Radiation in RE38 and UJ32 under nominal LHC operation

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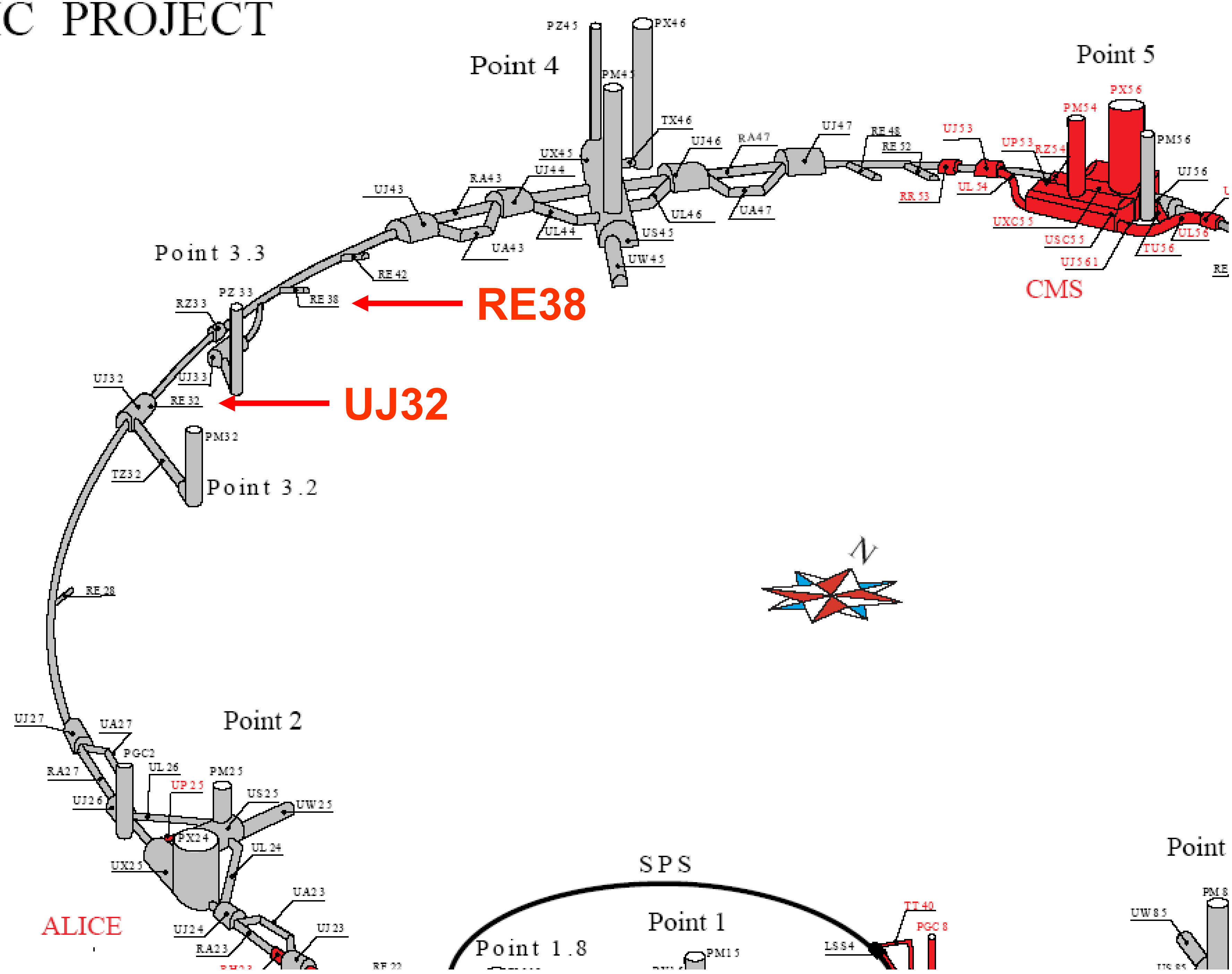
Outline

