HARP targets pi+ production measurements for MiniBooNE

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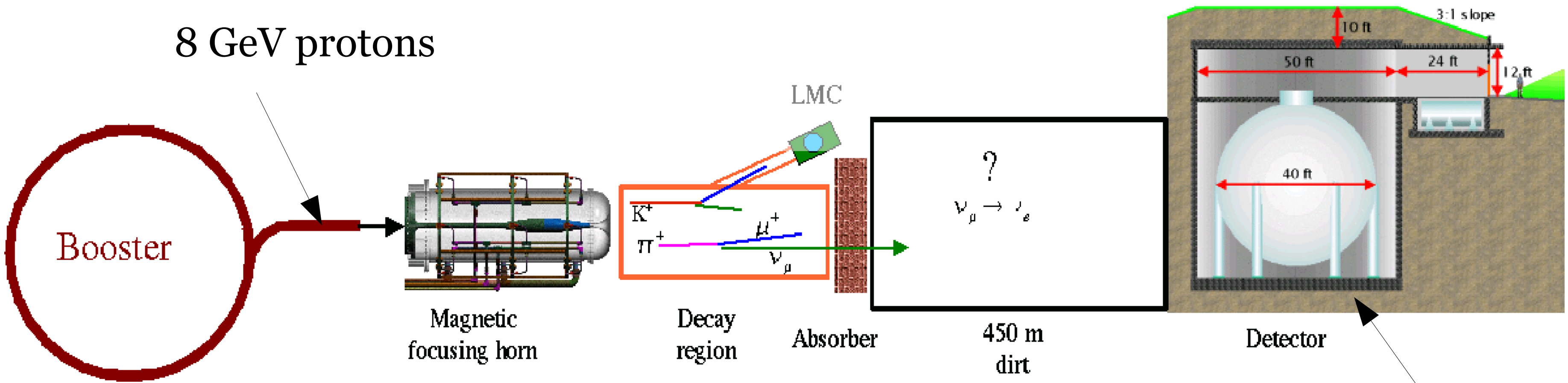
Outline:

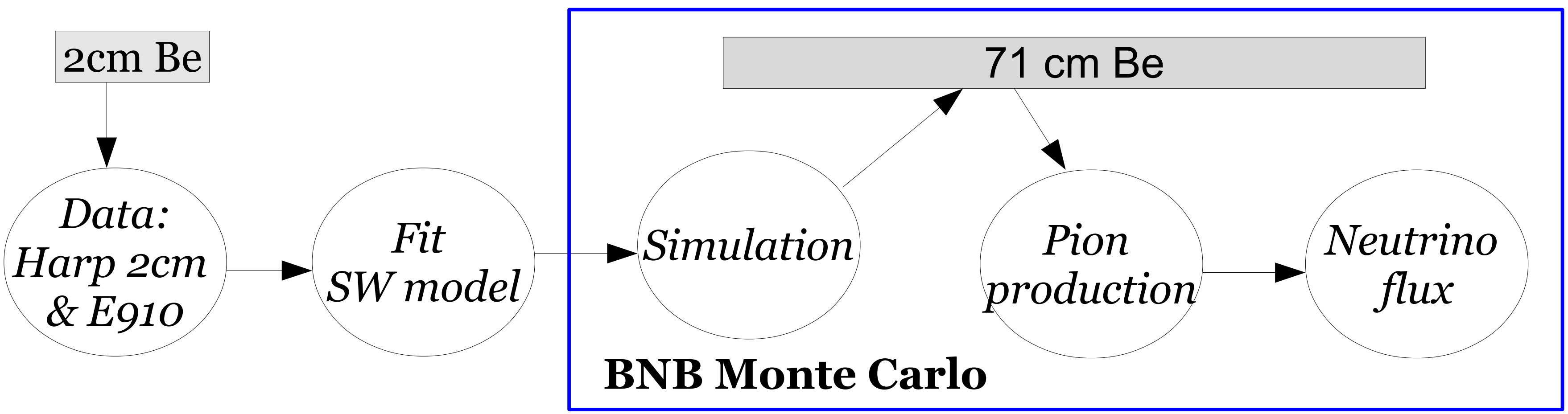
Motivation for long targets pi+ analysis
Overview of HARP setup
Thin target: cross sections and SW models
Long target: yield measurements
Extrapolation from thin to thick

