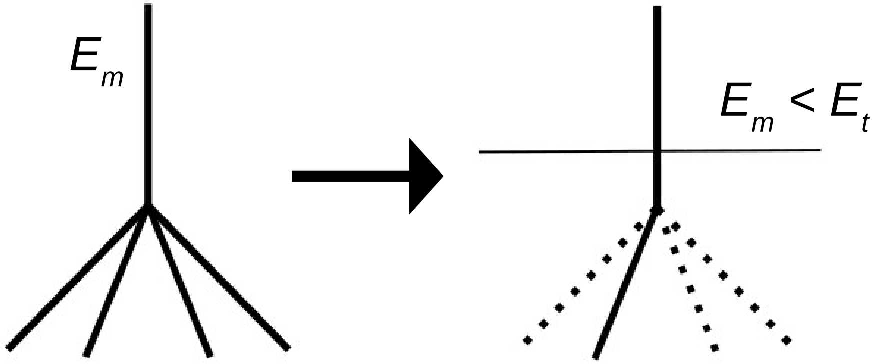
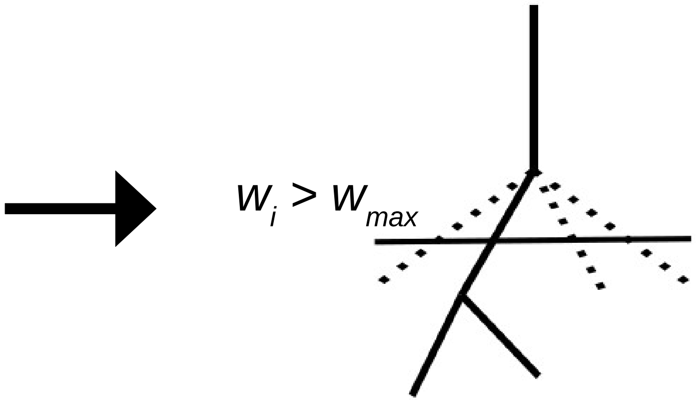
Implementation of Thinning

- 2 parameters influence thinning:

$$\varepsilon = \frac{E_t}{E_0} \qquad\qquad w_{max}$$



- 5 different thinning-modes
- differ in the method of thinning and the interpretation of w_{max}



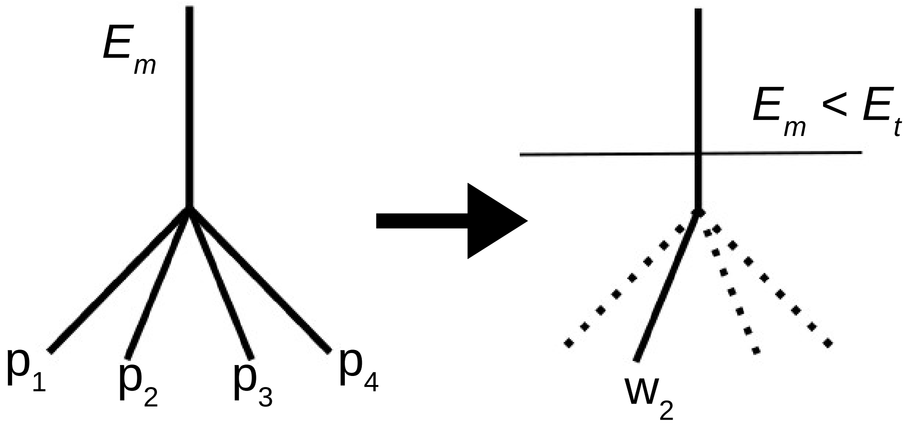
Thinning methods

- energy based methods:

$$p_i = \frac{E_i}{E_m}$$

- weights get attached to remaining particles:

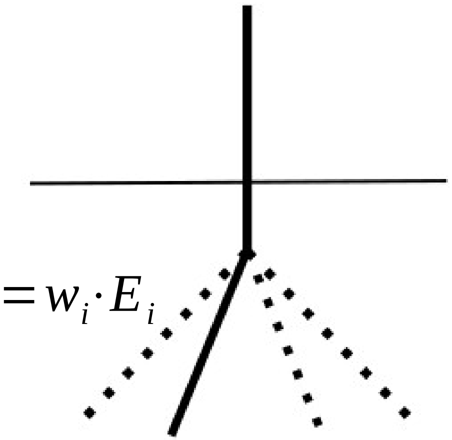
$$w_i = \frac{w_m}{p_i}$$



Thinning methods

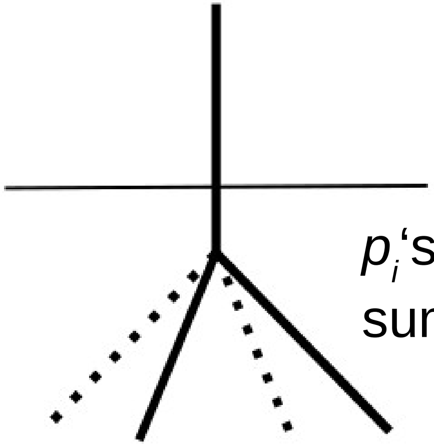
- total number of particles: $\langle N \rangle = \sum_i p_i \cdot w_i = \sum_i 1 = N_{total}$
- total energy: $\langle E \rangle = \sum_i p_i \cdot w_i \cdot E_i = \sum_i E_i = E_{total}$

