# Guide Comparison Project

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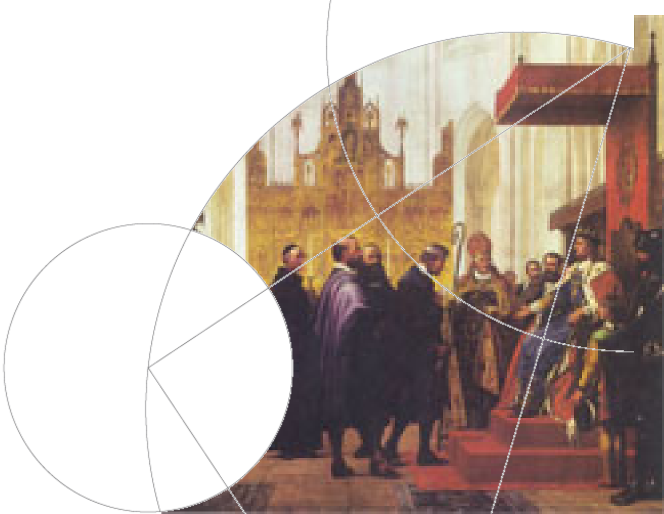
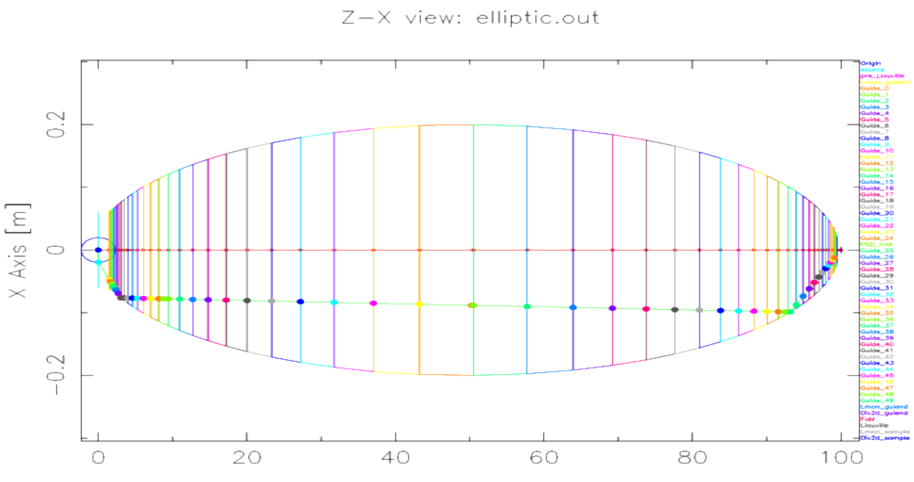


# The Aim

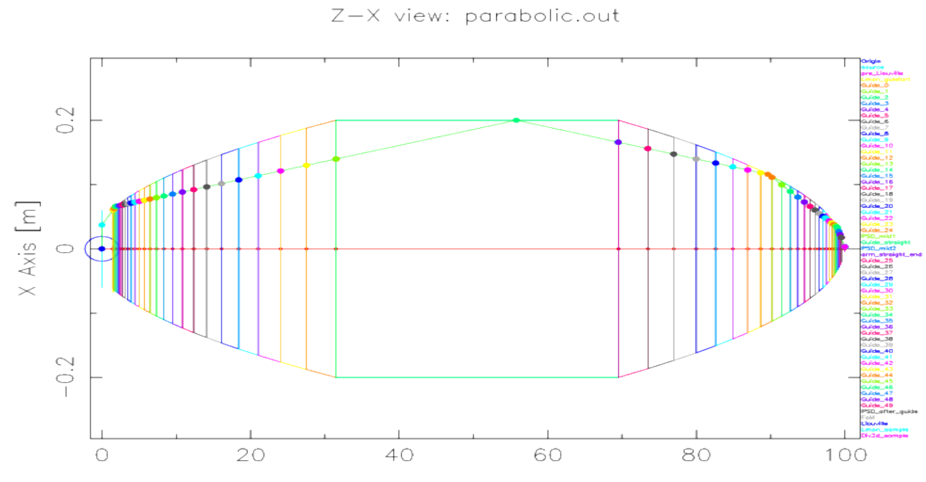
- Comparing the performance of four different guide geometries, each for 12 different settings.
- Figure of merit is flux in n/s/cm², on a 1x1 cm² sample, within the given divergence and wavelength restrictions.
- To perform all the simulations using both McStas and VITESS and compare the results.

