

# Performance of a Hexagonal, Segmented Railgun

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Electromagnetic acceleration

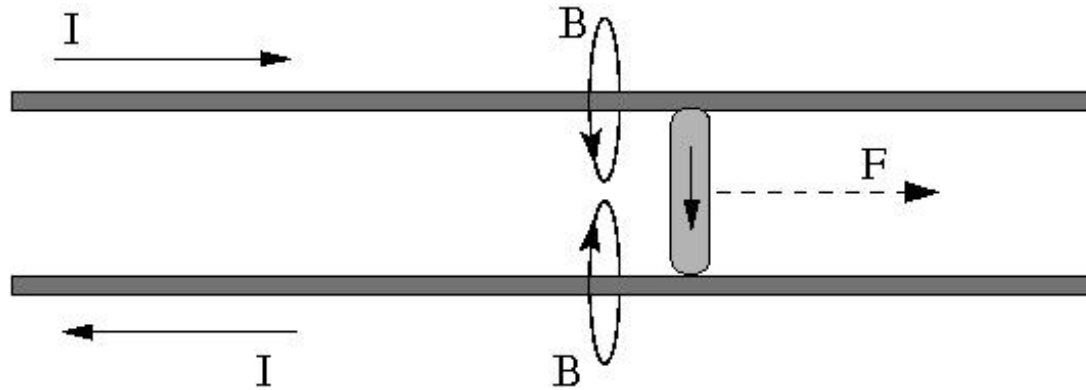


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# Principle of a Railgun



Railgun force law:

$$F = \frac{1}{2} L' \cdot I^2$$

$$E_{el} \sim 10^6 \dots 10^8 \text{ Joule}$$

$$I \sim \text{Megaampere}$$

$$T_{accel} \sim 10^{-3} s$$

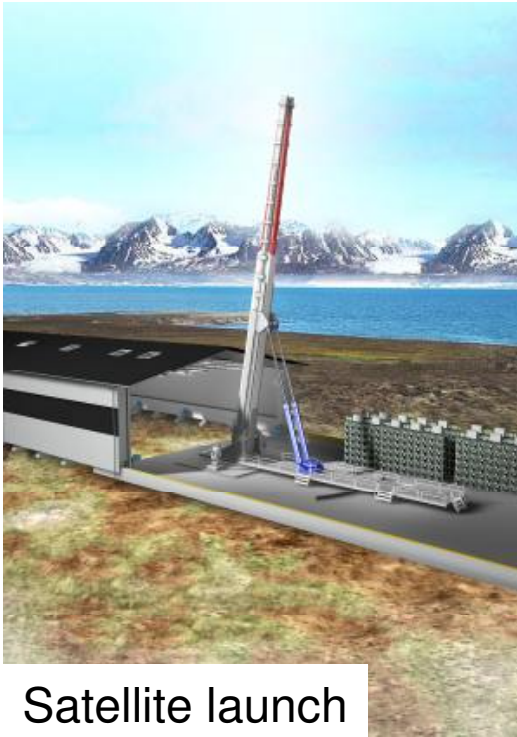
$$P \sim \text{Gigawatt}$$

$$v \geq \text{several km/s}$$

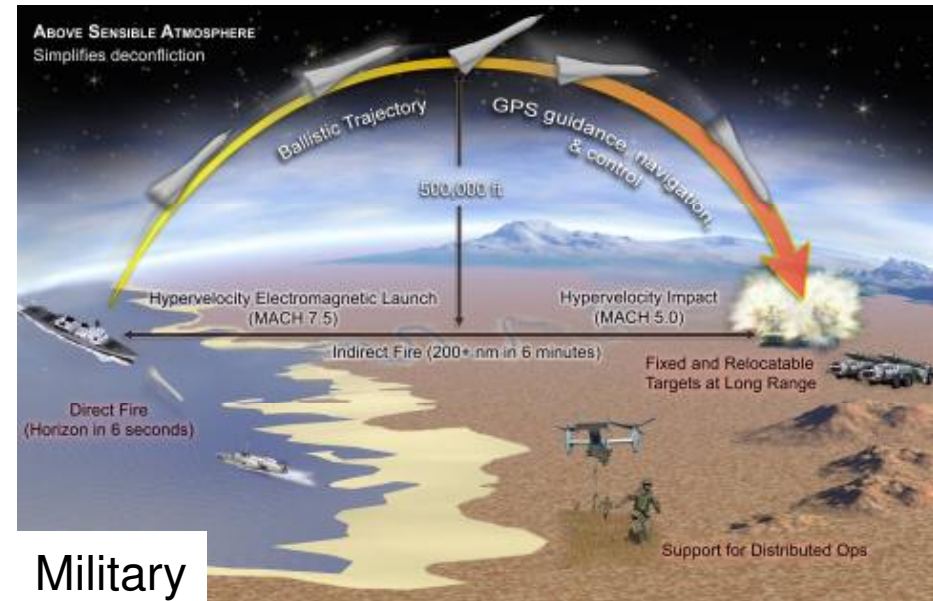


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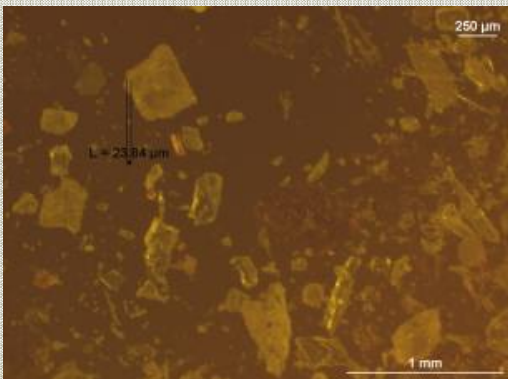
# Railgun Applications



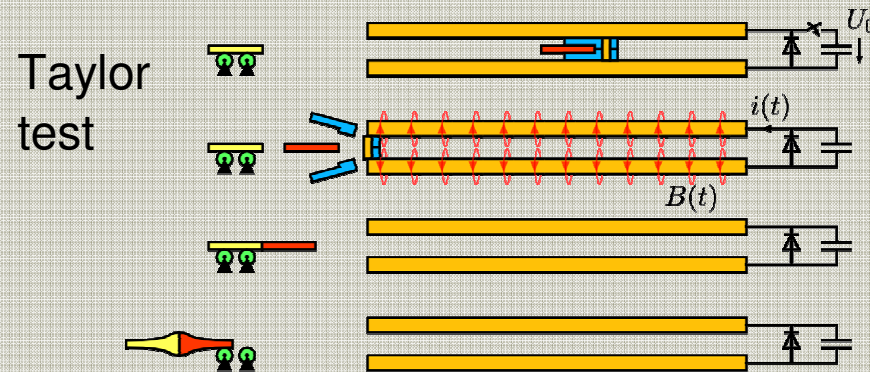
Satellite launch



## Research tool



Micro meteorites



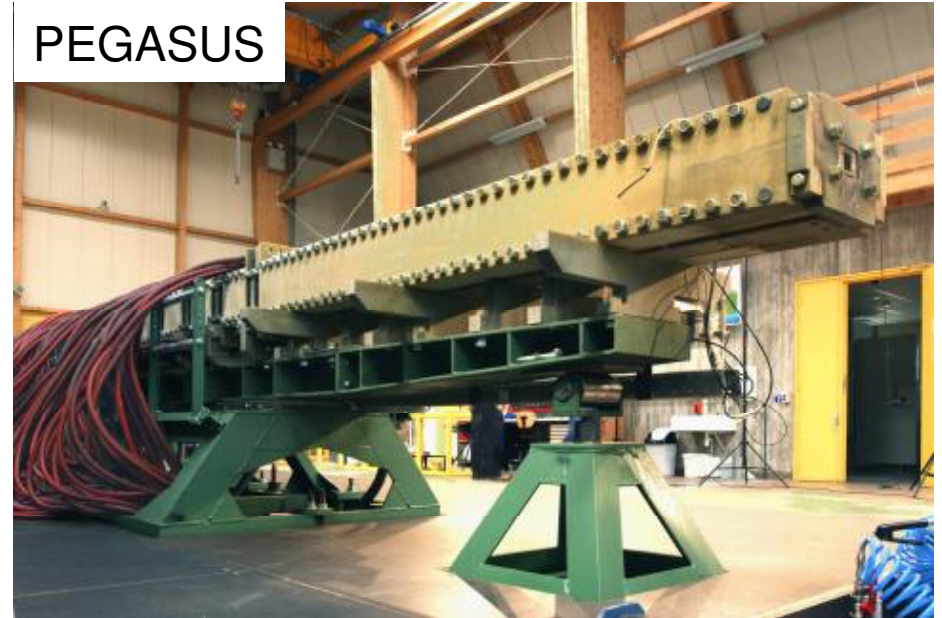
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# Railguns @ ISL

