, DTU Physics

Sources and Monitors

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Sources: In general

- A source component generates Monte Carlo neutrons.
  In McStas terms this means:
  - Set the neutron state to something representative of the source we are trying to model.
  - i.e.: insert values in the neutron state vector {x,y,z, vx,vy,vz, t, sx,sy,sz, p} drawn from appropriate distributions.

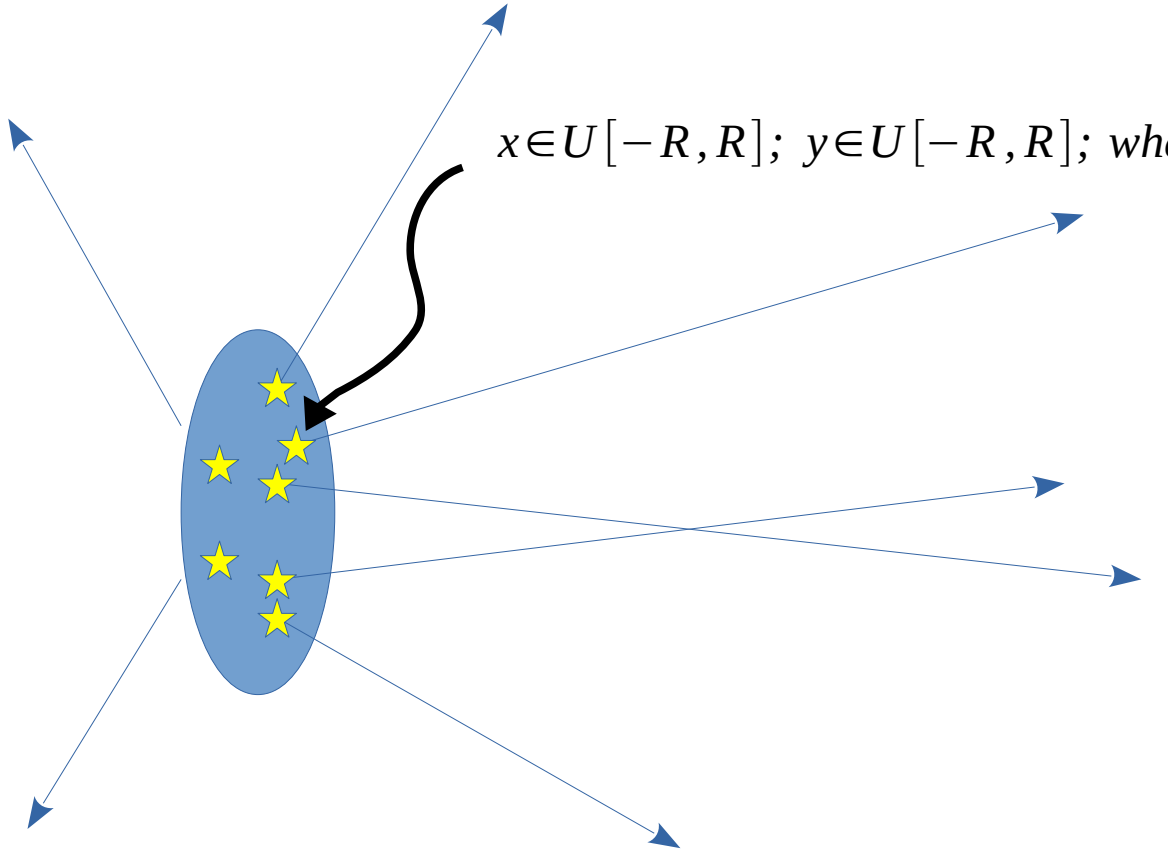
    EXAMPLE:
    Neutrons from a uniform wavelength distribution emerging from a circular aperture.

Access the docs

IMPORTANT:
All (and more) of this information can be found in the online pdf component documentation, e.g.
http://www.mcstas.org/documentation/manual/mcstas-2.5-components.pdf
- also distributed with your McStas installation - `mcdoc -c`

The component documentation along with the command:
"`mcdoc <component_you_are_searching_for>`"
are your best friends when using McStas

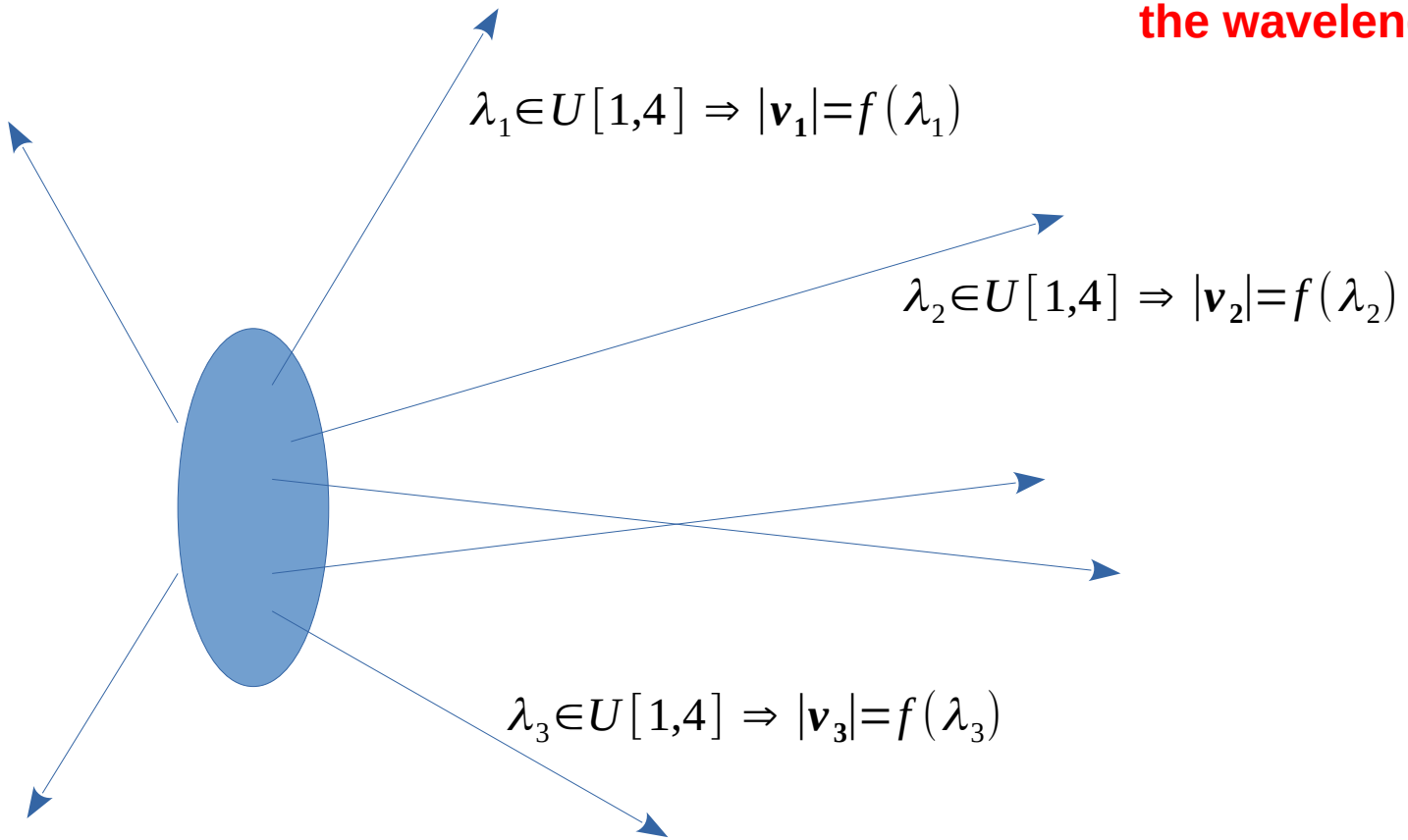
Sources: Example 1



Neutron spatial coordinates are picked from a uniform distribution on a circle with radius R.

Sources: Example 1

Length of the velocity vector encodes the wavelength



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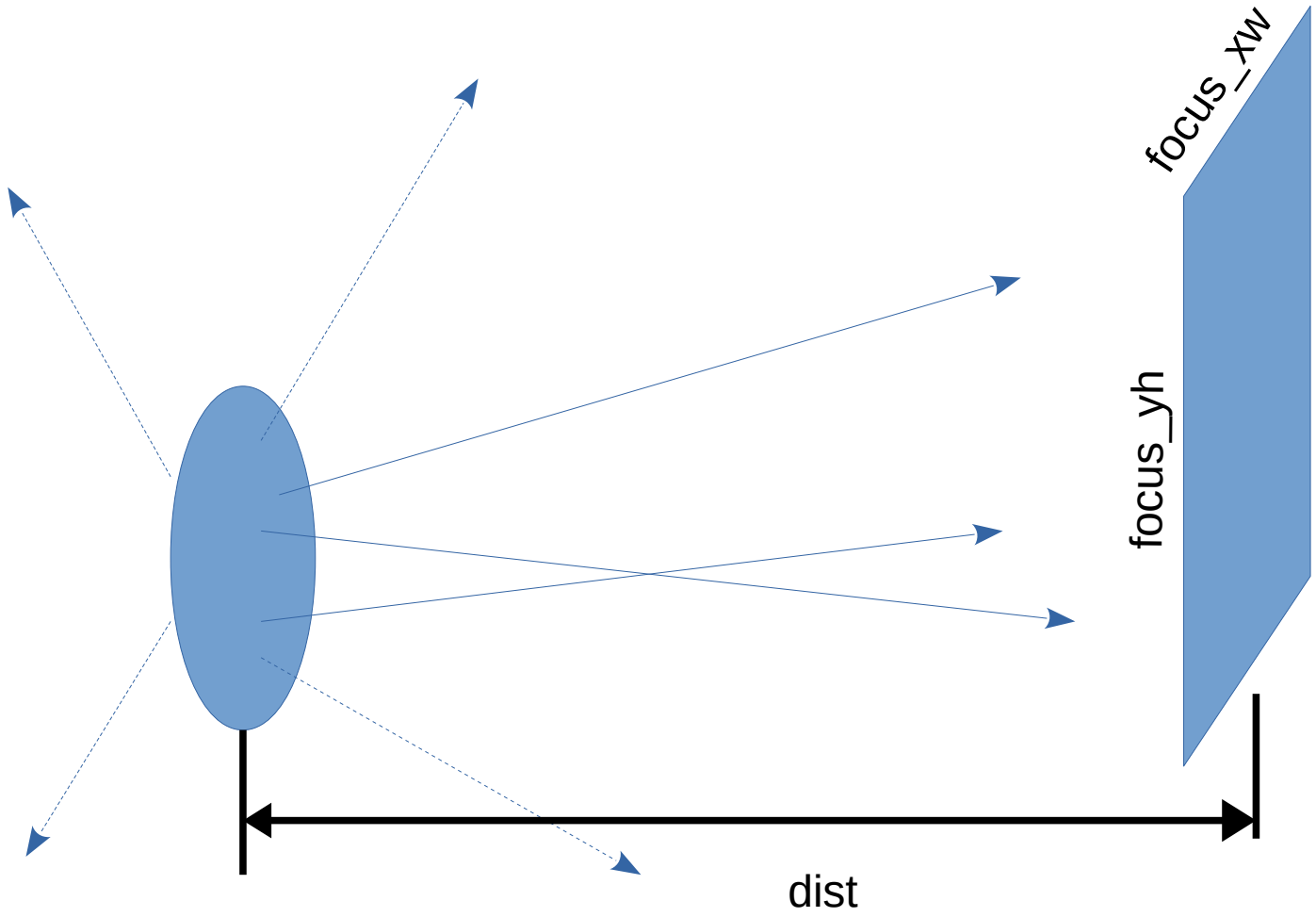
Sources: Example 1



Neutron velocity vector is picked to point at a ROI.

