Geometrical Event Biasing

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Geometrical Event Biasing Overview

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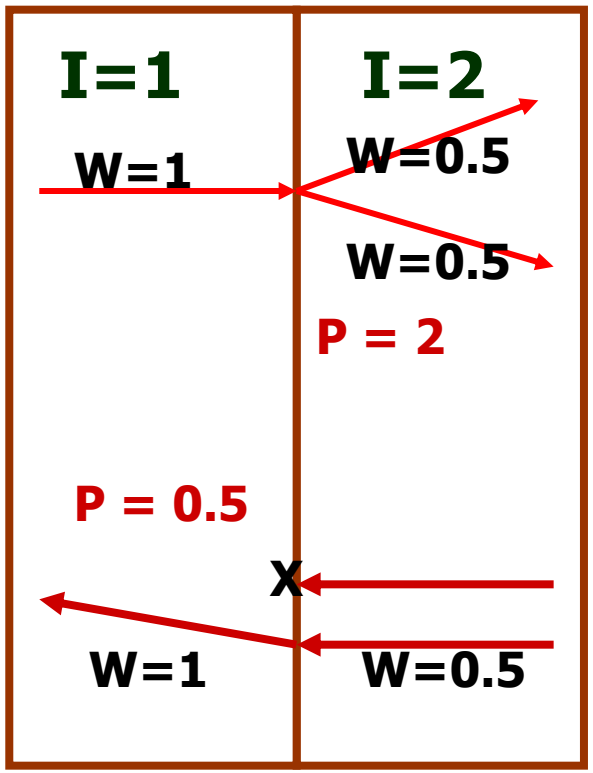
Geometric Biasing

The purpose of geometry based event biasing is to save computing time by sampling less often the particle histories entering "less important" geometry regions, and more often in more "important" regions.

* Importance sampling technique
* Weight window technique

Importance sampling technique

- Importance sampling acts on particles crossing boundaries between "importance cells".
- The action taken depends on the importance value assigned to the cell.
- In general, a track is either split or plays Russian roulette at the geometrical boundary depending on the importance value assigned to the cell.



- Splitting
- Russian Roulette

Importance sampling technique

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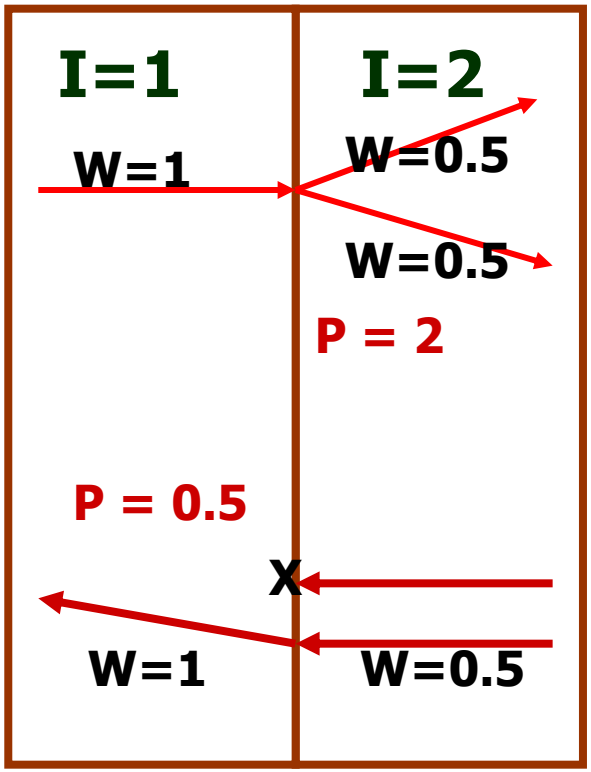


- Survival probability (P) is defined by the ratio of importance value.
  $P = I_{post} / I_{pre}$
- The track weight is changed to W/P.

- Splitting a track (P > 1)
  - E.g. creating two particles with half the 'weight' if it moves into volume with double importance value.

