High momentum/COMET beam line status

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- Beam line Design & Construction
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  - On-going activities
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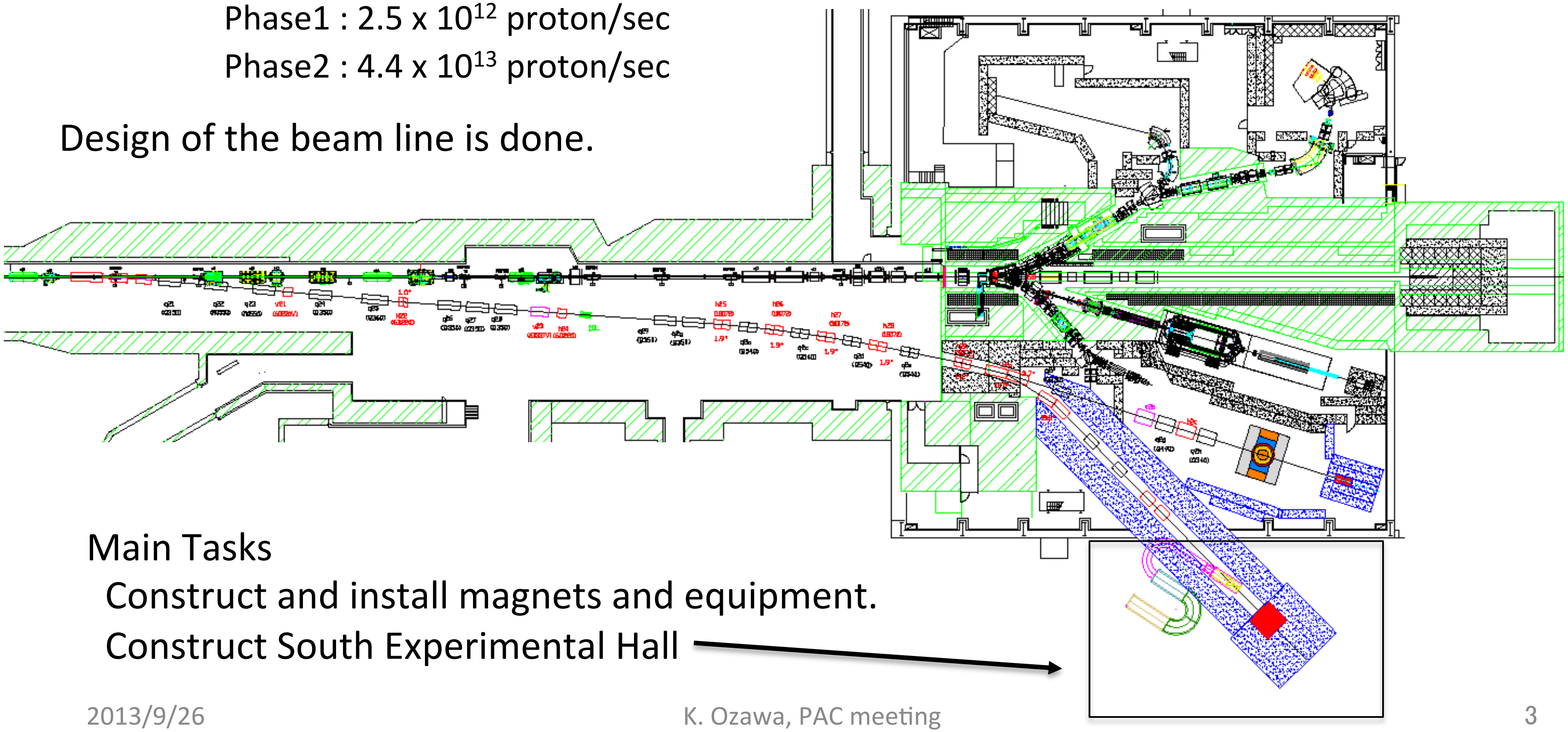
New High Momentum Beam Line

Construction budget of a New Beam Line is approved by the Government.
Characteristics of the beam line are following.

- Primary Proton Beam (30GeV), $10^{10\text{-}12}$ per spill
- High Momentum un-separated secondary beam (< 20GeV/c), 10^{8} per spill
- Primary Proton Beam (8GeV) for COMET
  - Phase1 : 2.5×10^{12} proton/sec
  - Phase2 : 4.4×10^{13} proton/sec

Design of the beam line is done.



Main Tasks

- Construct and install magnets and equipment.
- Construct South Experimental Hall

