Pion production in MARS & tracking in ICOOL from 5-15 GeV beam for NF Front-End study

This is an update on:

Comparison of MARS BNL and MARS CERN codes.

Comparison between ST2 and ST2a for particle production @5-8-14 GeV (MARS @CERN).

Pions yield (ST2a - MARS @CERN) and tracking (ST2a ICOOL deck) @5-8-14 GeV.

Still need to be done:

- **re-run with updated CERN MARS code**
- **run all energy bins**
- **compare to HARP LA/FA yields**
- **tracking with an ICOOL ST2 deck**

MARS BNL and CERN codes (1/)

Two different versions of the MARS code:

- CERN (last update: 16th March 2009)

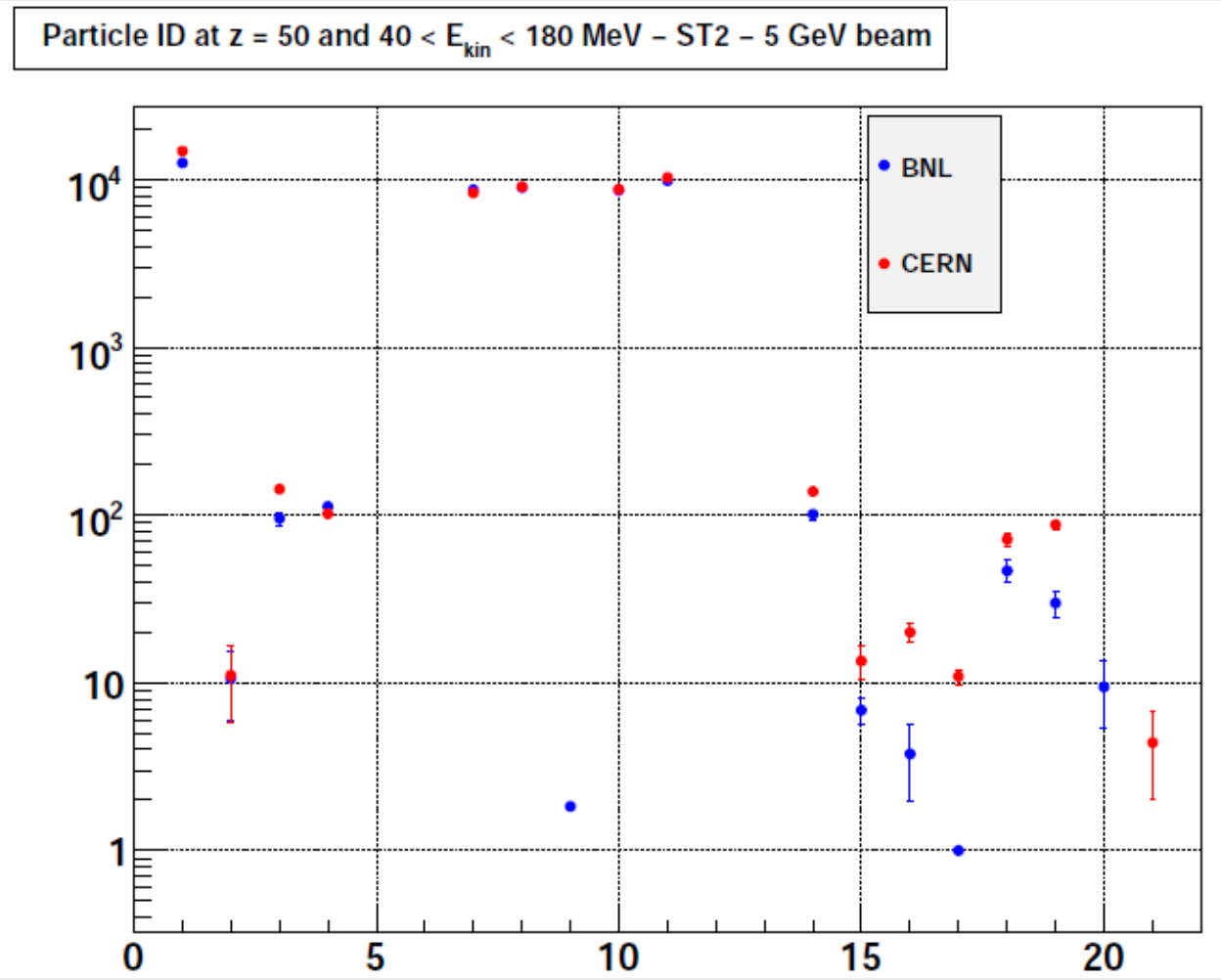
- BNL (last update: 1st May 2009).

Comparison of the codes using 100000 MARS particles for 5-8-14 GeV beams with ST2 field map.

Look at particle yield at z = 50 m and 40 < Ekin < 180 MeV.

MARS BNL and CERN codes (2/)

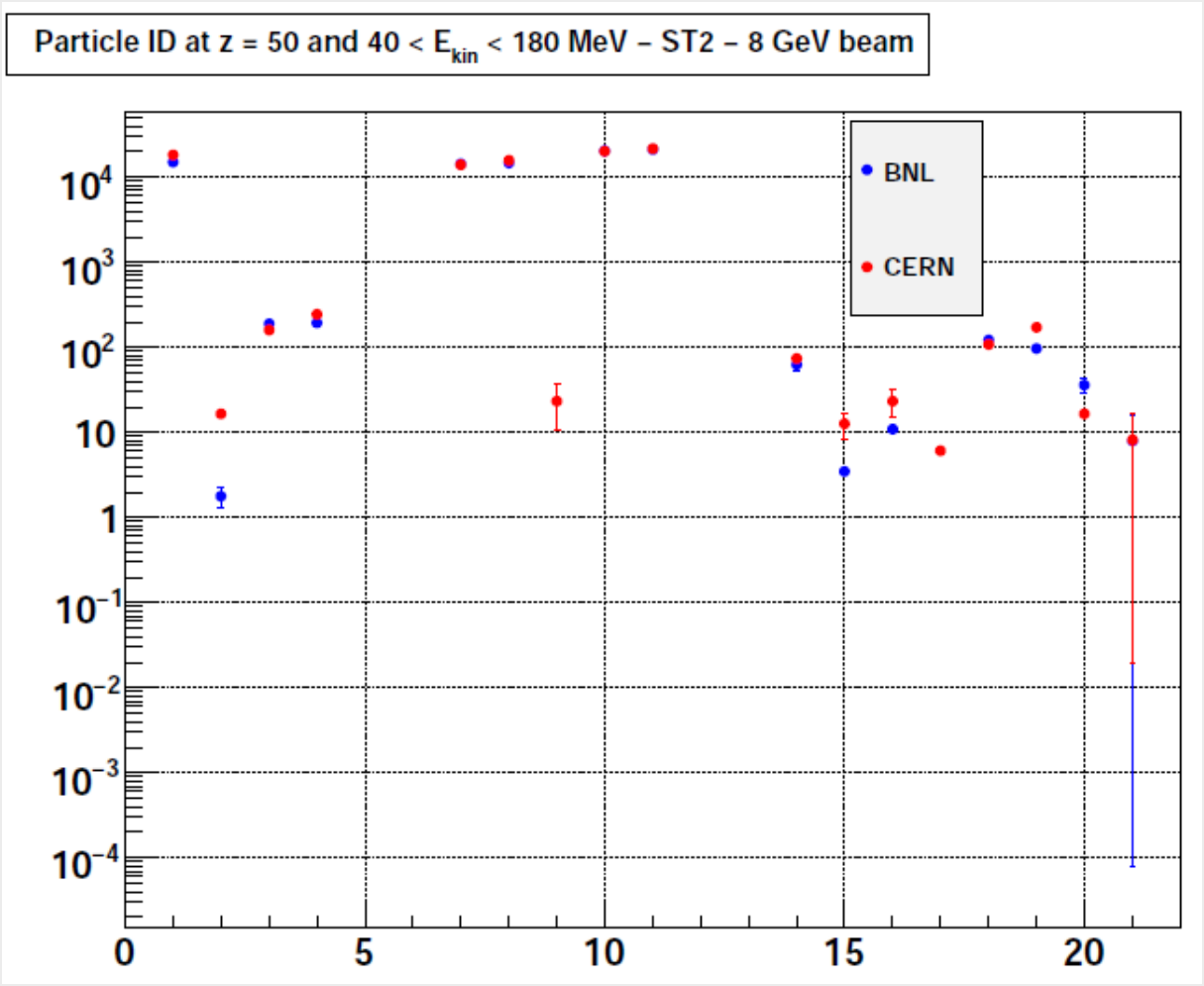
@5 GeV +8% π^+, -10% π^-, -4.5% μ^+, +1.5% μ^-.



PID	Type	$N_{CERN} - N_{BNL}$	Errors
1	p	2246	212
2	n	0	7
3	π^+	47	12
4	π^-	-10	9
7	μ^+	-376	154
8	μ^-	117	157
9	γ	-2	0
10	e^-	107	198
11	e^+	413	238
14	D	37	12
15	T	7	3
16	^{3}He	16	3
17	^{4}He	10	1
18	ν_μ	25	9
19	$\overline{\nu}_\mu$	58	8
20	ν_e	-9	4
21	$\overline{\nu}_\varepsilon$	4	2

MARS BNL and CERN codes (3/)

