Radiation from Cavities at P4 in LHC:

Possible Induced Problems

Presented at Machine Protection WG
12 April 02

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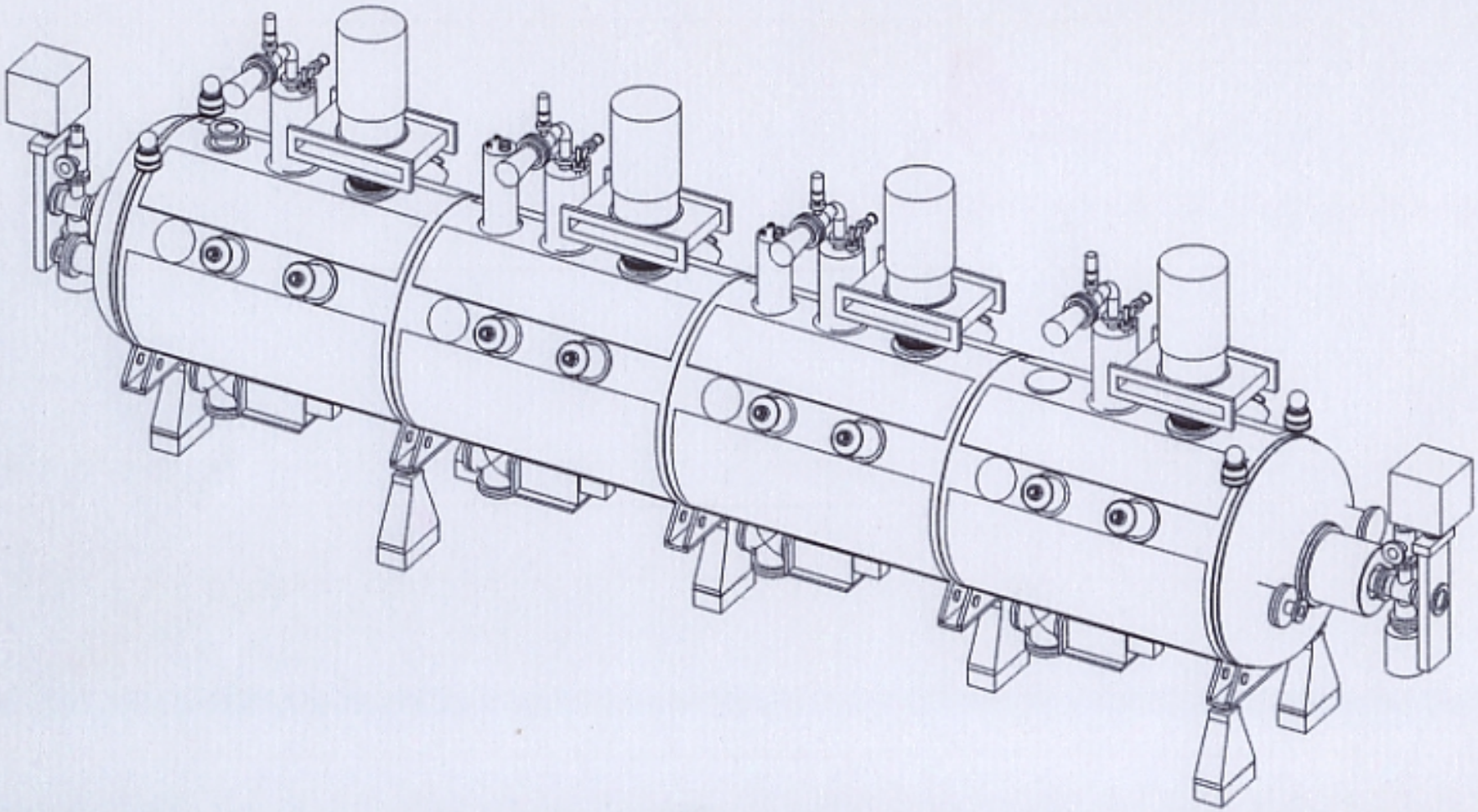

