Fiducial volume for trigger.

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Basic Idea

Radiological backgrounds limit trigger sensitivity due to high rates.

Could exploit difference in spatial signal & background distributions to improve signal visibility.

- Likelihood of observing neutrino signal is uniform across the detector.

  → Expect signal event rates to scale linearly with detector volume.

- Background rates accumulate in certain detector regions.

Is there pay-off in using only signal from a fiducial volume (FV) region to inform Trigger Decisions?

- In this context, signal could mean either TPs or TAs.

Current Background Model

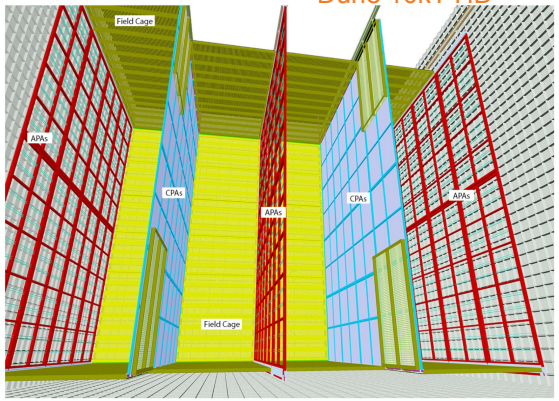
Existing detector setup doesn't tell the whole story about external backgrounds:

- **1x2x6 Workspace**:
  - Configuration: **CPA | APA | CPA**
  - Represents detector environment for internal APA.
- **Full 10 kT Detector**:
  - Configuration: **APA | CPA | APA | CPA | APA**
  - Additional external APAs on either side of the CPAs.

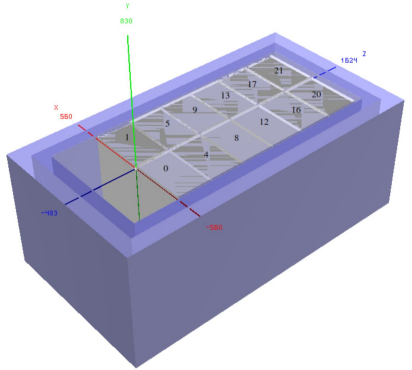
Background Models:

1. **Central APA**:
   - Simulates internal drift environment.
2. **Lateral (external) APA**:
   - Simulates outer drift volume influenced by external backgrounds.
   - Only x>0 side of the 1x2x6 geometry (APA | CPA).

