ESS Target Station Optimization: new moderator concept

Planning and timeline

Main milestones:

Q1 2013: Technical Design Review (TDR) published
Tight schedule, "best practice" design for feasibility and costing

Q3 2014: Target design optimization complete, lay-out frozen
Plenty of time left (~ 1 year) to meet accelerator schedule
- lower costs at equal performance
- increase performance at equal costs

Q1 2016: Main manufacturing contracts placed

Q4 2018: Target Station installed, commissioning without beam (Risk: delay with target hall)

Q3 2019: First beam on target, commissioning with beam starts

Q2 2020: Commissioning complete, routine operation

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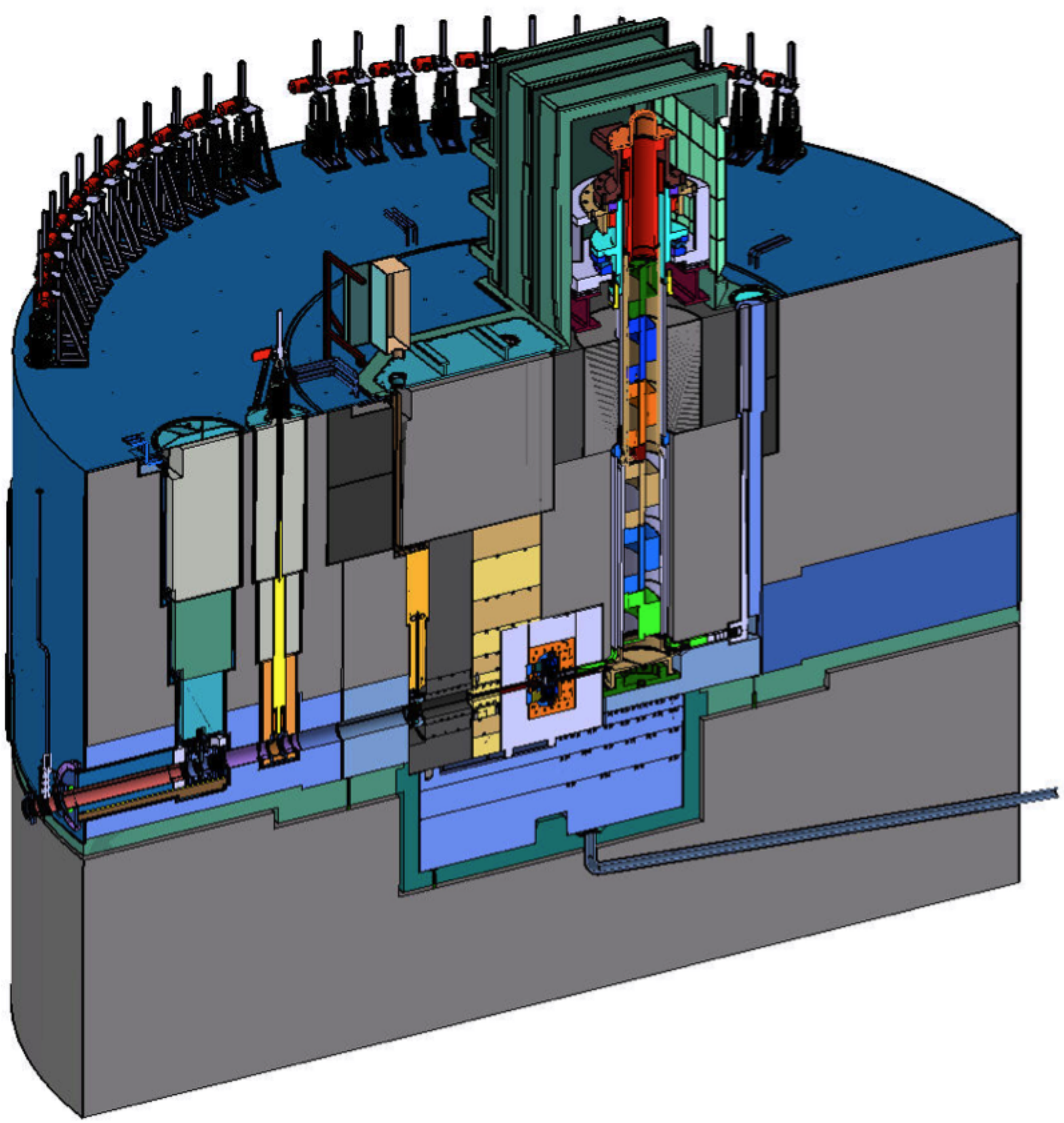
Target station: the monolith

