SIMULATION OF MACHINE BACKGROUNDS

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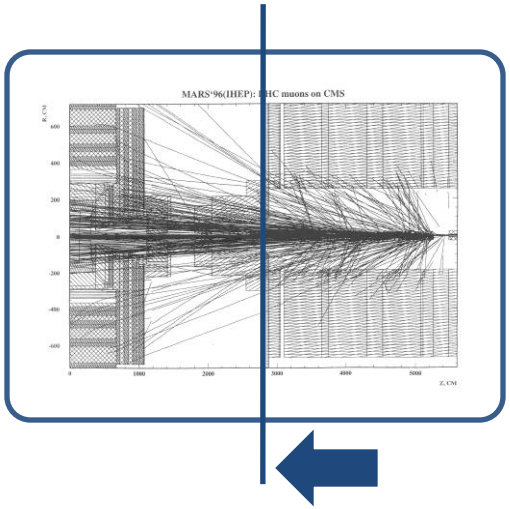
Workshop on Experimental Conditions and Beam Induced Detector Backgrounds
CERN April 3 2008

MACHINE INDUCED BACKGROUND



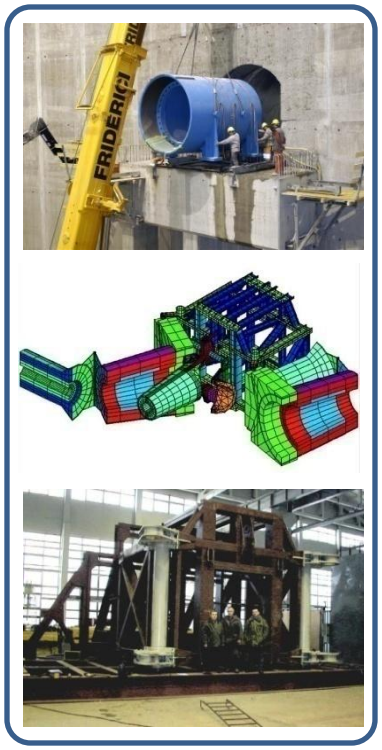
"Products of secondary cascades, initiated by proton losses upstream of the LHC interaction points, that reach the zones of the experiments from the machine tunnel" [Chamonix XV]

First comprehensive review:

"Workshop on LHC Backgrounds"

CERN March 22 1996

What we think we know? What we need to know?

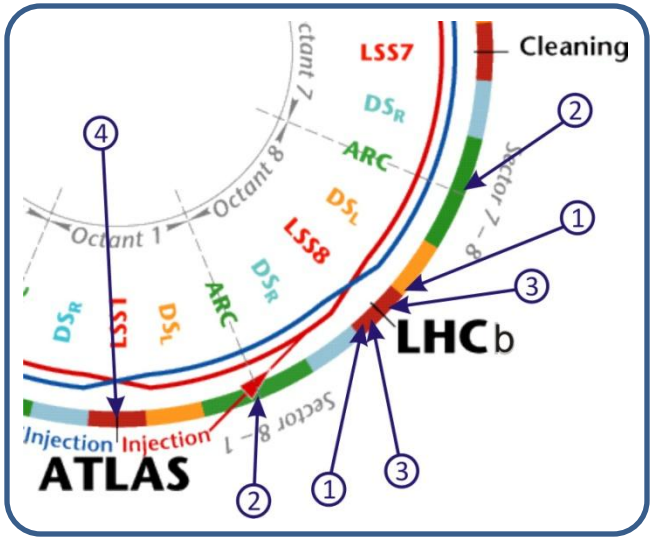


Something to remember about MIB:

- Becomes visible with the very first bunch in the machine
- Scales with the beam intensity, not with luminosity at the IP
- Depends on: optics, apertures, filling scheme, residual gas pressure, cleaning efficiency etc. — and their combination
- IP1/5 were shielded from MIB "by default", IP2/8 were not!

