Neues von der Strahlungsquelle ELBE

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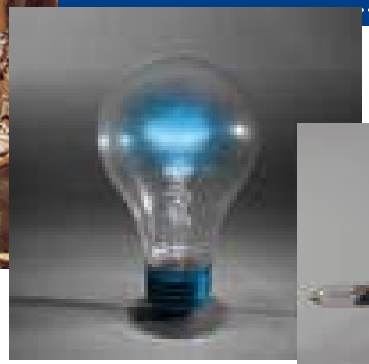
- Einführung zu Strahlungsquellen
- Die Strahlungsquelle ELBE
- Wie funktioniert ein Freie-Elektronen-Laser
- Anwendungsbeispiel

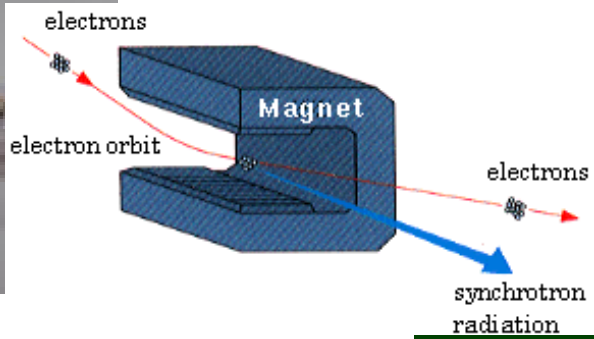
vor 500.000 J.

1854



8.11.1895

1947...

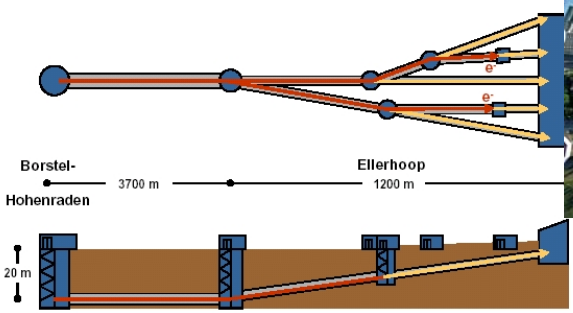


1957

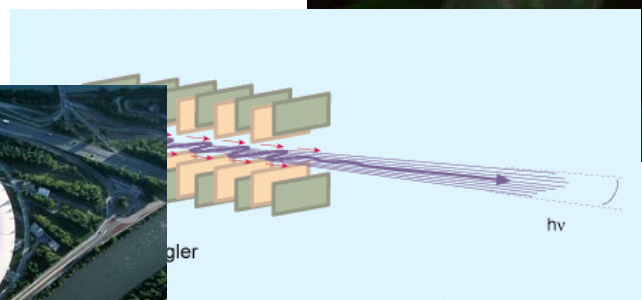
1970...

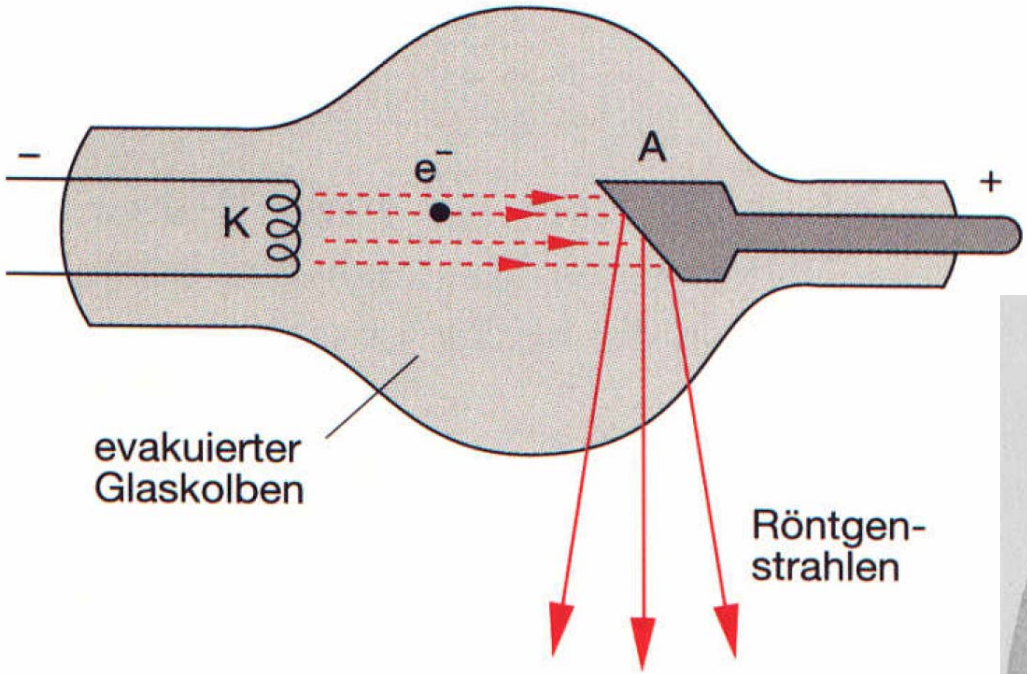
1994

2012



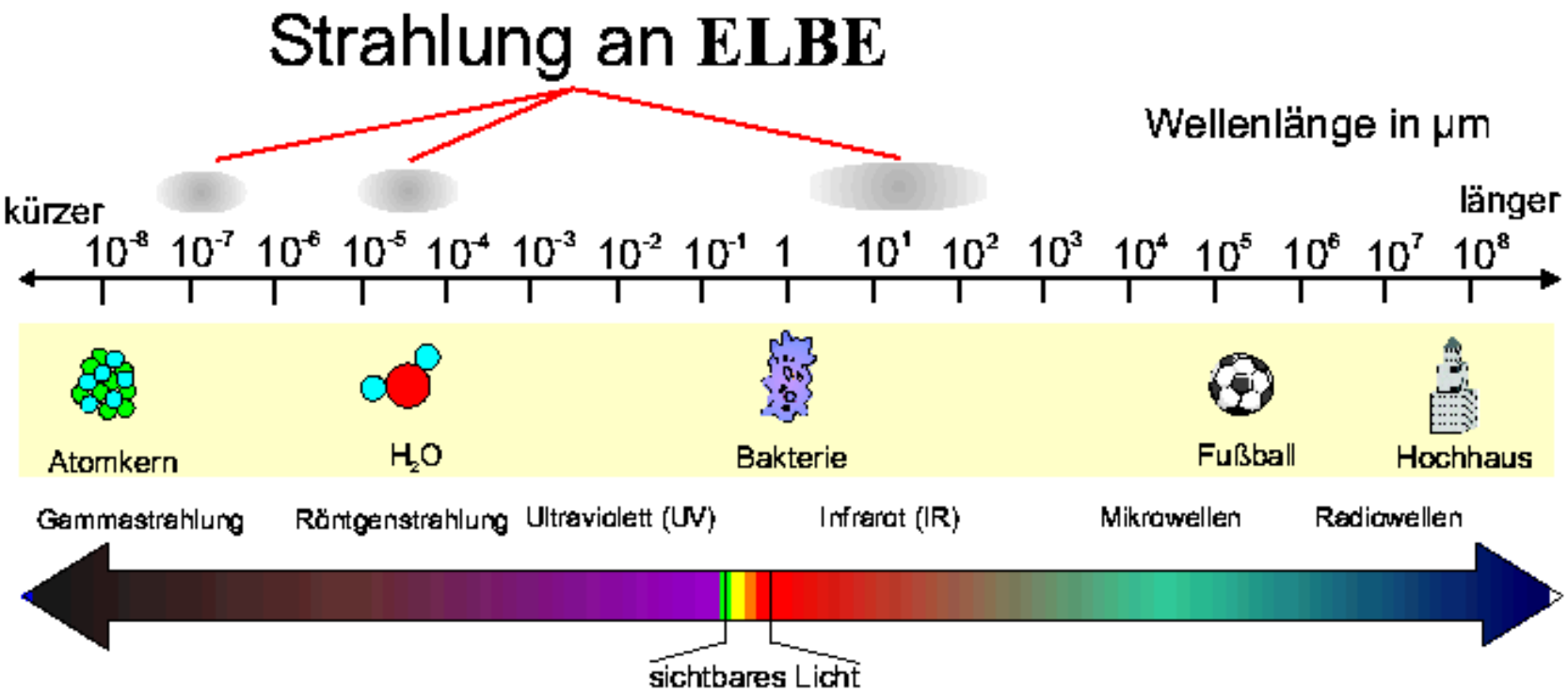
?





