

Mads Bertelsen, ESS DMSC

Guide optimization

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Brilliance transfer

- Phase space diagrams, space and divergence pairs (x, η_x) (y, η_y)
- Liouville's theorem states the phase-space density does not change
- The brilliance transfer is the fraction of the original phase-space density that is left at a given point, for a given phase-space area

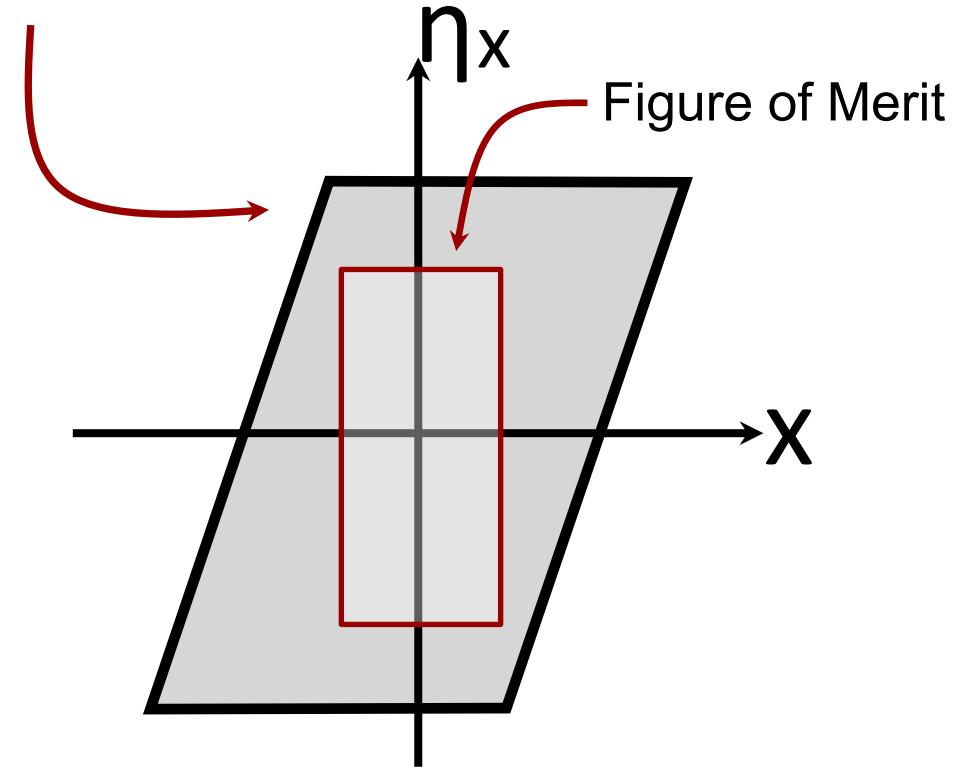
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Beam phase-space

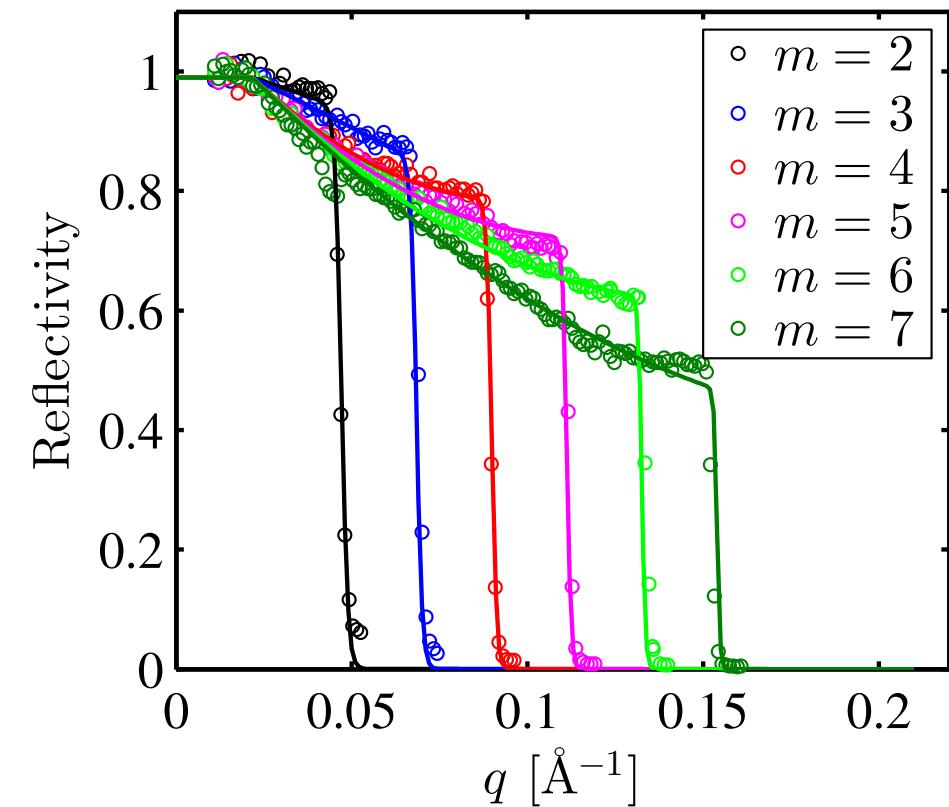


$$\frac{d\rho}{dt} = \frac{\partial \rho}{\partial t} + \sum_{i=1}^n \left(\frac{\partial \rho}{\partial q_i} \dot{q}_i + \frac{\partial \rho}{\partial p_i} \dot{p}_i \right) = 0.$$

Losses in supermirrors

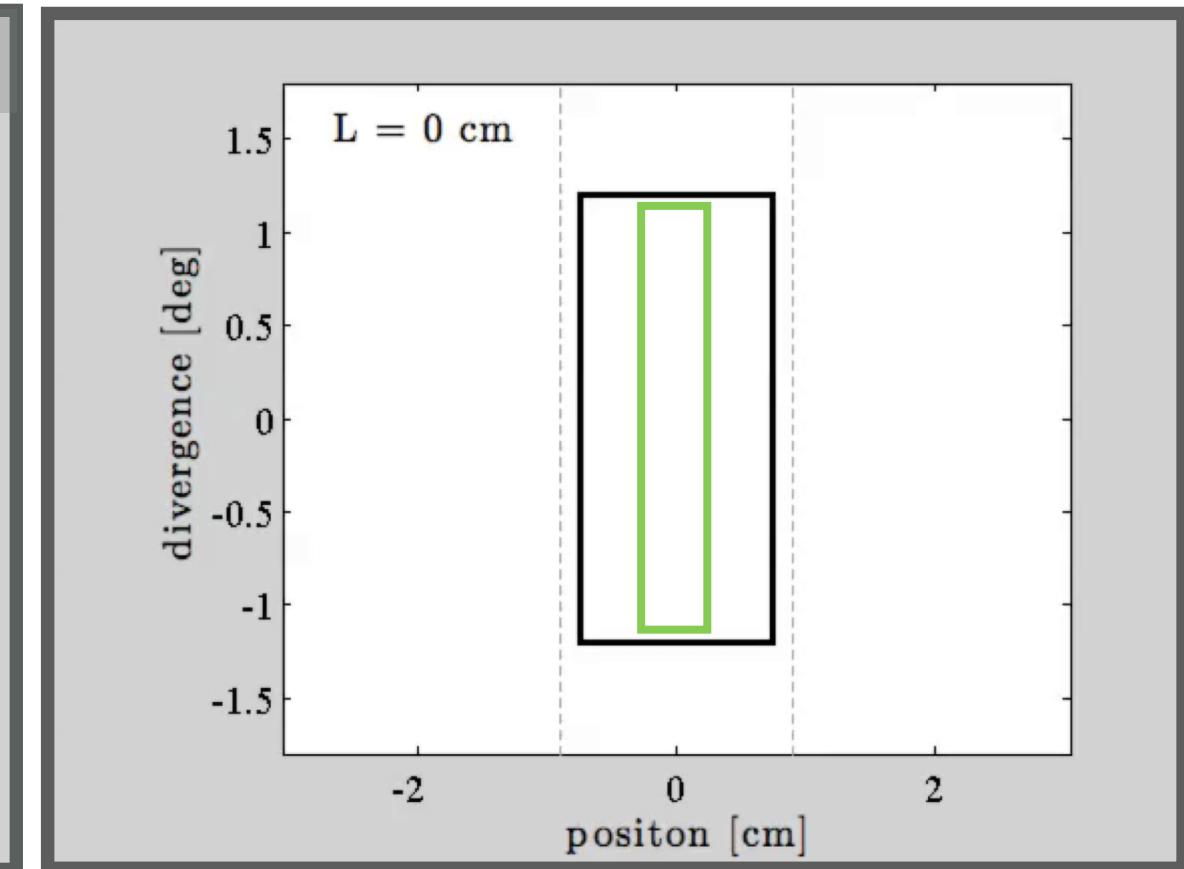
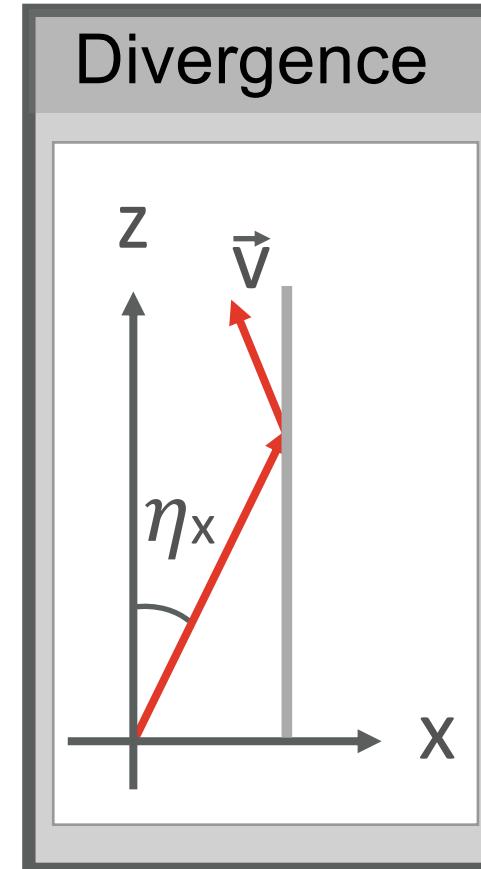
- Losses due to reflectivity

$$\frac{d\rho}{dt} < 0$$



Brilliance transfer after guide

- Brilliance transfer can not exceed fraction of target that is covered by beam!



Consequence of brilliance transfer

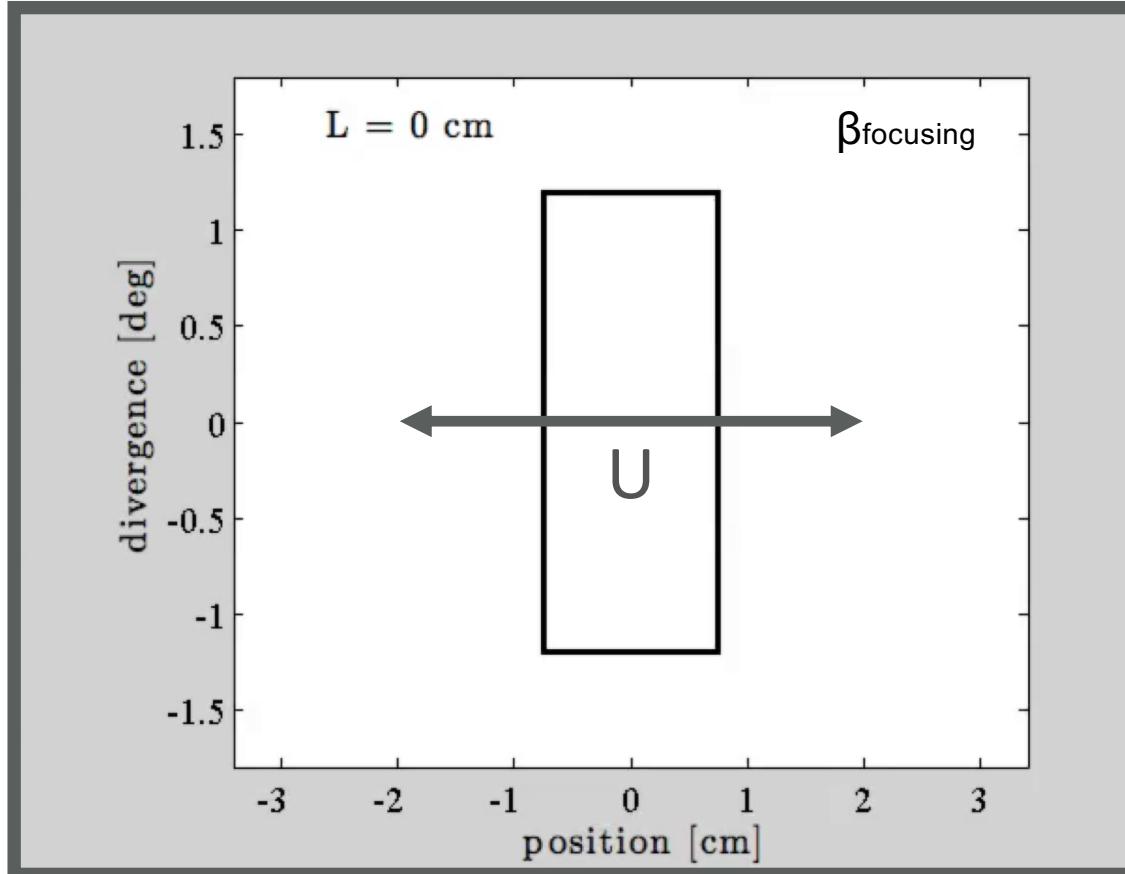
- Limit to maximum brilliance transfer with closed figure of merit
- Must be a maximum amount of phase-space that should be extracted from source

