

EvtGen – on its first steps towards thread safety

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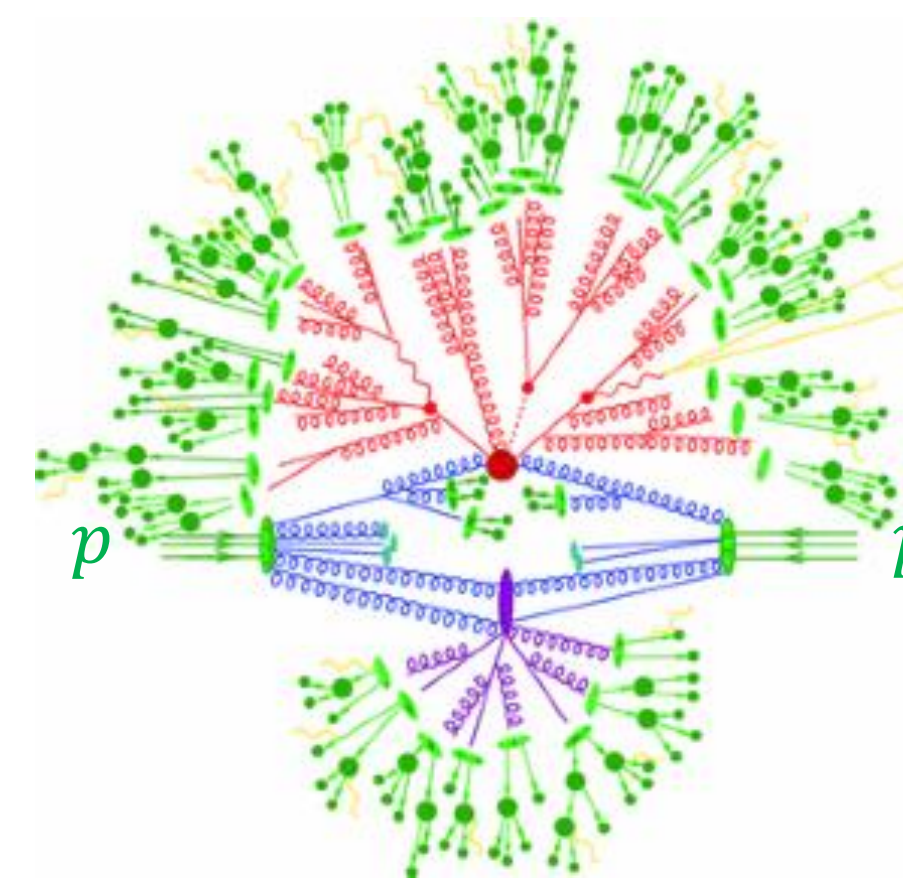
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EvtGen in a nutshell

