



FIRST HEAVY ION BEAM ACCELERATION WITH A SUPERCONDUCTING MULTI GAP CH-CAVITY

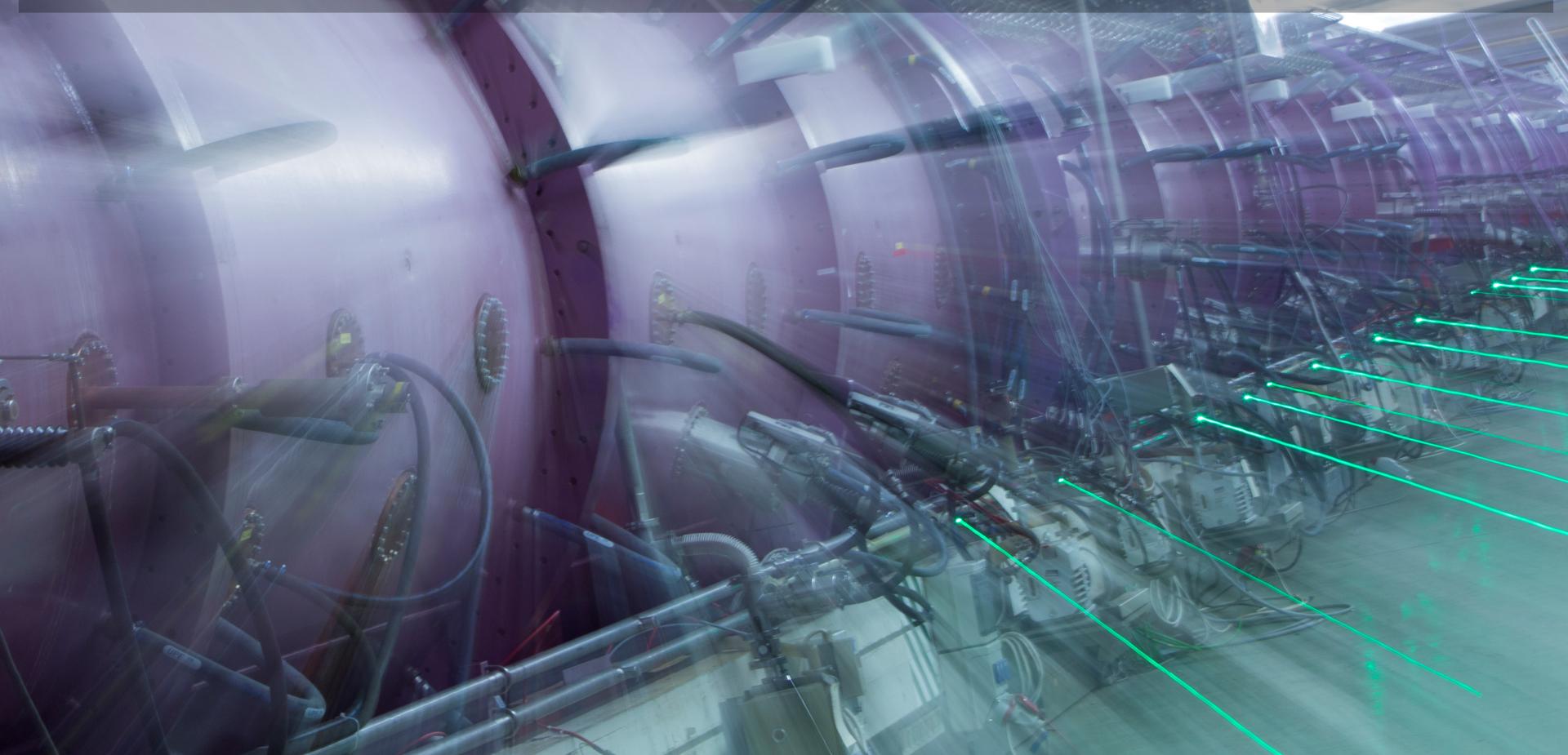
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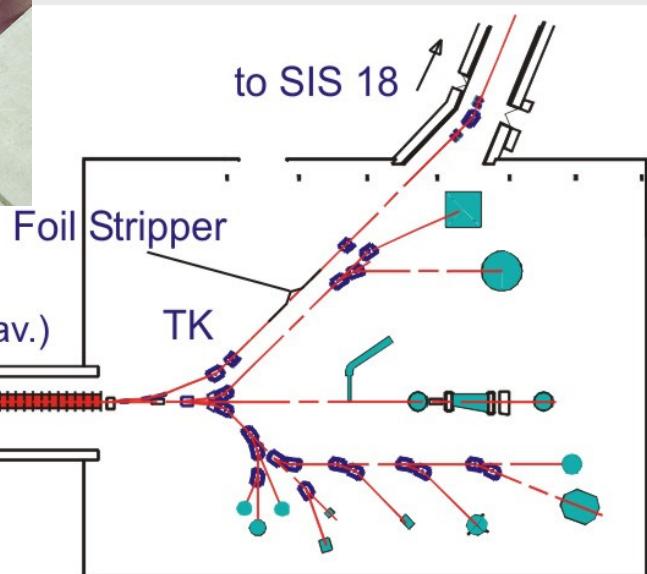
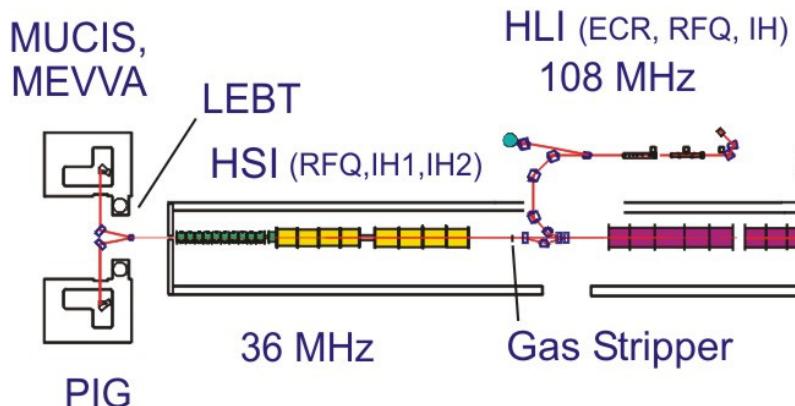
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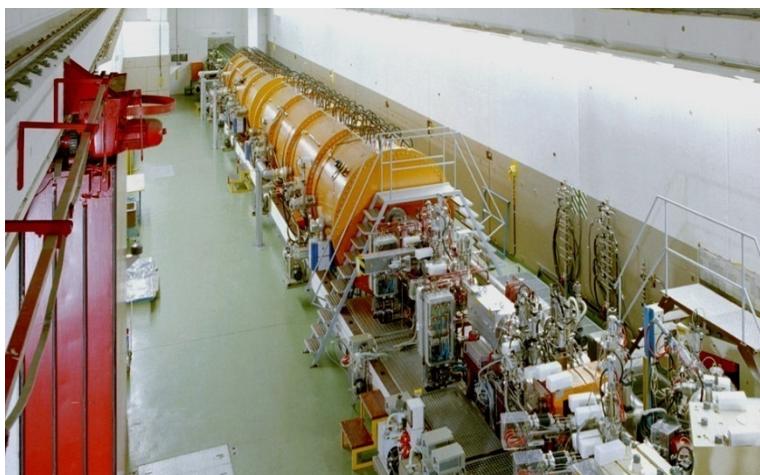
1. Introduction
2. Cavity Development
3. CW-Linac layout
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5. Heavy ion beam test at cw-Linac Demonstrator
6. Further R&D und Outlook

Introduction GSI UNIversal Linear ACcelerator

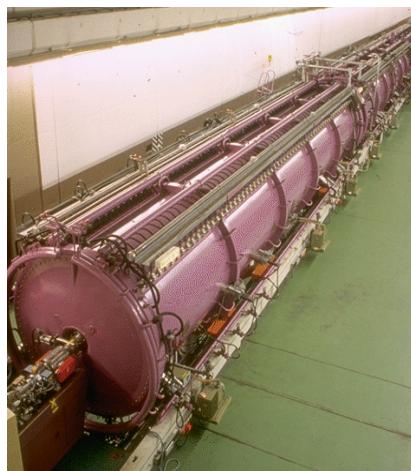
High Charge State Injector(1991)



High Current Injector (1999)



Alvarez (1975)



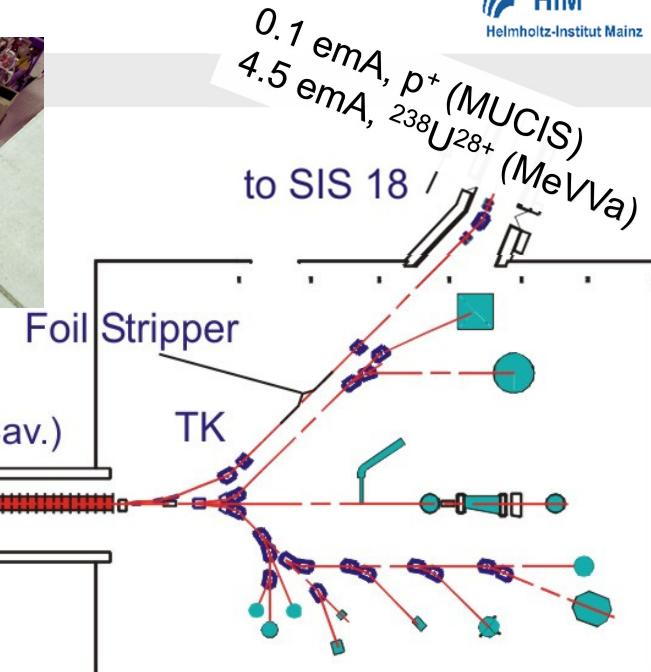
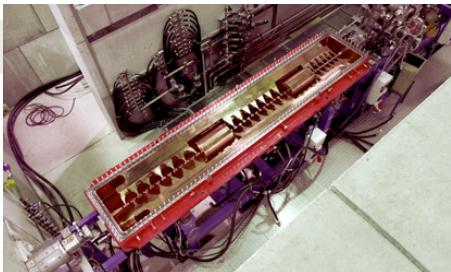
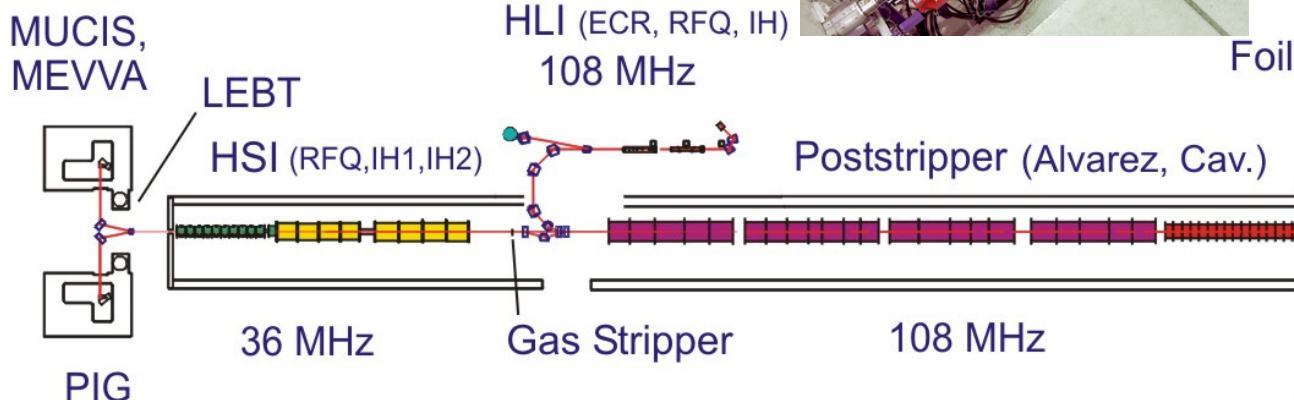
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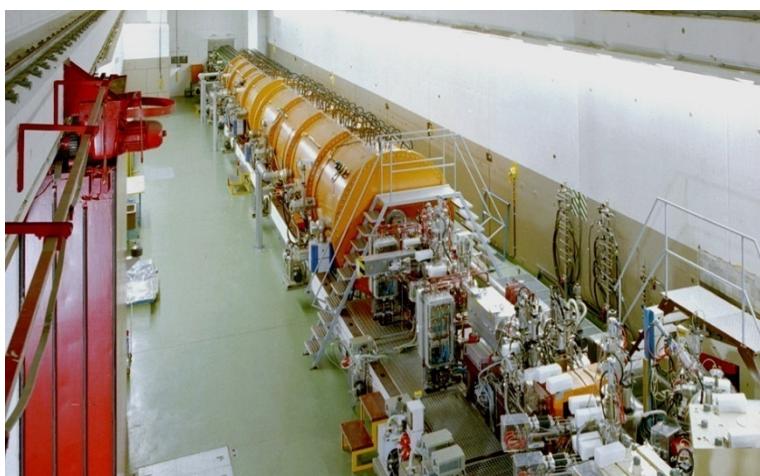
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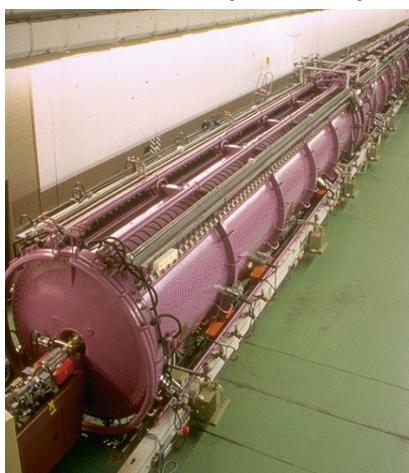
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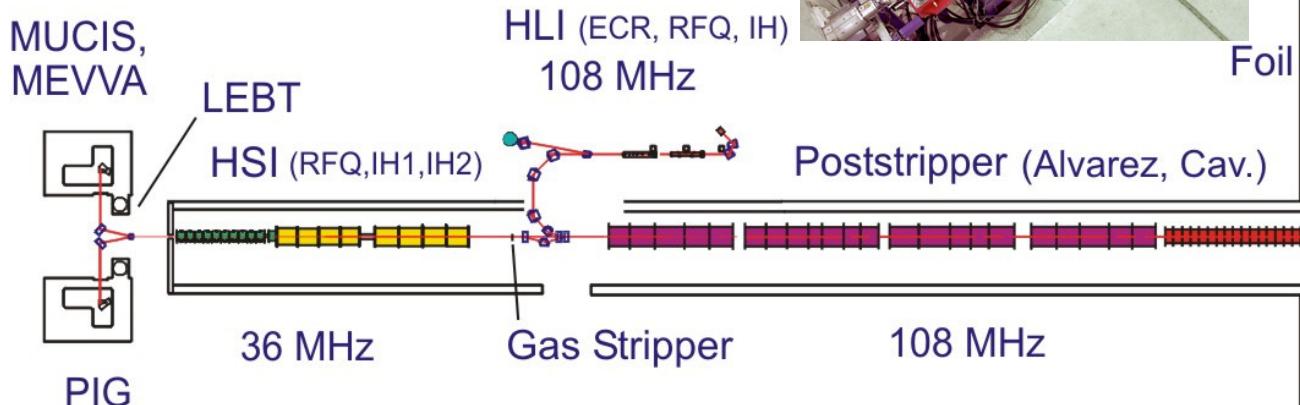
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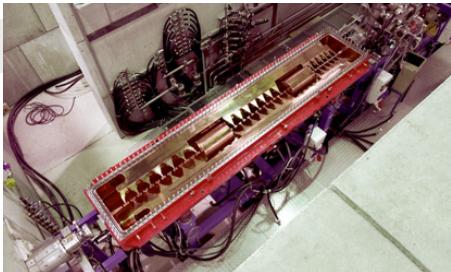
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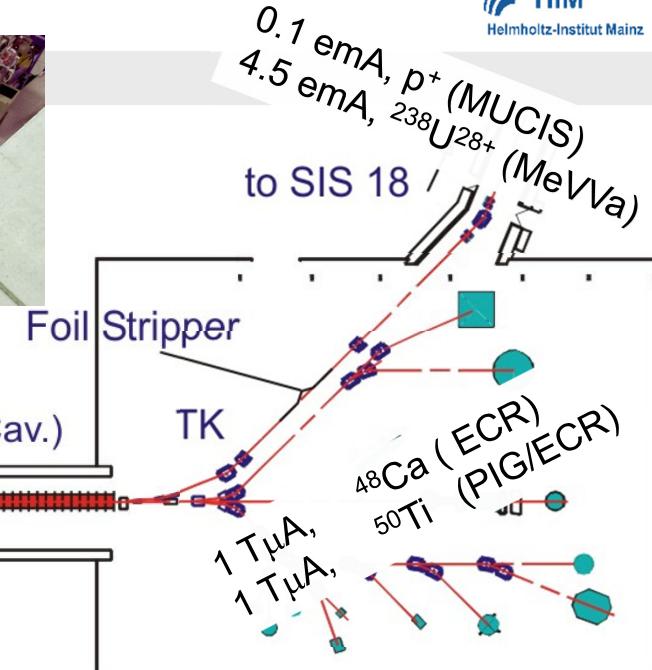
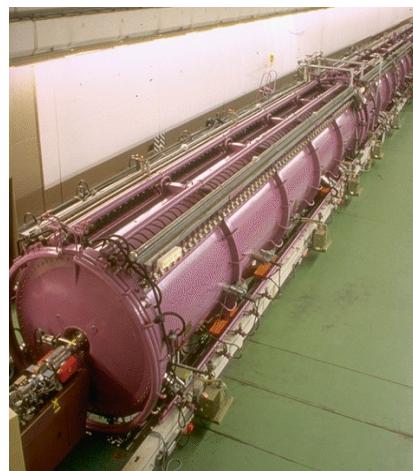
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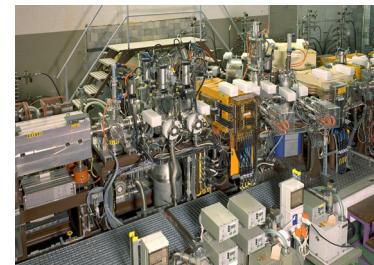


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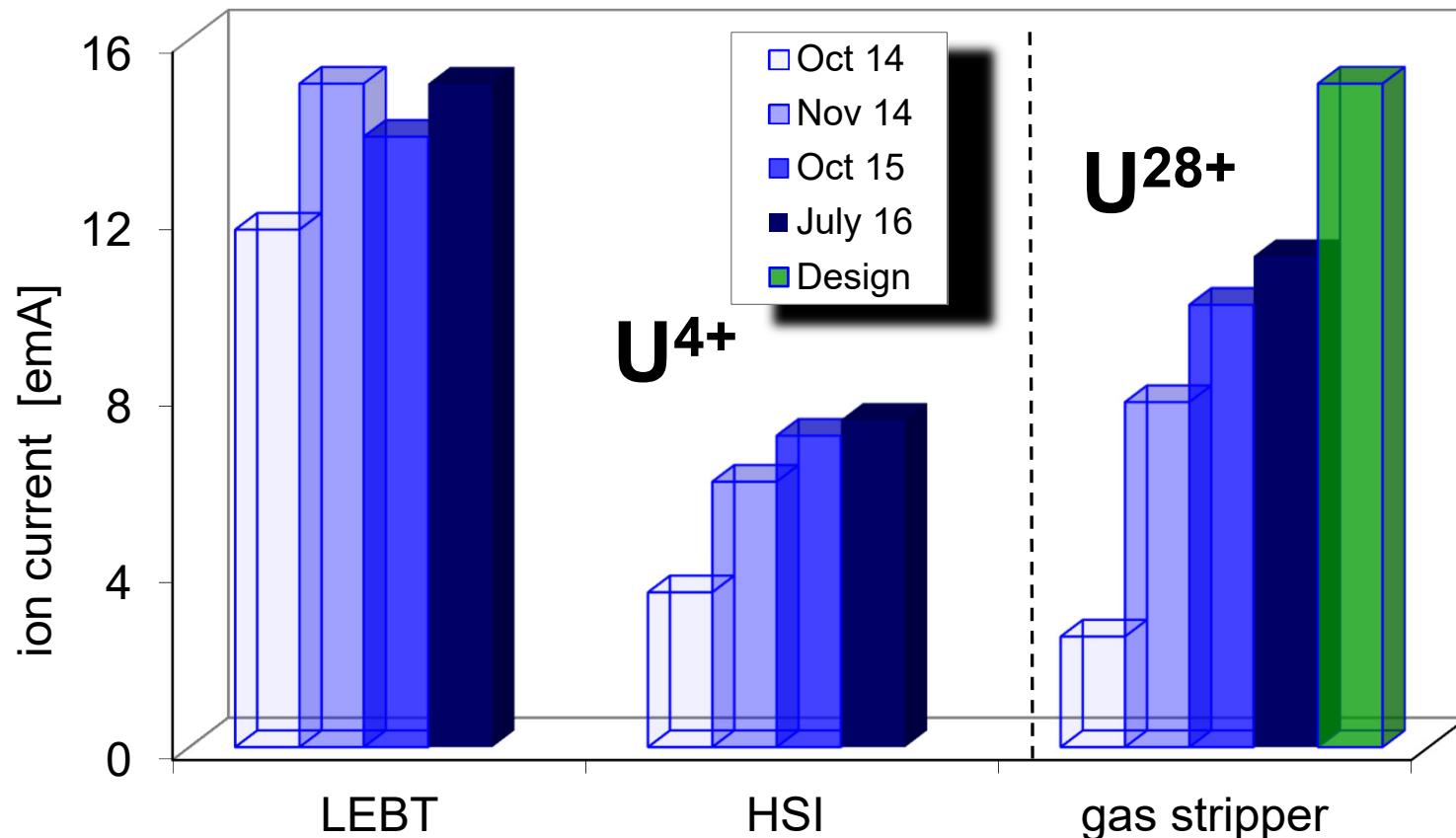


Status “UNILAC Uran-High Current”

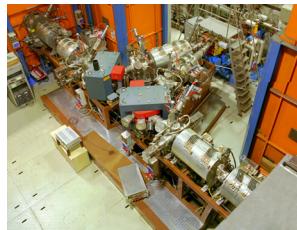
W. Barth, et al., Phys.
Rev. ST Accel. & Beams
20, 050101 (2017)



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FAIR:

- high beam currents
- low repetition rate (max. 3 Hz)
- low duty factor (0.1 %, pulse length for SIS18 only 100 µs)



GSI/FAIR-Requirements

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“Super Heavy Element”:

- relatively low beam currents
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“Material Science”:

- Heavy Ions ($m \geq 200$)
- High Beam Energy (up to 10 MeV/u)
- Continuous Beam Energy Variation (1.5 – 10 MeV/u)



cw-LINAC-project: Motivation and Design-Parameter

- Nuclear reactions at the Coulomb-barrier → production of Super Heavy Elements (SHE)
- Operation mode cw
- Mass / Charge 6
- Beam current $\leq 1 \text{ emA}$
- Injection energy 1.4 MeV/u
- Output energy 3.5 - 7.3 MeV/u

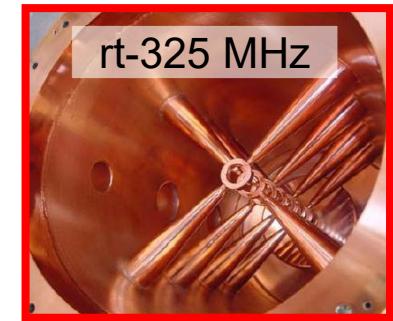
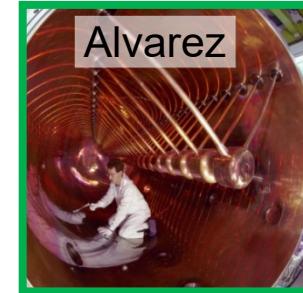
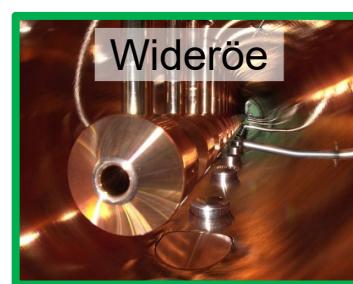
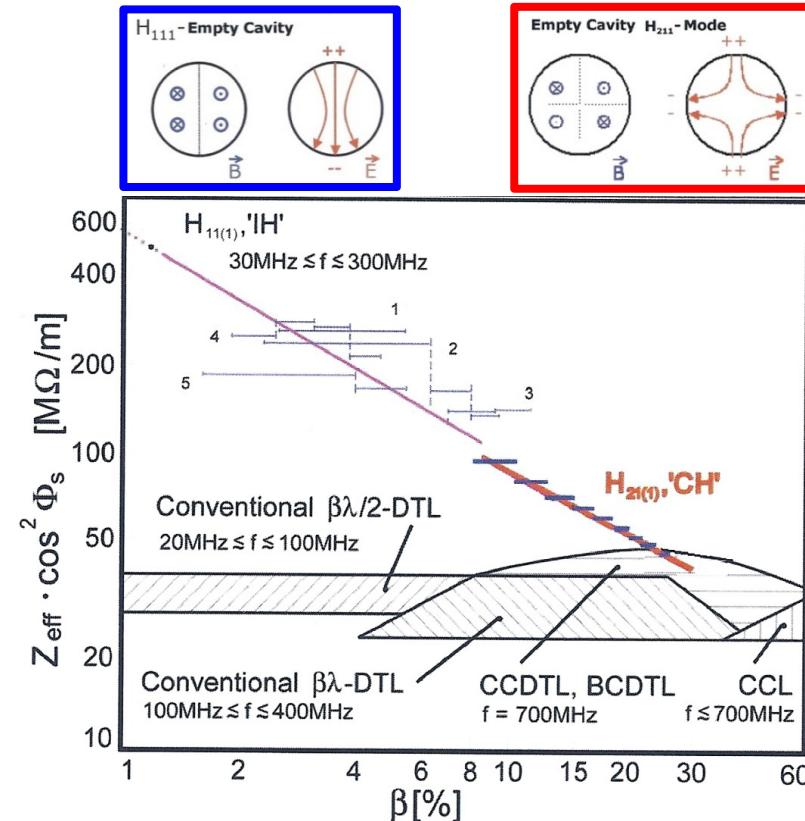
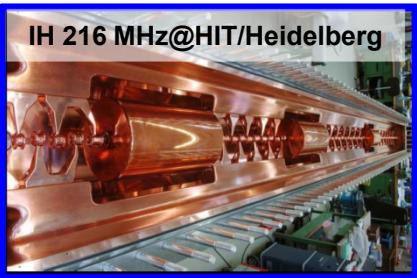
Production of Element $^{288}_{115}\text{uut}$, $^{289}_{115}\text{uut}$, 30 events

(D. Rudolph, Lund Univ., PRL 111, 112502 (2013))

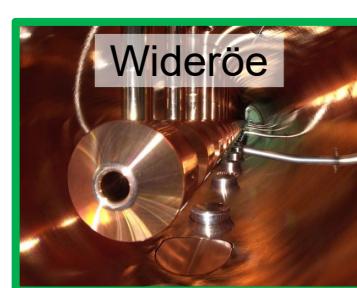
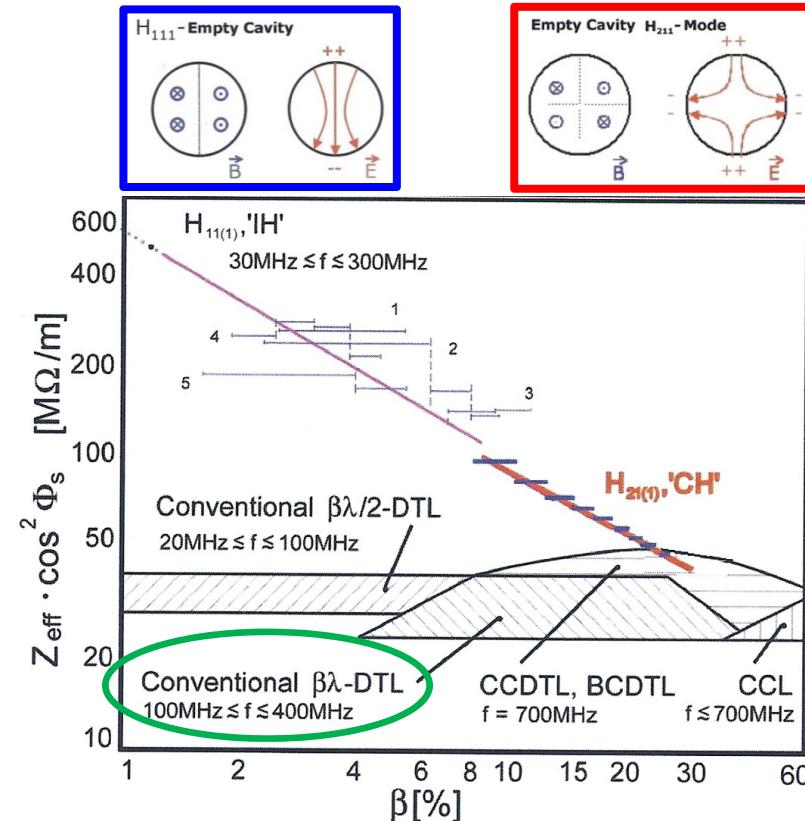
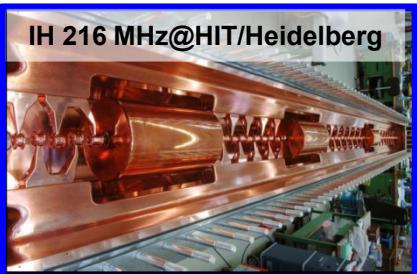
	GSI- Unilac	cw-Linac
Beam intensity (particle/s)	$6 \cdot 10^{12}$	$6 \cdot 10^{13}$
Beam on target	3 weeks	2 days



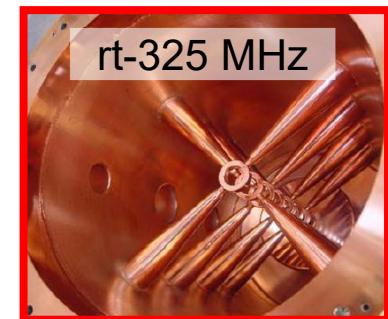
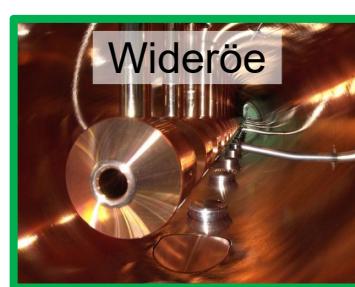
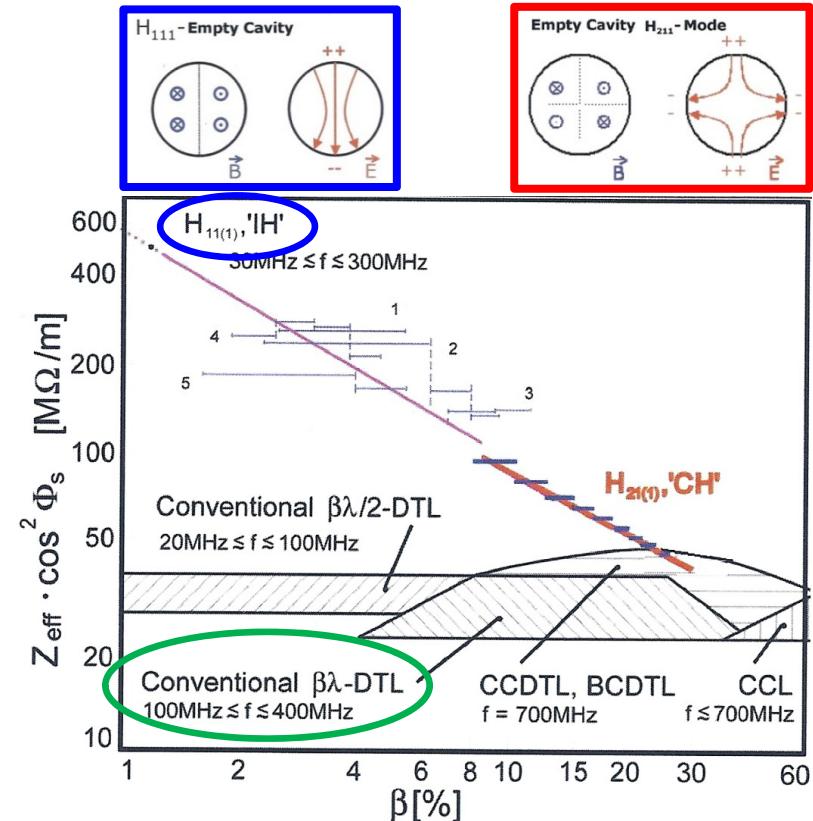
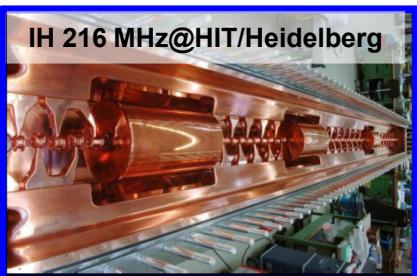
H-type Cavity developments



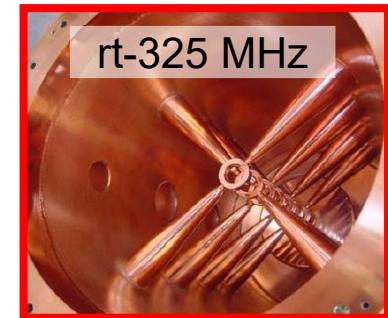
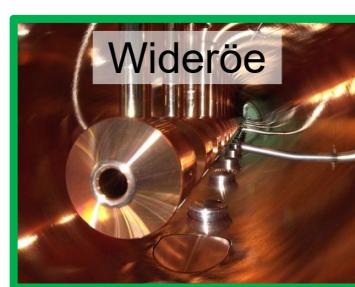
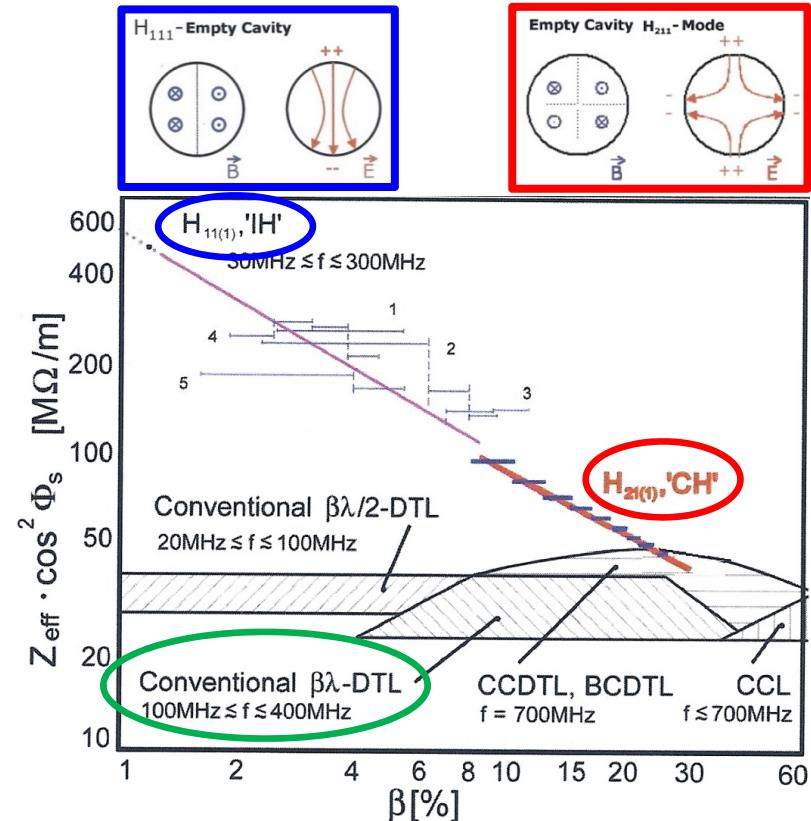
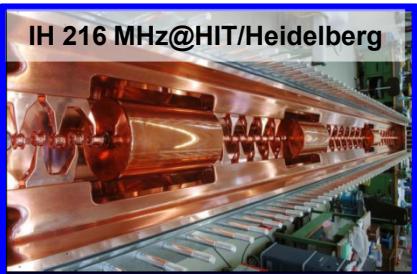
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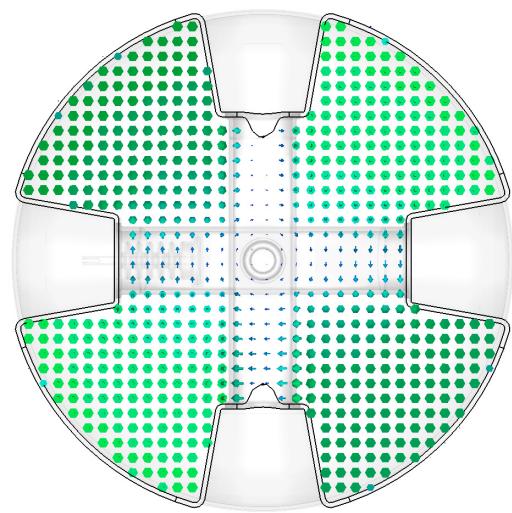


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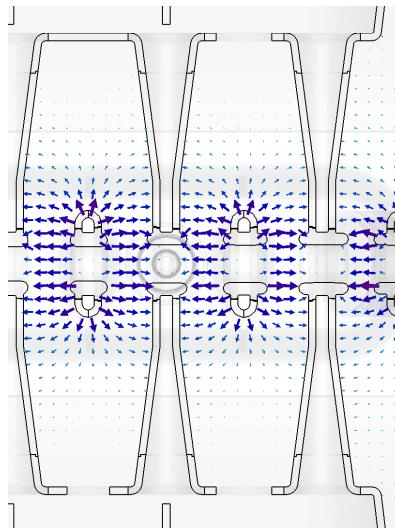


CH-cavity: Field profiles

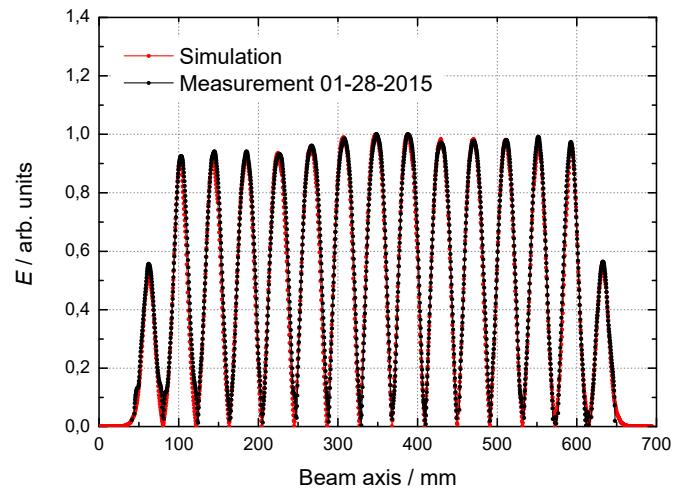
H field



E field



E field along beam axis

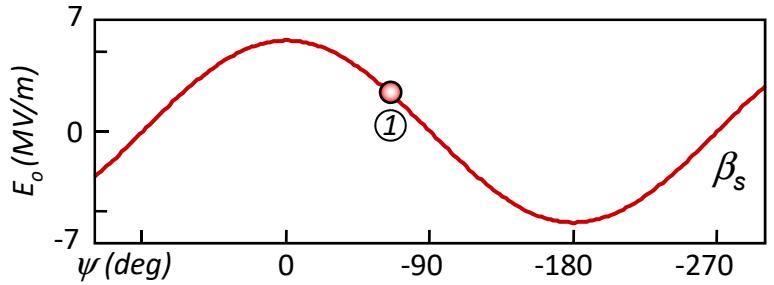
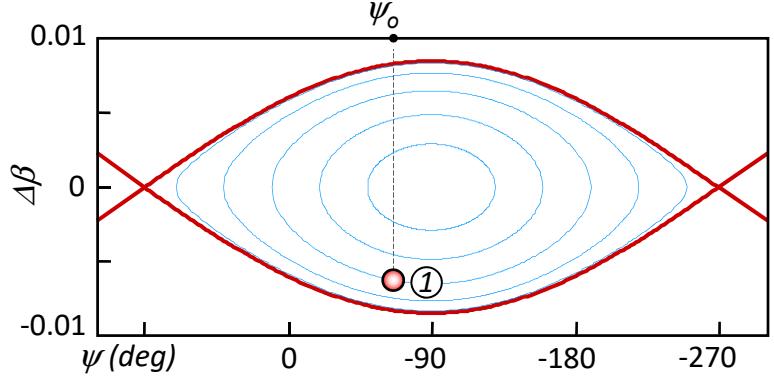


- Multigap drift tube cavity for the acceleration of protons and ions in the low and medium energy range
- Drift tubes are alternating connected to “+” and “-” potential
- **Cross-bar-H-mode cavity** → CH cavity
- Equidistant drift tubes length → special beam dynamics

EQUUS beam dynamics concept

EQUUS - EQUidistant mUltigap Structure

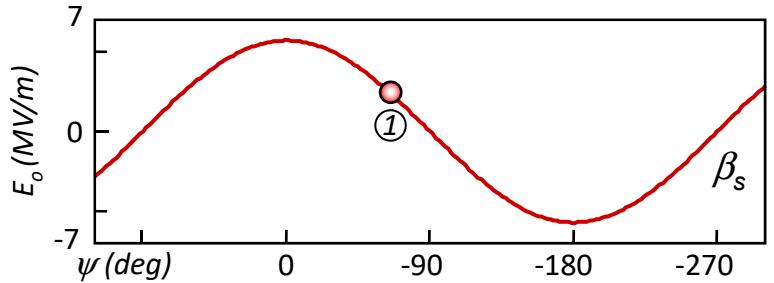
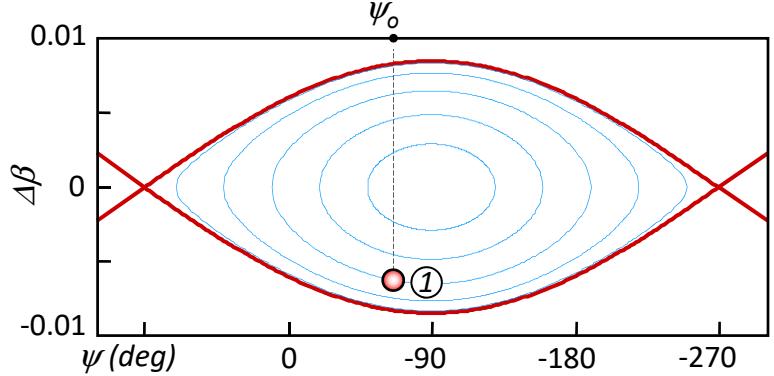
Longitudinal motion of an accelerated bunch in the constant- β -section



