

**Joint ICTP-IAEA Workshop on Monte Carlo Radiation Transport
and Associated Data Needs for Medical Applications**

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ICTP, Trieste, Italy

Lecture 11

Phase space file analysis with beamdp

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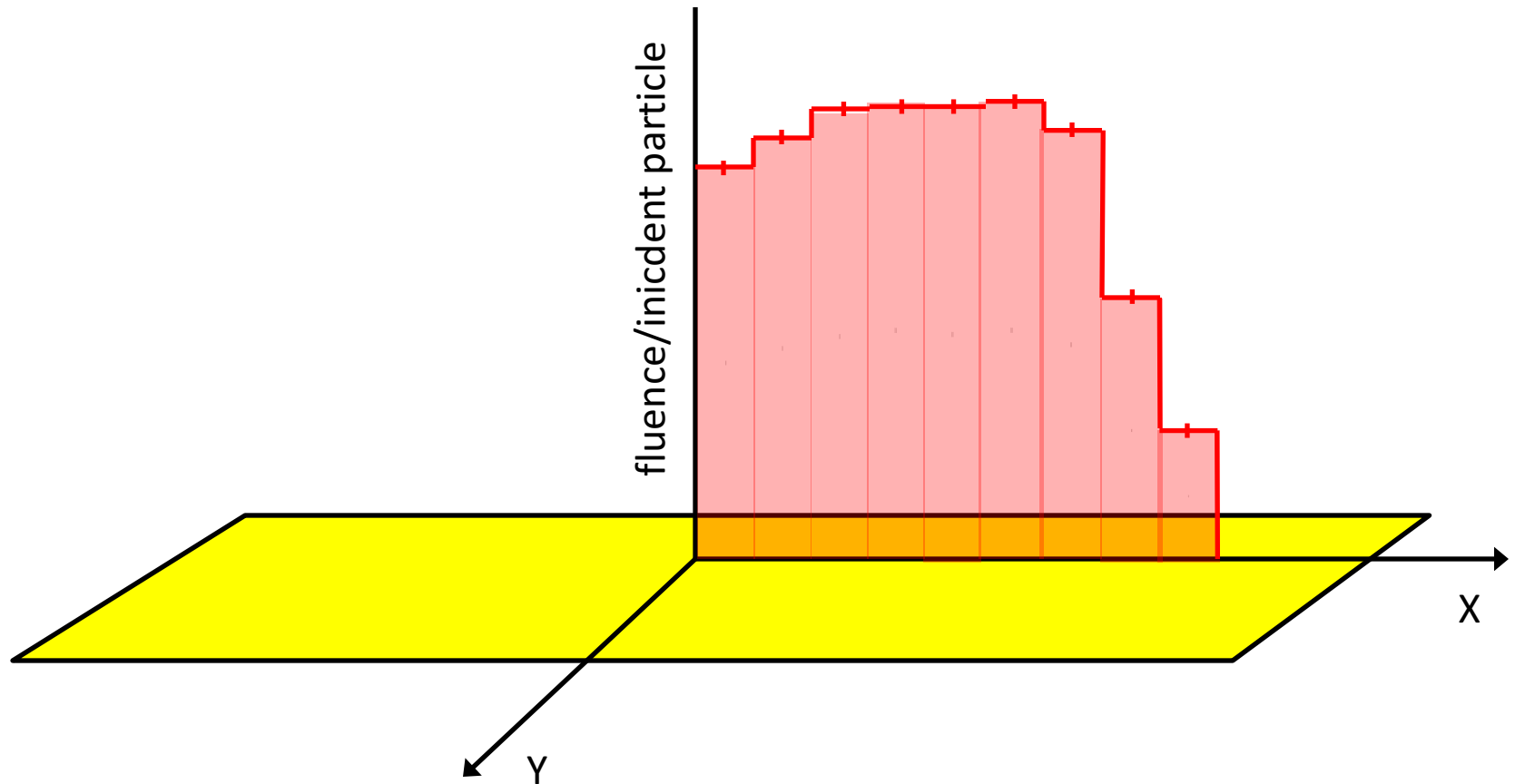


