

Ferrous Materials:

GEM Rotator – Updated
Stepper Bearing Design
From Chandika

Eric King

April 4th, 2024

Review

Summary of Ferrous Materials in GEM Rotator

Where we sat at the end of
December with a basic skirted
design.

(12/13/23) GEM Rotator Summary (cont'd)

Note: Results in green may be updated in main docdb for gem rotator ferrous materials studies.

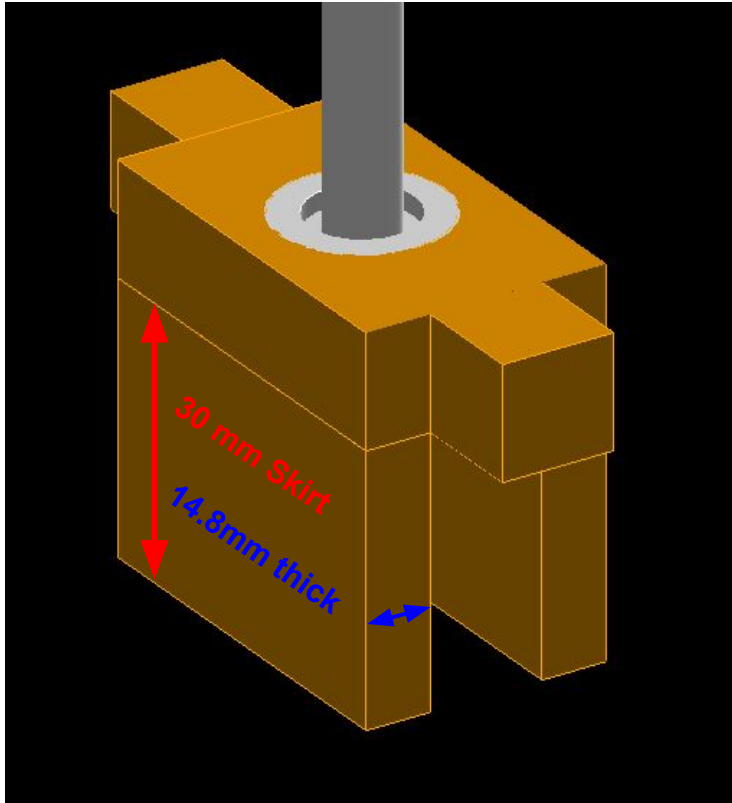
Ferrous Detector	Ferrous Volume Common Name	Material(s)	Ferrous BG ¹ Limit [per e.o.t.]	OLD Main Det Sim BG ¹ [per e.o.t]	NEW Main Det Sim BG ¹ [per e.o.t]	Comment
9306	T-Nut Fasteners	SS304	10 ⁻⁸	~2(10 ⁻¹⁰)	4(10 ⁻¹¹)	Model result was ~4(10 ⁻¹¹), doubling to account for unmodeled mass we come to <8(10 ⁻¹¹). Assuming that SS-304 is absolute worst quality this is still well below tolerable limits.
9307	Wheel Pins	SS316	10 ⁻⁸	N/A	2(10 ⁻¹²)	Tolerable to be made of SS316 or better.
9308	Stepper Rods	SS [Unspecified Type]	10 ⁻⁸	N/A	4(10 ⁻¹¹)	Stepper Rods are fine.
9309	Stepper Bearings	Carbon Steel	10⁻¹¹	N/A	3.4(10⁻¹²) ↓ ~1(10⁻¹²)	These are closest to the beamline of any ferrous item in the rotator. High background rates are not surprising. Depolarization reduces by factor of 3. Skirted design reduces backgrounds by close to two orders of magnitude.
9310	Stepper Bearing Housing	SS316	10 ⁻⁸	N/A		

The toy model skirted design greatly reduced backgrounds from the stepper bearings. Simulations will be done on Chandika's formal design. Toy design was slightly thicker so numbers should increase somewhat.

¹BG=Background

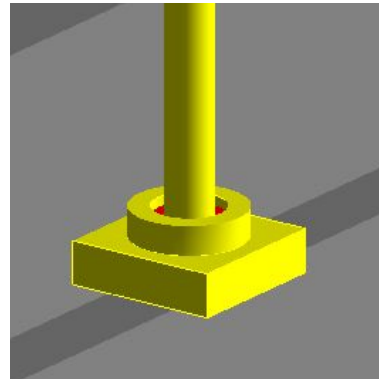
New Simulation

9309 – GEM Rotator Stepper Bearings (Chandika's Design)



Between the skirt there's 25.4 mm of aluminum.

Bearing holder holds the bearing to the aluminum frame and provides shielding against ferrous scattering.



Chandika's design is a bit thinner than the toy design I looked at in December 2023 but impact should be minimal.

