Magnetic Background Issues above 1Hz for CLIC beams

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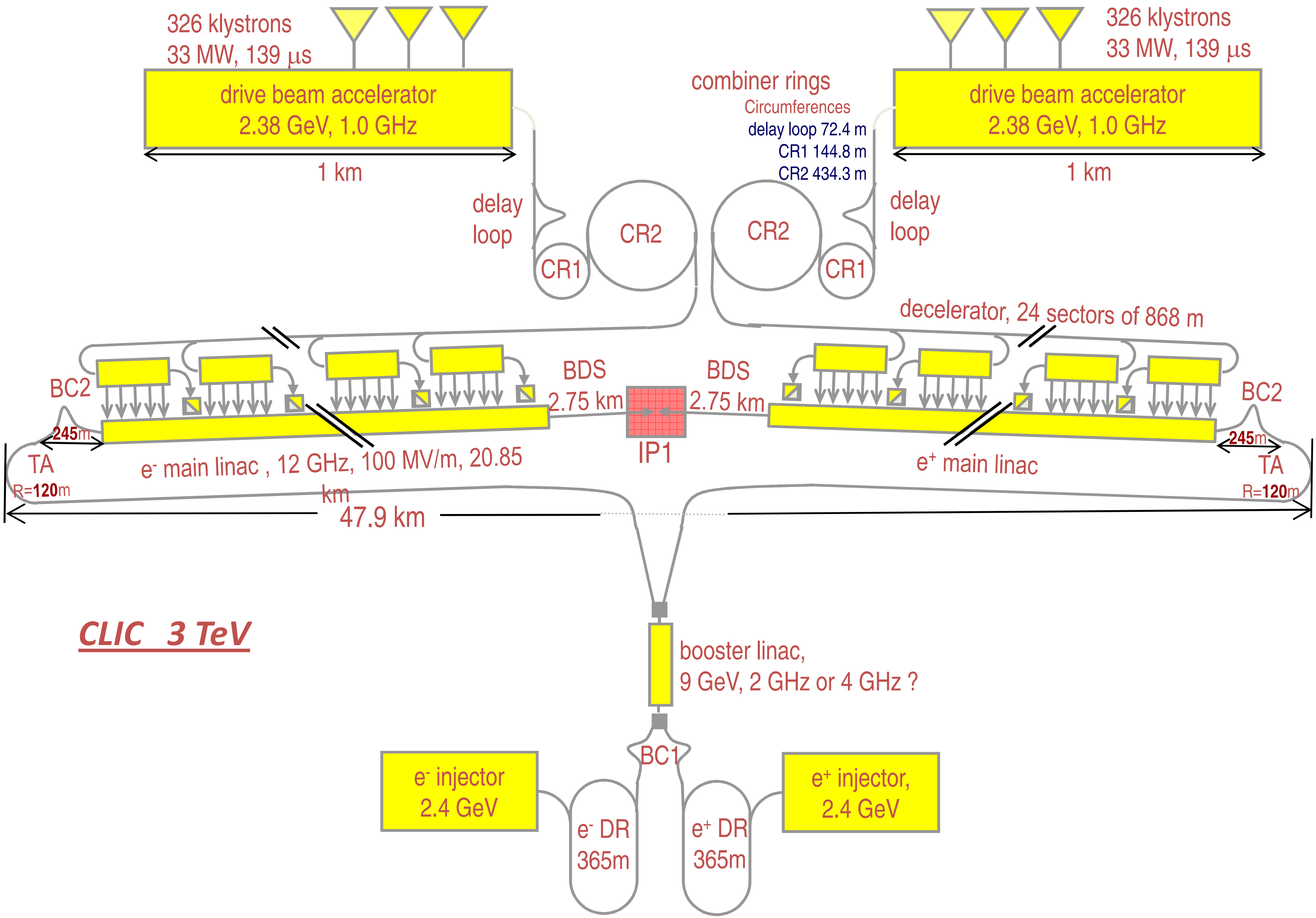
CLIC2009



