WireCell/DNN-ROI Signal Processing in ICARUS

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WireCell
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Introduction

- I am trying to get WireCell 2D deconvolution / signal processing working for ICARUS

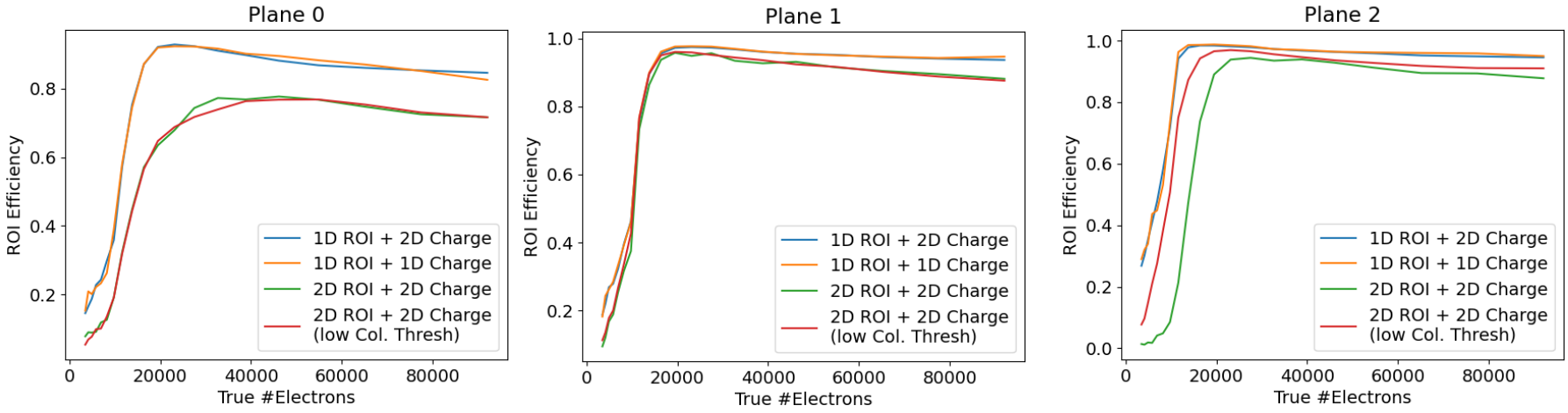
- As part of this, I am optimizing our filters in the deconvolution

Existing ICARUS WireCell Filter Values

	MicroBooNE	ProtoDUNE	SBND	ICARUS
Wire Induction	1.4/sqrt(pi)	0.75/sqrt(pi)	1.05/sqrt(pi)	**0.75/sqrt(pi)**
Wire Collection	3.0/sqrt(pi)	10/sqrt(pi)	3.6/sqrt(pi)	**3/sqrt(pi)**
Gaus HF	0.114 MHz	0.12 MHz	0.1 MHz	**0.12 MHz**
Wiener (tight) HF U	0.1439 MHz Power: 4.10358	0.148788 MHz Power: 3.76194	0.15 MHz Power: 5.5	**0.15 MHz Power: 3.8**
Wiener (tight) HF V	0.1498 MHz Power: 4.20820	0.1596568 MHz Power: 4.36125	0.15 MHz Power: 5.0	**0.16 MHz Power: 4.4**
Wiener (tight) HF W	0.1472 MHz Power: 4.17455	0.13623 MHz Power: 3.35324	0.25 MHz Power: 3.0	**0.14 MHz Power: 3.4**
ROI LF Loose	0.0025 MHz	0.002 MHz	0.00175 MHz	**0.0025 MHz**
ROI LF tight	0.02 MHz	0.014 MHz	0.0185 MHz	**0.014 MHz**
ROI LF tighter	0.1 MHz	0.06 MHz	0.145 MHz	**0.06 MHz**

Starting Point: Comparison of Existing SP

- 1D ROI + 1D Charge: existing ICARUS signal processing
- 1D ROI + 2D Charge: “Alternative” WireCell
- 2D ROI + 2D Charge: Conventional WireCell
- 2D ROI + 2D Charge (low col-thresh): Conventional WireCell, lowered collection threshold from 5 to 3x RMS



