buckets filled from RCS
- Indication of inefficiency of the chopper



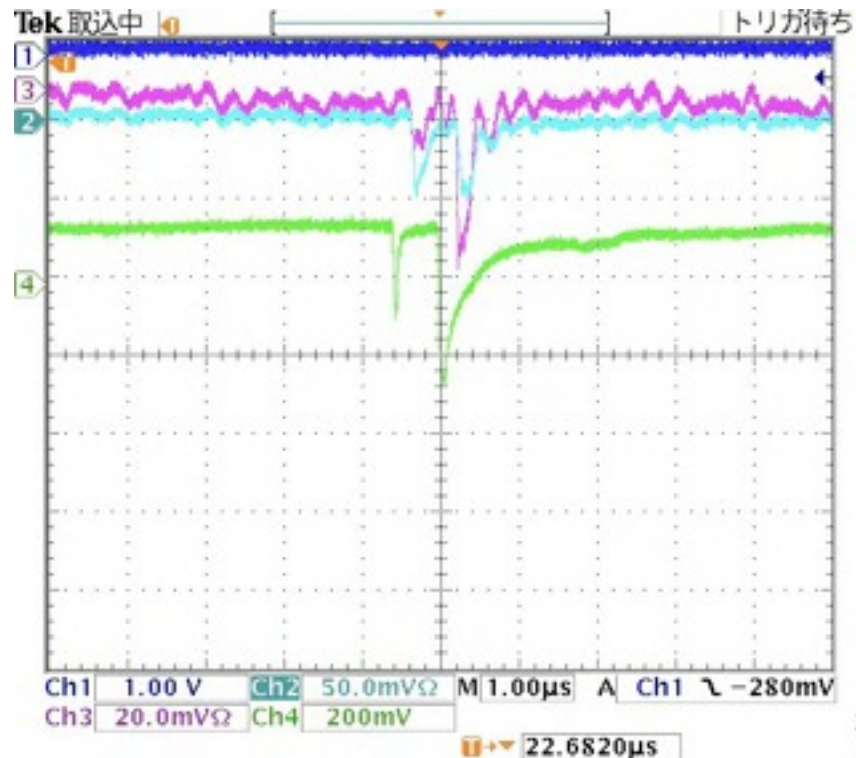
Short Summary of the Study

- There are certainly protons in empty buckets
- Due to inefficiency of the chopper
 - Confirmed by
 - Kicker alone operation → not noise effect by the kicker
 - Different bunch configuration → related to the chopper
 - Empty-filled buckets
 - Filled-Empty buckets
 - 6 empty buckets
- How many protons in an empty bucket?
- Can we reduce this by any means?

How Many Particles in an Empty Bucket?

- Empty bucket was left unchanged
- Proton intensity in the filled bucket is controlled by changing the number of intermediate bunches to be filled in RCS
 - Chopper width was reduced in advance, 280nsec \rightarrow 6.2nsec or 12.4nsec
 - Proton intensity is proportional to the number of intermediate bunches

- Calibration point
 - Width=12.4nsec
 - Nib = 47
 - Proton intensity by DCCT 8×10^8 protons



21 Jun 2009
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Extinction Estimation

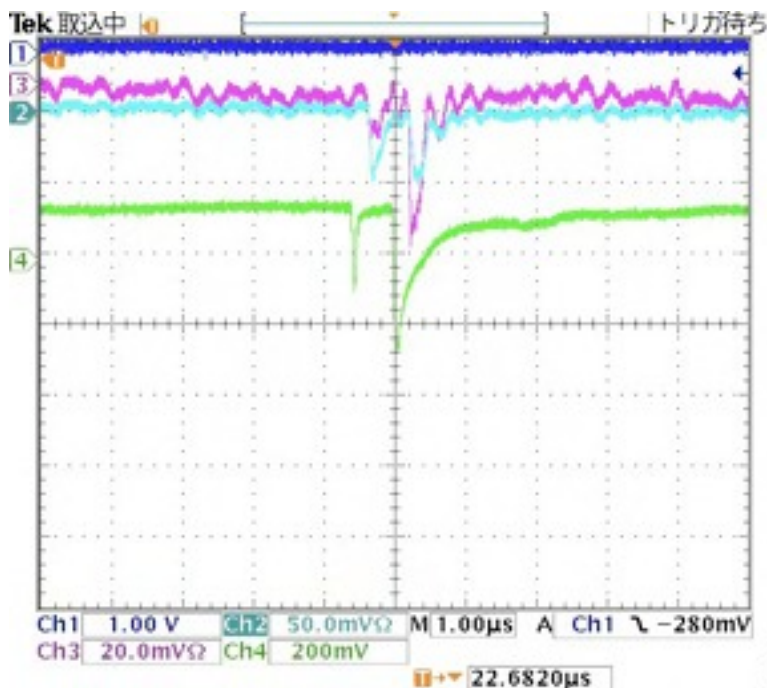
- The bunch with only 1 intermediate bunch is equivalent to an empty bunch
 - $8 \times 10^8 \times 1/47 = 1.7 \times 10^7$ ppp