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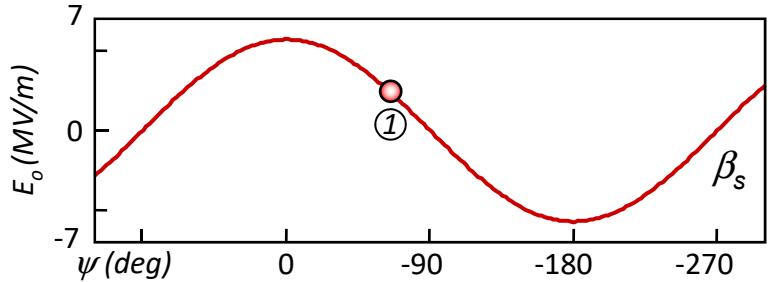
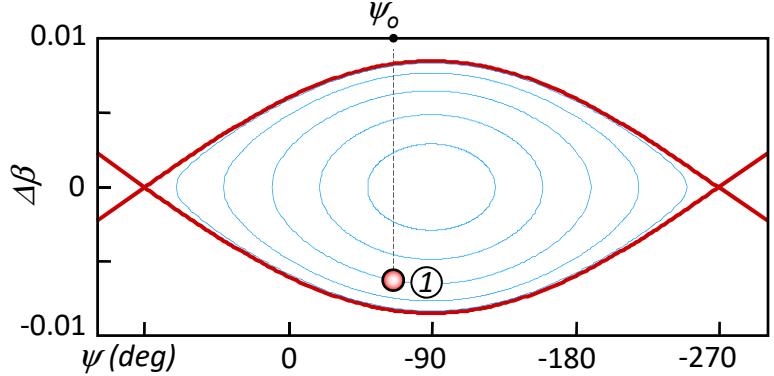
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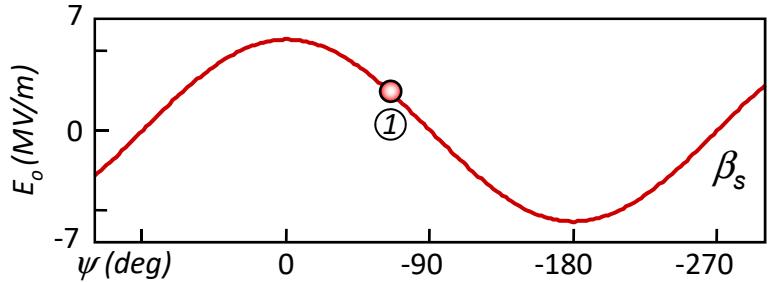
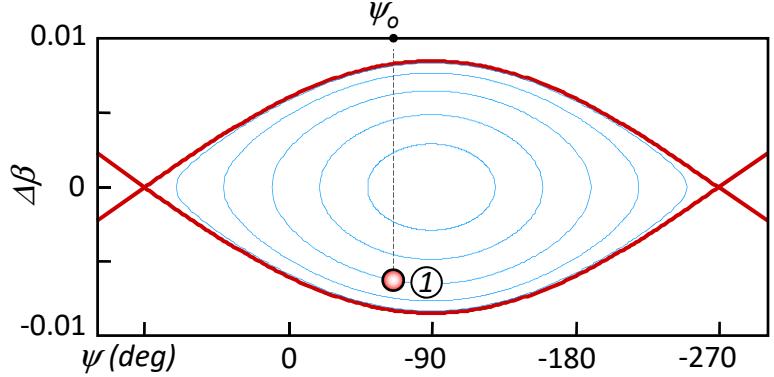


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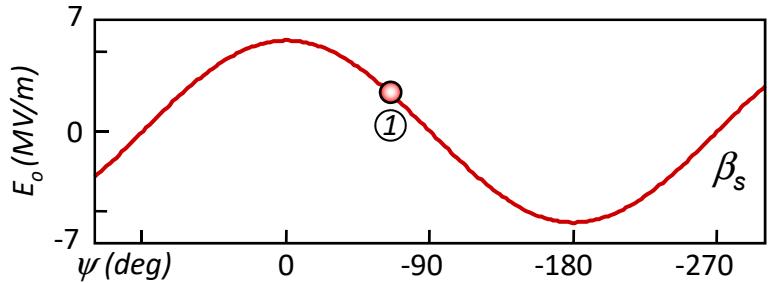
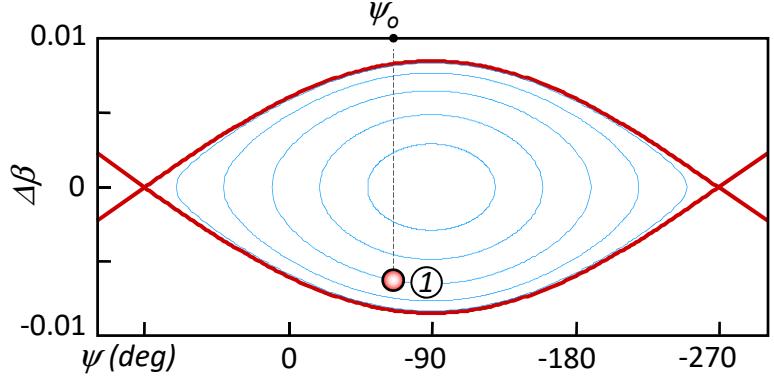
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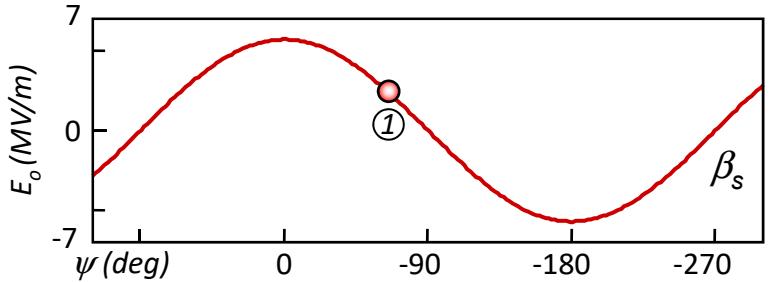
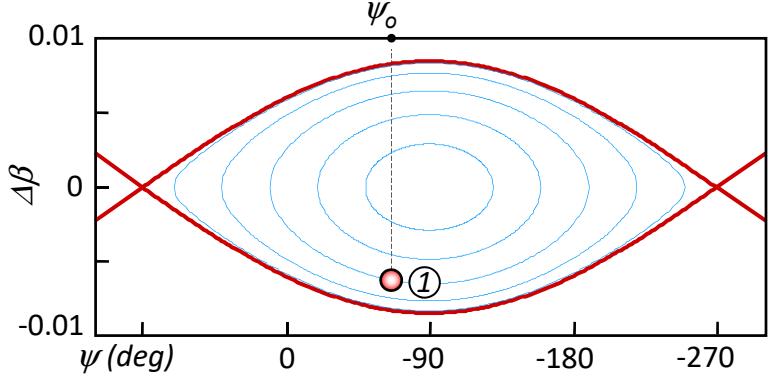


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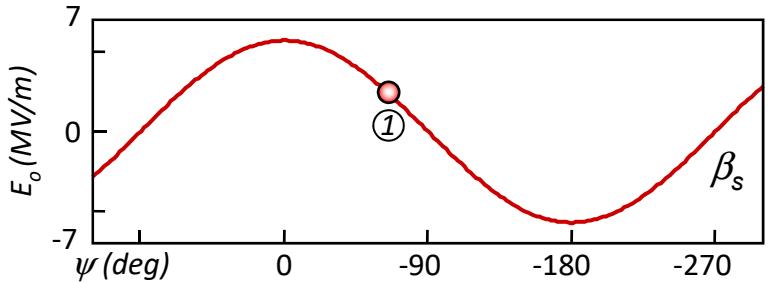
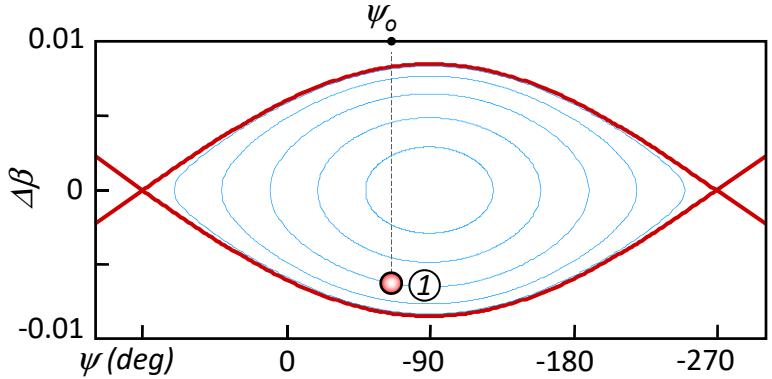


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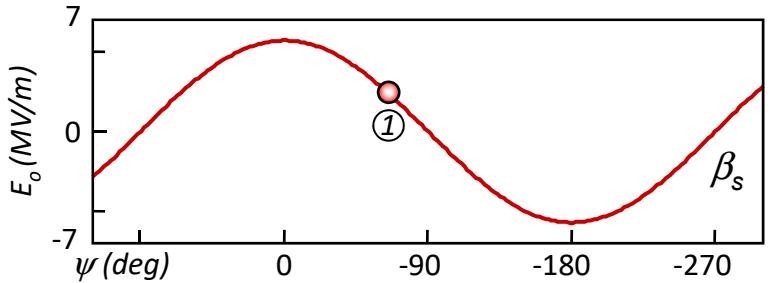
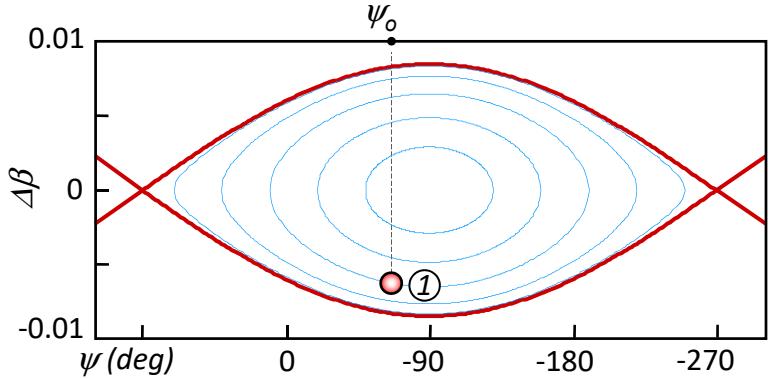
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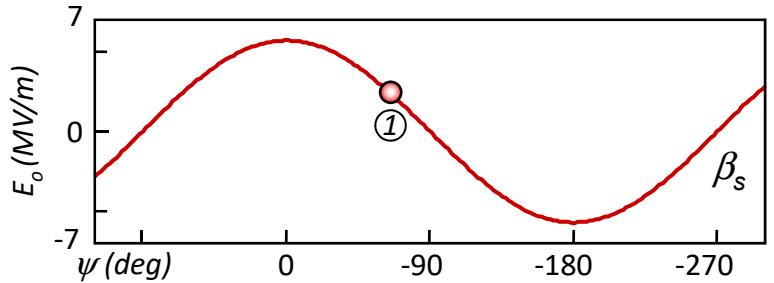
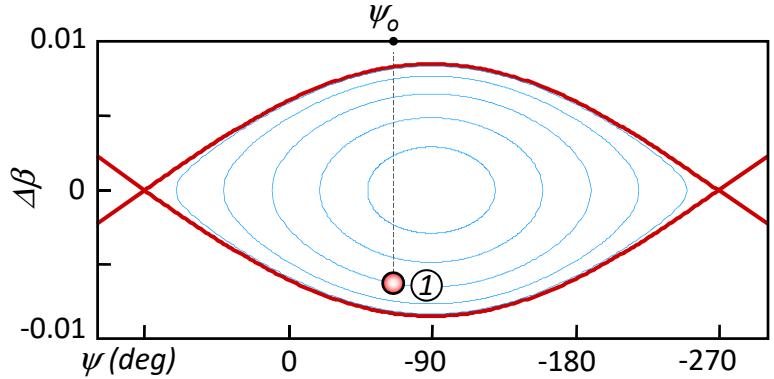
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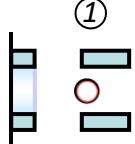
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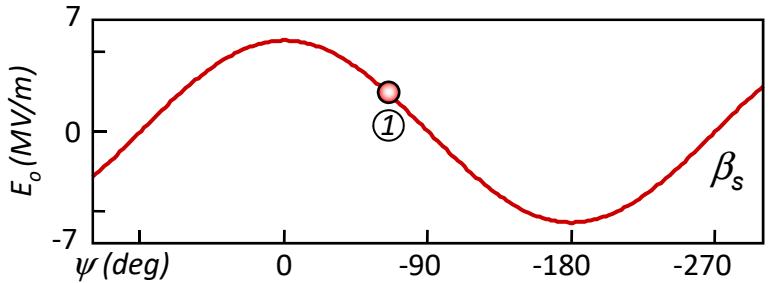
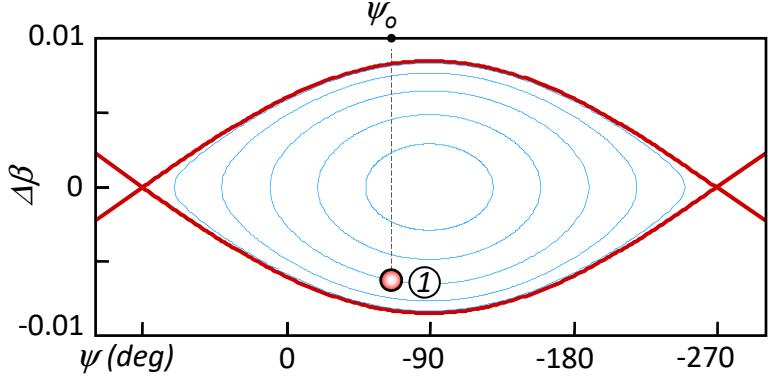
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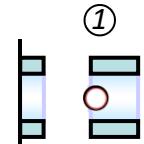
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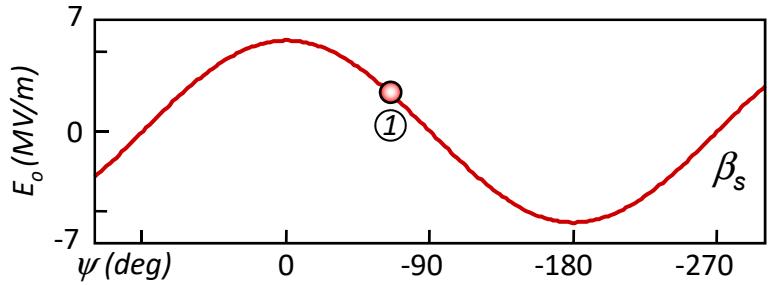
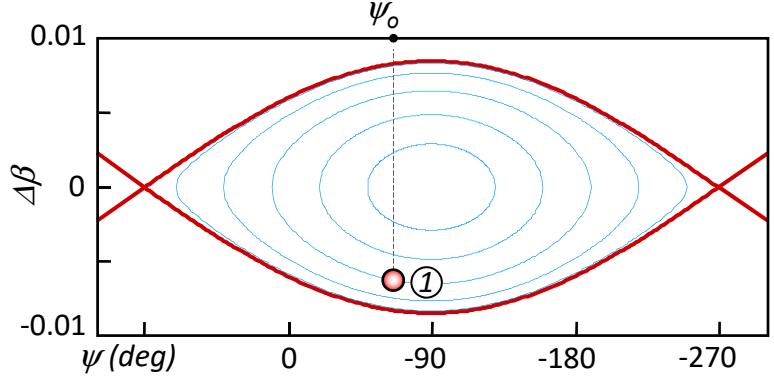
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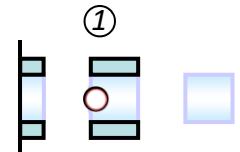
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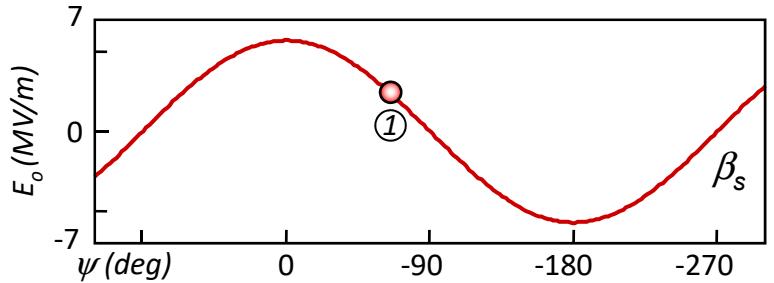
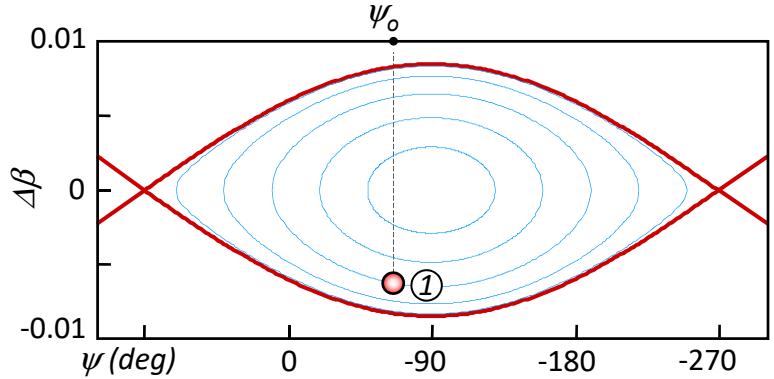
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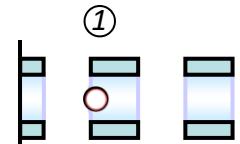
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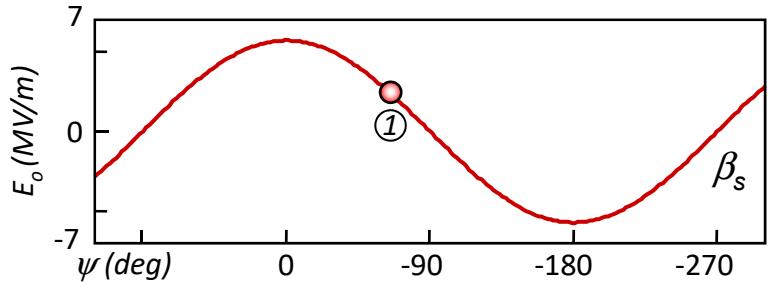
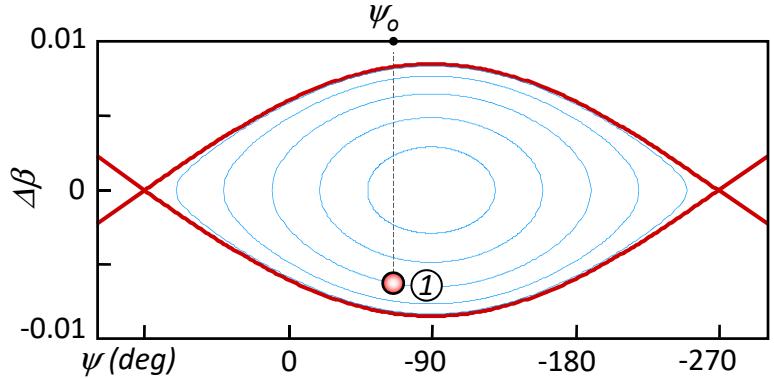
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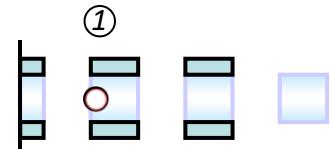
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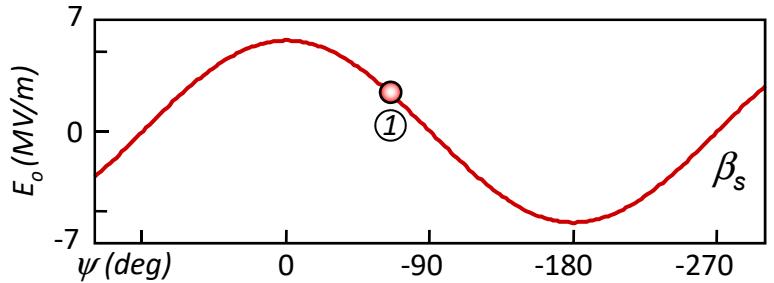
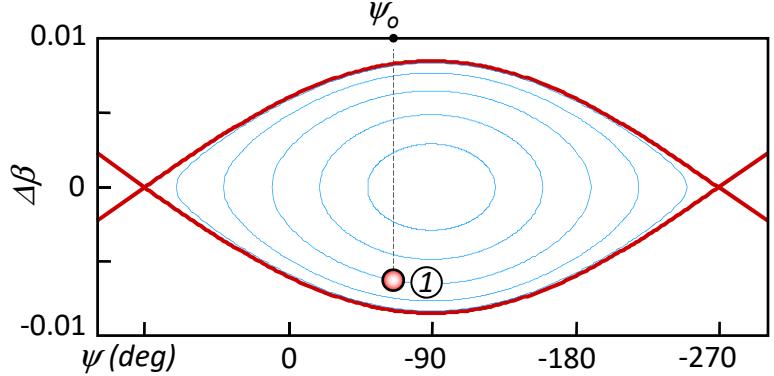
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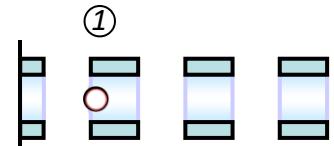
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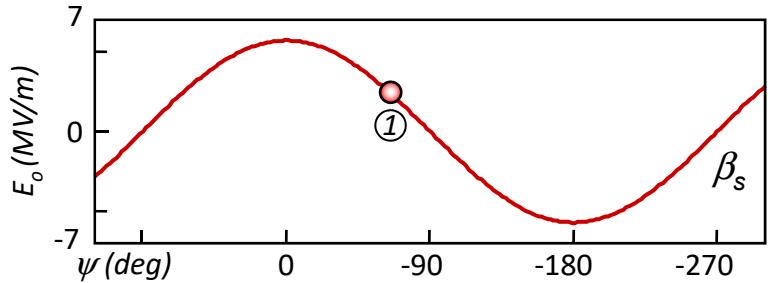
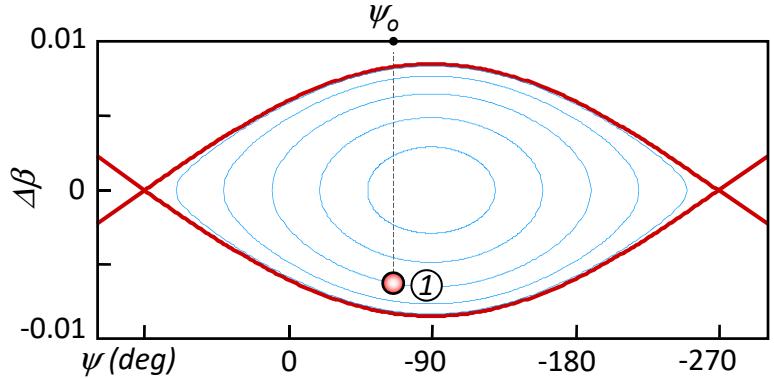
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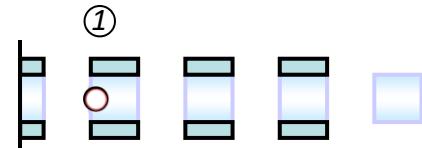
EQUUS beam dynamics concept

