

A Study of MIP Signals in BGO



**UNIVERSITÉ
DE GENÈVE**

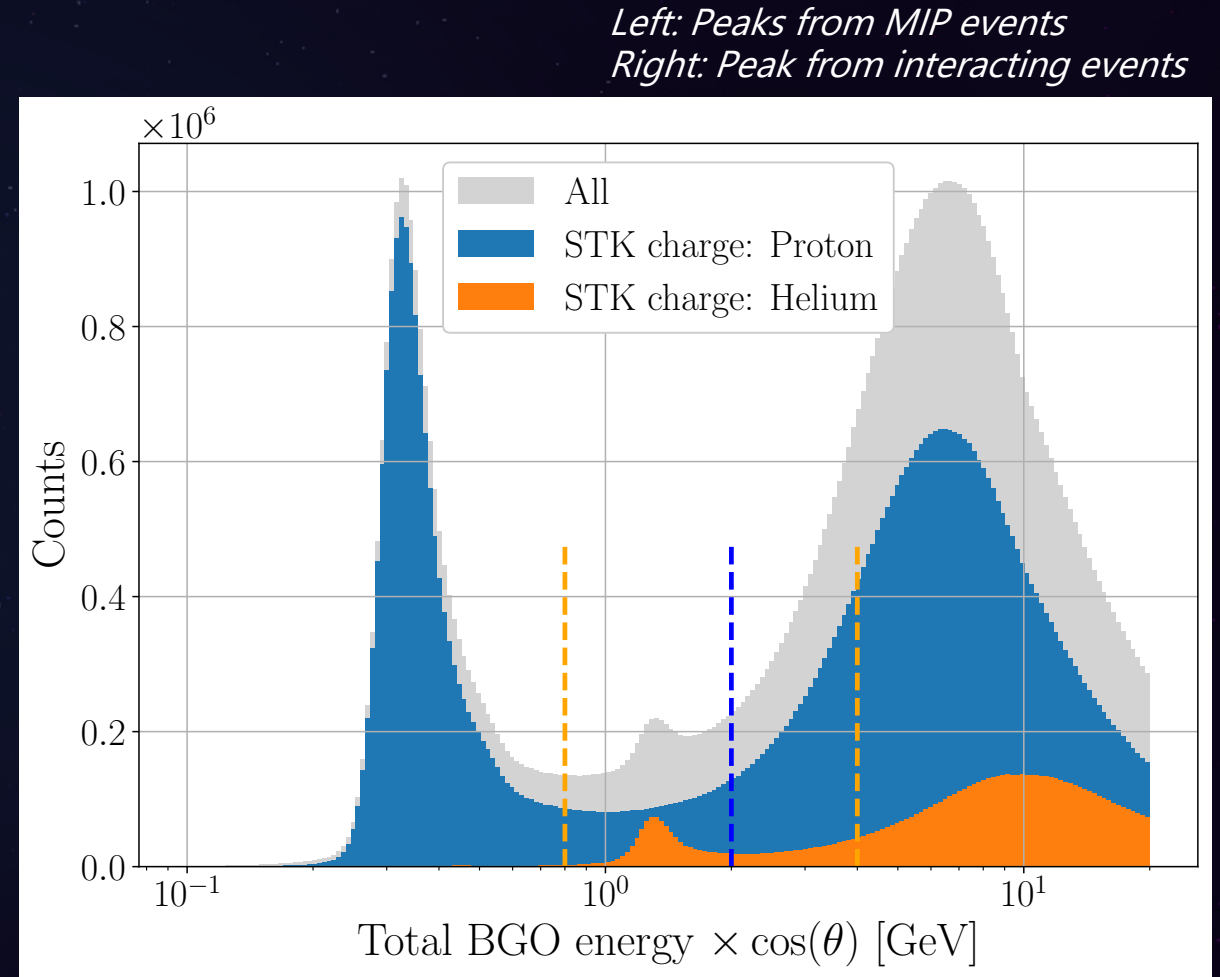
Paul Coppin

Motivation

- The response of DAMPE's BGO bars is calibrated to the signal of proton MIP-events
- With an ideal calibration, the MIP peaks of other ions should be internally consistent
→ We fit the MIP peak of:
 - Proton
 - Helium
 - Carbon
 - Oxygen

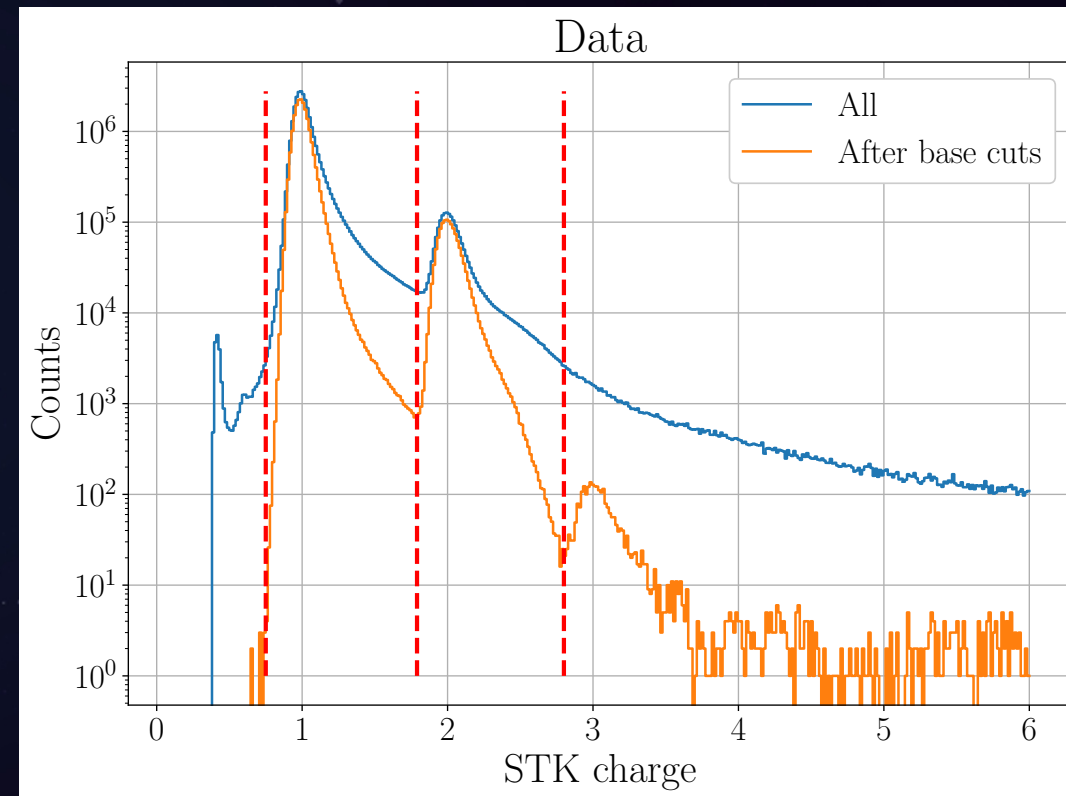
Selection

- Two years: 2020 & 2022
- Removal of:
 - SAA events
 - Bad days:
 - 2020-03-07, 2020-03-08
 - 2022-02-14, 2022-02-15
 - 2022-12-12, 2022-12-13
- Unbiased or MIP trigger
- ML track is contained and points to ≥ 1 PSD hit



Selection (2nd step)