- Layouts and Locations
- Radiation sources
- Monte-Carlo method
- Arc description
- Approximations and errors
- Results
- Summary

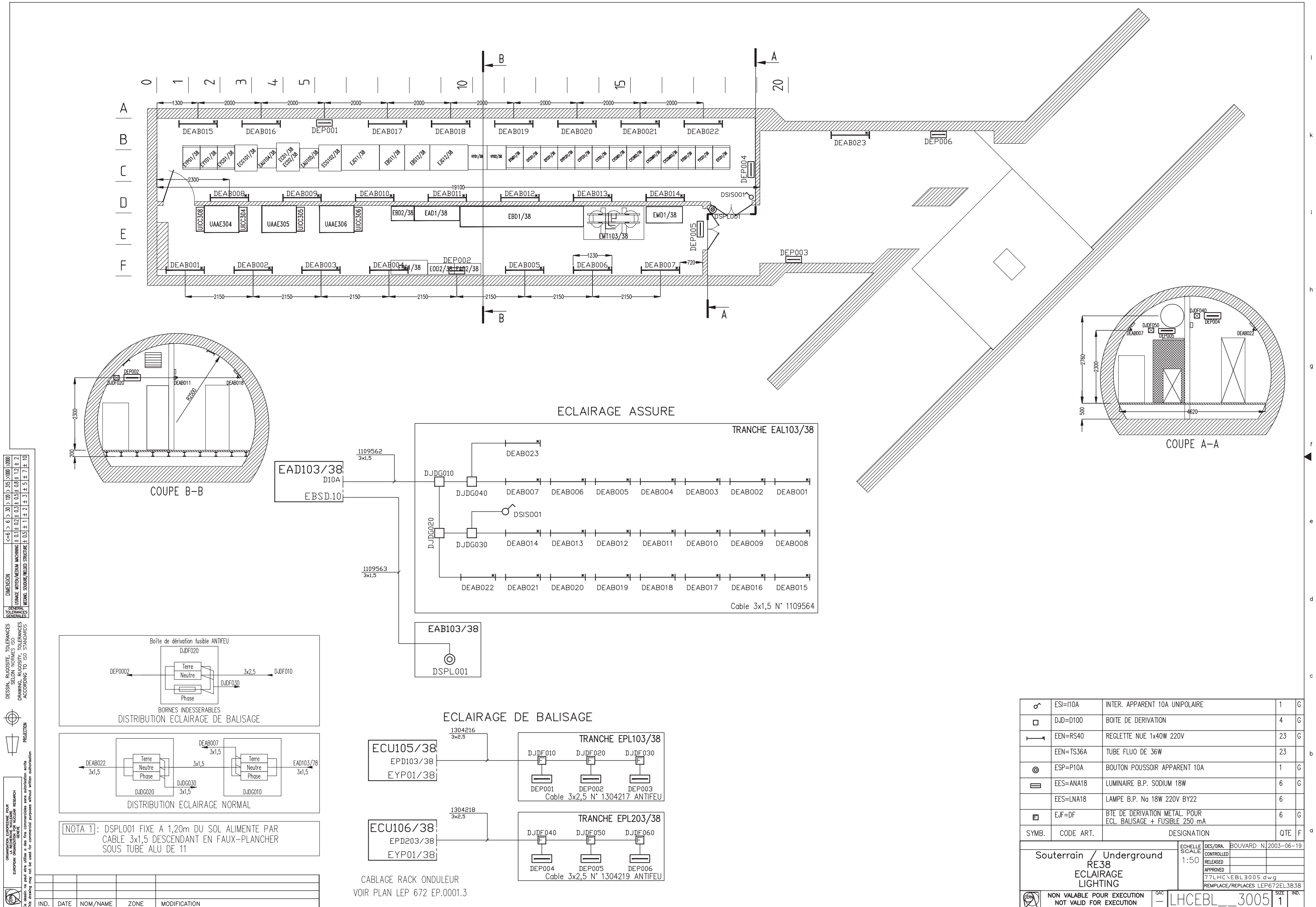
Locations

- Location
  - UJ32 in Arc23 half-cell 18L3
  - RE38 in Arc34 half-cell 21R3

LHC PROJECT



Point 4
Point 5
Point 3.3
Point 3.2
Point 2
Point 1
Point 1.8
SPS
Point
RE38
UJ32
CMS
ALICE
N
PZ45
PX46
PM45
TX46
UX45
UJ44
RA43
UJ43
UJ46
RA47
UJ47
RE 48
RE 52
UJ53
UP53
RZ54
PM54
PX56
PM56
UJ56
RR 53
UL 54
UXC55
USC55
UJ561
TU56
UL56
UL46
UA47
UL44
US45
UW45
UA43
RE 42
RE 38
PZ 33
RZ33
UJ33
UJ32
RE 32
PM32
TZ32
RE 28
UJ27
UA27
PGC2
RA27
UL 26
PM25
UP25
US25
UW25
UJ26
PX24
UL 24
UX25
UA23
UJ24
UJ 23
RA23
TT 40
PGC 8
LSS4
PM15
UW85
PM 8



SYMB.	CODE ART.	DESIGNATION	QTE	F
	ESI=I10A	INTER. APPARENT 10A UNIPOLAIRE	1	G
	DJD=D100	BOITE DE DERIVATION	4	G
	EEN=RS40	REGLETTE NUE 1x40W 220V	23	G
	EEN=TS36A	TUBE FLUO DE 36W	23	
	ESP=P10A	BOUTON POUSSOIR APPARENT 10A	1	G
	EES=ANA18	LUMINAIRE B.P. SODIUM 18W	6	G
	EES=LNA18	LAMPE B.P. Na 18W 220V BY22	6	
	EJF=DF	BTE DE DERIVATION METAL. POUR ECL. BALISAGE + FUSIBLE 250 mA	6	G