EQUUS - EQUidistant mUltigap Structure

Longitudinal motion of an accelerated bunch in the constant- β -section



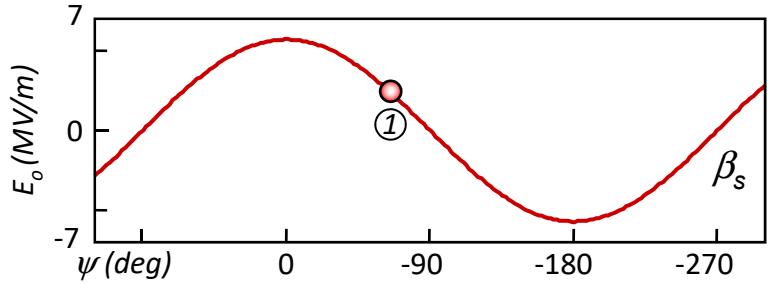
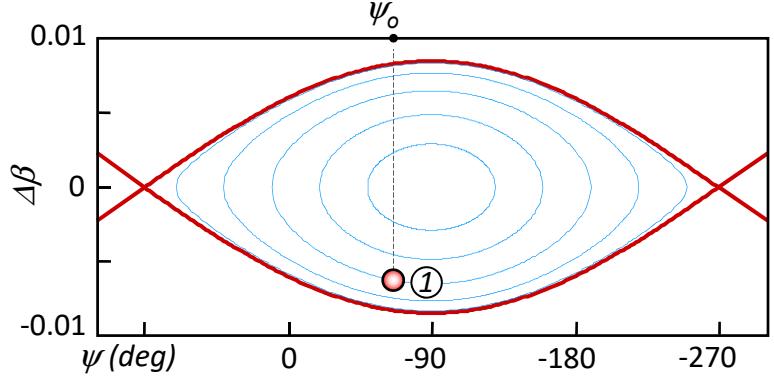
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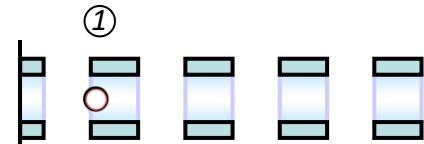
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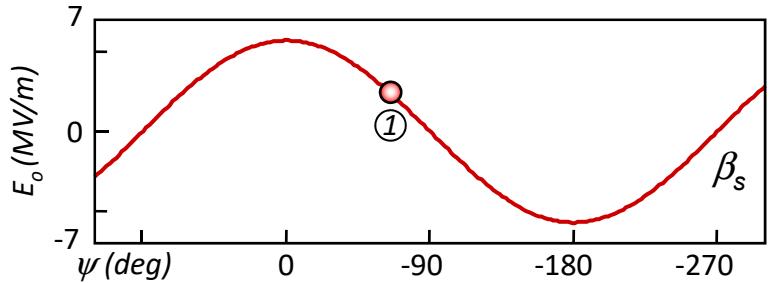
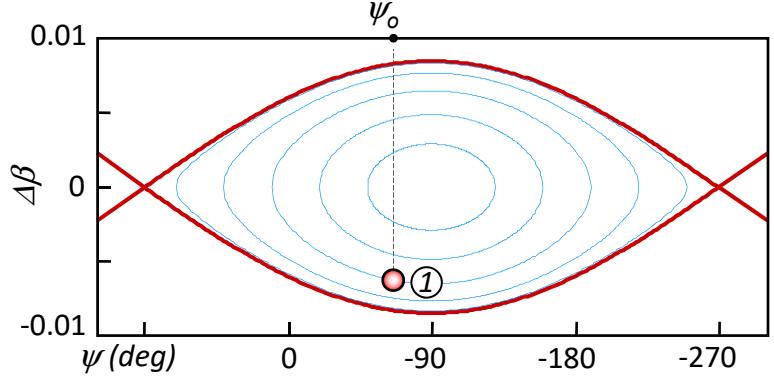
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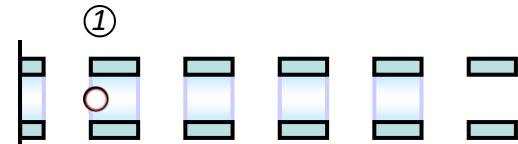
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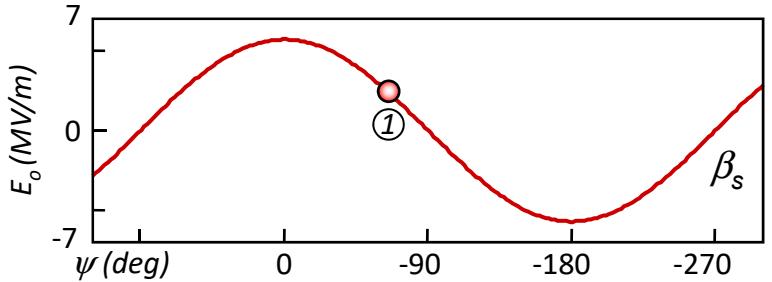
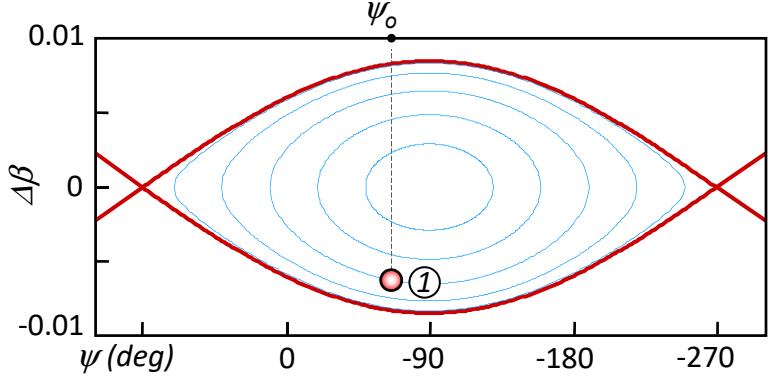
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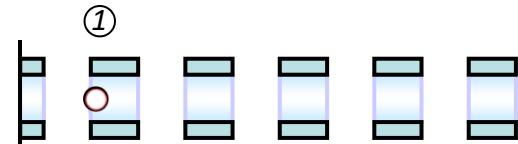
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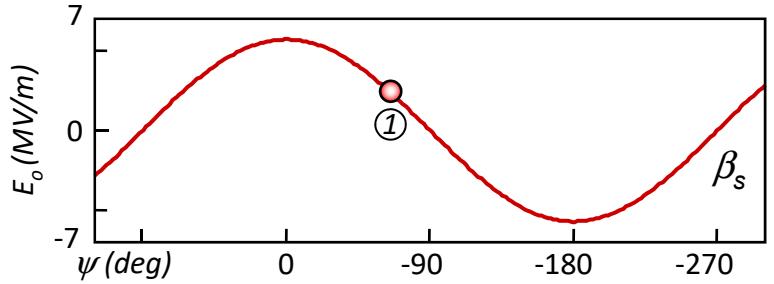
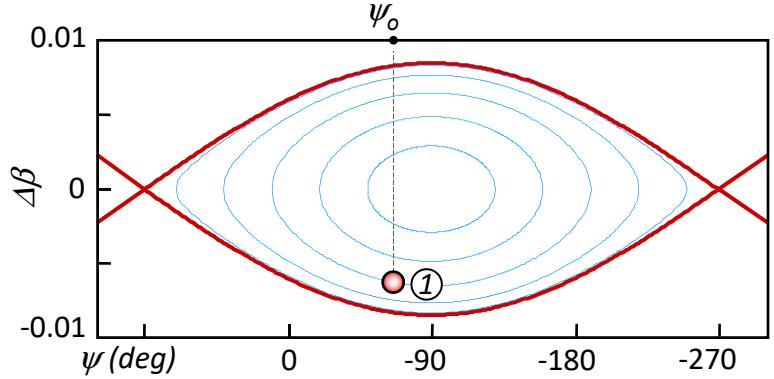
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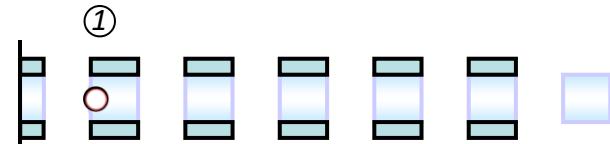
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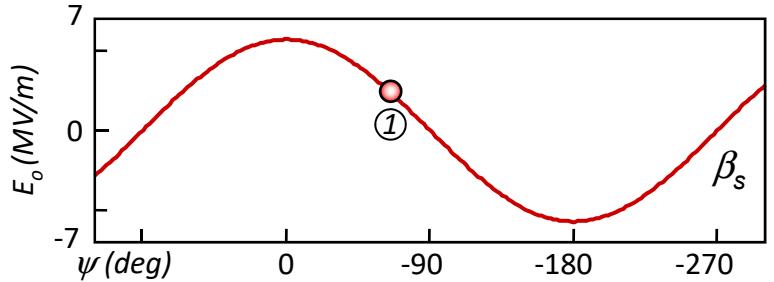
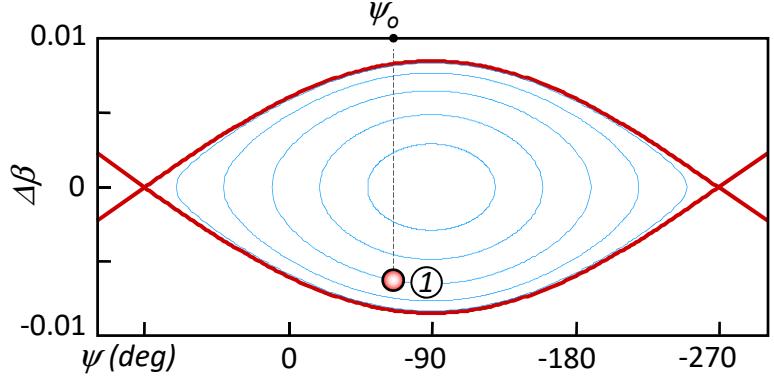
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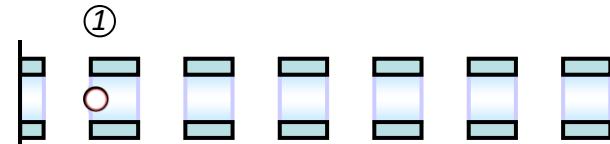
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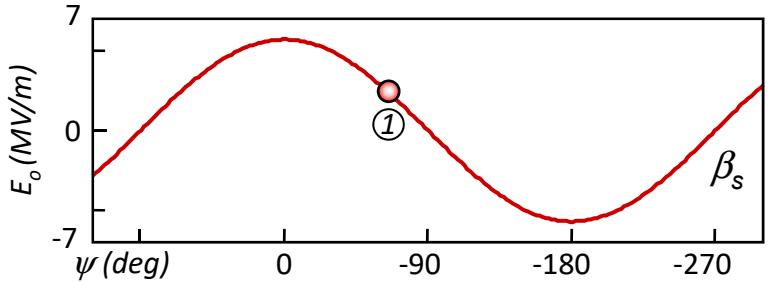
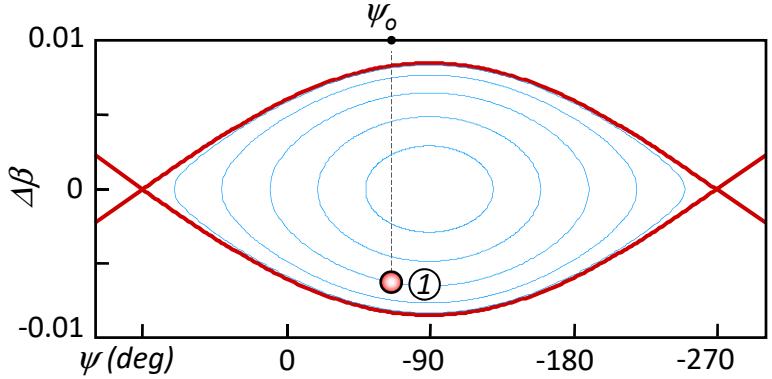
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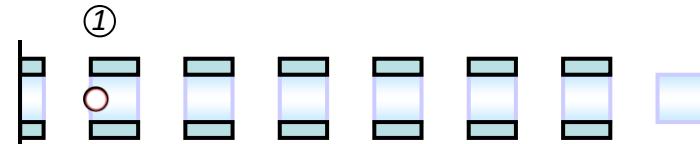
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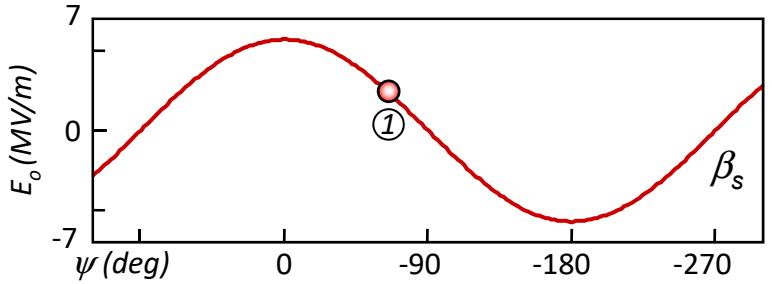
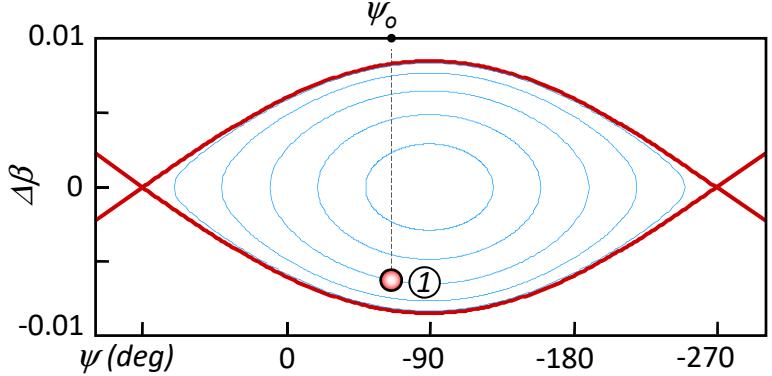
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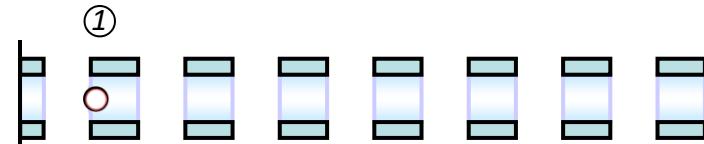
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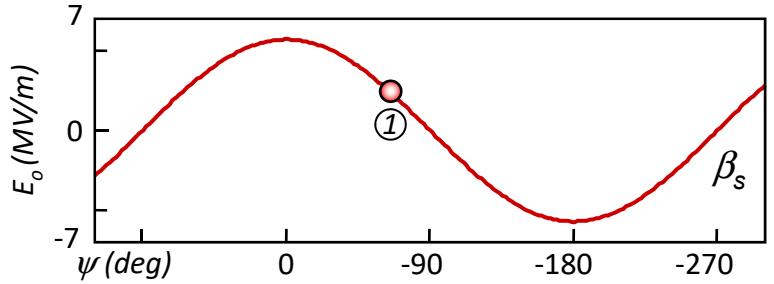
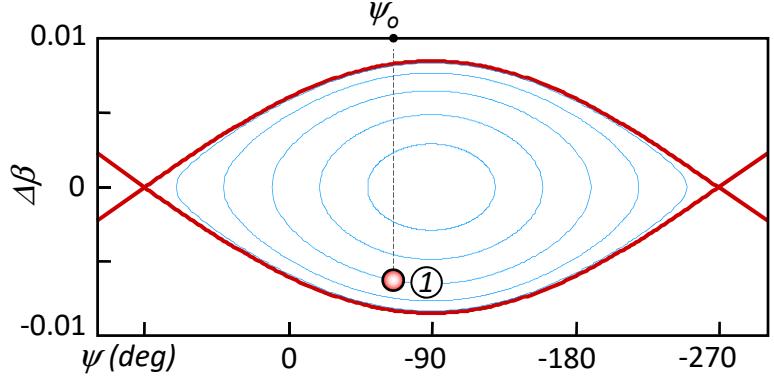
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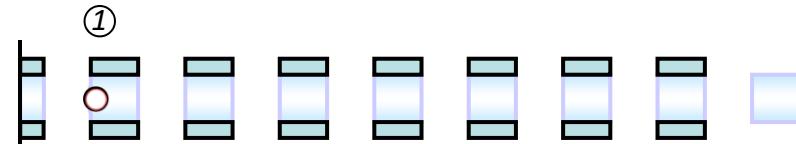
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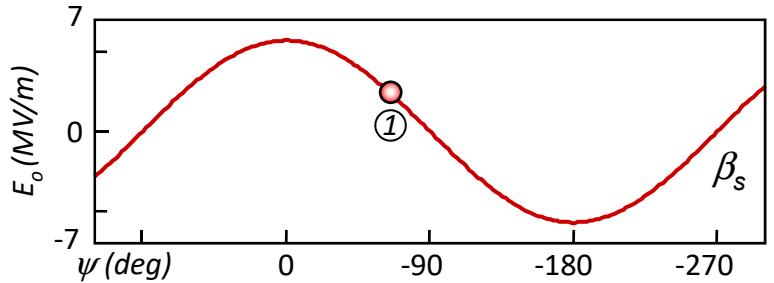
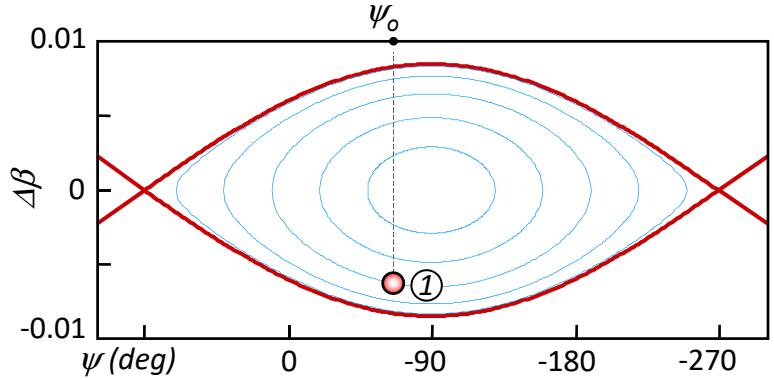
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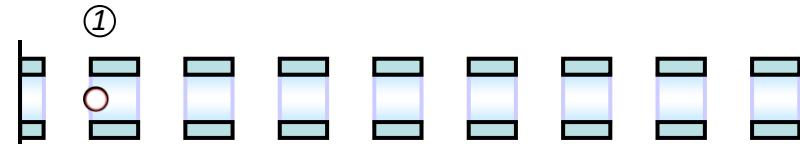
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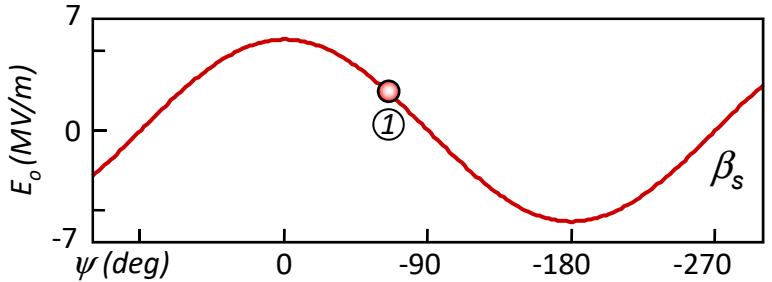
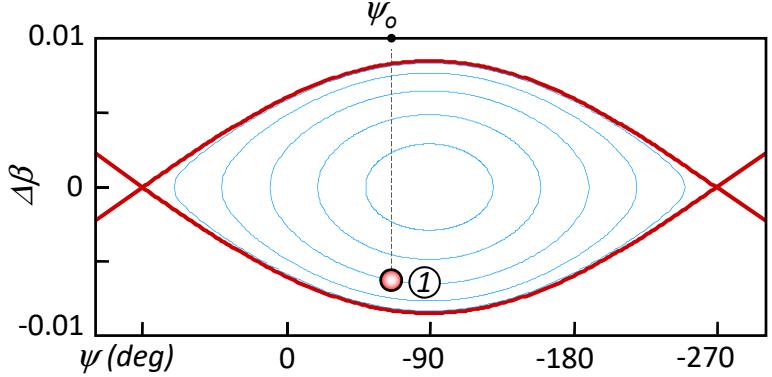
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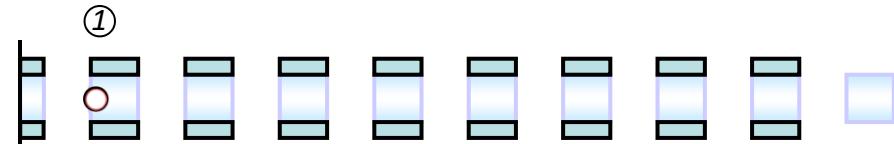
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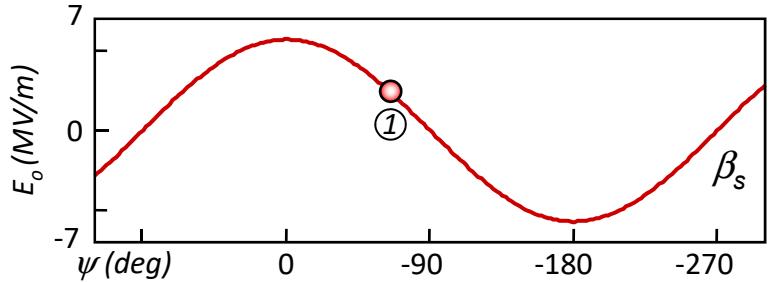
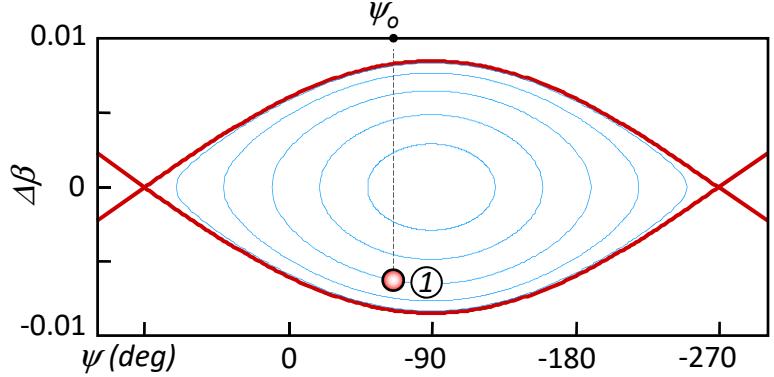
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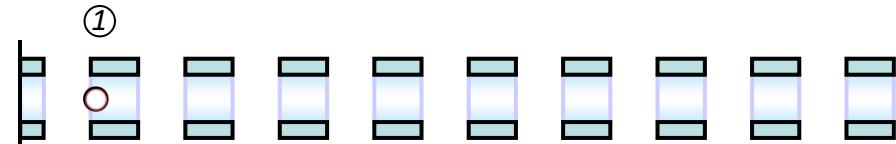
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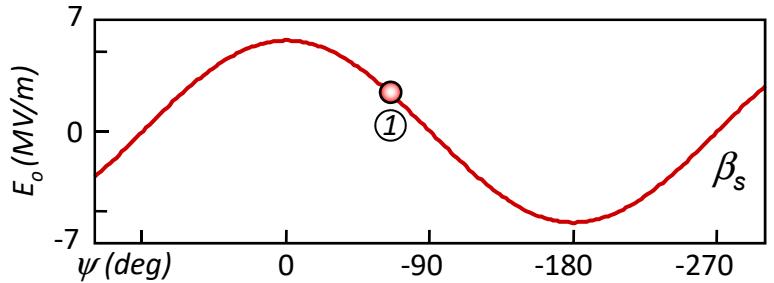
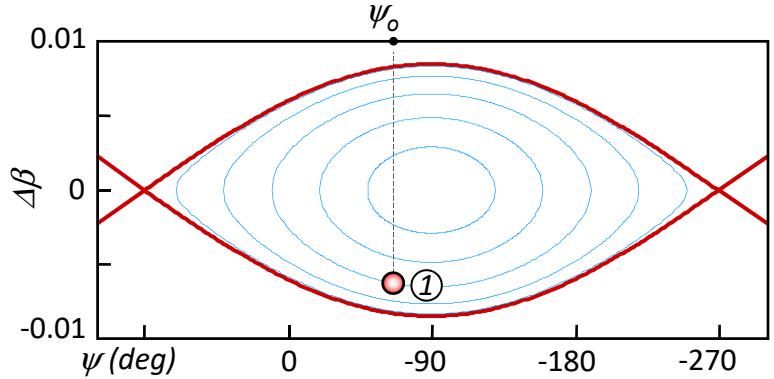
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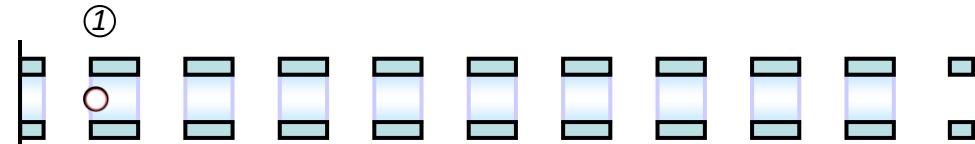
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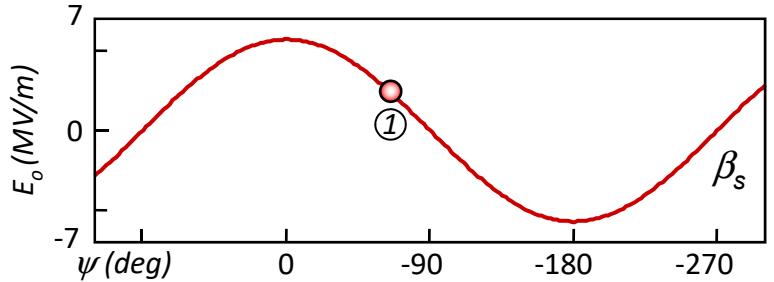
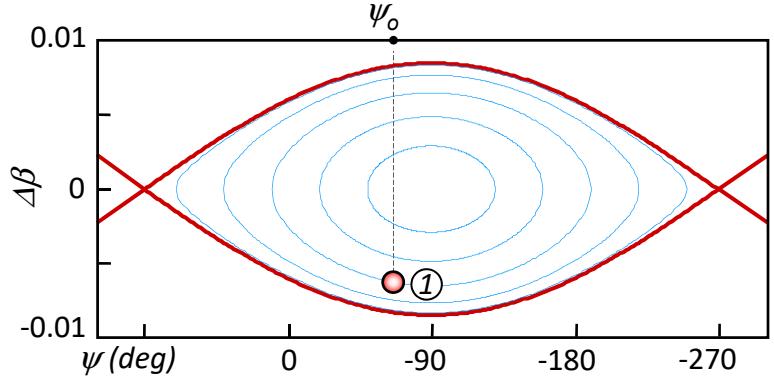
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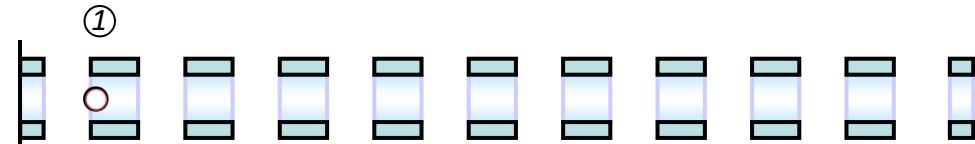
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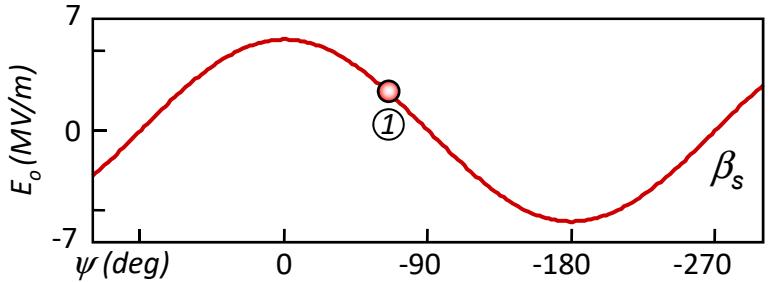
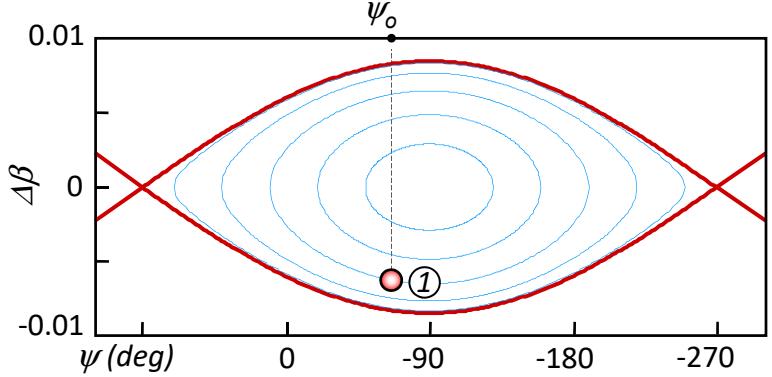
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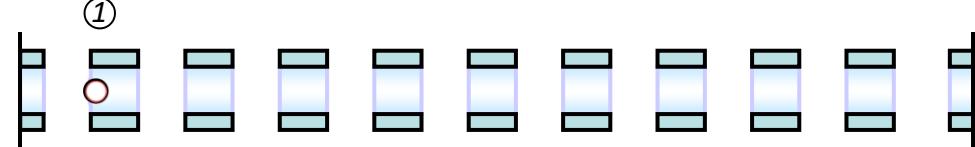
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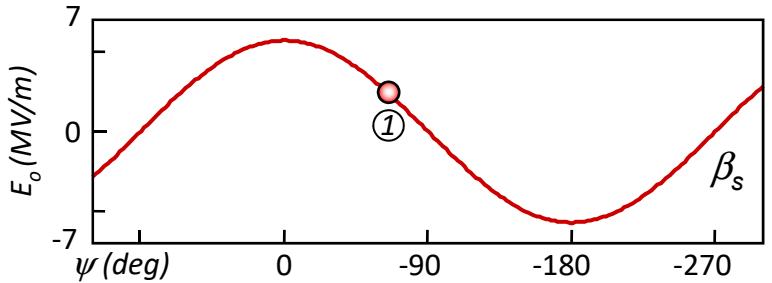
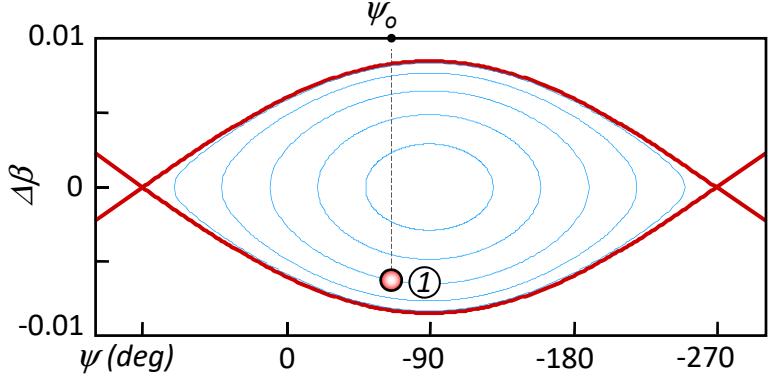
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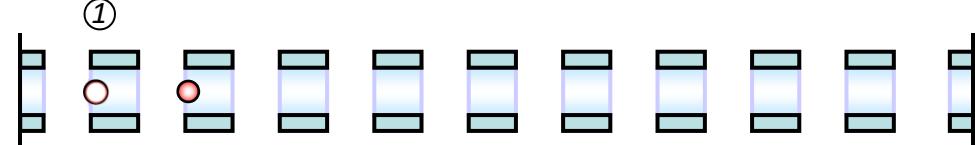
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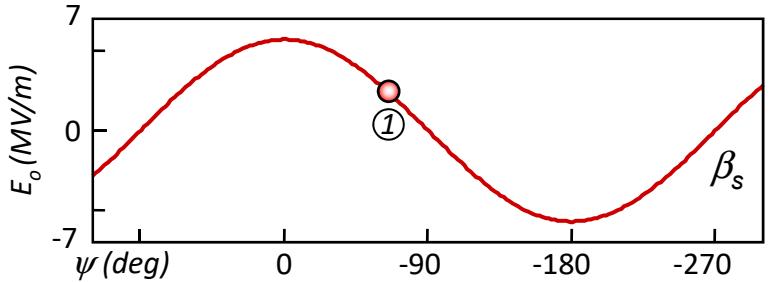
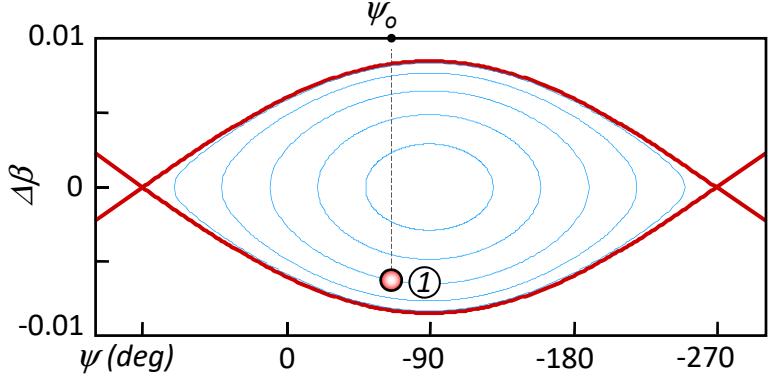
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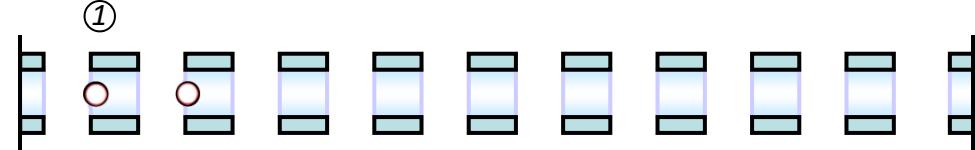
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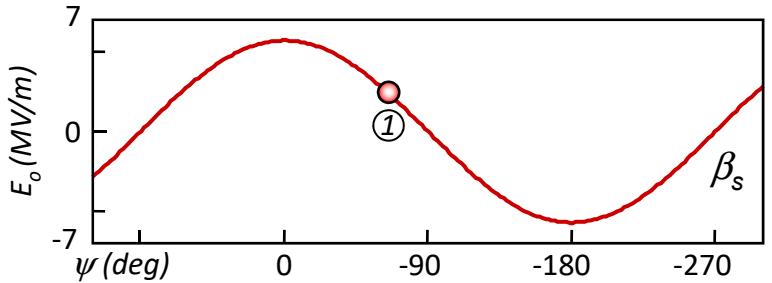
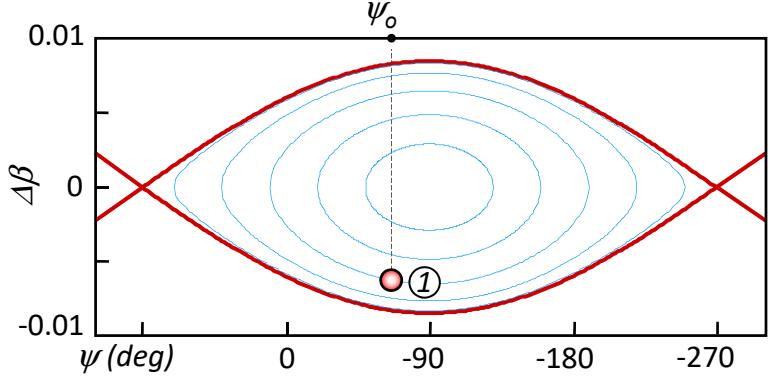
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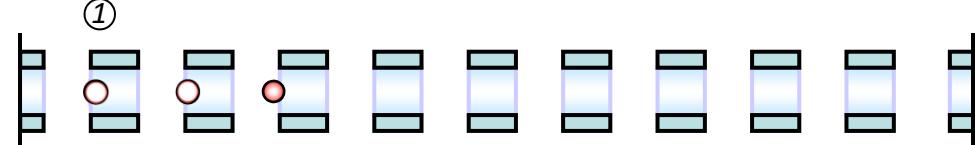
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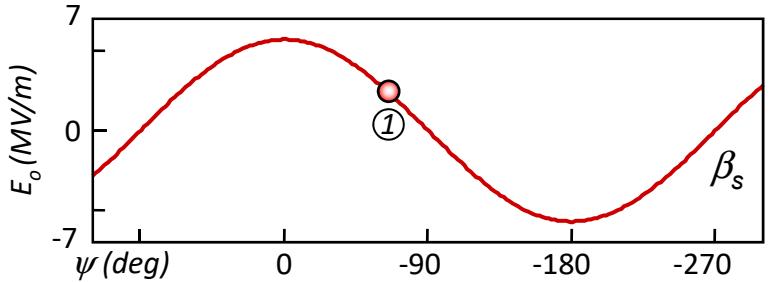
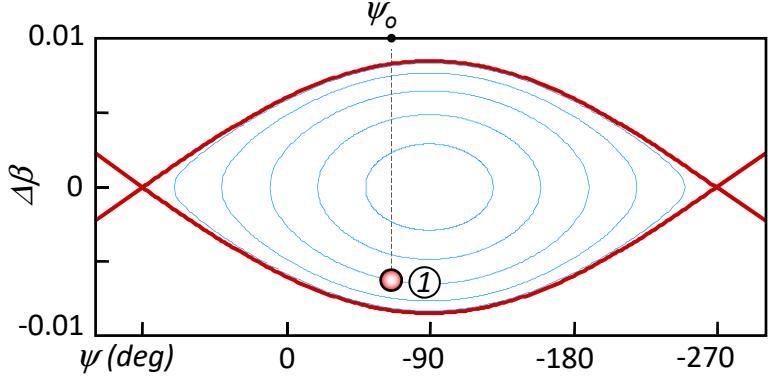
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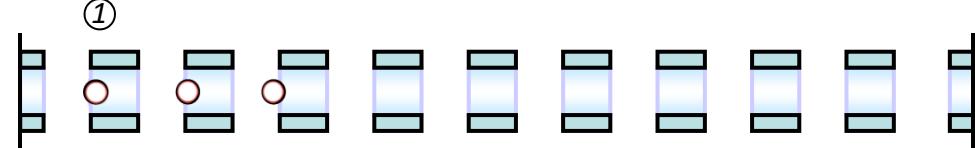
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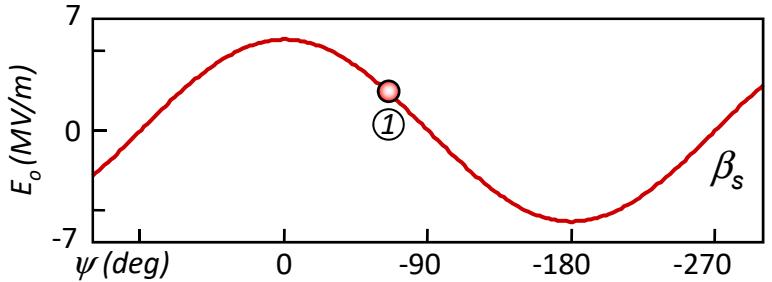
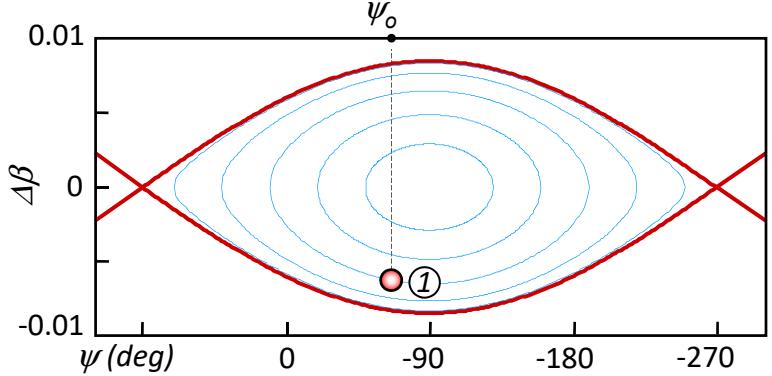
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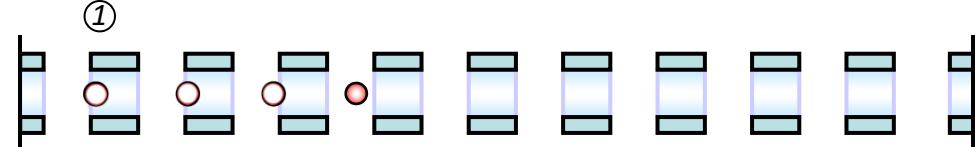
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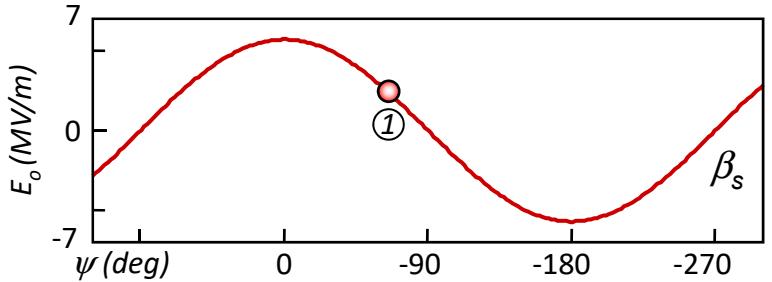
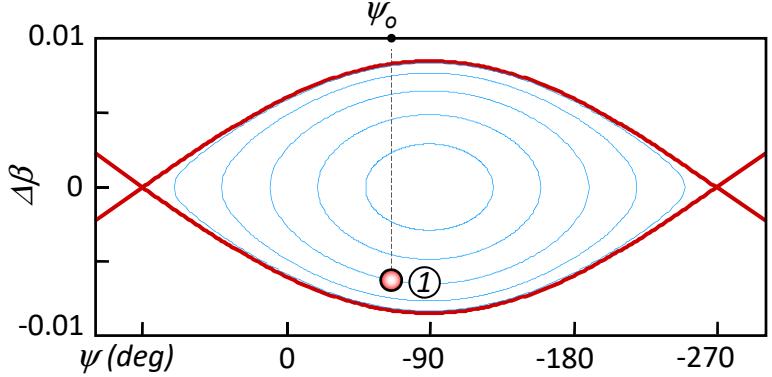
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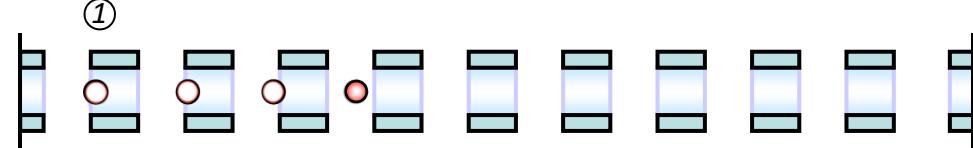
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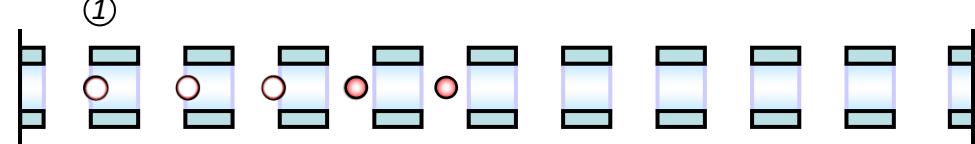


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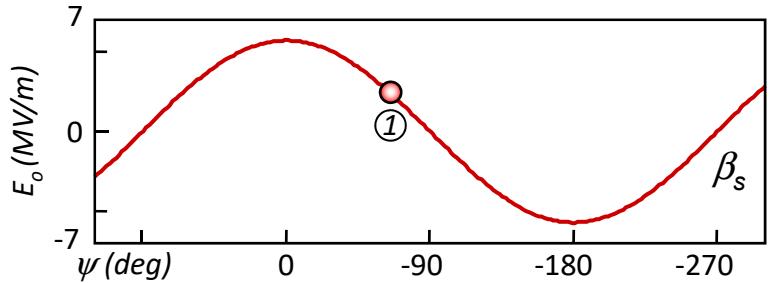
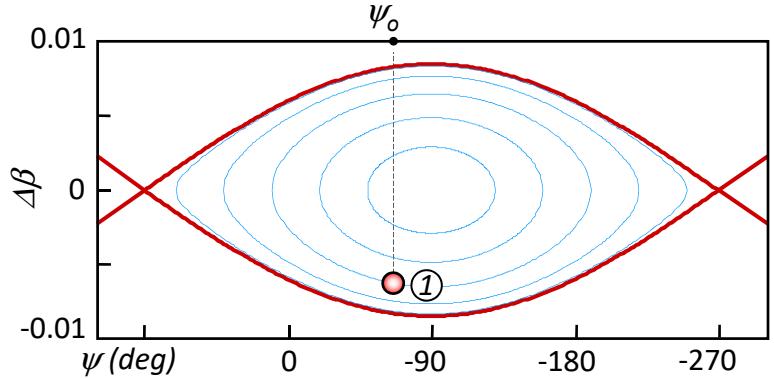


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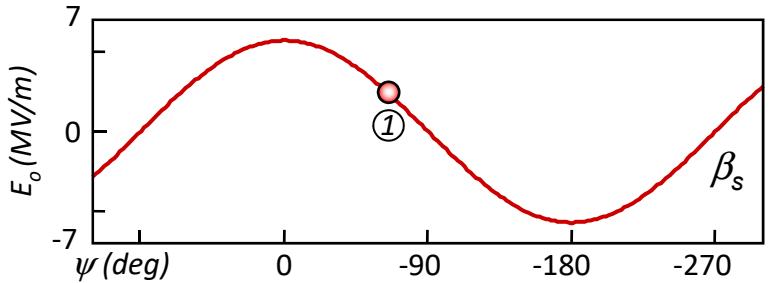
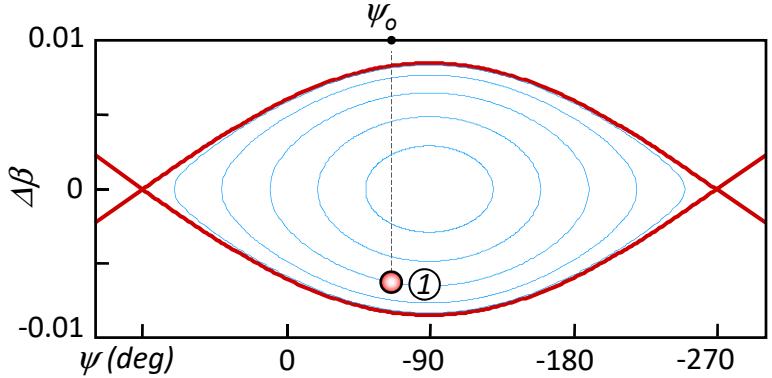
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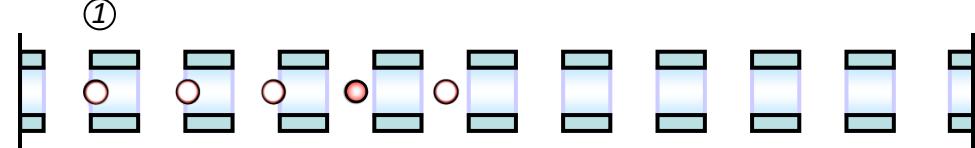
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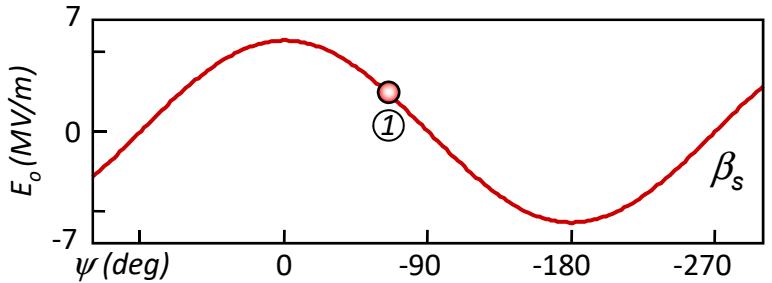
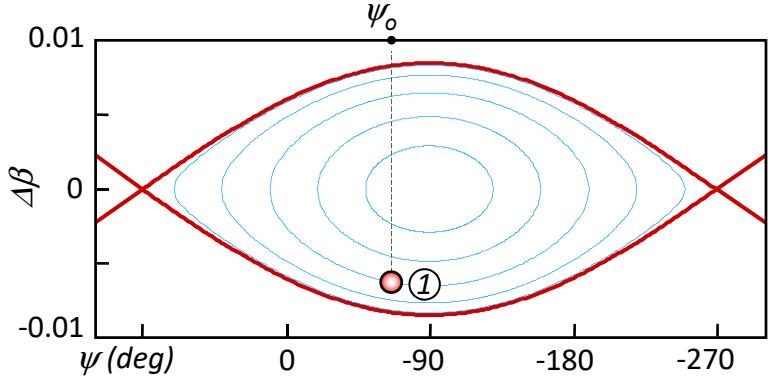
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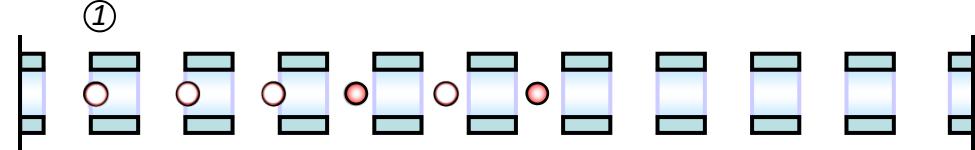
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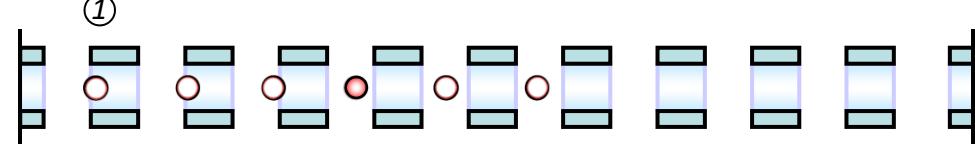


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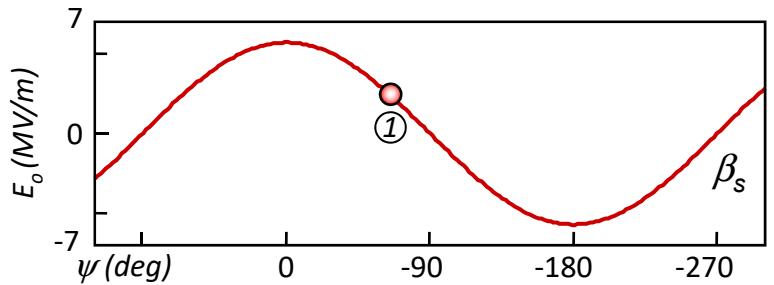
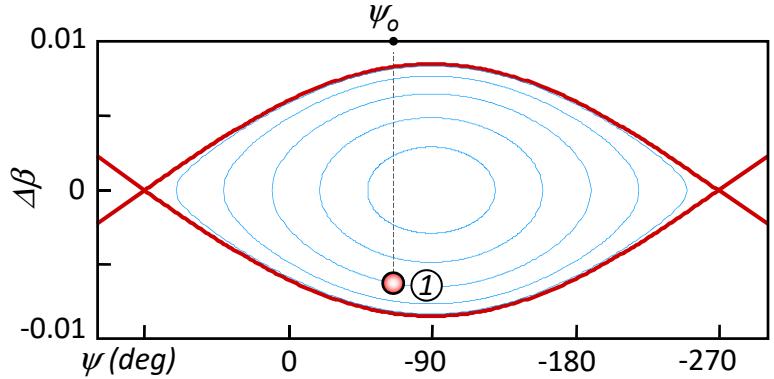


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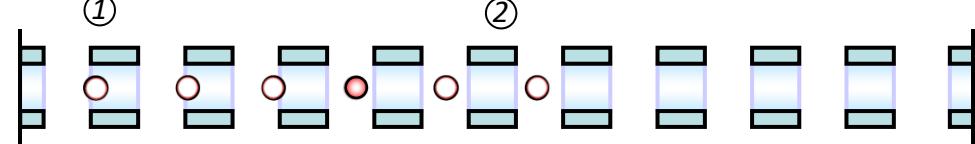


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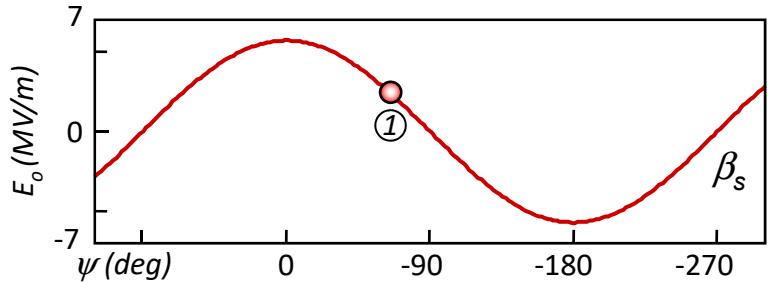
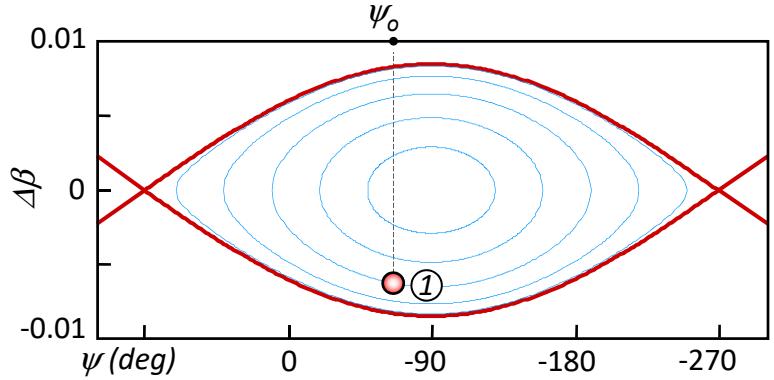


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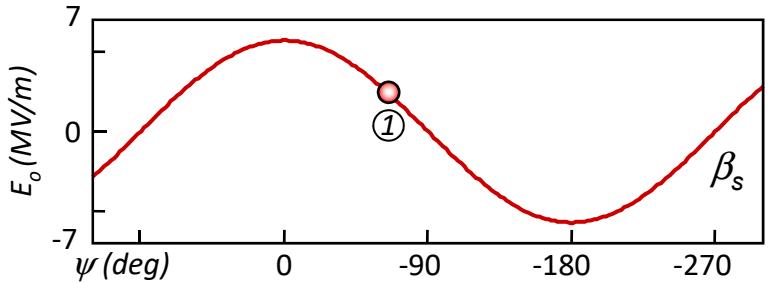
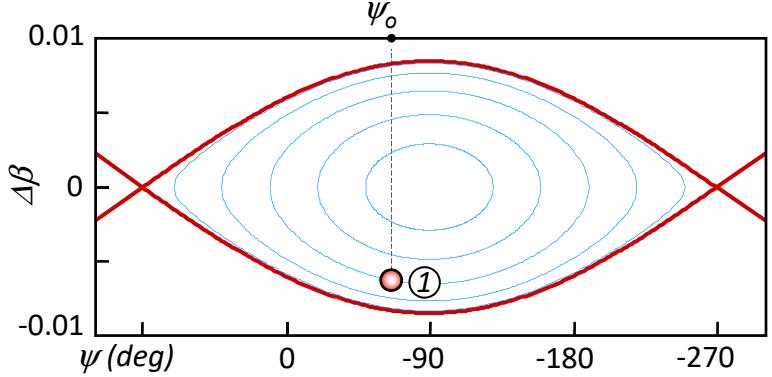
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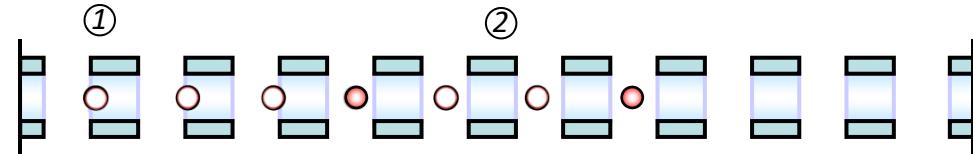
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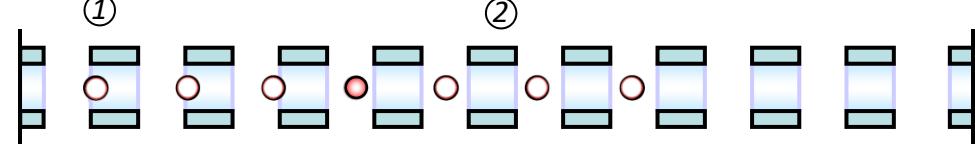


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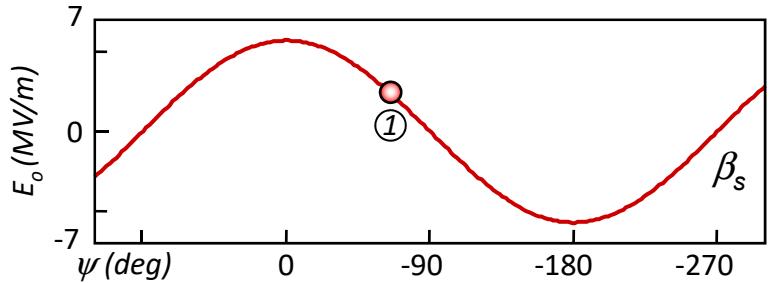
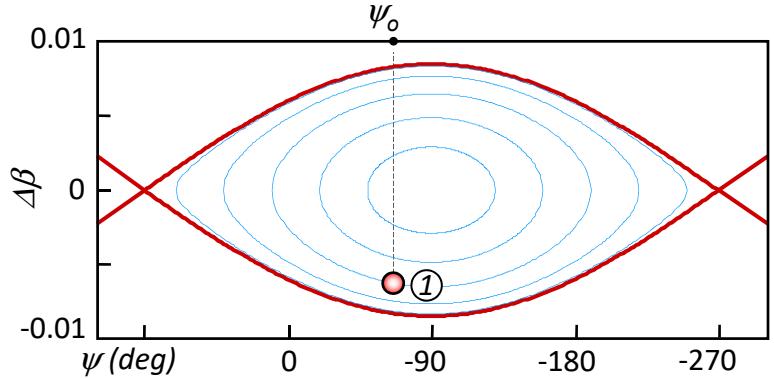


EQUUS beam dynamics concept

EQUUS - EQUidistant mUltigap Structure

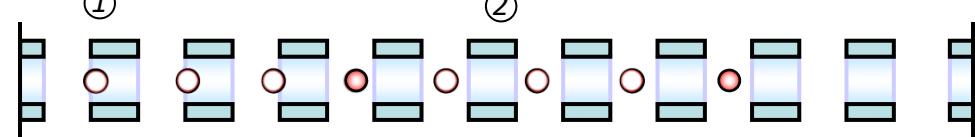


Longitudinal motion of an accelerated bunch in the constant- β -section

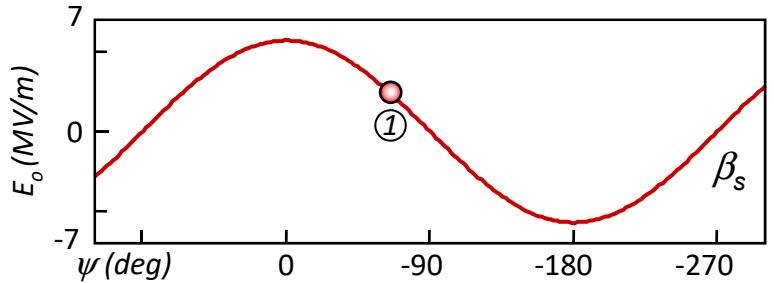
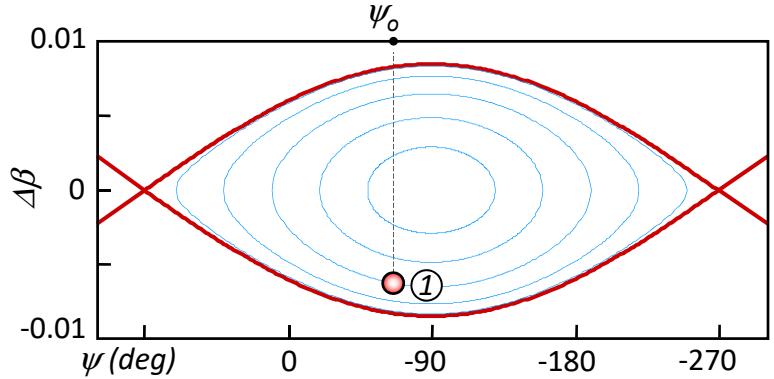


