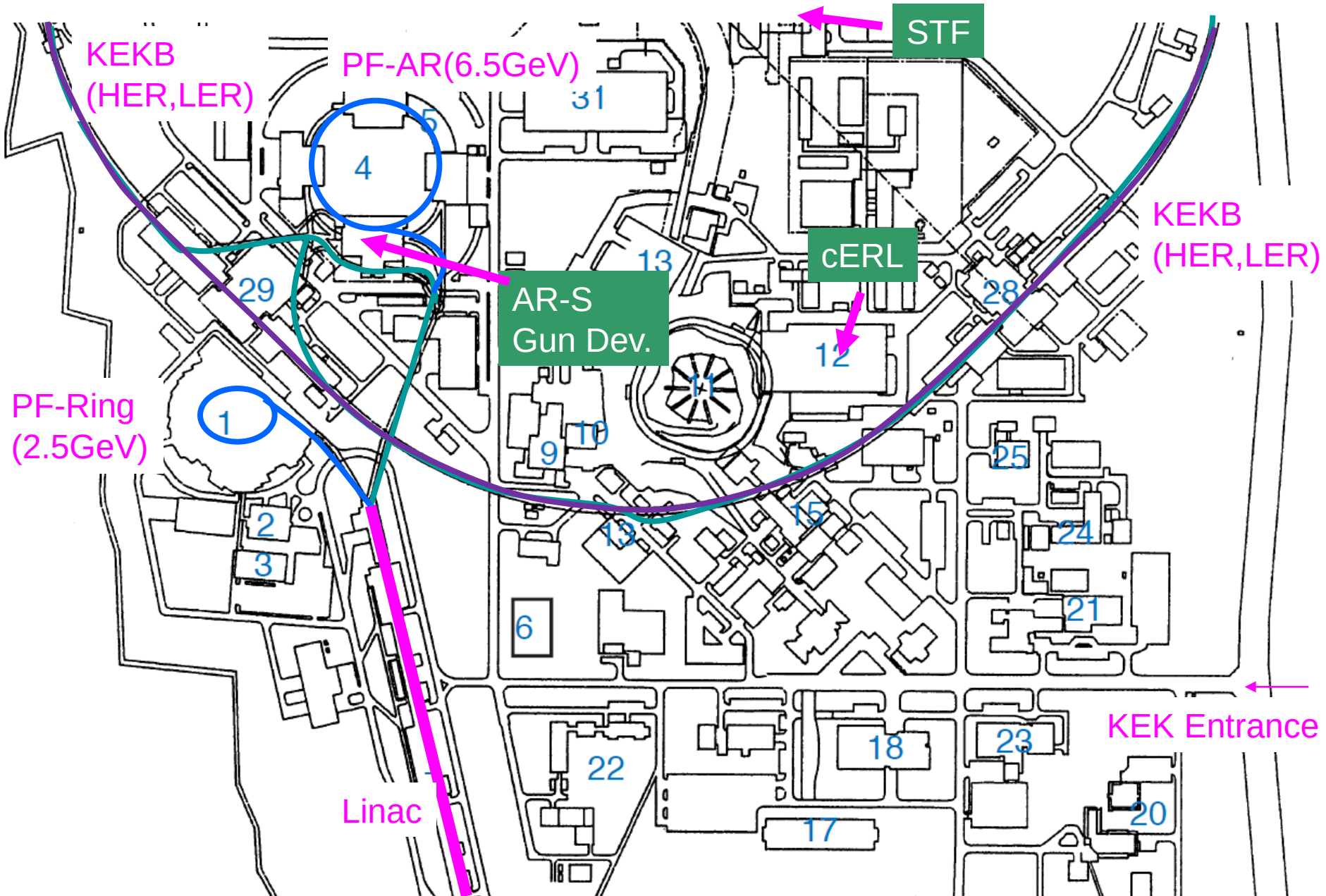
Beam Instrumentations for the Compact ERL at KEK

Takashi Obina, Kaiichi Haga, Tohru Honda, Yosuke Honda,
Tsukasa Miyajima, Mikito Tadano, Ryota Takai, Yasunori Tanimoto, Makoto Tobiyama, Takashi Uchiyama (KEK),
Shunya Matsuba (Hiroshima University)

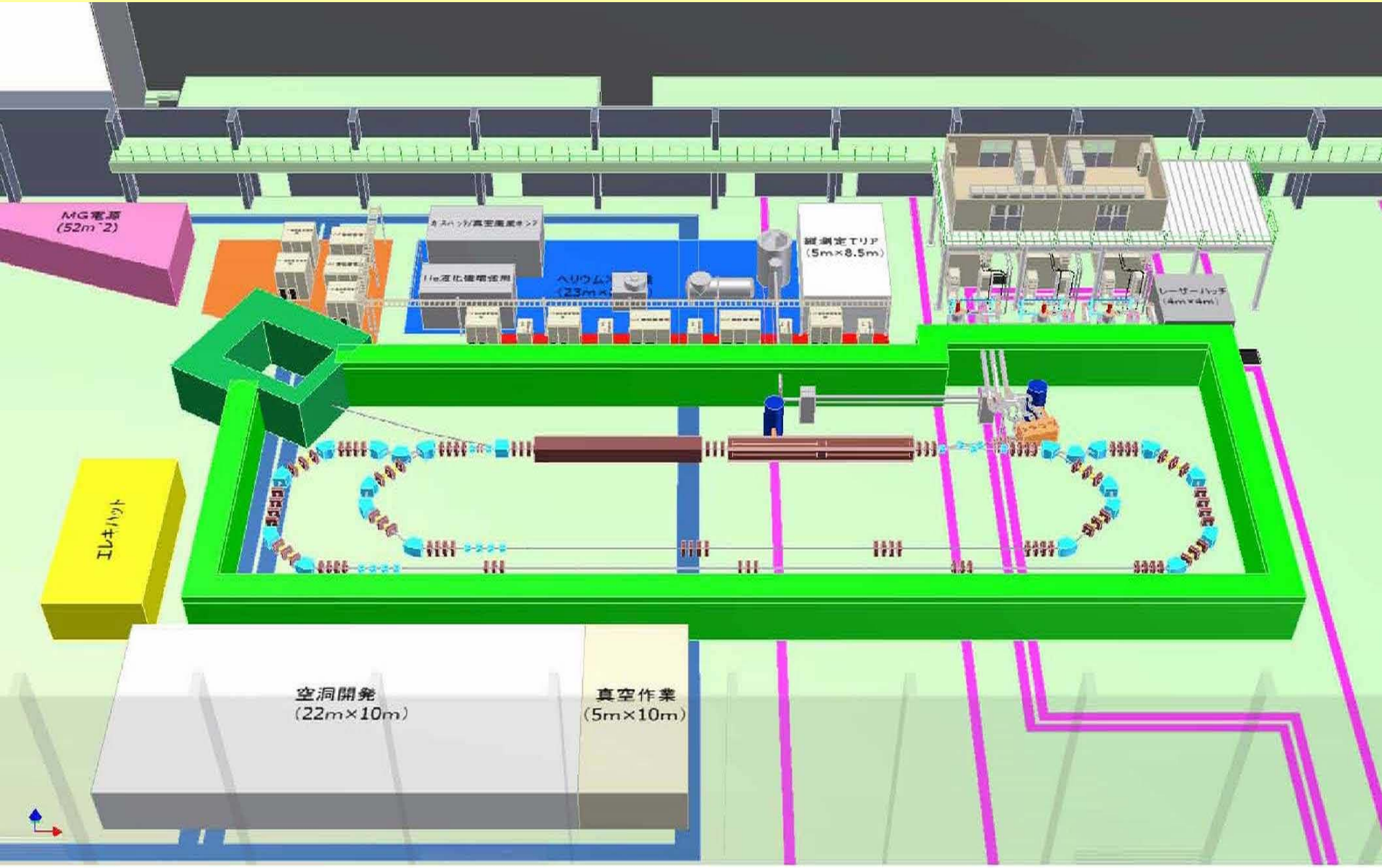
outline

- Introduction
  - Location, Machine Layout of cERL
  - Schedule, future plan of cERL
- Standard diagnostics instrumentations
- Radiation shield, Loss monitor
- Misc Monitors
- Summary

KEK map (visited on Monday)

