TUPP24

IBIC 2021 International Beam Instrumentation Conference

Development of a Profile Monitor Using OTR and Fluorescence for Injected Beams in J-PARC Main Ring

Y. Hashimoto[1, 2#], Y. Sato[1, 2], T. Toyama[1, 2], T. Mitsuhashi[1, 2], T. Nakamura[1, 2], H. Sakai[3], M. Tejima[1, 2], and M. Uota[1, 2]

[1] J-PARC Center, Tokai, Ibaraki 319-1195, Japan
[2] Accelerator Laboratory, KEK, Tsukuba, Ibaraki 305-0801, Japan
[3] Mitsubishi Electric System & Service Co., Ltd., Tsukuba, Ibaraki 305-0045, Japan

#: yoshinori.hashimoto@kek.jp

Abstract

A two-dimensional beam profile monitor having a high dynamic range approximately six orders of magnitude by using of Optical Transition Radiation (OTR) and fluorescence screens has been operated in the injection-beam transport (3-50BT) line of the J-PARC main ring (MR) [1, 2]. This device contributes to the diagnosis of beam core and halo of intense proton beams before injection to MR, particularly measurement of beam cut effects by beam collimators located in upstream of the device is useful for beam shaping. We have been developing the second device to be installed into MR for diagnosing on injected beams. By using the both of first and second devices, beam core and halo can be diagnosed in different phases. Moreover, by using the second device, beam profiles including halo can be measured with circulating beams in almost twenty turns after injection. Property tests of the second device have been conducted at a test bench to install it in the ring. But its longitudinal coupling impedance of several ohms (by Z/n value) is an issue, especially due to high-frequency resonance at the in-vacuum optical system structure by beam wake fields. Then we have been studying the absorption of the rf power of the resonances up to about 1 GHz using SiC. In this presentation, we will discuss the characteristics of the developing device, and simulation results of suppressing the coupling impedance.

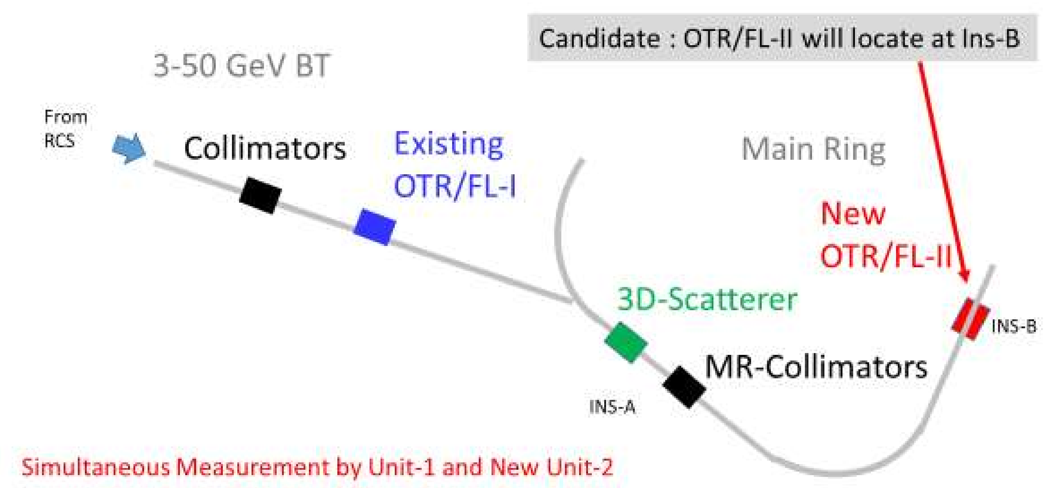
*This work was supported by JSPS KAKENHI Grant Number JP16H06288.