The Booster Neutrino Beam Production



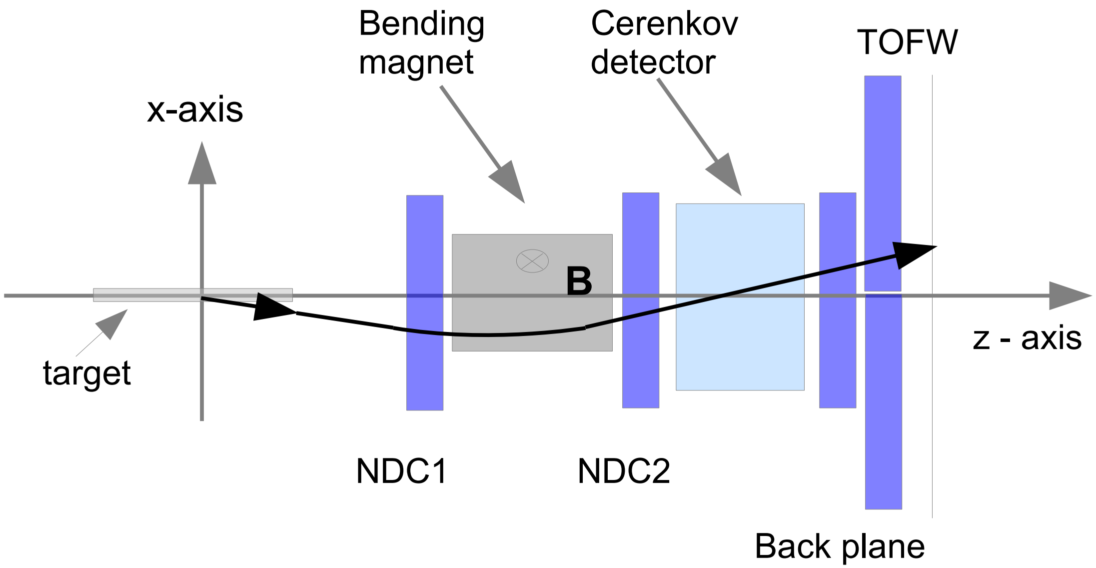
* MiniBooNE experiment has a 71 cm long beryllium target.

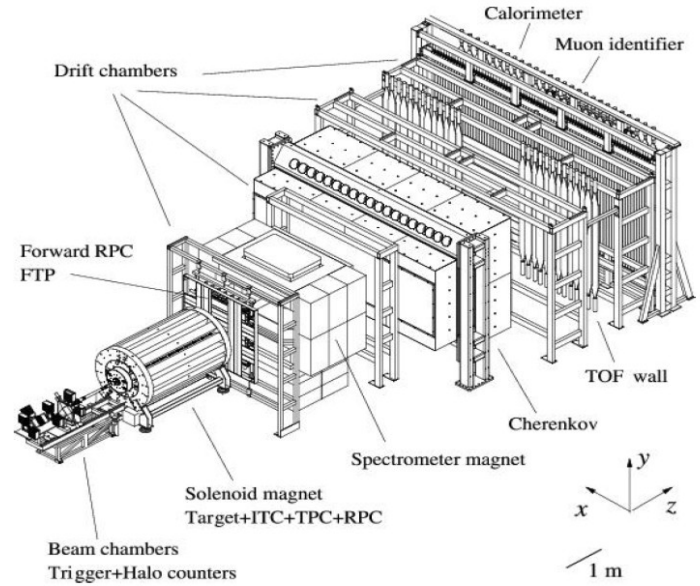
Motivation for long targets data



* Better to check HARP pion production data on 20.0 cm and 40.0 cm Be targets

p2 and p4 momentum reconstructions





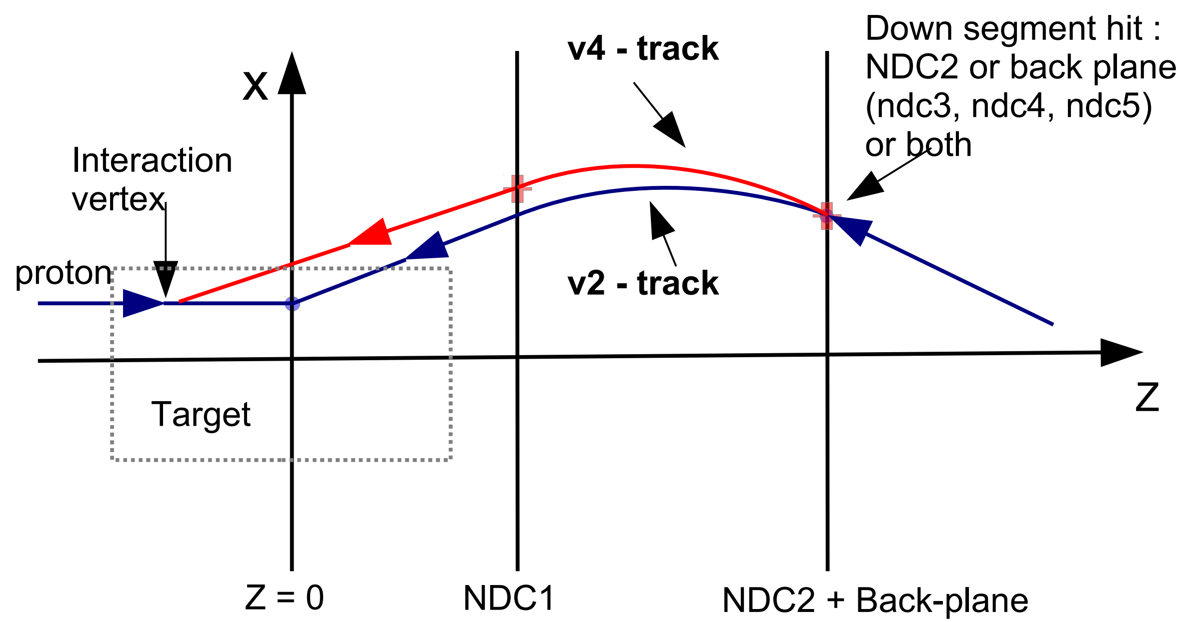
VERTEX 2 tracks (p2 momentum):

connect down segment hit to the plane z = 0 at the center of the target. This is called "vertex2 -algorithm".