Souterrain / Underground
RE38
ECLAIRAGE
LIGHTING

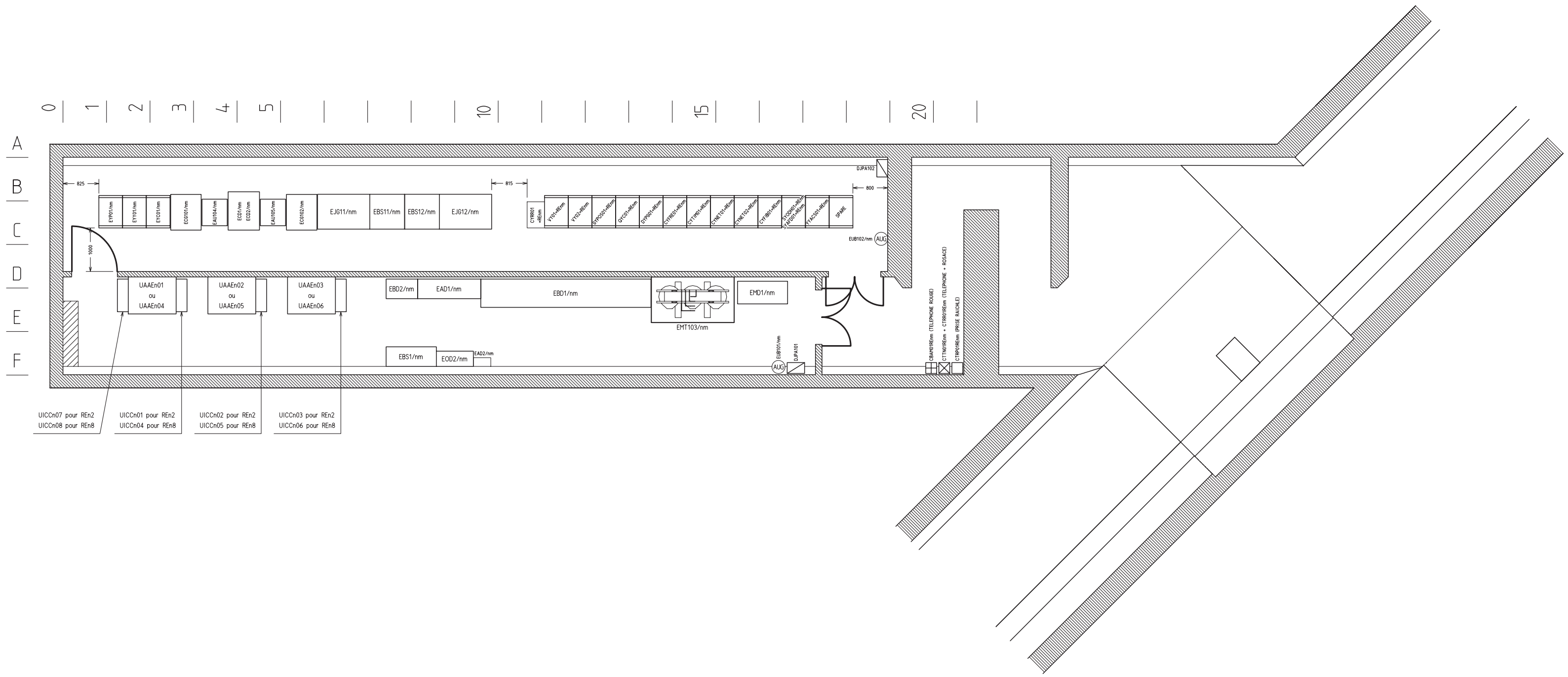
ECHELLE SCALE 1:50

DES/DRA. BOUVARD N. 2003-06-19
CONTROLLED
RELEASED
APPROVED
77LHC\EBL3005.dwg
REMPLACE/REPLACES LEP672EL3838

NON VALABLE POUR EXECUTION
NOT VALID FOR EXECUTION

QAC –
LHCEBL__3005
SIZE 1
IND.

IND.	DATE	NOM/NAME	ZONE	MODIFICATION



IND.	DATE	NOM/NAME	ZONE	MODIFICATION
C	2003-02-21	P. ORLANDI		APPELLATION RACKS INCENDIE ET MANQUE O2
B	2002-12-03	P. ORLANDI		DEPLACEMENT ET DIMENSIONS DU RACK CYRR01=REnm
A	2002-06-12	P. ORLANDI		RACK CYCOM01 DEVIENT CYRR01

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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
GENEVE
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EQUIPMENT LAYOUT IN BUILDINGS AND STRUCTURES

