

# 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.

# m1507 & m1510 @CERN (1/)

- Run to run comparison -  $10^5$  protons - ST2 – 5-9 GeV beams – Biggest deviation of  $|N_{1507} - N_{1510}|/N_{1507}$ .

PID#	Name	0 m	50 m
1	p	3%	10 %
2	n	2%	-
3	$\pi^+$	3%	7%
4	$\pi^-$	2%	9%
5	K+	19%	-
6	K-	10%	-
7	$\mu^+$	19%	6%
8	$\mu^-$	13%	3%
9	$\gamma$	7%	-
10	e-	5%	5%
11	e+	5%	6%

PID#	Name	0 m	50 m
12	pbar	-	-
13	$\pi^0$	-	-
14	d	11%	21%
15	t	-	-
16	3He	-	-
17	4He	-	-
18	$\nu\mu$	8%	34%
19	$\nu\mu\text{bar}$	10%	39%
20	$\nu e$	13%	38%
21	$\nu e\text{bar}$	42%	-
22	$\nu\tau$	38%	-

Weighted yield > 100.

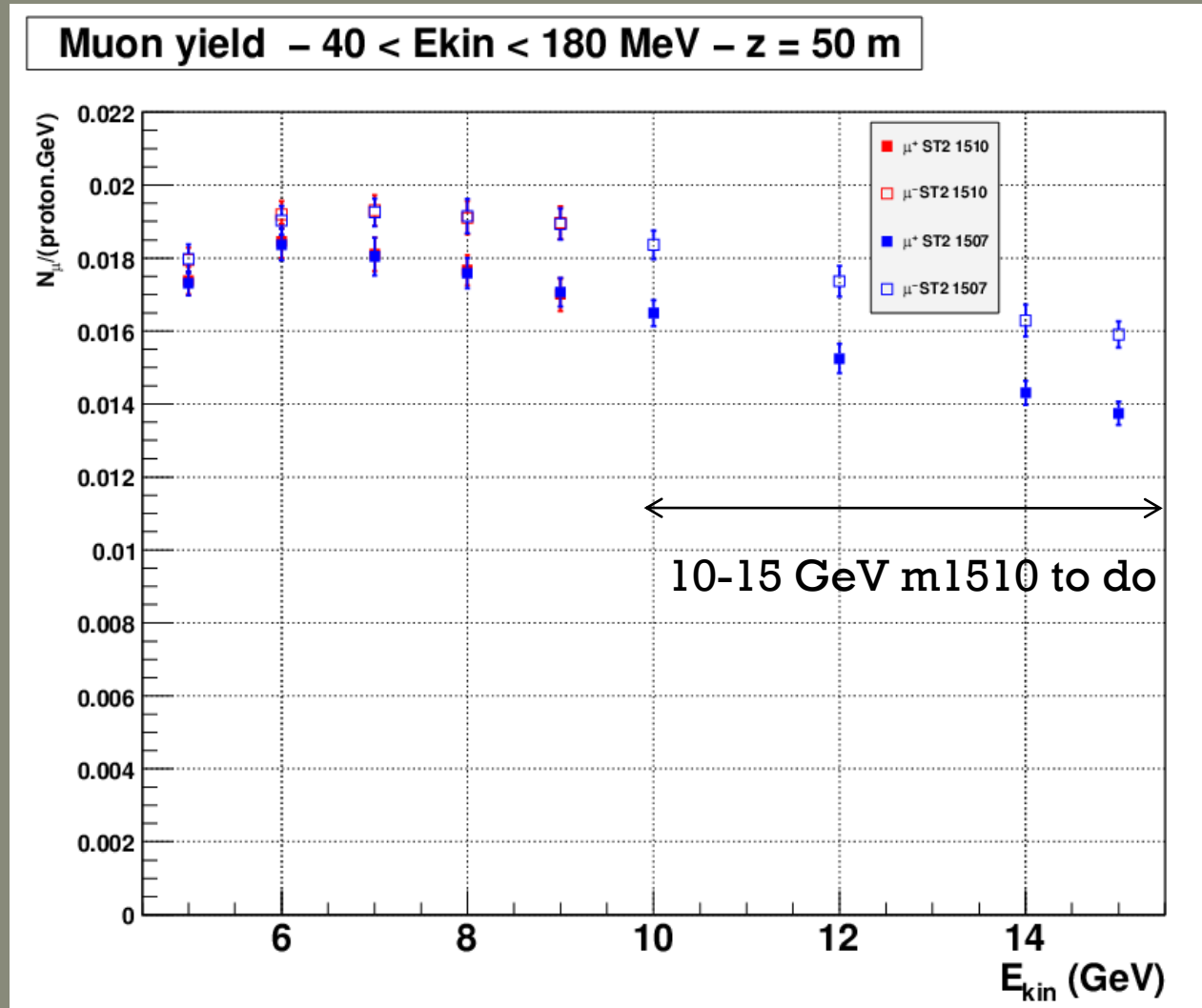
black < 5 % - green 5-10% - blue 10-20% - red > 20%

# m1507 & m1510 @CERN (2/)

- Statistical fluctuation ( $\sigma$  for 50 runs with different random seeds) is  $\sim 2\text{-}3\%$  (as for MARS1507).

- Figure of merit for muons at 50 m.

Difference in versions within stat. errors.

