Building better baffles

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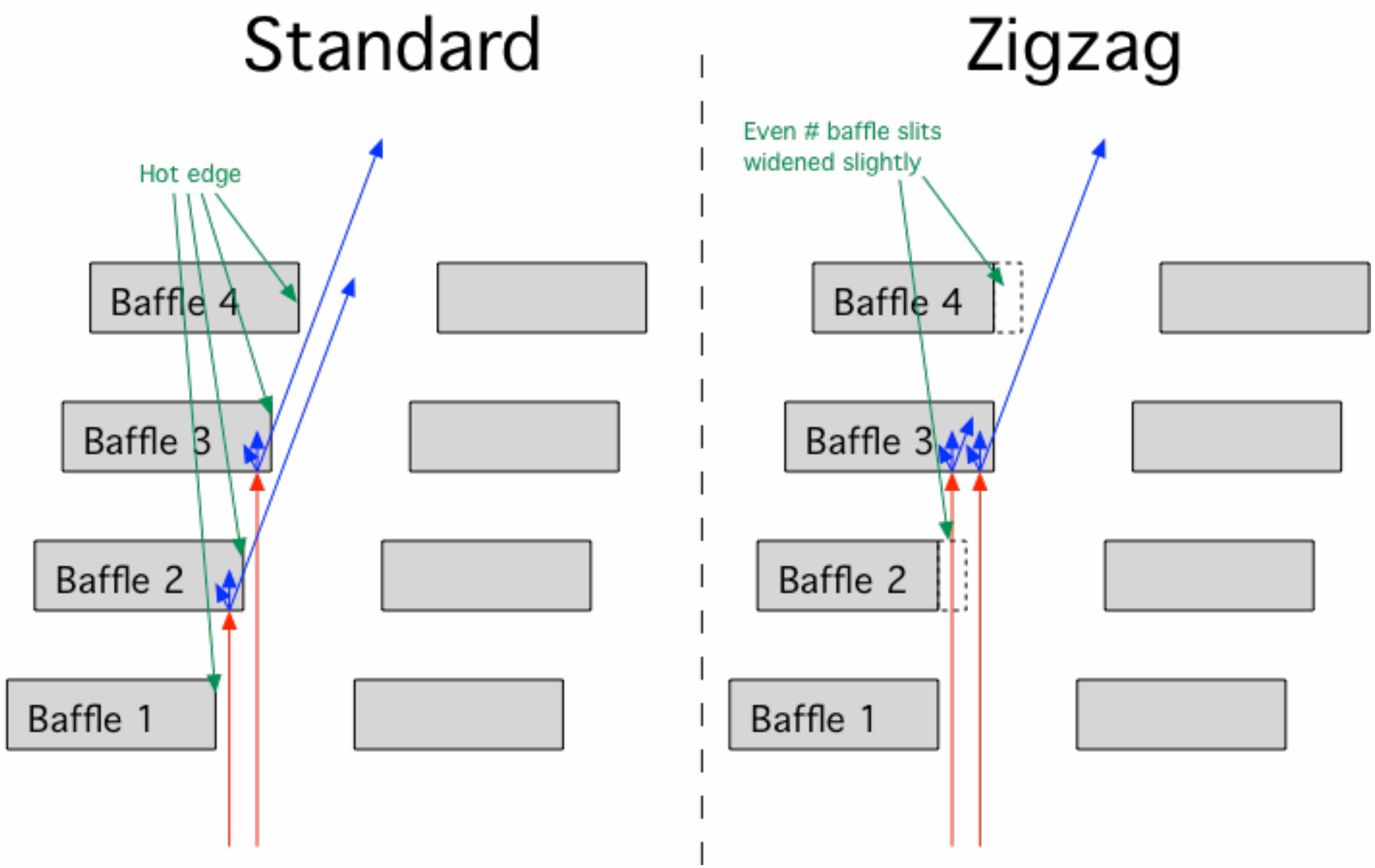
SoLID collaboration meeting 5/14/15



Standard
Zigzag
Hot edge
Even # baffle slits
widened slightly
Baffle 4
Baffle 3
Baffle 2
Baffle 1
Baffle 4
Baffle 3
Baffle 2
Baffle 1

