CMS Requirements on Multi-threading

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Present Application

CMS uses one application for all event processing

- Particle generation
- Simulation
- Online High Level Trigger
- Reconstruction
- Analysis

Each event processing algorithm is encapsulated into a 'module'

- Geant4 is wrapped by one particular module

CMS' application controls the processing

- It decides which event to process next
- It decides the order to call each module and passes it the proper event
  - Application calls specific Geant4 functions when it is Geant4's turn to do work

Multithreading

Plan for new multithreaded application

- Will process multiple events simultaneously
- Will run multiple modules processing the same event simultaneously
- This will all be controlled explicitly by the application

All parts need to work within one concurrency model

- Present application is memory resource limited
  - in future may not be able to afford 2GB / CPU core
- Each additional thread requires its own stack
  - default size on SL5 is 10MB/stack
- One concurrency model will allow use of only one thread pool
  - minimizes memory
  - avoids oversubscribing available cores
- CMS has chosen Intel Thread Building Blocks as the concurrency model

Interested in Geant-MT if it can fit with this working model

- Where concurrency is controlled by the experiment's application
  - E.g. Application calls specific Geant methods at proper time from threads controlled by application

TBB Task Model

Work to be done in parallel are encapsulated in a tbb::task object

- Object holds what ever data is needed to do the work
- TBB calls `execute()` when it is the task's turn to run

Must tell TBB how many threads should be used

For each thread, there is a work queue

`task::spawn` adds a task to the queue for the thread that calls `task::spawn`

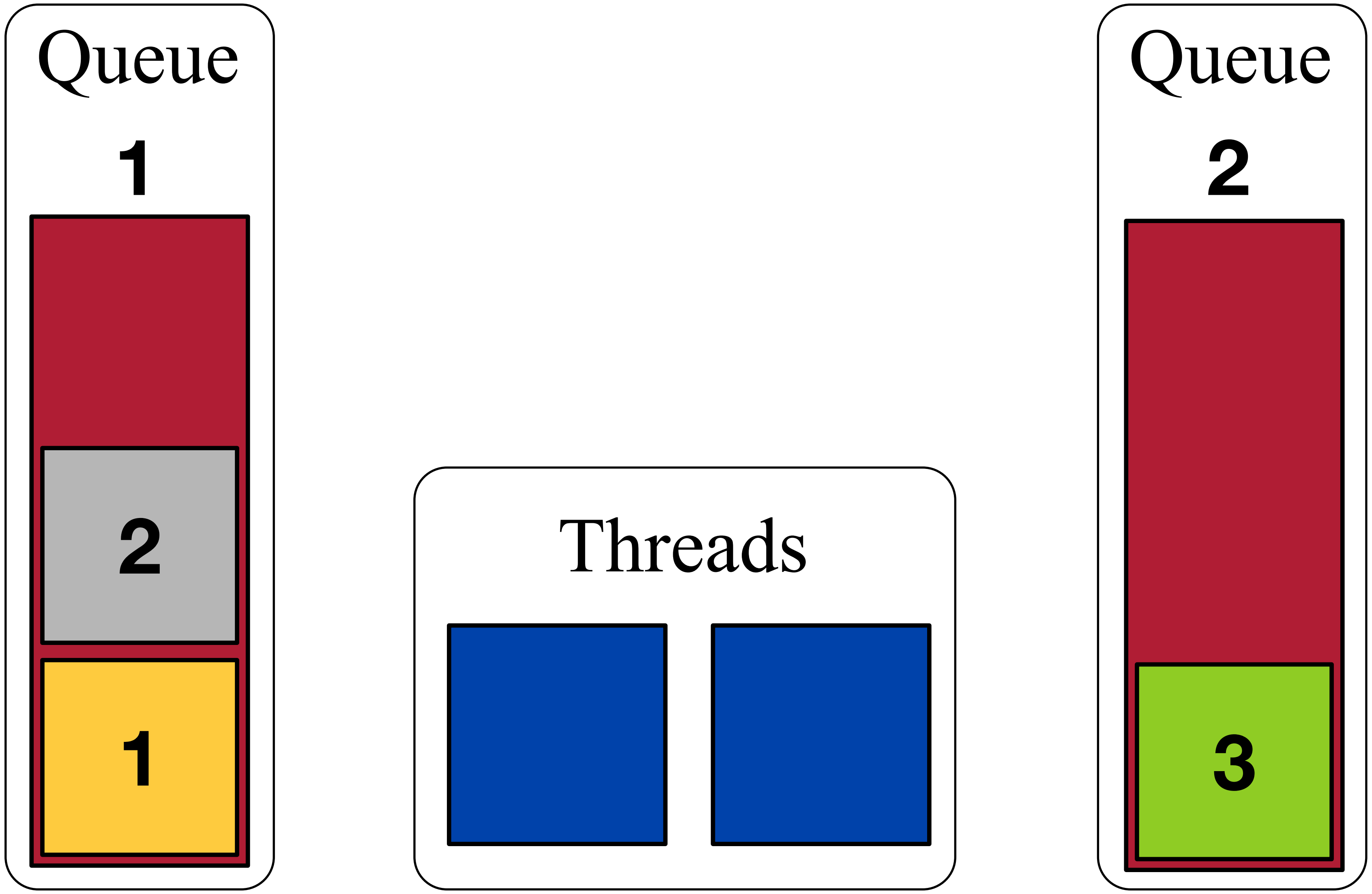
Tasks are pulled from the work queue in Last In First Out order