EQUUS beam dynamics concept

EQUUS - EQUidistant mUltigap Structure

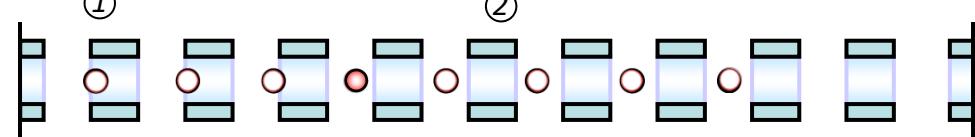


Longitudinal motion of an accelerated bunch in the constant- β -section

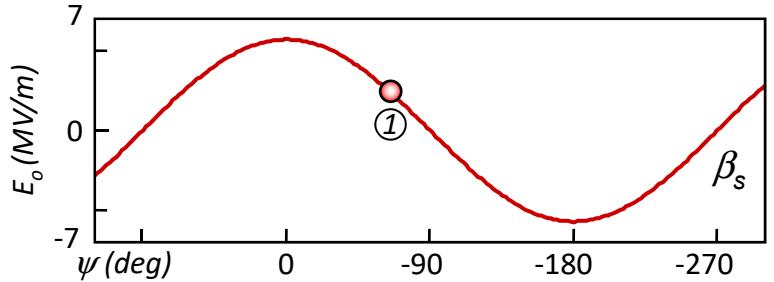
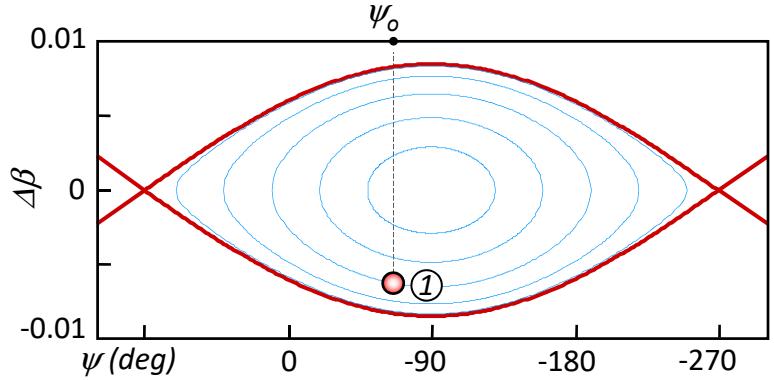


EQUUS beam dynamics concept

EQUUS - EQUidistant mUltigap Structure

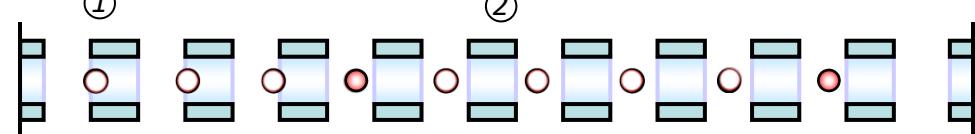


Longitudinal motion of an accelerated bunch in the constant- β -section

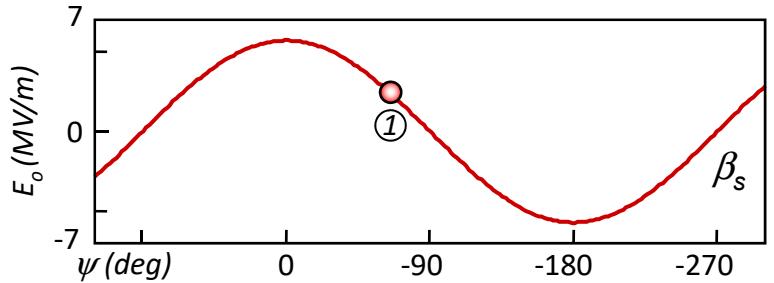
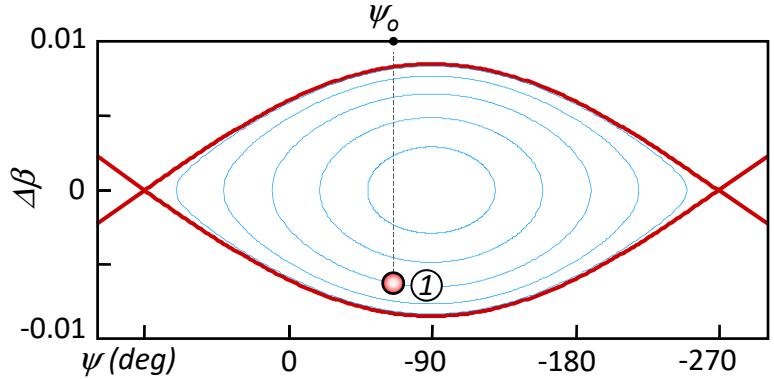


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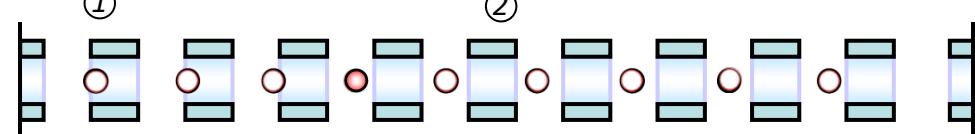


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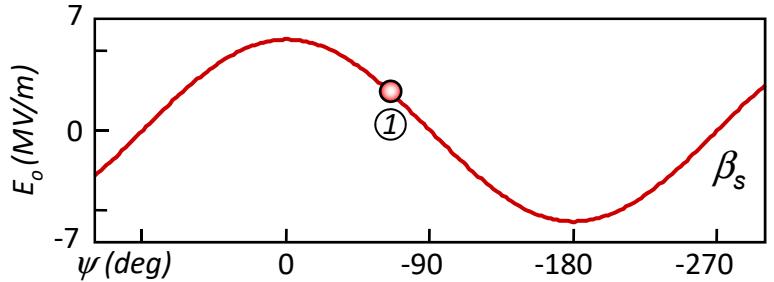
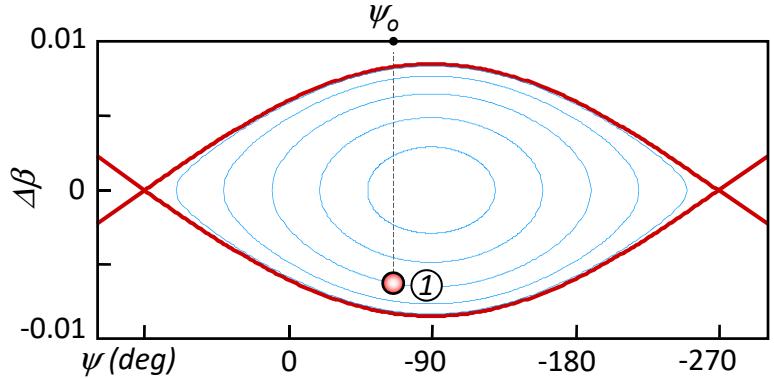


EQUUS beam dynamics concept

EQUUS - EQUidistant mUltigap Structure



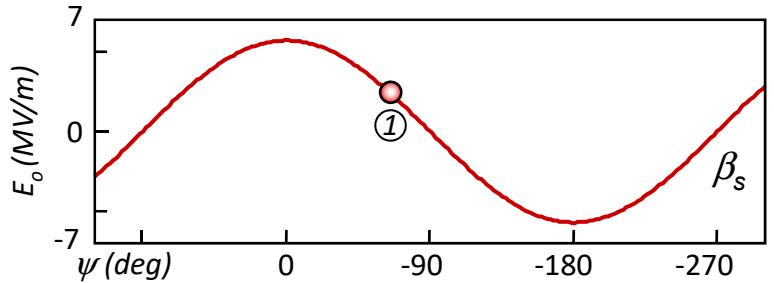
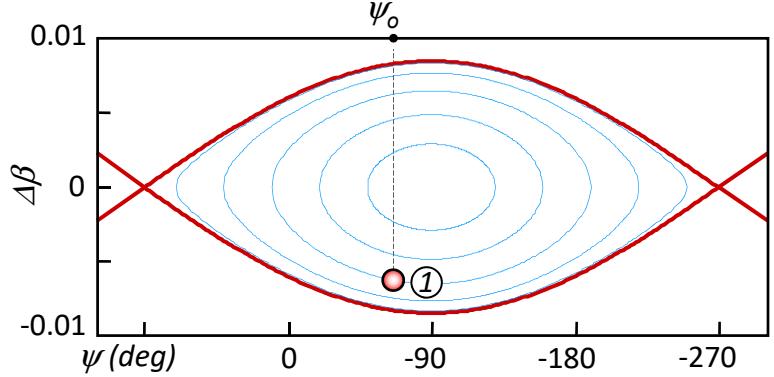
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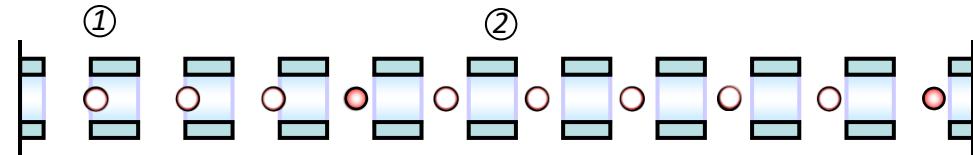
EQUUS beam dynamics concept

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Longitudinal motion of an accelerated bunch in the constant- β -section



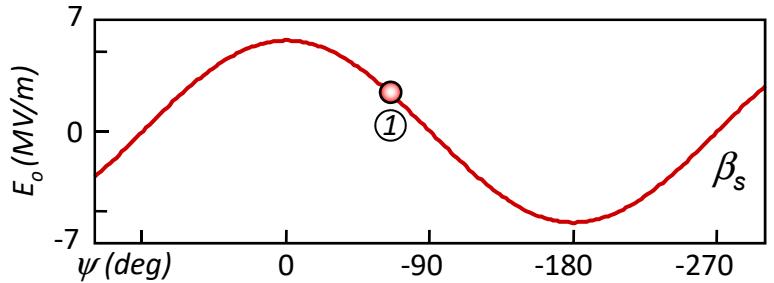
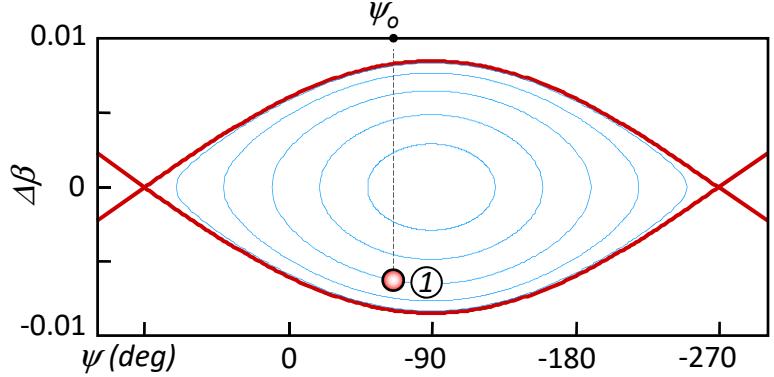
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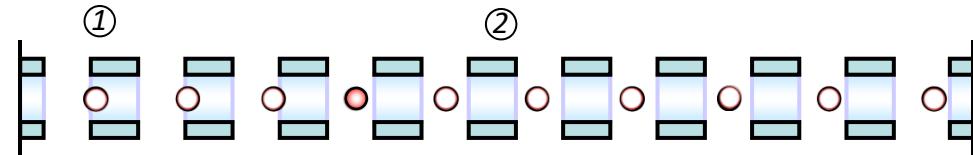
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Longitudinal motion of an accelerated bunch in the constant- β -section



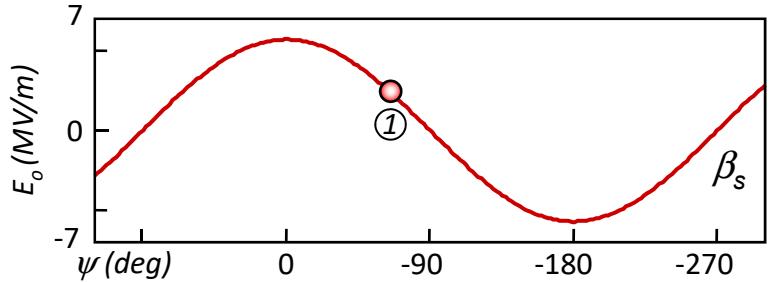
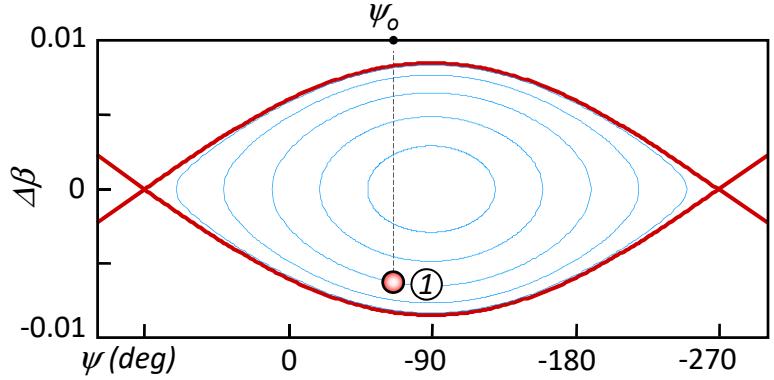
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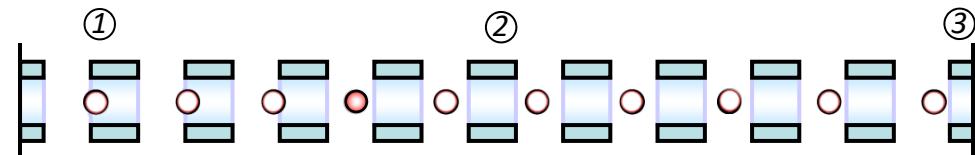
EQUUS beam dynamics concept

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Longitudinal motion of an accelerated bunch in the constant- β -section



EQUUS

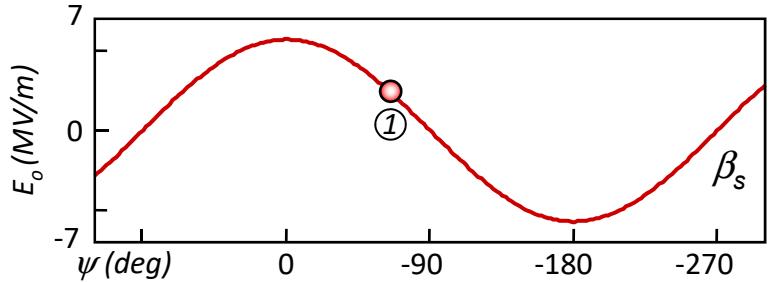
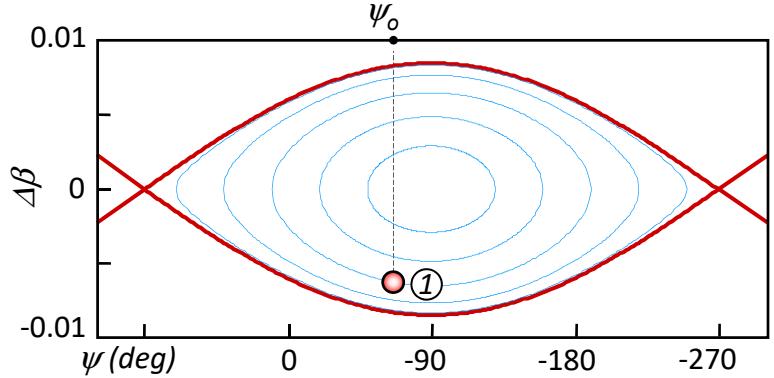


EQUUS beam dynamics concept

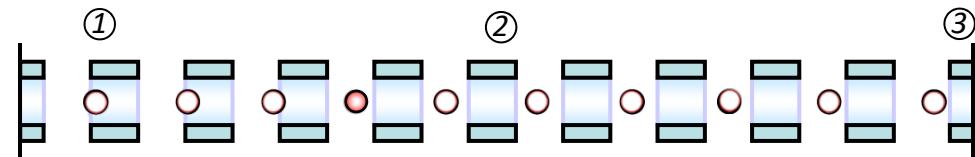
EQUUS - EQUidistant mUltigap Structure

①

Longitudinal motion of an accelerated bunch in the constant- β -section



EQUUS



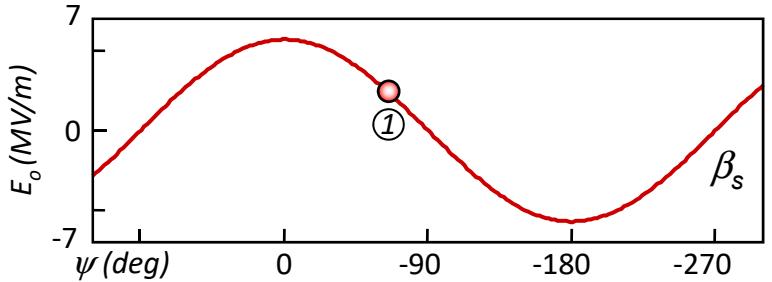
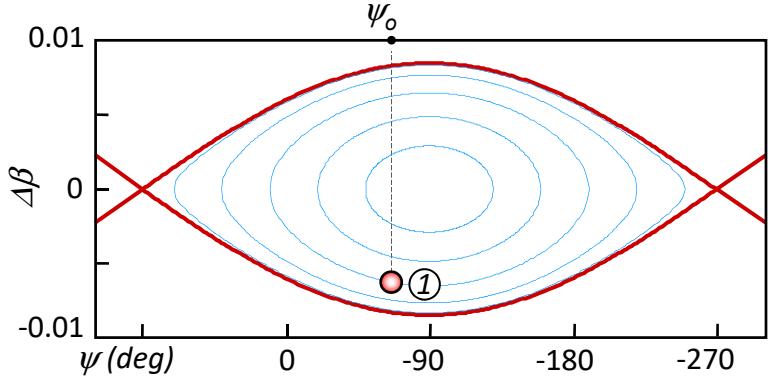
EQUUS beam dynamics concept

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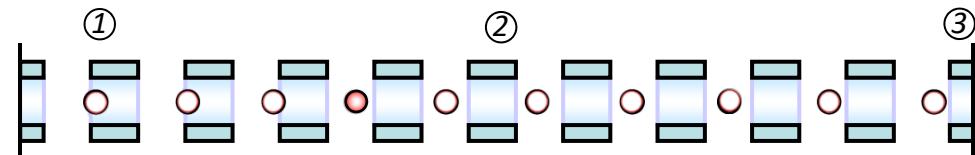
① Particles too early

obtain less acceleration
longitudinal focussing

Longitudinal motion of an accelerated
bunch in the constant- β -section



EQUUS

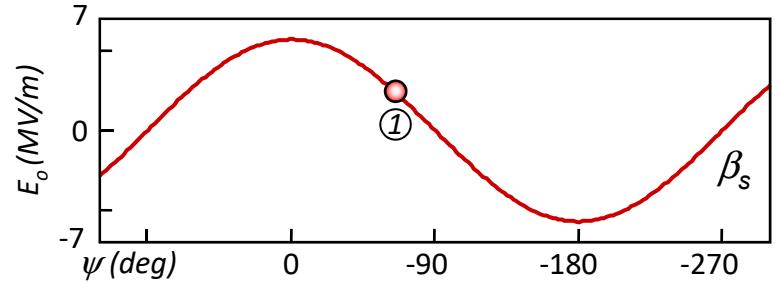
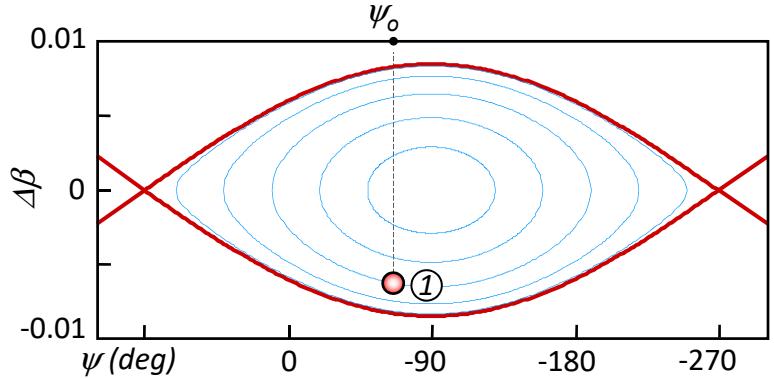


EQUUS beam dynamics concept

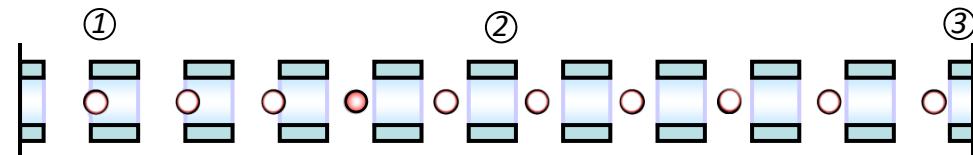
EQUUS - EQUidistant mUltigap Structure

- ① Particles too early → obtain less acceleration longitudinal focussing

Longitudinal motion of an accelerated bunch in the constant- β -section



EQUUS



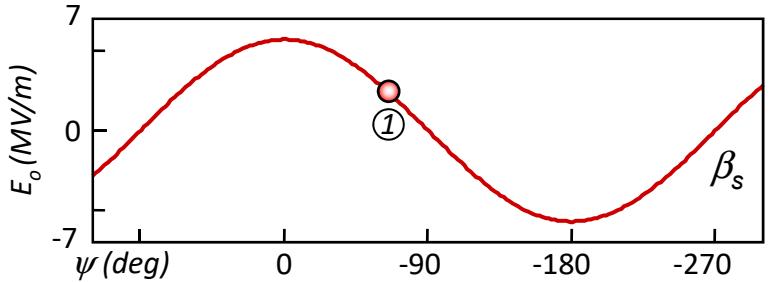
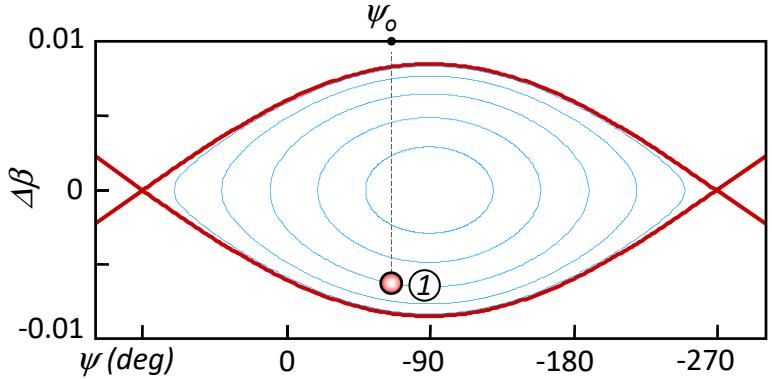
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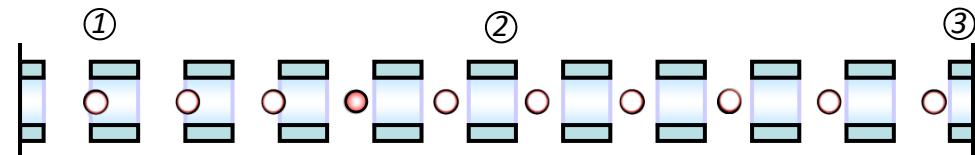
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Longitudinal motion of an accelerated bunch in the constant- β -section



EQUUS



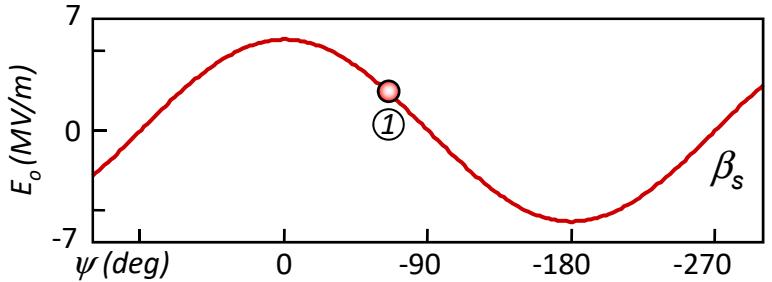
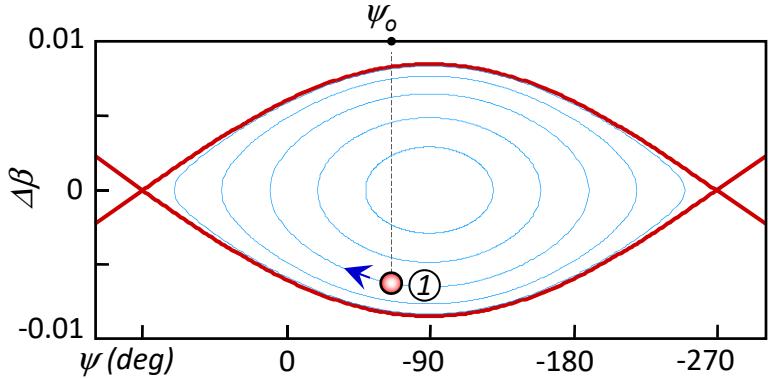
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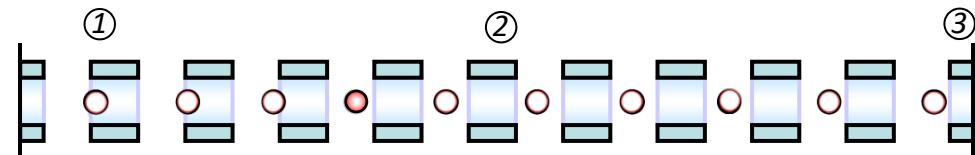
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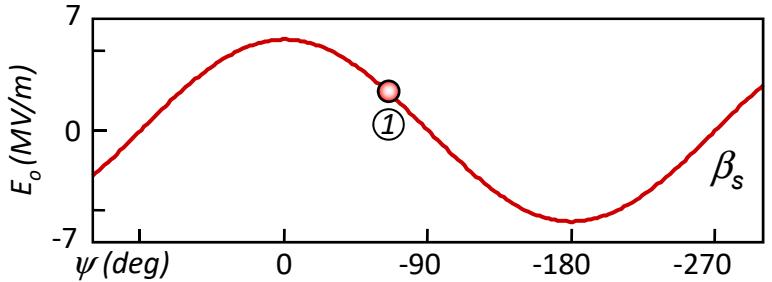
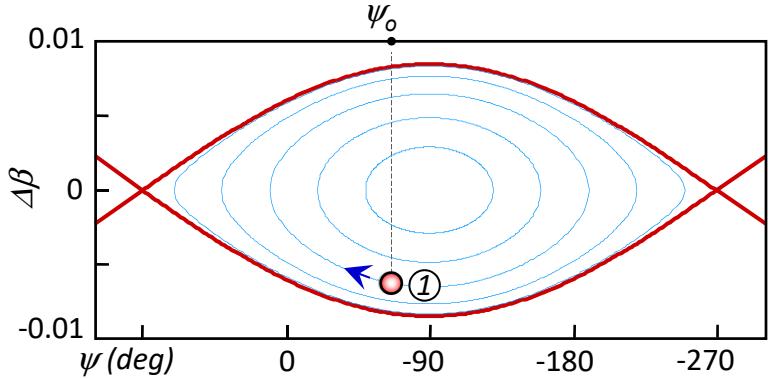
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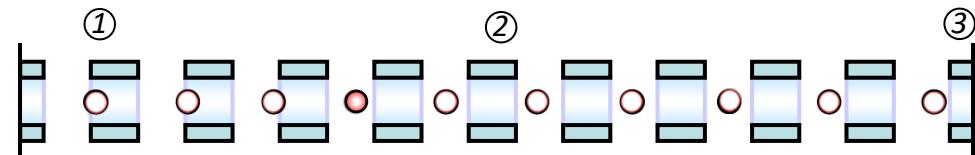
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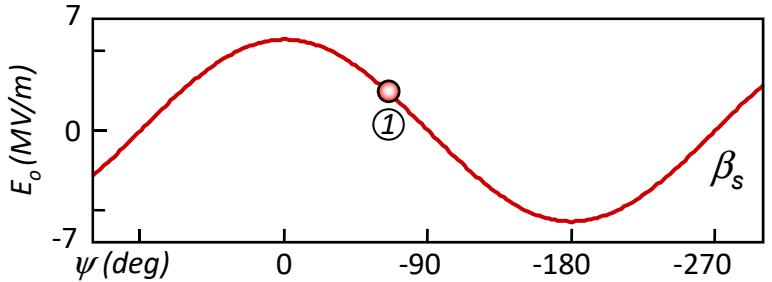
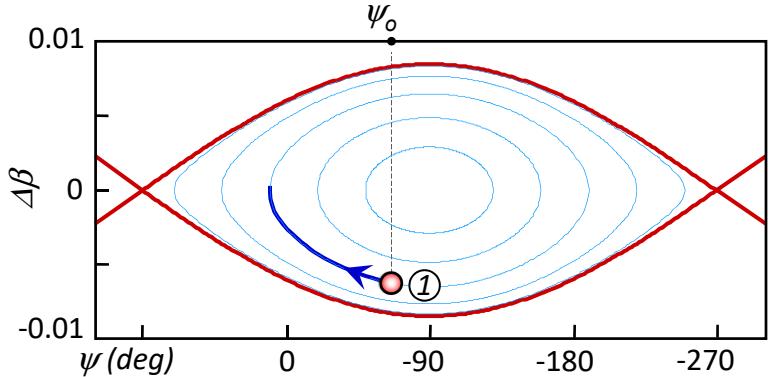
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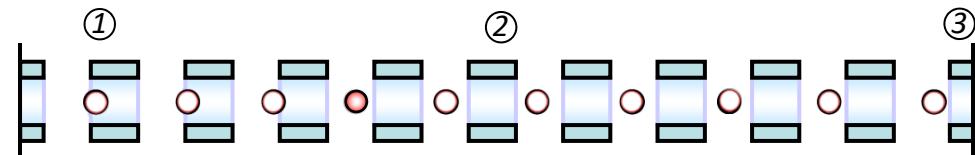
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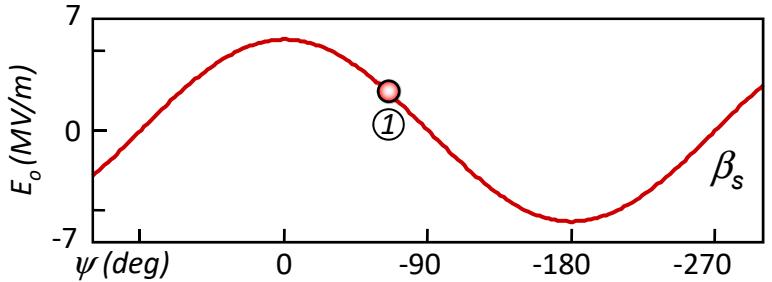
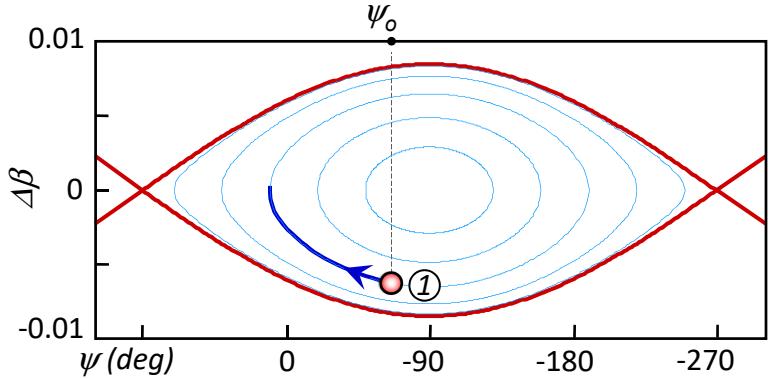
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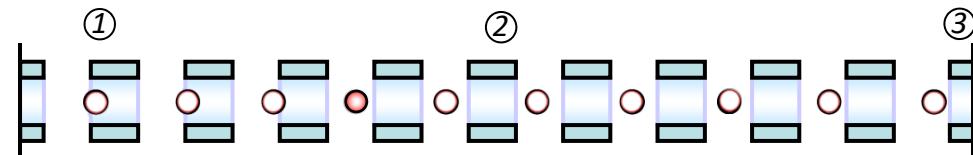
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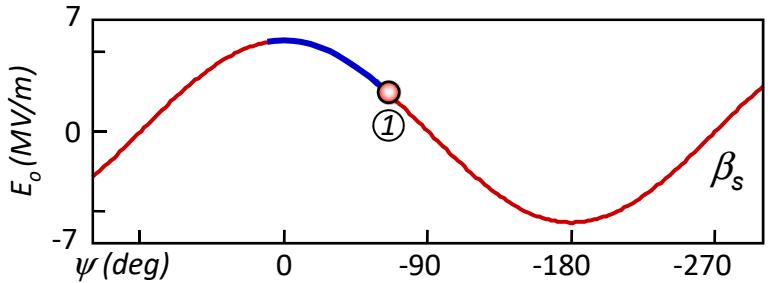
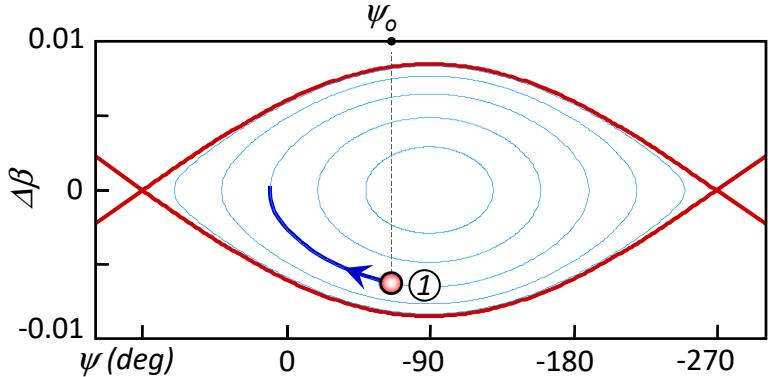
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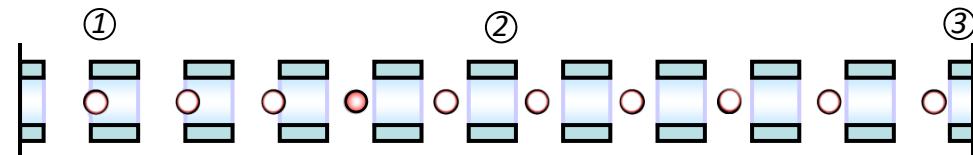
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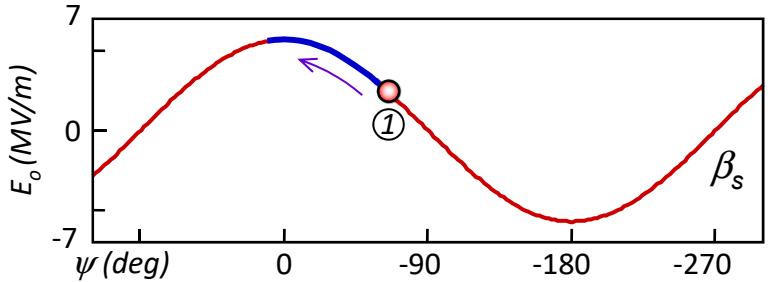
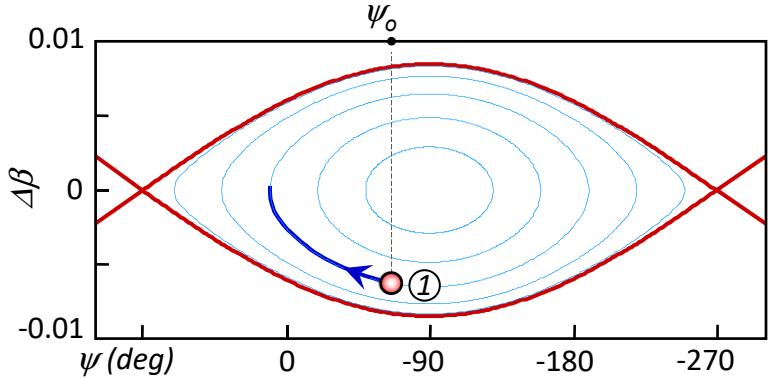
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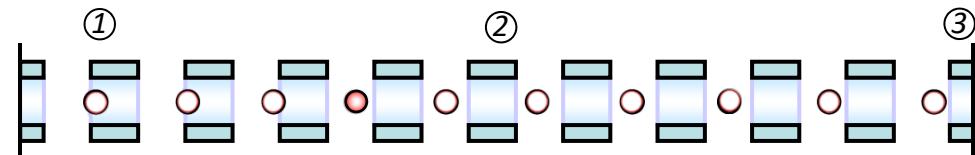
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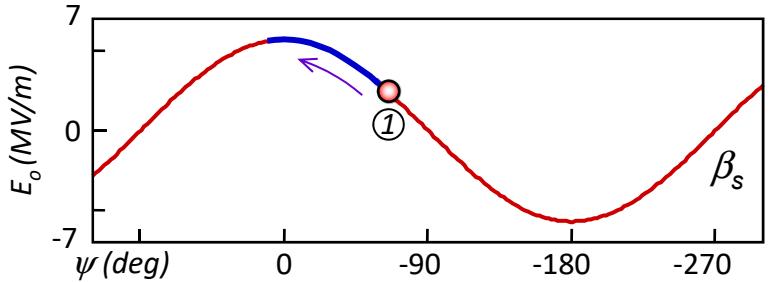
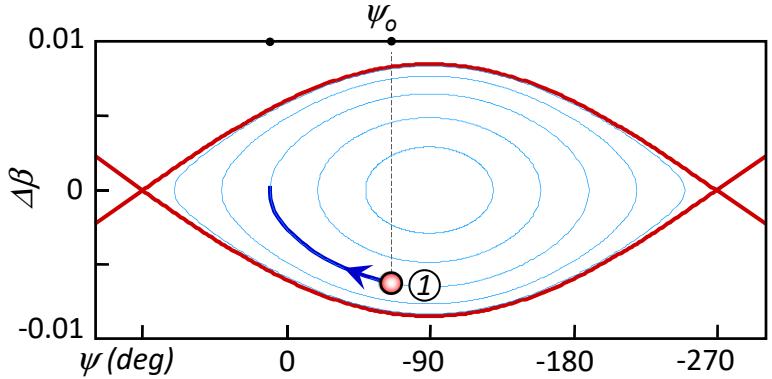
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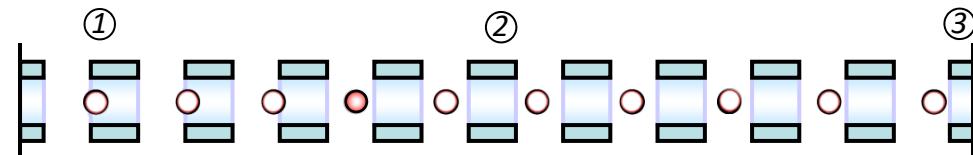
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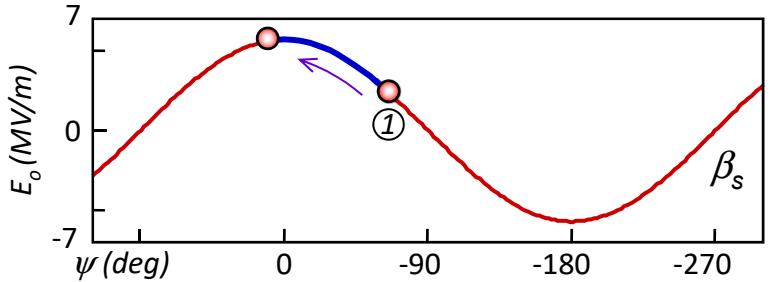
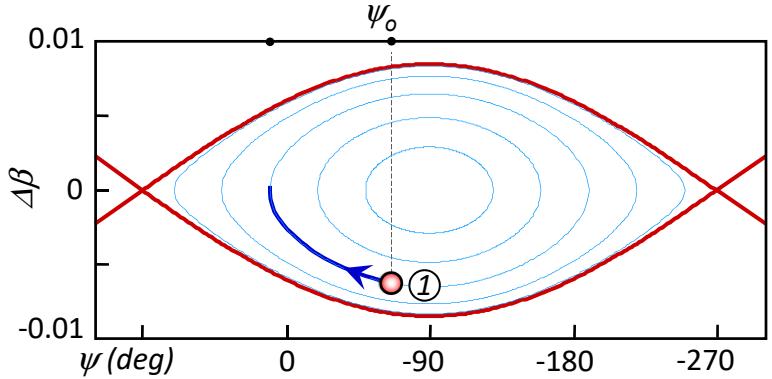
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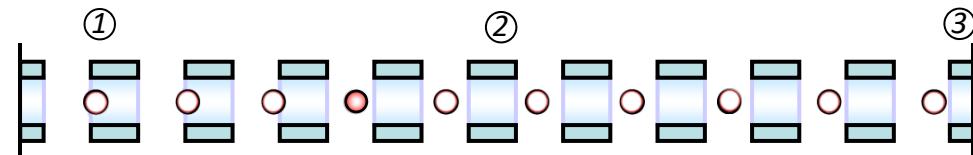
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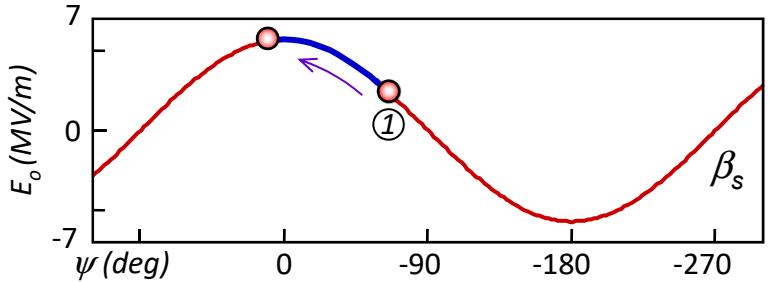
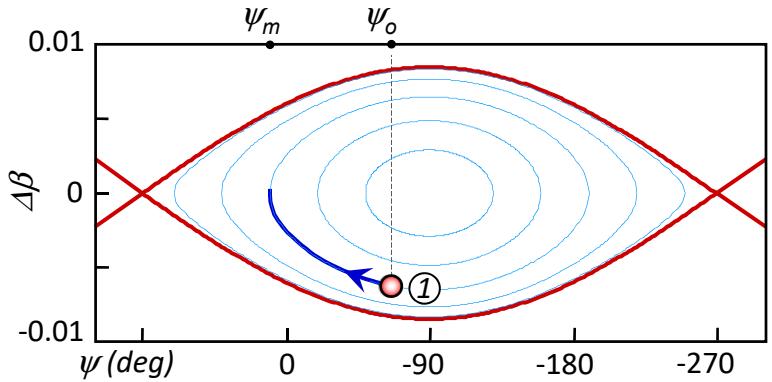
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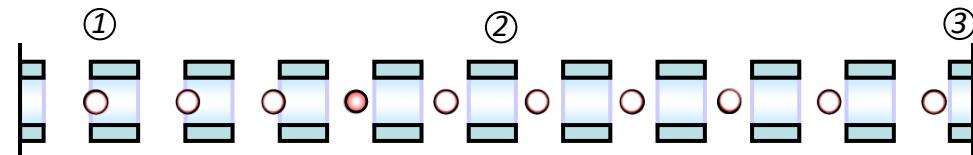
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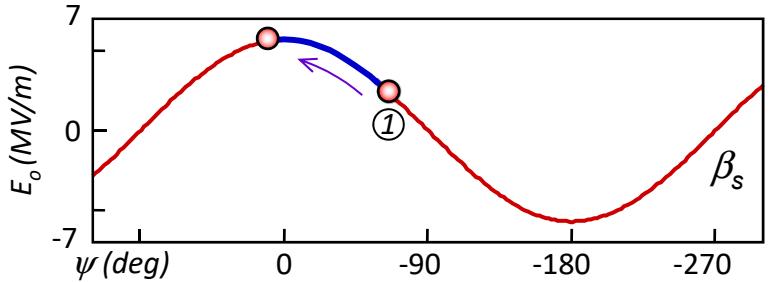
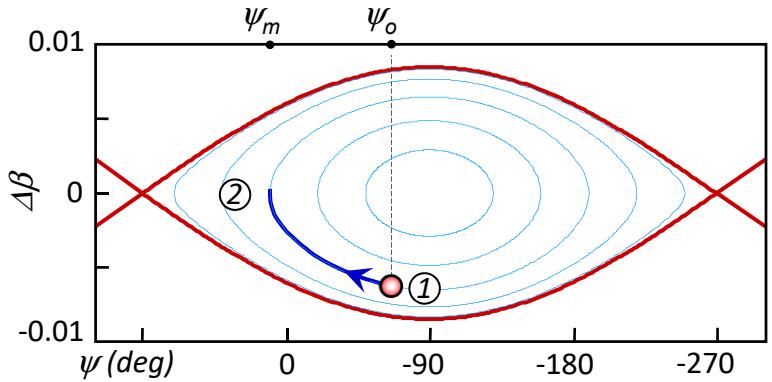
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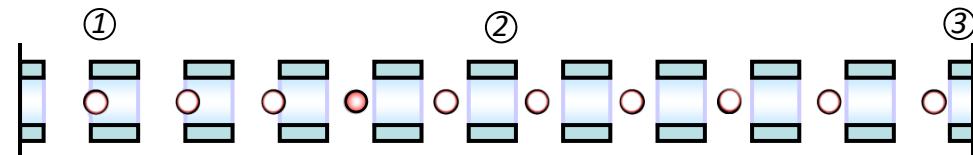
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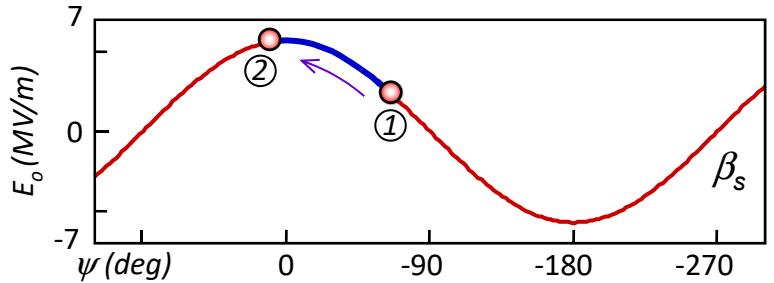
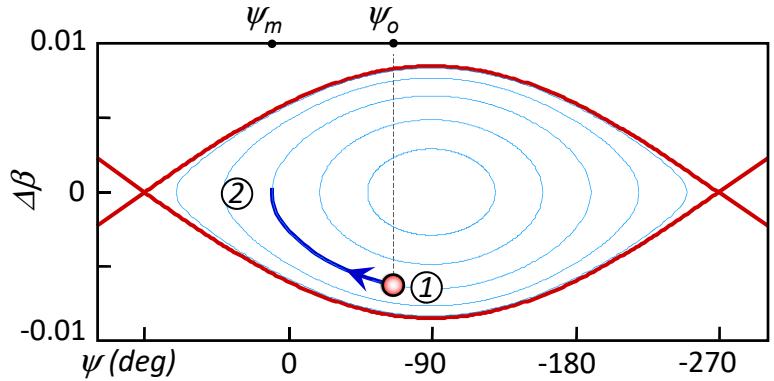
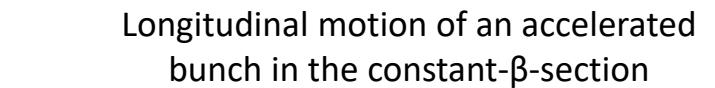


