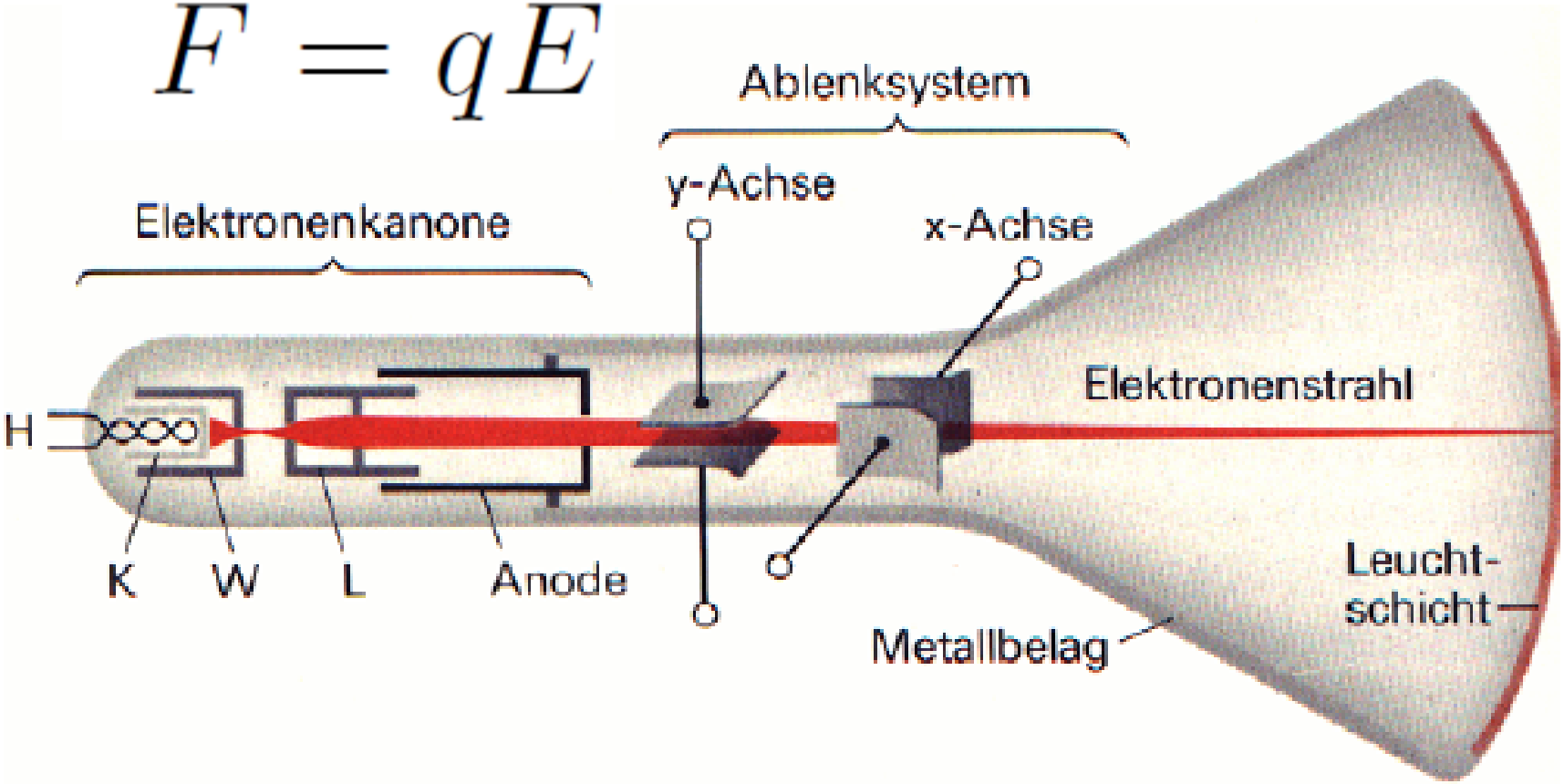
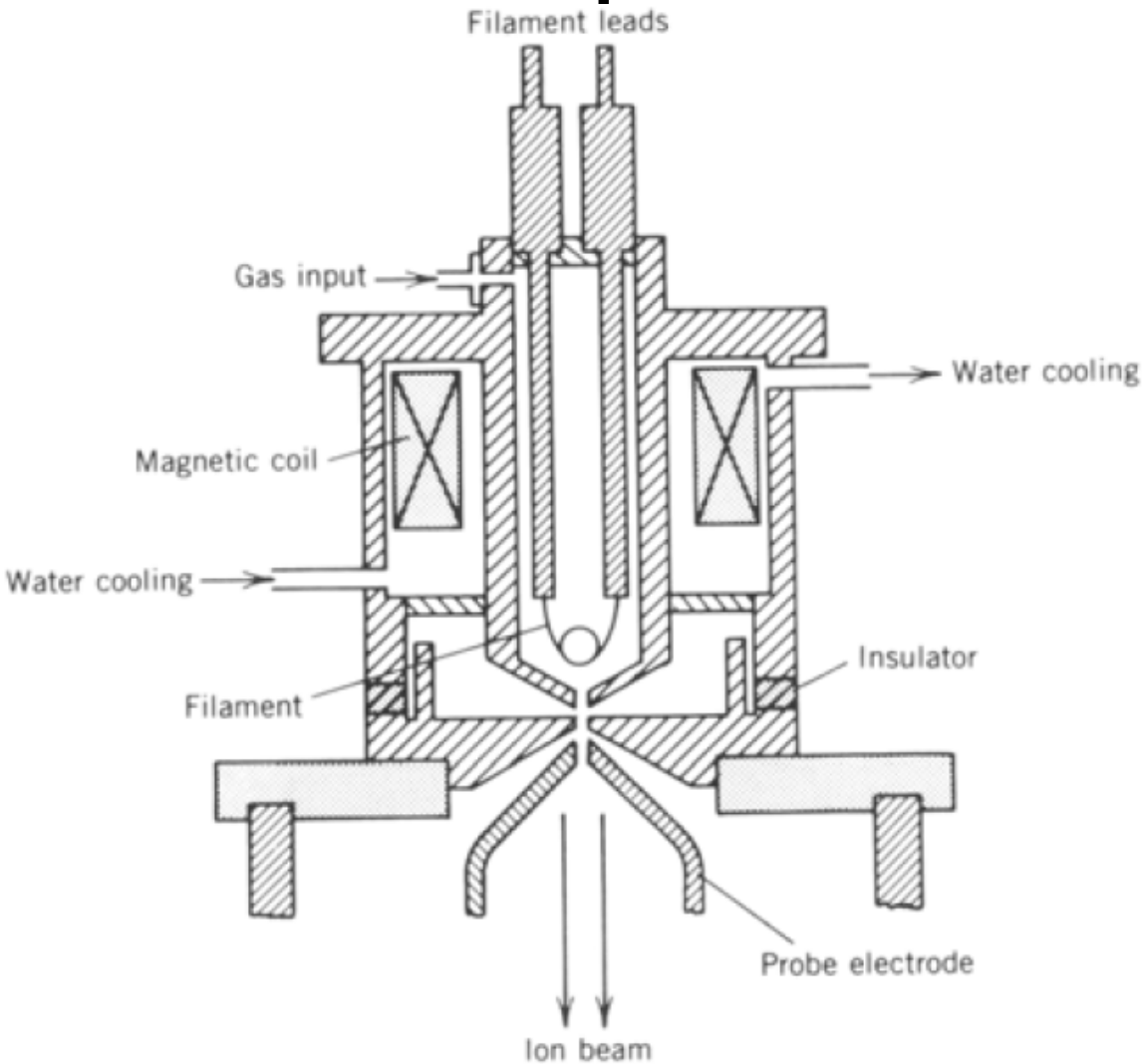
$$\vec{F} = q\vec{E}$$

