EM physics plans in the next 10 years

Farah Hariri
CERN-PH

22-05-2017

Contents

1. Geant4 electromagnetic (EM) physics sub-libraries provide, in general, accurate simulation for various applications in HEP, space science, medical and other applications
2. ATLAS and CMS are sensitive to EM effects on $\mathcal{O}(10^{-3})$
3. There are limited thin and thick target data allowing to proof EM models on such level
4. Geant4 and GeantV teams are working on detailed validation of EM models versus theory and available data

Contents

GOAL: Cope with experimental needs for modeling next generation detectors in the coming decade: HL-LHC

- More experimental data $\longrightarrow$ higher statistics $\longrightarrow$ smaller errors $\longrightarrow$ higher precision needed
- Full simulation occupies a significant part of computing resources (which varies depending on the experiment), $\longrightarrow$ Simulation of EM showers takes a substantial part
- **Need to improve precision of physics models & speed up simulations**

Review main EM physics processes:

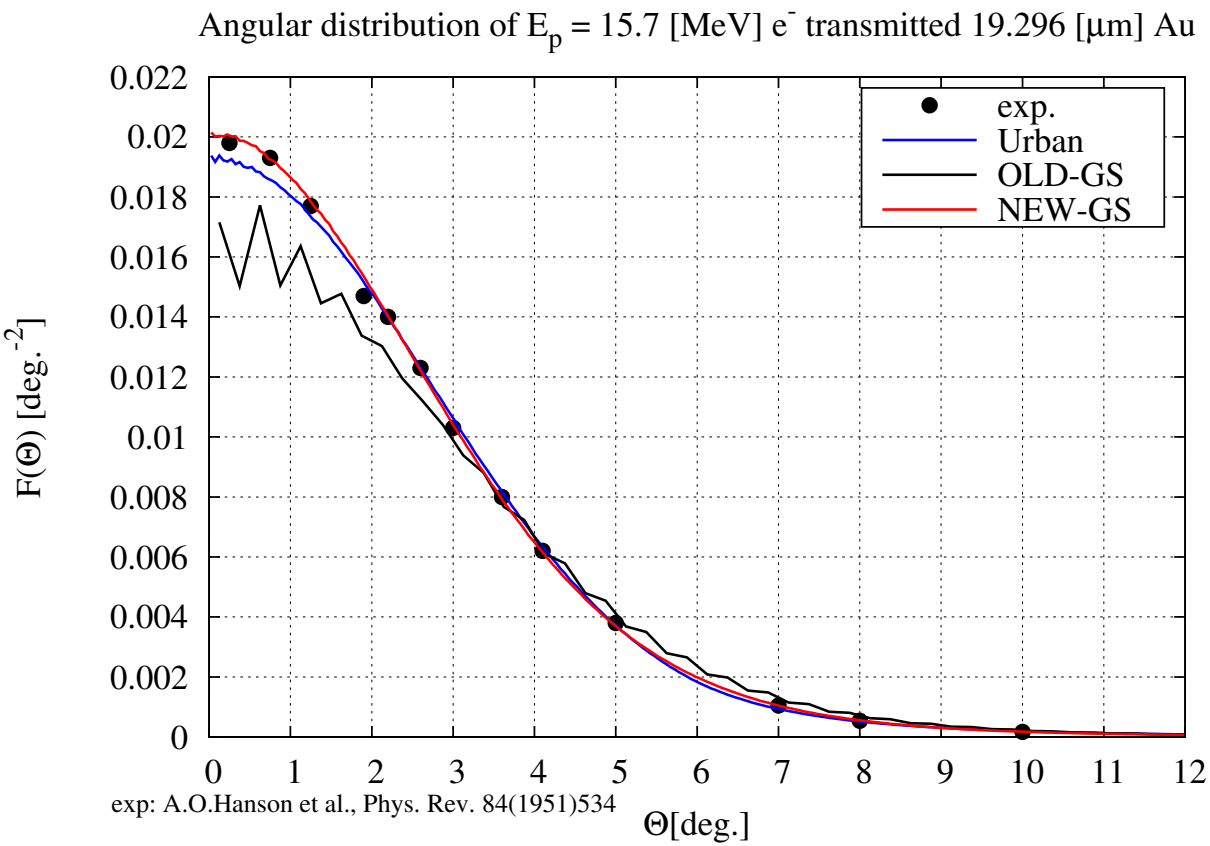
- To reach the $\mathcal{O}(10^{-3})$ level needed by experiments: leading and next to leading electromagnetic corrections should be taken into account
- Crucial for HL-LHC (to limit the systematic error)
- Extend validity of EM models up to FCC energies and beyond

