Short Baseline Beams at a Neutrino Factory

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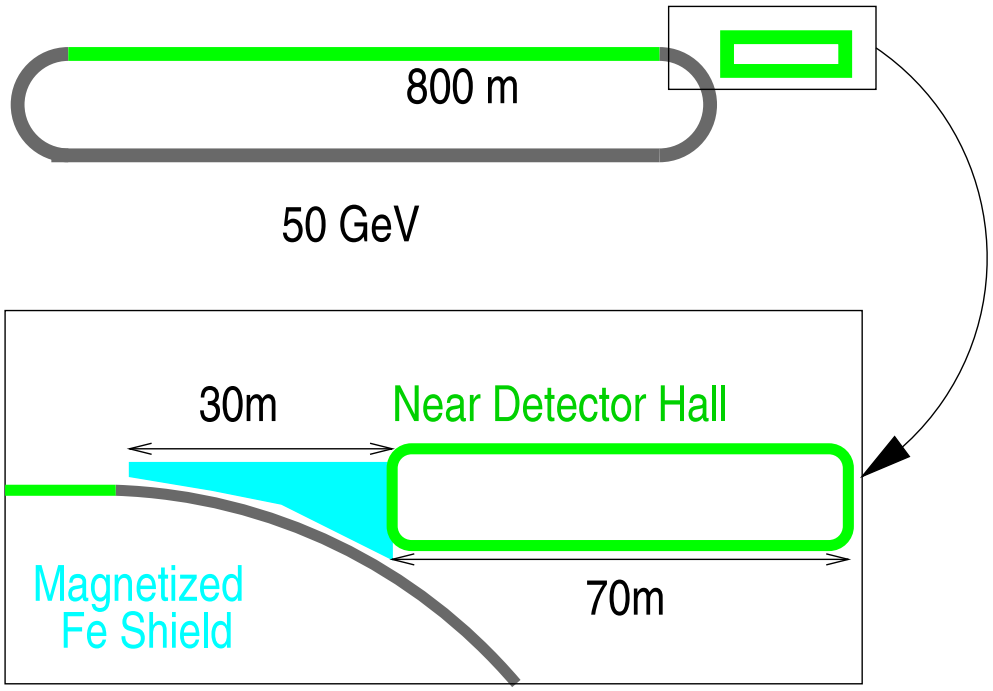
Strawman Experimental Hall

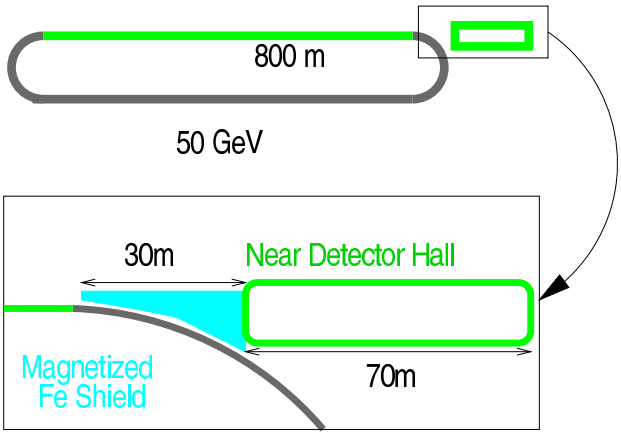
10^{20}/yr μ decays in the green straight section $\Rightarrow$
5–8% of all interactions in detector 10 cm in radius
40–50% of all interactions in detector 50 cm in radius
$\approx 1.5\text{–}3 \times 10^6 \times \frac{E_\mu}{50\ \text{GeV}}$/kg/yr at beam center
(FNAL Neutrino Factory Study Group Parameters)

