Beam Commissioning Scenario of L-band Electron Linac*

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Introduction

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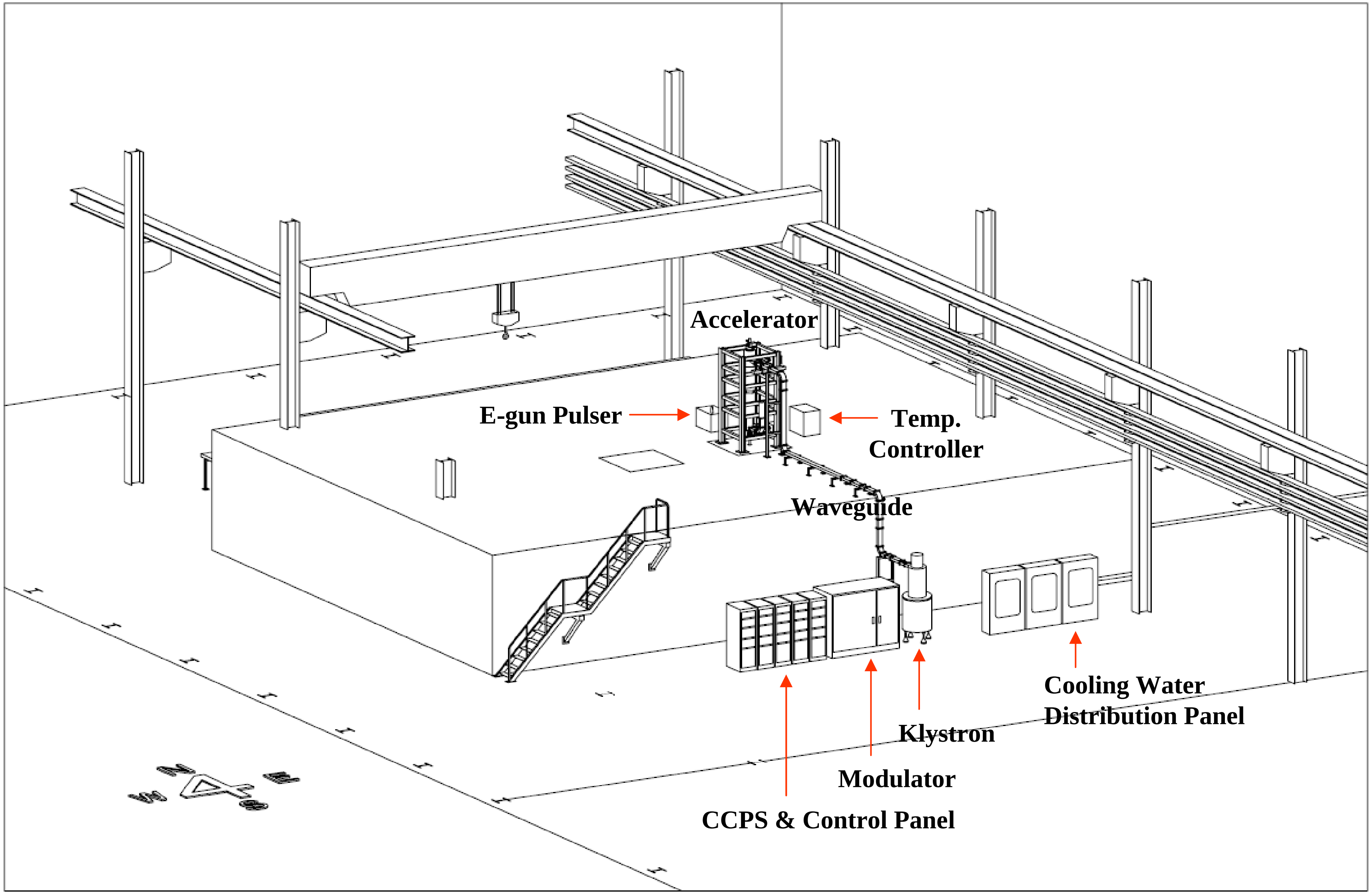
- L-band traveling-wave electron linac
- Irradiation applications
- 10 MeV and average 30 kW
- Single klystron (pulsed 25 MW)
- Single accelerating column
- Vertical mount

