

Ferrous Materials:

Pion Donut

- ⇒ Struts,
- ⇒ Strut Fasteners
- ⇒ Wall Tie Rods
- ⇒ Diagonal Supports

Eric King

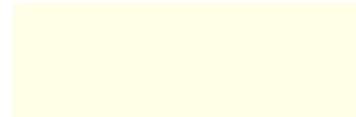
Last Updated:

08.28.2023

Ferrous Information

Ferrous Background Tolerances By Relative Susceptibility

Material	X _r	Spin Polarization (P _f)	Frac e- on Target	Frac of events 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



Depolarization

Photon and Electron Polarization in High-Energy Bremsstrahlung and Pair Production with Screening*

HAAKON OLSEN, *Fysisk Institutt, Norges Tekniske Høgskole, Trondheim, Norway*

AND

L. C. MAXIMON,† *Fysisk Institutt, Norges Tekniske Høgskole, Trondheim, Norway and Department of Theoretical Physics, The University, Manchester, England*

(Received November 24, 1958)

This slide is from old polarimetry talk.

$$D(\mathbf{p}_1, \boldsymbol{\zeta}_1) = \frac{k^2(1 - \frac{1}{3}\zeta_{1z}^2)}{\epsilon_1^2 + \epsilon_2^2 - \frac{2}{3}\epsilon_1\epsilon_2}. \quad (\text{No sc.}) \quad (9.3)$$

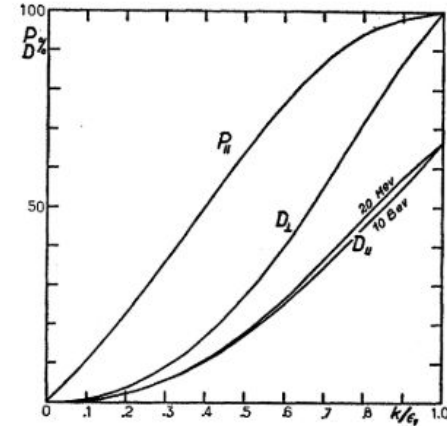


FIG. 5. Circular polarization of bremsstrahlung beam from longitudinally polarized electrons,

$$P_{||} = P(\mathbf{p}_1, \boldsymbol{\zeta}_1 \text{ long}, \mathbf{e}_{\text{circ}}),$$

and depolarization of longitudinally polarized electrons,

$$D_{||} = D(\mathbf{p}_1, \boldsymbol{\zeta}_1 \text{ long})$$

and of transversely polarized electrons, $D_{\perp} = D(\mathbf{p}_1, \boldsymbol{\zeta}_1 \text{ trans})$. Coulomb and screening effects are included. The curves for $P_{||}$ and $D_{||}$ are valid for all elements and for any incident electron energy above ≈ 20 Mev. $D_{||}$ depends slightly on the electron energy; curves are shown for incident electron energies 20 Mev and 10 Bev.

Depolarization

Variables

E_γ	=	gamma energy
E_i	=	initial electron energy
E_f	=	final electron energy
ζ_{1z}	=	0:longitudinal pol or 1:transverse
x	=	fraction of energy remaining after internal brems

From the Maximon paper:

$$D = \frac{k^2(1 - \frac{1}{3}\zeta_{1z}^2)}{E_i^2 + E_f^2 - \frac{2}{3}E_i E_f}$$

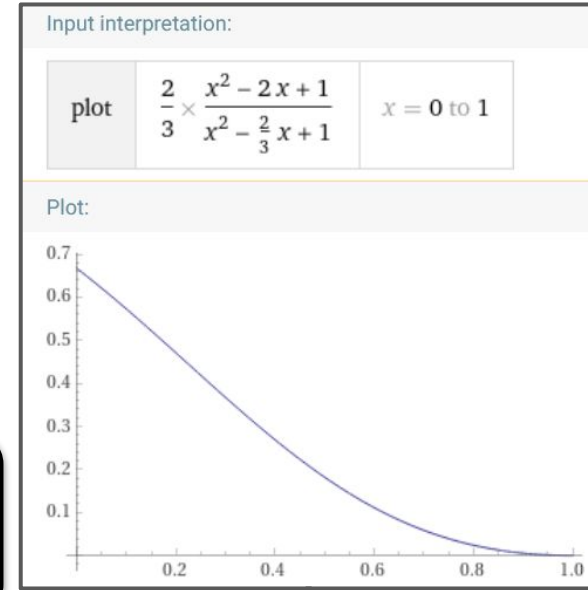
This slide is from old polarimetry talk.

Using our variables for ζ_{1z} longitudinally polarized electrons...

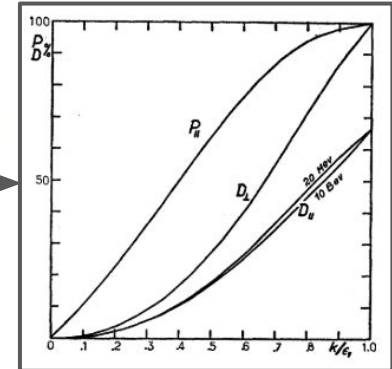
$$D = \frac{2}{3} \frac{x^2 - 2x + 1}{x^2 - \frac{2}{3}x + 1}$$

$x=1 \Rightarrow$ No brems
 $x \sim 0 \Rightarrow$ Almost all brems'd away

Consulting the gods of computing...



