

Reconsideration of distance between modules of Baby-MIND

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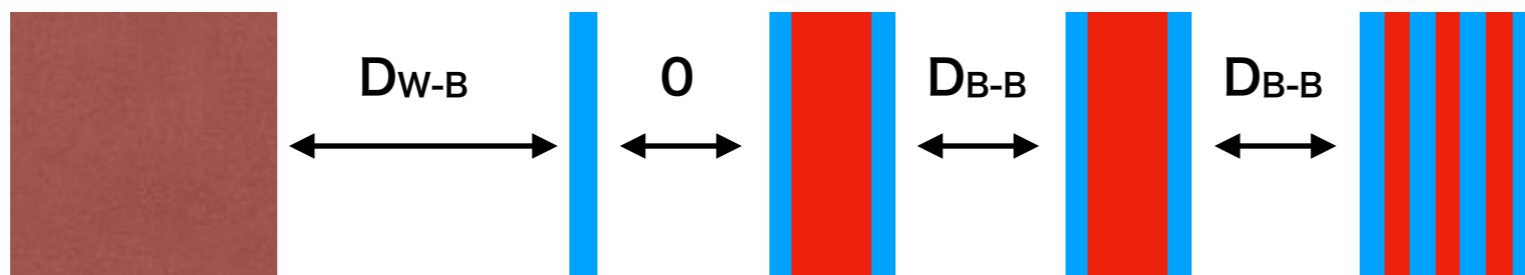
Kyoto Univ. Japan

supported by A.K.Ichikawa

Collaboration Meeting at December 7, 2017

Purpose

want to optimize the distances between modules.



WAGASCI

Baby-MIND

Distance	Acceptance	Angle Resolution (Charge ID)
large	worse	better
small	better	worse

Purpose



Scintillator bars

Bending angle and angle of multiple scattering is almost same in case of Baby-MIND. Width of horizontal scintillator bar is 3 cm ,so precision of muon position does not seem good.

Gap between modules is extended to improve the angle resolution.

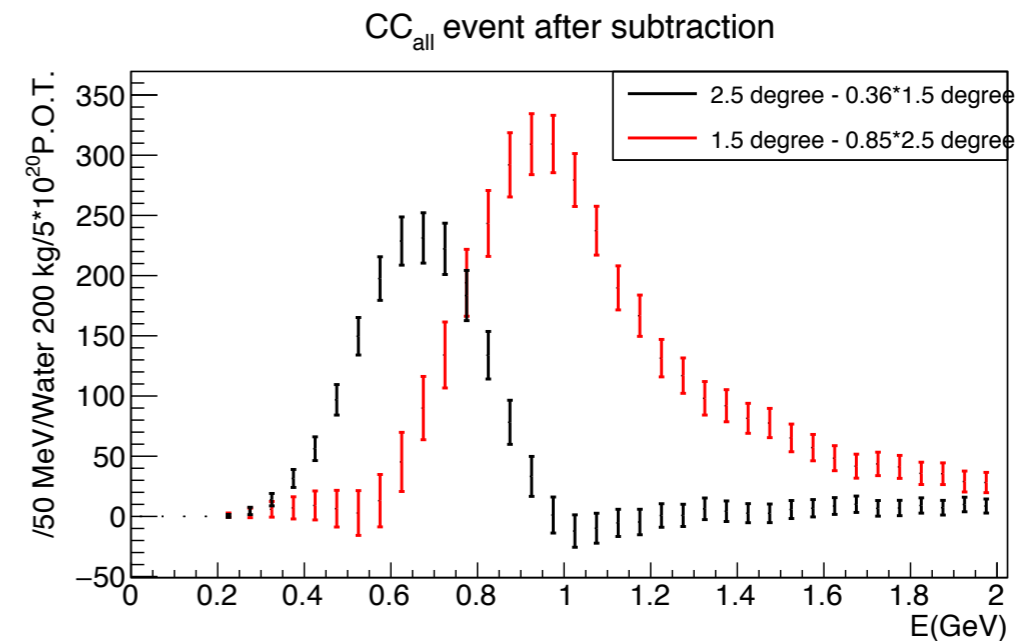
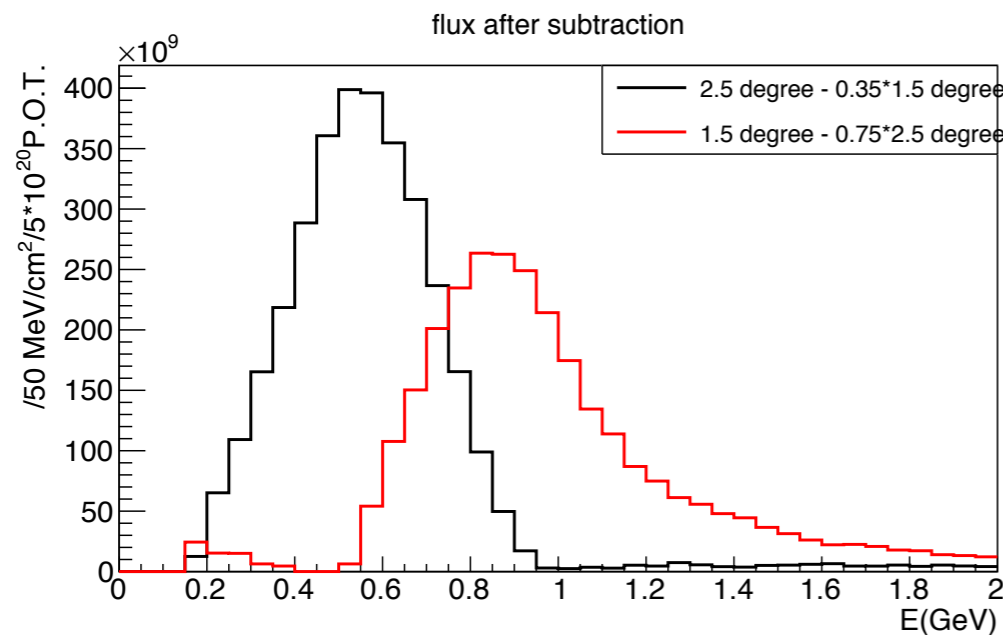
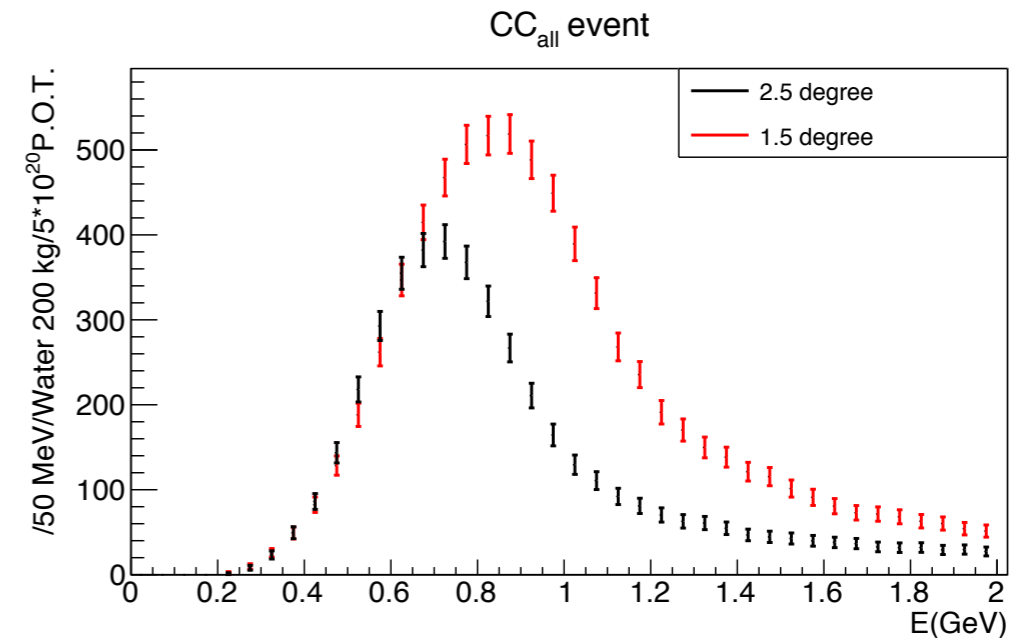
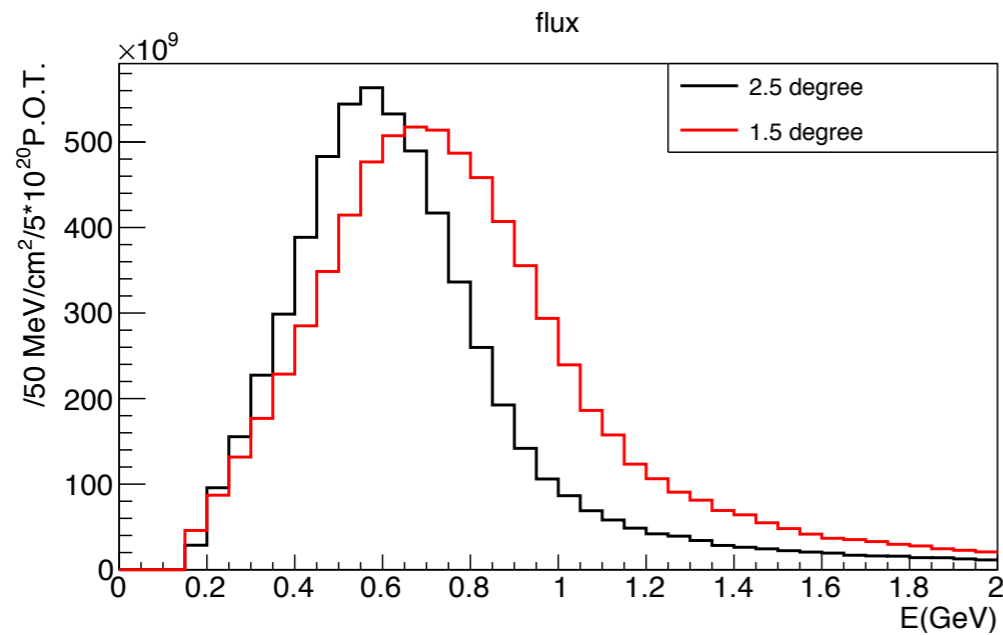
Purpose

- According to the preceding research, requirement of Baby-MIND is 90 % Charge ID.
- The requirement of charge ID should be based on the final systematic error.
- If high CID performance is needed, distance mentioned in previous slide should be larger, otherwise be smaller.