326 klystrons
33 MW, 139 μs
drive beam accelerator
2.38 GeV, 1.0 GHz
1 km
326 klystrons
33 MW, 139 μs
drive beam accelerator
2.38 GeV, 1.0 GHz
1 km
combiner rings
Circumferences
delay loop 72.4 m
CR1 144.8 m
CR2 434.3 m
delay loop
CR2
CR1
CR2
CR1
delay loop
decelerator, 24 sectors of 868 m
BC2
BDS 2.75 km
BDS 2.75 km
BC2
245m
245m
IP1
TA R=120m
e- main linac , 12 GHz, 100 MV/m, 20.85 km
e+ main linac
TA R=120m
47.9 km
CLIC 3 TeV
booster linac,
9 GeV, 2 GHz or 4 GHz ?
BC1
e- injector
2.4 GeV
e- DR
365m
e+ DR
365m
e+ injector,
2.4 GeV

Tolerance to variable fields

- In the Main Linac
- In the long transfer line of the Main Beam
- Near the IP
- In all cases, we must consider
  - Frequencies above 1 Hz
  - Quasi-static field (above tolerance, implies re-adjustment of the line)

Main Linac & MB_LTL

- Main Linac :

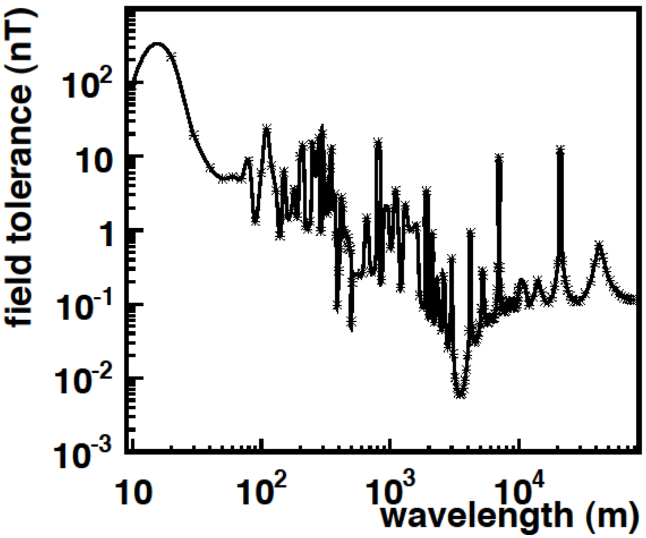
$\dot{B} < 0.2$ nT at f>1 Hz (To allow neat feed-back at 50 Hz - D. Schulte)

- Long Transfer Line :
  - Adding fields of variable f to the FODO line
  - Track, get the beam displacement
  - From this, compute the tolerance , corresponding to 10% emittance growth after filamentation

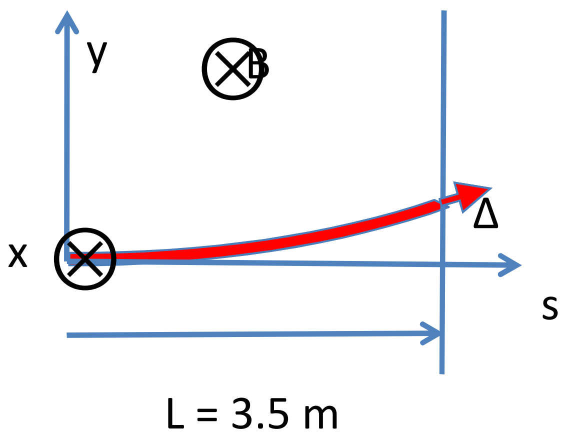
$\dot{B} \approx 0.01$ nT at f>1 Hz

(For incoherent addition by sector)

Study by J. Snuverink



Near the IP



$$\Delta = \frac{L^2}{2\rho} = \frac{0.15BL^2}{p} \quad [\mathrm{Gev/c, T, m}]$$

$$\Rightarrow \quad B = \frac{p\Delta}{0.15L^2}$$

Current to produce B, in a conductor parallel to the beam in the horizontal plane at *r* from the beam axis :

