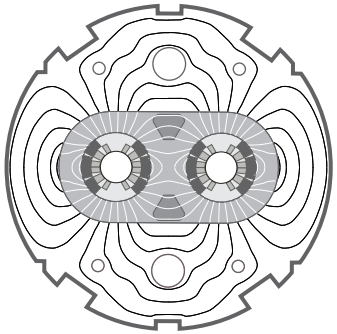
LHC Technical Co-ordination Committee meeting
15 December 2000



Qualification of the radiation environment in the TCC2 experimental Test Area

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LHC Project Note 235

Overview

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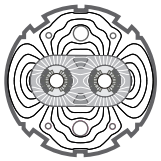
- TCC2 experimental area
- Simulation results of radiation environment for TCC2:

  Spectra
  Fluence:Dose ratios
- Comparison of TCC2 test area and LHC (arc) radiation environments.
- Summary



Classification of radiation environment

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want to know

- # neutrons/hadrons per cm^2 which are above a certain minimum energy (e.g. E_{cut} = 1 MeV) for a dose of 1 Gy.

$$R = \text{Fluence } (\Phi) / \text{Dose } (D)$$

$$\text{neutrons/hadrons} \,.\, cm^{-2} \,.\, Gy^{-1}$$

require

- $R_{TCC2} = R_{LHC}$

if have similar radiation environments.

=> for absolute doses measured in the TCC2 area, particle numbers will scale appropriately as for the LHC.

DOSES in TCC2

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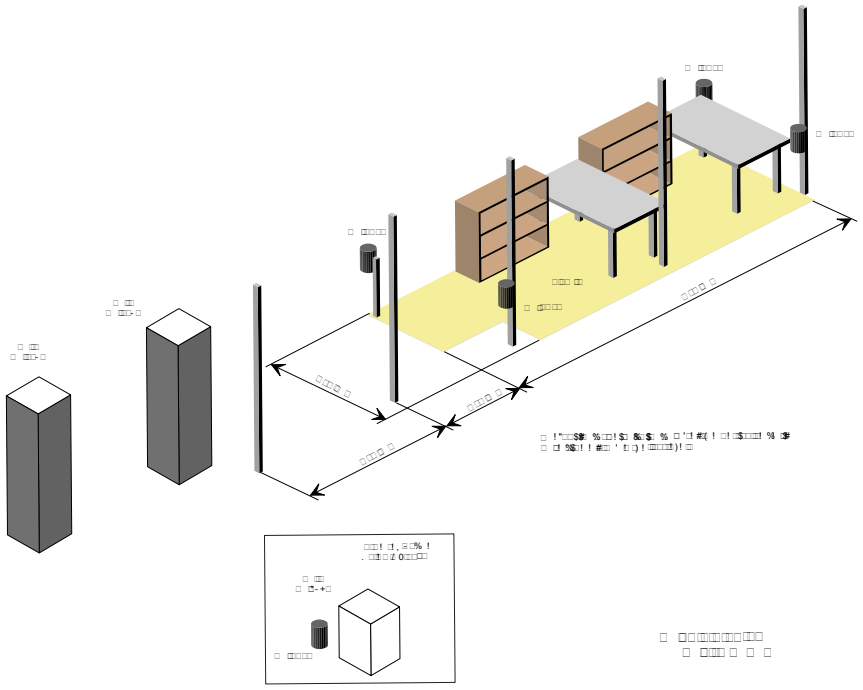
http://lhc-radwg.web.cern.ch/LHC-radwg/