Government
of Canada

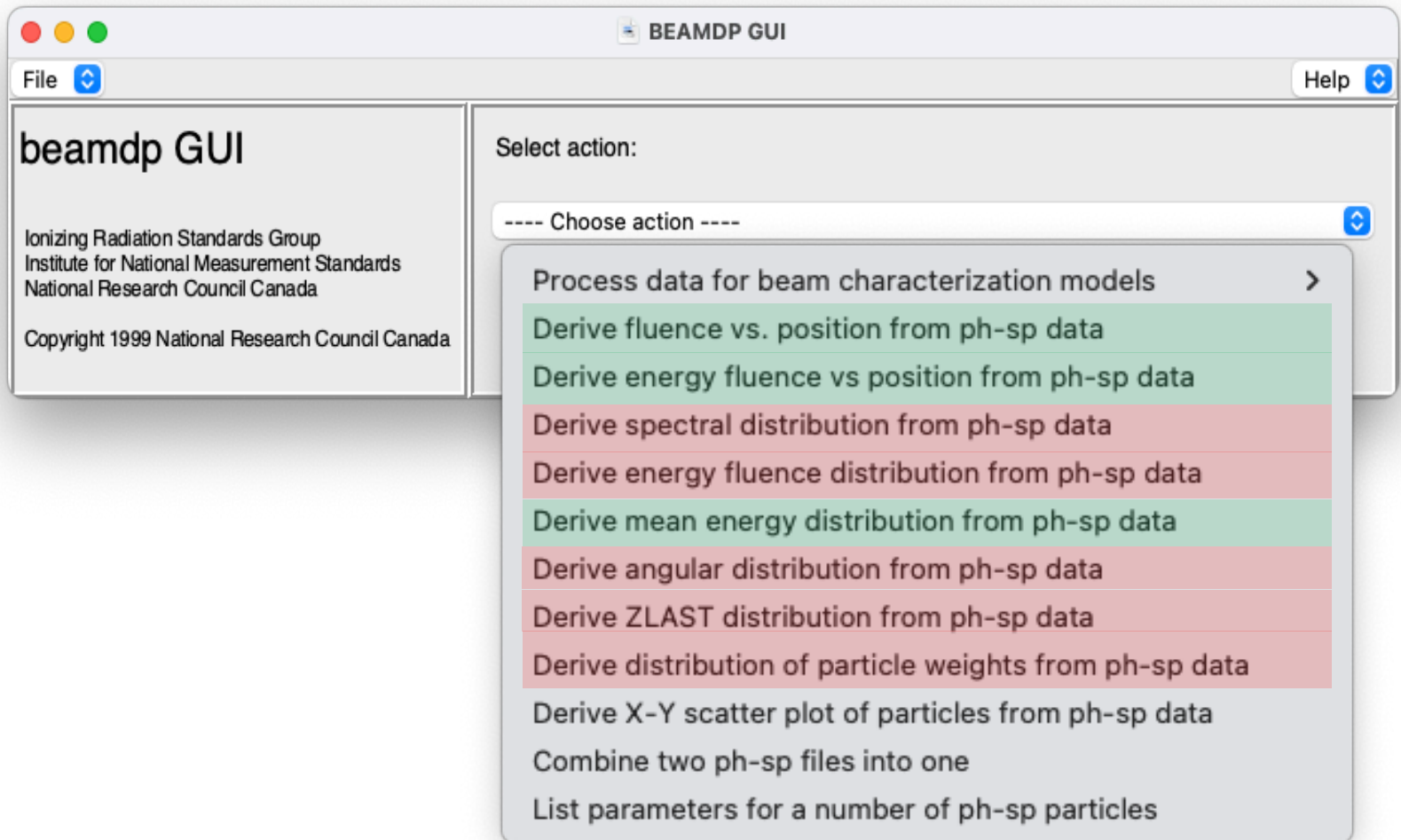
Gouvernement
du Canada



beamdp analyzes data stored in (2D) phase space files



Spatial vs Spectral quantities



Spatial fields

- circular or square fields centred at origin divided into bins of equal area

Parameters for option 1

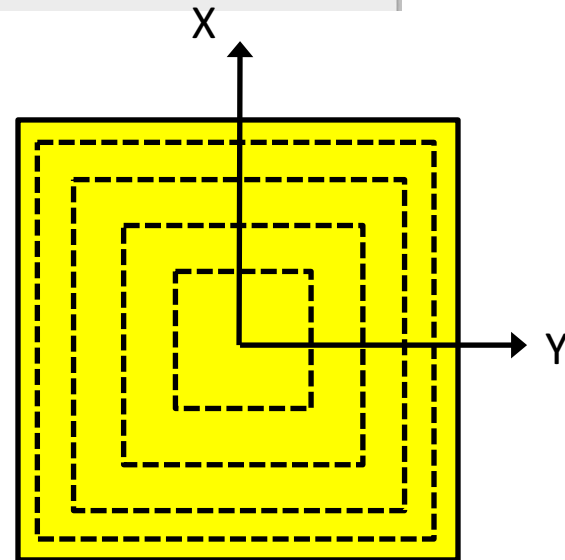
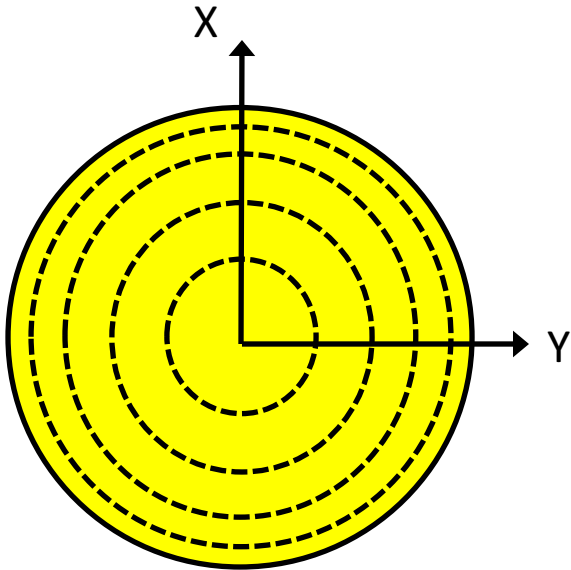
Derive fluence vs. position from ph-sp data

Circular field with circular ring bins

Number of radial bins into which the field is divided 50

Particle type photons

Outer radius of the circular field 15



Spatial fields

- rectangular fields anywhere on the phase space plane divided into bins of equal width
- bins (plots) oriented in X- or Y-direction

Parameters for option 1

Derive fluence vs. position from ph-sp data

Rectangular field with rectangular bins

Number of bins in X direction 50

Particle type photons

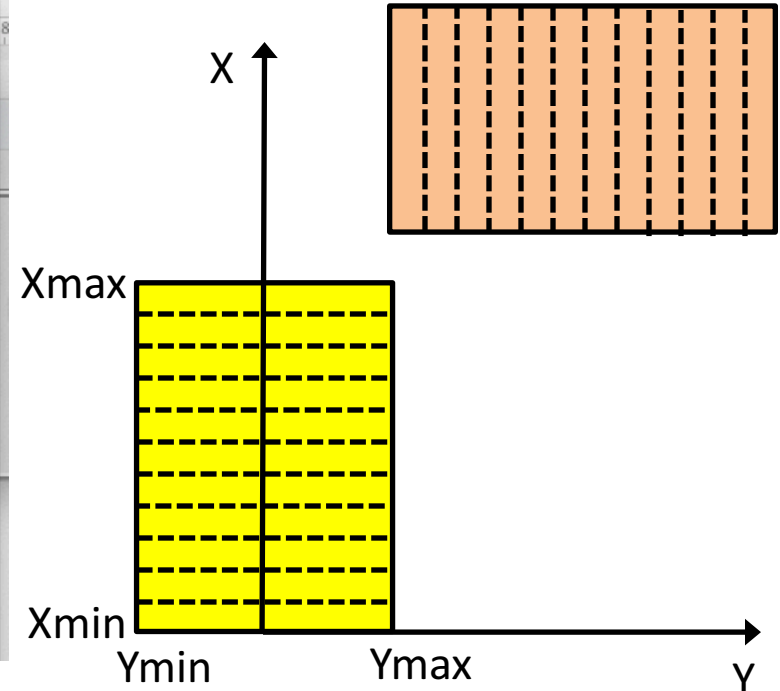
Plot orientation X

? Xmin of rectangular field 0

Xmax of rectangular field 10

Ymin of rectangular field -5

Ymax of rectangular field 5



Spectral fields

- Rectangle anywhere on the plane or annular region centred at origin

Parameters for option 3

Derive spectral distribution from ph-sp data

Particle type

☒ Rectangular region anywhere on the scoring plane OR ☐ Annular region centred at the z-axis

Xmin for the rectangular region (default -15)

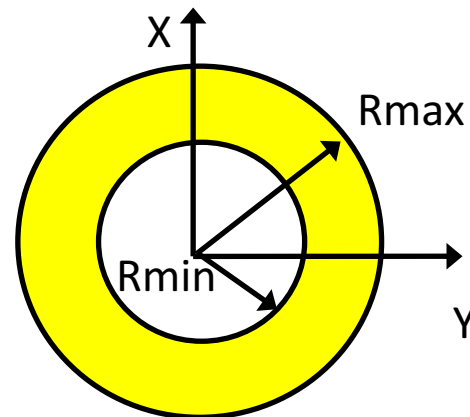
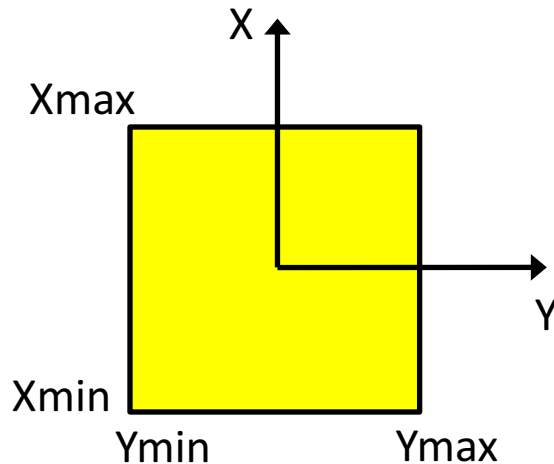
Xmax for the rectangular region (default 15)

Ymin for the rectangular region (default -15)

Ymax for the rectangular region (default 15)

Rmin for the annular region (default 0)

Rmax for the annular region (default 15)



Spectral quantities

- Specify range and number of bins
- e.g. Angular distribution:

Number of angular bins (default 200)

? Minimum angle (degrees, default 0)

Maximum angle (degrees, default 90)

? Minimum energy (MeV)

Maximum energy (MeV)

For angular distribution only: also specify an energy range

LATCH Review I

From beamnrc_gui:

Define slabs, window 1

Slab 1

Slab thickness (cm) 0.5

? Electron cutoff energy (default ECUTIN) (MeV) 0.7

? Photon cutoff energy (default PCUTIN) (MeV) 0.01

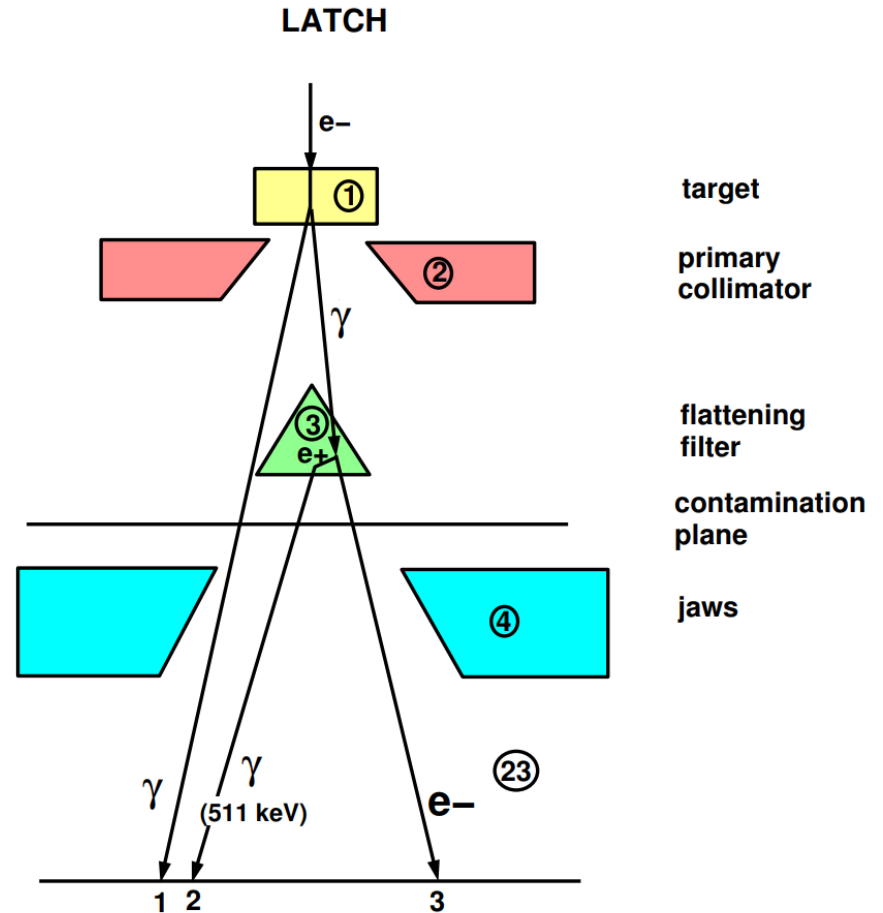
? Dose zone (0 for no scoring) 1

? Associate with LATCH bit 1

? ESAVE for this region 1.0

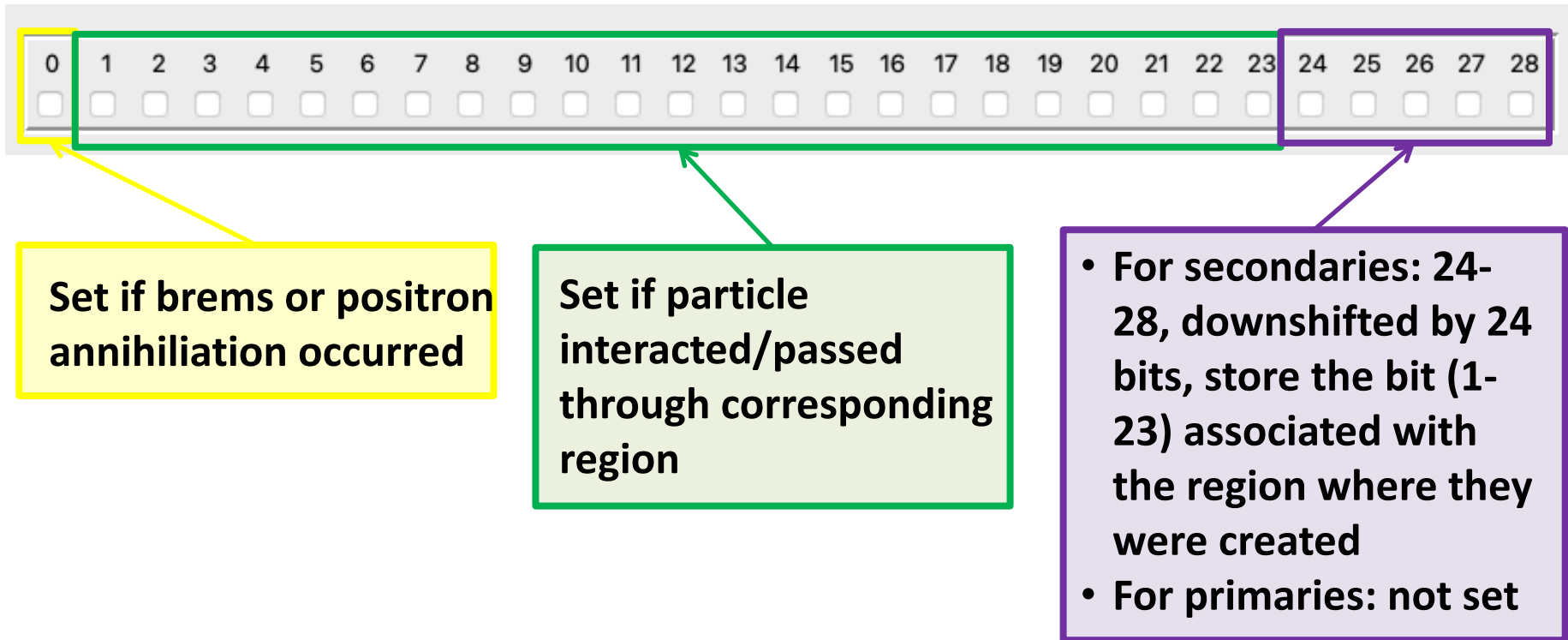
? Material W700ICRU

OK



- **LATCH** is a 32-bit integer variable that travels with the particle
- **LATCH** bits are associated with regions in BEAMnrc or other application

LATCH Review II



- In BEAMnrc, AIR regions default to bit 23

BEAMDP LATCH filtering: inclusive/exclusive for bits

? LATCH option Inclusive/Exclusive filter for bits

LATCH bit filters

For any given particle, if any of the inclusive bits are set and none of the exclusive bits are set, the particle is used.

inclusive bits:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Exclusive bits:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Done

Include the particle only if any “inclusive bits” are set

AND none of the “Exclusive bits” are set

Latch filtering: exclusive for bits

? LATCH option Exclusive filter for bits

LATCH bit filters

For any given particle, if any of the bits selected are set, the particle is not used.

