Report on the behaviour of Active Vacuum Gauges under radiation

by

Wim Koelemeijer-LHC/VAC

Nice

Quantities

The following Pi/Pe gauge quantities will be needed for the LHC (arcs only):

* 160 Pirani gauges (1000 mB - 10^{-4} mB)

* 640 Penning gauges (10^{-4} mB – 10^{-8} mB)

Baseline design:

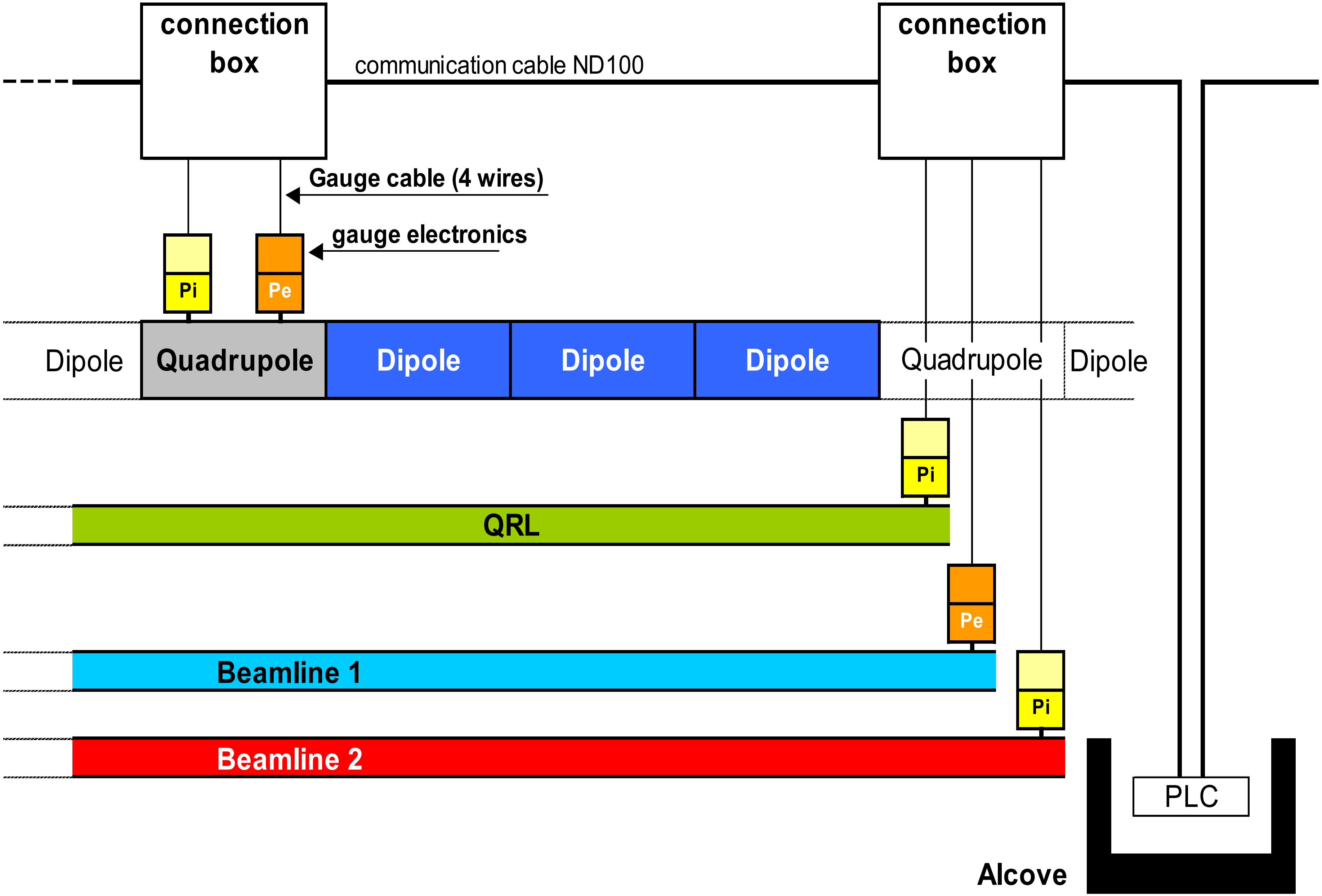
In order to reduce the gauge cabling to an absolute minimum, it was decided to use the so called active gauges.
These are gauges with built-in electronics.
Only 4 (low voltage) wires have to be connected to these gauges:

* 2 wires for the powering (24 V), and

* 2 wires for the pressure read-out (0-10V)

A 4 conductor gauge cable (2 meters long) was foreseen between each gauge and its connection box