# The guide geometries

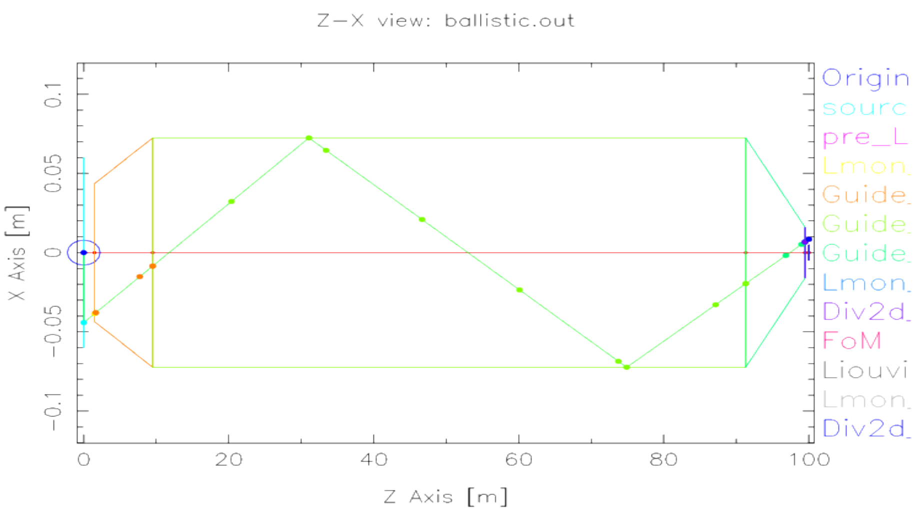
*Elliptic guide*



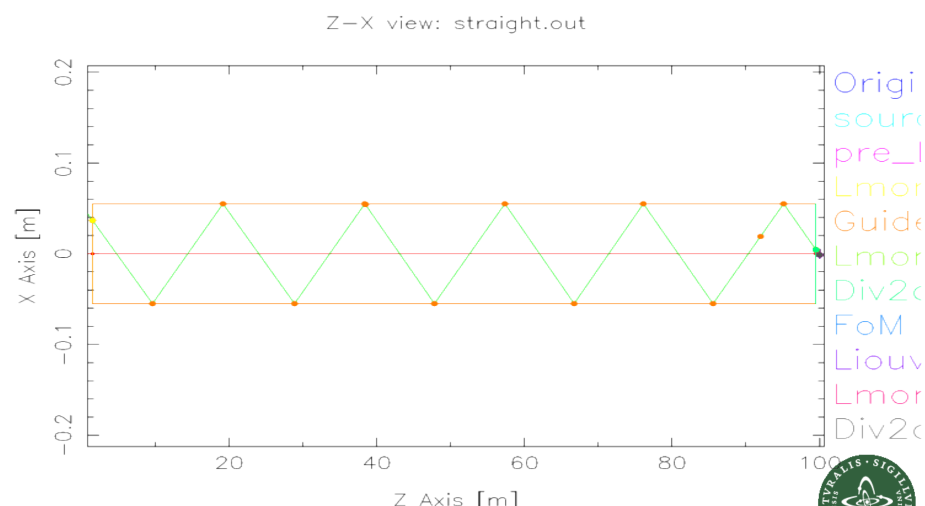

*Parabolic guide*




*Ballistic guide*




*Straight guide*



# The settings investigated

- Each geometry was optimized for maximum FoM for each of the different combinations of source-sample length, maximum acceptable divergence, and wavelength range.
- Length: 50 m, 100 m, 150 m.
- Divergence: 0.5 degrees and 2 degrees.
- Wavelengths: Thermal, centered on 1.5 Å, and Cold, centered on 5 Å. The bandwidth is then given by frame overlap restrictions, assuming a pulse period of 60 ms.
- This gives 12 settings to be optimized for each of the four different guide geometries; i. e. a total of 48 settings to be investigated.
- *This took a long time!*

# Optimization procedure

- For each setting the parameters of each geometry is modified by a simplex algorithm to maximize the FoM for that particular setting, within the boundary conditions given for those parameters. This was done using VITESS for the ballistic guide and McStas for the others. For simplicity, we have defined each geometry to always be symmetrical in the horizontal and vertical directions.

  *The parameters to be optimized are:*
- Elliptic: Source focus point, the sample focus point, the centre width, and the total guide length.
- Parabolic: Source focus point, the sample focus point, the centre width, the length of the expanding section, the length of the focusing section, and the total guide length.
- Ballistic: Width at guide start, width at guide end, the centre width, the length of the expanding section, the length of the focusing section, and the total guide length.
- Straight: Width of the guide.

# Optimization results

*Far too much data to show, so instead the typical results:*

- Elliptic: sample focus point usually near the sample, often some distance after it; centre width → max allowed (40 cm); guide length → max allowed.
- Parabolic: Same as elliptic.

  Additionally: lengths of the expanding and focusing sections of the guide → max allowed (30 % of the total guide length each).
- Ballistic: Guide length → max; lengths of expanding and focusing sections of the guide → ~ 8-10 m; centre width → ~ 10-15 cm; width of expanding section → ~ 7-10 cm; width of focusing section → ~ 3-6 cm.
- Straight: Width of the guide ~ 10 cm.

# Simulation Results

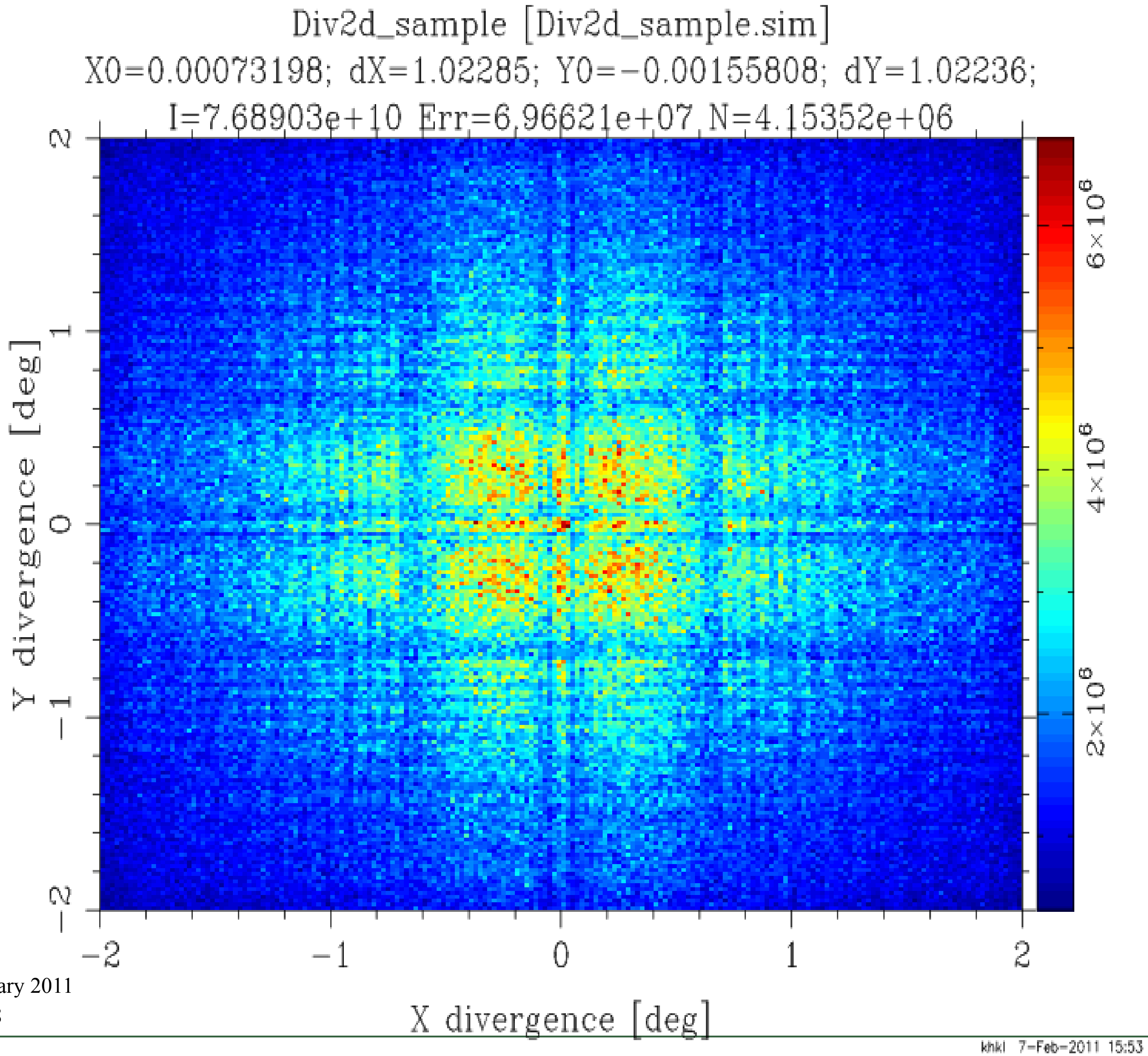
*Relative FoM*

| Length (m) | Max divergen | Wavelength | Elliptic | Parabolic | Ballistic | Straight |
|---|---|---|---|---|---|---|
| 50 | 0.5 | Thermal | 1.79 | 1.83 | 1.65 | 1.00 |
| | | Cold | 0.96 | 1.02 | 1.05 | 1.00 |
| | 2 | Thermal | 9.44 | 8.22 | 5.49 | 1.00 |
| | | Cold | 5.02 | 5.32 | 4.01 | 1.00 |
| 100 | 0.5 | Thermal | 2.41 | 2.45 | 2.14 | 1.00 |
| | | Cold | 1.1 | 1.09 | 1.07 | 1.00 |
| | 2 | Thermal | 14.6 | 12.18 | 6.24 | 1.00 |
| | | Cold | 6.88 | 6.52 | 5.32 | 1.00 |
| 150 | 0.5 | Thermal | 2.97 | 3.07 | 2.7 | 1.00 |
| | | Cold | 1.12 | 1.1 | 1.09 | 1.00 |
| | 2 | Thermal | 20.37 | 18.41 | 6.33 | 1.00 |
| | | Cold | 8.28 | 7.92 | 6.17 | 1.00 |

