LHC Collimation Project CERN

5th LHC RADIATION WORKSHOP

29 November 2005

RADIATION LEVELS IN THE MOMENTUM CLEANING INSERTION IR3

Igor A. Kurochkin IHEP, Protvino, Russia

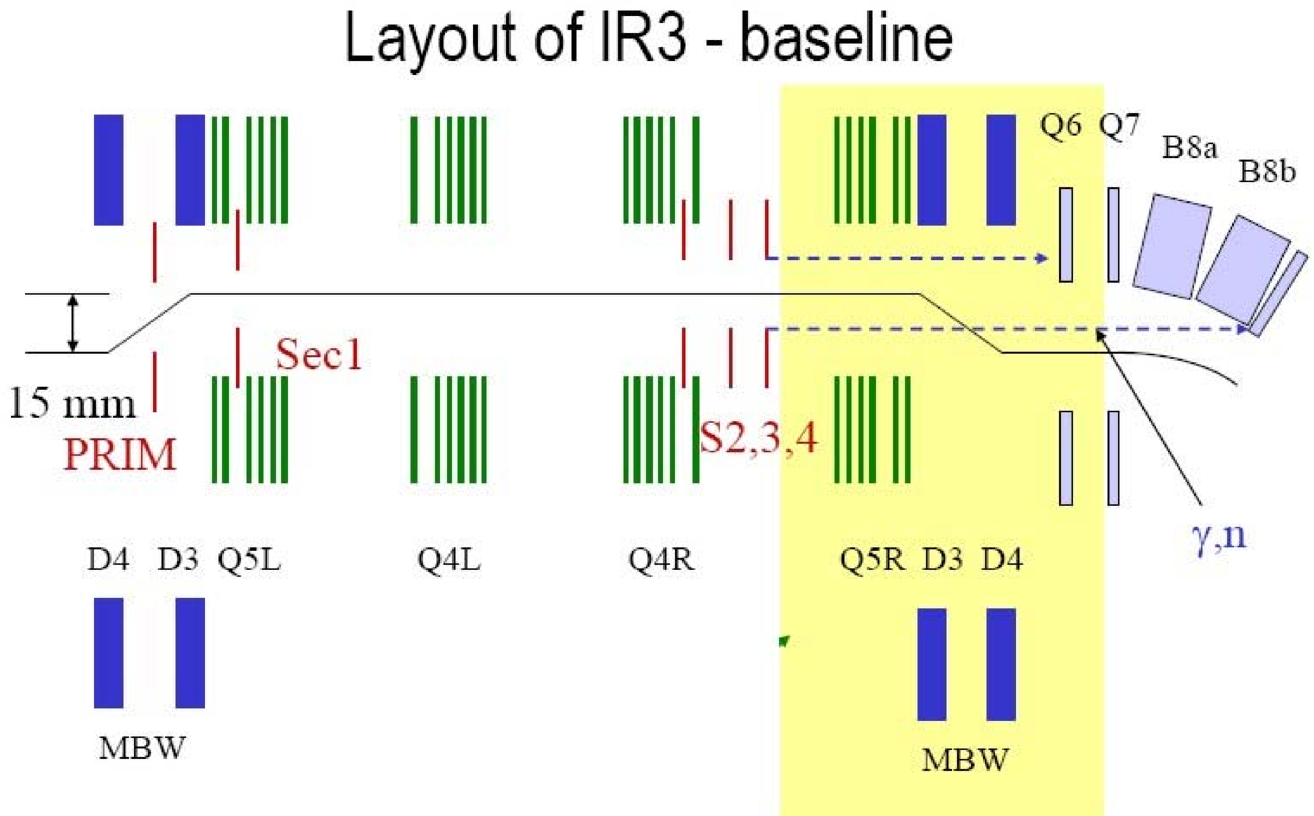
Introduction

- Historical background
  - 2001-2003 IR3: layout and optics version 6.4 [LHC Project Note 263,286,297,331]
  - 2004-2005 IR3: layout and optics version 6.5 [IB, JBJ, IK CWG, International Review]
- Main goals
  - to prevent quenching to the closest SC magnets
  - to attenuate the high intensive radiation fields to the acceptable levels for humans and apparatus
- Some radiation limits:
  - QL = 5 mW·cm^{-3} – quench limit
  - Maximal allowed dose load to coils – 50 MGy(MBW)

