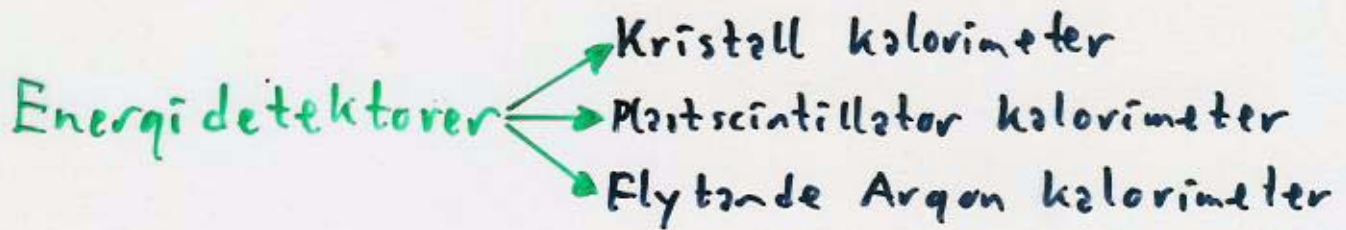
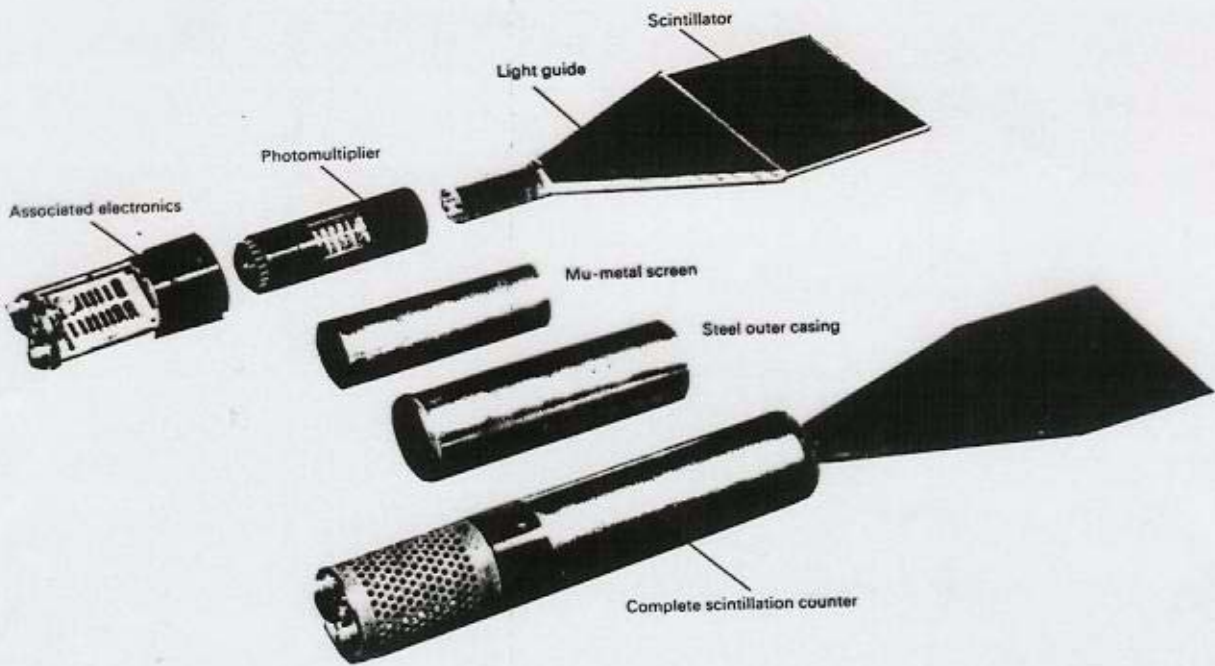


## Detektorer:

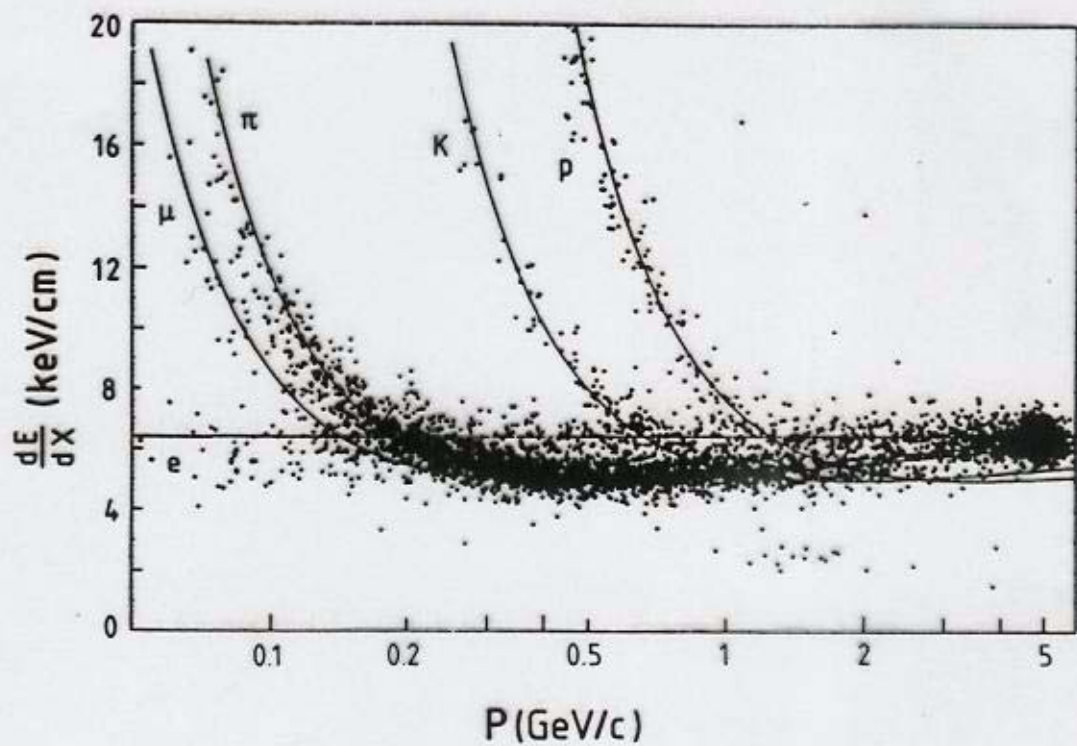


Tids detektorer → Plast scintillatorer

# Scintillations detector



$\frac{dE}{dx}$  - mätning med drittkammare



# Plan Driftkammer

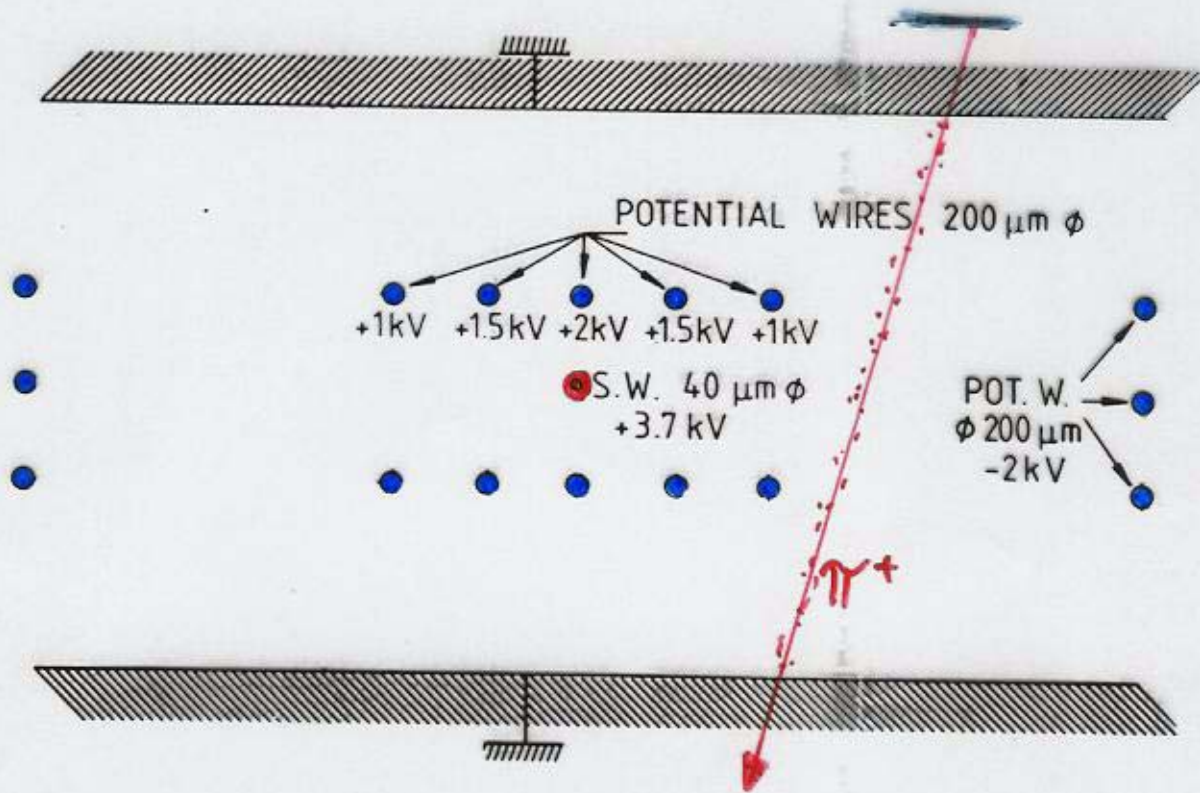
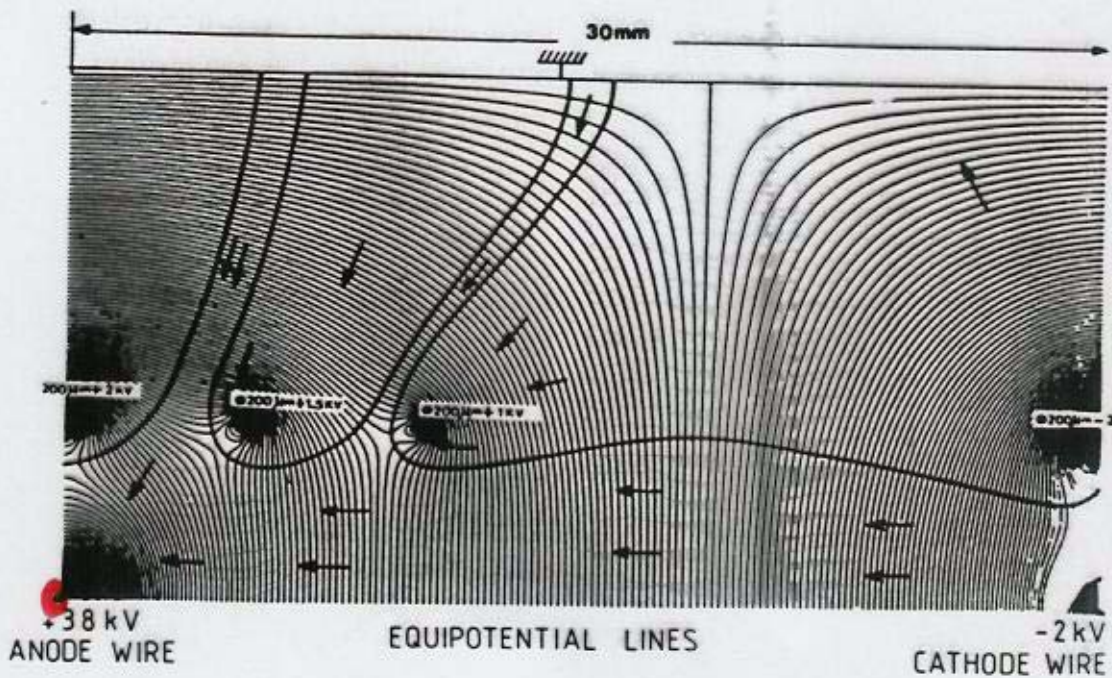