Vertex2 tracks are correlated with the center plane of the target.

VERTEX 4 tracks (p4 momentum):

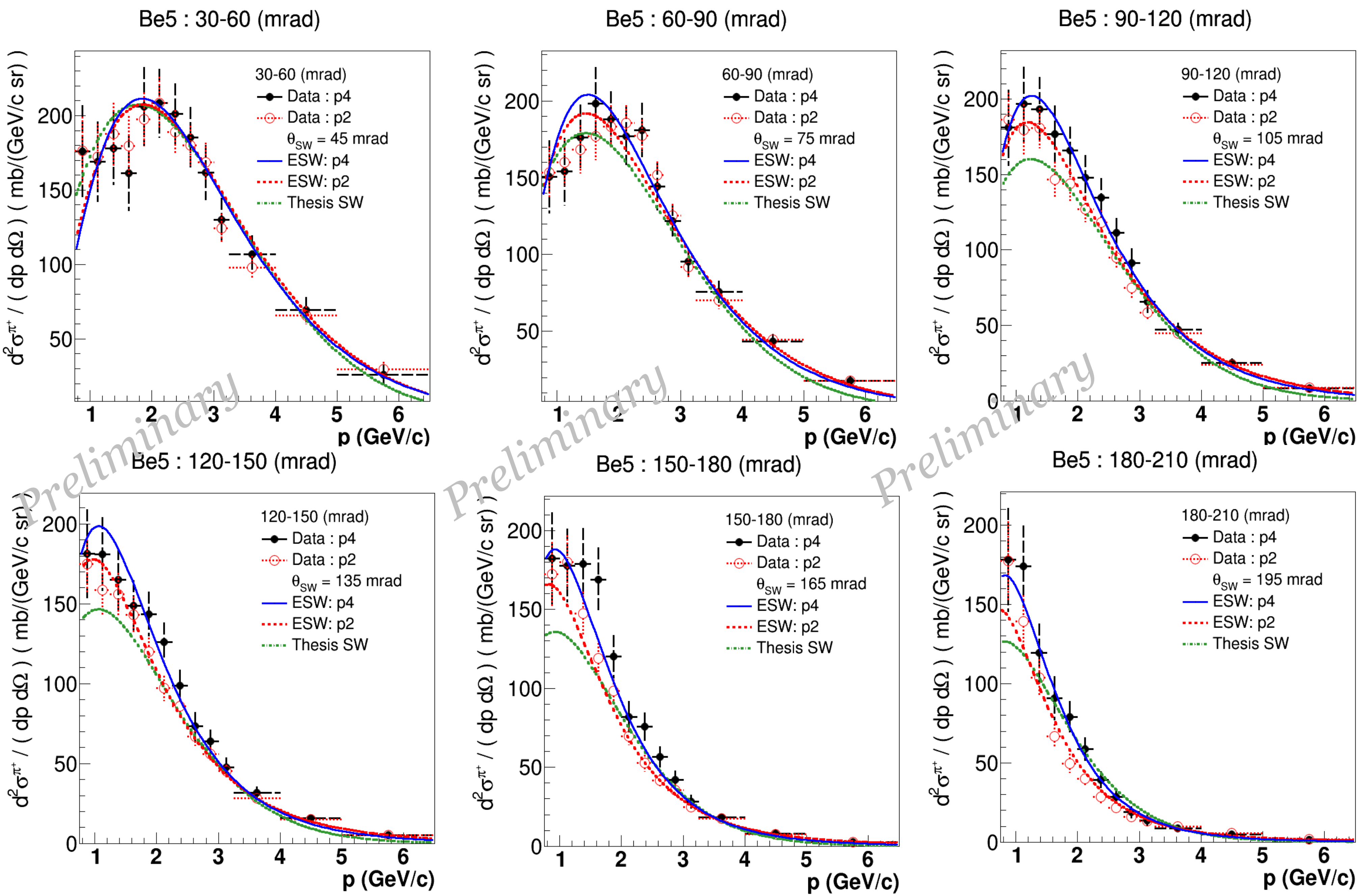
connect down segment hit to a 3D segment of NDC1 chamber. This is called "vertex4-algorithm".



