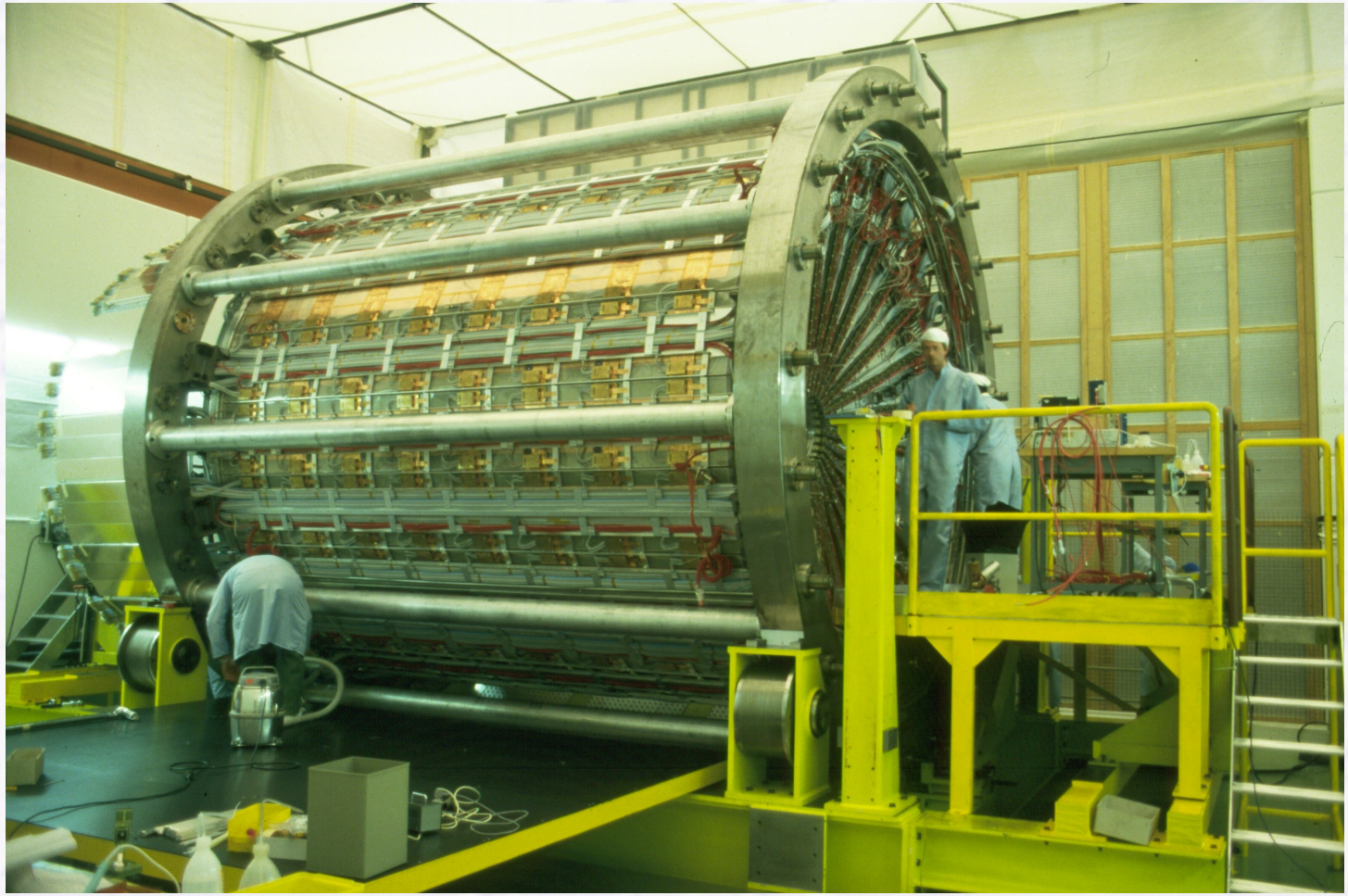
CJ + the Pilot Run



Early Days

- JADE at PETRA@DESY was the "kernel" of OPAL
  - lead glass
  - jet chamber
    - invented by Joachim Heintze / HD
- Some deficiencies with the JADE jet chamber
  - 3 separate "rings" with independent jet cells
    - difficult alignment
  - Z resolution...
- Do it better at OPAL
  - loooong wire planes, no boundaries
  - laser calibration system

RD H

A. Wagner
2.9.1981

Resolution of the Central Detector

The resolution in space, momentum and dE/dx should of course be as good as possible. The approach taken in this note is to try to give a realistic estimate of the resolutions which could be achieved in the framework of the present chamber concept. Numerical evaluations are based on the following parameters : chamber radii : R_i = 20 cm, R_o = 180 cm, L_{track} = 160 cm, L_{wire} = 500 cm, B = 5 KG.

The next step would be to see if the resolutions are adequate for the physics goals.

Rφ - and momentum resolution. The minimal requirement is charge identification at highest machine energies. A sagitta error of Δs/s = 0.5 leads to a (3-5)% misidentification of Q. If one accepts this level of uncertainties this leads to a condition

$$\Delta s \leq 0.5s = 0.5 \cdot 0.00375 \cdot BL^2 \cdot \frac{1}{p} , \qquad [m, KG, GeV/c]$$

for L = 1.6 m and B = 5 KG

$\Delta s \leq 0.024 \cdot \frac{1}{p}$ or $\Delta s \leq 240\mu$ (p = 100 GeV/c)

$\Delta s \leq 160\mu$ (p = 150 GeV/c)

These conditions can easily be met.

Relation between sagitta error and momentum resolution :

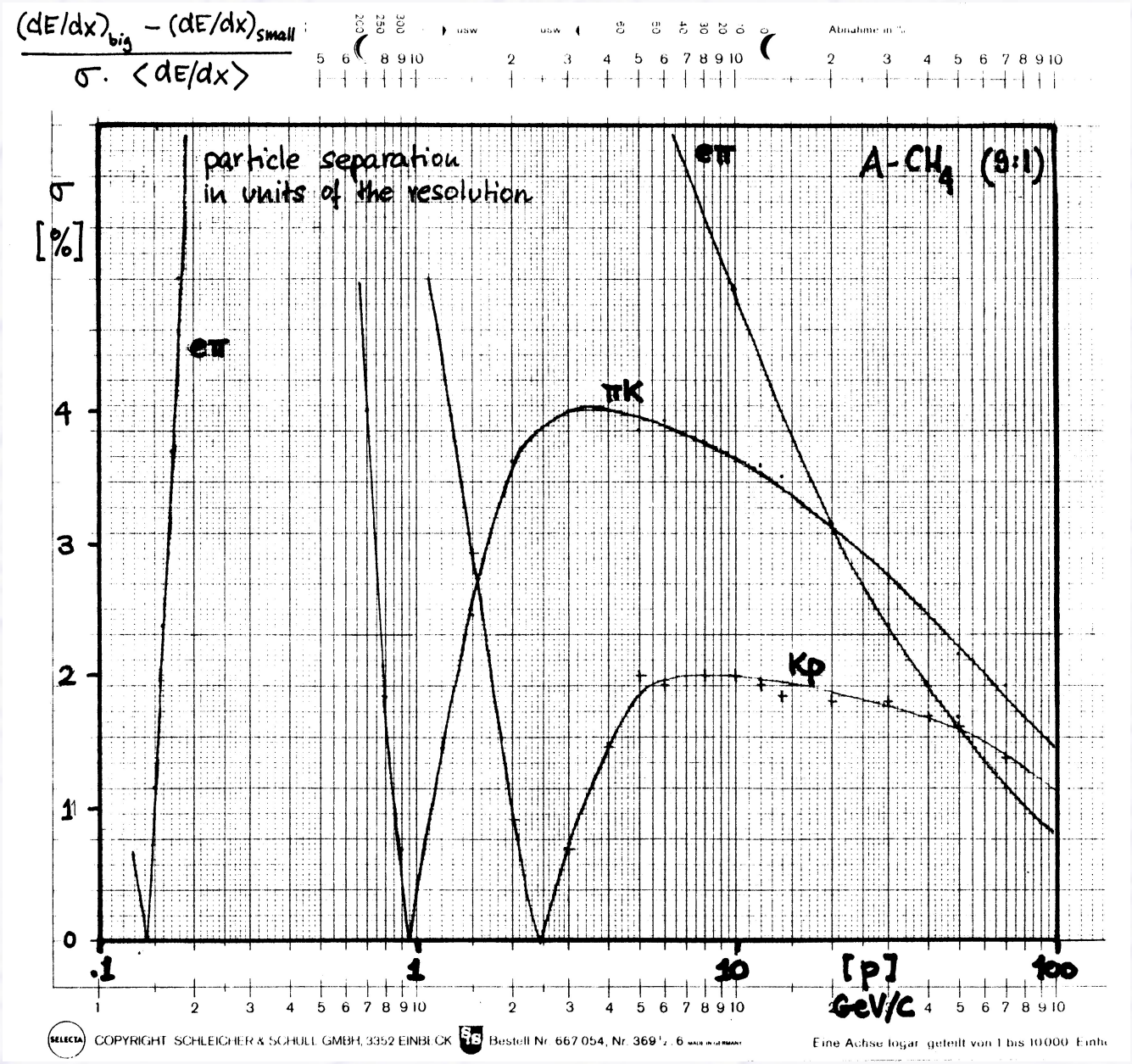
$$\Delta s = .00375\, L^2 B \frac{\Delta p_t}{p_t^2} = .048 \frac{\Delta p_t}{p_t^2}$$

$$\frac{\Delta p_t}{p_t^2} = 20.8\, \Delta s$$

A $\Delta s = 160\mu$ leads to a momentum resolution $\frac{\Delta p_t}{p_t^2} = 3 \cdot 10^{-3}$.