9309: Gem Rot Stepper Bearings

Material	X r	Spin Polarization (P f)	Frac e- on Target	Frac of events Per Moller
Mild Steel	2000	1E-02	1E-11	1E-07
Stainless Steel (Worst)	1	1E-05	1E-08	1E-04
Stainless Steel (Ideal)	0.01	1E-07	1E-06	1E-02
Aluminum	0.0001	1E-09	1E-04	1E+00
Inconel 625	0.001	1E-08	1E-05	1E-01
Brass/Bronze (Worst)	0.001	1E-08	1E-05	1E-01

With Brass Holder+Skirt

Update with Chandika's holder design with additional skirt

Sens Volume:	GEM Rotator Stepper Bearings
Sim Date:	4/4/2024
Detector #:	9309

GEM Rotator Stepper Bearings -- W/ SKIRTED BRASS BEARING HOLDER -- Unweig

Total Prim's:	19,760,000,000
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Total Sec's:	500,000 (per sens det)
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Primary Counts		
Primaries	0	0&1
9309		89

Primary Fractional		
Primaries	0	0&1
9309		4.50E-09

(9928 Main Det) Secondary Counts 0&1		
Secondaries	Electrons	Gammas
9309	997	11902

(9928 MainDet) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9309	1.99E-03	2.38E-02

(9928 MainDet) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9309	8.98E-12	1.07E-10

(9911 PMT Region) Secondary Counts - 0&1		
Secondaries	Electrons	Gammas
9309	2618	42559

(9911 PMT Region) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9309	5.24E-03	8.51E-02

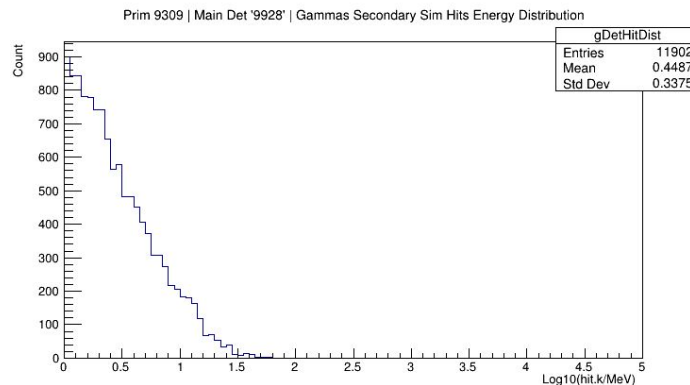
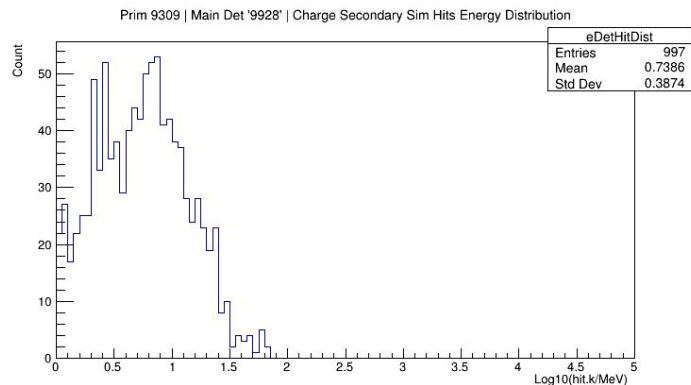
(9911 PMT Region) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9309	2.36E-11	3.83E-10

Stepper bearings are some type of carbon steel. This puts tolerable ferrous background limits at 10^{-11} .

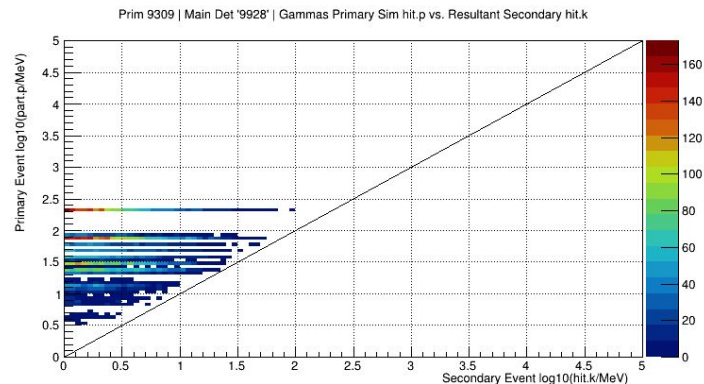
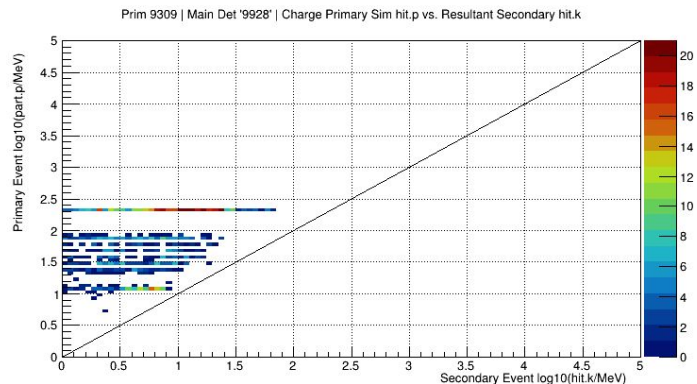
Chandika's design puts us right around the tolerable limit for ferrous backgrounds.

9309: Gem Rot Stepper Bearings

Backgrounds that hit detector '28'



**With
bearing
holders
+skirt**



9309: Gem Rot Stepper Bearings

Backgrounds that hit PMT Region

**With
bearing
holders
+skirt**