Fig. 3.9. Equipotential lines in one quadrant of the cell shown in fig. 3.8 [MA 77]. Curves are equipotential lines; arrows indicate drift direction of electrons.

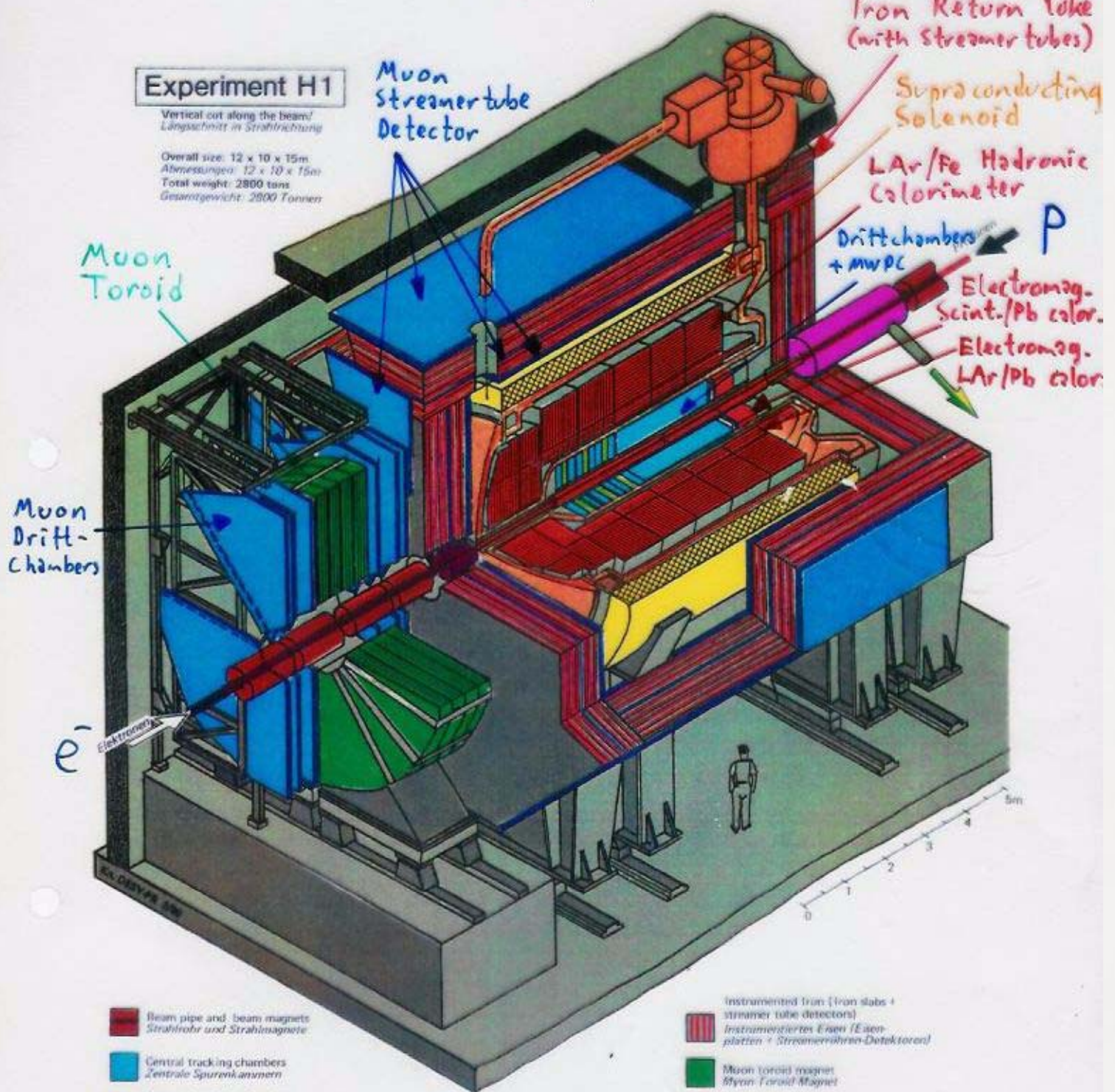


# H 1

## Experiment H1

Vertical cut along the beam/  
Längsschnitt in Strahlrichtung

Overall size: 12 x 10 x 15m  
Abmessungen: 12 x 10 x 15m  
Total weight: 2800 tons  
Gesamtgewicht: 2800 Tonnen



Beam pipe and beam magnets  
Strahlrohr und Strahlmagnete

Central tracking chambers  
Zentrale Spurenkammern

Forward tracking chambers  
and transition radiators  
Vorwärts-spurenkammern und  
Übergangstrahlungsmodul

Electromagnetic Calorimeter (lead)  
Elektromagnetisches Kalorimeter (Blei)

Hadronic Calorimeter (stainless steel)  
Hadronisches Kalorimeter (Edelstahl)

Superconducting coil (1.2 Tesla)  
Supraleitende Spule (1,2 Tesla)

Compensating magnet  
Kompensationsmagnet

Helium cryogenics  
Helium Kälteanlage

Muon chambers  
Myon-Kammern

Instrumented iron (iron slabs +  
streamer tube detectors)  
Instrumentiertes Eisen (Eisen-  
platten + Streamerröhren-Detektoren)

Muon toroid magnet  
Myon-Toroid-Magnet

Warm electromagnetic calorimeter  
Warmes elektromagnetisches  
Kalorimeter

Plug calorimeter (Cu, Si)  
Vorwärts-Kalorimeter

Concrete shielding  
Betonabschirmung

Liquid Argon cryostat  
Flüssig Argon Kryostat

Muon  
Toroid

Muon  
Drift-  
Chambers

$e^-$   
Elektronen

Muon  
Streamer tube  
Detector

Iron Return Yoke  
(with streamer tubes)