Summary of radiation doses in TCC2 in Year 1999

month	PMI No	PMI (Sv)	PAD (Gy)	RPL (Gy)	**dose (Gy)**	correction factor	Diodes E10 n/cm2
October	1	55	39,5	65	**55**	**1**	62
October	2	48	85	100	**96**	**2**	150
October	3	39	25,7	48,2	**39**	**1**	23
October	4	29	20,2	40,6	**29**	**1**	23
Sept.	1	169	333	377	**337**	**2**	360
Sept.	2	206	526	451	**411**	**2**	400
Sept.	3	125	240	451	**250**	**2**	270
Sept.	4	93	185	324	**185**	**2**	160
August	1	139	97	219	**139**	**1**	100
August	2	167	106	219	**167**	**1**	147
August	3	57	46	95	**57**	**1**	36
August	4	65	47	85	**65**	**1**	34
July	1	131	103	200	**131**	**1**	150
July	2	184	184	287	**184**	**1**	290
July	3	115	751	572	**575**	**5**	999
July	4	83	99	130	**108**	**1,3**	150
June	1	158	50	117	**158**	**1**	40
June	2	177	427	287	**355**	**2**	997
June	3	71	229	572	**353**	**5**	320
June	4	74	112	287	**96**	**1,3**	79
May	2	99	24	641	**99**	**1**	250
May	3	29	54	100	**58**	**2**	11
May	4	34	25	95	**34**	**1**	25

1999 measurements Marc Tavlet TIS/TE (Gy)

2000 - daily dose measurements (mSv)



Test Area Setup

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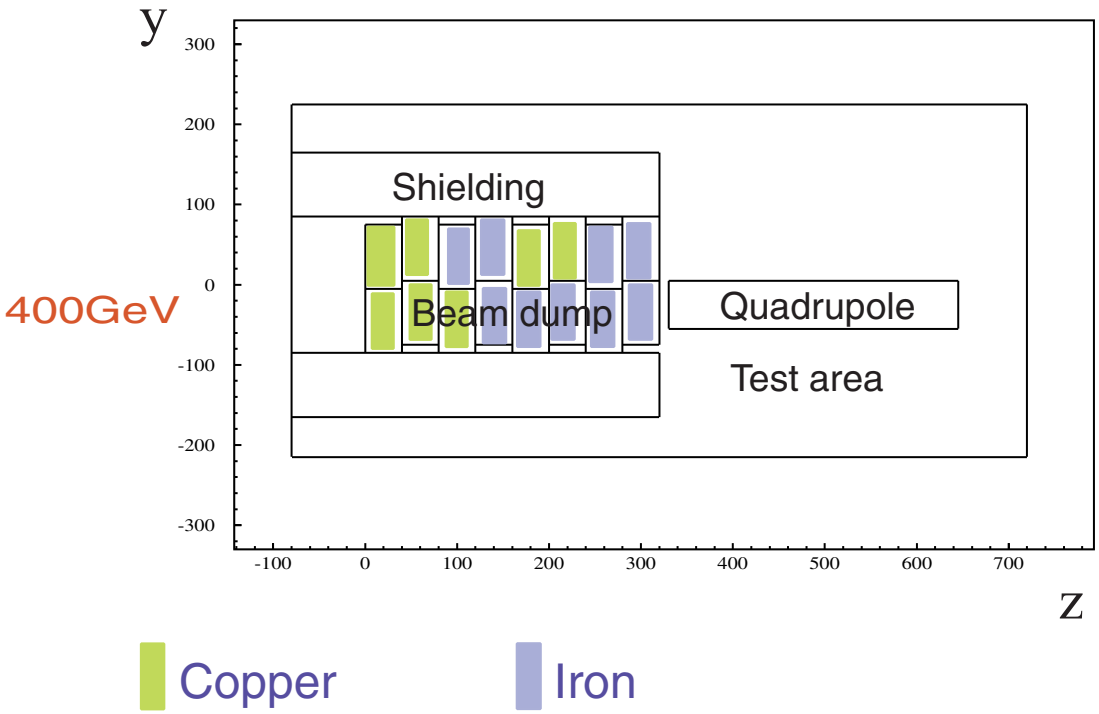

Concrete experimental hall:
h 8m / b 16m / l 120m

Test area: $10m^2$
consisting of shelves & workbenches on which electronics sit.