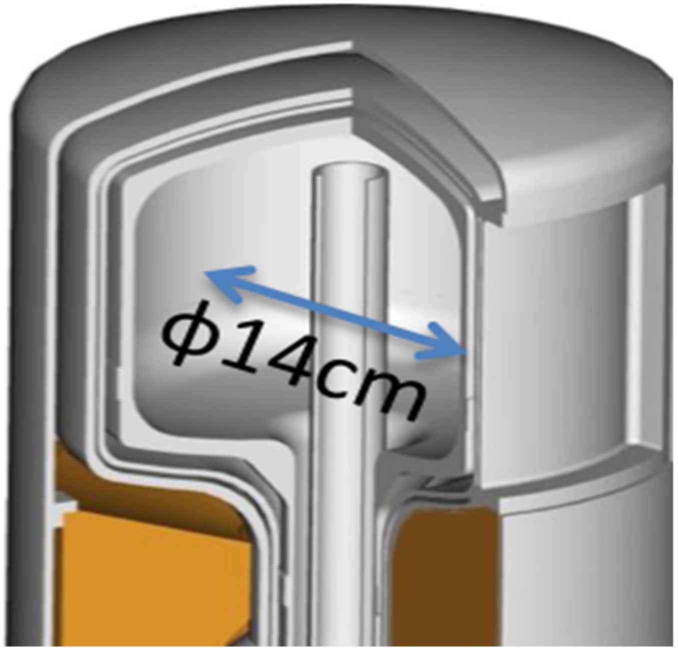


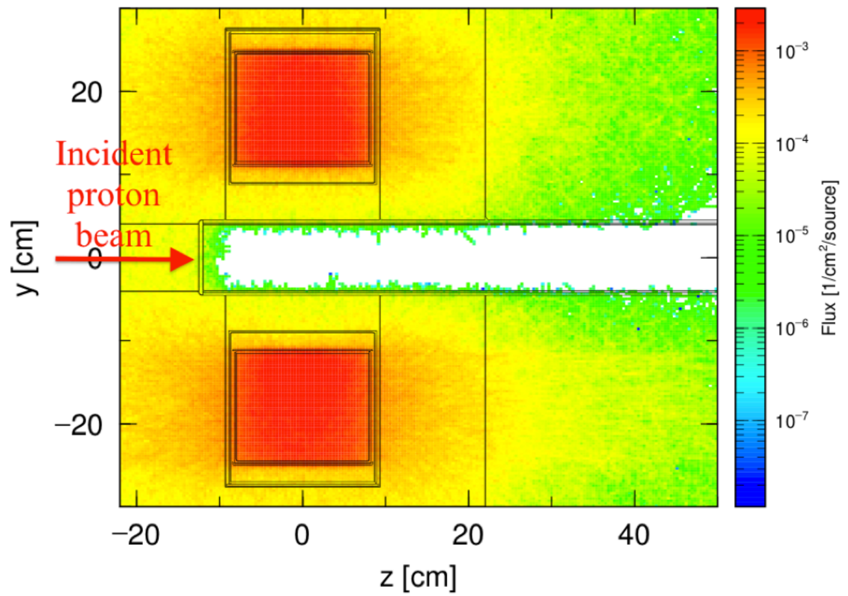
High performance cold moderators

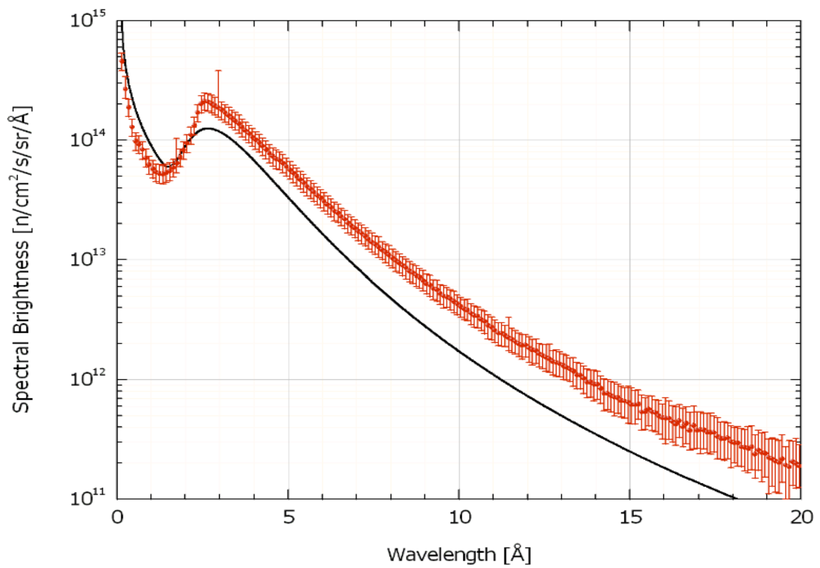
Volume moderator: para-H_2

- implemented at J-PARC
- flux gain ~ 2 vs. box mods. without filter

reflector







Bi-spectral beam extraction

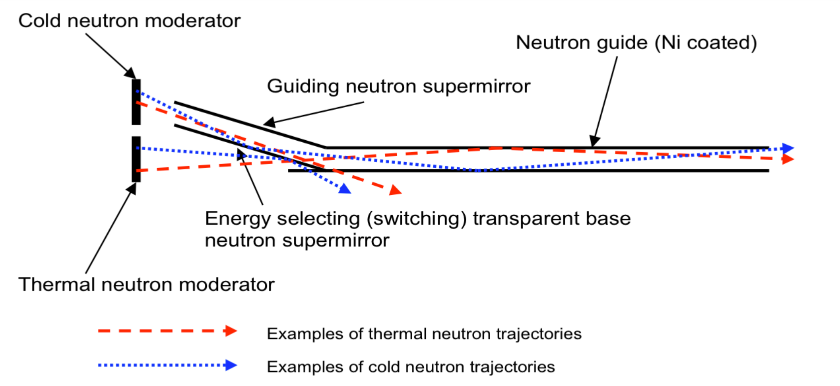
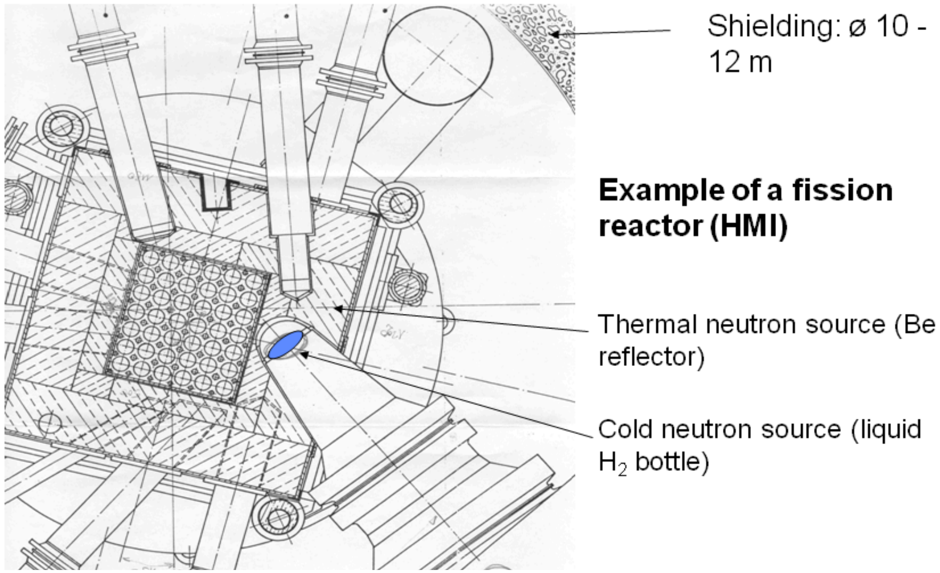


Fig.1. Example of realization of multi-spectral beam extraction

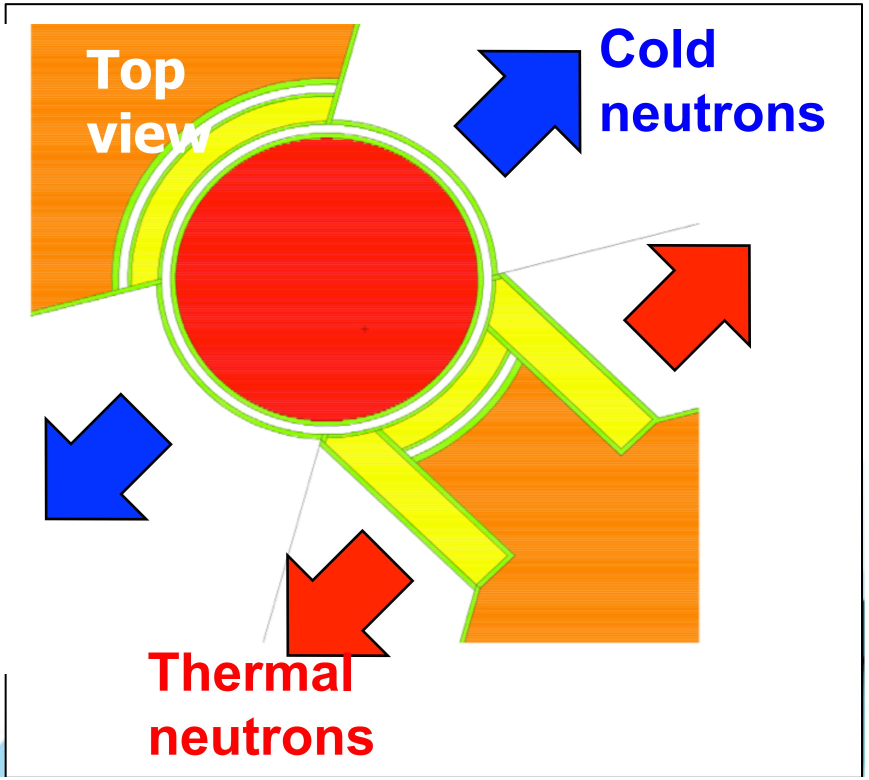
(F. Mezei, M. Russina, 2002)

Wide neutron energy dynamic range available on all beam-lines

HZ Berlin: thermal source = Be reflector



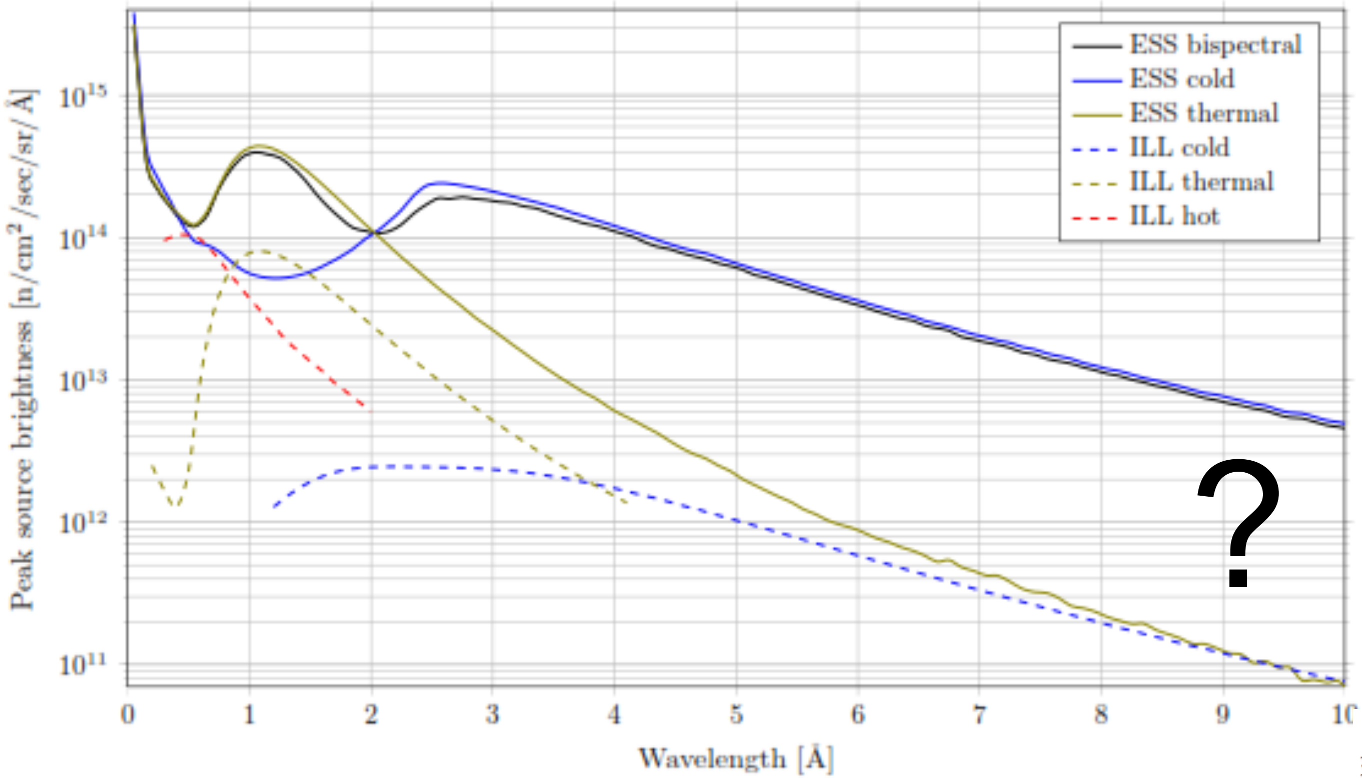
Example of a fission reactor (HMI)



