The primary Instrument of the BIFROST Spectrometer

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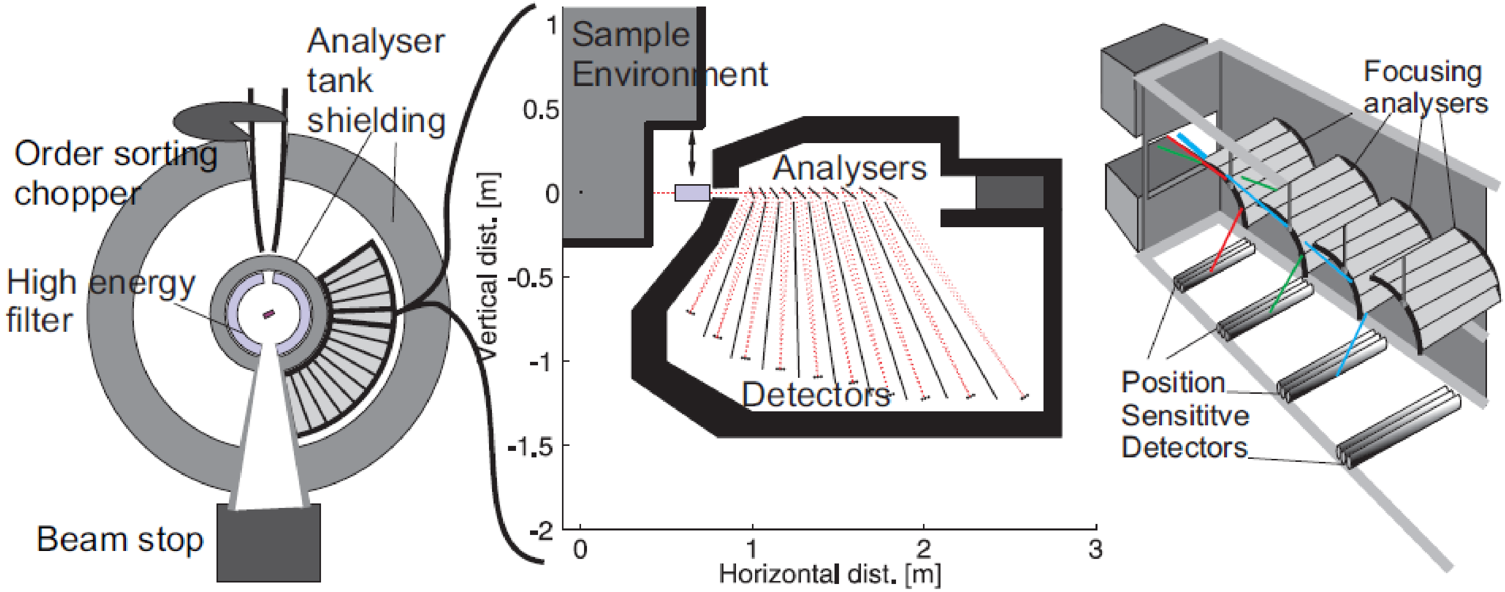
BIFROST

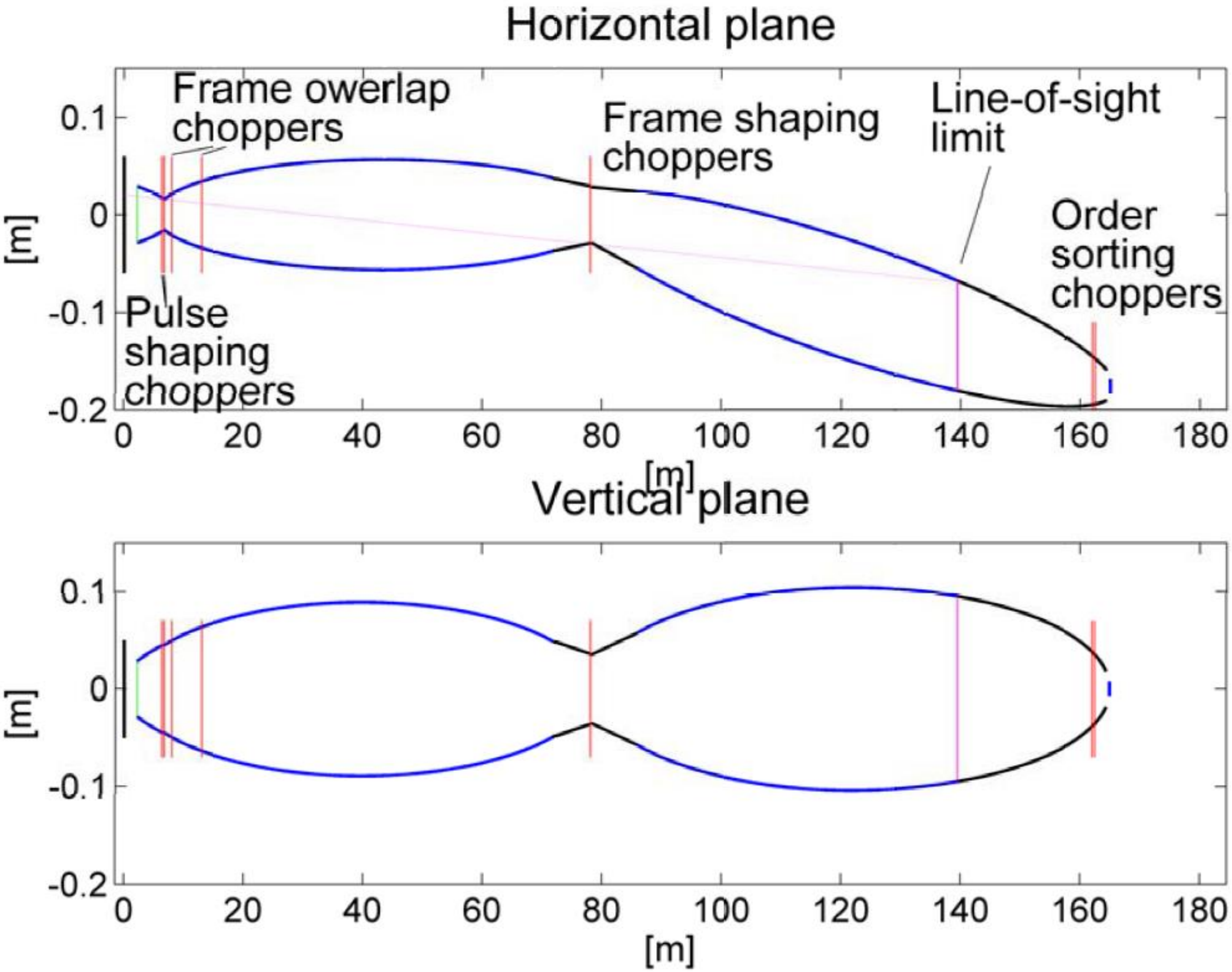


$E_f = 2.3 – 4.7$ meV,
up to 8.3 meV?

