MARS15 Files of Background Loads on CMS and ATLAS: Tertiary Beam Halo (Collimation Tails)

Nikolai V. Mokhov
November 13, 2008

Results of detailed MARS15 [1] calculations of machine-induced background (MIB) loads on the CMS and ATLAS detectors can now be downloaded from http://www-ap.fnal.gov/users/mokhov/LHC/beam-halo for the first component of MIB, tertiary beam halo (collimation tails) related to the inefficiency of the main collimation system. This is for protons escaping the betatron cleaning insertion IP7 and being intercepted by the IP1 and IP5 tertiary collimators TCT.

An ideal LHC machine (no alignment and magnet errors) is assumed at 7 TeV with the high-luminosity insertions (IP1 and IP5) squeezed to $\beta^* = 0.55$m, for a 10-hr beam lifetime and nominal intensity. The collimators were set to the nominal settings, in this case 8.3σ for the tertiary collimators. Other details of the setup, simulation procedure and beam loss rates as well as the main properties of background loads are described in Ref. [2]. The files in this directory are normalized for the Beam-2 approaching IP5 in a counter-clockwise direction. They can be directly used for the Beam-1 approaching IP1 in the clockwise direction by multiplying all results by a factor of 1.64. Corresponding contributions on the other sides of IP1 and IP5 are about 10% of those obtained with the source term of this directory. Contributions from the momentum cleaning at IP3 are thought to be substantially lower.

Any use of the files of this directory assumes the references to [1] and [2]:

[1] N.V. Mokhov, "The Mars Code System User's Guide", Fermilab-FN-628 (1995); N.V. Mokhov, S.I. Striganov, "MARS15 Overview", in *Proc. of Hadronic Shower Simulation Workshop*, Fermilab, September 2006, AIP Conf. Proc. 896, p. 50 (2007); Fermilab-Conf-07/008-AD (2007); http://www-ap.fnal.gov/MARS/

[2] N.V. Mokhov, T. Weiler, "Machine-Induced Backgrounds: Their Origin and Loads on ATLAS/CMS", Fermilab-Conf-08-147-APC, May 2008.

Results in this directory are organized in 10 separate files each containing about 180 thousand particles with kinetic energy $E > E_{th}$=20 MeV crossing the machine-detector interface plane at z=22.6 m for the beam approaching the IP (see Fig. 1). Each file is a result of an independent MARS15 run for 3.e6 beam loss events on the TCTs (PRIME=3.e6), totaling in 3.e7 beam loss events and 1830318 particles at the interface plane. One can concatenate these files into the one with PRIME=3.e7 and NSTACK=1830318, or use these files independently for the purpose of runs in CMS and ATLAS with statistical analysis and – possibly – with a reduced statistics. Each of the ten files is about 35 MB in size, or 9.7 MB in a compressed form. To uncompress, use the "gunzip" command.

Each particle carries a statistical weight of W which must be used in the CMS and ATLAS runs. At least one of the ten files needs to be processed to get a correct normalization. Then, to get a correct normalization in units of "per second", the scoring results for weighted particles (W) must be multiplied by the factor of W1 = 8.3e9/PRIME. One can always check if the normalization is correct by comparing with the results of [2]. For historical/technical reasons, the right-handed coordinate system used in the MARS15 runs for Beam-2 approaching IP5 is with z-axis pointing from the IP towards the incoming beam, y-axis is pointing from the IP to the outside of the LHC ring, and x-axis is pointing from the IP down to the floor (Fig. 1). Rethink this yourself for 3 other cases. This note is especially important for the strongly asymmetric case of beam-gas scattering to be released soon. Format of the files is described in the following two pages.

Each line in the files contains the following variables:

```
NI,JJ,E,W,X,Y,DCX,DCY,TOFF,PRIMEHITZ,
      ZORIG,XORIG,YORIG,EORIG,WORIG,IORIG,KORIG
```

where

NI = event number (irrelevant for detector simulations because correlations are destroyed by the weighting anyway).

JJ = particle ID, as follows:

Mars ID	Lund type	Fluka type	Particle name
1	2212	1	p
2	2112	8	n
3	211	13	pi+
4	-211	14	pi-
5	321	15	K+
6	-321	16	K-
7	-13	10	mu+
8	13	11	mu-
9	22	7	g
10	11	3	e-
11	-11	4	e+
12	-2212	2	ap
13	111	23	pi0
14	0	0	D
15	0	0	T
16	0	0	He3
17	0	0	He4
18	14	5	num
19	-14	6	nam
20	12	5	nue
21	-12	6	nae
22	130	12	K0L
23	310	19	K0S
24	311	24	K0
25	-311	25	AK0
26	3122	17	LAM
27	-3122	18	ALA
28	3222	21	SI+
29	3212	22	SI0
30	3112	20	SI-
31	-2112	9	nba
32	3322	34	KS0
33	3312	36	KS-
34	3334	38	OM-
35	-3112	31	sb-
36	-3212	32	sb0
37	-3222	33	sb+
38	-3322	35	Ak0
39	-3312	37	Ak+
40	-3334	39	OM+

