3rd Joint HiLumi LHC - LARP Annual Meeting

Nov 12, 2013

WP10
Energy Deposition & Absorber

# ENERGY DEPOSITION IN THE (HL-)LHC: AN OVERVIEW

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**contributions from**

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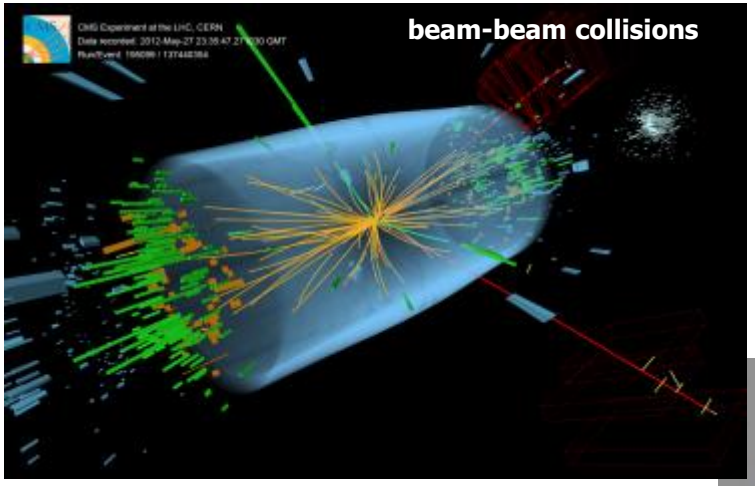
P. Fessia, L. Favre, P.A. Thonet

G. Arduini, R. De Maria WP2 R. Kersevan WP12

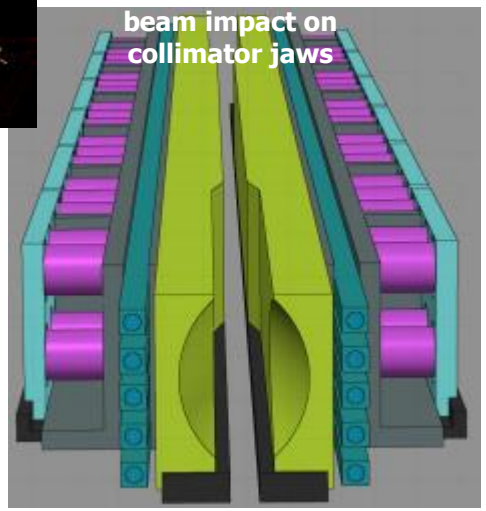
S. Redaelli, R. Bruce, E. Quaranta, B. Salvachua WP5 R. Calaga WP4

# OUTLINE

- the IR1 and IR5 triplet-D1 region

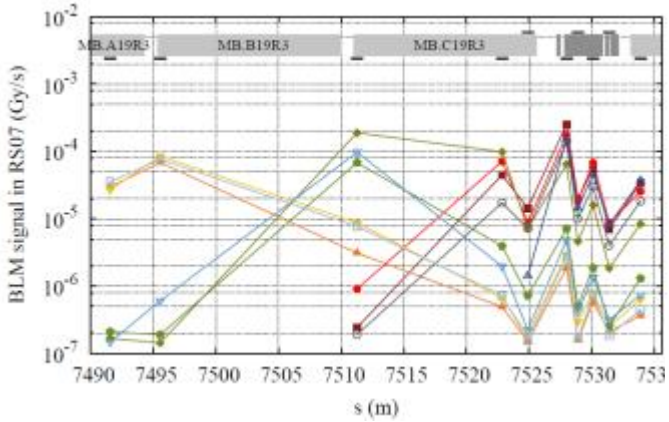



- the IR1 and IR5 matching section



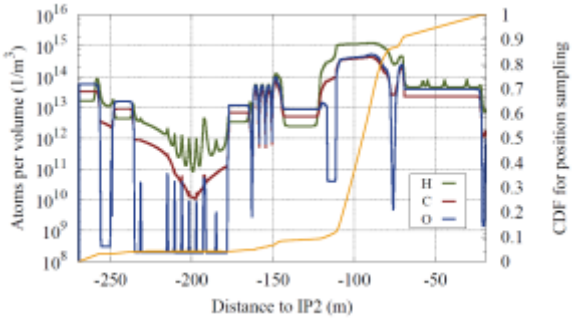

- the collimation insertion(s) (warm magnets and Dispersion Suppressor)

