The TASSO Experiment – Exploring the strong and the weak side of nature.

Saxon-Fest, Glasgow, May 30, 2008.

E.Lohrmann, Universität Hamburg

Volume 83B, number 2 PHYSICS LETTERS 7 May 1979

PROPERTIES OF HADRON FINAL STATES IN e^+e^- ANNIHILATION AT 13 GeV AND 17 GeV CENTER OF MASS ENERGIES

TASSO-Collaboration

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Received 12 March 1979

We have observed e^+e^- hadrons at C.M. energies of 13 GeV and 17 GeV at PETRA using the TASSO detector. We find R(13 GeV) = 5.6 ± 0.7 and R(17 GeV) = 4.0 ± 0.7. The additional systematic uncertainty is 20%. Comparing inclusive charged hadron spectra we observe scaling between 5 GeV and 17 GeV for $x = p/p_{beam} > 0.2$; however the 13 GeV cross section is above the 17 GeV cross section for smaller x. This may be due to copious $b\bar{b}$ production. The events become increasingly jet like at high energies as evidenced by a shrinking sphericity distribution with increasing energy.

For footnotes, see next page.

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Abbildung 1: The first TASSO-publication

The PETRA Storage Ring

circumference 2304 m

max. energy/beam 23.4 GeV

luminosity $2 \cdot 10^{31}\, cm^{-2}\, s^{-1}$

approved Oct. 1975

end of construction 1978

end of operations 1986

Minister Hans Matthöfer from the BMFT made a decision.

Investment cost 35 Mio £

No additional personnel.

The PETRA Project

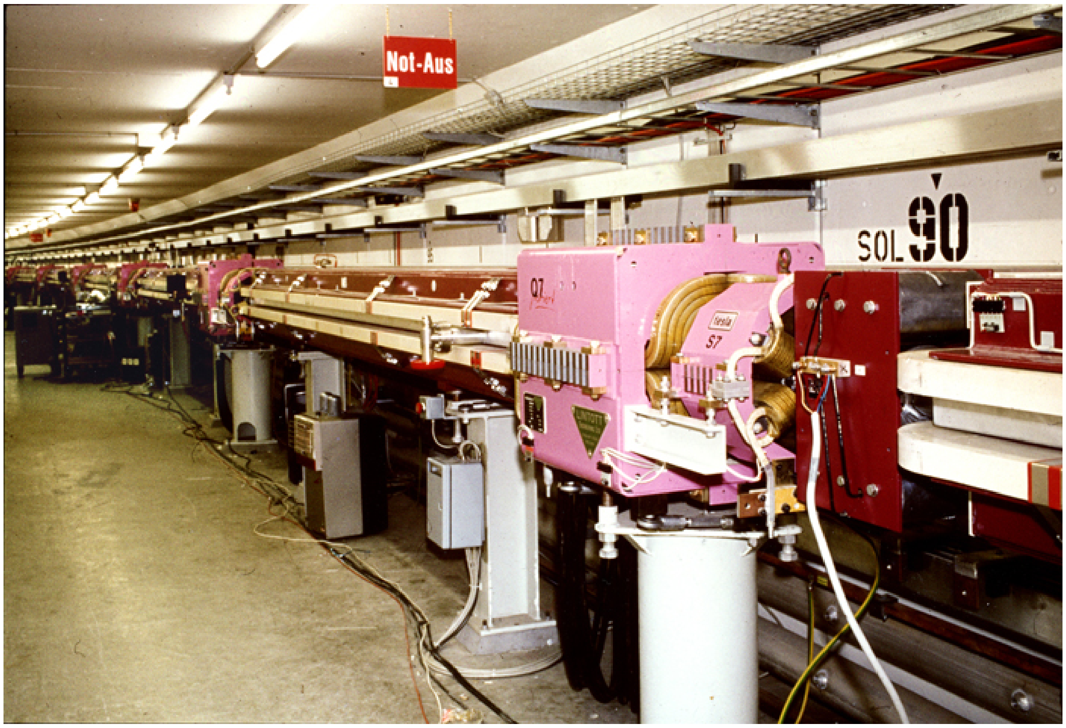
Abbildung 2: Professor G.-A.Voss

How to build a large project with a lack of personnel, below cost, and ahead of schedule?

