Why it's not "Landau" Fluctuation

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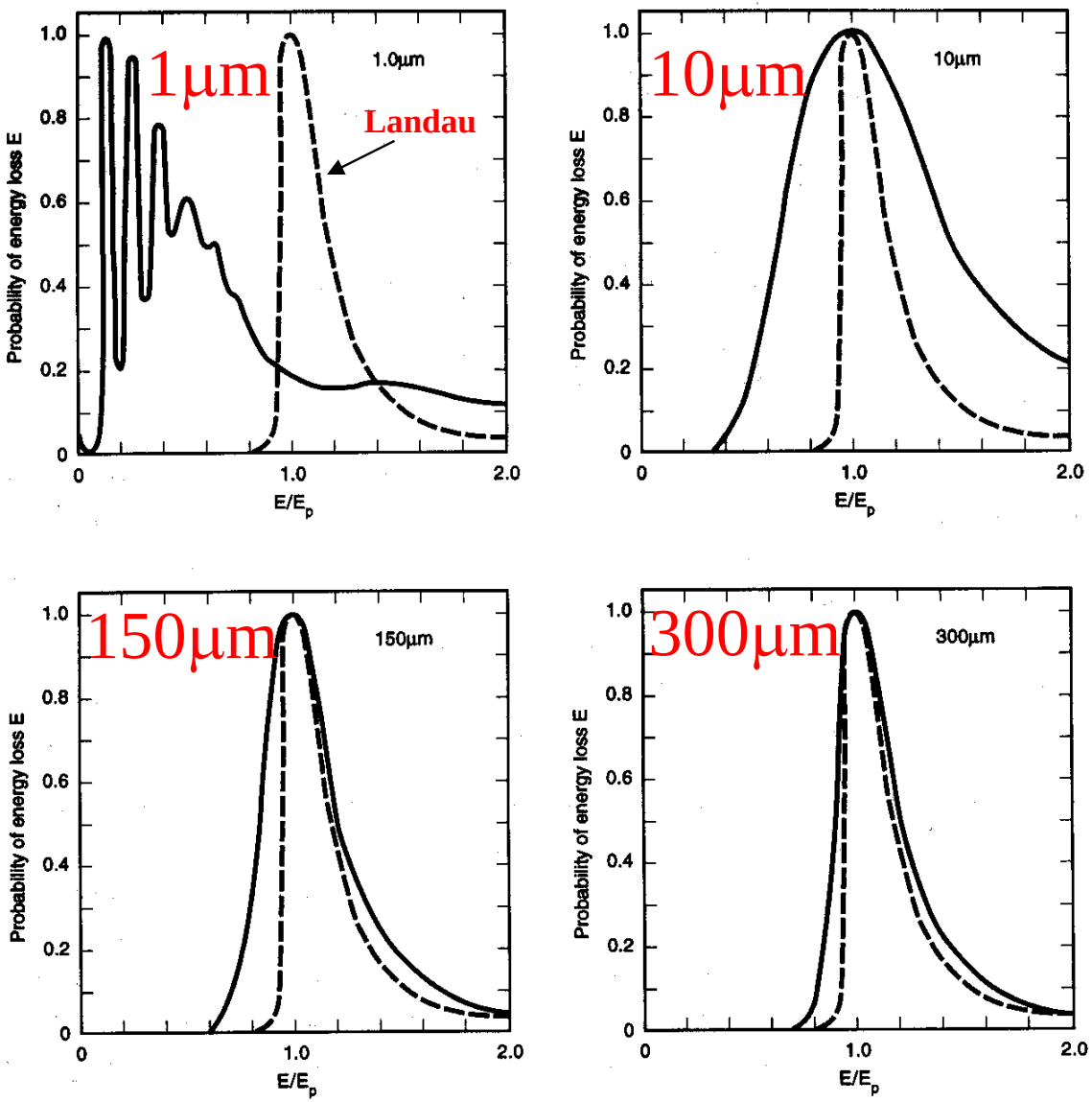
Track ionization is surely well understood ?