- UFO's




**beam interaction with …**

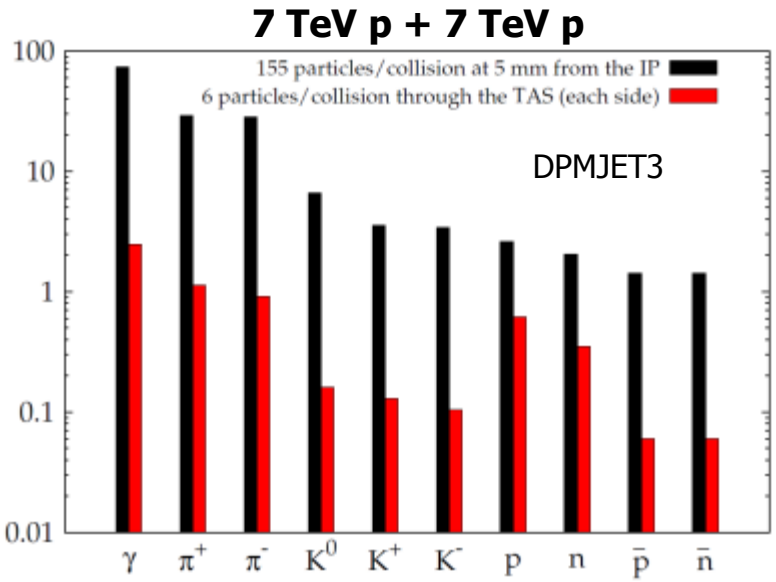
**… dust particles**




- background

**… residual gas**

# SHIELDING THE NEW TRIPLET – CP – D1 [I]

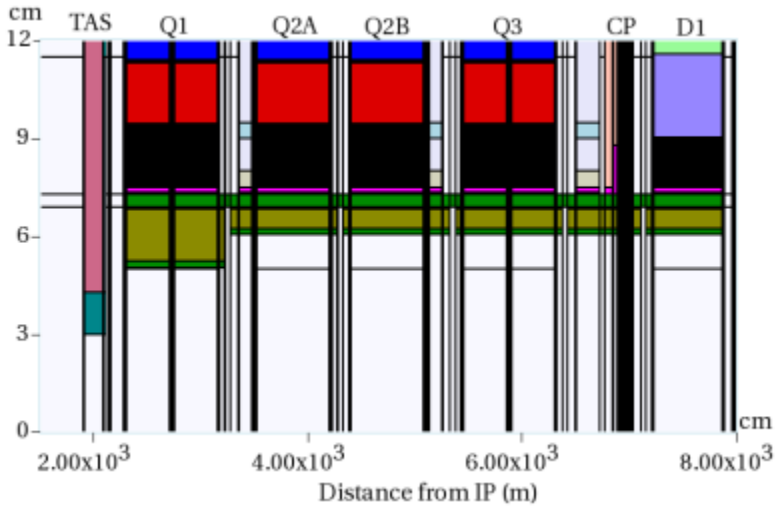


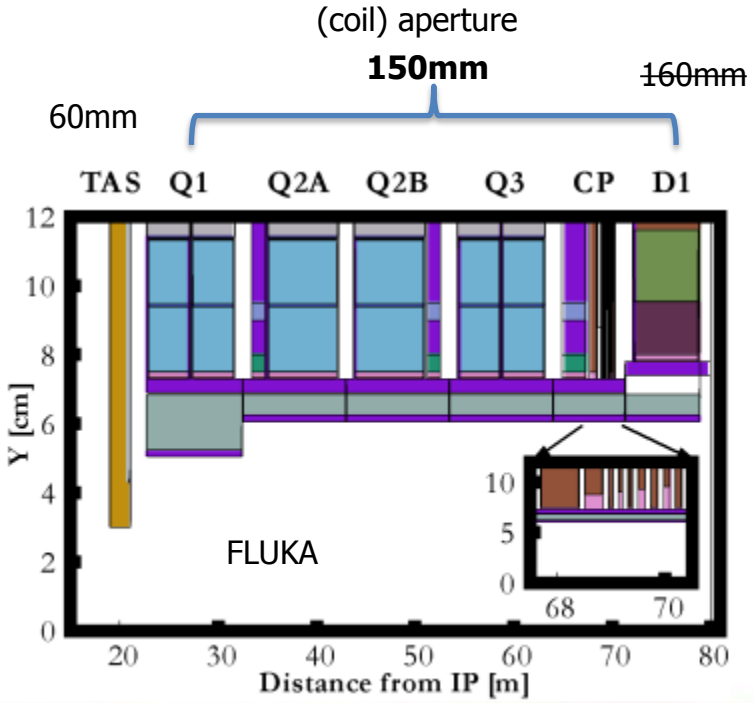

@ $L=5L_0$

400 W in the TAS

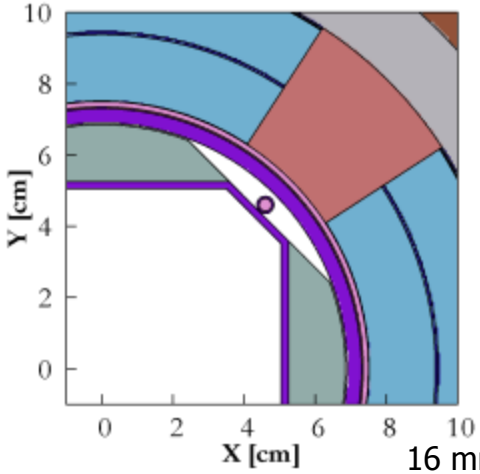
3.75 kW through the TAS

MARS15

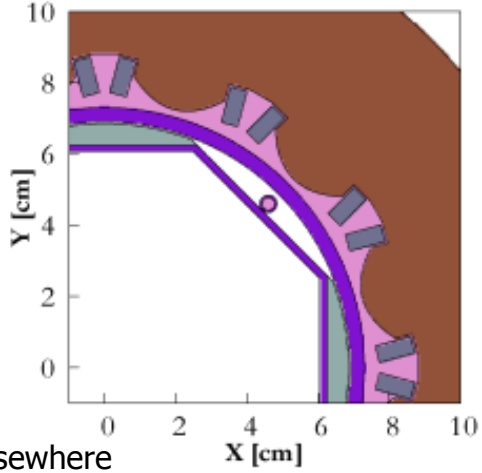


# SHIELDING THE NEW TRIPLET – CP – D1 [II]

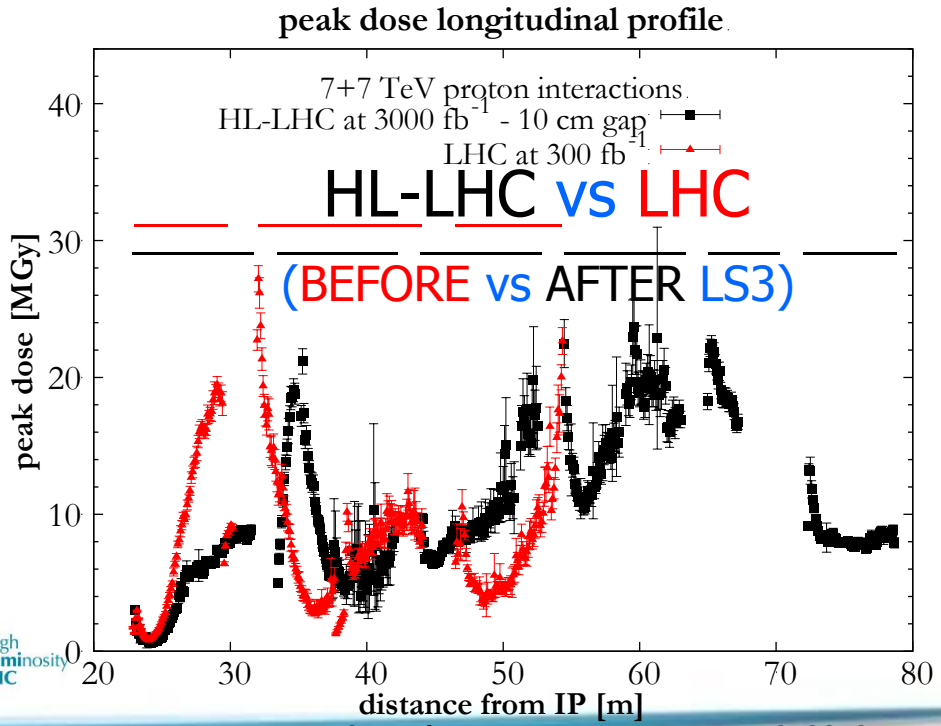



**tungsten** inserts on the beam screen




4mm cold bore

16 mm in Q1 and 6 mm elsewhere




larger values for increasing crossing angle

beam screen gap in the interconnects is critical

⇒ tungsten in the BPM's

more than **600 W** in the cold masses

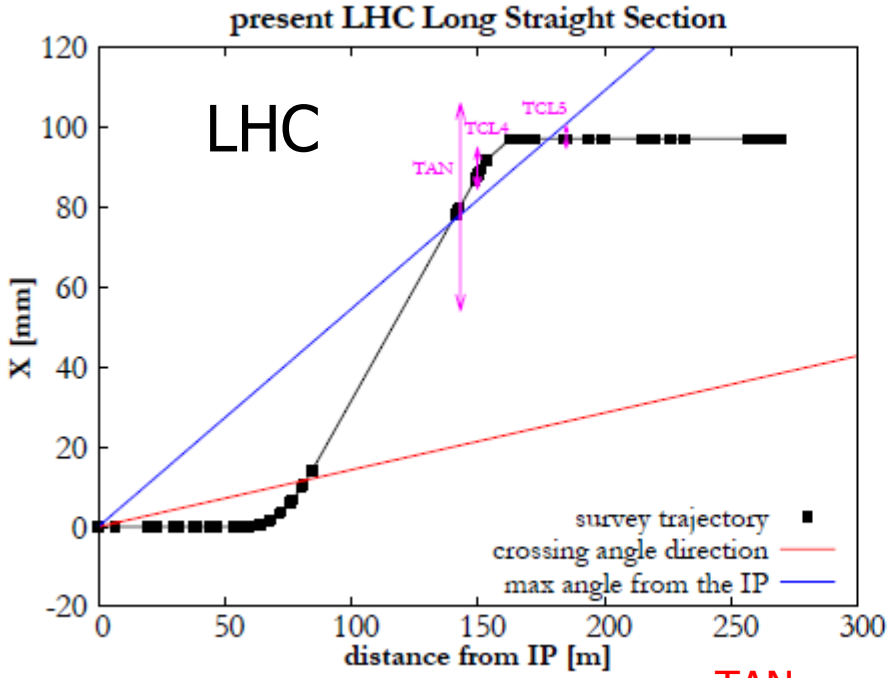
as well as in the beam screen

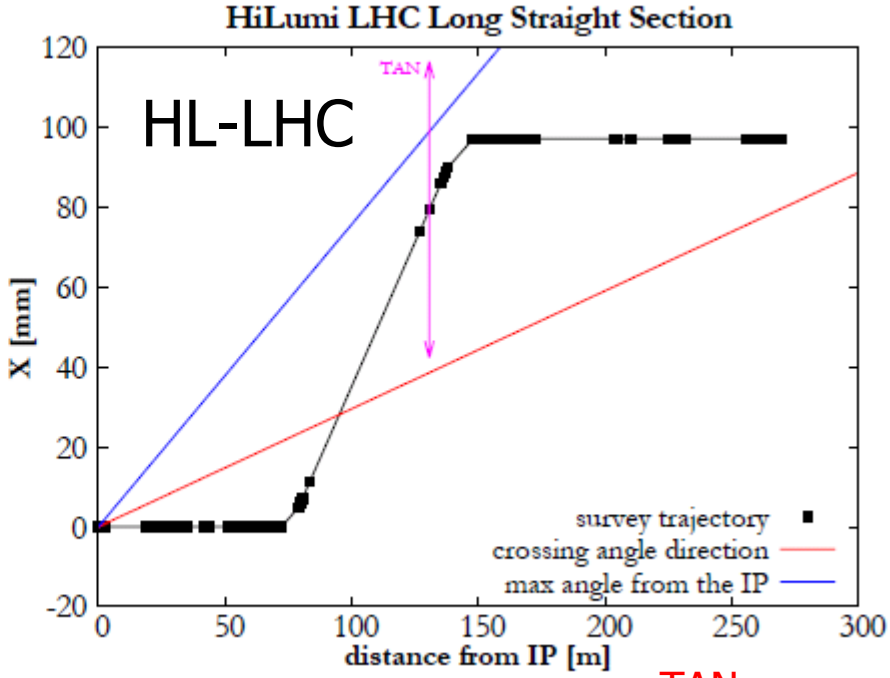
(i.e. 1.2-1.3 kW in total)

