Ozone production in IR7

Preliminary results

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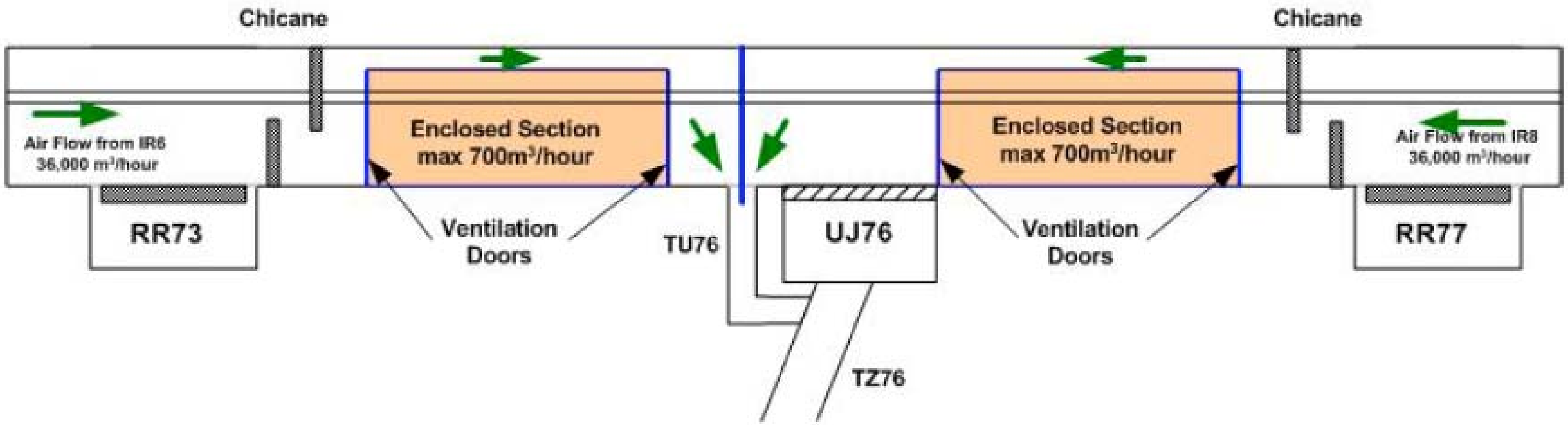
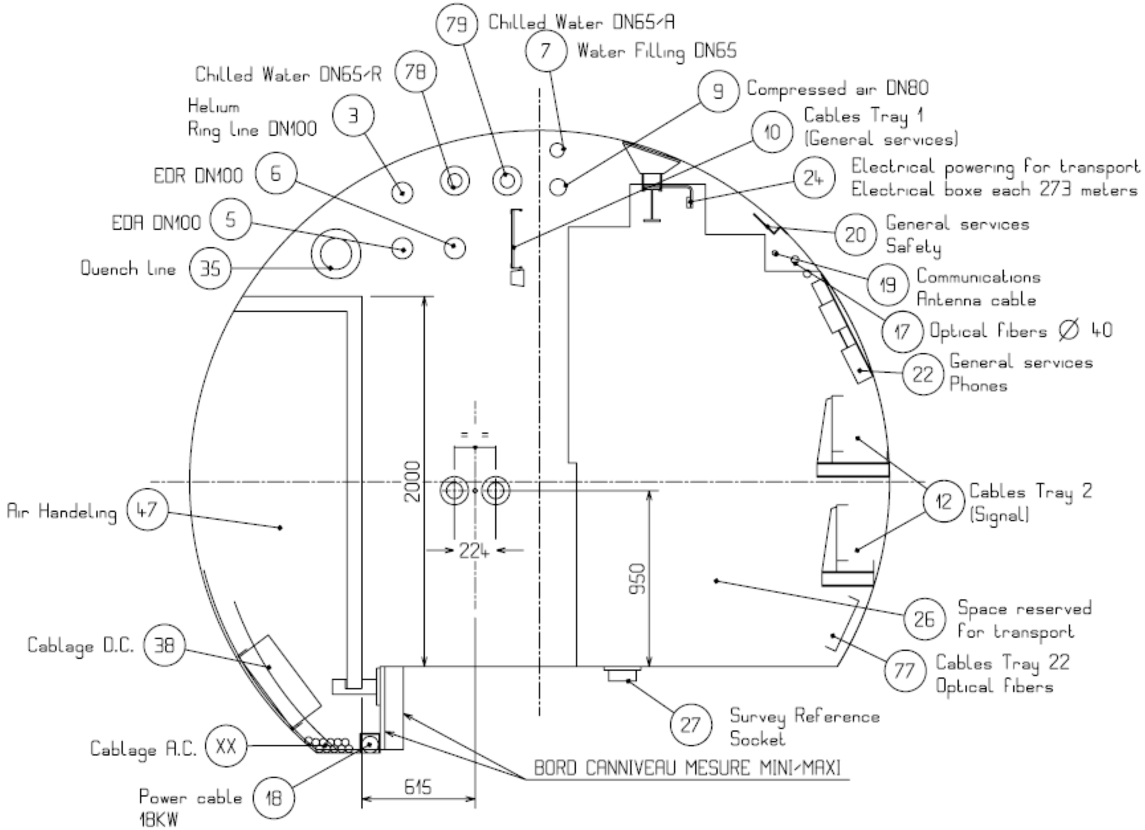
Introduction