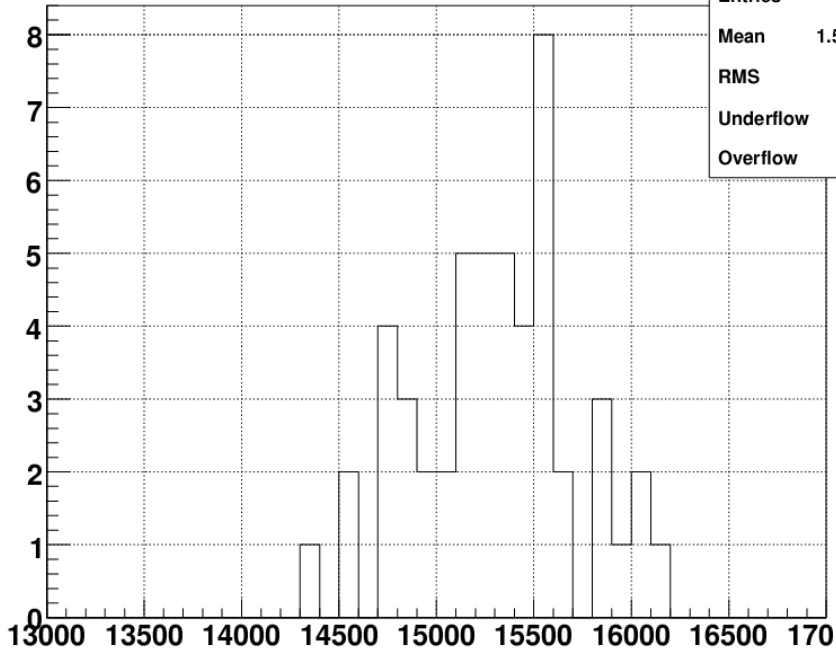


# m1510 @CERN (1/)

Checking particles distribution for 50 runs with different seeds – 9 GeV – ST2 at  $z = 50$  m.

$\mu^+$  distribution 9 GeV – ST2 –  $40 < E_{kin} < 180$  MeV/c

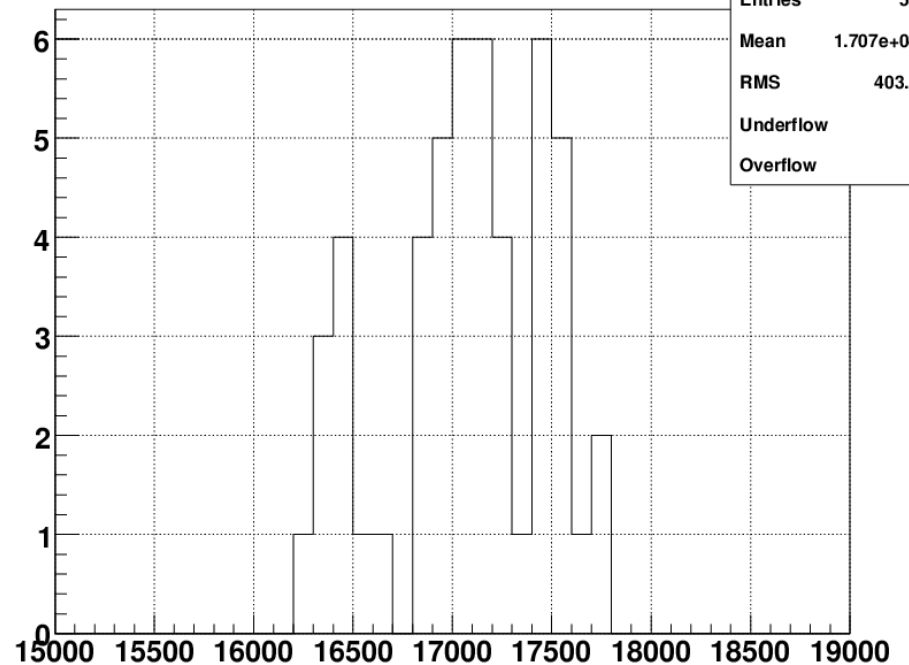
HP	
Entries	50
Mean	1.53e+04
RMS	401.3
Underflow	0
Overflow	0



Standard deviation ( $\sigma$ ) below 5% for the muons (within an energy cut).

$\mu^-$  distribution 9 GeV – ST2 –  $40 < E_{kin} < 180$  MeV/c

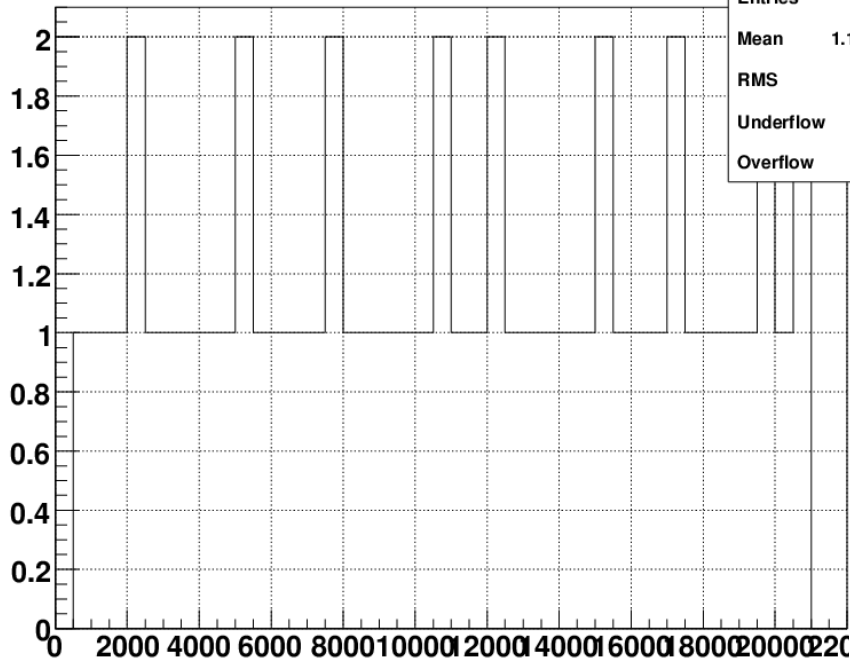
HM	
Entries	50
Mean	1.707e+04
RMS	403.7
Underflow	0
Overflow	0



