Capture flux and Guide losses

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Capture flux estimates
- Definition of capture flux
- Measurement and accuracy
- McStas simulation

Guide losses
- Mechanisms involved
- Simulation

Disclaimer: in case of errors and uncertainties, please correct me...

Capture flux: definition

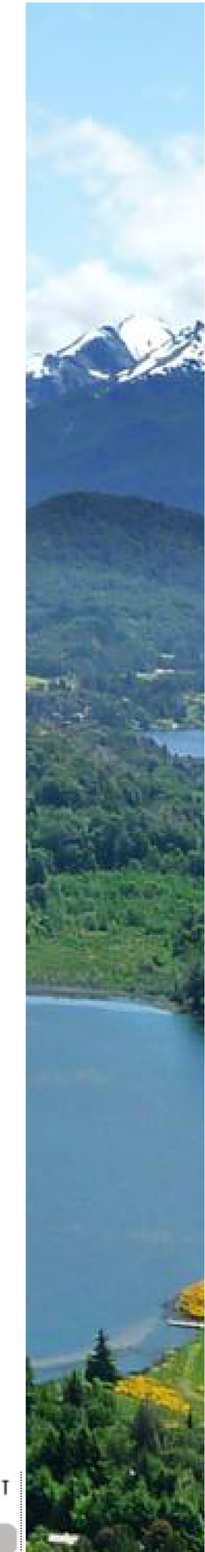
- The 'capture flux' is the standard way to measure an integrated flux in facilities. A white beam is absorbed into a gold foil, in an energy range up to 500 meV neutrons. Then this is normalized to the thermal neutron absorption cross section for λ =1.8 Å (2200 m/s), and finally:

$$\Phi_c = \int_0^{0.5\,eV} \frac{d\varphi}{d\lambda} \frac{\lambda}{\lambda_{2200\,m/s}} d\lambda$$

- Even though the formula is valid for thermal neutrons, it has been extended to cold and hot neutrons.
- So, in a few words, the real integrated flux $\Phi = \int \frac{d\varphi}{d\lambda} d\lambda$

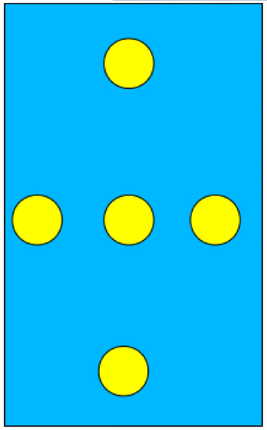
  is roughly $\Phi \sim \Phi_c$ for a spectrum peaked around 1.8 Å,

  and $\Phi \sim \Phi_c/2$ for a spectrum peaked around 3.6 Å
- *Capture flux = integrated, **wavelength weighted** flux*



Capture flux: measurement accuracy

- The health physics/guide staff put 1 cm^2 gold foils in the beam, and they measure their activity after irradiation. Au: σ_{abs} =98.65 [barns]



- The intrinsic measurement accuracy of the method is of the order of 10 %.
- **Simulating** capture flux measurement with McStas:

```
Monitor_nD(options= “capture per cm2”, …)
```

- Or use `EXTEND %{ p *= 2200/v; %}` before the monitor, and `%{ p /= 2200/v; %}` after.


Warning : in the following nasty neutrons will be shot
Virtual radiation hazard
Trespassers will be shot !
Survivers will be shot again !

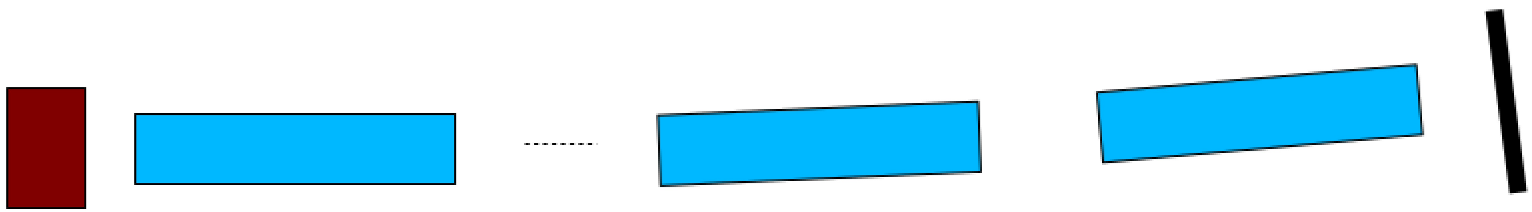
Capture: Exercise 1

Aim: Capture flux after a curved guide

- Create a new **Template**, with input parameters **Lmin**=.4 and **Lmax**=10 for the wavelength range. Explain why *Lmin* = 0.4 Å ($E=81.8/\lambda^2$)
- Insert a `Source_gen(I1=3e11, T1=330, radius=0.15/2, focus_xw=.1, focus_yh=.1, Lmin=`**`Lmin`**`, Lmax=`**`Lmax`**`)` which corresponds to a 1MW thermal research reactor.
- Insert a `Guide(w1=.1,h1=.1, l=1, m=2)` at 2 m, with 'cheap' super-mirror coating.

