Ferrous Materials

Detector Region – Detector Supports & Wheel Sprockets/Rod

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TL;DR Summary

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Note: Tolerable ferrous backgrounds for carbon steel is 10^{-11} per electron on target [eot].

Detector Supports

- Previous preliminary simulation work suggested backgrounds 100x over tolerable ferrous background limits [~10^{-9}/eot vs 10^{-11}/eot].
- ➢ New simulations incorporate GEM Rotator mass from previous ferrous sim work and relevant main detector mass added into simulation. Both volumes serve as attenuators of primary electrons and the relevant main detector mass also serves as an attenuator of ferrous backgrounds.
- Current results give ferrous backgrounds estimates that are a factor of six over tolerance **[~6(10^{-11})/eot vs 10^{-11}/eot]. (See slide 14)**
- ➢ **If we accept the following**:
  - The majority of the backgrounds are backscattered and the analyzing power of these events [we are presuming] is much lower than forward scattered events.
  - The likelihood of these low-energy hitting the PMT region actually hitting the quartz pmt window is low.

then we are likely okay with the results from the simulations.

Sprockets and Rods

- Sprockets (near main detector modeled) along with drive shaft rods.
  - Sprockets on showermax end inadvertently not modeled. Backgrounds on PMT region or main detector quartz would be backscattered.
  - Chains not modeled.
  - Motor also not included in these simulations.
- Current results suggest backgrounds from the sprockets and rods is order of magnitude over tolerable ferrous background limits **[~1(10^{-10})/eot vs 10^{-11}/eot]. (See slide 20)**
- Accepting the statements made for the Detector supports the sprockets and rods are *probably* okay. **Although, I think if we can remove them during production we should remove them during production.**

One potentially important caveat here that may be important is that the simulations were done with symmetric magnetic field maps. It's unknown, at the moment, whether or not the introduction of asymmetric field maps could increase primary electron hits enough to cause a significant increase in ferrous background rates.

Summary Attachment [Addt'l Bearings]

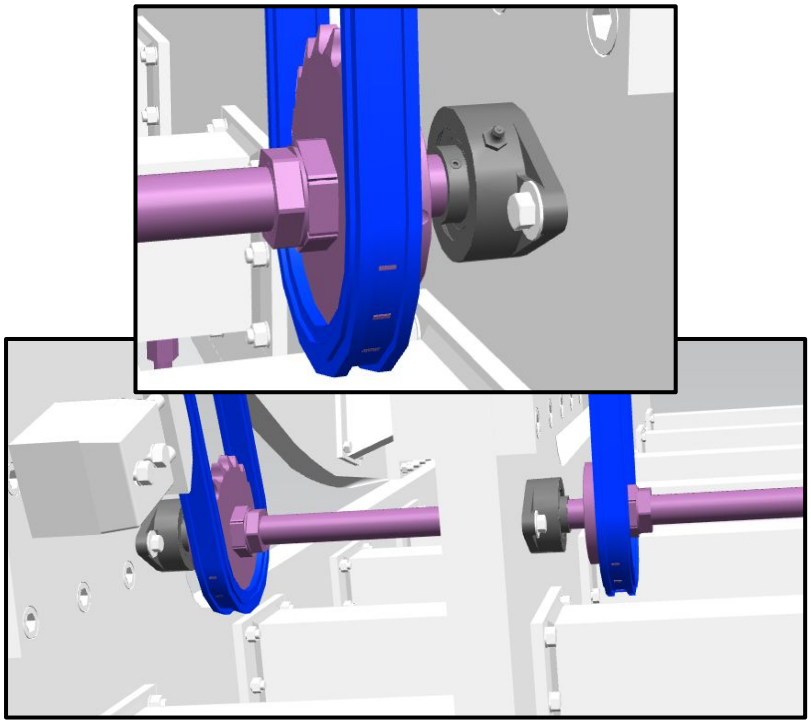
McMaster Carr item 5968K91 listed on materials sheet and lists a quantity of 3. Made of cast iron housing and steel bearings.

[Mentioned in DocDB 1313]

These are positioned hear the sprockets and hold the rods to the main detector support structure. Therefore the results of the sprocket and rod simulation are relevant to these bearings.

These are ~1kg each and would not contribute a significant change with mass scaling for the sprocket/rod simulation work. 1kg vs. 55kg for stated results.

Presumably these will also be removed with the sprockets and rod during production.