System Layout



Accelerator Parameters

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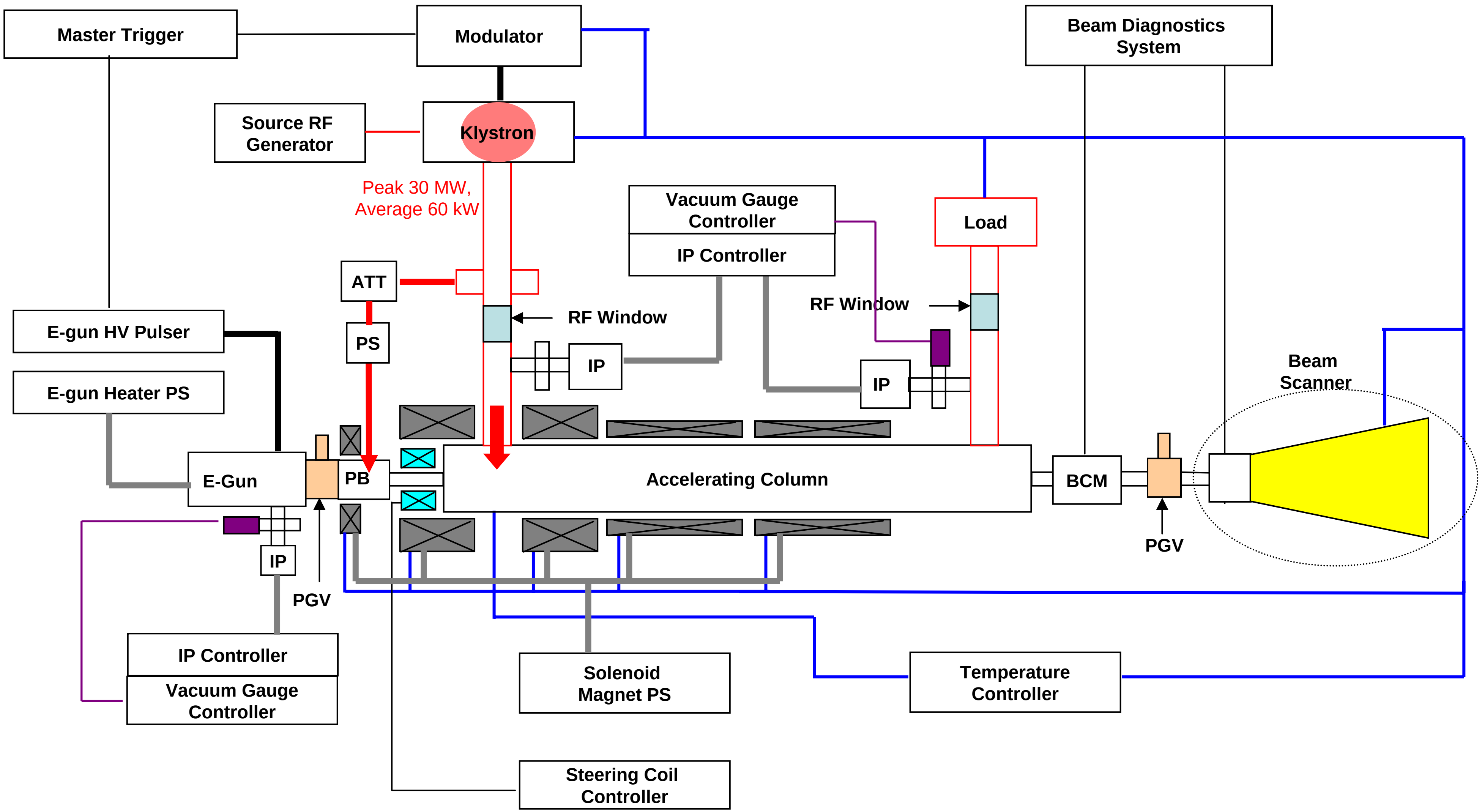
RF System Parameter	
Operating Frequency	**1.3 GHz**
Pulsed RF Power	**25 MW**
Pulse Length	**7 μs**
Repetition Rate	**350 Hz**
Average RF Power	**60 kW**

E-gun Parameter	
High Voltage	**80 kV**
Pulsed Beam Current	**1.6 A**
Pulse Length	**6 μs**
Repetition Rate	**350 Hz**

Beam Parameter	
Beam Energy	**11.3 MeV**
Pulsed Beam Current	**1.39 A**
Beam Transmission Rate	**87%**
Averaged Beam Power	**33.0 kW**

Accelerating Structure Parameter	
Type of Structure	**Constant-impedance**
Shape of Cell	**Disk-loaded**
Operating Mode	**2π/3 mode**
RF Filling Time	**0.8 μs**
Operating Temperature	**40˚C ± 1˚C**
Averaged Accelerating Gradients	**4.2 MV/m**
Beam Loading Factor	**- 4.7 MeV/A**
Temperature Shift Factor	**- 2.3 MeV/˚C**

