# Introduction to synchrotron radiation

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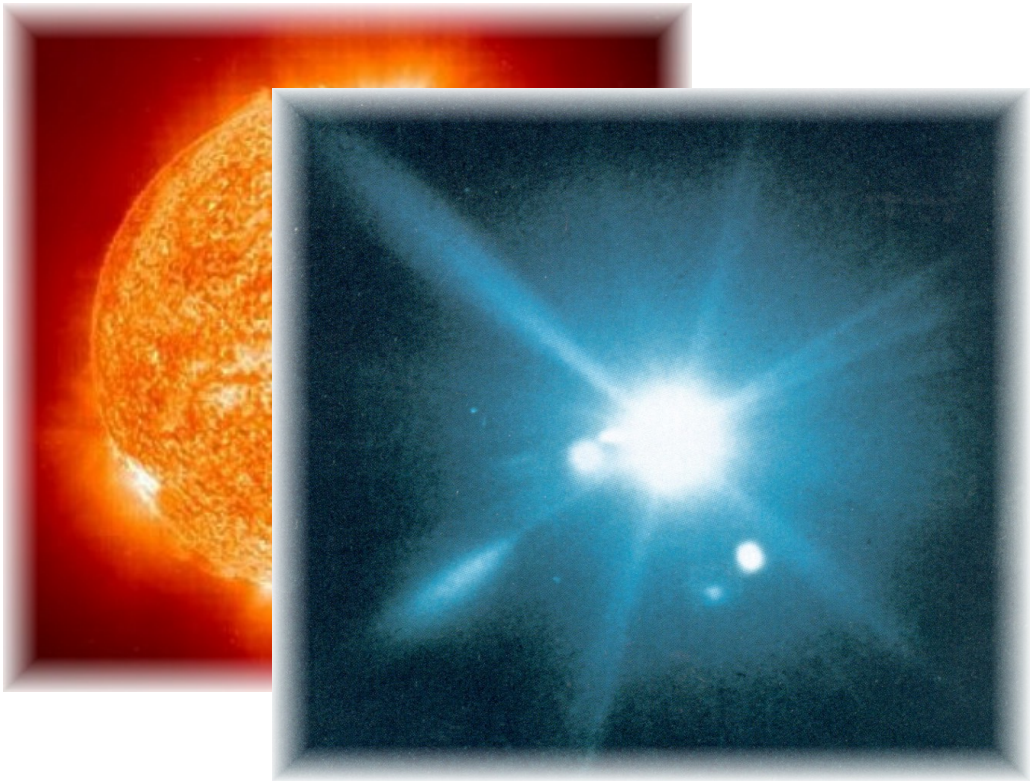


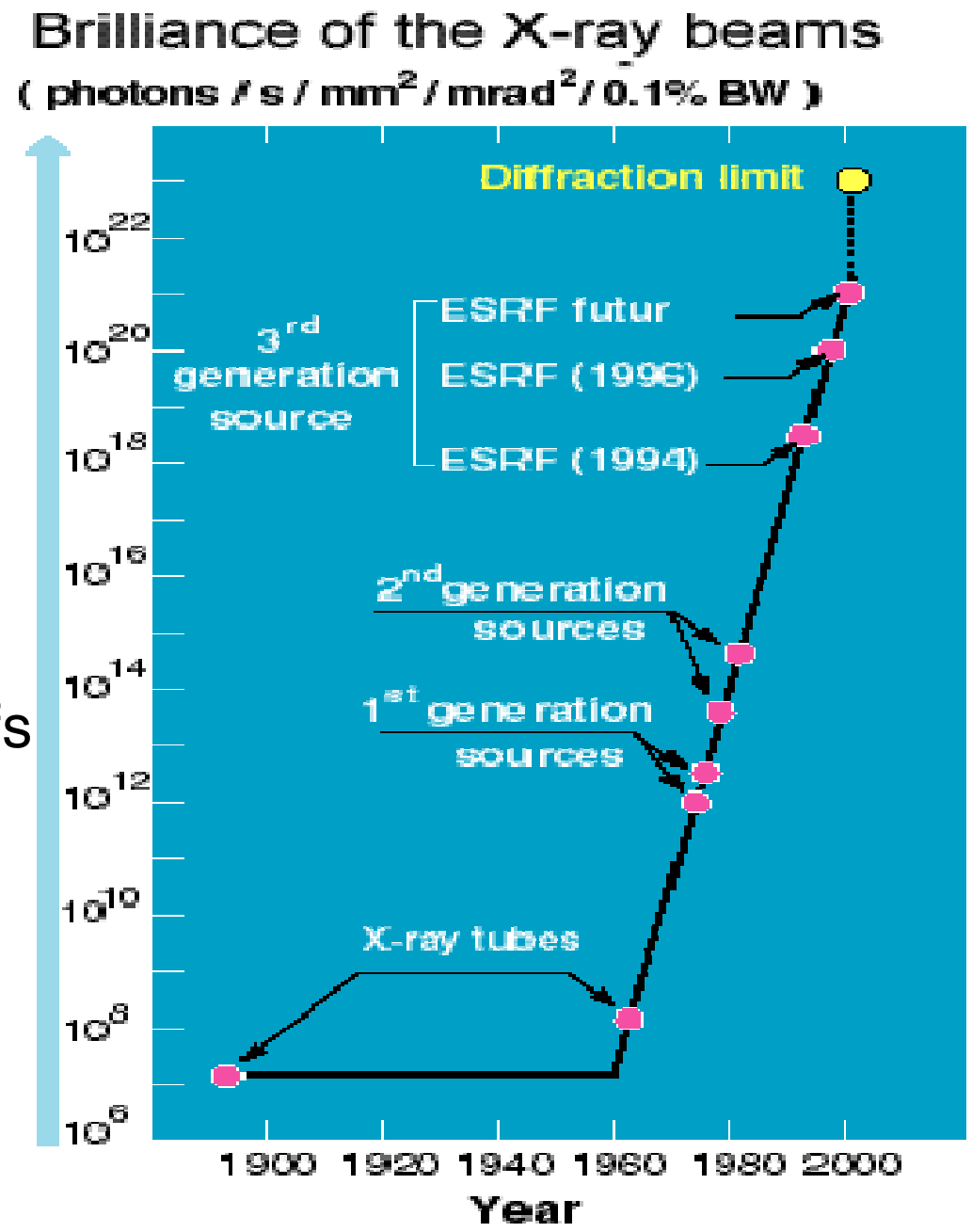
Brighter than the sun!

# Synchrotronstrahlung

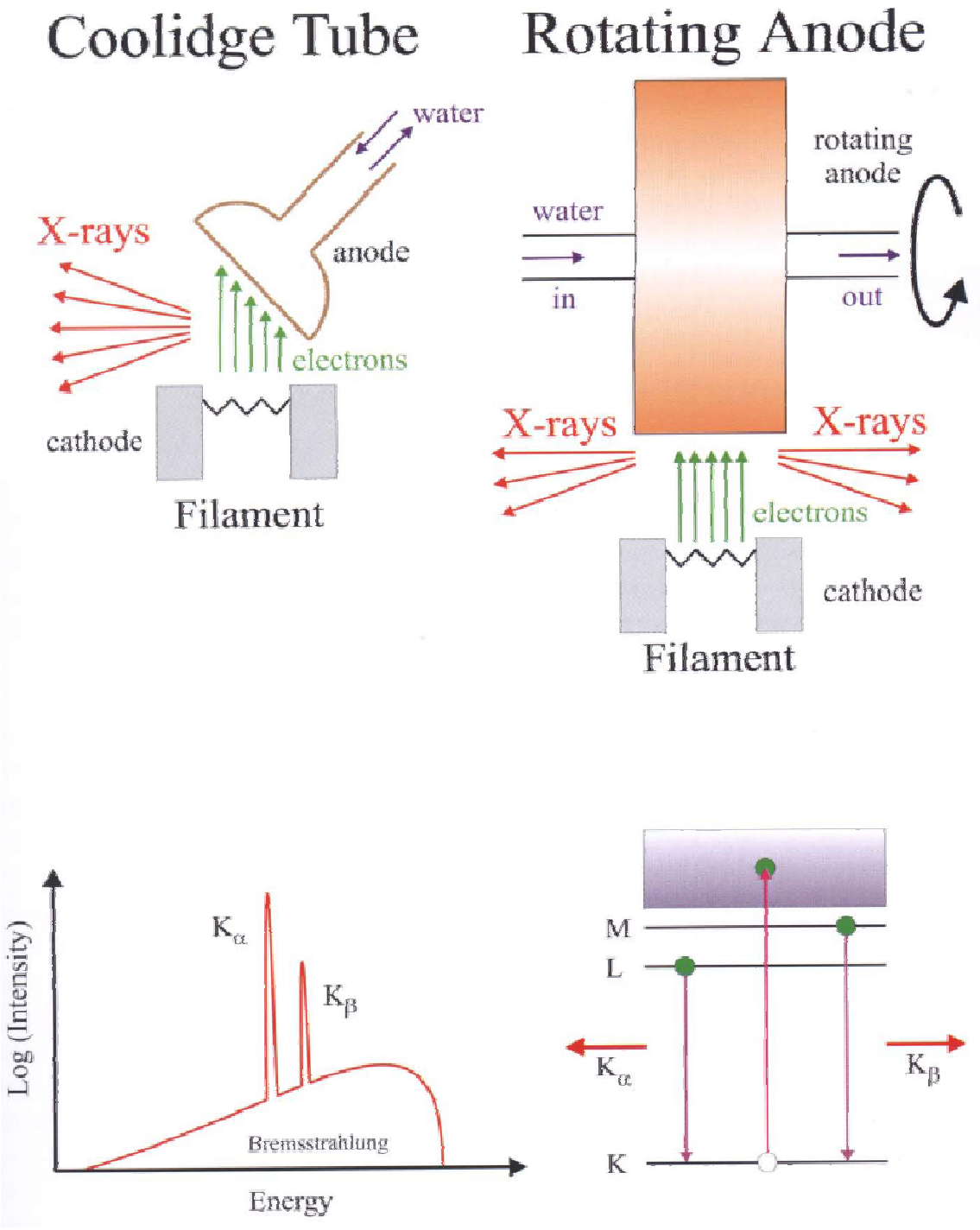
Synchrotron-Infos
auf Kieler Website:

Komitee
Forschung mit
Synchrotronstrahlung

http://www.physik.uni-kiel.de/kfs



# Konventionelle Röntgenquellen

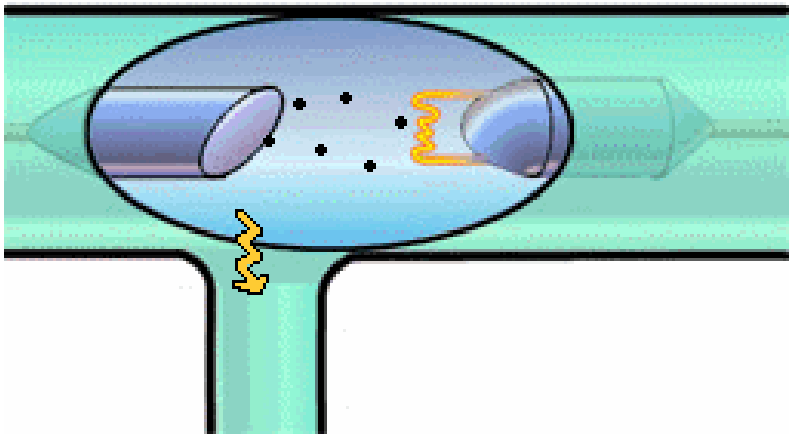


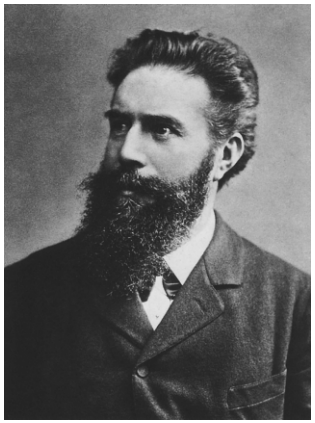

Als-Nielsen 2001, Abb. 2.1

# Generation of X-rays…

...by decelerated / accelerated electrons

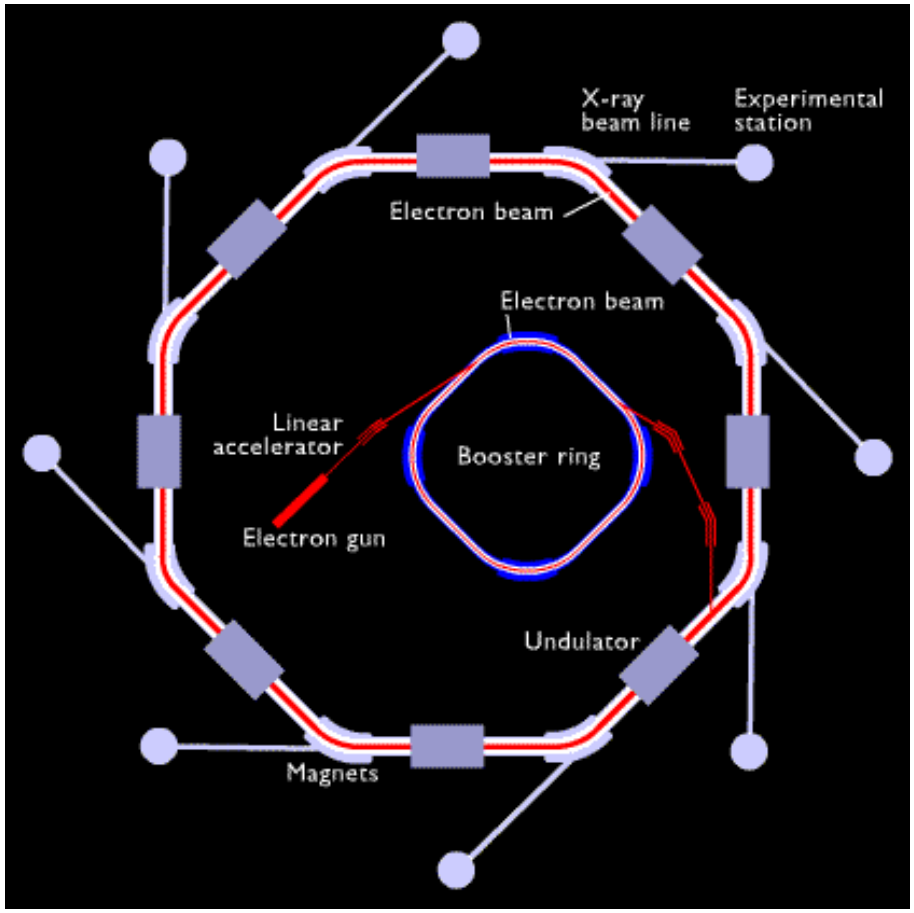
X-ray tube (anode)



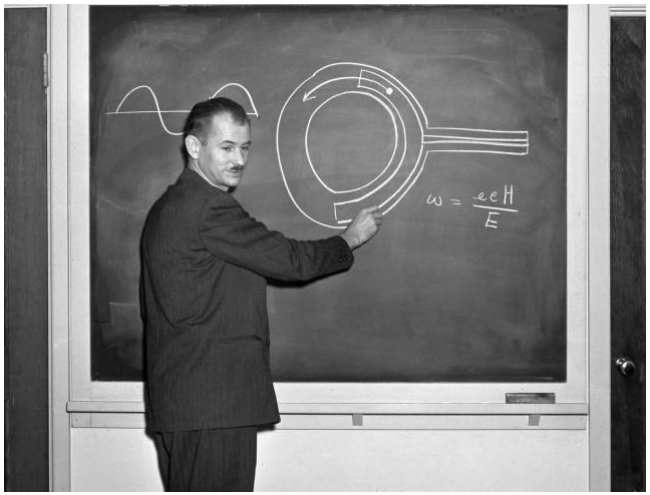


1895

Electron Synchrotron



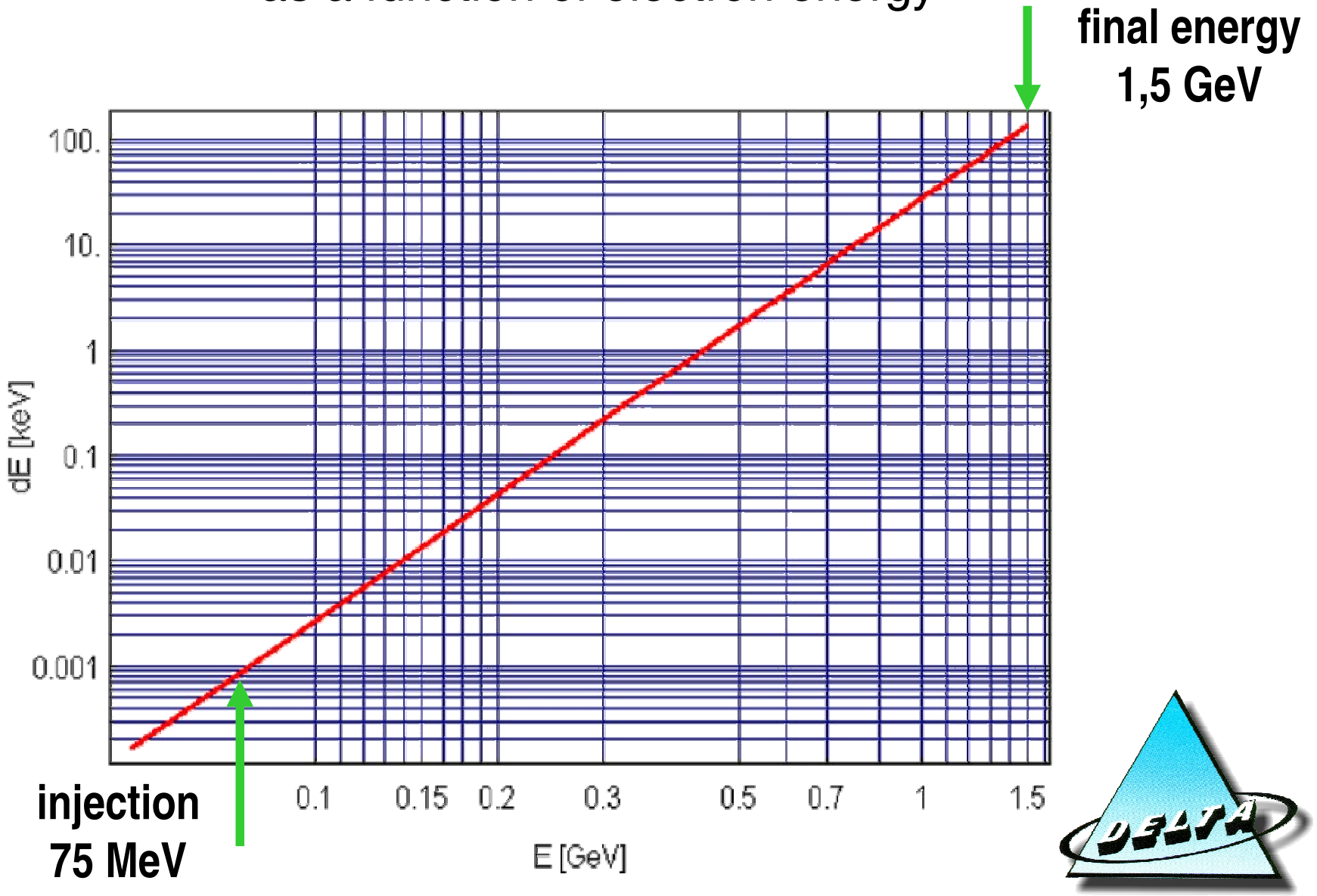
# The first synchrotron (1948)