RAFIRA



PEGASUS



SR\3-60



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# Projectile Impact

Payload projectile

$$M = 600 \text{ g}$$

$$V = 1460 \text{ m/s}$$

$$E_{\text{kin}} = 0.6 \text{ MJ}$$



Tir166a\_video



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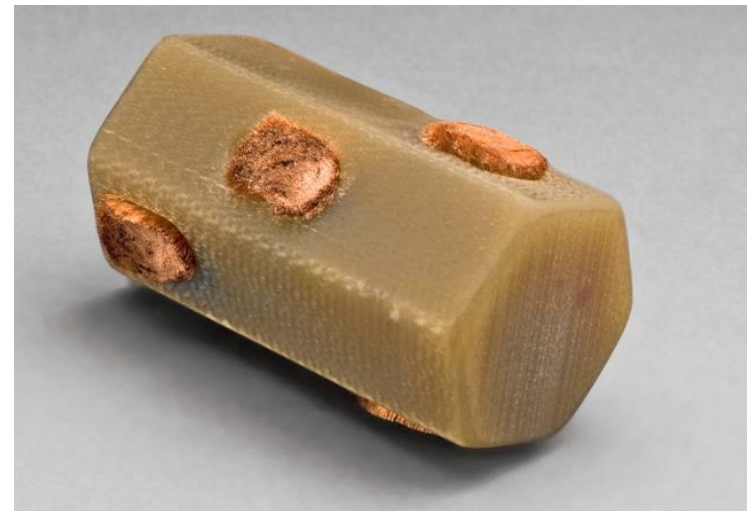
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# The SR\3-60

