SuperB EMC FastSim under high background

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FastSim? Not so fast

- We found out that, while running FastSim mixed with “normal” background level the speed is acceptable, running at 5x background is way too slow.
  - To increase background in FastSim, we increase bunch-crossing frequency.
- The time per event grows far worse than linearly as the background level increases.

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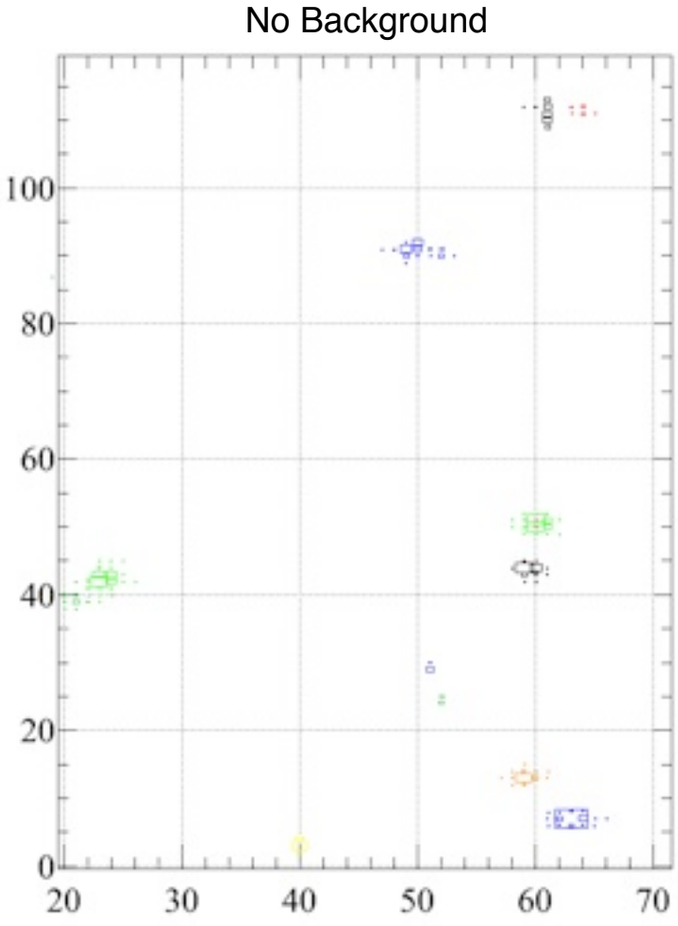
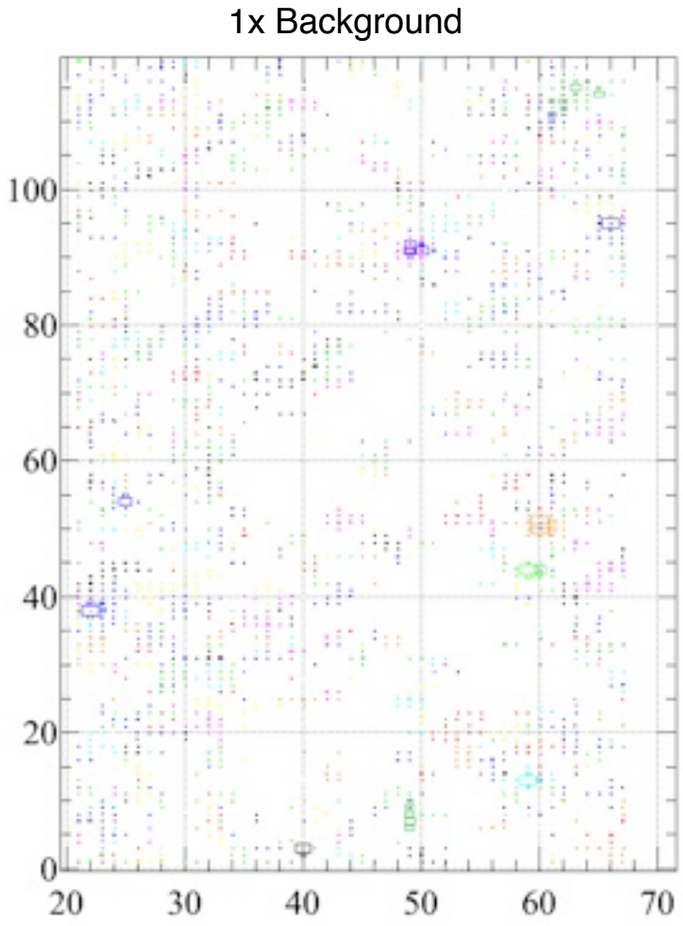
CPU time per event (ms/event) consumed by modules (running 10 B0B0bar events)