ROI Efficiency

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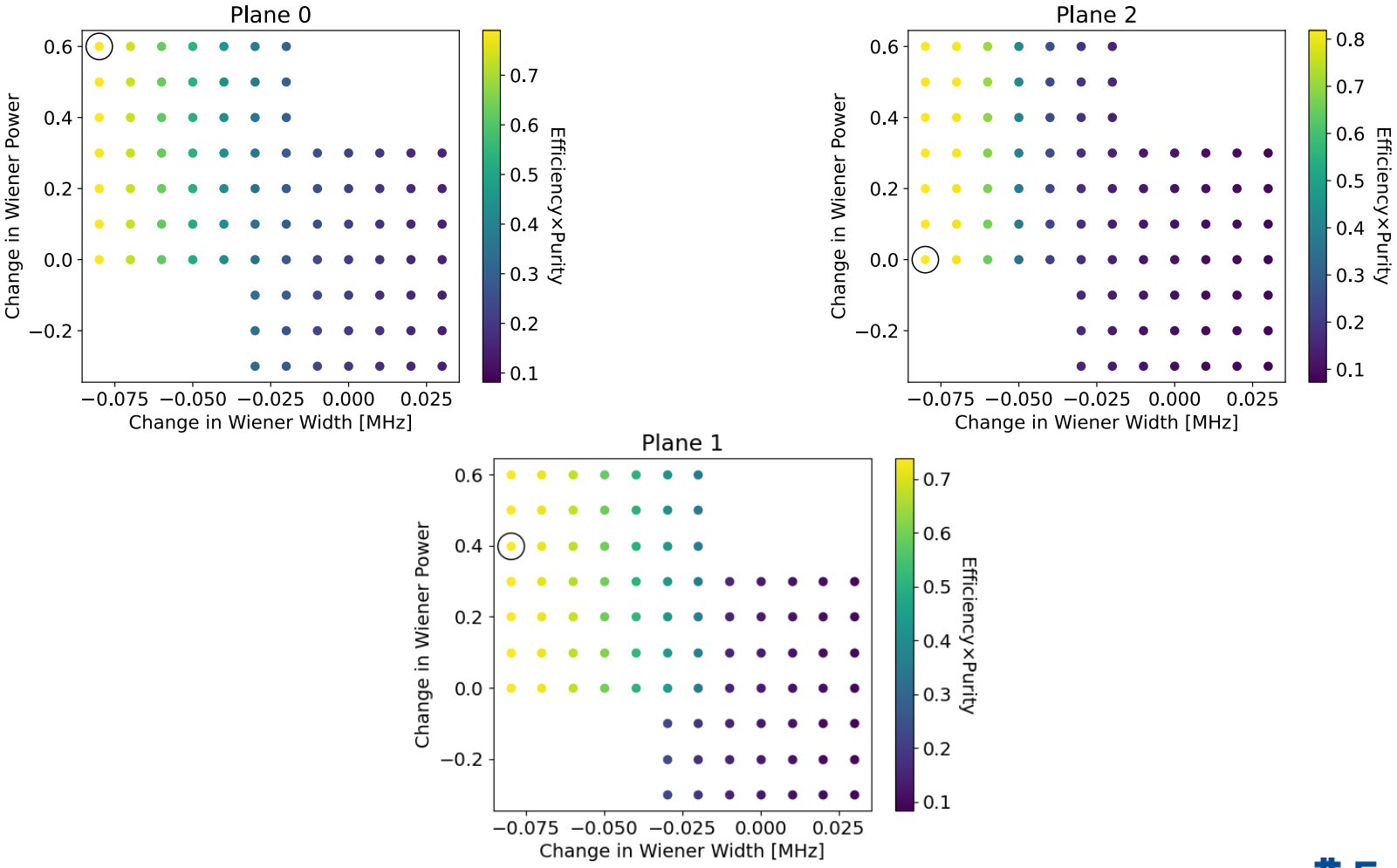
Filter Optimization

- Optimize for Efficiency × Purity in space of (Wiener filter power, Wiener filter width, wire filter width)



