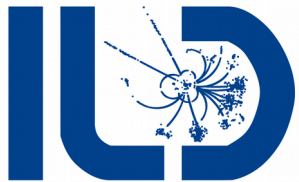


dE/dx-Check for new 250 GeV-Production

Uli Einhaus
LCTPC Meeting
30.04.2020



HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES



- After the large 500 GeV MC production in 2018, now preparation is ongoing for a large 250 GeV MC production. First step: test production of single particles and few physics events for validation.
- Took single particle files and checked dE/dx:

```
/pnfs/desy.de/ilc/prod/ilc/mc-opt/ild/dst-merged/1-calib/single/ILD_I5_o1_v02_nobg/v02-01/
```

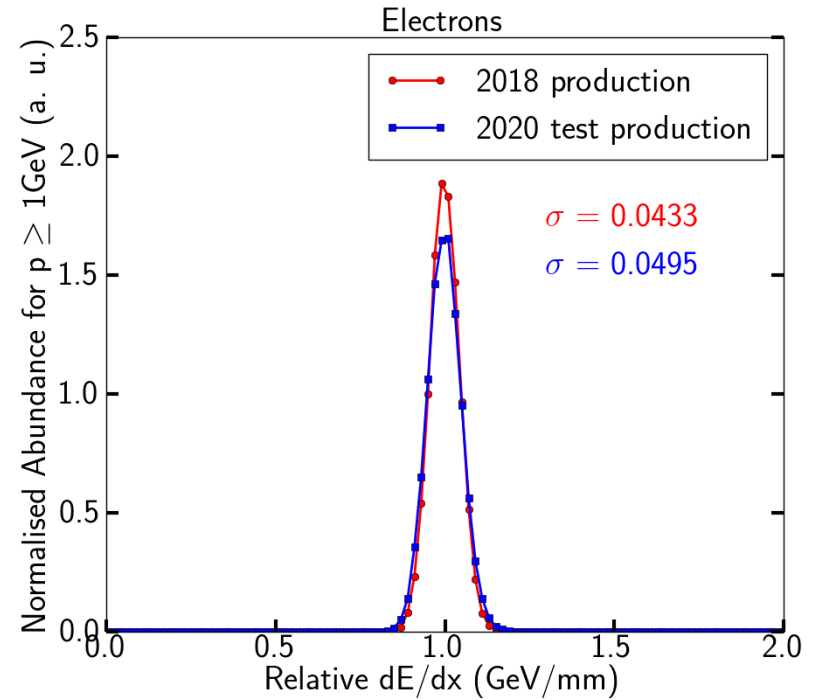
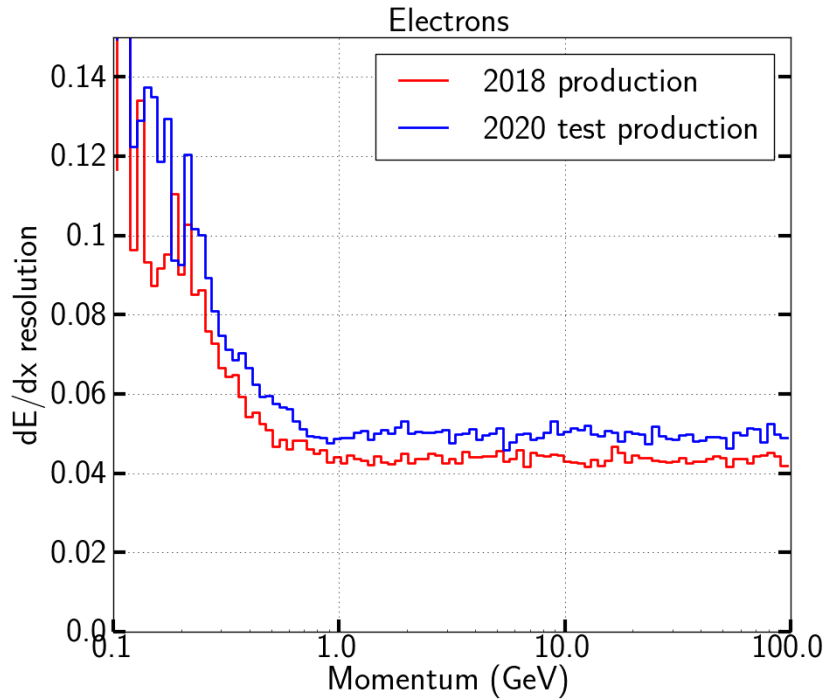
```
rv02-01.sv02-01.mILD_I5_o1_v02_nobg.E1-calib.I110081.Ps_pm11_prnd.e0.p0.n001.d_dstm_14703_0.slcio  
rv02-01.sv02-01.mILD_I5_o1_v02_nobg.E1-calib.I110082.Ps_pm13_prnd.e0.p0.n001.d_dstm_14703_0.slcio  
rv02-01.sv02-01.mILD_I5_o1_v02_nobg.E1-calib.I110083.Ps_pm211_prnd.e0.p0.n001.d_dstm_14703_0.slcio  
rv02-01.sv02-01.mILD_I5_o1_v02_nobg.E1-calib.I110084.Ps_pm321_prnd.e0.p0.n001.d_dstm_14703_0.slcio  
rv02-01.sv02-01.mILD_I5_o1_v02_nobg.E1-calib.I110085.Ps_pm2212_prnd.e0.p0.n001.d_dstm_14703_0.slcio
```

- Result: Looks basically alright, no big issues, but extracted dE/dx-resolution is worse than before.
- Compared to previous large production:

```
/pnfs/desy.de/ilc/prod/ilc/mc-opt-3/ild/dst-merged/1-calib/single/ILD_I5_o1_v02_nobg/v02-00-01
```

