Wakefield Acceleration in Structured Solids:

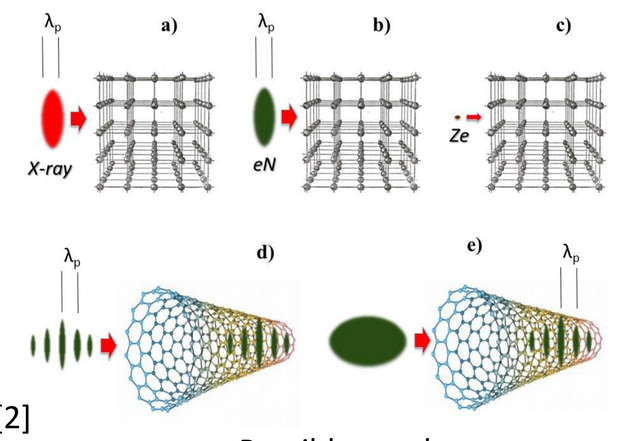
E336 Experiment at FACET-II

Max F. Gilljohann, Yuliia Mankovska, Pablo San Miguel Claveria, Alexei Sytov, Laura Bandiera, Robert Ariniello, Xavier Davoine, Henrik Ekerfelt, Frederico Fiuza, Laurent Gremillet, Alexander Knetsch, Bertrand Martinez, Aimé Matheron, Henryk Piekarz, Doug Storey, Peter Taborek, Toshiki Tajima, Vladimir Shiltsev, Sébastien Corde

Alexei Sytov on behalf of the E336 collaboration

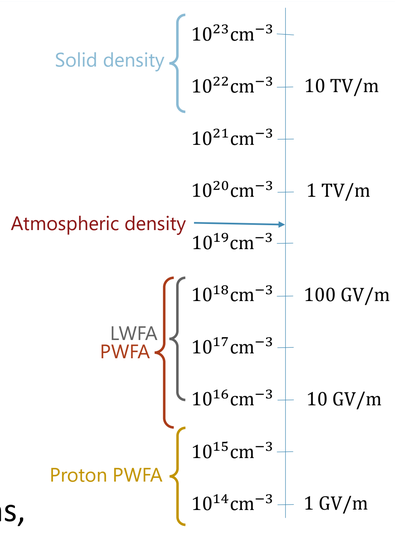
Laboratoire d'Optique Appliquée, Palaiseau, France
Istituto Nazionale di Fisica Nucleare, Ferrara Division, Italy
Korea Institute of Science and Technology Information, Daejeon, Korea
University of Colorado Boulder, Department of Physics, Boulder, USA
SLAC National Accelerator Laboratory, Menlo Park, USA
CEA, DAM, DIF, Arpajon, France
Superior Técnico, Lisbon, Portugal
Fermi National Accelerator Laboratory, Batavia, USA
University of California, Irvine, USA

Wakefield Acceleration [1] in Solids



[2]

Possible accelerator types
a) X-ray pulse, b) fermion bunch, c) high-z ions,
d) Modulated beam, e) long bunch undergoing self modulation