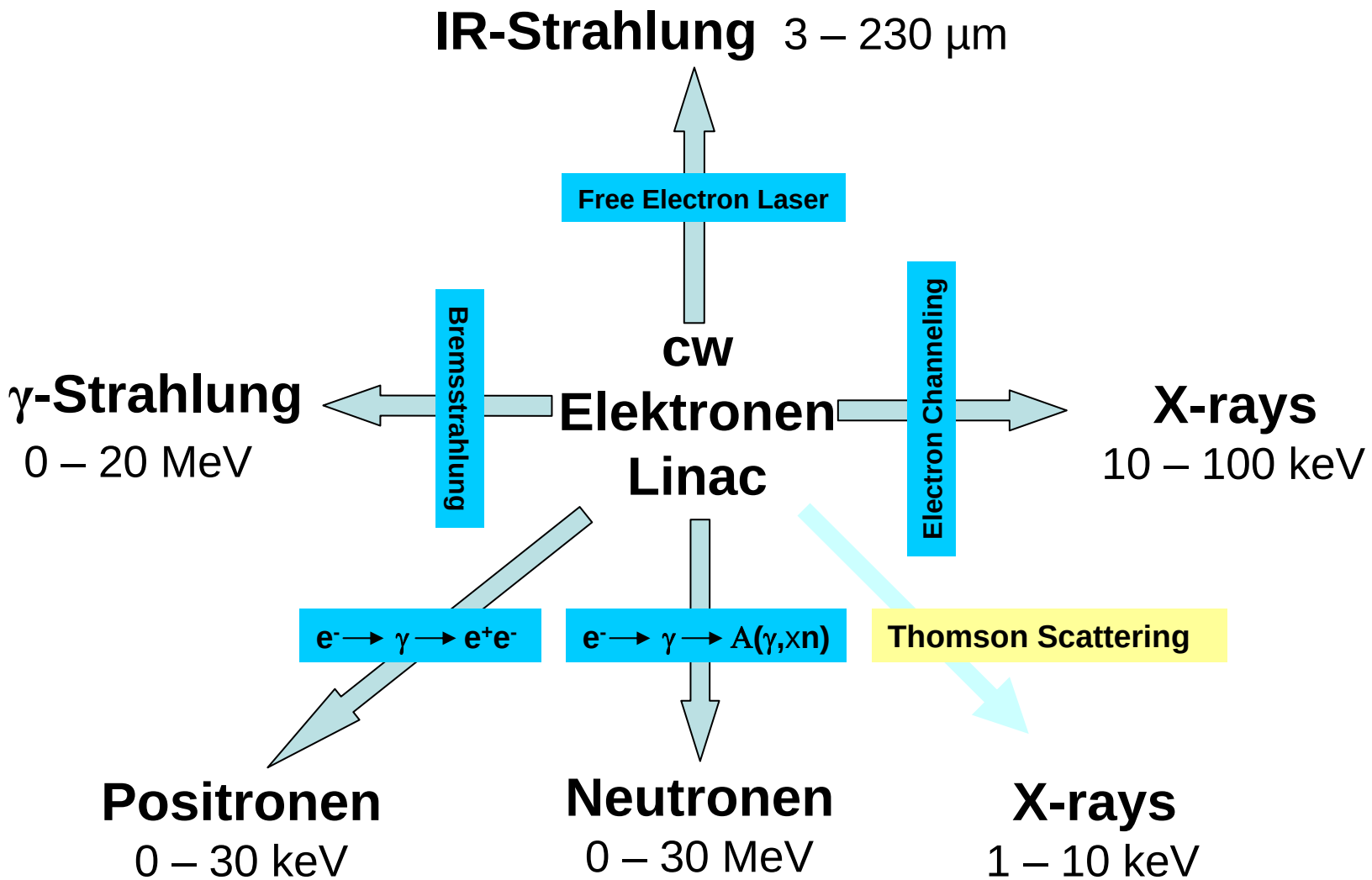
Wilhelm Conrad Röntgen
1845-1923

Das Spektrum der elektromagnetischen Strahlung

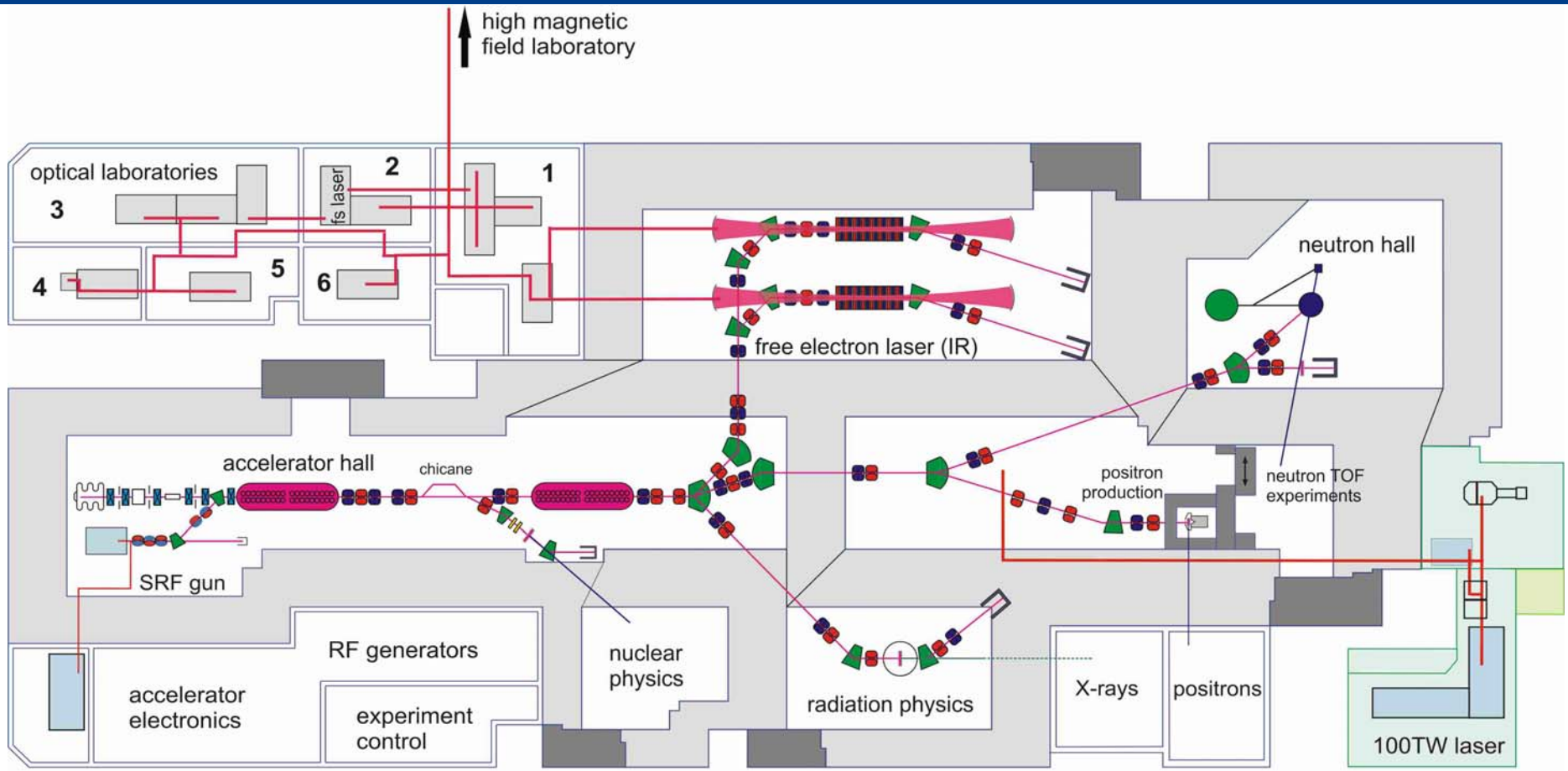


Strahlungsquelle ELBE

superconducting **E**lectron **L**inac of high **B**rilliance and low **E**mittance



ELBE Schema



Bremsstrahlung :	**2002**
Channeling Strahlung (X-rays):	**2003**
Infrarotstrahlung:	**FEL 1 2004 / FEL 2 2006**
Positronen:	**2008**
Thomsonstreuung (X-rays):	**2008/9**
Neutronen:	**2007**

ELBE Beschleuniger

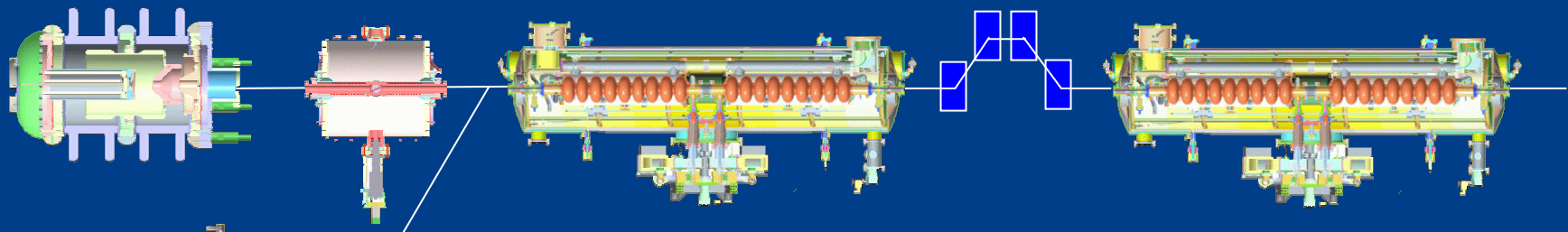
Thermionische Elektronenquelle
250 kV
<= 260 MHz
<80 pC
~ 500ps
~10 mm mrad

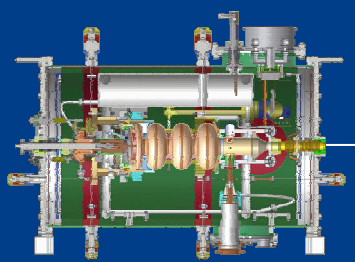
HF Buncher
260 MHz
+1,3GHz
compr. ~ 100:1