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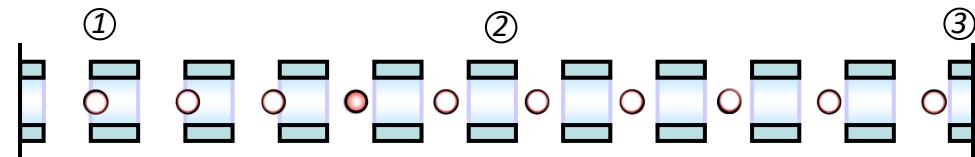
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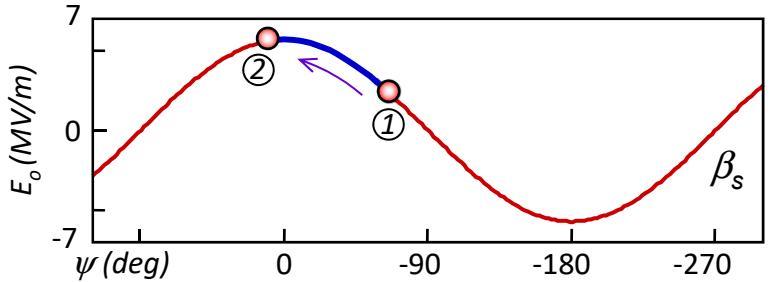
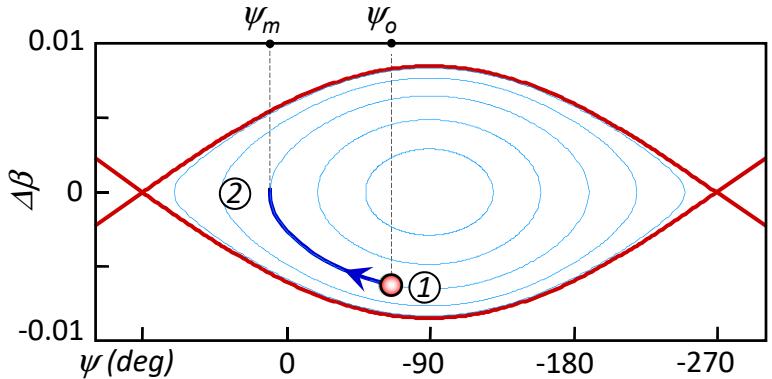
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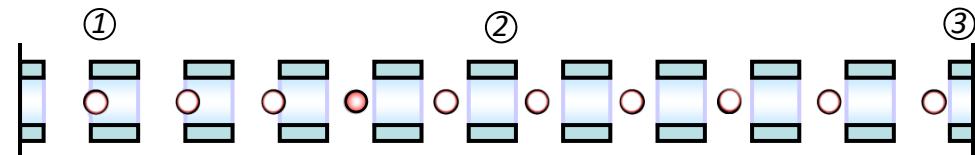
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Longitudinal motion of an accelerated bunch in the constant- β -section



EQUUS



EQUUS beam dynamics concept

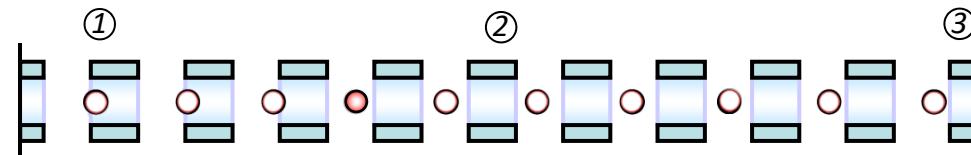
EQUUS - EQUidistant mUltigap Structure

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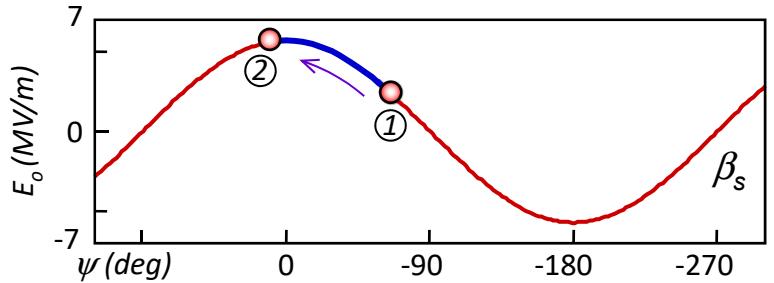
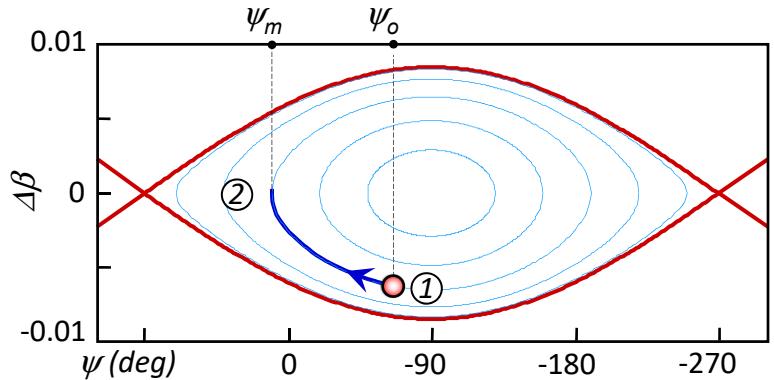
- obtain less acceleration
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②

EQUUS



Longitudinal motion of an accelerated bunch in the constant- β -section



EQUUS beam dynamics concept

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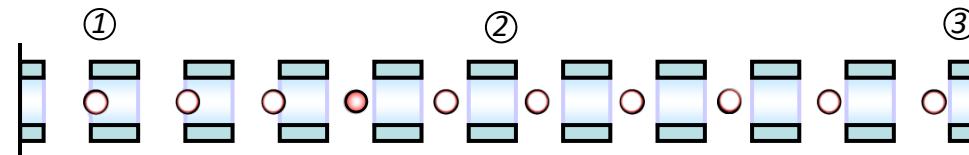
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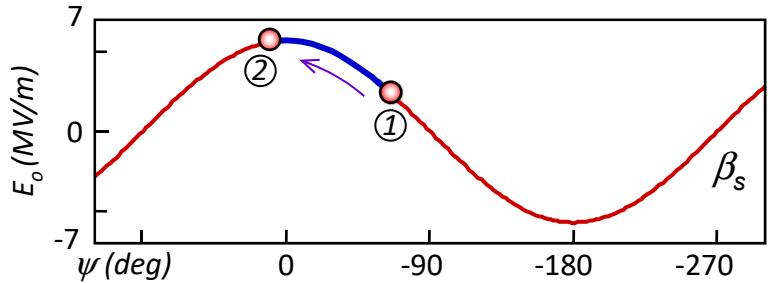
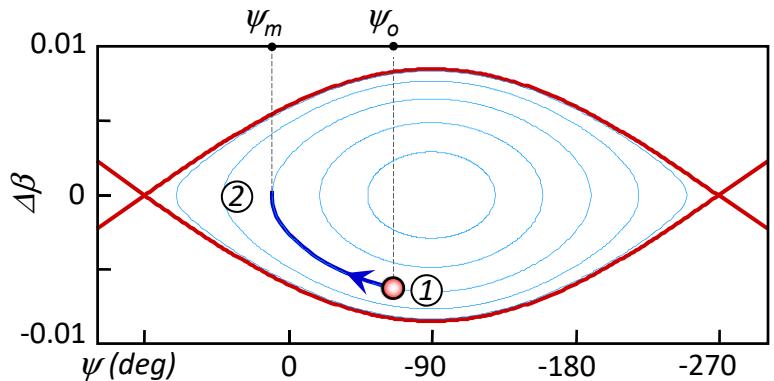
②



EQUUS



Longitudinal motion of an accelerated bunch in the constant- β -section



EQUUS beam dynamics concept

EQUUS - EQUidistant mUltigap Structure

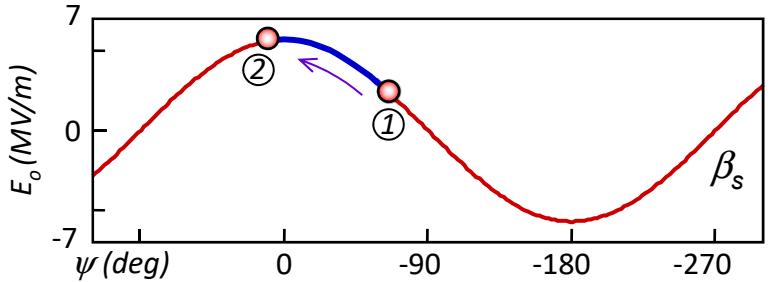
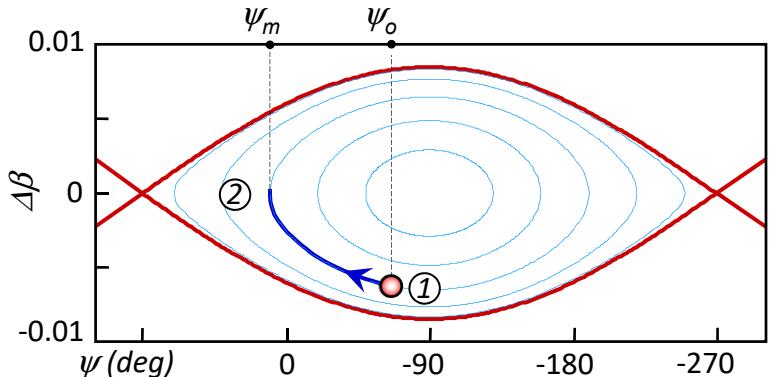
① Particles too early

- obtain less acceleration
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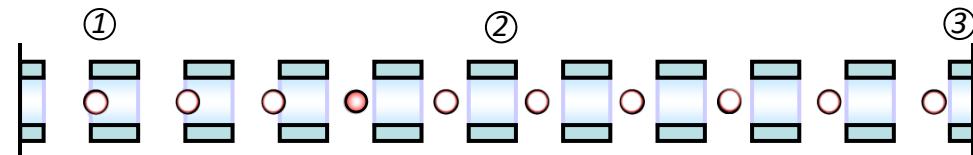
②



Longitudinal motion of an accelerated bunch in the constant- β -section



EQUUS



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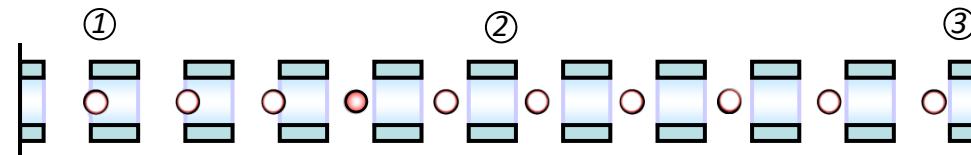
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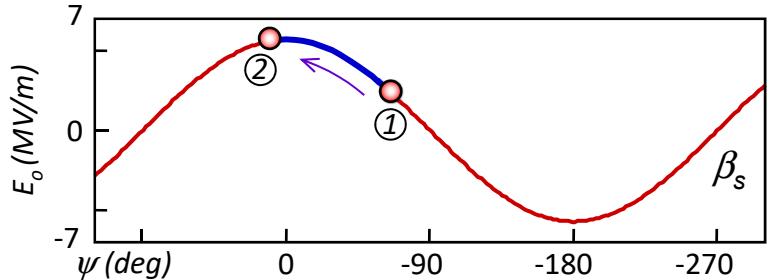
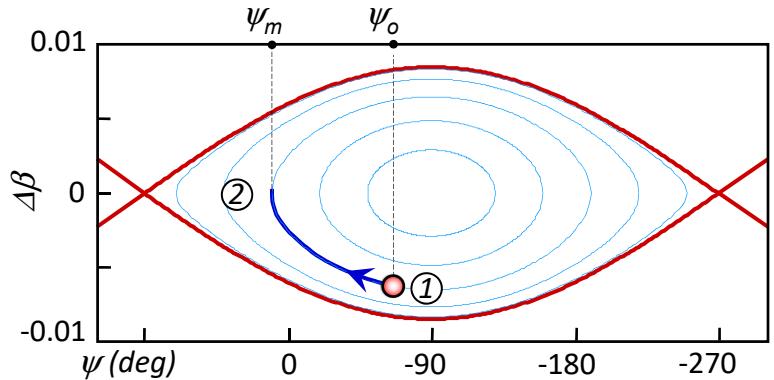
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EQUUS



Longitudinal motion of an accelerated bunch in the constant- β -section



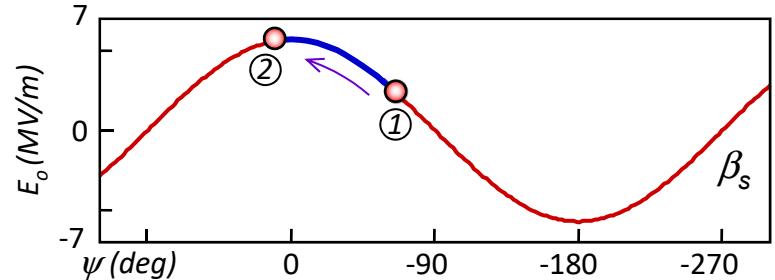
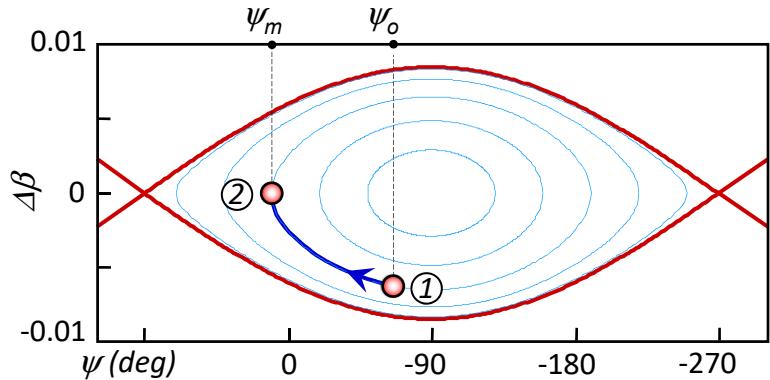
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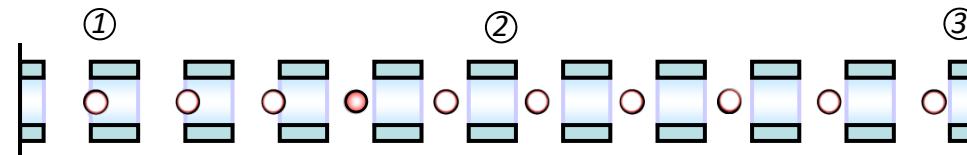
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Longitudinal motion of an accelerated bunch in the constant- β -section



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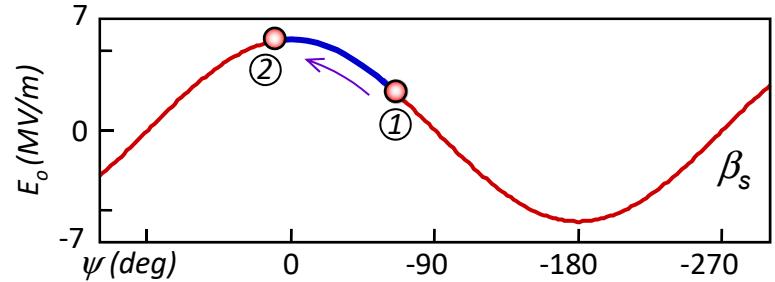
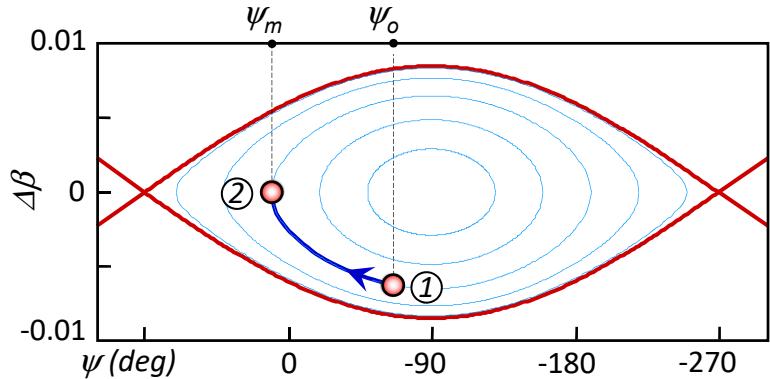
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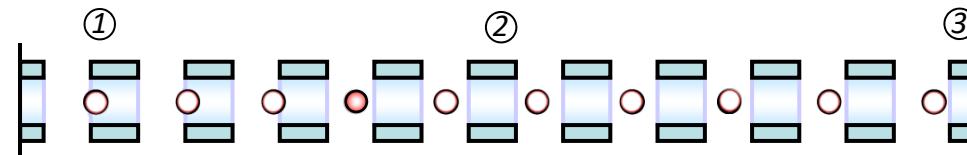
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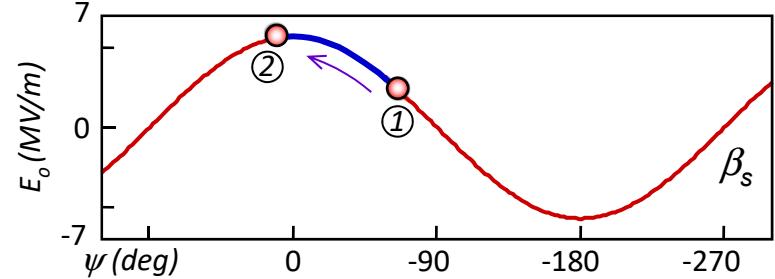
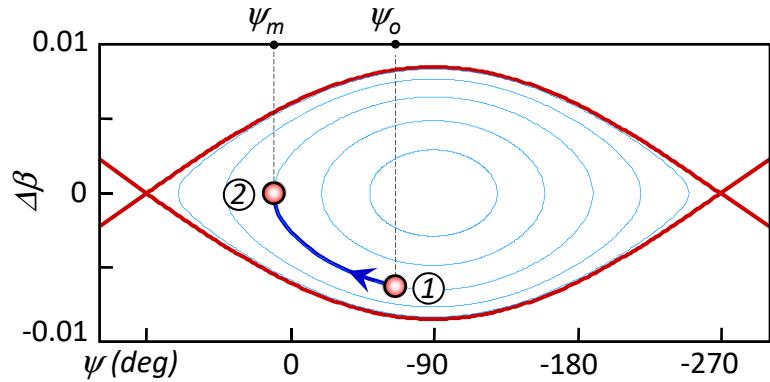
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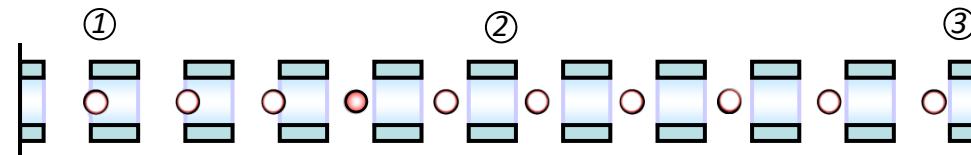
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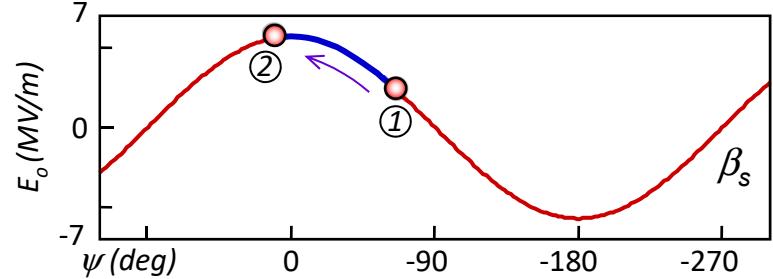
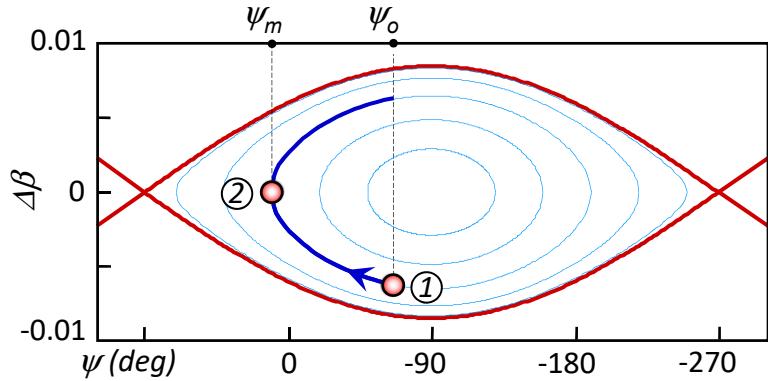
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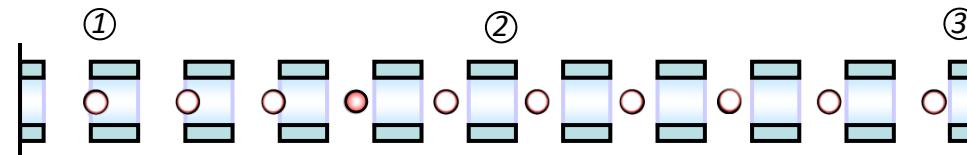
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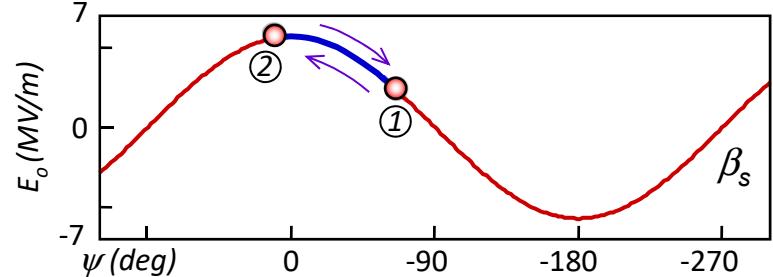
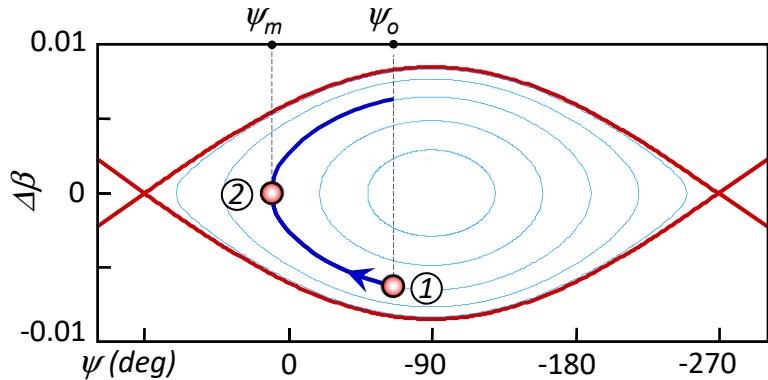
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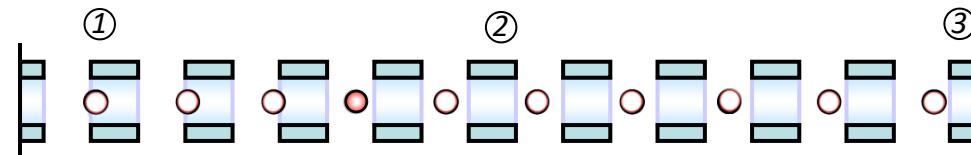
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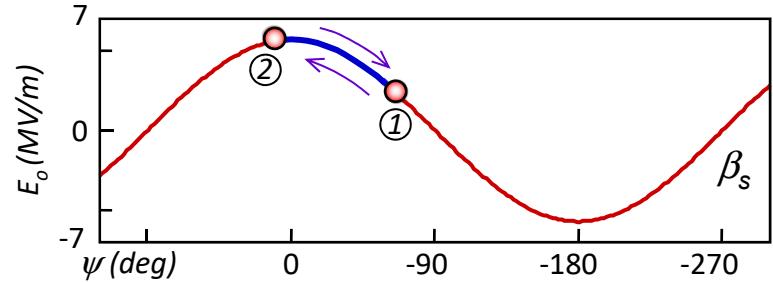
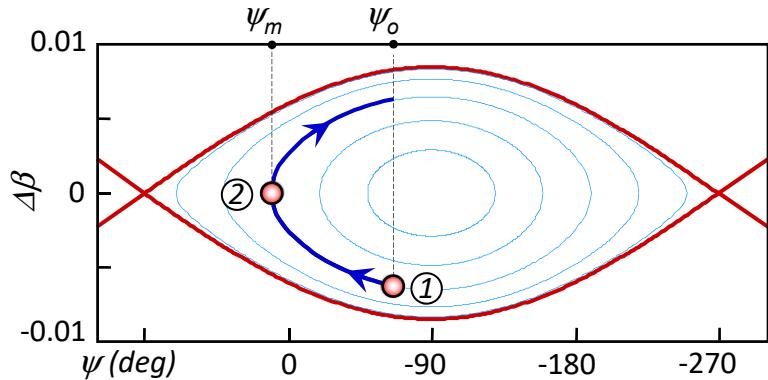
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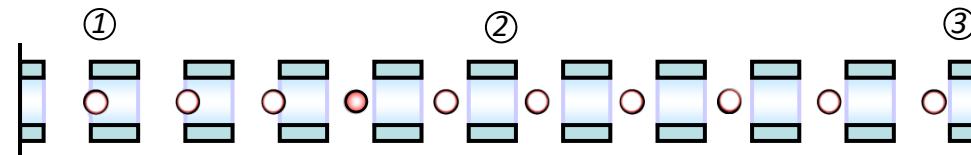
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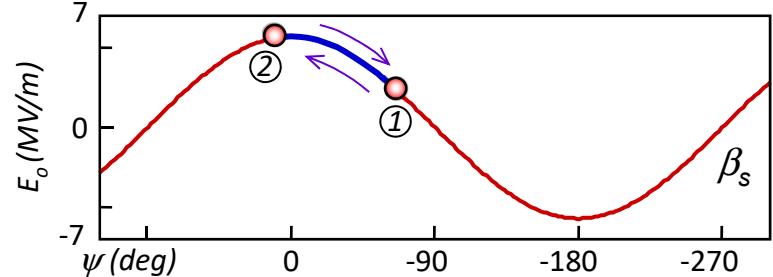
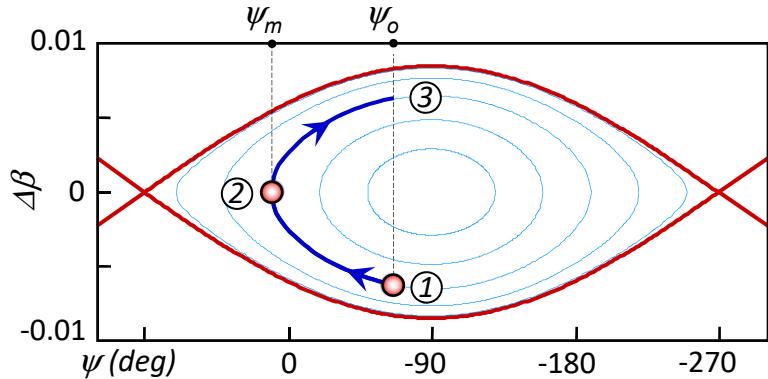
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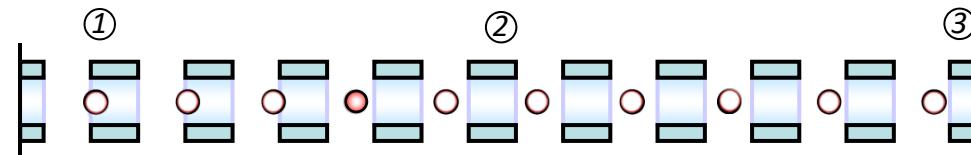
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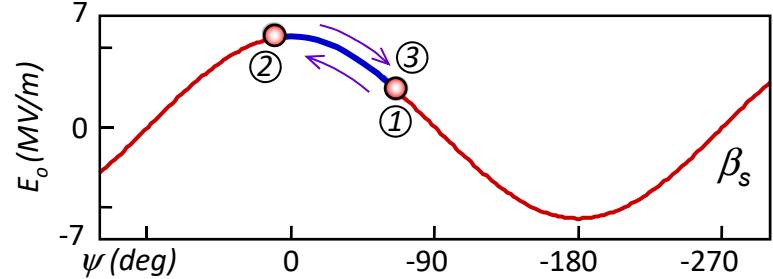
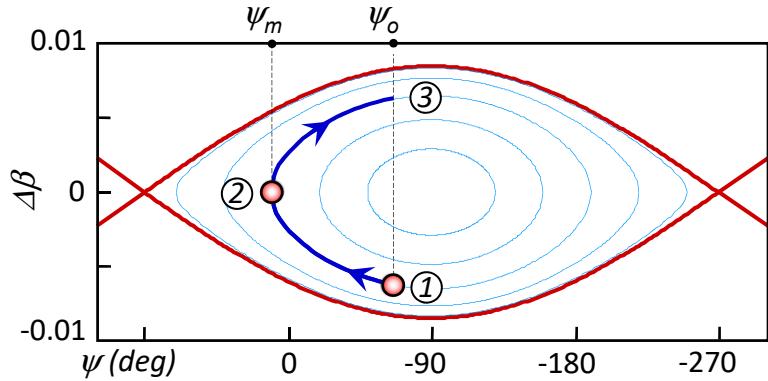
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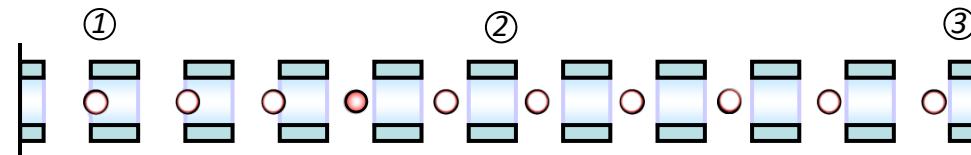
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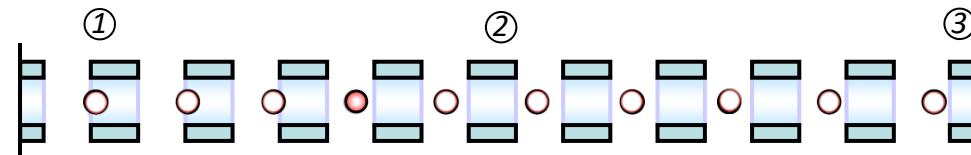
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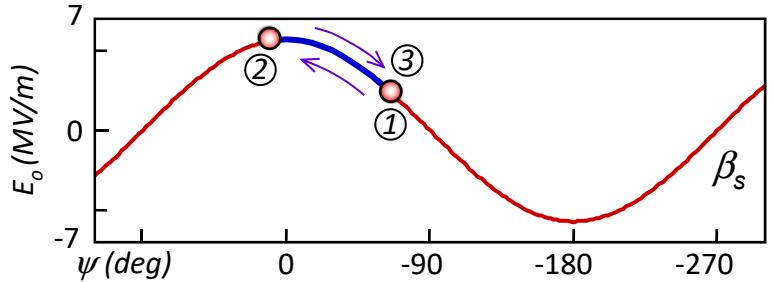
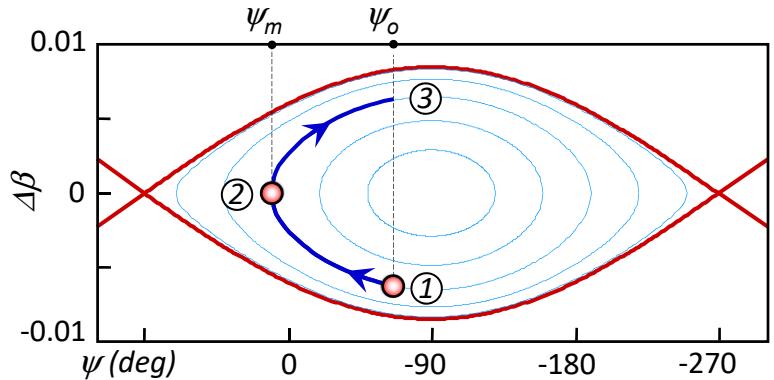
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EQUUS



Longitudinal motion of an accelerated bunch in the constant- β -section

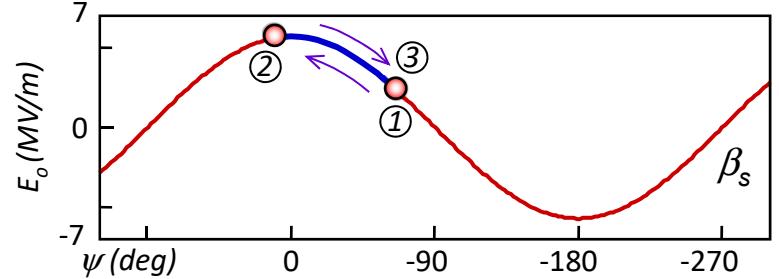
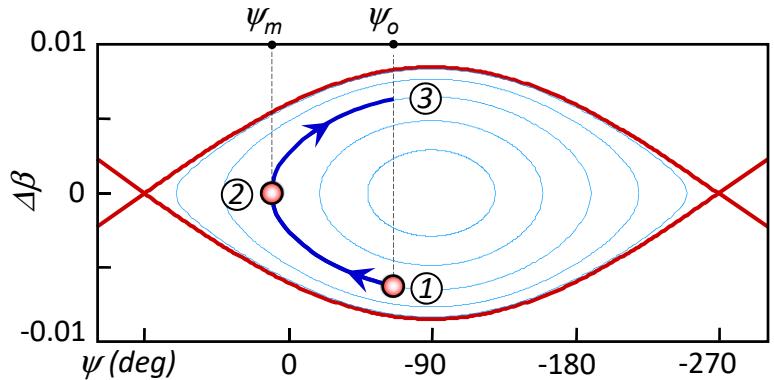


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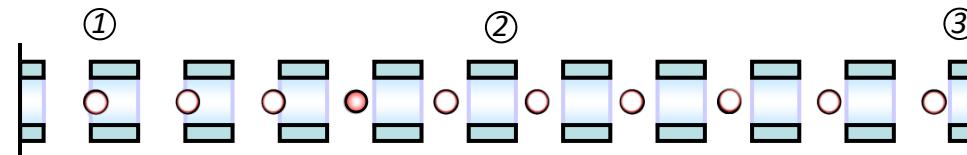
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Longitudinal motion of an accelerated bunch in the constant- β -section



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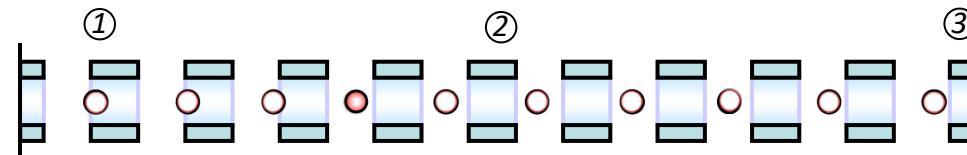
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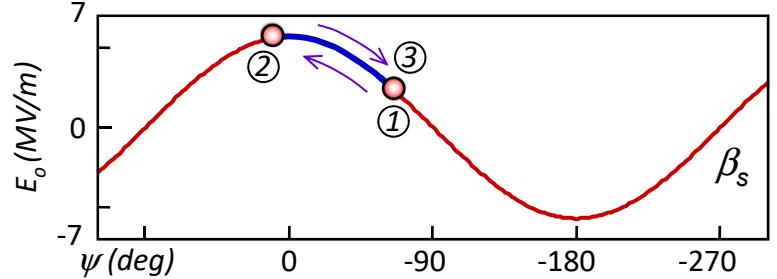
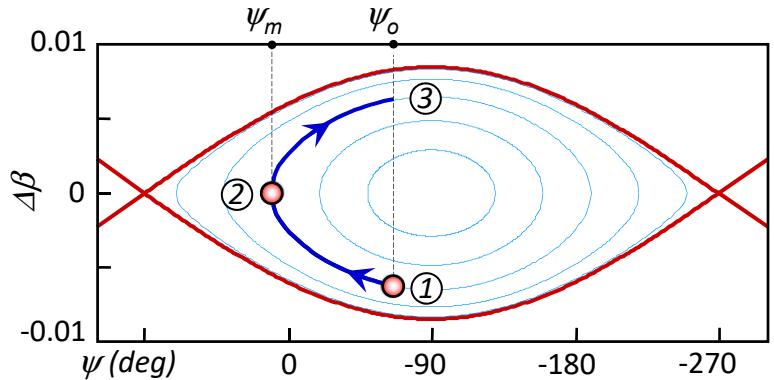
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Longitudinal motion of an accelerated bunch in the constant- β -section



