Beam loss monitoring using proportional counters at J-PARC

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(1) Using proportional conters at the KEK-PS

KEK-PS Booster (500 MeV) *Yamaguchi, Someya et al.*

Fast response turn by turn

Amplifier using electron tube (impedance conversion)

Contributed to finding H^- injection inefficiency

using @gain = 2 - 100

Life time ? (gain degradation?)

Linearity ?

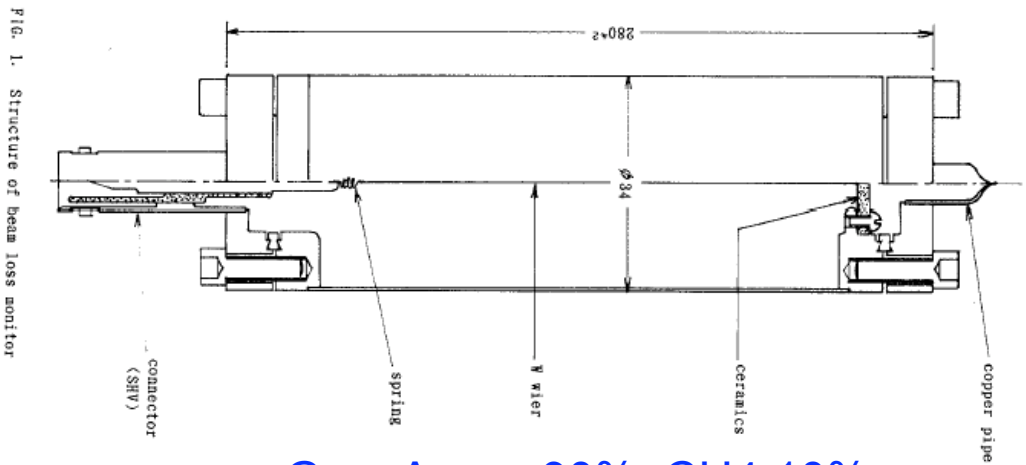
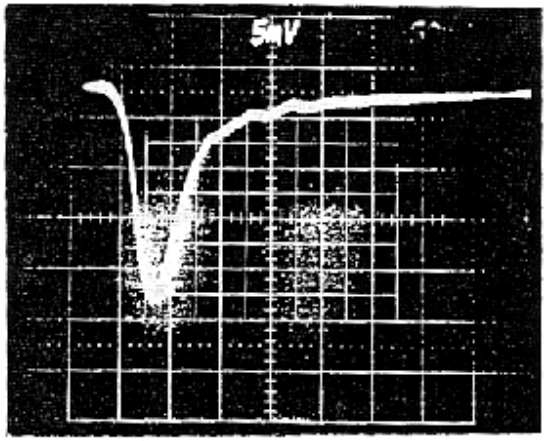
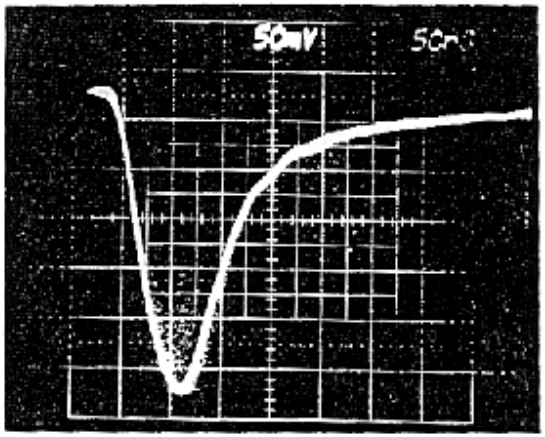


Fig. 1. Structure of beam loss monitor

Gas: Argon 90%, CH4 10%



(a) 50ns/div



(b)

Fig. 4 Photograpfs of detector output signal at the RG1 resister for two values of resistance: (a) RG1 = 50 Ω, and (b) RG1 = 1kΩ. These signals are outputs for single raciation which was obtained using a Cs^{137} γ source with an anode voltage of 2.3 kV.