In McStas: this is defined by the parameters: focus_xw, focus_yh, and dist

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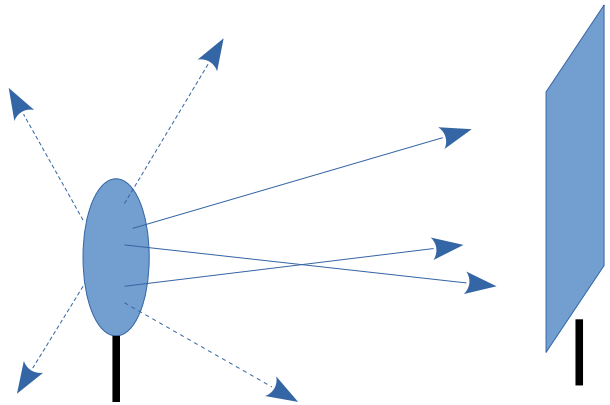
Sources: Example 1



```
TRACE

COMPONENT origin = Progress_bar()
AT(0,0,0) ABSOLUTE

COMPONENT src = Source_simple(
    radius=0.05, lambda0=2.5, dlambda=1.5,
    focus_xw=0.1, focus_yh=0.1, dist=5)
AT(0,0,0) RELATIVE origin
```

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Monitors: in general

REALITY:

Monitors:
- Intensity probe of the beam
- Transparent to neutrons → Efficiency <1%

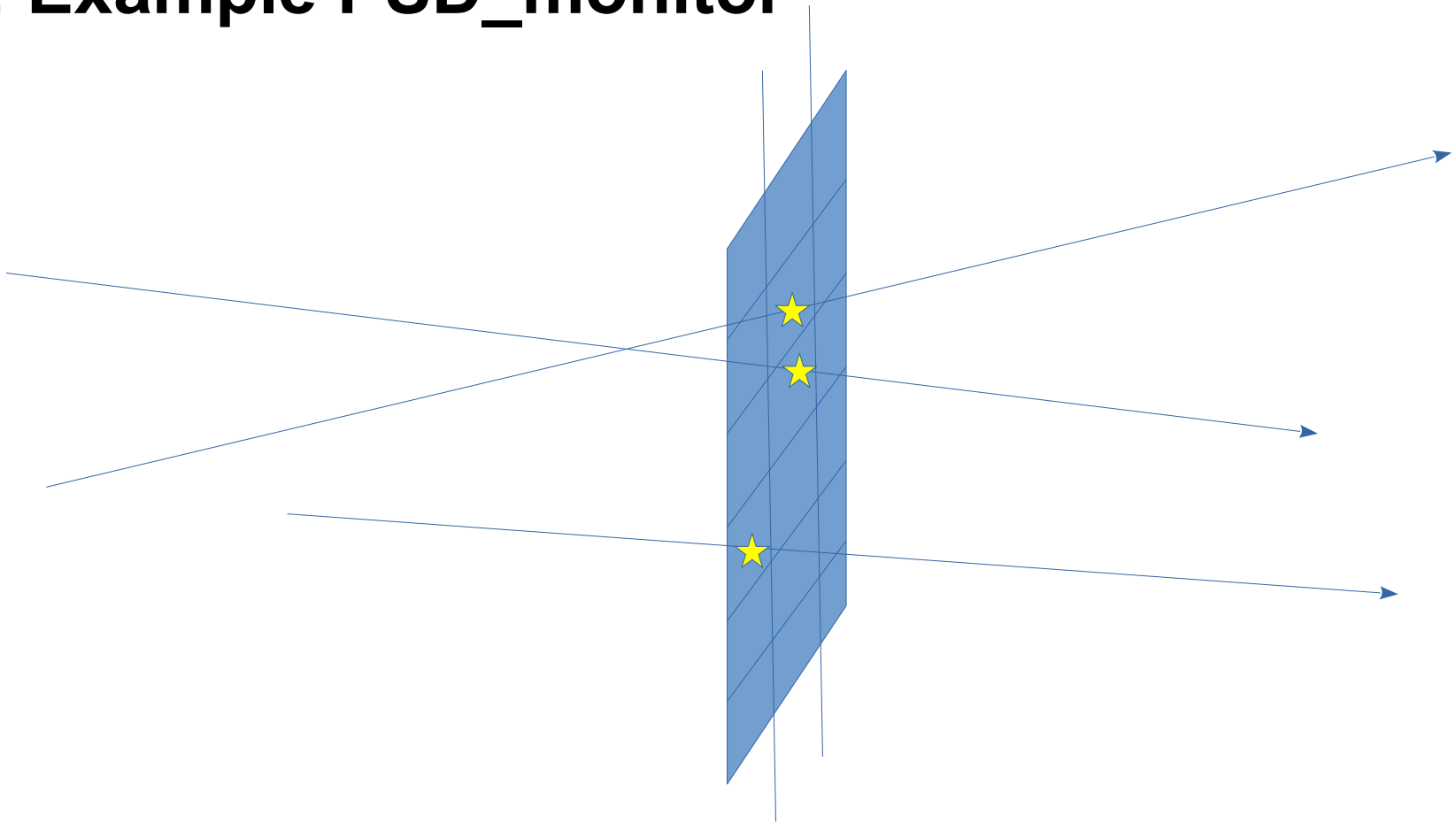
Detectors:
- Should detect *all* neutrons → Efficiency as high as possible

SIMULATIONS (McStas):

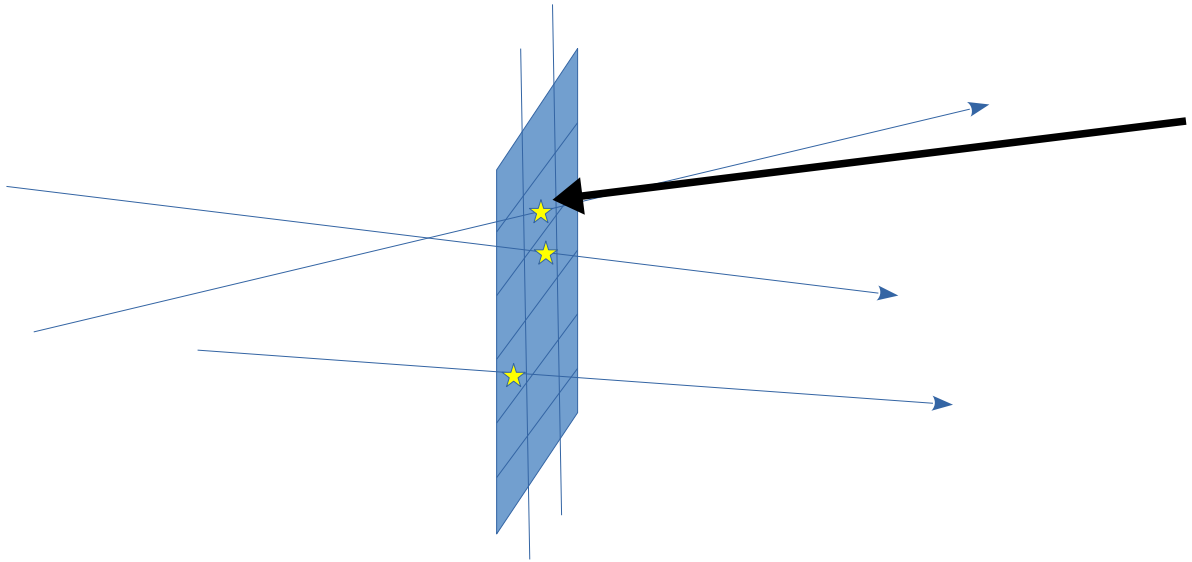
In McStas:
- We can program monitors and detectors to behave any way we like. We refer to both of those indistinguishably as ‘monitors’.
- E.g. monitor with Efficiency =100% and Transparency=100%

- (With exception of PSD_Detector that models a “physical” He^3 detector)

Monitors: Example PSD_monitor



Monitors: Example PSD_monitor



When the simulation has been completed, the detected intensity in pixel (i,j) is:

$$I(i,j) = \sum_{x_k, y_k \in pixel(i,j)} p_k ; k = ray\ number .$$

… during simulation, the pixels are maintained as running sums.

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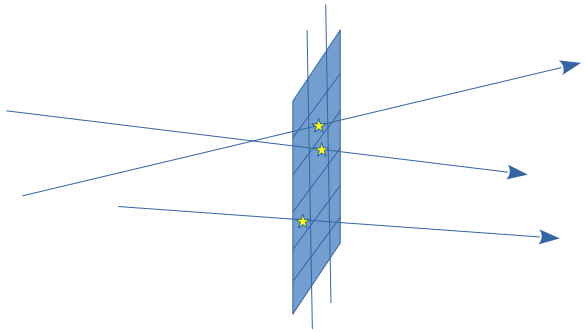
Monitors: Example PSD_monitor



```
...
TRACE

COMPONENT origin = Progress_bar()
AT(0,0,0) ABSOLUTE

COMPONENT src = Source_simple(
    radius=0.05, lambda0=2.5, dlambda=1.5,
    focus_xw=0.1, focus_yh=0.1, dist=5)
AT(0,0,0) RELATIVE origin

COMPONENT psd = PSD_monitor(
    xwidth=0.2, yheight=0.2, filename="psd.dat")
AT (0,0,5) RELATIVE src

COMPONENT lm = L_monitor(
    xwidth=0.2, yheight=0.2, filename="lm.dat",
    Lmin=0, Lmax=8)
AT (0,0,5+0.01) RELATIVE src
```