400 MHz CAVITY

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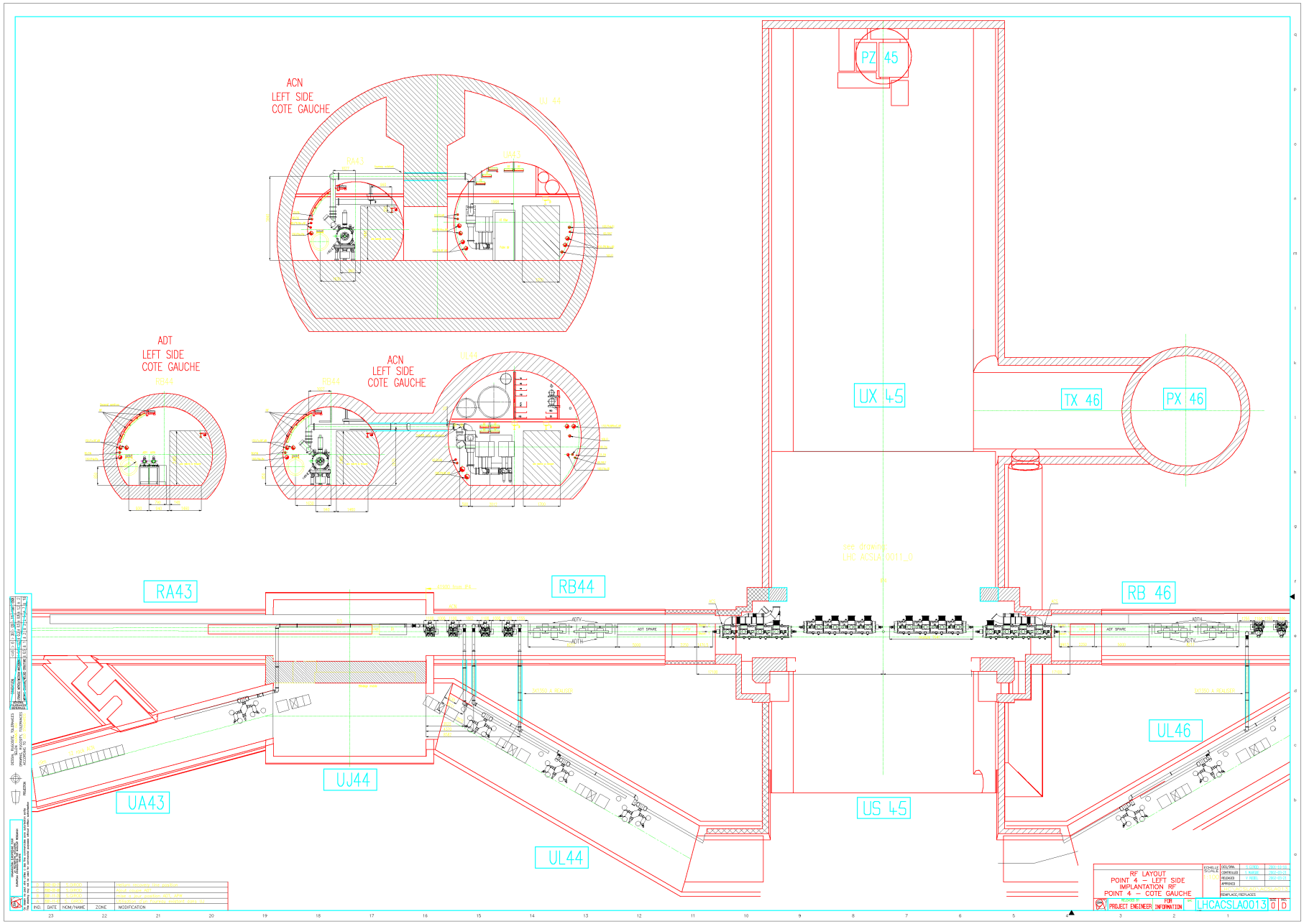
ACN
LEFT SIDE
COTE GAUCHE
UJ 44
RA43
UA43
ADT
LEFT SIDE
COTE GAUCHE
RB44
ACN
LEFT SIDE
COTE GAUCHE
UL44
RB44
PZ 45
UX 45
TX 46
PX 46
see drawing
LHC ACSLA 0011_0
RA43
RB44
RB 46
UA43
UJ44
UL44
US 45
UL46
RF LAYOUT
POINT 4 – LEFT SIDE
IMPLANTATION RF
POINT 4 – COTE GAUCHE
PROJECT ENGINEER
FOR
INFORMATION
LHCACSLA0013
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Fieldemission, some facts:

• **Very strong electric field (1000 MV/m) pulls electrons out of a (conducting) surface, even at 'normal' temperatures (contrast: glow-emission)**

• **All (real) surfaces carries tiny 'objects' which allow fieldemssion far below the theoretically predicted field**

"EMITTER"

-> nothing to do with superconductivity, but fields in sc. cavities higher than in Cu cavities: problem more evident but exists as well in Cu cavities !!!

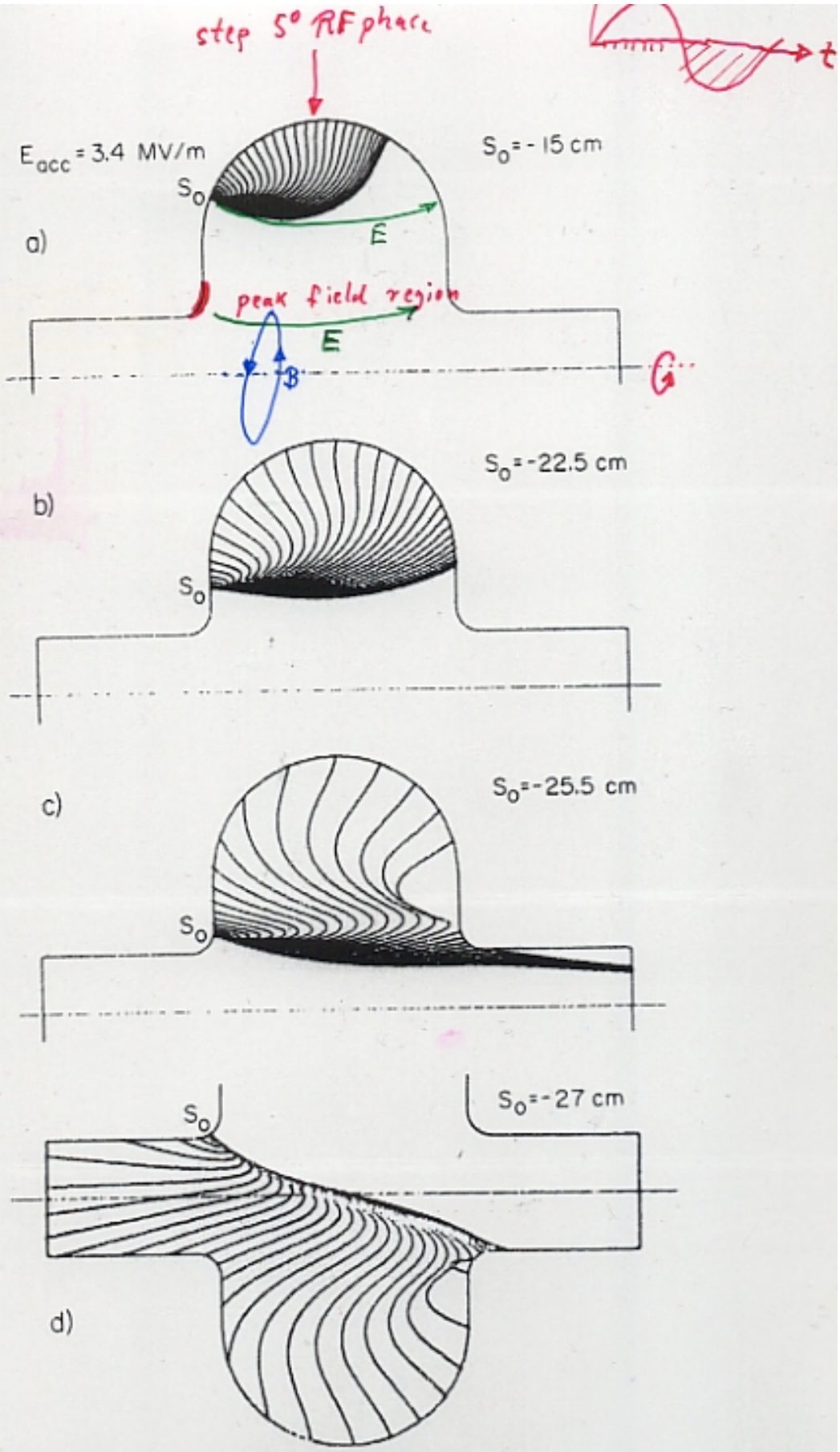
fact: a lot of surface 'junk' but not all are emitters