Scoring setup:
128 bins - $40x40x100\ cm^3$
16 bins - $60x40x100\ cm^3$ (above)

Particle spectra in the TCC2 area

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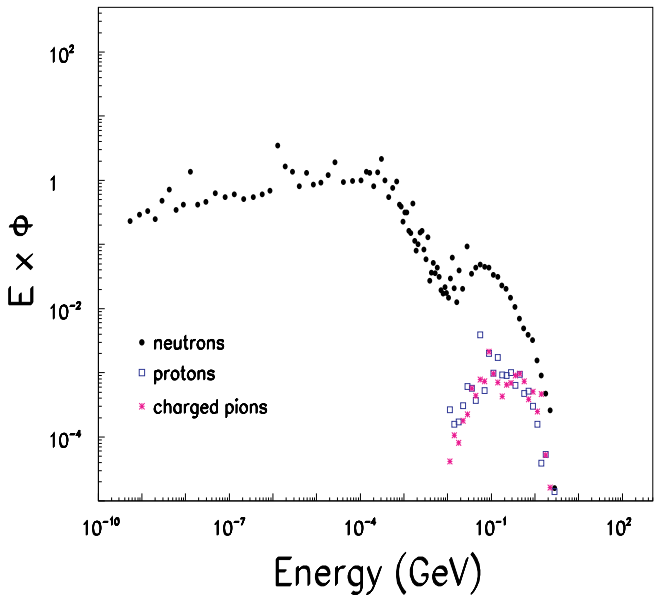
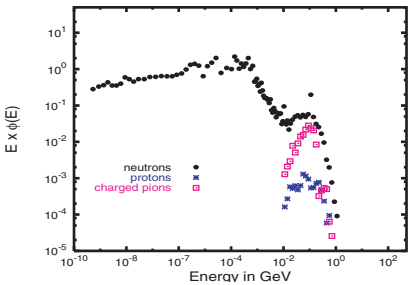
Typical example of particle spectra found in TCC2 test area.



(scoring bin 80-120cm from quadrupole edge,
40-80cm above floor, 1-2m behind beam dump)

- Very little variation is seen in the particle spectra over the entire test area region (1-4m behind dump, all radial and height bins) .