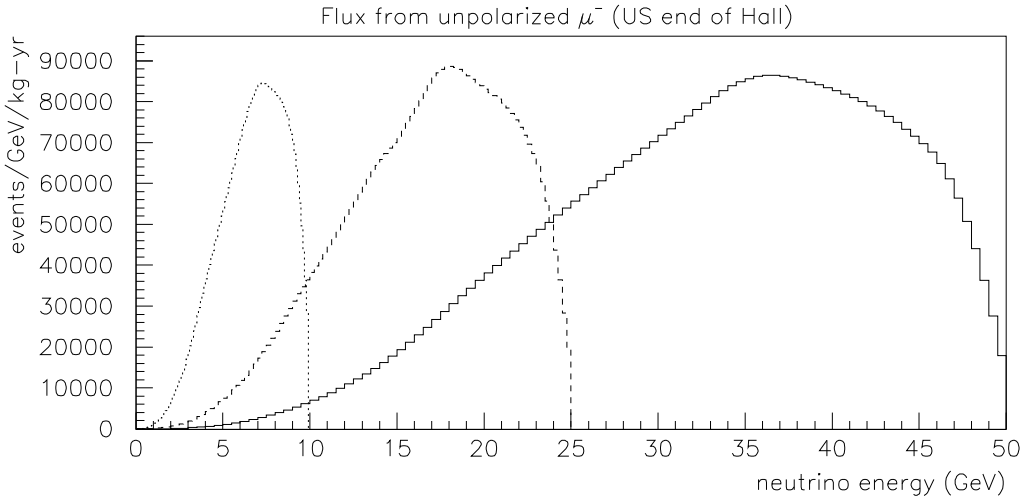


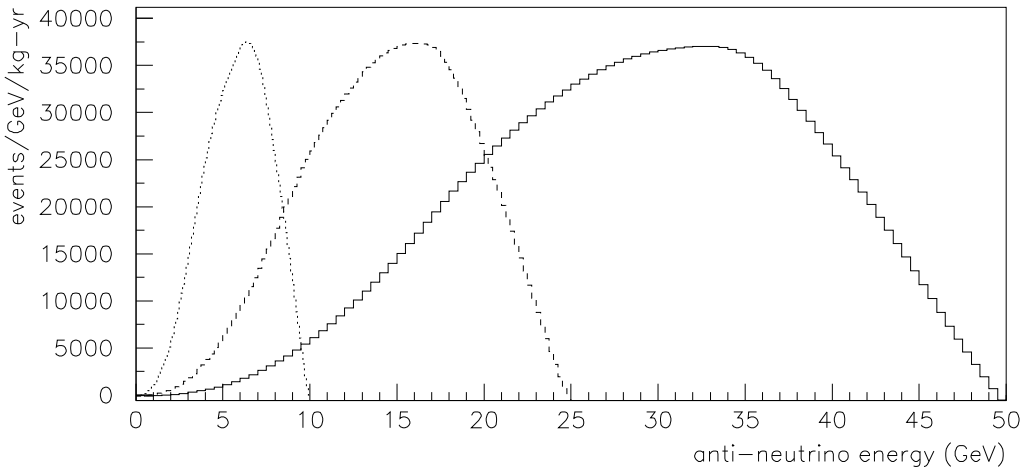
c.f.: Competing facilties

Beam	$\langle E_\nu \rangle$ [GeV]	ν/yr, near detector
NuTeV/CCFR	100	$\sim 10^{14}/1\ \text{m}^2$
CHORUS/NOMAD	30	$\sim 3 \times 10^{15}/1\ \text{m}^2$
MINOS Near	15	$\sim 10^{17}/1\ \text{m}^2$
Neutrino Factory	30	$5 \sim 10^{19}/1\ \text{m}^2$