Next:

Thin target pi+ production cross section measurements

Best fitted Be5 cross section comparison :



Where SW thesis : MiniBooNE flux PRD (Ref :A. A. Aguilar-Arevalo, et al., The Neutrino Flux prediction at MiniBooNE, Phys.Rev. D79 (2009) 072002)

Fitting HARP data with two Sanford Wang models

1. Sanford-Wang model (SW:thesis):

$$\frac{d^2\sigma}{dpd\Omega}(p,\theta) = c_1 \cdot p^{c_2}\left(1 - \frac{p}{p_B - c_9}\right) e^{-g(p,\theta)}$$

Where

$$g(p,\theta) = c_3 \cdot \frac{p^{c_4}}{p_B^{c_5}} + c_6\theta\left(p - c_7 \cdot p_B \cdot \cos^{c_8}\theta\right)$$

Beam momentum = p_beam = 8.89 GeV/c

Data : Fitting Be5 p2 and E910 (SW thesis)

c1 = 220.7; c2 = 1.080; c3 = 1.0; c4 = 1.978; c5 = 1.320; c6 = 5.572; c7 = 0.08678; c8 = 9.686; c9 = 1.0;

Ref : A. A. Aguilar-Arevalo, et al., The Neutrino Flux prediction at MiniBooNE, Phys.Rev. D79 (2009) 072002

2. Extended SW model (ESW):

$$\frac{d^2\sigma}{dpd\Omega}(p,\theta) = \exp[A]p^{c_2}\left(1 - \frac{p}{p_{\text{beam}}}\right) \times \left(1 + \frac{p}{p_{\text{beam}}}\right)^{c_9\theta(p - c_7 p_{\text{beam}}\cos^{c_8}\theta)}$$

Where

$$A = c_1 - c_3\frac{p^{c_4}}{p_{\text{beam}}^{c_5}} - c_6\theta(p - c_7 p_{\text{beam}}\cos^{c_8}\theta)$$

Ref: M. G. Catanesi et al. [HARP Collaboration], arXiv:hep-ex/0702024

Data :Be5 p2-data (ESW:p2)

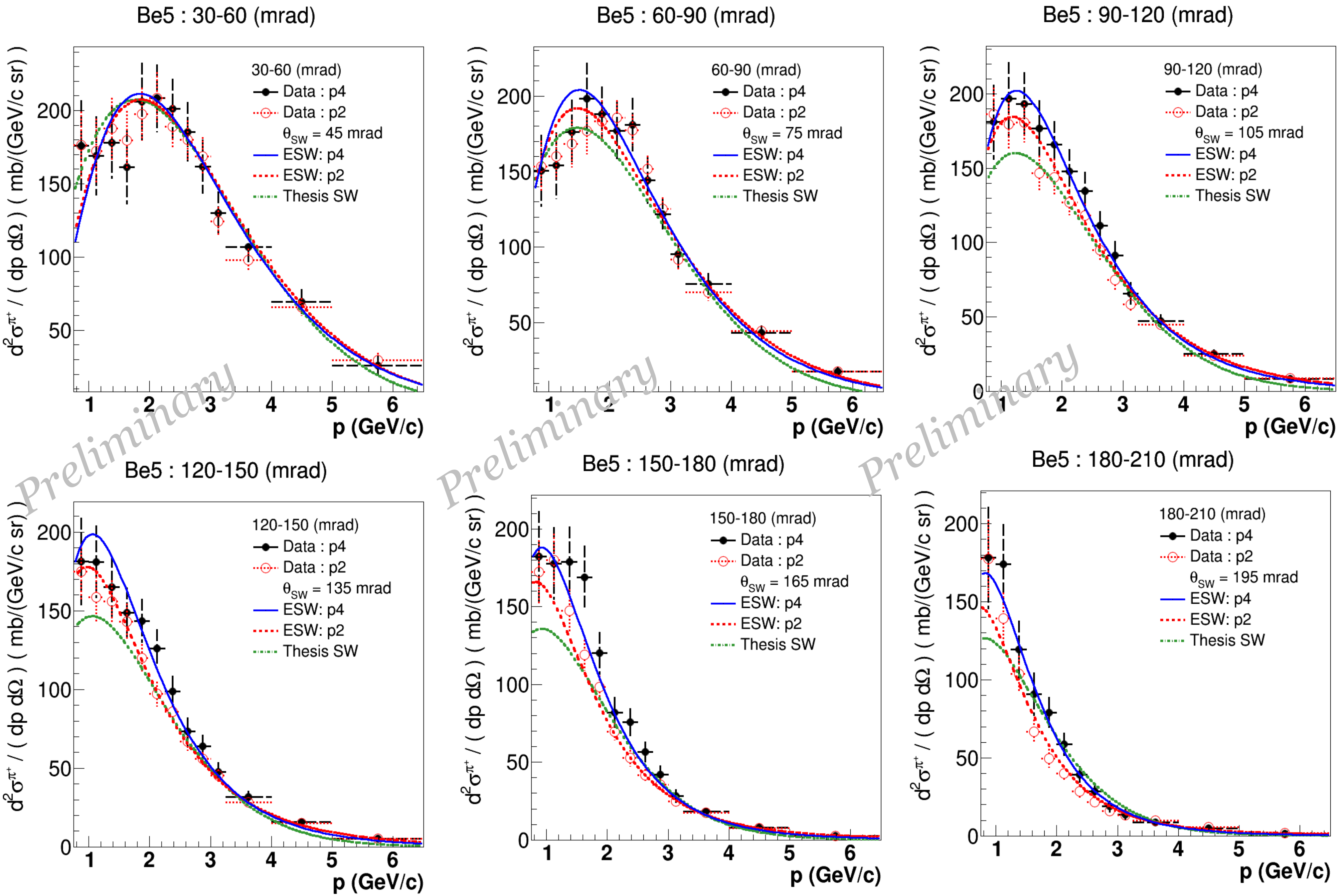
c1 = 5.13; c2 = 1.87; c3 = 6.67; c4 = c5 = 1.56; c6 = 11.9; c7 = 0.173; c8 = 19.8; c9 = 16.0;