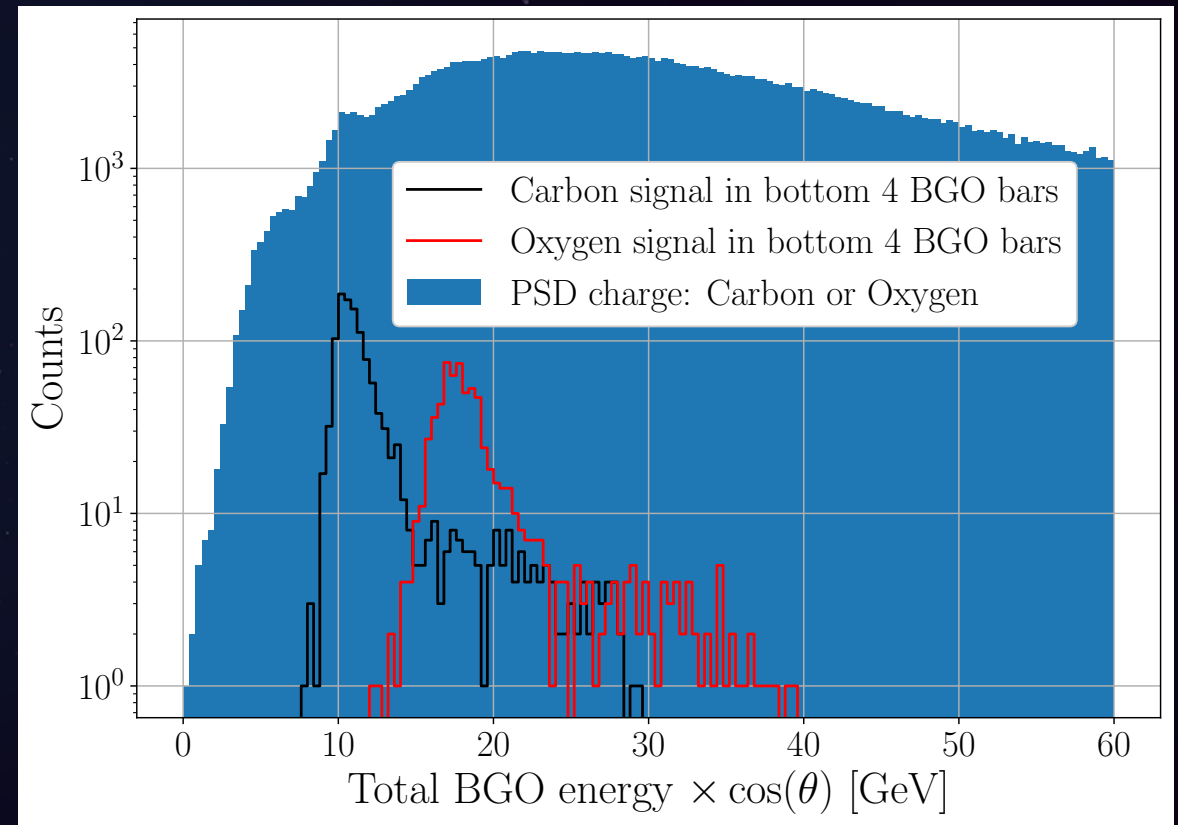
- Base cuts:
 - At least 7 BGO bars with a track length ≥ 25 mm
 - No HE trigger
 - Total BGO energy $\times \cos(\theta)$:
 - Proton: $E < 2$ GeV
 - Helium: $0.8 \text{ GeV} < E < 4 \text{ GeV}$
 - STK has >6 layers with charge within 0.3 of median
- Cut on median STK charge:
 - Proton: $[0.75, 1.79]$
 - Helium: $[1.79, 2.80]$



Selection (2nd step)

- Base cuts:
 - At least 7 BGO bars with a track length ≥ 25 mm
 - Median STK charge > 3
 - Total BGO energy $\times \cos(\theta)$:
 - Carbon: $E < 30$ GeV
 - Oxygen: $E < 40$ GeV
- Cut on PSD-x & -y charge:
 - Carbon: $5.6 < Q < 6.5$
 - Oxygen: $7.65 < Q < 8.7$

Carbon and Oxygen MIP peak become visible in total BGO charge if requiring that signal in last 4 BGO layers matches MIP

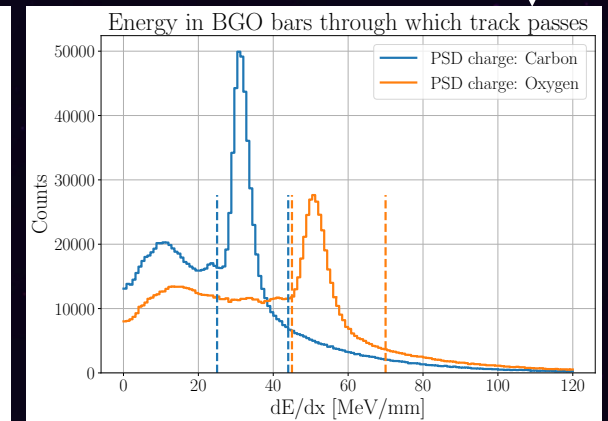
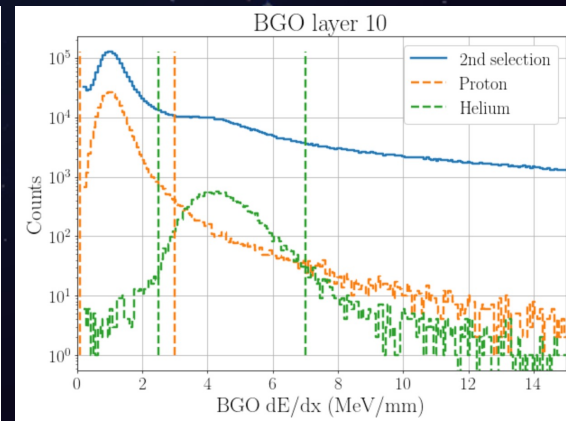
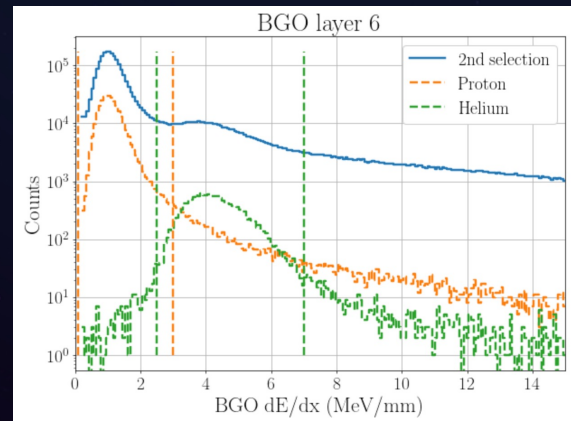
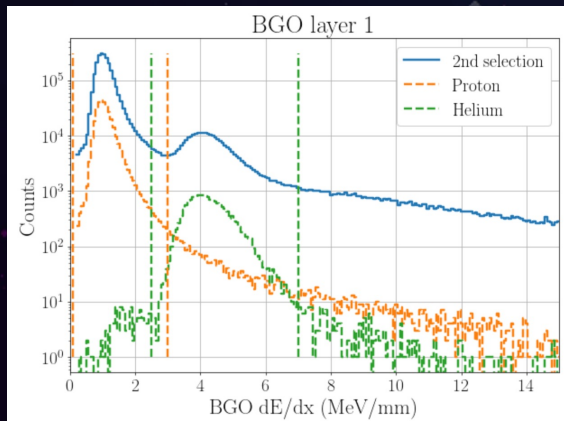


Selection (3rd step)

To make sure particle did not start to shower, cut on dE/dx in last 4 BGO-layers:

- Proton: 0.1 – 3
- Carbon: 20 – 45
- Helium: 2 – 7
- Oxygen: 45 – 70

Carbon and Oxygen MIP peak clearly visible when only considering the BGO bars through which the track passes, using data from all layers



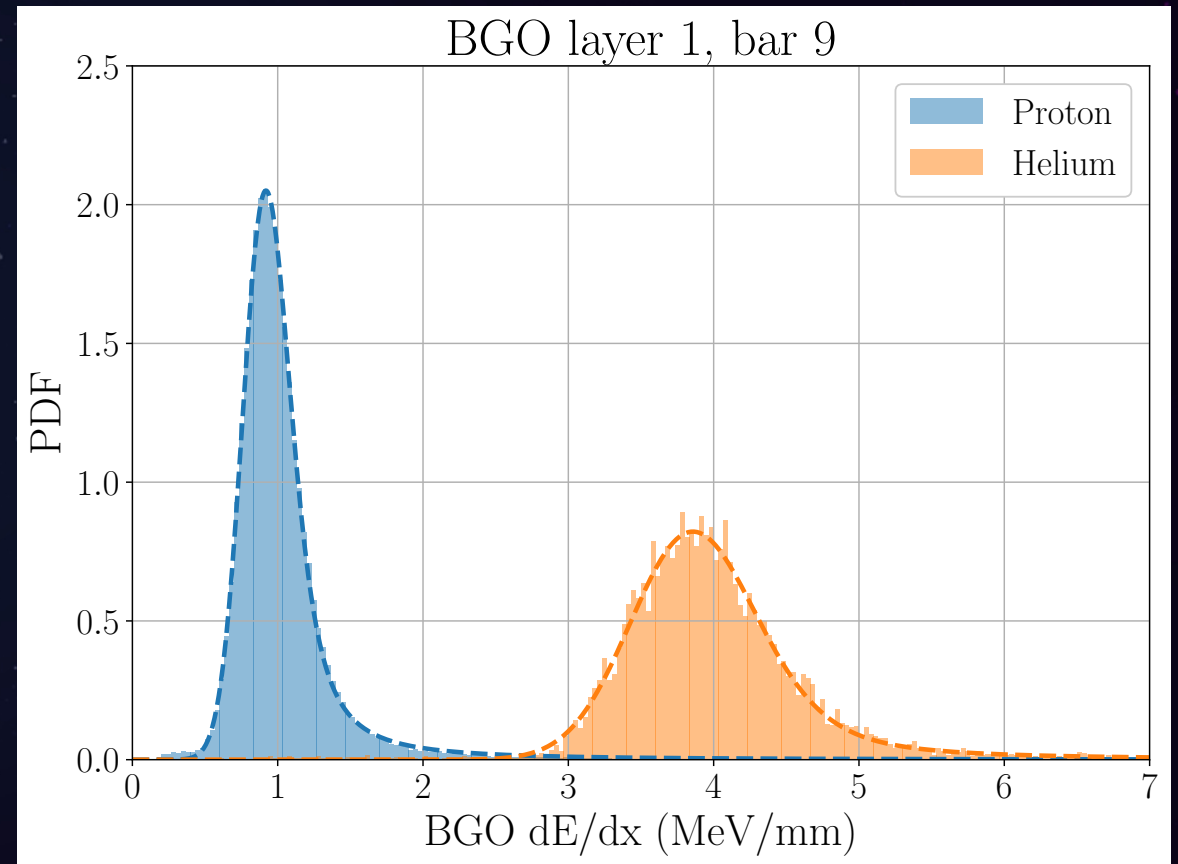
Selection

- Number of selected events:
 - Proton: 3.327.091
 - Helium: 183.769
 - Carbon: 1.249
 - Oxygen: 682