Quick Background

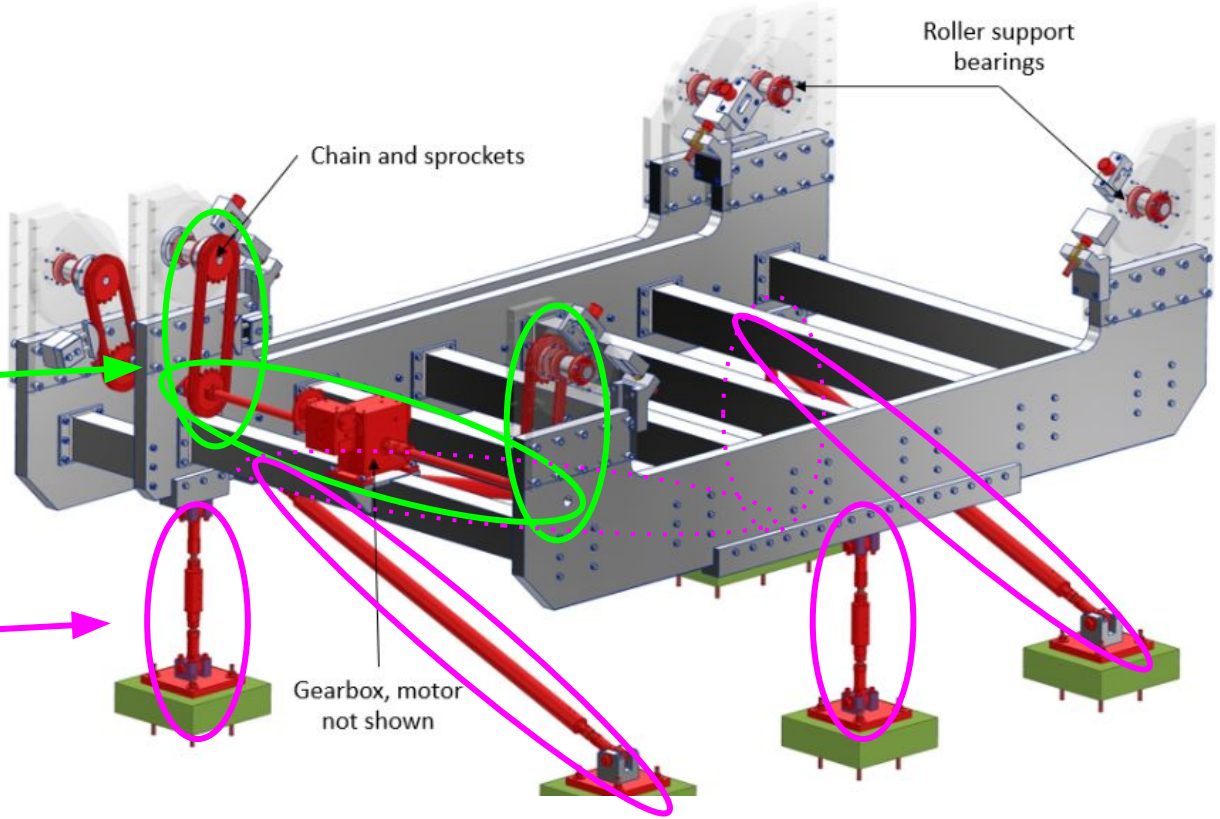
Main Detector Ferrous Materials

Steel materials in the lower support structure

(Image from Larry's slides)

