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
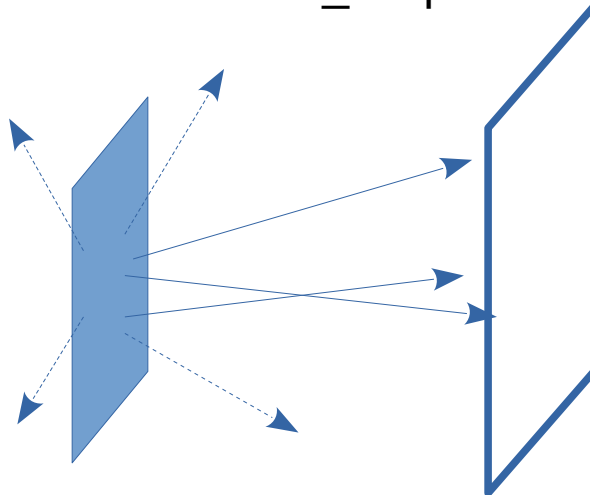
Sources: Source_Maxwell_3

```
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:

$$I(\lambda) = \sum_{i \in 1,2,3} I_i M(\lambda, T_i); \qquad M(\lambda, T_i) = 2\,\alpha^2 \exp\left(\frac{-\alpha}{\lambda^2}\right)/\lambda^5;$$
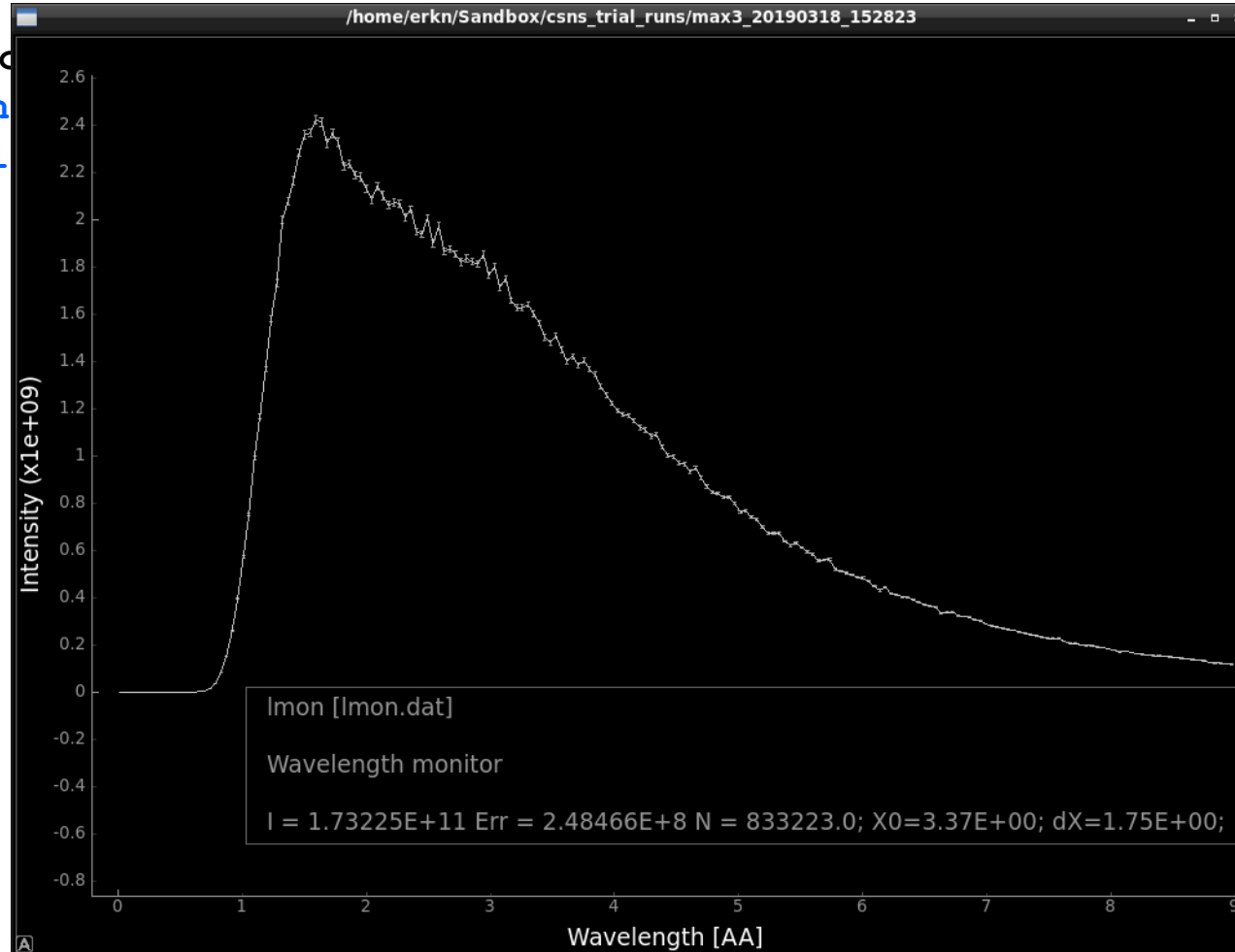
$$\alpha = 949.0\,K\,AA^2/T_i$$

Sources: Source_Maxwell_3

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

