

Energieverlust schwerer geladener Teilchen durch Ionisation

Mean energy loss via ionisation:

well described ($\pm 5\%$) by empirical Bethe Bloch formula in range $\beta\gamma$ in $[0.1 - \infty]$:

low energy:

$$-dE/dx \sim \frac{1}{\beta^2}$$

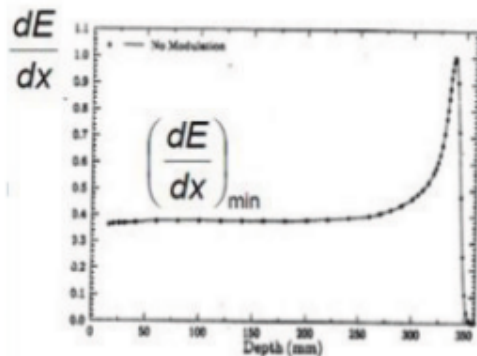
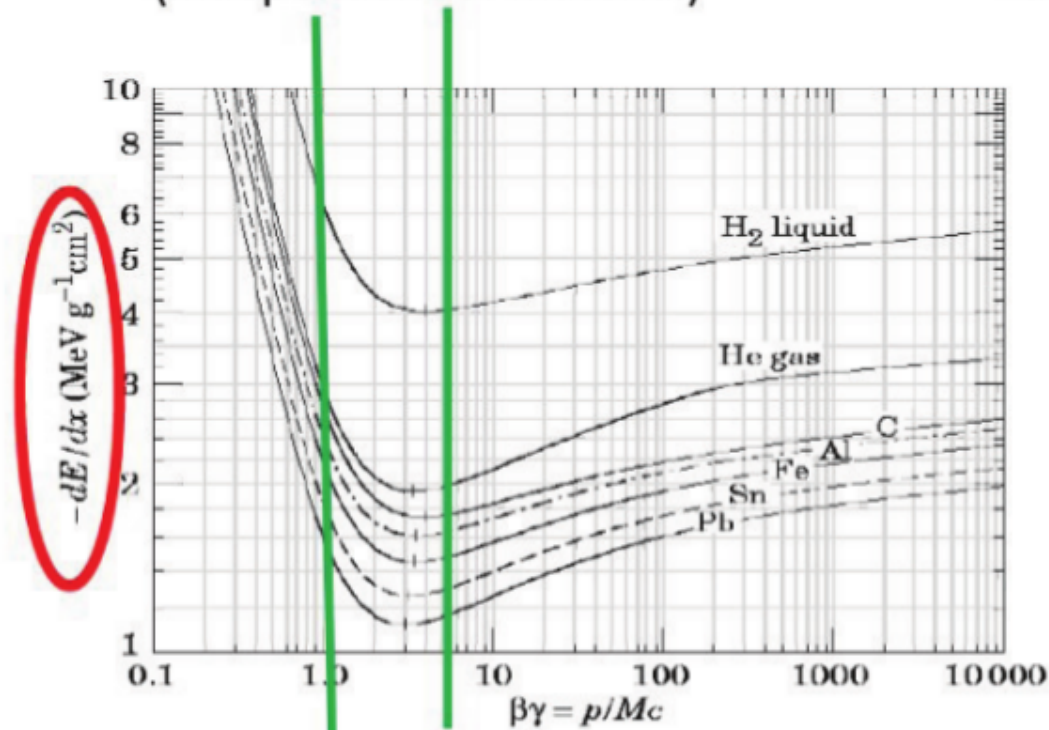


Abb 5.1

minimum at $\beta\gamma = \frac{p}{m} \epsilon [2 - 4]$

$$-dE/dx \frac{1}{\rho} = 1-2 \text{ MeV cm}^2/\text{g}$$

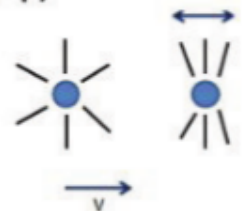
(independent of material)