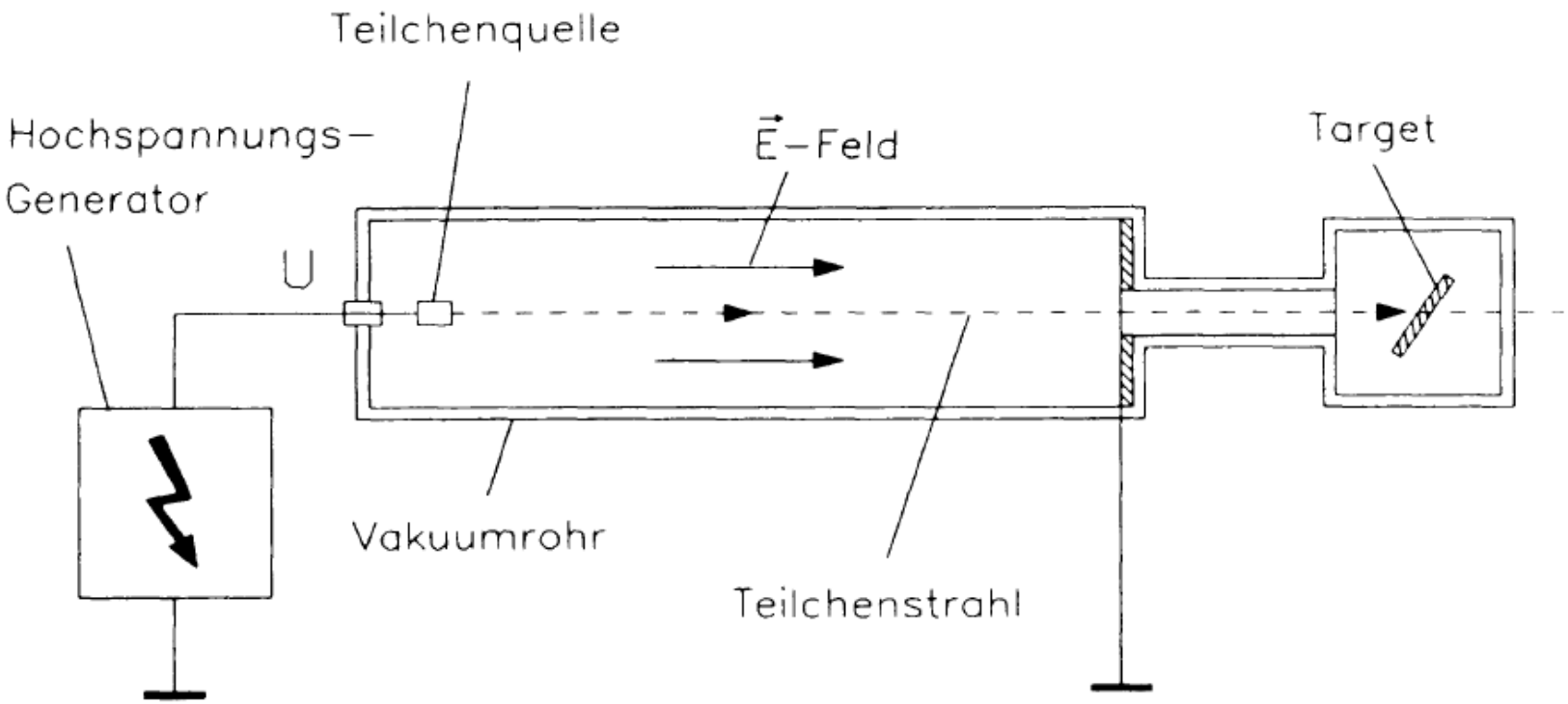

Ablenksystem
y-Achse
x-Achse
Elektronenkanone
Elektronenstrahl
H
K
W
L
Anode
Leucht-
schicht
Metallbelag

