

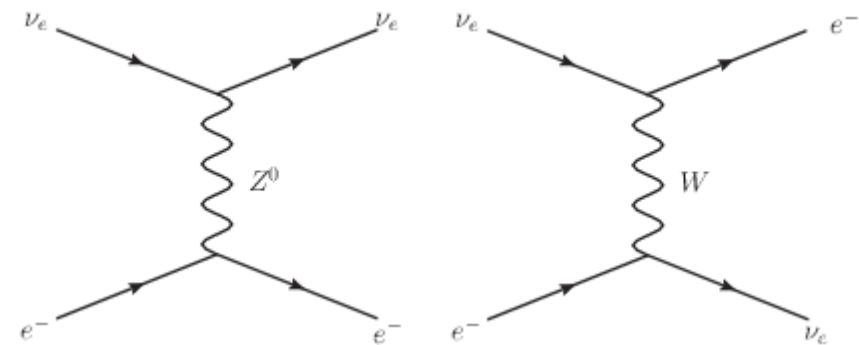
Elastic scattering of neutrinos on electrons

Kaja Krhač

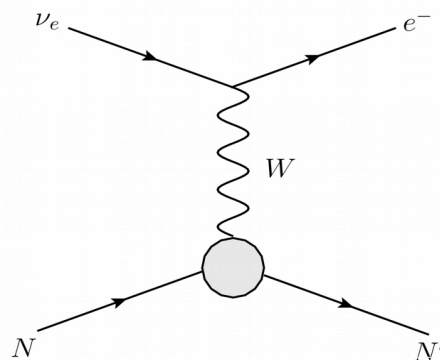
Why are we interested in this?

- obtaining neutrino flux – we know cross sections for neutrinos scattering on electrons and interaction rate
 - background process - neutrinos scattering on nuclei
- cross section is not precisely known

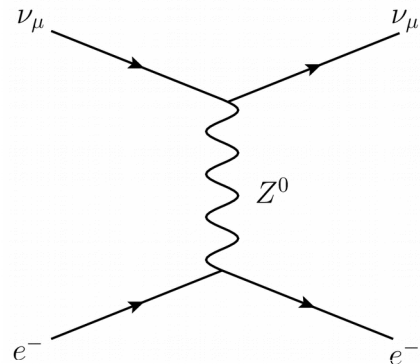
$$1. \quad \nu_e + e^- \xrightarrow{\text{NC} + \text{CC}} \nu_e + e^-$$



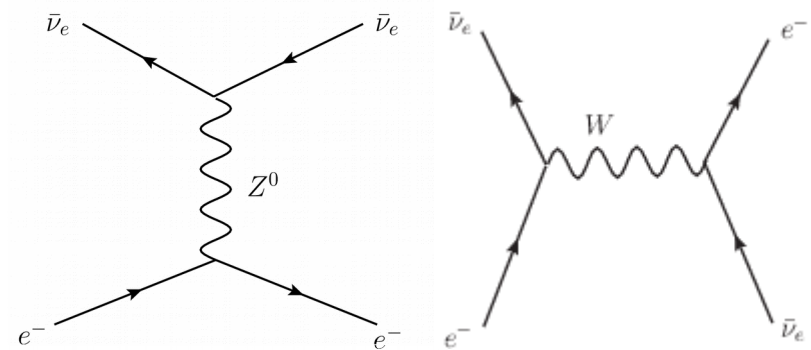
$$2. \quad \nu_e + N \xrightarrow{\text{CC}} N' + e^-$$



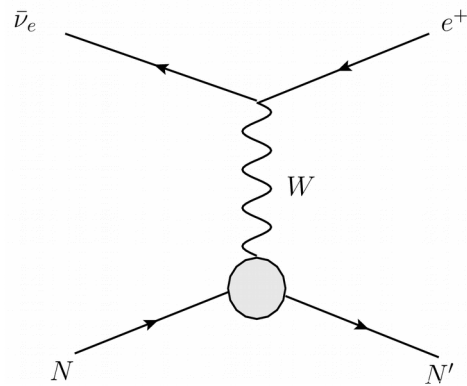
$$3. \quad \nu_\mu + e^- \xrightarrow{\text{NC}} \nu_\mu + e^-$$



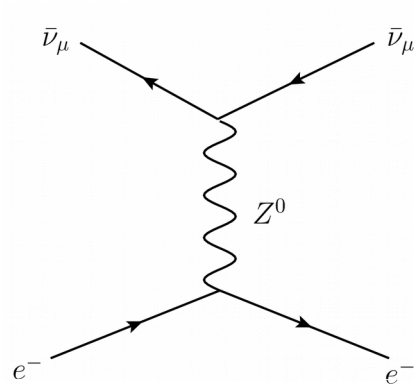
$$1. \quad \bar{\nu}_e + e^- \xrightarrow{\text{NC} + \text{CC}} \bar{\nu}_e + e^-$$



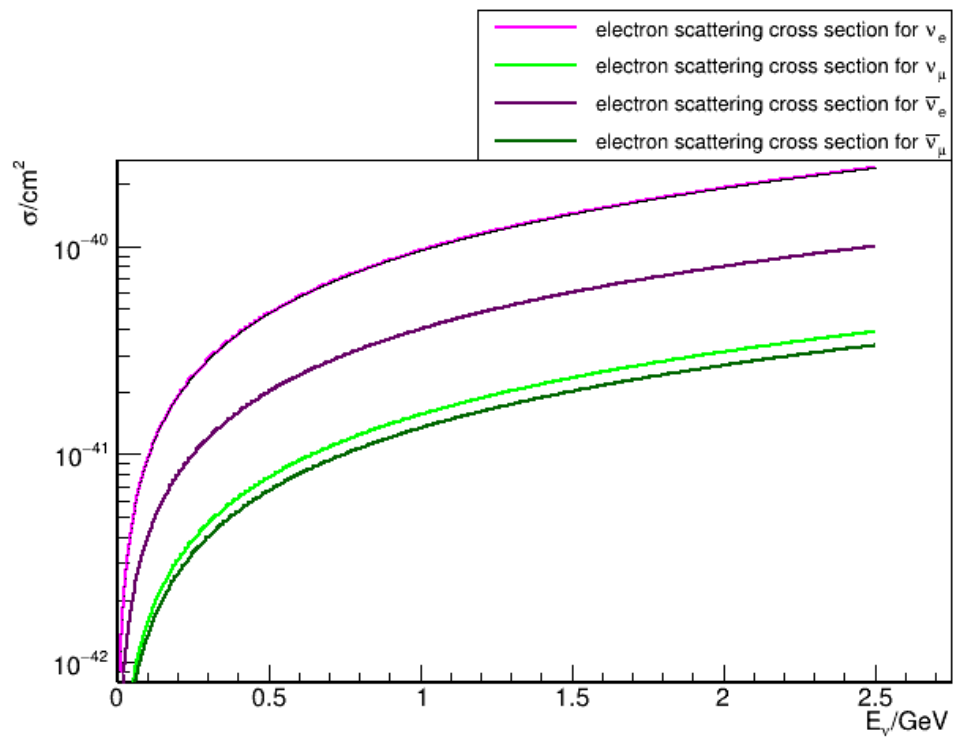
$$2. \quad \bar{\nu}_e + N \xrightarrow{\text{CC}} N' + e^+$$