1° Zigzag, lead (π^0 generator)

	p > 1			p > 10		
Baffle	**standard**	**zigzag**	**% diff**	**standard**	**zigzag**	**% diff**
1	29740	32529	9.400%	5854	6200	5.900%
2	14784	5124	-65.300%	3461	865	-75.0%
3	15134	18552	22.600%	3444	4084	18.600%
4	13173	2714	-79.400%	3014	361	-88.0%
5	16037	17819	11.100%	3550	3725	4.900%
6	15021	1858	-87.600%	3281	251	-92.300%
7	18780	20968	11.700%	3752	3824	1.900%
8	18952	1464	-92.300%	3619	181	-95.0%
9	23485	29021	23.600%	4071	4337	6.500%
10	28486	2256	-92.100%	4254	215	-94.900%
11	37706	60312	60.0%	5067	6450	27.300%
Total in baffles	231298	192617	-16.700%	43367	30493	-29.700%
Total all	239019	200104	-16.300%	48649	35761	-26.500%

1° Zigzag, tungsten 1st/last baffles

	p > 1			p > 10		
Baffle	**standard**	**zigzag**	**% diff**	**standard**	**zigzag**	**% diff**
1	29740	21101	-29.0%	5854	4285	-26.800%
2	14784	4318	-70.800%	3461	745	-78.500%
3	15134	17925	18.400%	3444	3946	14.600%
4	13173	2495	-81.100%	3014	371	-87.700%
5	16037	17621	9.900%	3550	3689	3.900%
6	15021	1869	-87.600%	3281	288	-91.200%
7	18780	20014	6.600%	3752	3819	1.800%
8	18952	1511	-92.0%	3619	199	-94.500%
9	23485	28402	20.900%	4071	4447	9.200%
10	28486	1912	-93.300%	4254	176	-95.900%
11	37706	40021	6.100%	5067	4206	-17.0%
Total in baffles	231298	157189	-32.0%	43367	26171	-39.700%
Total all	239019	164057	-31.400%	48649	31204	-35.900%

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*	*StainlessSteel, 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

Materials — γ study

- Generators: Wiser pions, e^- beam on target
- Count photons above various momentum thresholds at 3rd, 5th GEMs (before Cerenkov and EC)
- Require track in GEM live region (2° gap between sectors)
- Material = Pb (std), Cu, Cu with Pb lining slits, and same with all-Pb last baffle
- Geometry = “more1”, “zigzag”

Just some samples of results:

5th GEM											
			All gammas			Gammas from n			Gammas not from n		
Generator	Baffle	p min	count	rate (MHz/sector)	% diff	count	rate (MHz/sector)	%diff	count	rate (MHz/sector)	%diff
pi+	Std	1	3191	276.4		2702	234.0		489	42.4	
pi-	Std	1	5157	446.6		4640	401.9		517	44.8	
pi0	Std	1	17462	1,512.4		39	3.4		17423	1,509.0	
all pi	Std	1	25810	2,235.4		7381	639.3		18429	1,596.1	
beam	Std	1	1492	2,586.1		176	305.1		1316	2,281.1	
pi+	Copper	1	2816	243.9	-11.8%	2123	183.9	-21.4%	693	60.0	41.7%
pi-	Copper	1	4913	425.5	-4.7%	4135	358.1	-10.9%	778	67.4	50.5%
pi0	Copper	1	19892	1,722.8	13.9%	53	4.6	35.9%	19839	1,718.2	13.9%
all pi	Copper	1	27621	2,392.2	7.0%	6311	546.6	-14.5%	21310	1,845.6	15.6%
beam	Copper	1	1723	2,984.8	15.4%	162	280.8	-8.0%	1561	2,704.0	18.5%
pi+	Pb lined Cu	1	2977	257.8	-6.7%	2295	198.8	-15.1%	682	59.1	39.5%
pi-	Pb lined Cu	1	4878	422.5	-5.4%	4276	370.3	-7.8%	602	52.1	16.4%
pi0	Pb lined Cu	1	18201	1,576.4	4.2%	43	3.7	10.3%	18158	1,572.7	4.2%
all pi	Pb lined Cu	1	26056	2,256.7	1.0%	6614	572.8	-10.4%	19442	1,683.9	5.5%
beam	Pb lined Cu	1	1618	2,804.5	8.4%	164	284.3	-6.8%	1454	2,520.3	10.5%
pi+	Pb/Cu+Pb	1	2849	246.8	-10.7%	2234	193.5	-17.3%	615	53.3	25.8%
pi-	Pb/Cu+Pb	1	4466	386.8	-13.4%	3918	339.3	-15.6%	548	47.5	6.0%
pi0	Pb/Cu+Pb	1	18639	1,614.3	6.7%	39	3.4	0.0%	18600	1,610.9	6.8%
all pi	Pb/Cu+Pb	1	25954	2,247.9	0.6%	6191	536.2	-16.1%	19763	1,711.7	7.2%
beam	Pb/Cu+Pb	1	1510	2,617.3	1.2%	158	273.9	-10.2%	1352	2,343.5	2.7%