Reproduces the Maximon Plot



Simulated Ferrous Volumes

Pion Donut

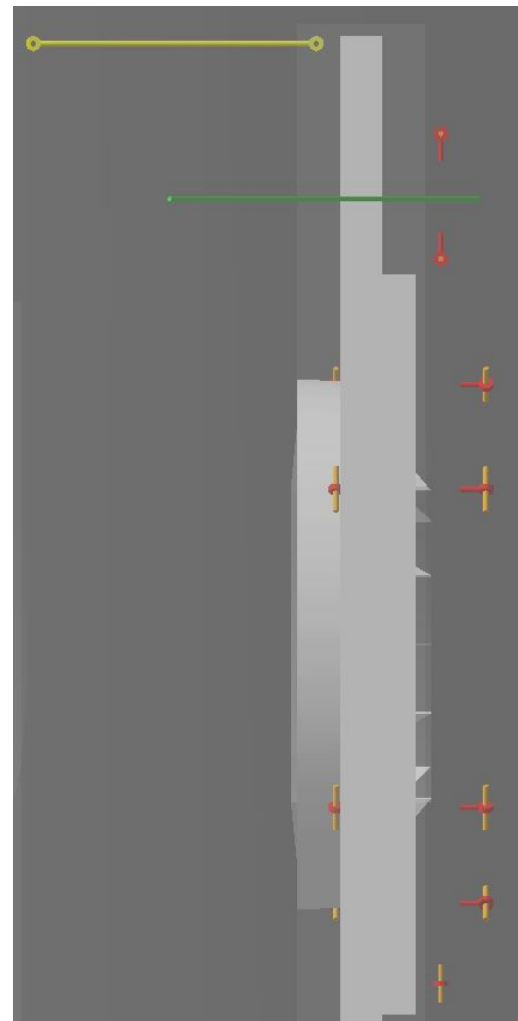
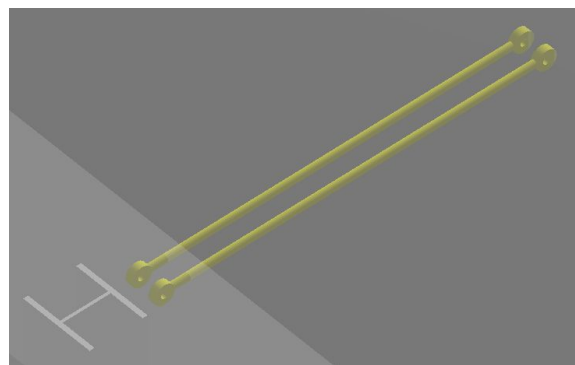
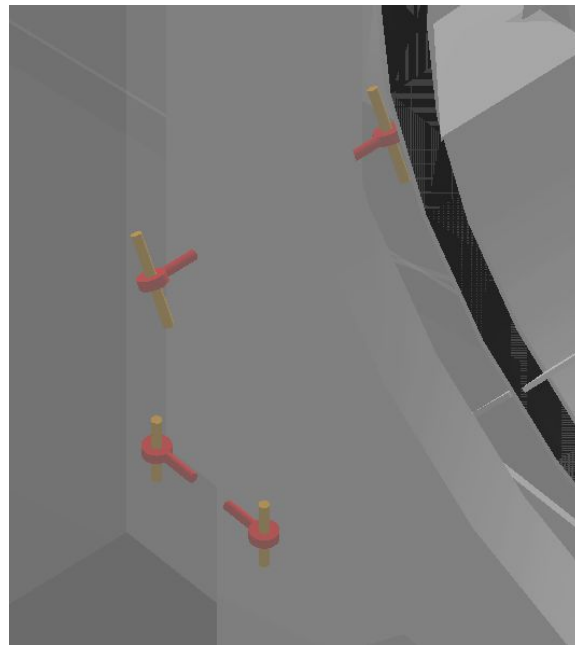
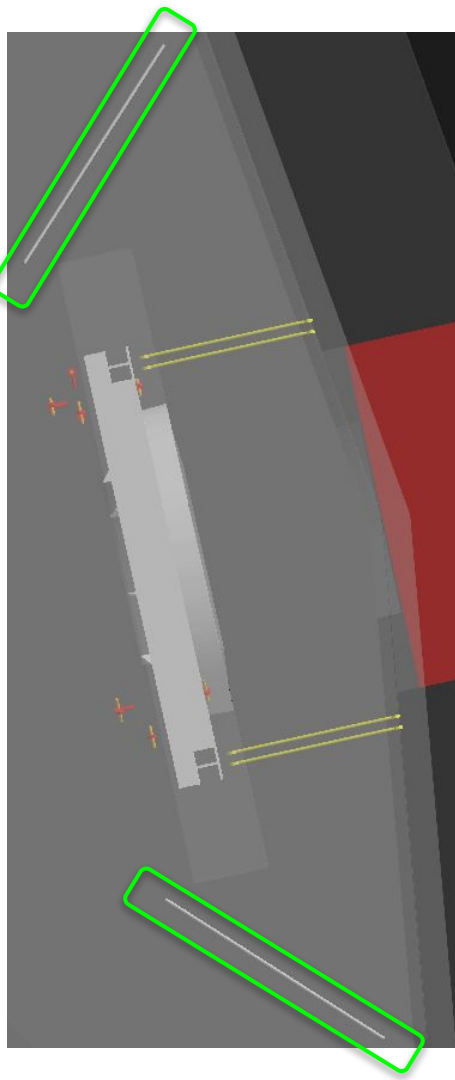
Distribution of ferrous material in remoll visualization.

Struts: Hold the donut in place

Strut Bolts:
Fasteners for the struts.

Tie Rods:
Connect pion donut support structure to Hall wall

Diagonal Support:
Connect donut structure to Hall wall.

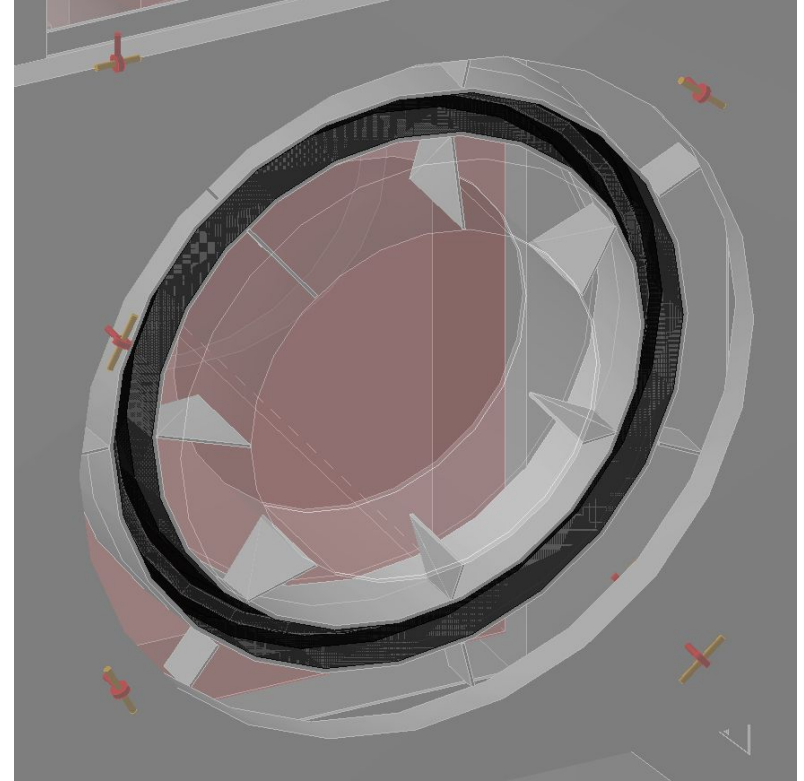
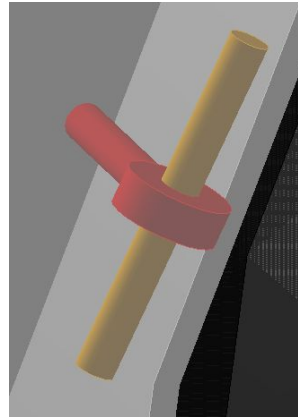
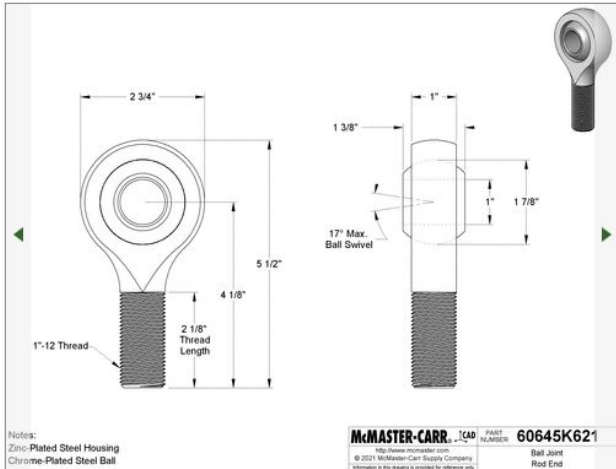


9221 – Pion Donut Strut Ends

Zinc-plated Carbon Steel

Length of strut ends reduced from previous simulations.

<https://www.mcmaster.com/6064/>



9221: Pion Donut Strut Ends

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

Sens Volume:	Pion Donut Strut Ends
Sim Date:	9/15/2023
Detector #:	9221

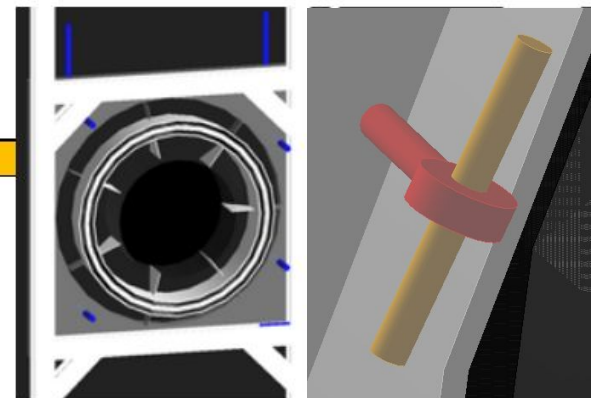
Pion Donut Strut Ends -- Unweighted By BField

Total Prim's:	15,000,000,000	Total Sec's:	500,000	(per sens det)
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Primary Counts			Primary Fractional		
Primaries	Electrons	Gammas	Primaries	Electrons	Gammas
9221	0	837	9221	0	5.58E-08