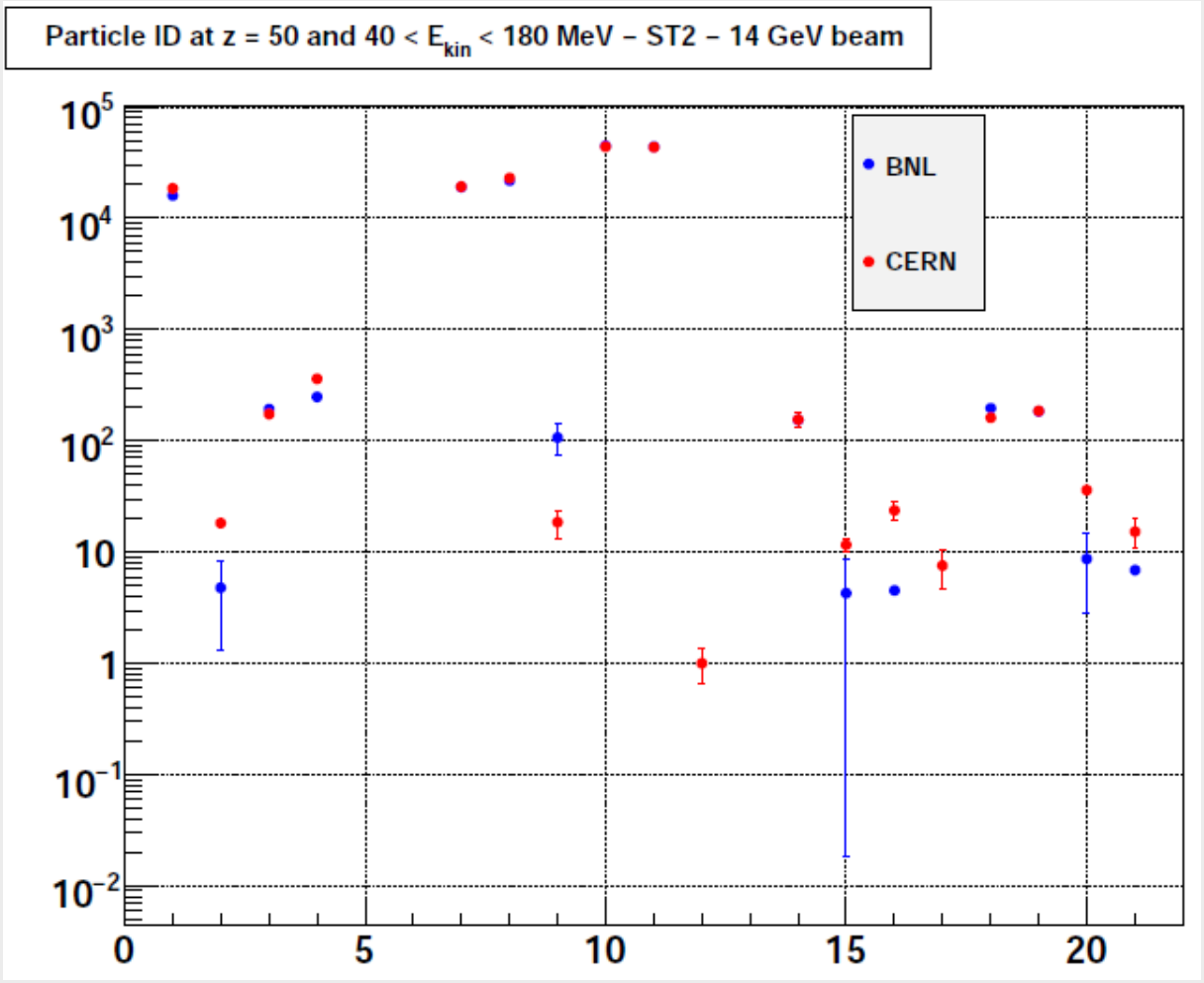
@8 GeV -18% π^+, +23% π^-, -2.5% μ^+, +7% μ^-.



PID	Type	$N_{CERN} - N_{BNL}$	Errors
1	p	3221	206
2	n	15	2
3	π^+	-31	18
4	π^-	51	21
7	μ^+	-351	240
8	μ^-	1022	354
9	γ	23	13
10	e^-	-300	443
11	e^+	744	445
14	D	11	12
15	T	9	4
16	^{3}He	12	8
17	^{4}He	6	1
18	$\bar{\nu}_\mu$	-14	17
19	ν_μ	76	19
20	$\bar{\nu}_e$	-20	7
21	ν_ε	0	11

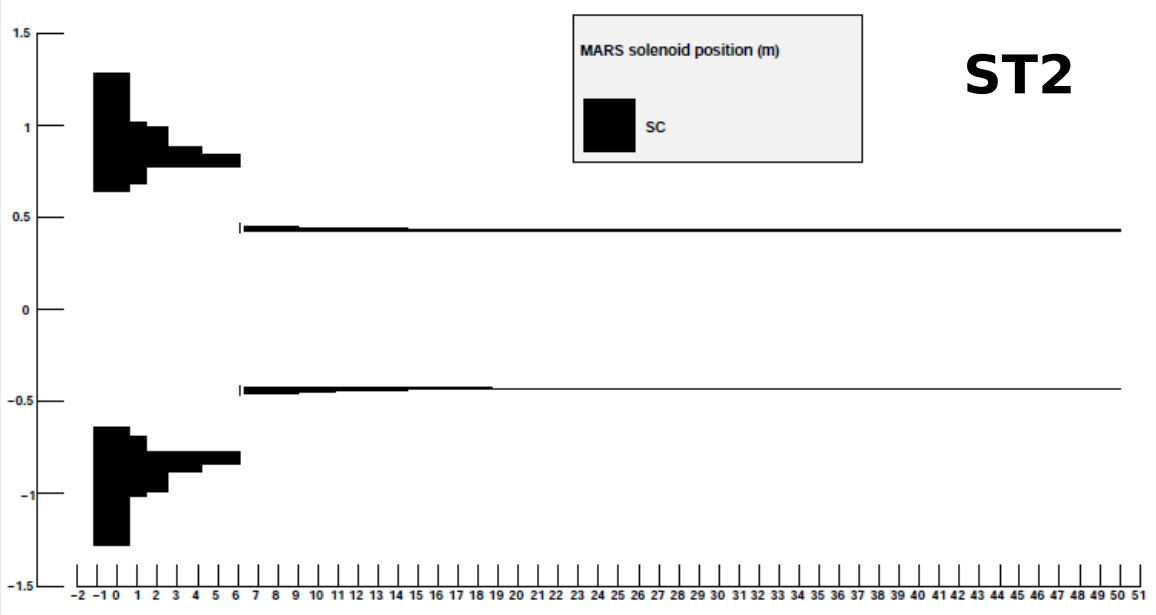
MARS BNL and CERN codes (4/)

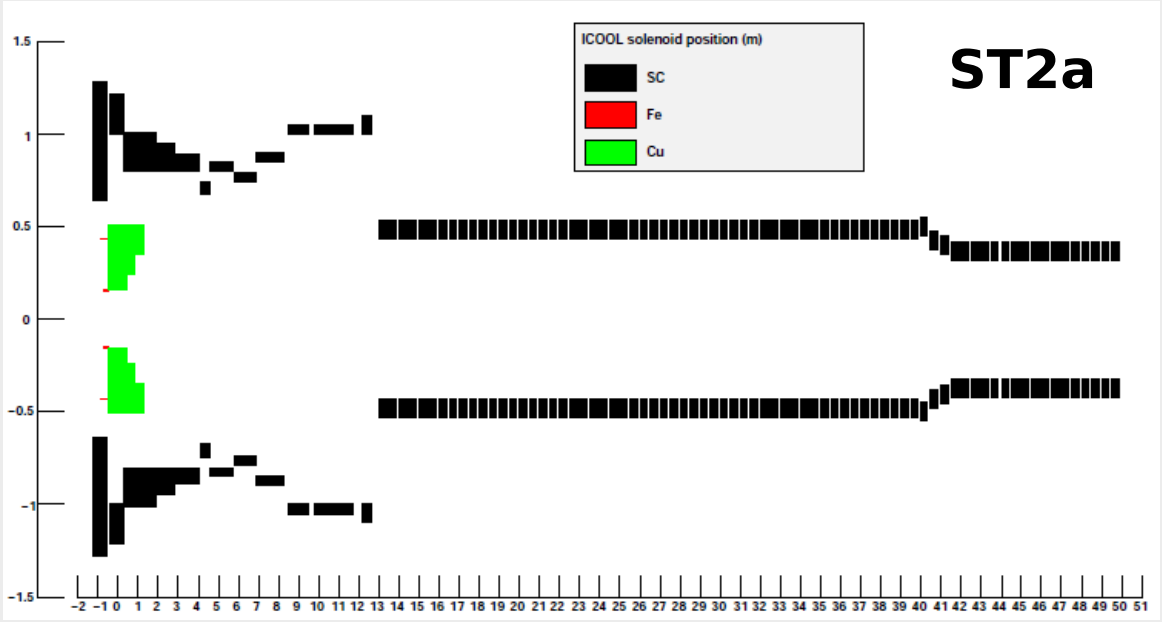
@14 GeV -10% π^+, +37.5% π^-, +1% μ^+, +6% μ^-.



PID	Type	$N_{CERN} - N_{BNL}$	Errors
1	p	2489	285
2	n	14	4
3	π^+	-19	22
4	π^-	114	28
7	μ^+	206	312
8	μ^-	1311	327
9	γ	-89	34
10	e^-	-1010	966
11	e^+	-542	947
14	D	1	28
15	T	7	5
16	^{3}He	19	5
17	^{4}He	8	3
18	$\bar{\nu}_\mu$	-34	18
19	ν_μ	3	26
20	$\bar{\nu}_e$	27	6
21	ν_ε	8	5

ST2 & ST2a magnets geometry





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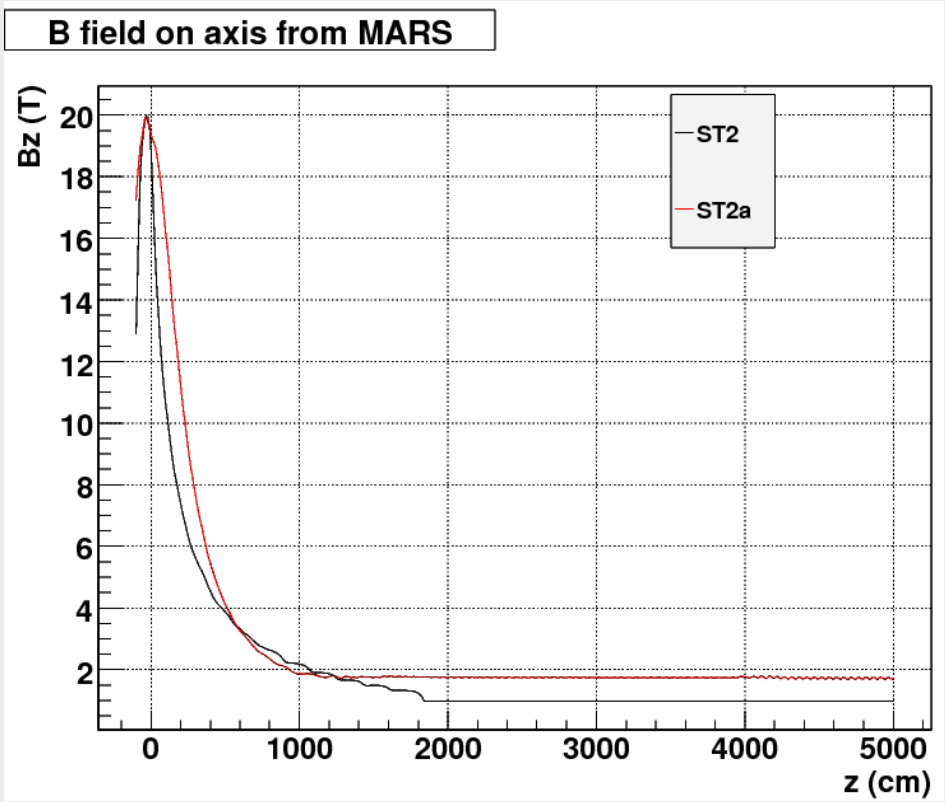
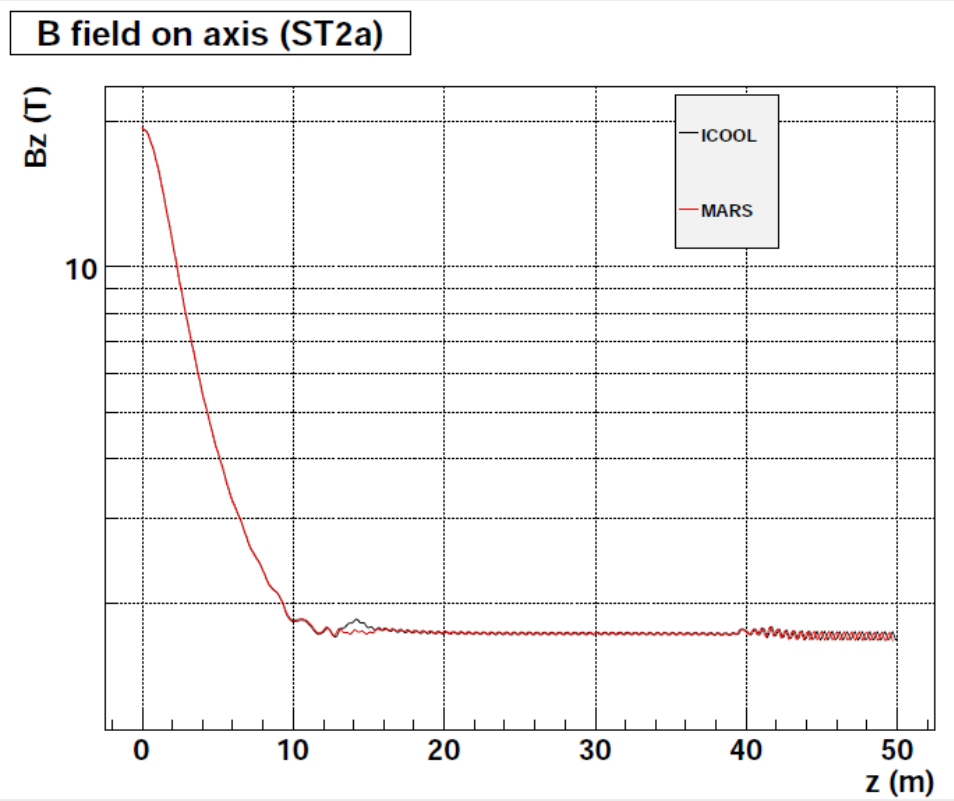
ST2 & ST2a field map



