

Figure 10: Maximum dose equivalent as a function of energy for neutrinos in equilibrium with their secondaries [Mok98].

Some dose estimates:

Solar neutrinos $\sim 10^{-7} \mu\text{Sv y}^{-1}$
($E_\nu \sim 1-10 \text{ MeV}$)

Atmospheric neutrinos $\sim 2 \cdot 10^{-9} \mu\text{Sv y}^{-1}$
($E_\nu \sim 100 - 200 \text{ MeV}$)

Long Base Line neutrino experiments:
($E_\nu \sim 10 \text{ GeV}$)

FERMILAB	@ 1 km distance	$\sim 10 \mu\text{Sv y}^{-1}$
	@ 730 km distance	$\sim 10^{-5} \mu\text{Sv y}^{-1}$
CERN/GRAN SASSO	SBL exp.	$\sim 20 \mu\text{Sv y}^{-1}$
	GRAN SASSO	$\sim 10^{-4} \mu\text{Sv y}^{-1}$

FOR COMPARISON

Natural background in the Geneva area $\sim 1 \text{ mSv y}^{-1}$

Max ambient dose equivalent caused by ionizing radiation or radioactivity emitted by CERN beyond the boundaries of its site 1.5 mSv y^{-1}

$$\frac{dN_\nu}{dE_\nu} = \Phi_0 \frac{2}{E_0} \left(1 - \frac{E_\nu}{E_0}\right) \quad \langle E_\nu \rangle = E_0/3$$

$E_0 =$ energy of μs

$$\Phi_0 = 8 \cdot 10^3 \text{ cm}^{-2} \text{ s}^{-1} \left(\frac{100 \text{ m}}{d}\right) \left(\frac{E_0}{1 \text{ TeV}}\right)$$

$C(E_\nu) =$ fluence to dose equivalent
conversion coefficient
($\mu\text{Sv cm}^2$)



$$\dot{H} = \int_0^{E_0} \frac{dN_\nu}{dE_\nu} C(E_\nu) dE_\nu$$

Assuming: $N^0 = 2 \times 10^{12} \mu\text{s/bunch}$
 Repetition rate: 15 Hz
 Operation: 120 days/year
 Spherical approximation of the Earth