Supraconducting  
Solenoid

LAr/Fe Hadronic  
Calorimeter

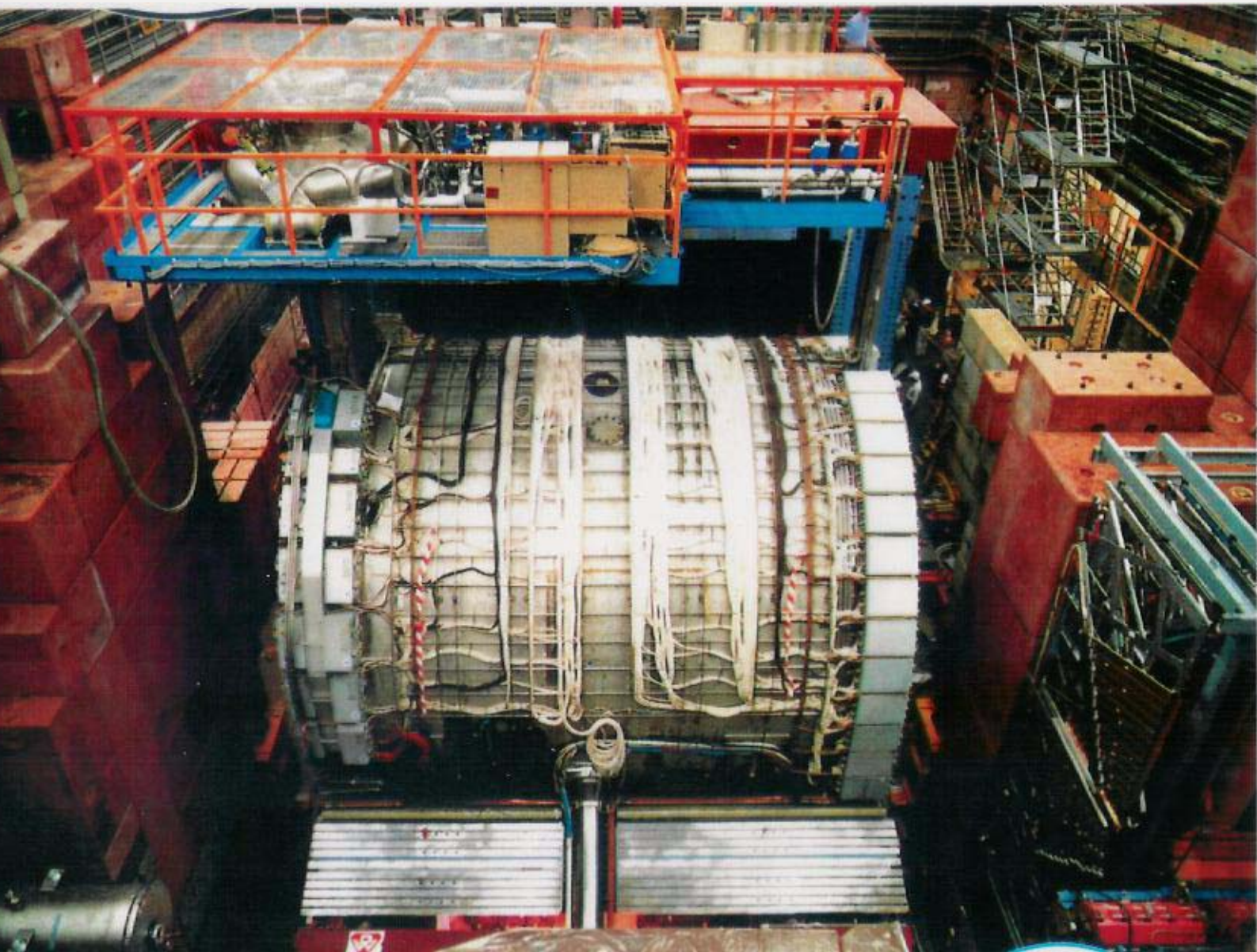
Drift chambers  
+ MWPC

Electromag.  
Scint./Pb calor.

Electromag.  
LAr/Pb calor.