$$I = \frac{Br}{2\ 10^{-7}}$$

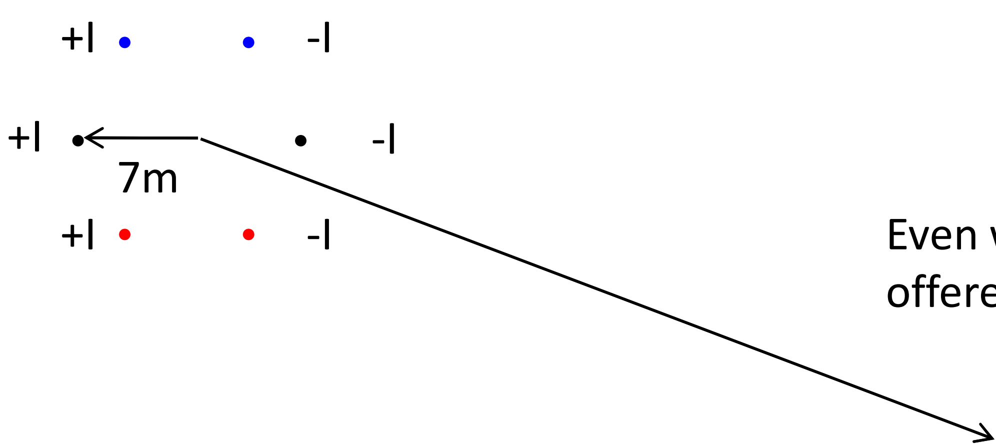
Momentum	Tolerance	Field	Current
P	Δ	B	I @ 1m
250 GeV/c	0.1 nm	30 nT	0.14 A
1500 GeV/c	0.2 nm	80 nT	0.4 A

Possible Sources of Stray Magnetic Field

- High voltage transmission lines
- Site power distribution system
- Linac power distribution system
- Electronics, vacuum pumps, compressors, etc.
- Railroads
- ?

High voltage transmission lines

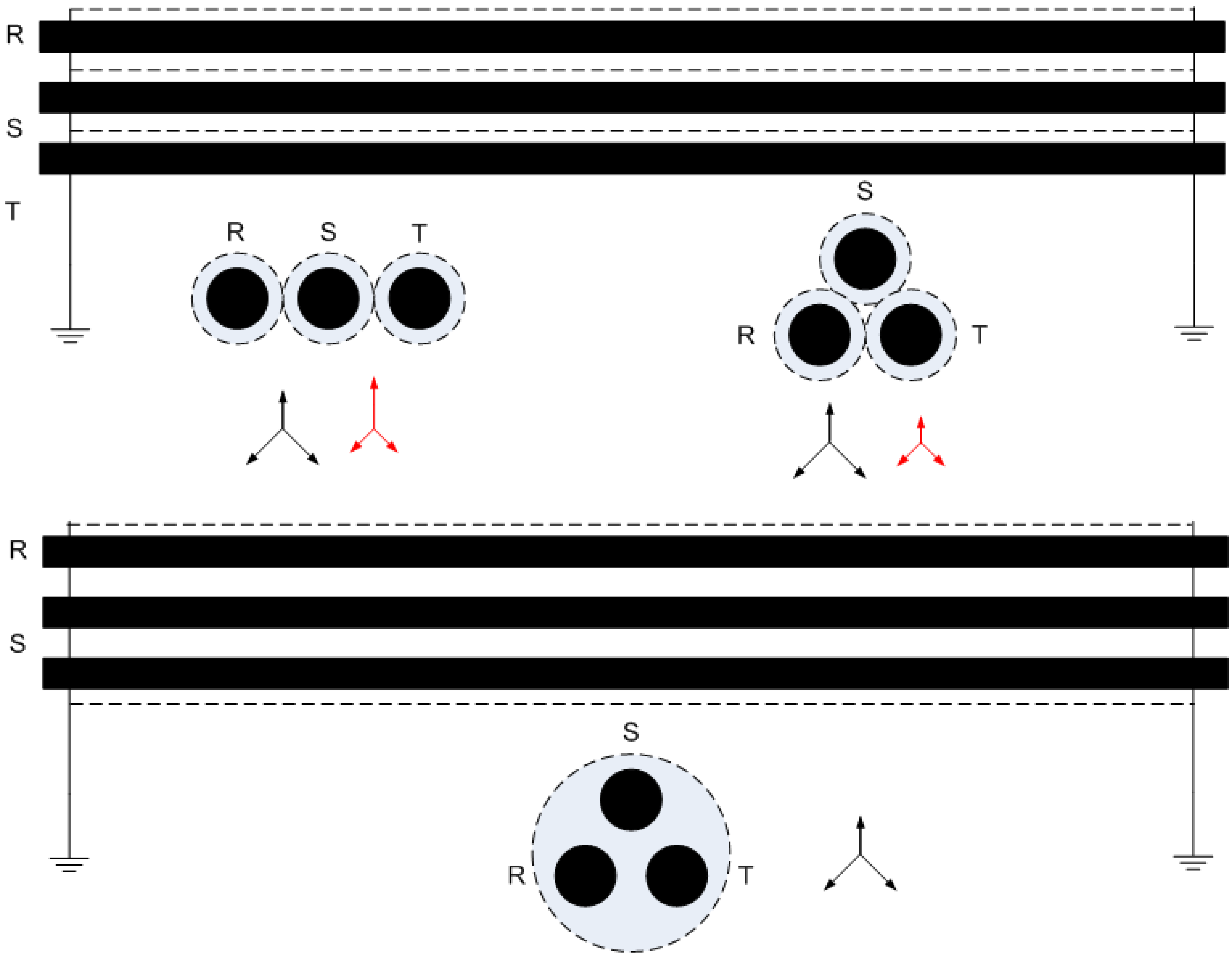
- Along the Jura, both in F +CH
- Still awaiting detailed data from EDF and EOS
- Considering a generic case:



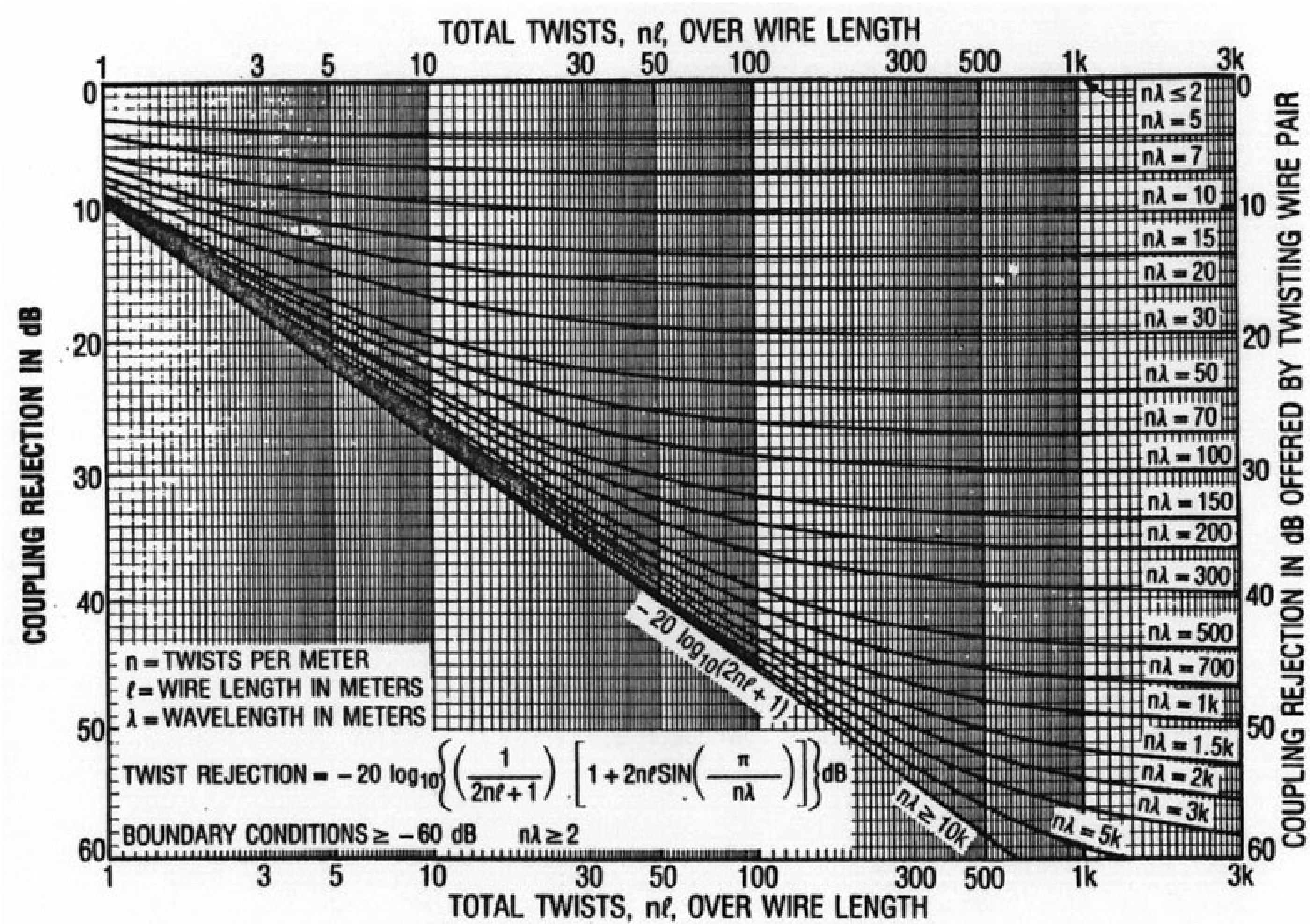
Even with the 1st-order cancellation offered by the 3 phases , it remains :