If a queue is empty, it will

- See if a task is on the shared list and if so take the oldest one, else
- Steal oldest task from another queue

TBB Task Model

Tasks are pulled in Last In First Out order



Queue 1

2

1

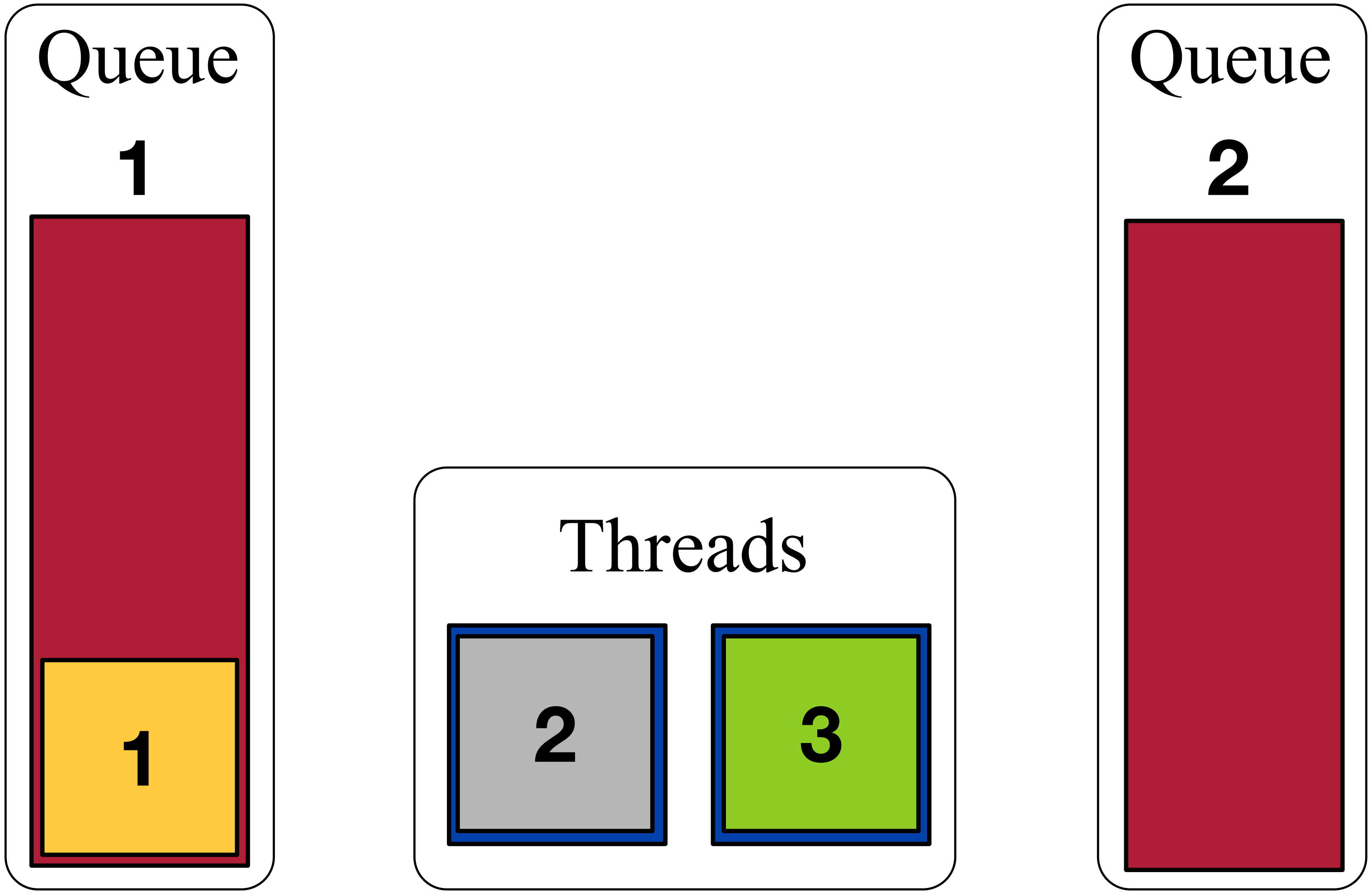
Threads

Queue 2

3

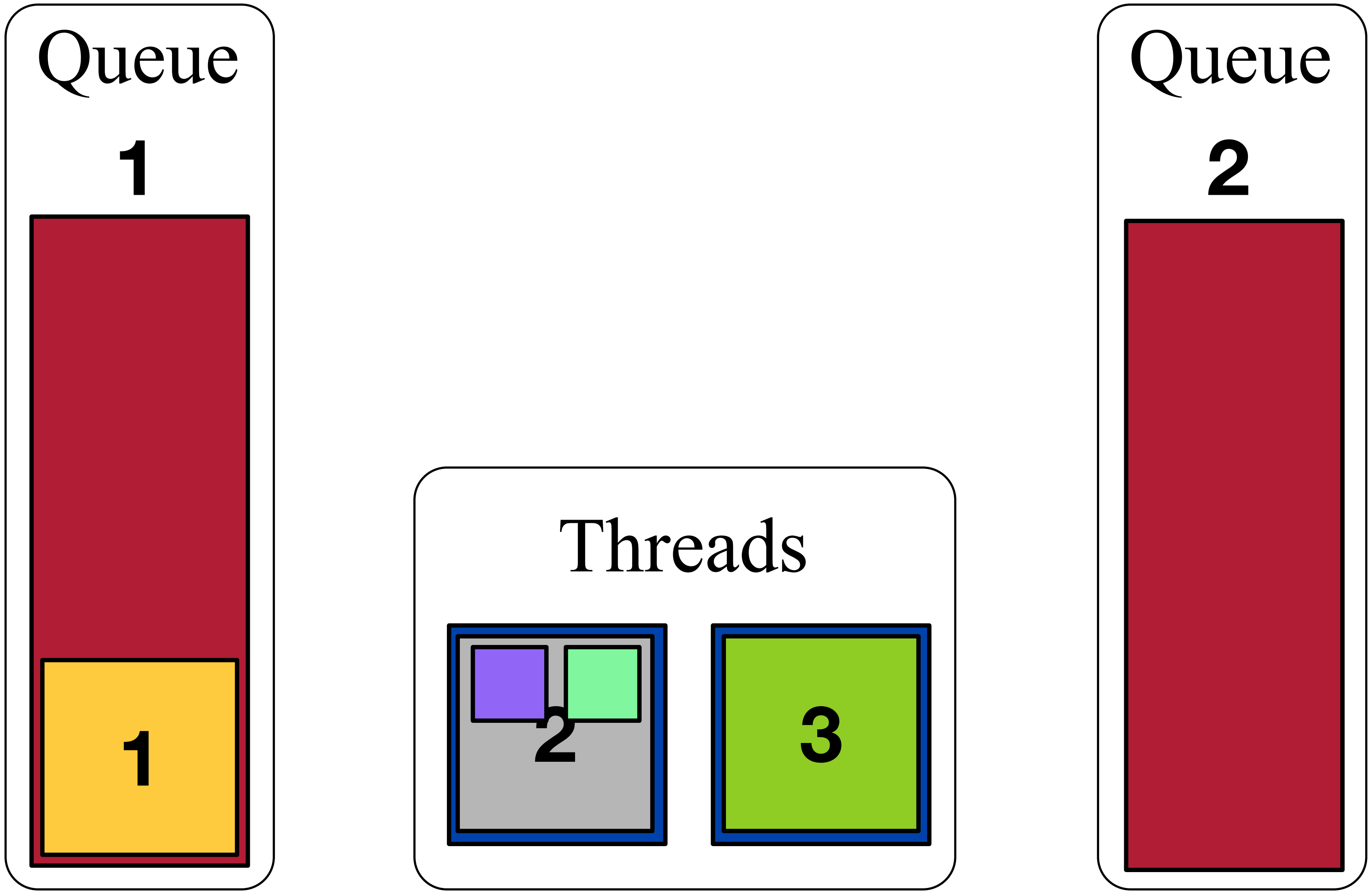
TBB Task Model

Tasks are pulled in Last In First Out order