5th GEM

Generator	Baffle	p min	All gammas			Gammas from n			Gammas not from n		
			count	rate (MHz/sector)	% diff	count	rate (MHz/sector)	%diff	count	rate (MHz/sector)	%diff
pi+	Std	1	3191	276.4		2702	234.0		489	42.4	
pi-	Std	1	5157	446.6		4640	401.9		517	44.8	
pi0	Std	1	17462	1,512.4		39	3.4		17423	1,509.0	
all pi	Std	1	25810	2,235.4		7381	639.3		18429	1,596.1	
beam	Std	1	1492	2,586.1		176	305.1		1316	2,281.1	
pi+	Zigzag	1	3441	298.0	7.8%	2881	249.5	6.6%	560	48.5	14.5%
pi-	Zigzag	1	5382	466.1	4.4%	4878	422.5	5.1%	504	43.7	-2.5%
pi0	Zigzag	1	14469	1,253.2	-17.1%	55	4.8	41.0%	14414	1,248.4	-17.3%
all pi	Zigzag	1	23292	2,017.3	-9.8%	7814	676.8	5.9%	15478	1,340.5	-16.0%
beam	Zigzag	1	1456	2,523.7	-2.4%	193	334.5	9.7%	1263	2,189.2	-4.0%
pi+	Lined zigzag 1°	1	3160	273.7	-1.0%	2432	210.6	-10.0%	728	63.1	48.9%
pi-	Lined zigzag 1°	1	5039	436.4	-2.3%	4305	372.9	-7.2%	734	63.6	42.0%
pi0	Lined zigzag 1°	1	16788	1,454.0	-3.9%	57	4.9	46.2%	16731	1,449.1	-4.0%
all pi	Lined zigzag 1°	1	24987	2,164.1	-3.2%	6794	588.4	-8.0%	18193	1,575.7	-1.3%
beam	Lined zigzag 1°	1	1465	2,539.3	-1.8%	149	258.3	-15.3%	1316	2,281.1	0.0%

Summary

- Materials or material combinations other than Pb may give as good shielding with better mechanical properties
- Other materials and geometry changes reduce backgrounds for some generators — no big improvement yet found overall
- Comprehensive baffle optimization needs to be done!

Extra

Simulation

- 6E5 Wiser π^0 (uniform weighting)
- Standard "MORE1" baffles and "Zigzag" baffles
    - 1° widening of slits in even-numbered baffles to start
- Count γs crossing a virtual hodoscope at the 3rd GEM (just in front of Cerenkov) with $p > 1$ MeV/c, $p > 10$ MeV/c

1° Zigzag, tungsten 1st baffle

	p > 1			p > 10		
Baffle	**standard**	**zigzag**	**% diff**	**standard**	**zigzag**	**% diff**
1	29740	21628	-27.300%	5854	4256	-27.300%
2	14784	4361	-70.500%	3461	792	-77.100%
3	15134	18365	21.300%	3444	4130	19.900%
4	13173	2535	-80.800%	3014	326	-89.200%
5	16037	17902	11.600%	3550	3703	4.300%
6	15021	1853	-87.700%	3281	257	-92.200%
7	18780	20288	8.0%	3752	3864	3.0%
8	18952	1526	-91.900%	3619	189	-94.800%
9	23485	28696	22.200%	4071	4394	7.900%
10	28486	2176	-92.400%	4254	196	-95.400%
11	37706	59726	58.400%	5067	6404	26.400%
Total in baffles	231298	179056	-22.600%	43367	28511	-34.300%
Total all	239019	186321	-22.0%	48649	33744	-30.600%

Optimization

Is narrow - wide - narrow - wide… the best choice?

- Tried narrow - wide - wide…; narrow - narrow - wide; narrow - narrow - wide - wide… etc.

- Best reduction with narrow - wide - narrow - wide…

- Optimal zigzag size?

    - Hard edge around 0.6°. 0.65° gives ~same reduction as 1.0° (for lead baffles, -16.5% p>1 MeV/c; -27.5% p>10 MeV/c); 0.6° and under is worse.

