Final Focus and Drift Compression Concepts

by

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Typical beam pulse at Experiment

Implications for final focus and Compression

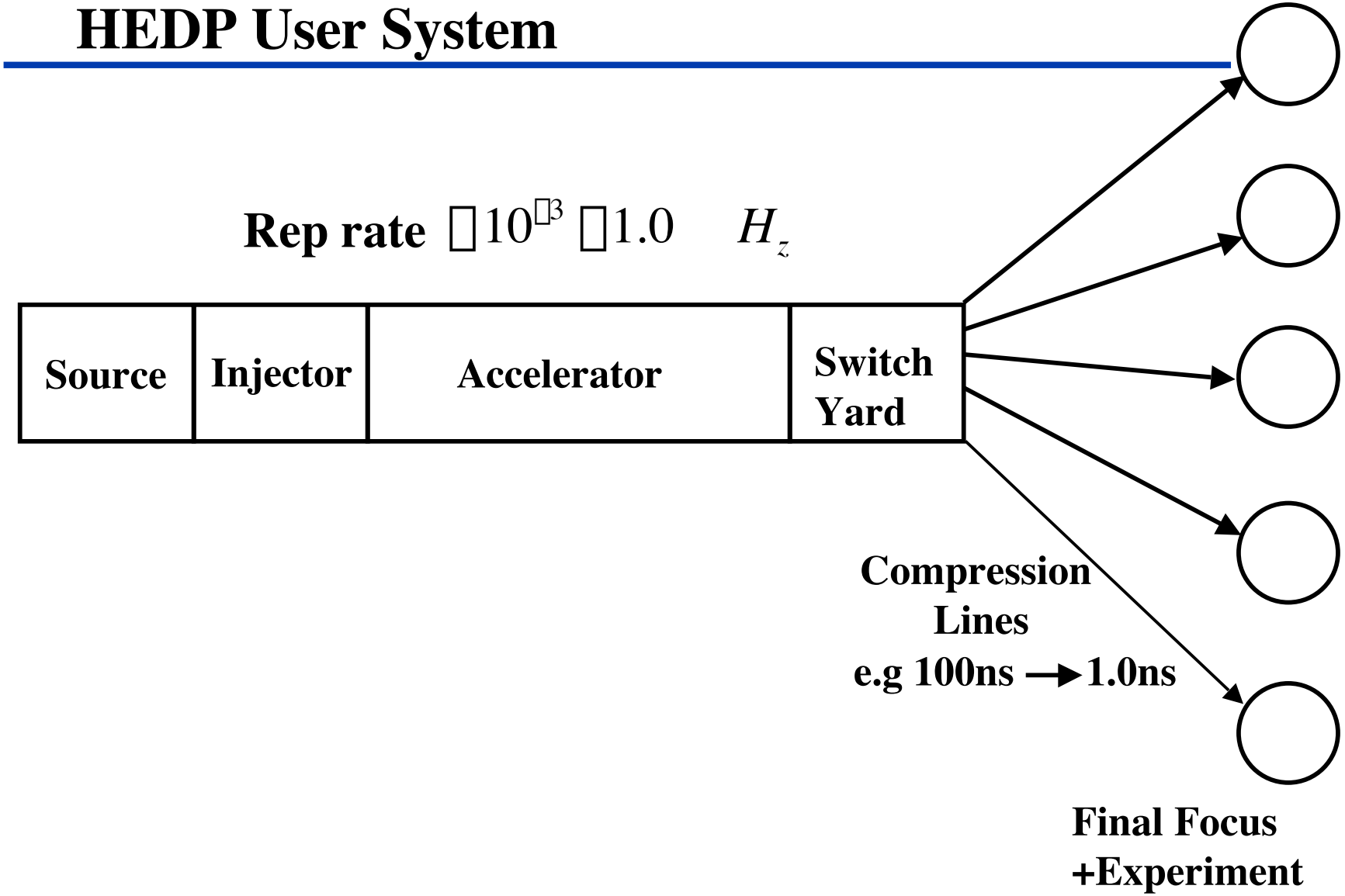
Some Issues

A simple focal system

More Considerations

Group Objectives

HEDP User System



Consider the "Workshop Objectives" Example

19 MeV Ne^{+}: □ = .0451, Mass = 20 amu

Spot radius = 1.0mm, $N_{ion} = 1.4 \times 10^{13}$

Pulse duration = 1.0ns, Target = 70□m Al foil

Total beam energy ≳ 42.6 J (beam wings are clipped)

Total charge = $\frac{energy}{volts}$ ≳ 2.24 □C

Ion Current = $\frac{charge}{time}$ ≳ 2.24 kA

Space Charge Potential / Accelerator Potential || .08 Large!