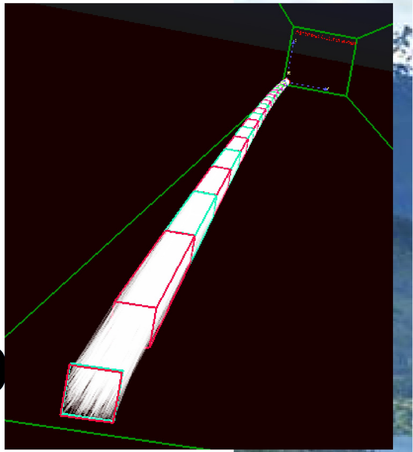
Capture: Exercise 1

Aim: Capture flux after a curved guide

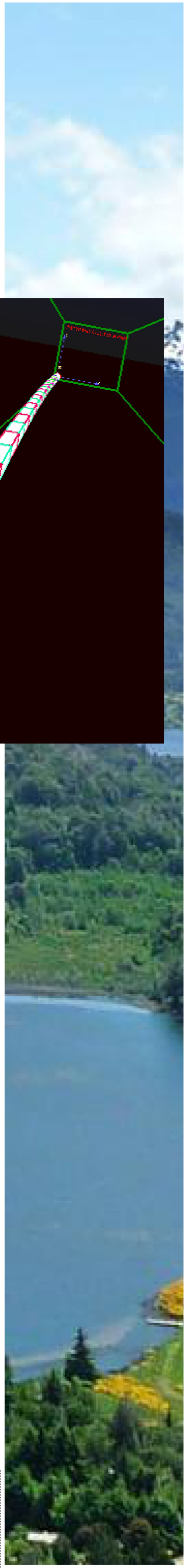


- Get `Ex_3_1_curved.instr` from previous session 'Guides'.
- Add a `Monitor_nD(options="x lambda, all auto", xwidth=.1, yheight=.1)` at 1.5 m from last Guide instance **exit**.
- Add a `Monitor_nD(options="x lambda, all auto, capture per cm2")` at 1cm from previous.

Capture: Exercise 1

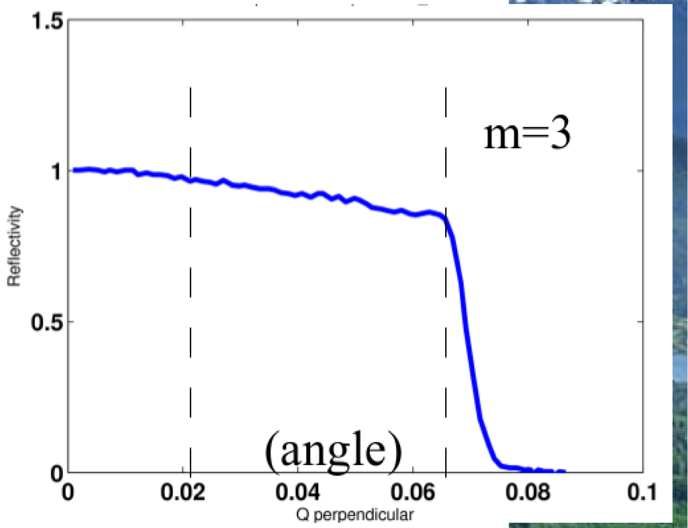


- **Save** and **Run** in **Trace** mode with VRML plotter and 1000 neutrons. Check the geometry.
- Run in **Simulation** mode, with PGPLOT p and 1e6 events. *Compare the ideal and capture fluxes.*
- Re-run with λ=0.4-5, 1-10, 2-20 Å. Compare again. How much does it vary ?



Guide losses: reflectivity

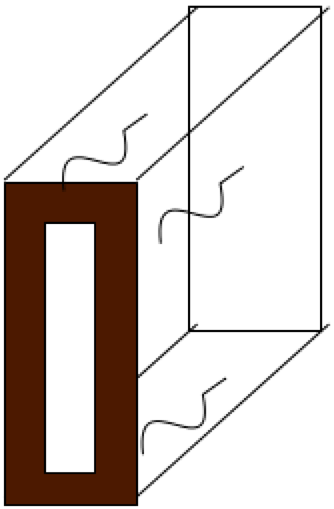
- Guides transporting neutrons are not 100 % efficient.
- Their **reflectivity** depends on the material, number and quality of the multi-layers deposited on top of the glass or metal substrate surface.



- Non reflected neutrons are either **absorbed** or **scattered**. In both cases, this creates background and radiation to protect from with proper shielding (concrete, lead, boron, PE).
- Divergence reflected by a guide: $\alpha_{[o]} = 0.1\ m\ \lambda_{[Å]}$

Guide losses: origin

- Some causes of non reflection:
  - too high divergence, above total reflection angle (depends on material cross section and m-value)
  - low angle scattering
  - poor waviness of surfaces (poor polishing)
  - dirty surfaces (dust, grease, …)
- In addition to radiations, the losses damage materials by creating He (α) bubbles which propagate cracks. Glass turns dark and brittle.



Guide losses: Exercise 2: per m

- Re-use the previous exercise.
- **Insert** flux monitors in between guide elements
- Run simulation with ***m***=0.65 (glass), 1 (Ni) and m=3 (super-mirror) for the Guide
- Estimate the losses per meter (in absolute and percentage)
- *Does super mirror coating increase background level at the end of the guide ?*

Guide losses: Exercise 3: Logger

- A set of components allow to record the 'lost' neutron events along a guide:
  - Scatter_logger/Scatter_logger_stop
  - Scatter_log_iterator/Scatter_log_iterator_stop
- Open the **Test_Scatter_log_losses** description from the Templates.
- Change the source 'src' into a `Source_gen(I1=3e11, T1=330,...)`
- Run in Simulate mode with 1e7 events.

Guide losses: Exercise 3: Logger

- From the description documentation, interpret the results. *Determine the loss per meter (m=2).*
- Does this loss correspond with that measured in Exercise 2 ?
- *Can you explain the difference ?*