

ICFA ERL Workshop

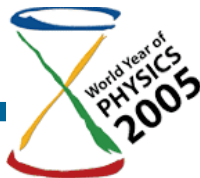
Introduction to Workshop Goals Opening Plenary

Swapam Chattopadhyay
March 19, 2005

ICFA ERL Workshop
Jefferson Laboratory
March 19-23, 2005

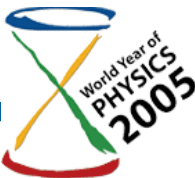


Thomas Jefferson National Accelerator Facility



A BIG THANK YOU!

- ❖ Thanks to Lia Merminga for the entire technical organization
- ❖ Thanks to all Working Group Conveners for outstanding organization of WG tasks/goals
- ❖ Thanks to Jefferson Lab's Staff Services Group (Marty Hightower, Cynthia Lockwood, Ruth Bizot, Noel Vermeire, Karen Chandler, Elizabeth Sheffield), Electronic Media (Shannan Kyte, Zo Brown), Kelly Hanifan and Tonya Evans of the Accelerator Division for excellent organization of the workshop
- ❖ Thanks to our sponsors: Cornell, 4GLS at Daresbury, BNL, ICFA



**2005: World Year of Physics, 100 years since
1905: Einstein's Annus Mirabilis with three significant papers:
Photoelectricity, Brownian Motion and Special Theory of Relativity**

Einstein's Annus Mirabilis

Albert Einstein. "Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt." *Annalen der Physik* 17 (1905), 132-148.

Albert Einstein. "Über die von der molekularkinetischen Theorie der Wärme geforderte Bewegung von in ruhenden Flüssigkeiten suspendierten Teilchen." *Annalen der Physik* 17 (1905), 549-560.

Albert Einstein. "Zur Elektrodynamik bewegter Körper." *Annalen der Physik* 17 (1905), 891-921.

THE COLLECTED PAPERS OF
Albert Einstein

VOLUME 2

THE SWISS YEARS:
WRITINGS, 1900-1909



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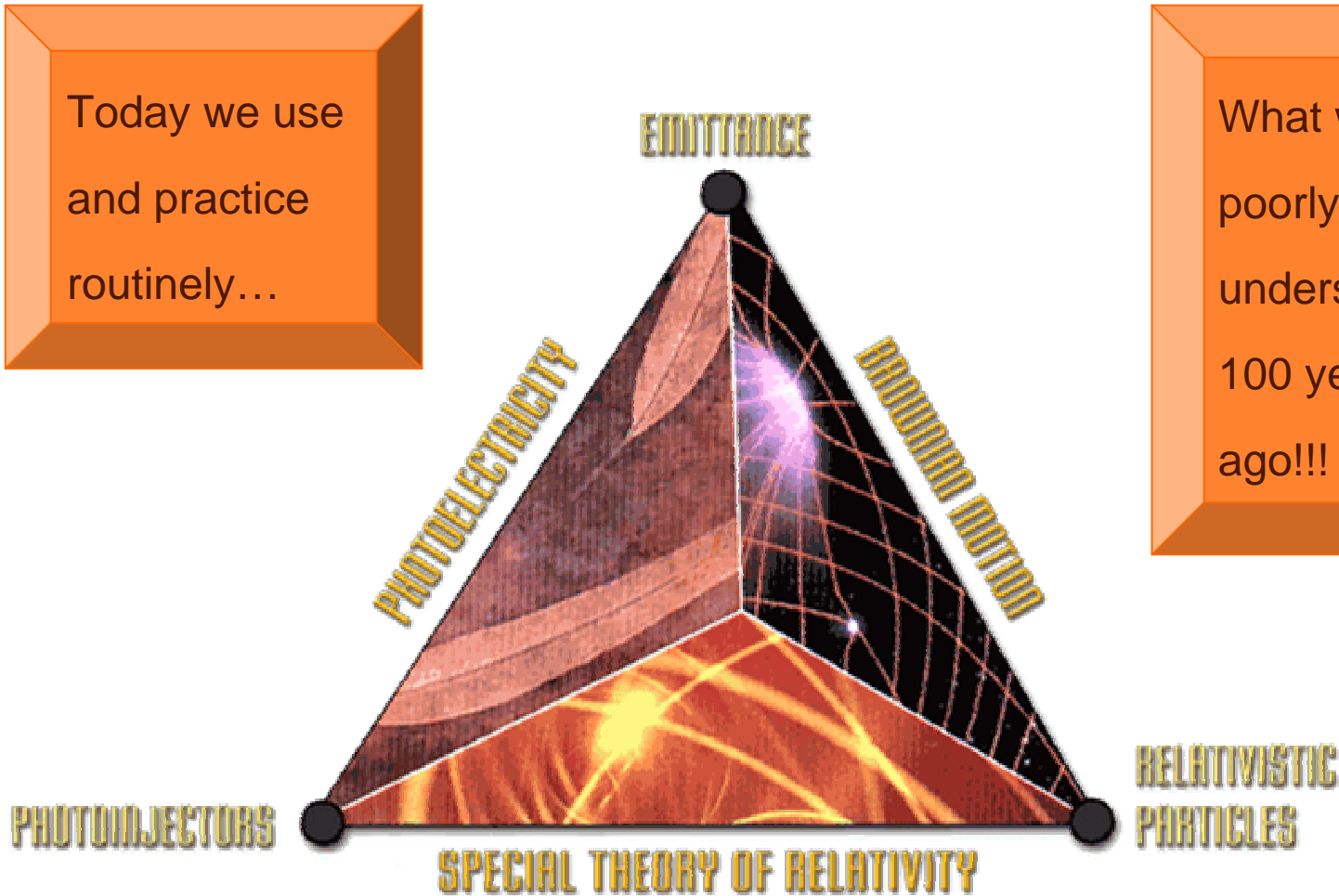
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Photoelectricity, Brownian Motion & Special Theory of Relativity