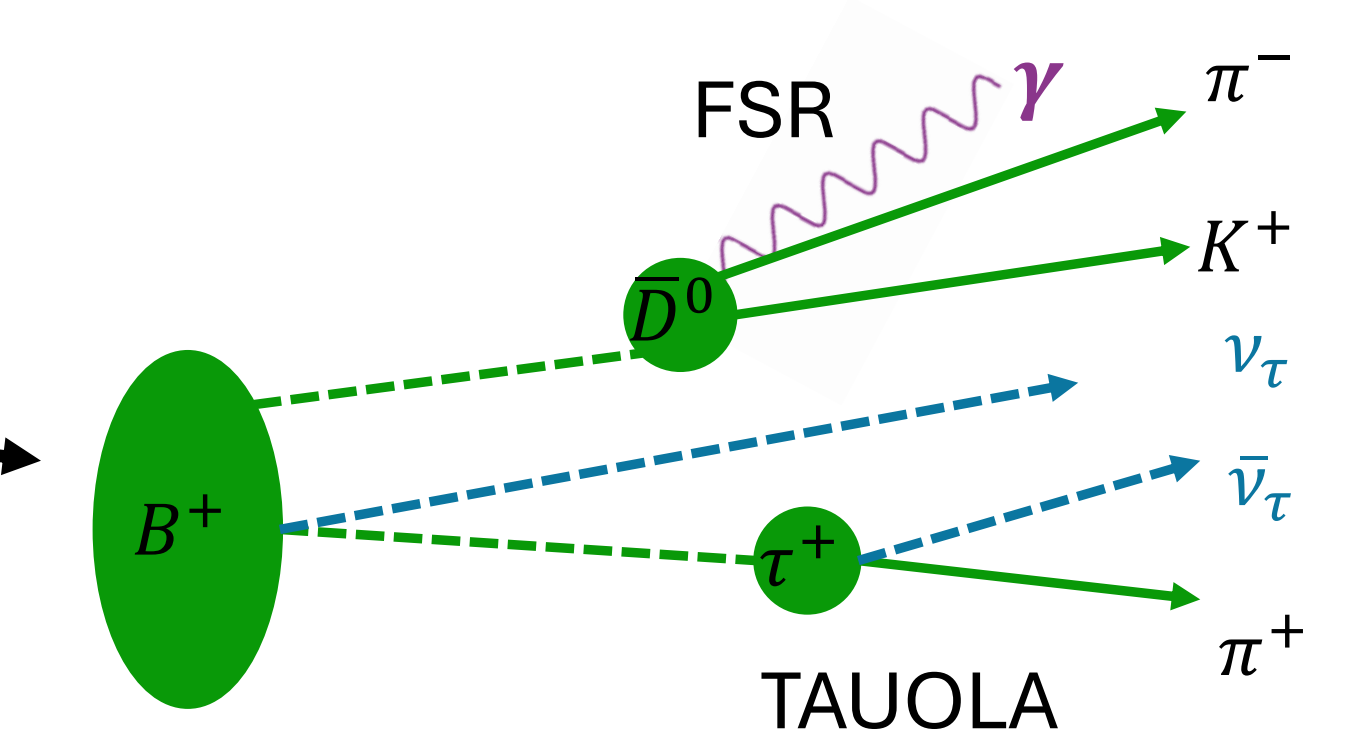
Simulation generator package specialised for decays of heavy-flavour hadrons (used as well inside simulation of b jets)

- Contains 130 decay models describing dynamics of specific decays
- Maintains detailed decay table with large number of explicit decays
- ⇒ When decay branching fractions do not add up to 100%, the rest is filled up by generating quark configurations and passing those to Pythia8 [1]
- Decays of τ leptons are simulated using TAUOLA [2]
- Final-state radiation (FSR) photons are simulated using PHOTOS [3] or Sherpa's PHOTONS++ [4]

Example collision simulated by Pythia8



Example decay simulated by EvtGen



The need for thread safety

- Exploiting modern CPUs requires generators to be thread-safe
- Experiments are moving their frameworks towards multithreading
- Multithreading allows us to reduce the number of submitted jobs

Challenges for multi-threading

Internal: structural limitations inside EvtGen

- Global instance of random number generator
- Global instance of particle properties and decay table

External: limitations from dependences

- TAUOLA
- FSR generators PHOTOS and Sherpa's PHOTONS++

Our current solution

Implemented modifications to enable thread safety

- Converted static objects to static const (or static thread_local)
- Global singleton objects made thread_local
- Serialized (mutex) calls to PHOTOS, PHOTONS++, and TAUOLA

