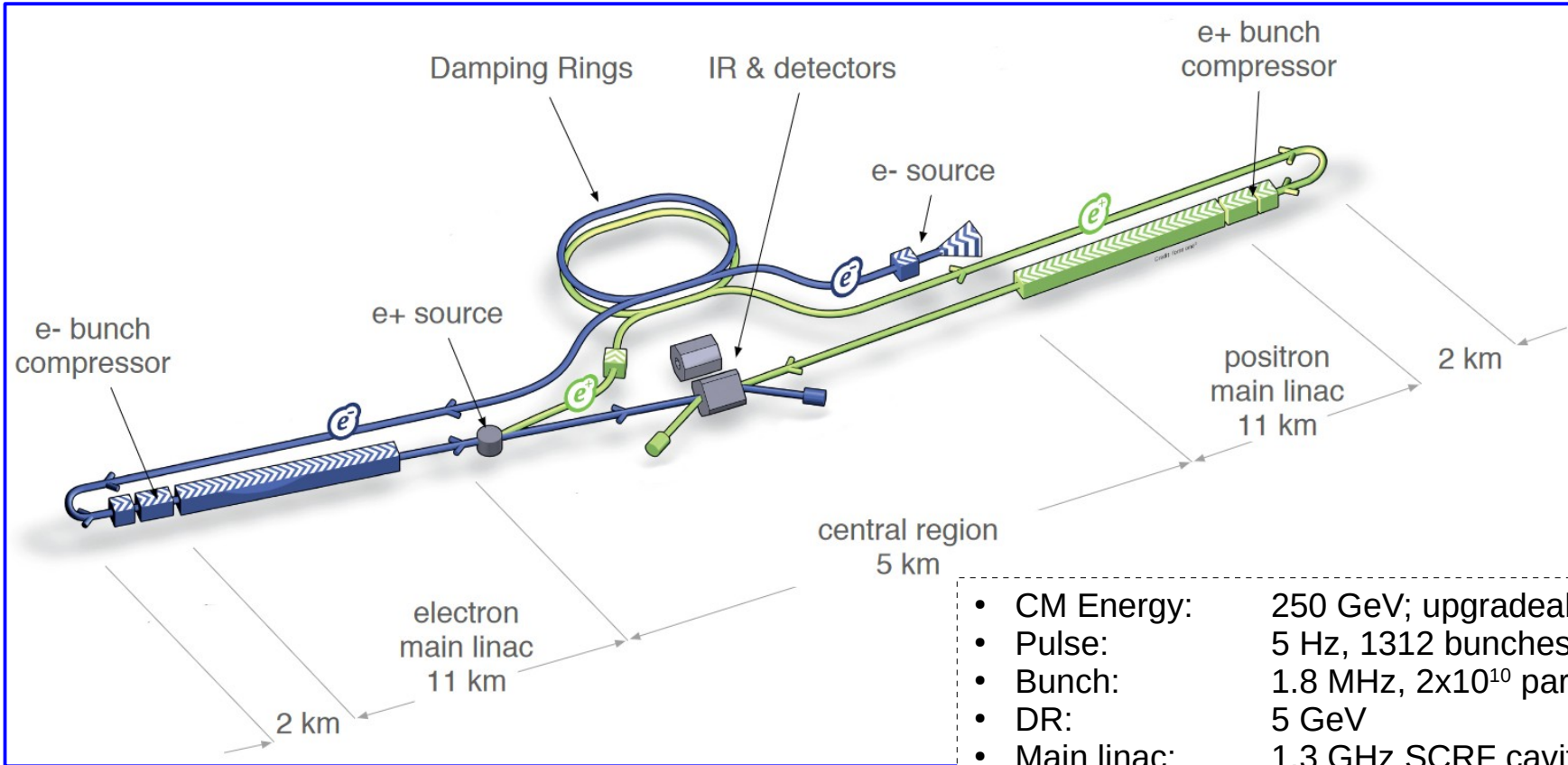


Plasma Lenses for the Positron Source: Challenges and Prospects

G. Moortgat-Pick, K. Floettmann,
S. Riemann, M. Formela, N. Hamann

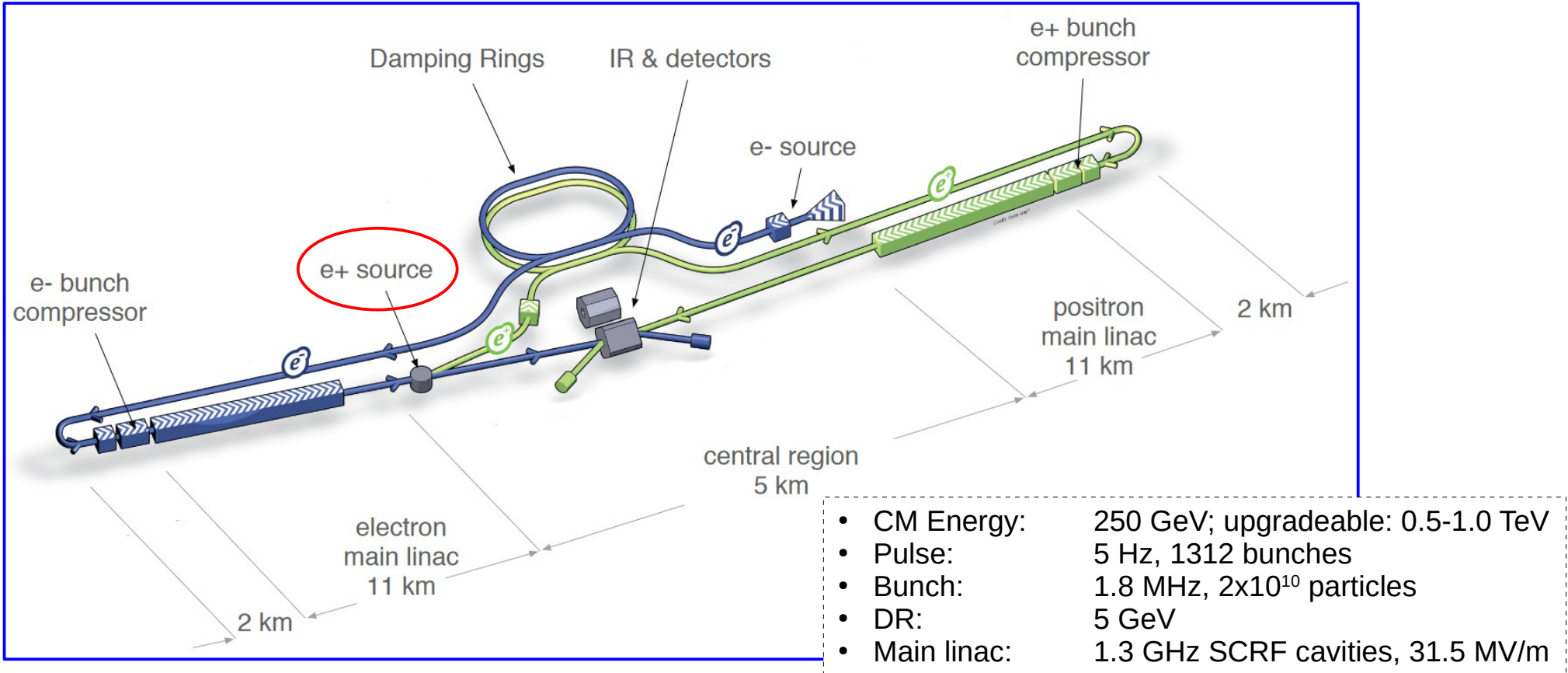
ILC



- CM Energy: 250 GeV; upgradeable: 0.5-1.0 TeV
- Pulse: 5 Hz, 1312 bunches
- Bunch: 1.8 MHz, 2×10^{10} particles
- DR: 5 GeV
- Main linac: 1.3 GHz SCRF cavities, 31.5 MV/m

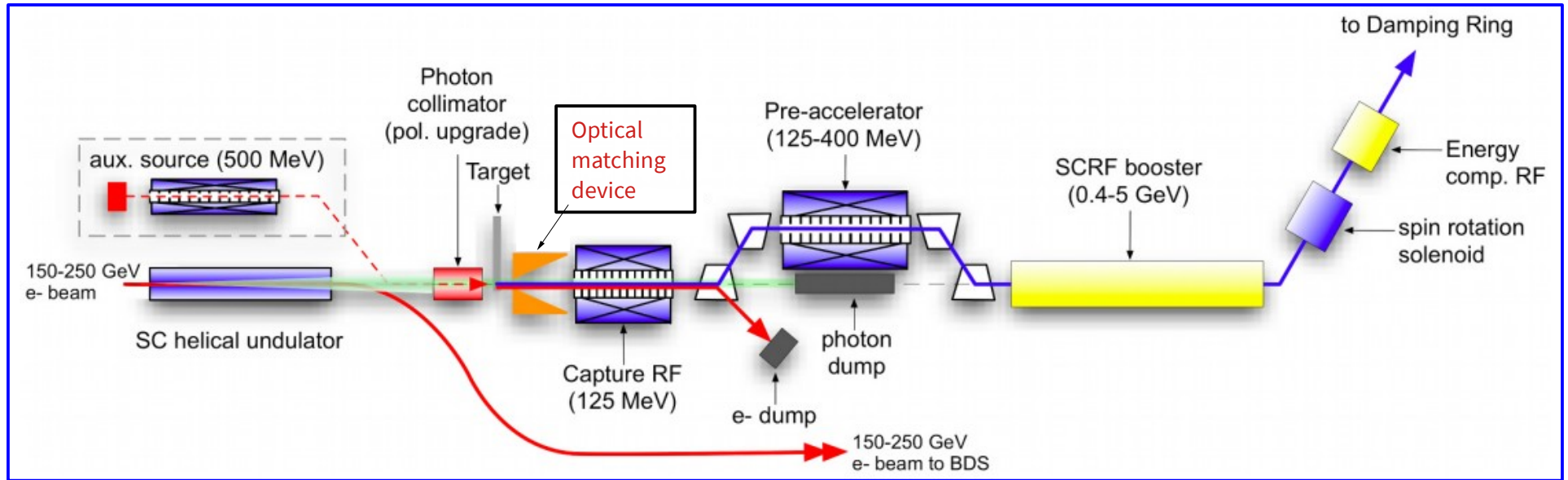
Source: Behnke, Ties, et al. "The international linear collider technical design report-volume 1: Executive summary." arXiv preprint arXiv:1306.6327 (2013).

ILC

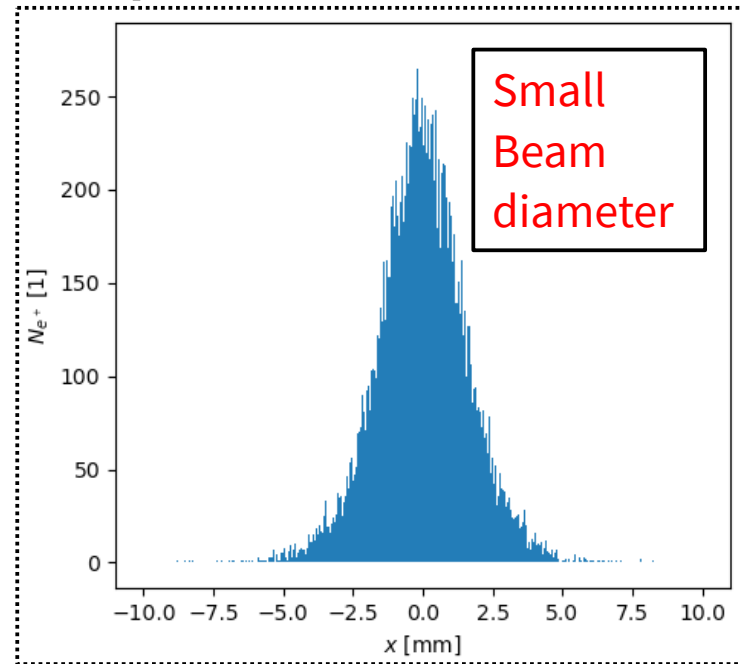
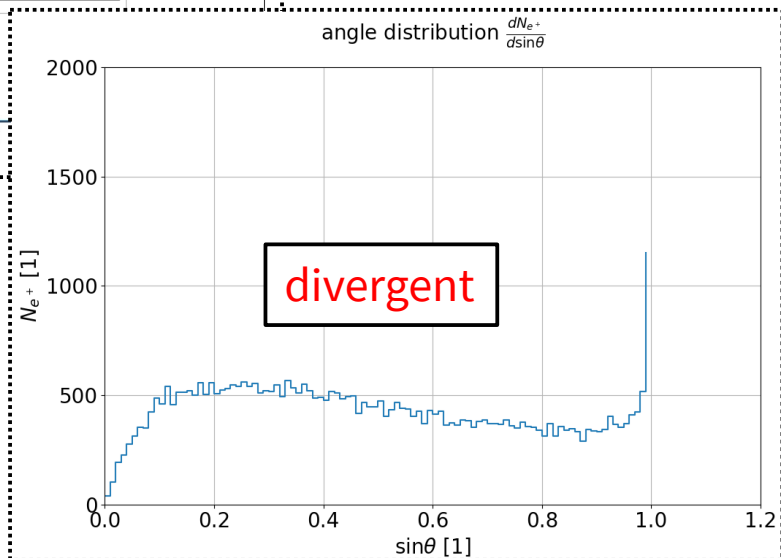
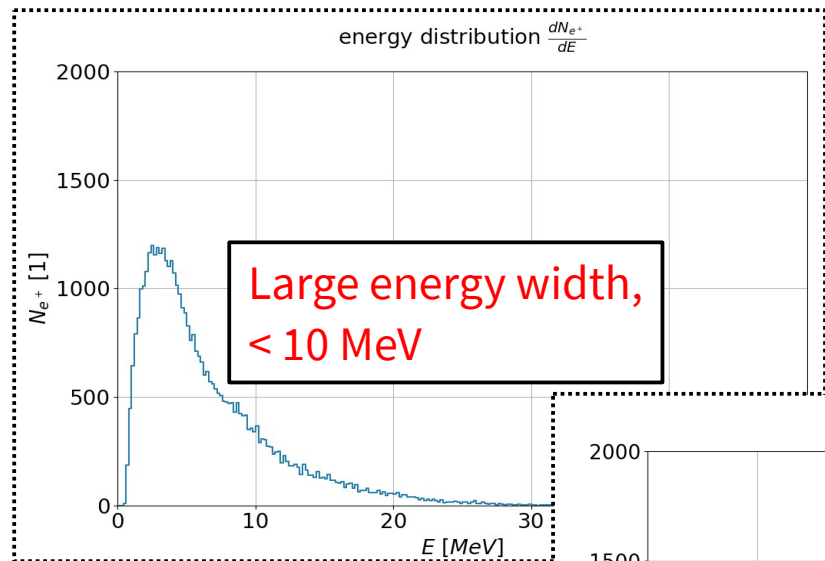


Source: Behnke, Ties, et al. "The international linear collider technical design report-volume 1: Executive summary." arXiv preprint arXiv:1306.6327 (2013).