Simulation details

- STRUCT - map of primary inelastic interactions in the jaws
- MARS - hadron and electromagnetic cascades development, energy deposition, map of particles downstream of Q7R, map of particles on entrance to UP33 and UJ33
- Model of IR3(28 elements): starts at the end of DS.3L and ends up at the entrance of the DS.3R, dipole fields and quad gradients in the apertures, magnetic lengths of magnets and the drift spaces between the module in a accordance with the optics version 6.5
- Radiation characteristics:
  - PDD - power deposition density per unit of cleaning rate
  - CRQ=QL/PDD - cleaning rate to quench magnets
  - BLTQ=$3{\cdot}10^{14}$/CRQ - beam life time corresponding to CRQ
  - D – total absorbed dose in Gy per year
  - Fh – hadron fluence with E$\geq$20 MeV
  - F_{eq1MeV} – "1 MeV neutron equivalent" fluence

Lifetime limits at 7 TeV (baseline)

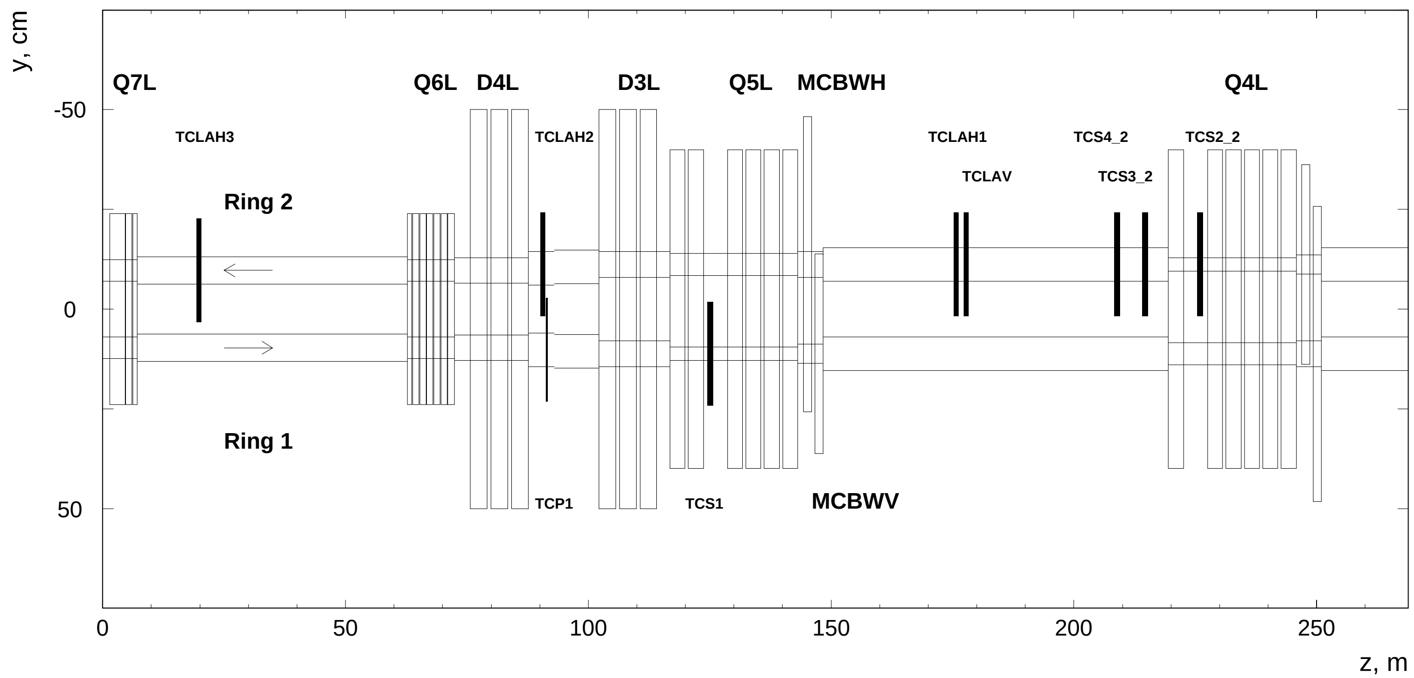


SC magnet	MCBCV	Q6	Q7	MB8a	MB8b	Q8
Beam lifetime, h	150	18	18	15	36	9

Active absorbers (TCLA)