Fluxes

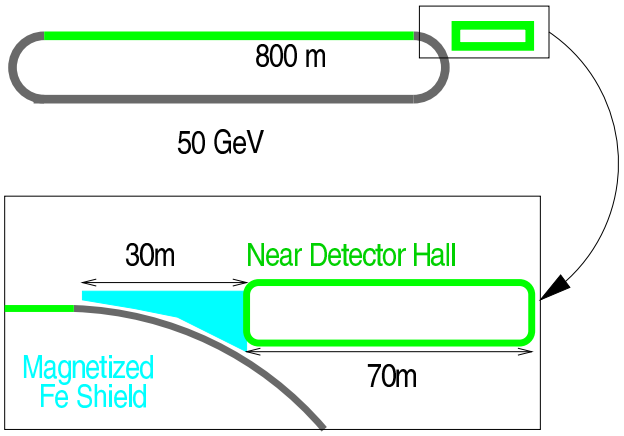


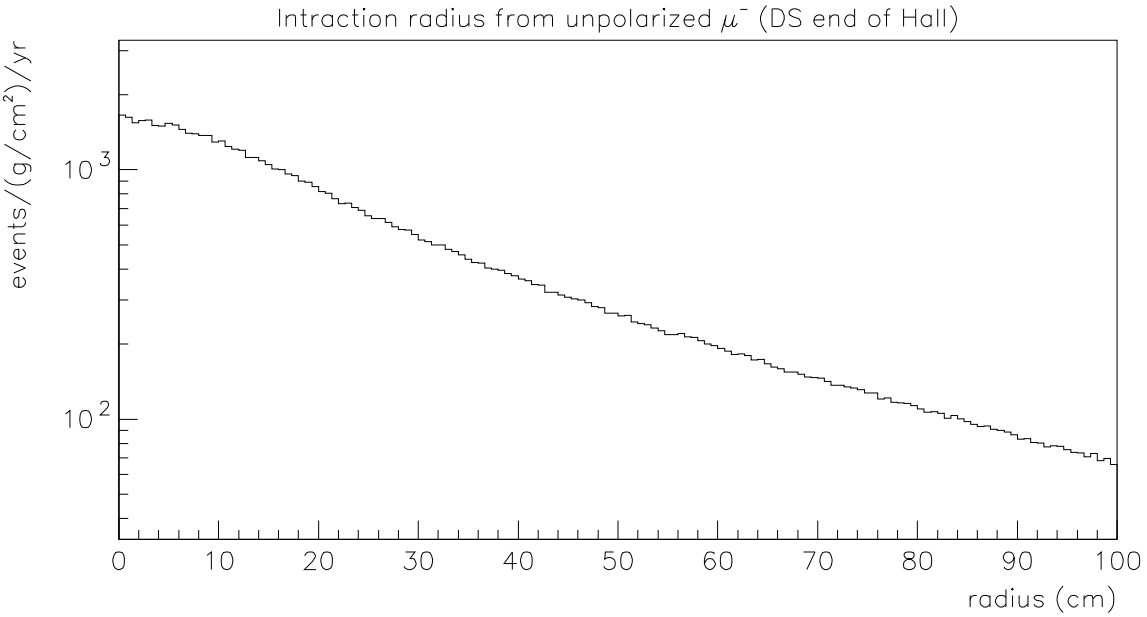




(50, 25, 10 GeV beams shown, distance scaled with E_μ)