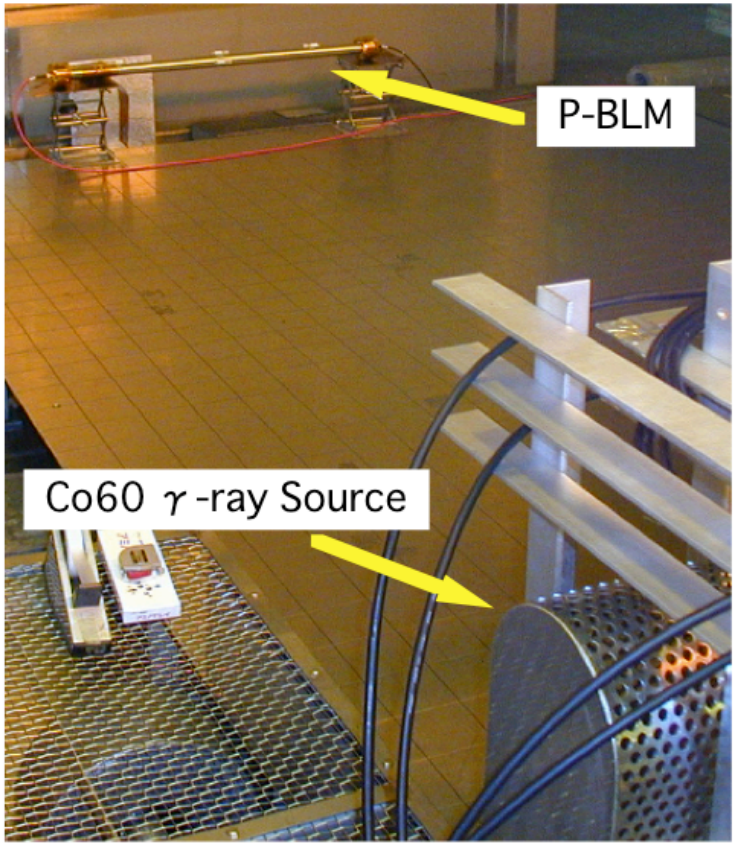
(2) Improvements

Longer life time

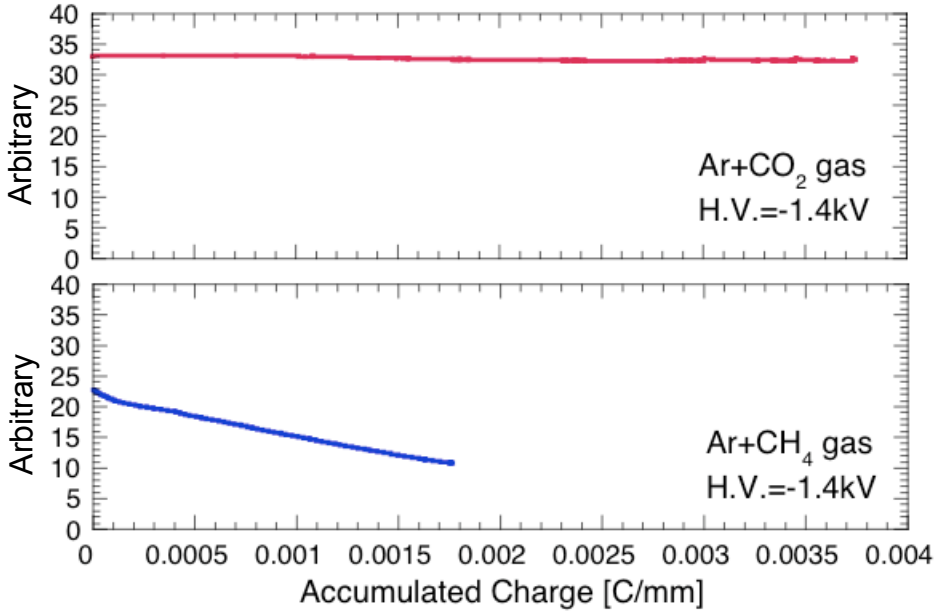
Gas : Ar 99%, CO_2 1 %

^{60}Co irradiation test

P-BLM collect secondary electrons induced by γ -ray flux with inner wall of SUS tube.



