ATLAS/CMS Machine Background Simulation WG

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History

Origins at the April 2008 workshop on
Workshop on Experimental Conditions and
Beam Induced Detector Backgrounds

Discovered several open questions or inconsistencies

Experiments were using MIB simulations based on obsolete and/or incomplete source terms. So nothing was really reliably and directly comparable

In order to clarify the situation at least between ATLAS/CMS (~identical insertions & requirements), we decided to join forces on simulations and their interpretation.

Composition

Co-conveners: W.Kozanecki, M.Huhtinen

Machine background simulation expert: N.Mokhov (& his FNAL team)

LHC beam conditions: H.Burkhardt (& D.Macina)

Other LHC experts (e.g. A.Rossi) invited to individual meetings

Interested people from ATLAS/CMS subprojects invited to participate, provide input, requests, questions etc…

Participation from RP (simulation experts): S.Roesler

Open to other experiments and interested parties (but we focus only on issues of ATLAS & CMS)

Primary subject (Backgrounds)

Get consistent and complete simulations for IP1 & IP5

In particular: resolve the issue of long-range elastic B-G lost on TCT
(Discovered at April-08 workshop that this is significant and NOT part of collimator tails)

With the help of N.Mokhov (& his team) work on simulations for 3 sources:

- Inelastic beam-gas scattering in up to 550m from IP
- Collimator tails (tertiary halo) lost on TCT
- Elastic beam gas all around the ring, lost on TCT

All these for nominal machine
7 TeV, I=580mA, b*=0.55m, nominal crossing, phase II collimation (?)

Other Subjects (accidents...)

Cross-calibrate the response of BCM & BLM detectors wrt simulated beam accidents and Pixel/Si Tracker damage levels, to help define beam-abort strategy & Control Room diagnostics

Consider "generic" beam loss scenarios:

7 TeV protons scraping the TAS

450 GeV protons scraping the TAS

450 GeV protons scraping central beam pipe

At the moment pursued mainly by ATLAS (D.Tardif, M.White)

http://indico.cern.ch/getFile.py/access?contribID=0&resId=0&materialId=slides&confId=46962
http://indico.cern.ch/getFile.py/access?contribID=0&resId=0&materialId=slides&confId=53203
(early CMS work on same subject: http://cmsdoc.cern.ch/~huu/mpwgtalk.pdf)

Might also have another look at the unsynchronized abort, potentially affecting CMS (but not really issue for ATLAS)
(first studies by N.M. & M.H. in 1999: http://cmsdoc.cern.ch/~huu/acctalk.ps)

Finalizing...

N.Mokhov is about to finish the simulations for the nominal machine

- 2 beams
- 2 experiments
- 3 different sources (collimator tails, inelastic BG, elastic BG)
- 10 files for each source (for statistics, error estimation)

120 files, each with about 10^5 primaries.

This is a considerable effort and hopefully will serve ATLAS & CMS for a long time

Hope to have the full set available by May 2009

Simulation procedure

Interface plane at z=22.6m form IP (MARS transport ends, Experiment software takes over)

1st Source term (collimator tails)

Loss patterns for "collimator tails" from LHC collimation group. In IP1&5 these give losses only on TCT. MARS15 simulation of proton interactions and transport to interface plane

2nd Source term (inelastic beam-gas)

Vacuum maps from Adriana Rossi (LPR 783 + private updates). MARS15 to generate inelastic* p-nucleus interactions in LSS+Arc (up to 550m from IP). Mars transport of secondaries to interface plane

* Includes also nuclear quasi-elastic & diffractive scattering

3rd Source term (elastic beam-gas)

Vacuum estimates of A.Rossi all around ring. Generate Elastic* beam-gas scattering in ring and STRUCT transport (multiturn) to interaction point. Further like source 1.