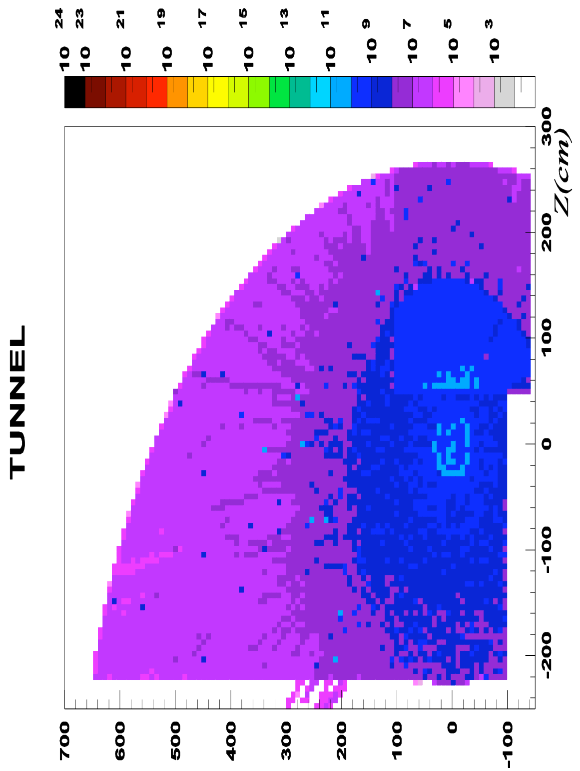
- Radiation induced production of O_3 around IP7.
  - dose estimates provided by Fluka
  - assumed 4.1×10^{16} lost protons per year.
  - assumed all Fluka energy loss in air is ionizing.
- Enclosures around regions of high dose (O_3 concentration)
  - enclosures seal the tunnel in areas where the ozone
  - voided independently of the main tunnel
  - air corridor to allow passage of tunnel air towards TU76