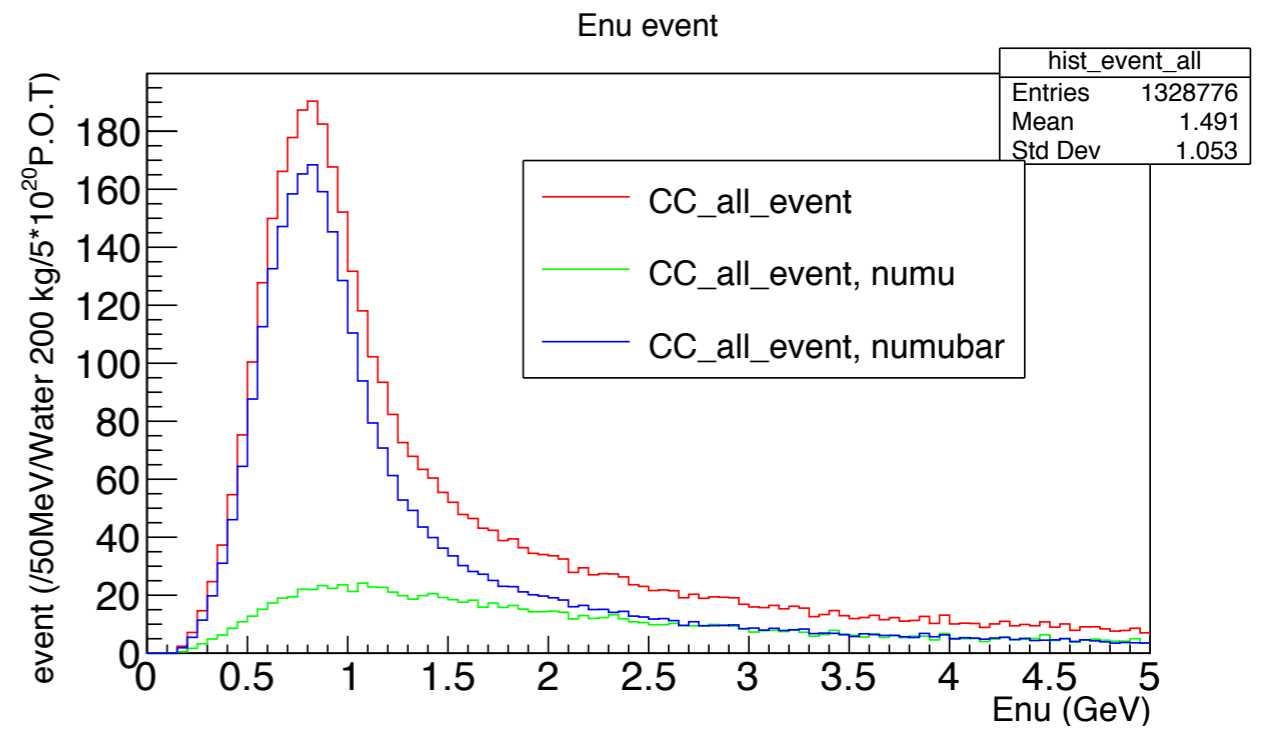
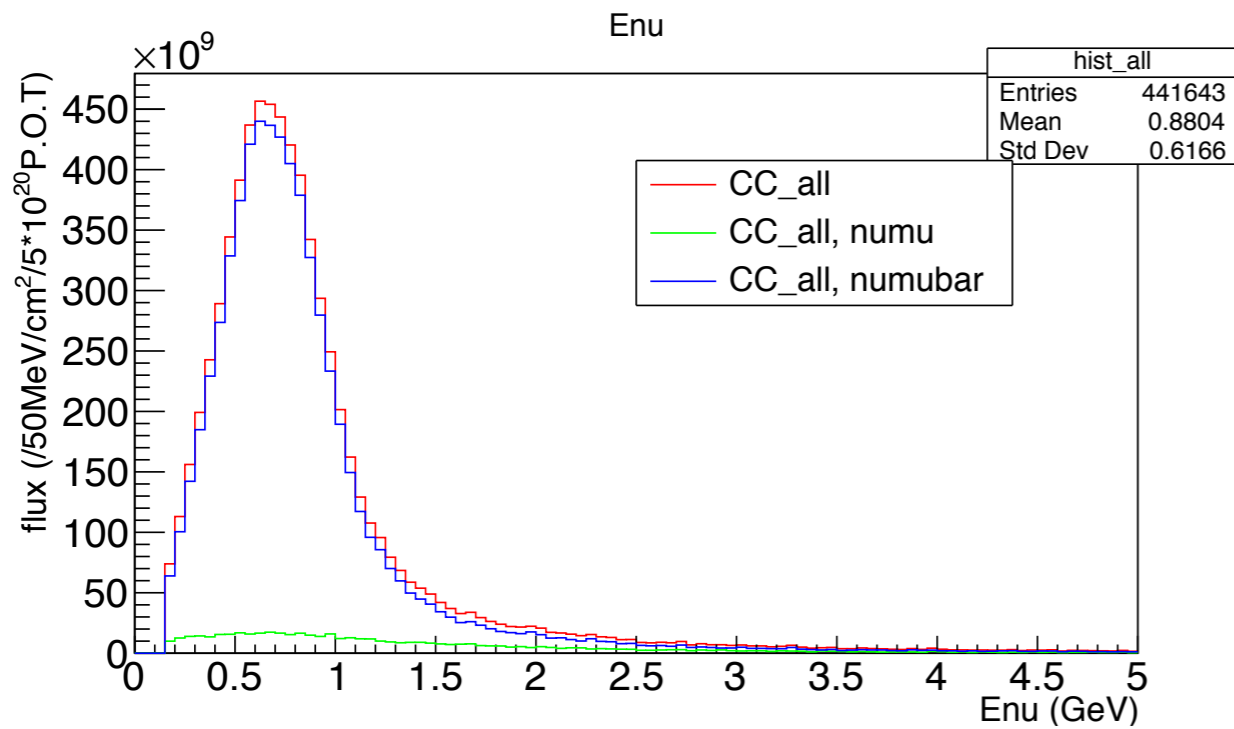
Flux of J-PARC Neutrino beam

CC_{all} Events at WAGASCI

(FHC mode)