Schematic Diagram of L-band Linac



Commissioning Parameters

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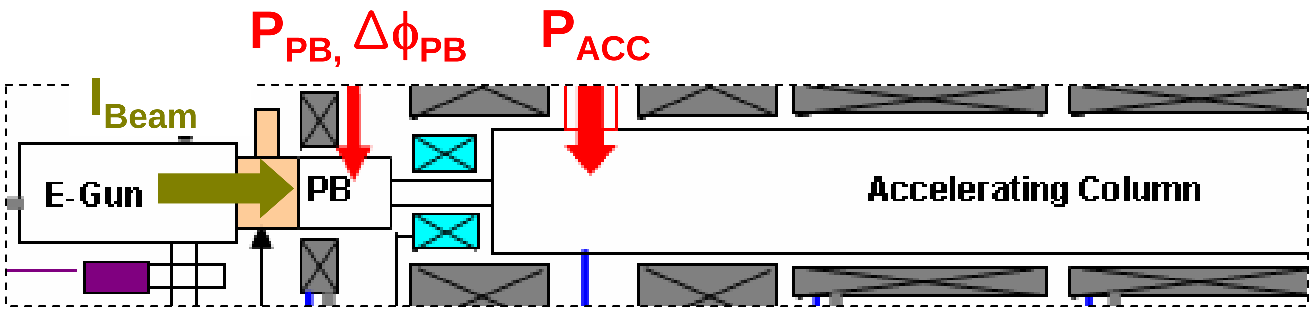