In order to achieve good mass resolution for high mass objects (e.g. Higgs search through $ee \to Z \to H^{ee}_{\mu\mu}$), one would like to have $\frac{\Delta p_t}{p_t^2} = (1\text{-}2) \cdot 10^{-3}$.

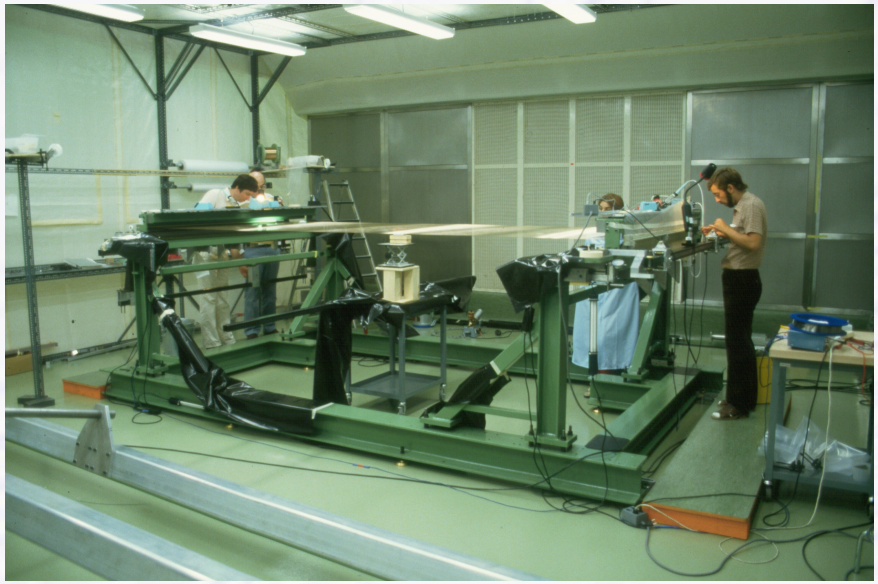
Also better Particle ID



Early Tests...

- **Small Chambers**
  - 1982: dE/dx test chamber (many, but short wires)
    - PS test beam, not very successful..., sparking problems
  - 1983: 8-wire prototype (few, but long wires)
    - electro-static stability tests
- **Full Size (or Scale) Prototype (FSP)**
  - 1984-86: 2 sectors, full size (160 wires, 4 m long, 4 bar pressure)
    - some initial sparking -> misaligned connectors
    - SPS X5 test beam in West Area, very successful
    - also tested with laser system
- **Also somehow important**
  - Januray 1984: Rolf became Jet Chamber Coordinator for the Construction

Full Size Prototype



Hall 186 Upper Floor

Design Study Group (DSG)

- "DSG" stands also for "Deutsche Schlafwagen Gesellschaft"
  - = German company that operates sleeping cars for trains
- **Idea**
  - create a CJ design group to finalize main parameters
  - 2 people from each institute participating in CJ
    - Bonn, Heidelberg, Freiburg, CERN (from North to South)
- **37 meetings, from mid-1984 to end-1987**
  - minutes written ("online") by Albrecht or (sometimes) Rolf
  - minutes were THE reference for e.g. HV distribution

DSG Minutes...

although Albrecht wrote the minutes, he didn't seem to have participated at the meeting...

Rolf

1

2. Meeting of the design study groups

CERN, 18.6 + 20.6.84

Present: H. Fischer (20.6.), M. Hauschild, P. Lennert, J. Ludwig, W. Mohr, O. Runolfsson, A. Wagner, R.-D. Heuer

1) Short report by RDH on the Vertexchamber meeting at Cambridge and Rutherford.

2) Situation of the bell:
Standard pressure bell (Klöpperboden) accepted by the collaboration with the dimensions given on the attached sketch.

3) RDH informed the groups that an installation procedure has been worked out where the heavy pumps on both ends of the beampipe are suspended from different parts of the detector during the installation, but not from the CD cones.

4) Numbers from Petra (AW, Bartels report in Vielas) indicate that one can run with a pressure of ~10^{-8} torr in the beampipe.

Albrecht

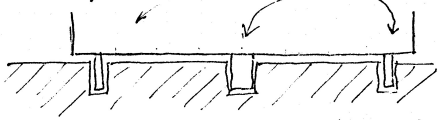
(1)

9th Design Study Group meeting 8./9.11.84

Present: J Ludwig, RDHelves, P. Lennert, M Hauschild, W Mohr, H Fischer

1) Report from FSP:
- laser rotated by a few degrees illuminates now both sides of 'down' anode
- LeCroy installed in centre of UP
- Pot wire termination resistor reduced in 2 groups: 2 x 470 Ω parallel
  470, 200 Ω parallel
- Resistors in Plastic box changed (bridge between 3 chains replaced by 10 MΩ)
- 2 chambers worked up to 20kV, now breakdown → to be repaired
- no more oxygen outgasing - (3.5 ppm const)

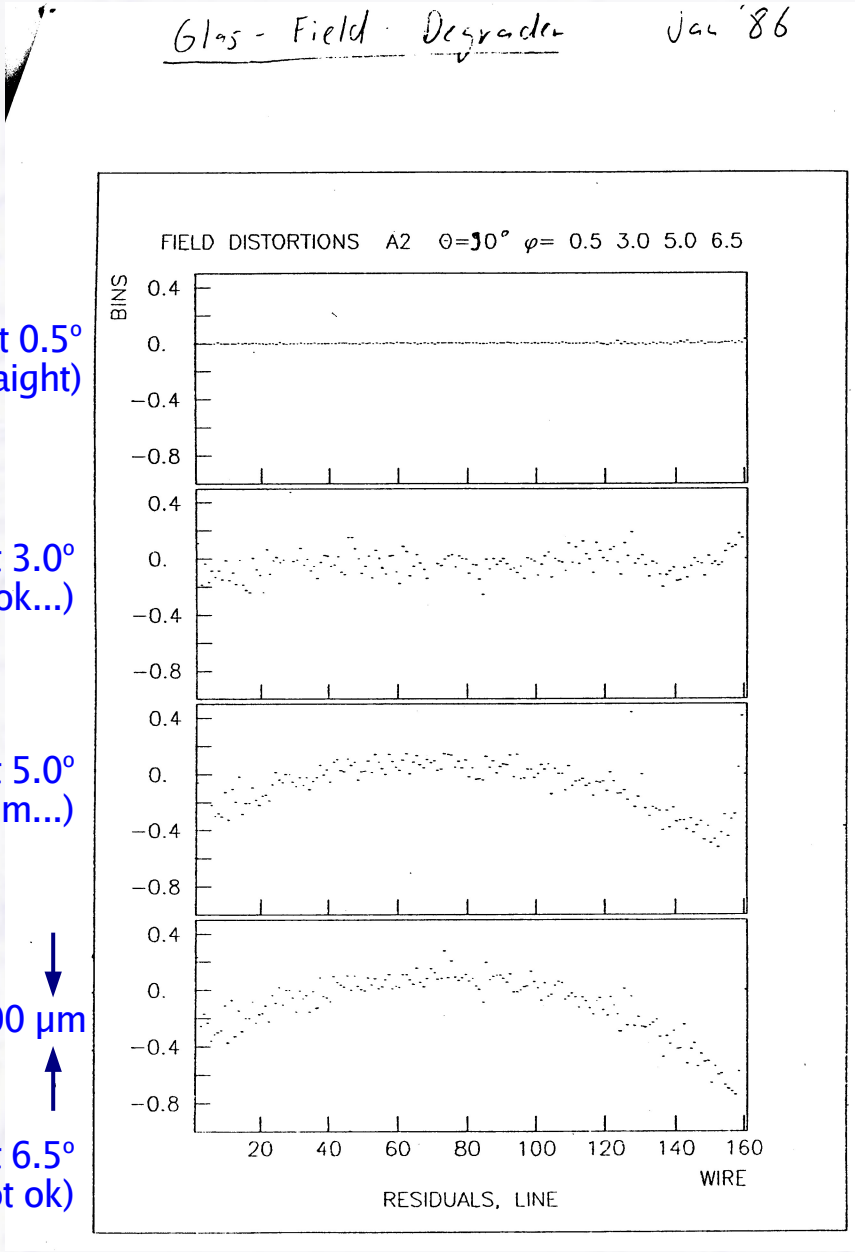
2) Panel Field degrades
- J.L reports about discussion with P. Wicht: proposed design:
  - not 2 dowel pins, but 1 precision slot (+pin) in centre and two slots + pins (against rotation)



slots are located in funnel ↘ This design principle should be pursued

Glas Field Degrader

- Field degraders made out of epoxy have potential weaknesses (but must be good for 24 kV over 6 mm)
  - small air bubbles, other unrecognized defects are dangerous
- **A new idea**
  - why not use glas instead
    - clear material, defects immediately visible
  - test made with FSP in January 1986 with laser beams
- **But (surprise...)**
  - laser tracks are not straight
  - E-field is not well homogeneous
    - reason: lower bulk resistance of glas



The real Thing...