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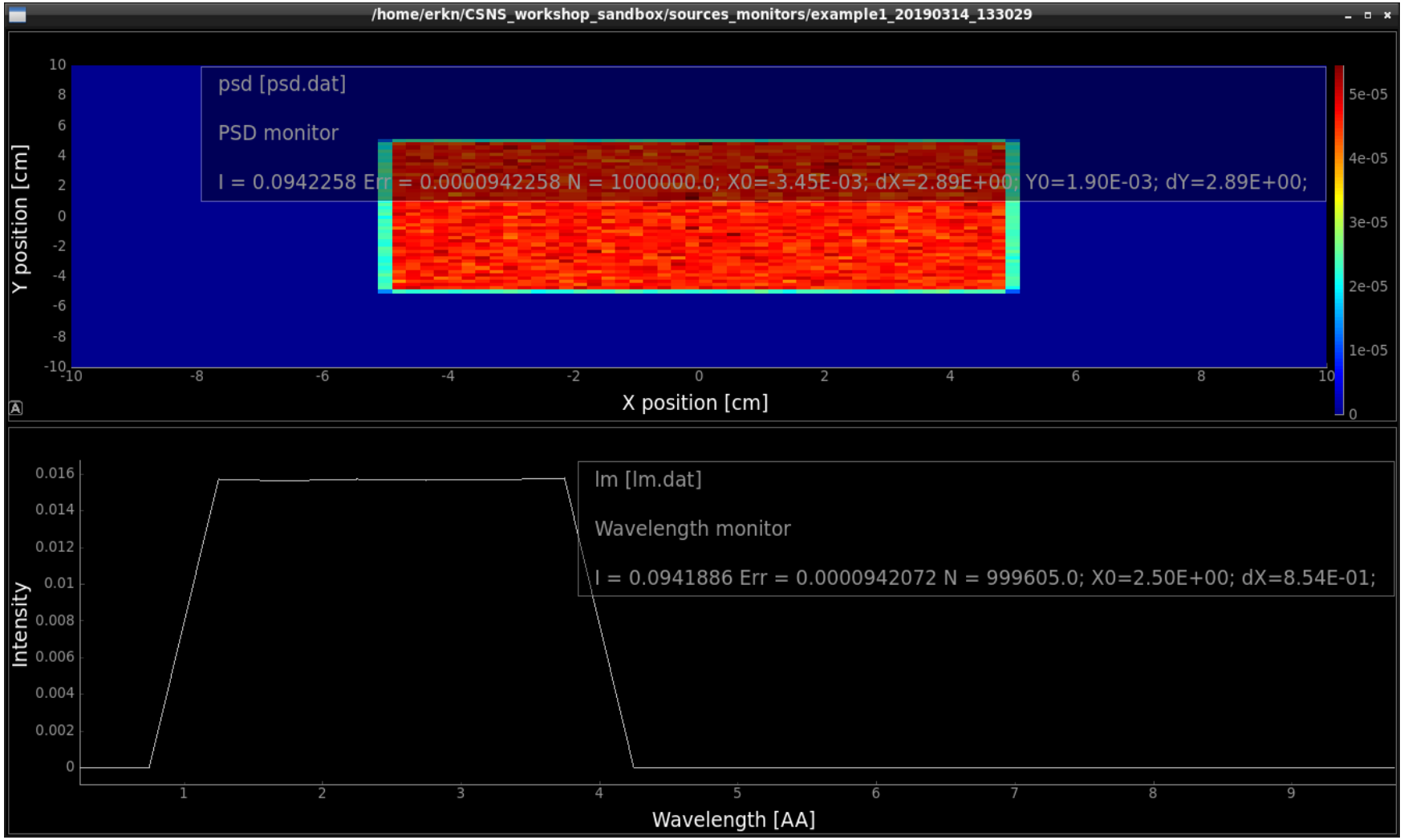
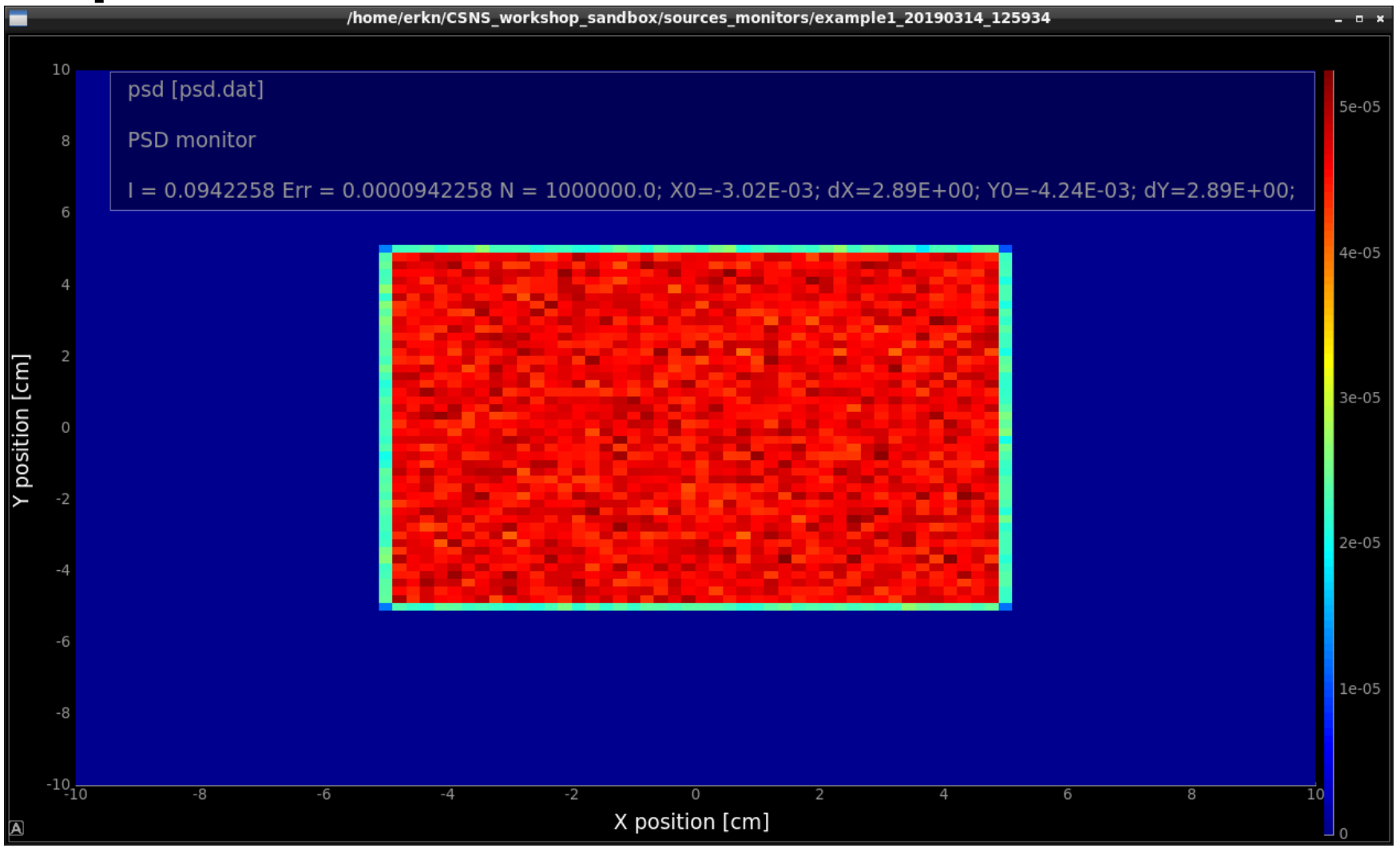
Example 1: Results



Example 1: Results



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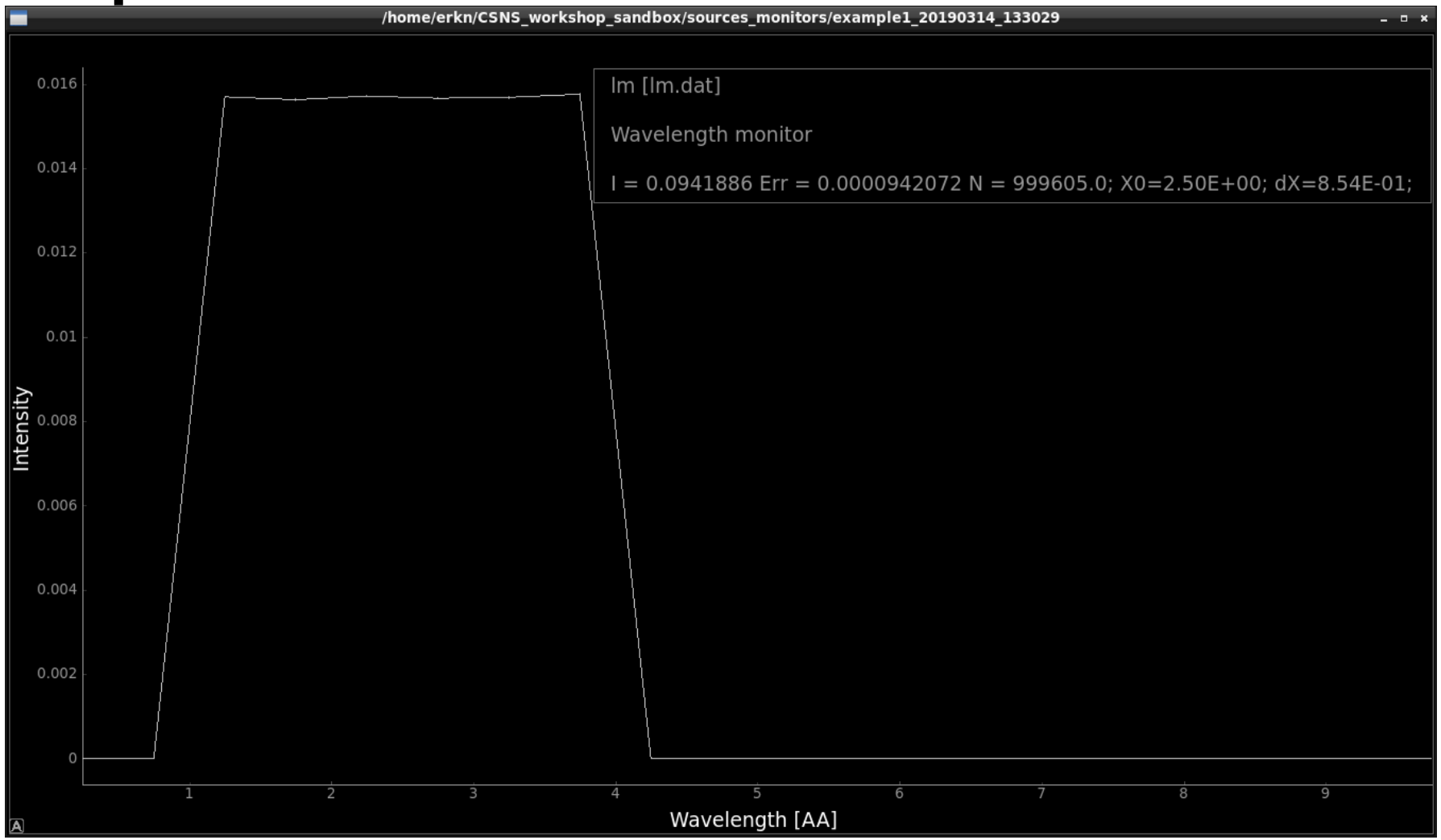
Example 1: Results