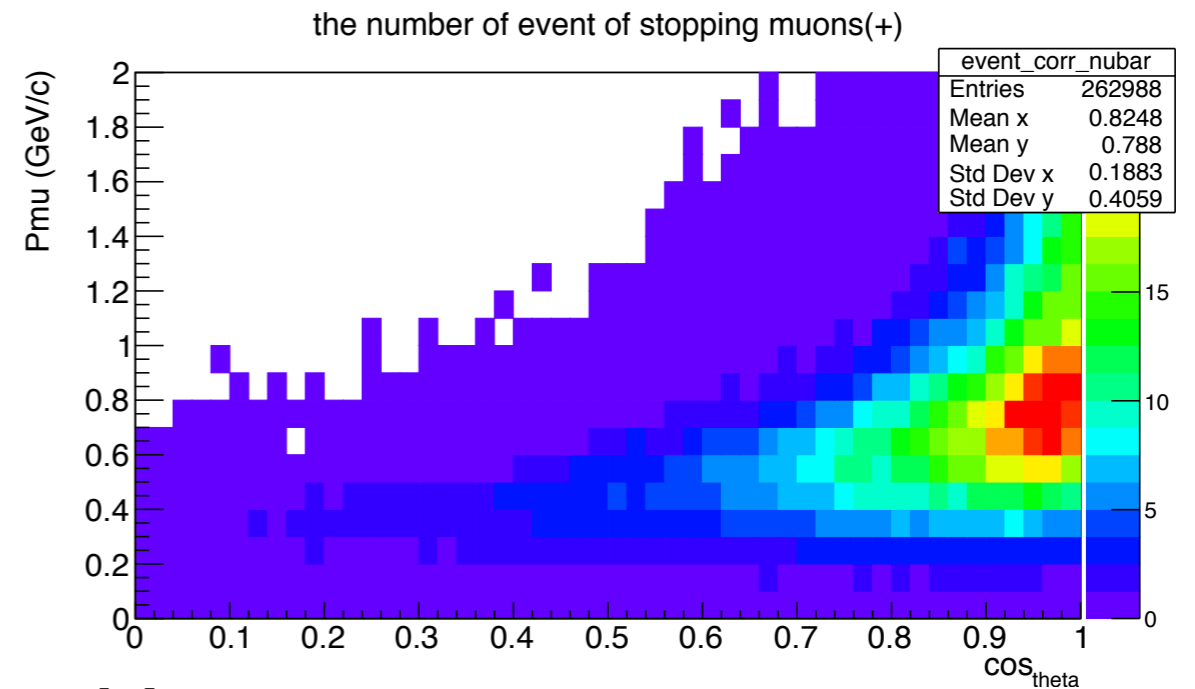
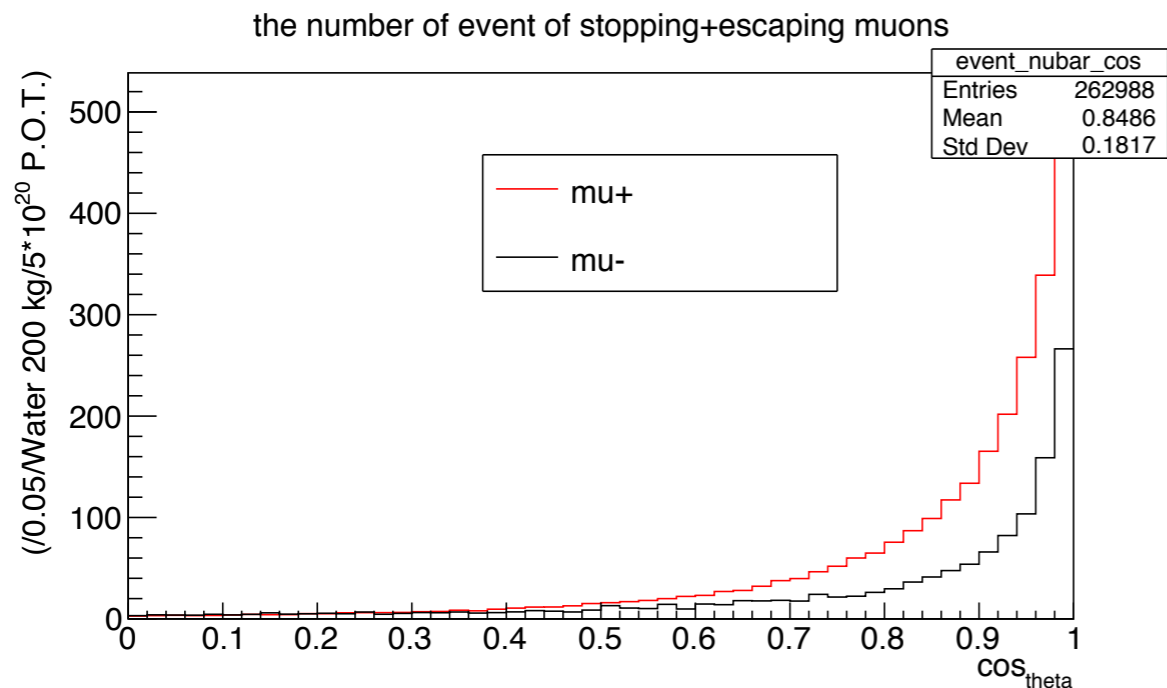
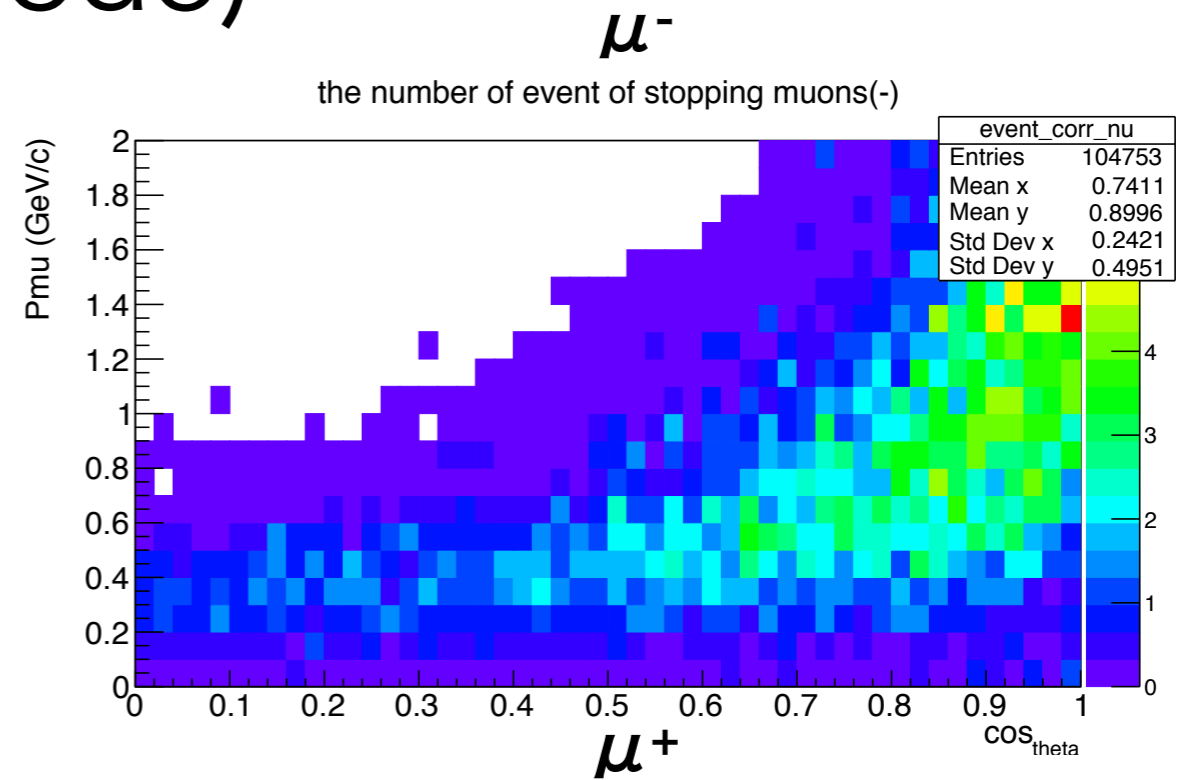
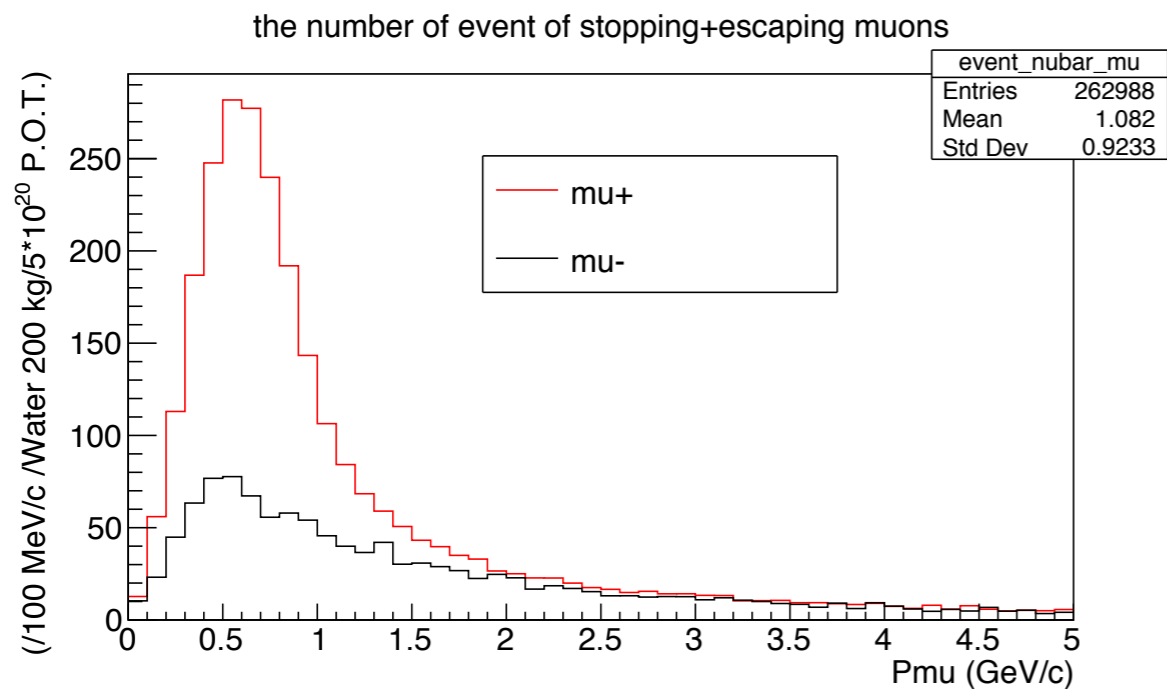


Flux of J-PARC Neutrino beam at off axis angle 1.5 degree (RHC mode)



CC_{all} events as the function of P_{mu}, cos

(RHC mode)



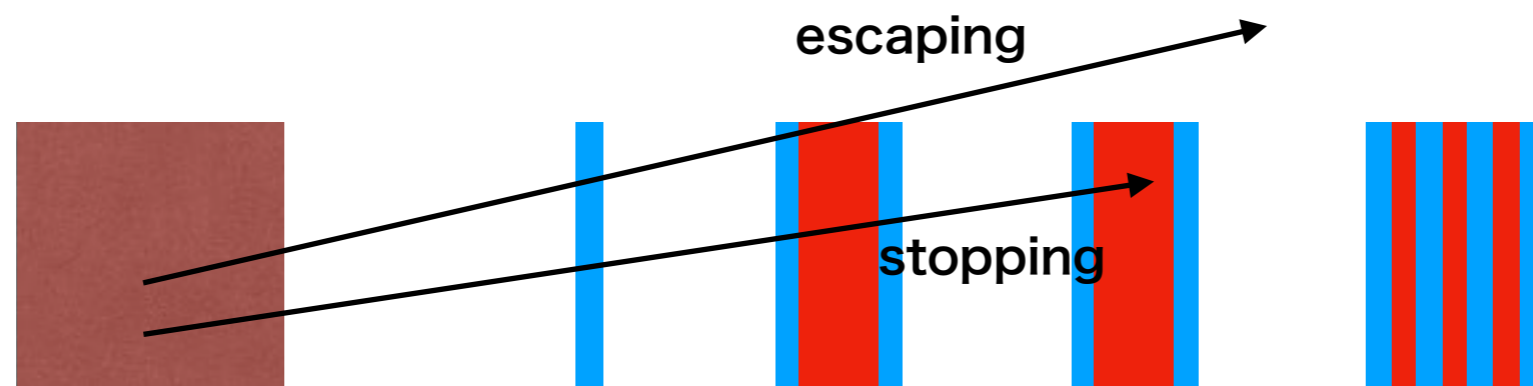
cut : cos_theta > 0

bin

cos : 0.05, Pmu : 100MeV/c

muon stopping rate

- Momentum of muons can be measured in case of muons' stopping in a module.

