DTU Physics

Sources and Monitors part 2.

中国散裂中子源

2019 CSNS McStas School

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*

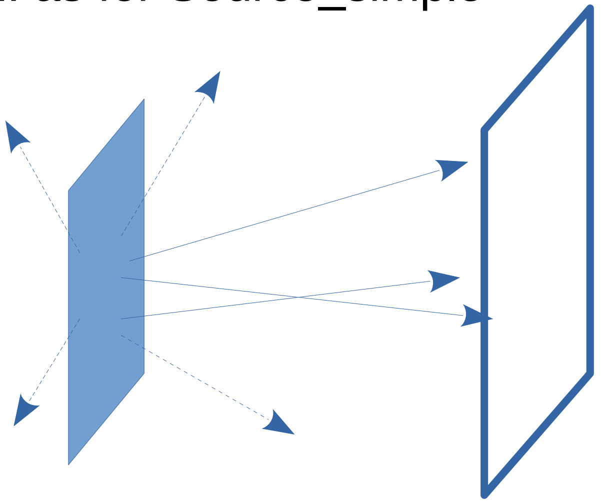
2019 CSNS McStas School

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



2019 CSNS McStas School

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:

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

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

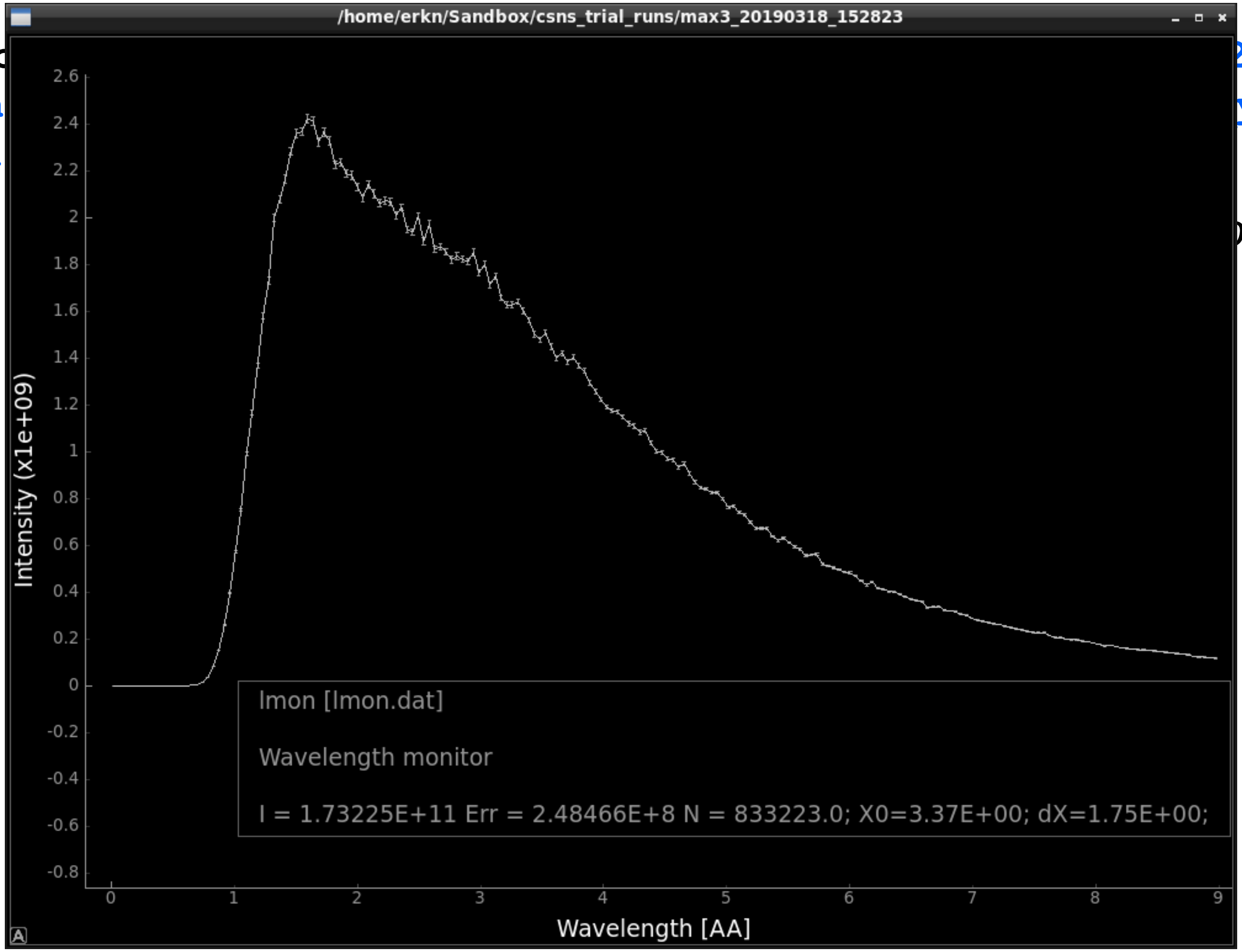
中国散裂中子源

2019 CSNS McStas School

Sources: Source_Maxwell_3

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

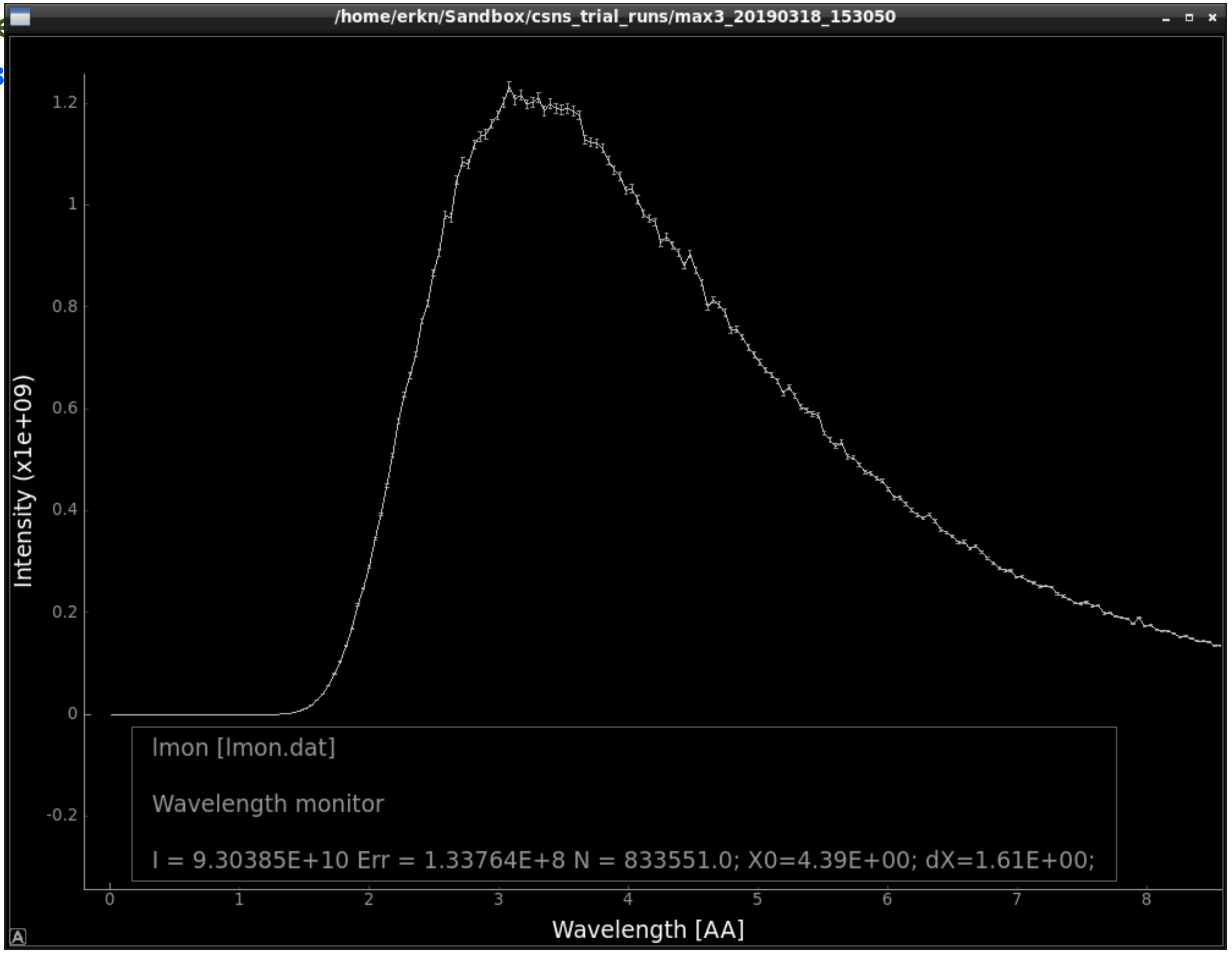
om the PSI cold source



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…



2019 CSNS McStas School

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

2019 CSNS McStas School

McStas

2019 CSNS McStas School

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")
```

中国散裂中子源

2019 CSNS McStas School

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.

2019 CSNS McStas School

中国散裂中子源

2019 CSNS McStas School

Sources: 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
```

Sources: Pulsed sources

Add a sample here
TOF_monitor.

2019 CSNS McStas School

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
```

2019 CSNS McStas School

Pulsed Sources:

Simplest case:

Use a continuous source!

Model a source with given wavelength and spatial distribution

… an infinitely sh eutron rays.

Or: Use a chopper

(Wednesday)