Baseline design



Note:
The vacuum gauge readings for the LHC must be very reliable: a bad gauge reading could result in machine damage, requiring months of repair time…

It has not been decided yet whether we will install exclusively individual Pirani and Penning gauges in the arcs, or also the so called FullRange gauges.
FullRange gauges are combined Pirani/Penning gauges. (Two in one)
To simplify and to speed up the radiation tests, only FullRange gauges were tested.
(The electronics for FullRange gauges or individual gauges are basically identical)

Two identical FullRange Pirani/Penning gauges have been tested in the TCC2 test area:

* Pfeiffer PKR 250 (unshielded)
* Pfeiffer PKR 250 (shielded with 60 mm of steel)

First results of the radiation tests:

* Pirani electronics work up to 20 Gy only ✩✩
* Unshielded Penning electronics work up to 55 Gy only ✩
* Shielding (60mm of steel) does improve the performance of the Penning electronics, but with a factor of 2 only ✩

In order to be 100 % sure that the gauge readings reflect the real vacuum pressure, we intend to introduce a safety factor of 5.

In other words:

We will multiply the radiation levels as predicted by Graham Stevenson with 5, and our gauges must be able to withstand this severe requirement….

All vacuum gauges will be installed in the vicinity of the quadrupoles, where the radiation levels are estimated to be 8 Gy/year.

When applying our safety factor, we can say that the tested Pirani gauge electronics had a guaranteed lifetime (GLT) of less than half a year, and the Penning gauges electronics a GLT of one year only.

This is –by far- not good enough!

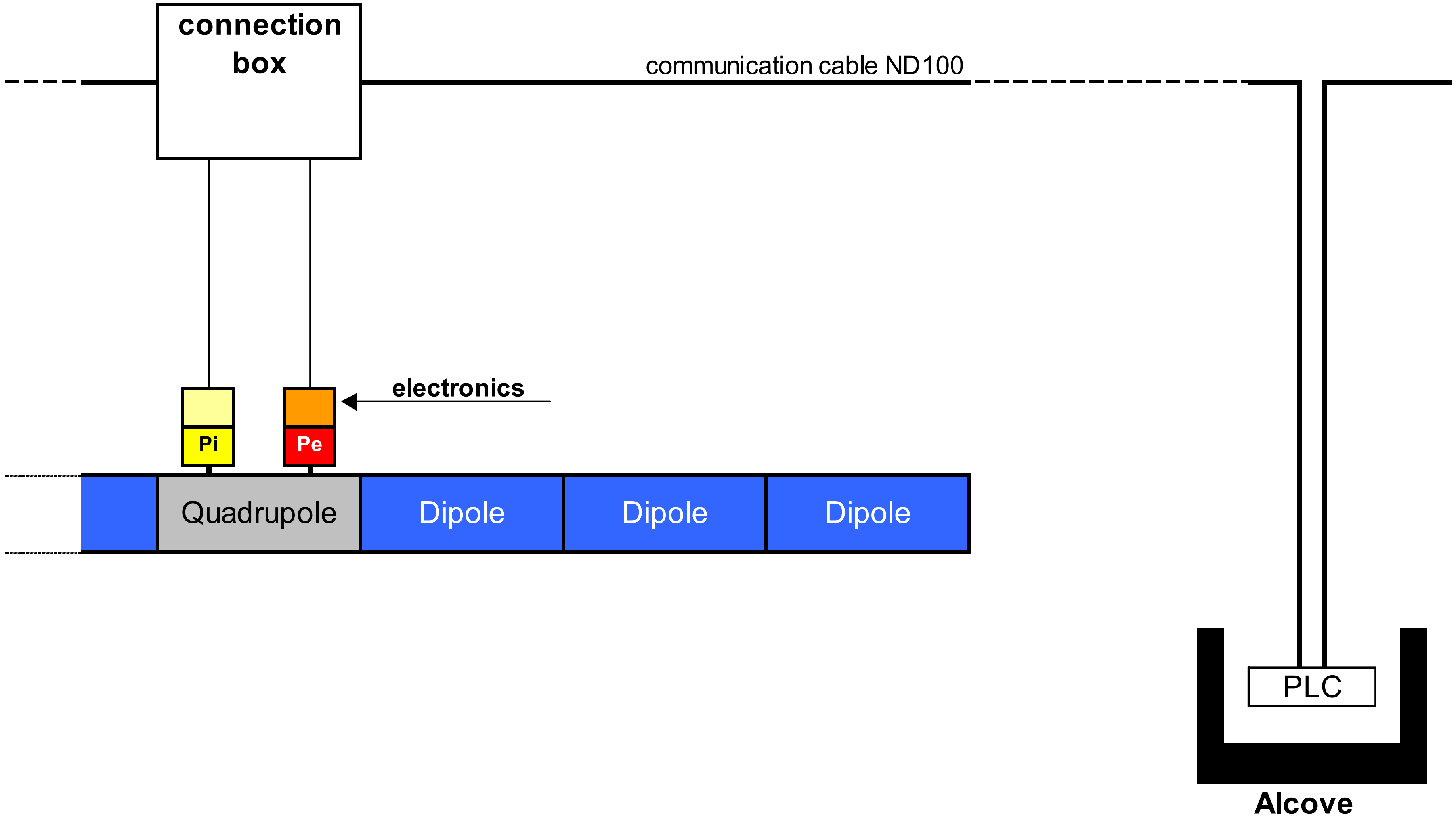
Not good enough...