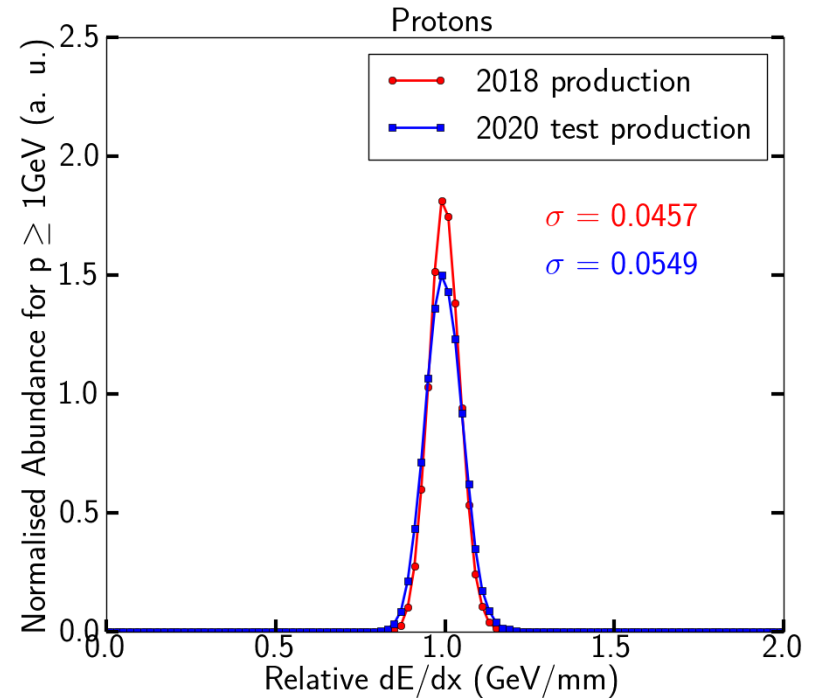
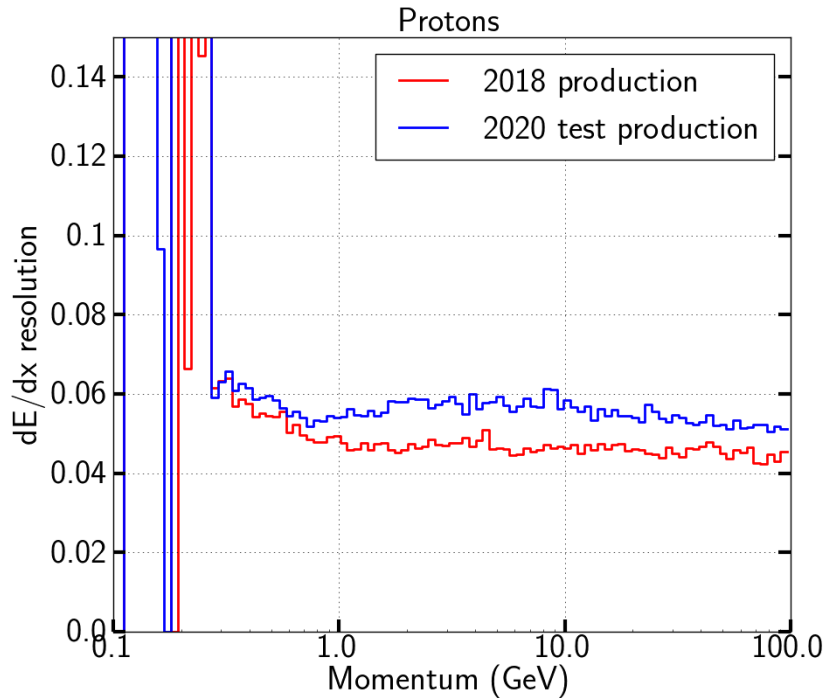


dE/dx Resolution - Electrons

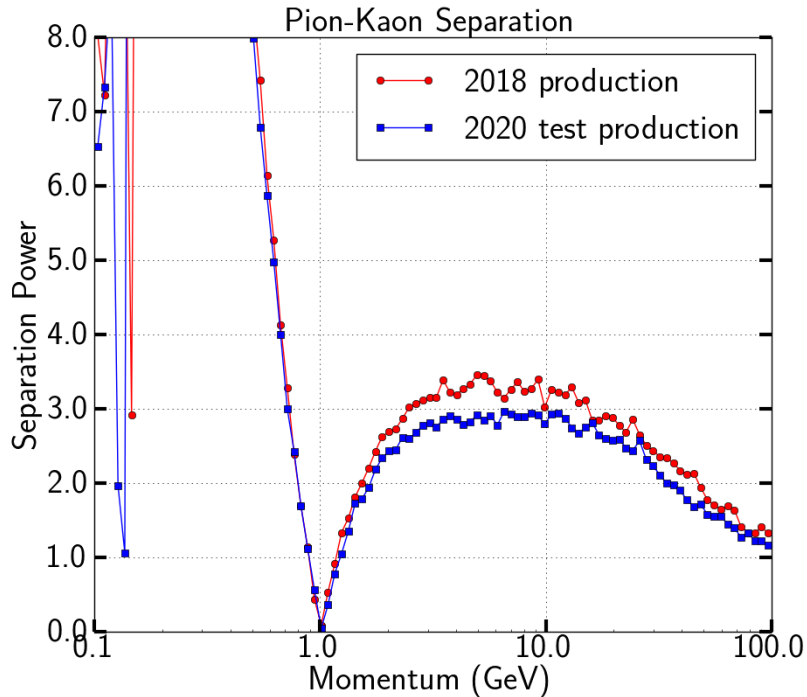


dE/dx Resolution Issue

With default parameters, the dE/dx resolution in the new test production is worse than the 2018 production (and than test beam results).