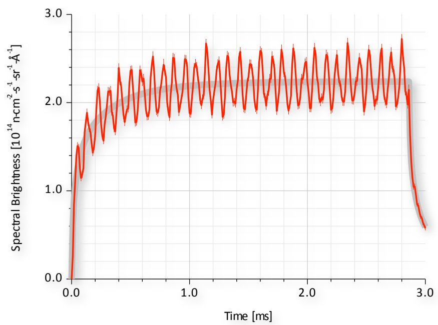
EUROPEAN SPALLATION SOURCE

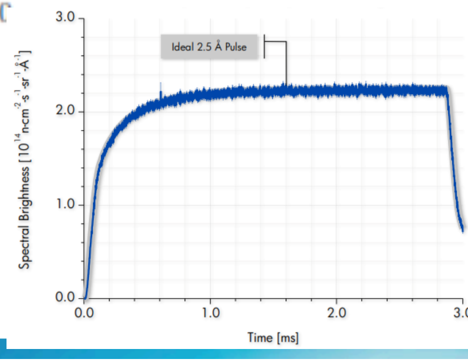
Neutronic performance

Current baseline: ESS peak flux vs. ILL yellow book



Proton beam rastering





For long enough pulses:
performance scales with peak flux

Planning and timeline

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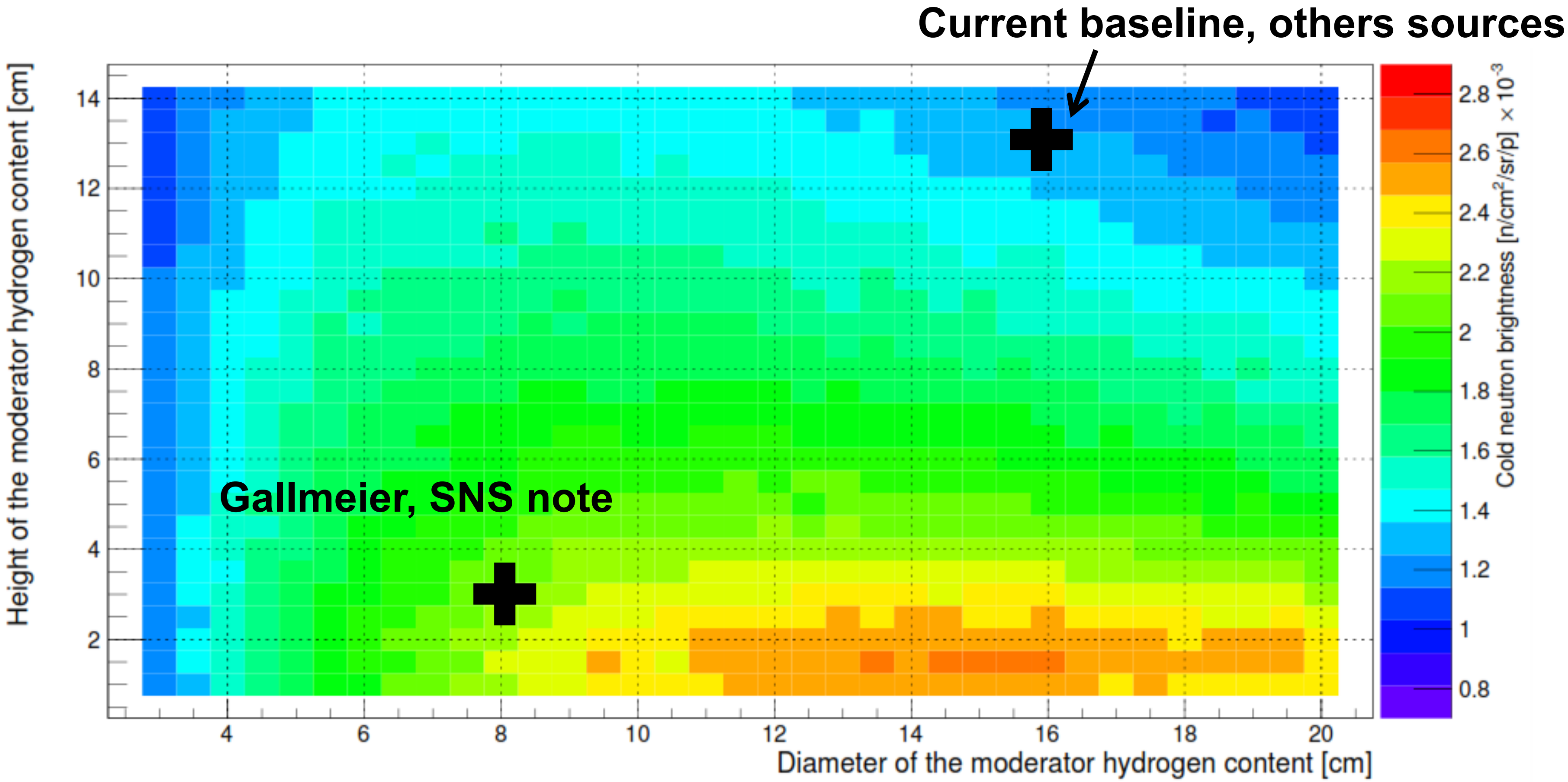
Unperturbed moderator flux

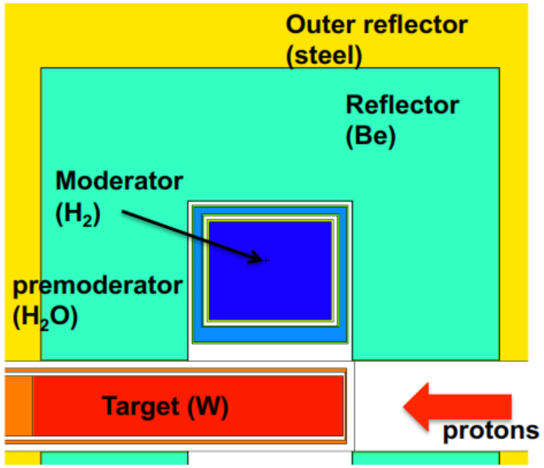


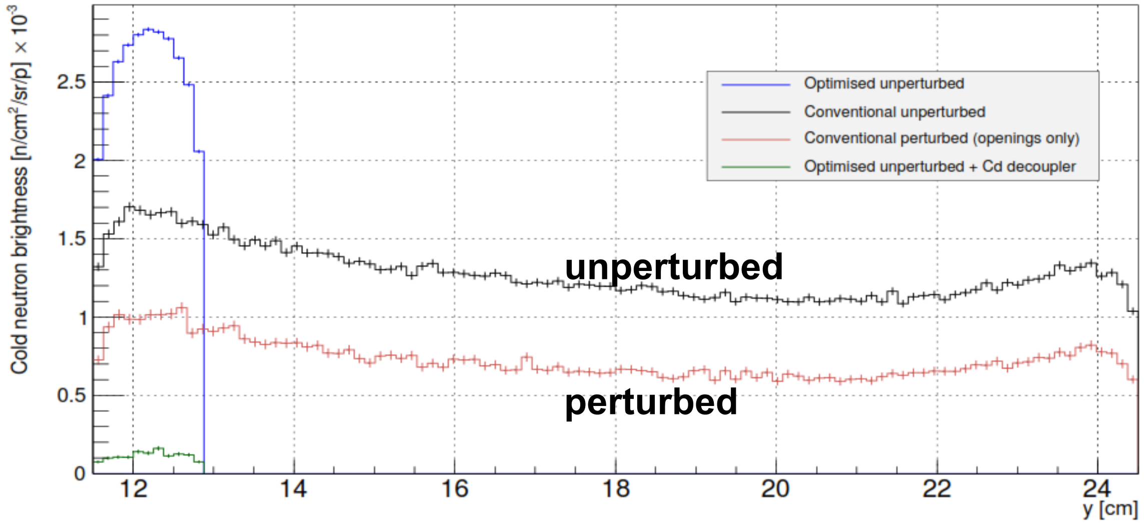
Moderator size for highest unperturbed brightness:

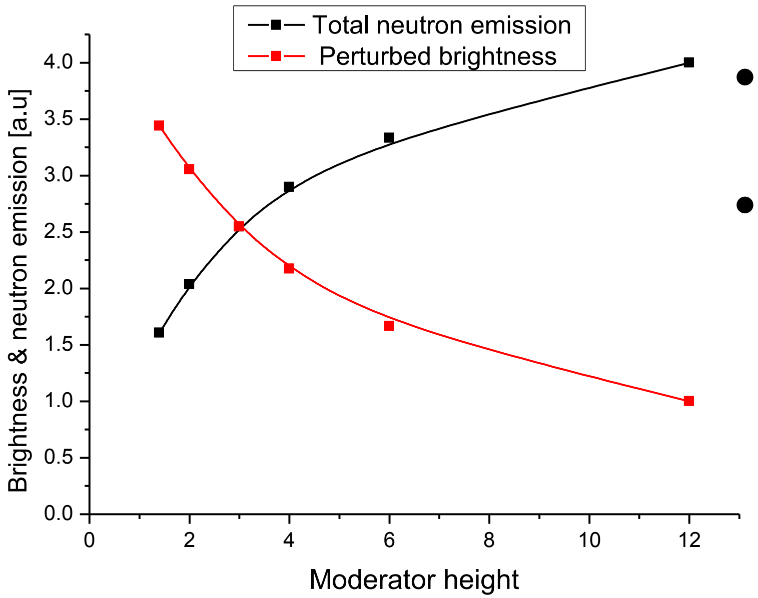
ϕ=15 cm, h=1.4 cm !!!

Batkov, Takibayev, Zanini, Mezei 2013

Unperturbed moderator flux

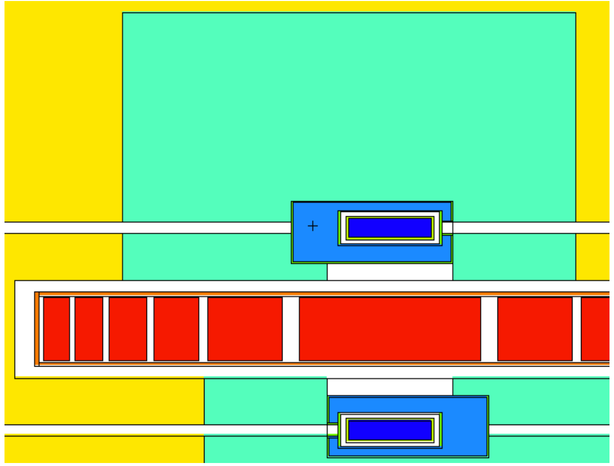


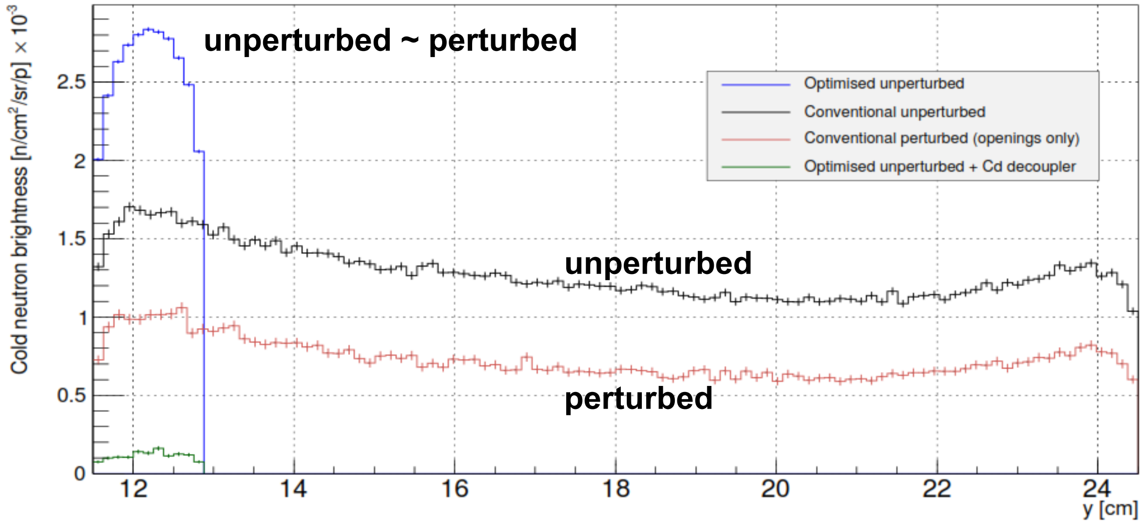




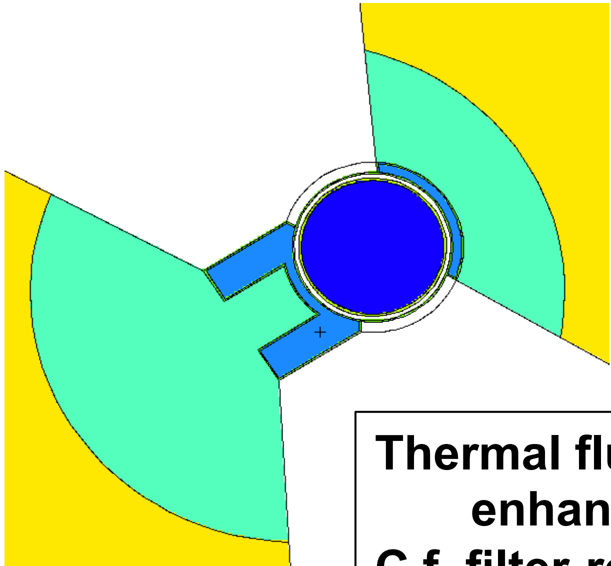
- Trend **even stronger for the perturbed flux**
- **Also applies to the thermal flux from water moderator / Be reflector**