Fitting procedure

- Fit convolution of Landau + Gaussian
- Extract MPV (and widths)
- Proton and helium:
 - For each BGO bar individually
 - Edge bars not included

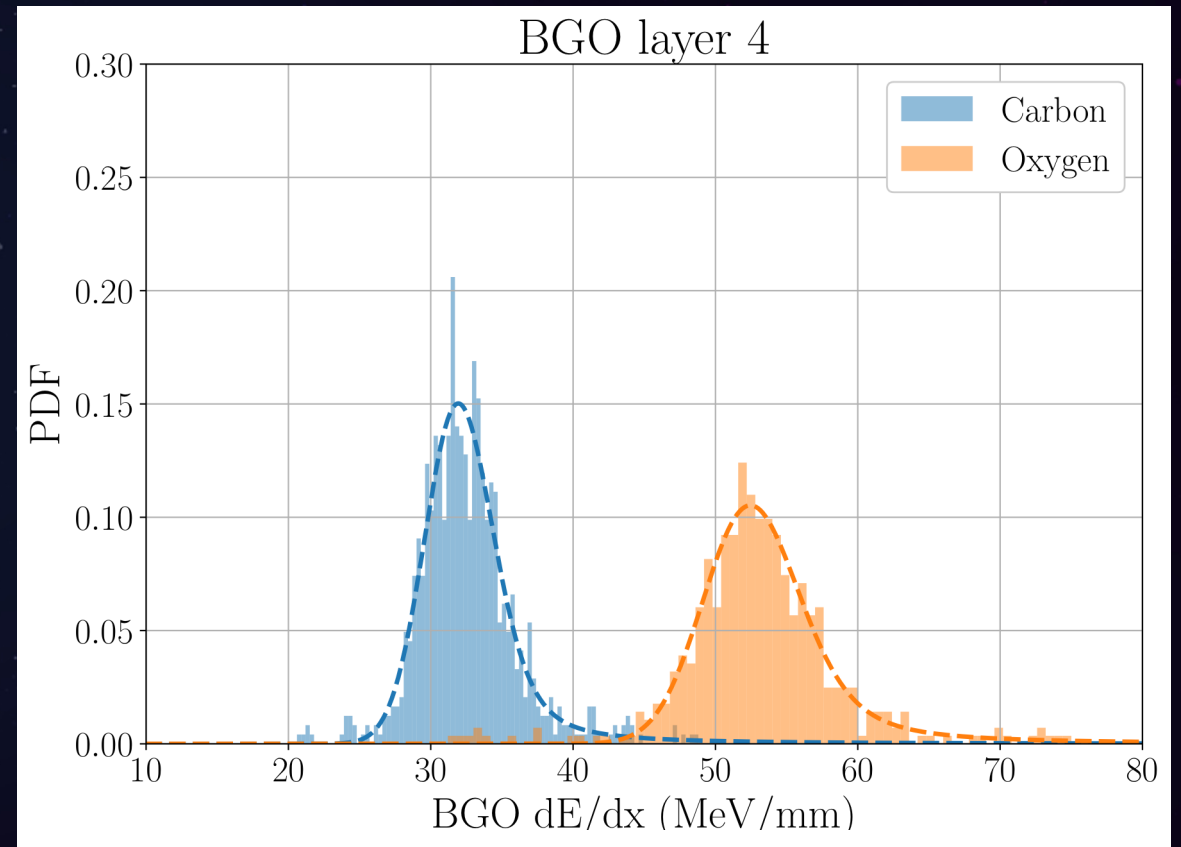
Full histogram: Data
Dashed lines: Landau fit



Fitting procedure

- Fit convolution of Landau + Gaussian
- Extract MPV (and widths)
- Proton and helium:
 - For each BGO bar individually
 - Edge bars not included
- Carbon and oxygen:
 - Done per layer due to limited statistics

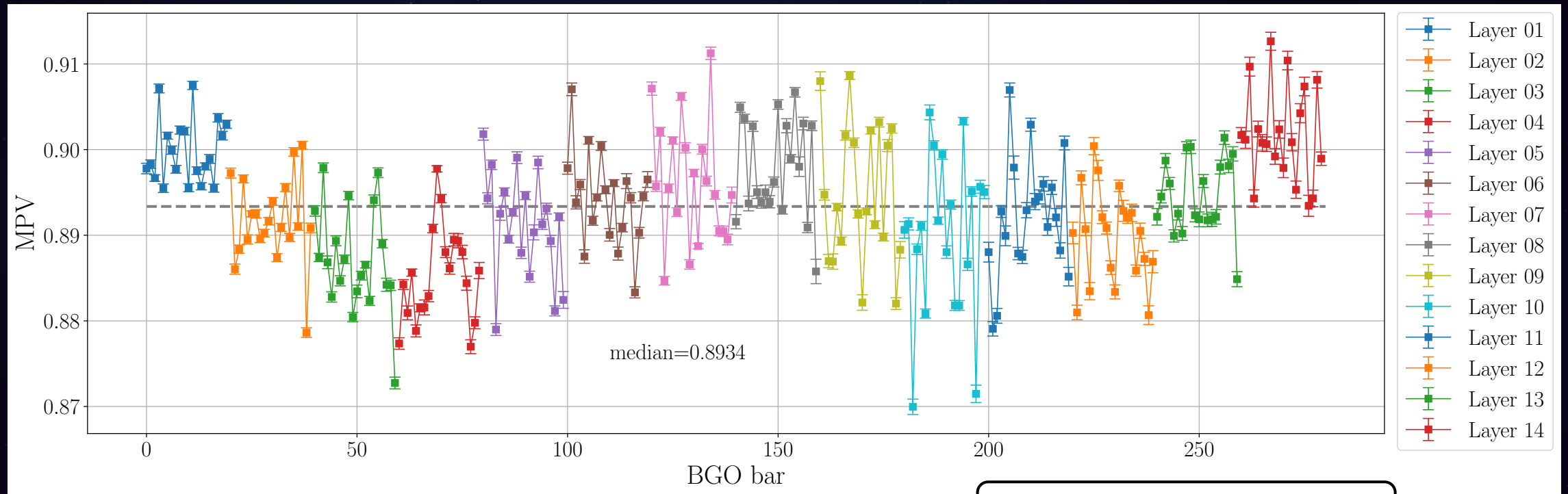
Full histogram: Data
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Fit per bar

- Consistent results for proton
- One point per bar, from 2→21 for each BGO layer

