A Regenerative Source for a High Average Current Energy Recovery Linacs

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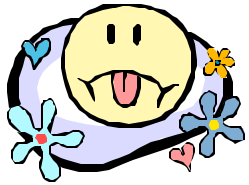
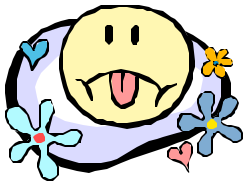
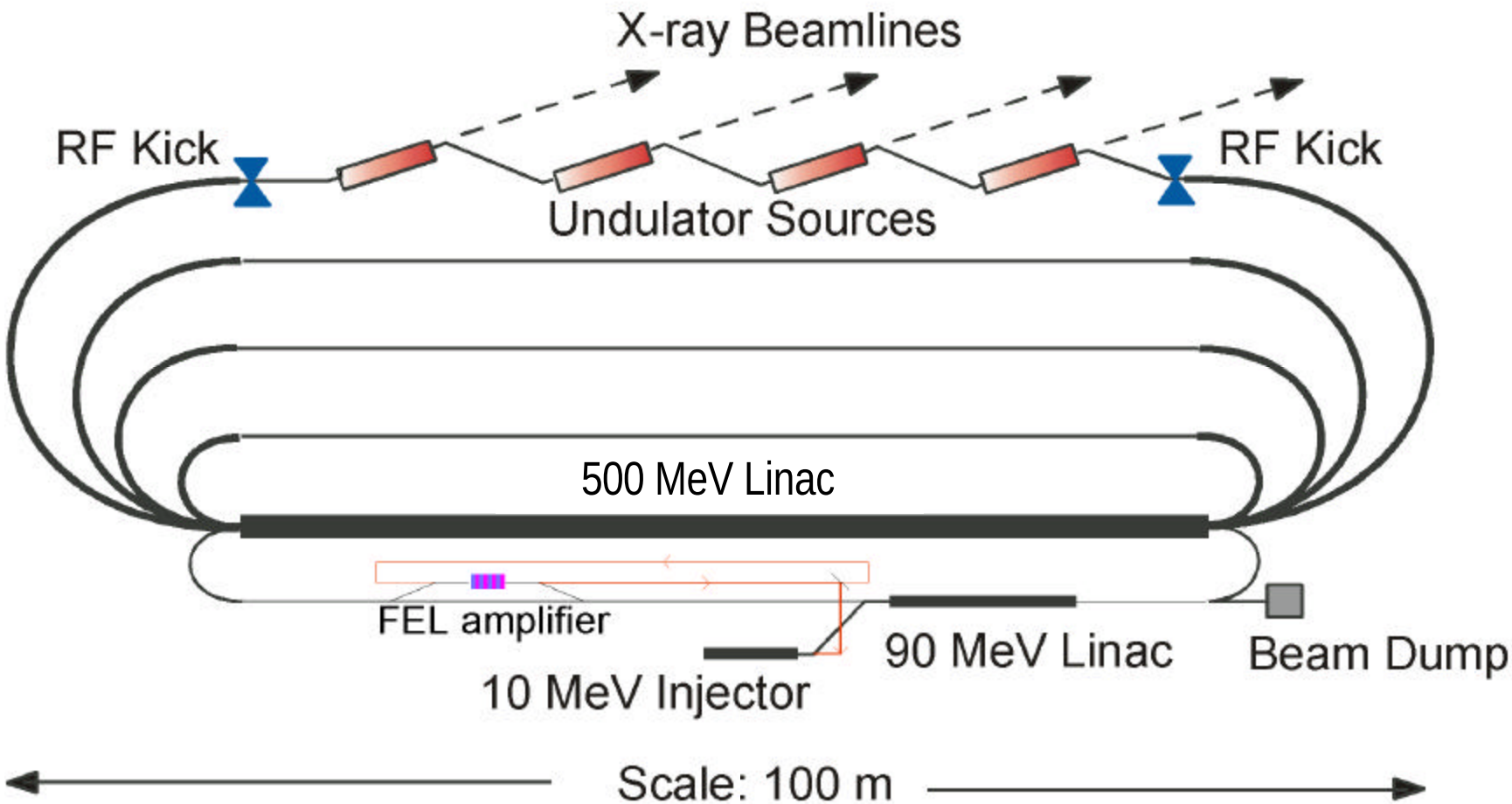
Scylla and Charibdys of Photocathode guns with a high average current

Metal cathodes (Cu, Mg):	Semiconductor (K_2CsSb, Cs_2Te):
excellent lifetime	poor lifetime 
 poor quantum efficiency; need ultraviolet laser	excellent quantum efficiency

