Comparison between MARS1507 and MARS1510 at CERN & BNL

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MARS installation

MARS1507:
- last update 21-July-2009 at CERN.
- benchmarked on x32 but not on x64 architecture.
- comparison with m1507 at BNL was giving different yields.

MARS1510:
- installed in 11-February-2011 at CERN.
- 64x architecture only.
- need small modifications in the .INP file in order to run (e.g., space after comment sign C needed).
- comparison with m1510 at BNL also giving different yields.
Run to run comparison - $10^5$ protons - ST2 – 5-15 GeV beams – Biggest deviation of $|N_{1507} - N_{1510}| / N_{1507}$ & corresponding energy setting in ().
Statistical fluctuation (σ for 50 runs with different random seeds) is ~2-3% (as for MARS1507).

Figure of merit for muons at 50 m.

Difference in versions within stat. errors.
Checking particles distribution for 50 runs with different seeds.

5-15 GeV – ST2 at z = 50 m.

Standard deviation (\(\sigma\)):

- below 3% for the muons (within an energy cut).
- 13% for \(\nu\mu\) and 10% for \(\nu\mu\bar{\nu}\).
- 51% for \(\nu\tau\) (but small statistics).

Consistent across the beam energy range.
10\(^5\) protons - ST2 – 5 -15 GeV beam.

Biggest deviation of \(|N_{\text{CERN}} - N_{\text{BNL}}| / N_{\text{CERN}}\) and corresponding energy setting in ().

<table>
<thead>
<tr>
<th>PID</th>
<th>Name</th>
<th>0 m</th>
<th>50 m</th>
<th>PID</th>
<th>Name</th>
<th>0 m</th>
<th>50 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>p</td>
<td>0.03±0.06 (5)</td>
<td>0.25±0.01 (7)</td>
<td>14</td>
<td>d</td>
<td>0.41±0.06 (5)</td>
<td>0.32±0.14 (6)</td>
</tr>
<tr>
<td>2</td>
<td>n</td>
<td>0.03±0.07 (5)</td>
<td>-</td>
<td>18</td>
<td>ν(\mu)</td>
<td>0.07±0.03 (12)</td>
<td>0.33±0.08 (5)</td>
</tr>
<tr>
<td>3</td>
<td>(\pi^+)</td>
<td>0.12±0.01 (5)</td>
<td>0.07±0.02 (9)</td>
<td>19</td>
<td>ν(\mu)</td>
<td>0.14±0.04 (12)</td>
<td>0.20±0.07 (15)</td>
</tr>
<tr>
<td>4</td>
<td>(\pi^-)</td>
<td>0.04±0.01 (7)</td>
<td>0.05±0.02 (5)</td>
<td>20</td>
<td>νe</td>
<td>0.19±0.05 (12)</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>K(+)</td>
<td>0.13±0.03 (8)</td>
<td>-</td>
<td>21</td>
<td>νe</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>K(-)</td>
<td>0.14±0.07 (15)</td>
<td>-</td>
<td>22</td>
<td>ν(\tau)</td>
<td>0.15±0.09 (9)</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>(\mu^+)</td>
<td>0.10±0.07 (8)</td>
<td>0.05±0.01 (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>(\mu^-)</td>
<td>0.10±0.07 (7)</td>
<td>0.06±0.01 (14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>γ</td>
<td>0.03±0.03 (6)</td>
<td>97.4±46.7 (14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>e(-)</td>
<td>0.04±0.02 (5)</td>
<td>0.19±0.02 (14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>e(+)</td>
<td>0.07±0.02 (8)</td>
<td>0.21±0.02 (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weighted yield > 100.

Black < 5 %

Green 5-9%

Blue 10-19%

Red > 19%
$10^5$ protons - ST2 – run to run comparison:

- Figure of merit at 50 m.

Up to 10% difference between BNL and CERN.
ST2 – 5 GeV beam – one run – $10^5$ and $2\times10^5$ protons – N.

