PVDIS baffle material and neutron shielding

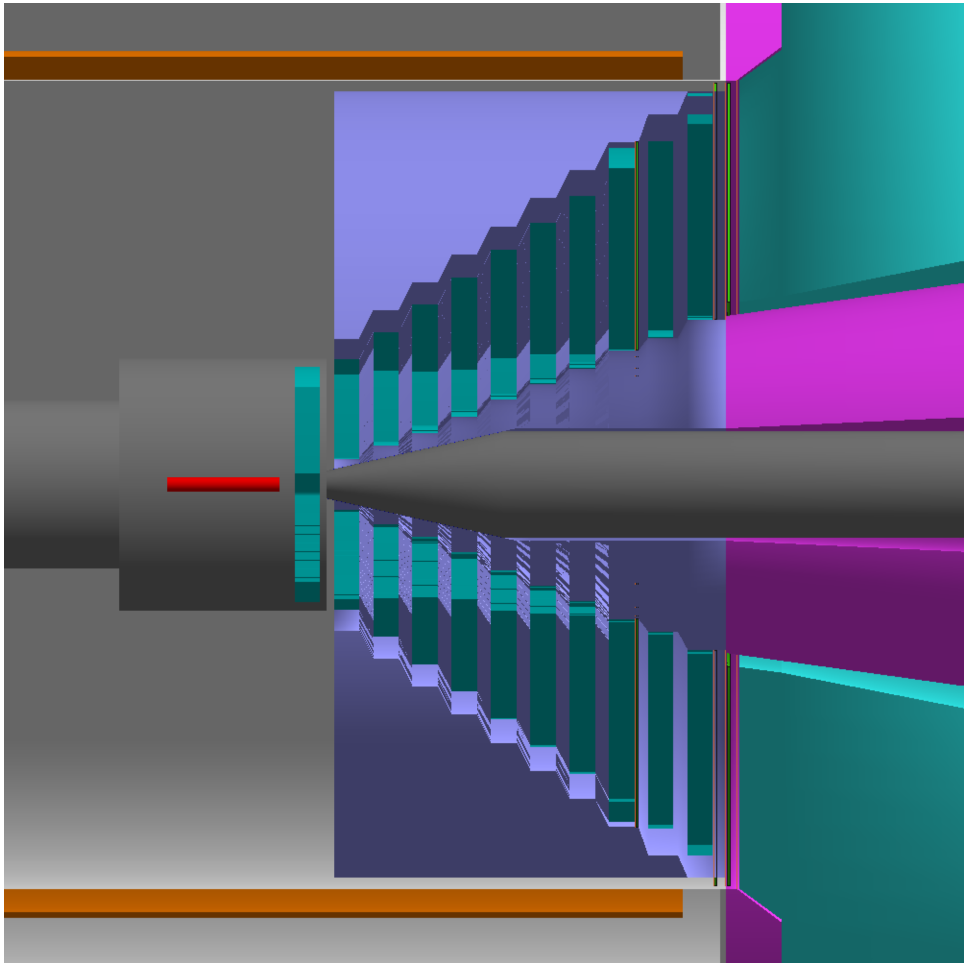
Zhiwen Zhao

2015/03/16

Introduction

- pCDR used baffle “babarmore1_block”
  - Baffle made of lead, all other materials are kryptonite
  - with no neutron shielding
  - by GEMC 1.7 and Geamt4.9.5.p01 with low energy neutron physics list “QGSP_BERT_HP”
  - EC trigger curve matches the same background
- Keep the baffle geometry and physics list same, keep photon block as lead, but add all real materials while changing simulation version, add neutron shielding, change baffle material to various kind, so DIS electron rate doesn’t change, only background rate changes

Neutron shielding by Borated Polyethylene
(density 1.19g/cm3, G4_POLYETHYLENE 0.7 G4_B 0.3)



Material Property

	Aluminum	Iron	Copper	lead	Tungsten Powder (60% density of Tungsten)	Tungsten
Radiation length (cm)	8.897	1.757	1.436	0.5612	0.583	0.3504
Nuclear interaction length (cm)	39.70	16.77	15.32	17.59	16.58	9.946
structure	easy	Easy (Stainless steel)	Easy (Alloy)	Too soft, need holder	Easy to mold and glue	Hard to machine
Cost	Cheap	Cheap	Cheap	Cheap	Expensive?	expensive
activation	Less	More?	Less?	More	More	more

- Current baffle weights 15t if made of lead and it needs precision within 0.5cm (?)
- Conductor like Copper won't affect solenoid magnetic field as far as ramping current slowly and the baffle is not made of one piece. (briefly discussed with Paul Brindza)