Proton

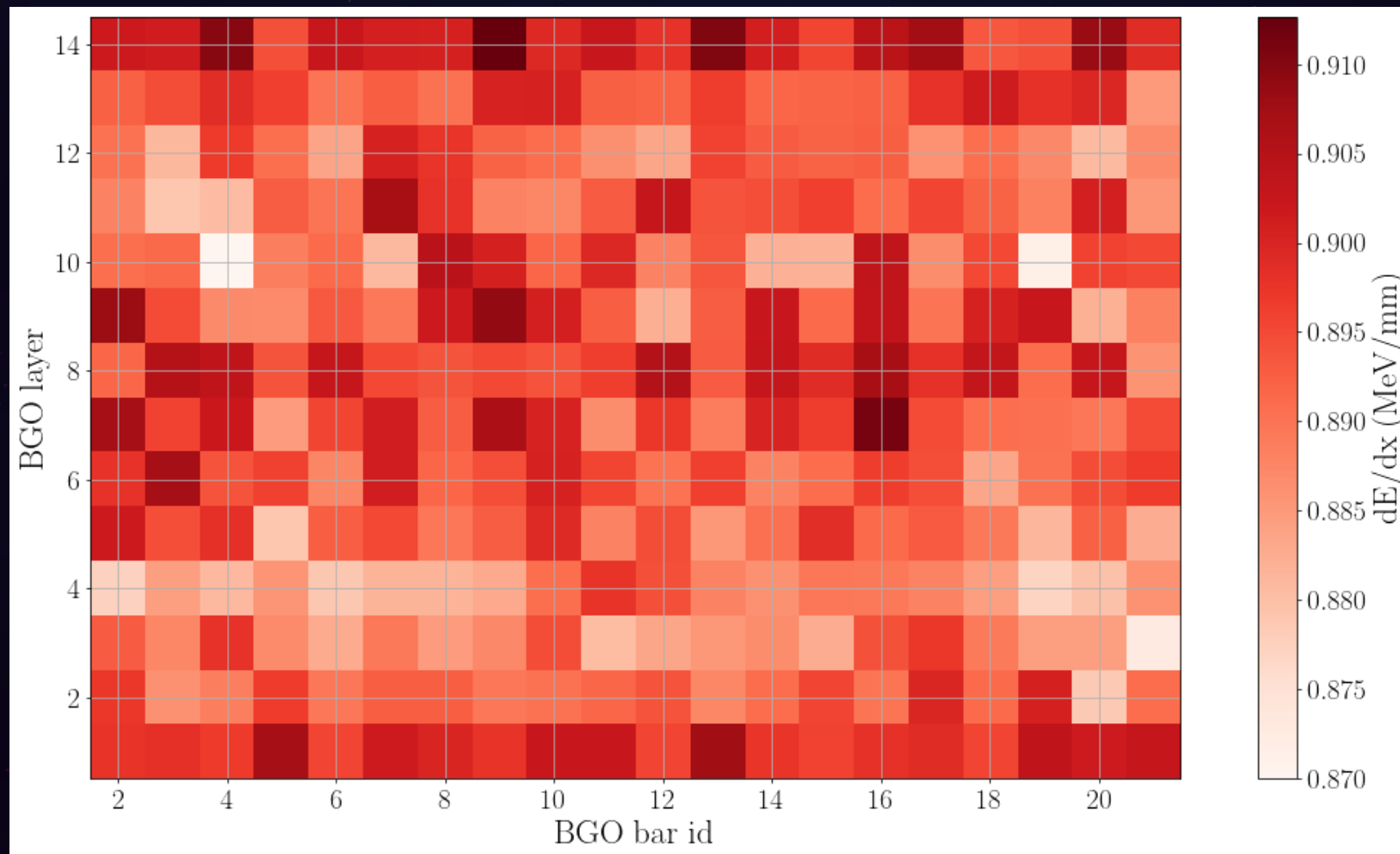


Default BGO calibration

Fit per bar

Default BGO calibration

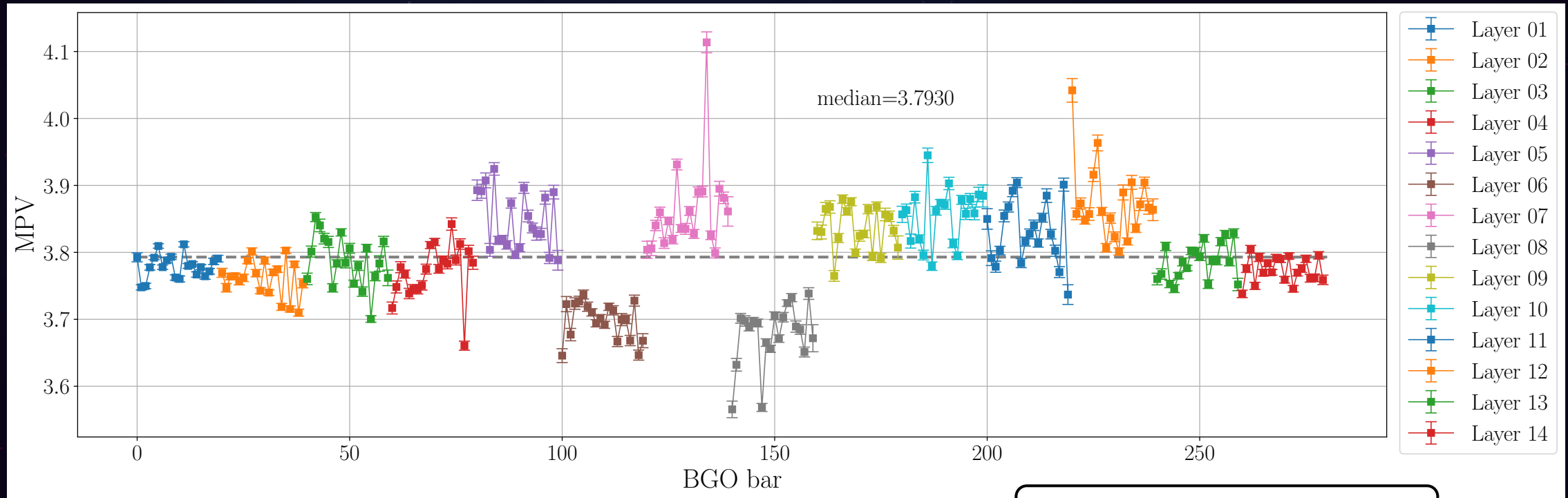
Proton



Fit per bar

- MPV of some layers shows a systematic shift
- One point per bar, from 2→21 for each BGO layer