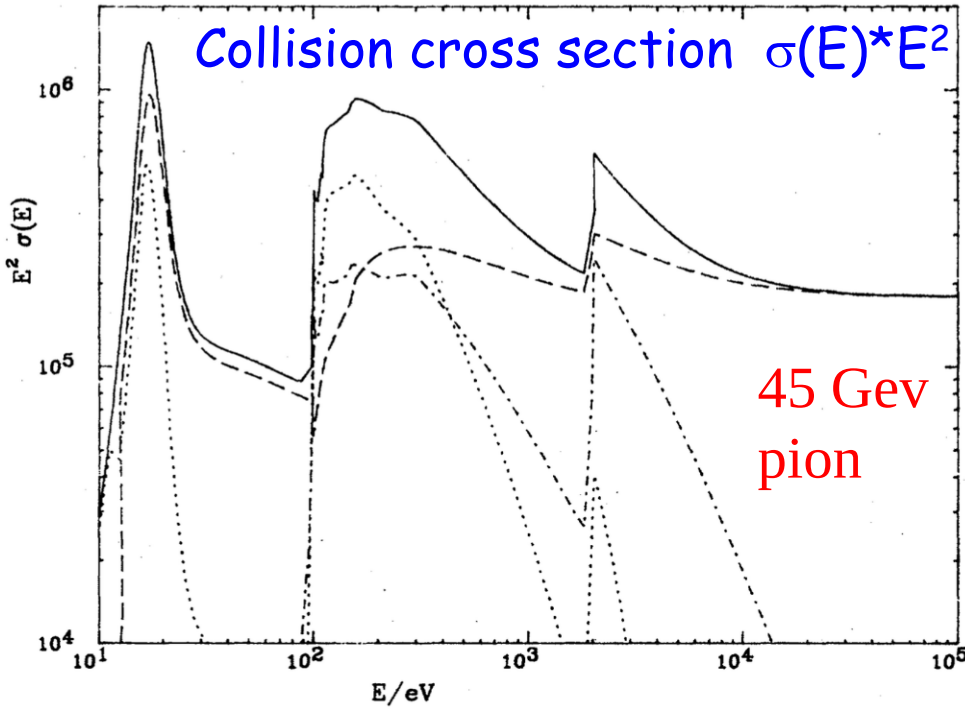
May be understood by a few, but not picked up by most simulations. Various kluges (e.g. Landau convoluted with Gaussian) help at limited thickness range and breakdown for very thin layers.

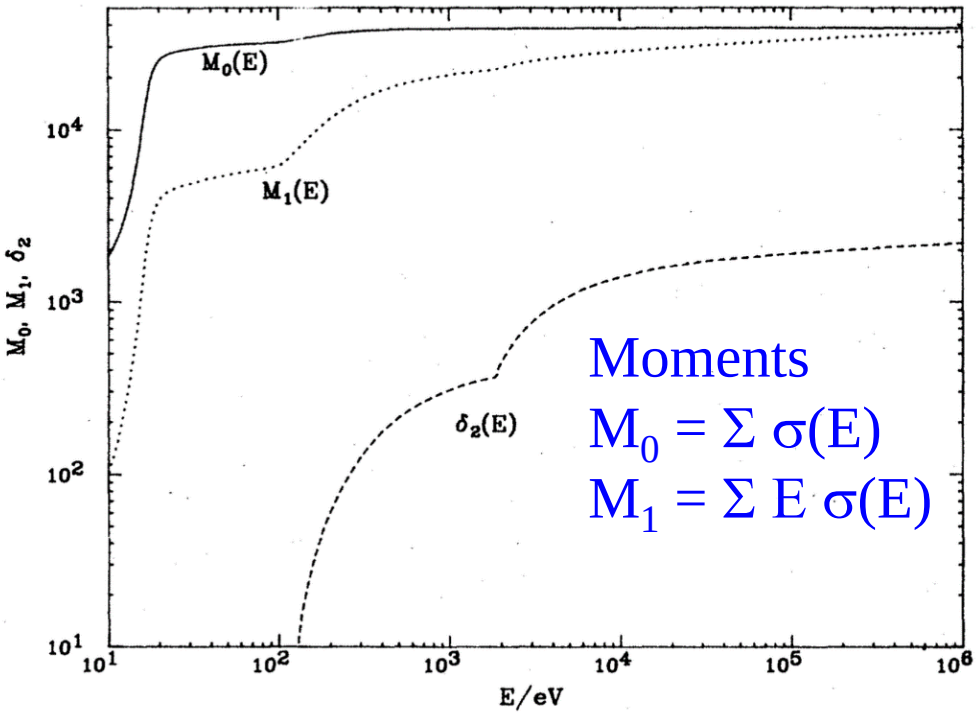
Not just a problem for silicon. Drift-chamber dE/dx for a single wire layer typically suffer similarly.

