



Space-Charge Compensation using MCP e-gun

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Helen Edwards Programme – First Presentation

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FAST & IOTA

- **FAST** (Fermilab Accelerator Science and Technology) facility
 - Develop testing facility for accelerator research
- **IOTA** (Integrable Optics Test Accelerator)
 - 40m dia. Storage ring
 - Linacs deliver 150 MeV electrons / 2.5 MeV protons
- Planned experiments involve:
 - Integrable optics with NL magnets
 - Space-charge compensation using e^- lenses & e^- columns
 - Investigating wavefunction of single electron

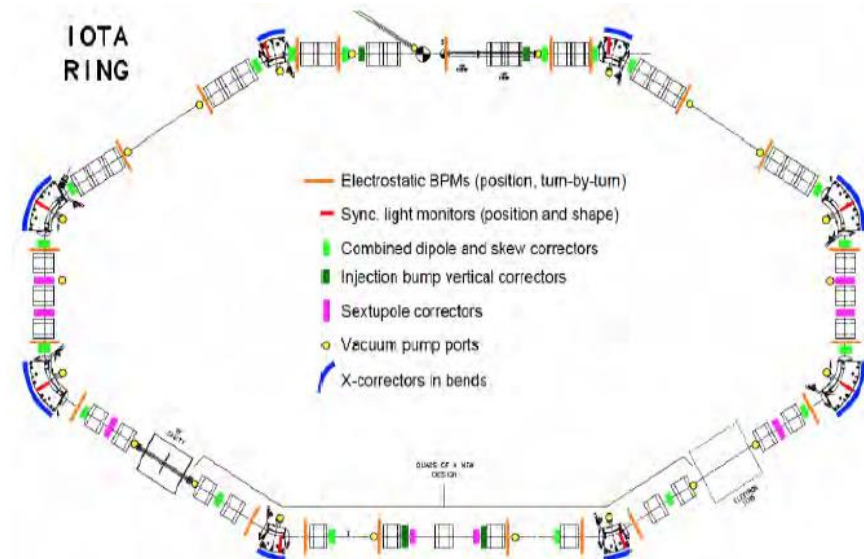
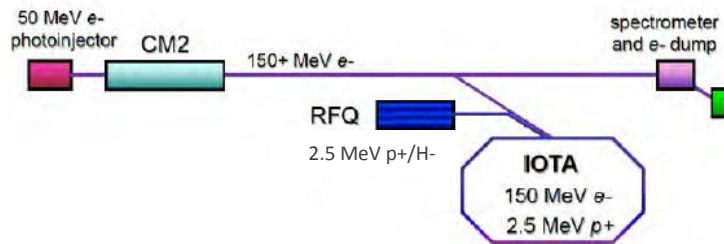


Fig. 1: Schematic of ASTA e- injector (left) and IOTA storage ring (right)

Space-charge (SC) Compensation

- **Idea:**

- SC forces arise from self-field generated by charge distribution (e.g. proton beam)
- Responsible for energy loss, shift of betatron frequencies

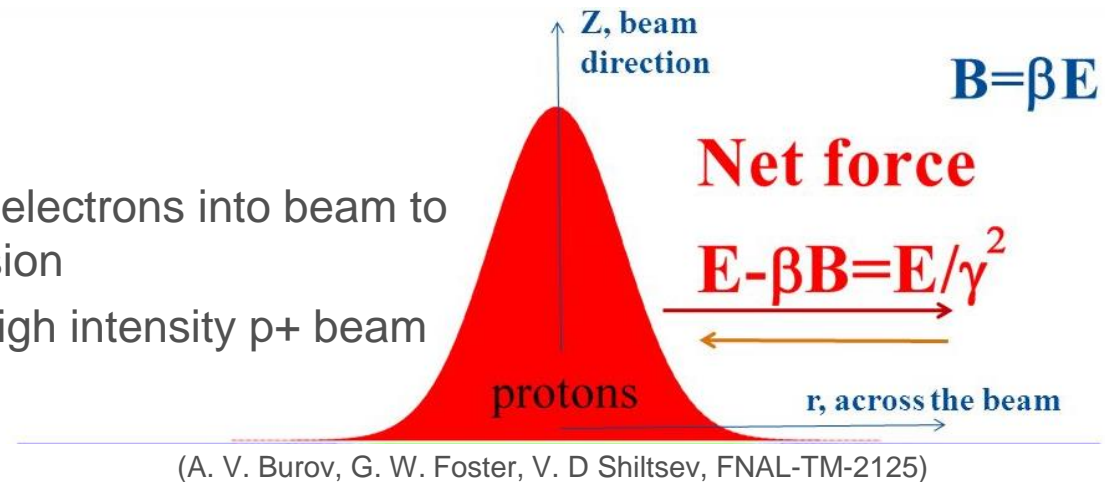
- **Motivation:**

- SC compensation: introduce electrons into beam to neutralise effect of p-p repulsion