*Includes nuclear and Coulomb elastic scattering. ~2% of rate on TCT is due to Coulomb, adjusted to avoid double counting quasi-elastic with previous source

Interface plane & file format

We define the interface plane at 22.6m (-> Q1 entirely in machine, but UX-shielding mostly in experiment simulations)

The file records:

NI: MARS primary event number

IJ: Particle identifier (MARS encoding)

E: Energy (GeV)

W: Statistical weight of particle

X,Y: Position on interface plane (cm)

DX,DY: Direction cosines of particle

TOFF: Time of flight (s since interaction of 7 TeV p)

PRIMEHITZ: z-coordinate of inelastic interaction of 7 TeV p

Z-, X-,Y-ORIG: Production coordinates of particle seen at interface plane (cm)

E-,W-ORIG: Energy & weight of the "mother" in above process

IJ-,K-ORIG: Particle ID and process ID for the above

Normalization (to s^{-1}):

F=NFILE*W0*Wi/(NPRIME*NSIM)

NFILE = # entries in MARS file

NPRIME = # of events in MARS run

NSIM = # of entries processed

W0 = MARS normalization factor

Wi = individual particle weight

Important for rescaling (e.g. new vacuum maps)

Preliminary results

The following presents preliminary results from simulations by N.Mokhov

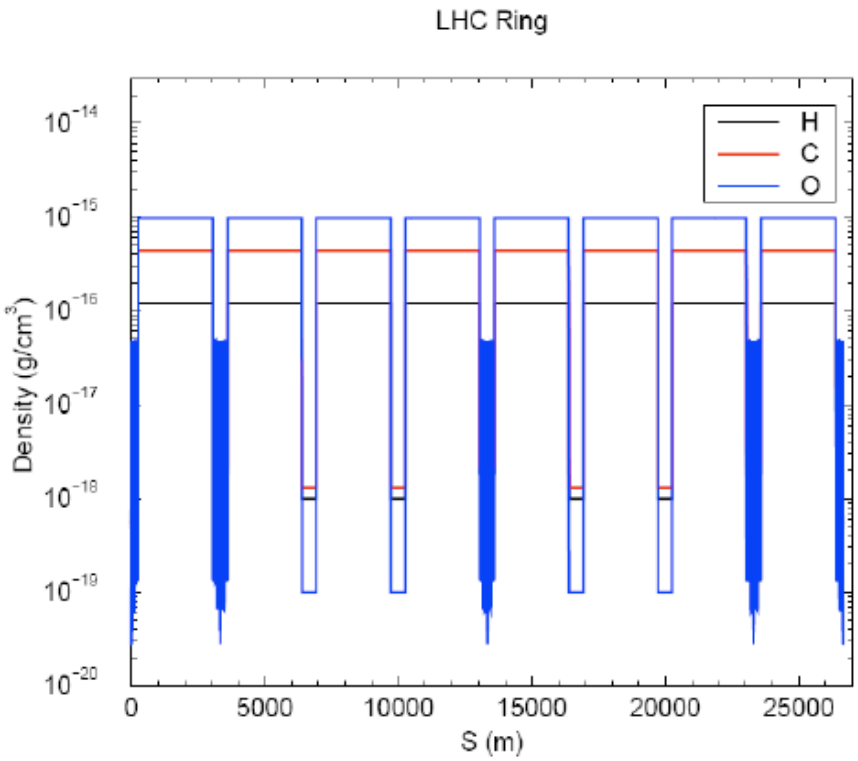
All are for the nominal machine

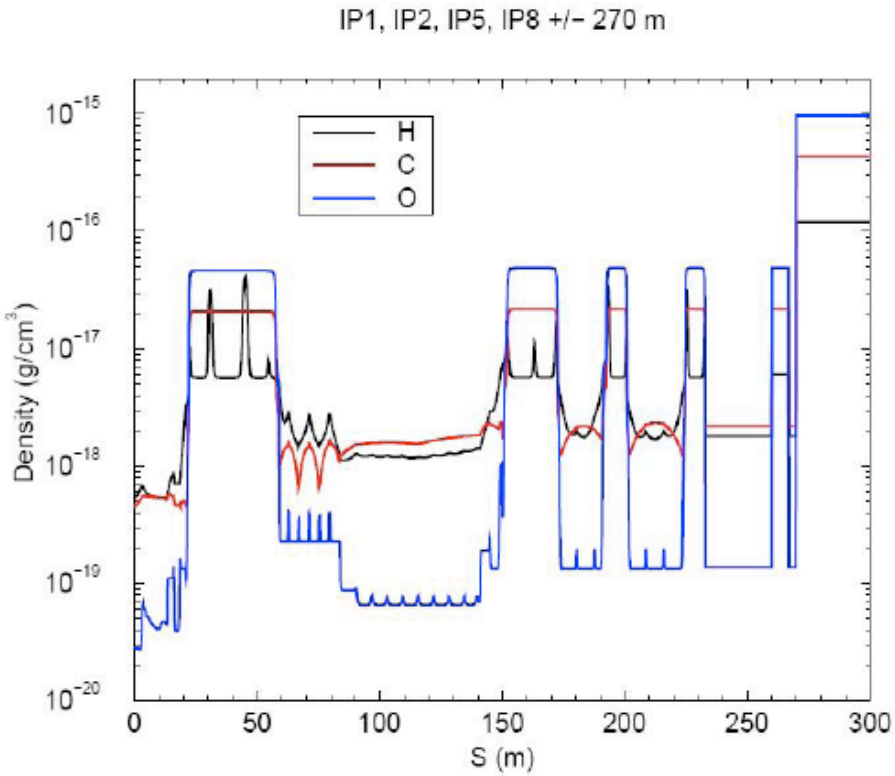
Some plots made by M.H. using the preliminary/old files at the interface plane.

Nothing shown here corresponds to the final release (still to come)
So take everything as qualitative, do not quote or refer to the absolute values shown in these plots

Pressure maps used

Residual gas compositions from LPR 783 for IR:s and
Private communication (A.Rossi) for entire ring