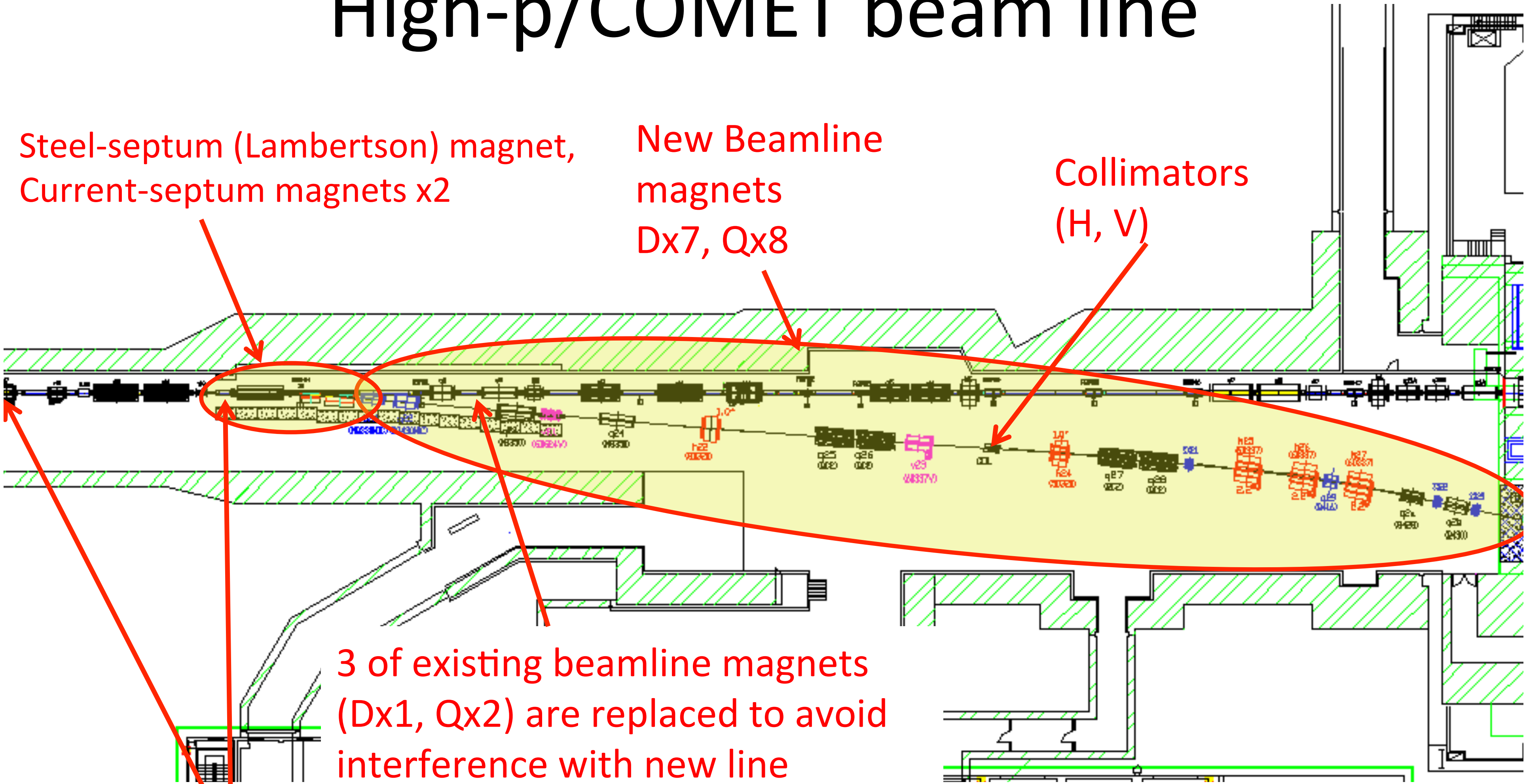
Requirements for the beam line

- 30 GeV Primary beam, 10^{10} per spill
  - $10^{-3} \sim 10^{-4}$ of the primary beam needs to be separated.
  - Magnets need to transport a 30 GeV beam.
- COMET Beam, 8 GeV, 4.4×10^{13} proton/sec
  - All primary beam needs to be bent to the new beam line.
  - Needs to cope with a relatively large emittance.
- Secondary Beam, up to 20GeV/*c*, 10^{8} per spill
  - An additional production target and collection magnets need to be installed instead of a beam separator.
  - Additional sixtupole magnets needs to be installed.

All above requirements are satisfied by the current design.
Note:

The difference of magnet configurations btw 30 GeV Primary beam and COMET beam is only in operation conditions. No replacement is needed.
Few magnets around the separation point needs to be replaced to deliver a secondary beam. It takes 2-3 months.

High-p/COMET beam line



Steel-septum (Lambertson) magnet,
Current-septum magnets x2

New Beamline magnets
Dx7, Qx8

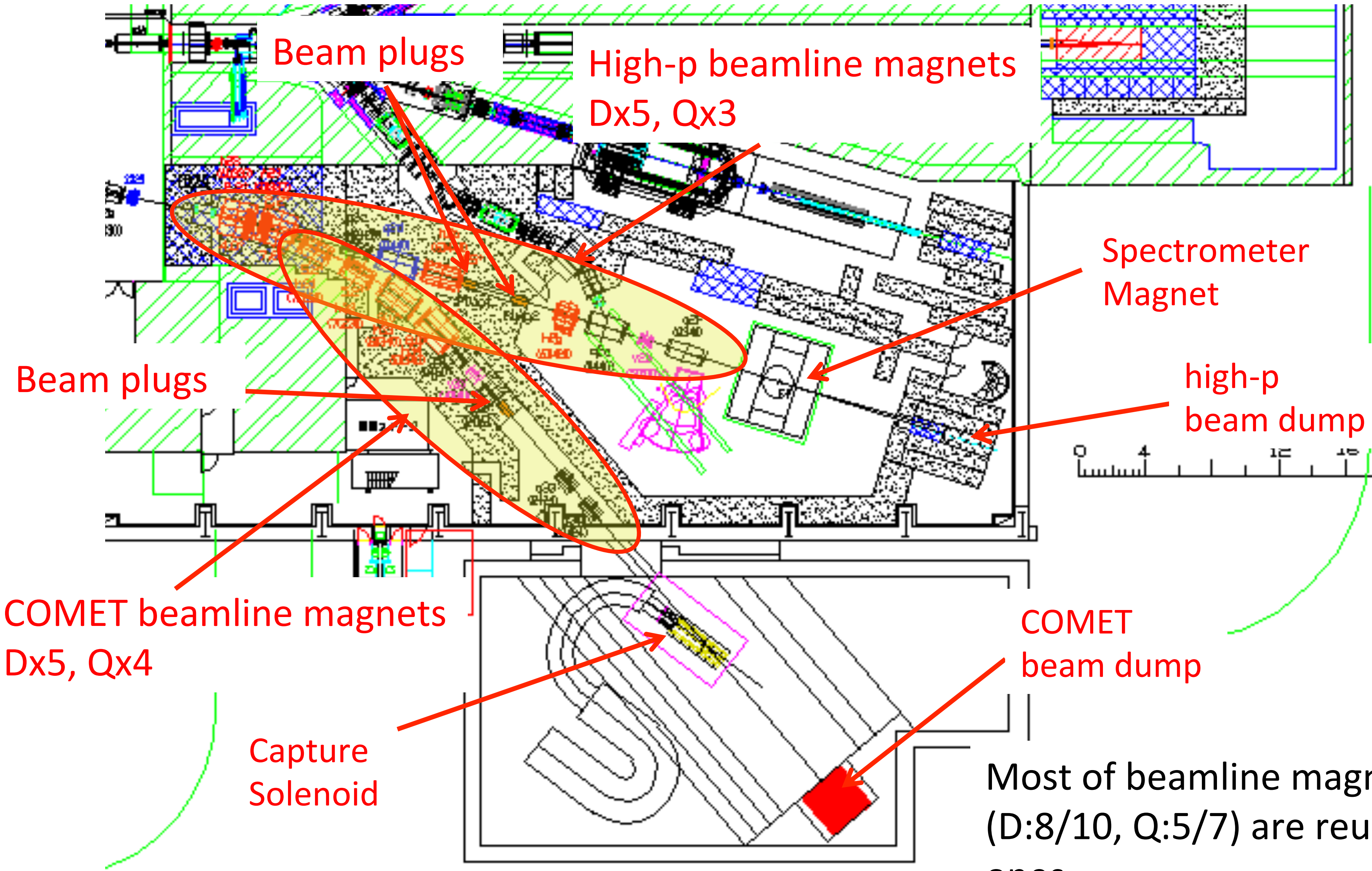
Collimators
(H, V)

3 of existing beamline magnets (Dx1, Qx2) are replaced to avoid interference with new line

Existing steering magnets (x2) to make a bump orbit vertically for beam extraction to high-p/COMET

