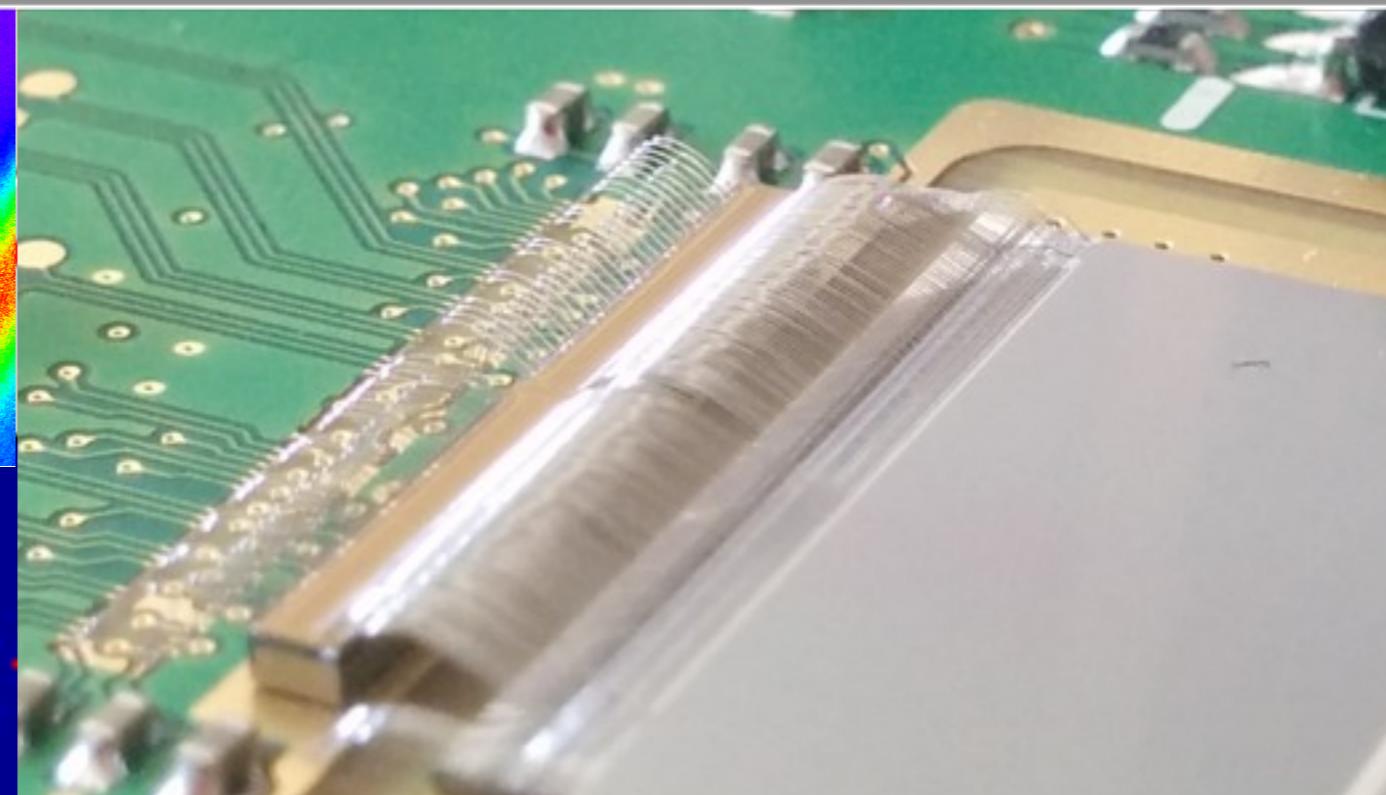