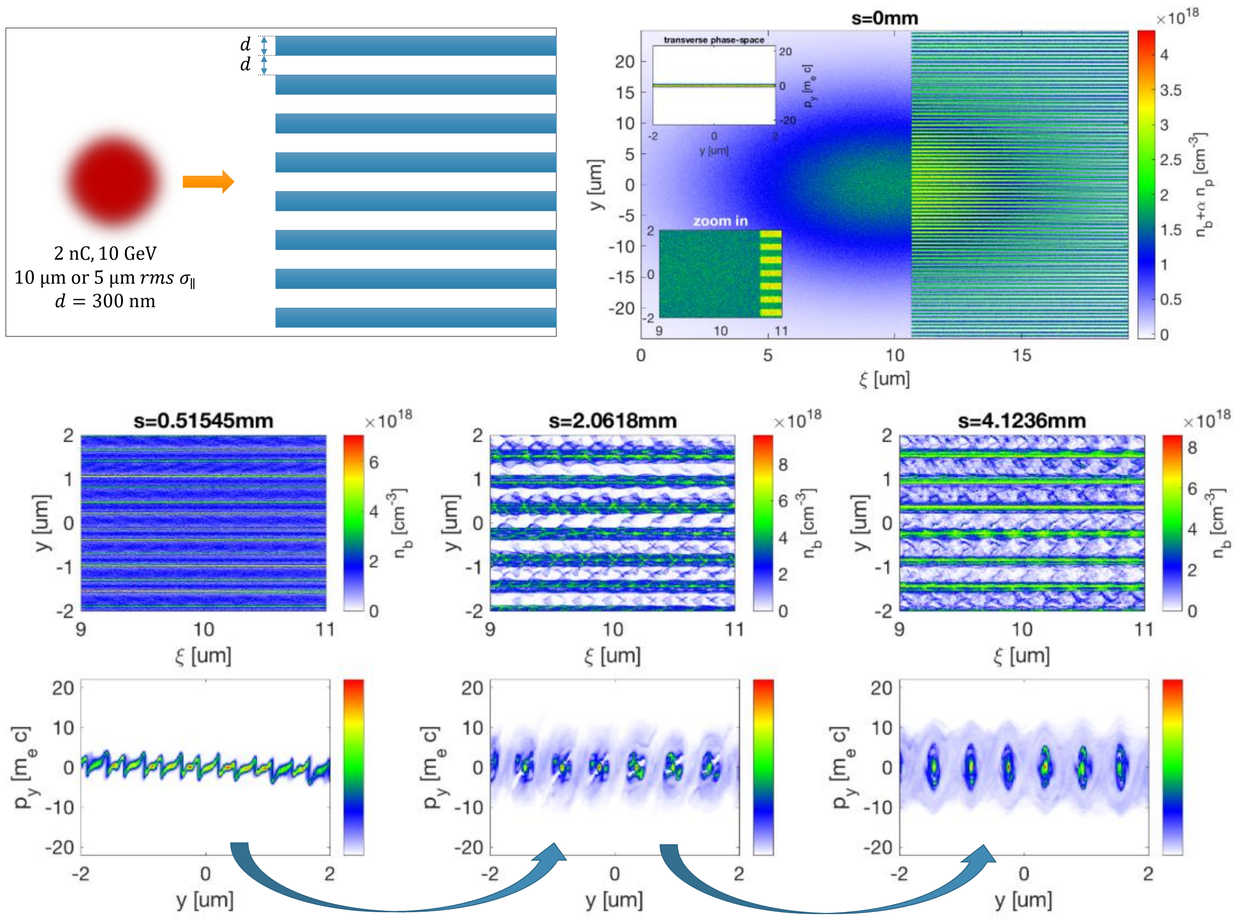


Solid density wakefield accelerators could produce fields up to 10 TV/m [3]

Though the driver of size $\sim\lambda_p$ for solids is not currently available, first explorations of beam-crystal interaction can already be done.

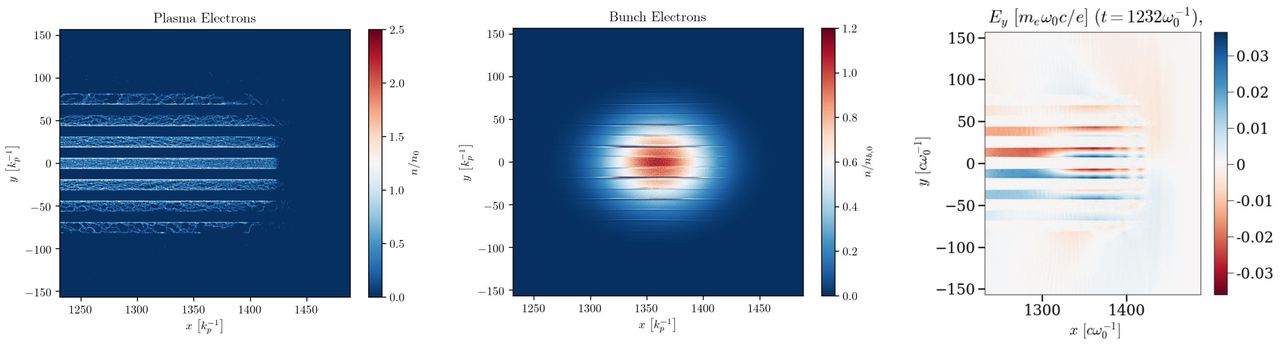
Simulations of Beam – Structured Target Interaction