- Construction of the final Jet Chamber started spring 1987
- Lots of quality control
  - wire tensions (sagging) of all wires
  - wire samples taken every 10th wire and investigated by electron microscope
- The real thing (cosmics + laser tests)
  - 2-sector test (summer 1987)
  - 24-sector test (summer 1988)
  - combined test (January 1989, with CZ and CV)
    - 3 detectors..., 3 coordinate systems..., 2 were wrong...
- And just before closing and transport to the pit...
  - ...dead fly found between the wires...
  - careful removal by Rolf, assisted by Jürgen Zimmer and MH

Wire Scans (one of many...)

Anode-Nr. 5

Results of the surface examination

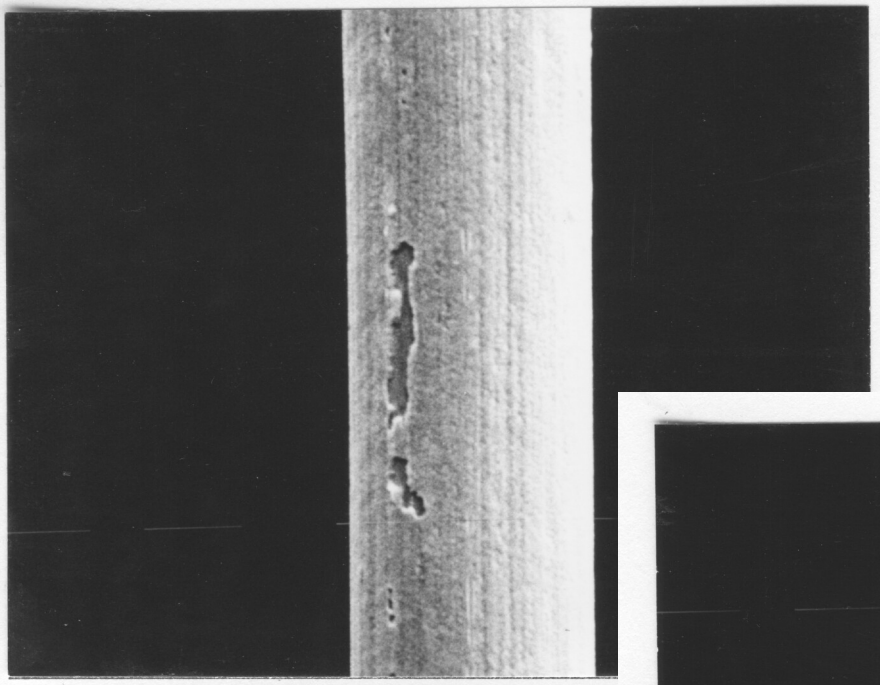
Sample No.	Wire Type.		Remarks
1 - 1	PCB4/A5	W/Au	A few small holes in the Au layer otherwise satisfactory
1 - 2	A11	W/Au	Several large holes in the Au layer
1 - 3	A16	W/Au	As above
1 - 4	P16	Cu/Be	Satisfactory
1 - 5	PCB5/A1	W/Au	A few medium-sized holes in the Au layer otherwise satisfactory
↓ new spool			
1 - 6	A9	W/Au	As for 1 - 1
1 - 7	A16	W/Au	Several medium-sized holes in the Au layer
2 - 1	PCB6/A6	W/Au	Several large holes in the Au layer
2 - 2	A14	W/Au	Satisfactory
2 - 3	PCB7/P10	Cu/Be	Satisfactory
2 - 4	A10	W/Au	Several large holes in the Au layer
2 - 5	A12	W/Au	Several medium-sized holes in the Au layer
2 - 6	PC8/A7	W/Au	As for 2 - 4
2 - 7	A16	W/Au	As for 2 - 5

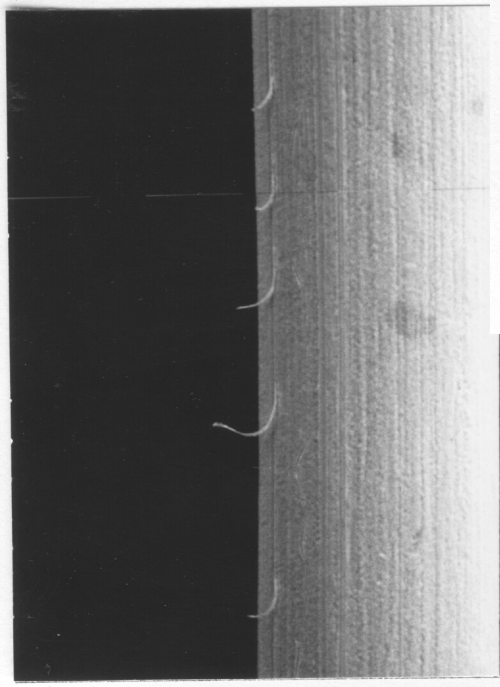
Results of the Surface Examination

Wire Type	Remarks
W-Au	Alignment of small and medium-sized holes in Au layer; Au layer locally irregular
W-Au	Alignment of big holes in Au layer; not good: photo taken already by Mr.Heuer
W-Au	Small and medium-sized holes in Au layer; some scratches; Au layer locally irregular
W-Au	As above
W-Au	As above
W-Au	As C 2/A 8
W-Au	As C 6/A 8
W-Au	Small and medium-sized holes in Au layer
W-Au	As C 7/A 8
W-Au	As C 9/A 8

Wire Defects found on Samples

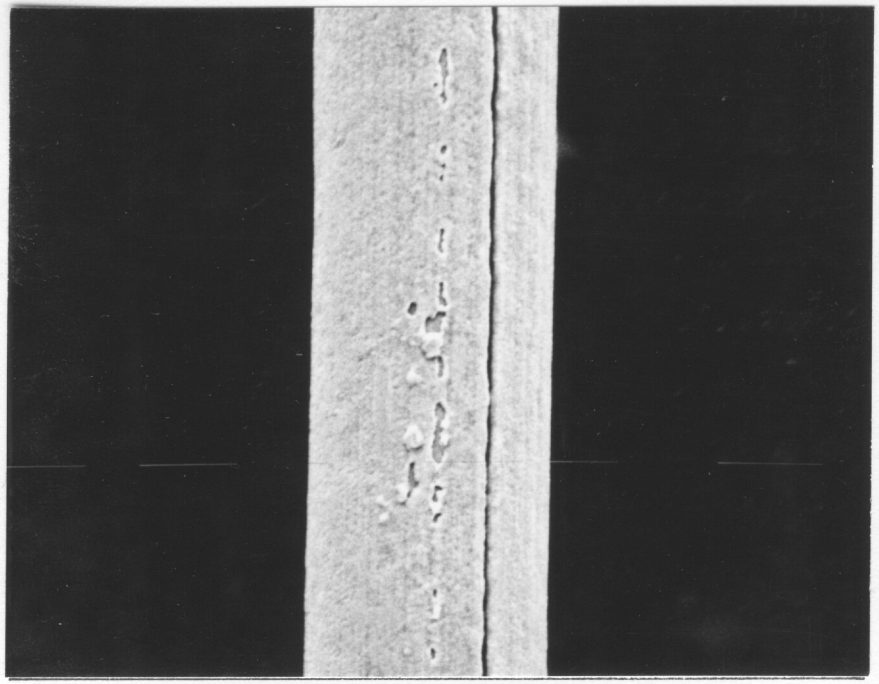
Typical surface defects.





