On a conceptual approach to collimation system for linear collider with bent crystals

Andrei Seryi (SLAC)

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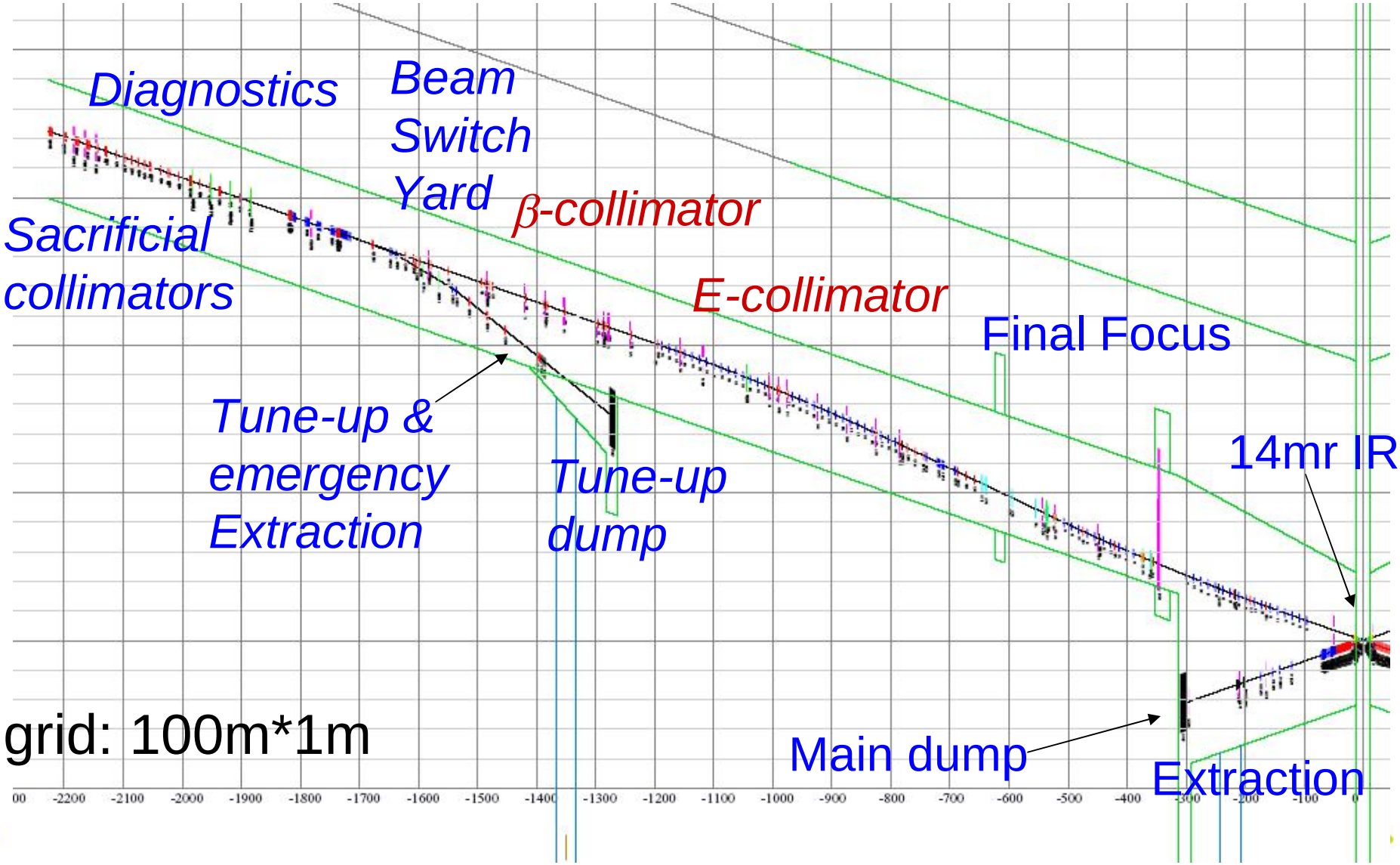
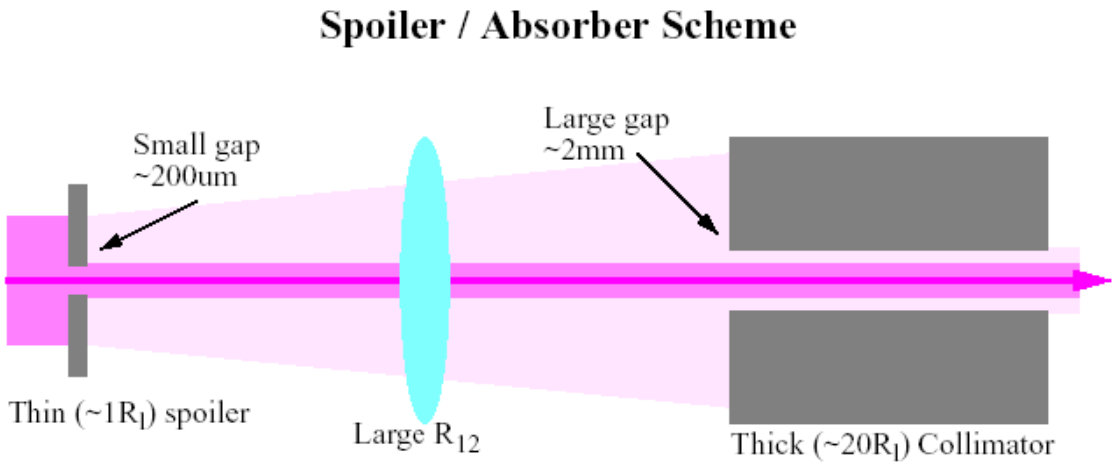
CM11, LARP