Linac
1,3 GHz
~20MeV@10 MeV/m
CW

magnetischer Bunchkompressor
R_{56} < 500 mm

Linac
1,3 GHz
~20 MeV@10MV/m
CW



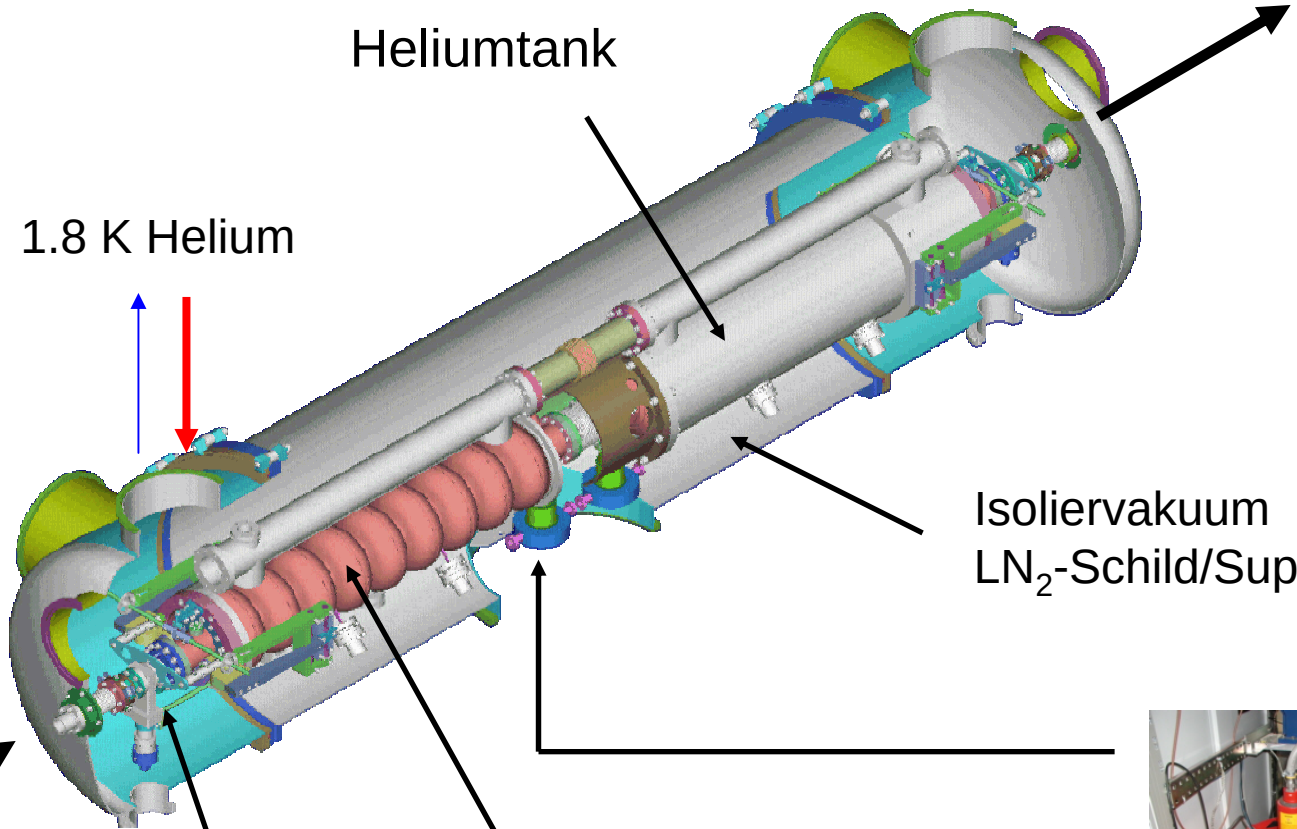


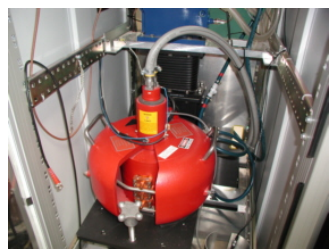
Supraleitende Foto-HF-Quelle
9.5 MeV
<= 13 MHz
80pC / 1nC / 2.5 nC
~ 5-20 ps
~ 1.5-3 mm mrad

Helium Verflüssiger LINDE
200 W @ 1,8 K

ELBE CW-Beschleunigermodul

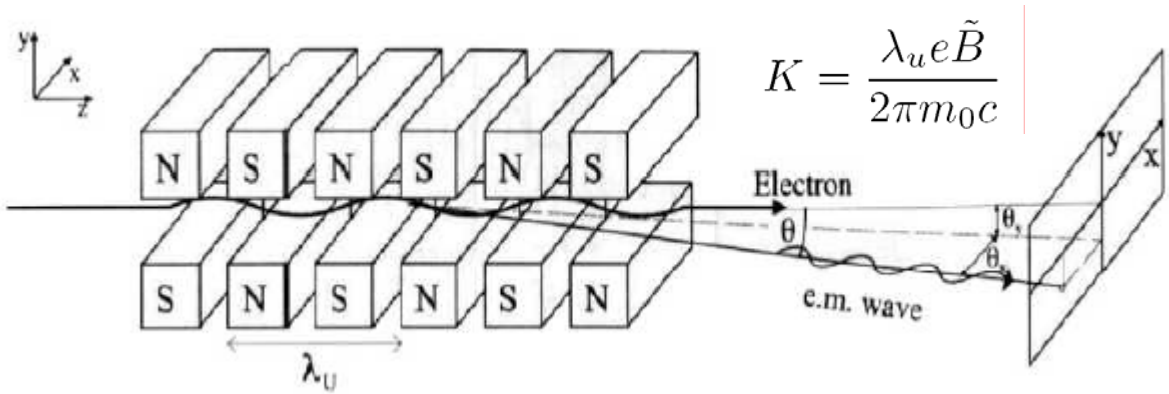
20 MeV · 1mA = 20kW





10kW Klystron

Undulatorstrahlung



$$K = \frac{\lambda_u e \tilde{B}}{2\pi m_0 c}$$

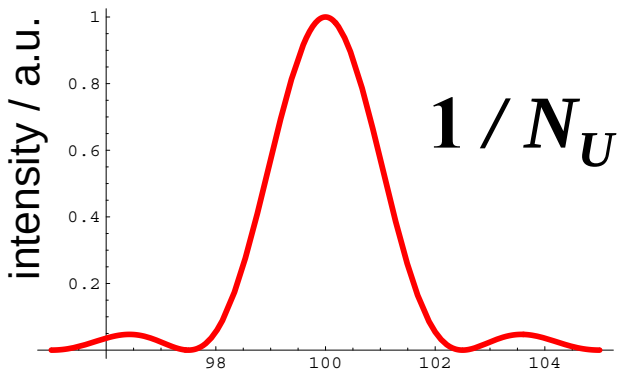
Kohärenzbedingung

$$\lambda_w = \frac{\lambda_u}{n}\frac{1}{2\gamma^2}\left(1 + \frac{K^2}{2} + \gamma^2\Theta_0^2\right)$$