➔ all three are related to ERLS via Photocathode Guns, Emittance Dilution and Speed-of-Light Particles

Today we use and practice routinely...

What was poorly understood 100 years ago!!!



World-Wide ERLs

❖ In Operation

- JLab FEL, Novosibirsk, JAERI,

❖ Under Construction

- Cornell prototype, Daresbury 4GLS prototype, BNL e-cooler, 100 kW FEL, ...

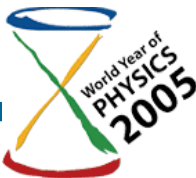
❖ Being Envisioned

- 4 GLS, Cornell ERL x-ray Ring, ELIC, eRHIC

→ **Need to have a comprehensive survey**



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Types of ERLs

❖ ERL X-ray Sources

(MeV \leftrightarrow GeV; \sim 100 mA)

Large “energy swing”

❖ ERL FELs

(MeV \leftrightarrow 100 MeV; 1 mA–1A)

Large “average current”

❖ ERL Electron Coolers

(\sim 10’s of MeVs; \sim 100 mA)

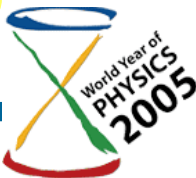
“Magnetized” beam

❖ ERL Electron-Ion Colliders

(\sim 10’s of GeVs; spin)

Large “absolute” energies and “spin manipulation”

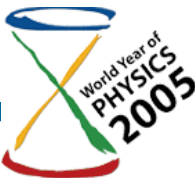
→ Need to identify “parametric space,” optimization and “operation modes”: “cw,” “switched” (gun), “merged” (beams), ...



Beam Physics Issues

- ❖ **Magnetic Optics:** linear and nonlinear, including magnetization and polarization
- ❖ **Current Dependent Effects:** Beam Break Up (BBU) and Coherent Synchrotron Radiation (CSR)
- ❖ **Beam Merger and Bunch Compression:** space charge, RF focusing, and emittance growth
- ❖ **Diagnostics at Sub-phase-space Level**

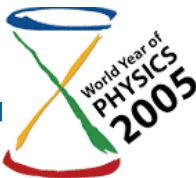
→ Need to have a “comprehensive” and “identified” set



Accelerator Technology

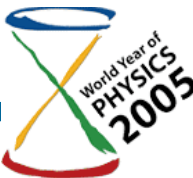
- ❖ High Current Guns: DC/NCRF/SRF
- ❖ SRF (cell shape, high-Q, HOM damping, high current cryomodule)
- ❖ RF Power and Control
- ❖ Cryogenics (operating temperature, pressure, load distribution,...)
- ❖ Magnets/Solenoids for e-cooler
- ❖ Industrial Fabrication/Technology Transfer

→ Need “prioritization”