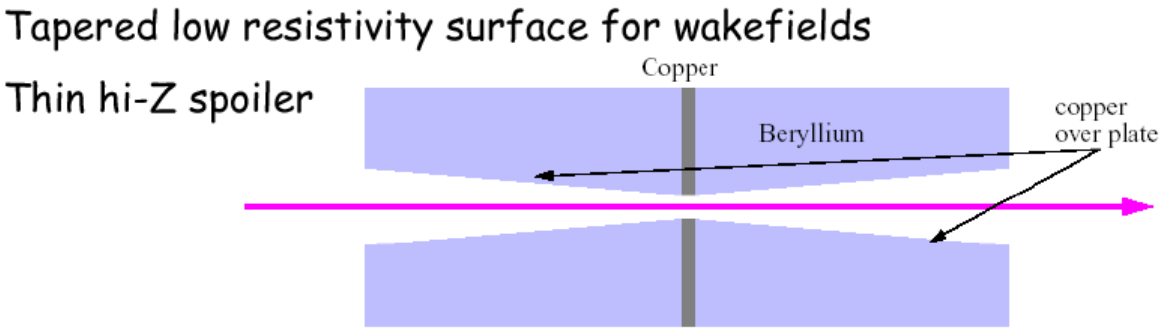
ILC Beam Delivery for 1TeV CM



Collimation by Spoiler-Absorber in ILC



Thin spoiler increases beam divergence and size at the thick absorber already sufficiently large. Absorber is away from the beam and contributes much less to wakefields.

