Status of Generic Biasing

Online Geant4 CM 2020

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Overview

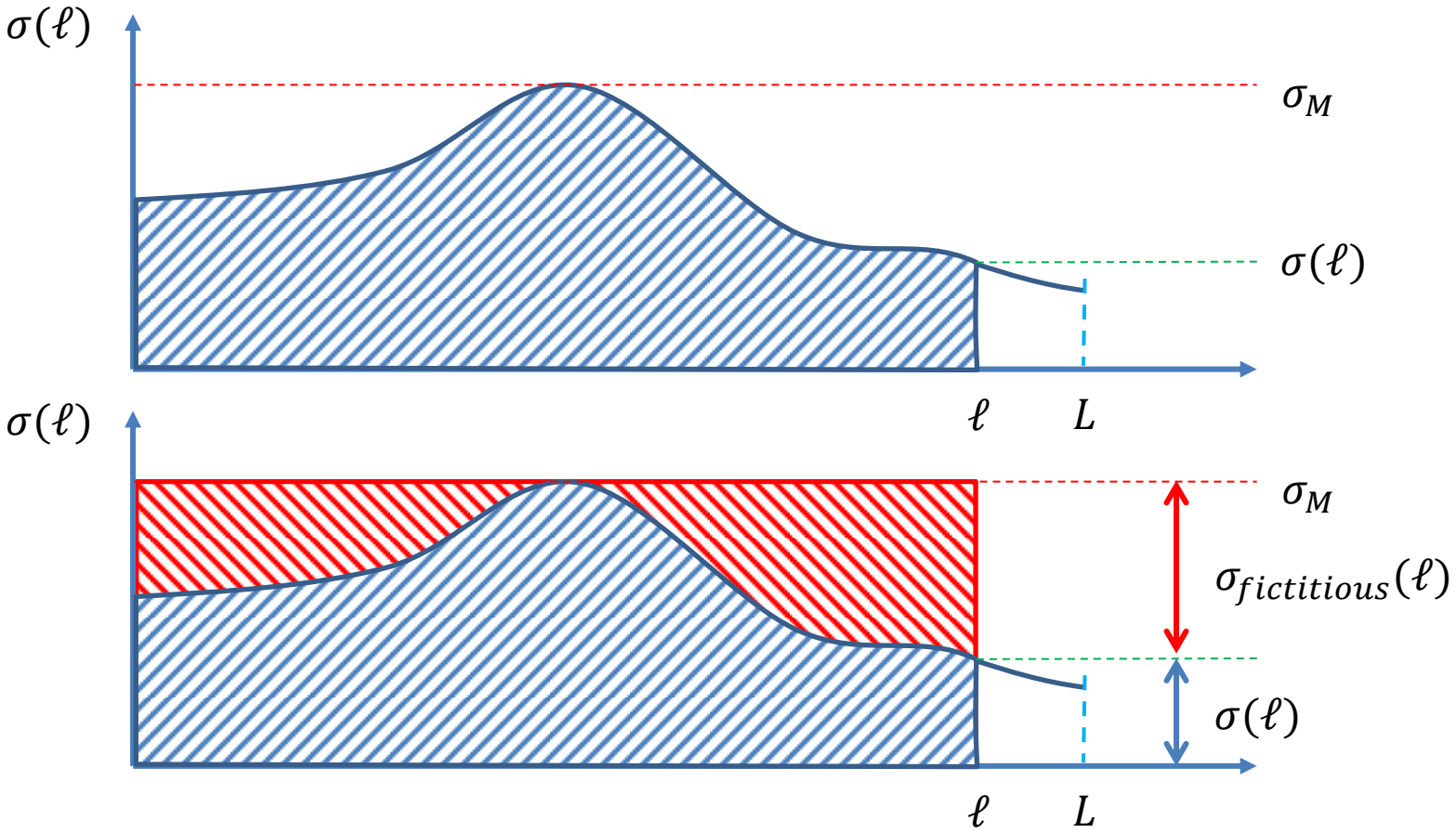
- Update on biasing of interaction occurrence of charged particles
- Overview of other items

