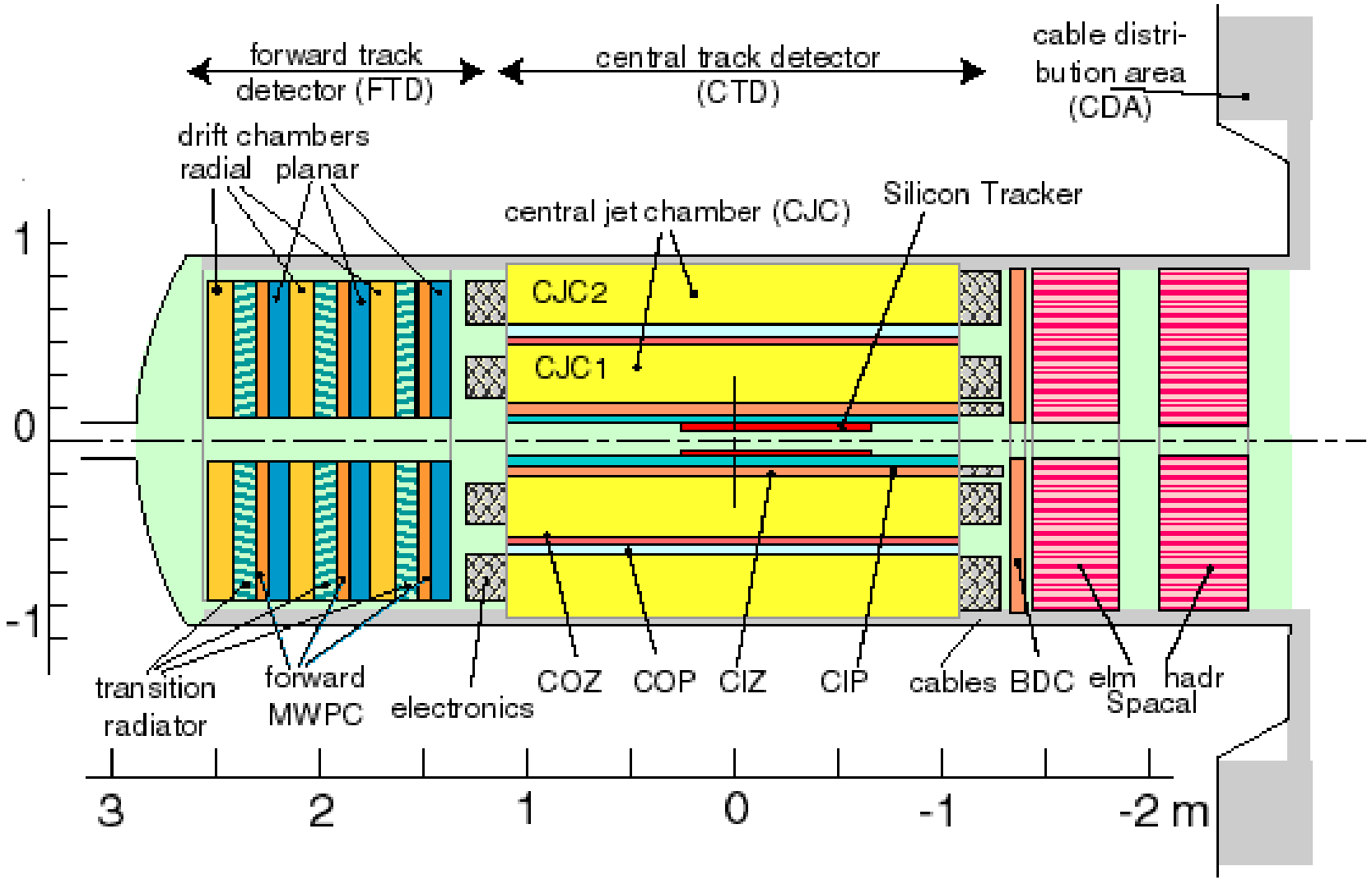
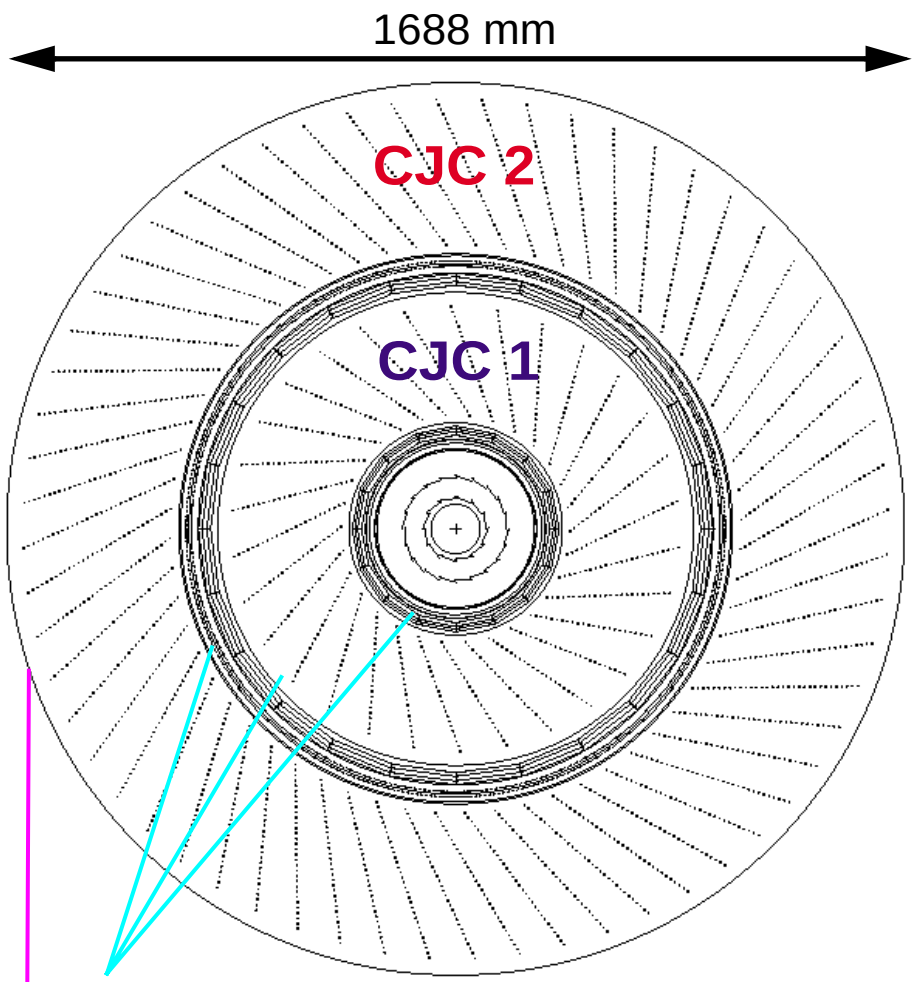
Aging Effects in the Central Jet Chamber of H1

- Introduction to H1 Tracking System
- 1) Corrosive Damage of Wires
- 2) Aging due to Sense Wire Deposits
- 3) Malter Effect on Cathode Wires