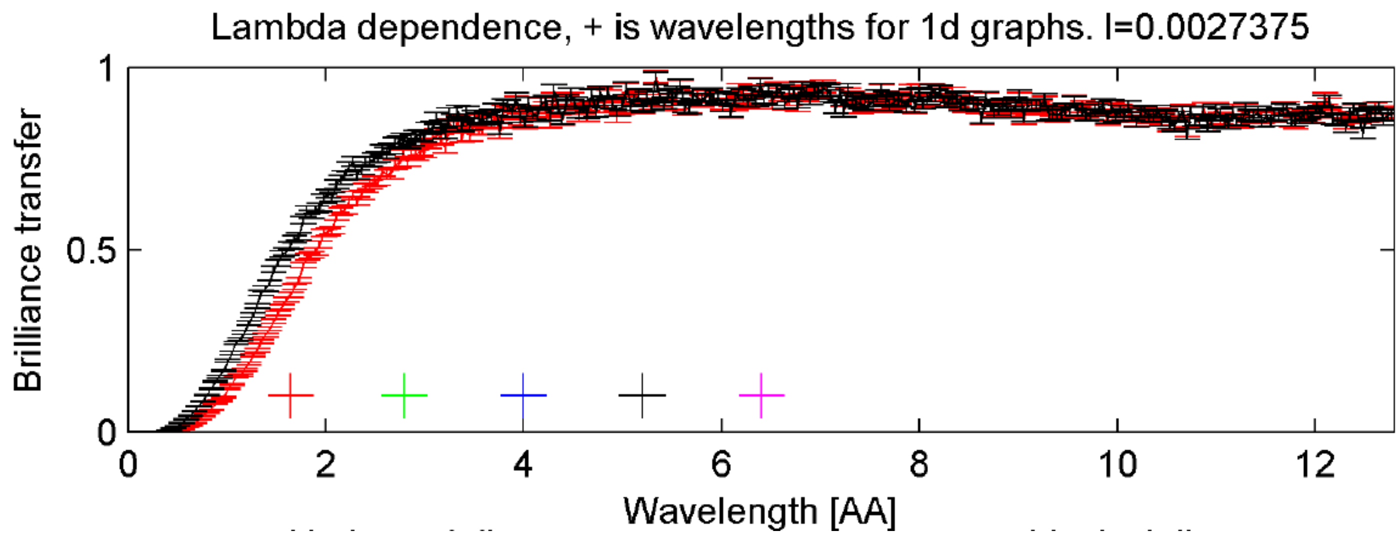
$\mathbf{k}_f = 1.05 – 1.5$ Å^{-1}

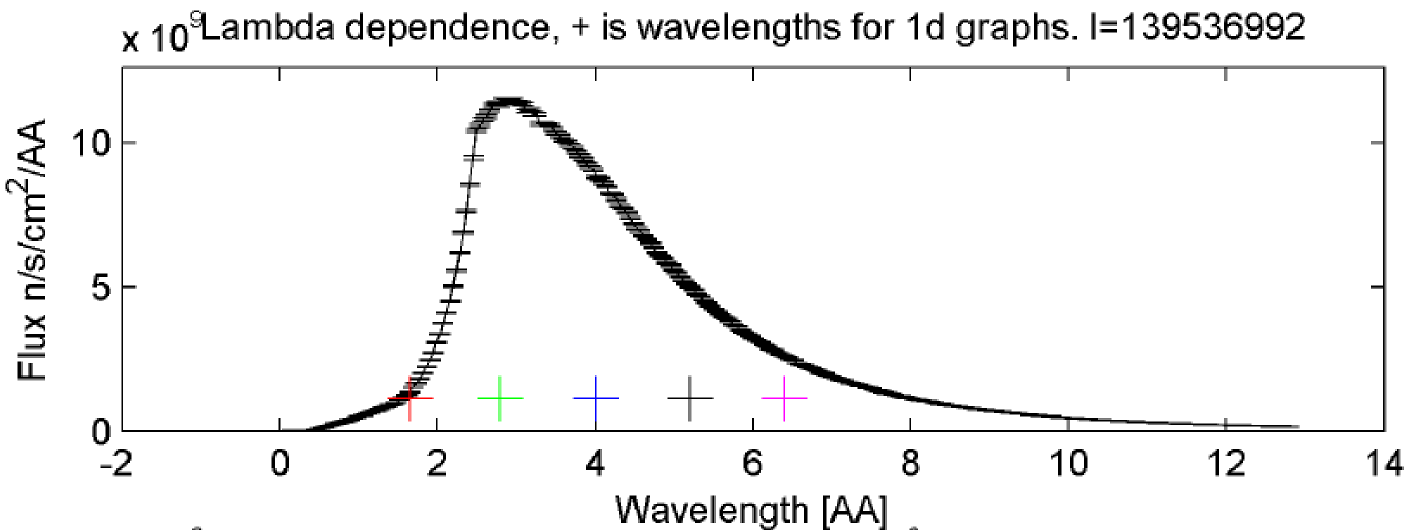
- Efficient use of pyrolytic graphite and a long primary flight path is a powerful cocktail (at least in one scattering plane)
- Scope is focused on extreme sample environment but there is plenty to do without a 20 T magnet
- Our primary concern is the ”order sorting” for the analyzers