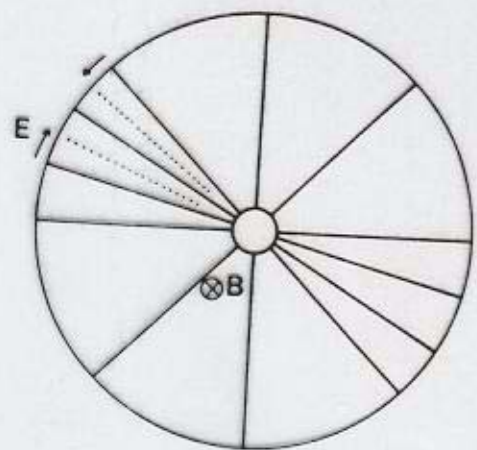
P







# Cylindrisk Driftkammer

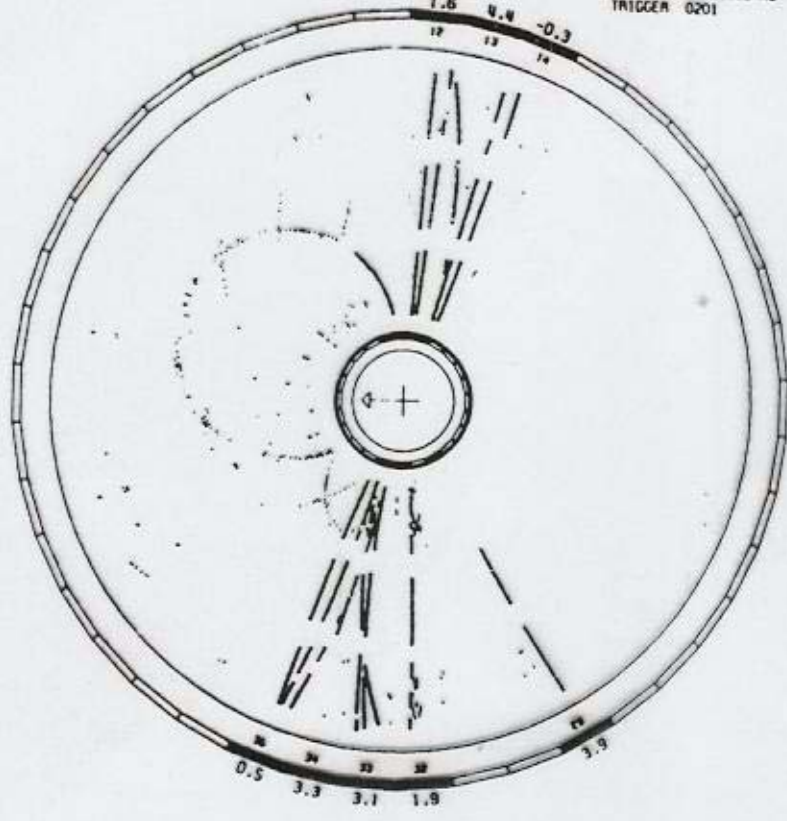


OSN F22EL5.TPW030  
 1344 2154 34  
 IDHETS 704  
 ELGTOT 12059  
 NUMETS 0  
 LGCTL 12059  
 LOGAPS 0 0  
 FUCAPS 0 0

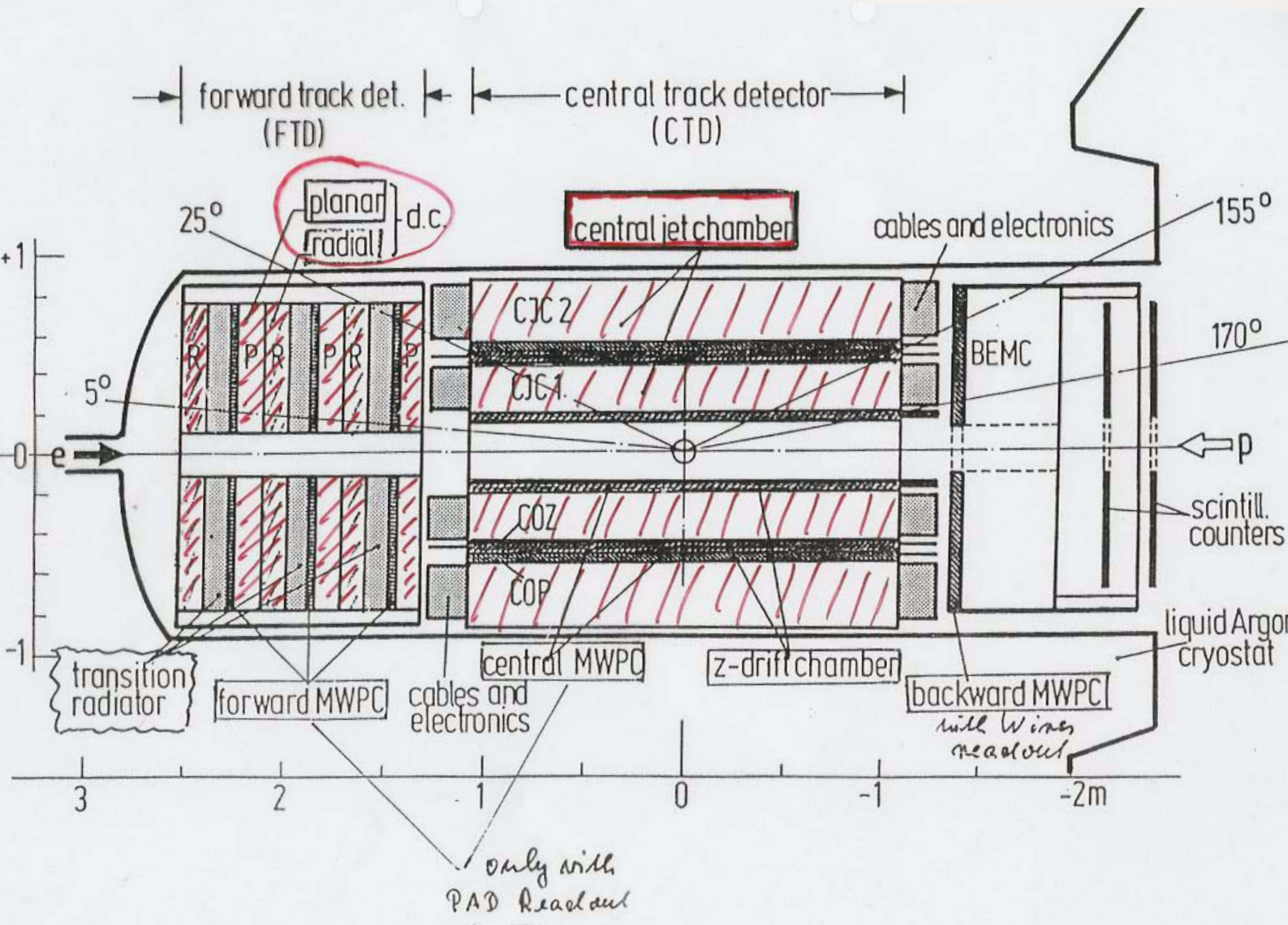
JADE R-F1 SECTION

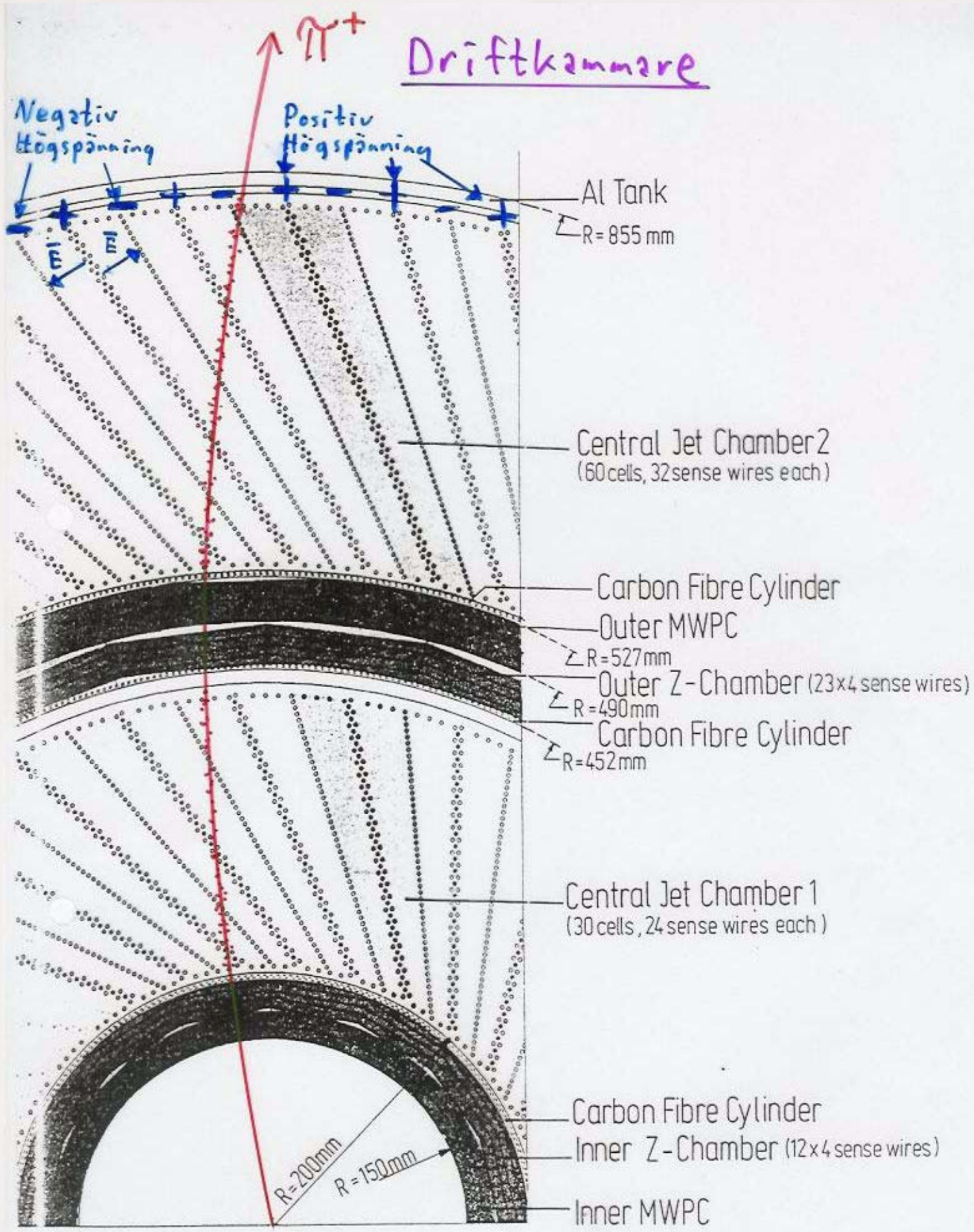
BEAM 15.000 GEV  
 1.6 4.4 -0.3  
 MAG.FIELD -4.532 MG  
 TRIGGER 0201

DATE 30/03/80  
 TIME 12.28.16



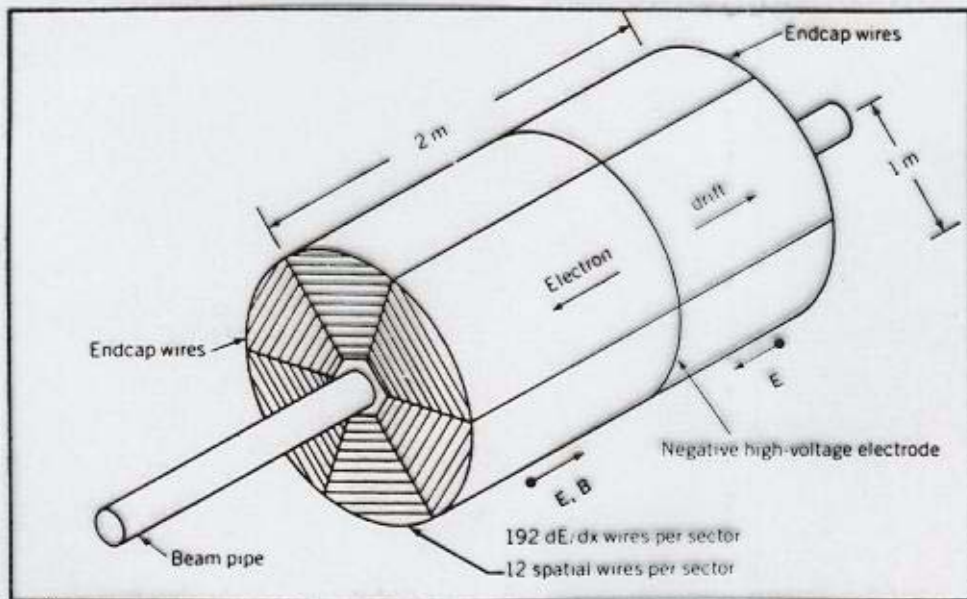
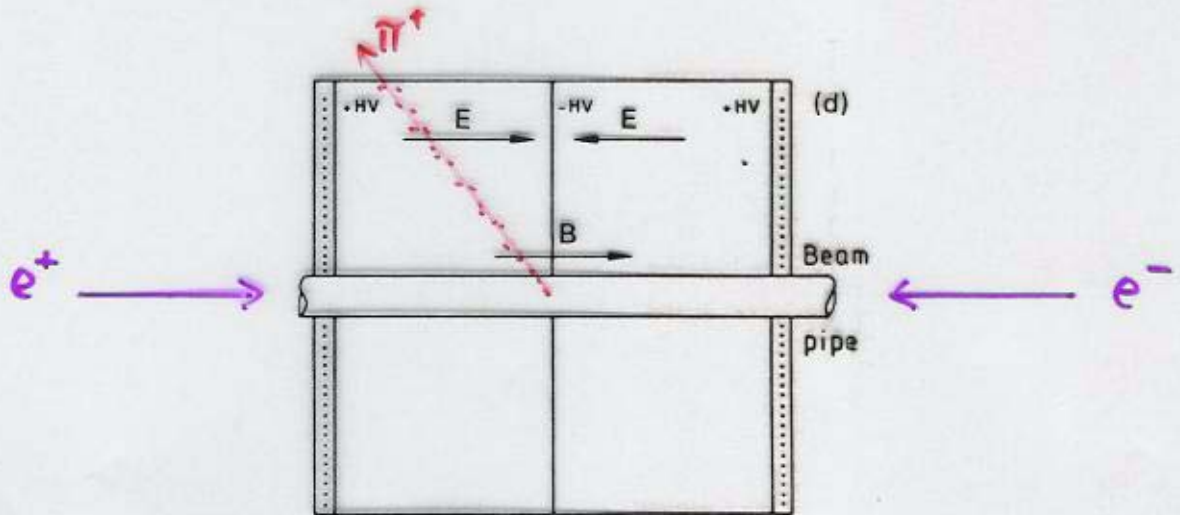






