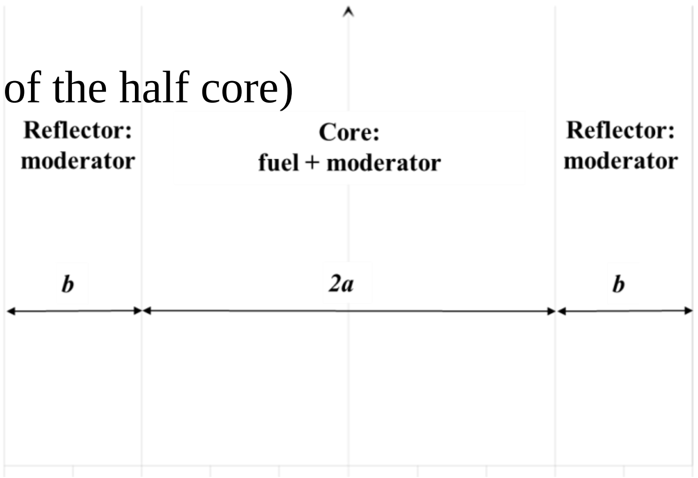
1D reactor slab

- We now consider a "realistic" 1D infinite slab reactor using a three batch core approach
- Each assembly is 20cm wide, there are 4 fresh (ID 1), 4 once burned (ID 2) and 4 twice burned (ID 3) fuel assemblies
- The reflector assembly has the ID 4
- The loading pattern is [3 3 2 2 1 1 4] from the core center to the core boundary (description of the half core)
  - $a = 120\ cm$
  - $b = 20\ cm$
- The total power generated by the core is 90 MW; the assemblies are 400cm tall
- The cross sections are represented with a two group energy structure
- Please make use of symmetry



Ass. ID	1		2		3		4	
Grp. ID	1	2	1	2	1	2	1	2
D	1.4824E+00	3.8138E-01	1.4854E+00	3.7045E-01	1.4850E+00	3.6760E-01	1.2000E+00	4.0000E-01
Σ_a	9.6159E-03	8.2153E-02	1.0577E-02	9.5616E-02	1.1109E-02	9.3004E-02	1.0000E-03	2.0000E-02
$\upsilon\Sigma_f$	7.1695E-03	1.4038E-01	6.0022E-03	1.4267E-01	5.1128E-03	1.2765E-01	0.0000E+00	0.0000E+00
$\kappa\Sigma_f$	9.1723E-14	1.8644E-12	7.4496E-14	1.7873E-12	6.1958E-14	1.5497E-12	0.0000E+00	0.0000E+00
Scattering Matrix								
to grp	1	2	1	2	1	2	1	2
from 1	1.9788E-01	1.7369E-02	1.9748E-01	1.6350E-02	1.9754E-01	1.5815E-02	2.5178E-01	2.5000E-02
from 2	1.6271E-03	7.9024E-01	1.8467E-03	8.0234E-01	1.8112E-03	8.1197E-01	0.0000E+00	8.1333E-01

upscattering is present !

Learning outcome

1. Improvement of a simple 2G diffusion solver to model a more complex problem (non-uniform fuel composition, power normalization, etc…)
2. Issues associated with an optimization exercise (cost, weighting the constraints, etc…)
3. Effect of core non-uniformity on safety (vessel embrittlement and DNBR); and how to address them through fuel loading

EPFL

- After convergence of the power iteration, the magnitude of the flux is determined using the total power generated by the system

- For a given mesh i, the power produced by fission is:

$$\boldsymbol{P}_{i,fiss} = \boldsymbol{h}\,\Delta\boldsymbol{x_i}\sum_{g'}^{G}\kappa\Sigma_{f,i}^{g'}\Phi_i^{g'}$$

- Then the total core power is

$$\boldsymbol{P}_{fiss} = \sum_{\boldsymbol{i}}\boldsymbol{h}\,\Delta\boldsymbol{x_i}\sum_{g'}^{G}\kappa\Sigma_{f,i}^{g'}\Phi_i^{g'}$$

- Normalization factor

$$\boldsymbol{F_{norm}} = \frac{\boldsymbol{P_{core}^{nom}}}{\boldsymbol{P}_{fiss}}$$

- And finally, $\Phi_{i,norm}^{g} = \boldsymbol{F_{norm}}\Phi_i^g$

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- Then the total core power is

$$\boldsymbol{P}_{fiss} = \sum_{\boldsymbol{i}} \boldsymbol{h}\,\Delta \boldsymbol{x}_{\boldsymbol{i}} \sum_{g'}^{G} \kappa \Sigma_{f,i}^{g'} \Phi_i^{g'}$$

- The averaged power produced in a given mesh (similar to averaged power density):

$$\overline{\boldsymbol{P}_{fiss}} = \frac{\boldsymbol{P}_{fiss}}{\boldsymbol{N}}$$

(only fuel regions are included in N). For the given mesh size, there are 240 meshes with fuel in the present problem

$$\boldsymbol{P}_{i,fiss}^{\boldsymbol{rel}} = \frac{\boldsymbol{P}_{i,fiss}}{\overline{\boldsymbol{P}_{fiss}}}$$

- Using the developed solver of Pb #3; implement a power iteration scheme, solve the multigroup diffusion equation for the reactor
  - Report the number of iterations, keff, peak power (relative to the average), fast flux at the core boundary for the provided core configurations (**mesh size 1cm**, conv criteria in terms of keff at 10^{-7} between consecutive iterations)
  - Plot the normalized fast and thermal fluxes as well as the relative power distribution
  - Explain the main features of the relative power distribution
- Optimize the fuel loading pattern so as to have a maximum peaking strictly less than 3.0 and a vessel fast flux $< 10^{13}$ $n.cm^{-2}.s^{-1}$ (at the last mesh point of the reflector).
  - Report loading pattern, keff (5 sig digs), power peaking and vessel fast flux (2 sig digs)
  - Plot the relative power, fast and thermal flux distributions