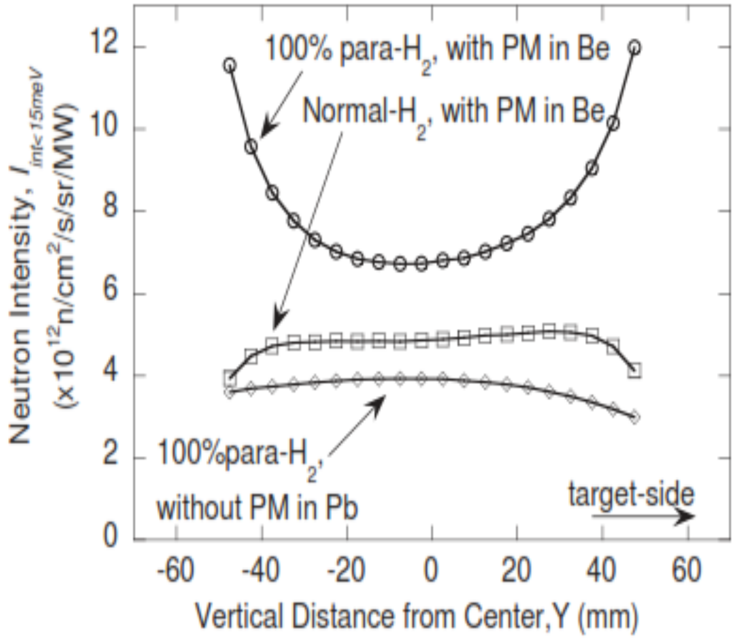
Perturbed moderator flux





Physics?





Thermal flux: similarly enhanced

C.f. filter-reflector !

Optimized brightness moderator option

How to use the high brightness of 12 cm x 1.5 cm cold
or (12 cm + 12 cm) x 1.5 cm bi-spectral
moderators?

Conventional wisdom: moderator size > guide entrance

Demonstrative basic examples for proof of principle

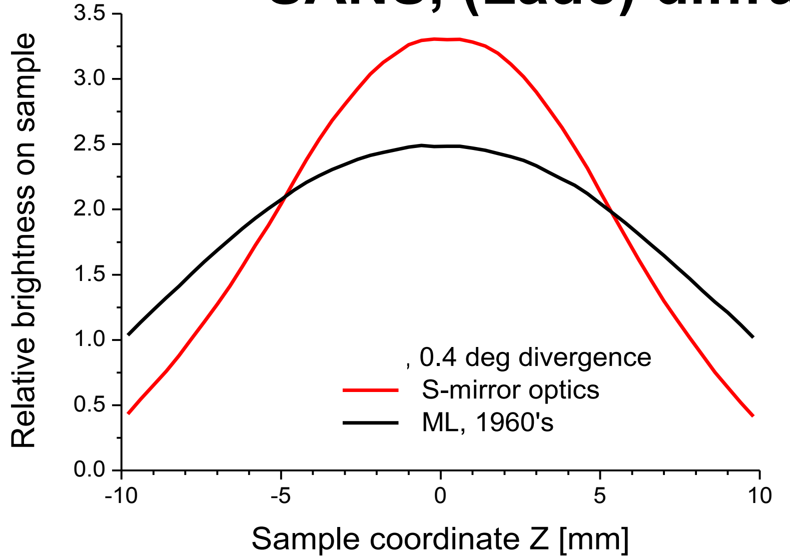
- Vertical and horizontal beam propagation: ~ independent
- Vertical dimension: ~ no influence on chopper action
- Global optimization important!!

Optimized brightness moderator option

How to use the high brightness of 12 cm x 1.5 cm cold
or (12 cm + 12 cm) x 1.5 cm bi-spectral moderators?

- **Direct view : (non-specular) reflectometry**

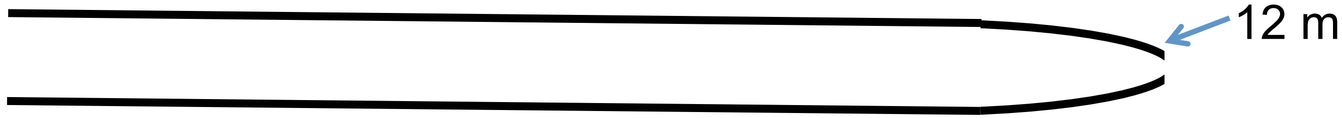
- **Conventional approach : ≤ 1 cm guide entrance height**
  SANS, (Laue) diffraction, Laue diffraction …

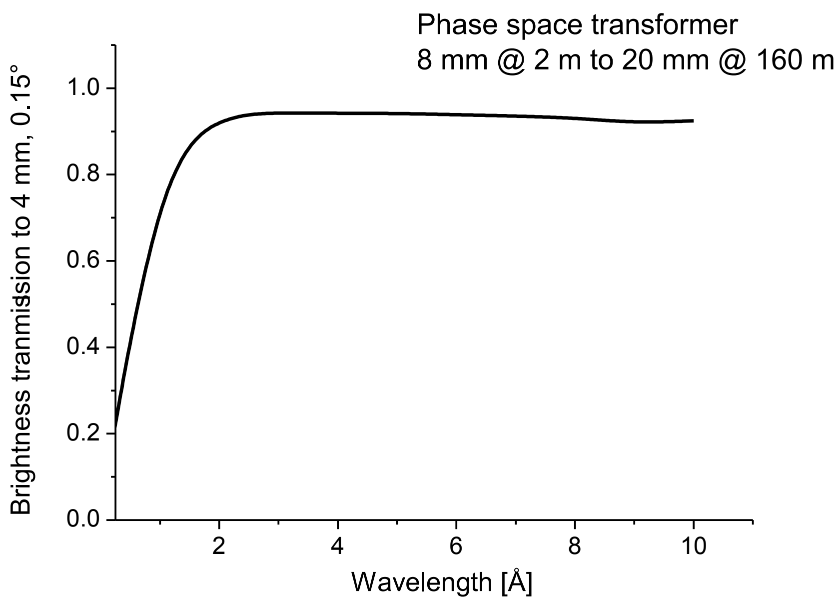


Conventional small entrance guides

Demonstrative example:

160 m phase space transformer, Ni coated





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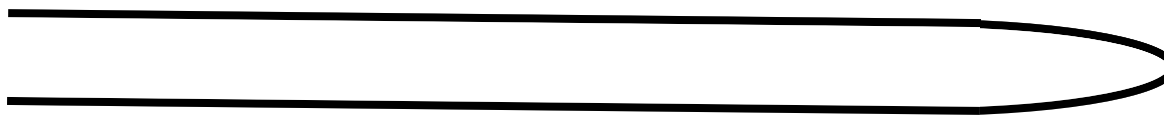
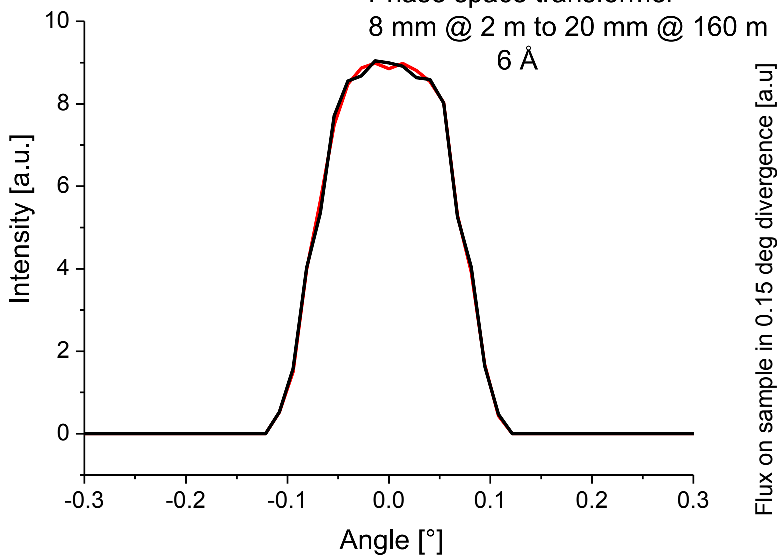
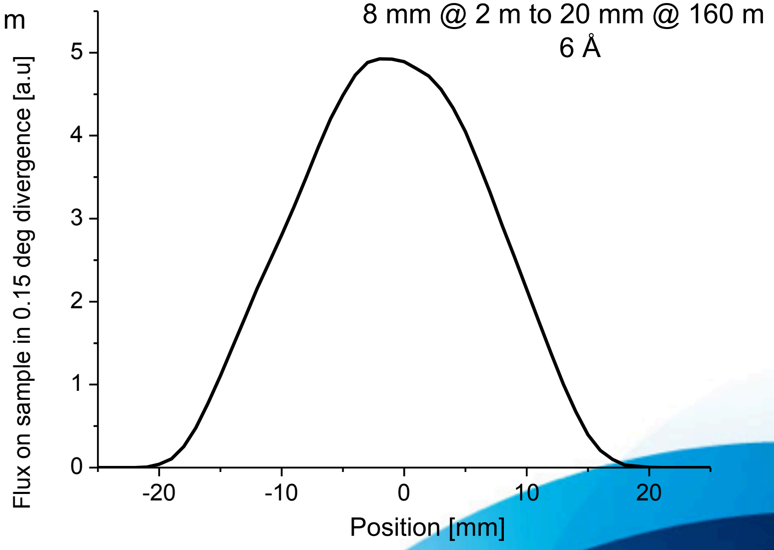


0.4° div

0.32 cm.deg phase space

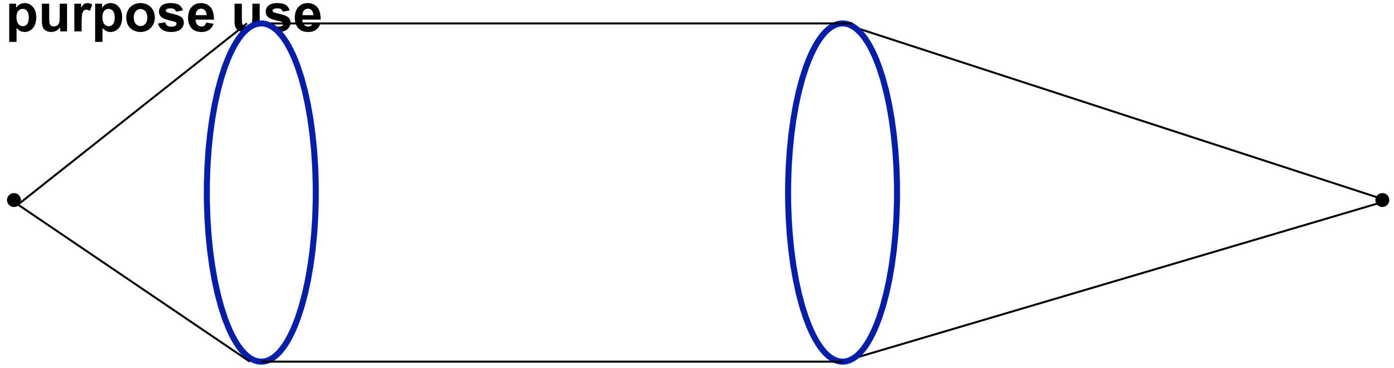




Focusing optics

How to use the high brightness of 12 cm x 1.5 cm cold or (12 cm + 12 cm) x 1.5 cm bi-spectral moderators?