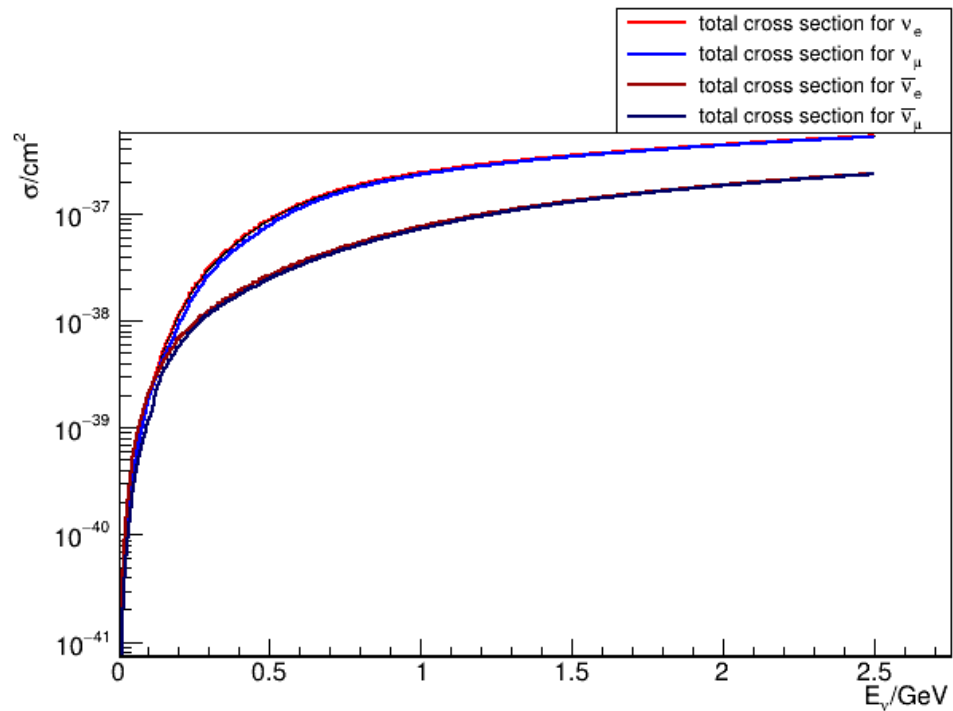
$$3. \quad \bar{\nu}_\mu + e^- \xrightarrow{\text{NC}} \bar{\nu}_\mu + e^-$$



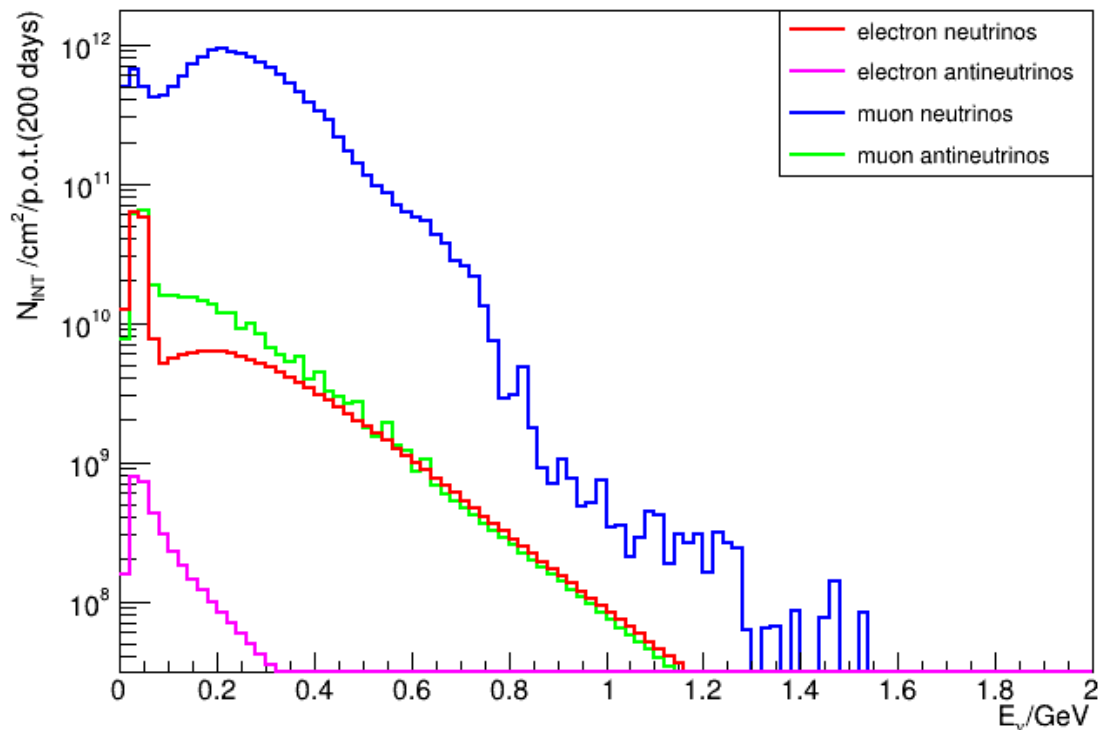
Cross section for neutrino scattering on electron



Total cross section

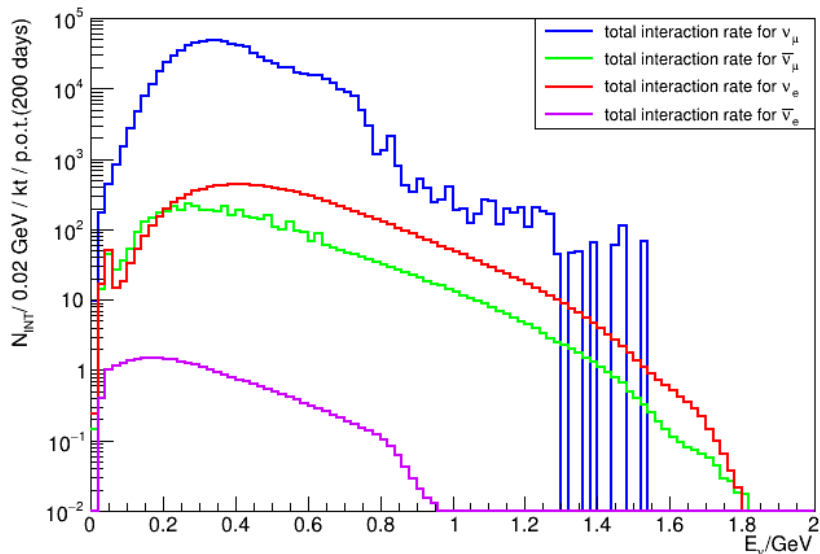


Flux at 500 m from target (positive horn polarity)