Positron Source



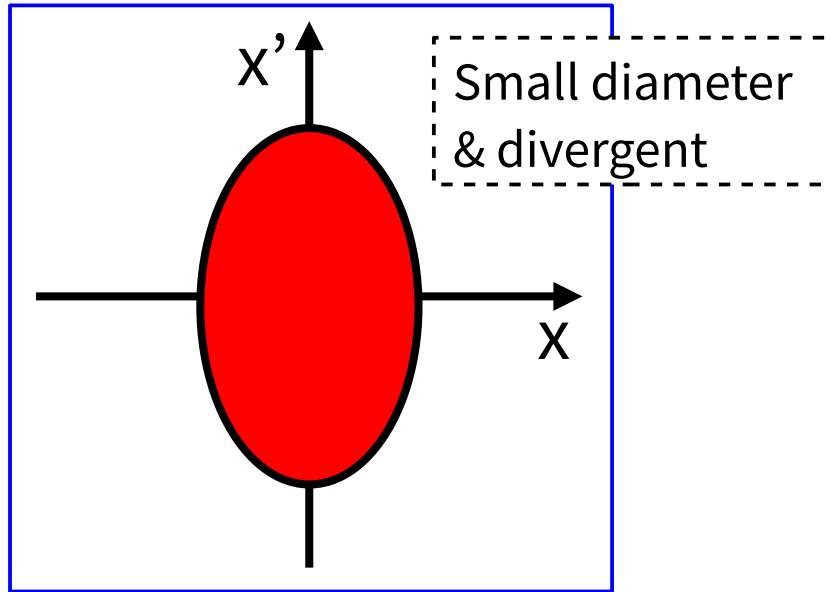
Positron Source: Bunch Properties



Emission time: ~80 ps emission

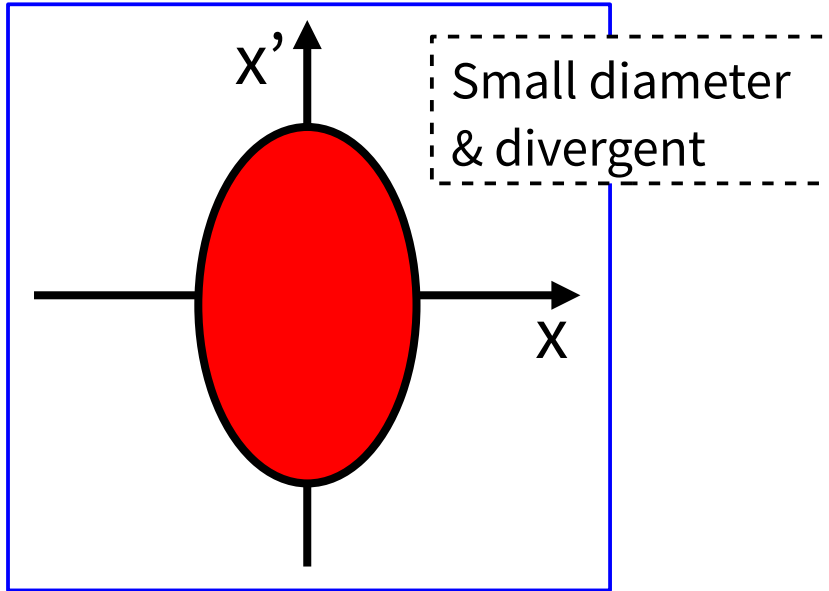
Matching: why?

Initial e⁺ beam

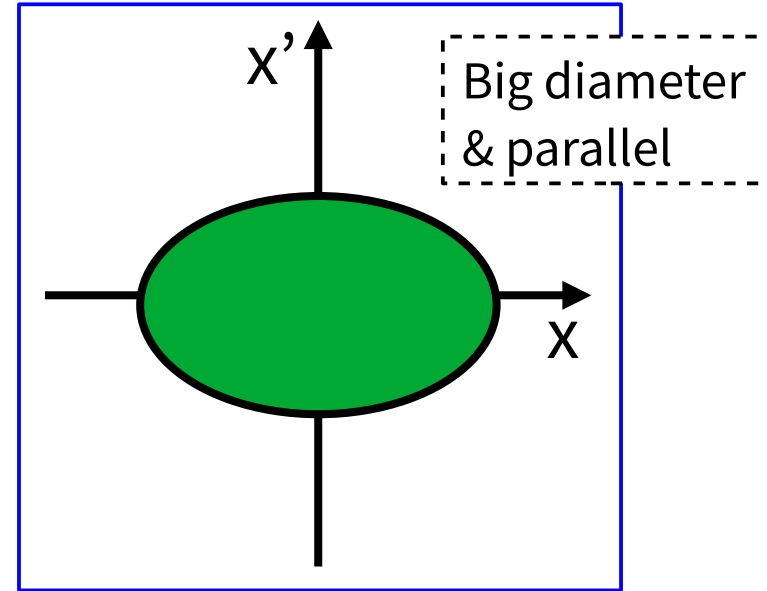


Matching: why?

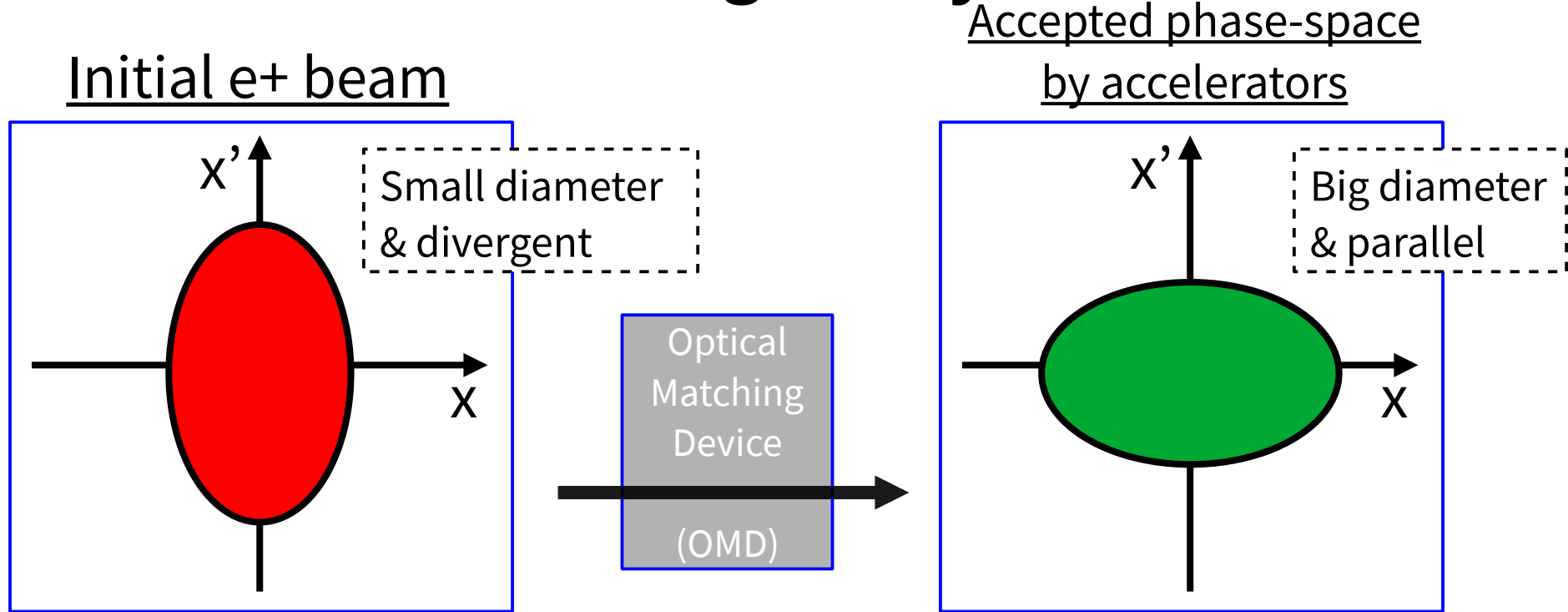
Initial e+ beam



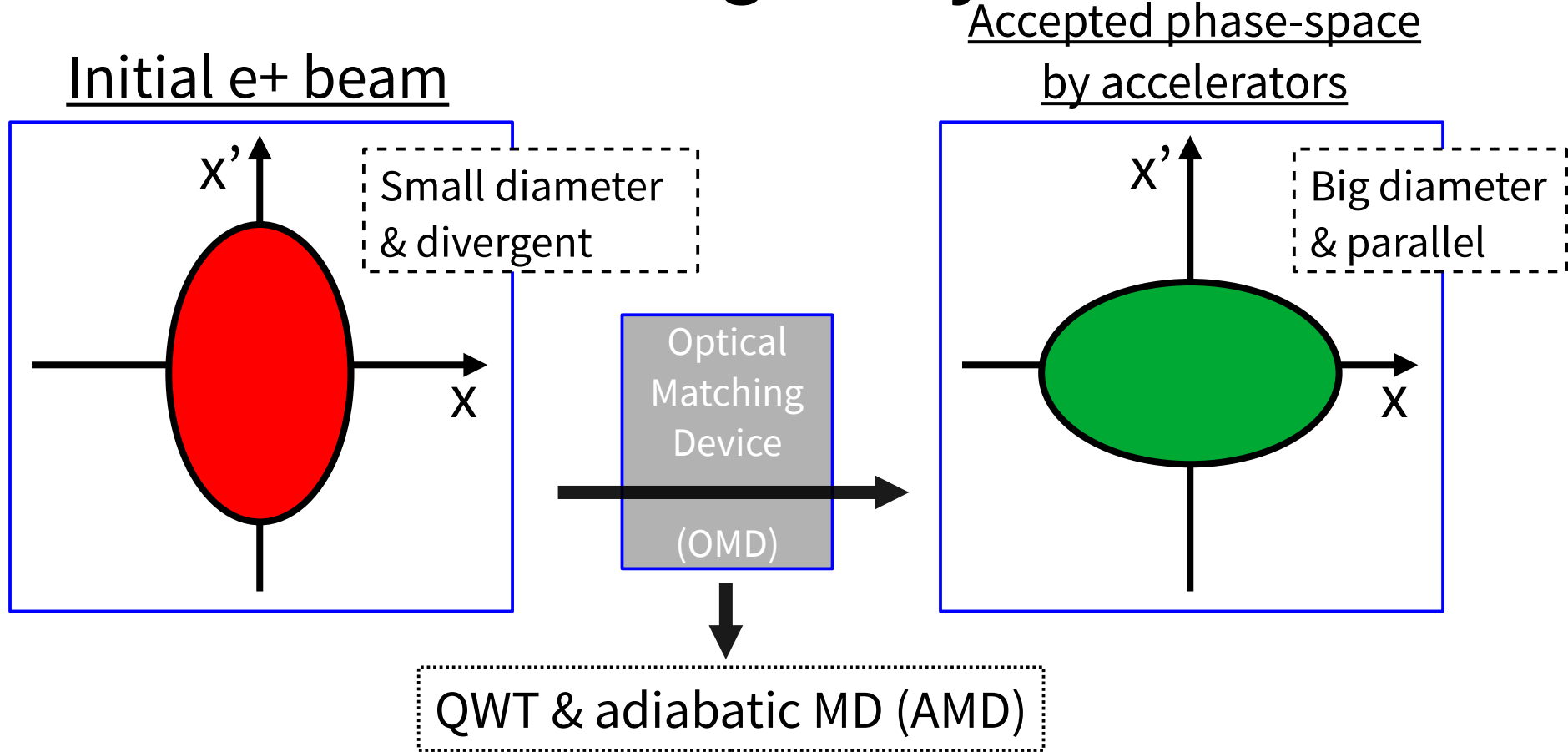
Accepted phase-space
by accelerators



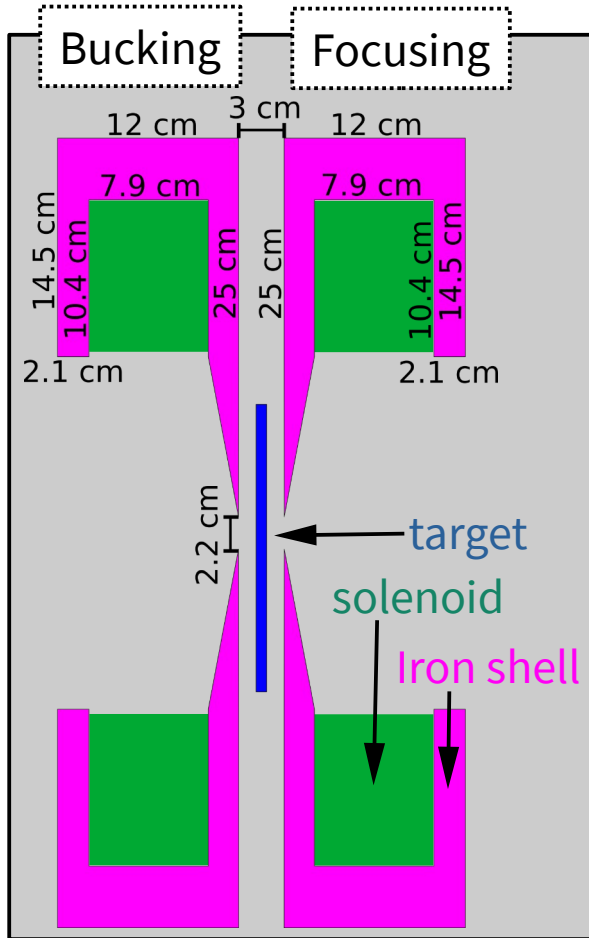
Matching: why?



Matching: why?

