Laser-driven particle acceleration

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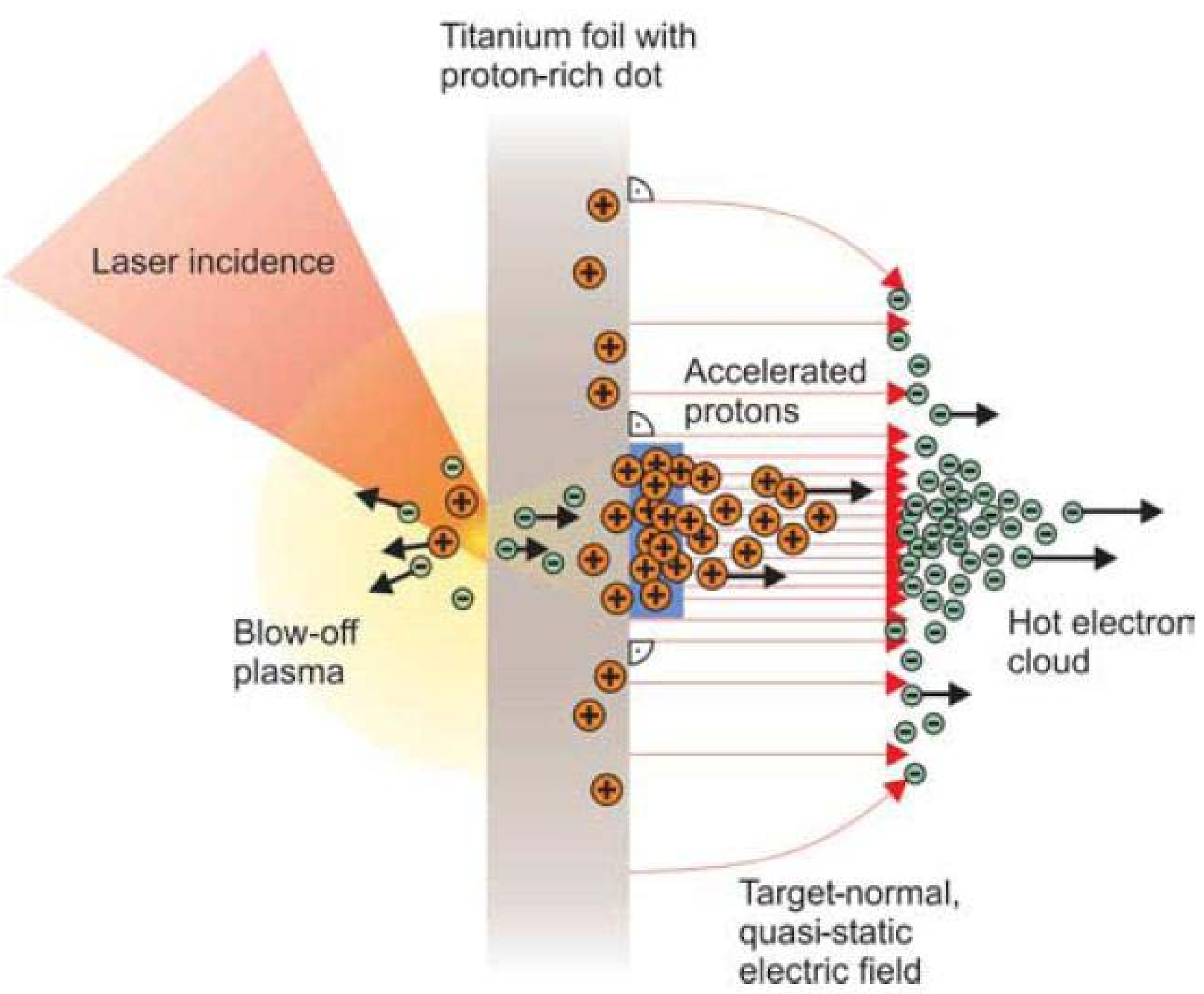
INTRODUCTION