Sprockets and Rods

Detector Supports

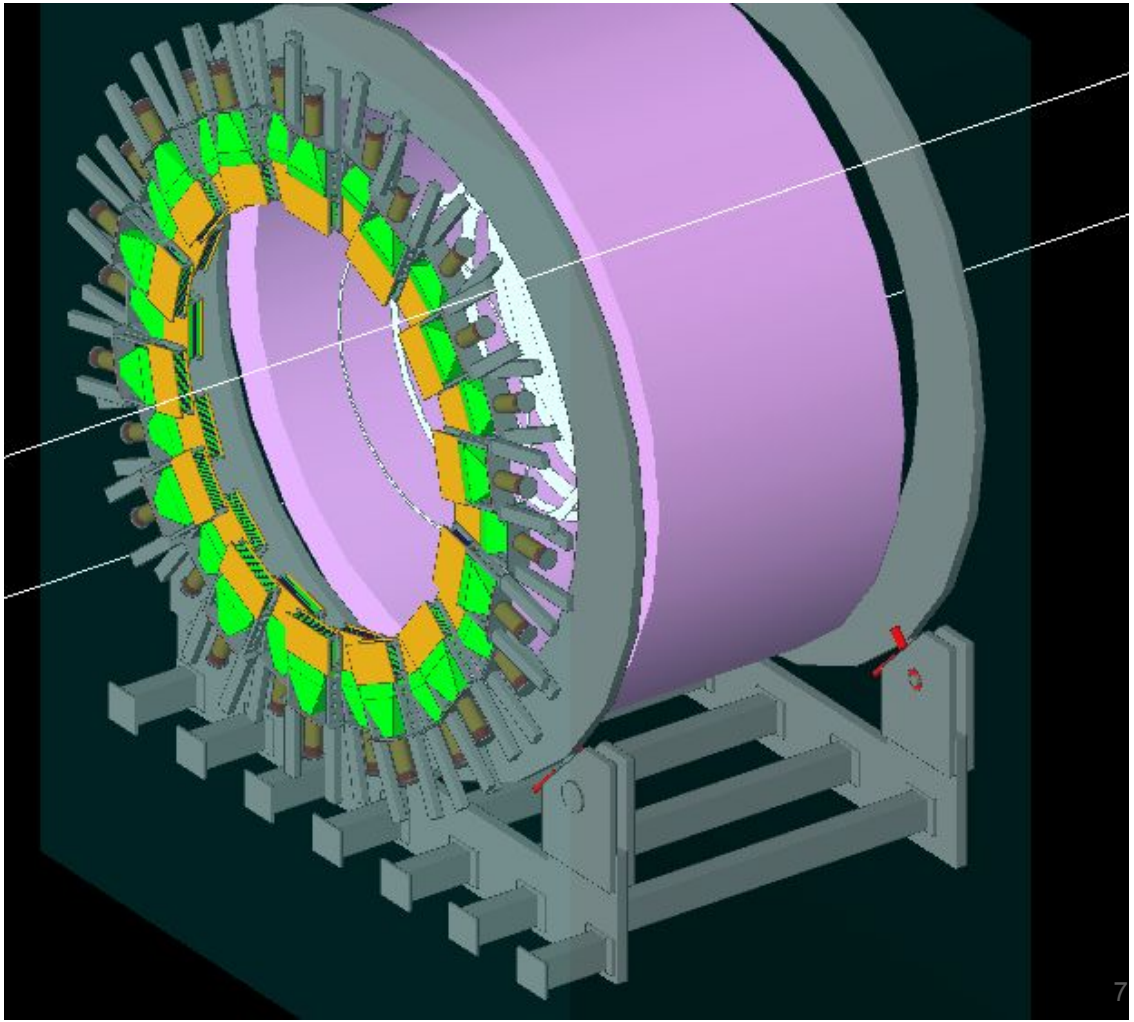


Detector 9911

Detector 9911 (lavender ring) is a parallel world plane that wraps around the min/max r & z of the PMTs.

There is a barrier of aluminum and lead before the quartz rings which is not present here but spans between the two circular rings of the wheel. This will significantly reduce the of-interest backgrounds heading towards the quartz.

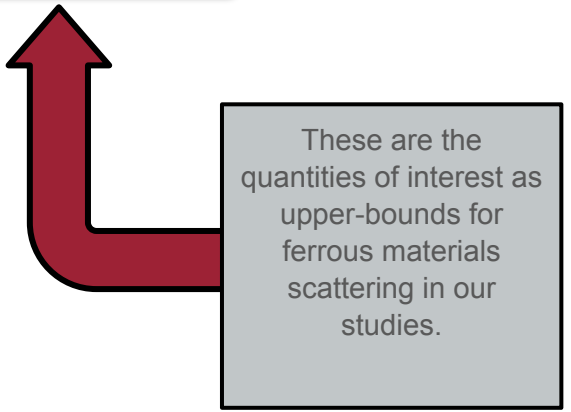
⇒ The sensitive detector volume of interest is therefore 9911



Tolerable limits for Ferrous Scattering Backgrounds

Material	X_r	Spin Polarization P_f	Fraction per e.o.t.	Fraction per Moller
Carbon 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

- These are the limits that we've set for normalized ferrous materials scattering backgrounds.
- I'm going to try to persuade you into agreeing these are very reasonable upper limits.

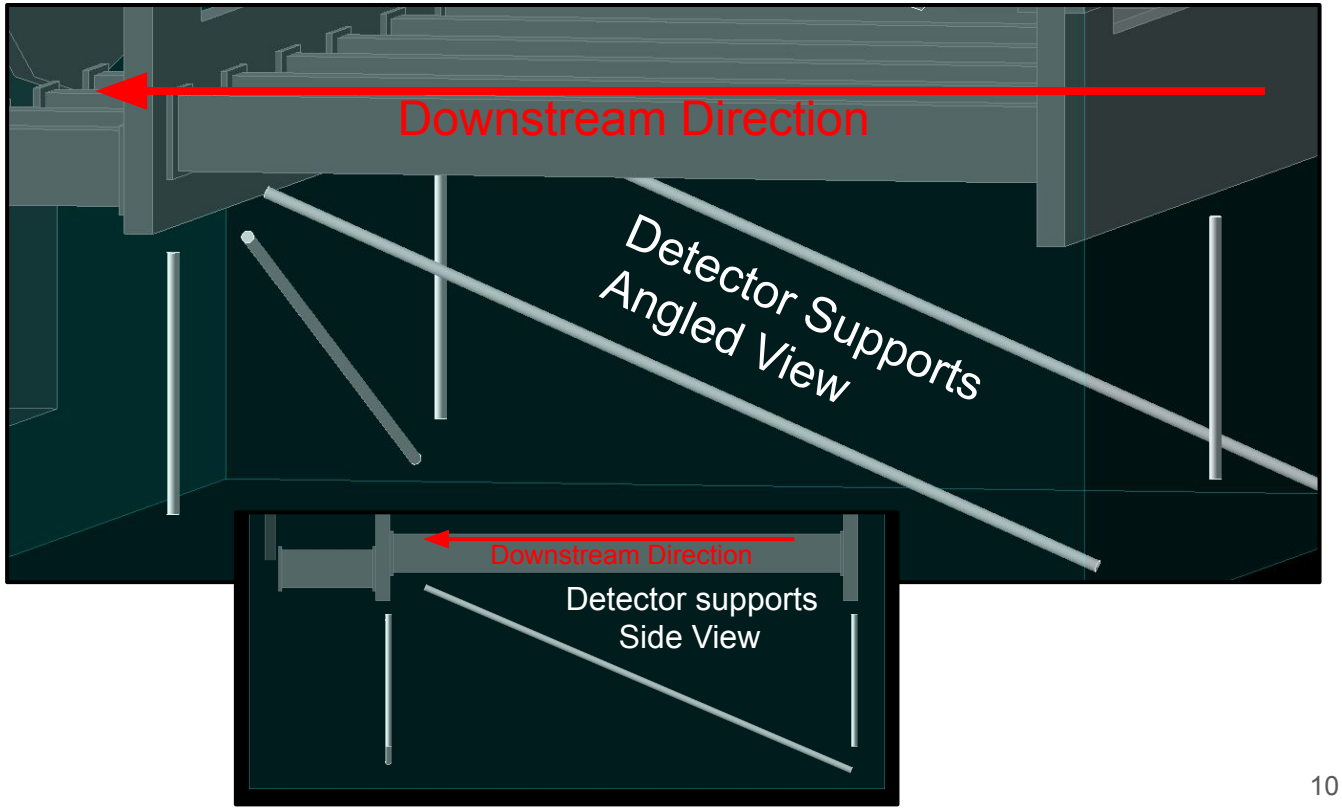


Detector Supports [Revisited]