- Extinction

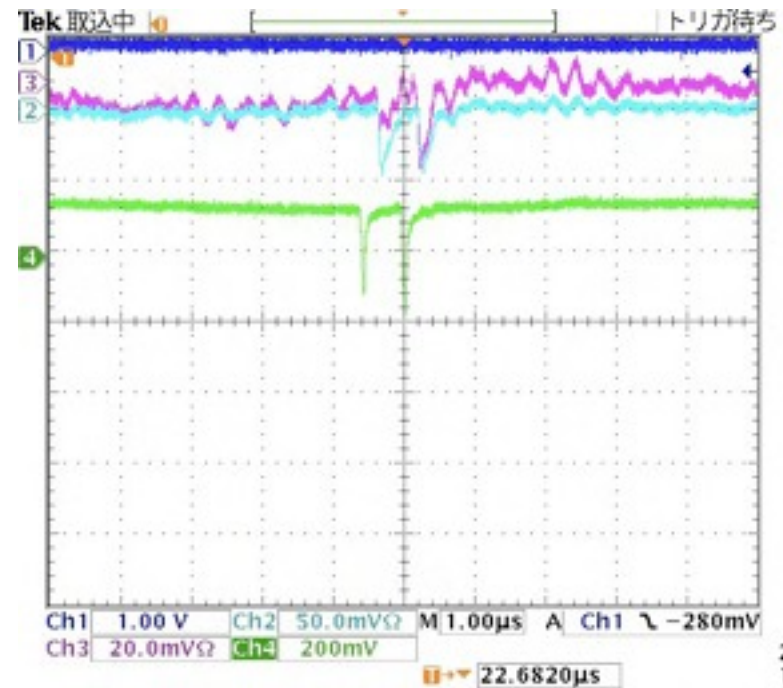
- $1.7 \times 10^7 / 4 \times 10^{11} = 4 \times 10^{-5}$

-

Nib = 5



Nib = 1



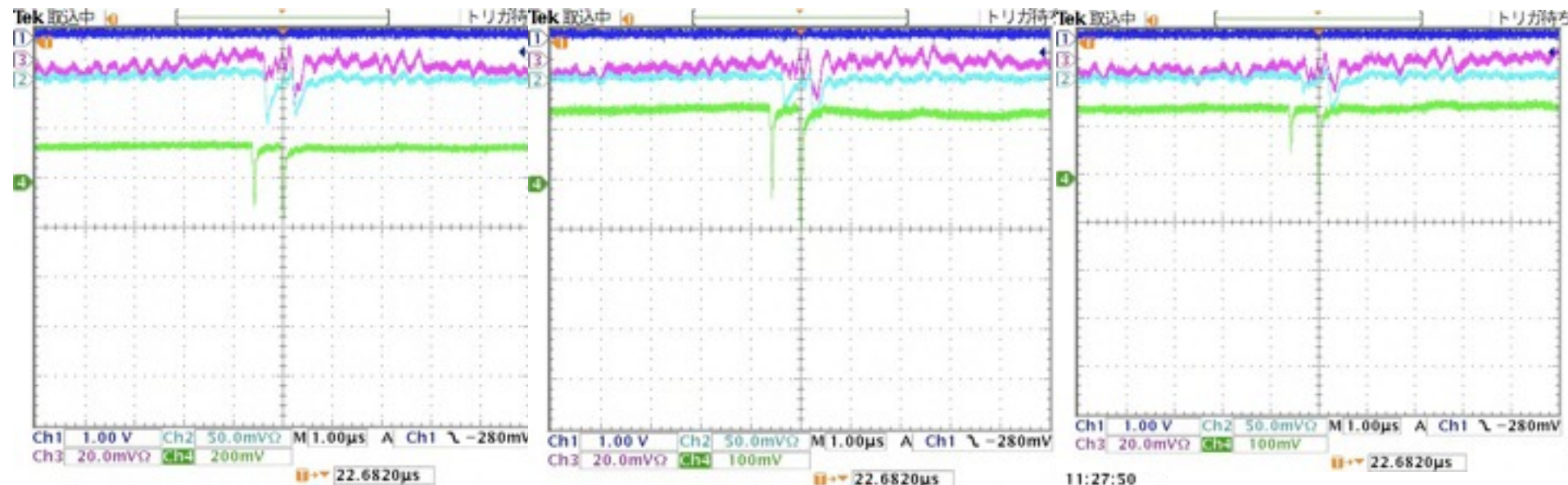
Can We Do Better?