Validation, speedup and memory checks

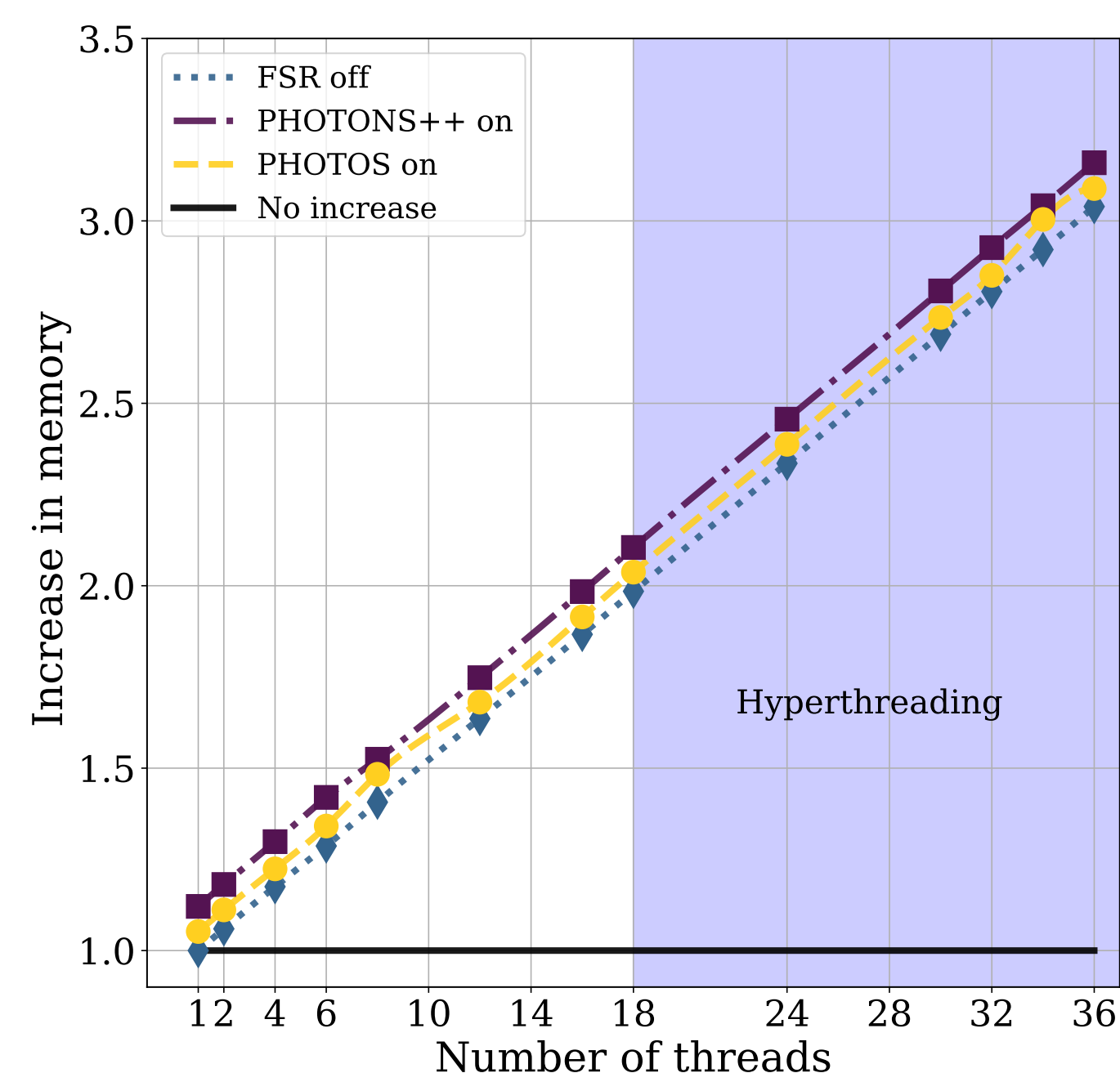
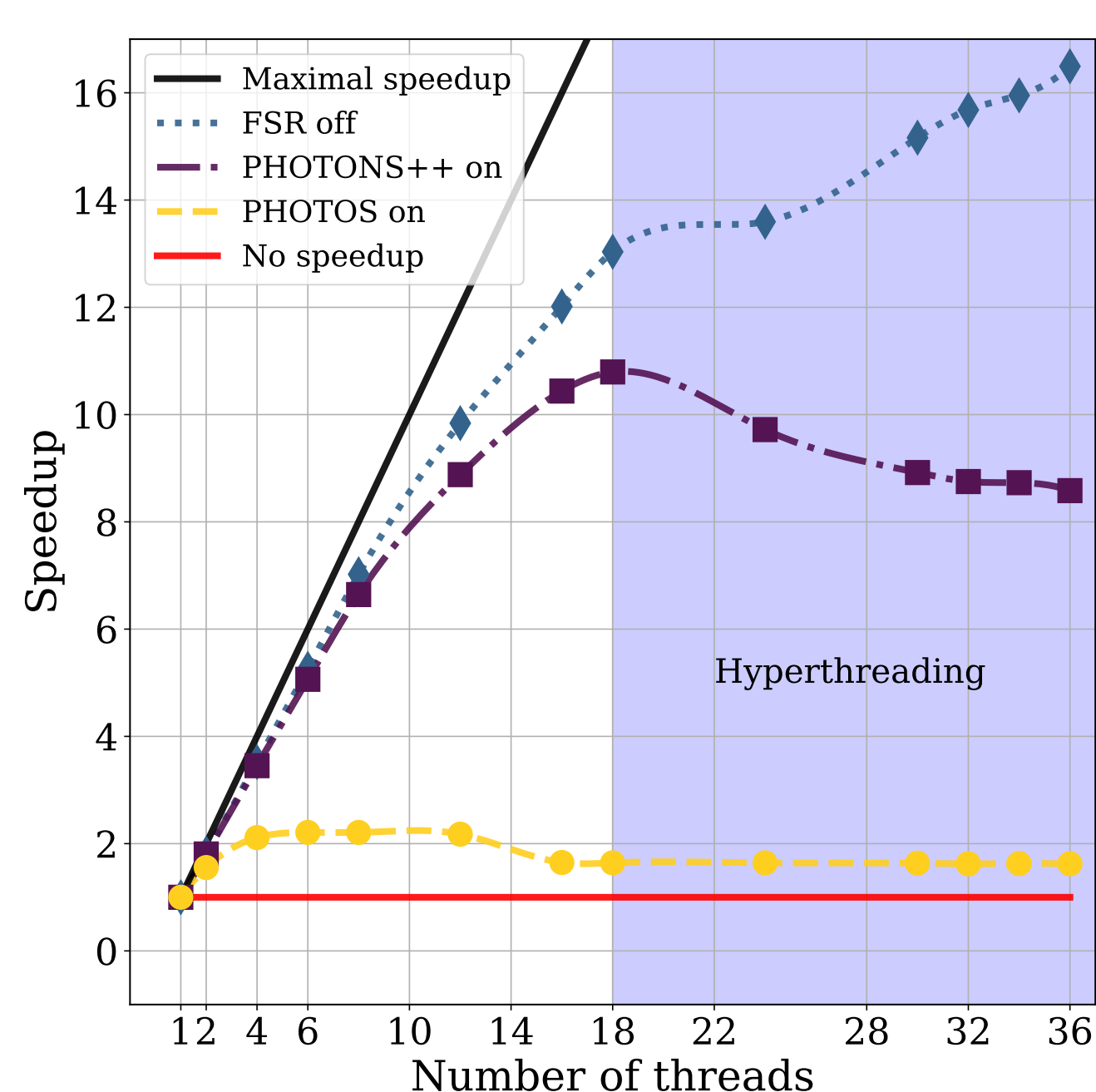
Simulation needs testing and validation after changes to ensure invariance of the physics models

