Software Compensation Considerations

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Software Compensation

Follow the procedure from software compensation paper draft https://arxiv.org/pdf/1705.10363.pdf

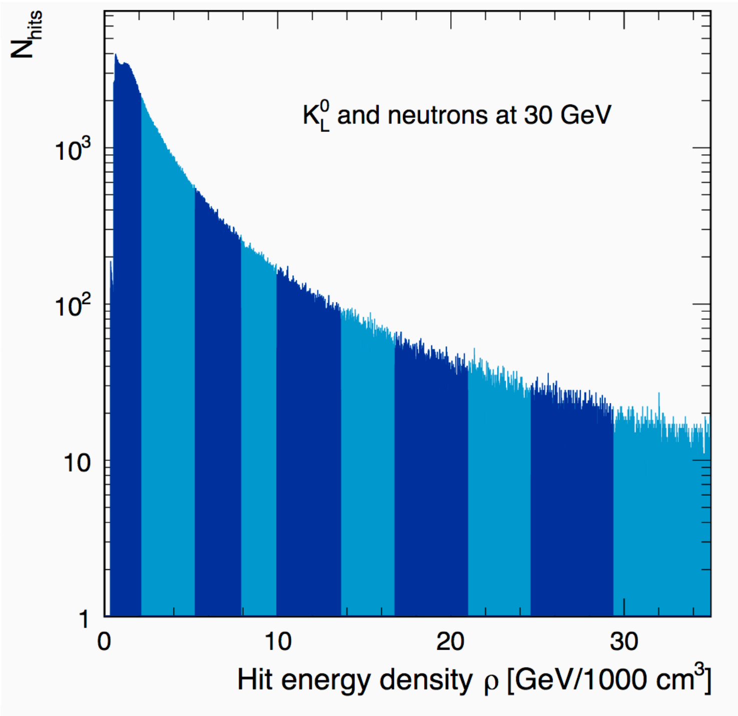

Fig. 2 Distribution of the hit energy density for a sample of K_L^0 and neutrons with 30 GeV energy. One MIP per cell corresponds to approximately 1 GeV / 1000 cm^3. The differently shaded areas show the subdivision into energy density bins used for the software compensation.

Idea: reweight the hits of the HCAL shower with a weight depending on the energy density (hit energy divided by cell volume) → electromagnetic component of the shower typically denser
→ weight is monotonically falling with energy density

The energy of calorimeter clusters are computed as:

$$E_{SC} = \sum_{\text{hits}} E_{ECAL} + \sum_{\text{bin } i} \left(E^i_{HCAL} \times \omega(\rho_i)\right)$$

$$\text{with } E^i_{HCAL} = \sum_{\text{hits} \in \text{bin } i} E_{hit},$$

$$\omega(\rho) = p_1 \exp(p_2 \rho) + p_3$$

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$$p_1 = p_{10} + p_{11} \times \mathrm{E}_{sum} + p_{12} \times \mathrm{E}_{sum}^2$$
$$p_2 = p_{20} + p_{21} \times \mathrm{E}_{sum} + p_{22} \times \mathrm{E}_{sum}^2$$
$$p_3 = \frac{p_{30}}{p_{31} + e^{p_{32} \times \mathrm{E}_{sum}}}.$$

The three parameters depend on the energy of the cluster
→weight shape changes quite a bit for different input hadron energies