- **Liouville principle: high quality optics allows for general purpose use**

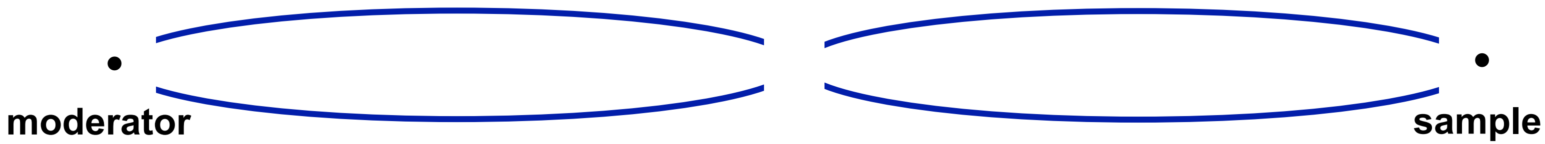


Lens combination

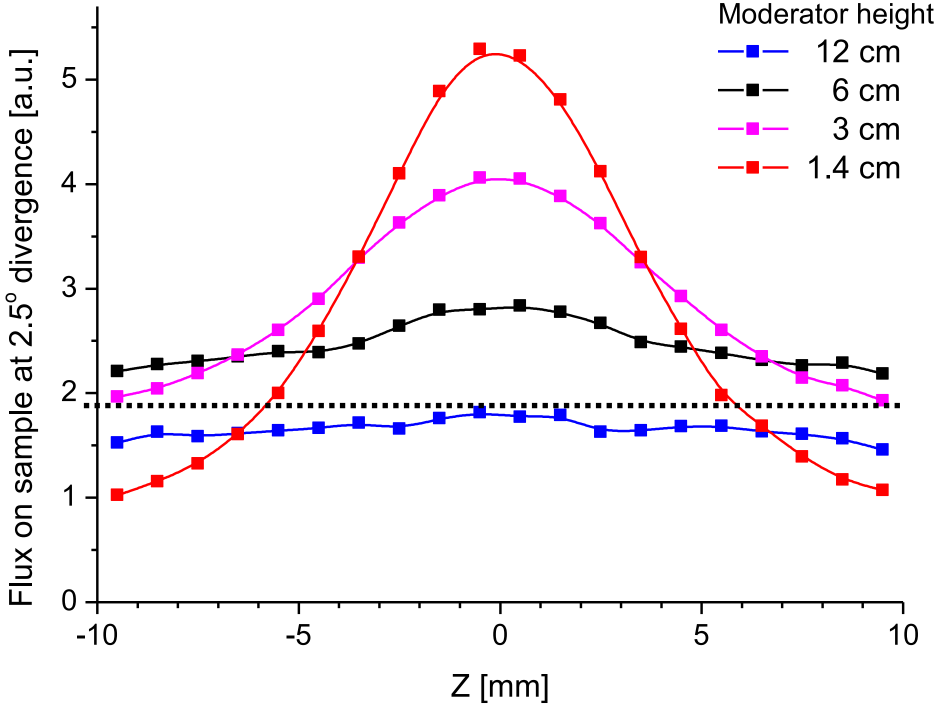
Neutron optics: low aperture, limited quality imaging
Supermirrors help, lot of room for progress

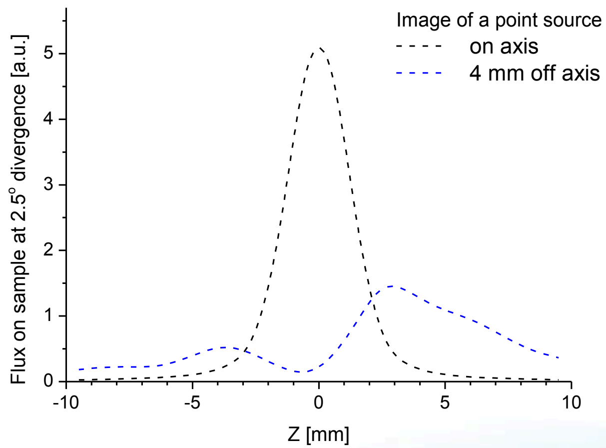
Focusing optics: large guide entrance

- **Using best proposed / tested supermirror optics (cf. Stahn)**



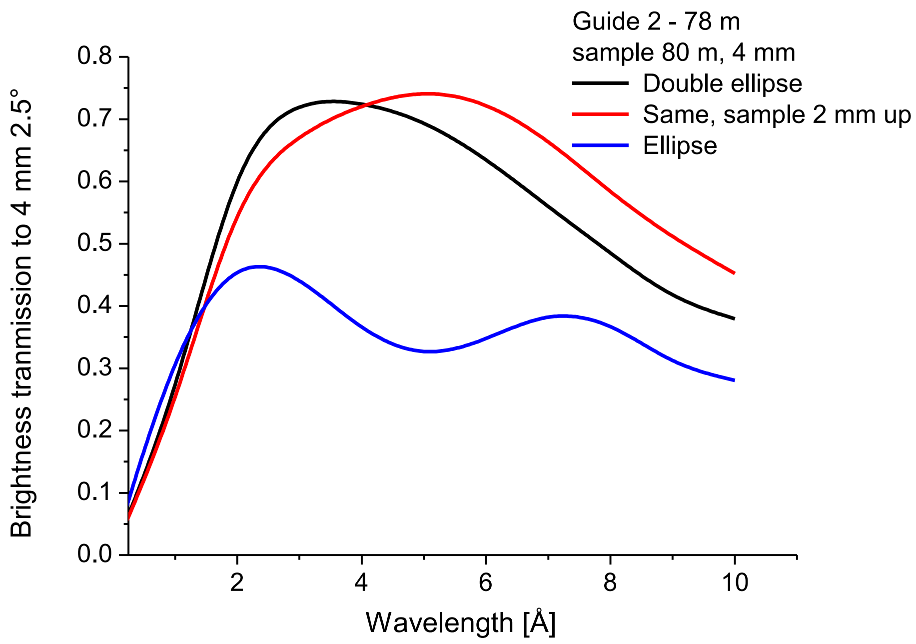
Example: 2.5° beam divergence at 80 m
4 Å wavelength