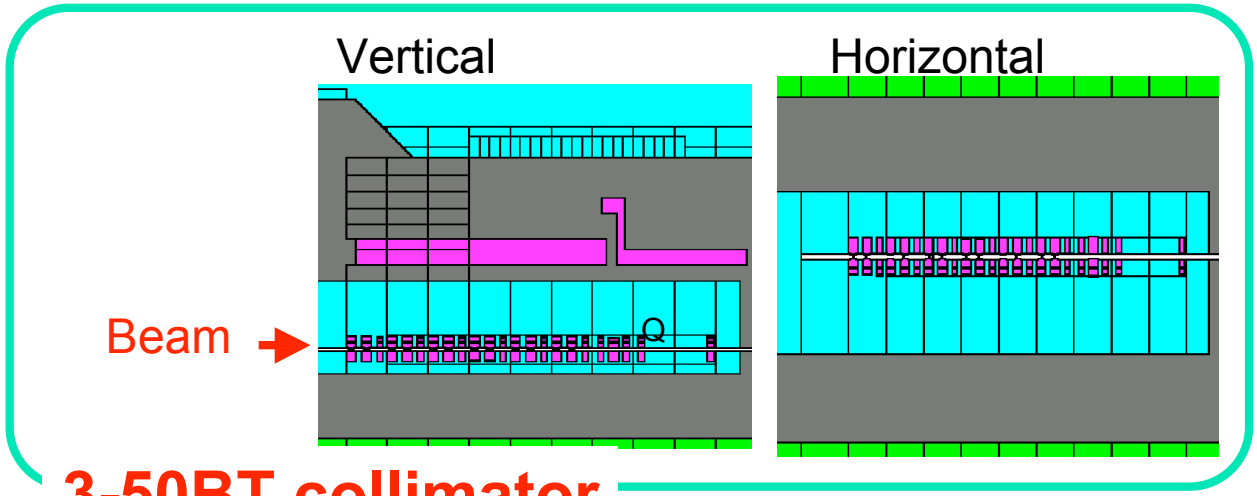
Radiation Dose 10kGy/h~0.2kGy/h



Improved with Ar 99%, CO_2 1 %

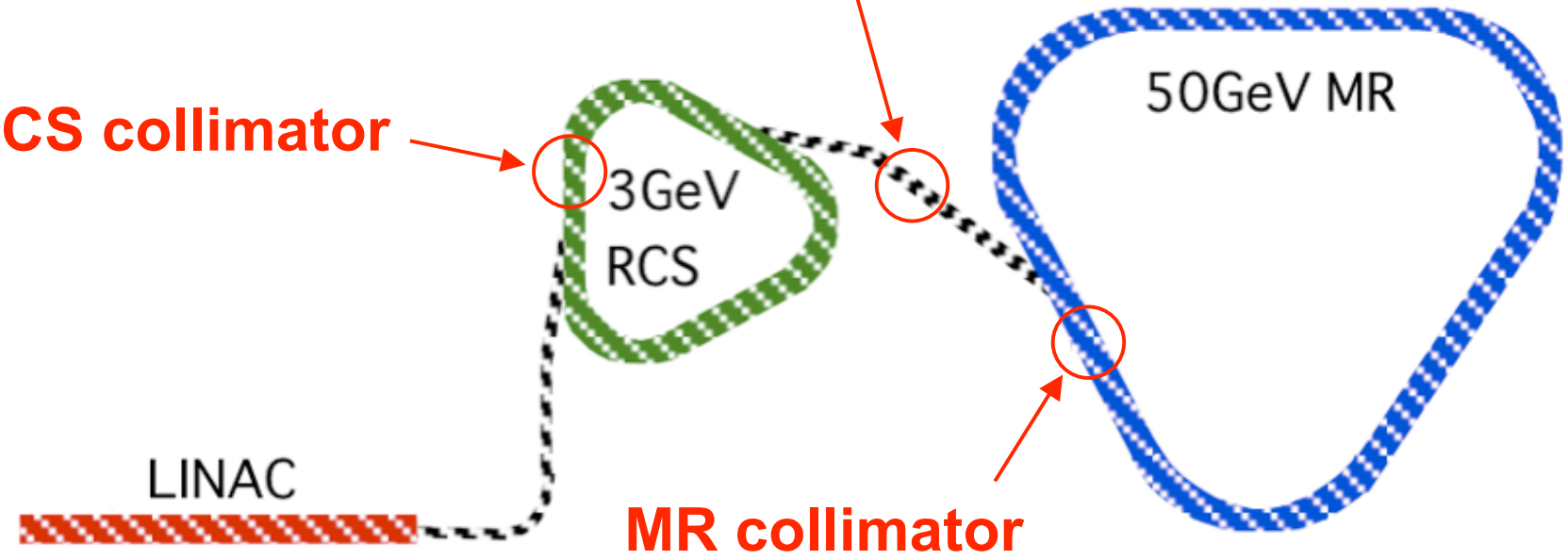
Linearity

Dose estimate
around the collimator
by MARS



3-50BT collimator

RCS collimator



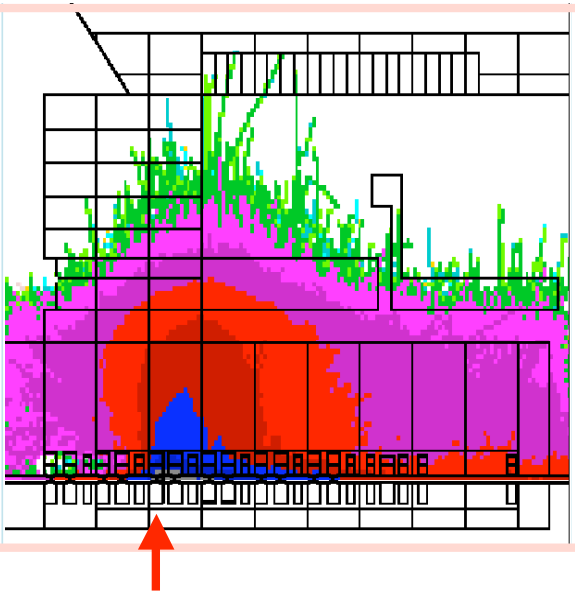
MR collimator

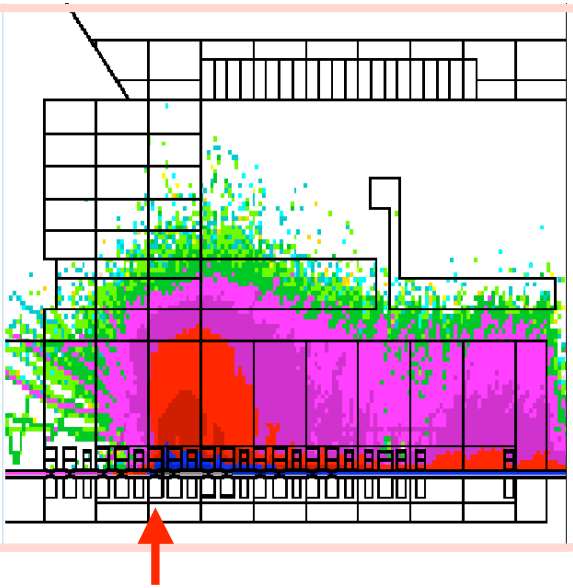
Dose calculation at 3-50BT Colliamator by MARS