Igor A. Kurochkin
29 November 2005

Layout of one half of the momentum cleaning section with TCLAs



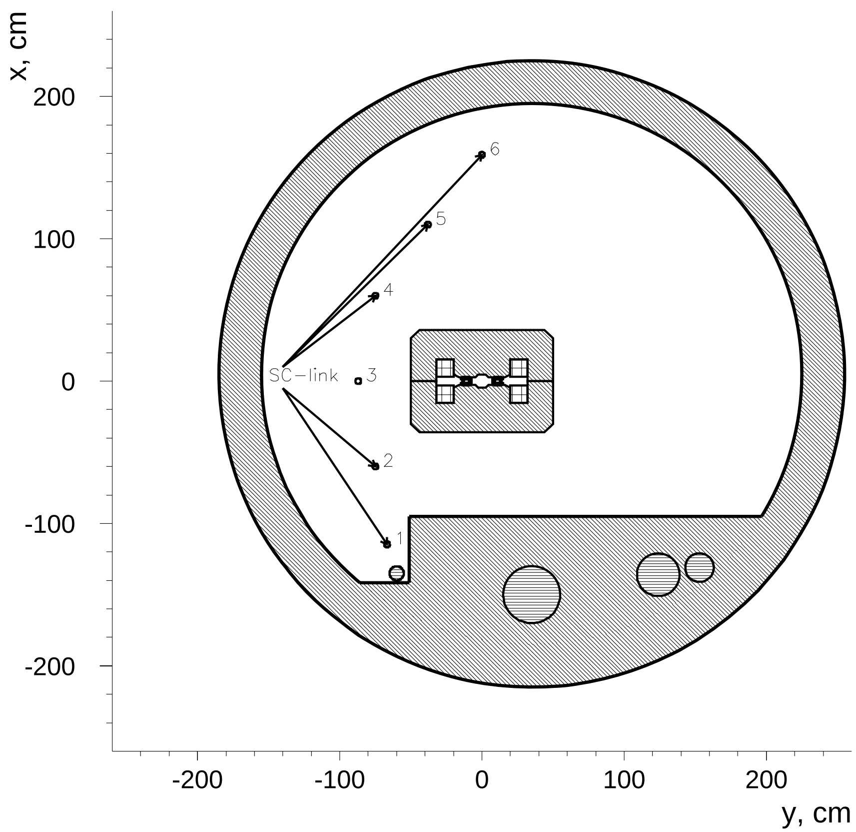
Local Allowed Lifetime in hours for SC magnet [IB]

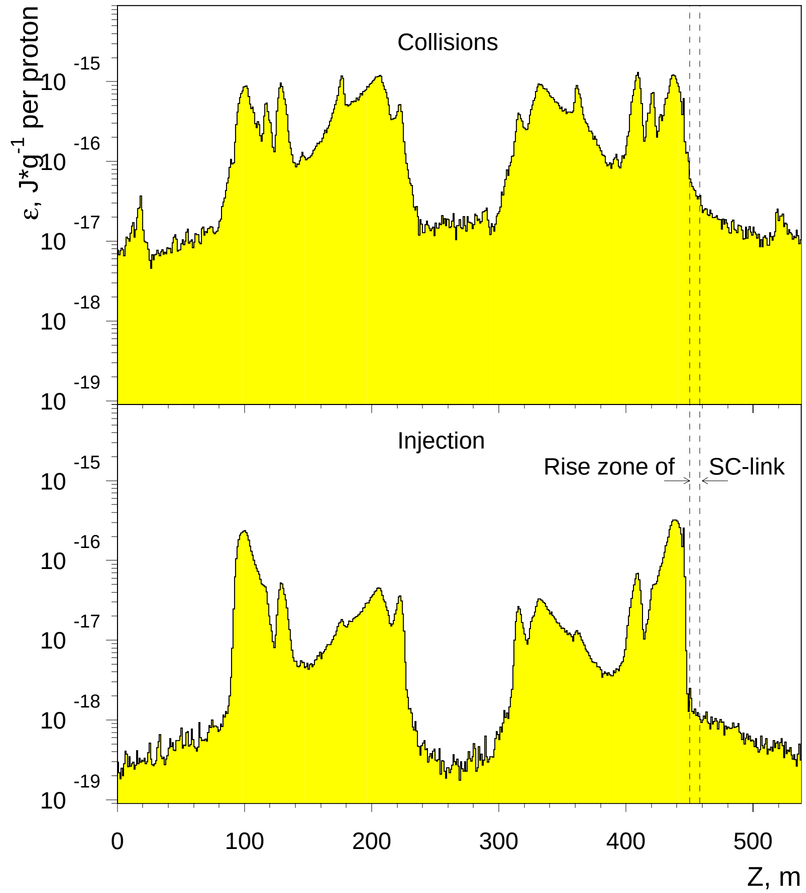
Setup	MCBCV	Q6	Q7	MB8a	MB8b	Q8
No TCLA	150	18	18	15	36	9
4TCLA	1.2	0.3	0.2	1.8	1.3	2.5