Update on biasing of interaction occurrence of charged particles

Getting inspired by Woodcock viewpoint

Reminder on Woodcock-inspired technique

How to escape from explicit integral of cross-section



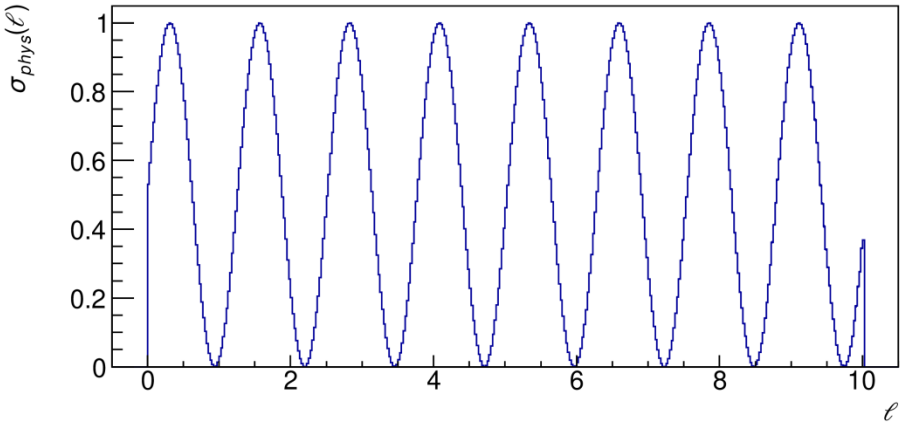
- Called also “integral approach”, but principle is the same

Woodcock & Biasing

Invention ?
Re-invention ?
Re-phrasing of an existing technique ?

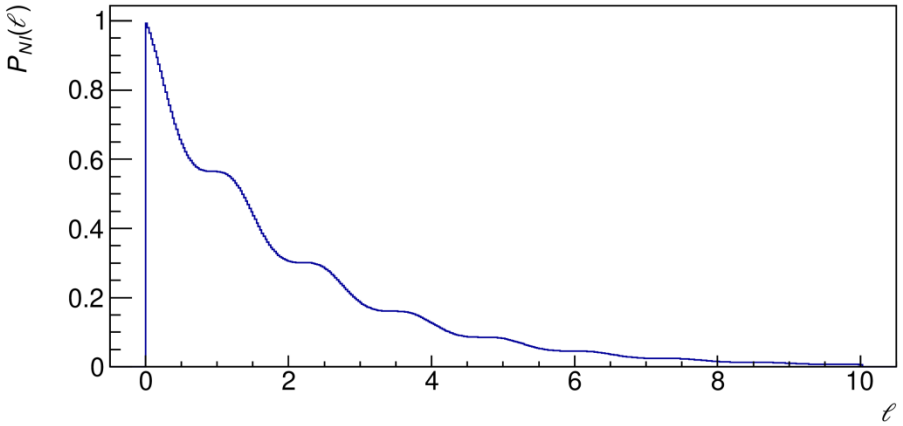
- The Woodcock viewpoint makes it easy the move to biasing:
  - In the analog world we have total physical and fictitious cross-sections:
  - $\sigma_M^a = \sigma_{phys}^a(\ell) + \sigma_{fictitious}^a(\ell)$
  - That we replace by their biased version in the biased world:
  - $\sigma_M^b = \sigma_{phys}^b(\ell) + \sigma_{fictitious}^b(\ell)$
  - From there, we apply the formalism we already know (see last general paper):
    - For a step ending with no interaction (eg : geometry), we multiply the track weight by the non-interaction weight, ratio of the non-interaction probabilities $P_{NI}^{a(b)}(0 \to \ell)$:
      - $w_{NI}(0 \to \ell) = \frac{P_{NI}^a(0 \to \ell)}{P_{NI}^b(0 \to \ell)}$
      - $P_{NI}^{a(b)}(0 \to \ell) = \exp\left(-\int_0^\ell \sigma_M^{a(b)} \cdot ds\right) = \exp\left(-\sigma_M^{a(b)} \cdot \ell\right)$
    - For a step ending with an interaction by process i, i = "physical" of "fictitious", we multiply the track weight by the interaction weight:
    - $w_I(\ell) = w_{NI}(0 \to \ell) \cdot \frac{\sigma_i^a(\ell)}{\sigma_i^b(\ell)}$
- And we're done !