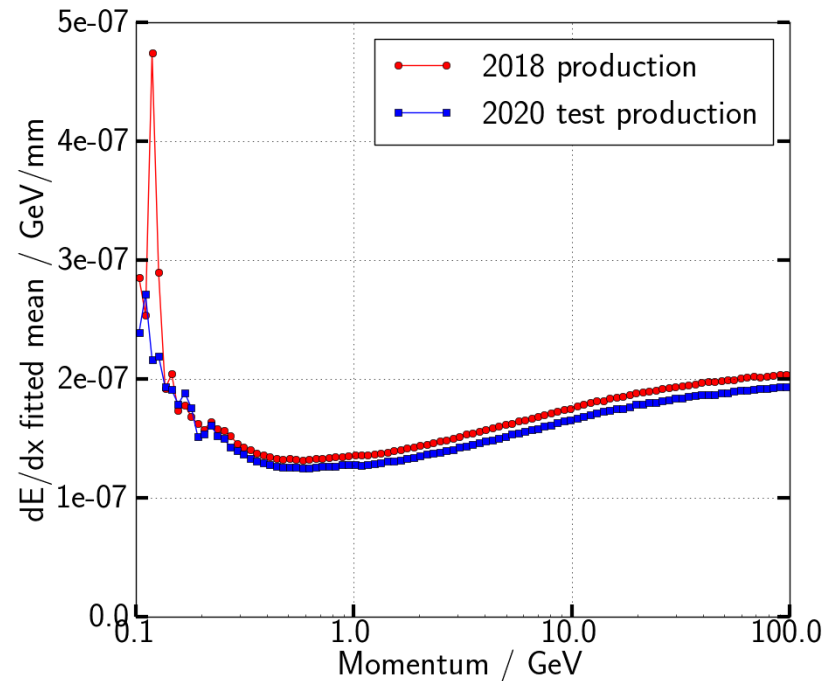
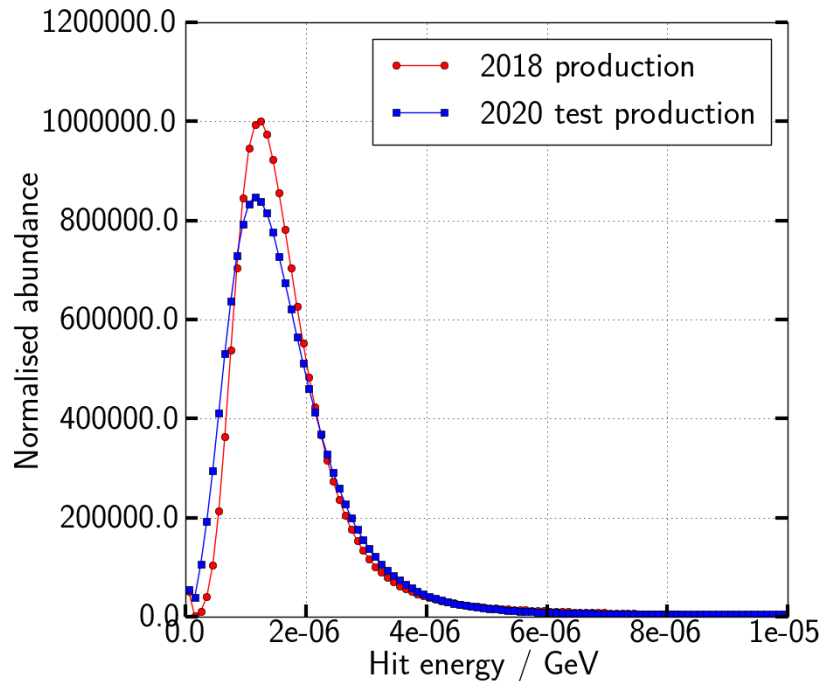
Separation Power: Pion/Kaon



- Worsened resolution and consequently separation power
- Possible reason: Geant4 version was changed
- Check hit-level properties

Probable Cause

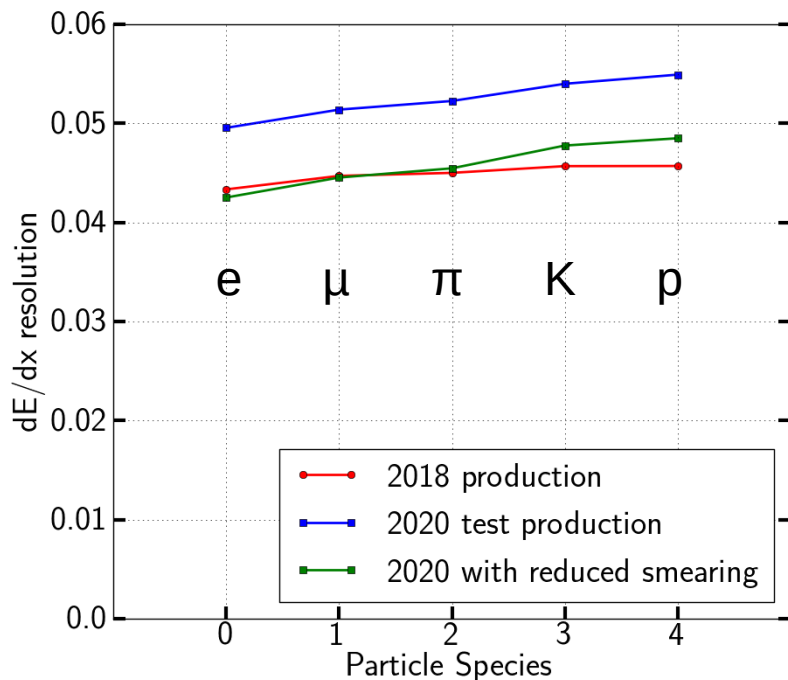
The probable cause for this is a new geant version. The ionisation has a wider and slightly overall lower hit energy distribution.



As cross check, Frank Gaede didn't find a change in DD4HEP.