B_x = 16 nT at (+300m,-100m)

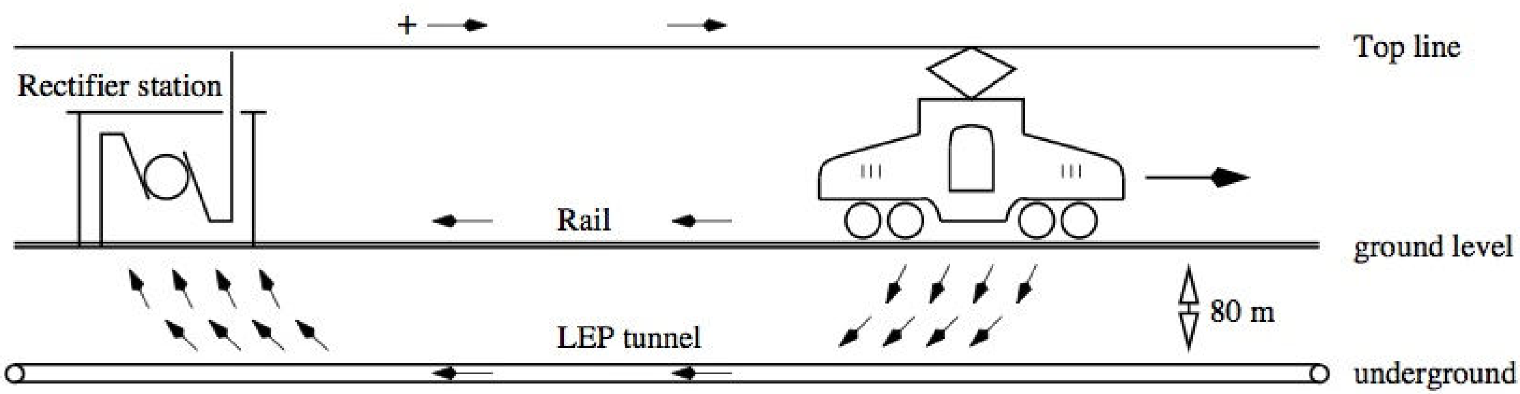
3-Phase Power Cables Configurations

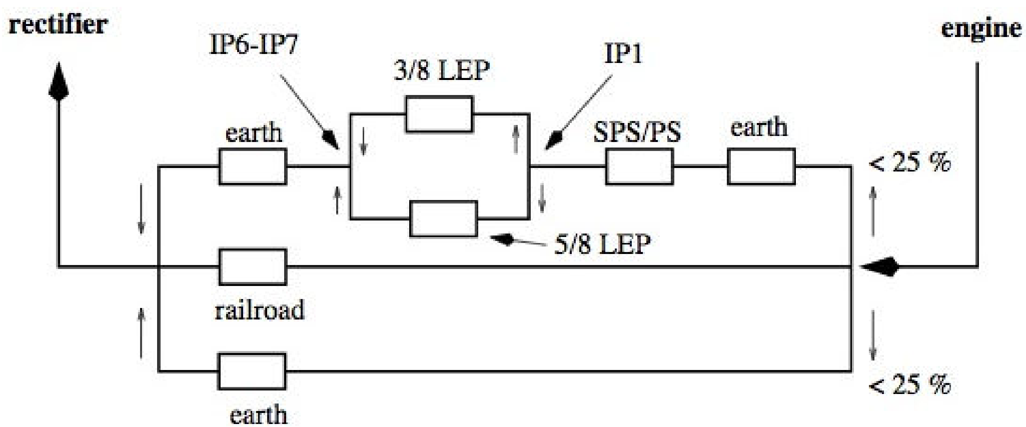


Coupling rejection



Train Leakage Currents (LEP)*





*"The Influence of Train Leakage Currents on LEP Dipole Field" - CERN SL 97-47

Train Leakage Currents (2)

