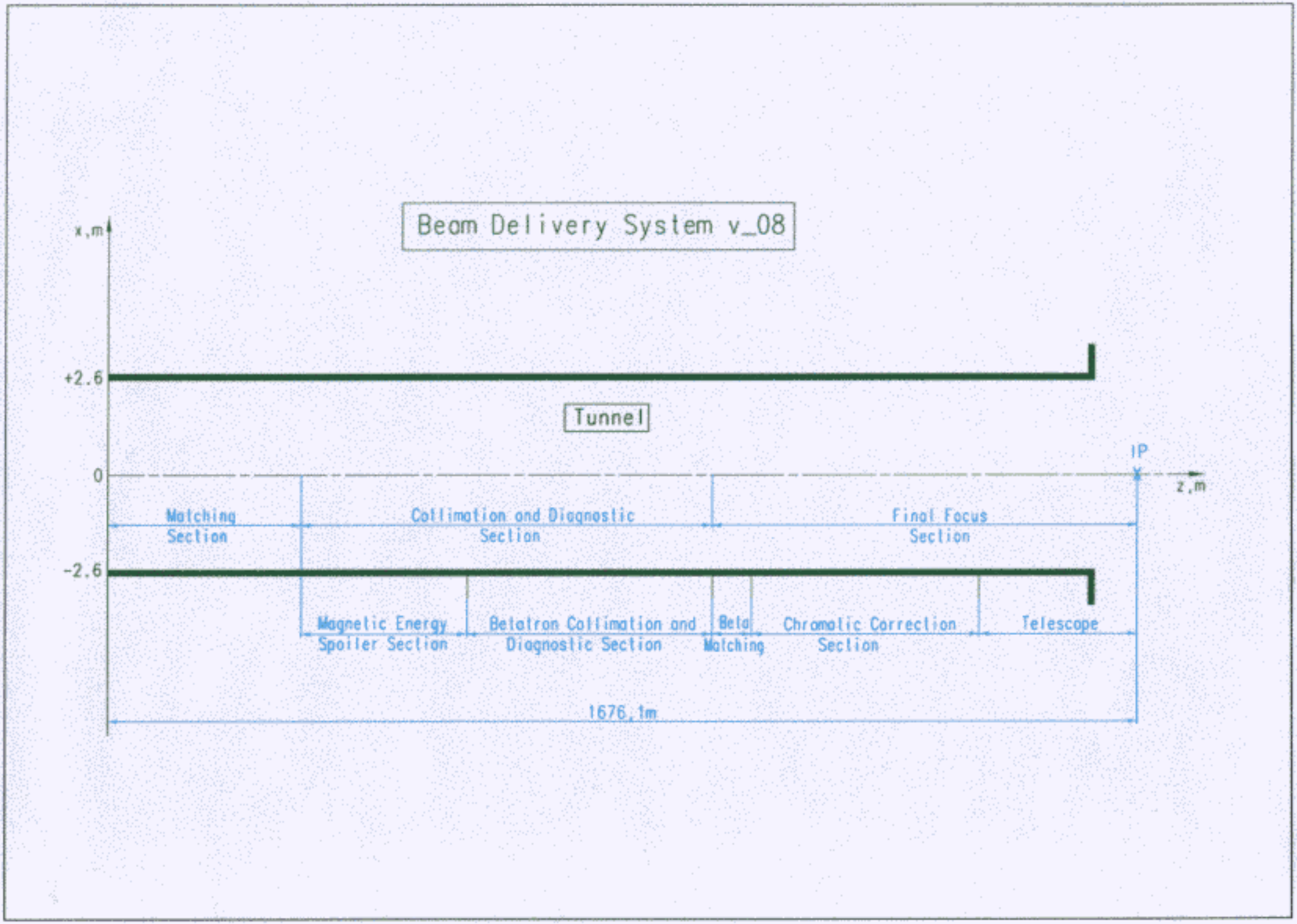
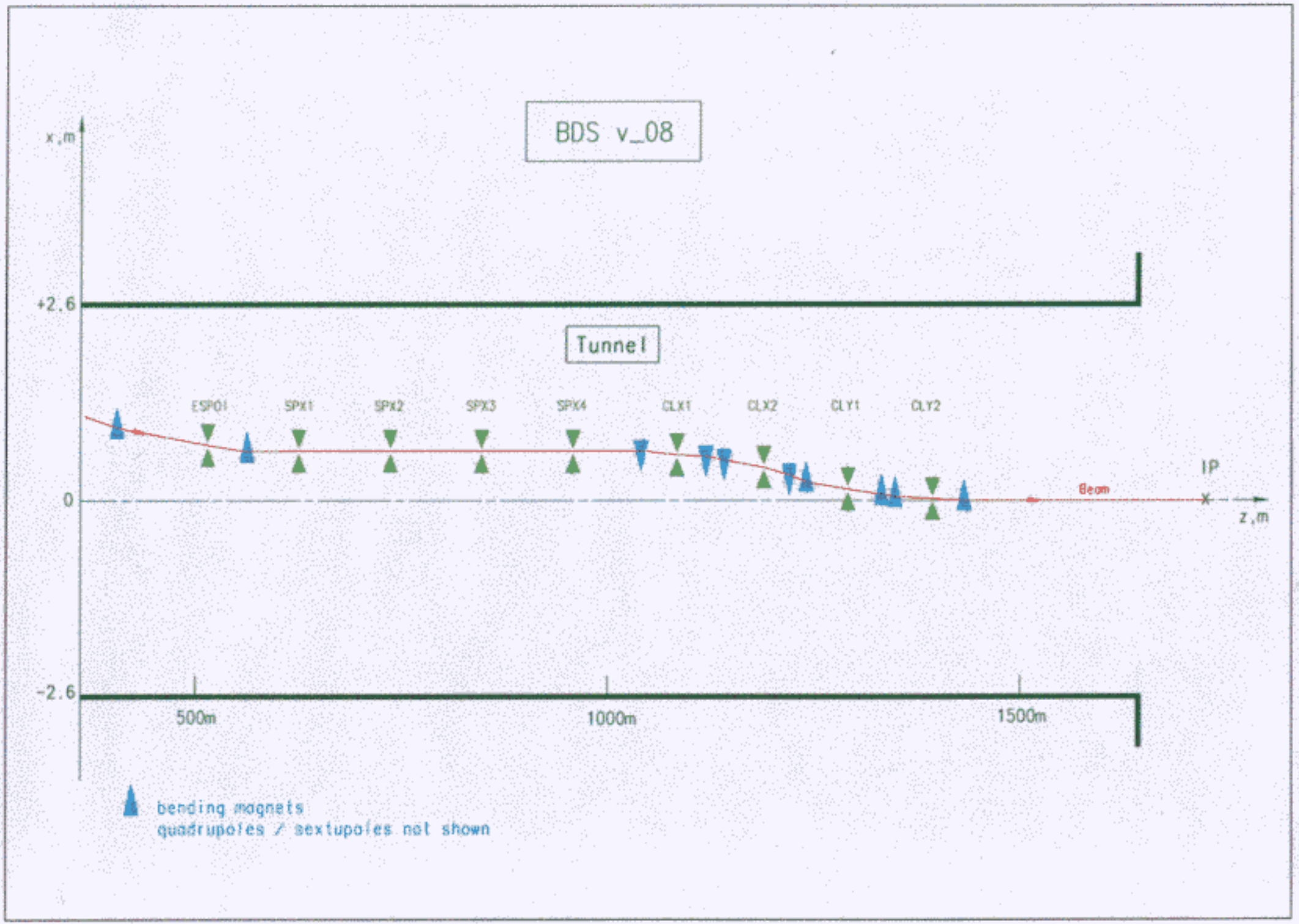
MUON BACKGROUND