# m1510 @CERN (2/)

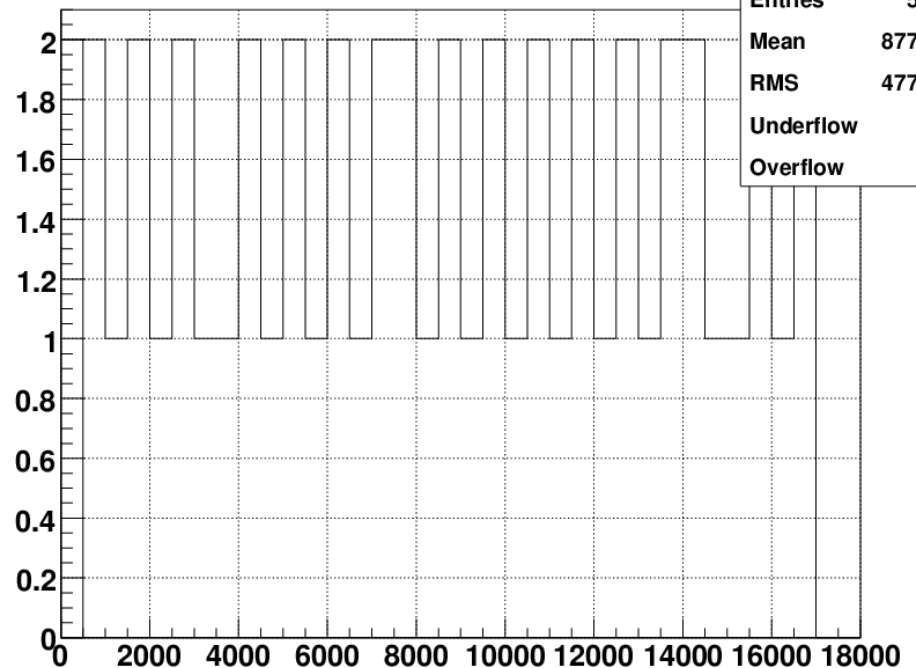
Checking particles distribution for 50 runs with different seeds – 9 GeV – ST2 at  $z = 50$  m.

$v_\mu$  distribution 9 GeV – ST2



Standard deviation ( $\sigma$ ) is 54%.