(9928 MainDet) Secondary Counts - 0&1			(9928 MainDet) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas	Secondaries	Electrons	Gammas
9221	179	144	9221	3.58E-04	2.88E-04

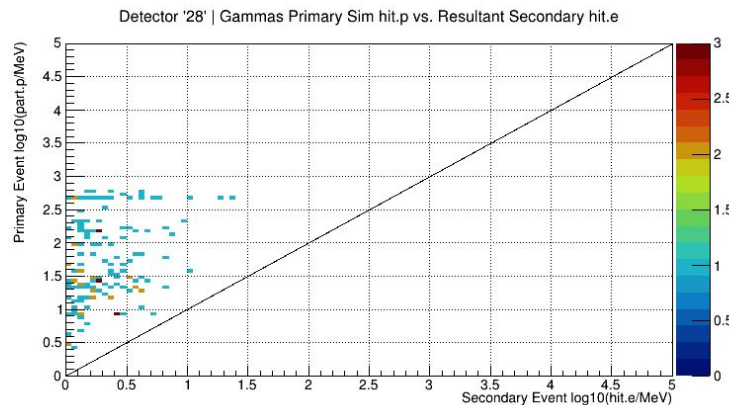
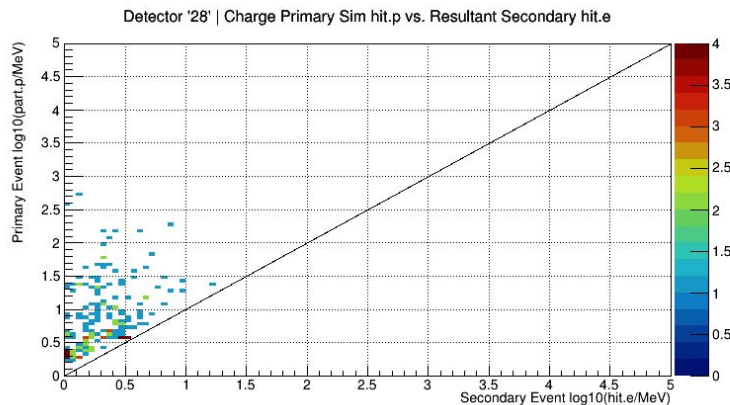
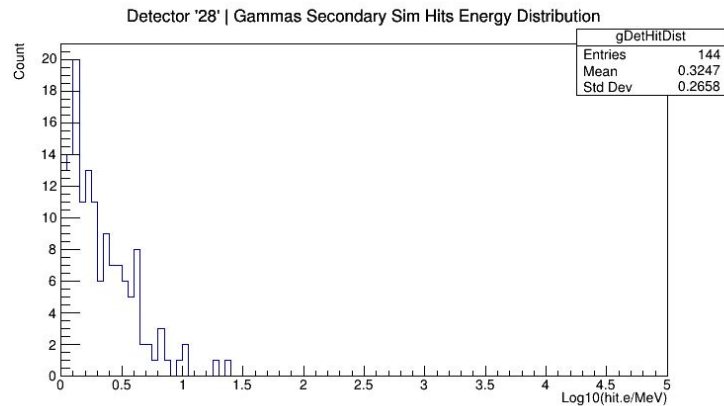
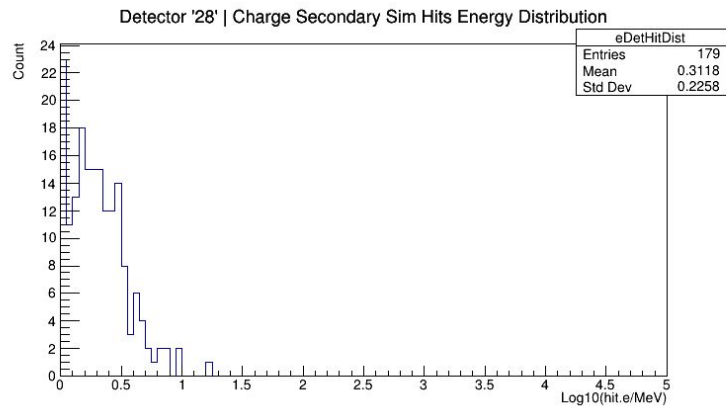
(9911 PMT Region) Secondary Counts - 0&1			(9911 PMT Region) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas	Secondaries	Electrons	Gammas
9221	1169	694	9221	2.34E-03	1.39E-03



(9928 MainDet) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9221	2.00E-11	1.61E-11

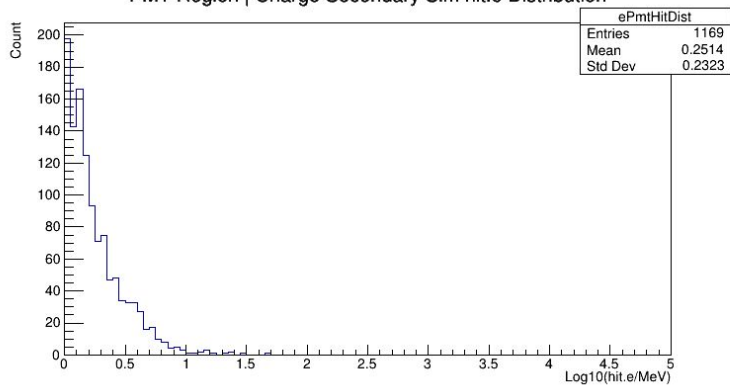
(9911 PMT Region) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9221	1.30E-10	7.75E-11

9221: Pion Donut Strut Ends

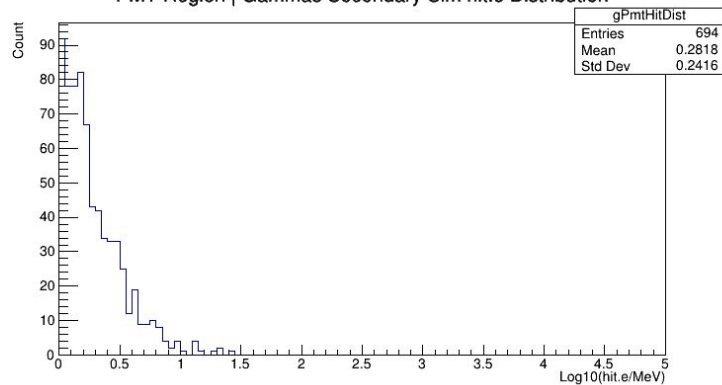


9221: Pion Donut Strut Ends

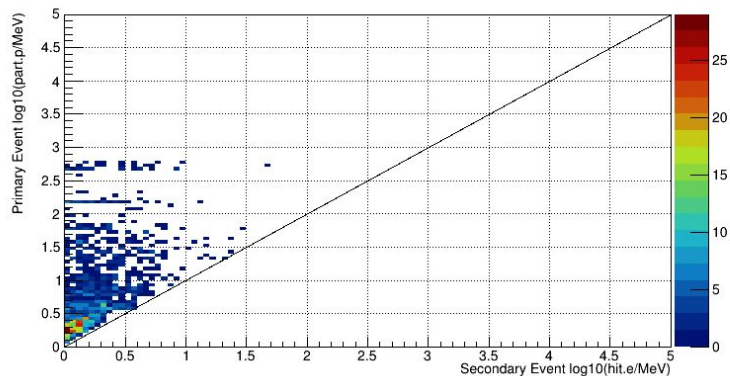
PMT Region | Charge Secondary Sim hit.e Distribution



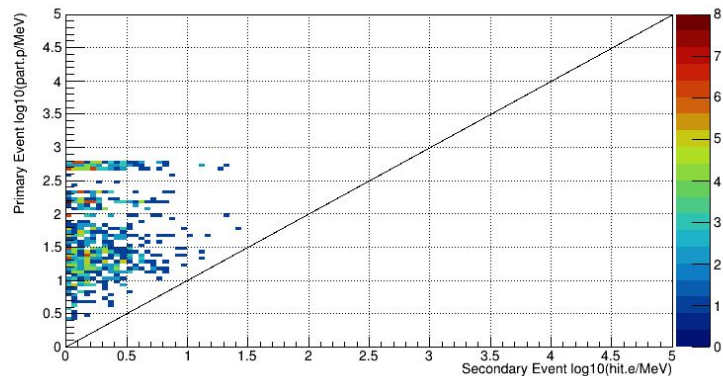
PMT Region | Gammas Secondary Sim hit.e Distribution



PMT Region | Charge Primary Sim hit.p vs. Resultant Secondary hit.e



PMT Region | Gammas Primary Sim hit.p vs. Resultant Secondary hit.e



9223 – Pion Donut Strut Bolts

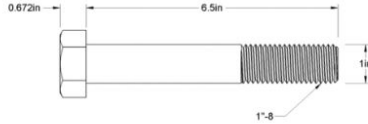
The 6.5" bolts are used for the struts oriented in the x and y directions and the 8.5" bolts are used in the struts oriented in the -direction.

