GeantV – I/O, MCTruth and Validation Database

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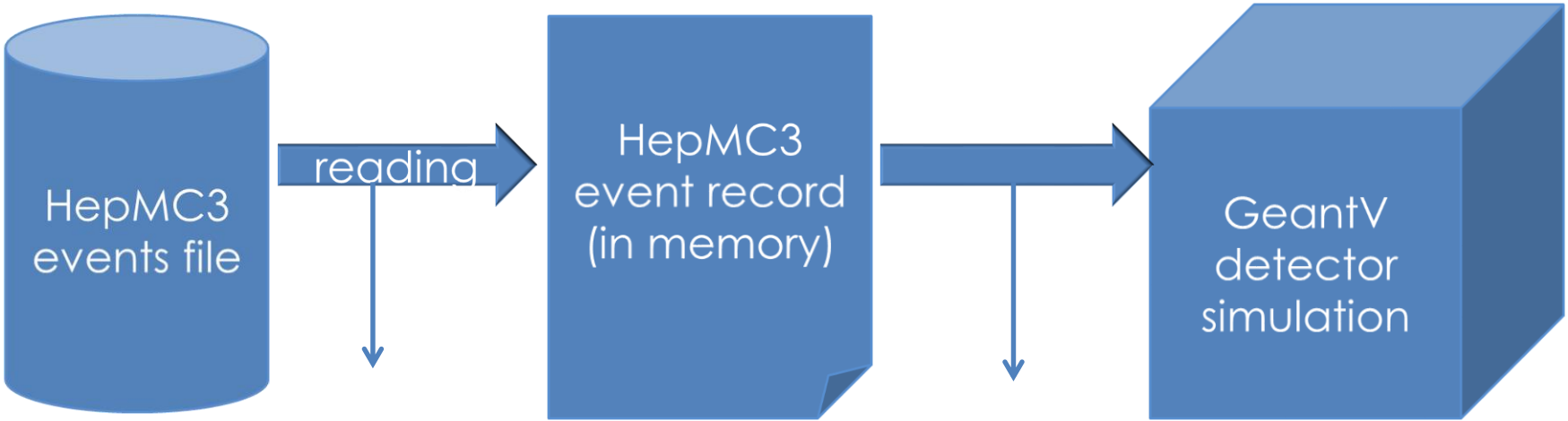
Outline

- GeantV input
- GeantV output
  - hits
  - kinematics
- Physics validation DB
- Conclusion

GeantV Input

- Simulation input
  - particles to be transported through the detector
    - Realistic collision events produced by Monte Carlo event generators (Pythia8, Herwig++, etc)
    - Single particles (like the test beam) to study particular response
- Use of interface (event record) make the generation and the simulation steps independent
  - GeantV does not ‘care’ where the particles are coming from
- Simulation threads concurrently process particles from the input

HepMC3 as GeantV input format



0.6ms / 14TeV pp signal event (negligible compared to simulation step)

Particles fed into concurrent simulation threads

GeantV input implementation

- interface implemented in HepMCGenerator class
  - depends (of course) on HepMC3
- can read HepMC3 ascii and root files
  - automatically recognizes them by extension
- selects stable (outgoing) particles from the event
- applies (if any) Eta, Phi, and momentum cuts

Status of GeantV Input

- implementation complete and fully functional
- nothing pending for short term development