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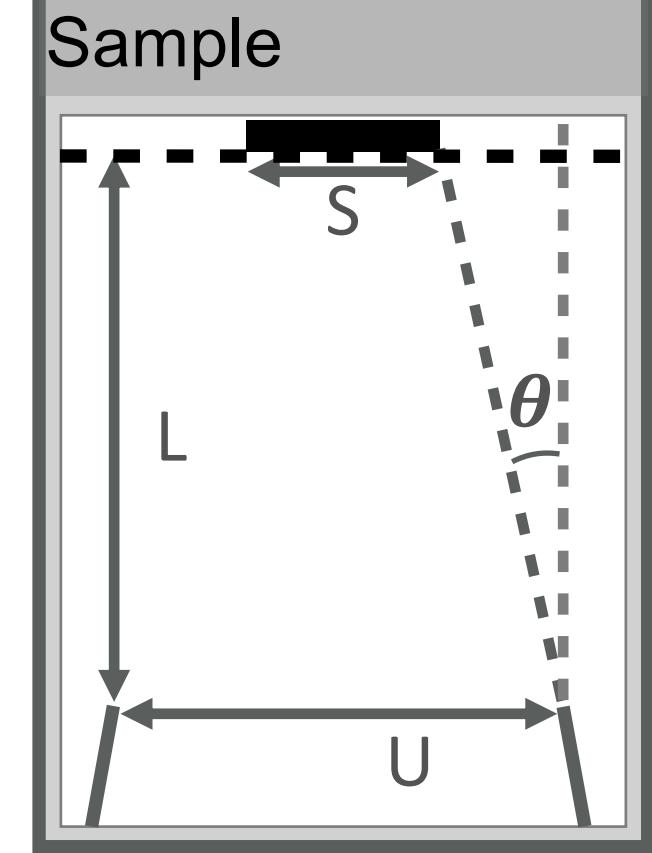
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Backpropagation from sample to guide

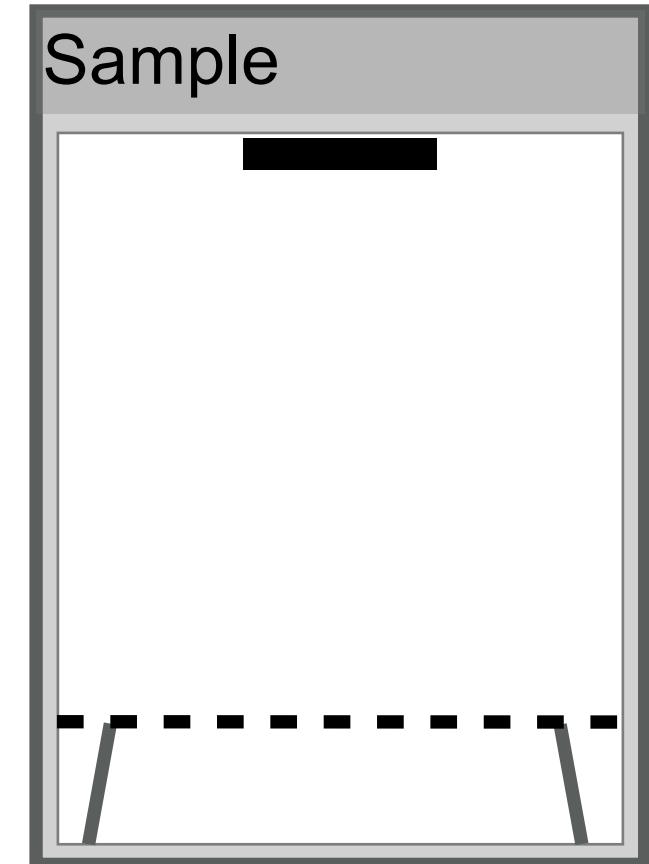
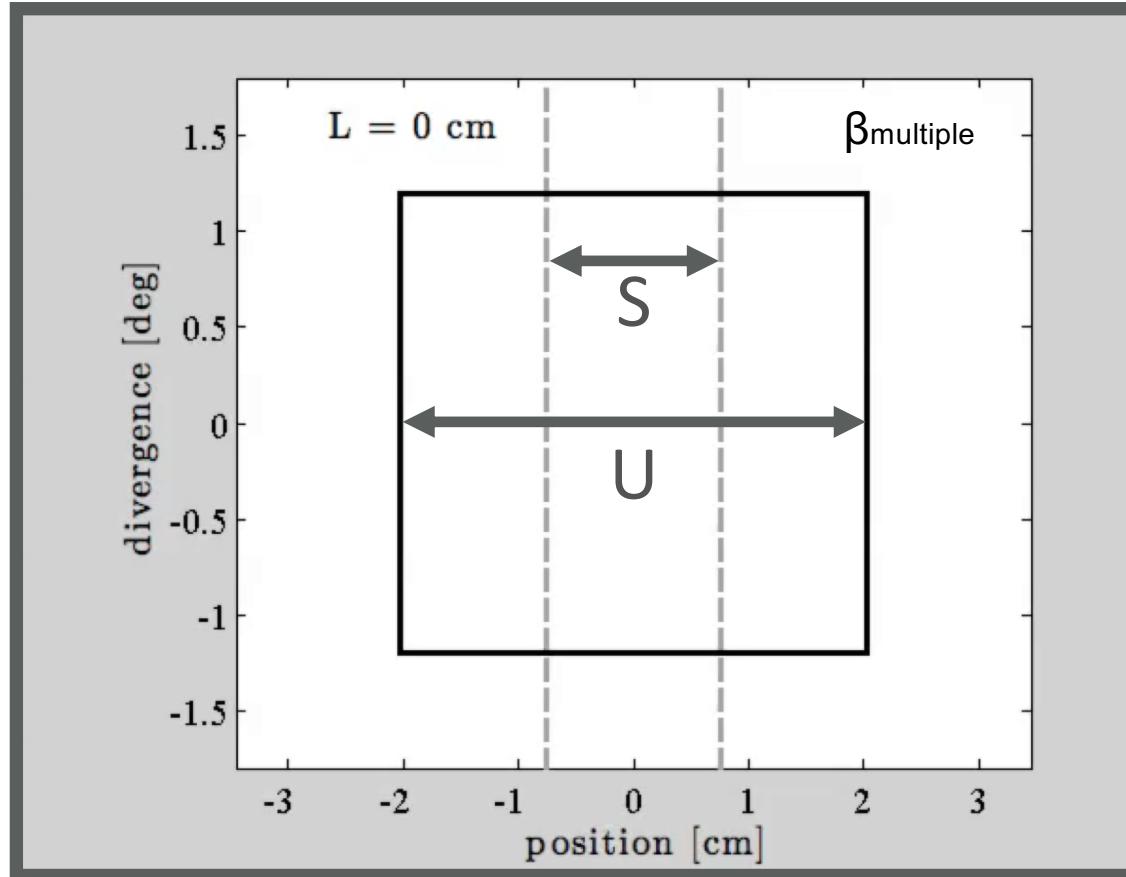


$$U = S + 2L\tan(\theta)$$

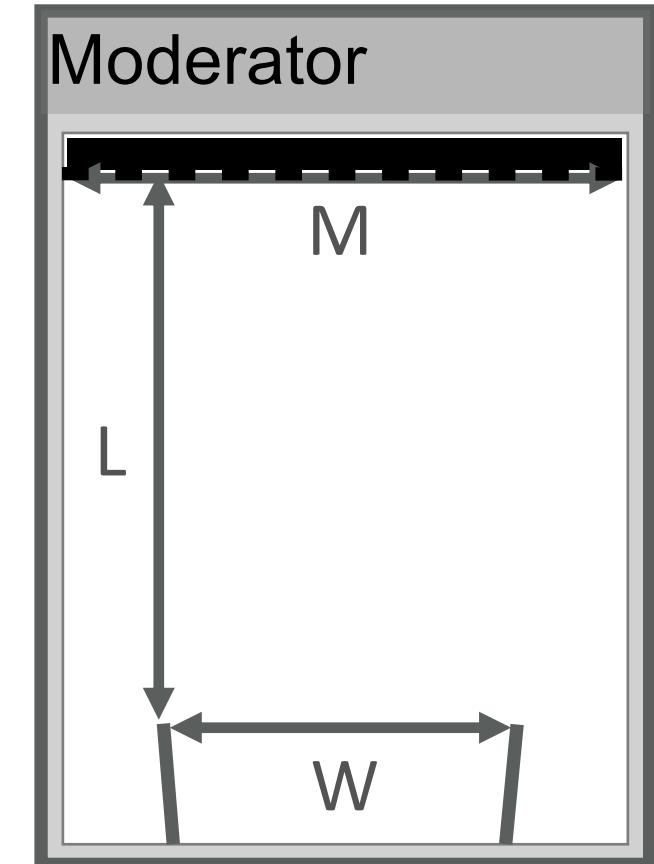
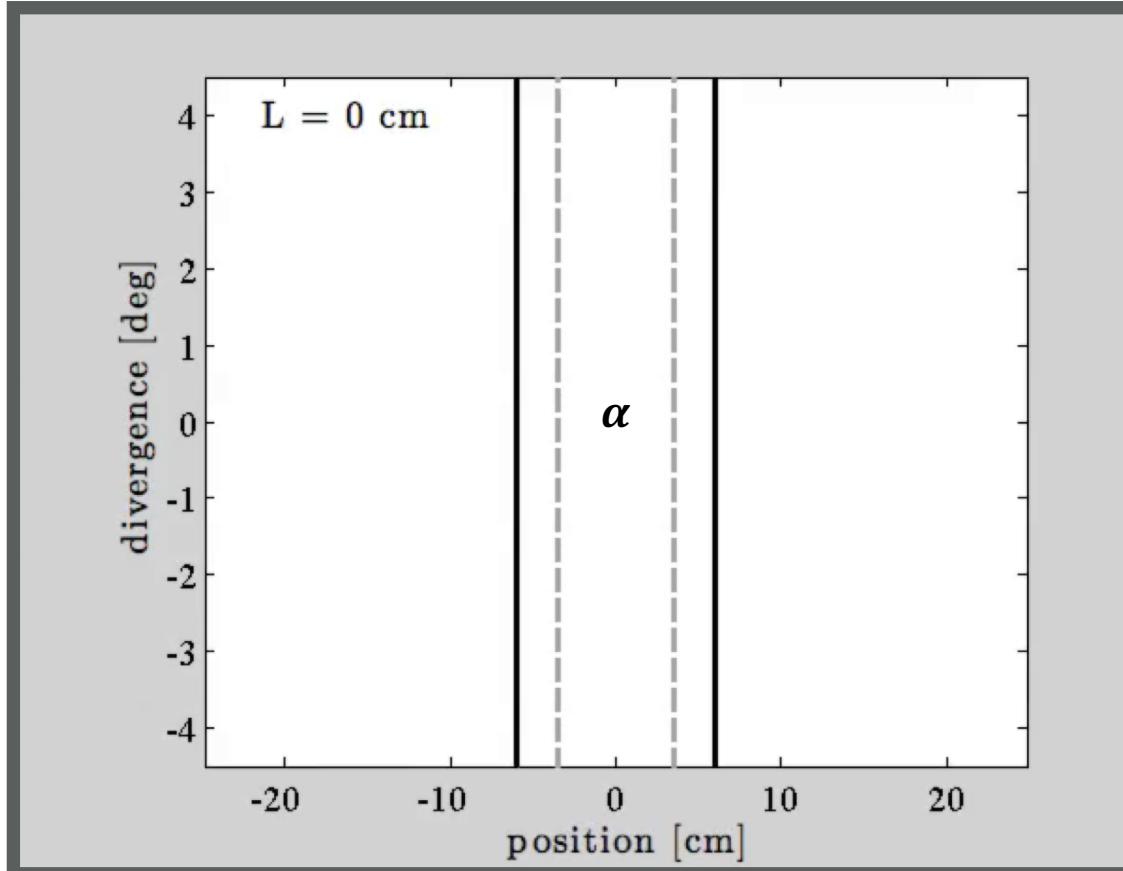


