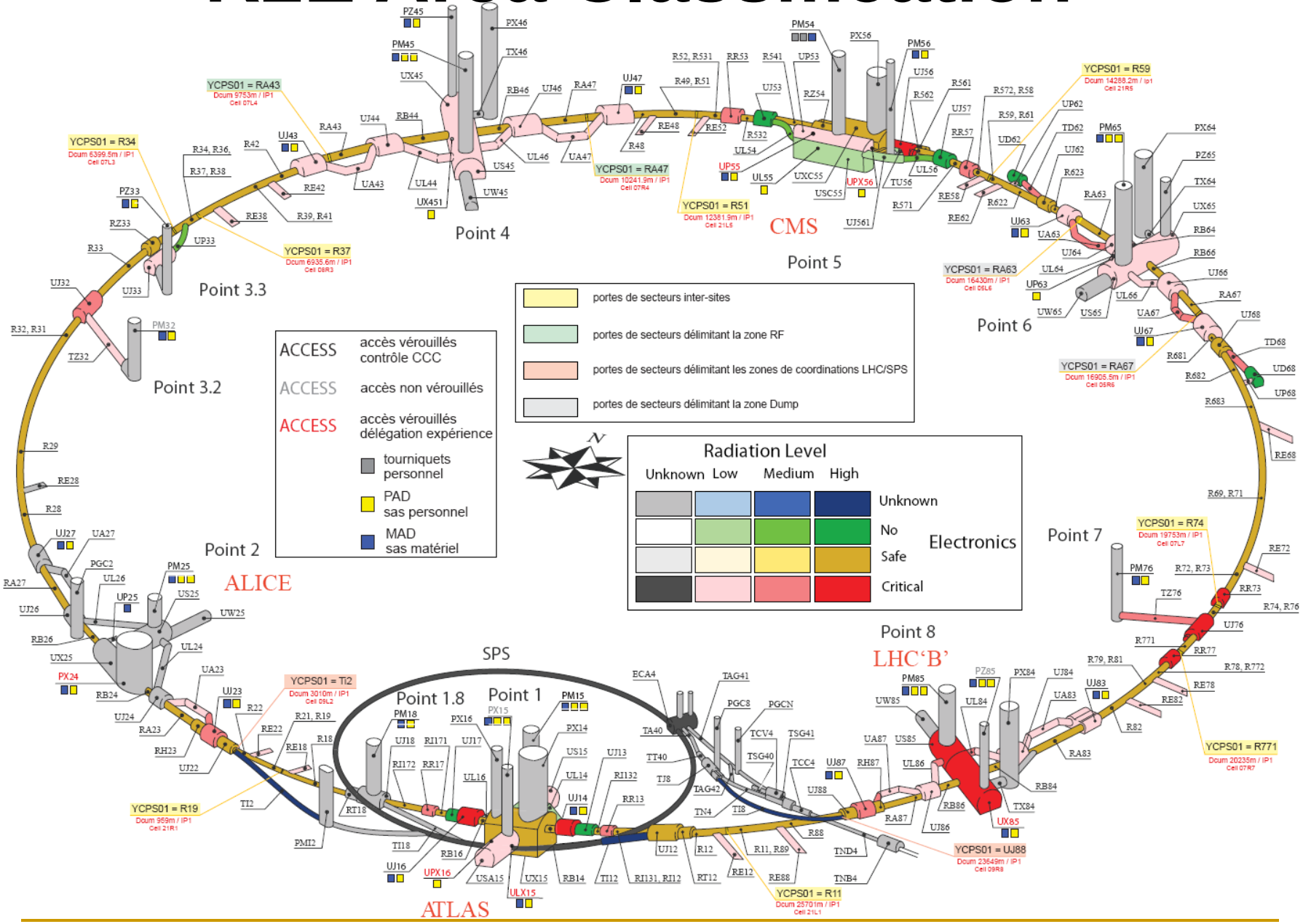
Simulated Radiation Levels in IR1 and IR5

RadWG Meeting, July 3rd 2009

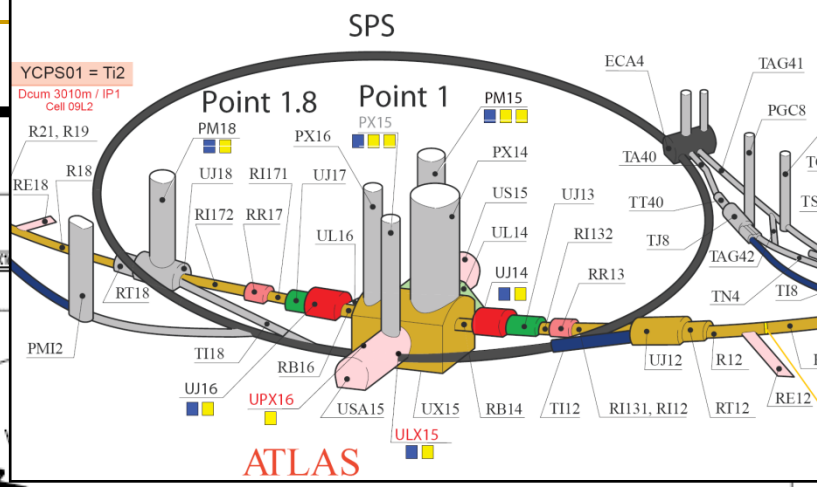
M. Brugger for the R2E Study Group

Calculations performed by the FLUKA-Team,
in particular A. Mereghetti & F. Cerutti