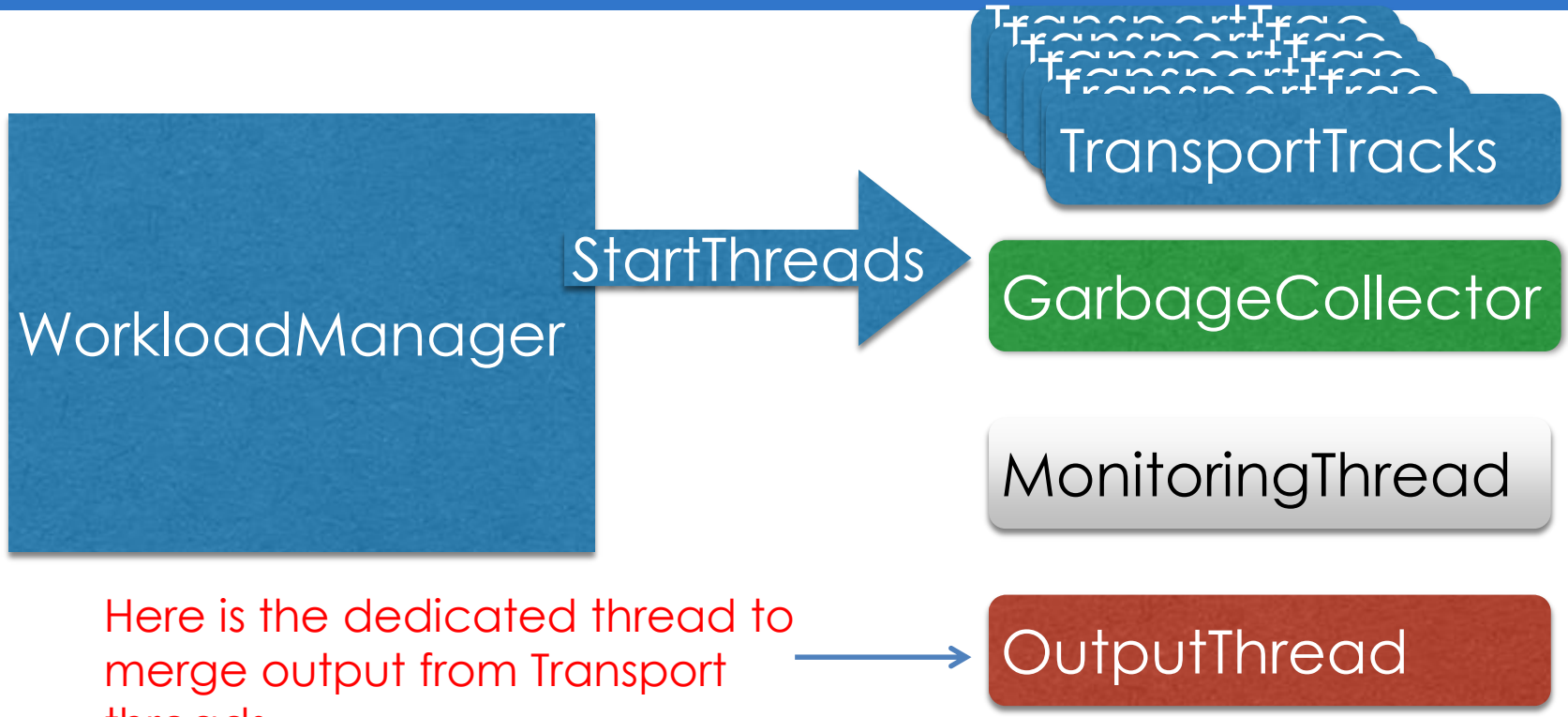
GeantV Output

- hits
- kinematics (MCTruth)

GeantV hits

- Physics simulation produces ‘hits’ i.e. energy depositions in the sensitive parts of the detector
- Those hits are produced concurrently by all the simulation (TransportTracks) threads
- Thread-safe queues have been implemented to handle asynchronous generation of hits by several threads
- hits from concurrent transport threads merged by the output thread