Fluxes II

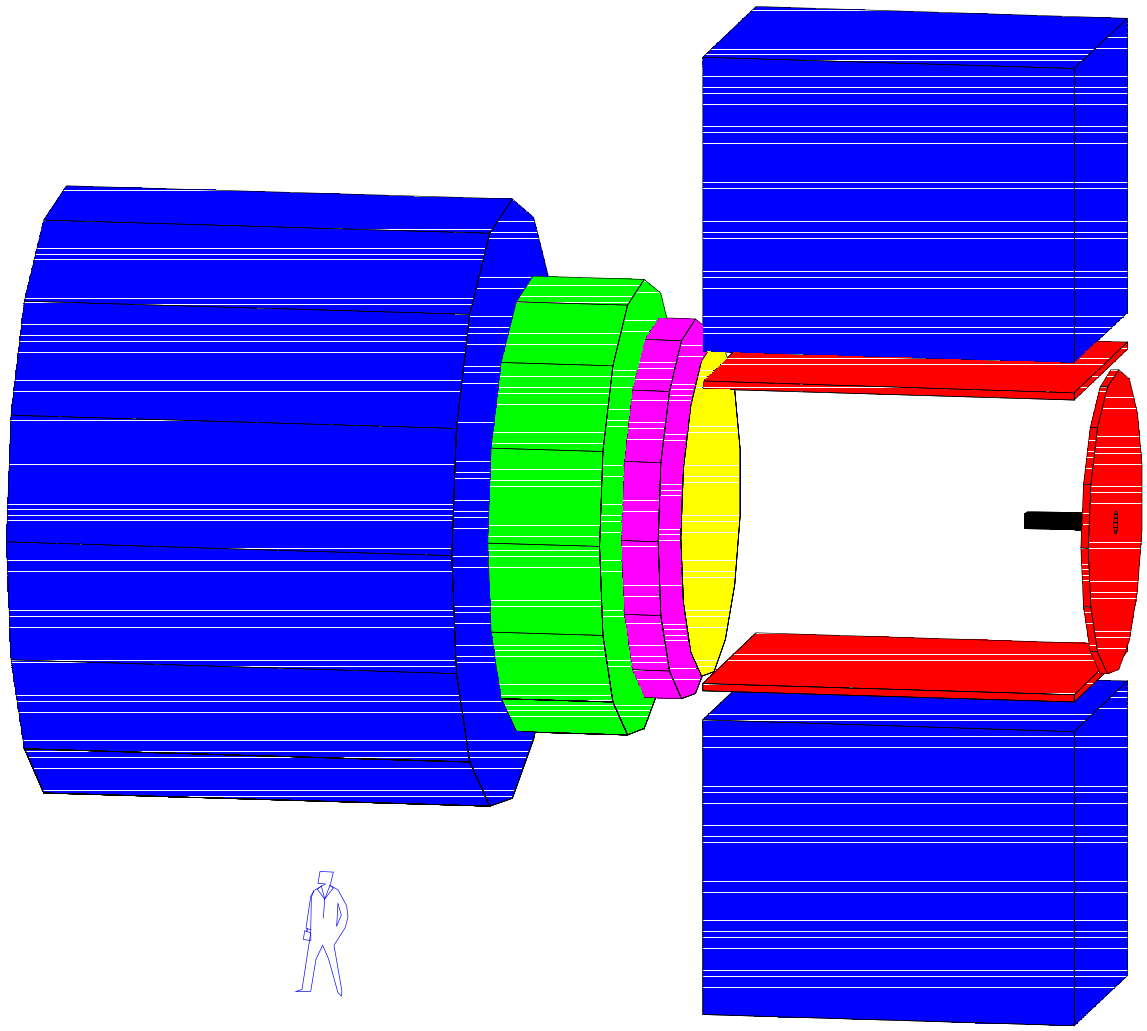




ν radial distribution for 50 GeV muon beam

$$\frac{1}{\gamma} \approx 500$$

Neutrino Detectors??