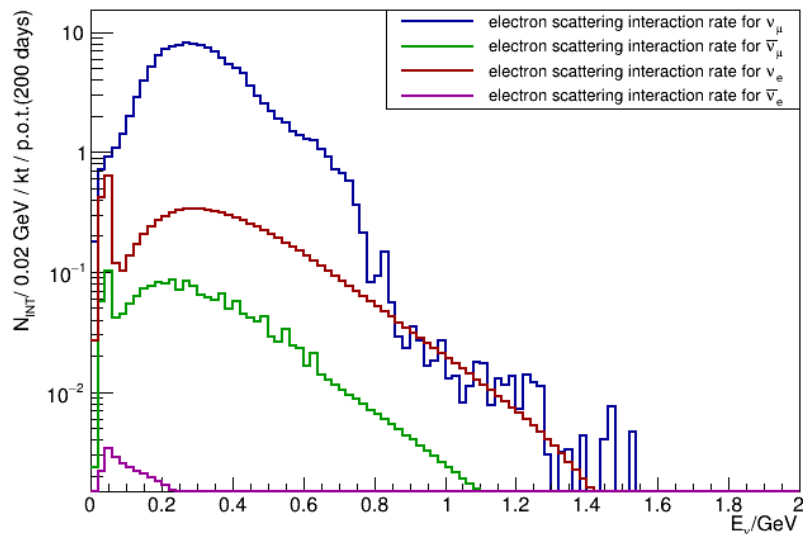


	total flux / $\text{cm}^2/\text{p.o.t.}(200 \text{ days})$ p.o.t.(200 days) = 2.16×10^{23}
muon neutrino	1.47×10^{13}
electron neutrino	2.52×10^{11}
muon antineutrino	3.49×10^{11}
electron antineutrino	3.70×10^9

Flux: <https://essnusb.eu/DocDB/private/ShowDocument?docid=342>



Total interaction rate at 500 m from target (positive horn polarity)

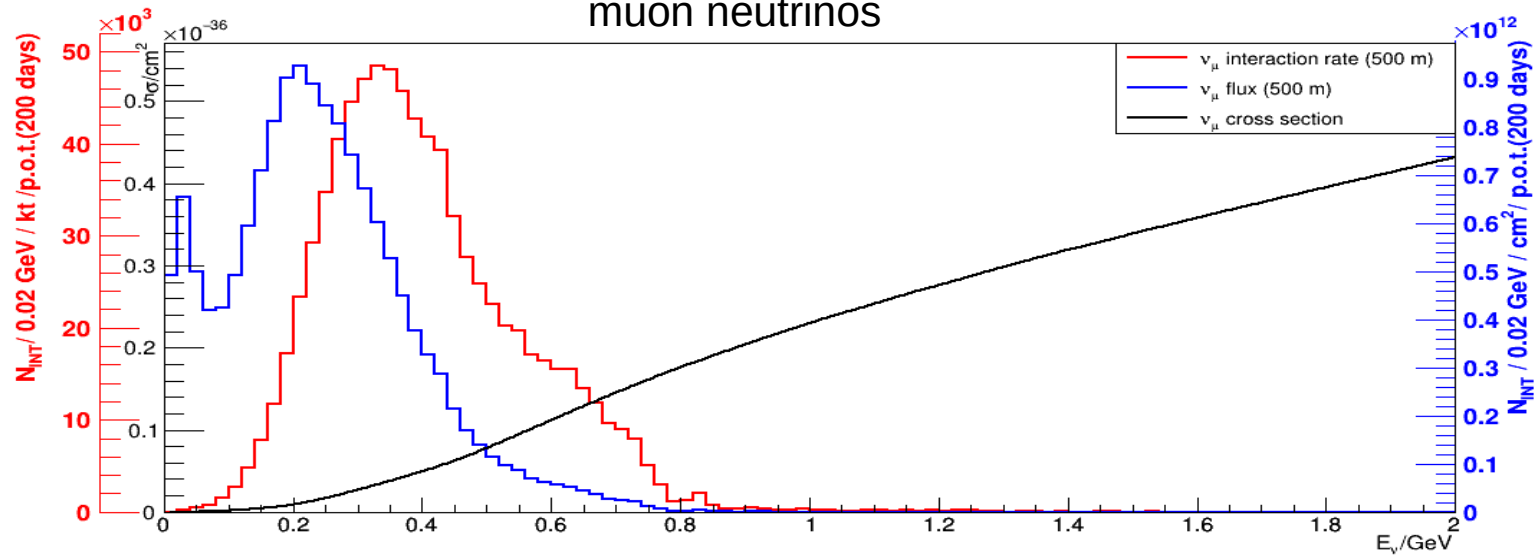


Interaction rate for neutrinos scattering on electrons at 500 m from target (positive horn polarity)

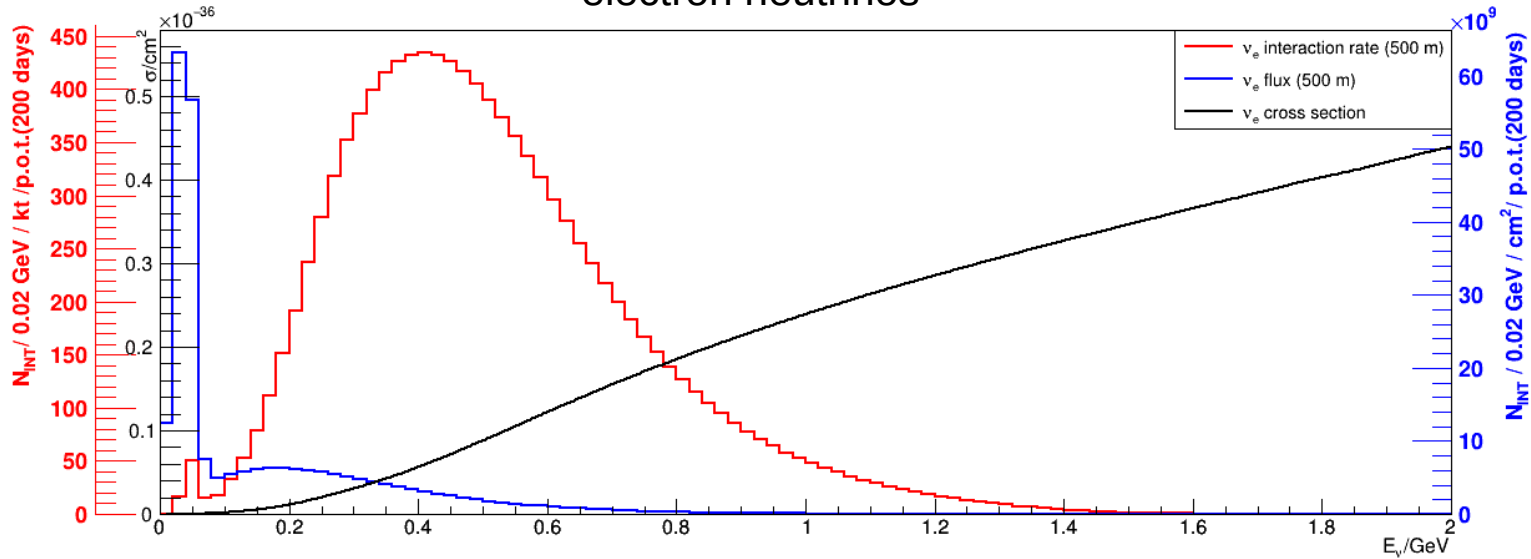
muon neutrino scatters on electron every 6024 events

	expected number of interactions (in kt in 200 days)
muon neutrino	814 217
electron neutrino	11 250
muon antineutrino	4324
electron antineutrino	30