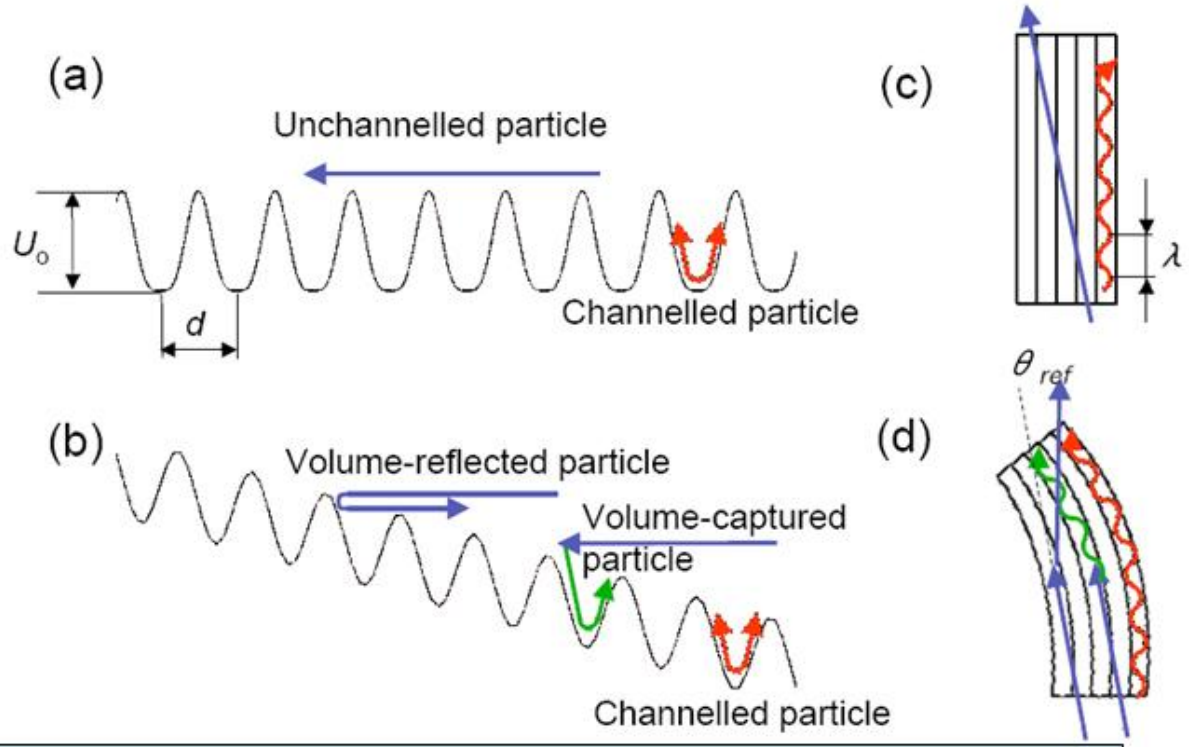


Need the spoiler thickness increase rapidly, but need that surface to increase gradually, to minimize wakefields. The radiation length for Cu is 1.4cm and for Be is 35cm. So, Be is invisible to beam in terms of losses. Thin one micron coating over Be provides smooth surface for wakes.