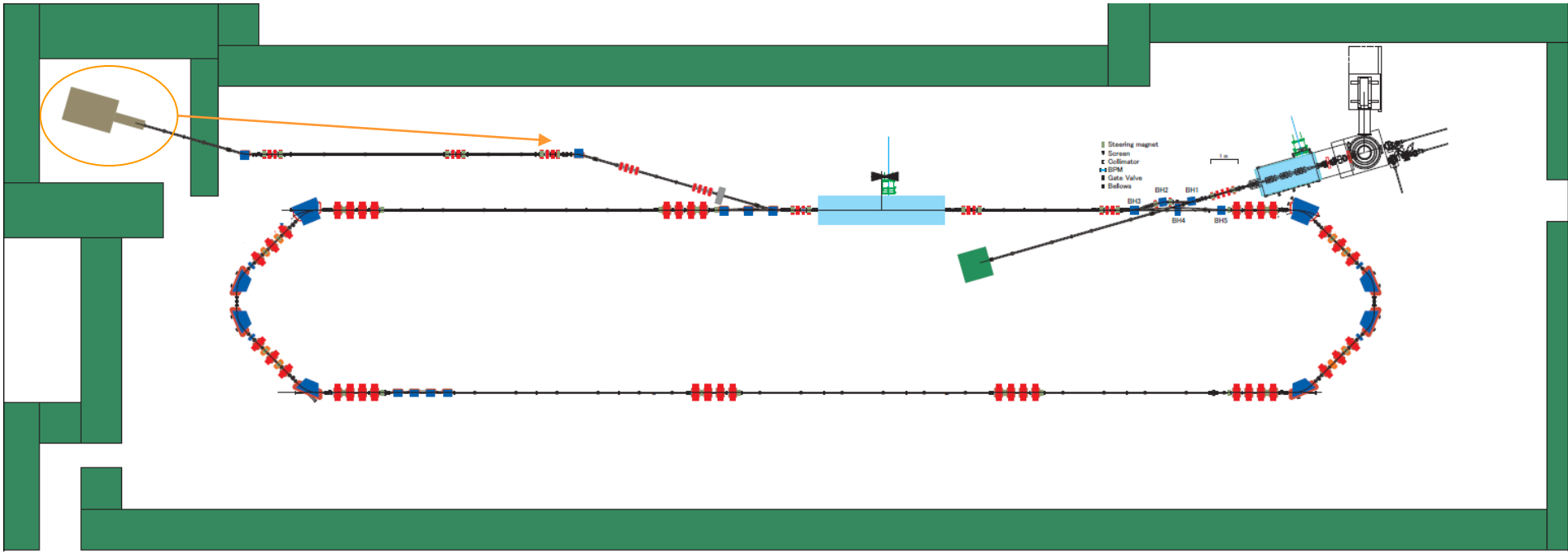


3D Model of cERL Construction Hall



(Old lattice version)

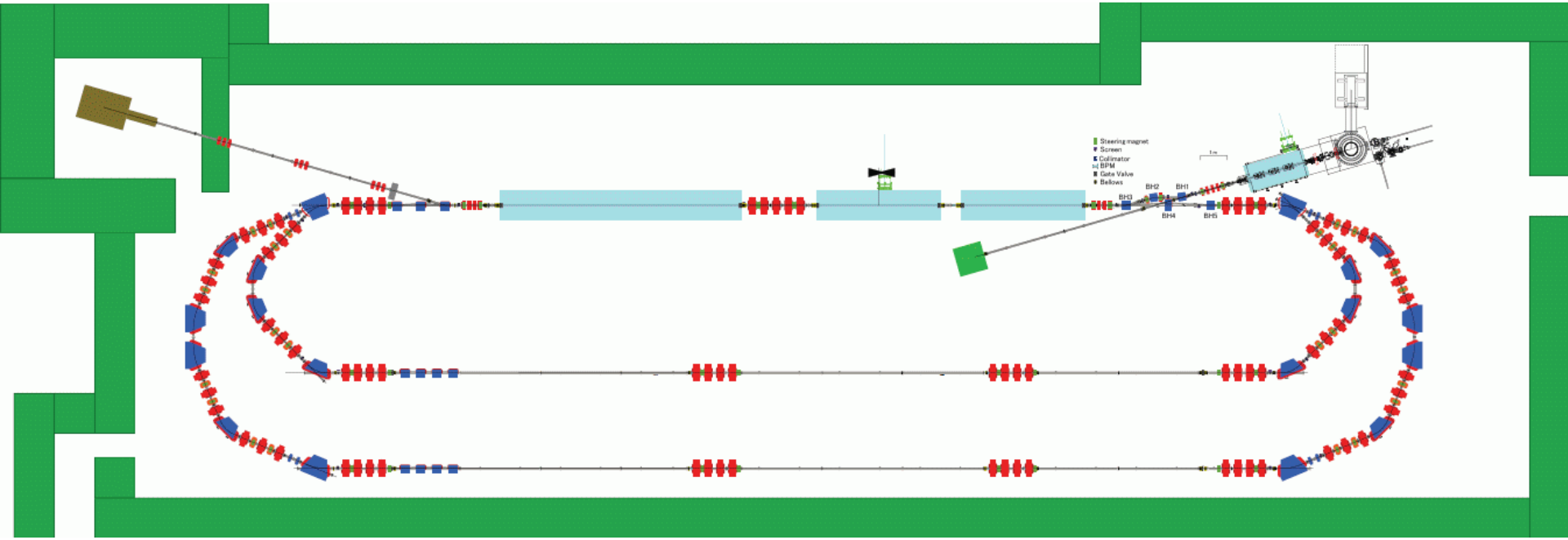
cERL at the end of FY2012



The compact ERL will start the operation under 35MeV, 10mA (start from lower current)

The compact ERL will demonstrate the ERL accelerator technologies , and also the experimental possibilities based on CSR of THz radiation and laser inversed Compton X-ray source.

Final Feature of cERL

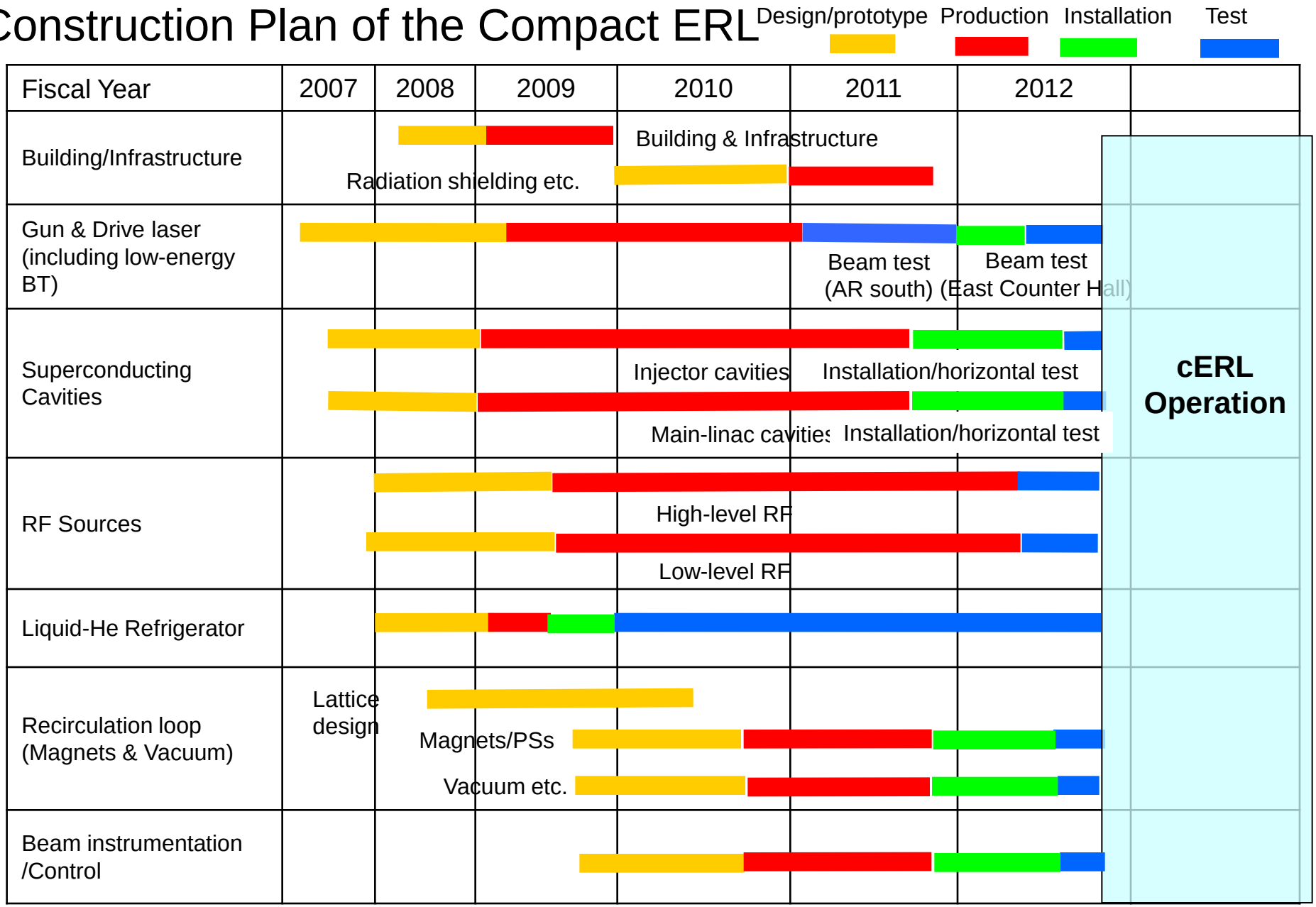


Continuous upgrading:

LCS-γ FY2013(Mar/2013)

FY2012: 35MeV, 10mA (start from low current)
FY2014: 65MeV, 10mA
FY2016: two-loop operation (125MeV, 10mA)
..... two-loop, 245MeV, 100mA ?