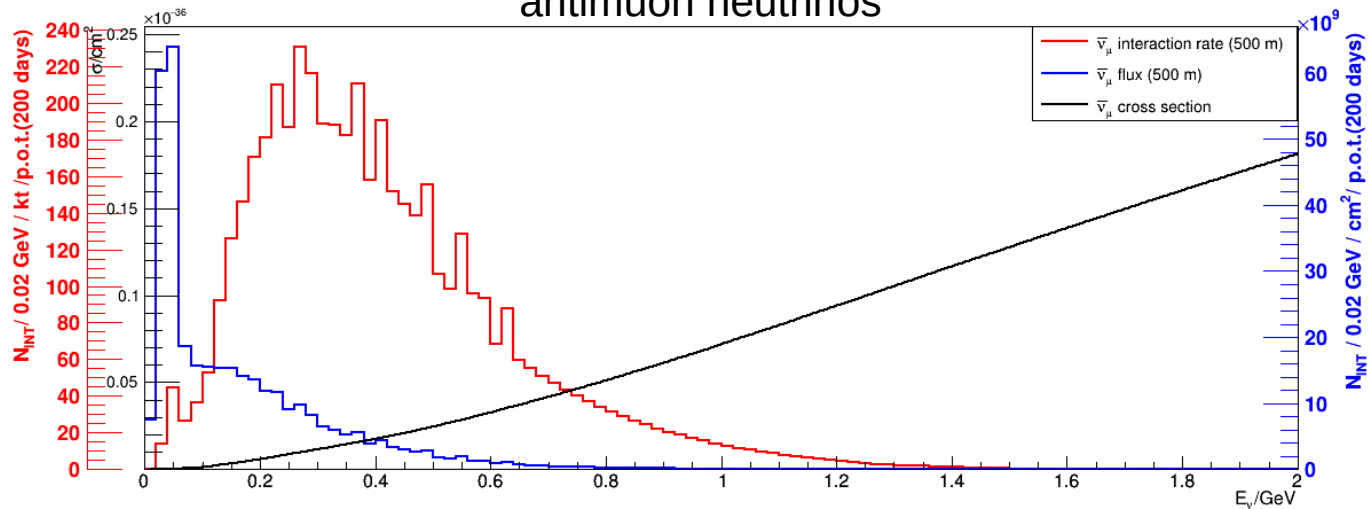
muon neutrinos



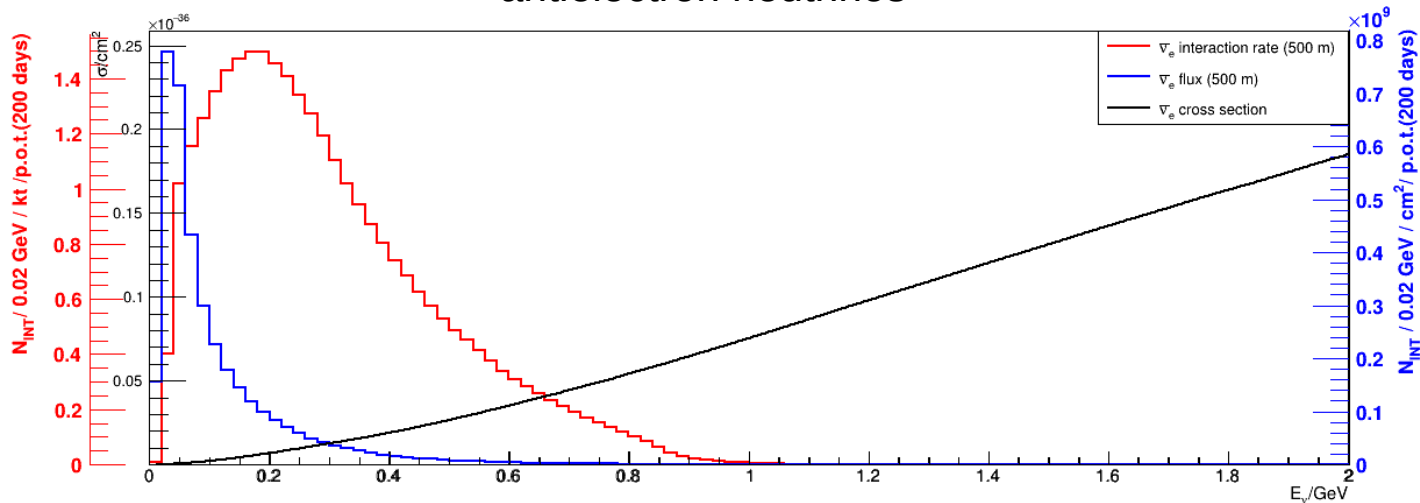
electron neutrinos

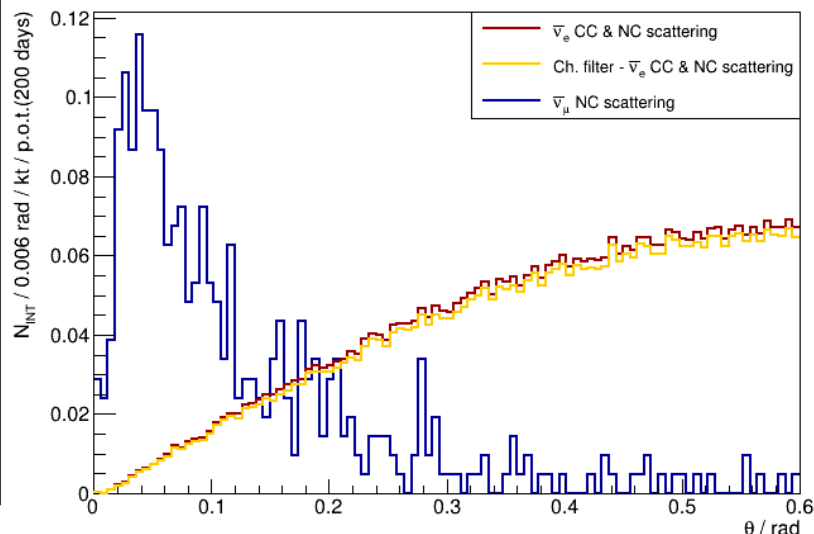