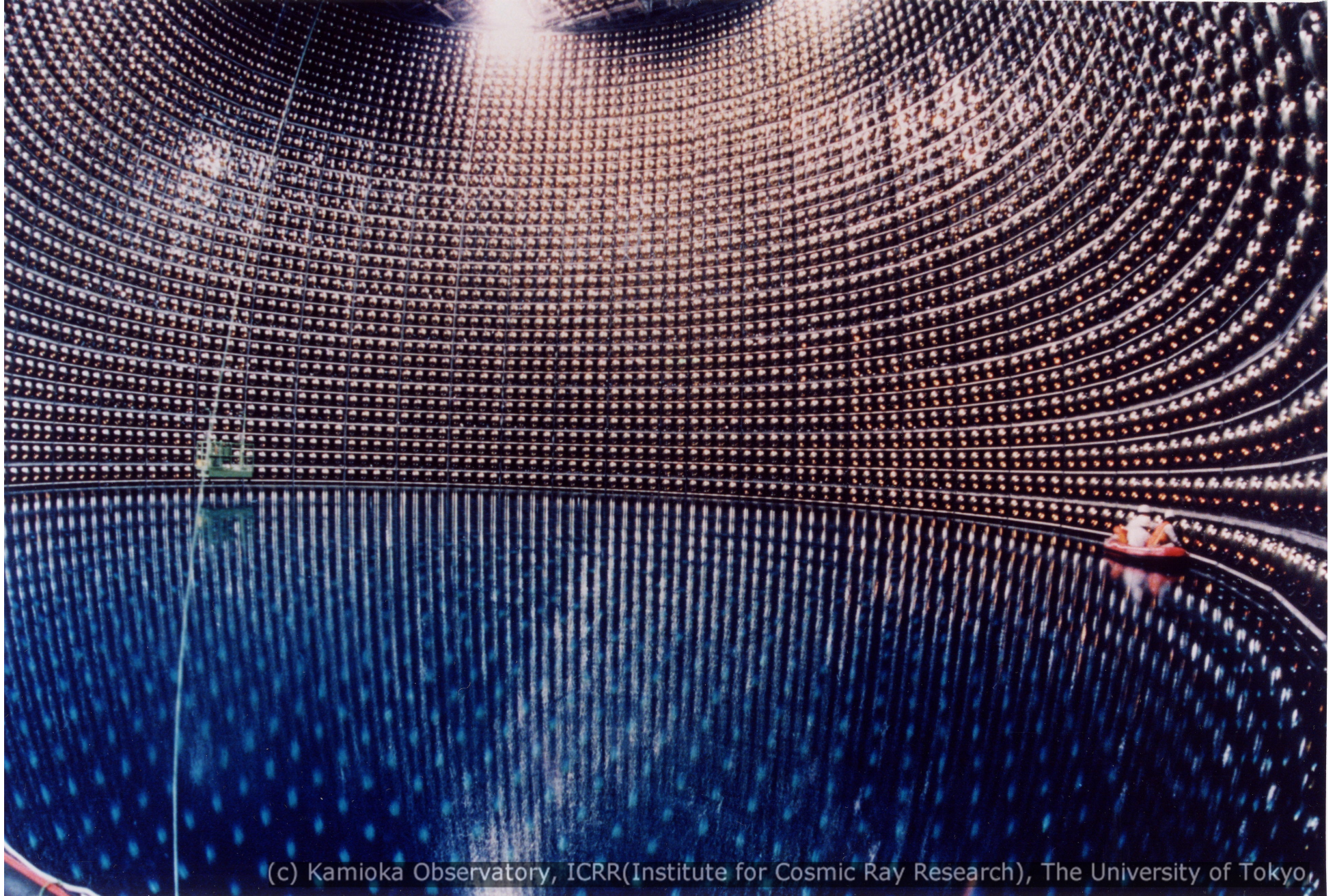


high energy

shallow relativistic rise

$$-dE/dx \sim \ln(\beta\gamma)$$

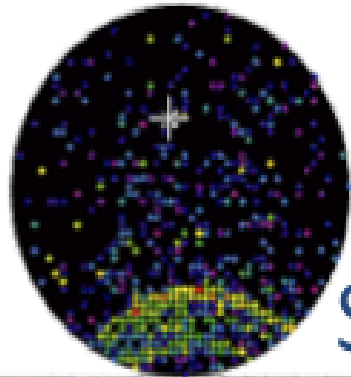




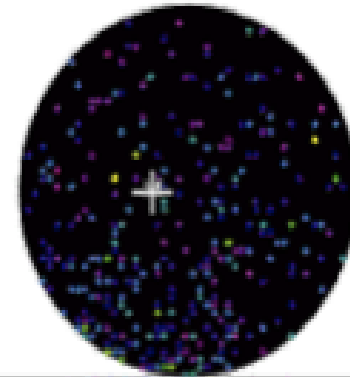
(c) Kamioka Observatory, ICRR(Institute for Cosmic Ray Research), The University of Tokyo,

Neutrinos schlagen Elektronen aus den Wasseratomen. Die Elektronen werden durch Cherenkovstrahlung nachgewiesen. Da der Wirkungsquerschnitt von Neutrino-Reaktion sehr klein ist werden dafür riesige Wassertanks benutzt. (Auf dem Foto sieht man Physiker im Boot die Wartungsarbeiten an den Photomultipliern durchführen.