$1p - 2n - 3\pi^+ - 4\pi^- - 5K^+ - 6K^- - 7\mu^+ - 8\mu^- - 9\gamma - 10e^- - 11e^+ - 12\bar{p}$ – $13\pi^0 - 14\bar{d}$
$15\tau - 16^3He - 17^4He - 18\nu\mu - 19\bar{\nu}\mu - 20\nu\bar{e} - 21\bar{\nu}e - 22\nu\tau$
ST2 – 5 GeV beam – $10^5$ and $2 \times 10^5$ protons - $N_{\text{CERN}} - N_{\text{BNL}}$. 

1 p - 2 n - 3 $\pi^+$ - 4 $\pi^-$ - 5 $K^+$ - 6 $K^-$ - 7 $\mu^+$ - 8 $\mu^-$ - 9 $\gamma$ - 10 $e^-$ - 11 $e^+$ - 12 pbar - 13 $\pi^0$ - 14 d 
15 t - 16 $^3$He - 17 $^4$He - 18 $\nu\mu$ - 19 $\nu\mu$bar - 20 $\nu e$ - 21 $\nu e$bar - 22 $\nu\tau$
m1510 at CERN and BNL (3/)

- ST2 – 5 GeV beam – $10^5$ and $2 \times 10^5$ protons

- $\left( N_{\text{CERN}} - N_{\text{BNL}} \right) / N_{\text{CERN}}$.

For $\nu_\mu$ (50 m) and $\nu_\tau$ (0 m) large difference not explained by statistics.

$1 \ p - 2 \ n - 3 \pi^+ - 4 \pi^- - 5 K^+ - 6 K^- - 7 \mu^+ - 8 \mu^- - 9 \gamma - 10 e^- - 11 e^+ - 12 \overline{p} - 13 \pi^0 - 14 \ d - 15 \ t - 16 \ ^3\text{He} - 17 \ ^4\text{He} - 18 \nu_\mu - 19 \nu_\text{\overline{\mu}} - 20 \overline{\nu}_e - 21 \overline{\nu}_e - 22 \nu_\tau$
**m1510 at CERN and BNL (4/**)

- **ST2** – 5 GeV beam – 50 runs with different random seeds (same seeds sequence at CERN & BNL).

Good agreement for 50 runs for muons within an energy cut.
Feedback from N. Mokhov (03 June 2011)

“No doubt, this TINY difference comes from the different compiler versions on the two sites resulting in a shift of random numbers in the course of Monte Carlo. For the statistics you studied, the agreement and differences are fully consistent. You can do a test with a simple toy model to see this. I will look myself later, just let me know what machines have exactly been used for this study at CERN and BNL ”.

Example of ICOOL 3.20 (which contains also random generators/seeds) on two different machines, SLC5 - 64x - gcc 4.1.2 and SLC4 – 32x – gcc 3.4.6 produces the EXACT same output for ~1000 particles ~ 100 m lattice with RF and solenoids.

Some of the PID, to me are not in agreement (discussing with Nikolai). Shift of random seeds due to compiler, seems still a strange explanation:

BNL - Scientific Linux (SL) 5.5 – gcc 4.1.2
CERN - Scientific Linux CERN (SLC) 5 (2.6.18-238.12.1.el5) - gcc 4.1.2
-> mystery not solved since we seem to have same compiler & kernel...
Conclusion & todo

m1507 & m1510 comparison @CERN:
- 5-10 GeV beams, muons yield @50 m within statistical errors (for 50 runs - using Ekin cuts).
- $\nu_\mu$ distribution (50 runs - m1510) spread 10-13% of the mean, excepted for $\nu_e$ at 51% (but also small statistics).

m1507 at CERN & BNL comparison:
- 5-15 GeV beams muons yield @50 m difference up to 10% (run to run – using Ekin cuts).

m1510 at CERN & BNL comparison – 5 GeV beam:
- Run to run difference does not seem to be due to statistics.
- Muon yield@50 m from 50 runs within energy cut, good agreement.

- MARS difference need feedback/explanation from N. Mokhov.
- Run in LAQGSM mode (m1510 only).
- Need to complete m1510 check at BNL.

Thanks to Xiaoping & Nicholas for the help with the MARS simulation comparison.