P_{ACC}

- Input RF power into ACC

I_{Beam}

- Input beam current

P_{PB}

- Input RF power into PB

$\Delta\phi_{PB}$

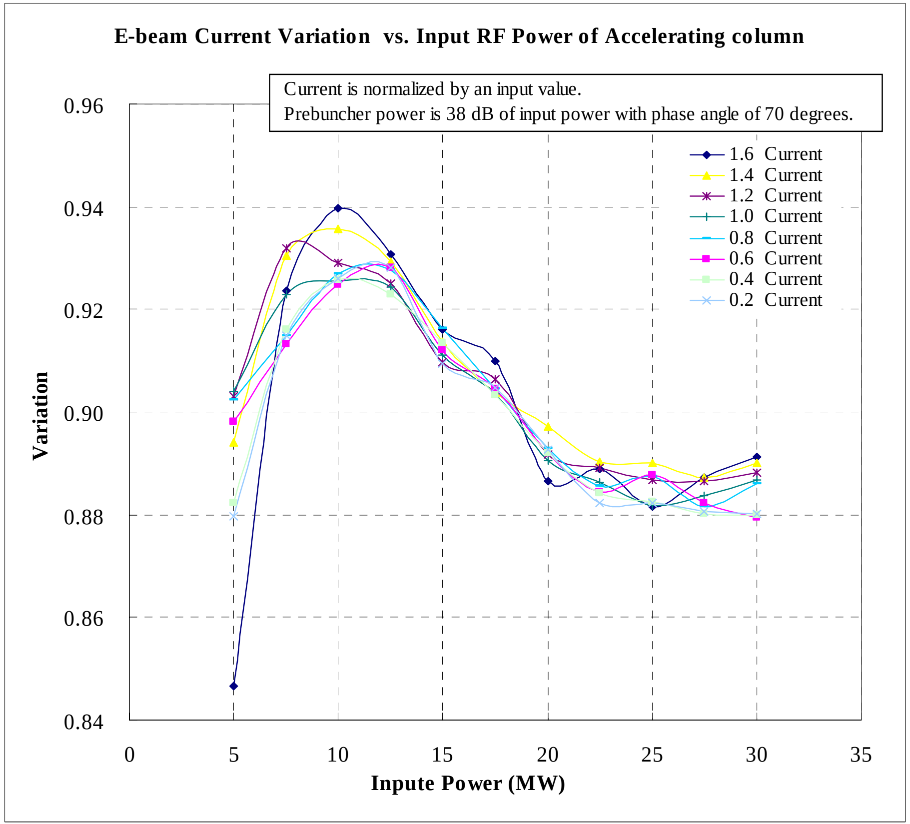
- Phase difference relative to ACC

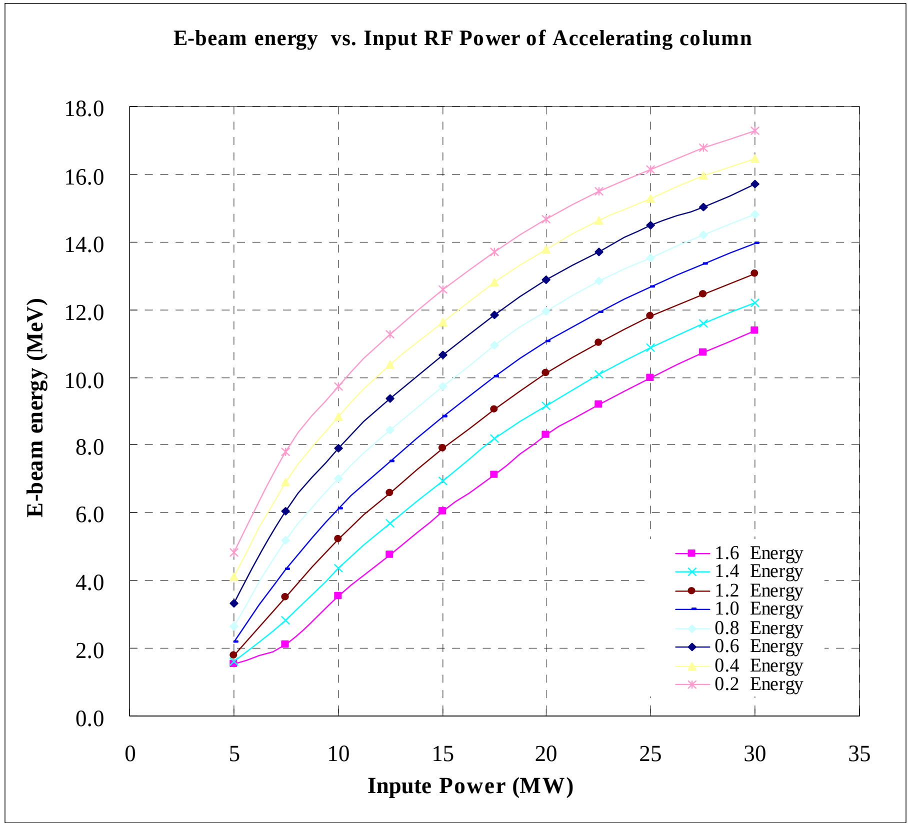
PARMELA simulation

Output Beam Energy

Beam Transmission Ratio

P_{ACC} and I_{Beam}





Input power into ACC ↑