New BDS_v08 Spring 2000

H. Jürgen Schreiber DESY/ECFA 22-25 Sept. 2000 Hamburg


Beam Delivery System v_08
x,m
+2.6
Tunnel
0
IP
z,m
Matching Section
Collimation and Diagnostic Section
Final Focus Section
-2.6
Magnetic Energy Spoiler Section
Betatron Collimation and Diagnostic Section
Beta Matching
Chromatic Correction Section
Telescope
1676.1m


BDS v_08
x,m
+2.6
Tunnel
ESP01
SPX1
SPX2
SPX3
SPX4
CLX1
CLX2
CLY1
CLY2
IP
Beam
0
z,m
-2.6
500m
1000m
1500m
bending magnets
quadrupoles / sextupoles not shown

Muon Production Processes:

- **Bethe - Heitler**

$e Z \to Z \mu^+ \mu^- e'$

- **direct annihilation** (dimuon production)

$e^+_B e^- \to \mu^+ \mu^-$

$\hookrightarrow E_B \gtrsim 44\ GeV$

- **pion production**

$e Z \to \pi^\pm + \ldots$

$\hookrightarrow \mu \nu$

- **muons from secondaries**

$\gamma, e^\pm$

may interact in downstream material (Fe) and produce muons

- **Bethe - Heitler**
  + **dimuon production**

→ Fig.

$$\langle \#\, e^{\pm} \text{ lost}/\mu \text{ in the detector} \rangle \simeq 2 \cdot 10^5$$

- **Pion decays**

→ Fig.

in spoiler region:

$$\#\, e^{\pm} \text{ lost}/\mu \Big|_{\substack{\text{pion} \\ \text{decay}}} \simeq 1.2 \; \#\, e^{\pm} \text{ lost}/\mu \Big|_{\text{BEHE}}$$

- **Muons from secondaries**

Ass.:

$$\#\, e^{\pm} \text{ lost}/\mu \Big|_{\text{sec.}} = \#\, e^{\pm} \text{ lost}/\mu \Big|_{\substack{\text{pion} \\ \text{decay}}}$$

All production mechanisms together

→ $\boxed{\#e^{\pm} \text{ lost}/\mu \simeq 7 \cdot 10^4}$

→ for a bunch ($2 \cdot 10^{10}$) dumped in BDS

→ $\boxed{0.3 \cdot 10^6}$ muons in the detector (or more)