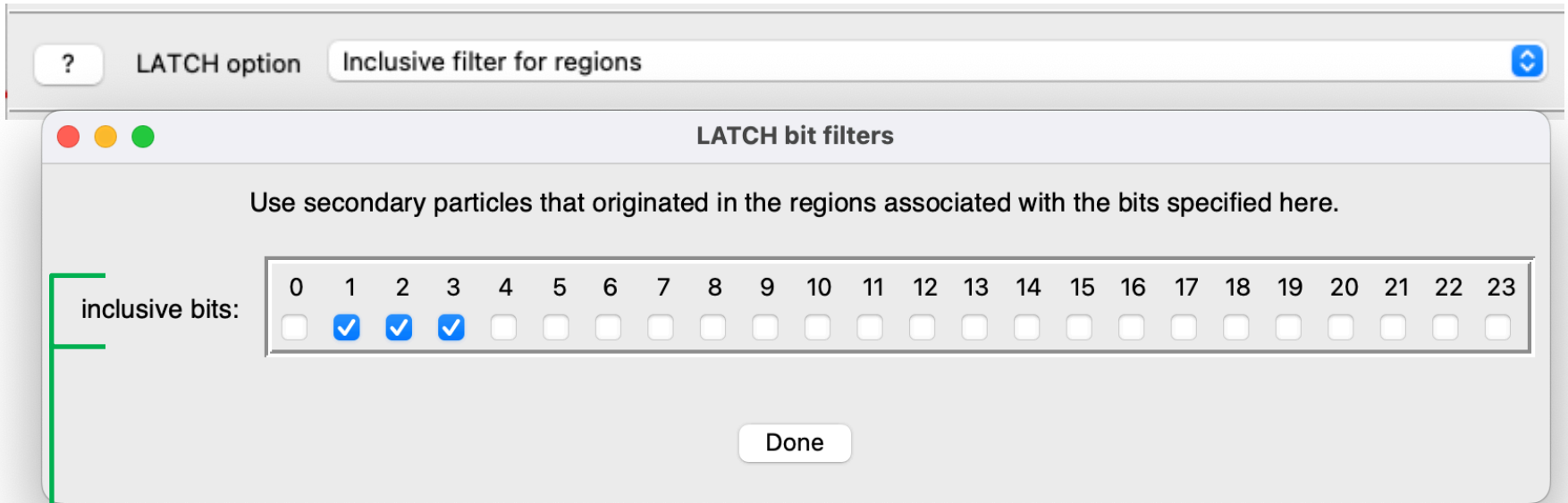
exclusive bits:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Done

Include the particle only if none of the “exclusive bits” are set

Latch filtering: inclusive for regions



Include only secondary particles originating in regions associated with “inclusive bits”

- **LATCH** bits associated with regions in BEAMnrc or other application
- Stored in bits 24-28 of **LATCH**
- Region 23 is usually reserved for air

Latch filtering: exclusive for regions

? LATCH option Exclusive filter for regions

Do not use secondary particles that originated in the regions associated with the bits specified here.

exclusive bits:

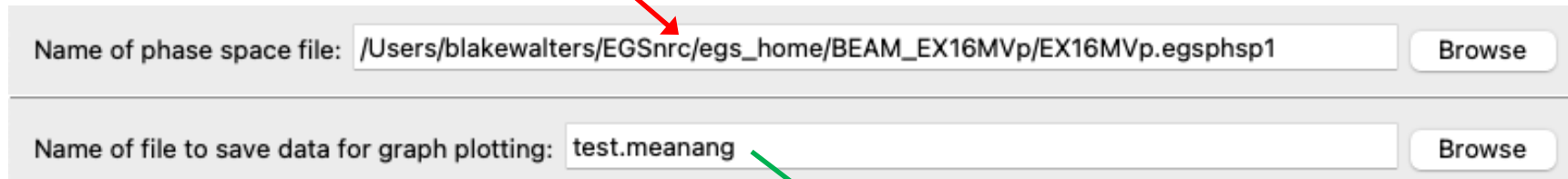
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Done

Include only secondary particles not originating in regions associated with “exclusive bits”

Input/Output files

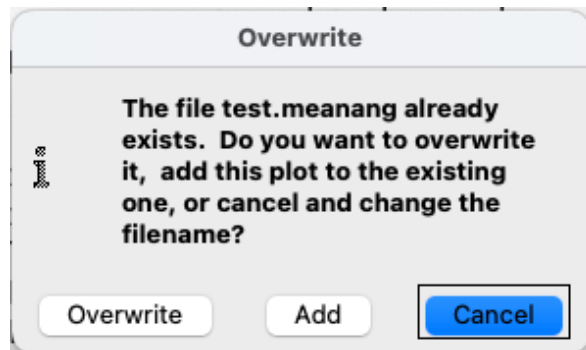
Input phase space data



Name of phase space file:

Name of file to save data for graph plotting:

Output data file optimized for plotting with xmgrace/qtgrace



Use the same output file for the option to add data to an existing plot

Plot type

---- Graph type ----

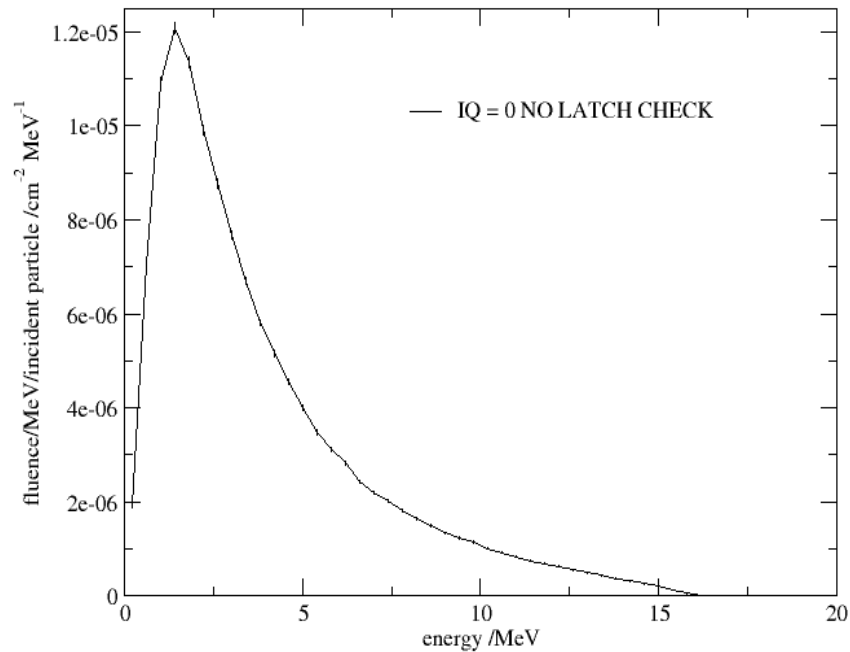
point graph
histogram

point plot

histogram

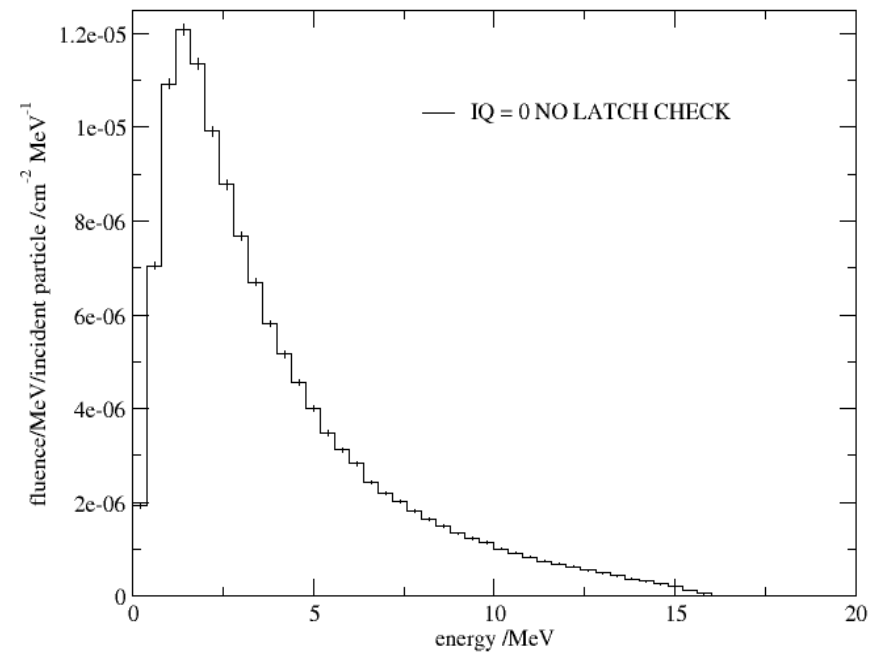
spectral distribution

/Users/blakewalters/EGSnrc/egs_home/BEAM_EX16MVp/EX16MVp.egs



spectral distribution

/Users/blakewalters/EGSnrc/egs_home/BEAM_EX16MVp/EX16MVp.egs



Thu Oct 24 16:21:34 2024

Oct 24 16:23:33 2024

Fluence type

?

