

Nanotechnology for Applications at Accelerator Facilities*

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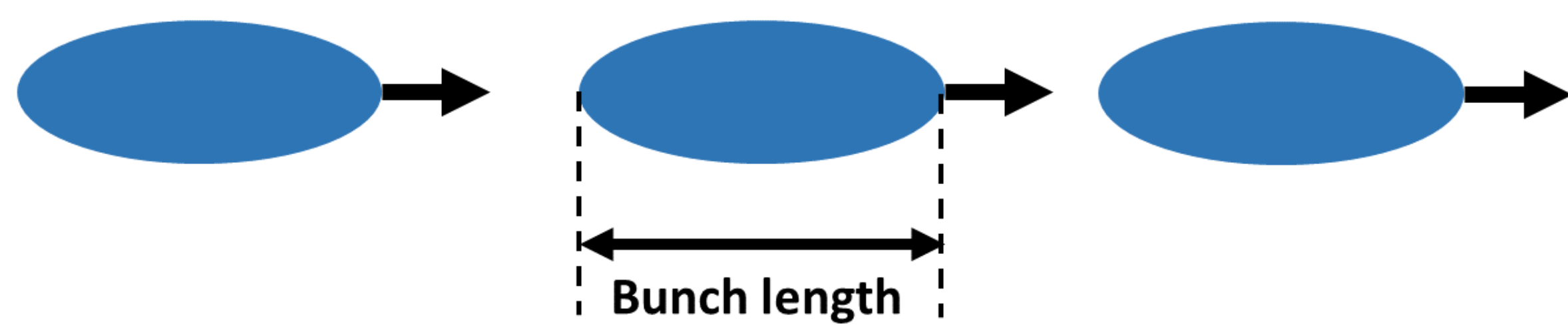
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Ultrashort electron bunches are widely used in accelerator physics such as in colliders or FELs (Free Electron Lasers). Their duration ranges from pico- ($\times 10^{-12}$ s) to femto- ($\times 10^{-15}$ s) seconds. Measurement of bunch duration is of extreme importance when it comes to application of accelerators (time-resolved studies and ultra-short phenomena experiments). Non destructive ways of measurements are significant. Laser based (EO) techniques have been developed to cope with these requirements. Novel accelerators will produce bunches shorter than standard EO monitors could work with, therefore an improvement is needed. This project aims at applying cutting-edge nanotechnology into the measurement technique by the use of silver nanoparticles.

1. Electron bunch length

Vacuum tube

Accelerated electron bunches



Electrons in accelerators are accelerated in the form of bunches with special characteristics- their bunch duration or length.

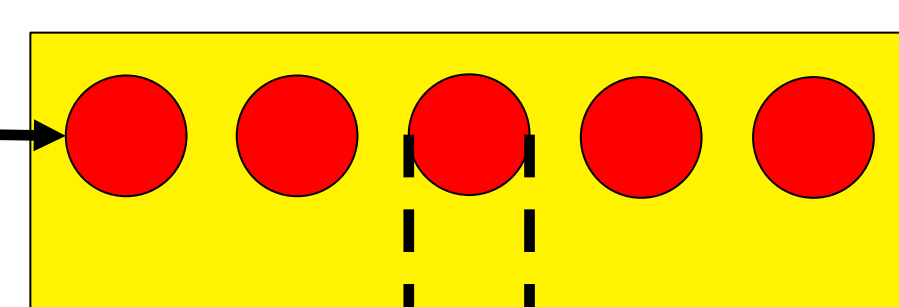
Knowing the length of each bunch → important for accelerator work and applications.

2. Nanoparticles (NP) in glass

- Metallic nanoparticles can be found in old stained glass windows
- Used for glass colouration of glass since Roman times
- Recently became scientifically interesting world-wide