Construction Plan of the Compact ERL



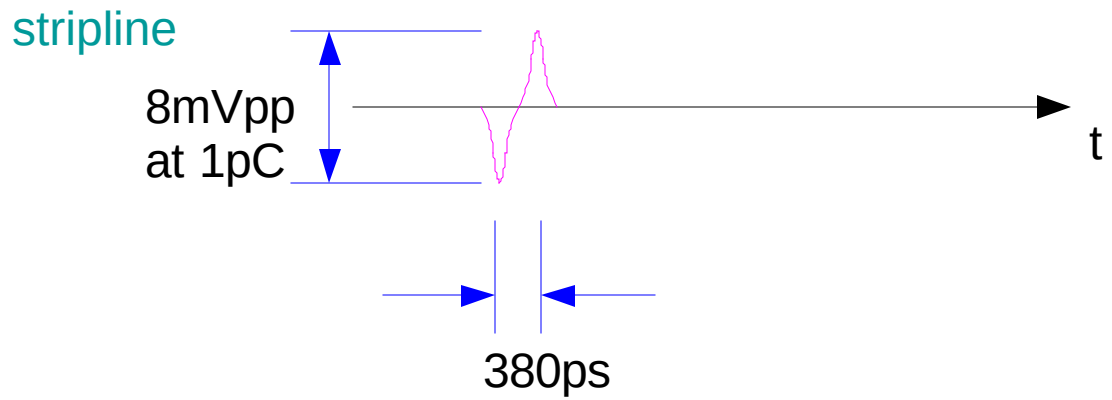
Scheduled Before 11/Mar Earthquake

Presented by Dr. S. Sakanaka at Light source subcommittee at IMSS Symposium 2010

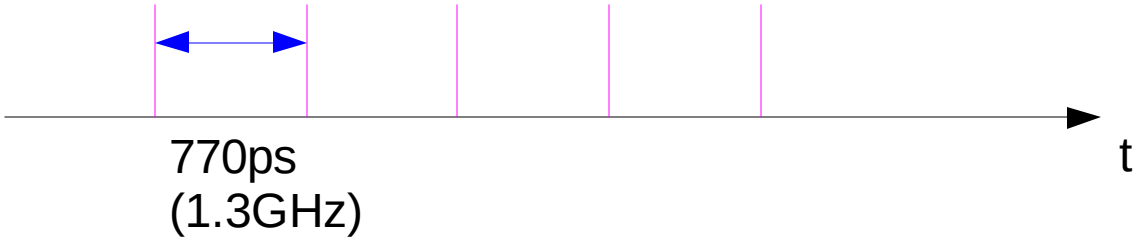
Beam Diagnostics Instruments

- Standard Beam Diagnostics
  - Beam Position Monitor : stripline / detection circuit
  - OTR, Screen Monitor (Scintillator)
  - Optical Monitor (SR Monitor; Streak, Gate Camera, etc)
  - Beam Loss Monitor (PMT and/or Fiber) and Interlock
  - Wire Scanner (not planned yet)
  - Beam Current Monitor (Abs, Diff), CT
- Special Beam Diagnostics
  - Bunch Arrival Monitor / precise timing distribution
  - Deflecting Cavity
  - High-resolution Cavity BPM (low current only)
  - Beam Halo Monitor

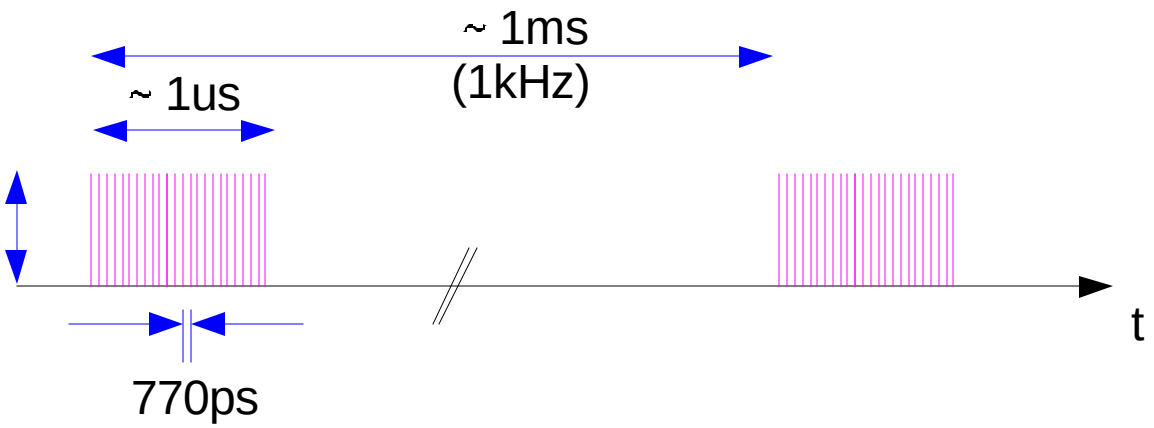
Beam Signal Pattern



CT output (CW)



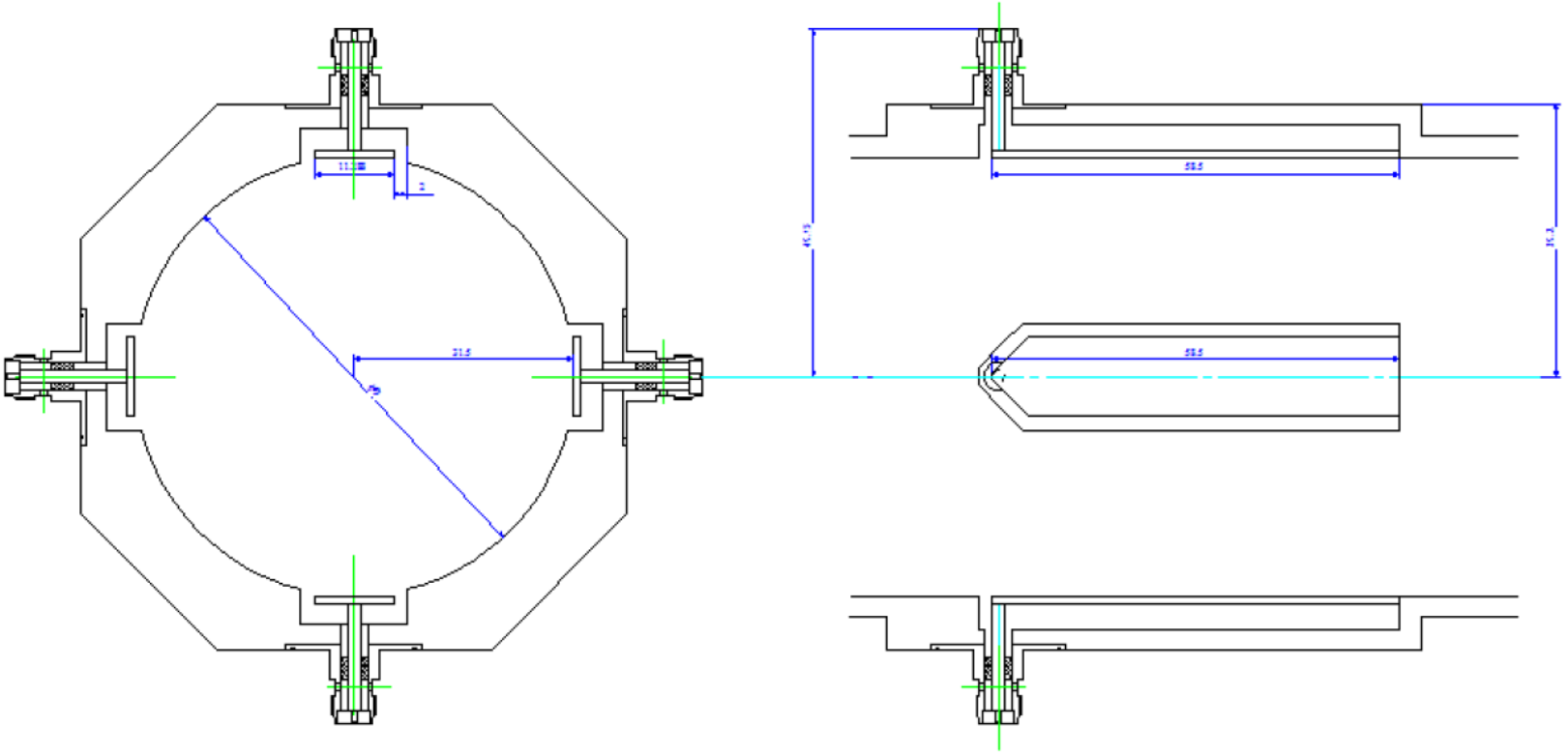
CT output (Pulse Train)