H1 Tracking System



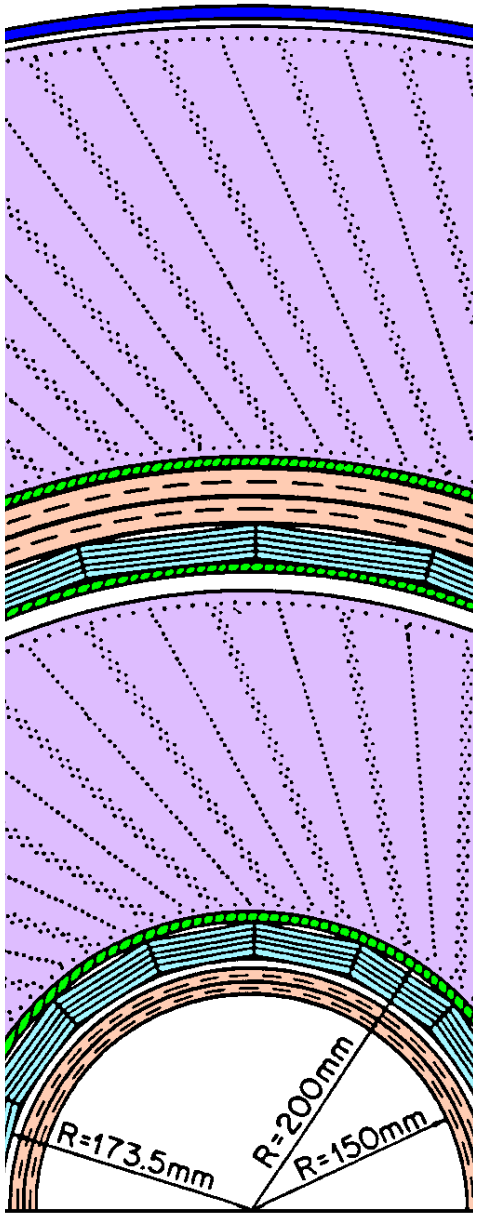
CJC Parameters

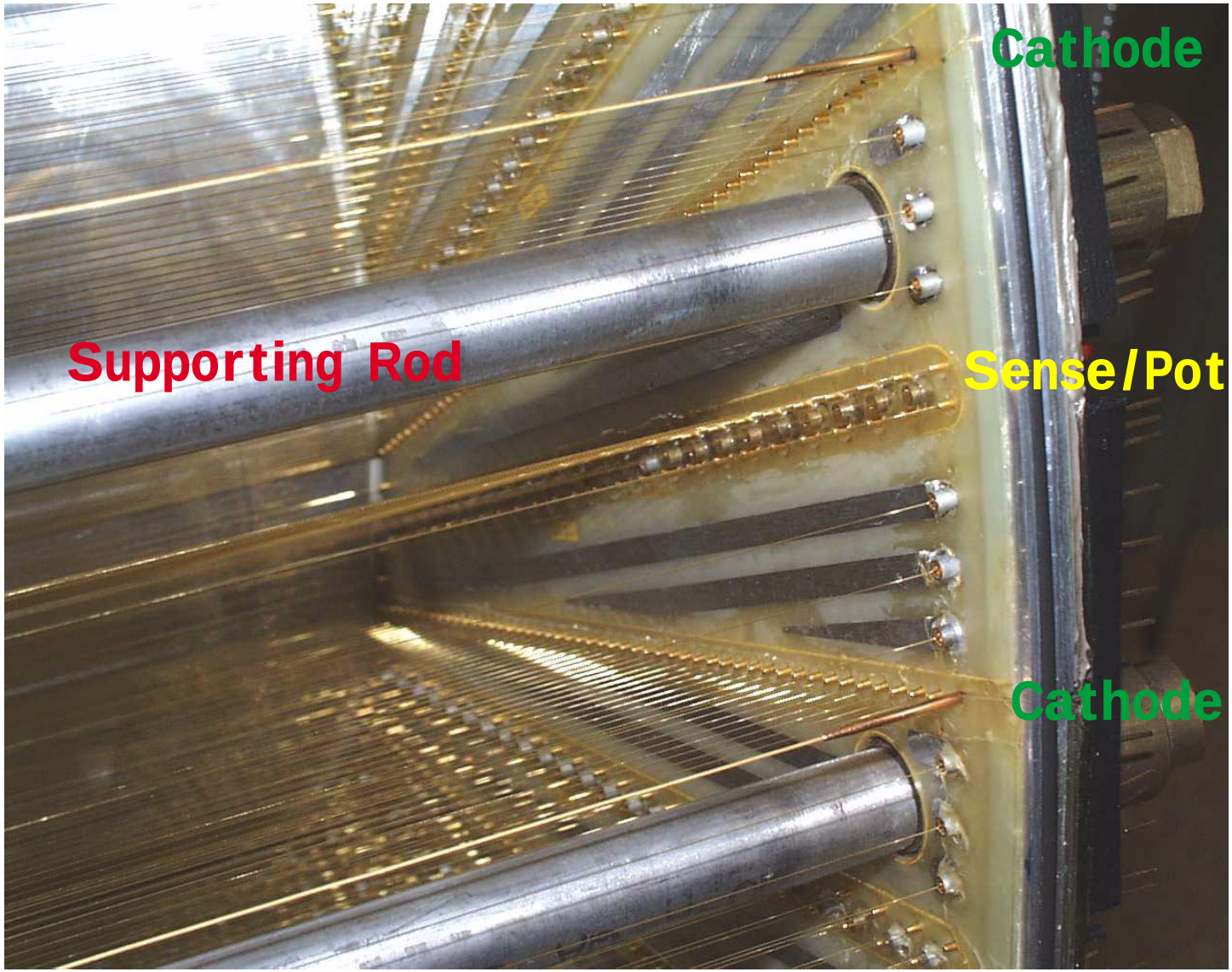


- 1.5 mm carbon fibre reinforced epoxy + 50 µm Al coating
- 4 mm Al outer cylinder (support vessel)

	CJC 1	CJC 2
# of cells	30	60
# of wires per cell		
... sense wires	24	32
... pot. wires	50	66
... field wires	10	10
... cath. wires	49	65
chamber dimensions		
active radius / mm	224.5	296.0
active length / mm	2200	2200
gas volume / m^3	1.14	3.08
wire material and diameter		
sense wires	20 (25)µm gold plated W (+2%Re)	
potential wires	127 µm Cu (+2%Be)	
cathode wires	180 µm Cu (+2%Be)	
gas		
normal ep-running	50% Ar + 50% C_2H_6 + 0.1% H_2O *(+0.8% C_2H_5OH)*	
in other periods	89.5% Ar + 9.5%CO_2 + 1% CH_4	
gas system	closed common circuit with purifier (mole sieve 5A / 3A + Deoxo) exchange rate 1-2 volumes / day	

Details of CJC Cell Structure





G 10 End Plate

Problem 1: Broken Wires in CJC 1 in 1992/3

Already after the first period of HERA operation, in the shutdown Dec 92, sense wires started to break spontaneously in CJC 1

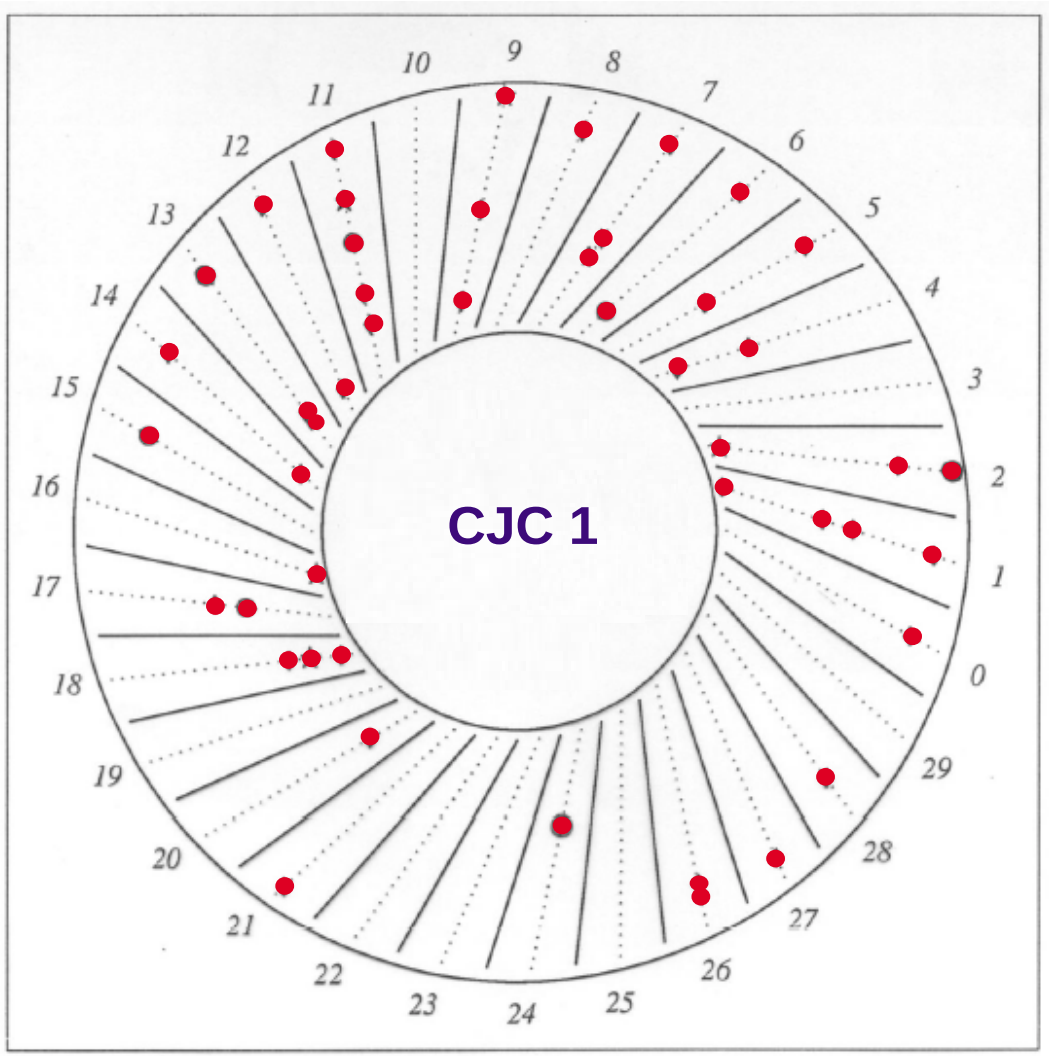
Until Jun 93 in total 48 wires were broken