References
[1] Y. Hashimoto, et al., Proc. IBIC2013, Oxford, UK, Sep. 2013, pp338-341; http://accelconf.web.cern.ch/IBIC2013/papers/tual2.pdf
[2] Y. Hashimoto, et al., Proc. HB2014, East-Lansing, USA, Nov. 2014, pp187-191; http://accelconf.web.cern.ch/HB2014/papers/tuo2ab04.pdf

IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Beam Halo Diagnosing-Tools for MR injection

OTR/FL - I, II and 3D-Scatterer



Simultaneous Measurement by Unit-1 and New Unit-2

- Injection Beam Matching (Phase Space, Beam Halo)
- 20 turns Beam Halo by Unit-2
- Evaluation for Beam Collimation by BT and MR collimators

IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

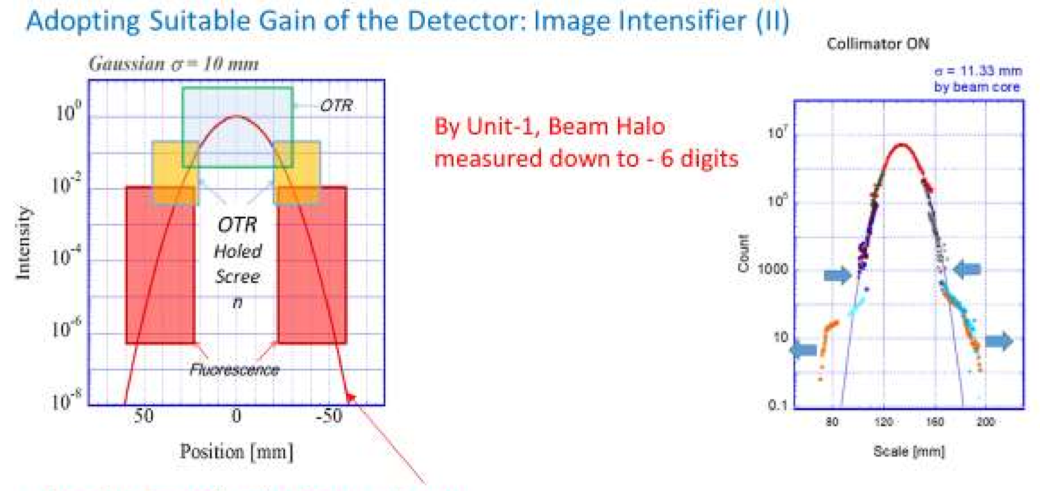
Concept (1): Dynamic range

Combination measurement with OTR and the fluorescence:

Beam core : Measure with OTR from 10 microns titanium foil with smaller beam loss

Beam Halo : Measure with Fluorescence from Chromium doped alumina screen

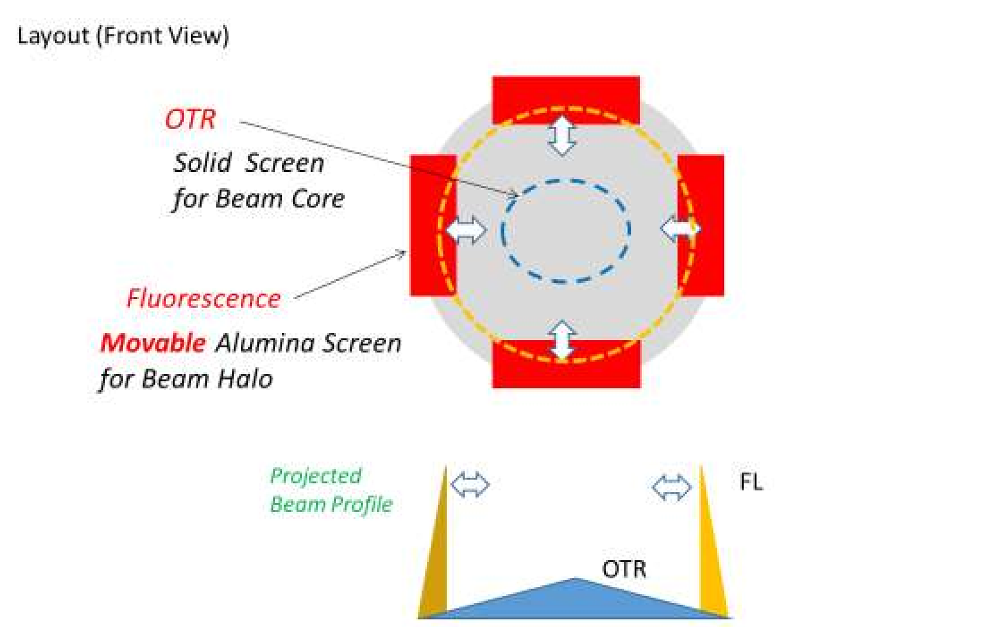
Adopting Suitable Gain of the Detector: Image Intensifier (II)



