

DTU Physics

# Sources and Monitors

## part 2.

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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 :**

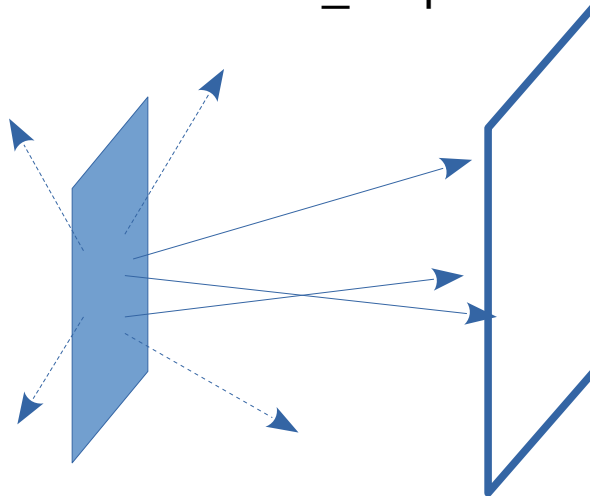
- *Source\_Maxwell\_3.comp*
- *Source\_gen.comp*
- *Source\_gen4.comp*
- *Source\_multi\_surfaces.comp (\*)*
- **I/O mechanisms:**
  - ***MCPL\_input/output.comp***
  - *Virtual\_input/output.comp*
  - *Virtual\_mcnp\_ss\_input/output.comp*
  - *Virtual\_tripoli4\_input/output.comp*
  - *Vitess\_input/output.comp*

# 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:

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

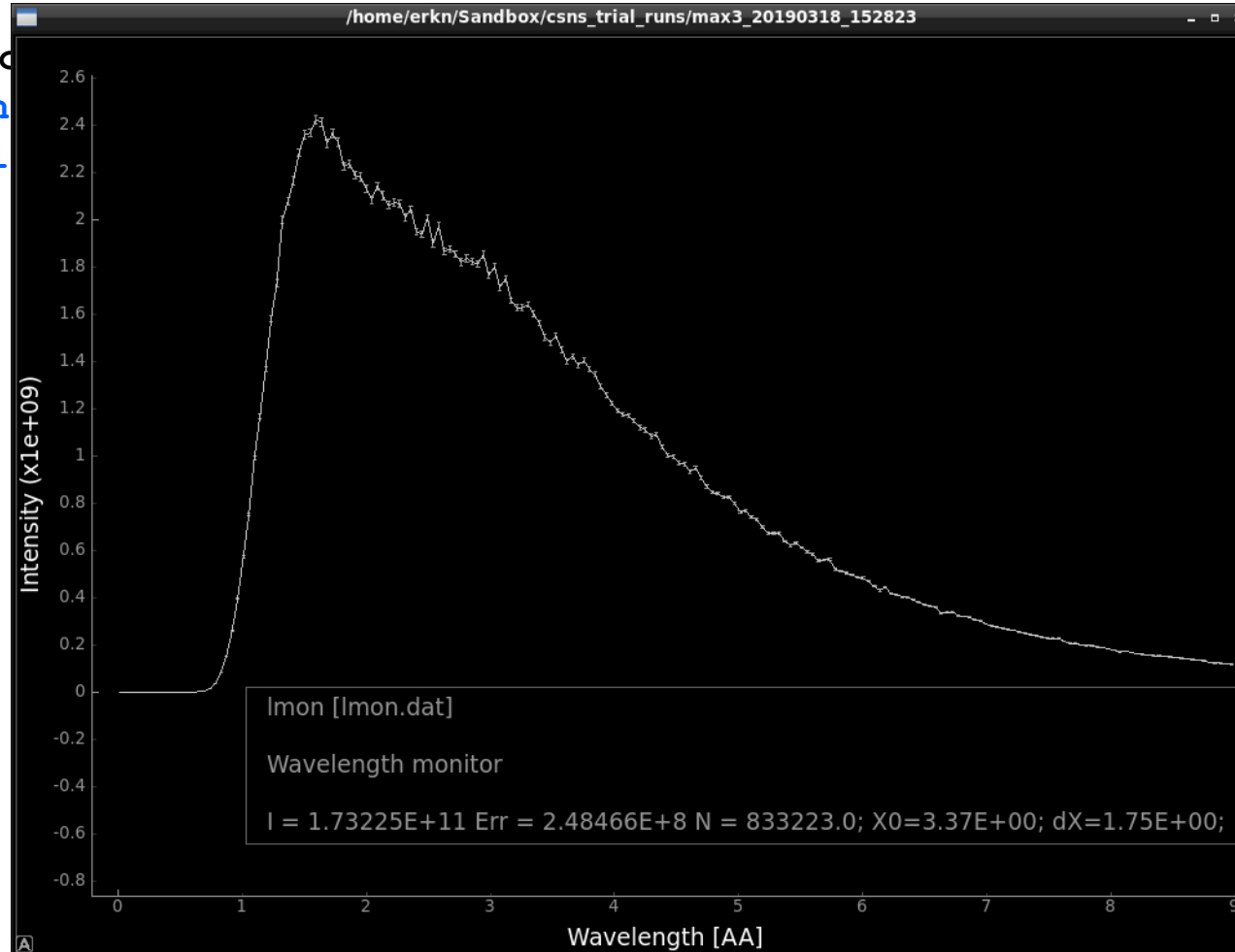
$$\alpha = 949.0 \text{ K } AA^2 / T_i$$