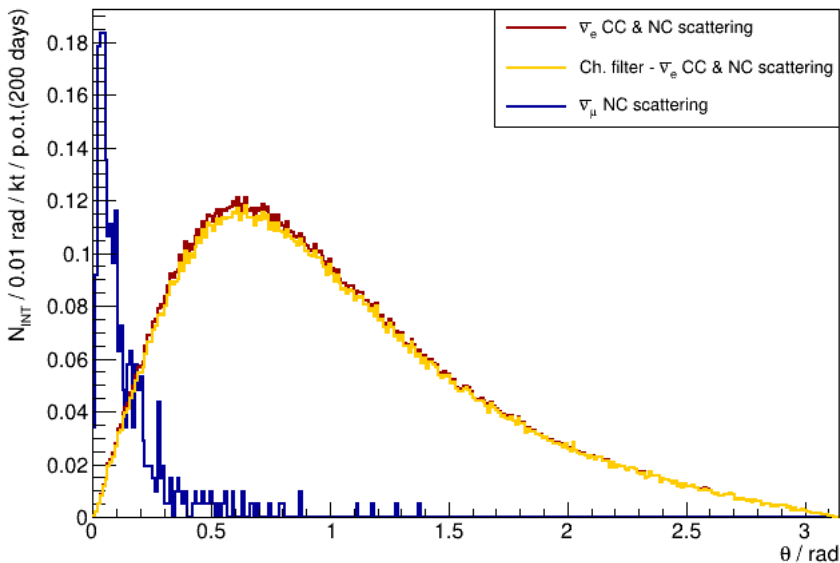
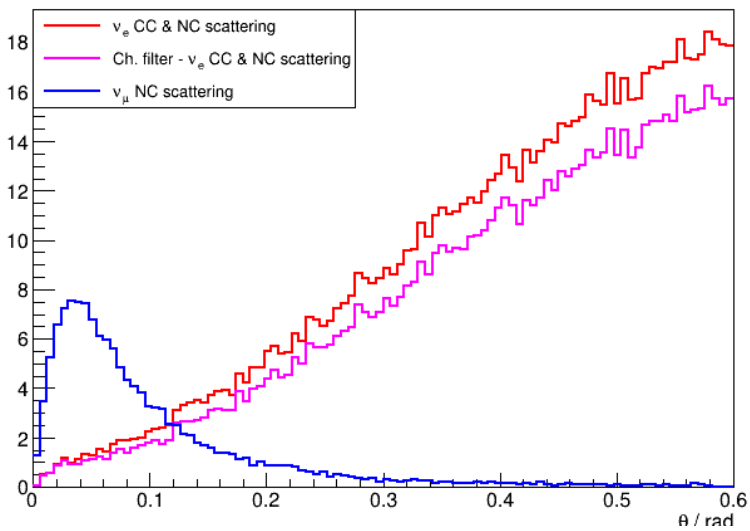
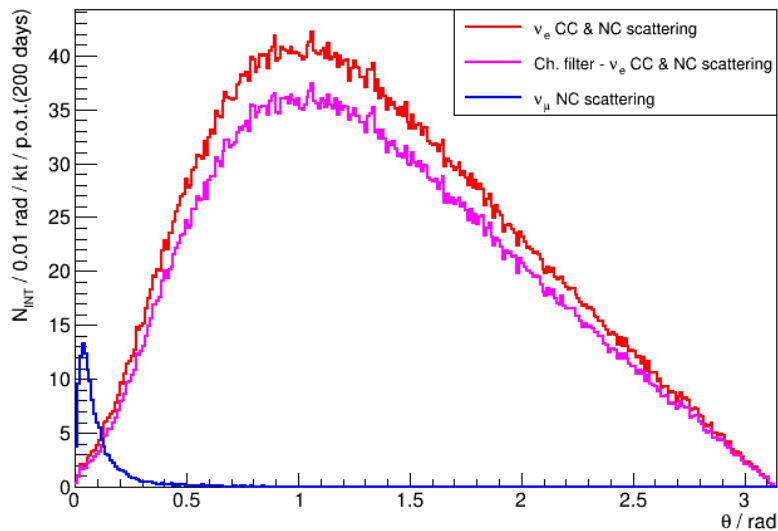