BACKGROUND SOURCES AND ORIGINS

NOTE: in MIB, “loss” = “inelastic interaction”



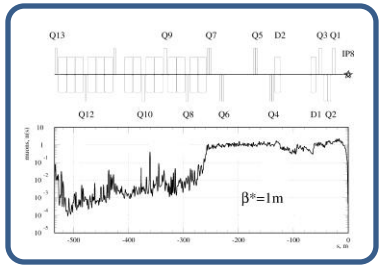
For a particular IP the sources can be grouped as:

- Beam-gas interactions in the LSS [1]
  → Depends on gas pressure and composition
  → Products have a direct line of sight into IP
- Elastic scattering in the cold sectors [2]
  → Key issues: optics and apertures in the LSS
- Tertiary halo (“tails from collimation”) out-scattered and not cleaned [3]
  → Depends on optics, apertures and cleaning inefficiency (must be < 10^{-3})
  → Different for Beam 1 and 2 — clear asymmetry of tertiary losses!
- Collisions in the neighboring IPs [4] — depends on the luminosity(!)
  → Most probably relevant only for the case of the IP1 influence on IP2/8

BEAM-GAS LOSSES IN THE STRAIGHT SECTIONS

Layout + Optics = Flux profile at the scoring plane per 1 beam-gas interaction

With the gas profile → Particle flux as a function of the loss distance to the IP



[LPN 258]

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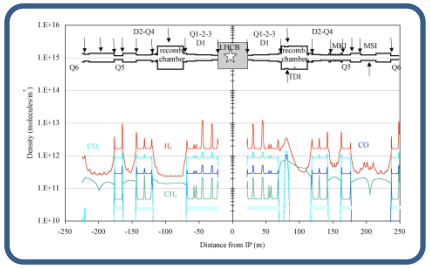

[LPR 674]

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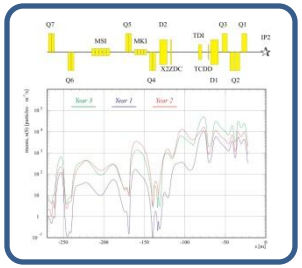
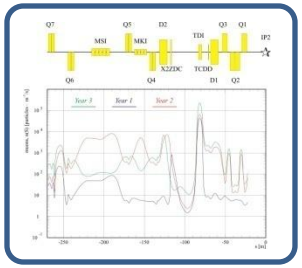


[LPR 567]



[LPR 567]

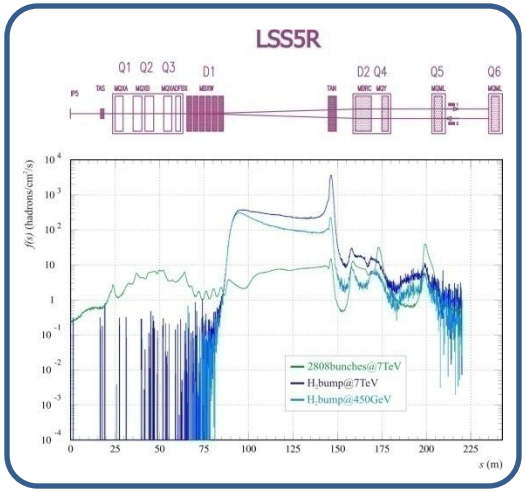
IR2/8(2002): ~10^{13} H_2 mol/m^3 → < 10^6 μ/s

Q: Why do we need to care?

A: Pressure bump in the warm section

" …a pressure of 10…100 times higher then the average density can exist locally for more than 100 hours… "

→ a few meters long pressure bump can produce the rate of the background compared to the whole LSS!

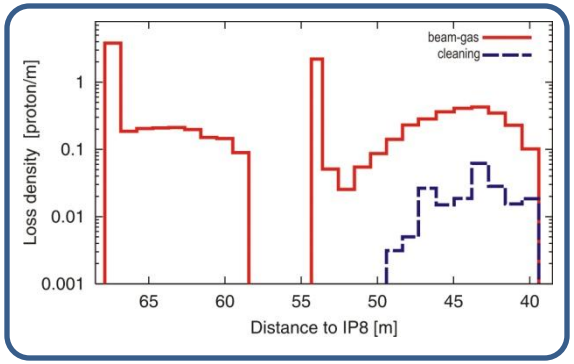


[LPN 378]

ELASTIC SCATTERING IN THE COLD ACRS

Depending on the resulting angle it gives a proton that may be lost at the next aperture limitation (D1-Q1 region@2001, now TCTs between D2 and D1)

→ Even before reaching the cleaning section!...