Improve CPU performance:

- Speedup by reviewing algorithms and their implementations to better adapt them to current architectures

Contents

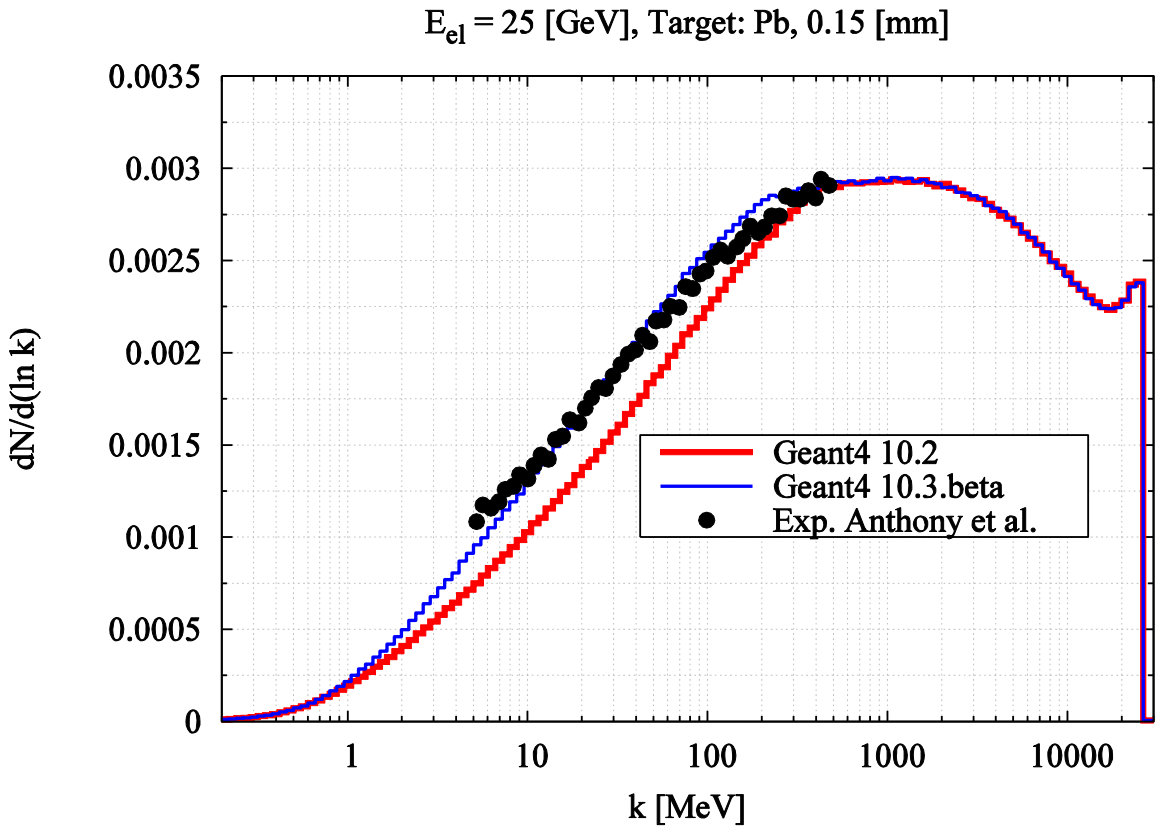
Multiple Scattering: new treatment of angular distributions $\longrightarrow$ New theoretical model of multiple scattering based on the most accurate computation of scattering parameters not sensitive to geometry and step size of electrons (no artefacts)



Bremsstrahlung: improved description of the LPM effect

$\longrightarrow$ theoretical inconsistencies in LPM suppression variables

$\longrightarrow$ new model gives better agreement with the available experimental data (modified in Geant4 10.3)