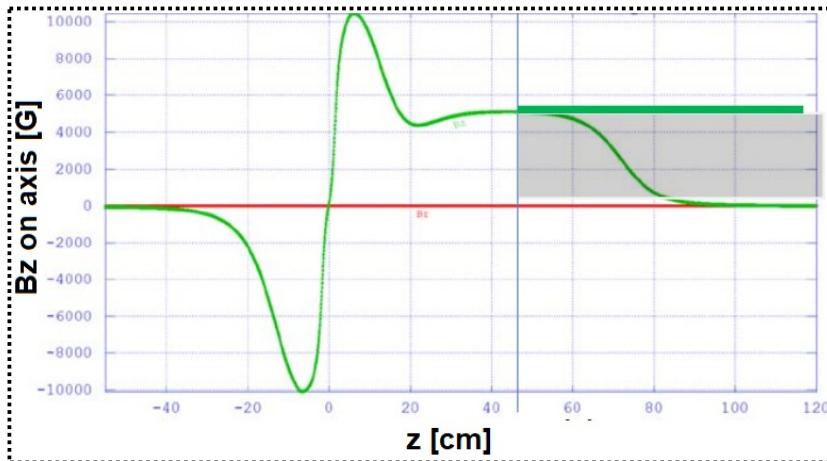


Quarter Wave Transformer (QWT)



2021-03-16

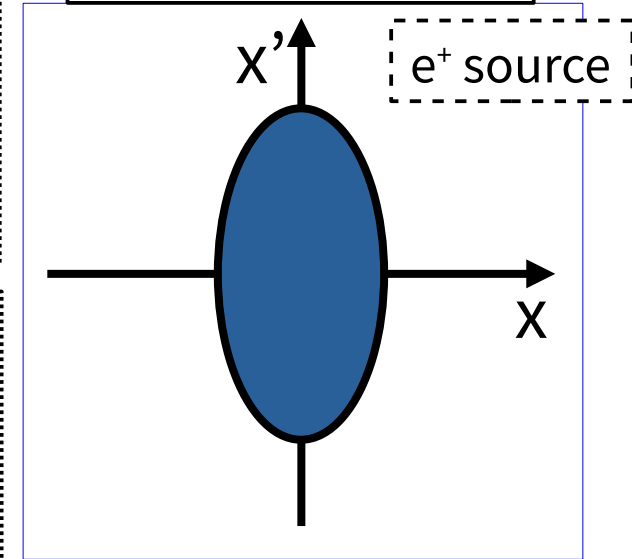
- Peak magnetic field:
1.04 T
- Focussing coil:
match e^+ source to accelerator acceptance
- Bucking coil & iron shell:
minimize eddy current in rotating target



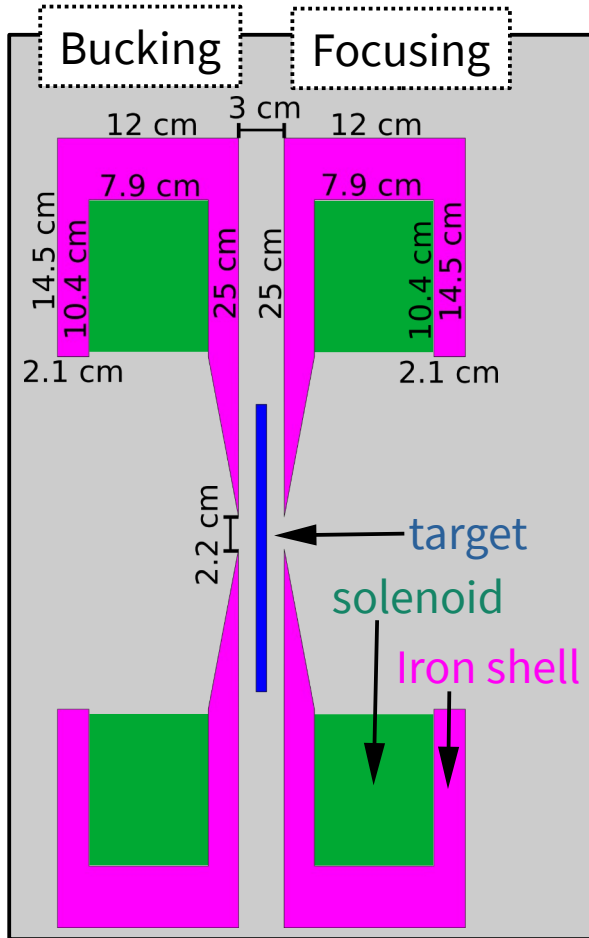
Source: M. Fukuda, 'Undulator Positron Source Capture Simulation' LCWS 2019

If narrow energy width:

Trace-space diagram

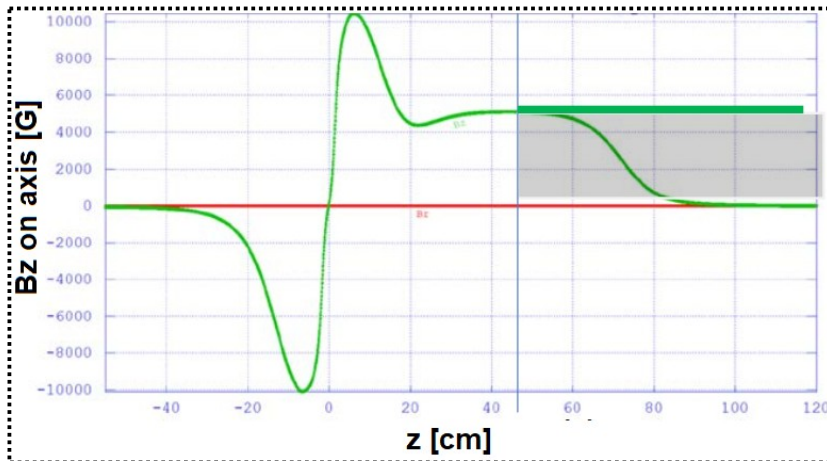


Quarter Wave Transformer (QWT)



2021-03-16

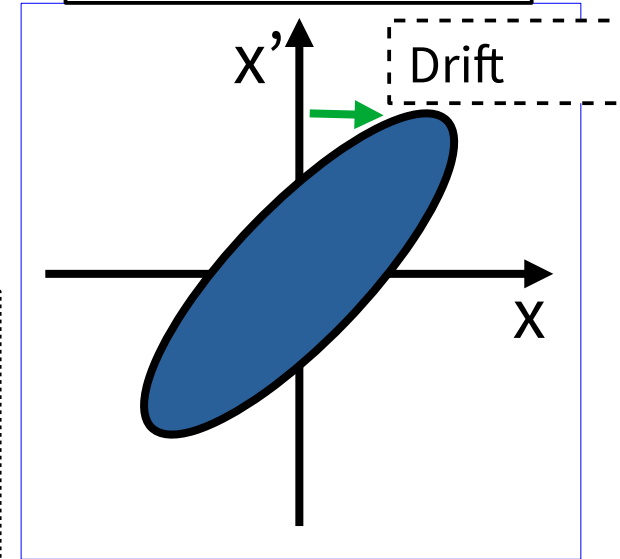
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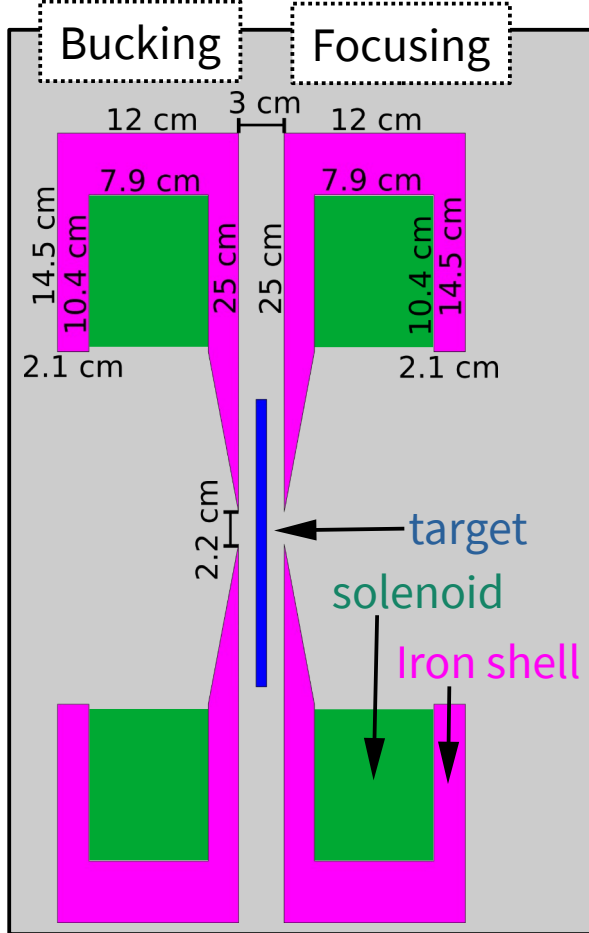
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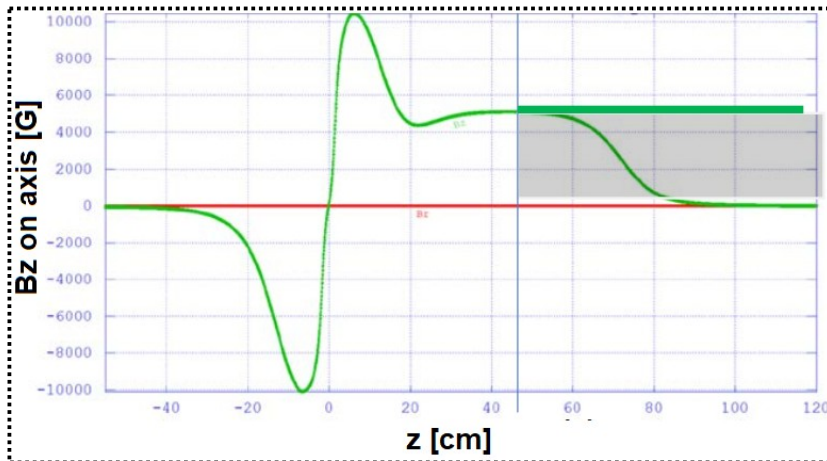


Quarter Wave Transformer (QWT)



2021-03-16

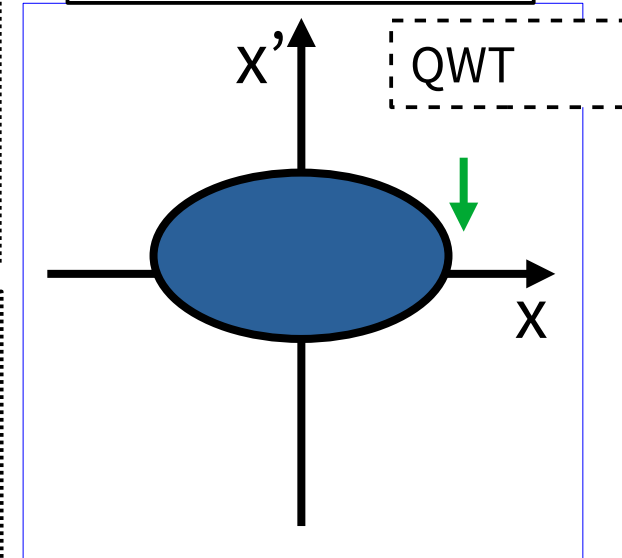
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Source: M. Fukuda, 'Undulator Positron Source Capture Simulation' LCWS 2019

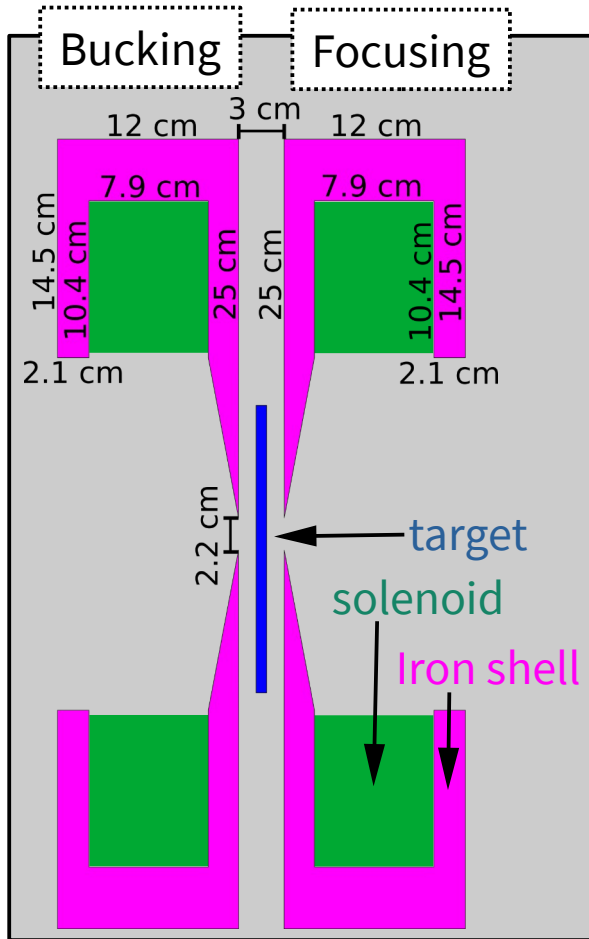
If narrow energy width:

Trace-space diagram



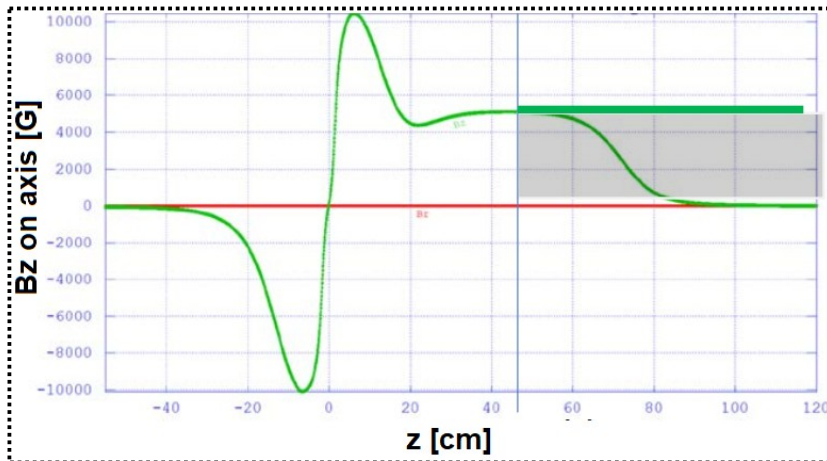
12

Quarter Wave Transformer (QWT)



2021-03-16

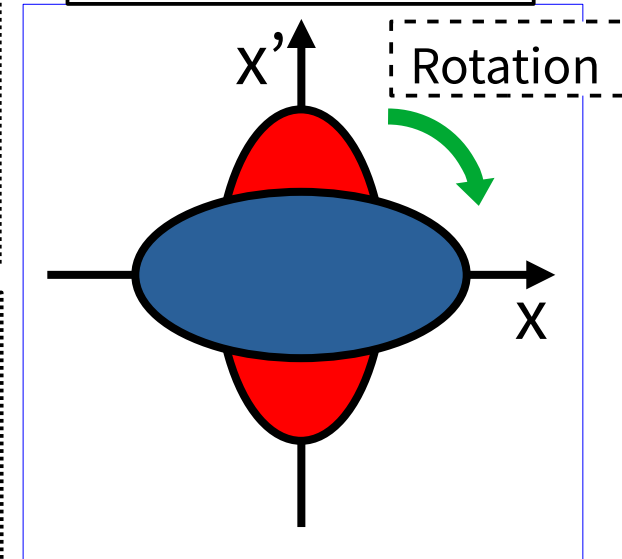
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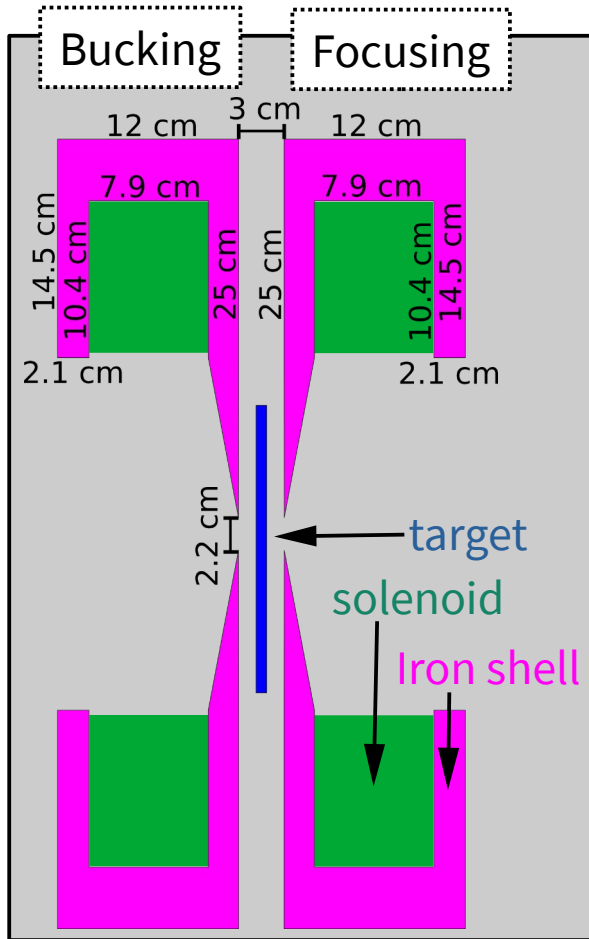
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Trace-space diagram