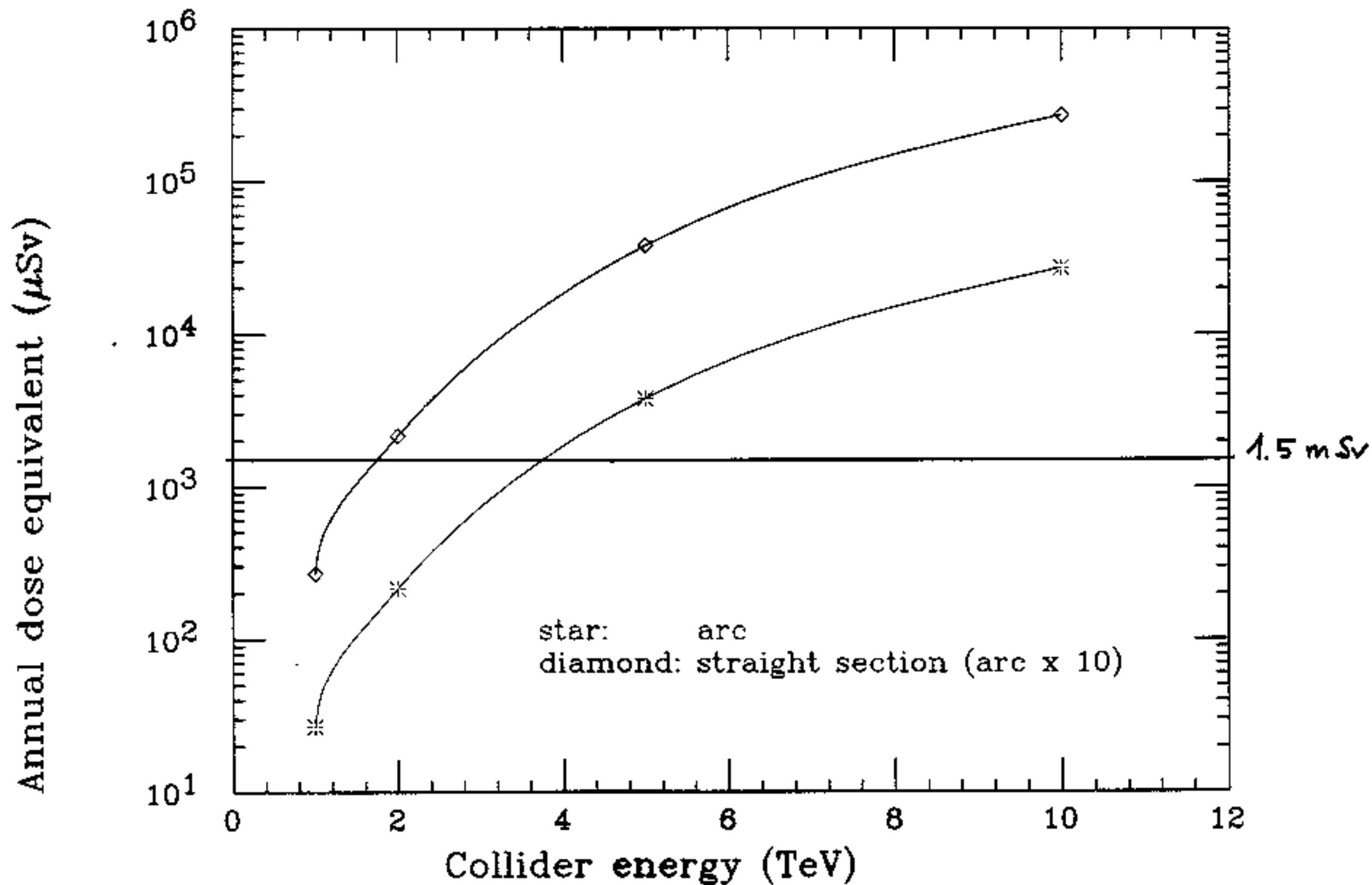


Fig. 1. Dose equivalent due to neutrino radiation at 36 km distance (collider at 100 m depth)