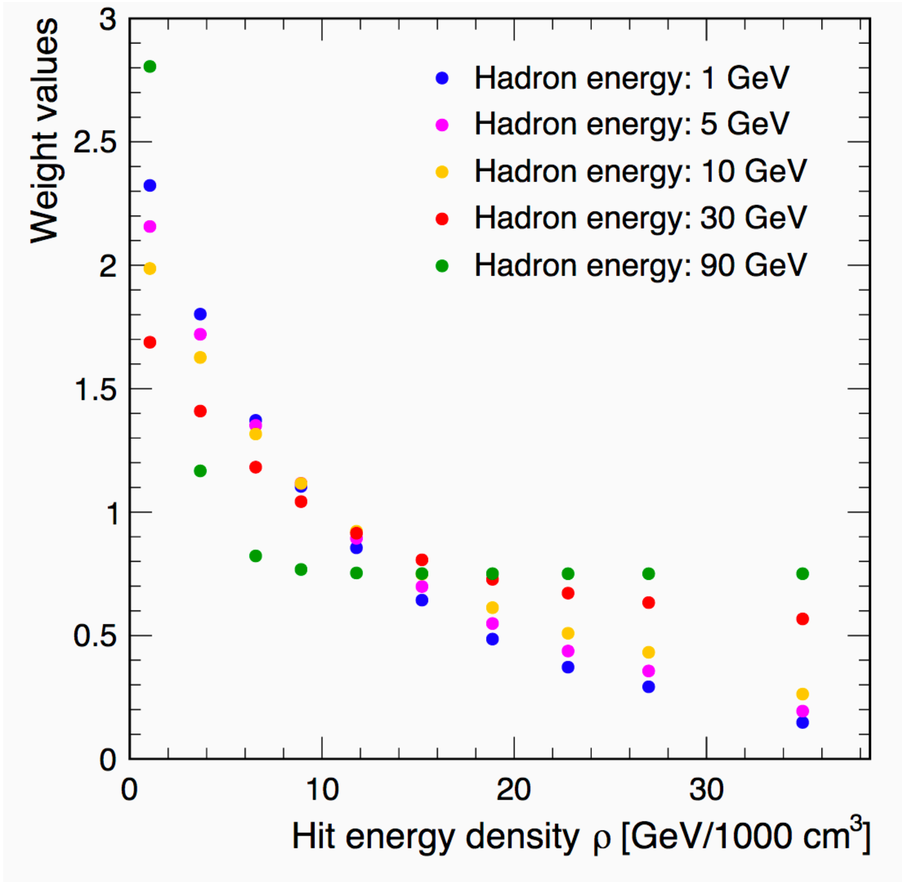
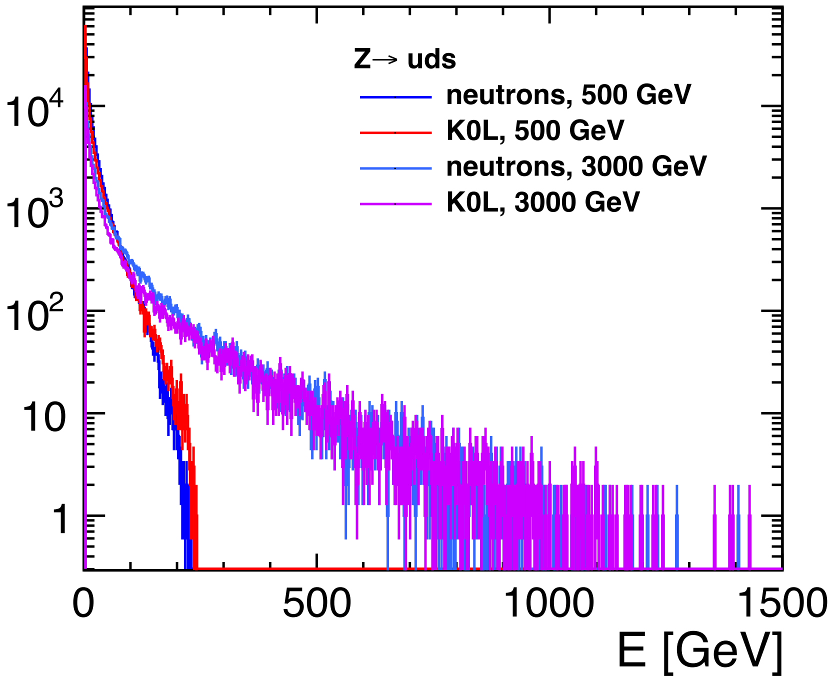
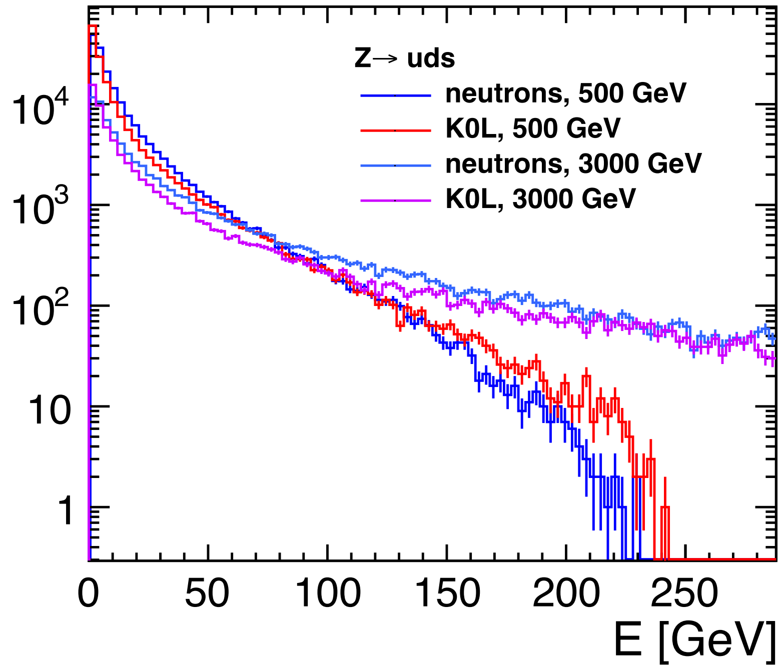