9211: Detector Supports [Revisited]

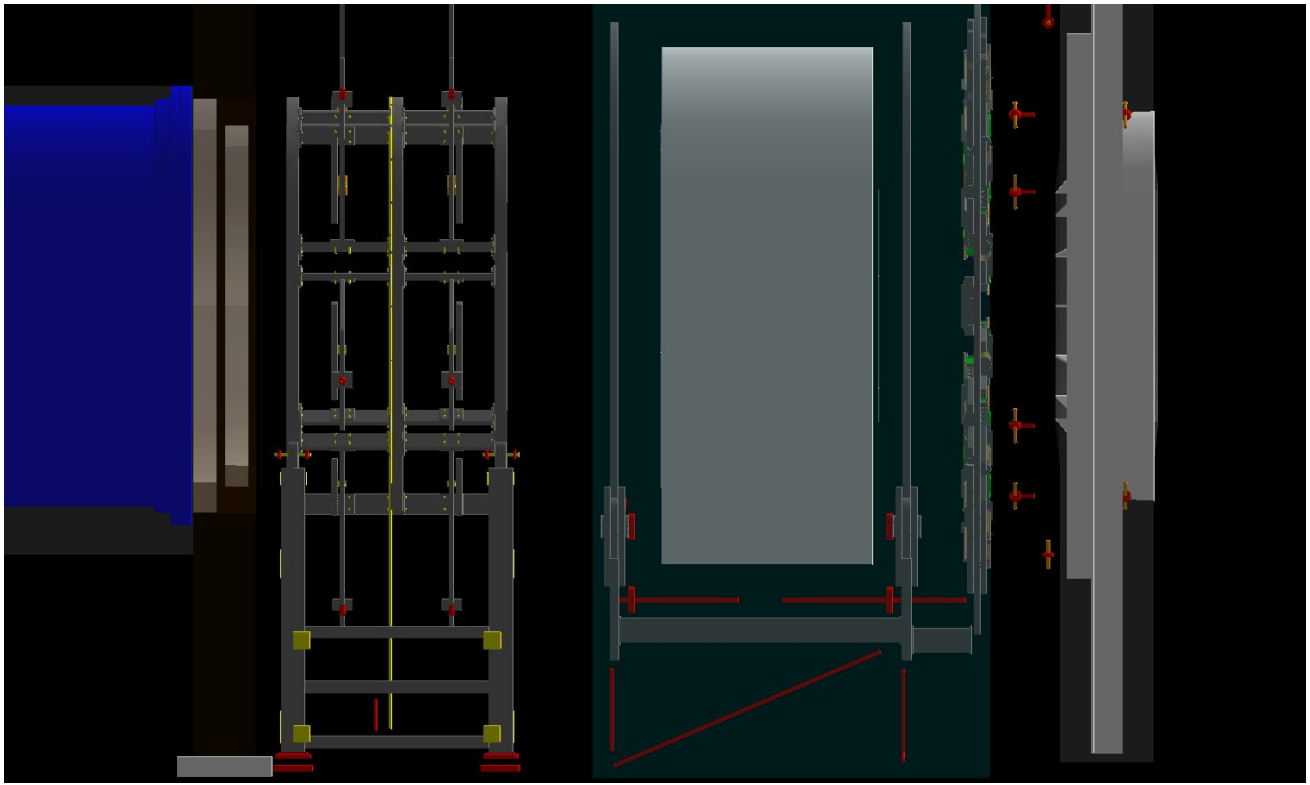
Detector supports previously simulated.

- Exceeded tolerances by two orders of magnitude.
- Additional mass for GEM rotator has been added since those simulations as well as mass for the main detector structure



9211: Detector Supports [Revisited]