Most of beamline magnets (D:7/7, Q:6/8) are reused ones

High-p/COMET beam line

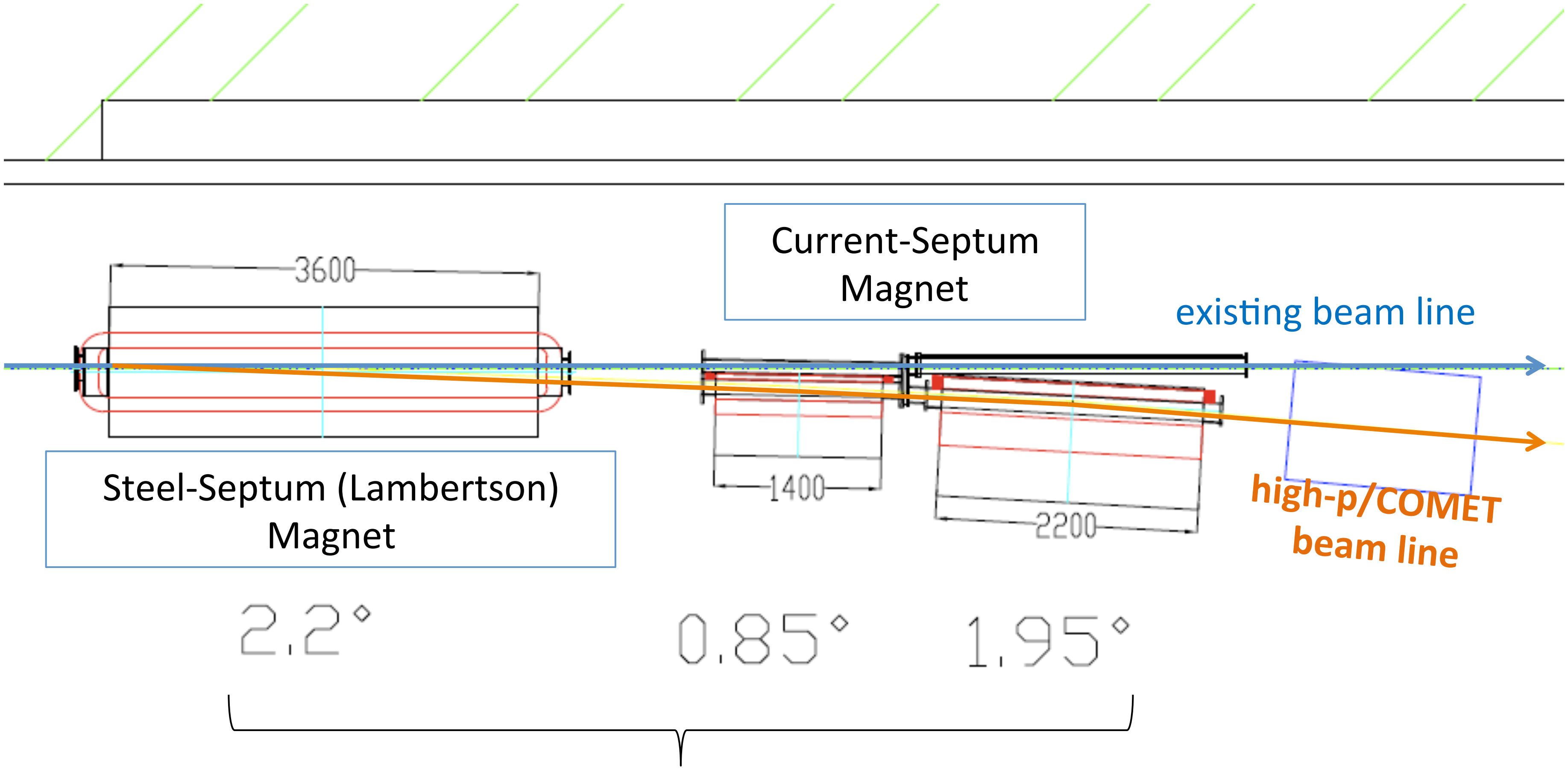


Most of beamline magnets (D:8/10, Q:5/7) are reused ones

Details

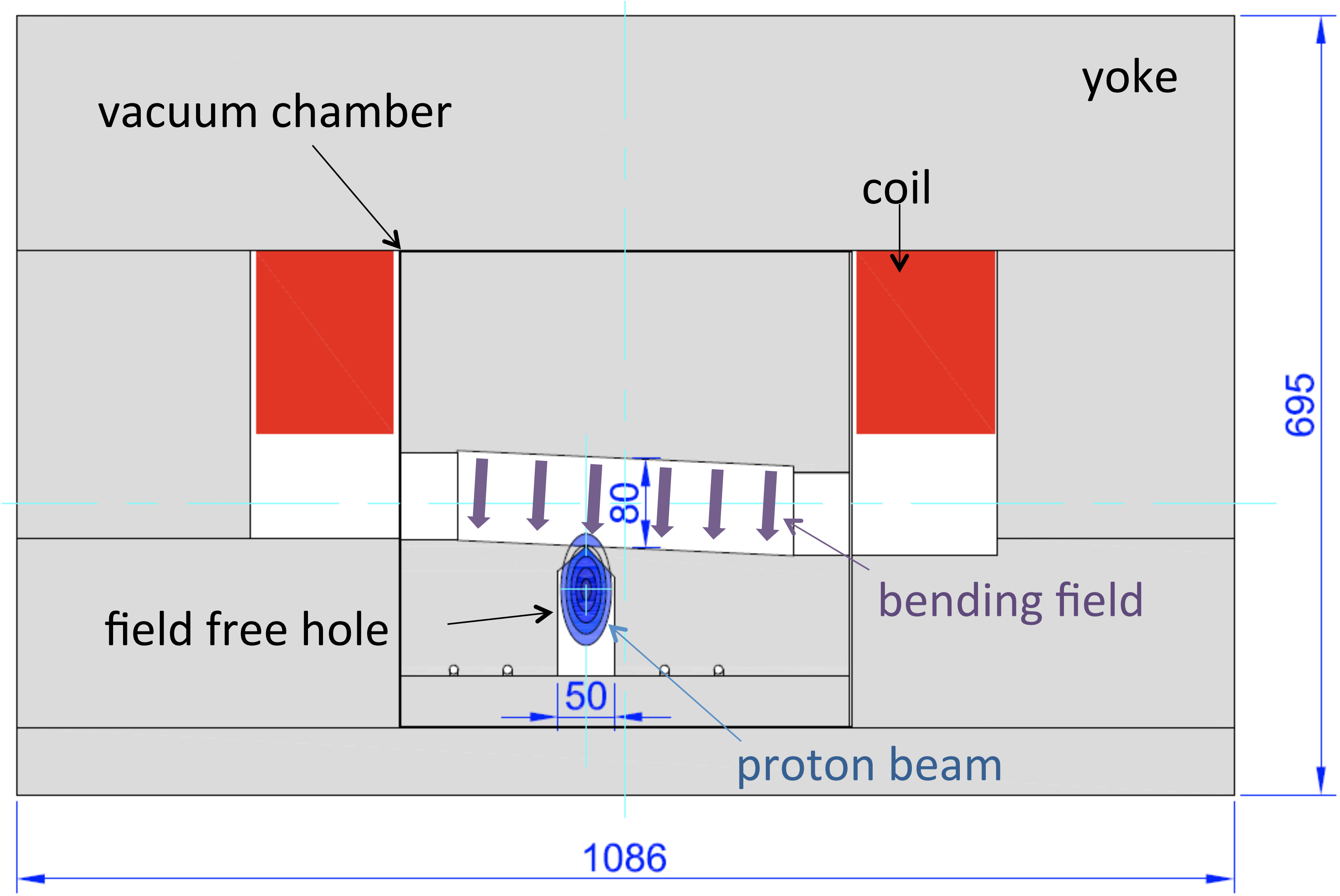
- Branching Point
- South Experimental Hall
  - COMET experimental area
  - Control Room
- High-p experimental area