# Ionenquelle

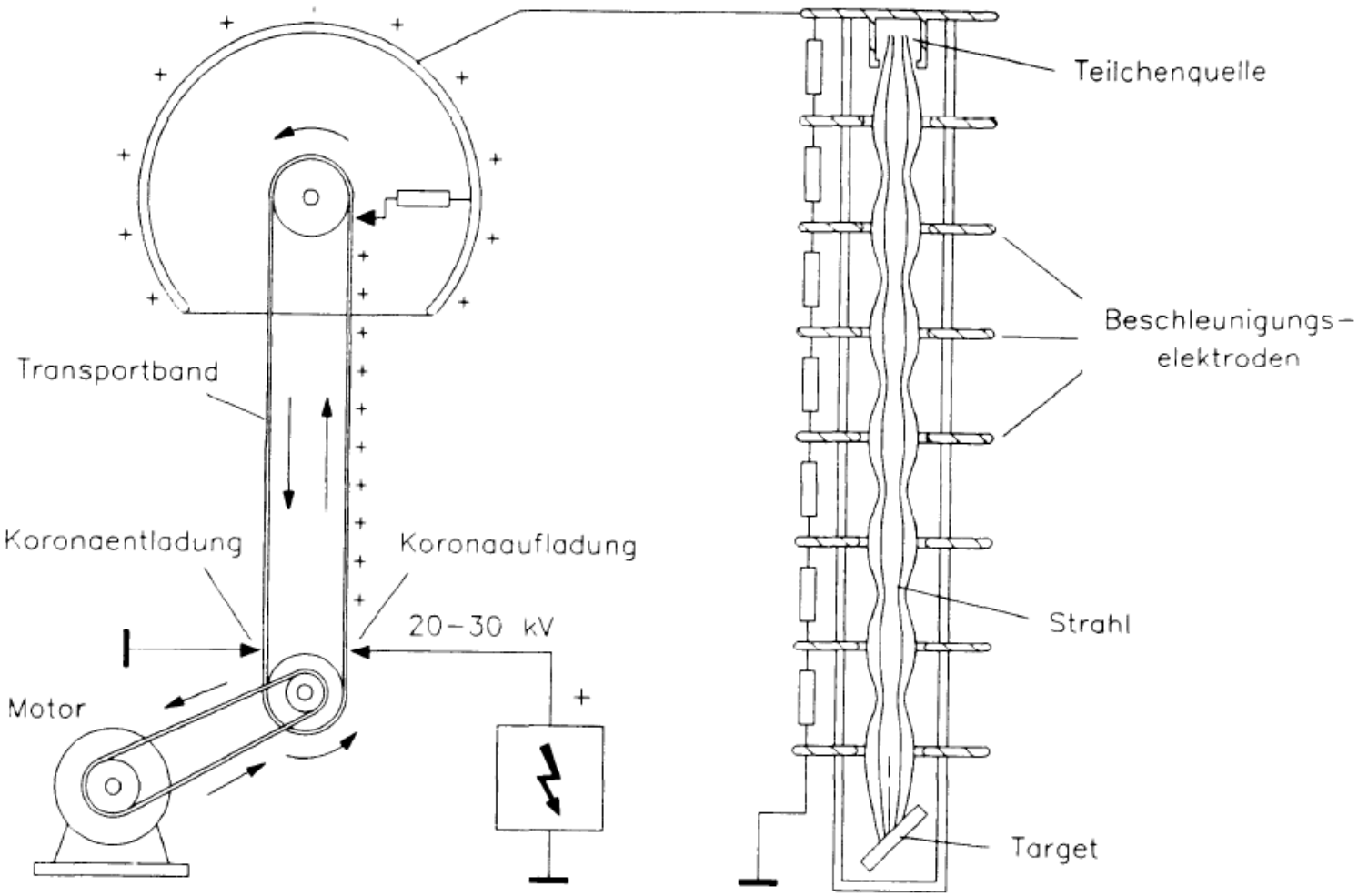



aus Krane

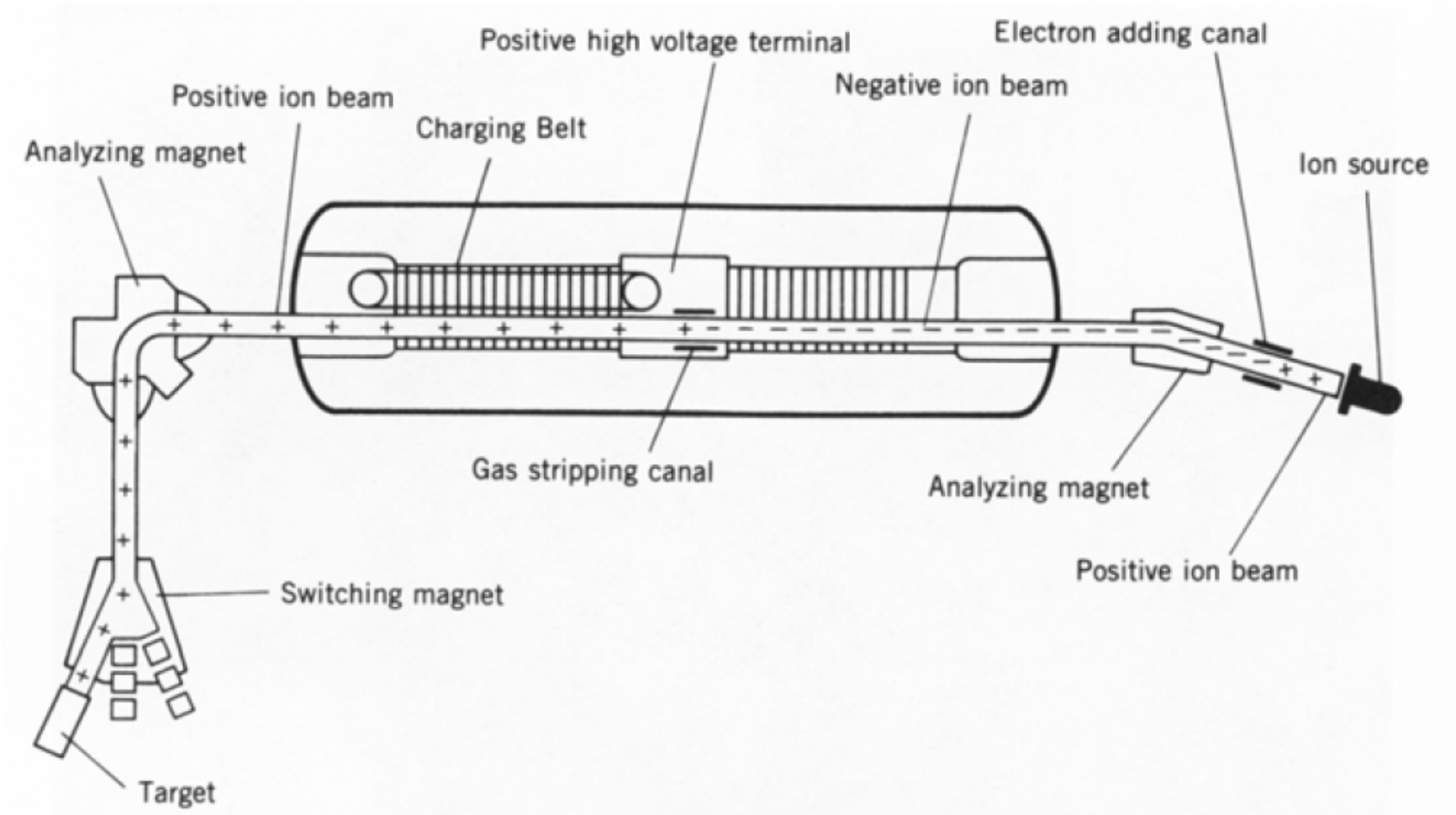
# Elektrostatischer Beschleuniger



# Van de Graaff Beschleuniger



# Tandembeschleuniger



# Münchner 15 MV Tandem

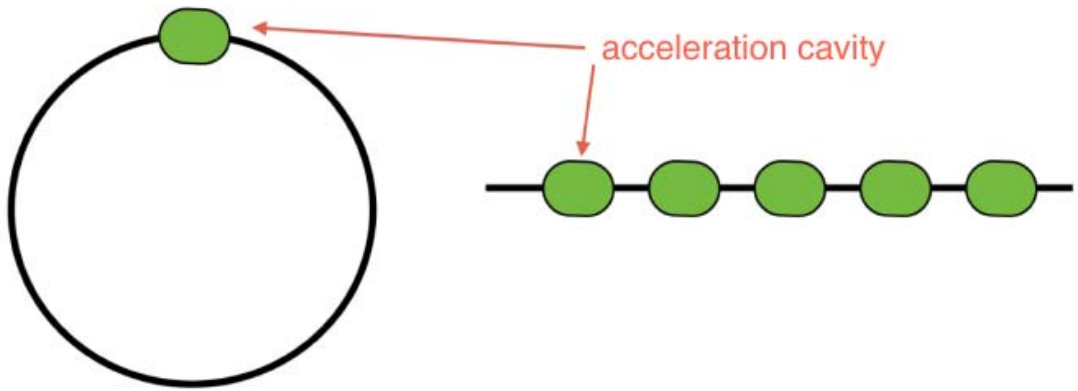



Figure 4.4: *Sketch of a circular (left) and linear (right) accelerator.