

Using FOAMs to Approximate Probability Densities for $t\bar{t}$ Processes

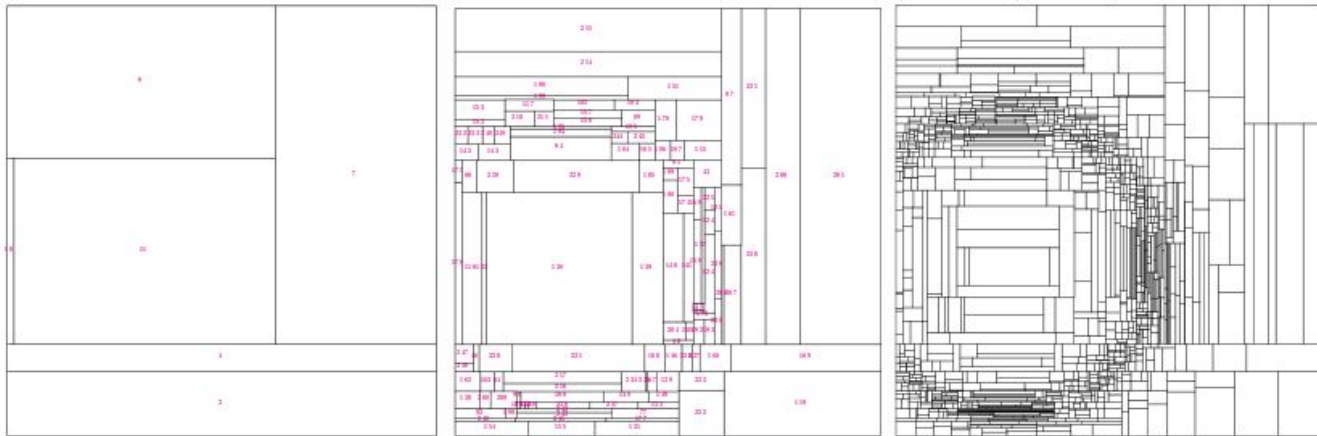
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ATLAS (EP-ADE-CA)

Background: Monte Carlo Simulations

- ◆ Obtain numerical results for problem via a probabilistic analogue
- ◆ Applications are incredibly widespread
 - Mathematics: integration and optimization problems
 - Finance: risk analysis, investment predictions
 - Signal processing, fluid dynamics, ion implantation, etc...
- ◆ [Summer Student Lecture by Bryan Webber \(Cambridge\)](#) [1]
- ◆ Specific to particle physics: want to generate particle collision/decay chains, integrate over them, and extract meaningful parameters.

Background: FOAM

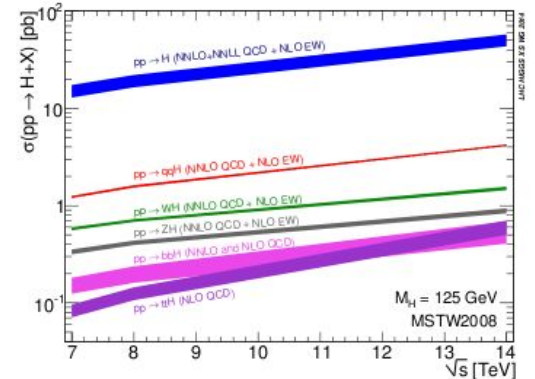
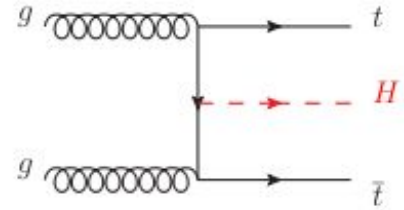
- ◆ FOAM models functions via a recursive cellular division algorithm. [2]



- ◆ Specifically, it can store an MC-distribution in a comp. efficient way.
- ◆ MC events can be generated very efficiently from this format.
 - But FOAM only converges to distribution after many cell divisions.
 - Number of cells needed is highly dependent on function sampled.