Particle-crystal interaction

Possible processes:

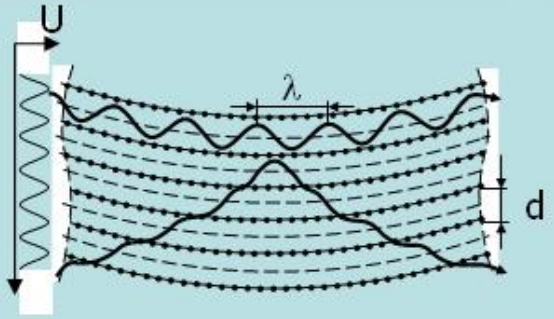
- multiple scattering
- channeling
- volume capture
- de-channeling
- *volume reflection*



Volume reflection

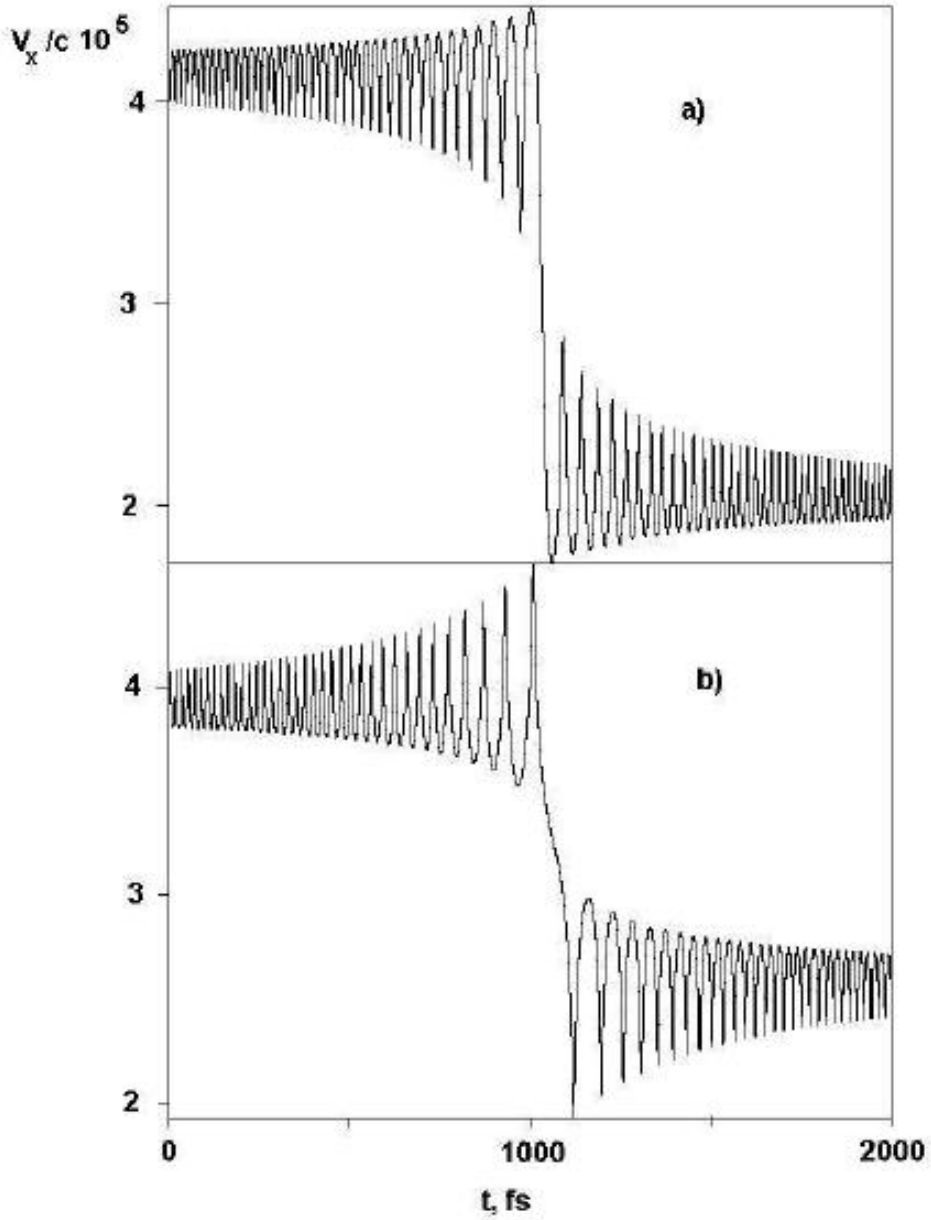
Prediction in 1985-'87 by
A.M.Taratin and S.A.Vorobiev,