Ref: M. G. Catanesi et al. [HARP Collaboration], arXiv:hep-ex/0702024

Data :Be5 p4-data (ESW:p4)

C1 = 5.39; C2 = 2.30; C3 = 7.19 C4 = C5 = 1.17 C6 = 11.2; C7 = 0.191; C8 = 18.4; C9 = 13.2

Best fitted Be5 cross section comparison :

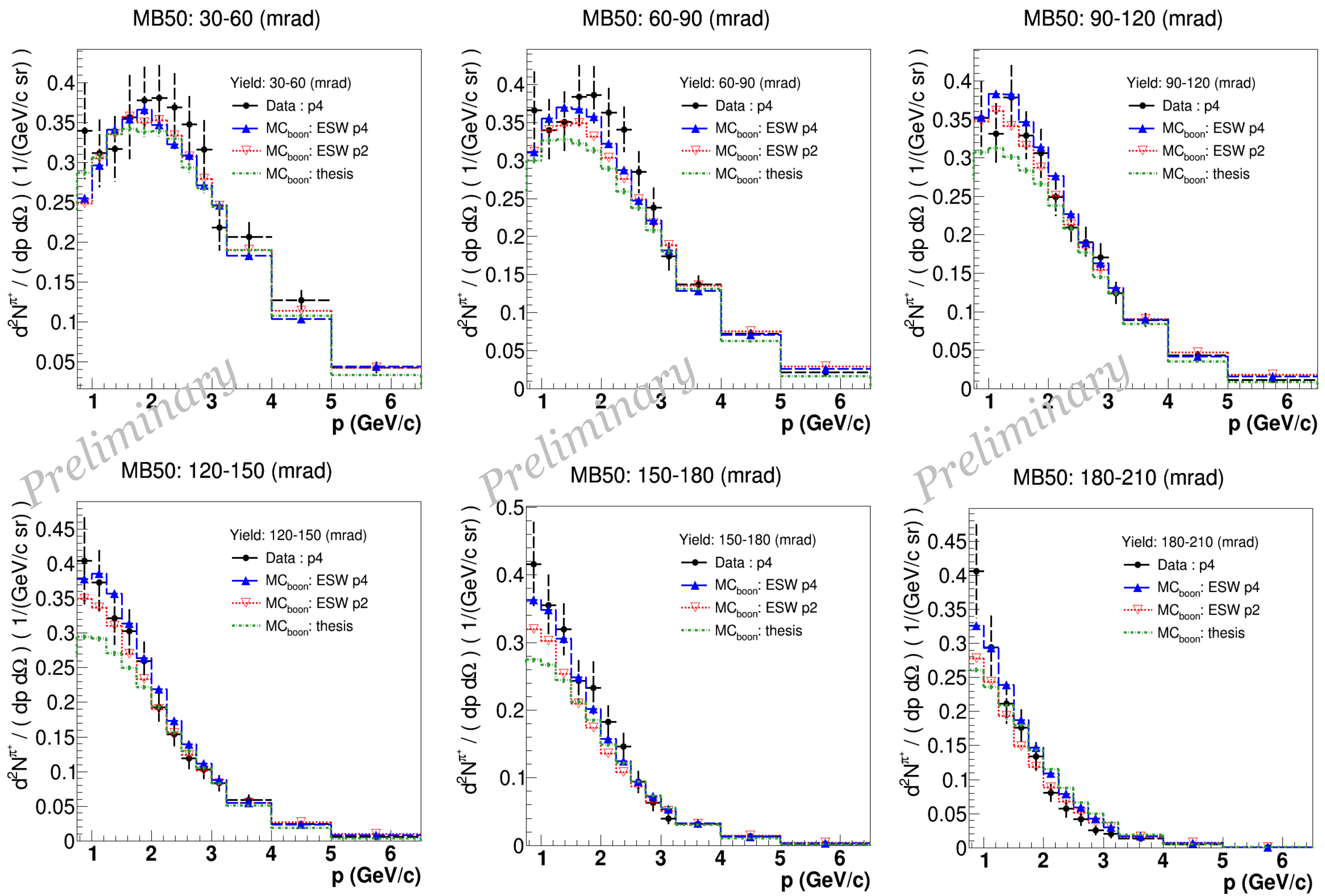


Where SW thesis : MiniBooNE flux PRD (Ref :A. A. Aguilar-Arevalo, et al., The Neutrino Flux prediction at MiniBooNE, Phys.Rev. D79 (2009) 072002)

