CLIC Drive Beam Injector Bunching System

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2. CERN, Geneva, Switzerland

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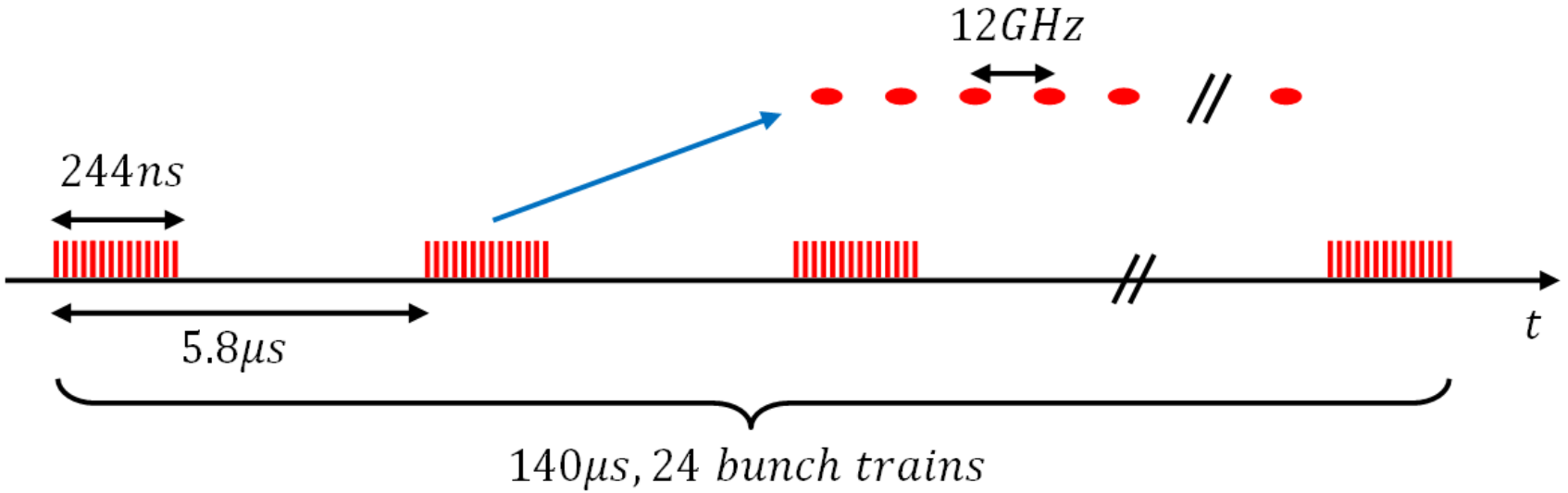
1. Introduction

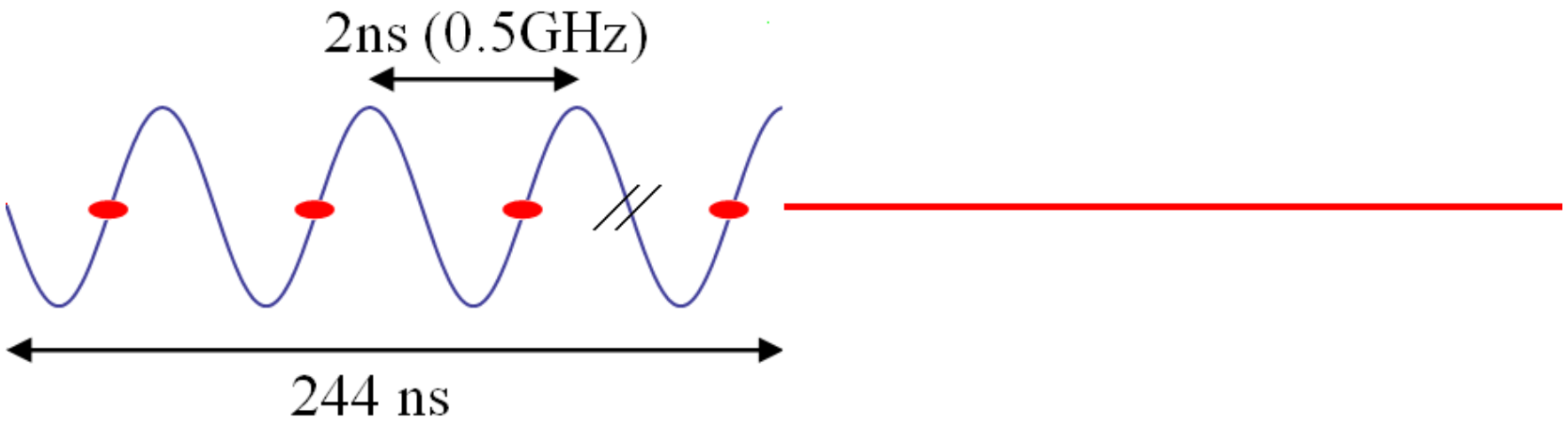
1.1 CLIC Drive Beam time structure



- Main pulse consists of **24** bunch trains of **244ns** length.
- Each of bunch trains consist of 2922 bunches with a time separation corresponds to **12 GHz.**

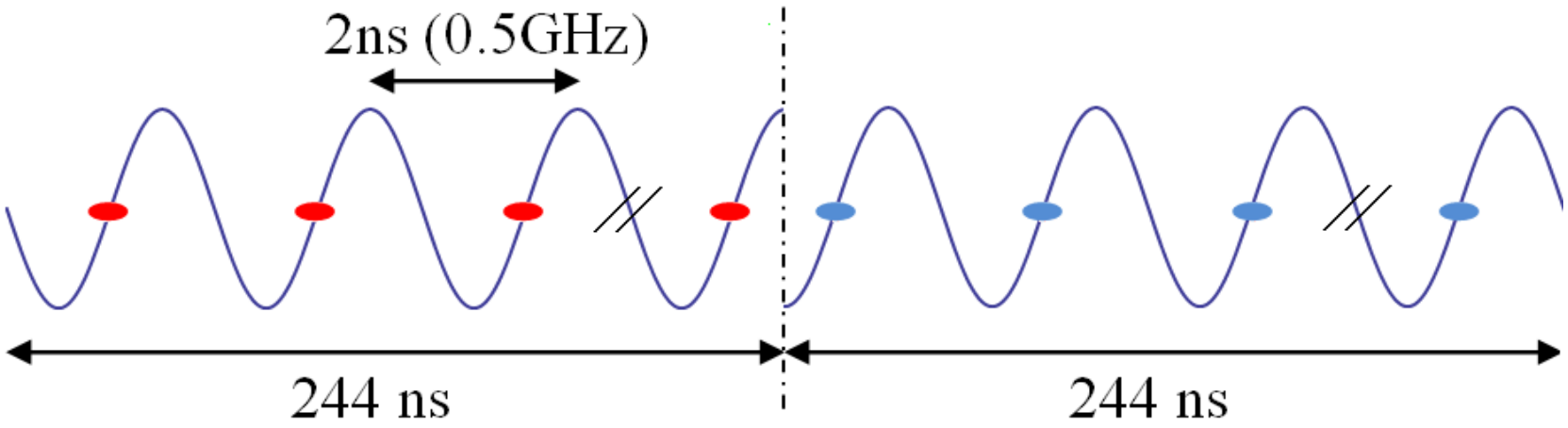
1.2 Phase coding

1.2 Phase coding

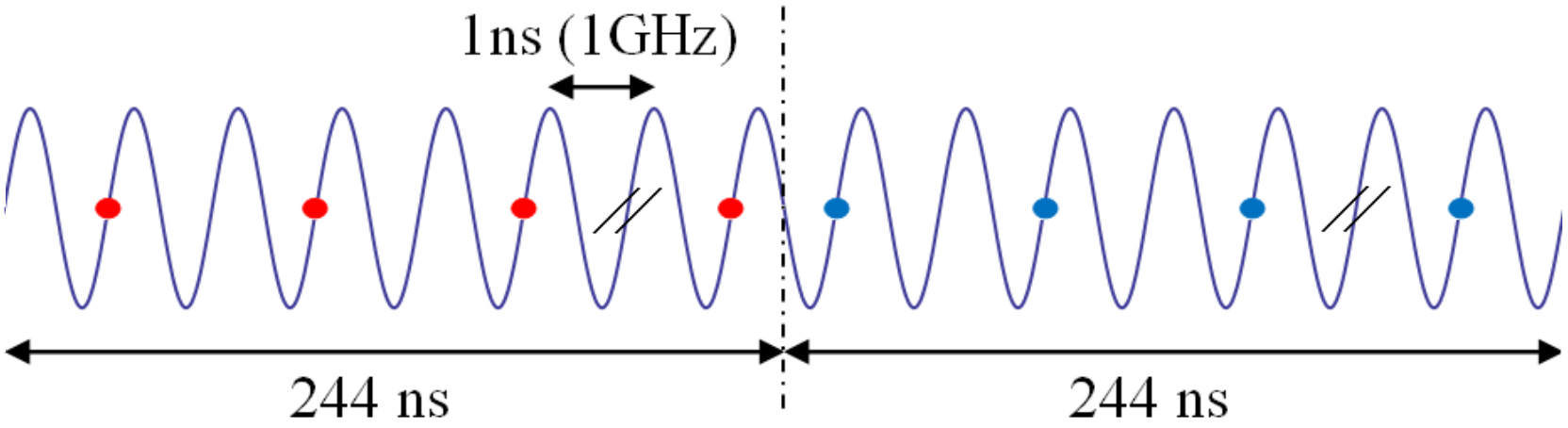


1.2 Phase coding

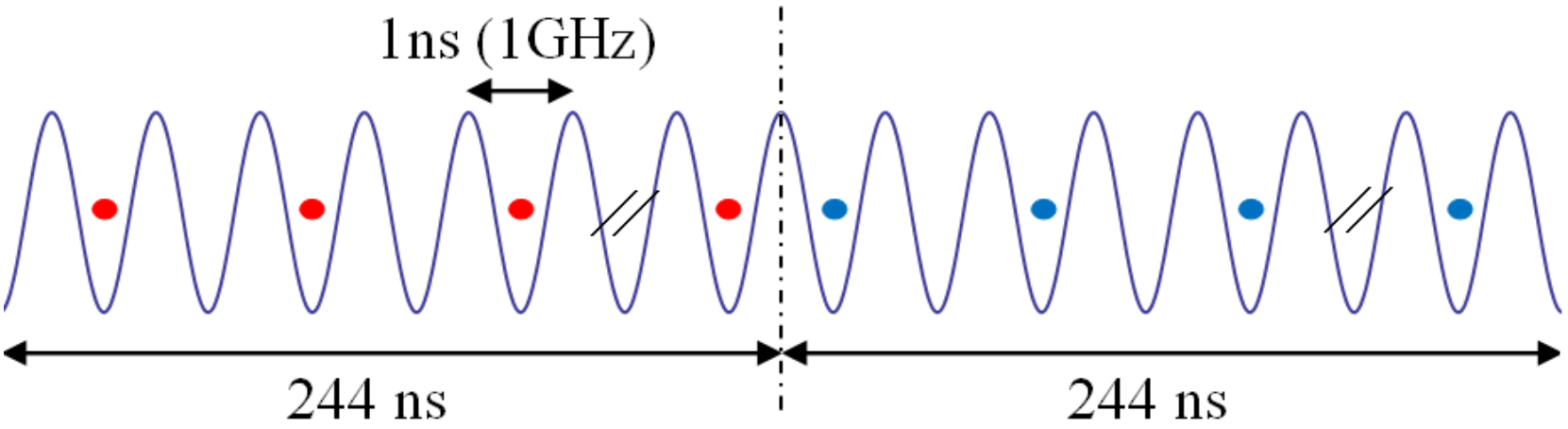
$\Delta\Phi_0=180^{o}$



1.2 Phase coding



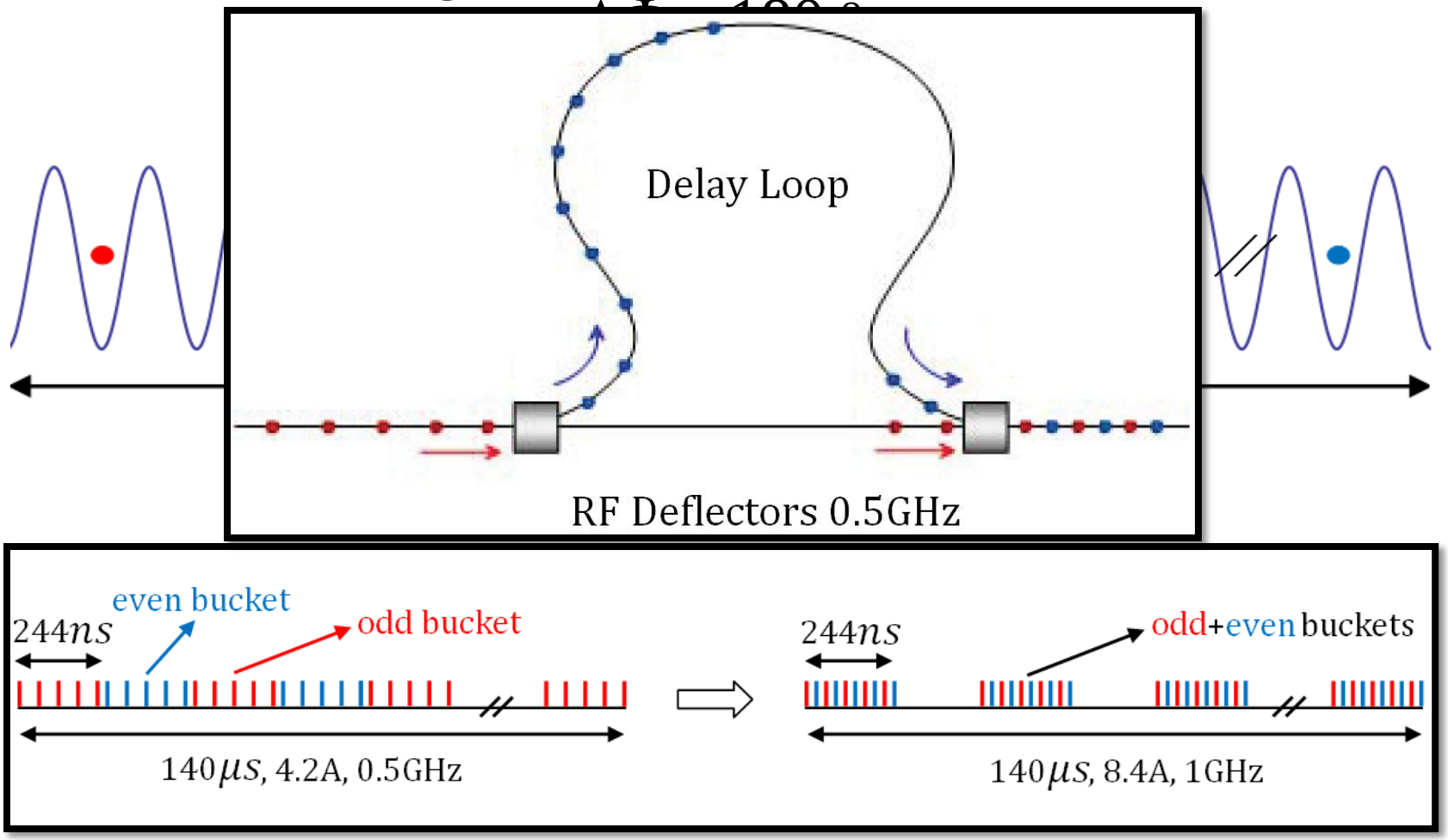
1.2 Phase coding



- Only every second bucket is occupied.

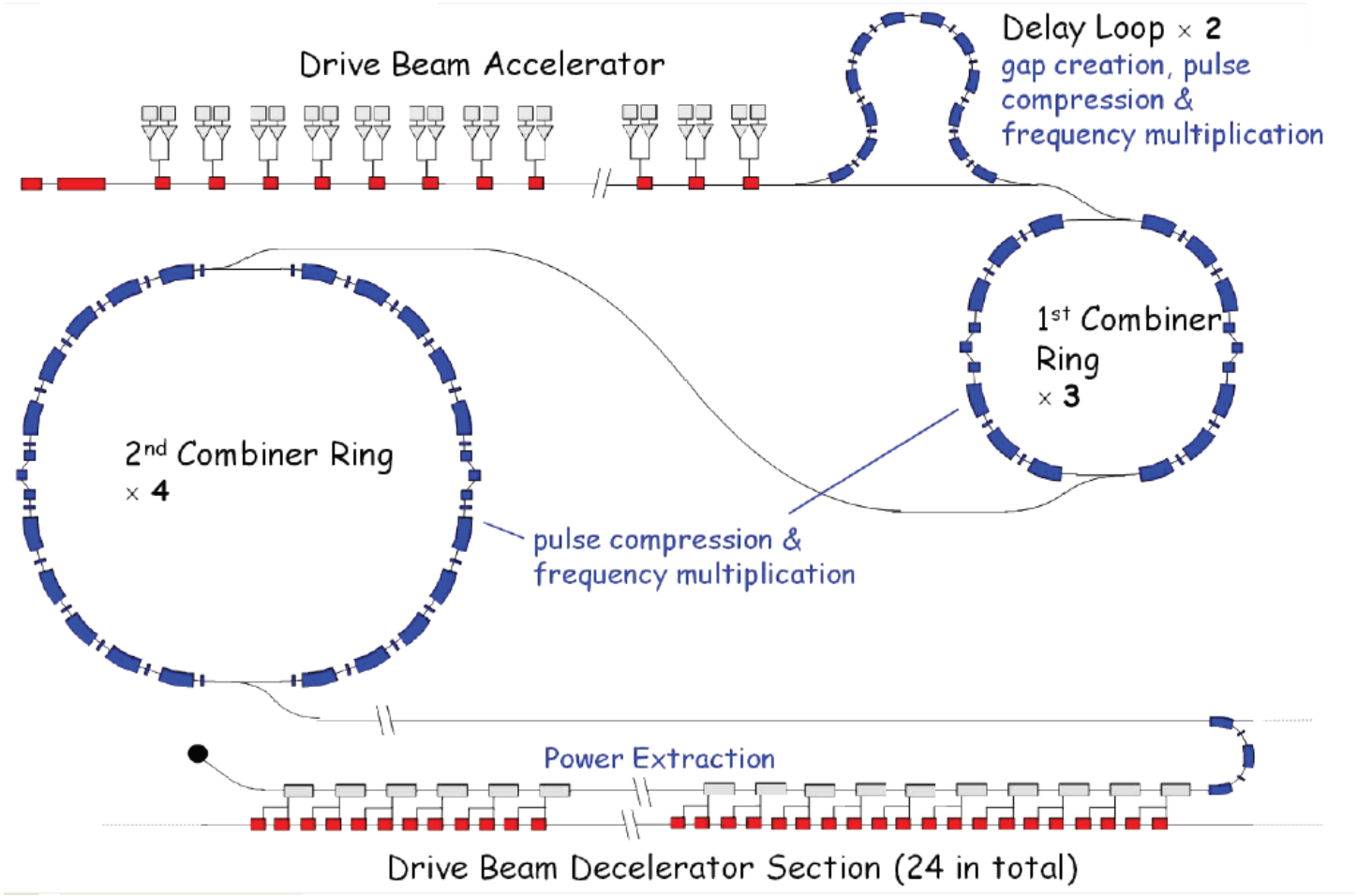
- About 5% of particles captured in wrong buckets, called satellite bunches.