# Sources: Source\_Maxwell\_3

COMPONENT source

Lmin

T1=1



26,

yh = 0.12,

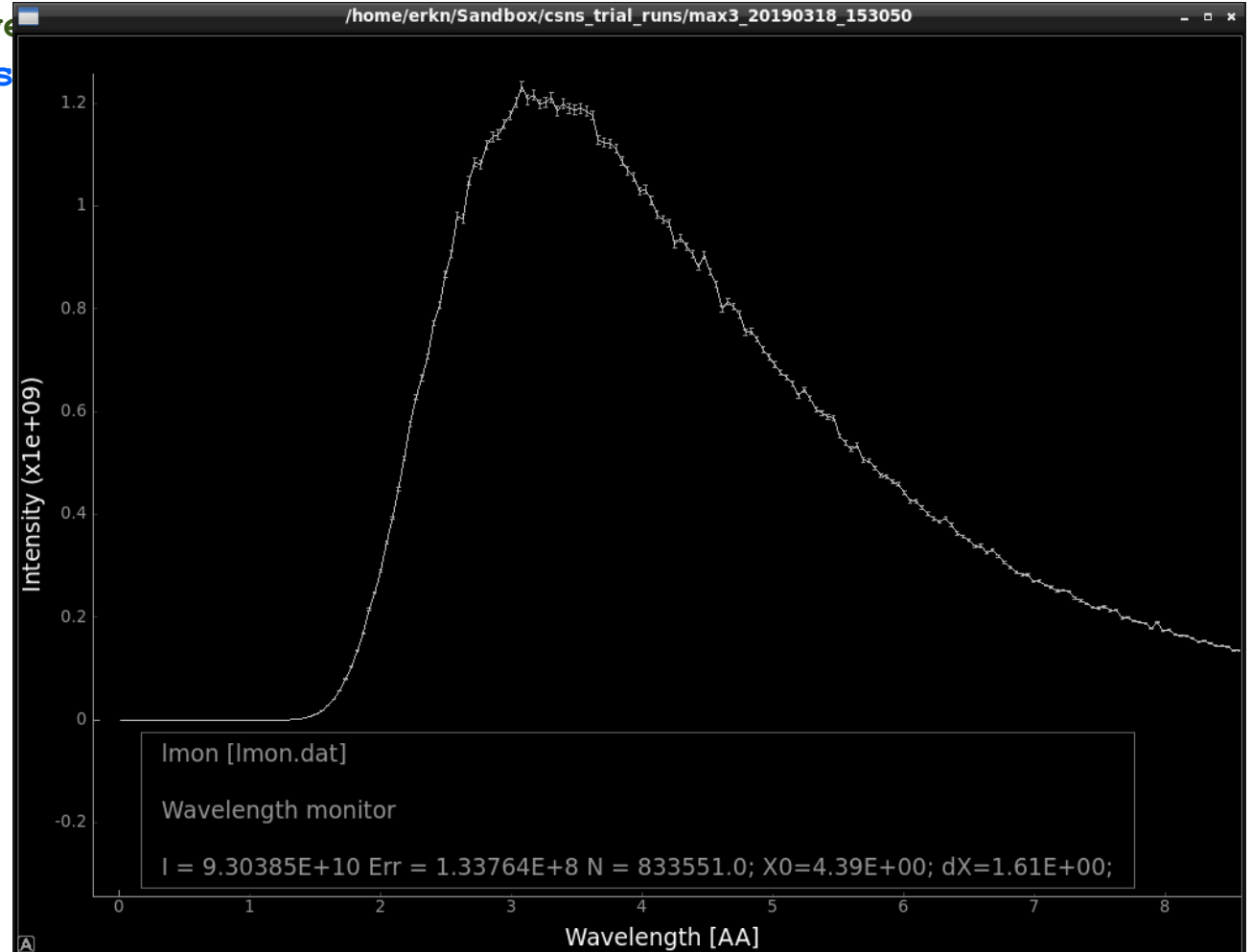
I3=0.95E11)

from the PSI cold source

# Sources: Source\_Maxwell\_3

```
COMPONENT source = Source_Maxwell_3
  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...



# 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
<b>Lmin</b>	AA	Lower edge of lambda distribution	
<b>Lmax</b>	AA	Upper edge of lambda distribution	
<b>dist</b>	m	Distance from source to focusing rectangle; at (0,0,dist)	
<b>focus_xw</b>	m	Width of focusing rectangle	
<b>focus_yh</b>	m	Height of focusing rectangle	
<b>T1</b>	K	1st temperature of thermal distribution	
T2	K	2nd temperature of thermal distribution	300
T3	K	3rd temperature of - - -	300
<b>I1</b>	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

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# Sources: Source\_gen (Source\_gen4)

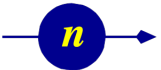
```
COMPONENT source = Source_gen(yheight=0.156, xwidth=0.126,  
    Lmin=0.1, Lmax=9.0, dist=1.5, focus_xw = 0.025, focus_yh = 0.12,  
    T1=150.42, I1=3.67E11, T2=38.74, I2=3.64E11, T3=14.84, I3=0.95E11)
```

Almost the same as Source\_Maxwell\_3: but with optional flux-files as input.

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# 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 <b>either</b> $[1/(s \cdot cm^2 \cdot st)]$ <b>or</b> $[1/(s \cdot cm^2 \cdot st \cdot AA)]$ (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_ah	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	$1/(cm^2 \cdot sr)$	Source flux per solid angle, area and Angstrom if I1=0, the source emits 1 in $4 \cdot \pi$ 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")
```

# MCPL\_input/output

Reads/writes events directly from MCPL-format files:  
“T. Kittelmann et. al., “”, J. Phys. Comp., 2017