A Recirculating SR Source for Ultrafast X-Ray Science



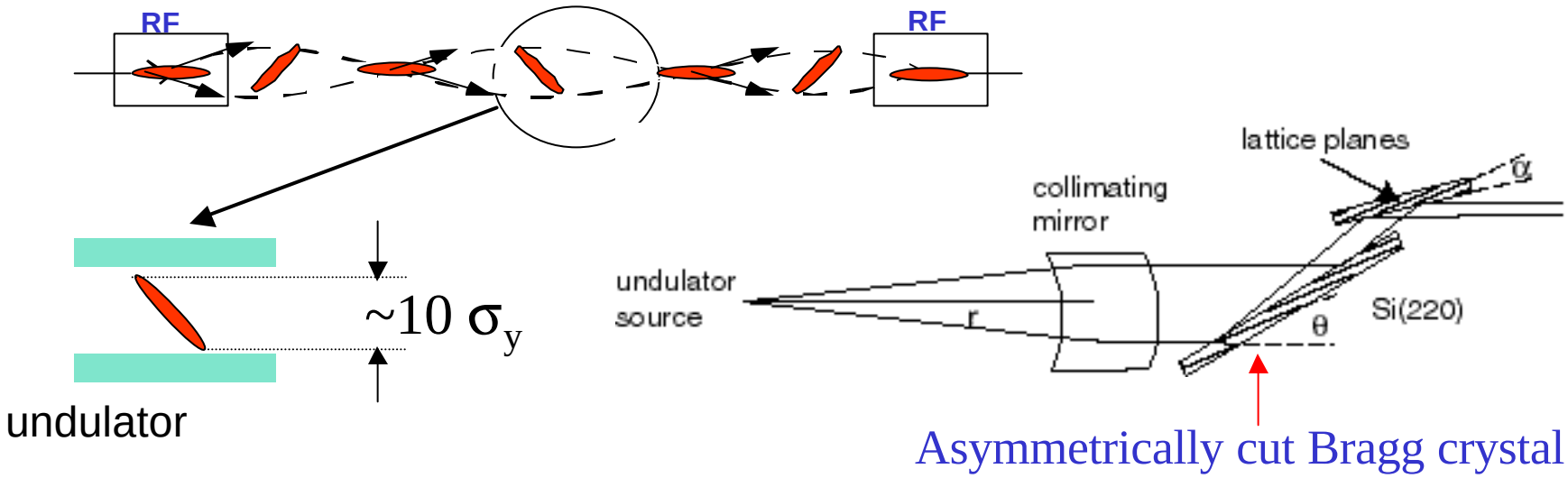
Two stages of pulse compression:

a) electron beam: 10 ps → 1 ps

b) x-rays: 1 ps → 100 fs

Compression of x-ray pulses

is possible due to a correlation between the longitudinal and transverse positions of electrons inside the electron bunch created by the RF orbit deflection in a cavity in the beginning of the final straight section.