Threads started by WorkloadManager



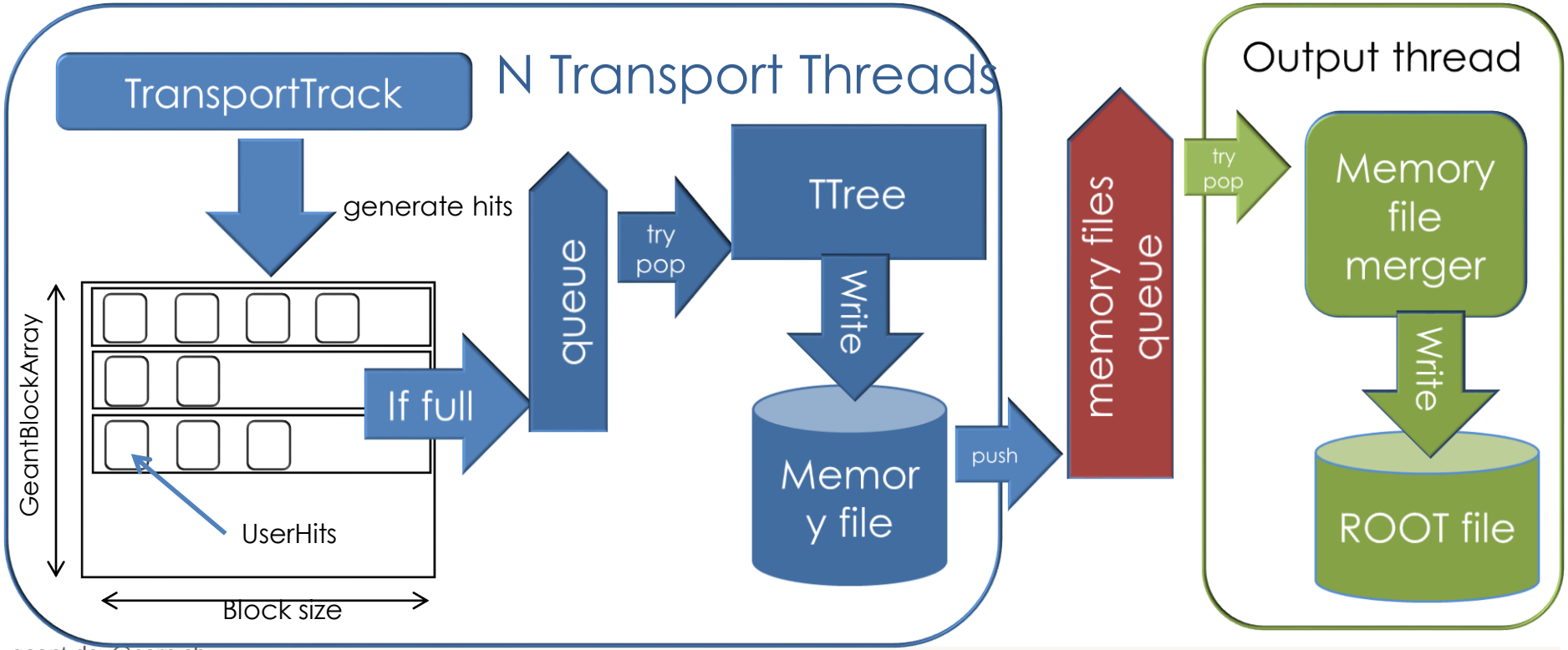
GeantV output thread

- (several) TransportTracks threads generate hits
  - GeantFactory machinery takes care of grouping the hits in HitBlocks and putting them in a queue
- Output related functionality implemented within OutputThread
  - first approach where serialization done within (one) output thread was creating a bottleneck
  - performing serialization within each transport thread solves the problem