H1 Central Tracking Detectors

# Time Projection Chamber



# Multiwire Proportional Chamber

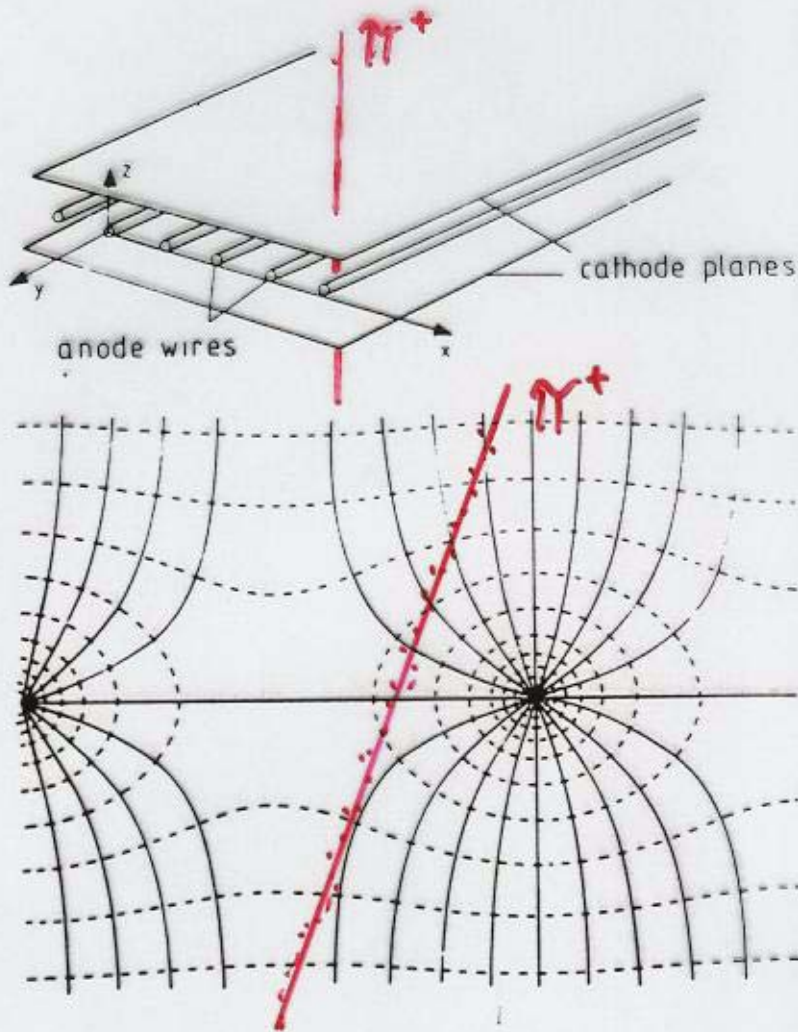
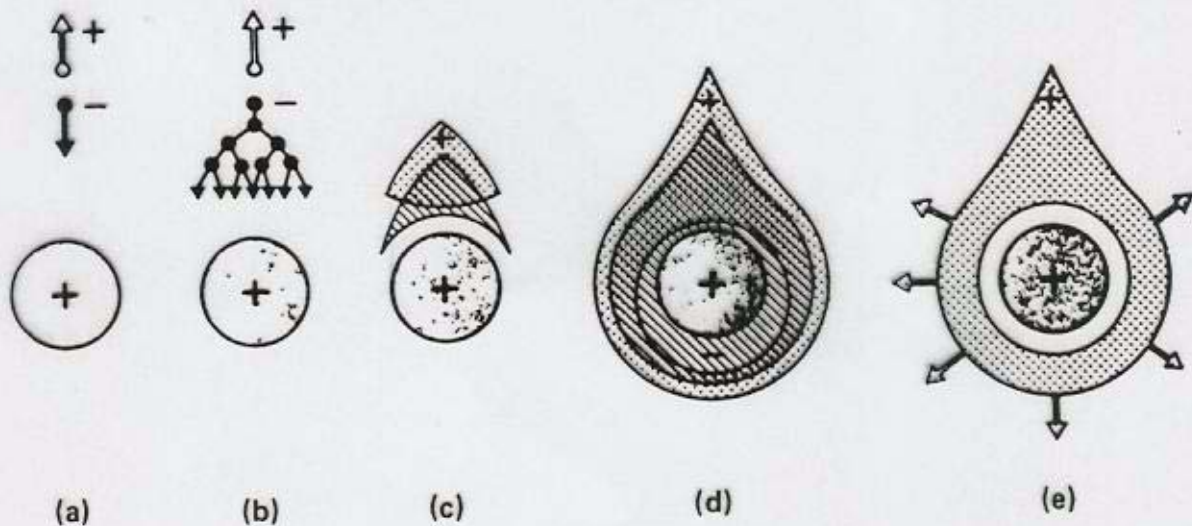
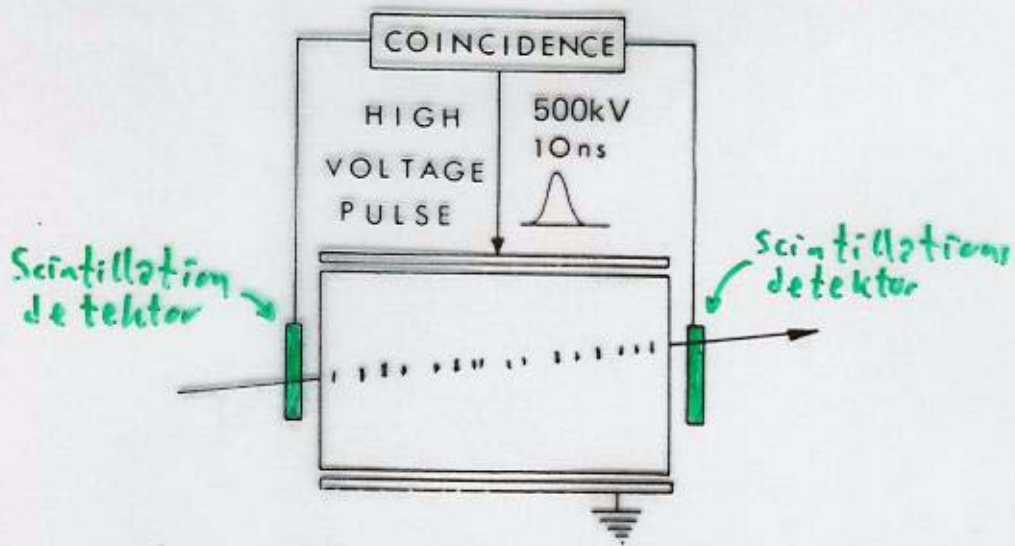


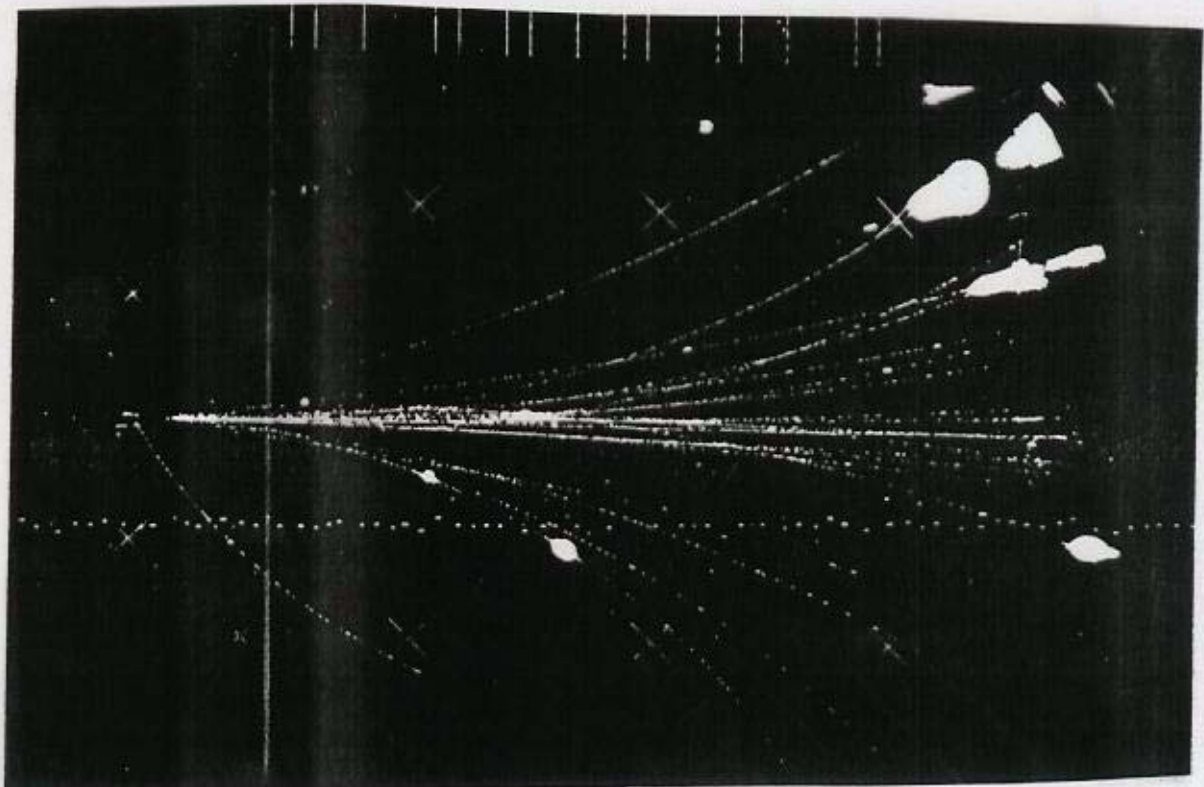
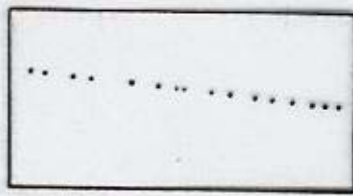
Fig. 3.2. Time development of an avalanche near to an anode wire in a proportional chamber. (a) Primary electron moving towards anode. (b) The electron gains kinetic energy in the electric field and ionizes further atoms; multiplication starts. (c) The electron and ion clouds drift apart. (d), (e) The electron cloud drifts towards the wire and surrounds it; the ion cloud withdraws radially from the wire [CH 72].



# Streamer Chamber



VIEW NORMAL TO E-FIELD



## Cherenkov Ljus

Process: När en laddad partikel rör sig med en hastighet  $\beta$  genom ett medium med brytningsindex  $n$  kan de atomer som exciteras av partikeln utsända Cherenkov ljus om

$$\beta > \frac{1}{n}$$

Tvärsnitt: Stort

Energiförlust: Försumbar

Övrigt: Cherenkov ljus utsänds med en karakteristisk vinkel  $\theta$  mot partikelns riktning. Det gäller att

$$\cos \theta = \frac{1}{\beta n}$$

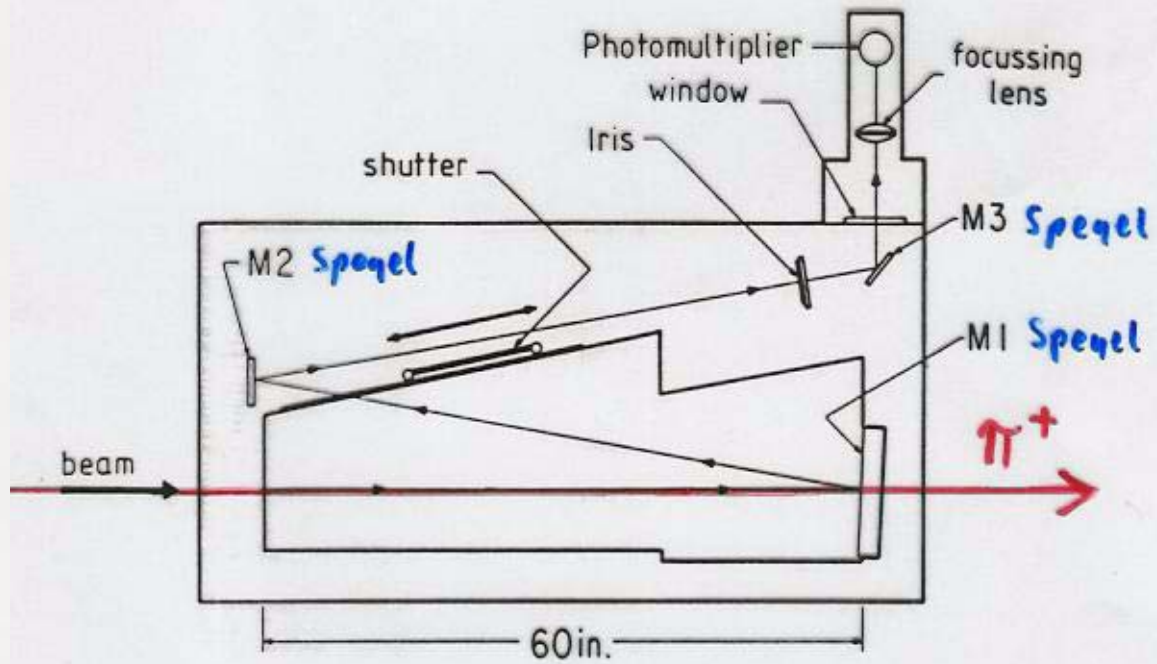
Genom att mäta  $\theta$  kan man alltså bestämma  $\beta$ .