Gaussian Beam distribution σ = 10 mm
Intensity: 10^{13} proton/bunch

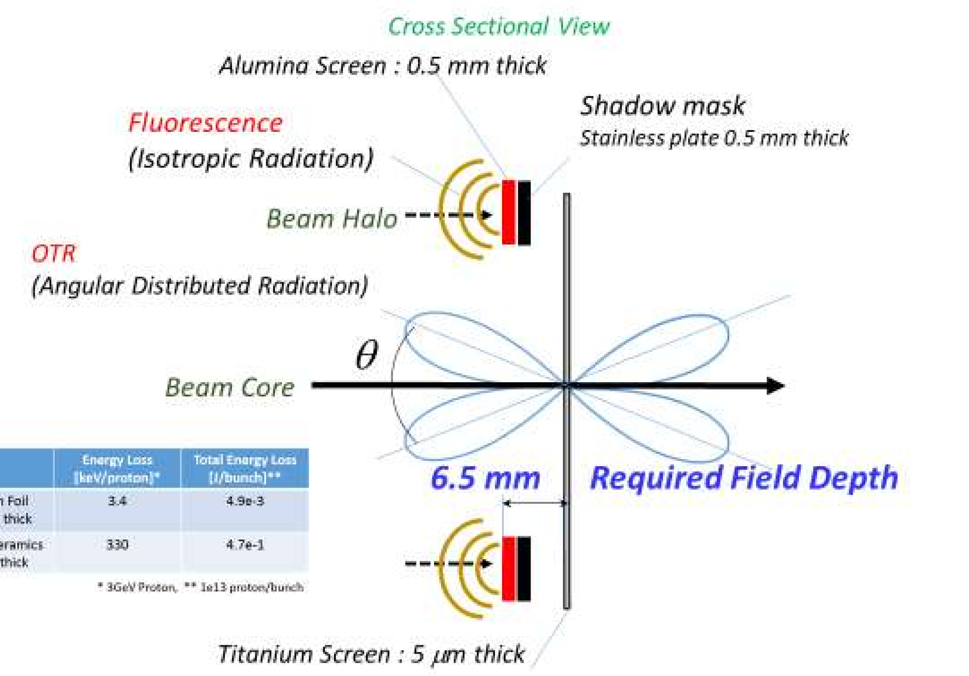
IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Concept (2): Screen Configuration



IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Concept (3): Screen Cross-sectional View