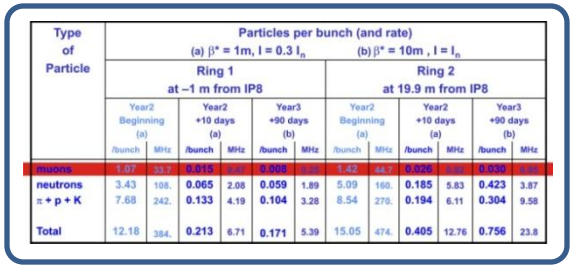


[LPR 500]

IR2/8: 5×10^{14} H_2 mol/m^3 (dated 1996!) → < 10^6 μ/s

Total for beam-gas from LSS + cold arcs: few 10^6 μ/s

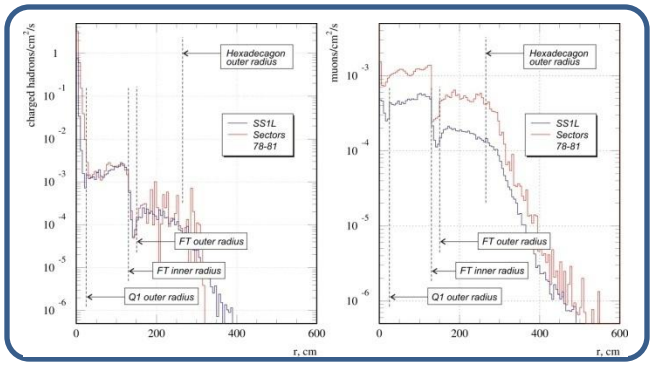
(Compare to the 16 MHz event rate in the IP8)



Type of Particle	Particles per bunch (and rate) (a) β* = 1m, l = 0.3 l_n — Ring 1 at –1 m from IP8						(b) β* = 10m , l = l_n — Ring 2 at 19.9 m from IP8					
	Year2 Beginning (a)		Year2 +10 days (a)		Year3 +90 days (b)		Year2 Beginning (a)		Year2 +10 days (a)		Year3 +90 days (b)	
	/bunch	MHz	/bunch	MHz	/bunch	MHz	/bunch	MHz	/bunch	MHz	/bunch	MHz
muons	1.07	33.7	0.015	0.47	0.008	0.25	1.42	44.7	0.026	0.82	0.030	0.95
neutrons	3.43	108.	0.065	2.08	0.059	1.89	5.09	160.	0.185	5.83	0.423	3.87
π + p + K	7.68	242.	0.133	4.19	0.104	3.28	8.54	270.	0.194	6.11	0.304	9.58
Total	12.18	384.	0.213	6.71	0.171	5.39	15.05	474.	0.405	12.76	0.756	23.8

[CH_XV]

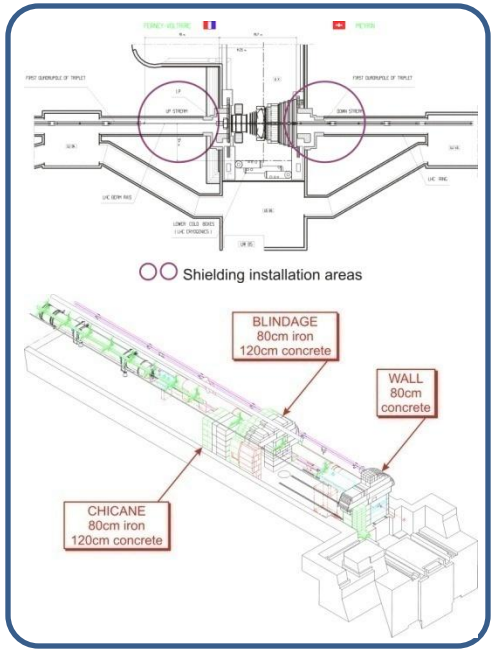
<u>Preliminary effect of the TCT (2004, IR1 and 13.5σ):</u>



[LPN 371]

"…up to 90% of the protons previously lost on the apertures in IR1 are now intercepted by TCTs…" — but at the price of the muon flux ~4 times higher at the cavern entrance…

BACKGROUND SHIELDING



[LPN 307]

Specific to IR2/8:

No shielding at the tunnel entrance present till 2002!

Low luminosity → No TAS at Q1 → No shielding at TAS

In 2002: basing on the background calculations, shielding installation areas around IP8 identified, and a couple of configurations evaluated

FULL shielding: chicane + blindage, concrete wall (IP7 side); STAGED: reduced number of iron blocks

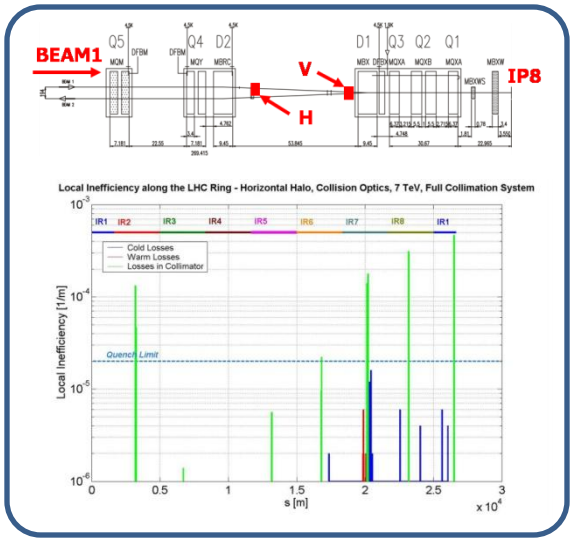
[D.Lacarrère, LHCb shield at the RB86 side]

Effect of the shielding:

(for beam-gas in LSS8!)