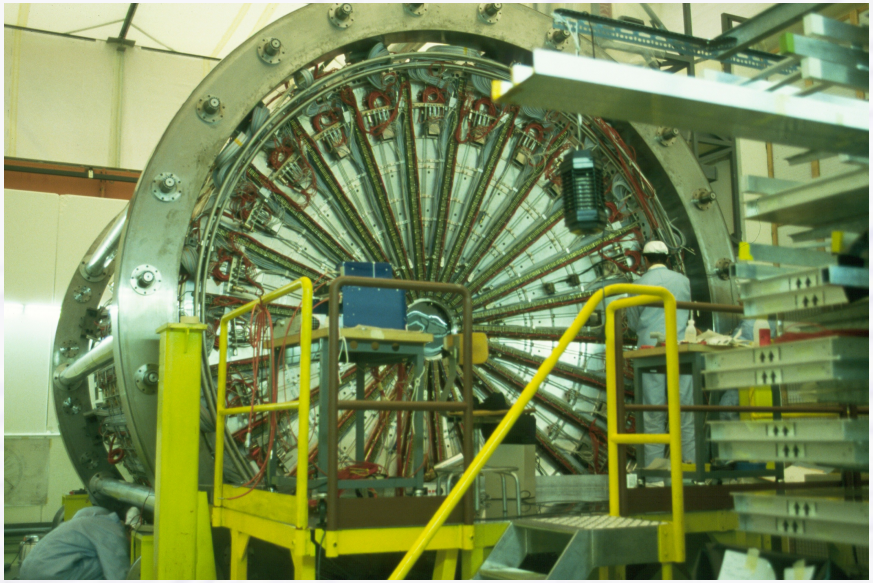
X 1250

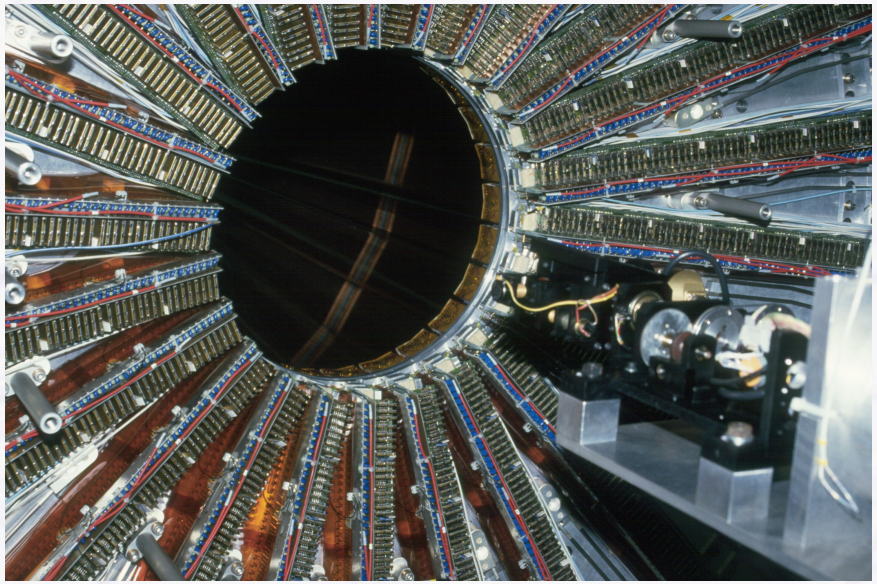
Longitudinal extrusion defect running the whole length of the sample examined

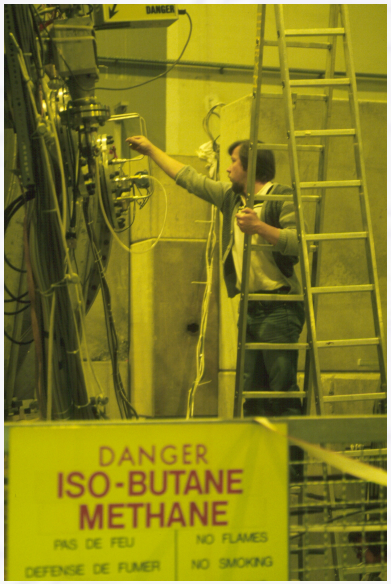


X 1250

Some Impressions

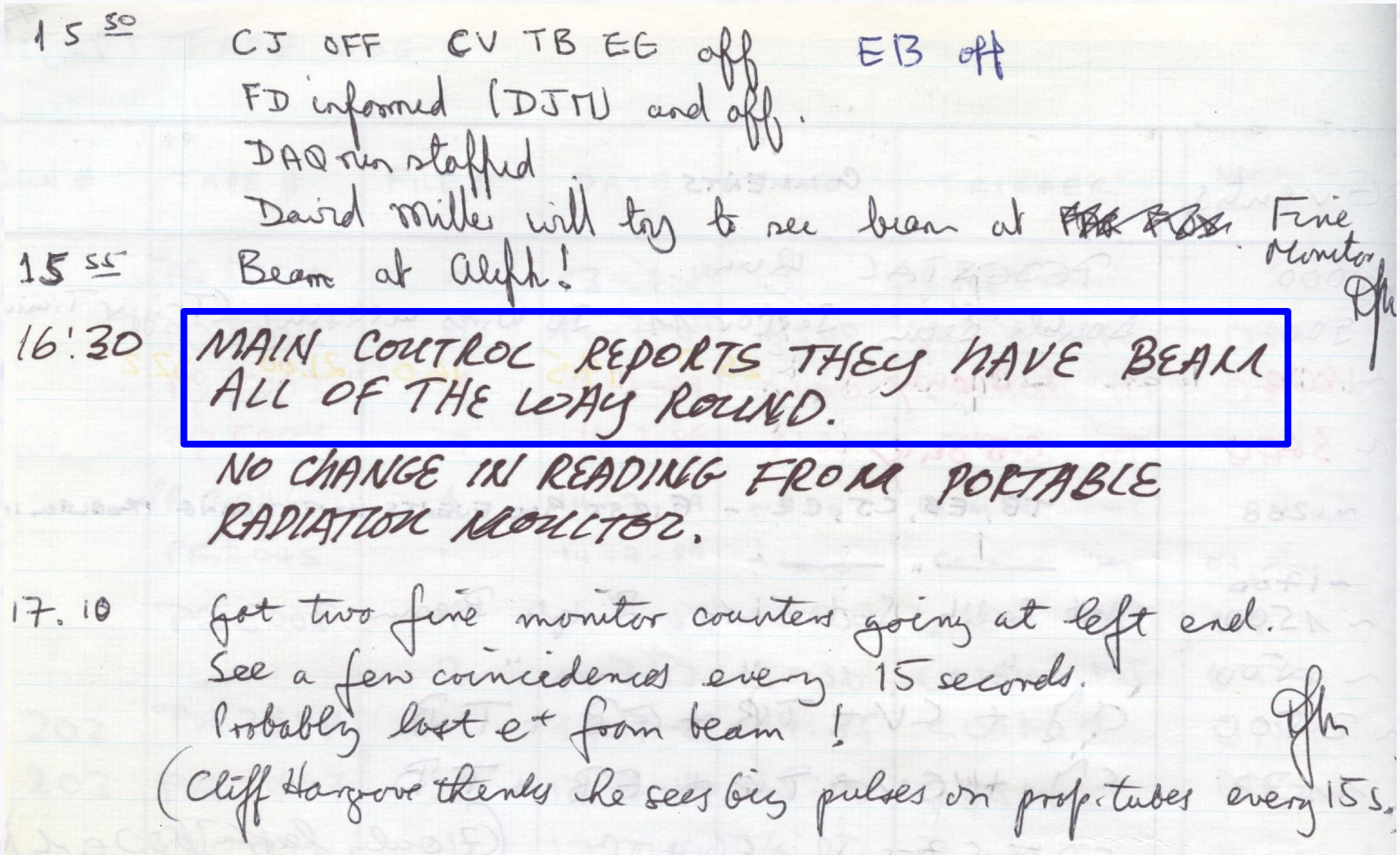






First Beams

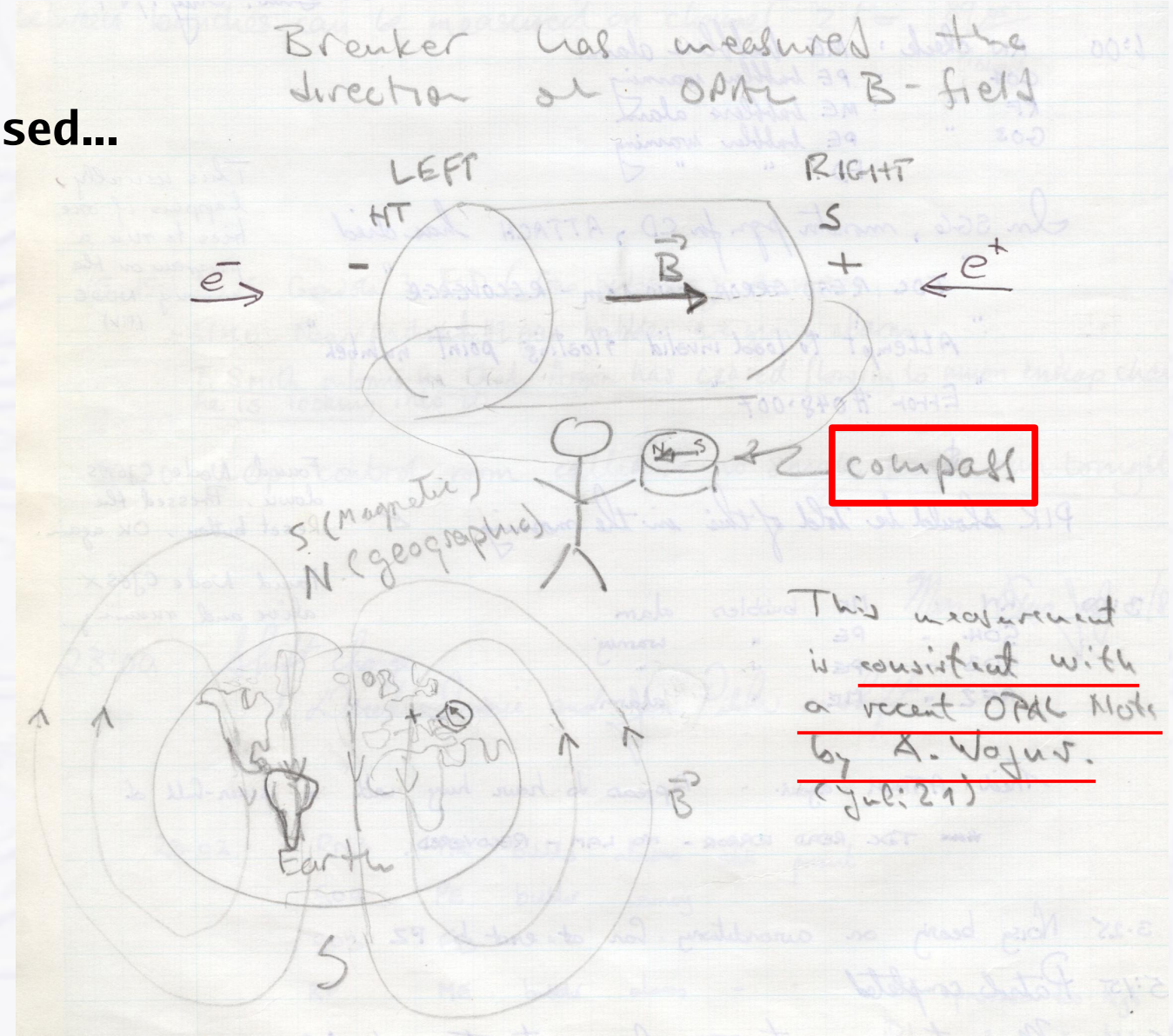
- **14th July 1989**
  - **LEP first turns in the afternoon**
    - **we learned that e^+ came from the Jura, e^- from the Lake**