Grade 8 Steel
[Medium Carbon]

<https://www.mcmaster.com/91257A970/>



<https://www.mcmaster.com/91257A970/>



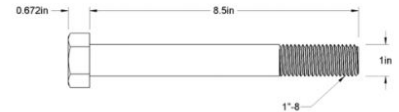
Thread length may vary from 2 1/2" to 3 1/8" in length.

McMASTER-CARR 1CAD PART NUMBER **91257A970**
© 2023 McMaster-Carr Supply Company
McMaster-Carr Supply Company Zinc Yellow-Chromate
Plated Hex Head Screw

<https://www.mcmaster.com/91257A979/>



<https://www.mcmaster.com/91257A979/>



Thread length may vary from 2 1/2" to 3 1/8" in length.

McMASTER-CARR 1CAD PART NUMBER **91257A979**
© 2023 McMaster-Carr Supply Company
McMaster-Carr Supply Company Zinc Yellow-Chromate
Plated Hex Head Screw

9223: Pion Donut Strut Bolts

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

Sens Volume:	Pion Donut Strut Bolts
Sim Date:	9/15/2023
Detector #:	9223

Strut bolts either 6.5" or 8.5" depending on location.

Pion Donut Strut Bolts -- Unweighted By BField

Total Prim's: 15,000,000,000

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

Primary Counts

Primaries	0	0&1
9223		916

Primary Fractional

Primaries	0	0&1
9223		6.11E-08

(9928 MainDet) Secondary Counts - 0&1

Secondaries	Electrons	Gammas
9223	177	175

(9928 MainDet) Secondary Fractional - 0&1

Secondaries	Electrons	Gammas
9223	3.54E-04	3.50E-04

(9928 MainDet) Total Fractional - 0&1

Secondaries	Electrons	Gammas
9223	2.16E-11	2.14E-11

(9911 PMT Region) Secondary Counts - 0&1

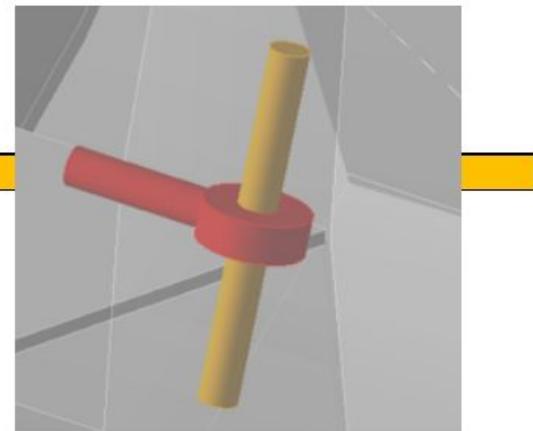
Secondaries	Electrons	Gammas
9223	1056	634

(9911 PMT Region) Secondary Fractional - 0&1

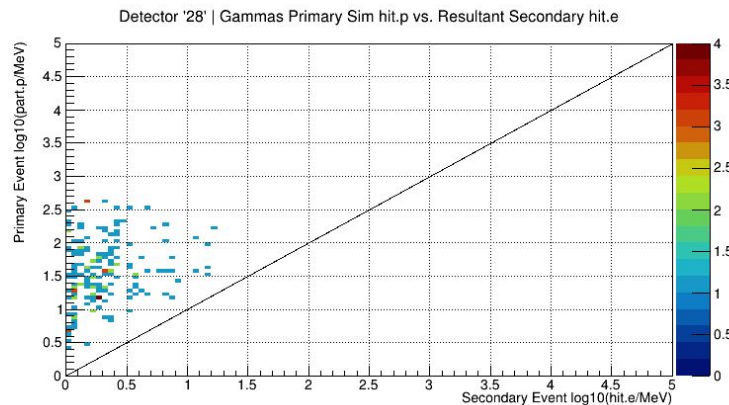
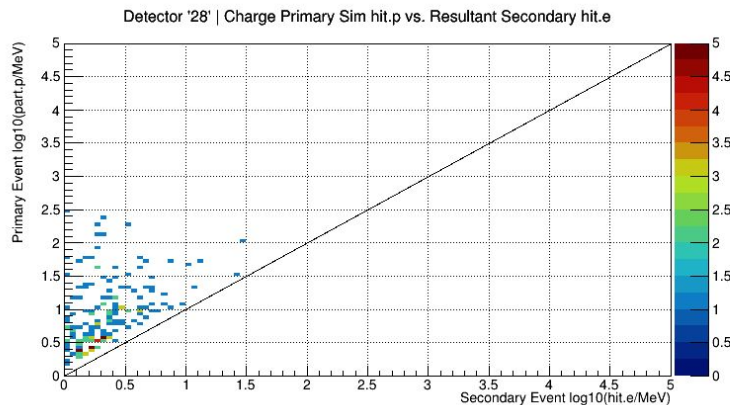
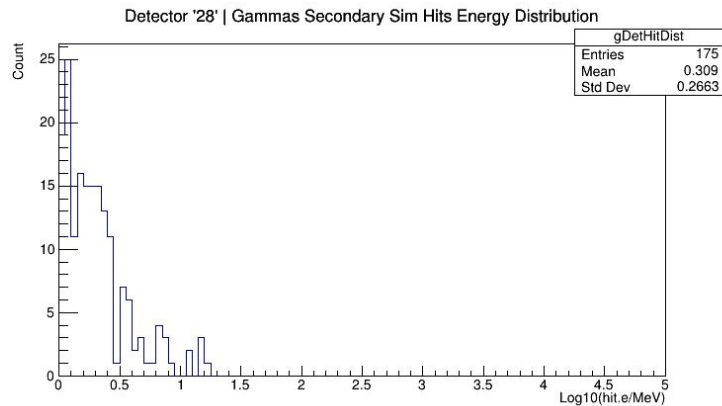
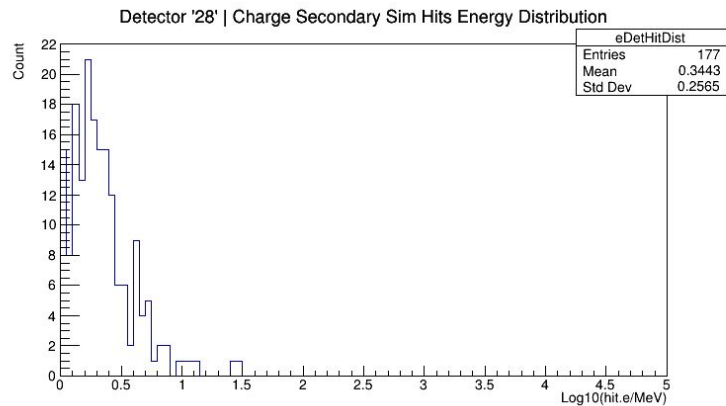
Secondaries	Electrons	Gammas
9223	2.11E-03	1.27E-03