⇒ Field strength in the bunching section ↑

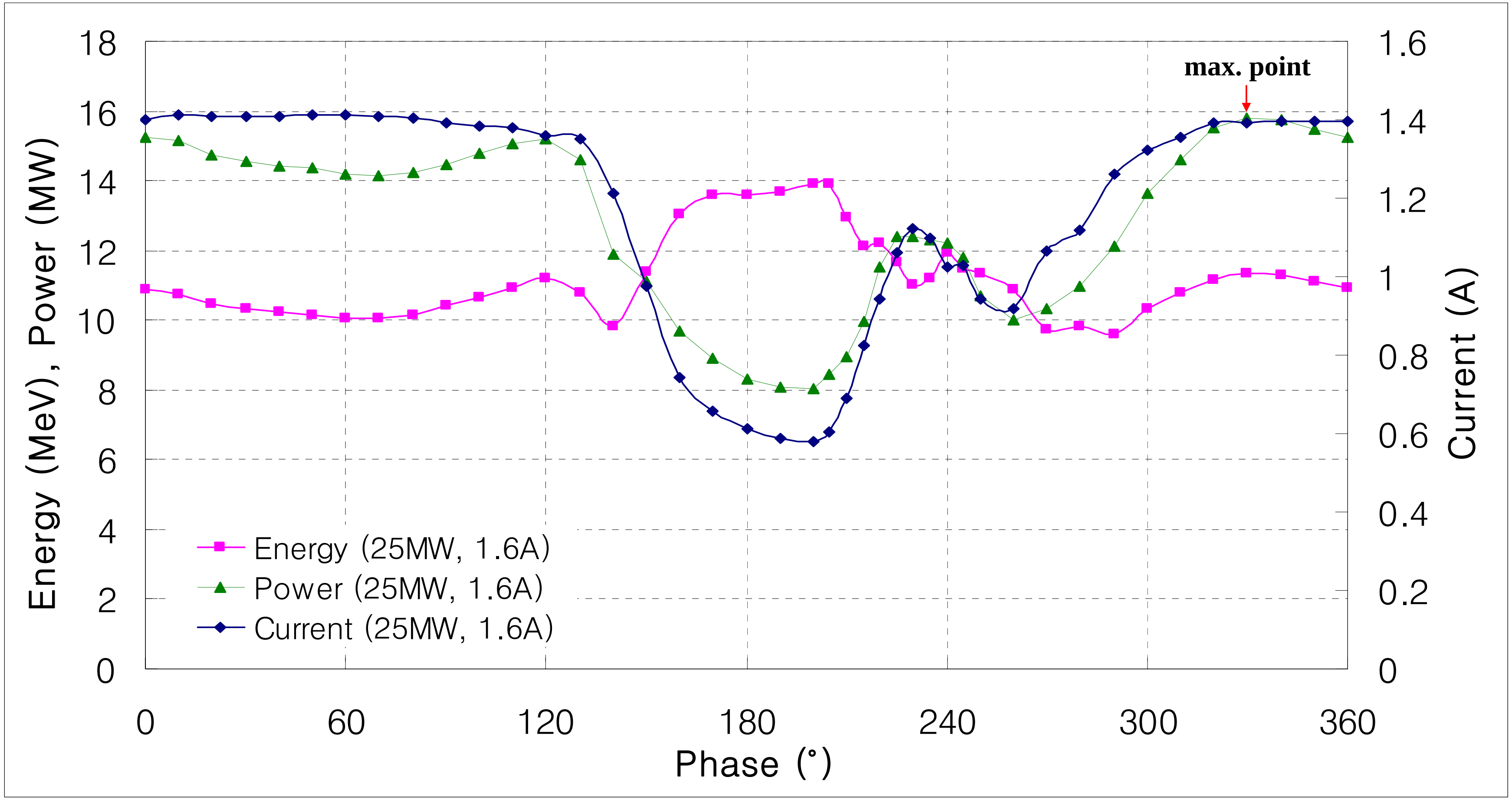
⇒ Capturing into the bunching section ↓

In agreement with the energy gain in a TW structure with beam-loading effect:

$$\Delta W / q = (2 r_s L P_{in})^{1/2} \cos\phi \left(\frac{1 - e^{-\tau_0}}{\sqrt{\tau_0}} \right) - i r_s L \left(1 - \frac{1 - e^{-\tau_0}}{\tau_0} \right)$$