~ 1nC/macro_pulse

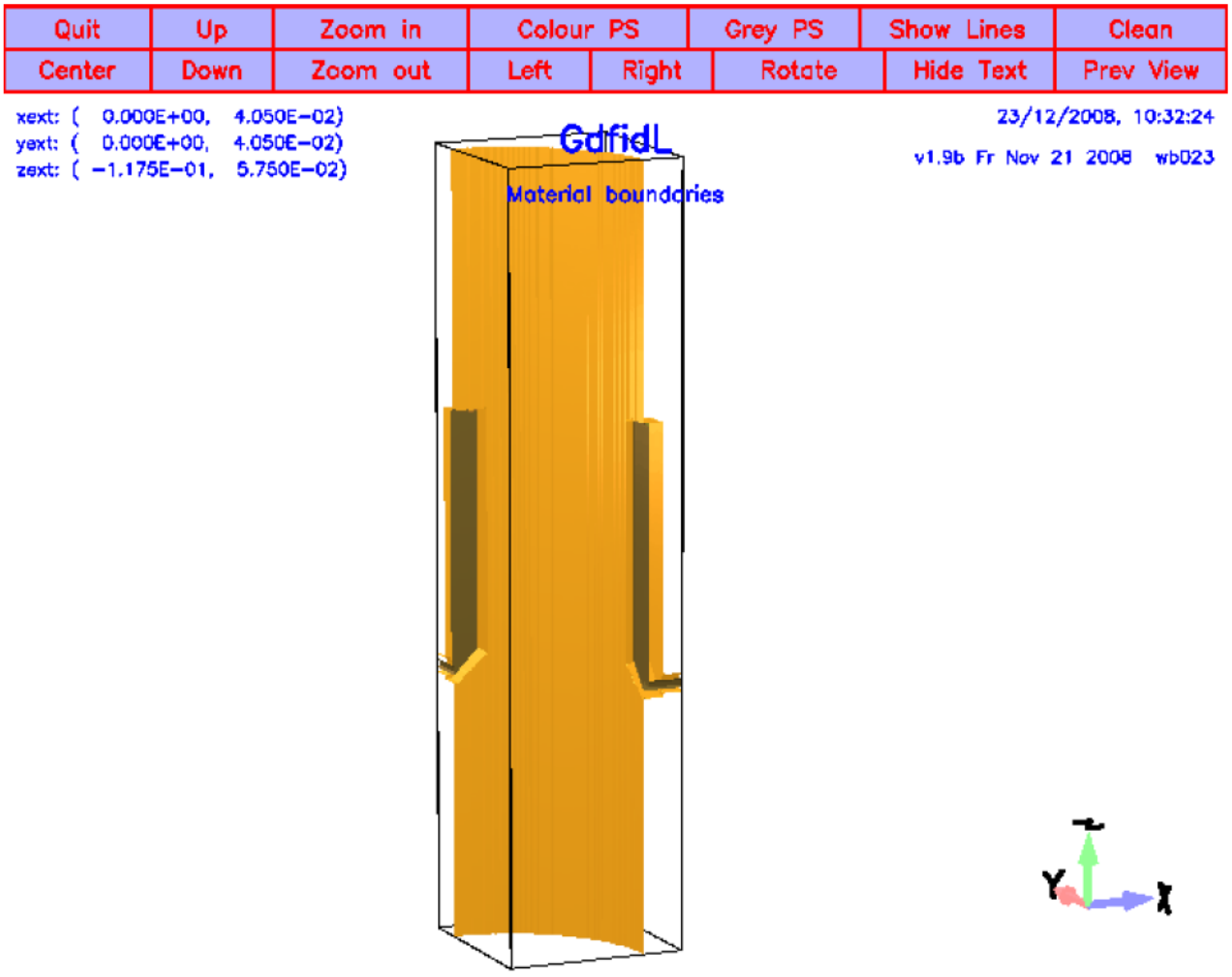
20度4電極版

M. Tobiyama, R. Takai

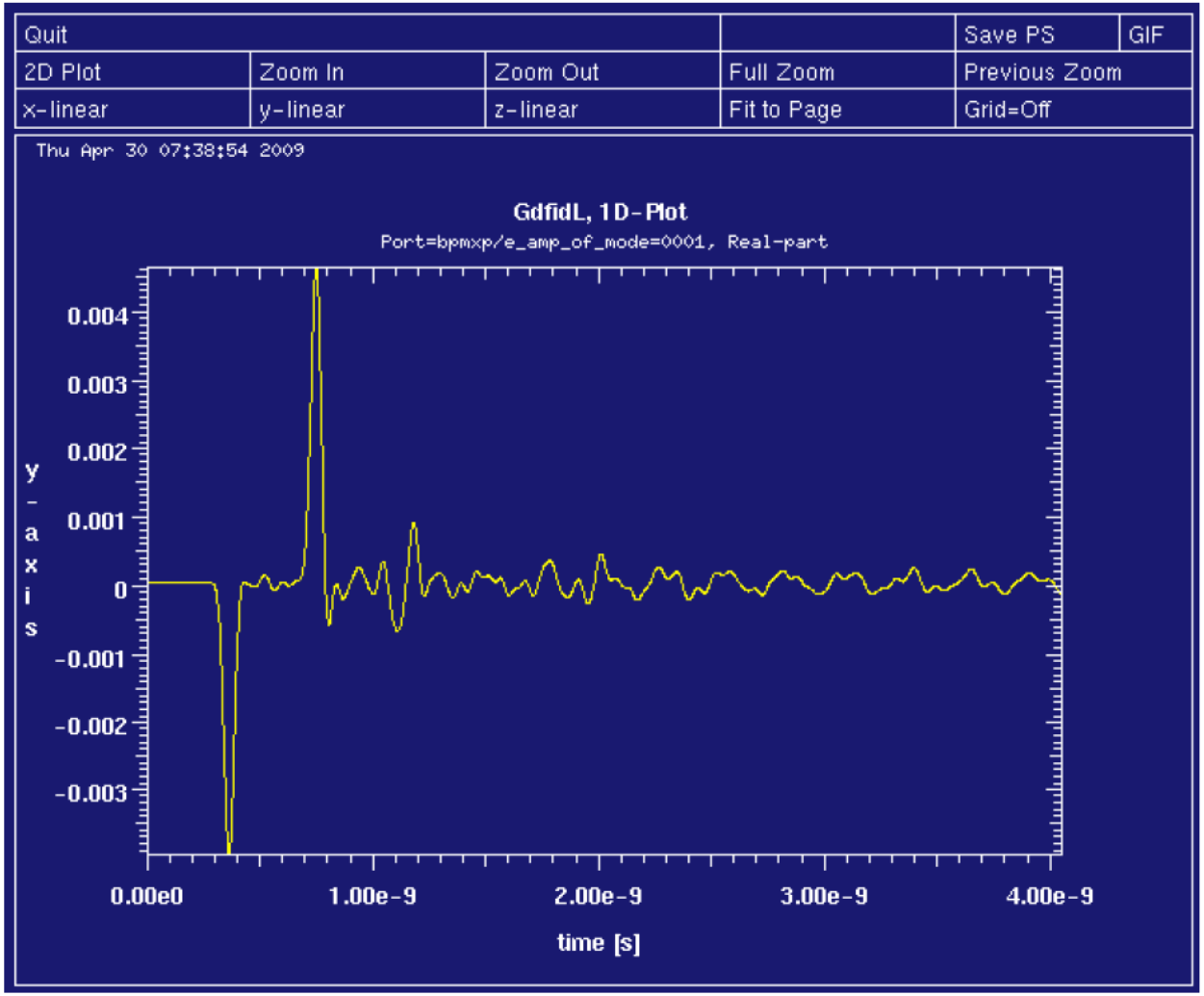


- Stripline BPM with glass type feedthrough
  - Small relative permittivity (ε_r)
  - Advantage : Wide-band response. Avoid heating due to resonance.