- Russian-roulette (P < 1) in opposite direction
  - E.g. Kill particles according to the survival probability (1 - P).

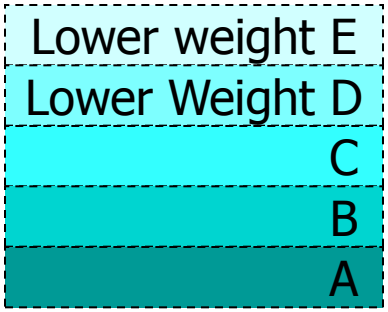
Weight Window

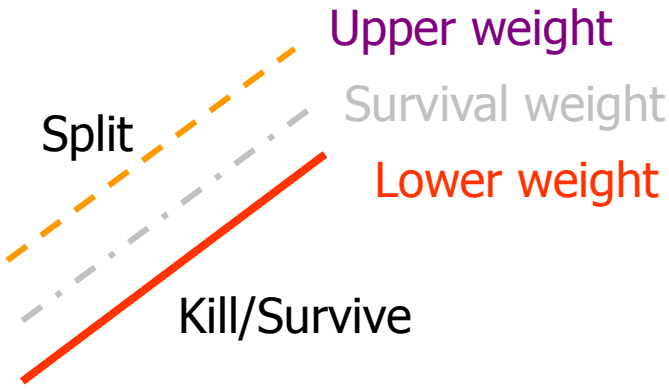
- Weight based enhancement to importance sampling
- Particles either split or Russian Roulette played based on space-energy cells
- User defines a weight window for each space cell, and optionally for different energies
- Can help control weight fluctuations introduced by other variance reduction techniques
- Maintains similar weights in a given region, which makes computation more efficient – (equal CPU per weight)

The Weight Window Technique

- The weight window technique is a weight-based algorithm – generally used together with other techniques as an alternative to importance sampling:
  - It applies splitting and Russian roulette depending on space (cells) and energy
  - User defines weight windows in contrast to defining importance values as in importance sampling

- A weight window may be specified for every cell and for several energy regions: *space-energy cell* .

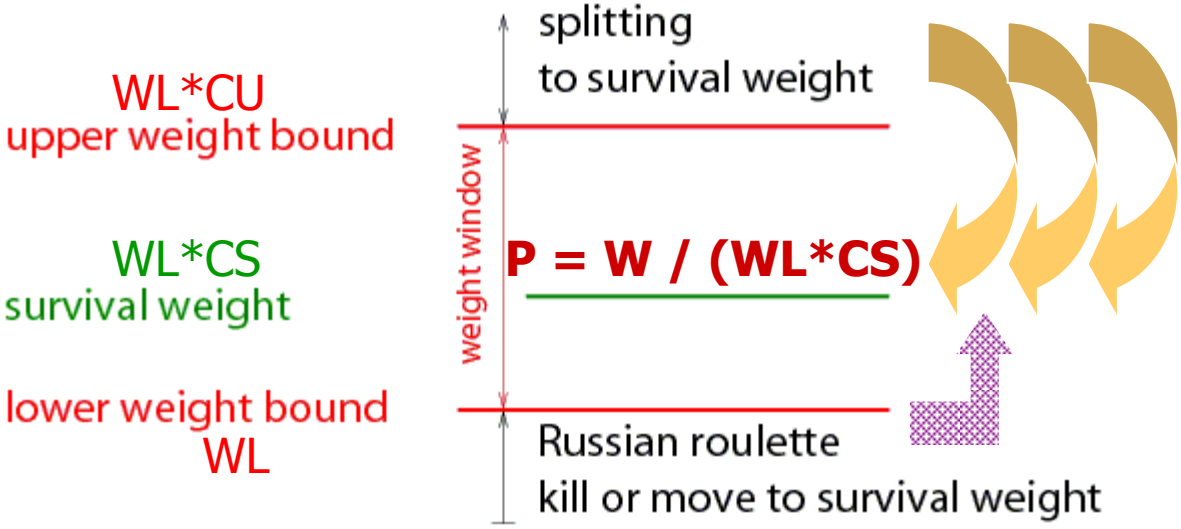




- Apply in combination with other techniques such as cross-section biasing, leading particle and implicit capture, or combinations of these.