$$V(\beta_{\text{focusing}}) = 2\theta S$$

Propagation from guide to sample



Propagation from moderator to guide



$$V(\alpha) = WM/L$$

Minimalist principle

Width of the end of the guide $U = S + 2L\tan(\theta)$

Phase-space received by guide $V(\alpha) = WM/L$

Phase-space needed by guide $V(\beta) = 2\theta U$

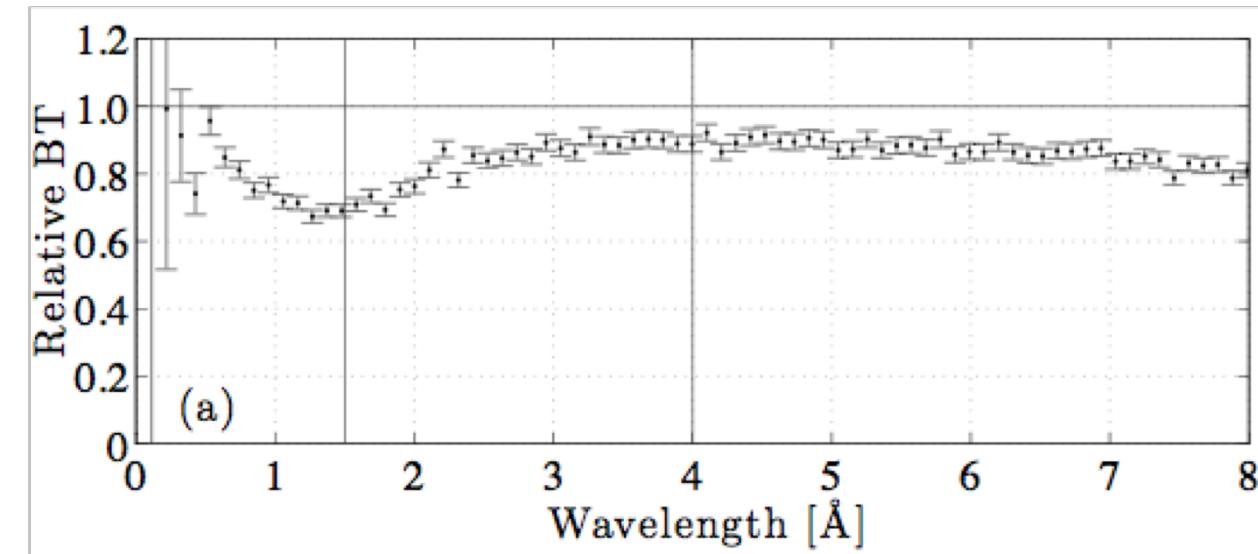
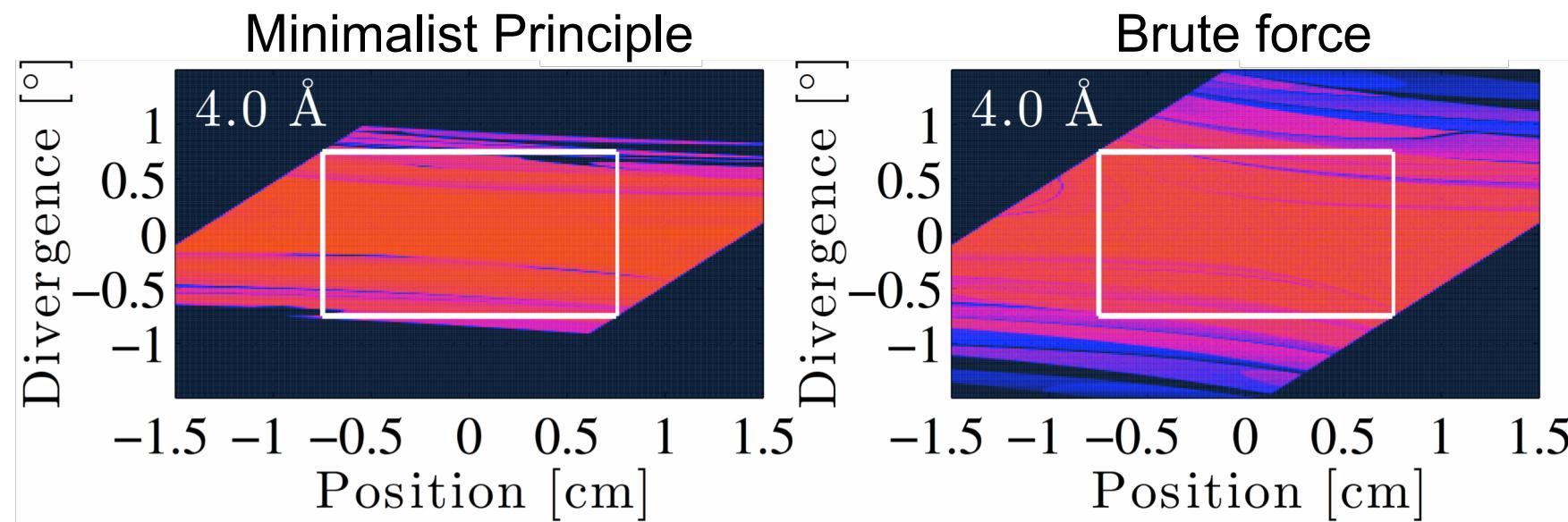
Minimalist constraint

$$V(\alpha) = V(\beta) \Rightarrow 2\theta U = WM/L$$

“Don’t put more food on your plate than you can eat!”

Minimalist principle

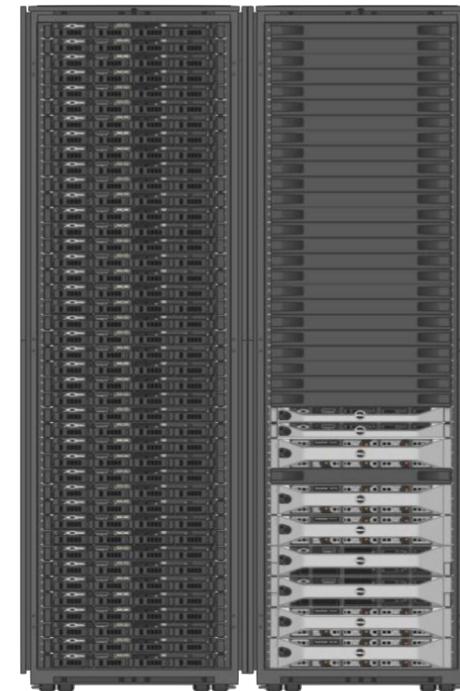
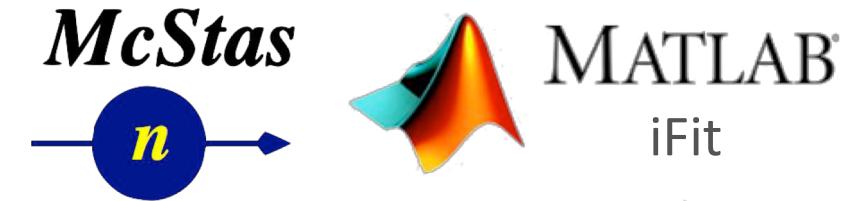
- Lower brilliance transfer, but still high
- Lower background
- Control over maximum divergence



guide_bot idea

- Neutron scattering facilities has a large requirement for guide optimization at start-up and in upgrade phases
- Demands and requirements change rapidly
- Many viable alternatives for each instrument
- guide_bot is an answer to this situation

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guide_bot

Input

Job description

Geometry string

- Description of desired beam

- Instrument length

- Facility information

- Computing options

- Coating description (not optimized)