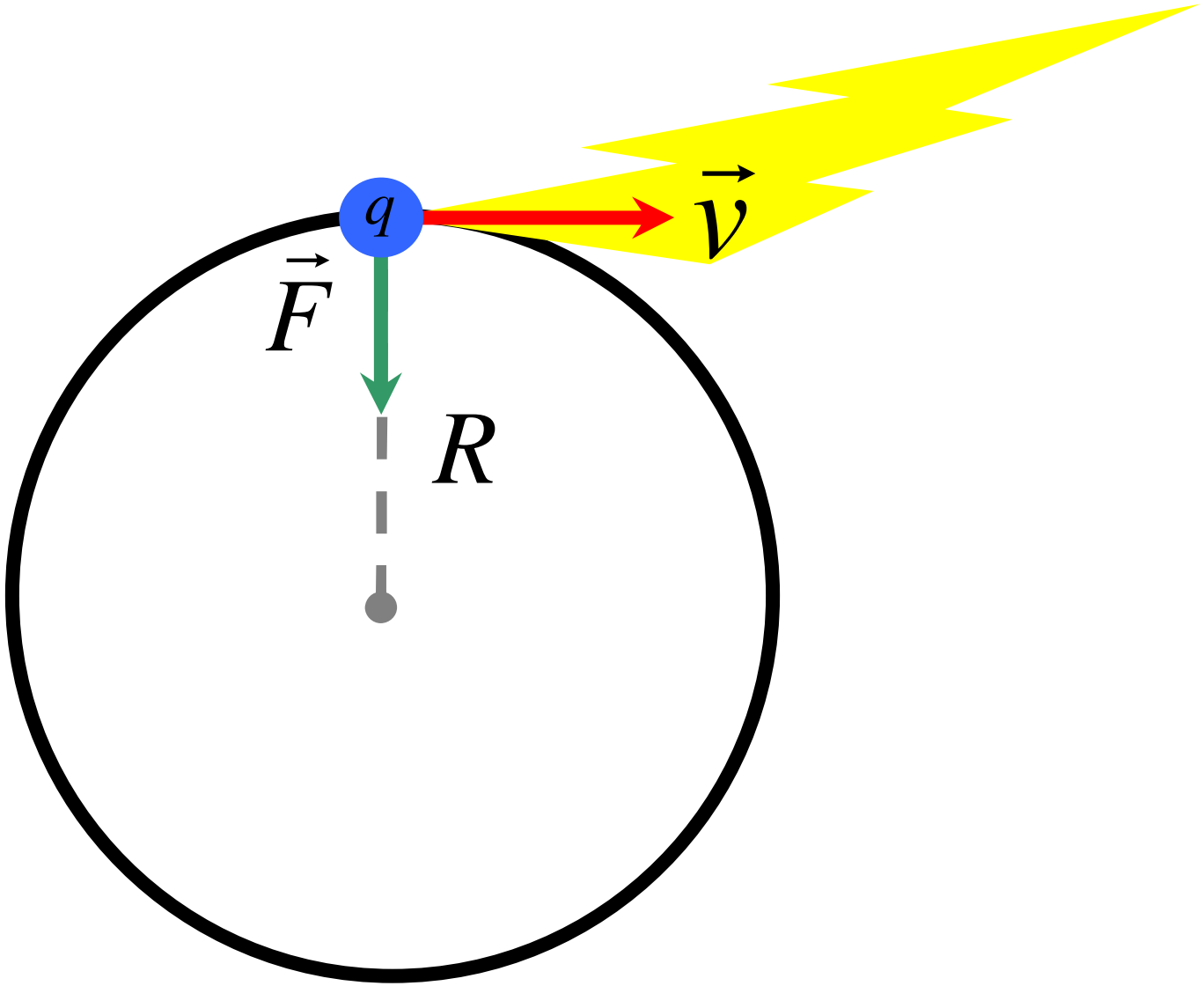

Edwin McMillan,
Berkeley Laboratory


# Energy loss per cycle

as a function of electron energy

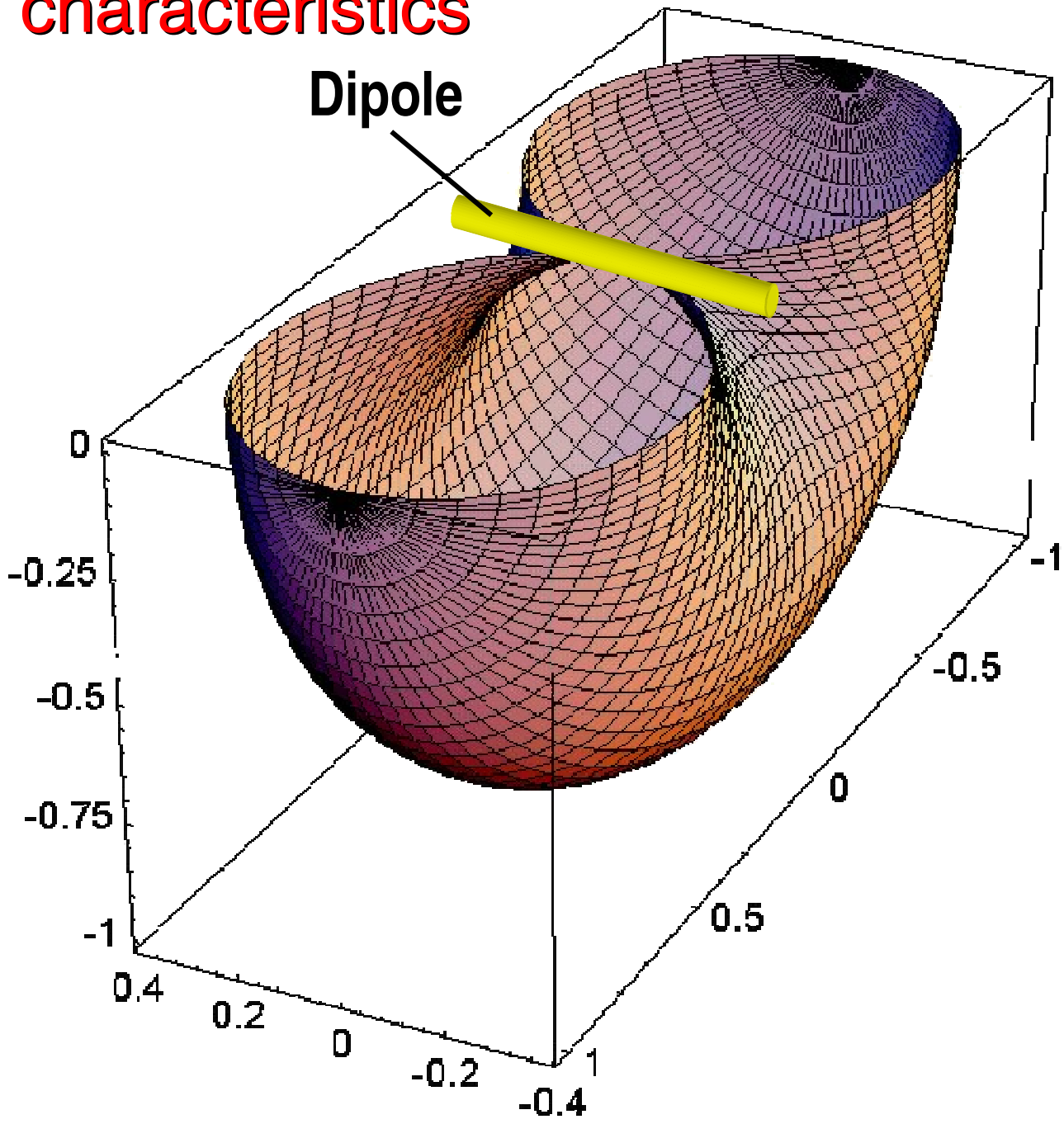


# Charge (e.g. electron) in circular orbit

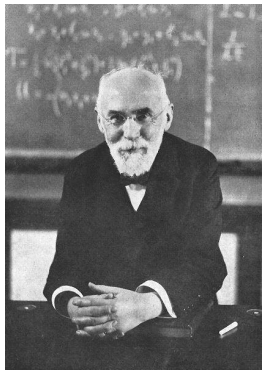


# Dipole radiation characteristics

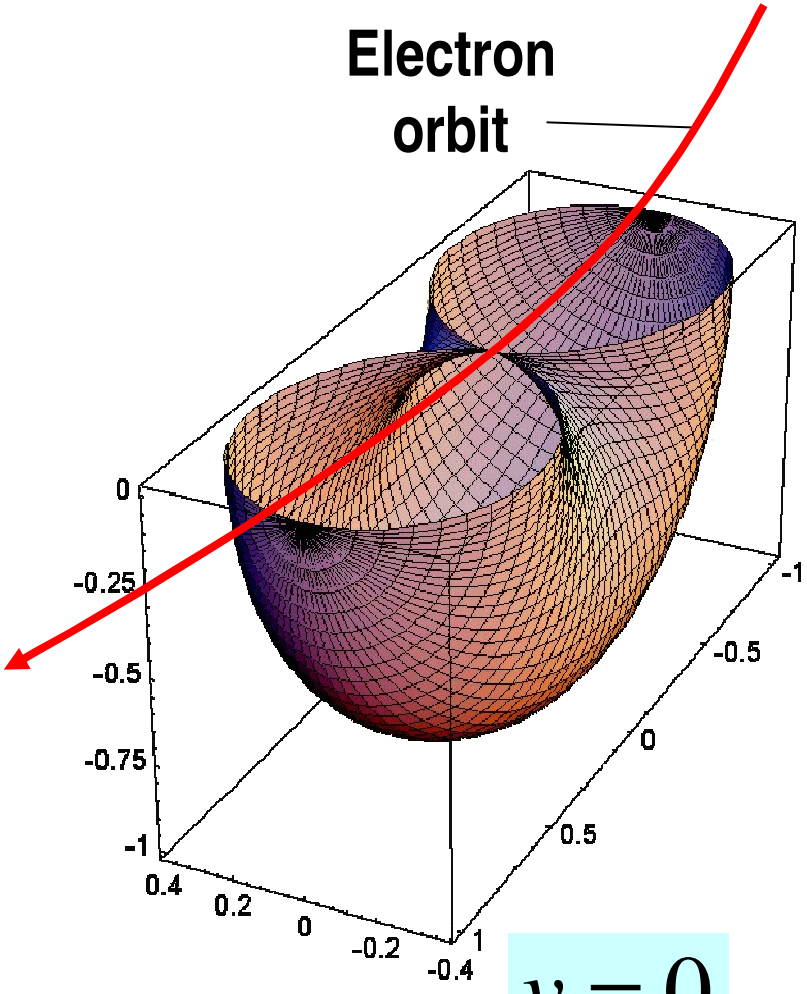
$v << c$



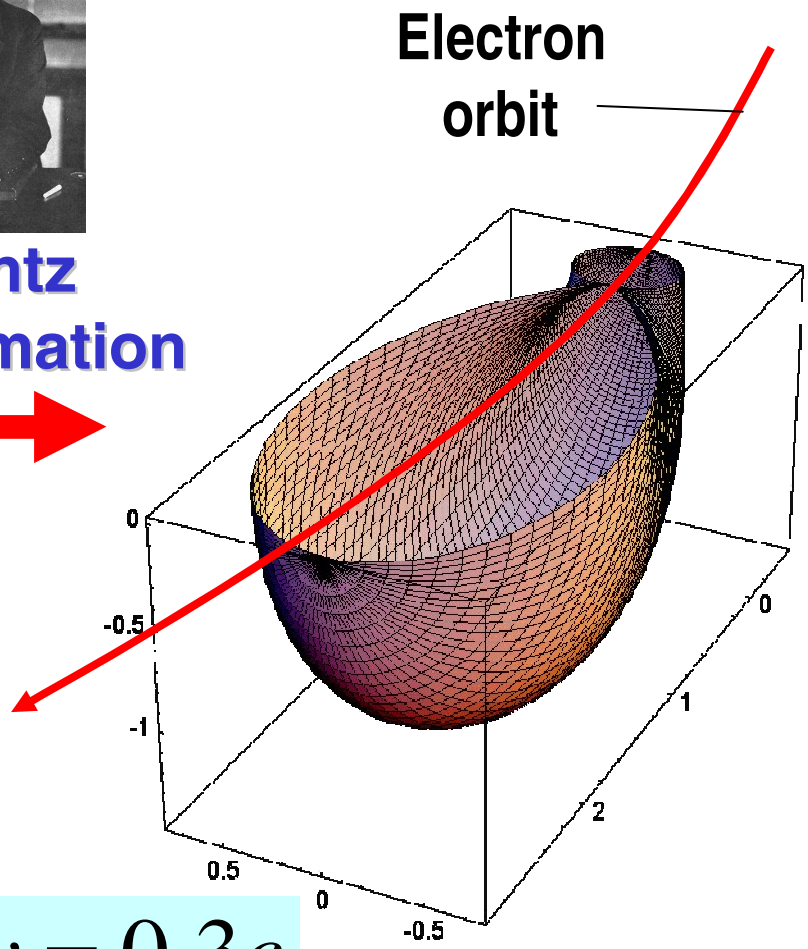