Permanent muon rate in the detector:

Rely on the number of beam particles expected in the halo

R.B. → ~ $\boxed{10^4}$ $e^{\pm}$/halo

→ permanent muon rate /bx:

$10^4/7 \cdot 10^4 \cdot 2 \simeq \boxed{0.3 \text{ muons/bx}}$

(2: two beams)

TPC:

$$\Rightarrow \quad 0.3 \times 150 \times 0.25 \simeq \underline{11 \text{ muons}_{/\text{TPC}}} \quad (250\,\text{GeV})$$

(0.3 ↑ bx's; 0.25 ↑ TPC acceptance)

$$\simeq \underline{3 \cdot 11 \text{ muons}_{/\text{TPC}}} \quad (400\,\text{GeV})$$

If I allow for not more than 1 muon in the TPC

→ **Muon Protection System** ←

with potential
to reduce the muon rate
$\gtrsim 100$

Muon Protection Systems

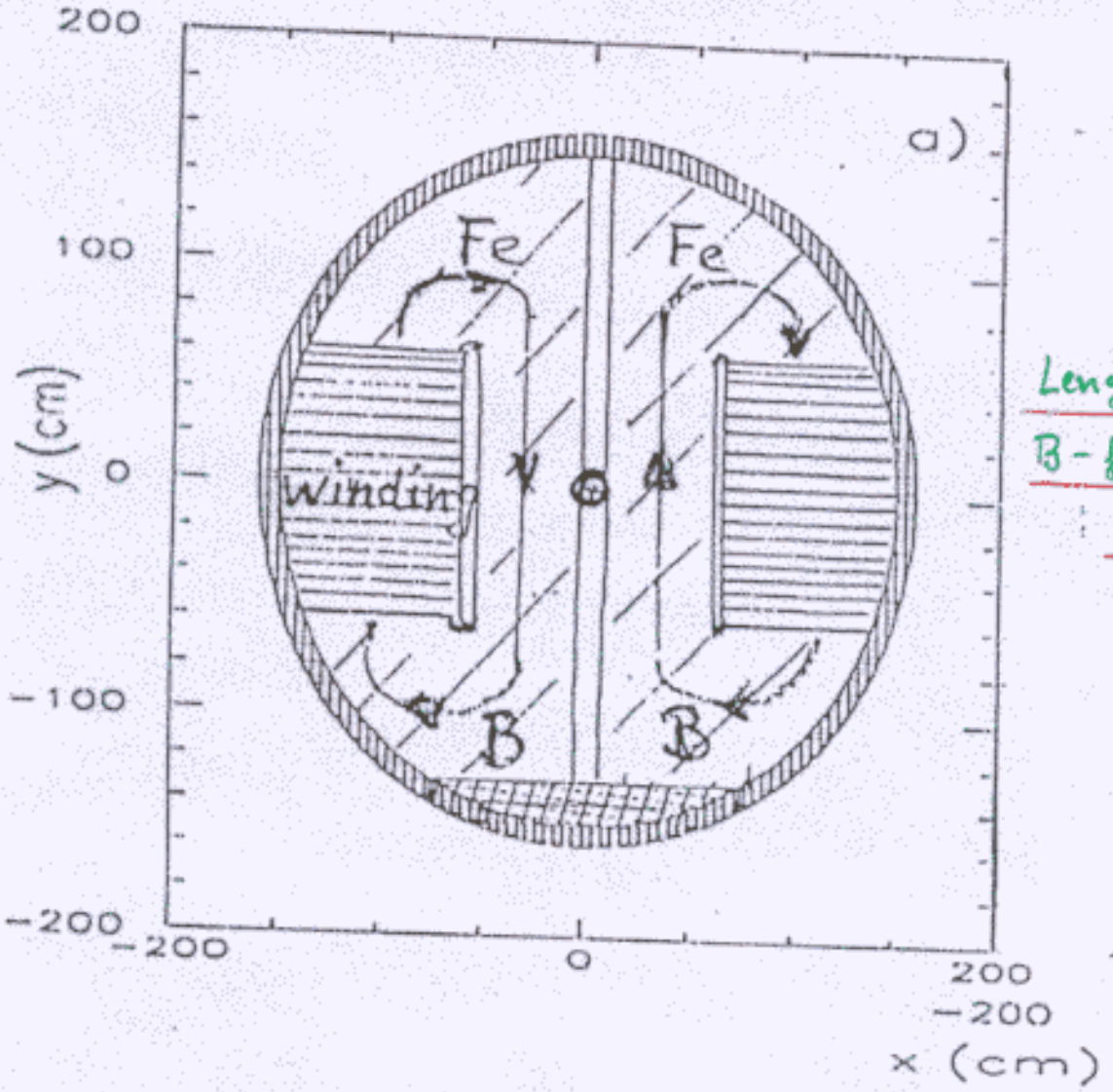
- Large magnetized iron spoilers (Tunnel fillers)
- Nested iron cylinders with opposite-polarity azimuthal magnetic fields
- small magnetized iron spoilers
- Toroids