Optimization

Optimization of the guide

Output

Guide characterization

Scan of optimizations

guide_bot

Input

Job description

Geometry string

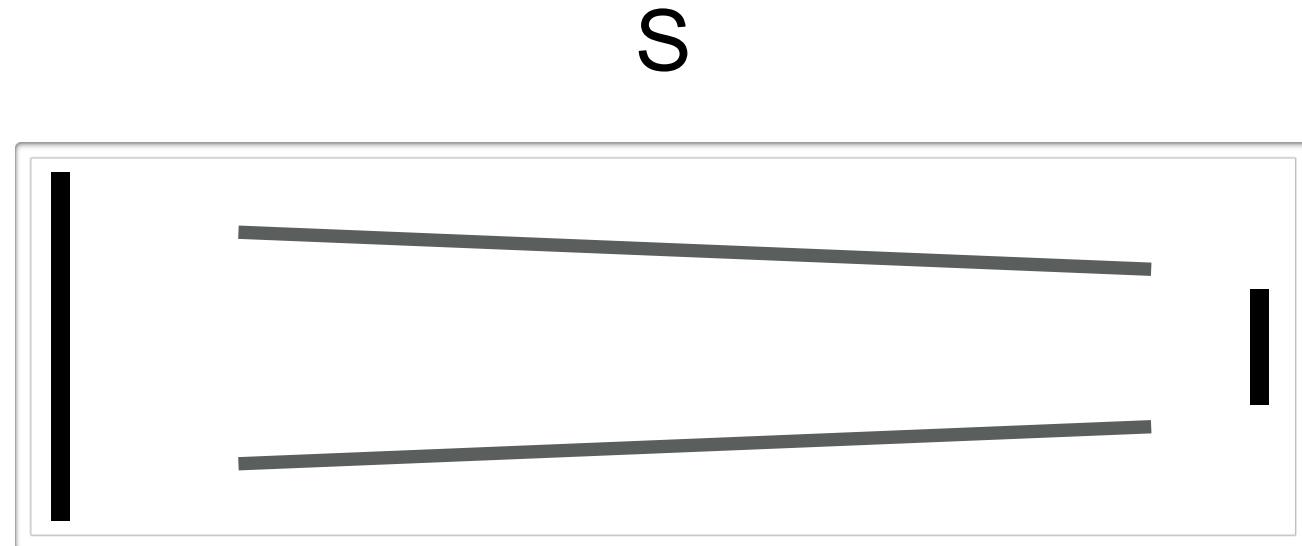
Optimization

Optimization of the guide

Output

Guide characterization

Scan of optimizations



guide_bot

Input

Job description

Geometry string

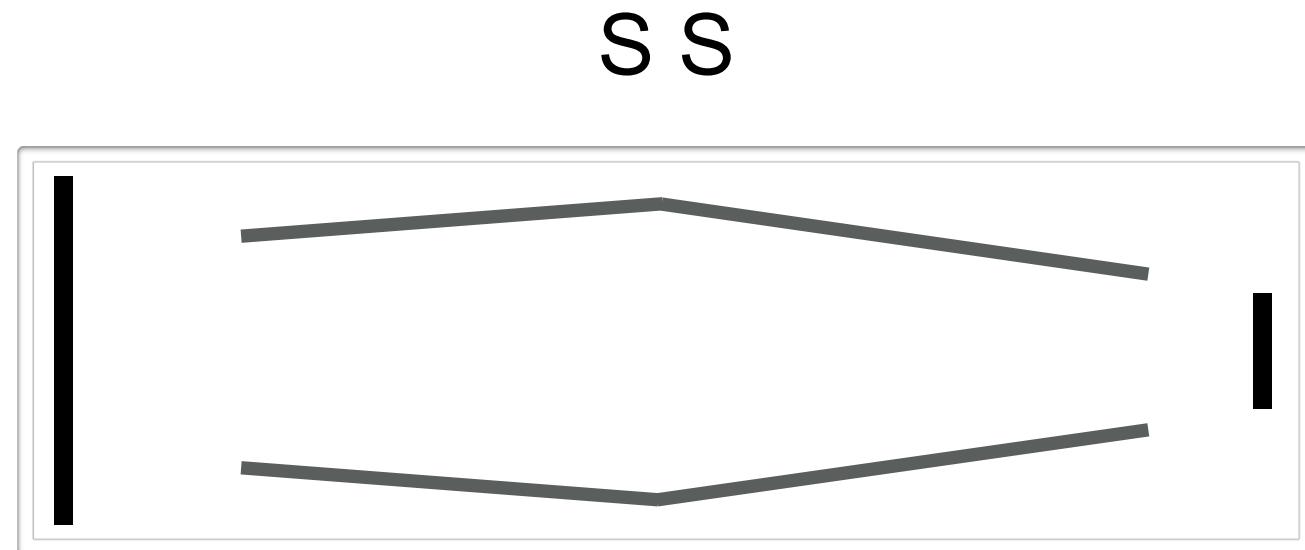
Optimization

Optimization of the guide

Output

Guide characterization

Scan of optimizations



guide_bot

Input

Job description

Geometry string

Optimization

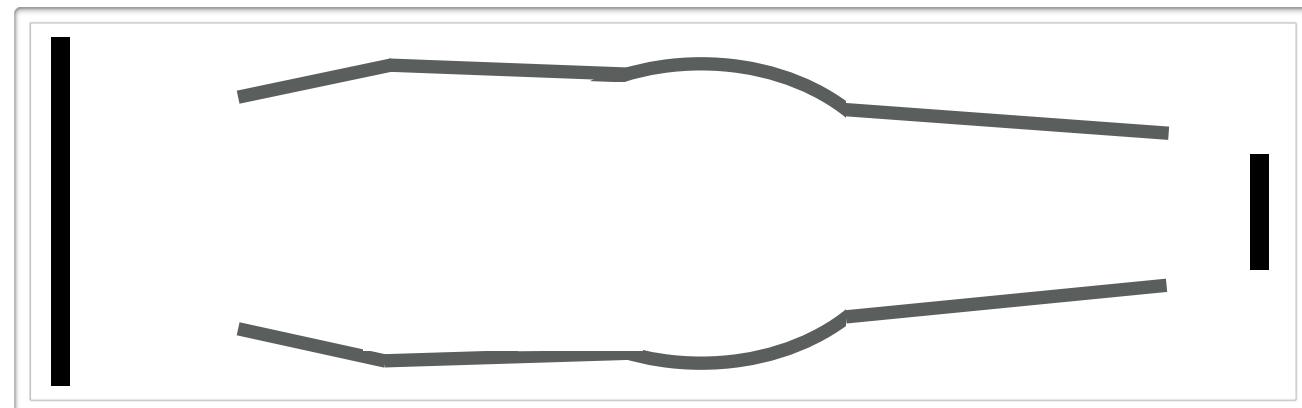
Optimization of the guide

Output

Guide characterization

Scan of optimizations

S S E S



guide_bot

Input

Job description

Geometry string

Optimization

Optimization of the guide

Output

Guide characterization

Scan of optimizations

Module	Description
S	Straight guide
E	Elliptic guide
P	Parabolic guide
G	Gap
C	Curved guide
K	Kink
Selene	Selene guide system
Slit	Slit
M	Monochromator

Contributed by
Leland Harriger, NIST, USA

guide_bot

Input

Job description

Geometry string

Optimization

Optimization of the guide

Output

Guide characterization

Scan of optimizations

`S C(start=6) S(maxlength=20)`

Code	Function
<code>length</code>	Length of the module
<code>start</code>	Start of the module
<code>StartWidth</code>	Start width of a module
<code>StartHeight</code>	Start height of a module
<code>EndWidth</code>	End width of a module
<code>EndHeight</code>	End height of a module