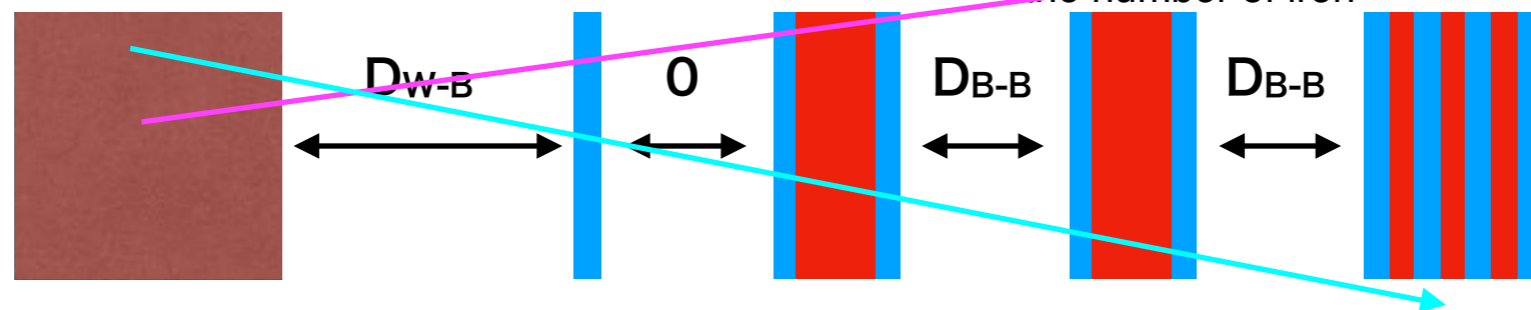
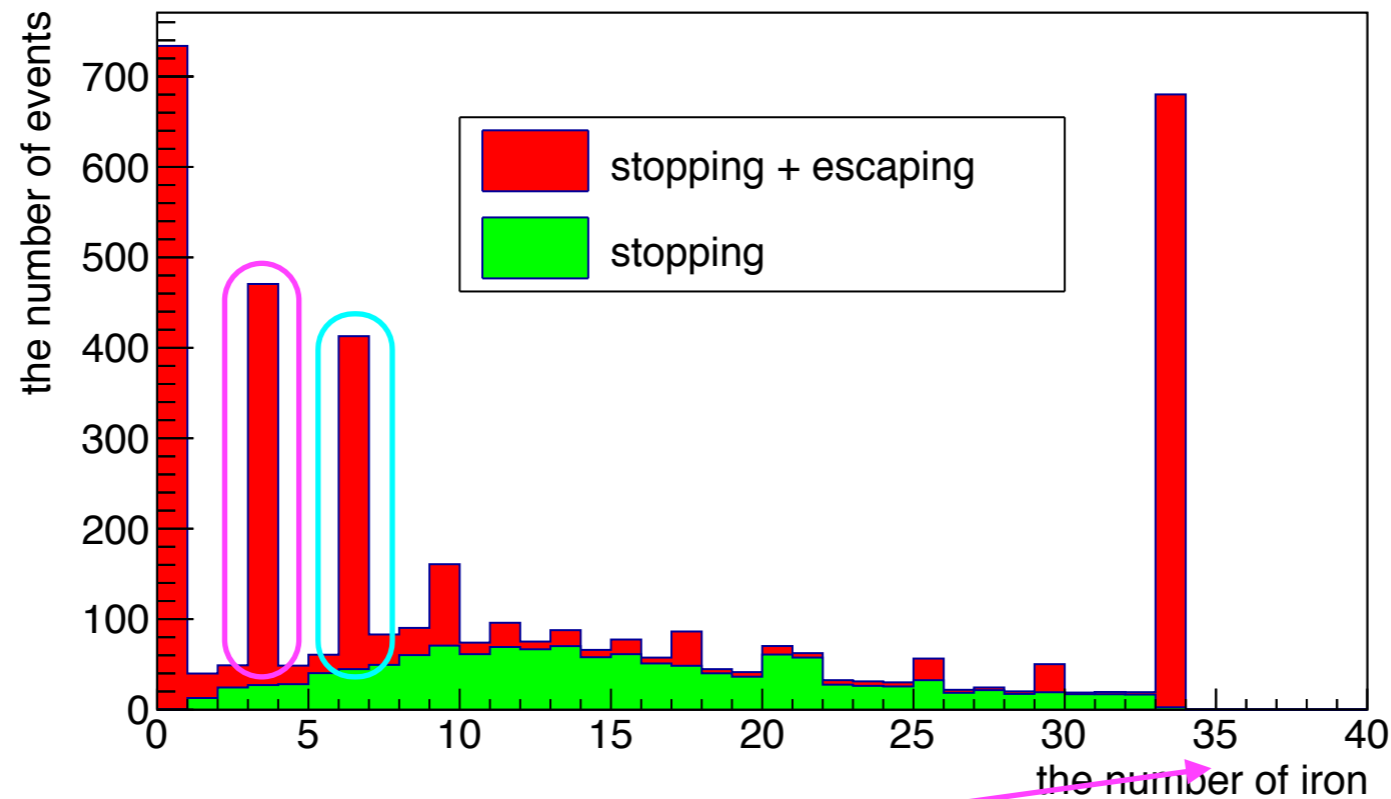


- The number of events of stopping muons are estimated by simple MC without considering magnetic field.
- Norm : /200 kg Water /5*10^{20} P.O.T.