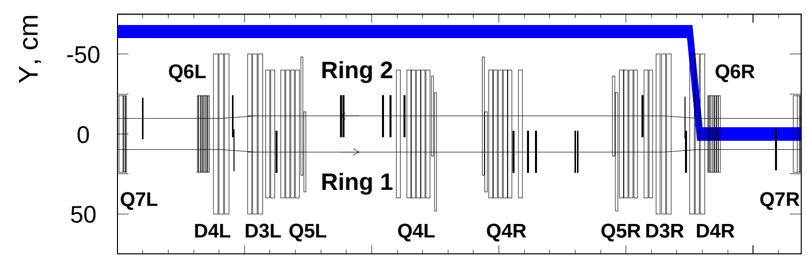
Energy deposition density in SC-link

Igor A. Kurochkin
29 November 2005

SC-link position in tunnel







Energy deposition density in SC-link

- Collisions
  - Steady quench limit – 1.5 mW·cm^{-3}[JBJ CWG 9.05.05]
  - Maximal power dissipated in SC-link(position 1)

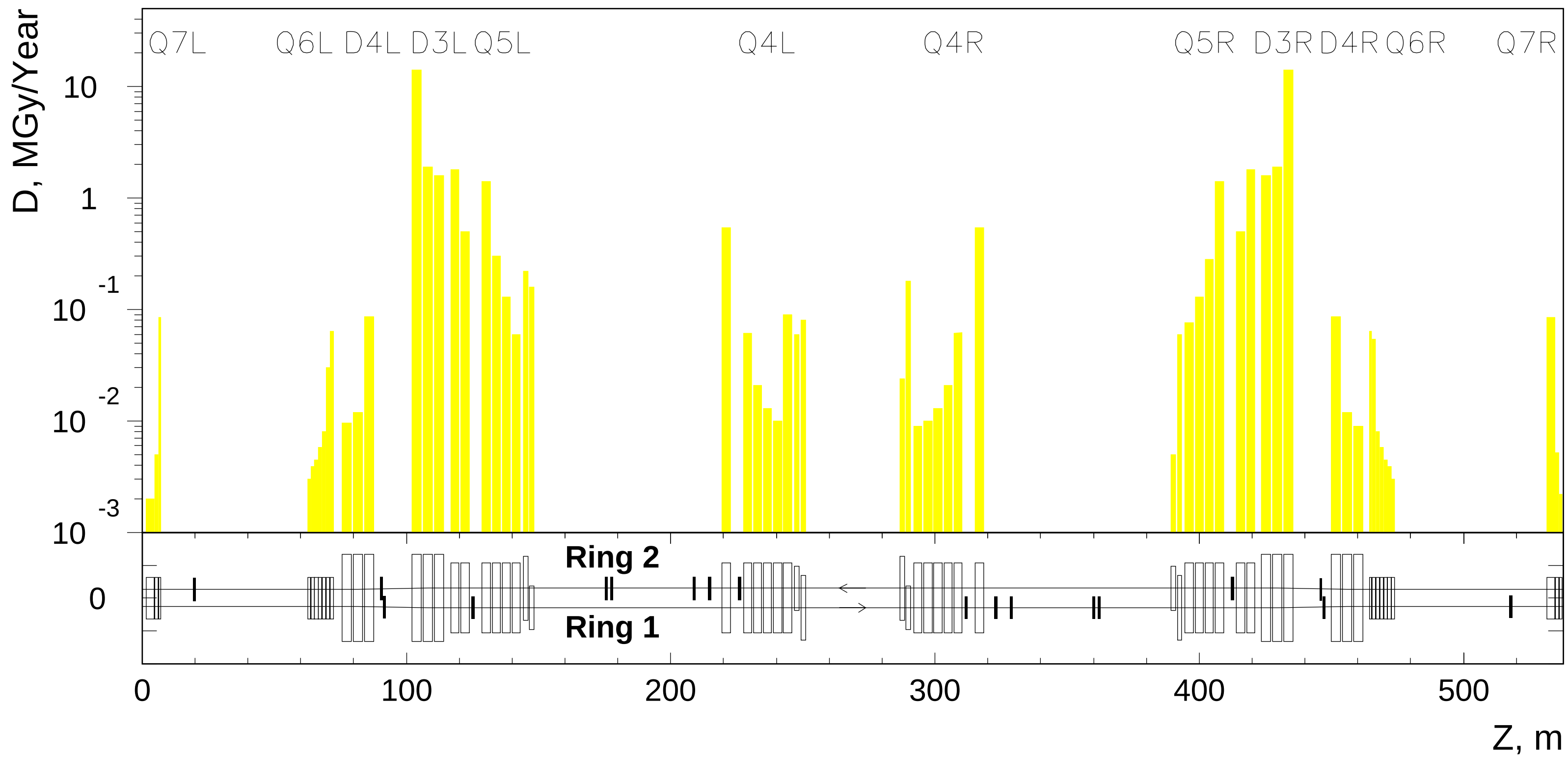
τ, h	0.2 ($4.3 \cdot 10^{11}$ p/s)	1.0 ($0.8 \cdot 10^{11}$ p/s)	30.0	100.0
PDD, mW·cm^{-3}	4.2	0.8	0.03	0.008

  - Allows τ =30 mn steady
- Injection
  - Transient quench limit from 5.5K to 9K: 30mJ·cm^{-3} [JBJ]
  - 5 % of injected protons will lie outside their RF bucket at the beginning of the ramp of acceleration ($1.6 \cdot 10^{13}$ p)
  - Maximal EDD in SC-link(position 1) – 43.0 mJ·cm^{-3} $\longrightarrow$ F = 3.5 % off-bucket
- Loss monitoring ? Shielding ?