guide_bot

Input

Job description

Geometry string

- Additional options to control escaping line of sight

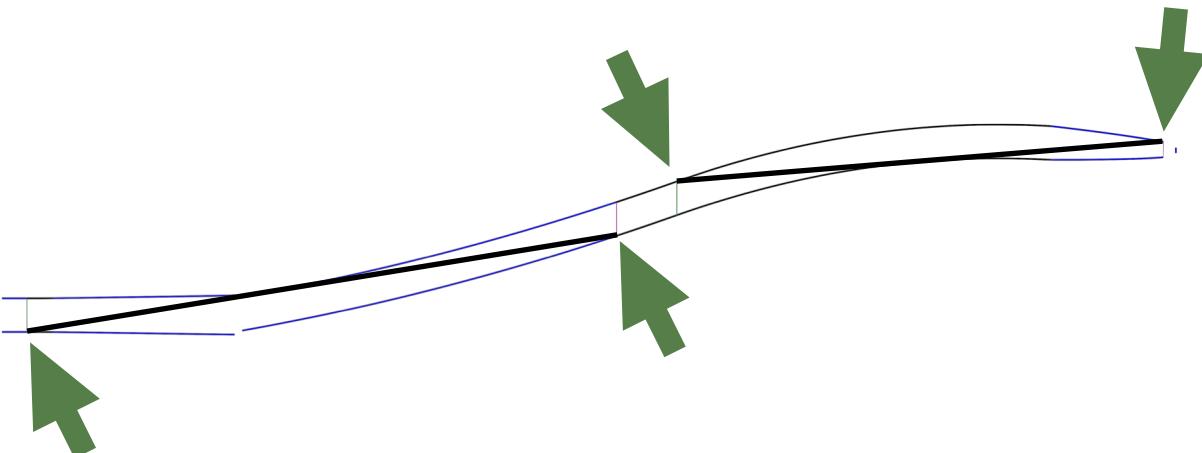
Optimization

Optimization of the guide

Output

Guide characterization

Scan of optimizations



guide_bot

Input

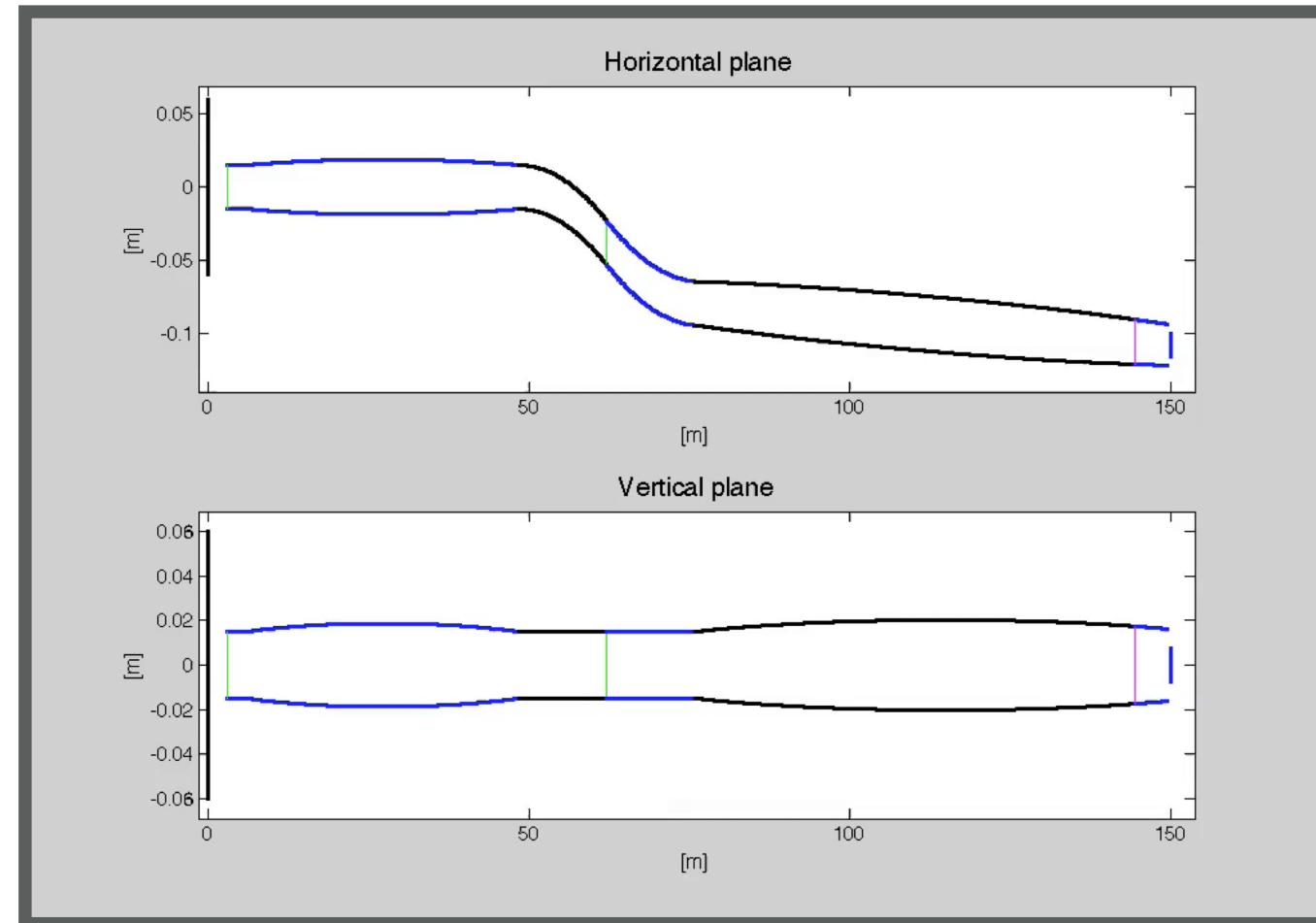
Job description
Geometry string

Optimization

Optimization of the guide

Output

Guide characterization
Scan of optimizations



guide_bot

Input

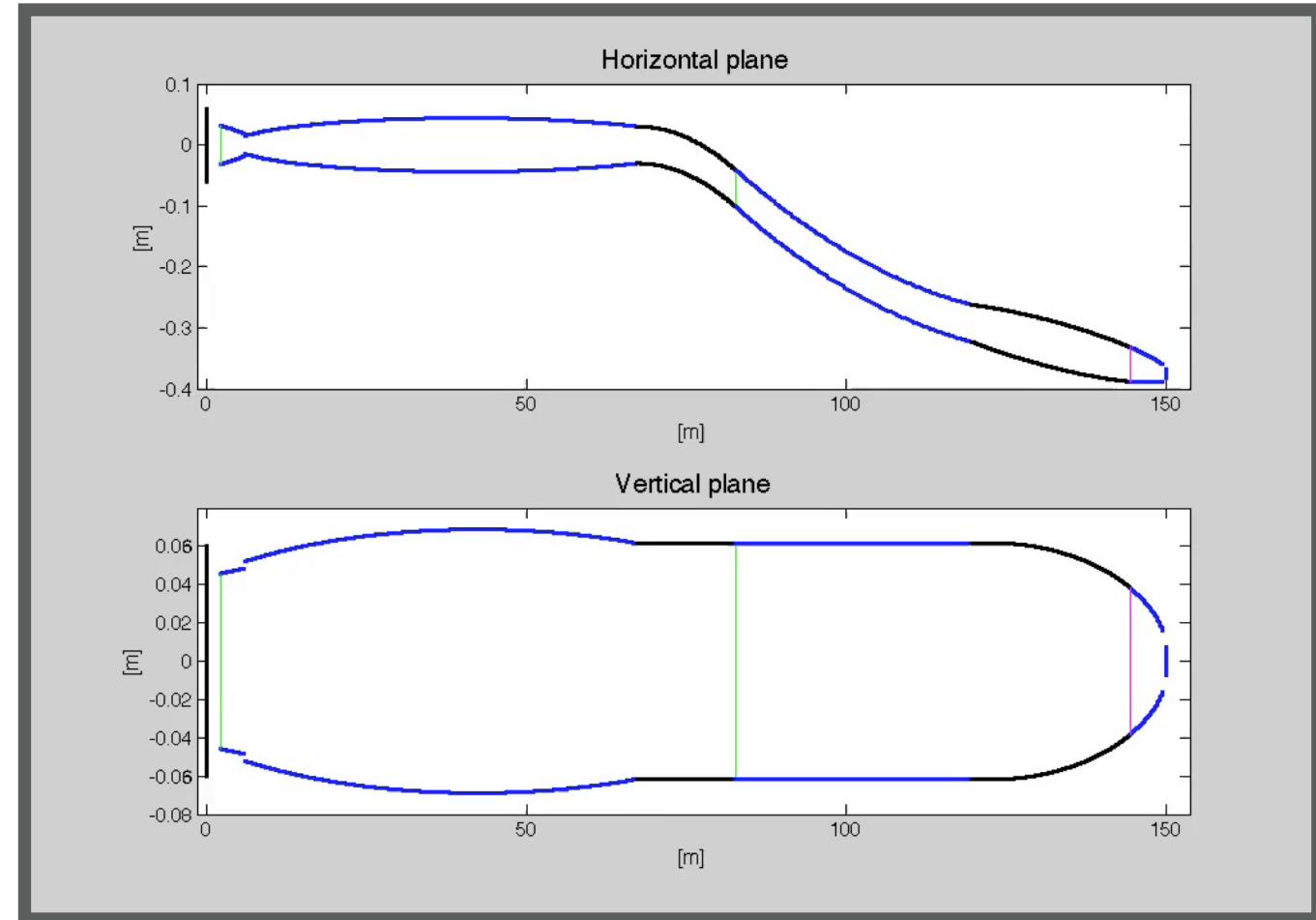
Job description
Geometry string

Optimization

Optimization of the guide

Output

Guide characterization
Scan of optimizations



guide_bot

Input

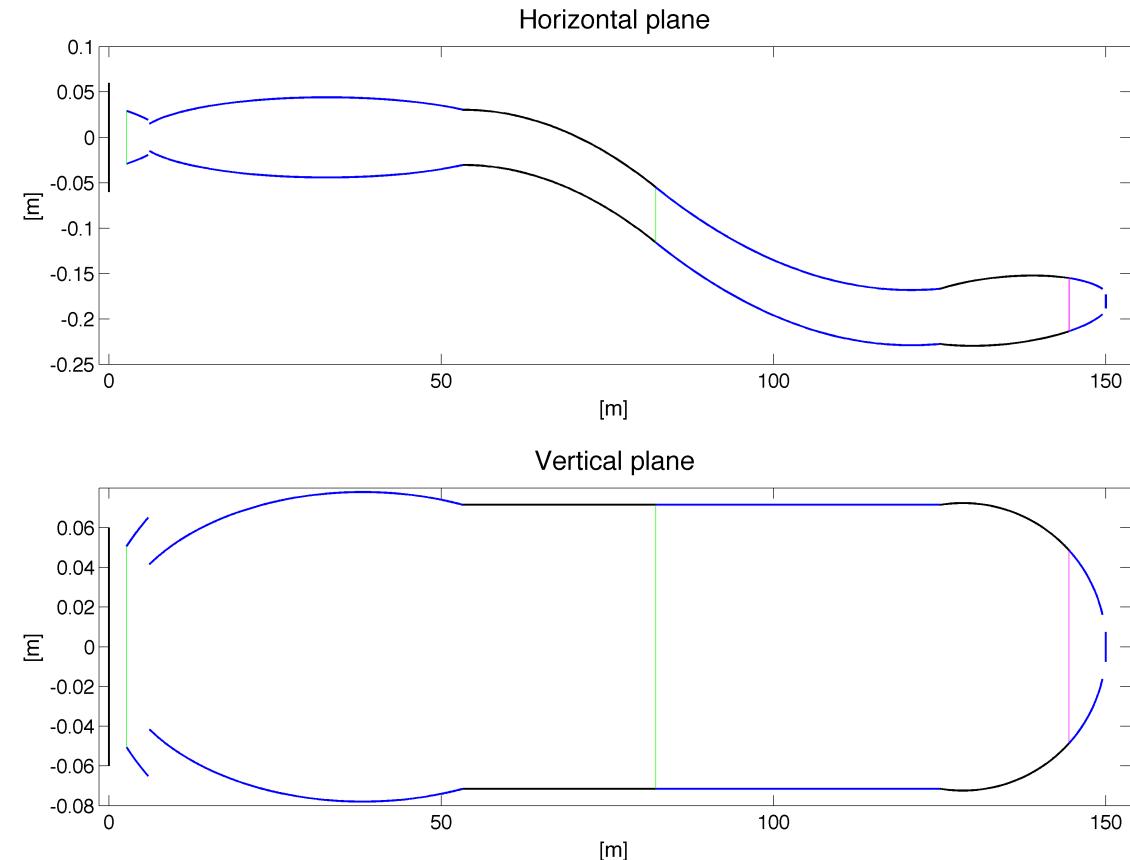
Job description
Geometry string

Optimization

Optimization of the guide

Output

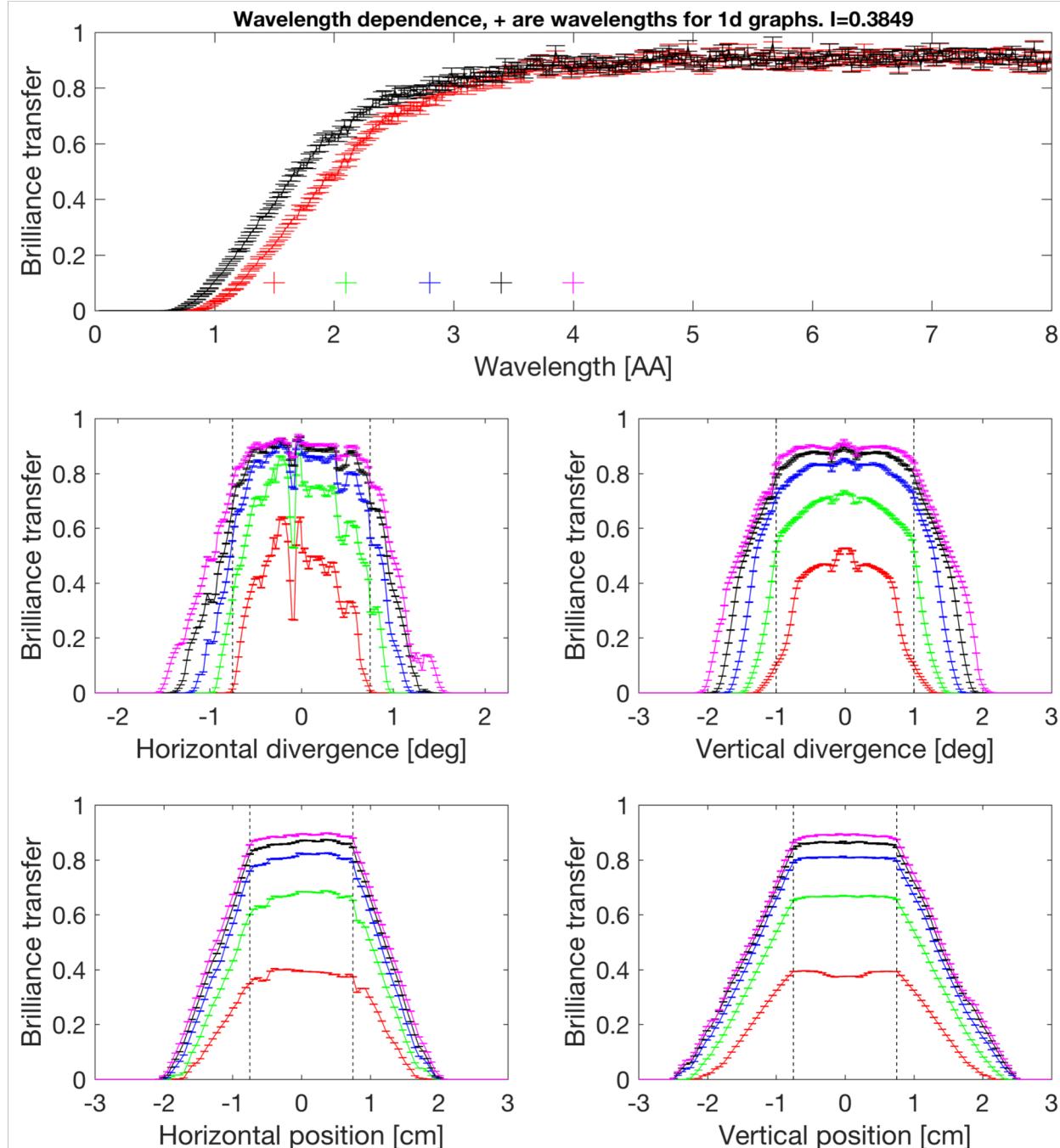
Guide characterization
Scan of optimizations

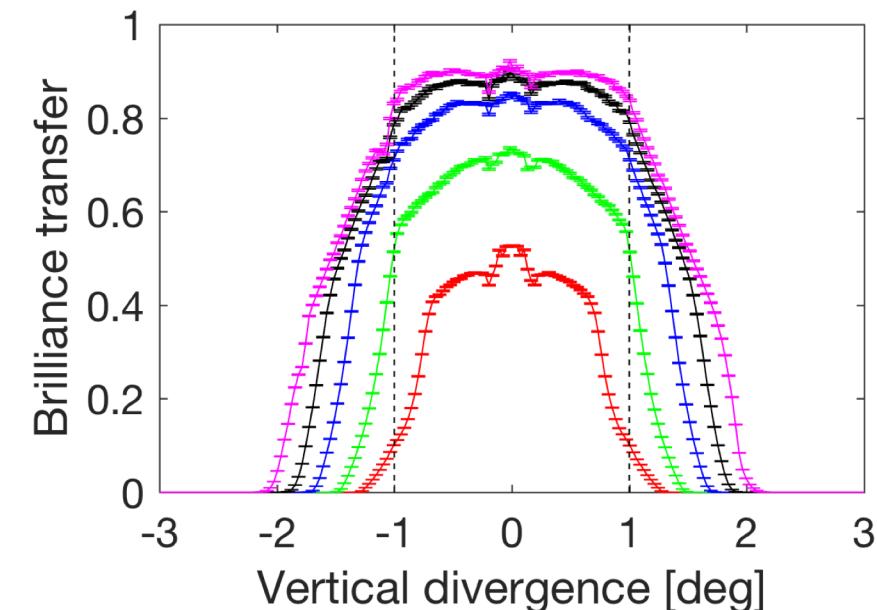
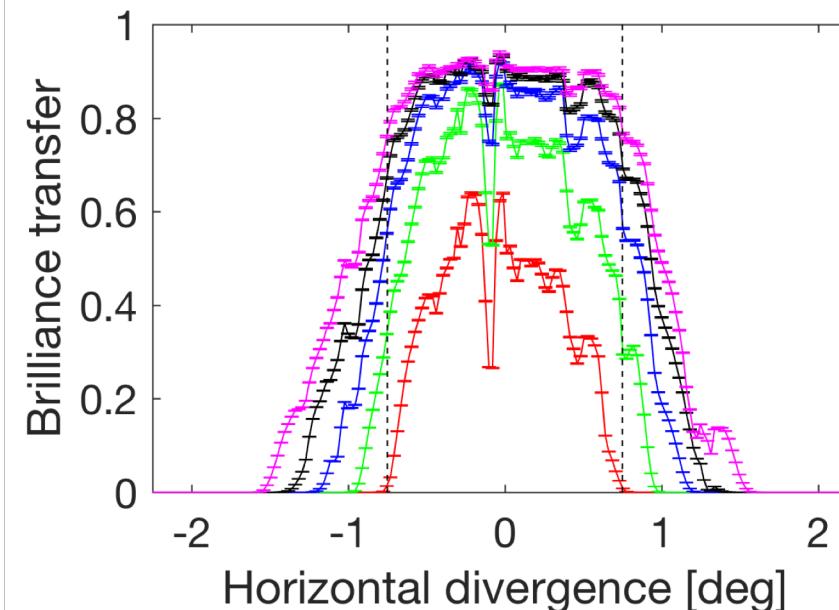
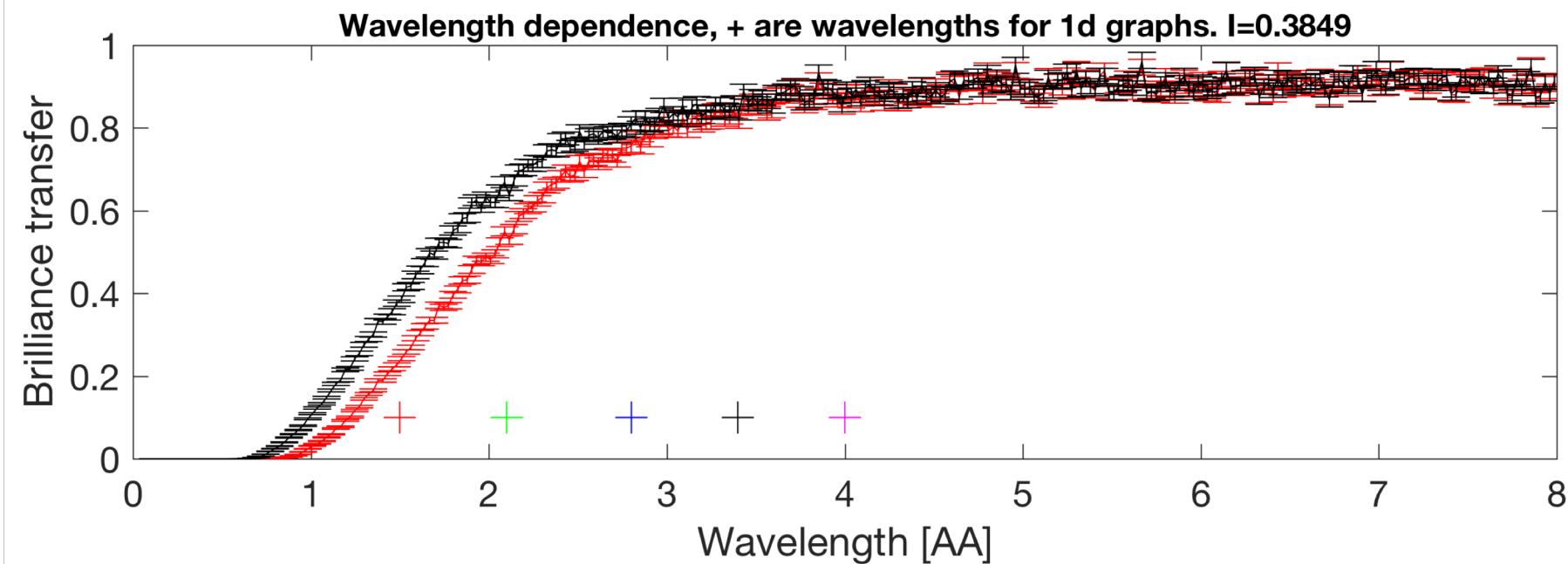