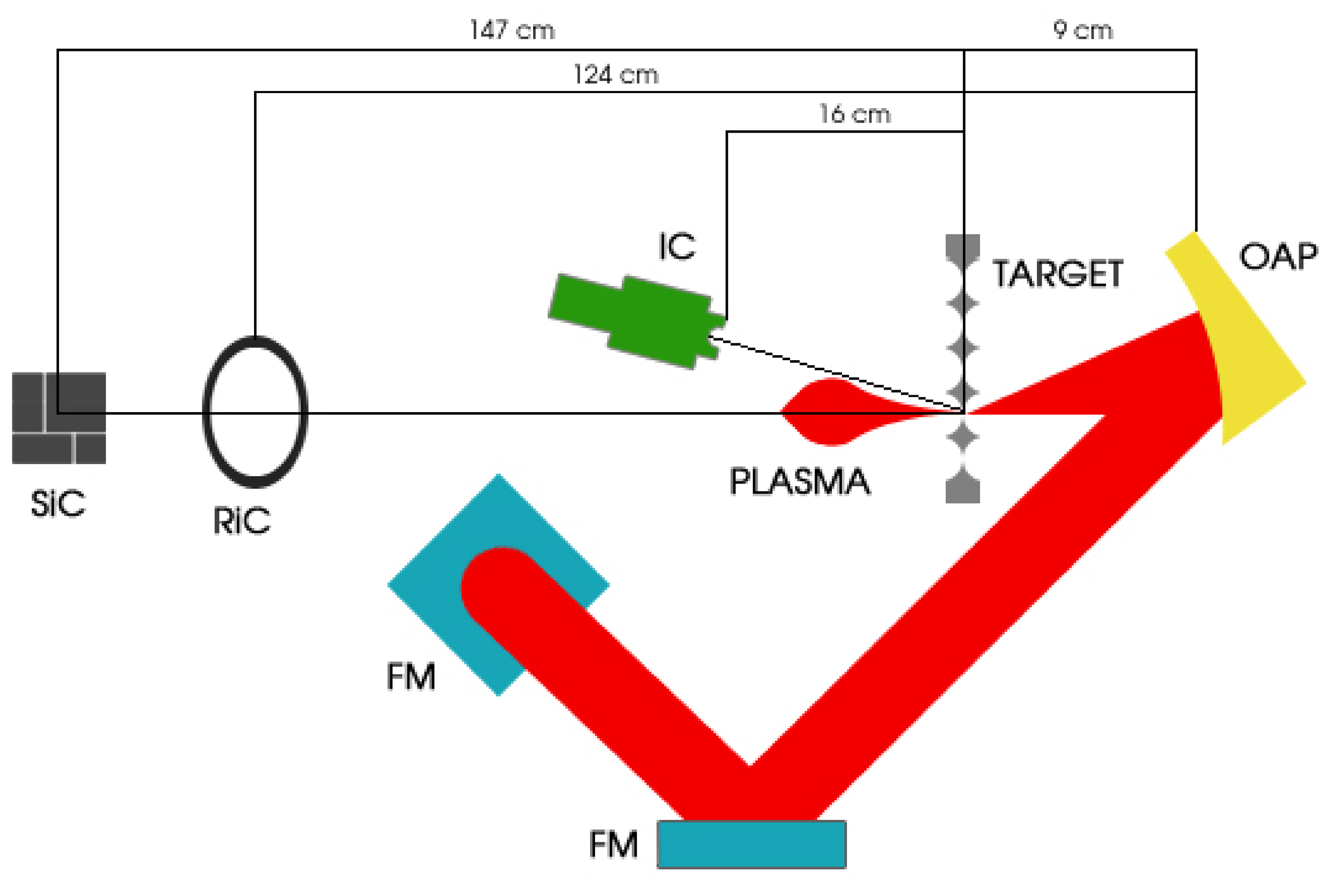
- Present particle accelerators (electrons and ions) are widely used in physics, medicine and technology.
- Size limits are determined by accelerating fields (the maximum value of that field is about 100 MV/m.
- Laser excited plasma waves accelerate particles at short distances (mm, cm) due to the high accelerating field (TV/m).