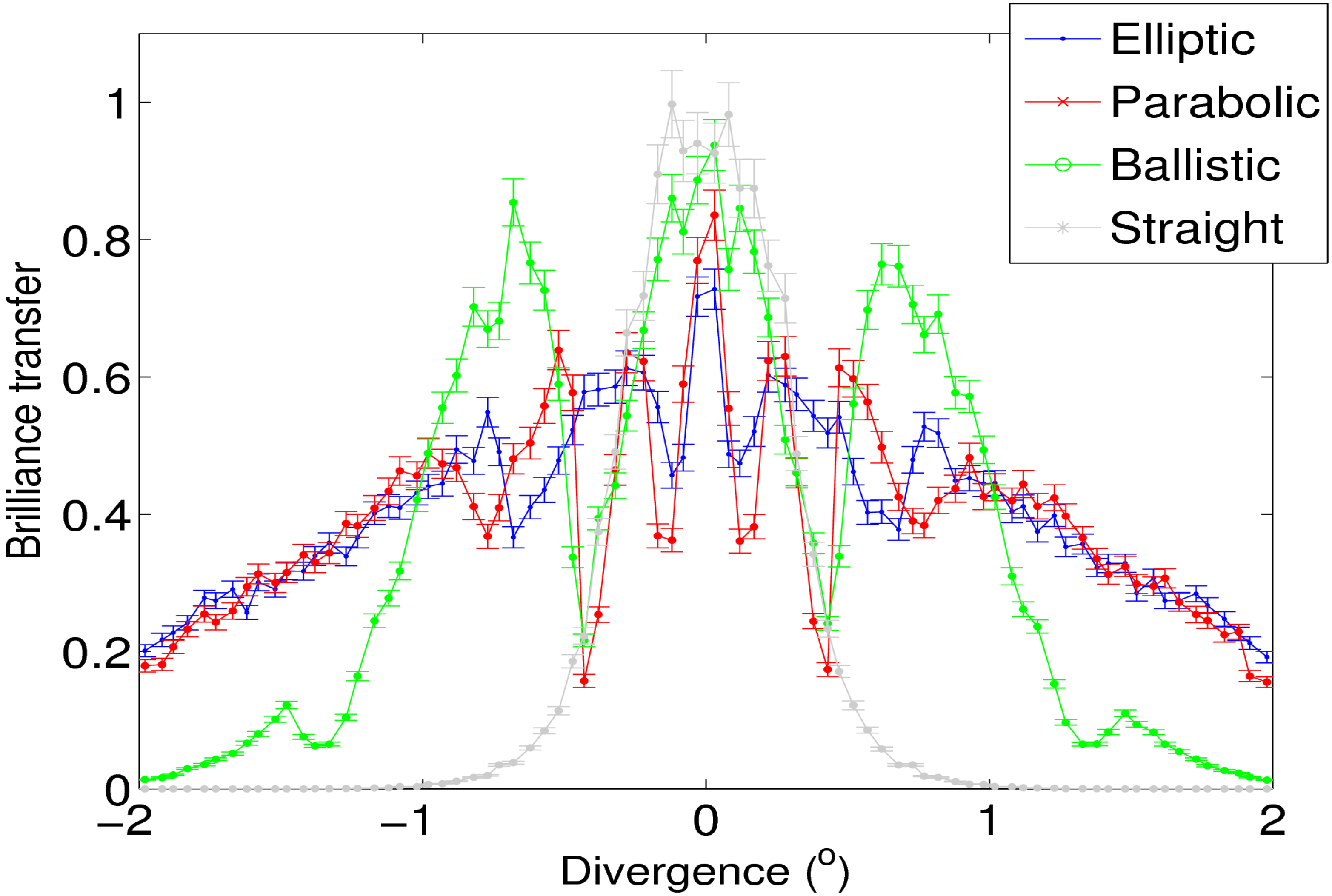
*Liouville factor*

| Length (m) | Max divergen | Wavelength | Elliptic | Parabolic | Ballistic | Straight |
|---|---|---|---|---|---|---|
| 50 | 0.5 | Thermal | 0.82 | 0.84 | 0.76 | 0.46 |
| | | Cold | 0.89 | 0.96 | 0.97 | 0.93 |
| | 2 | Thermal | 0.32 | 0.28 | 0.19 | 0.03 |
| | | Cold | 0.8 | 0.85 | 0.64 | 0.16 |
| 100 | 0.5 | Thermal | 0.86 | 0.88 | 0.76 | 0.36 |
| | | Cold | 0.98 | 0.96 | 0.96 | 0.90 |
| | 2 | Thermal | 0.35 | 0.29 | 0.15 | 0.02 |
| | | Cold | 0.91 | 0.86 | 0.7 | 0.13 |
| 150 | 0.5 | Thermal | 0.86 | 0.89 | 0.78 | 0.29 |
| | | Cold | 0.97 | 0.95 | 0.95 | 0.87 |
| | 2 | Thermal | 0.39 | 0.35 | 0.12 | 0.02 |
| | | Cold | 0.91 | 0.87 | 0.68 | 0.11 |