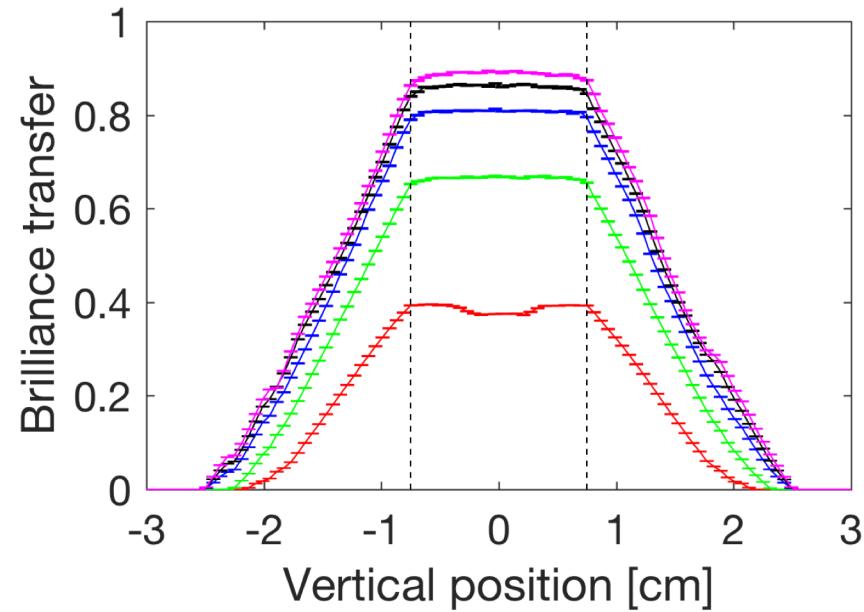
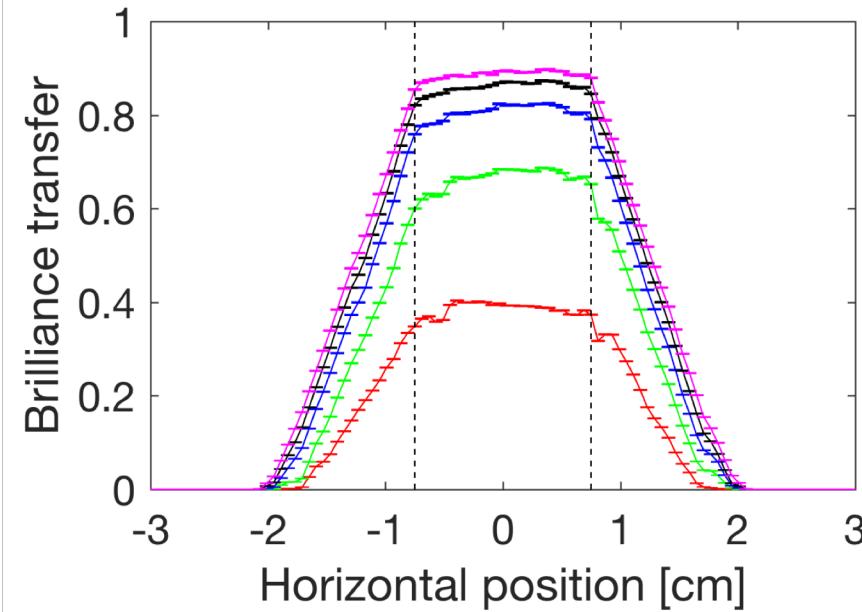
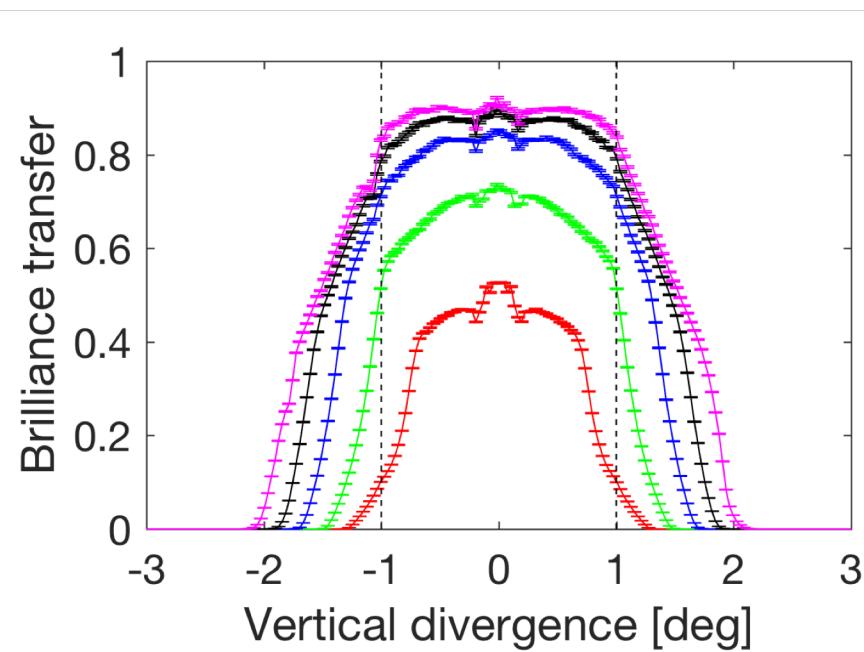
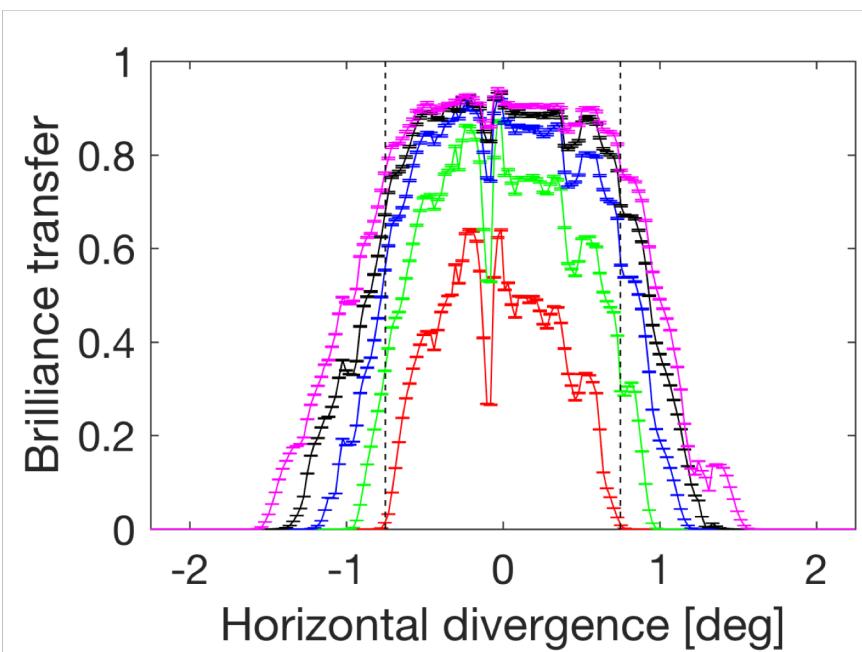
guide_bot