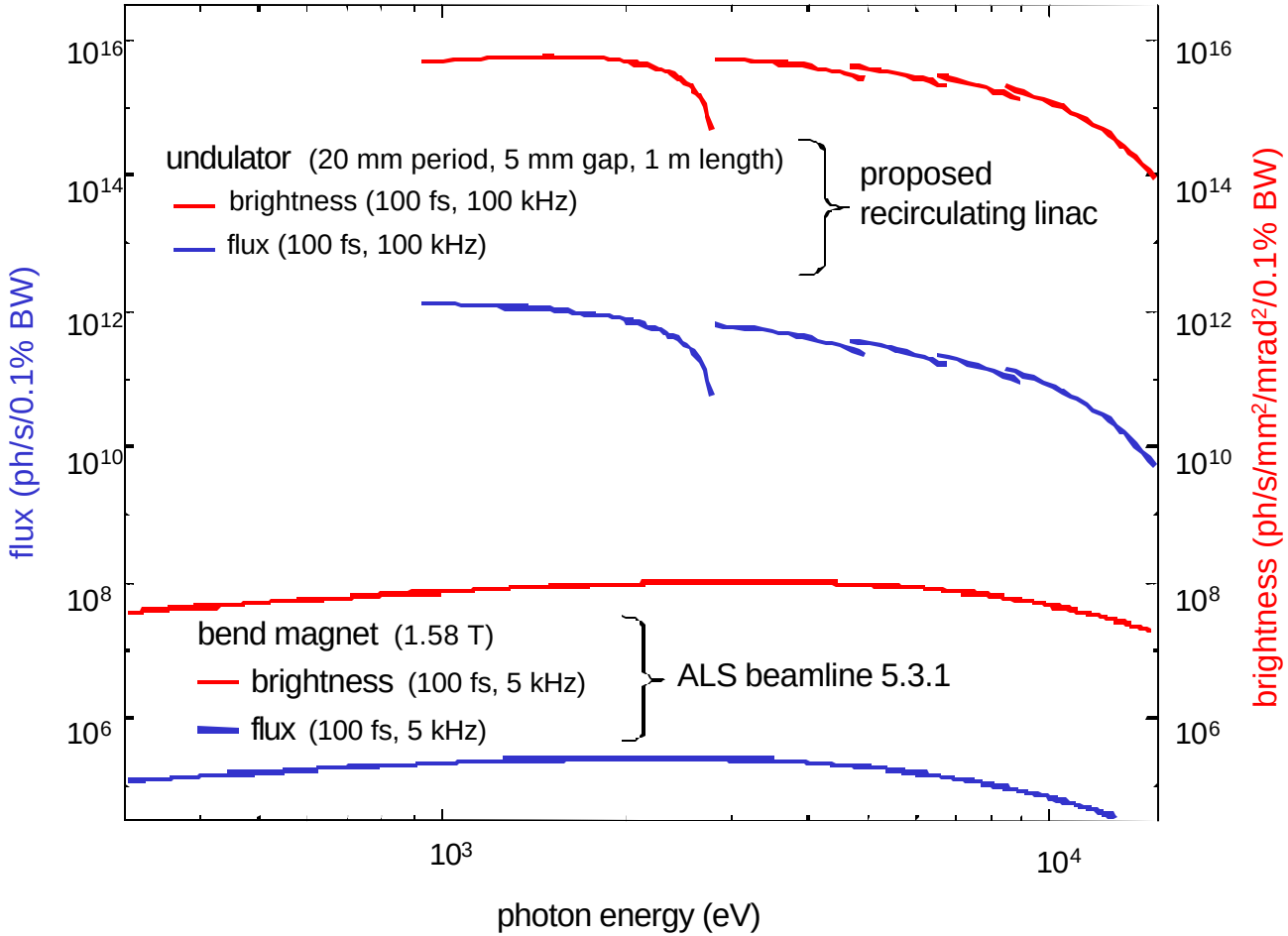


Diffraction limited size of a source at λ 1Å is 2 μm

Beam size at ε_n=0.4 mm-mrad is ~10 μm

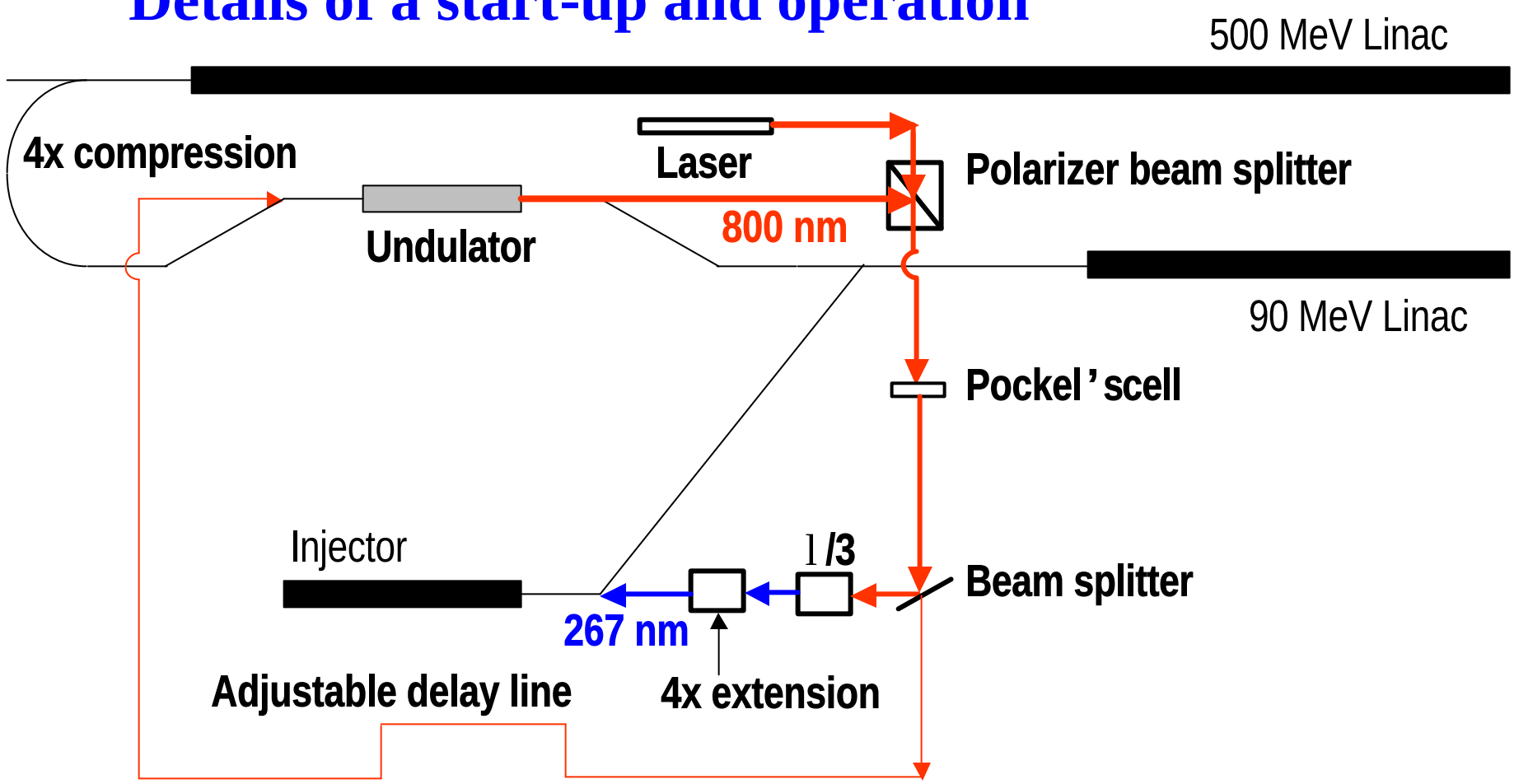
Electron beam parameters out of the injector