relativistische Längenkontraktion und Dopplereffekt

Geschwindigkeits-korrektur

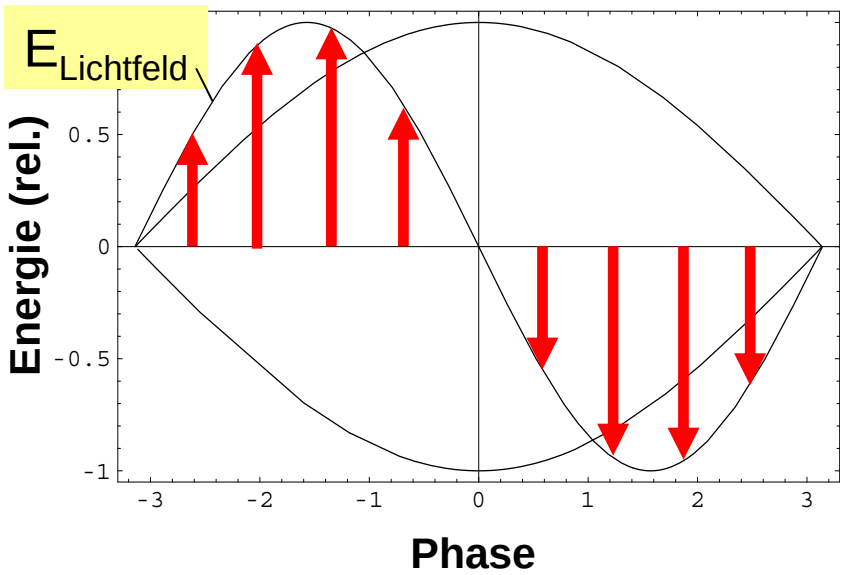
Winkelabhängigkeit Dopplereffekt



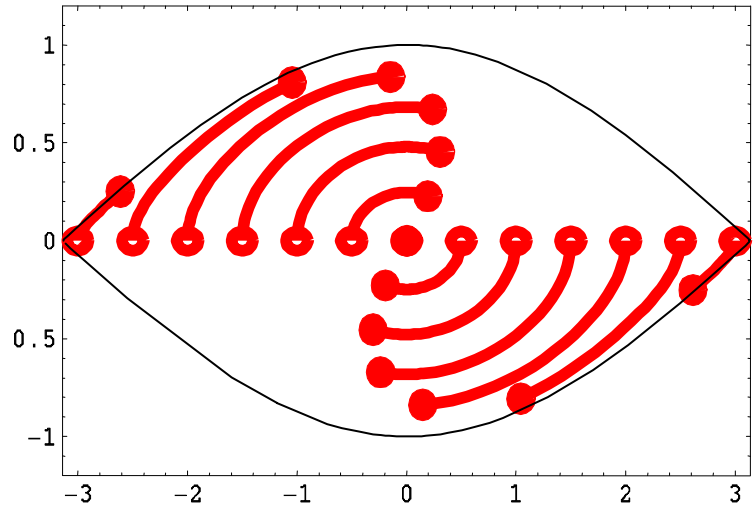
$\mathbf{1 / N_U}$

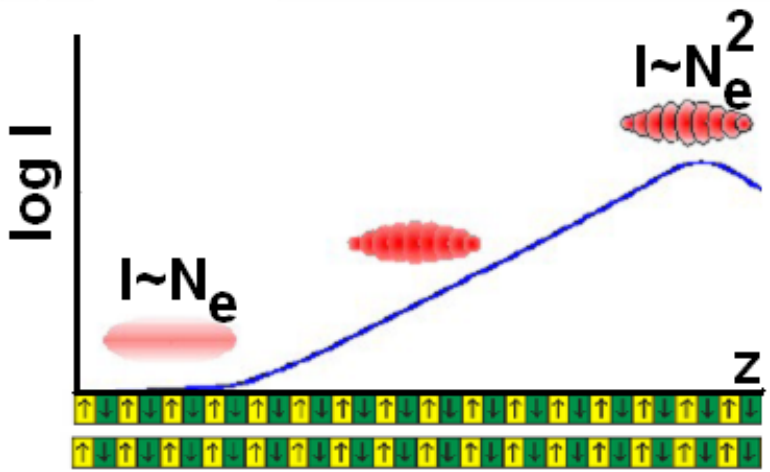
Strahlungsverstärkung (Freie-Elektronen-Laser)