Hillas

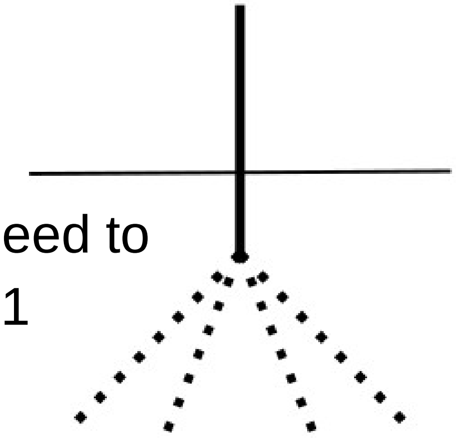


$E_{total} = w_i \cdot E_i$

Statistical



p_i's don't need to sum up to 1

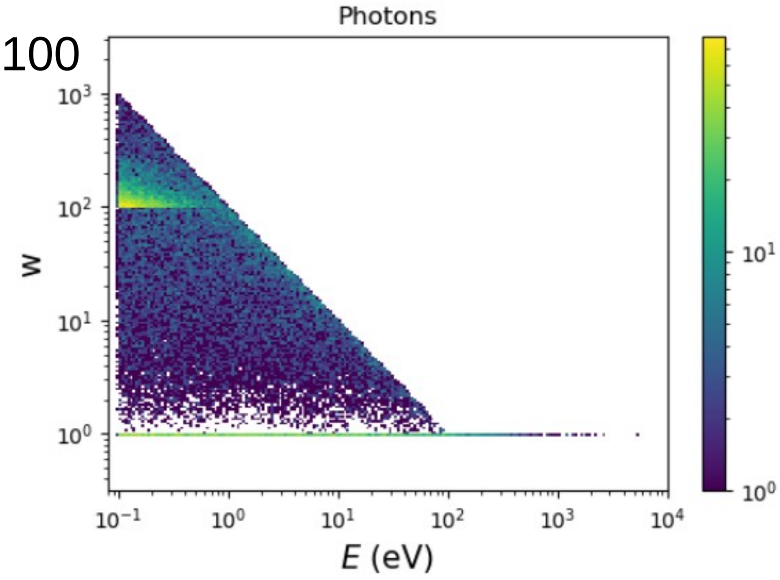


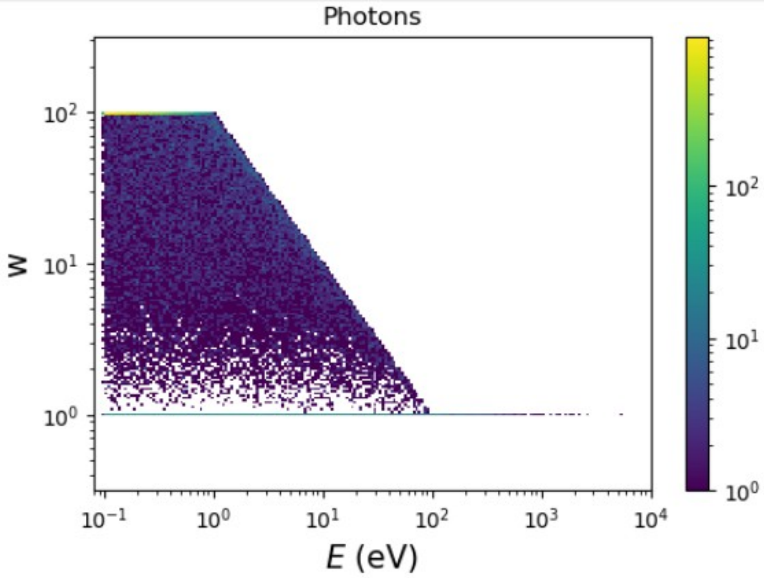
Interpretation of w_{max}

- soft border: thinning stops after $w_i > w_{max}$
- hard border: p_i is set to $p_{min} = \frac{w_m}{w_{max}}$ and w_i is set to w_{max}