EQUIPMENTS LAYOUT
ELECTRICAL ALVEOLE RE
IMPLANTATION DES EQUIPEMENTS
ALVEOLE ELECTRIQUE RE

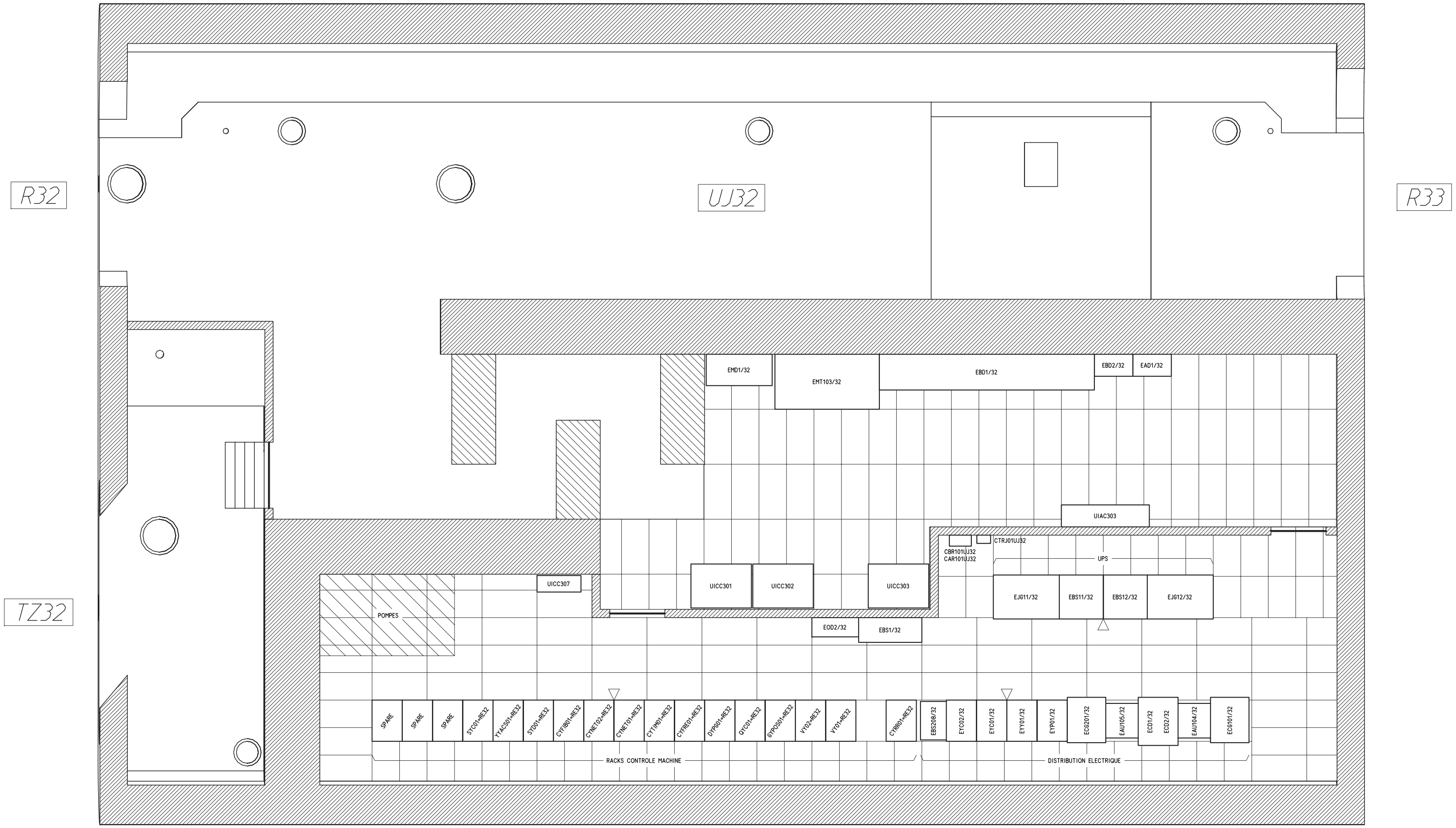
ECHELLE SCALE 1/50

DES/DRA.	P. ORLANDI	2001-07-10
CONTROLLED		
RELEASED		
APPROVED		

LHCE,LHC_ETUDE,E010,LHCEY0009

REMPLACE/REPLACES

QAC A | LHCEY___0009 | SIZE 1 | IND. C



GENERAL TOLERANCES GENERALES	DIMENSION	<=6	> 6	> 30	> 120	> 315	> 1000	> 2000
	USINAGE MOYEN/MEDIUM MACHINING	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2.
	MECANO.SOUDE/WELDED STRUCTURE	± 0.5	± 1	± 2.	± 3.	± 5.	± 7.	± 10.

DESSIN, RUGOSITE, TOLERANCES SELON NORME ISO
DRAWING, RUGOSITY, TOLERANCES ACCORDING TO ISO STANDARD

PROJECTION

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IND.	DATE	NOM/NAME	ZONE	MODIFICATION
A	2002-06-28	M. DUPERIER		SUPPRESSION DE L'EQUIPEMENT CYDCRE32