Energy	20 MeV
Charge	1 nC
Normalized rms horizontal emittance	20 mm-mrad
Normalized rms vertical emittance	0.4 mm-mrad
Energy spread at 20 MeV	15 keV
Pulse length (uniform distribution)	10 ps
The RF gun parameters:	
RF frequency	2.6 GHz
Peak electric field on a cathode	100 MV/m
Repetition rate of injection pulses	10-100 kHz
Laser parameters:	
Wavelength (3-rd harmonic of Ti:sapphire laser)	267 nm
Pulse energy	100 μJ
Pulse length (FWHM)	10 ps
Repetition rate	10-100 kHz



Average femtosecond flux and brightness compared with that of the existing bend-magnet fs beamline.

Details of a start-up and operation



In the regenerative mode (continuous operation):

1 mJ/pulse, 20 MHz rep. rate from FEL amplifier at 800 nm

At a start-up (~ 1 sec):

~100 pulses, 1 mJ/pulse from Ti:sapphire laser at 800 nm

FEL operation

Undulator: length = 2m, period =2 cm, K=2

Peak current = 400 A

Light in = 12.5 μJ

Light out = 2500 μJ

A_w versus Z

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FEMTO
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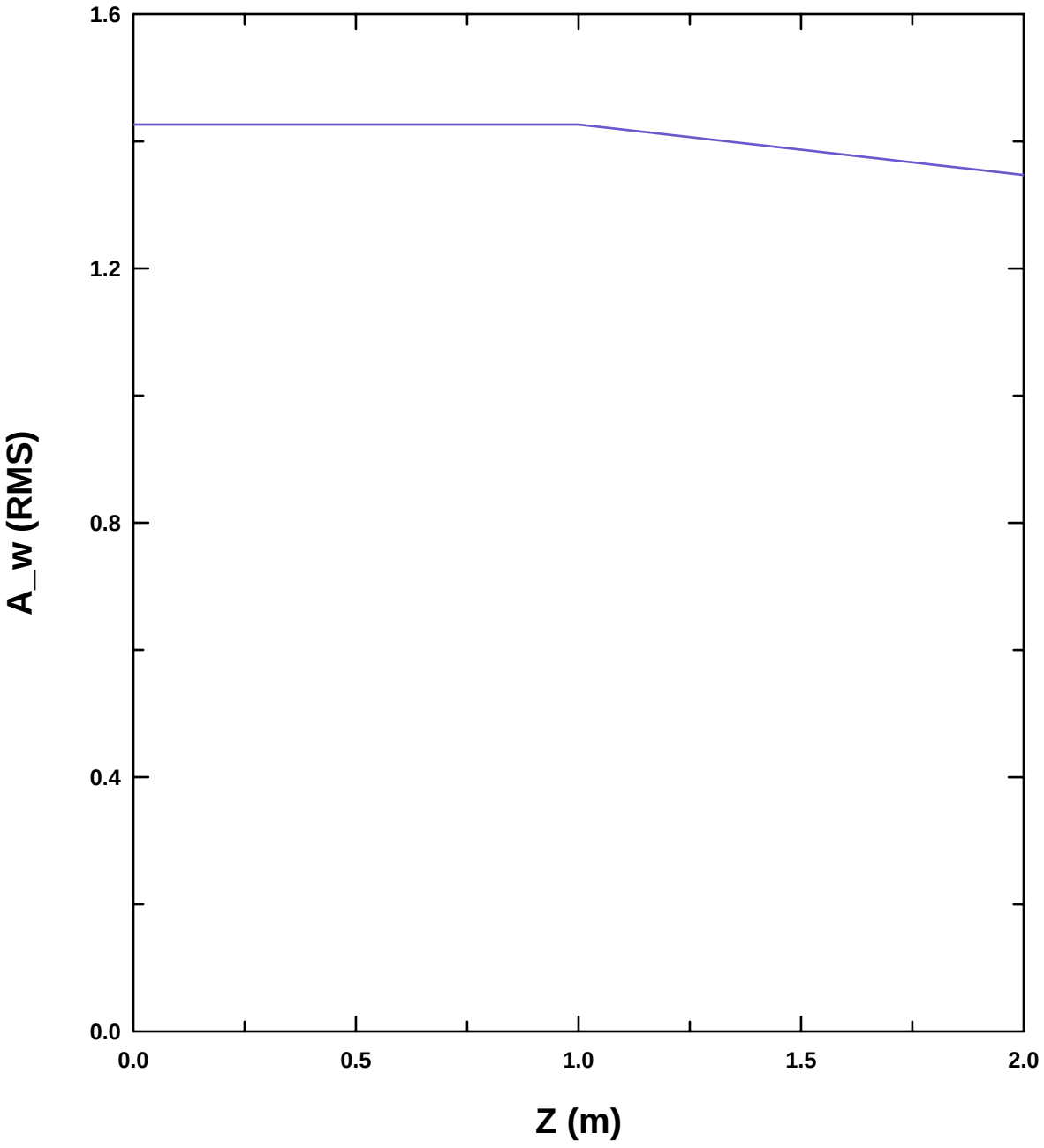