---- Fluence type ----

estimated real fluence
planar fluence

$$\text{planar fluence} = \frac{\sum wt_i}{\text{area}}$$

$$\text{estimated real fluence} = \frac{\sum \frac{wt_i}{w_i}}{\text{area}}$$

w = Z-direction cosine

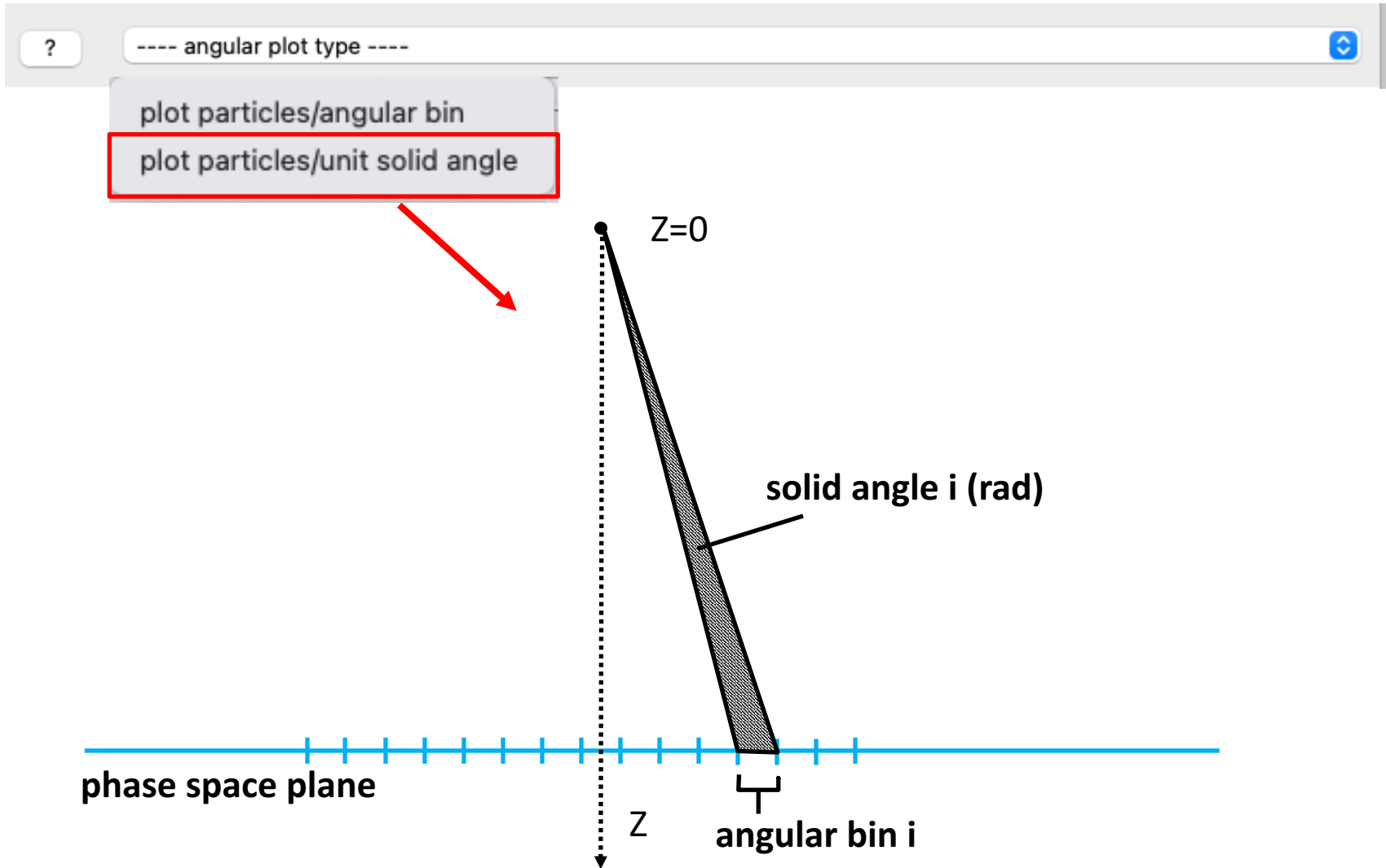
w_i
 γ_i (weight = wt_i)

phase space plane

min. w = 0.08716 (85°)

z

Angular distributions



Example: *Derive spectral distribution*

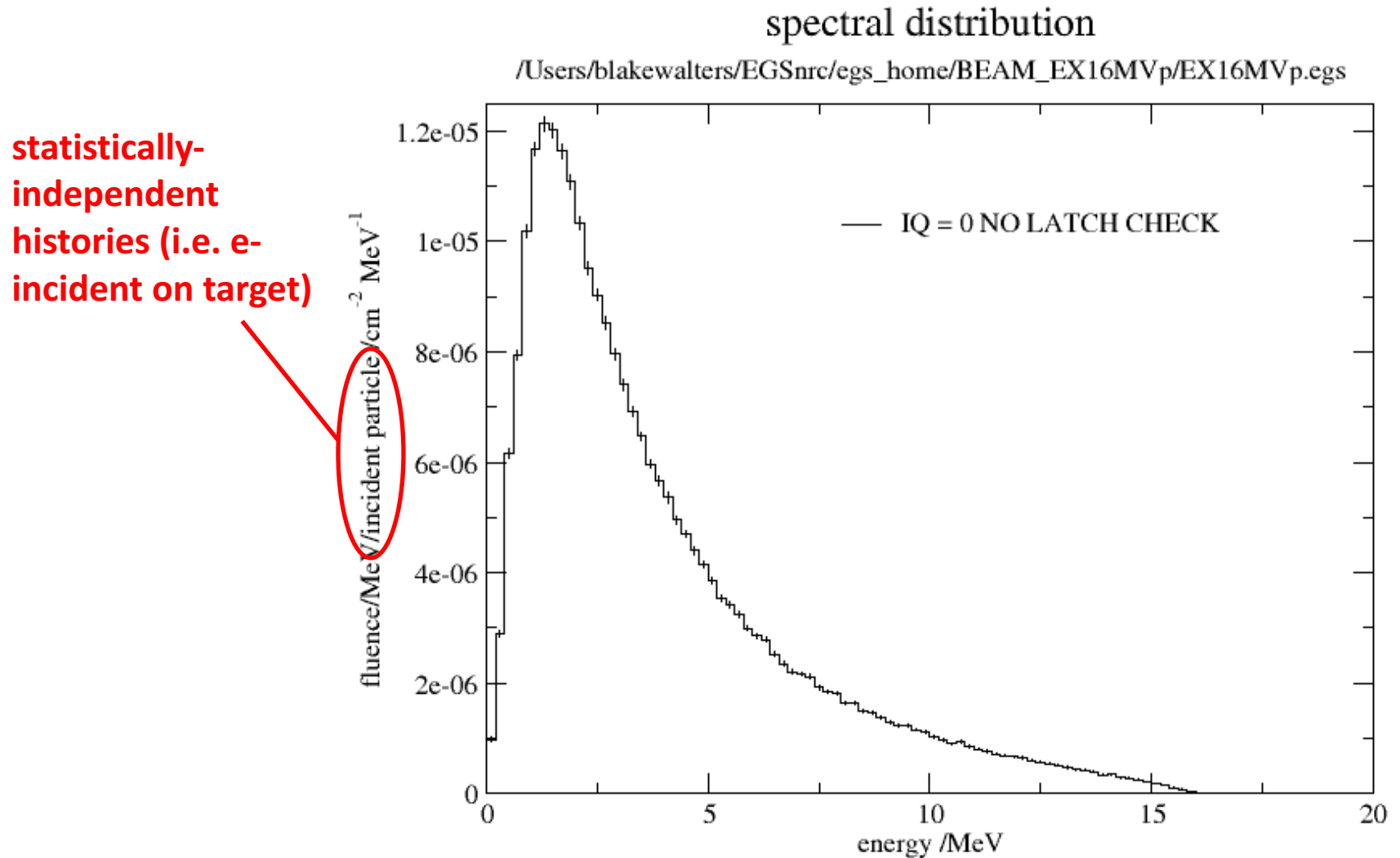


Don't forget to select particle type!