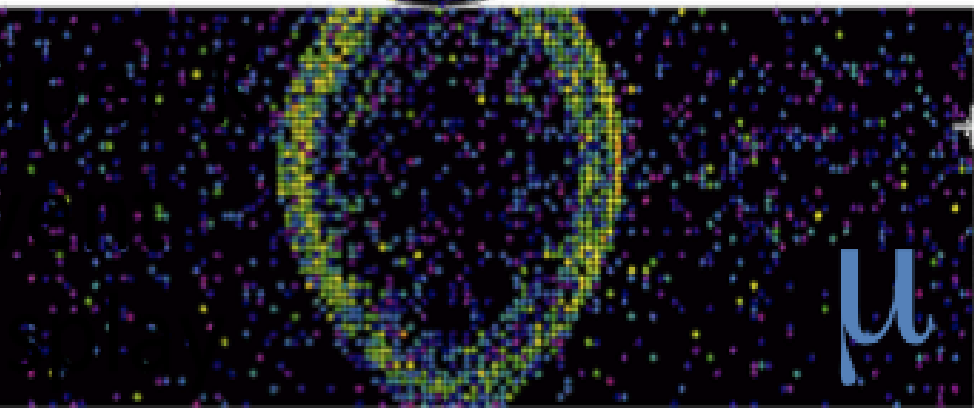
Signale im Kamiokande Detektor



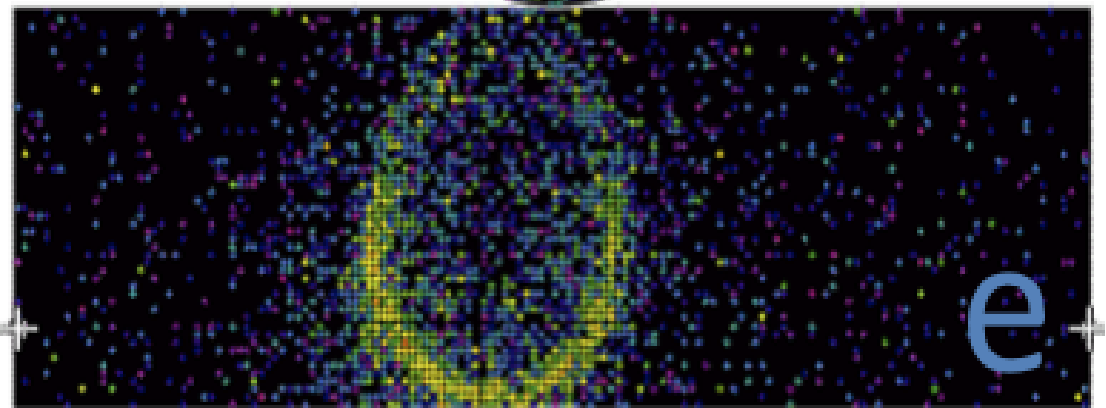
Sharp edge



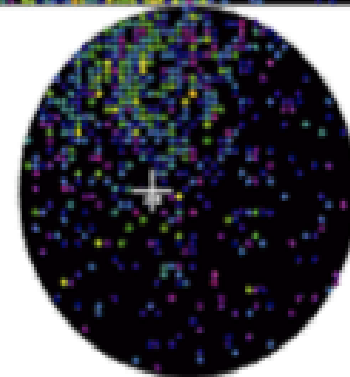
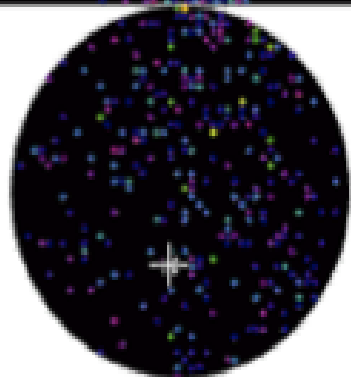
Fuzzy ring