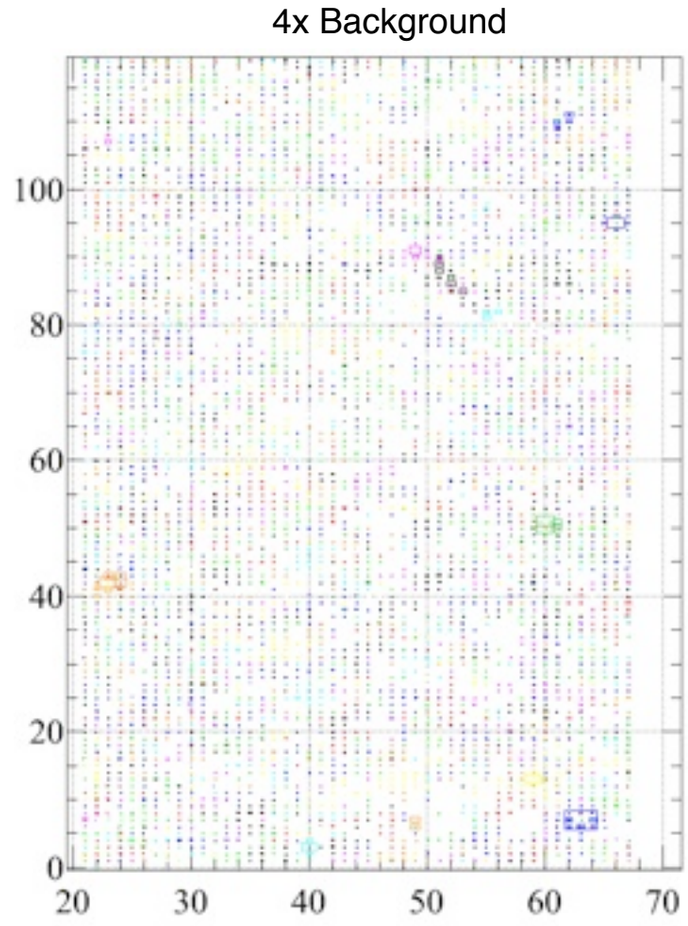
Module	no bkg	1x	2x	3x	4x
PmcReconstruct	205	340	572	917	1191
PmcSimulate	60	176	290	522	625
BtaLoadMcCandidates	0	303	1671	8987	16147
PacCaloSplitMerge	1	190	3086	18178	54315
PmcRadBhabhaNeutronBkgInput	0	177	227	336	319
RacTestInput	6	80	158	317	366

Old algorithm

- Each SimTrack produces one cluster. It is then split to single bump clusters if necessary. All pairs of clusters are then tested to check if they can be merged to a single bump cluster.
- Pairing is O(N^2). Other operations in each merging process make it worse than O(N^2). It won't work if N ~ hundreds.