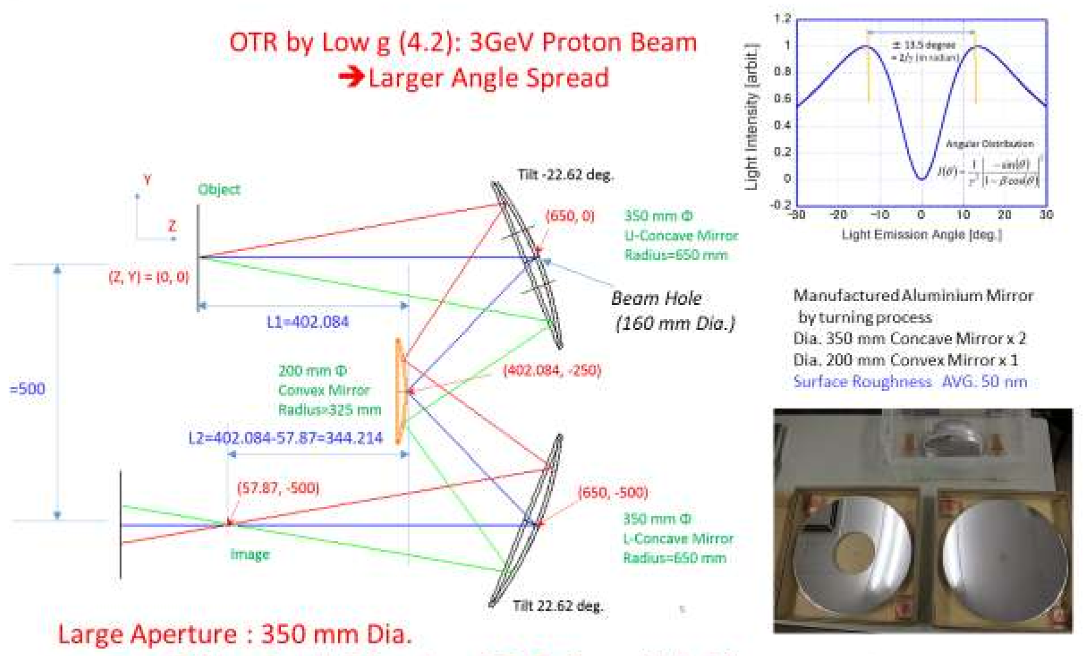
	Energy Loss [keV/proton]*	Total Energy Loss [J/bunch]**
Titanium Foil 5 micron thick	3.4	4.9e-3
Alumina Ceramics 0.5 mm thick	330	4.7e-1

* 3GeV Proton, ** 1e13 proton/bunch

IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Concept (4): Optics, Offner Relay System

OTR by Low g (4.2): 3GeV Proton Beam
➔ Larger Angle Spread

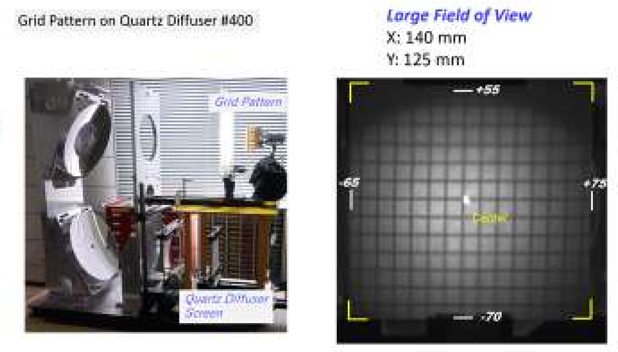


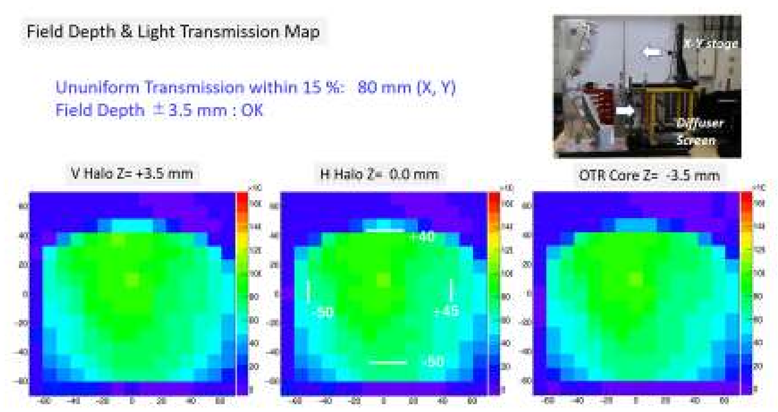
Large Aperture : 350 mm Dia.
➔ Very Small F Number : 0.7 ➔ Beam Halo Measurement
➔ Thinner Field Depth 7 mm

IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Optics, Features

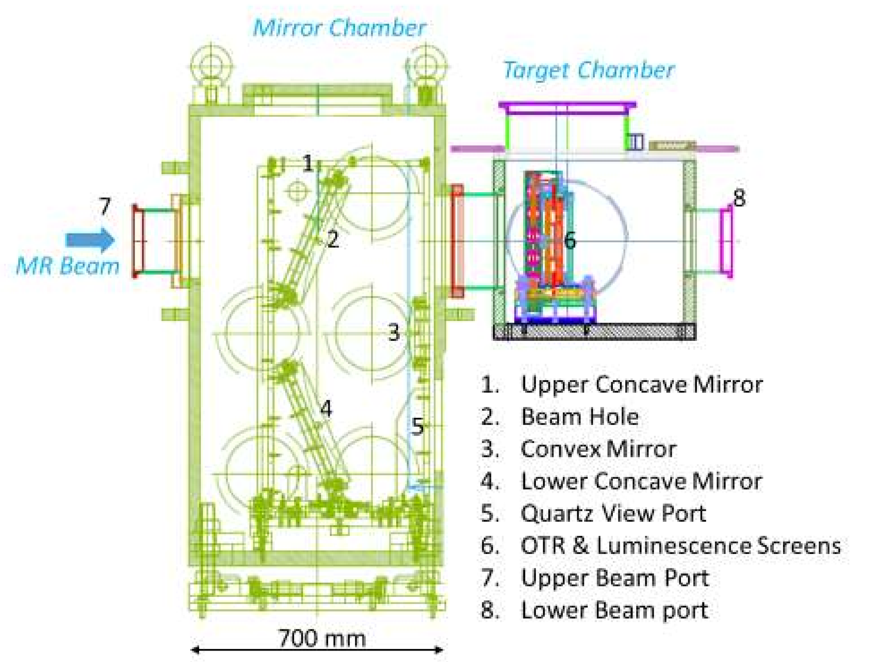
Large Field of View
➔ X: 140 mm, Y: 125 mm
Field Depth : 7 mm





IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

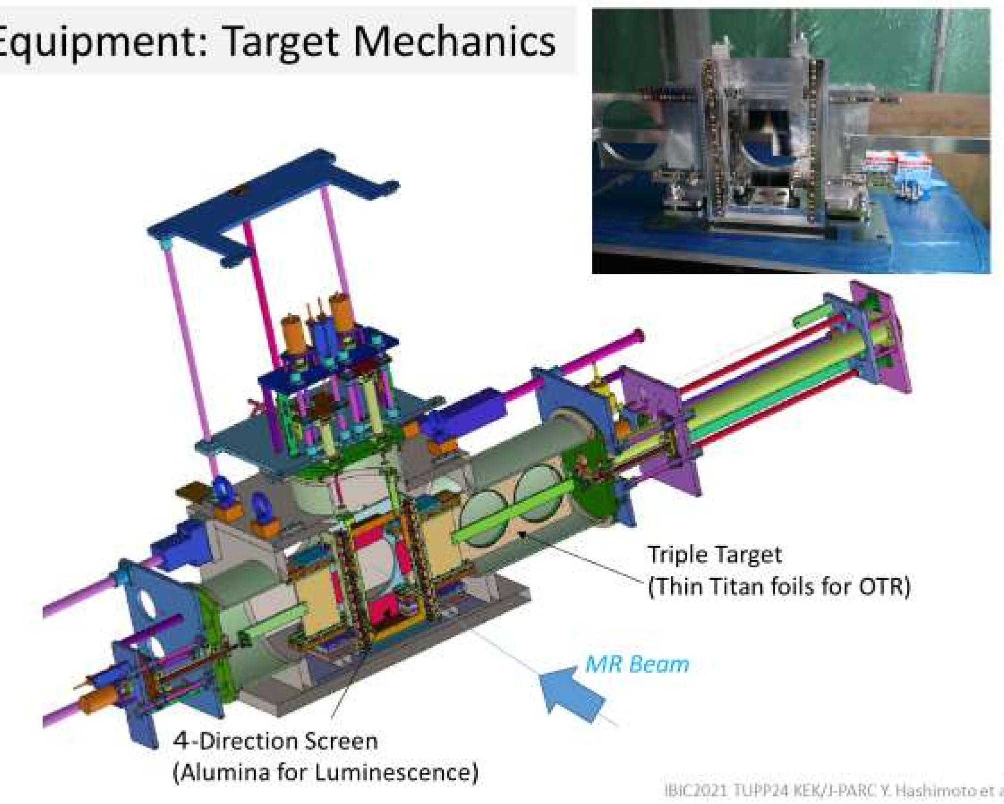
Equipment: Side Cross-sectional View



1. Upper Concave Mirror
2. Beam Hole
3. Convex Mirror
4. Lower Concave Mirror
5. Quartz View Port
6. OTR & Luminescence Screens
7. Upper Beam Port
8. Lower Beam port

IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

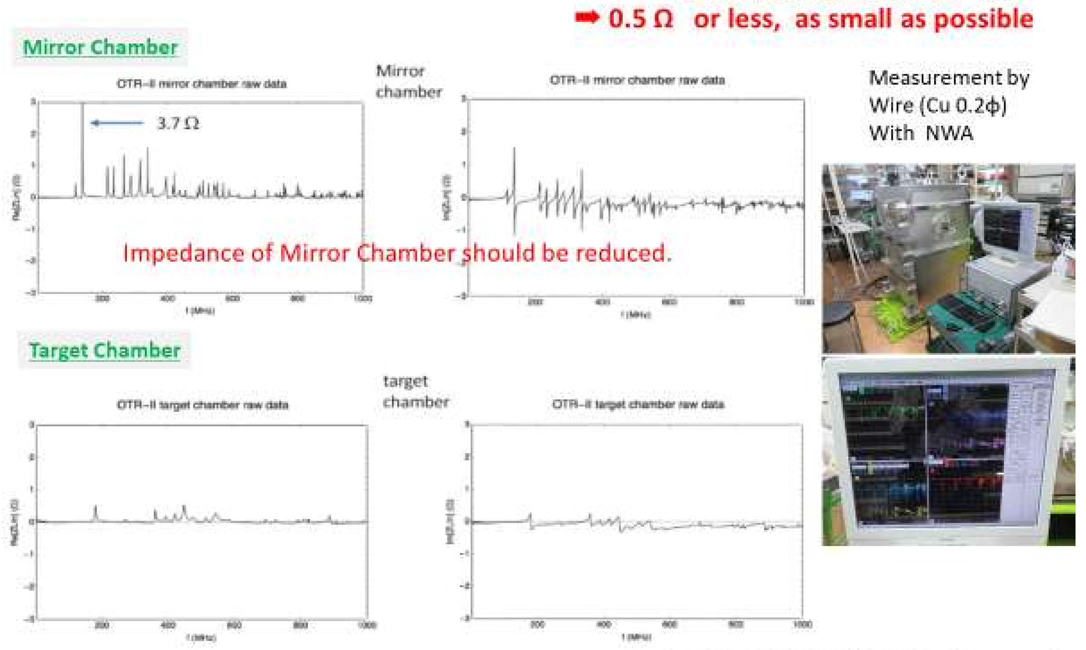
Equipment: Target Mechanics



IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Coupling Impedance

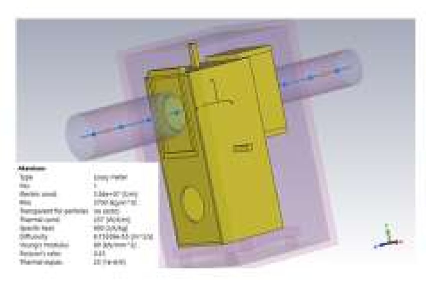
Microwave Instabilities at the time of beam de-bunch in Slow Extraction
Keil-Schnell Criterion for CW beam :
9 Ω @ SX debunch w 3.3 × 10^{14}ppp
➡ 0.5 Ω or less, as small as possible