```
COMPONENT si
    radius=0.        a0=2.5, dlambda=1.5,
    focus_xw=    , focus_yh=0.1, dist=5 )
AT(0,0,0) RELATIVE origin
```

Pulsed Sources: Moderator

A flat pulsed source with uniform energy spectrum:

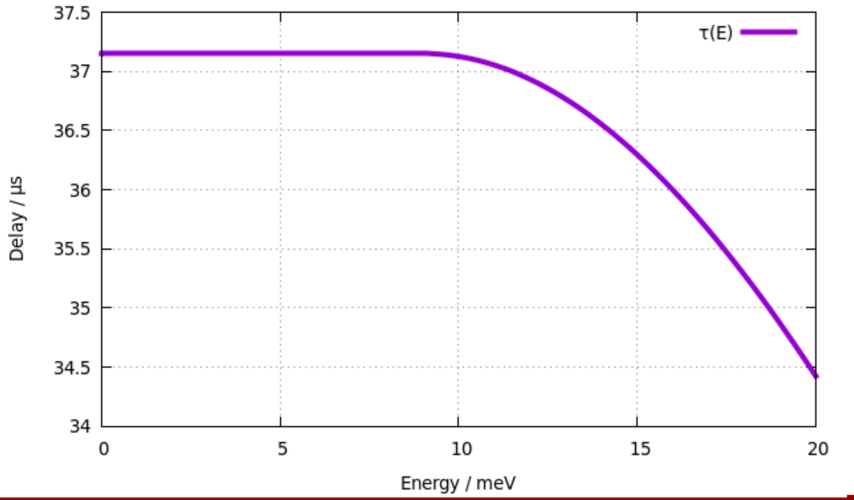
$$x \in U\left[-\frac{xwidth}{2}, \frac{xwidth}{2}\right] \quad y \in U\left[-\frac{yheight}{2}, \frac{yheight}{2}\right]$$

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

Time structure is given by energy dependent probability density function:

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