R2E Area Classification

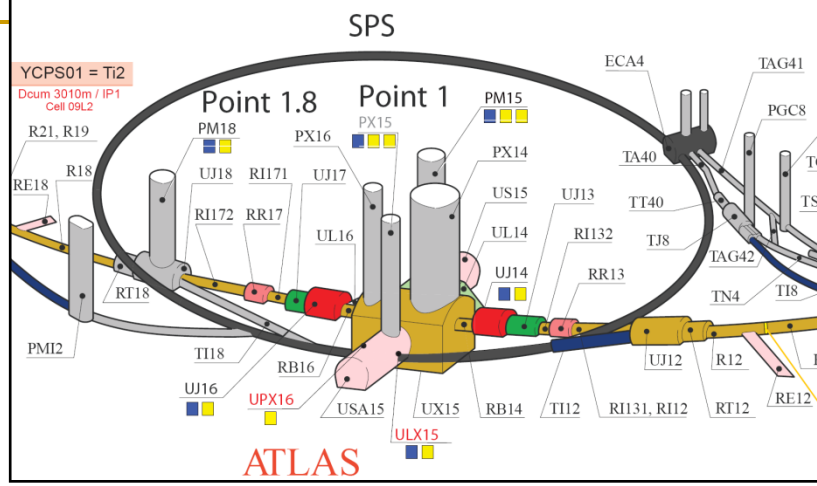


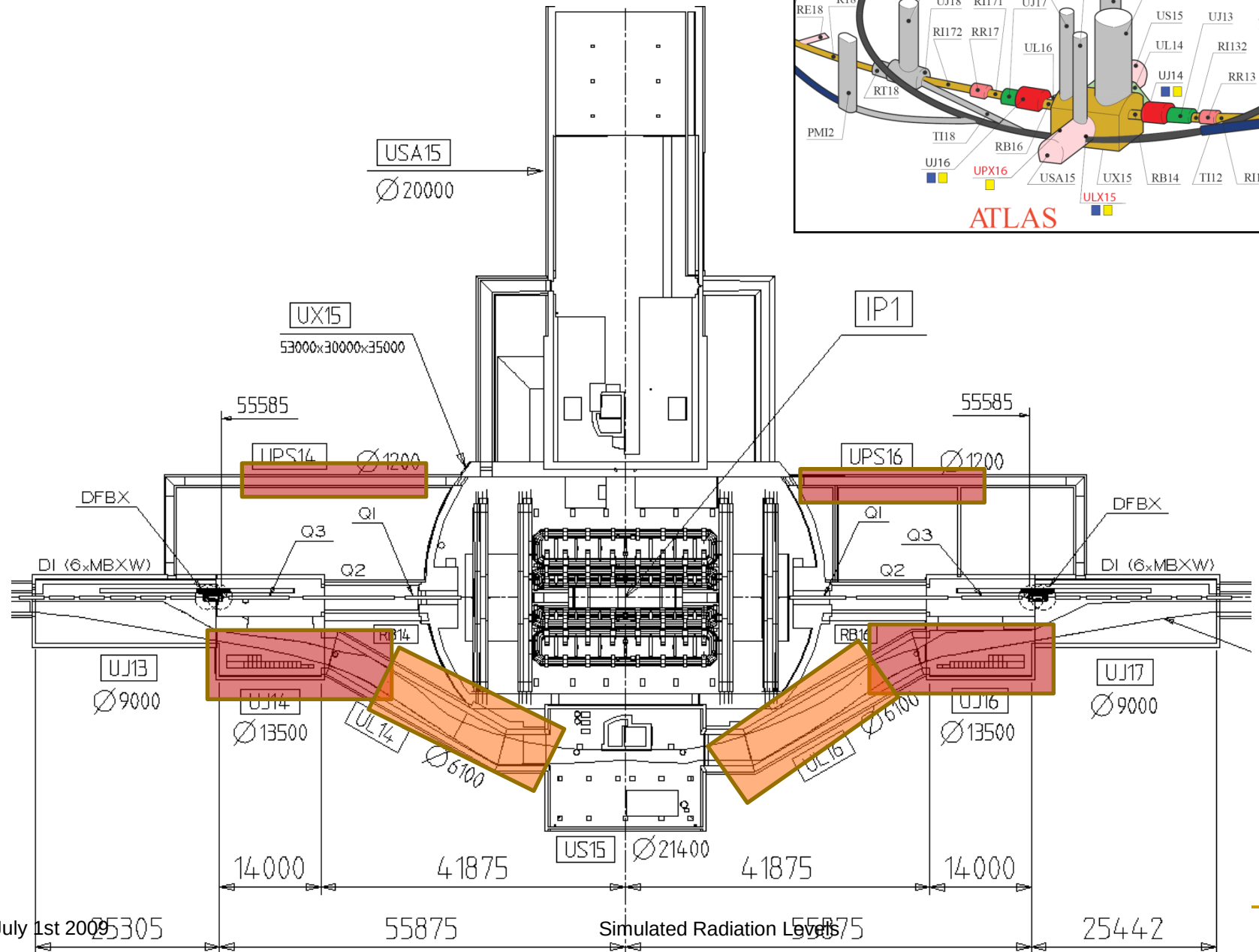
Point 1


SPS
YCPS01 = Ti2
Dcum 3010m / IP1
Cell 09L2
Point 1.8
Point 1
ATLAS

MAQUETTE GENIE CIVIL A JOUR EN J0012160MQ
MAQUETTE GENIE CIVIL COUPE EN J0012164MQ
MAQUETTE INTEGRATION EN J0012165MQ
MAQUETTE AIMANTS GAUCHE EN J0012145MQ
MAQUETTE AIMANTS DROITE EN J0012144MQ
POINT 8
POINT 2
RR13
RR17
RI13
RI17
US15
UX15
USA15
UJ13
UJ14
UJ16
UJ17
PX14
PX15
PX16
PM15
DFBX
MBXW
EXPERIENCE ATLAS
POINT I – VUE DE DROITE
RR13
UPS14
UPS16
RR17
UJ14
UJ16

Point 1


SPS
YCPS01 = Ti2
Dcum 3010m / IP1
Cell 09L2
Point 1.8
Point 1
ECA4
TAG41
PGC8
PM15
PX15
PM18
PX16
PX14
R21, R19
R18
RE18
UJ18
RI171
UJ17
TA40
US15
UJ13
TT40
RI172
RR17
UL16
UL14
RI132
TJ8
TAG42
UJ14
RR13
RT18
TN4
TI8
PMI2
TI18
RB16
UJ12
R12
UJ16
UPX16
USA15
UX15
RB14
TI12
RI131, RI12
RT12
RE12
ULX15
ATLAS


USA15
∅20000
UX15
53000x30000x35000
IP1
55585
55585
UPS14
∅1200
UPS16
∅1200
DFBX
DFBX
Q1
Q3
Q2
Q1
Q3
Q2
DI (6xMBXW)
DI (6xMBXW)
RB14
RB16
UJ13
∅9000
UJ14
∅13500
UL14
∅6100
UL16
∅6100
UJ16
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US15
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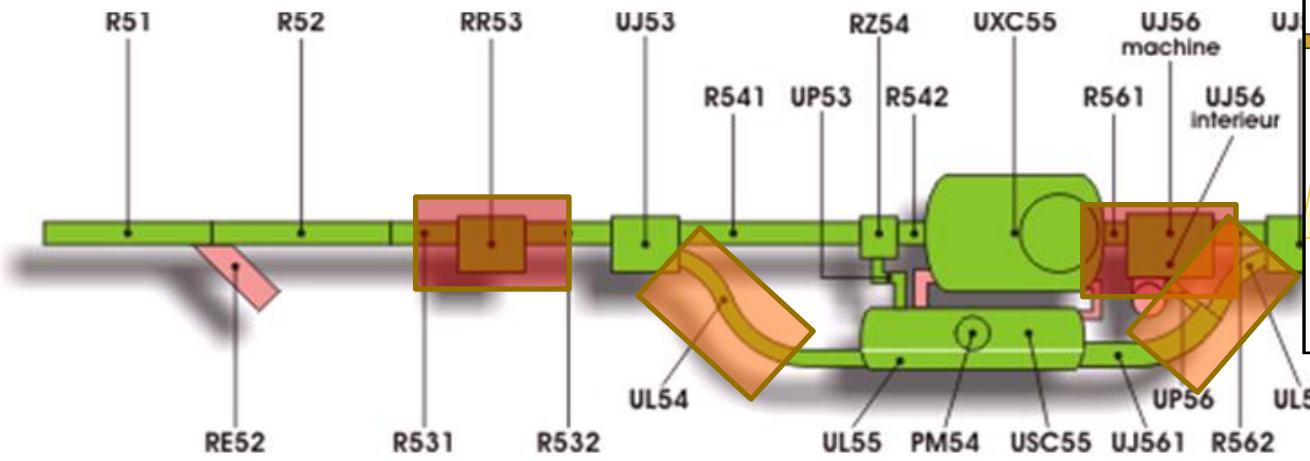
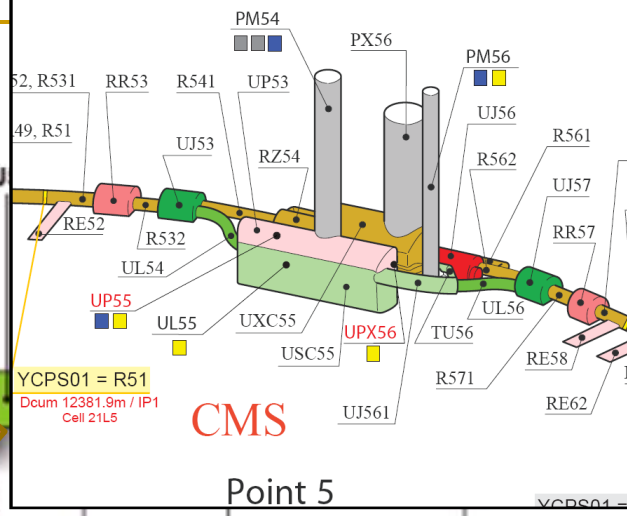
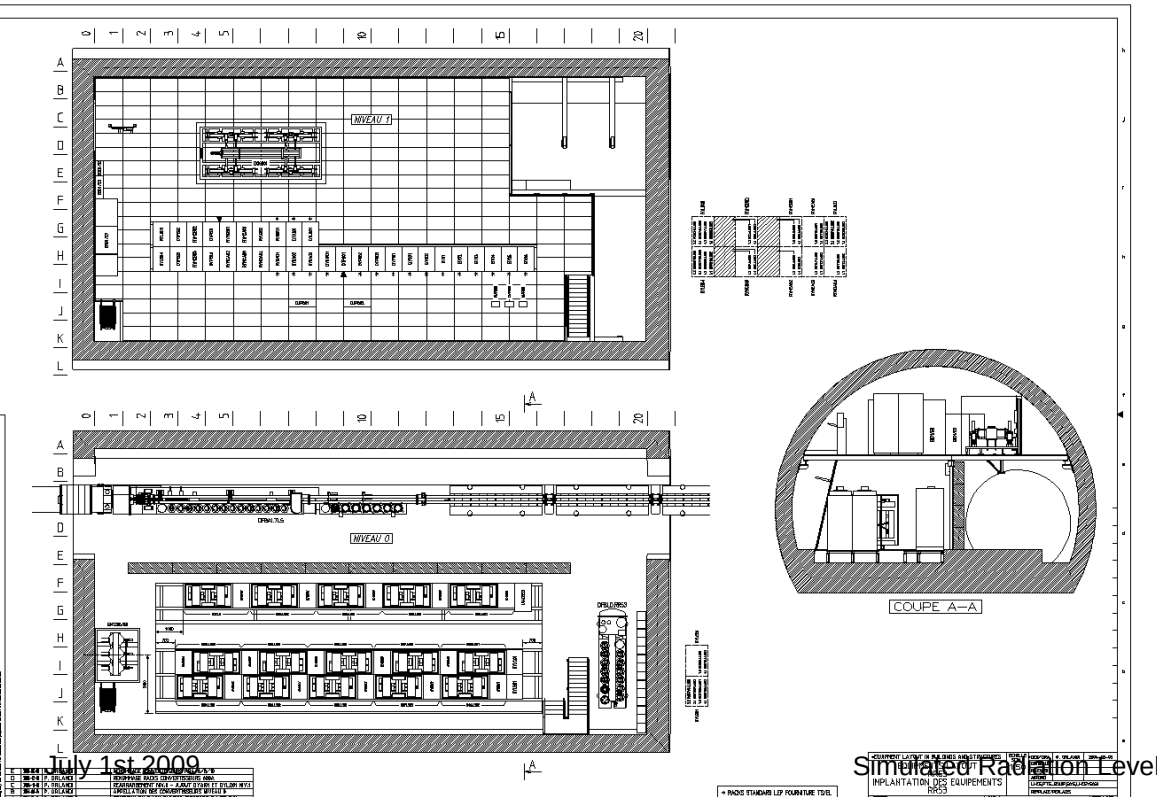
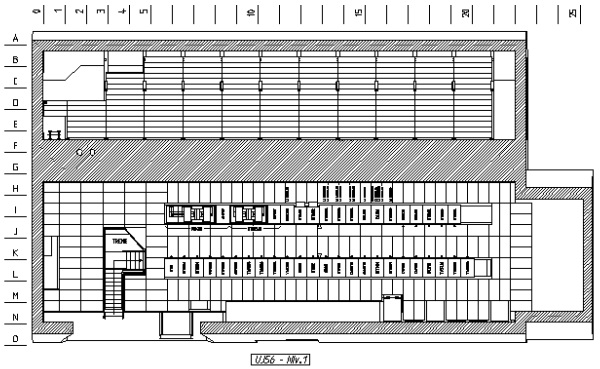
41875
14000
25305
55875
55875
25442