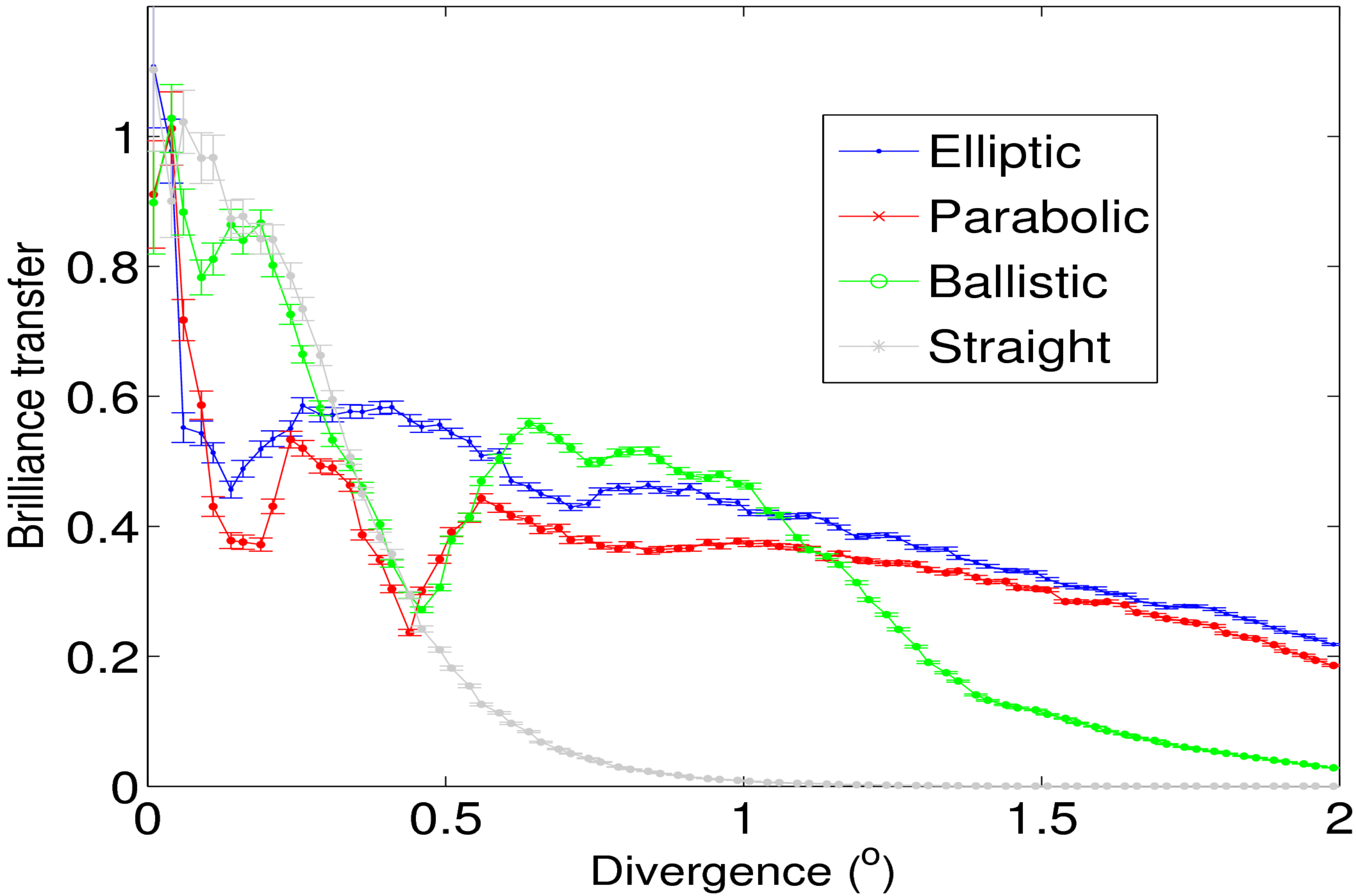
# Divergence at sample position



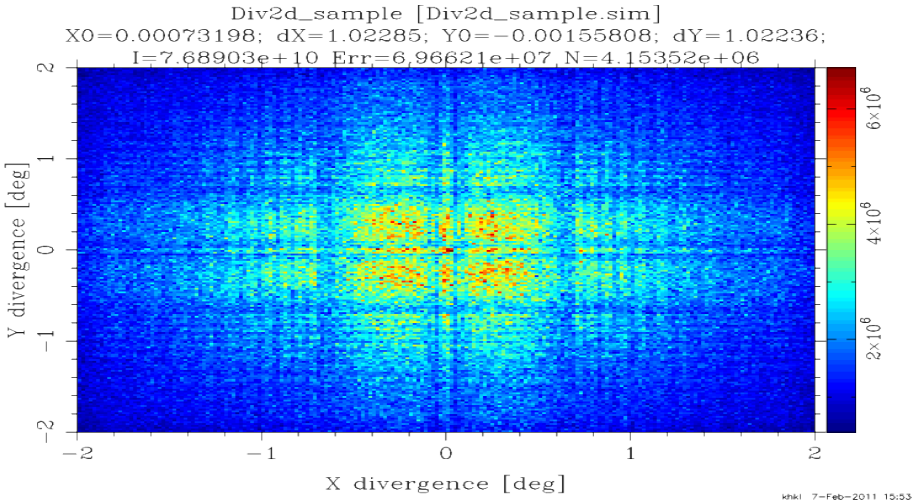
# Divergence at sample position

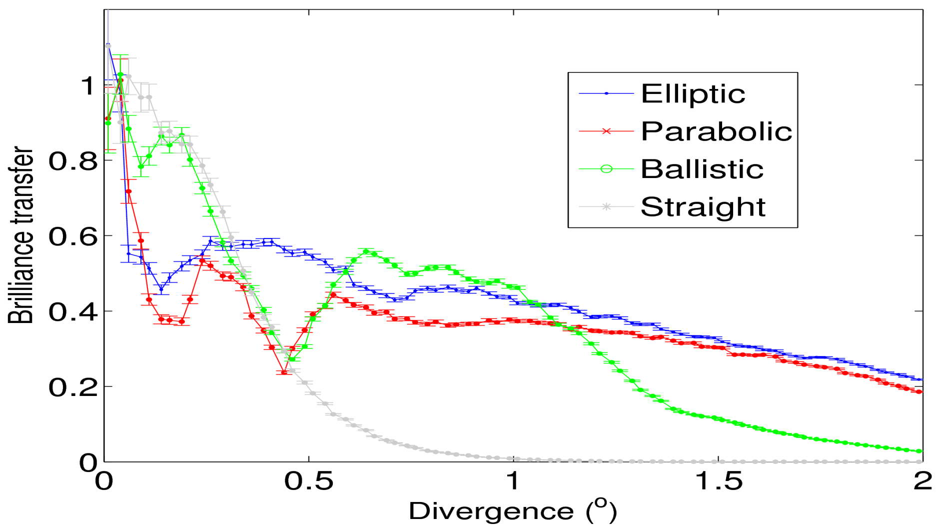