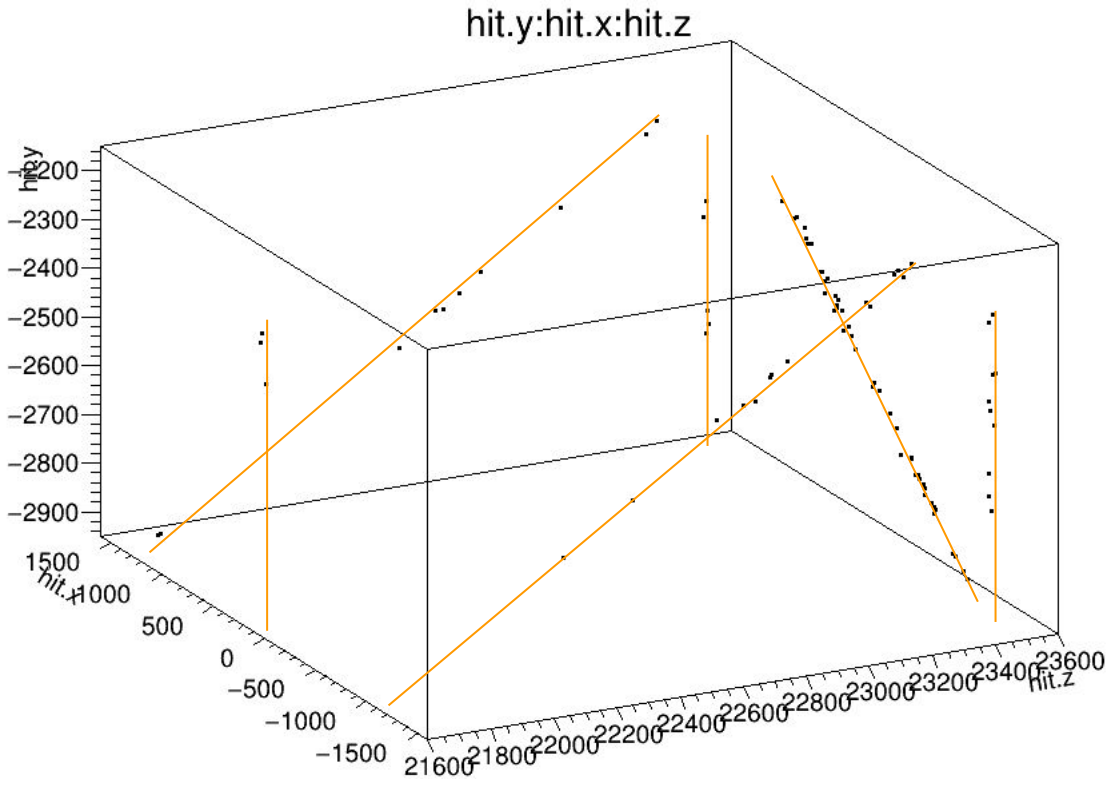
More complete view of GEM Rotator mass added since original simulations and the additional main detector frame mass added.



9211: Detector Supports [Revisited]

Primary hit locations:

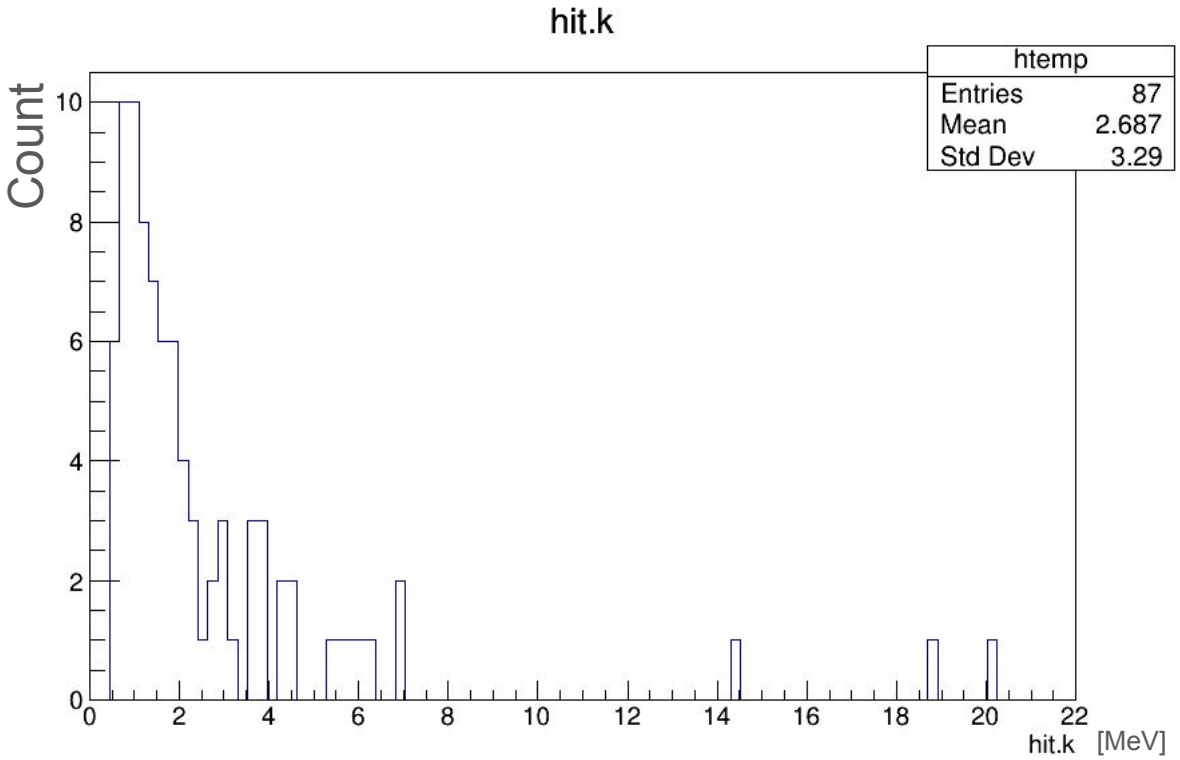
- Mostly on the downstream side as I would expect.
- Orange lines drawn in to show where locations of supports are.
- Connective plates/feet not included in sim. These lack of these shouldn't distort results and mass-scaling can be done if necessary.