3 Segments á 75 cm  
Length: 225 cm  
 $E_{\text{Electric}}$ : 450 kJ  
Velocity:  $\leq 300$  m/s



Material: GRP  
Length: 55 mm  
Height: 28 mm  
Weight: 90 g

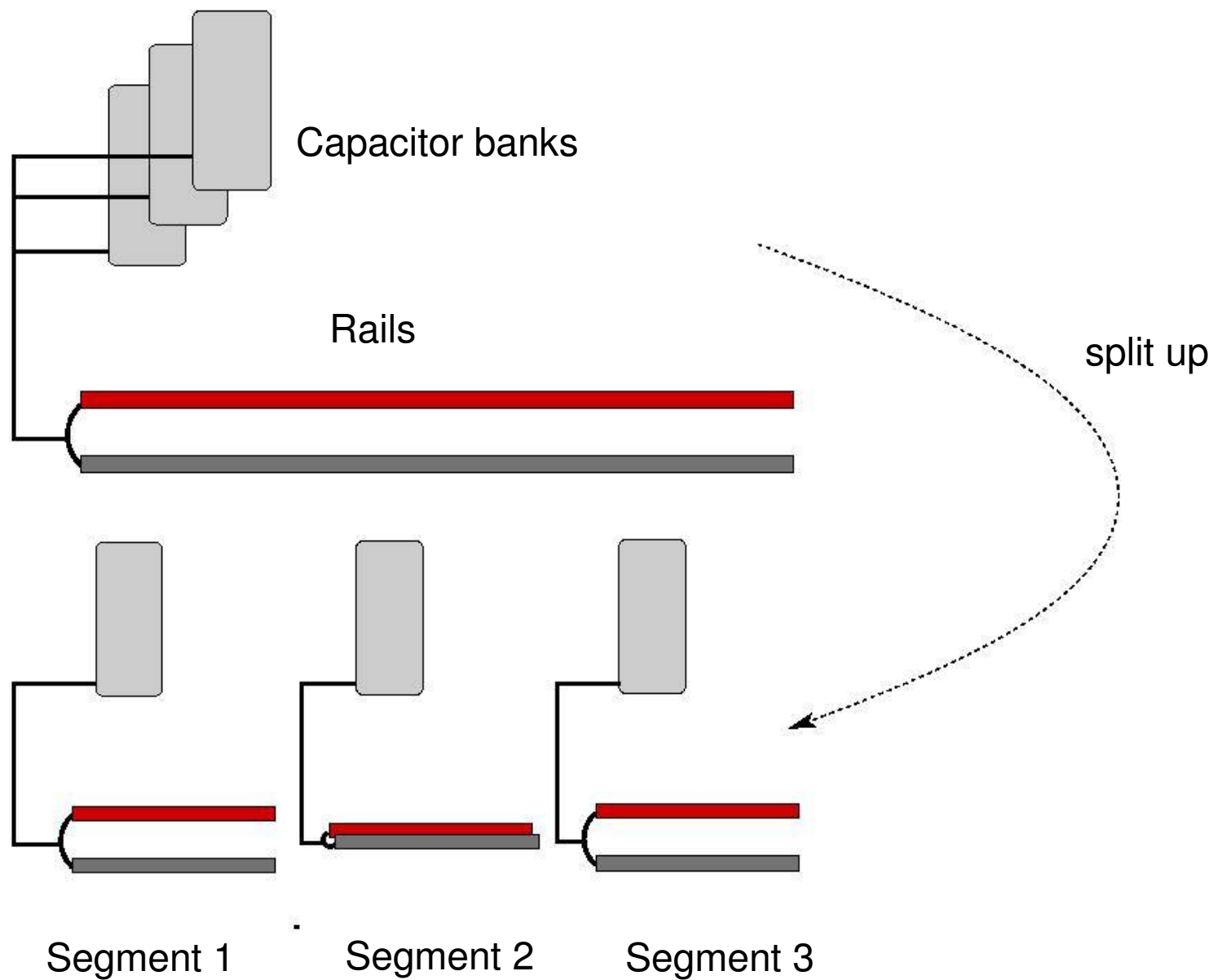


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# Simple Railgun → Segmented Railgun



# Advantages of a Segmented Railgun

- Reduced ohmic resistance (shorter rails) → reduced heat losses
- straight forward partitioning of the energy supply
- built in flexibility, segments can be added or removed
- **mechanical advantages**: shorter railguns are easier to produce and handle
- **different segments** might use **different brushes**
- possibility to increase the velocity limit for solid contact railguns