Metallic nanoparticles

Glass volume

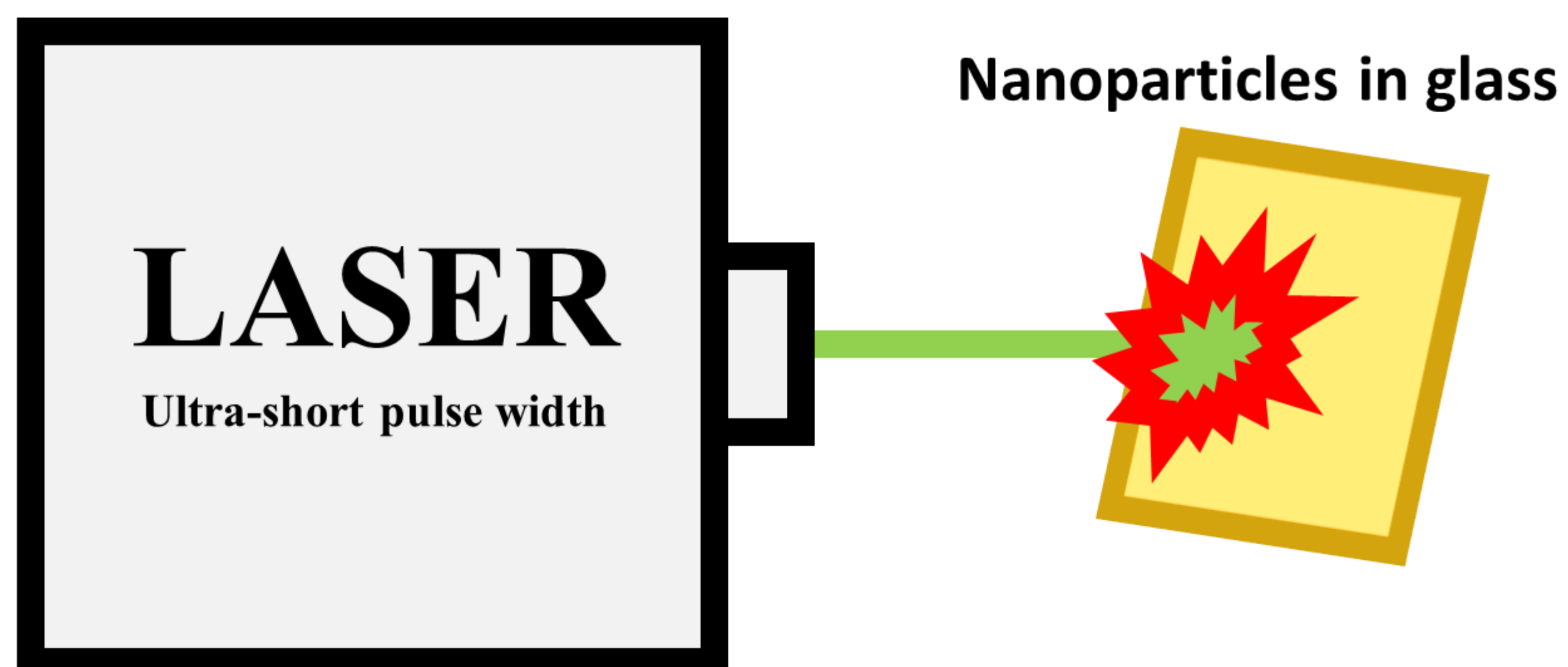


1000 smaller than human hair



STAINED GLASS WINDOW

3. Nanoparticle development



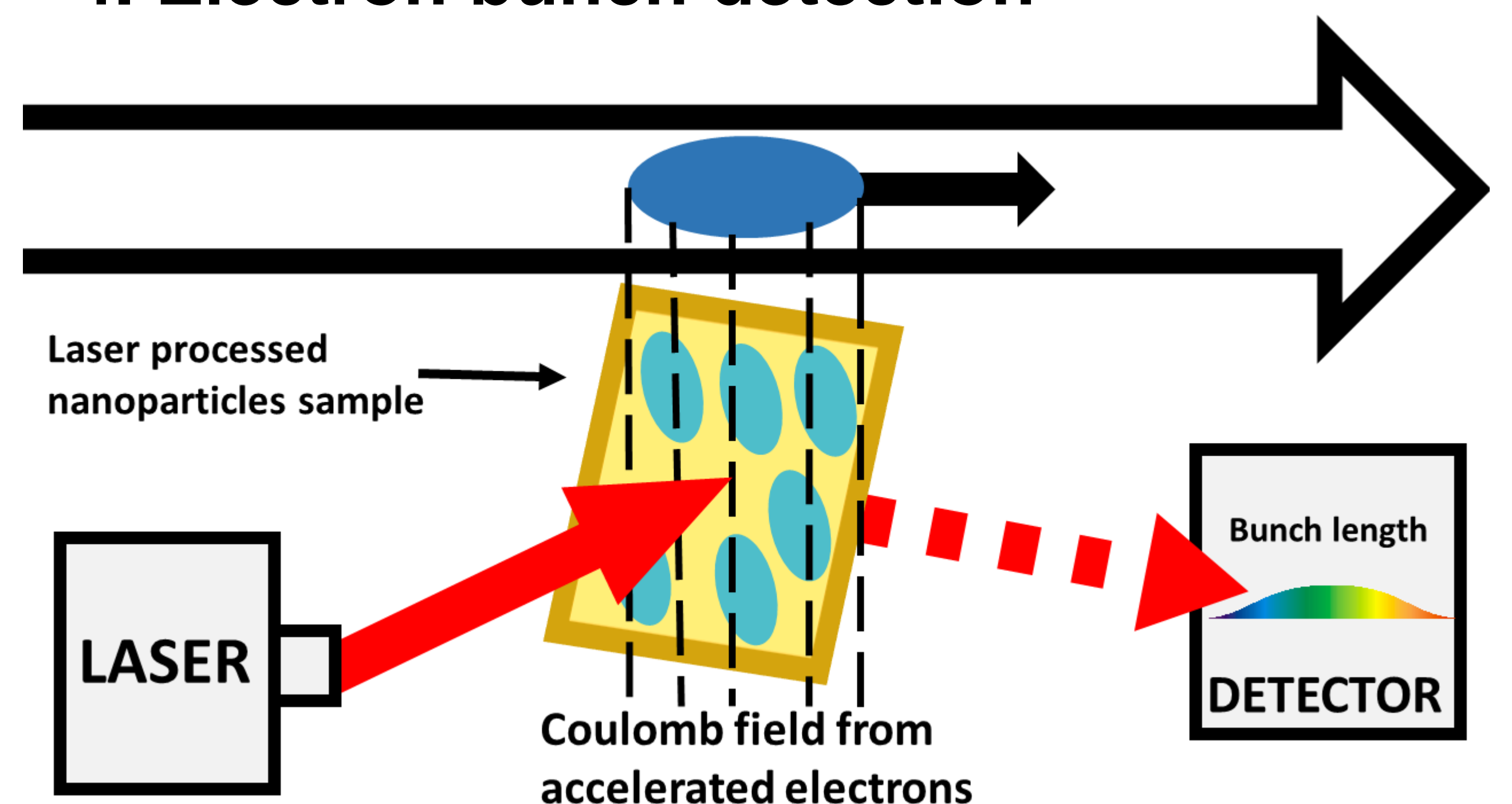
- Laser processing of silver NPs embedded in glass
- Shape change to gain unique optical properties

Spherical

Laser modification of silver NPs

Ellipsoidal, disc-like, etc.

4. Electron bunch detection



- NP parameters are altered due to the Coulomb field of an accelerated electron bunch
- Possible improvement of bunch monitors to measure even shorter bunches with the use of metallic nanoparticles

Relevant Resources

- [1] S. P. Jamison, G. Berden, W. A. Gillespie, P. J. Phillips, A. M. MacLeod. *Limitations of electro-optic measurements of electron bunch longitudinal profile*. proc EPAC. 1149
- [2] M. A. Tyrk, W. A. Gillespie, G. Seifert and A. Abdolvand, *Opt. Express* **21**, 21823 (2013).
- [3] A. Podlipensky, A. Abdolvand, G. Seifert and H Graener, *Appl. Phys. A* **80**, 1647 (2005).
- [4] S. P. Jamison, G. Berden, A. M. MacLeod, D. A. Jaroszynski, B. Redlich, A. F. G. van der Meer and W. A. Gillespie, *Nuclear Instruments and Methods A* **557**, 305-308 (2006).

5. Conclusions

A novel metamaterial for ultra-short electron bunch diagnostics has been developed at the University of Dundee. Preliminary tests have been conducted showing promising results that could lead to substitution of the inorganic EO crystals traditionally used – such as ZnTe and GaP.