9211: Detector Supports [Revisited]

Majority of primary simulation hits are below 10MeV (~95%)

Minority of primary simulation hits are above 10MeV (~5%)



9211: Detector Supports [Revisited]

Sens Volume:	Sprockets and Rods
Sim Date:	11/19/2024
Detector #:	9358

Sprockets and Rods -- Unweighted By BField

Total Prim's:	4,000,000,000

Total Sec's:	500,000	(per sens det)

Primary Counts		
Primaries	0	0&1
9358		50

Primary Fractional		
Primaries	0	0&1
9358		1.25E-08

(9928 Main Det) Secondary Counts 0&1		
Secondaries	Electrons	Gammas
9358	0	0

(9928 MainDet) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9358	0.00E+00	0.00E+00

(9928 MainDet) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9358	0.00E+00	0.00E+00

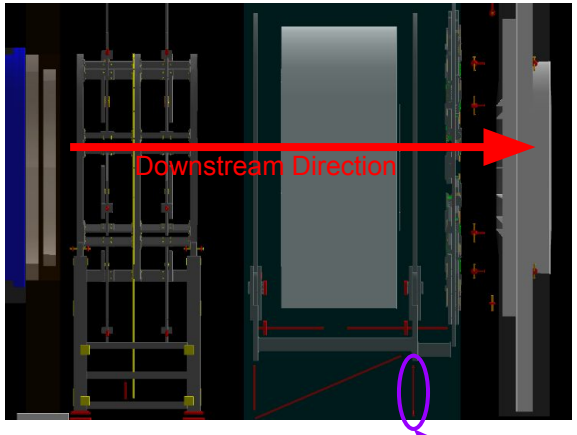
(9911 PMT Region) Secondary Counts - 0&1		
Secondaries	Electrons	Gammas
9358	3207	545

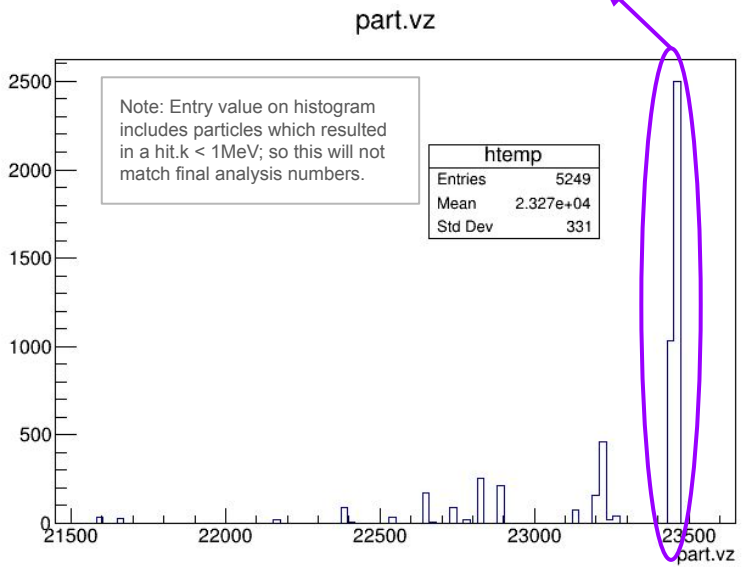
(9911 PMT Region) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9358	6.41E-03	1.09E-03

(9911 PMT Region) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9358	8.02E-11	1.36E-11

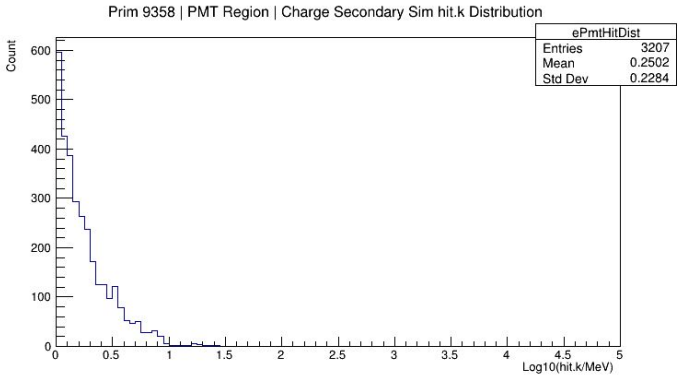
9211: Detector Supports [Revisited]

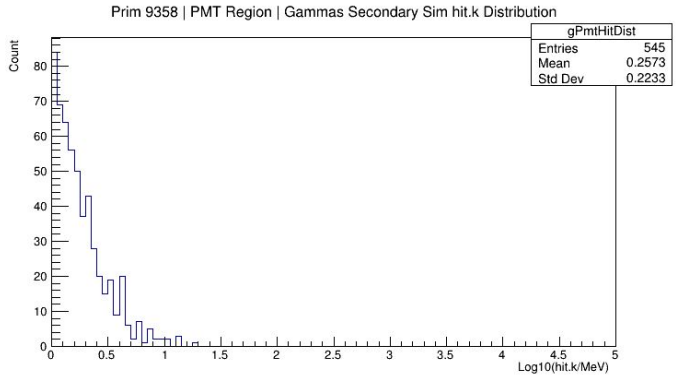
- Tolerable background rates for the carbon steel is 10^{-11} per e.o.t.
- Simulated ferrous background rates for the detector support struts/tierods are
  - ~8(10^{-11}) per e.o.t.
- Depolarization adds a factor of ⅓
  - Adjusted ferrous background is ~3(10^{-11}) per e.o.t.
- Floor attachments were simulated and this about doubles the mass (scaling is appropriate)
  - Adjusted ferrous background is ~6(10^{-11}) per e.o.t.
  - This leaves us over the 10^{-11} per e.o.t. limit by a factor of six.
- The majority of hits originate on the downstream side of the PMTs. *Thus, the majority of ferrous backgrounds are backscattered events*. Actual analyzing power of these is unknown but presumed to be low.
- Additionally, the PMT area is overmodeled and likelihood of these events hitting quartz windows and producing light is low.