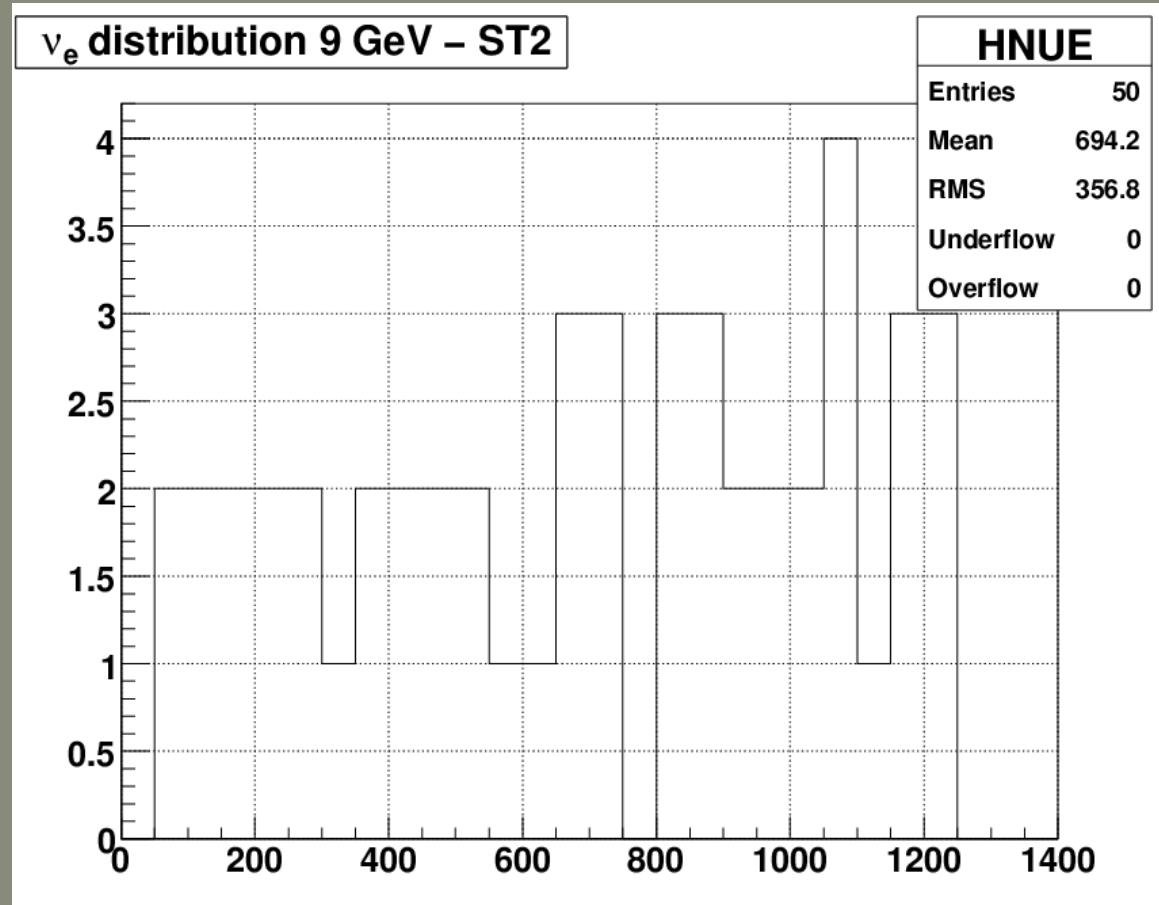
$v_\mu$  bar distribution 9 GeV – ST2



# m1510 @CERN (2/)

- Checking particles distribution for 50 runs with different seeds – 9 GeV – ST2 at  $z = 50$  m.

Standard deviation ( $\sigma$ ) of 51%.

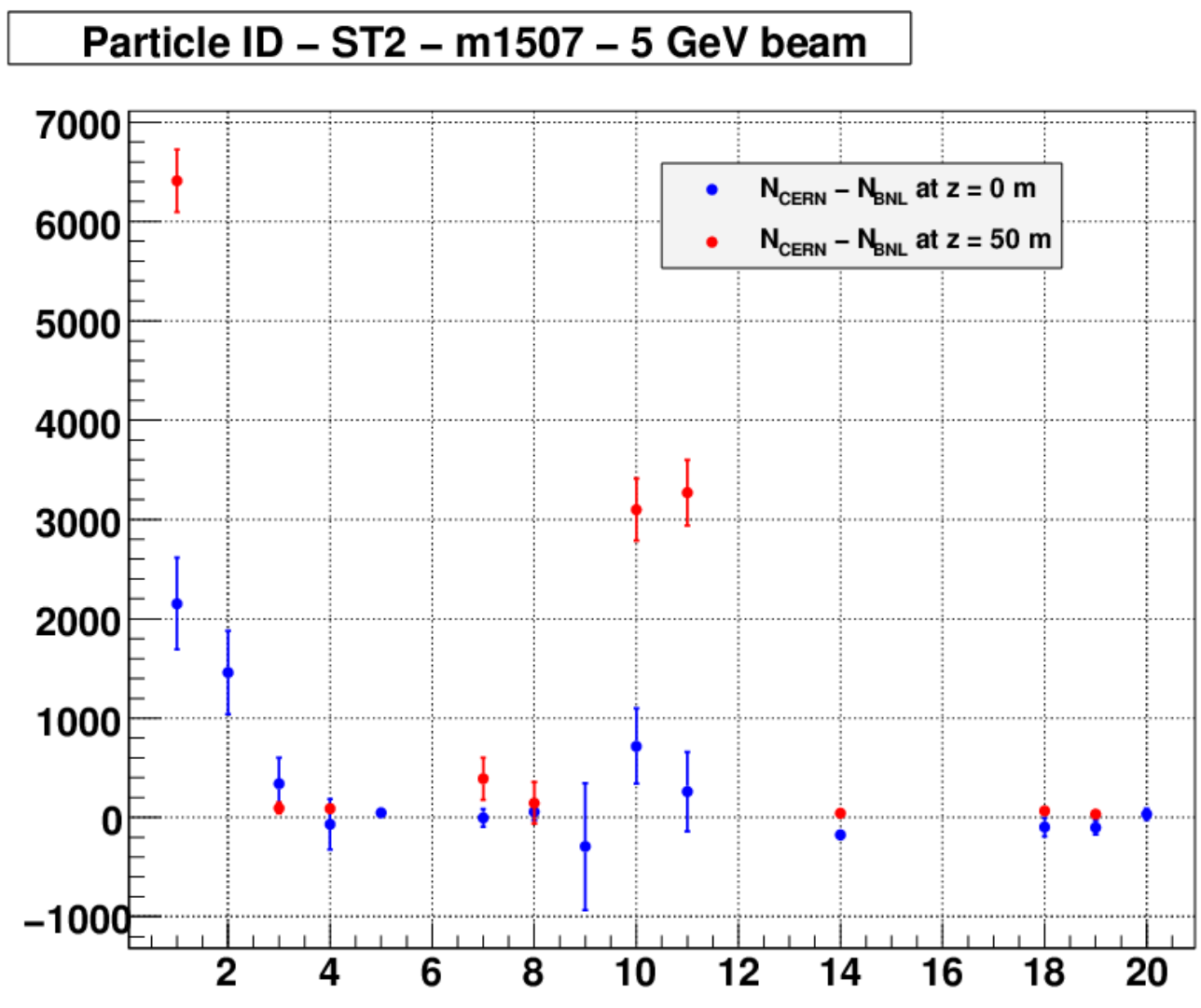


Unfortunately cannot check back 1507 since the code is not available.

# m1507 at CERN and BNL (1/)

●  $10^5$  protons - ST2 - 5 GeV beam - Diff =  $N_{\text{CERN}} - N_{\text{BNL}}$ .