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



2019 CSNS McStas School

McStas

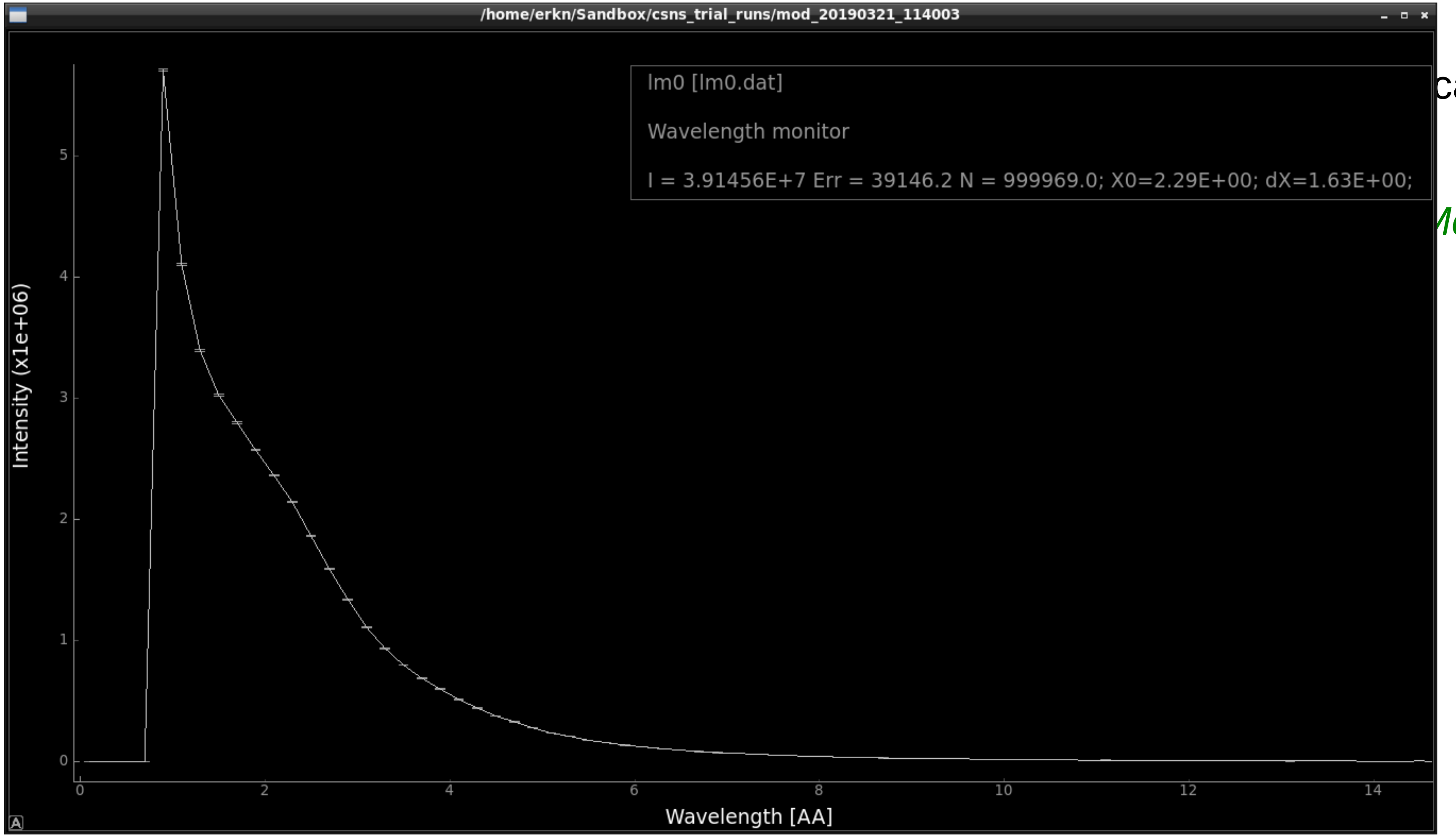
2019 CSNS McStas School

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.

2019 CSNS McStas School

Pulsed Sources: SNS_source



calculations.

cStas.

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.

2019 CSNS McStas School

2019 CSNS McStas School

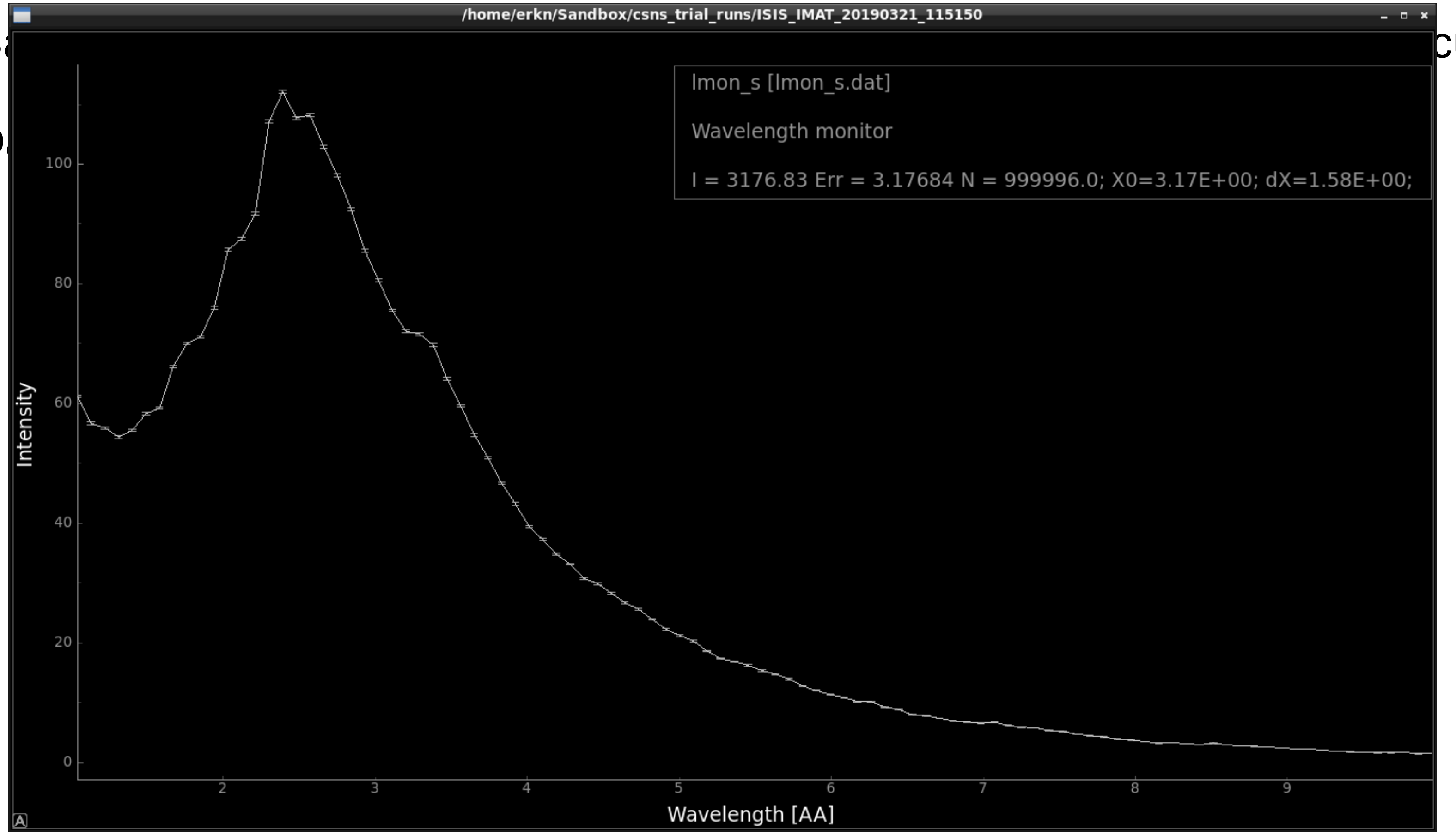
Pulsed Sources: ViewModISIS

- 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…



2019 CSNS McStas School

Monitors (some)

1D