antimuon neutrinos



antielectron neutrinos

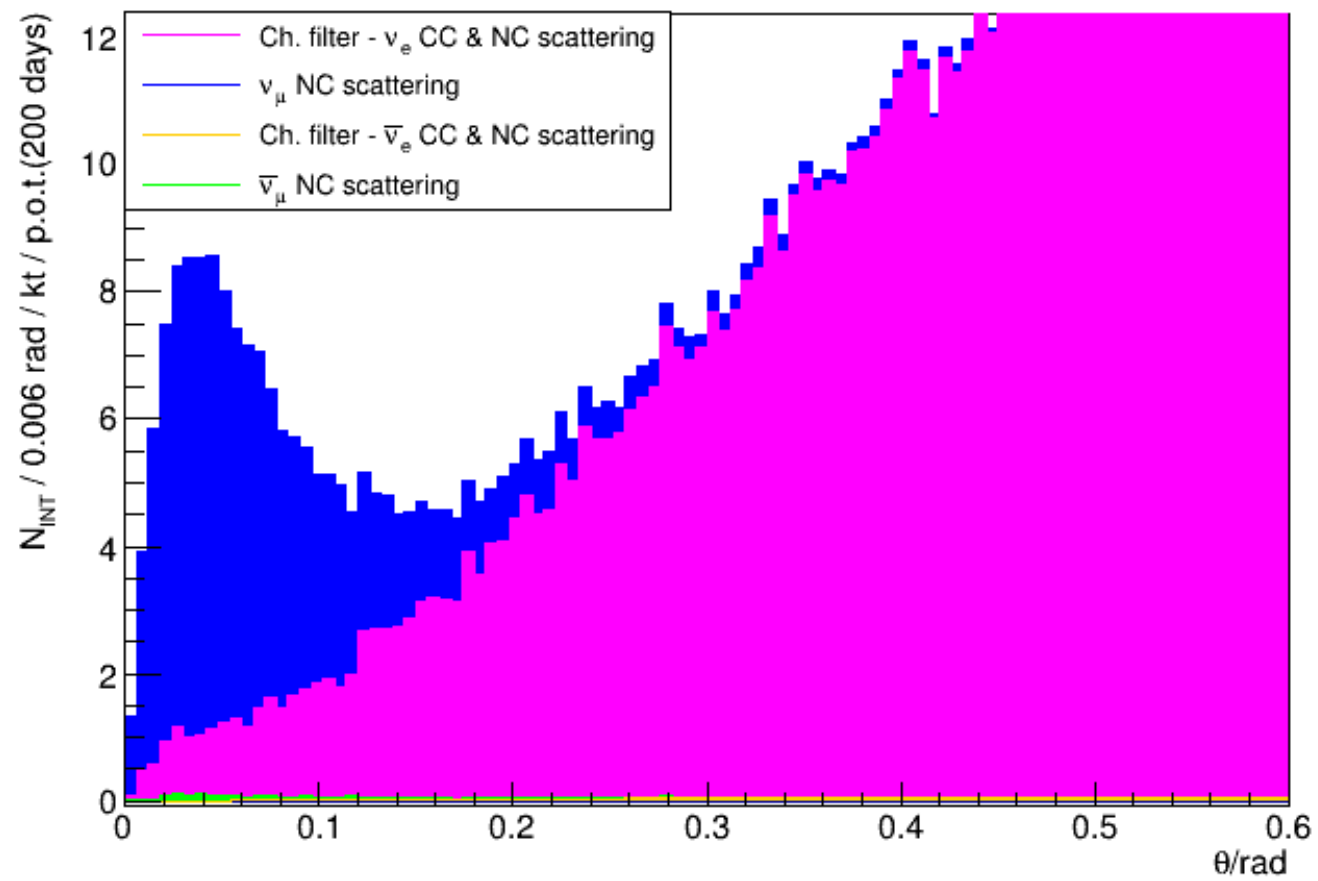


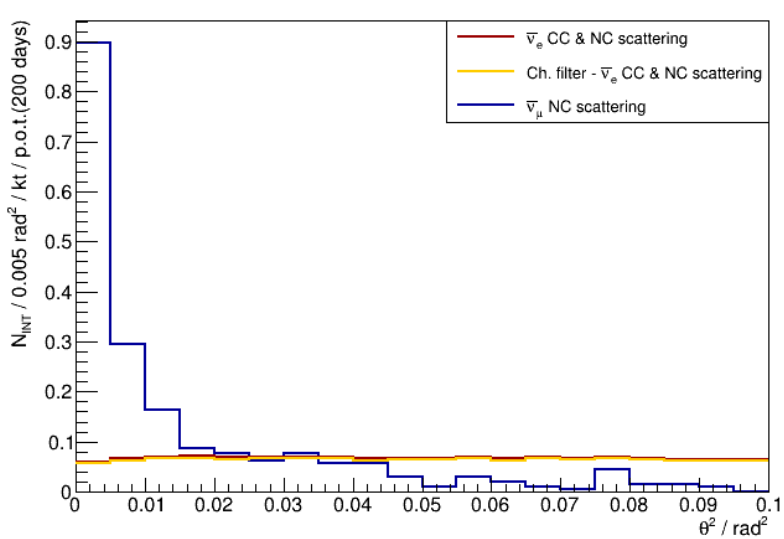
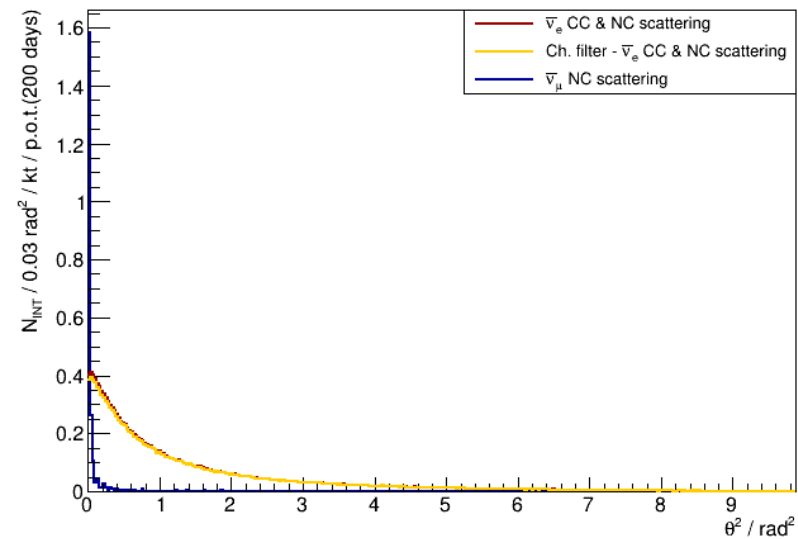
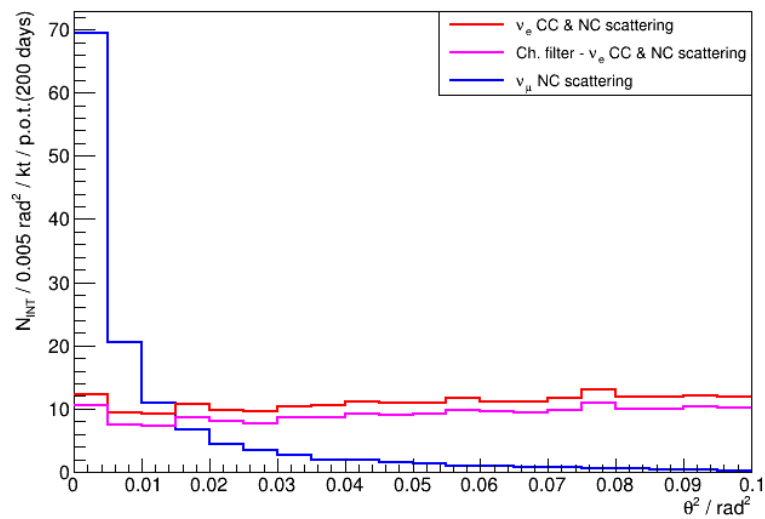
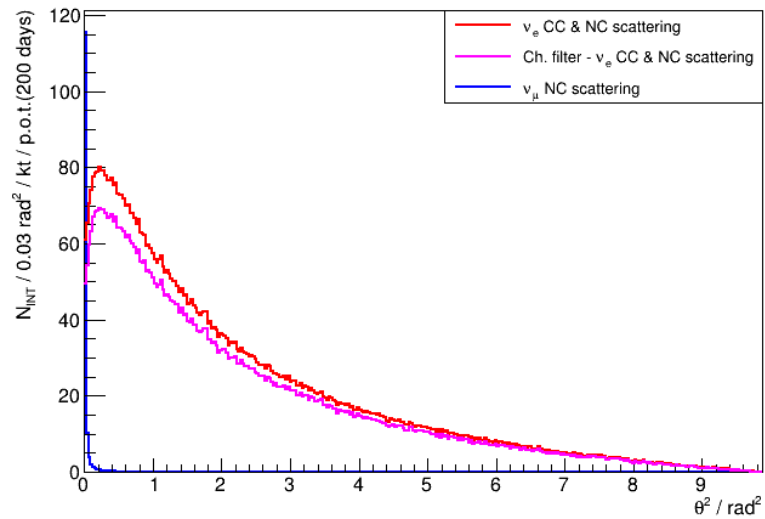


$b = \text{signal}$
 $r = \text{background}$
 before Čerenkov filter
 $p/y = \text{background}$
 after Čerenkov filter

θ	background/total	
$b = \text{blue}$	total area ratio	~min. area ratio
$r = \text{red}$		
$p = \text{pink}$		
$r/(r+b)$	0.9800	0.1180
$p/(p+b)$	0.9775	0.1107
r/b	49.03	0.1339
p/b	43.45	0.1245

θ	background/total	
$b = \text{blue}$	total area ratio	~min. area ratio
$r = \text{red}$		
$y = \text{yellow}$		
$r/(r+b)$	0.8733	0.0654
$y/(y+b)$	0.8706	0.0623
r/b	6.8942	0.0700
y/b	6.7305	0.0665