"Physical" test cross-section

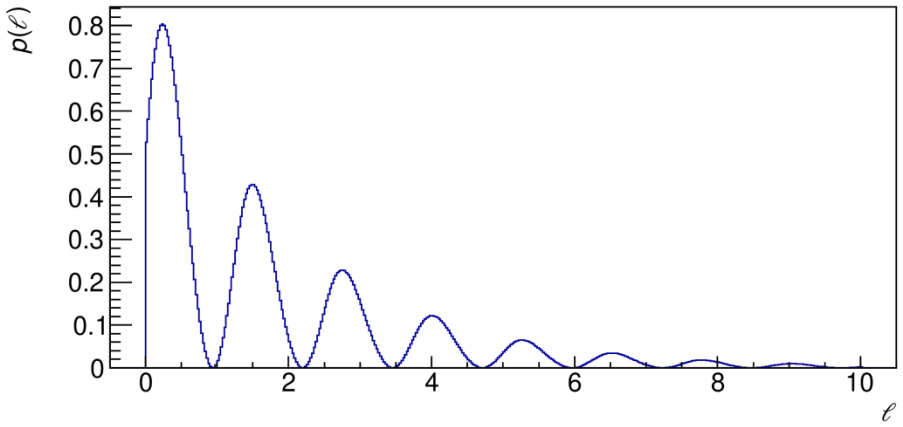


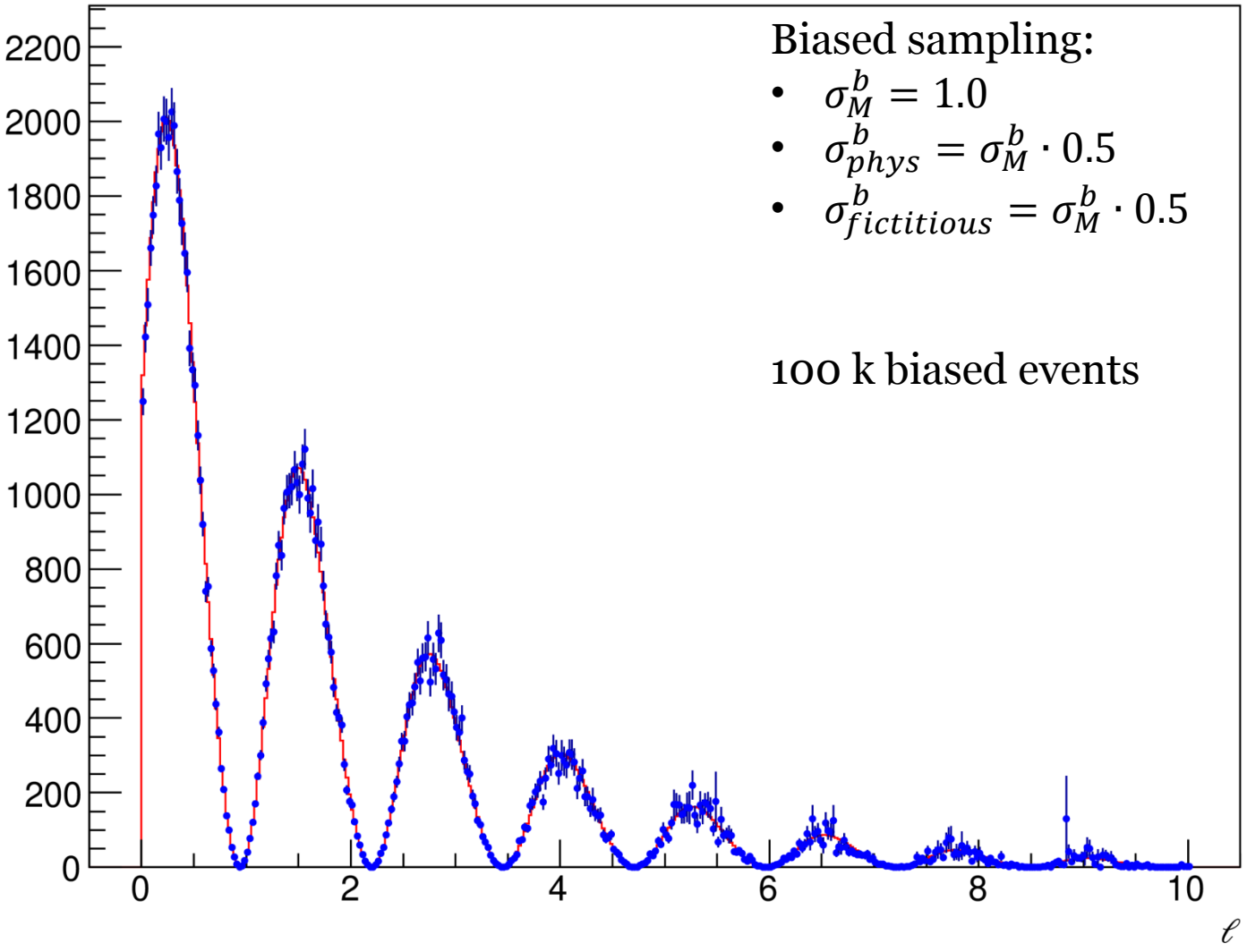
Related non-interaction probability over a path $0 \rightarrow \ell$