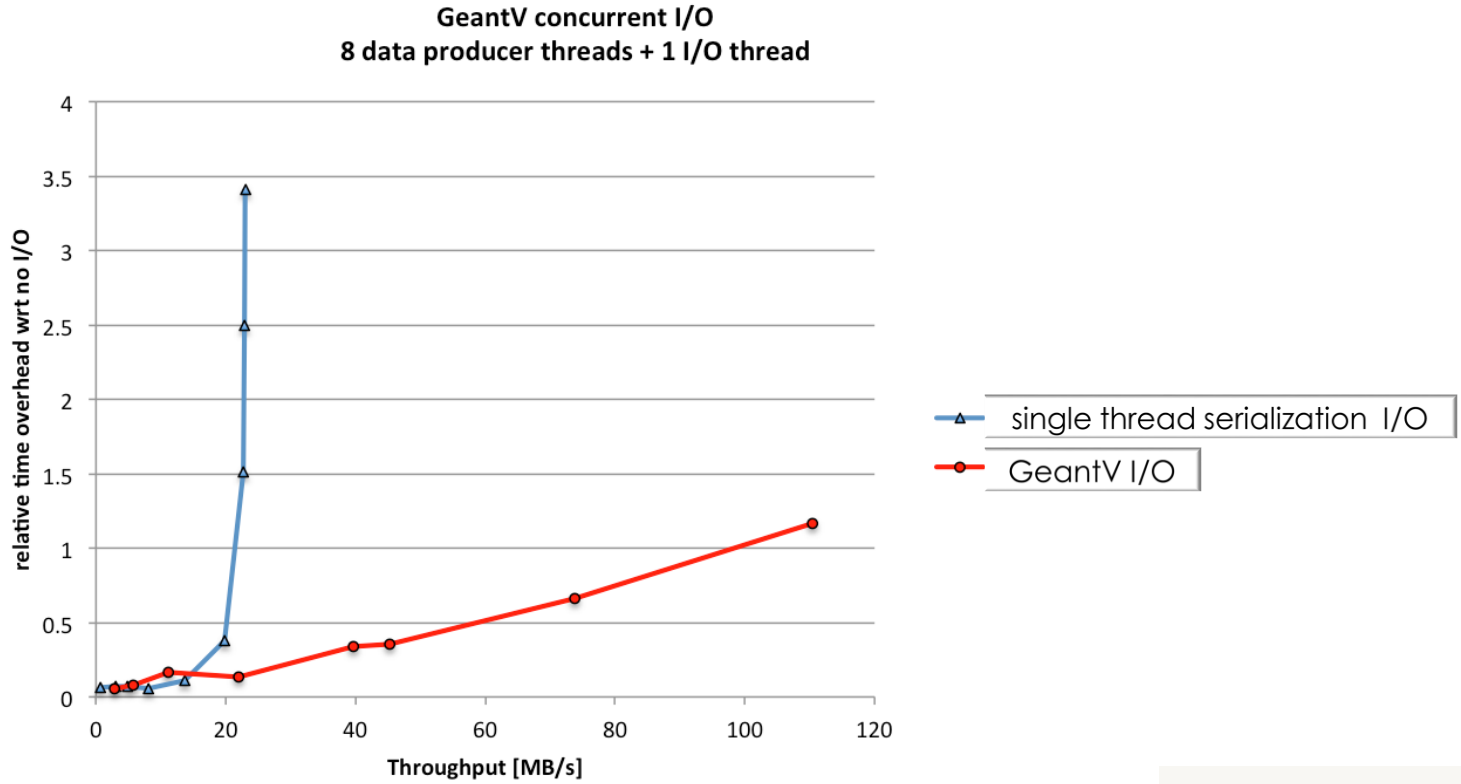
GeantV output implementation

- idea:
  - several ROOT TTrees should be filled in parallel by each of the TransportTracks threads
  - Output thread should be ‘only’ in charge of merging TTrees and writing them to I/O
- implementation:
  - derived from ROOT TParallelMergingFile and parallelMergerServer which are socket-based
  - TThreadMergingFile and TThreadMergingServer use a queue (dcqueue<TBufferFile*>*) as the ‘communication channel’

GeantV I/O data flow



GeantV Output performance



Hits Output status

- (optional) hits persistency available in GeantV
  - further improvements (reordering of hits in file, etc) possible at later stage
- tested in multithread environment with several concurrent transport threads

GeantV kinematics output (MC truth)

- handling of MC truth is problematic per se
  - which particles to store, how to keep connections, where to connect hits
- multithreading adds the complexity
  - order of processing of particles is ‘random’
    - processing of ‘daughter’ particle may be completed before ‘mother’ particle ‘end of life’
  - events need to be ‘put together’ after parallel processing

MC truth

- we can’t (and we don’t want) to store all particles
  - no delta-e, no gamma showers, etc
- we need to store particles necessary to understand the given event (process)
- we need to store particles to associate hits
- we need to (re)connect particles to have consistent event trees

MC truth handling requirements

- no MC truth-handling strategy is perfect, nor complete, but:
- we need to have
  - links between mother and daughter particles
  - the possibility to flag particles as ‘to be stored’
  - possibility to introduce ‘rules’ what to store
  - a way to ‘reconnect’ tracks and hits if some are skipped
    - if we don’t store a particle, we need to update the daughter particles to point back to the last stored one in the chain
- for the final output we need to have some event record
  - we can start with HepMC