Neutral Fluence Distribution

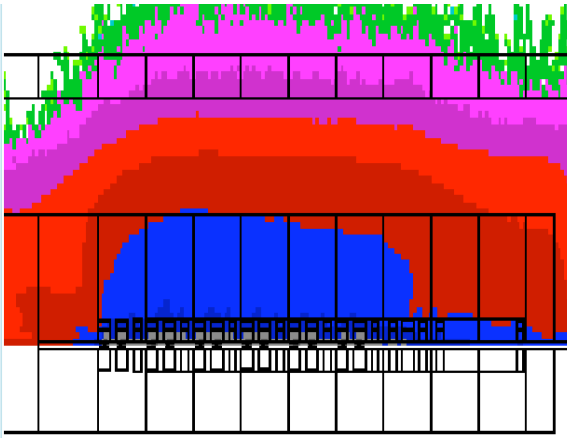
Charged Fluence Distribution

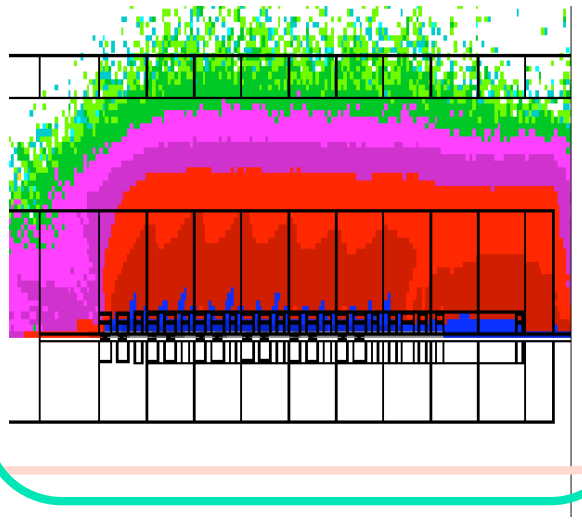
Point loss





Uniform loss





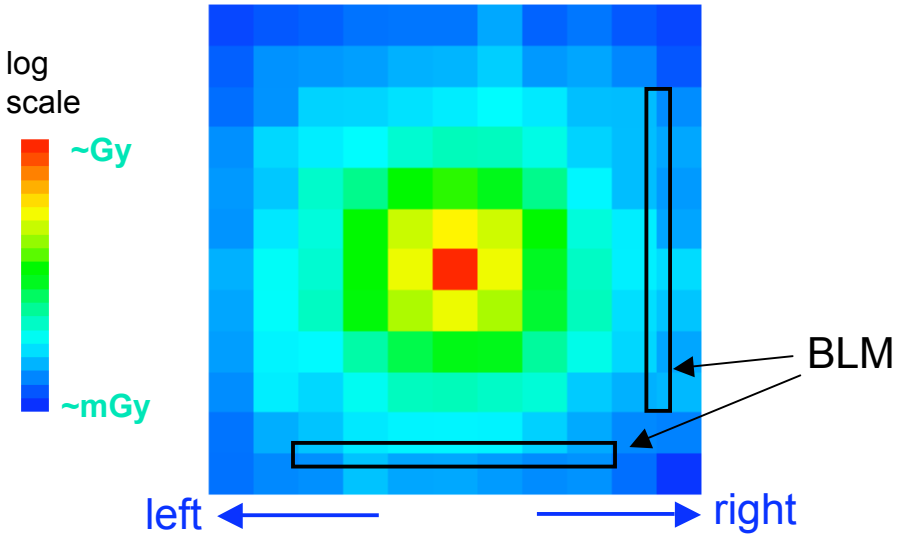
Instantaneous pulsed dose at the collimator

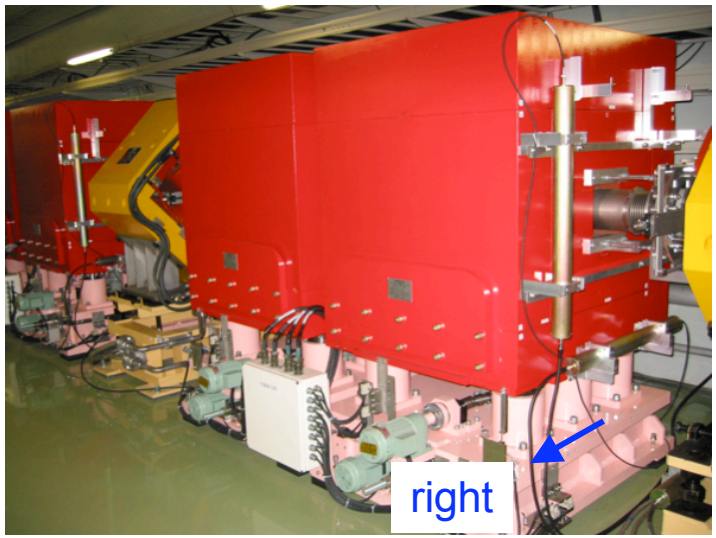
1 shot ~ 8.5 10^{11} p: equivalent to 450 W loss (limit)

Point loss ~ 0.15 Gy/shot = 15 rad

Uniform loss ~ 0.012 Gy = 1.2 rad

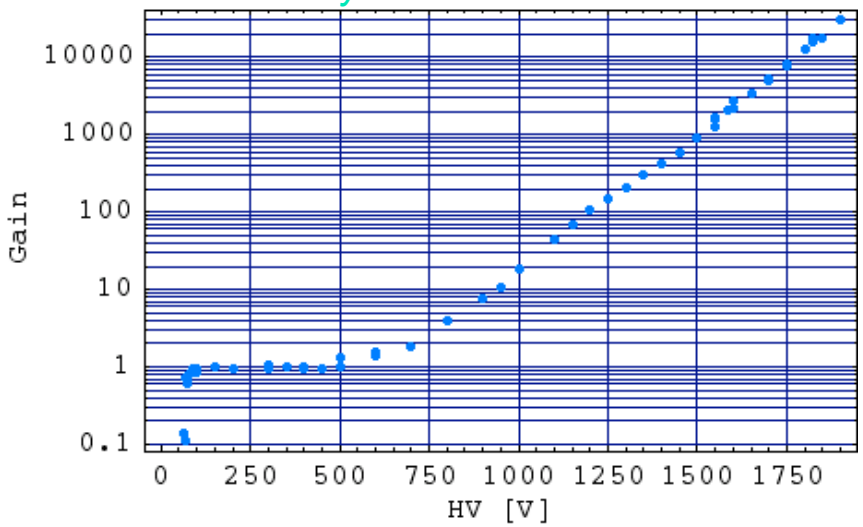
Dose at the collimator downstream (Ar)

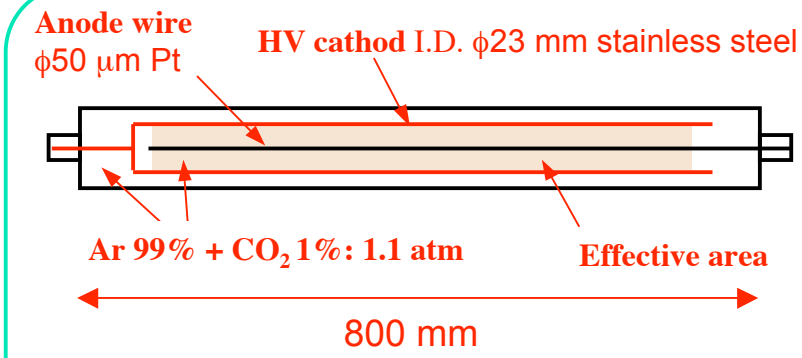




Gain curve obtained with cosmic ray

Preliminary



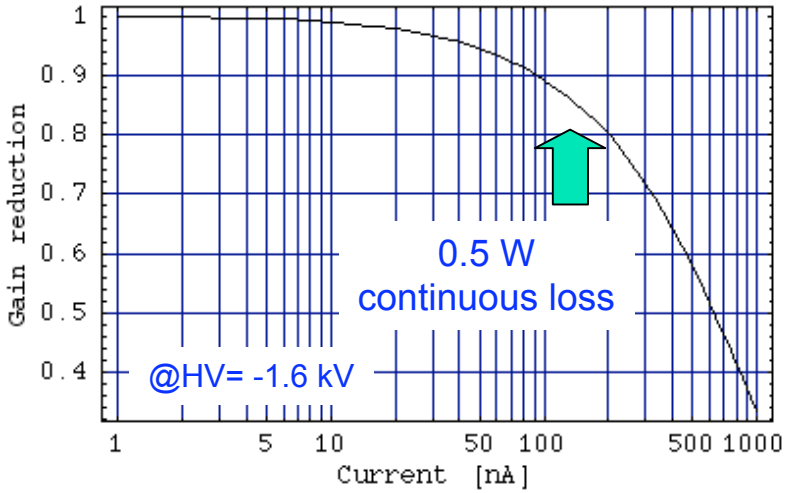


Sensitivity

200 nC / rad x gain (calculation)

gain ~ 60000 (~2 kV)