muon stopping rate

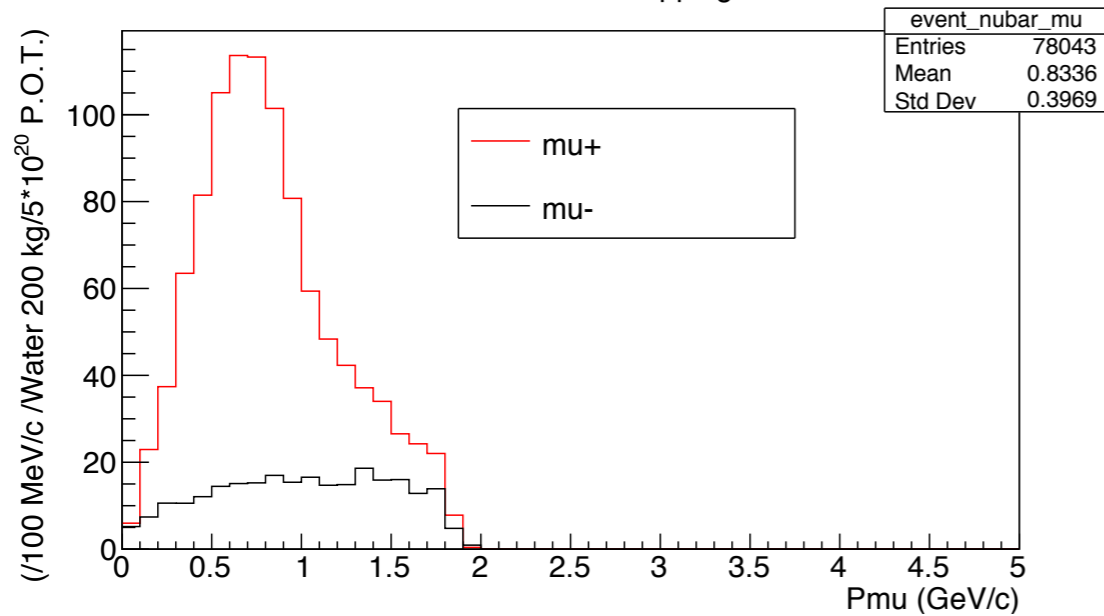
$D_{W-B}=100$ cm, $D_{B-B}=50$ cm

Events of stopping/escaping muons

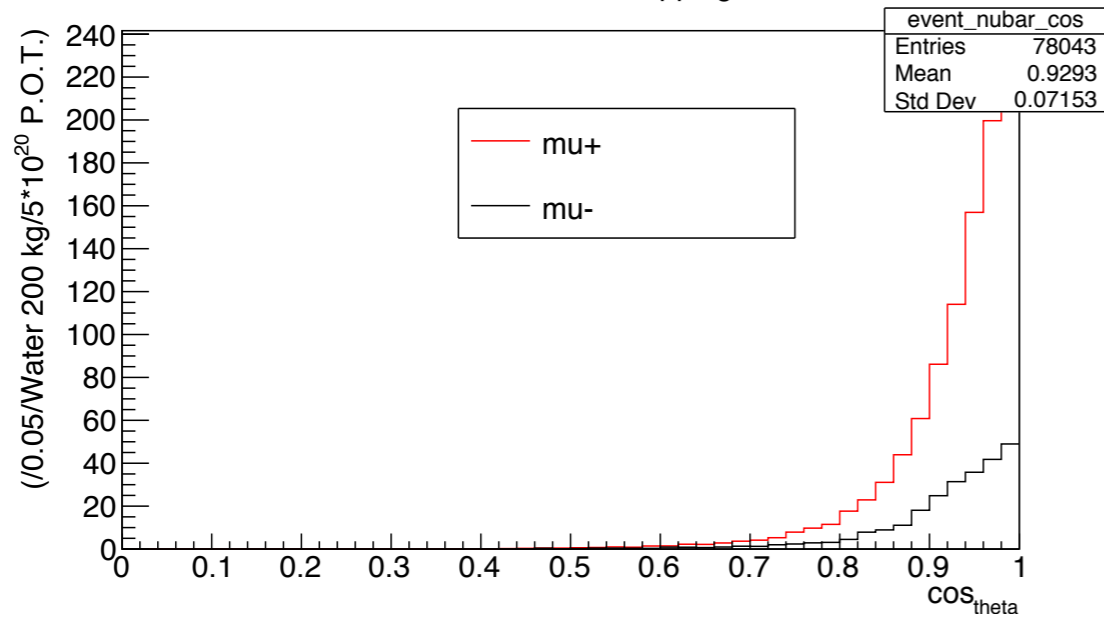


Stopping muons

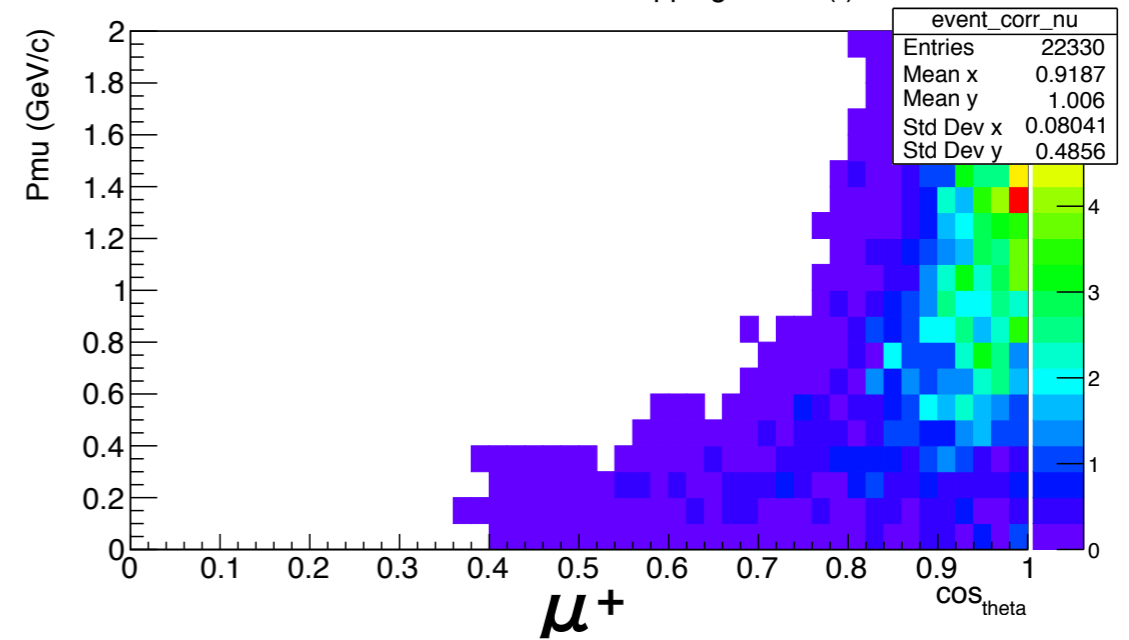
the number of event of stopping muons



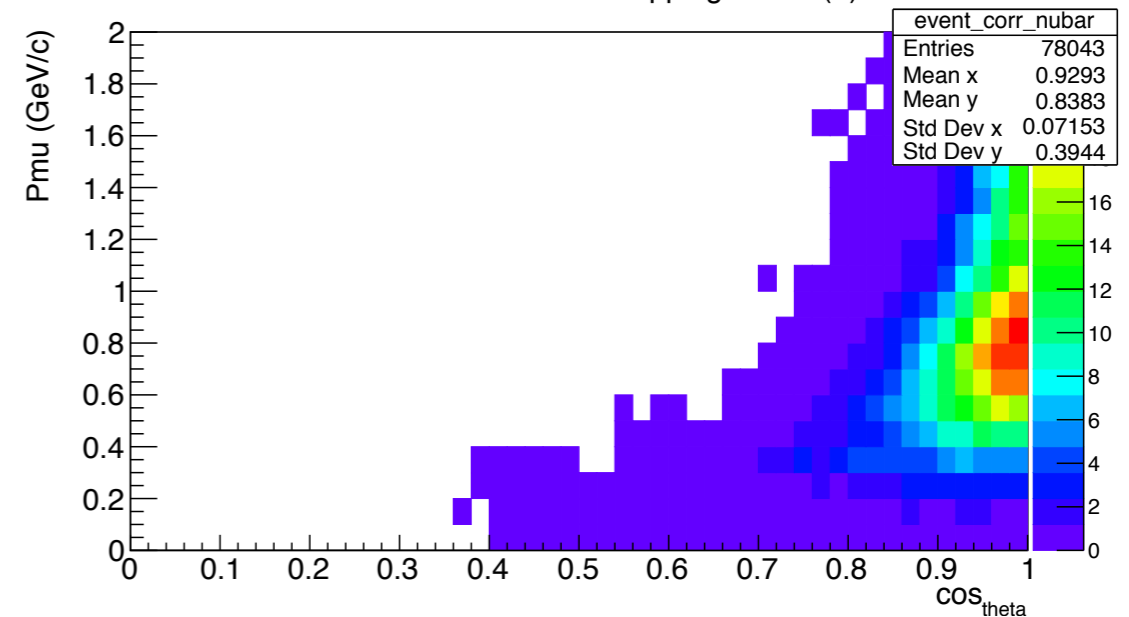
the number of event of stopping muons



the number of event of stopping muons(-)



the number of event of stopping muons(+)



bin

cos : 0.05, Pmu : 100MeV/c

Systematic error from wrong sign

- Systematic error from statistical error of wrong sign contamination is calculated as following.

$$N_{\nu}^{obs} = N_{\nu} \varepsilon + N_{\bar{\nu}} (1 - \varepsilon)$$

$$N_{\bar{\nu}}^{obs} = N_{\nu} (1 - \varepsilon) + N_{\bar{\nu}} \varepsilon$$

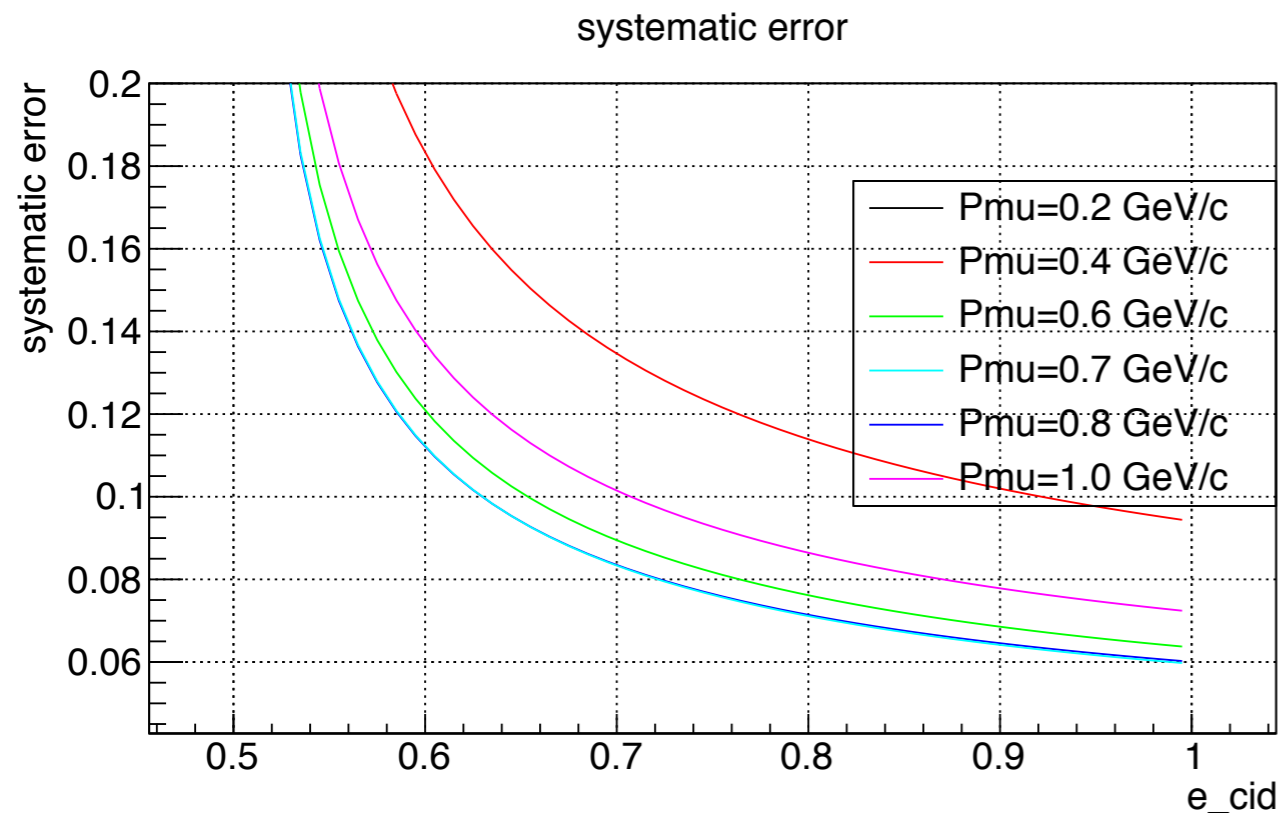
Assumed that CID efficiency (ε) is same in both case of ν and anti- ν , and it has no error.