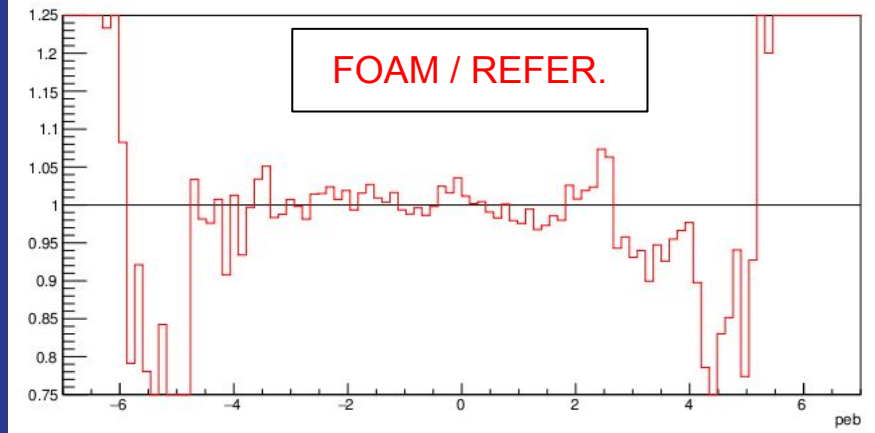
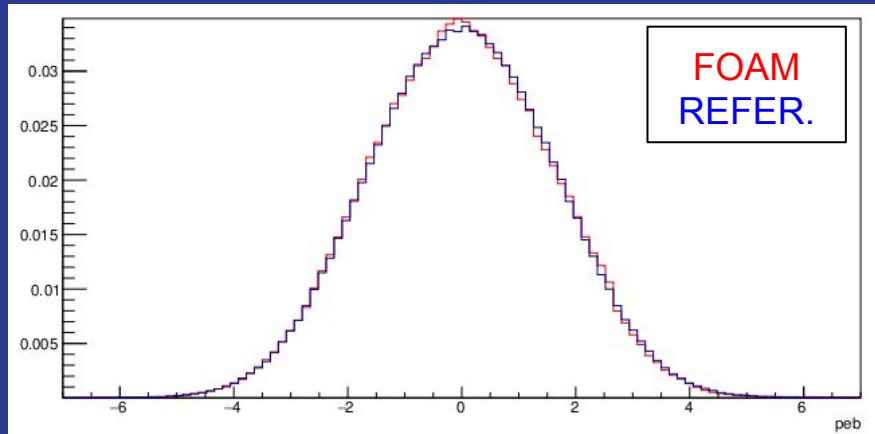
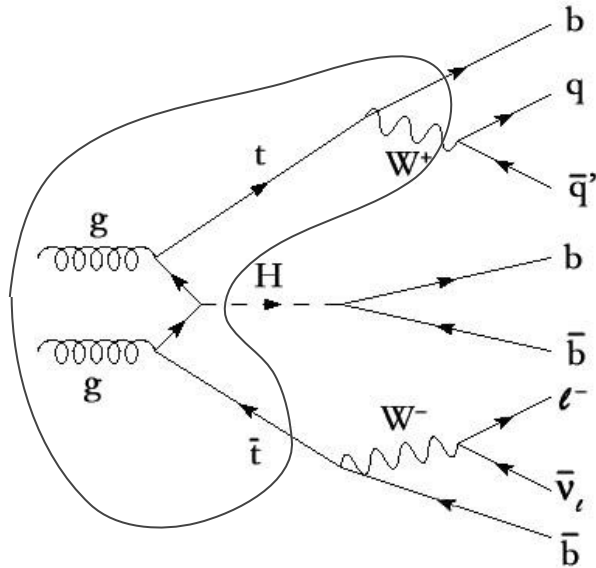
Application: ttH

- ◆ ATLAS Experiment: general-purpose detector for SM and BSM physics.
- ◆ ttH: rare Higgs production mode, interesting because sensitive to top Yukawa-coupling.
- ◆ Matrix Element Method (MEM) is powerful here.
 - Evaluates consistency of measured event with a hypothesis, specifically using the ttH “likelihood ratio” as a discriminant [3].
- ◆ Effective, but very computationally intensive.
- ◆ FOAM should supplement MEM by improving efficiency of MC event generation.



Example simulation

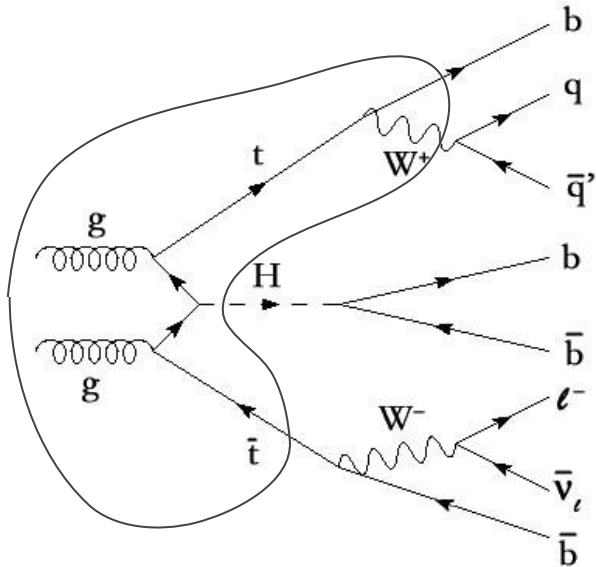
Investigating lower-dimensional subsets of full ttH diagram:
Overall success!