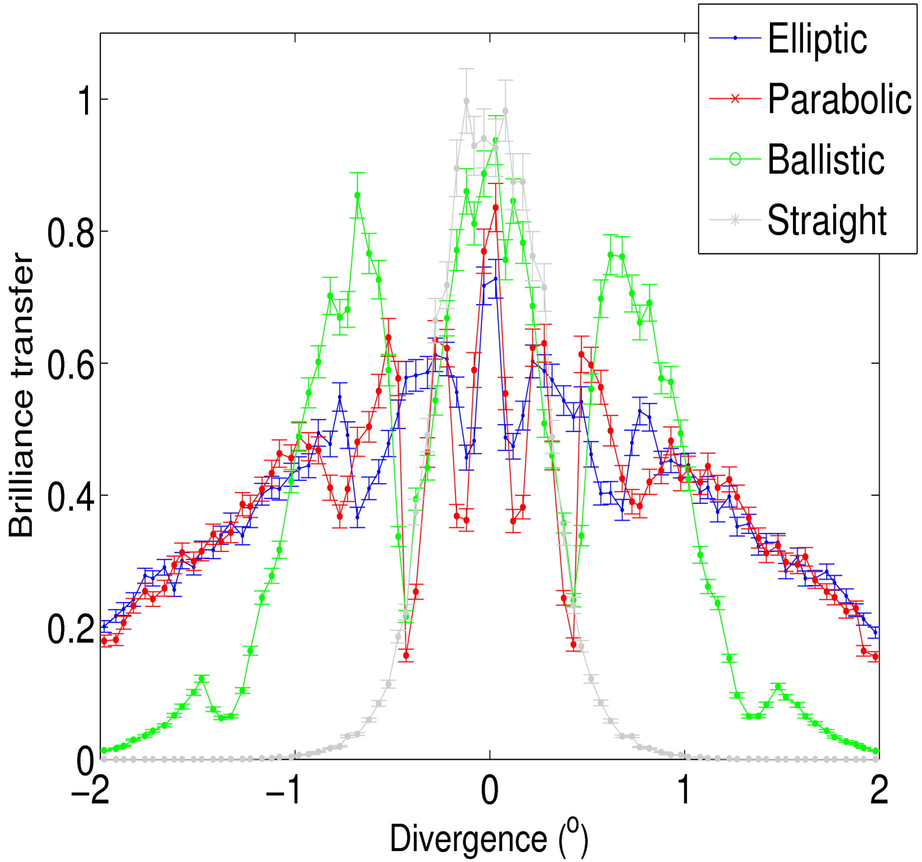
# Divergence at sample position



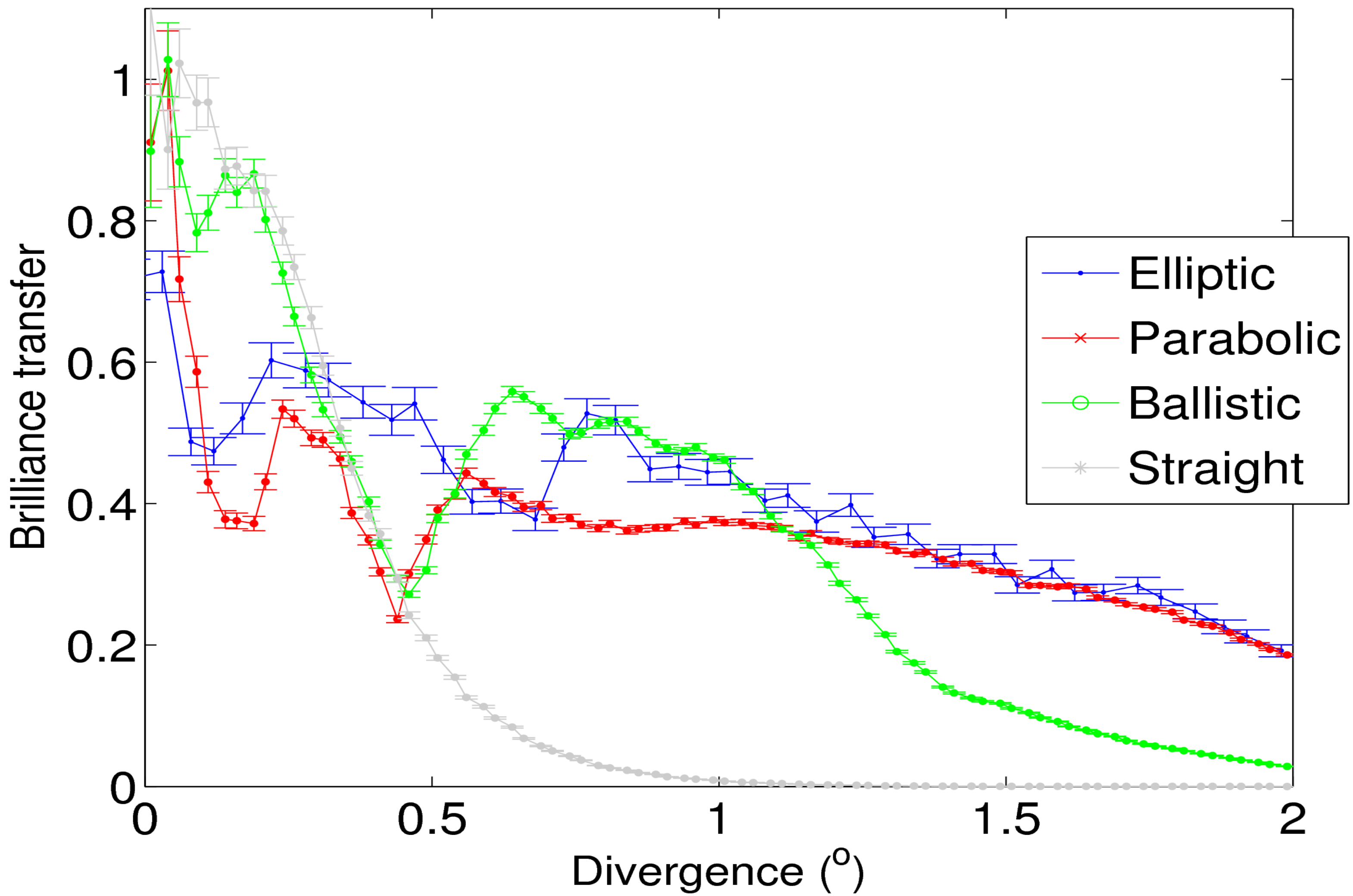
# Divergence at sample position. 50 m, 2 °, thermal neutrons