• **Fieldemission is a nuisance in DC and RF (physics fast compared to T_{osc}):**
High voltage switches, ..., cavities, ...

• **The field emitted electron current (number of e) increases EXPONENTIALLY with the field/voltage !!**

• **Electrons are accerated, hitting surface somewhere**

-> impact creates heat (increased thermal losses)
-> impact creates bremsstrahlung ('X ray tube')
(rays not much directed -> plot)
(P. Darriulat: γ -ray camera shows 'hot' areas)


step 5° RF phase
t
E_{acc} = 3.4 MV/m
S_0 = - 15 cm
S_0
a)
E
peak field region
E
B
G
S_0 = -22.5 cm
b)
S_0
S_0 = -25.5 cm
c)
S_0
S_0 = -27 cm
S_0
d)

• **We do what we can to avoid field emission but it**
CANNOT BE AVOIDED COMPLETELY
-> we (and you !!) have to live with it
IT IS (ALSO) YOUR PROBLEM

• **Switching off the RF stops the radiation completely**
-> immediate beam loss not much appreciated ...
Small remanent excitation observed for LEP cavities (short lived), for LHC cavities wait and see

• **To reduce field emission during operation,**
PROCESSING = high field operation
(maybe with 10^{-5} mbar GHe) often helps

• **<u>Type of radiation</u>:**
'Breamsstrahlungs spectrum' up to some MeV

• **<u>Intensity and duration</u>:**
There are two 'modes' of radiation:

1) **<u>Processing</u> (no beam) for set up: Strong radiation for hours, days, a week .?.?**
1a) If a cavity develops problems, processing between beam dump and re-injection ...

LEP2 cavities: worst case up to 100 kRad/h, probably less for LHC single cell cavities

2) **During <u>operation</u> (with or without beam): Some mSv/h possible within a few metres away from the cryostat**

and the Cu cavities .....

Remark: Even if cavities are excited incoherently (slightly different freqeuencies on test stand), the radiation for 'all cavities excited' is much larger (*10) than the sum of the radiation for 'single-excited' cavities (always same field level):

a) electrons travel through beam hole into next cavity and are picked up there by the E-field

b) gammas pass though the metal walls and hitting the wall of another cavity create photo-electrons

- **Radiation level will or may change**
  -> rapidly: while changing cavity field (exponential !)
  -> erratically: due to Maxwell's demon or ??

Conclusion: A beam loss trigger-level 'slightly above cavity background' will not work !!

- **Emission is pulsed by RF oscillation 400 MHz but 16 cavities - with many possible emitters - are spaced by multiples of $\lambda/2$:**
  Radiation(time) @point x is a 'mess'

Conclusion: Any 'anti-coincidence' will not work !!

• **<u>Who is concerned</u>:**

Everybody with equipment

around P4, including
'everywhere around the ring'

-> high intensity γ destroy 'soft' plastic
(cable insulation, supports, ...)

-> medium intensity: semiconductors, ...

-> low intensity: sensitive measuremants disturbed

• **p.s.: There is also visible light radiation !**

-> 'Glowing spots' (cold light ?) have been obserevd on (RF-excited) sc. cavity surfaces

-> 'Light figures' (plasma ?) have been observed in the centre of cavities (beam axis)