ΔφPB

Input RF power into the pre-buncher : 3.75 kW

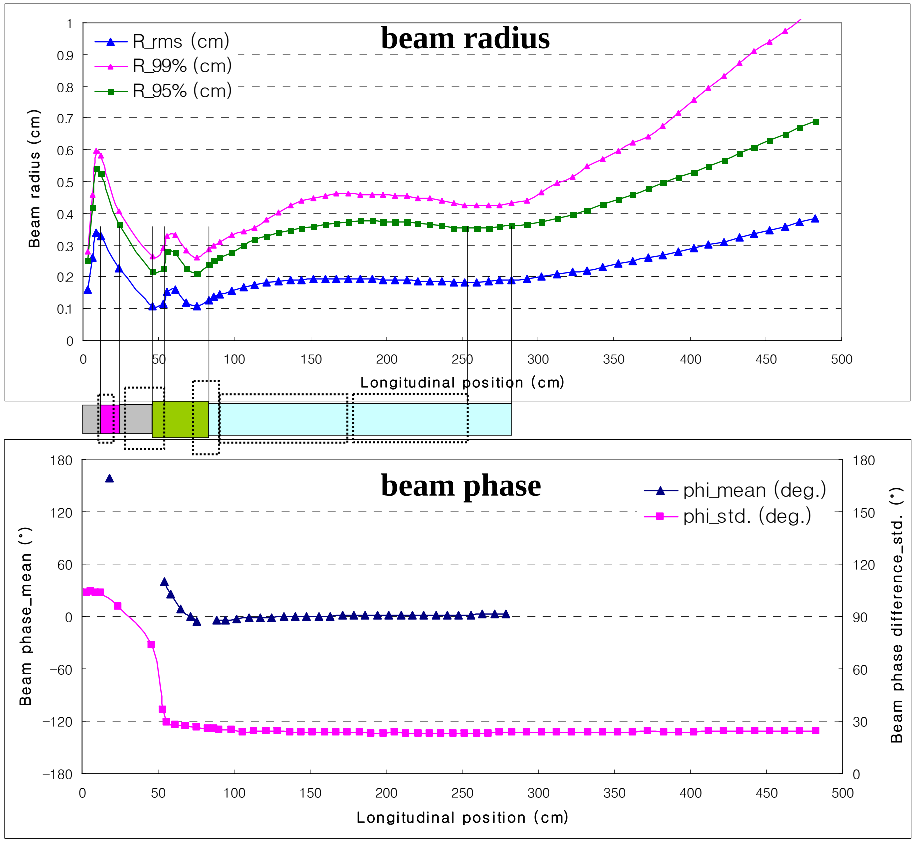


Phase difference within -60˚ to 120˚

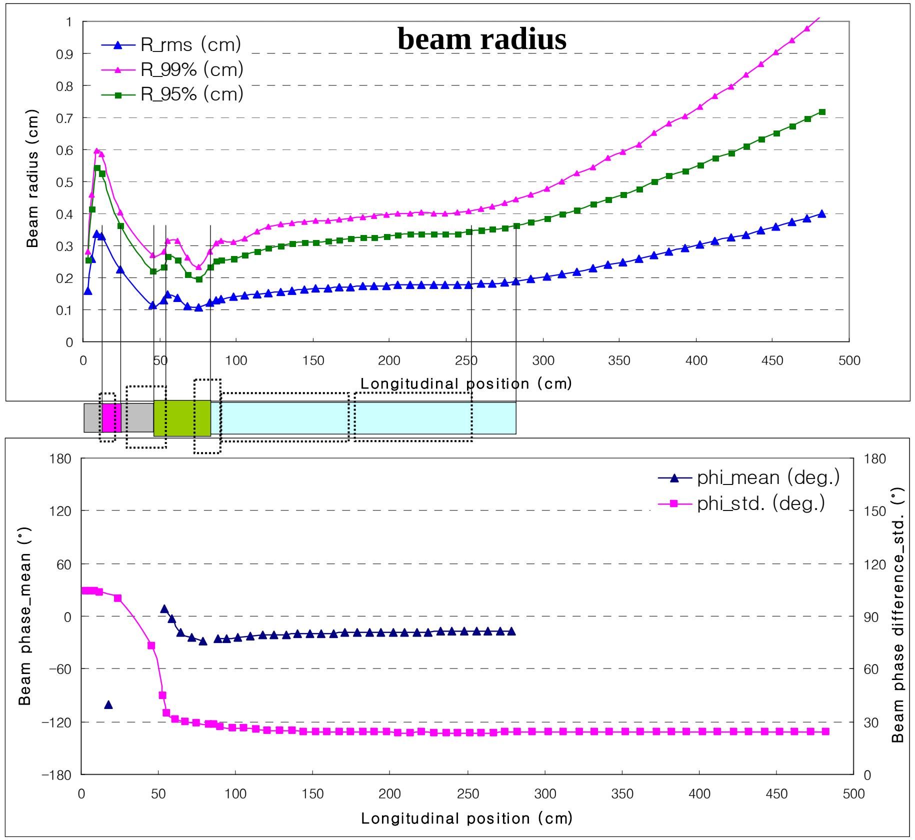
⇨ Insensitive variations of the energy and current

Beam Characteristics with $\Delta\phi_{PB}$ (1)