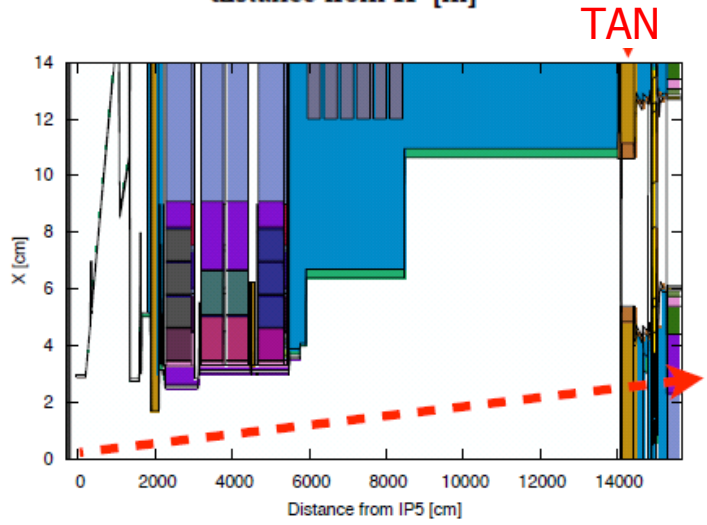
more details in the N. Mokhov's talk

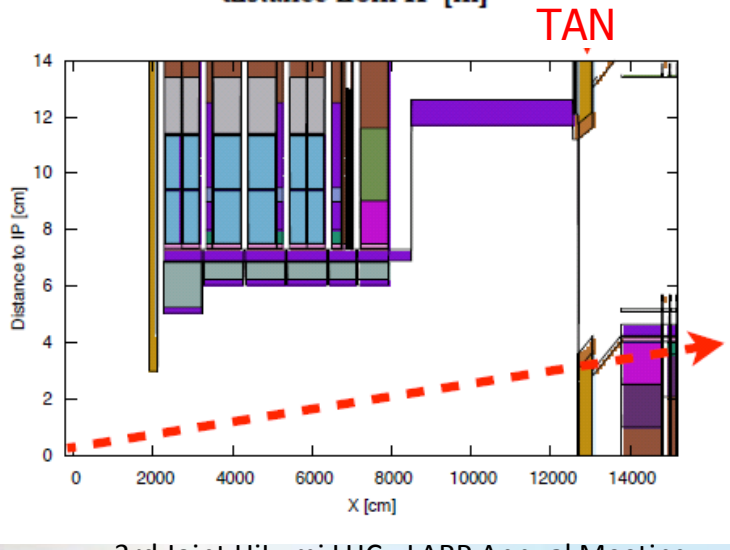
WP3 session tomorrow early afternoon

# LEAKAGE IN THE MATCHING SECTION [I]



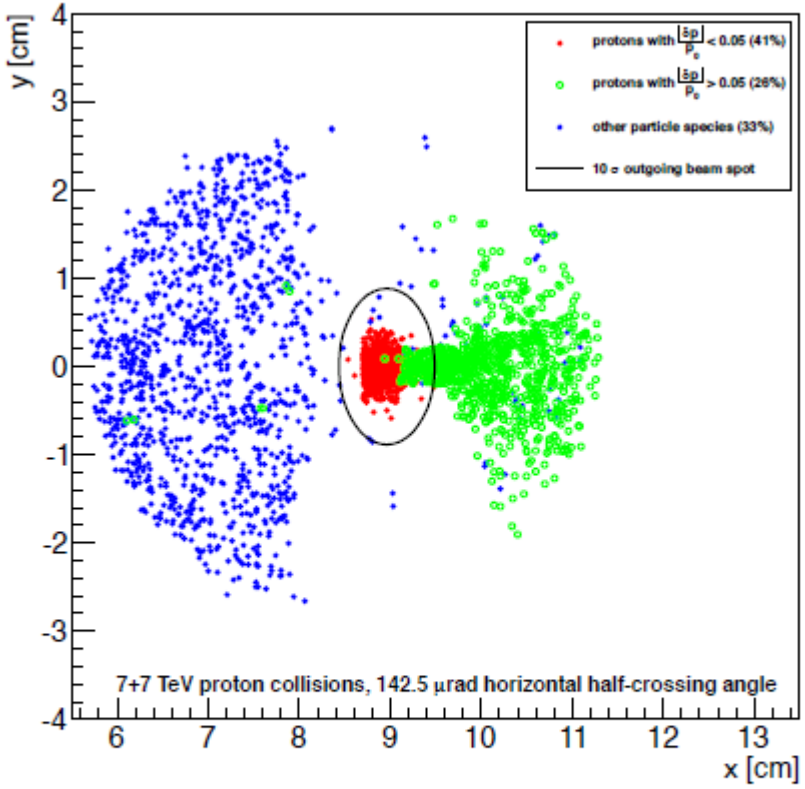



# LEAKAGE IN THE MATCHING SECTION [II]

## LHC

debris distribution at TCL.4R5 entrance

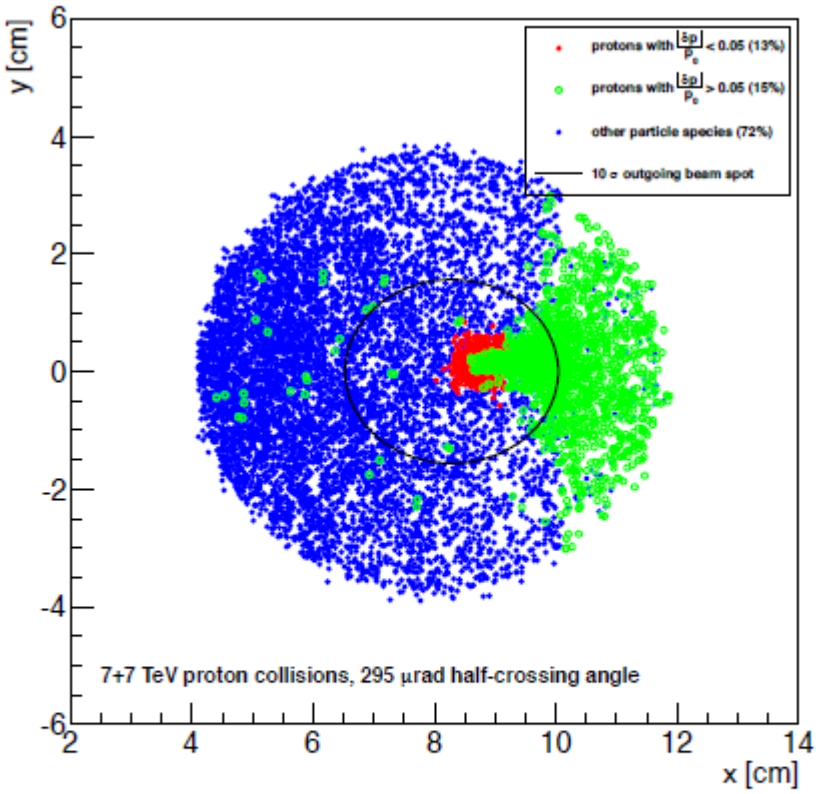



0.12 protons/collision (32.5% cleaned*)
0.06 others/collision (98.7% cleaned*)