Difference between Species



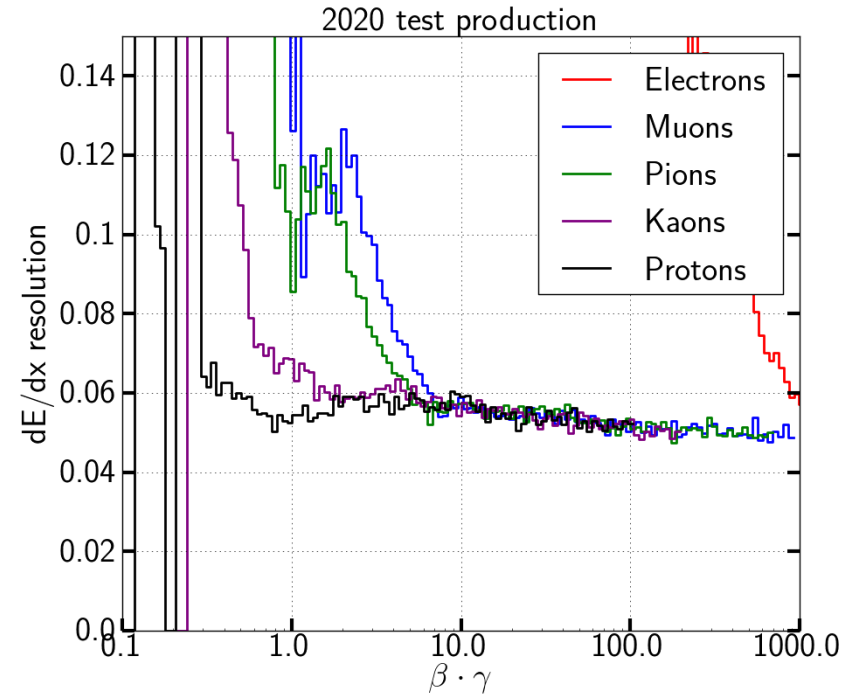
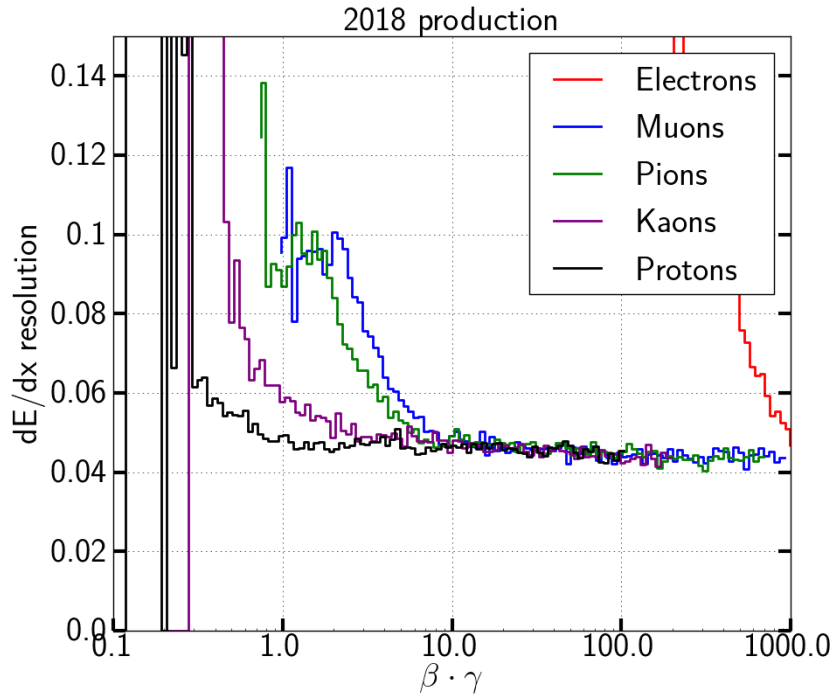
2018 intrinsic: 2.6% smearing: 3.5%
2020 intrinsic: 3.7% smearing: 2.4%

- After correction by adjusting the smearing factor, the resolution returns to previous levels.
- But: difference in resolution values of different species (worse with growing mass) is enhanced.
- Why?
- → Bias through looking at different $\beta\gamma$ of each species. Resolution depends on $\beta\gamma$!



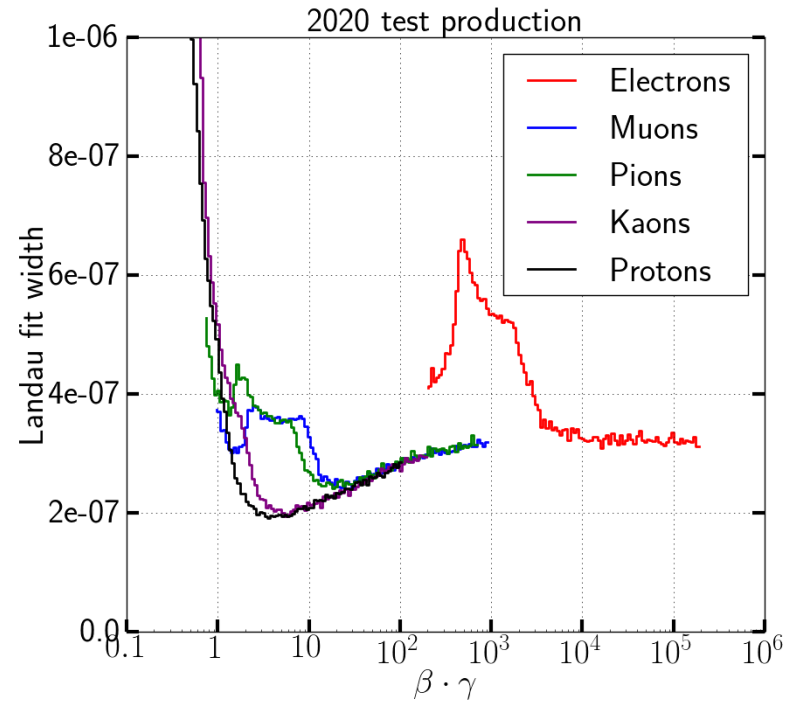
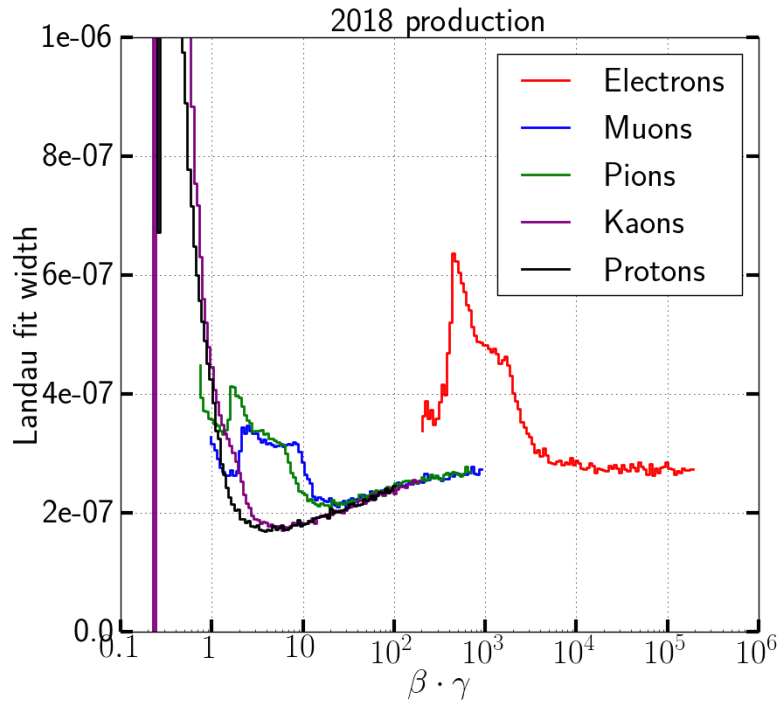
dE/dx Resolution over $\beta\gamma$