EQUIPMENT LAYOUT IN BUILDINGS AND STRUCTURES

EQUIPMENTS LAYOUT UJ32
IMPLANTATION DES EQUIPEMENT UJ32

ECHELLE SCALE 1:50

DES/DRA.	P.ORLANDI	2002-04-16
CONTROLLED	M.DUJARDIN	2002-08-07
RELEASED	A.FERON	2002-10-04
APPROVED	A.FERON	2002-10-09

LHCE,PT3_EQUIP,E013,LHCEY3002

REMPLACE/REPLACES

RELEASED BY PROJECT LEADER OFFICE

FOR INFORMATION

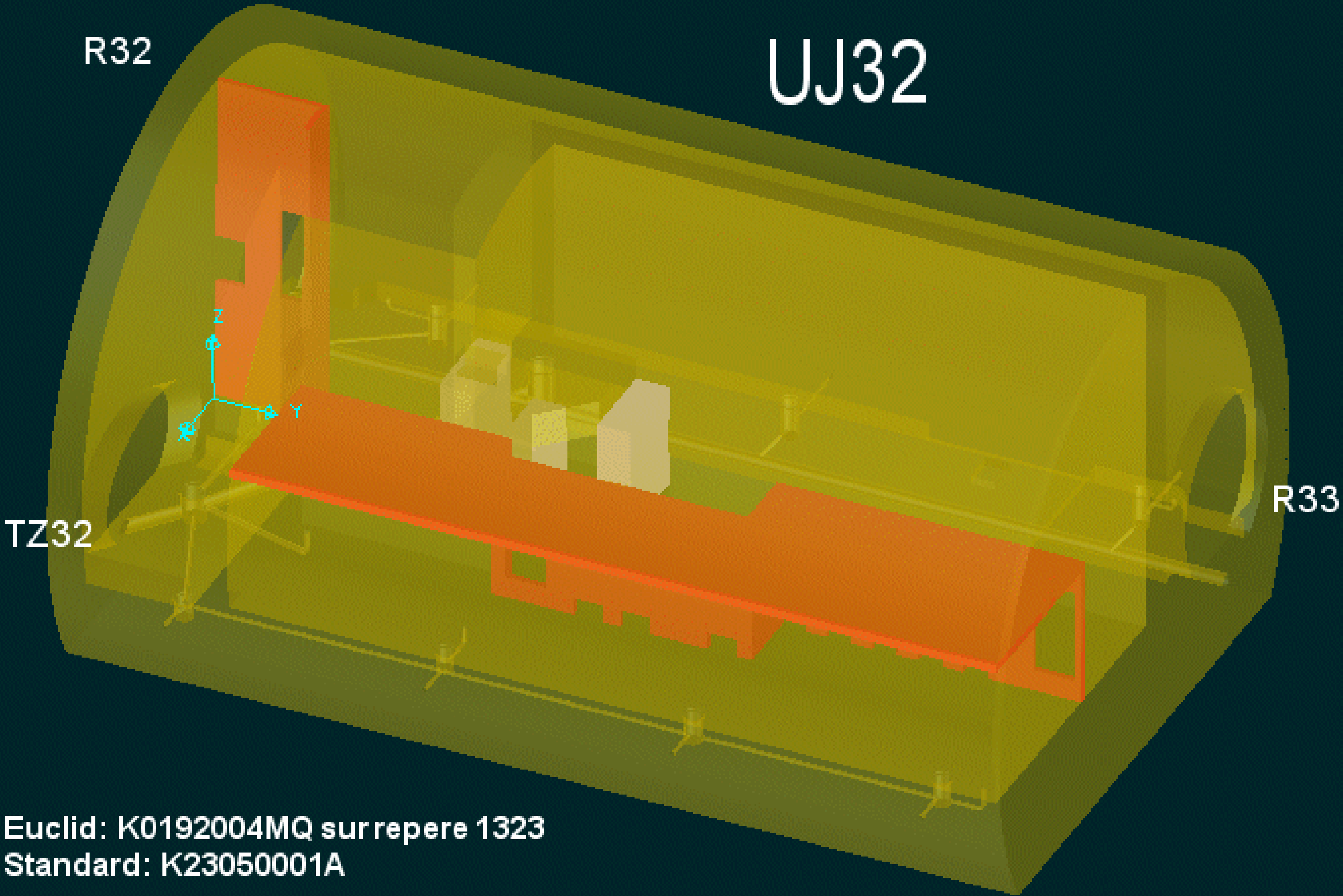
QAC A

LHCEY___3002

SIZE 2

IND. A

UJ32



Euclid: K0192004MQ sur repere 1323
Standard: K23050001A

UJ32 - Ajout saferoom + mur + chicane - A.Kosmicki - 21 Mars 2003

Radiation sources (I)