μ



e



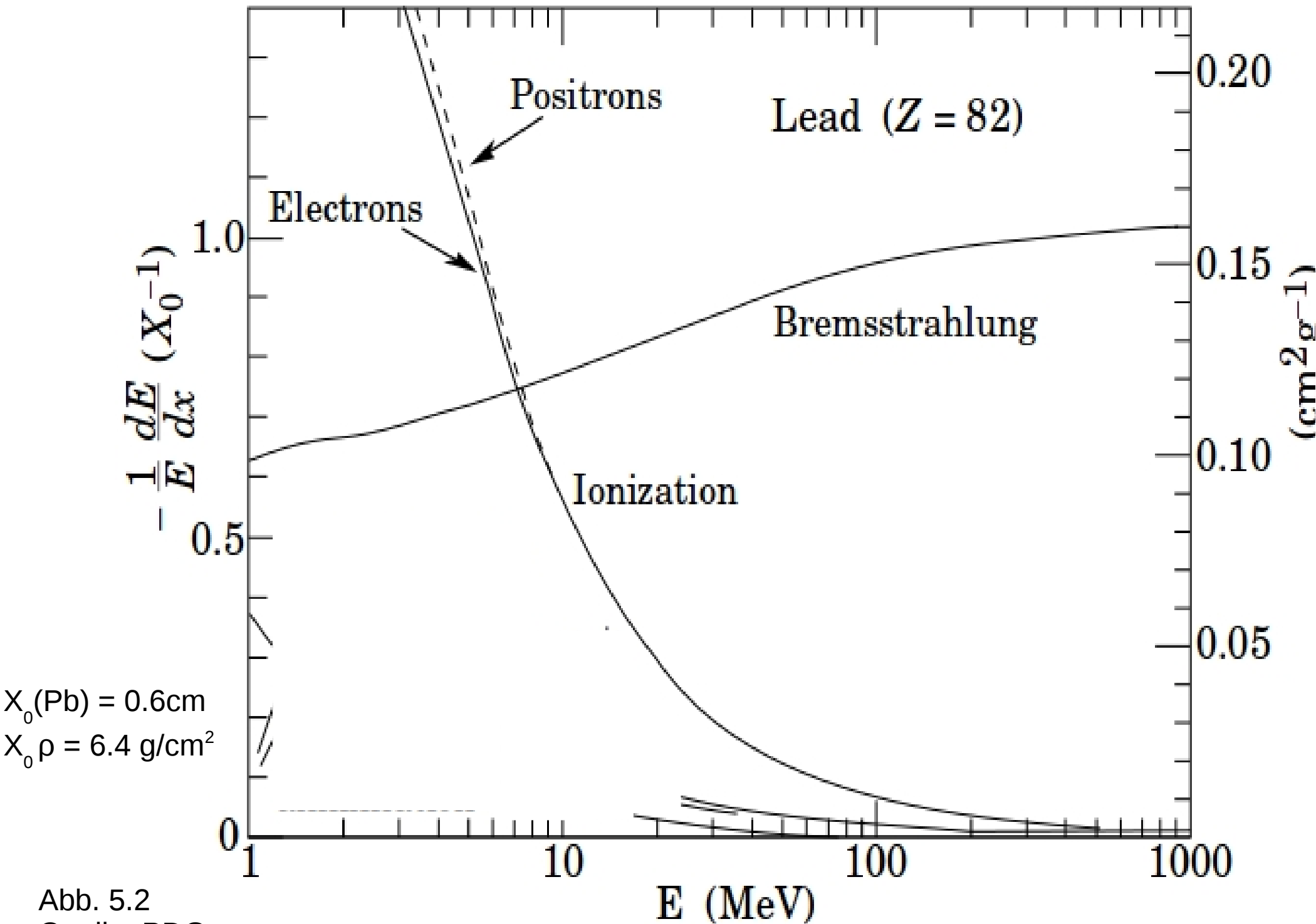


Abb. 5.2
 Quelle: PDG

Struktur entspricht der Energie der Elektronenschalen

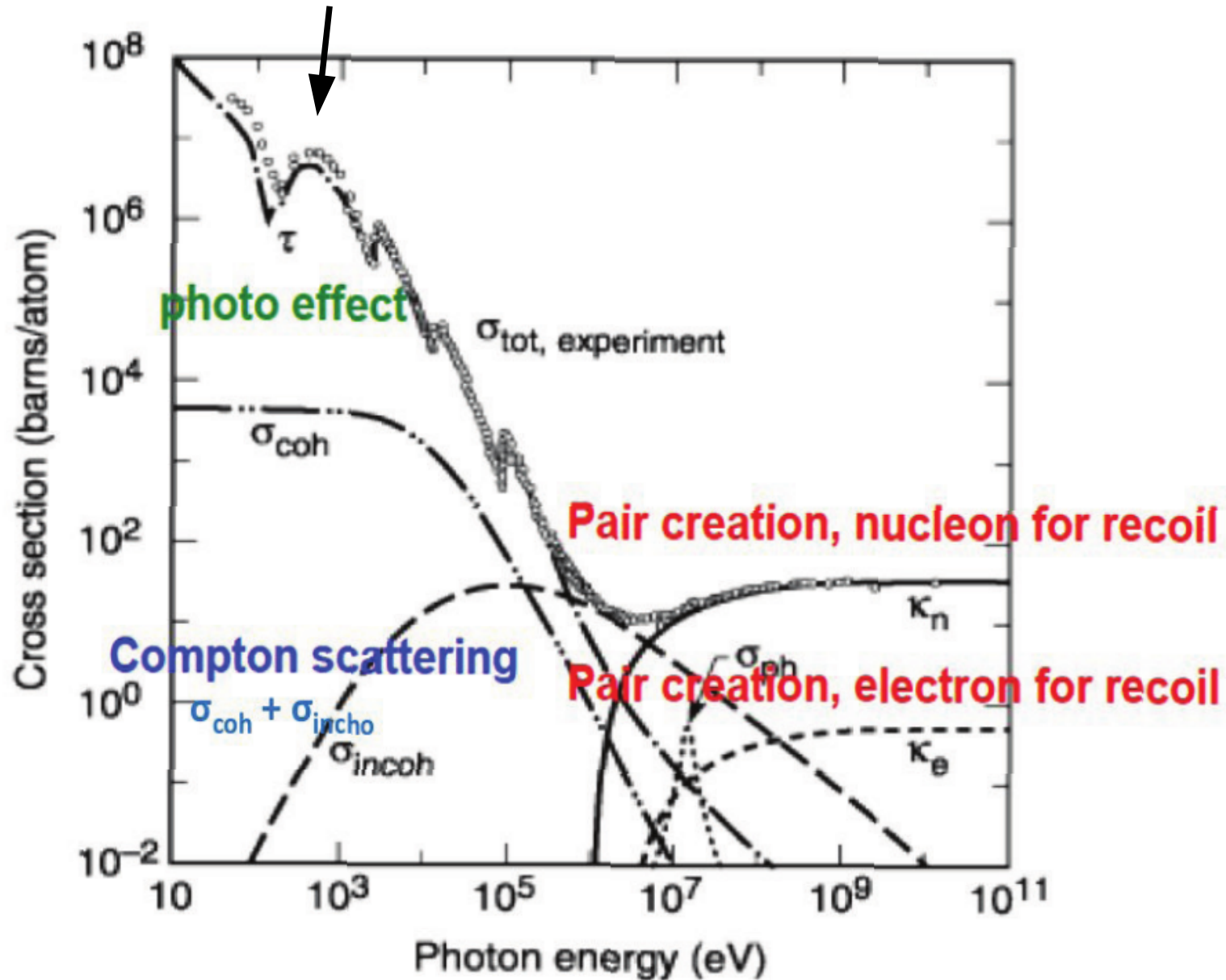
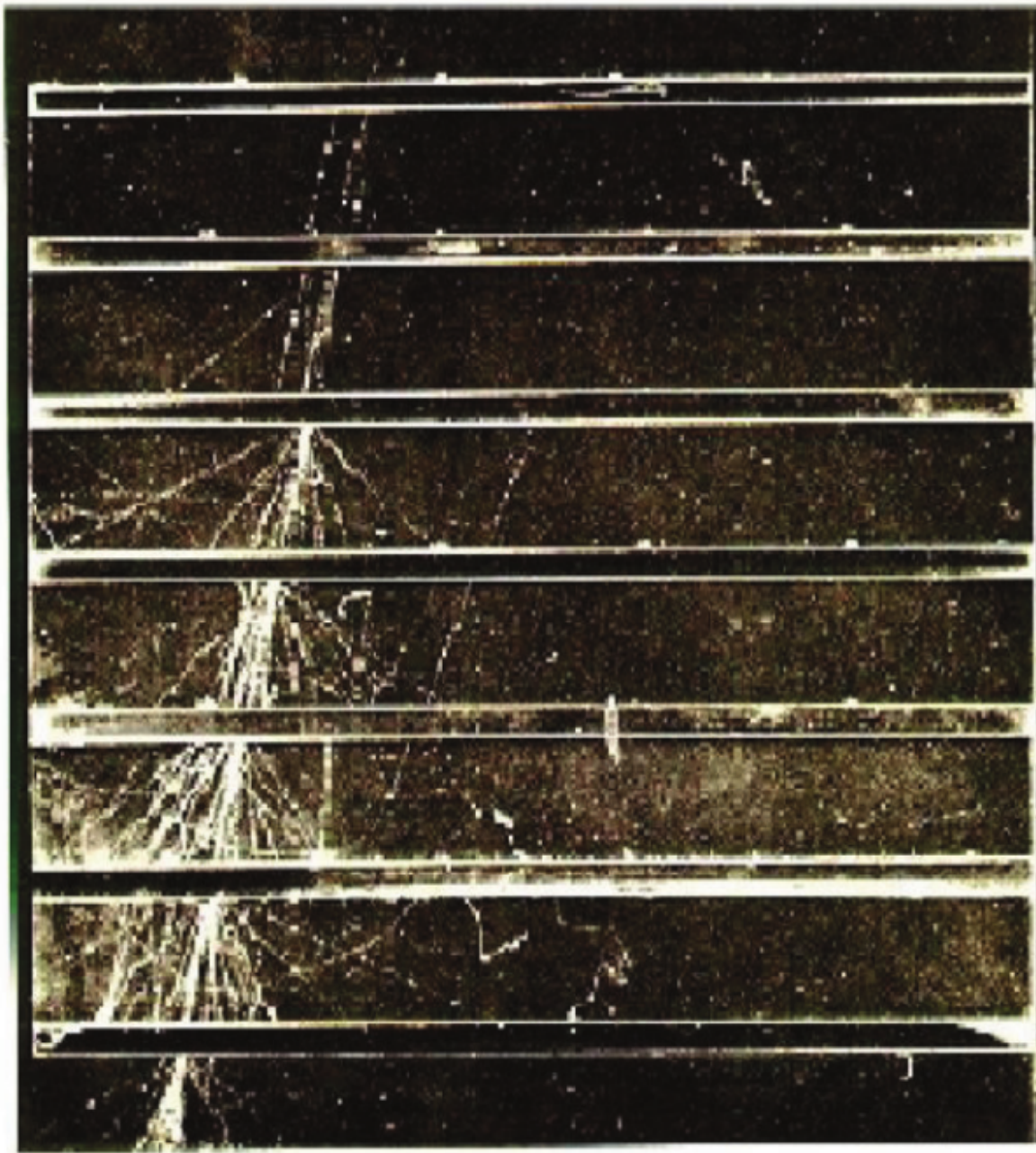