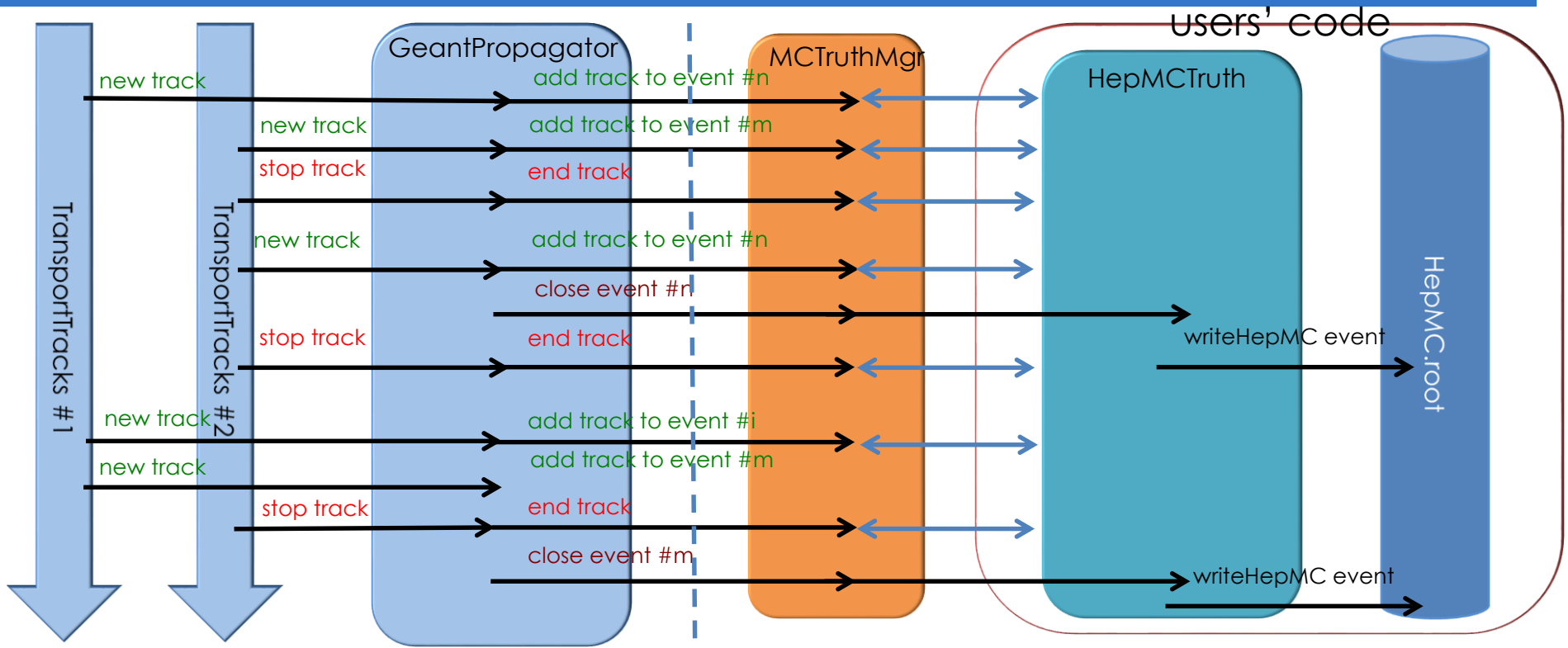
MC truth handling architecture

- light coupling to transport
  - minimal ‘disturbance’ to transport threads
  - maximal flexibility of implementing custom particle history handlers
- lightweight interface provided by MCTruthMgr
  - receives (concurrent) calls from transport threads to
    - add particles
    - end particles
    - finish events
  - delegates processing of particles history to concrete MC truth implementation

MC truth infrastructure and users code

- MCTruthMgr provides interface and underlying infrastructure for particles history
  - light-weight transient, intermediate event record
- users code:
  - decision making (filtering) algorithm
  - conversion to users' event format
- concrete example implementation provided based on HepMC3

MC truth call sequence



MC truth output status

- GeantV MC truth manager provides handles to deal with particles history
  - allows ‘physics’ studies
  - first implementation, further iterations possible to look in detail at performance
- example implementation based on HepMC3 provided
- further performance testing/improvements in highly concurrent environment to be studied

