蘭州大學
LANZHOU UNIVERSITY

Exercise: Biasing

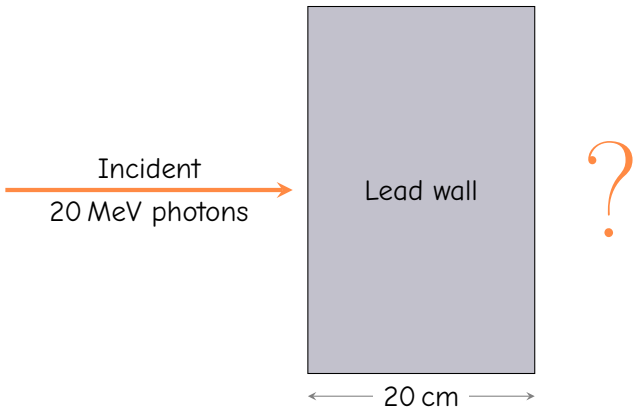
23rd FLUKA Beginner's Course
Lanzhou University
Lanzhou, China

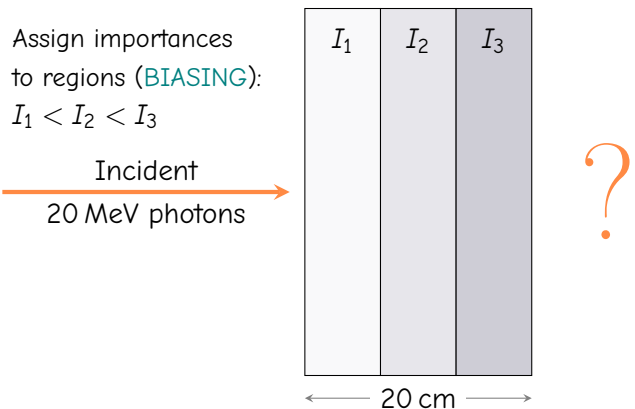
June 2–7, 2024

Outline

1. Geometry
2. Add layers
3. Detector setup
4. Test: Analog run
5. Assign importances to layers
6. Try it yourself
7. Optimisation of layer importances

Outline


Incident
20 MeV photons
Lead wall
?
20 cm


Assign importances
to regions (BIASING):
$I_1 < I_2 < I_3$
Incident
20 MeV photons
I_1
I_2
I_3
20 cm
?

Outline

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Add layers

Split the wall by 10 layers of equal thickness

1. Use additional XYP surfaces
2. Name the corresponding regions: L0, …, L9

Outline

Detector setup

Add a boundary crossing estimator (USRBDX) at the wall exit plane:

1. Score photon current from L9 to void
2. Single energy bin between 0 eV and the incident photon energy
3. Single angular bin covering all possible tracks
4. Do not normalise by detector area
5. Use file unit 48 for binary output
6. Name the estimator as FoM (figure-of-merit)

```
USRBDX    1.0    PHOTON   -48.0    L9      BACK              FoM
USRBDX    0.1       0.0     1.0                      1.0     &
```

Outline

Test: Analog run

- You already know how to run FLUKA and process output files with its graphical user interface, Flair
- But one can also do it using Linux terminal
  - it might look less user-friendly, but
  - it gives a lot of flexibility when doing extensive calculations

Let's try it!

Running FLUKA from terminal
Fix run time

1. In order to be able to compare efficiencies of different runs, we need to fix the CPU time T. In this case, as we already know, the relative error R will be the measure of efficiency of our calculation $R\sqrt{T} = C$
2. To do this, we set a very large number of primaries in the START card (so that the run does not finish before our fixed time period is over):

```
START     1.0E9
```

3. And add the -t 120 flag to rfluka, which tells it to stop the run after approx. 2 min:

```
time $FLUPRO/flutil/rfluka -t 120 biasing.inp
```

- we prepend the rfluka script call with the optional Linux time command just to print the total running time in the terminal at the end of calculation
- the run will be a bit longer because some time will be occupied for initialisation and termination of the calculation

Running FLUKA from terminal
Merge the output data files

- When we use Flair, it calls the FLUKA utilities to merge the output files once you have pressed the Process button located under the Run tab
- When we run FLUKA from terminal, we have to do it ourself:

```
$FLUTIL/bdxsum.sh biasing 48
```

- This generates 3 files with the same contents but in different formats:
  - biasing_48bdx_sum.lis — convenient to be read by humans
  - biasing_48bdx_tab.lis — convenient to be read by analysis scripts, ASCII format
  - biasing_48bdx.bnx — even more convenient to be read by analysis scripts, binary file format is described in the Manual