- Implemented testing framework with common testing module and JSON configuration files
- Migrated all previous tests and added new ones to framework
- Tests cover all models and external generators
- Available also for users to facilitate testing models

Deeper structural changes needed to fully exploit multi-threading

- Current preliminary status reached thread safety
- Passes all tests for all decay models, and external generators
- Performance remains largely limited by external dependencies

⇒ Look for FSR and τ simulation alternatives!



New alternative for final-state radiation

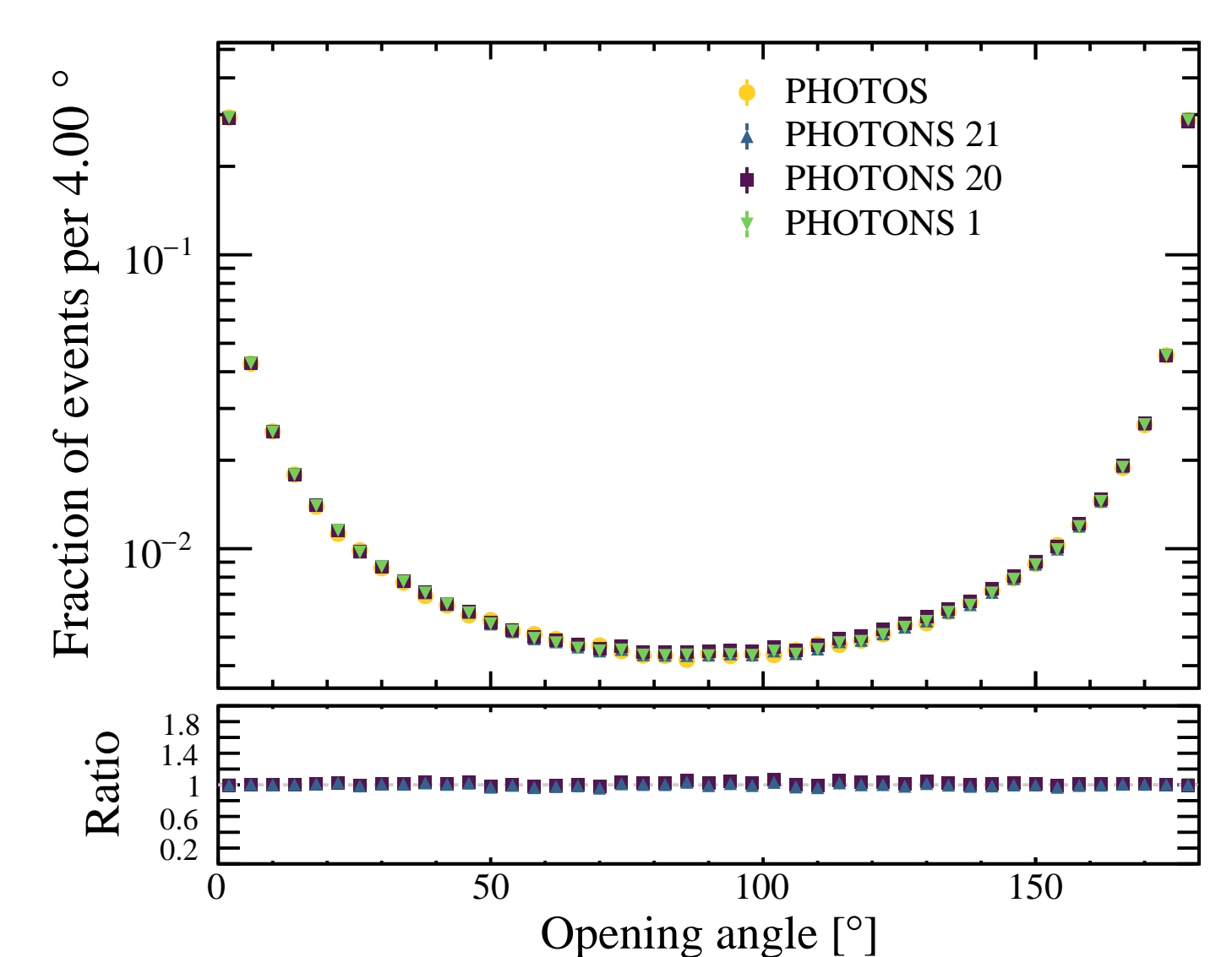
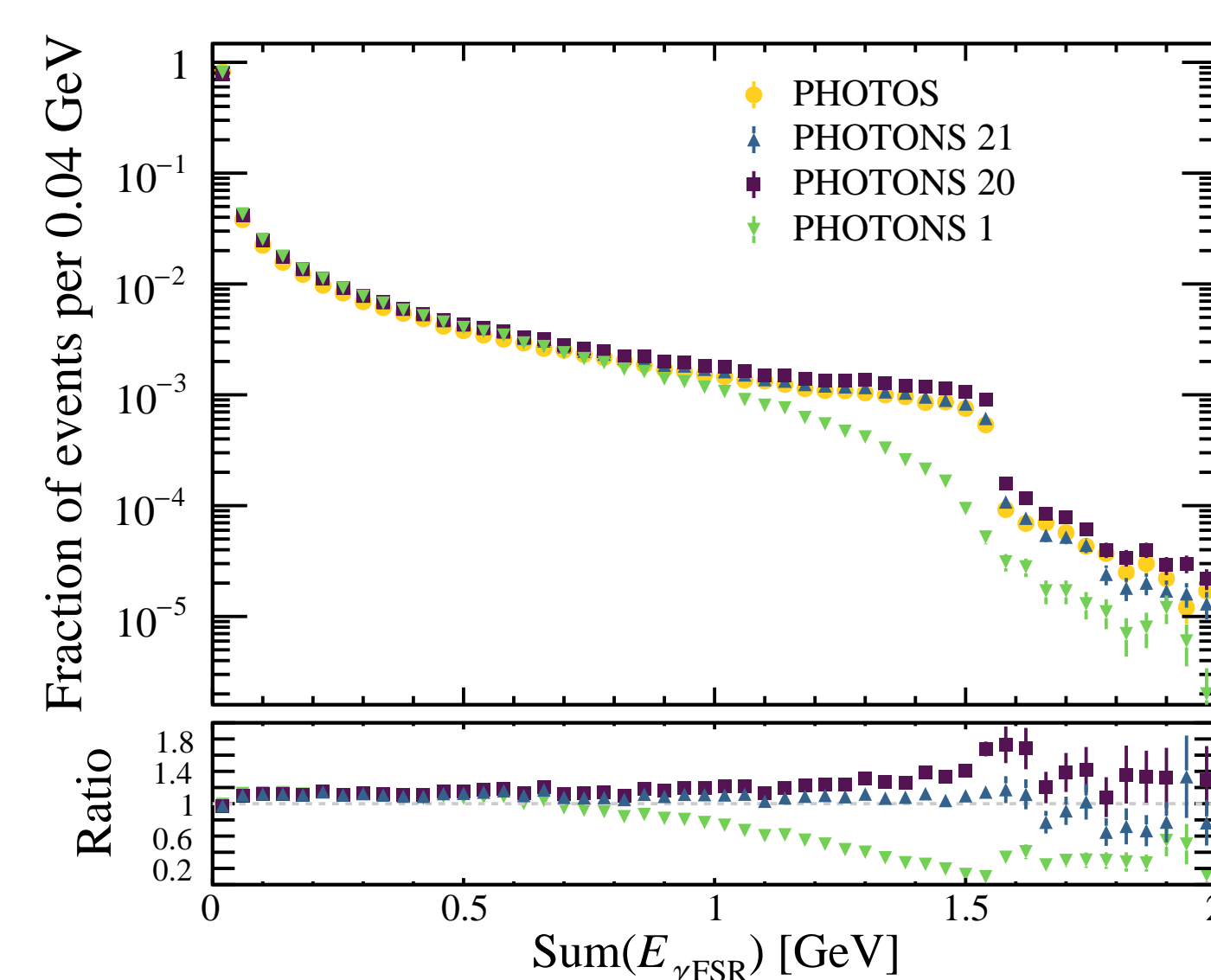
Implemented Sherpa's PHOTONS++ generator as alternative FSR plugin