Helium

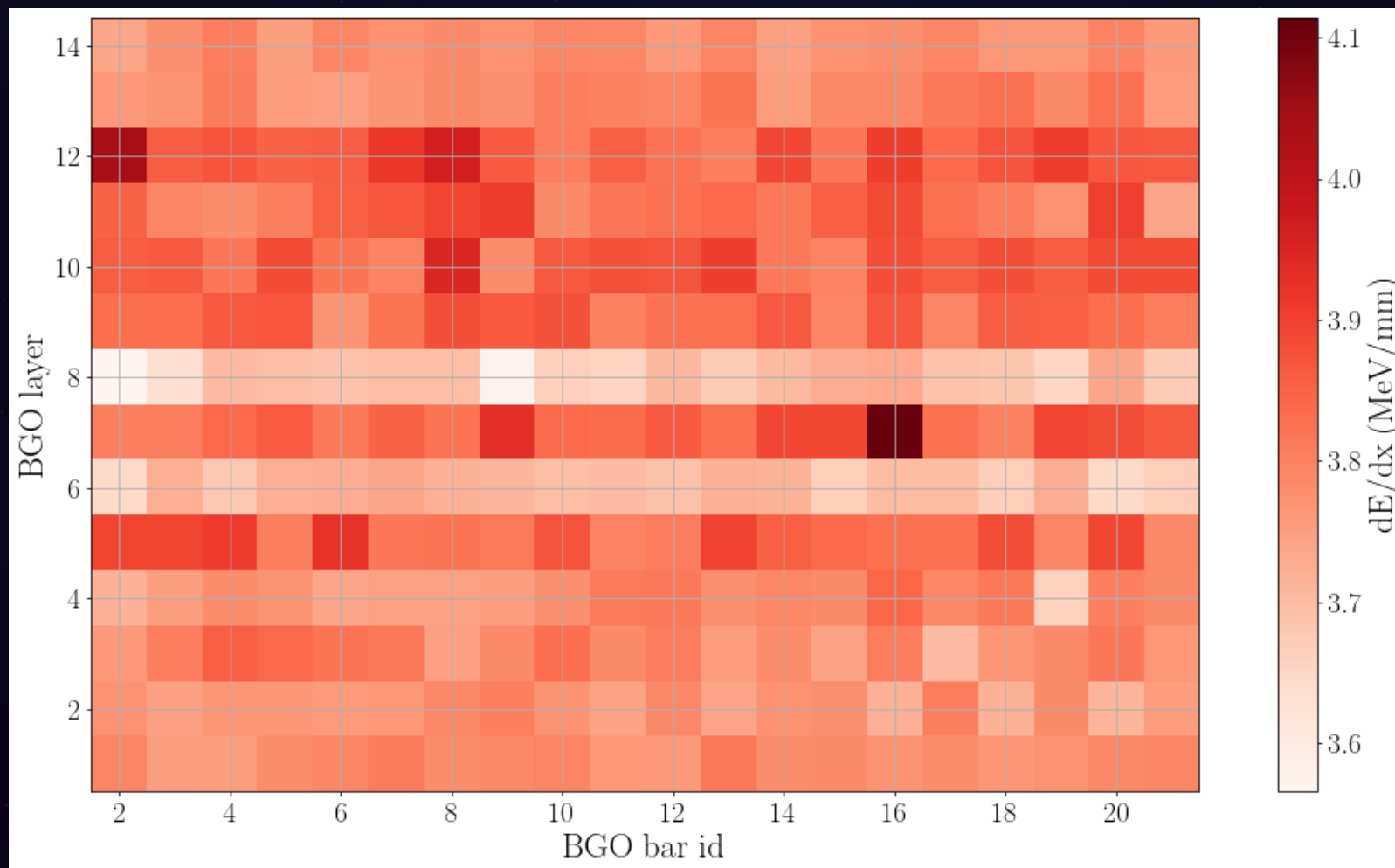


Default BGO calibration

Fit per bar

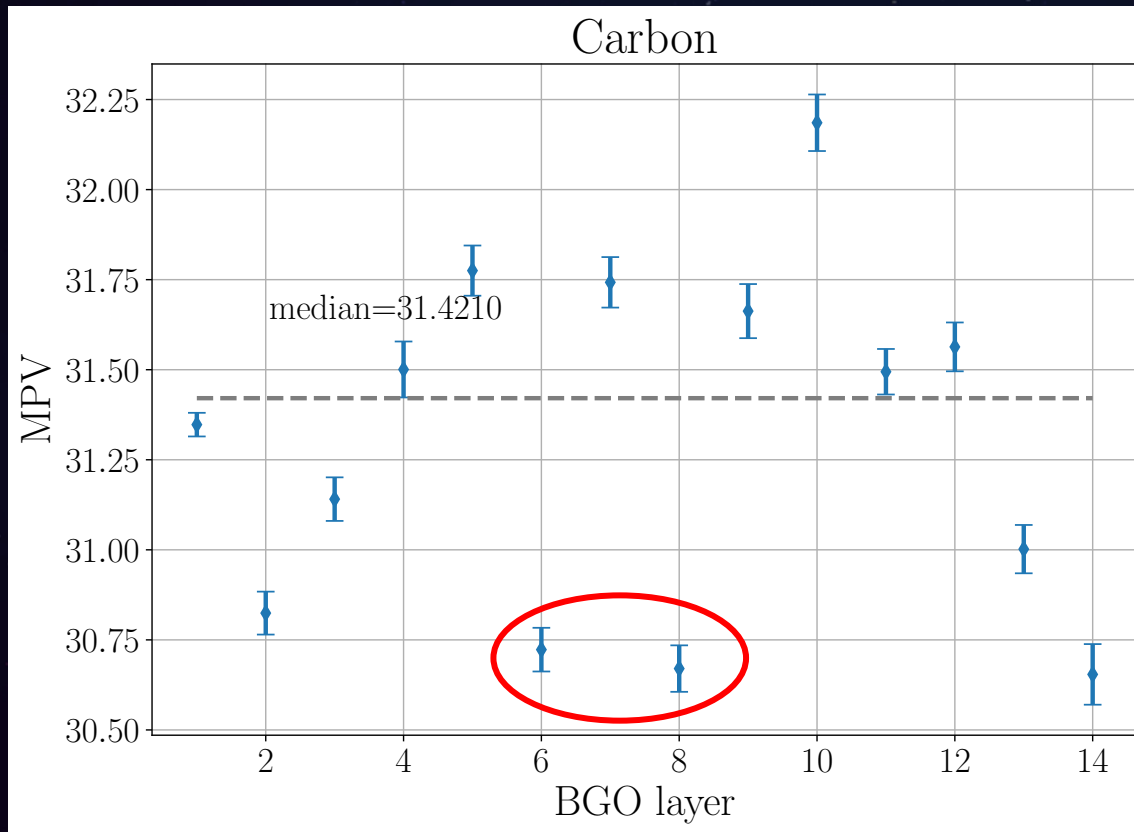
Default BGO calibration

Helium



Fit per layer - Carbon

Overview of all layers

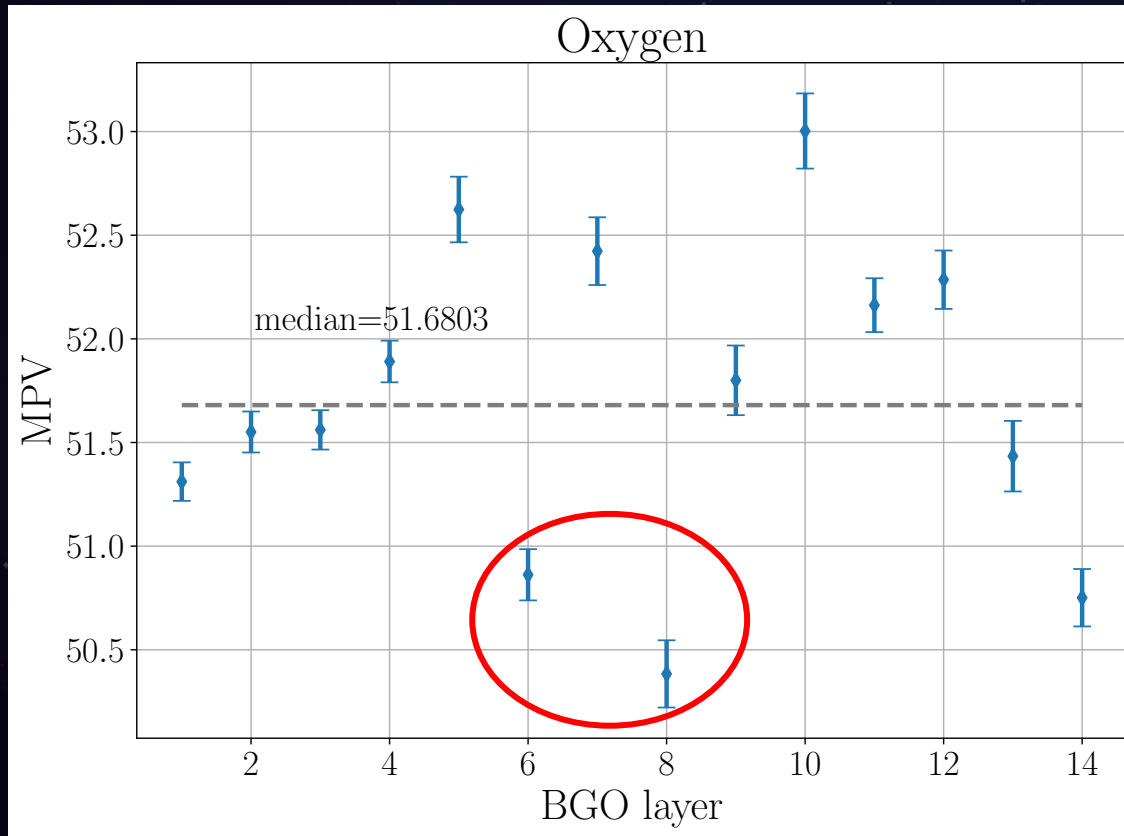


Similar case to helium
→ values of adjacent bars seems reasonably close, but as for helium, layer 6 and 8 are outliers

Default BGO calibration

Fit per layer - Oxygen

Overview of all layers



Similar case to helium
→ values of adjacent bars seems reasonably close , but as for helium, layer 6 and 8 are outliers

Default BGO calibration

Variation of MPV among layers

Value of the relative deviation is show per layer in percent:
 $100 \cdot [MPV_{layer} - median(MPV)] / median(MPV)$

	Median	1	2	3	4	5	6	7	8	9	10	11	12	13	14	max
Proton	0.8926	+0.8	-0.1	-0.5	-0.5	0.0	+0.3	+0.4	+0.7	+0.1	-0.4	-0.2	-0.6	0.0	+0.9	0.9
Helium	3.782	-0.1	-0.6	0.0	-0.2	+1.4	-2.2	+1.8	-2.7	+1.3	+1.6	+1.1	+1.8	0.0	-0.3	2.7
Carbon	31.42	-0.2	-1.9	-0.9	+0.3	+1.1	-2.2	+1.0	-2.4	+0.8	+2.4	+0.2	+0.5	-1.3	-2.4	2.4
Oxygen	51.68	-0.7	-0.3	-0.2	+0.4	+1.8	-1.5	+1.4	-2.5	+0.2	+2.6	+0.9	+1.1	-0.5	-1.8	2.6