But what can be done?

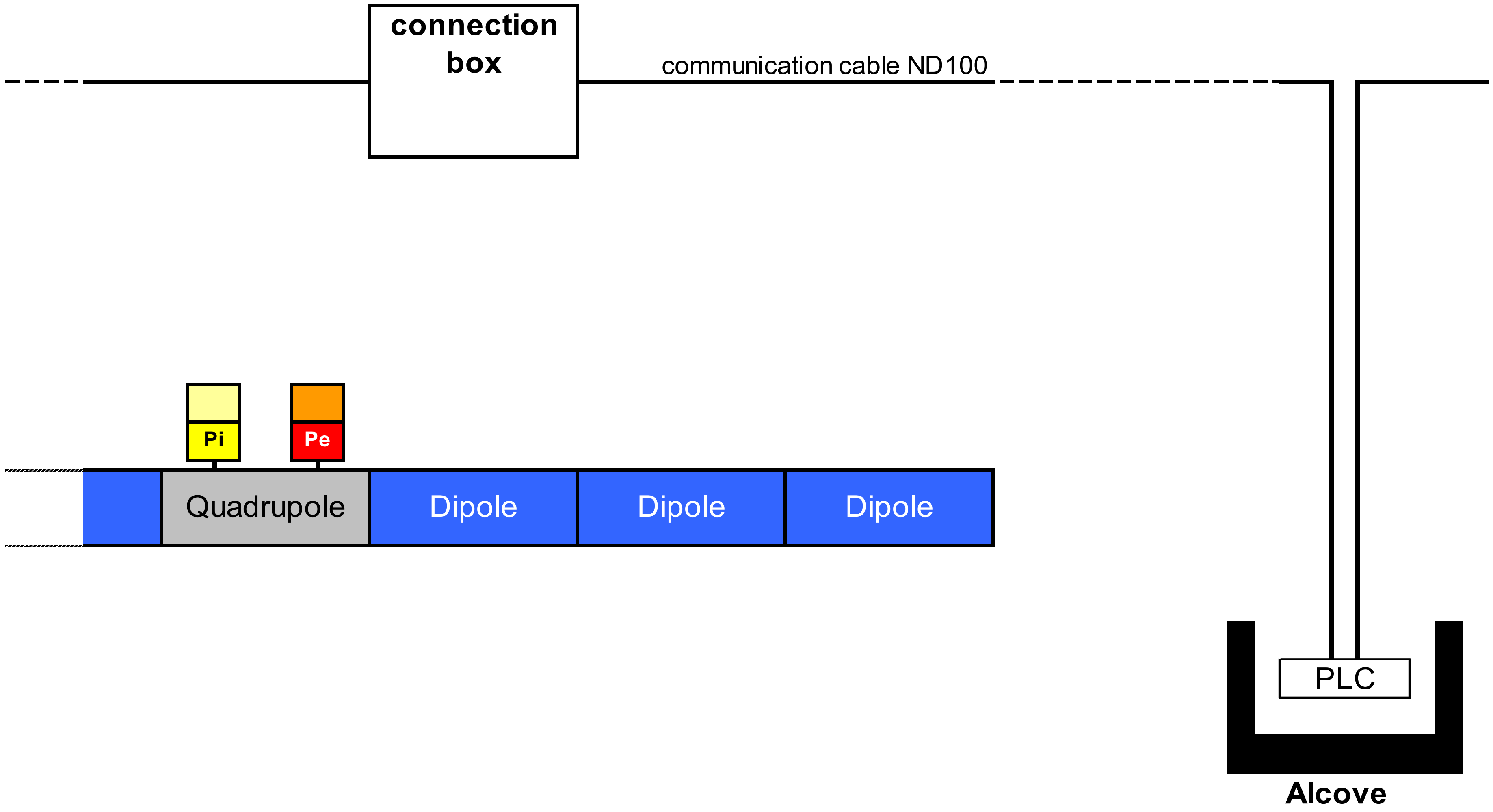
The various vacuum systems are equipped with vacuum flanges, but exclusively near the quadrupoles
It is therefore impossible to displace the vacuum gauges to an area with less radiation

