Photon reconstruction in ILD with GARLIC

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GARLIC - An algorithm for GAmma Reconstruction at the LInear Collider

- Try to improve clustering of photon contribution in jets
- Implemented in the MARLIN software framework
- For SiW ECAL: Prototype + ILD version (different cell sizes)
- Steering parameters available for tuning
- Clustering based on neighbour criterion
- Designed for pointing photons
- Works over whole solid angle
- Rejection via simple criteria (#hits, minimum energy, seed criteria,...)
- + Computation of cluster variables (eccentricity, width, direction, energy deposit in different regions,...) - ANN
- Correction for wafer guard ring and module gaps
GARLIC for ILD
GARLIC on taus
GARLIC for the SiW ECAL prototype
GARLIC

Pre-Clustering via hit distance: RoI
- Remove hits close to extrapolated tracks

Per RoI:
- Seed finding: 2-dim energy projection

Per Seed:
- Core building (hits close to seed axis)
- Neighbor clustering (front to back)
- Simple verification (min.en/hits,dist track)
- Gap correction
- ANN rejection
- Satellite merging
- Final energy estimation

- Recursive with 20cm 3d distance
GARLIC

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- Distance variable (default: 2 times cell-size)
- Important for rejection of charged hadrons
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• First 20 layers = \(\sim 0.5\lambda\)
• Use 12 first layers \((7X_0)\)
• Projection depends on seed position:
  – Barrel: cylinder
  – Endcap: plane
  – Overlap: sphere
• Regroup histogram entries
• Seed validation with min en/hits
• List of seeds ordered by energy
Pre-Clustering via hit distance: RoI
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- Pointing photons: shower direction is IP → seed
- Add hits with distance < 1*cell size from main axis
- Minimum hits in 10X₀
- Reject longitudinal holes (one than 1 layer) in 2ⁿᵈ stack
Pre-Clustering via hit distance: RoI
Remove hits close to extrapolated tracks

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- Proceed from front to back
- Several iterations (default: 3)
- Variable distance (default: $\sqrt{2} \times \text{cell size}$)
- Same layer and two following
- Check for module/wafer gaps
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- 150 MeV minimum En
- 5 hits minimum
- 1.5*cell size distance from nearest track
GARLIC

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- Conservative approach
- Add „Ghost hits“ in gaps with linear extrapolation of surround hits
- Weighing by (gap area/cell size), cluster energy and θ
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- Several variables using longitudinal, transverse or overall shower shape
- Cuts per energy region (<20GeV) and location (endcap - barrel)

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• Remerge split showers
• Criteria
  – Distance
  – Energy ratio
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Per RoI:
Seed finding: 2-dim energy projection
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- Geometrical corrections
- Energy estimation with two 2\textsuperscript{nd} order polynomials connected at 20GeV
- More precise energy estimation with fitted prefactors for 1\textsuperscript{st} /2\textsuperscript{nd} stack and number of hits
Single photon efficiencies

Uniform efficiency, except critical areas: barrel-endcap overlap, module transitions

Works down to 150MeV
Efficiency:
>94% @ 500 MeV
98% @ 1GeV
>99% for E>2GeV
Rejection efficiencies

Interactions in the tracker region double the number of fake clusters (real $\pi^0$ that are impossible to reject)

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Jets: $u\bar{u}$ at 500GeV

Visible photons: $E>150$MeV, pointing to ECAL volume

Correlations look good
Several cases where a big photon from radiative return to Z pole is lost
Jets: $u\bar{u}$ at 500GeV

Fraction of photons lost due to inefficiency and interaction
Part wise recovering of converted photons + fake clusters
Fake energy mostly from pion interactions
Conclusions

Satisfying performance:
- High, uniform efficiencies down to low energies
- Low level of fake clusters
- Good performance in jets
- Works with different cell sizes
- Easily tunable for different physics needs

But:
- Gap correction needs a more intelligent approach
- Establish criteria for neutral hadron rejection at high energies
- Refine geometrical corrections if necessary
- Need to loosen criteria where distance to track is used when going to 1TeV
- Still a rather private tool...