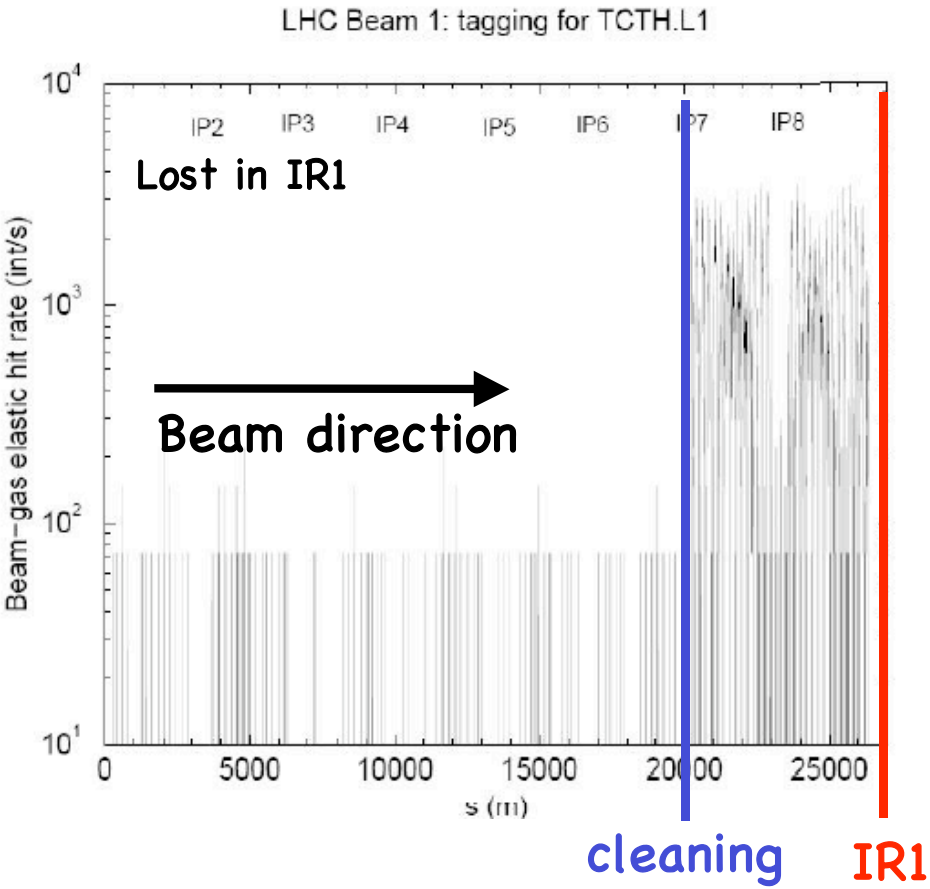


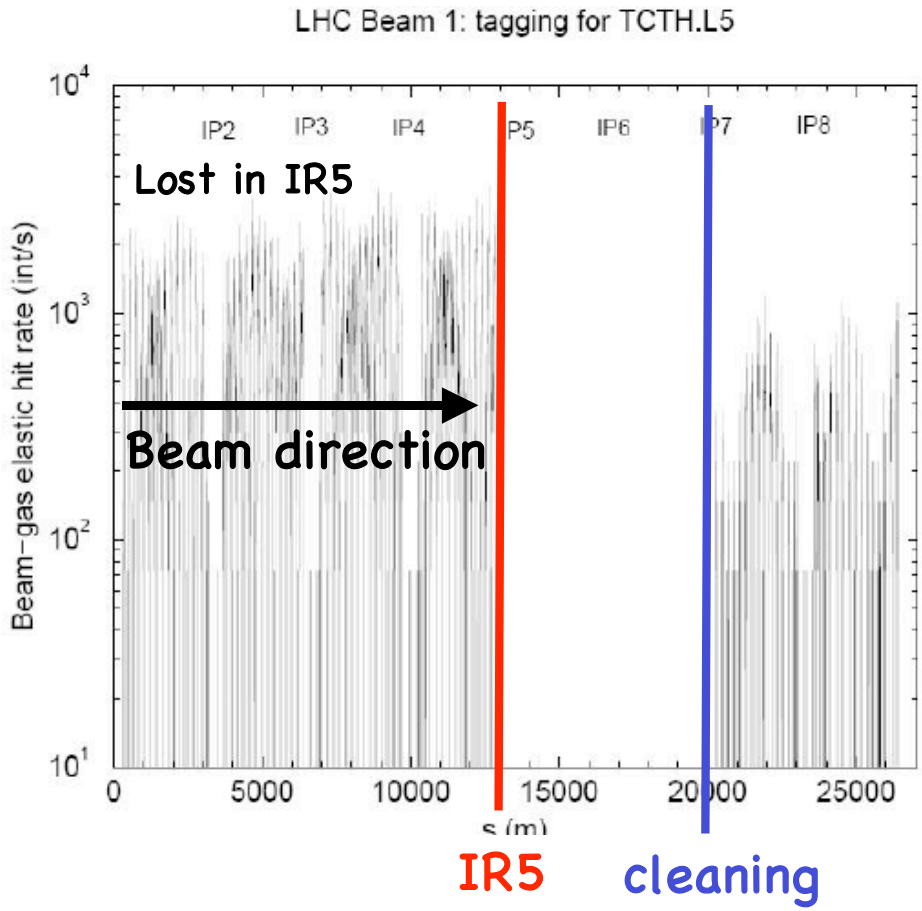


Pressure maps: A.R. plots N.V. & M.H.

Elastic B-G around ring

Origins of elastic protons lost on IR1/IR5 TCTs for (clockwise) beam 1





Beam 2 for IR1 will be much like beam 1 for IR5 and vice versa.

Simulation data & plots: N.M

Elastic Beam-Gas loss rates

Mokhov:

The pressure maps of A.R. result in 7.4E7 s^{-1} elastic interactions around ring (at 0.6 A). -> 2.5E8 B-G (total)/s

This gives a total beam-gas lifetime of ~330h (assuming 30% elastic)

Losses on IP5 TCT: 6.7E6 s^{-1}

Bayshev:

Assumes 100h beam-gas lifetime (8.9E8 B-G (total)/s)

Max losses on TCT: 3.3E7 s^{-1} (renormalized to 330h: ~1E7 s^{-1})