* A circular machine needs to have one acceleration cavity, while a linear machine needs several cavities in series in order to reach high energies.

# Cyclotron

$$m\frac{v^2}{\rho} = qvB$$

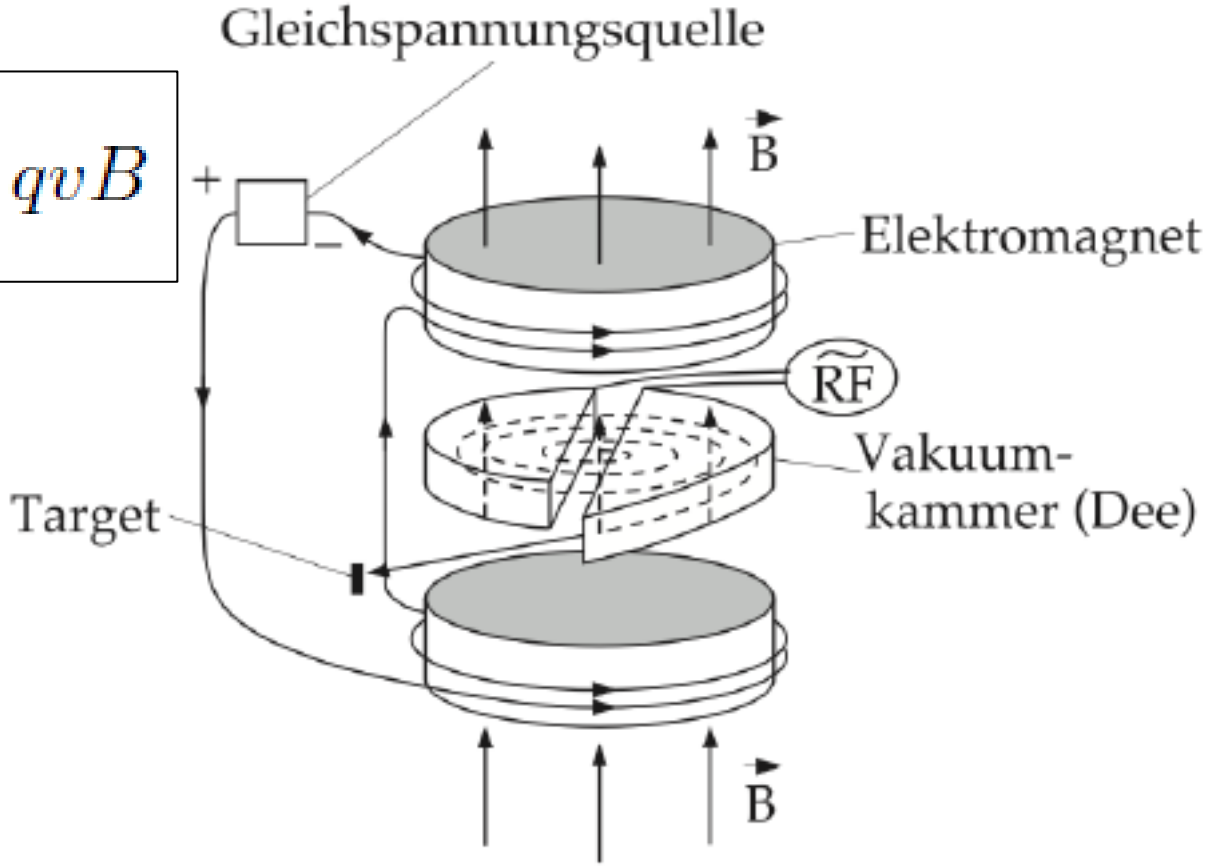



Figure 4.5: *Sketch of a cyclotron accelerator.* Source: [8, p. 108].