...om the PSI cold source

Imon [lmon.dat]

Wavelength monitor

I = 1.73225E+11 Err = 2.48466E+8 N = 833223.0; X0=3.37E+00; dX=1.75E+00;

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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…
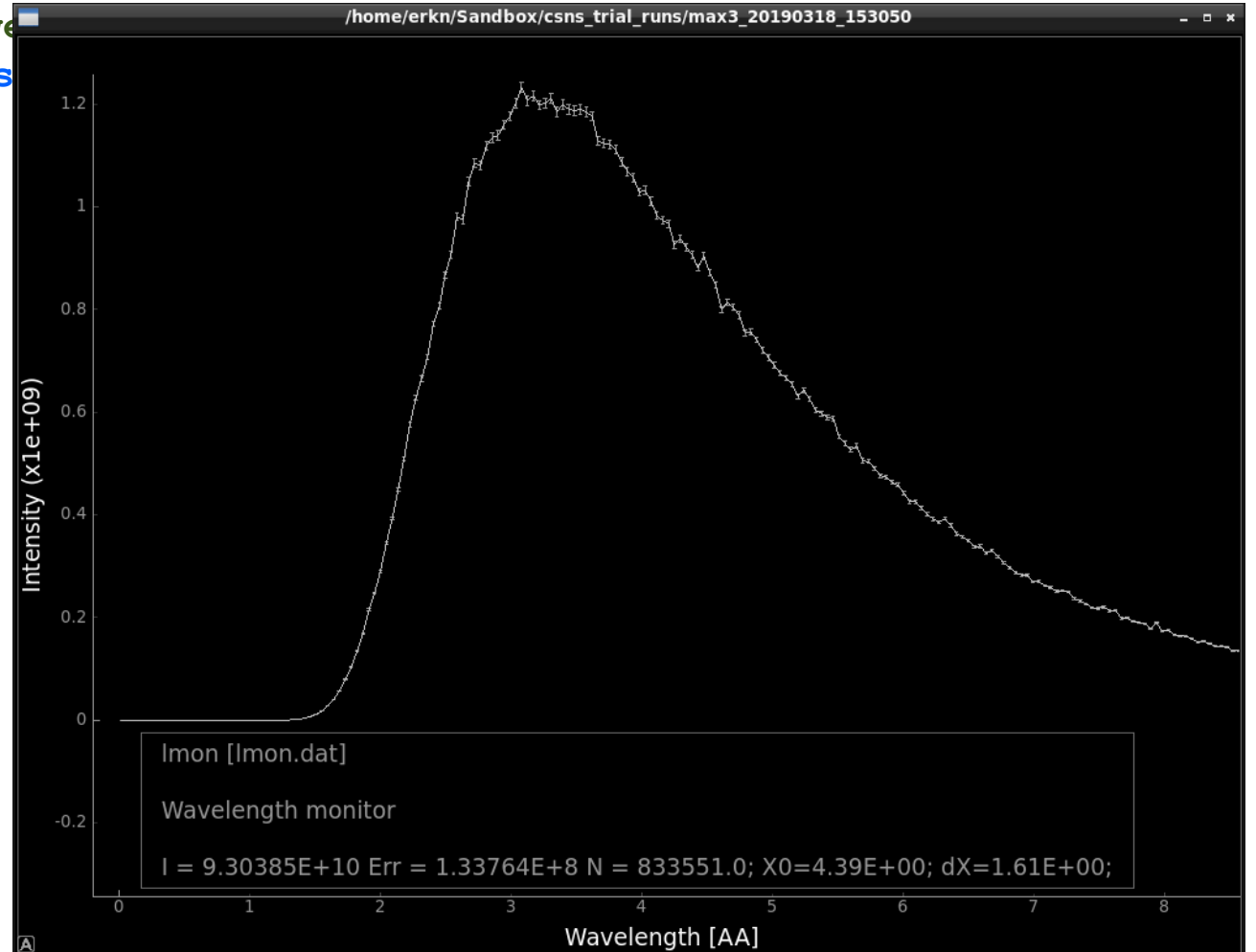
Input parameters

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

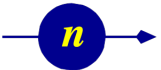# Sources: Source_gen (Source_gen4)