The only known method works for very thin silicon:

H. Bichsel, Rev. Mod. Phys. Vol 60, 663 (1988)

Atomic Collisions in Silicon





- ~4 collisions per μm but mostly very low loss (~17eV)
- Total E loss and fluctuation driven by the sporadic large E loss collisions.

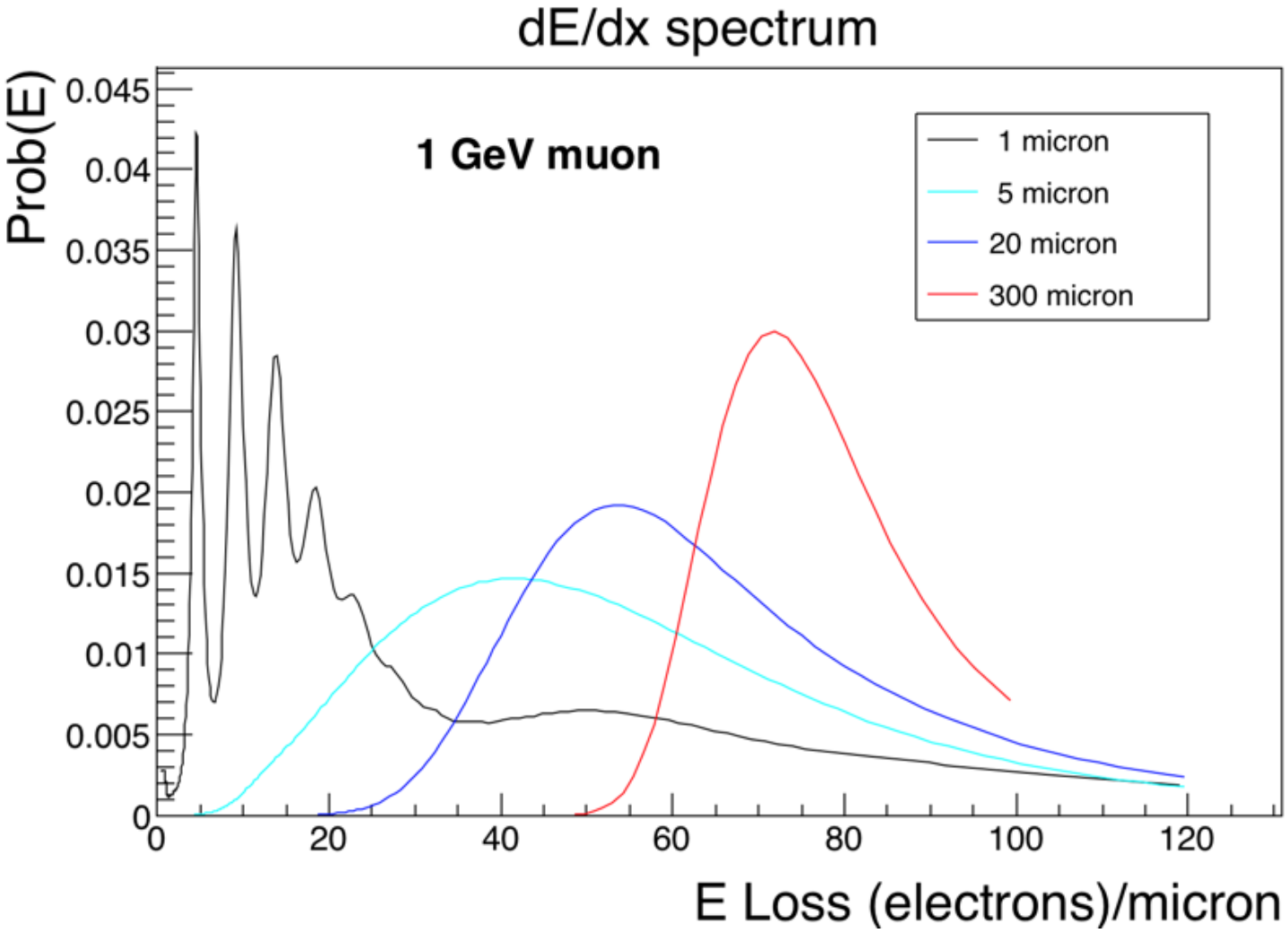
Bichsel Model

- Based the Bichsel RPM paper and Bichsel's private COV software (FORTRAN!) now can be obtained from:

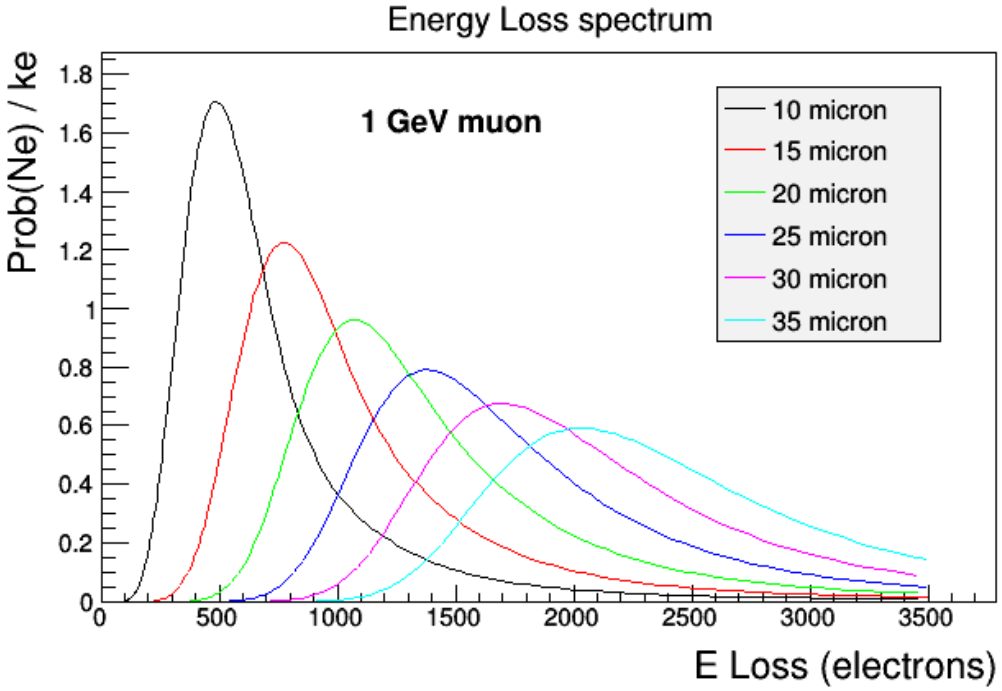
  http://www.slac.stanford.edu/~sudong/silicon/

  (see README file there)
- Single atomic collision cross section for different particles at different momenta.
- Using very thin layers (one collision) to 'fold' up to any particular thickness by doubling thickness at each stage.