Branching Point



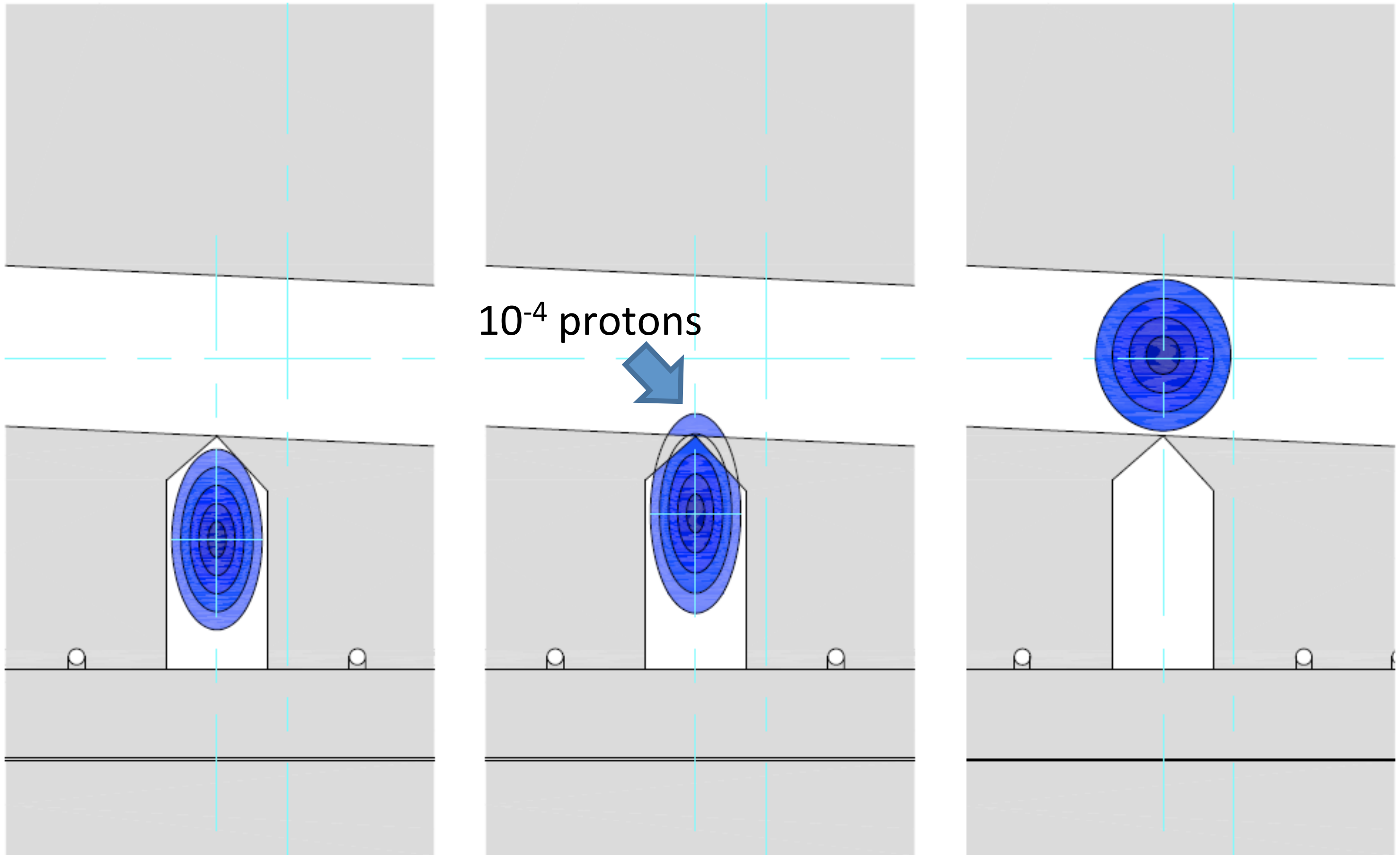
Bending angle of 5° in total

Steel-Septum (Lambertson) Magnet



Operation Modes at Branching Point

vertical beam position at the branching point is adjustable using 2 steering magnets