(9911 PMT Region) Total Fractional - 0&1

Secondaries	Electrons	Gammas
9223	1.29E-10	7.74E-11

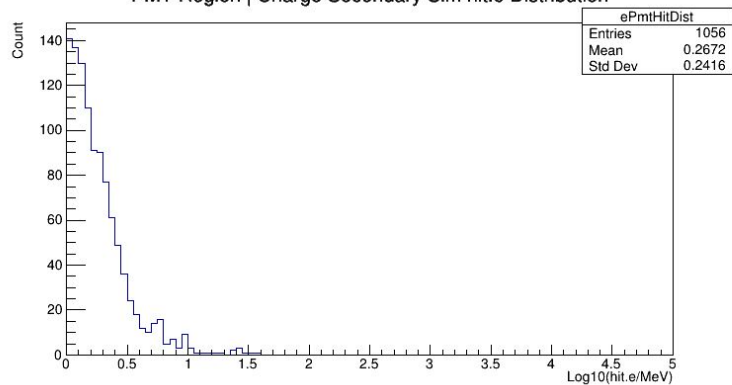


9223: Pion Donut Strut Ends

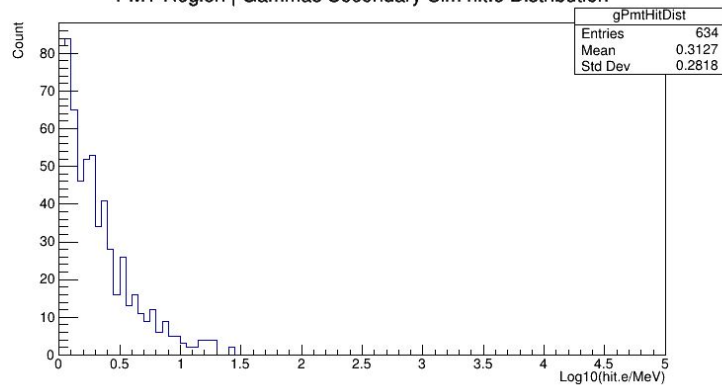


9223: Pion Donut Strut Bolts

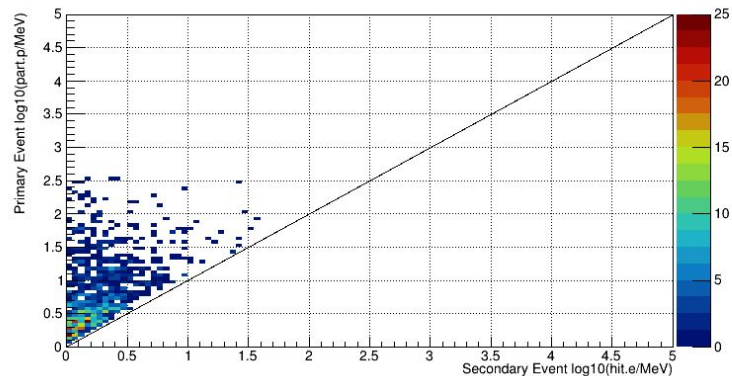
PMT Region | Charge Secondary Sim hit.e Distribution



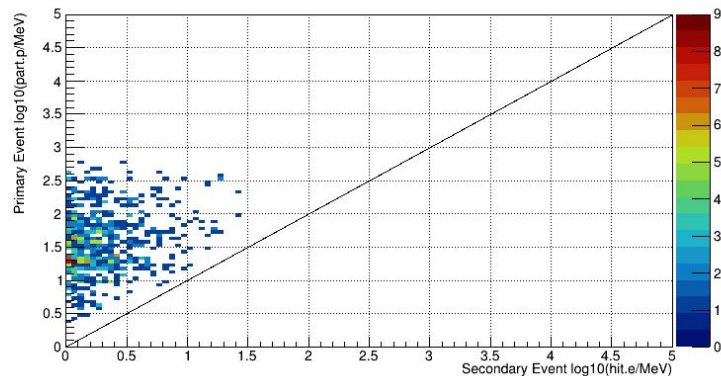
PMT Region | Gammas Secondary Sim hit.e Distribution



PMT Region | Charge Primary Sim hit.p vs. Resultant Secondary hit.e



PMT Region | Gammas Primary Sim hit.p vs. Resultant Secondary hit.e

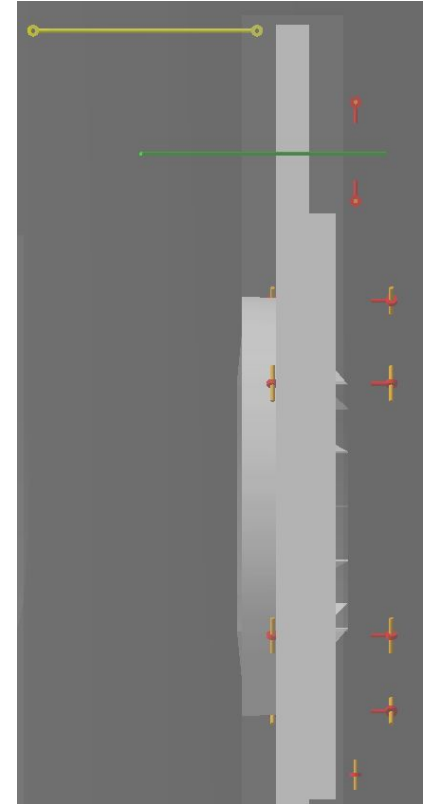
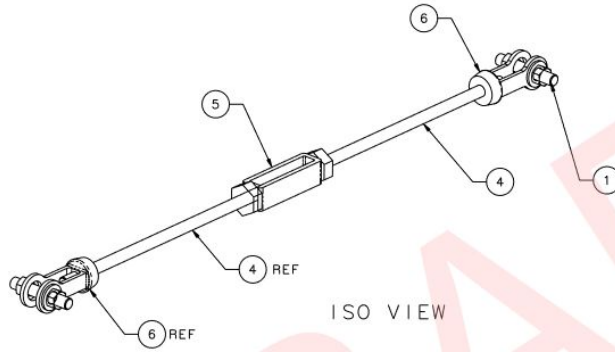
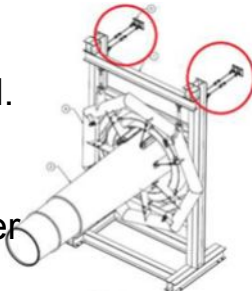


9222 – Pion Donut Tie Rods

Made the model before I had access to document control.

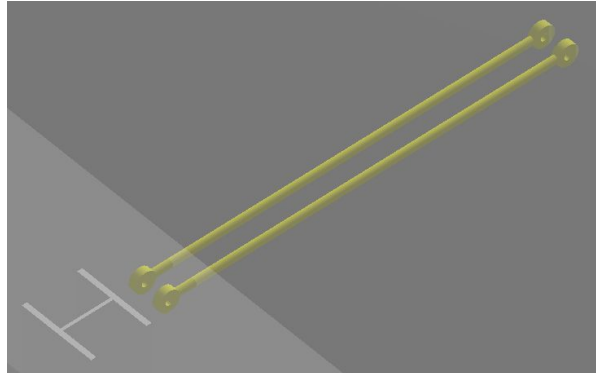
A36 low-carbon steel.

No details about rod width. I gave diameter of 1".