- Simulates emission of soft photons based on YFS algorithm (mode 1)
- If switched on also hard photons based on collinear approx. (mode 2)

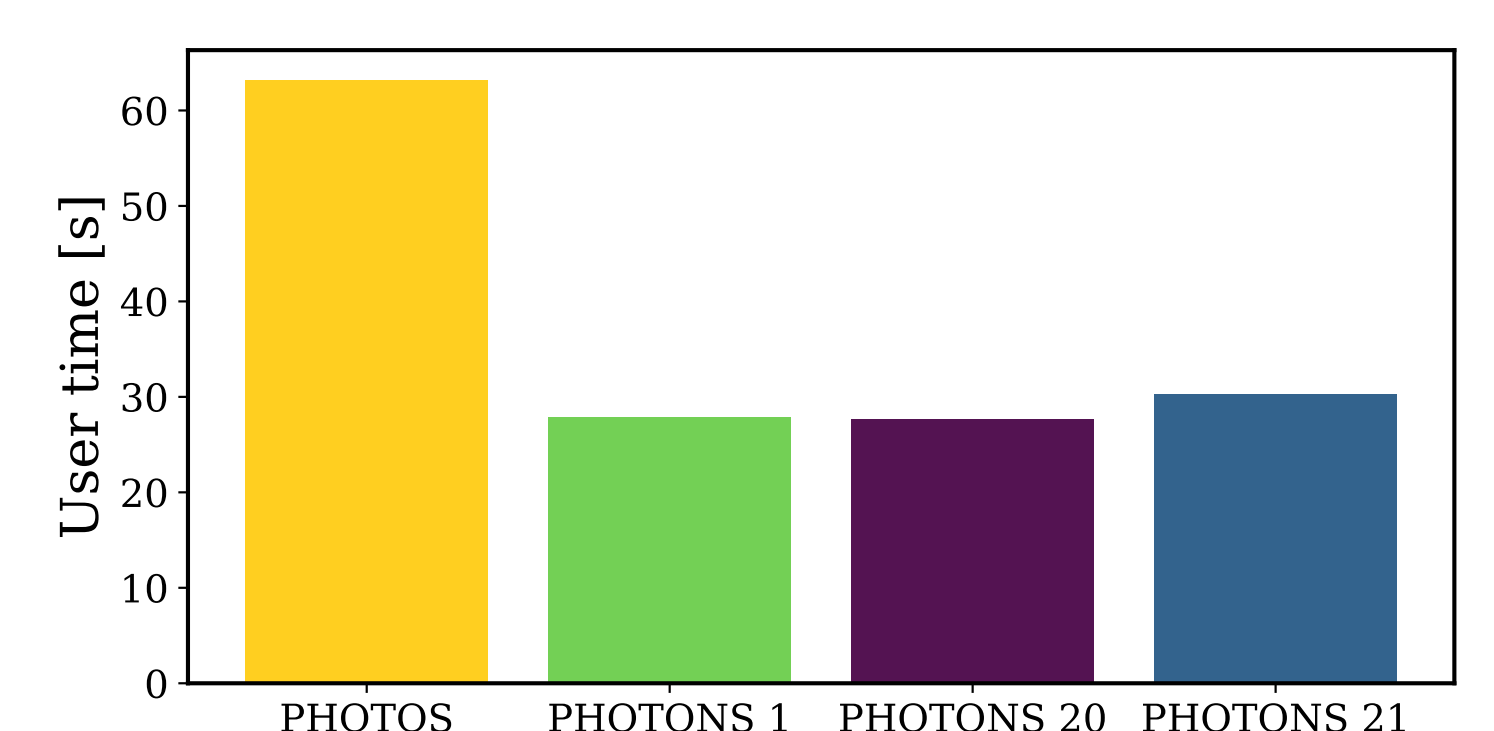
⇒ Approximate matrix-element corrections (mode 20), or

⇒ Exact matrix-element corrections (mode 21)

Simulated $J/\psi \rightarrow e^+e^-$ decays



Simulated $\Upsilon(4S) \rightarrow B\bar{B}$ decays



⇒ Overall good physics agreement between simulators

⇒ Speedup by a factor of ~ 2 when using PHOTONS++

The new beta release

Released **R03-00-00-beta1** for users to test

- Implemented thread safety
- Implemented new testing framework
- Added Sherpa's PHOTONS++ as FSR alternative
- Fixed various decay models (removed obsolete ones)
- Fixed bug with tensor particle rotation to helicity basis

Check it out!



Plans for the future

- Improve documentation (on it!) ⇒ prepare main Journal article
- Implement alternatives for τ simulation (fix τ -spin propagation)
- Make singleton objects const (requires modifications in all models!)
- Explore providing event weights from alternative decay tables

References

- (1) T. Sjöstrand, S. Mrenna et al., *Comput. Phys. Commun.*, 2008, **178**, 852–867.
- (2) S. Jadach, J. H. Kuhn et al., *Comput. Phys. Commun.*, 1990, **64**, 275–299.
- (3) N. Davidson, T. Przedzinski et al., *Comp. Phys. Comm.*, 2016, **199**, 86.
- (4) M. Schönherr and F. Krauss, *JHEP*, 2008, **12**, 018.