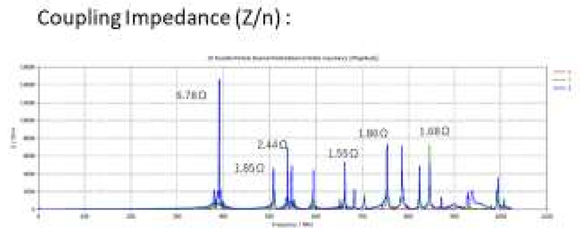
IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Impedance Reduction by Structure (Simulation)

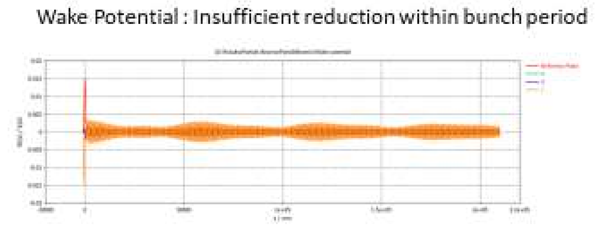
Offner Mirrors were covered with metal case
➡Resonating reduction time was too long
➡Impedances were not so reduced



Coupling Impedance (Z/n) :

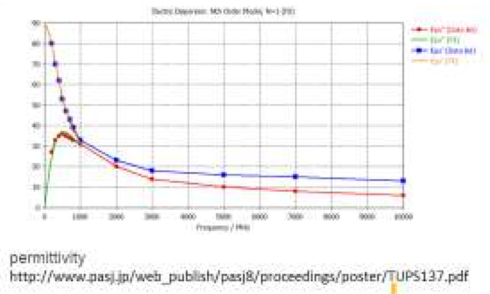


Wake Potential : Insufficient reduction within bunch period



IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

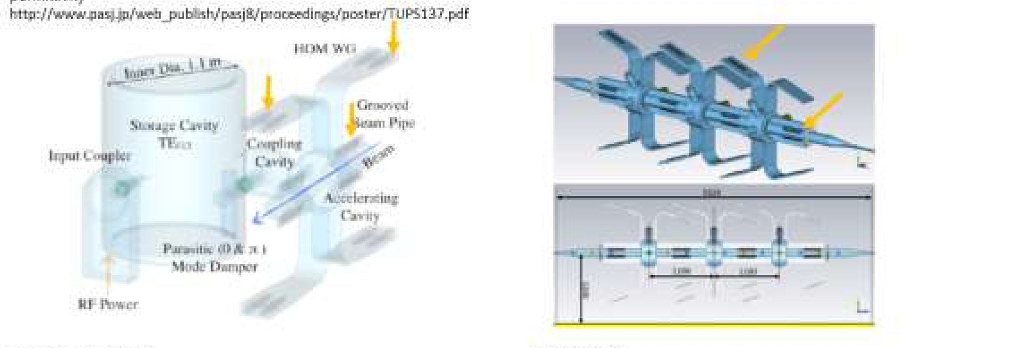
Field Absorption with SiC (Silicon Carbide)



$P_1 = K \cdot \varepsilon_r \cdot \tan\delta \cdot f \cdot E^2$ [W/m³]