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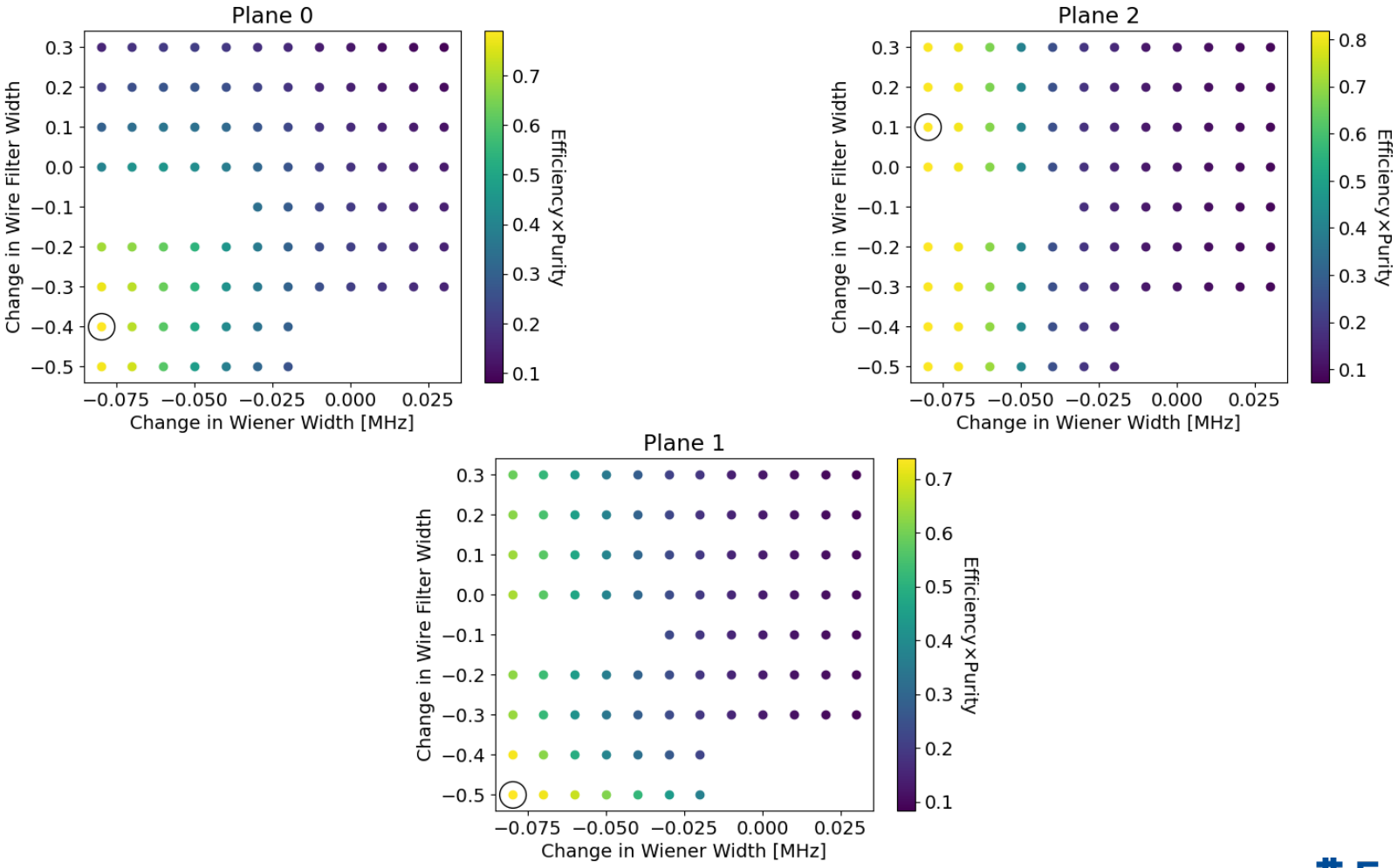

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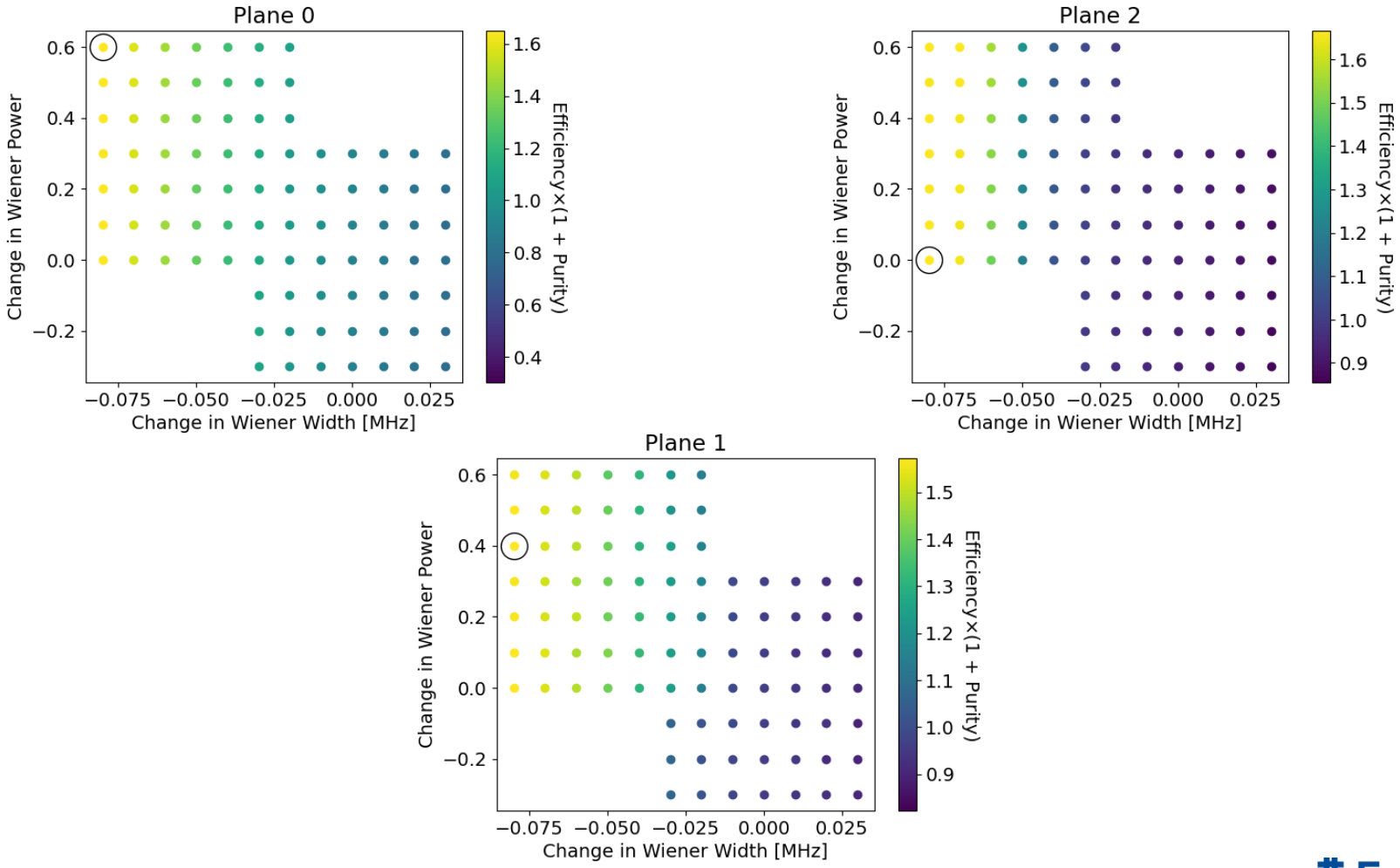