The image shows the 'Parameters for option 3' dialog box, titled 'Derive spectral distribution from ph-sp data'. A red rectangle highlights the 'Particle type' dropdown menu, which is currently set to 'photons'. A red arrow points from the text 'Don't forget to select particle type!' to this dropdown. The dialog contains several input fields and options:

- Particle type:** A dropdown menu set to 'photons'.
- Region selection:** Two radio buttons. The first, 'Rectangular region anywhere on the scoring plane', is selected. The second, 'Annular region centred at the z-axis', is unselected.
- Rectangular region parameters:** Four input fields for 'Xmin for the rectangular region (default -15)', 'Xmax for the rectangular region (default 15)', 'Ymin for the rectangular region (default -15)', and 'Ymax for the rectangular region (default 15)'. The 'Ymax' field is currently set to '5'.
- Annular region parameters:** Two input fields for 'Rmin for the annular region (default 0)' and 'Rmax for the annular region (default 15)', both currently set to '-5'.
- Number of equal energy bins (default 200):** An input field set to '100'.
- Minimum energy (MeV):** An input field set to '0'.
- Maximum energy (MeV):** An input field set to '20'.
- LATCH option:** A dropdown menu set to 'None'.
- Name of phase space file:** An input field containing '/Users/blakewalters/EGSnrc/egs_home/BEAM_EX16MVp/EX16MVp.egsphsp1' and a 'Browse' button.
- Name of file to save data for graph plotting:** An input field containing 'test.pspect' and a 'Browse' button.
- Plot type:** A dropdown menu set to 'histogram'.
- Fluence type:** A dropdown menu set to 'estimated real fluence'.
- Buttons:** 'Execute beamdp' and 'Close' buttons at the bottom.

Example: *Derive spectral distribution*



Thu Oct 24 16:15:18 2024

Example: *Derive spectral distribution*

Parameters for option 3

Derive spectral distribution from ph-sp data

Particle type: photons

☐ Rectangular region anywhere on the scoring plane OR ☐ Annular region centred at the z-axis

Xmin for the rectangular region (default -15): -5 Rmin for the annular region (default 0): -5

Xmax for the rectangular region (default 15): 5 Rmax for the annular region (default 15): 5

Ymin for the rectangular region (default -15): -5

Ymax for the rectangular region (default 15): 5

Number of equal energy bins (default 2):

? Minimum energy (MeV): 0

Maximum energy (MeV): 20

? LATCH option: Exclusive filter for regions

Name of phase space file: /Users/blakewalters/EGSnrc/egs_home/BEAM_EX16MVp/EX16MVp.egsphsp1 Browse

Name of file to save data for graph plotting: test.pspect Browse

histogram

? estimated real fluence

Execute beamdp Close

LATCH bit filters

Do not use secondary particles that originated in the regions associated with the bits specified here.