Whatever muon protection system you choose

the amount of muon reduction

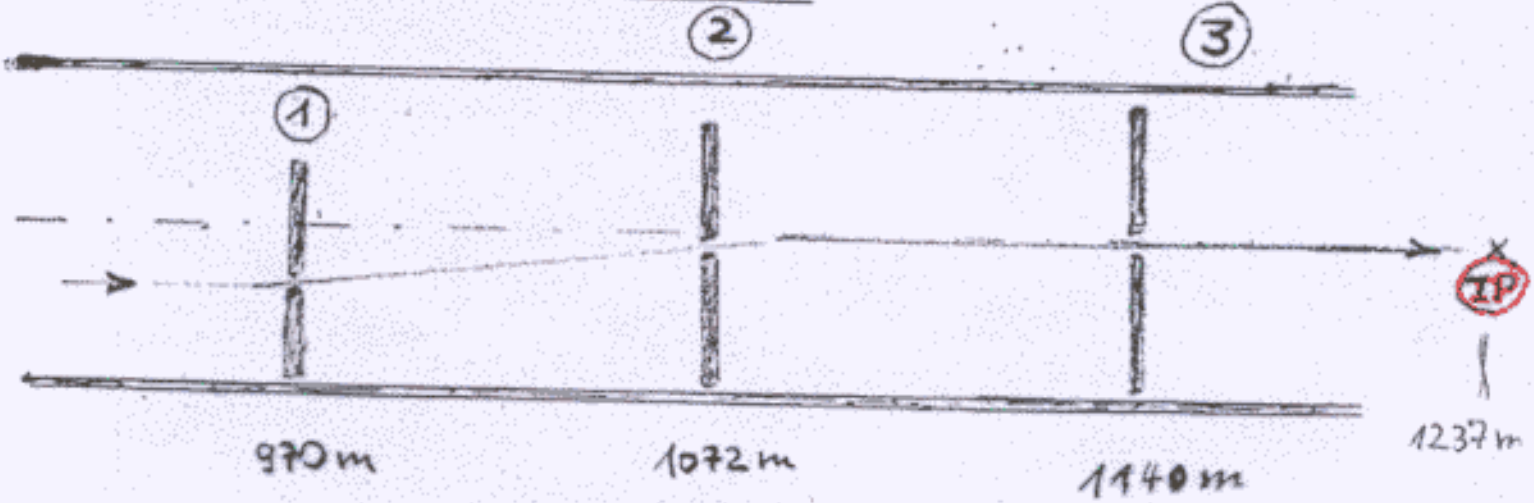
fkt (# of individual components,
their positions,
their dimensions (transv., long.)
strength of B , polarity)

Magnetized iron spoilers (tunnel fillers)

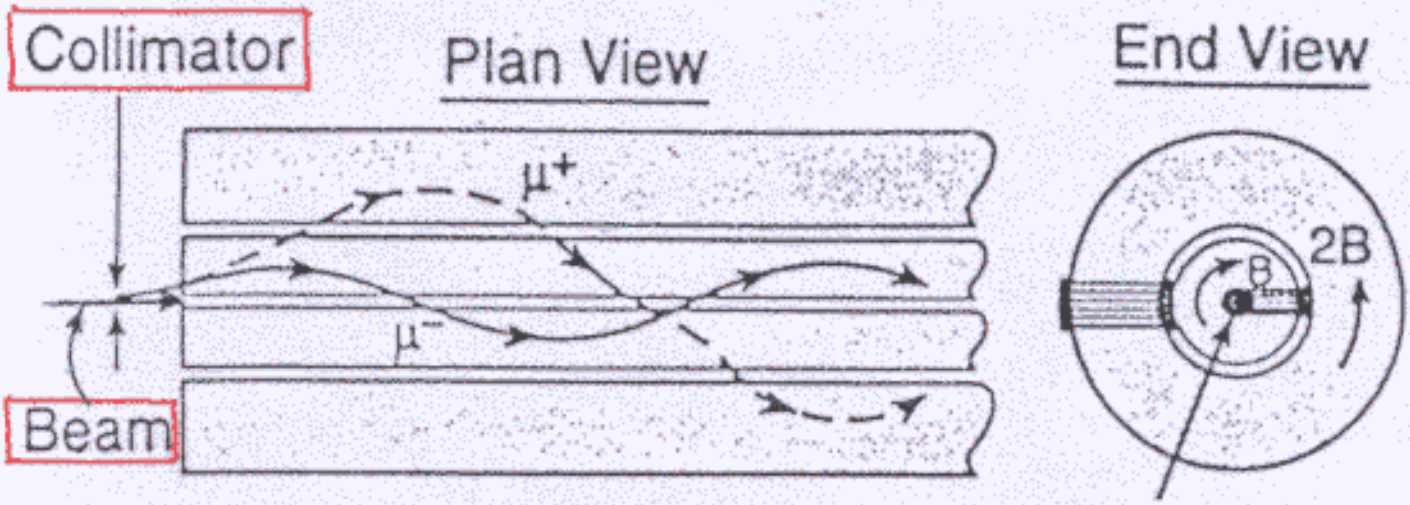


Length = 9.2 m
B-field : 16 kG
: +/−/+

Final Focus Section:



Nested iron cylinders with opposite-polarity azimuthal magnetic fields

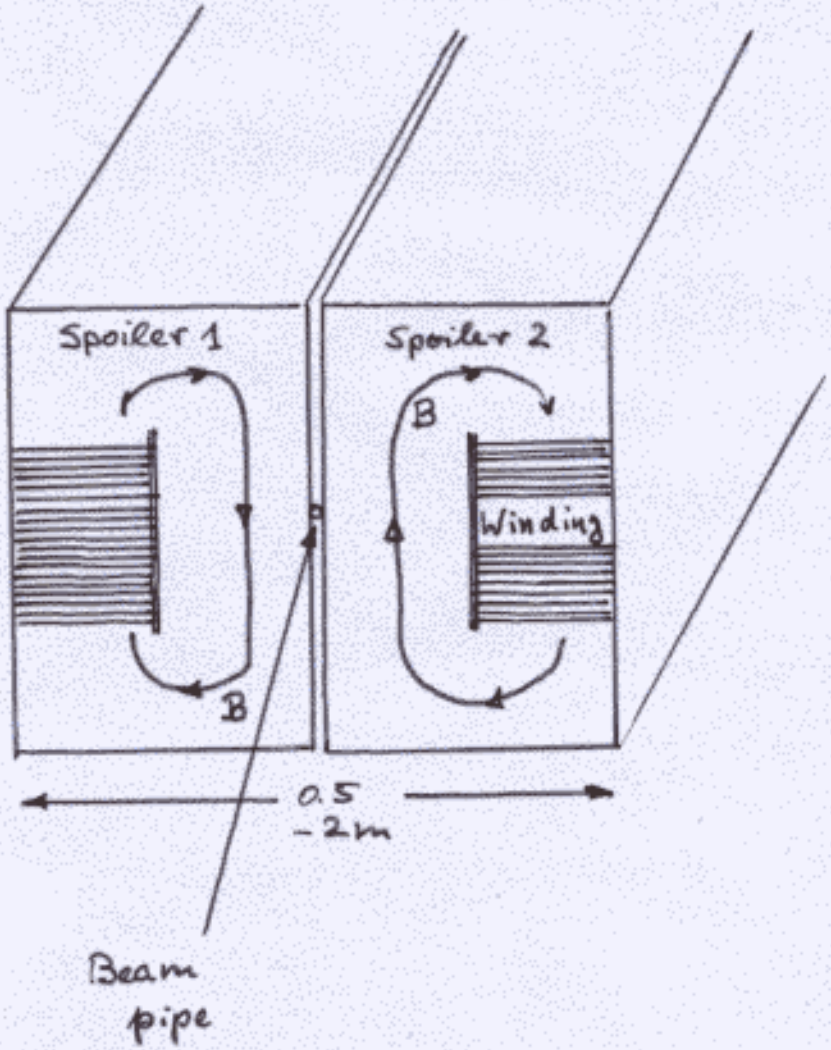


- located quite close to muon source
- $\mu^{\pm}$ are channeled through long ($\gtrsim 100$ m) cylinders

  ⇒ problem: interrupted by beam elements → channeling disrupted

efficiency ?