Randomly distributed in CJC 1

Only wires broken at forward end could be removed from the chamber

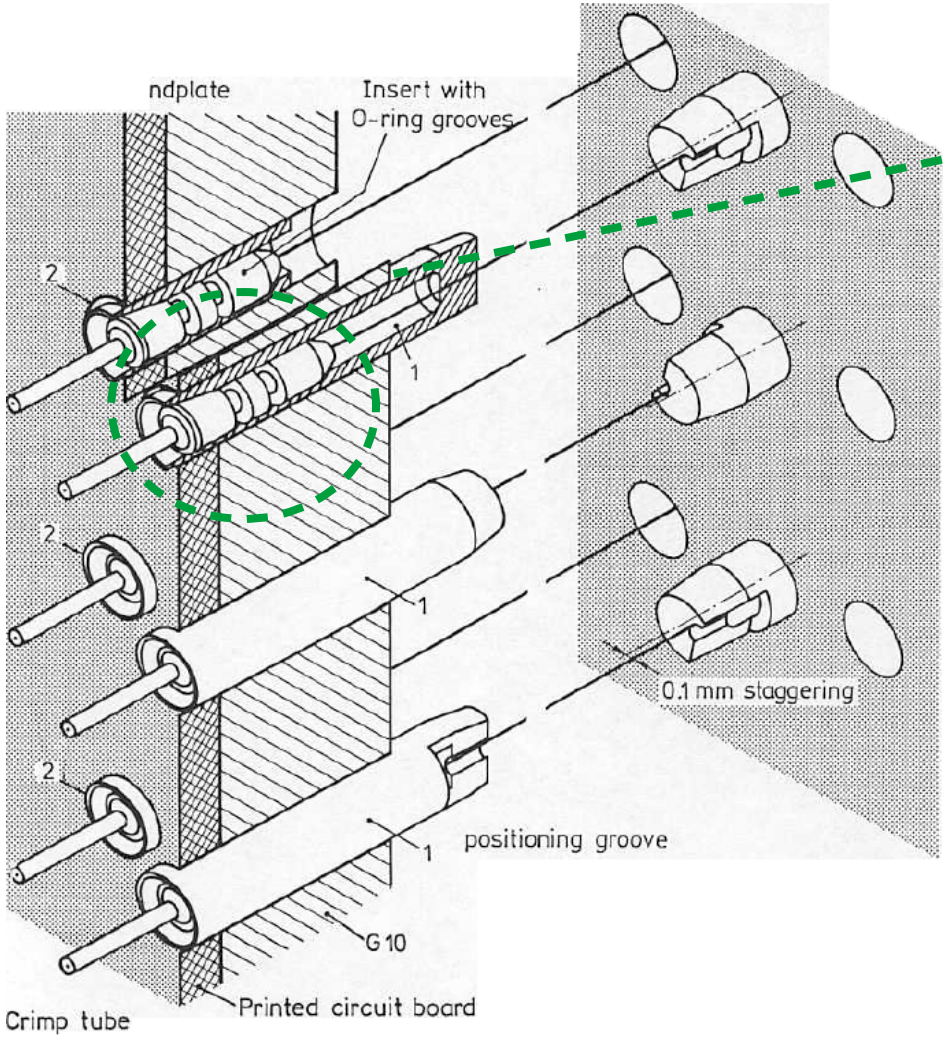
Other wires could not be removed and caused large dead areas due to shorts

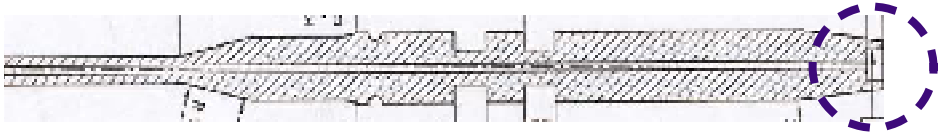
No broken wire in CJC 2 !



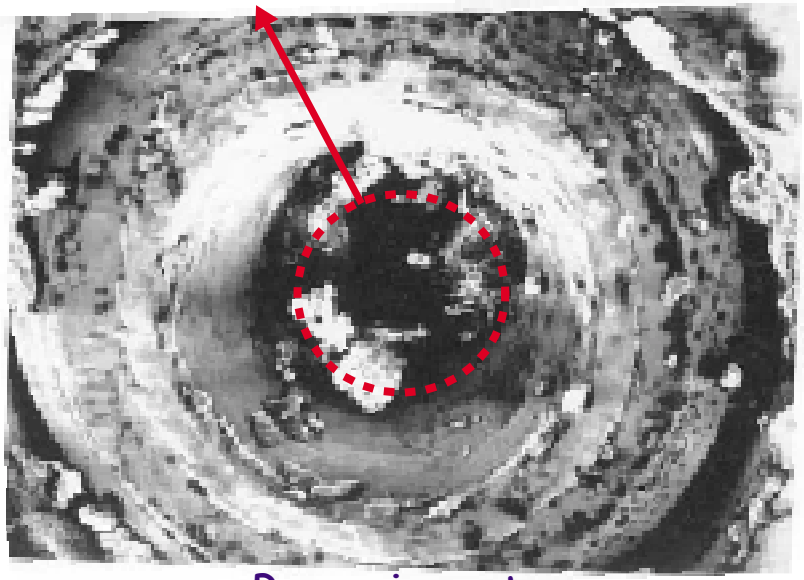
Principle of Wire Fixation

All wires broken close to the wire ends !





60 µm diameter bore for wire



Brass insert

Remnants from gilding process of wire feed through -> sharp edges cause damage of gold layer on wires

Analysis of broken Wires and Crimp Tubes

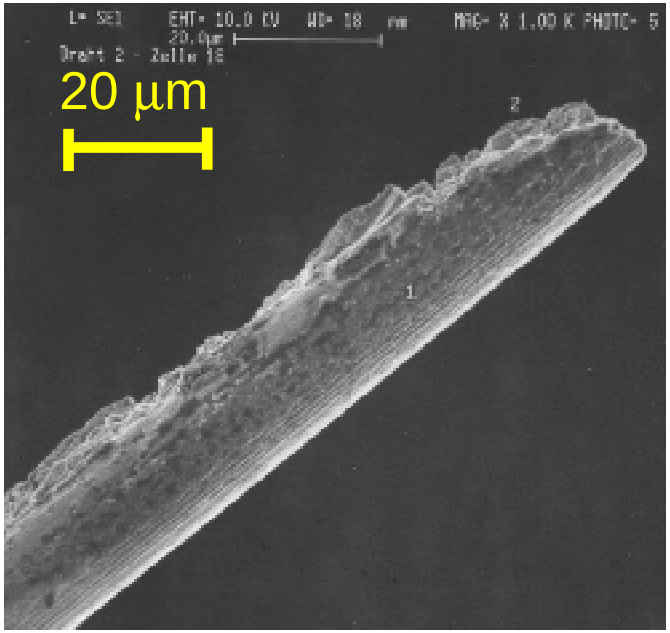
Analysis at VOM Münster and other places using:

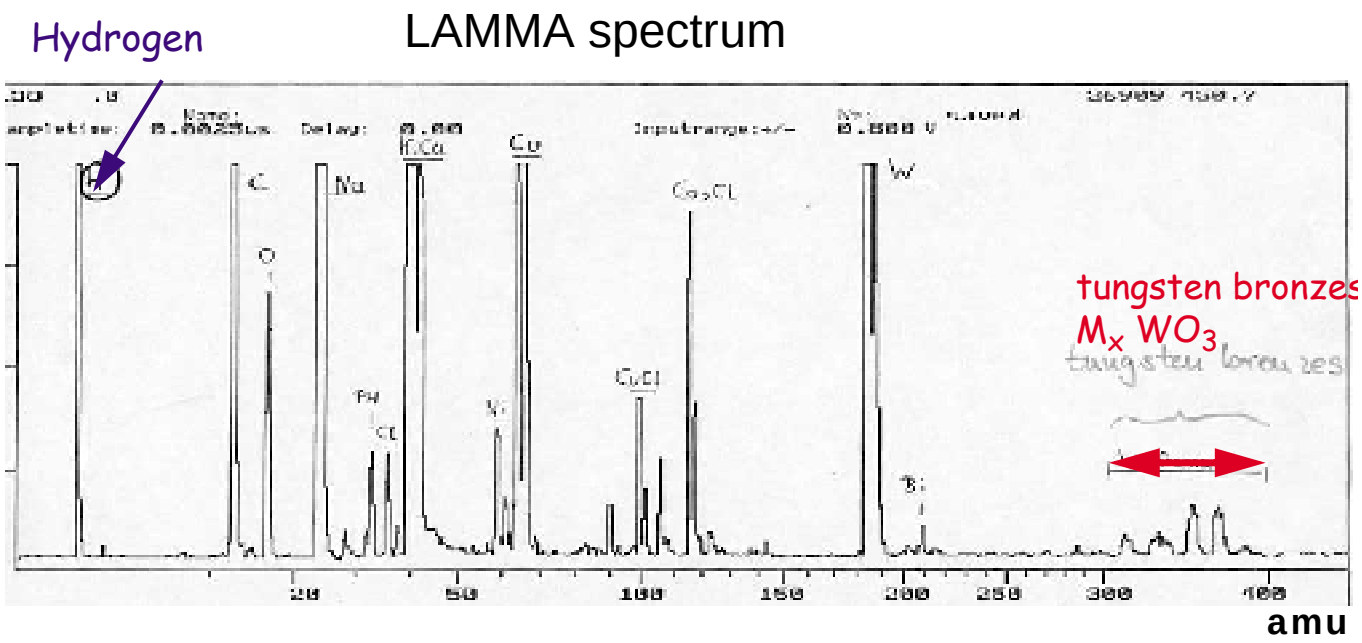
- REM / RMA:
  raster electron microscopy with x-ray micro analysis
- LAMMA:
  laser mass spectroscopy => sensitivity down to Hydrogen

Compare broken/non-broken wires and crimp tubes:

- gold layer on wire damaged by sharp edges
- W partially missing
- clear evidence for complex chemical reaction
- fracture morphology + occurrence of H and W bronzes

=> most likely explanation: **H induced brittle fracture**





Consequences

Shutdown 93/94

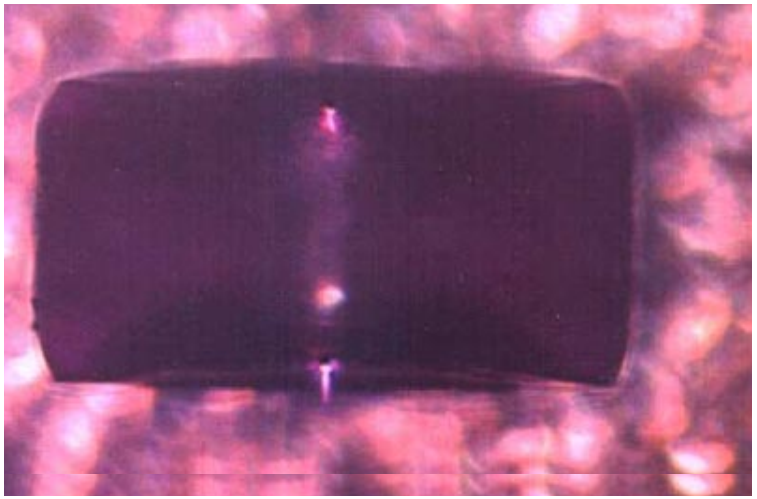
- replace all sense wires of CJC 1
- improve quality control during production process of crimp tubes
- replace brass inserts in wire feed through by jewel

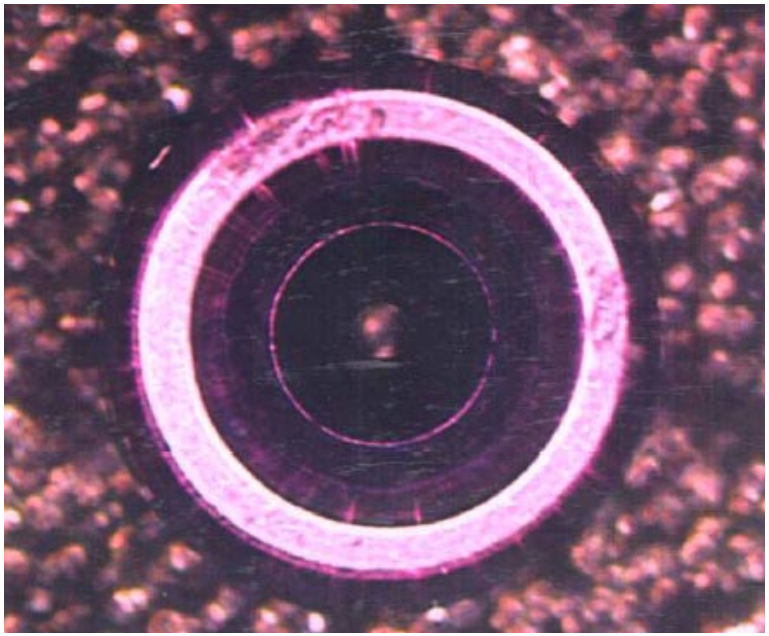
No further corrosive wire damage observed since then !

Still open question:

why no broken wires in CJC 2 ?