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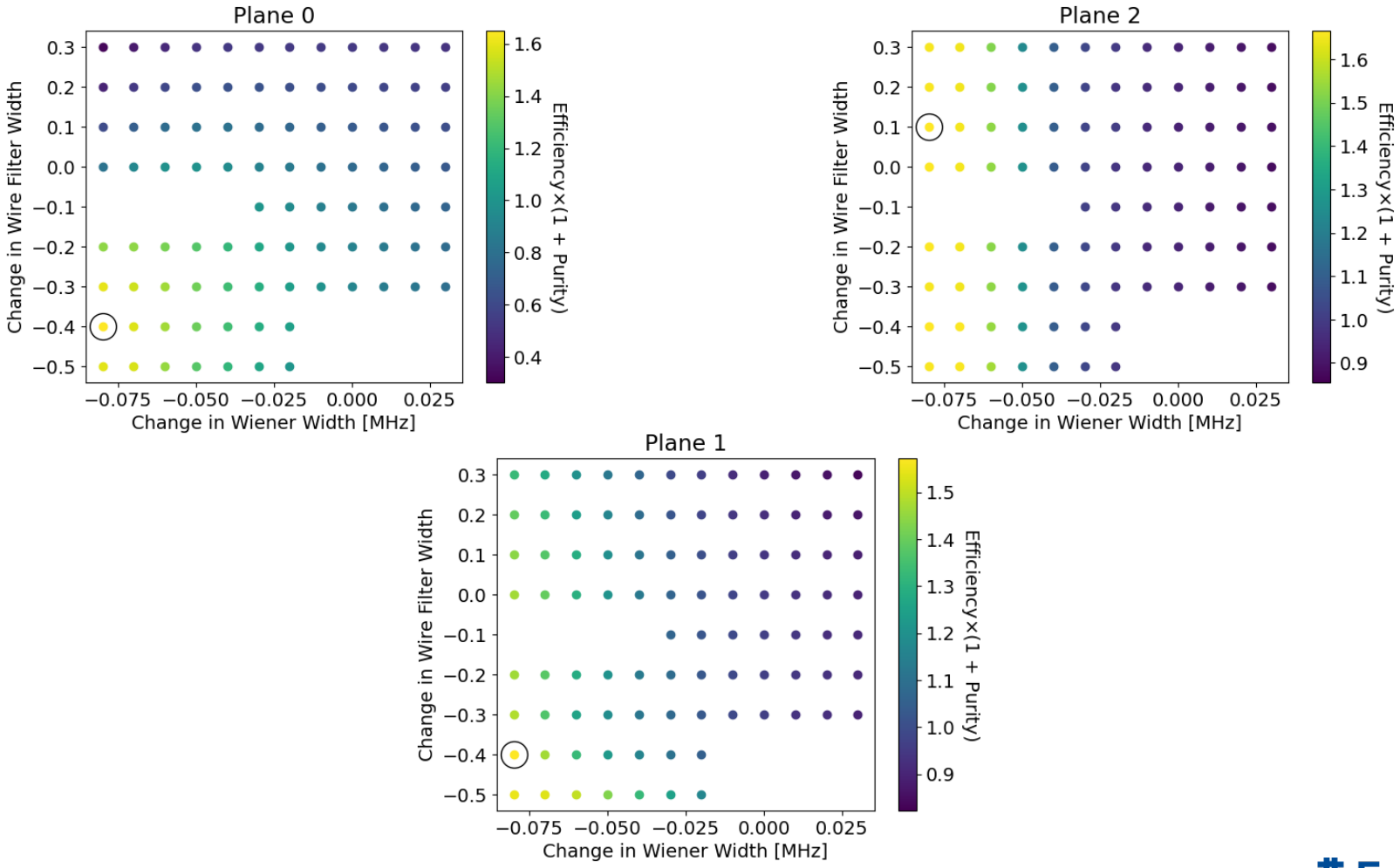