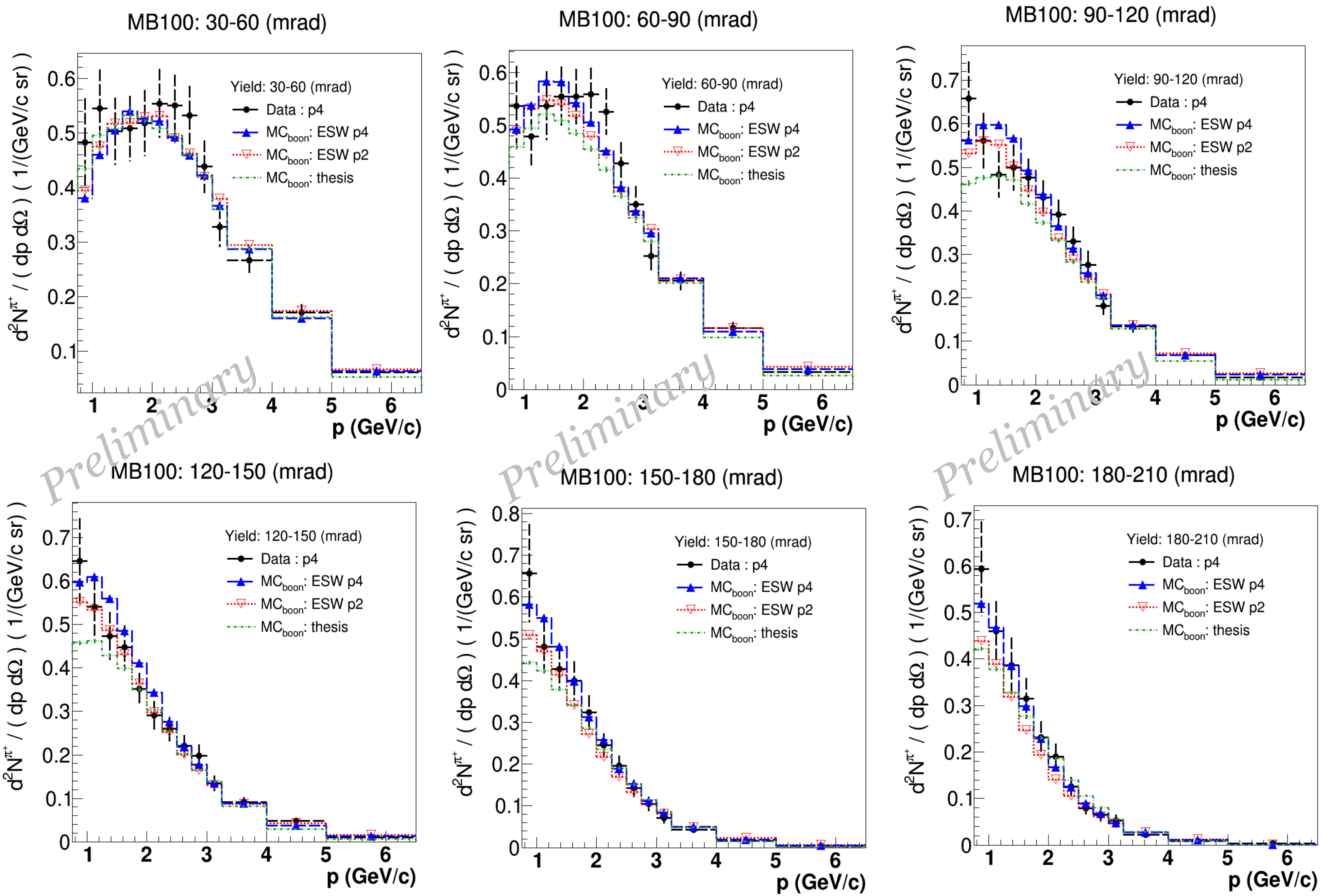
Next:

Long targets pi+ production yield measurements

Data - BooNE MC comparison : MB50 (20 cm) pi+ yield



Data - BooNE MC comparison : MB100 (40 cm) pi+ yield



Extrapolation from thin to thick:

$$\eta_{5\%\lambda \to 100\%\lambda_I} = \left\{ \frac{N_{100\%\lambda_I}}{\sigma_{5\%\lambda_I}} \right\}^{DATA} \cdot \left\{ \frac{\sigma_{5\%\lambda_I}}{N_{100\%\lambda_I}} \right\}^{MC}$$

$$\delta\eta = \eta \left[\sum_{data,MC} \left(\frac{\delta N}{N} \right)^2 + \sum_{data,MC} \left(\frac{\delta\sigma}{\sigma} \right)^2 \right]^{1/2}$$

$$\eta_{5\%\lambda \to 50\%\lambda_I} = \left\{ \frac{N_{50\%\lambda_I}}{\sigma_{5\%\lambda_I}} \right\}^{DATA} \cdot \left\{ \frac{\sigma_{5\%\lambda_I}}{N_{50\%\lambda_I}} \right\}^{MC}$$

$$\eta_{50\%\lambda \to 100\%\lambda_I} = \left\{ \frac{N_{100\%\lambda_I}}{N_{50\%\lambda_I}} \right\}^{DATA} \cdot \left\{ \frac{N_{50\%\lambda_I}}{N_{100\%\lambda_I}} \right\}^{MC}$$

- Expected ratio for good extrapolation ~ 1.0
- Here we use HARP data and Beamline Boone MC predictions.