- |                  |                          |
|------------------|--------------------------|
| 1 p              | 15 t                     |
| 2 n              | 16 $^3\text{He}$         |
| 3 $\pi^+$        | 17 $^4\text{He}$         |
| 4 $\pi^-$        | 18 $\nu_\mu$             |
| 5 $K^+$          | 19 $\nu_{\mu\text{bar}}$ |
| 6 $K^-$          | 20 $\nu_e$               |
| 7 $\mu^+$        |                          |
| 8 $\mu^-$        |                          |
| 9 $\gamma$       |                          |
| 10 $e^-$         |                          |
| 11 $e^+$         |                          |
| 12 $p\text{bar}$ |                          |
| 13 $\pi^0$       |                          |
| 14 d             |                          |



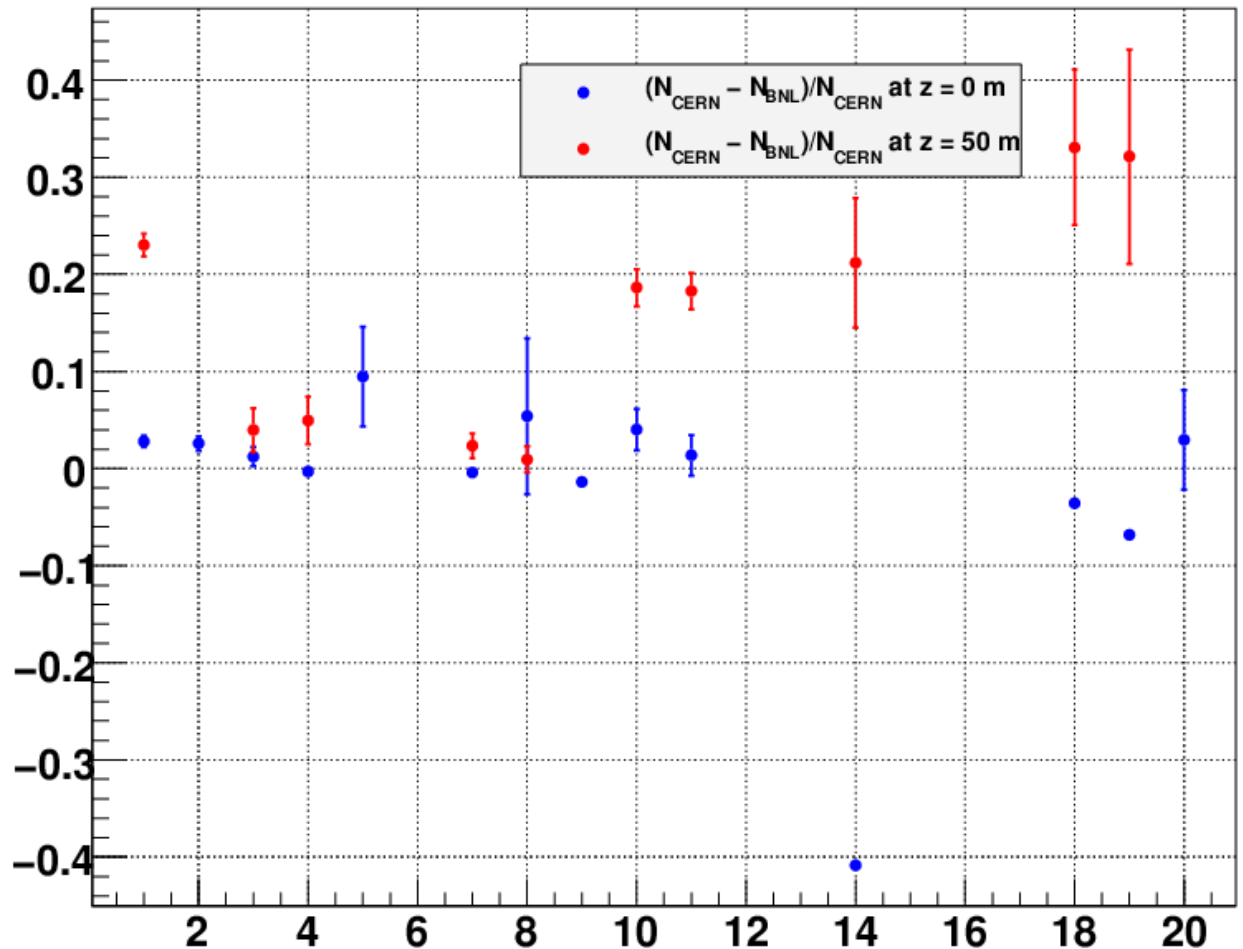


# m1507 at CERN and BNL (2/)

●  $\text{Frac} = (N_{\text{CERN}} - N_{\text{BNL}}) / N_{\text{CERN}}$

- 1 p
- 2 n
- 3  $\pi^+$
- 4  $\pi^-$
- 5  $K^+$
- 6  $K^-$
- 7  $\mu^+$
- 8  $\mu^-$
- 9  $\gamma$
- 10  $e^-$
- 11  $e^+$
- 12  $p\text{bar}$
- 13  $\pi^0$
- 14 d
- 15 t
- 16  $^3\text{He}$
- 17  $^4\text{He}$
- 18  $\nu_\mu$
- 19  $\nu_{\mu\text{bar}}$

Particle ID – ST2 – m1507 – 5 GeV beam



# m1507 at CERN and BNL (3/)

- $10^5$  protons - ST2 – 5 -15 GeV beam max. of  $|N_{\text{CERN}} - N_{\text{BNL}}|/N_{\text{CERN}}$ .