- Change the chopper RF phase relative to the micro bunch
 - Phase mismatch causes beam loss at RCS
 - Previous setting was optimized by using RCS loss monitors
- We scanned the relative phase with looking at abort line monitor signal

$\Delta\phi = 0$ deg

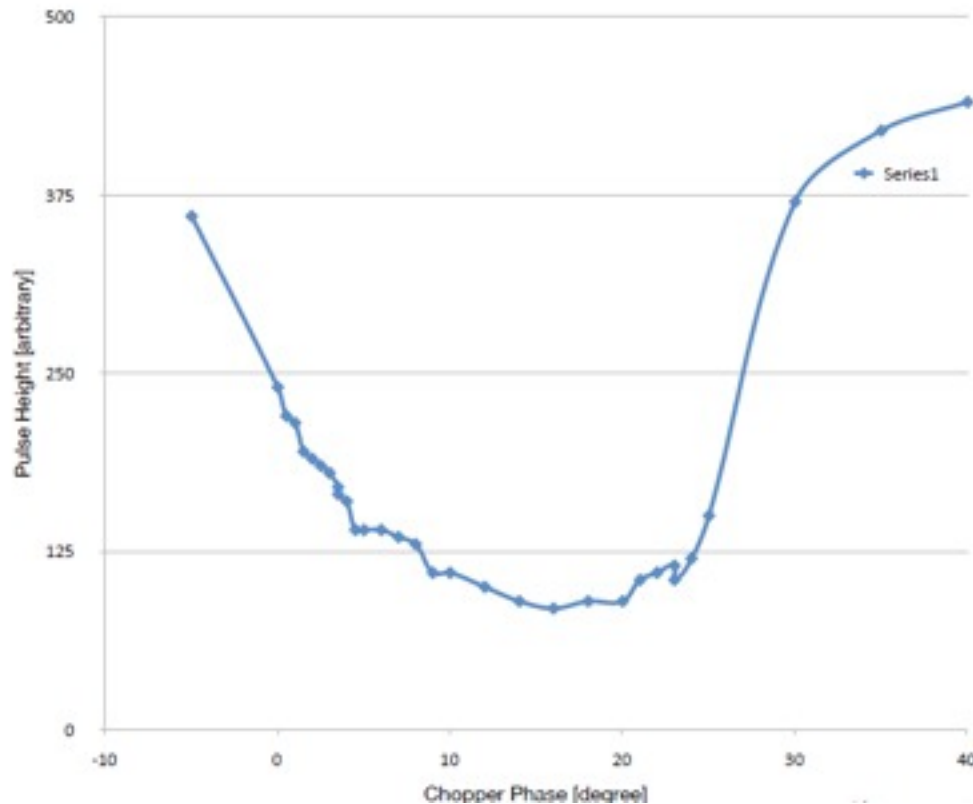
$\Delta\phi = 8$ deg

$\Delta\phi = 16$ deg



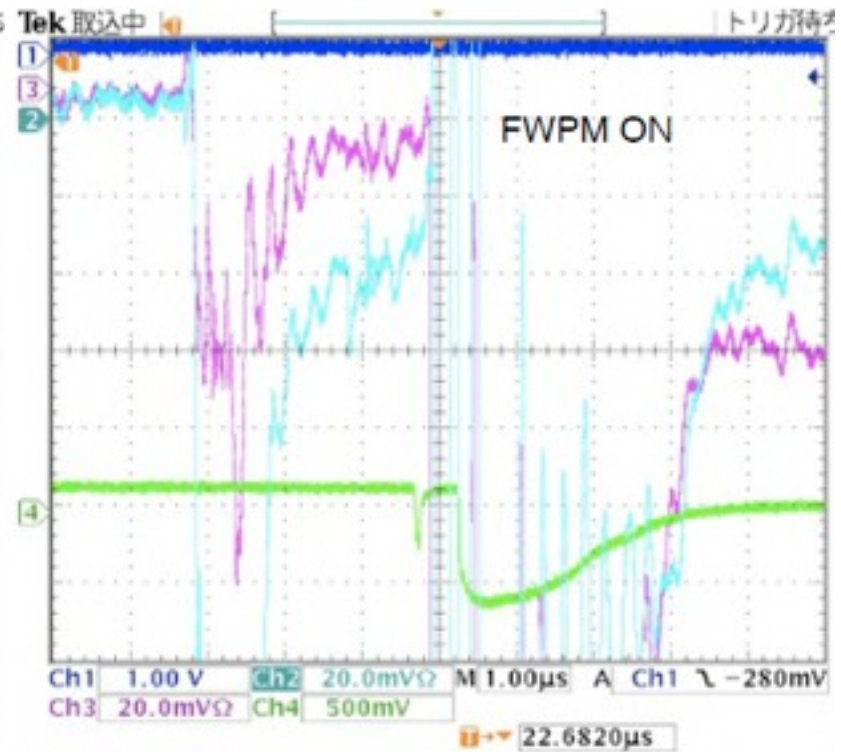