Result Comparison

Rate (kHz)	GEMC 1.7 with geant4.9.5.p01	GEMC 2.1 with geant4.9.5.p01	GEMC 2.1 with geant4.9.6.p02							
	Lead, No shield	Lead, No shield	Lead, No shield	Lead, shield	Copper, shield	Stainless Steel, shield	Tungsten Powder, shield	Tungsten, shield	Aluminum, shield	No baffle, No shield
EC trigger (total)	5.61e3	6.13e3	5.26e3	5.45e3	4.78e3	5.68e3	5.25e3	4.59e3	14.44e3	101.7e3
EC trigger (pi-)	4.83e3	5.03e3	4.37e3	4.37e3	3.57e3	4.47e3	4.21e3	4e3	7.33e3	2.95e4
EC trigger (pi+)	0.28e3	0.287e3	0.249e3	0.261e3	0.244e3	0.332e3	0.283e3	0.07e3	2.94e3	2.87e4
EC neutron		2.83e8	1.94e8	0.47e8	0.335e8	0.316e8	0.4e8	0.29e8	0.479e8	1.265e8

- Rate by simulation has stat error at least 10% level, particularly when rate is small
- Only look at result for P>1GeV, which is 2/3 total trigger rate in pCDR
- Neutron rate estimation is from beam on target and only count neutron entering EC

Summary

- Copper might be a good choice for baffle
  - EC trigger rate is similar to lead
  - Easier to construct with precision
  - cheap
  - Less activation
- I will add effect on Gem later
- The effect on Cherenkov needs study

- Neutron rate are reduced by factor a few after shielding, but it needs more damage study

Rate (kHz)		GEMC 1.7 with geant4.9.5.p01, lead (pCDR)			GEMC 2.1 with geant4.9.5.p01, lead			GEMC 2.1 with geant4.9.6.p02, lead		
		full	High	Low	full	High	Low	full	High	Low
e	kry	413	149	265	404	150	254	404	150	254
π-	kry									
	real	5.08e5	2.72e5	2.36e5	6.35e5	3.3e5	3.05e5	5.85e5	3e5	2.85e5
π^+	kry									
	real	2.13e5	0.98e5	1.15e5	2.31e5	1.5e5	1.81e5	3.22e5	1.45e5	1.77e5
$e(\pi^0)$	kry									
	real				17.94e5	11.2e5	6.74e5	17.9e5	11e5	6.9e5
$\gamma(\pi^0)$	kry	5.06e3	5.06e3	0						
	real	8.44e7	4.16e7	4.28e7	8.77e7	4.34e7	4.43e7	8.67e7	4.25e7	4.42e7
p	kry									
	real	5.50e4	2.38e4	3.12e4	12.17e4	5.81e4	6.36e4	10.75e4	4.91e4	5.84e4
neutron	real				2.83e8	1.37e8	1.46e8	1.94e8	0.94e8	1e8
e (W>2)	kry	311	80	231	317	89	228	317	89	228
π-	kry									
	real	4.83e3	3.43e3	1.40e3	5.03e3	3.45e3	1.58e3	4.37e3	3.1e3	1.27e3
π^+	kry									
	real	0.28e3	0.11e3	0.17e3	0.287e3	0.195e3	0.092e3	0.249e3	0.154e3	0.085e3
$e(\pi^0)$	kry									
	real				4	3	1	3	2	1
$\gamma(\pi^0)$	kry									
	real	4	4	0	2	2	0	0	0	0
p	kry									
	real	0.18e3	0.10e3	0.08e3	0.484e3	0.254e3	0.23e3	0.335e3	0.181e3	0.154e3
	Total (real)	5.61e3	3.72e3	1.88e3	6.13e3	4e3	2.13e3	5.26e3	3.52e3	1.74e3

Rate (kHz)		GEMC 2.1 with geant4.9.6.p02, lead, shield			GEMC 2.1 with geant4.9.6.p02, copper, shield			GEMC 2.1 with geant4.9.6.p02, Tungsten, shield		
		full	High	Low	full	High	Low	full	High	Low
e	kry	390	141	249	390	141	249	390	141	249
π-	kry									
	real	4.12e5	2.18e5	1.94e5	2.92e5	1.57e5	1.35e5	2.32e5	1.32e5	1e5
π^+	kry									
	real	1.768e5	0.794e5	0.974e5	1.475e5	0.7e5	0.775e5	0.72e5	0.348e5	0.37e5
$e(\pi^0)$	kry									
	real	17.7	11e5	6.7e5	22.5e5	13.5e5	9e5	14.68e5	9.44e5	5.24e5
$\gamma(\pi^0)$	kry									
	real	8.2e7	4.1e7	4.1e7	10.62e7	5.18e7	5.44e7	6.72e7	3.5e7	3.22e7
p	kry									
	real	11.82e4	5.54e4	6.28e4	11.81e4	5.48e4	6.33e4	6.32e4	3.02e4	3.3e4
neutron	real	0.47e8	0.23e8	0.24e8	0.335e8	0.17e8	0.165e8	0.29e8	0.142e8	0.15e8
e (W>2)	kry	307	82.1	225	307	82.1	225	307	82.1	225
π-	kry									
	real	4.37e3	2.63e3	1.74e3	3.57e3	2.7e3	0.869e3	4e3	2.6e3	1.38e3
π^+	kry									
	real	0.261e3	0.135e3	0.126e3	0.244e3	0.134e3	0.11e3	0.07e3	0.031e3	0.037e3
$e(\pi^0)$	kry									
	real	7	6	1	3	1	2	1	0	1
$\gamma(\pi^0)$	kry									
	real	21.8	21.8	0	156	156	0	6	6	0
p	kry									
	real	0.489e3	0.26e3	0.229e3	0.49e3	0.248e3	0.249e3	0.235e3	0.124e3	0.111e3
Total (real)		5.45e3	3.13e3	2.32e3	4.78e3	3.32e3	1.46e3	4.59e3	2.837e3	1.753e3