The weight window technique (continue)

- Checks the particle weight
  - Compare the particle weight with a 'window' of weights defined for the current *energy-space* cell
  - Play splitting or roulette in case if it is outside, resulting in 0 or more particles 'inside' the window
    - E.g. WL is a lower weight bound of a cell.
      CU and CS are upper limit factor and survival factor, respectively.
      - W > WL*CU Split track
      - W < WL*WL Roulette

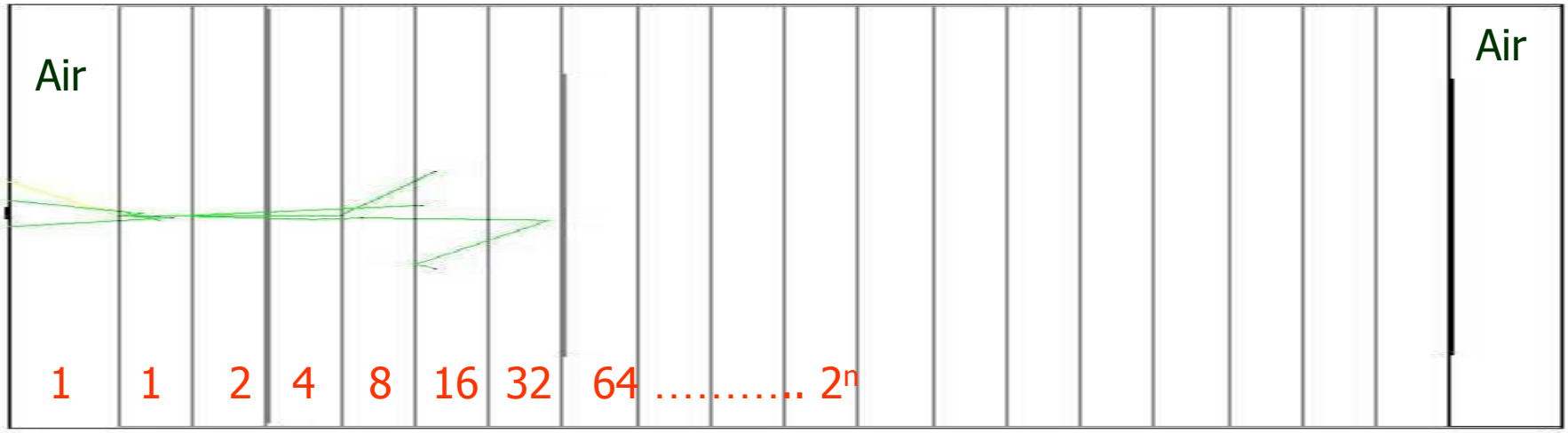


Examples

- Extended/Biasing contains 2 examples of biasing
  - B01 (one geometry biasing)
  - B02 (biasing in the parallel world)
    - Both looking at 10MeV neutrons travelling through concrete shielding