T1

all protons are
delivered to T1 target

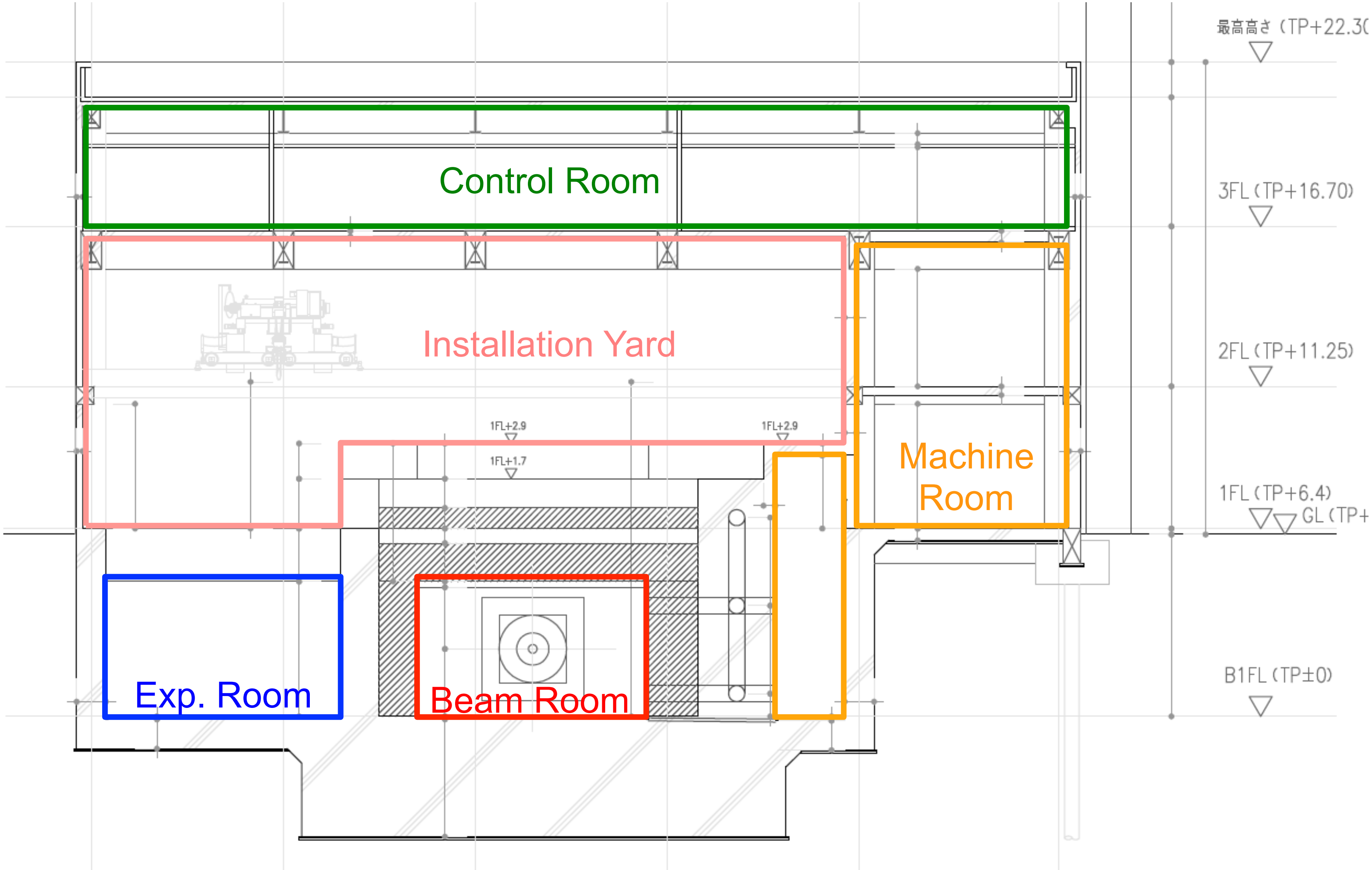
T1 + High-p

10^{-4} protons are
branched into
high-p/COMET line

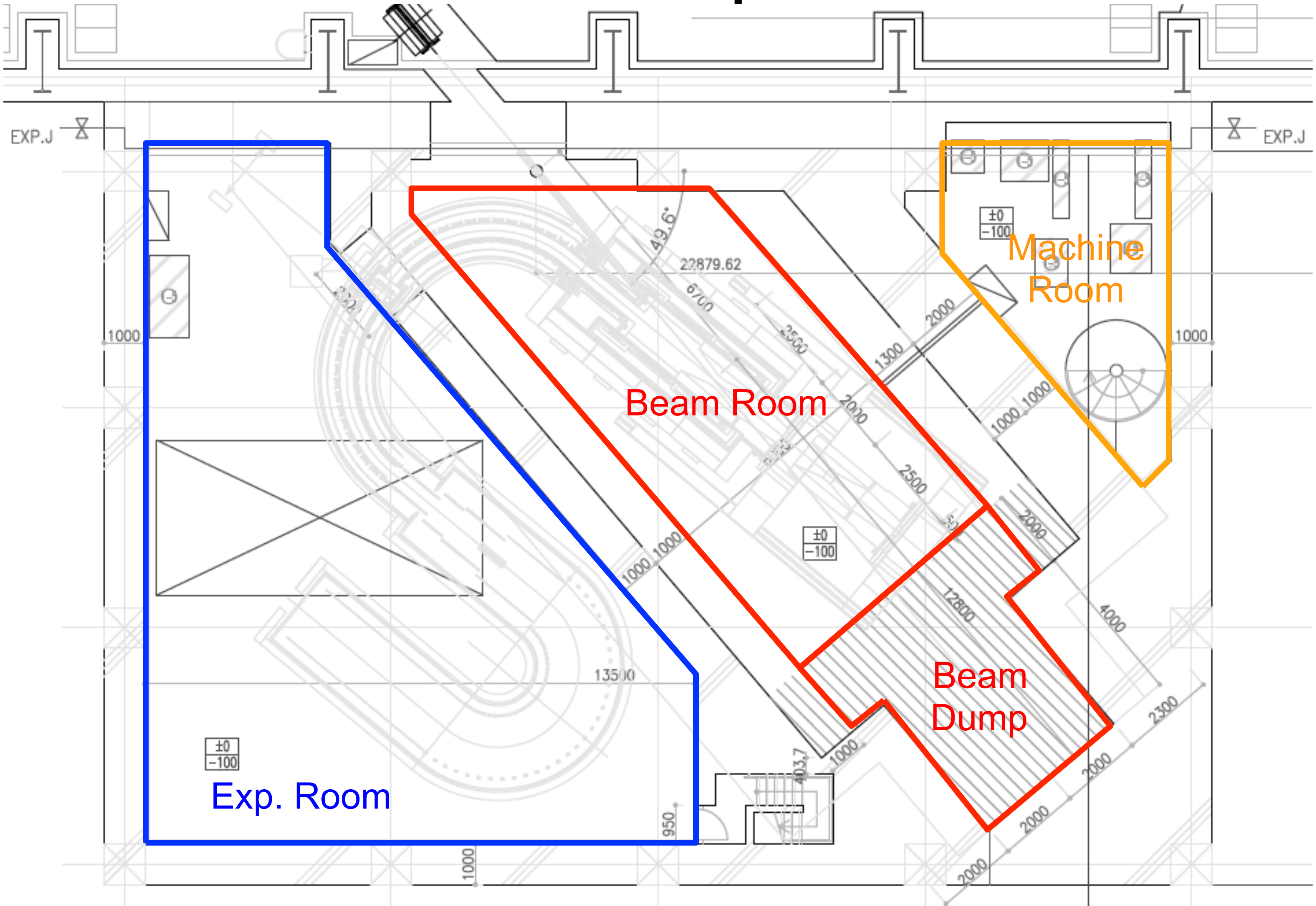
COMET

all protons are
bent into
high-p/COMET line

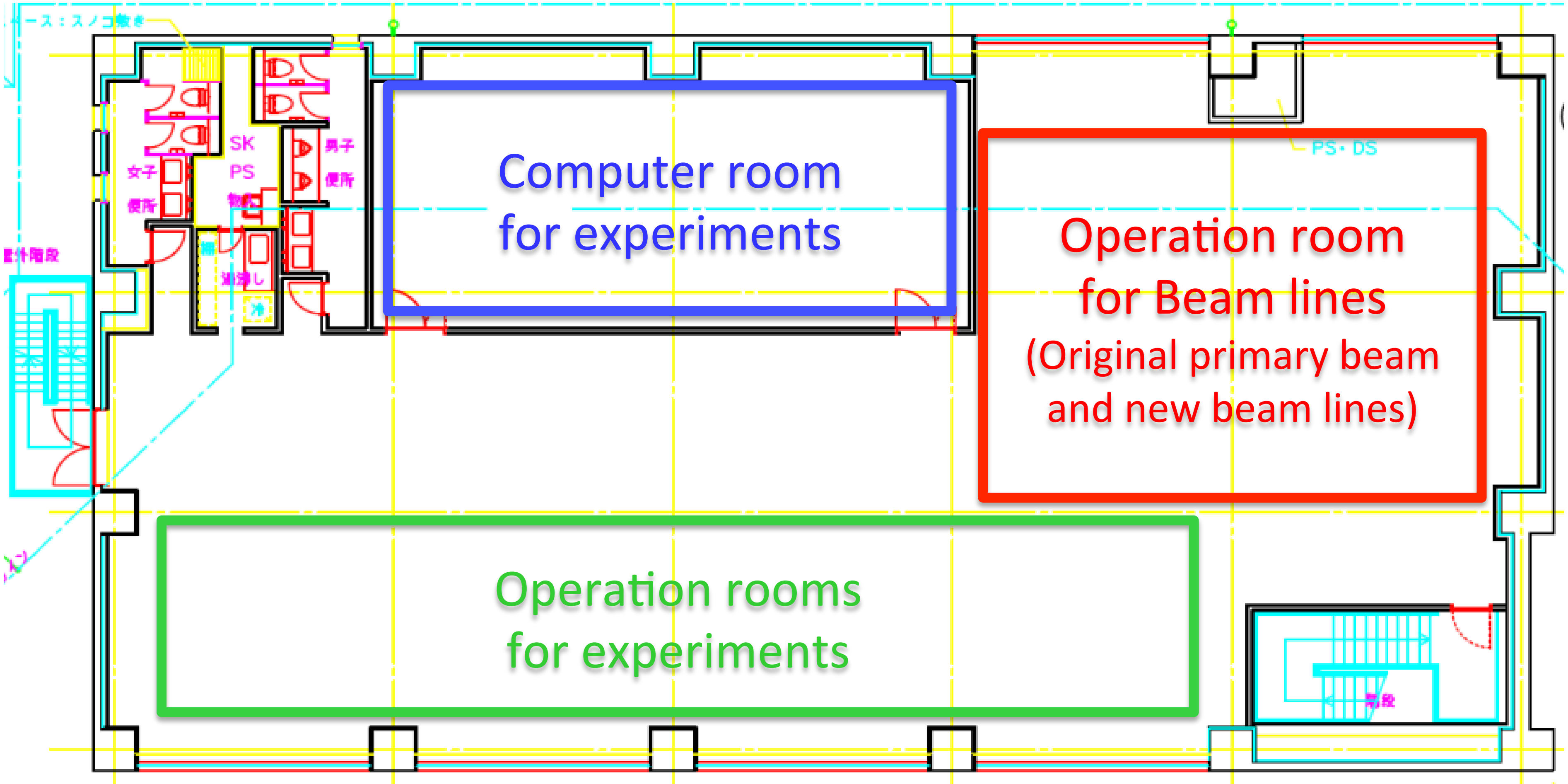
New South Hall Building



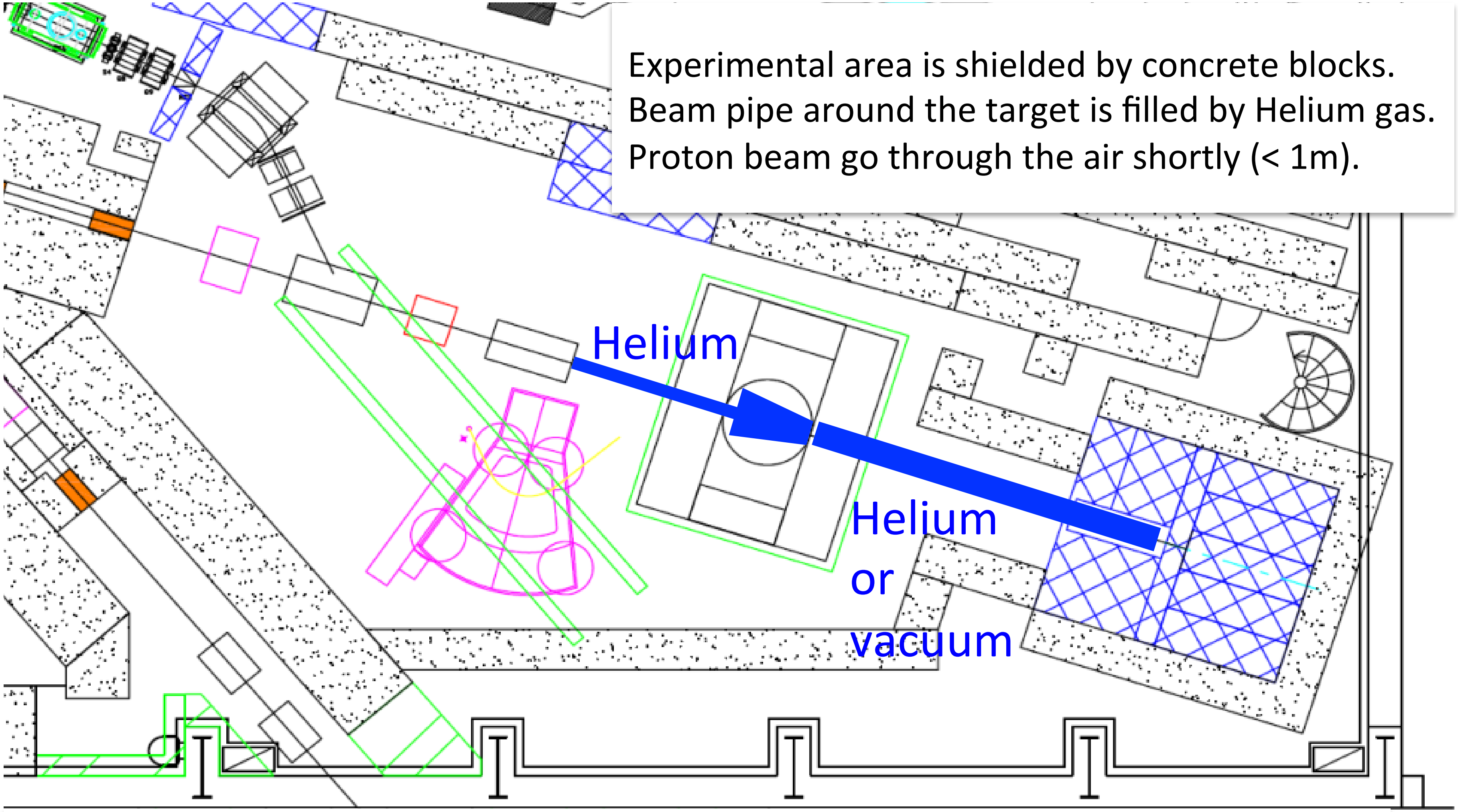
South Hall : B1F Experimental area



South Hall: 3F Control Room



Experimental area: high-p



Configuration of magnets, concrete blocks, and a beam dump is almost fixed.
Preliminary evaluation of radiation from targets, vacuum foils, and the dump is done.
Evaluation of radioactivity contamination in the air will be finished soon.