Guide design

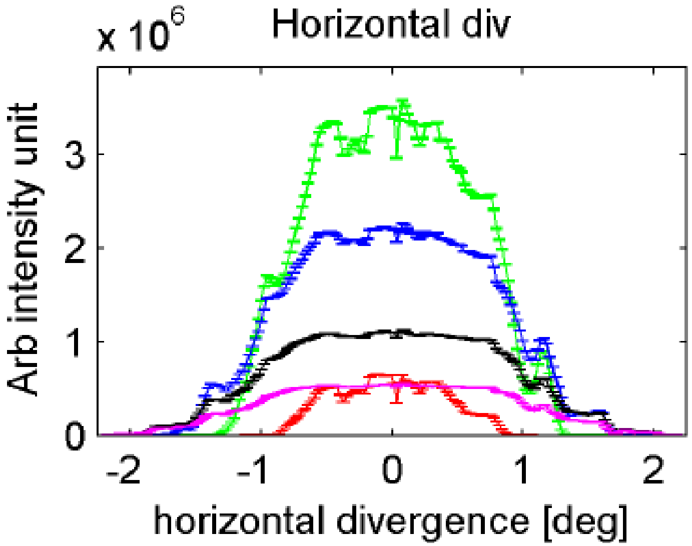


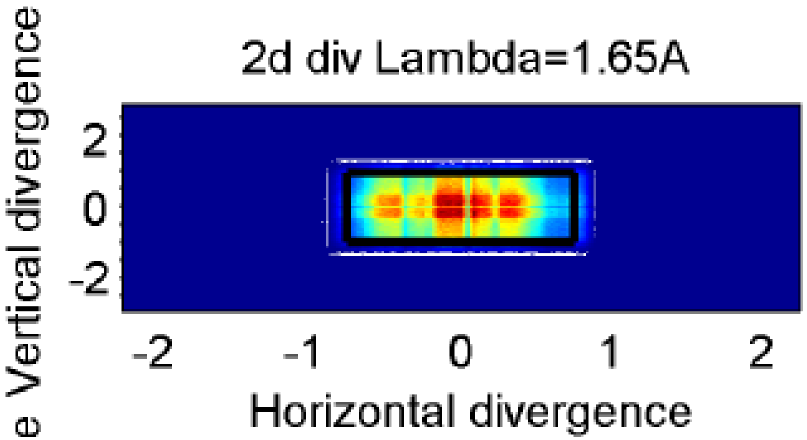
Flux

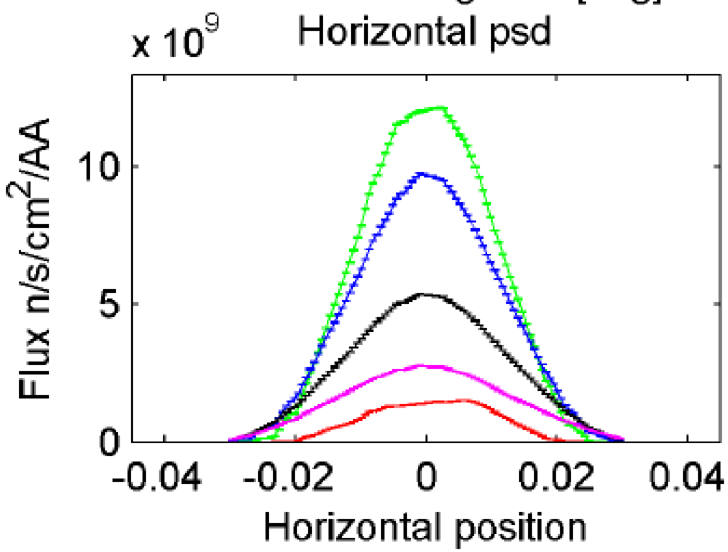

Lambda dependence, + is wavelengths for 1d graphs. I=0.0027375
Brilliance transfer
1
0.5
0
0
2
4
6
8
10
12
Wavelength [AA]

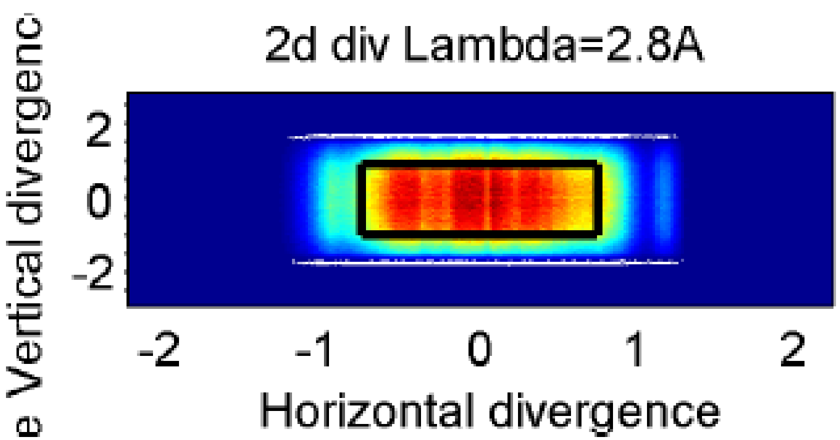

x 10^9
Lambda dependence, + is wavelengths for 1d graphs. I=139536992
Flux n/s/cm^2/AA
10
5
0
-2
0
2
4
6
8
10
12
14
Wavelength [AA]

Divergence and spatial distribution









Acceptance band of the BIFROST back end

EUROPEAN SPALLATION SOURCE

The resolution is determined by Bragg's law and acceptance angles. Mosaicity provides the acceptance

$$k_I = \frac{\tau}{2\sin\theta} \Rightarrow \Delta k_I = -k_I \cot\theta\, \Delta\theta$$

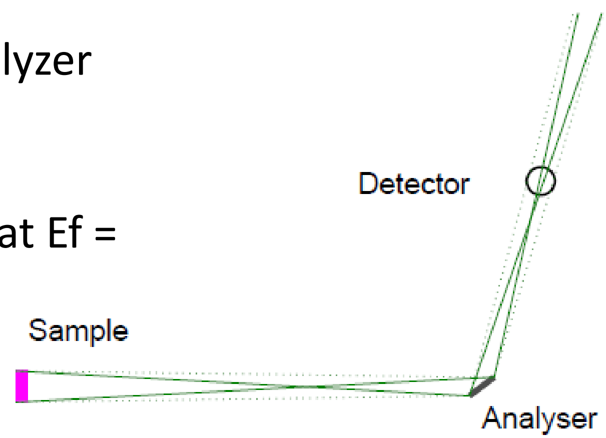
E_f	FWHM [μeV]	I_{peak}	I_{int}
2.5 meV	57(2)	3.9(1)	220(9)
3.0 meV	79(1)	4.7(1)	374(7)
3.5 meV	129(2)	3.0(1)	385(10)
4.0 meV	182(4)	1.8(1)	331(15)
4.5 meV	209(5)	[illegible]	[illegible]

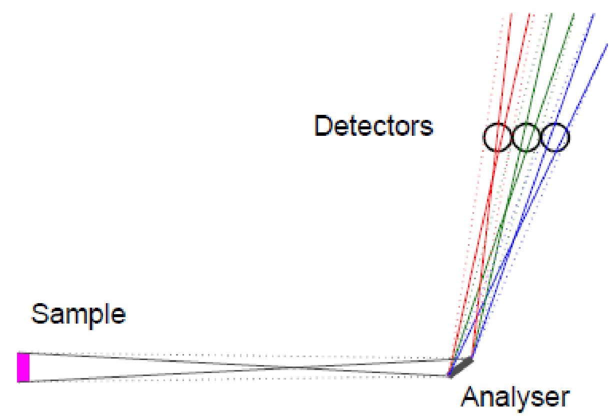
The analyzer take-off angle completely dominates the resolution.