Simulating beam interaction with hollow tubes in an aluminium substrate



Nano-structured targets lead to a transverse beam density modulation → Measurable increase in divergence w.r.t. interaction with bulk material

Large tube diameters



Ionization on the tube surface shields the substrate material → Highest fields and influence on bunch electrons close to the surface

The E336 Experiment at FACET-II

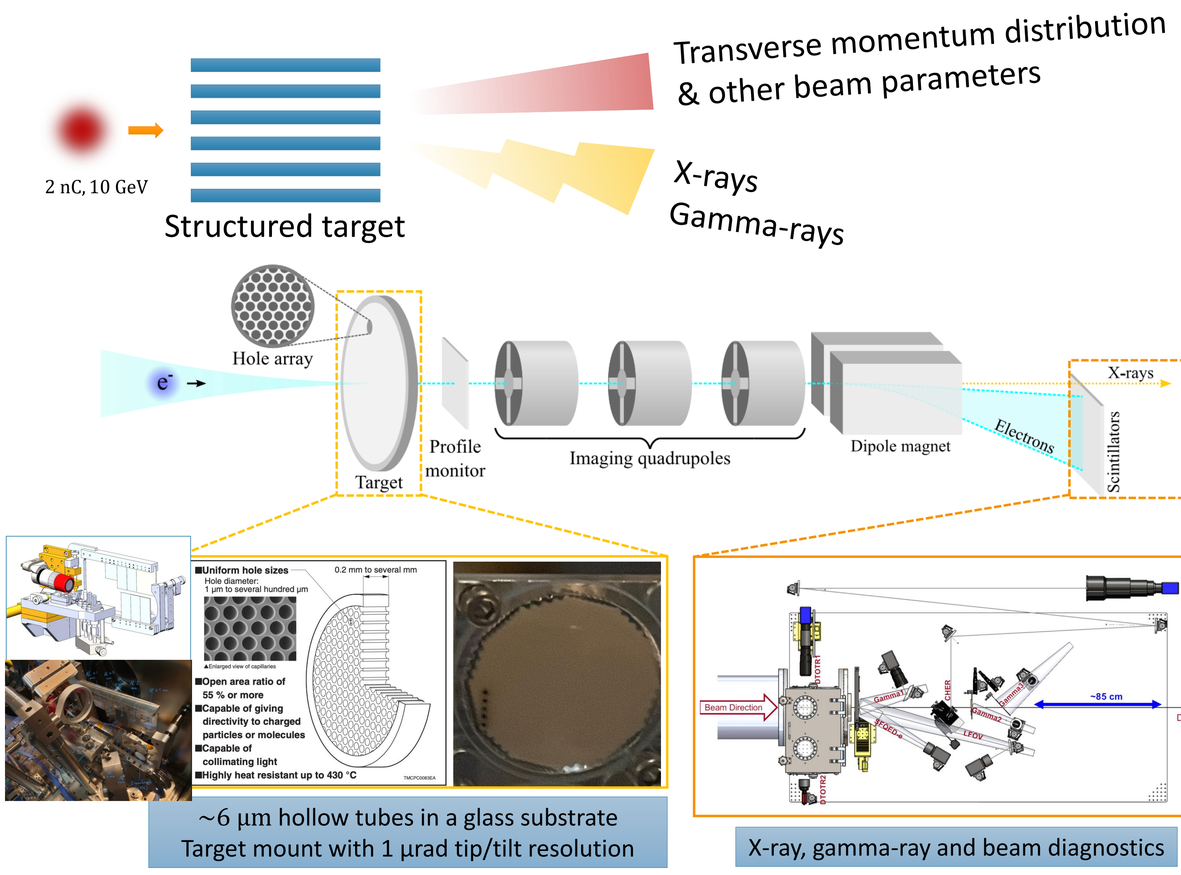
Exploring the electron beam interaction with structured materials