Field on axis in ICOOL:

small difference at 12 m



Field on axis:

1.25 T/1.75 T for the taper

Higher B field for ST2a

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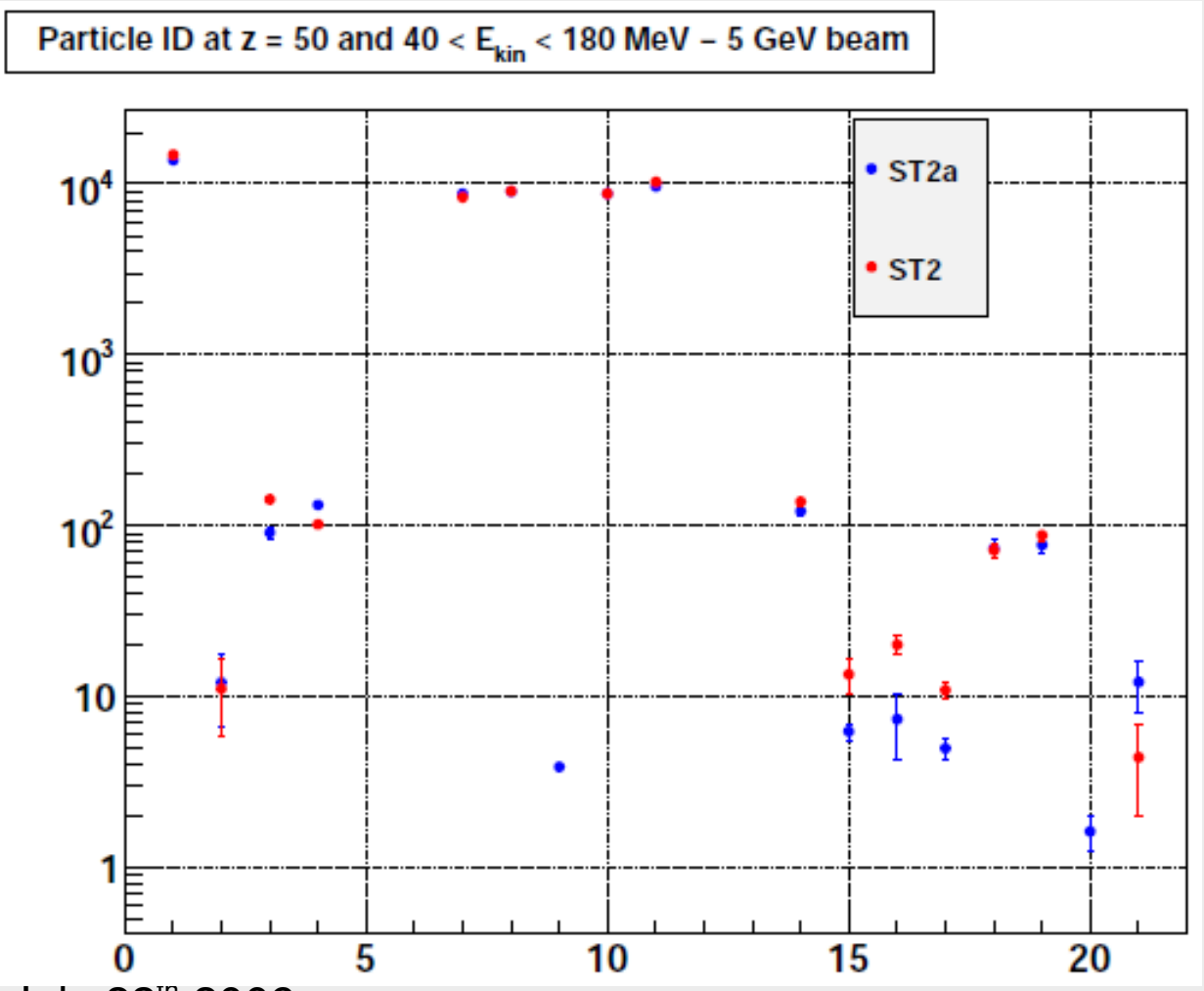
Particle production using ST2/ST2a

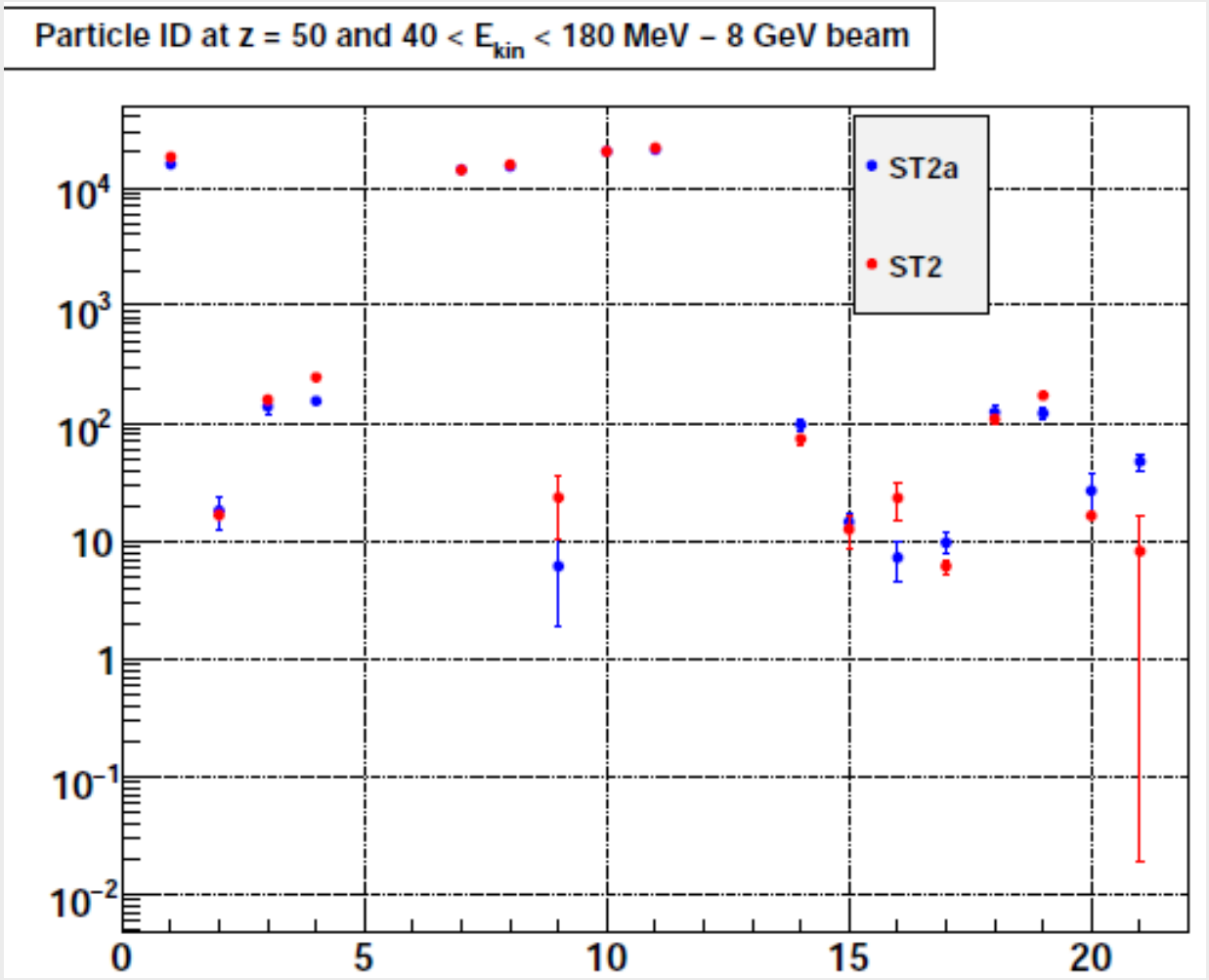
@5 GeV ~5% increase in μ^+ and ~1% loss in μ^-.