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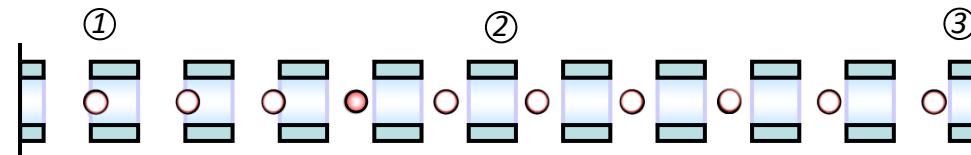
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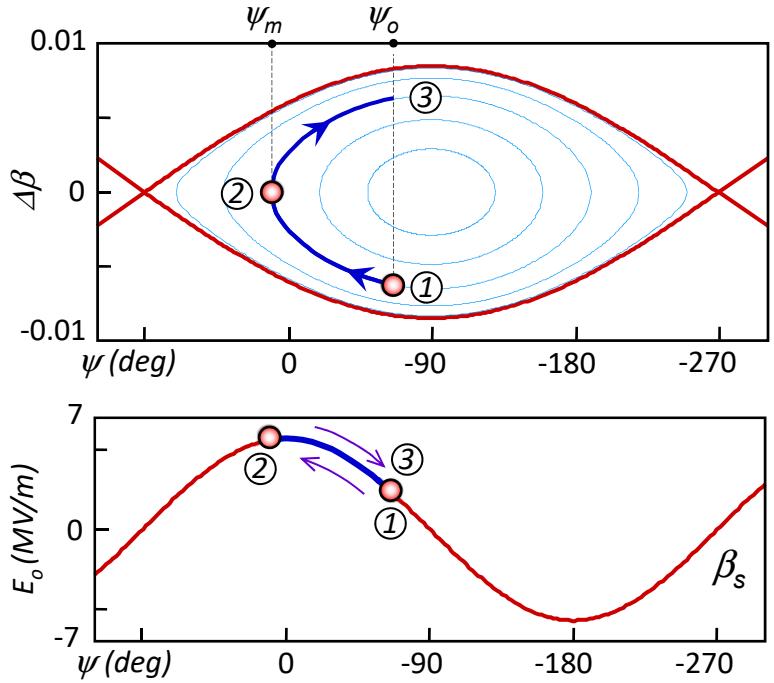
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Longitudinal motion of an accelerated bunch in the constant- β -section

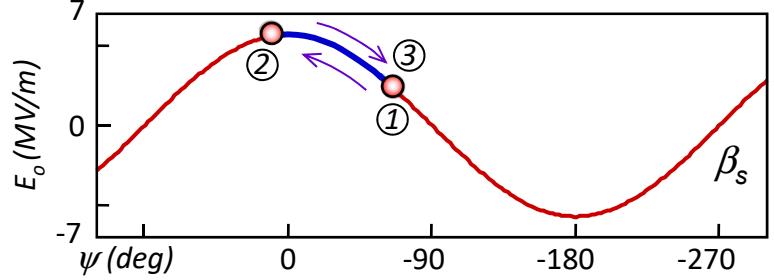
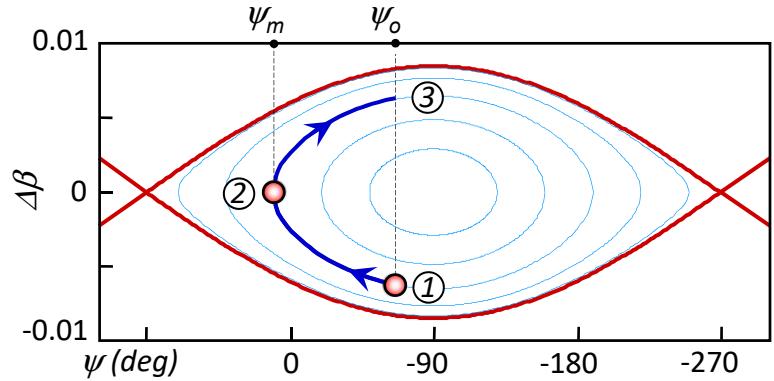


EQUUS beam dynamics concept

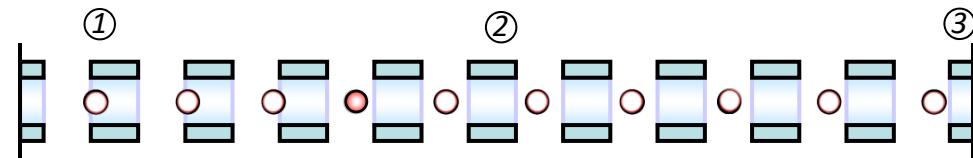
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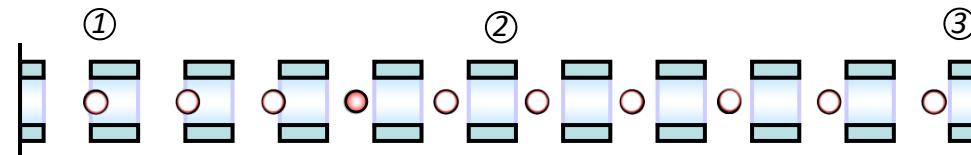
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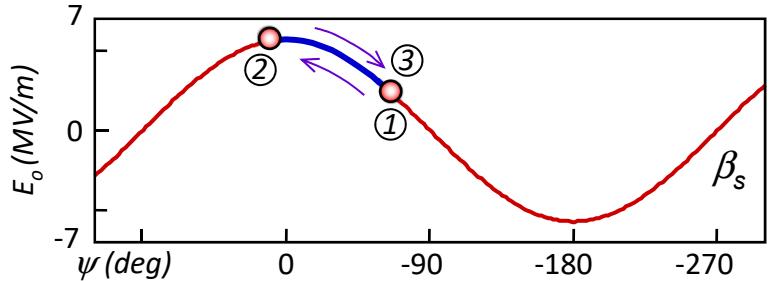
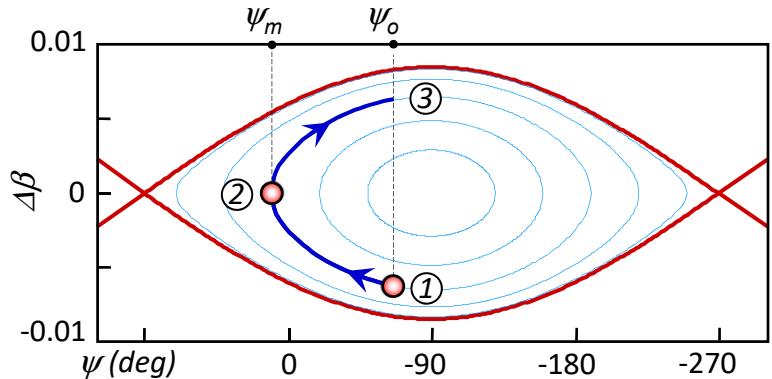
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Longitudinal motion of an accelerated bunch in the constant- β -section



Resonant acceleration at $\phi=-30^\circ$

EQUUS beam dynamics concept

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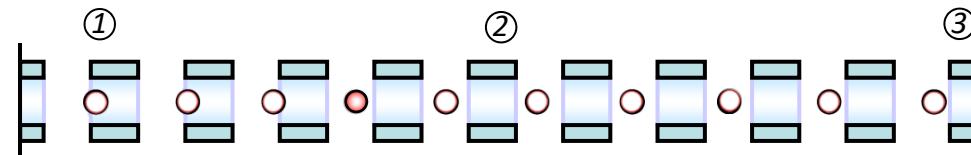
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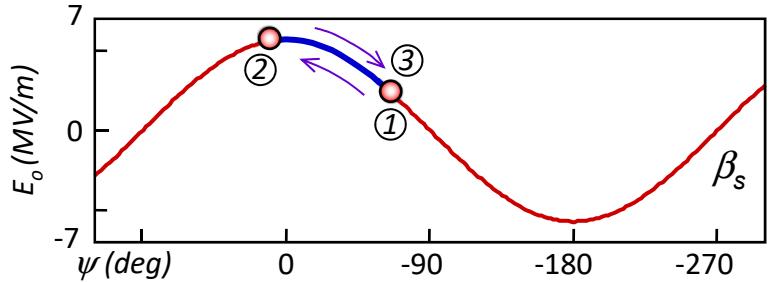
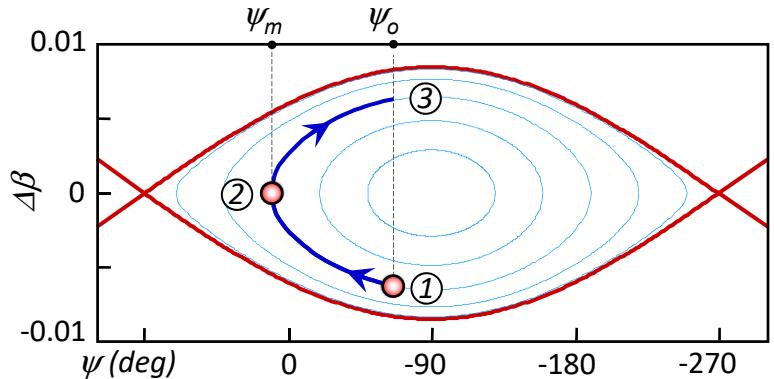
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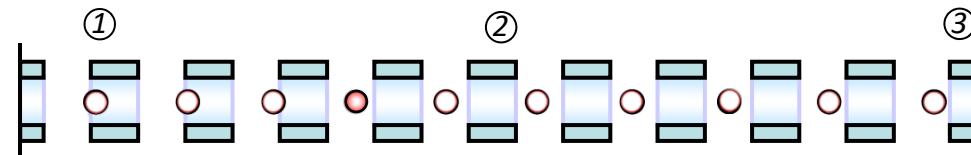
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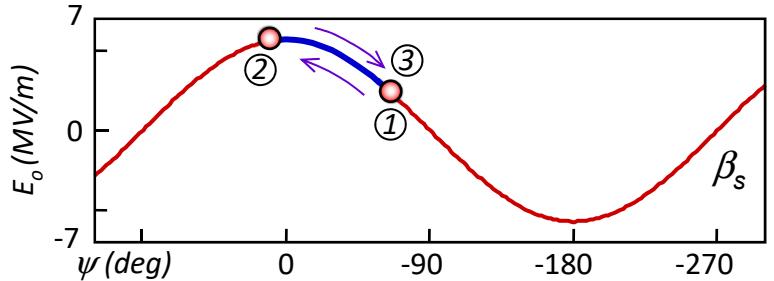
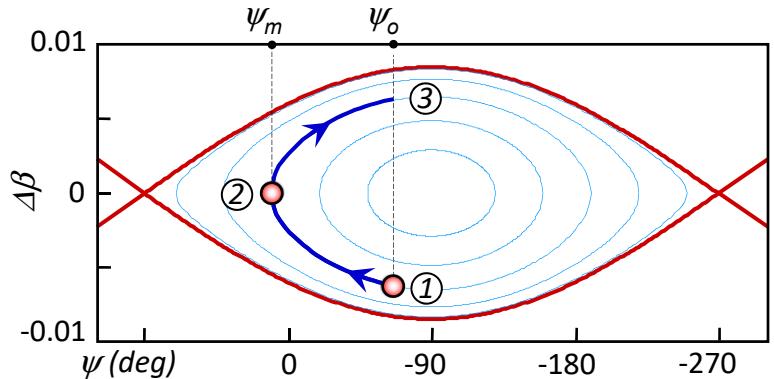
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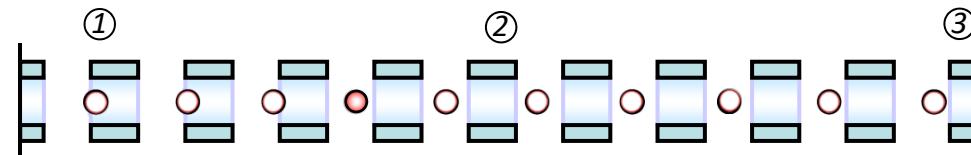
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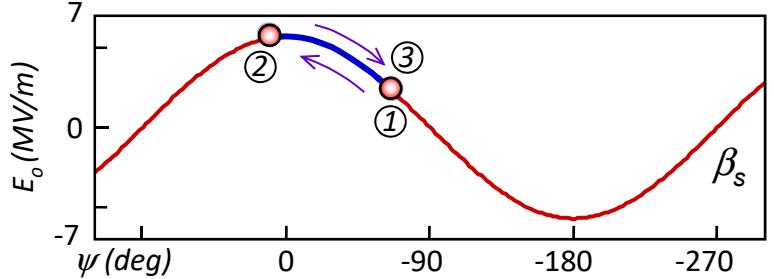
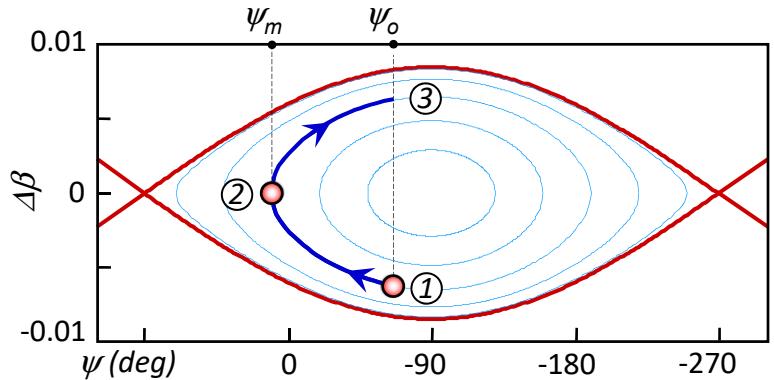
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Longitudinal motion of an accelerated bunch in the constant- β -section



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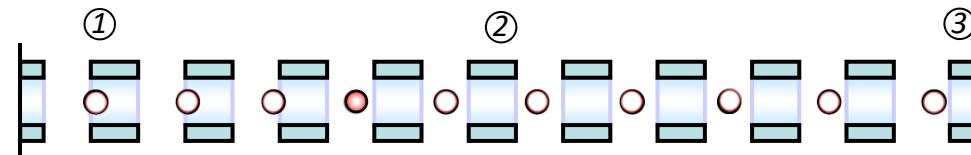


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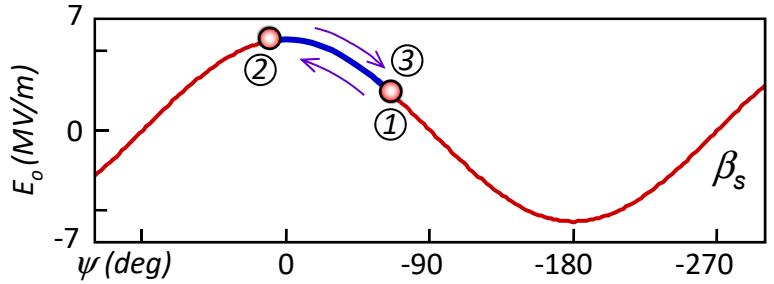
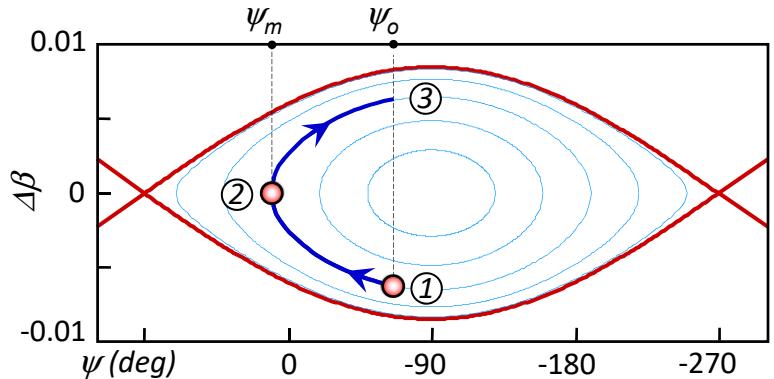
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Longitudinal motion of an accelerated bunch in the constant- β -section



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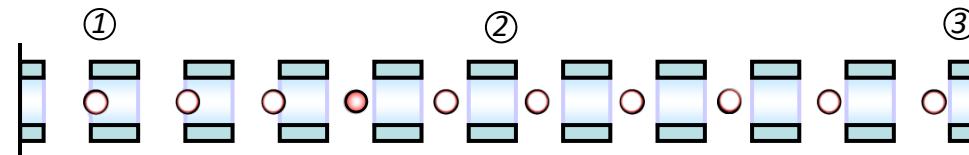


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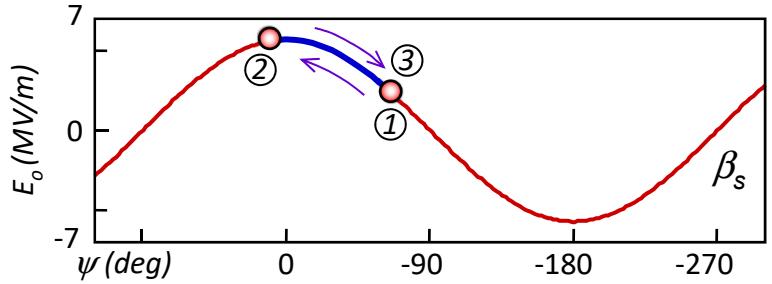
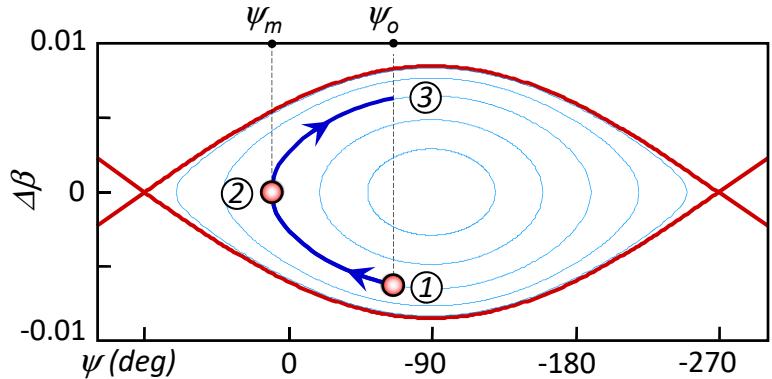
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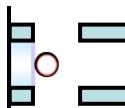
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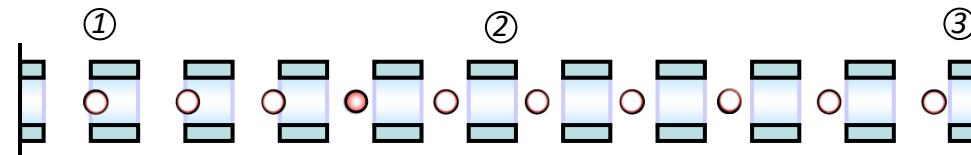
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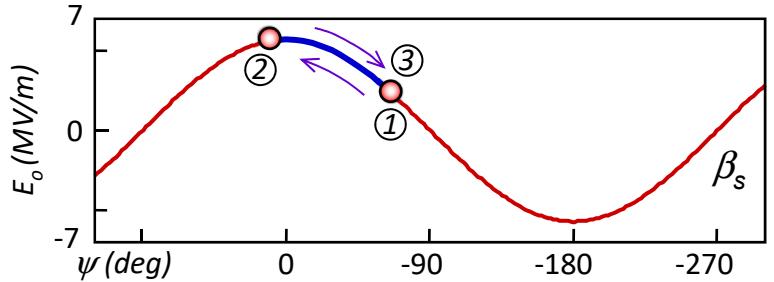
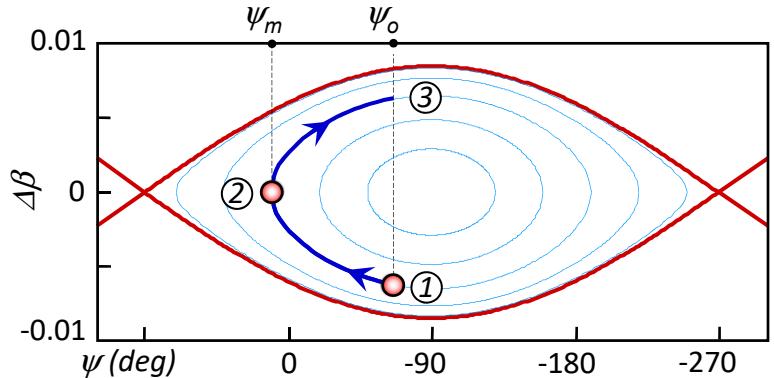
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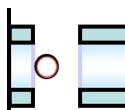
EQUUS



Longitudinal motion of an accelerated bunch in the constant- β -section



Resonant acceleration at $\phi = -30^\circ$

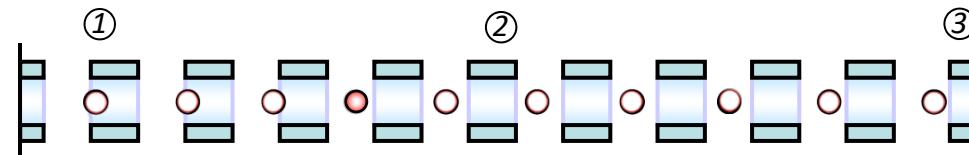


EQUUS beam dynamics concept

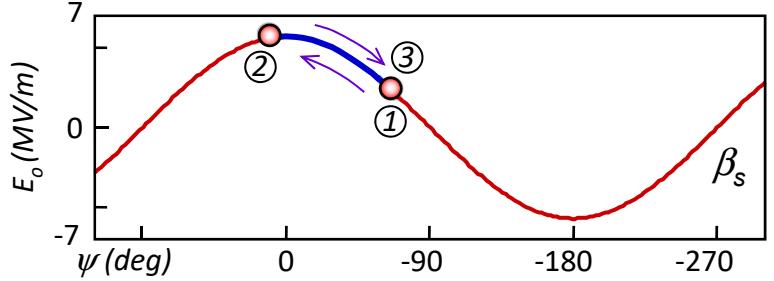
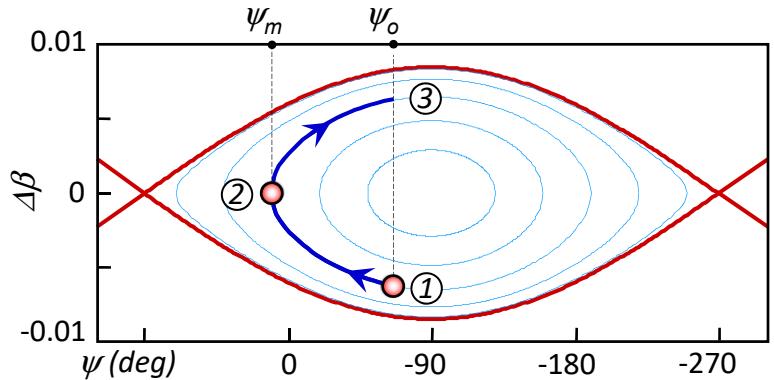
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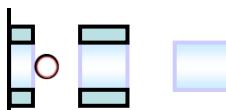
EQUUS



Longitudinal motion of an accelerated bunch in the constant- β -section



Resonant acceleration at $\phi=-30^\circ$

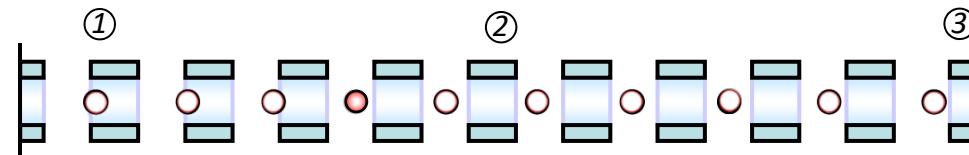


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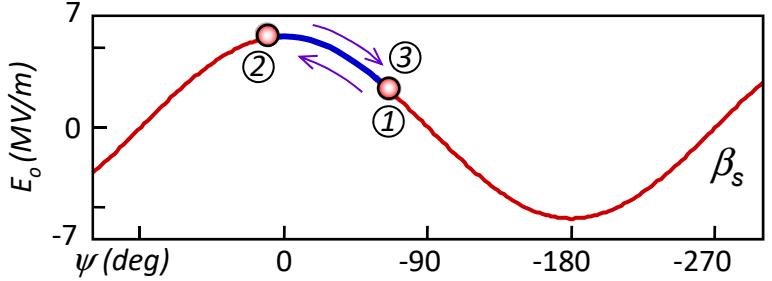
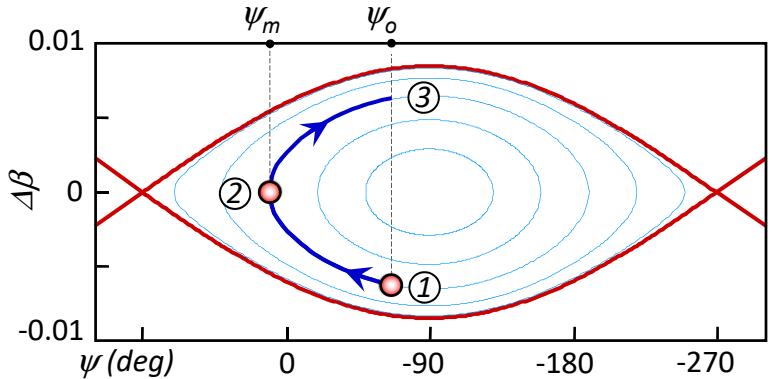
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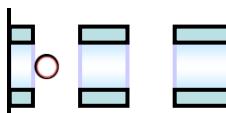
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Longitudinal motion of an accelerated bunch in the constant- β -section



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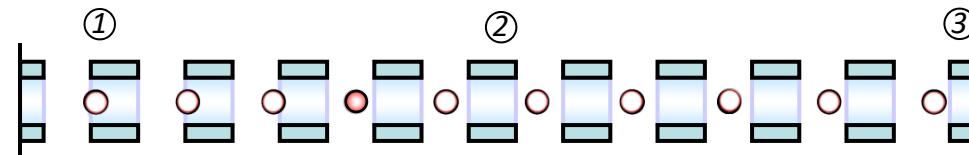


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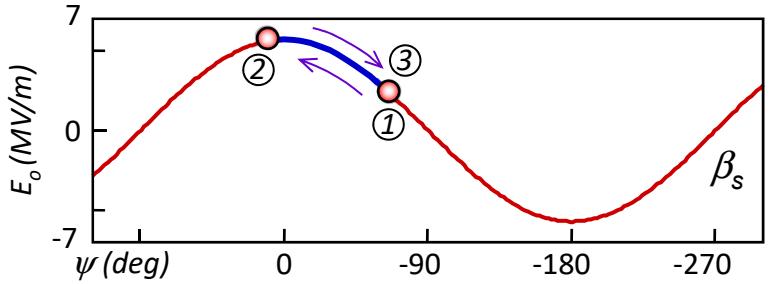
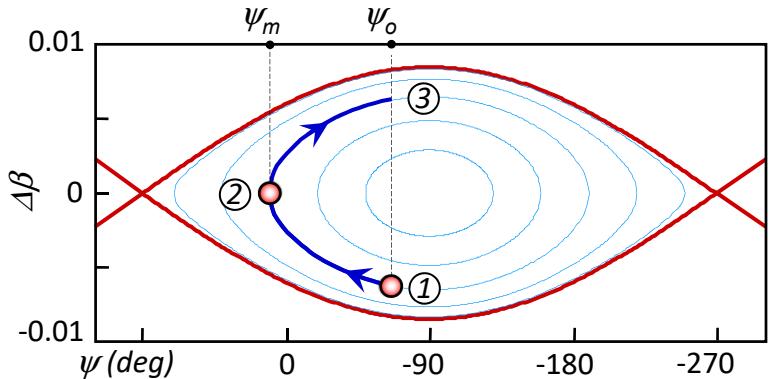
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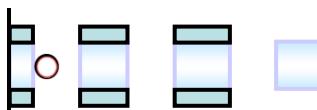
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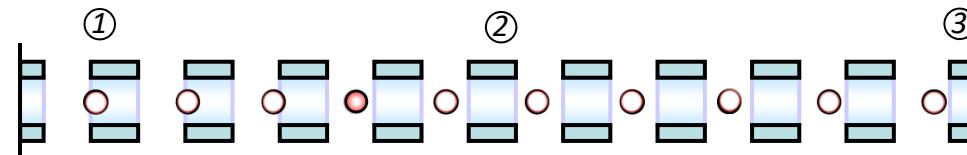


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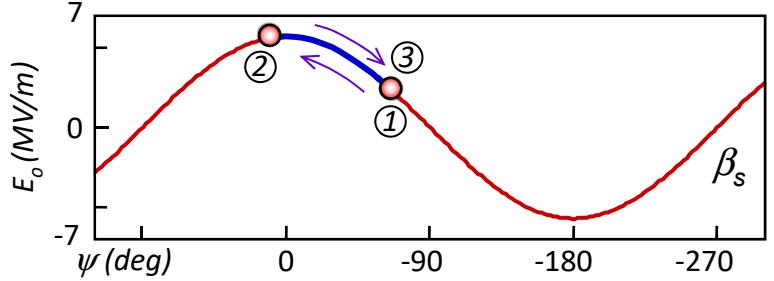
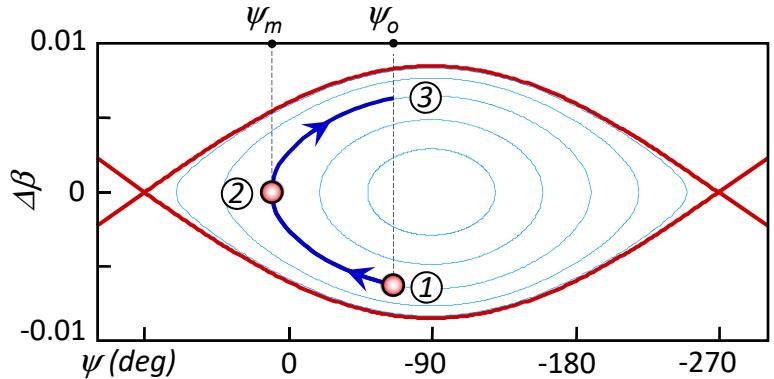
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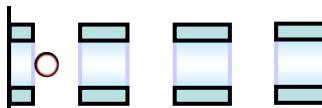
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Resonant acceleration at $\phi=30^\circ$

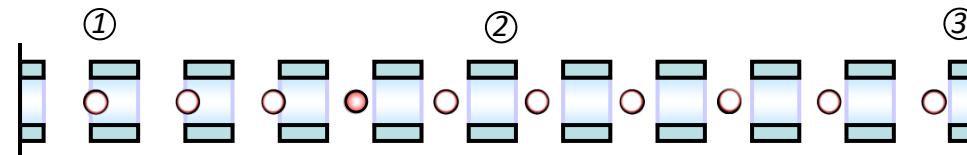


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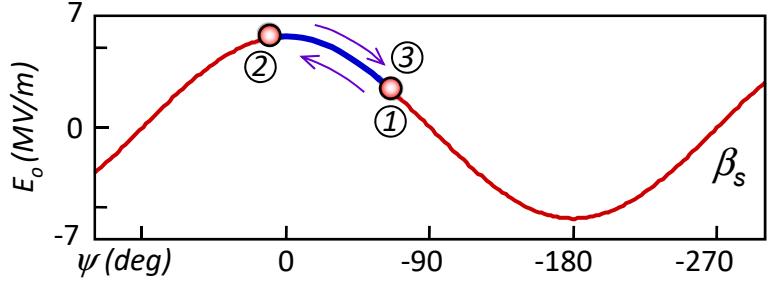
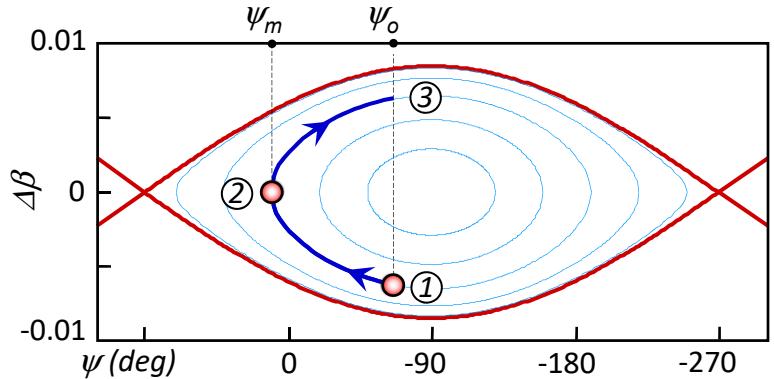
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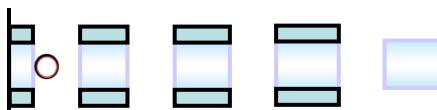
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Longitudinal motion of an accelerated bunch in the constant- β -section



Resonant acceleration at $\phi=-30$



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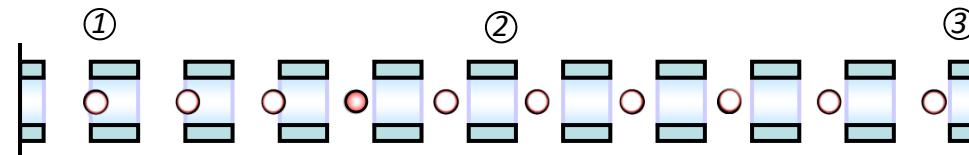
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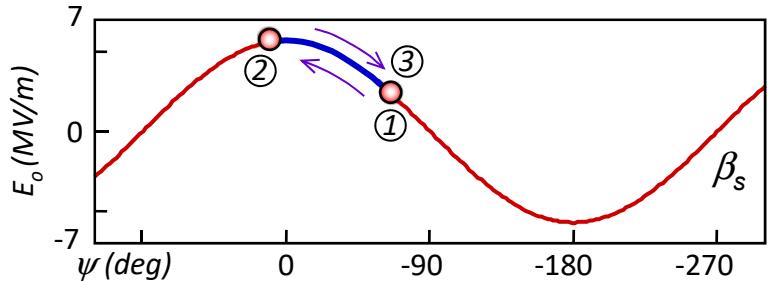
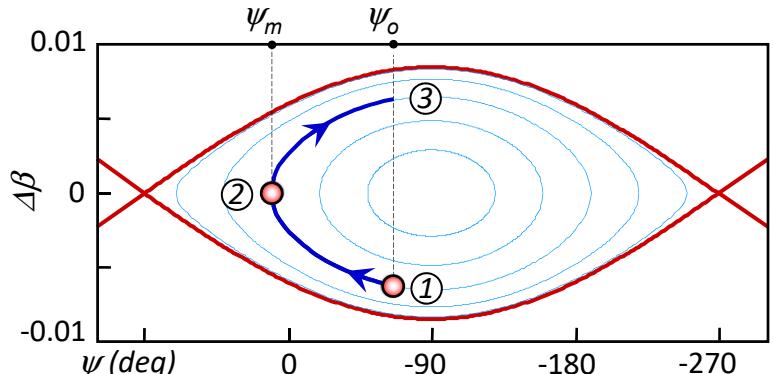
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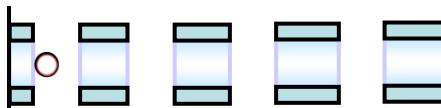
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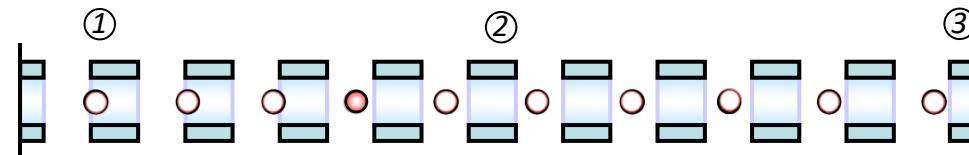
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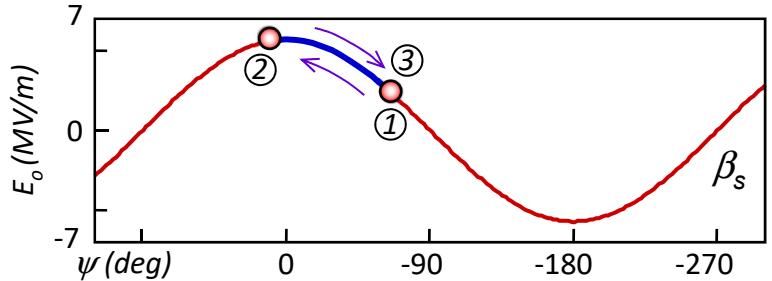
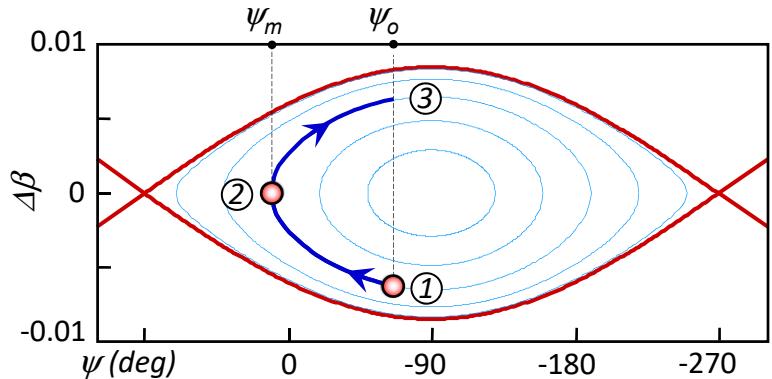
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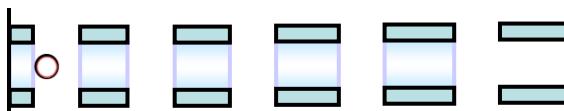
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Longitudinal motion of an accelerated bunch in the constant- β -section



Resonant acceleration at $\phi=-30$

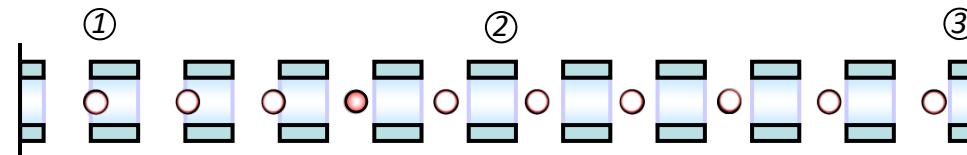


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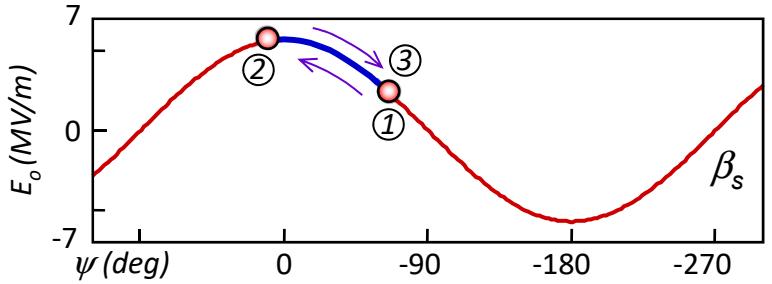
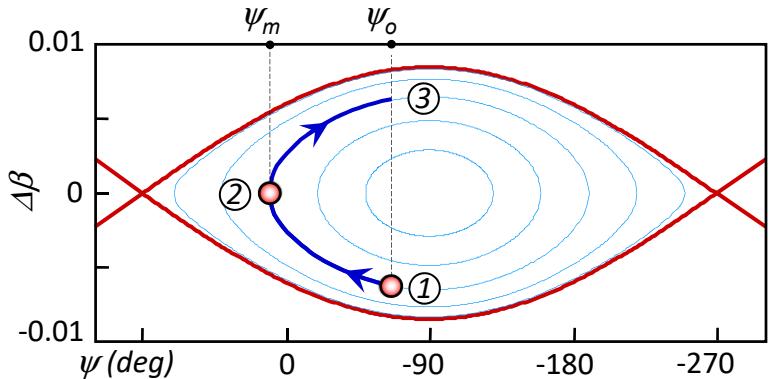
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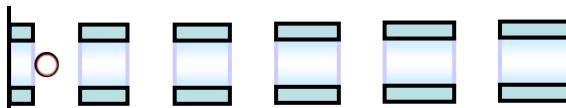
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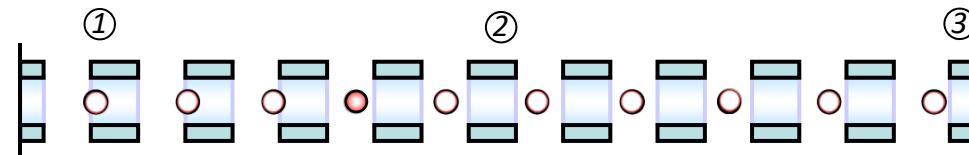
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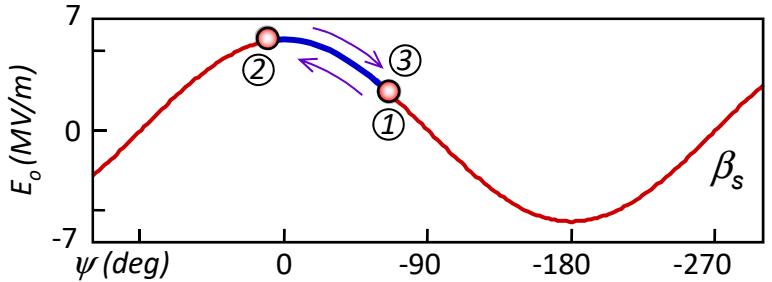
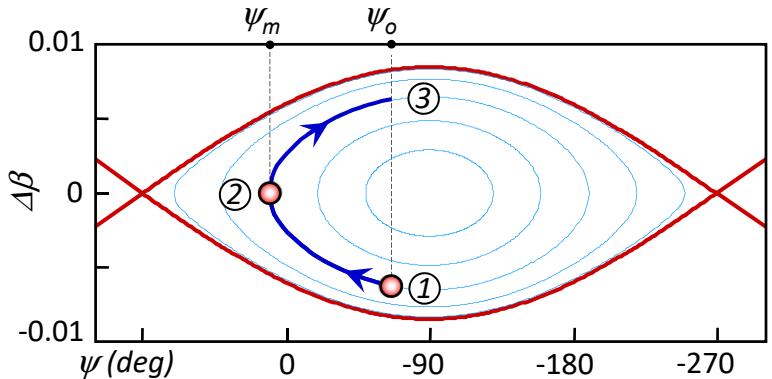
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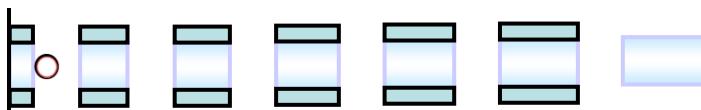
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Longitudinal motion of an accelerated bunch in the constant- β -section