# Lorentz transformation



Lorentz transformation

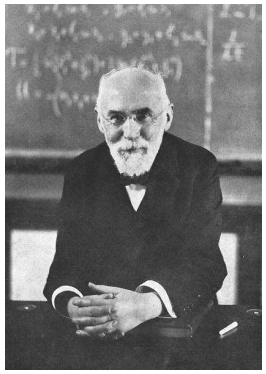



$v = 0$

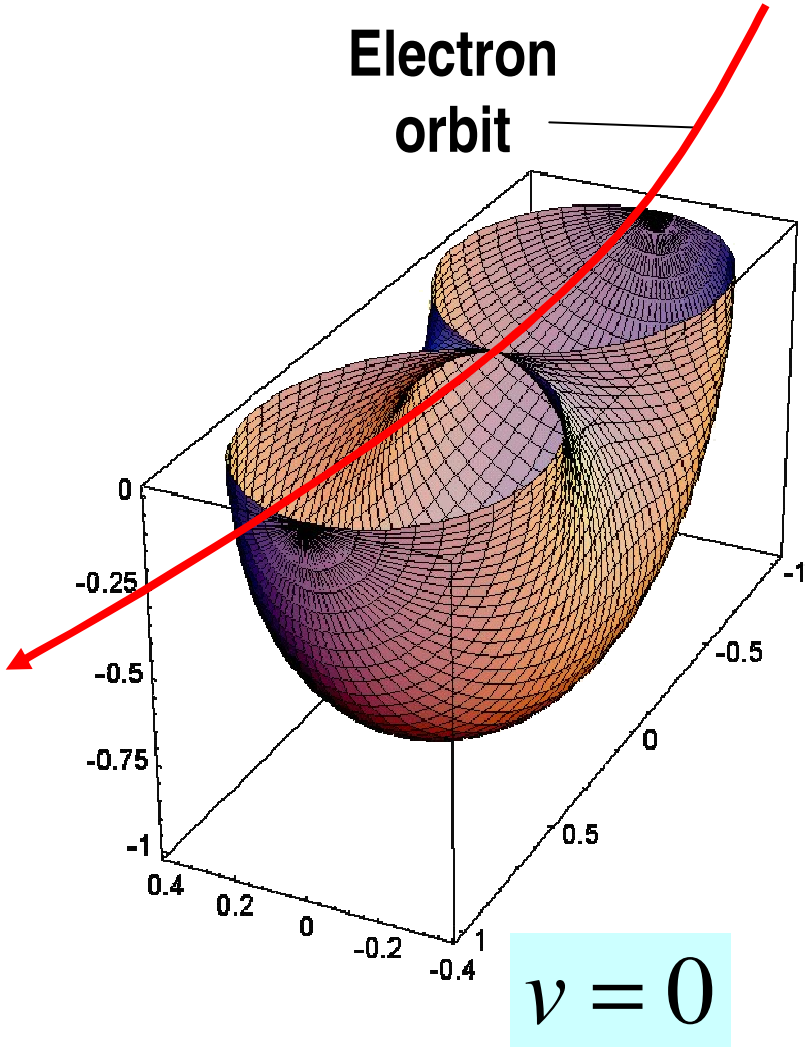



$v = 0.3c$

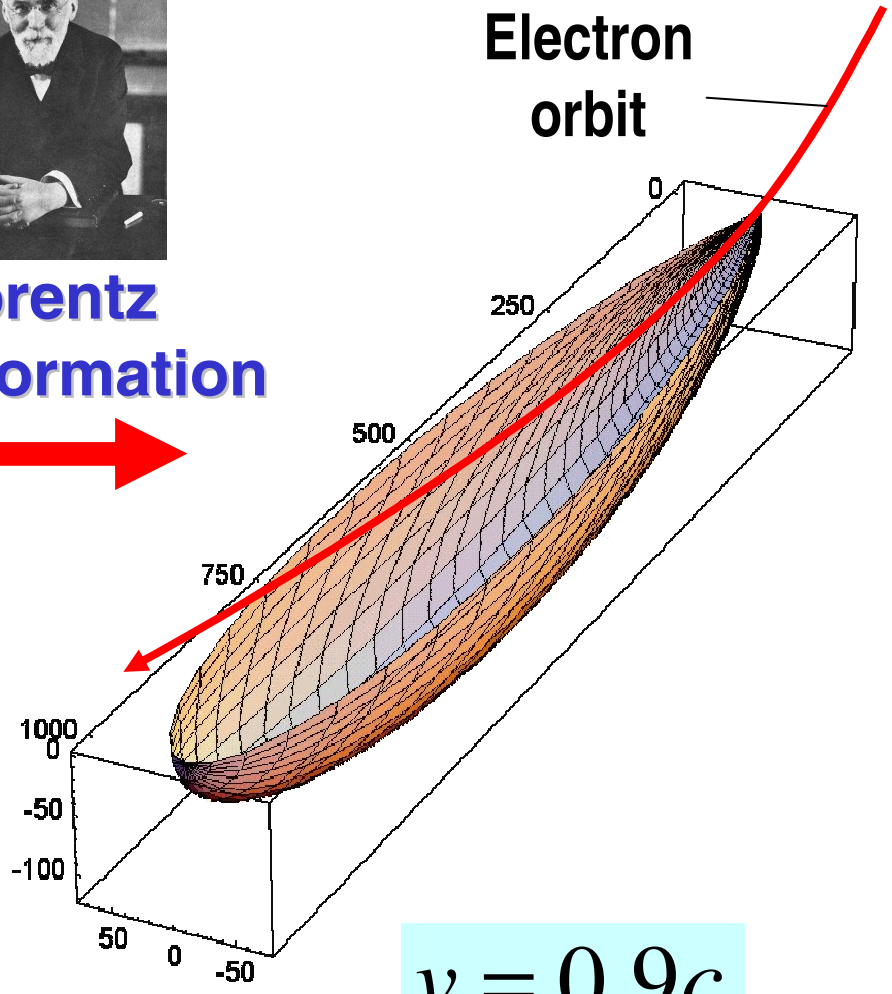
# Lorentz transformation



Lorentz transformation

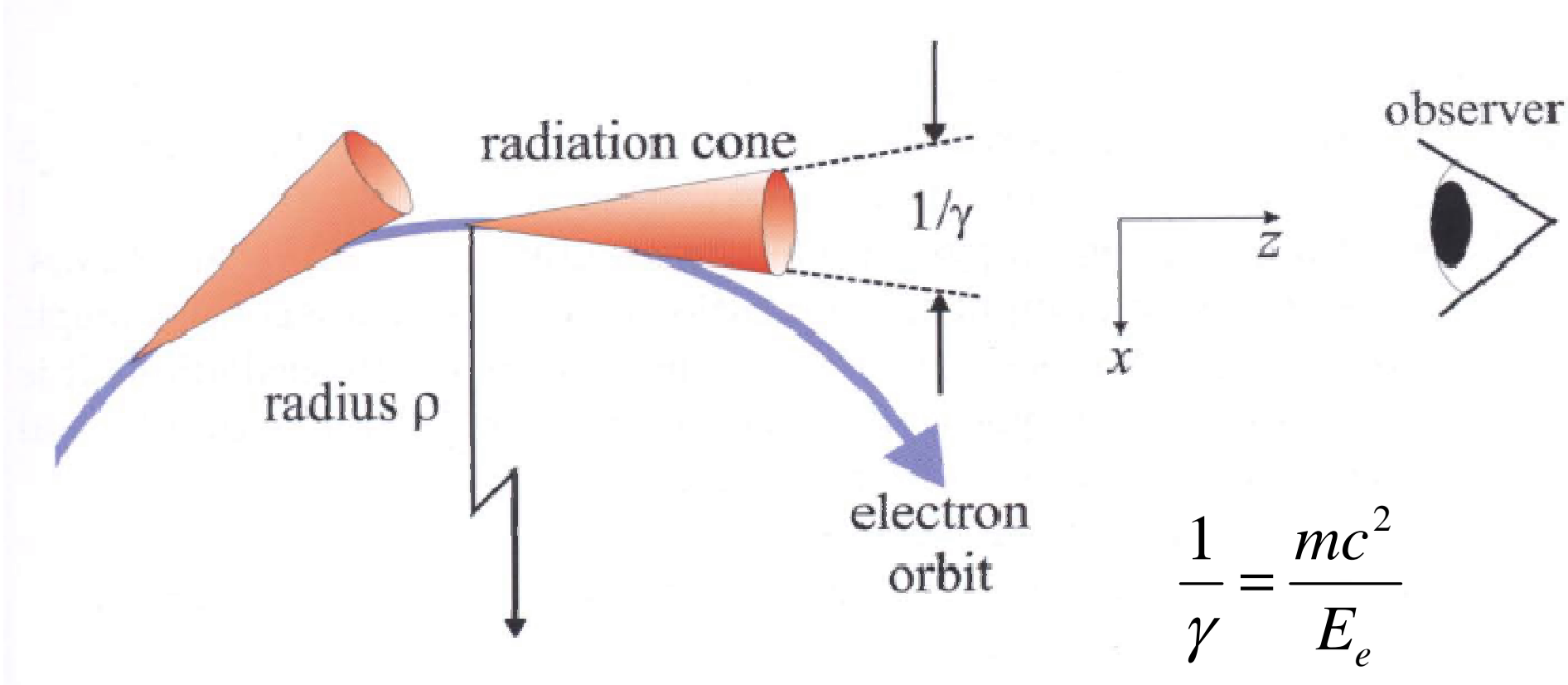



$v = 0$




$v = 0.9c$

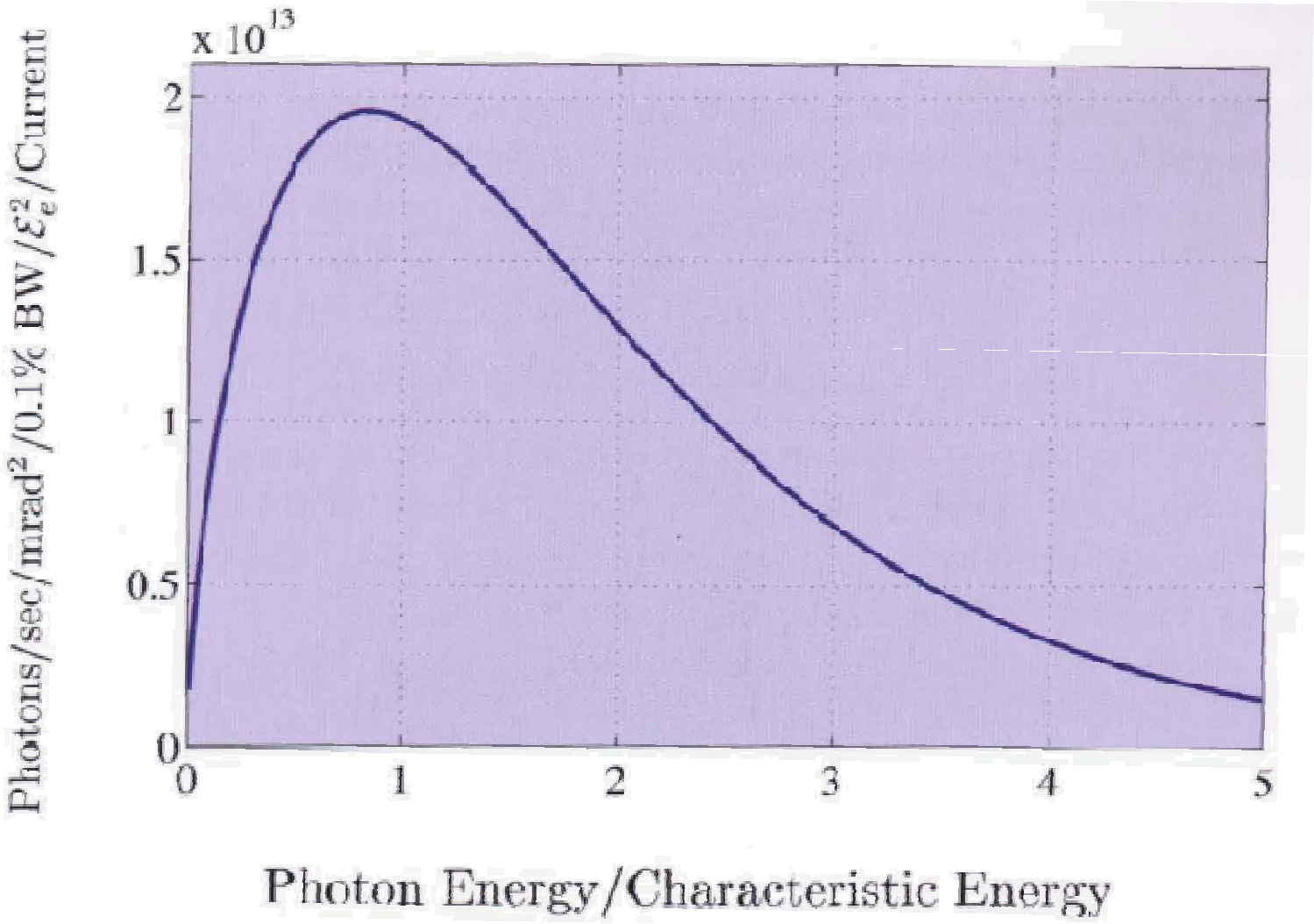
# Synchrotronstrahlung von einem Kreisbogen