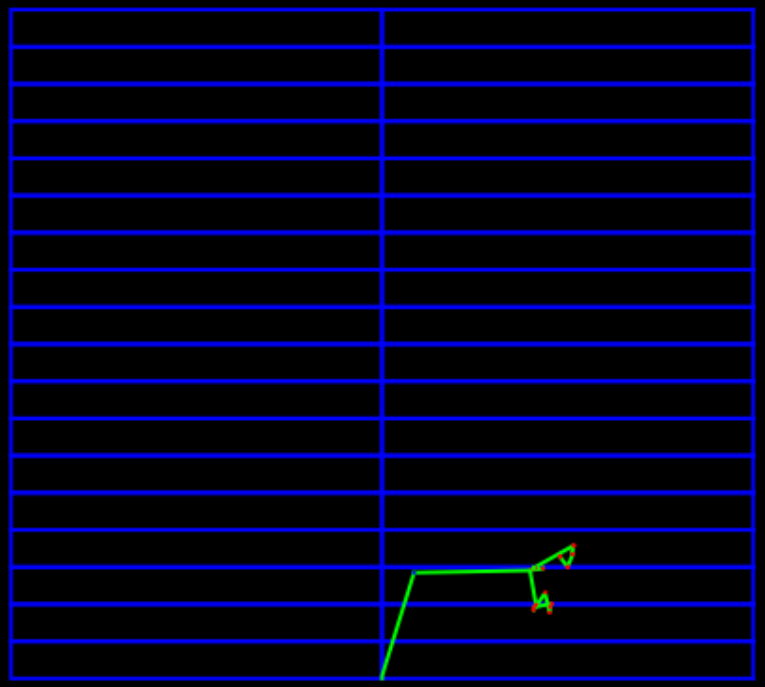
Biasing example B01

- Shows the **importance sampling** in the mass (tracking) geometry
- Option to show weight window
- 10 MeV neutron shielding by cylindrical thick concrete material
- Geometry
  - 80 cm high concrete cylinder divided into 18 slabs
  - Importance values assigned to 18 concrete slabs in the DetectorConstruction for simplicity.
  - The G4Scorer is used for the checking result
    - Top level class uses the framework provided for scoring.