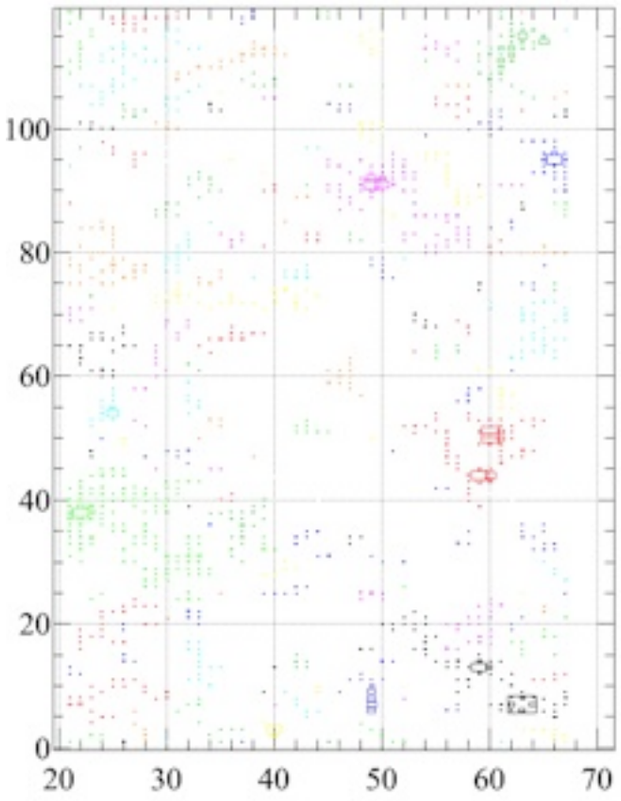




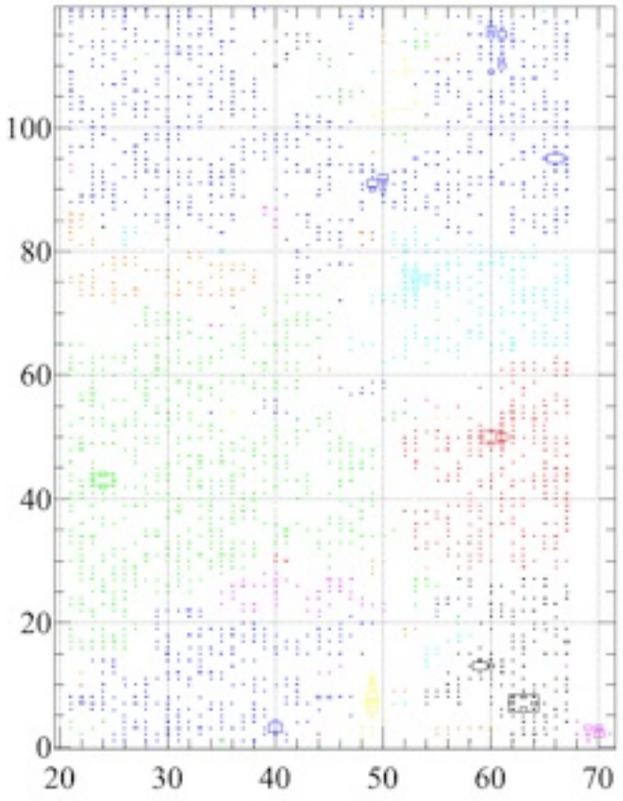
Smarter clustering

- Each SimTrack produces a cluster. Fill the energy in a map of crystals. Select seeds and build clusters, and then split them up to single bump clusters.
- First test: cluster is defined as connected crystals with more than 0.5 MeV.