GdfidLでのsimulation



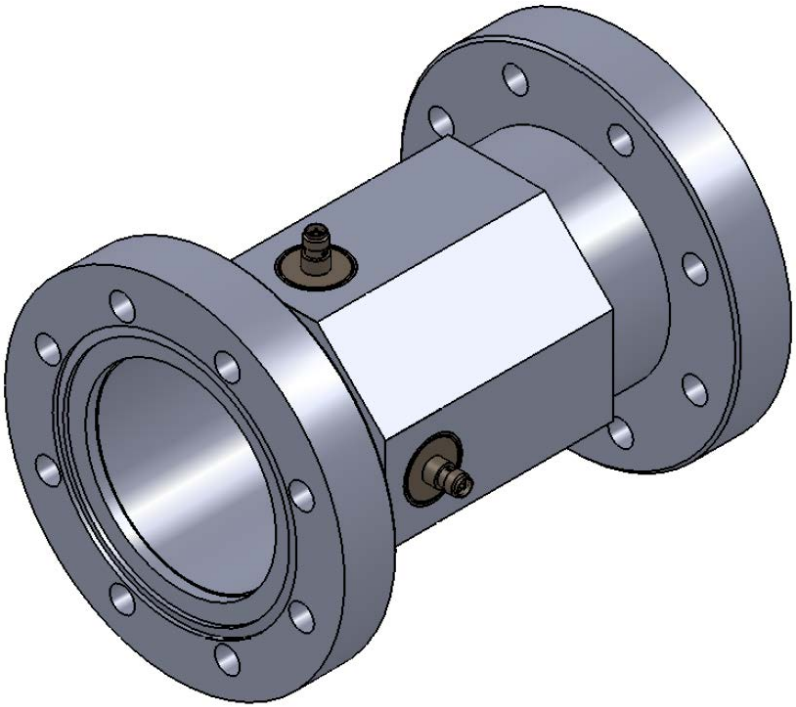
sz=6mm、1pCのバンチ(光速)

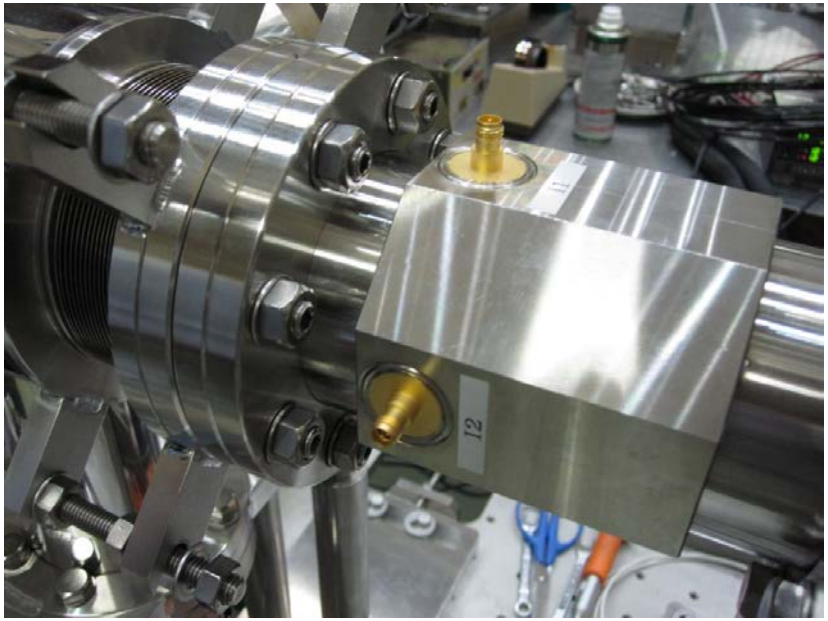


Peak-to-Peakで8.6mV出力

CAD, Photo

(M. Tobiyama, R. Takai)

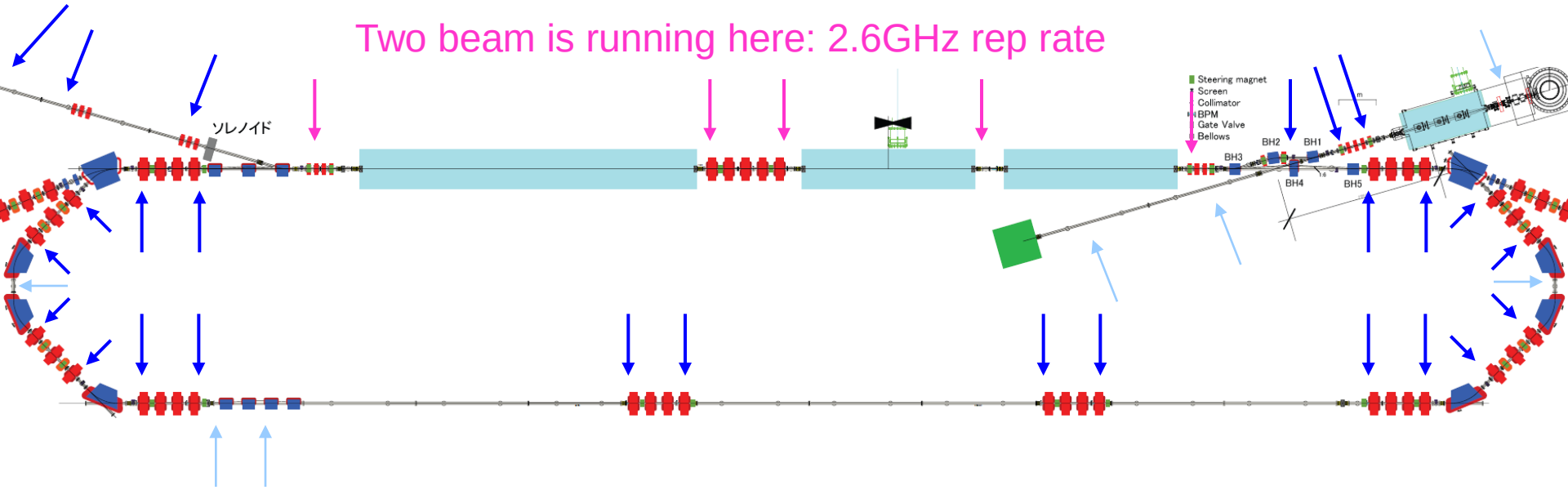




Injector Dev. at AR-S
Pipe I.D. 63mm
Chamber Length 150mm

cERL
Pipe I.D. 50mm for circulation part

Stripline BPM (I.D. 50mm)

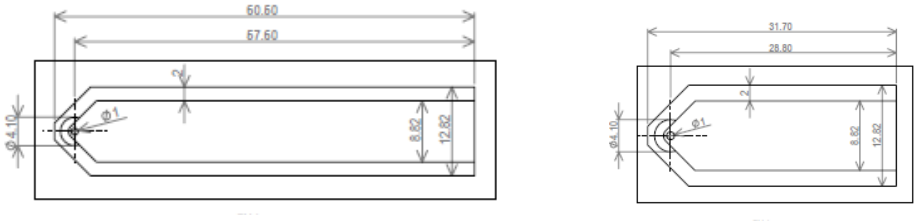


Long: 23 (+ 4 + 2)
Short : 5
Dump : 3

If we can decide the beam rep-rate up to 650MHz, every things become easy.
cf. RF HOM BBU, GUN, Laser, etc....

Short / Long stripline

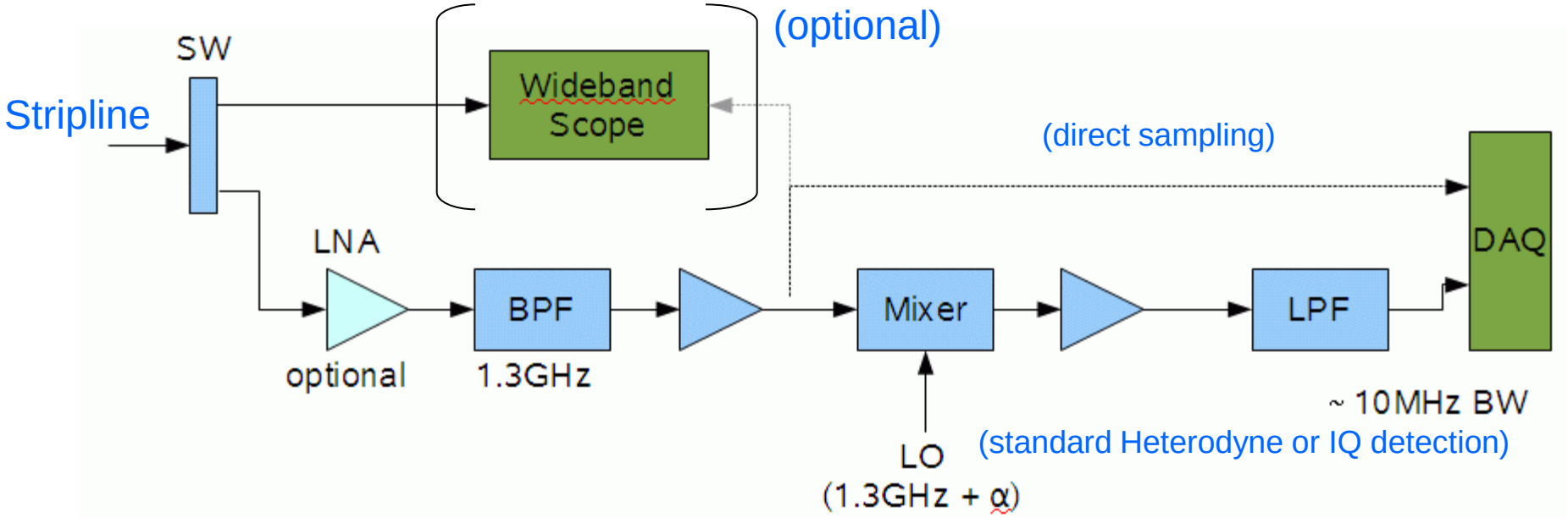
- short for 2.6 GHz, long for 1.3 GHz
- No difference from "button-type" pickup?



- good
  - no need to worry about charge up
  - easy to make large opening angle electrode
- bad
  - thermal expansion (baking)
- Cost ?