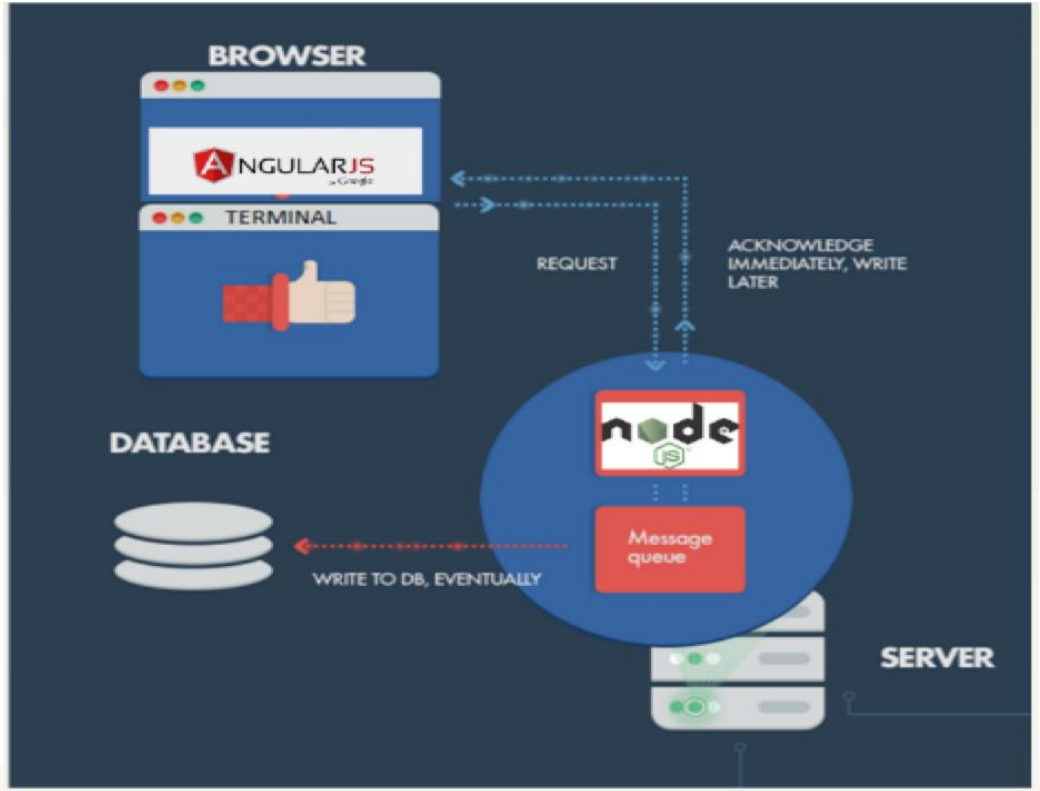
Physics Validation Database

- provide repository for tests results allowing regression testing
  - physics tests for any new version of GeantV compared to the previous version
- provide repository for experimental data allowing physics validation
  - no ‘physics’ tests should be run without corresponding experimental data in the validation DB