TBB Task Model

Spawned tasks go into the same thread queue as creating task



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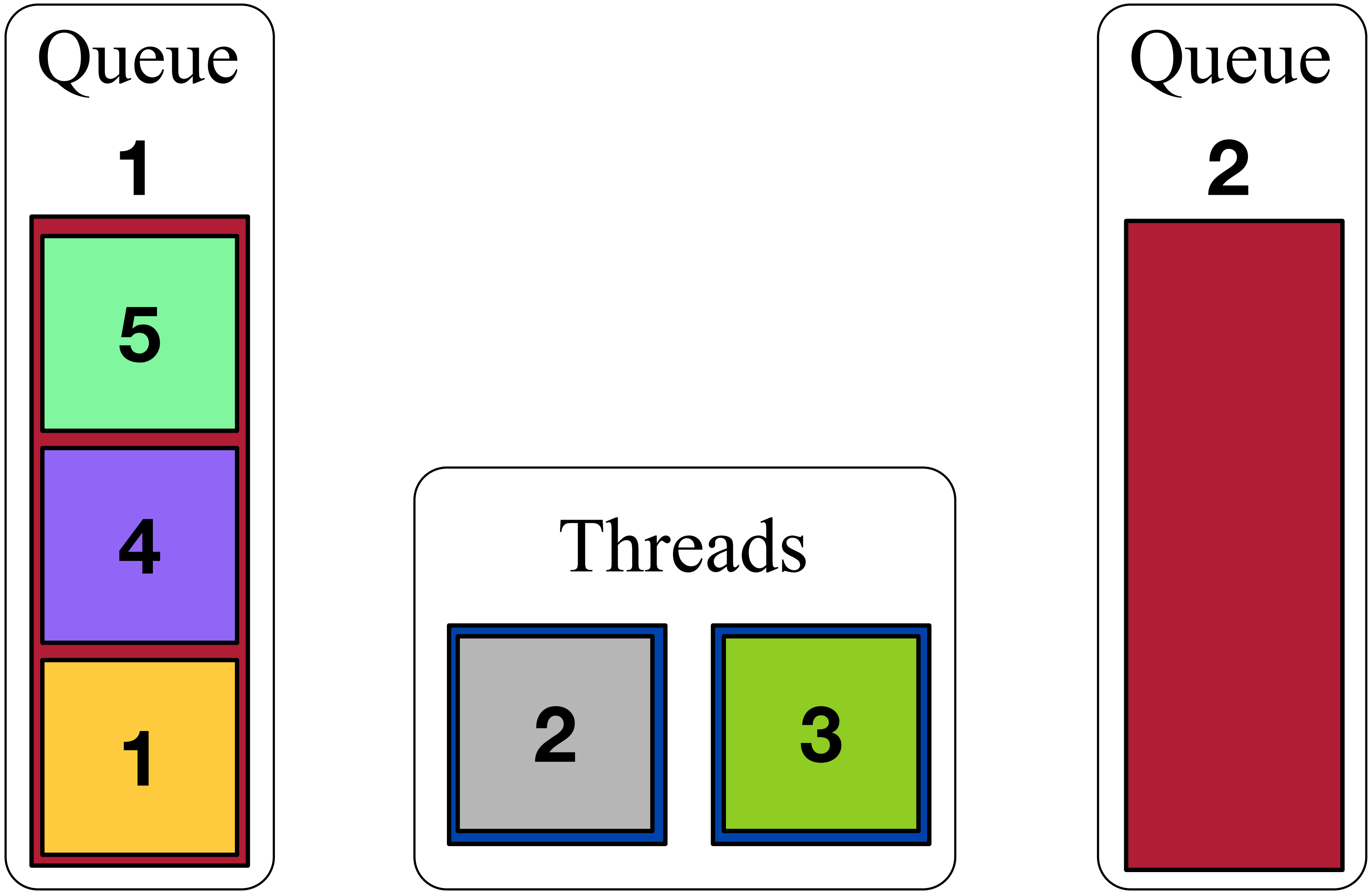