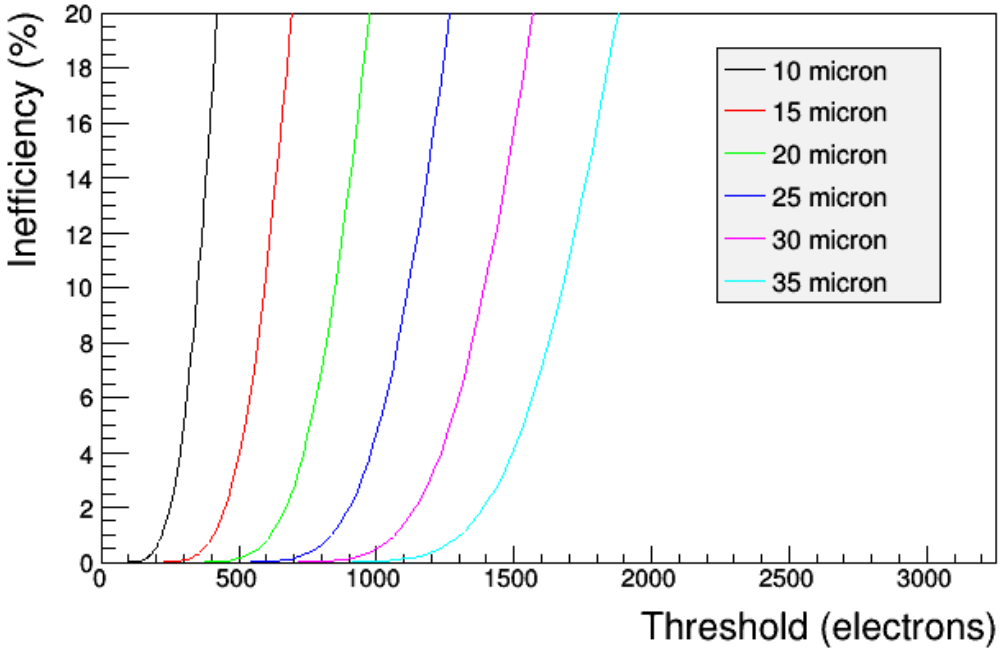
dE/dx is a misleading concept



Ionization loss spectrum is far from being scalable to different thicknesses as the naïve term dE/dx might suggest.



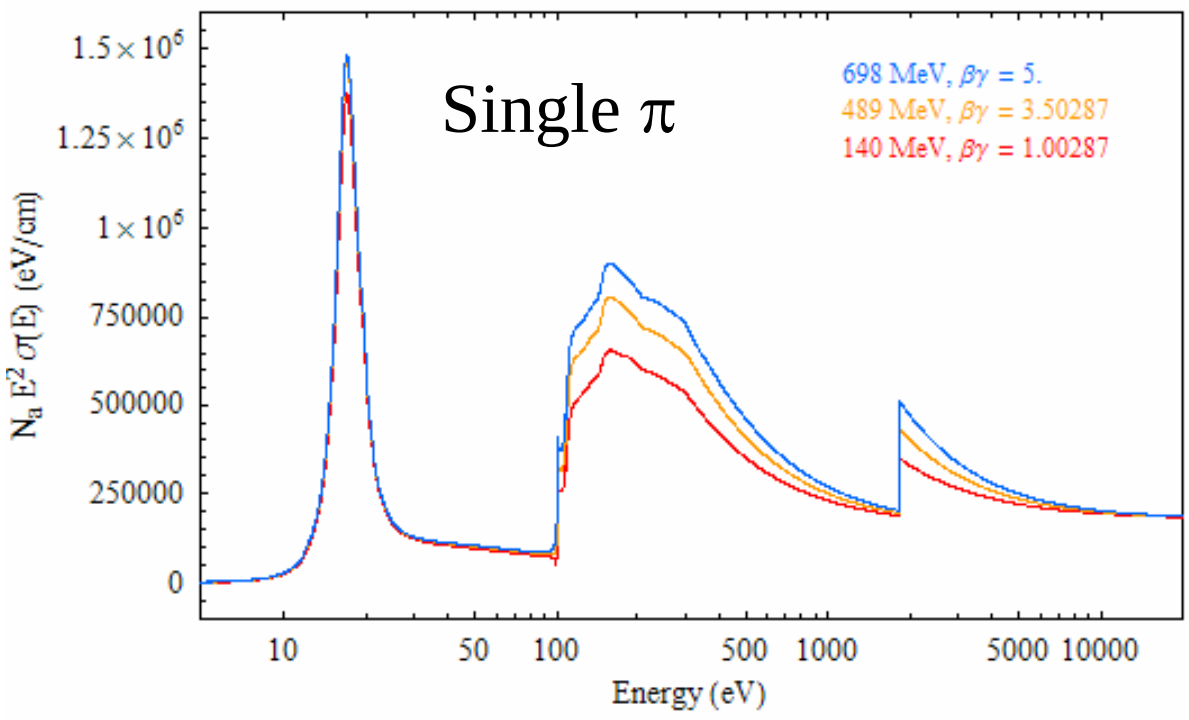
Examples of COV based plots



Investigation of thin silicon detectors for signal spectrum and threshold effects.

Parameterizing Bichsel Function

- Single atomic collision spectrum COV code
- Use the COV output as table a few $\beta\gamma$ to interpolate to all momenta.
- Simulation can generating individual collisions but needs to watch CPU time with conscious strategy.



The key difficulty is handling different $\beta\gamma$ factors.

Remarks on Simulation

- Implementation based on Bichsel single collision spectrum by Qi Zeng (SLAC) going into ATLAS pixel full simulation.
- Bichsel model is particularly important for very thin sensors. This includes detailed full simulation of irradiated detectors with great variation of behavior at different depths to necessitate fine slicing the silicon depth for simulation.
- Spectrum cut off needs careful coordination with G4 δ-ray threshold.