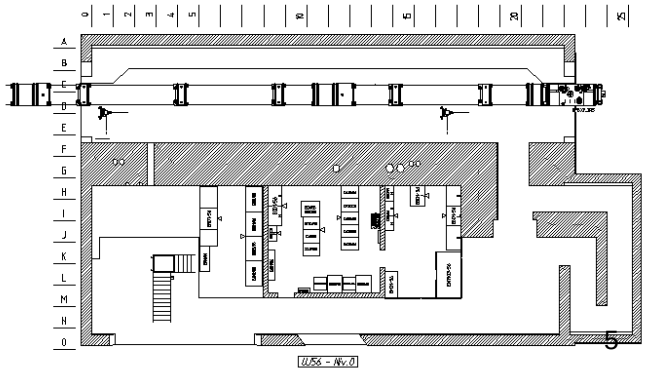
Point 5


R51
R52
RR53
UJ53
RZ54
UXC55
UJ56
machine
UJ
R541
UP53
R542
R561
UJ56
interieur
UL54
UP56
UL56
RE52
R531
R532
UL55
PM54
USC55
UJ561
R562
R571
R572
RE58


PM54
PX56
PM56
52, R531
RR53
R541
UP53
UJ56
49, R51
UJ53
RZ54
R561
R562
UJ57
RE52
R532
RR57
UL54
UP55
UL55
UXC55
UPX56
TU56
UL56
USC55
RE58
R571
YCPS01 = R51
Dcum 12381.9m / IP1
Cell 21L5
CMS
RE62
UJ561
Point 5


NIVEAU 1
NIVEAU 0
COUPE A–A
IMPLANTATION DES EQUIPEMENTS


UJ56 - NIv.1


UJ56 - NIv.0

Considered Scenarios & Scaling

Beam-Beam collisions

- Nominal:
  100 fb^{-1} (=10^7 s at L_0=10^{34} cm^{-2} s^{-1});
- 80 mb as pp inelastic cross section at 14 TeV centre-of-mass energy;

Beam-Gas interactions

- 10^{15} mol m^{-3} H_2-equivalent (rough threshold for cold quench)
- 76 mb as p-H_2 inelastic cross section at 7 TeV;
- 10^7 s y^{-1} operation;
- 3.63 10^{18} p s^{-1} nominal current (no intensity decay & duty factor!);

Scaling for 2009/10

- Luminosity:
  300 pb^{-1} (=a scaling factor of ~300)
- Beam-Gas:
  average intensity might reach a maximum of 1/10^{th} of nominal

Results in Colour Plots shown as Multiples of "Reference values"

- 10^6 cm^{-2} for HIGH ENERGY HADRON FLUENCE;
- 1 Gy for DOSE;
- 10^9 cm^{-2} for 1 MeV EQUIVALENT NEUTRON FLUENCE;

IR1 Beam-Beam Collisions - Nominal

High-Energy hadron fluence:
[units of 10^6 cm^{-2} per 100 fb^{-1}]

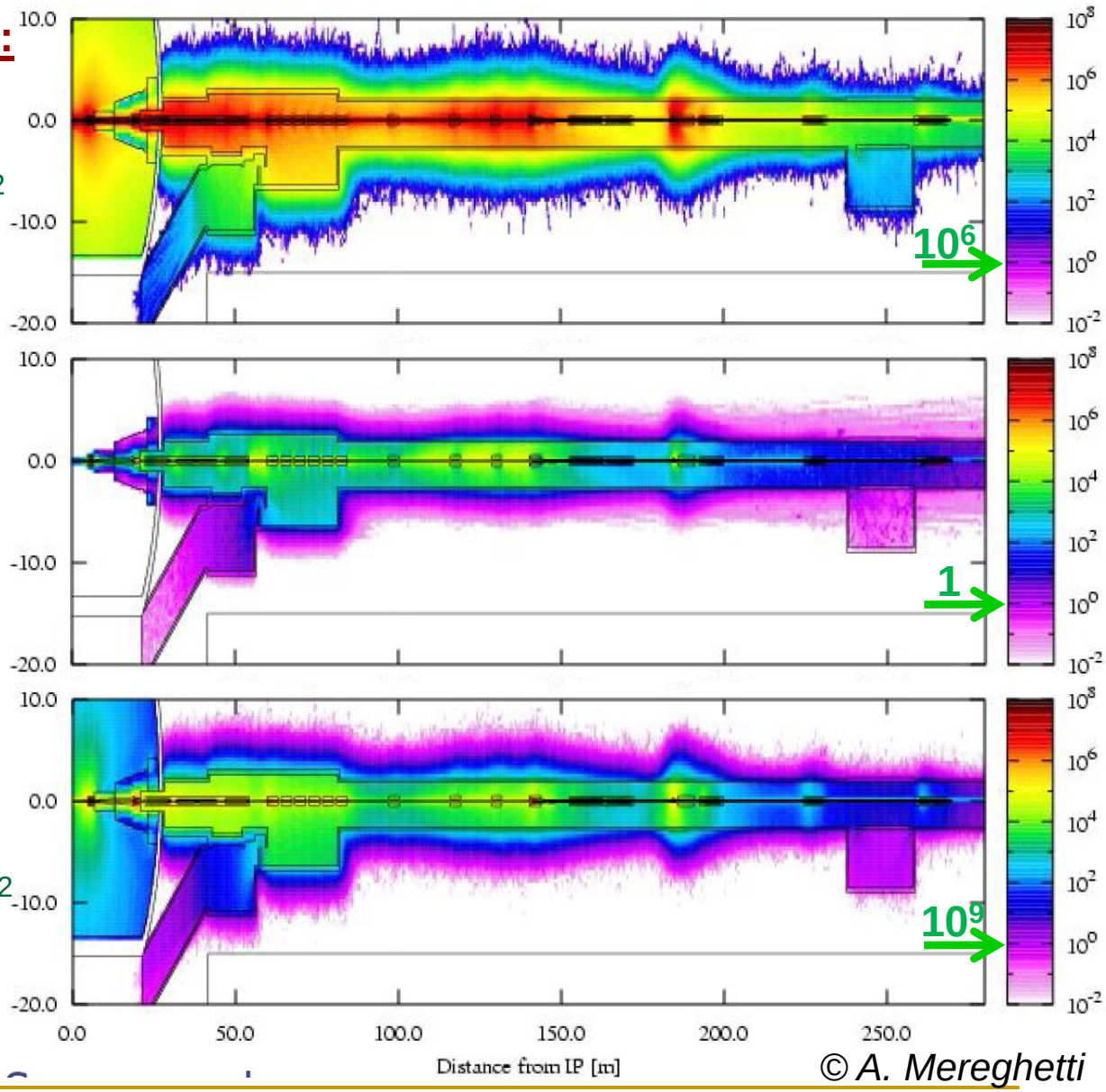
- UJ14/16: up to 10^9 - 10^{10} cm^{-2}
- RR13/17: up to 10^8 - 10^9 cm^{-2}

Dose:
[units of 1 Gy per 100 fb^{-1}]

- UJ14/16: up to 0.1 - 100 Gy
- RR13/17: up to 0.1 -1 Gy

1-MeV Neutron Equivalent:
[units of 10^9 cm^{-2} per 100 fb^{-1}]

- UJ14/16: up to 10^{10} -10^{11} cm^{-2}
- RR13/17: up to some 10^9



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IR1 Beam-Beam Collisions – 2009/10

High-Energy hadron fluence:
[units of 10^6 cm^{-2} per 300 pb^{-1}]

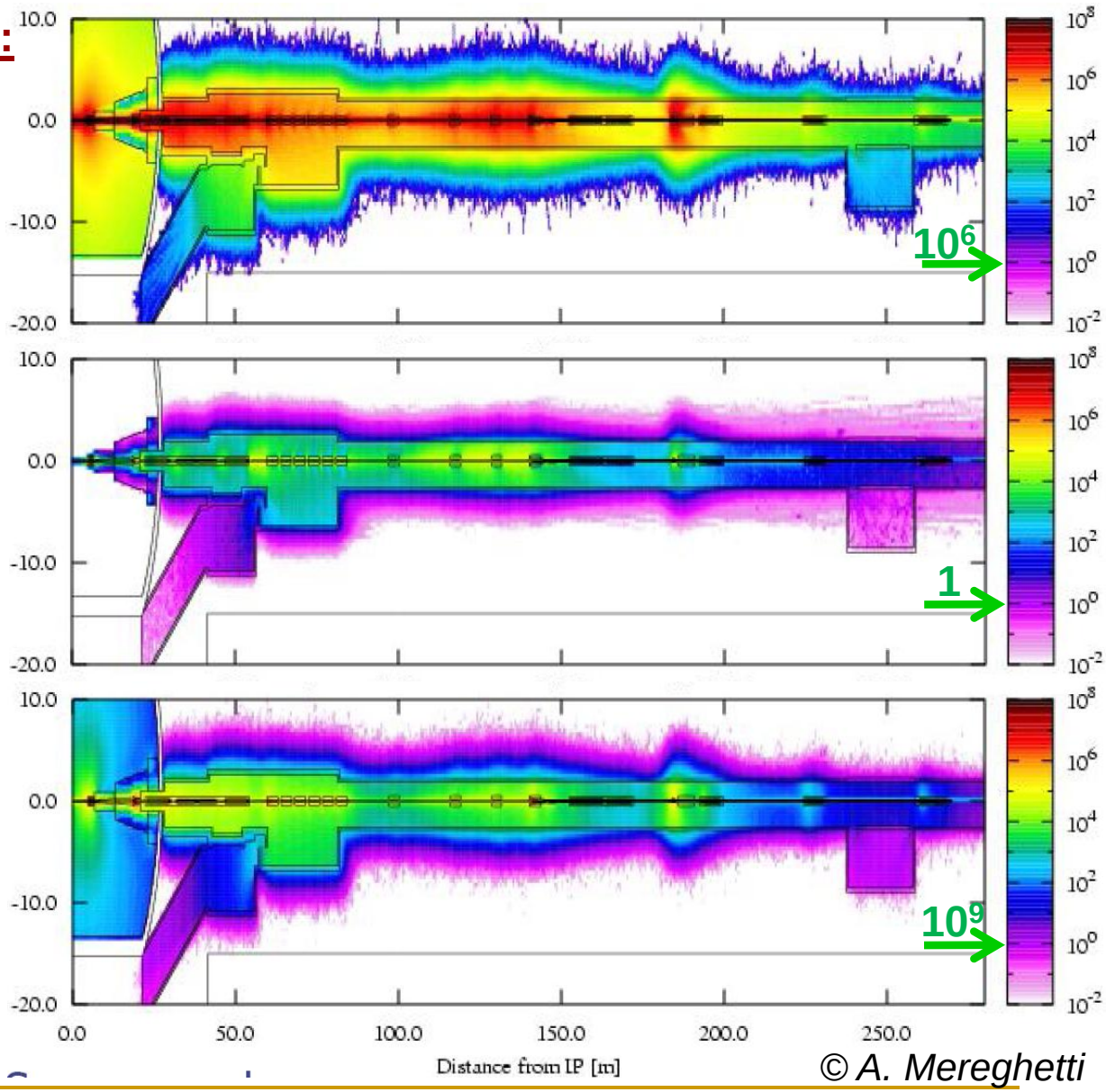
- UJ14/16: some 10^7 cm^{-2}
- RR13/17: some 10^6 cm^{-2}