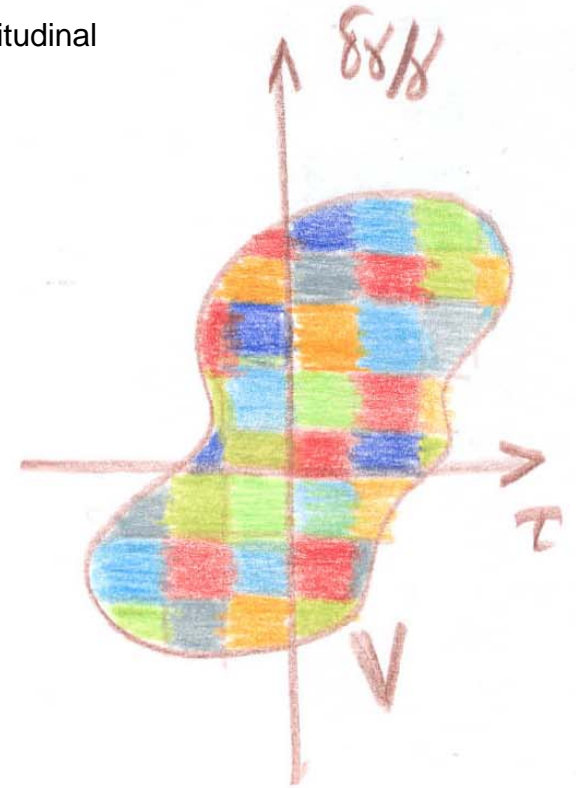
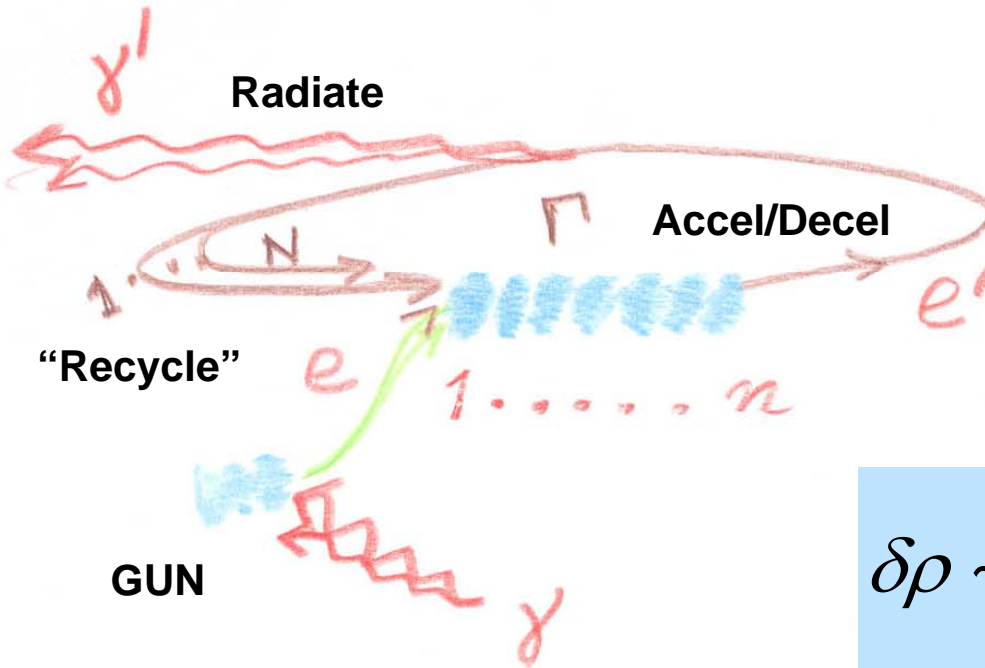
Diagnostics, Synchronization and Control are Critical for ERL Stability and Operation

- ❖ High Current implies that unique “Nondestructive” diagnostics is a MUST
- ❖ Protective Operation with High Current demands active and passive, fast Machine Protection Systems (MPS)
- ❖ Large Dynamic range of parameters:
.01 mA–1,000 mA, 1 pC–10 nC, kHz-GHz, 1 μm –10 μm (emittance), .01 mm–10 mm (size)
- ❖ Beam-based diagnostics and control preferred