Positive ion space charge depresses gas gain



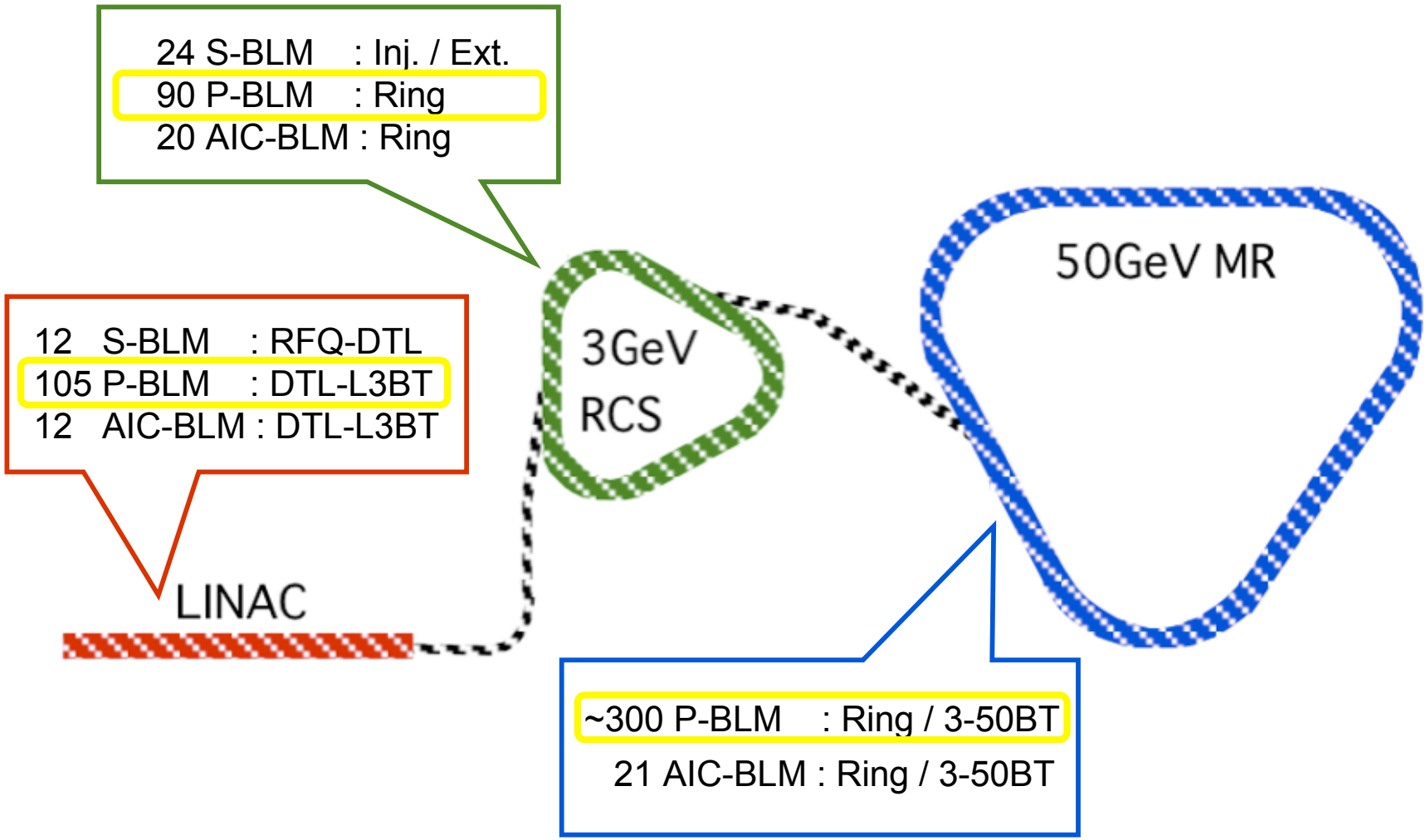
simplified calculation
R.W.Hendricks,
Rev.Sci.Inst. 40 (1969)
p.1216.
(factor "π" is corrected)