* by a TCL4 installed at that position

## HL-LHC

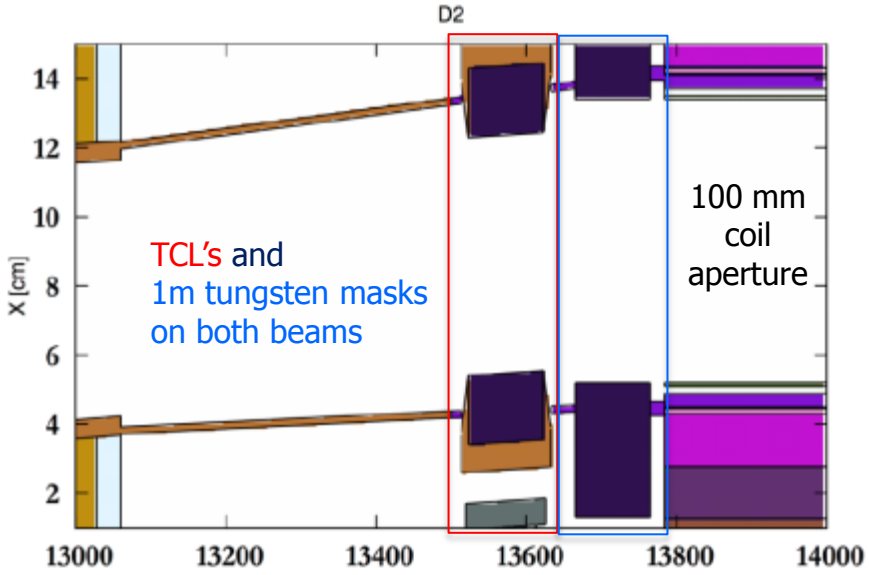
debris distribution at TAN.4R5 exit (truncated cone)

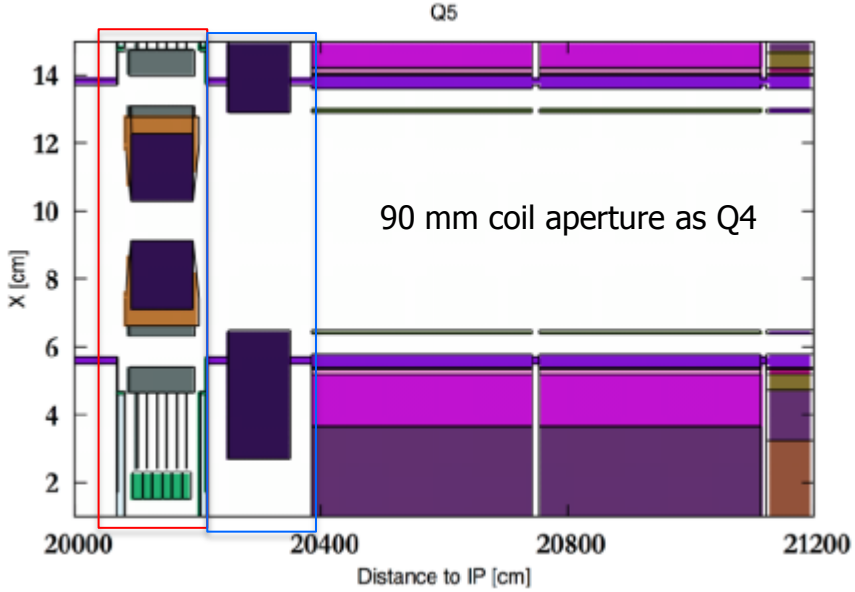



0.16 protons/collision (25.7% cleaned*)
0.41 others/collision (51.1% cleaned*)

* by a TCL4 installed at that position

# MATCHING SECTION PROTECTION



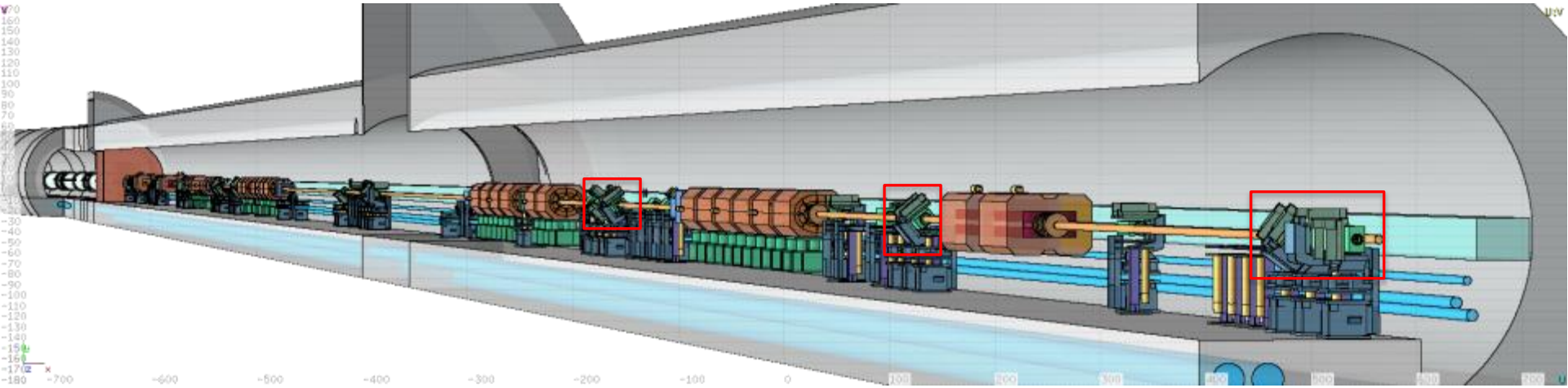

achievable <1 mW/cm$^3$ @ 5L$_0$ and <15 MGy /3000 fb$^{-1}$ in the D2-Q7 coils

1 kW in the TAN
(+20% for vertical crossing)