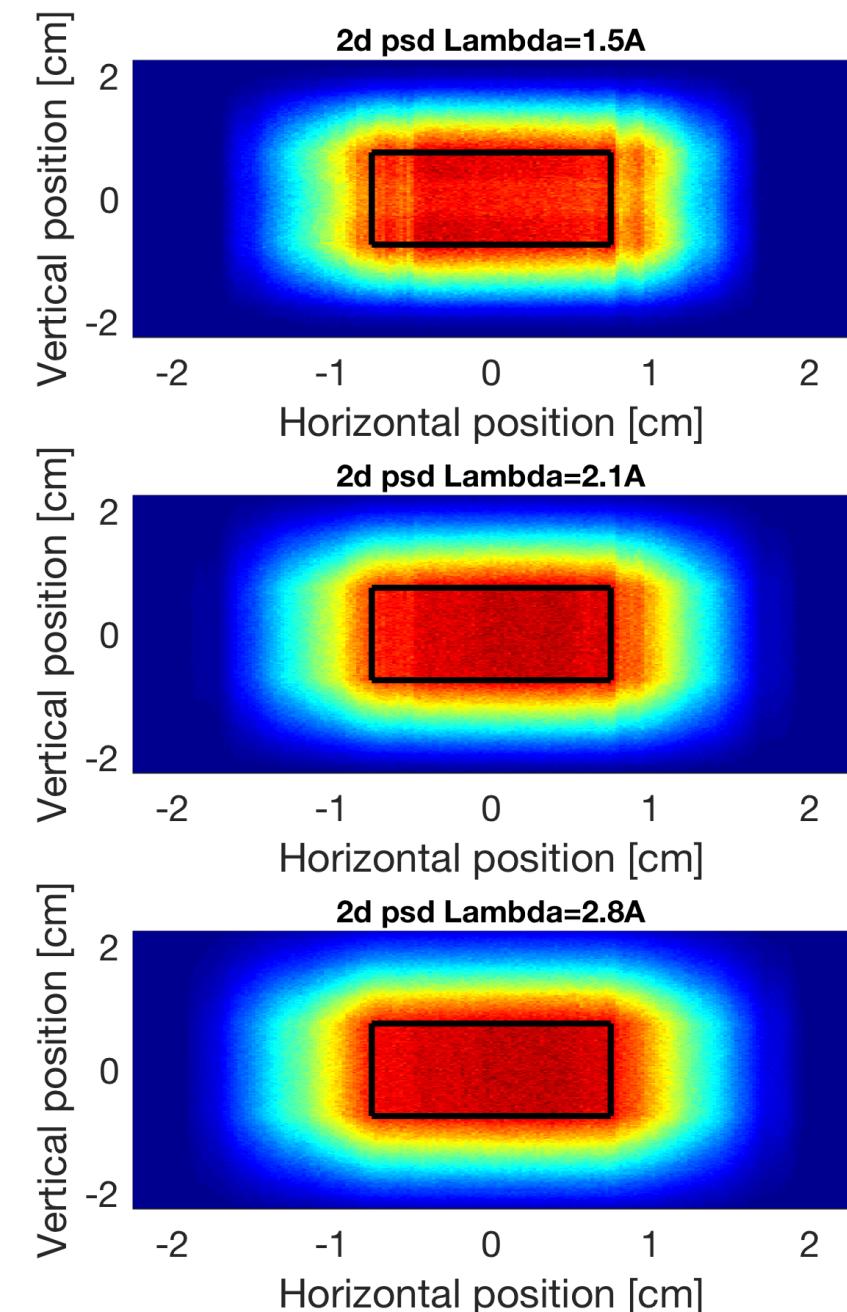
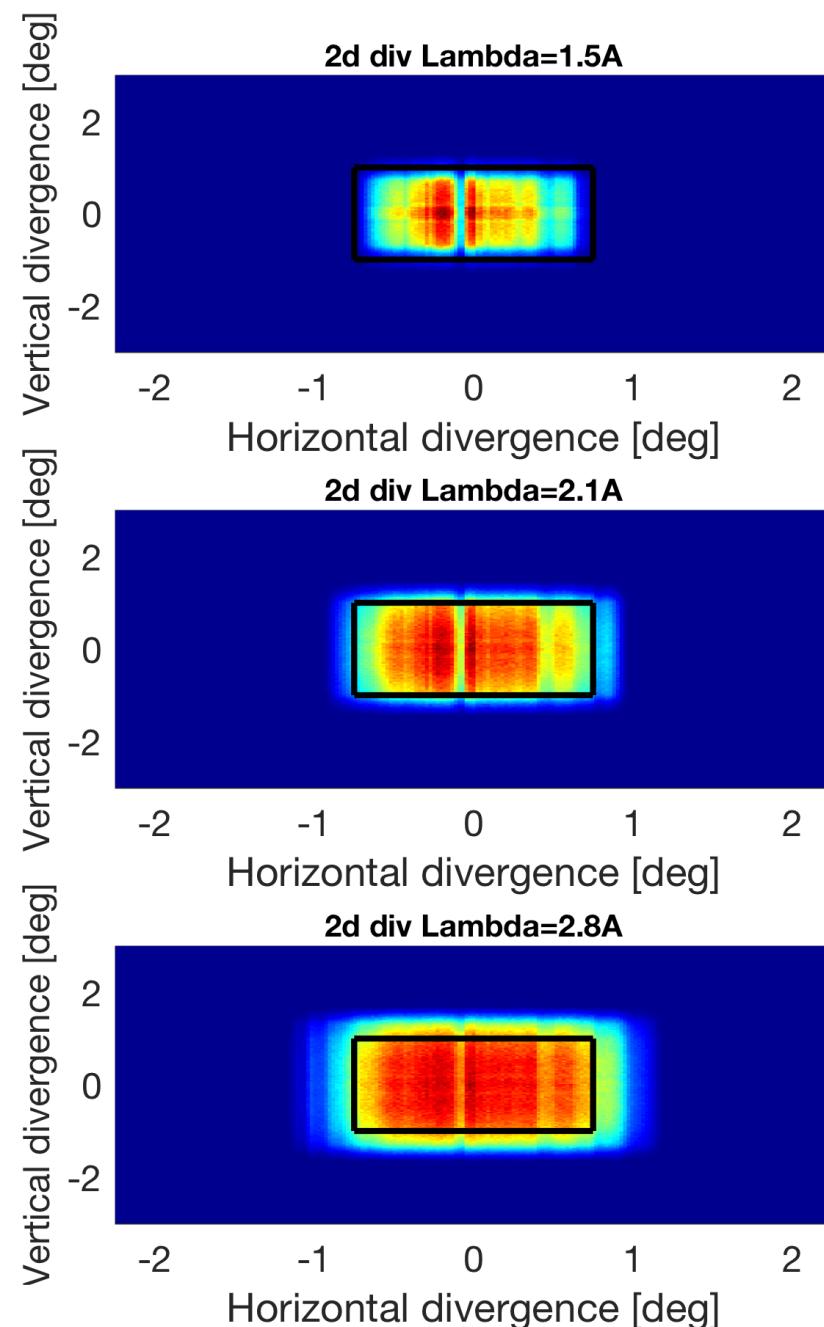
Used parameters

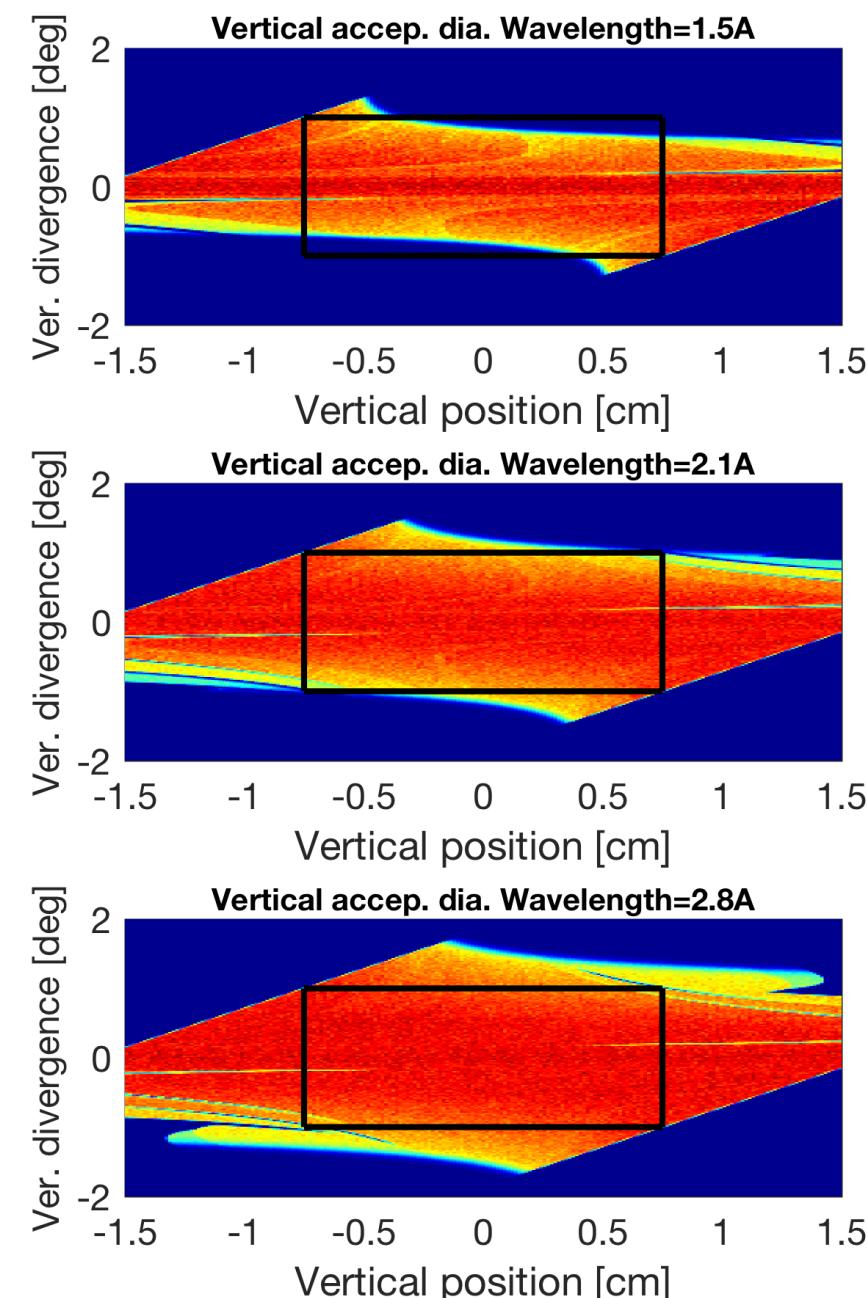
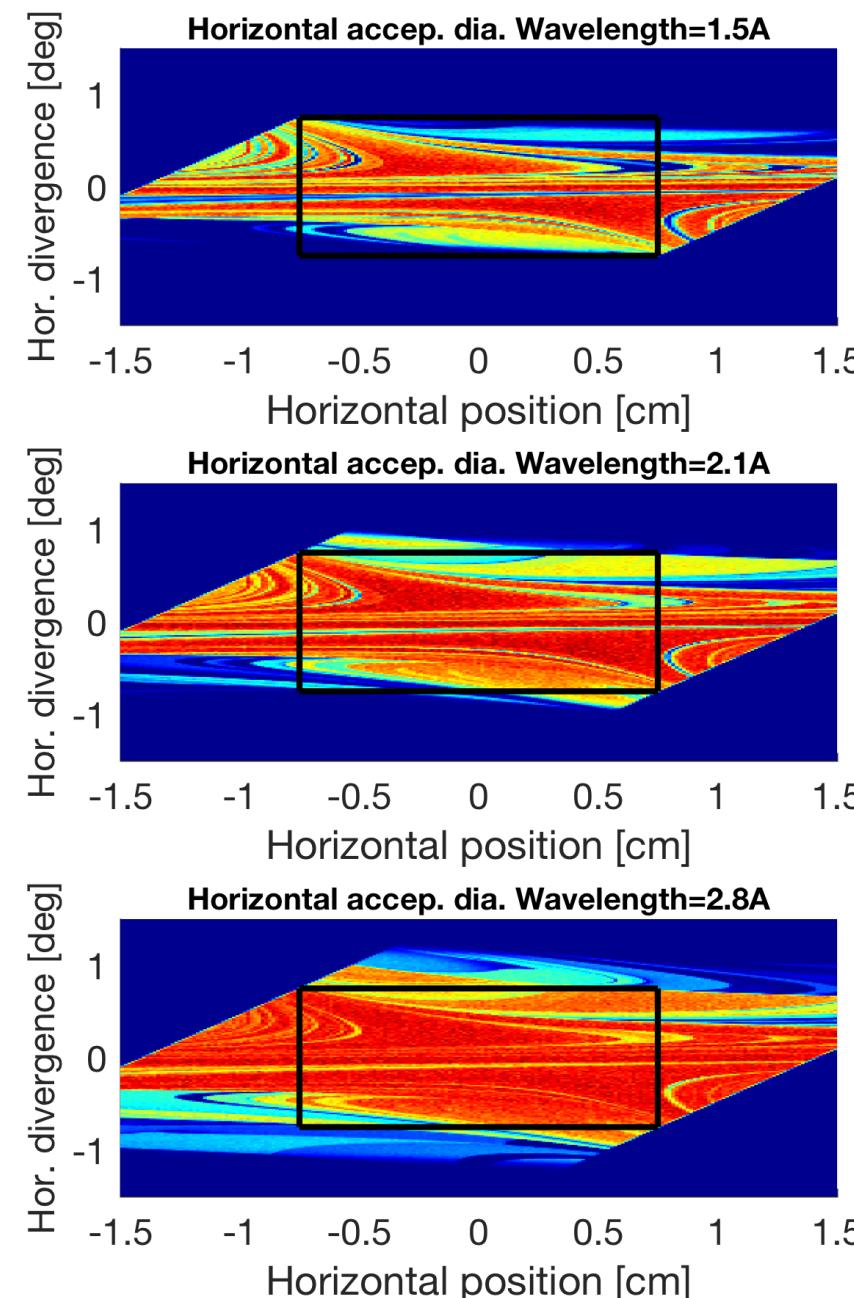
Divergence H	$\pm 0.75^\circ$
Divergence V	$\pm 1.0^\circ$
Size H	1.5 cm
Size V	1.5 cm
Wavelength min	1.5 Å
Wavelength max	4.0 Å
Guide - sample	0.5 m
Moderator - sample	150 m
m value for coating	3











guide_bot

Input

Job description

Geometry string

Many geometry strings are usually optimized in parallel

Optimization

Optimization of the guide

Little book of guide reports to choose from!