Dose:
[units of 1 Gy per 300 pb^{-1}]

- UJ14/16: up to ~0.3 Gy
- RR13/17: up to some mGy

1-MeV Neutron Equivalent:
[units of 10^9 cm^{-2} per 300 pb^{-1}]

- UJ14/16: some 10^8 cm^{-2}
- RR13/17: some 10^6 cm^{-2}



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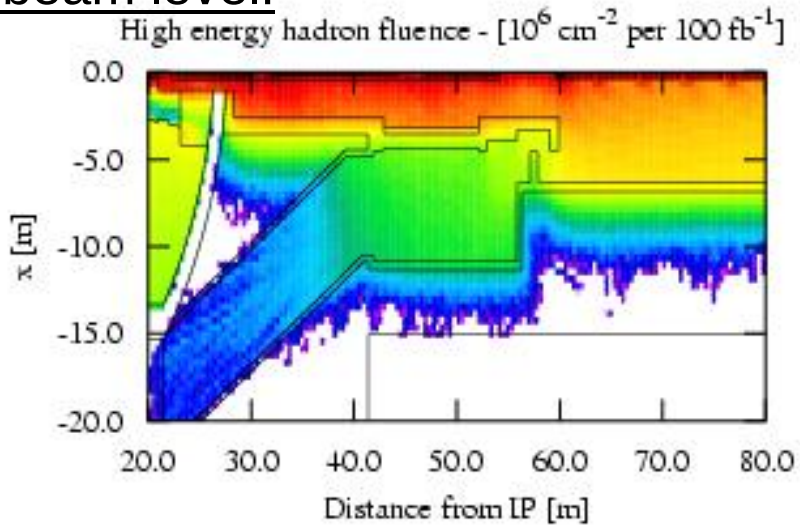
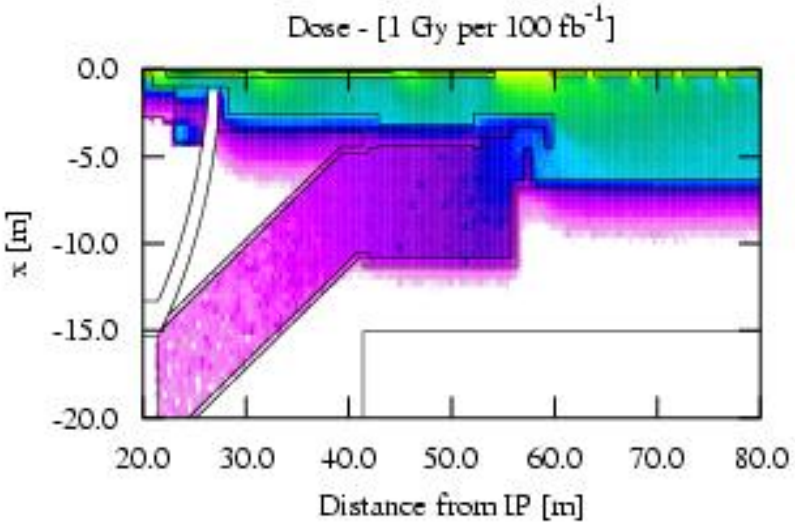
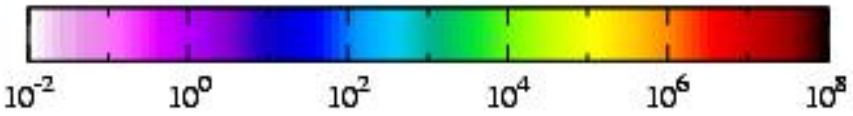
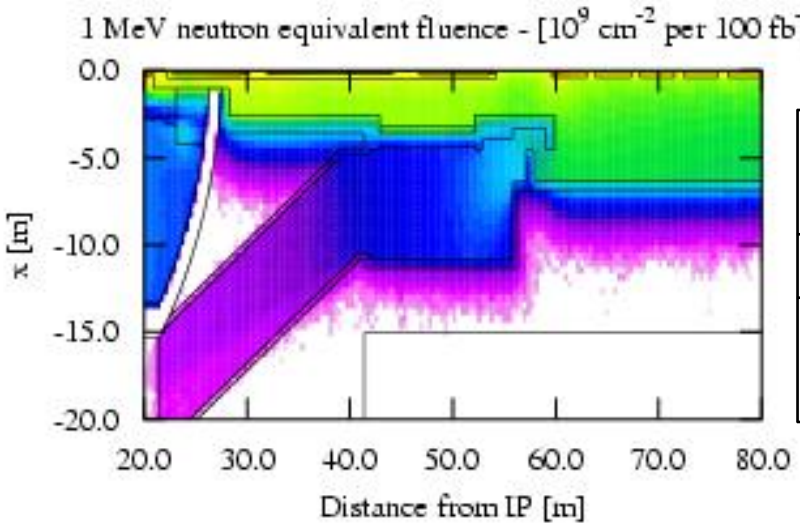
Beam-Beam – UJs and UL

at beam level:









High energy hadron fluence	**10^7 - 10^{10}**	cm^{-2} per 100 fb^{-1}
Dose	**0.1 - 100**	Gy per 100 fb^{-1}
1 MeV neutron equivalent	**10^8 - 10^{11}**	cm^{-2} per 100 fb^{-1}

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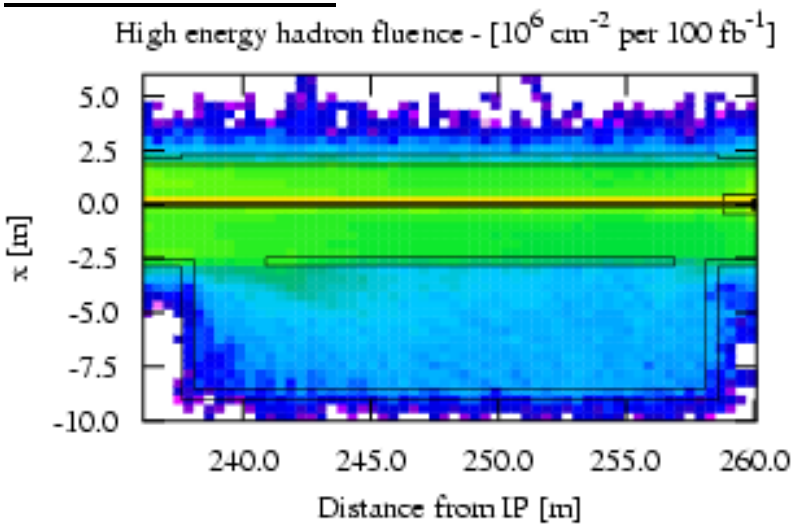
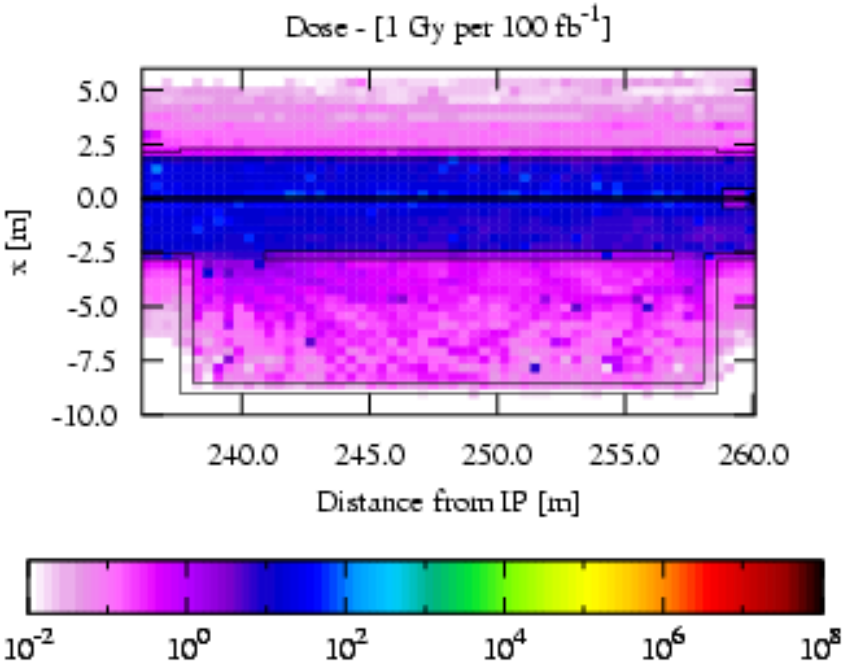
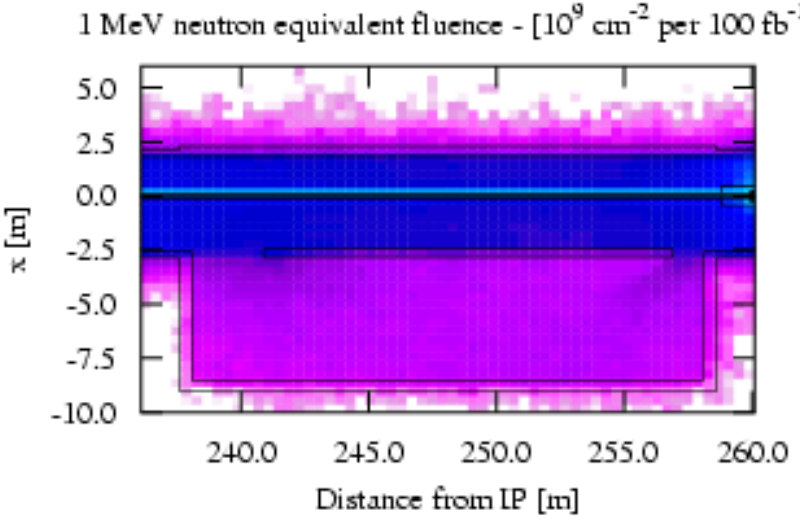
Beam-Beam – RR (I)

at beam level:







High energy hadron fluence	**10^8 – 10^9**	cm^{-2} per 100 fb^{-1}
Dose	**0.1 – 1**	Gy per 100 fb^{-1}
1 MeV neutron equivalent	**~ 10^9**	cm^{-2} per 100 fb^{-1}

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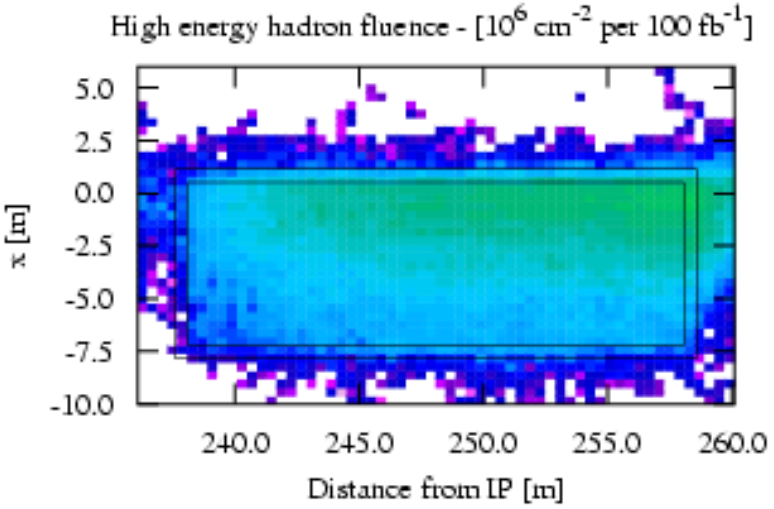
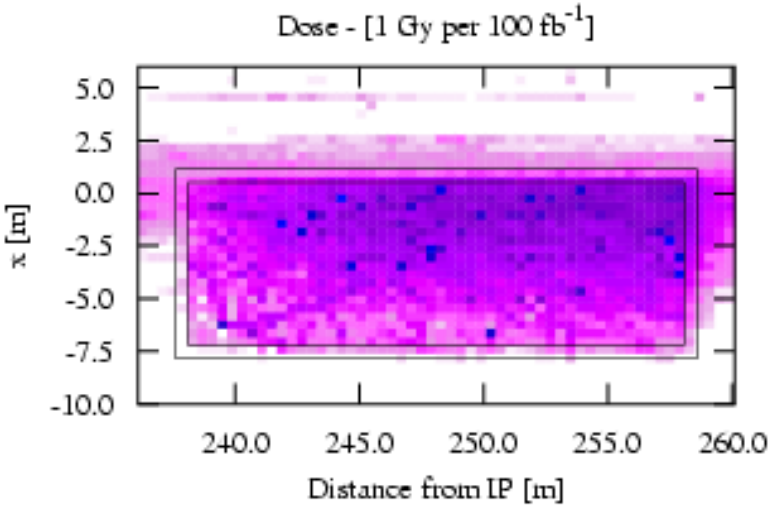
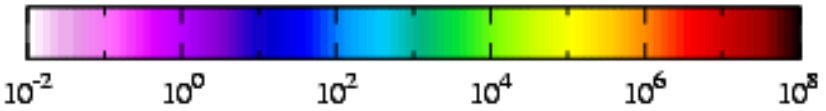
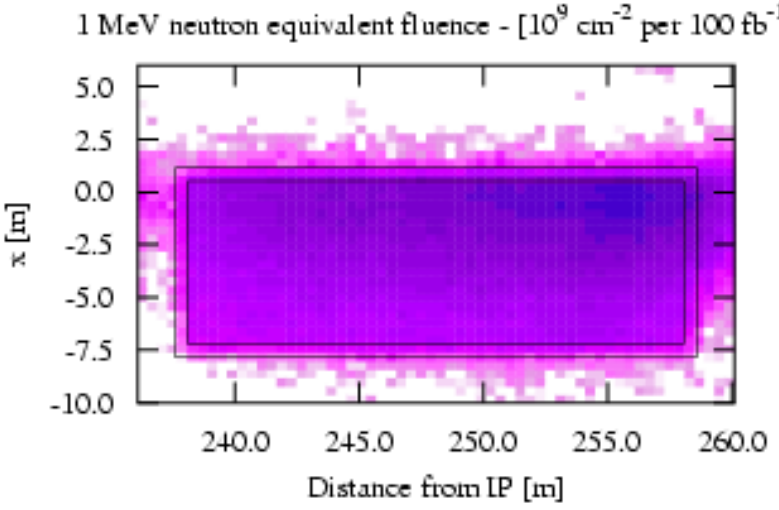
Beam-Beam – RR (II)

upper floor, at 1.5 m (4.0 m above beam)









A factor 2-3 higher!

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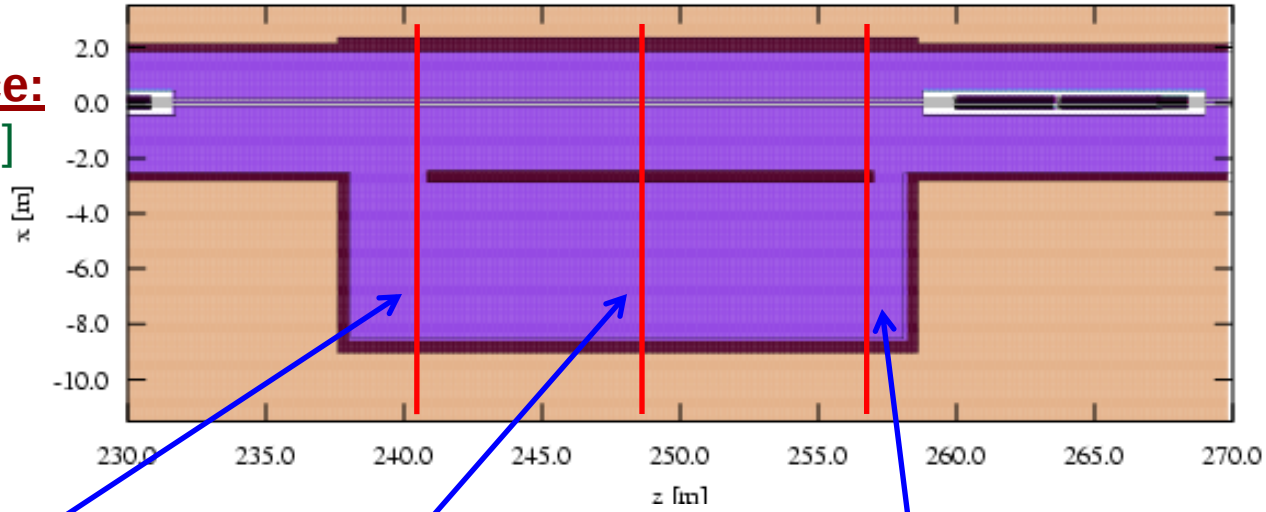
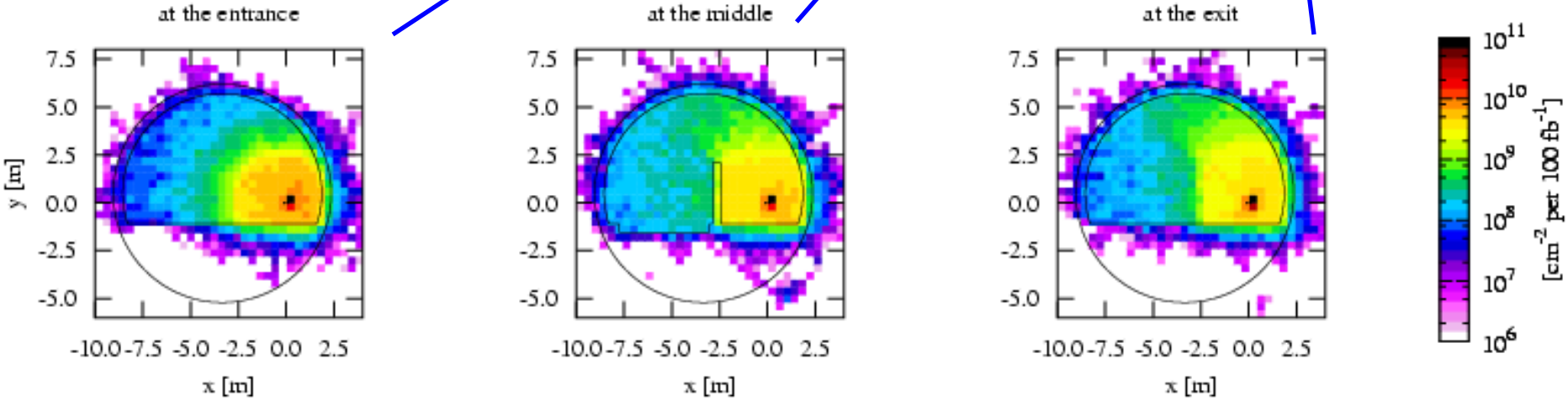
Beam-Beam – RR (III)