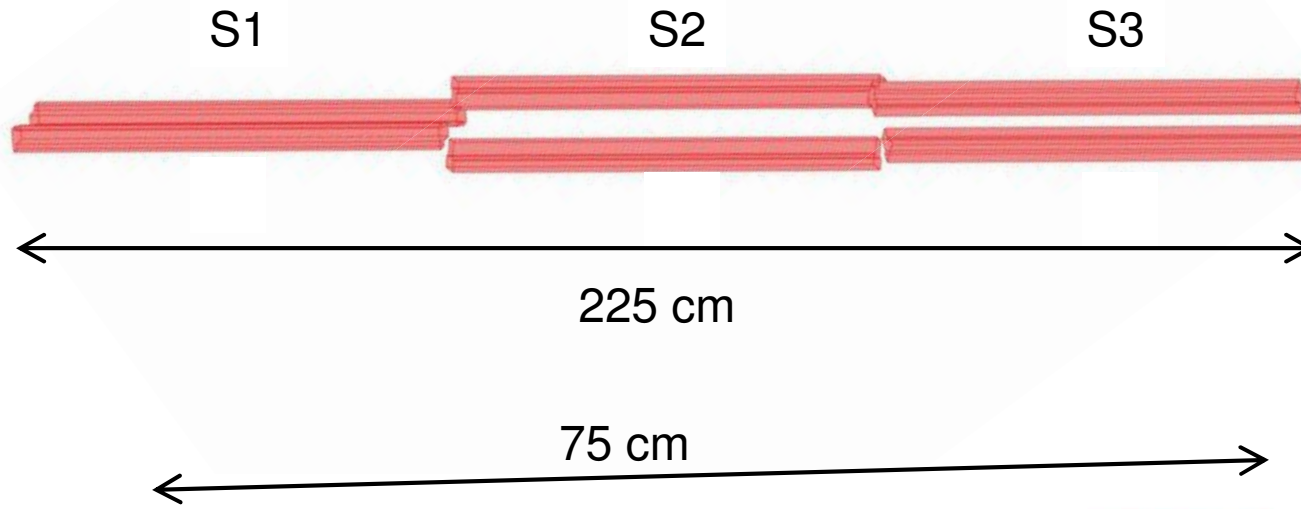


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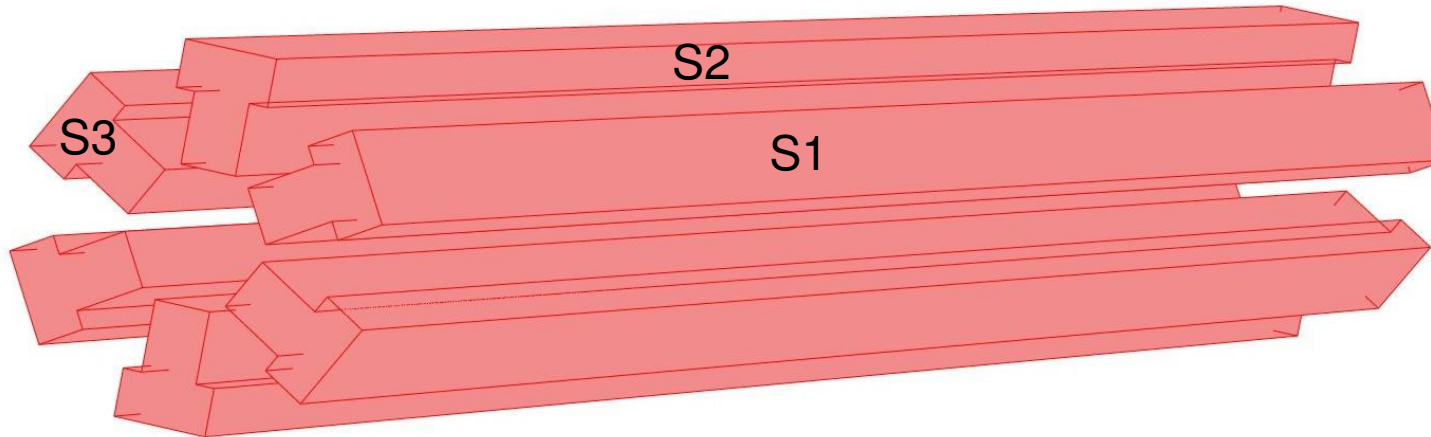


# Sequential vs. Overlap Setup

Sequential:



Overlap:



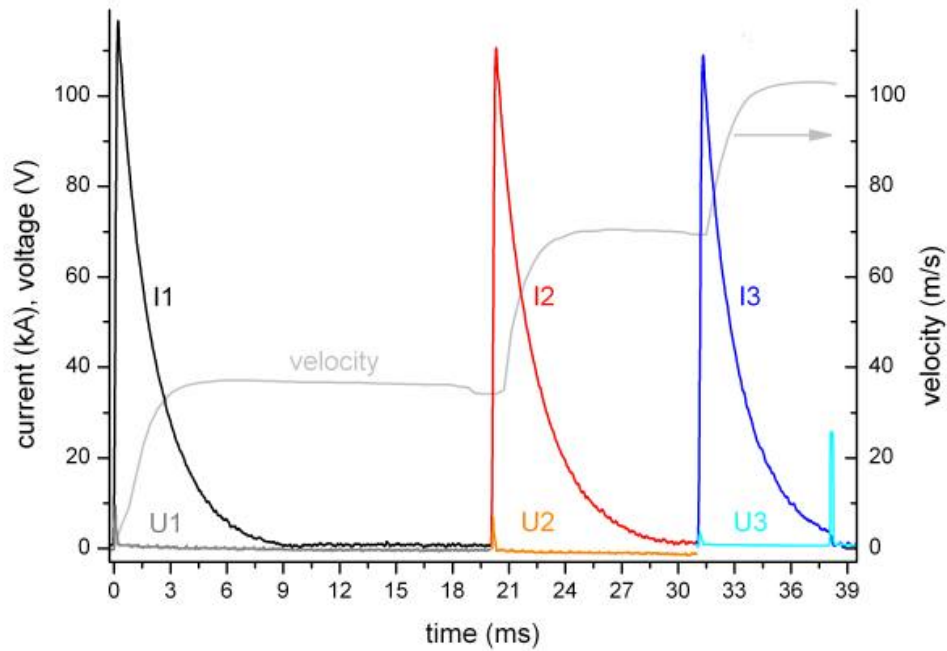
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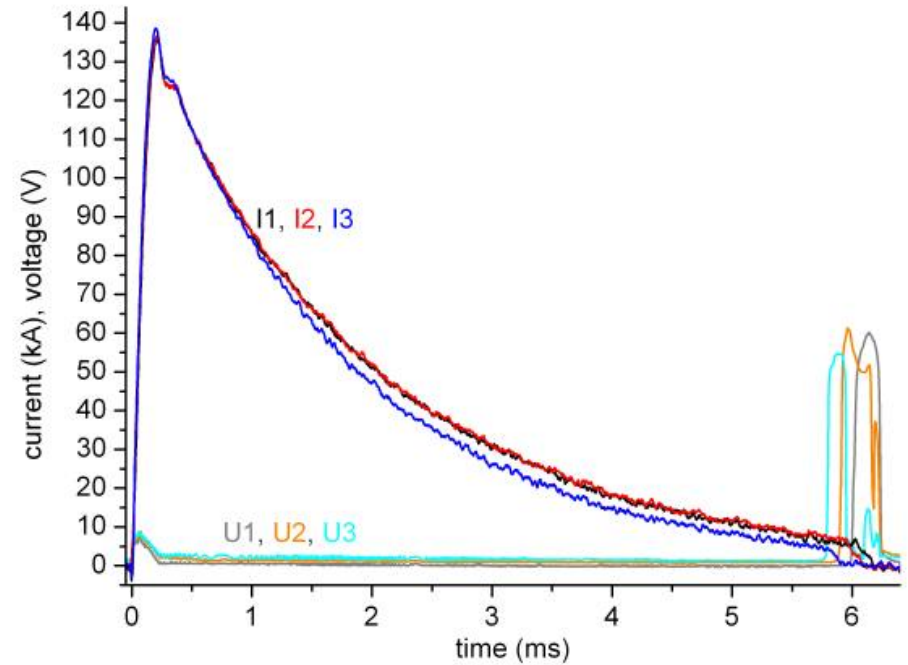
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# Comparison: Sequential -- Overlap