$$\frac{1}{\gamma} = \frac{mc^2}{E_e}$$

Als-Nielsen 2001, Abb. 2.2

# Spektrum eines Ablenkmagneten

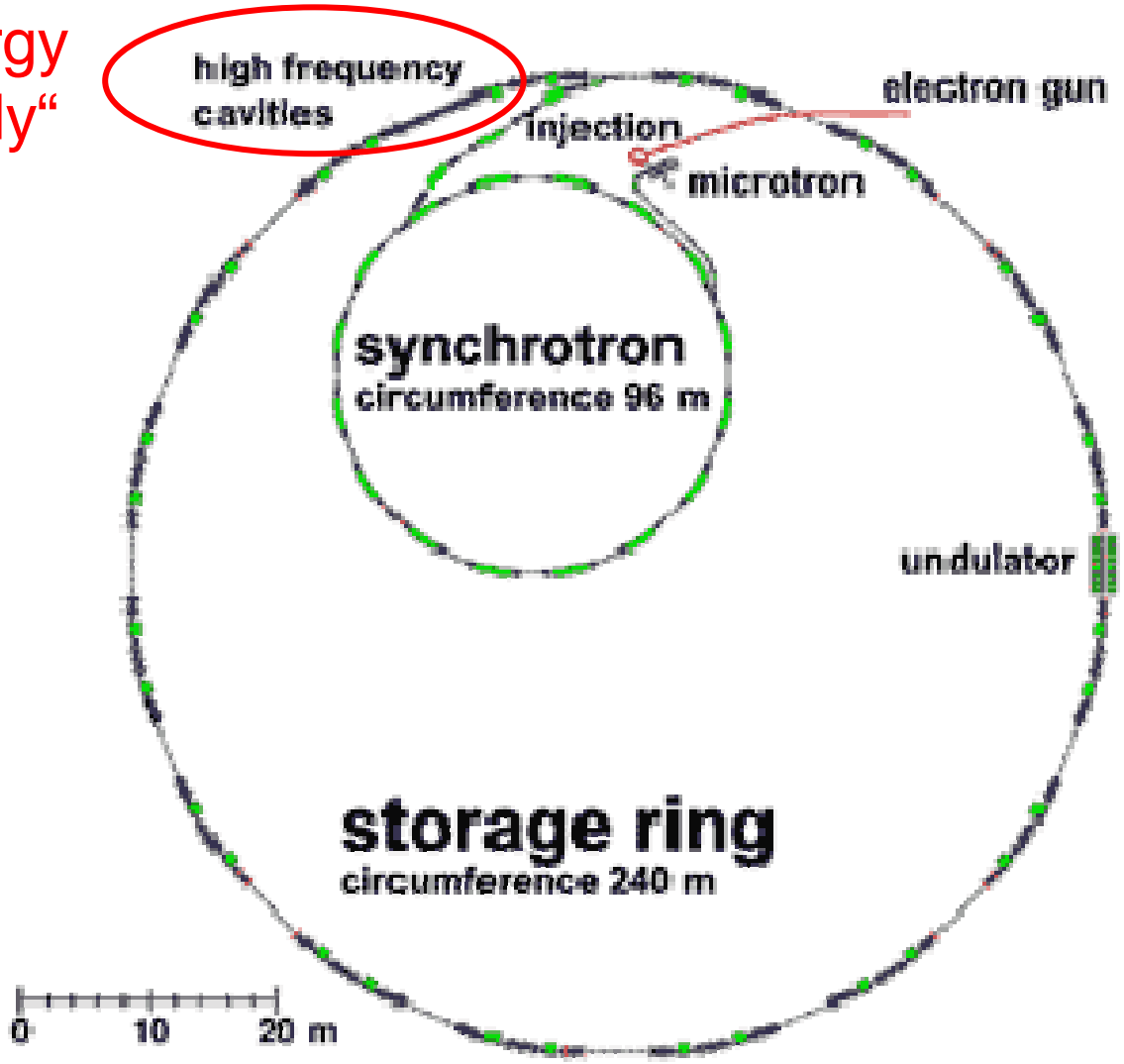



Beispiel: ESRF-Ablenkmagnet

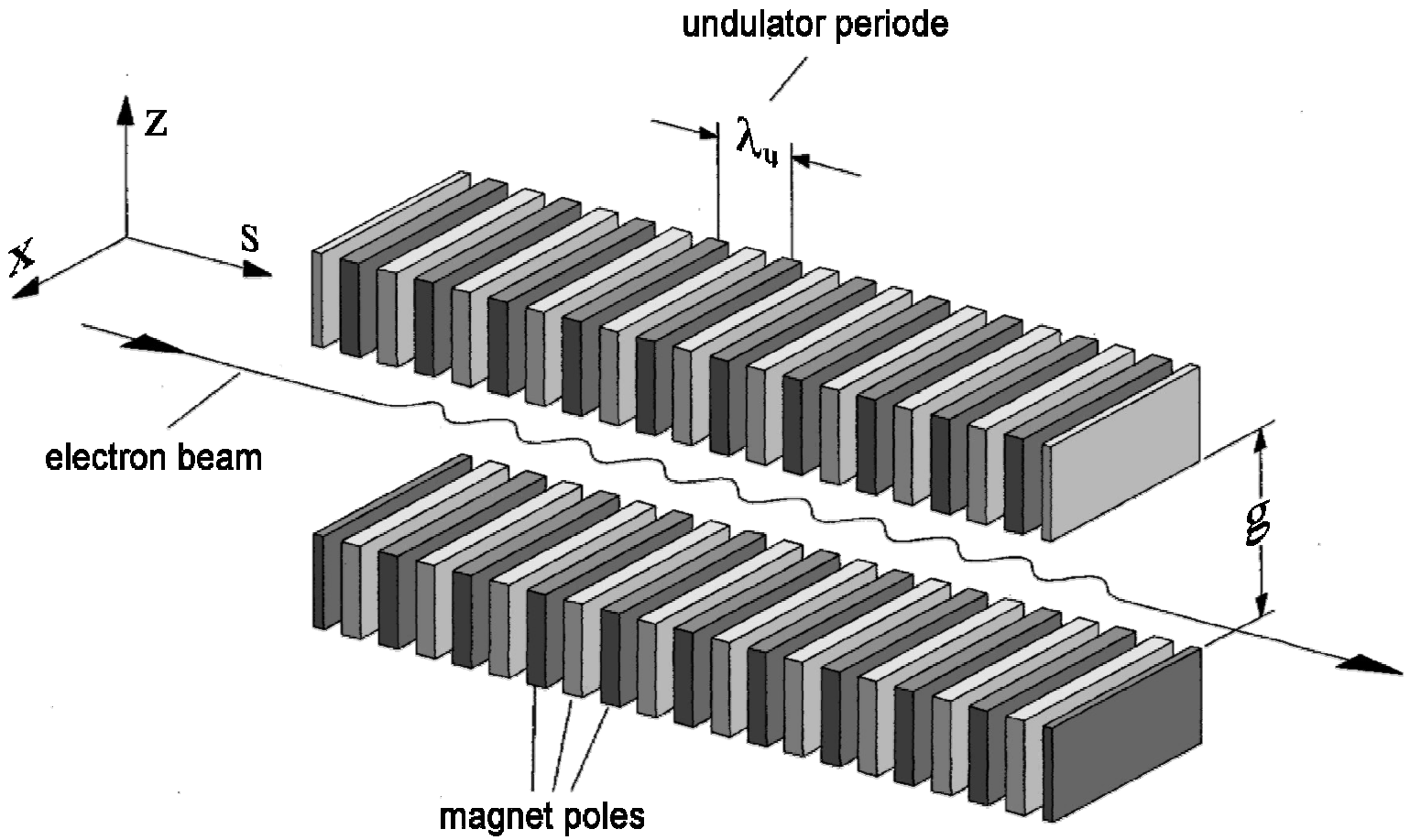
Als-Nielsen 2001, Abb. 2.5

# 3rd generation synchrotron (BESSY II)

„energy supply“

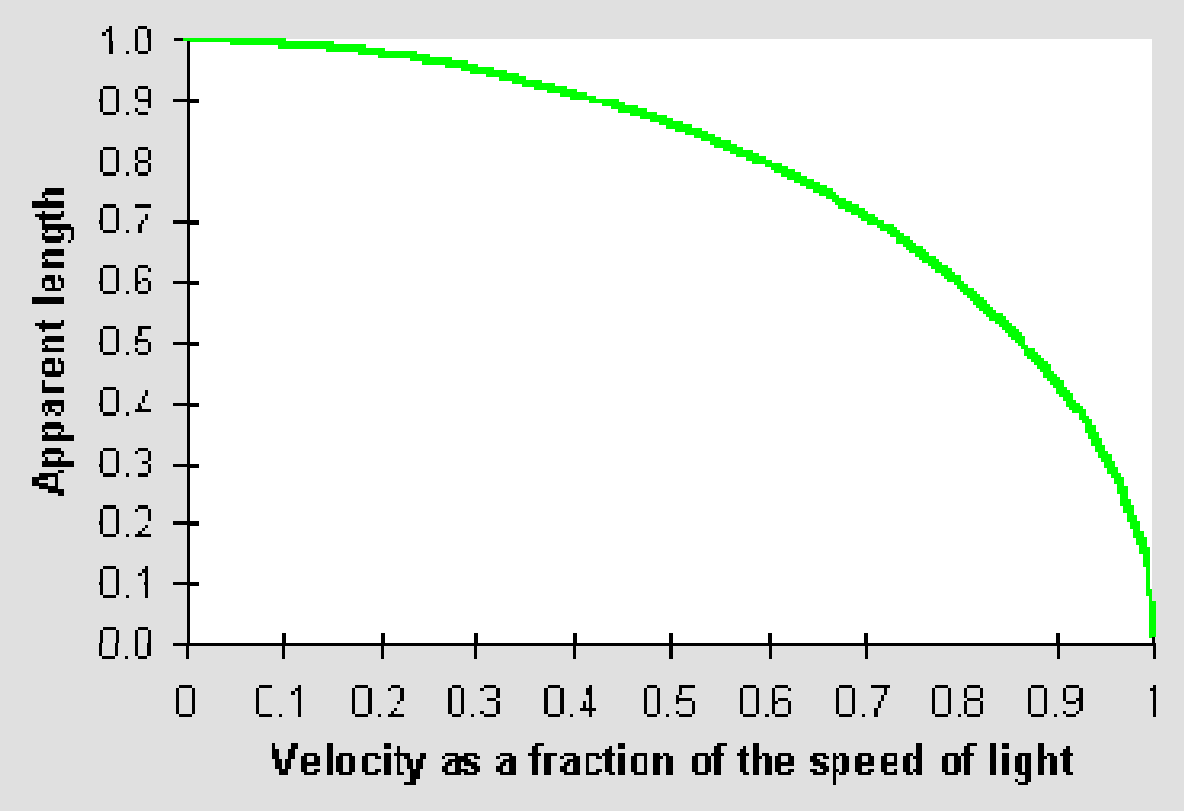


# Principle of an undulator




constructive **interference** of all waves: how?

# Lorentz contraction




$$l' = l\sqrt{1 - \frac{v^2}{c^2}} = l / \gamma$$

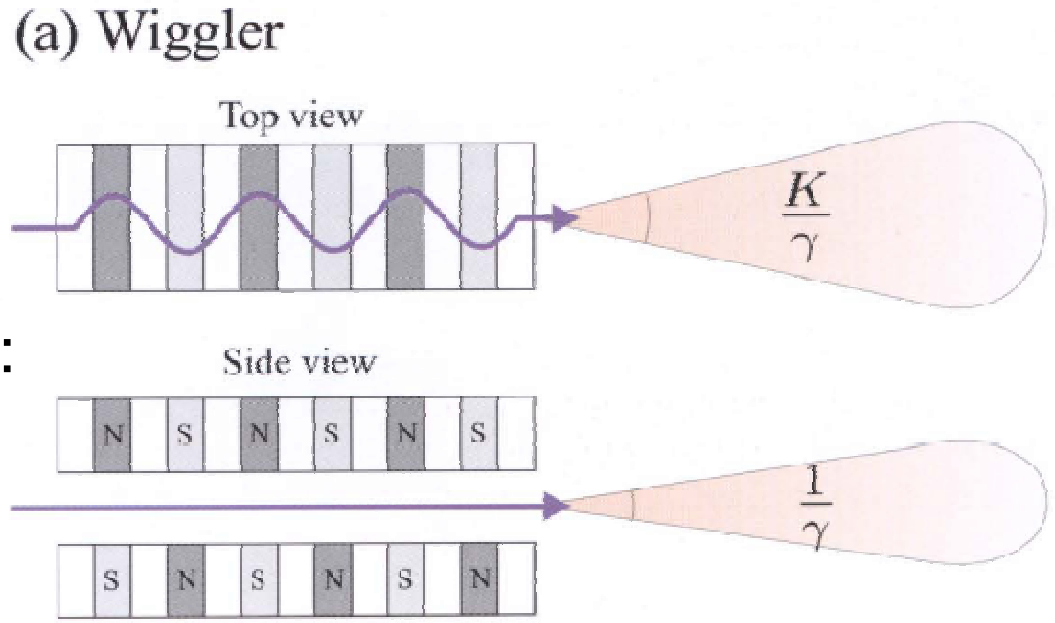
typical $\gamma$: $10^3$ - $10^4$

additional factor $= 1/(2\gamma)$ from Doppler effect

$\Rightarrow$ from **cm** (undulator structures) to **Å** (X-ray wavelengths)