Avg. Field Power vs. Z

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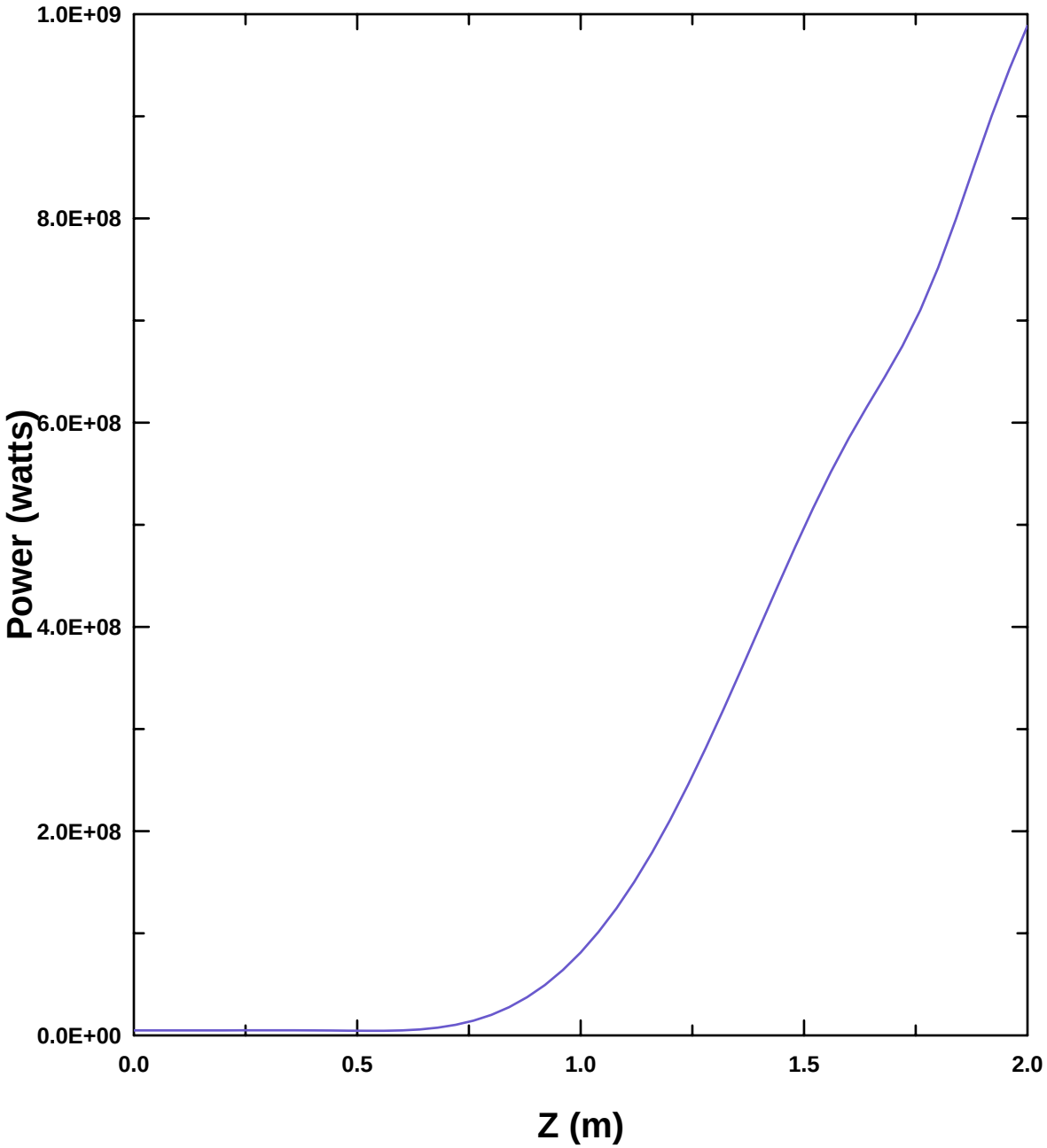