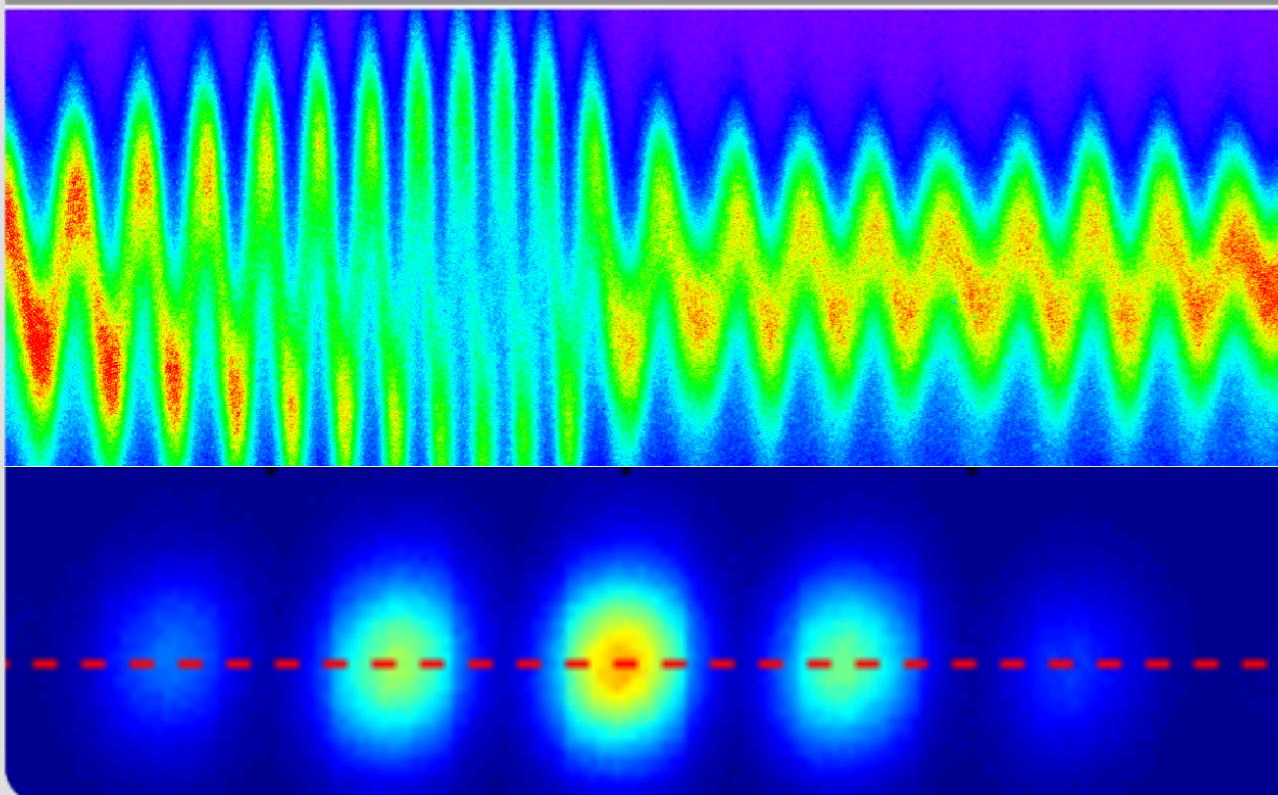