# Wiggler und Undulatoren

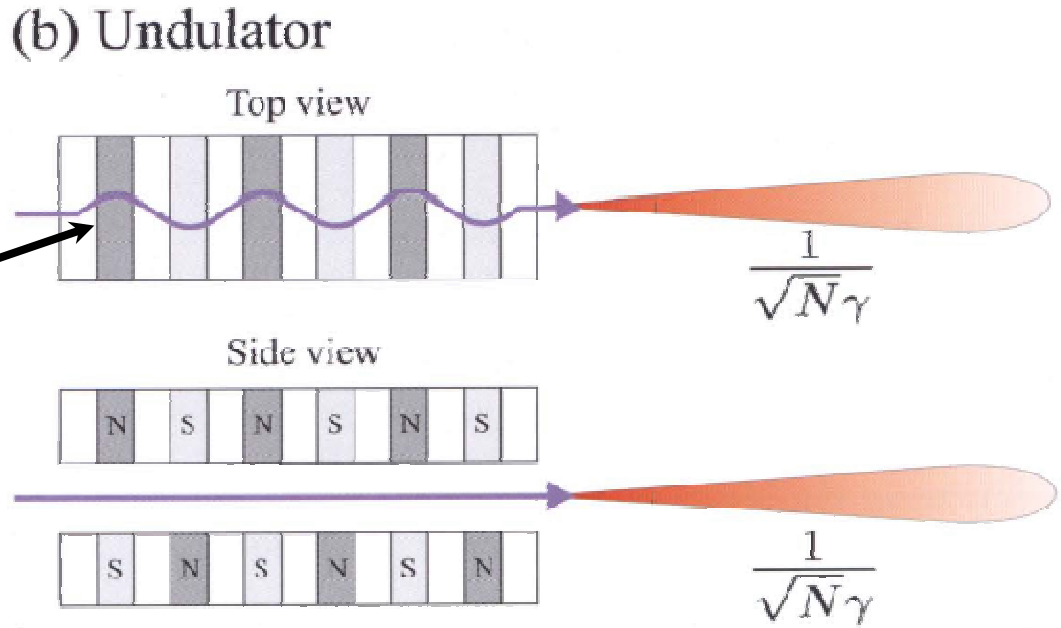
Summation von Intensitäten:
$I \times N$



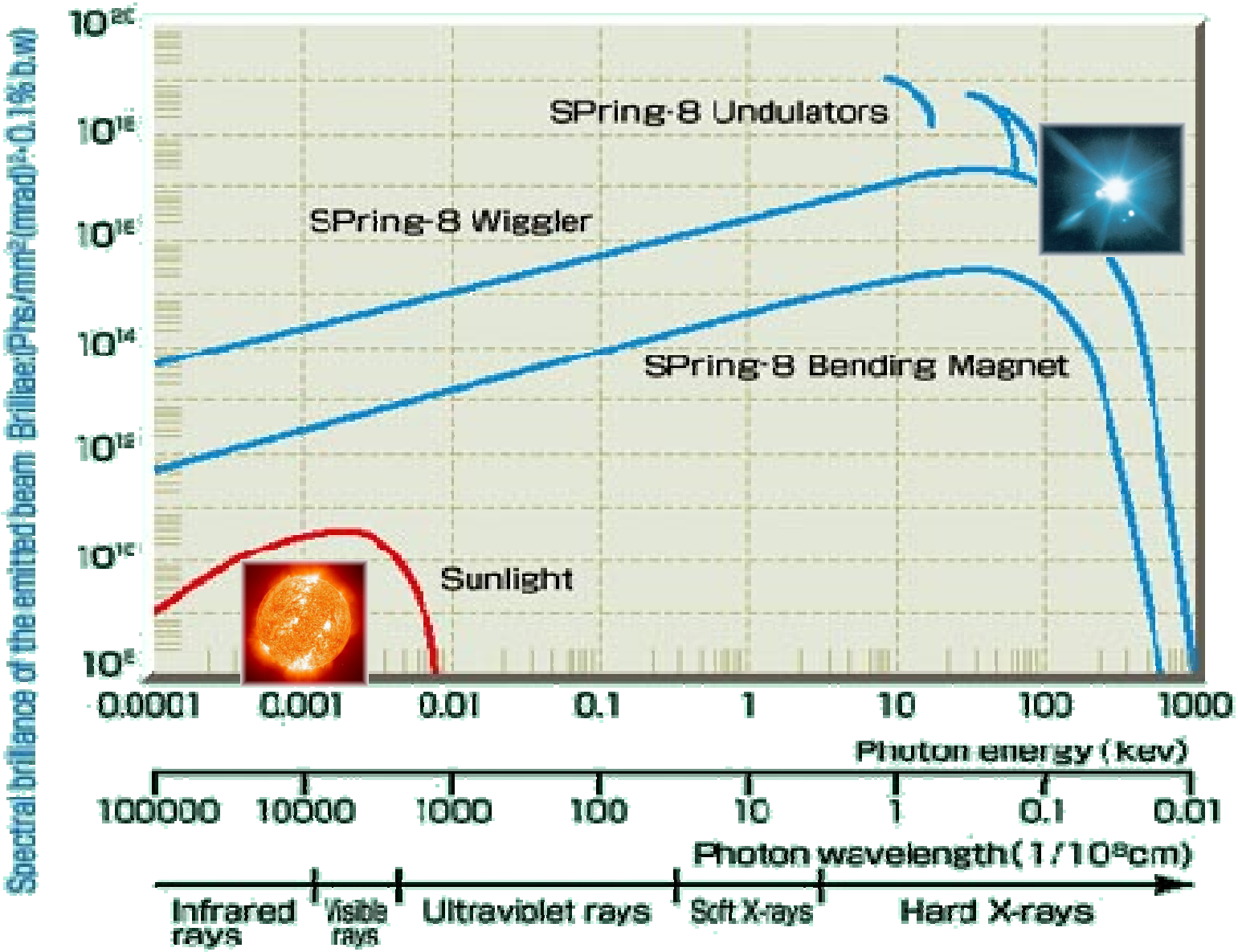

Als-Nielsen 2001, Abb. 2.7

Summation von Amplituden (Oszillationen in Phase):
$I \times N^2$

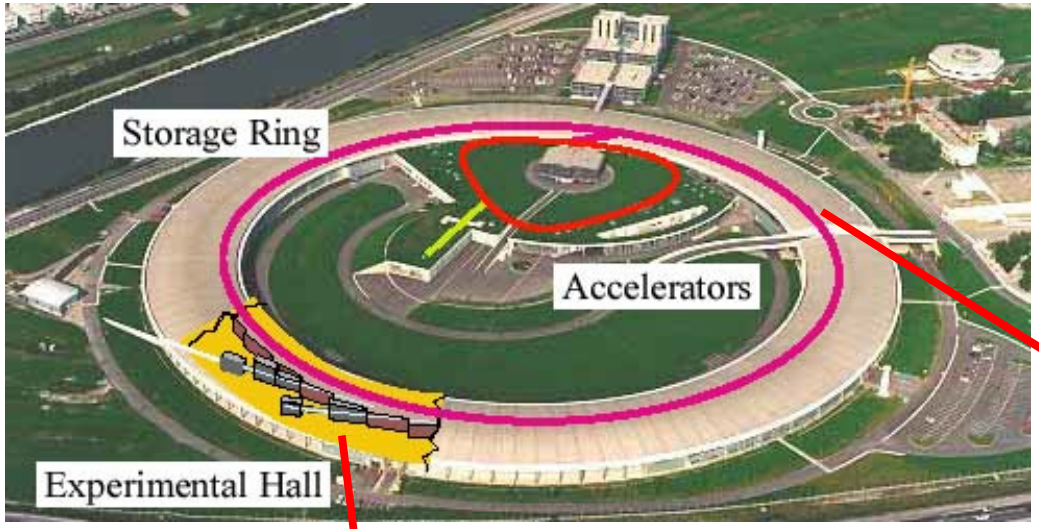
kleine Auslenkungen, Winkel $K$



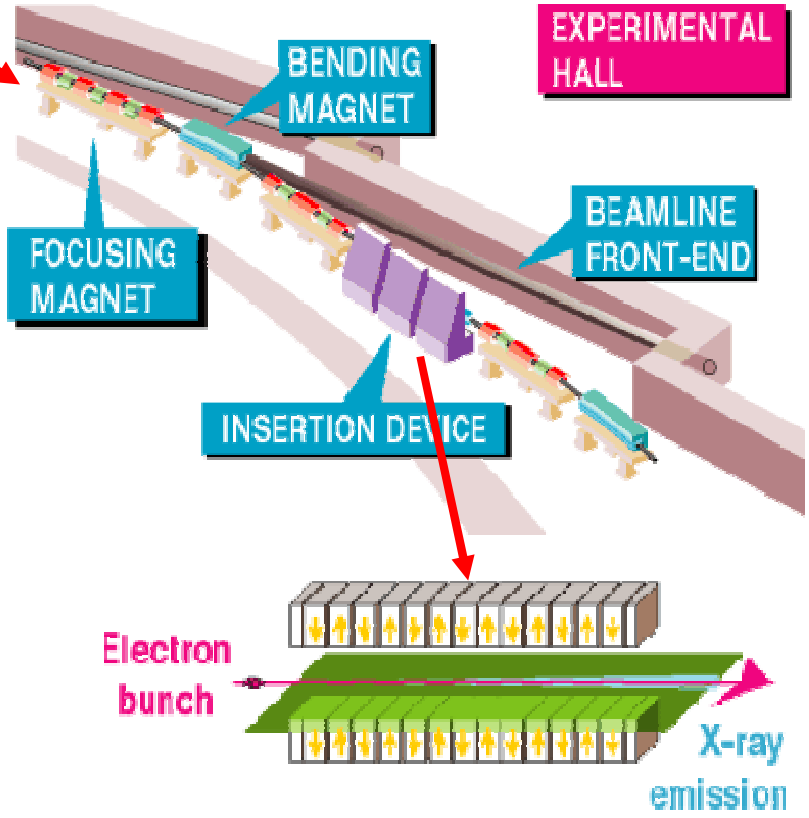
# Spectral brilliance: Brighter than the sun!