Resonant acceleration at $\phi = -30^\circ$



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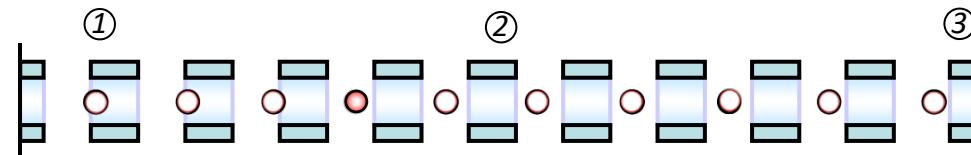
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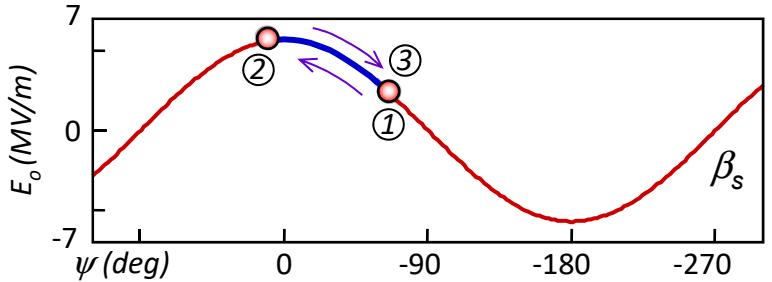
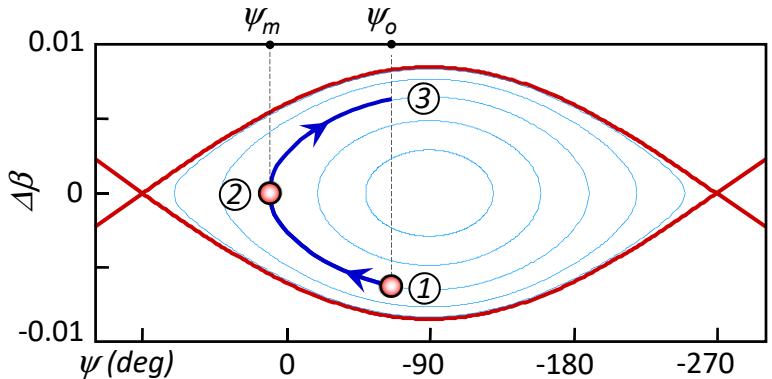
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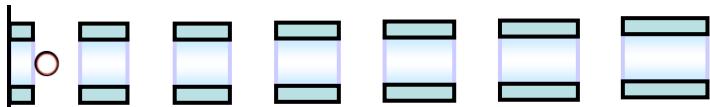
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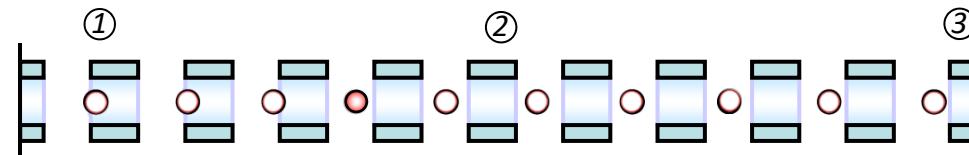
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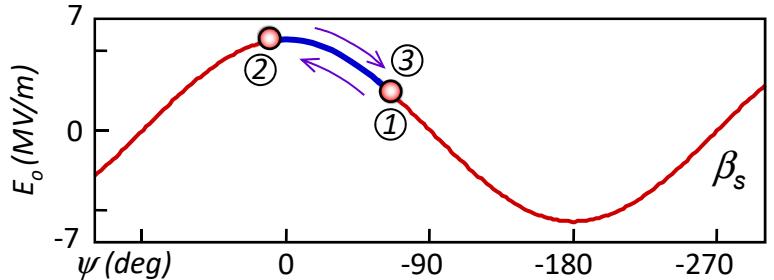
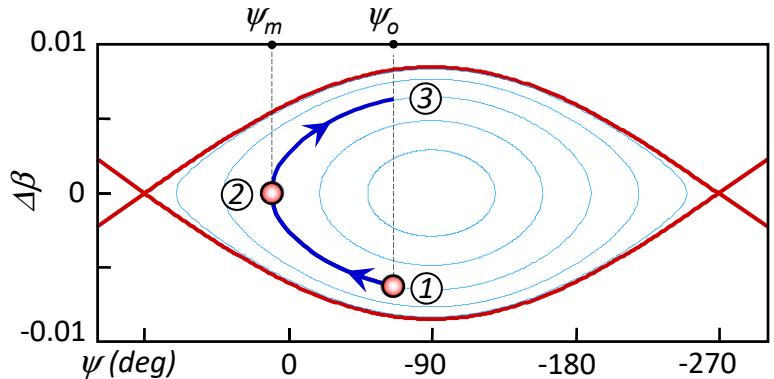
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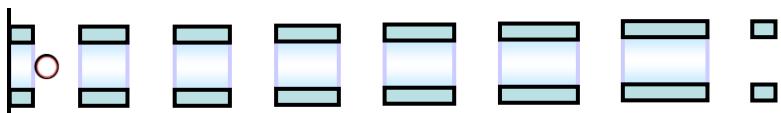
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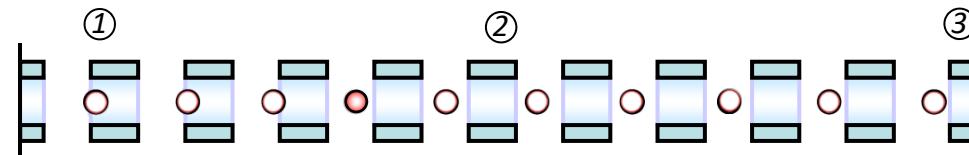
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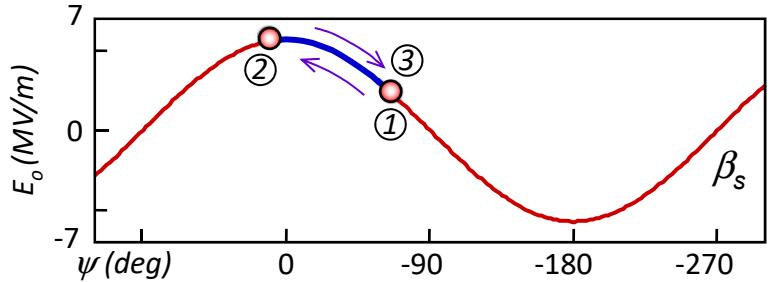
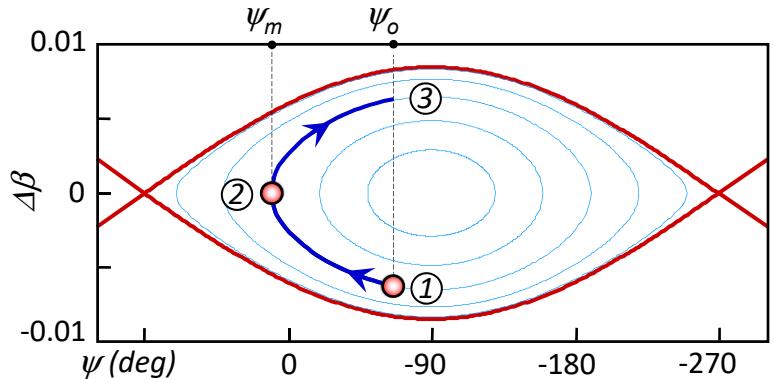
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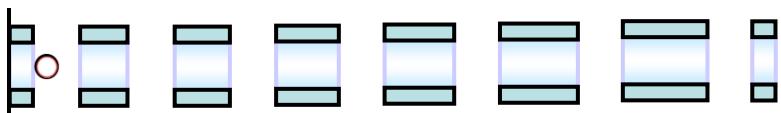
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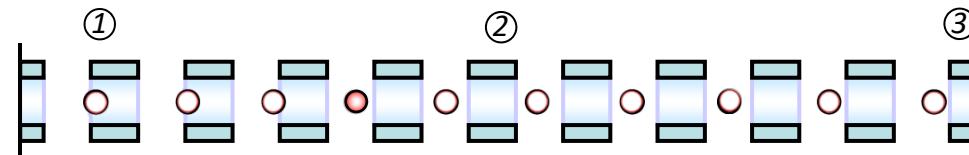
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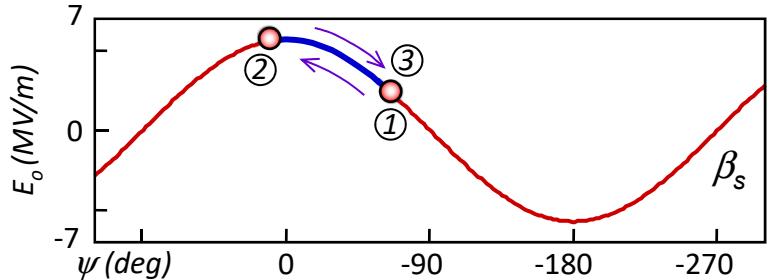
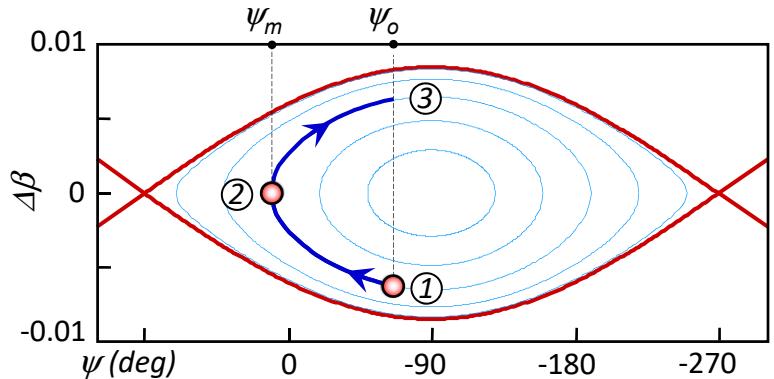
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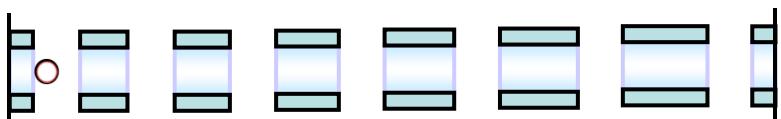
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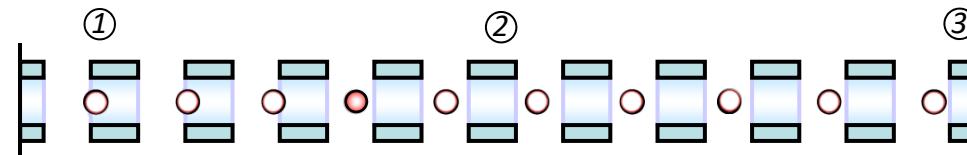


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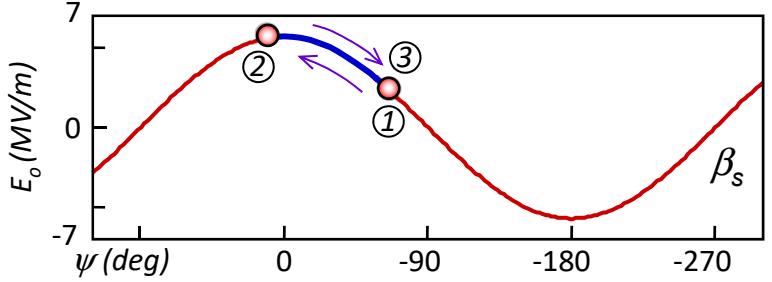
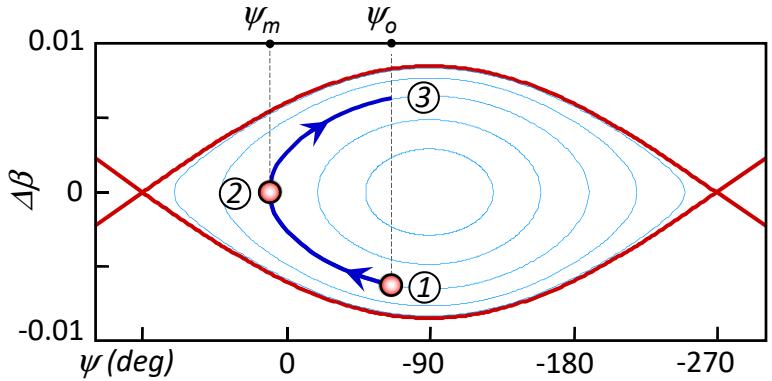
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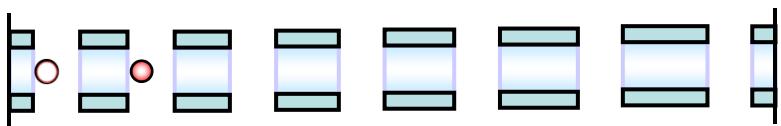
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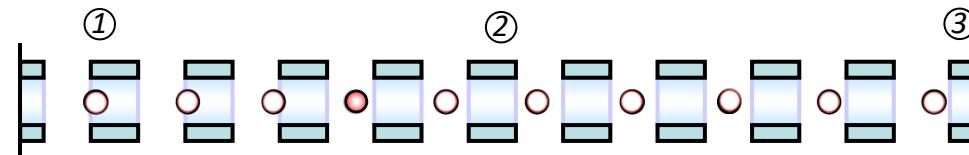


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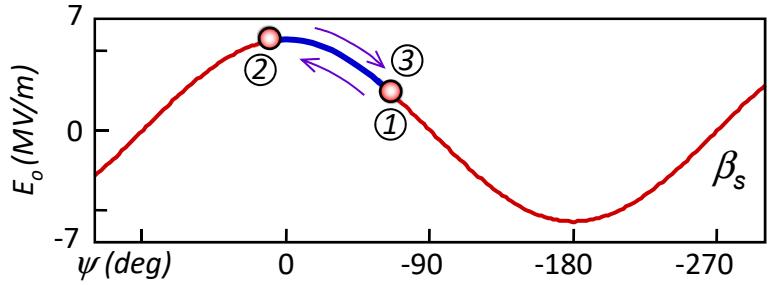
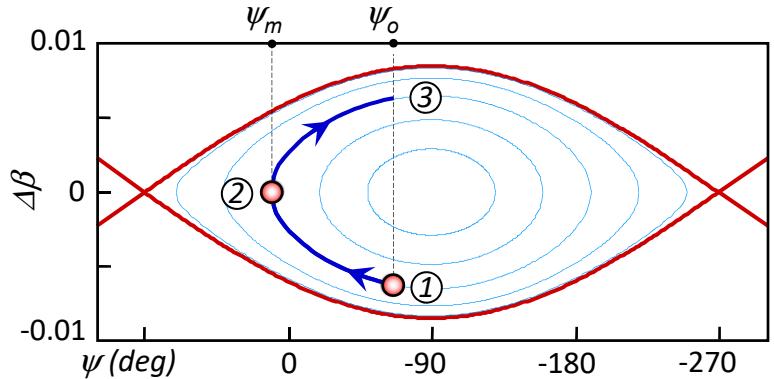
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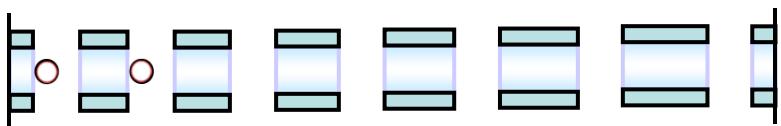
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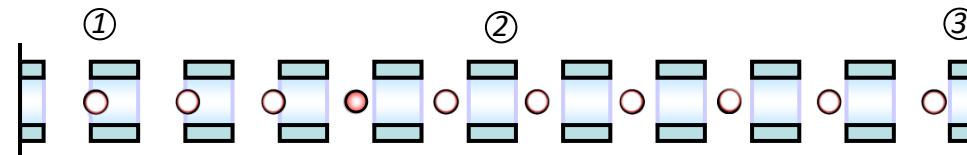


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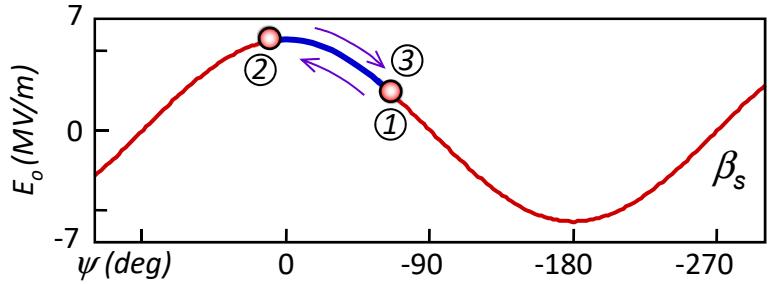
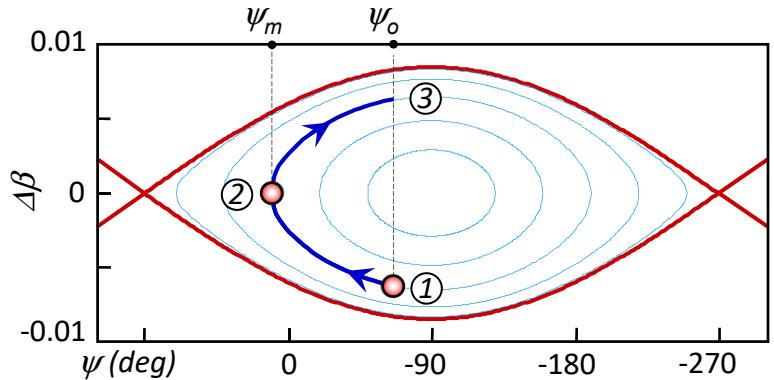
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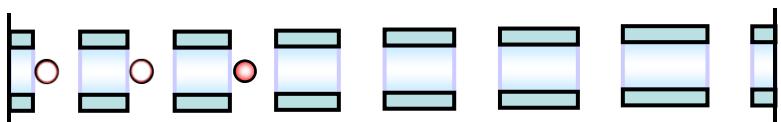
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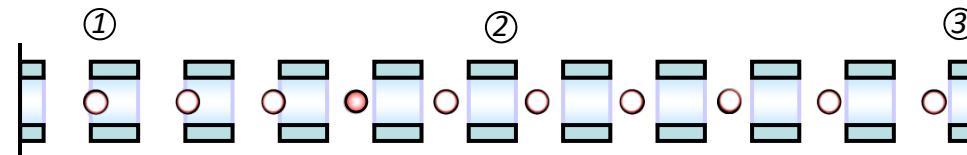


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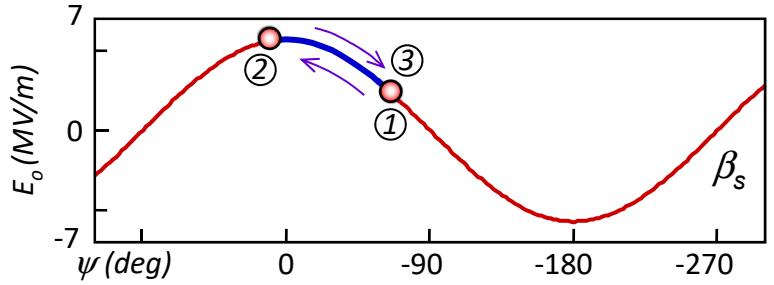
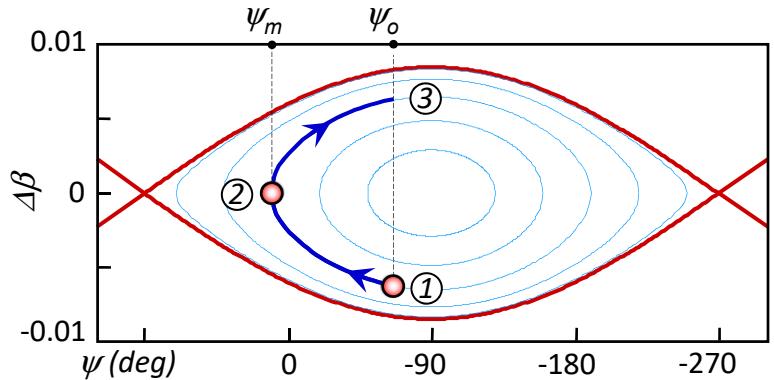
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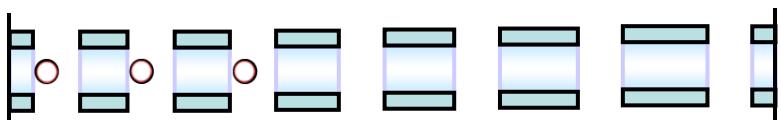
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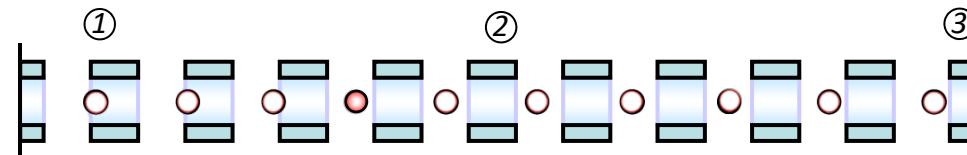


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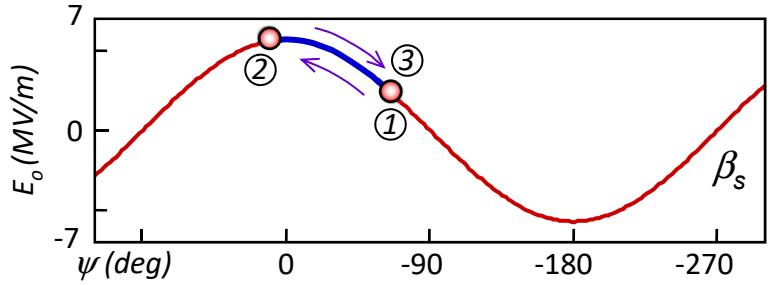
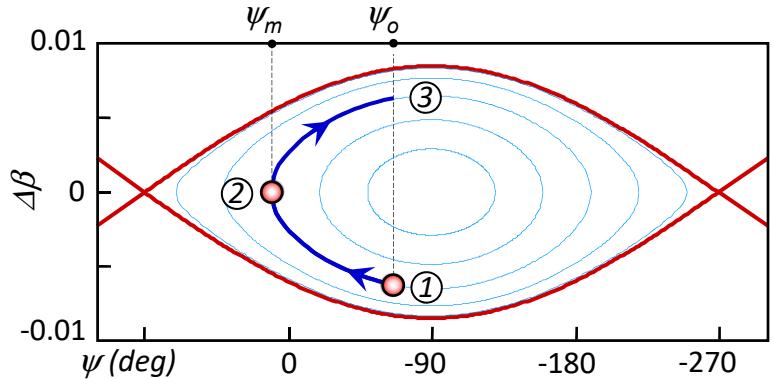
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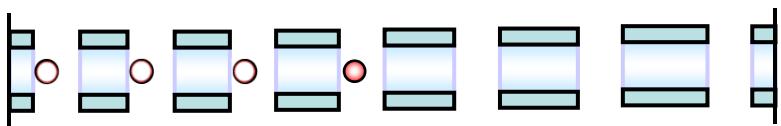
EQUUS



Longitudinal motion of an accelerated bunch in the constant- β -section



Resonant acceleration at $\phi=-30^\circ$

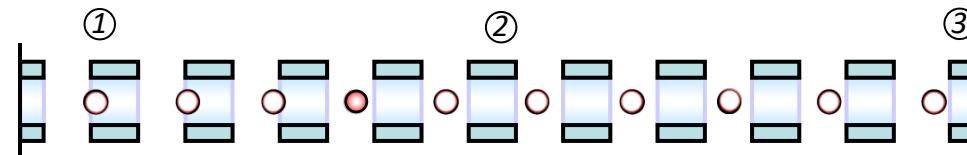


EQUUS beam dynamics concept

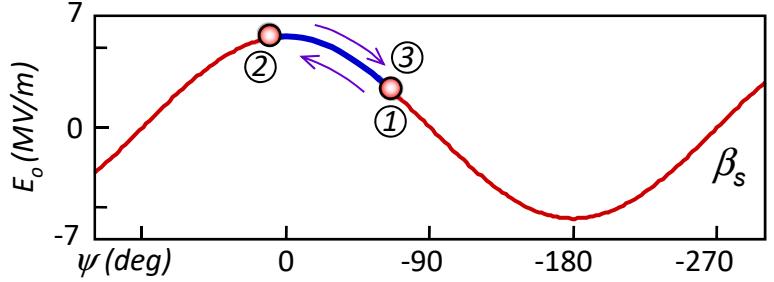
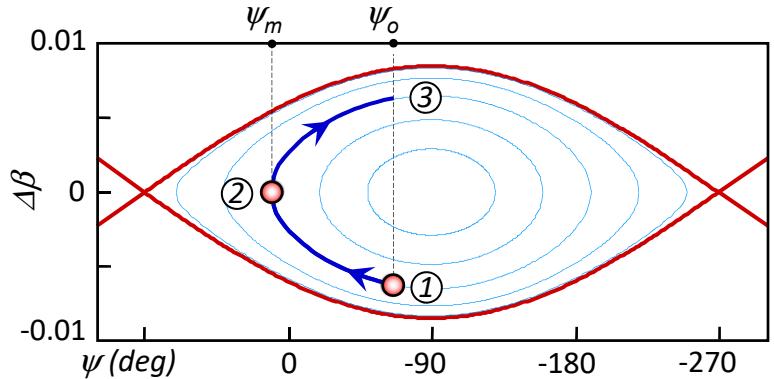
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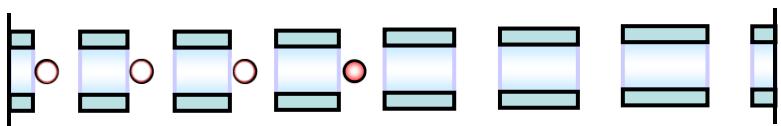
EQUUS



Longitudinal motion of an accelerated bunch in the constant- β -section



Resonant acceleration at $\phi = -30^\circ$

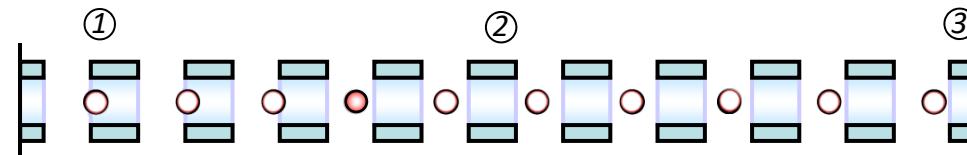


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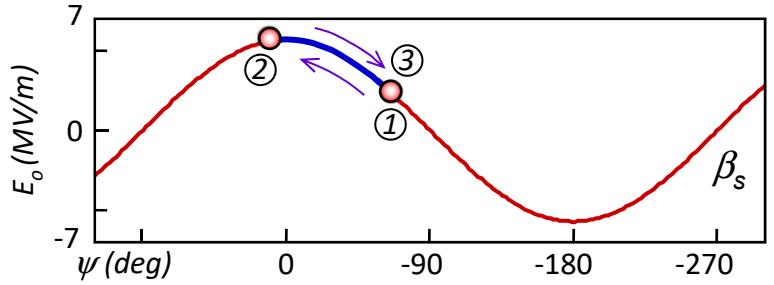
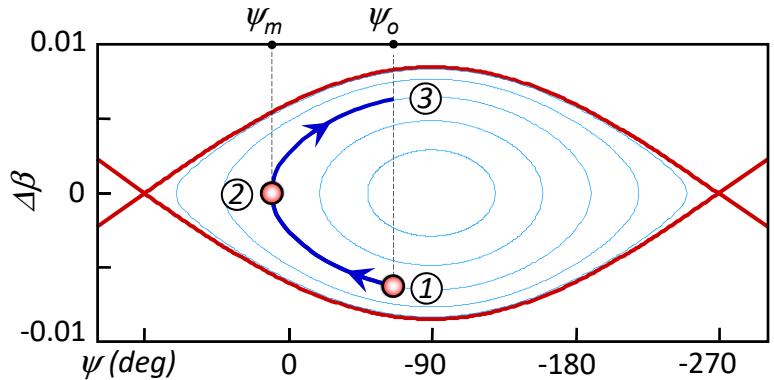
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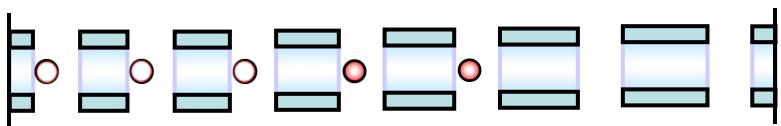
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Longitudinal motion of an accelerated bunch in the constant- β -section



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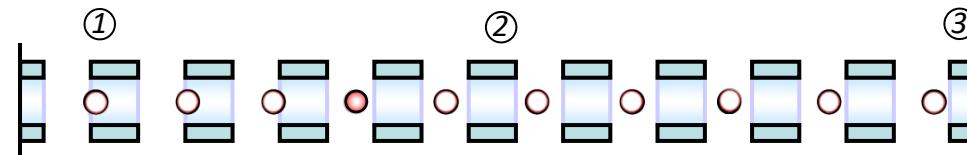


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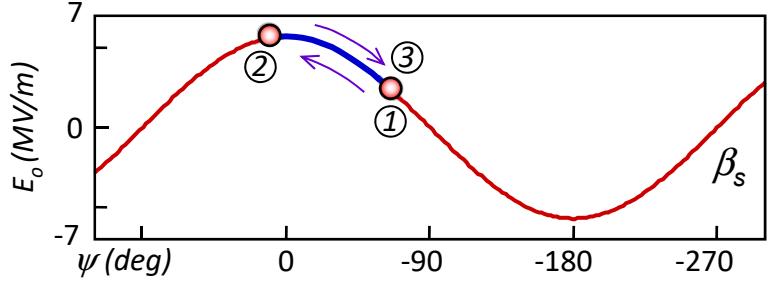
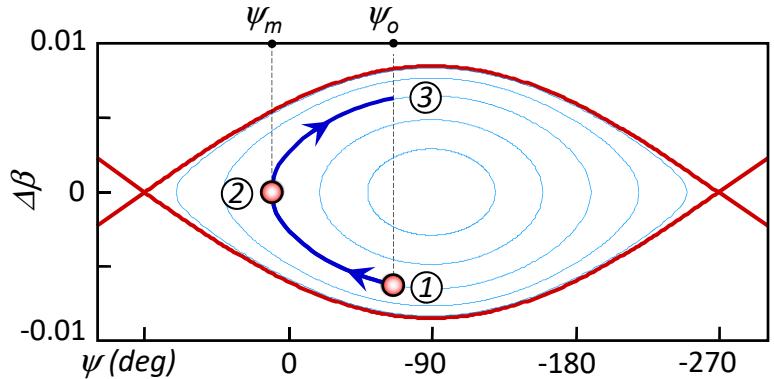
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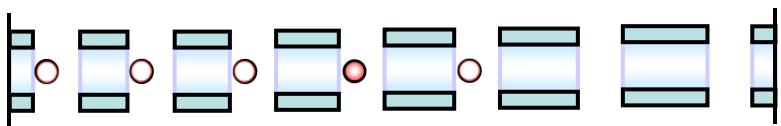
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Longitudinal motion of an accelerated bunch in the constant- β -section



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EQUUS beam dynamics concept

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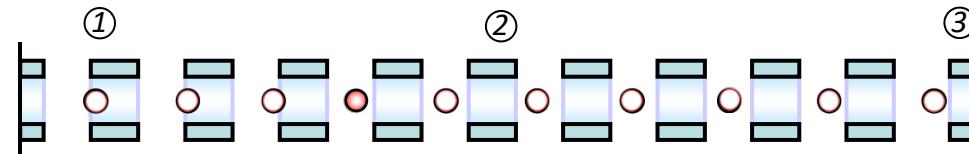
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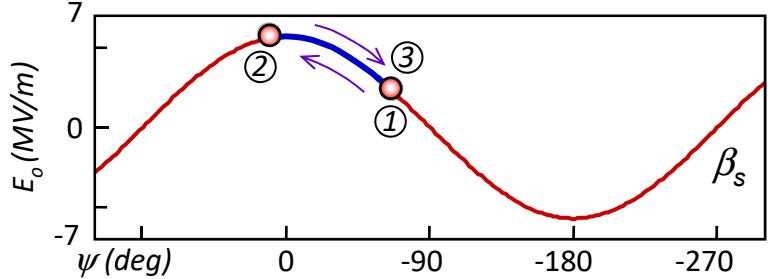
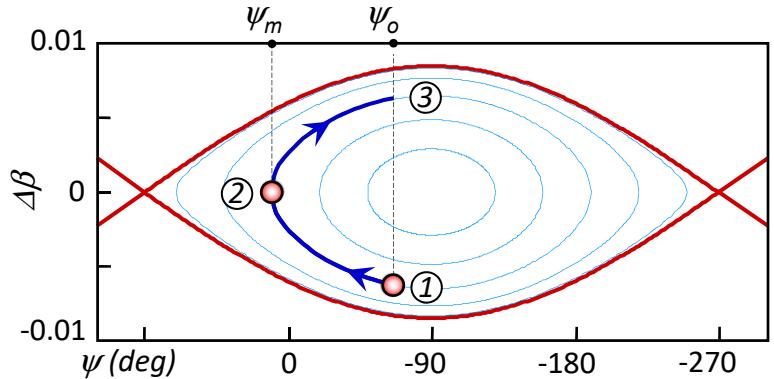
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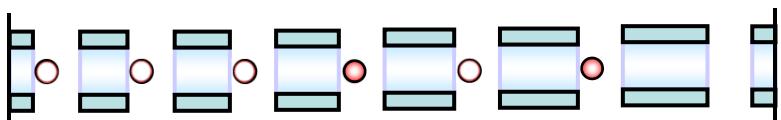
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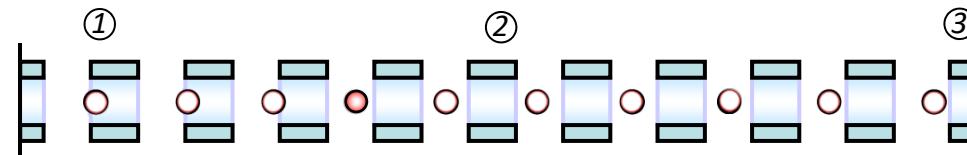


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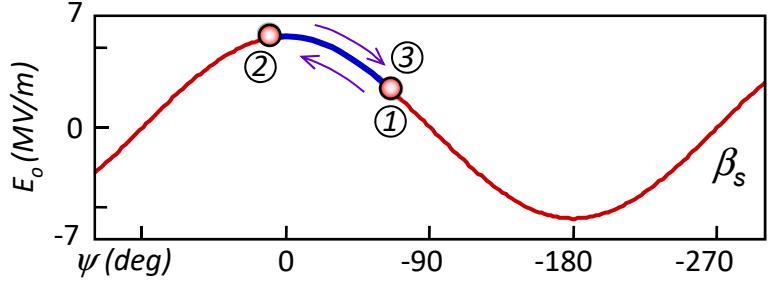
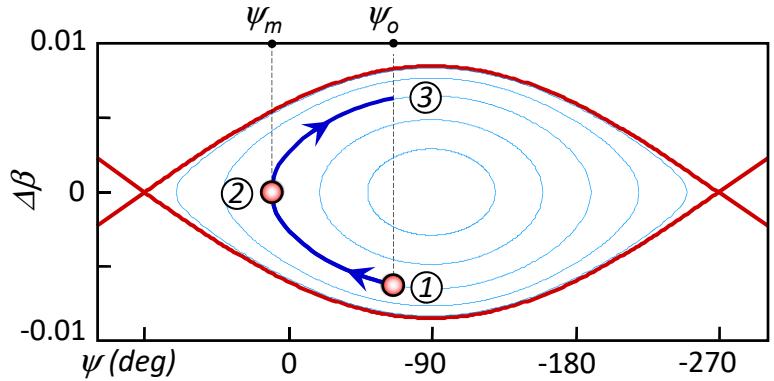
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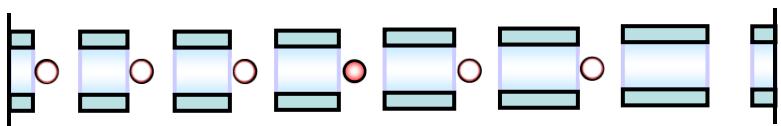
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EQUUS beam dynamics concept

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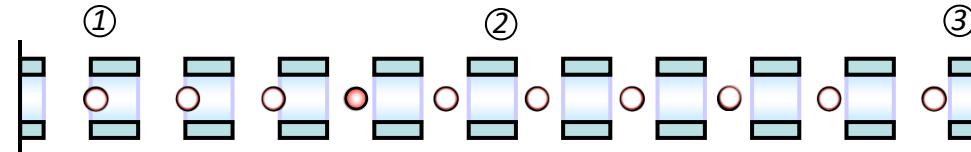
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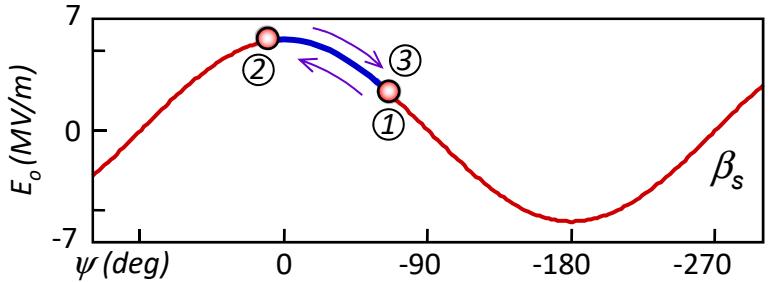
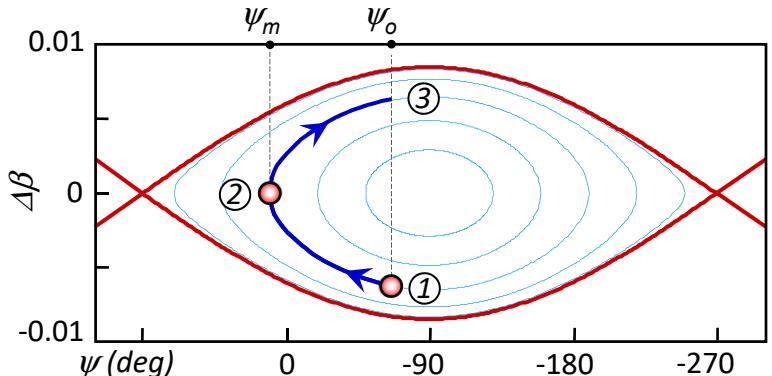
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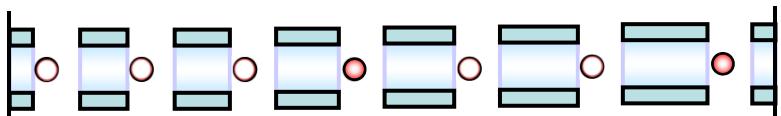
EQUUS



Longitudinal motion of an accelerated bunch in the constant- β -section



Resonant acceleration at $\phi = -30^\circ$

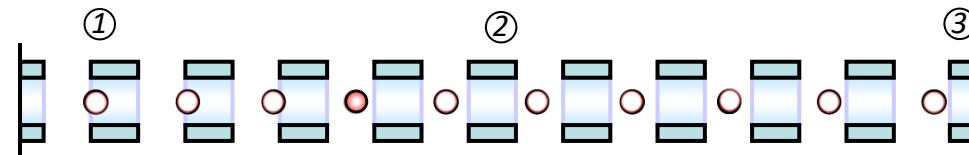


EQUUS beam dynamics concept

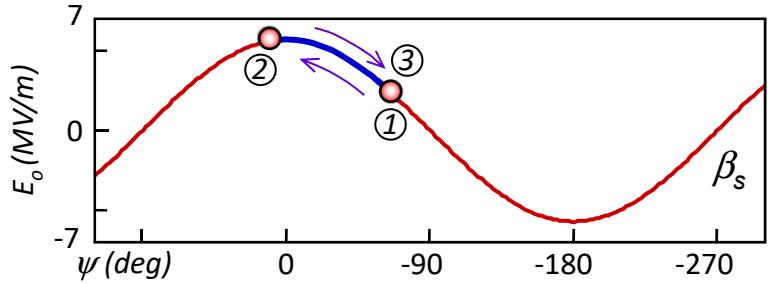
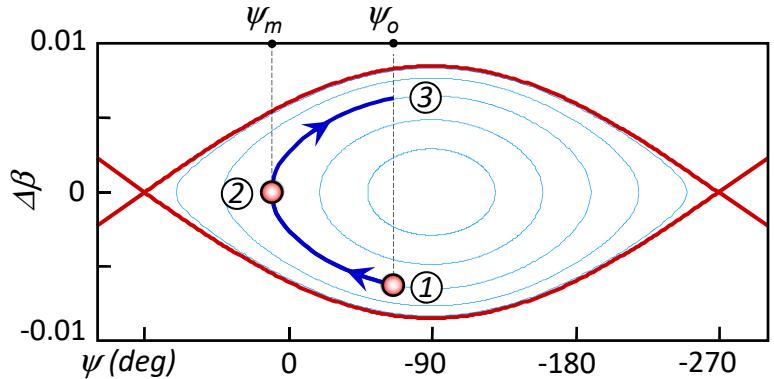
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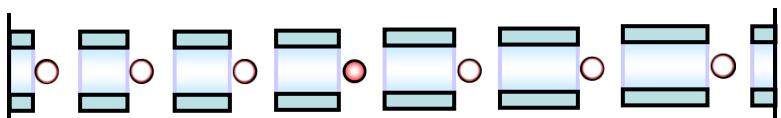
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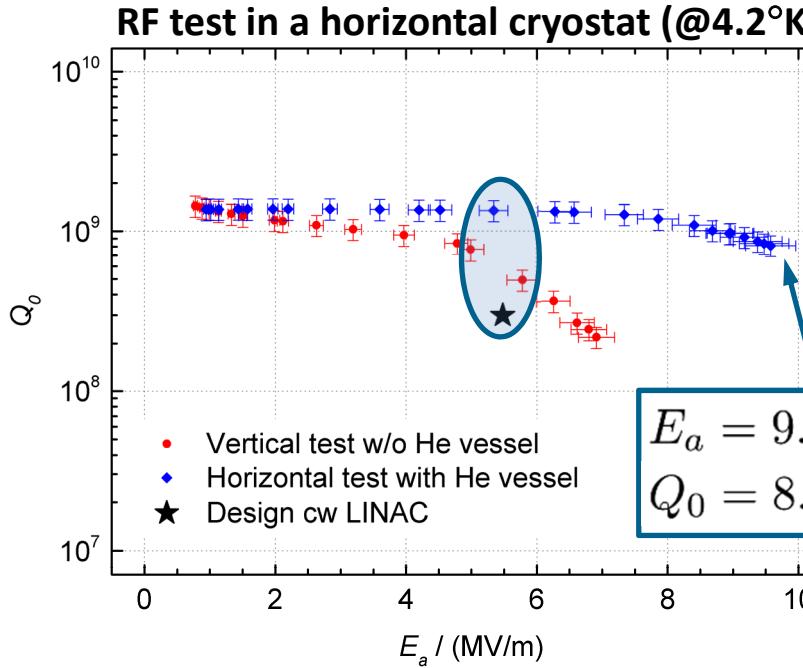
Longitudinal motion of an accelerated bunch in the constant- β -section