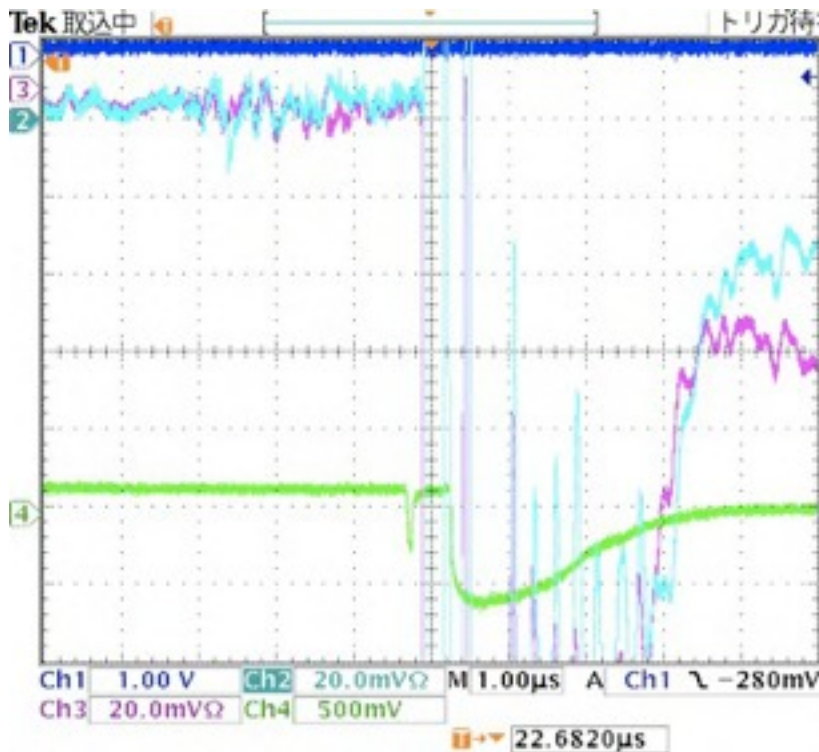
Chopper Phase Optimization

- Factor of 2.5 improvement → Extinction $< 2 \times 10^{-5}$
 - Estimated only from pulse height
 - Perhaps better than this because of scintillator saturation
- The chopper (two cavities) is currently driven by a single power supply. Operation with two independent power supply is planned. This is expected to improve.