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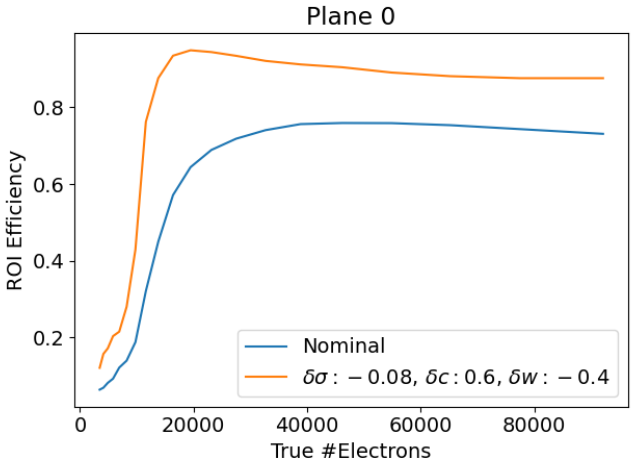
Filter Optimization Takeaway

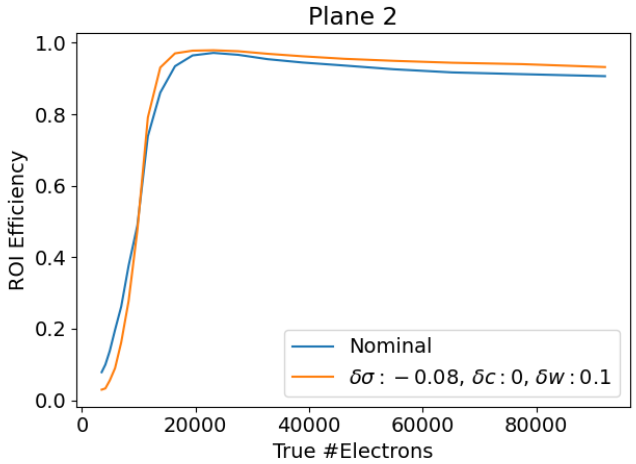
- ICARUS seems to want very broad filters in the time domain (both in wire and time directions)
  - Preferred filter frequency width is at least ½ on all three planes
  - Preferred wire frequency width is about ½ on induction planes

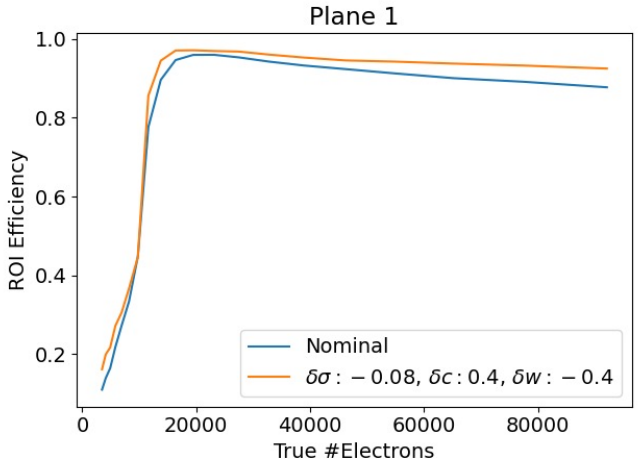
- This preference is consistent even after de-weighting purity (eff*pur v. eff*(1+pur))