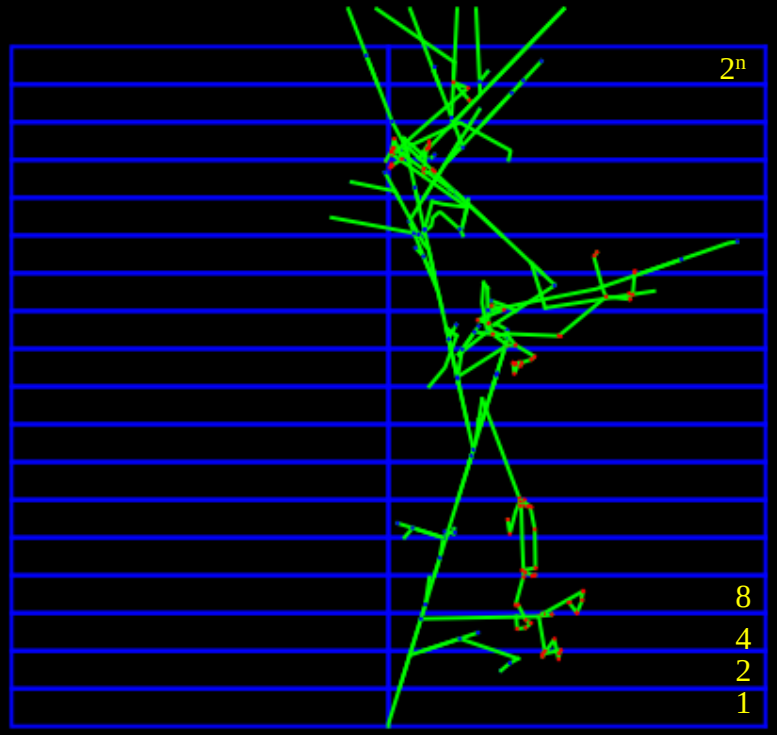


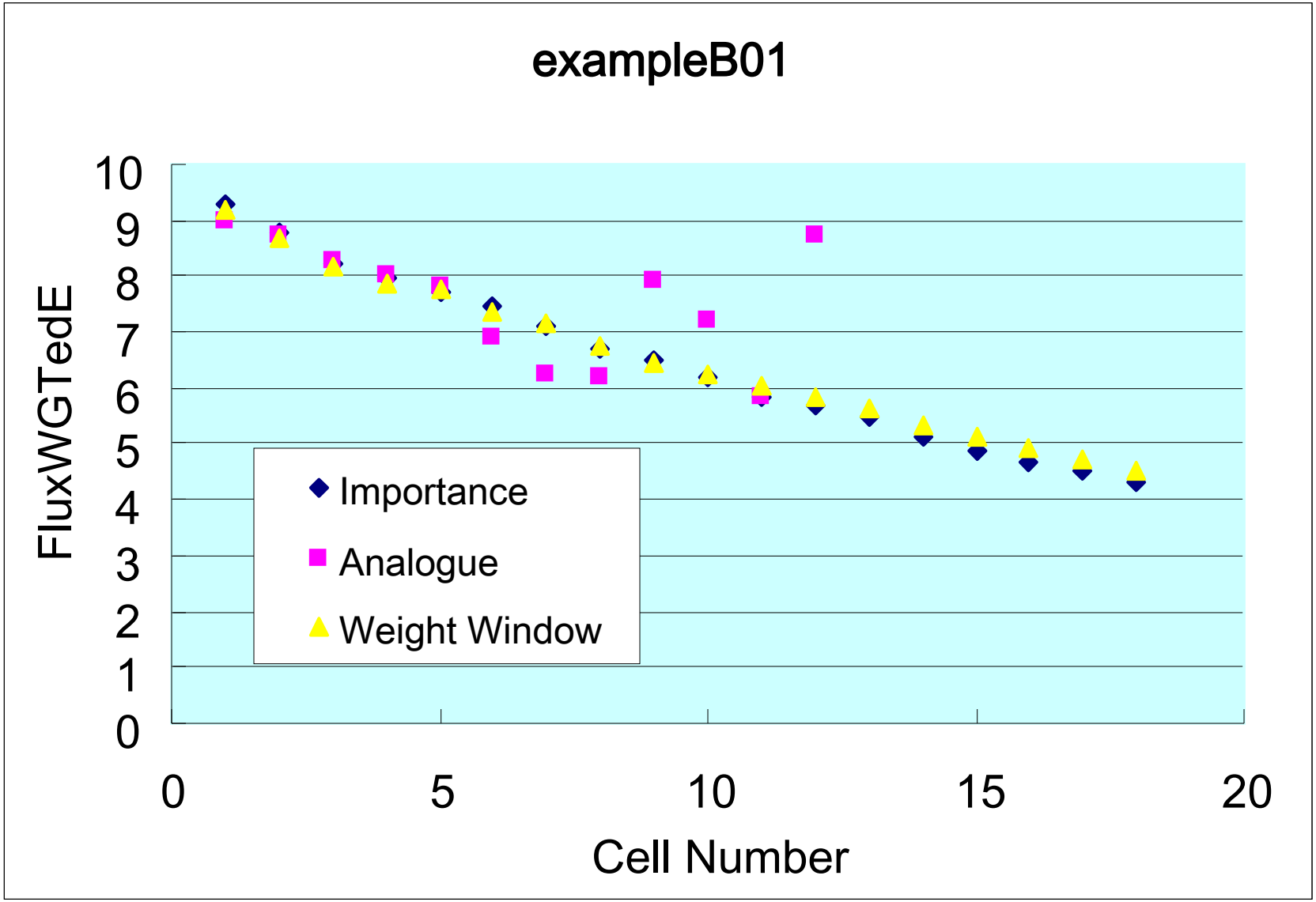
Example B01 - 10 MeV neutrons, thick concrete cylinder

Analogue Simulation



Importance Sampled




exampleB01
FluxWGTedE
10
9
8
7
6
5
4
3
2
1
0
0
5
10
15
20
Cell Number
Importance
Analogue
Weight Window

Example B02

- Shows importance sampling in a parallel geometry
- Includes a customized scoring making use of the scoring framework
- Mass geometry consists of a 180 cm high simple bulk concrete cylinder
- A parallel geometry is created to hold importance values for slabs of width 10cm and for scoring
- The scoring uses the G4CellSCorer and one customized scorer for the last slab

Shortcomings

- Statistical analysis/accuracy of result/convergence of result
- Performance improvement measure
- Interface – command line? Why in physics list?
- Sensible weight values? Protection against "dumb" users?
- Real Examples
- Validation for given use cases in terms of CPU, Variance reduction and physics performance
- Documentation
- Publicity