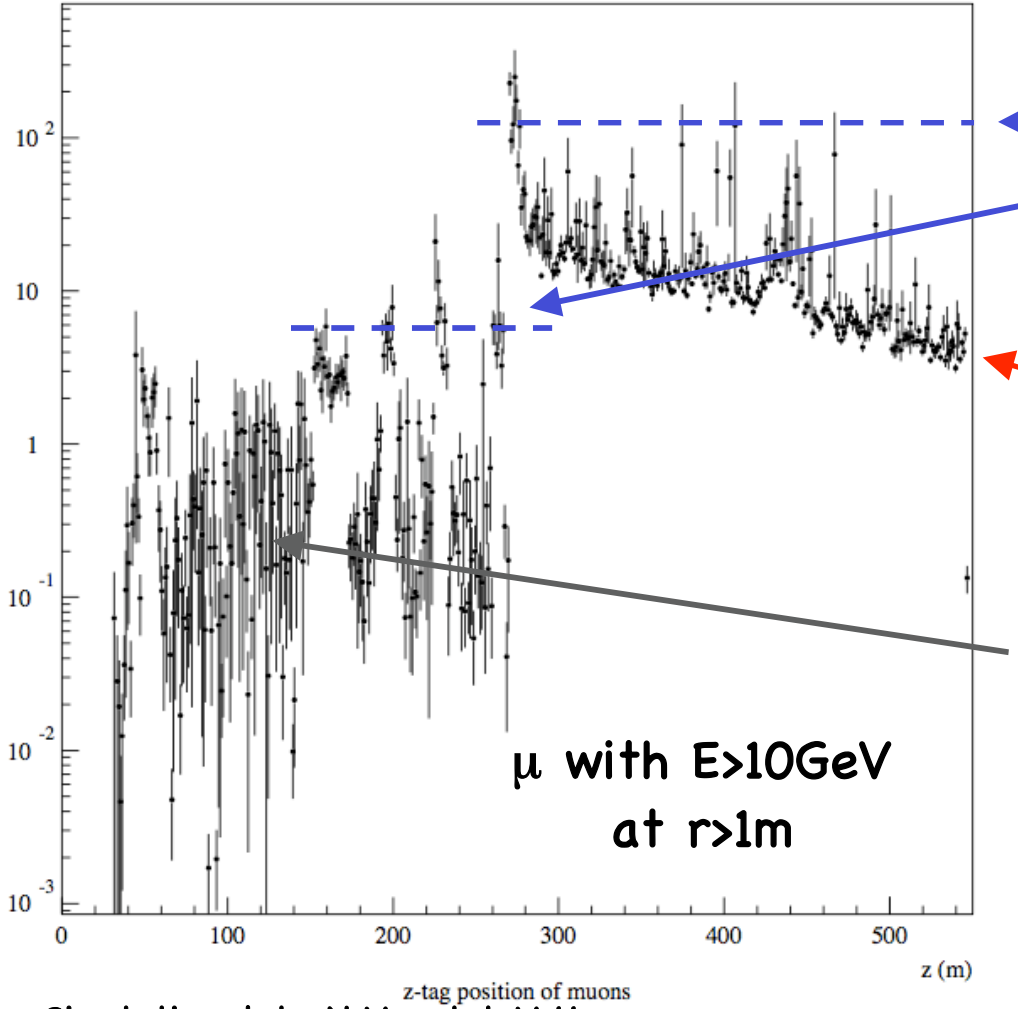
(Bayshev used old vacuum maps of I.Collins, where H_2 was the dominating gas. In A.R. maps O_2 dominates in the arcs)

Collimator tails: Losses on TCT ~4E6 s^{-1} (max)

Elastic B-G scattering around ring is clearly non-negligible wrt collimator tails

Inelastic Beam-Gas

Secondaries from inelastic beam-gas can reach experiment



20 times higher pressure in arc than in cold LSS

Some muons even from far (>500m) in the arc

Muons originating from very close do not reach r=1m

DATA FROM AUG 2007
UPDATE TO COME
(but should be similar)

Simulation data N.M., plot M.H.