Jonas Okkels Birks prismatic analyzer concept.

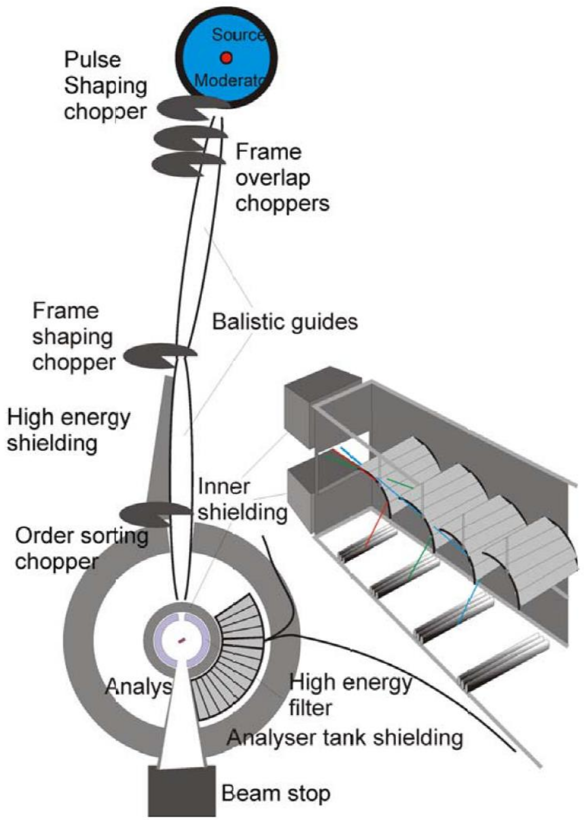
Resolution down below 80 μeV at Ef = 4.5 meV.

That acceptance bandwidth is a maximum for the setup and it is cheap.

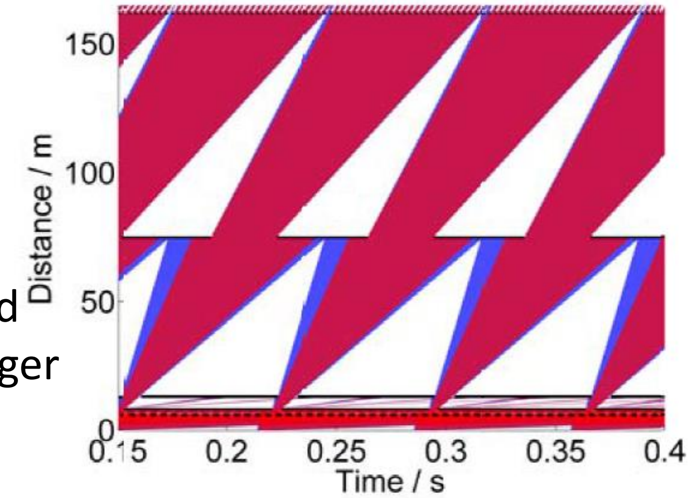


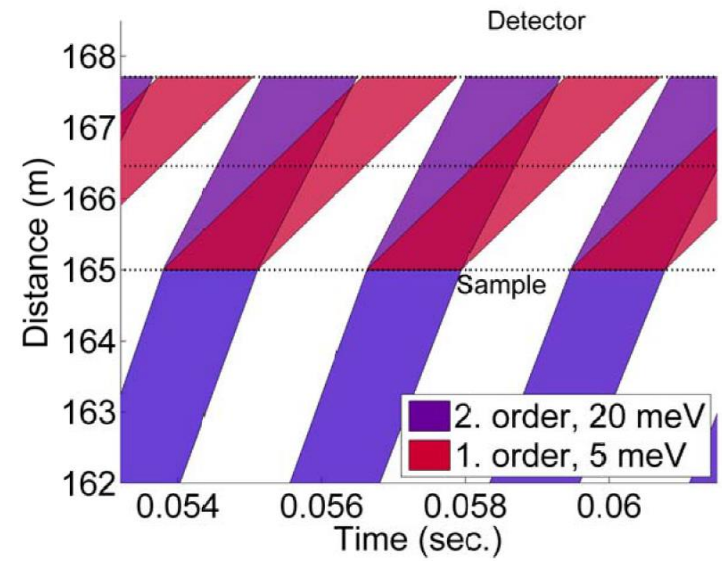


Chopper system and order sorting



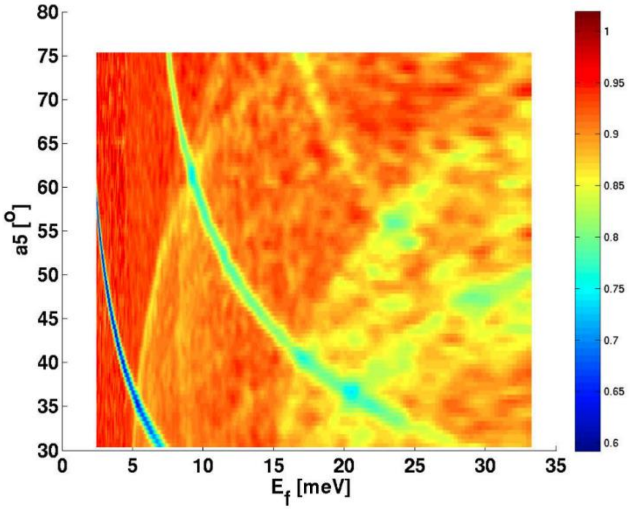
Pulse shaping choppers (210 Hz)
Allows unprecedented resolution even at larger energy transfers