A - brainstorming - view on future accelerators/concepts

Anke-Susanne Müller

INSTITUTE FOR BEAM PHYSICS AND TECHNOLOGY (IBPT)



Influence / availability of new technologies

- Farming techniques experienced steady progress since new stone age
- Now: advances in LED technology allow vegetable production with higher yields and shorter grow cycles, indoors, and space-efficient



By NASA Marshall Space Flight Center - <http://www.msfc.nasa.gov/news/news/photos/2000/photos00-336.htm>,
<https://commons.wikimedia.org/w/index.php?curid=39544881>

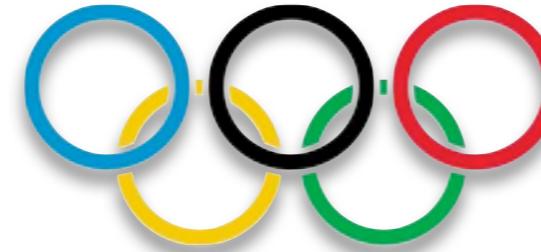
vertical farming



By Valcente - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=9387472>

General remarks

Key-parameters: size, energy, intensity, particle types, cost (!)



[https://commons.wikimedia.org/
w/index.php?curid=503600](https://commons.wikimedia.org/w/index.php?curid=503600)

In the future

- accelerators for a given energy will in general be smaller...
 - fully tunable, miniature FELs?