Scientific goals
- Observation of electron beam nano-modulation
- Observation of betatron X-ray radiation
- Confirmation of numerical models

Short-term applications
- Seeding current filamentation instabilities in solids in a controlled and tunable way. → see the E305 experiment at FACET-II: TUPA104

Initial Experimental Setup

Interaction of the FACET-II electron beams with µm-diameter hollow tubes in a glass substrate



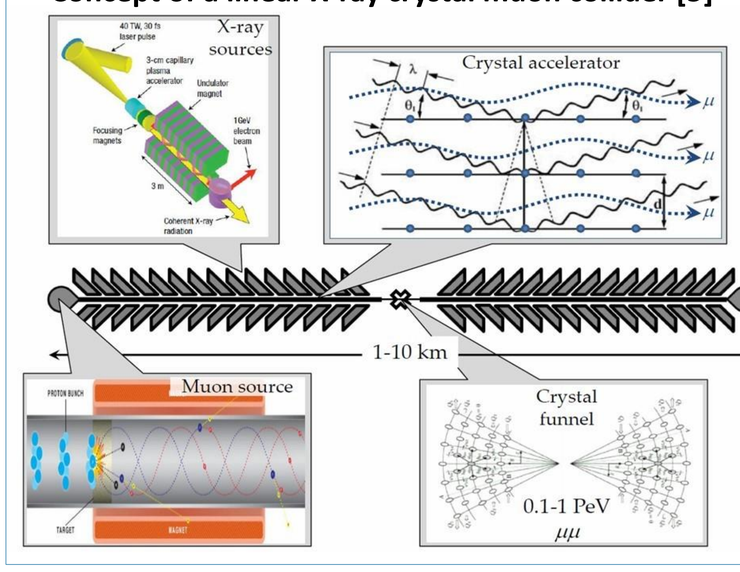
~6 µm hollow tubes in a glass substrate
Target mount with 1 µrad tip/tilt resolution

X-ray, gamma-ray and beam diagnostics

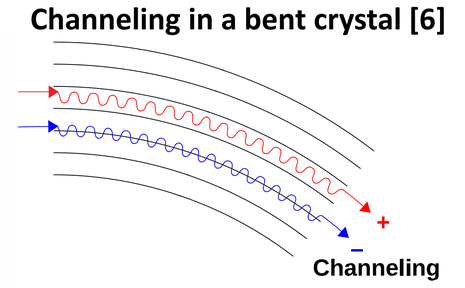
Long-term applications: lepton colliders

Crystals and nanostructured targets offer ultra-high acceleration gradients as well as the use as various other beam line elements:
- Charged beam steering, collimation and focusing using channeling effect
- High intensity positron source for future e+/e- and muon colliders

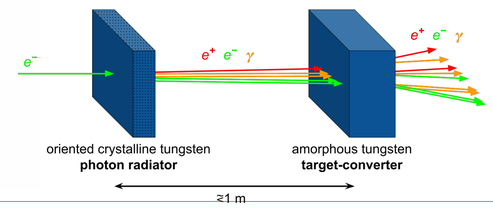
Concept of a linear X-ray crystal muon collider [5]



Channeling in a bent crystal [6]



Hybrid crystal-based positron source [7]



Conclusions

The E-336 experiment at the FACET-II aims at studying the interaction of micrometer-size electron beams with structured targets, which will give a better understanding of the physics down to a level of solid-density λp. The simulations show a transverse modulation that qualitatively and quantitatively depends on the structure size. In the future these results can be used for the design of beam-driven plasma-based e+/e- and muon colliders.

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References and Literature

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