Since we have defined USRBDX with only one energy and angular bins, our result is just a single number with its relative uncertainty:

```
      head -3 biasing_48bdx_tab.lis
# Detector n: 1 FoM (integrated over solid angle)
# N. of energy intervals 1
  0.000E+00   1.000E-01   3.962E-02   2.970E+00
```

- Estimator name: FoM
- Energy bin: from 0 GeV to 0.1 GeV
- Estimated value: 3.962×10^{-2} photon/GeV/primary $\pm$ 2.97 %
  - not normalised by solid angle since this is the integrated value
  - to convert to "photons/primary" we must multiply by the energy bin width, 0.1 GeV
- Last number is the relative error R we are interested in

Outline

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2 Add layers

3 Detector setup

4 Test: Analog run

5 Assign importances to layers

6 Try it yourself

7 Optimisation of layer importances

Assign importances to layers

Now let's setup surface splitting.
Assign importances to the wall layers in order to minimise the relative error while running FLUKA for the same time as analog run (two minutes):

	WHAT1	WHAT2	WHAT3	WHAT4	WHAT5	WHAT6	SDUM
BIASING	2.0		1.0	L0			
BIASING	2.0		2.0	L1			
...							

- Add similar BIASING cards for all 10 wall layers
- Use your own numbers in the WHAT3 column
- Remember that the importances should be in the increasing order towards your detector
- Keep the neighbour layers ratios below 5.0 to avoid problems

Outline

Try it yourself

- Experiment with different numbers in order to find the optimal set of importances that minimise the relative error while running FLUKA for the same time as analog run: two minutes
- Split into groups or do it individually

Outline

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Optimisation of layer importances

Optimal setup of importances should keep number of tracks in each layer constant:

Tracks	Importance	New Importance
300	1	1
200	2	3 = (2/1) × (300/200) × 1
100	4	12 = (4/2) × (200/100) × 3
25	8	96 = (8/4) × (100/25) × 12

$$I^i_{new} = \frac{I^i_{orig}}{I^{i-1}_{orig}} \times \frac{T^{i-1}}{T^i} \times I^{i-1}_{new}$$

Incident beam goes downwards

[MCNP]

Optimisation of layer importances
Number of tracks

- Where do we get information about number of tracks?
- We can print it with the BIASING card:

	WHAT1	WHAT2	WHAT3	WHAT4	WHAT5	WHAT6	SDUM
BIASING	0.0		1.0	BH	BACK		PRINT

- BH is the first region of our geometry
- BACK is last region of our geometry
  - we could alternatively specify last region using a special FLUKA variable, @LASTREG, which always points to last region of geometry

Optimisation of layer importances

- Now comment-out those BIASING cards which assign imporances to the layers (we need analog run again)
- Insert the BIASING card printing number of tracks (previous slide)
- Run a single cycle with better statistics

```
$FLUTIL/rfluka –t 300 –N0 –M1 biasing.inp
```

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

- BH: particles are not transported $\Rightarrow$ 0

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

- FRONT: backscattering particles coming from L0

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

- L0: particles from FRONT and backscattering particles from L1

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

Total number of tracks enering the region: N. of RR + N. of SP
not normalised by the number of histories (N. of SP is always zero in analog runs)

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

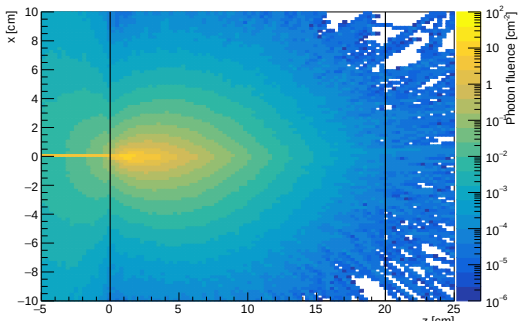
- The meaning of the other numbers is explained below (we do not need them now)

Optimisation of layer importances

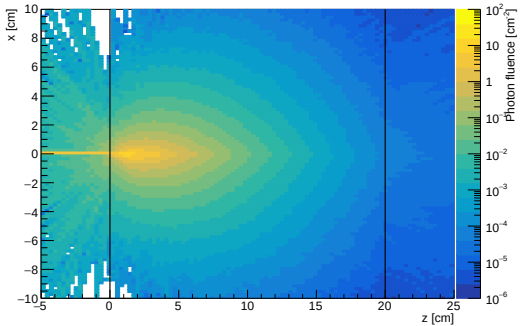
1. Assign (quasi) optimal importances for each layer using the BIASING cards and the table from `biasing001.out`
2. Run 5 run-cycles with our original 120 sec time, merge the output files and notice the relative error
   - it should be lower than in the non-optimised run
3. Go to step 1 while relative error keeps reducing with respect to the previous run