- 330˚



- 70˚



Beam bunch center on the crest of wave

⟹ **Maximum energy gain**

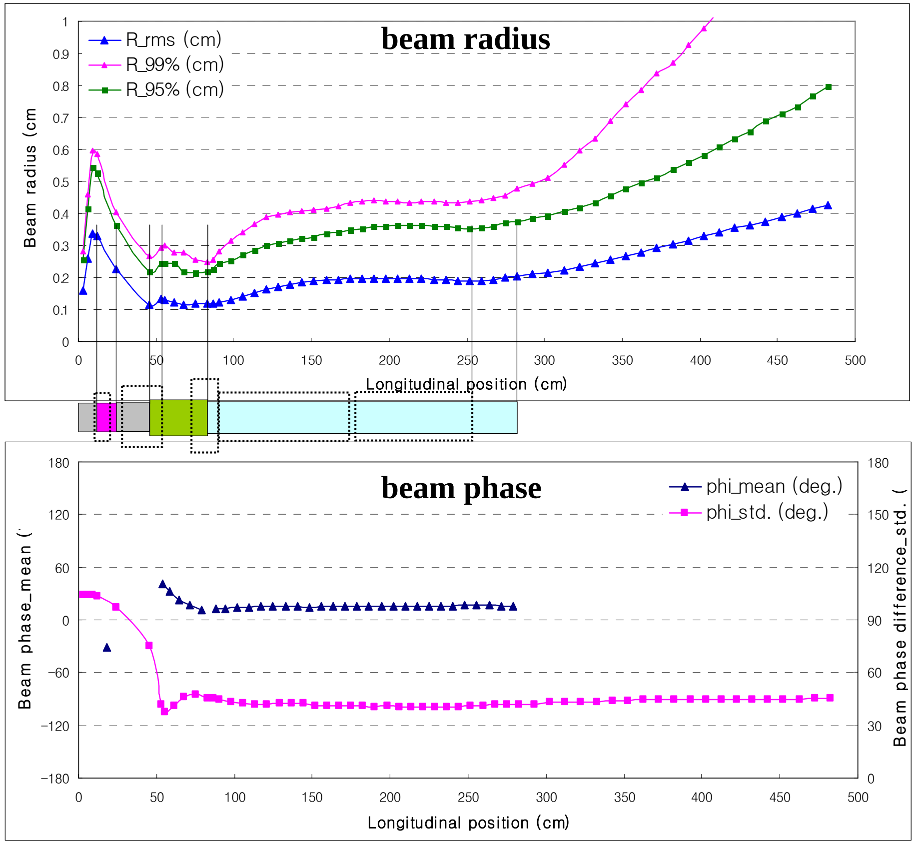
⟹ **Highest power**

Bunch center before the crest

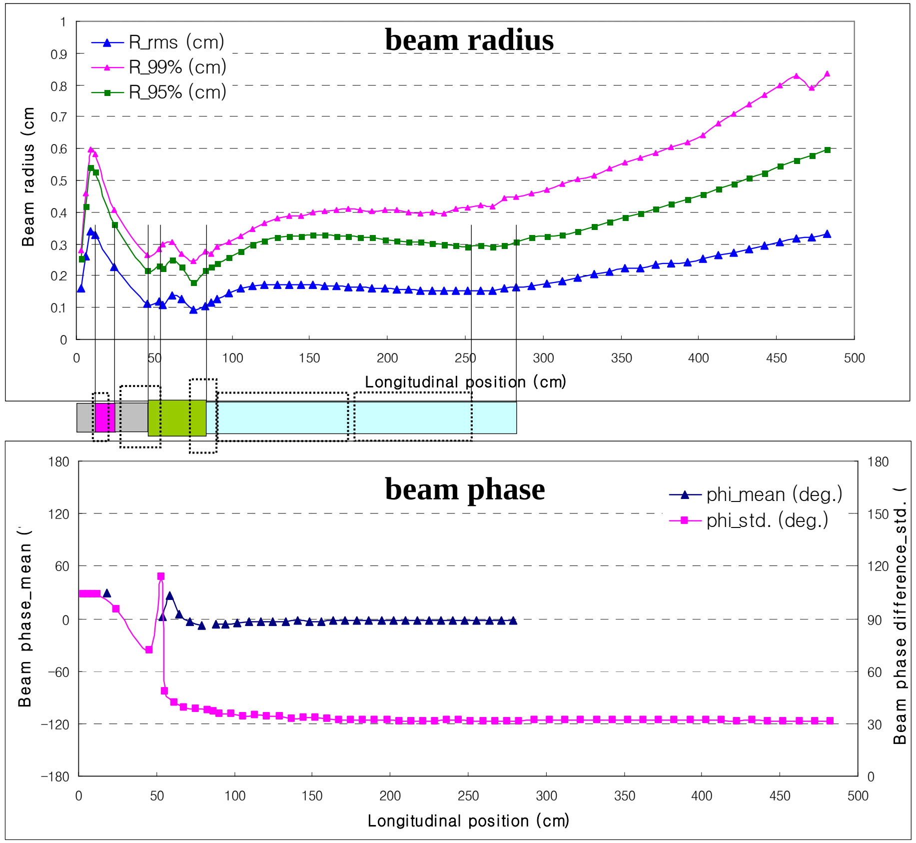
⟹ **Well-bunched**

Beam Characteristics with $\Delta\phi_{PB}$ (2)