Maximal doses without passive absorbers

Igor A. Kurochkin

Absorbed dose is normalized to 10^{16} inelastic proton interactions per year

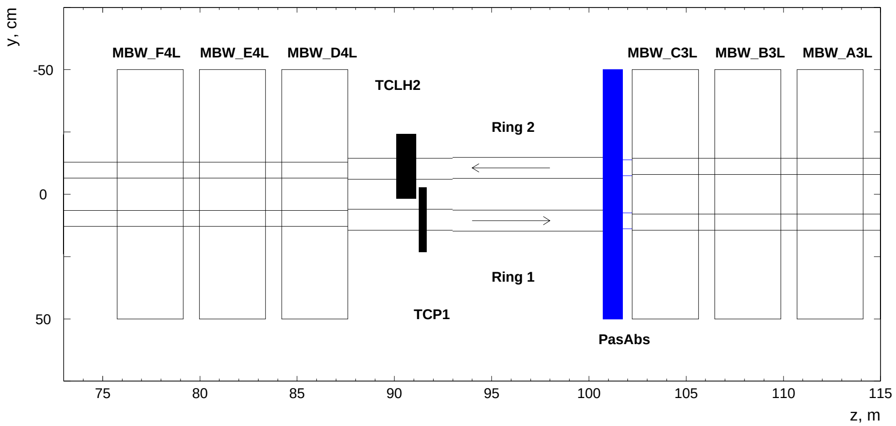


Magnet	MBW.C3	MBW.B3	MBW.A3	MQWA.E5	MQWA.C5	MQWA.E4
D, MGy·yr^{-1}	14	1.9	1.6	1.8	1.4	0.54