Study with Higher PMT Gain

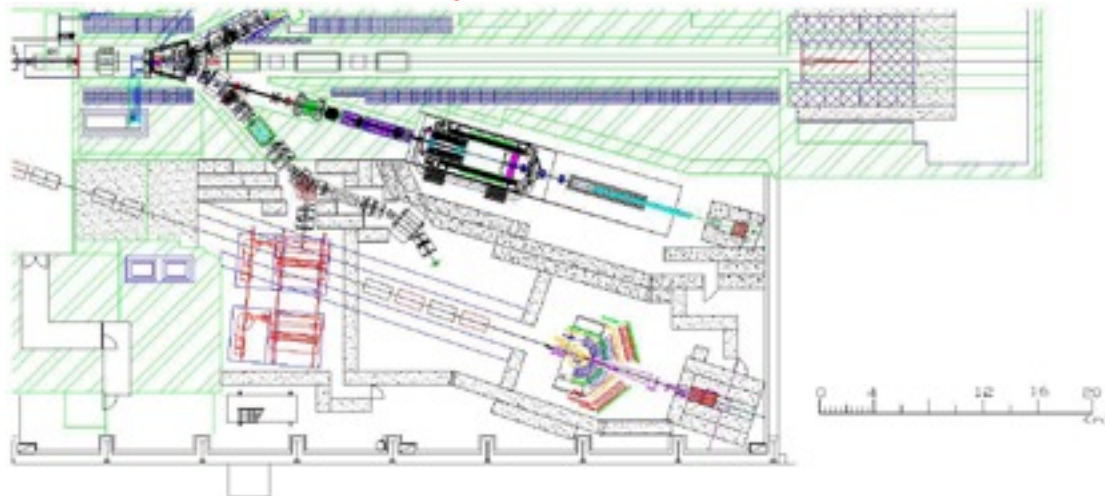
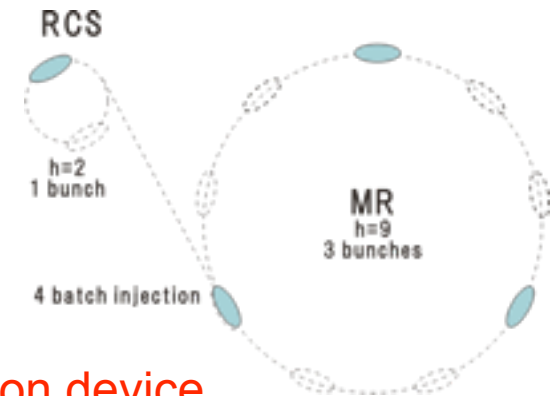
- Increased the gain of the PMT
- Installed FWPM (Flying Wire Profile Monitor) for evaluating the effect of material on the proton trajectory
 - Not equivalent, but any indication of ESS septum foil effect ?
 - Need to investigate with bunched slow extraction
- “Scattered” protons are not captured in RF buckets but coasting along the ring