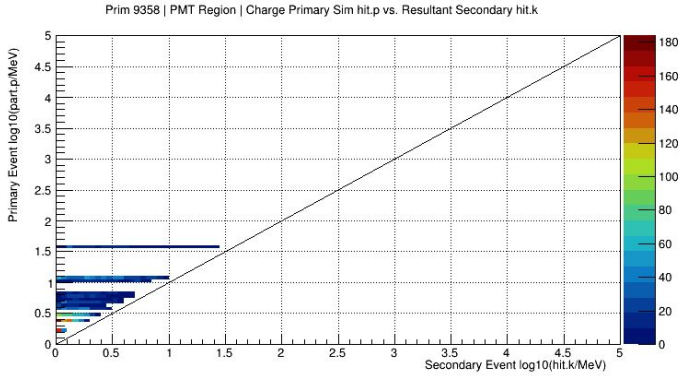


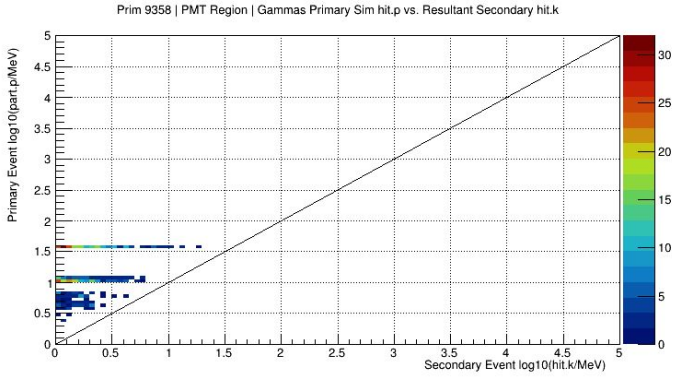


9211: Detector Supports [Revisited]









Sprockets and Rods

9358: Sprockets

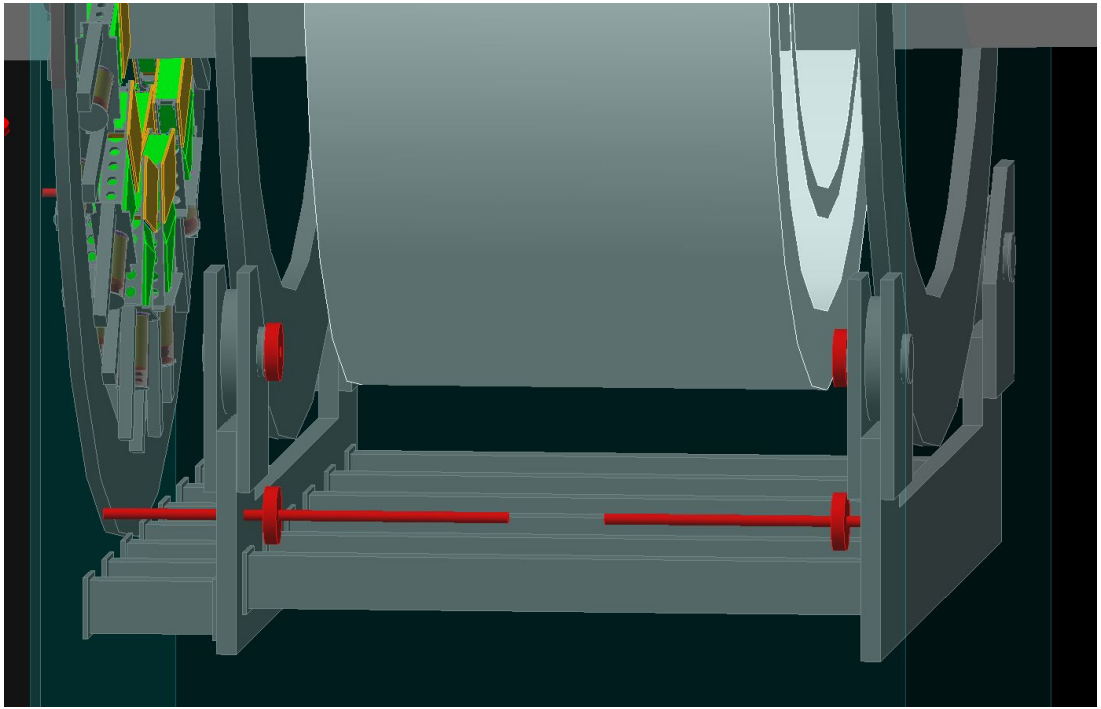
Sprockets modeled as simple tubes with IR/OR taken from specs and z-thickness adjusted to account for entire mass of sprocket.

Rods are according to dimension.