exclusive bits: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

☐ ☒ ☐

Done

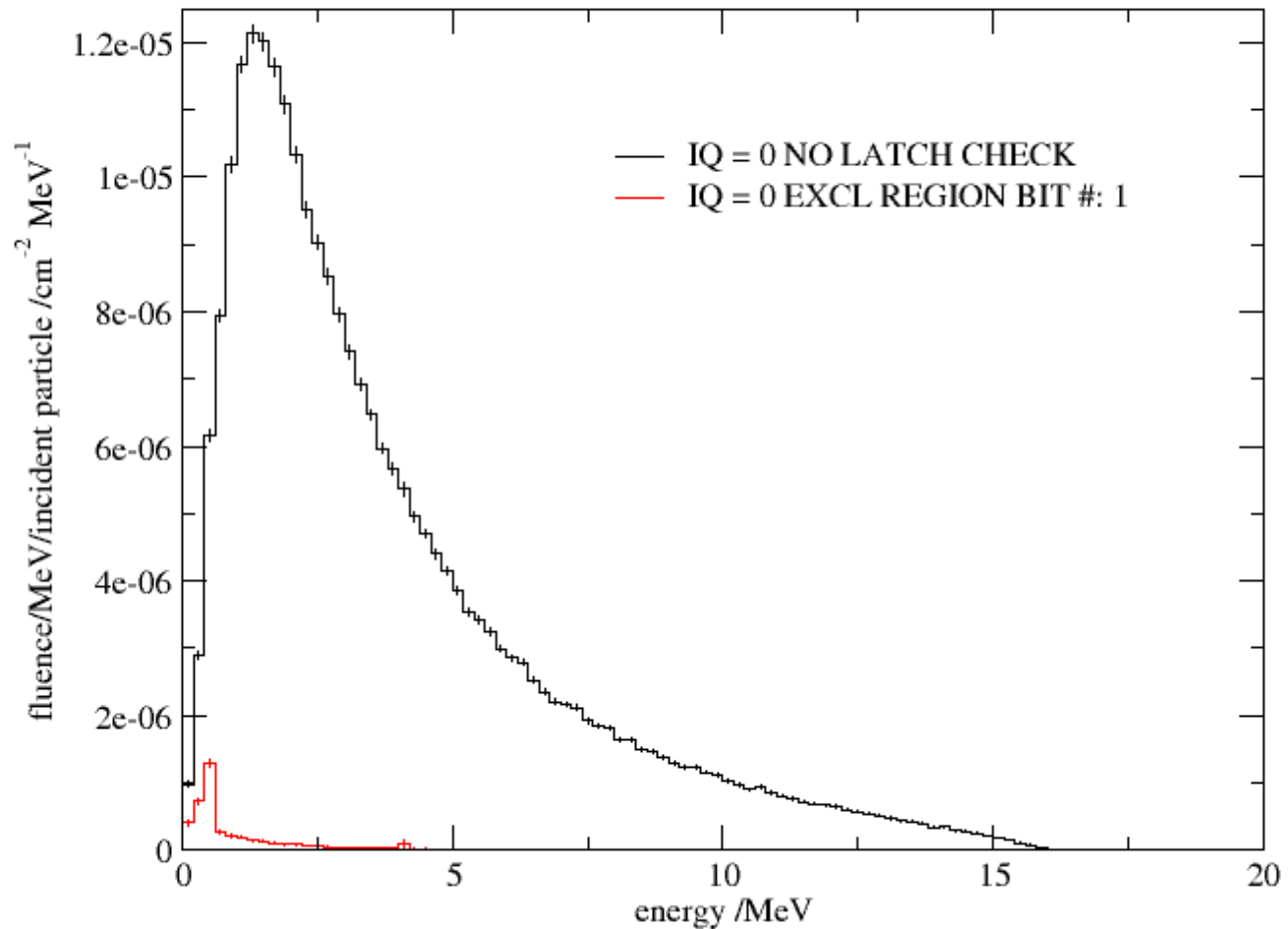
Plot secondary photons

LATCH bit 1 associated with target

Example: *Derive spectral distribution*

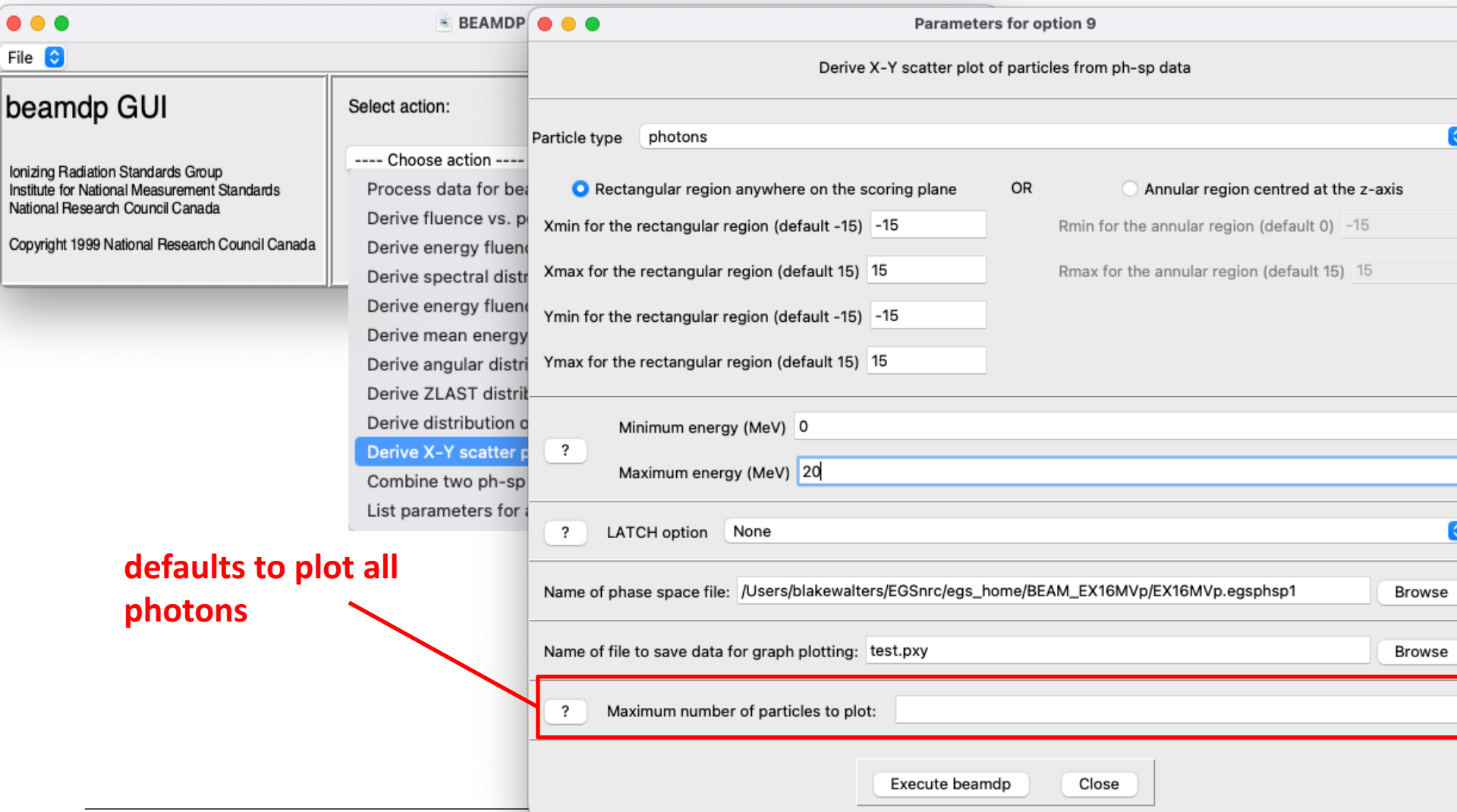
spectral distribution

/Users/blakewalters/EGSnrc/egs_home/BEAM_EX16MVp/EX16MVp.egs

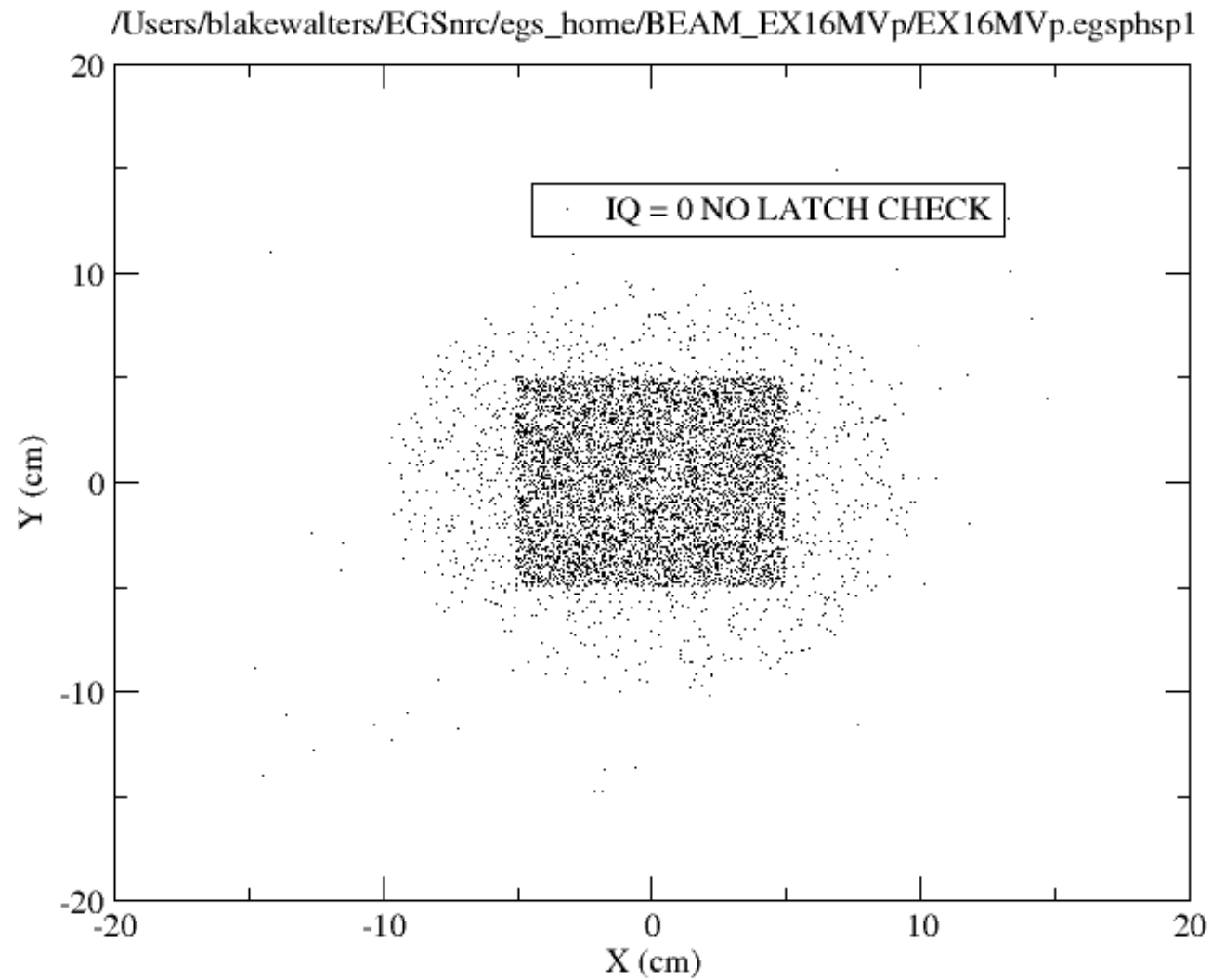


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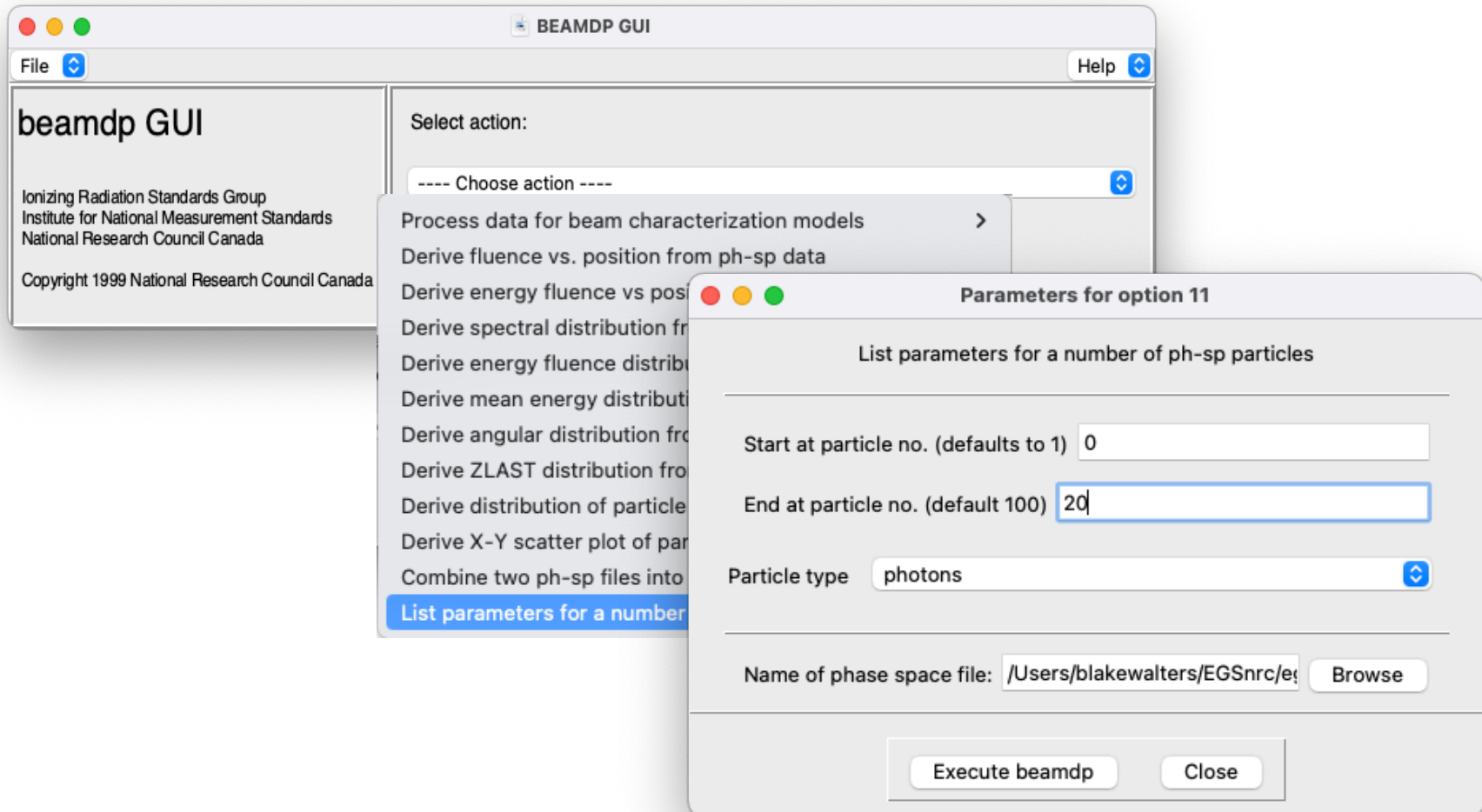
X-Y Scatter plot



X-Y scatter plot



List parameters for a number of particles



List parameters for a number of particles

```
beamdp Output

IQ = 0 (only for photons)

Name of file containing phase space data (with ext., < A100):
File name input is:/Users/blakewalters/EGSnrc/egs_home/BEAM_EX16MVp/EX16MVp.egsphsp1

First, try to open it as a MODE0 file

    Total number of particles in file:  5754377
    Total number of photons:  5300754
The rest are electrons/positrons.

    Maximum kinetic energy of the particles:  19.991 MeV
    Minimum kinetic energy of the electrons:  0.189 MeV
# of incident particles from original source:  50000.0

ENERGY IQ  X    Y    U    V    W  WEIGHT  LATCH (set=1, not set=0)

1.590  0  4.523  1.546  0.045  0.015  0.999 9.731E-04  00001 00000000000000000000000011

ENERGY IQ  X    Y    U    V    W  WEIGHT  LATCH (set=1, not set=0)

1.997  0 -0.381 -1.565 -0.004 -0.016  1.000 9.754E-04  00001 00000000000000000000000011
7.322  0  1.157  0.019  0.012  0.000  1.000 9.767E-04  00001 00000000000000000000000011