Charged hadrons flux reduced by factor 1.6-1.9 (50 above 25cm!), muon flux — 2.4-2.6, for the IP1/IP7 sides of LSS8

COLLIMATION BACKGROUND



[LPR 953]

30h beam lifetime = 2.8×10^9 p/s@IR7

Beam halo calculated for:

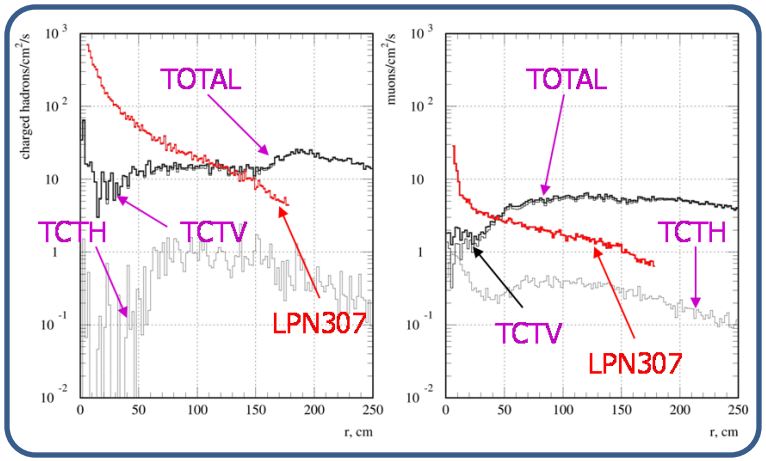
- "Full collimation and ideal machine"
- Collimators in IR7 at 6σ/7σ
- Nominal beam parameters and optics (10m@IP8)
- IR2/8: 1m (W jaws) long TCTs at 8.3σ(!)

Cleaning inefficiency (IR7 side):

- Vertical halo: (0.84, 0.22)× 10^{-3} at TCT(V,H)
- Horizontal halo: (0.003, 0.3)× 10^{-3} at TCT(V,H)

Particle flux at 1m from IP8:

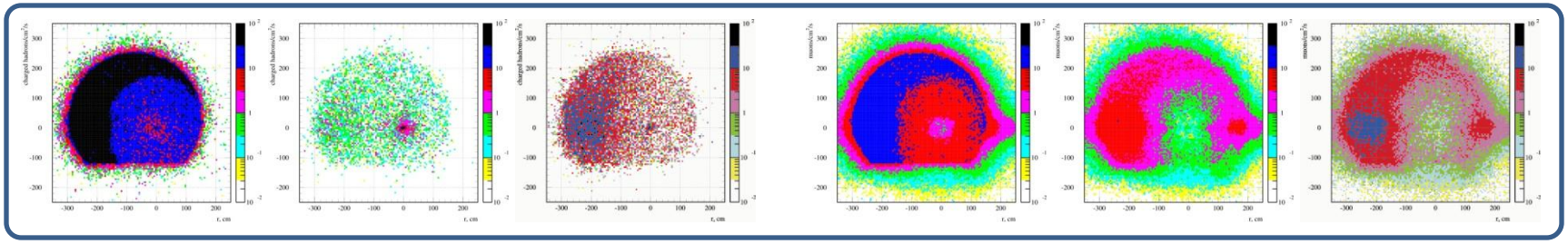
	Charged hadrons	Muons
TCTV	5.7x10^6	1.7x10^6
TCTH	8.3x10^4	4.7x10^4
TOTAL	5.8x10^6	1.8x10^6



[RadMon WS 2005]

SHIELDING EFFICIENCY

"Staged" shielding configuration: already available and installed at IP8



[charged hadrons/cm^2/s] [LPR 953] [muons/cm^2/s]