# Cyclotrons

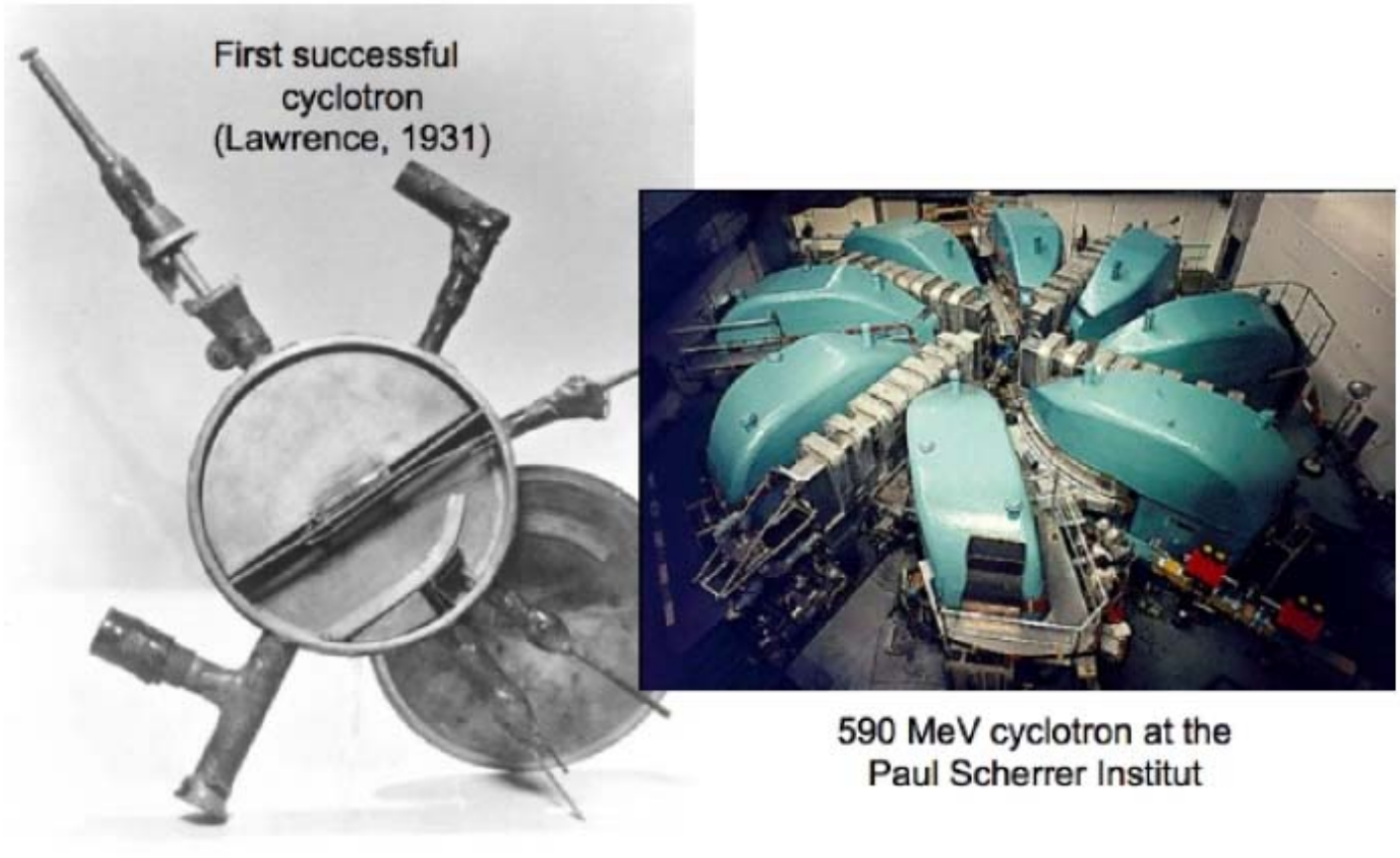
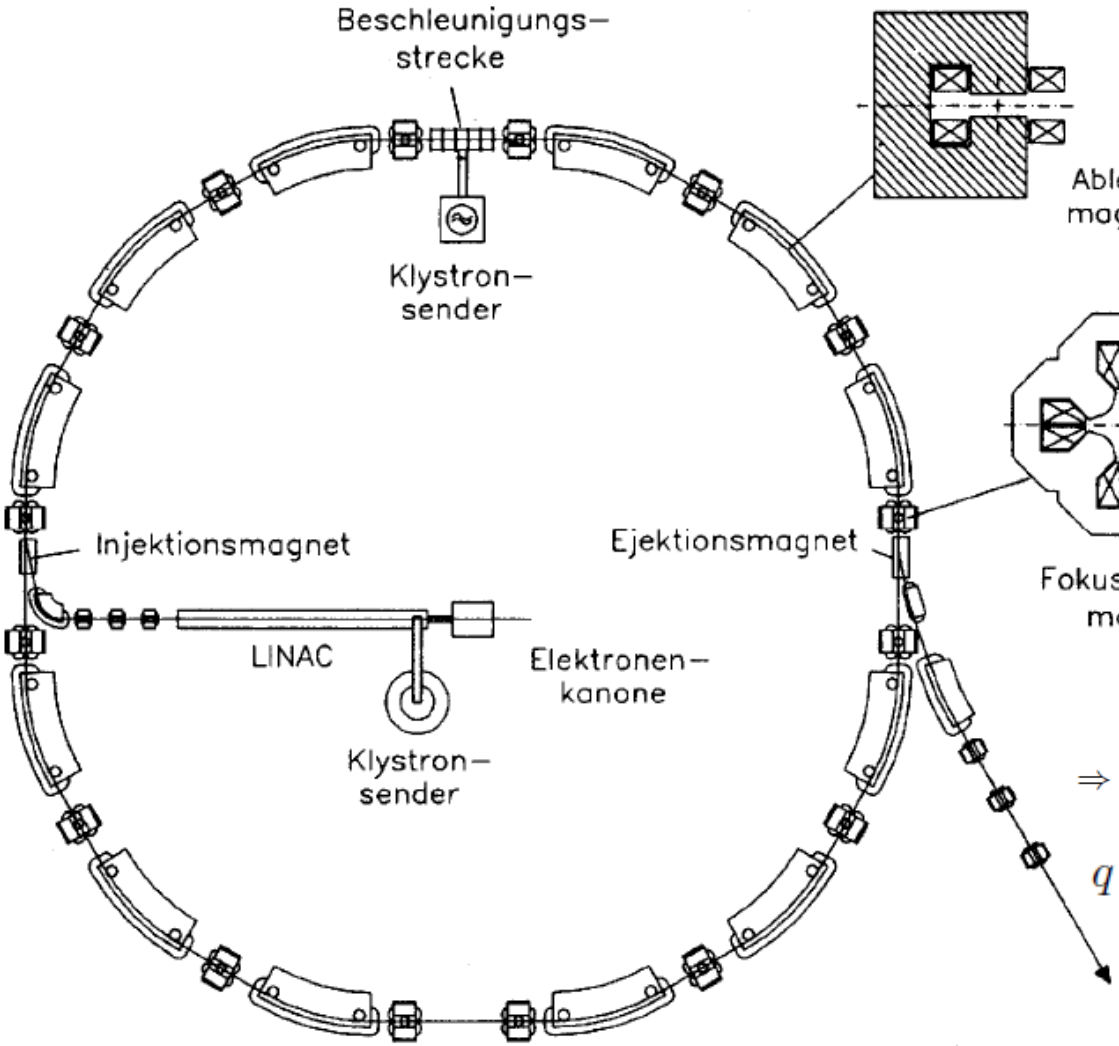
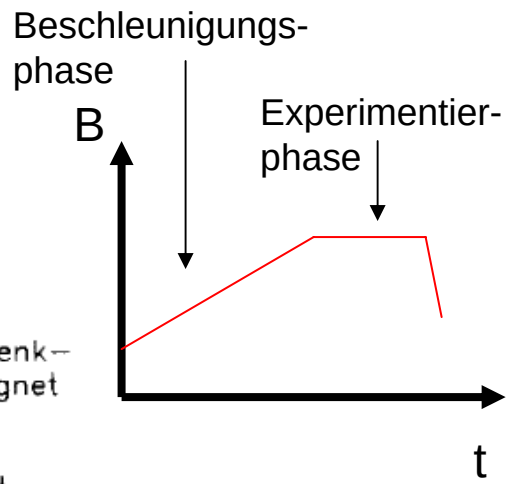