ERL-induced Phase Space Fluctuations

- ❖ “Fluctuations” are inherent in the thermodynamic energy exchange between particles and fields at sub-phase-space level demanding spatio-temporal and phase-space resolution to resolve “graininess” at a level higher than low order moments of transverse and longitudinal distributions → **phase space “slicing,”** “imaging” and synchronization” techniques



$$\delta\rho \sim \frac{V}{\sqrt{nN}}$$

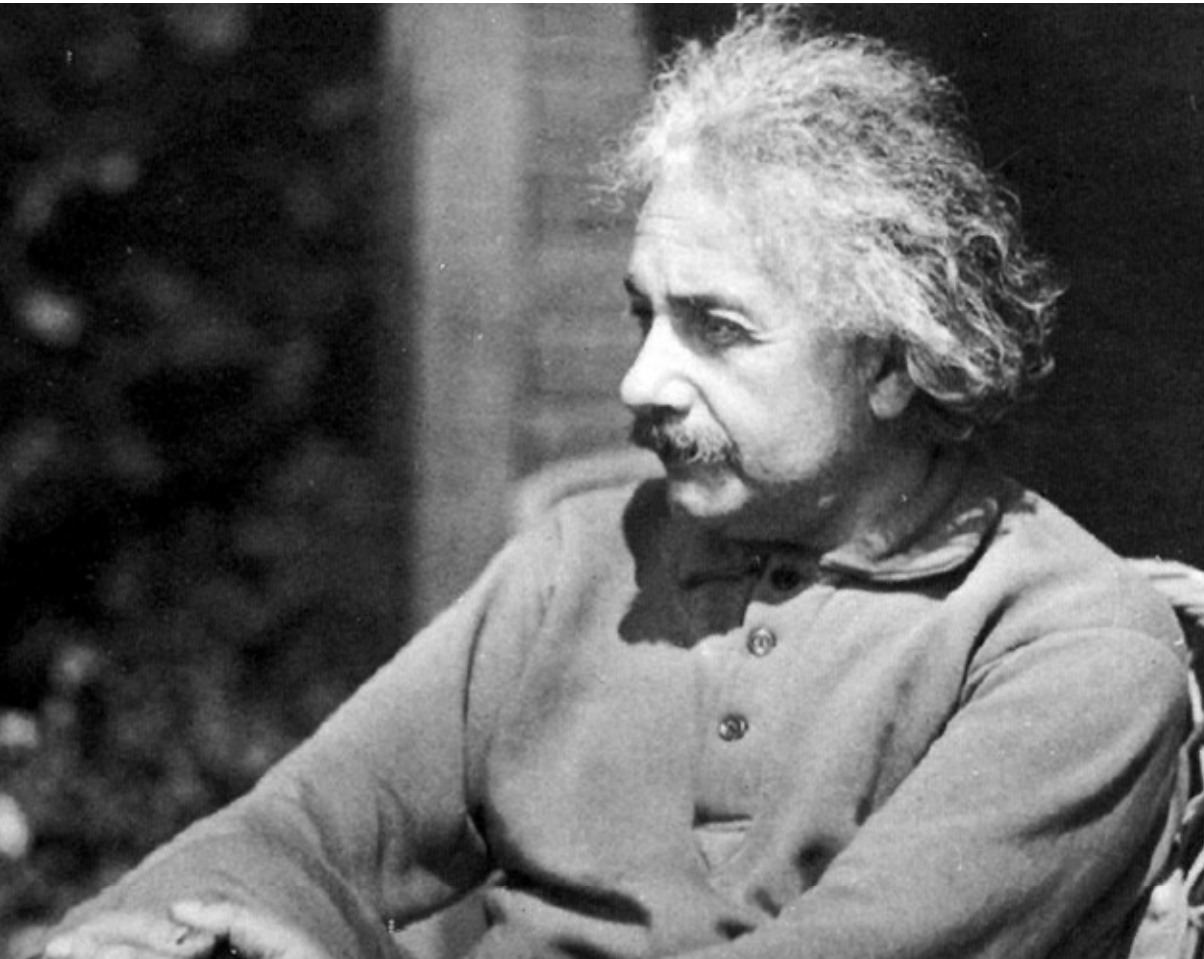
→ Room for **“innovation”** here

ERL-induced Phase Space Fluctuations



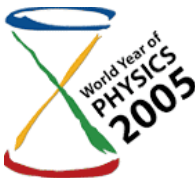
$$\delta\rho \sim (nN)^{-1/2}$$

→ Room for “innovation” here



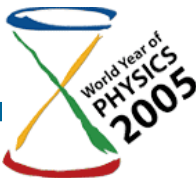
“Creative minds have
always faced violent
opposition from
mediocrity!”