more details in the L.S. Esposito's talk
WP2 joint session tomorrow late morning

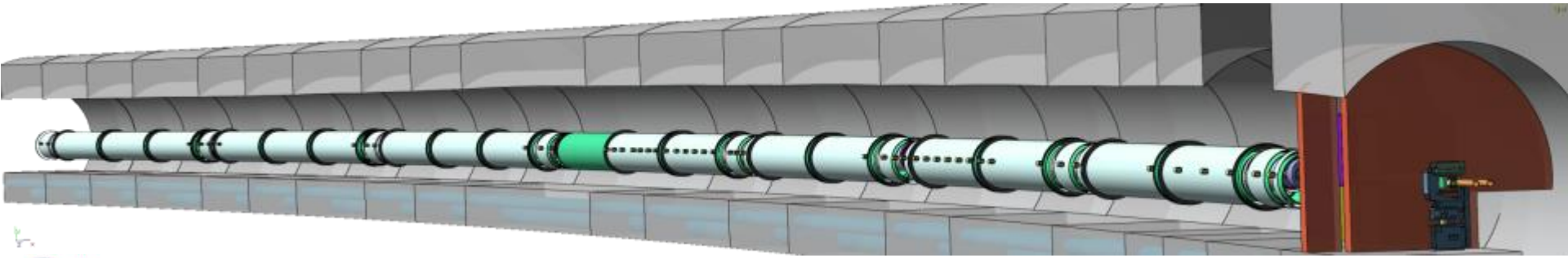
# COLLIMATOR LOSSES

**IR7** Long Straight Section (beam 2 internal)

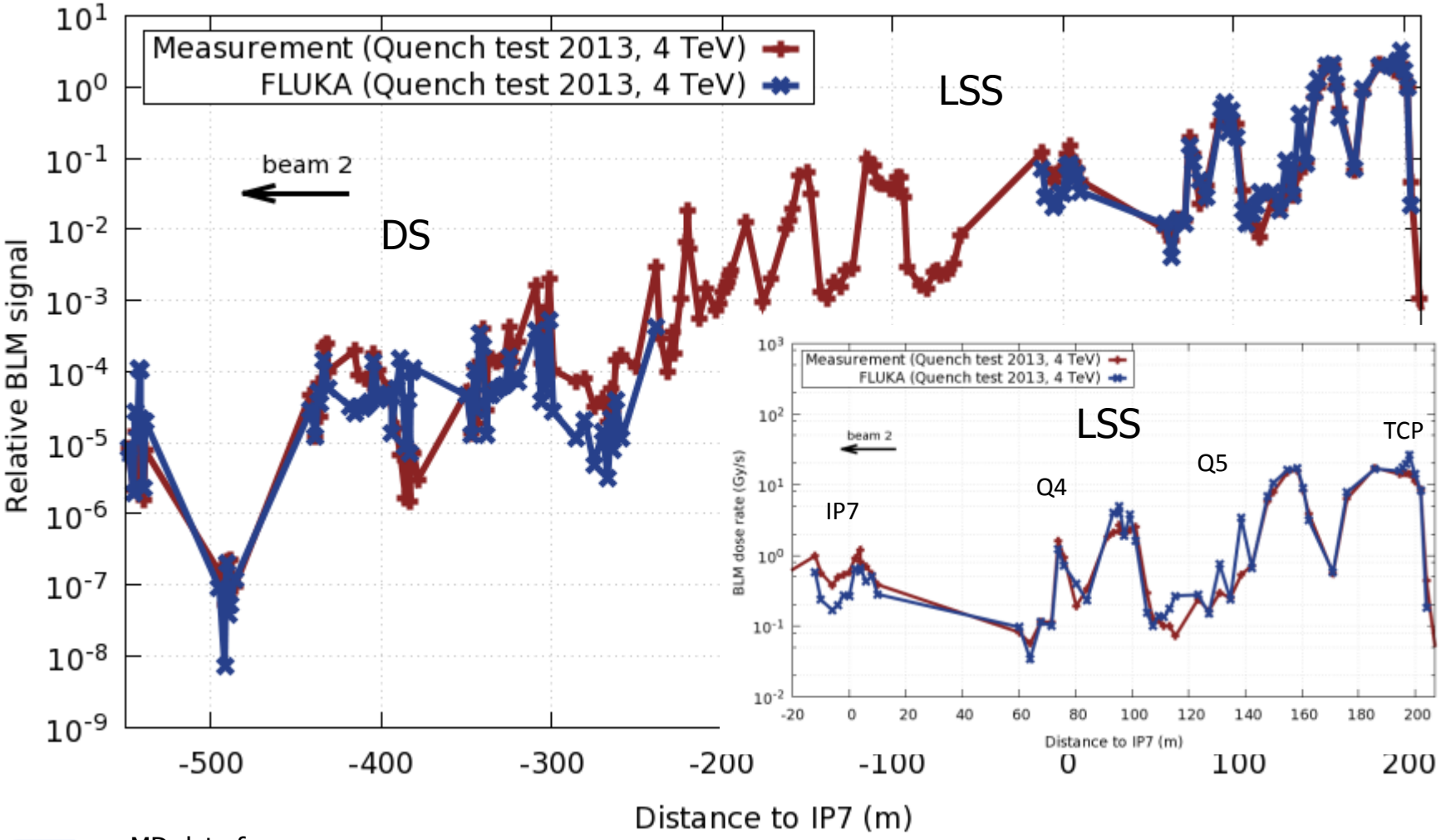


*source term:* distribution of beam protons interacting in the collimator jaws
calculated by SixTrack (R. Bruce & S. Redaelli, collimation team)

Left Dispersion Suppressor



# BLM "BENCHMARKING"




MD data from

CERN-ATS-Note-2013-XXX MD

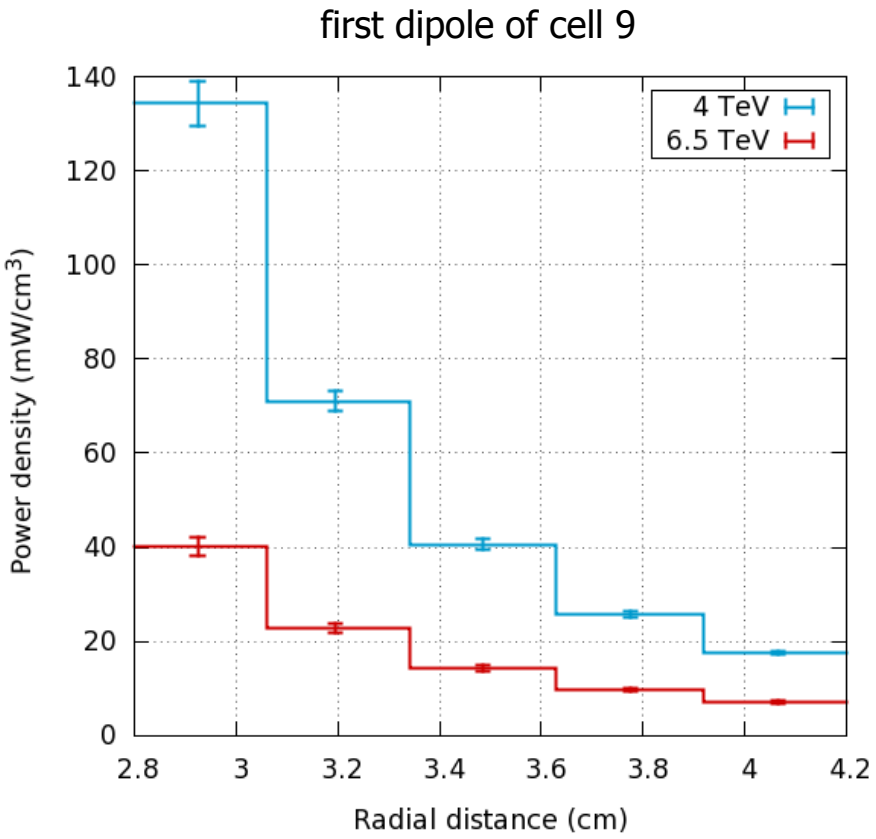
4 June 2013

Belen.Salvachua@cern.ch

by B.Salvachua, R.Bruce, M.Cauchi, D.Deboy, W.Hofle, E.B.Holzer, D.Jacket, L.Lari, E.Nebot, D.Mirarchi, E.Quaranta, S.Redaelli, M.Sapinski, R.Schmidt, G.Valentino, D.Valuch, J.Wenniger, D.Wollmann, M.Zerlauth,

**Results proton collimation quench tests MD at 4 TeV**

# QUENCH RISK ESTIMATE




1.6 $10^{12}$ p/s (**1 MW**), quench test

4.5 $10^{11}$ p/s (**0.2 h beam lifetime**), "relaxed" collimator settings

compared to quench limit evaluations

(A. Verweij and P.P. Granieri)