Charged pions

Wiser π^+, π^- generator; count charged pions at last GEM (just before calorimeter)

Primary	**Baffles**	**π- (in 5th GEM)**	**% diff from std**	**π+**	**% diff from std**
π+	std	66		1620	
π+	zigzag 0.65°	61		1749	8.00%
π+	zigzag 1°	79		1933	19.00%
π-	std	2612		80	
π-	zigzag 0.65°	2802	7.00%	65	
π-	zigzag 1°	2980	14.00%	71	

PVDIS baffle material and neutron shielding

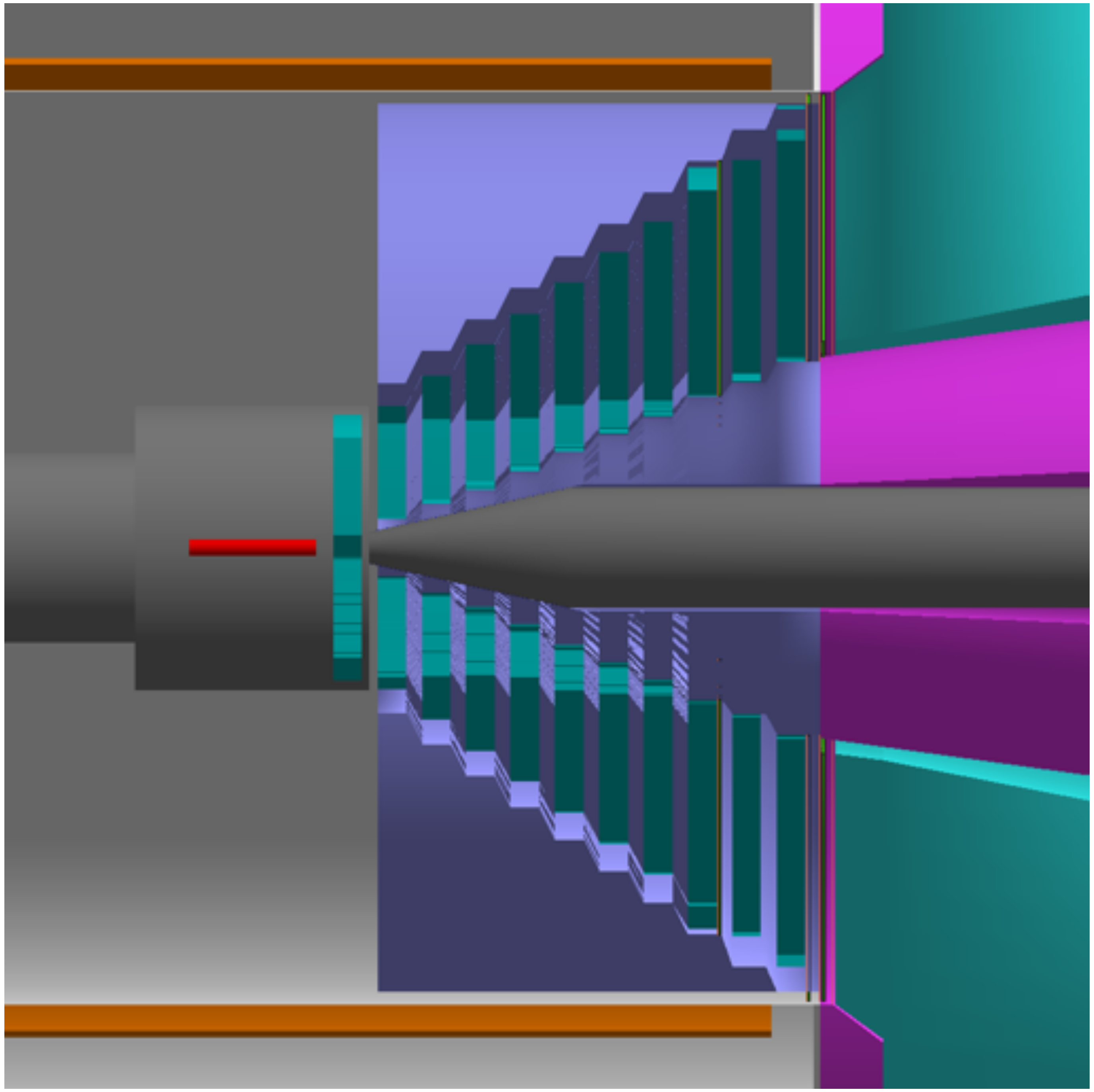
Zhiwen Zhao

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*	*StainlessSteel, 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(π0)	*kry*									
	real				*17.94e5*	*11.2e5*	*6.74e5*	*17.9e5*	*11e5*	*6.9e5*
γ(π0)	*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*

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(π^0)	*kry*									
	real	*17.7*	*11e5*	*6.7e5*	*22.5e5*	*13.5e5*	*9e5*	*14.68e5*	*9.44e5*	*5.24e5*
γ(π^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*

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(π0)	*kry*									
	real	*87.1e5*	*48.1e5*	*39e5*	*24e5*	*14.2e5*	*9.7e5*	*17.73e5*	*11e5*	*6.73e5*
γ(π0)	*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*

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(π0)	*kry*						
	real	*11.16e6*	*7.52e6*	*3.64e6*			
γ(π0)	*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*			

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*