1.2 Phase coding



1.3 Drive Beam Complex

I = 24×4.2A=100.8A
f = 24×0.5GHz=12GHz



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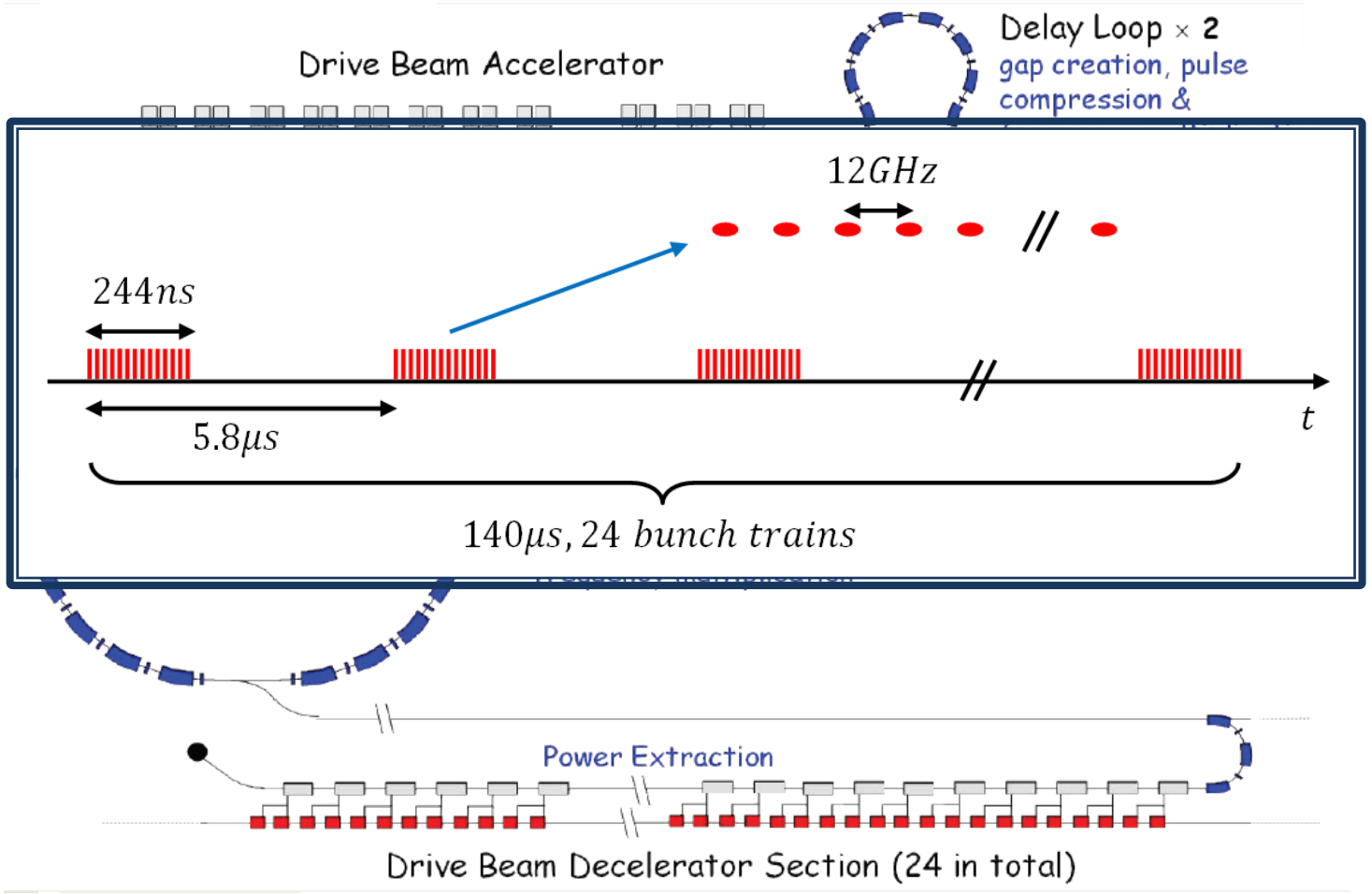
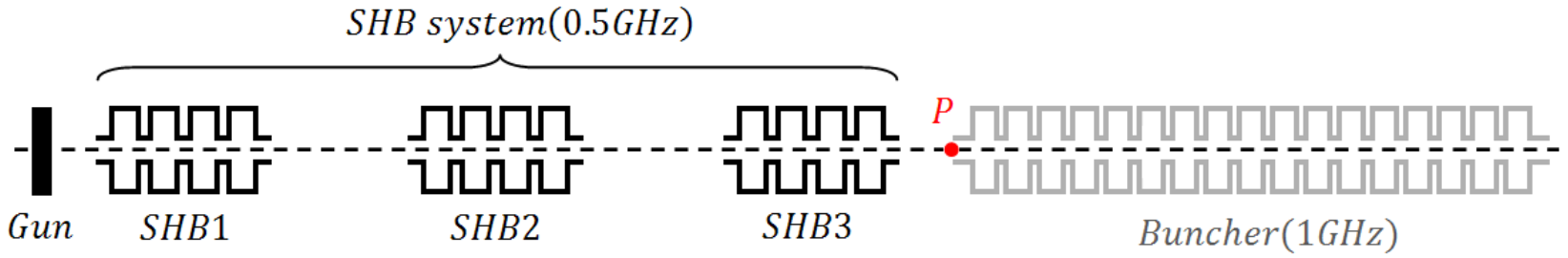


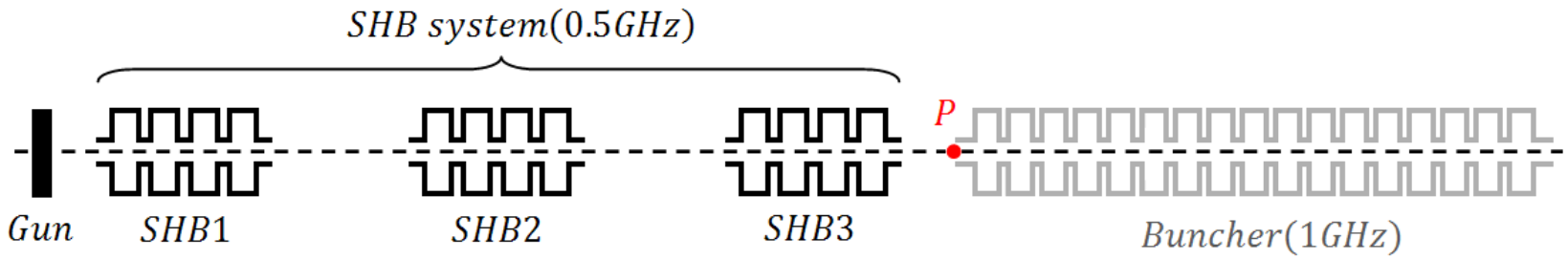
2. Sub-harmonic bunching system

2.1 General layout of bunching system

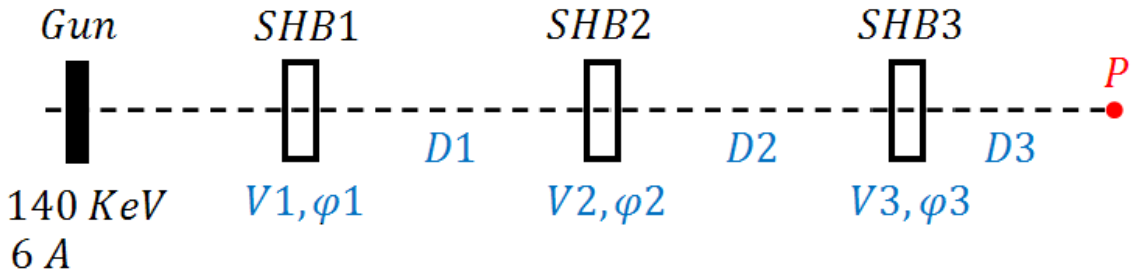


2. Sub-harmonic bunching system

2.1 General layout of bunching system

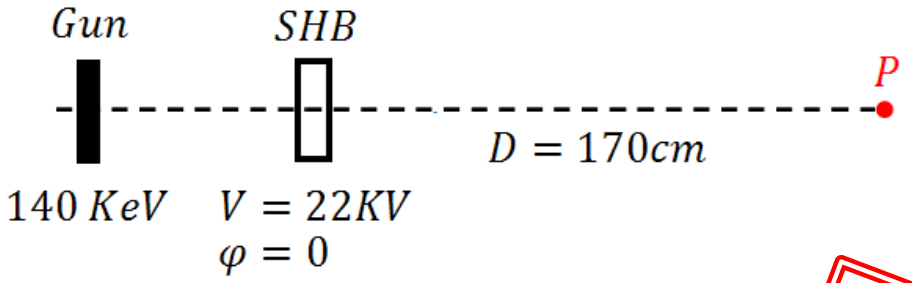


2.2 Thin lens approximation



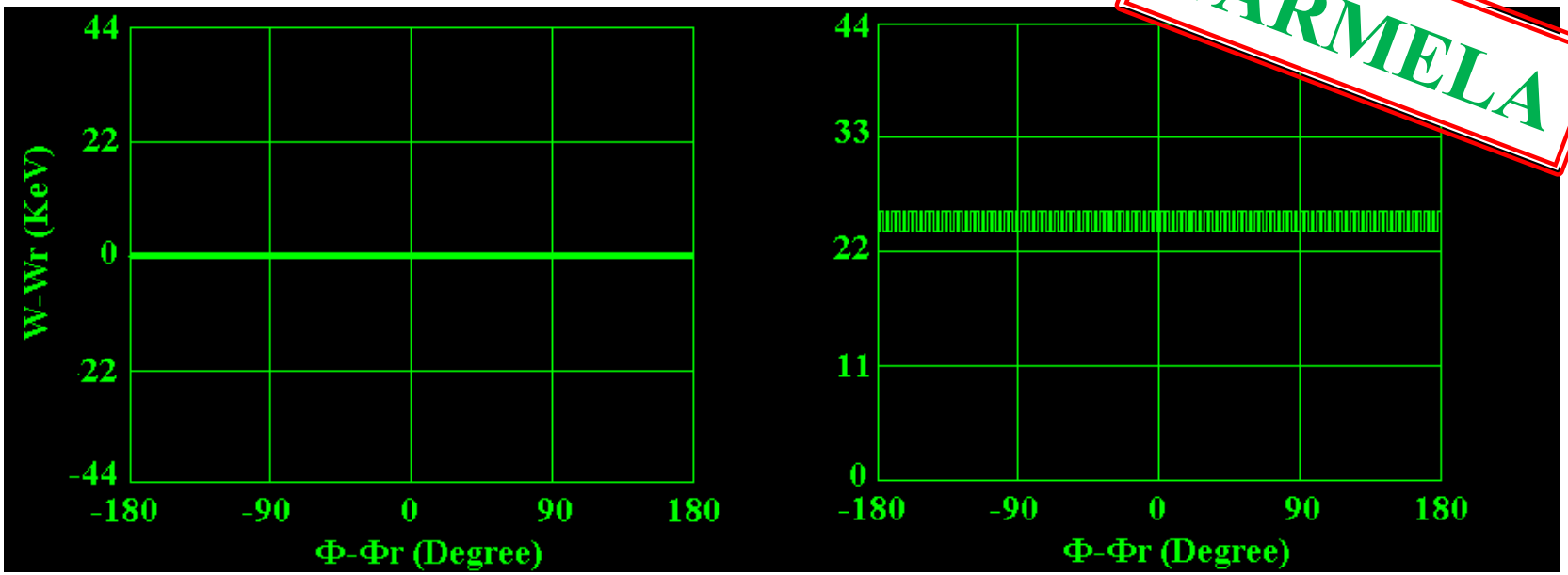
- To maximize the population of the particles in the acceptance of the buncher.
- To minimize the population of satellite bunches.