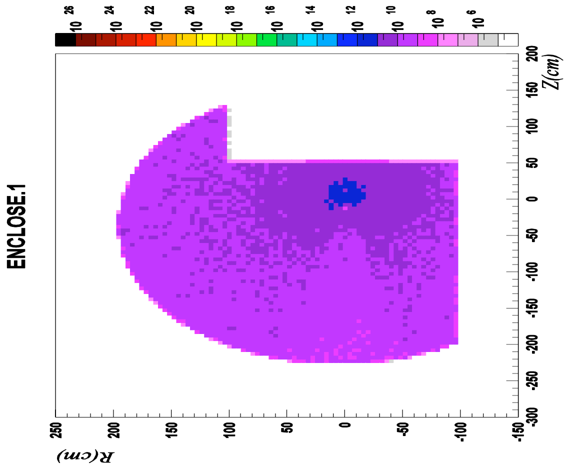
Tunnel Section

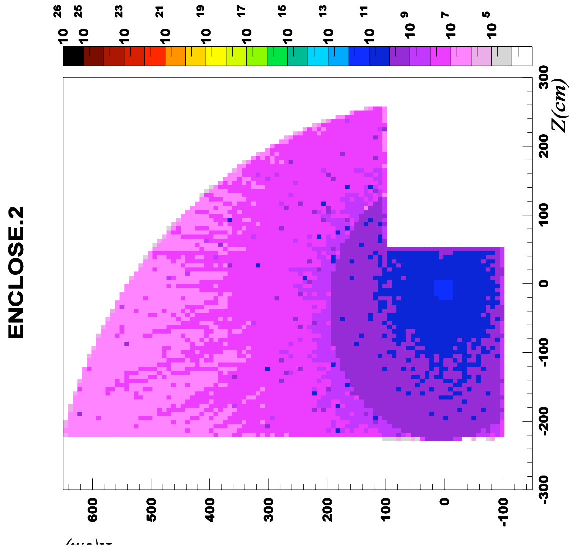


Energy scorings

- Annual dose (GeV/cm^3) based 4800 beam-hours
- Compliant with the standard $10^4 - 10^5$ Gy/year







Calculation (1)

- Fasso et el (1982) **LEP Note 379** gives the following differential equation

dissociation ventilation

$$\frac{dN}{dt} = IG - \alpha N - kIN - \frac{Q}{V}N$$

formation decomposition

I	=	ionizing energy deposited in air per unit time, in $eVcm^{-3}s^{-1}$	
G	=	number of ozone molecules formed, in eV^{-1}	(7.4×10^{-2} eV^{-1})
α	=	dissociation constant for ozone, in s^{-1}	(2.3×10^{-4} s^{-1})
N	=	concentration of ozone at time t, in cm^{-3}	
k	=	decomposition constant, in $eV^{-1}cm^{3}$	(1.4×10^{-16} $eV^{-1}cm^{3}$)
Q	=	ventilation rate, in $cm^{3}s^{-1}$	
V	=	irradiated volume, in cm^{3}	

- Integration leads to the following **concentration kinetics**:

$$N(t) = \frac{IG}{\alpha + kI + Q/V}\left\{1 - \exp\left[-\left(\alpha + kI + Q/V\right)t\right]\right\}$$

Calculation (2)

- More useful **steady state** formulation in a tunnel
  - average energy , I_{ave}, is deposited per unit time
  - air circulates with speed v ms^{-1}
  - length z of tunnel is irradiated

$$N(z) = \frac{I_{ave}G}{\alpha + kI_{ave}} \left\{ 1 - \exp\left[-\left(\alpha + kI_{ave} \right) z / v \right] \right\}$$

This is a special case of the previous equation where the concentration N cm^{-3} increases with distance z traversed and air traverses a length z meters of tunnel in z/v seconds accumulating a concentration N(z) molecules of ozone

Results

- Steady state results for air exiting regions

	Tunnel	Encl. 1	Encl. 2
N_{O3} (ppm)	**2.20×10^{-3}**	**1.378×10^{-1}**	**1.334×10^{-1}**

- Assumed ventilation rates
  - 36000 m^3h^{-1} for the main tunnel
  - 700 m^3h^{-1} for the enclosures

- Parts per million conversion requires
  - air density of 1.202 kg m^{-3}
  - molecular weight of 28.95 g mol^{-1}
  - Avogadro constant $N_A = 6.022 \times 10^{23}$

Results

- Concentration kinetics using averaged dose
  - assumes ‘magic ventilation’ where air is not considered to travel to the ventilation point through a radiation environment.
  - only useful to compare growth rates etc