X, Y = transverse position of the particle at the interface plane

DCX, DCY = direction cosines of the particle at the interface plane

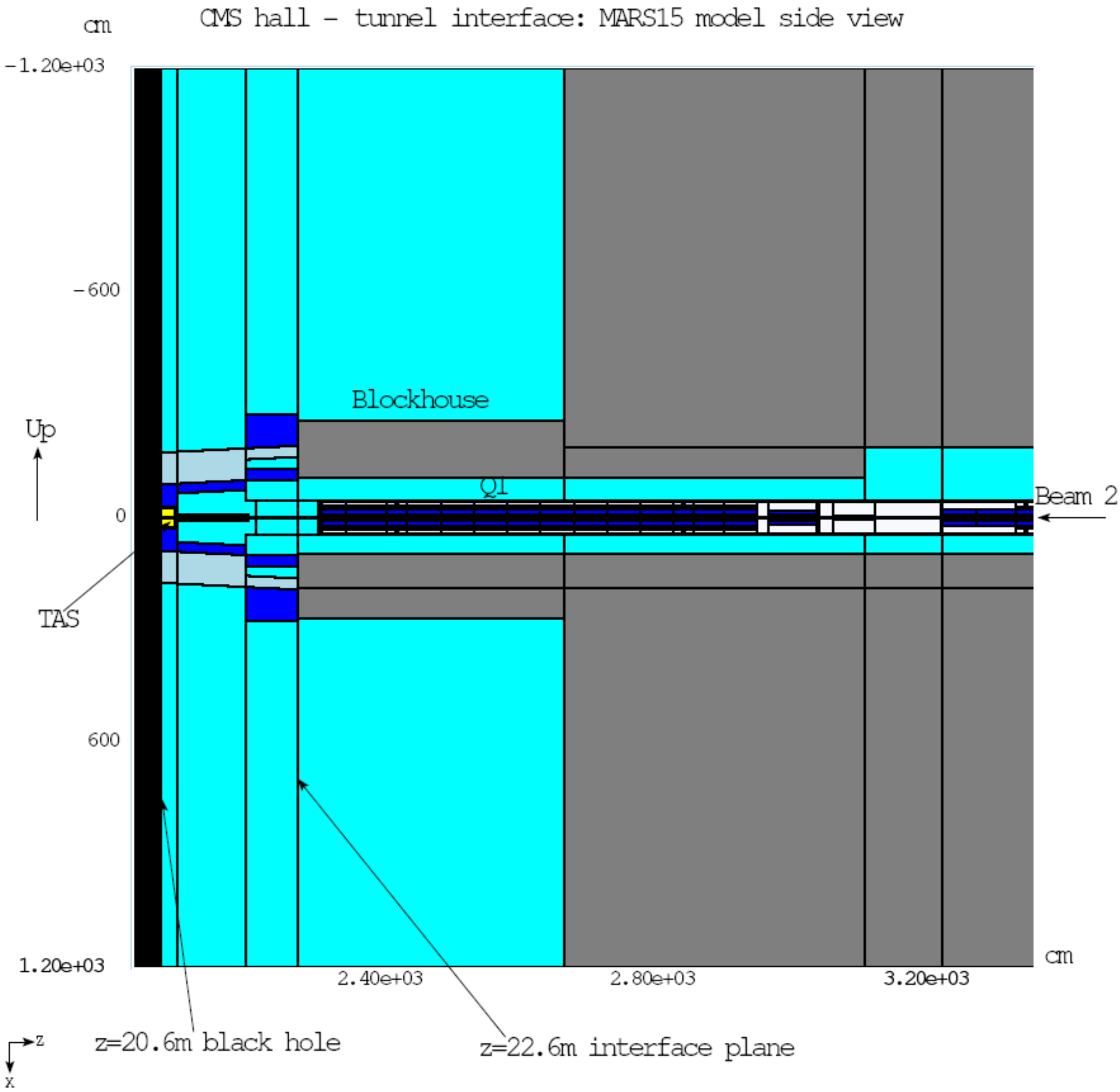
```
TOFF      =  TOF between the primary proton loss and
             the interface plane at 22.6 m.

PRIMEHITZ = z-coordinate of the primary proton loss
            (for halo produced by scraping at the TCT,
            should be about 148m in all cases,
            i.e. z_TCT).

ZORIG, ..., KORIG tag the origin of hadrons, muons,
            heavy ions and electromagnetic showers (EMS),
            as follows.
            This particle (JJ is not 9, 10 or 11)
            or the EMS (JJ = 9, 10 or 11) originated
            from a particle with particle type IORIG=ID
            (see table of particle types above)
            of energy EORIG and weight WORIG in
            the process KORIG at the point
            (XORIG,YORIG,ZORIG).

KORIG =      0 - primary beam
             1 - muons, unstable particle decay
             2 - muons, prompt at hA-vertex
             3 - muons, Bethe-Heitler pair
             4 - muons, e+e- annihilation
             5 - hadrons, hA-vertex
             6 - hadrons, elastic
             7 - hadrons, from muons
             8 - hadrons, unstable particle decay
             9 - hadrons, EMS
            10 - hadrons, recoil LEN
            11 - hadrons, from neutrinos
            12 - EMS, induced by photons from pi0-decay
            13 - EMS, induced by synchrotron photons
            14 - EMS, induced by g,e+,e-, at hA vertex
            15 - EMS, induced by knock-on electrons
                  from muons or hadrons
            16 - EMS, induced by g,e+,e-
                  from unstable particle decay
            17 - EMS, induced by prompt e+e-
                  from muons or hadrons
            18 - EMS, induced by brems photons from muon
            19 - EMS, induced by photons from stopped muons
            20 - EMS, induced by photons from low-energy neutrons
            21 - muons, vector mesons
```

Fig. 1:


CMS hall – tunnel interface: MARS15 model side view
cm
-1.20e+03
-600
0
600
1.20e+03
Blockhouse
Up
Q1
Beam 2
TAS
2.40e+03
2.80e+03
3.20e+03
cm
z
x
z=20.6m black hole
z=22.6m interface plane