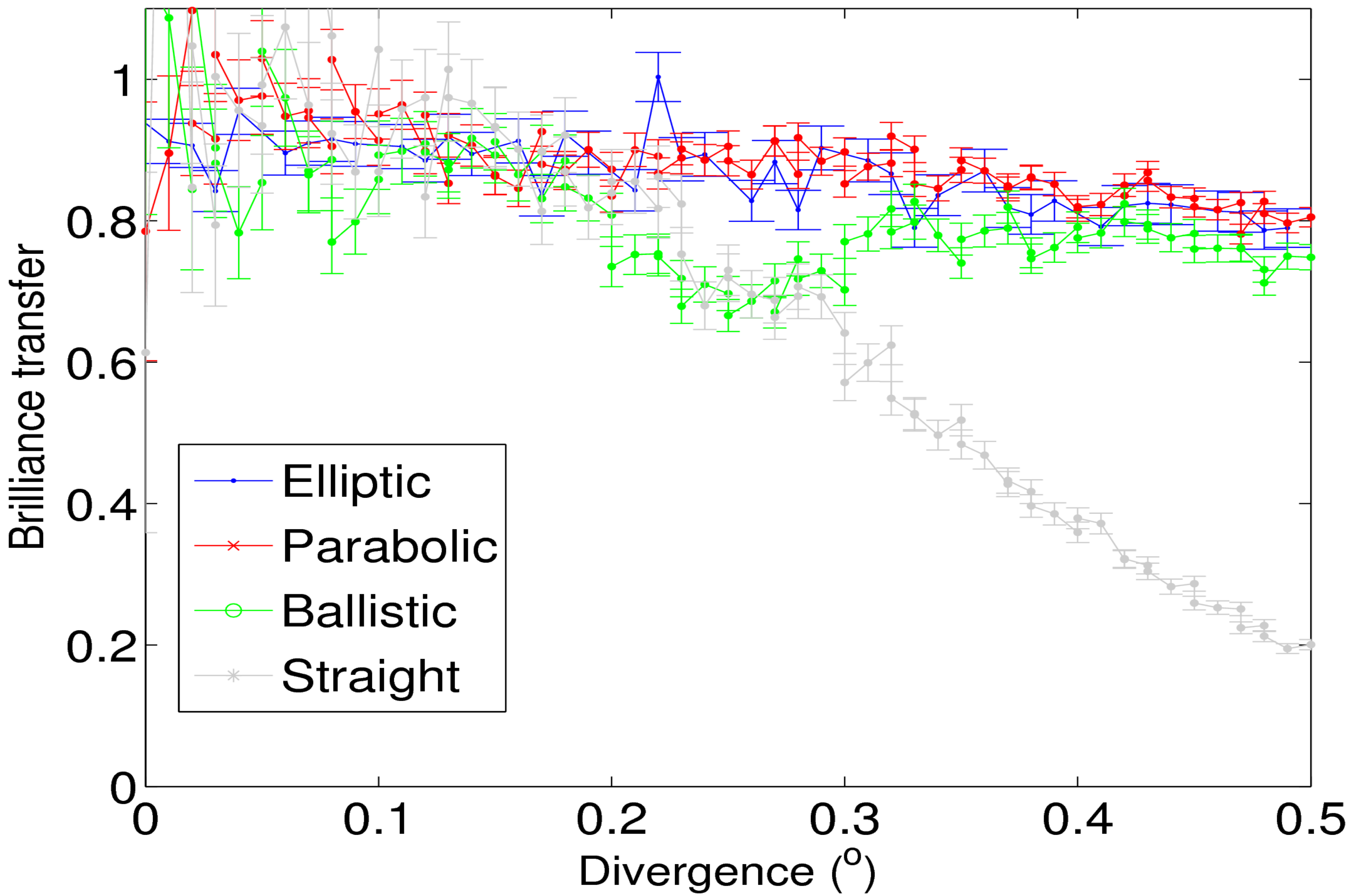



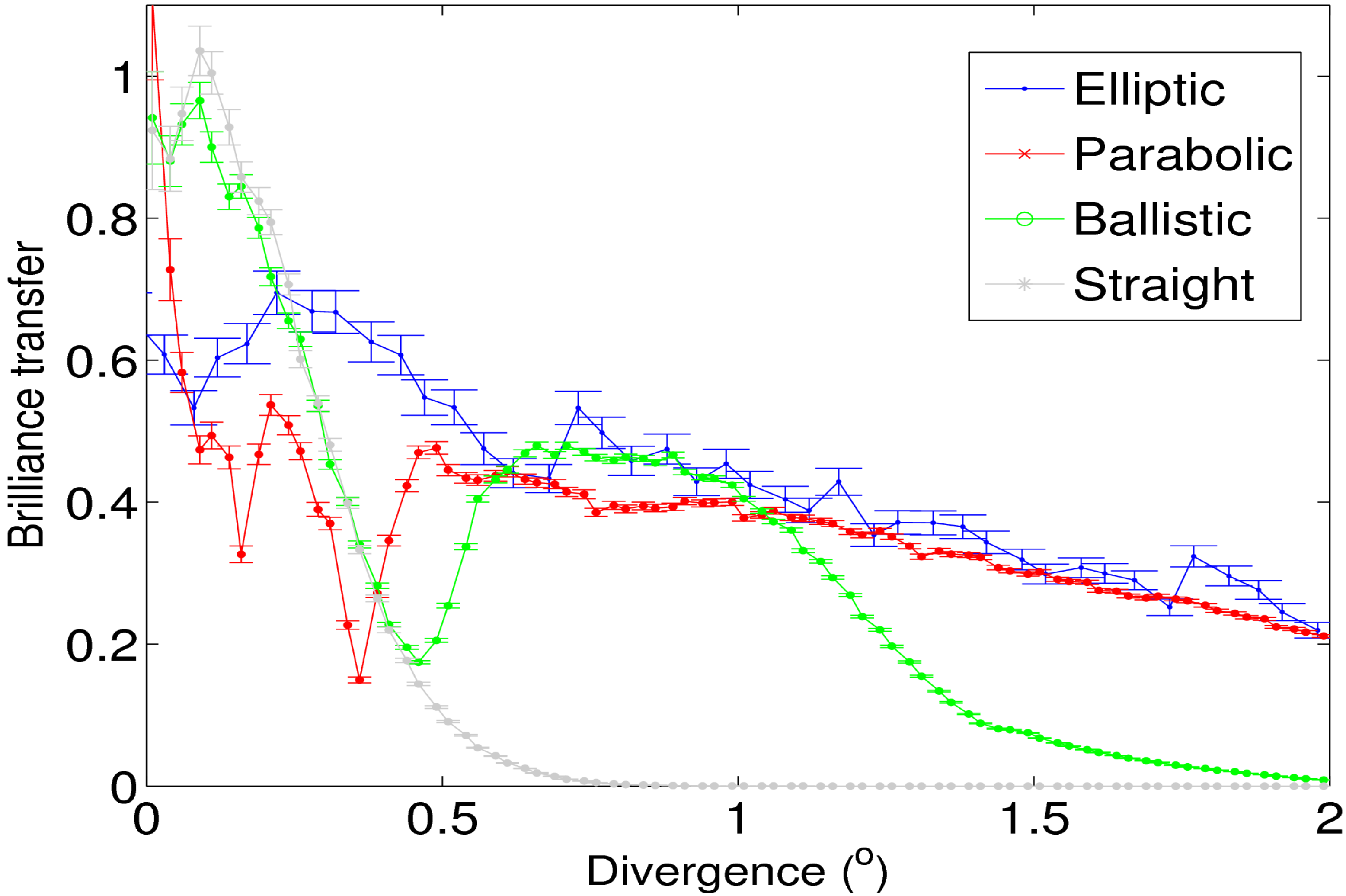
# Divergence at sample position. 50 m, 2 °, cold neutrons