For each layer, the 3 bars with the largest deviation are highlighted

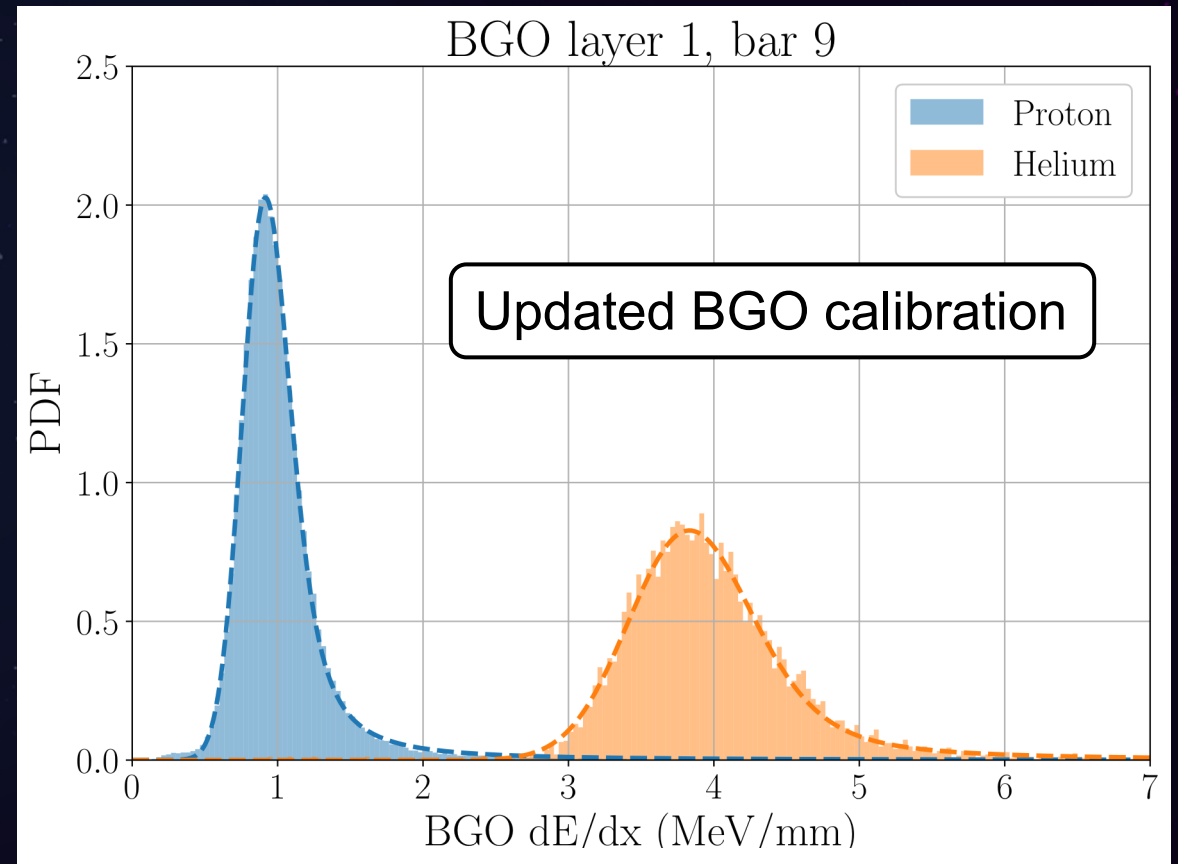
→ Layer 8 is in the top 3 for each primary ion

The MPV between layers is consistent to within <3% of all ion species

Fitting procedure

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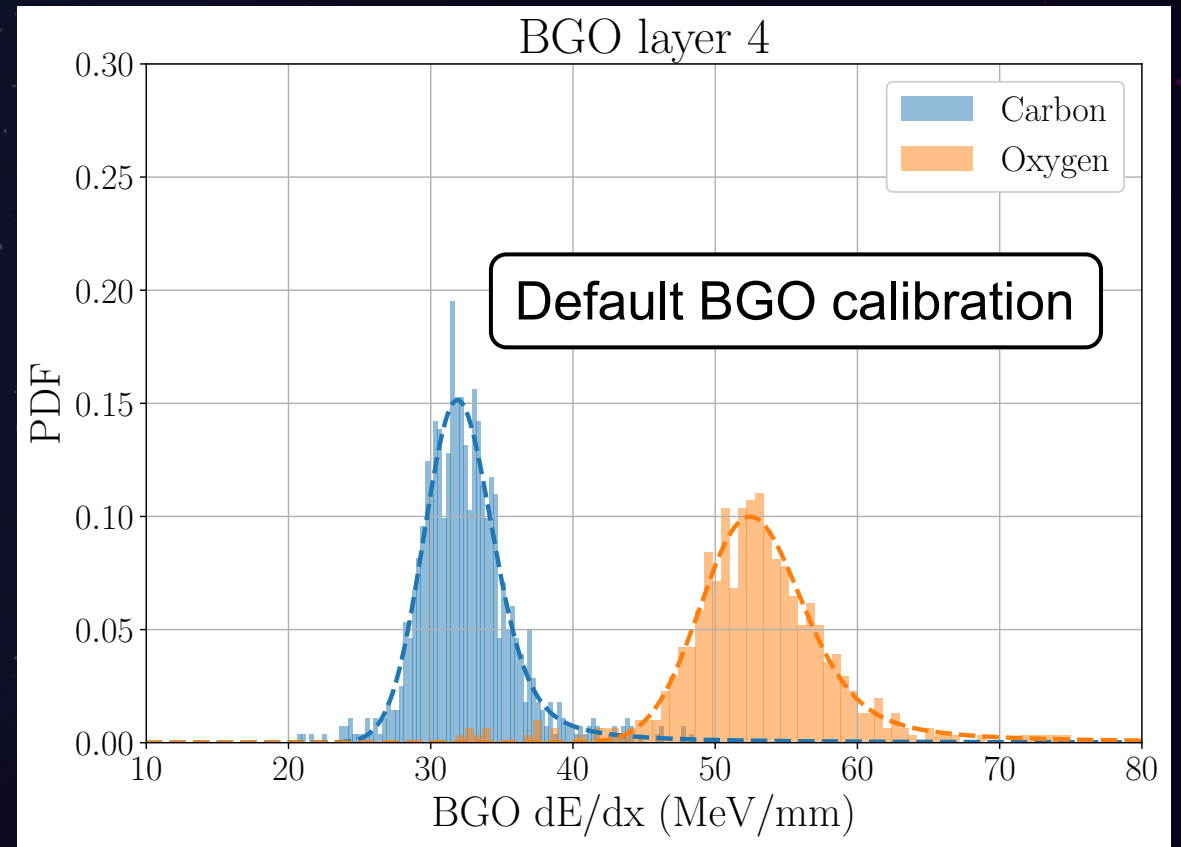
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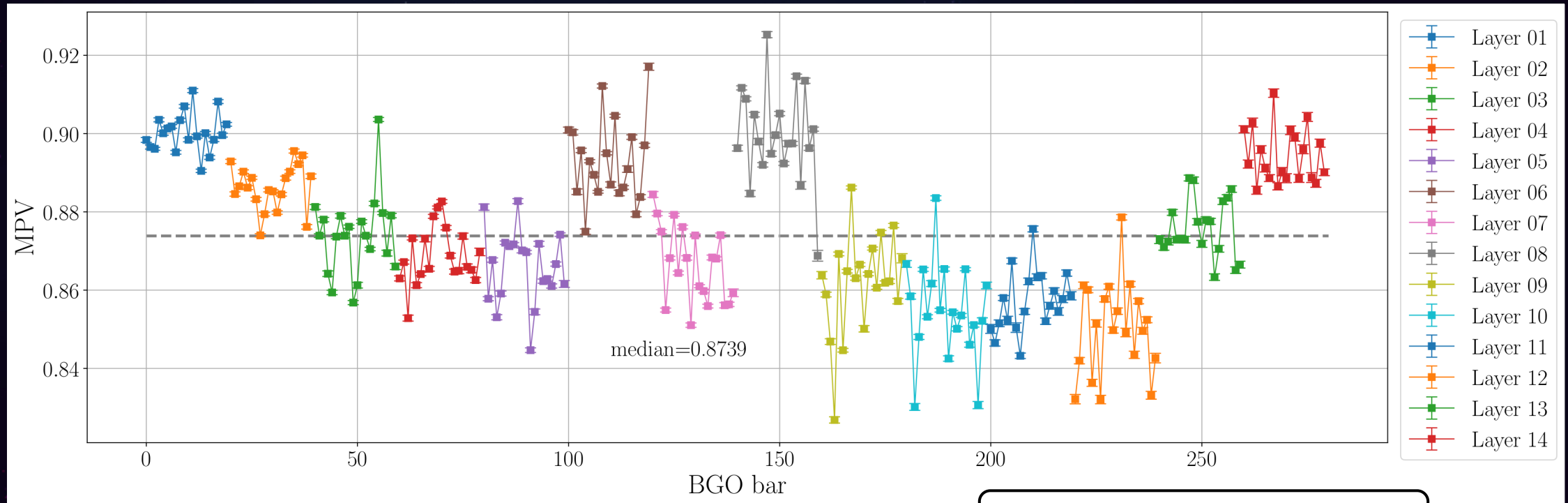
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Fit per bar