consistency with no quench occurrence at 4 TeV

at top energy, margin dependent on

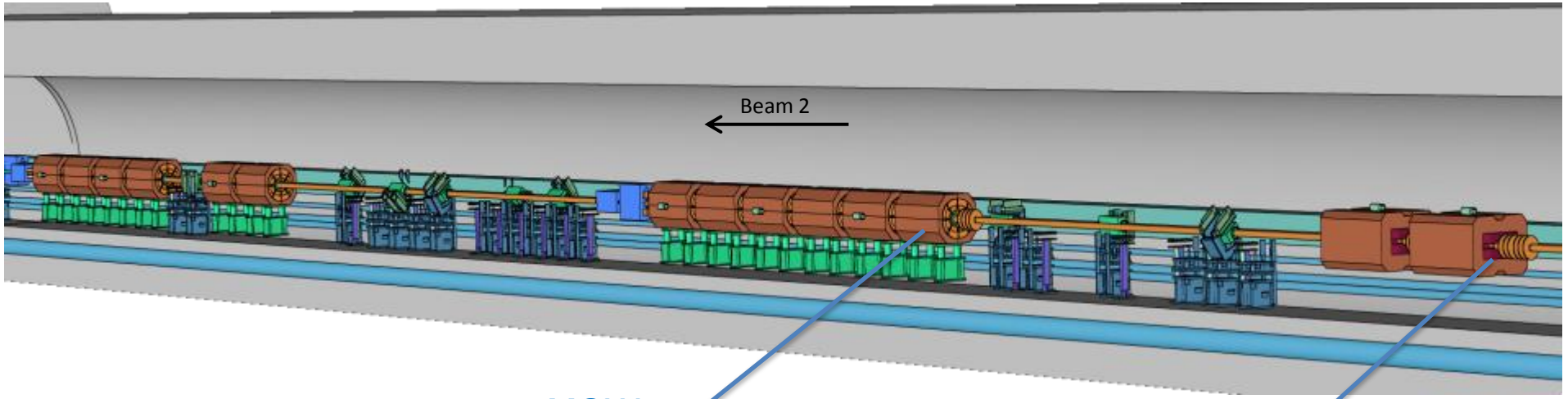
beam lifetime and collimator settings

⇒ DS collimator and 11T dipole option

more details in the A. Lechner's talk

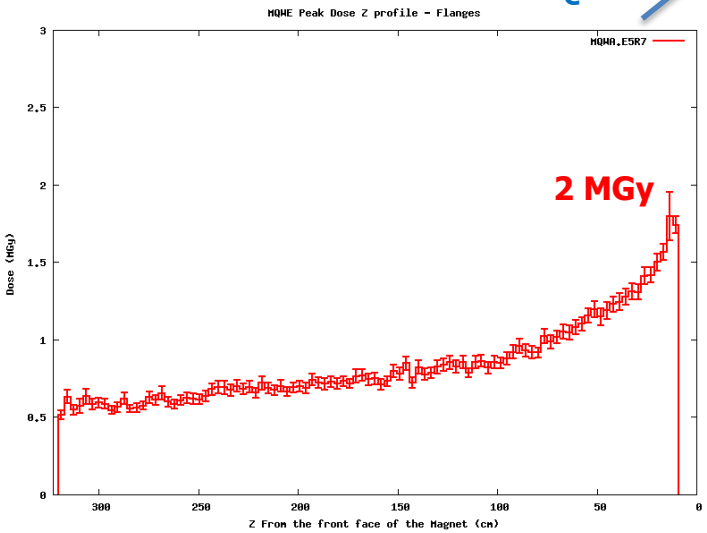
WP5 session tomorrow early afternoon

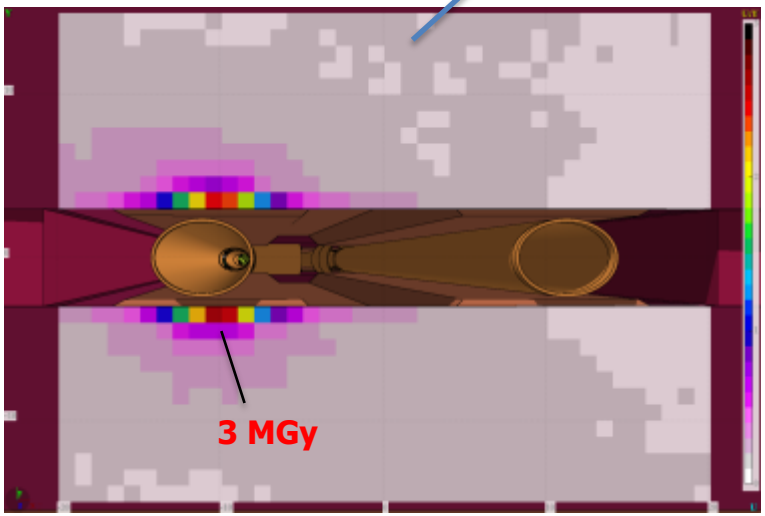
# WARM MAGNET DEGRADATION




MQW

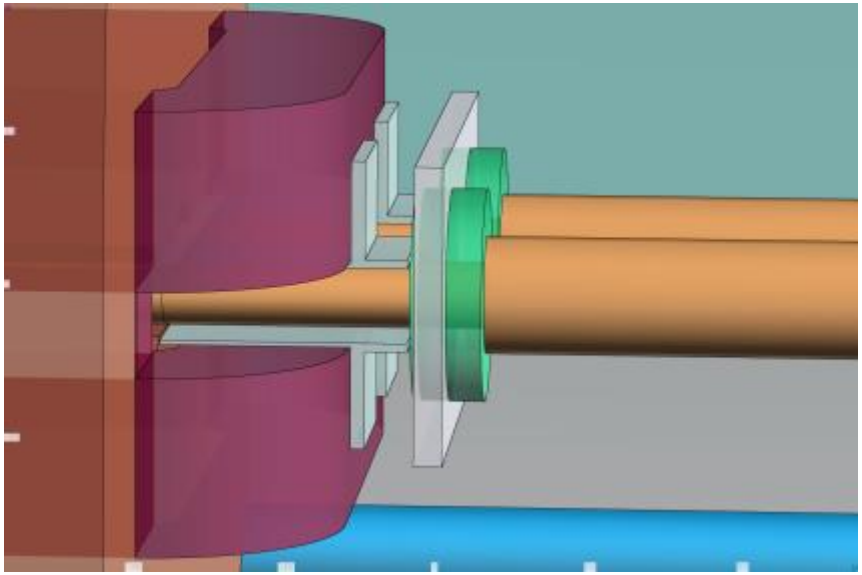
MBW

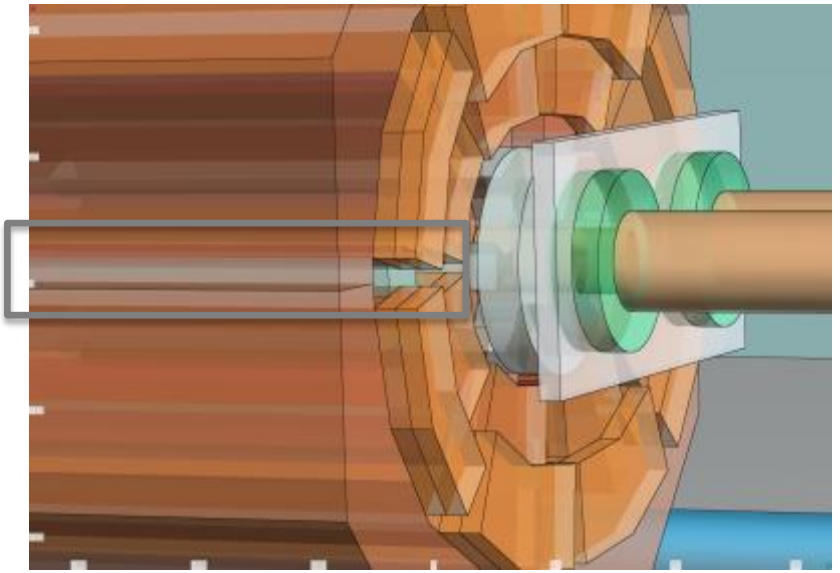



values for 1.15 $10^{16}$ protons lost in the collimators
(unstably corresponding to 50 $fb^{-1}$)

# WARM MAGNETS: MITIGATION MEASURES





**tungsten screens** provide a factor of 3 reduction in the peak dose (increase in the lifetime)

in IR3, with the additional TCAPD, peak doses 1.5 (MBW) – 2.5 (MQW) higher per lost proton

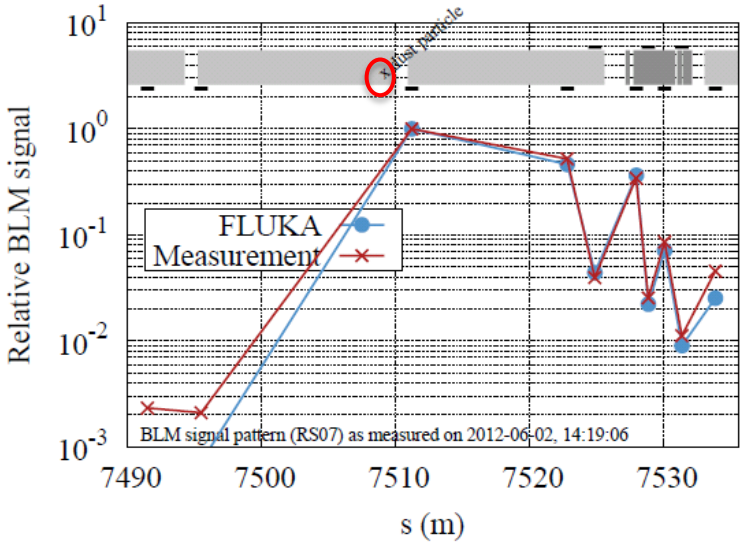
(relying on advantageous loss sharing with IR7)