Signal Processing Part (outline)

- Switch Narrow Band/Wide Band
  - all BPM cables are fed to racks outside shield wall
- 1 circuit for 1 electrode (4ch parallel)



Detection Circuit

- 1.3GHz for detection
  - 2.6 GHz is better to avoid RF noise
- Direct sampling considered
  - cost, and resolution seems not adequate
- Libera (i-tech) can handle 700MHz or less
  - Need development for 1.3GHz or 2.6GHz detection

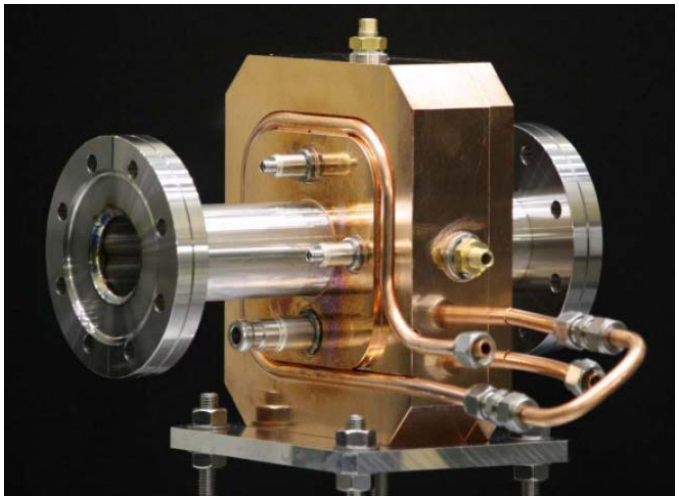
- Down conversion for precise measurement
  - down convert to 500MHz is not effective
- Wideband measurement (Scope) for other diagnostics

DAQ

- Oscilloscope for Wideband Signal
- 10MHz BW signal
  - VME+ADC or DAQ-Box(Yokogawa SL1000)
  - Need cheap solution for 30 BPMs
- Calc Beam Position in EPICS record
  - Fast FB is not necessary ; 10Hz update rate
- Pulse-by-pulse Event System is necessary
- Slow signal/Feedback (<10kHz) other than BPM
  - Laser, Loss monitor, etc
  - Digitizer : all-in-one DSP box "iBIS" (mtt Co.)
    - 16bit ADC, 16bit DAC, DIO, EPICS capability

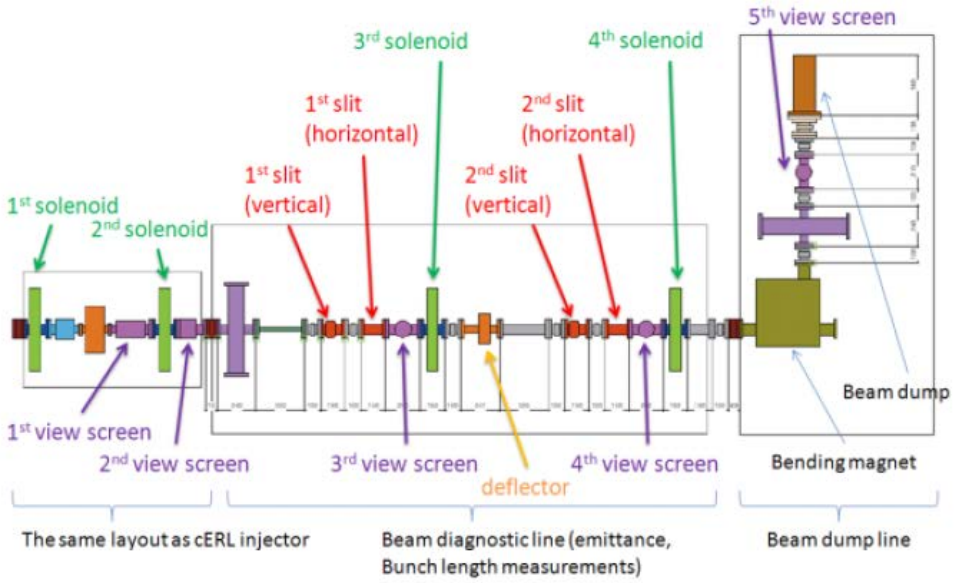
Beam Diagnostics at AR-South (Gun development facility)

- Stripline, Screen Monitor, Deflecting Cavity, etc.



Y. Honda, S. Matuba, T. Miyajima

Beam Instrumentations at AR South

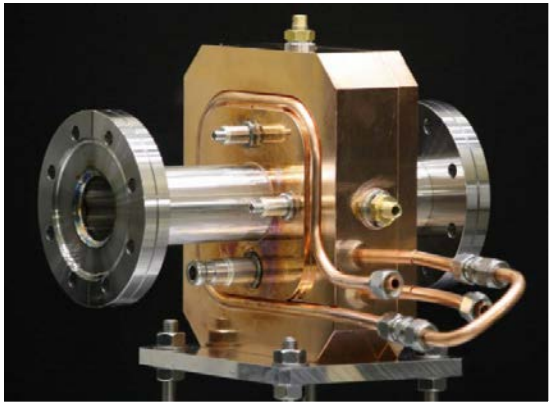


200kV Gun Development Area

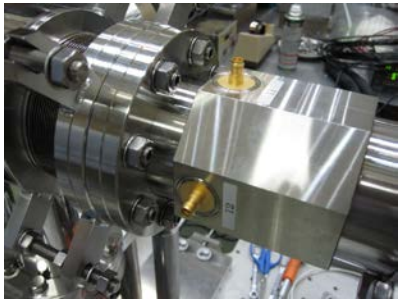
- Deflecting Cavity
  - For longitudinal charge distribution measurement

(S. Matsuba, Y. Honda, T. Miyajima)

2.6 GHz Dipole Mode
0.5 ps resolution with beam slit

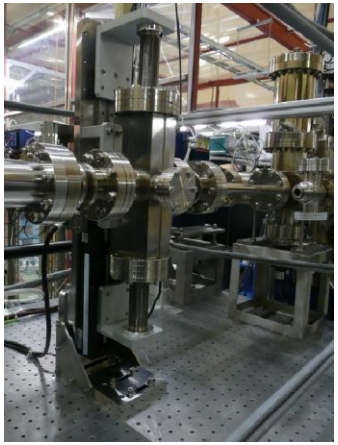


Stripline BPM



Beam Instrumentations at AR-S

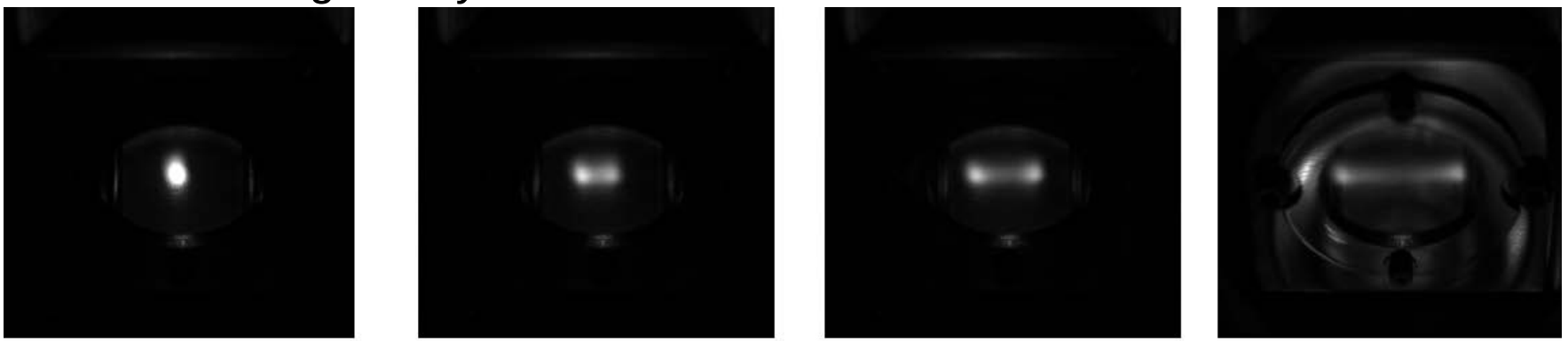
- Screen monitor, Slit for emittance meas. (S. Matsuba, Y. Honda, T. Miyajima)



Emittance measurement by
Slit scan and Solenoid scan

Result will be reported by Y. Honda, et.al. (WG-1: Electron Sources)
"Temporal Response Measurements of GaAs-Based Photo-Cathodes"
"Initial Emittance Measurements of GaAs-Based Photo-Cathodes"