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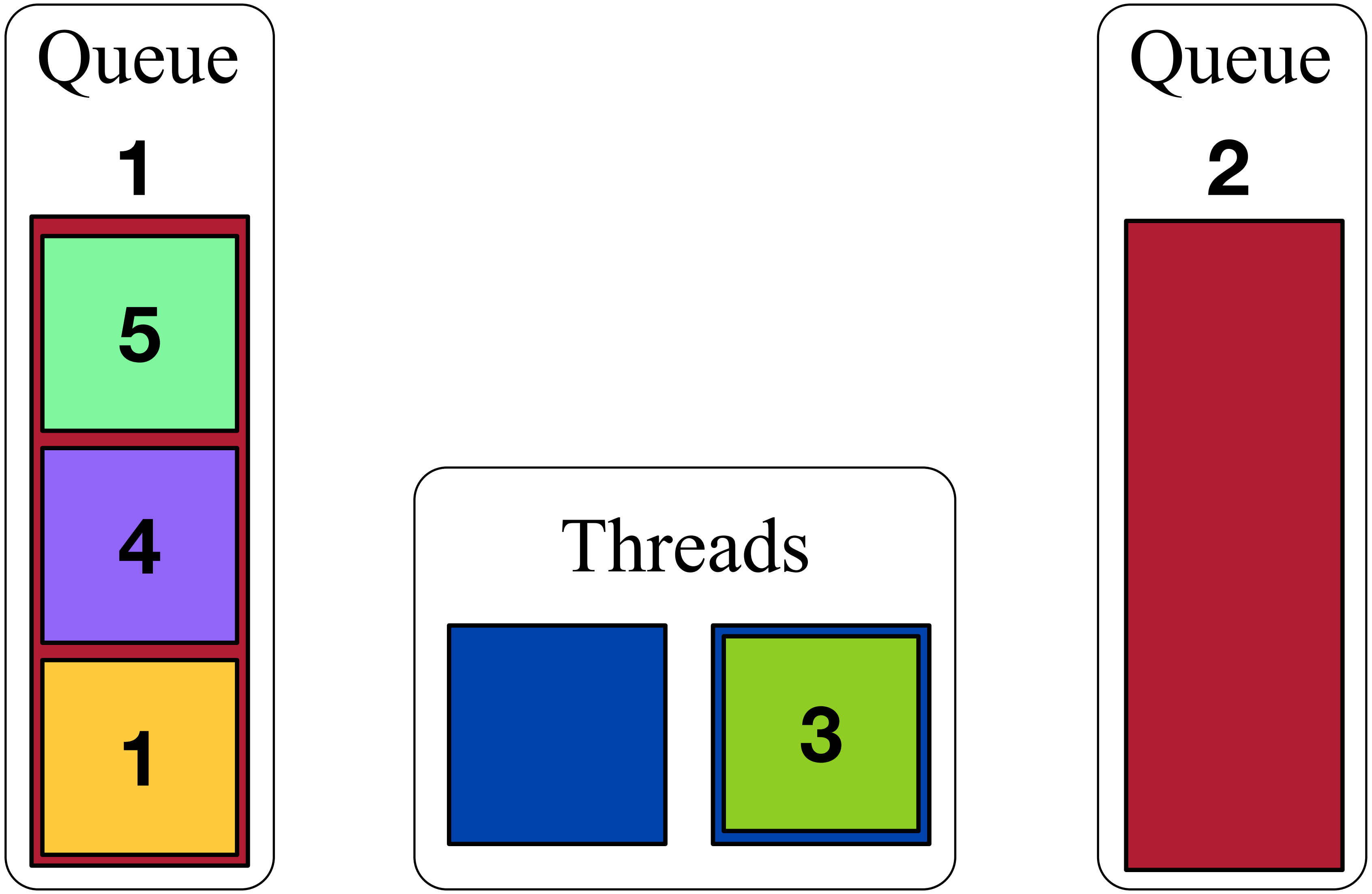