First observation 2006 (IHEP - PNPI - CERN)



Slide from Walter Scandale (CERN)

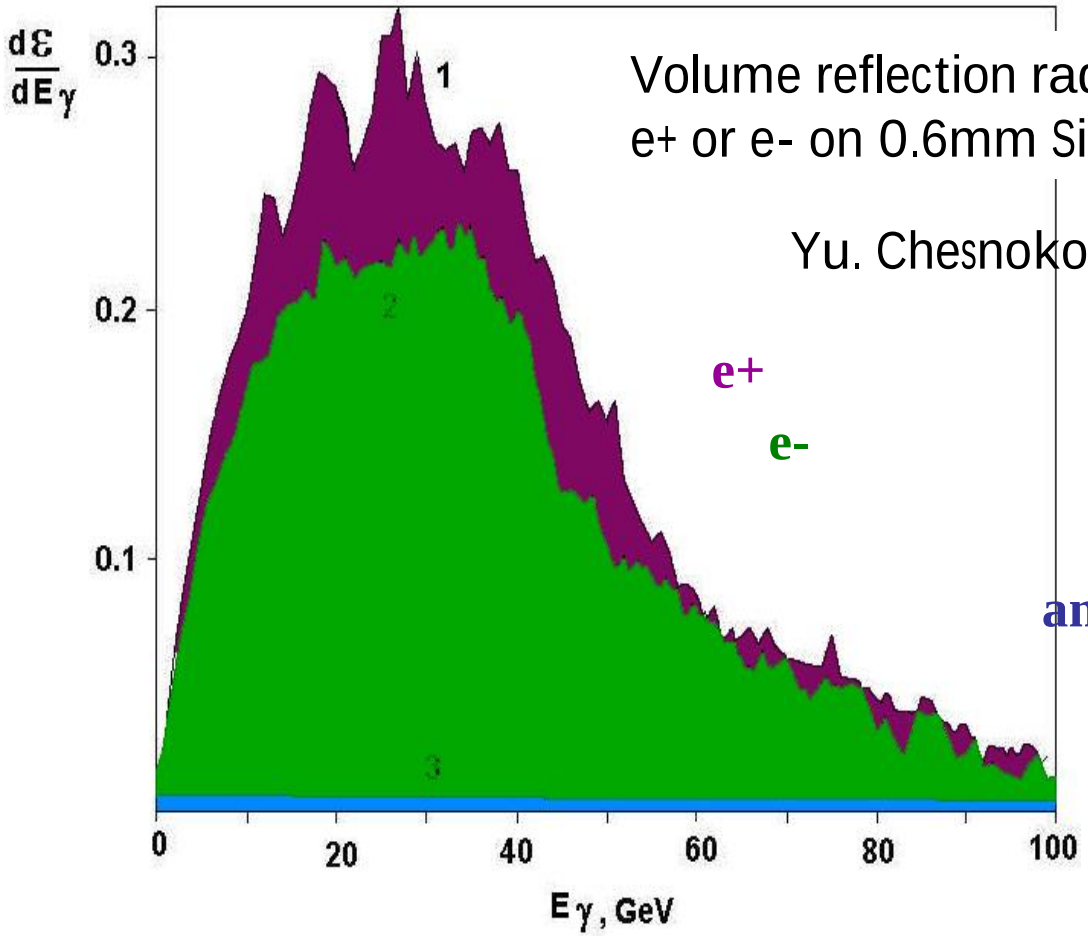
Volume reflection radiation



Relative transversal velocities of positrons (a) and electrons (b) at volume reflection in bent silicon crystal. E = 200 GeV, crystal thickness 0.06 cm, radius of bending 10 m.

Yu. Chesnokov et al, IHEP 2007-16

Volume reflection radiation



Volume reflection radiation of 200GeV e+ or e- on 0.6mm Si crystal (R_{bend}=10m)