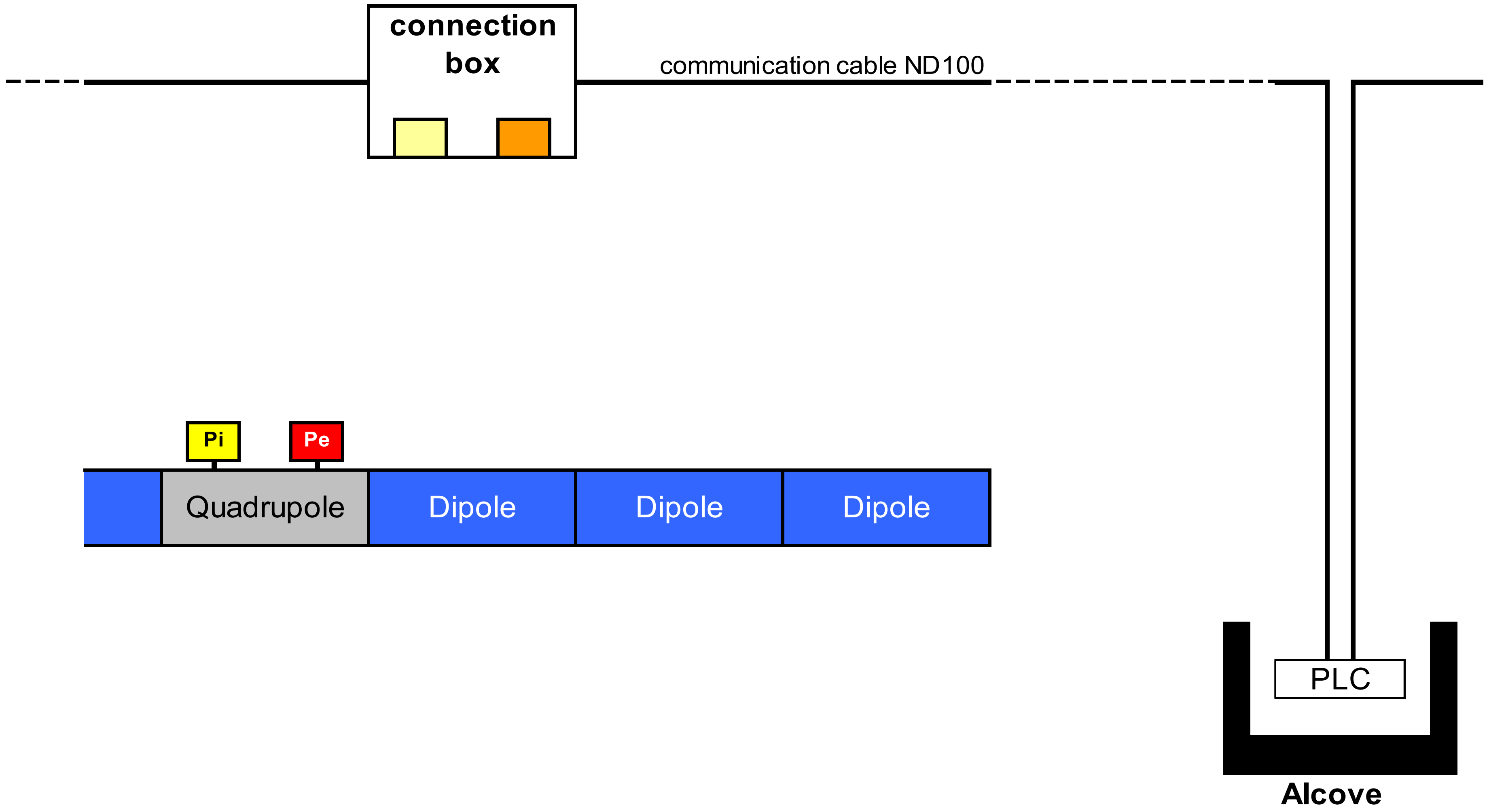
However, it is possible to displace the gauge electronics to an area with less radiation !