Energiemodulation im elektrischen Lichtfeld



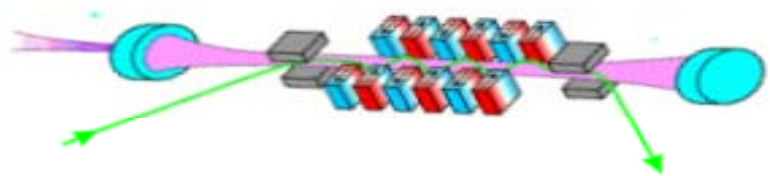
Dichtemodulation im magn. Undulatorfeld



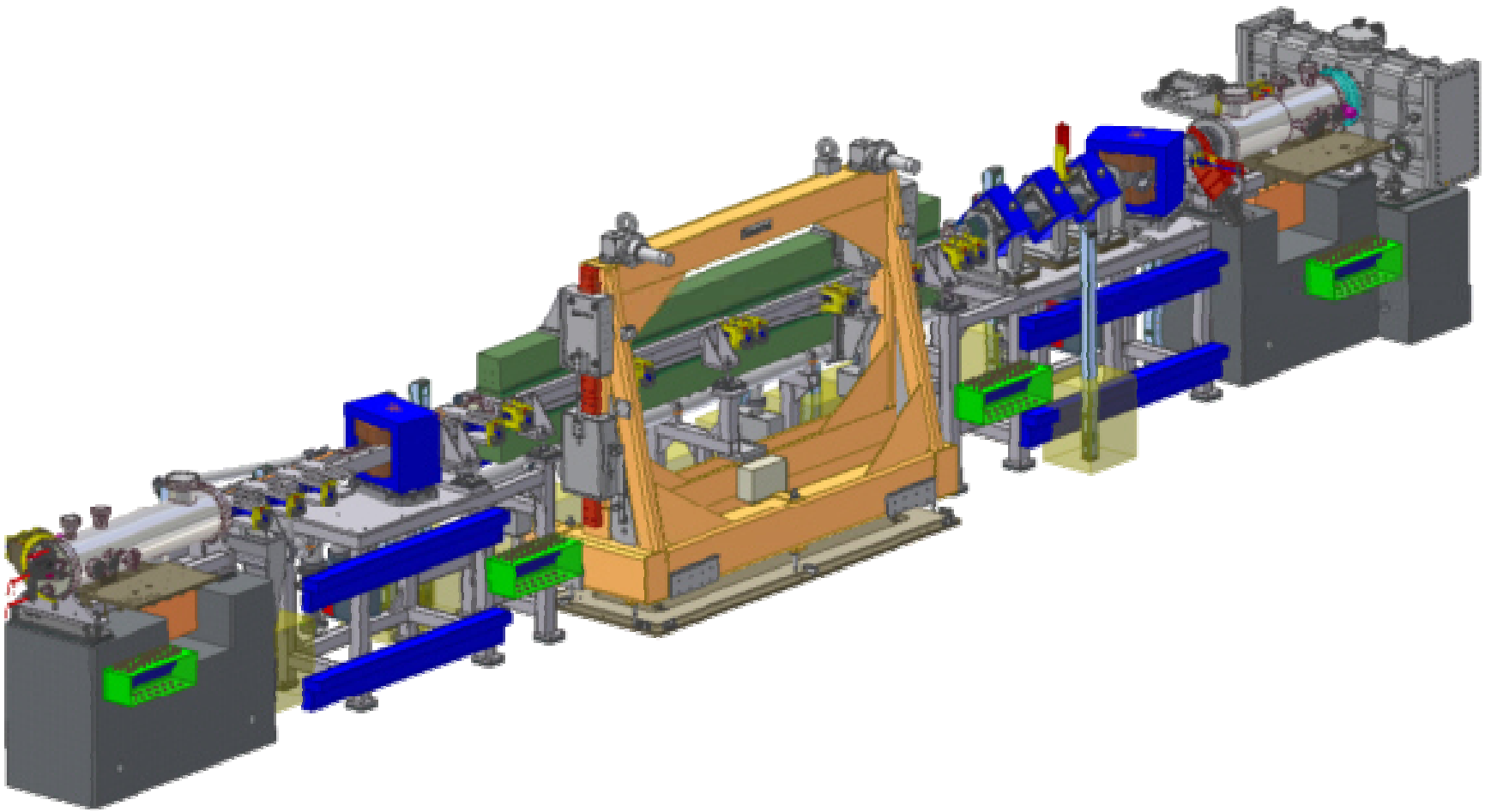


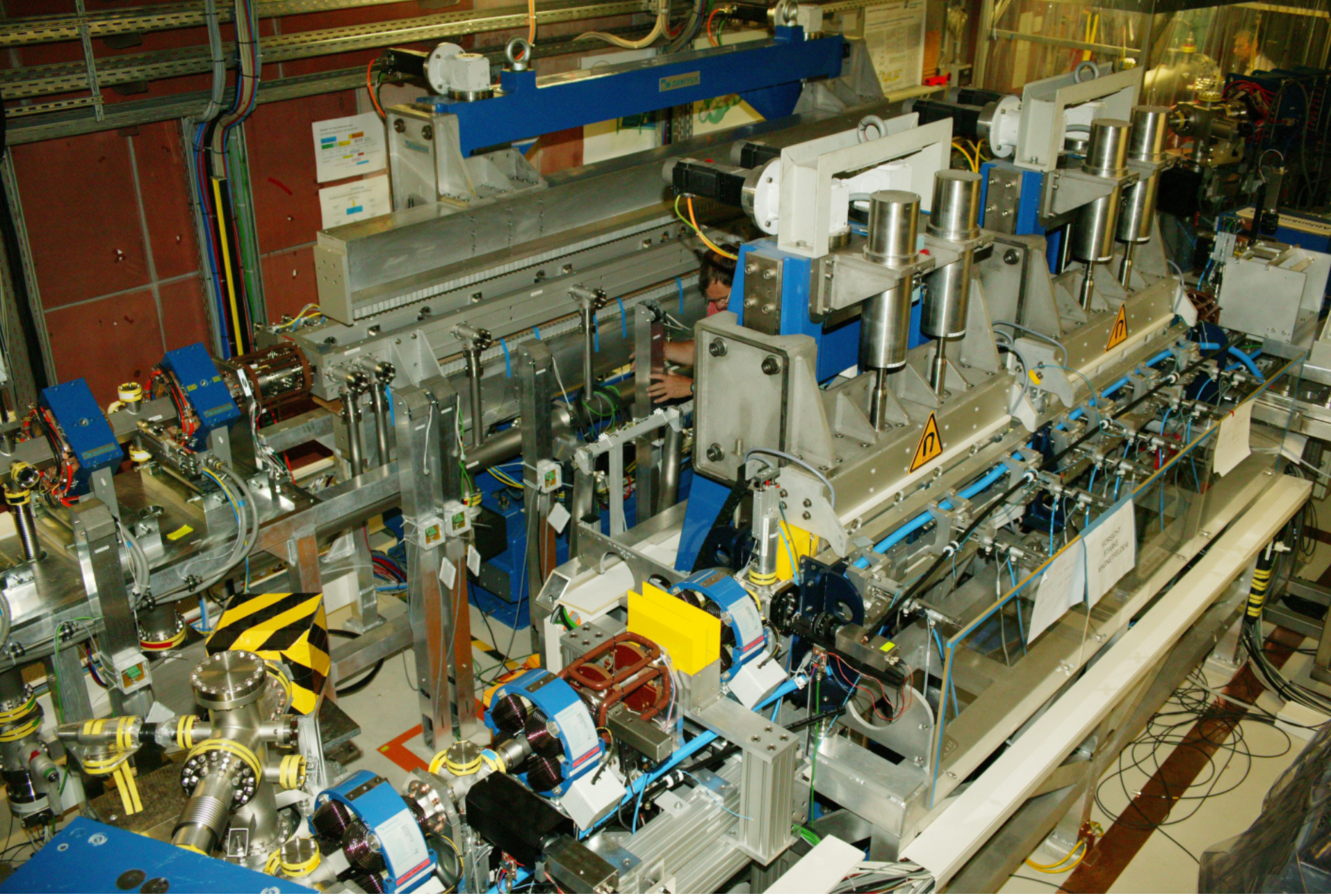
Kohärente Emission !

- single-pass FEL (high Gain) X-rays
- multi-pass FEL (low Gain) IR

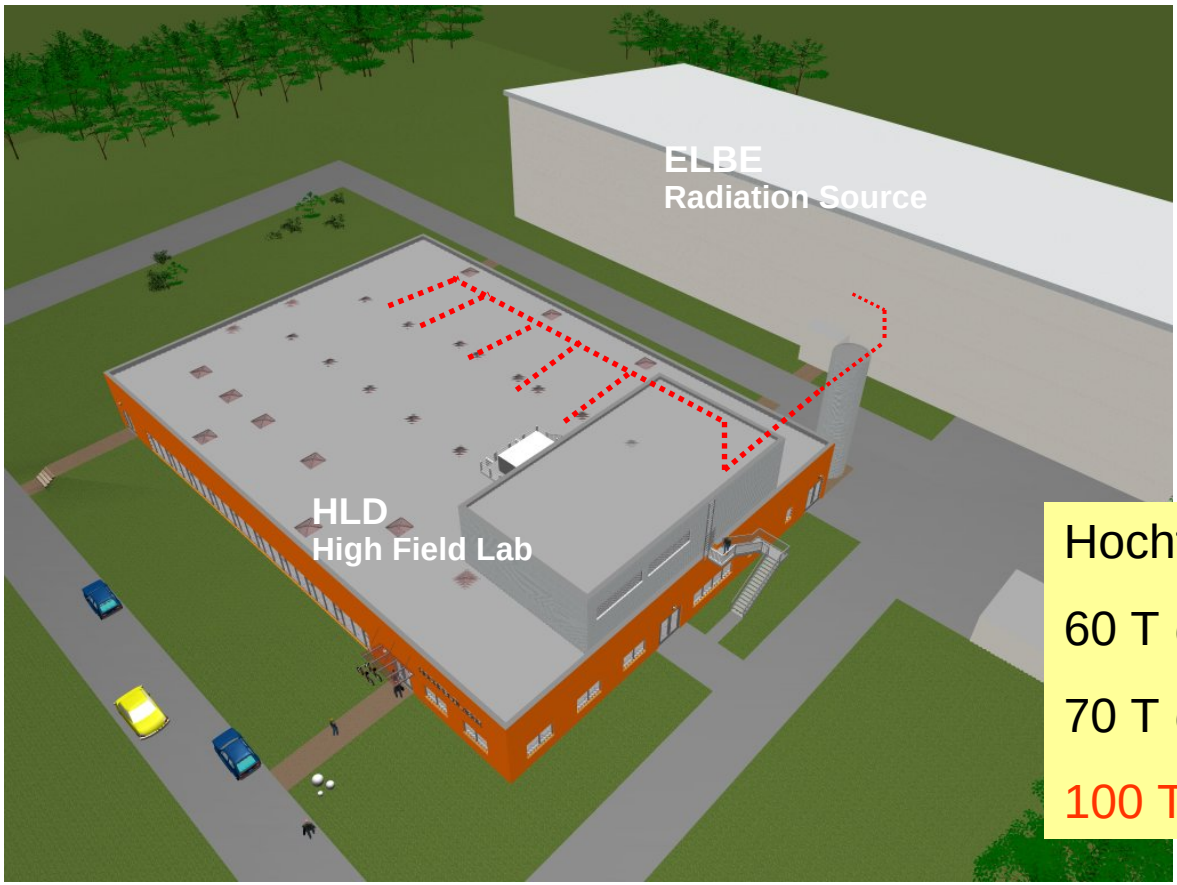


ELBE-U100 FEL





Labor für hohe Magnetfelder & ELBE



Hochfeldlabor Dresden

60 T @ 1000 ms

70 T @ 100 ms

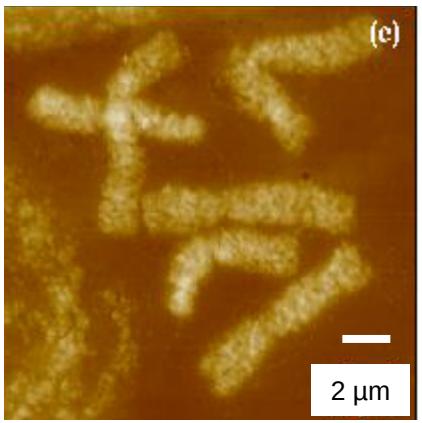
100 T @ 10 ms

Kombination des Freie-Elektronen-Infrarotlasers (3 … 200 μm) und des Hochfeldlabors bietet ideale Bedingungen für Hochfeld-Infrarotspektroskopie

