NMX guide system

Márton Markó

Wigner RCP

NMX

- Very small sample (MX: <1mm, materials science: <5mm)
- Low divergence: $\pm 0.2^o$
- Extremely low phase space needed

Goal of the guide design

- High brillance transfer
- Transfer only the "good" neutrons
- Fast neutrons should not go out of the bunker
- dose from absorption: ALARA -> minimizing the number of reflections during transport

Phase space

Phase space

The phase space is 6D ($\mathbf{r}$, $\mathbf{v}$)
I calculate with 2D: y - δ_y or z - δ_z
The dimension I use: cm deg

Phase space of NMX

- The useful 2D phase space for MX is: $0.1cmX0.4/^o = 0.04$ cm deg
- The useful 2D phase space for MS is: 0.2 cm deg

Vertical phase space with 3cm slit in the light shutter,
no inpile optics: 0.9 cm deg !!

Comparison: useful (4D) Phase space of ITOF

- BIFROST: $\approx$ NMX X 400
- MIRACLES: $\approx$ NMX X 2700

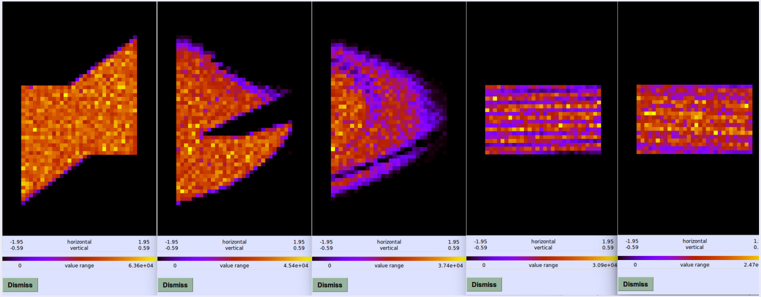
The wavelength resolution decreases the intensity in the guide but both
instrument will sometimes use the full ESS pulse

Liouville theorem

"Braking" of Liouville theorem

The phase space can be fragmented:

The average phase space density gets decreased



Stewart's function for dose rate calculation

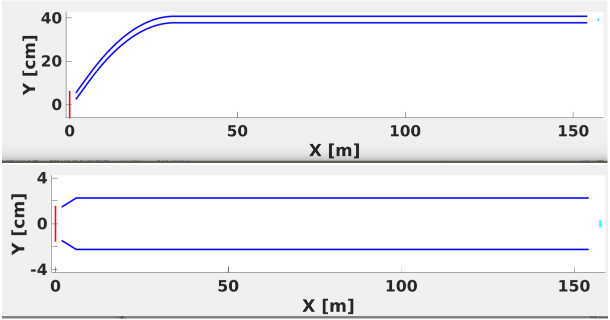
Dose rate: $D[\mu Sv] = I[n/s]/L[cm]\ n\ a\ 0.01$

- I: total intensity in the guide in n/s
- D: dose rate in $\mu Sv/hr$
- L: length of the guide in cm
- N: average number of reflections
- a: average absorption ratio per reflection on m=1 mirror: 0.01
- 0.01: Conversion betwen number of neutrons absorbed by Ni/Ti and μSv

It gives only the dose rate coming from the absorption of the Ni/Ti layers

Baseline design

- In monolith: 2m-6m 3X3 cm^2 -> 4.5X3 cm^2
- In bunker: 6m - 31.5m. 4.5 X 3 cm^2 horizontally curved, R=1200m, almost 2 X LOS
- Out of bunker: 31.5m - 154m 4.5 X 3 cm^2 straight



Baseline design

Advantages

- Simple system
- Looks cheap

Disadvantages

- Bunker changed
- Does not go out of the spot of the fast neutrons
- Transport min 54 X more neutrons than useful ones
- Misalignment and waviness decreases the brilliance transfer

Intensity in the guide

I≈ 3 10^9 N n/s ??
From BIFROST data (McStas):5 10^7 N n/s !!
N is the ratio between transported and useful 4D phase space volumes

Averaged number of reflections

n≈ $100\delta(1/d_h + 1/d_v)$
In the base line: $n \approx 15$

Dose rate

$\approx 400N\ \mu Sv/hr$
20% other loss: $\approx 30N\ \mu Sv/hr$

In the base line model: N=45 for 0.5cm sample
N should be decreased

Optimization possibilities

Ballistic guide increases the efficiency

- Smaller divergence in the straight section
- Smaller phase space has to be transported
- Possibily no in pile section

Decreased dose rate around the gide and no need for in-pile section

Optimized guide in the bunker

Possibilities:

- Larger curvature (thinner guide)
- Curving vertically
- Half Selene guide (using 50cm straight sections)

Bunker questions to be answered

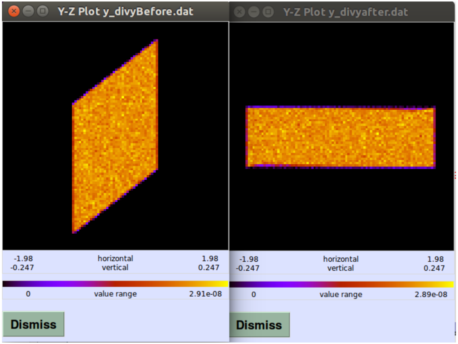
- Should we go out of the "Hot Spot"?
- 1 or 2 X LOS?, LOS of the vacuum house?
- Does saphire in the bunker wall help?

The answers define the needed curvature / guide width:
We can run out of the phase space
Transported phase space defines the further guide system

Ballistic guide

Defocusing

Good phase space volume can be transformed practically without loss (some %)



Ballistic guide

Focusing

- Parabolic focusing is long (focused divergence is $\pm 0.2^o$)
- Increasing focusing ratio decreases the guide-sample distance and increases the focal length
- Focusing decreases N (decreases the number of "bad" neutrons)
- Parabolic focusing decreases the phase-space at the sample: better geometry is needed!

Extra optimization for focusing

- Focusing needs smaller divergence in the guide:
  less absorbed neutron close to the sample
- Focusing increases the reflections:
  More prompt gamma from Ni
- Gamma background has to be calculated
- Guide in different buildings is bad

Focusing defines the previous sections