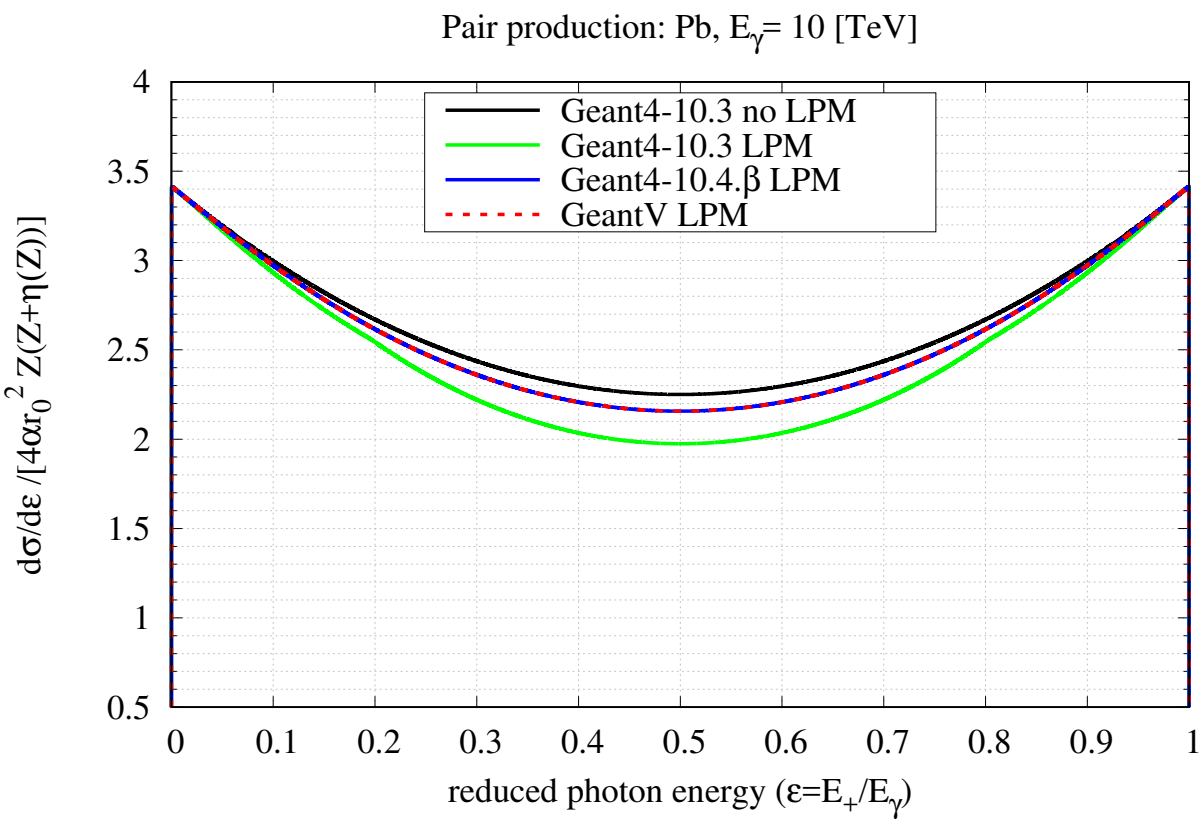


- The effect is seen on $\mathcal{O}(10^{-3})$ level for EM shower shape parameters in PbWO4

Pair-production: improved description of the LPM effect

$\longrightarrow$ theoretical inconsistencies in LPM suppression

$\longrightarrow$ new model shows a reduction in the DCS: oversuppression in the old model, but no available experimental data



Contents

Current & Planned activity for detector simulation

- Prepare for HL-LHC and FCC detector simulations
- Review main electromagnetic physics processes both for precision and for extension to higher energy, development of common modules to Geant4 and GeantV
- Revise also EM processes for hadrons and ions
- Investigate nuclear recoil effects, and other channels necessary at extreme relativistic energies like: triplet production, γ conversion to muon and hadron pairs, etc...
- Improve main algorithms

Outlook

- Implementing EM physics effects including leading and next to leading order corrections
- Development of fast sampling algorithms
- Development of FastSim simulation bypassing detailed simulation of EM showers