Collimator tails

Even if the efficiency of the collimation (IP7) is 99.9(9)%, a small fraction of protons escapes and is mainly lost on the TCT:s ~150m from the experiments

In the nominal machine normal losses on the TCT should be ~2E6 p/s

(At 7 TeV quench limit (τ=800s) TCT losses would be ~2E8 p/s)

(Early relaxed IP7 collimator settings would increase relative losses on TCTs)

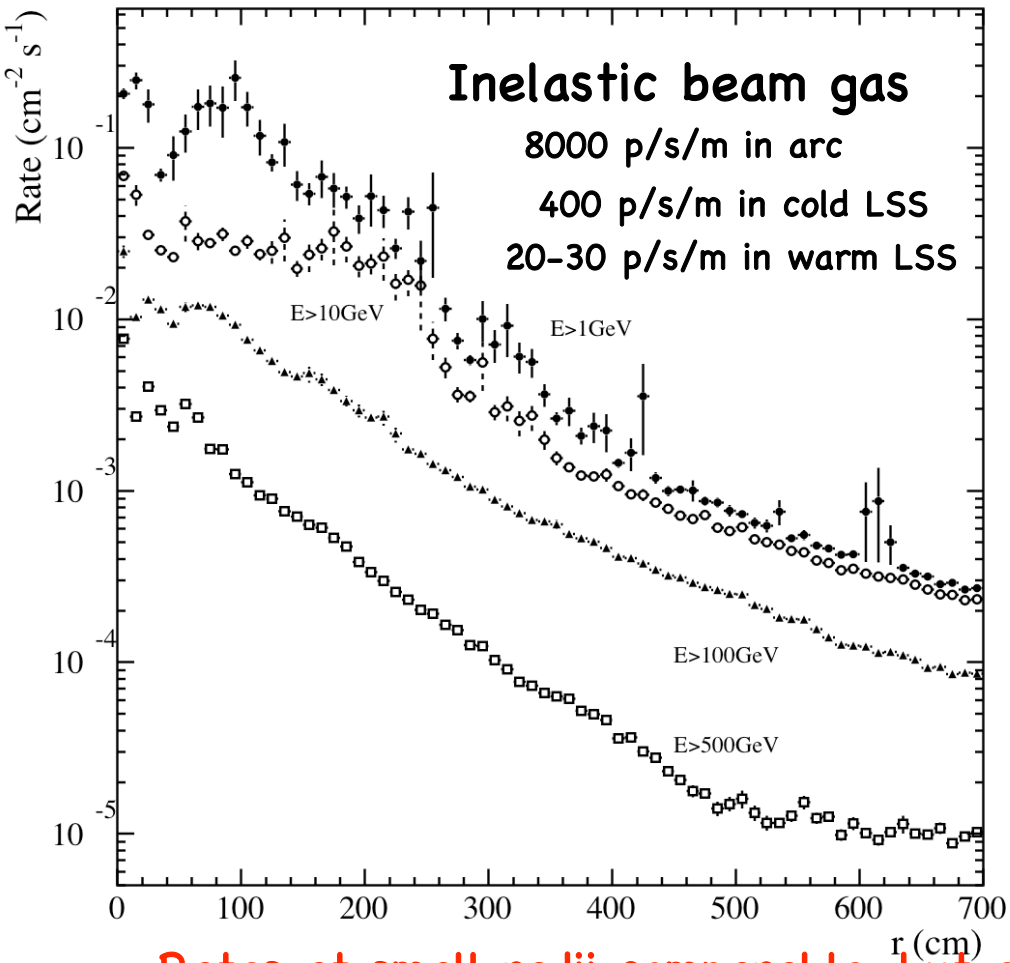
Since these losses are quasi point-like (wrt distance to IP) on the TCT, results should scale quite well with the absolute loss rate