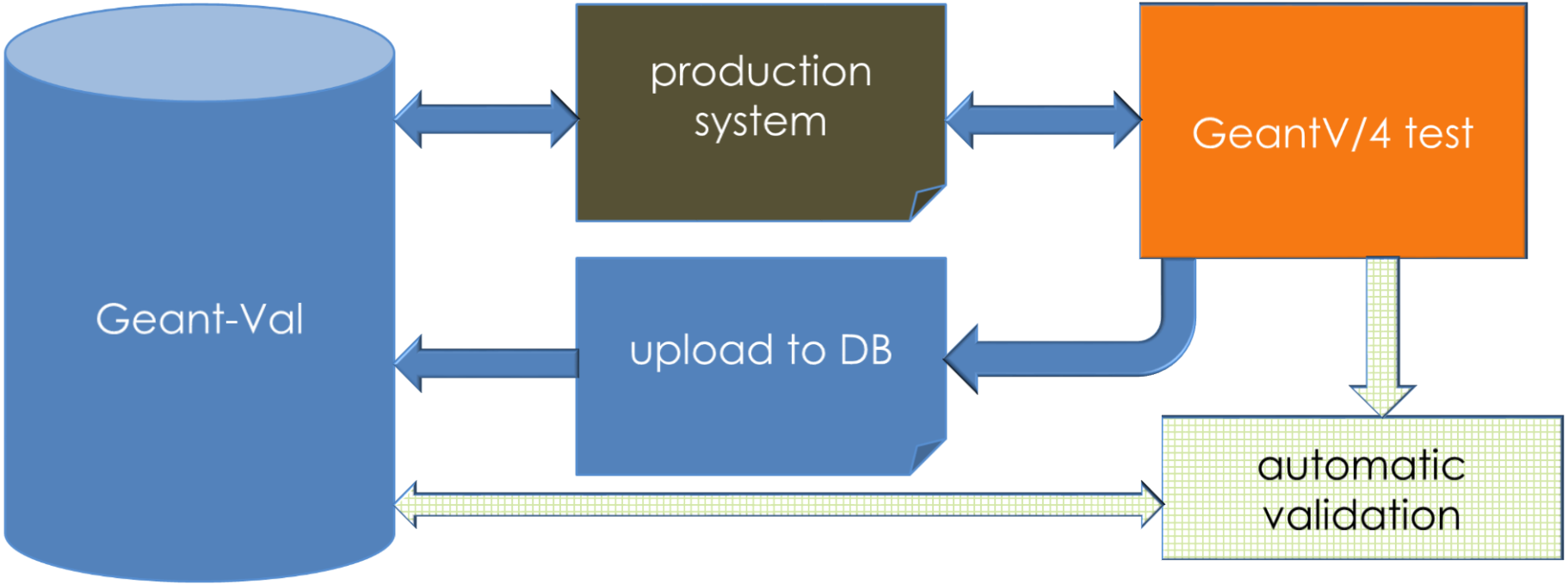
Physics Validation DB approach

- next generation of g4-val service (implemented in 2014, based on django framework)
  - efficient web interface allowing interactive comparison of plots
  - interface to production system allowing automatic production and uploading of results
- extending the functionality to GeantV (in addition to Geant4)
- adding more tests
- modernizing architecture and implementation

Physics Validation DB architecture



Validation Data flow



Geant Validation Portal

Visualisation for test results

test X

Version

Select From Existing Ones

GEANT4: 10.3.beta01 ✖ GEANTV: 17/10/2016 ✖

Beam

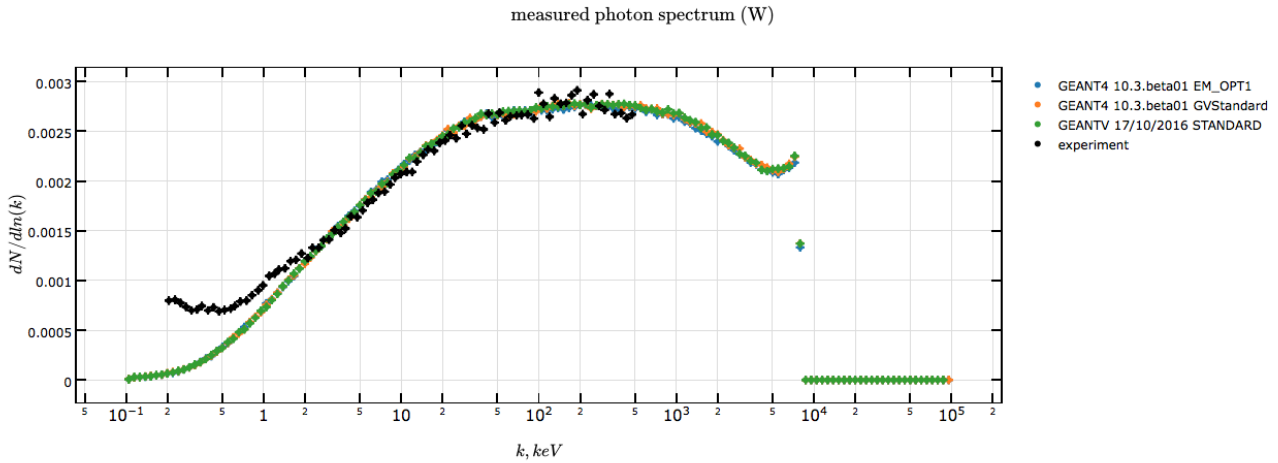
Select From Existing Ones

e- ✖

Physics List

Select From Existing Ones

X axis: log



Conclusion

- interface to HepMC3 for particles input available
- users hits persistency possible with memory file merging
- lightweight MC truth interface available allowing to study particle history according to users' specific selections
- Geant Validation repository provides the functionality needed for regression testing and physics validation