Testbeam dE/dx Analysis

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LCTPC Collaboration Meeting

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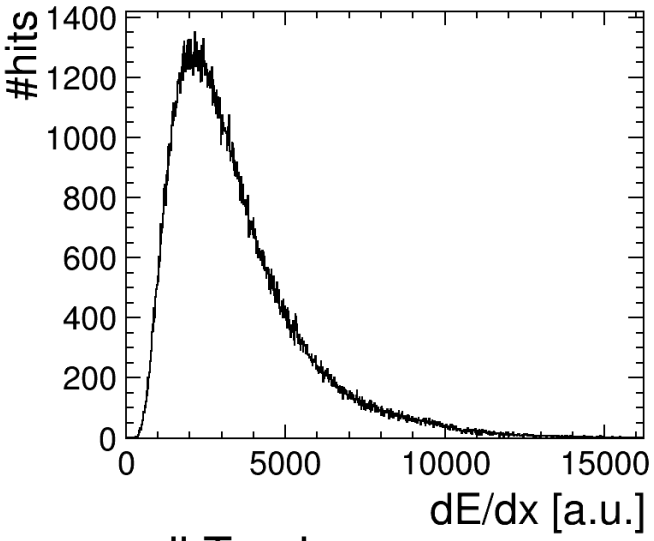
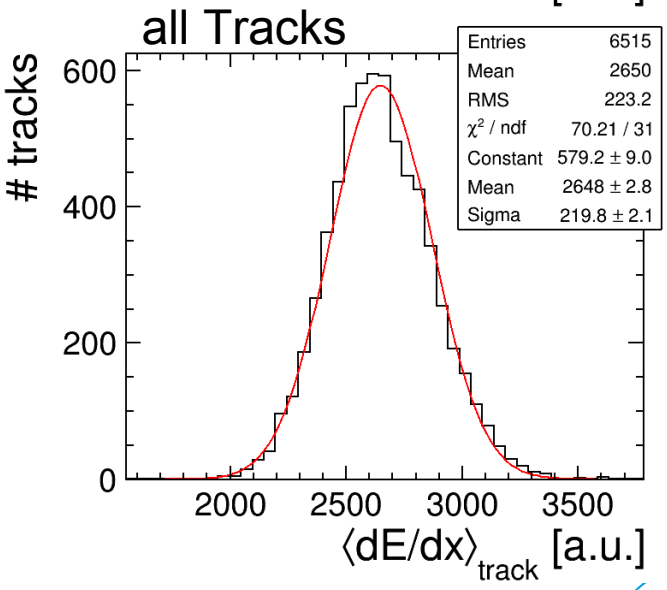
HELMHOLTZ ASSOCIATION

DESY

Measuring Track dE/dx

- Take reconstructed tracks and look at associated hits.
- Valid hits for dE/dx measurement must
  - not be at module edge or next to central grid.
  - not have any overflow pulses.
  - not have any dead channels nor be next to one.
- Track dE/dx is calculated from a 20% truncated mean of remaining valid hits.
- In data the number of valid hits averages at ~56 (of 72 maximum).
- Resolution is determined from RMS after 5σ iterative cut of outliers to be ~8.5% (~8% for 56 hits only)