PID	Type	$N_{ST2a} - N_{ST2}$	Errors
1	p	-986	215
2	n	1	8
3	π^+	-51	12
4	π^-	31	10
7	μ^+	436	155
8	μ^-	-64	156
9	γ	4	0
10	e^-	-17	201
11	e^+	-600	220
14	D	-16	13
15	T	-7	3
16	^{3}He	-13	4
17	^{4}He	-6	1
18	ν_μ	2	11
19	$\overline{\nu}_\mu$	-11	10
20	ν_e	2	0
21	$\overline{\nu}_\varepsilon$	8	5

Particle production using ST2/ST2a

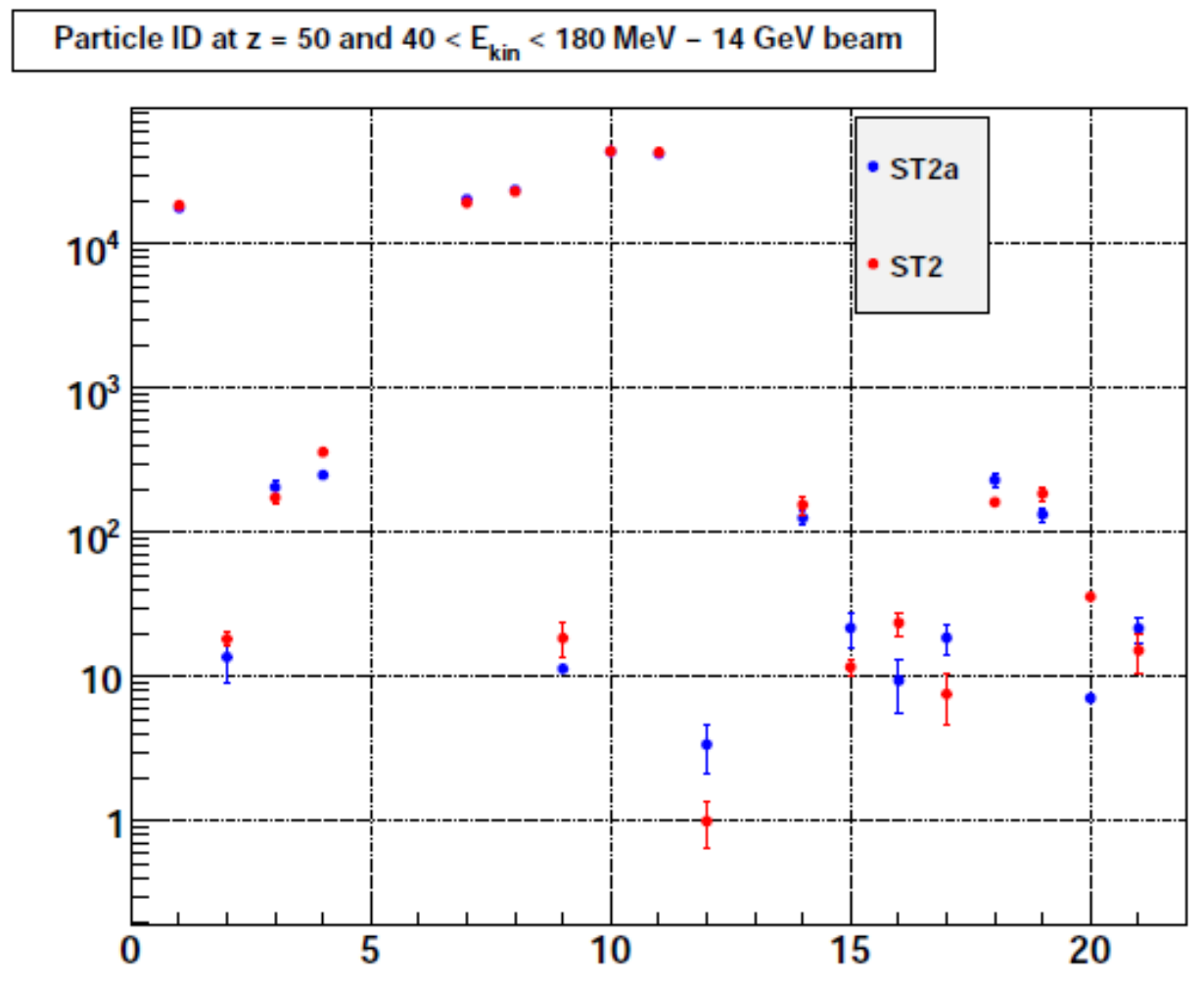
@8 GeV ~2% increase in μ^+ and ~3.5% increase in μ^-.



PID	Type	$N_{ST2a} - N_{ST2}$	Errors
1	p	-2459	206
2	n	2	6
3	π^+	-19	24
4	π^-	-91	20
7	μ^+	246	245
8	μ^-	548	257
9	γ	-17	14
10	e^-	109	443
11	e^+	-729	457
14	D	24	14
15	T	2	5
16	^{3}He	-16	9
17	^{4}He	4	2
18	$\bar{\nu}_\mu$	16	18
19	ν_μ	-50	20
20	$\bar{\nu}_e$	10	11
21	ν_ε	39	11

Particle production using ST2/ST2a

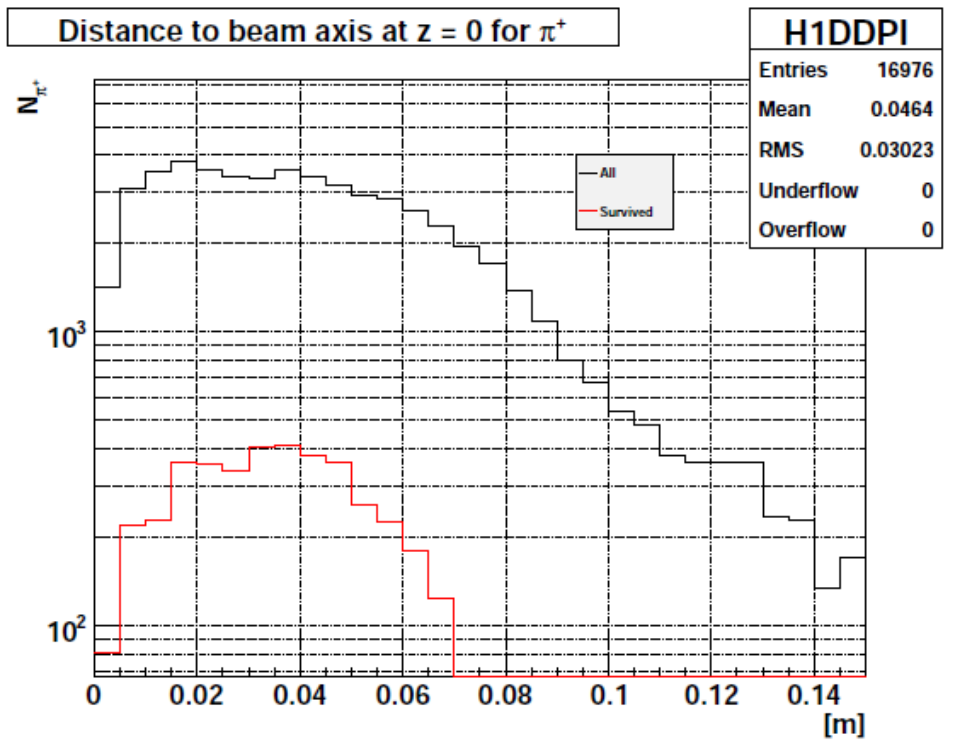
@14 GeV ~5.5% increase in μ^+ and ~3% increase in μ^-.

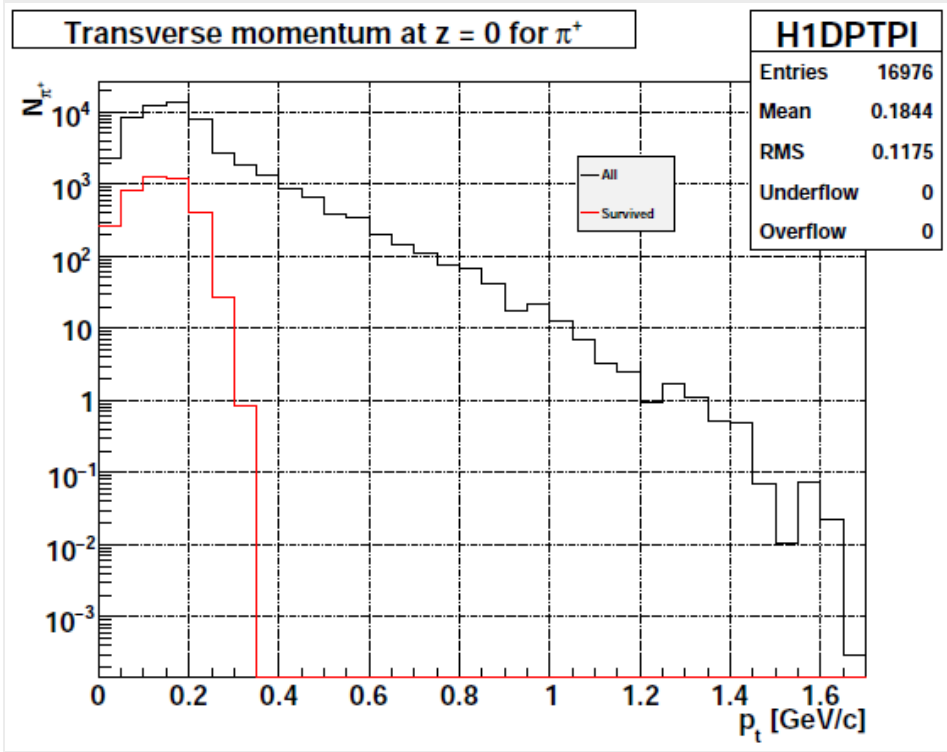


PID	Type	$N_{ST2a} - N_{ST2}$	Errors
1	p	-812	290
2	n	-5	5
3	π^+	33	25
4	π^-	-112	30
7	μ^+	1087	320
8	μ^-	651	333
9	γ	-7	5
10	e^-	-115	964
11	e^+	-1084	937
14	D	-30	27
15	T	10	6
16	^{3}He	-14	6
17	^{4}He	11	5
18	ν_μ	69	31
19	$\overline{\nu}_\mu$	-52	24
20	ν_e	-29	2
21	$\overline{\nu}_\varepsilon$	6	6

Pions production & survival (1/)

Pions lost for R > 7 cm or p_T > 400 MeV/c.



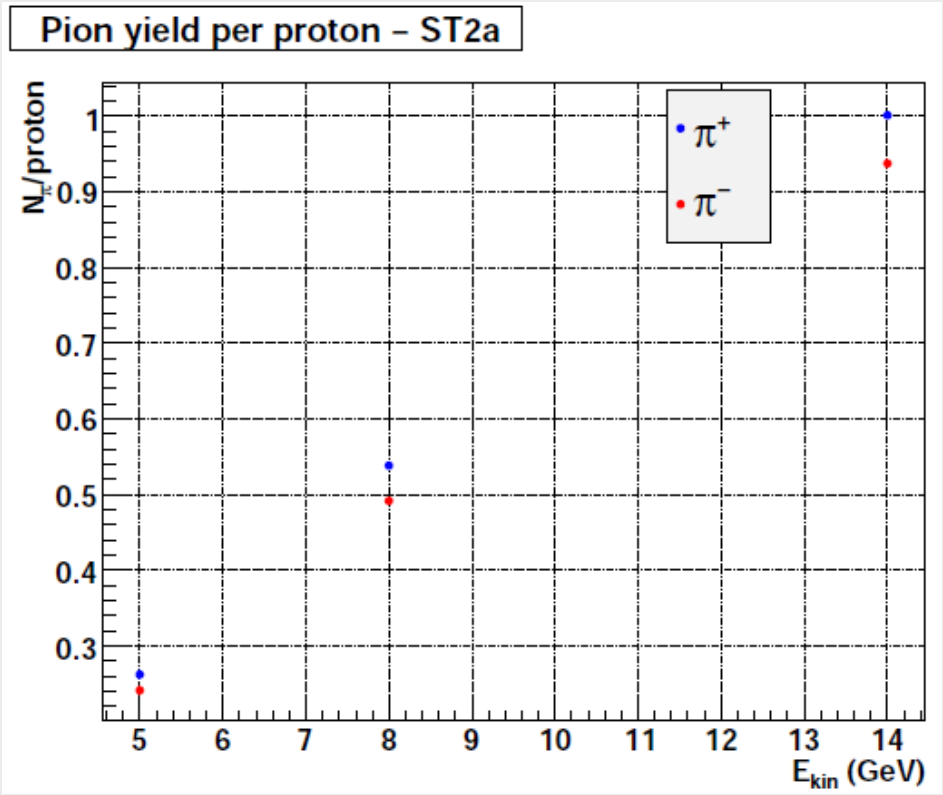


Fraction of pions accepted:

π^+: 6% (5 GeV) – 7% (8 GeV) – 9% (14 GeV)

π^-: 5% (5 GeV) – 6% (8 GeV) – 7% (14 GeV)

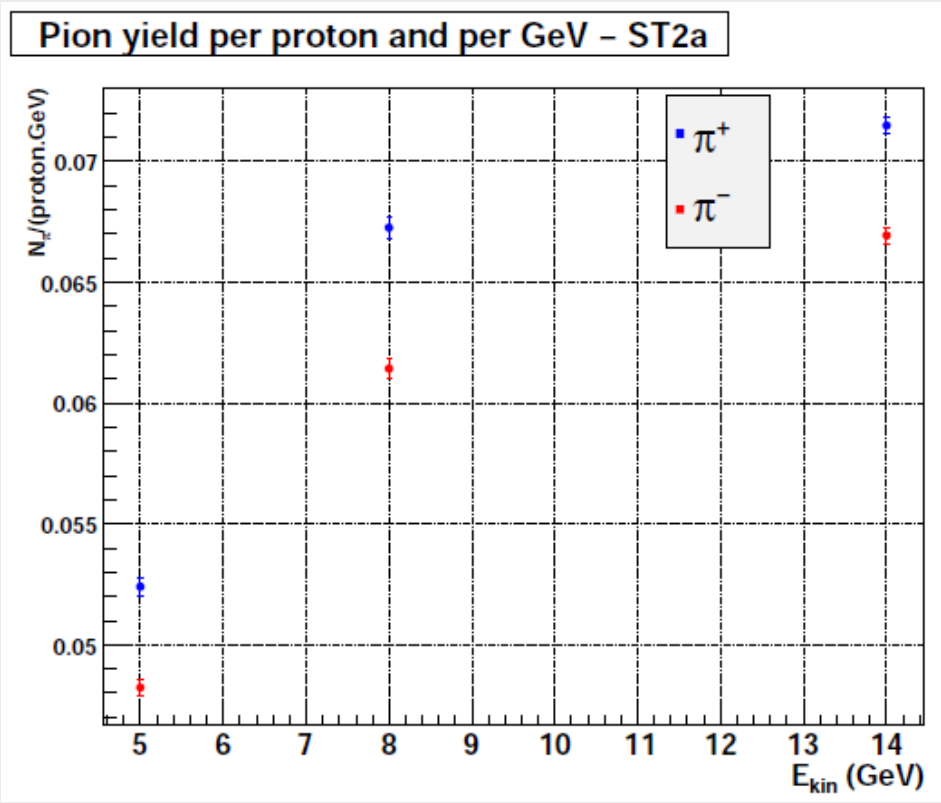
Pions production & survival (2/)



Between 5 - 8 GeV:

π^+: up to 28% gain

π^-: up to 27% gain



Between 8 - 14 GeV:

π^+: up to 6% gain

π^-: up to 9% gain

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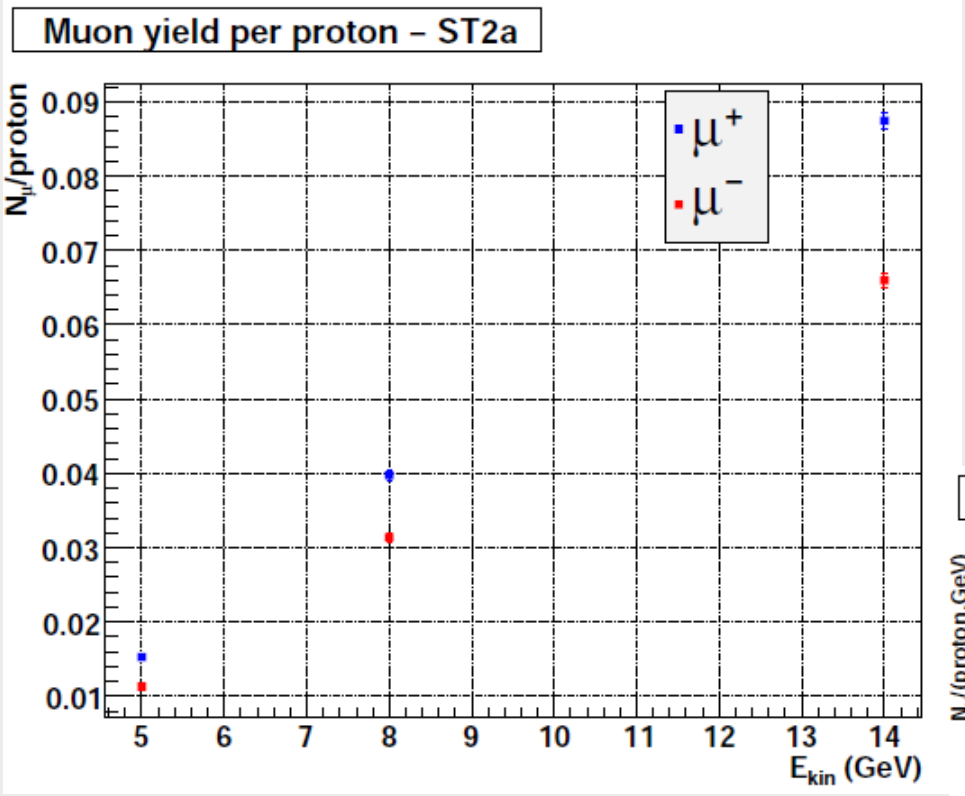
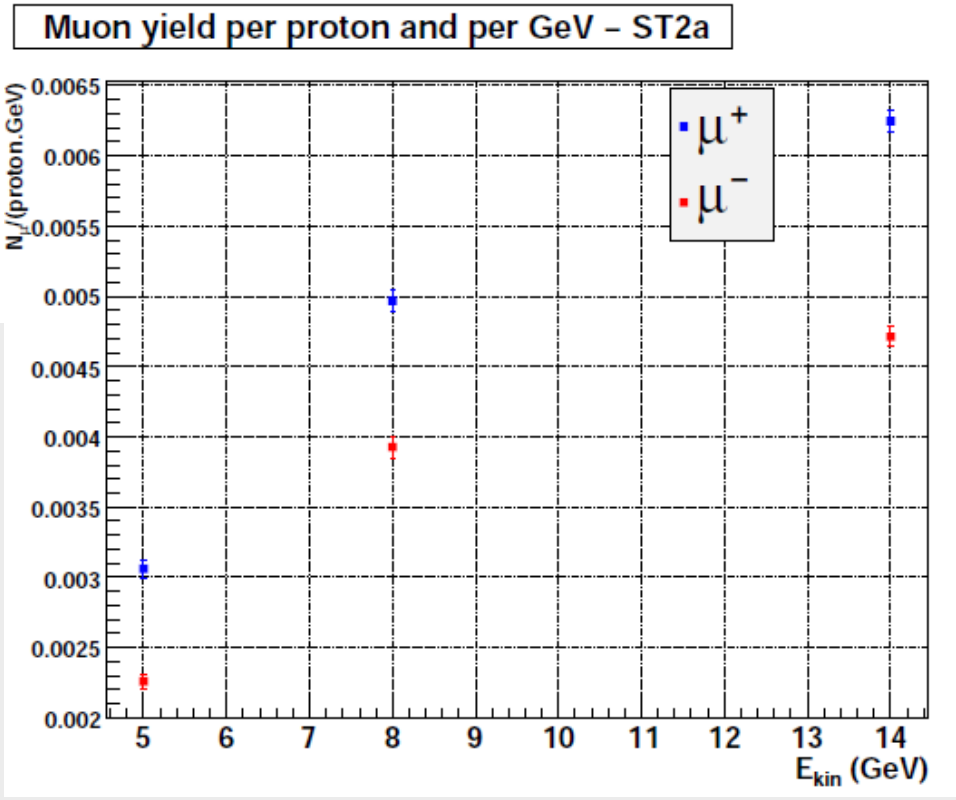
Pions production & survival (3/)



Between 5 - 8 GeV:

μ^+: up to 62% gain

μ^-: up to 74% gain



Between 8 - 14 GeV:

μ^+: up to 26% gain

μ^-: up to 20% gain

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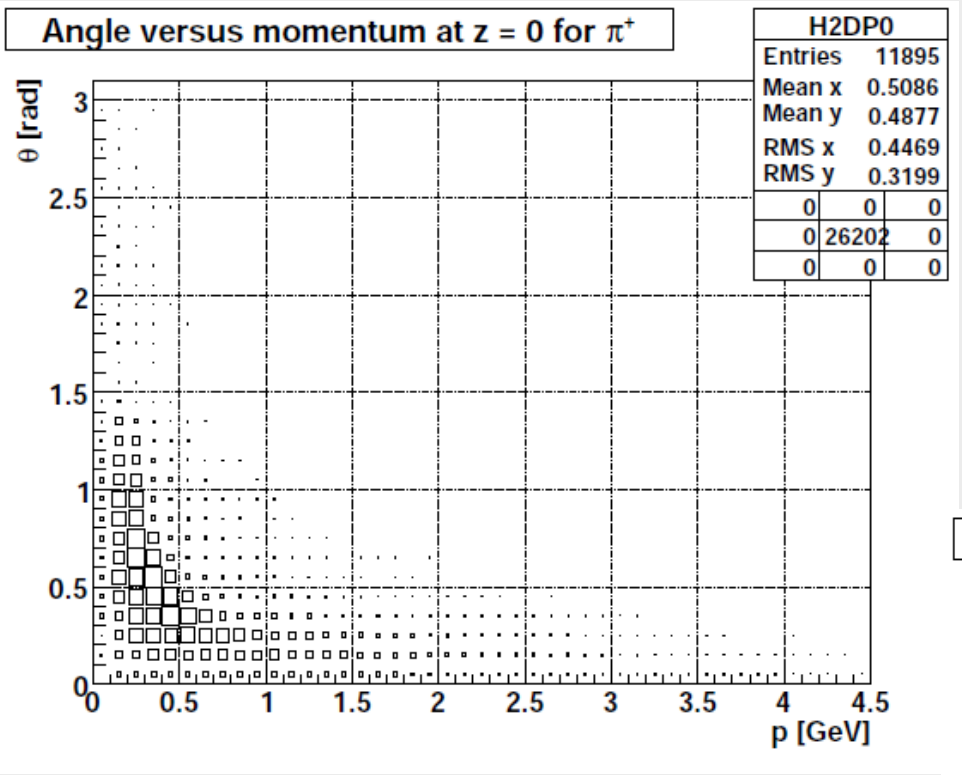
Pions production and survival (4/)