Construction Schedule

- Currently, construction works are suspended. After we resume the work, the construction of the beam line will be done in two years.
  - Manufacturing of beam line magnets will be finished within 1.5 years.
    - Almost magnets are reused and major modification is not needed for such magnets. We can install such magnets one by one.
  - Installation of magnets
    - To install magnets in Switch Yard, Main Ring should be stopped.
      - Two summer seasons are needed.
    - Installation of magnets in Hadron Hall takes 7 months.
      - It can be done in parallel to the SY work.
  - Construction of South Experimental Hall
    - It takes 1.2 years.
    - After the building construction, equipment around COMET production target will be installed for 1 year.

Possible accidents analysis (Example)

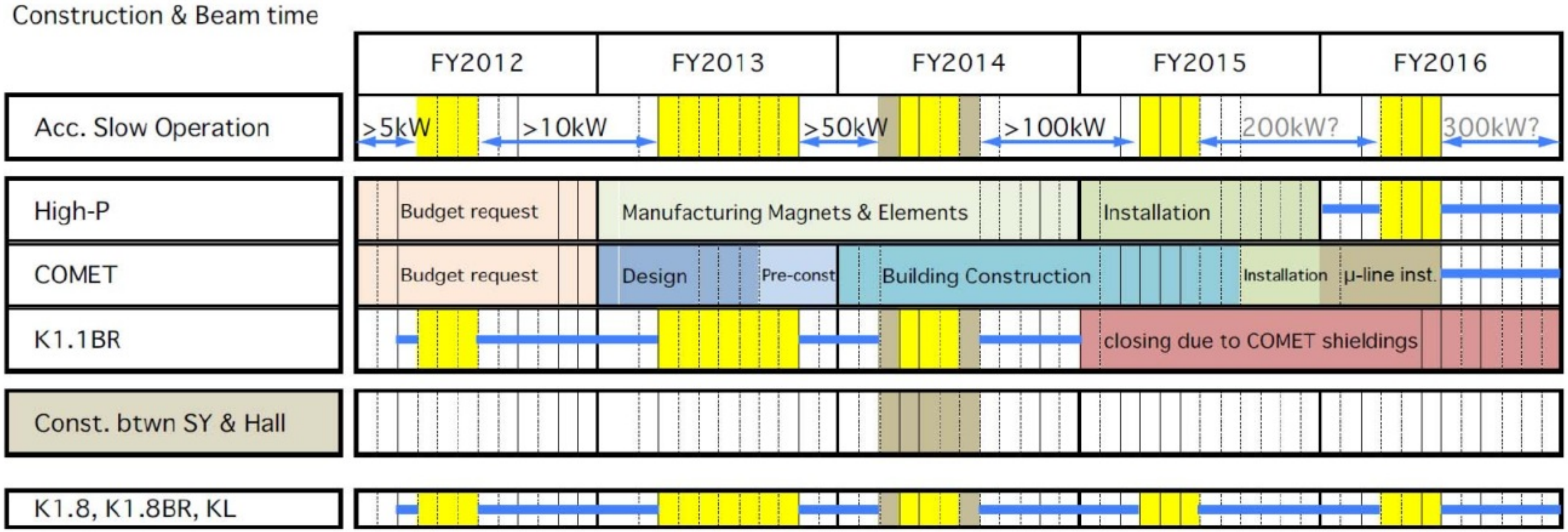
- High-p Experimental Target (E16 case)
  - The experiment uses very thin target and energy deposit is very small.
    - CH_2 0.4mm, C 0.2mm, Cu 0.08mm, Pb 0.02mm
  - An increase of the target temperature for accidental beams is very low.
    - 10K for 2 sec & Full(10^{13}) intensity for Pb
    - 1K for 5 μ sec & normal (10^{10}) intensity for Pb
- COMET Experimental Target
  - Graphite target
    - Several experiences at T2K experiment.
    - An increase of the temperature for accidental beam (fast extraction) is 100k. It is well below the graphite evaporation temperature.

Summary

- The design of new high momentum/COMET beam line is done to satisfy requirements of three beams, such as Primary Proton, COMET, and Secondary beam.
- Detailed design of experimental area and south experimental hall is almost done.
- We need two years to finish construction works after resuming our activities.
- We have started hazard analysis for possible experiments.

BACK UPS

Original Plan before the accident



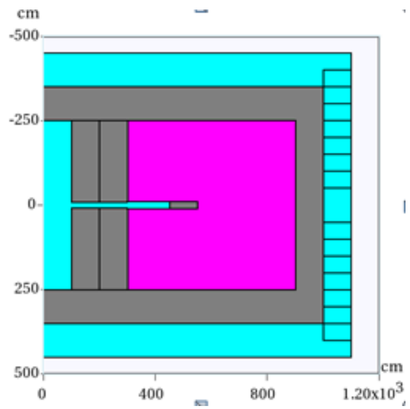
Radiation Evaluation @ high-p

Radioactivities by the proton beam in the air

Nuclei	Normal Density (Bq/cc)	Density @ Accident (Bq/cc)	3 min. after accident (Bq/cc)	Density Limit (Bq/cc)
15O	0.004	0.03	0.01	0.02
13N	0.002	0.005	0.004	0.02
11C	0.001	0.002	0.002	0.02
14O	0.0003	0.005	0.001	0.004