15 50 CJ OFF CV TB EG off EB off
FD informed [DJTN and off.
DAQ run stopped
David Miller will try to see beam at ~~FBA FBC~~. Fine Monitor
15 55 Beam at Aleph!
16:30 MAIN CONTROL REPORTS THEY HAVE BEAM ALL OF THE WAY ROUND.
NO CHANGE IN READING FROM PORTABLE RADIATION MONITOR.
17.10 Got two fine monitor counters going at left end.
See a few coincidences every 15 seconds.
Probably last e^+ from beam !
(Cliff Hargove thinks he sees big pulses on prop. tubes every 15 s.

Magnetic Field Direction

- **What's the direction of the magnetic field?**
  - **how to figure out?**
  - **classical method used...**

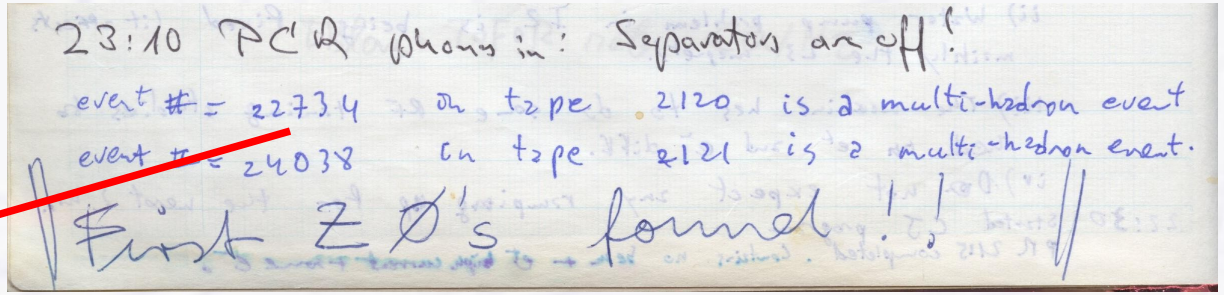


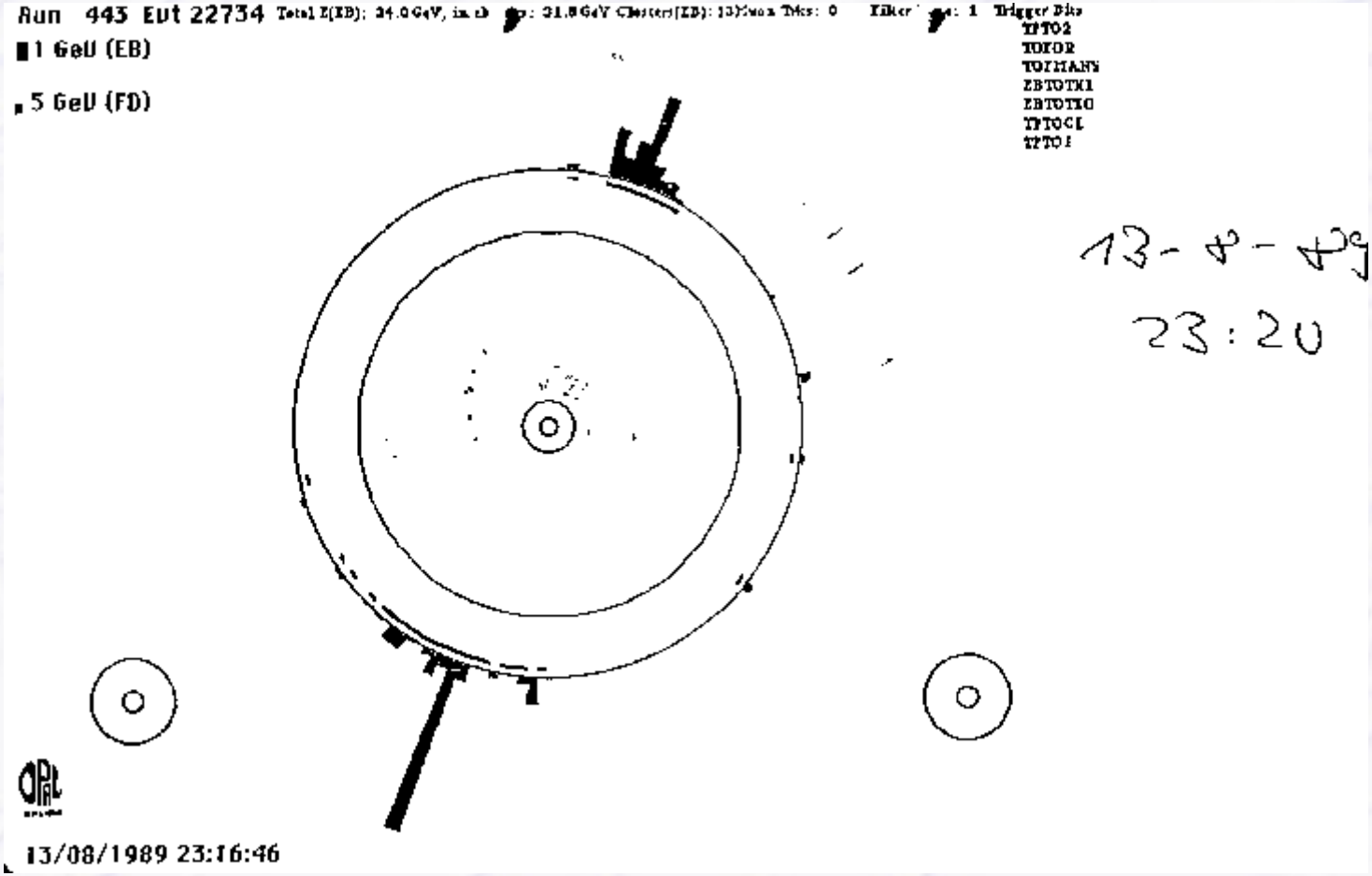
The Pilot Run

- 1 week in August 1989...
  - ...we all spent day and nights at the pit...
  - ...slept upstairs in the barracks or just on top of the desk whenever there was no beam for some hours
- 1st OPAL Run Coordinator: Rolf
- 13th August 1989: first collisions at 2 x 45 GeV
  - first OPAL Z^0 (and first at LEP) 10 min after beam separation was removed (23:20)
    - no CJ yet, too much backgrounds (collimators not yet moved in)
  - Aldo wasn't present (Rolf sent him home for sleep before)
  - LEP Control Room was called immediately
    - Rubbia on phone, didn't believe it!
- OPAL driver sent to LEP Control Room with online event display print-out -> Rubbia believed it eventually

The first Z^0

- 13th August 1989, 23:20





The first Z^0


13/8/89
14-8-89
155
23 00
A. Diedrich + J. Maring
on shift
23 05
call from LEP machine: e+, e- at 45.5 GeV
14.08
0:05
LEP PAGE 1
"First Z° seen by OPAL"
Aldo


NO BEAM
First Z0 seen by OPAL
NOKIA

Pilot Run Results I

- **Aldo gave talk at EPS Conference in Madrid, September 1989**

PILOT RUN:

LEP DELIVERED AT I6 ~900' OF e^+e^- COLLISIONS AT AVERAGE LUMINOSITY OF ~ .7 x 10^{28} cm^{-2} sec^{-1}

OPAL OVERALL ON TIME (SENSITIVE TO TRIGGER) HAS BEEN 88 %

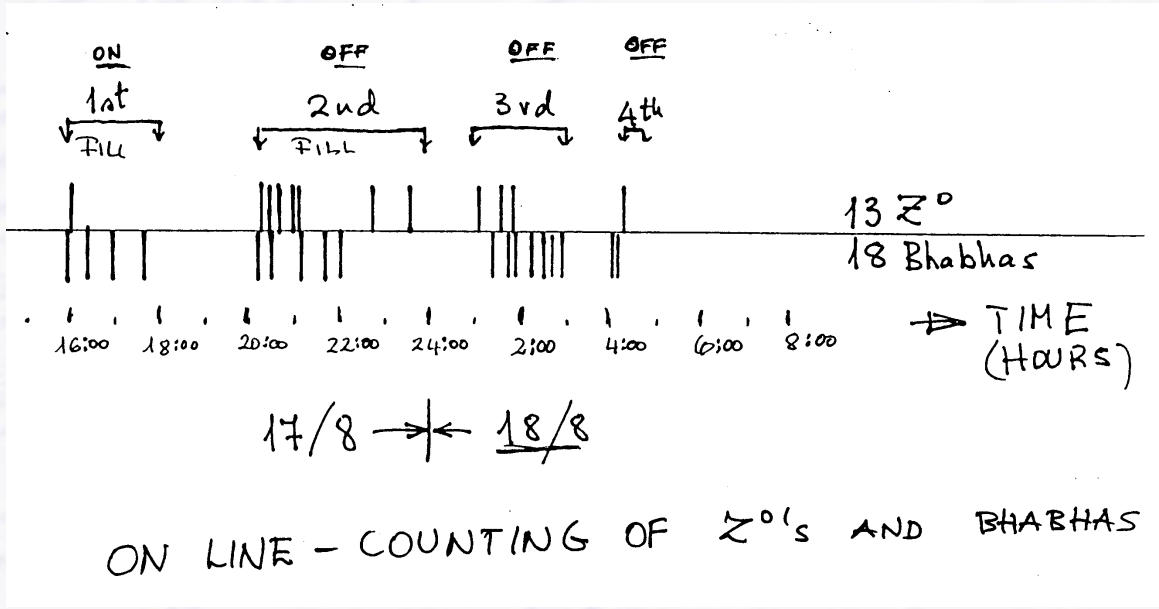
DATA RECORDED:

- 21 Z^0 - DECAYS → 18 MH, 2 e^+e^-, 1 $\tau^+\tau^-$
- 25 SMALL ϑ BHABHAS, $E_{L,R} > 25$ GEV