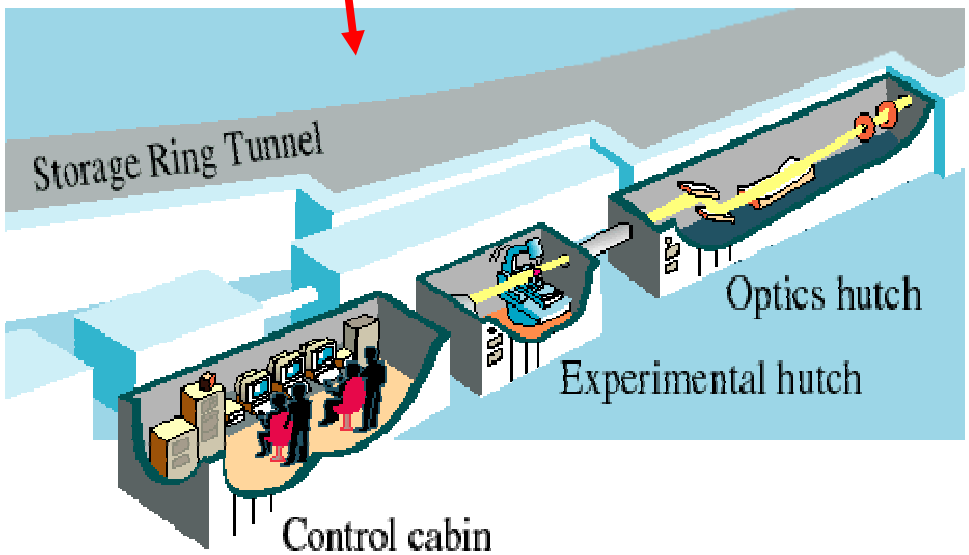


# Synchrotrons today: user facilities

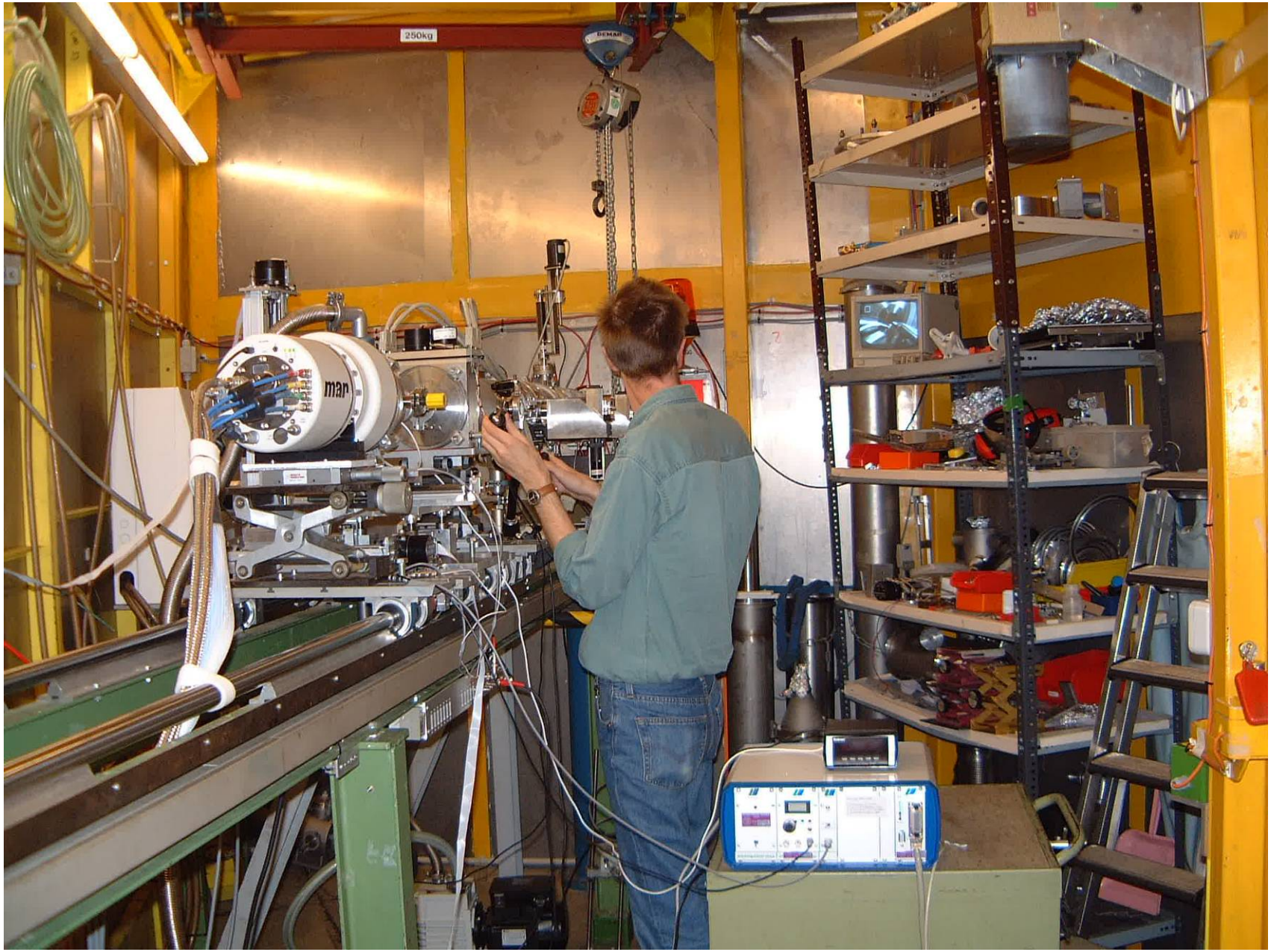



ESRF

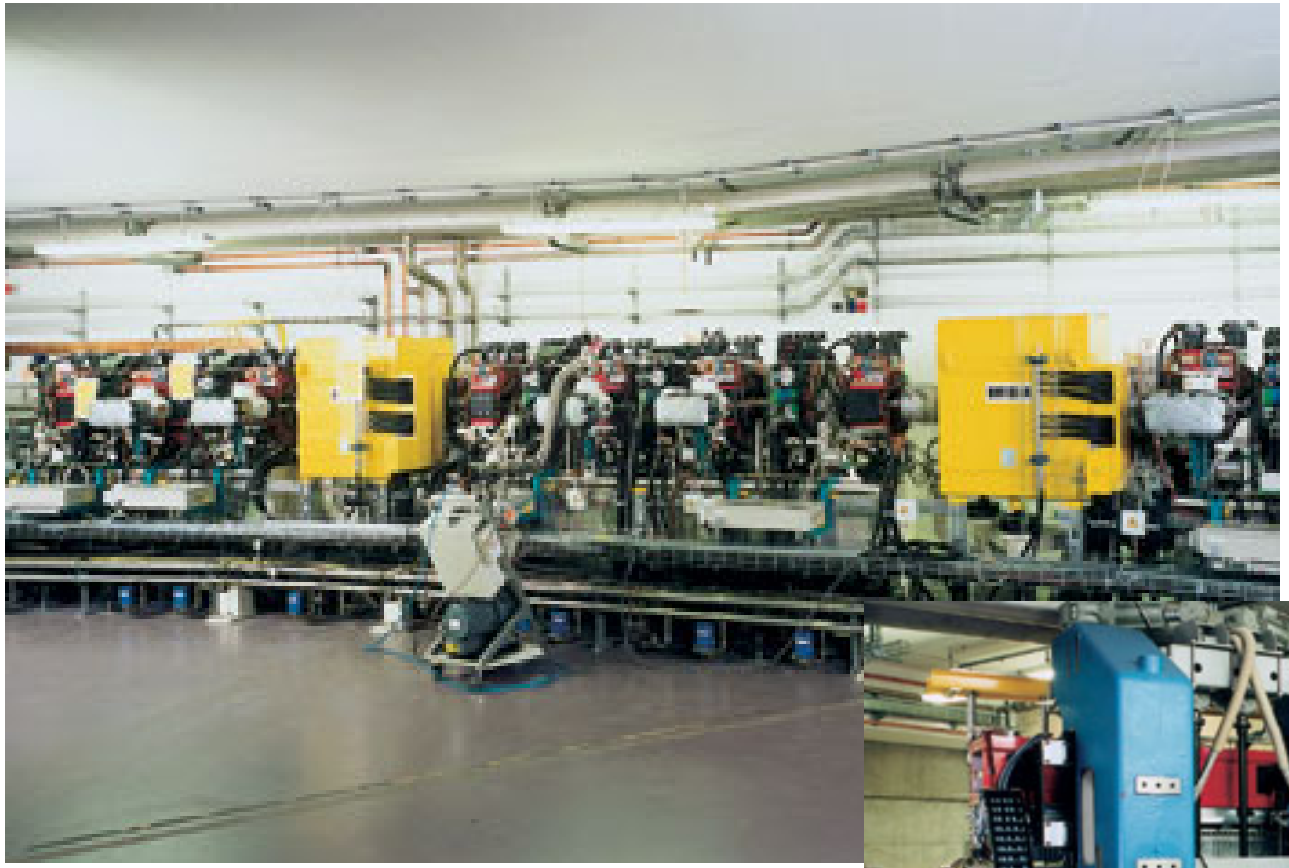


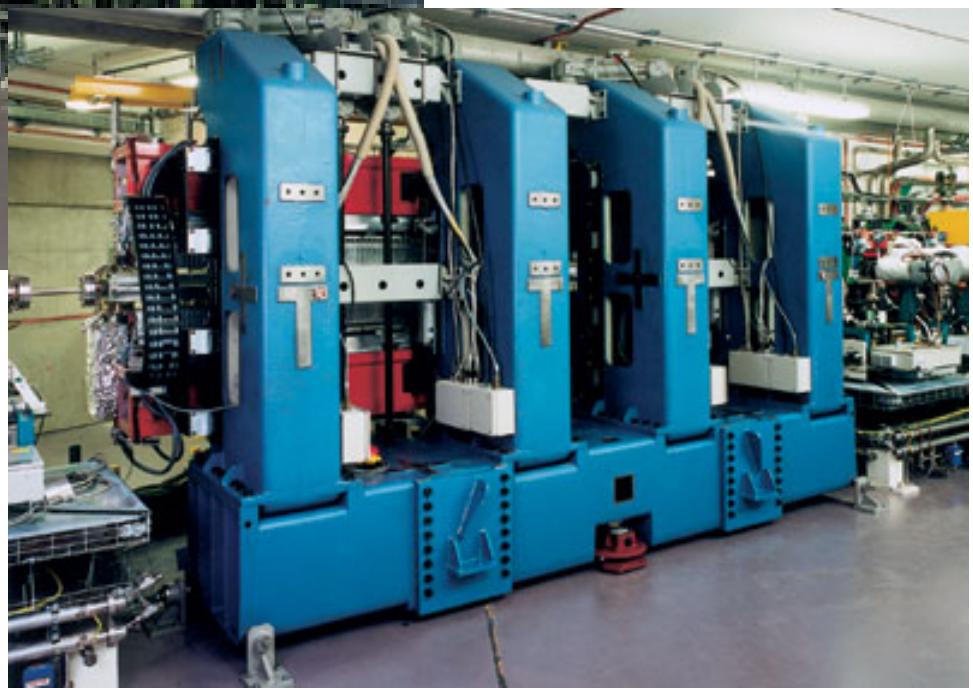



# user@work

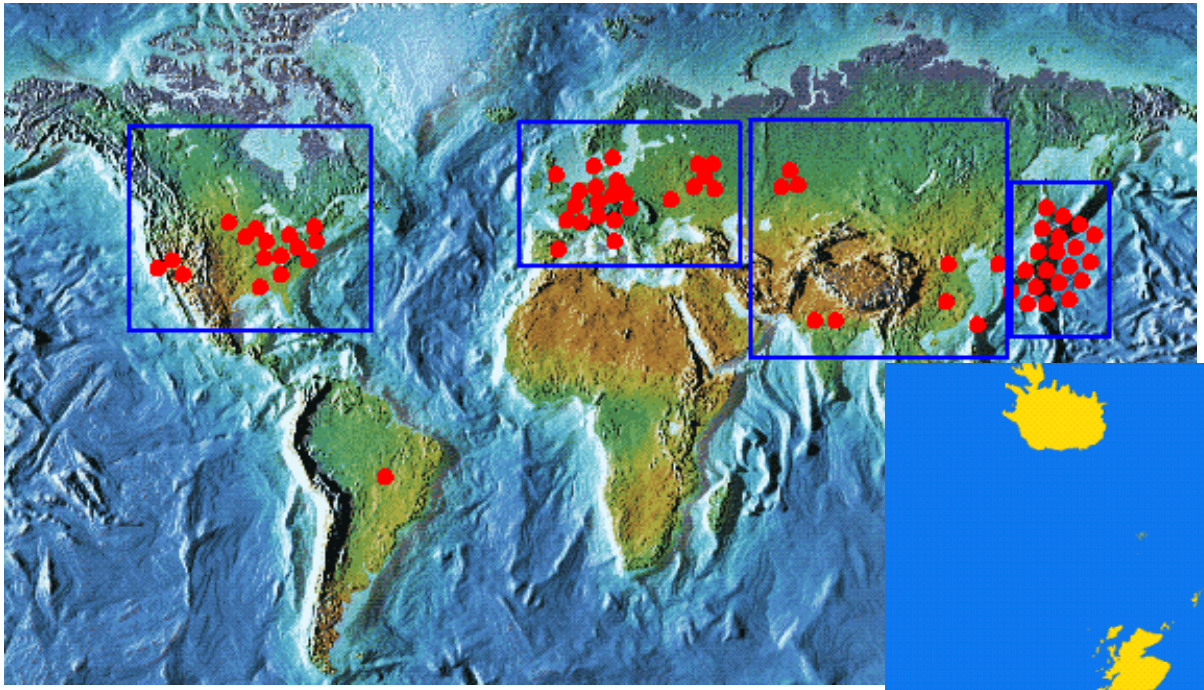


# Storage ring and undulator

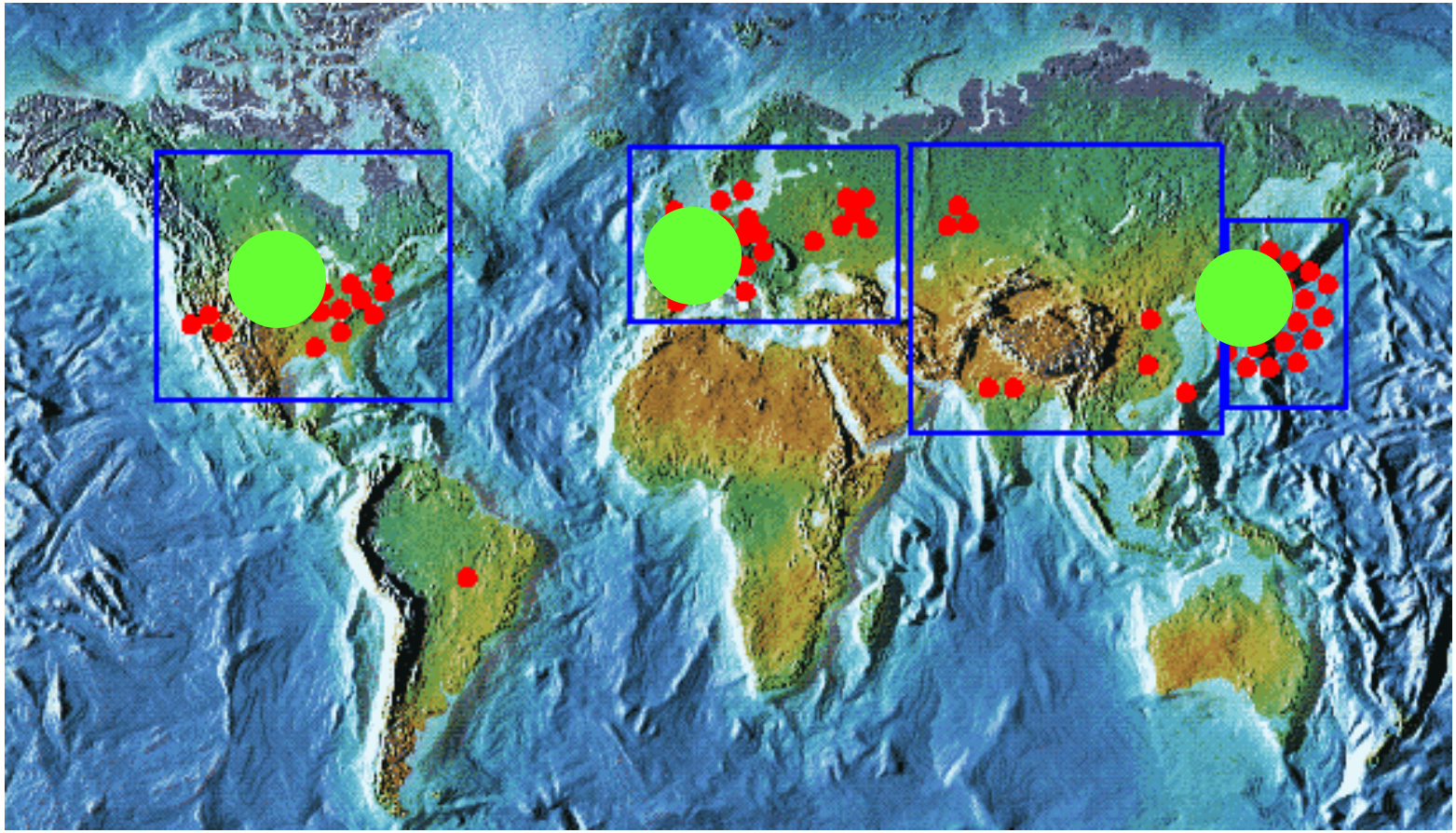




# Synchrotrons worldwide



# The three big synchrotrons

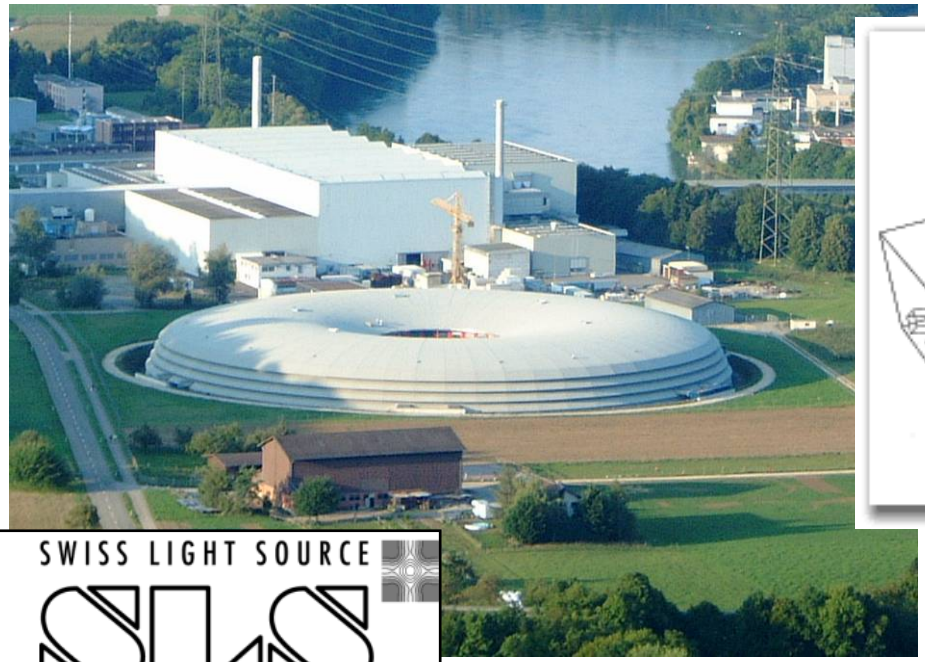



SPring-8
SPring-8: E = 8 GeV, U = 1436 m
Harima Science Garden City (Japan)