2.3 Velocity modulation bunching



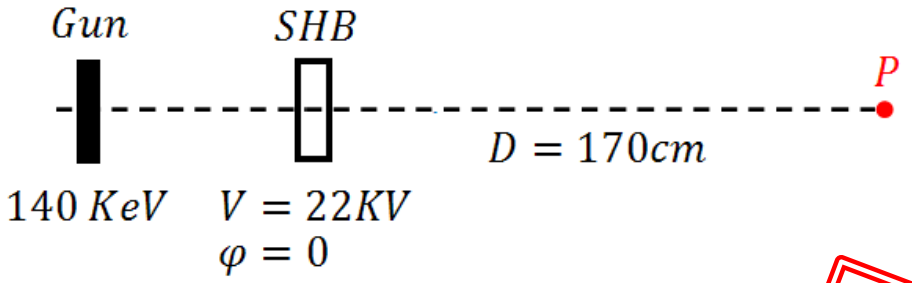
Before SHB

PARMELA



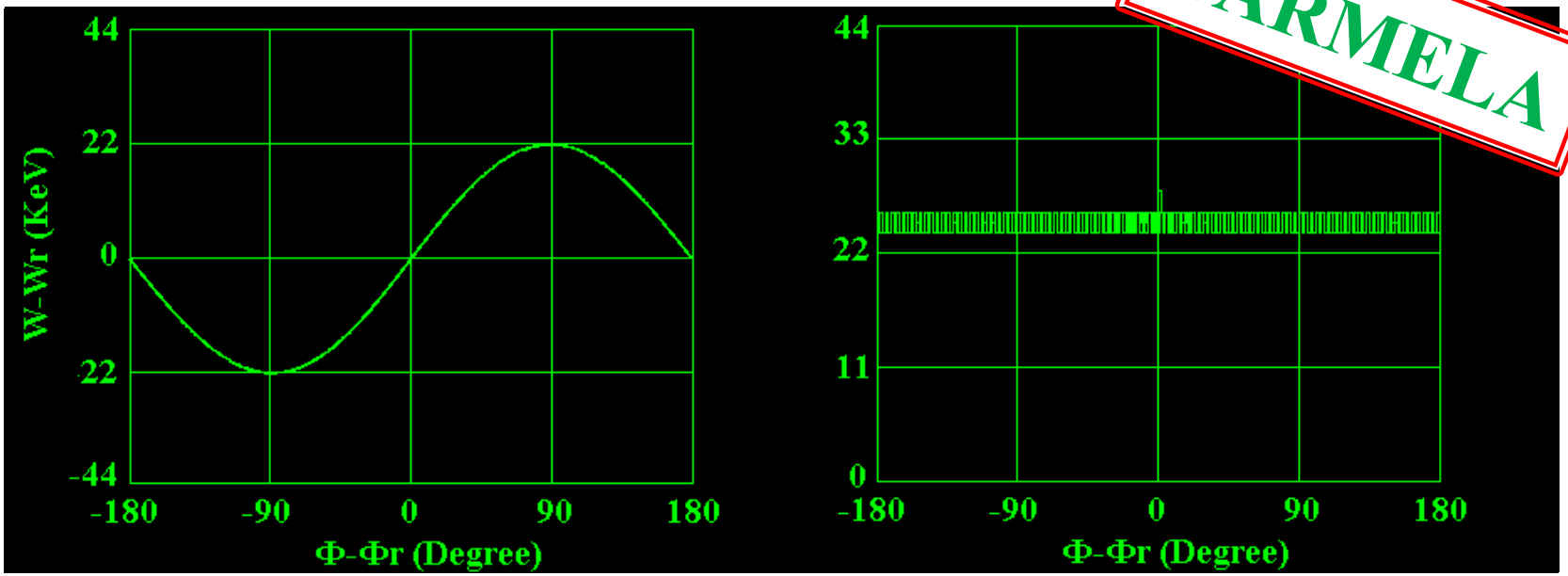
Phase Space **Phase Spectrum**

2.3 Velocity modulation bunching



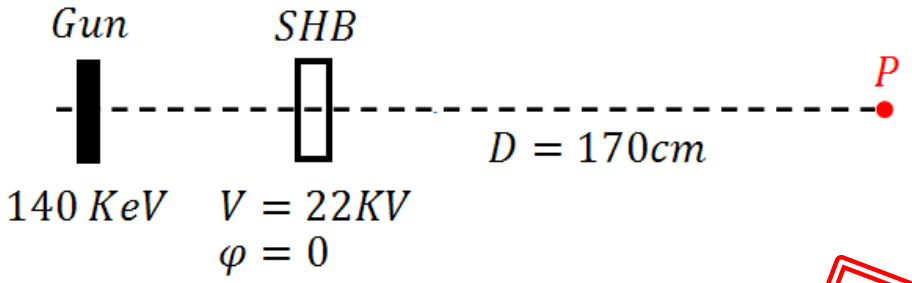
Just after SHB

PARMELA



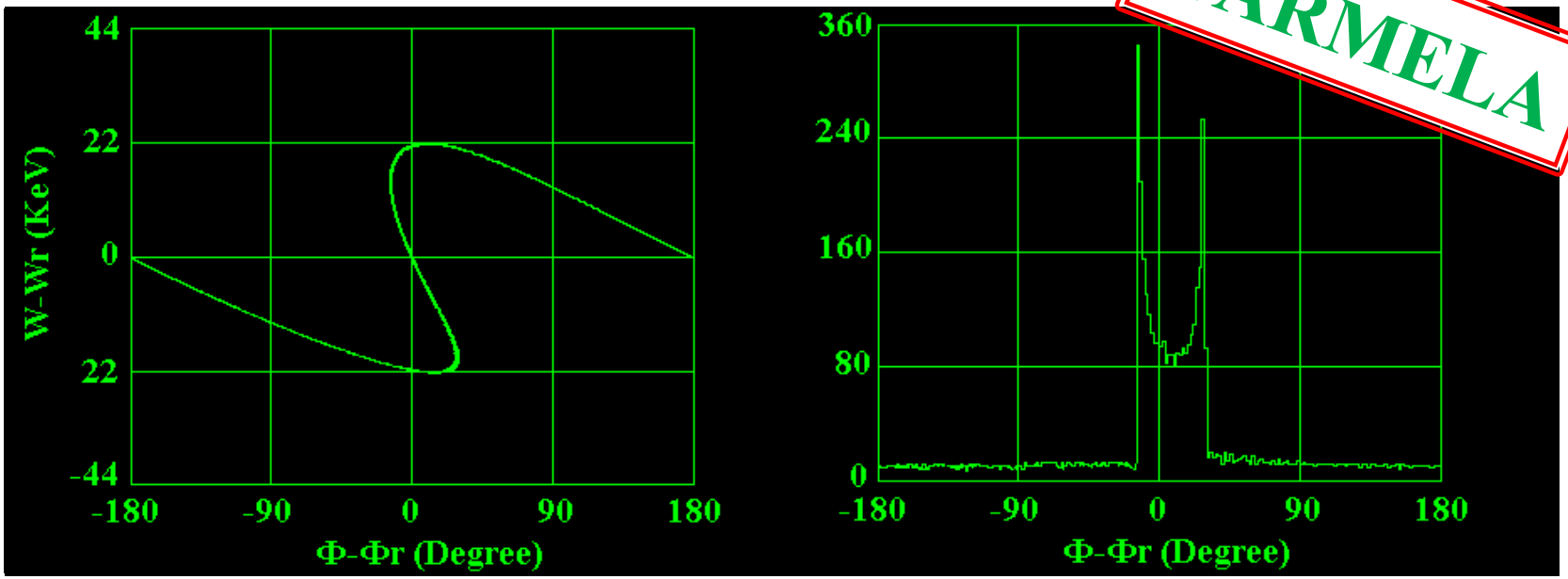
Phase Space **Phase Spectrum**

2.3 Velocity modulation bunching



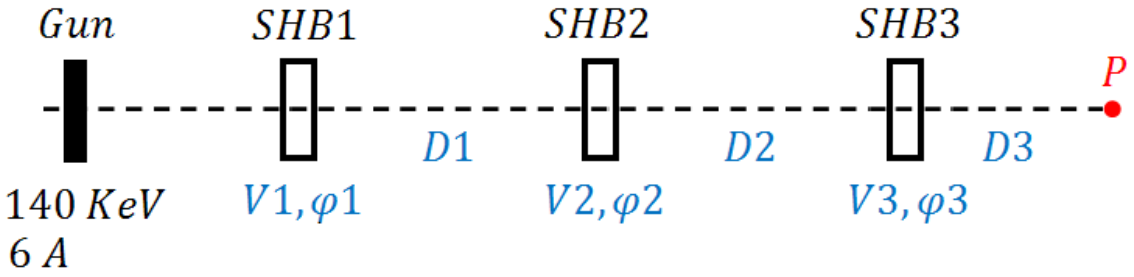
At point P

PARMELA



Phase Space **Phase Spectrum**

2.4 Optimization of the thin lens system



In drift section:

$\Delta\varphi = 360 f D/\beta c$

$\Delta W = 0$

In SHB(thin lens):

$\Delta\varphi = 0$

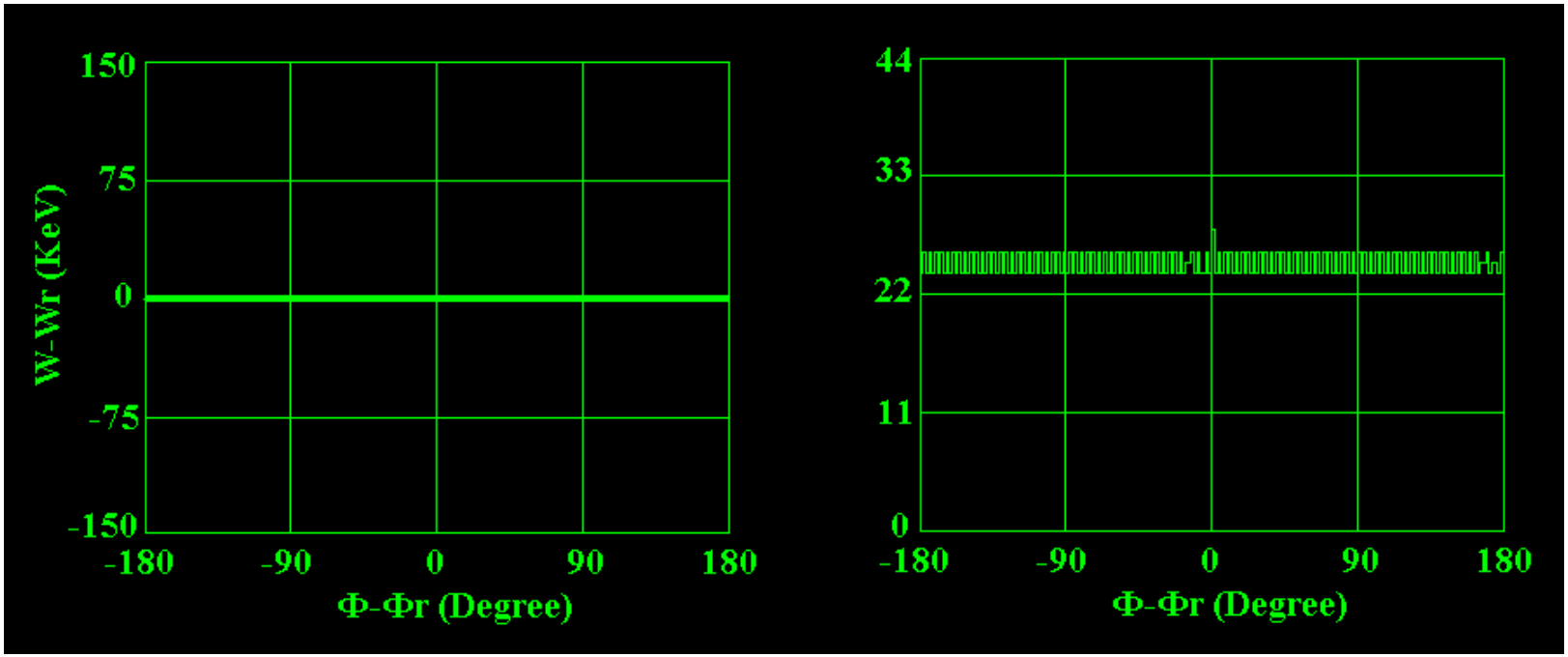
$\Delta W = eV sin[\Phi_0 + \varphi - \varphi_r]$

$$-60^o < \varphi_P < 60^o \Rightarrow \textbf{buncher acceptance} \rightarrow max$$

$$\begin{cases} -180^o < \varphi_P < -90^o \\ 90^o < \varphi_P < 180^o \end{cases} \Rightarrow \textbf{satellite} \rightarrow min$$