- Is large proportion of low energy neutrons (due to presence of concrete walls & floor)

  Still have significant contribution from high energy neutrons & hadrons (> 5 MeV)
- Deviation in spectra seen for high scoring bins at large radial distances immediately behind beam dump -> excess of charged pions



Fluence : Dose ratios in test area

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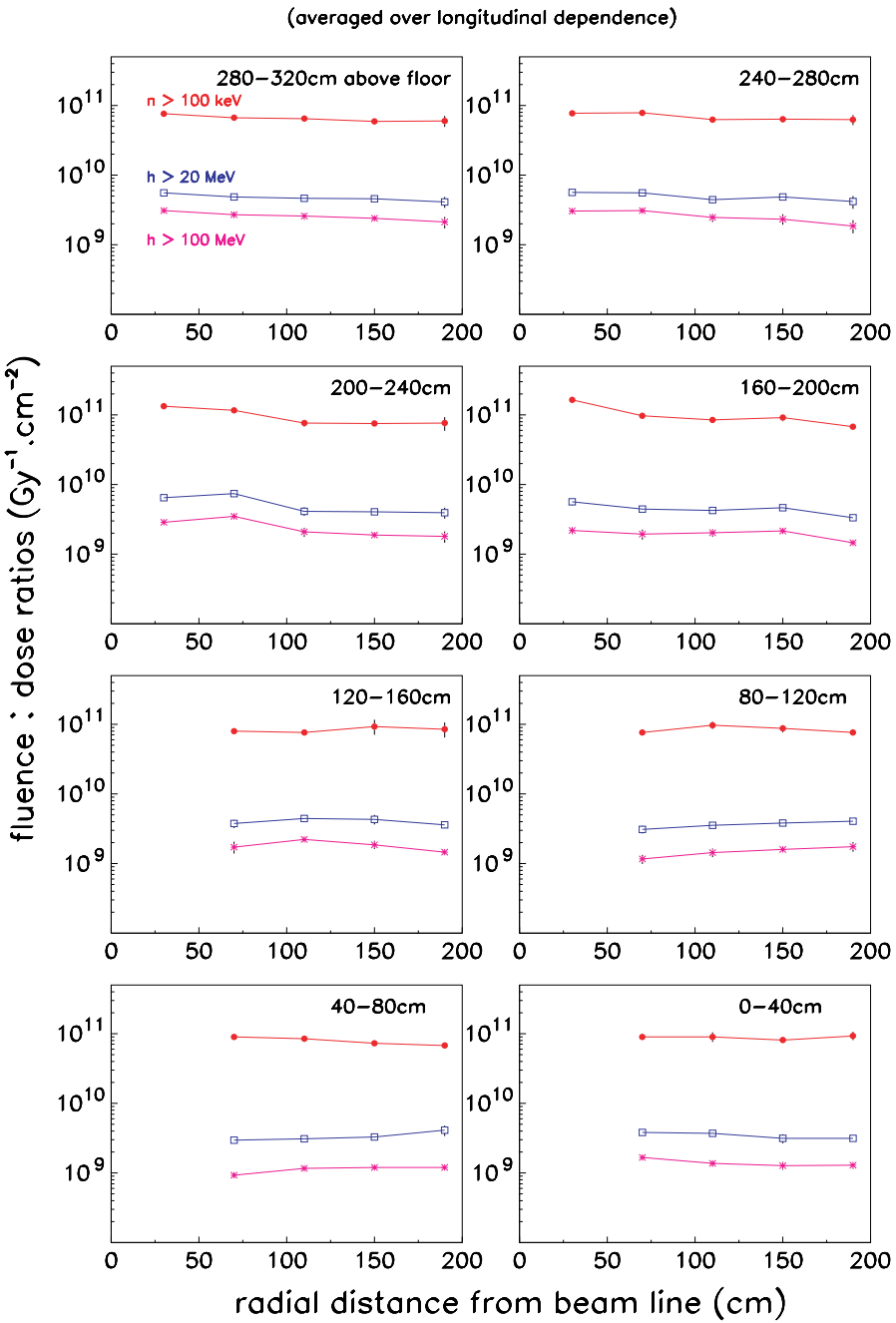