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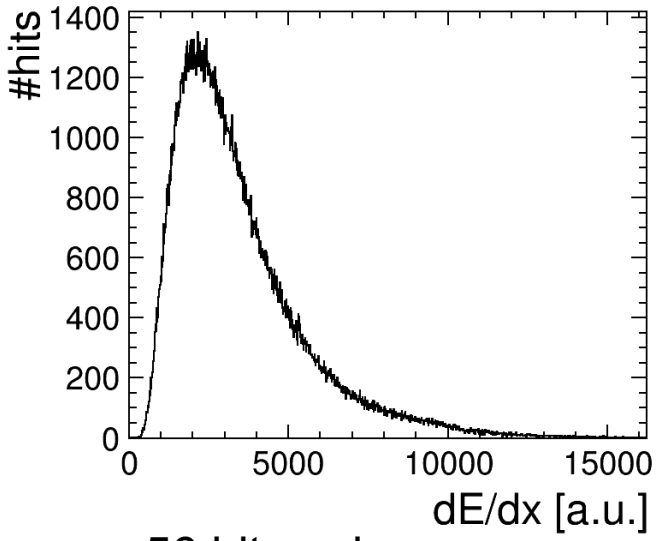
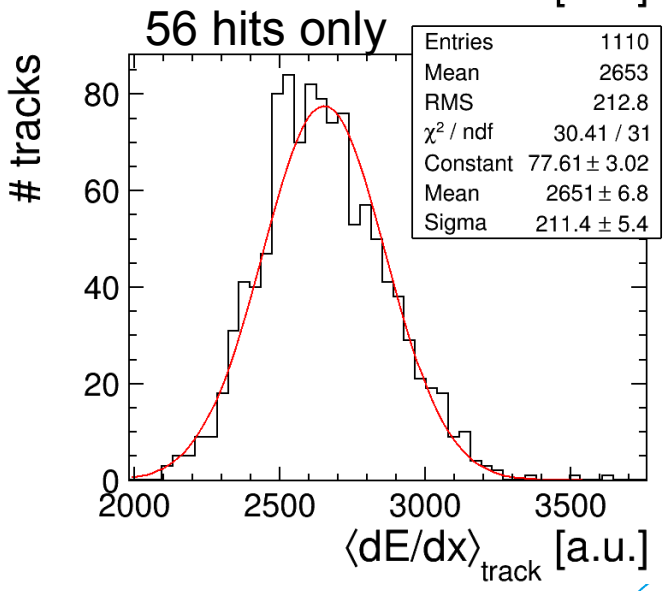
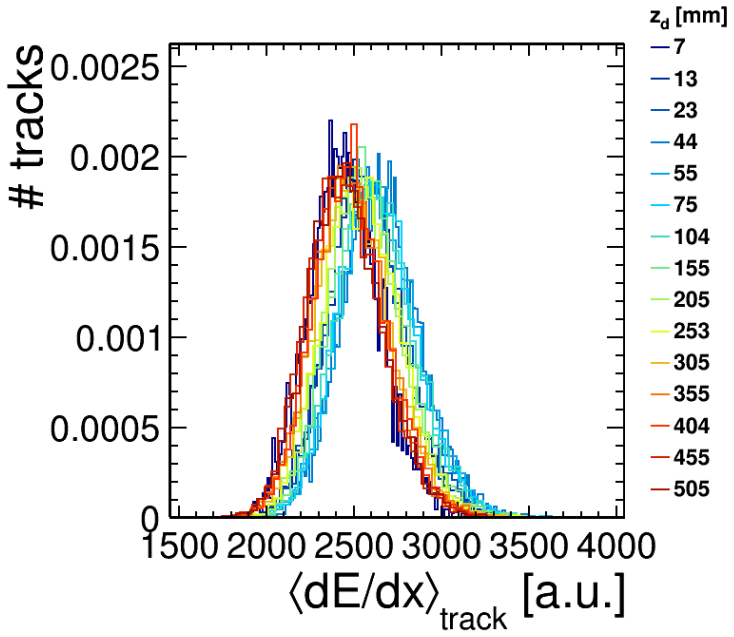
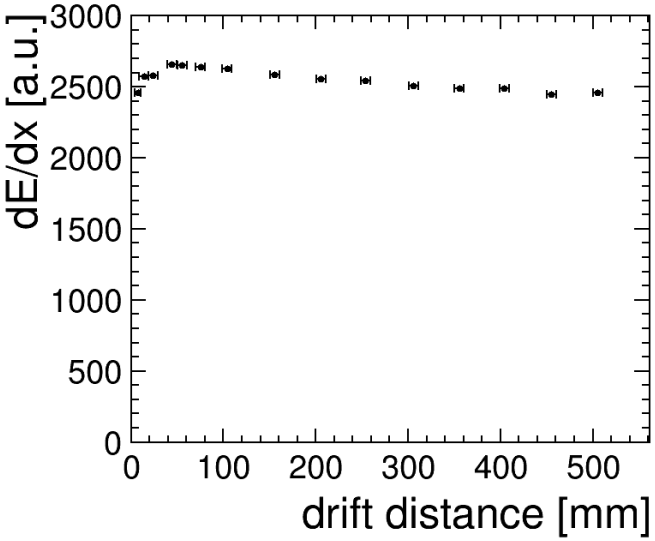