2.4 Optimization of the thin lens system

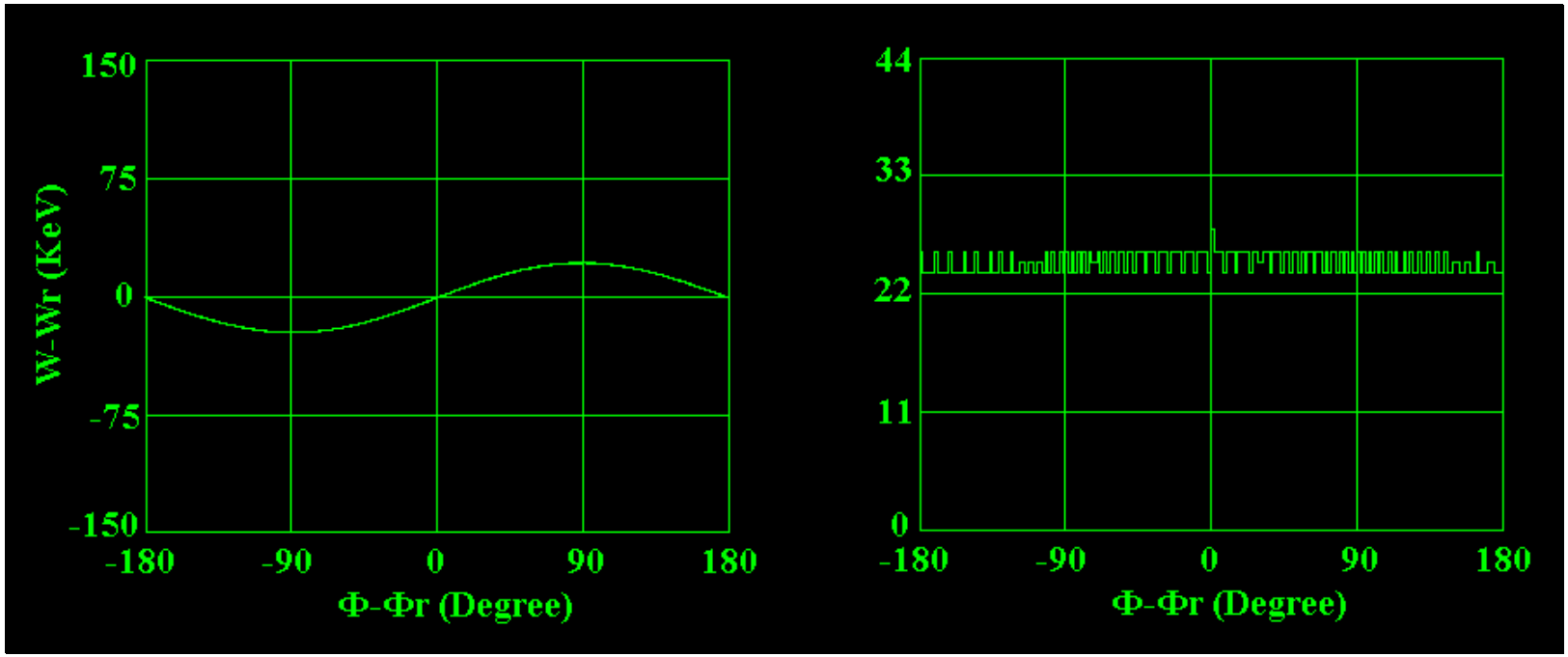
Before SHB1



Phase Space **Phase Spectrum**

2.4 Optimization of the thin lens system

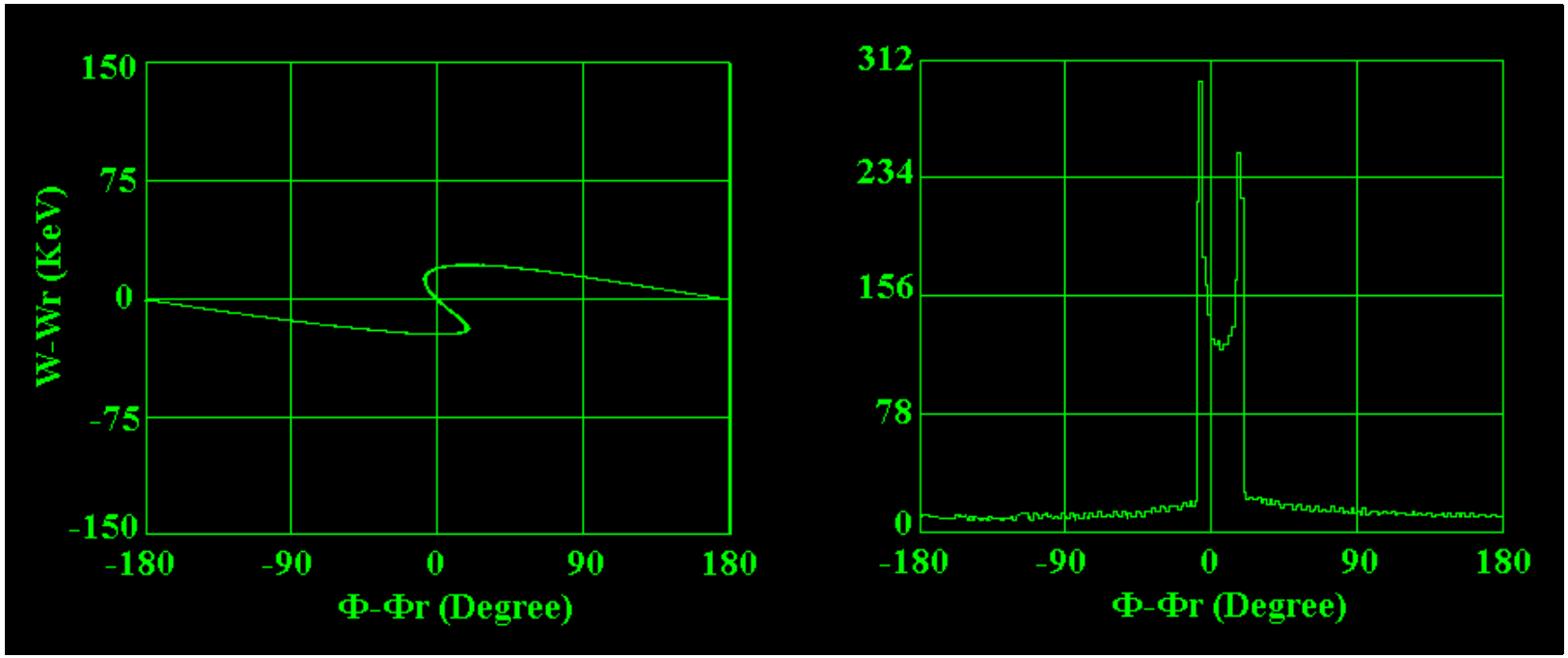
After SHB1



Phase Space **Phase Spectrum**

2.4 Optimization of the thin lens system

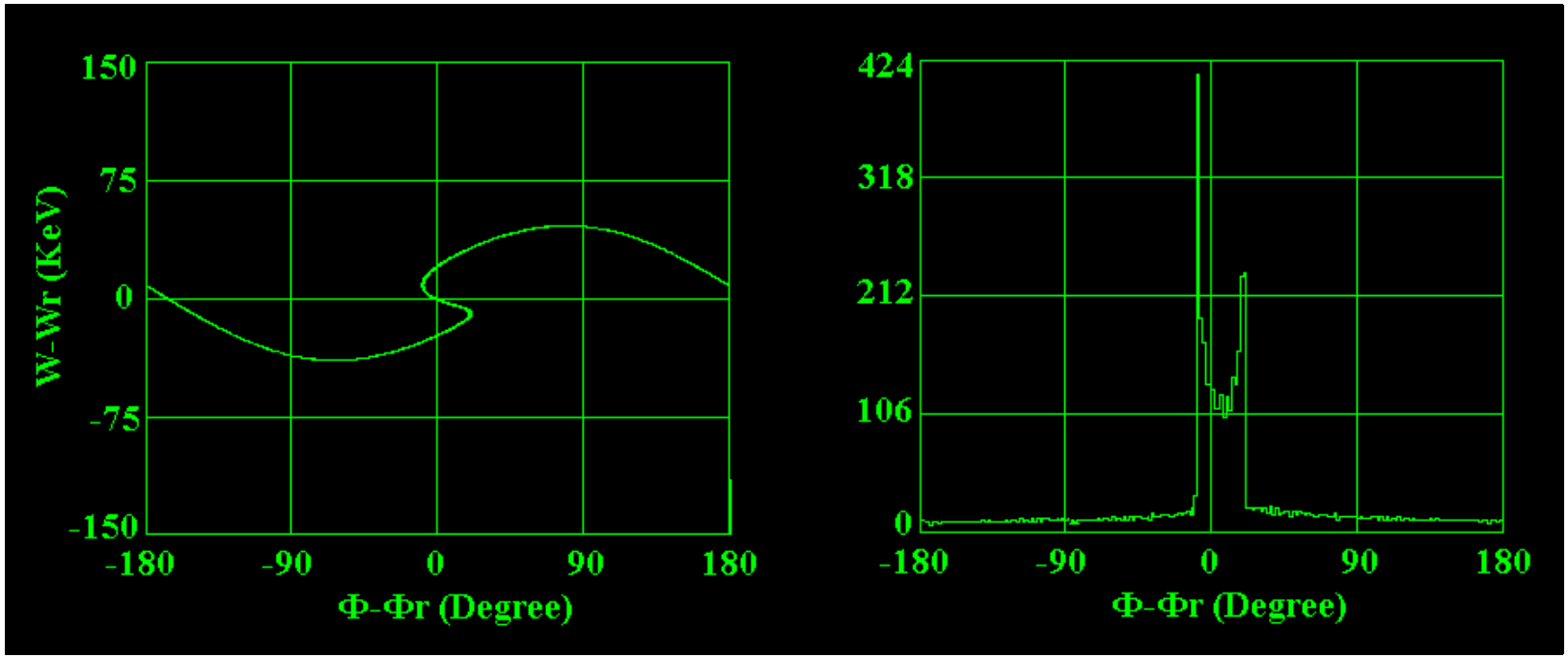
Before SHB2



Phase Space **Phase Spectrum**

2.4 Optimization of the thin lens system

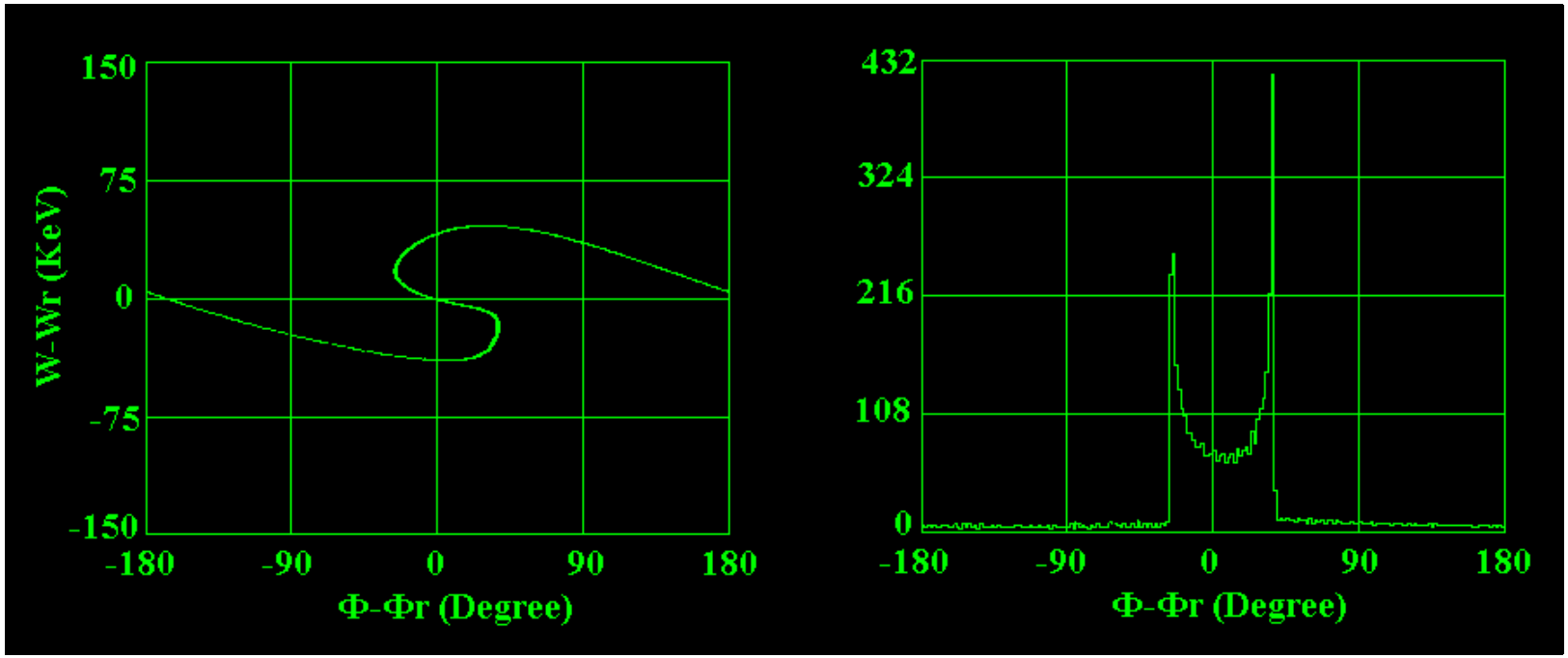
After SHB2



Phase Space **Phase Spectrum**

2.4 Optimization of the thin lens system

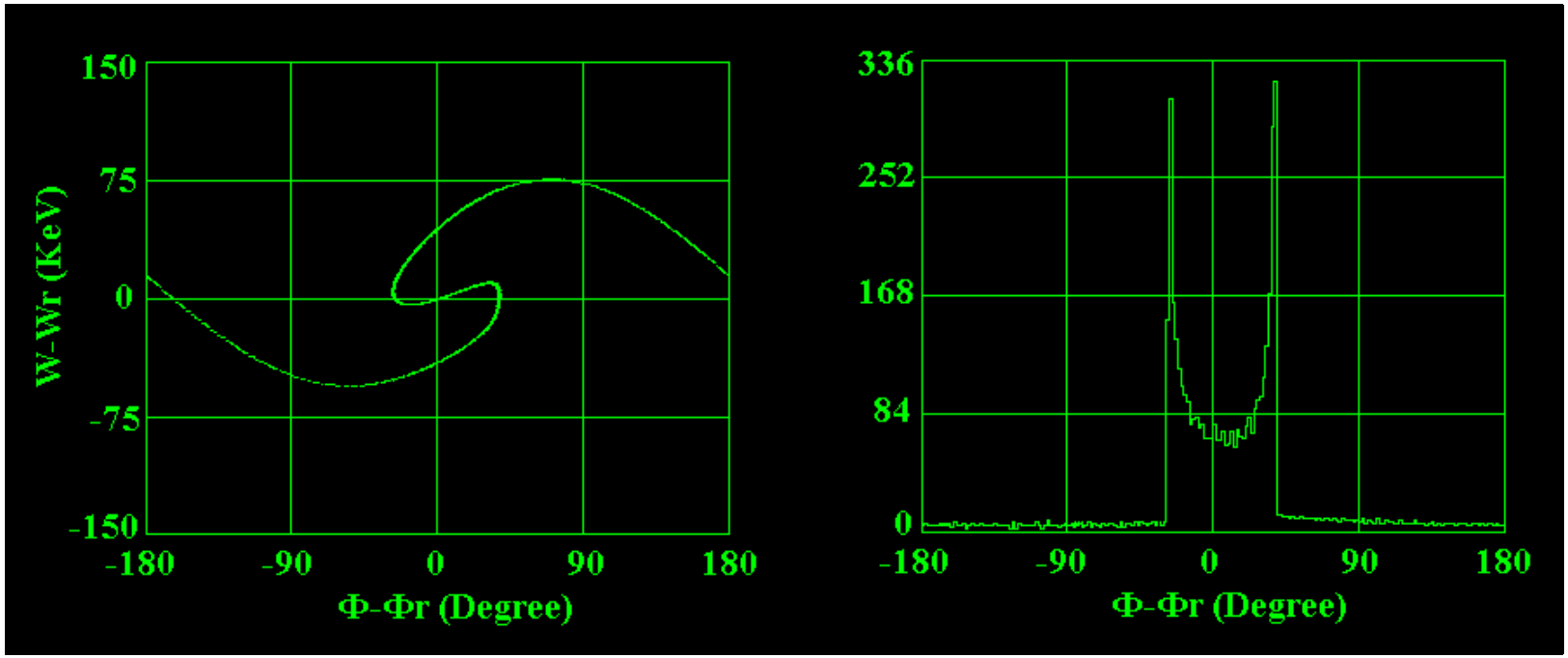
Before SHB3



Phase Space **Phase Spectrum**

2.4 Optimization of the thin lens system

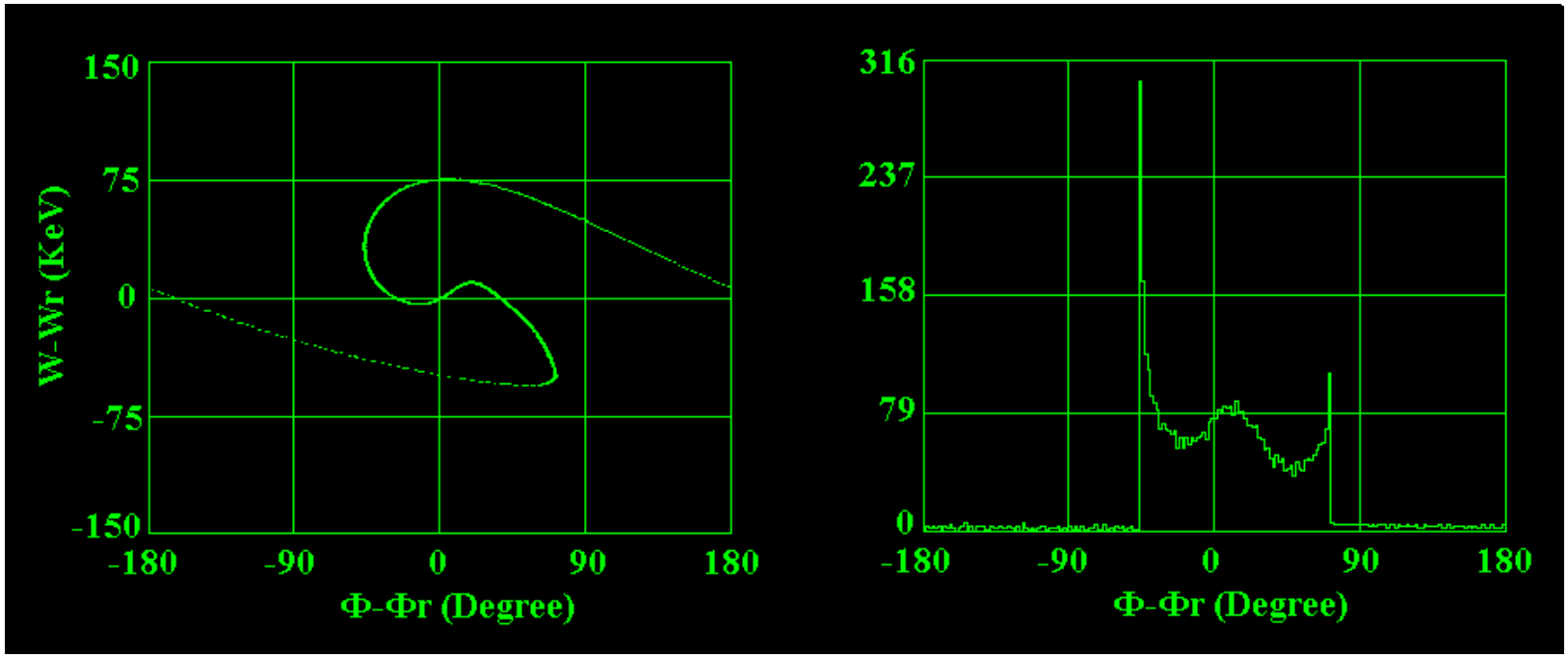
After SHB3



Phase Space **Phase Spectrum**

2.4 Optimization of the thin lens system

At point P



Phase Space **Phase Spectrum**

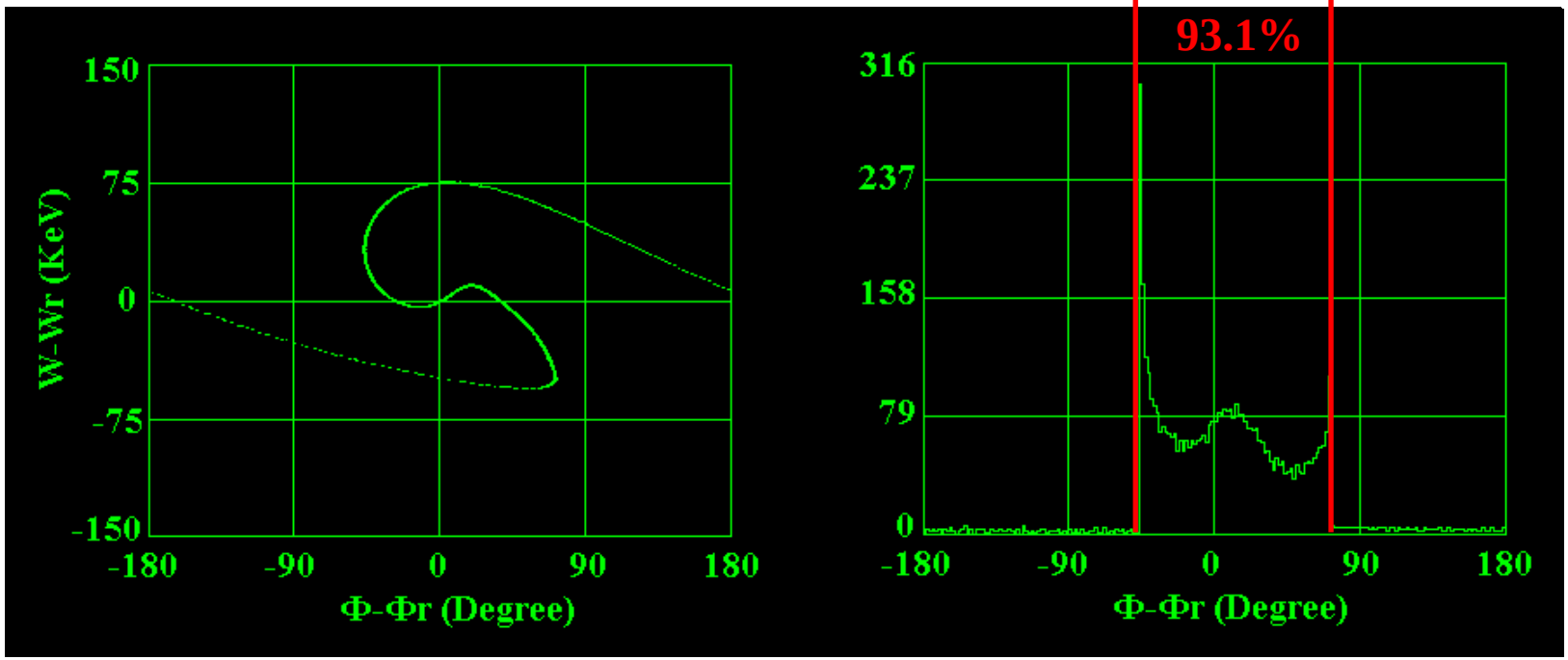
2.4 Optimization of the thin lens system