Assumption: air 1m, Experimental area 760m^3

Assumed Accident: 10^{13} protons beam

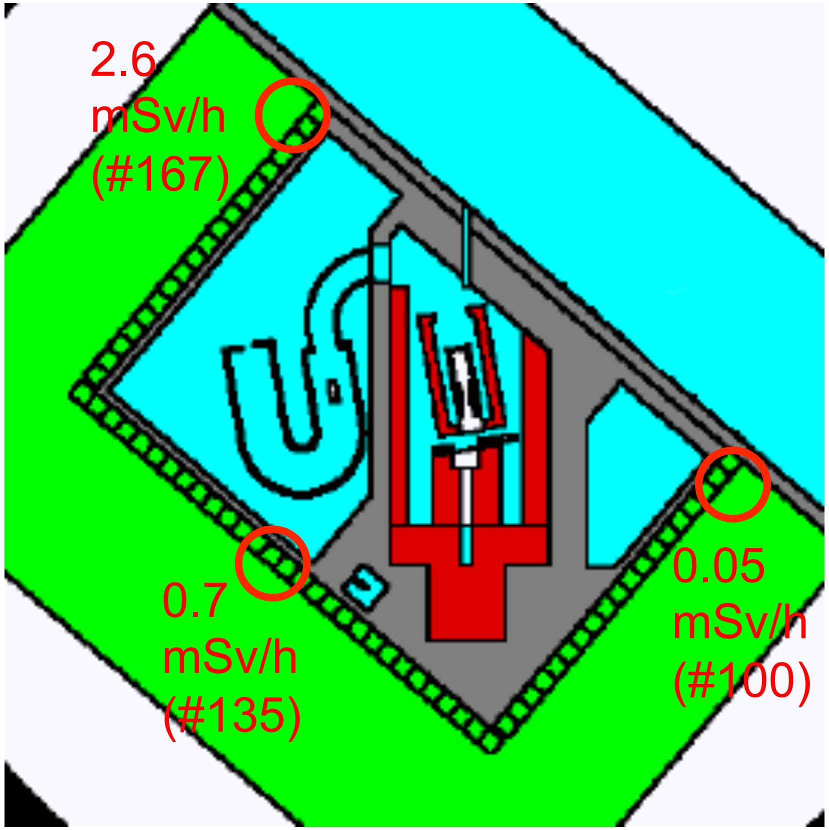


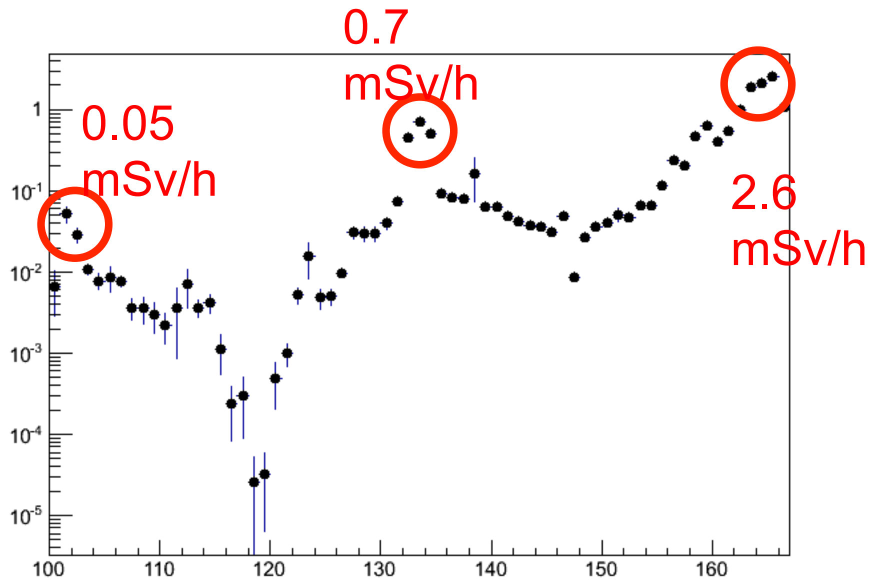
- Density of ^{3}H in Helium chamber is 0.1Bq/cc. If all ^{3}H spread out to the area, the density is 0.0005Bq/cc.

- Other issue is neutron from the dump. We have optimized the shape of the dump entrance to minimize the amount of neutrons in the area.
  - One proton produces 0.025 neutrons per 10x10cm^2 at 2.5m away from the dump

Radiation Evaluation

Radiation level around the South Hall building
was evaluated using MARS simulation.





Each Box in the left figure corresponds
to each point in right plot.

Radiation contamination of the soil is estimated to be smaller than the limitation of 11 mSv/h.

Radioactivation of Air / Water

Radioactivation of air in the beam room / experimental room and cooling water after 90-days operation was evaluated based on MARS.

	Half Life	Air Beam room (Bq/cc)	Air Exp. Room (Bq/cc)	Air Evacuation Limit	Water (Bq/cc)	Water Drain Limit
3H	12.26y	3.1E+00	7.07E-03	5.0E-03	542	60
7Be	53.4d	2.3E+00	7.32E-03	2.0E-03	1408	30
15O	2.04m	6.0E+01	1.00E-01	7.0E-04	180567	5
13N	9.97m	8.1E+01	2.01E-01	7.0E-04	2558	5
11C	20.4m	5.1E+00	2.00E-02	7.0E-04	5113	0.1
41Ar	1.85h	3.7E+01	4.81E-01	5.0E-04	NA	NA

- Radioactive nuclide density in air exceeds evacuation limit. Both beam room and experimental room are air-sealed during beam operation.
- Radioactive nuclide density in cooling water exceeds drain limit. 7Be is collected by filter. Short-life nuclides density is sufficiently reduced in 1 day. 3H must be drained after diluting.

Accident Scenarios (Phase I)

- Accidental fast extracted beam pulse
  - T2K target temperature rise in a cycle is 100K
    - σ_x = 4mm in T2k while σ_x=2mm in COMET
    - 750 kW in T2K while 3.2kW in COMET
  - Well below graphite evaporation temperature
  - Detection system of extraction failure and temperature monitoring are mandatory
- Loss of vacuum during operation
  - Any sublimation or oxidation ?
    - The COMET target is expected to run at a temperature well below the level
  - May be possible to contain the target within a thin metal capsule
    - Protects the target from oxidation and radiates the heat load
  - An alternative is
    - Coat the graphite with a refractory metal e.g. tantalum or iridium
  - Connecting the pump exhausts to a vessel through a filter system is an issue
- Failure of any of dipole magnets bending the beam from the high-p line
  - Status will be included in MPS; If any of them is off, stop the accelerator
  - Even if any magnet fails during extraction, magnetic field goes down slowly due to the coil inductance and thus the beam won't localize a small area on the beam duct/magnet.

COMET Phase I Schedule

- 2013
  - Design of the building & beam line
    - Bid tendering and start construction
  - Design of superconducting solenoid magnets and start of construction
    - Production of SC wires as well
  - Design of the pion production target
- 2014
  - Completion of the building
  - Construction of superconducting solenoid magnets
  - Start magnet and radiation shielding (and beam dump) installation
    - Transport solenoid
  - Start preparation of cryogenic system
  - Tests of the target production target
- 2015
  - Construction of superconducting solenoid magnets
  - Preparation of cryogenic system
  - Construction of the pion production target
- 2016
  - Installation of the capture solenoid
  - Completion of the cryogenic system
    - Tests of the magnet system
  - Installation of the target
  - Ready to accept the 8GeV beam