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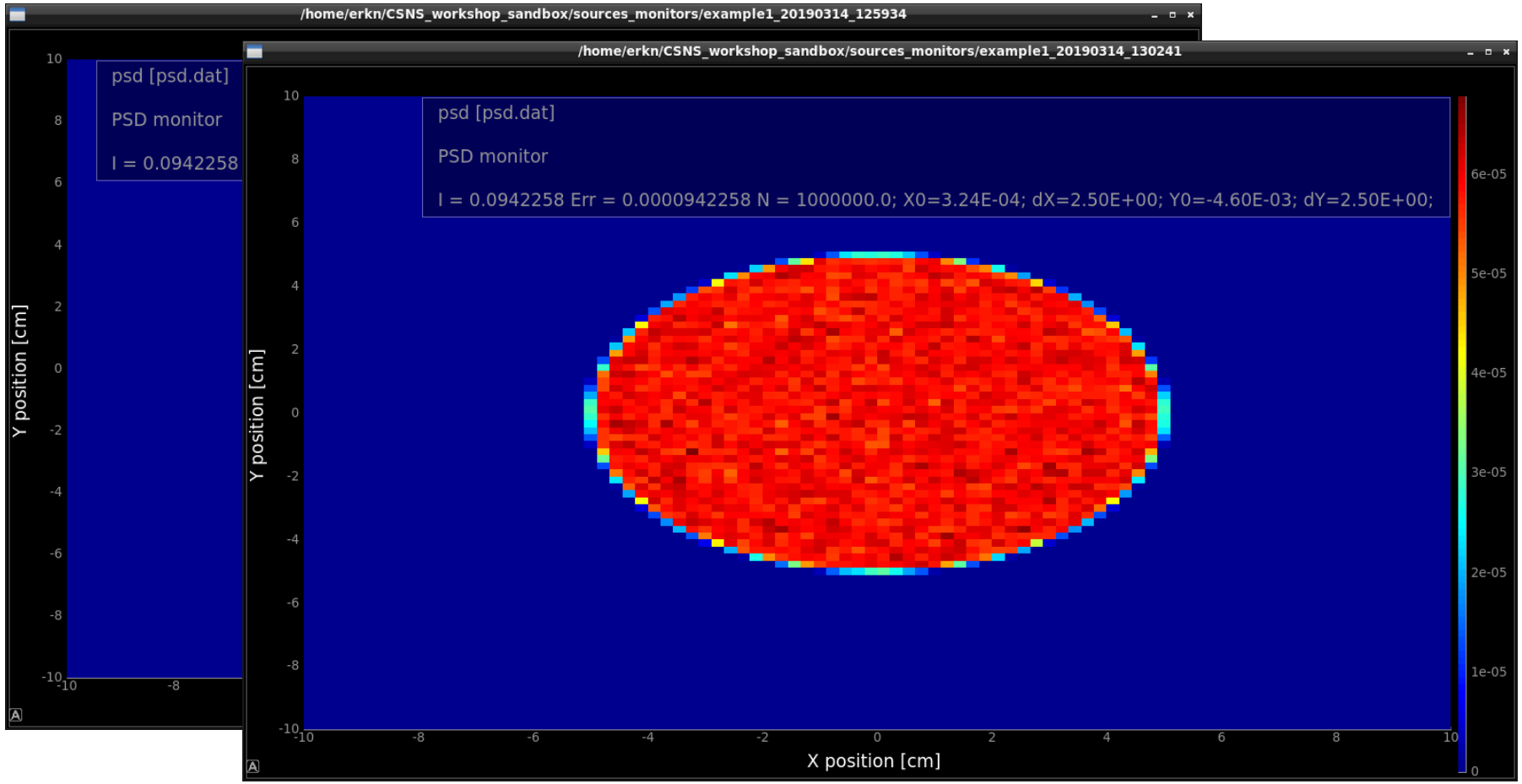
Example 1: Results

If we move the PSD_monitor close to the src...



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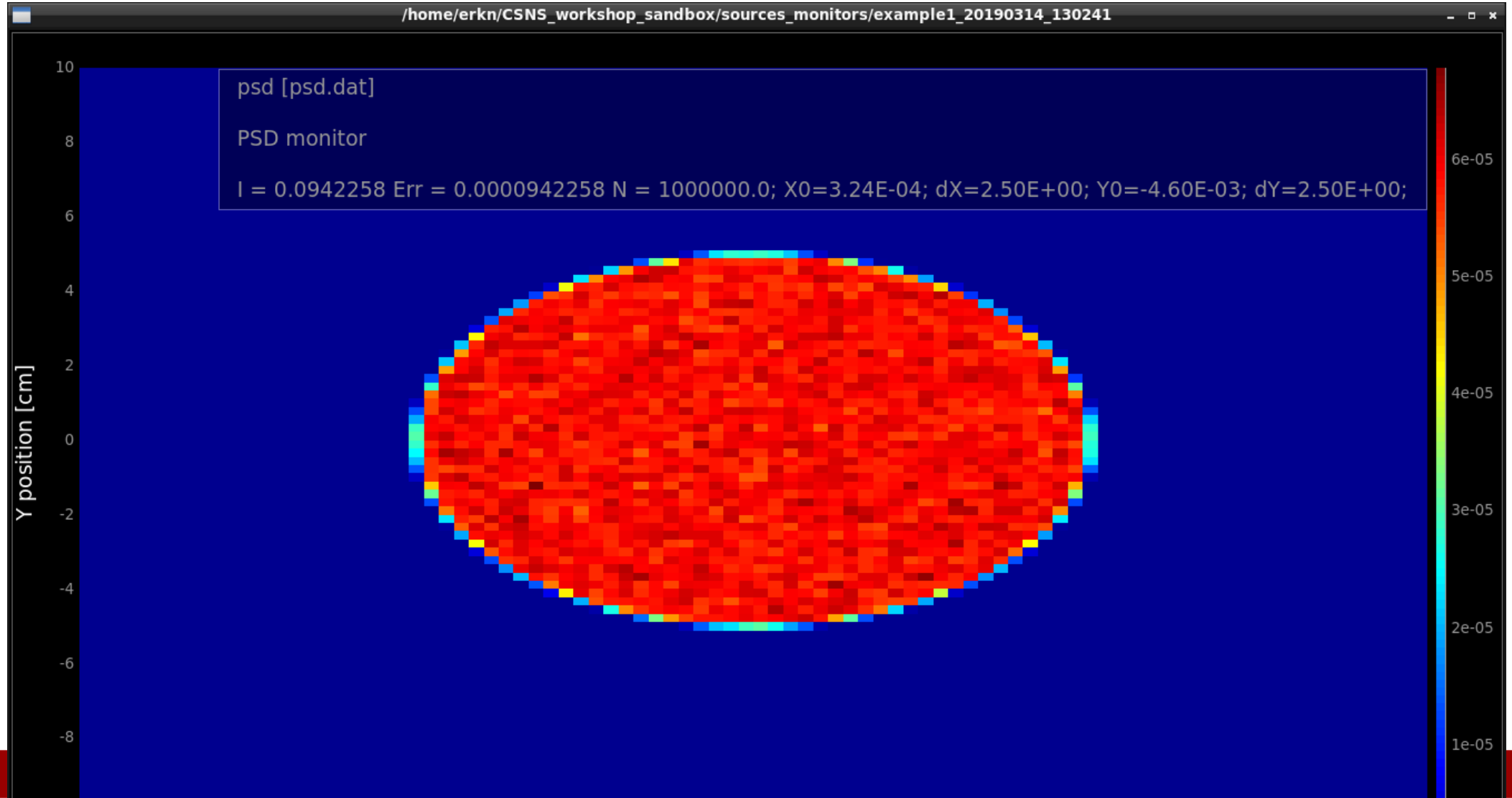
Monitors: information content



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Sources: Source model overview

- ***Mathematical***:
  - *Source_simple.comp*
  - *Source_div.comp*
- ***Pulsed sources***:
  - *ESS_butterfly.comp*
  - *ESS_moderator.comp*
  - *Moderator.comp*
  - *SNS_source.comp (*)*
  - *SNS_source_analytic (*)*
  - *ViewModISIS (*)*
  - *ISIS_moderator.comp (*)*
- ***Reactors*** *:*
  - *Source_Maxwell_3.comp*
  - *Source_gen.comp*
  - *Source_gen4.comp*
  - *Source_multi_surfaces.comp (*)*
- *I/O mechanisms:*
  - ***MCPL_input/output.comp***
  - *Virtual_input/output.comp*
  - *Virtual_mcnp_ss_input/output.comp*
  - *Virtual_tripoli4_input/output.comp*
  - *Vitess_input/output.comp*

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Sources: Mathematical sources

Source_simple:

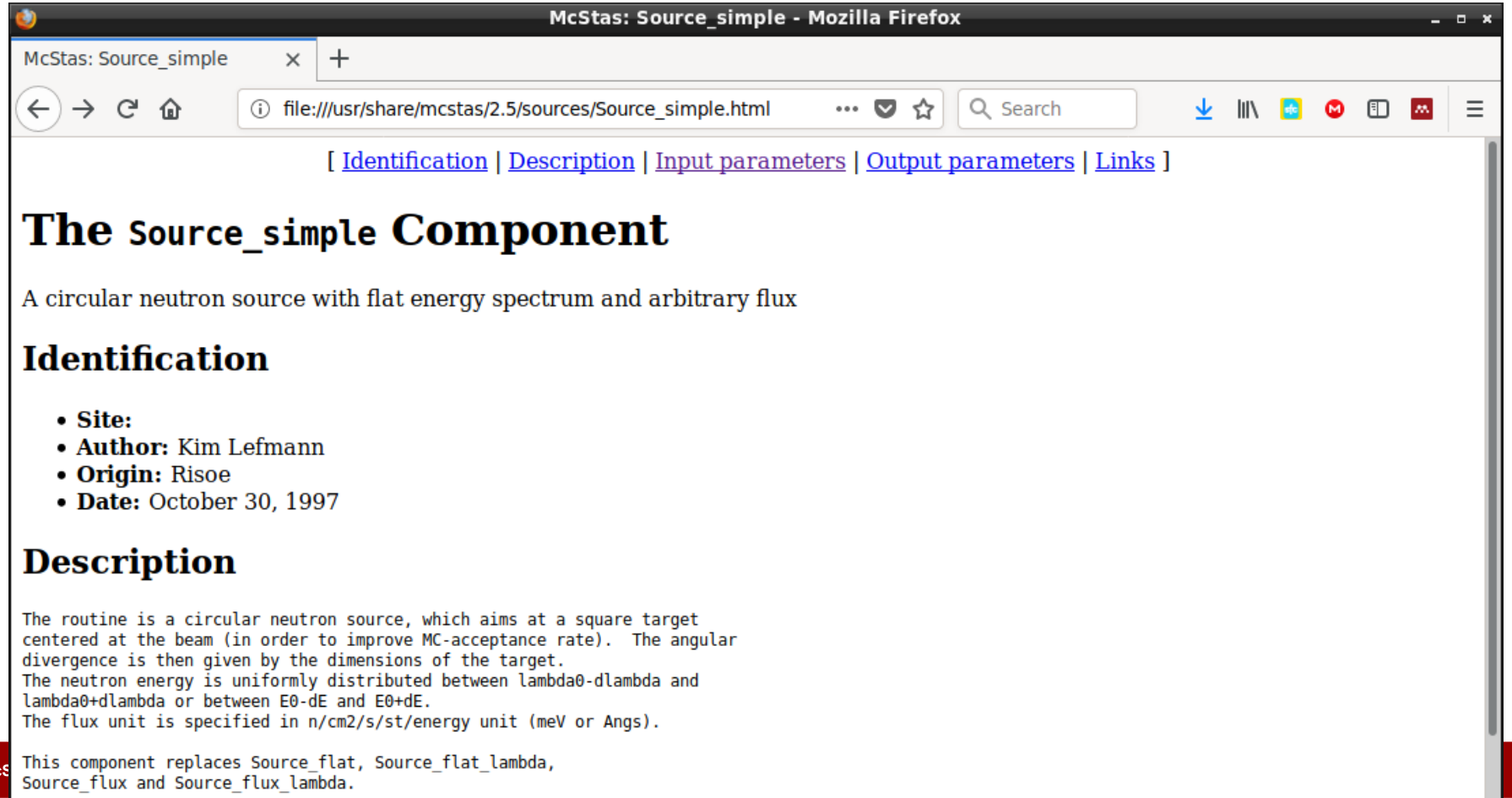
- Square or circular surface emitting neutrons from either uniform or Gaussian wavelength (or energy) distribution.
- Neutrons are directed towards a square target.