Satellite population = 4.4%

120º

93.1%

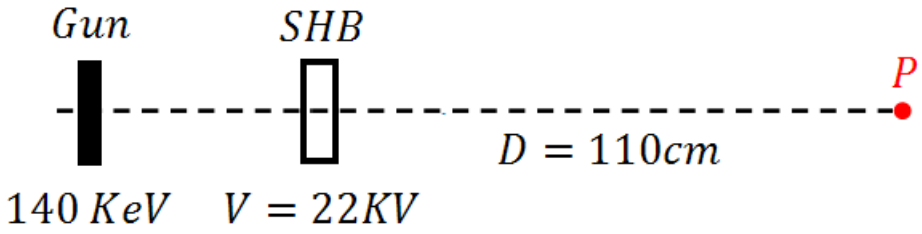
At point P

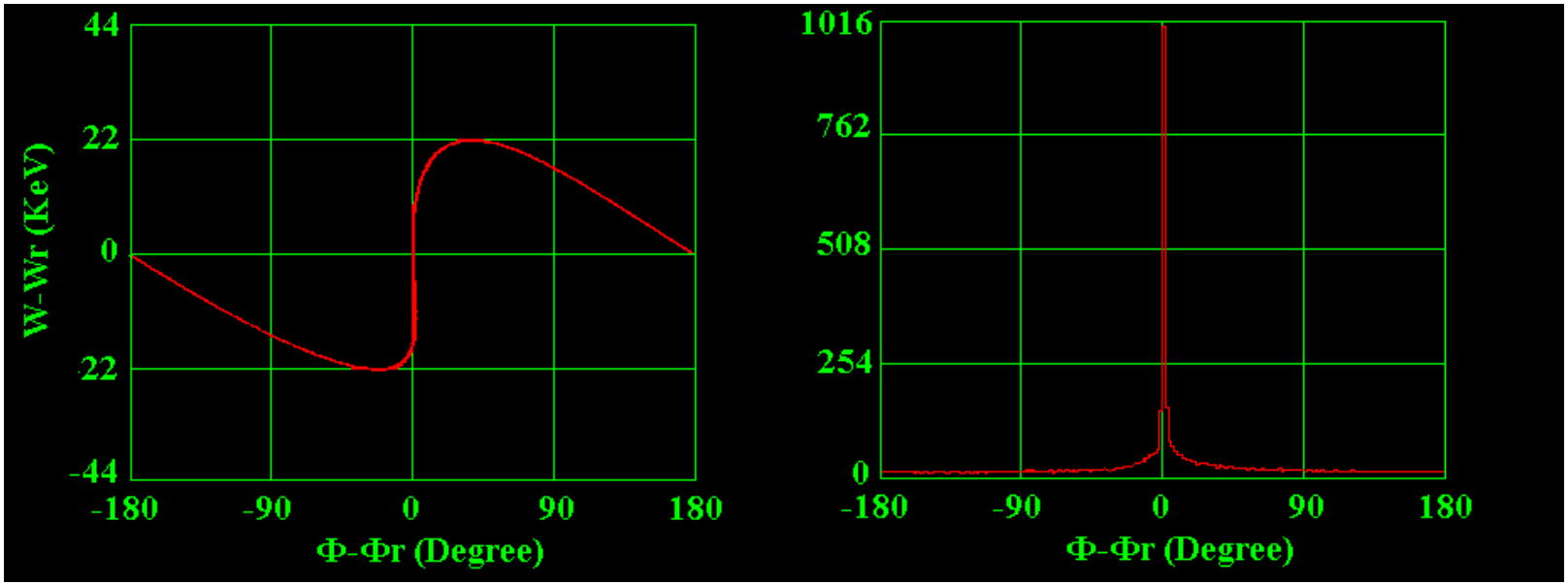


Phase Space **Phase Spectrum**

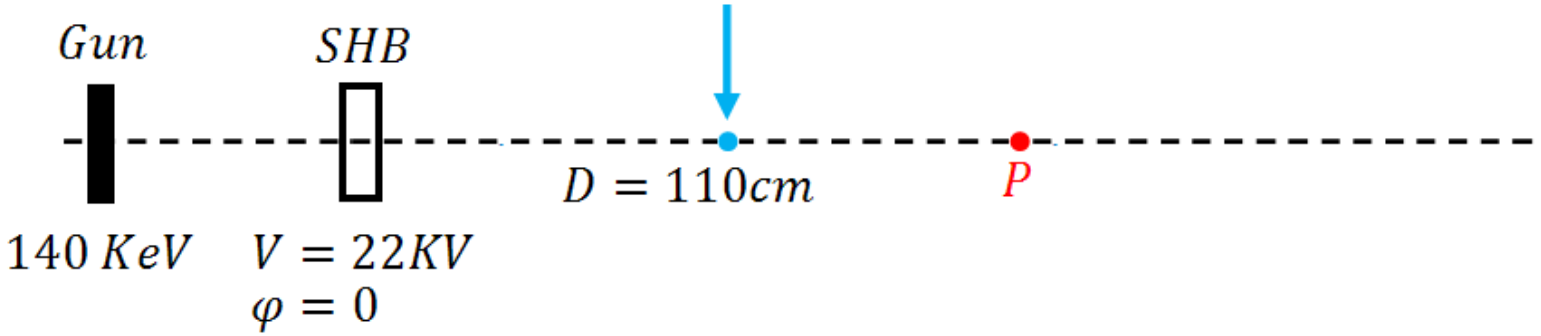
2.5 The space charge effect

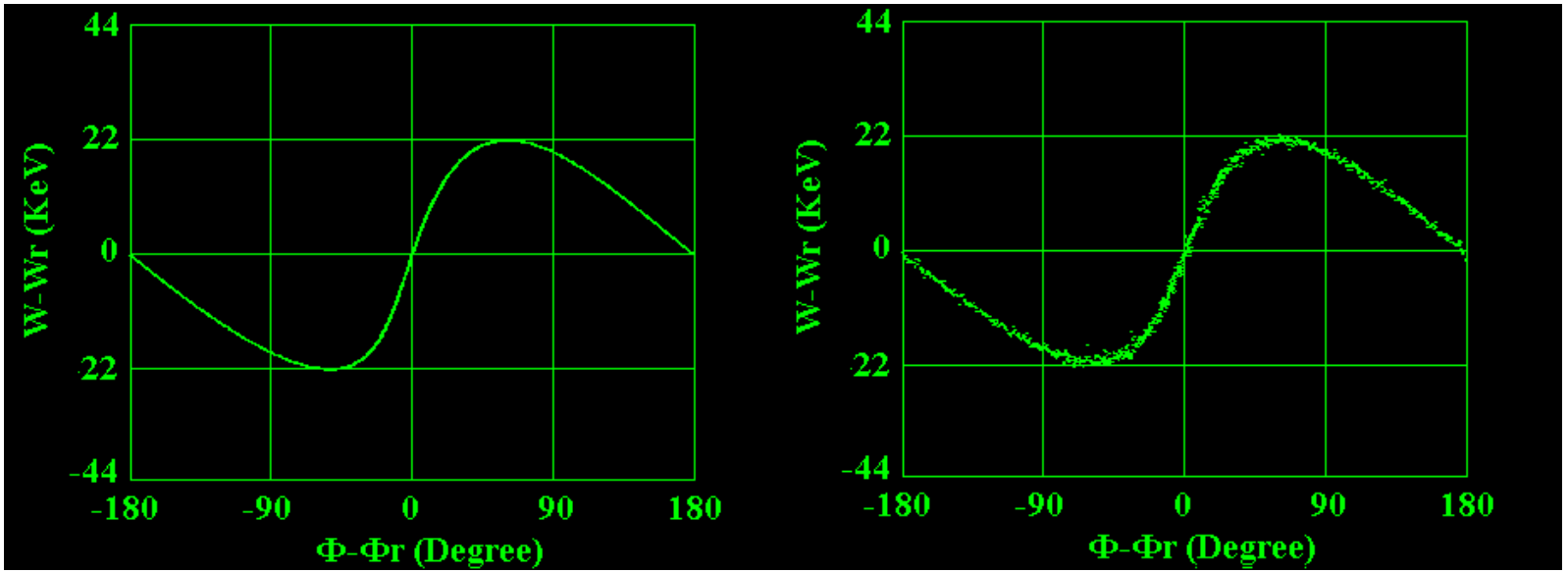
➢ The effect of the space charge forces is investigated in various configuration of the system.