Abb 5.4



lead plates (cause shower)

liquid/gas to detect charged particles (cloud chamber)

Abb 5.3

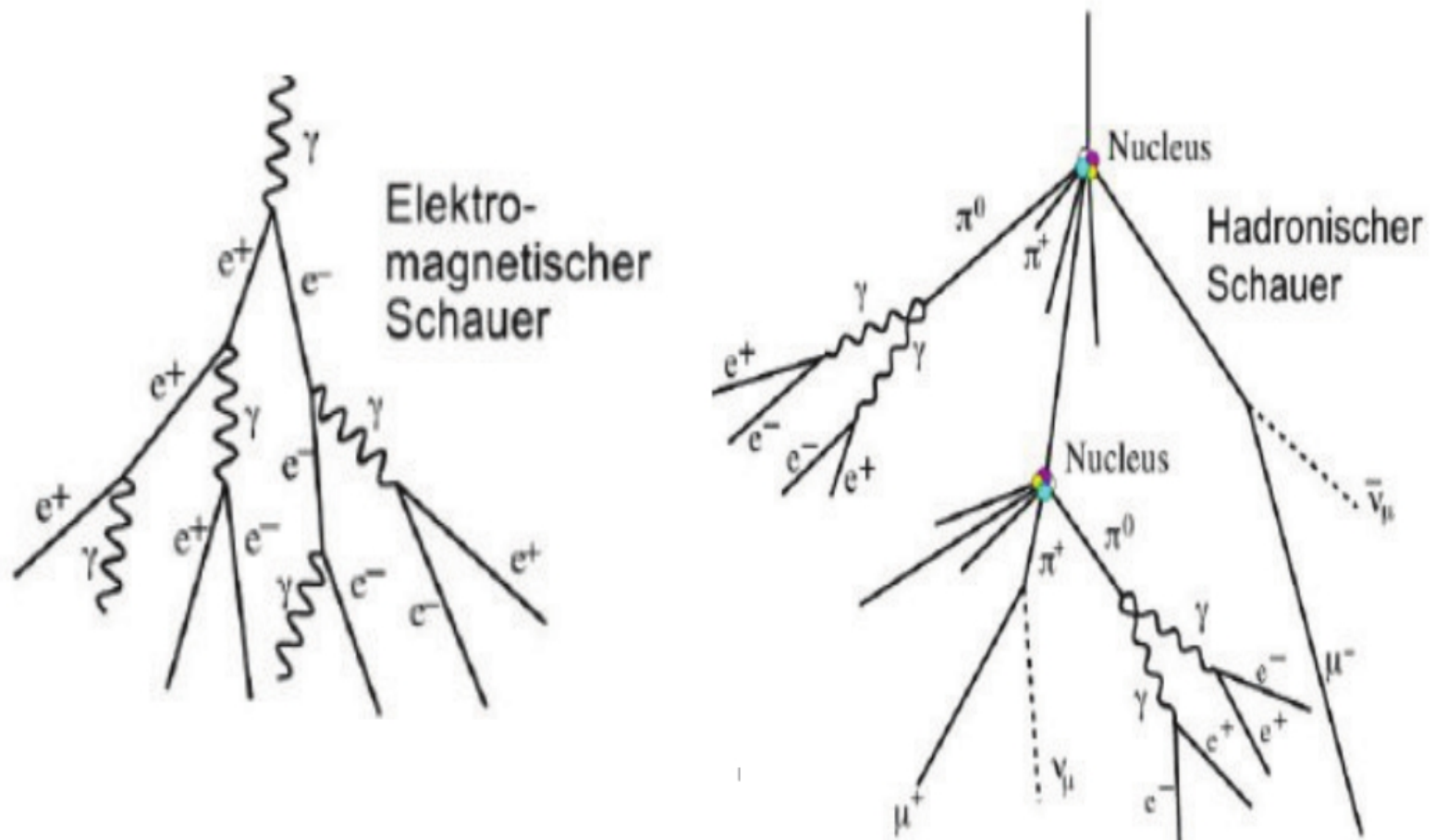
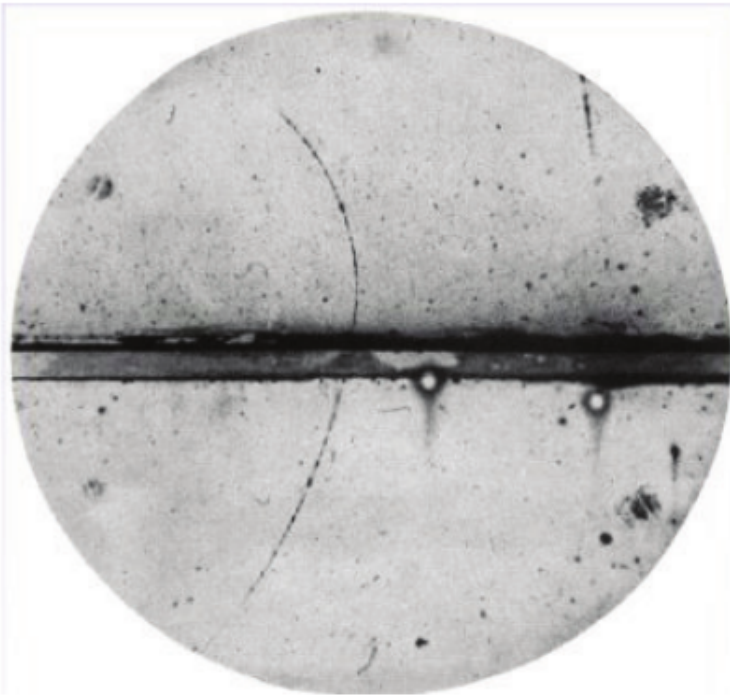