Figure 4.6: *A first prototype of a cyclotron (by Lawrence) and the* 590 MeV *isochronous cyclotron at PSI.*

aus ETHZ Skript

# Synchroton




$$\rho = \frac{p}{qB}.$$

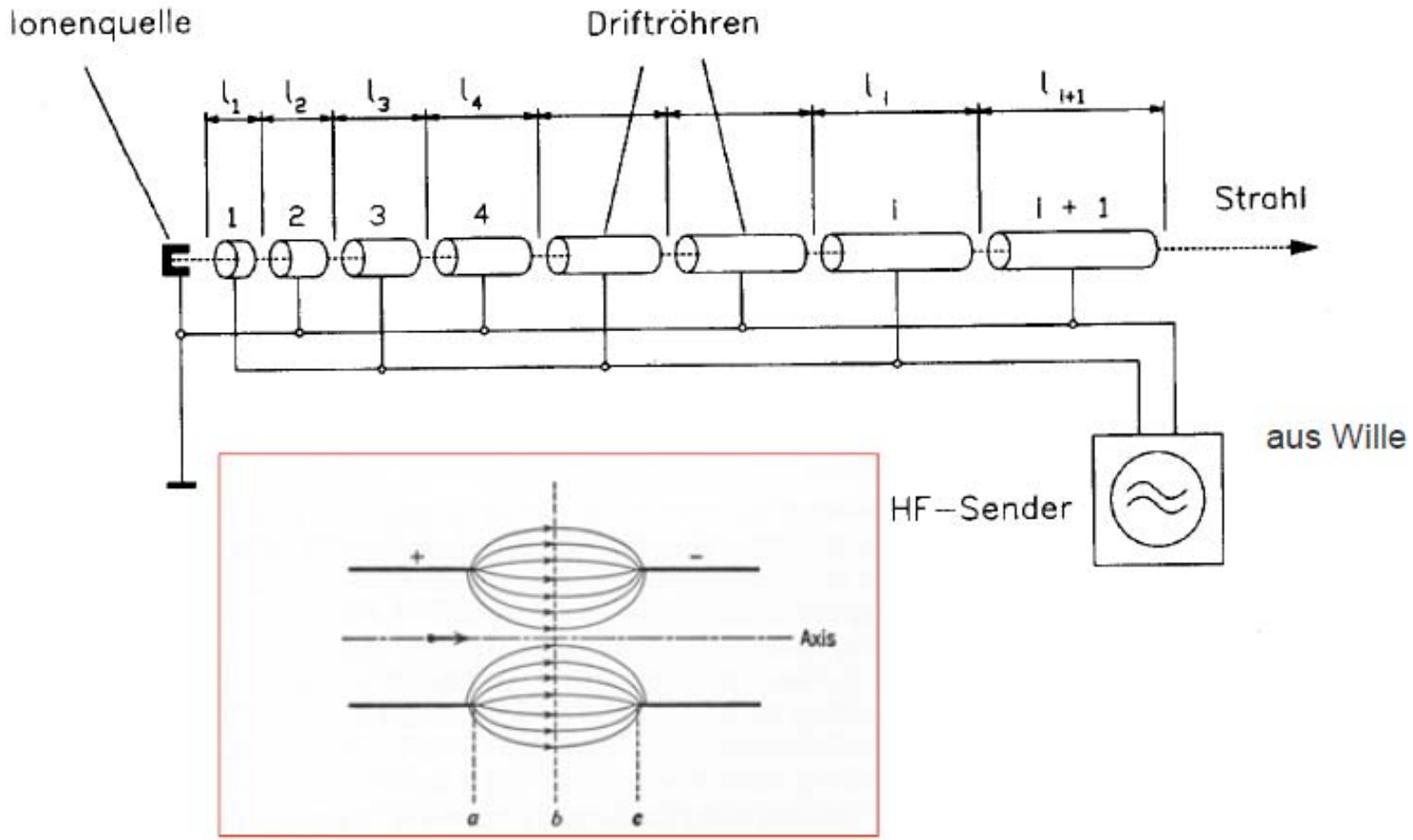
$$cp[\mathrm{eV}] = czB\rho = 3 \cdot 10^8 \frac{\mathrm{m}}{\mathrm{s}} zB[\mathrm{T}]\rho[\mathrm{m}]$$

$$\Rightarrow p\left[\frac{\mathrm{GeV}}{\mathrm{c}}\right] = 0.3zB[\mathrm{T}]\rho[\mathrm{m}]$$

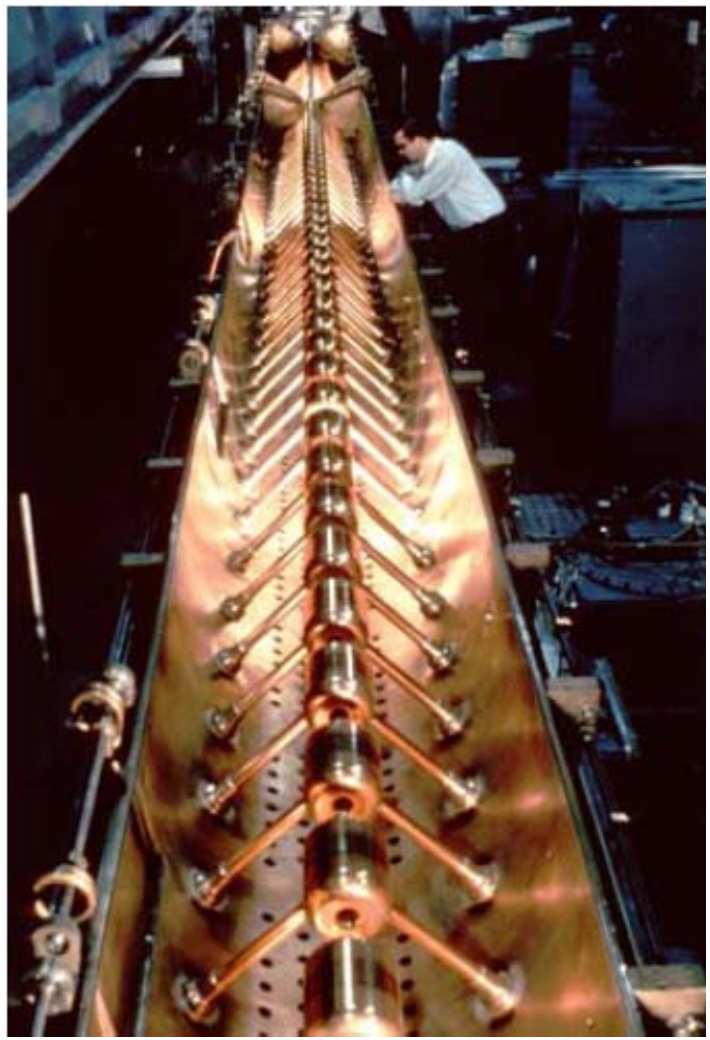
$q = ze$ (with $e$ the unit charge)