Hence, it has been decided to move the connection boxes to the middle of the next dipole, where the radiation is 8 times less…

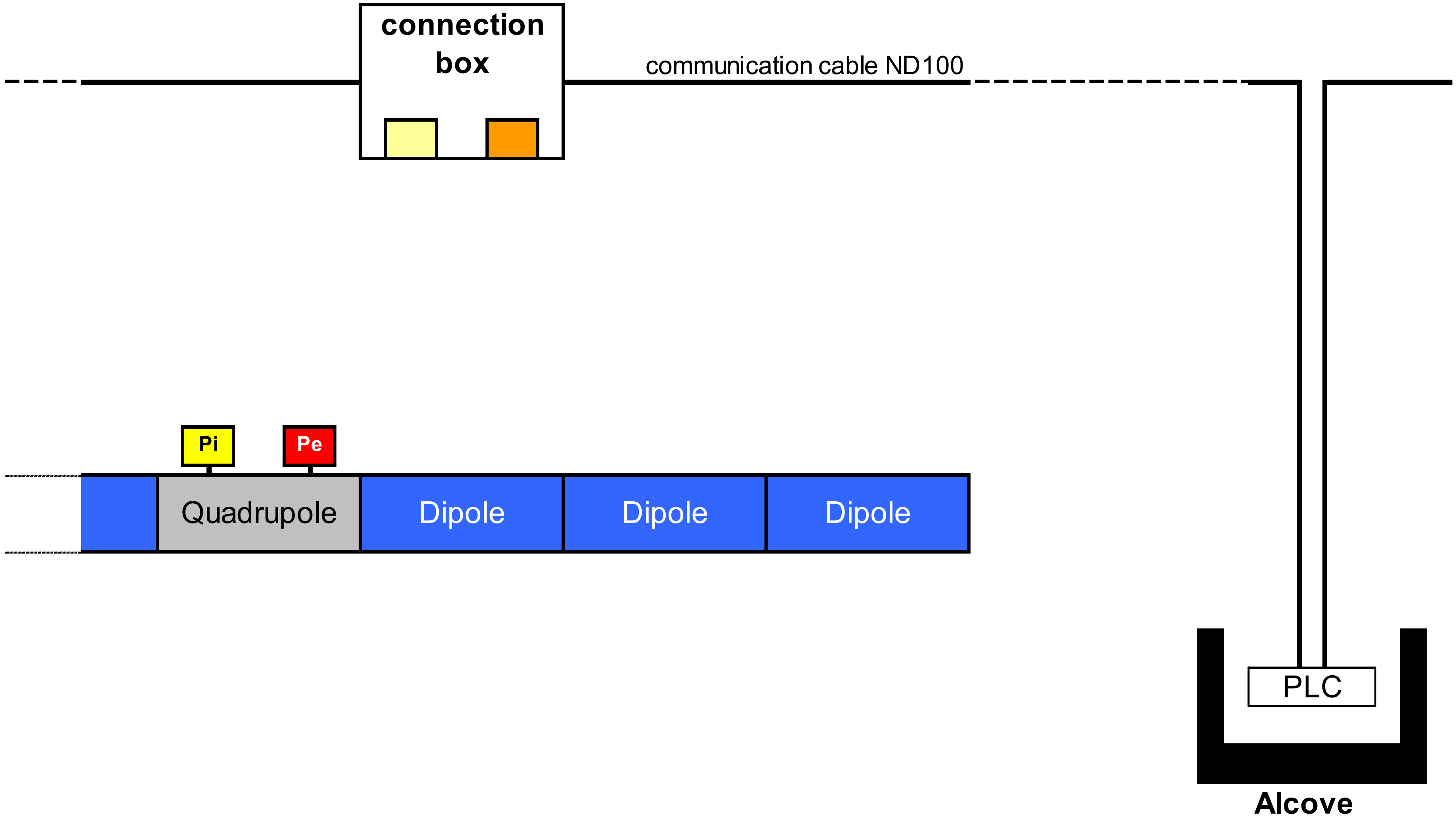

connection box
communication cable ND100
electronics
Pi
Pe
Quadrupole
Dipole
Dipole
Dipole
PLC
Alcove