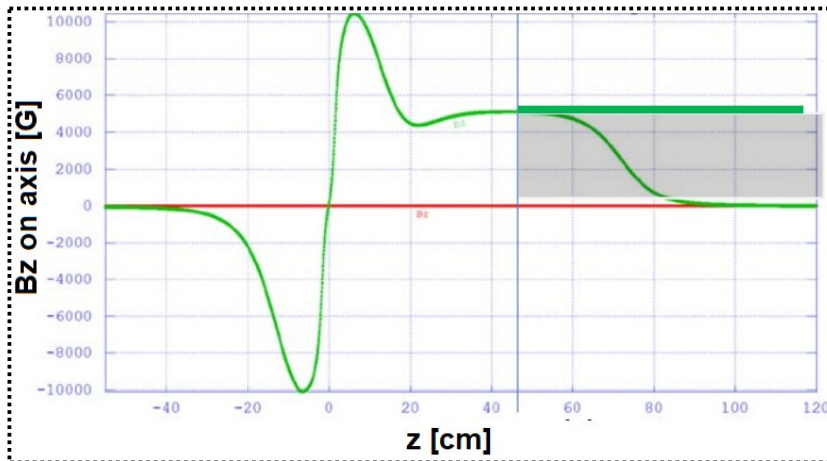


Quarter Wave Transformer (QWT)



2021-03-16

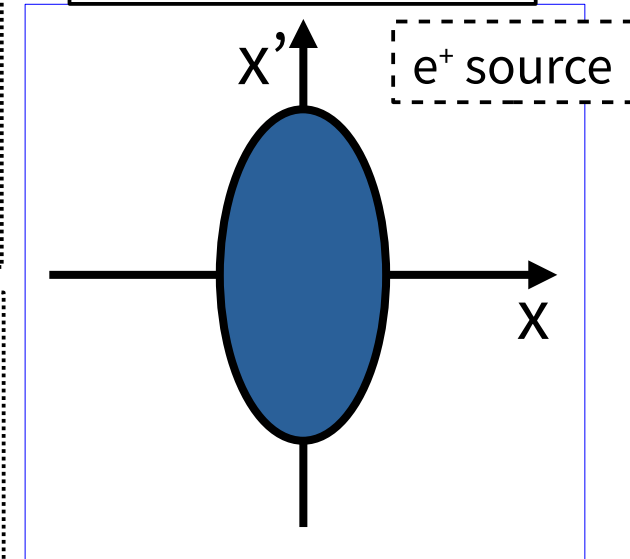
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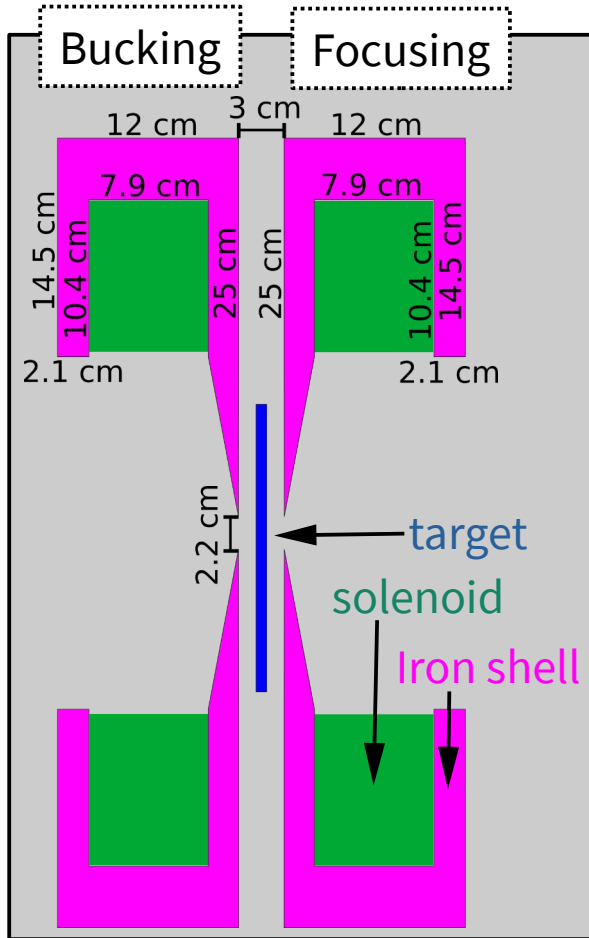
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If wide energy width:

Trace-space diagram

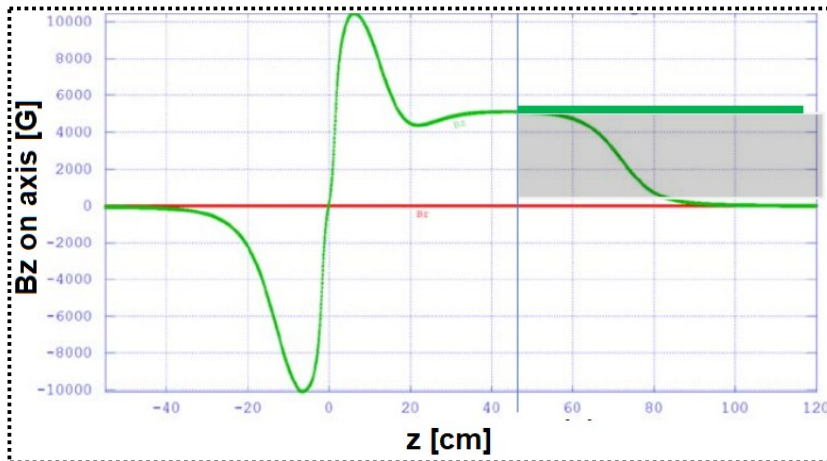


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2021-03-16

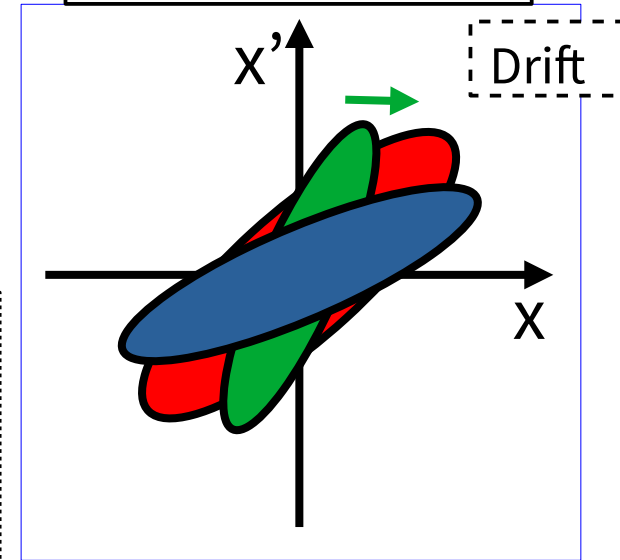
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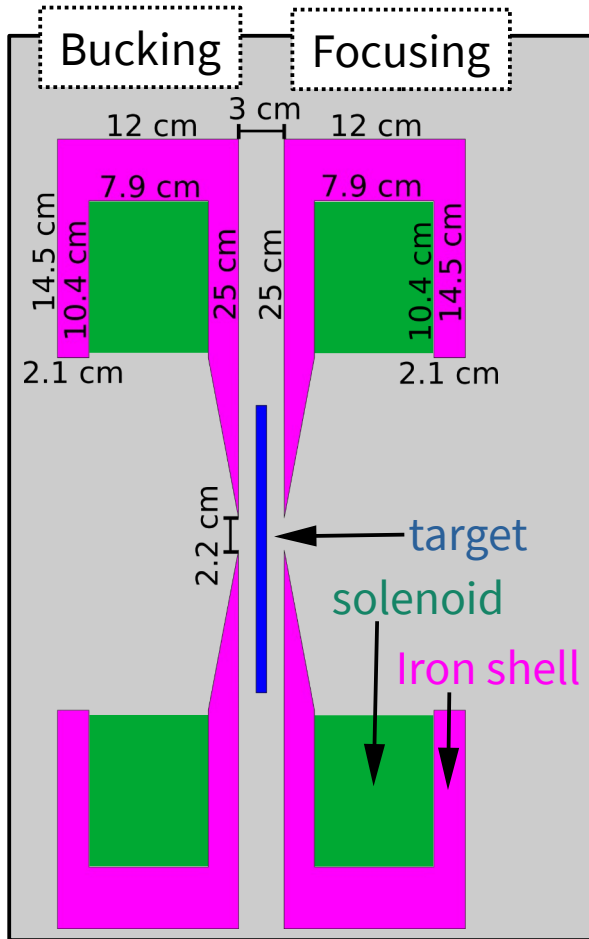
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Trace-space diagram

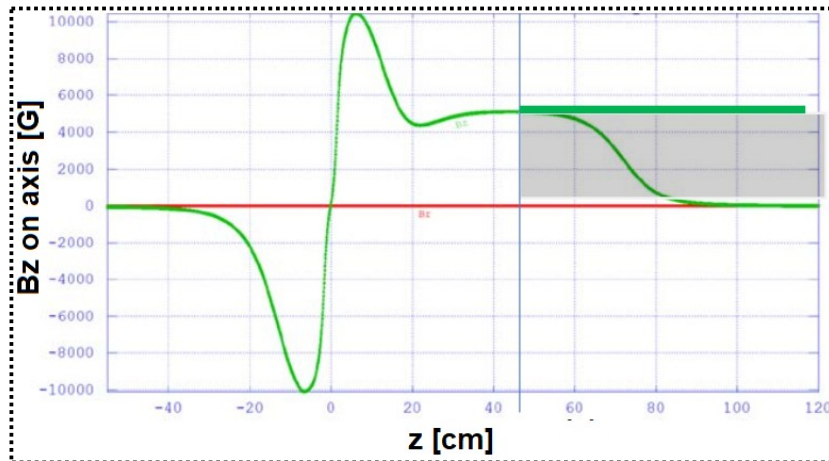


Quarter Wave Transformer (QWT)



2021-03-16

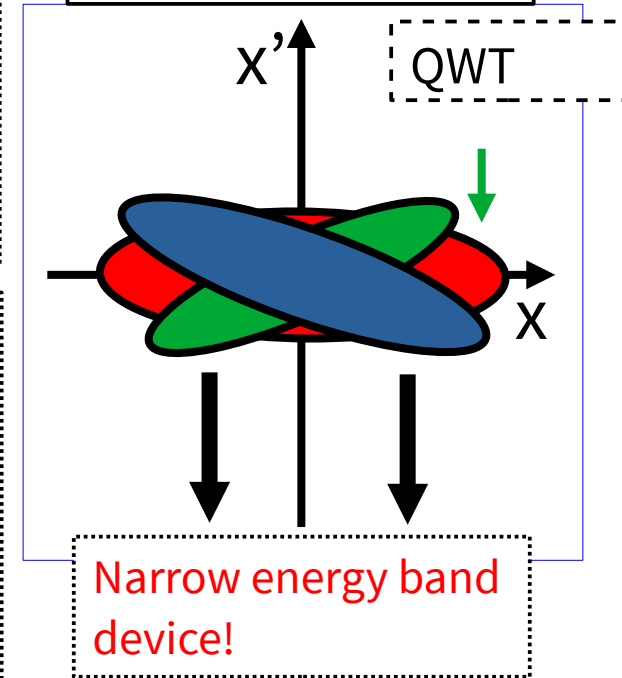
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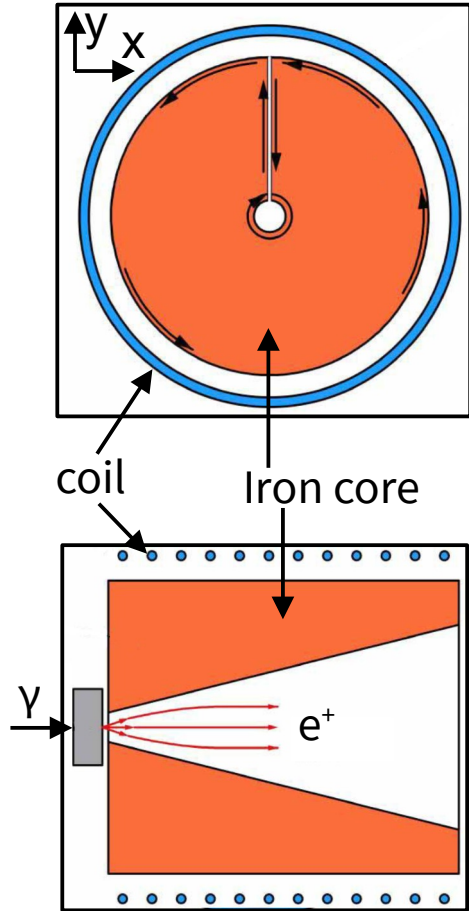
If wide energy width:

Trace-space diagram

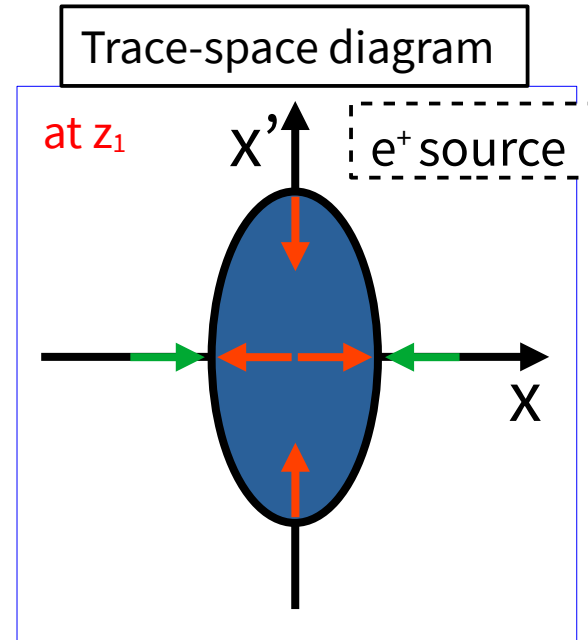
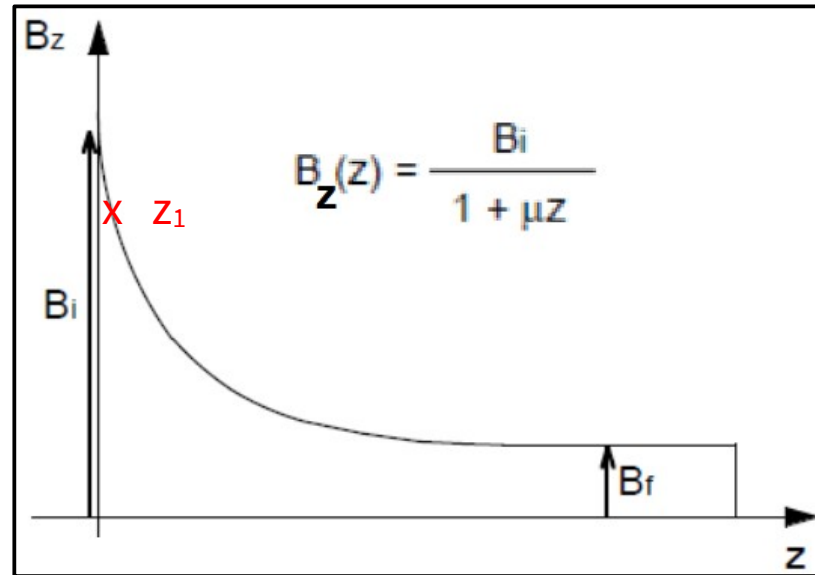