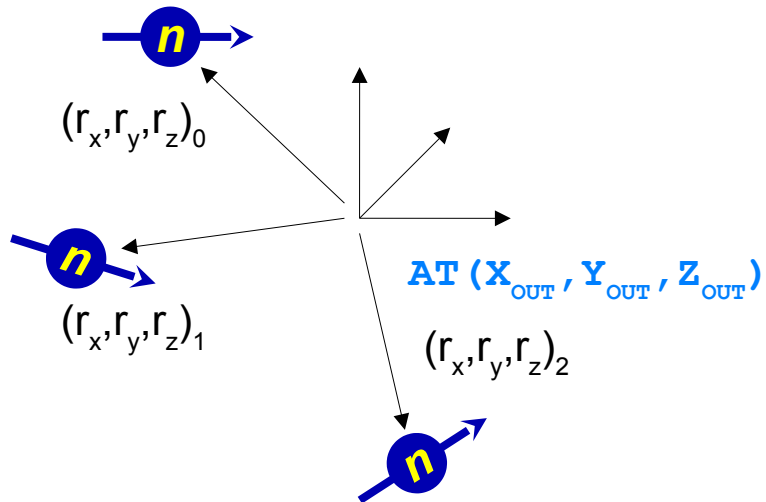
```
COMPONENT vout = MCPL_output(filename="voutput.mcpl",
                                doubleprec=1,polarisationuse=1,verbose=1)
AT (Xout,Yout,Zout) RELATIVE PREVIOUS
```

```
COMPONENT vin = MCPL_input(filename="voutput.mcpl",
                              polarisationuse=1,verbose=1)
AT (Xin,Yin,Zin) RELATIVE PREVIOUS
```

# MCPL\_input/output

Can include an Implicit Translation:

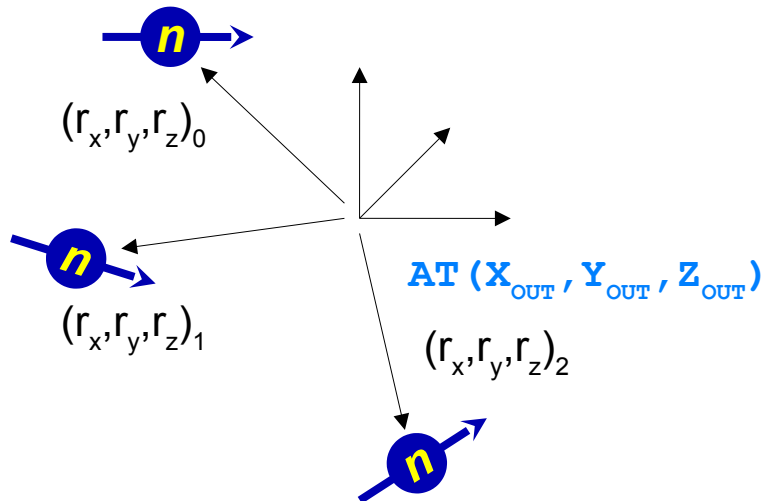
MCPL\_output.comp



# MCPL\_input/output

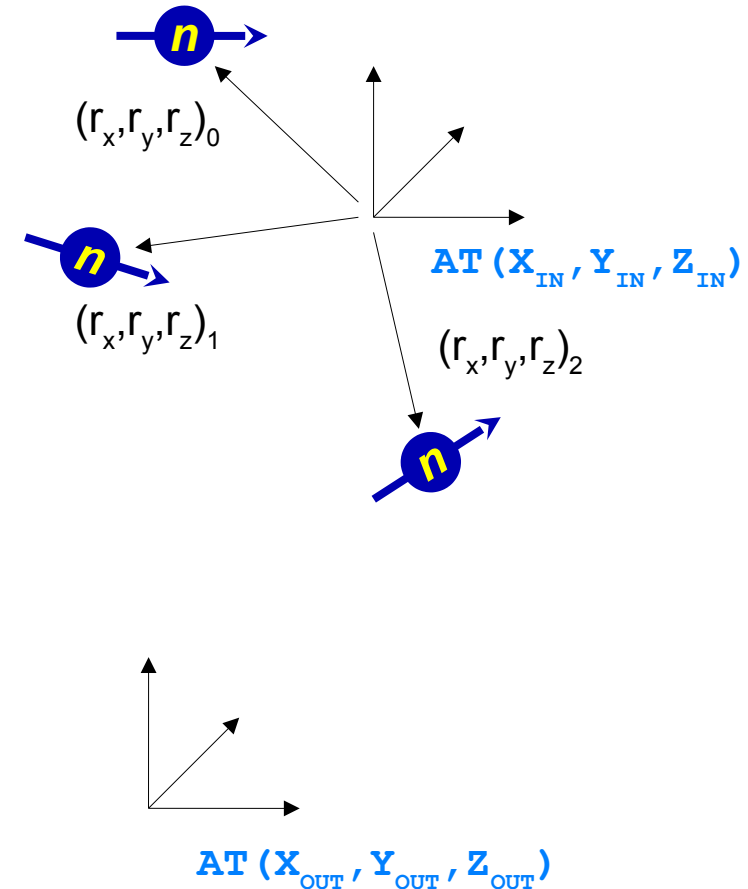
Can include an Implicit Translation:

*MCPL\_output.comp*



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*MCPL\_input.comp*



# Pulsed sources:

Simplest case:

Use a continuous source!

Model a source with given wavelength and spatial distribution

*and*

... an infinitely short pulse length. I.e.  $t = 0$  for all neutron rays.

```
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
```

# Pulsed sources:

Add a sample here  
TOF\_monitor.