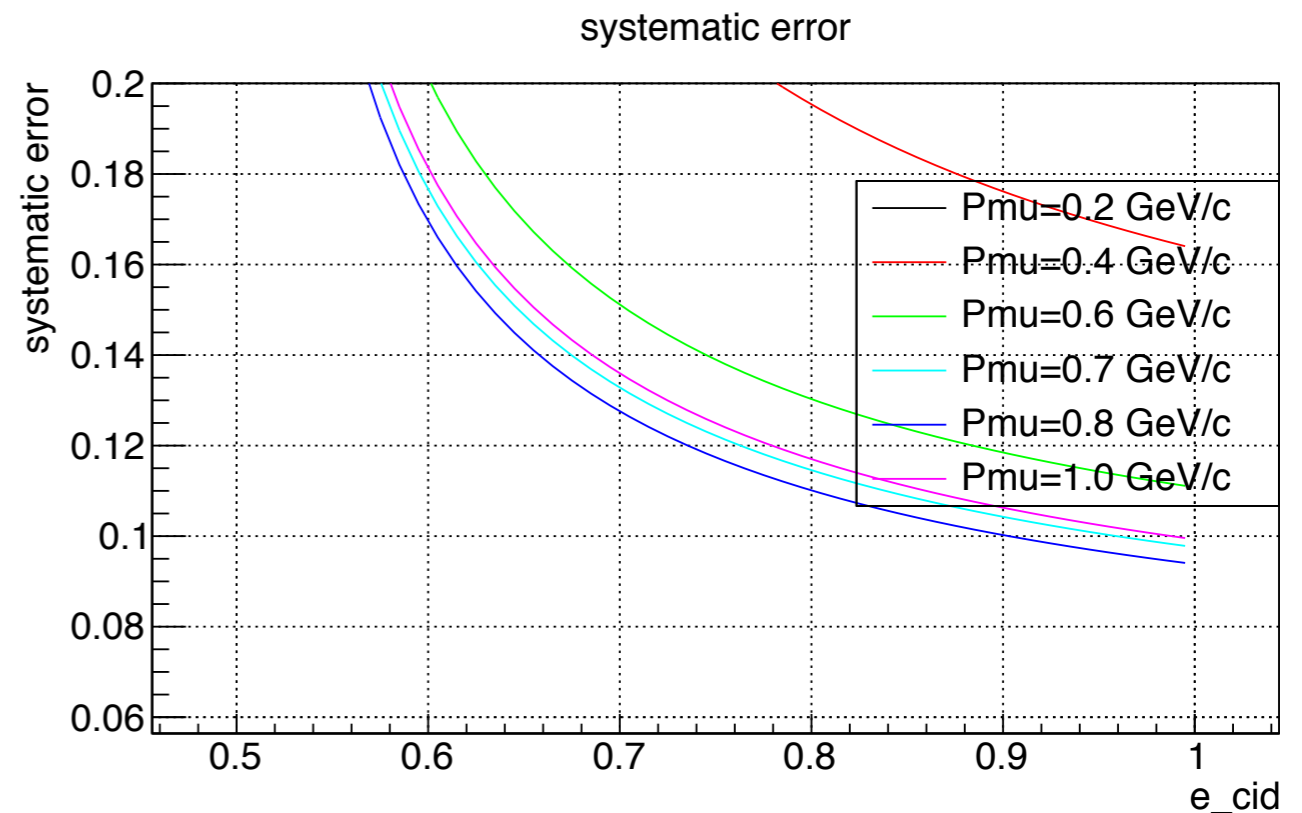
$$N_{\bar{\nu}} = \frac{\varepsilon}{2\varepsilon - 1} N_{\bar{\nu}}^{obs} - \frac{1 - \varepsilon}{2\varepsilon - 1} N_{\nu}^{obs}$$

$$\frac{\sigma(N_{\bar{\nu}})}{N_{\bar{\nu}}} = \frac{\sqrt{\frac{\varepsilon}{2\varepsilon - 1} N_{\bar{\nu}}^{obs} + \frac{1 - \varepsilon}{2\varepsilon - 1} N_{\nu}^{obs}}}{N_{\bar{\nu}}}$$

Systematic errors for stopping muons



Stopping + escaping muons

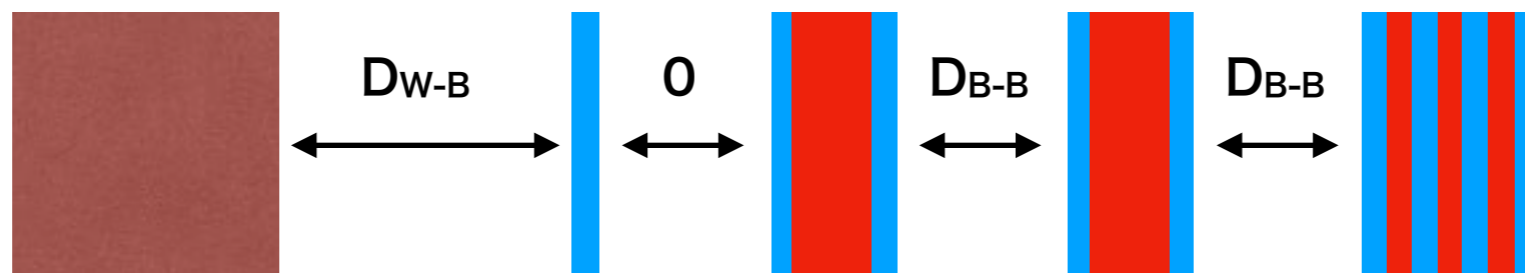


Stopping muons

Comparison

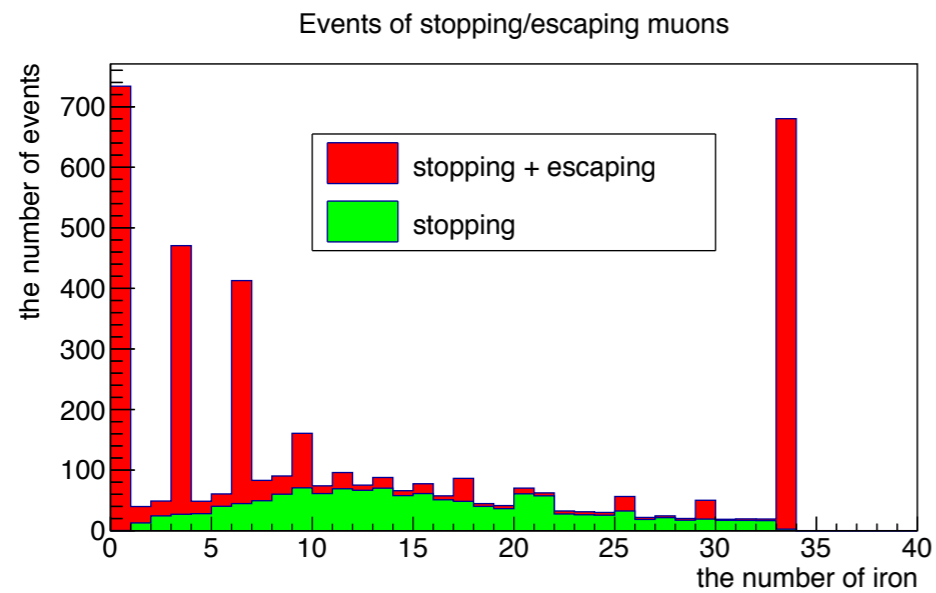
- Four kinds of combination are studied.