Fig. 3 Software compensation weights as a function of hit energy density for different hadron energies, derived from Eq. 1.

Hadron spectrum for CLIC (Zuds 500 vs Zuds 3000 GeV)

For 500 GeV dataset neutral hadron energies beyond 90 GeV are 1.9 %, for 3000 dataset 13.7 % → if we want same coverage of neutral hadron energy spectrum need to calculate weights for samples up to 400 GeV (1.7 % beyond that point for 3000 GeV sample)





Weight determination

Software compensation weights are determined by minimisation of a χ^2 like function using all energy points and densities up to 30 GeV/1000 cm^3

$$\chi^2 = \sum_{\text{events}} \frac{(E_{\text{hadron}} - E_{SC})^2}{(0.5)^2 E_{\text{hadron}}}$$

Overflow of densities beyond this point amount to 0.7 % to 3.1 % from 1 GeV to 90 GeV, at 250 GeV to 4.7 % and 5.9 % at 500 GeV (larger energies not necessary)

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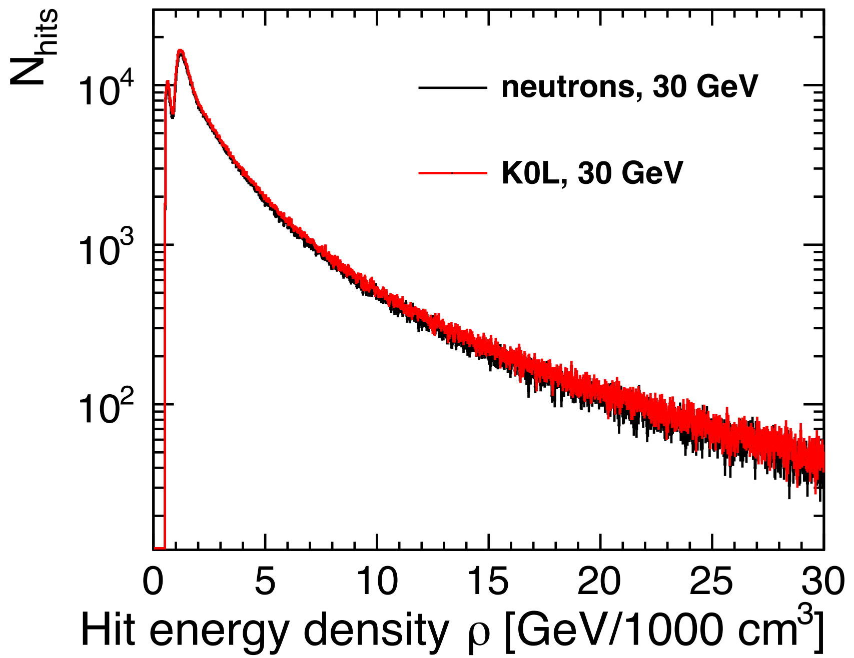