Simplest case:

Use a continuous source!

Model a source with given wavelength and spatial distribution

*and*

... an infinitely short pulse length. I.e.  $t = 0$  for all neutron rays.

```
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
```

# Pulsed Sources:

Simplest case:

Use a continuous source!

Model a source with given wavelength and spatial distribution

... an infinitely sharp neutron rays.

Or: Use a chopper  
(Wednesday)

```
COMPONENT source
radius=0.1, dlambda=2.5, dlambda=1.5,
focus_xw=0.1, focus_yh=0.1, dist=5 )
AT (0,0,0) RELATIVE origin
```



# Pulsed Sources: Moderator

A flat pulsed source with uniform energy spectrum:

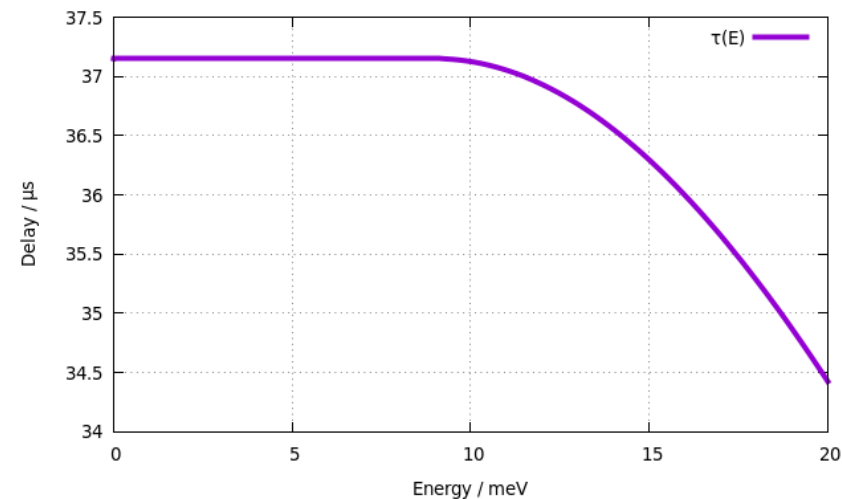
$$x \in U\left[-\frac{xwidth}{2}, \frac{xwidth}{2}\right] \quad y \in U\left[-\frac{yheight}{2}, \frac{yheight}{2}\right]$$

$$|v| = f(\lambda) ; \lambda \in U[L_{min} L_{max}]$$

Time structure is given by energy dependent probability density function:

$$f_t = \frac{1}{\tau} \exp\left(-\frac{t}{\tau}\right)$$

$$\tau = \begin{cases} t_0; & E < E_c \\ t_0 \left( \frac{1}{1 + \frac{(E - E_c)}{\gamma}} \right); & E \geq E_c \end{cases}$$





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# Pulsed Sources: SNS\_source

- Samples directly from tallies coming from e.g. MCNP target+moderator calculations.
- Originally from SNS but also used extensively at J-PARC
- Can be used (with the proper input files) to model CSNS-source.  
*Example (coming from you) is expected to be included in next release of McStas.*

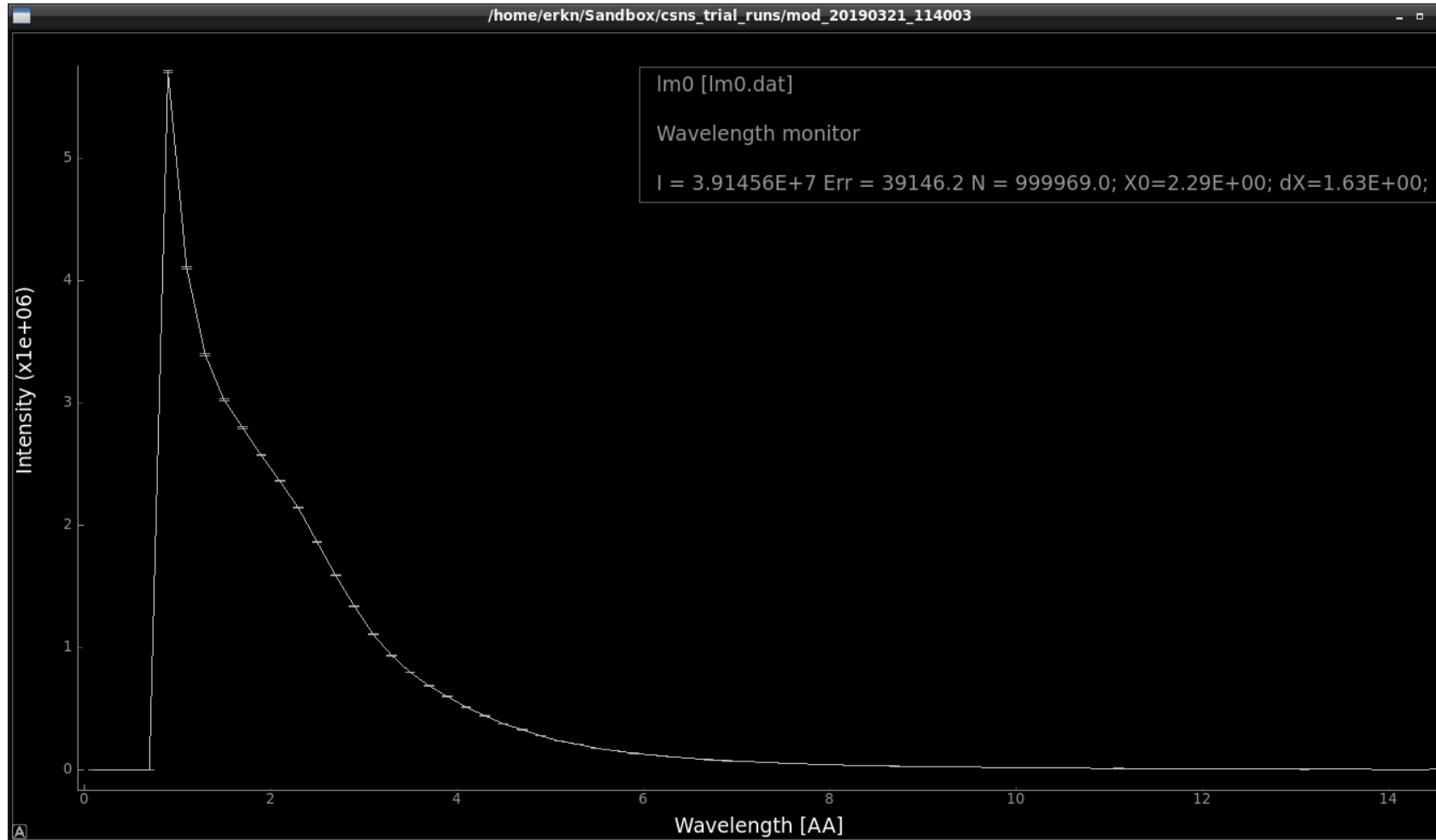
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# Pulsed Sources: SNS\_source