16

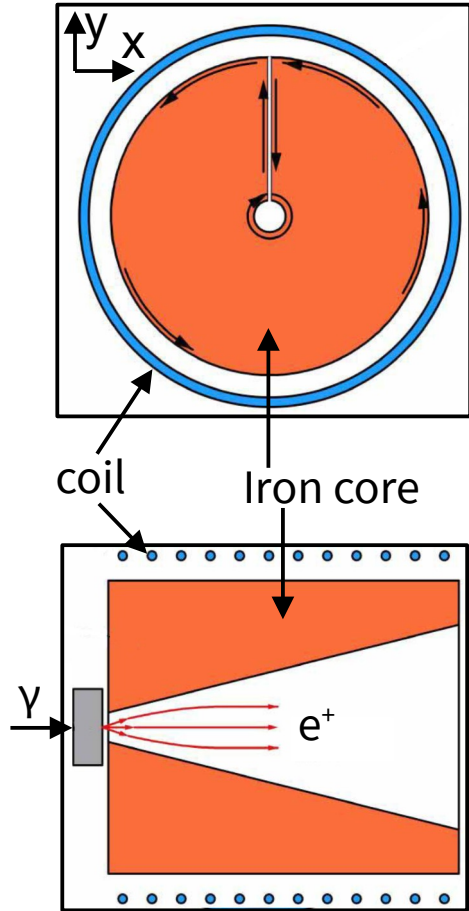
AMD: Flux Concentrator (FC)



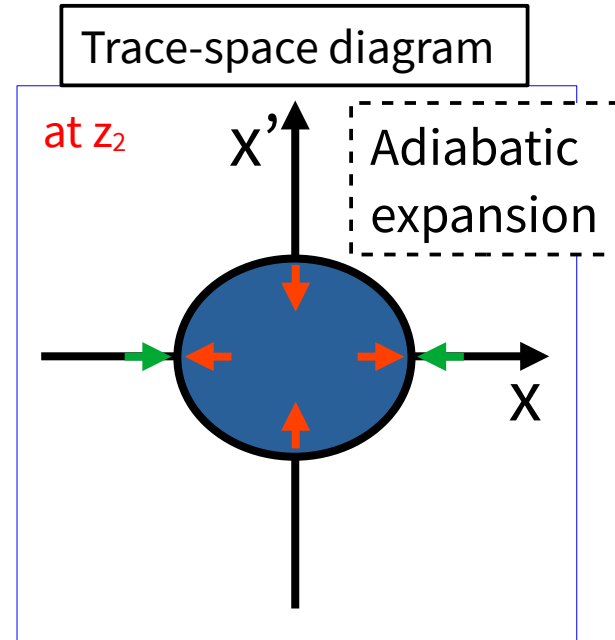
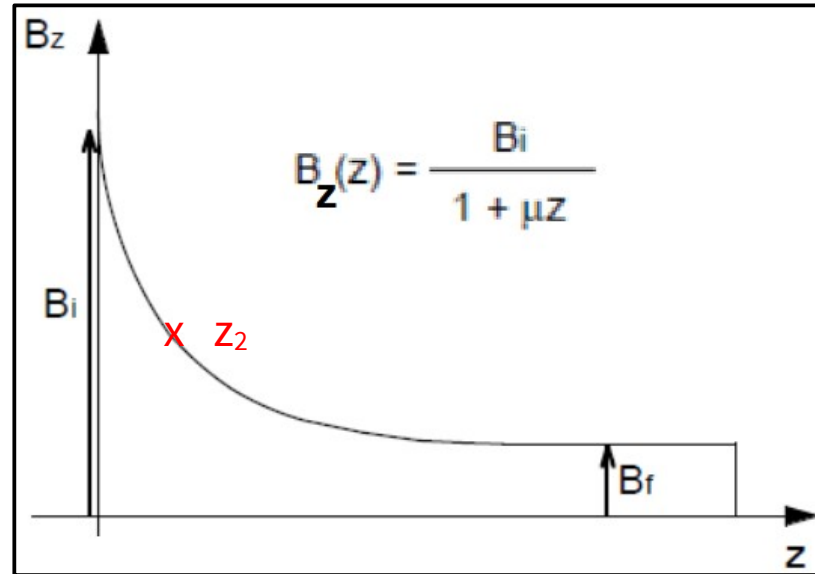
- Normal conducting, pulsed magnetic field:
3.2 T close to target, 0.5 T downstream
- Drag force \rightarrow heat load, stronger drive motor, 5 Hz resonance effects



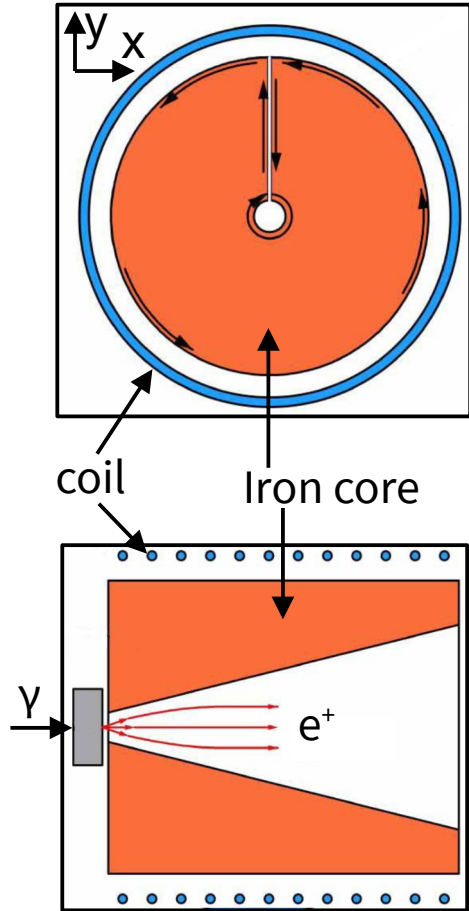
AMD: Flux Concentrator (FC)



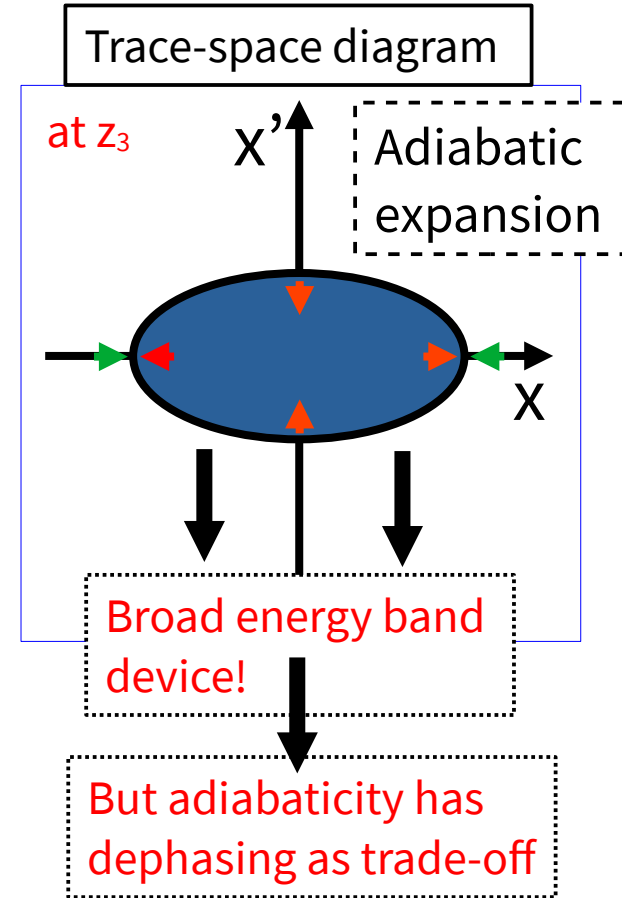
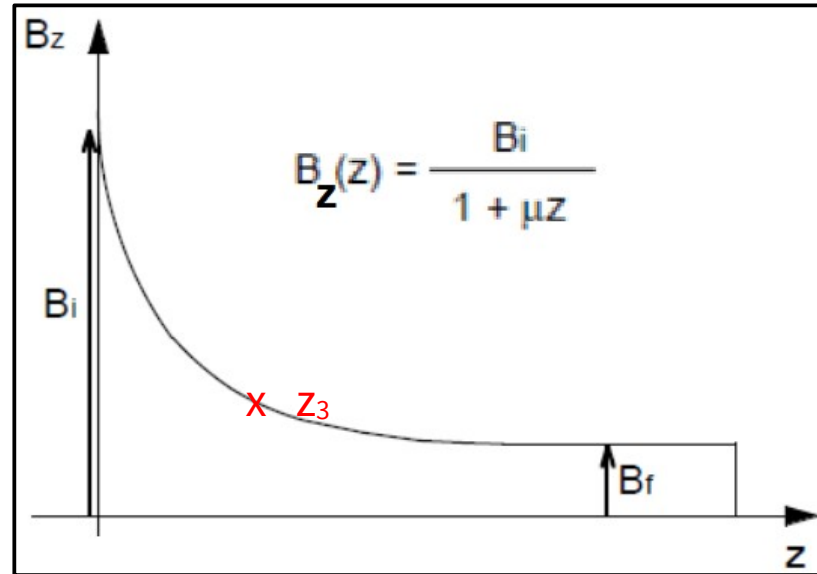
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AMD: Flux Concentrator (FC)



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Plasma Lens: Potential

	QWT	FC
1) Dephasing	- helical	- helical
2) Chromaticity	- high	+ low
3) Eddy current in rotating target	+ manageable	- problematic

Plasma Lens: Potential

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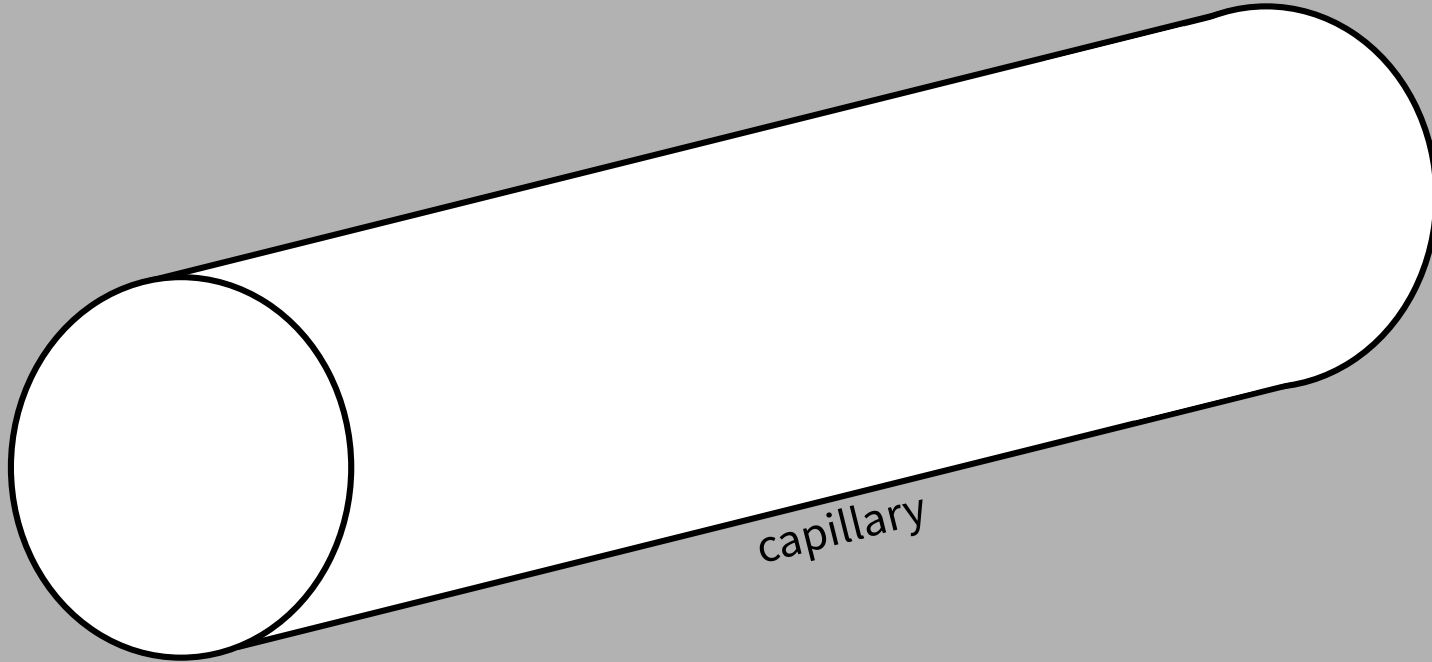


→ difficult for **fast rotating** target
→ **QWT** proposed for ILC

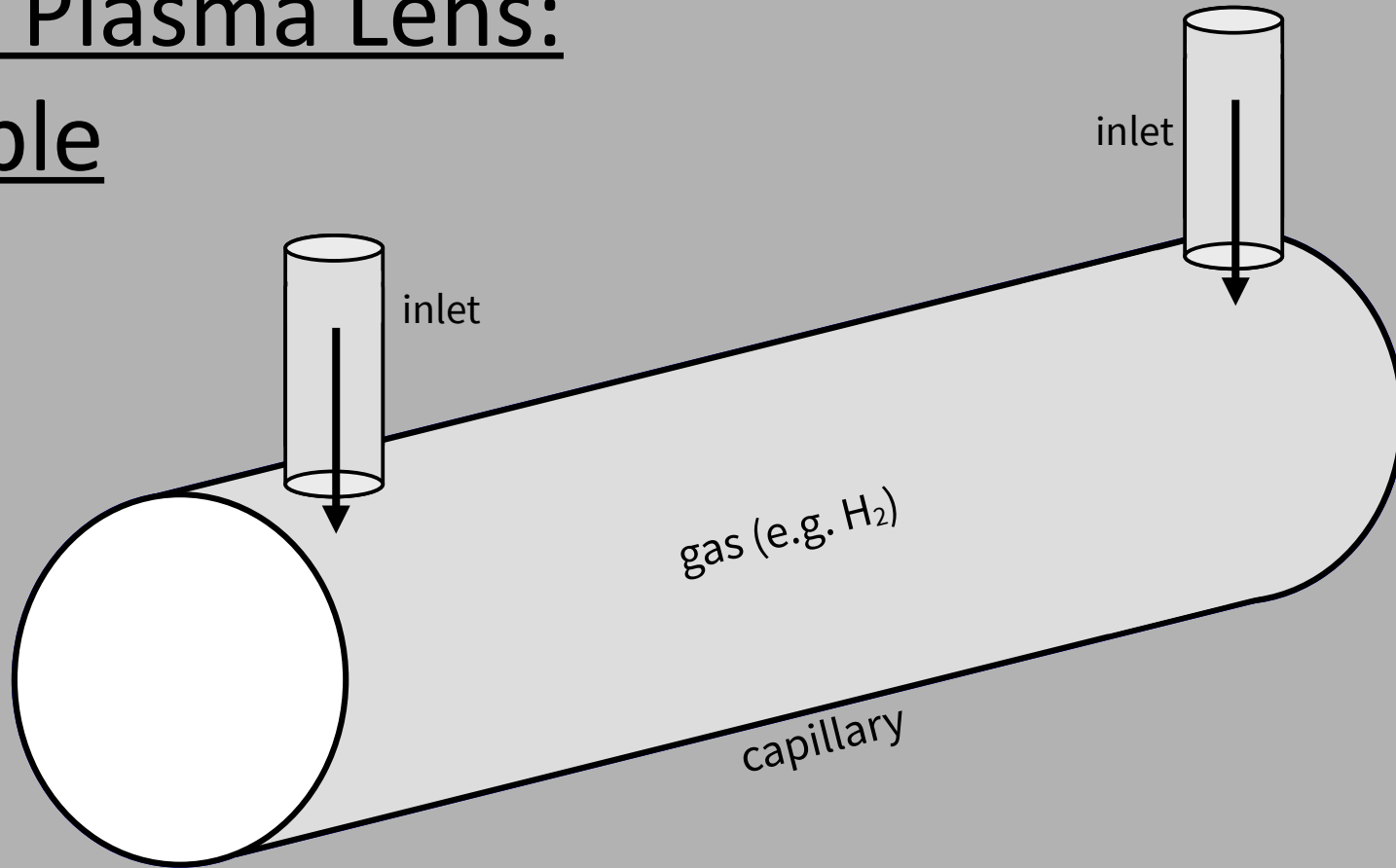
Plasma Lens: Potential

	QWT	FC	PL
1) Dephasing	- helical	- helical	+ sinusoidal
2) Chromaticity	- high	+ low	+ low
3) Eddy current in rotating target	+ manageable	- problematic	++ low