- Deflecting Cavity



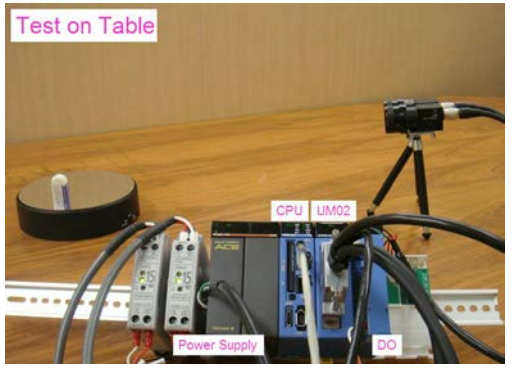
0W 2.5W 10W 40W

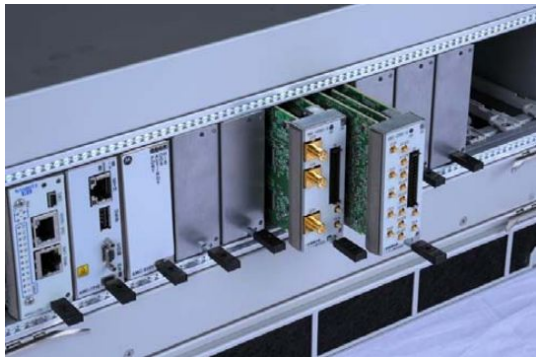
Control System

- Image Processing Unit (testing)
  - Image acquisition module with EPICS
  - Linux CPU + PLC module for I/O
- micro-TCA for LLRF
  - EPICS on FPGA (Xilinx Virtex4)
- Channel Archiver for history data
  - running for LLRF and Gun development
  - Web-based plotting tool

(T. Miura, S. Michizono)

- EDM for GUI (CSS is under consideration)





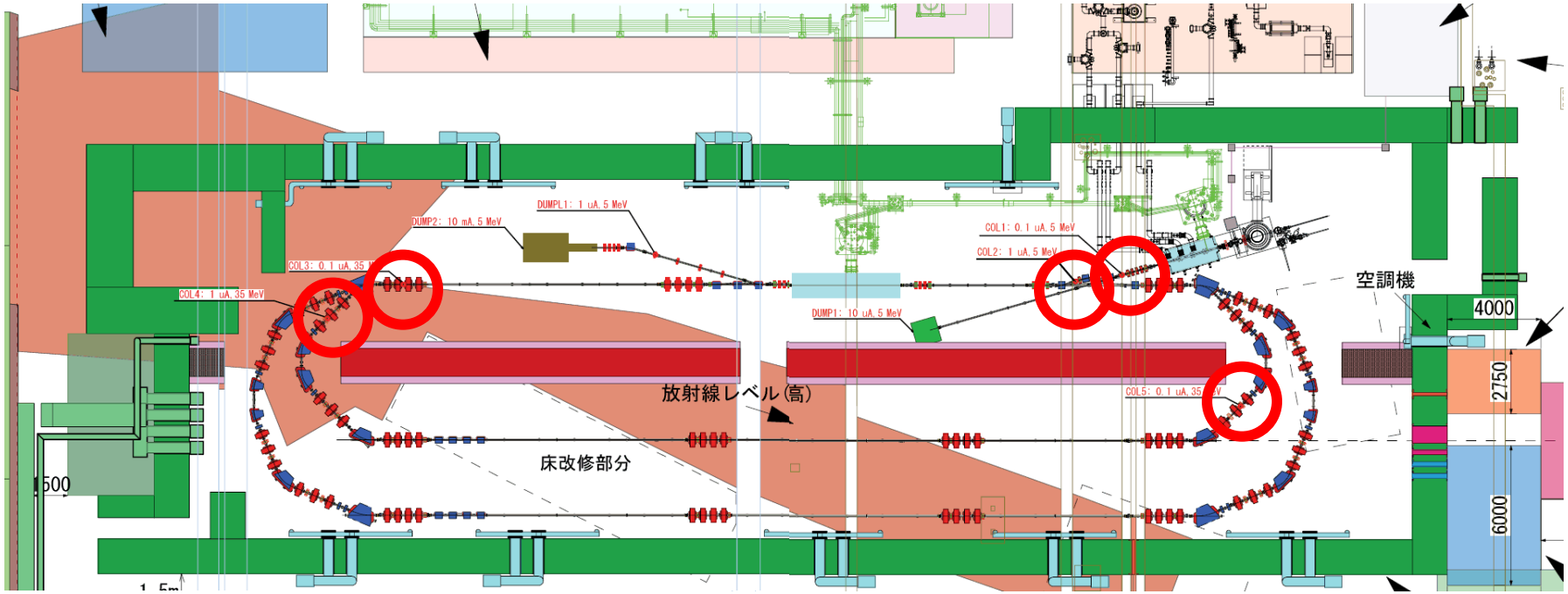
Beam Loss / Radiation Shield

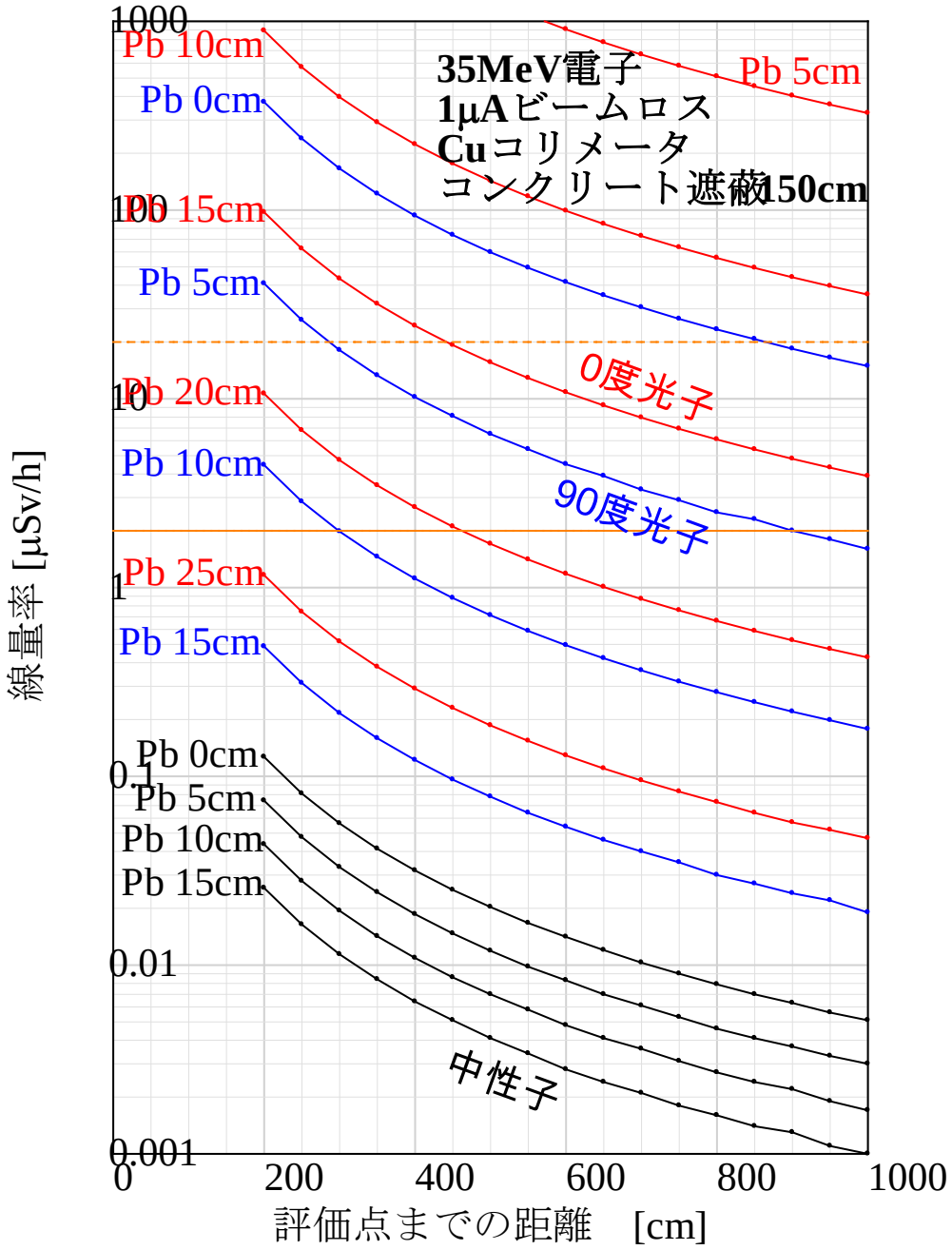
- Use collimator to limit loss location
  - 4 coaxial rod type is planning
  - Impedance ?
- Determine :
  - Thickness of wall / roof
  - shield of collimator