PID#	Name	0 m	50 m
1	p	3%	25%
2	n	3%	-
3	$\pi^+$	11%	7%
4	$\pi^-$	4%	5%
5	$K^+$	13%	-
6	$K^-$	14%	-
7	$\mu^+$	10%	5%
8	$\mu^-$	10%	6%
9	$\gamma$	4%	9736%
10	$e^-$	4%	19%
11	$e^+$	7%	21%

PID#	Name	0 m	50 m
12	pbar	-	-
13	$\pi^0$	-	-
14	d	41%	32%
15	t	-	-
16	$^3\text{He}$	-	-
17	$^4\text{He}$	-	-
18	$\nu_\mu$	7%	33%
19	$\nu_\mu\text{bar}$	14%	32%
20	$\nu_e$	19%	-
21	$\nu_e\text{bar}$	-	-
22	$\nu_\tau$	15%	-

Weighted yield > 100.

black < 5 % - green 5-10% - blue 10-20% - red > 20%

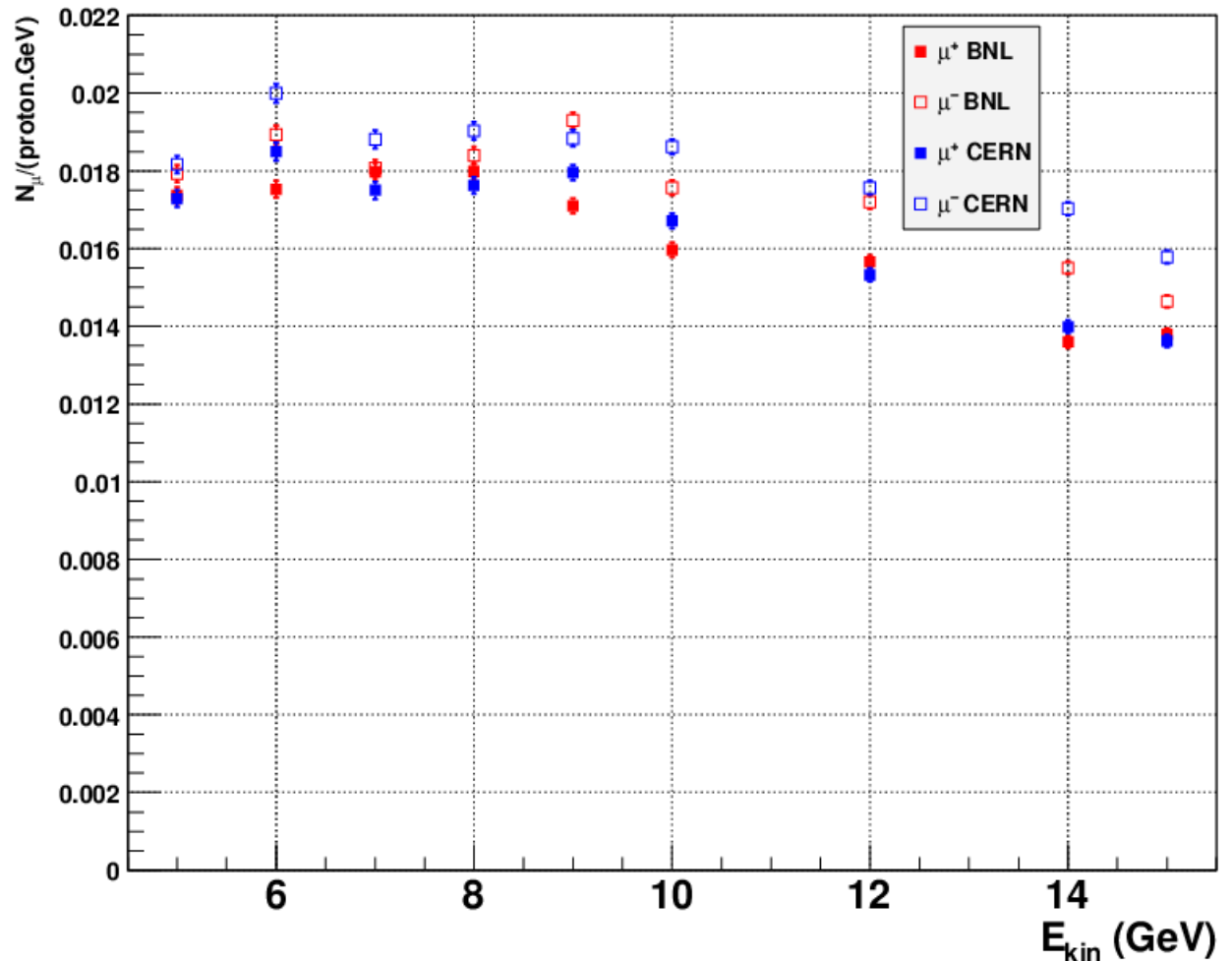
# m1507 at CERN and BNL (4/)

•  $10^5$  protons - ST2 – run to run comparison:

• Figure of merit at 50 m.

Up to 10% difference between BNL and CERN.