D_{W-B}/D_{B-B}	50 cm	10 cm
100 cm	100-50	100-10
20 cm	50-20	20-10



Comparison

The number of stopping muons



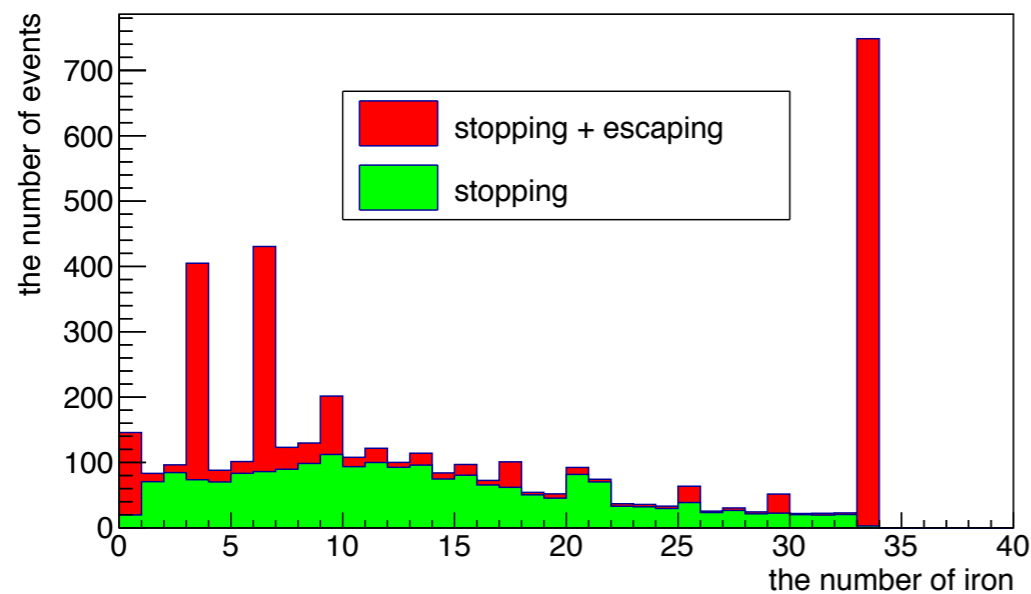
100-50

Events of stopping/escaping muons

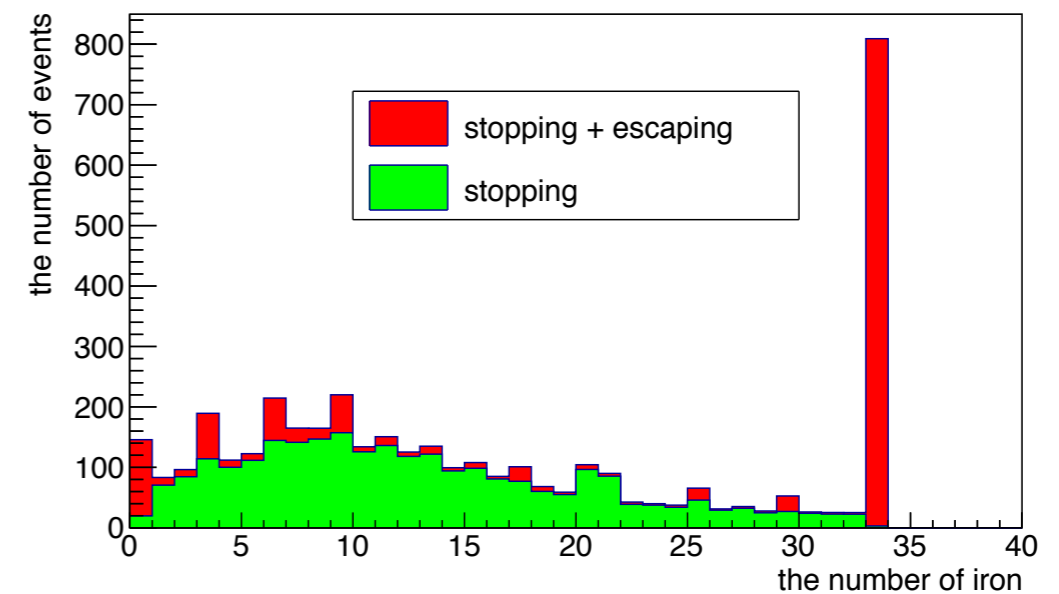


100-10

Events of stopping/escaping muons



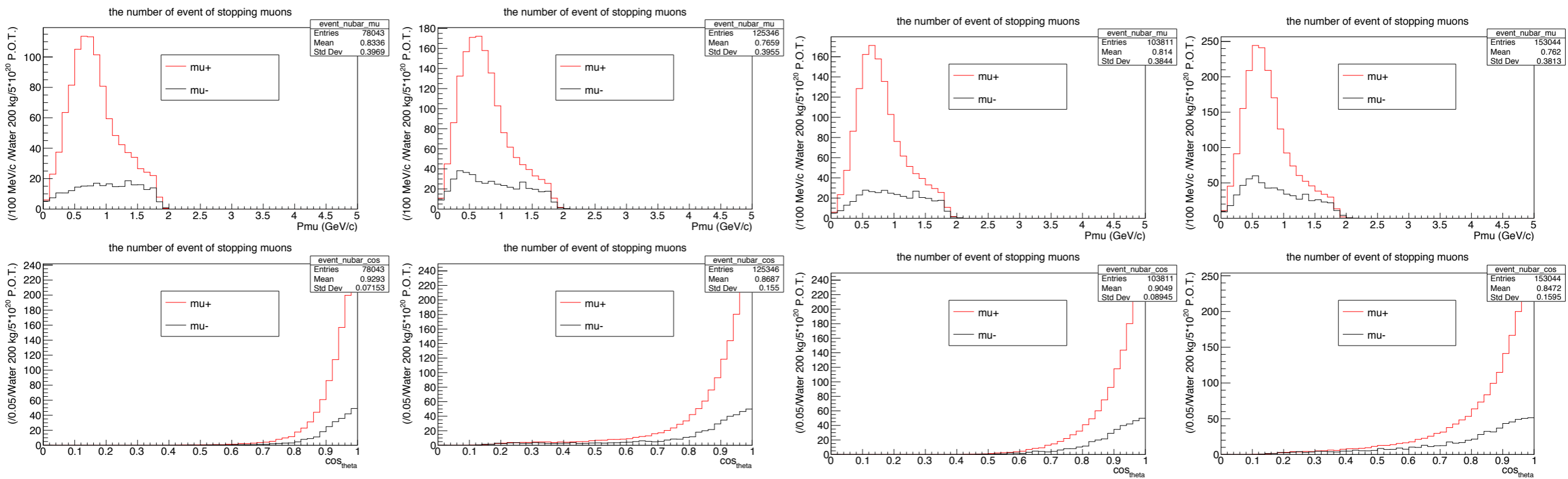
20-50



20-10

Comparison

The number of stopping muons



100-50

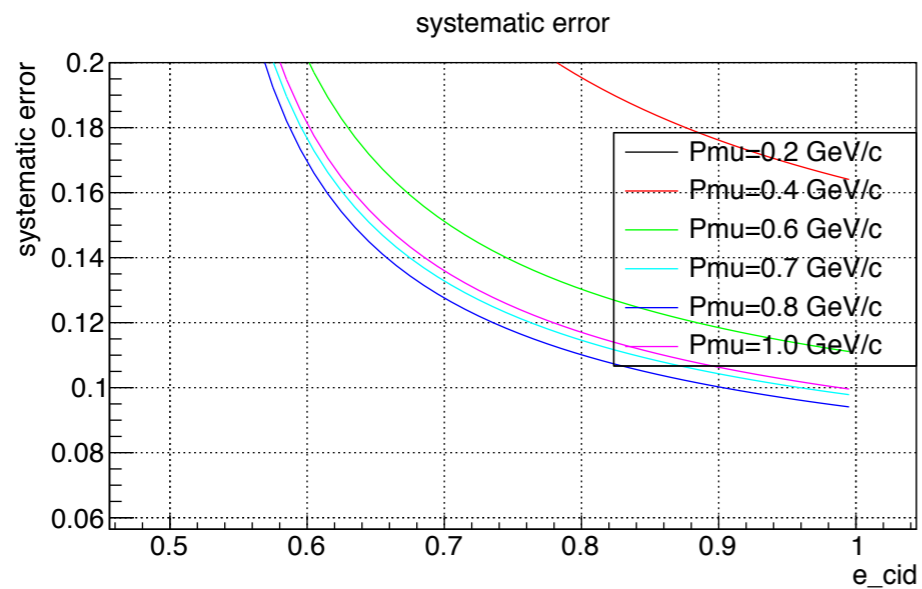
20-50

100-10

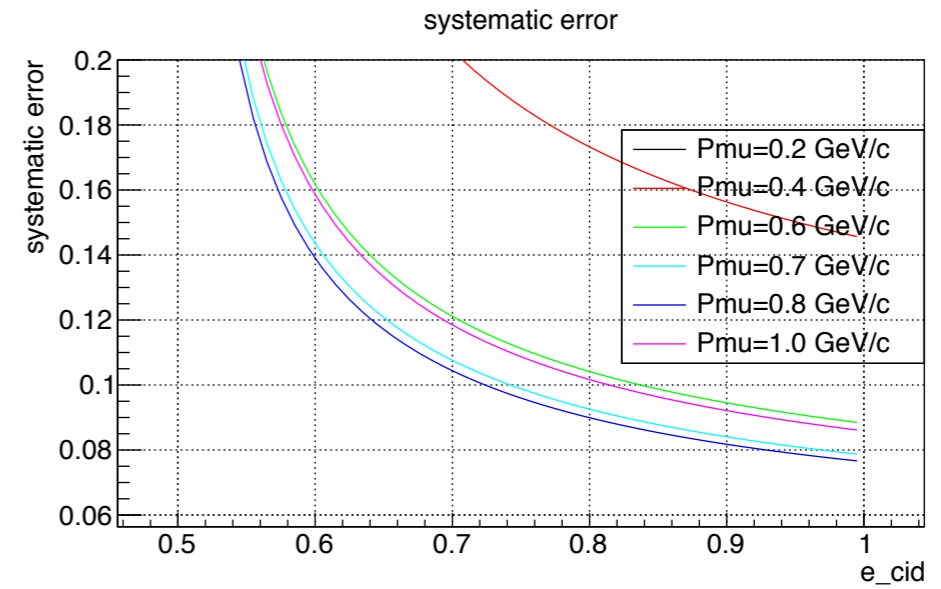
20-10