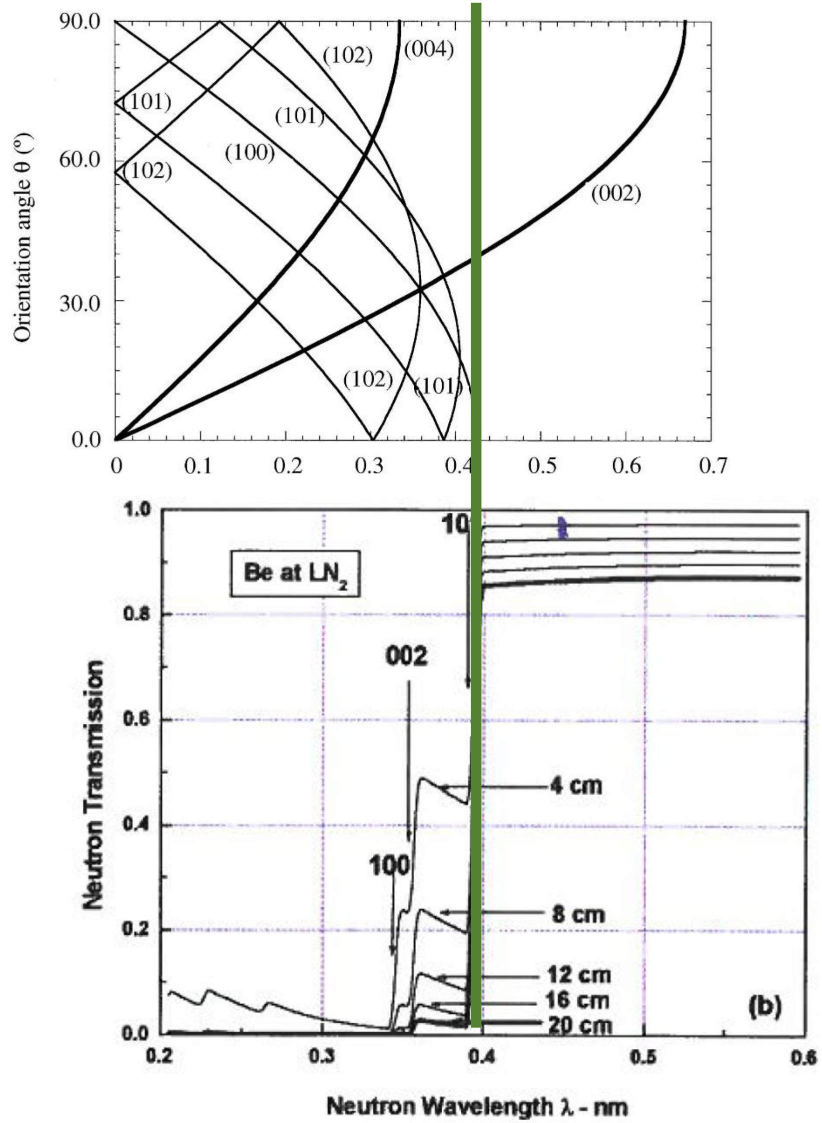




At larger E_i and energy transfers, the momentum transfer range become a problem as
$|\mathbf{k}_i - \mathbf{k}_f| < \mathbf{Q} < |\mathbf{k}_i + \mathbf{k}_f|$.
is simply too weird for the first order setting.

Problems using 2nd order reflections in HOPG





Reflectivity goes down at short wavelengths. Parasitic reflections become prominent and the intensity has to go somewhere.

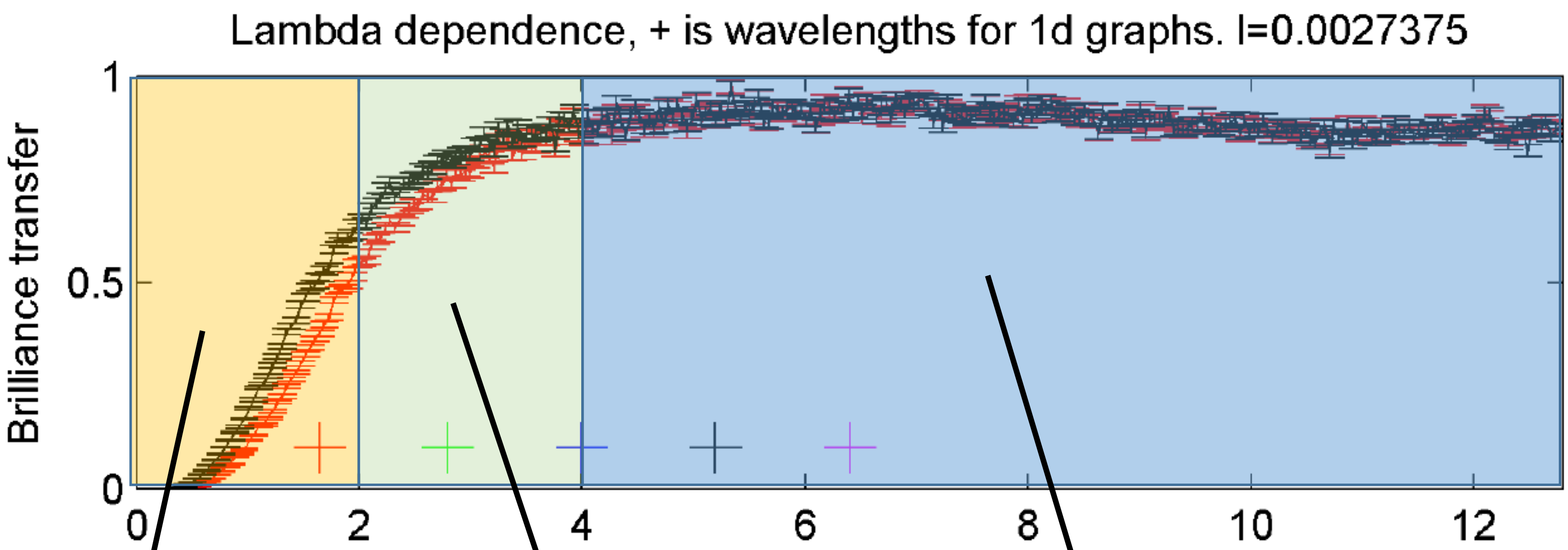
We need a translatable filter in any case.
With a filter there is no problem at all.
Spurions from PG are well understood

Utilizing of high incoming energies at BIFROST

$$\Delta k_I = -\frac{k_I}{2} \cot\theta_A (\gamma_1 - \gamma_0)$$

Going second order is cheap – the resolution would only be quadrupled. It opens up a whole new range of stuff to do: Complex high energy dispersions