- both photons and charged particle beams are provided...
- dedicated large scale facilities for ultimate parameters (flux, brilliance,...)
- photon sources will have a wide spectrum from THz to x-rays...
- small low intensity accelerators will become available to generate single photon or single electrons/protons with well defined properties for diagnostic purposes, such as quality control or medical scans...
- possible applications: molecular and quantum engineering

Possible show stoppers

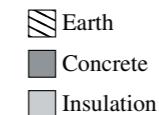
Wikipedia:

Show stopper: “originally a performance or segment of a theatrical production that induces a positive audience reaction strong enough to pause the production”

■ safety / health considerations

- future miniature accelerator with high E_0 still needs the same shielding as present day's model

source: MAX IV DDR



■ laws of nature...?

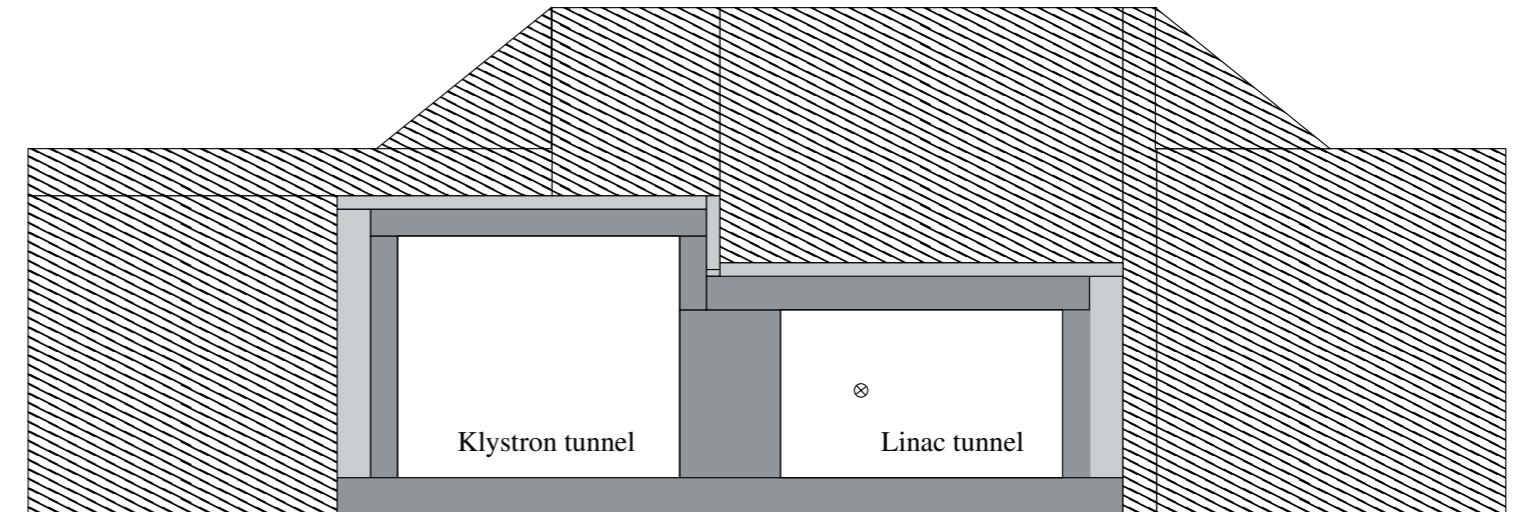
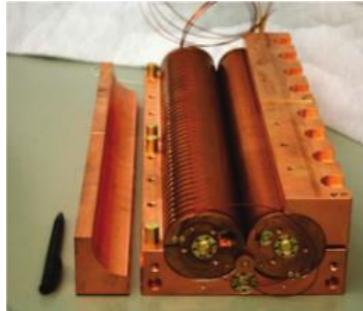
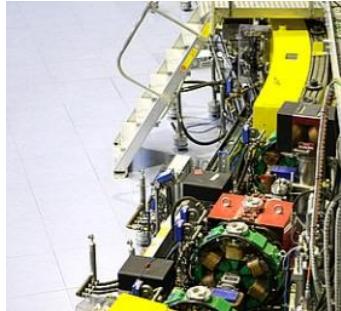
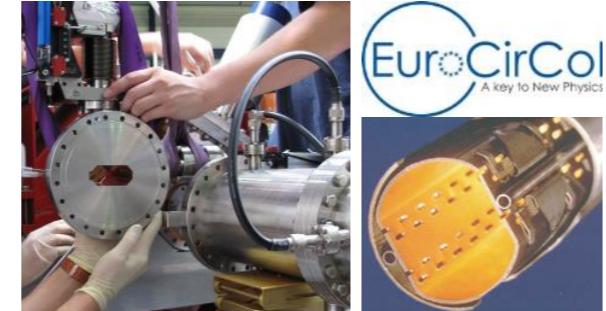