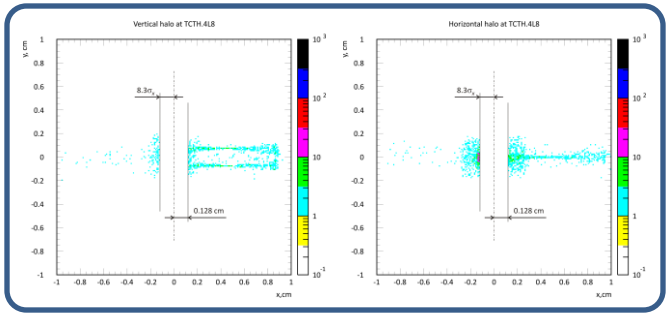
Vertical collimator TCTV at 73m:

	No shielding	Full	Staged
Charged hadrons	5.7×10^6	5.8×10^4 [~1%]	8×10^5 [14%]
Muons	1.7×10^6	4.9×10^5 [29%]	7.6×10^5 [45%]

Q: TCT settings

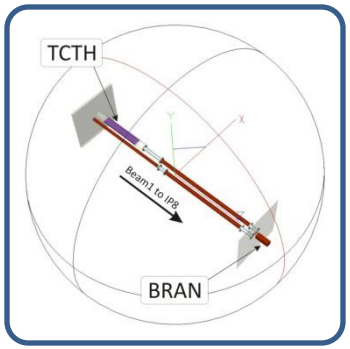
TCTs in IR2/8 were closed to 8.3σ

→ but does not it look like an overkill?...



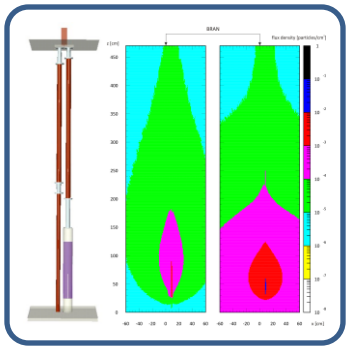
[LPR 953]

BACKGROUND AT COLLISION RATE MONITORS



Luminosity monitors (BRANs):

- Installed in front of the D2 dipole, same region as the horizontal collimator TCTH
- In IR2/8 not shielded against background from the TCTH (no TAN absorber)

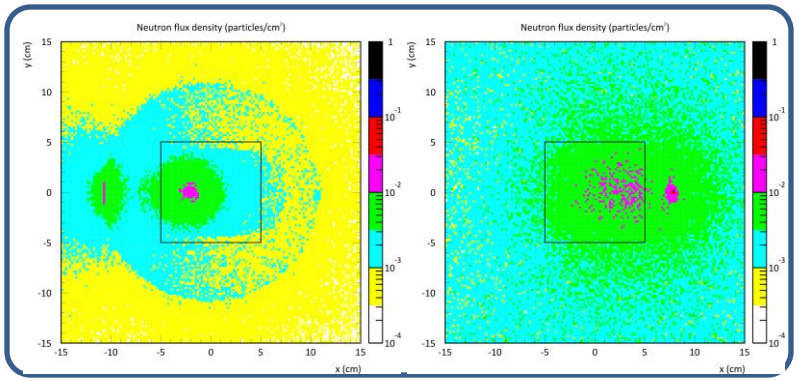


→ What will be signal/background ratio in the presence of the losses at TCTH?

- Background estimation: same loss maps as for the calculations above
- Compared to the signal at the BRAN from the p-p collisions in the IP

Signal/background ratio at the BRAN:

- For 16 MHz@IP8 and 1.5×10^{6} p/s@TCT — 10:1 (for neutrons)
- What about:
  - → IP2? ($L = 3\times10^{30}cm^{-2}s^{-1}$)
  - → Loss rates at the start-up?



[Per 1 p-p event at IP] [Per 1 p at TCTH]

CONCLUSION AND OUTLOOK

THE EFFECT OF THE BACKGROUND SOURCES IN IR2/8 WAS ESTIMATED:

- Beam-gas losses in the LSS: basing on the year 2002 numbers
- Losses in the cold arcs: some assumption that comes from 1996(!)

  → Total for the beam-gas from LSS + cold arcs: few 10^6 μ/s

  → Need to be updated with the new gas estimates and THE SHIELDING(!!!)
- Tertiary losses at the TCTs: most recent loss maps used → few 10^6 μ/s

  → The performance of the IR2/8 shielding estimated for this source

  → Charged hadrons: 99% efficiency, muons: reduction factor of 2-3

  What are the start-up/optimal settings for the TCTs in IR2/8?!
- Background at the Collision Rate Monitors:

  → Critical for the luminosity measurement in IP2/8

  → **Dramatically** depends on the rate of the losses at the TCTs…