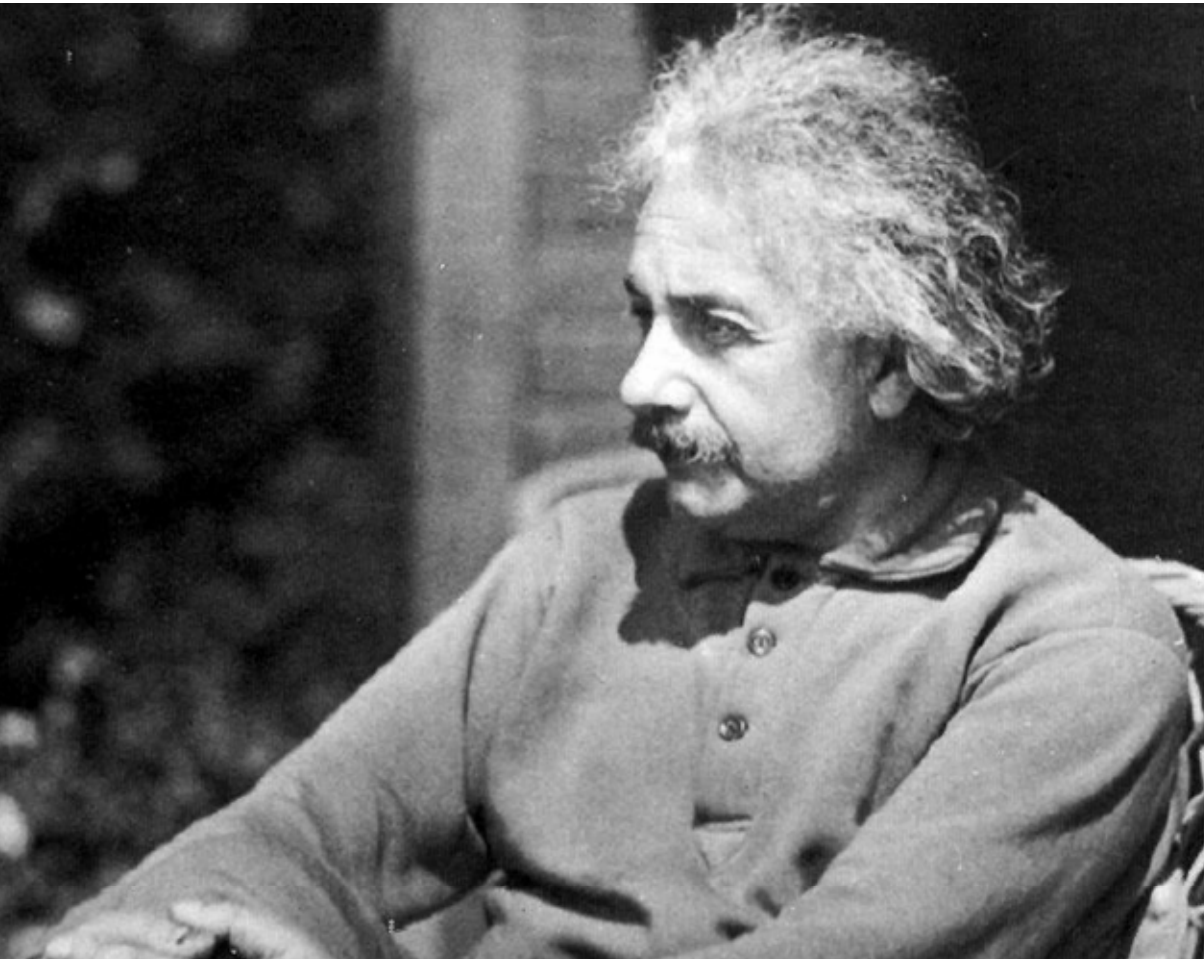
Albert Einstein



Workshop Goals

- ❖ **Comprehensive survey of all ERLs:** operating, under construction or being envisioned
- ❖ **Identify problems** “solved” in the past, being “solved” today and “to be solved” in the future
- ❖ **Brief report with R&D goals “prioritized”**
 - Key experiments: when, where, ...
 - Modeling/Simulation: who, which codes,...
 - Collaboration: national and international
- ❖ **Technology Packages**
 - Photocathode library/database/development
 - Laser library/database/development
 - Cathode + laser package
 - Laser Pulse Shaping “kit”
 - RF and SRF
- ❖ **Opportunities in Technology Transfer and Industrial Development**
- ❖ **New concepts/innovative Ideas**
 - Non-destructive diagnostics,...





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