Detektorer:

Threshold Cherenkov  $\rightarrow$  Partikel identifiering

Ring Image Cherenkov  $\rightarrow$  Mätning av  $\beta$

# Threshold Cherenkov Detector



## Exempel:

En pion och en proton med energin 2 GeV passerar igenom en Cherenkov detektor.

Kommer partiklarna att registreras av detektorn om gasen i detektorn har brytningsindex  $n=1.05$ ?

$$\begin{cases} E = \gamma m \\ \gamma = \frac{1}{\sqrt{1-\beta^2}} \end{cases} \Rightarrow \frac{E}{m} = \frac{1}{\sqrt{1-\beta^2}} \Rightarrow \beta = \sqrt{1 - \left(\frac{m}{E}\right)^2}$$

$$m_{\pi} = 0.14 \text{ GeV} \quad \Rightarrow \quad \beta_{\pi} = 0.998$$

$$m_p = 0.94 \text{ GeV} \quad \Rightarrow \quad \beta_p = 0.88$$

Villkoret för Cherenkov strålning är  $\beta > \frac{1}{n}$  dvs

$$\beta > \frac{1}{1.05} = 0.95 \text{ ger signal i detektorn}$$

Svar:  $\begin{cases} \text{Pionen registreras.} \\ \text{Protonen registreras ej.} \end{cases}$



# Övergångsstrålning (Transition Radiation)

**Process:** När en partikel passerar igenom en gränssyta mellan två ämnen med olika dielektrisk karakteristisk kan övergångsstrålning bildas. Intensiteten på denna strålning beror på partikelns energi dvs  $\gamma$  (ty  $E = \gamma m$ ).

**Tjörnsnitt:** Stort

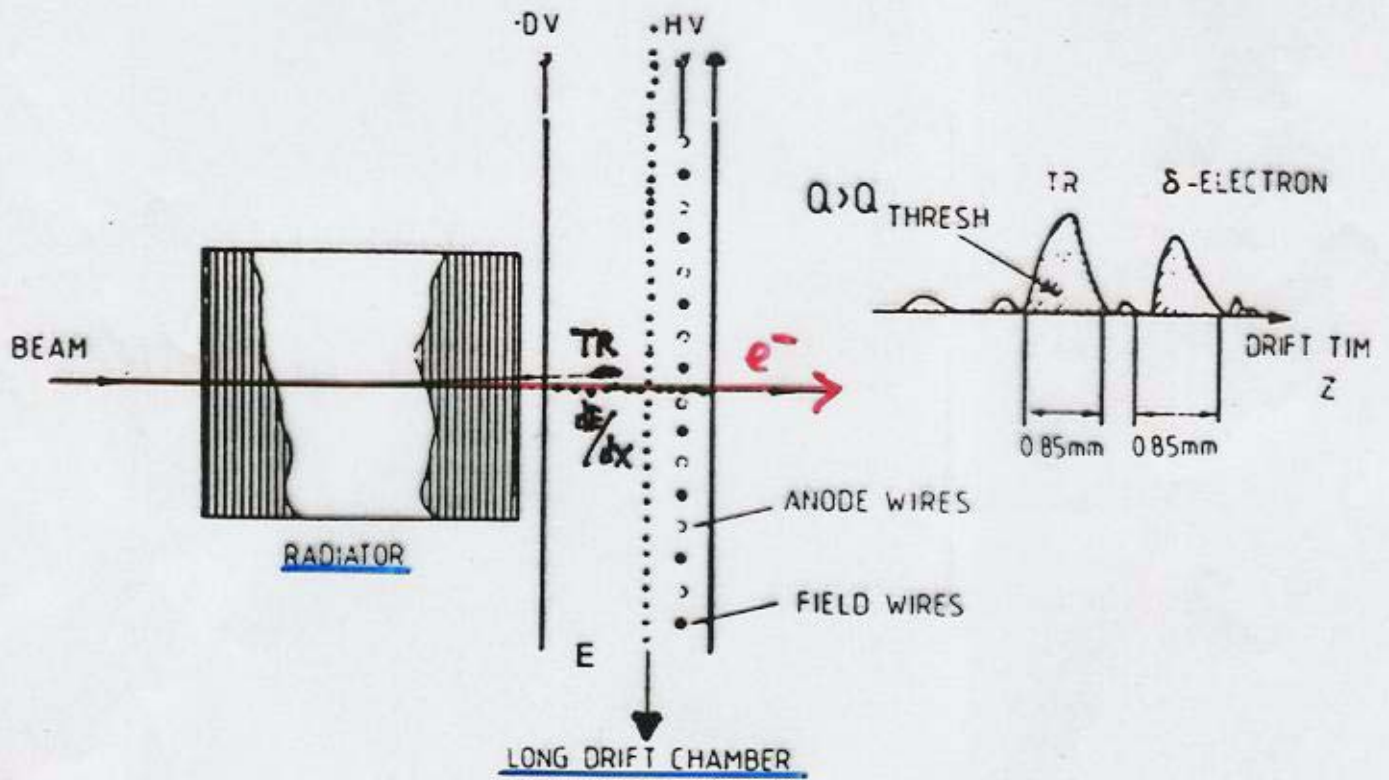
**Energiförlust:** Försumbar

**Övrigt:** Övergångsstrålning är Röntgenstrålning.

**Detektorer:**

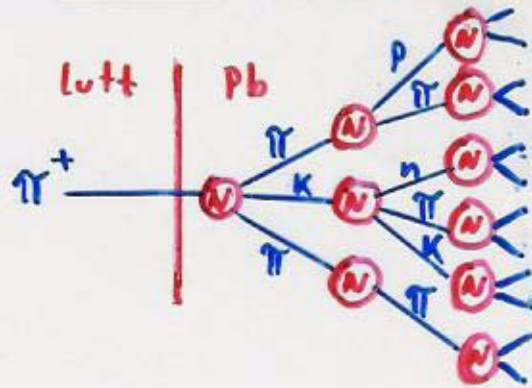
Transition Radiation Detector → Partikel  
Identifiering  
(främst e)

# Transition Radiation Detector



# Stark växelverkan

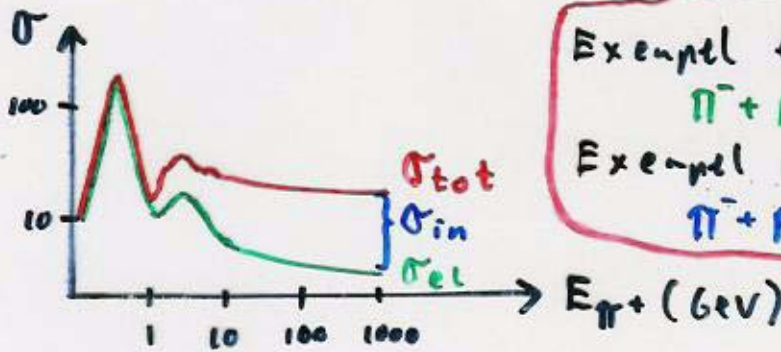
Process:



Om energin på den inkommande hadronen är tillräckligt hög kan man få en kedjereaktion av inelastiska kollisioner en så kallad "Hadronic shower".

"Hadronic shower"

Tvärsnitt:



Exempel elastic scattering:



Exempel inelastic scattering:



$$\sigma_{tot} = \sigma_{in} + \sigma_{el}$$

Energiförlust: Eftersom den inkommande partikeln förstörs kan man säga att den förlorar all sin energi.