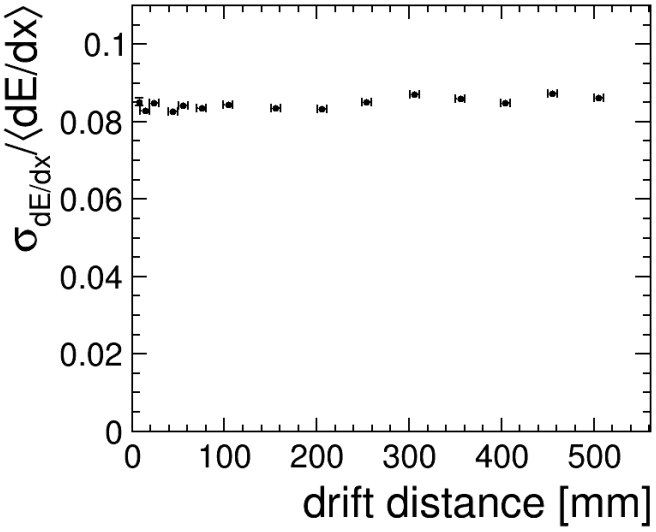


Drift Dependency

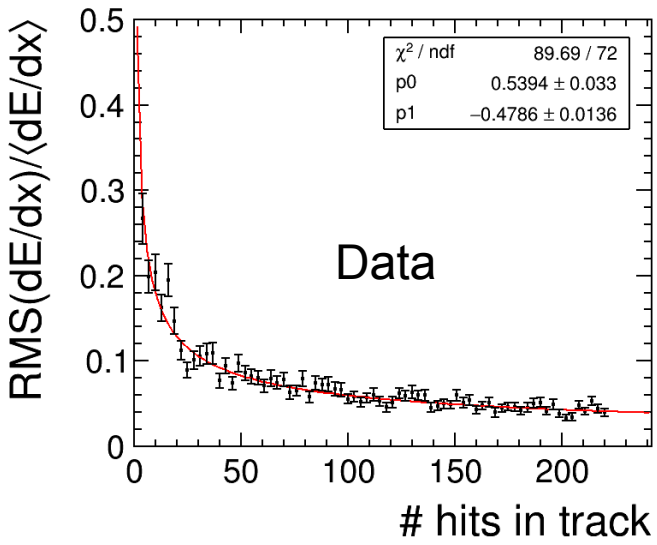
- Some attachment is observed as mean dE/dx reduces with rising drift distance.
- dE/dx resolution is unaffected by this, as expected.