- Point losses
  - loss distribution around the ring have local maxima
    - high luminosity interaction points IP1 and IP5
    - collimation insertion regions IR3 and IR7.
  - contributions from off-momentum protons created IP1 and IP5
    - calculations have shown negligible contributions
      - IP1 (RE38): neglect beyond QF19 in the adjacent arcs (Arc12, Arc81)
      - IP5 (UJ32): neglect beyond QF19 in the adjacent arcs (Arc45, Arc56)
  - contribution from off-momentum protons created in IR3
    - Estimates by Baischev show the downstream proton losses are concentrated in the chain of Dispersion Suppressor (DS) magnets B8B-Q8-B9A.
  - to good approximation we can neglect point losses

Radiation sources (II)

- Beam-gas interactions
  - number of beam-gas interactions
    - depends on molecular composition of the gas
    - limiting value deduced from max heat load to cryo magnets
    - alternatively estimated from operational scenarios.
  - historically assumed value $1.65\times10^{11}\ m^{-1}y^{-1}$ [Potter 95]
    - used previously to compute dose levels in the ARCs
    - derived from limit on cryogenic heating by hadronic showers
    - assumes 250 hour beam-gas lifetime limit
  - this study adopts historical value in absence of better estimate
    - enables easy comparison to earlier work
  - an important input is 10 years old

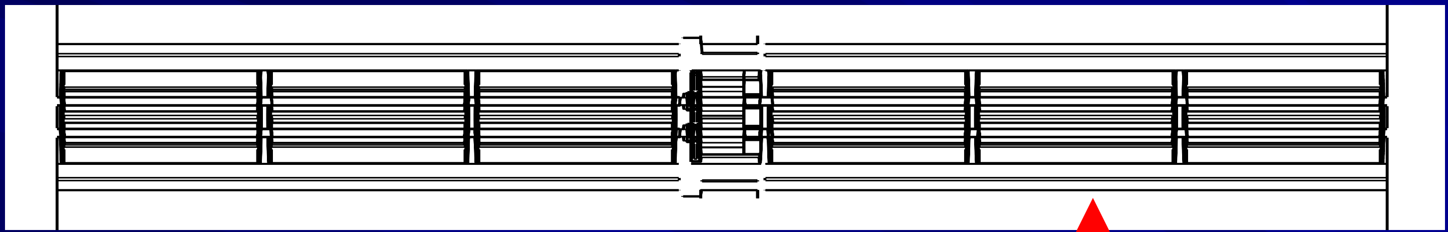
Monte-Carlo Method

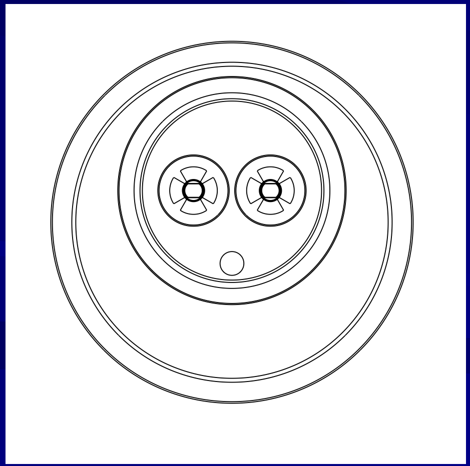
- 7 TeV proton interactions
  - isotropic distribution along each beam line
  - Interactions forced with carbon nuclei (dominate cross-section for beam-gas)
- Radiation scoring
  - radiation (dose, hadron fluence, 1 MeV n^0) in a scoring bin is given by the sum of all contributions scored in that bin arising from each interactions.
  - data is normalised to give the levels per interacting proton.
- Weighting
  - data per interacting proton are weighted by the beam-gas interaction rate
- Conversions
  - total energy deposition (GeV/cm^3) is converted to dose (1 Gy = 1 J/Kg)
    - at run-time using fluka material densities
  - fluence converted to 1MeV n^0 equiv. on a particle-by-particle basis
    - interpolating between the values of NIEL curve data.
  - hadron fluence converted to 20 MeV by applying scoring threshold