Source_div:

- Square surface emitting neutrons from either uniform or Gaussian wavelength (or energy) distribution.
- Neutrons have a divergence defined by either uniform or Gaussian distribution.

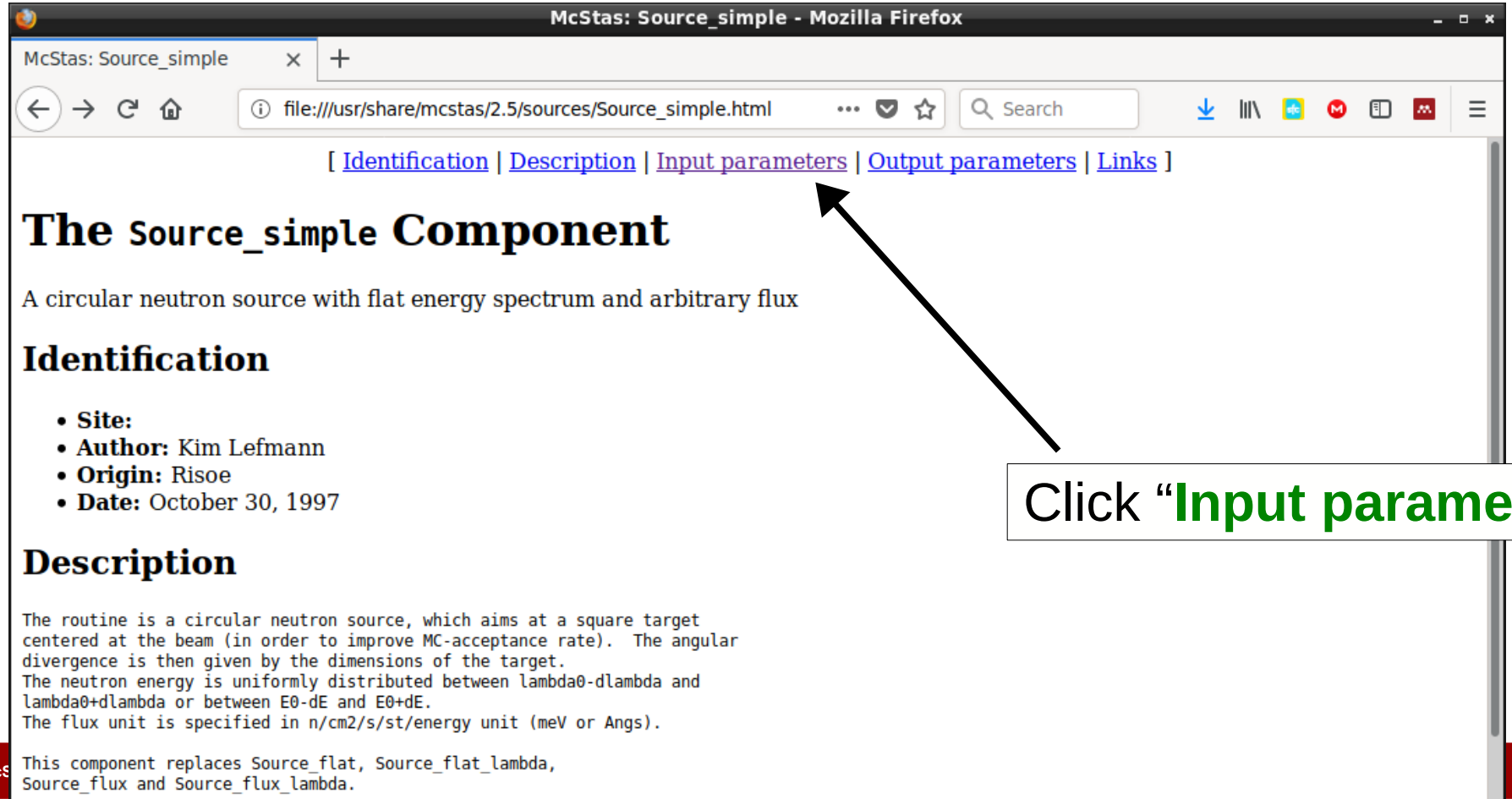
Source_simple docs

Try "**mcdoc Source_simple**"
or
(in GUI) **Help** → **mcdoc Component Reference** → (In Webpage) **Source_simple**



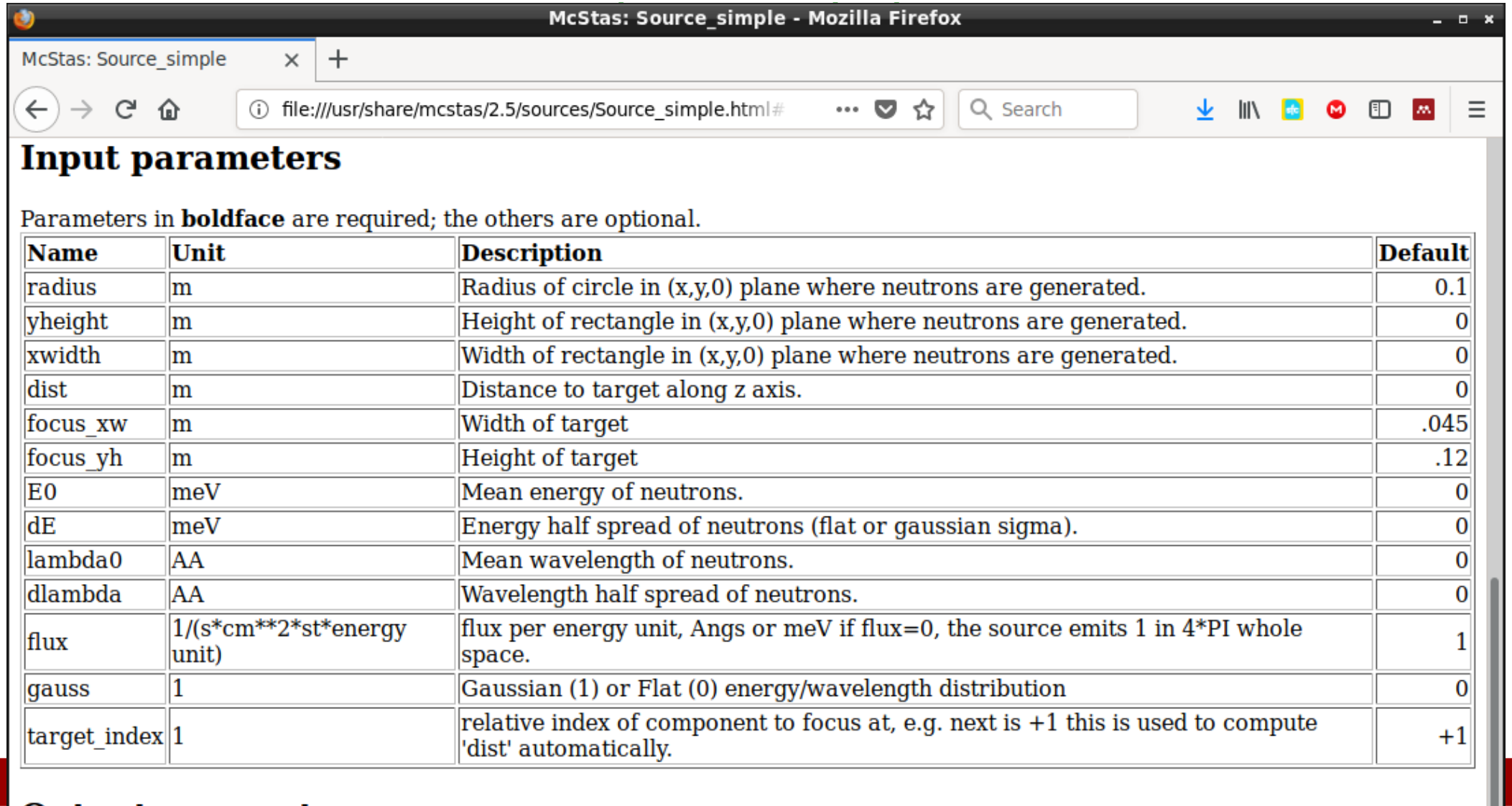
Source_simple docs

Try "**mcdoc Source_simple**"
or
(in GUI) **Help** → **mcdoc Component Reference** → (In Webpage) **Source_simple**



Click "**Input parameters**"