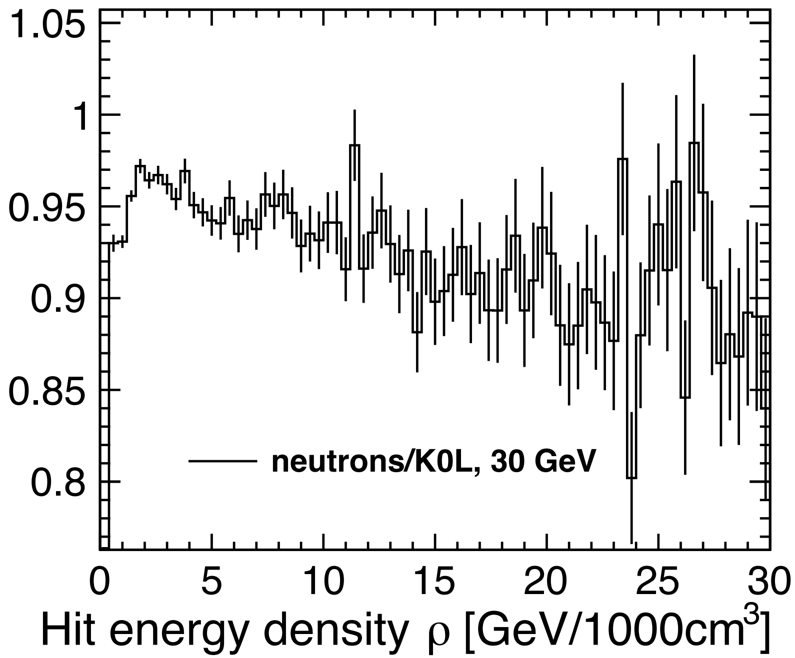

Our spectrum looks slightly different than ILD's, preselection: exactly one cluster reconstructed (maybe condition more fullfilled for K0L's)

Hit energy density for 1000 GeV neutral hadrons

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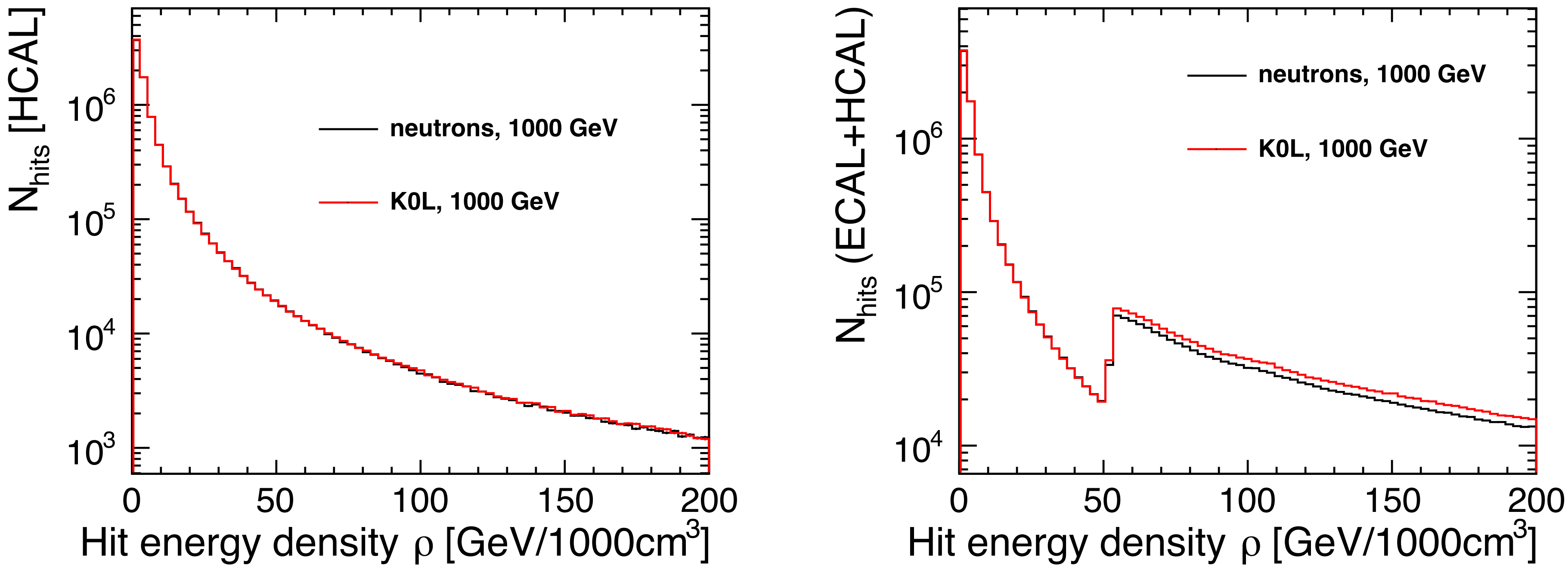

Quite a few hits with high energy density, ECAL densities start at 50 GeV/1000cm^3 (ECAL hits not reweighted at the moment)