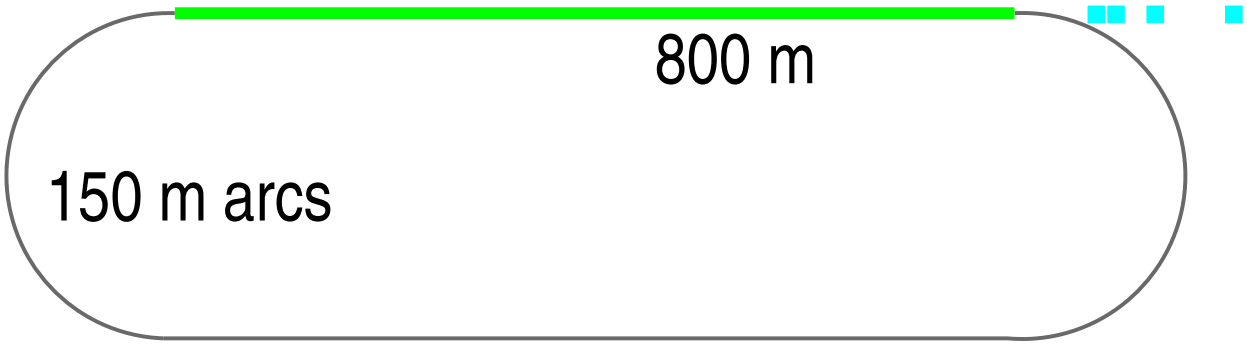


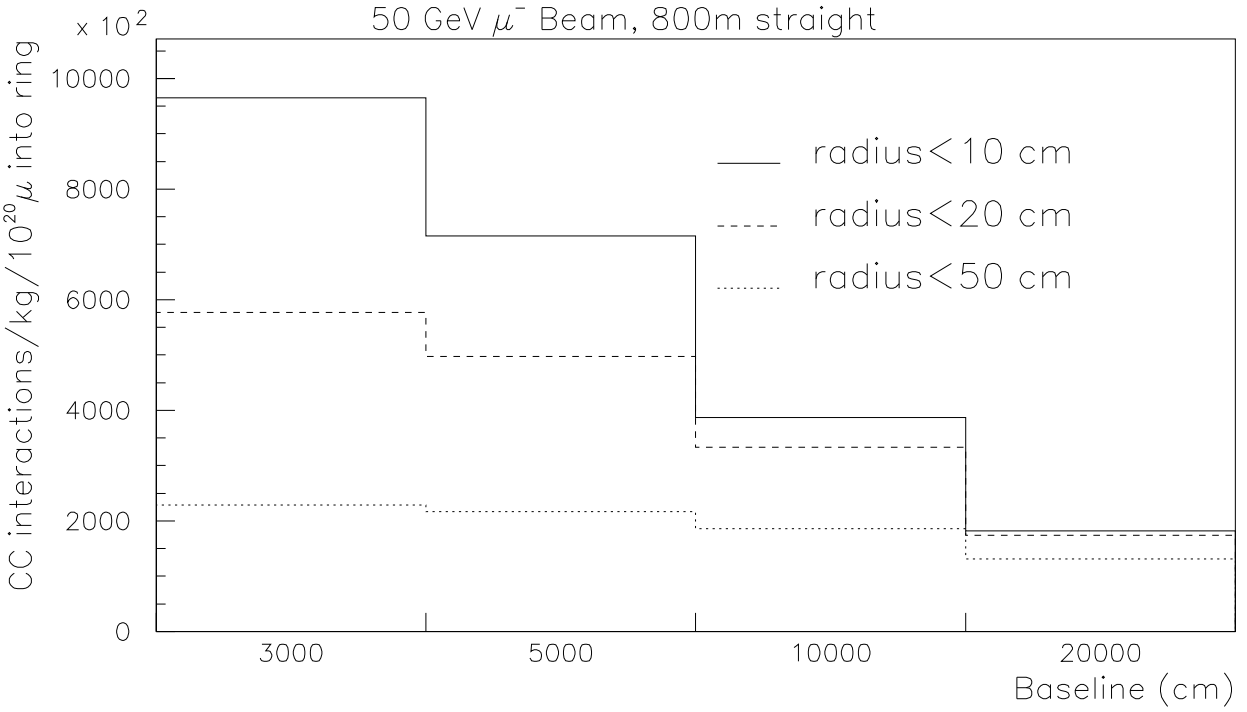
(multi-purpose detector design of B. King)