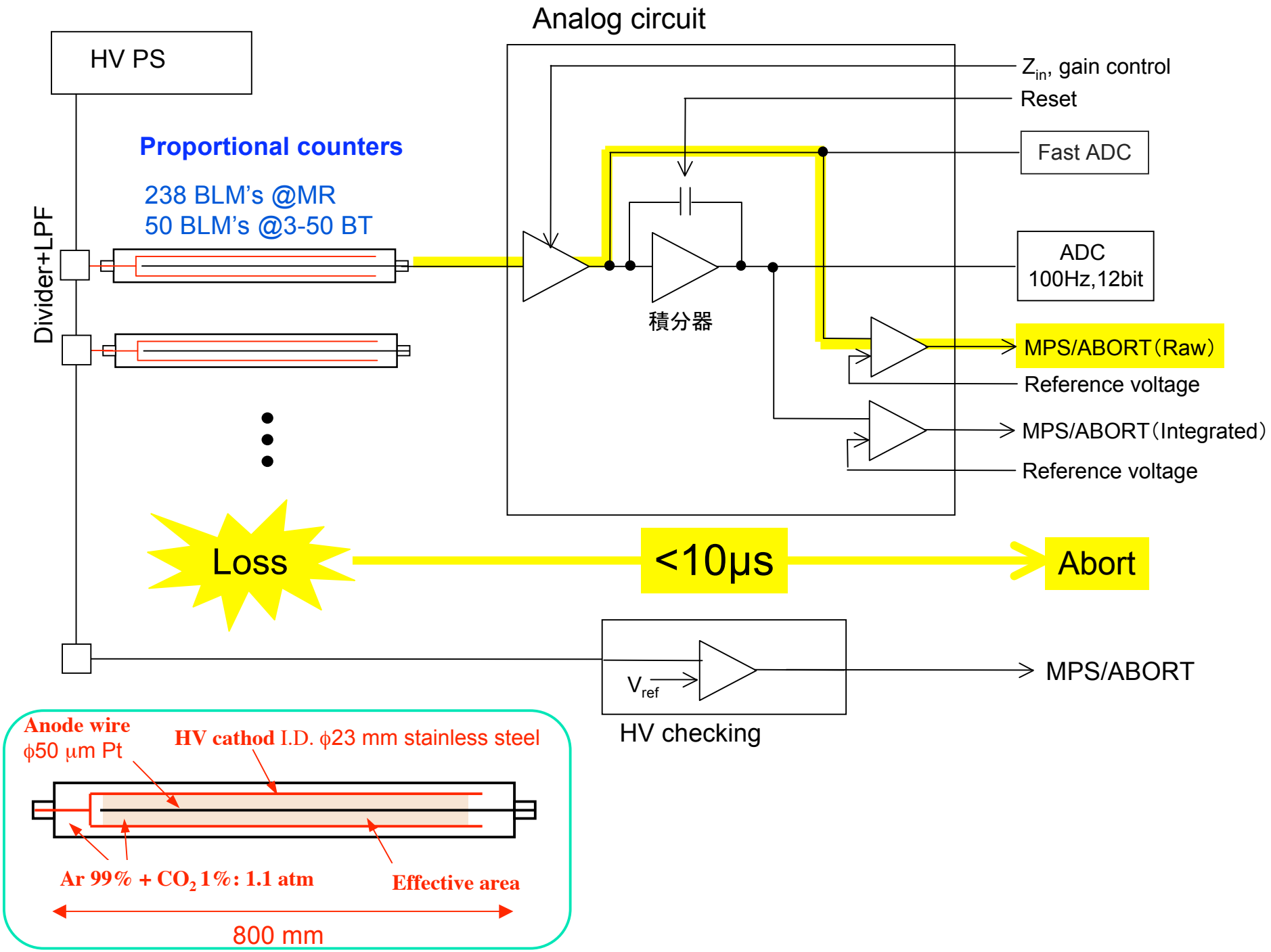
200 nC / rad x 1.2 rad / shot x gain
= 240 nC / shot x gain

Instantaneus loss
far beyond

For the collimators working at high intensities
Ionization chamber may be appropriate
will be prepared, complement prop. counter