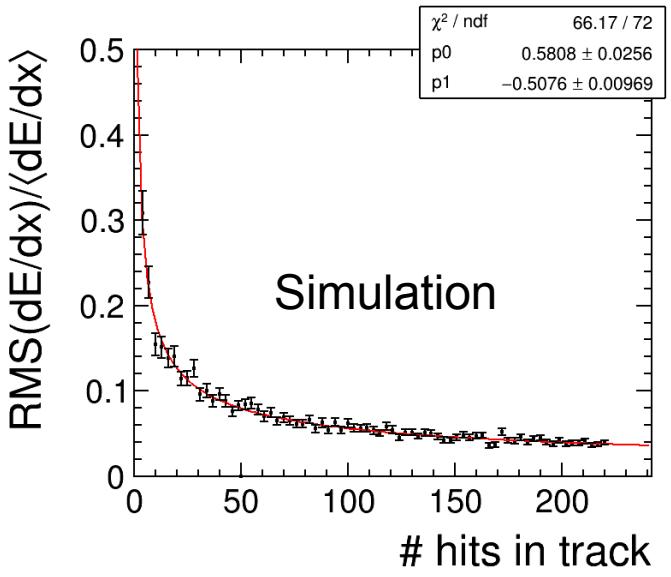






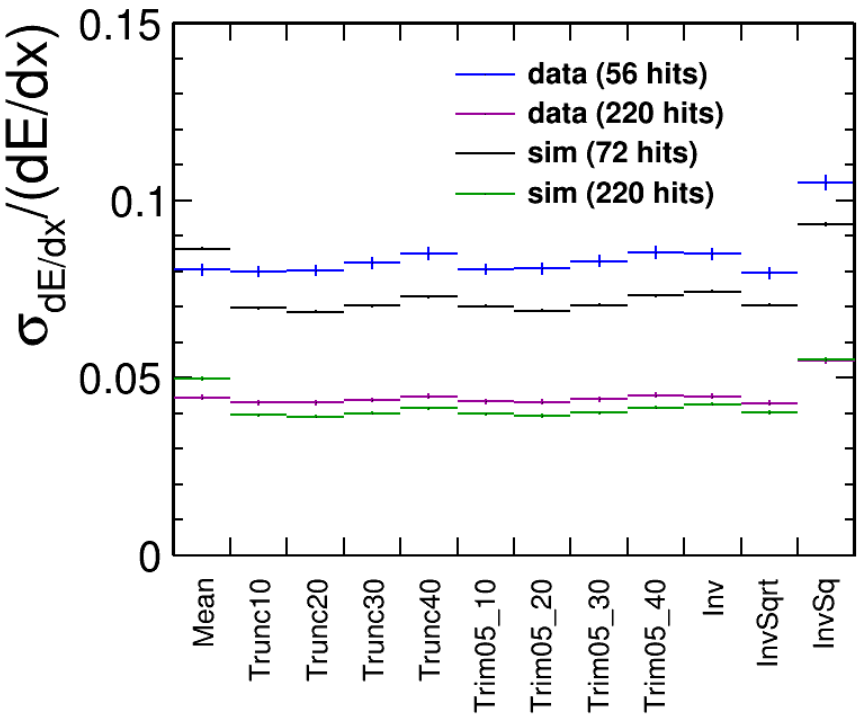
Track Length Dependency





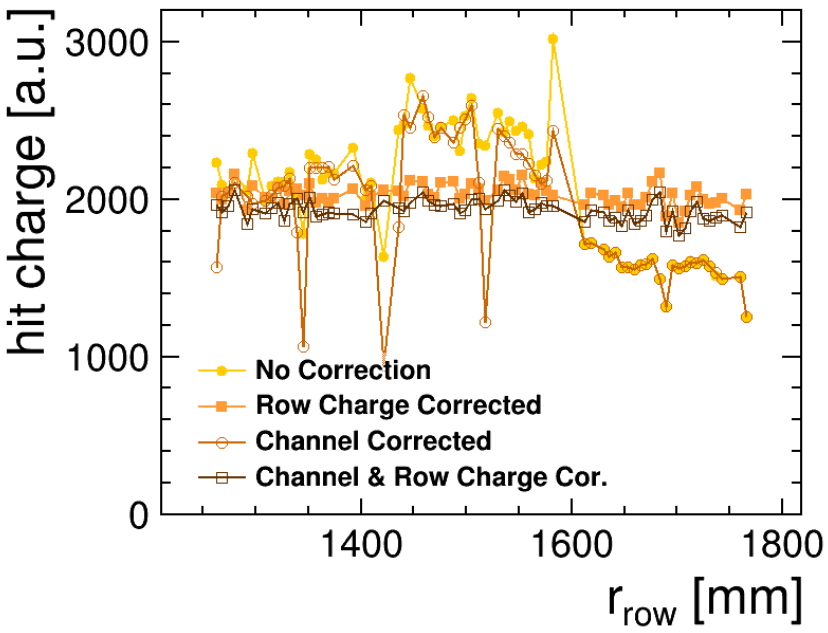
- To estimate dE/dx resolution for the full scale ILD TPC hits from several tracks are combined.
- This allows to test arbitrary track lengths.
- A dependency on the number of hits of $1/N^X$ is found with X ranging from 0.45 to 0.5 between data runs.
- In simulation the exponent ranges from 0.47 to 0.5 between "runs".
  - OPAL: 0.43
- Good agreement between data and simulation.

dE/dx Estimator Comparison



- TruncXX → cut of XX% of highest charge hits.
- TrimYY_XX → in addition cut of YY% of lowest charge hits.
- Inv / InvSqrt / InvSq → downweight Landau tail by taking inverse (square root / square) of hit charge.
- Best estimation methods are 20% truncation and trimming with 5% / 20%, as measured in simulation.
- In data inverted square root appears slightly better.
  - Simulated electronics do not handle overflow pulses accurately.