Dune 10kT HD



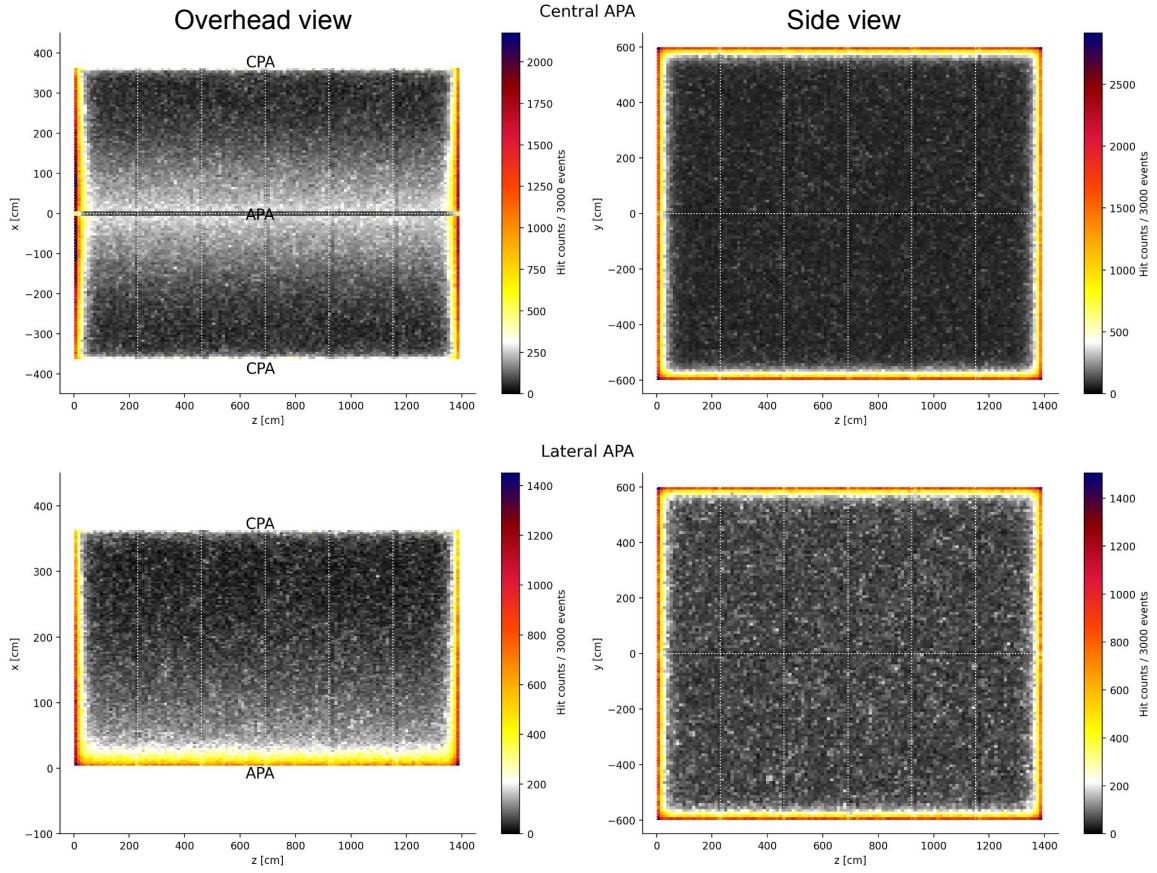
Dune 10kT HD 1x2x6



Radiological hit distributions

Background rates are highest near:

- Detector edges
- APA planes



Radiological hit distributions

Background rates are highest near:

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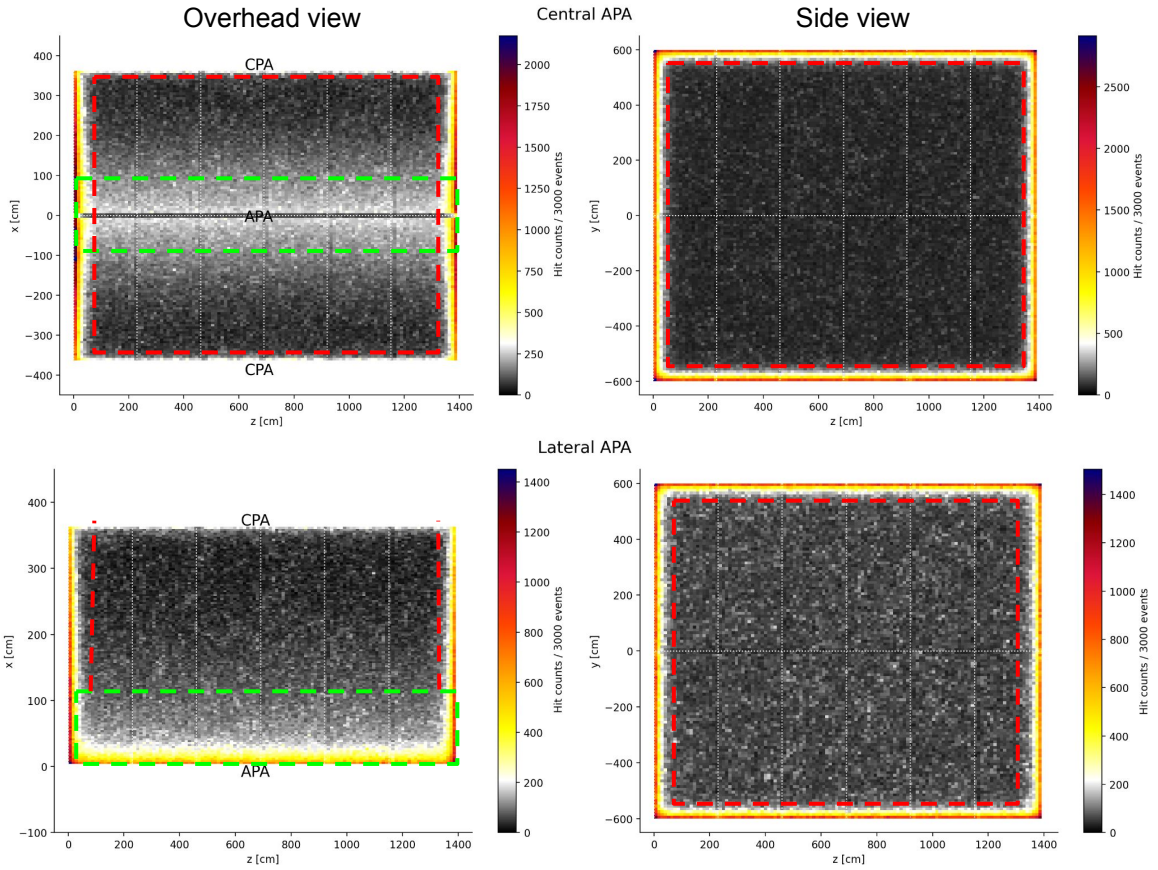
Two types of fiducial cuts to improve S/B:

- **Edge Cut**: Removes regions near detector edges.
- **APA Cut**: Excludes regions close to APA planes.



Singal (S) & Background (B) definitions

Signal (S):

- Assume **generic, spatially uniform** signal.
- Scales linearly with the **fiducial detector volume**: $\mathrm{S_{fv}} = \mathrm{S_{tot}} \cdot \frac{\mathrm{V_{fv}}}{\mathrm{V_{tot}}}$

Background (B):

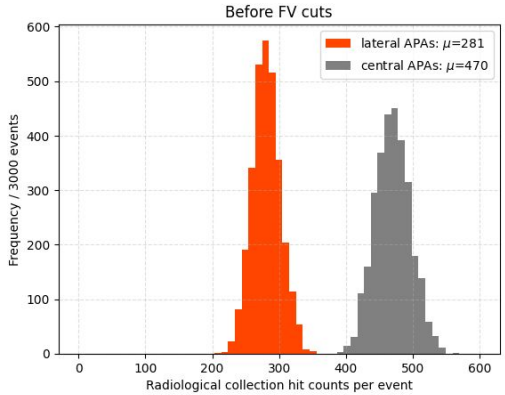
- Here defined as the **average number of hits/event** within the detector volume before and after fiducial cuts.
- Calculated for both **central** and **lateral** APA background models.

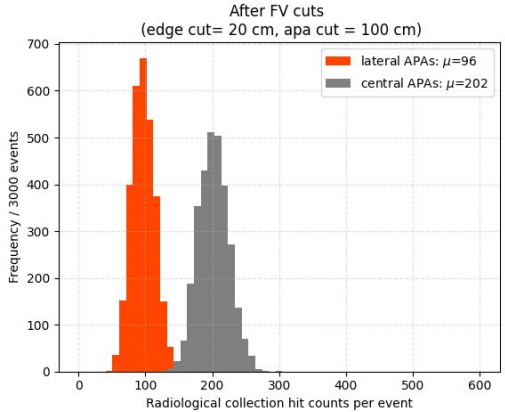
Signal-to-Background (S/B):

- Only interested in relative improvement between $(S/B)_{tot}$ and $(S/B)_{fv}$ thus:

$$S = \frac{S_{fv}}{S_{tot}} \qquad B = \frac{B_{fv}}{B_{tot}}$$

Both S & B represent surviving signal and background fractions after the FV filtering, and fall in the range [0,1].