2.5 The space charge effect

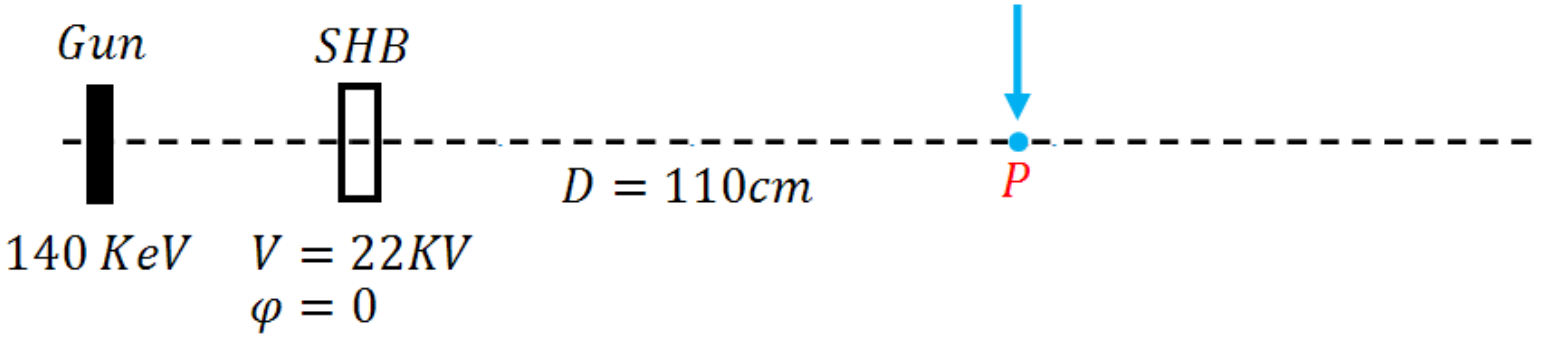


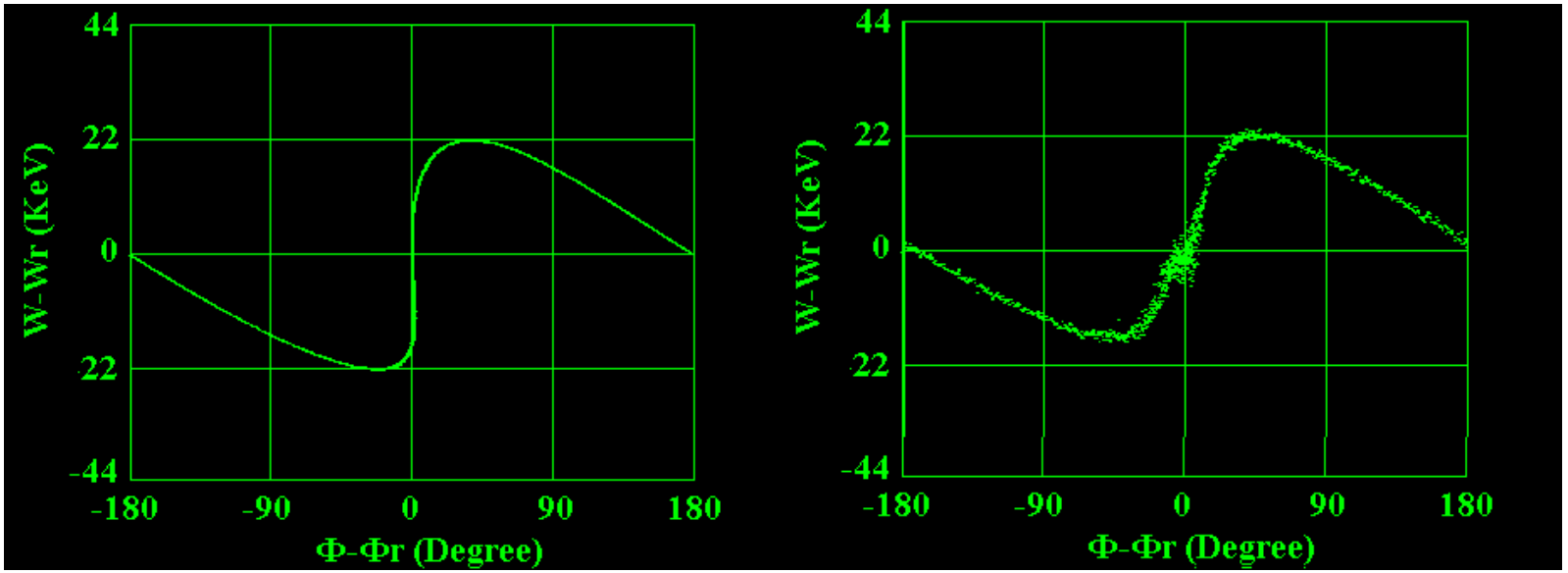


Ignoring the space charge

With the space charge

2.5 The space charge effect

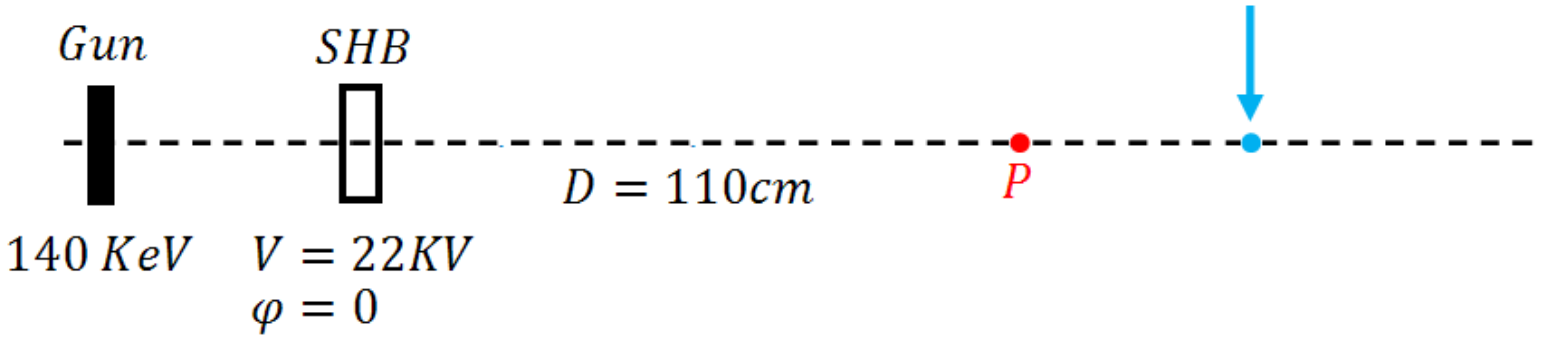


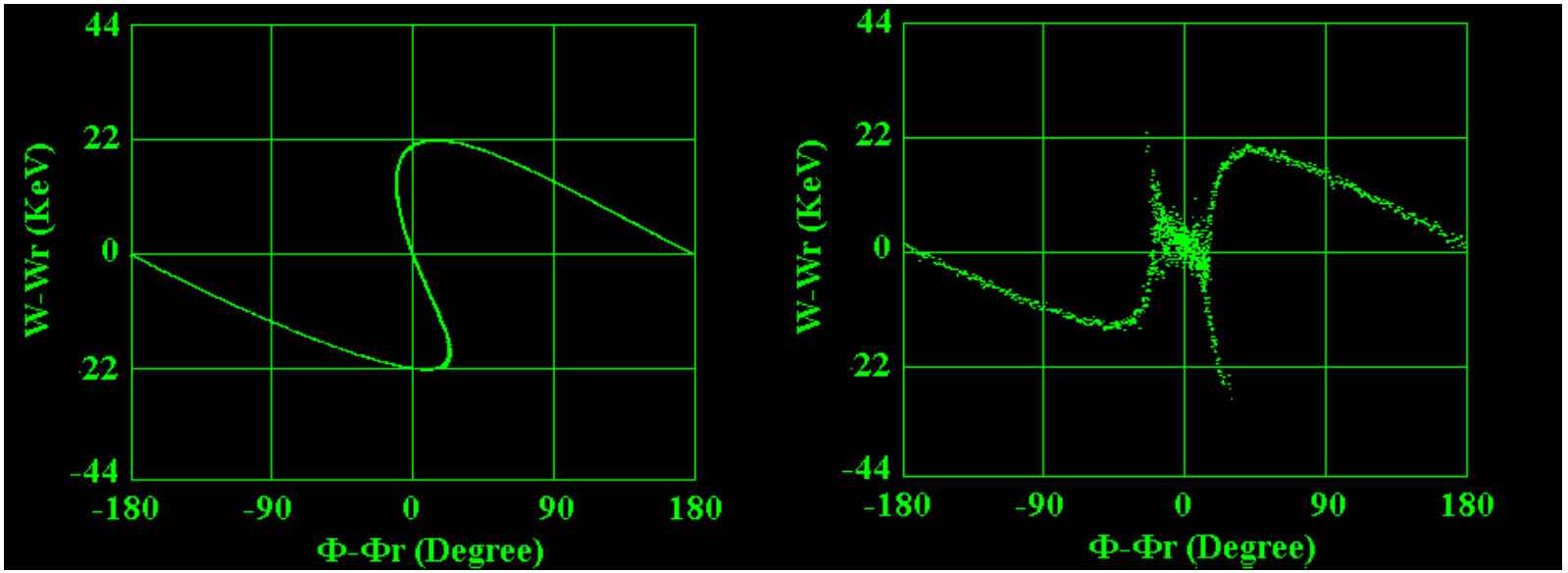


Ignoring the space charge

With the space charge

2.5 The space charge effect





Ignoring the space charge

With the space charge

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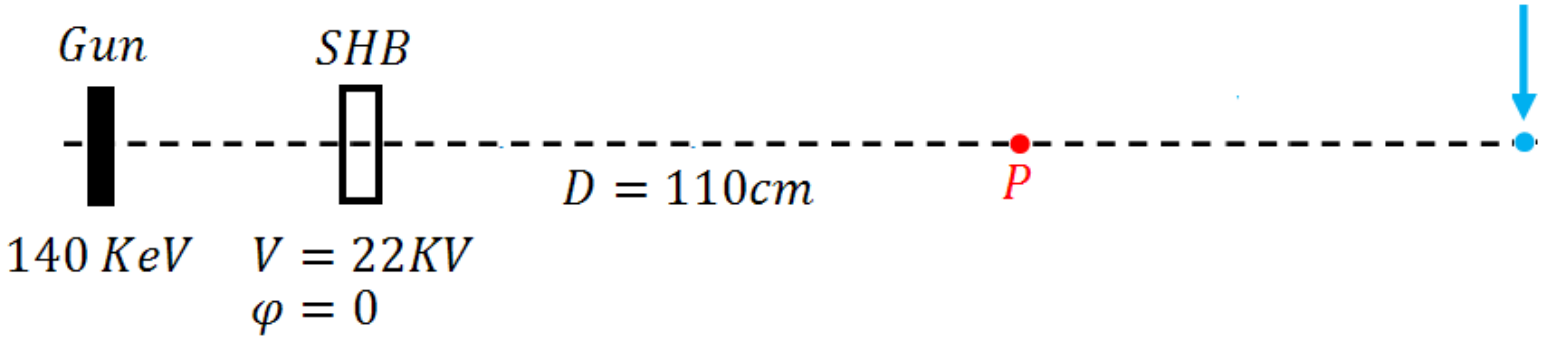
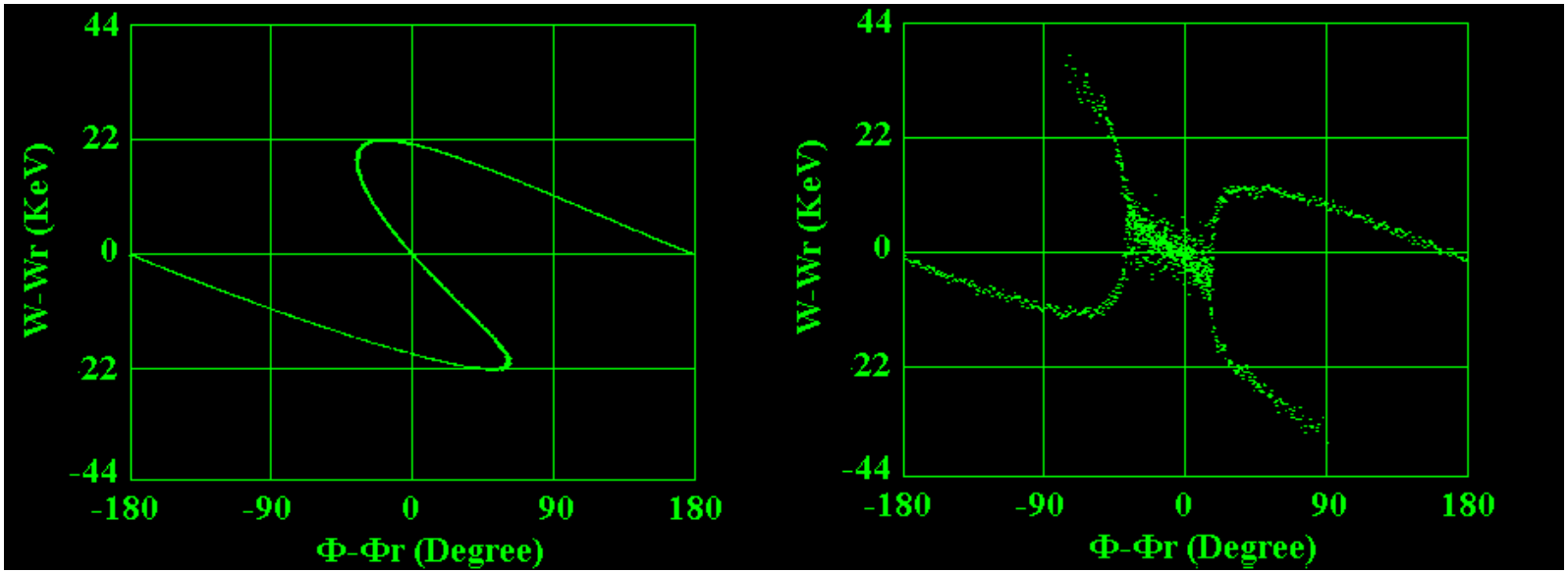
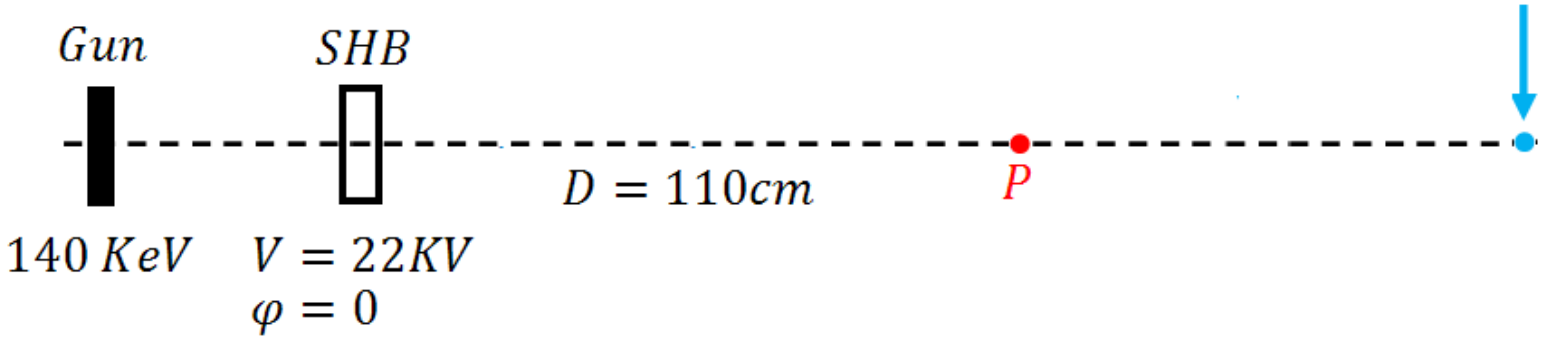


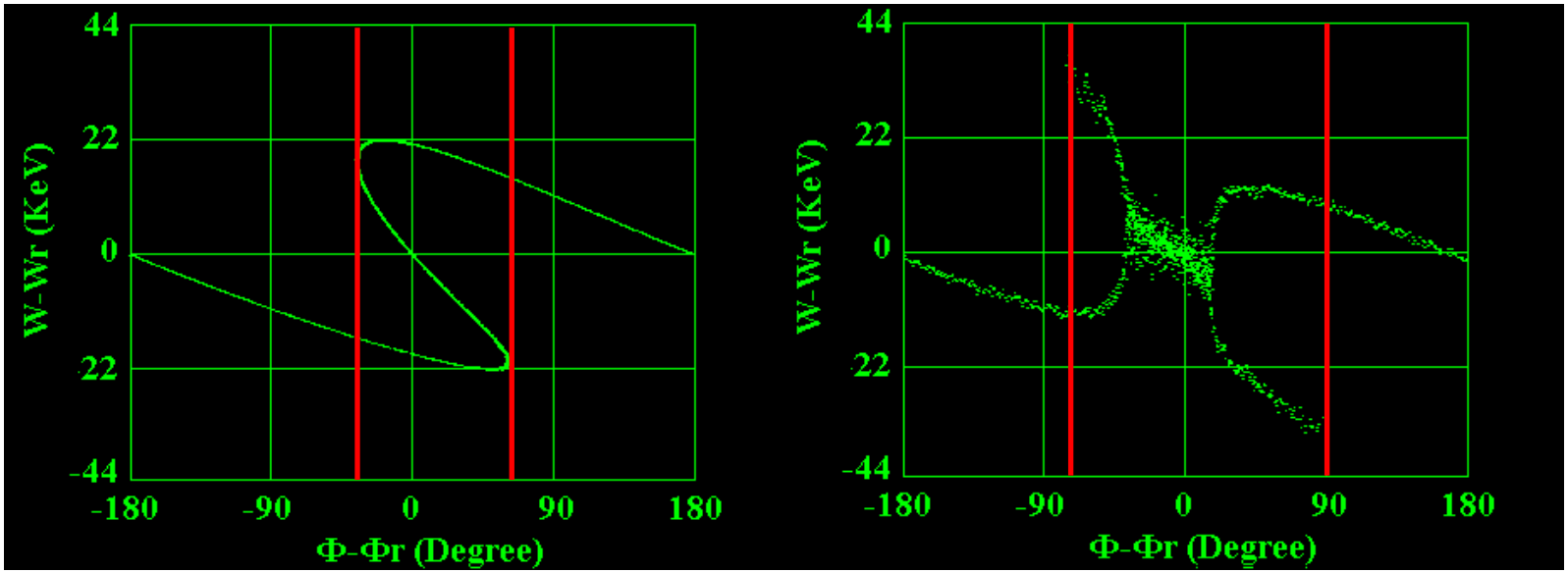


Ignoring the space charge

With the space charge

2.5 The space charge effect





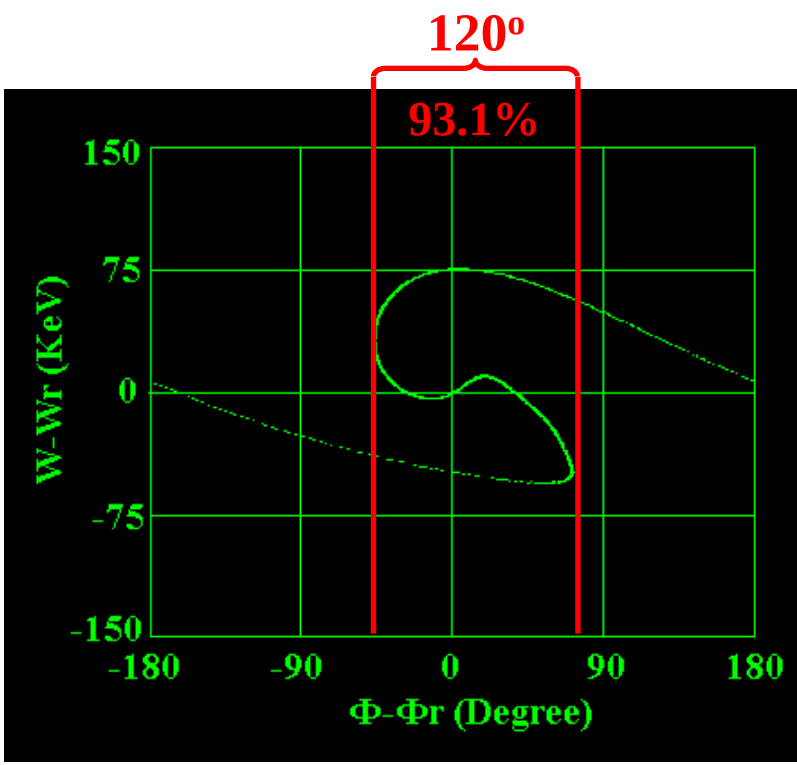
Ignoring the space charge

With the space charge

2.5 The space charge effect

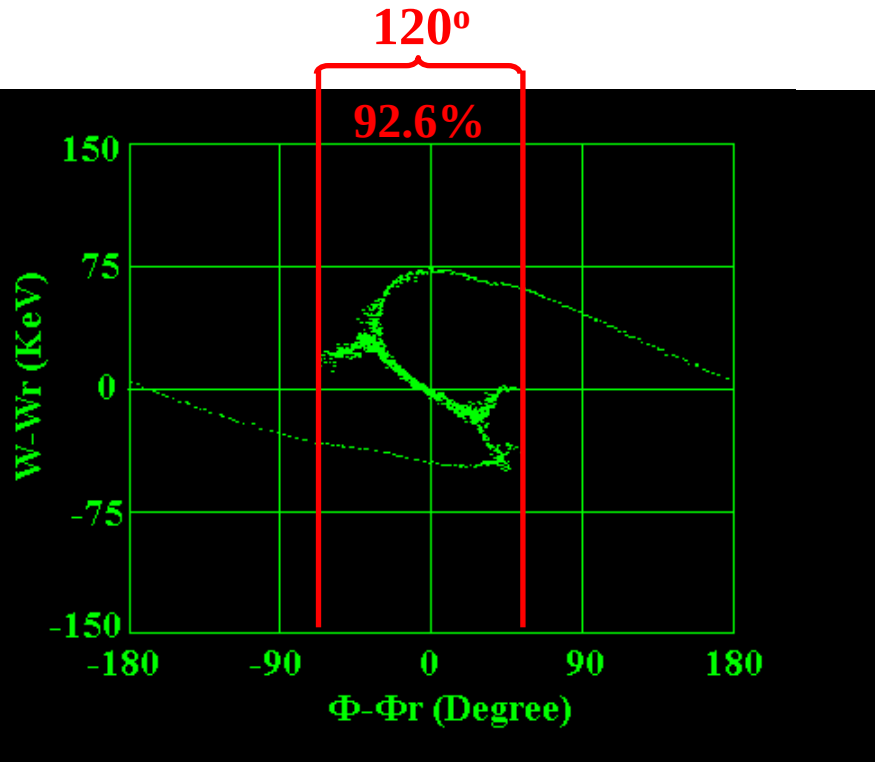
➢The phase space at the entrance of buncher