Efficiency Comparison

- Nominal v Optimized Filter

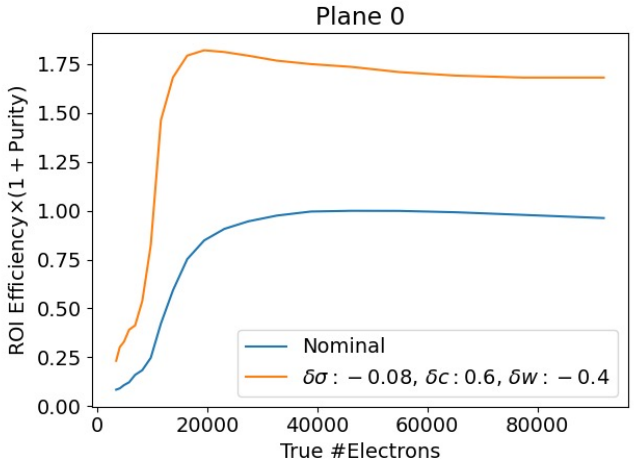


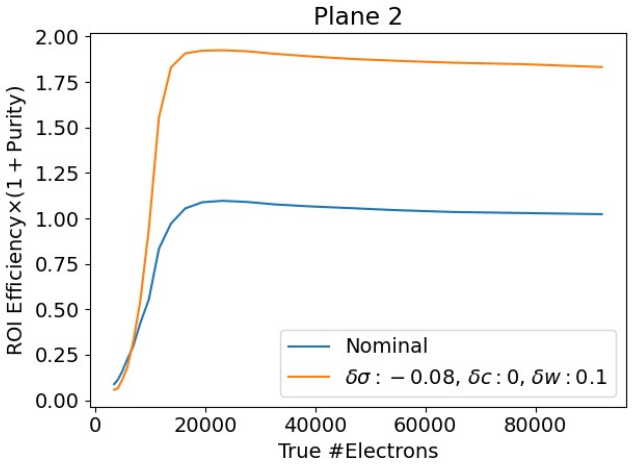


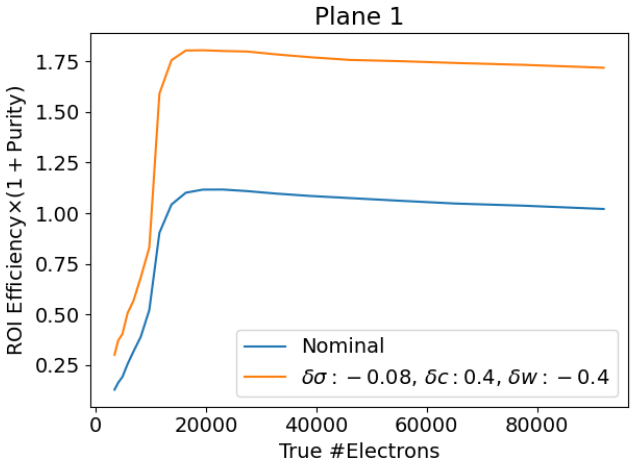


Efficiency-Purity Comparison

- Nominal v Optimized Filter



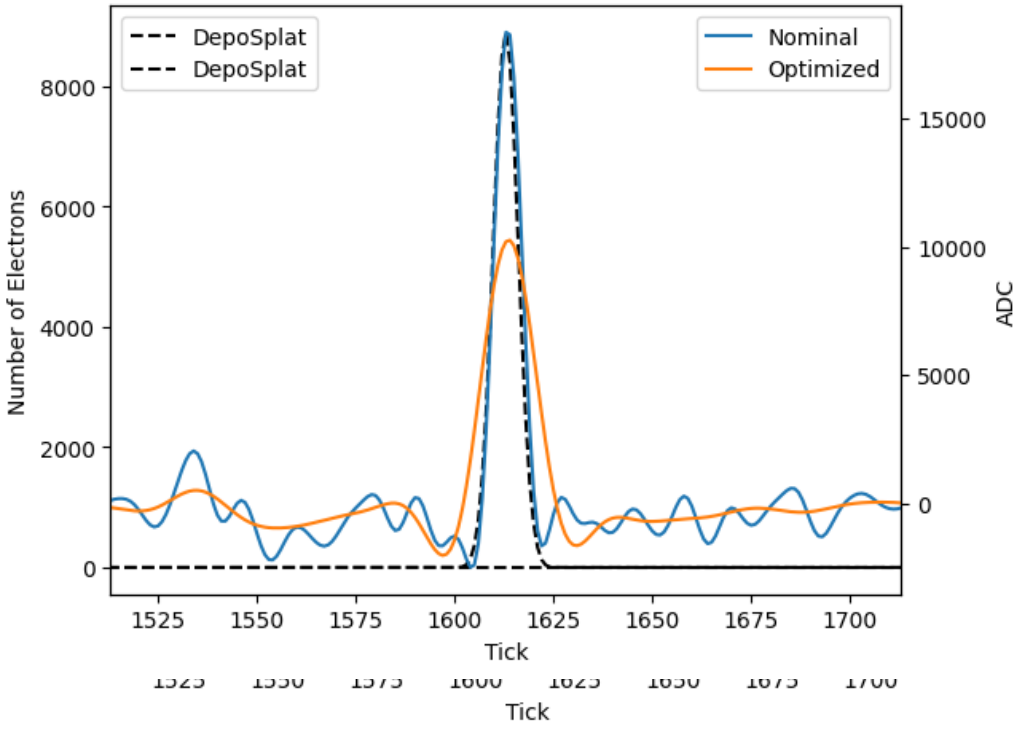




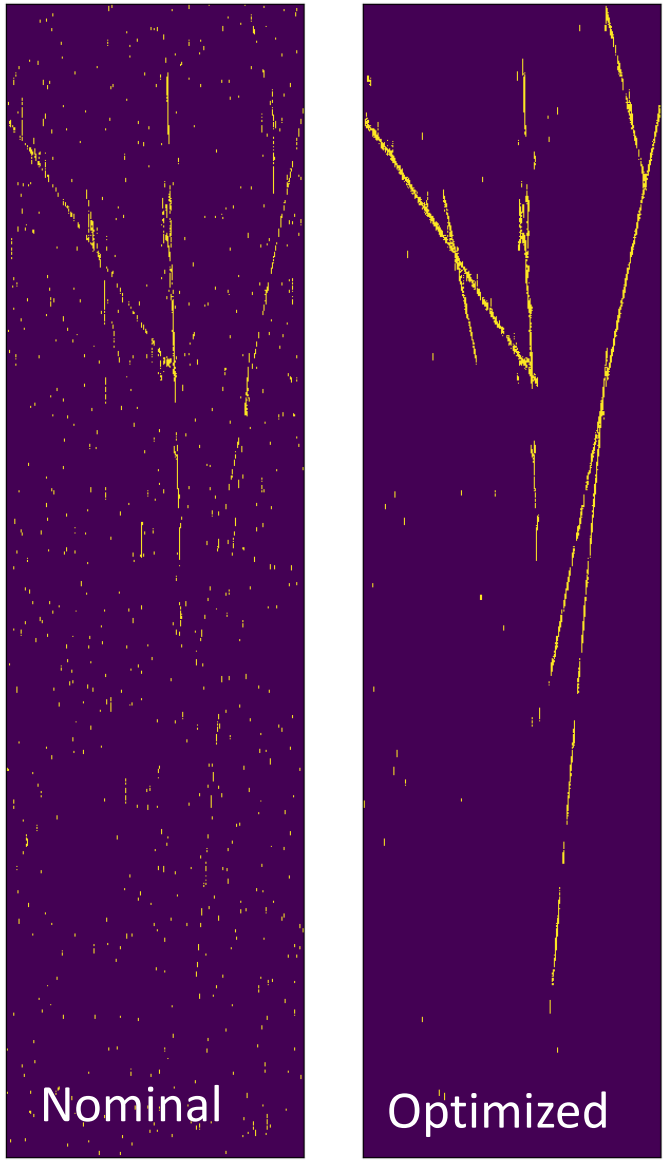
Qualitative Comparison

- Looks much better!

Example Front Induction Waveform