Yu. Chesnokov et al, IHEP 2007-16

e+

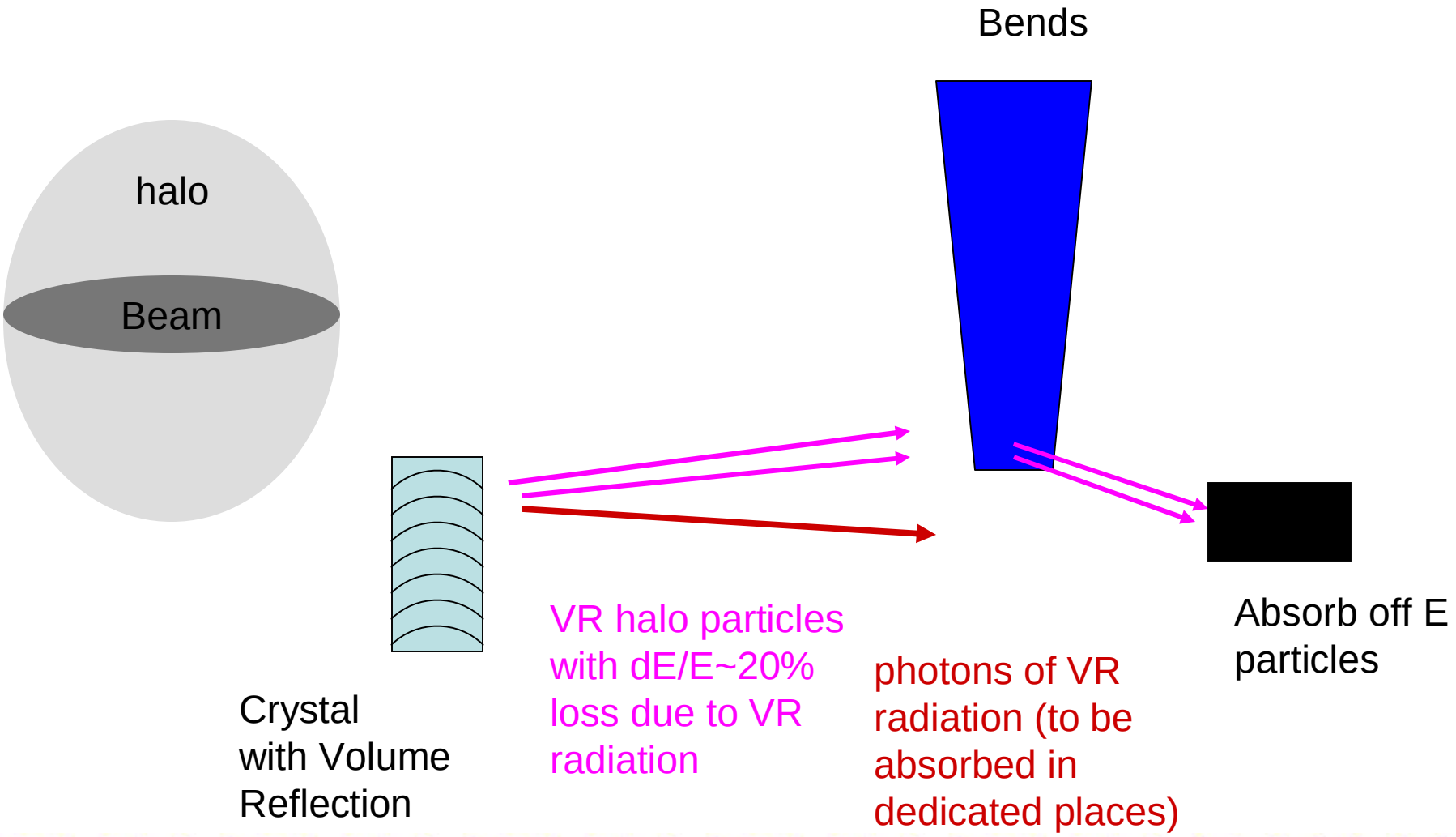
e-

amorphous

Scaling E_γ with E: ~$E^{3/2}$ for E<<10GeV and E^2 for E>>10GeV (Gennady Stupakov)

VR radiation is very similar for both e+ and e-, and has large angular acceptance – it makes this phenomena good candidate for collimation system of linear collider

LC Collimation concept based on VR radiation

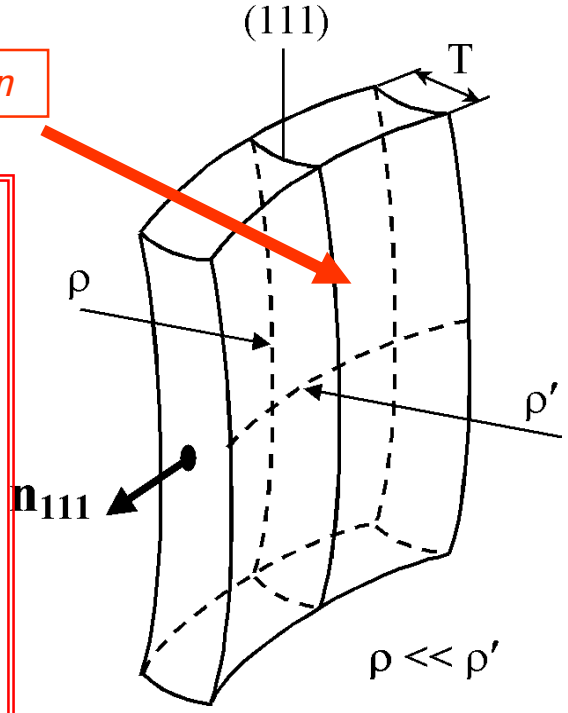


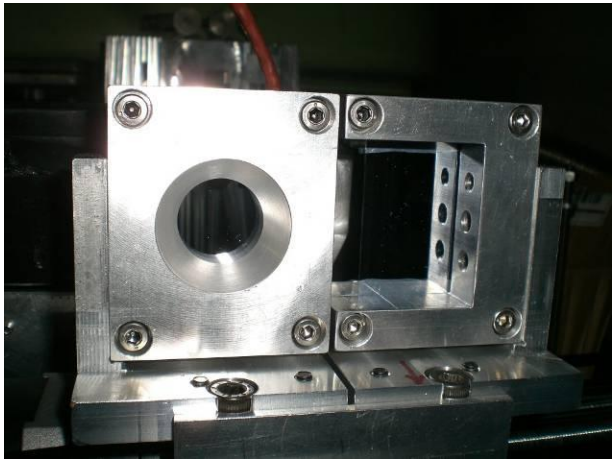
Quasimosaic crystals

Built at PNPI - Gatchina

Quasi-Mosaic effect (Sumbaev , 1957)

- The crystal is cut parallel to the planes (111).
- An external force induce the main curvature.
- The anticlastic effect produces a secondary curvature
- The anisotropy of the elastic tensor induces a curvature of the crystal planes parallel to the small face.