Figure 2.2: Crossection of the linac and klystron tunnels. The electrons travel into the figure.

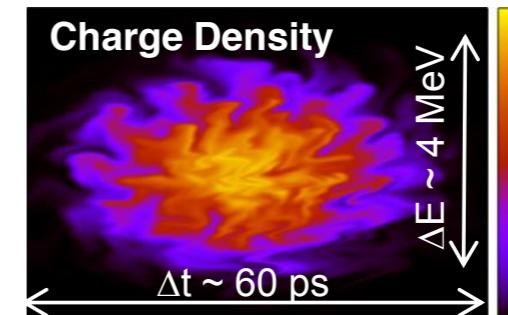
Accelerators use lots of different technologies...



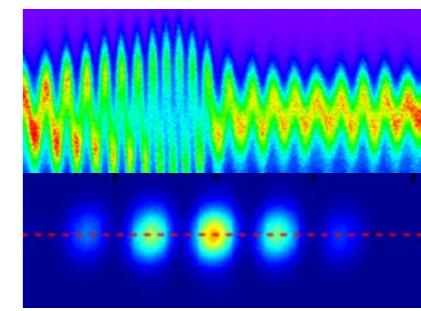
Compact Magnet Technology



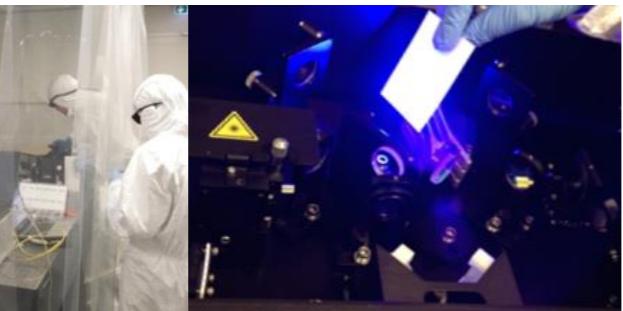
Vacuum Technology



Multi-dimensional
Spectroscopy & Imaging



Simulations
Mathematics
Theory

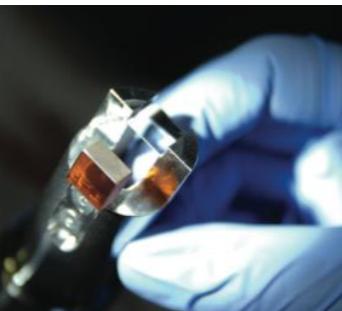


Femtosecond Lasers

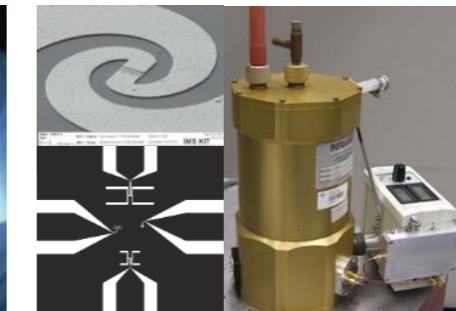
THz & IR &
VIS & UV Laser



Fibers



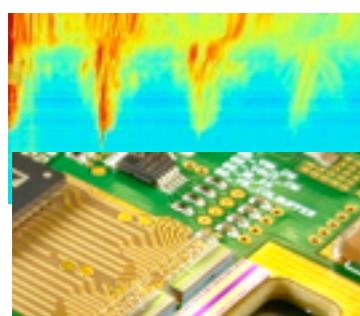
Electro-Optics
Materials Science



Ultra-Fast
THz Detectors



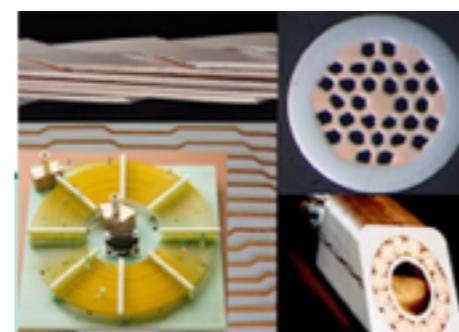
Nanotechnology



Electronics



Cryogenics



Superconductivity



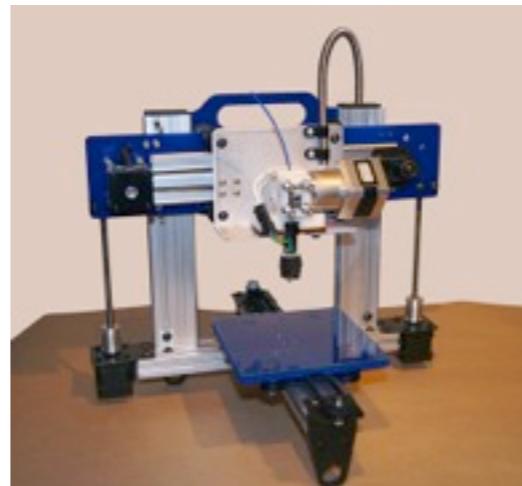
Storage Ring
Test Facility



Short-Pulse Linac
Test Facility

Available / emerging technologies

■ 3D printed parts



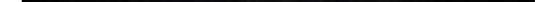
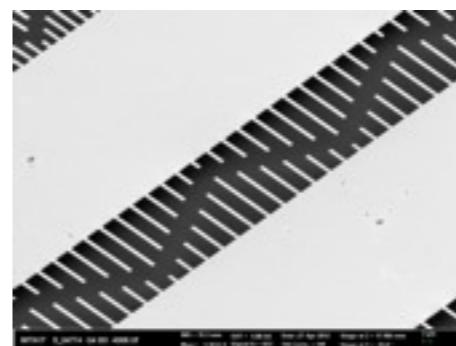
Von Bart Dring - http://www.buildlog.net/wiki/doku.php?id=ord_bot:the_ord_bot, GFDL 1.2, <https://commons.wikimedia.org/w/index.php?curid=18805970>