- Consistent results for proton
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Proton

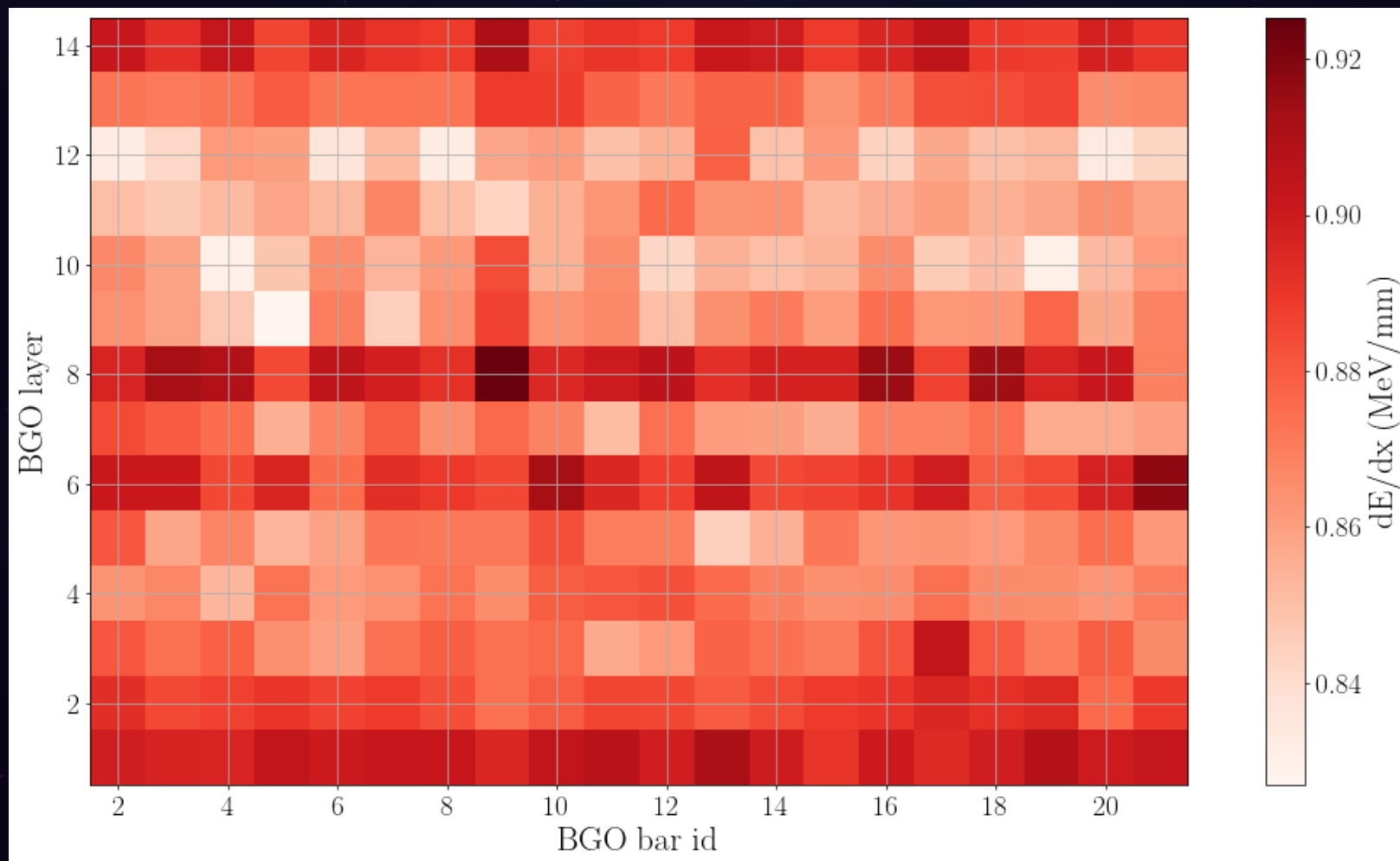


Updated BGO calibration

Fit per bar

Updated BGO calibration

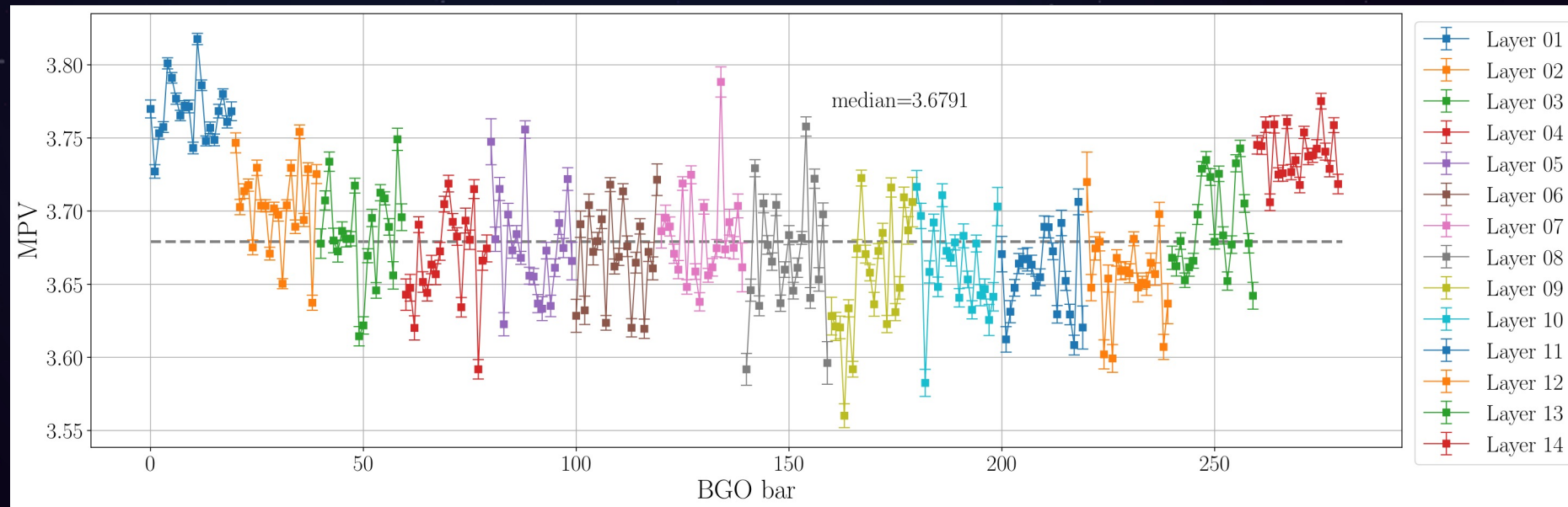
Proton



Fit per bar

- MPV of some layers shows a systematic shift
- One point per bar, from 2→21 for each BGO layer