QTY	ITEM NO.	PART OR IDENTIFYING NO.	DESCRIPTION OR SPECIFICATION	MATERIAL	NOTES
2	6	JL0148098	CLEVIS #2.5 X 1 1/4 GRIP	STEEL A36	
1	5	JL0145834	TURNBUCKLE .88	STEEL A36	
2	4	JL0145844	TURNBUCKLE ROD	STEEL A36	
4	3	JL0145918	FLAT WASHER 7/8 X 2.00 OD	STEEL A36	
4	2	JL0145924	HEX NUT 7/8 - 9 UNC	STEEL A36	
2	1	JL0145925	STUD 7/8 - 9 UNC X 4.5 LG.	STEEL A36	

PARTS LIST		UNIT STATES DEPARTMENT OF ENERGY	REPORT NO. YJ114
SEE PARTS LIST		Jefferson Lab <small>Thomas Jefferson National Accelerator Facility</small>	HALL A - A09005 - 12GeV MOLLER SUPPORT STRUCTURES - PION DONUT PION DONUT ASSY PION DONUT TIE ROD ASSEMBLY
FINISH 120 UNLESS OTHERWISE NOTED SURFACES & BREAK ALL SHARP EDGES DO NOT SCALE DRAWING DRAWN: J. SPELL DATE: 06.30			



9222: Pion Donut Tie Rods

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 depolarization considerations, reduce by a factor of 1/3, and these become 'tolerable'.

Sens Volume:	Pion Donut [Wall Support] Tie Rod
Sim Date:	9/15/2023
Detector #:	9222

Pion Donut [Wall Support] Tie Rods -- Unweighted By BField

Total Prim's: 10,000,000,000

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

Primary Counts		
Primaries	0	0&1
9222		1355

Primary Fractional		
Primaries	0	0&1
9222		1.36E-07

(9928 MainDet) Secondary Counts - 0&1		
Secondaries	Electrons	Gammas
9222	48	9

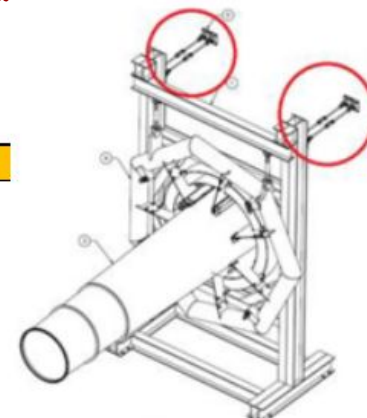
(9928 MainDet) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9222	9.60E-05	1.80E-05

(9928 MainDet) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9222	1.30E-11	2.44E-12

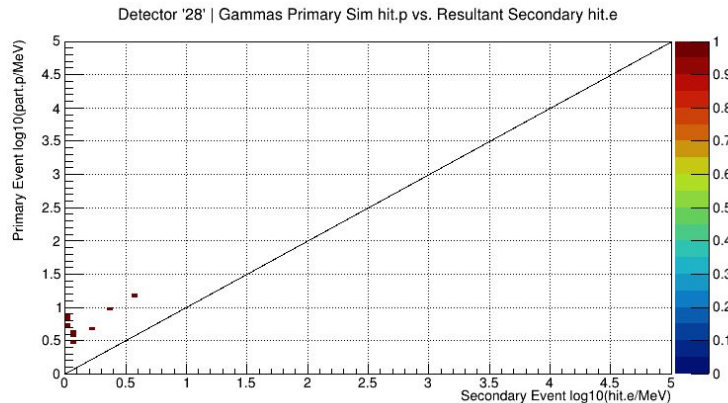
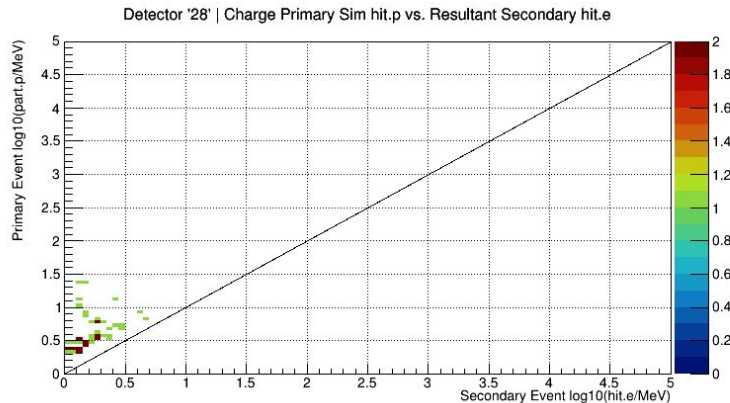
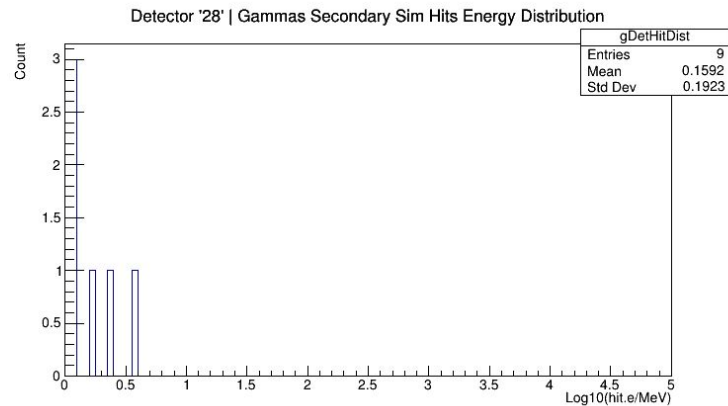
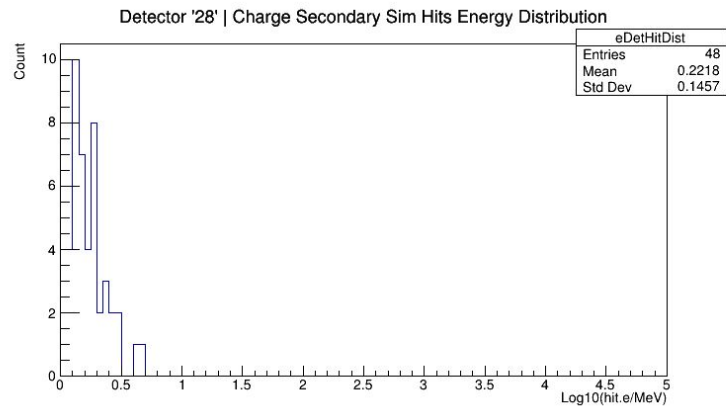
(9911 PMT Region) Secondary Counts - 0&1		
Secondaries	Electrons	Gammas
9222	429	31

(9911 PMT Region) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9222	8.58E-04	6.20E-05

(9911 PMT Region) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9222	1.16E-10	8.40E-12