```
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.

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MCPL_input/output

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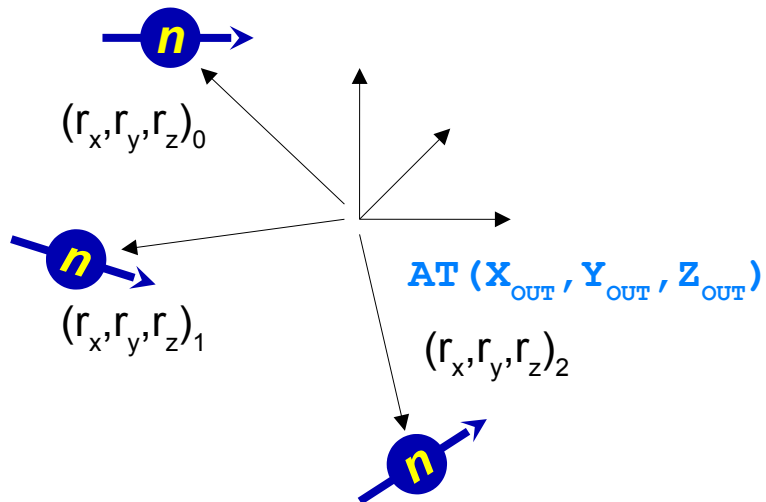"T. Kittelmann et. al., "", J. Phys. Comp., 2017

```
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
```

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MCPL_input/output

Can include an Implicit Translation:

MCPL_output.comp
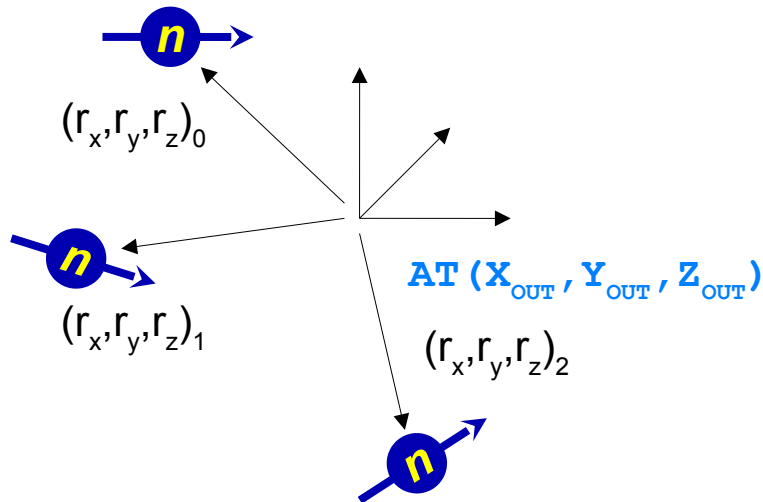
$(r_x, r_y, r_z)_0$

$(r_x, r_y, r_z)_1$

AT (X_{OUT}, Y_{OUT}, Z_{OUT})

$(r_x, r_y, r_z)_2$

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MCPL_input/output

Can include an Implicit Translation:

MCPL_input.comp

$(r_x, r_y, r_z)_0$

AT (X_{IN} , Y_{IN} , Z_{IN})

$(r_x, r_y, r_z)_1$

$(r_x, r_y, r_z)_2$

MCPL_output.comp

BECOMES
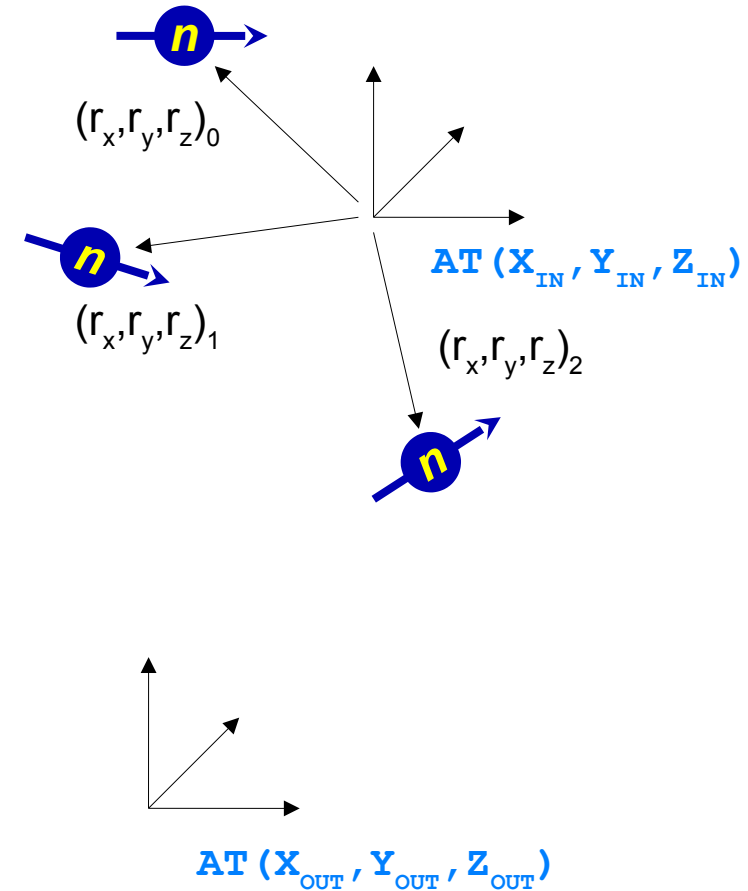
$(r_x, r_y, r_z)_0$

$(r_x, r_y, r_z)_1$

AT (X_{OUT} , Y_{OUT} , Z_{OUT})

$(r_x, r_y, r_z)_2$

AT (X_{OUT} , Y_{OUT} , Z_{OUT})