calculations.

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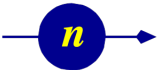
# Pulsed Sources: SNS\_source\_analytic

- Samples from fits of Padé-functions to tallies from SNS\_source.
  - Requires a complex fitting campaign
  - + Much faster than SNS\_source
  - + “Cleaner” distributions where statistics are sketchy
- Can be used (with the proper input files) to model CSNS-source.

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# Pulsed Sources: ViewModISIS

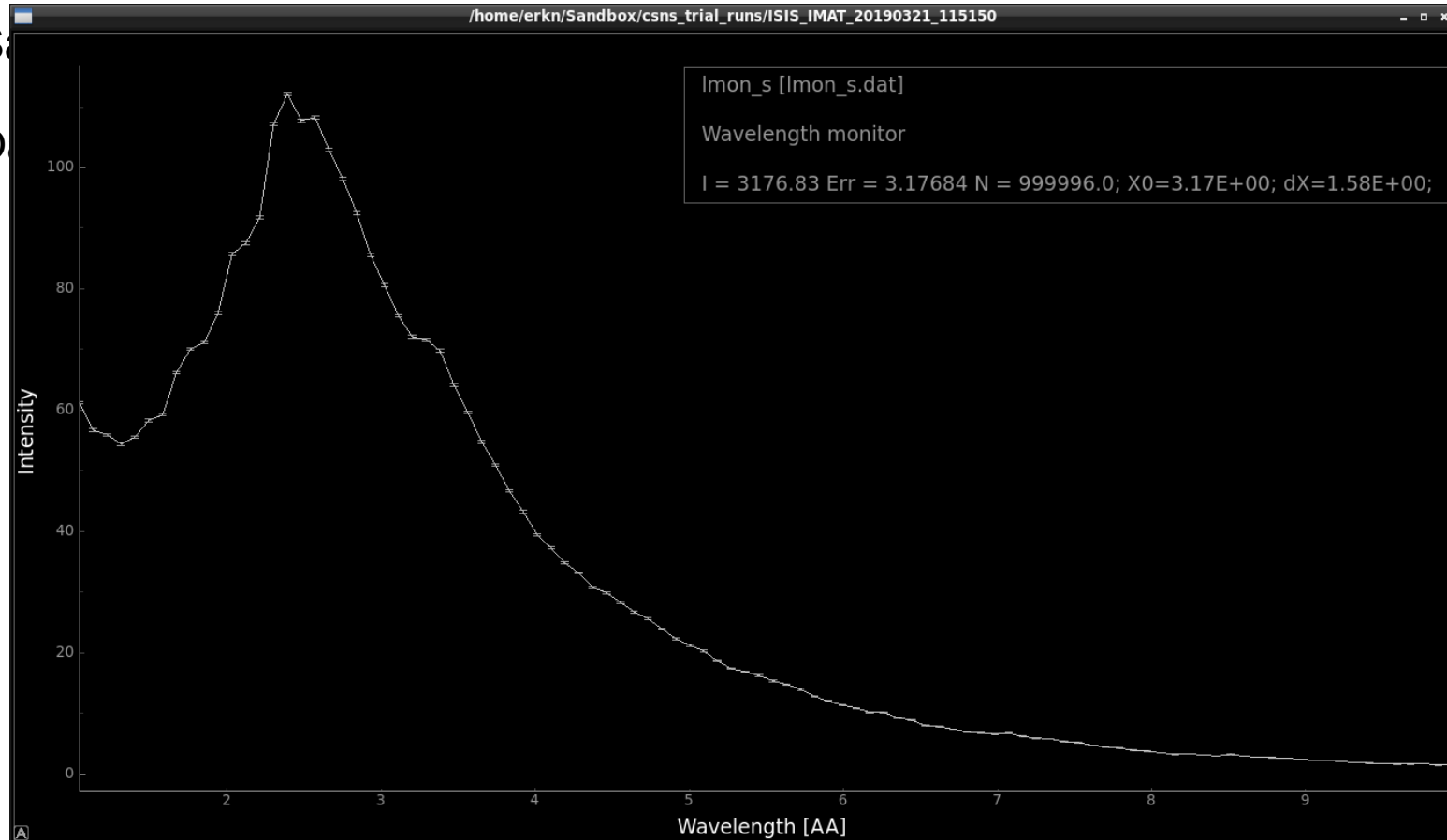
- Samples directly from tallies coming from e.g. MCNP target+moderator calculations.
- Data file supplied for each beam port at ISIS.