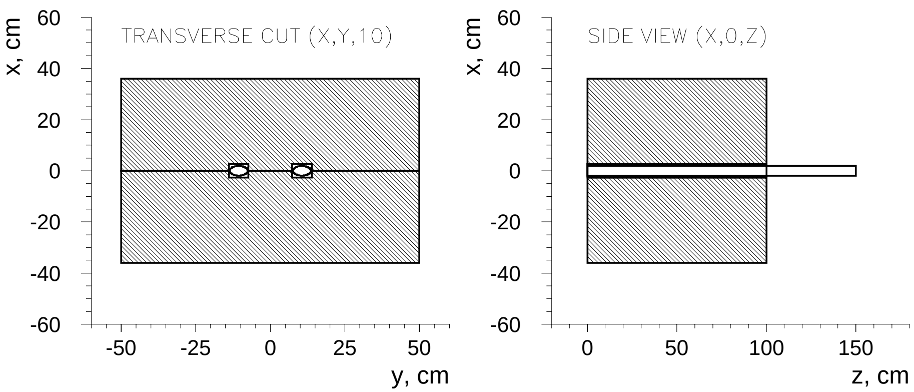
Annual dose in the D3 coils

Igor A. Kurochkin

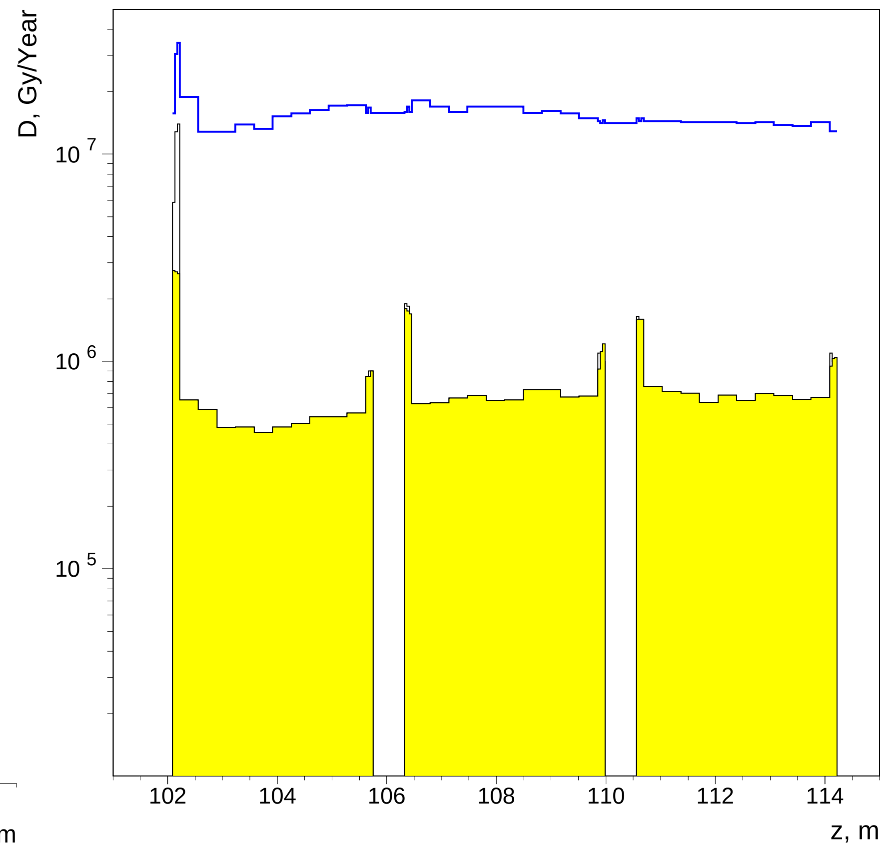
Location of passive absorber



Passive Absorber design

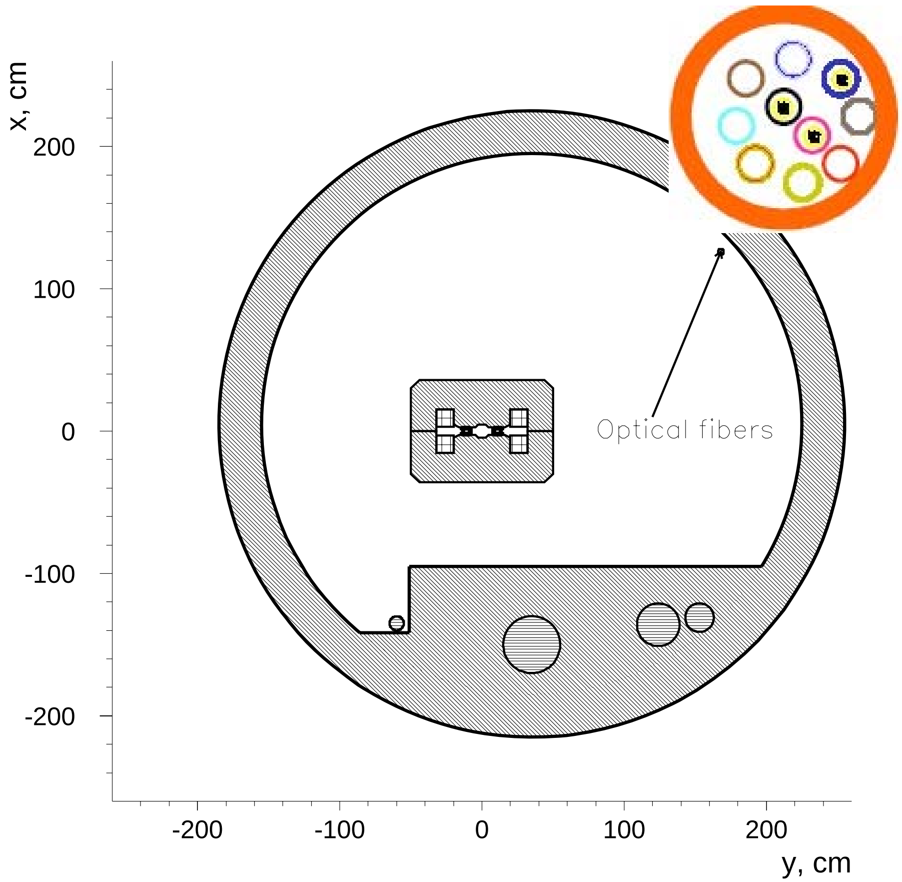


Blue line - absorbed dose in beam pipe, solid clear histogram - dose in coils without PasAbs, yellow histogram - dose in coils with PasAbs