Small targets open up new possibilities in

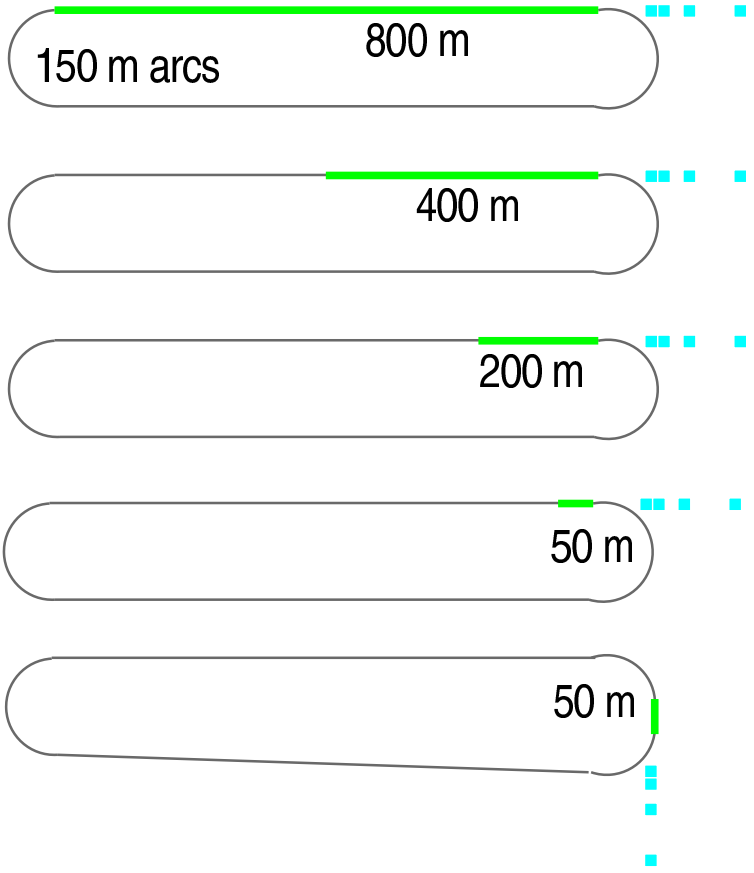
- Target material
- Final state detection