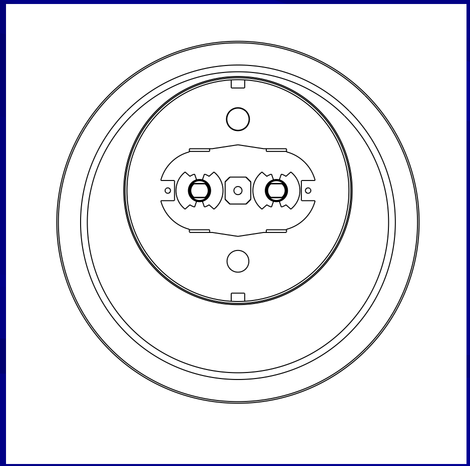
Arc geometry

Optics v6.2

- Arcs unchanged in upgrades
- No effect on results expected







RE38
942.95 m from IP3

Error sources

- Physics model
  - uncertainty in the inelastic *pp* cross section at 7 TeV
  - uncertainty in the energy flow and multiplicity as a function of rapidity
  - these effects have been studied by comparing event generators
    - a factor 1.3 was observed [Huh95]
- Geometrical errors
  - a factor 2 for geometry description and material composition is customary.
- Radiation environment
  - [Huhtinen 00] has approached this problem by comparing the results of FLUKA and MARS codes in a simple, well defined geometry.
    - this test will not be affected by experimental errors
    - since the two codes are independent they should not contain the same errors.
    - almost perfect agreement for energy-integrated neutron fluxes and for energy deposition
    - good agreement in the charged hadron spectra
    - this error can be neglected.
- results presented here have a factor 2 cumulated error

Results::RE38

refer to scorings.ppt

Summary

- RE38 and UJ32
  - beam-gas interactions are predominant radiation source
  - historical beam-gas interaction rate used
- RE38
  - two geometries were considered
    - baseline layout corresponding to the completed civil works
    - shielded layout that including a standard shielding configuration
  - shielding will reduce the radiation levels by an order of magnitude
    - the annual dose reduces from 3×10^{-2} Gy y^{-1} to 1×10^{-3} Gy y^{-1}
    - the 20 MeV hadron fluence reduces from 1×10^{8} $cm^{-2}y^{-1}$ to 1×10^{7} $cm^{-2}y^{-1}$
    - the 1 MeV neutrons equivalent fluence reduces from 5×10^{8} $cm^{-2}y^{-1}$ to 5×10^{7} $cm^{-2}y^{-1}$
  - electronic equipment is not rad hard by design - shielding construction is recommended
- UJ32
  - existing wall provides a reduction of the radiation levels
    - reduction approaching a factor 100 is obtained for total ionizing dose- dose will be below 0.01 Gy/y
    - 20 MeV hadrons fluence expected to range from 10^{8} hadrons $cm^{-1}y^{-1}$ to 10^{7} hadrons $cm^{-1}y^{-1}$
    - 1 MeV n^{0} equivalent fluence expected to range from 10^{9} neutrons $cm^{-2}y^{-1}$ to 10^{8} neutrons $cm^{-2}y^{-1}$
  - dose is not an issue and electronics are expected to operate within specification
  - energetic neutrons may be a problem for the power distribution racks close to the beam
    - The neutron flux monitoring equipment that will be installed at the chicane entry, will help to make this issue more precise.