Source_simple docs

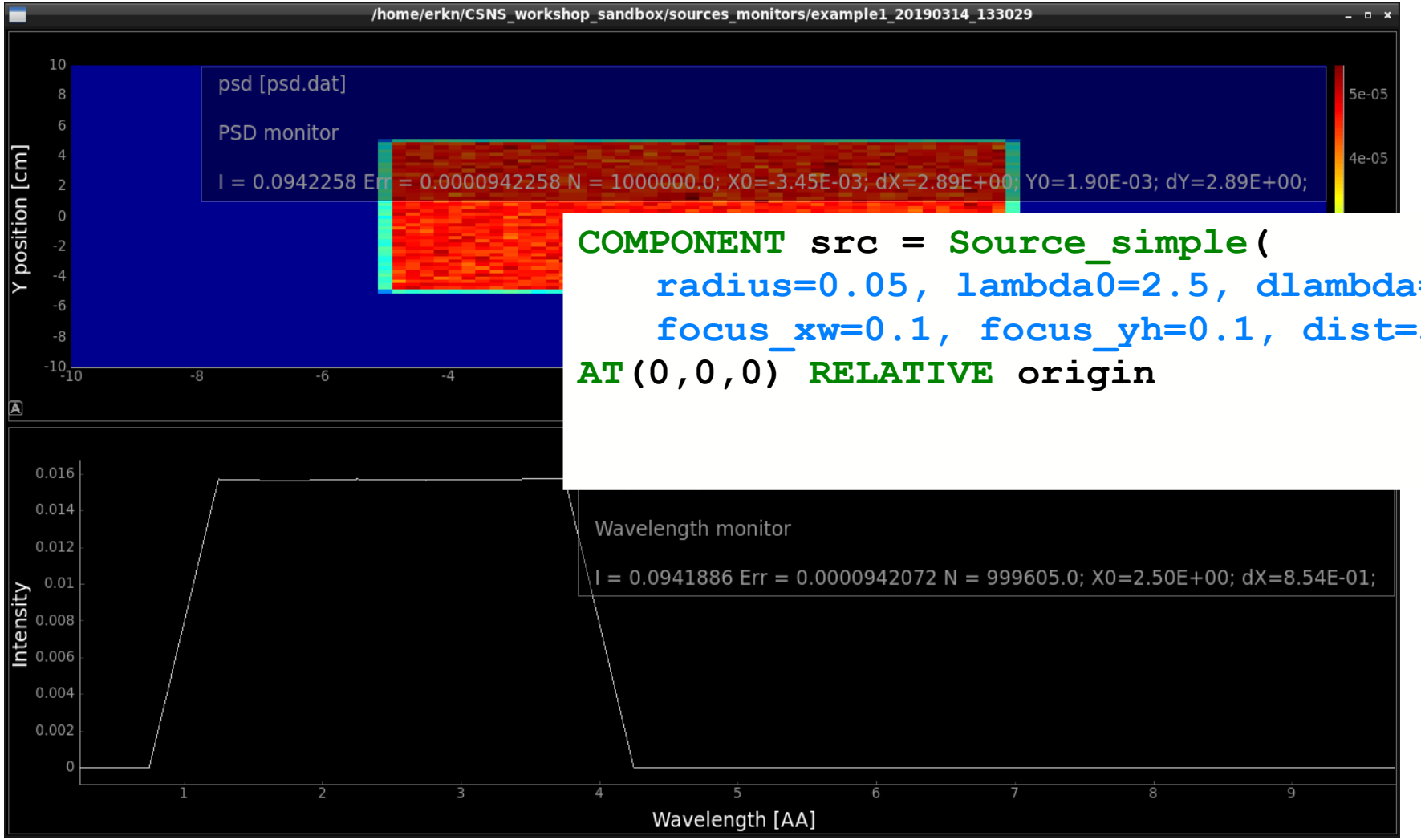


Input parameters

Parameters in **boldface** are required; the others are optional.

Name	Unit	Description	Default
radius	m	Radius of circle in (x,y,0) plane where neutrons are generated.	0.1
yheight	m	Height of rectangle in (x,y,0) plane where neutrons are generated.	0
xwidth	m	Width of rectangle in (x,y,0) plane where neutrons are generated.	0
dist	m	Distance to target along z axis.	0
focus_xw	m	Width of target	.045
focus_yh	m	Height of target	.12
E0	meV	Mean energy of neutrons.	0
dE	meV	Energy half spread of neutrons (flat or gaussian sigma).	0
lambda0	AA	Mean wavelength of neutrons.	0
dlambda	AA	Wavelength half spread of neutrons.	0
flux	1/(s*cm**2*st*energy unit)	flux per energy unit, Angs or meV if flux=0, the source emits 1 in 4*PI whole space.	1
gauss	1	Gaussian (1) or Flat (0) energy/wavelength distribution	0
target_index	1	relative index of component to focus at, e.g. next is +1 this is used to compute 'dist' automatically.	+1

Example 1: Results revisited




```
COMPONENT src = Source_simple(
    radius=0.05, lambda0=2.5, dlambda=1.5,
    focus_xw=0.1, focus_yh=0.1, dist=5 )
AT(0,0,0) RELATIVE origin
```

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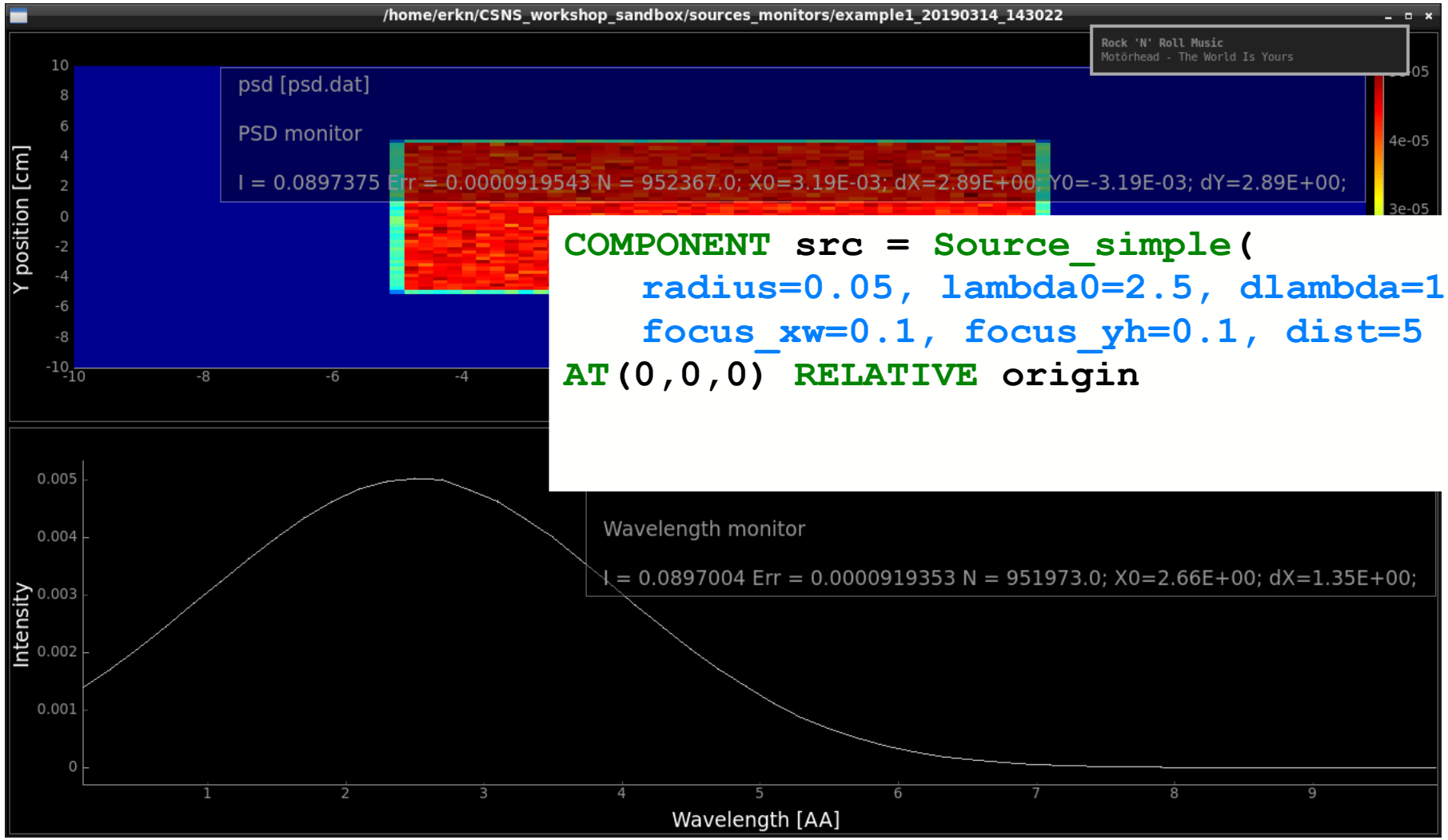
Example 1: Results revisited



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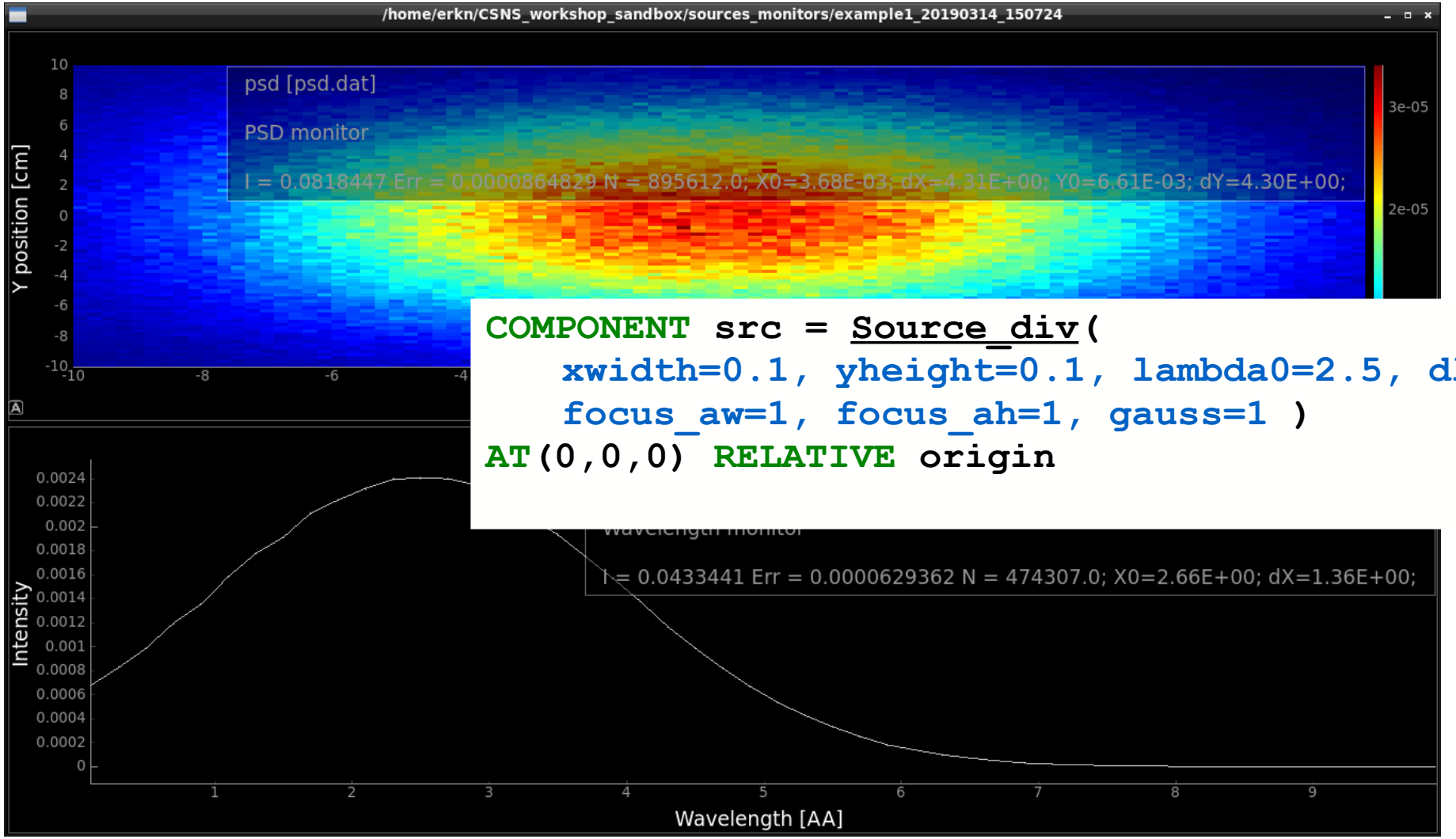
Example 1: Results revisited




```
COMPONENT src = Source_div(
    xwidth=0.1, yheight=0.1, lambda0=2.5, dlambda=1.5
    focus_aw=1, focus_ah=1, gauss=1 )
AT(0,0,0) RELATIVE origin
```