- 140˚



- 200˚



Bunch center after the crest

➡ **poor bunching**

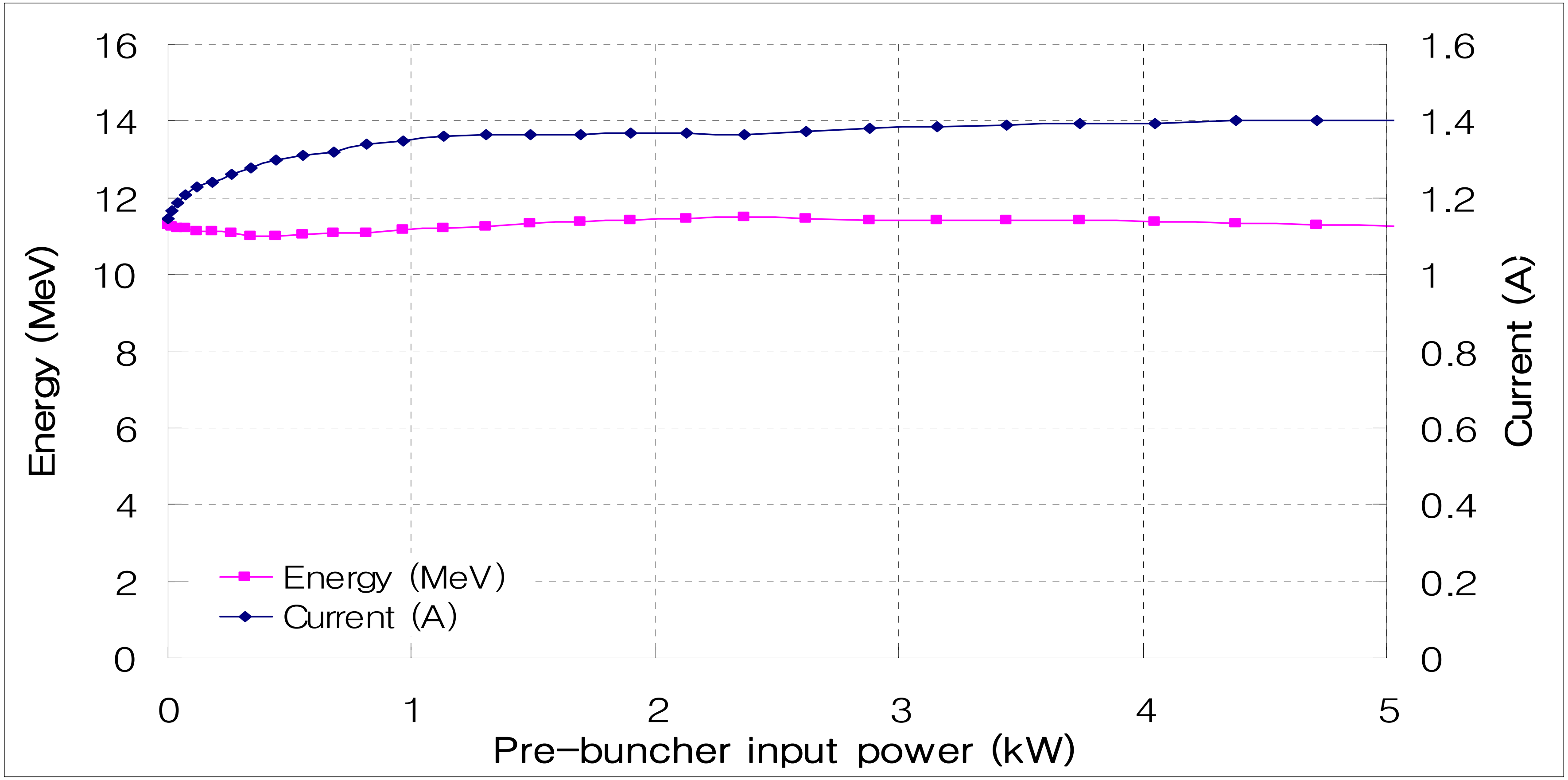
➡ **poor beam radius**

Worst transmission

- **Backward loss at the 1st bunching section**
- **Transmitted particles: well-bunched and focused**

P_{PB} – Input Power

Input RF phase difference : 330˚



PB: bunching particles within acceptable phase at the bunching section in ACC.

→ **Insensitive to output beam**

Conclusion

P_{ACC} : Input RF power into ACC

- Beam energy: $\propto \sqrt{P_{ACC}}$.
- Transmission: linearly decreased, but slightly.

I_{Beam} : Input beam current

- Beam energy: linearly decreased.
- Transmission: no particular tendency.

→ Obtain operation condition for desired beam energy and power

$\Delta\phi_{PB}$: Phase difference relative to ACC

- Beam energy: depends on transmission.
- Transmission: specific phase ranges acceptable at bunching section in ACC.

→ ~180˚ acceptable range

P_{PB} : Input RF power into PB

- Beam energy: no dependency.
- Transmission: proportional, but insensitive.

→ Nominal at 3.75 kW, but lower power is possible.

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