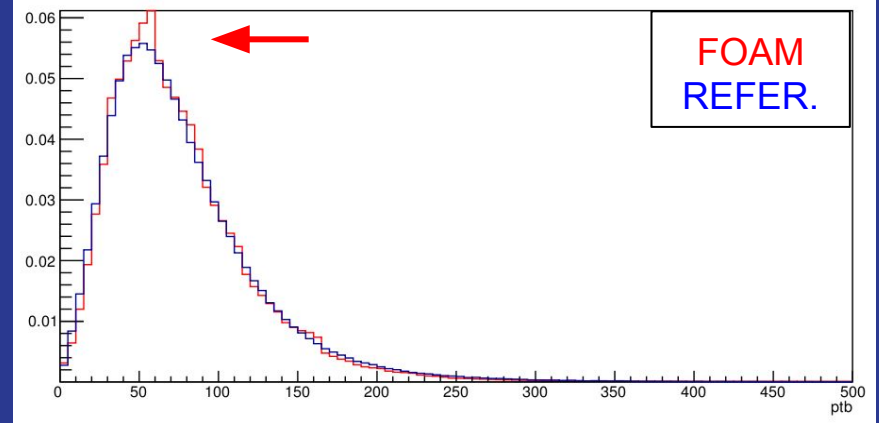
D = 7 $g g > t \bar{t}$ with $(t > b w^+)$

Example simulation

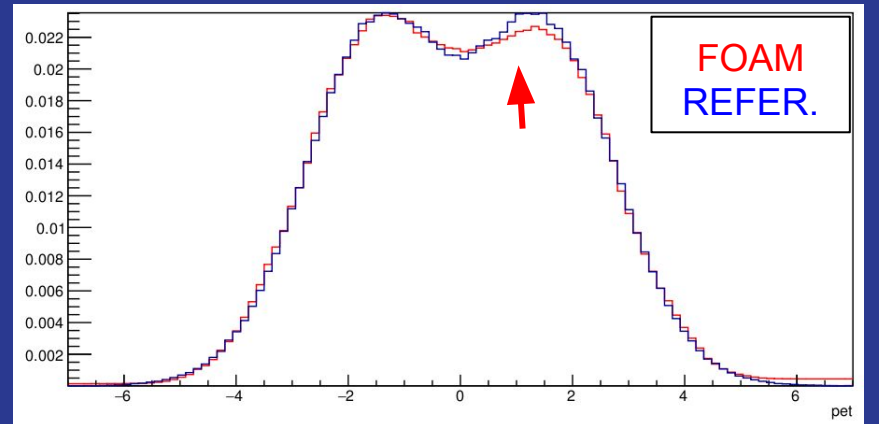
Lingering asymmetries...
Are they connected?



[4]



Transverse momentum of b

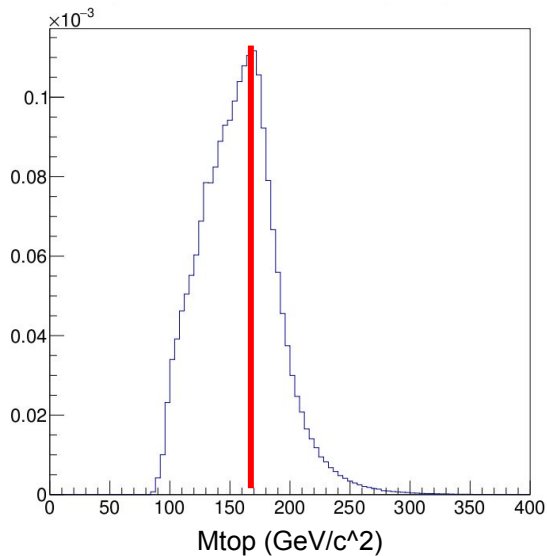
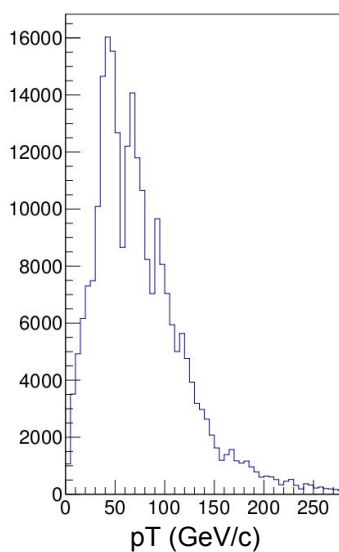