EXPERIMENT

- Huge advantages in comparison with electro-magnetic accelerators.
  - TV/m field rather than the MV/m
  - Plasma is already broken down and the accelerating field is not limited by this effect
  - TV/m field can serve as compact ultrahigh-gradient accelerating structure
  - Ultra short beams on very short distances
- Target Normal Sheet Acceleration (TNSA) is the method of accelerating ions, usually from metal foil in the normal direction to the surface
- The interaction of the ultra intense laser with the target produces an intense beam of hot electrons moving right through the target.
- The most energetic electrons (MeV) escape from the target.
- A few of the electrons are confined inside the target by the electrostatic force.
- The bulk material (especially hydrogen contained in impurities) in the surface layers is directly ionized by the field ionization
- Protons have the highest charge/mass ratio to achieve the highest kinetic energy than heavier ions



- Experimental setup
  - 20 TW titanium-sapphire laser in Prague on PALS.
  - Impulses reach energy up to 1 J
  - Puls duration 40 fs , repetition rate 10 Hz, wavelength 810 nm
  - Whole experimental equipment was placed in airtight spherical chamber

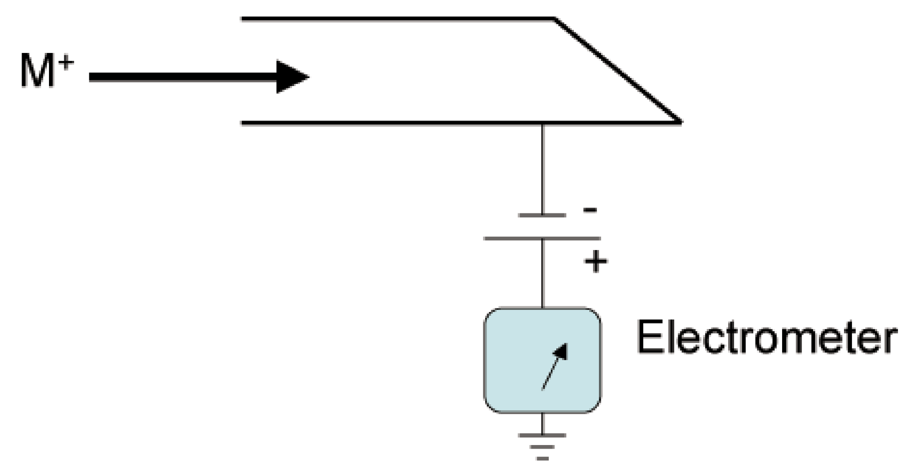


- FM – optimalized mirrors
- OAP - off-axis parabola (f/3, f = 90 mm)
- TARGET - aluminium foil with the thickness of 2.4 μm
- off-axis placed Faraday cup (IC)
- on-axis placed ring ion collector (RIC) and SiC detector

- detectors were used as time of Flight Mass Spectrometry method (TOF, where ions are accelerated by an electric field)
  - the ring ion collector is composed of four independent collectors
  - only two channels were used (one channel was covered by the aluminium foil to stop low energy ions, and the second channel was uncovered to capture all ions)