$\varepsilon = 10^{-5}$

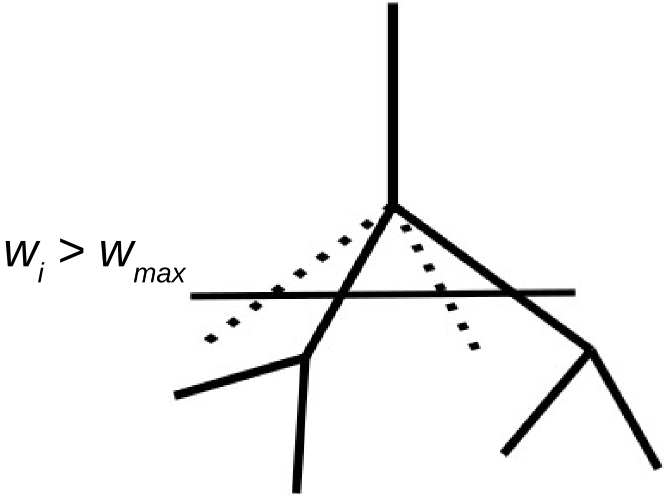
$w_{max} = 100$





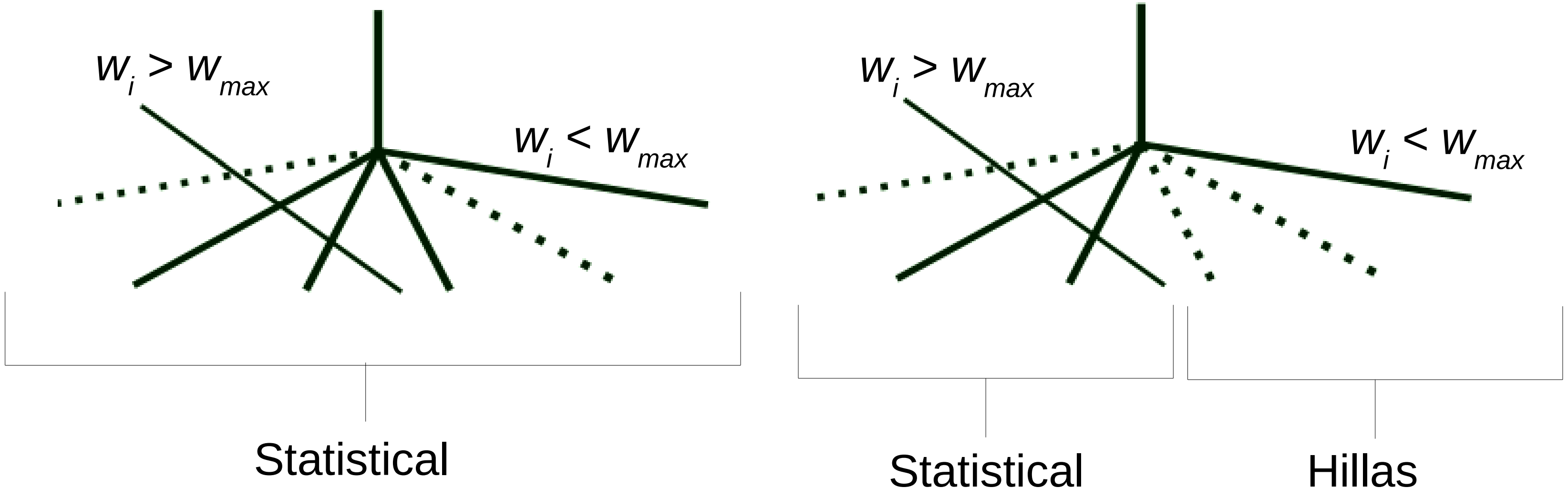
Hard border with Hillas-thinning

- change of p_i's $\longrightarrow$ $\sum_i p_i \neq 1$
- solution: at the border statistical thinning is used



Hard border with Hillas-thinning

- 2 ways of implementing:



5 thinning-modes

Hillas with soft border

(SoftO)

Hillas with statist. hard border

(HardO_S)

Hillas with mixed hard border

(HardO_SO)