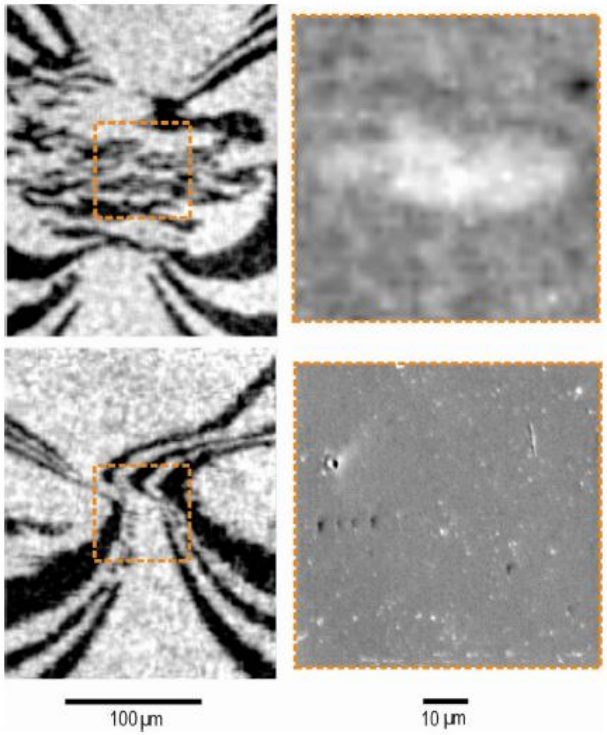
Crystal size: 0.7 x 30 x 30 mm^3

Crystal survivability questions

- Crystal – how to remove heat?
  - **continuous, due to interaction with halo**
  - **Crystal is thin, thermal conductivity is low?**
  - **Connect it to high conductivity and thicker plate? (E.g. pyro-graphite? -- as suggested by Y.Chesnokov and V.Maisheev (IHEP))**

- Damage due to accidental passage of the entire bunch?
  - **can benefit from reduced damage phenomena that was observed at FFTB experiments (J. Stohr et al)**
    - reduced damage observed for short bunches (50 microns)
    - ILC bunch length: 300microns, CLIC: 40microns
  - **From conversation with J. Stohr: it is likely that similar reduced damage phenomena will happen for Si bent crystals**