Front Induction



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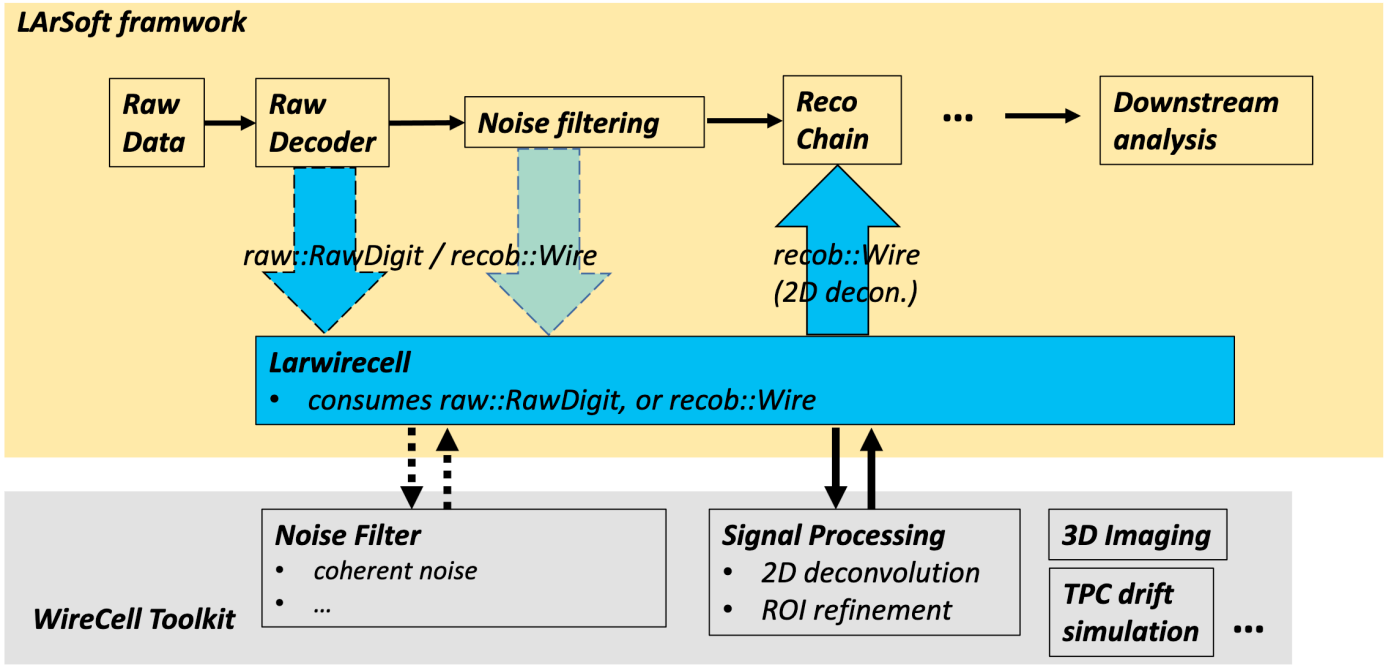
Conclusion

- I'm partway through optimizing the ICARUS filter values
- Preliminary optimization shows a preference for much broader filters in both time and wire space
  - Does this make sense?
  - Would having such broad filters break anything downstream in WireCell / signal processing?