↳ Provide a way to achieve high intensity p+ beam

- **Techniques:**

- One option to have electrons circulating continuously alongside proton beam
- Another option uses e-lenses to inject high density of electrons into beam --- matching transverse distribution of p+ beam
- Modulating electron current to match p+ bunch current profile --- matching longitudinal distribution of p+ beam



Project - MCP e-gun

- **Idea:** to use MCP as the cathode of e-gun
- **Microchannel Plate (MCP)**
 - Millions of glass capillaries fused together, each acting as electron multiplier
 - Sensitive to ions, photons, electrons, neutrons etc.

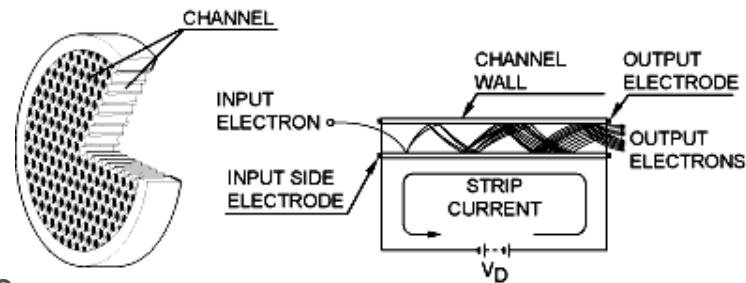


Fig. 3: Schematic of MCP / single capillary (www.dmphotonics.com)

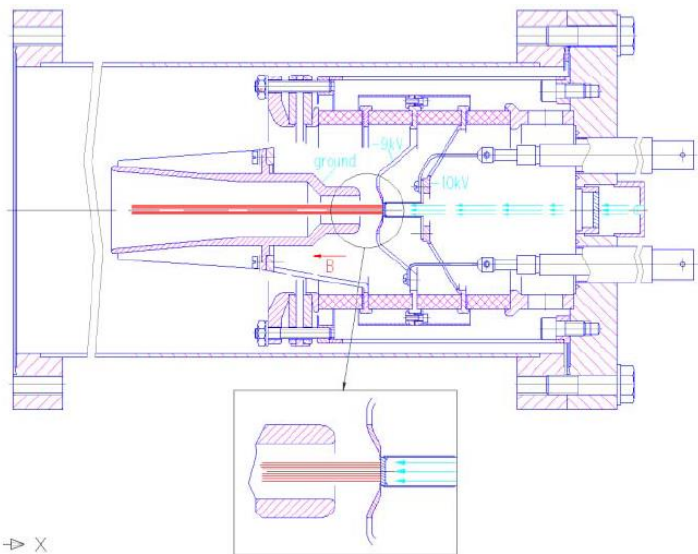



Fig. 4: Layout of e-gun with MCP cathode (V. D. Shiltsev, 2007 IEEE Particle Accelerator Conference (PAC), Albuquerque, NM, 2007)

- **MCP e-gun**

- Benefits over traditional heated filament cathode include:
 - Greater mechanical stability
 - Better vacuum conditions
 - Lower emittance (particles lost)
 - Higher quantum efficiency
- Laser illuminates MCP from behind
 - Simplified design
- Can modulate & control output current easily by controlling laser pulses
 - ↳ Possibility to match longitudinal p+ distribution

No heating required

Scope of Project

- **Find / purchase MCP detector assembly**  (MCP detector ordered)
 - Online research, contact photonics retailers
- **Assemble LED / PMT array system** (System is being assembled)
 - System assembled in 2016 by PARTI intern
 - Get this system working, obtain output on scope from active PMT channels
 - Can I create LED pulses as short as 130 ns (IOTA frequency)?
 - Can I create LED pulses as short as 10 ns (booster beam frequency)?
- **Assemble similar system with MCP detector (instead of PMT)**
 - Learn how to use the MCP detector assembly
- **Analyse MCP capabilities**
 - Determine maximum charge & current MCP can deliver
 - Understand relationship between input pulse length & output current
 - Investigate MCP lifetime vs. current
- **Write report / presentation on results**

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