# Pulsed Sources: ViewModISIS

## ISIS T2: IMAT

● S

● D



culations.

# Monitors (some)

## 1D

- ◆ L\_monitor  $\rightarrow I(\lambda)$
- ◆ TOF\_monitor  $\rightarrow I(t)$
- ◆ Hdiv\_monitor  $\rightarrow I(\text{div}_x)$
- ◆ MeanPolLambda  $\rightarrow \langle \bar{P} \rangle(\lambda)$
- ◆ E\_monitor  $\rightarrow I(E)$

## 2D

- PSD\_monitor  $\rightarrow I(x, y)$
- PSD\_monitor\_4PI  $\rightarrow I(\theta, \phi)$
- PolLambda\_monitor  $\rightarrow I(\bar{P}, \lambda)$
- Divergence\_monitor  $\rightarrow I(\text{div}_x, \text{div}_y)$
- DivPos\_monitor  $\rightarrow I(\text{div}_x, x)$

## nD

- Monitor\_nD  $\rightarrow I(X)$
- or
- $I(X, Y)$
- or
- $Z(X, Y, Z)$
- or ...

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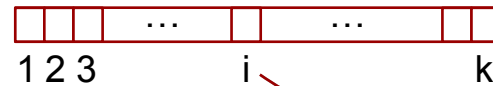
# Monitors: Quick examples

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



# In a histogram sense

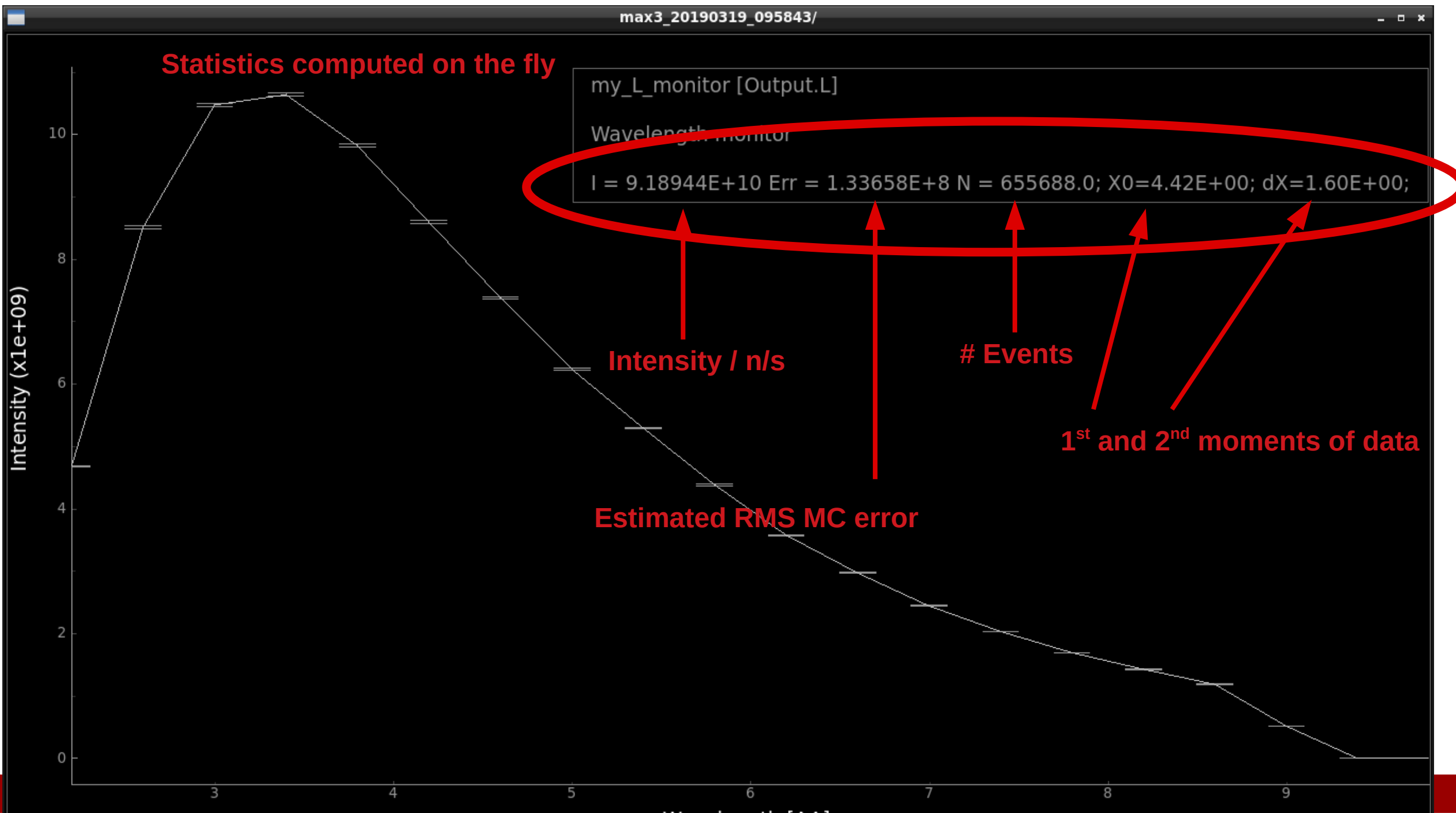
□ Imagine a histogram, e.g.  $\mathbf{I}(\lambda)$