$$P_{NI}(0 \rightarrow \ell) = \exp\left(- \int_0^{\ell} \sigma_{phys}(s)\mathrm{d}s \right)$$



Related probability density function of interactions (product of the two above functions)





Reconstructed distribution of physical interactions using biasing

Status

- On paper work at this stage
- Note that NA64 is very interested in this functionality !
  - For background studies of particles interacting in beam-pipe
- We need explicit calculation of cross-section maxima:
  - Thanks to Vladimir for guidance
  - In EM :
    - Done in G4VEmProcess and G4VEnergyLossProcess
      - in GetPhysicsInteractionLength, PostStepDoIt, and GetIntegralLambda
    - Assumes one maximum only
  - In hadronic:
    - Done in G4HadronicProcess
    - Assuming that the cross-section only grows when energy increase.
- Issue:
  - Physics calculations needed from other package(s)
  - Create new dependencies
    - How to handle these ?
  - Part of the issues for 2021 release
- Plan:
  - Create an extended example, to exercise the scheme (and share with users)
  - Move to source when issue of dependencies cleared

Other items

On-going items

- Statistical test suite to verify correctness of biasing wrt to analog
  - Many biasing options can be tested the same way
    - Checking the same variables
  - Idea is to create such a suite in geant-val
  - Good progress made thanks to Kyungseop Yoon, 2019 summer student at CERN, under guidance of Anna
    - But we need to converge
- DXTRAN
  - Option to favor scattering toward some ROI
  - Requires explicit dependencies on other physics packages
    - And introduction of new differential cross-section class
    - Discussed with Laurent D.
  - Postponed (again) to 2021
- Implicit capture:
  - Option to “cancel” absorption of neutrons, to make them travelling further in –eg- shields
  - Essentially a matter of creating an example for that
    - The needed functionalities exist
  - May happen this year
- Extend generic biasing scheme for at rest case
  - Not forgotten
- One common issue : manpower !
- Bug to address : unseen boundaries with ghost geom., as reported by Makoto