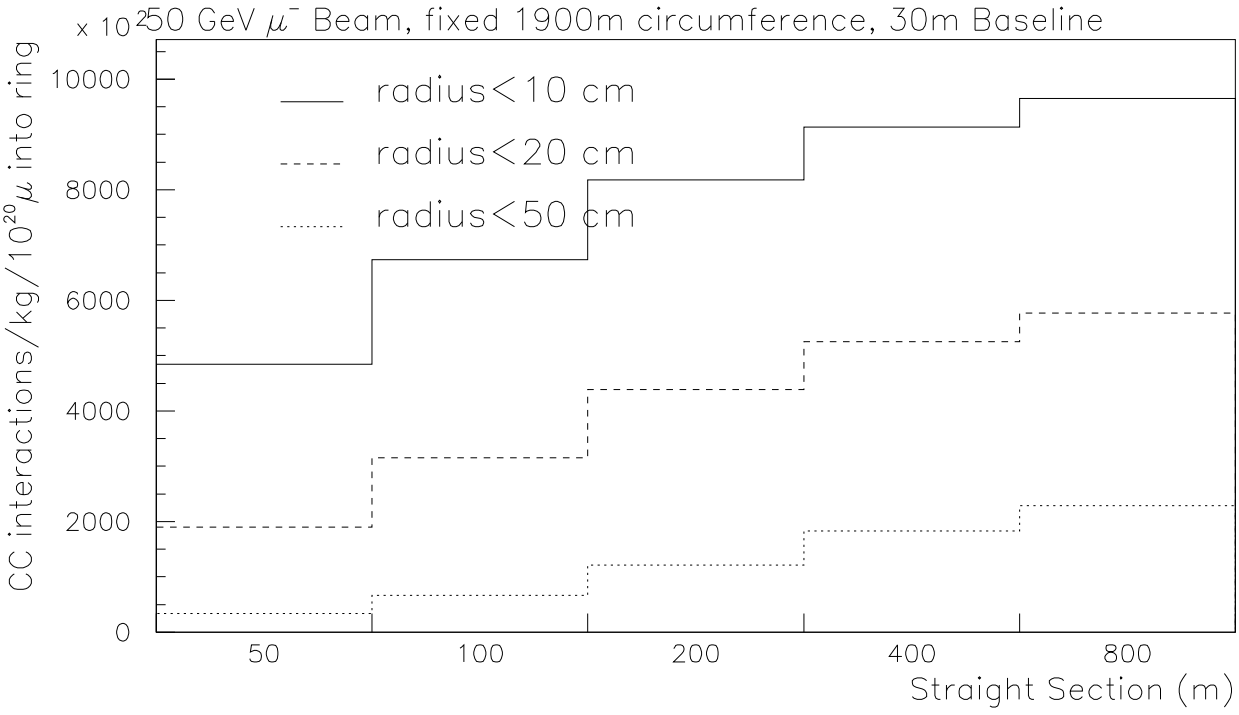
Detector Location



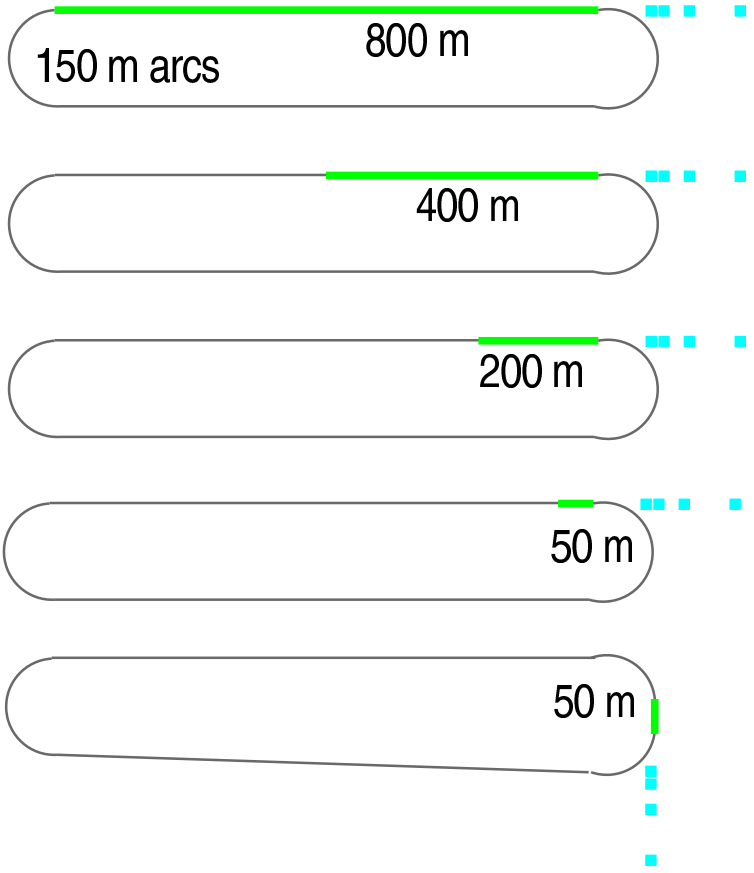


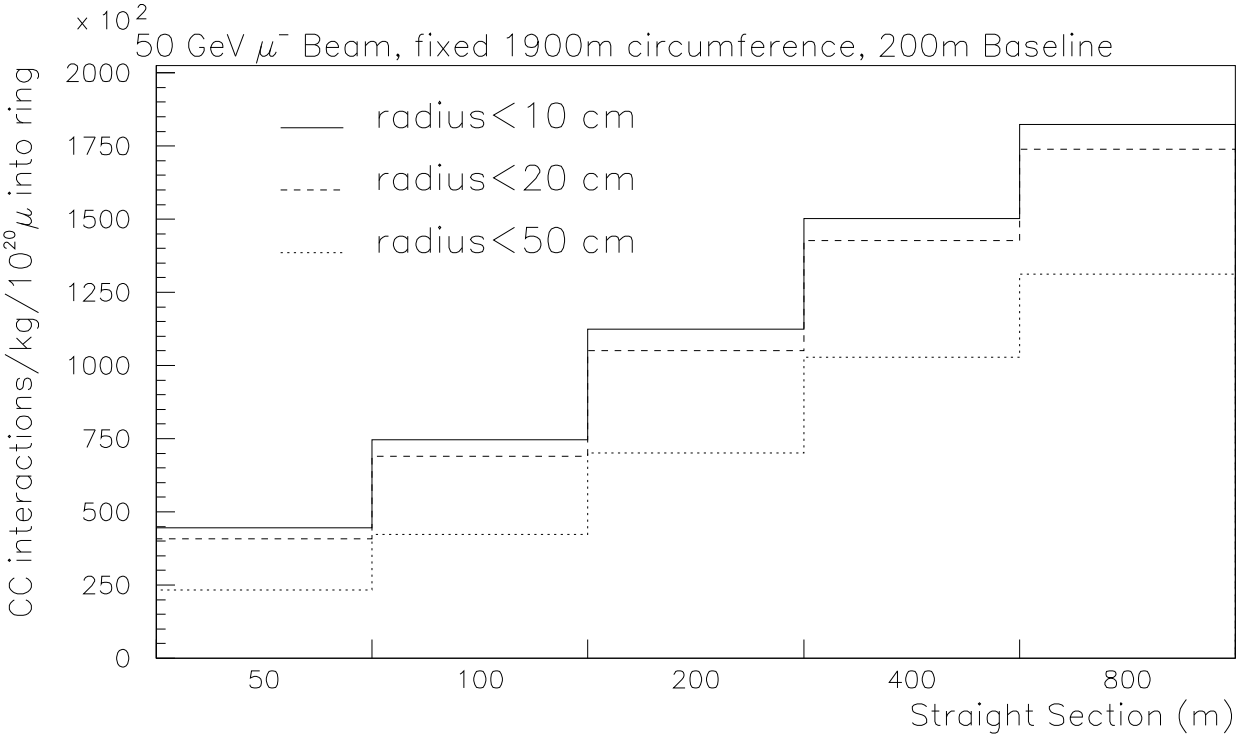
Length of Straight Section





Length of Straight Section II





Beam Divergence

Big impact on rates for short baseline physics

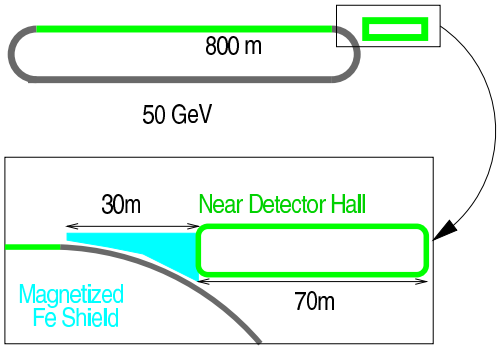
50 GeV μ^-, 10^{20} in 800 m straight section, 30 m baseline

Divergence ($\sqrt{\langle\theta_{1D}^2\rangle}$)	Millions of CC events per g/cm^2 $R < 10$ cm	$R < 20$ cm	$R < 50$ cm	
0	0.96	2.16	5.02	