	ESW - p4	SW - Thesis
Be5->MB50	0.97 +/- 0.02	1.05 +/- 0.02
Be5->MB100	0.96 +/- 0.02	1.03 +/- 0.02
MB50->MB100	0.99 +/- 0.02	0.98 +/- 0.02

Short Summary

- *ESW:p4 model prediction is in a good agreement with all targets p4 data measurements.*

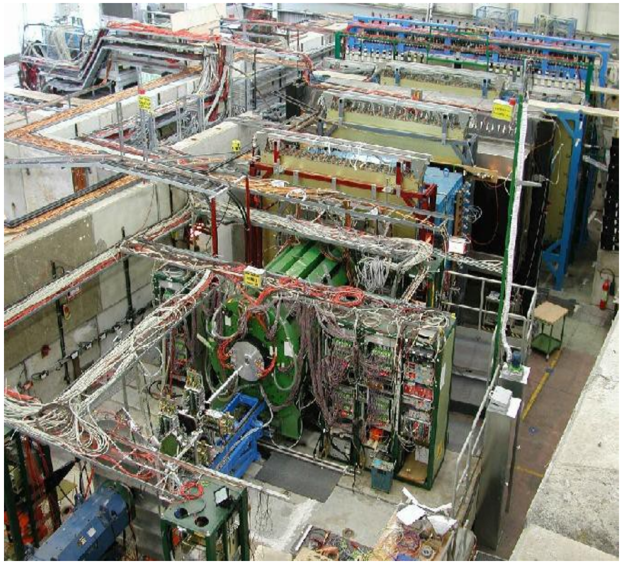
- *Extrapolation study shows that the MiniBooNE MC is doing a good job of modeling secondary particle interactions.*

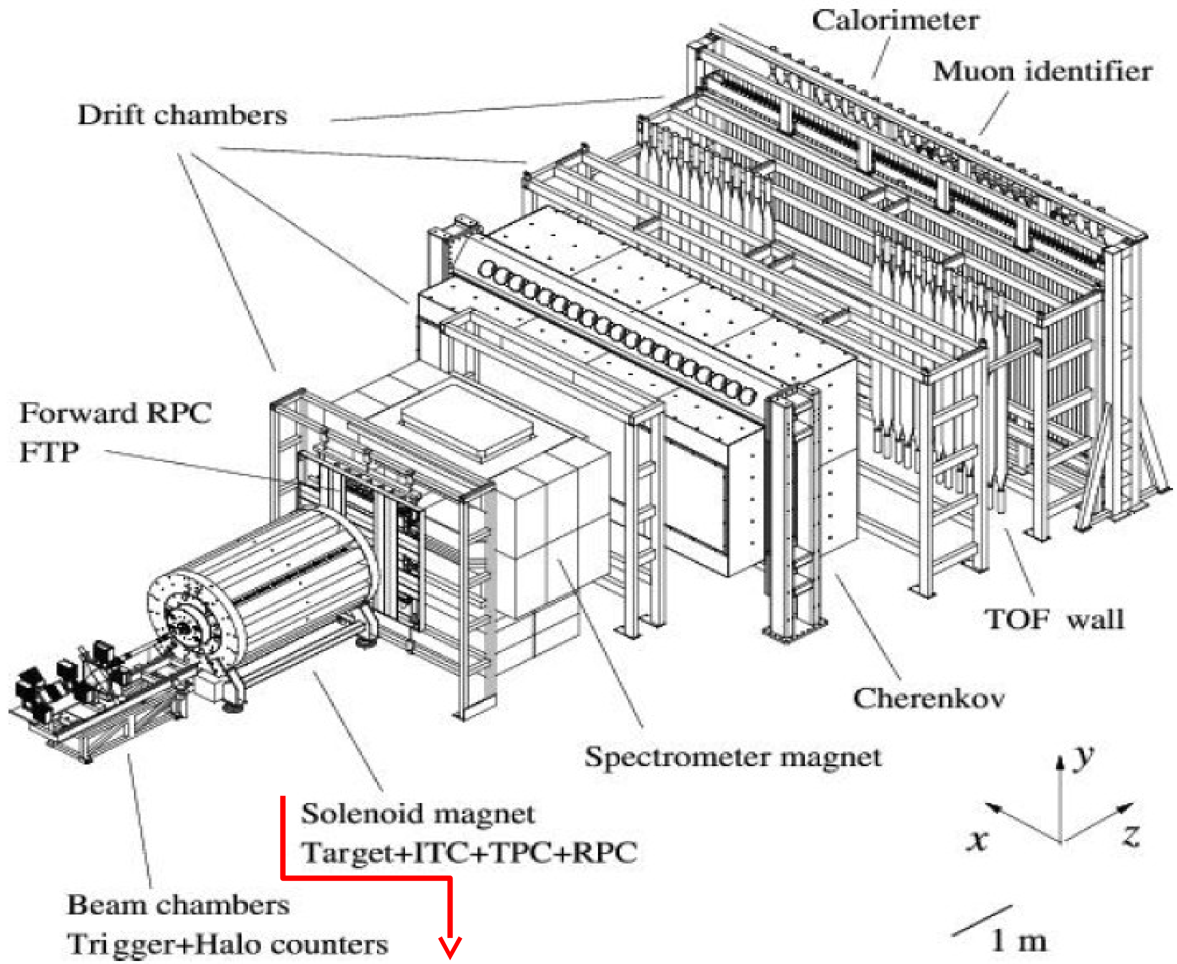
- *Work will reduce the systematic errors on extrapolation to 71 cm long Be target.*