→ We must neutralize with electrons to focus

The pulse is compressed by imposing a head-to-tail velocity tilt at the end of acceleration

e.g. 100 ns ⟶ 1.0 ns

1.35 m ⟶ 1.35 cm

Tilt = $\frac{\square\!/}{\square}$ **<< 1 (avoid chromatic problems)**

example

Compression Distance = $\frac{Pulse\ \ length}{tilt} = \frac{1.35m}{.06} = \underline{\underline{22.5m}}$

The pulse must also be neutralized for this to work

Conclude so far:

HEDP with ion beams → large space charged force → neutralize

→ this must work in magnets

Some issues:

How large are deviations from charge and current neutralization?

Is the beam - electron interaction stable?

If plasma is used, what about stripping, scattering and energy loss?

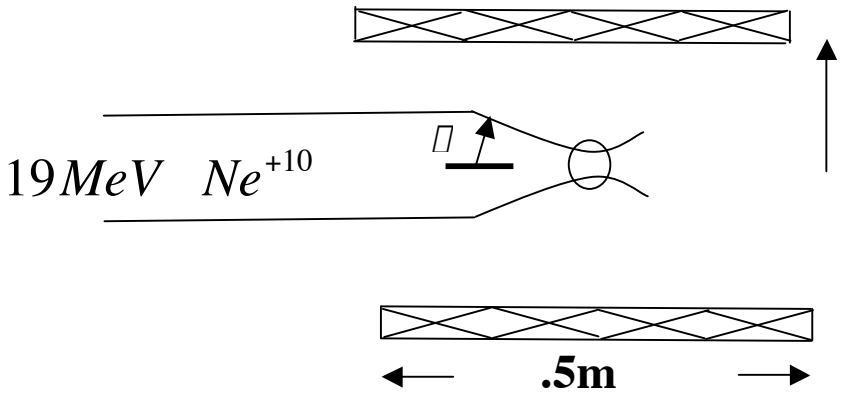
What is the limit on tilt?

Answers will depend on details - system and experiment

Motivation for a short, simple focusing system

- Short drift compression sections are achieved with large head-to-tail velocity tilt
- Due to large space charge force the pulse must be neutralized by electrons
- Tilt (e.g. $\pm$ 5%) is not removed by space charge field before final focus
- Large tilts cause large chromatic aberrations in traditional final focus systems
- Aberration may not be compensated with pulsed lenses - due to plasma -

HEDP with a single beam can employ a single solenoid



(Not to Scale)

Bpeak ~ 4.1T

beam radius (a)	1.0cm
convergence angle (α)	65mr
beam rigidity (Bρ)	.28T-m
beam emittance (ε)	10^{-5}-10^{-4}m-r
spot radius (r_s)	.15-1.5mm
momentum variation	ΔP/P = 0- ± .05

(Simple parallel - to - point focus)

- Fringe field and geometric aberrations are negligible due to small beam radius
- Watch out for "depth of focus" in experiment

Chromatic aberration can be estimated (and numerically verified)

$$r_{spot}^2 = \left(\frac{\theta}{\theta'}\right)^2 + \left(\frac{1}{2} a \frac{\Delta P}{P}\right)^2 = (.14 \to 1.4mm)^2 + (0 \to .78mm)^2$$

$$\theta = 10^{-5}\, m \to r$$

$$a = 1.0cm$$

$\Delta P/P$	r_s	r_s estimated
-.06	.96mm	.96mm
-.04	.64	.65
-.02	.34	.35
.00	.15	.15
.02	.33	.35
.04	.60	.65
.06	.87	.96

More Considerations

Beam switch yard achromatic design?

Transport magnets in compression - solenoid best?

Strip before final focus or compression?

Matching into neutralized drift

Experiment inside the final focus ok?

Emittance growth mechanisms

How accurately must the tilt be applied?

Flexibility for the experimenter

Final Focus/ Compression Group

Keep in close contact with accelerator and experiment groups. Accommodate the possible, object to the impossible!

Carry out a wide range of calculations and analysis for final focus//compression

Desire useful design formulas

Write many short reports ⟶ Final Report

Guidance for future work