5 μB in 20 T is roughly 15 meV



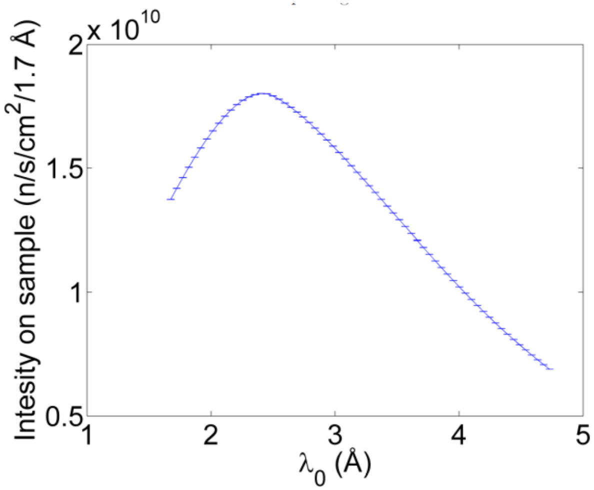
Risky, but with game changer potential

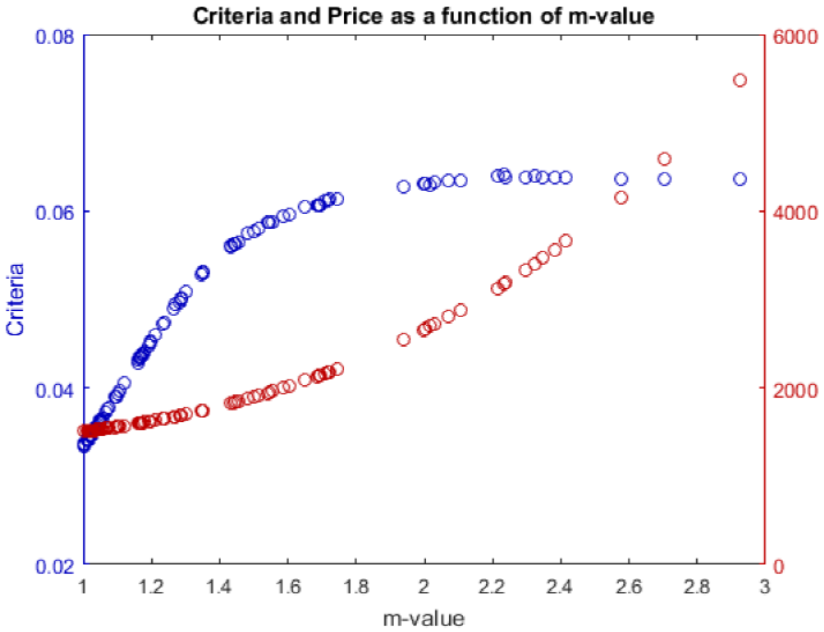
Work horse range

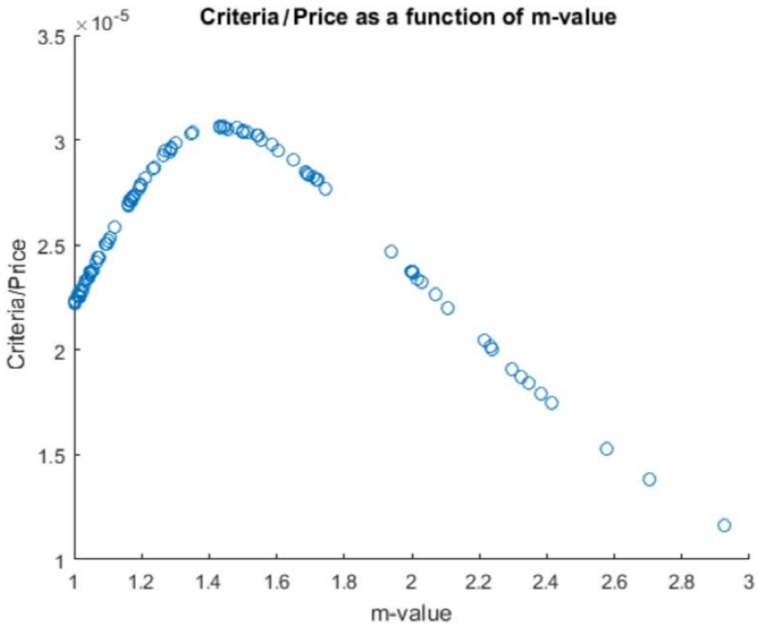
Suboptimal range

Utilizing of high incoming energies at BIFROST

We need to find out exactly how expensive it is to keep the order sorting option on the table. Can we save money by sacrificing only the short wavelengths ?







The most expensive posts

- Guide – 1.3 M€
- Shielding – 1.1 - 2.1 M€ (uncertain)
- Second order:
  PG analyzers, chopper, end shielding (2 M€)
- Vacuum tank (1.1 M€)
- Polarization analysis (2.1 M€)

Optimize with respect to price and examine if short wavelengths can be reasonably sacrificed

Examine the price of heavy shielding at guide end

Restrict ourselves below the Be cutoff, save 1 chopper plus shieldling

Stick to argon overpressure?

Keep it as an option, examine discount solutions

Conclusions

- The short wavelengths may be expendable
- Removing order sorting can cut costs via less shielding at the endpoint, less PG, a saved chopper and a cheaper guide
- Price of shielding a question mark that we need to address

Guide design

EUROPEAN SPALLATION SOURCE

Component	length of coating segment	coating value	position relative to moderator
Feeder	1.74 m	3	2.16 m - 3.90 m
Feeder	1.74 m	3.5	3.90 m - 5.63 m
Feeder	0.87 m	3	5.63 m - 6.5 m
Ellipse	6.52 m	3.5	6.6 m - 13.12 m
Ellipse	6.52 m	2	13.12 m - 19.64 m
Ellipse	39.12 m	1.5	19.64 m - 58.78 m
Ellipse	6.52 m	2	58.78 m - 65.28 m
Ellipse	6.52 m	3	65.28 m - 71.80 m
Straight	13.94 m	2	71.80 m - 85.74 m
Ellipse	15.73 m	2	85.74 m - 101.47 m
Ellipse	47.20 m	1	101.47 m - 148.67 m
Ellipse	7.87 m	2	148.67 m - 156.53 m
Ellipse	7.87 m	3.5	156.53 m - 164.4 m

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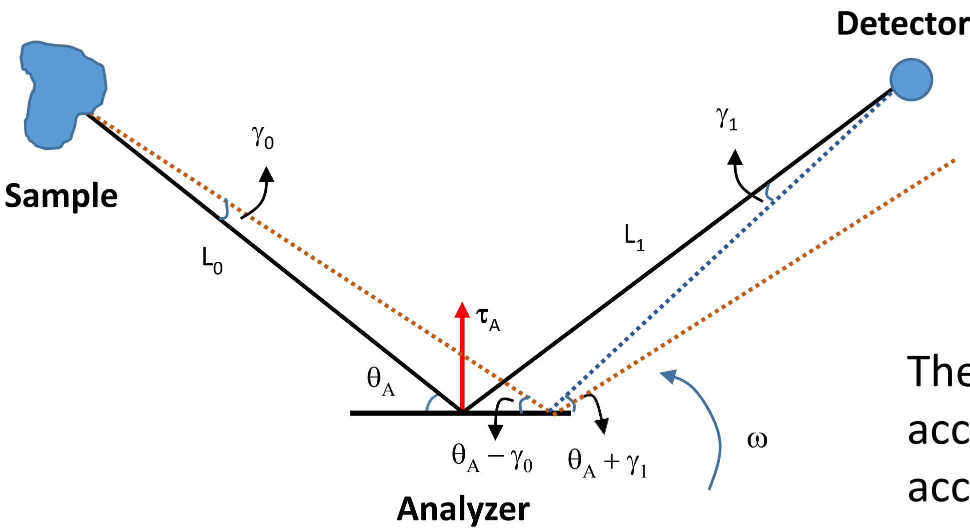