Rate (kHz)		GEMC 2.1 with geant4.9.6.p02, Al, shield			GEMC 2.1 with geant4.9.6.p02,Steel, shield			GEMC 2.1 with geant4.9.6.p02,Wpowder, shield		
		full	High	Low	full	High	Low	full	High	Low
e	kry	390	141	249	390	141	249	390	141	249
π-	kry									
	real	20e5	9.62e5	10.4e5	3.64e5	1.94e5	1.68e5	3.83e5	2.11e5	1.72e5
π^+	kry									
	real	20.45e5	9.55e5	10.9e5	1.88e5	0.9e5	0.98e5	1.61e5	0.76e5	0.86e5
$e(\pi^0)$	kry									
	real	87.1e5	48.1e5	39e5	24e5	14.2e5	9.7e5	17.73e5	11e5	6.73e5
$\gamma(\pi^0)$	kry									
	real	26.7e7	14.3e7	12.4e7	11.1e7	5.35e7	5.72e7	8.5e7	4.2e7	4.3e7
p	kry									
	real	60.7e4	28.2e4	32.5e4	13.25e4	6.1e4	7.15e4	11.5e4	5.4e4	6.1e4
neutron	real	0.479e8	0.247e8	0.232e8	0.316e8	0.156e8	0.16e8	0.4e8	0.2e8	0.2e8
e (W>2)	kry	307	82.1	225	307	82.1	225	307	82.1	225
π-	kry									
	real	7.33e3	4.63e3	2.7e3	4.47e3	2.96e3	1.51e3	4.21e3	2.77e3	1.44e3
π^+	kry									
	real	2.94e3	1.41e3	1.53e3	0.332e3	0.1e3	0.232e3	0.283e3	0.174e3	0.109e3
$e(\pi^0)$	kry									
	real	65.2	50.5	14.7	6	2	4	3	1	2
$\gamma(\pi^0)$	kry									
	real	828	507	321	2.2	2.2	0	0	0	0
p	kry									
	real	2.97e3	1.47e3	1.5e3	0.572e3	0.287e3	0.285e3	0.452	0.243	0.209
Total (real)		14.44e3	8.15e3	6.29e3	5.68e3	3.43e3	2.25e3	5.25e3	3.27e3	1.98e3

Rate (kHz)		GEMC 2.1 with geant4.9.6.p02, nobaffle					
		full	High	Low	full	High	Low
e	kry	8000	3960	4040			
π-	kry						
	real	2.51e7	1.15e7	1.36e7			
π^+	kry						
	real	2.54e7	1.18e7	1.36e7			
$e(\pi^0)$	kry						
	real	11.16e6	7.52e6	3.64e6			
$\gamma(\pi^0)$	kry						
	real	24.84e7	16.8e7	8.04e7			
p	kry						
	real	2.17e6	1.03e6	1.14e6			
neutron	real	1.265e8	0.643e8	0.622e8			
e (W>2)	kry	1239	620	619			
π-	kry						
	real	2.95e4	1.54e4	1.41e4			
π^+	kry						
	real	2.87e4	1.44e4	1.43e4			
$e(\pi^0)$	kry						
	real	606	481	125			
$\gamma(\pi^0)$	kry						
	real	3.48e4	1.56e4	1.92e4			
p	kry						
	real	12.62e3	6.4e3	6.22e3			
Total (real)		101.7e3	47.14e3	54.56e3			

How to read the rate table

- All rate are in kHz
- All rate on whole EC plane, divide by 30 to get sector rate
- Top section is without trig cut, bottom section is with trig cut
- Rate has distribution over phi angle every 12 degree, we take 0-6 degree as high rate area and 6-12 degree as low rate area. The full rate area includes both

- Normalization factor comparison

PVDIS_LD2	pip,pim,pi0	Kp,Km	Ks,Kl	p
Old	155000	3500	1750	27000
New	155898	2947	1474	14559

SIDIS_He3_window	pip	pim	pi0	Kp	Km	Ks,Kl	p
Old	134	136	136	3.0	3.4	1.53	23
New	134	137	135	2.5	2.6	1.3	12.7

SIDIS_He3	pip	pim	pi0	Kp	Km	Ks,Kl	p
Old	241	183	212	5.9	3.7	2.4	37
New	242	183	212	4.9	3.2	2.0	20