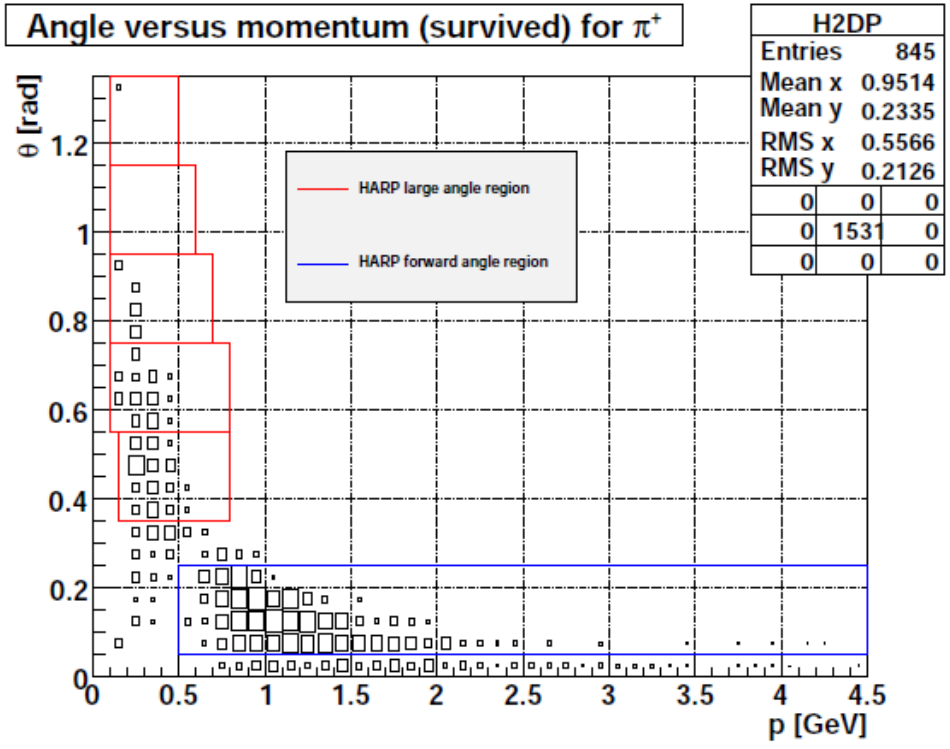


π^+ @ 5 GeV:

916 (60%) in HARP FA region

349 (23%) in HARP LA region

266 (17%) out of HARP regions



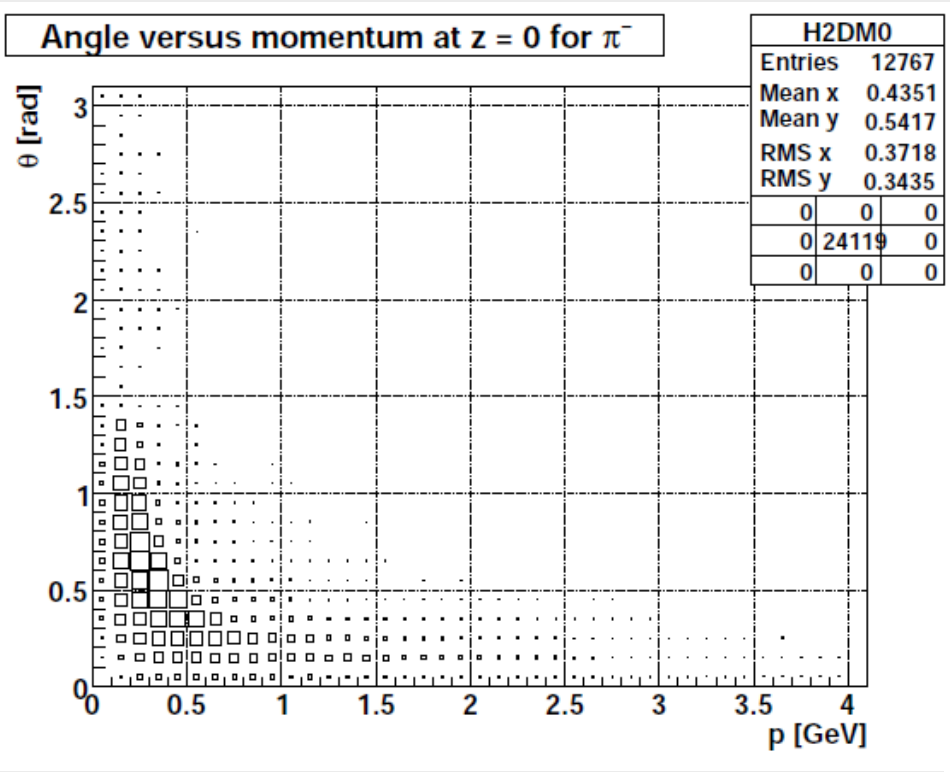
Fraction compared to number of pions in the region:

19% in HARP FA region

2.5% in HARP LA region

4% out of HARP regions

Pions production and survival (5/)

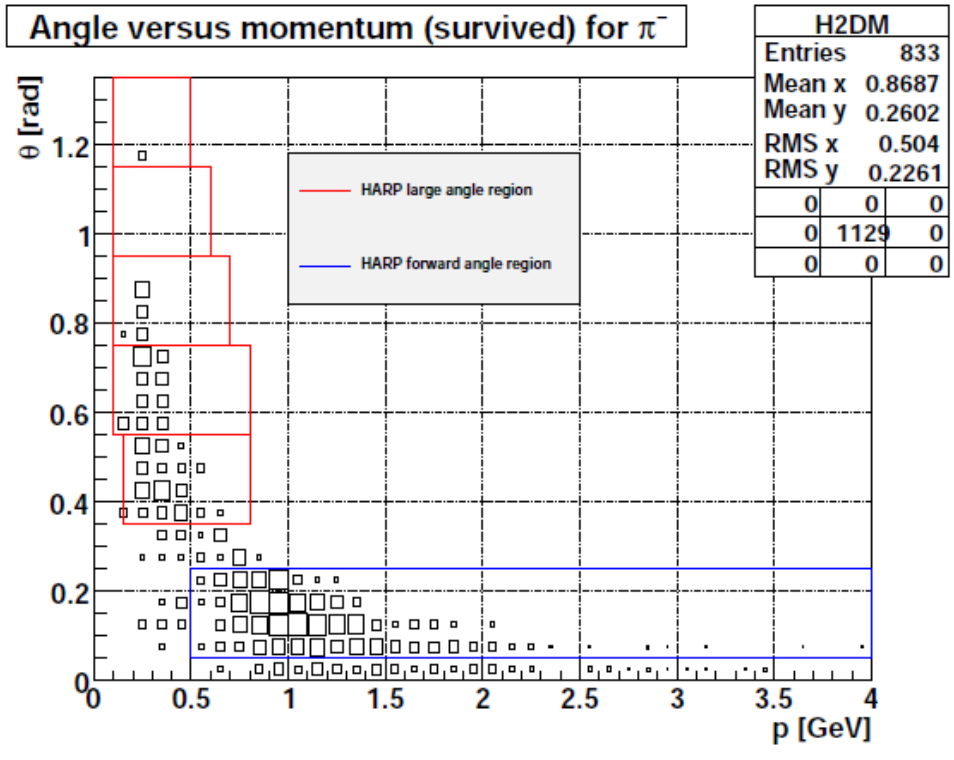


π^- @ 5 GeV:

645 (57%) in HARP FA region

312 (28%) in HARP LA region

172 (15%) out of HARP regions



Fraction compared to number of pions in the region:

19% in HARP FA region

2% in HARP LA region

3% out of HARP regions

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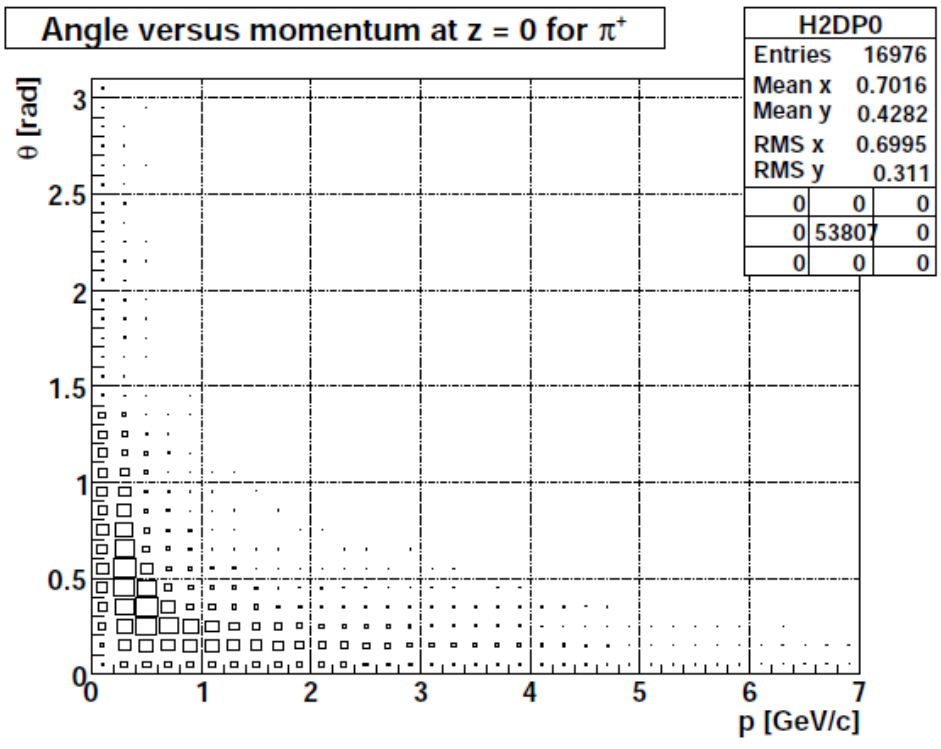
Pions production and survival (6/)