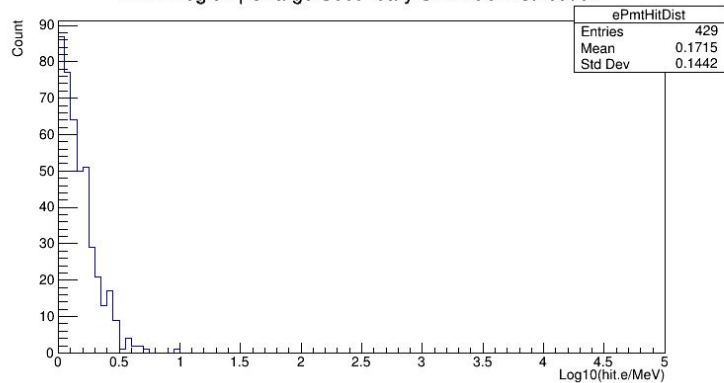


9222: Pion Donut Tie Rods

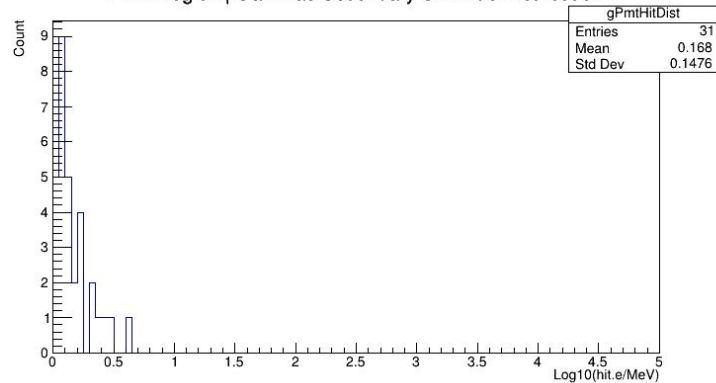


9222: Pion Donut Tie Rods

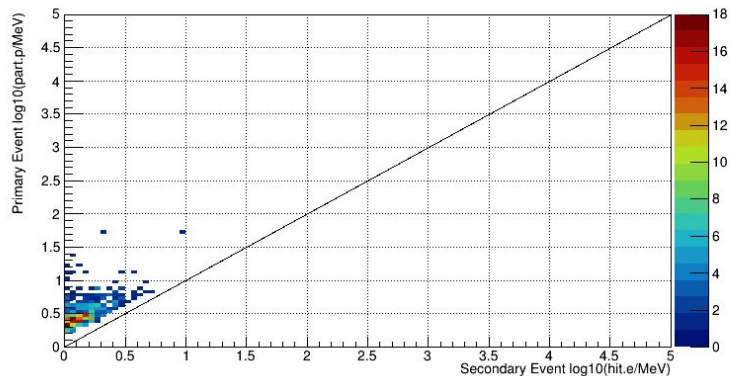
PMT Region | Charge Secondary Sim hit.e Distribution



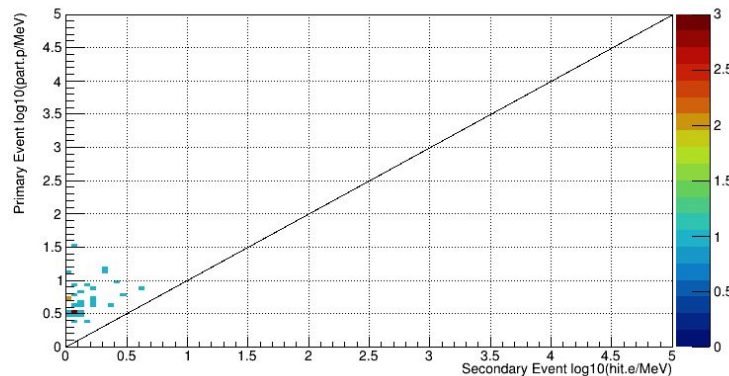
PMT Region | Gammas Secondary Sim hit.e Distribution



PMT Region | Charge Primary Sim hit.p vs. Resultant Secondary hit.e



PMT Region | Gammas Primary Sim hit.p vs. Resultant Secondary hit.e



9224 – Pion Donut Diag Supps

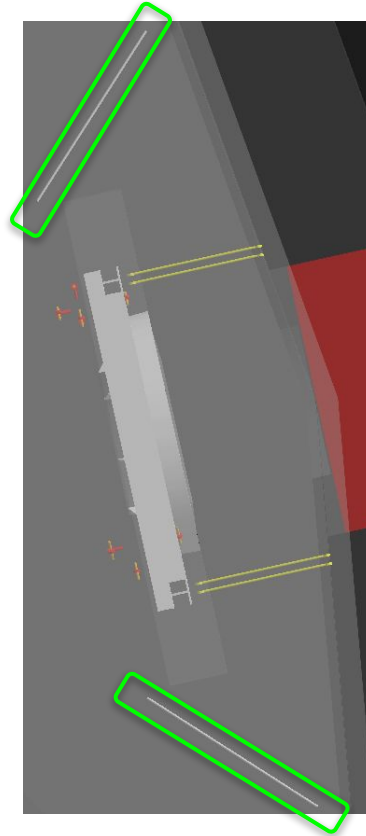
Diagonal support's for Pion Donut assembly placed per specs from Cip

200" above floor

Starting at 90" in x-position and move out at 45*deg angle off beamline and continue until wall.

Starting z-position should at the showermax.

Supports outlined in green.



Probably could have made it closer to the wall. I shifted in forward but forgot to increase length.

This is not a significant difference.

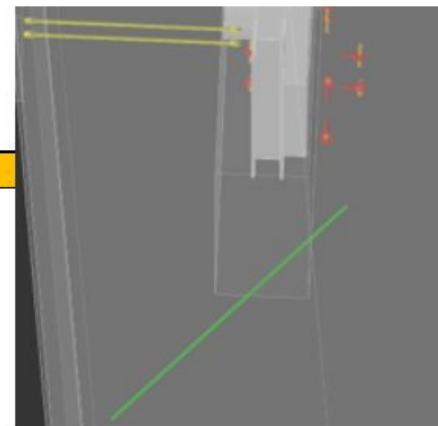
⇒ I am presuming that these will be made out of the same A36 Steel that the Tie Rods will be made out of. It is not clear to me exactly what this material is.

9224: Pion Donut Diag Supports

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

Sens Volume:	Pion Donut Diagonal Supports
Sim Date:	9/15/2023
Detector #:	9224

Green volume in image to side.



Pion Donut Diagonal Supports -- Unweighted By BField

Total Prim's: 15,000,000,000

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

Primary Counts		
Primaries	0	0&1
9224		526

Primary Fractional		
Primaries	0	0&1
9224		3.51E-08

(9928 MainDet) Secondary Counts - 0&1		
Secondaries	Electrons	Gammas
9224	85	18

(9928 MainDet) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9224	1.70E-04	3.60E-05

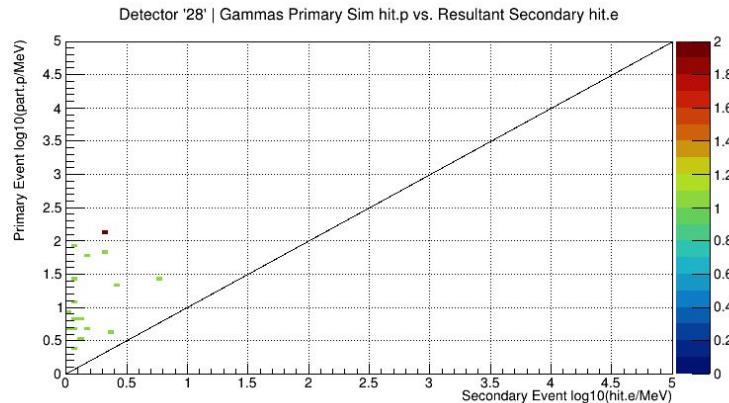
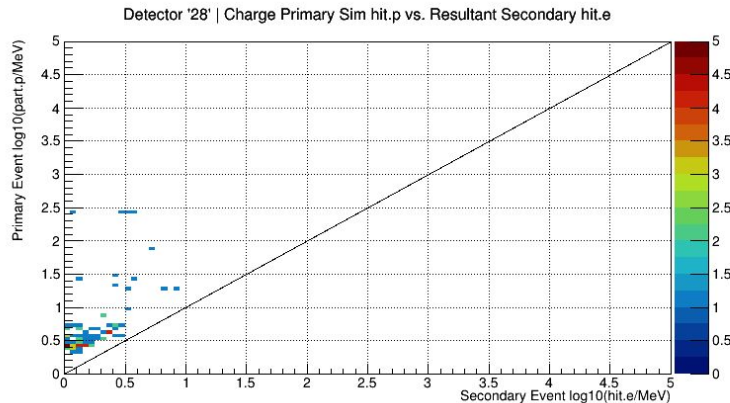
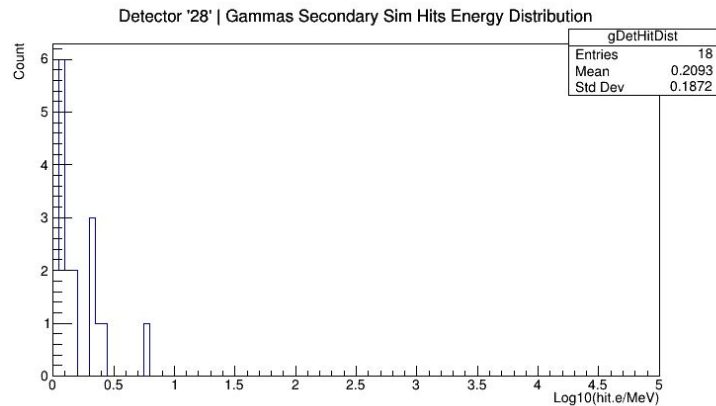
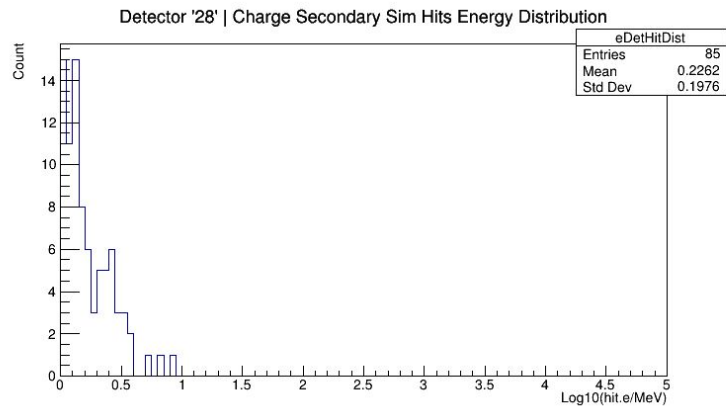
(9928 MainDet) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9224	5.96E-12	1.26E-12