Helium

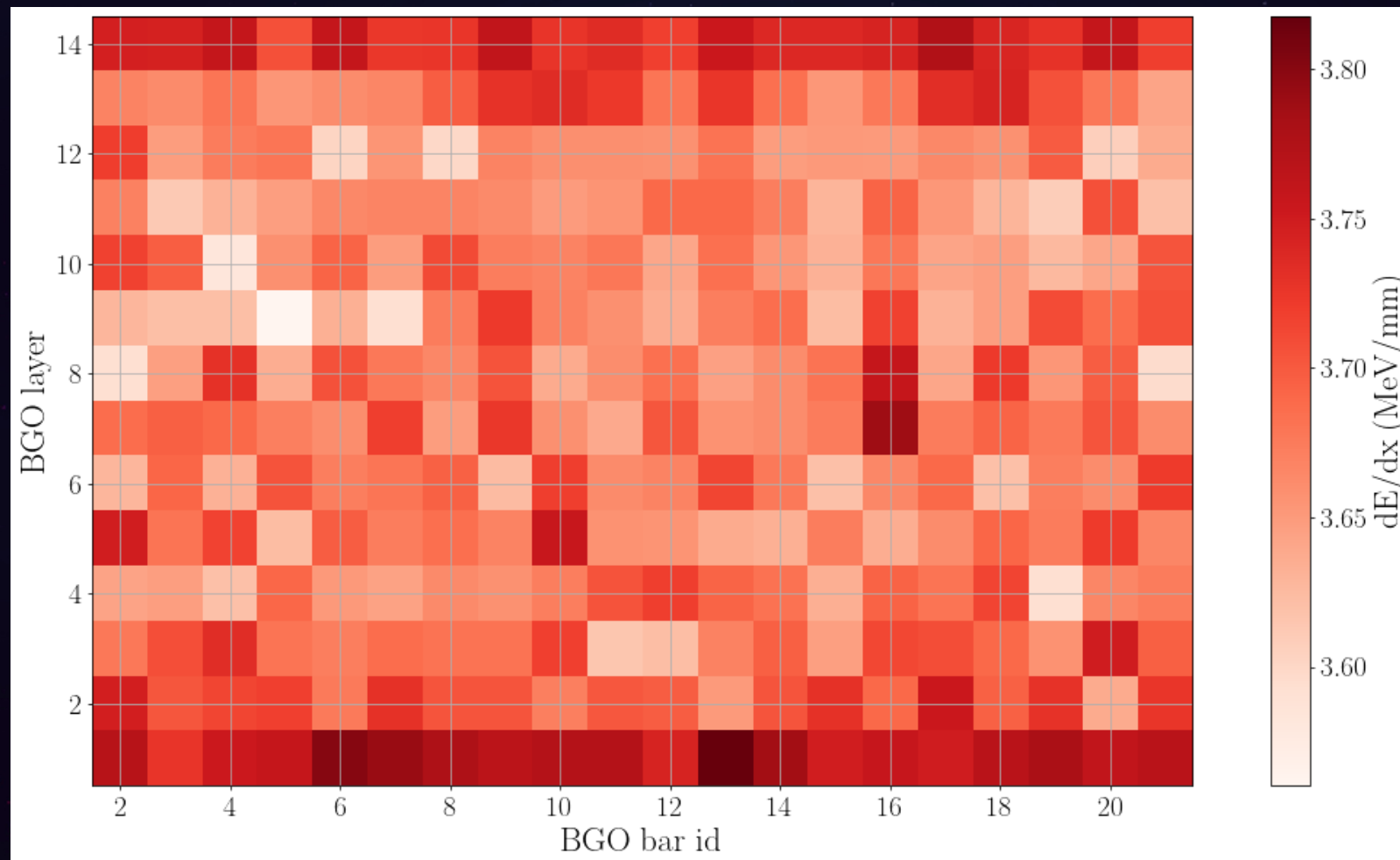


Updated BGO calibration

Fit per bar

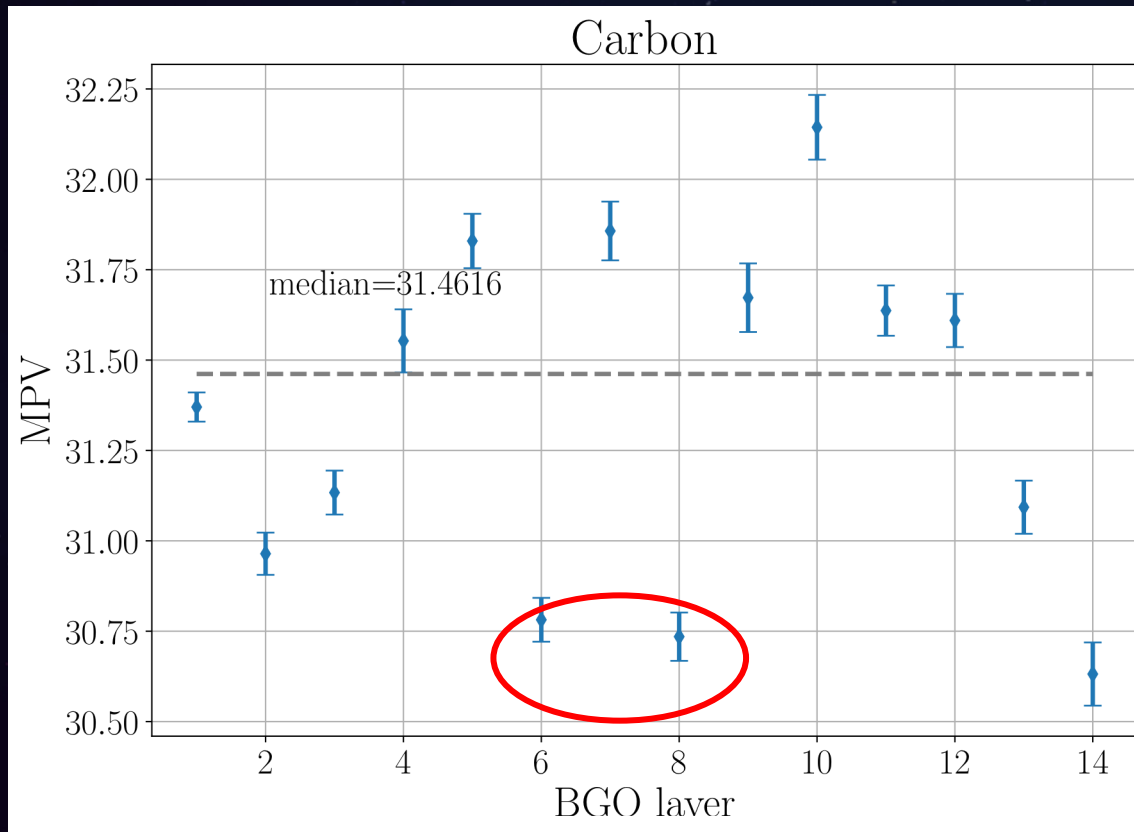
Updated BGO calibration

Helium



Fit per layer - Carbon

Overview of all layers

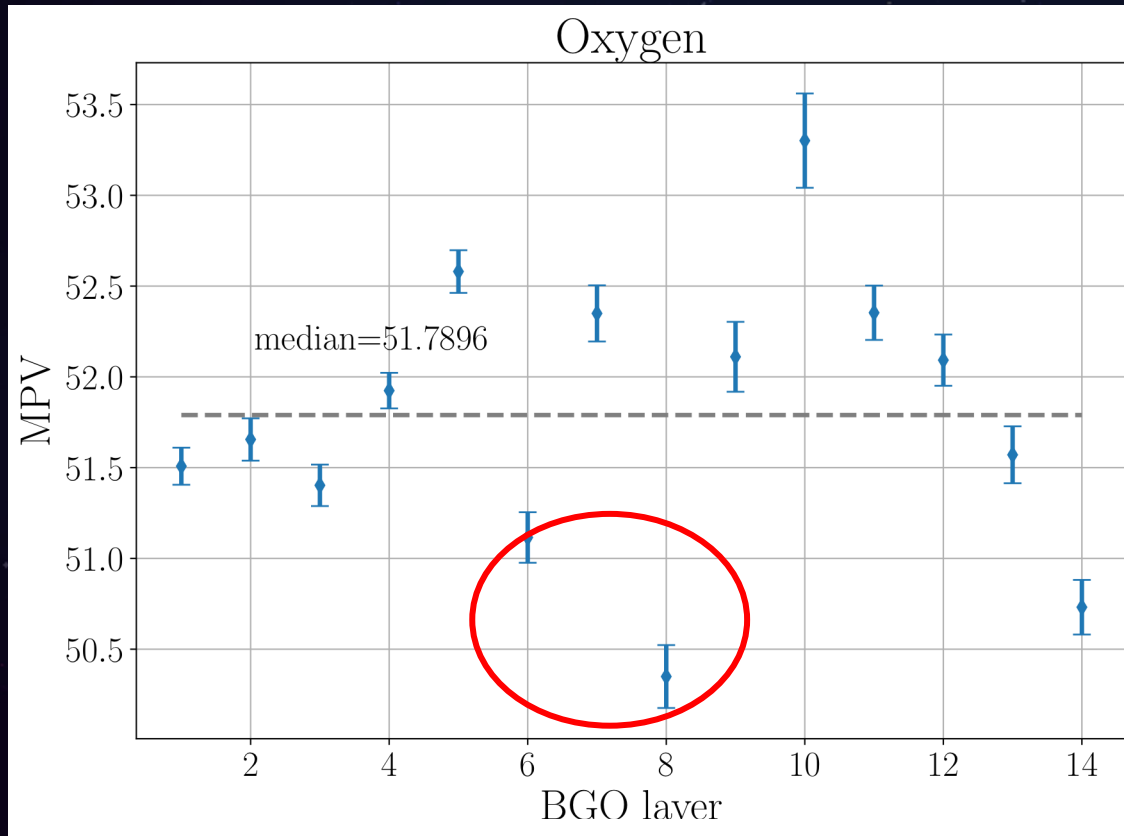


Similar case to helium
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Updated BGO calibration

Fit per layer - Oxygen

Overview of all layers



Similar case to helium
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Updated BGO calibration

Conclusions

- Selected MIP events for:
Proton, Helium, Carbon, Oxygen
- Fit Langau distribution to extract MPV
 - Per bar for proton and helium
 - Per layer for carbon and oxygen
- MPV values within layers show consistent overall normalisation
- MPV values between layers shown systematic shifts:
 - Layer 8 is always in the top-3 of largest outliers
 - Systematic differences are always $<3\%$
- New BGO better for helium-MIP, but worse for proton-MIP