For previous resolution numbers, $p > 1$ GeV was required, so protons with $\beta\gamma > 1$ were accepted, but pions with $\beta\gamma > 10$.



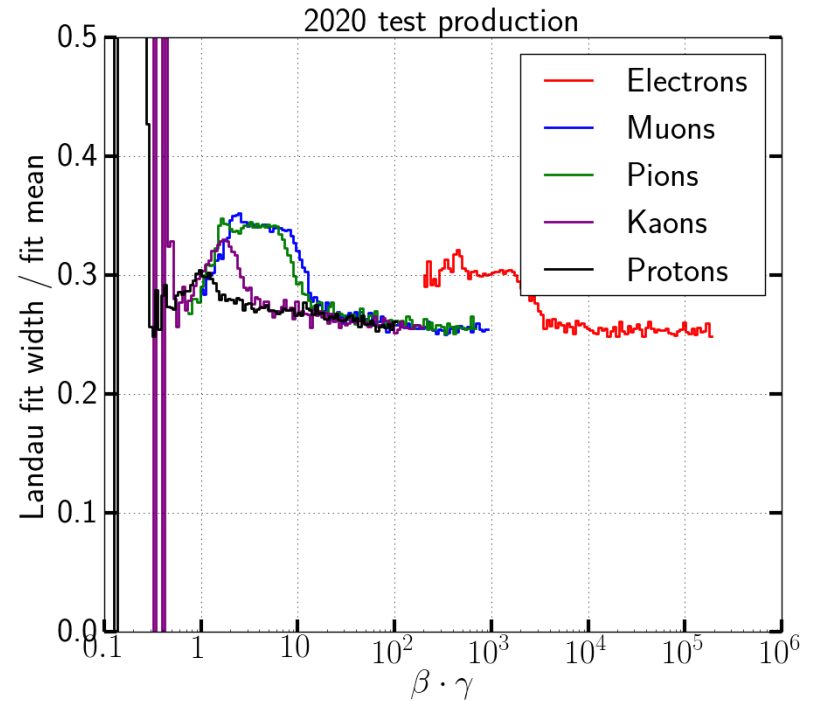
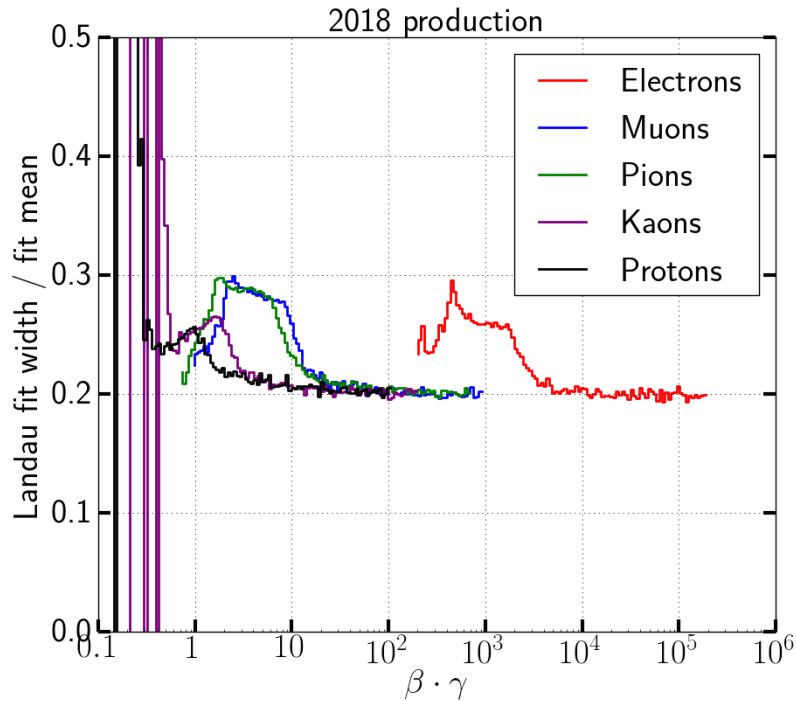
Width of Landau Fit of Hit Energy Distribution

The effect on the resolution stems from the underlying hit energy distribution.