■ telecommunication systems

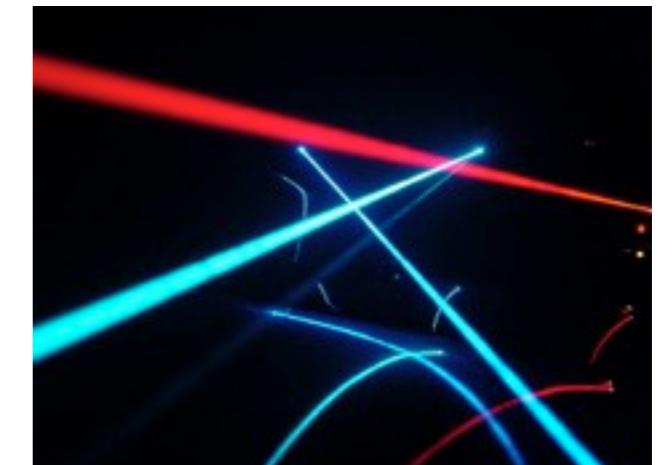


By BigRiz - First upload: (Sep 25 2004) en:Wikipedia, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=46561>

■ micro- / nano-fabricated parts



■ high power lasers



■ plasma & dielectric acceleration



...

By Jeff Keyzer from San Francisco, CA, USA - Beams in Fog + Car WindshieldUploaded by PDTillman, CC BY 2.0, <https://commons.wikimedia.org/w/index.php?curid=7065667>

Industrial needs

- very large and very small beam sizes



- high availability

- high flux

- high repetition rate

- low cost per hour

- high flexibility (“instant” on / off)

- low (no) maintenance



Societal needs

Micro-accelerators for

- aircraft control & maintenance (“faster = cheaper”)
- medicine (e.g., compact imaging)
- food processing / engineering
- wall-climbing robots or multi-copters for inspection purposes on buildings, bridges, etc.



That means

- autonomous systems
- low operation cost
- high availability / reliability
- high flexibility (“instant” on / off)
- low (no) maintenance



By KUKA Roboter GmbH, Bachmann - KUKA Roboter GmbH, Zugspitzstraße 140, D-86165 Augsburg, Germany, Dep. Marketing, Mr. Andreas Bauer, <http://www.kuka-robotics.com>, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=3345405>

Crazy ideas - MicroAccArrays

- Today: development towards multi-element detector arrays

- example: micro bolometer arrays

FLIR Systems ThermoVision SENTRY
Infrared Imaging System utilizes a
320×240 microbolometer array.



<https://commons.wikimedia.org/w/index.php?curid=167219>

- Option? Multi-element arrays of micro-accelerators
 - synchronization, spacing, ...

Crazy ideas - Mößbauer accelerator

- New accelerating mechanisms for low intensity accelerators based on coherent control of quantum systems
 - crystal in which a large number $O(10^9)$ of “active” sites, each storing an energy of 1 eV, in an entangled state
 - coherently transfer entire energy to a single photon, electron or proton
 - like in the Moessbauer effect, the crystal as a whole takes the recoil, i.e. the emitted 1 GeV particle is perfectly mono-energetic
- under study for quantum computing....



Coherent Control of the Waveforms of Recoilless Gamma-Photons

Farit Vagizov^{1,2}, Vladimir Antonov^{3,1}, Y.V. Radeonychev^{3,1}, R. N. Shakhmuratov² and Olga Kocharovskaya¹

¹ Department of Physics and Astronomy and Institute for Quantum Studies and Engineering, Texas A&M University, College Station, TX: 7784-4242, USA