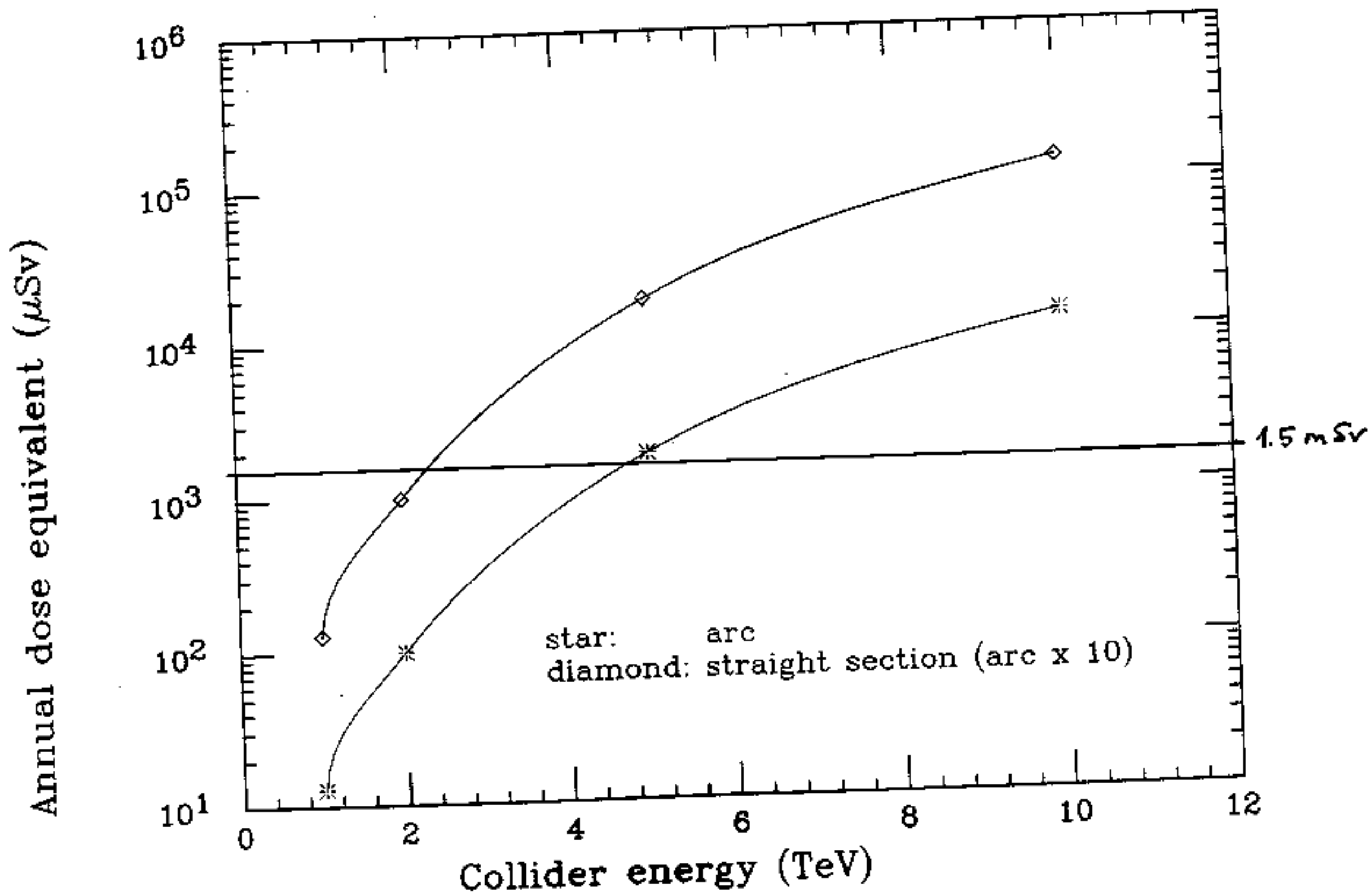


Fig. 2. Dose equivalent due to neutrino radiation at 51 km distance (collider at 200 m depth)

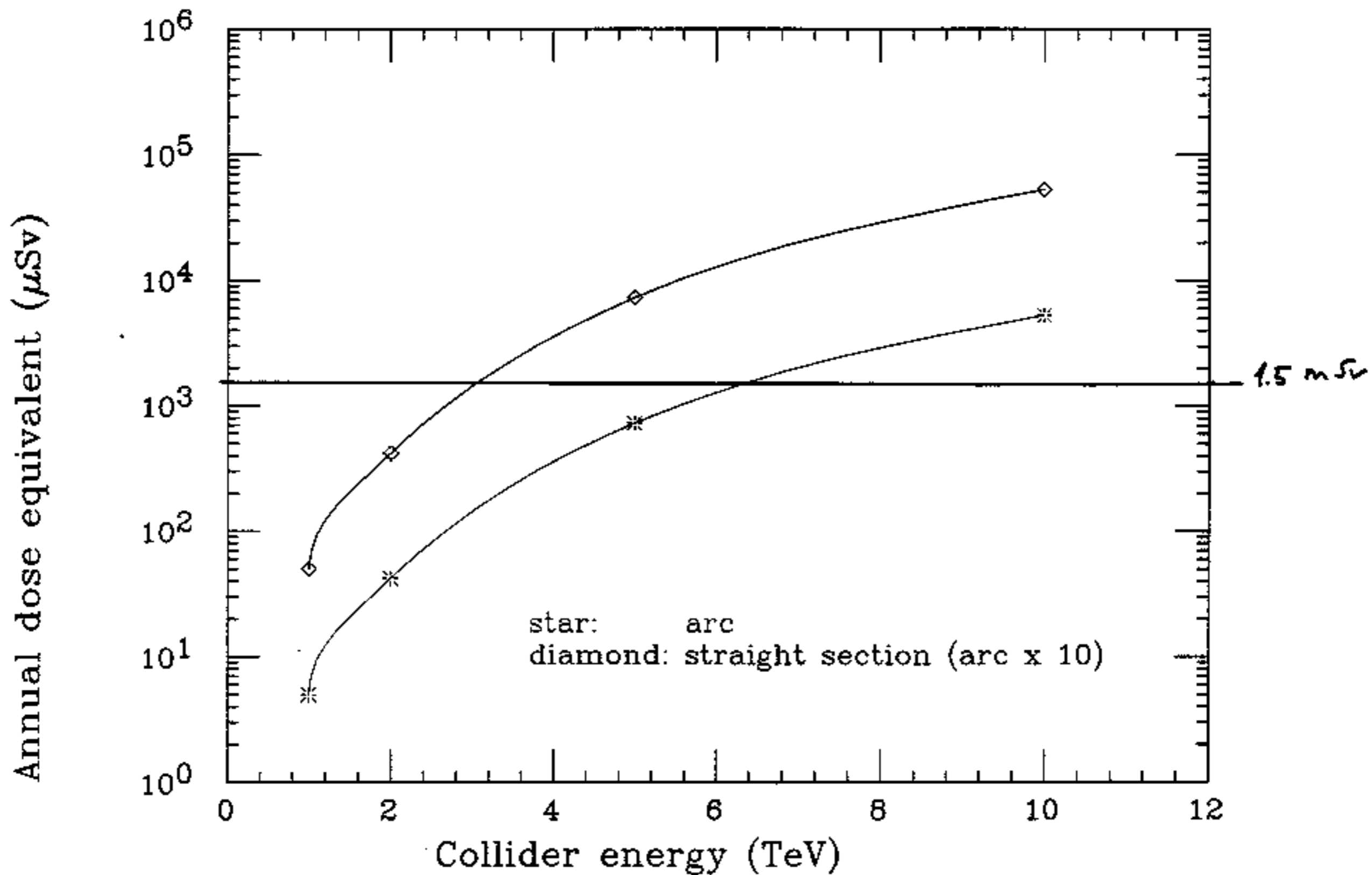


Fig. 3. Dose equivalent due to neutrino radiation at 80.5 km distance (collider at 500 m depth)