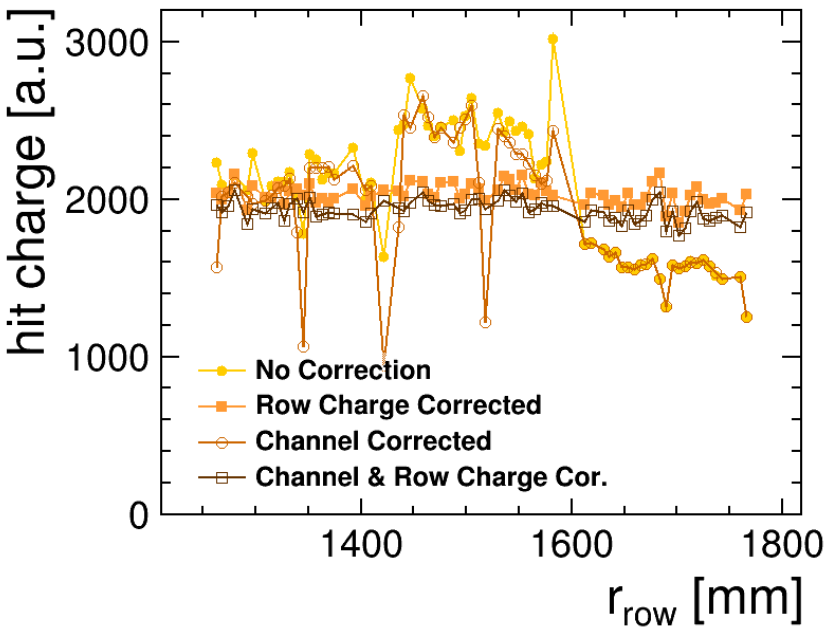
Charge Corrections

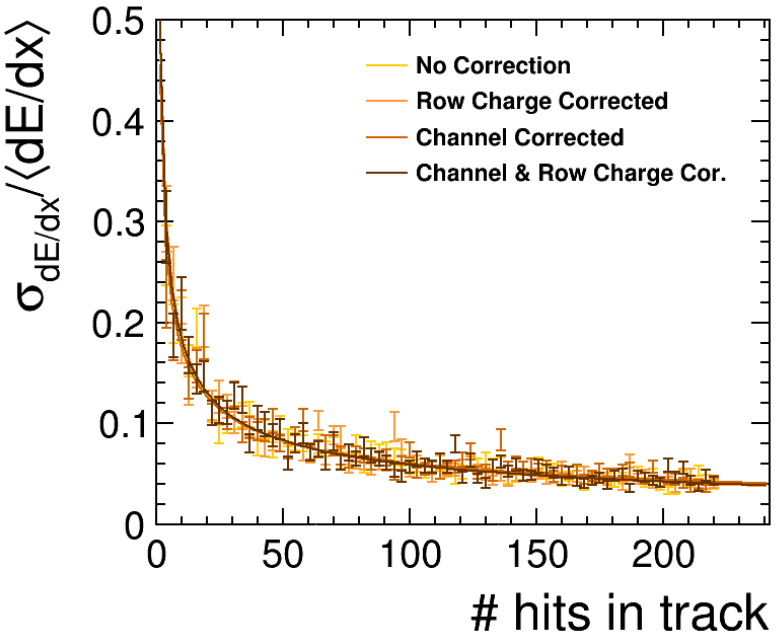


	Mean	RMS	RMS (%)
No Cor.	2044±49	374±35	18.3±1.8
RCC	2029±8	63±6	3.1±0.3
CC	2011±46	347±32	17.3±1.6
CRCC	1928±8	63±6	3.3±0.3

- Row Charge Correction (**RCC**) corrects mean charge on each row to the average charge of all rows.
- Channel Correction (**CC**) was determined by pulsing the common electrode of the lowest GEM with varying amplitudes to determine a correction factor.
  - Module 5 was not accessible.
- Channel Correction has no significant impact on the RMS of charge between rows.
- Row Charge Correction improves RMS to 3%.
- Combining both corrections (**CRCC**) yields no improvement over RCC alone.