Satellite population = 4.4%



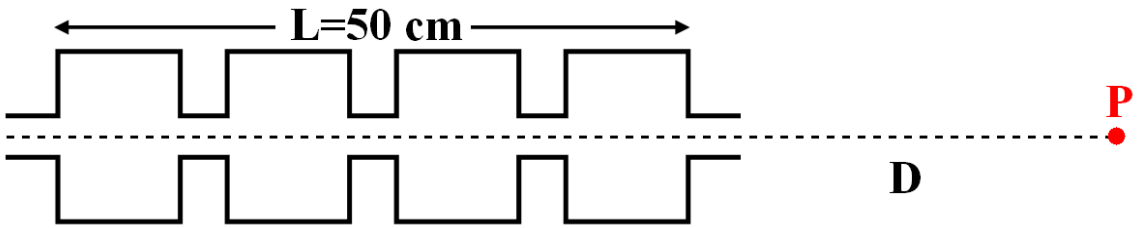
Ignoring the space charge

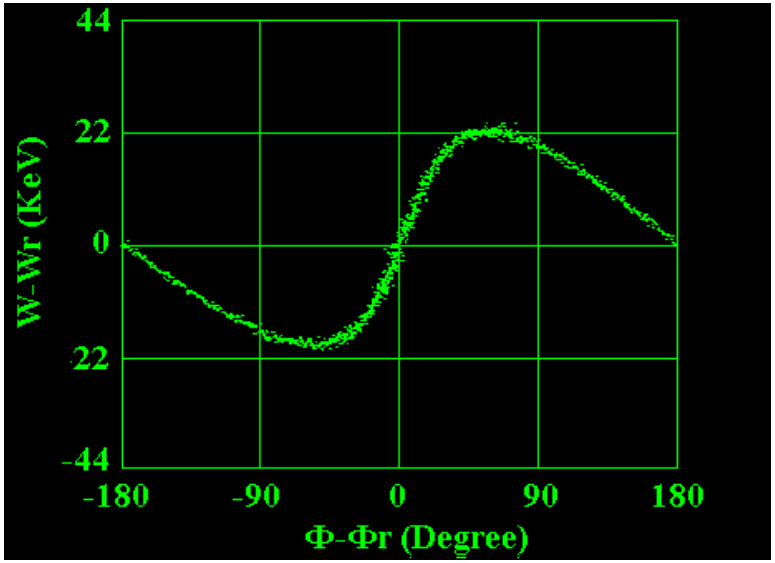
Satellite population = 4.7%



With the space charge

2.6 Travelling wave SHBs





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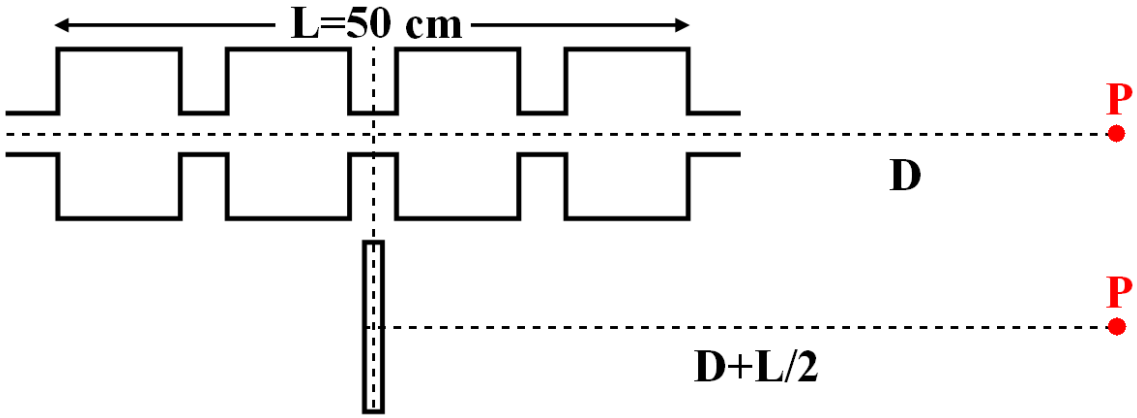
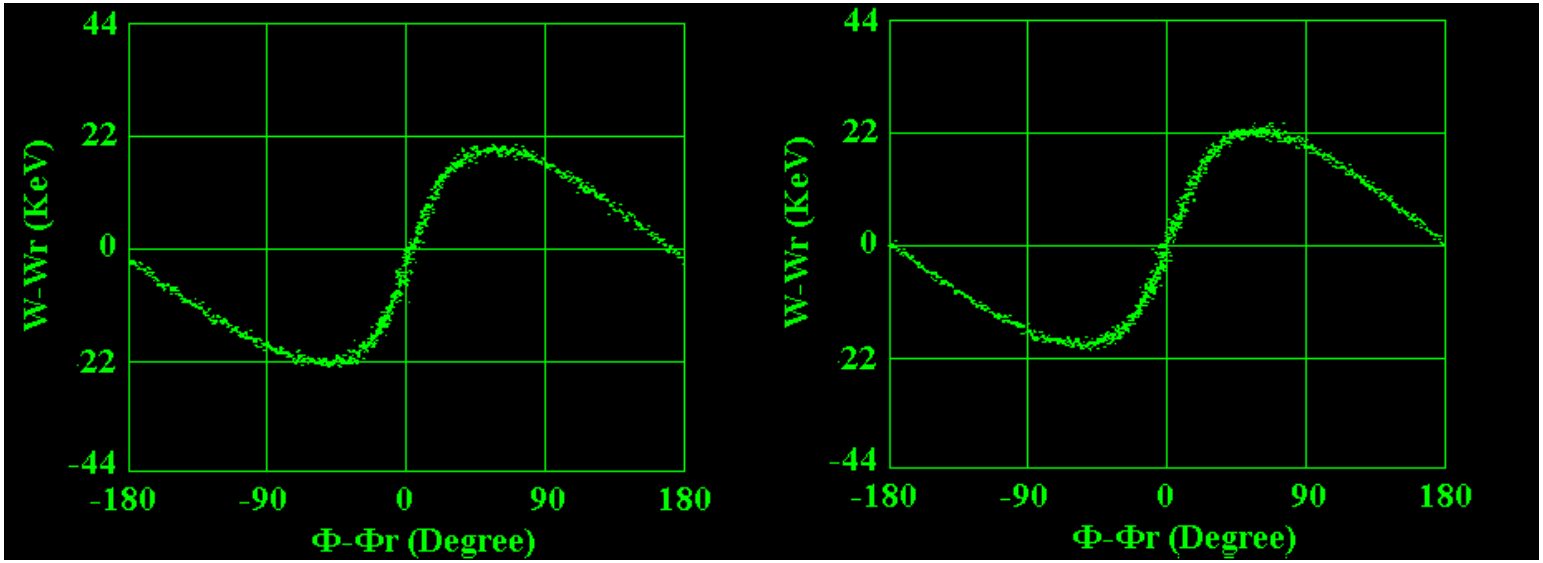
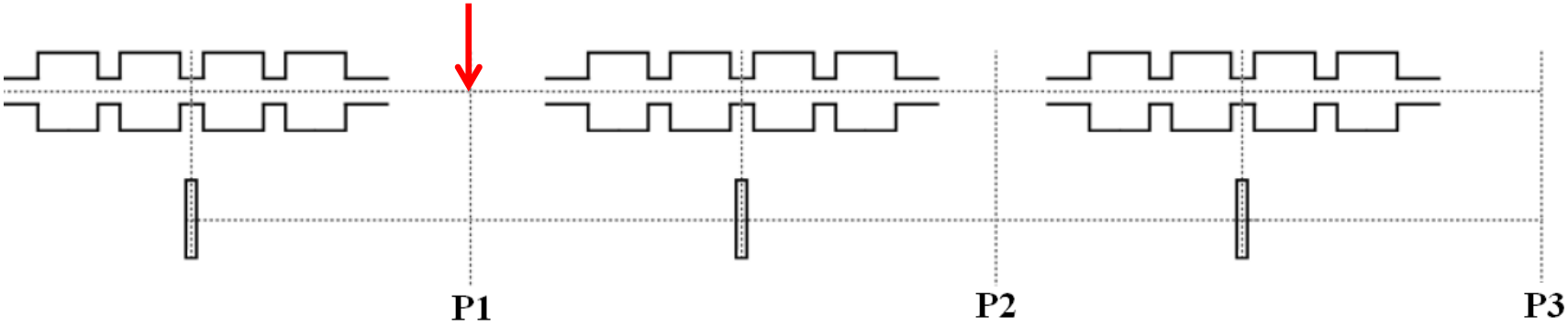
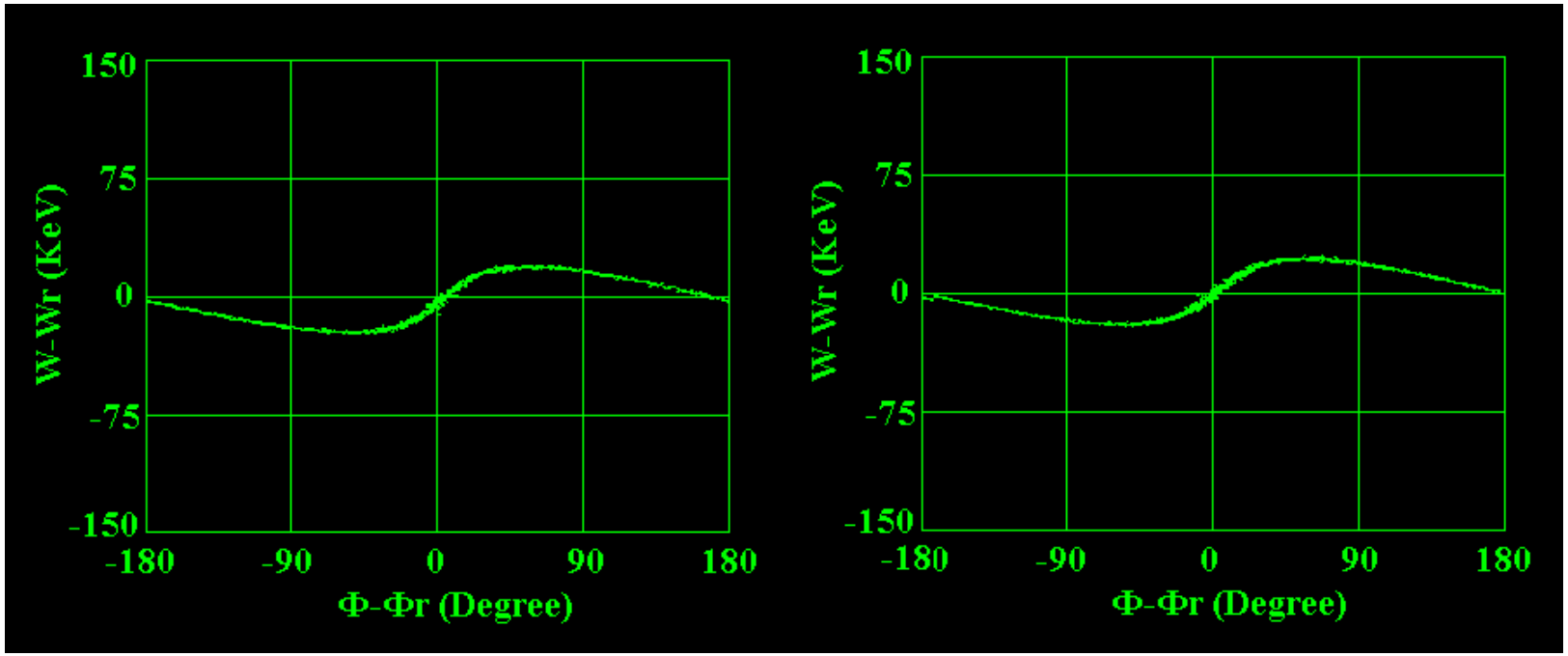