Parameter scan | lateral APA

Performed a parameter scan of different FV cut values noting how S and B change.

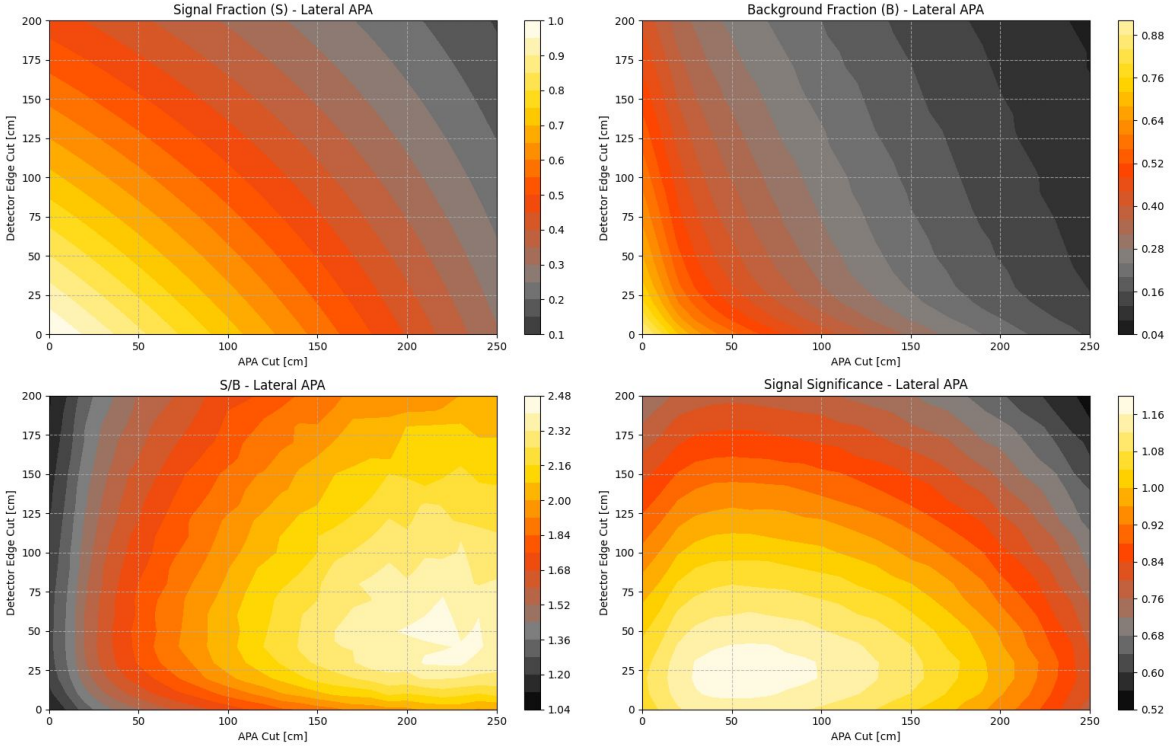
- As expected, observe more rapid decrease in bgd events with increasing cut values.

Compared two performance metrics:

- S/B ratio
- signal significance (S/√B)

Choosing cuts will be a trade off between S/B & signal significance:

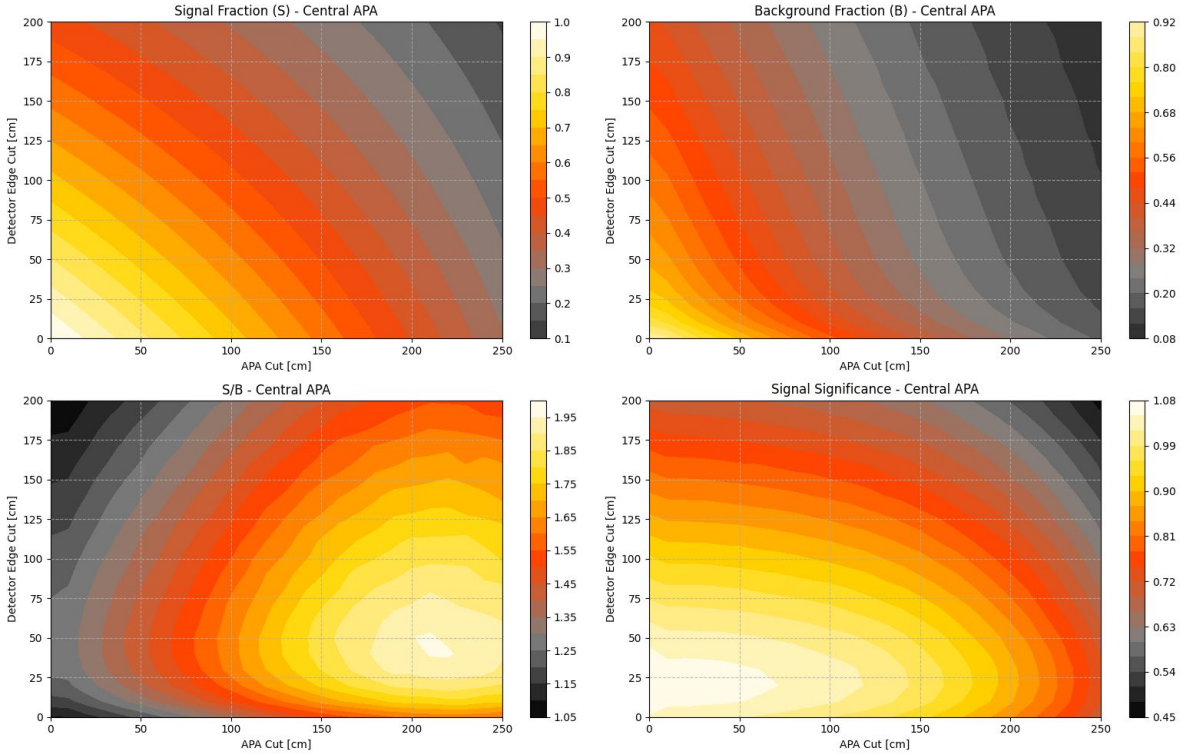
- Smaller volume (tighter cuts) improve S/B but degrade signal significance due to low signal acceptance.



Parameter scan | central APA

Similar trends to lateral APA, with one main exception:

Fall in bgd rates with APA cuts less steep since dealing with internal (i.e. “quieter”) APA.