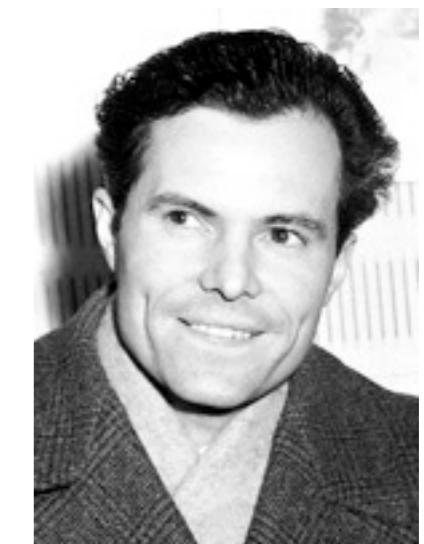
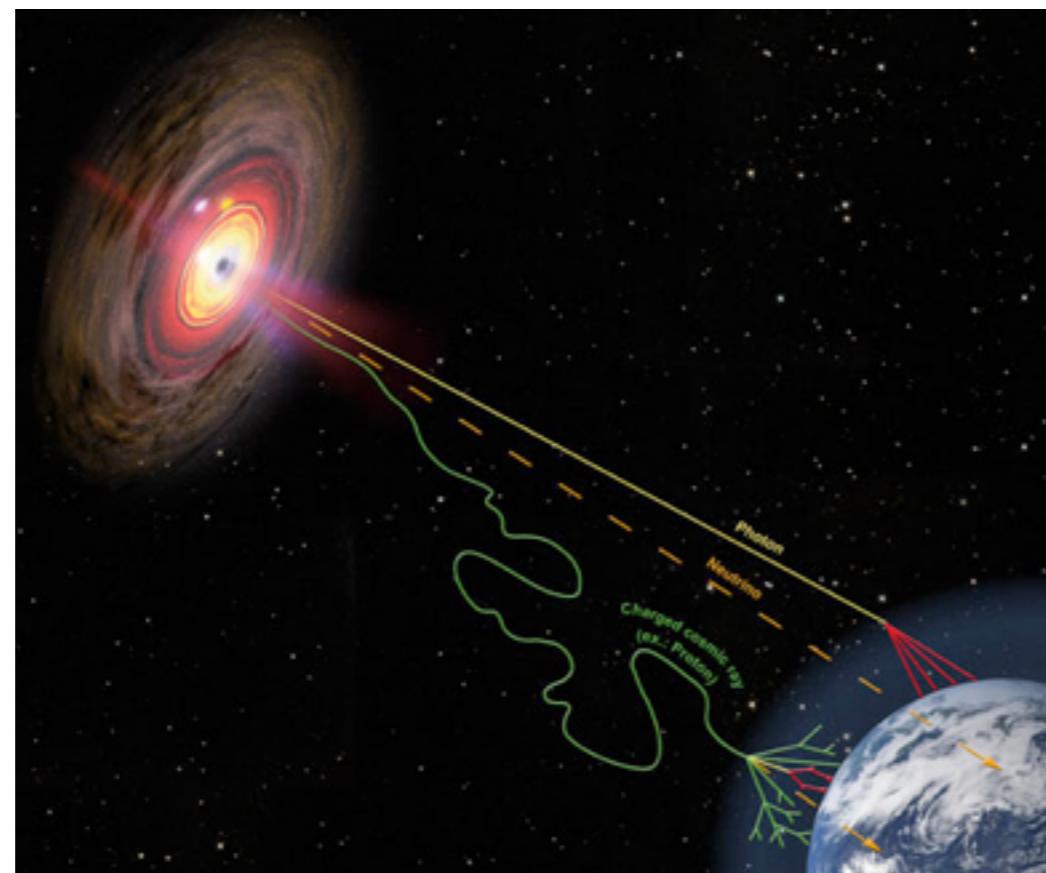
² Kazan Federal University and Kazan Physical Technical Institute of the Russian Academy of Sciences, Kazan 420008, Russia

³ Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod 603950, Russia

By Nobel foundation - http://nobelprize.org/nobel_prizes/physics/laureates/1961/mossbauer-bio.html, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=6148339>