Transverse Cuts:

High-Energy hadron fluence:
[units of 10^6 cm^{-2} per 100 fb^{-1}]

- up to 10^8 - 10^9 cm^{-2}





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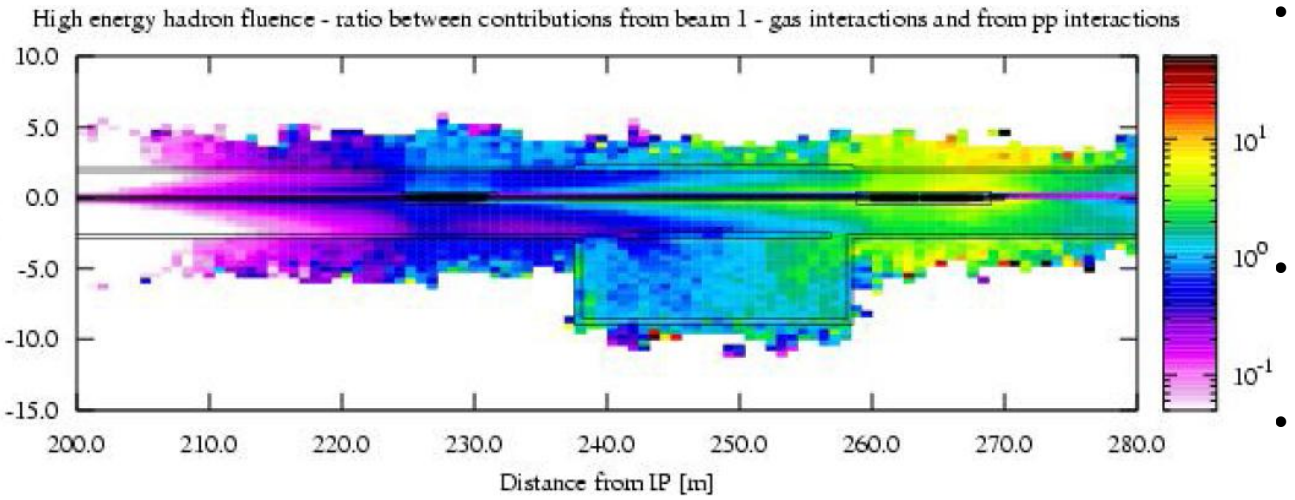
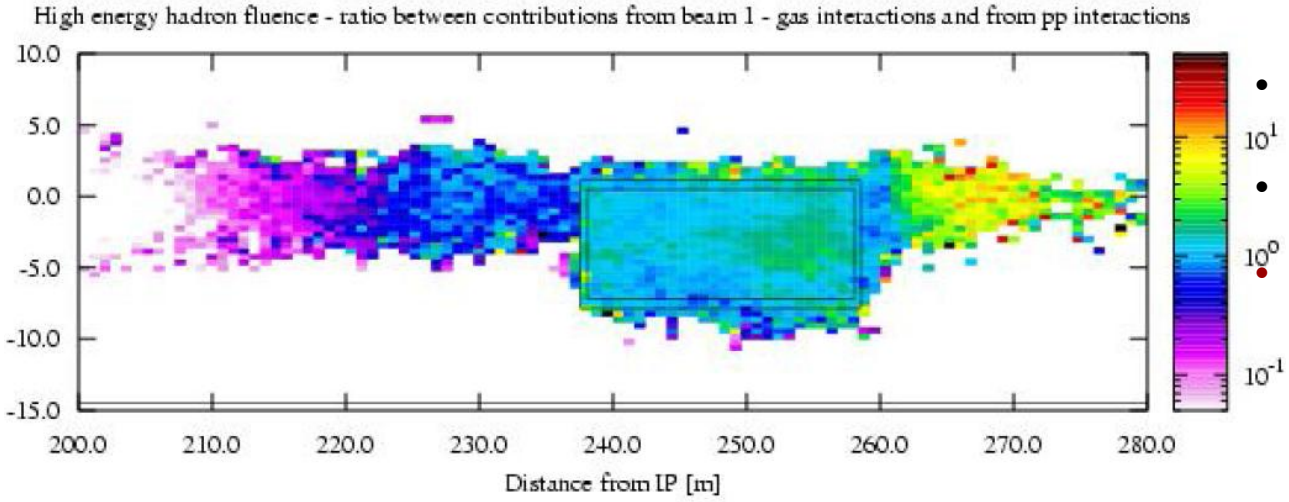
Beam-Gas – RR

Expressed as: Beam-Gas / Beam-Beam ratio

- beam level -



- upper floor, at 1.5 m (4.0 above beam) -



- Simulation with only beam 1 (coming from IP) interacting with the gas in the external pipe.
- Scoring only of High Energy Hadron Fluence.
- Contribution of the beam-gas interaction of the same order as beam-beam collisions:
  - beam level: 10^8 – 10^9
  - Upper floor: few 10^9

2009/10 Contribution will be dominated by beam-gas

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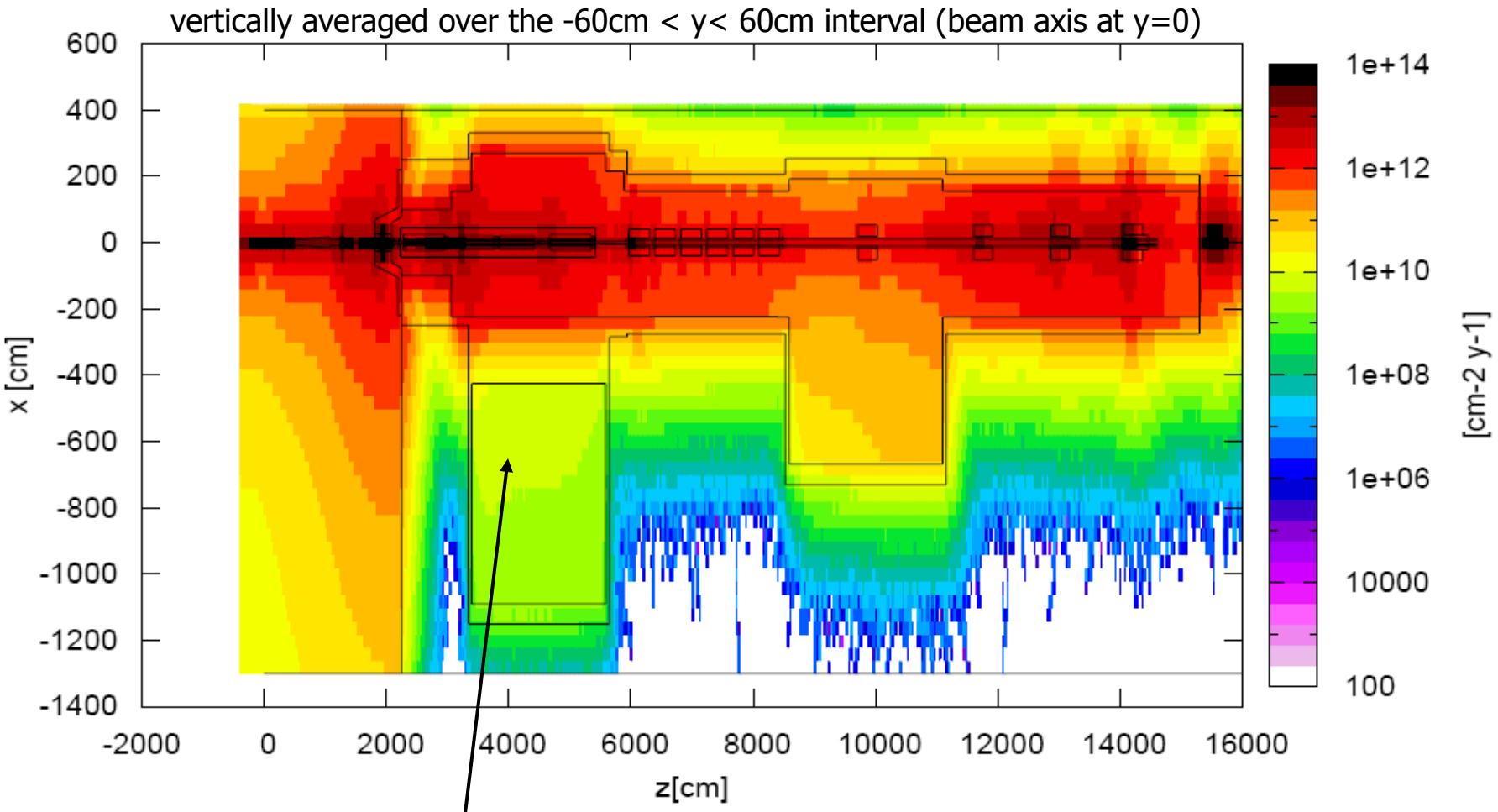
IR5 - High Energy Hadron Fluence

for a total luminosity of 100 fb^{-1} y^{-1} (*i.e.*, L=L$_0$ for 10^7 s/y)