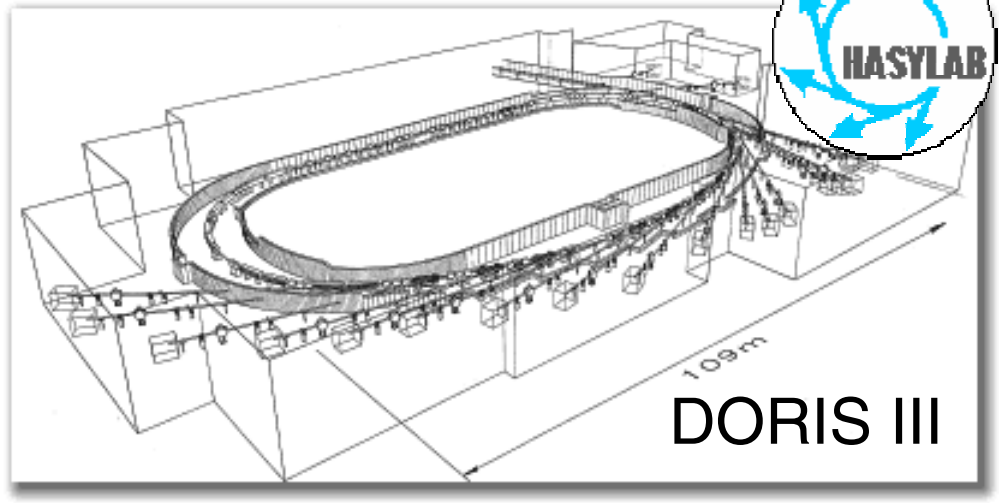

ADVANCED
PHOTON
SOURCE
APS: E = 7 GeV, U = 1104 m
Argonne, Chicago


ESRF
European Synchrotron Radiation Facility
Grenoble (France): E = 6 GeV, U = 844 m

# Examples of smaller (national) synchrotrons



SWISS LIGHT SOURCE
SLS



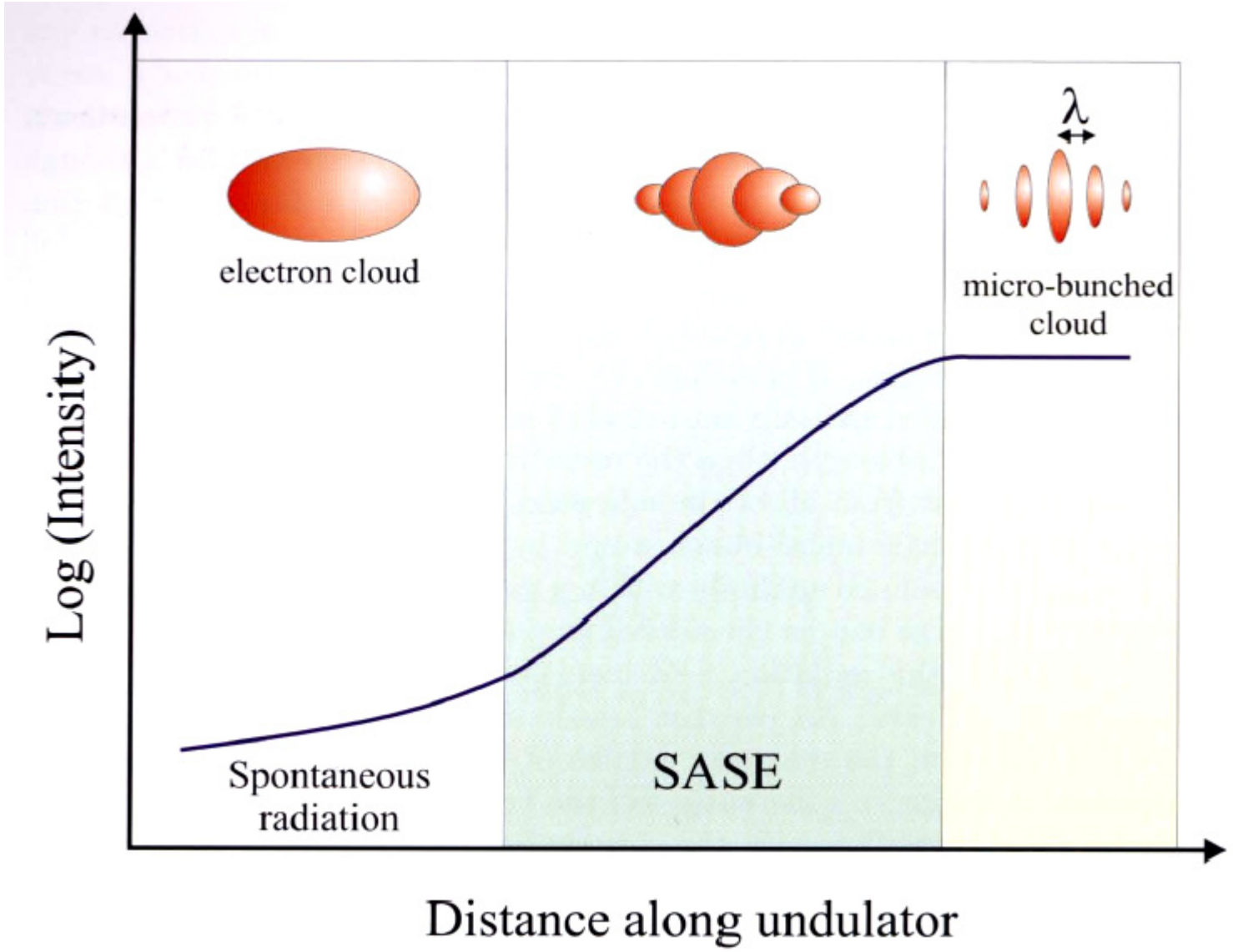

ANKA

BESSY

# (Northern) German project


PETRA III, HASYLAB, Hamburg
E = 6 GeV, U = 2304 m

# Freier Elektronenlaser: Kohärenz




http://xfelinfo.desy.de/de/artikel.fel-prinzip/2/index.html

Als-Nielsen 2001, Abb. 2.15