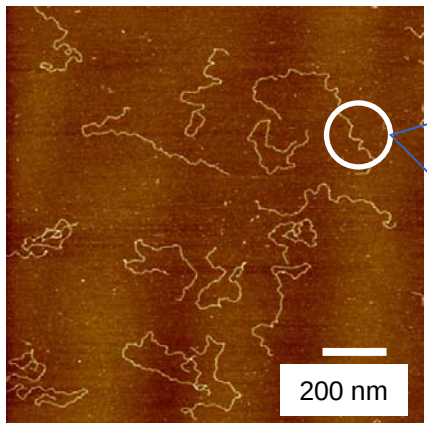
$2\mu B \cdot 100\ T \gg h \cdot c / 100\ \mu m$

Echtzeitbeobachtung molekularer Bewegungen in DNS

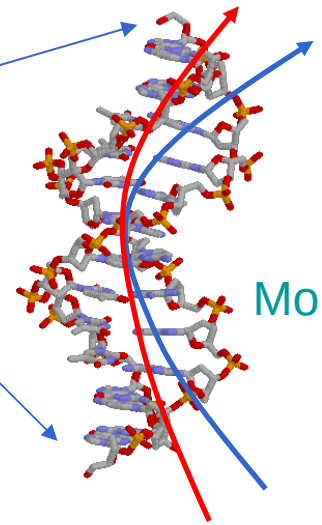
Das Erbmolekül DNS liegt in extrem verschiedenen Formen vor



kompakt im Chromosom



gestreckt im Zellkern



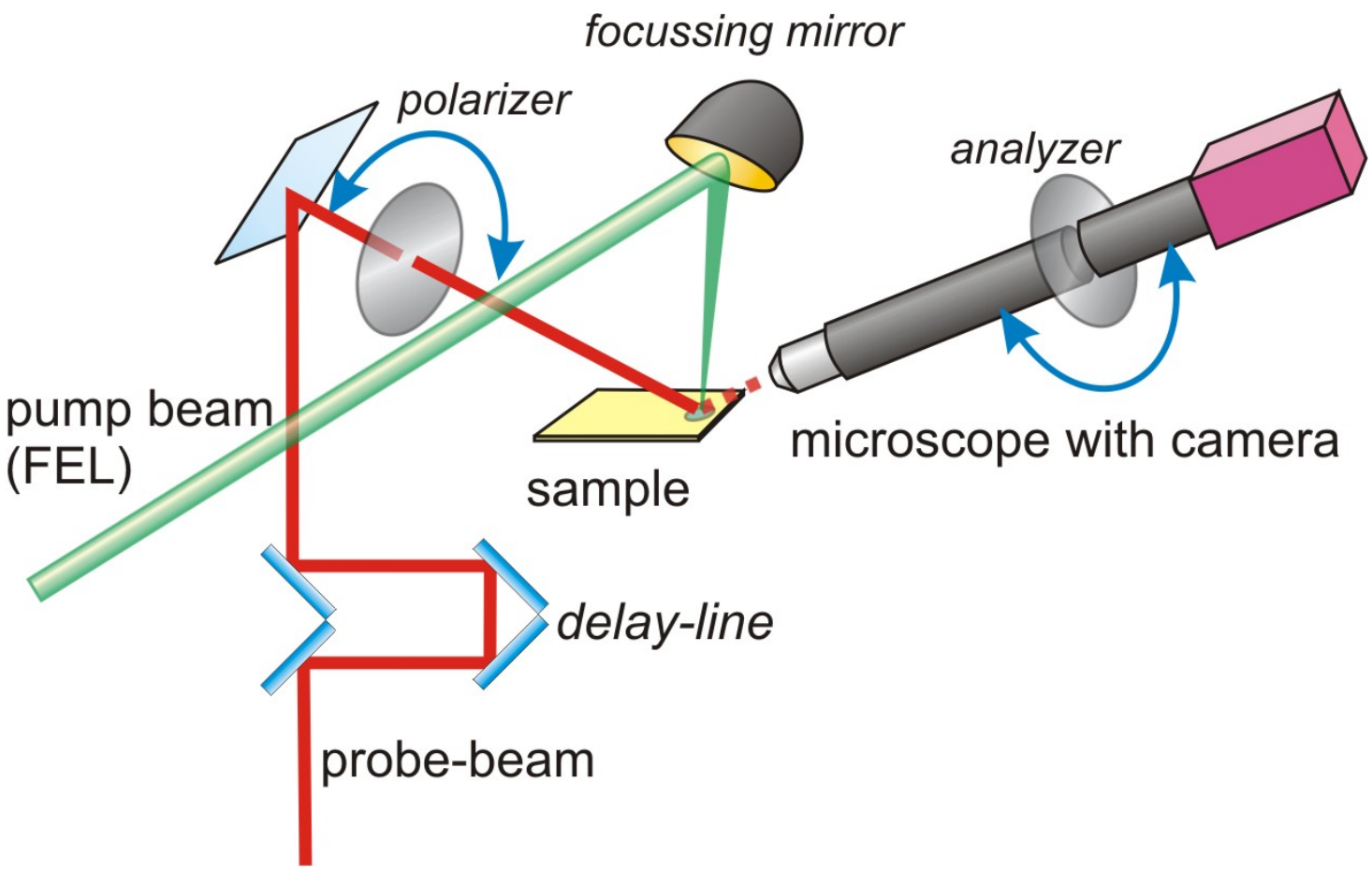
flexible Molekülstruktur

Ablesen der genetischen Information erfordert spezifische Formänderungen.