Jewel side view

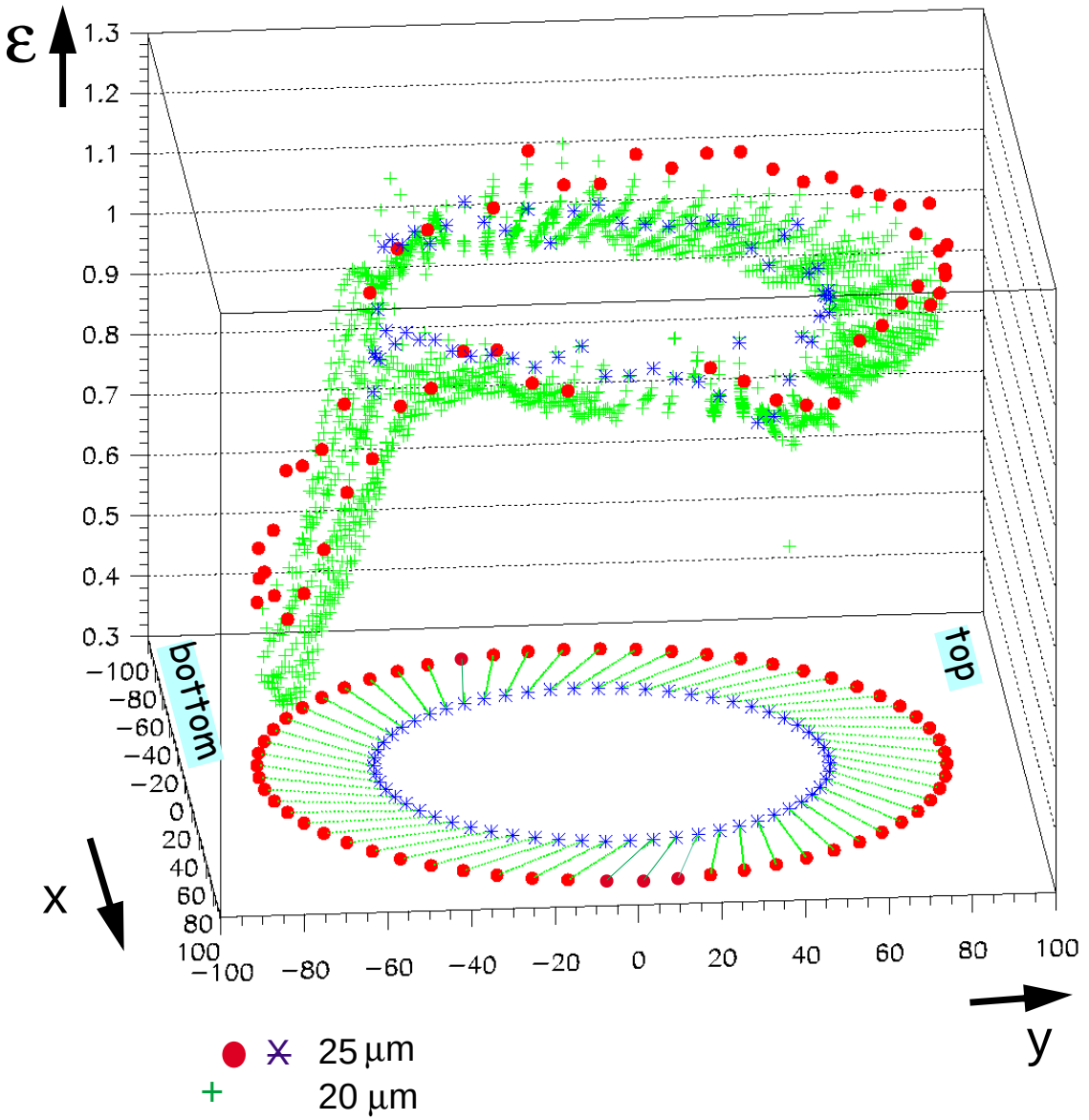




Problem 2: Gain Drop in CJC 2

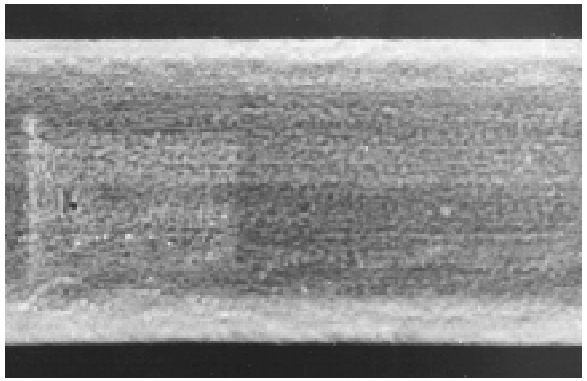
- In 1996 a small φ dependence of the gain was observed in CJC 1 & CJC 2
- This was partly expected from top bottom temperature gradient in the tracking volume (≈15° C)
  => local compensation by HV adjustment in summer 96
- During 96/97 top-bottom asymmetry aggravated continuously in CJC2 although corresponding integrated charge on wires still rather low:
  < 0.01 C/cm
- Strong correlation observed between hit efficiency and y-coordinate (height) of the affected wire

Wire efficiency vs. position end of 1997

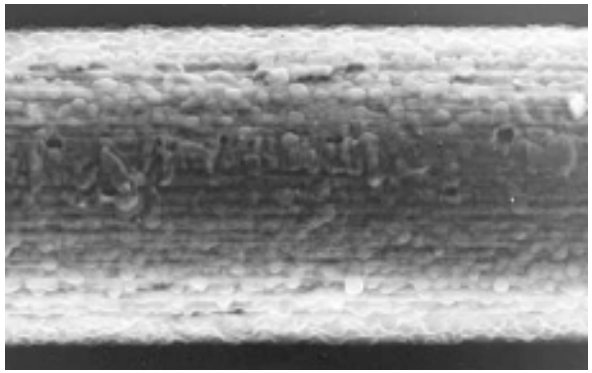


Example Wires scanned using Electron Microscope

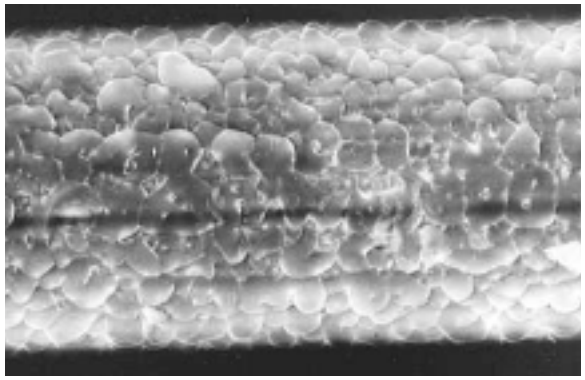
deposits invisible?