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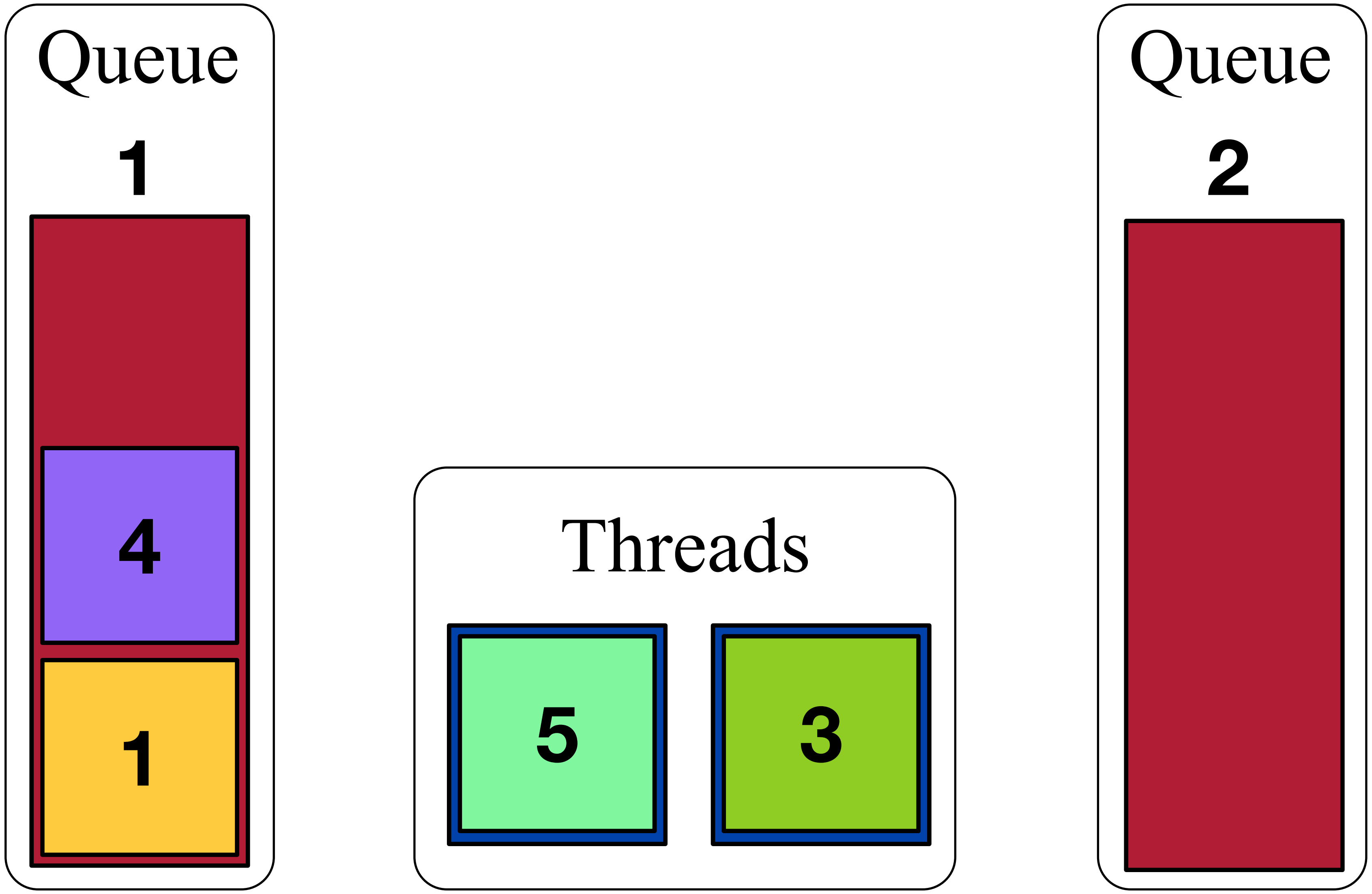
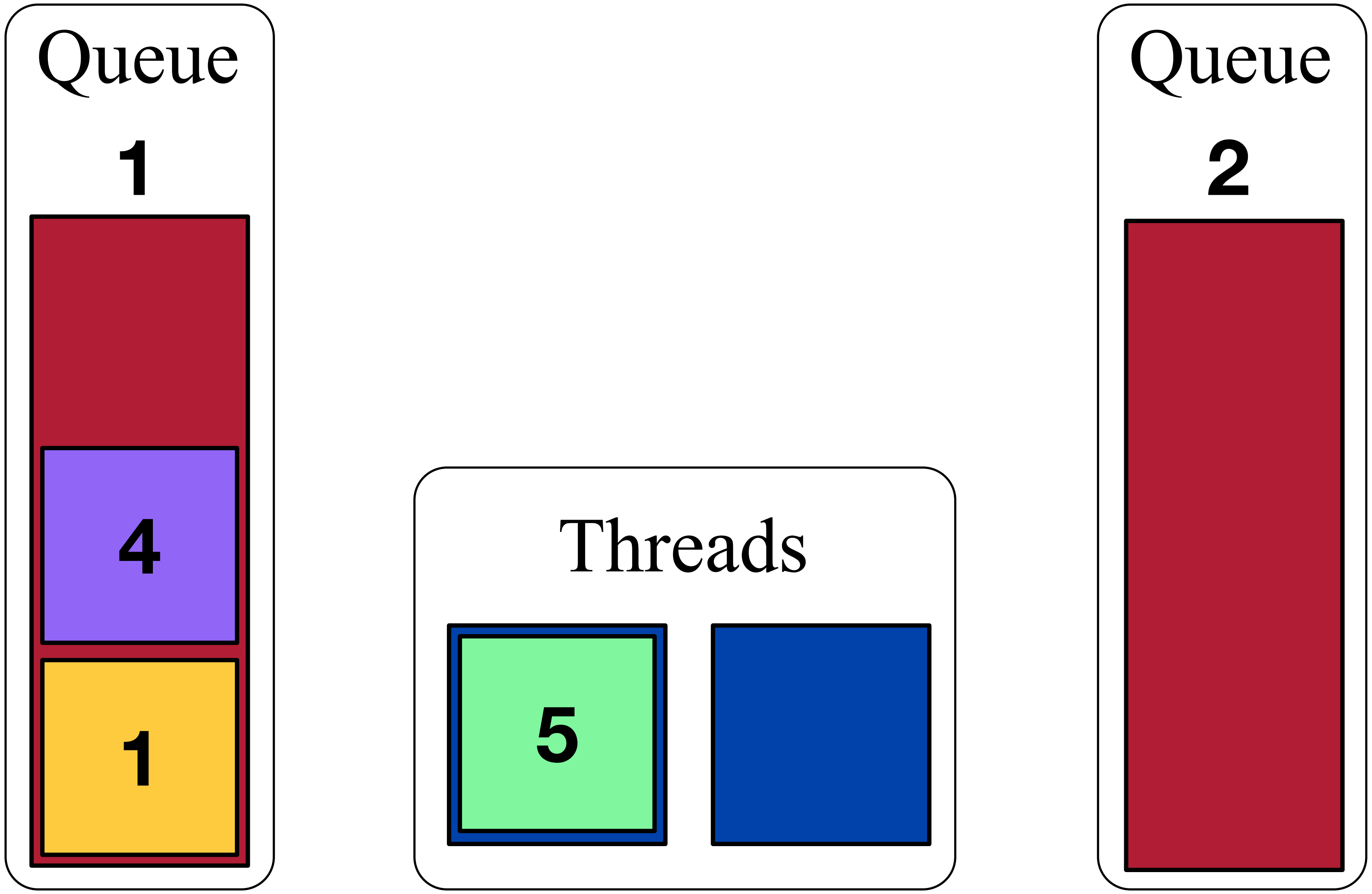