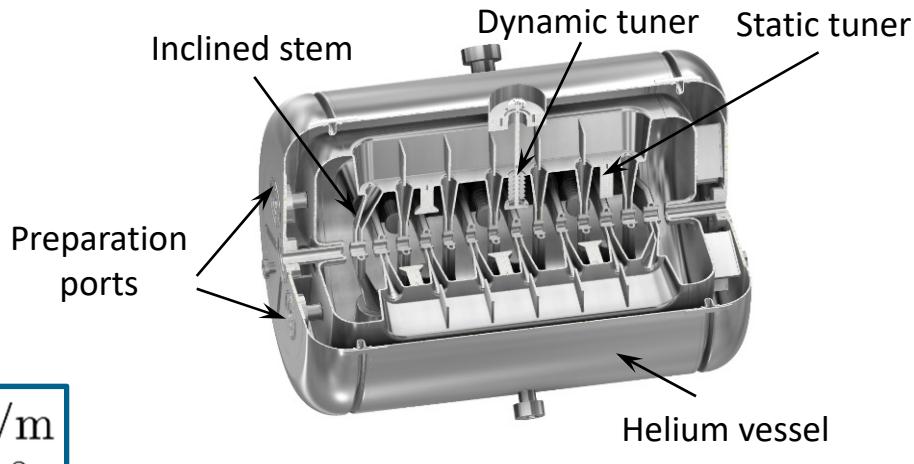
Resonant acceleration at $\phi=-30$



RF Testing of the CH-Cavity (10/2016)



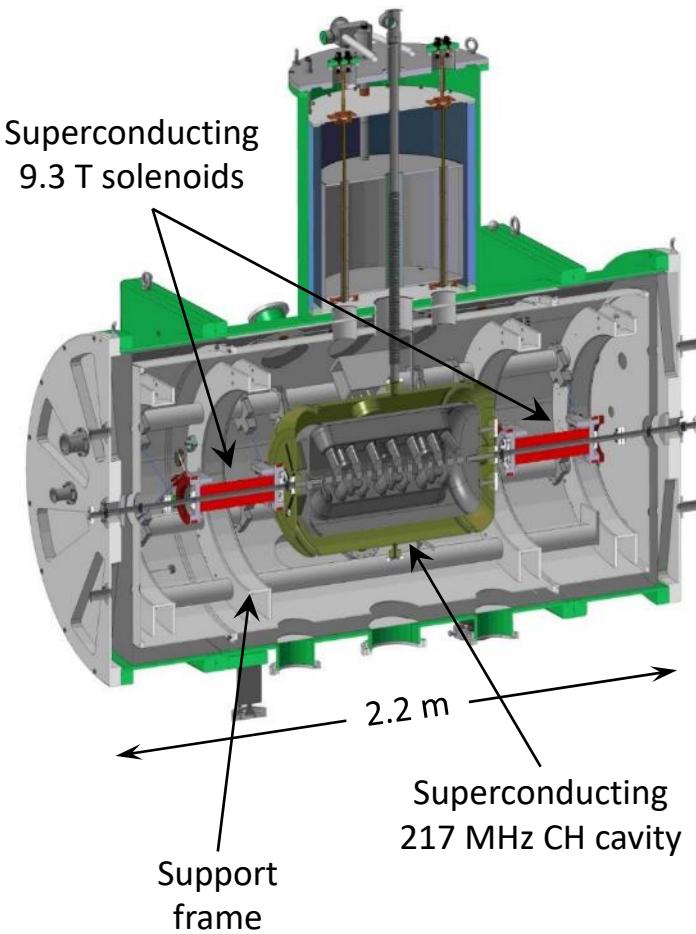
- Improved performance (add. HPR)
- Low field emission rate
- High field gradient
- Therm. quenching beyond 9.6 MV/m



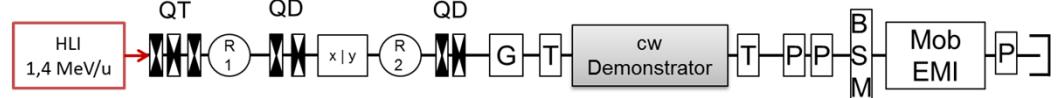
	Vertical test w/o He vessel	Horizontal test with He vessel
Q_0^{low}	$1.44 \cdot 10^9$	$1.37 \cdot 10^9$
R_S	nΩ	36
R_{BCS}	nΩ	15
R_{mag}	nΩ	9
R_0	nΩ	12
E_a	MV/m	6.9
Q_0		$2.19 \cdot 10^8$
V_a	MV	4.2
E_p	MV/m	43
B_p	mT	39
		9.6
		$8.14 \cdot 10^8$
		5.9
		60
		55

Experimental setup of the demonstrator at GSI

Layout of the horizontal cryomodule

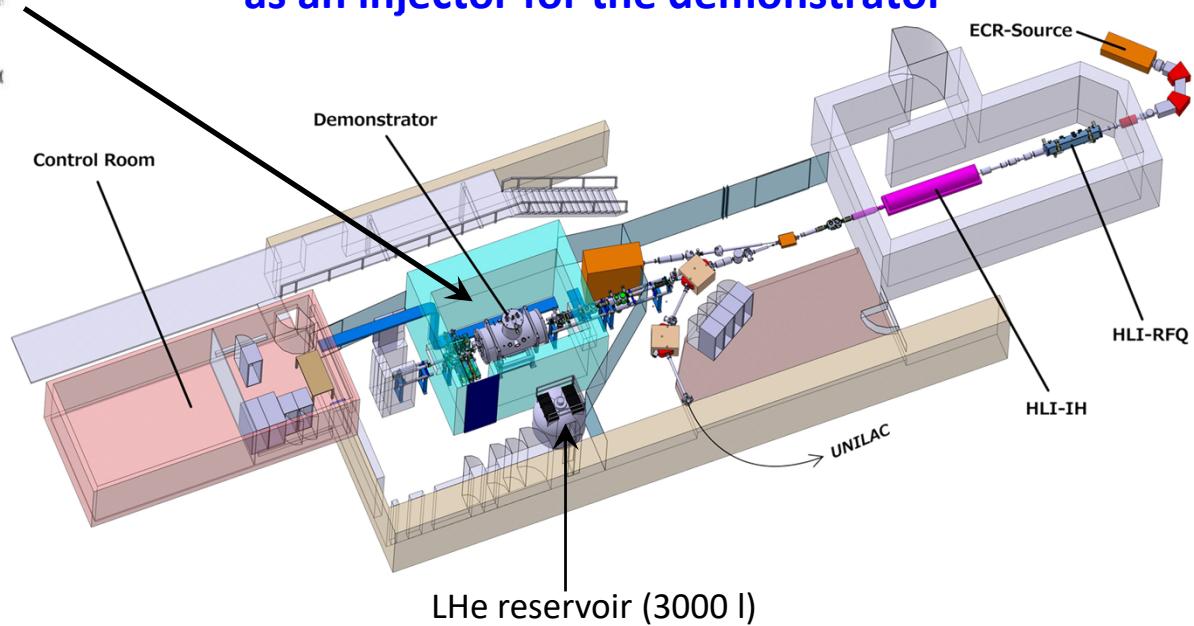


Matching line - demonstrator – test bench



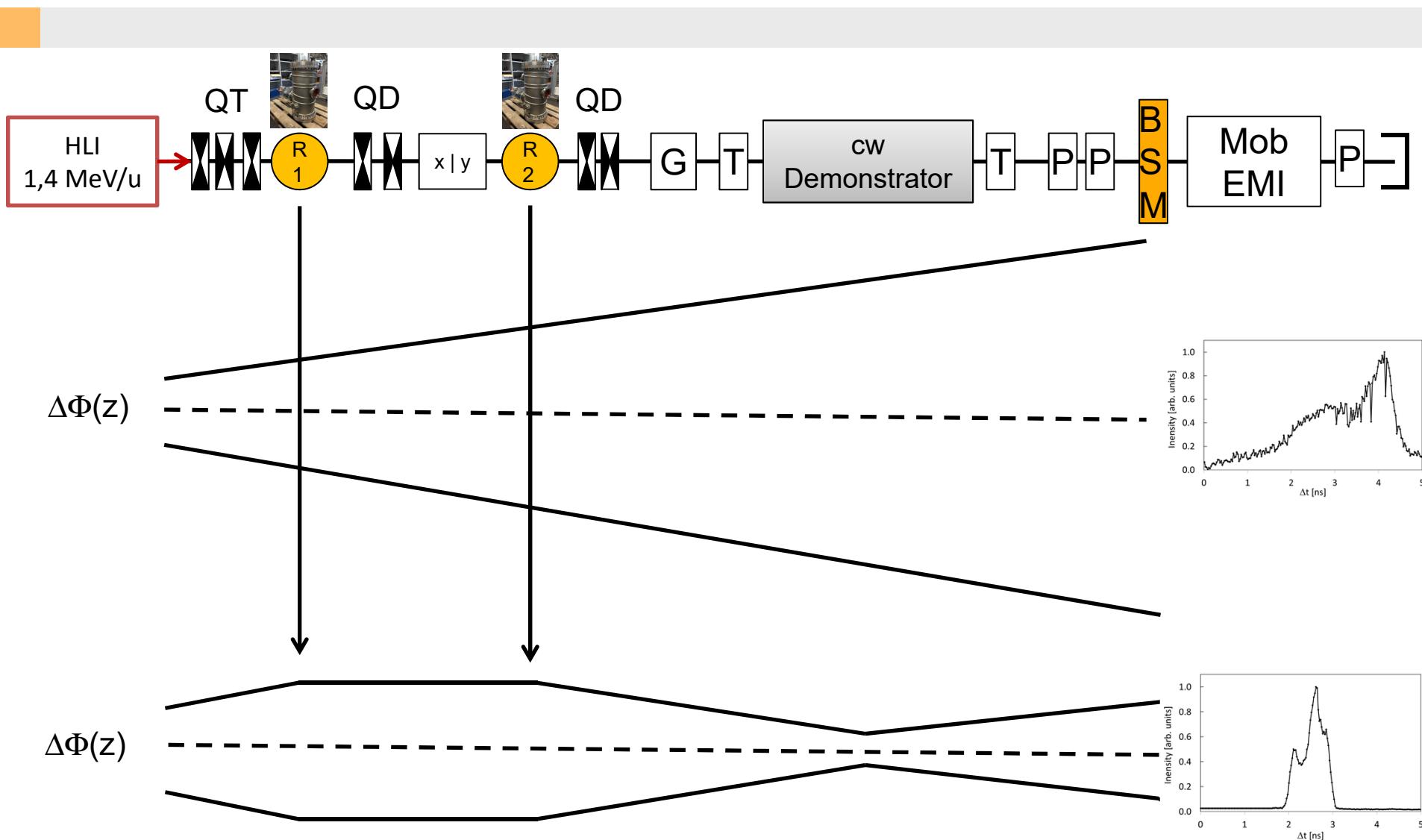
- Steering magnets
- Rebuncher
- Quadrupole doublet
- Profile grids
- Phase probes for TOF measurement
- Beam current transformers
- Bunch shape monitor (Feschenko)
- Emittance measurement

The High Charge State Injector (HLI) at GSI serves as an injector for the demonstrator

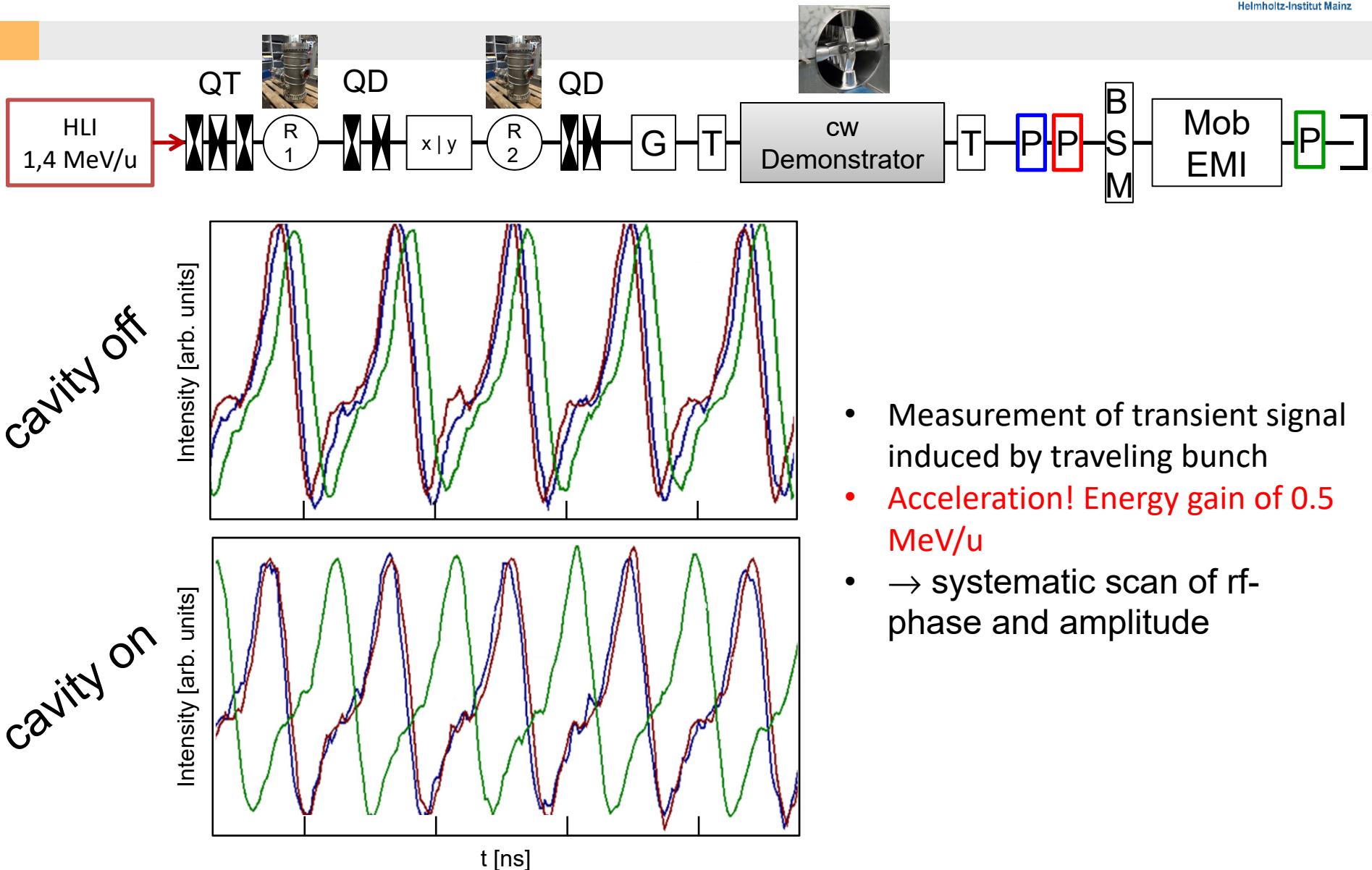




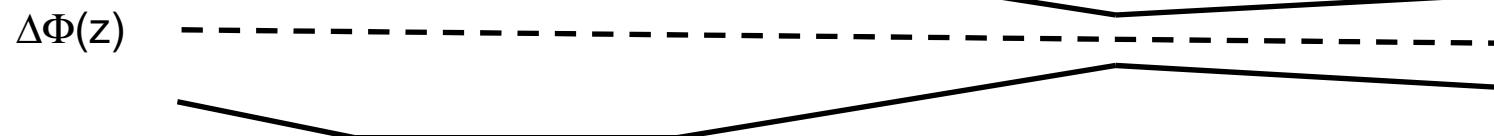
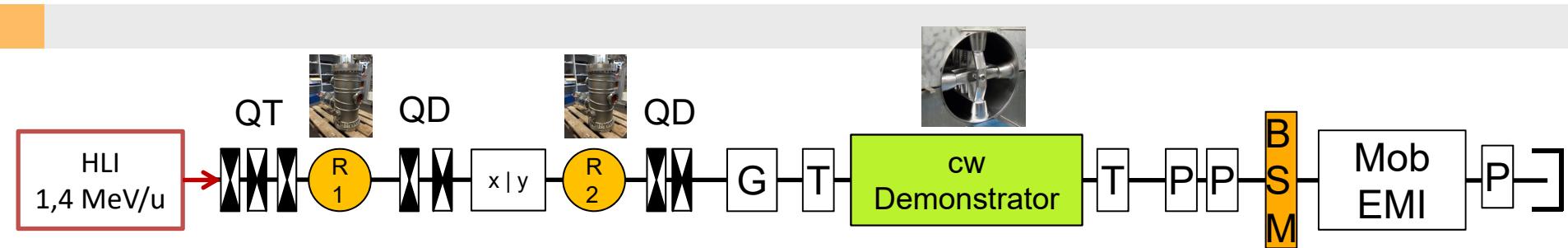
Longitudinal matching



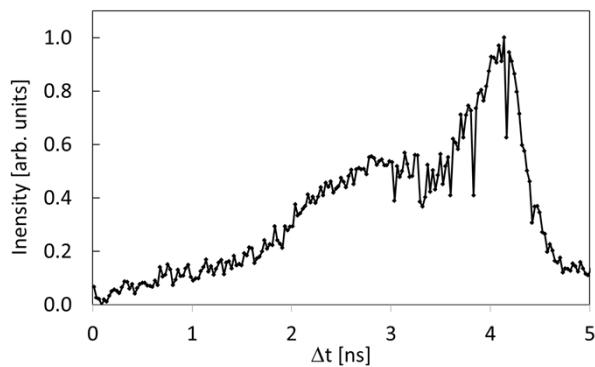
First Acceleration



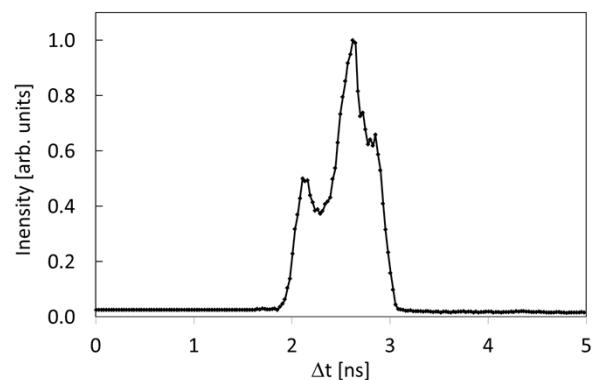
Bunch structure measurement



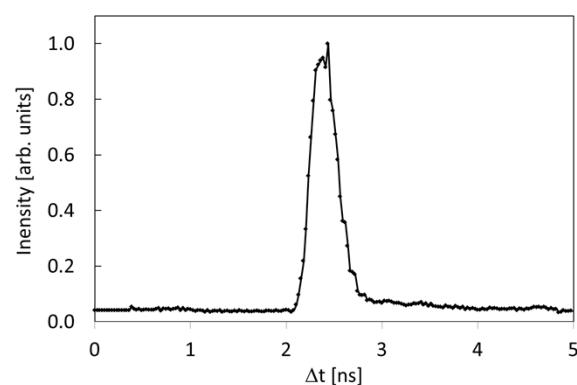
cavities off



$R_1 + R_2$



$R_1 + R_2 + \text{CH0}$



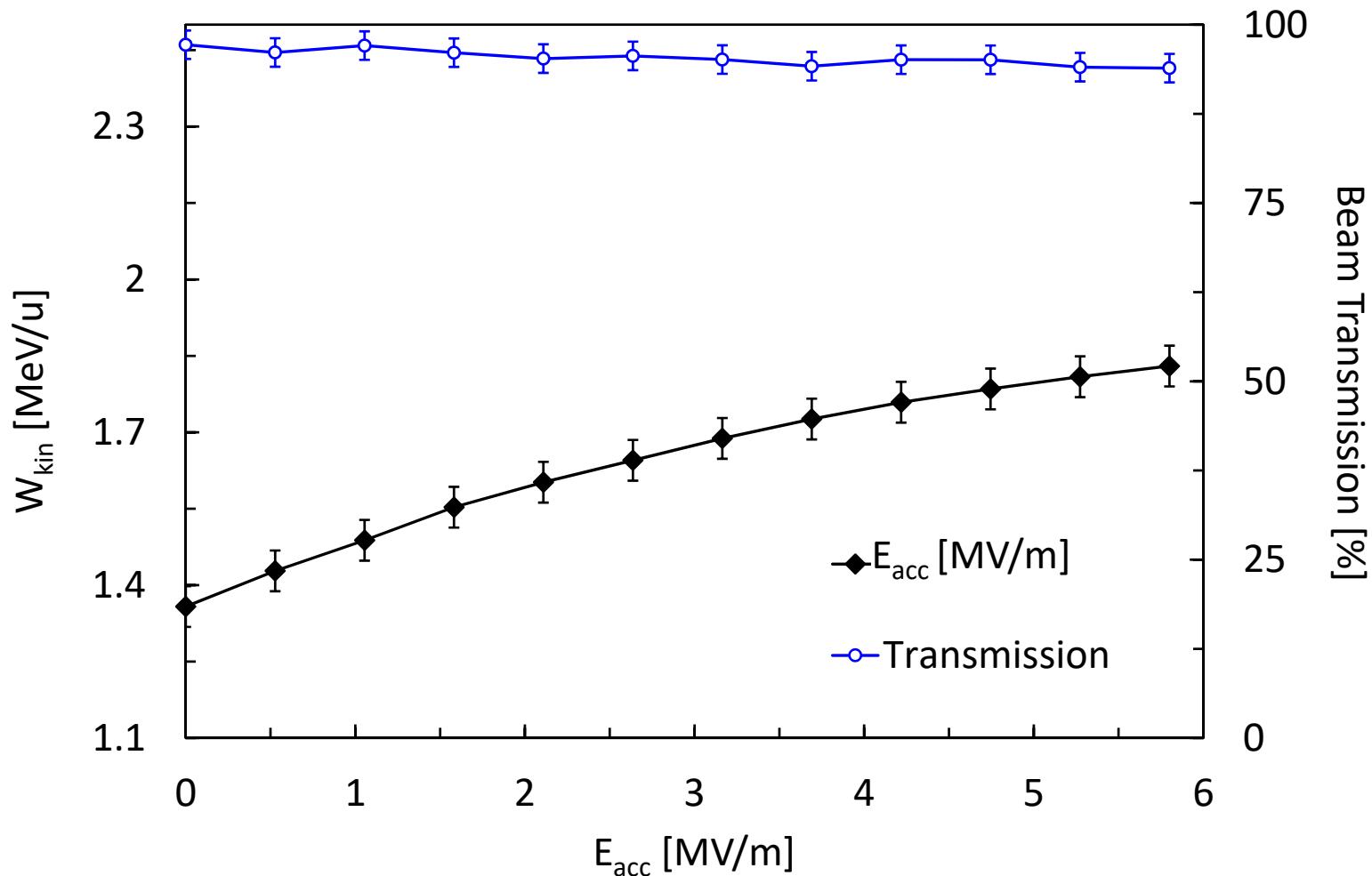
RF-parameter (matched case)

	He²⁺	Ar¹¹⁺	Ar⁹⁺	Ar⁶⁺
<i>A/q</i>	2.0	3.6	4.4	6.7
U _{Reb1,eff.} [kV]	8.3	15.0	18.3	27.9
U _{Reb2,eff.} [kV]	22.7	40.8	49.9	75.9
E _{acc,CH} *[MV/m]	1.8	3.2	3.9	5.9
U ₀ [MV]	1.2	2.2	2.7	4.0

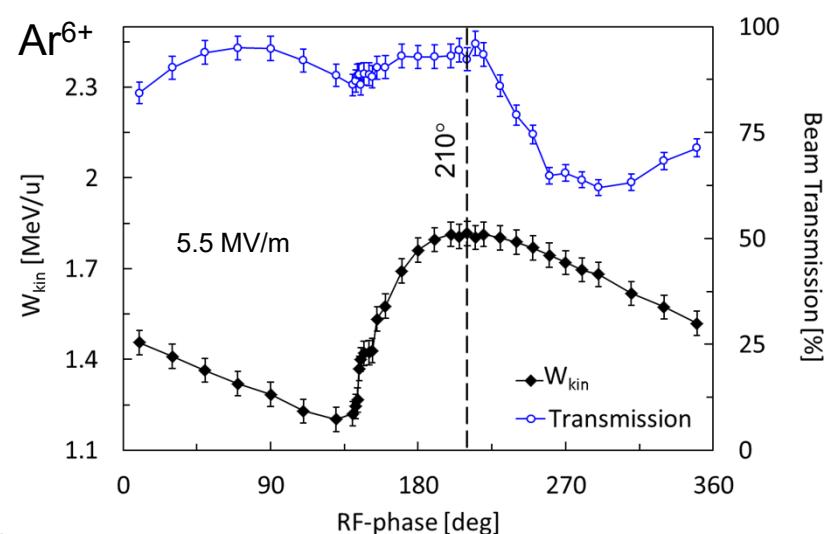
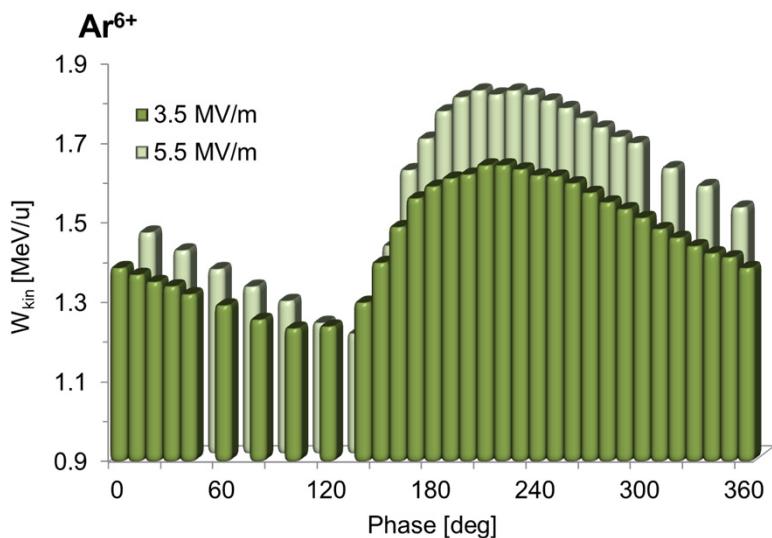
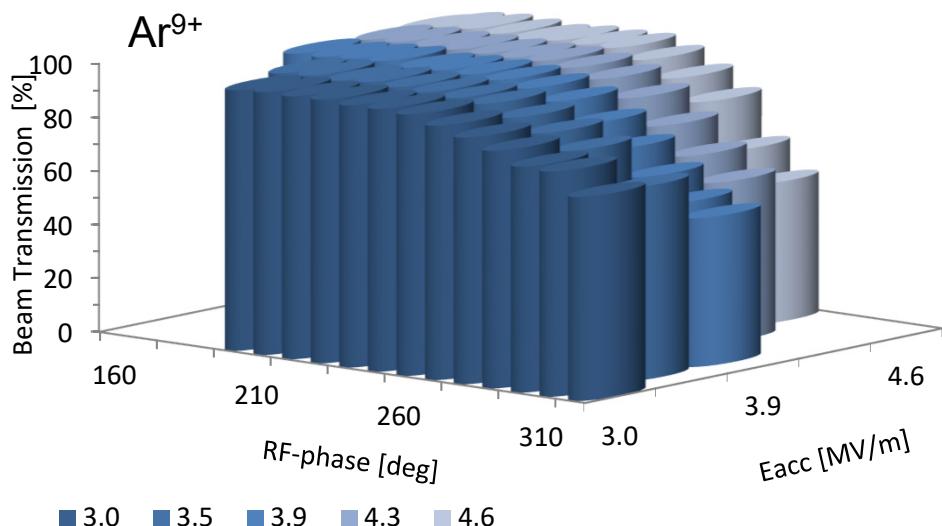
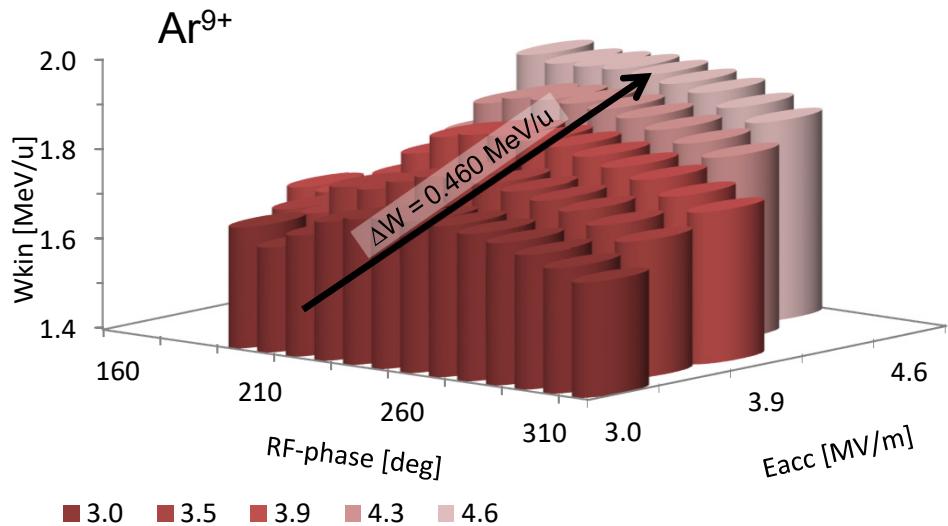
* $E_{acc} = \text{transit time factor} \times \text{total accelerating voltage}/(n \times 0.5 \times \beta \lambda)$



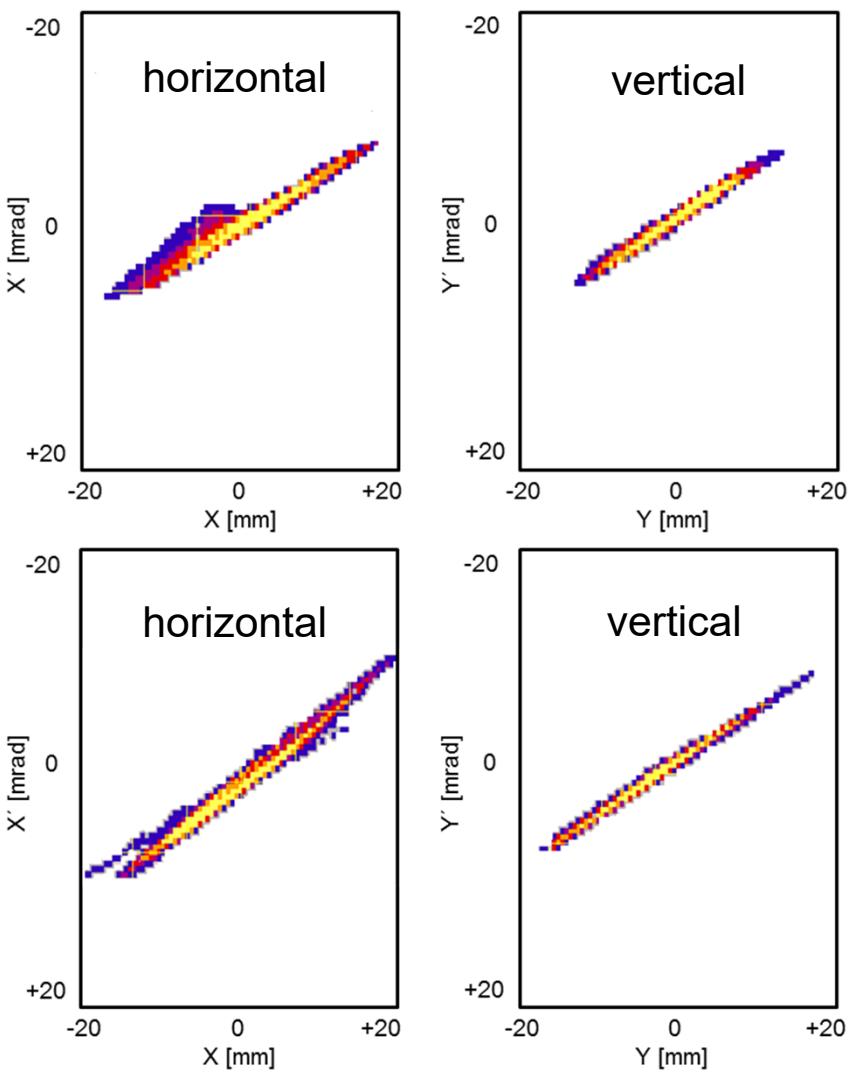
Amplituden-scan



Systematic Scans (RF-phase/-amplitude)



Emittance measurement



1.40 MeV/u

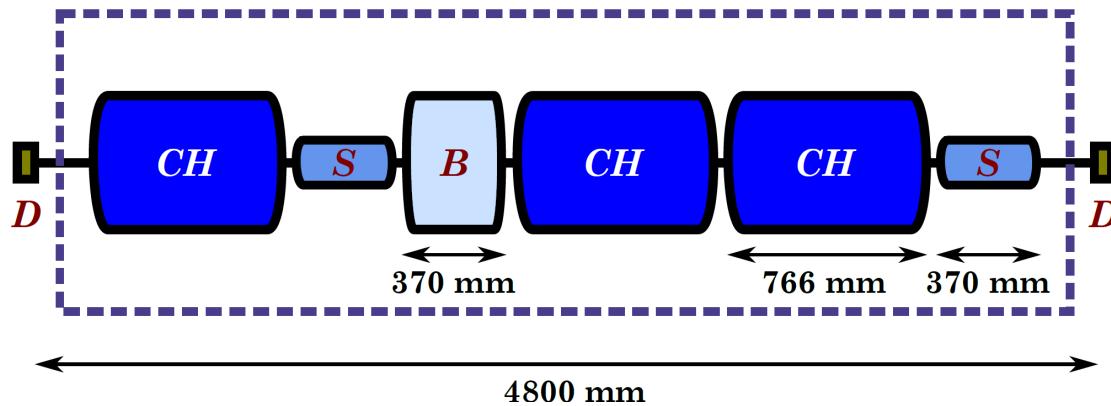
Ion species: $^{40}\text{Ar}^{11+}$, $^{40}\text{Ar}^{9+}$, $^{40}\text{Ar}^{6+}$ ($A/q=6.7$),
 50 Hz, 5ms, 25% beam duty, cw (rf duty), 1.5 pμA
 (particle current),
 ≈95% (beam transmission), 0.460 MeV/u (ΔW),
 transv. emittance growth ≈12%

1.86 MeV/u

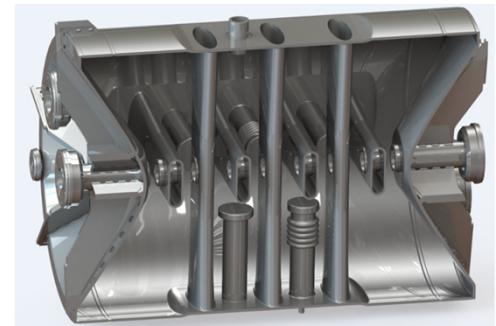


Advanced Demonstrator

Standard cryomodule layout

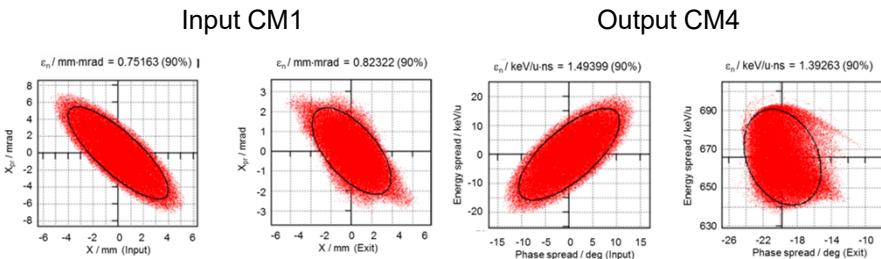
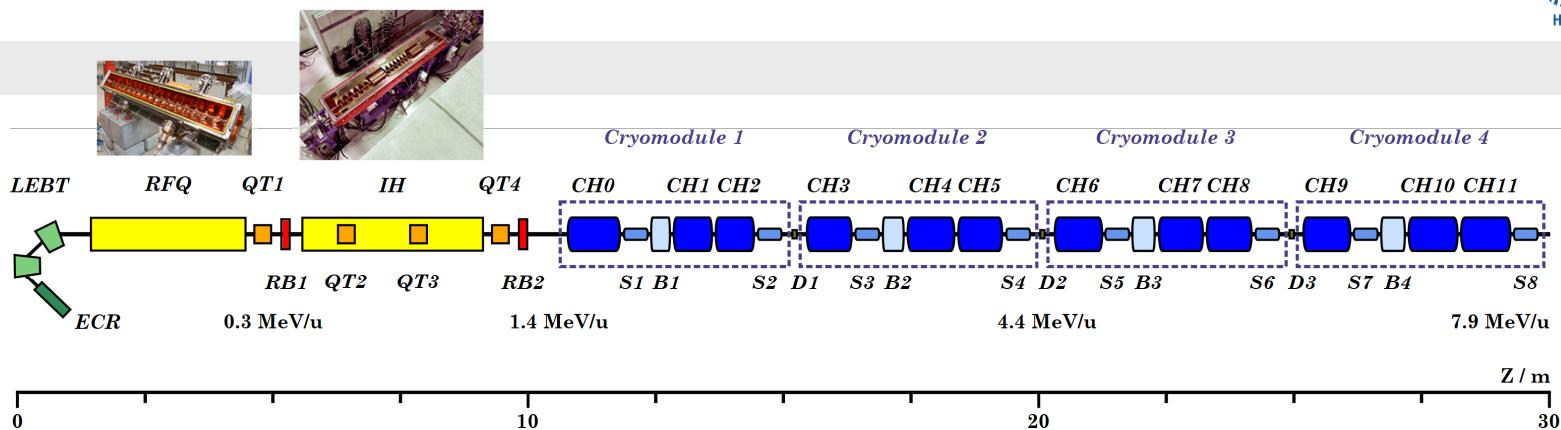


(8 gap)-CH-cavity



- New cryo module layout containing demonstrator CH cavity, 2 short CH cavities, 1 buncher and 2 solenoids
- Simplified cavity design (easier manufacturing & surface processing)
- CH1 & CH2 are already in production (delivery at 4th quarter of 2018)
- Tendering for cryostat at 3rd quarter of 2018
- Moderate increase of design gradient → more compact linac design or higher A/q

Current cw-Linac Layout



- Total of 12 CH cavities
- Each cryo module contains 3 CH cavities + 1 rebuncher + 2 solenoids
- Variable beam energy 3.6-7.5 MeV/u

Cryo Module	Cavity	Output energy (MeV/u)		
		A/Z=6	A/Z=3	A/Z=1
CM1	HLI	1.4	1.4	1.4
	CH0	2.1	2.2	3.0
	CH1	2.6	3.0	4.2
	CH2	2.9	3.6	4.6
CM2	CH3	3.4	4.3	5.7
	CH4	3.8	4.8	6.3
	CH5	4.2	5.5	7.7
	CH6	4.7	6.2	8.6
CM3	CH7	5.2	7.0	9.9
	CH8	5.8	7.8	10.9
	CH9	6.4	8.7	12.3
	CH10	7.0	9.5	13.2
CM4	CH11	7.6	10.5	14.6

Summary&Outlook



Summary&Outlook

- Demonstrator beam commissioning is a major milestone paving the way to the GSI/HIM-cw-Linac
- Design acceleration gain was achieved with heavy ion beams even above the design mass to charge ratio at full transmission and maximum available beam intensity
- Beam quality was measured as excellent in a wide range of different beam energies, confirming EQUUS beam dynamics design
- Advanced cw-Linac layout based on four cryomodules, each equipped with three CH-cavities and a sc-rebuncher, demonstrates the high capabilities due to energy variation preserving the beam quality
- New design could provide beam acceleration for a wide range of different ions (protons to uranium) above the design beam energy, featuring the ambitious GSI-user program, while the GSI-UNILAC is upgraded for short pulse high current FAIR-operation



Thank You for Your attention!