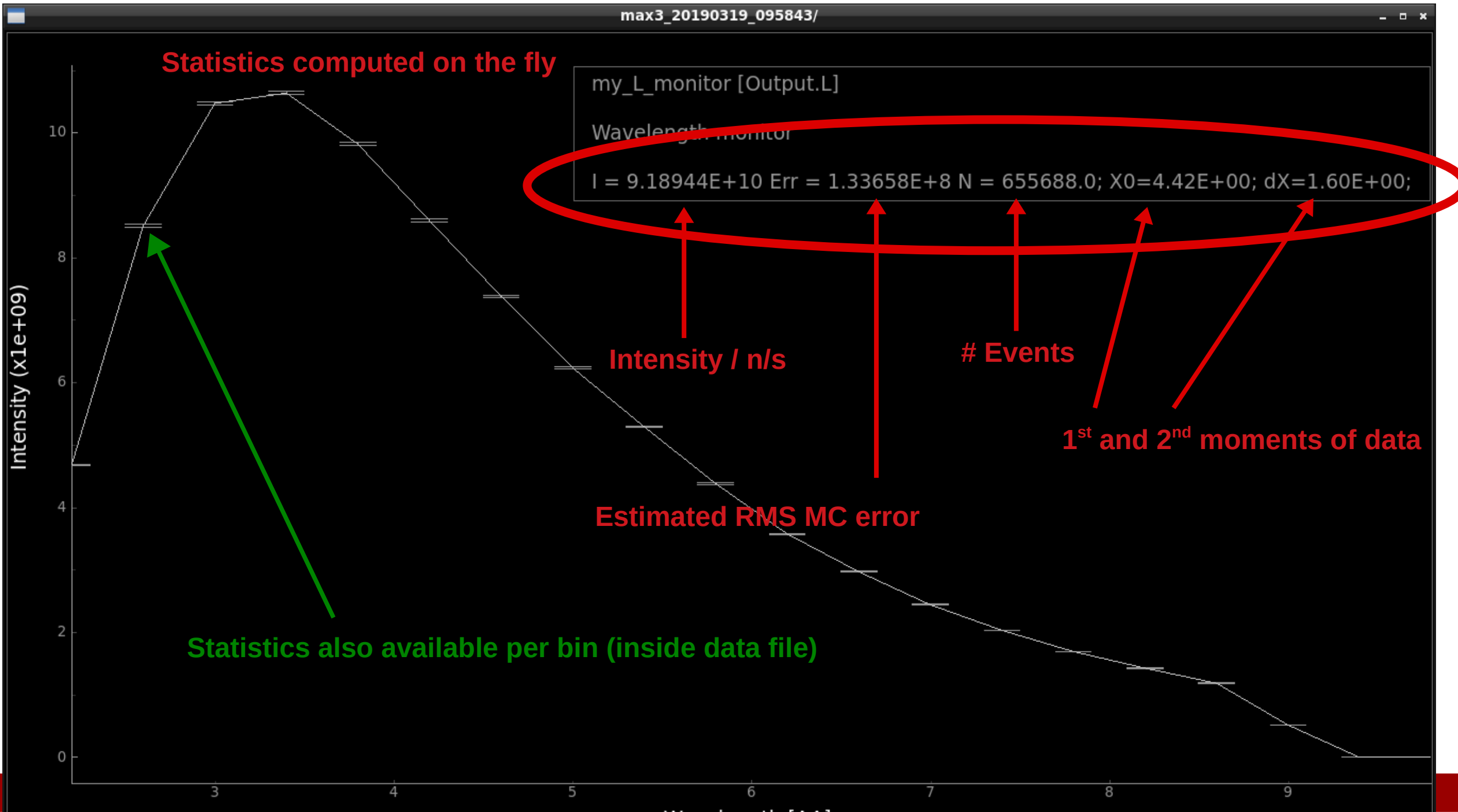


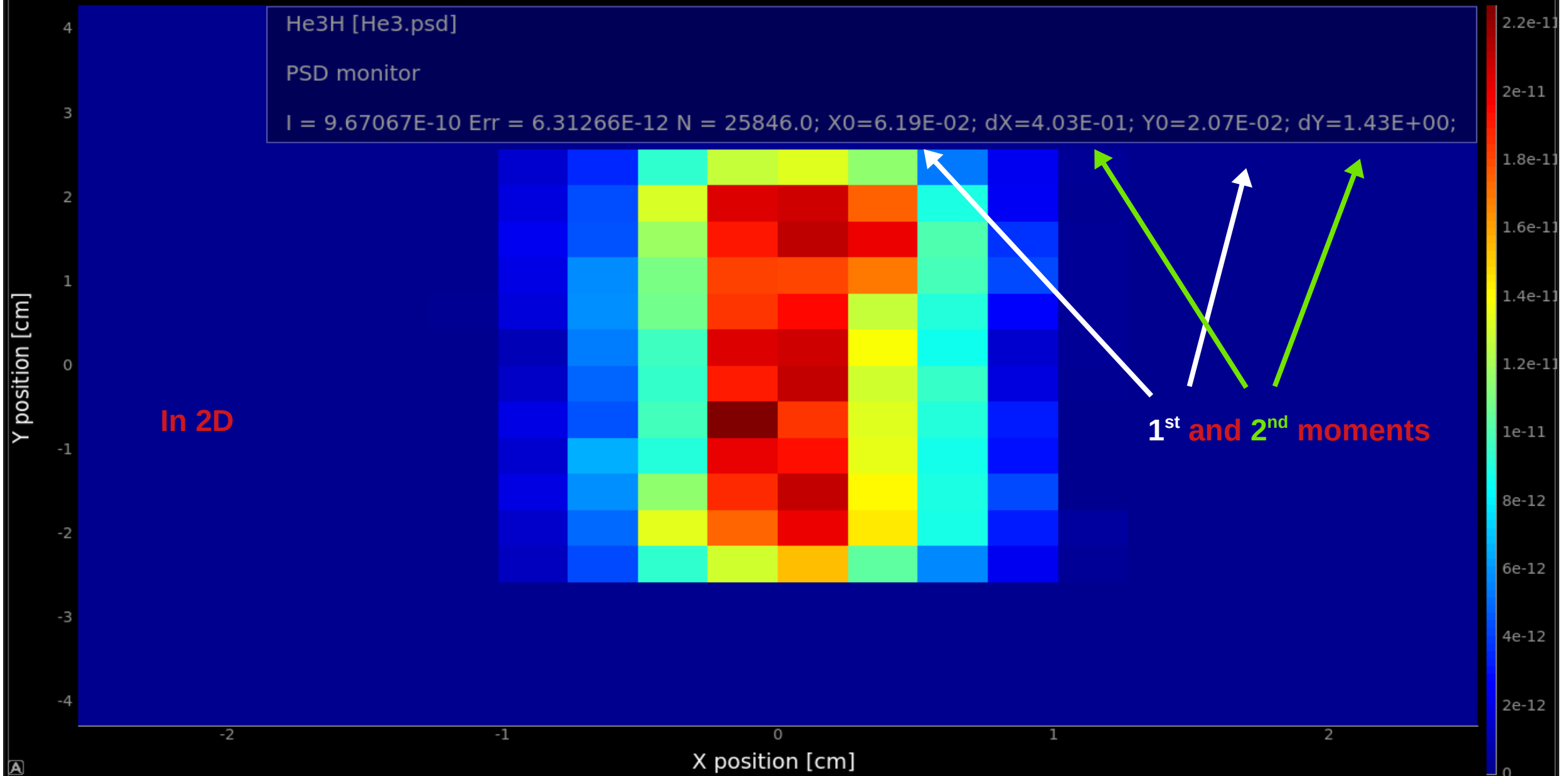
In bin  $i$ ,  $\mathbf{N}$  events each carrying a fractional intensity  $p_j$  so that

$$I = \sum_N p_j$$

□ The RMS variance over that set becomes our statistical error bar  $\mathbf{E}$







# From "Virtual experiments - the ultimate aim of neutron ray-tracing simulations", K. Lefmann et al., Journal of Neutron Research 16, 97-111 (2008)

Let  $n$  be the number of neutron rays reaching the detector, and let the rays have (different) weights,  $w_i$ . The simulated intensity is then given by

$$I = \sum_{i=1}^n w_i. \quad (1)$$

The estimate of the error on this number is calculated in the McStas manual [1], and the standard deviation is approximated by

$$\sigma^2(I) = \sum_{i=1}^n w_i^2. \quad (2)$$

In real experiments,  $w_i = 1$ , whence we reach  $I = n$  and  $\sigma(I) = \sqrt{I}$  as expected (for counts exceeding 10). Let the virtual time be denoted by  $t$ . The simulated counts during this time becomes

$$C = tI, \quad (3)$$

# From "Virtual experiments - the ultimate aim of neutron ray-tracing simulations", K. Lefmann et al., Journal of Neutron Research 16, 97-111 (2008)

and its error bar estimate is

$$\sigma^2(C) = t^2 \sigma^2(I). \quad (4)$$