TIME DISTRIBUTION →

A) DETECTING Z^0's

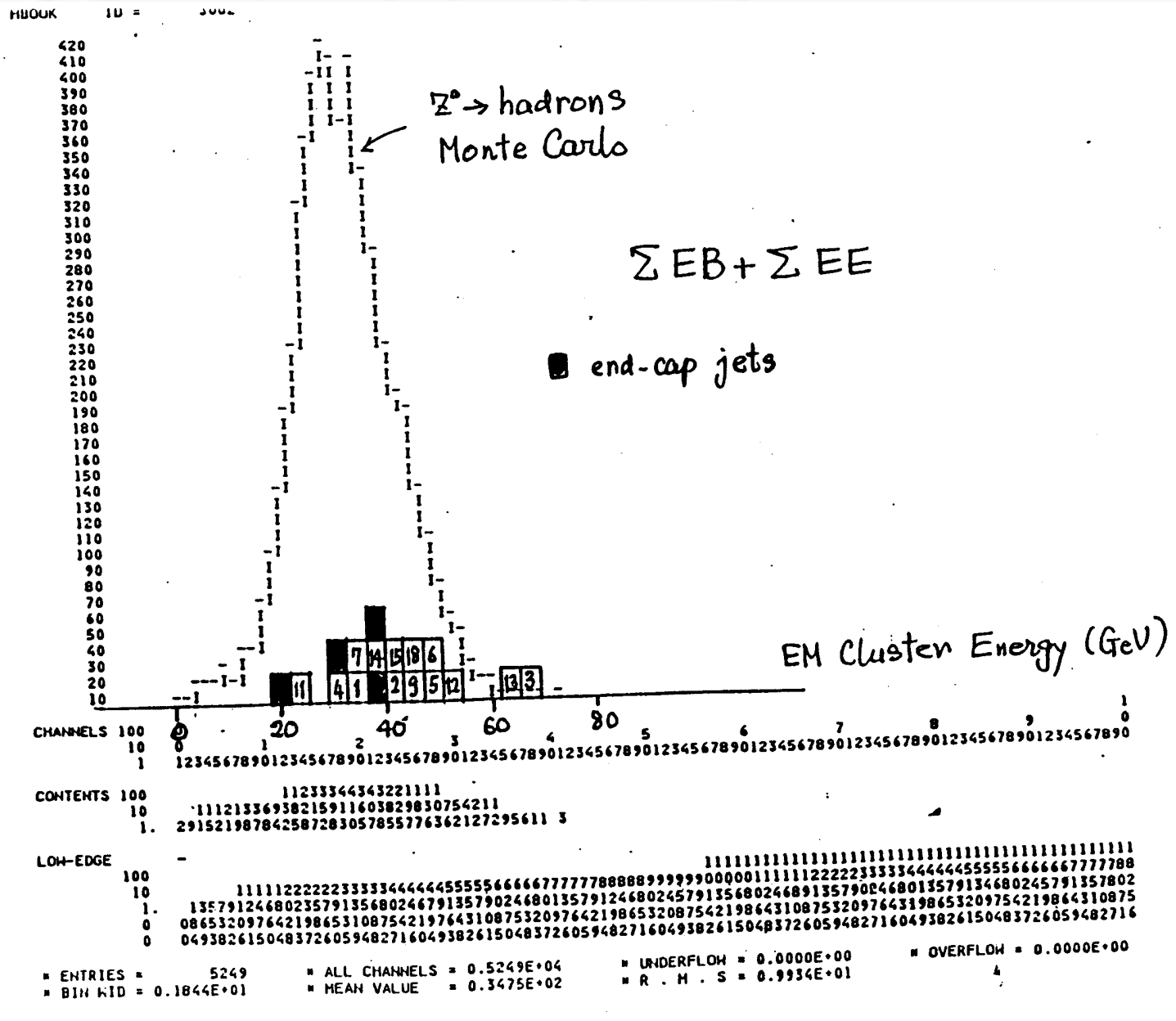
B) DETECTING SMALL ANGLE BHABHAS



The first Z^0 peak

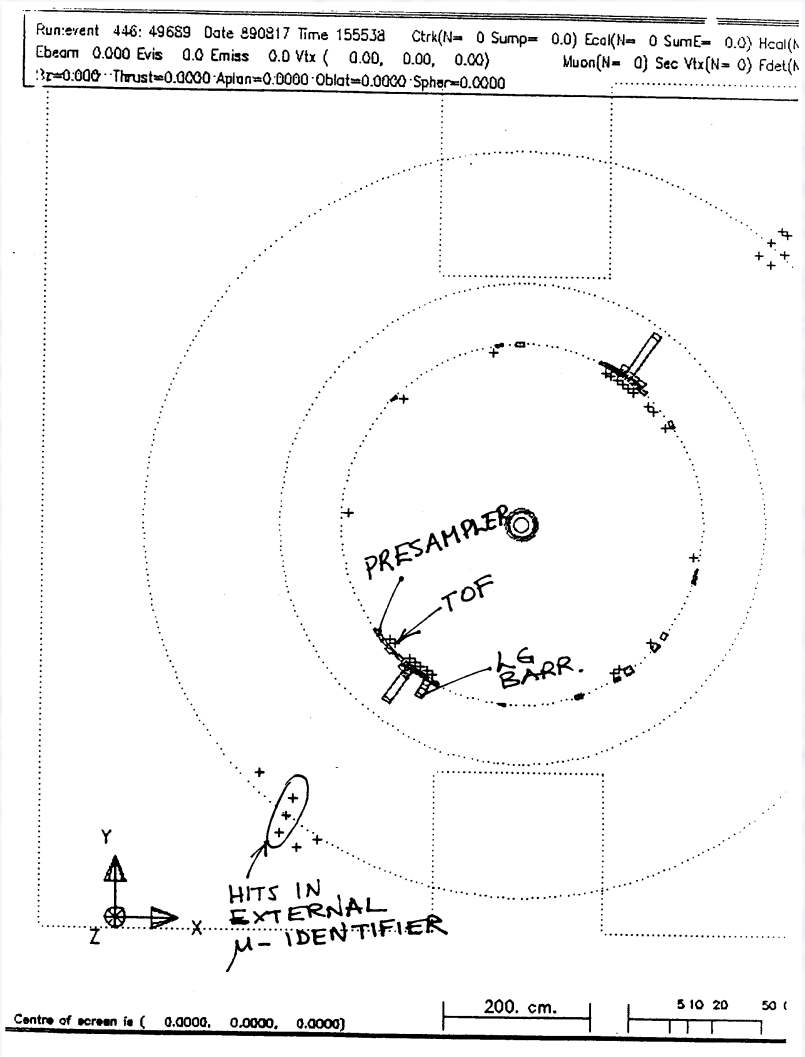
Z_0 EVENTS

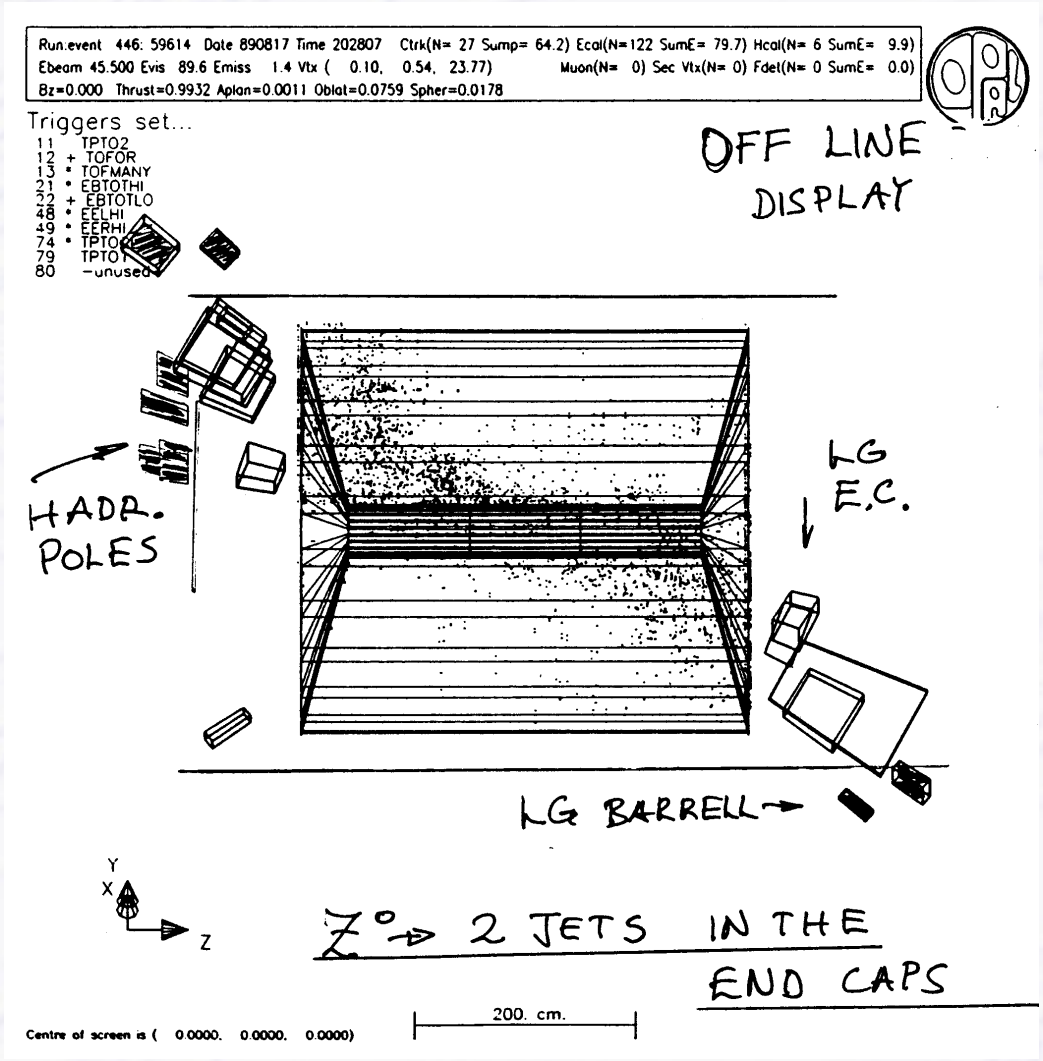
Event#	JET	Online Filter Flag	
Multi-Hadron Barrel (14)			
22734	off	YES	
24038	off	YES	
28412	off	YES	
30848	off	YES	
31439	off	YES	
24394	off	YES	
49689	ON	YES	
58854	off	YES	
61050	ON	YES	
66905	ON	YES	
69177	ON	YES	
71737	off	YES	
73728	ON	YES	
81416	ON	YES	
Multi-Hadron End Cap (4)			
58496	off	no	
59614	ON	no	
74584	ON	no	
78046	ON	no	
E+ E- (2)			
53726	off	YES	
61019	ON	YES	
TAU+ TAU- (1)			
60155	ON	no	



Pilot Run – Detectors Working

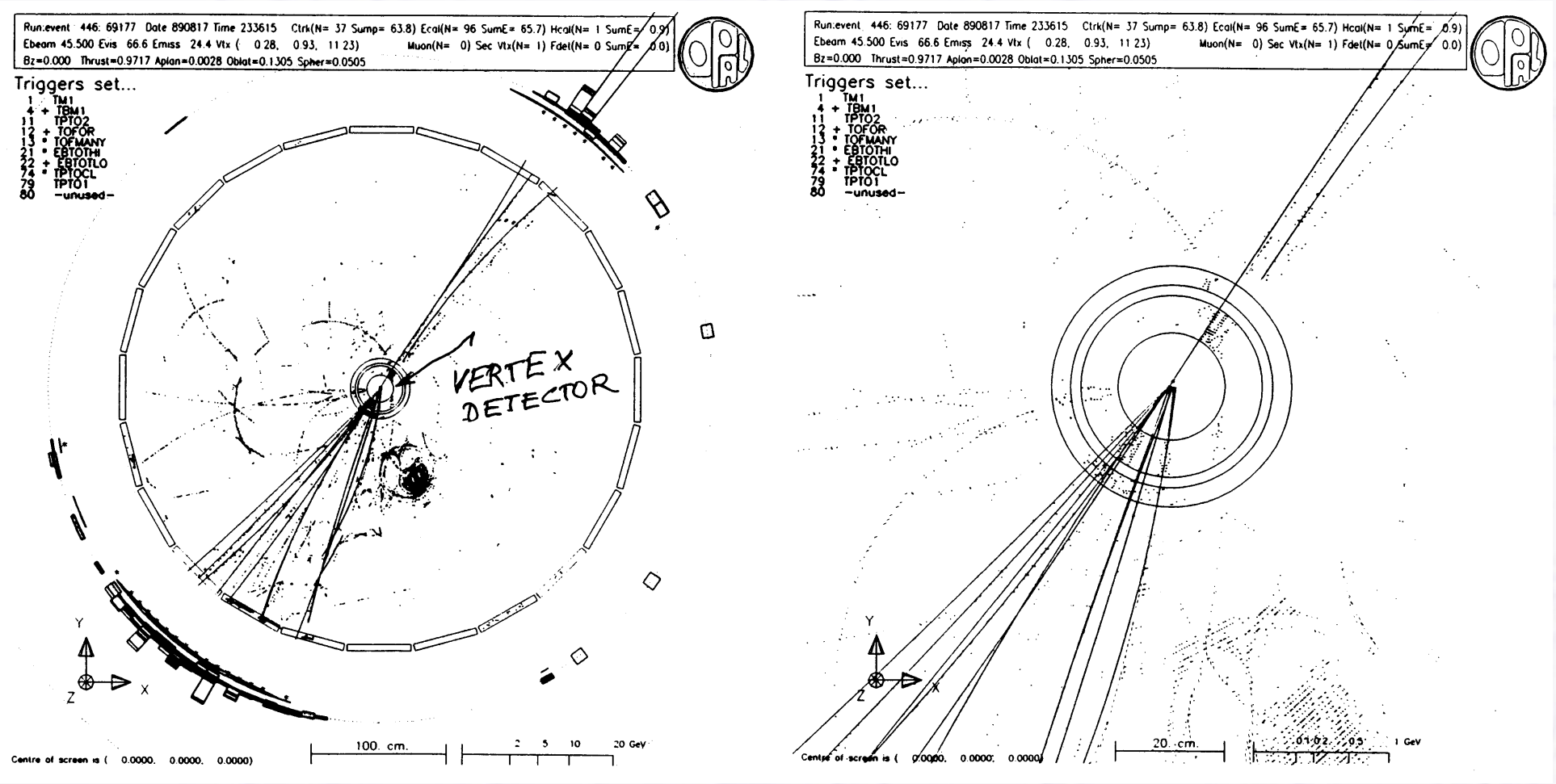
- Calorimeters, Muons, Endcap working...



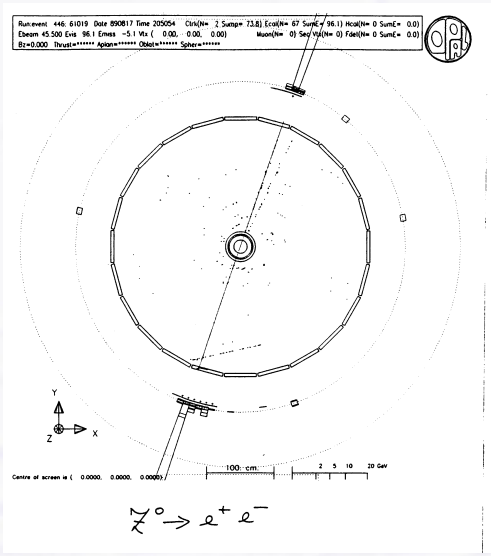


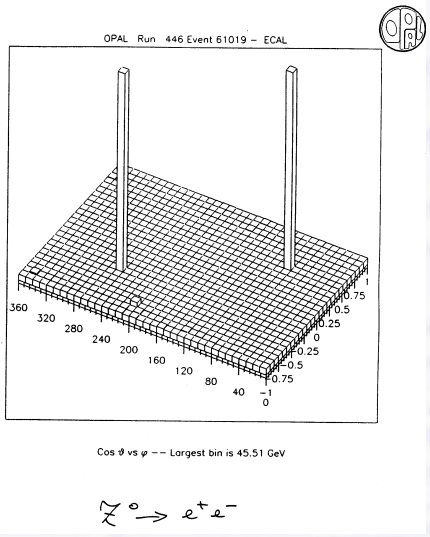
Pilot Run – Detectors Working

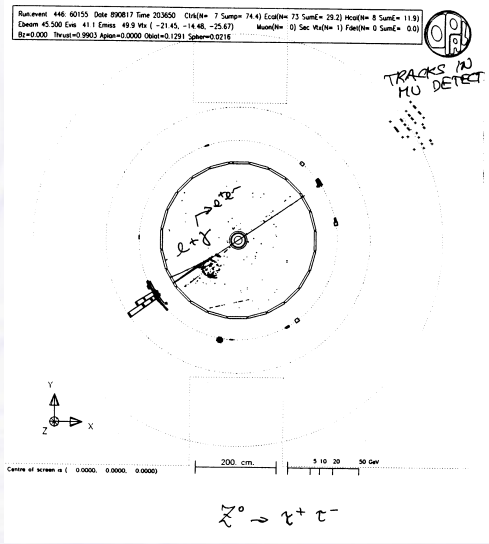
- Also tracking...