Impact on dE/dx Resolution





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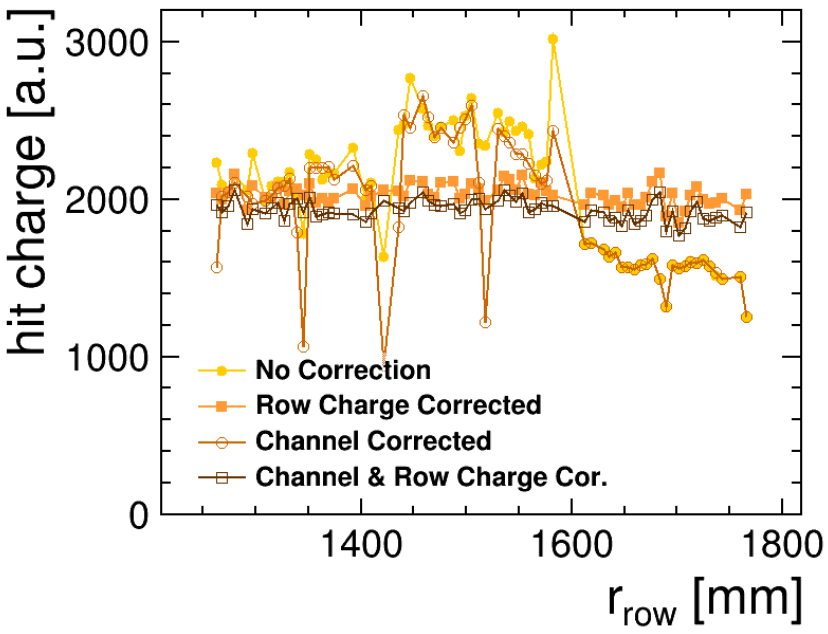
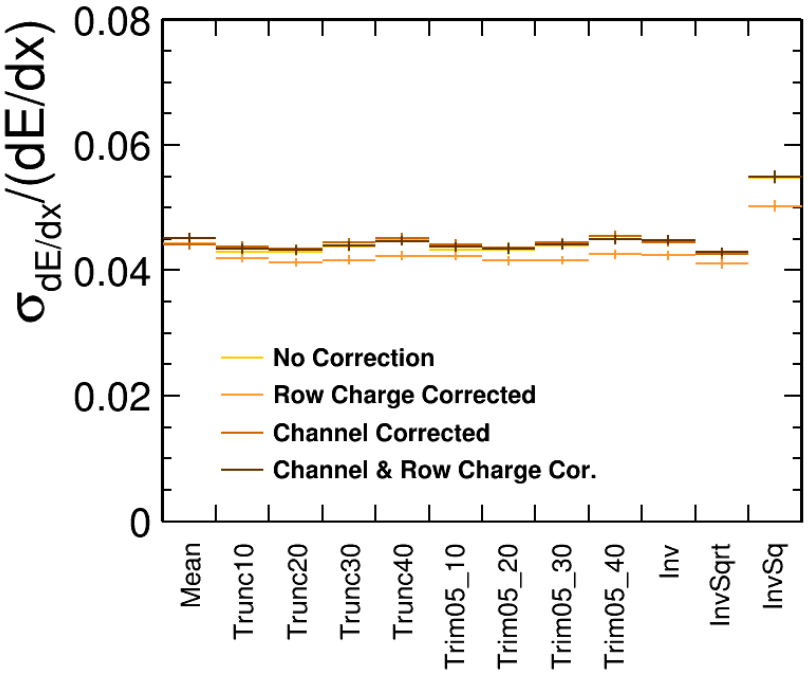
	σ_0	power
No Cor.	0.539±0.033	-0.479±0.014
RCC	0.590±0.038	-0.502±0.014
CC	0.497±0.031	-0.457±0.014
CRCC	0.567±0.038	-0.490±0.015

Impact on dE/dx Resolution (2)





- Track length dependency is not changed significantly by corrections
- Generally resolution is not improved by the corrections.
- At fixed track length of 220 hits Row Charge Correction alone shows improvement, but not in combination with Channel Correction → under investigation.

Summary

- dE/dx resolution with the DESY GEM modules in the LP was successfully measured to be 8% for tracks with 56 usable hits.
- The optimal truncation fraction was found to be 20%.
  - Trimming also at the low charge end seems to give no improvement.
- Using the mean of $1/\sqrt{(dE/dx)}$ as an estimator to suppress the landau tail might be a valid alternative.
- A process to measure dE/dx resolution in dependency of the track length was established.
- From this the dE/dx resolution for the full ILD TPC (220 hits) was extrapolated to be ~4.5%.
- Charge calibrations (per channel / per row) yield no significant improvement on dE/dx resolution.
  - Expected, since it is dominated by primary ionisation fluctuations.
- Angular dependencies are still under investigation.