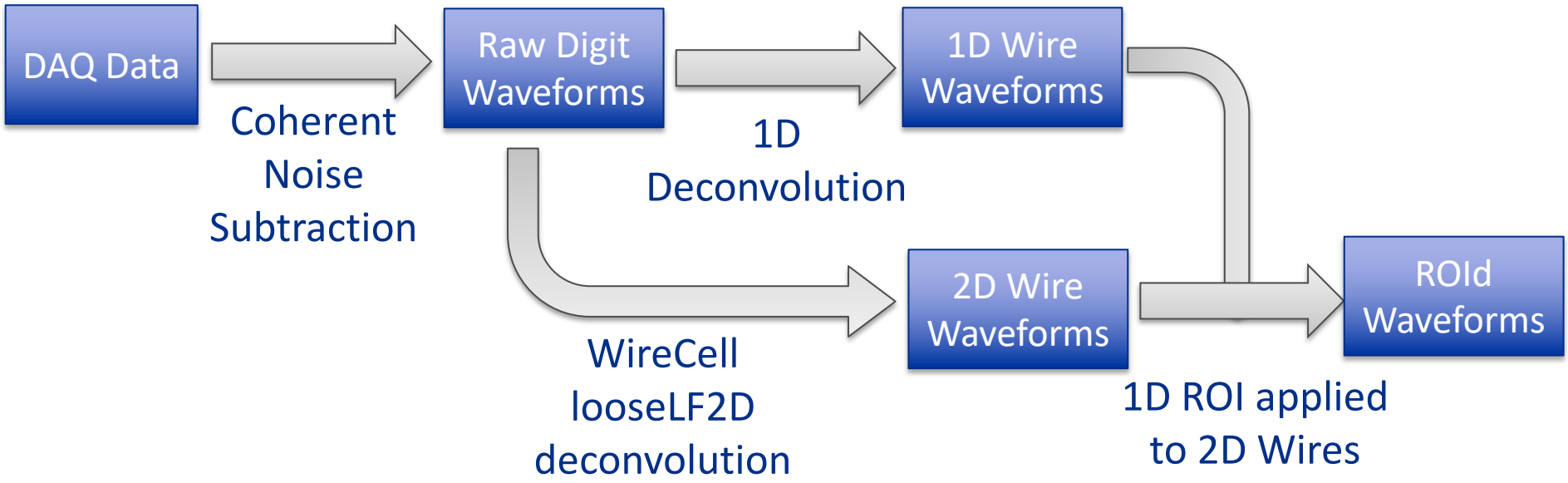
Existing WireCell Implementation in ICARUS

- Wenqiang previously got WireCell signal processing integrated into ICARUS (SBN DocDB 20915)
- Not totally clear to me where this was left off – seems like more work on filter tuning was needed



Alternative WireCell Implementation in ICARUS

- Sergey and Tracy also put together a partial integration of WireCell into ICARUS simulation (1D ROI + 2D charge extraction)



- Drawbacks: no 2D deconvolution for ROI finding, looseLF filter (Wiener-style filter w/ low-frequency cutoff) is not suitable for charge extraction

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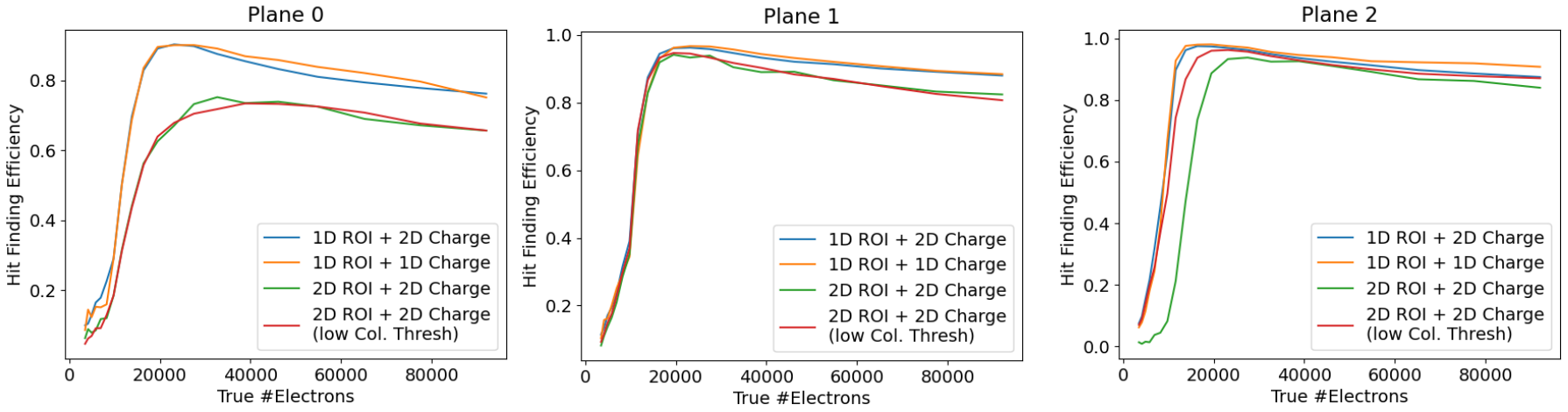

Hit Finding Efficiency

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