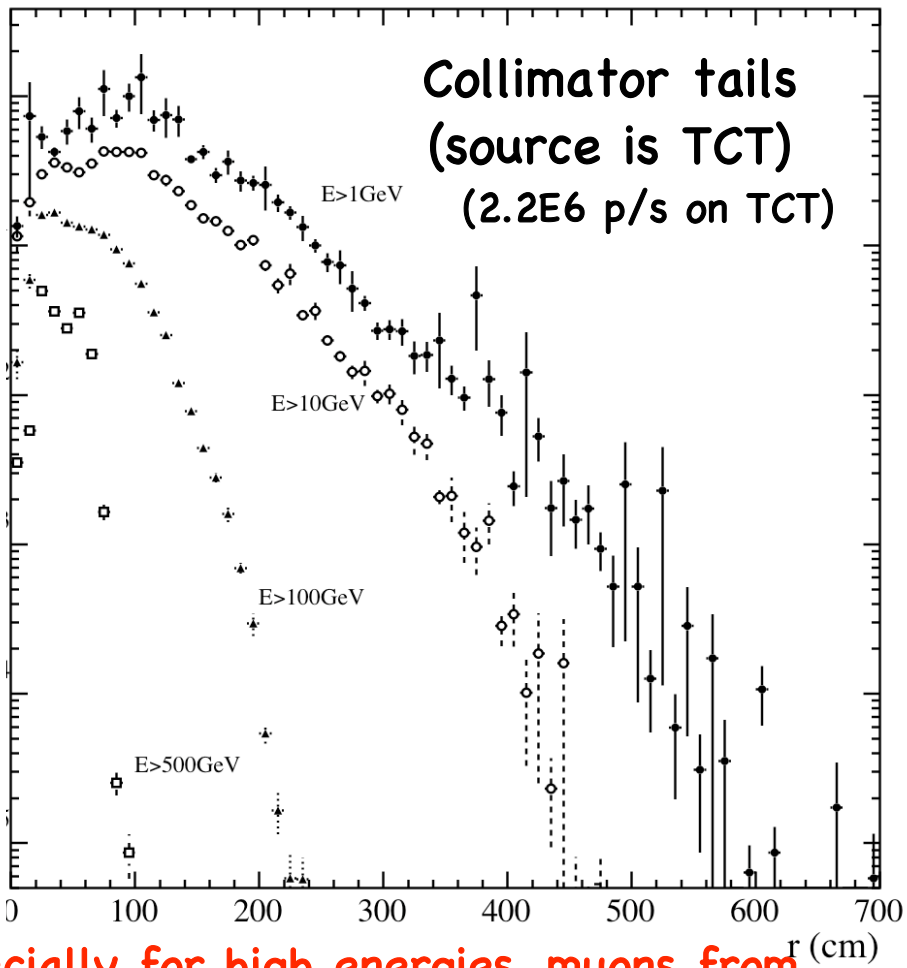
To be clarified:

- How much diffference between 5/7 TeV ?
- Does the optics (β^*) make a difference (and how much) ?
- Does the crossing angle make a difference (and how much) ?

Muon Radial Distributions

Old Aug 2007 data - update to come soon





Rates at small radii comparable, but especially for high energies, muons from protons lost on TCT stay at much smaller radii (no 'tangent'-effect as from arc)

Simulation data N.M., plots M.H.

Future plans (after nominal machine)

Most likely we will take quite long data at ~5+5 TeV

To predict & understand backgrounds during this time and to verify simulations, we asked Nikolai to redo the simulations for the startup machine

Tentatively:

E_{beam} = 5 TeV

Protons/bunch = 4E10

β^*=2m

No crossing angle

43 bunches

Phase 1 collimation (settings tbd *)

Unconditioned vacuum

* Personally I would go for 'startup collimation' as it is probably the worst case (and might last for a while). But I have no strong opinion…

Conclusion (co-existence)

We have made good progress since starting our meetings

First goal of getting complete and consistent background files, usable by ATLAS/CMS software is almost reached (only final production runs missing)

Both collaborations benefit from this exchange of ideas, concerns and studies at a fairly informal forum

We will continue our meetings in parallel with the wider LBS-WG

Our meetings are open to everybody, but we restrict our discussions to ATLAS/CMS specific issues

There must (and will) be a continuous information exchange (in both directions!) with the LBS-WG. We will need input from the machine and we will report regularly on our studies.

Unlike LBS-WG we also discuss beam accident conditions/consequences