Aus Wille

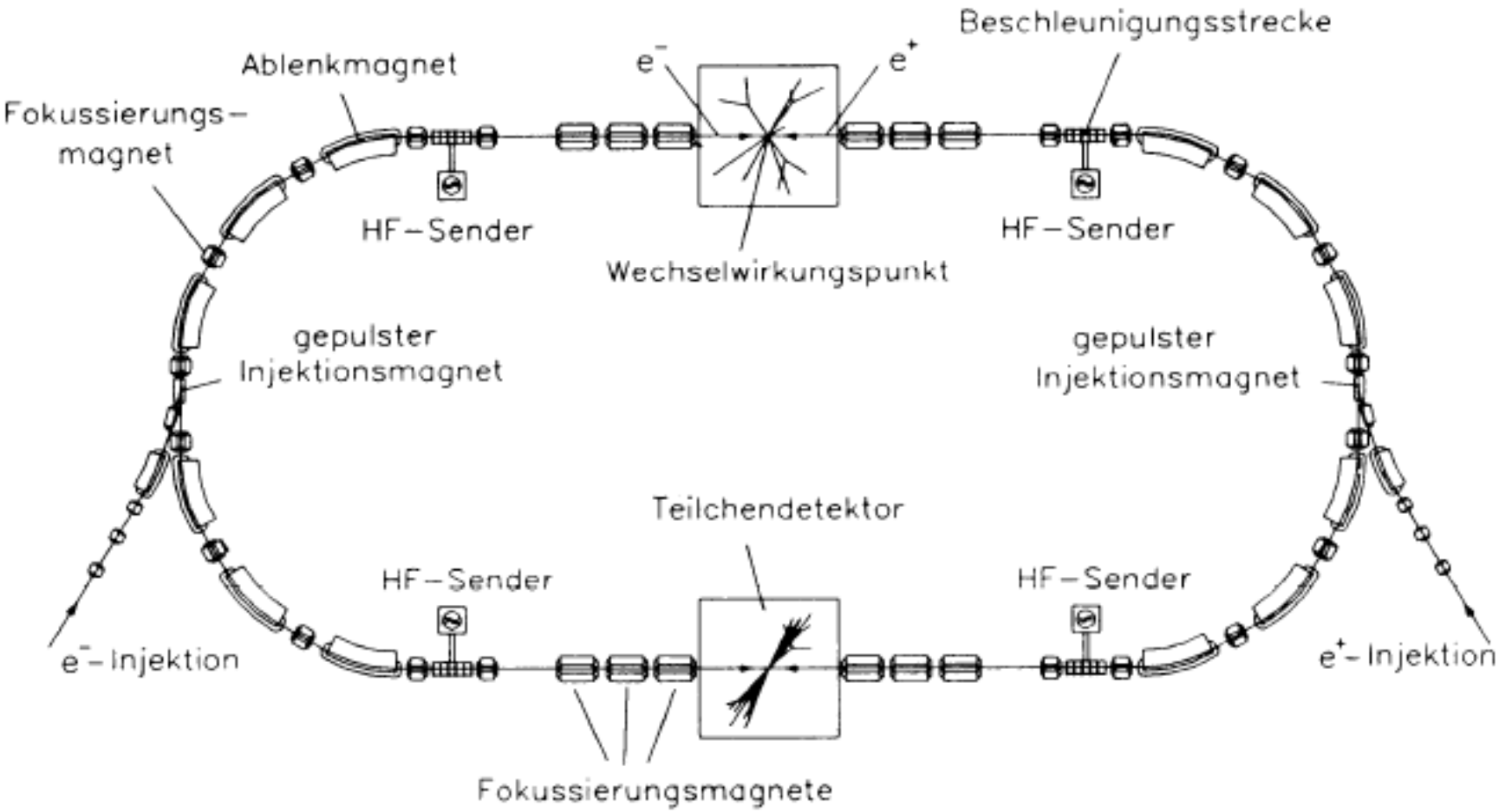
# Linac (Wideroe type)