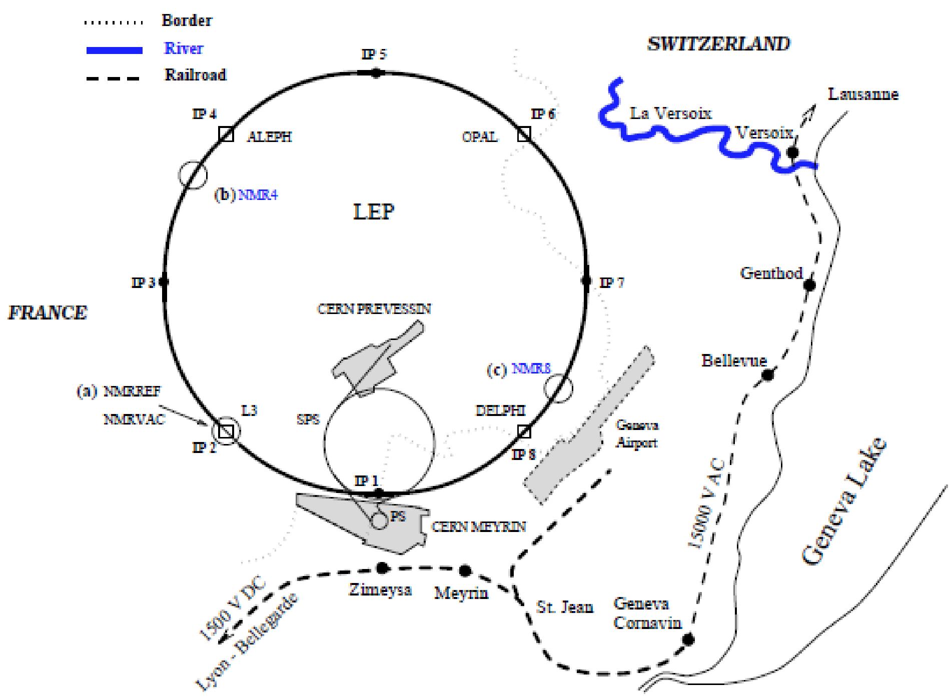


Figure 1: *The LEP ring surrounded by the French and Swiss railroads with the locations of the NMR probes and the four experiments. Two probes (a) are installed in a reference dipole magnet, which is connected in series with the tunnel dipoles. NMR4 (b) and NMR8 (c) are mounted in tunnel magnets.*

Train Leakage Currents (3)

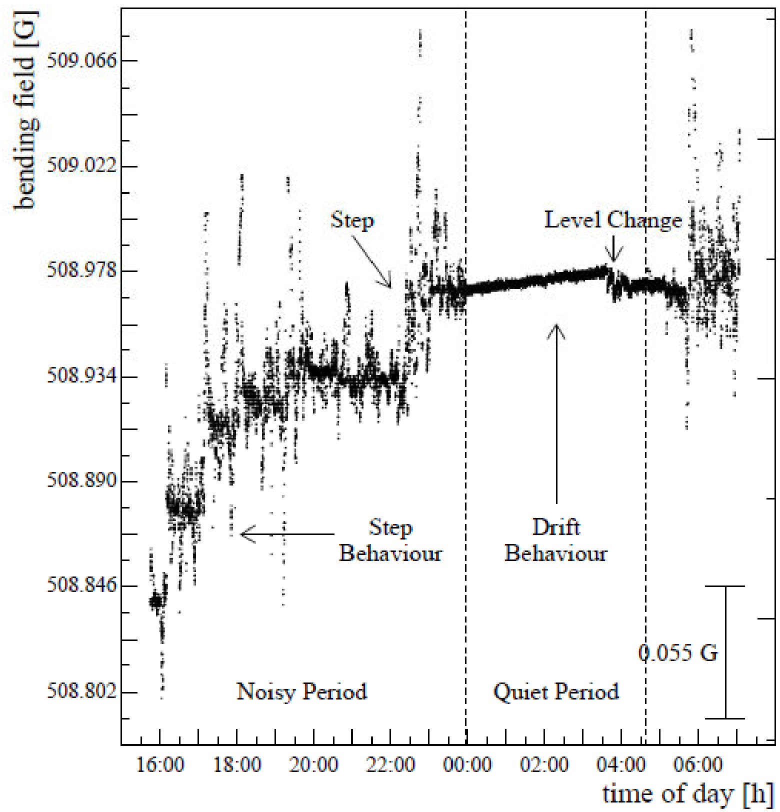


Figure 2: *Magnetic field evolution measured in the tunnel by NMR8. The field increase during this period shows variations of the slope and steps of various sizes.*