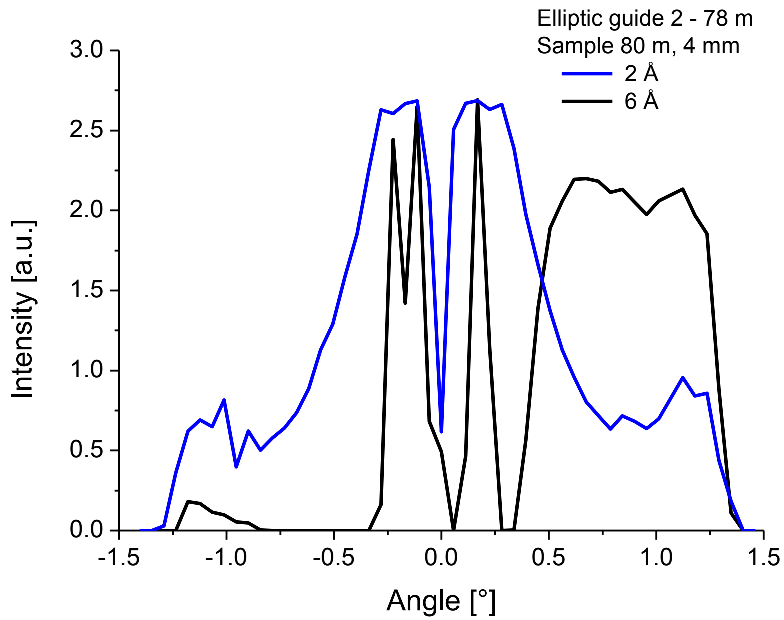




Focusing optics: large guide entrance

Ellipse vs. double ellipse

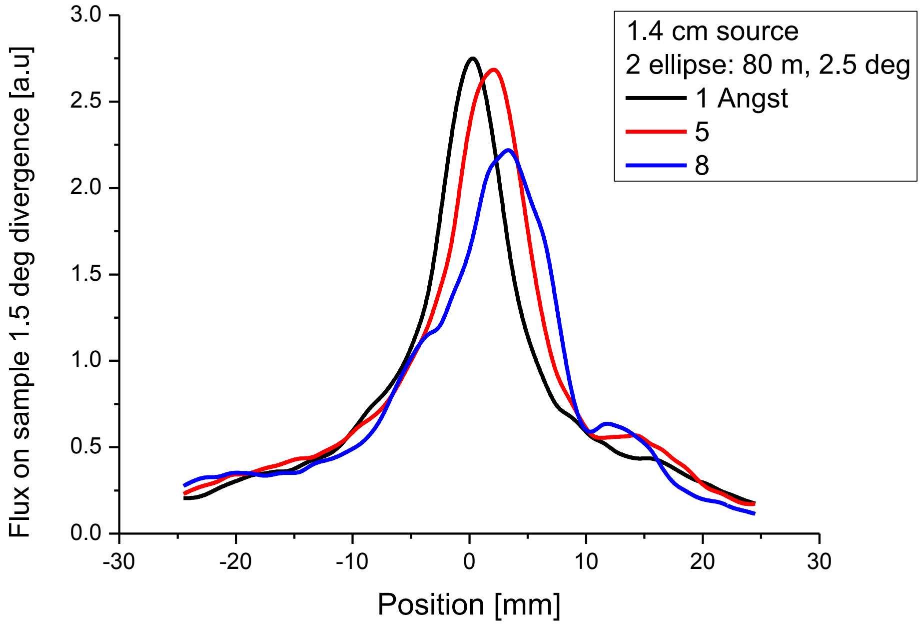


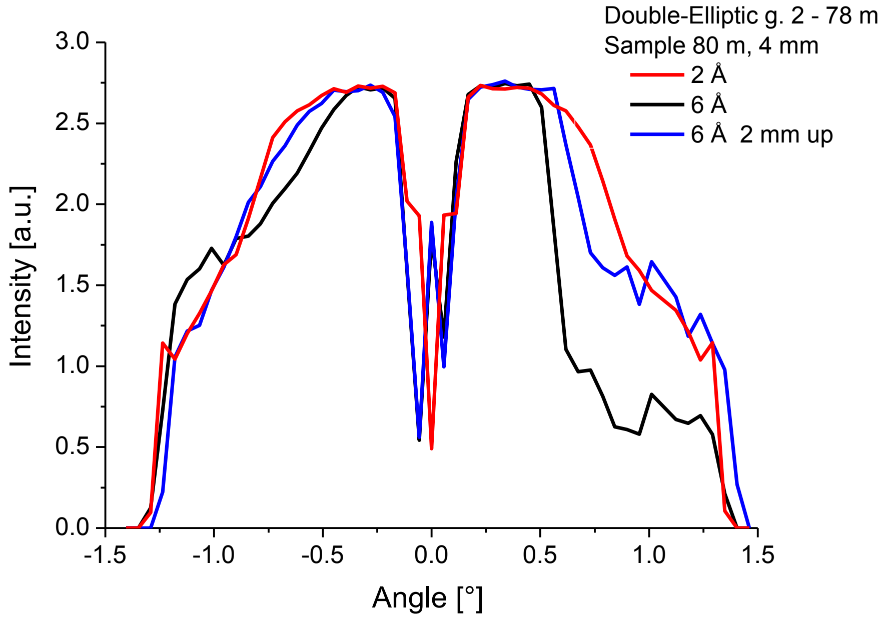


Angular distribution on 4 mm sample

Focusing optics: large guide entrance

Ellipse vs. double ellipse





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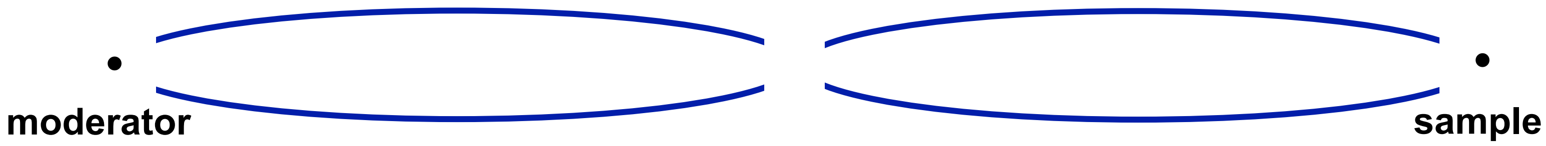

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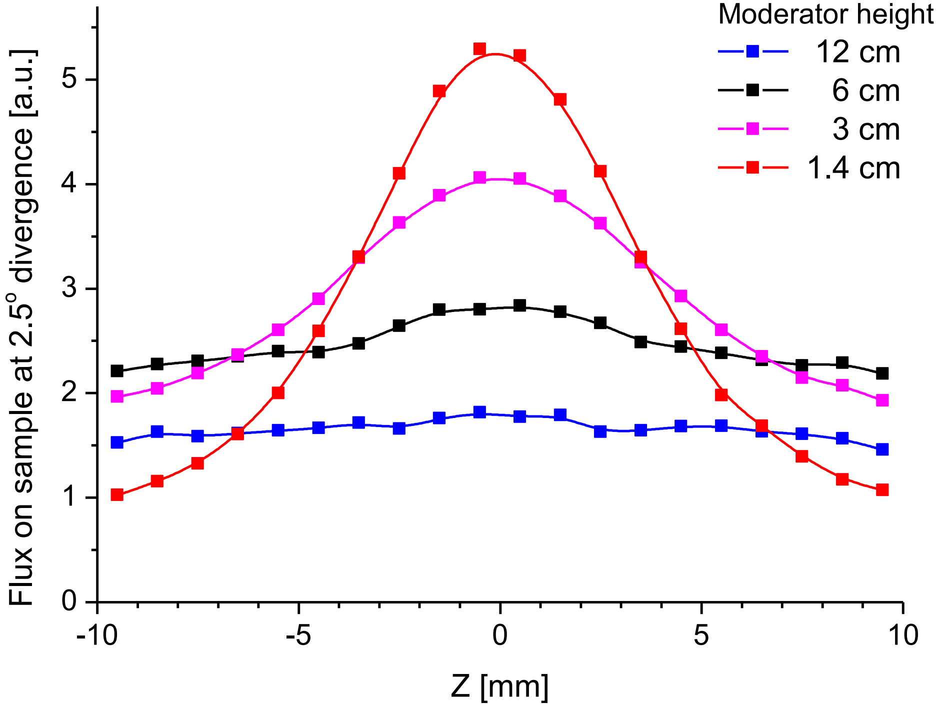
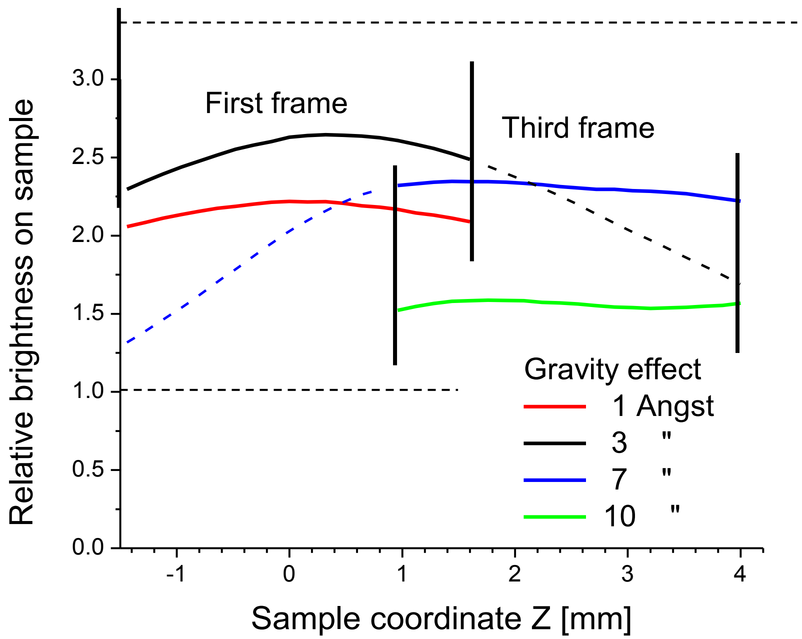


Effect of gravity & mitigation



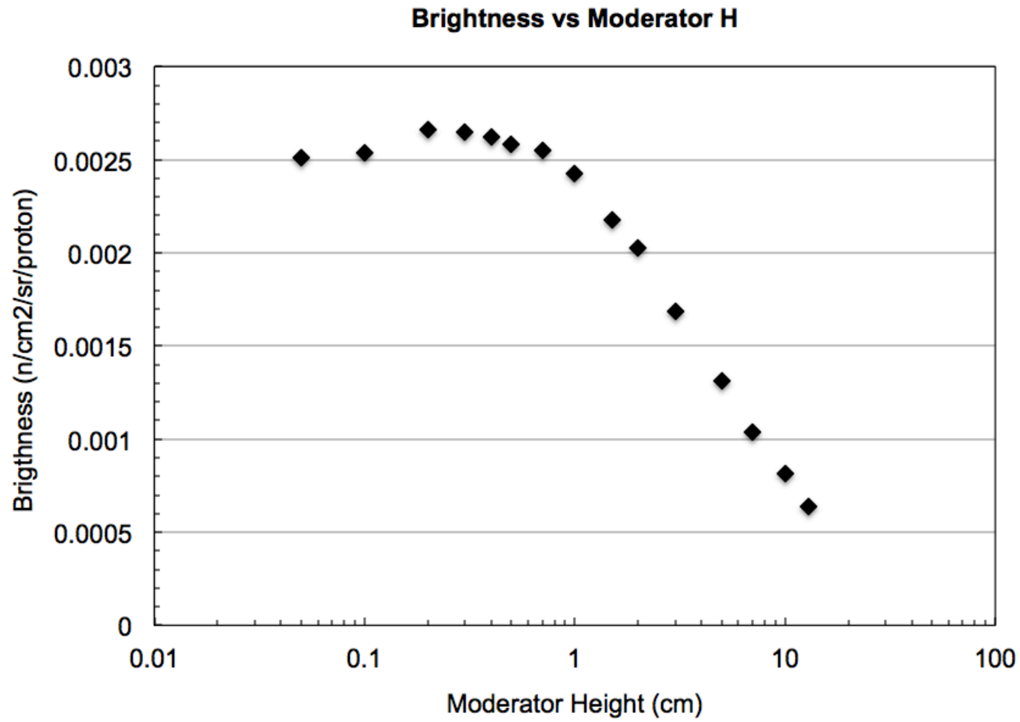
Optimal perturbed moderator thickness

- **Brightness for a moderator with fixed diameter of 16 cm, viewing a surface of 12 cm X (moderator height).**