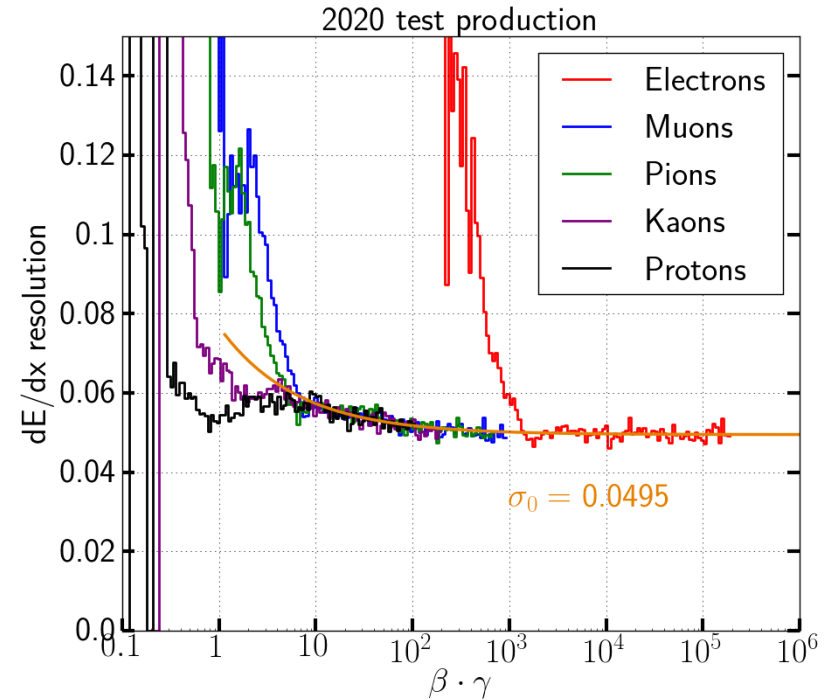
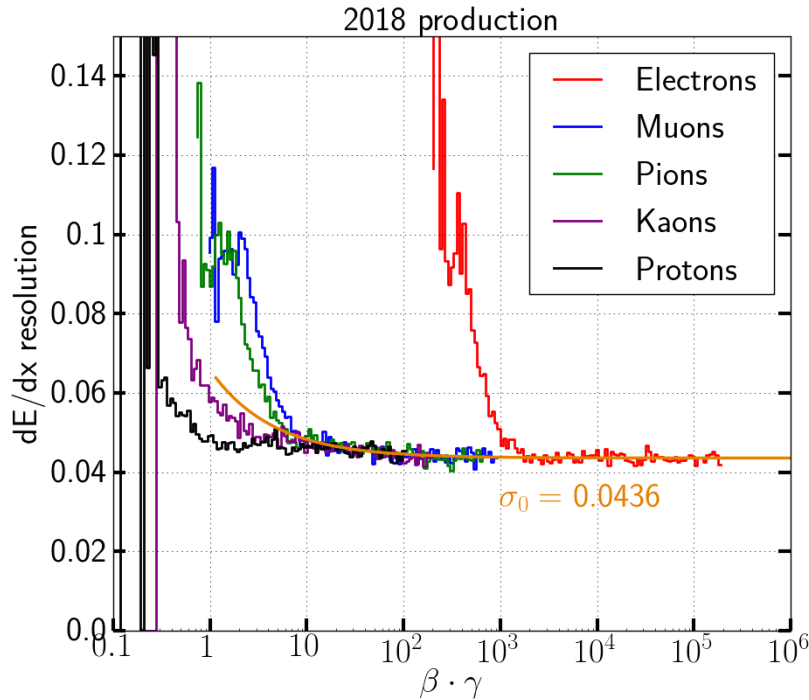
Width / Mean of Landau Fit of Hit Energy Distribution

The width / mean is falling with increasing $\beta\gamma$.

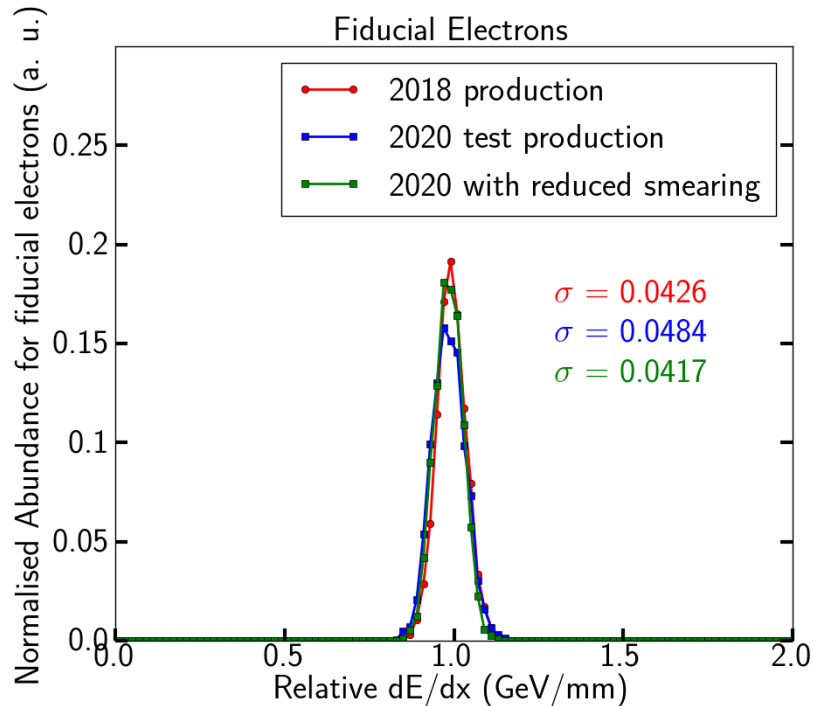


dE/dx Resolution over $\beta\gamma$, asymptotic Behavior

An exponential fit for $\beta\gamma > 2000$ (electrons) and $\beta\gamma > 10$ (others) gives an estimate for the asymptotic resolution. Still affected by angular distribution.