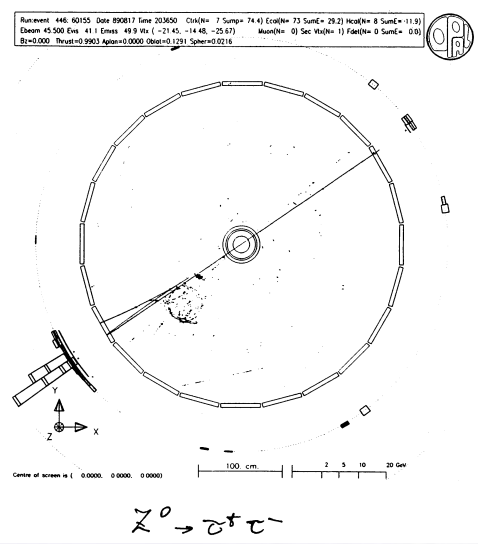


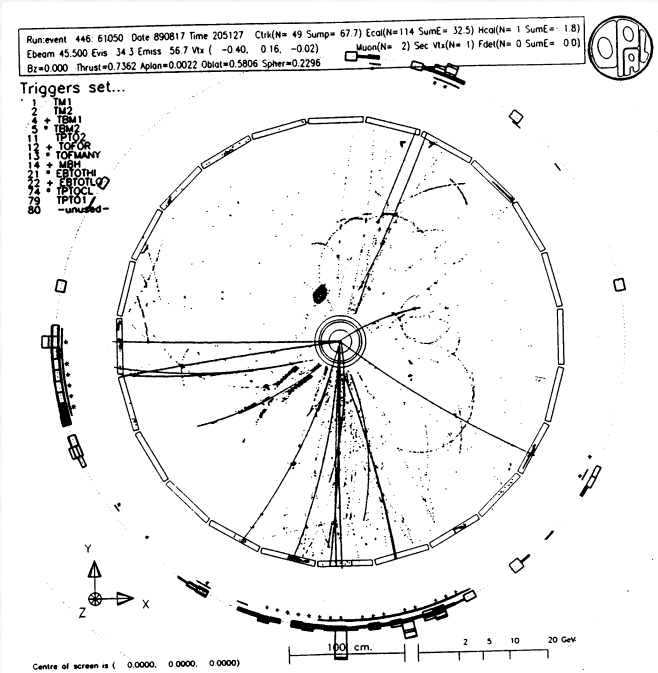
Nice Events

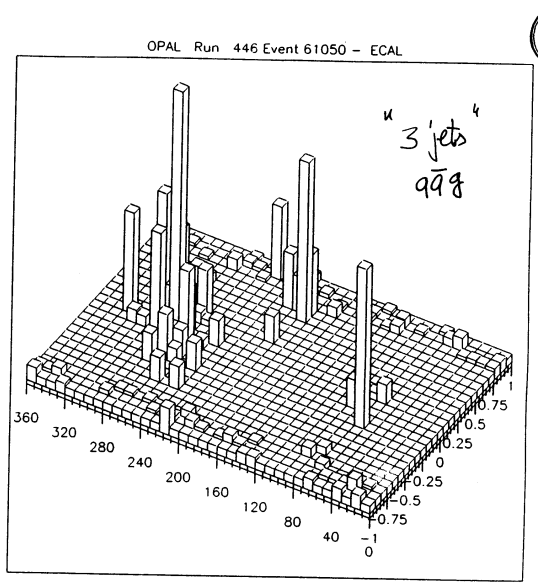

Z° → e⁺e⁻


OPAL Run 446 Event 61019 – ECAL
Cos ϑ vs φ -- Largest bin is 45.51 GeV
Z° → e⁺e⁻


TRACKS IN MU DETECT
Z° → τ⁺τ⁻

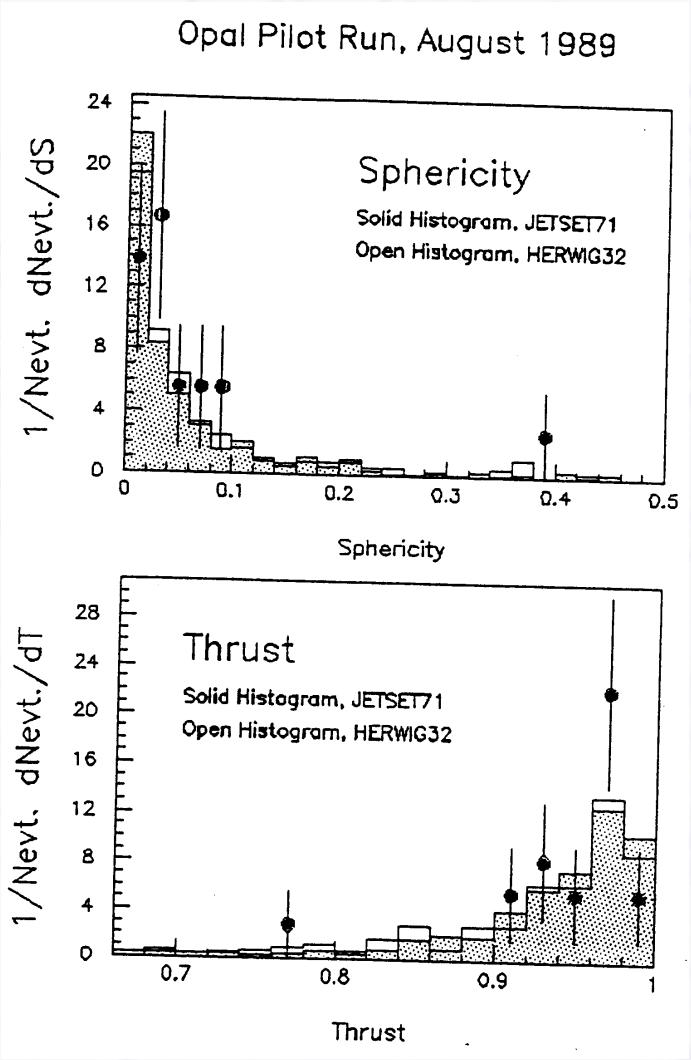

Z° → τ⁺τ⁻

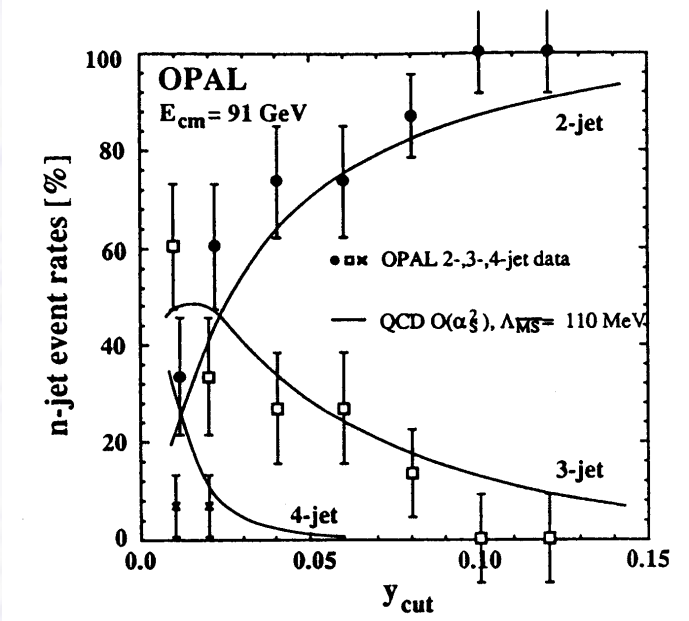

Triggers set...
Z° → qq̄g


OPAL Run 446 Event 61050 – ECAL
3 jets
qq̄g
Cos ϑ vs φ -- Largest bin is 3.40 GeV

First Physics with 18 Multihadrons

- **Event Shapes + QCD**





y_{cut}	# of 3-jets observed	# of 3-jets expected
.04	4	5.2
.06	4	3.6
.08	2	2.6
.10	0	1.9

More than 10 Years later...