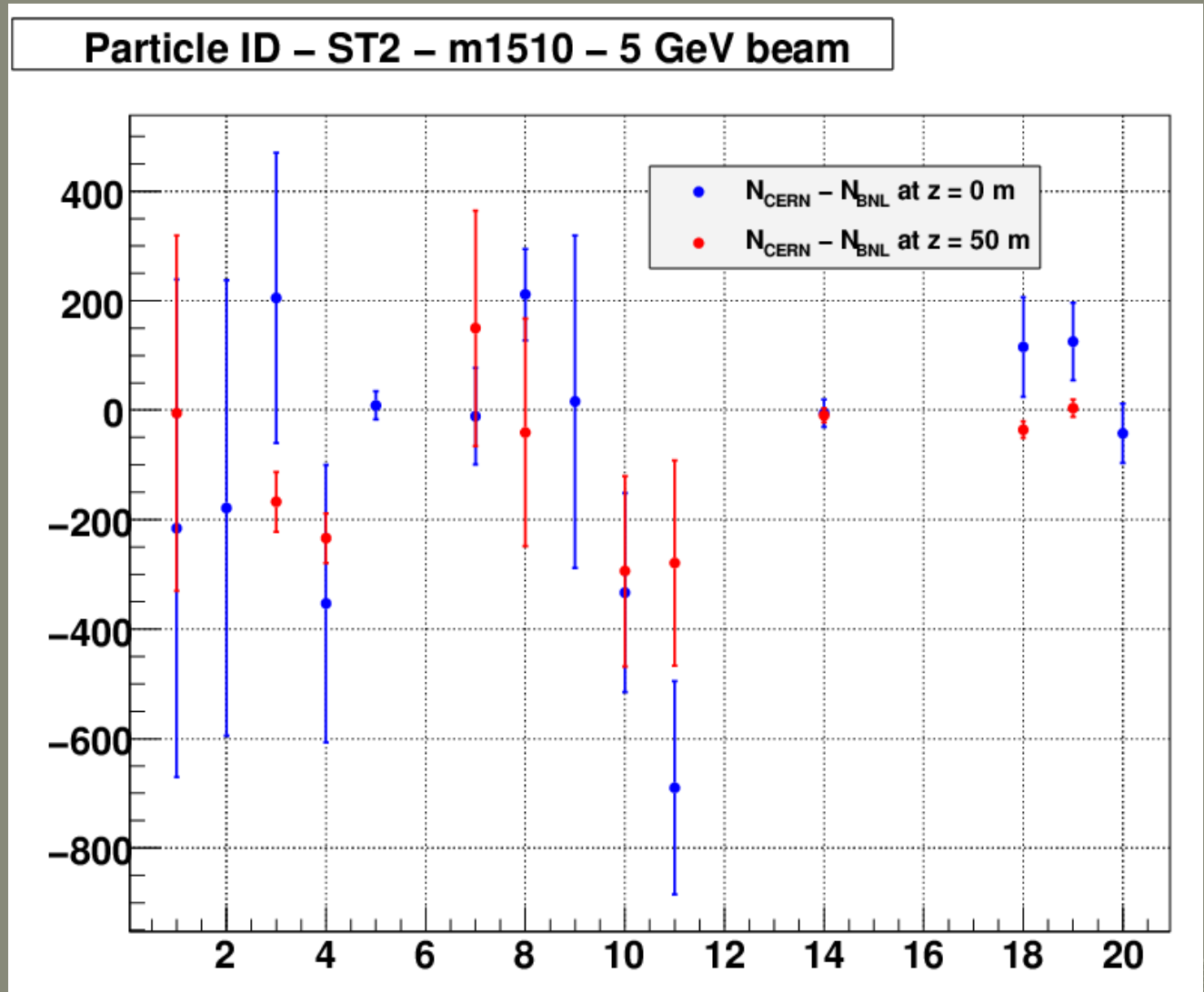
Muon yield – ST2 – 1507 –  $40 < E_{kin} < 180$  MeV –  $z = 50$  m



# m1510 at CERN and BNL (1/)

●  $10^5$  protons - ST2 - 5 GeV beam - Diff =  $N_{\text{CERN}} - N_{\text{BNL}}$ .

- |                  |                          |
|------------------|--------------------------|
| 1 p              | 15 t                     |
| 2 n              | 16 $^3\text{He}$         |
| 3 $\pi^+$        | 17 $^4\text{He}$         |
| 4 $\pi^-$        | 18 $\nu_\mu$             |
| 5 $K^+$          | 19 $\nu_{\mu\text{bar}}$ |
| 6 $K^-$          | 20 $\nu_e$               |
| 7 $\mu^+$        |                          |
| 8 $\mu^-$        |                          |
| 9 $\gamma$       |                          |
| 10 $e^-$         |                          |
| 11 $e^+$         |                          |
| 12 $p\text{bar}$ |                          |
| 13 $\pi^0$       |                          |
| 14 d             |                          |