Phase Space at Z = 0.52 M

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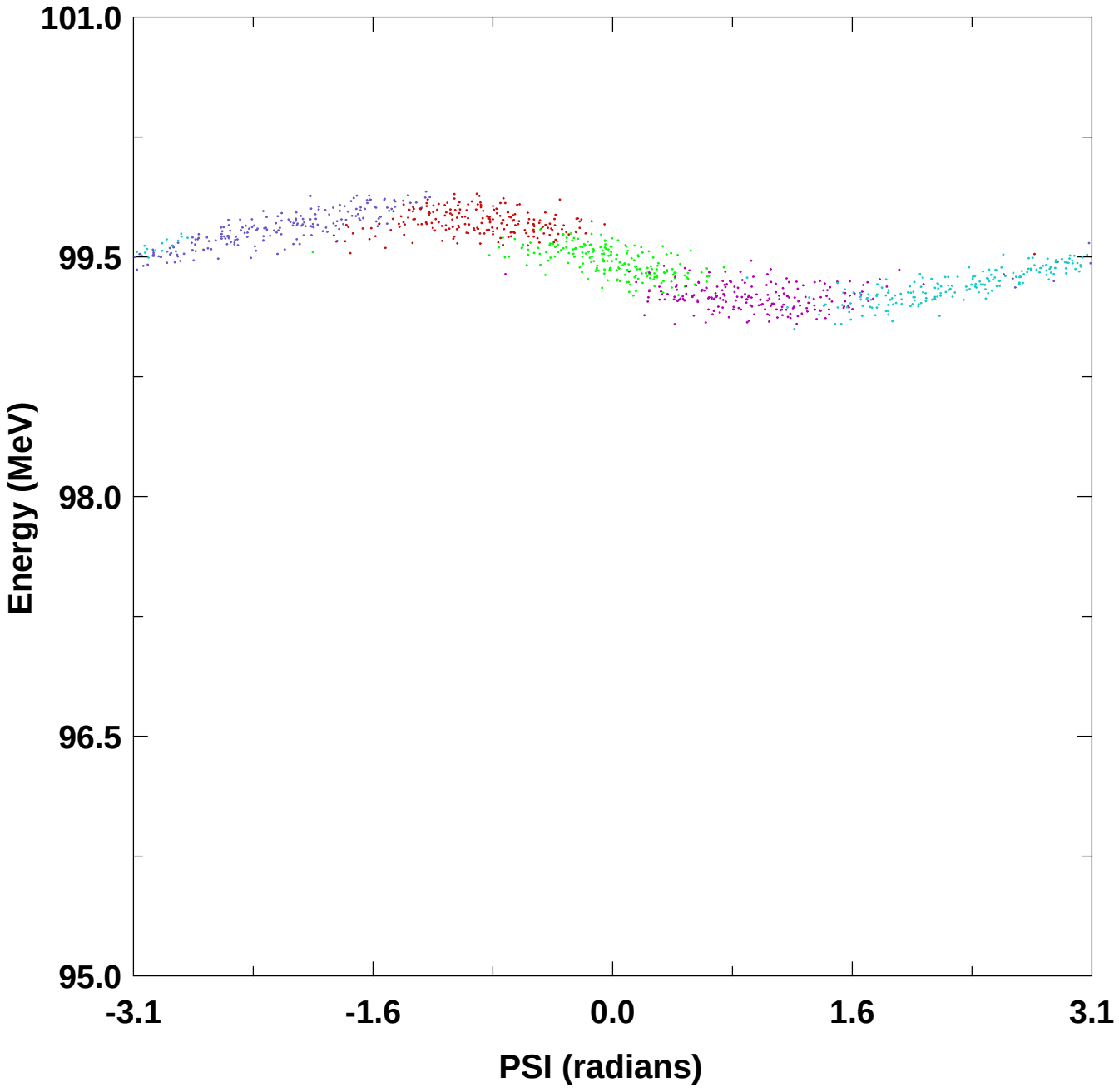