- L_monitor → $I(\lambda)$
- TOF_monitor → $I(t)$
- Hdiv_monitor → $I(div._x)$
- MeanPolLambda → $\langle \bar{\mathbf{P}} \rangle (\lambda)$
- E_monitor → $I(E)$

2D

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

2019 CSNS McStas School

McStas

Monitors: Quick examples

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

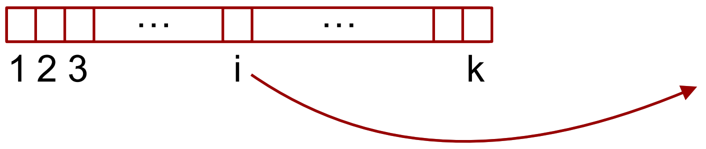
2019 CSNS McStas School

中国散裂中子源

2019 CSNS McStas School

In a histogram sense

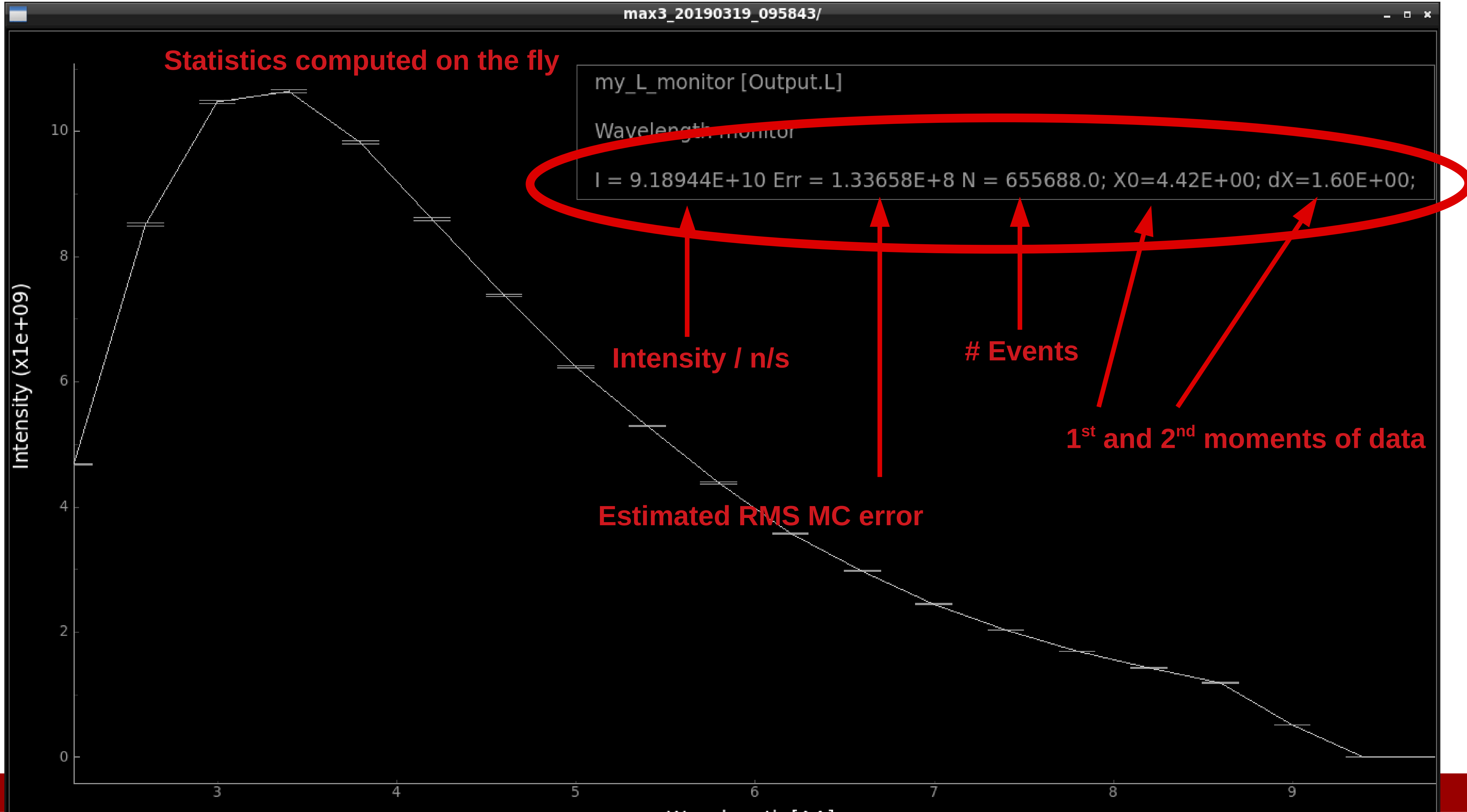
- Imagine a histogram, e.g. **I**(λ)



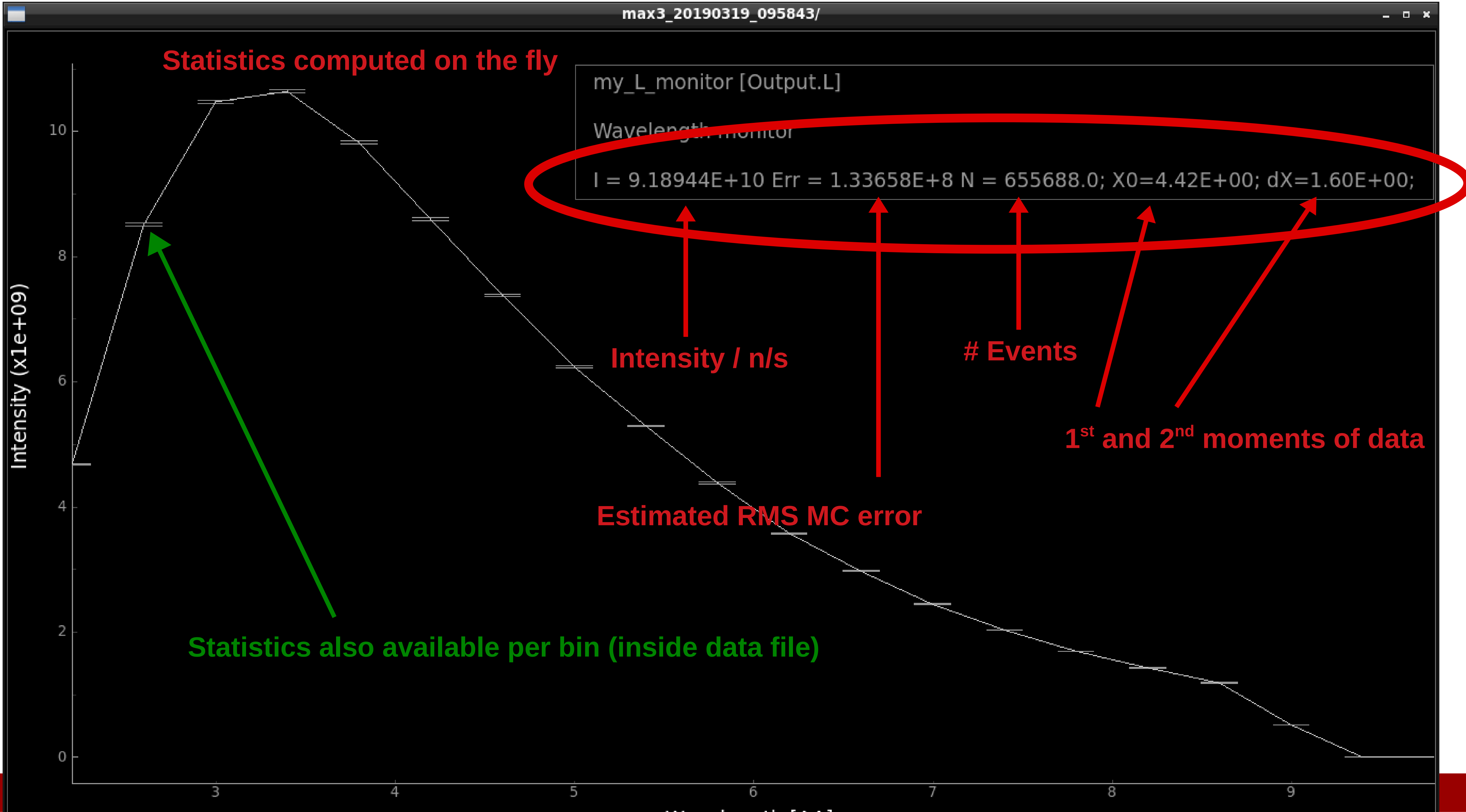