No radial dependence of R(TCC2)

neutrons > 100 keV — bulk damage in Si
hadrons > 20 / 100 MeV — SEU's

R(TCC2):

neutrons > 100 keV	8 x10^{10} n/Gy cm^{-3}
hadrons > 20 MeV	4 x10^{9} h/Gy cm^{-3}
hadrons > 100 MeV	2 x10^{9} h/Gy cm^{-3}

Comparison of TCC2 & LHC radiation environments

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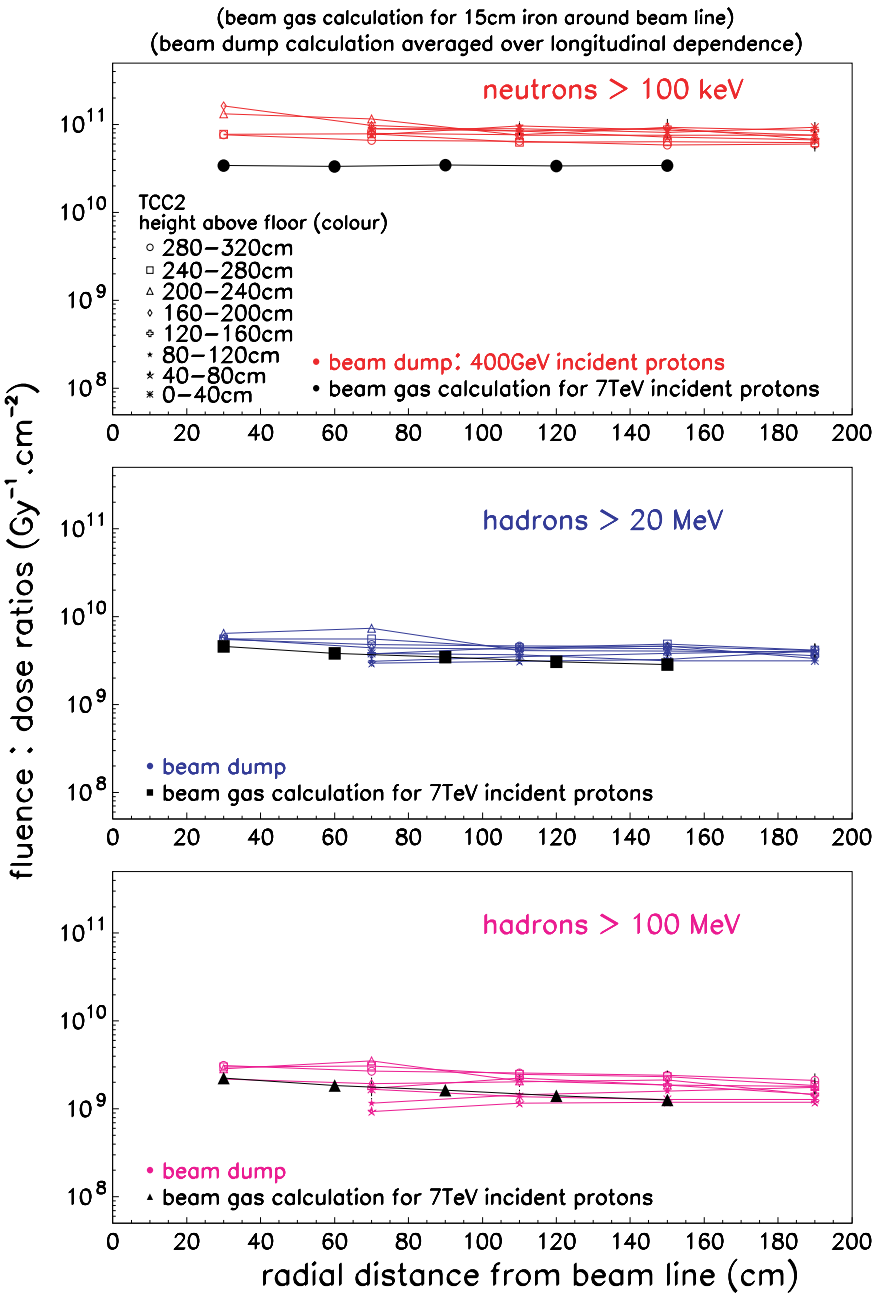

Radial dependence of fluence:dose ratios

- Radiation environments for high E hadrons identical for TCC2 area and LHC (alongside Arc dipoles)
- R(TCC2) > R(LHC) for neutrons above 100 keV.

Comparison of Particle Spectra

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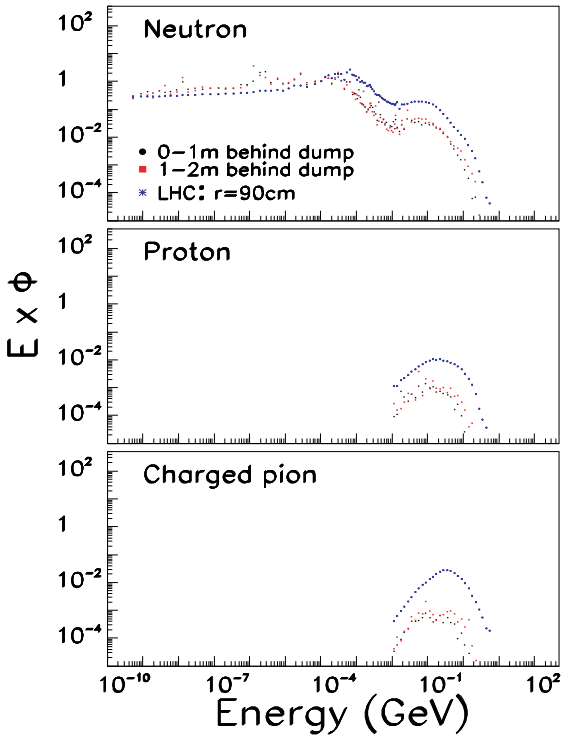
(radial bin 80-120cm from quad edge,
40-80 cm above floor)



TCC2 area is down compared to LHC for dose per incident proton.