Phase Space at Z = 1.00 M

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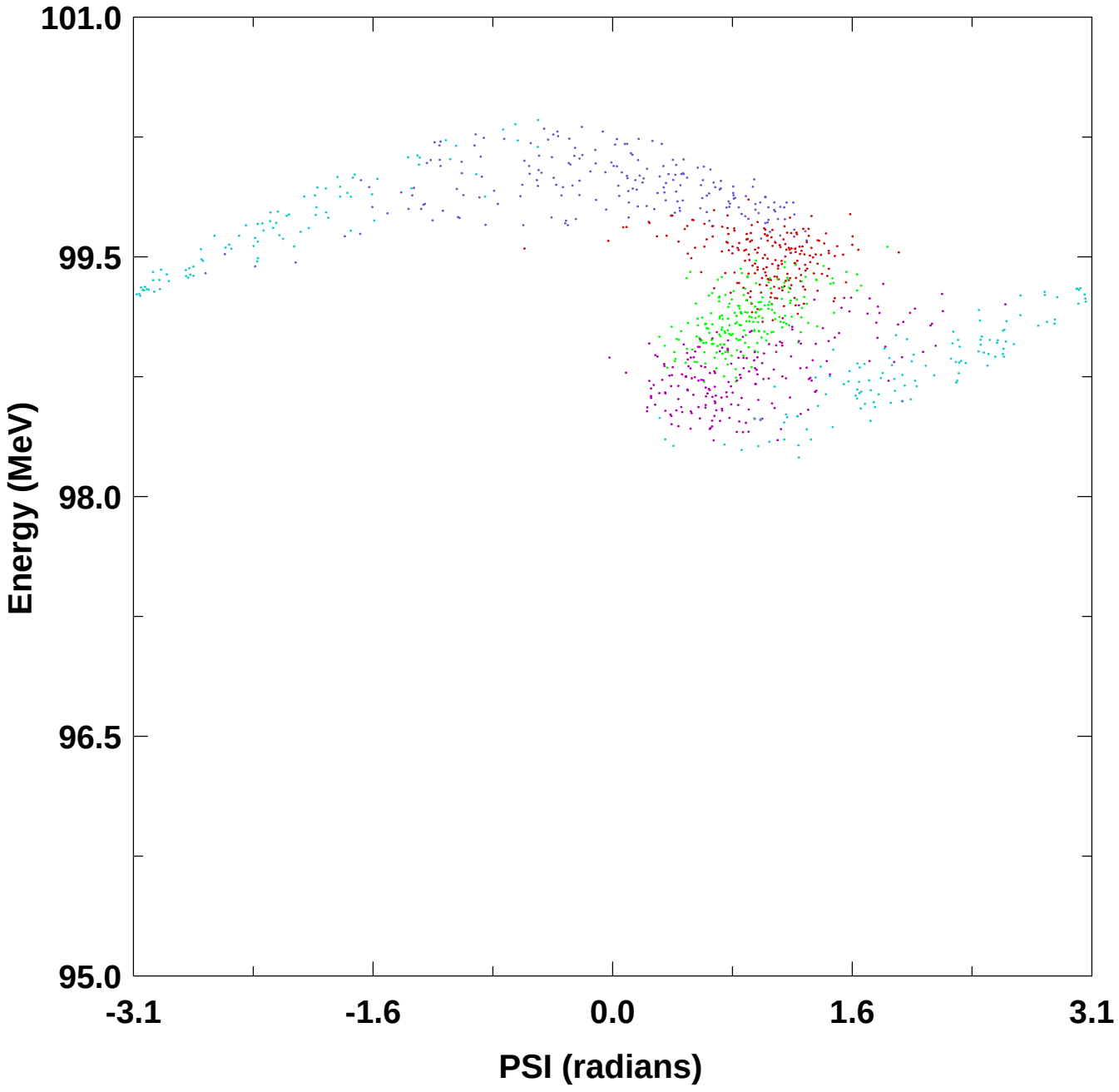