Abb 5.5

Ionisation im Detektorvolumen durch geladene Teilchen wird ausgenutzt um deren Spur (Position + Impuls) zu rekonstruieren

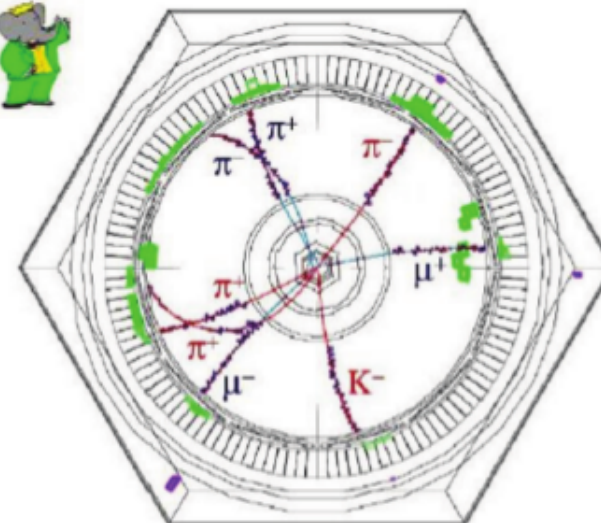
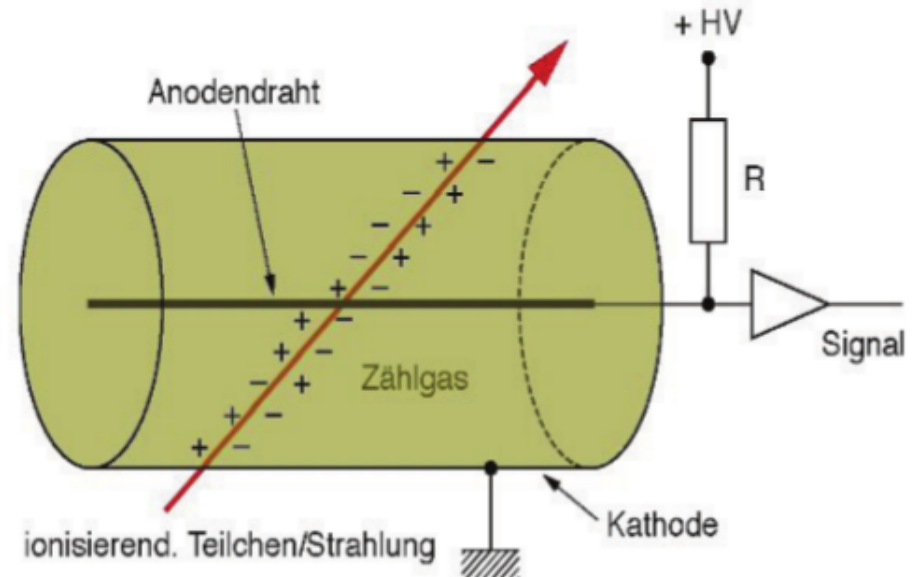
Beispiel: Nebelkammer:



Tröpfchenbildung an den Ionisationskernen entlang der Spur eines geladenen Teilchens