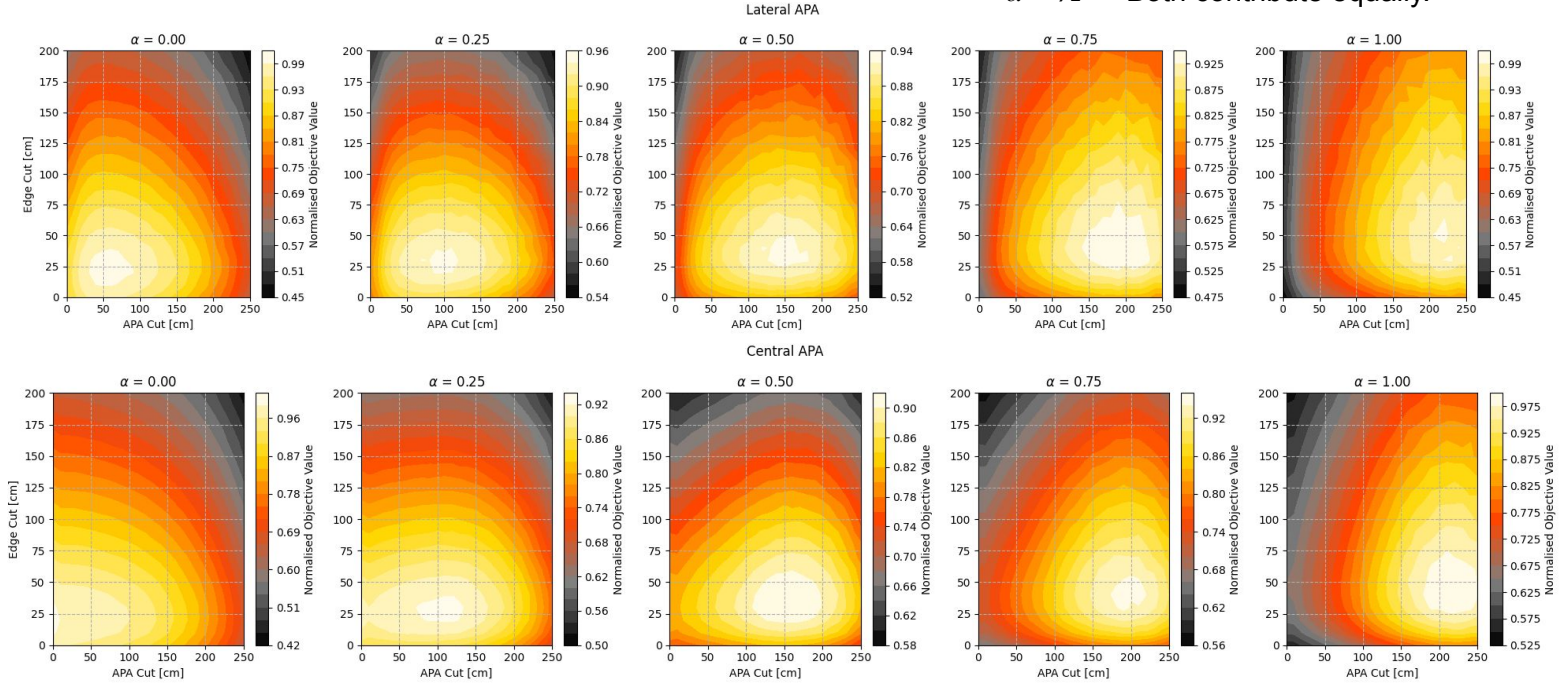


Optimising cuts

Optimum cut values can be extracted by maximising the objective function :

$$\alpha \cdot \frac{S}{B} + (1-\alpha) \cdot \frac{S}{\sqrt{B}}$$

α = 1 → S/B maximised
α = 0 → signal significance maximised.
α = ½ → Both contribute equally.



Results

Loose FV cuts maximising signal significance :

	APA cut [cm] (α = 0)	Edge cut [cm] (α =0)	S/B improvement factor	Approx. S/√B improvement
Lateral APA	50	25	1.20	~16%
Central APA	0	25	1.25	~8%

Tight FV cuts maximising S/B:

	APA cut [cm] (α = 1)	Edge cut [cm] (α = 1)	S/B improvement factor	Approx. S/√B improvement
Lateral APA	215	50	2.48	-5%
Central APA	225	30	1.95	-15%

Best of both worlds:

	APA cut [cm] (α = ½)	Edge cut [cm] (α = ½)	S/B improvement factor	Approx. S/√B improvement
Lateral APA	150	30	2.22	+8%
Central APA	130	30	1.85	+3%

Conclusions

Very basic proof-of-concept study, but it looks like..

With the right cut values, it's possible to simultaneously improve S/B & S/√B.

➢ Expect marginal improvement in signal significance, but at least we don't degrade it!

Final results depend on what we'd like to prioritise (signal acceptance, S/B, S/√B.. ??).

➢ How do all of these translate to the trigger performance & physics sensitivity?

This FV signal "filtering" could be done either at TP or TA level.

➢ Do we have the means to select data in this way online?