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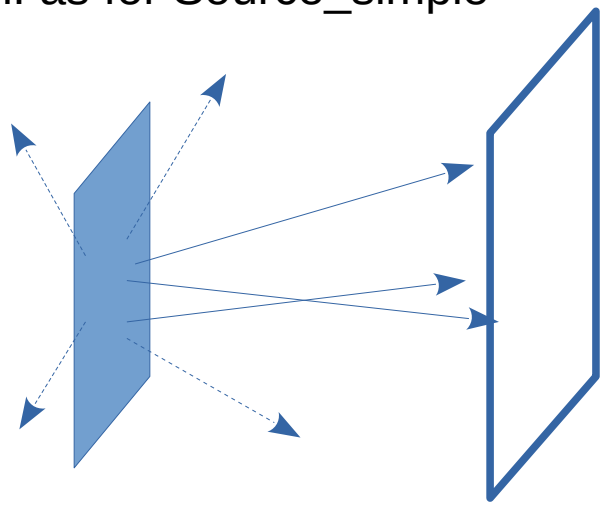
Sources: Source_Maxwell_3

```
COMPONENT source = Source_Maxwell_3(yheight=0.156, xwidth=0.126,
        Lmin=0.1, Lmax=9.0, dist=1.5, focus_xw = 0.025, focus_yh = 0.12,
        T1=150.42, I1=3.67E11, T2=38.74, I2=3.64E11, T3=14.84, I3=0.95E11)
```

Parameters from the PSI cold source

Initial position and direction: as for Source_simple



Sources: Source_Maxwell_3

```
COMPONENT source = Source_Maxwell_3(yheight=0.156, xwidth=0.126,
        Lmin=0.1, Lmax=9.0, dist=1.5, focus_xw = 0.025, focus_yh = 0.12,
        T1=150.42, I1=3.67E11, T2=38.74, I2=3.64E11, T3=14.84, I3=0.95E11)
```

Parameters from the PSI cold source

Intensity at a given wavelength drawn from a sum of (up to) 3 normalized Maxwellian distributions:

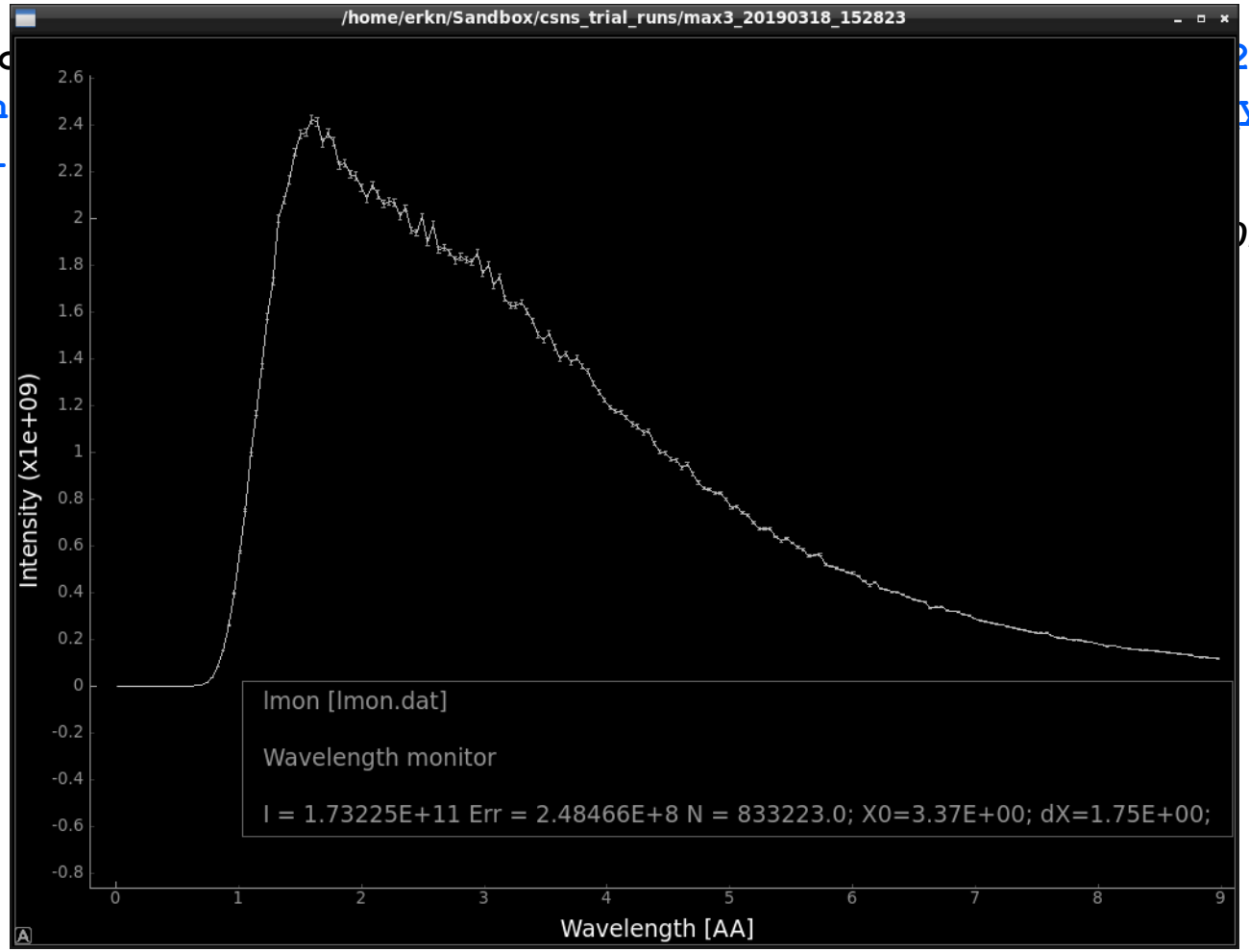
$$I(\lambda)=\sum_{i\in 1,2,3} I_i M(\lambda,T_i); \qquad M(\lambda,T_i)=2\alpha^2\exp(\frac{-\alpha}{\lambda^2})/\lambda^5;$$

$$\alpha=949.0\,K\,AA^2/T_i$$

Sources: Source_Maxwell_3

```
COMPONENT so                                    26,
          Lmin                                  yh = 0.12,
          T1=1                                    I3=0.95E11)
```

om the PSI cold source



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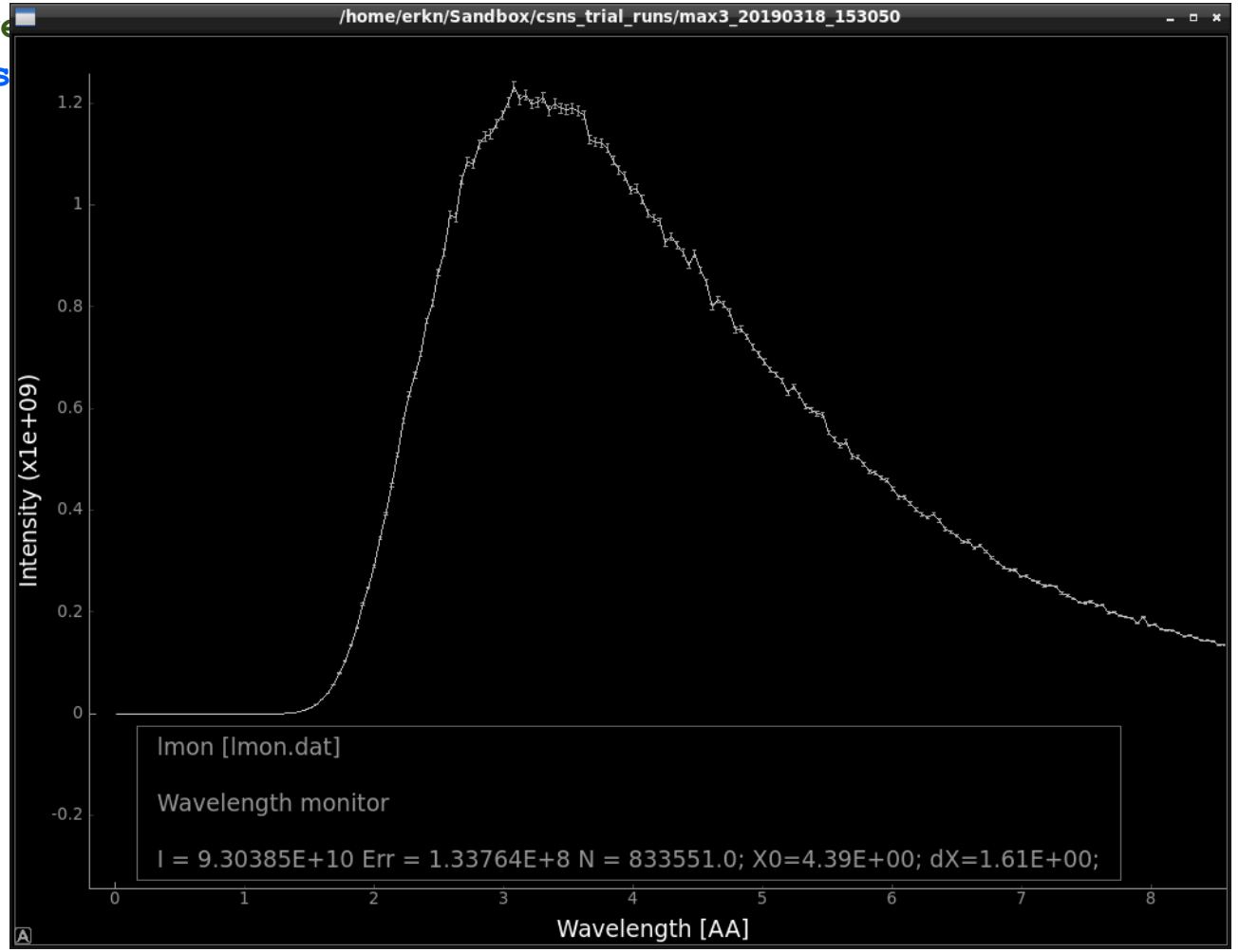
Sources: Source_Maxwell_3

```
COMPONENT source = Source_Maxwe
        Lmin=0.1, Lmax=9.0, dis
        T1=150.42, I1=3.67E11,
```

Just for fun – let's see what happens if we remove the fast peak…



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Input parameters

Parameters in **boldface** are required; the others are optional.