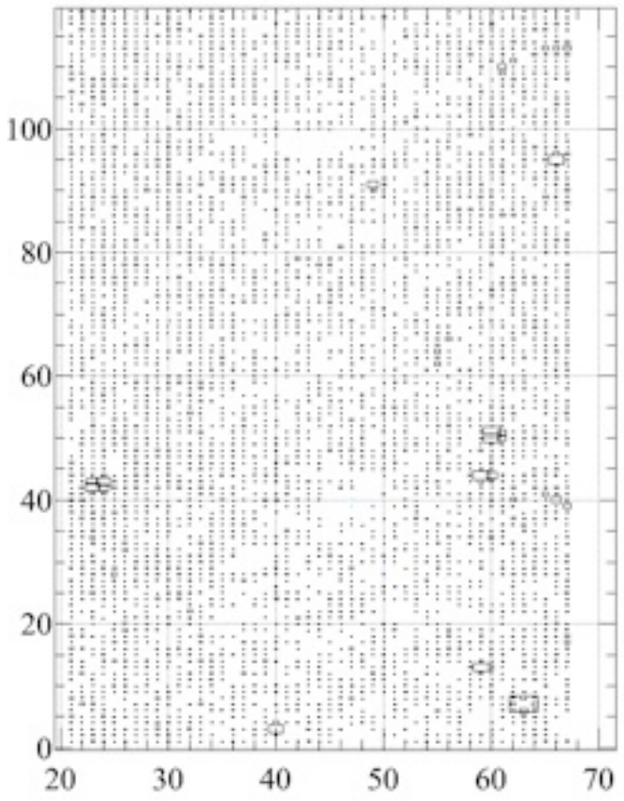
1x Background



2x Background
Very large clusters



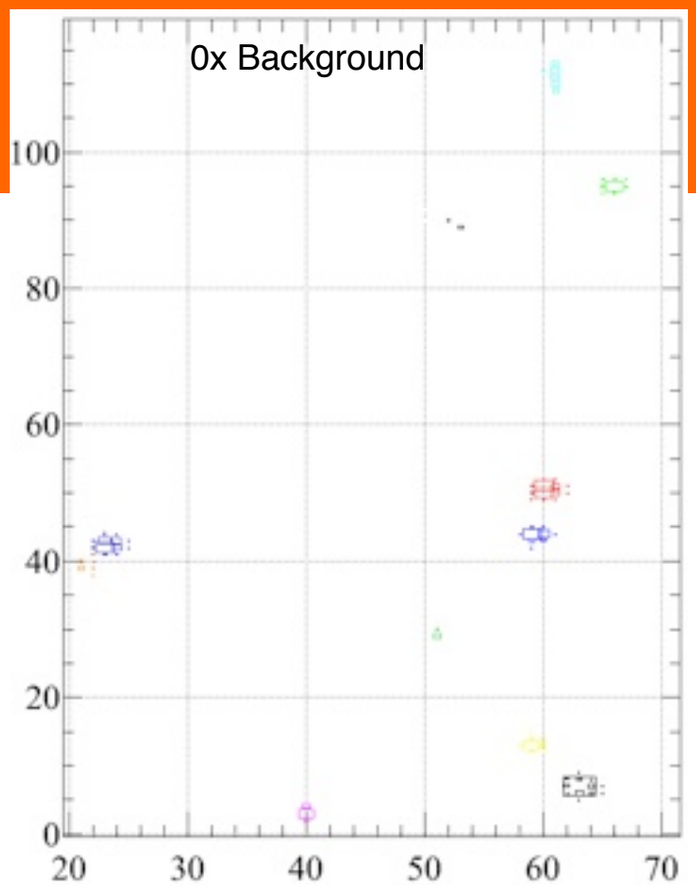
5x Background
One giant cluster, almost everyone is connected