Train Leakage Currents (4)

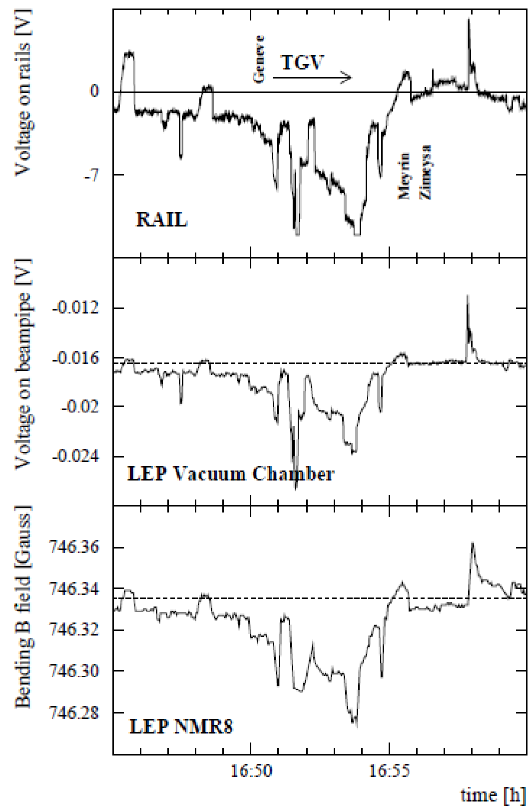


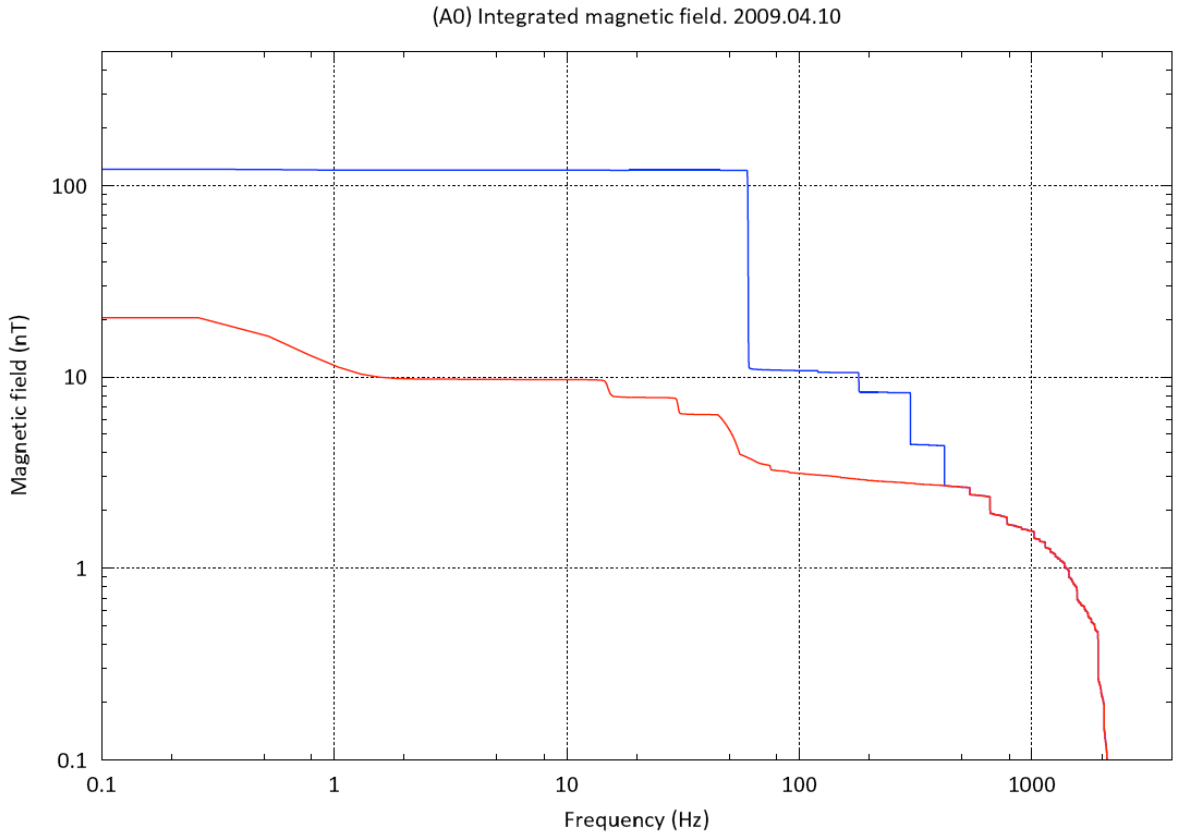
Figure 3: *Train leakage currents, vacuum chamber currents and the associated magnetic field perturbation on Nov. 13th, 1995. The observed peaks are coincident with the departure of the 16:50 Geneva-Paris TGV (SNCF).*