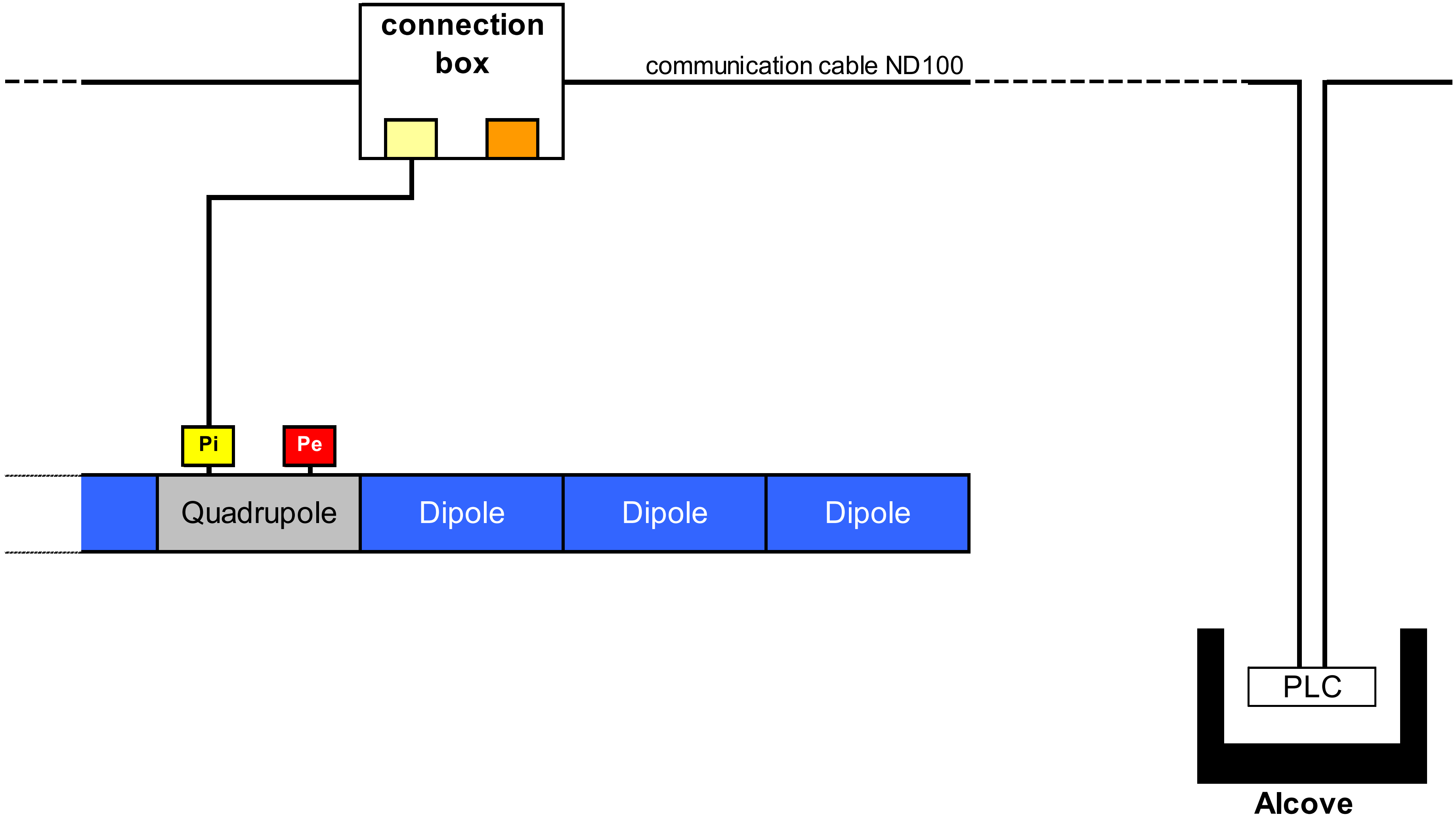
We will install the gauge electronics in the interconnection boxes:

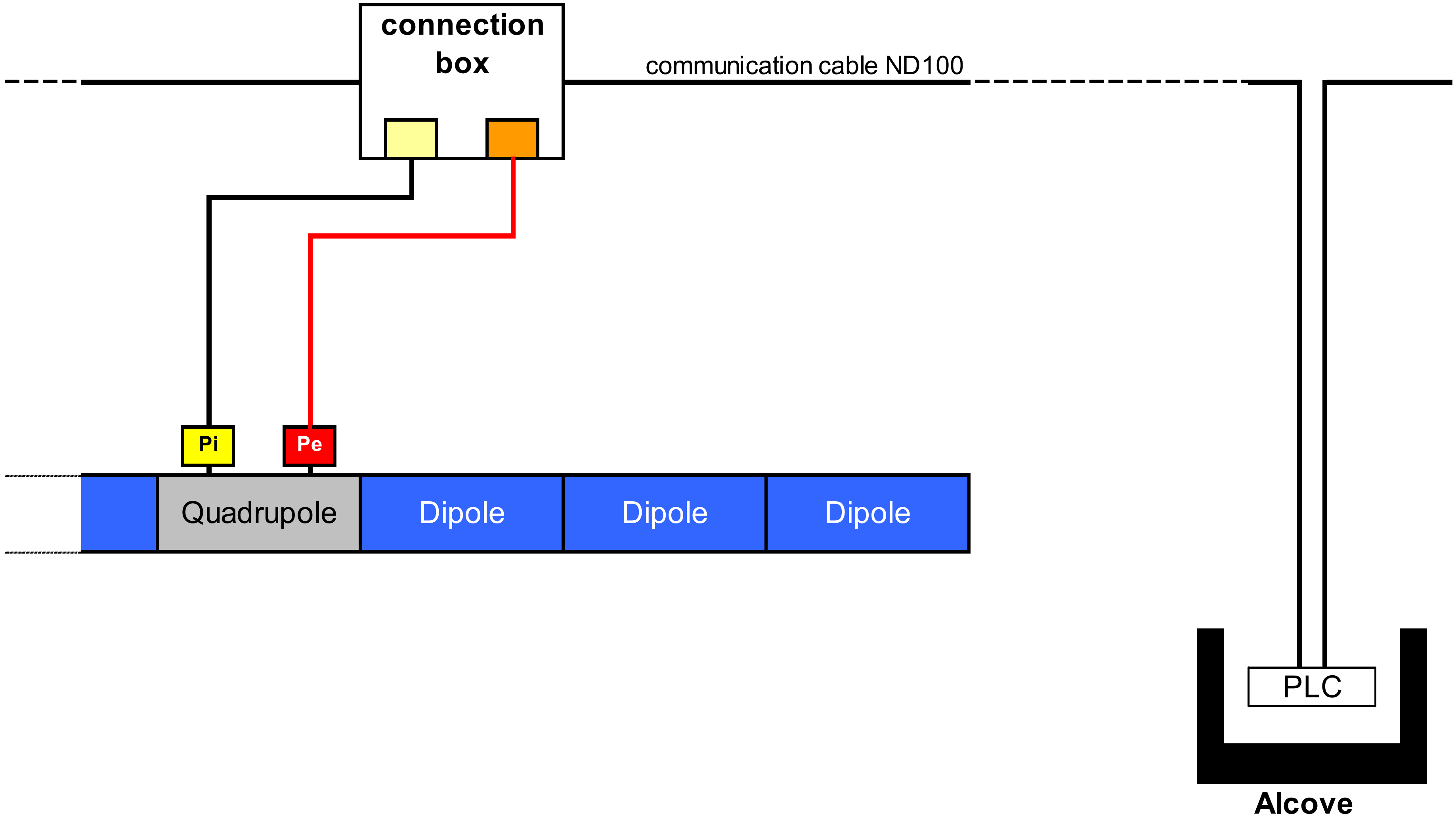

connection box
communication cable ND100
Pi
Pe
Quadrupole
Dipole
Dipole
Dipole
PLC
Alcove