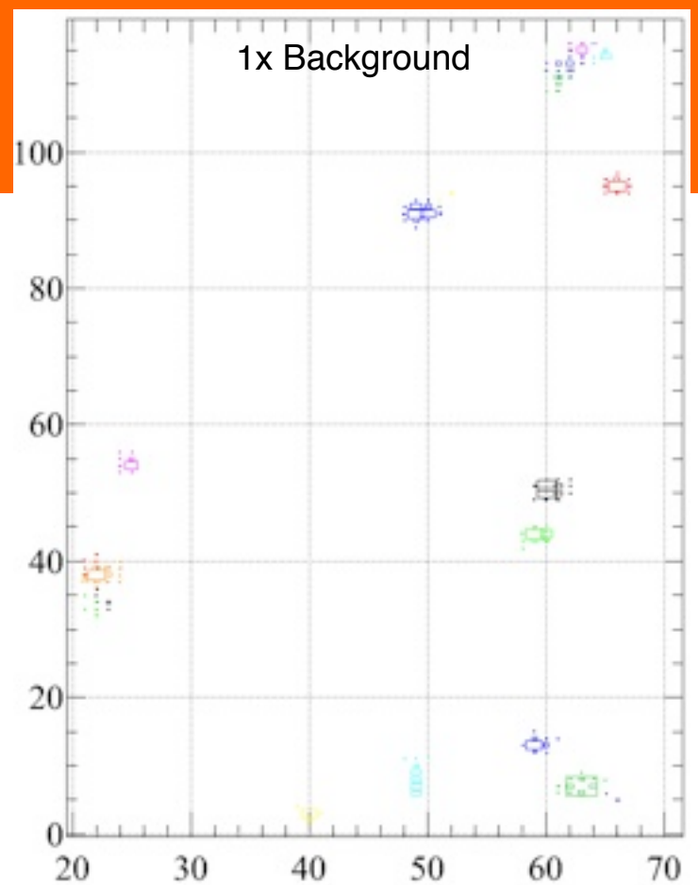


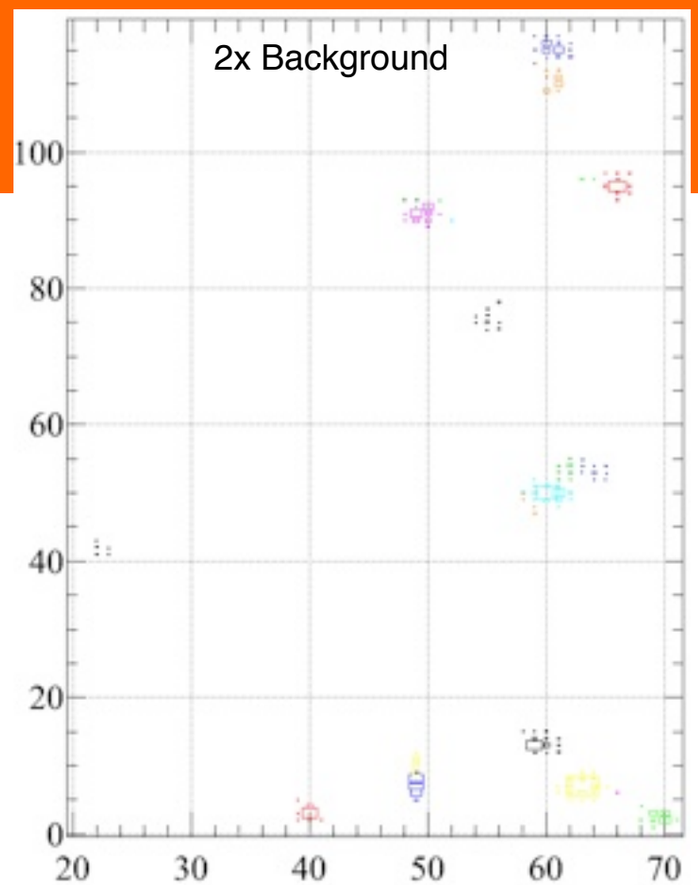
Even though clustering takes a short time to do, splitting up large clusters is not possible because splitting is an iterative process that calculating each crystal's contribution to each bump.