Ultra-short, ultra-strong field pulse shows no heating and damage

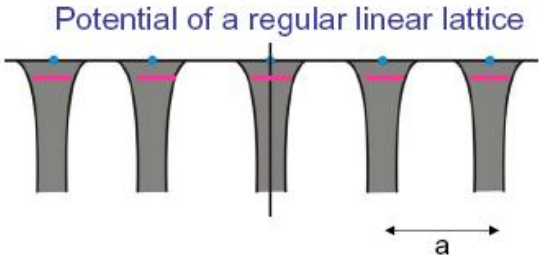


Pulse length: 4 ps

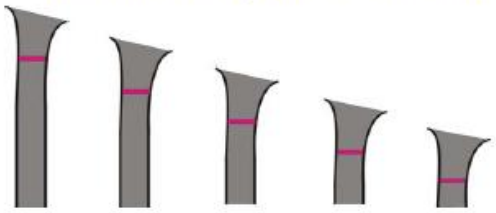
Pulse length: 140 fs

Peak field 35 times stronger

J. Stohr et al



Co bandwidth ~ 3eV



$E \sim 10^{10}$ V/m

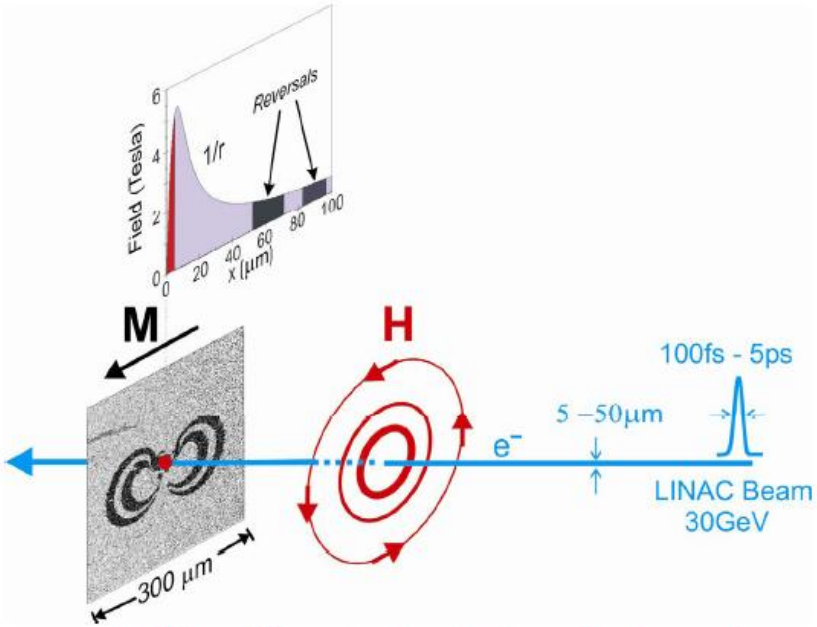
a = 0.25 nm

$\Delta V = e\,E\,a \sim 2.5$ eV

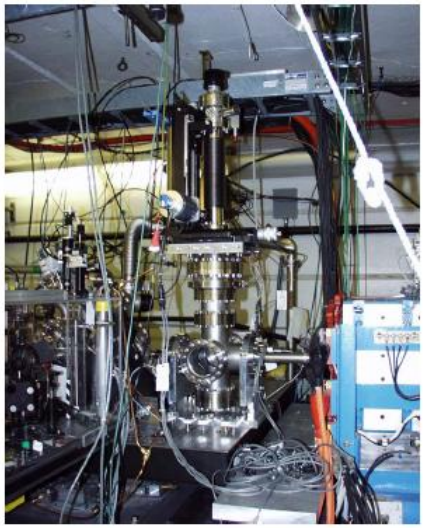
potential gradient leads to breakup of conduction path
no current flow due to field – not heating

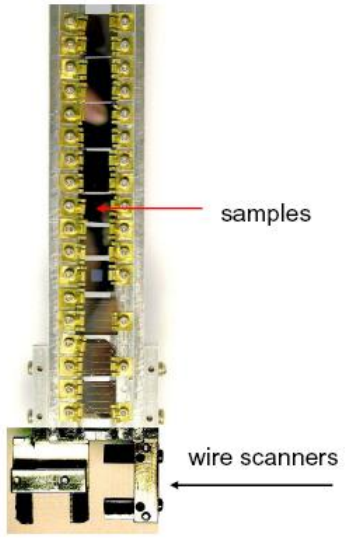
Collimation system of Linear Colliders with short bunch (e.g. CLIC or PWFA-LC) may benefit from recently observed phenomena that short bunches produce much less damage

Experimental Geometry and Magnetic Field

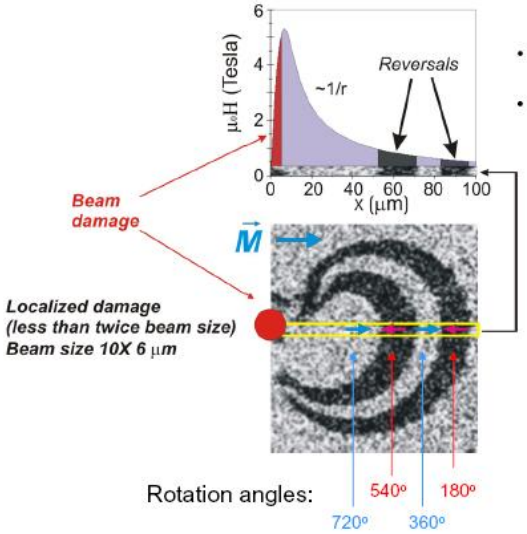


Experimental Setup in FFTB



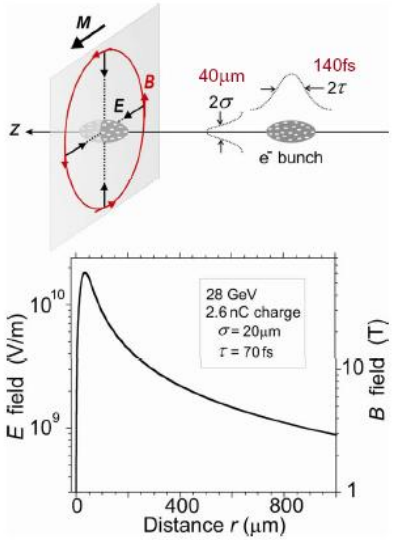


In-Plane Magnetization: Pattern development



- Magnetic field intensity is large
- Precisely known field size

Experiments with femtosecond bunches



Observe two key new effects

J. Stohr (SLAC), “Other Experiments using FACET ASF”, Feb 19, 2008 SLAC FACET review.
http://www-group.slac.stanford.edu/ppa/Reviews/facet-review-2008/Agenda.asp

Summary

- Crystals and LC collimation system:
- Applicability and benefits to be studies further
  - **one of advantages may be much smaller wake-fields due to collimators**
- If advantages are significant, detailed design is to be done
- Design approach then would be different
  - **and would also include new things to deal with (VR photons)**