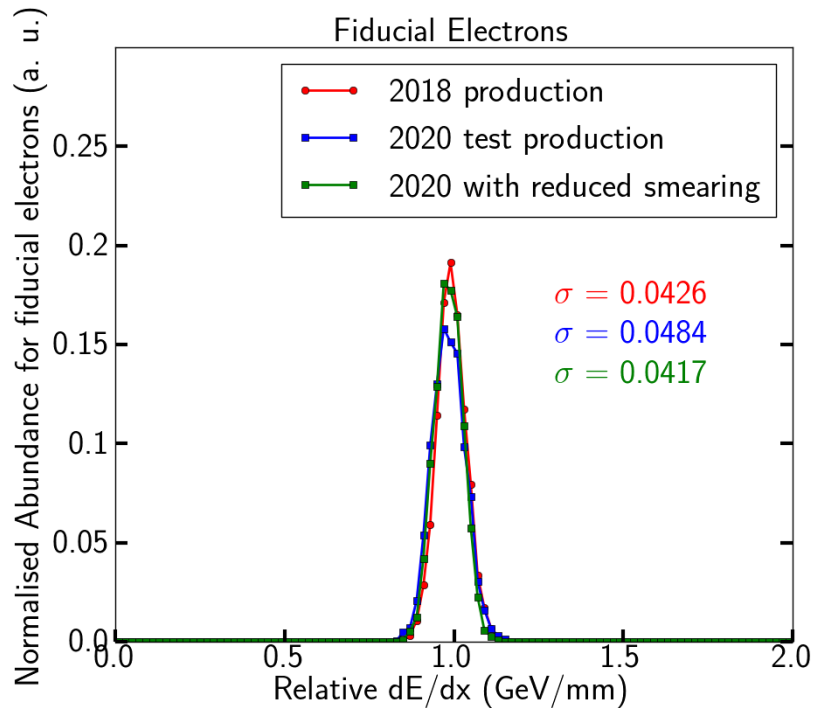
Fiducial Electrons



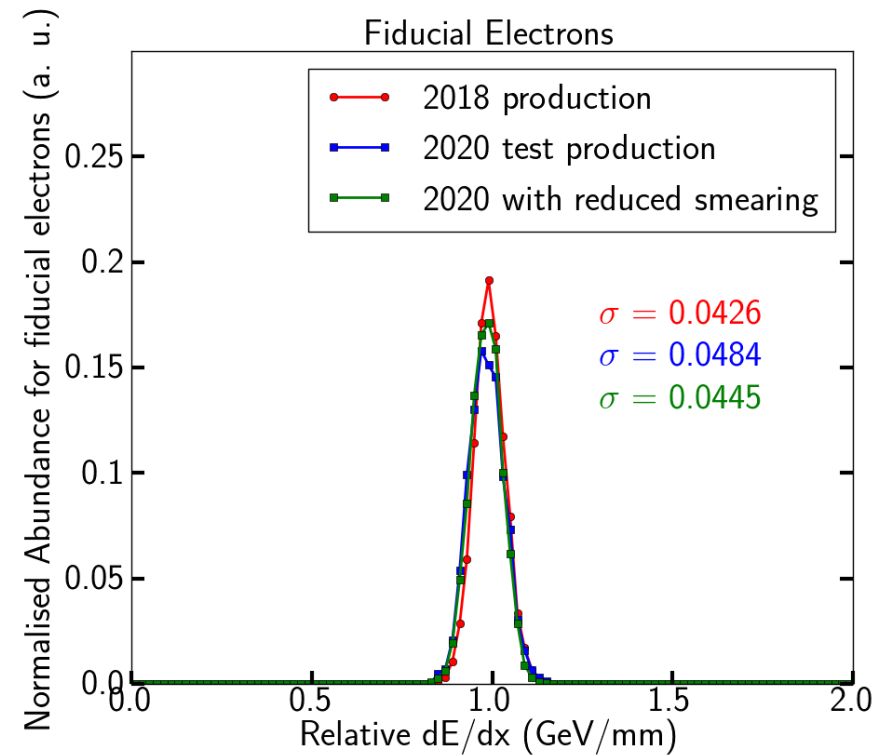
- To compare resolution with test beam, define fiducial electrons:
 $3 \text{ GeV} < p < 10 \text{ GeV}$
 $1^\circ < |\lambda| < 10^\circ$
 $\#\text{Hits} > 200$
- Fiducial cut out of 100k isotropic single particle electrons.
~ 2300 entries remaining.
- Suggestion: dedicated run with ~ 100k electrons of 6 GeV parallel to cathode and $.1\text{m} < |z| < .2\text{m}$.
- Should be most realistic comparison to test beam data.