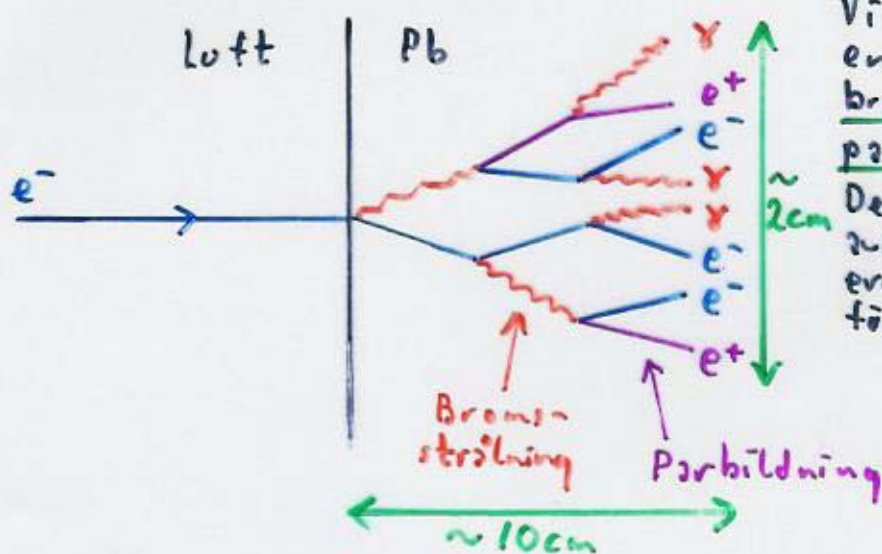
Detektorer:

Hadronisk kalorimeter → Mäter hadroners energi

# Vad är en kalorimeter?

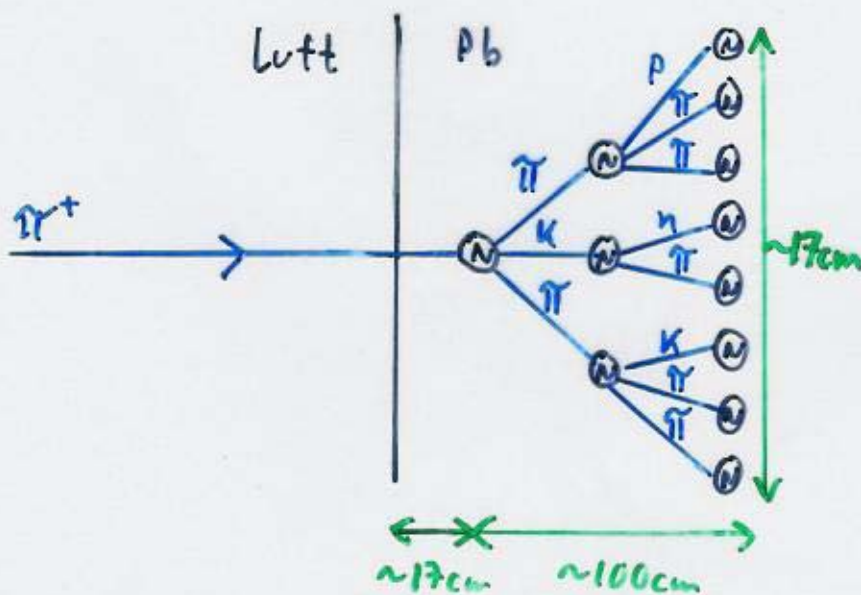
Svar: En detektor som mäter en partikels energi men som samtidigt förstår partikeln.

## Elektromagnetisk skur:



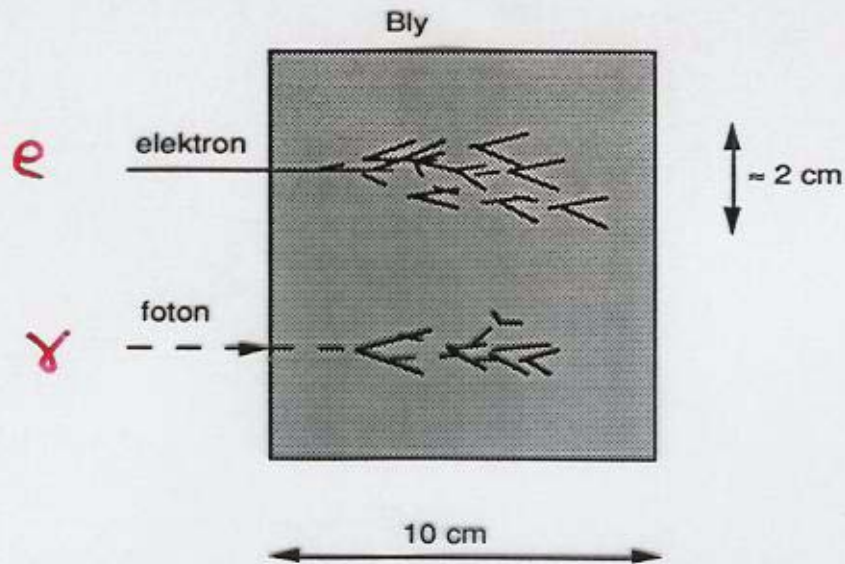
Vid höga energier kan en kedjereaktion av bromsstrålning och parbildning uppstå. Denna kedjereaktion avstannar när elektronernas energi blivit för låg.

## Hadronisk skur:

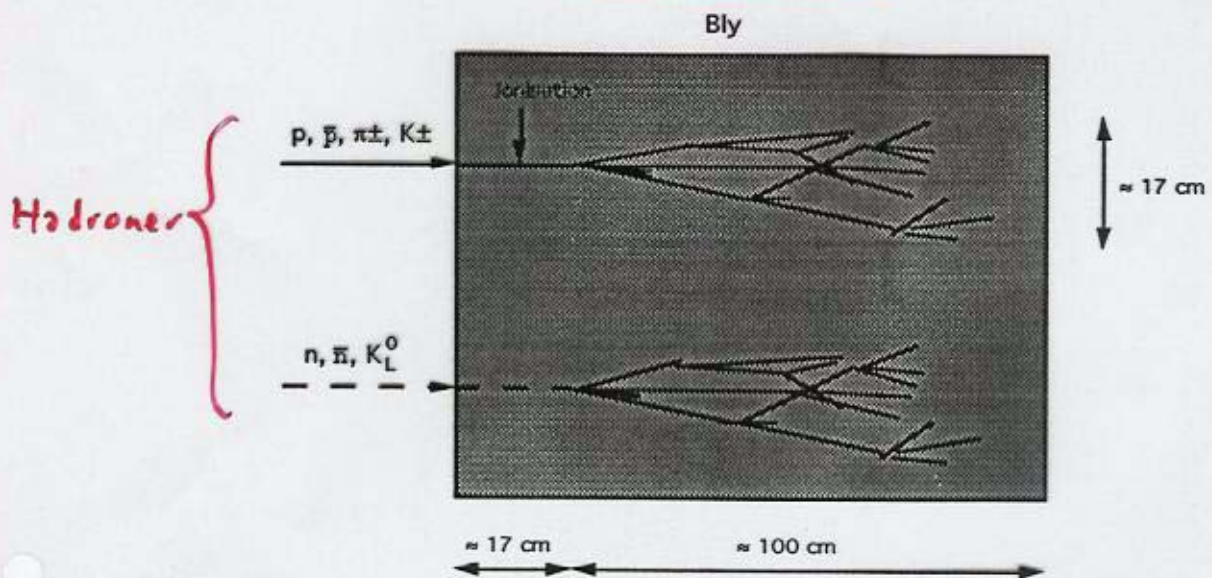


Vid höga energier kan en kedjereaktion av hadron-nukleon kollisioner äga rum. Kedjereaktionen avstannar när hadronernas energi blir för liten.

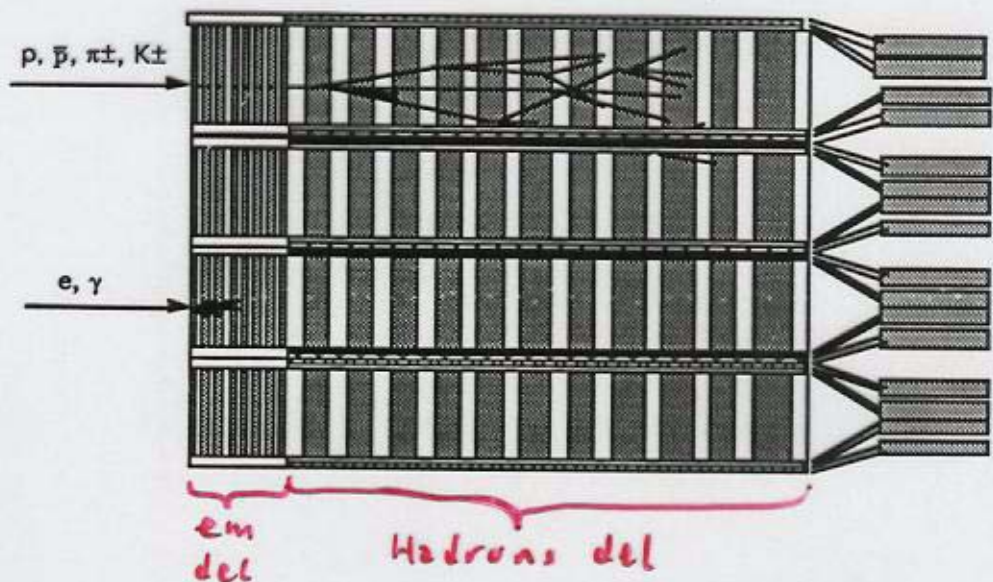
## Elektromagnetisk skur



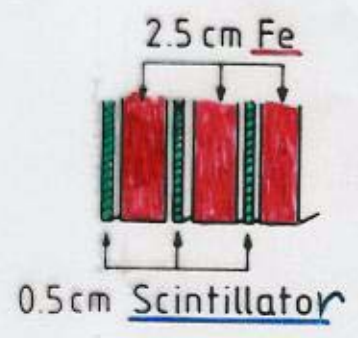
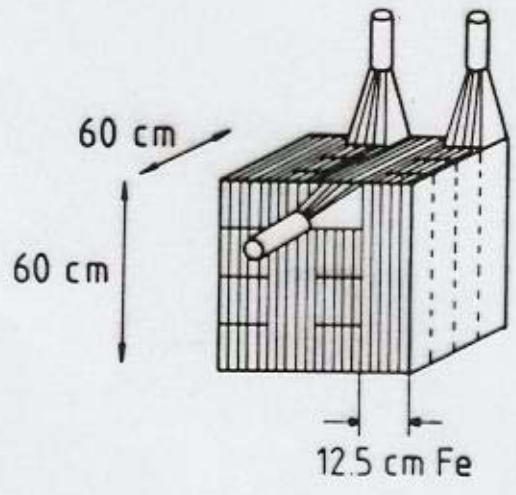
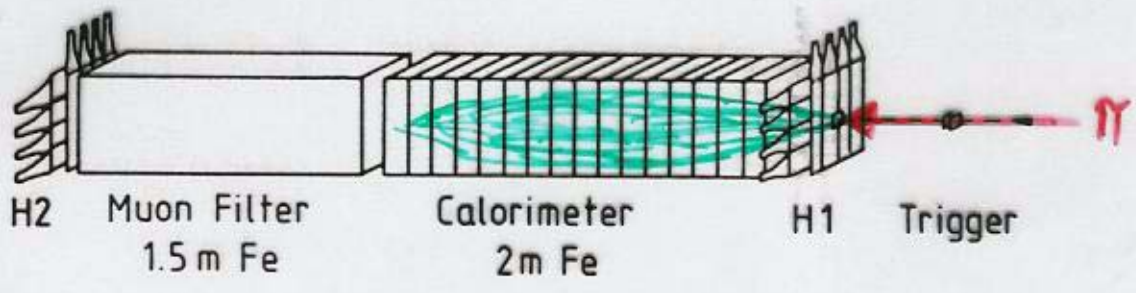
## Hadronisk skur