Sequential, 6 kV, 102 m/s



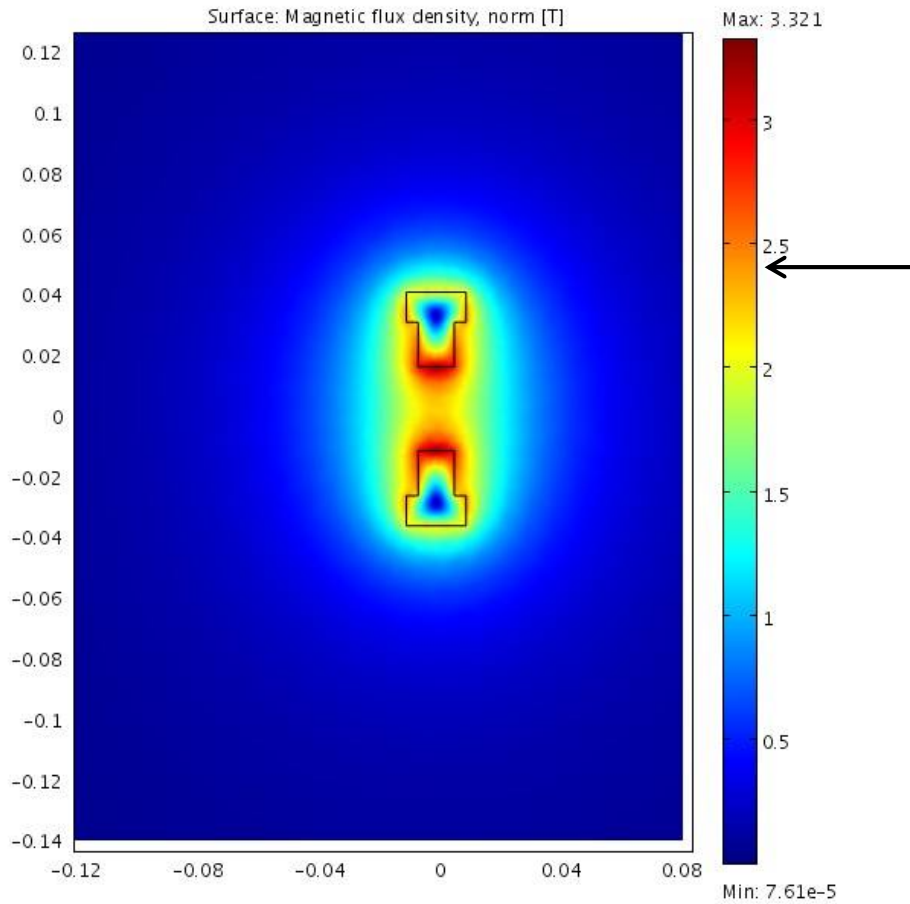
Overlap, 7 kV, 143 m/s



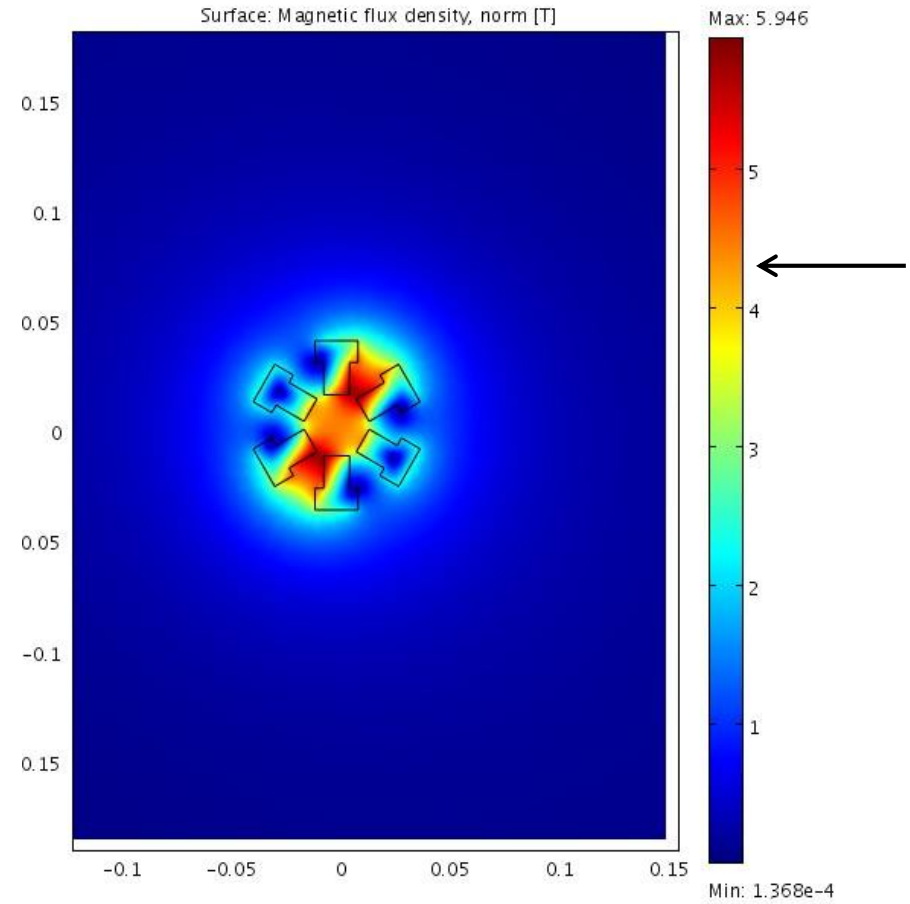
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# Magnetic Fields

sequential



overlap



⇒ Overlap configuration has larger magn. field strength inbetween rails

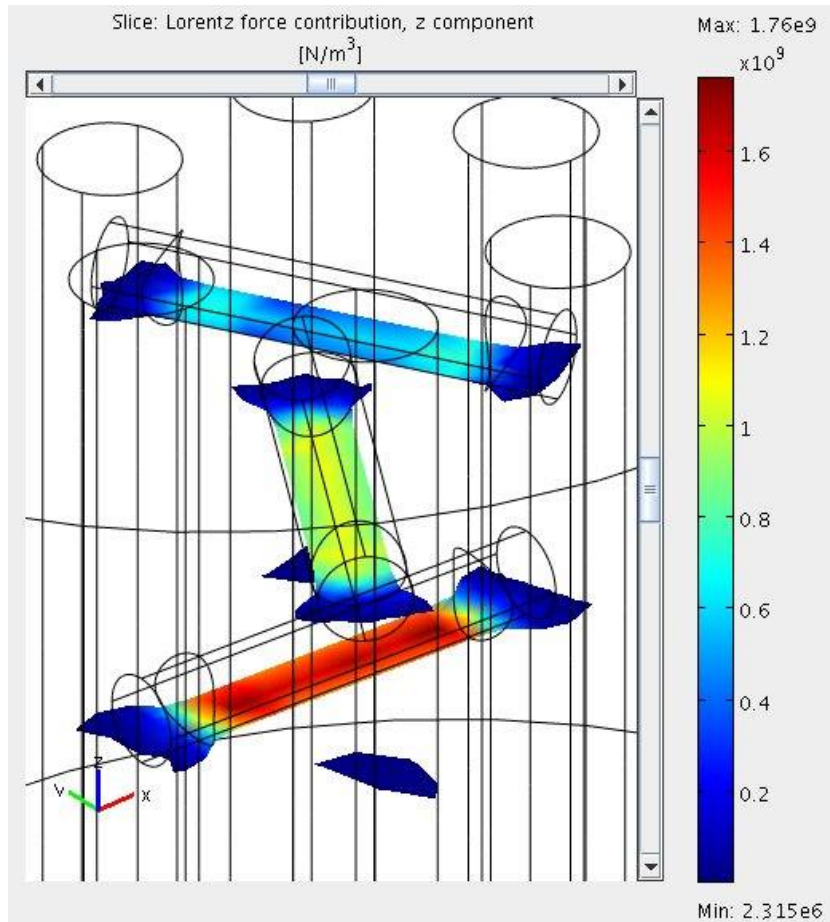


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# Lorentz Force in Projectile Overlap Setup



3 brushes:

complex magnetic field  
inside the projectile

Frontmost brush contributes  
very little to acceleration

Summary:

- + Stronger magn. field strength
- Uneven distribution of forces
- Development of torque

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Overlap setup better (faster) ?