Thin lens SHB **Travelling Wave SHB**

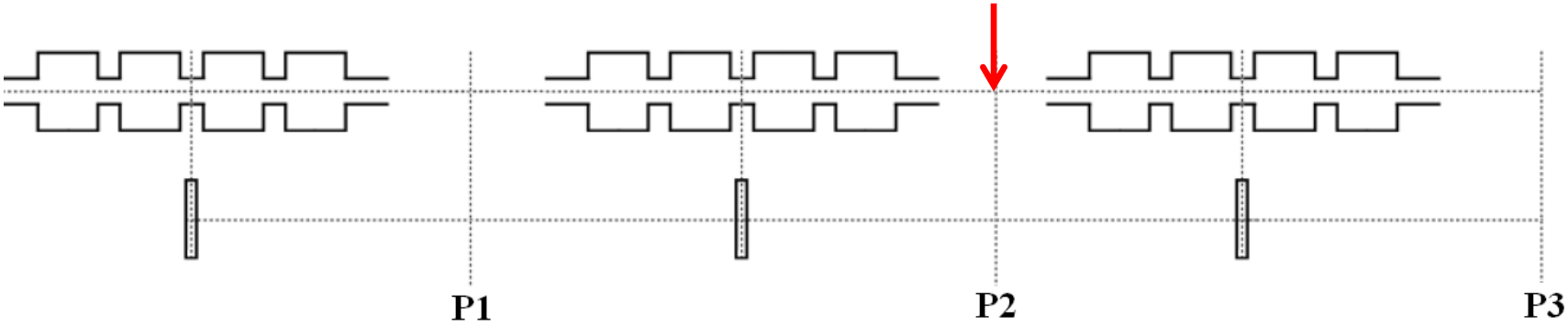
2.6 Travelling wave SHBs

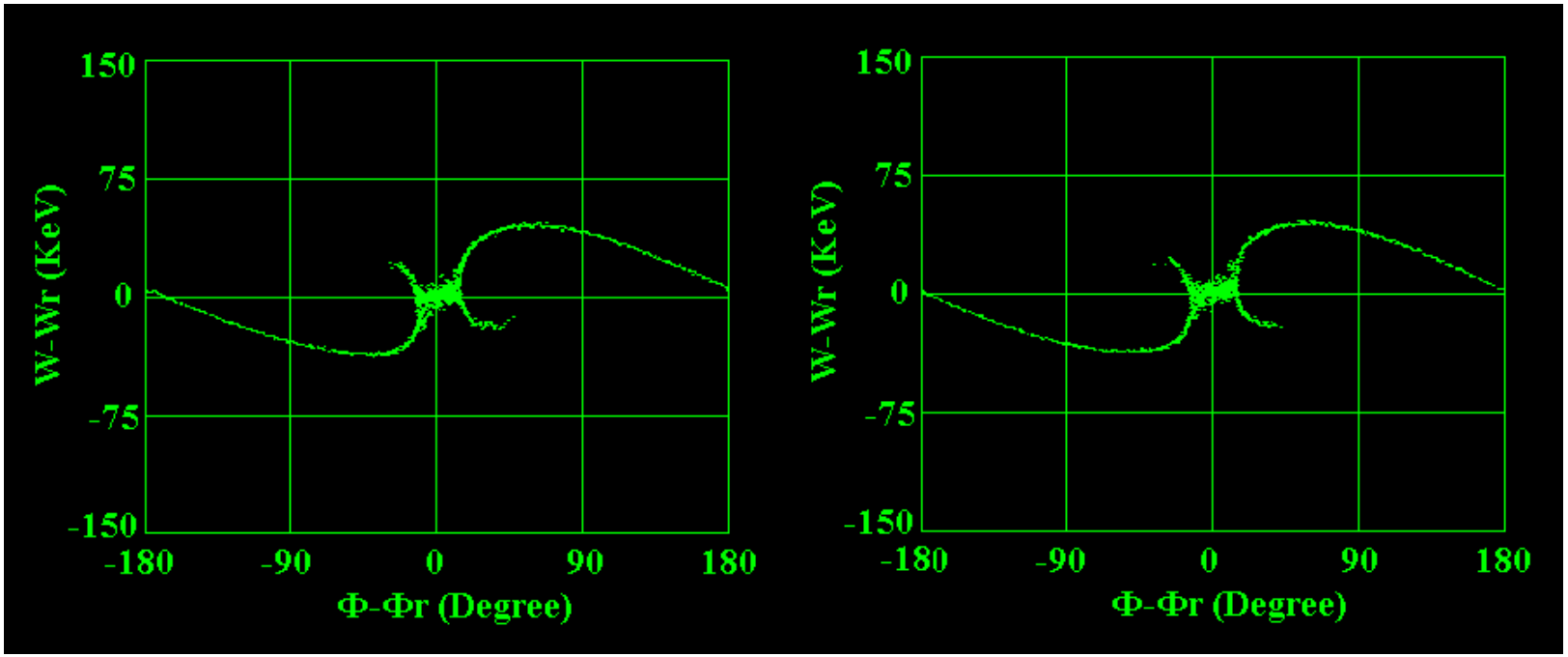




Thin lens SHB **Travelling Wave SHB**

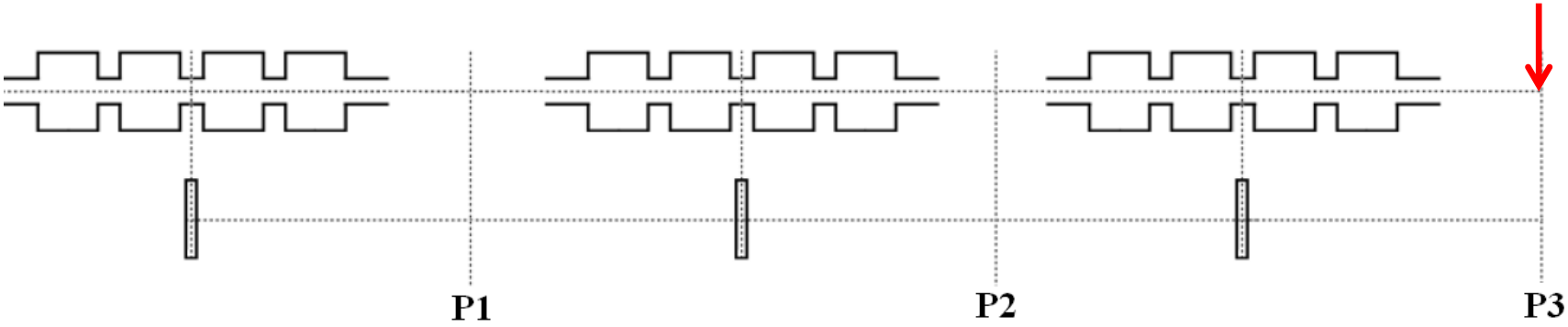
2.6 Travelling wave SHBs

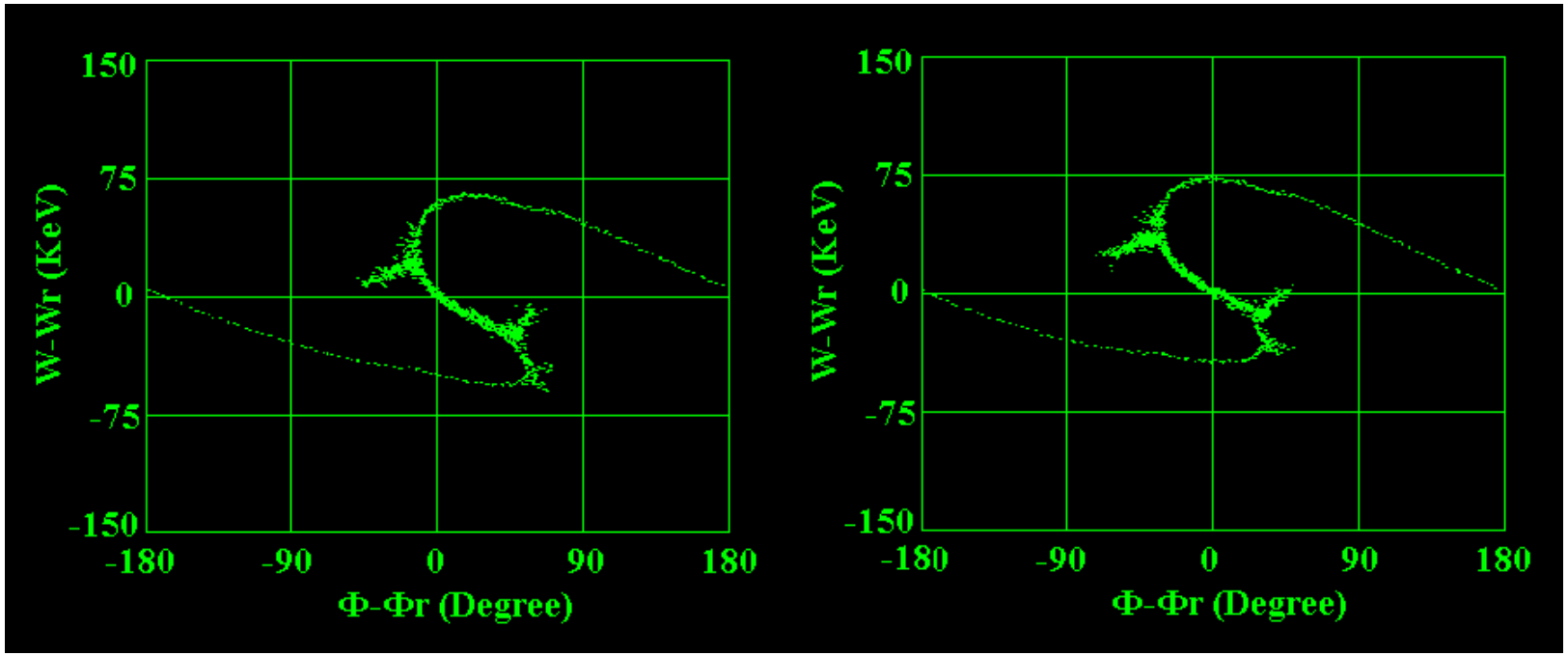




Thin lens SHB **Travelling Wave SHB**

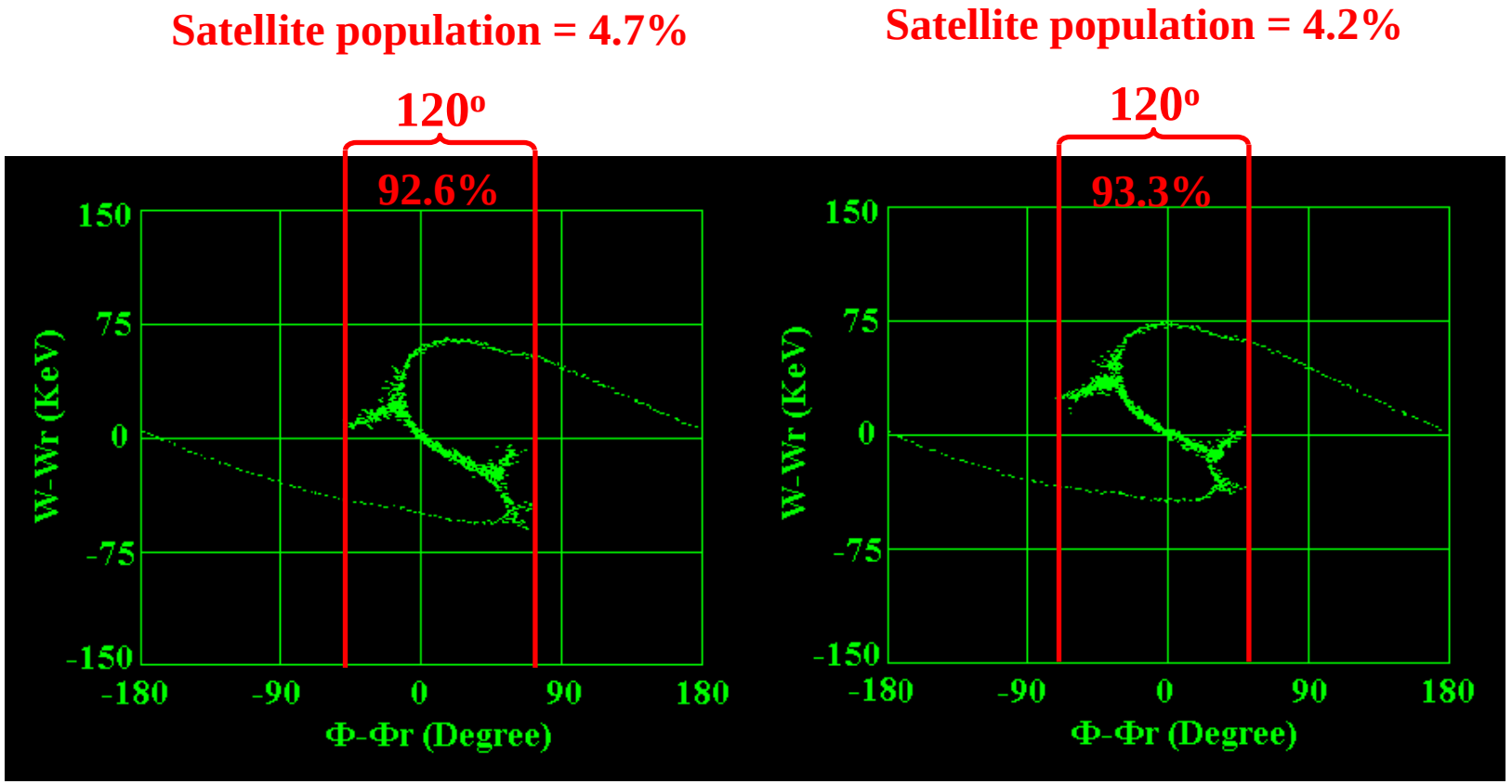
2.6 Travelling wave SHBs





Thin lens SHB **Travelling Wave SHB**

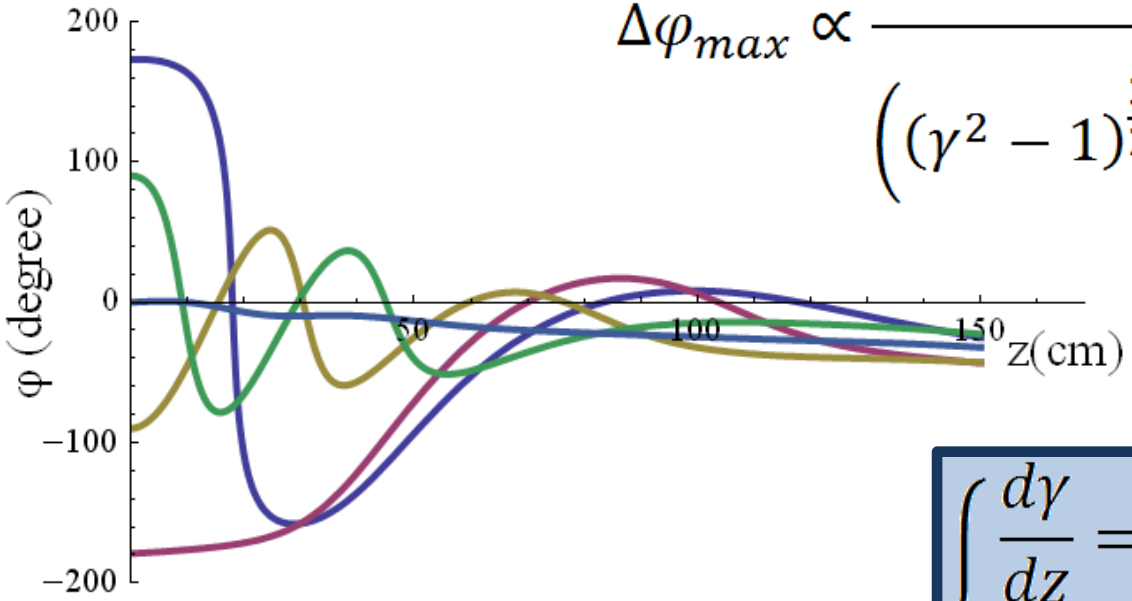
2.6 Travelling wave SHBs



Thin lens SHB **Travelling Wave SHB**

3.Travelling wave tapered buncher

3.1 Longitudinal dynamics in TW buncher

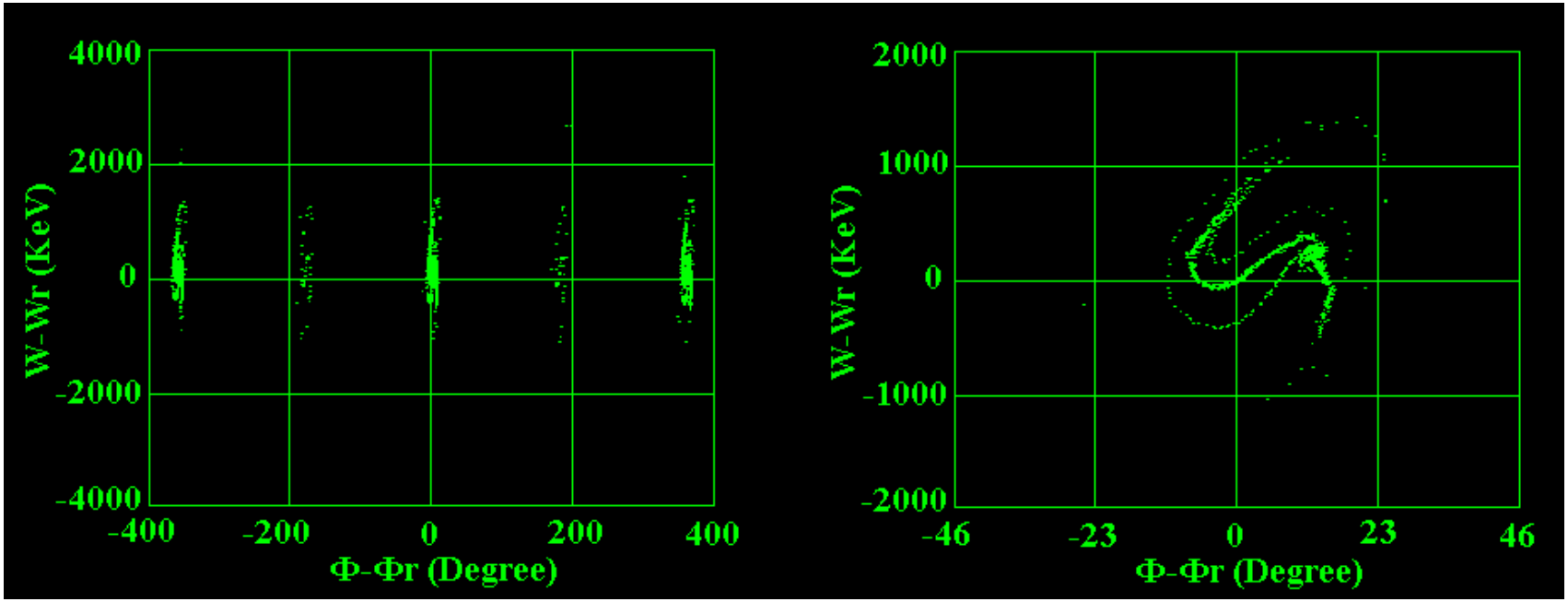


$$\Delta\varphi_{max} \propto \frac{1}{\left((\gamma^2-1)^{\frac{3}{2}} E_z \cos(\varphi_s)\right)^{\frac{1}{4}}}$$

$$\begin{cases} \dfrac{d\gamma}{dz} = -\dfrac{e}{mc^2} E_z \sin\varphi \\ \dfrac{d\varphi}{dz} = \dfrac{2\pi}{\lambda}\left(\dfrac{1}{\beta_w} - \dfrac{1}{\beta}\right) \end{cases}$$

3.Travelling wave tapered buncher

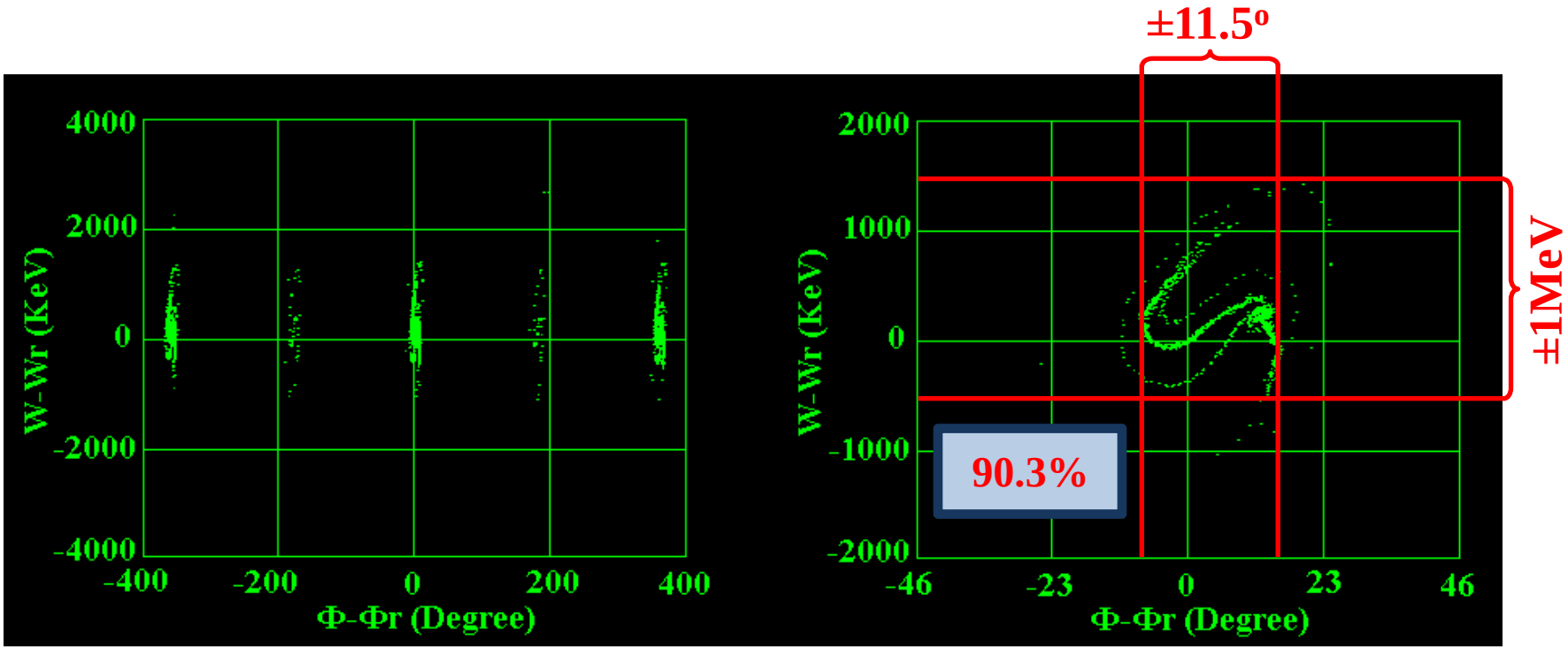
3.2 Optimization result



3.Travelling wave tapered buncher

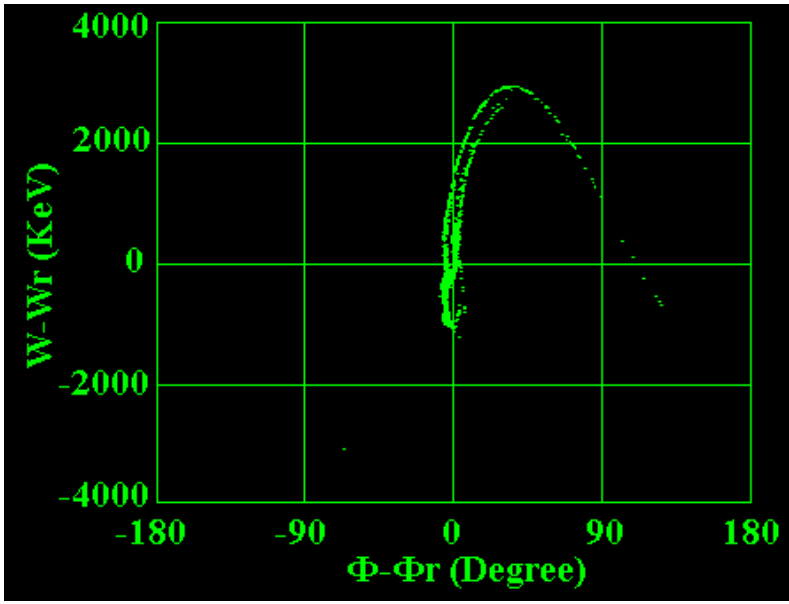
3.2 Optimization result

Satellite population = 3.8%



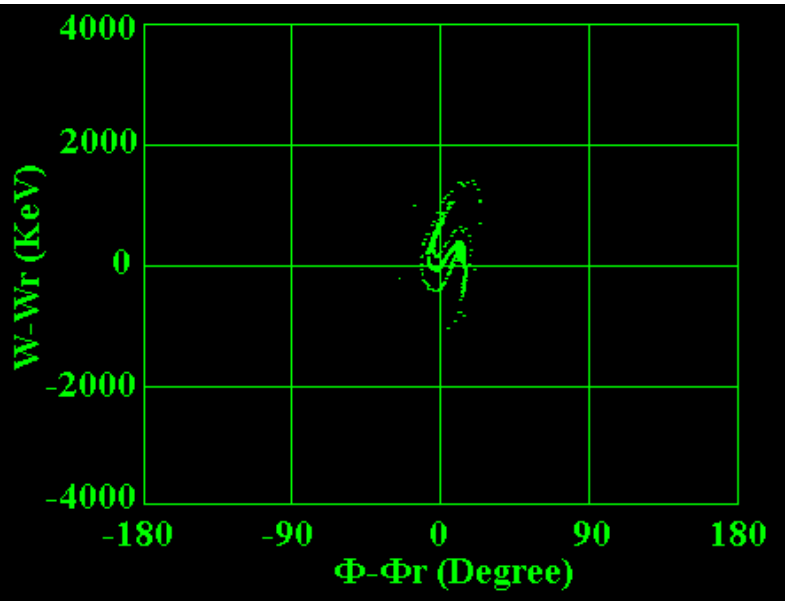
4.Comparison with previous model

Satellite population = 4.9%



Previous model

Satellite population = 3.8%

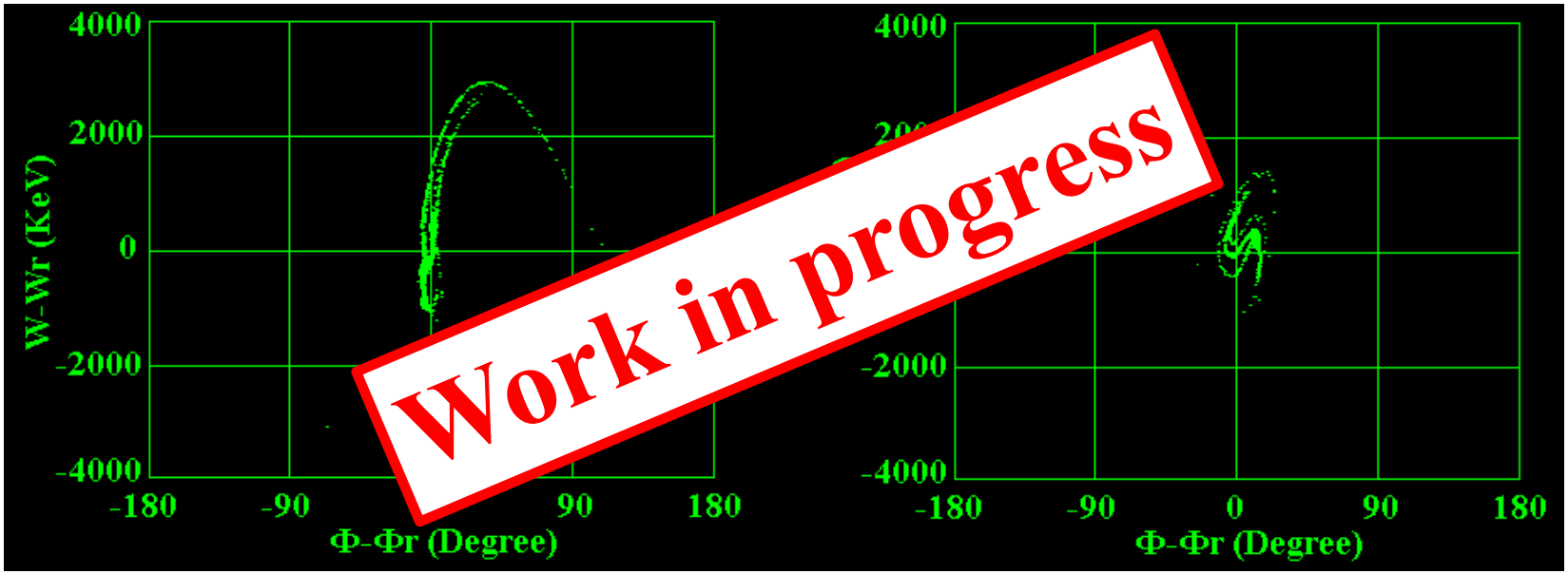


Current model

4.Comparison with previous model

Satellite population = 4.9%

Satellite population = 3.8%



Previous model

Current model

Tanks for your attention