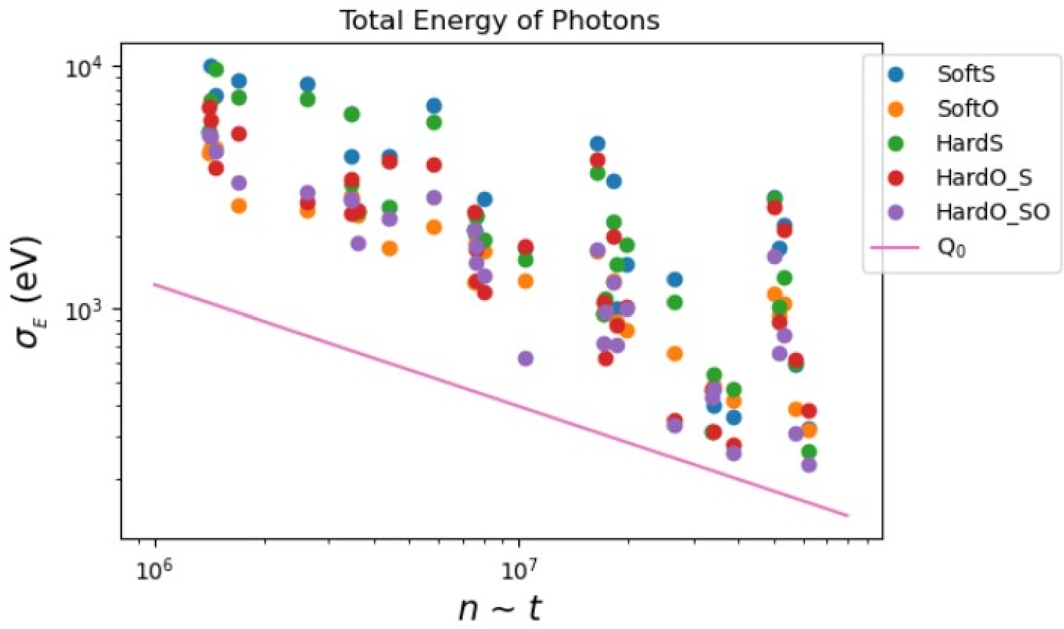
$$Q \propto \frac{1}{\sigma \sqrt{t}}$$

Statistical with soft border

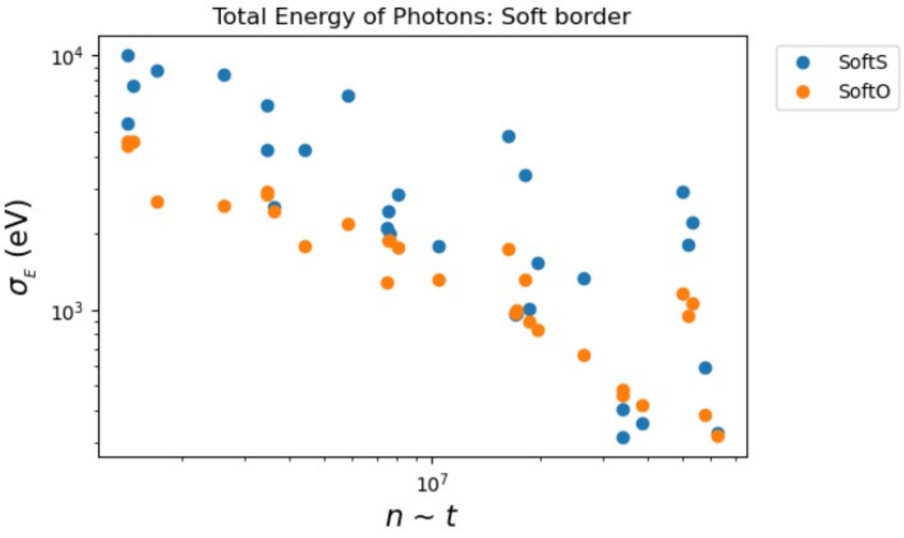
(SoftS)

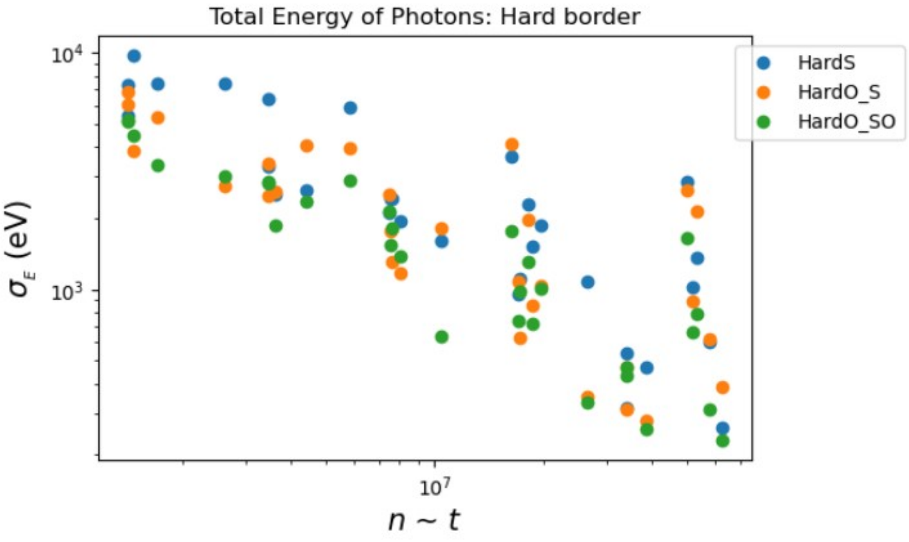
Statistical with hard border

(HardS)