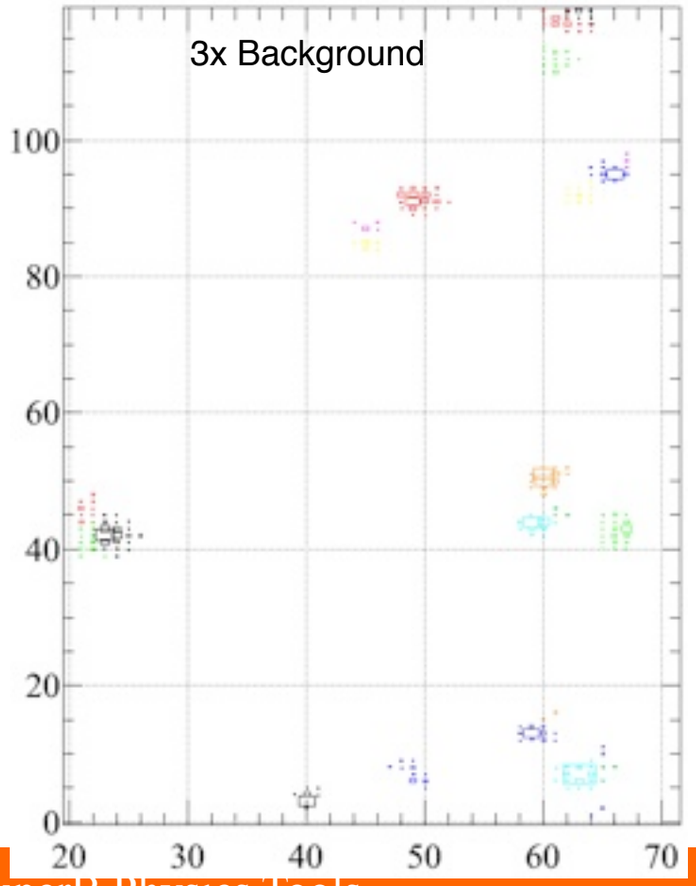
Improved algorithm

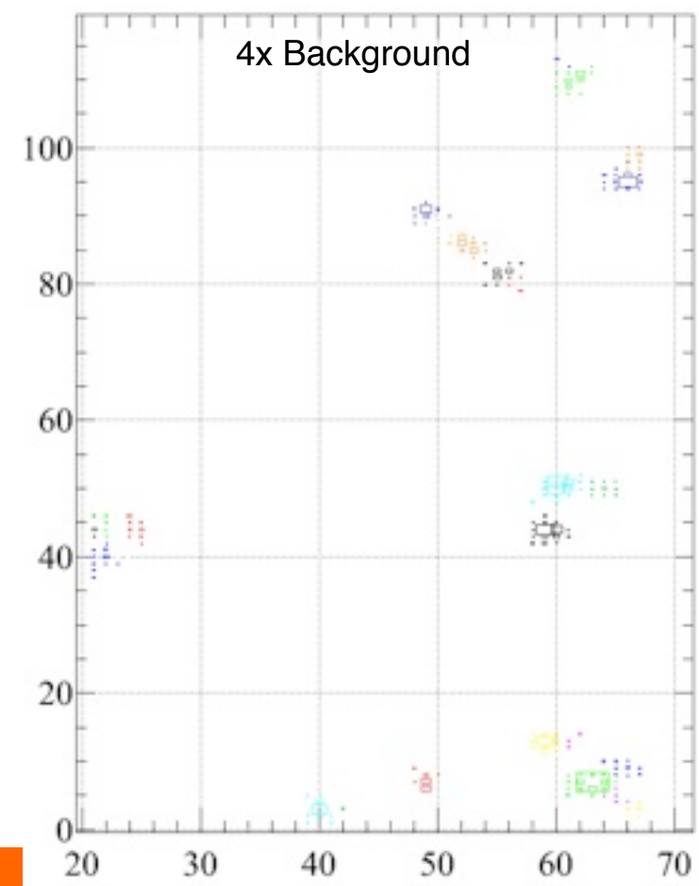
- One needs to stop growing clusters at some point.
- Although it may be necessary to keep every single low energy hit for background study, we want to remove as much noise as possible for physics while keeping the physics clusters as complete as possible.
- Algorithm (recursive):
  - Select seed crystals above 20 MeV; starting from the highest one.
  - Connecting adjacent crystals (once used, removed from the map).
  - If a crystal is below 5 MeV and none of its neighbors is above 10 MeV, stop (this crystal is not used).
  - Resulting clusters are then split into single bump clusters.

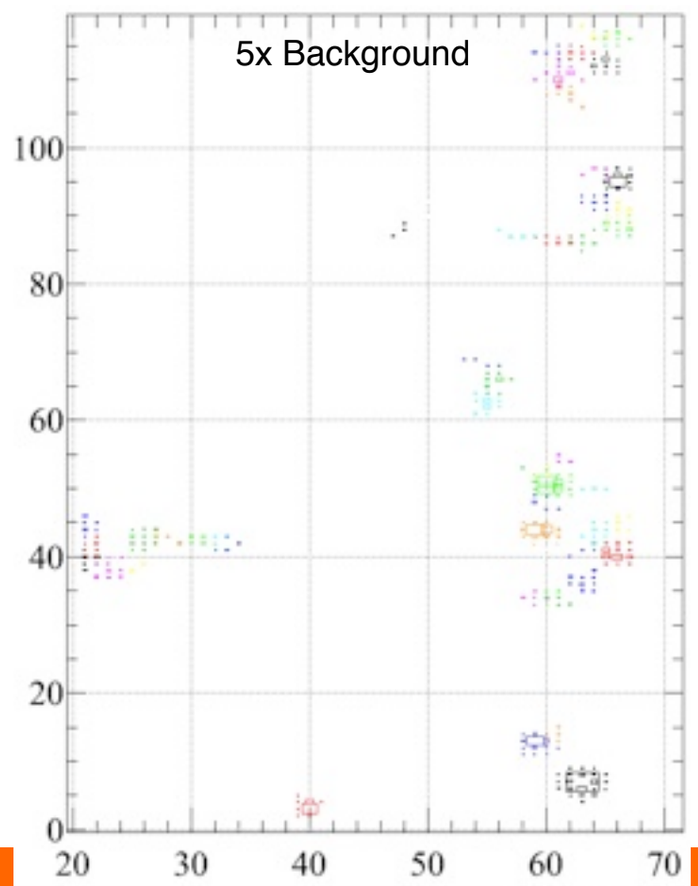

0x Background


1x Background


2x Background


3x Background


4x Background


5x Background

Improving BtaLoadMcCandidates

- BtaLoadMcCandidates builds MC BtaCandidates from GTracks, including genealogy.
- It is very inefficient in searching for daughters of each GTracks. It loops over the entire GTrack list in search for each given GTrack, including those from background, which don't have daughters (great majority of them).
- Simply checking whether the GTrack has any daughters before looping over the list saves a lot of time.
  - It's a one-line fix.