Thank you !

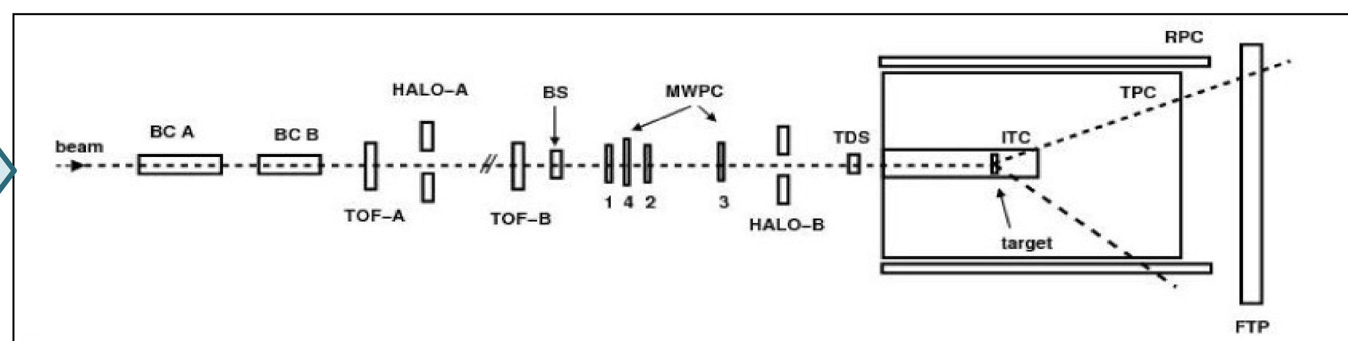
Backup slides

Overview of Harp apparatus

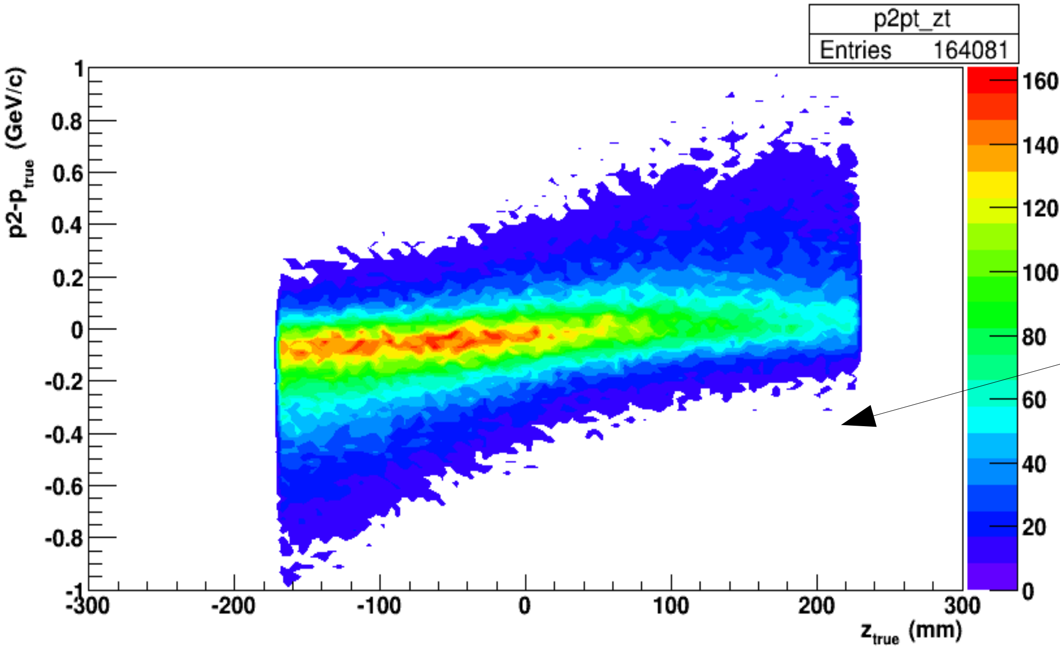




Primary Beamline
8.9GeV/c
(T9 beam)



Correlation of p2 and p4 momentum with the target length



Since p2 is highly correlated with center plane,
p2 tracks have an asymmetry at the edges

Since p4 does not correlate with center plane, this is good for long targets.