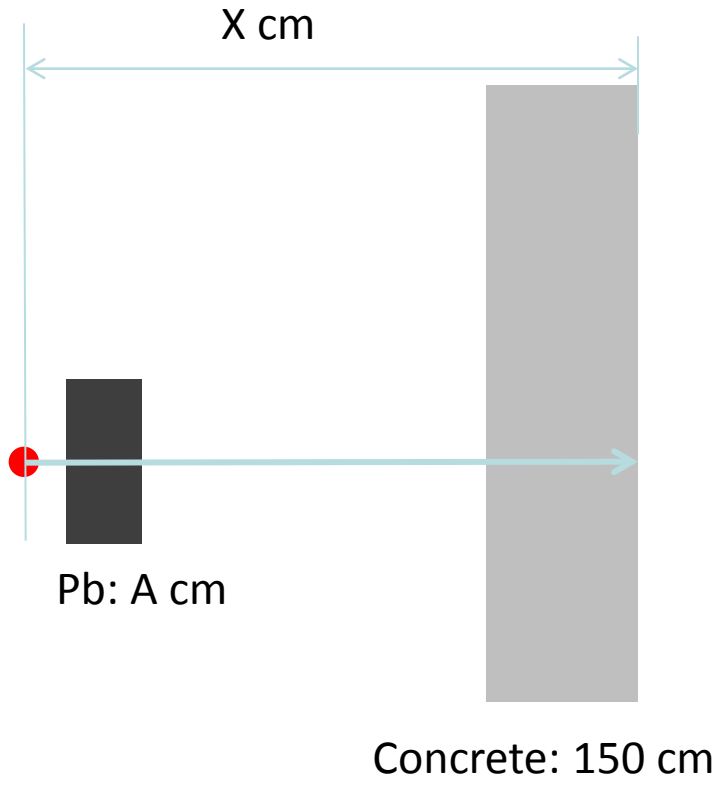
- standard "Resistance to Earthquake" changed
  - before : 0.25G (Jpn. intensity scale 5 lower)
  - after :0.50G (Jpn. intensity scale 6 upper)
  - usage of "chemical anchor" instead of normal anchor

Beam Loss Point

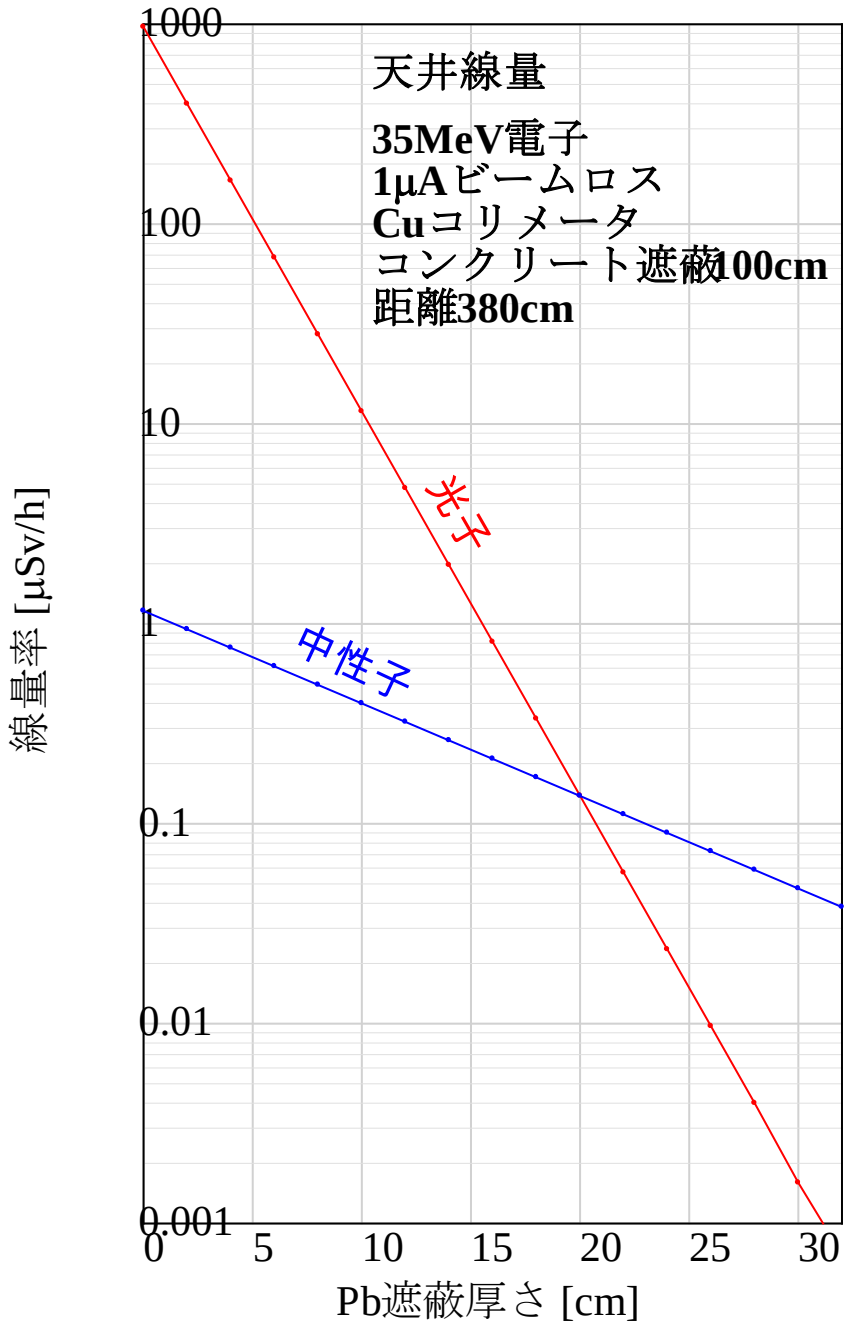
- Assume : Loss point is limited
- Shield near the loss point -> avoid "HUGE" shield wall/roof

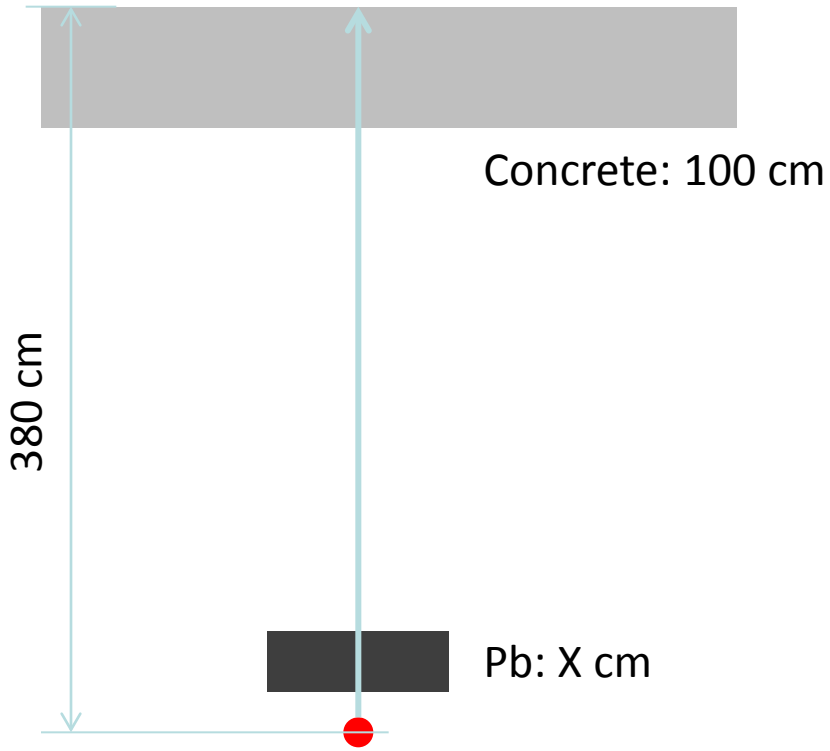



35MeV電子
1μAビームロス
Cuコリメータ
コンクリート遮蔽150cm
Pb 10cm
Pb 0cm
Pb 15cm
Pb 5cm
Pb 20cm
Pb 10cm
Pb 25cm
Pb 15cm
Pb 0cm
Pb 5cm
Pb 10cm
Pb 15cm
0度光子
90度光子
中性子
1000
100
10
1
0.1
0.01
0.001
0
200
400
600
800
1000
線量率 [μSv/h]
評価点までの距離 [cm]


X cm
Pb: A cm
Concrete: 150 cm

H. Matsumura


天井線量
35MeV電子
1μAビームロス
Cuコリメータ
コンクリート遮蔽100cm
距離380cm
光子
中性子
線量率 [μSv/h]
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
20
25
30
Pb遮蔽厚さ [cm]


Concrete: 100 cm
380 cm
Pb: X cm

H. Matsumura

see suppl. slide

Beam Loss Monitor

- Optical Fiber or Ion Chamber based one are planning
- We have Bergoz PIN diode detector
- Connect to machine interlock system
  - human protection is another story

- Question
  - Need PMT as high sensitivity detector?
  - Need BPM difference signal for redundancy?
  - CT for circulating part .... Impedance?

Misc Monitors

- DCCT
  - Normal DCCT (Kudo or Bergotz)
- Total difference from Gun->Dump (voltmeter?)
- Temperature sensor (many)
- IR camera ?
- Timing distribution for Laser, RF, LCS-γ, user, etc.
- Bunch arrival monitor
  - fast oscilloscope
  - BPM + BPF + phase detector
  - EO crystal (not designed yet)
- Halo monitor
  - viewscreen with hole (only for low current)
  - colonagraph (only high energy regeion)

- Not designed yet
  - wire scanner / laser wire

and so many....

Summary and Plan

- Overview of standard (no new topics) beam instrumentations are explained here
- Present status of radiation shield design

- Commissioning of cERL will start on X/2013
- Human resource is limited (How many FTE?)

- We have a lot of things to do!

Thank you!

Before Renovation of the Building

Present Status : Photo