## Kalorimeter

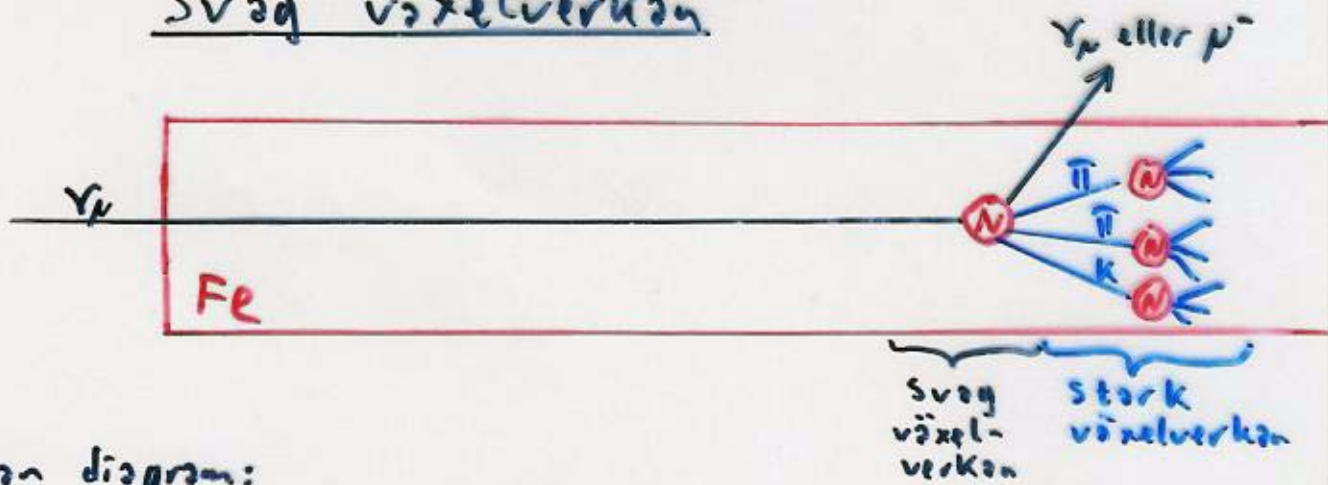


# Kalorimeter

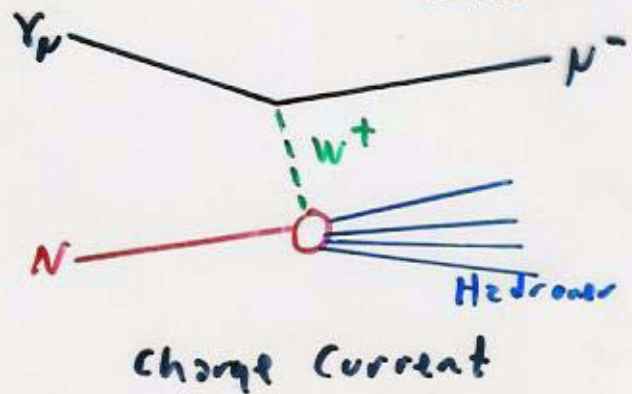
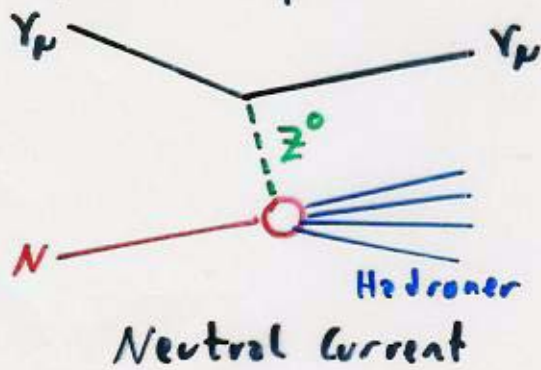


# Svag växelverkan

Process:



Feynman diagram:



Tvärsnitt: **Mycket litet.**

Exempel: 
$$\begin{cases} \sigma_{\nu N} \approx 20 \text{ mb} & \text{om } E_p = 100 \text{ GeV} \\ \sigma_{\nu N} \approx 10^{-9} \text{ mb} & \text{om } E_\nu = 100 \text{ GeV} \end{cases}$$

Energi förlust: **Varierar mycket från kollision till kollision.**

Detektorer:

Neutrino detektorer

# Neutrino detektor

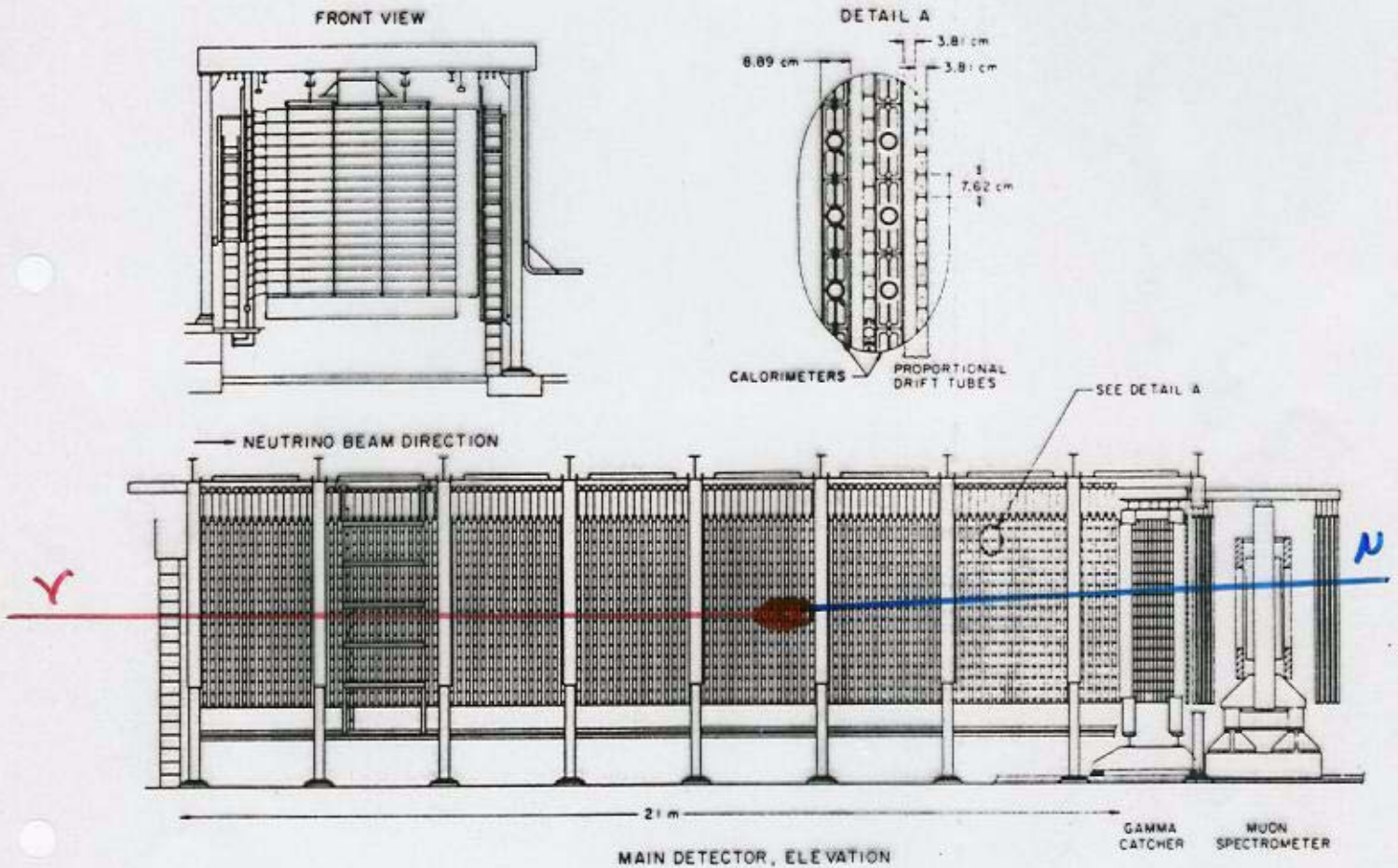


FIGURE 6.8 A neutrino detector at the AGS proton accelerator at Brookhaven. This 175-ton detector is composed of 112 identical modules, each containing a vertical array of scintillator cells and measuring planes of proportional drift tubes, followed by a shower counter and a magnetic spectrometer. It is used to measure the elastic scattering of neutrinos and antineutrinos on electrons and protons and to search for neutrino oscillations.