Comparison

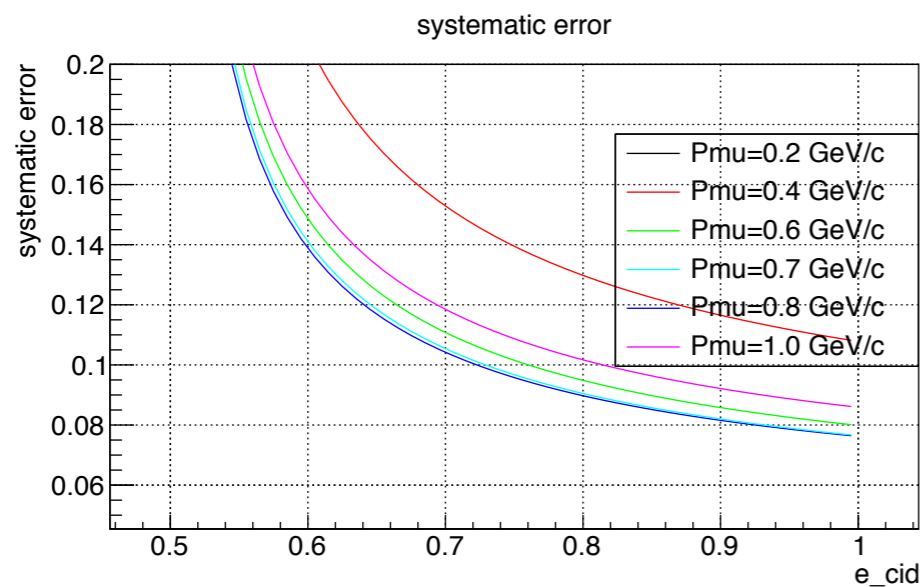
systematic error for stopping muons



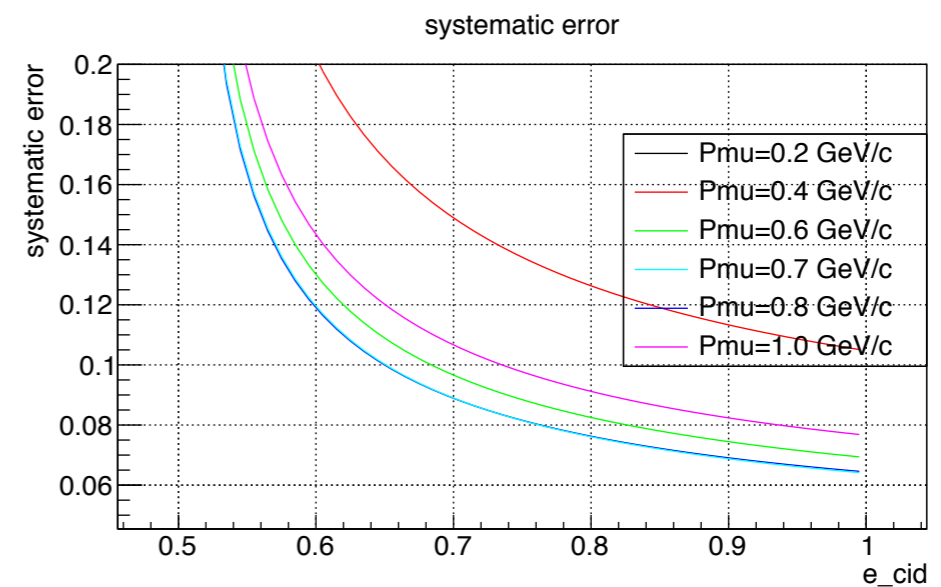
100-50



100-10

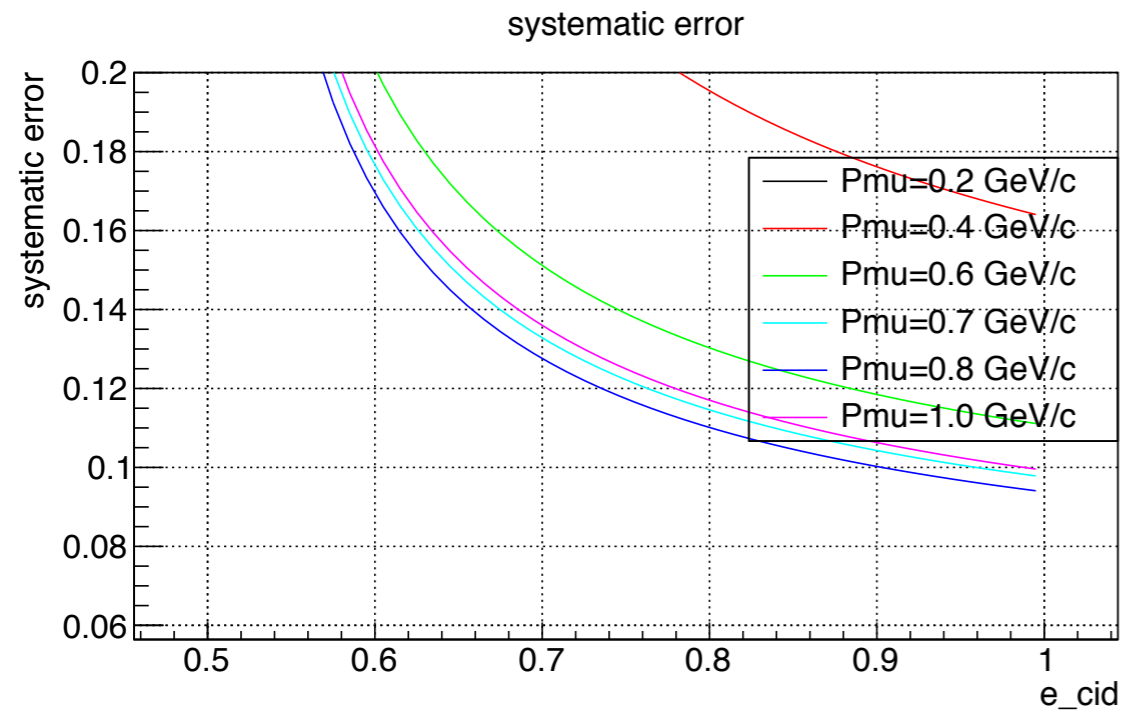


20-50

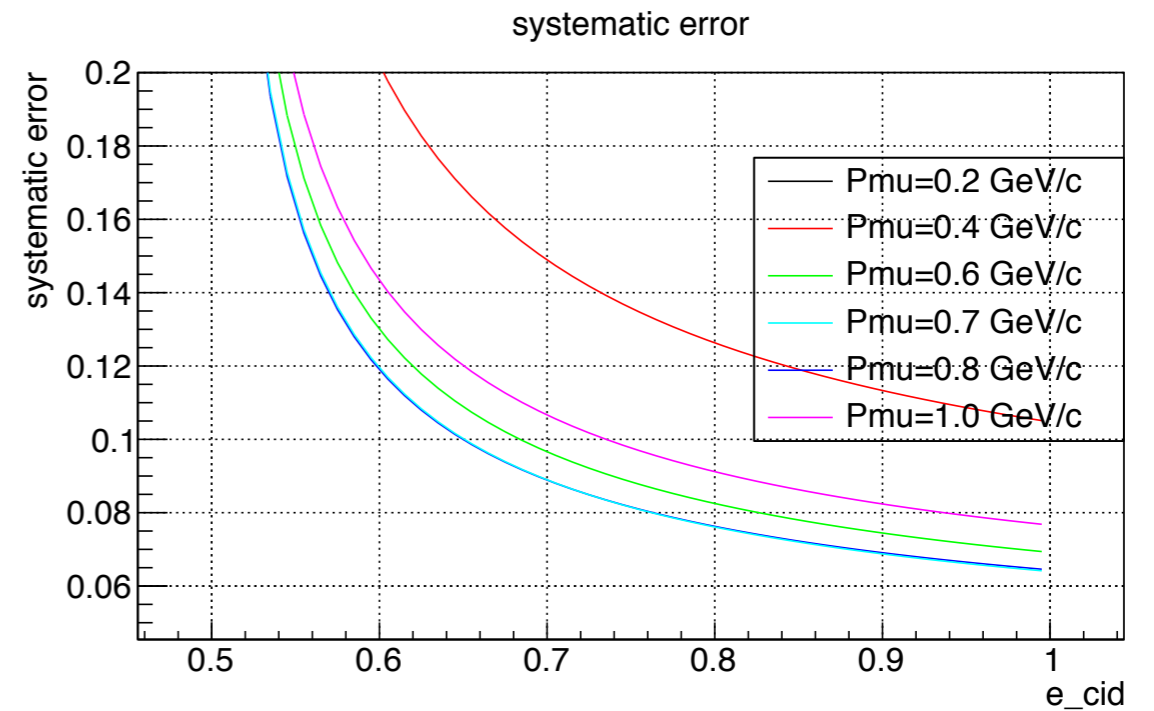


20-10

Comparison



100-50



20-10

Conclusion

- 20 - 50 and 100 - 10 configuration require 90 % charge ID performance to get 8 % sys-error for wrong sign subtraction , while 75 % in the case of 20 - 10.
- Next : We need to know how CID depends on the gap.