(9911 PMT Region) Secondary Counts - 0&1		
Secondaries	Electrons	Gammas
9224	710	74

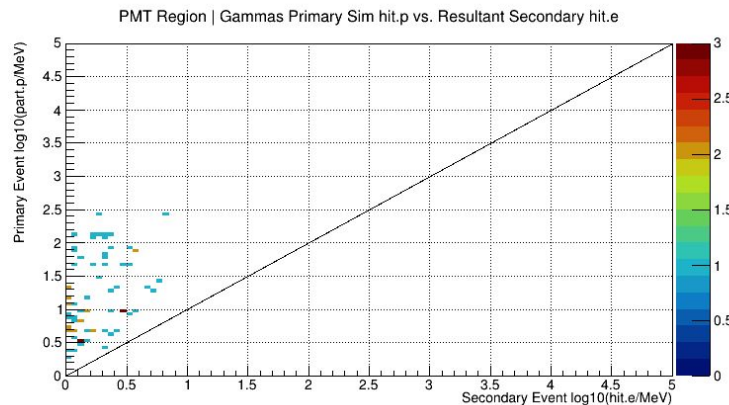
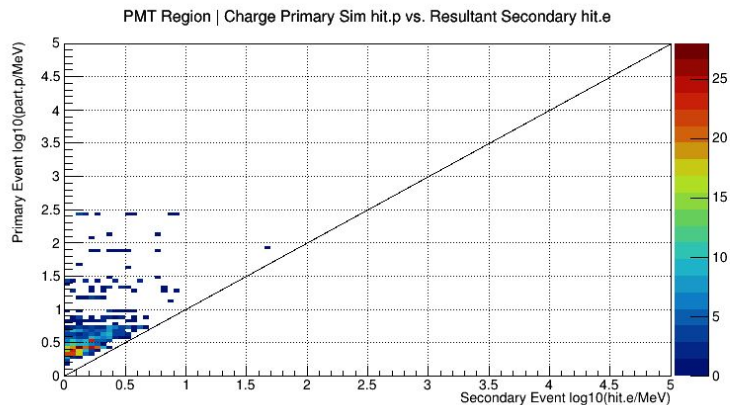
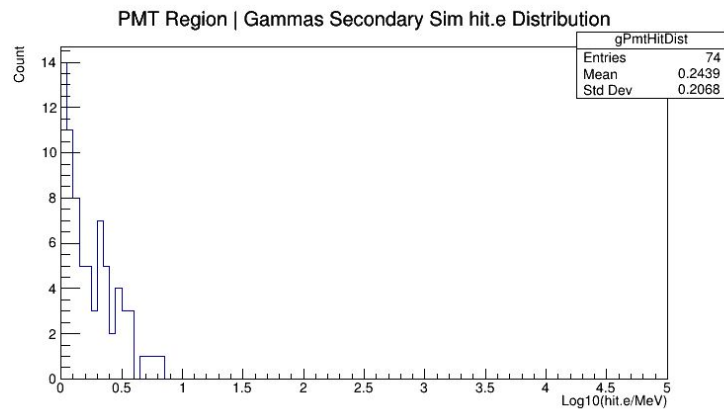
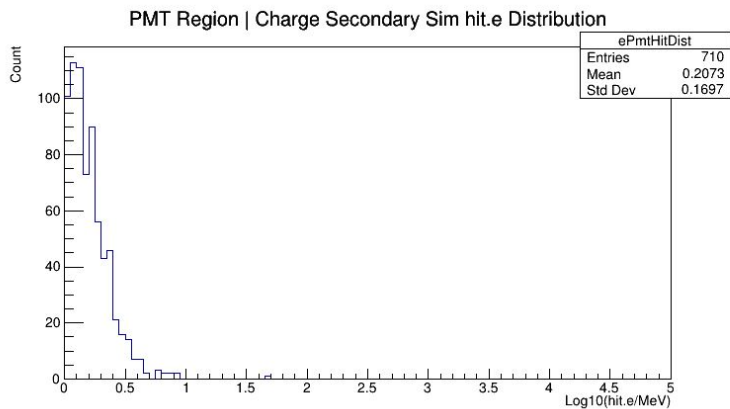
(9911 PMT Region) Secondary Fractional - 0&1		
Secondaries	Electrons	Gammas
9224	1.42E-03	1.48E-04

(9911 PMT Region) Total Fractional - 0&1		
Secondaries	Electrons	Gammas
9224	4.98E-11	5.19E-12

9224: Pion Donut Diagonal Supports



9224: Pion Donut Diagonal Supports



Takeaway

Comments

Difference from Previous:

- Change in modeling of the strut ends to 2" rather than 6" has decreased background by about 33%. Which makes sense as the upstream faces were responsible for the bulk of backgrounds.
- Addition of the Grade 8 bolts, though, adds previous gains (above bullet point) right back in.
- Previous simulation for the tie rods were just ends, but it looks like they will be completely made of A36 steel. This takes us from 'it's okay' territory to 'not too comfortable' territory.

Materials:

- It would be nice to get some additional information on the Grade 8 steel. I've seen this reference as medium-carbon steel.
- Same goes for the A36 which I've seen referenced as low-carbon.
- At this point, I'm just considering them to all be 'carbon steel' and subject to our 10^{-11} ferrous background limit

Summary of Pion Donut Region

Summing all of this up under the hopefully overly-conservative assumption that the all of them share the same susceptibility.

This leaves us at $6(10^{-11})$... taking off a factor of 3 for depolarization and that still has us at $2(10^{-11})$.

Photon efficiency in quartz gives 10^{-2} leeway here.

PMT region boundary overmodeled.
Factor Reduction???

Ferrous Volume	Volume Common Name	Ferrous Material	Background Tolerance	Main Det Charges	Main Det Gammas	PMT Region Charges	PMT Region Gammas
9221	Pion Donut Strut Ends	Carbon Steel	1e-11	2.00e-11	1.61e-11 1.61e-13	1.30e-10	7.75e-11
9222	Pion Donut Tie Rods	Steel A36 [Low-Carbon]	1e-11	1.30e-11	2.44e-12 2.44e-14	1.16e-10	8.40e-12
9223	Pion Donut Strut Fasteners	Grade 8 Med-Carbon ???	1e-11	2.16e-11	2.14e-11 2.14e-13	1.29e-10	7.74e-11
9224	Pion Donut Diagonal Supports	Steel A36 [Low-Carbon]	1e-11	5.96e-12	1.26e-12 1.26e-14	4.98e-11	5.19e-12

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