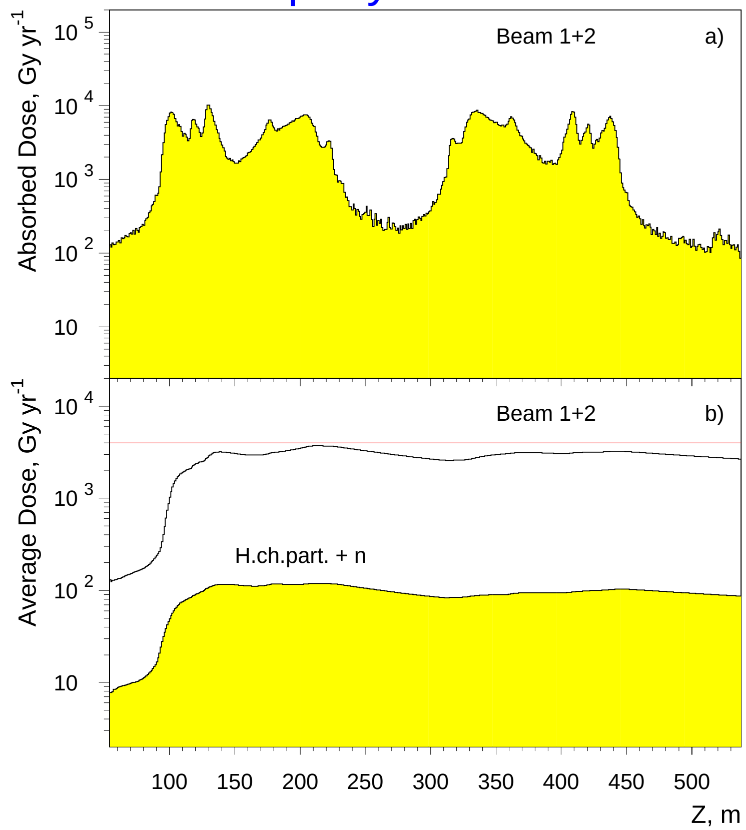


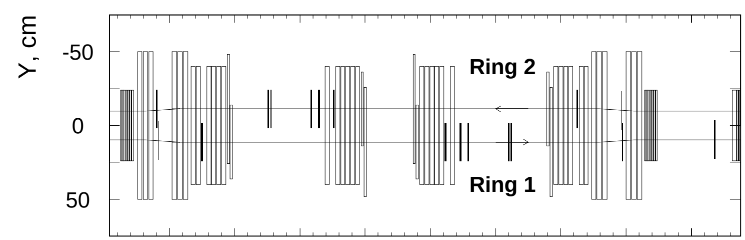
Absorbed dose to fibers

$\emptyset$ 40 mm duct with 10 x $\emptyset$ 7 mm tubes,
10 x 24 = 240 optical fibers



Absorbed dose is normalized to $5{\cdot}10^{15}$ inelastic proton interactions per year





Absorbed dose to fibers

Annual total number(per one ring) of protons lost in the IR3 $[M.Lamont]$

- First year – 8.0·10^{14}
- Nominal case – 3.15 ·10^{15}
- Ultimate case – 5.0·10^{15}

Dose, Gy·yr^{-1}	First year	Nominal	Ultimate
Total	640	2500	4000
H.ch.part.+n	24	94	150
only n	2.0	7.9	12.5

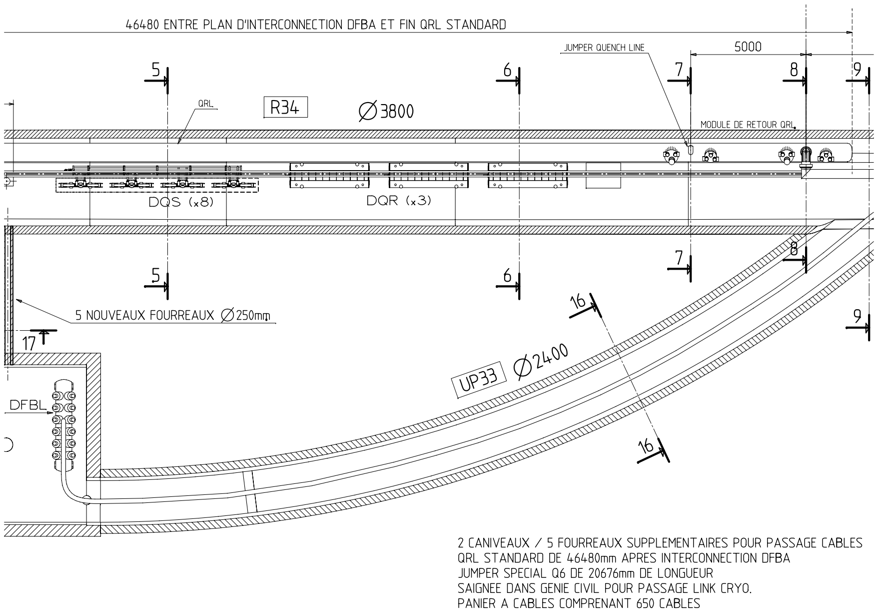
Attenuation of light at 1310 nm in fibers (nominal case)