≧ 100 MHz
High tanδ

permittivity
http://www.pasj.jp/web_publish/pasj8/proceedings/poster/TUPS137.pdf



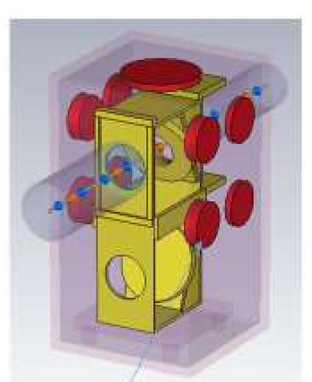
SuperKEKB ARES Cavity
http://www.pasj.jp/web_publish/pasj8/proceedings/poster/TUPS126.pdf

KEKB DR Cavity
http://www.pasj.jp/web_publish/pasj8/proceedings/PDF/THLR/THLR06.pdf

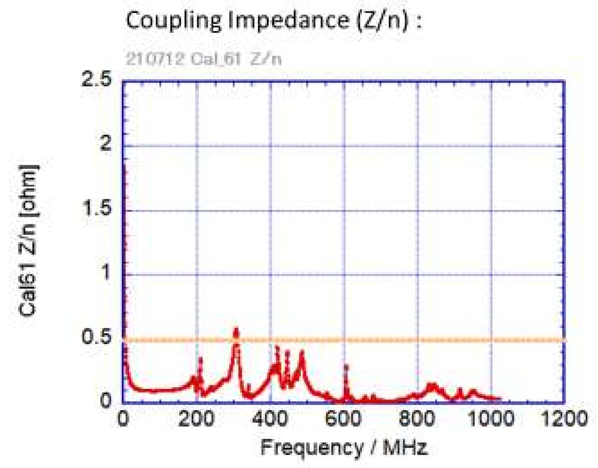
IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Impedance Reduction by SiC (Simulation)

SiC Plates (Red color)



Coupling Impedance (Z/n) :



Downstream side 4 plates thickness : 60 mm
Others thickness :30 mm

Z/n : ~0.6 Ω
Under 200 MHz :
small components remains to be considered

IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Impedance Reduction by SiC -2 (Simulation)

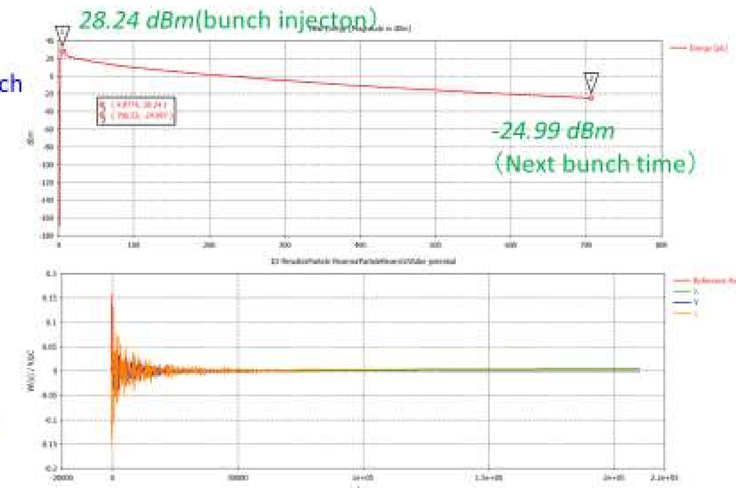
Field Energy :

-52dB reduced during bunch separation

0.66 W at 4.8e-7C/bunch
*(3e12p/bunch)
*1GHz Gaussian beam

Wake Potential :

*Sufficient reduction by 1/3 bunch separation



IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.

Summary & Prospects:

- OTR / FL profile monitor have been developed to be installed in t J-PARC MR.
- It is necessary to suppress the coupling impedance (Z / n) to about 0.5 Ω or less as possible.
- High frequency absorption by SiC have been studied.
- By attaching SiC to chamber inside, we obtained a calculation result that can be expected to have a Z/n of about 0.6 Ω.
- The actual high-frequency absorption test using SiC is scheduled to start within this year.

IBIC2021 TUPP24 KEK/J-PARC Y. Hashimoto et al.