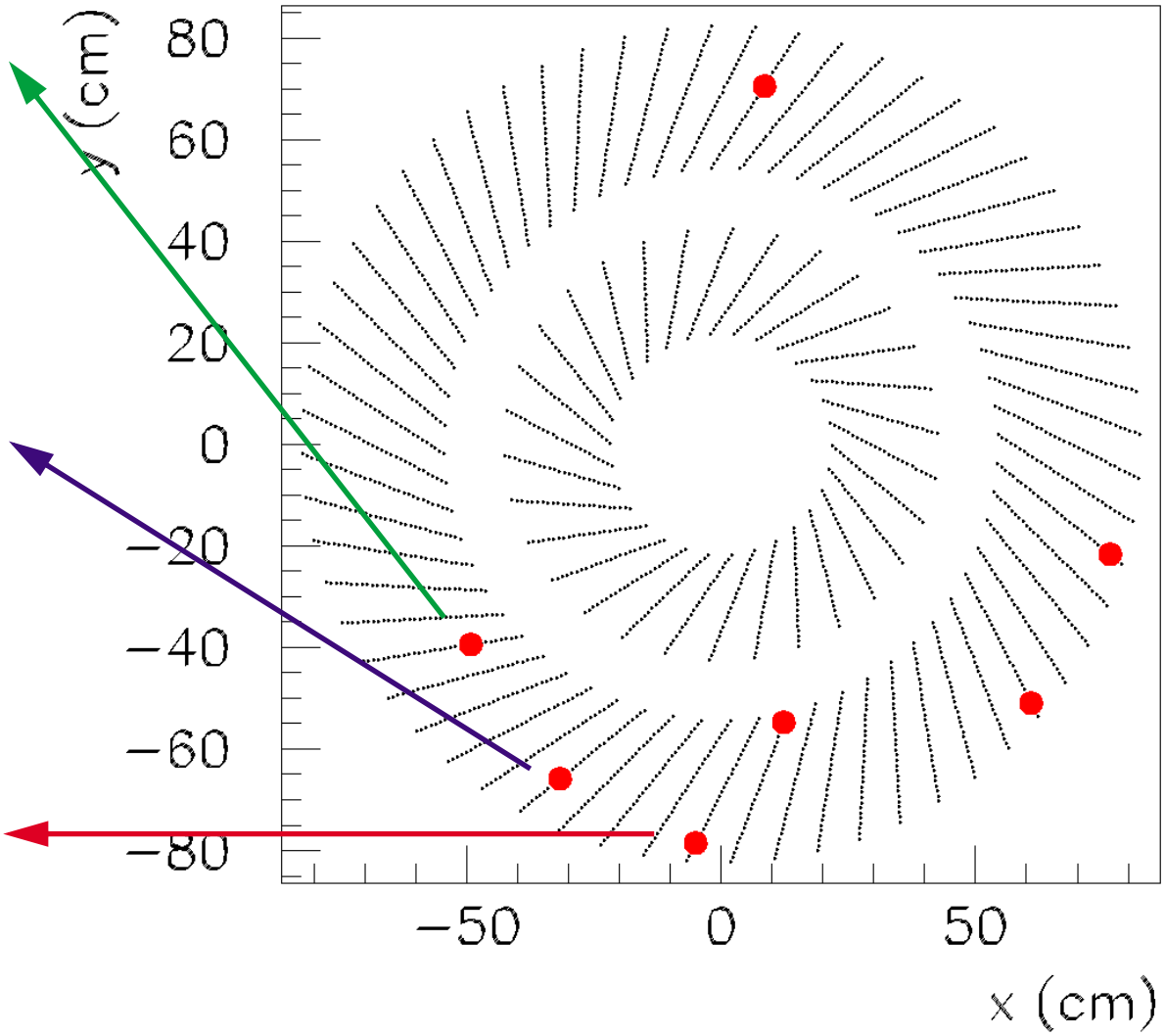


deposits visible



deposits substantial





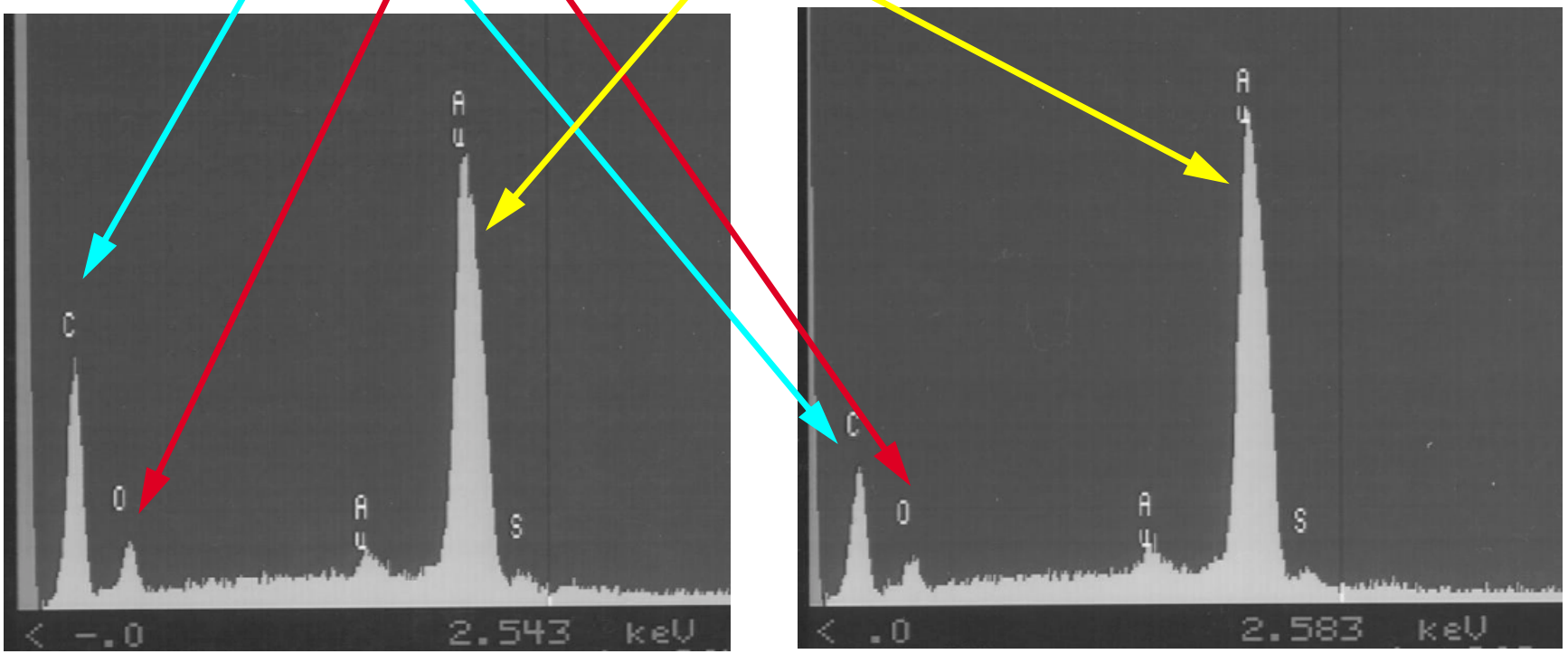
Analysis of Wire Surface

REM with EDAX probe allows rough decomposition of deposits and quantification:

C and O fraction varies from wire to wire

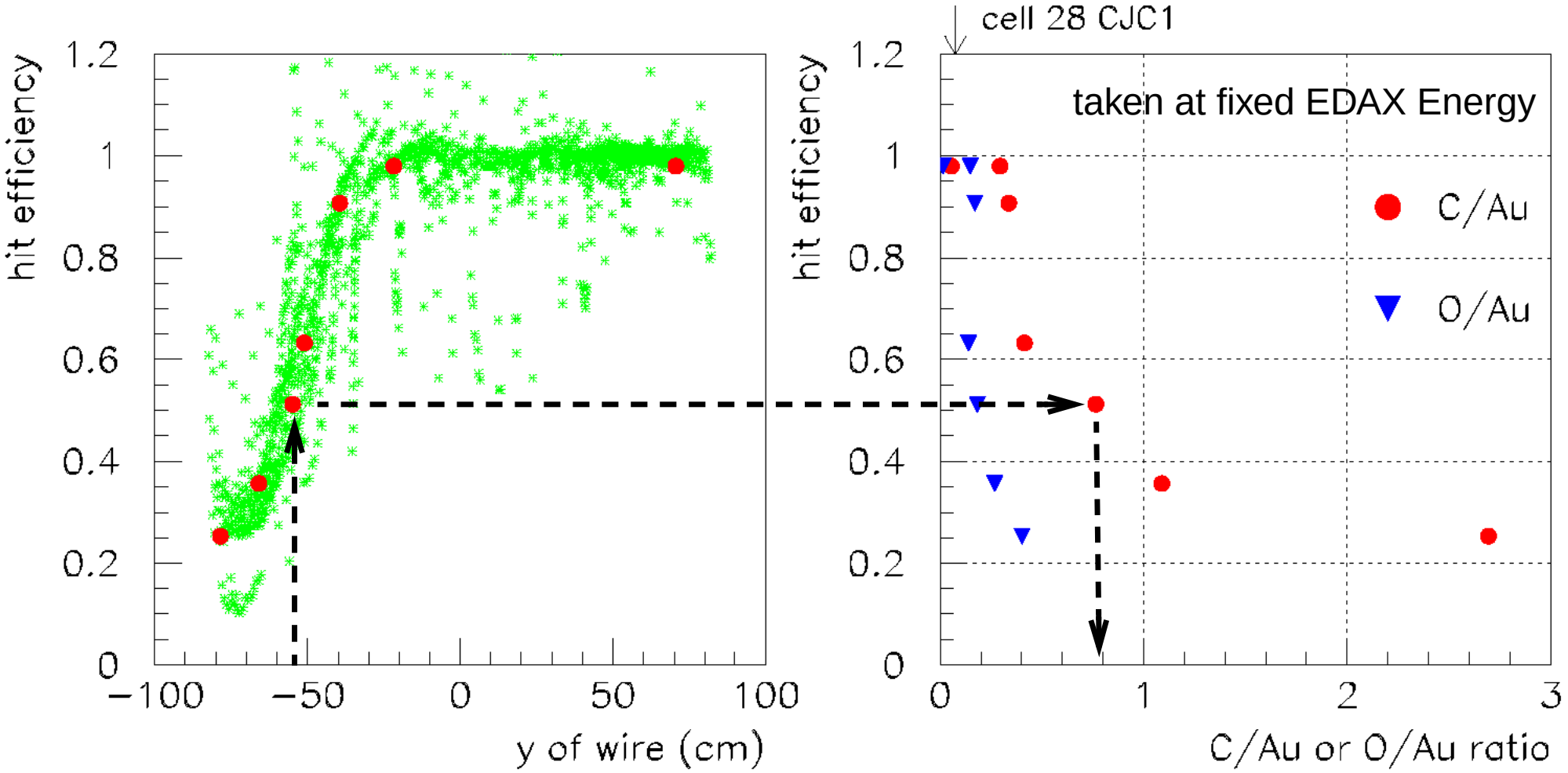
Au from gold layer

No evidence for Si !