- Ge-P doped fiber – 61 dB/year
- Ge doped fiber – 7.6 dB/year

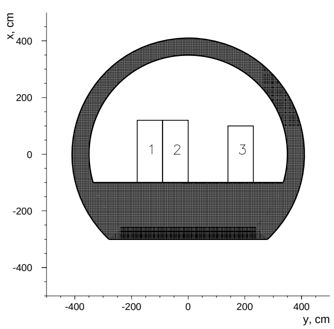
Radiation levels in UJ33

Igor A. Kurochkin

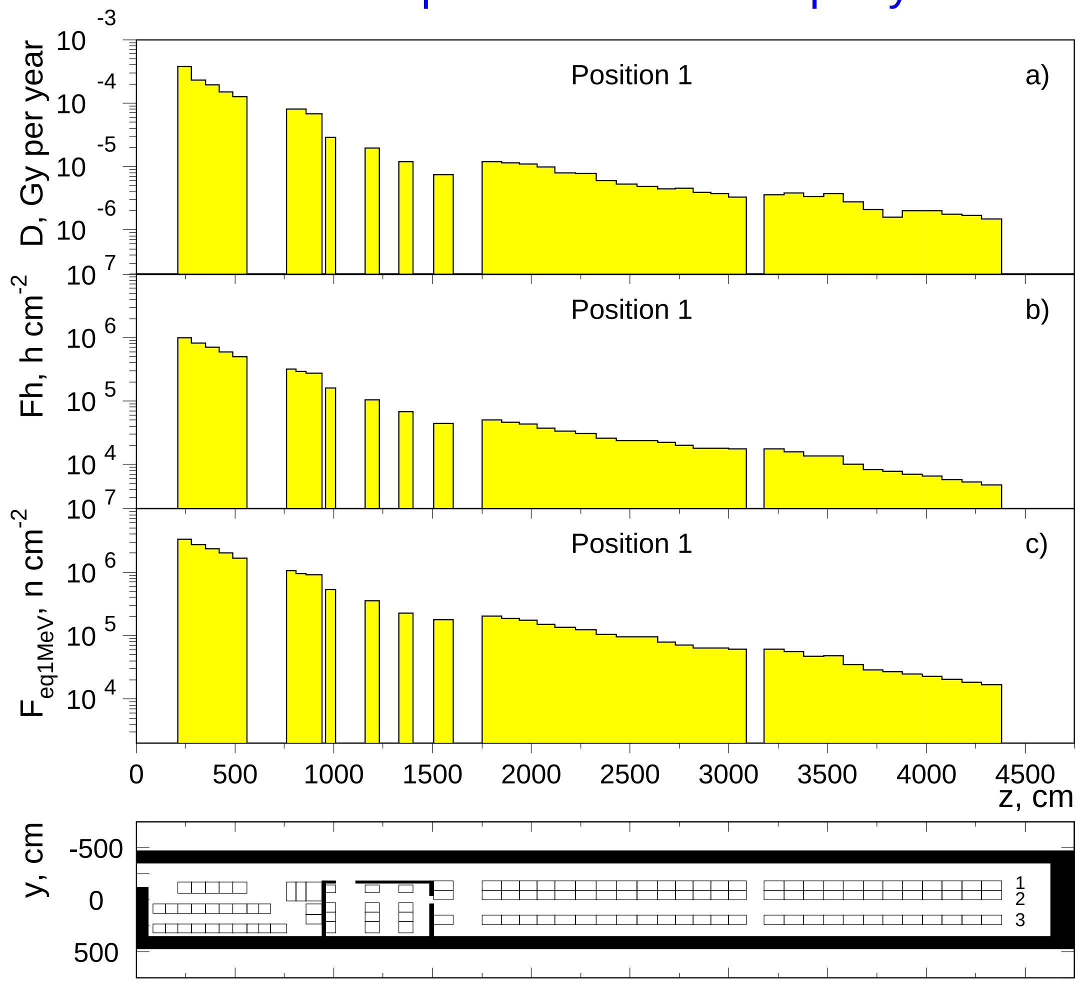
Schematic view of the IR3, UP33 and UJ33 tunnels



Schematic XY-cut of UJ33 tunnel with electronic racks



Absorbed dose, hadron fluence with E≥20 MeV, "1 MeV neutron equivalent" fluence are normalized to $5 \cdot 10^{15}$ inelastic proton interactions per year



Summary

- TCP(L=60cm) and 4 TCLAs allow for beam lifetime of 2.5 h
- Passive absorbers for D3 modules allow to reduce doses to coils in 5 times, down to 1.5 MGy per year (ultimate case)
- High level of average dose to fibers along IR3 (about 2.5 KGy and 4 KGy per year for nominal and ultimate cases, respectively)
- Dose loads to electronics do not exceed values of 0.5 mGy per year in the ultimate case
- Maximal hadron fluence $< 1 \cdot 10^{6}$ h cm^{-2} per year
- 1 MeV neutron equivalent fluence $< 4 \cdot 10^{6}$ n cm^{-2} per year