Output

Guide characterization

Scan of optimizations

guide_bot

Input

Job description

Geometry string

- Scan dimensions
Moderator dimensions
Divergence requirement
Sample size
- Used in connection with ESS moderator decision

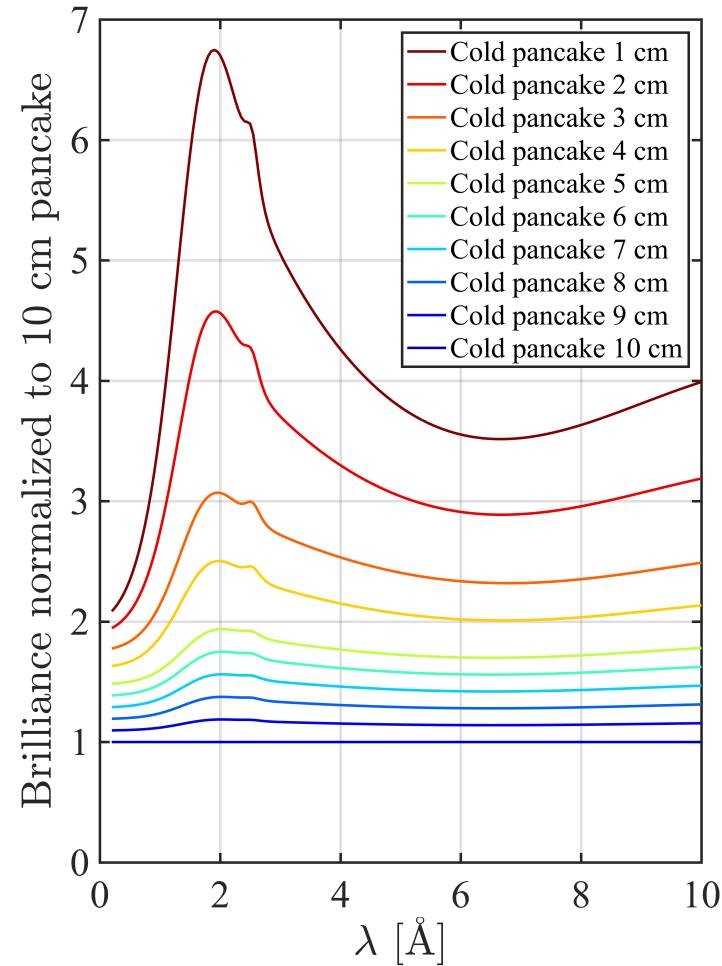
Optimization

Optimization of the guide

Output

Guide characterization

Scan of optimizations



guide_bot

Input

Job description
Geometry string

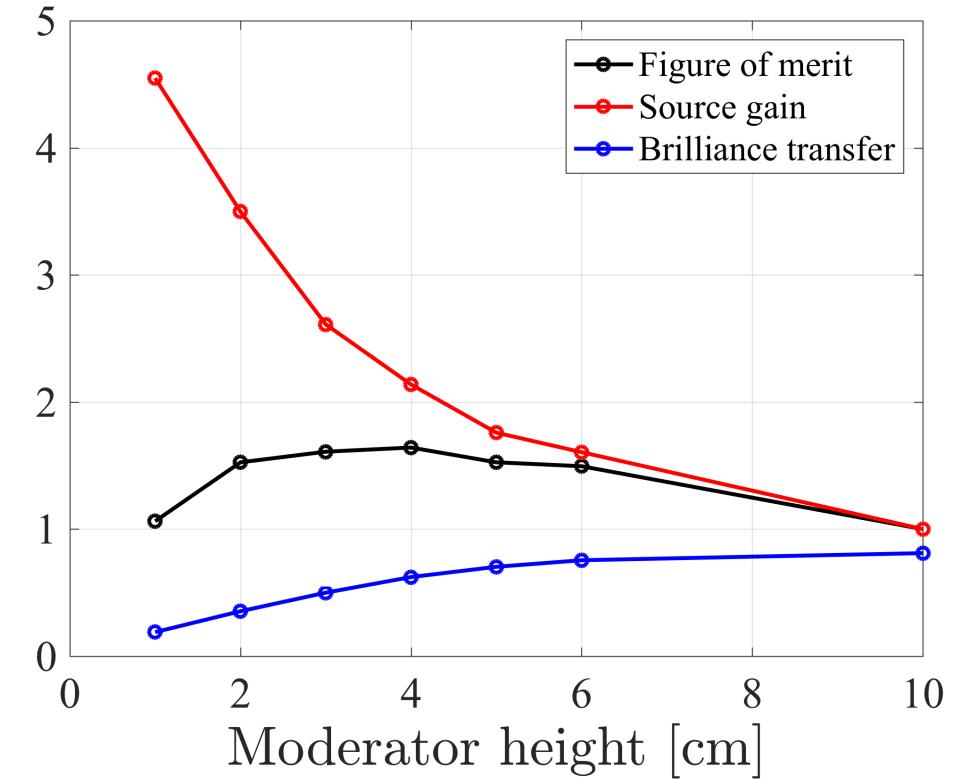
Optimization

Optimization of the guide

Output

Guide characterization
Scan of optimizations

C-SPEC results



guide_bot

Input

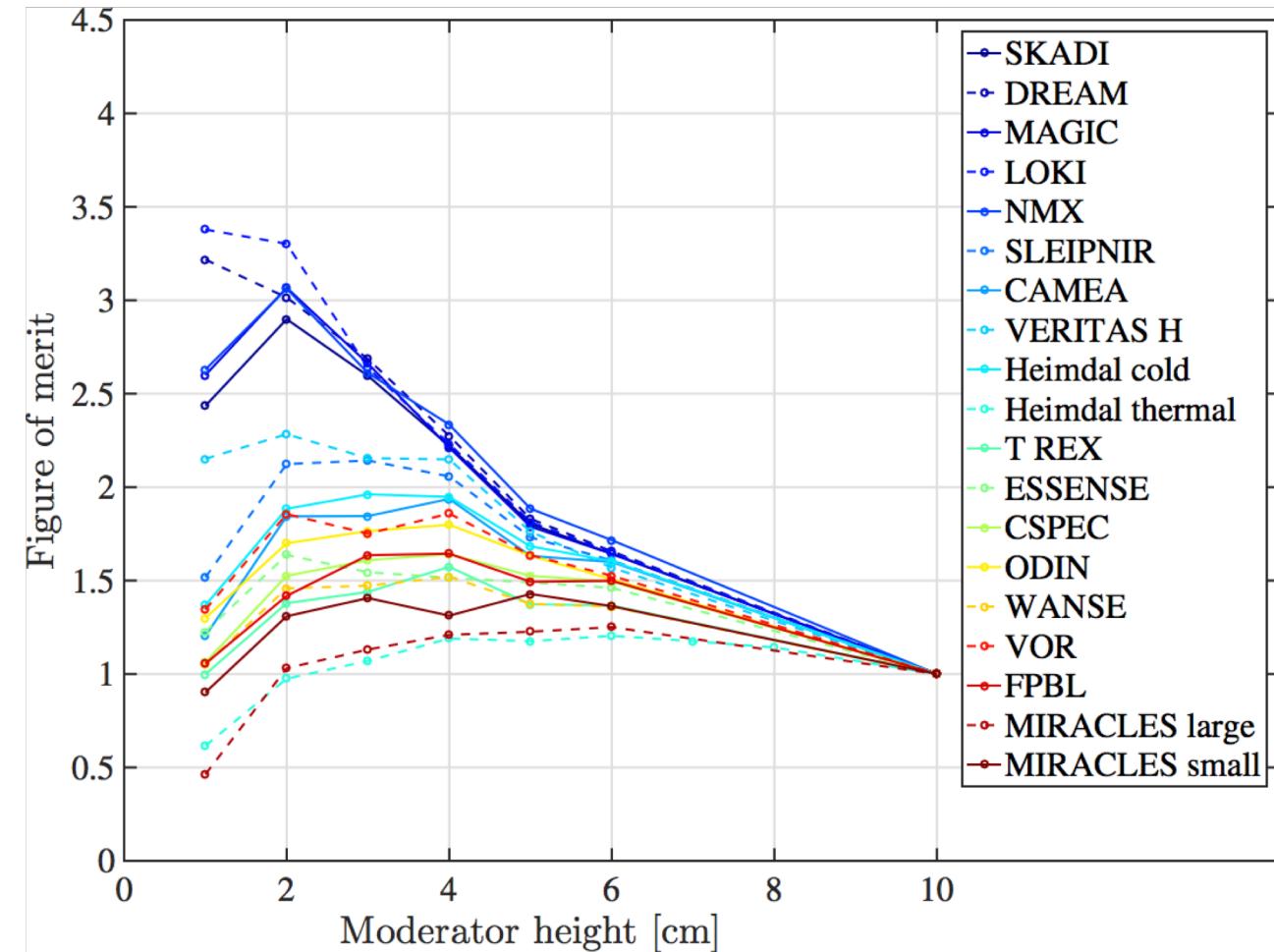
Job description
Geometry string

Optimization

Optimization of the guide

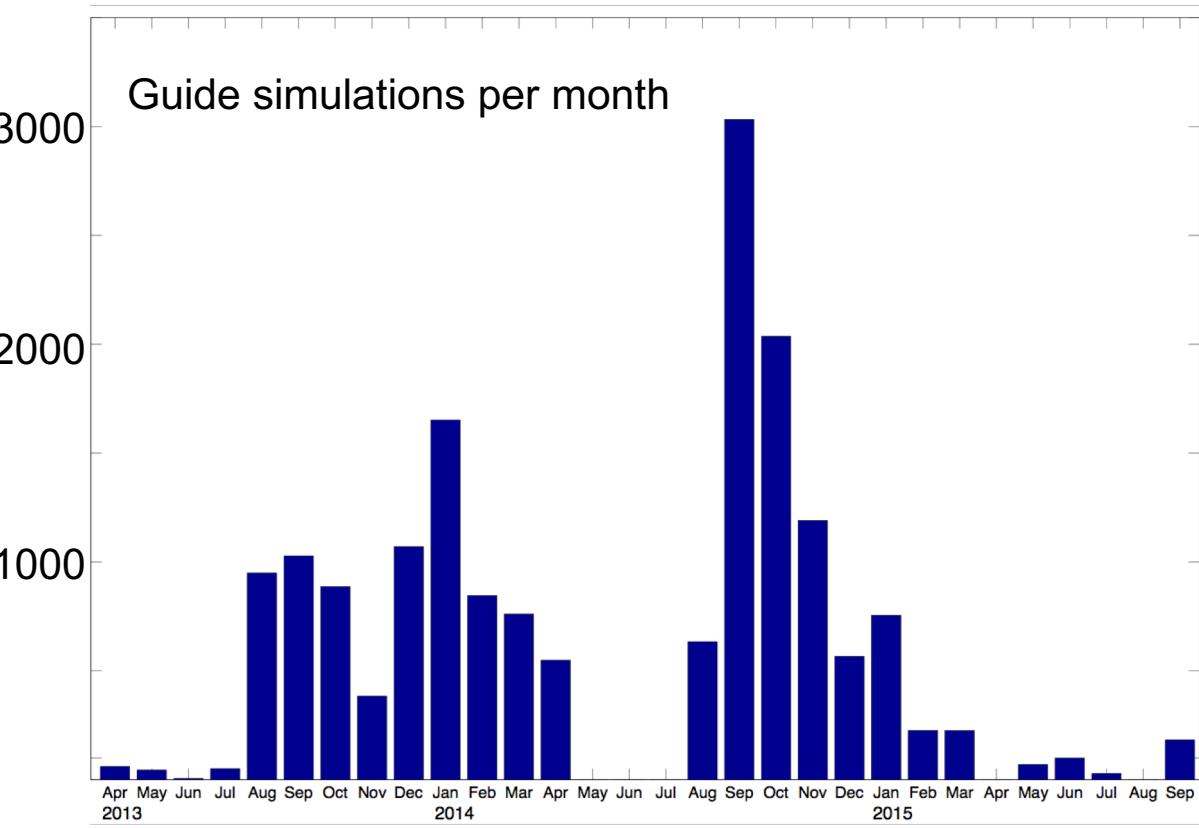
Output

Guide characterization
Scan of optimizations



My guide_bot use

- Performed more than 20000 guide optimizations
- Tens of millions of McStas simulations
- Guides for several ESS instruments
- Used at PSI in Switzerland
- Used at NIST in America



Code on github

- The project is available on github
- https://github.com/mads-bertelsen/guide_bot
- Not part of my current employment, not very active but available

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Coating Writer

- Student project by Martin Olsen at University of Copenhagen
- Optimizes coating for performance or performance per cost

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Conclusion

- Guide design is about conserving brilliance transfer while avoiding background
- The Minimalist Principle provides some boundaries and understanding
- `guide_bot` automates McStas guide optimizations on supported clusters
- Even without supported cluster, `guide_bot` can generate instrument files
- Requires MATLAB license