Crazy ideas - Mößbauer accelerator

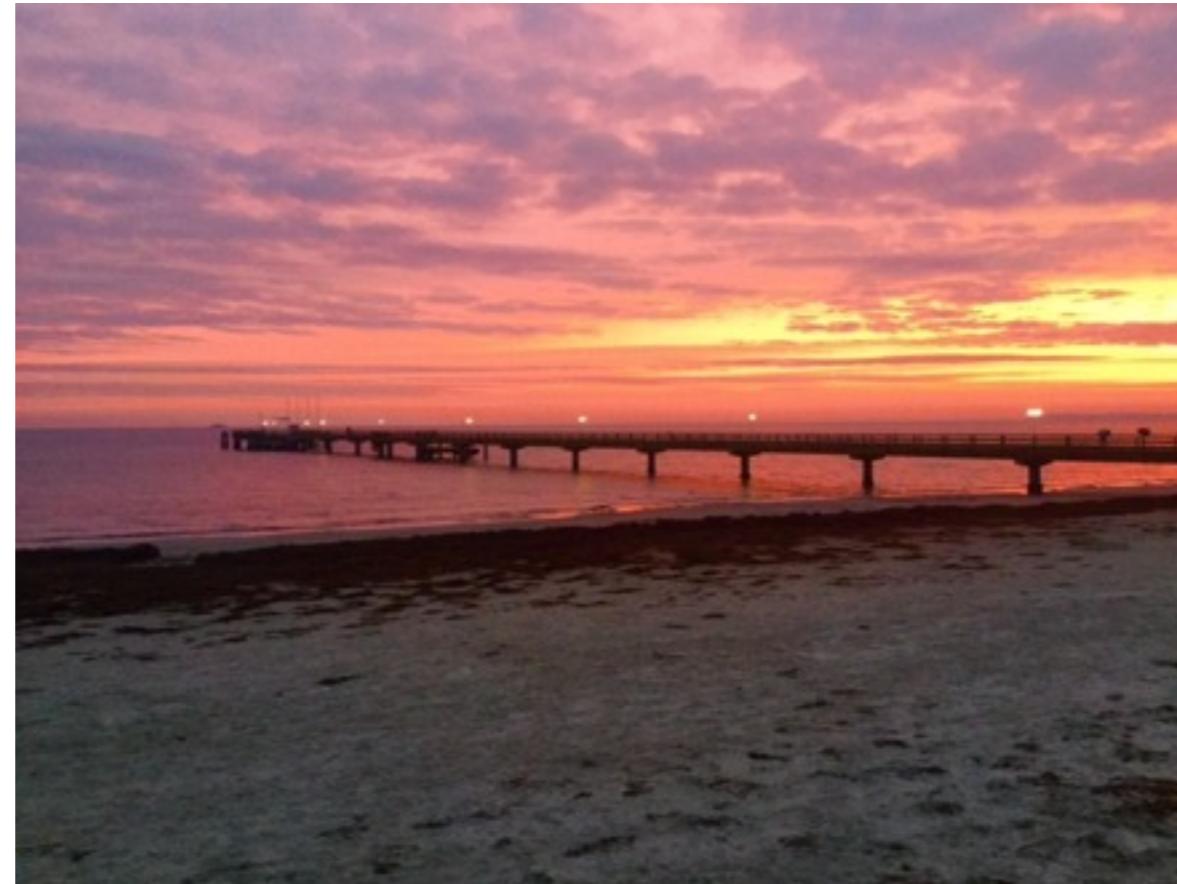
- New accelerating mechanisms for low intensity accelerators based on coherent control of quantum systems
 - first systems of that kind will probably operate with just a few active sites
 - in the far future, the level of control may be extended to $O(10^{20})$ active sites in a crystal, opening the door to lab studies with energies seen in the highest cosmic ray particles



By Nobel foundation - http://nobelprize.org/nobel_prizes/physics/laureates/1961/mossbauer-bio.html, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=6148339>

HAP / A. Chantelauze; <http://www.hap-astroparticle.org/184.php>

Whatever the future may bring....



“We know what we are, but not what we may be.”

— William Shakespeare, Hamlet