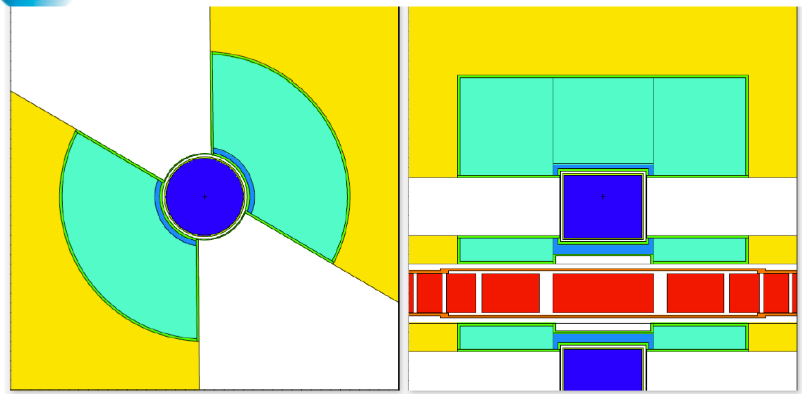
- **Cole neutrons < 5 meV**

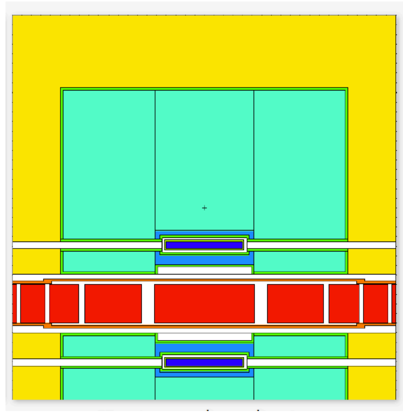
- **Maximum below 1 cm height.**

- **Calculations performed so far consider 1.5 cm height.**



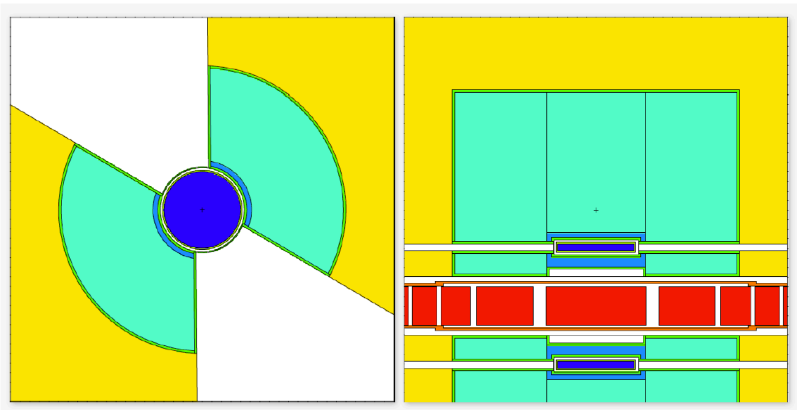
From volume to flat moderator

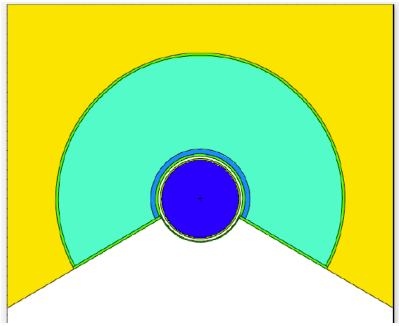




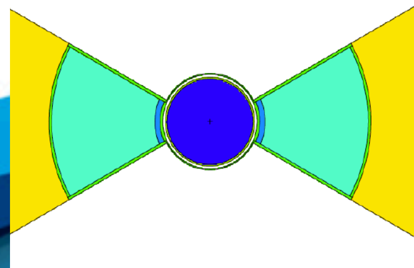
Gain 3.2
(13% perturbation loss)

Considering different opening options:





Gain 3.0

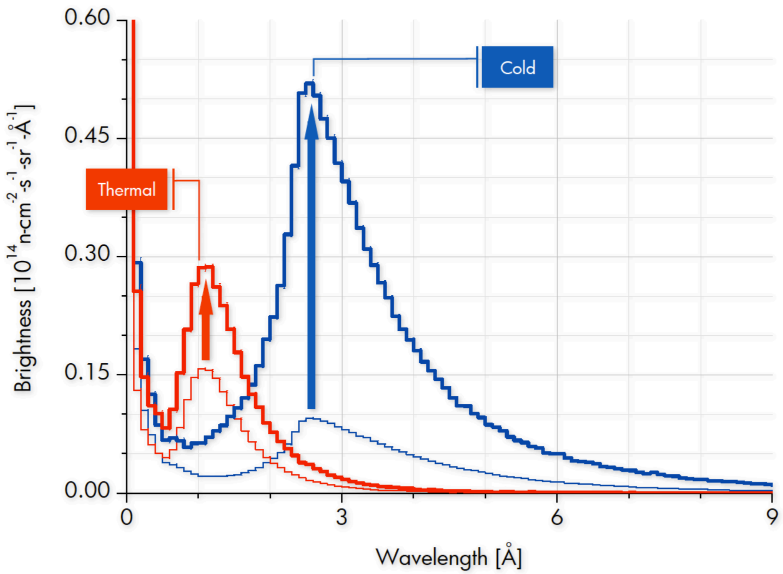


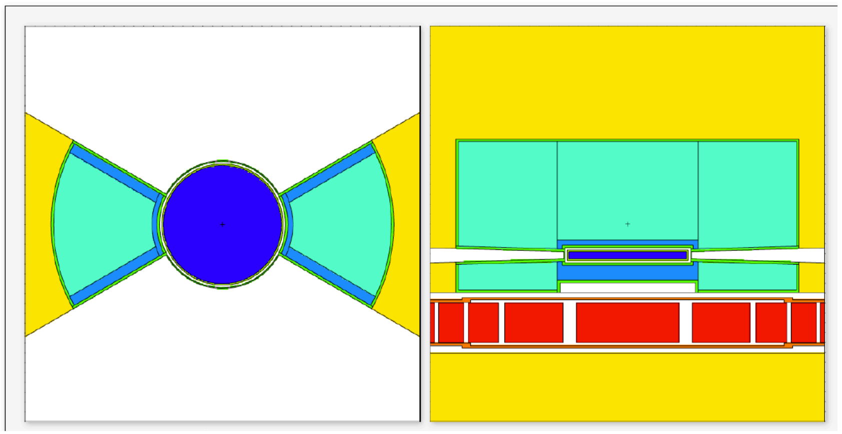
Gain 2.8

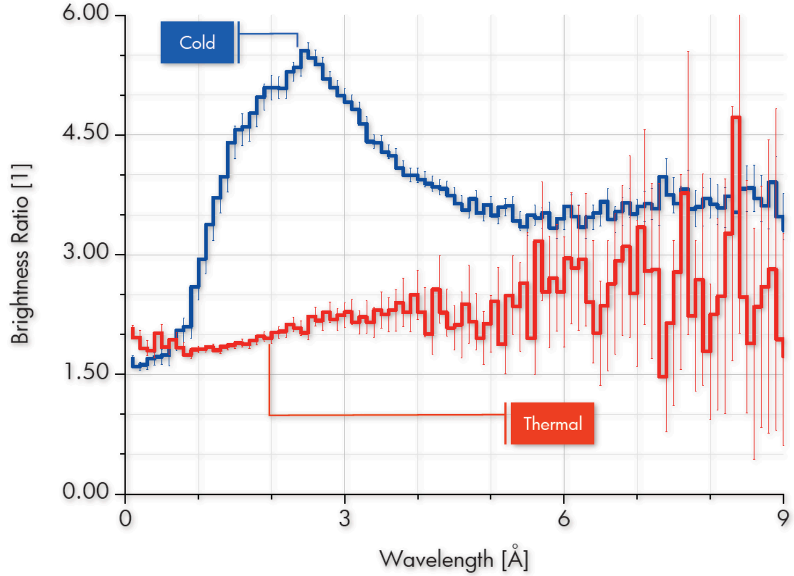
There is not a big loss due to perturbation, even for two 120 openings!

Gain in brightness

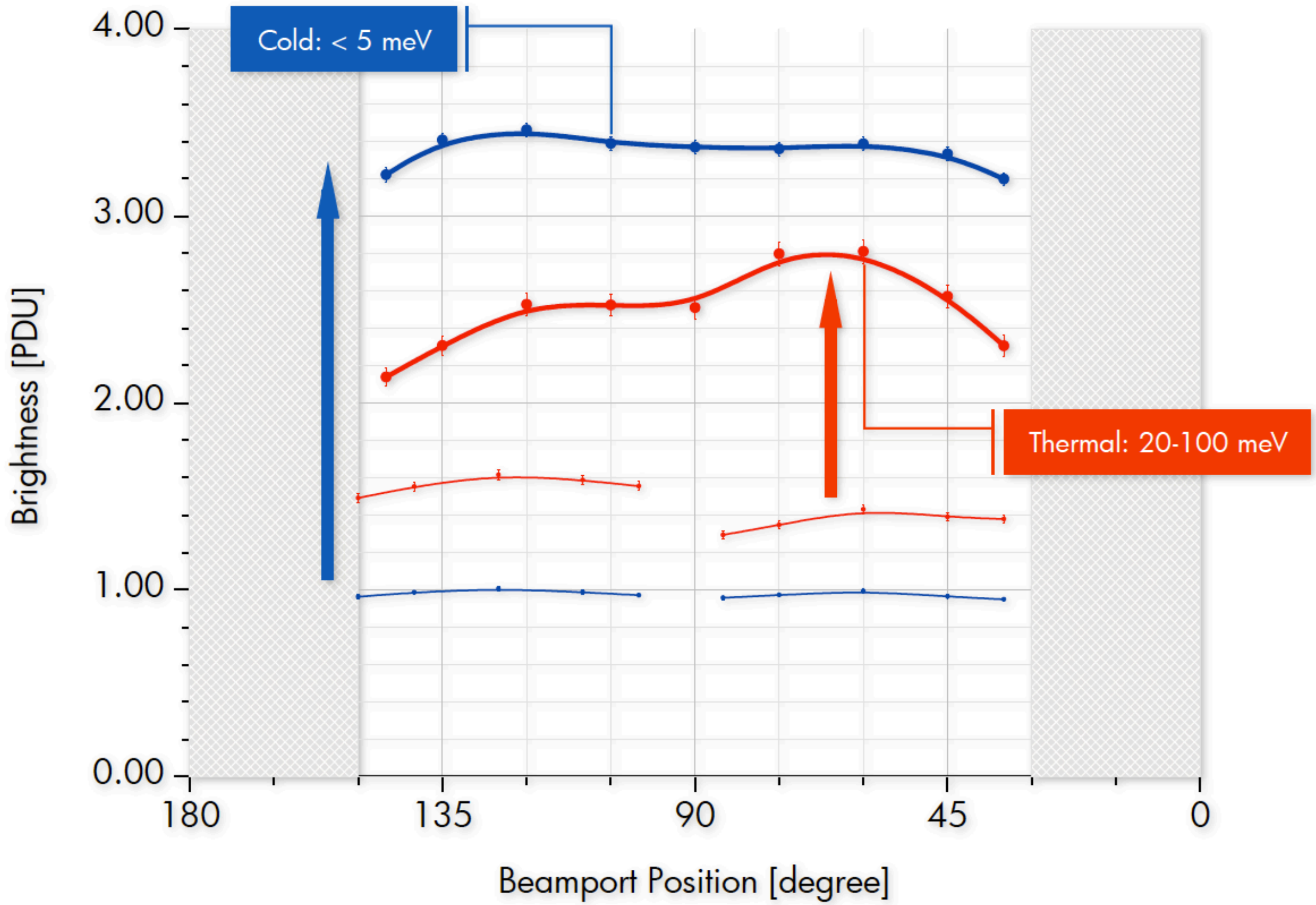
- There is an increase for thermal and cold brightness.
- Thermal flux increase by about factor of 2.
- Cold flux increase by a factor of 5 (from 2 to 3 Angstrom) and factor 3.5 (above 4 Angstrom)