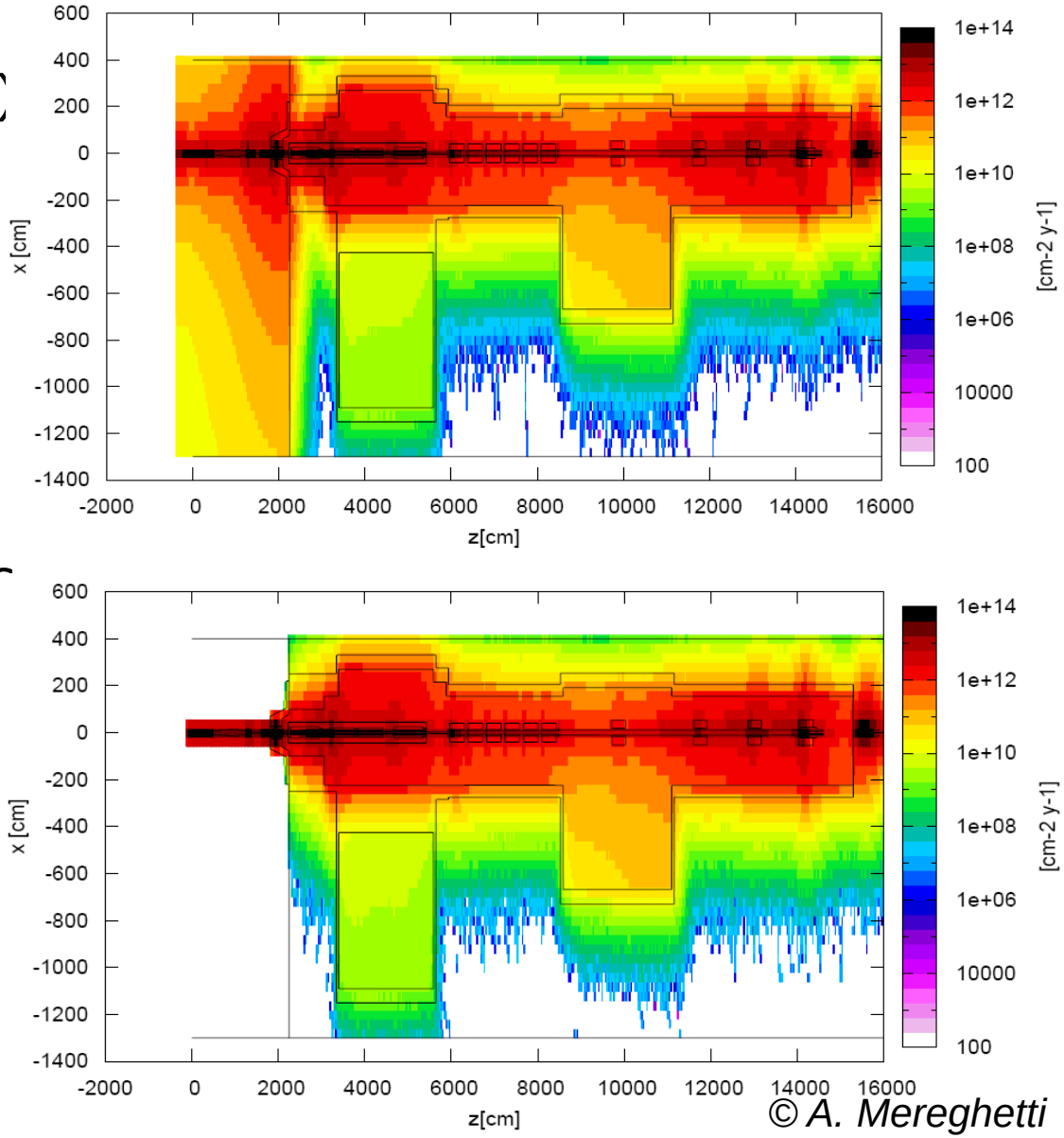
2009/10 (300pb^{-1}): after a 2m concrete shielding, the high energy hadron fluence at beam level ranges from 4x10^6 up to 4x10^7 cm^{-2} y^{-1}

xCheck for direct Contribution from CMS?

- 1st case: assuming CMS cavern empty (no detector) and walls set to concrete, thus very conservative assumption

- 2nd case: as above, but assuming CMS cavern walls as totally absorbing

- **high energy hadrons in UJ come from interactions between TAS and D1 (Q2)**



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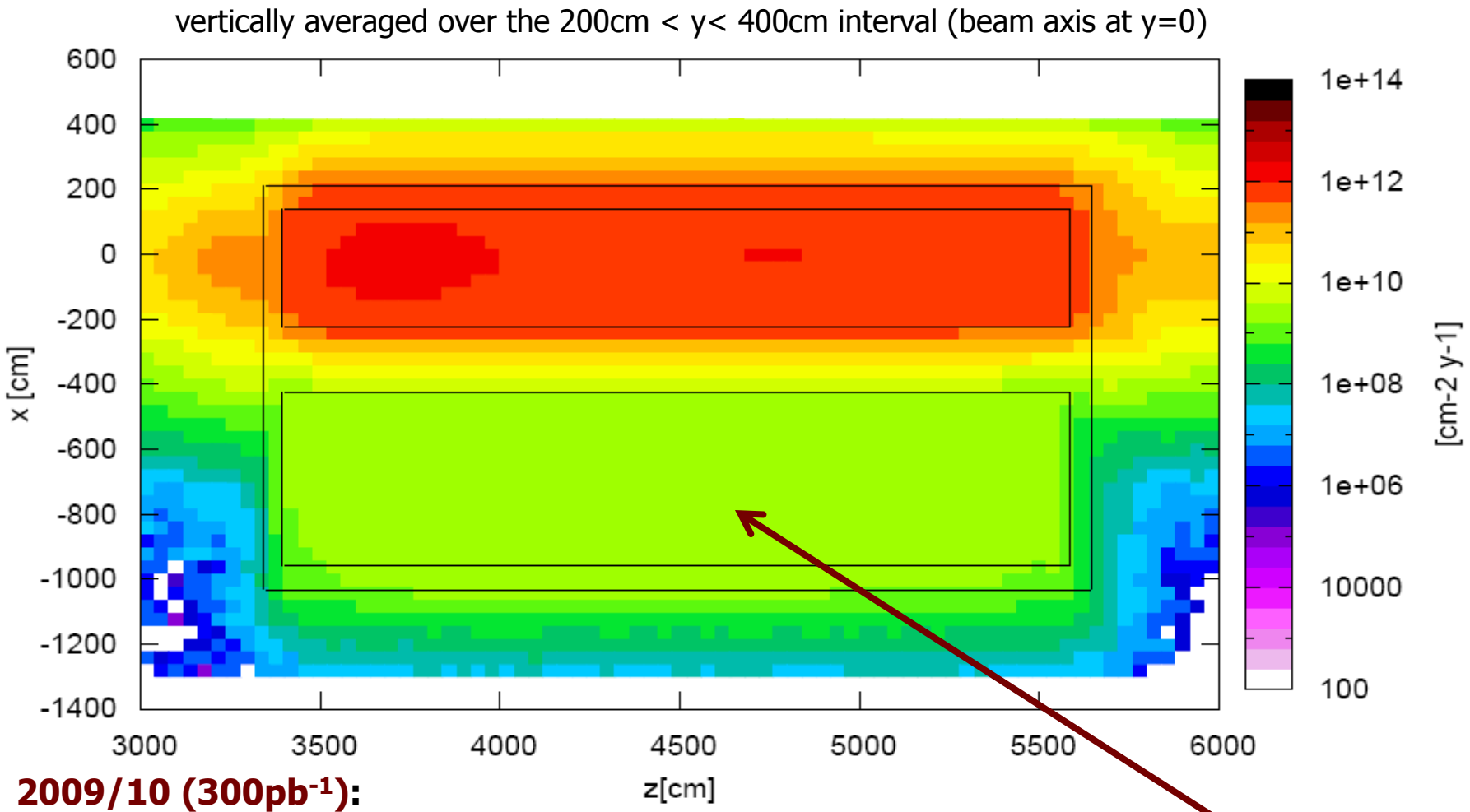
High Energy Hadron Fluence

for a total luminosity of 100 fb^{-1} y^{-1} (*i.e.*, $L=L_0$ for 10^7 s/y)

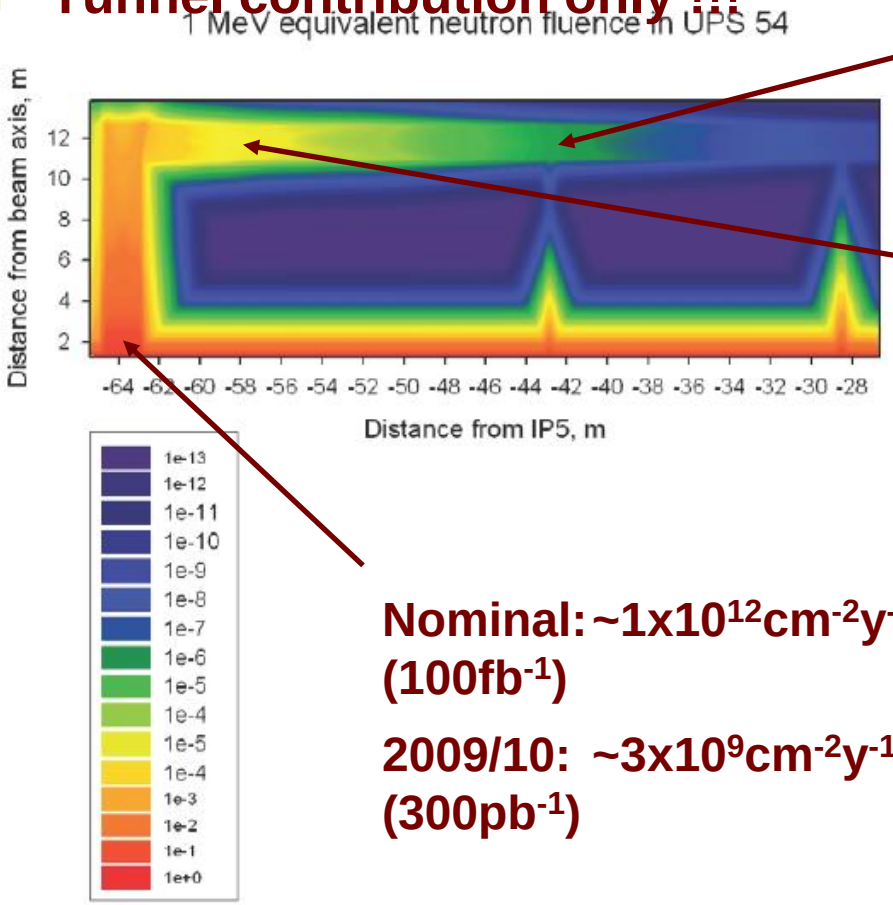


2009/10 (300pb^{-1}):