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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
```

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Pulsed Sources:

Simplest case:
    Use a continuous source!

Model a source with given wavelength and spatial distribution

… an infinitely sh... ...eutron rays.

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

Or: Use a chopper (Wednesday)

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:

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

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

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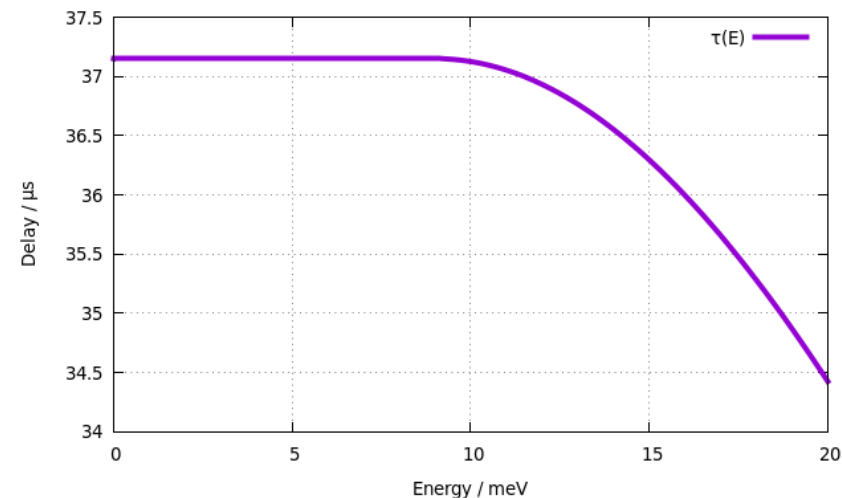
Pulsed Sources: SNS_source

- 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.
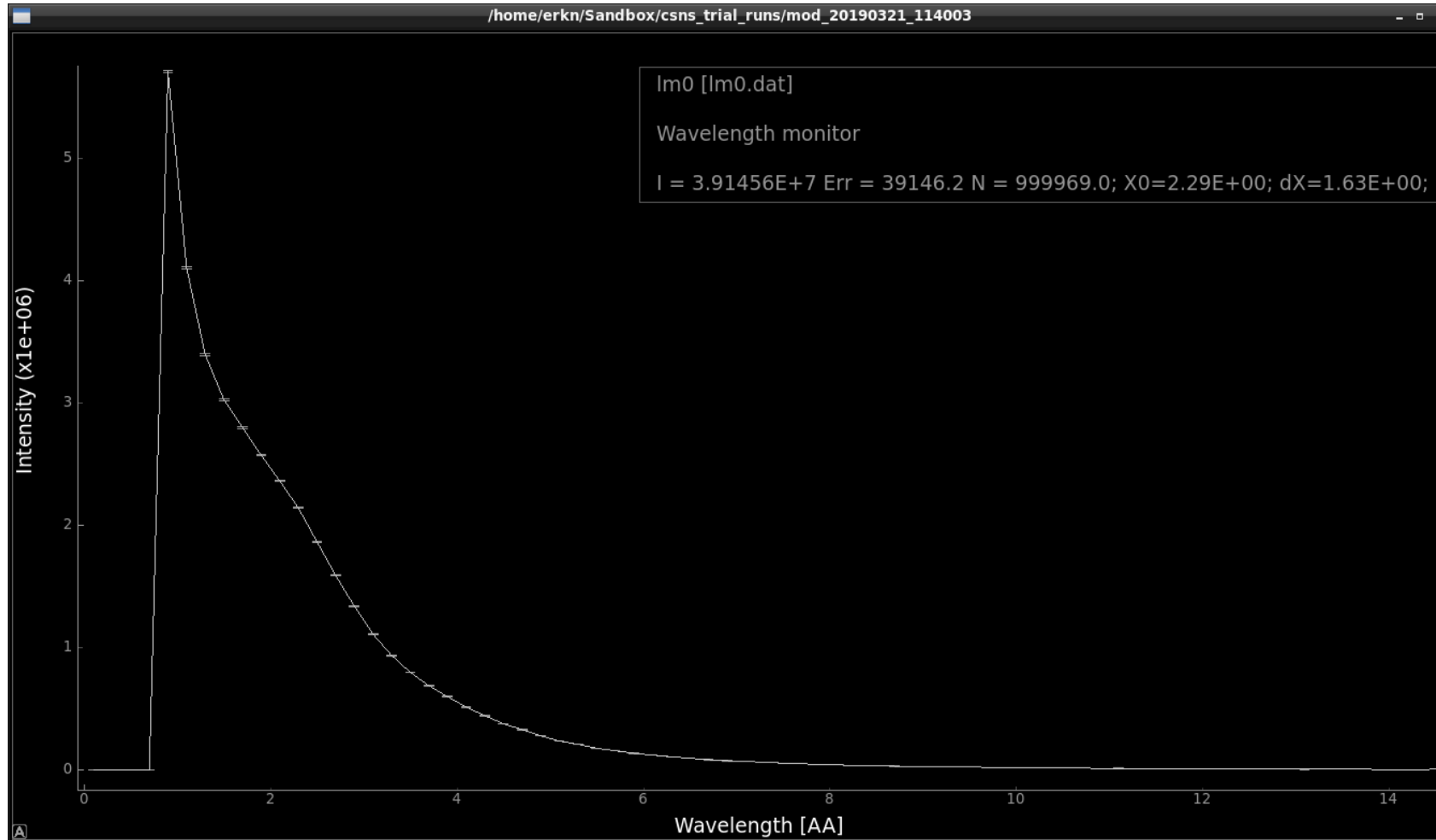*Example (coming from you) is expected to be included in next release of McStas.*

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Pulsed Sources: SNS_source

/home/erkn/Sandbox/csns_trial_runs/mod_20190321_114003

lm0 [lm0.dat]

Wavelength monitor

I = 3.91456E+7 Err = 39146.2 N = 999969.0; X0=2.29E+00; dX=1.63E+00;