EDAX spectra from two different wires

Correlation with Hit Efficiency



Clear correlation with hit efficiency observed

Traces of C and O already found when no significant degradation is seen on wire

Origin of the Problem ?

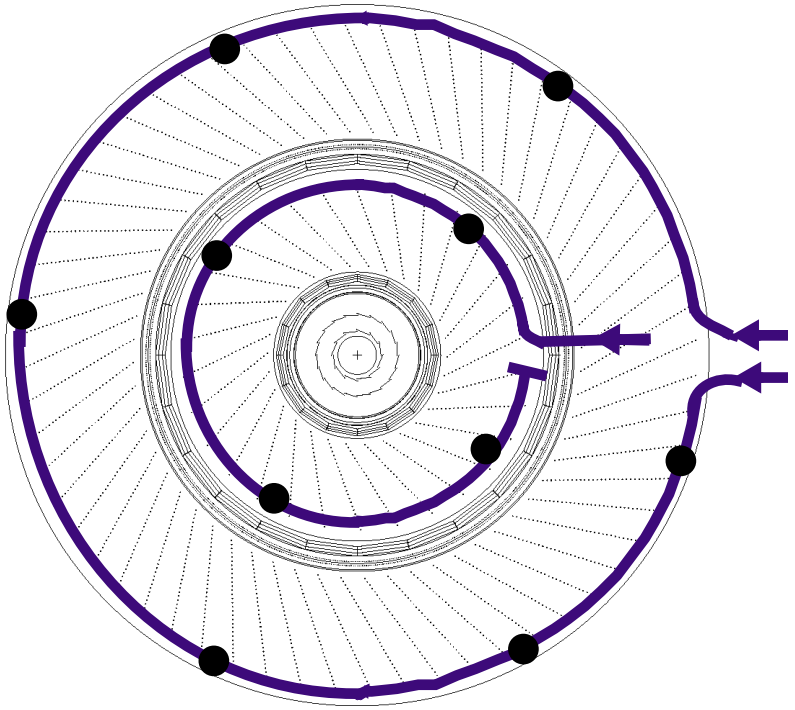
y-dependence strongly suggests **gravitational** influence, perhaps also related to temperature

=> suspect gas impurities
however no indication from routinely performed gas analysis using gas chromatograph which is part of the gas system

Potential source of impurities

- internal origin - from chamber itself ?
  CJC1 and CJC2 made from identical components (except outer Al-cylinder in CJC2)
- external origin
  CJC1 and CJC2 connected to same gas circuit
- accumulation due to non-uniform gas circulation?
  potential problem might be **gas distribution ring** which is not common for CJC1 and CJC2

Gas distribution 1992-97



Gas inlet (similar for outlet on other side)

Gas ring

Gas Analysis at CERN

Several gas samples analyzed at CERN (Mar Carpeans)

- Two types of detectors were used:
  MSD (mass spectrometer) sensitivity ~ ppm
  ECD (electron capture device) detects electronegative species @ ppb
- 4 samples were investigated
  1. Argon : supply lines + distribution
  2. Argon : supply lines + distribution
  3. Argon : supply lines only
  4. Argon/Ethane : supply lines only
- Results somewhat inconclusive:
  1+2 identical: main pollution air and water, presence of C_4H_9Cl
  3 also some Cl-molecules, but no air and only little water
  4 clean, very little water
  1-4 some traces of unidentified electronegative pollution

=> gas distribution modified in shutdown 97/98 :

gas rings replaced with **individual pipes** equipped with flow meters

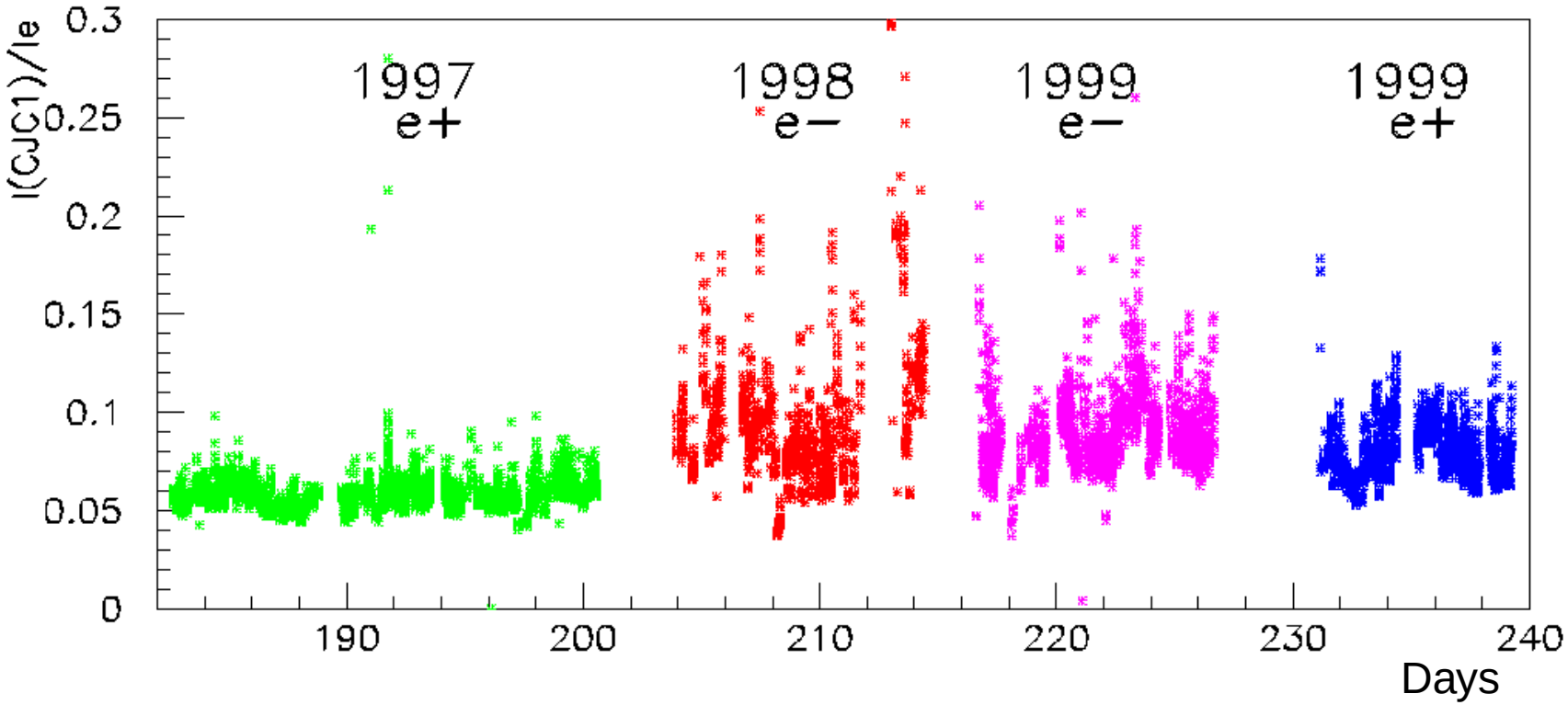
in order to guarantee homogenous gas distribution for all inlets

Problem 3: Increased Dark Currents

Starting in 1998 HERA was operated in e^-p mode leading to increased background levels in the H1 interaction region