Name	Unit	Description	Default
size	m	Edge of cube shaped source (for backward compatibility)	0
yheight	m	Height of rectangular source	0
xwidth	m	Width of rectangular source	0
Lmin	AA	Lower edge of lambda distribution	
Lmax	AA	Upper edge of lambda distribution	
dist	m	Distance from source to focusing rectangle; at (0,0,dist)	
focus_xw	m	Width of focusing rectangle	
focus_yh	m	Height of focusing rectangle	
T1	K	1st temperature of thermal distribution	
T2	K	2nd temperature of thermal distribution	300
T3	K	3nd temperature of - - -	300
I1	1/(cm**2*st)	flux, 1 (in flux units, see above)	
I2	1/(cm**2*st)	flux, 2 (in flux units, see above)	0
I3	1/(cm**2*st)	flux, 3 - - -	0
target_index	1	relative index of component to focus at, e.g. next is +1 this is used to compute 'dist' automatically.	+1
lambda0	AA	Mean wavelength of neutrons.	0
dlambda	AA	Wavelength spread of neutrons.	0

Sources: Source_gen (Source_gen4)

```
COMPONENT source = Source_gen(yheight=0.156, xwidth=0.126,
        Lmin=0.1, Lmax=9.0, dist=1.5, focus_xw = 0.025, focus_yh = 0.12,
        T1=150.42, I1=3.67E11, T2=38.74, I2=3.64E11, T3=14.84, I3=0.95E11)
```

Almost the same as Source_Maxwell_3: but with optional flux-files as input.

Sources: Source_gen (Source_gen4)

Input parameters

Parameters in **boldface** are required; the others are optional.

Name	Unit	Description	Default
flux_file	str	Name of a two columns [lambda flux] text file that contains the wavelength distribution of the flux in **either** [1/(s*cm**2*st)] **or** [1/(s*cm**2*st*AA)] (see flux_file_perAA flag) Comments (#) and further columns are ignored. Format is compatible with McStas/PGPLOT wavelength monitor files. When specified, temperature and intensity values are ignored.	"NULL"
xdiv_file	str	Name of the x-horiz. divergence distribution file, given as a free format text matrix, preceeded with a line '# xylimits: xmin xmax xdiv_min xdiv_max'	"NULL"
ydiv_file	str	Name of the y-vert. divergence distribution file, given as a free format text matrix, preceeded with a line '# xylimits: ymin ymax ydiv_min ydiv_max'	"NULL"
radius	m	Radius of circle in (x,y,0) plane where neutrons are generated. You may also use 'yheight' and 'xwidth' for a square source	0.0
dist	m	Distance to target along z axis.	0
focus_xw	m	Width of target.	0.045
focus_yh	m	Height of target.	0.12
focus_aw	deg	maximal (uniform) horz. width divergence	0
focus_ah	deg	maximal (uniform) vert. height divergence	0
E0	meV	Mean energy of neutrons.	0
dE	meV	Energy spread of neutrons, half width.	0
lambda0	AA	Mean wavelength of neutrons.	0
dlambda	AA	Wavelength spread of neutrons,half width	0
I1	1/(cm**2*sr)	Source flux per solid angle, area and Angstrom if I1=0, the source emits 1 in 4*PI whole space.	1
yheight	m	Source y-height, then does not use radius parameter	0.1
xwidth	m	Source x-width, then does not use radius parameter	0.1
verbose	0/1	display info about the source. -1 unactivate source.	0
T1	K	Temperature of the Maxwellian source, 0=none	0

Sources: Source_gen (Source_gen4)

```
COMPONENT source = Source_gen(yheight=0.156, xwidth=0.126,
        flux_file="file1.dat", xdiv_file="file2.dat", ydiv_file="file3.dat")
```

Almost the same as Source_Maxwell_3: but with optional flux- and divergence-files as input.

Source_gen4: Same as for Source_gen but more accurate tail-description for PSI.

To generate files – e.g.

```
Monitor_nD(options="auto lambda per cm2", filename="file1.dat")
Monitor_nD(options="x hdiv, all auto", filename="file2.dat")
Monitor_nD(options="y vdiv, all auto", filename="file3.dat")
```

Sources: Source_gen (Source_gen4)

```
COMPONENT source = Source_gen(yheight=0.156, xwidth=0.126,
        Lmin=0.1, Lmax=9.0, dist=1.5, focus_xw = 0.025, focus_yh = 0.12,
        T1=150.42, I1=3.67E11, T2=38.74, I2=3.64E11, T3=14.84, I3=0.95E11)
```

Almost the same as Source_Maxwell_3: but with optional flux-files as input.

Sources: Pulsed sources

Simplest case:

Use a continuous mathematical source and add time dependence:

```
COMPONENT src = Source_simple(
    radius=0.05, lambda0=2.5, dlambda=1.5,
    focus_xw=0.1, focus_yh=0.1, dist=5 )
AT(0,0,0) RELATIVE origin
EXTEND
%{
    t=rand01()*1e-6;
%}
```

Sources: Pulsed sources

Simplest case:

Use a continuous mathematical source and add time dependence:

```
COMPONENT src = Source_simple(
    radius=0.05, lambda0=2.5, dlambda=1.5,
    focus_xw=0.1, focus_yh=0.1, flux=5 )
AT(0,0,0) RELATIVE PREVIOUS
EXTEND
%{
    t=rand01()*0.1;
%}
```

Or: Use a chopper

Sources: SNS_source

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Sources: ViewModISIS

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Sources: ESS_butterfly

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Monitors (some)

1D

- L_monitor → $I(\lambda)$
- TOF_monitor → $I(t)$
- Hdiv_monitor → $I(divergence_x)$
- MeanPolLambda → $\langle \bar{\boldsymbol{P}} \rangle(\lambda)$
- E_monitor → $I(E)$

2D

- PSD_monitor → $I(x, y)$
- PSD_monitor_4PI → $I(\theta, \phi)$
- PolLambda_monitor → $I(\bar{\boldsymbol{P}}, \lambda)$

nD

- Monitor_nD

$I(X)$

or

$I(X, Y)$

or

$Z(X, Y, Z)$

or ...

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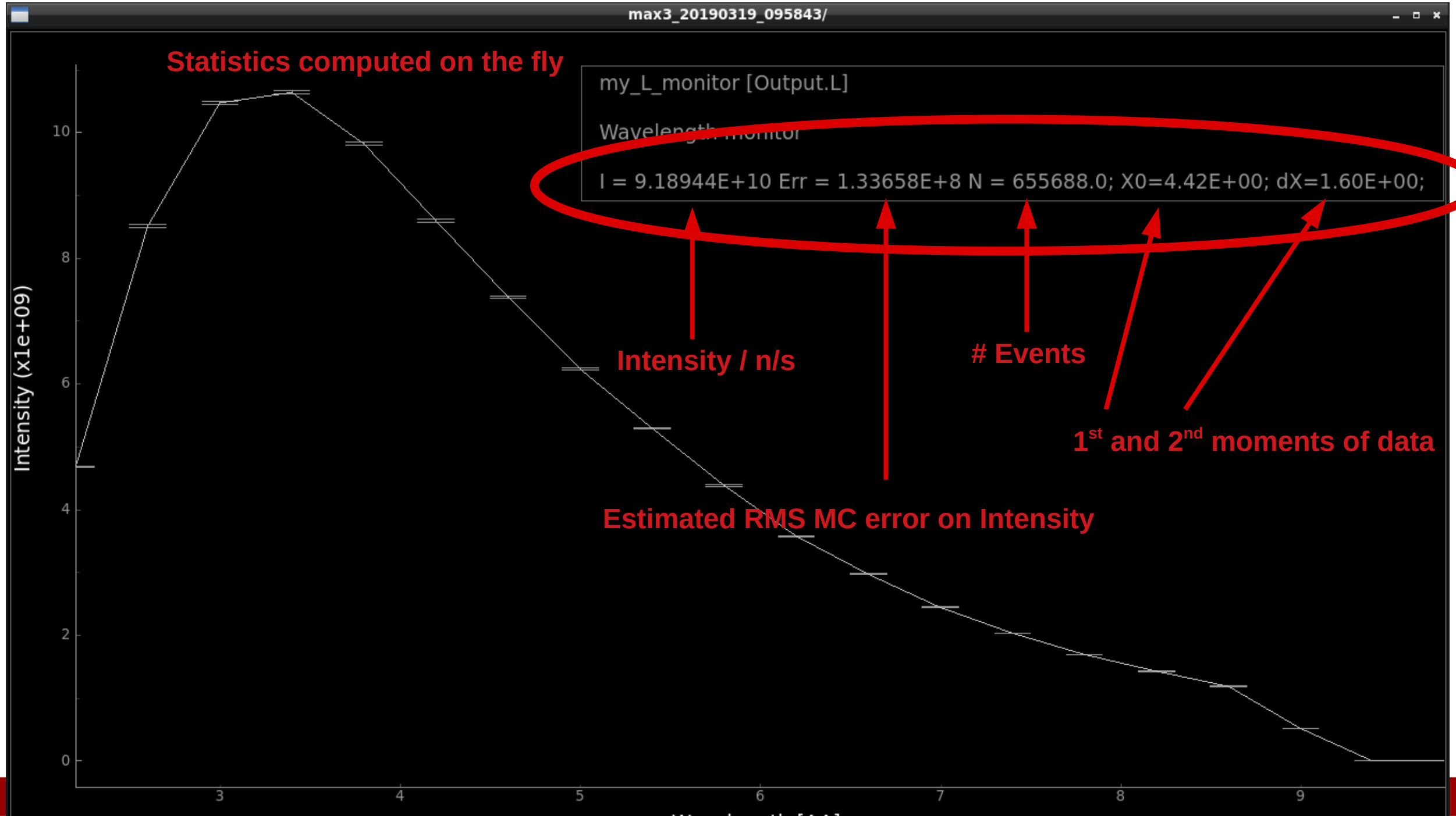
Monitors: Quick examples

```
COMPONENT my_L_monitor = L_monitor(xwidth=0.2, yheight=0.2,
                                   nL=20, filename="Output.L", Lmin=2, Lmax=10)
```


max3_20190319_095843/
Statistics computed on the fly
my_L_monitor [Output.L]
Wavelength monitor
I = 9.18944E+10 Err = 1.33658E+8 N = 655688.0; X0=4.42E+00; dX=1.60E+00;
Intensity / n/s
Events
1st and 2nd moments of data
Estimated RMS MC error on Intensity
Intensity (x1e+09)
0
2
4
6
8
10
3
4
5
6
7
8
9

DTU

EUROPEAN SPALLATION SOURCE

CSNS

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EUROPEAN
SPALLATION
SOURCE

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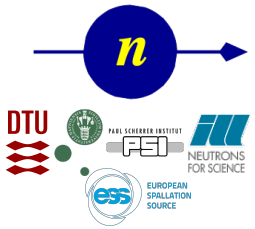

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