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.
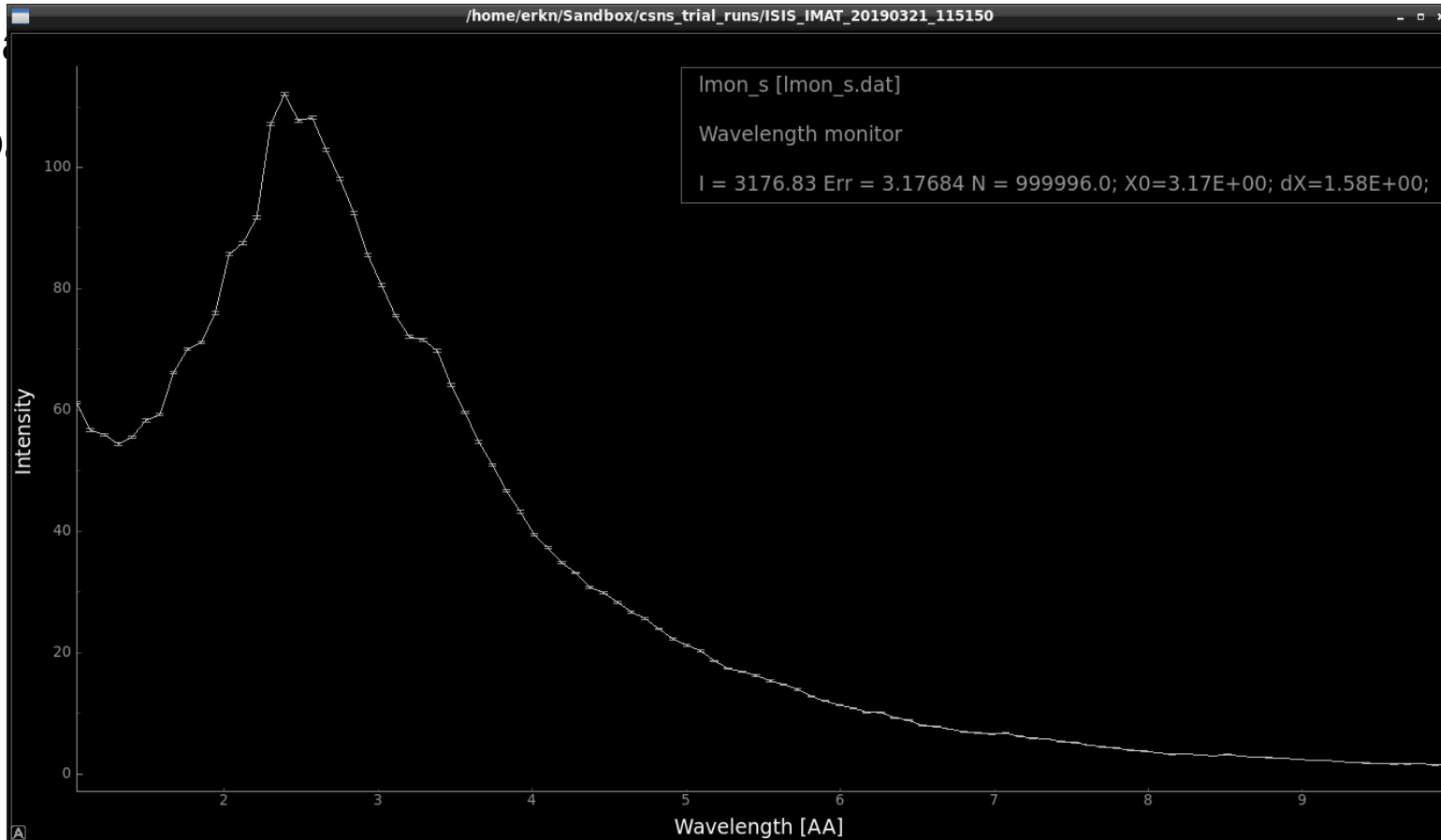
Pulsed Sources: ViewModISIS

- 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

- Sa... ...culations.

- D...

/home/erkn/Sandbox/csns_trial_runs/ISIS_IMAT_20190321_115150

lmon_s [lmon_s.dat]

Wavelength monitor

I = 3176.83 Err = 3.17684 N = 999996.0; X0=3.17E+00; dX=1.58E+00;

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Monitors (some)

1D

◆ L_monitor → $I(\lambda)$

◆ TOF_monitor → $I(t)$

◆ Hdiv_monitor → $I(div._x)$