However, to simulate a realistic counting statistics, we must fulfill

$$\sigma_{VE}(C_{VE}) = \sqrt{C_{VE}}. \quad (5)$$

This is obtained by adding to (3) a Gaussian noise  $E(\Sigma)$  of mean value zero and standard deviation  $\Sigma$ :

$$C_{VE} = tI + E(\Sigma). \quad (6)$$

The standard deviation for the VE becomes

$$\sigma_{VE}^2(C) = t^2 \sigma^2(I) + \Sigma^2. \quad (7)$$

Now, the requirement (5) allows us to determine  $\Sigma$ :

$$\Sigma^2 = tI - t^2 \sigma^2(I). \quad (8)$$

Since  $\Sigma^2$  must remain positive, we reach an upper limit on  $t$

$$t_{\max} = \frac{I}{\sigma^2(I)}. \quad (9)$$

# Sketch of an algorithm...

1. On a given McStas histogram

2. For the non-zero bins. calculate

$$t_{\max} = \frac{I}{\sigma^2(I)}.$$

$t_{\max}$

The *smallest* defines the “maximal counting time” allowed by your statistics

3. Preferably a “background” should be added - use a “known experimental value” or an estimate...

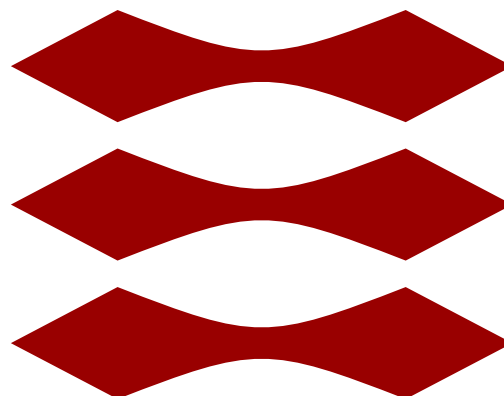


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SPALLATION  
SOURCE

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DTU



中国  
China

中国散裂中子源

China Spallation Neutron Source

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