CRITICAL ISSUES

Collider energy

Number, location and length
of straight sections



Enhancement factor of
neutrino flux from straight section
(very critical - to be assessed carefully)

Site selection, positioning,
orientation and tilting
of the ring

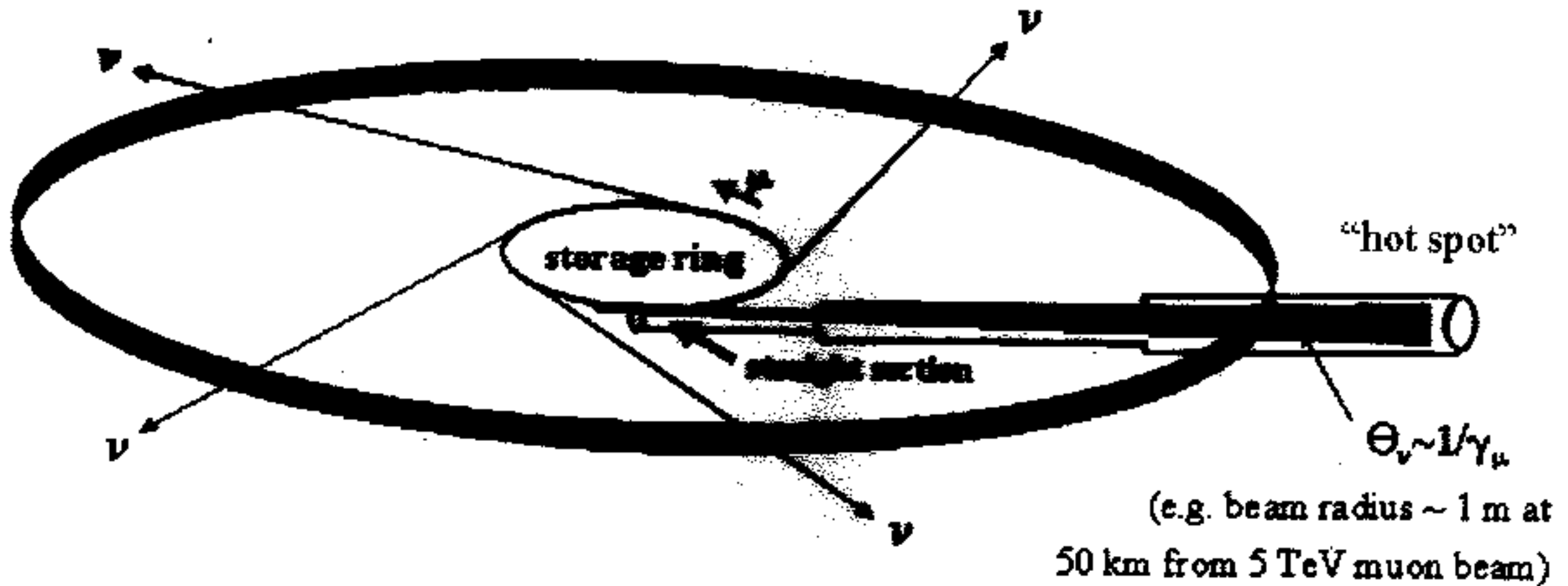
POSSIBLE REMEDIES ?

- DECREASE INTENSITY OF THE MUON BEAMS CIRCULATING IN THE RING
→ COOLING AND BEAM-BEAM TUNE SHIFT COMPENSATION (SKRINSKY)
- VARY THE PRODUCTION DIRECTION OF THE NEUTRINO BEAM BY INSTITUTING A VERTICAL WAVE IN THE COLLIDER (FERMILAB)
- DECREASE NUMBER OF STRAIGHT SECTIONS BY A MAGNET LATTICE WITH COMBINED FUNCTION MAGNETS (B. KING)

"HOT SPOTS"

- DEFINE RADIATION ENCLOSURE WHERE THE NEUTRINO BEAM EMERGES FROM THE GROUND
- "TRANSPORT" NEUTRINO BEAM IN AIR OR IN VACUUM
- ANY OTHER IDEA ?

Neutrino Radiation Disk



ν beam stronger at str. sections: e.g. even 0.1 m str. section is ~ twice disk average