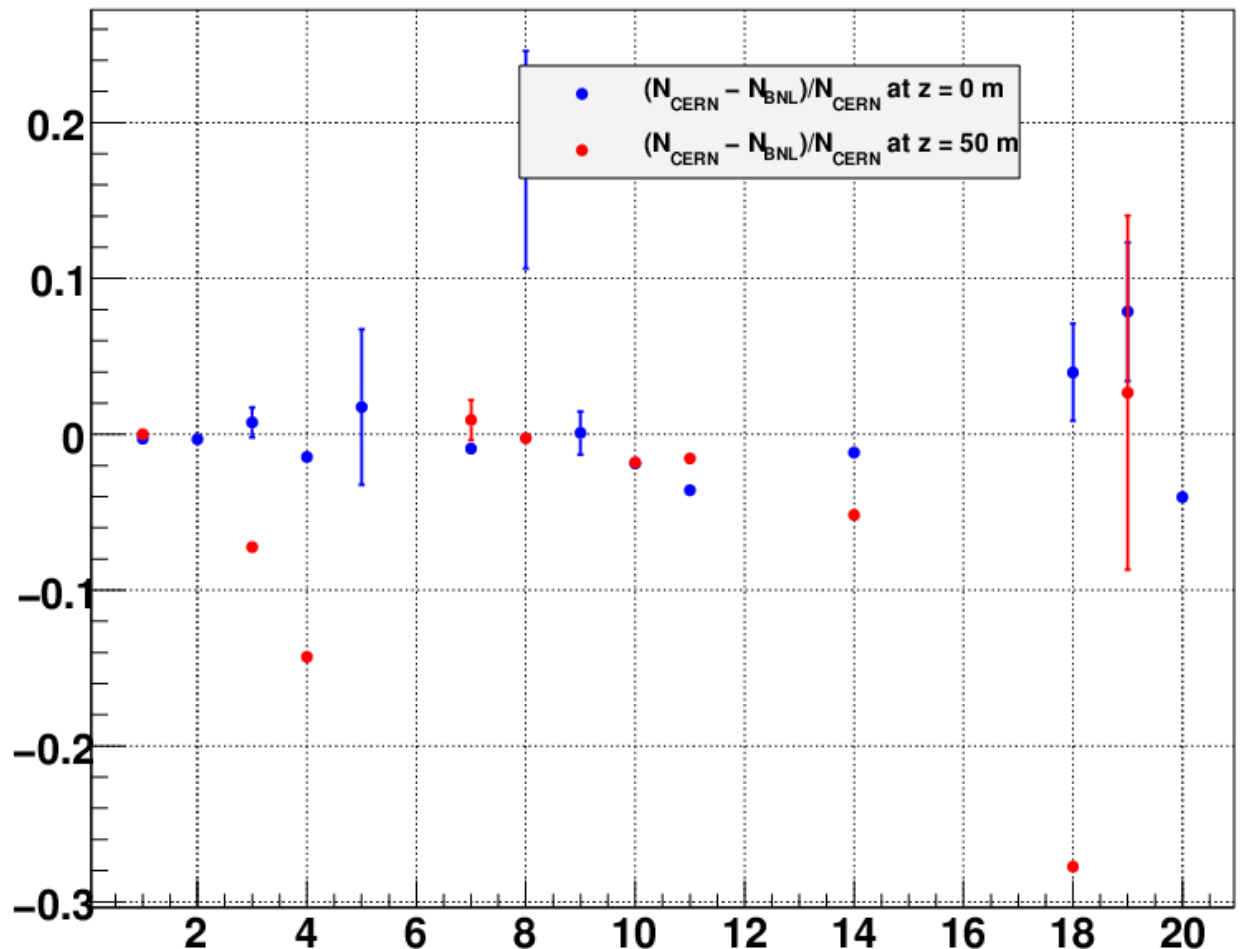


# m1510 at CERN and BNL (2/)

- $10^5$  protons - ST2 - 5 GeV beam.
- $\text{Frac} = (N_{\text{CERN}} - N_{\text{BNL}})/N_{\text{CERN}}$ .

- |                  |                       |
|------------------|-----------------------|
| 1 p              | 15 t                  |
| 2 n              | 16 $^3\text{He}$      |
| 3 $\pi^+$        | 17 $^4\text{He}$      |
| 4 $\pi^-$        | 18 $\nu\mu$           |
| 5 $K^+$          | 19 $\nu\mu\text{bar}$ |
| 6 $K^-$          | 20 $\nu e$            |
| 7 $\mu^+$        |                       |
| 8 $\mu^-$        |                       |
| 9 $\gamma$       |                       |
| 10 $e^-$         |                       |
| 11 $e^+$         |                       |
| 12 $p\text{bar}$ |                       |
| 13 $\pi^0$       |                       |
| 14 d             |                       |

Particle ID - ST2 - m1510 - 5 GeV beam



# m1510 at CERN and BNL (3/)

- Checking runs with twice the statistics ( $2 \cdot 10^5$  protons) at BNL/CERN .
- Checking statistical fluctuation from random seeds at BNL/CERN.
- Feedback from N. Mokhov:

“In vast majority of cases, results should be identical. Certainly, different compiler versions can cause a random number generator shift, then the results should agree within statistical errors. It is practically the case on your plot. I don't remember what gcc versions were used for the installation at BNL and CERN in February. All of the above is true only if your colleagues at Brookhaven Lab use indeed that installation: there are several MARS sites there and a couple of them had a problem during the February's update therefore the code was not updated there”.
- Nicholas confirmed that he uses the “updated BNL site”.
- N. Mokhov also promised to have a look in more details to the code at BNL & CERN (waiting for his feedback).

## Conclusion & todo

- m1507 & m1510 comparison @CERN:
  - 5-9 GeV beams, muons yield @50 m within statistical errors (for 50 runs - using  $E_{kin}$  cuts).
  - **neutrino yields with very large fluctuation (50 runs – 1510).**
- m1507 at CERN & BNL comparison:
  - 5-15 GeV beams muons yield @50 m difference up to 10% (run to run – using  $E_{kin}$  cuts).
- m1510 at CERN & BNL comparison:
  - 5 GeV beam – difference does not seem to be due to stat. fluctuation only.
- **10-15 GeV beams to do in m1510 @CERN.**
- **Finish comparison CERN/BNL (twice the statistics+ random seeds).**
- **Get detailed feedback from N. Mokhov (after May 11).**
- **Run in LAQGSM mode (m1510 only).**

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