Processing time

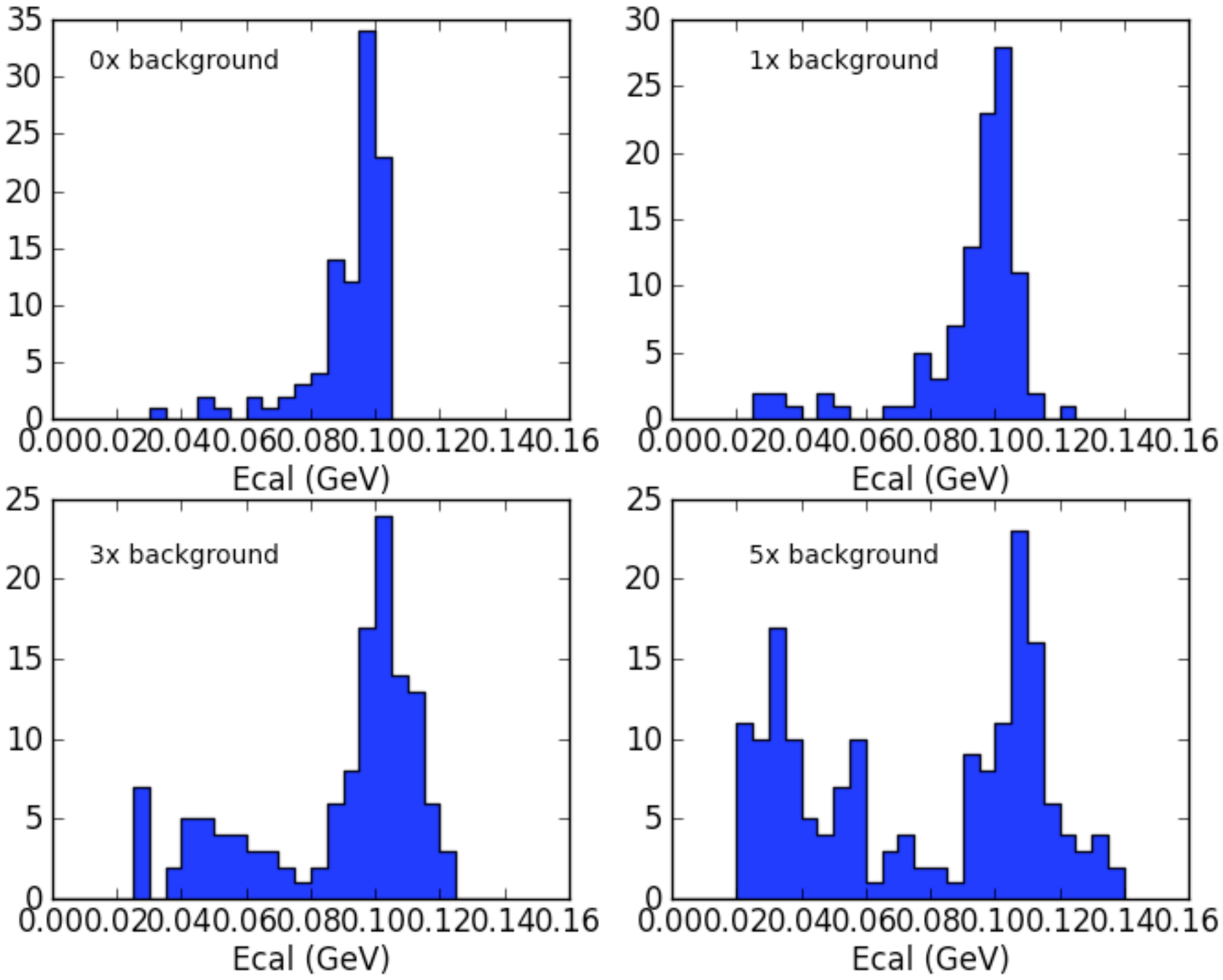
- Time consumption is greatly improved.

CPU time per event (ms/event) consumed by modules (running 10 B0B0bar events)