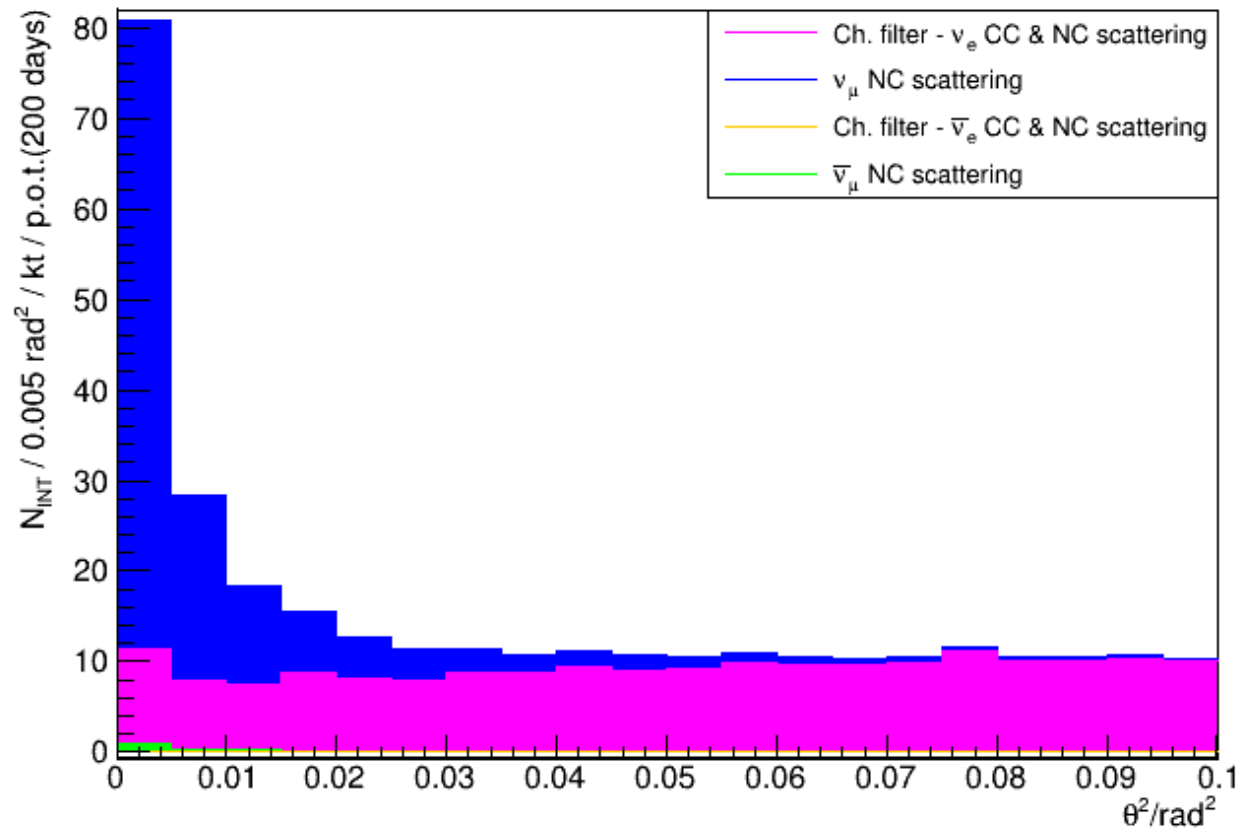


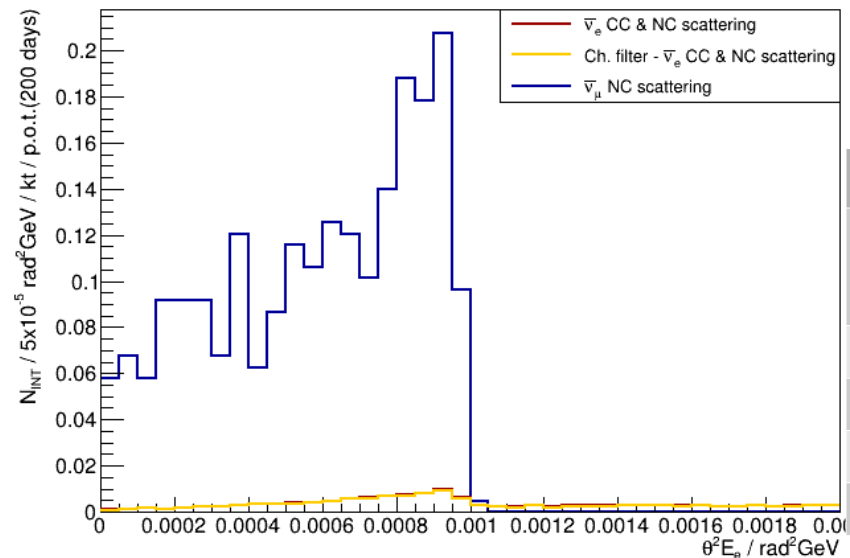
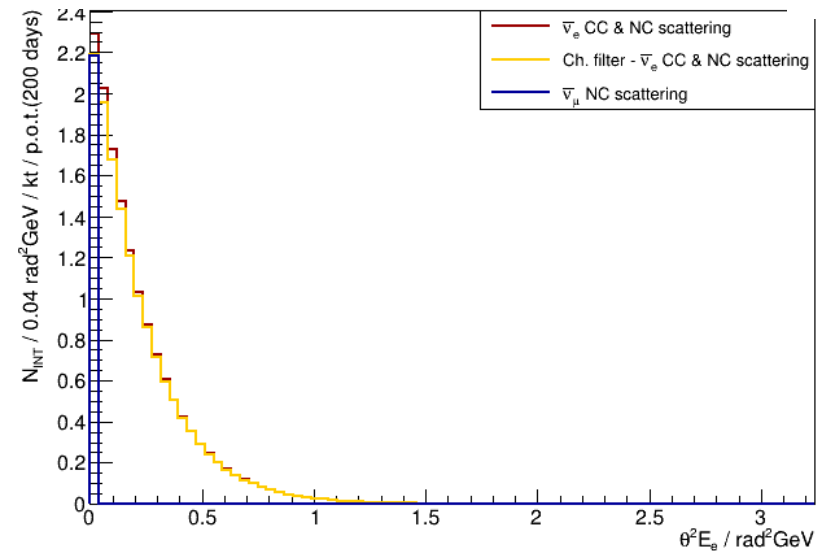
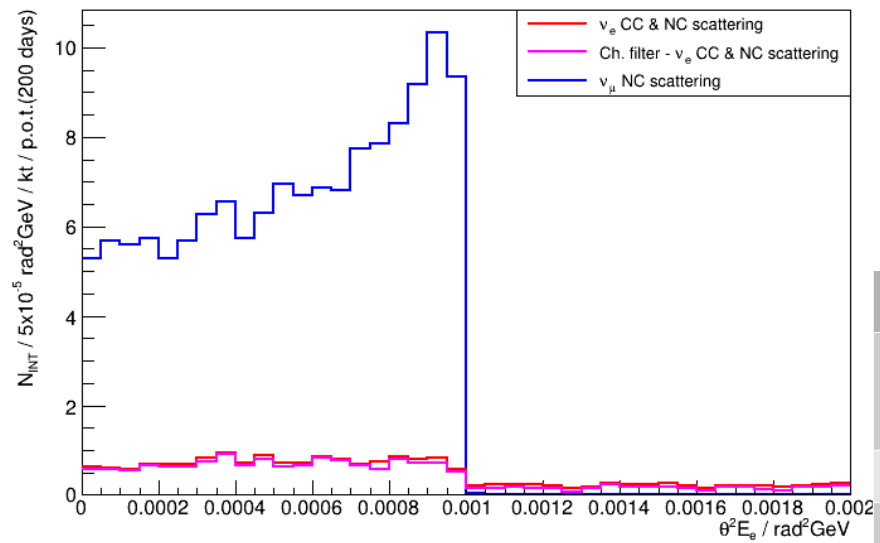
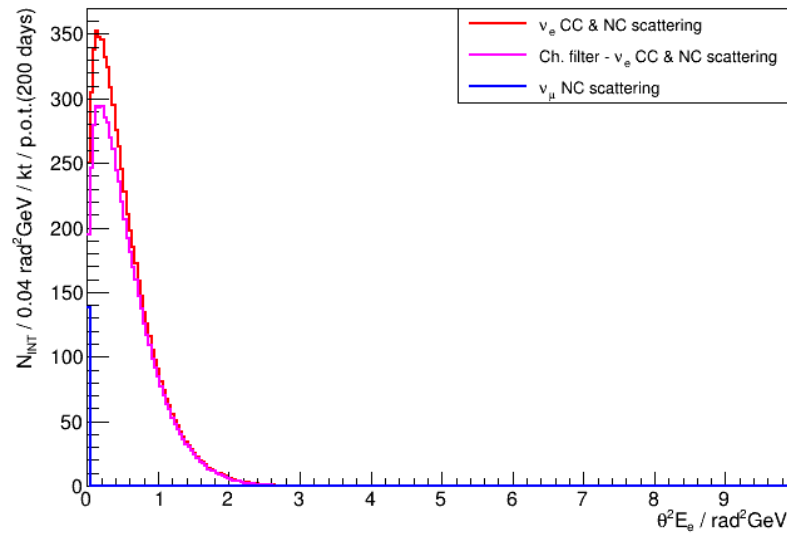


b = signal
 r = background
before Čerenkov filter
 p/y = background
after Čerenkov filter