Faraday Cup

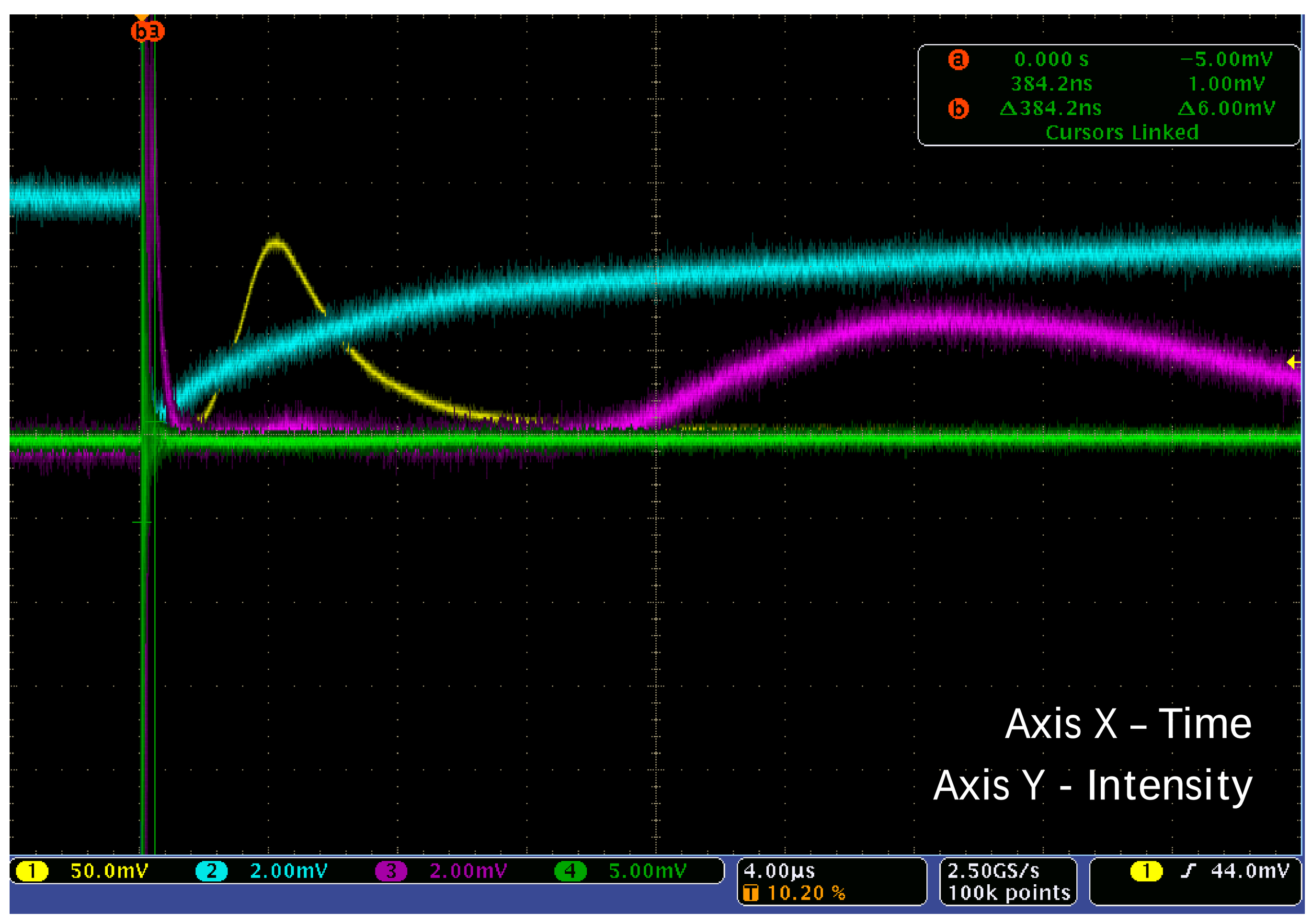
This is a simple detector consists of cup-shaped electrodes, usually copper. The electrode surface is covered with a layer of BeO routinely. The impact of ions is to cause the electrons to eject from the surface, which is then captured and an anode creates an electrical current. The current is amplified by an amplifier, unfortunately reducing the noise sensitivity of the detector. This is the preferred method in the measurement of lower energy.



Besides the normal Faraday Cup, we also used the circle Faraday cup. To screen the low energy ions, noise and other particles we used 2,4 μm of Aluminium. All that because except the participles of Silicon from foil, SiO_2 (emerging passivation of silicon with oxygen) is accelerated.

RESULTS

- Yellow and violet curves are outputs of the on-axis ring ion collecto
  - Those curves have not the same axis range, the y axis is for yellow curve 50x smaller than for other curves (range of the time axis are equivalent)
- The first visible yellow pike is caused most energetic ions, the second (violet) pike is caused less enregetic ions, for our experiment useless



CONCLUSION

- The biggest future opportunities are revealing in medicine
- This method will be after elimination all defects and after tuning (that means possibility of setting a stabilizing the beam of participles of same energy) very suitable for radiotherapy of cancer tumors
- Radiotherapy will be more effective in destroying cancer cells and more friendly to the surrounding
  - To reach that, we have to figure a way to accelerate all particles to same energy level.

REFERENCES

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