Comparing particle spectra then TCC2 area is also down for high energy hadrons - thus compensates drop in dose =>

$$R(TCC2) = R(LHC) \text{ at high } E_{cut}$$

For neutrons, still have drop in numbers for high E, but are virtually same for low E neutrons (due to presence of concrete wall / floor / tunnel) - thus drop in neutron numbers for low E cuts does not fully compensate the drop in dose/proton =>

$$R(TCC2) > R(LHC) \text{ at low } E_{cut}$$

Ecut dependence of fluence:dose ratios comparison for R(TCC2) & R(LHC)

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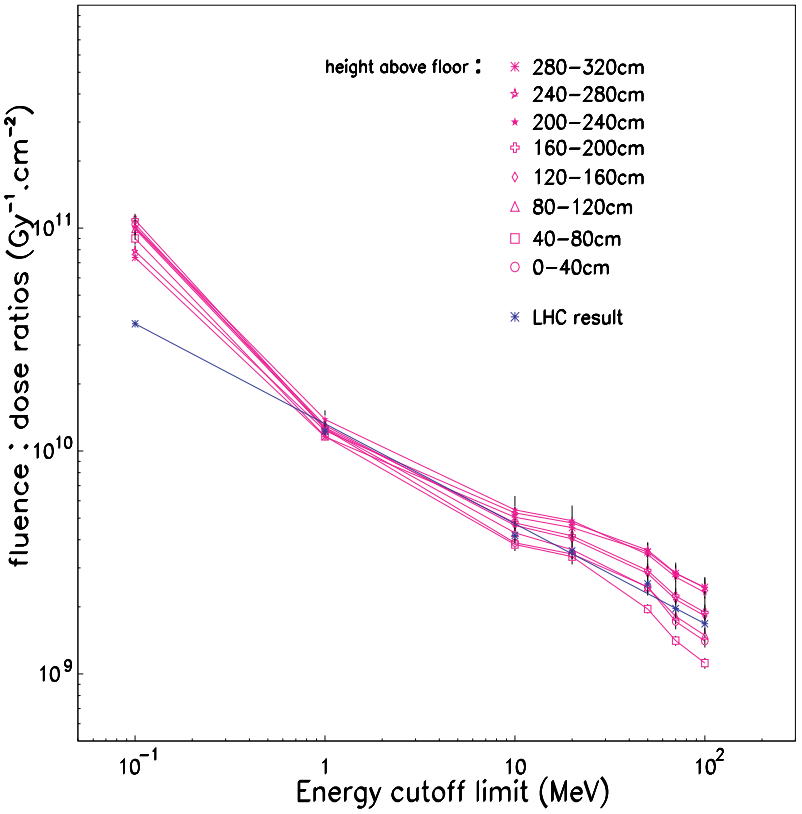
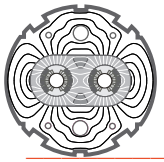


For equipment sensitive to particle fluences above E_{cut} = 1MeV , radiation environments of TCC2 test area and LHC are the same.

Good testing ground.

For equipment sensitive to particle fluences with E_{cut} < 1MeV, equipment in the TCC2 experimental area will be exposed to higher neutron fluences than those at the LHC => SEU problems experienced under TCC2 testing would be greater than at the LHC (although does not say will not be problem at LHC)

TCC2 pessimistic results.



Summary

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TCC2 experimental test area

- No particle variation over the test area region - (charged π increase immediately behind the beam dump at large heights & radial distances)
- Equipment placed anywhere will see same ratio R(TCC2) - except immediately behind dump.
- Can enlarge area by going to higher positions (even above quadrupole).

Comparison of TCC2 & LHC

- Radiation environments of the LHC and TCC2 experimental test area are the same for particle fluences > 1 MeV.
- For fluences above low energy cutoffs eg. neutrons > 100 keV, the TCC2 test area has a higher neutron:dose ratio than the LHC radiation environment.

SEU's caused by (min) had > 20 MeV
=> TCC2 test area will provide the same radiation environment as the LHC for testing electronics.

NB. LHC results are for the "magnet configuration".
if have less material surrounding beam pipe e.g. intermagnet gaps or RF cavities will get different particle spectra (noticeably inc. of charged π)

TCC2 same only for regions alongside main magnets.