Masses:

Rod1: 4.86 kg
Rod2: 7.39 kg
Sprockets Modeled: 28.8 kg
Sprockets Not Modeled: 14.4 kg
Chain: UNKNOWN MASS

Mass scale for missing sprockets:
(14.4+28.8+7.39+4.86) / (28.8+7.39+4.86) ~ **1.34**



9358: Sprockets

Sens Volume:	Detector Supports [Revisted]
Sim Date:	11/19/2024
Detector #:	9211

Detector Supports [Revisted] -- Unweighted By BField

Total Prim's:	4,000,000,000

Total Sec's:	500,000	(per sens det)

Primary Counts		
Primaries	0	0&1
9211		87

Primary Fractional		
Primaries	0	0&1
9211		2.18E-08

(9928 Main Det) Secondary Counts 0&1		
Secondaries	Electrons	Gammas
9211	0	0

(9928 MainDet) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9211	0.00E+00	0.00E+00

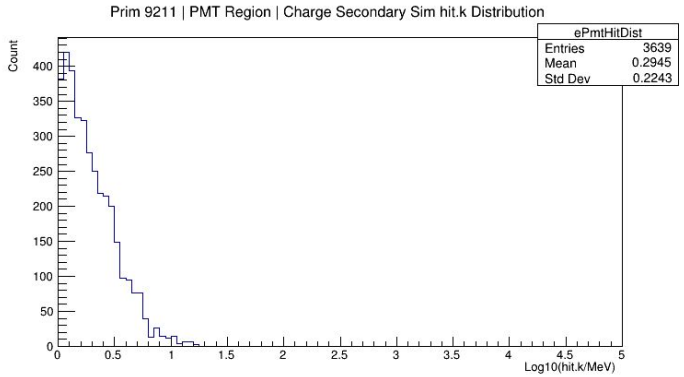
(9928 MainDet) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9211	0.00E+00	0.00E+00

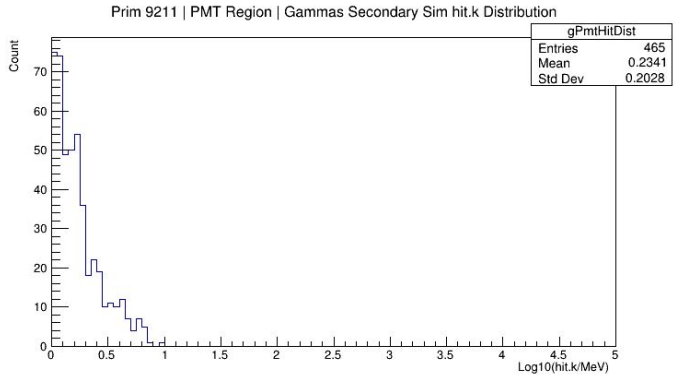
(9911 PMT Region) Secondary Counts - 0&1		
Secondaries	Electrons	Gammas
9211	3639	465

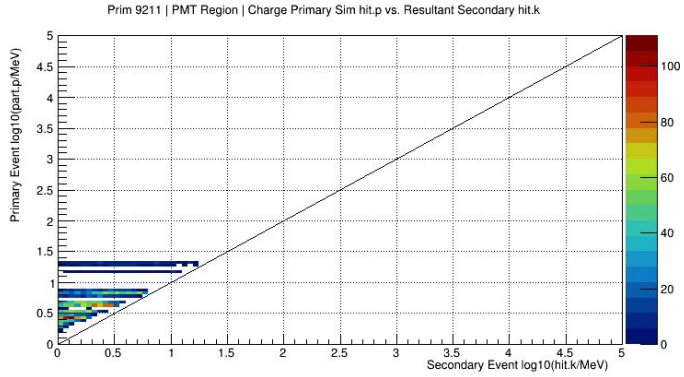
(9911 PMT Region) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9211	7.28E-03	9.30E-04

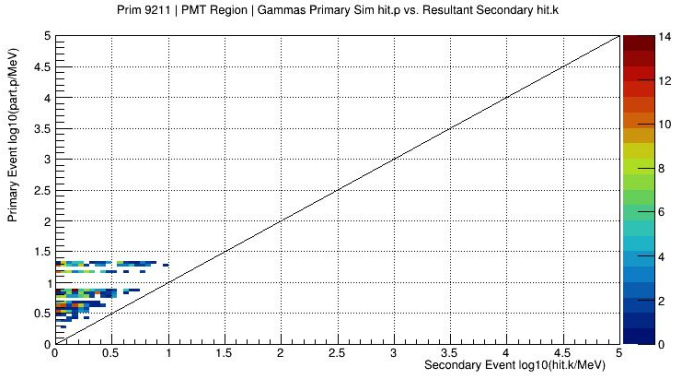
(9911 PMT Region) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9211	1.58E-10	2.02E-11

9358: Sprockets









9358: Sprockets

- Tolerable background rates for the carbon steel is 10^{-11} per e.o.t.
- Simulated ferrous background rates for the sprockets and rods is
  - $2(10^{-10})$ per e.o.t.
- Depolarization adds a factor of ⅓
  - Adjusted ferrous background is $6(10^{-11})$ per e.o.t.
  - This leaves us over the 10^{-11} per e.o.t. limit by a factor of six.
- Taking into consideration the missing mass of the two showermax [factor of 1.35] the adjusted ferrous background is ~$8(10^{-11})$
- Assuming the mass of the chains is equal to that of the sprockets the scaling for missing mass becomes a factor of ~1.7 giving an adjusted ferrous background of ~$1(10^{-10})$
- Consider:
  - The majority of hits originate on the downstream side of the PMTs. *Thus, the majority of ferrous backgrounds are backscattered events.*
  - Additionally, the PMT area is overmodeled and likelihood of these events hitting quartz windows and producing light is low.