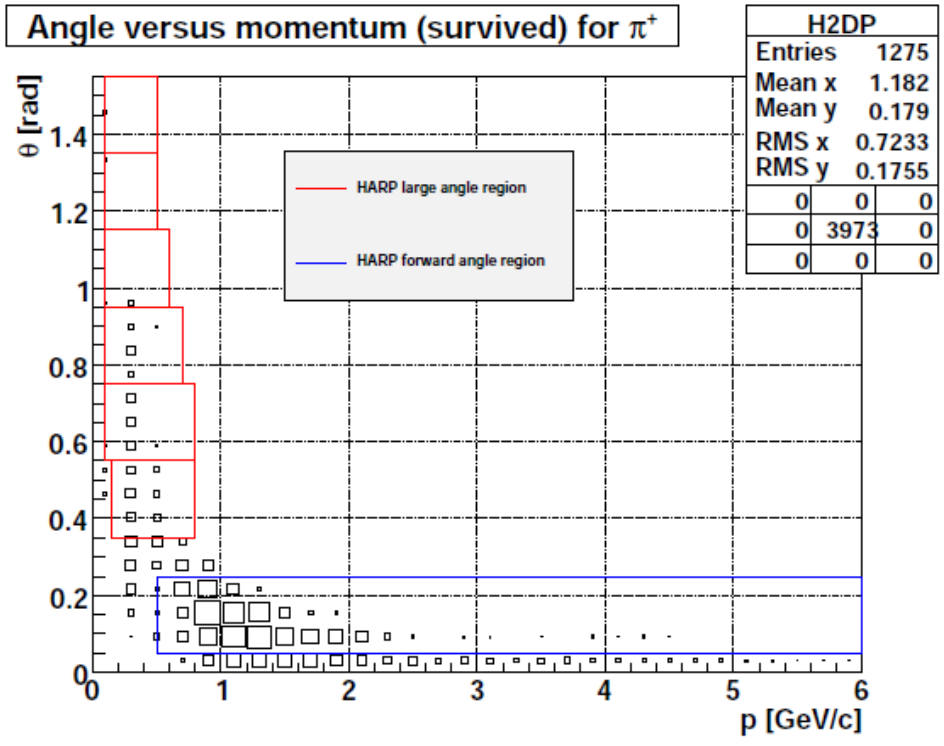


π^+ @ 8 GeV:

2656 (67%) in HARP FA region

445 (11%) in HARP LA region

872 (22%) out of HARP regions



Fraction compared to number of pions in the region:

19% in HARP FA region

2% in HARP LA region

6% out of HARP regions

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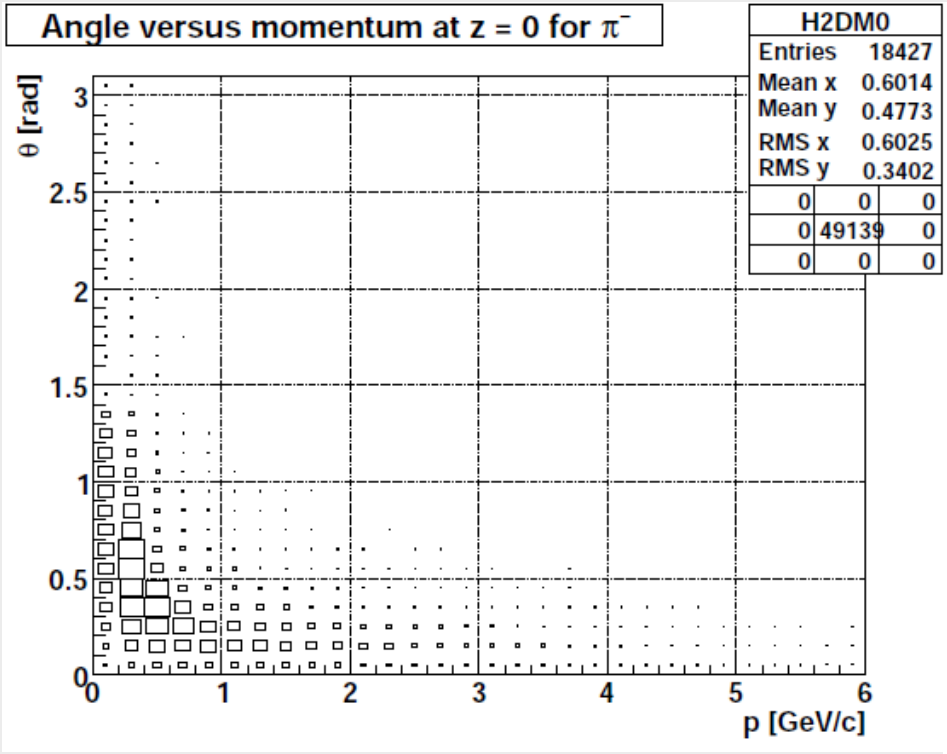
Pions production and survival (7/)

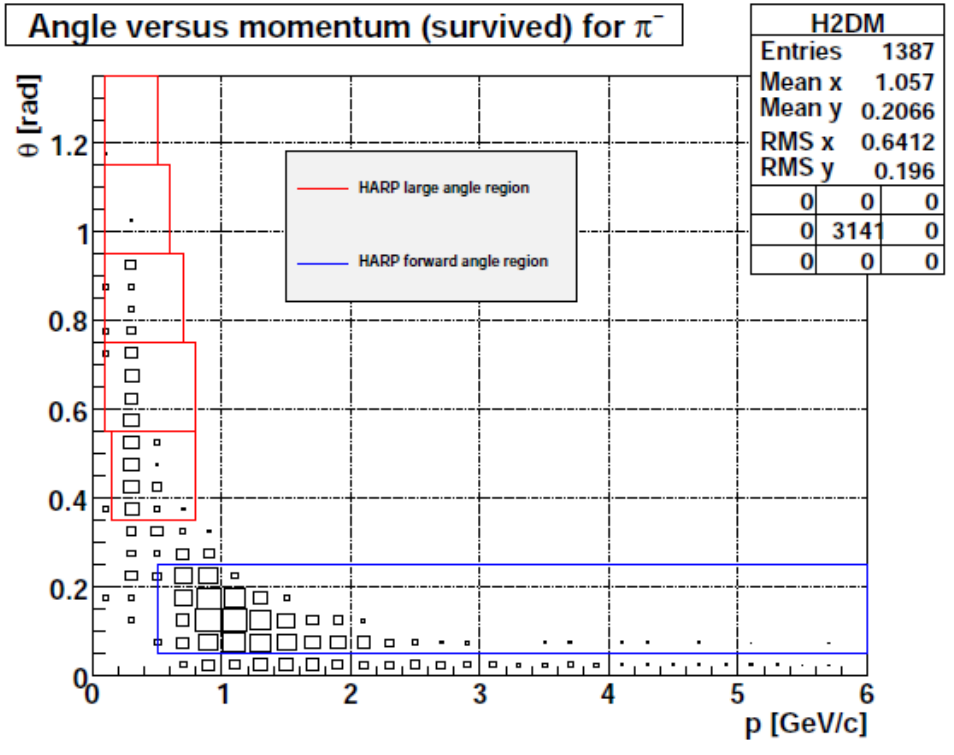


π^- @ 8 GeV:

1955 (62%) in HARP FA region

564 (18%) in HARP LA region

622 (20%) out of HARP regions



Fraction compared to number of pions in the region:

18% in HARP FA region

2% in HARP LA region

5% out of HARP regions

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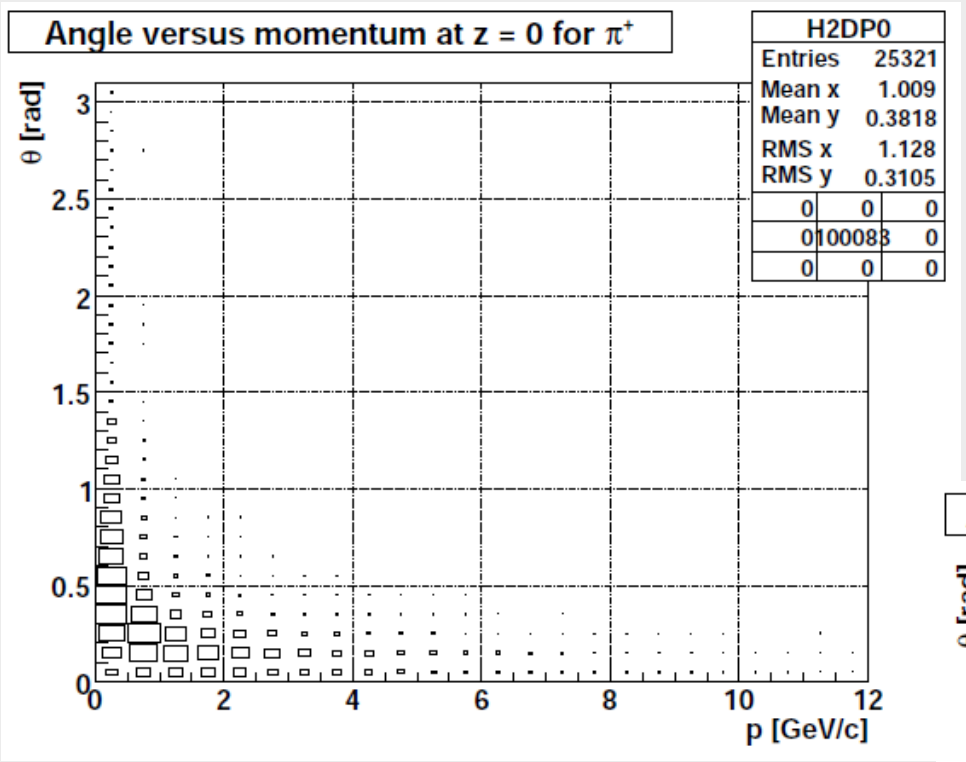
Pions production and survival (8/)

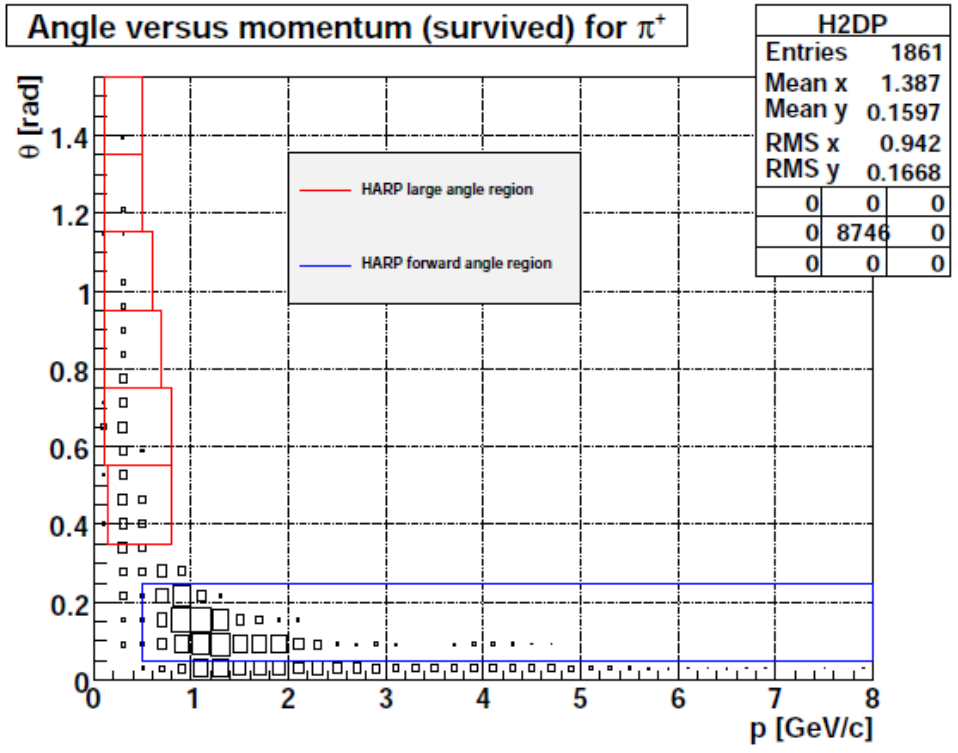


π^+ @ 14 GeV:

5843 (67%) in HARP FA region

858 (10%) in HARP LA region

2245 (26%) out of HARP regions



Fraction compared to number of pions in the region:

16% in HARP FA region

2% in HARP LA region

6% out of HARP regions

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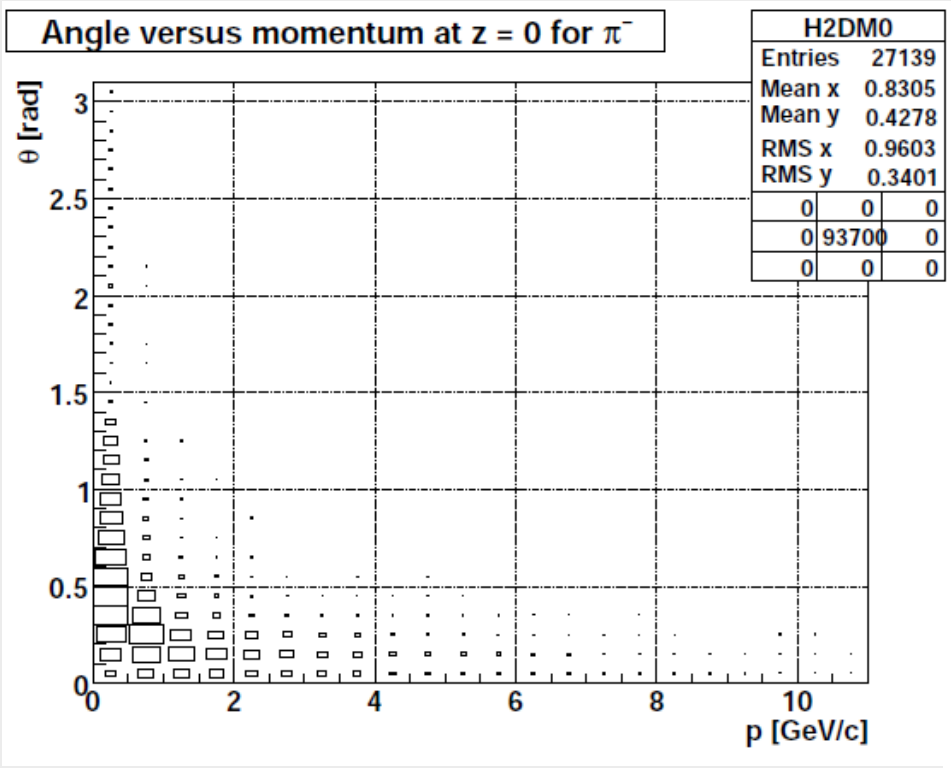
Pions production and survival (9/)

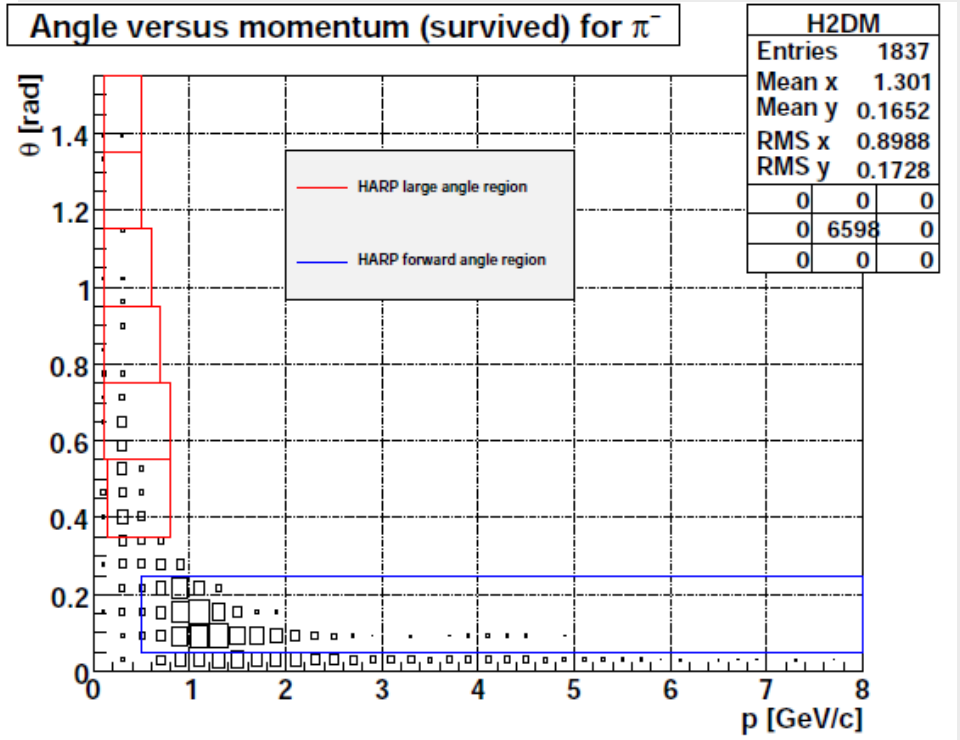


π⁻ @ 14 GeV:

5198 (64%) in HARP FA region

734 (11%) in HARP LA region

1666 (25%) out of HARP regions



Fraction compared to number of pions in the region:

16% in HARP FA region

2% in HARP LA region

6% out of HARP regions

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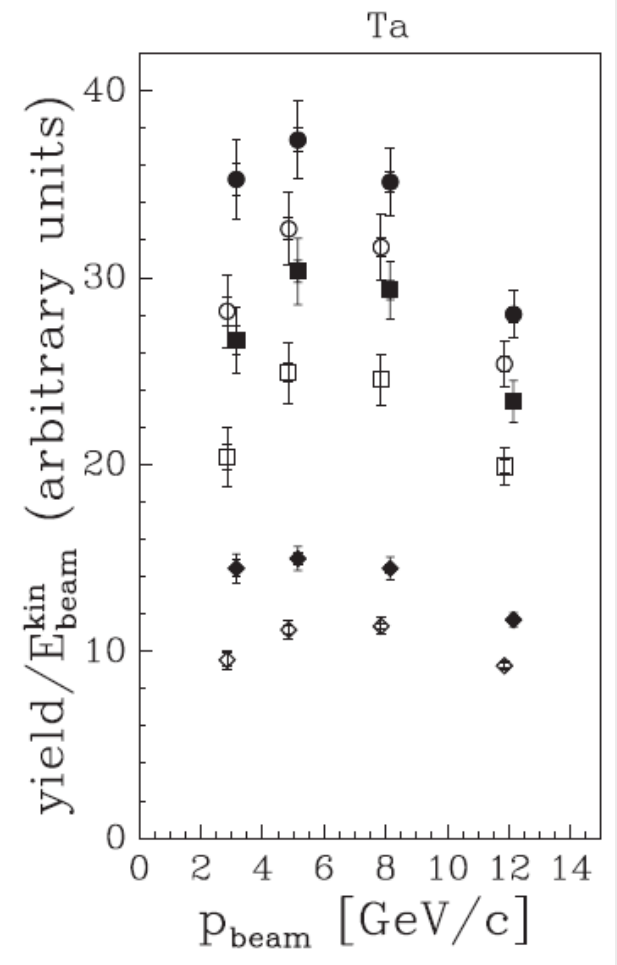
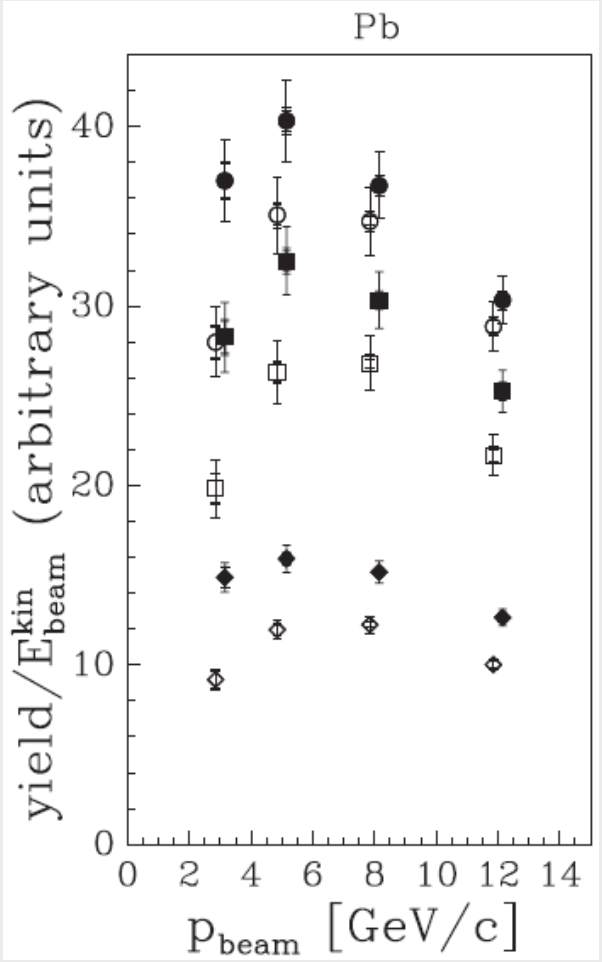
HARP data (1/)

Large Angle: circles are $d^2\sigma/dpd\Omega$ [mb/(GeV/c . sr)] for π^+ (close) and π^- (open) integrated over 100 < p < 700 MeV/c and 0.35 < θ < 1.55 rad.





Ta: Z = 73, A-Z = 108 (5.6 mm)

Pb: Z = 82, A-Z = 125 (8.5 mm)

Hg: Z = 80, A-Z = 121 (~15 cm)

HARP best yield:

π^+: 3-8 GeV/c

($2.2 < E_{kin} < 7.12$ GeV)

π^-: 5-8 GeV/c

($4.15 < E_{kin} < 7.12$ GeV)

Phys. Rev. C 77 055207 (2008)

HARP data (2/)

How to use HARP LA results:

1- Compare to yield from MARS in 100-700 GeV/c and 0.35-1.55 rad range for beam between 5-11 GeV (approx. thick target = thin target).

if big difference in pion yield, use HARP data to re-weight the MC.

2- HARP LA paper on 100% interaction (11.14 cm Ta & 17.05 cm Pb) targets in preparation.

HARP FA data:

Paper in preparation (cf. Talk R. Schroeter)

waiting for cross-section to compare with MARS yields

Conclusions

MC code: different versions can give ~10-20% difference in π/μ yields.

Field map: no clear evidence for using ST2a instead ST2. (ST2 deck to be prepared)

Pion production & tracking:

- **fraction of pions surviving is small (7-9%) (can be improved ?)**
- **yield/p/GeV increase with beam energy**
- **fractions of pions surviving from the different p-θ regions not dependent of the beam energy.**
- **HARP LA data can be used to re-weight the MC.**
- **HARP FA data awaited.**