Abb 5.6

Beispiel: Gaselektronenmultiplikator



Spuren in der Babar Driftkammer

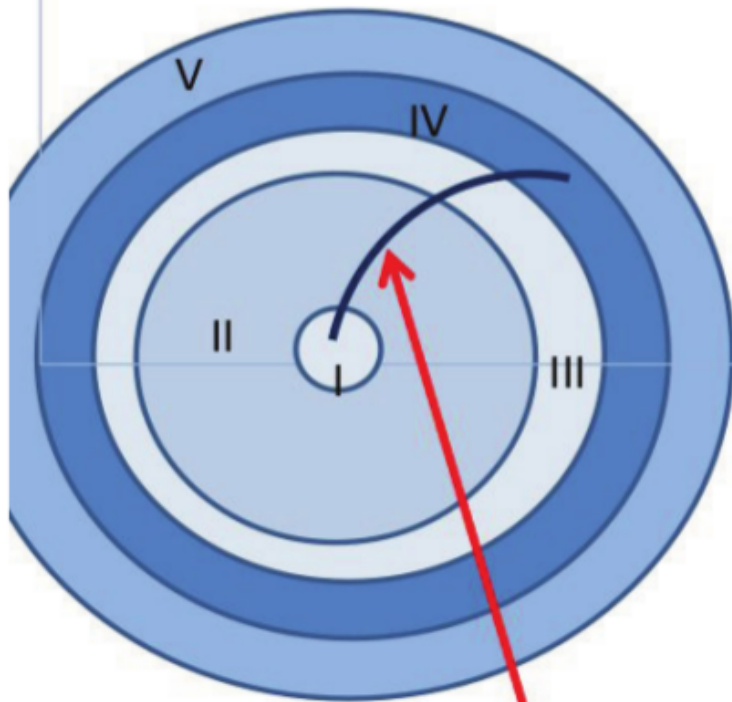
Standard Detector Layout

We like to measure: (x,y,z) , mass, charge, (p_x, p_y, p_z) , need combination of detectors

locate in homogenous B field (in z-direction)

onion-like shell structure

cylinders around collision point



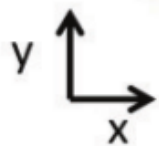
I - tracking detector : very precise position measurement (using ionisation)

II - tracking detector: momentum measurement long lever arm, to measure curvature of trajectory in magnetic field (using ionisation)

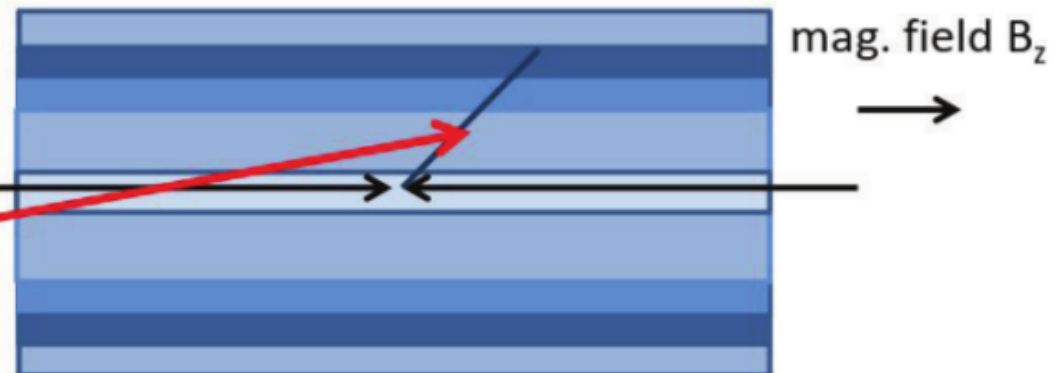
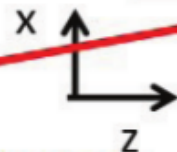
III - PID system – ToF, Cherenkov Detector