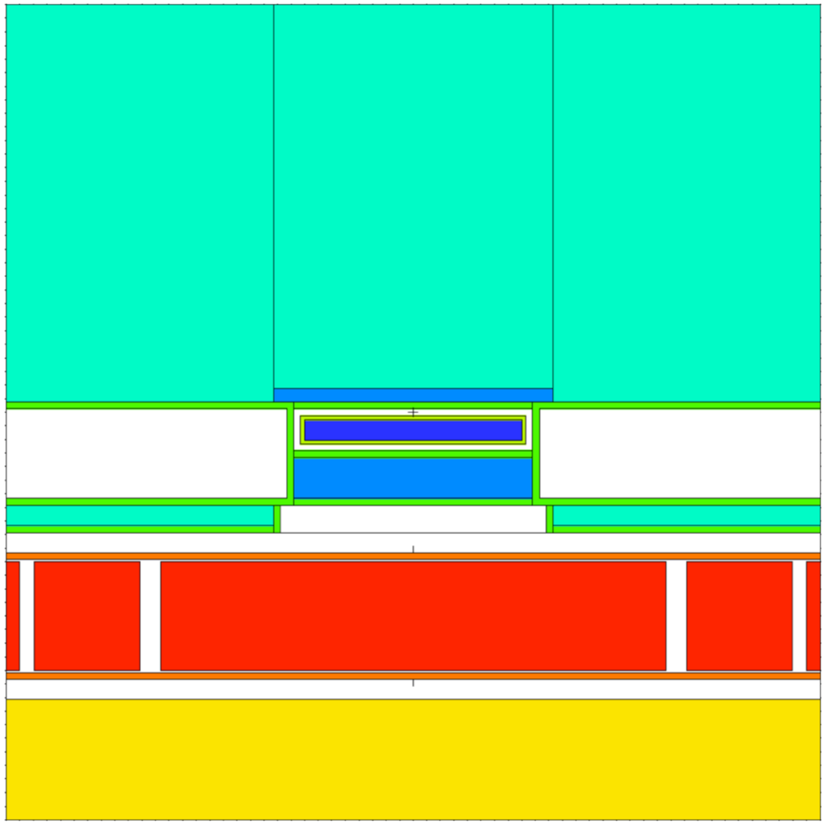
Angular distribution

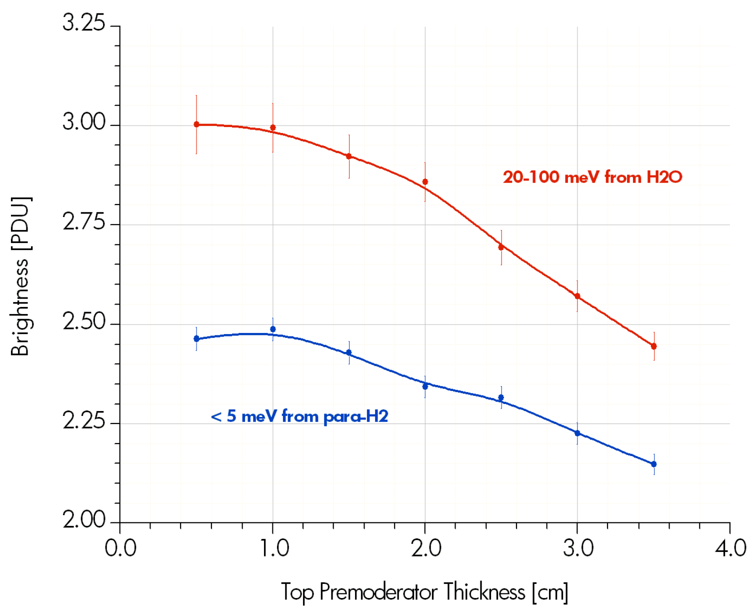


Thermal vs. cold neutrons

- **Find good balance between thermal and cold brightness.**

- **Gap in Be reflector is a crucial parameter.**





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- **Proof of principle demonstrative examples:**

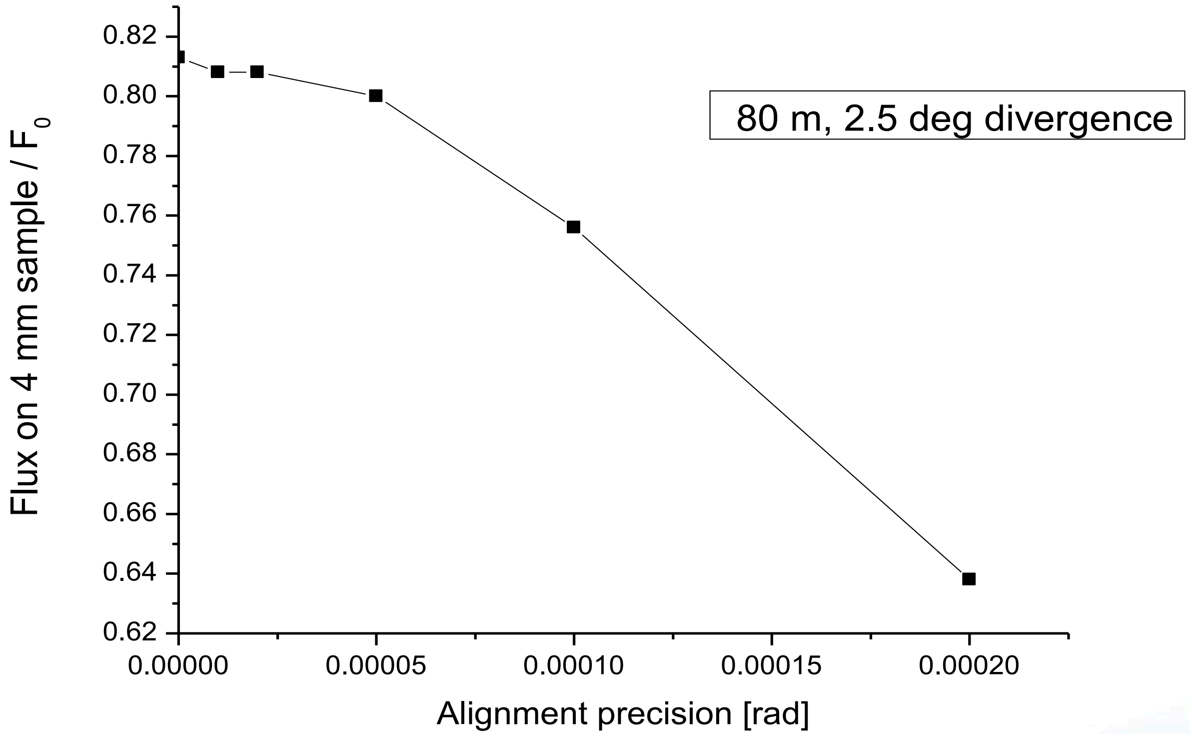
  It is possible to transfer much of the brightness gain to the samples for low face space volume applications
  low beam divergence and/or small samples
  Losses would cumulate for a small moderator in 2D!
  Comparison to ILL: x 50 -100

- **Optimization, implementation for the facility:**

  Collaborative effort needed between instrument scientists, target and simulators: One "flat", one "thicker" moderator? 2 flat moderators? Single "360° moderator"? Best "flat" moderator & beam extraction / delivery combination? Best bi-spectral combination?

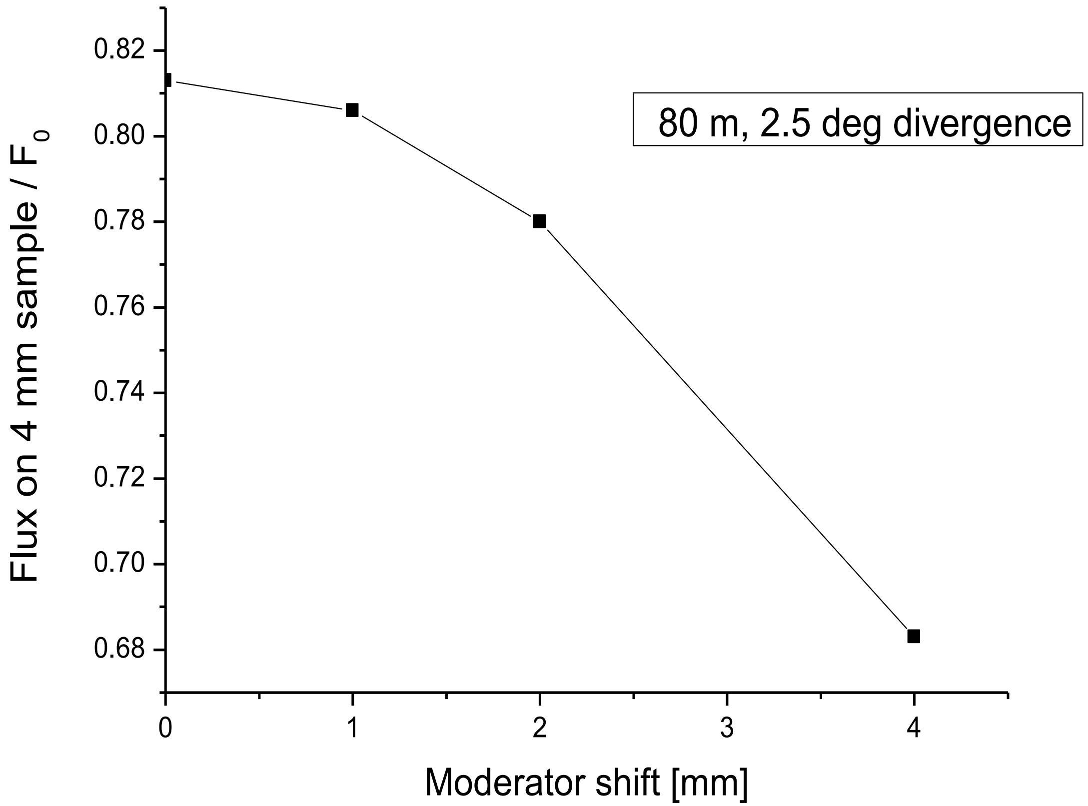
Thank you!

Impact of plate misalignment



Needs pre-aligned section >1 m

Impact of moderator elevation



Engineering homework