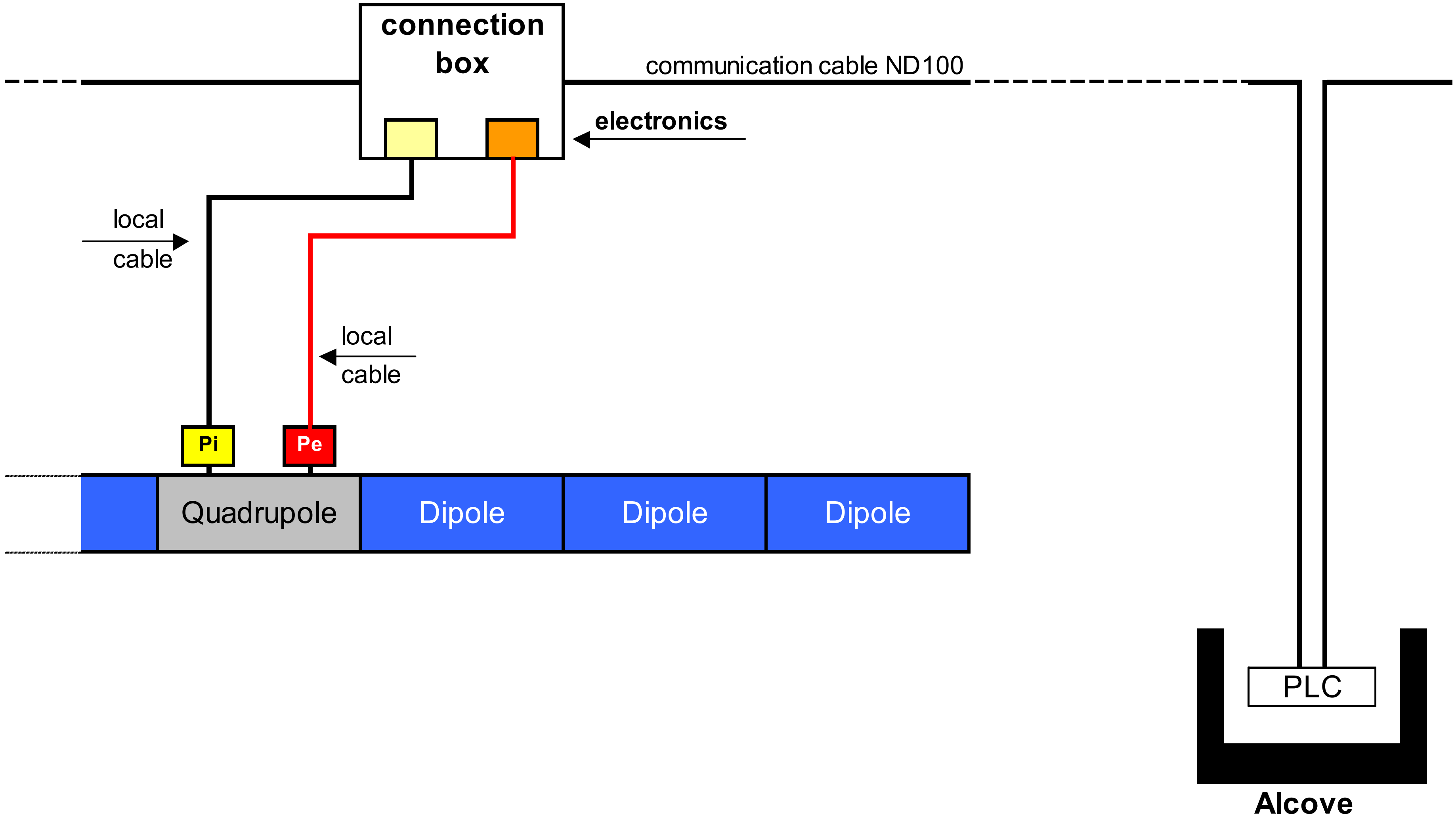

connection box
communication cable ND100
Pi
Pe
Quadrupole
Dipole
Dipole
Dipole
PLC
Alcove

For this the gauges have to be modified, and additional local cabling has to be installed


connection box
communication cable ND100
Pi
Pe
Quadrupole
Dipole
Dipole
Dipole
PLC
Alcove


connection box
communication cable ND100
Pi
Pe
Quadrupole
Dipole
Dipole
Dipole
PLC
Alcove


connection box
communication cable ND100
Pi
Pe
Quadrupole
Dipole
Dipole
Dipole
PLC
Alcove


connection box
communication cable ND100
electronics
local cable
local cable
Pi
Pe
Quadrupole
Dipole
Dipole
Dipole
PLC
Alcove

With this scheme we gain a factor of 8, so

* The GLT (guaranteed lifetime) of the Pirani electronics becomes now 3 years, which is still

not brilliant, but

* The GLT of the Penning electronics is now

estimated to be 7 years

The insulation vacua of magnets and QRL are dirty, due to the presence of small particles of super-insulation.

The lifetime of a Penning gauge depends therefore very much on the pressure: at low pressures (10 $^{-8}$ mB) it is at least 10 years, but at high pressures (10^{-4} mB) the gauge is quickly polluted and its lifetime will be a few minutes only. When we are at high pressures the Penning gauges can be switched-on for short periods of time only, and we have to rely for the rest of the time on the information from the Pirani gauges

The correct functioning of the Pirani gauges is therefore extremely important: only the Pirani gauges can be powered continuously at any pressure.

It was therefore considered worthwhile to try to increase the three years lifetime of the Pirani electronics by developing radiation-hard electronics

Pirani bridge amplifiers are being developed at Cern, and prototypes have been tested in the TCC2, together with a cannibalized Pfeiffer Pirani gauge (TPR 265)

These tests have not been finalized yet, but we know already the behaviour of a number of components

* The old fashioned LM 741 op amps worked still quite well after 100 Gy,
* The newer LM 324's (4 op amps in one package) worked well up to 35 Gy, but started to show bad aftereffects at 65 Gy,
* The ICL 7660's (normally used to produce negative supply voltages) are not usable,
* Fixed voltage regulators are better than variable ones, but if one can live with non-stabilized supplies, then regulators should be avoided, and most important:

* All IC's must be mounted on sockets, for easy replacement during shutdowns

THE END