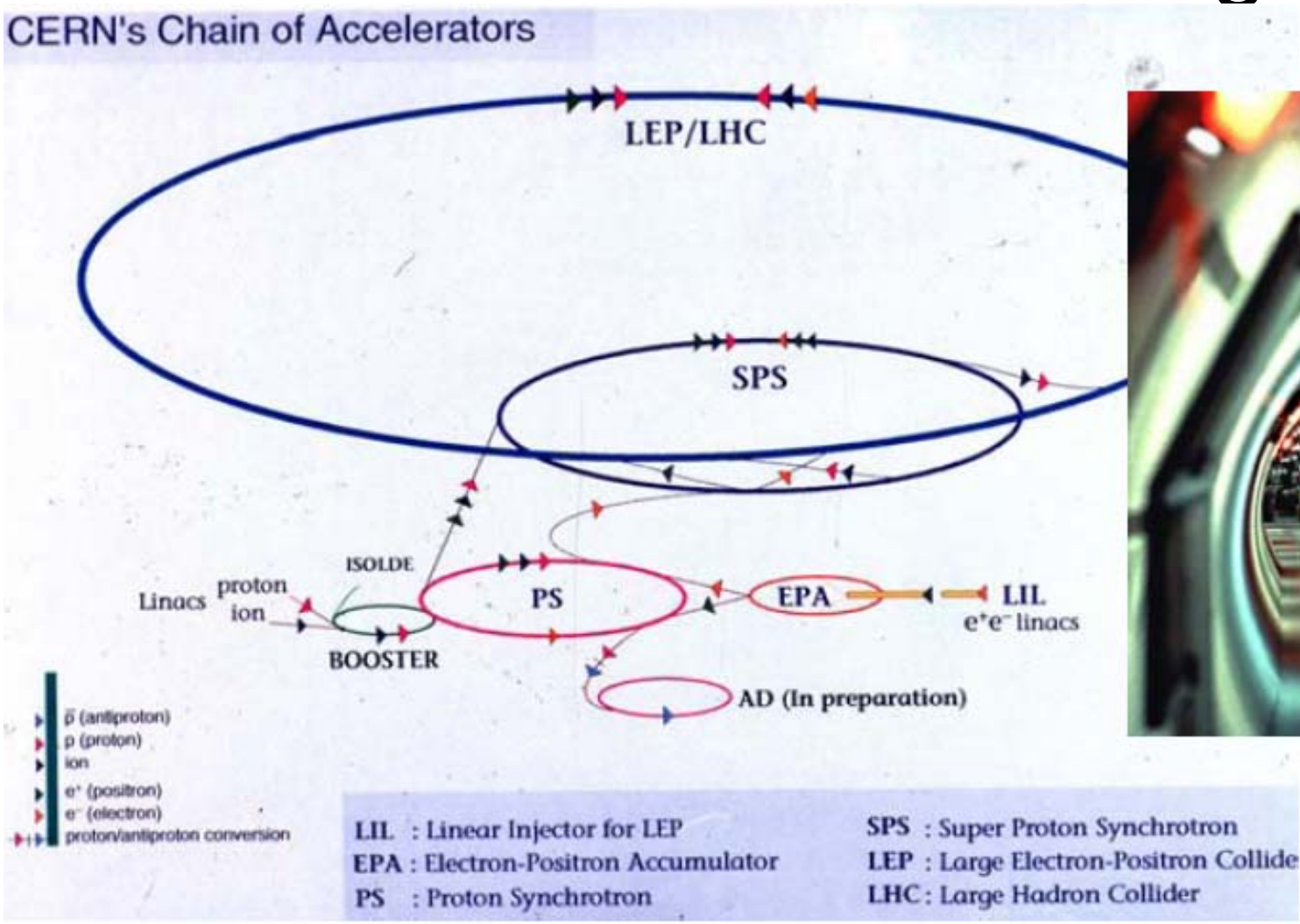
# Protonen Linac



# Collider


Beschleunigungsstrecke
Ablenkmagnet
e⁻
e⁺
Fokussierungs–
magnet
HF–Sender
HF–Sender
Wechselwirkungspunkt
gepulster
Injektionsmagnet
gepulster
Injektionsmagnet
Teilchendetektor
HF–Sender
HF–Sender
e⁻–Injektion
e⁺–Injektion
Fokussierungsmagnete

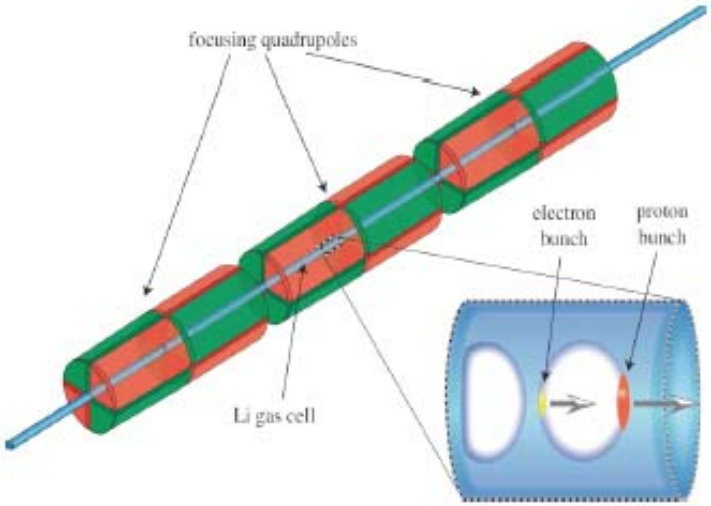
# Die CERN Beschleuniger

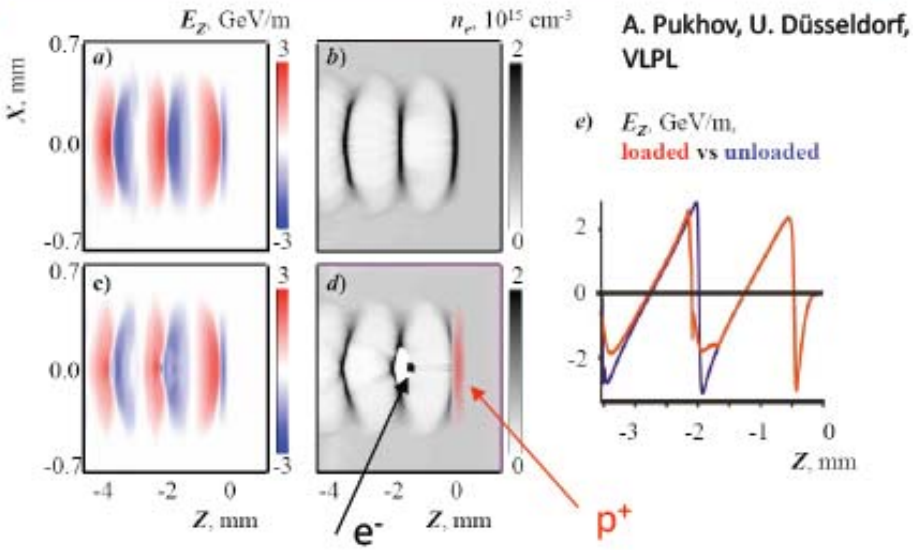



7 TeV protons => 5.4 T for r=4.3 km

# CERN bei Genf

# Proton-driven plasma wakefield acceleration (PDPWA)




A. Pukhov, U. Düsseldorf, VLPL




## Drive beam: $p^+$

E=1 TeV, $N_p=10^{11}$

$\sigma_z$=100 μm, $\sigma_r$=0.43 mm

$\sigma_\theta$=0.03 mrad, ΔE/E=10%

## Witness beam: $e^-$

$E_0$=10 GeV, $N_e=1.5\times10^{10}$

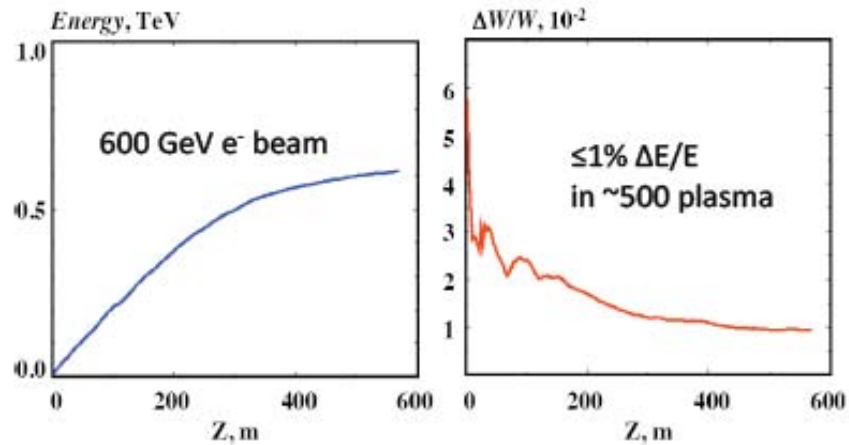
## Plasma: $Li^+$

$n_p=6\times10^{14}$cm$^{-3}$

## External magnetic field:

Field gradient: 1000 T/m

Magnet length: 0.7 m




A. Caldwell, K. Lotov, A. Pukhov, F. Simon, Nature Physics 5, 363 (2009).