Field-Response Augmentation for the LArTPC Foundation Model

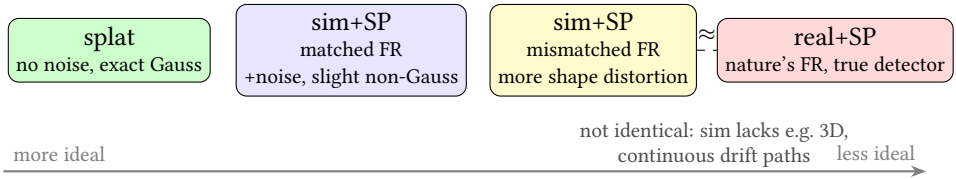
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Idea: augment the FM with field-response (FR) variation

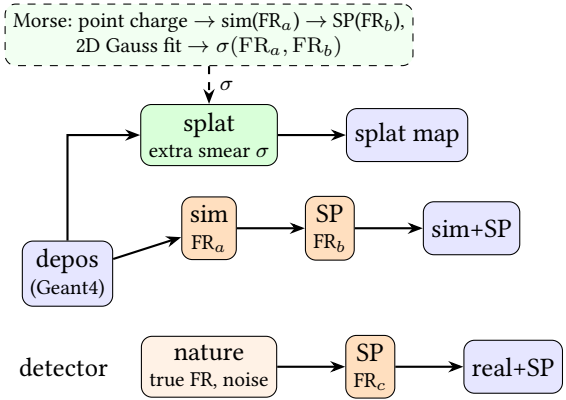
- Vary the FR used in **sim** and in **sigproc** (SP on sim or on real data).
- Sim+SP may additionally be augmented with **depo flux splat**.
  - Splat itself can be varied by the "extra smearing" applied per splat.
- Complements existing image augmentations (rotation, patches)
- Made practical by the new **firep** analytic FR solutions
  - Copious FR variants: 2D vs 3D models, voltages, element sizes, …

An “idealism ordering”



The leap of faith: varying sim FR-mismatch and real FR-mismatch builds an effective **sim/real domain overlap** in the FM training distribution.

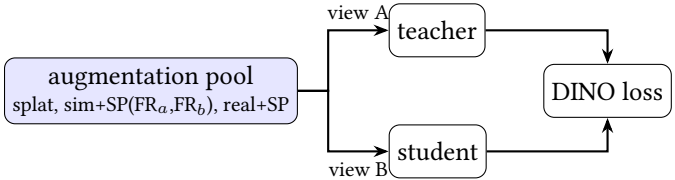
FR-mismatch: where the FR enters



FR$_a$=FR$_b$: cancels, "too ideal"
FR$_a$ $\neq$FR$_b$: mimics real
mismatch likely $\Rightarrow$ larger σ (unstudied)

- Same depos, a **family** of (FR$_a$, FR$_b$) pairs $\rightarrow$ sim+SP samples spanning the mismatch.
- Real data: nature's FR convolves, our model FR$_c$ deconvolves $\rightarrow$ inherent mismatch.

Training: pairing policy and validation



- **Default:** random assignment of augmentations to teacher and student.
- **Special FMs** (needs digging):
  - teacher sees only splat; student sees varied FR-mixes of sim+SP.
  - **Bracket nature's FR:** fit FR parameters to real data (differentiable splat + new FRs, possibly via an FM); sample within $N\sigma$ of the best fit.

Summary

- We can add FR variation as another form of augmentation in FM training.
- FR variations give a chance for the ensemble of simulation domains to overlap with the data domain.
- Hints at possible specialized FRs, eg biasing them toward more idealistic feature representations.