Proportional to train leakage current

Proportional to LEP vacuum chamber current

$\Delta B/B \approx 10^{-5}$

FNAL data I - Courtesy of Dmitri Sergatskov

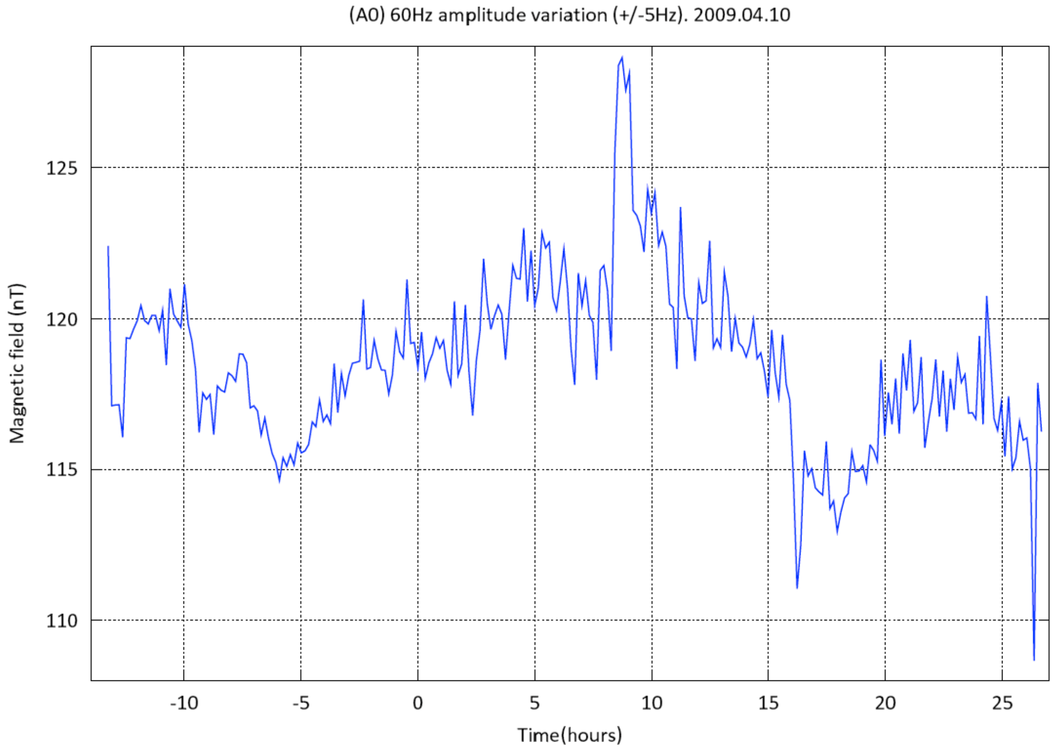


Data taken in the A0 exp-hall

In a 'quiet' office building : 10 × lower

RMS integrated, 24h-averaged noise spectrum. Blue – original, red – with 50 Hz, and 60Hz and its harmonics removed.

FNAL data II - Courtesy of Dmitri Sergatskov



60Hz signal shows weak, if any, 24-hours periodicity. Surprise?

- Level ~10 × above HV-network estimate

Next Steps

- Confirmation of stray magnetic field sensitivities
- Stray magnetic field mapping
- Proposals for stray magnetic field reduction methods
  - Local
  - general
- Cost impact