0.2 mr	0.94	2.12	4.95	← Oscillation Default
0.73 mr	0.71	1.72	4.27	← Short Baseline Default
1.2 mr	0.52	1.35	3.55	
2 mr	0.21	0.65	2.05	
7.3 mr	0.04	0.14	0.65	

Backgrounds

Two issues:

1. Interactions in shielding

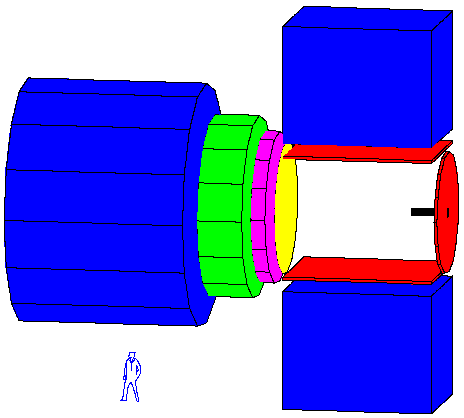


30 meters of steel is

- 2.3×10^4 g/cm^2
- 40 GeV of μ dE/dx

$\Rightarrow$ μ flux through detector is $\sim 10^{10}/10^{20}$ μ

2. Interactions in calorimeters



8 λ_0 of steel is

- 1.2×10^3 g/cm^2

$\Rightarrow \sim 10^9/10^{20}$ μ ν interactions in calorimeter

Conclusions