PROTON EXTRACTION/TRANSPORT

Extraction and Transport

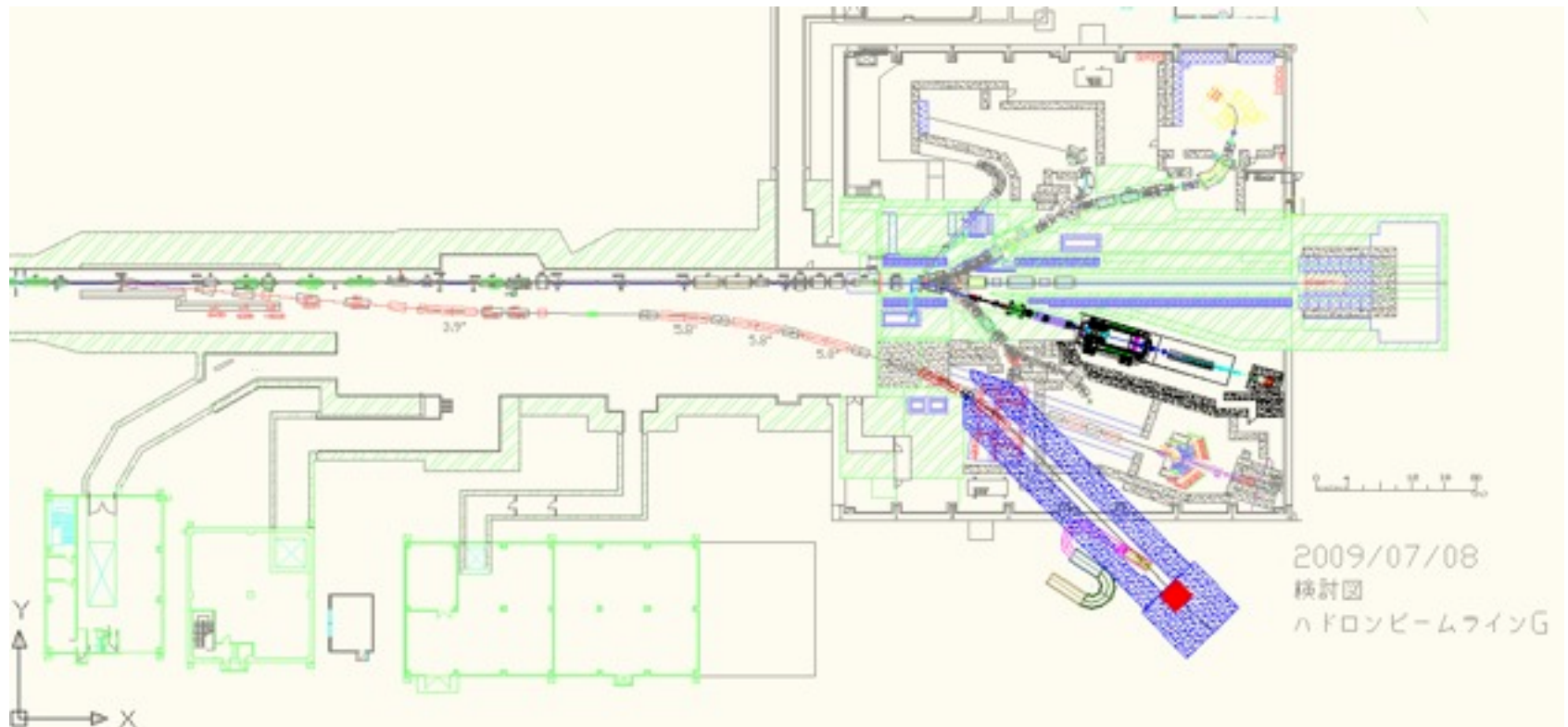
- AC dipole R&D is in progress
- Investigation of different kind of external extinction devices
 - RF separator
- Internal extinction device is also under consideration
 - RF kicker
 - Scraper
- Request to measure the extinction with external extinction device
 - The device must be ready and installation must be completed before that
 - Perhaps at B-line or in switch yard



EXPERIMENTAL SPACE

Experimental Space

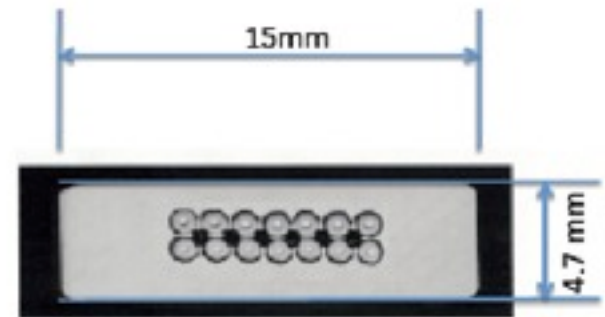
- Discussion in the task force
 - Target and beam dump outside the hall
 - Share the upstream proton transport line with the high p beam line
 - External extinction device in the switch yard



SOLENOID MAGNET

Solenoid Magnet R&D

- Progress with the COMET collaboration
- Recent activities are summarized in CDR and presentation by A.Sato and M.Yoshida
- Task Force has been considering mainly necessary facilities like power supplies and refrigerator.
 - Report at the 7th PAC meeting
- Production of three different aluminum stabilizer in FY2009
 - Ni
 - Mg+Cu
 - Y
 - Investigating the possibility to study degradation of RRR under neutron radiation above $10^{20-21}n/m^2$
- Production of 200m super-conducting wire
 - Study of basic manufacturing process
 - Adhesive strength between conductor and aluminum



Summary

- Proton acceleration
 - Chopper inefficiency is not negligible for COMET
 - Pre-chopper is expected to improve this
 - Chopper operation with two independent power supplies
 - New bunch configuration (3 filled out of 9 buckets) is considered
- Extinction
 - 1st measurement at abort line
 - Preliminary result of extinction level 2×10^{-5}
 - secondary beam line measurement
- Extraction/Transport
 - Bunched slow extraction test when we perform the secondary beam line measurement of the extinction
 - Development of external extinction devices
 - AC dipole
 - Other method
- Experimental Space
 - JPNC discussion based on task force discussion
- Solenoid magnet
 - R&D started with the collaboration