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# Experimental Comparison of Velocities

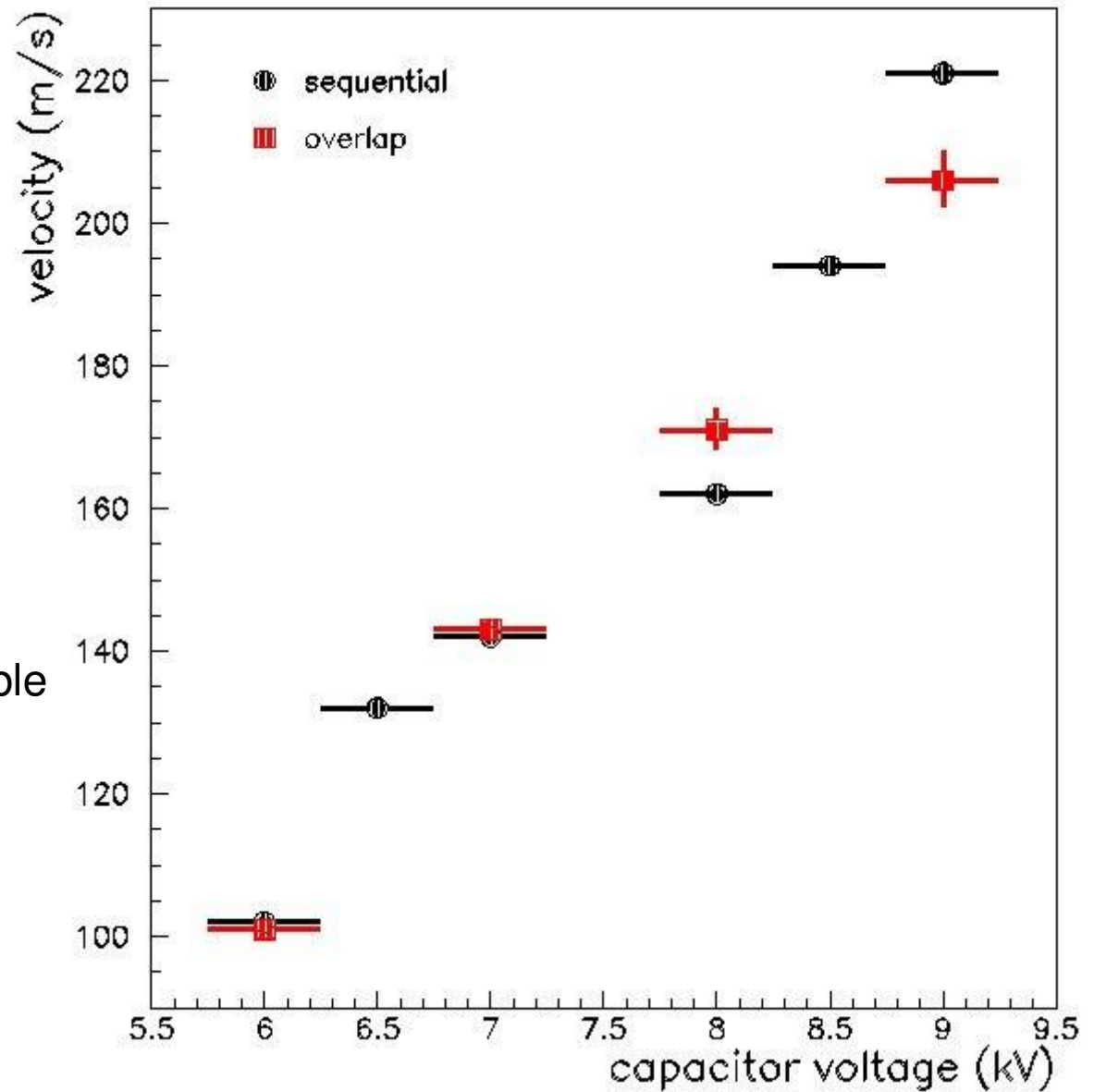
Velocity scales linearly with capacitor voltage

Velocities for both configurations are comparable



In this velocity regime both configurations are comparable

The overlap configuration is more compact



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# Summary and Outlook

There is a large experimental railgun program at ISL

Recently, two segmented railguns were set up and used for experiments

One segmented railgun was used to change the spatial arrangement of rails

Simulations with respect to the magnetic field distribution were made

(Surprisingly) the sequential and overlapping configuration achieve similar velocities

Currently we focus on:

- Multishot capability
- Magnetic Field investigations (University Vilnius, Lithuania)
- Micrometeorites (University of New Brunswick, Canada)
- High energy, large velocity (US-Navy, FH Gelsenkirchen)



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