small maghetized iron spoilers

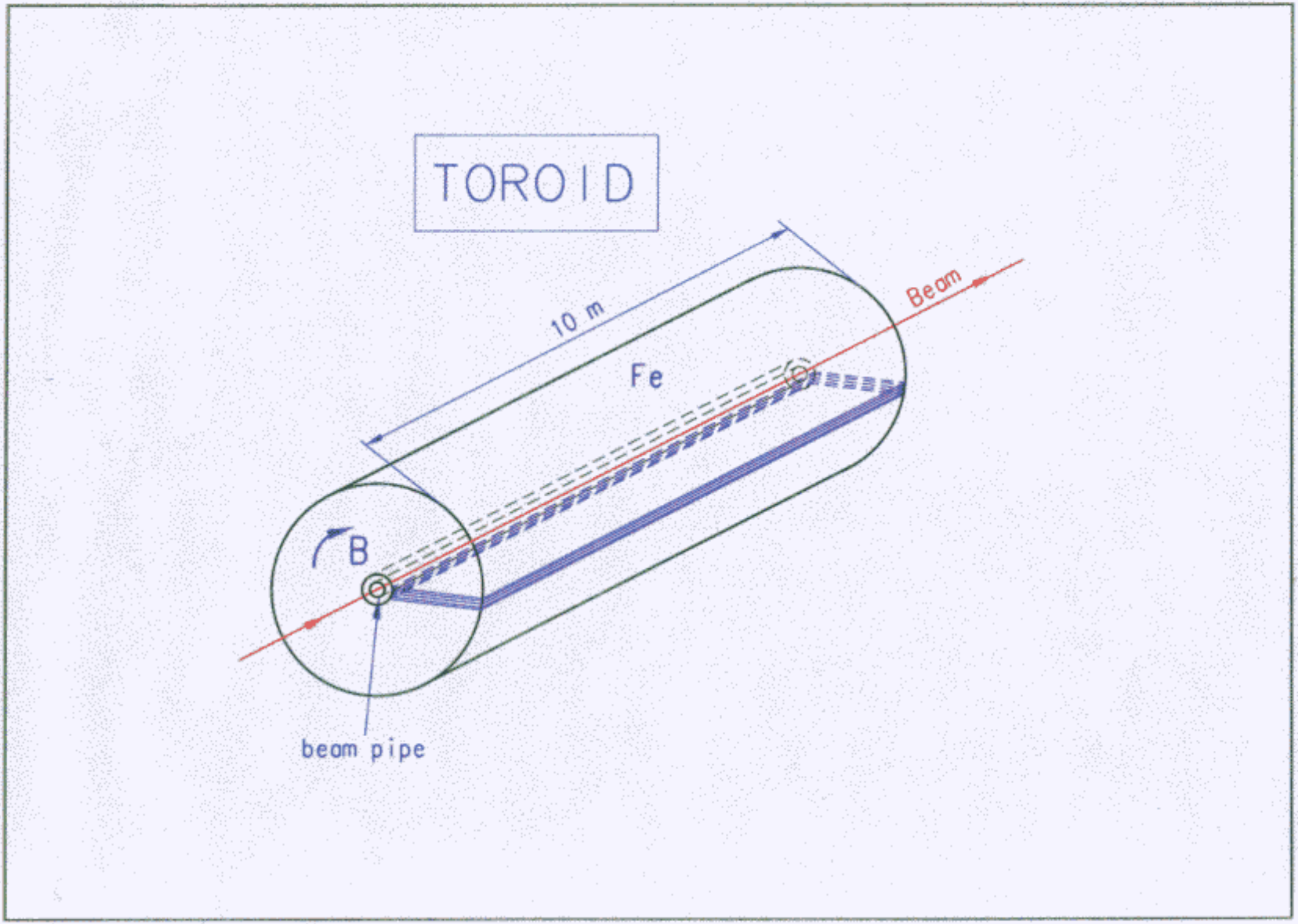


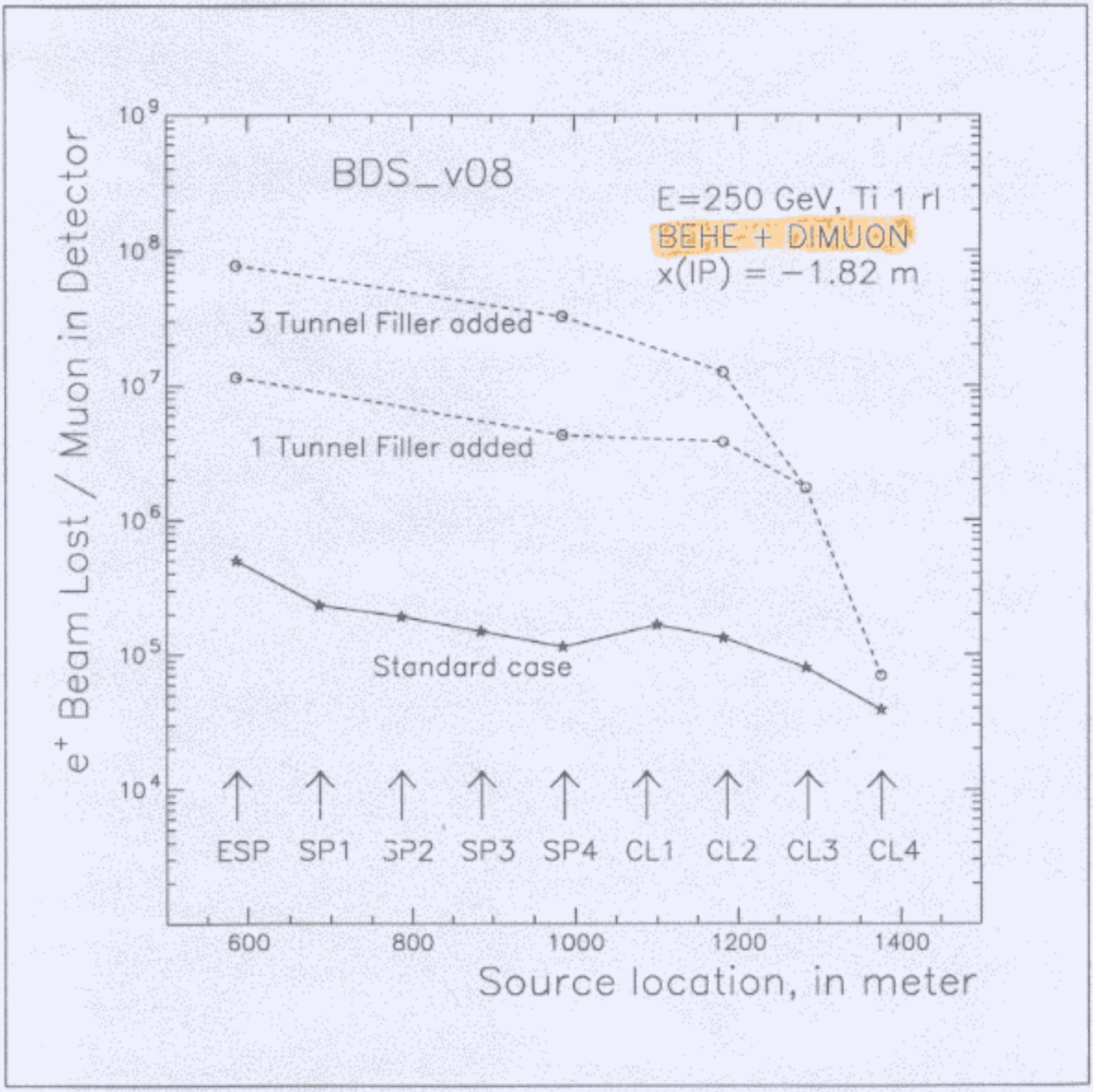
Length = 10m

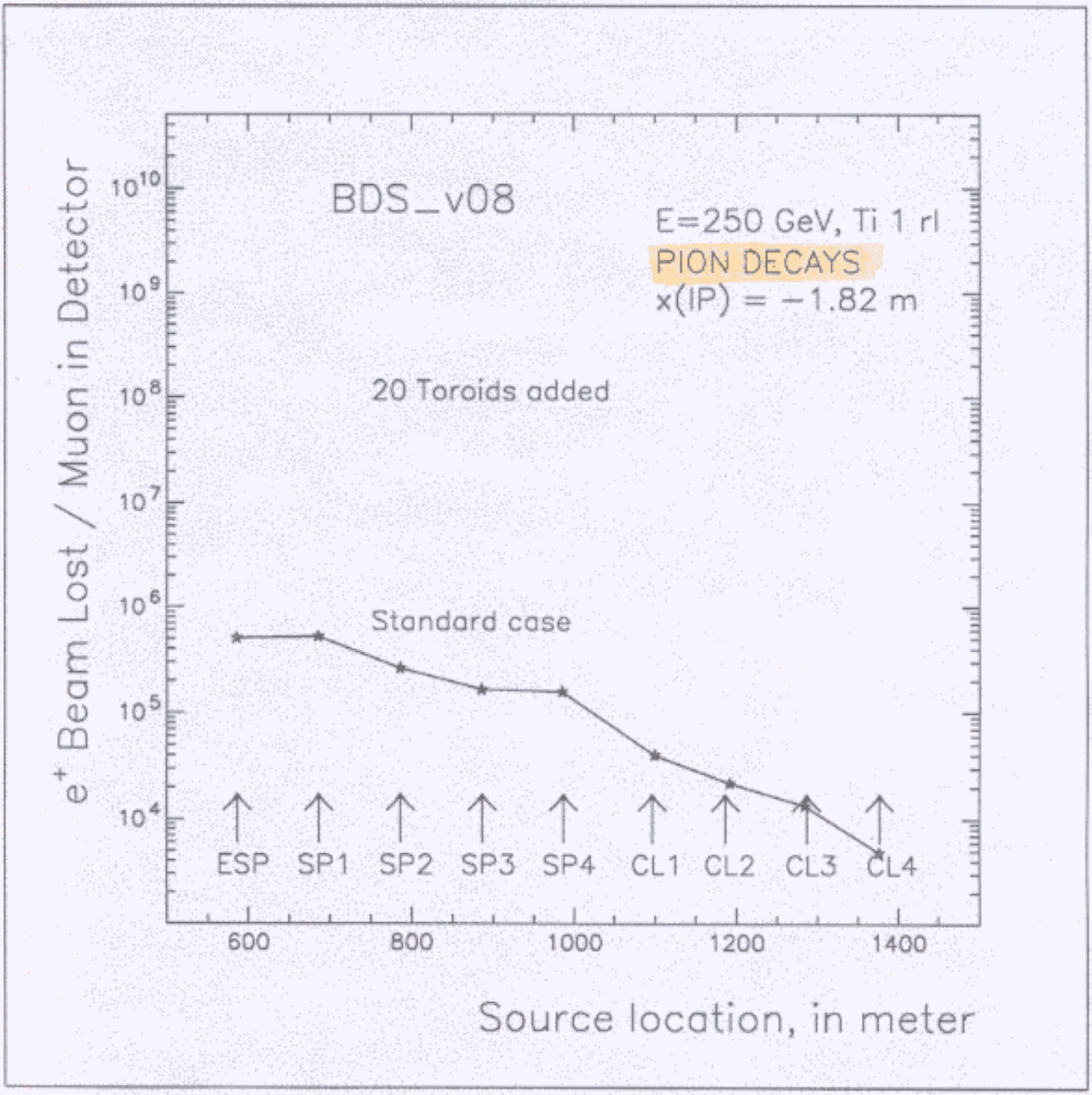
B-field : 18 – 20 kG

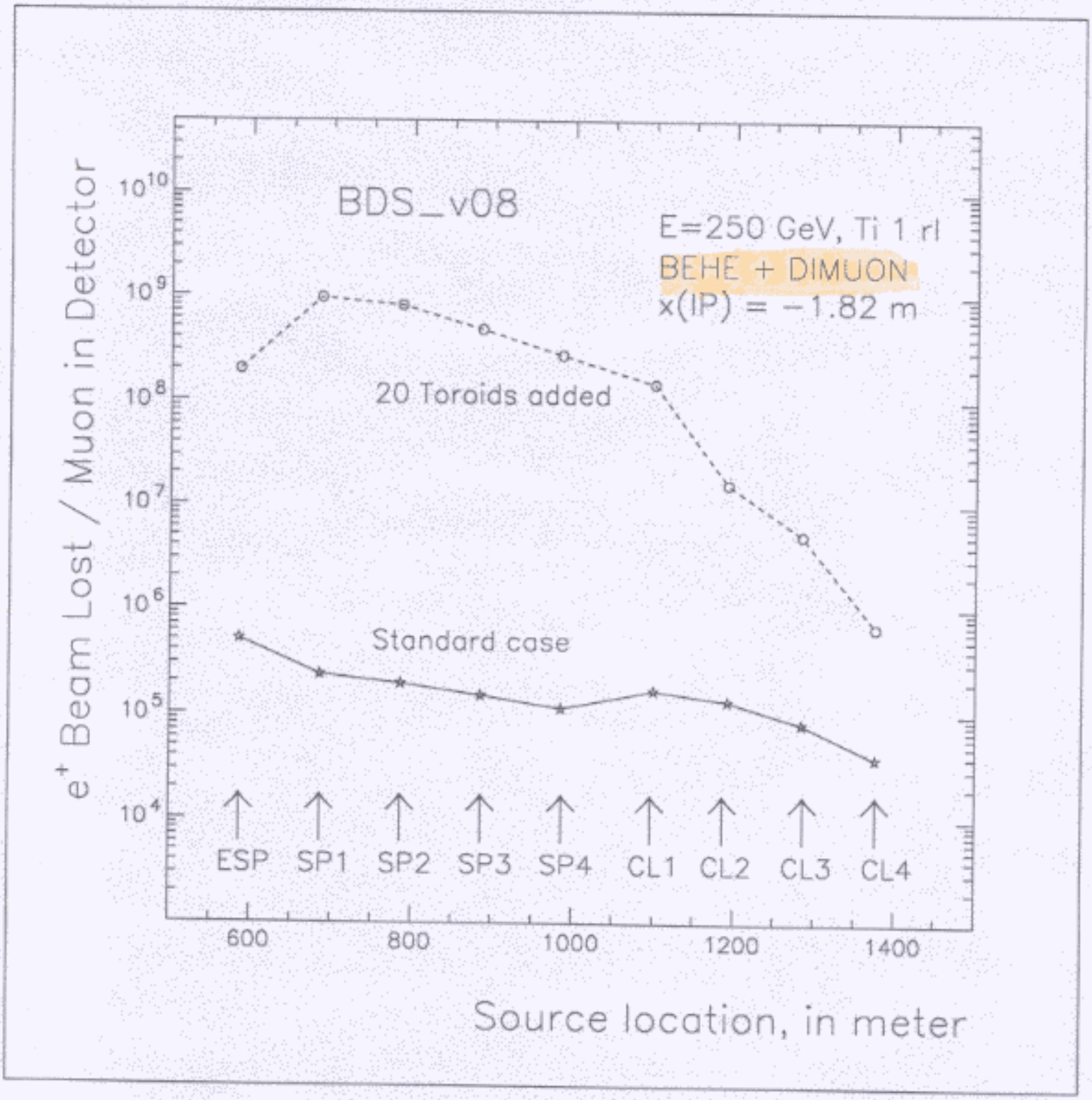
series with

alternating polarity


TOROID
10 m
Fe
Beam
B
beam pipe


BDS_v08
E=250 GeV, Ti 1 rl
BEHE + DIMUON
x(IP) = −1.82 m
3 Tunnel Filler added
1 Tunnel Filler added
Standard case
e+ Beam Lost / Muon in Detector
10^9
10^8
10^7
10^6
10^5
10^4
ESP
SP1
SP2
SP3
SP4
CL1
CL2
CL3
CL4
600
800
1000
1200
1400
Source location, in meter


BDS_v08
E=250 GeV, Ti 1 rl
PION DECAYS
x(IP) = −1.82 m
20 Toroids added
Standard case
e+ Beam Lost / Muon in Detector
10^10
10^9
10^8
10^7
10^6
10^5
10^4
ESP
SP1
SP2
SP3
SP4
CL1
CL2
CL3
CL4
600
800
1000
1200
1400
Source location, in meter


BDS_v08
E=250 GeV, Ti 1 rl
BEHE + DIMUON
x(IP) = −1.82 m
20 Toroids added
Standard case
e+ Beam Lost / Muon in Detector
10^10
10^9
10^8
10^7
10^6
10^5
10^4
ESP
SP1
SP2
SP3
SP4
CL1
CL2
CL3
CL4
600
800
1000
1200
1400
Source location, in meter

- 3 Tunnel Fillers :

  gain = 200 - 500

- Toriods (20) :

  gain ≈ 1000 - 3000