IV - elm, hadronic calorimeters

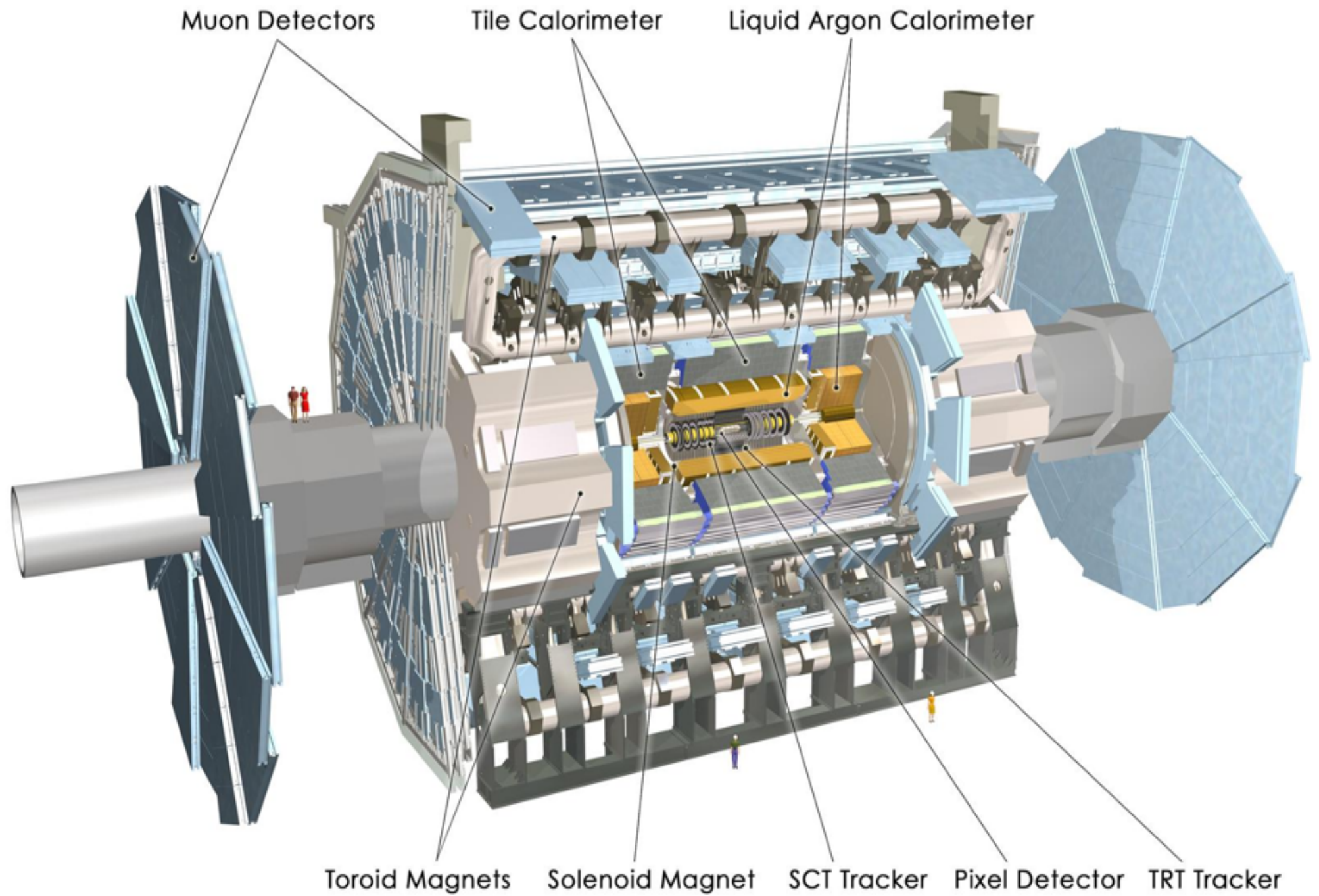
V - muon chambers



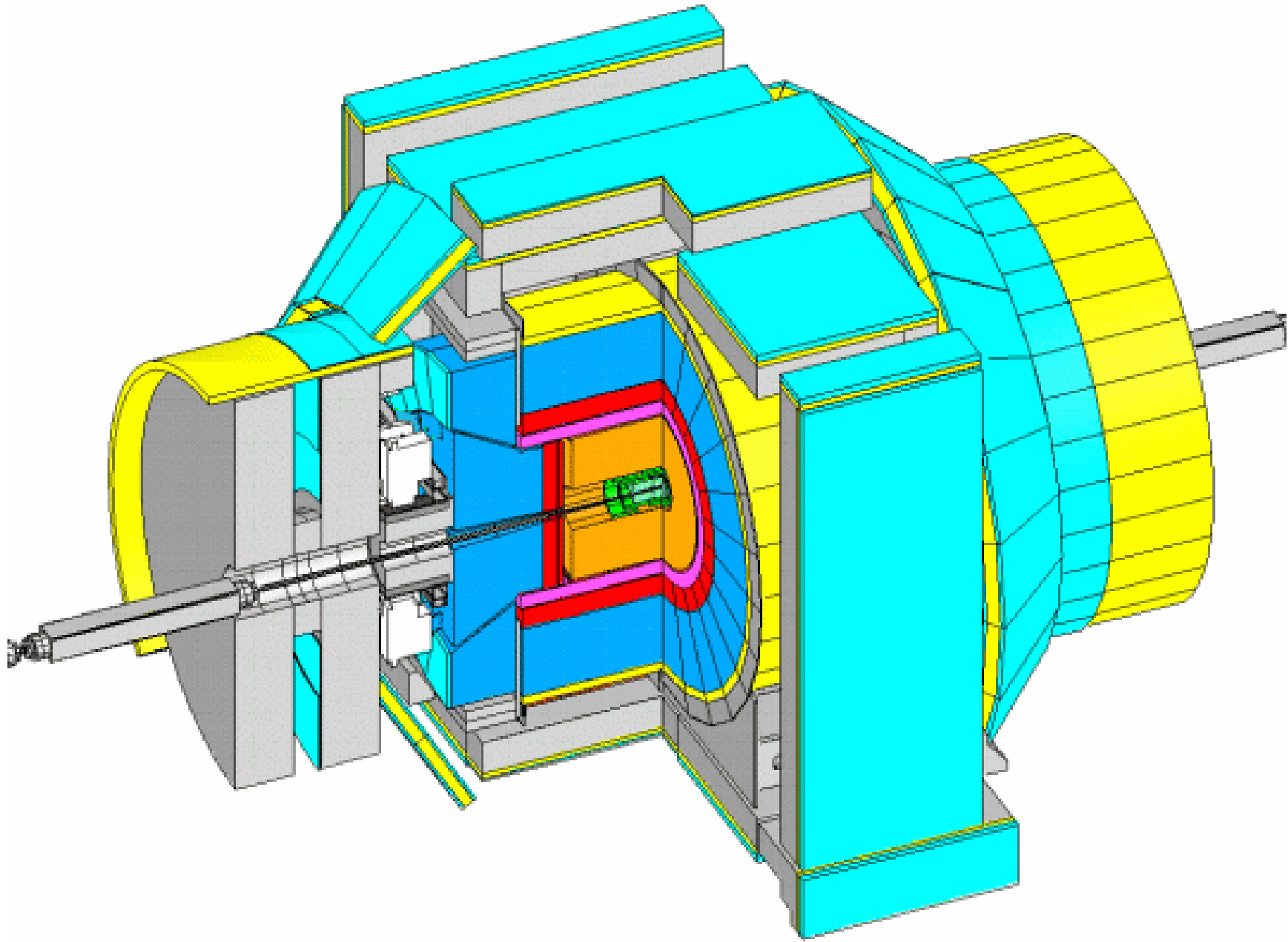
beam axis



one example of charged particle trajectory



ATLAS Detektor am LHC



CDF Detektor am Tevatron