Active Plasma Lens: Principle

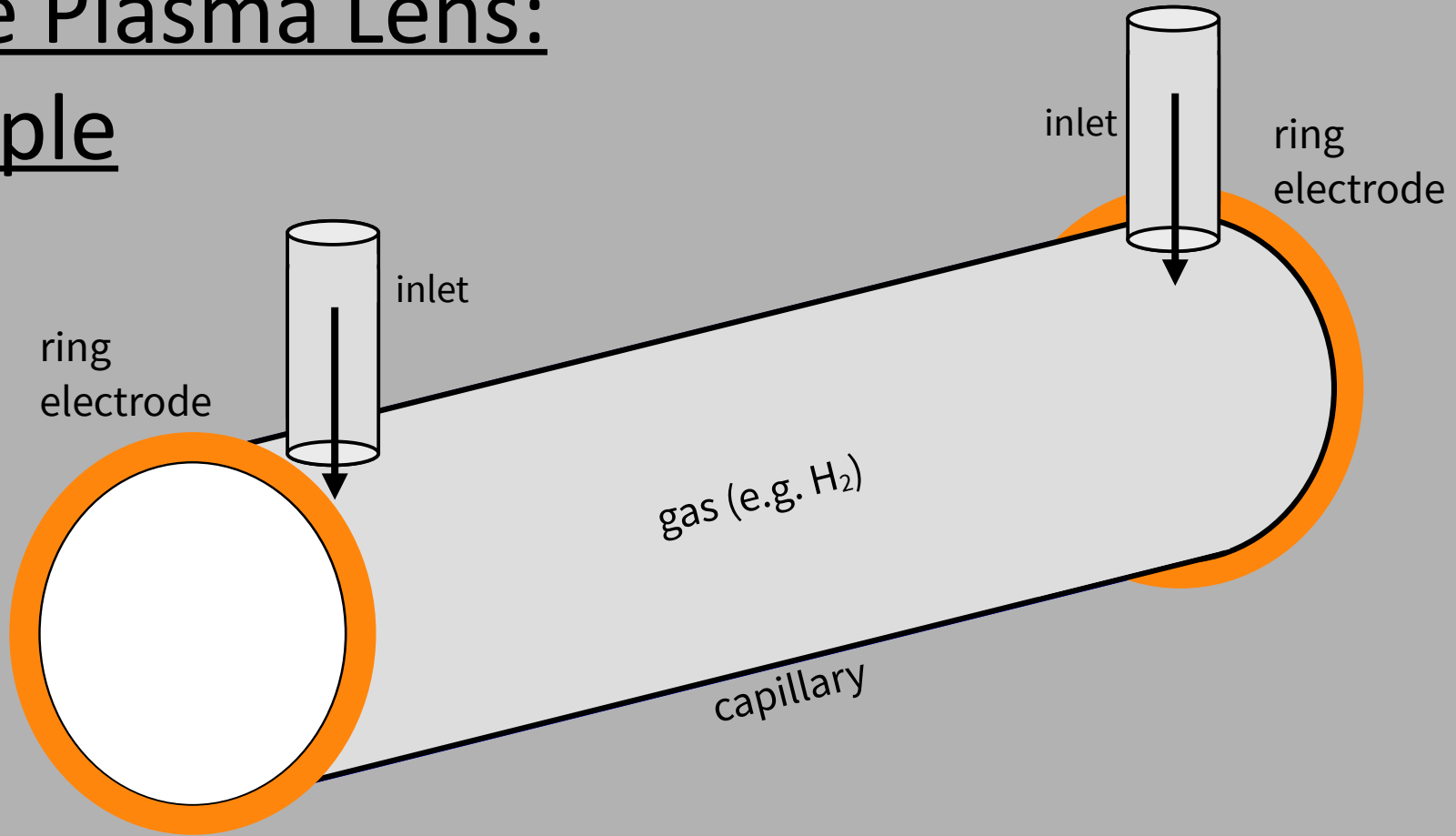


Active Plasma Lens: Principle



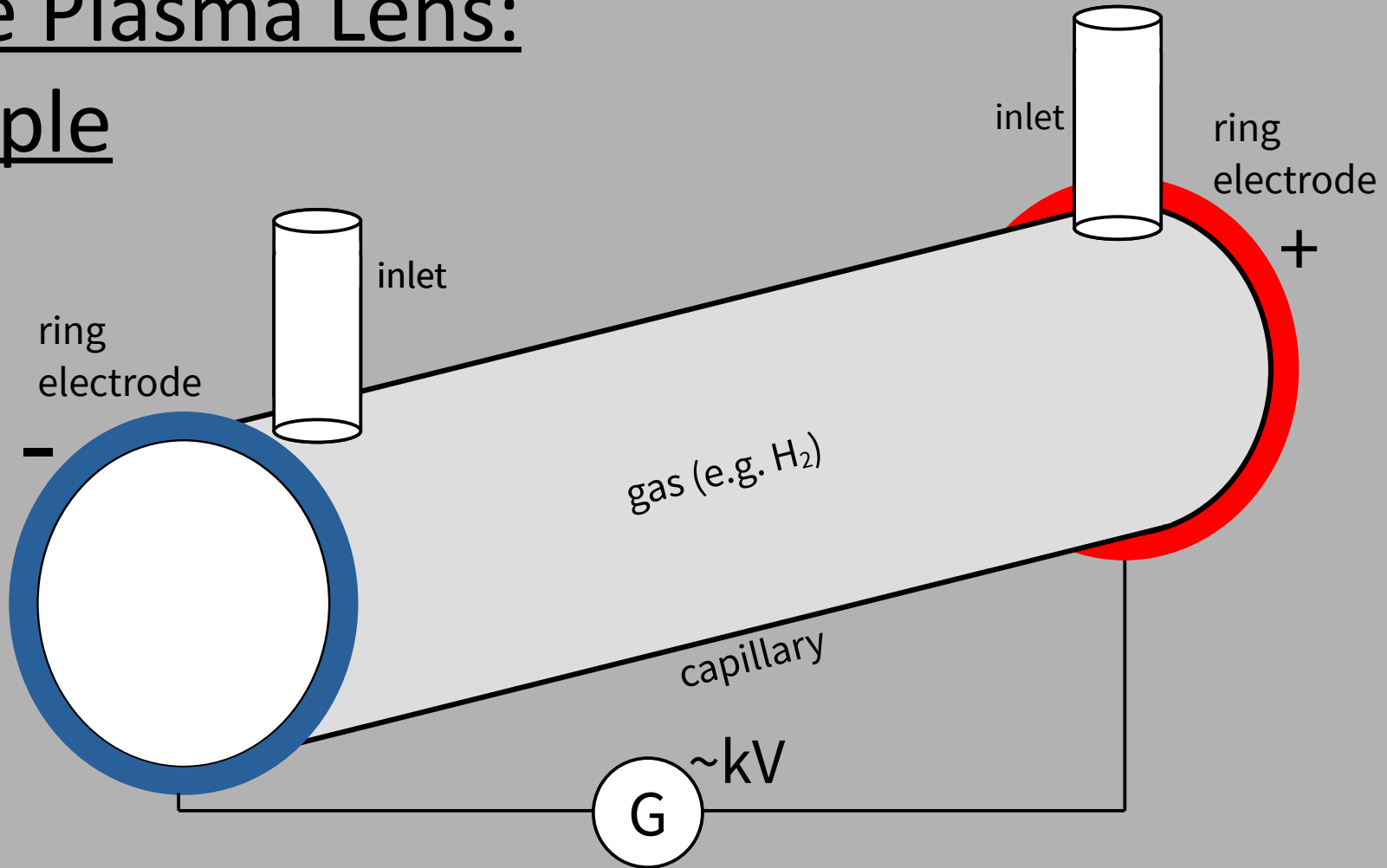
Active Plasma Lens:

Principle



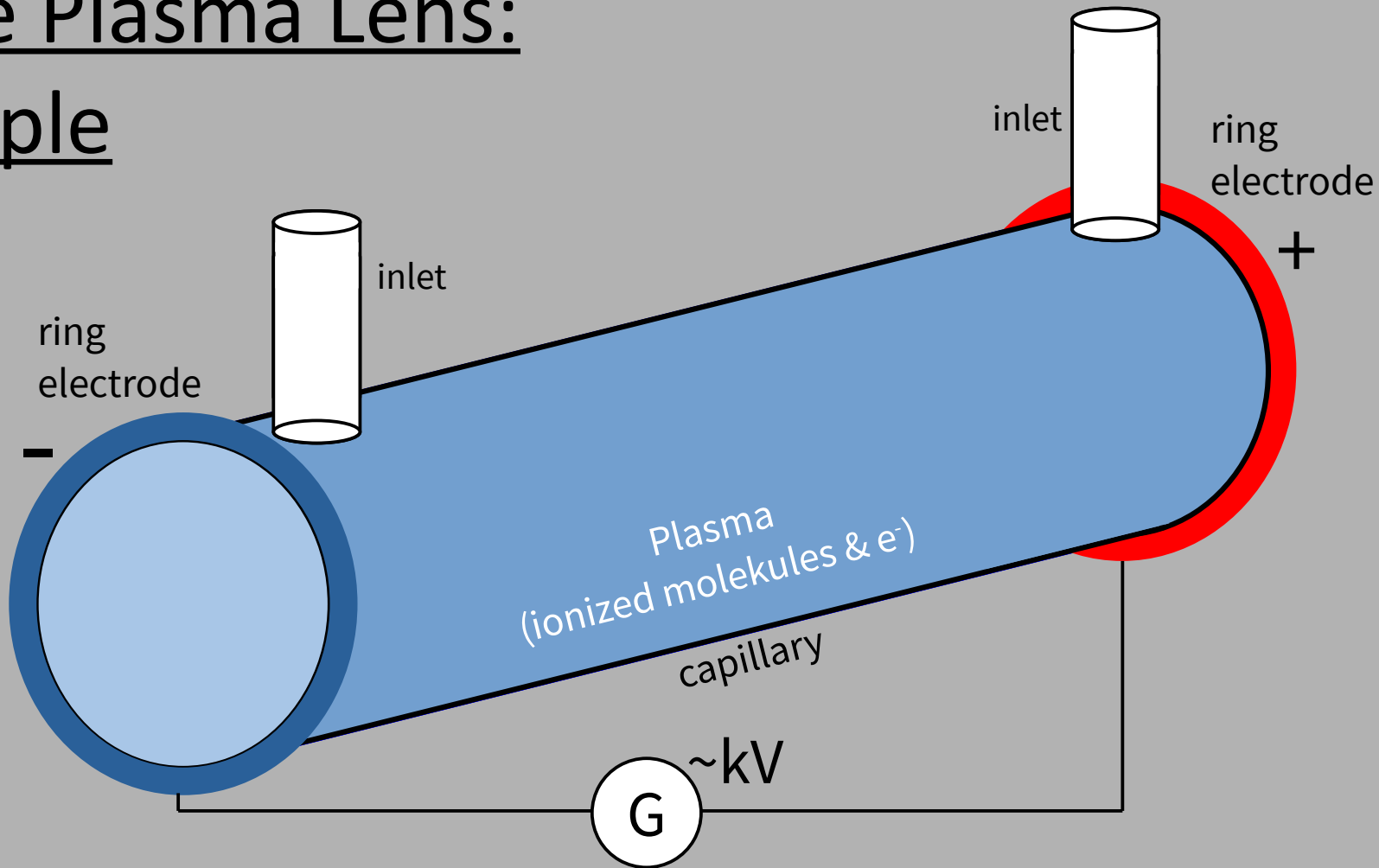
Active Plasma Lens:

Principle



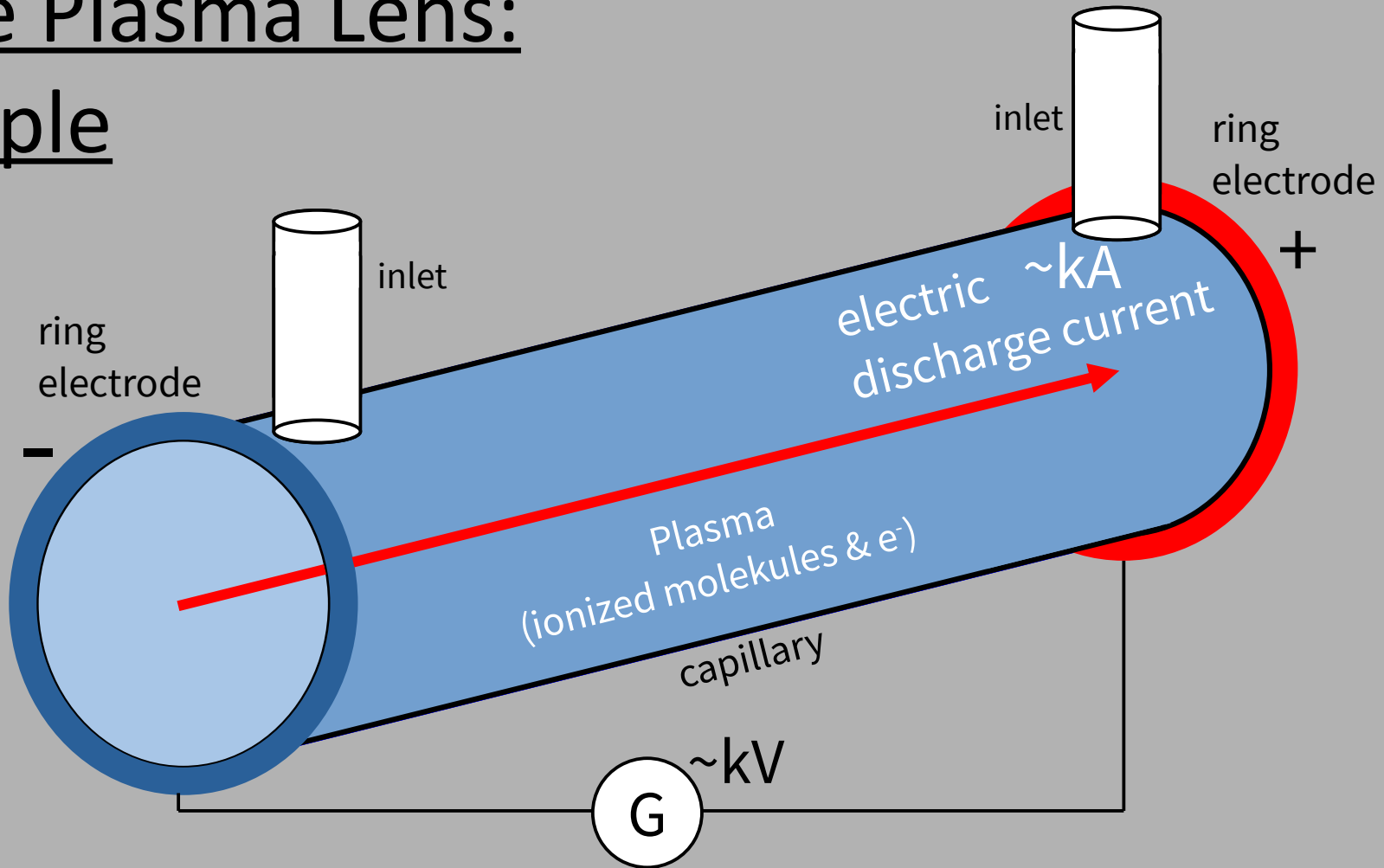
Active Plasma Lens:

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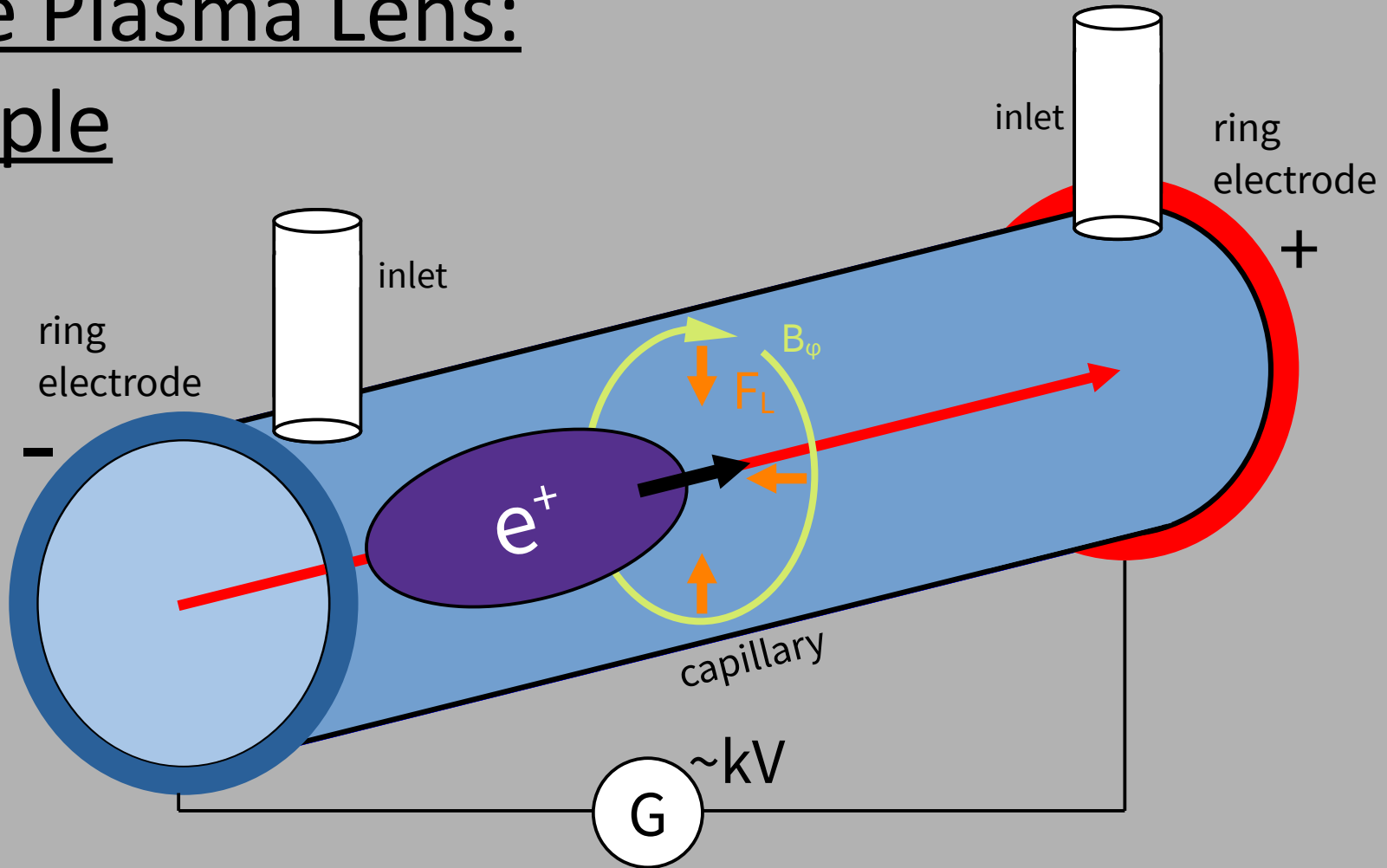
Active Plasma Lens:

Principle

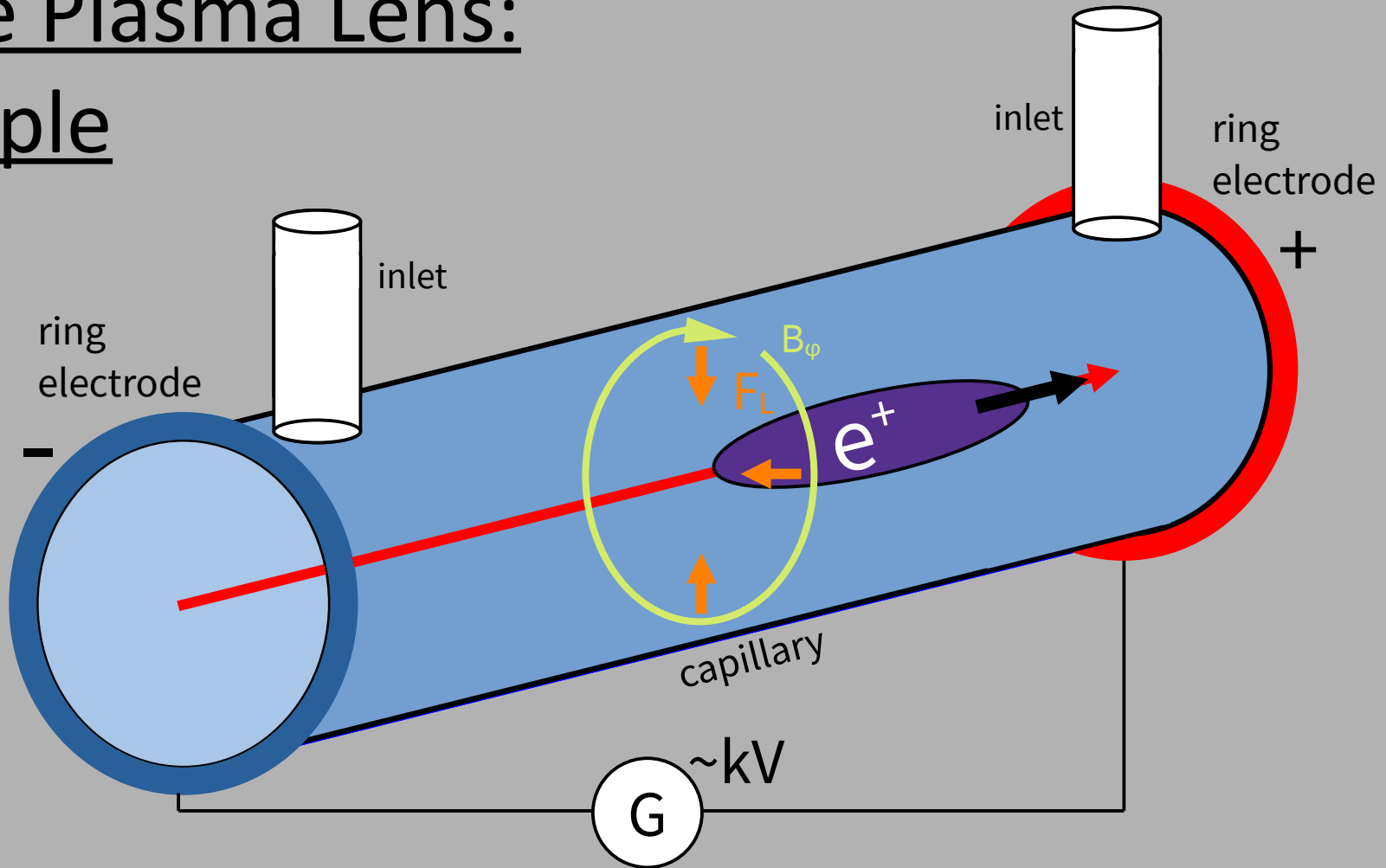


Active Plasma Lens:

Principle

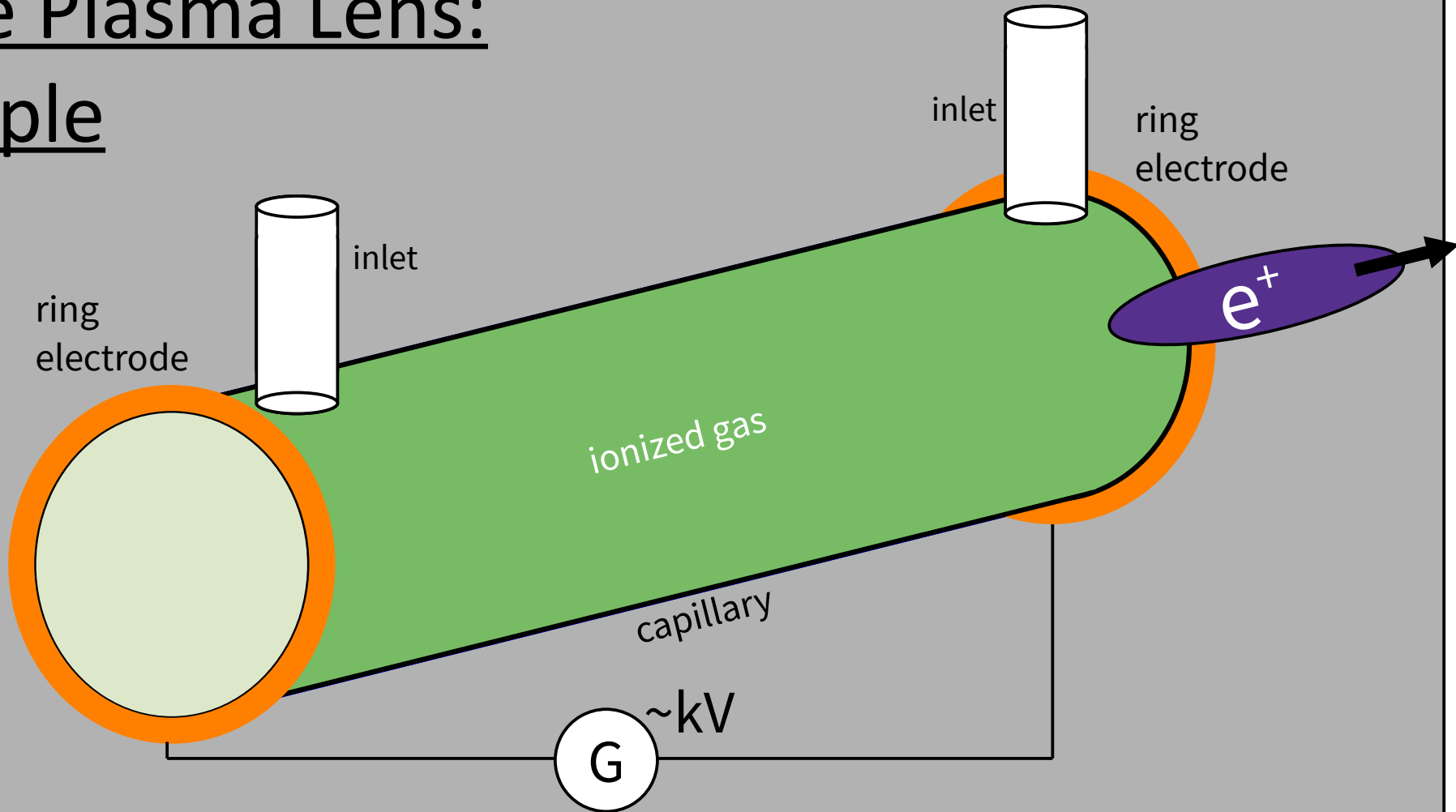


Active Plasma Lens: Principle



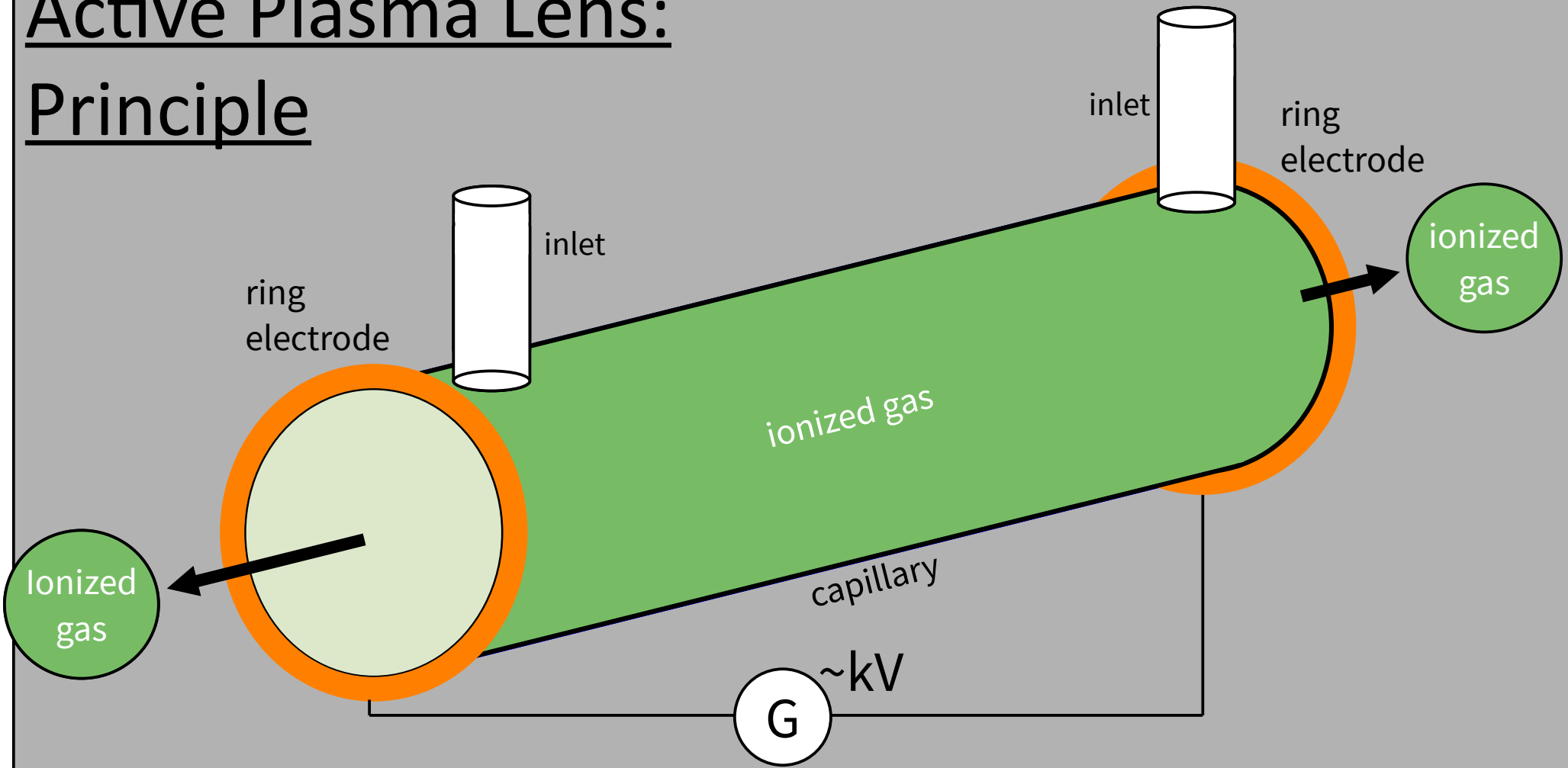
Active Plasma Lens:

Principle



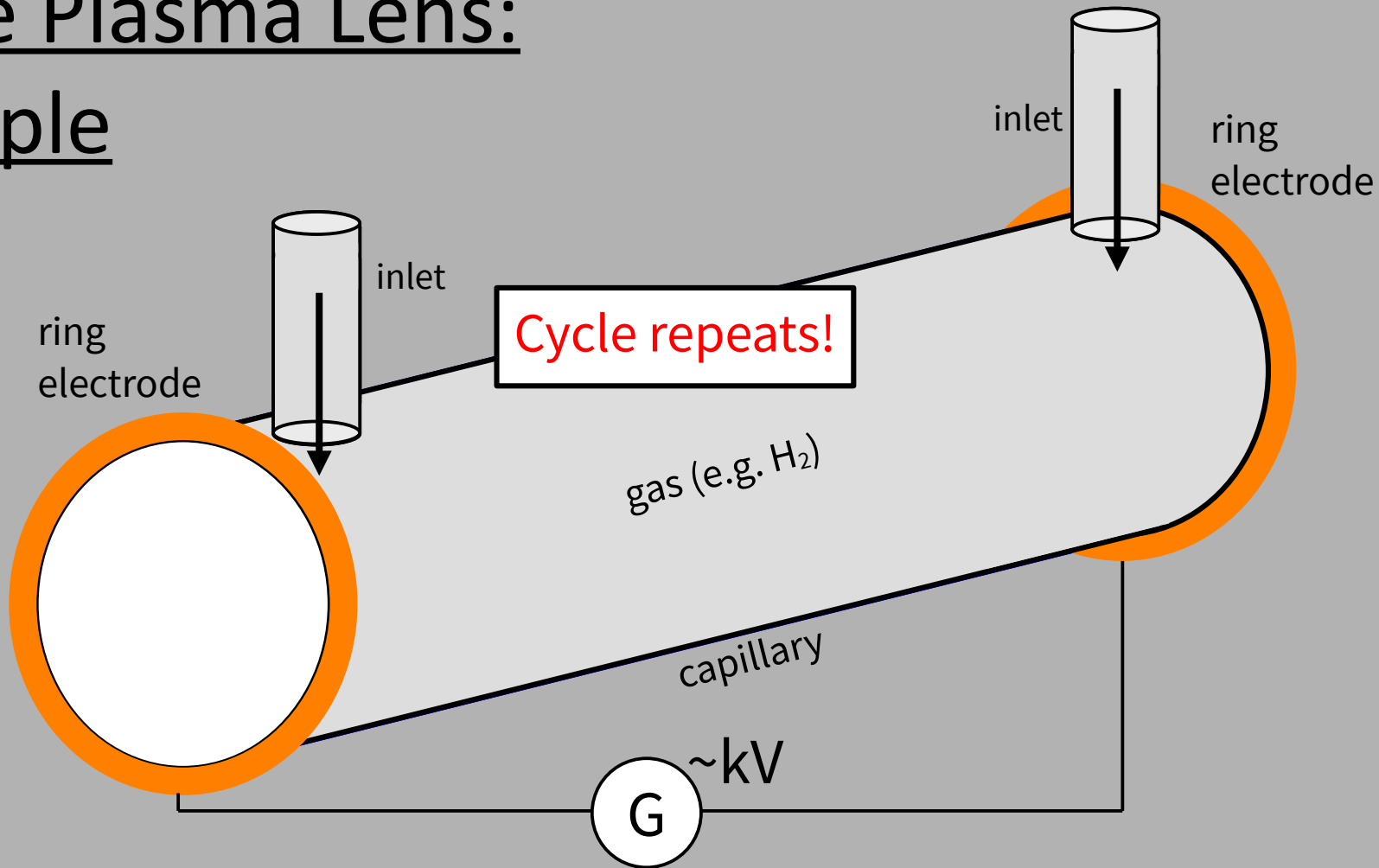
Active Plasma Lens:

Principle

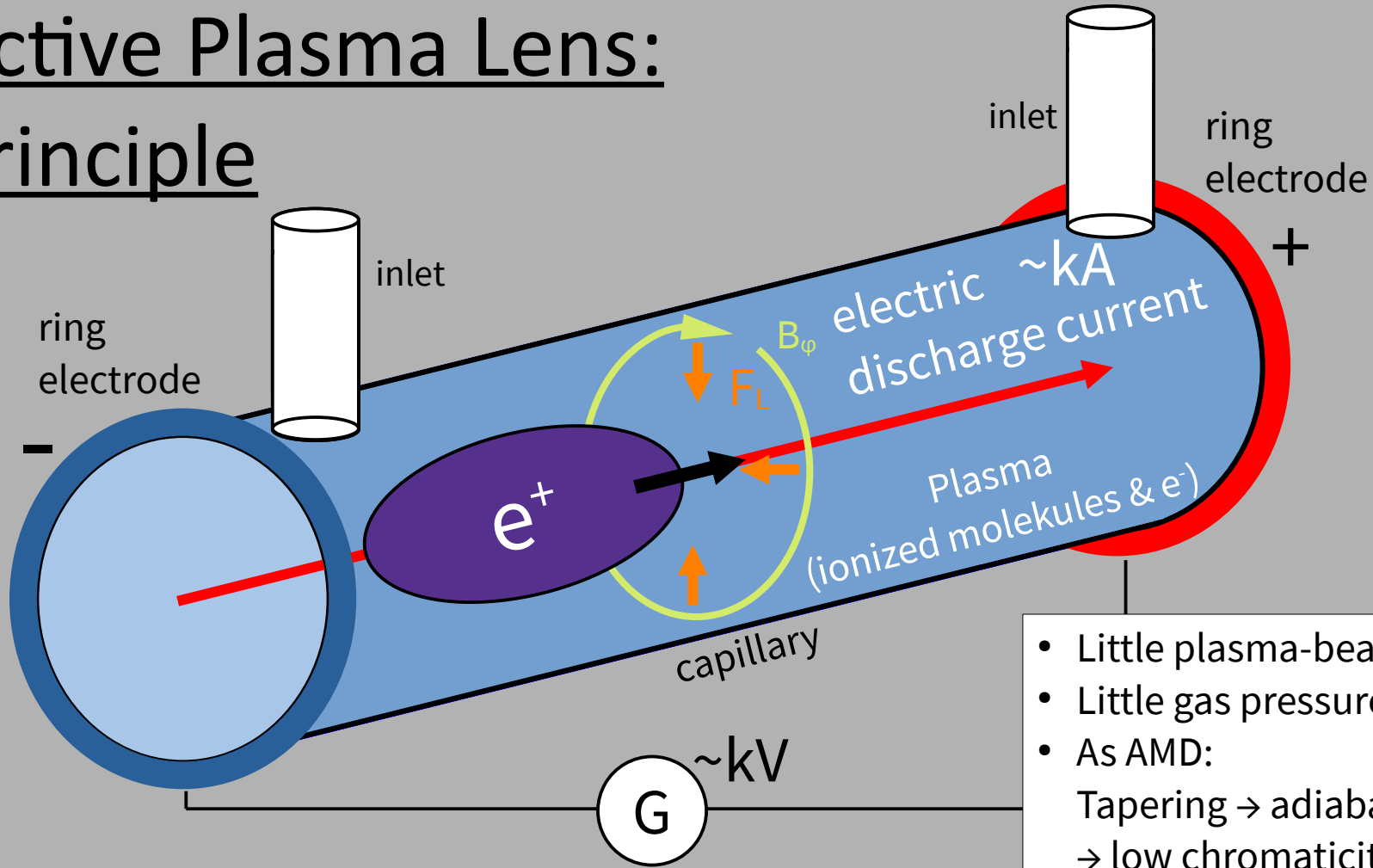


Active Plasma Lens:

Principle

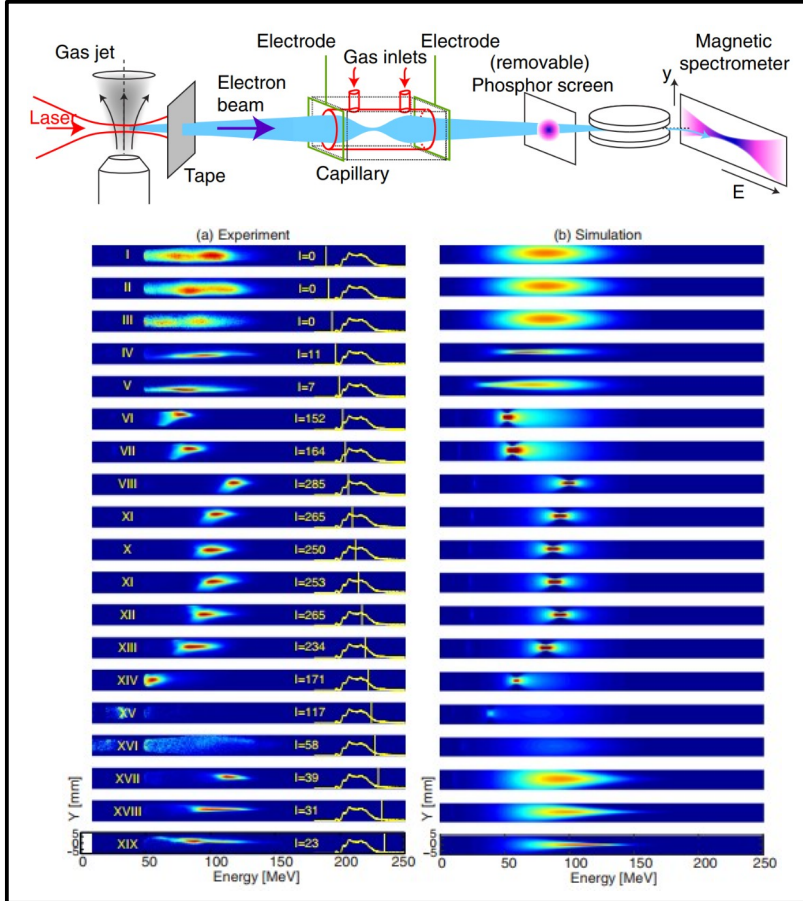


Active Plasma Lens: Principle



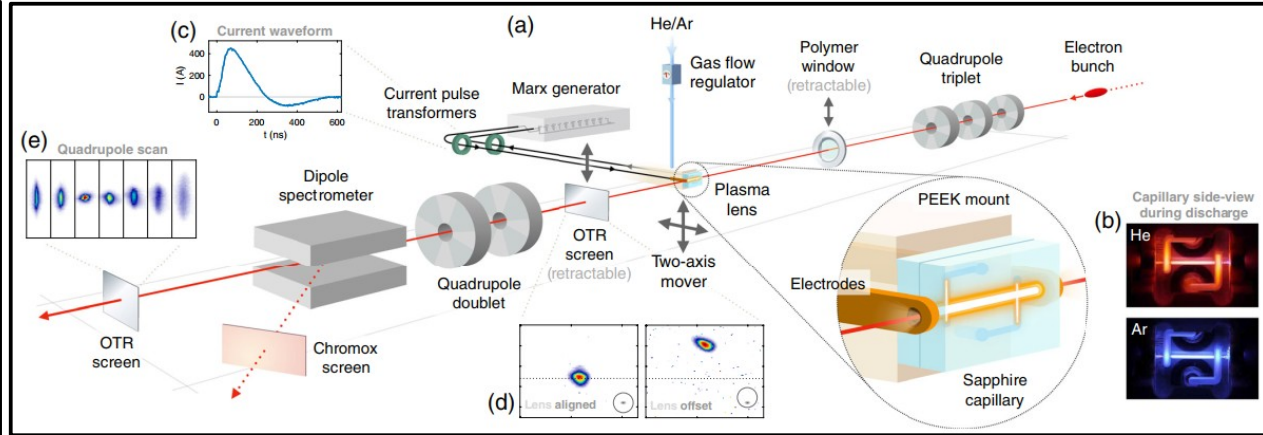
- Little plasma-beam scattering
- Little gas pressure needed
- As AMD:
Tapering → adiabaticity
→ low chromaticity

Active field of research!



Source: Van Tilborg, Jeroen, et al. "Active plasma lensing for relativistic laser-plasma-accelerated electron beams." *Physical review letters* 115.18 (2015): 184802.

3/17/21



Source: Lindström, Carl A., et al. "Emittance preservation in an aberration-free active plasma lens." *Physical review letters* 121.19 (2018): 194801.

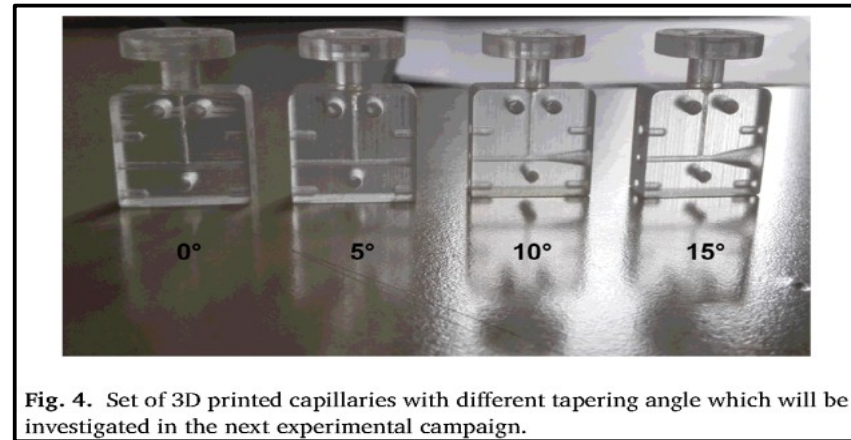


Fig. 4. Set of 3D printed capillaries with different tapering angle which will be investigated in the next experimental campaign.

Source: Filippi, F., et al. "Tapering of plasma density ramp profiles for adiabatic lens experiments." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 909 (2018): 339-342.

Outlook

- No windows? Is an exit window possible due to widened beam?
- Electrode implementation?
- Gas inlets?
- Wakefields? Avoided by neutral e^-e^+ beam passing the capillary?
- Cavity behaviour under vacuum conditions near the target?
- What discharge routine? One for each bunch? For each pulse?



Next Talk: Simulations of PL as OMD
by Niclas Hamann

Thank you for your
attention!