Gauge Smearing Factor wrt. Fiducial Electrons

smearing factor: 0.024

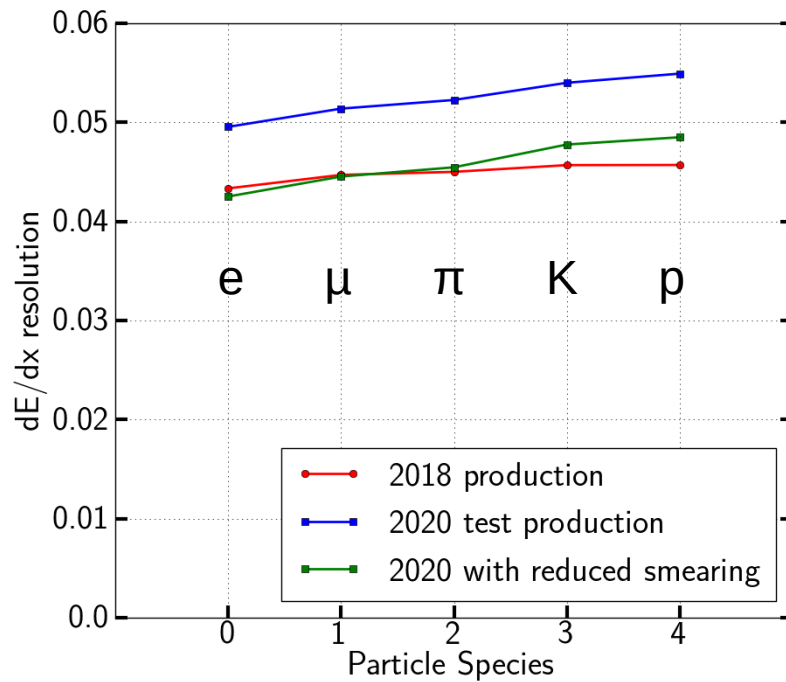


smearing factor: 0.029

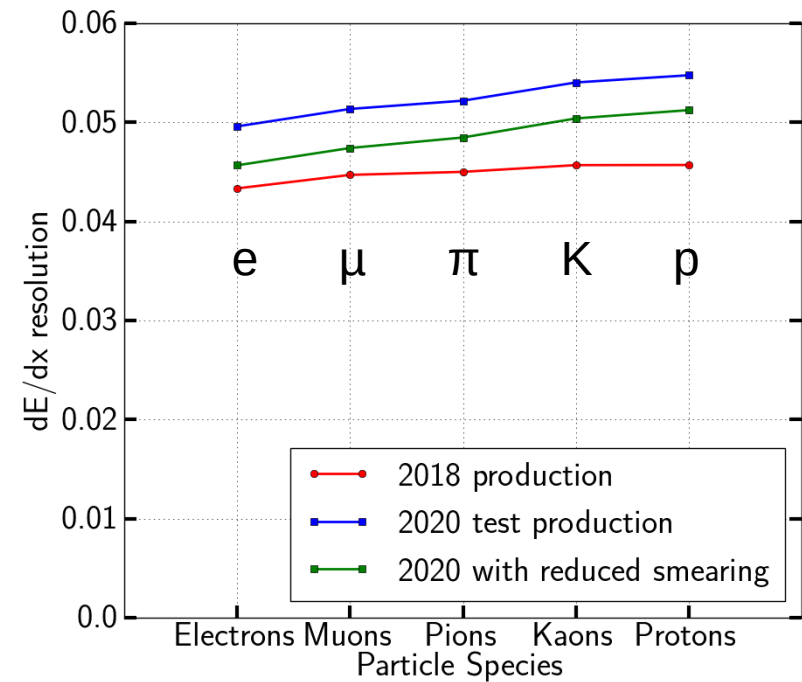


Effect on Resolution

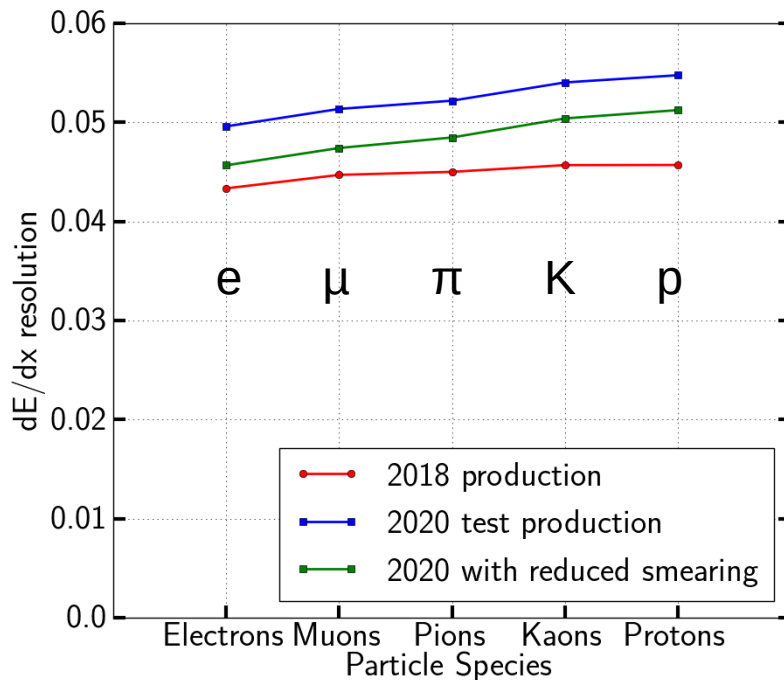
smearing factor: 0.024



smearing factor: 0.029

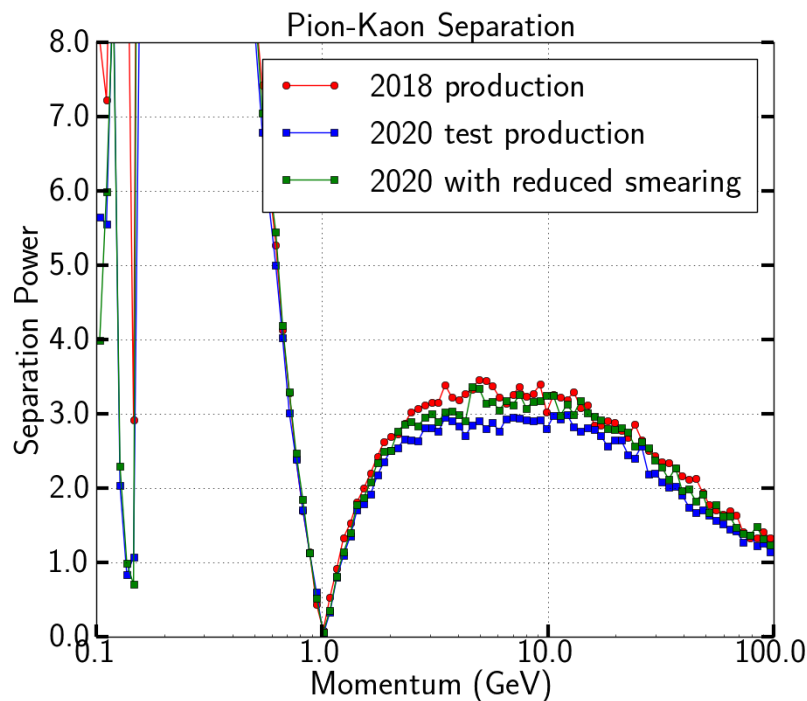


Conclusion



- Differences between species seem resolved, the resolution is the same for all when looking at $\beta\gamma$.
- Note: Even though we now know why the resolution is different for the different species, this feature still exists and causes the particles in the detector to still have different effective resolutions.
- In the 2018 production the resolution for heavier particles was over-estimated because of the dominating smearing factor.

Conclusion



- **Proposal:**
Use dedicated ‘fiducial electrons’ runs in MC to have the best direct comparison to test beam data. Can be done in second test production.

In the future have test beams with heavier particles (protons) over a momentum range to validate simulation.