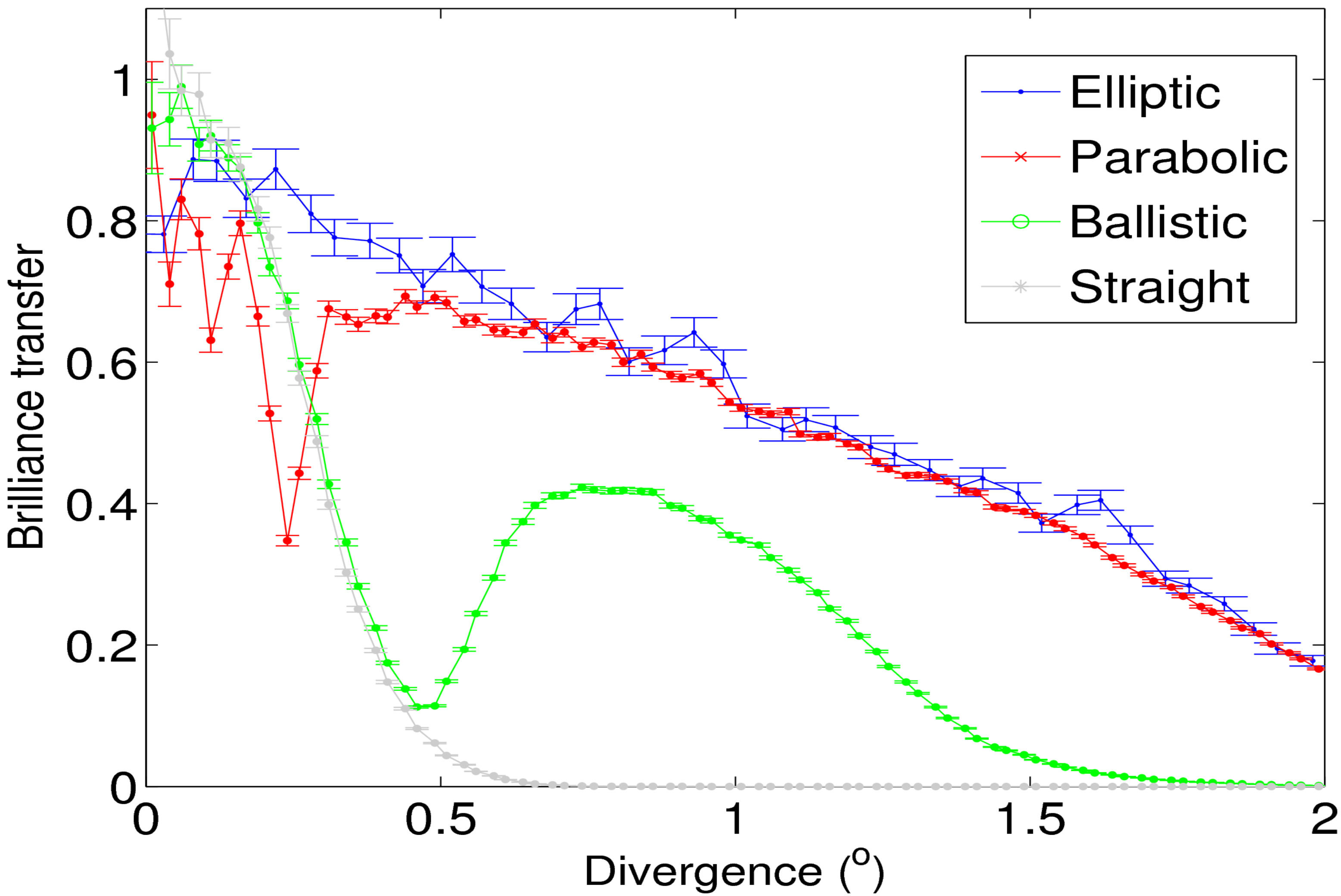
# Divergence at sample position. 50 m, 0.5 °, thermal neutrons



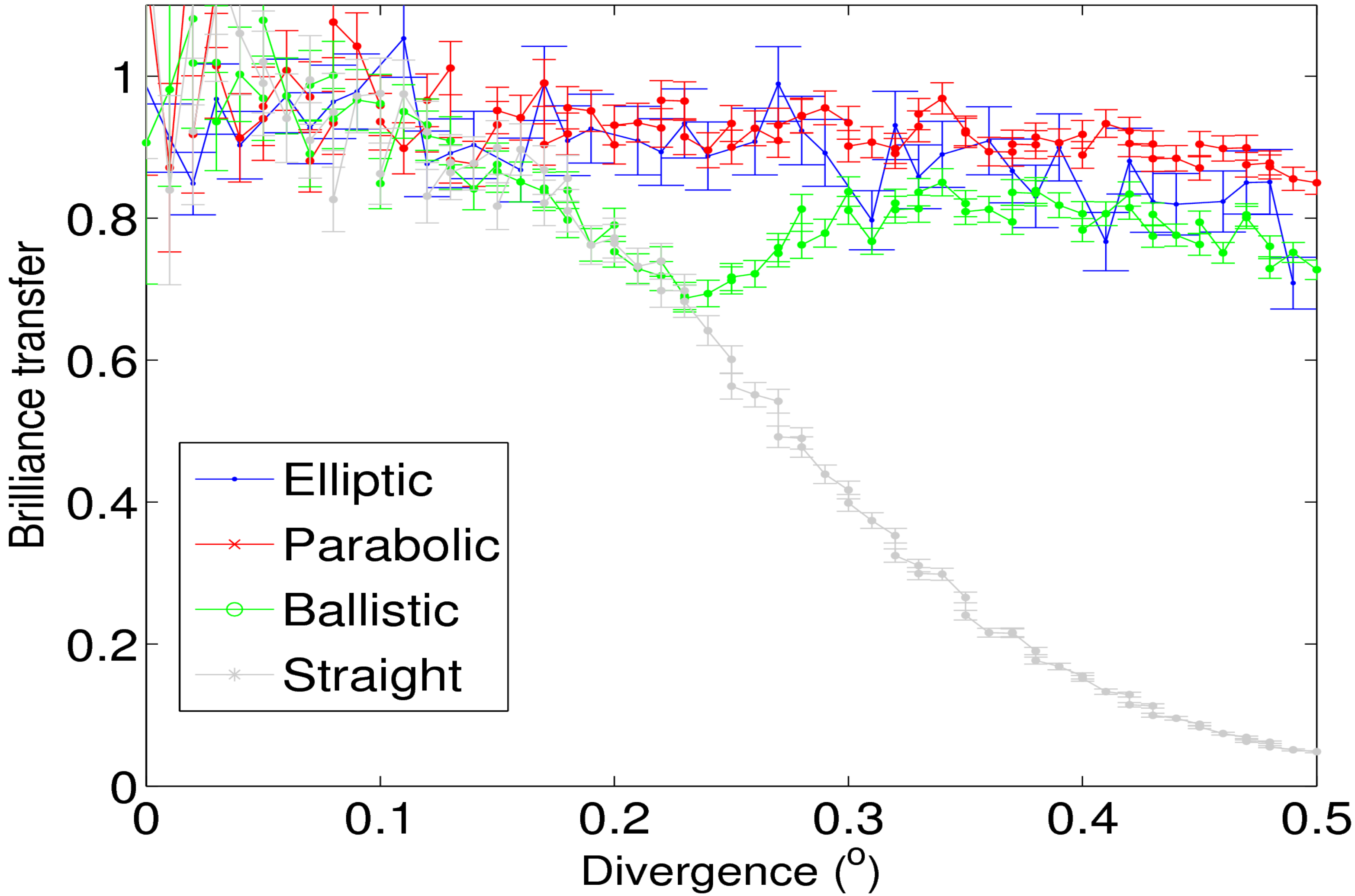
# Divergence at sample position. 100 m, 2 °, thermal neutrons