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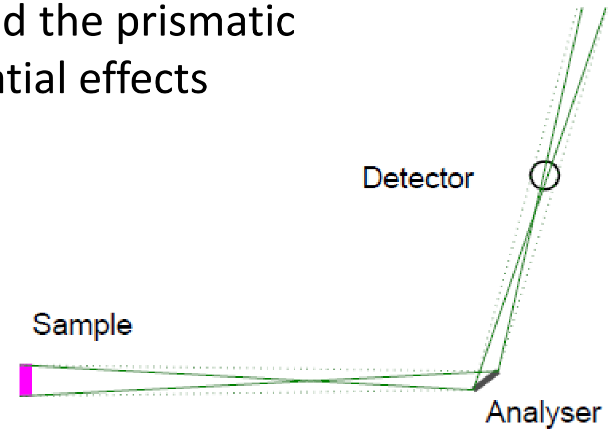
4.5 meV	209(5)	1.7(1)	344(20)

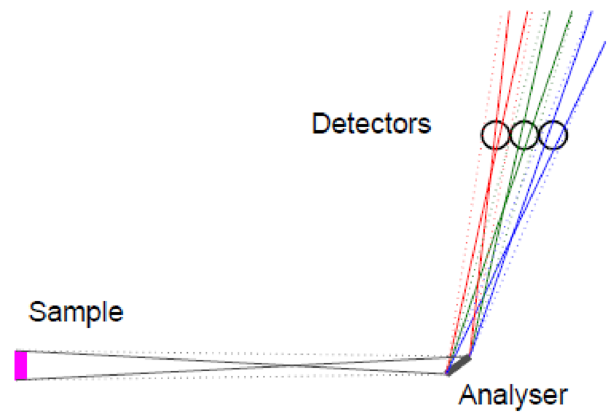
The analyzer take-off angle completely dominates the resolution.

Improving this acceptance band

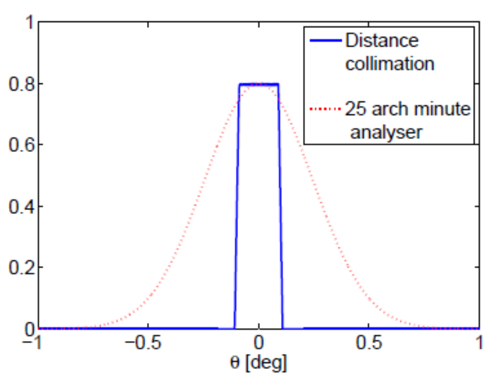
Jonas Okkels Birk developed the prismatic analyzer concept when spatial effects are minimized.

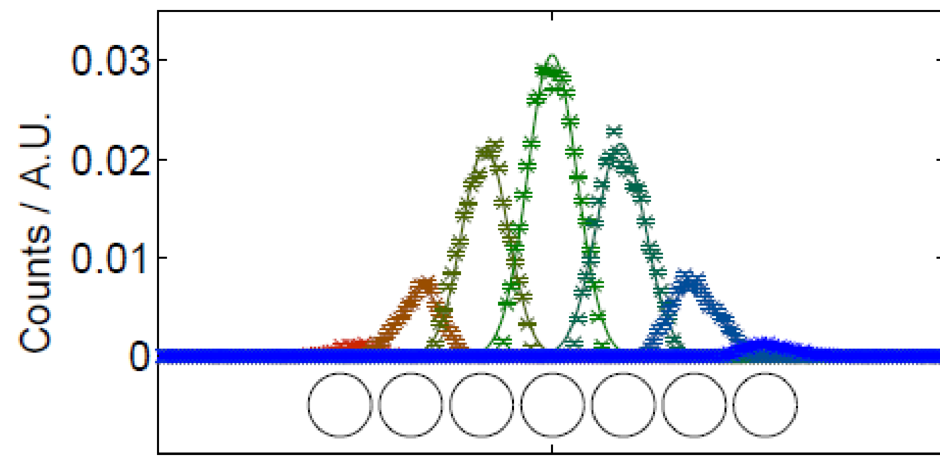
Resolution
at the $E_f = 4.5$ meV
Analyzer -> 80 μeV.