TBB Task Model

An empty thread queue steals oldest task from another queue



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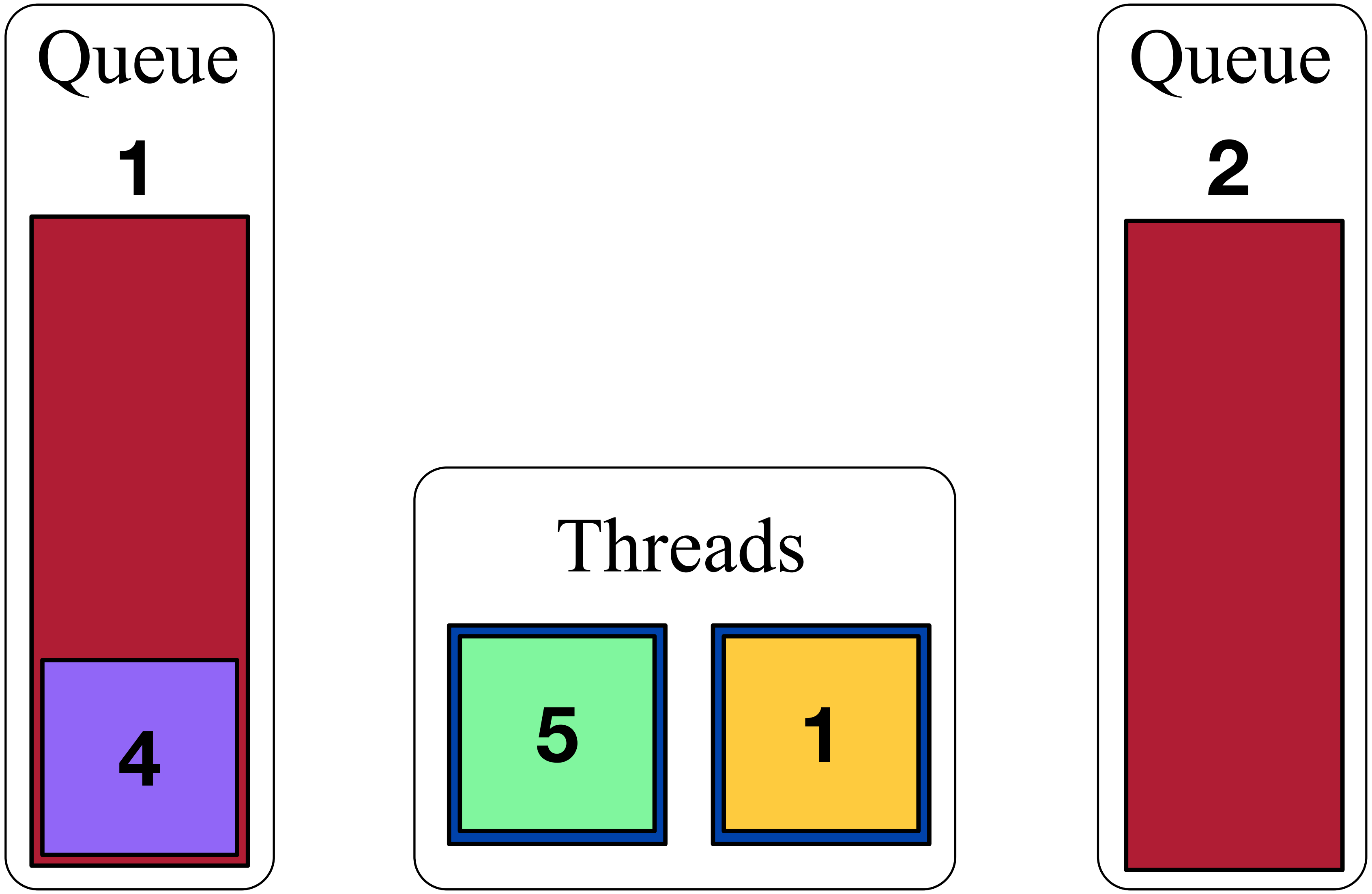

CMS' Use of TBB

- Application will be told to process N events simultaneously
- Application will be told to use M threads
  - N events <= M threads
- In beginning modules will configure themselves
  - This will be single threaded
  - Modules can setup data structures to be used by all simultaneous events
    - Must be concurrent access safe
    - e.g. a physics list or geometry
  - Modules can setup data N data structures, one per simultaneous event
    - e.g. data structures that temporarily cache per event info such as track lists
- When process an event, module will be called from a TBB task
  - Module has access to
    - the event
    - the module's shared by all simultaneous events data structure
    - the module's data structure for that event (i.e. 1 of the N structures)
  - Module is also allowed to create its own TBB tasks
    - Module must wait for all of its TBB tasks to complete before returning

Conclusion

CMS is pursuing a threaded process framework

Using Intel's TBB as the concurrency model

Model is task based not explicitly thread based

Will need future Geant4 to be amenable to TBB