1. Können IR-Pulse diese Formveränderungen auslösen?
2. Können Art und Zeitverlauf der Molekülbewegung studiert werden?

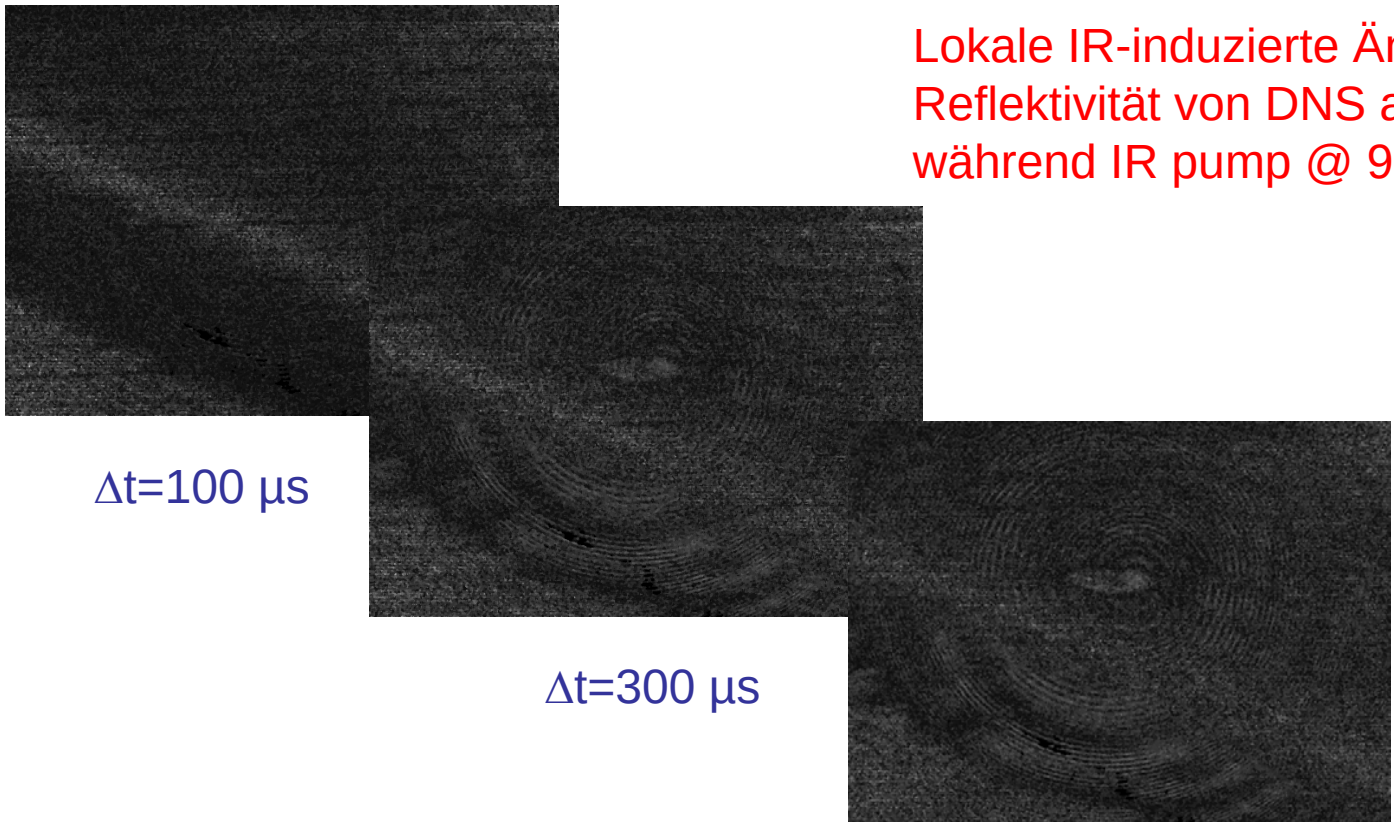
Courtesy of K.Fahmy

Experimenteller Aufbau:
IR-Puls-induzierte Reflexionsänderung in DNS



Courtesy of K.Fahmy

Schnelle Reflexionsänderung in DNS während IR-macro bunch (400 µs)



Lokale IR-induzierte Änderung der Reflektivität von DNS auf ZnSe während IR pump @ 9.25 µm

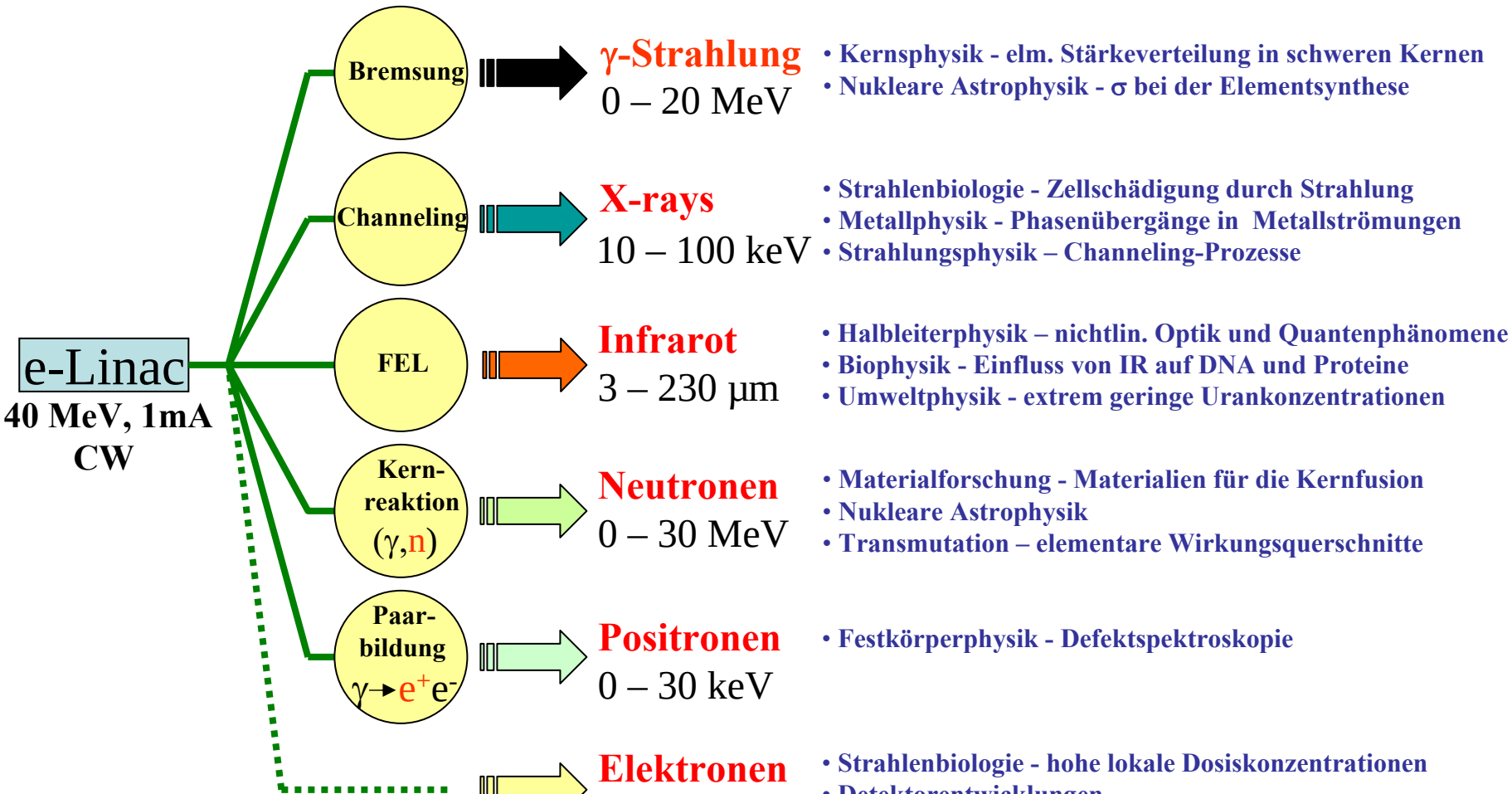
Δt=100 µs

Δt=300 µs

Δt=500 µs

Courtesy of K.Fahmy

Strahlungsquelle ELBE



Vielen Dank für Ihre Aufmerksamkeit