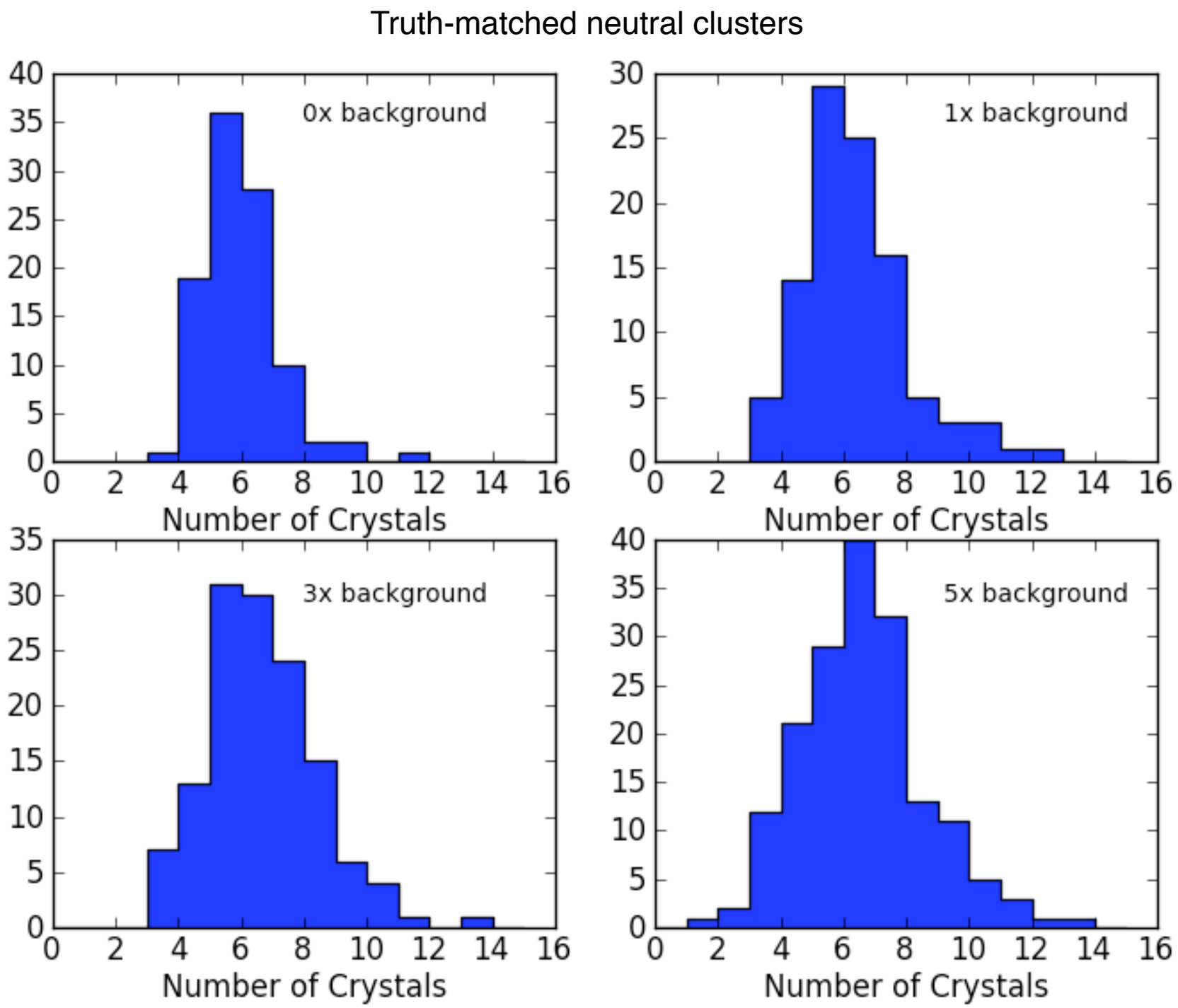
Module	no bkg	1x	2x	3x	4x
PmcReconstruct	279	355	705	1035	1442
PmcSimulate	82	192	376	550	696
BtaLoadMcCandidates	0	34	130	243	450
PacEmcReclustering	1	4	11	15	21
PacCaloSplitMerge	0	1	1	4	11
PmcRadBhabhaNeutronBkgInput	0	171	260	291	299
RacTestInput	9	73	190	299	393

Single photon test (100 MeV)

All neutral clusters



Single photon test (100 MeV)



Summary

- The very inefficient EMC cluster reconstruction in high background environment is basically solved with a clustering algorithm.
- Inefficiency in BtaLoadMcCandidates module is fixed too.
- Signal clusters get dirtier with background, and many background clusters still survive.
- The resolution is obviously worsened by background. And the peak shifts too. That is, the mean energy depends on the background level. Maybe a “background subtraction” algorithm is needed.
- At 5x nominal background, the low energy photon can get very difficult to reconstruct.
- Need to find ways to cut down background.
- *ps. The study here uses the simple analytical pulse shape. The more realistic pulse shape look up table has a much longer tail and thus much higher background. It still has problem at 5x background.*