θ^2	background/total	
$b = \text{blue}$ $r = \text{red}$ $p = \text{pink}$	total area ratio	~min. area ratio
$r/(r+b)$	0.9800	0.3769
$p/(p+b)$	0.9775	0.3299
r/b	49.03	0.6048
p/b	43.45	0.4523

θ^2	background/total	
$b = \text{blue}$ $r = \text{red}$ $y = \text{yellow}$	Total area ratio	~min. area ratio
$r/(r+b)$	0.8733	0.2729
$y/(y+b)$	0.8706	0.2640
r/b	6.8942	0.3754
y/b	6.7305	0.3589

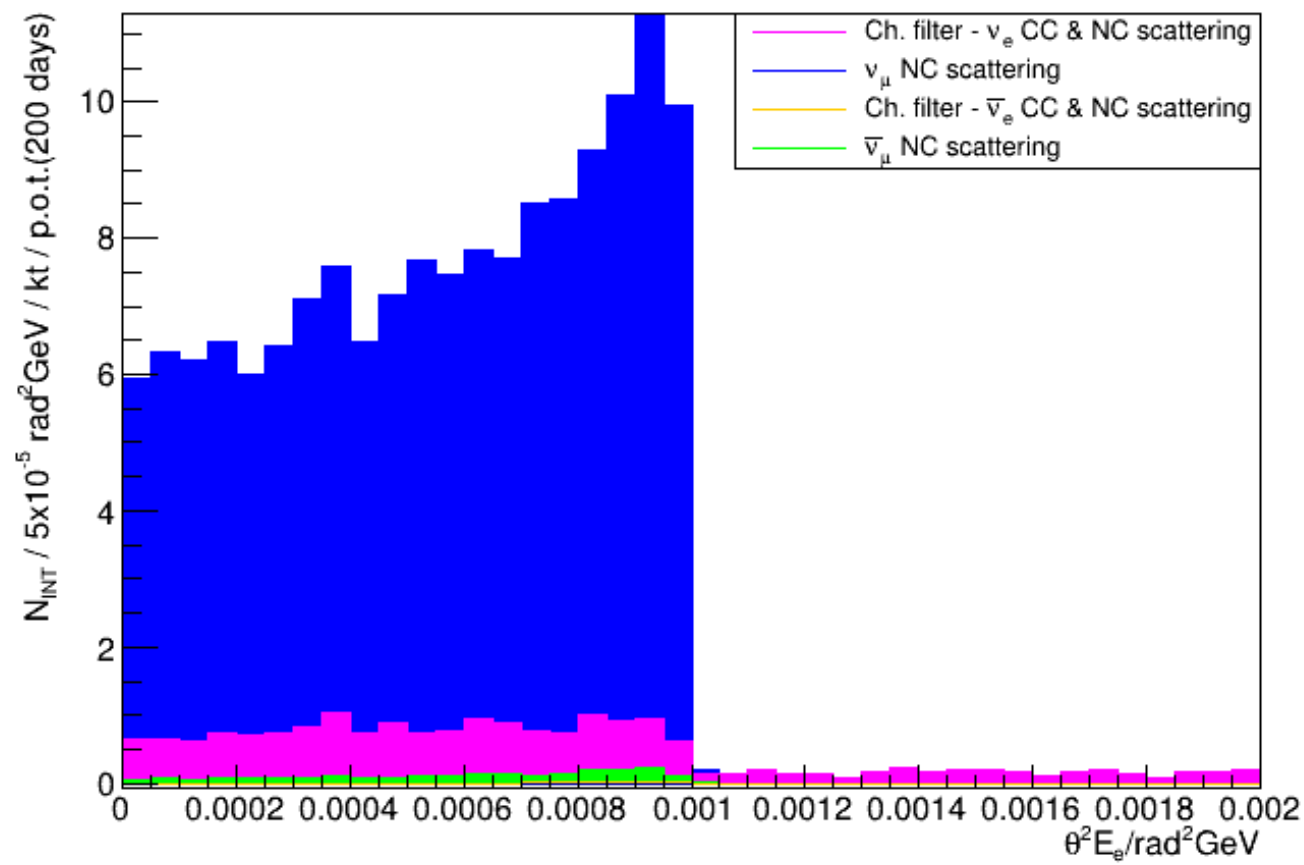




b = signal
 r = background
 before Čerenkov filter
 p/y = background
 after Čerenkov filter

$\theta^2 E_e$	background/total	
$b = \text{blue}$ $r = \text{red}$ $p = \text{pink}$	total area ratio	~min. area ratio
$r/(r+b)$	0.9800	0.1045
$p/(p+b)$	0.9775	0.0945
r/b	49.03	0.1167
p/b	43.45	0.1043

$\theta^2 E_e$	background/total	
$b = \text{blue}$ $r = \text{red}$ $y = \text{yellow}$	total area ratio	~min. area ratio
$r/(r+b)$	0.8733	0.0433
$y/(y+b)$	0.8706	0.0418
r/b	6.8942	0.0453
y/b	6.7305	0.0436



Additional analysis – pile up

- possibility of two or more neutrino interaction in the same pulse

PILE - UP

v_{μ} probability of interaction (in kt/pulse)	1 target (expected value = 0.045)	4 targets (expected value = 0.0113)
zero	0.956	0.989
one	0.045	0.0113
two or more	9.27×10^{-4}	6.346×10^{-5}

v_e probability of interaction (in kt/pulse)	1 target (expected value = 6.25×10^{-4})	4 targets (expected value = 1.56×10^{-4})
zero	0.9993	0.9998
one	6.25×10^{-4}	1.56×10^{-4}
two or more	1.95×10^{-7}	1.22×10^{-8}

Conclusion

- muon neutrino scatters on electron every 6024 events
- we can discriminate from the background events by looking at $\theta^2 E_e$ and Cherenkov radiation produced by other charged particles when electron (anti) neutrinos scatter on nuclei
- it might be possible to reconstruct muon neutrino flux from simulated events
- no significant pile-up expected

Thank you

\bar{v}_μ probability of interaction (in kt/pulse)	1 target (expected value = 2.68×10^{-4})	4 targets (expected value = 6.70×10^{-5})
zero	0.9997	0.99993
one	2.7×10^{-4}	6.70×10^{-5}
two or more	3.6×10^{-8}	2.24×10^{-9}

\bar{v}_e probability of interaction (in kt/pulse)	1 target (expected value = 1.68×10^{-6})	4 targets (expected value = 4.19×10^{-7})
zero	0.999998	1
one	1.68×10^{-6}	4.19×10^{-7}
two or more	1.40×10^{-12}	8.80×10^{-14}