=> significantly increased normalized CJC current 1998/1999 compared to 1997

Chamber Current normalized to HERA-e current vs. Time

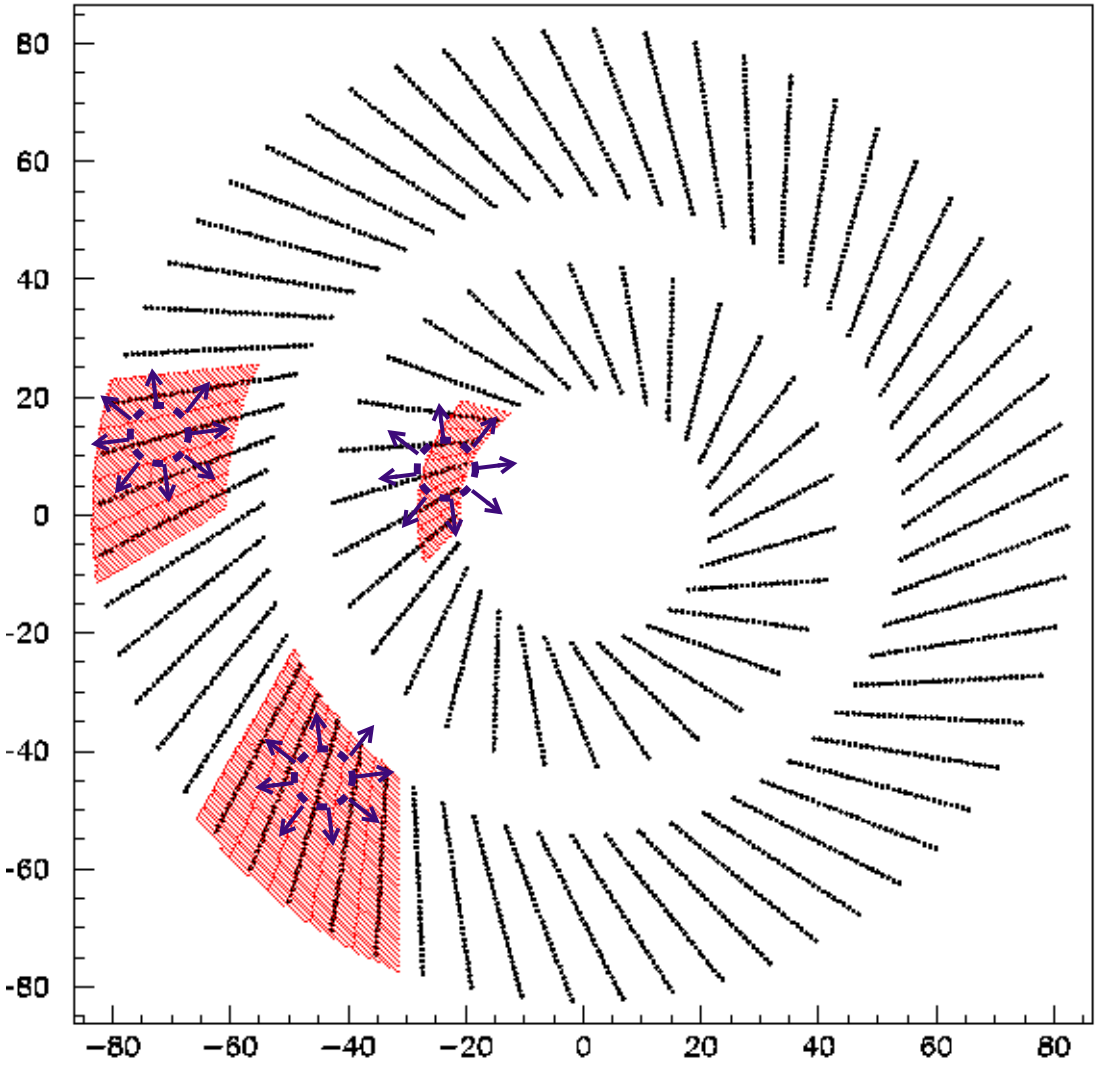


Affected Regions in CJC1 and CJC2

Evidence for **Malter Effect** :

- sudden step in cell current of 1-2 μA
- simultaneously seen in ≈two adjacent cells on both sides
- if central cell is disconnected from HV current disappears in adjacent cells
- if operated for longer period further step in dark current can occur
  => HV instabilities
- subsequent visual inspection revealed large spots (≈few cm^2) of black deposits on cathode wires in the problematic areas
- replacing additive H_2O (0.1%) with C_2H_5OH (0.8%) in May99 cured the problem

Cells with increased currents



Present Status

Nine month Shutdown 2000/01 for HERA Luminosity Upgrade => access to CJC

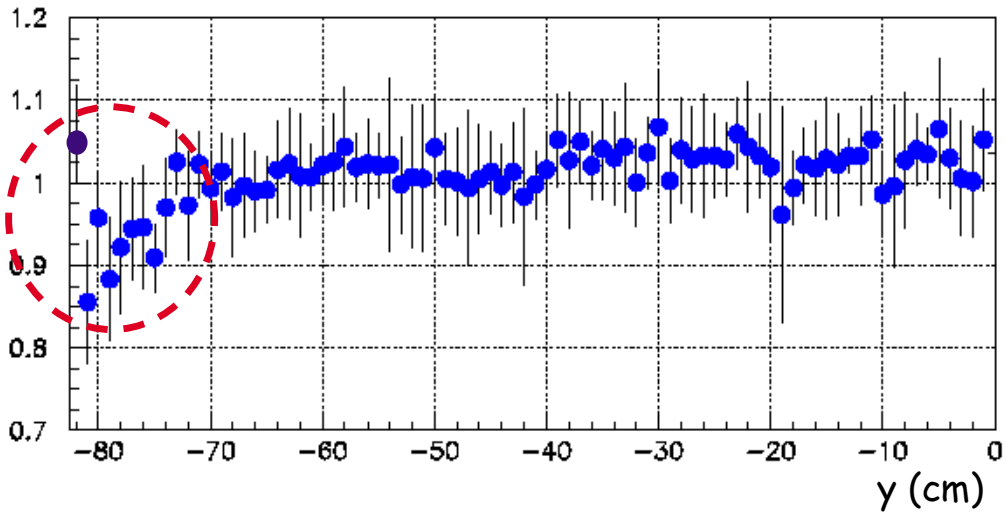
CJC 2 partly rewired

- replace all wires (cathode and sense) that were affected by Malter effect
- indications for gain drop during 2000 period again in lower part of CJC 2 => as a preventive measure sense wires in lower cells also replaced

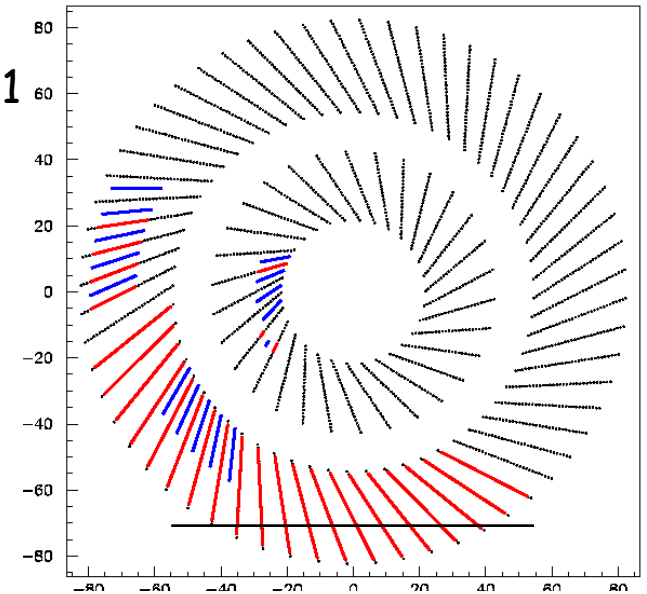
Further changes

- in order to increase the gas flow through CJC2 each chamber is now connected to its own gas circuit
- replace gas pipe from gas room to detector?

Gain July 2000 / Gain July 1999



Wires replaced in Shutdown 00/01



Summary and Conclusions

Several aging phanomena have been observed in the Central Jet Chamber of H1:

1) Broken Wires in CJC 1

Observation / possible reason:
remnants from gold plating process lead to complex chemical reactions

Consequences:

- new design of crimp tube: jewels
- better quality control

Question:
why not also in CJC 2 ?

3) Malter Effect in CJC 1 and CJC2

Observation / possible reason:
induced by increased background

Consequences:
changed additive from H_2O to C_2H_5OH

?

2) Sense Wire Deposits in CJC2

Observation / possible reason:
y dependence implies most likely gas impurity

Consequences:

- sense wires replaced
- changes in gas distribution
- increased gas flow

Question:
why not also in CJC 1?

These problems underline importance of having control over all detector parameters, BUT often it is quite difficult to draw final conclusions since:

- nominally identical detectors (e.g. CJC1 and CJC2) may behave very differently
- systematic studies often hampered in running expt's as detector parameters can not easily be changed

Layout of Gas System