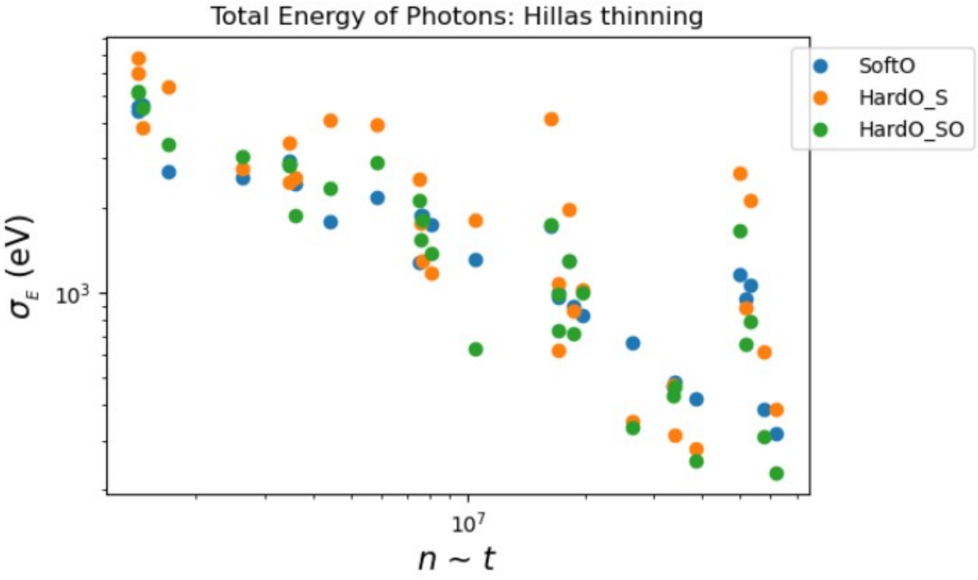


Hillas vs. Statistical

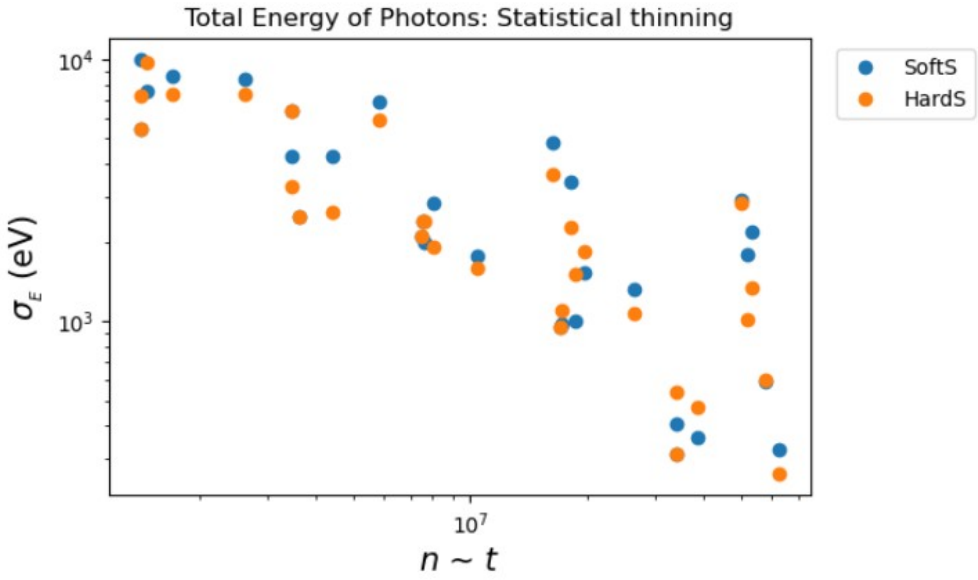




Hard vs. Soft



Total Energy of Photons: Hillas thinning
SoftO
HardO_S
HardO_SO
σ_E (eV)
10^3
10^7
$n \sim t$



Total Energy of Photons: Statistical thinning
SoftS
HardS
σ_E (eV)
10^4
10^3
10^7
$n \sim t$

Conclusion

- Hillas thinning has higher quality than statistical thinning
- for a hard border it is better to choose mixed thinning method
- soft border is faster
- (mixed) hard border has lower fluctuations