High energy hadron fluence in UJ56 (upstairs): 3.6x10^6-1.0x10^7 cm^{-2} y^{-1}

UPS Results based on Published Data

- Valid for UPS14/16 and UPS54/56
- applying streaming and renormalisation based on FLUKA results (shown in **RED**)
- **Tunnel contribution only !!!**



Nominal: ~9×10^{7}cm^{-2}y^{-1} (100fb^{-1})

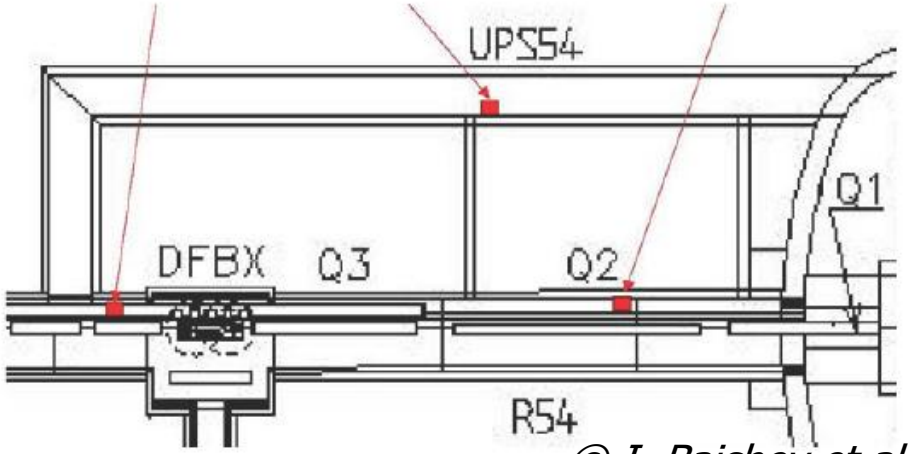
2009/10: ~3×10^{5}cm^{-2}y^{-1} (300pb^{-1})

Nominal: ~9×10^{9}cm^{-2}y^{-1} (100fb^{-1})

2009/10: ~3×10^{7}cm^{-2}y^{-1} (300pb^{-1})

Nominal: ~1×10^{12}cm^{-2}y^{-1} (100fb^{-1})

2009/10: ~3×10^{9}cm^{-2}y^{-1} (300pb^{-1})



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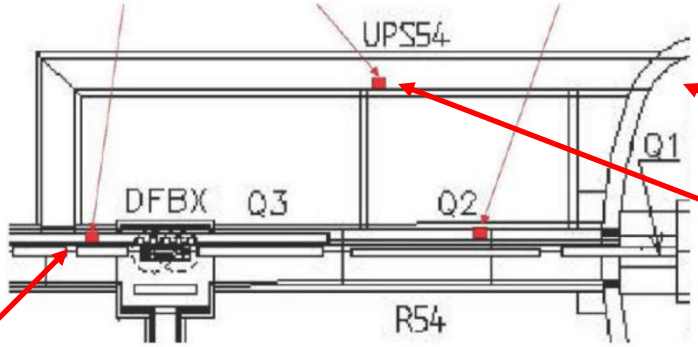
UPS54 & UL56

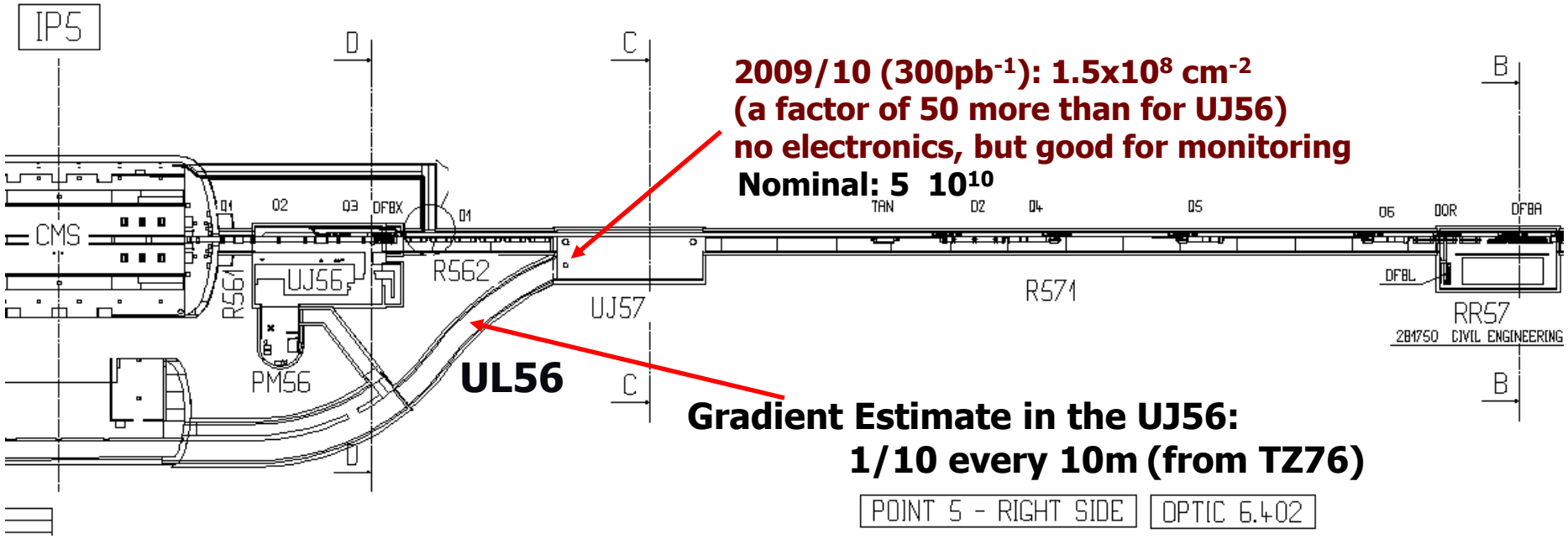


high energy hadron fluence [$cm^{-2}/100fb^{-1}$]

Nominal: 5 x 10^8 at the internal boundary of the detector (ATLAS!) cavern

Nominal: ~ 10^8 (rough estimate)

10^{12} at the internal boundary of the tunnel (present D1 IP side)



2009/10 (300pb^{-1}): 1.5x10^8 cm^{-2}
(a factor of 50 more than for UJ56)
no electronics, but good for monitoring
Nominal: 5 10^{10}

UL56

Gradient Estimate in the UJ56:
1/10 every 10m (from TZ76)

USA15 and US15

ATL-GEN-2005-001
S. Baranov et al.

8 μSv/h

5 μSv/h

but DOORS!

high energy hadron fluence

max ~10^7 cm^{-2}/100fb^{-1}
(conservative estimate)

Radiation Levels Summary

See also www.cern.ch/r2e

LHC Point	Area(s)	Radiation Levels						Priority
		20MeV [cm^{-2}/y]	1MeV [cm^{-2}/y]	Dose [Gy/y]	Normalisation	Scaling	Comments	
Point 1	UJ14 UJ16	1.E9-1.E10	1.E10-1.E11	5-100	100 fb-1	Luminosity	1st Shielding Studies performed	2
	RR13 RR17	1E8-5E9	1.E9-1.E10	0.1-1	100 fb-1	Luminosity Beam-gas	shielding as currently installed (full shielding as in ECR would reduce it by ~20-50)	2
	UPS14 UPS16	~1E8-1E9	~5E8-5E9		100 fb-1	Luminosity Beam-gas	direct contribution, estimate based on FLUKA calculations and gradient as from I. B.	3
	US15 USA15	1E6-1E7		0.001-0.02	100 fb-1	Luminosity	based on extrapolation and conversion coefficients	4
Point 5	UJ56	1.E9-1.E10	1.E10-1.E11	5-100	100 fb-1	Luminosity	1st Shielding Studues performed	2
	UPS54 UPS56	~1E8-1E9	~5E8-5E9		100 fb-1	Luminosity Beam-gas	direct contribution, estimate based on FLUKA calculations and gradient as from I. B.	3
	RR53, RR57	1E8-5E9	1.E9-1.E10	0.1-1	100 fb-1	Luminosity Beam-gas	shielding as currently installed (full shielding as in ECR would reduce it by ~20-50)	2

- Continuous evaluation – Prioritization (Colour Coding)
  - Ongoing work during this shutdown (UJ76,…)
  - Highest priority for ongoing iterations/evaluations
  - Second priority, cross-check with measurements
  - Lowest priority, layout check and evaluation

Conclusions

- High radiation levels for nominal radiation
- 2009/10 operation is expected to be on the edge, *i.e.*, failures can be observed
- Ongoing studies look into:
  - Shielding for failure mitigation (can't solve it, only shift in time)
  - Equipment relocation options (integration, etc…)
  - Civil engineering options
- For the above your input is crucial to allow for an optimization
  - Equipment inventory must be complete (see Giovanni's talk)
  - All (known) constraints must be collected (cable lengths, power requirements)
  - What are the equipment failure consequences
  - In what way can the equipment be optimized, *i.e.*, possibly hardened, separation of control part,…