0.257  0  0.837 -2.299  0.008 -0.023  1.000 8.057E-04  00001 00000000000000000000000011
0.689  0 -1.843 -2.906 -0.018 -0.029  0.999 9.515E-04  00001 00000000000000000000000011
0.181  0 -1.810 -0.141 -0.018 -0.001  1.000 6.187E-04  00001 00000000000000000000000011
0.368  0 -0.308 -2.003 -0.003 -0.020  1.000 8.958E-04  00001 00000000000000000000000011
1.156  0 -0.557 -4.960 -0.006 -0.050  0.999 9.678E-04  00001 00000000000000000000000011
2.462  0 -4.439 -2.943 -0.044 -0.029  0.999 9.767E-04  00001 00000000000000000000000011
0.759  0  0.416 -2.143  0.004 -0.021  1.000 9.555E-04  00001 00000000000000000000000011
0.263  0  4.185 -2.664  0.042 -0.027  0.999 8.139E-04  00001 00000000000000000000000011
1.202  0  0.441  1.495  0.004  0.015  1.000 9.687E-04  00001 00000000000000000000000011
1.193  0  3.102  3.625  0.070  0.067  0.995 3.132E-05  00001 10000000000000000000000011
15.336 0 -0.609 -1.518 -0.006 -0.015  1.000 9.718E-04  00001 00000000000000000000000011
1.602  0  2.675 -1.463  0.027 -0.015  1.000 9.732E-04  00001 00000000000000000000000011
0.108  0  0.112 -0.475  0.001 -0.005  1.000 1.718E-04  00001 00000000000000000000000011
0.782  0  4.275 -4.788  0.043 -0.048  0.998 9.566E-04  00001 00000000000000000000000011
13.642 0  0.104 -1.875  0.001 -0.019  1.000 9.727E-04  00001 00000000000000000000000011
1.865  0  0.138  4.953  0.002  0.120  0.993 2.726E-05  01100 000000000001000000000011
0.336  0  0.798 -1.102  0.008 -0.011  1.000 8.798E-04  00001 00000000000000000000000011

BYE!

If running gui, this window will close before next run!
```