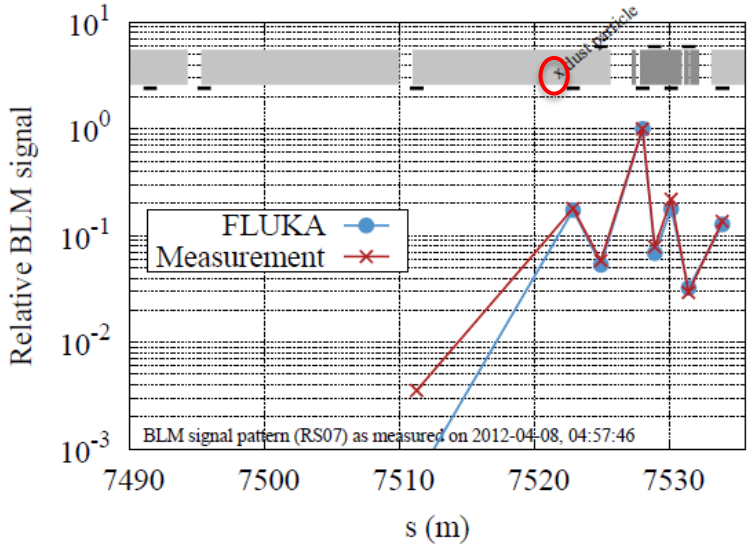
more details in the P. Fessia's talk

WP3 session on Thu early morning

# UFO: FROM PAST …

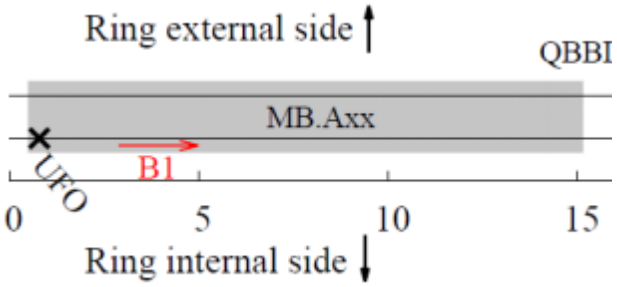
arc cell 19R3, 4 TeV operation

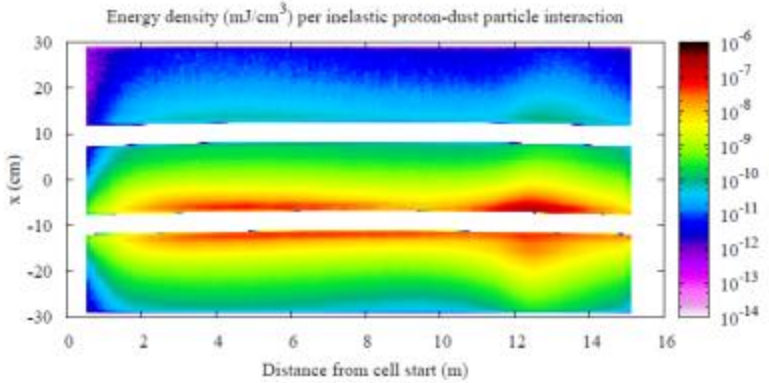


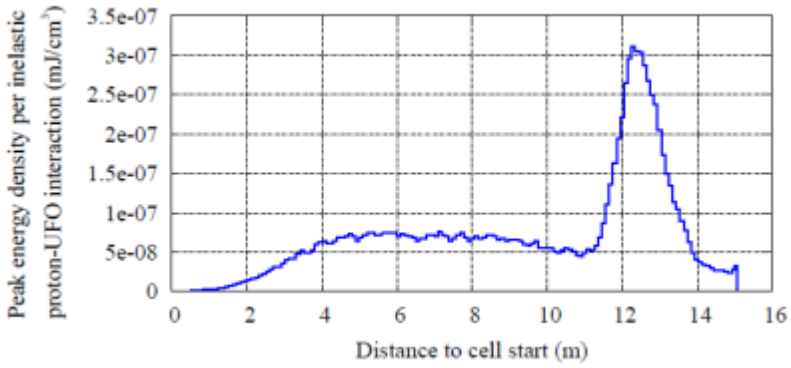

position definition and *proton losses quantification*

# UFO: … TO FUTURE



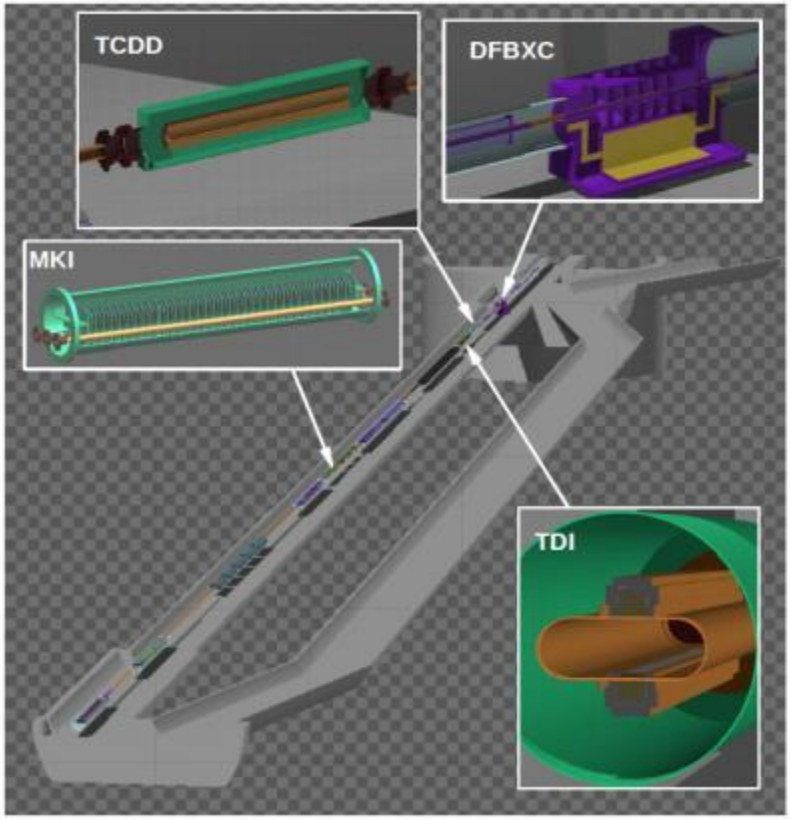

@ 7 TeV

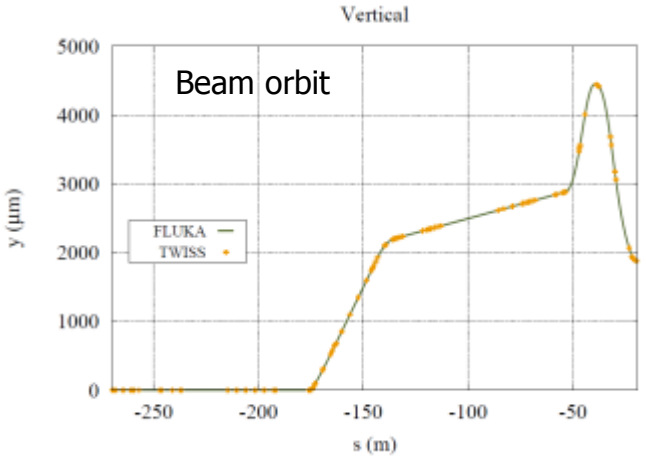



for "typical" ~$10^7$ p losses,
1-10 mJ/cm$^3$ in the coils
would be exceeded

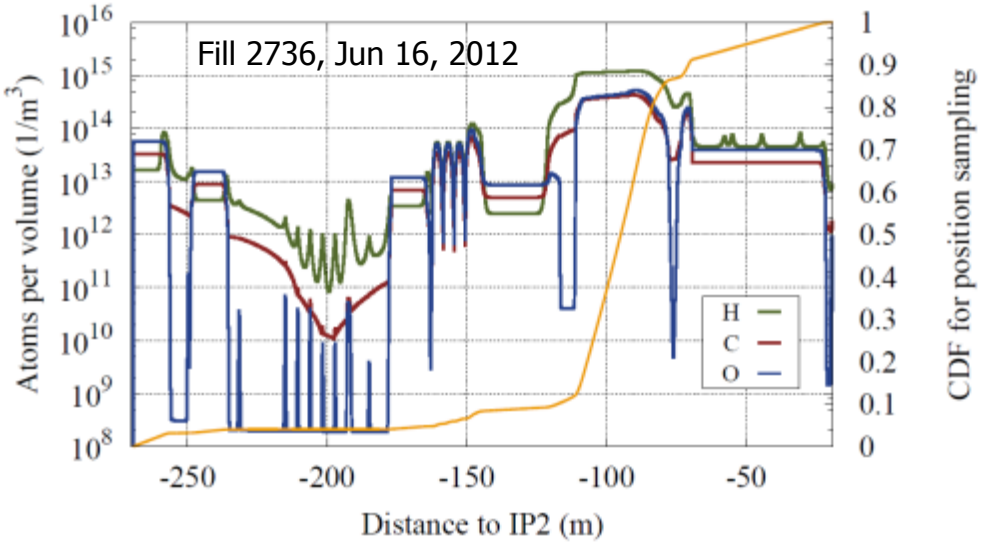
# BACKGROUND: ALICE [I]

**IR2** Long Straight Section (Left)



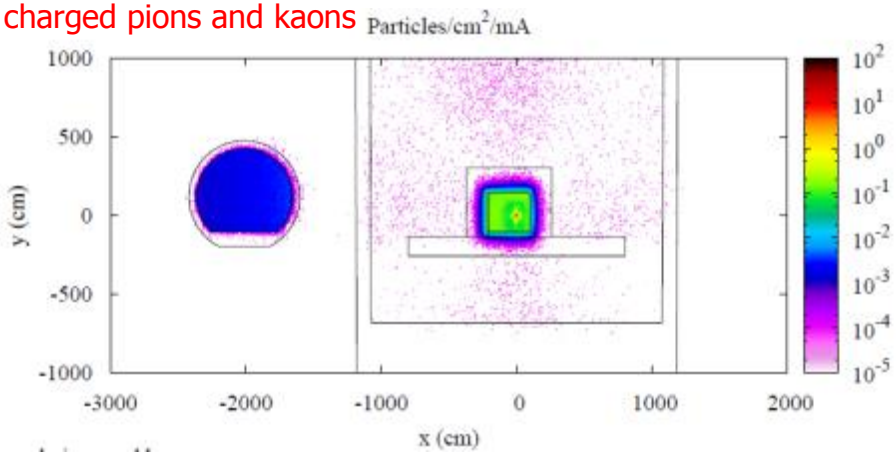

Residual Gas density



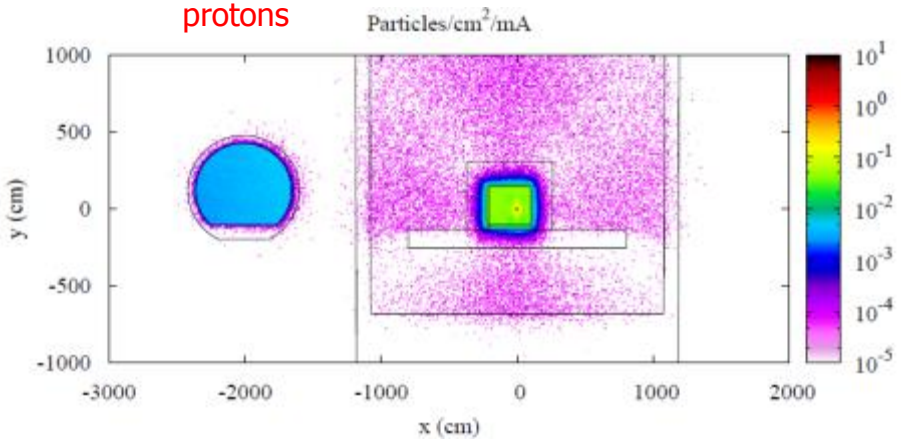

A. Lechner, G. Bregliozzi, E. Leogrande, A. Di Mauro
LHC Background Study Group Meeting, Jan 28th, 2013

# BACKGROUND: ALICE [II]

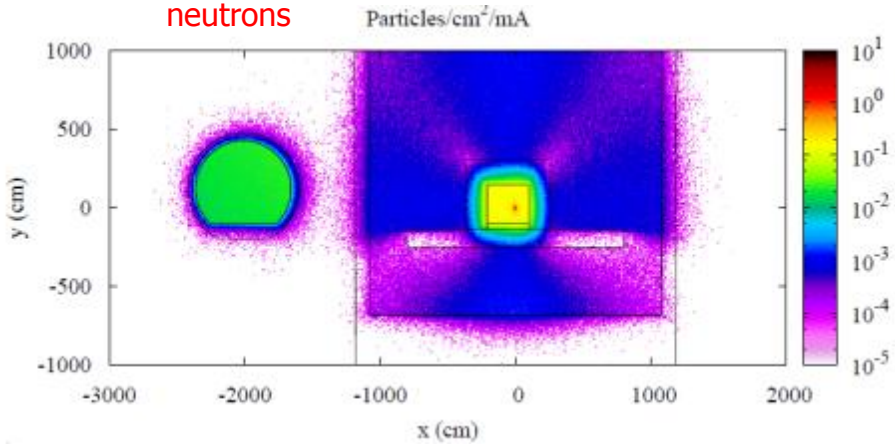
charged pions and kaons



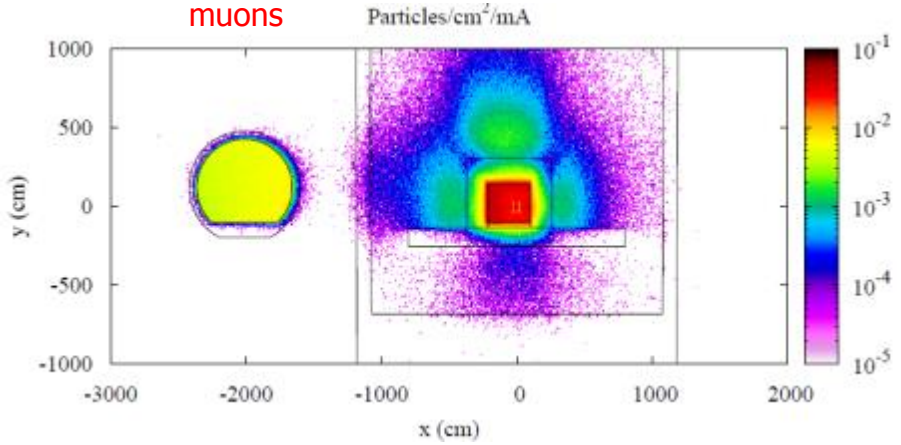

protons




neutrons




muons




see also the R. Kwee's talk

WP5 session tomorrow early afternoon

# CONCLUSIONS

• The HL triplet-D1 string can be adequately shielded by thick tungsten inserts on the beam screen in view of the luminosity targets. A long shielding *gap in the interconnect* is clearly harmful and cannot be effectively compensated by a larger radius mask. The TAS aperture is not critical, contrary to the *crossing angle*. The expected integral power is 8 times larger than the one on the present triplet at nominal lumi.

• The systematic coupling of tungsten TCL collimators and masks allows to face the heavy leakage in the matching section through the *new TAN* (optimized) apertures .

• Sophisticated *physics and geometry models* allow to reliably simulate secondary particle showers to many purposes (cold and warm magnet protection, radiation to electronics, operation assistance, background, activation, …).

# RESERVE SLIDES

# WHATEVER