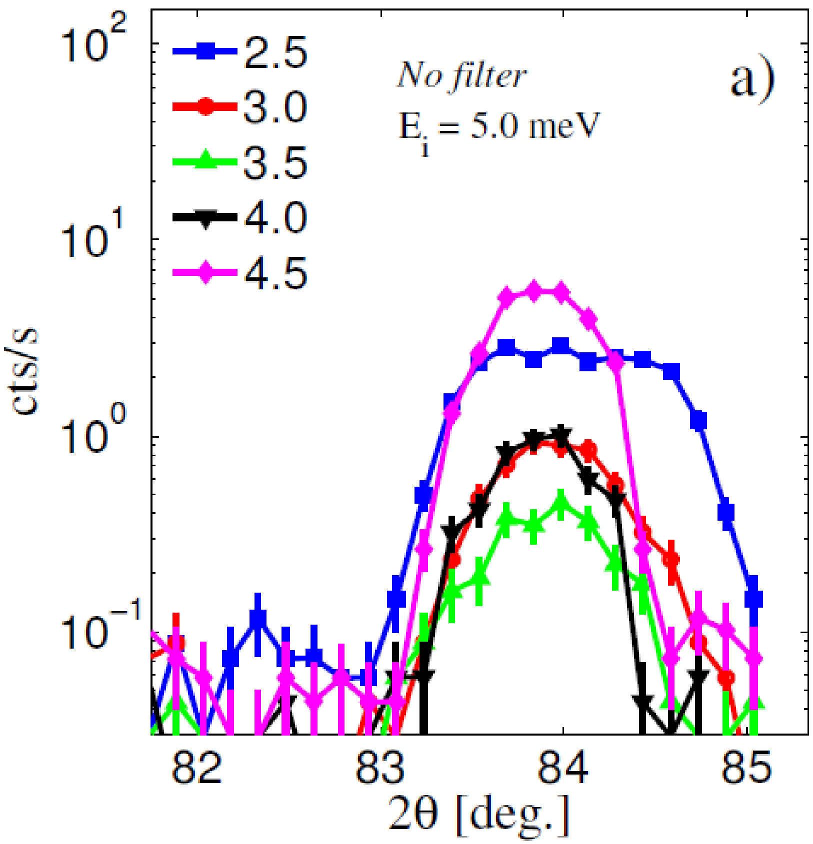


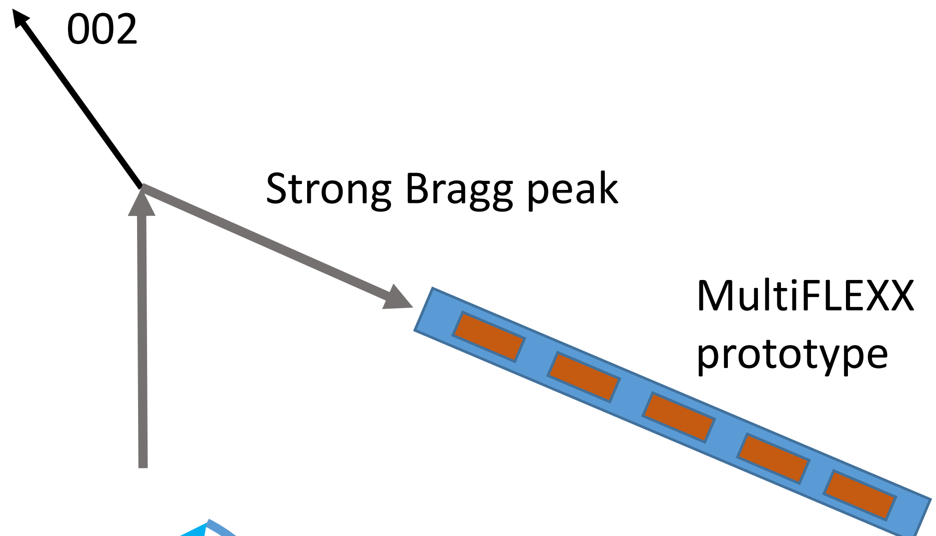
That acceptance bandwidth is a maximum for the setup and it is cheap. It gives a lot of perspective.

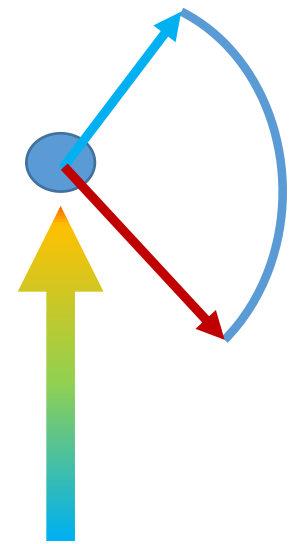




Problems on the TAS versions





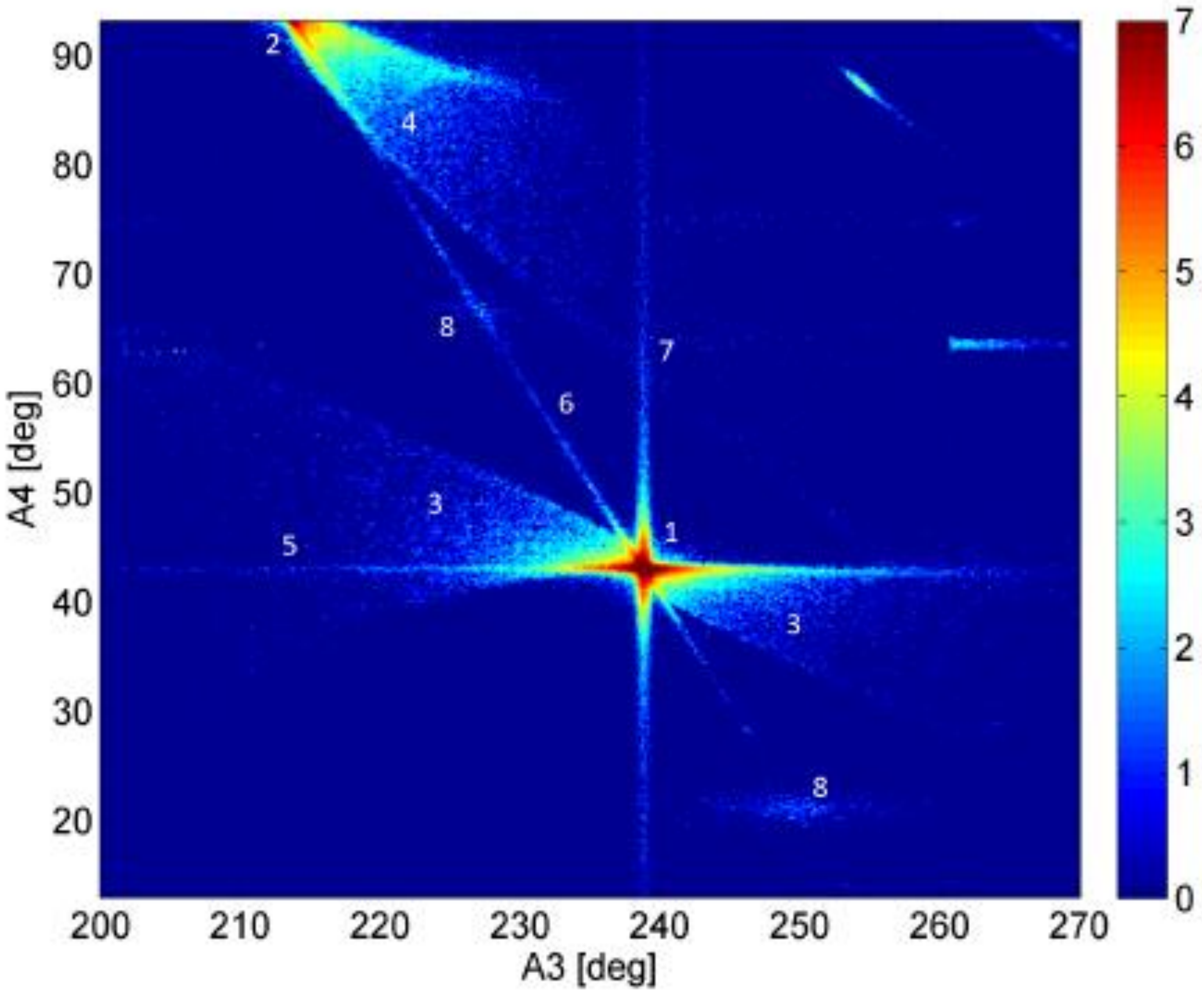


White beam =>
Bragg peaks become
Lines in Θ,2Θ space

Thermal beam =>
Loads of Bragg peaks

Low symmetry systems
would generate a universe
of spurions

Characterizing HOPG



Beautiful DMC data taken by master student Rasmus Laurberg Hansen

Well understood by McStas simulations