(3) Beam loss monitor system at the J-PARC MR

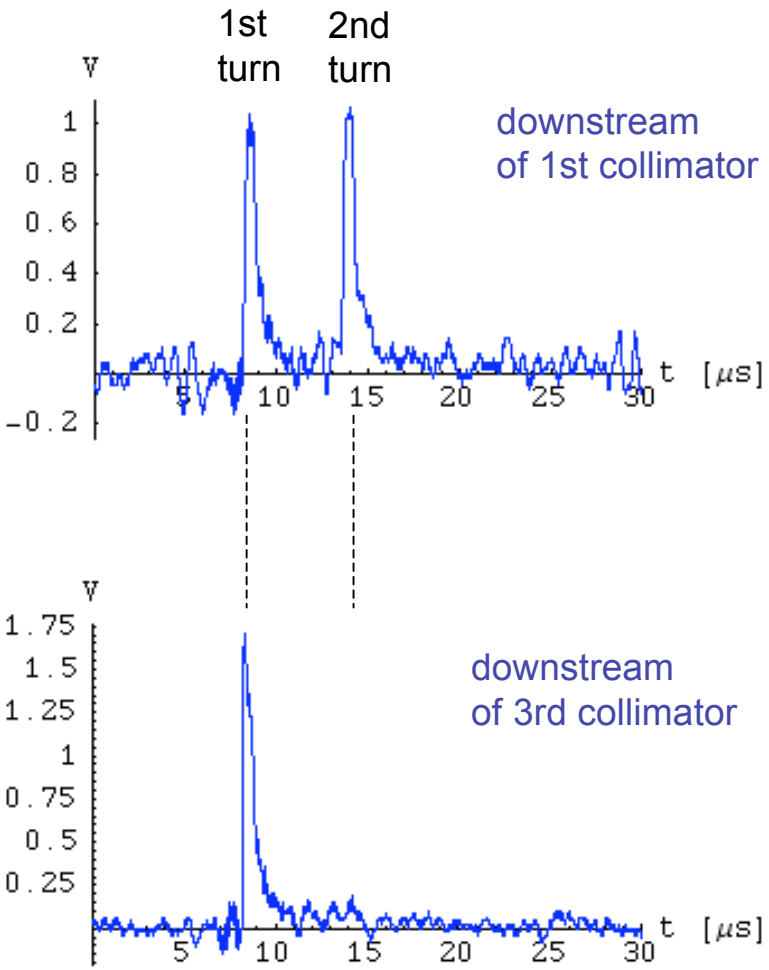


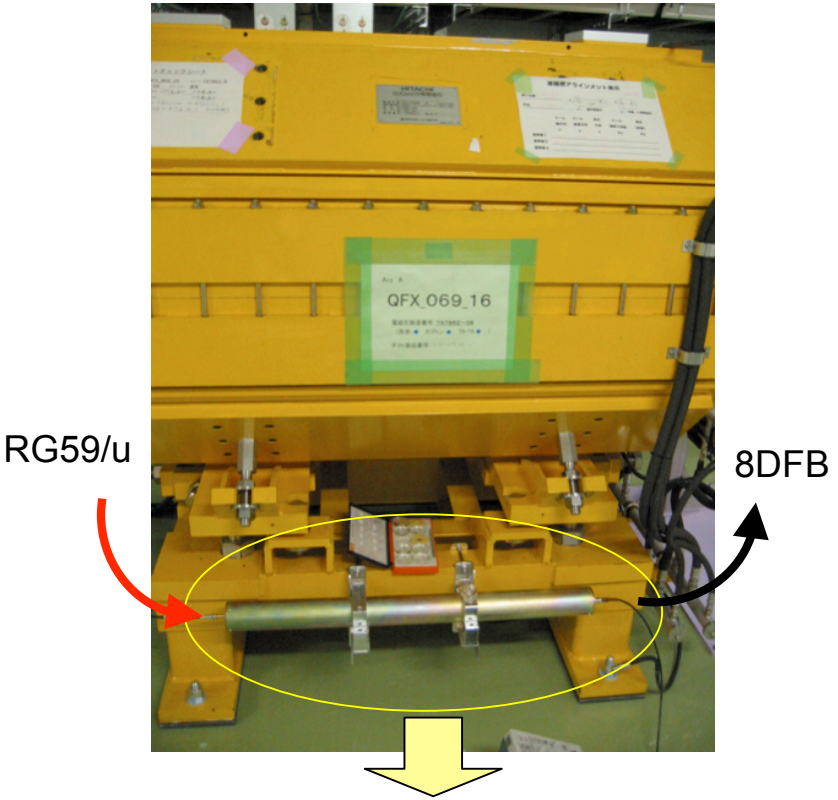

Analog circuit
HV PS
Proportional counters
238 BLM's @MR
50 BLM's @3-50 BT
Divider+LPF
Z_{in}, gain control
Reset
Fast ADC
ADC
100Hz,12bit
積分器
MPS/ABORT（Raw）
Reference voltage
MPS/ABORT（Integrated）
Reference voltage
Loss
<10μs
Abort
V_{ref}
MPS/ABORT
HV checking
Anode wire
ϕ50 μm Pt
HV cathod I.D. ϕ23 mm stainless steel
Ar 99% + CO_2 1%: 1.1 atm
Effective area
800 mm

(4) Experience at the J-PARC MR

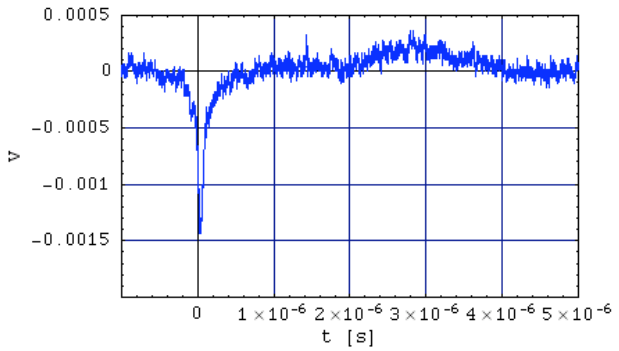
Response rise time ~ 100ns

Integrated Zin = 50Ω, gain = 10, HV = −1.6 kV





Cosmic ray



Sensitivity

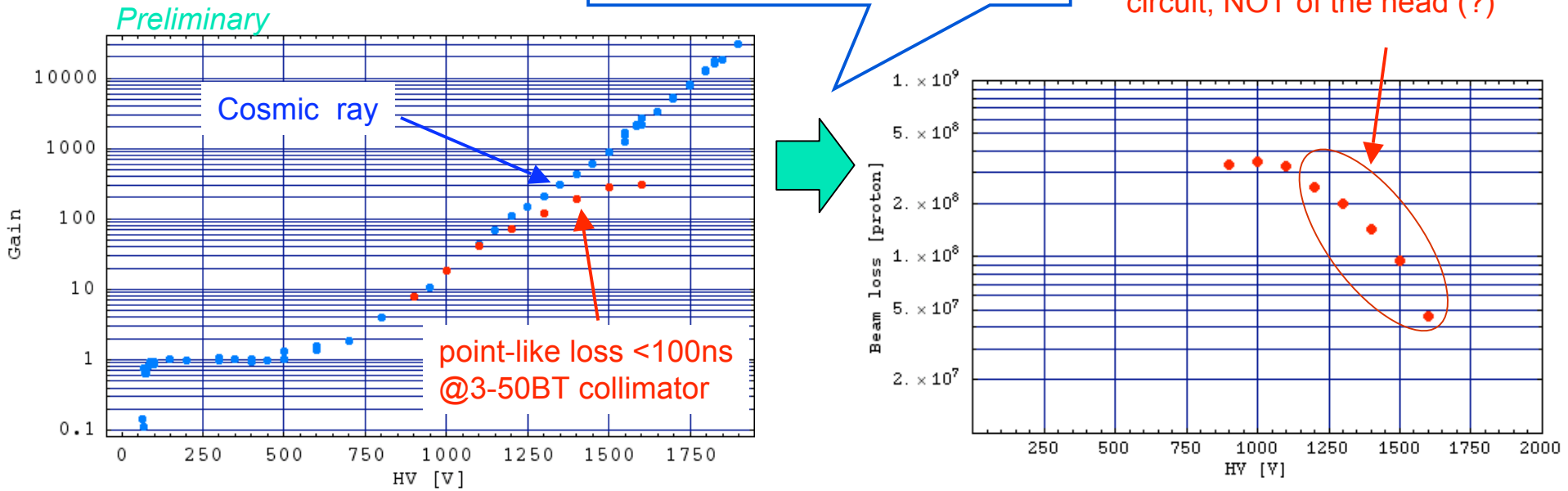
200 nC / rad x gain (calculation with MIP)

gain ~ 60000 (~2 kV)