Comparison of analog and biased runs
Photon fluence

Analog run

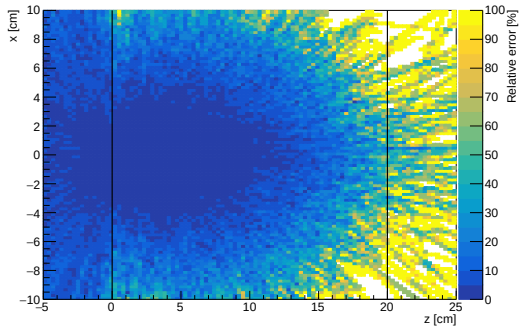


Biased run

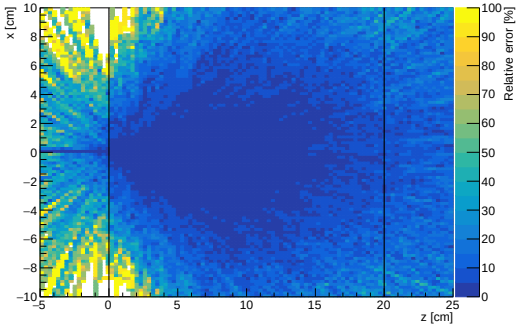


Comparison of analog and biased runs
Photon fluence — relative uncertainties

Analog run



Biased run



www.fluka.org

Details

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

- BH: particles are not transported ⇒ 0

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

- FRONT: backscattering particles coming from L0

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

- L0: particles from FRONT and backscattering particles from L1

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

<Wt> in Average weight of these particles

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

<Wt> in Average weight of these particles

- BH: particles are not transported ⇒ 0

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

<Wt> in Average weight of these particles

- FRONT and L0: run is analog ⇒ weight of all particles is 1

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

<Wt> in Average weight of these particles

<Wt> kil Average weight of particles killed after being submitted to Russian Roulette

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

<Wt> in Average weight of these particles

<Wt> kil Average weight of particles killed after being submitted to Russian Roulette

- BH: particles are not transported ⇒ 0

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

<Wt> in Average weight of these particles

<Wt> kil Average weight of particles killed after being submitted to Russian Roulette

- FRONT and L0: run is analog ⇒ no particles are submitted to Russian Roulette

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

- BH: particles are not transported ⇒ 0

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

- FRONT and L0: run is analog ⇒ no particles are split

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

<Wt> in Average weight of these particles

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

<Wt> in Average weight of these particles

- BH: particles are not transported $\Rightarrow$ 0

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

<Wt> in Average weight of these particles

- FRONT and L0: run is analog ⇒ no particles are split

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

<Wt> in Average weight of these particles

<Wt> out Average weight of particles after being submitted to splitting

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

<Wt> in Average weight of these particles

<Wt> out Average weight of particles after being submitted to splitting

- BH: particles are not transported $\Rightarrow$ 0

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out	**Reg. #**	**N. of Sp**	<Wt> in	<Wt> out
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

<Wt> in Average weight of these particles

<Wt> out Average weight of particles after being submitted to splitting

- FRONT and L0: run is analog ⇒ no particles are split

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

Total number of tracks enering the region: N. of RR + N. of SP

not normalised by the number of histories (N. of SP is always zero in analog runs)

Optimisation of layer importances
Number of tracks

Very end of `biasing001.out` obtained with analog run:

EMF importance RR/Splitting counters

Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil	Reg. #	N. of RR	<Wt> in	<Wt> kil
1	0.00E+00	0.00E+00	0.00E+00	2	1.55E+05	1.00E+00	0.00E+00	3	5.10E+05	1.00E+00	0.00E+00
Reg. #	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**	**Reg. #**	**N. of Sp**	**<Wt> in**	**<Wt> out**
1	0.00E+00	0.00E+00	0.00E+00	2	0.00E+00	0.00E+00	0.00E+00	3	0.00E+00	0.00E+00	0.00E+00

Reg. # Region number

- 1: BH (black hole), 2: FRONT (void), 3: L0 (first wall layer)

N. of RR Number of particles entering the region which are not split

N. of Sp Number of particles entering the region which are split

- The meaning of the other numbers is explained below (we do not need them now)