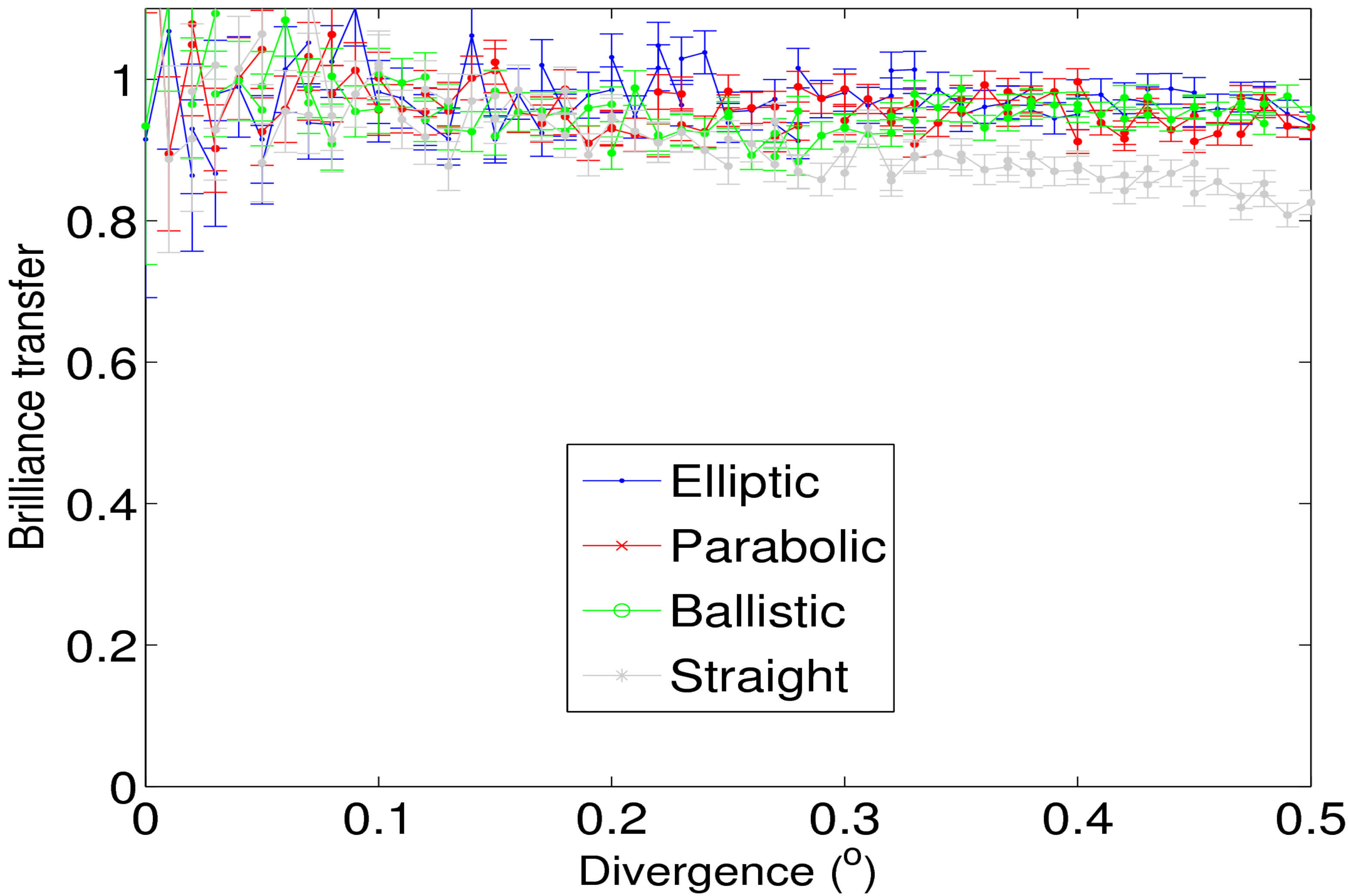
# Divergence at sample position. 150 m, 2 °, thermal neutrons



# Divergence at sample position. 150 m, 0.5 °, thermal neutrons



# Divergence at sample position. 150 m, 0.5 °, cold neutrons



# Comparison with VITESS

Mostly good agreement, but some discrepancies at 10 %.

| *Ratio McStas to VITESS* | | | | | | |
|---|---|---|---|---|---|---|
| Length (m) | Max divergen | Wavelength | Elliptic | Parabolic | Ballistic | Straight |
| 50 | 0.5 | Thermal | **0.98** | **0.98** | **1.02** | **1.01** |
| | | Cold | **1.01** | **1.00** | **0.99** | **1.00** |
| | 2 | Thermal | **0.92** | **0.92** | **1.09** | **1.02** |
| | | Cold | **1.01** | **0.99** | **1.06** | **1.01** |
| 100 | 0.5 | Thermal | **0.98** | **0.98** | **0.99** | **1.04** |
| | | Cold | **1.03** | **1.01** | **0.97** | **0.99** |
| | 2 | Thermal | **0.93** | **0.90** | **1.10** | **1.03** |
| | | Cold | **1.00** | **1.01** | **1.04** | **1.01** |
| 150 | 0.5 | Thermal | **1.02** | **0.96** | **1.00** | **1.04** |
| | | Cold | **1.04** | **0.99** | **0.95** | **0.96** |
| | 2 | Thermal | **1.00** | **0.97** | **1.11** | **0.97** |
| | | Cold | **1.01** | **1.00** | **1.04** | **1.07** |

# Conclusion

- Simple guide shapes (straight and ballistic) is competivite with advanced guide shapes (elliptic and parabolic), for the transport of cold, low-divergent neutrons. Advanced guides have far superior transport in other areas of phase space.
- Advanced guide shapes perform better at long distances, due to easier focusing.
- Parabolic guide shapes have almost equal performance to elliptical guides in most settings, with a slight lead for elliptical guides.

Thank you for staying awake!

# Appendix

Various parameters:

Pulse width: 2 ms

Pulse period: 60 ms

Thermal: 0.1-4.6 Å for 50 m, 0.35-2.65 for 100 m, and 0.75-2.25 Å for 150 m

Cold: 2.75–7.25 Å for 50 m, 3.85-6.15 Å for 100 m, and 4.25-5.75 Å for 150 m

*Absolute FoM*

| Length (m) | Max divergen | Wavelength | Elliptic | Parabolic | Ballistic | Straight |
|---|---|---|---|---|---|---|
| 50 | 0.5 | Thermal | 1.27E+010 | 1.29E+010 | 1.17E+010 | 7.06E+009 |
| | | Cold | 2.27E+009 | 2.42E+009 | 2.47E+009 | 2.36E+009 |
| | 2 | Thermal | 7.84E+010 | 6.83E+010 | 4.56E+010 | 8.31E+009 |
| | | Cold | 3.26E+010 | 3.45E+010 | 2.61E+010 | 6.49E+009 |
| 100 | 0.5 | Thermal | 1.20E+010 | 1.22E+010 | 1.07E+010 | 4.98E+009 |
| | | Cold | 1.01E+009 | 1.00E+009 | 9.84E+008 | 9.19E+008 |
| | 2 | Thermal | 7.72E+010 | 6.44E+010 | 3.30E+010 | 5.29E+009 |
| | | Cold | 1.50E+010 | 1.42E+010 | 1.16E+010 | 2.18E+009 |
| 150 | 0.5 | Thermal | 1.04E+010 | 1.07E+010 | 9.41E+009 | 3.49E+009 |
| | | Cold | 6.14E+008 | 6.02E+008 | 5.97E+008 | 5.47E+008 |
| | 2 | Thermal | 7.54E+010 | 6.82E+010 | 2.34E+010 | 3.70E+009 |
| | | Cold | 9.21E+009 | 8.81E+009 | 6.86E+009 | 1.11E+009 |