◆ 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 → $I(\bar{\boldsymbol{P}}, \lambda)$

● Divergence_monitor → $I(div._x, div._y)$

● DivPos_monitor → $I(div._x, x)$

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)
```
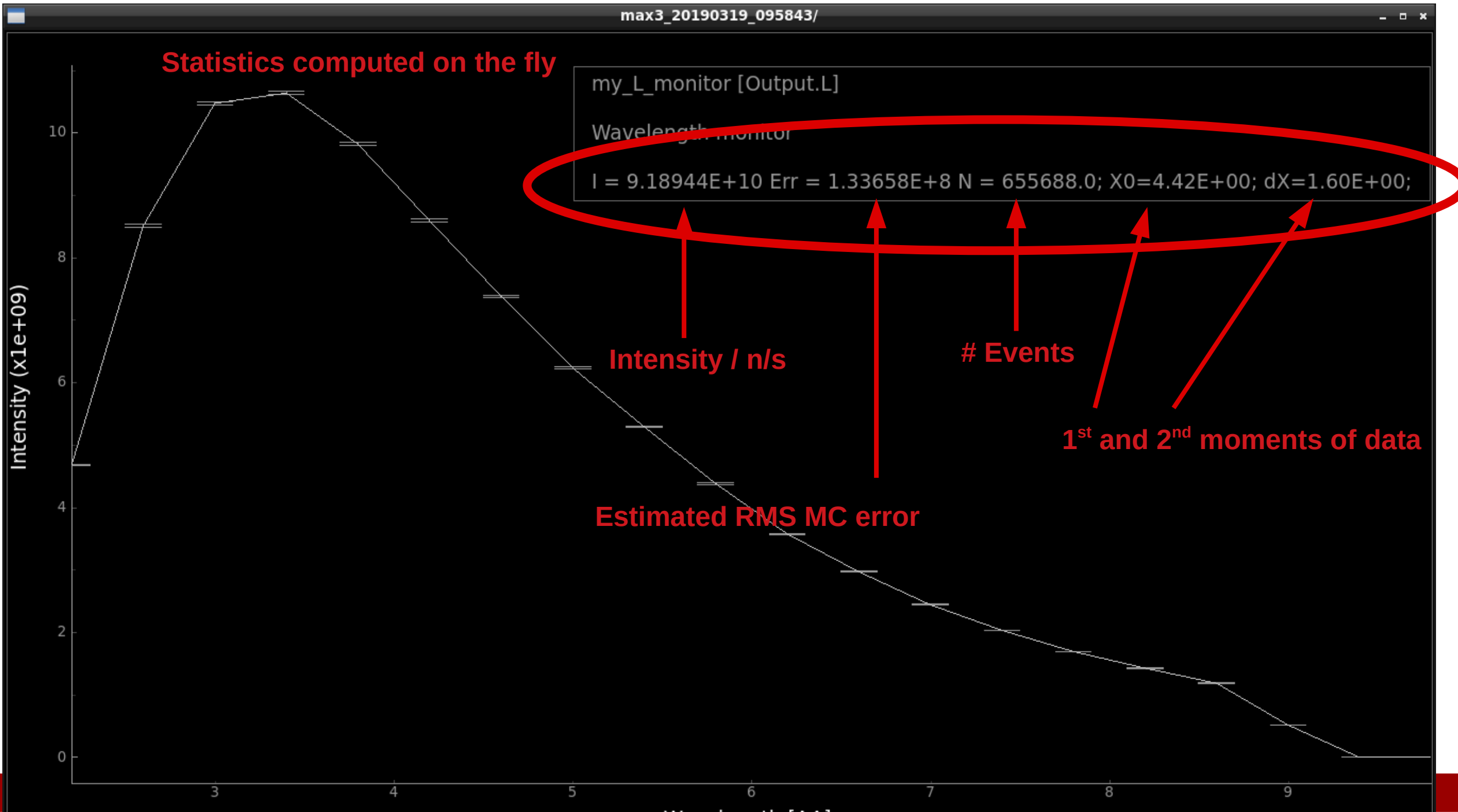
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In a histogram sense
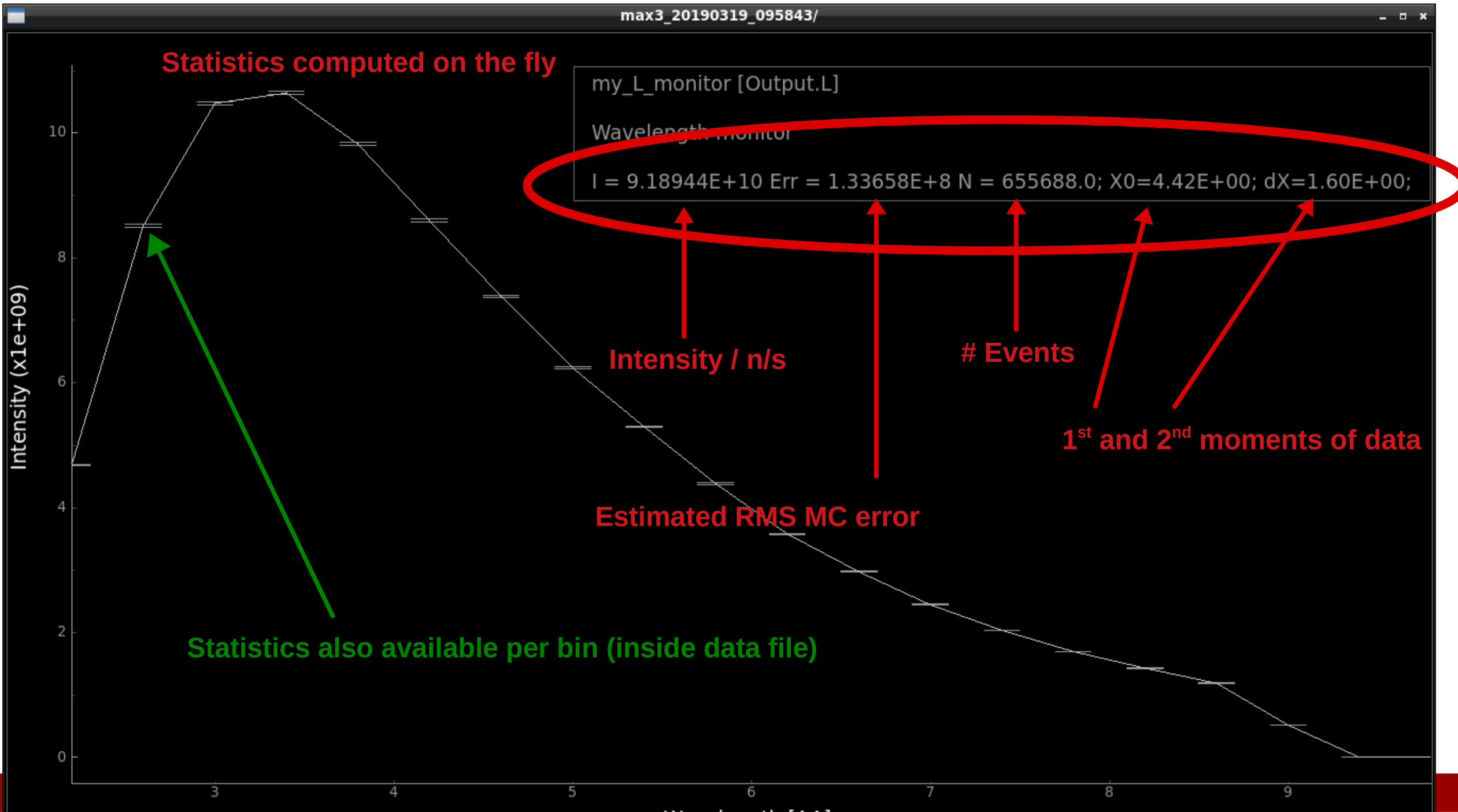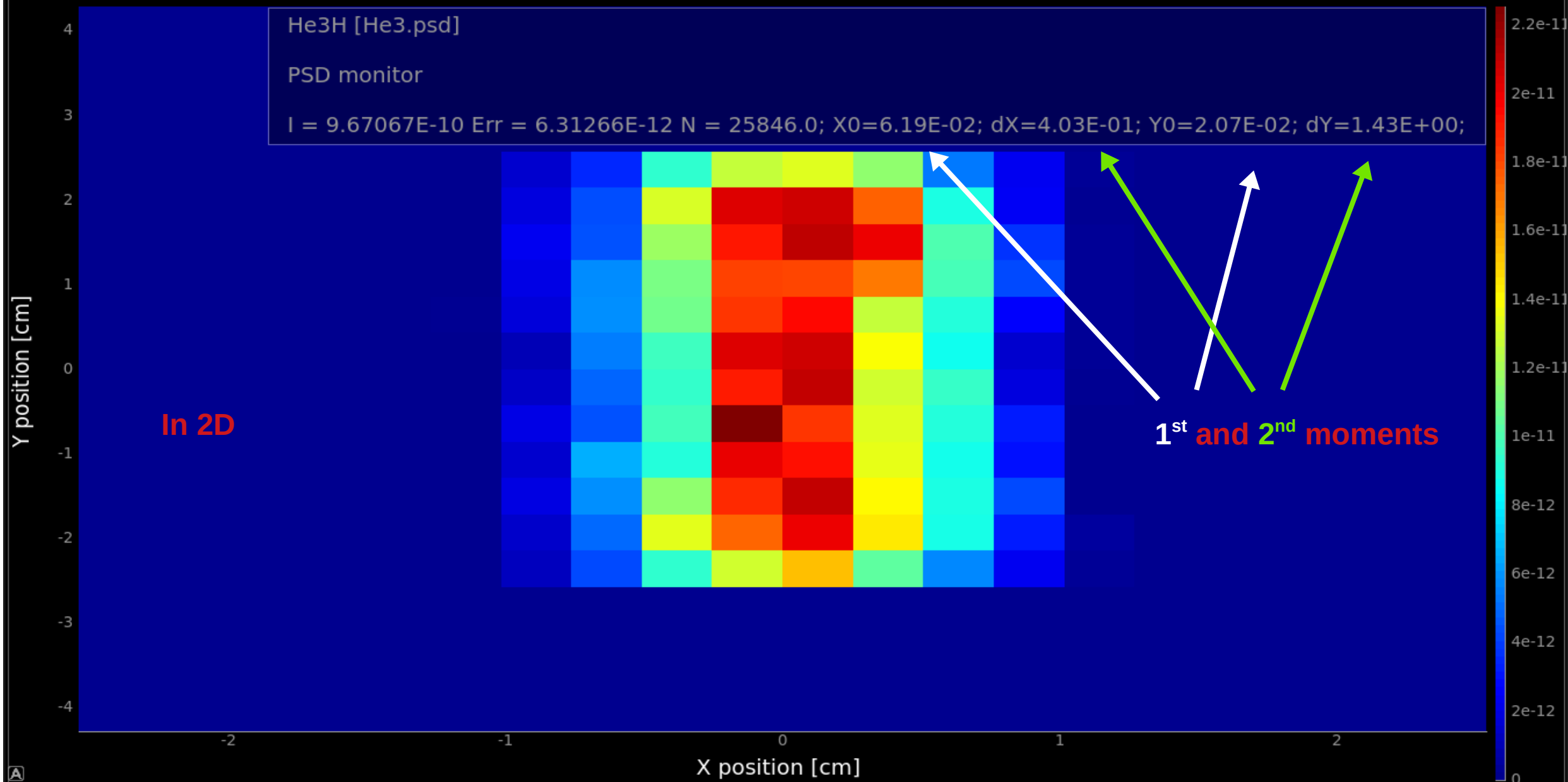
- Imagine a histogram, e.g. $\mathbf{I}(\lambda)$
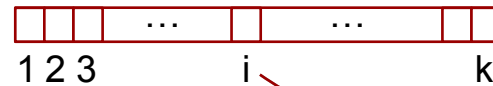
In bin i, $\mathbf{N}$ events each carrying a fractional intensity p_j so that