Phase Space at Z = 1.52 M

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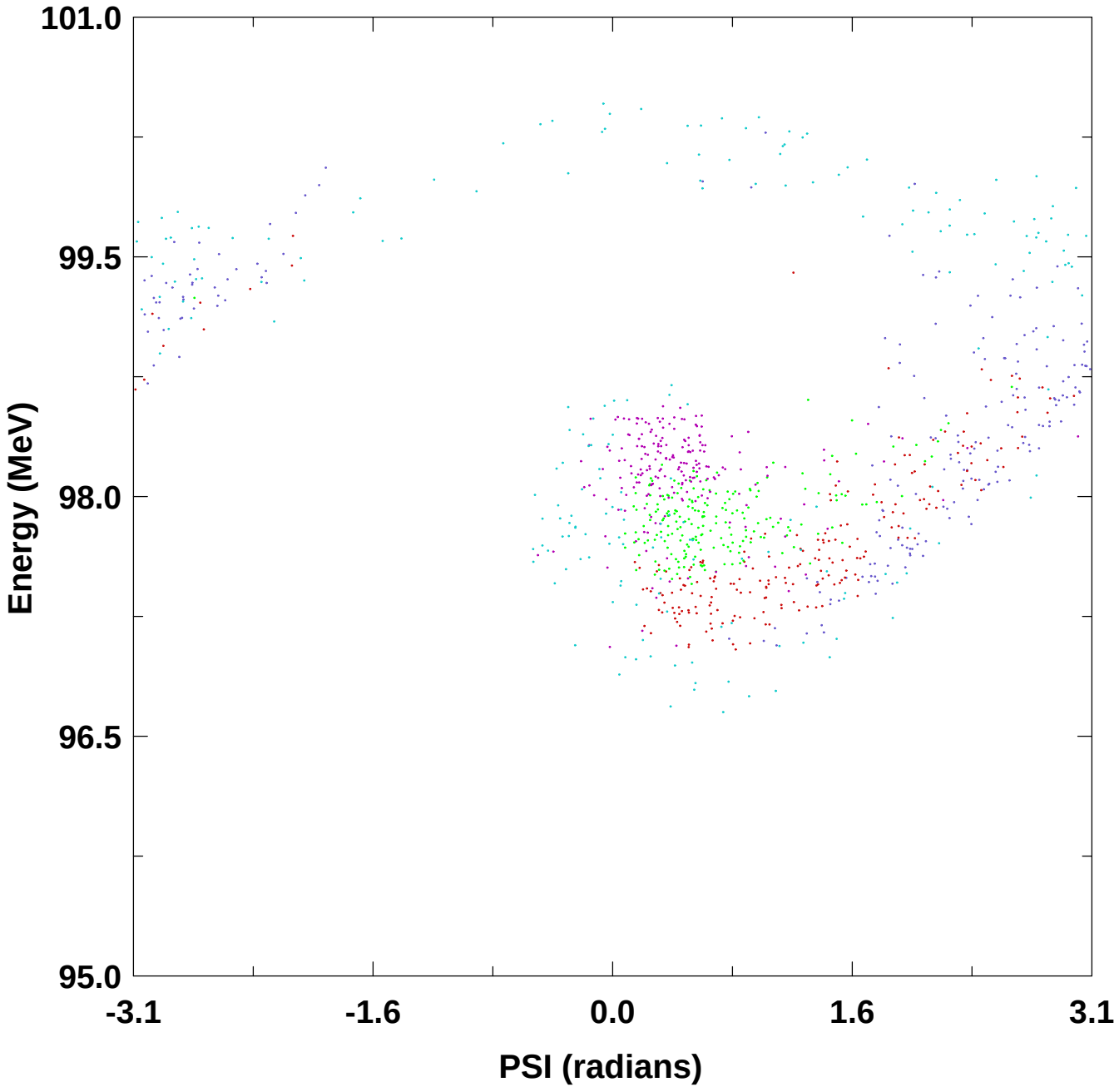
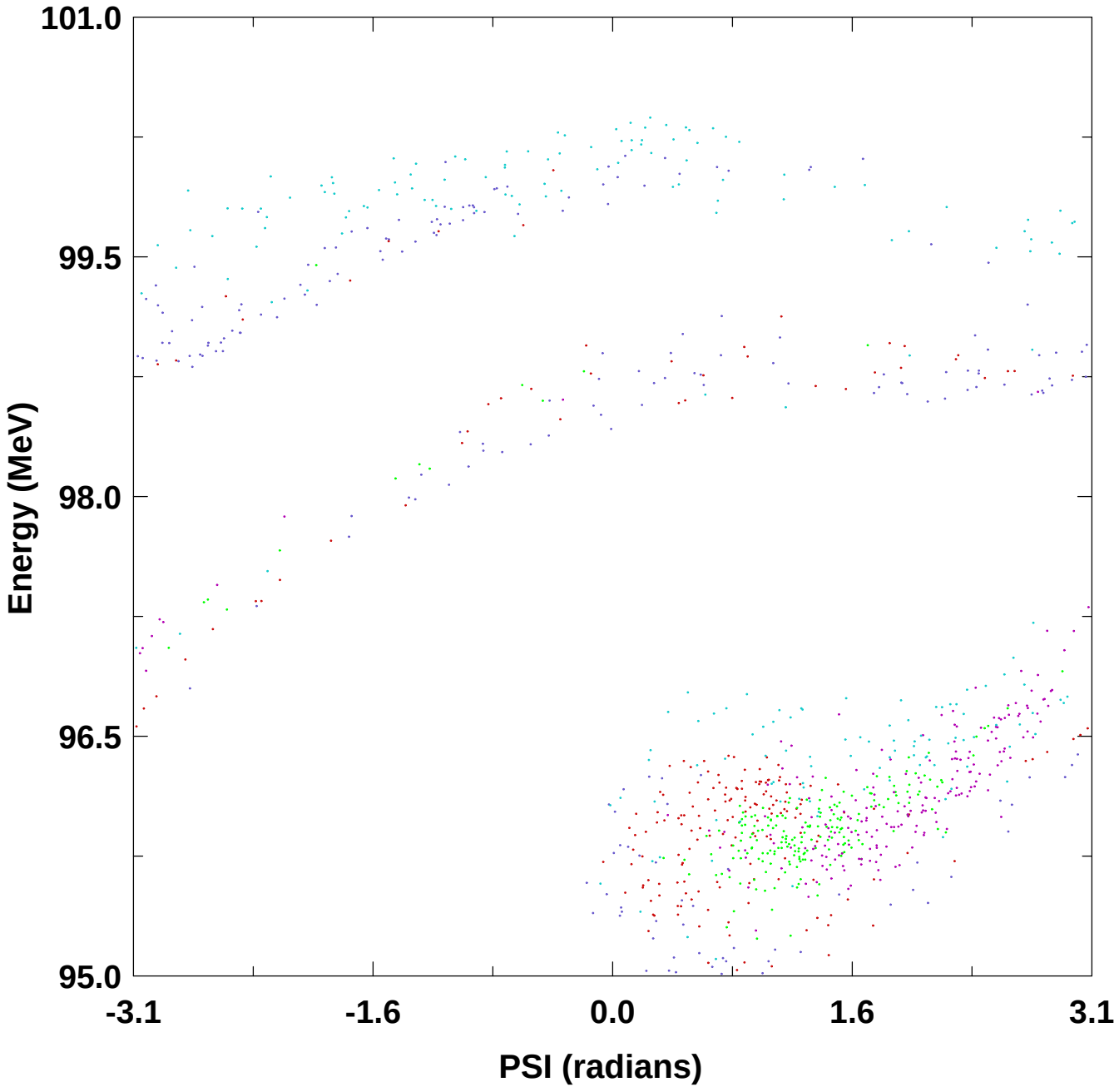


Phase Space at Z = 2.00 M

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