Additional Material

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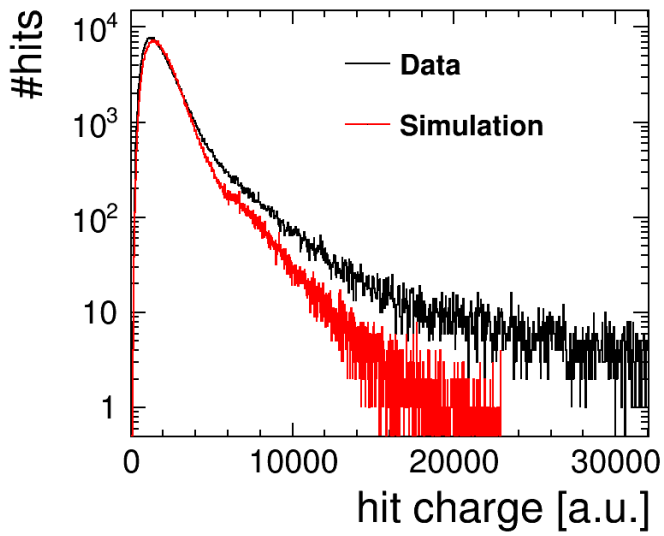
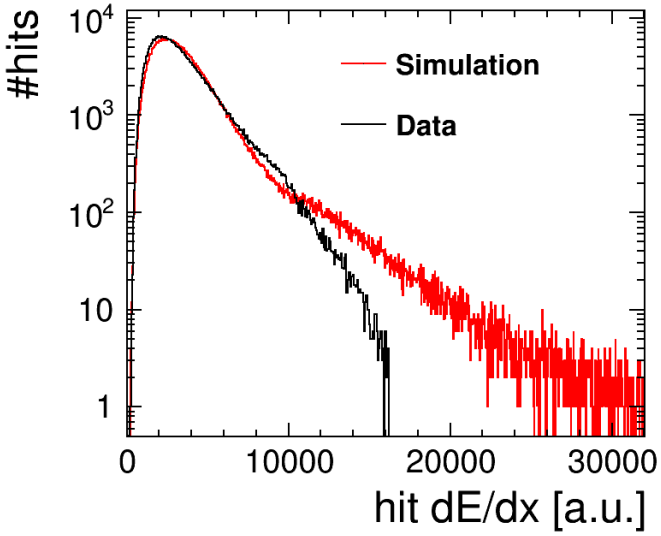
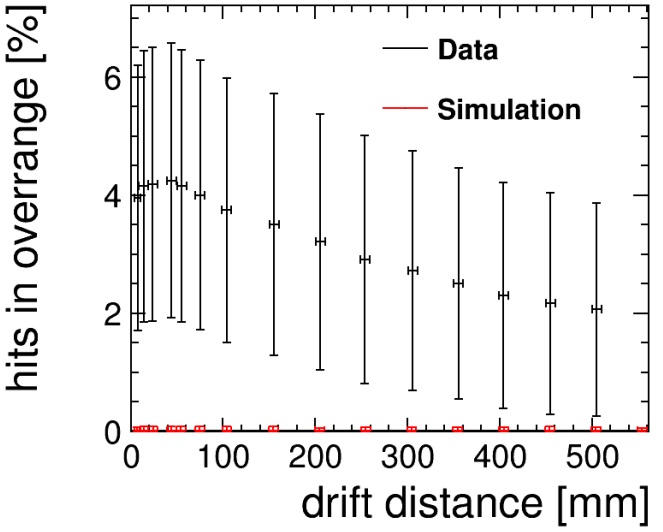
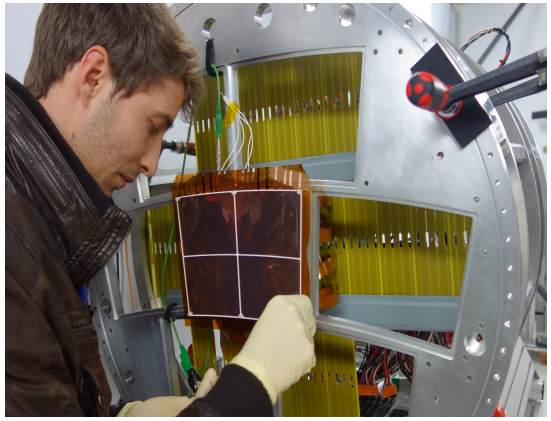
Overflow in Simulation







- Charge and time calibration by pulsing the bottom-most GEM side
  - Tested before testbeam period with mock setup



  - Measurements with testbeam setup tricky (for 3rd module not possible),
    since HV contacts had to be connected free-hand for pulsing the GEM
    ← ALTRO electronics and cables block easy access
  - Next module iteration should include easily accessible contact (over capacitor?) to bottom-most GEM layer