Linearity

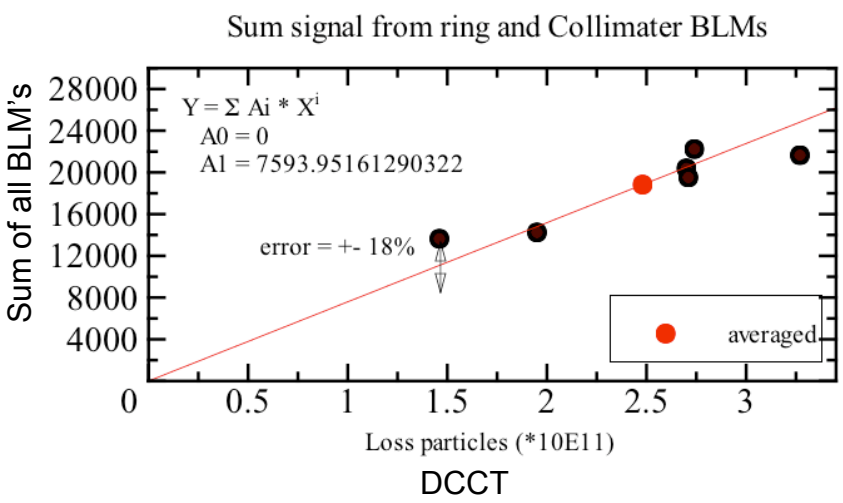
Translate the signal charge
to loss amount
using MARS result of point loss

Saturation of the processing
circuit, NOT of the head (?)

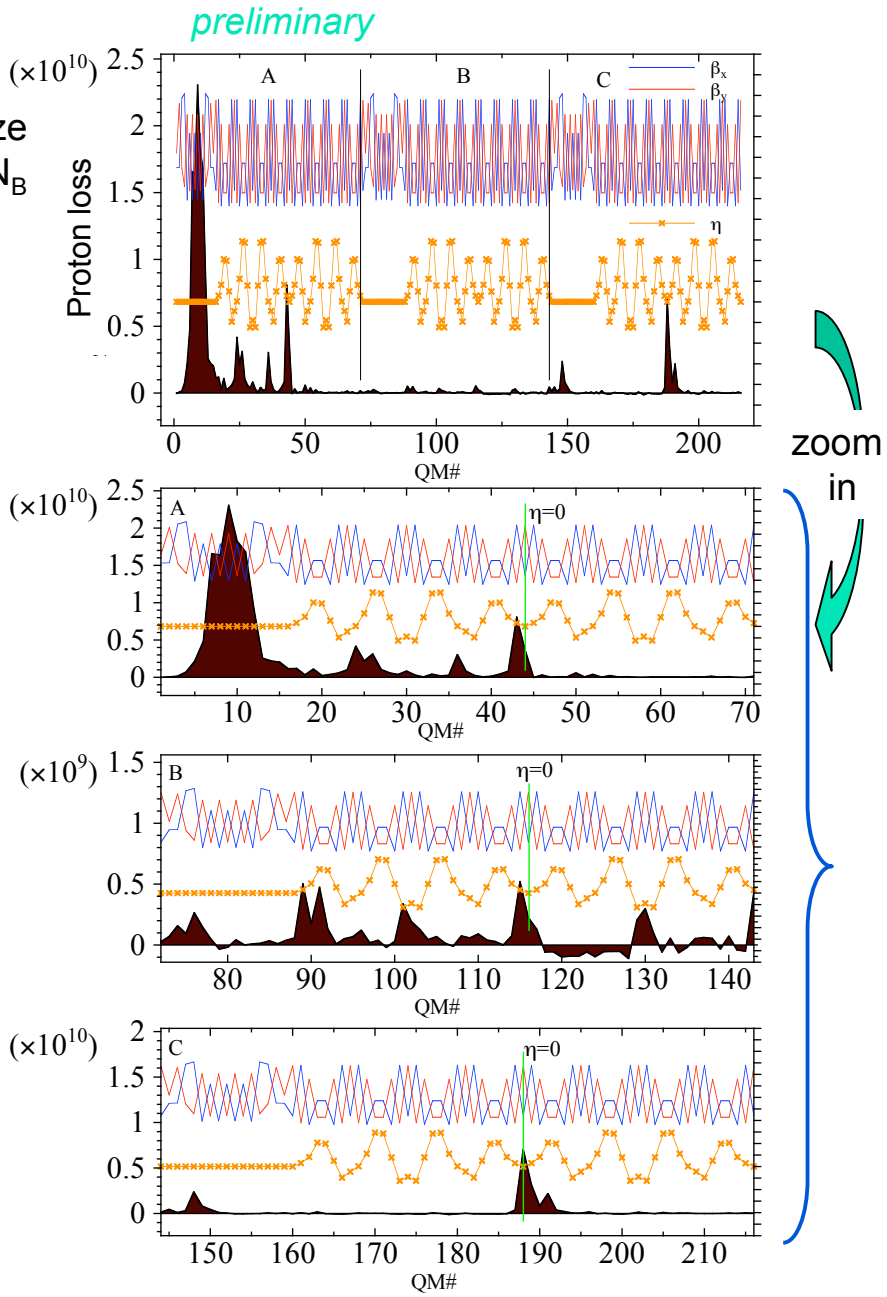


To be checked

Sensitivity with the beam



normalize by lost N_B



Integrated Zin = 10kΩ, gain = 10, HV = −1.6 kV

0.5 W/m loss:

0.1% 5.7×10^{12} ppp (@ 3GeV)

1.7% 3.4×10^{11} ppp (@50GeV)

0.5 W loss (point loss):

3.7×10^{9} ppp (@ 3GeV)

2.2×10^{8} ppp (@50GeV)

sensitivity ~ 10^8 protons loss

(5) Conclusion

Sensitivity (1 MIP @ HV = -2kV)
- ~10^8 p loss equivalent @HV = -1.6kV
depend on the HV (gain)

Response ~ 100 ns

Linearity < ~ 10^{10} p to be examined more with the beam
(complemented with ion chambers at
lossive area as collimators, extraction area ...)

Radiation hardness
little problem in principle
J-PARC uses PE connector outside the gas-sheel
small gain degradation to be confirmed