Pseudorapidity of \bar{b}

Investigating further

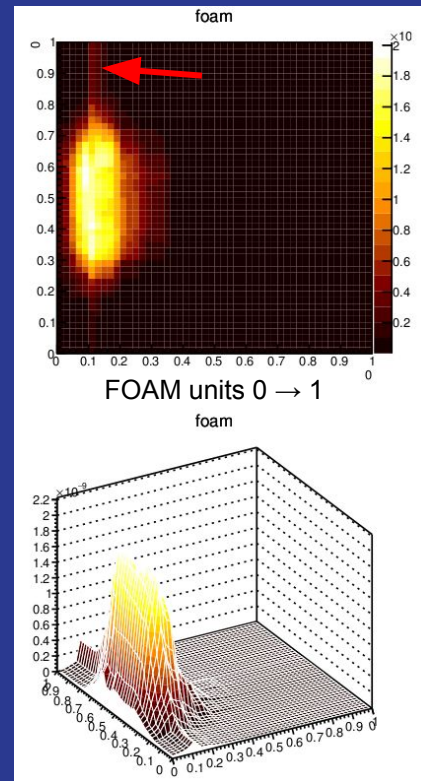
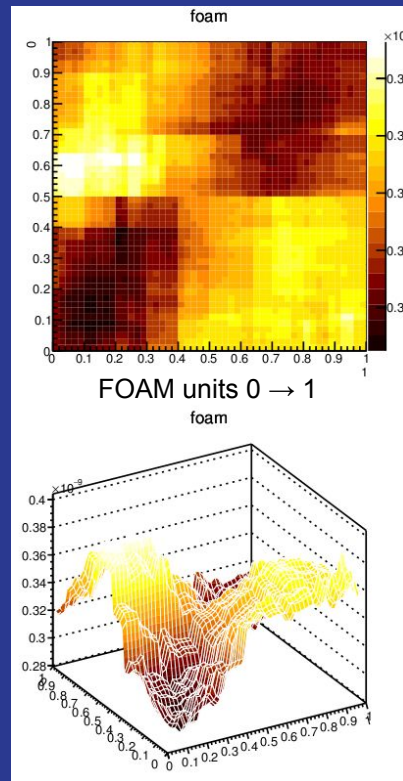
Extracted and plotted split locations for each dimension.

Calculated top resonance mass from b and W+ momenta.



Plotted all 2-d projections of FOAM (only 2/7, but better than 1/7!).

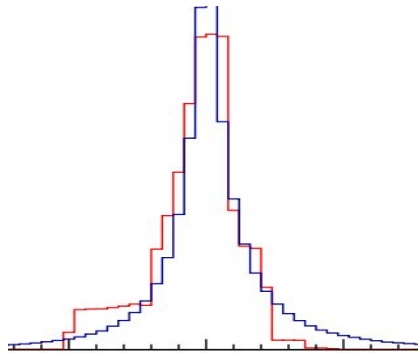
Two interesting features, in b.phi vs W+.phi & b.pT vs tbar.eta



Conclusions

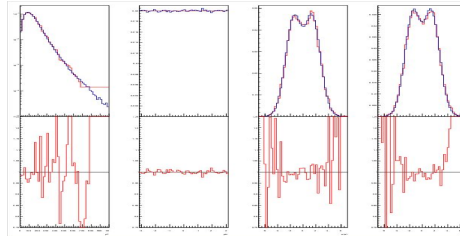
The Challenge

Rate of FOAM convergence decreases rapidly in higher dimensions, especially with strong peaking.



Progress So Far

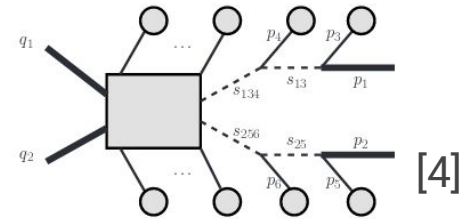
Implementation of 7-dimensional FOAM for $g > (t > bw+) tbar$ process.



Development of tools for building and evaluating FOAMs with different choices of variables.

Ongoing Work

Extending techniques to $g > (t > bw+) (tbar > bbar w-)$, general decay chains.



Assembling all developed tools into cohesive package for interfacing with FOAM.

Works Cited:

- [1]: Webber, Bryan. “Introduction to Monte Carlo Techniques.” CERN Summer Student Lectures. 31 July 2017, Meyrin, Switzerland.
- [2]: Jadach, S. “Foam: A General-Purpose Cellular Monte Carlo Event Generator” arXiv:physics/0203033 [physics.comp-ph]
- [3]: Search for the Standard Model Higgs boson produced in association with tt and decaying into bb at 8 TeV with the ATLAS detector using the Matrix Element Method - Nackenhorst, Olaf CERN-THESIS-2015-186
- [4]: Automation of the matrix element reweighting method - Artoisenet, Pierre et al. JHEP 1012 (2010) 068 arXiv:1007.3300 [hep-ph] CP3-10-27, RM3-TH-10-17



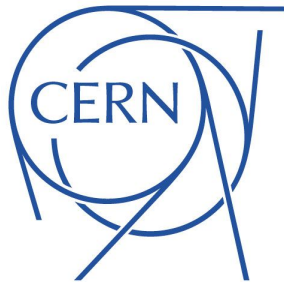
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Any Questions?