$$I = \sum_N p_j$$

1 2 3   i   k

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

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He3H [He3.psd]

PSD monitor

I = 9.67067E-10 Err = 6.31266E-12 N = 25846.0; X0=6.19E-02; dX=4.03E-01; Y0=2.07E-02; dY=1.43E+00;

In 2D

1st and 2nd moments

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

$$I = \sum_{i=1}^{n} w_i. \tag{1}$$

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

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

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

$$C = tI, \tag{3}$$

and its error bar estimate is

$$\sigma^2(C) = t^2\sigma^2(I). \tag{4}$$

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

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

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

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

The standard deviation for the VE becomes

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

Now, the requirement (5) allows us to determine Σ:

$$\Sigma^2 = tI - t^2\sigma^2(I). \tag{8}$$

Since Σ^2 must remain positive, we reach an upper limit on t

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

Sketch of an algorithm…

1. On a given McStas histogram

2. For the non-zero bins, calculate

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

$$t_{\mathbf{max}}$$

   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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Monitor_nD

The all-in-one , swiss-army-knife of monitors

Monitor_nD *can have almost any shape, and record any requested standard quantities*

Monitor_nD

Examples

```
COMPONENT MyMon = Monitor_nD( xwidth = 0.1, yheight = 0.1, zdepth = 0,
                    options = "intensity per cm2 angle,limits=[-5 5],
                    bins=10,with borders, file = mon1")
```

options = "banana, theta limits=[10,130], bins=120, y"

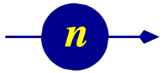*options = "multiple kx ky kz, auto abs log t, and list all neutrons"*

Monitor_nD

… or monitor just about anything:

```
COMPONENT MyMon = Monitor_nD(xwidth = 0.1, yheight = 0.1,
    user1=age, username1="Age of the Captain [years]",
    options="user1, auto")
```

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Exercise 2:

Head over to the github site and continue the exercise we started before:

https://github.com/McStasMcXtrace/Schools/tree/master/CSNS_March_2019/1_Monday_March_25th/ 2_Sources_and_Monitors
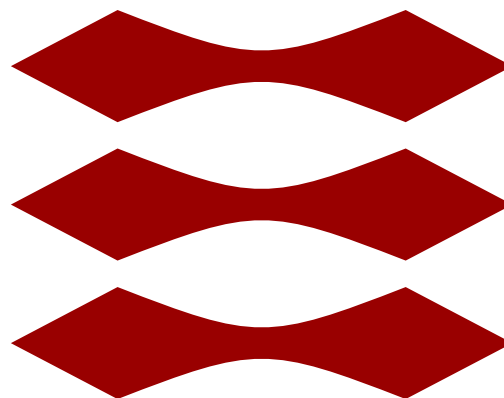
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