In bin *i*, ***N*** events each carrying a fractional intensity p_j so that

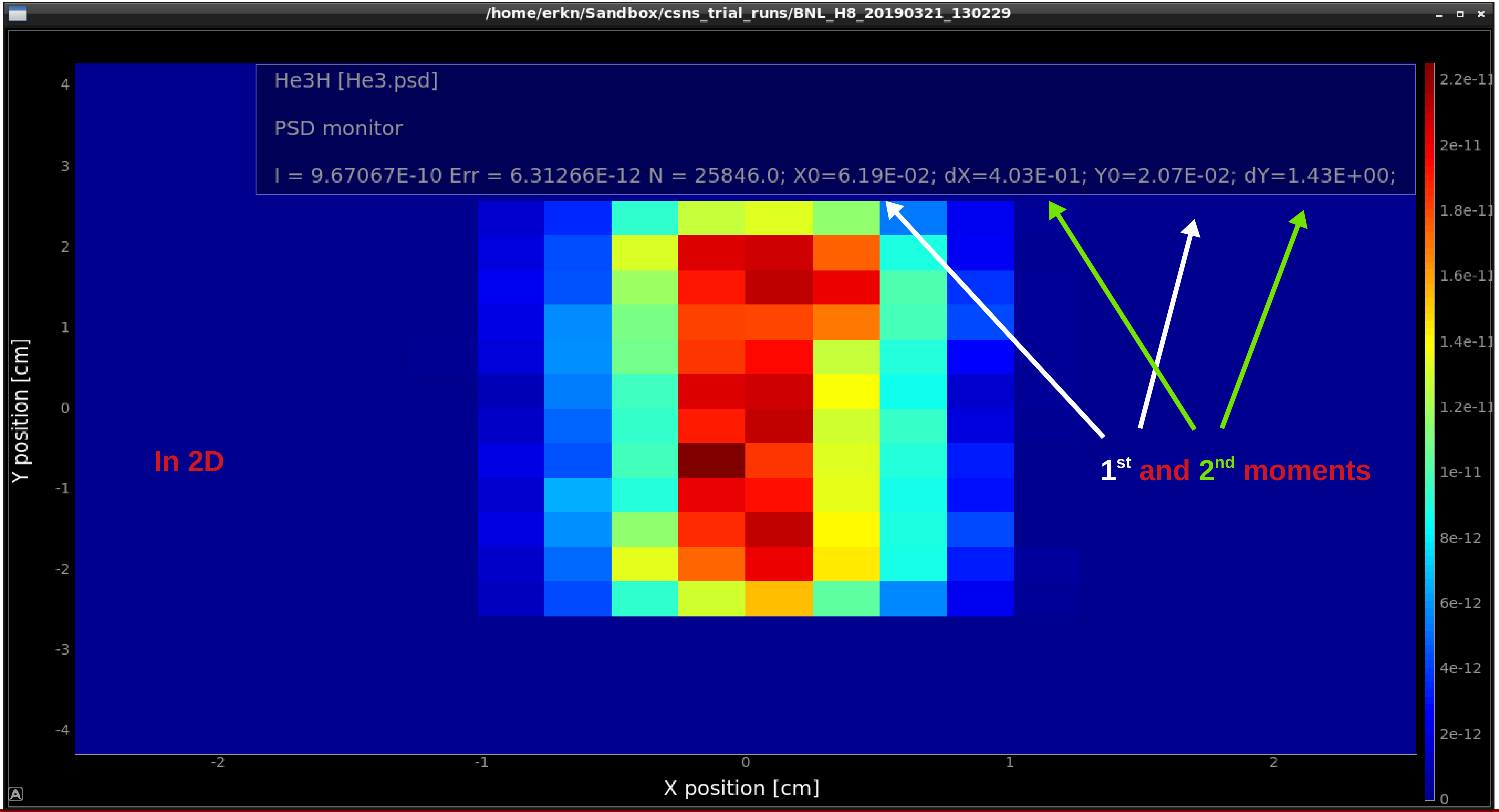
$$I = \sum_N p_j$$

- The RMS variance over that set becomes our statistical error bar ***E***



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
Intensity (x1e+09)
10
8
6
4
2
0
3
4
5
6
7
8
9


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
Statistics also available per bin (inside data file)
Intensity (x1e+09)
0
2
4
6
8
10
3
4
5
6
7
8
9


/home/erkn/Sandbox/csns_trial_runs/BNL_H8_20190321_130229
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;
Y position [cm]
X position [cm]
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

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

2019 CSNS McStas School

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

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

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

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

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

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

The standard deviation for the VE becomes

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

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

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

2019 CSNS McStas School

McStas

Sketch of an algorithm…

1. On a given McStas histogram

2. For the non-zero bins, calculate

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

   The *smallest* t_{max} defines the "maximal counting time" allowed by your statistics

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

EUROPEAN SPALLATION SOURCE

DTU

中国散裂中子源

China Spallation Neutron Source

McStas

2019 CSNS
McStas School