- No project leaders, no individual budgets.
- Weekly meetings, open to all to discuss status, last no longer than 2 h.
- Aims: Make all efforts to save time and money.
- At end of meetings: 'We decide'.

Finally, PETRA was ready at 90% of the cost and almost one year ahead of schedule, after 2 1/2 years.

PETRA Tunnel



The TASSO Experiment
Preparatory Meeting Frascati March 1976

Proposal
for
A LARGE 4π MAGNETIC DETECTOR FOR PETRA

RWTH Aachen

Universität Bonn

DESY

Universität Hamburg

Imperial College London

Universität Mainz

Oxford University

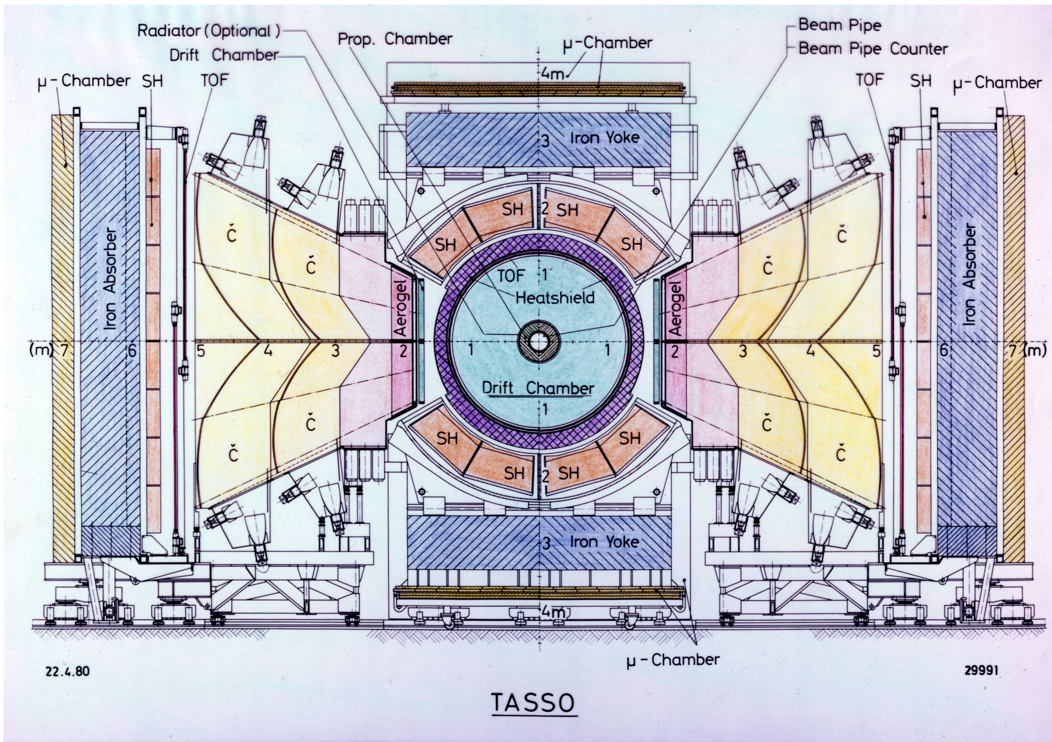
Rutherford Laboratory

Weizmann Institute

Approved October 1976

The problem of PETRA running costs.

TASSO



Radiator (Optional)
Drift Chamber
Prop. Chamber
μ-Chamber
Beam Pipe
Beam Pipe Counter
μ-Chamber
SH
TOF
TOF
SH
μ-Chamber
4m
Iron Yoke
SH
SH
SH
SH
Iron Absorber
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Aerogel
Aerogel
TOF
Heatshield
Drift Chamber
(m) 7
6
5
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7 (m)
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Iron Yoke
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μ-Chamber
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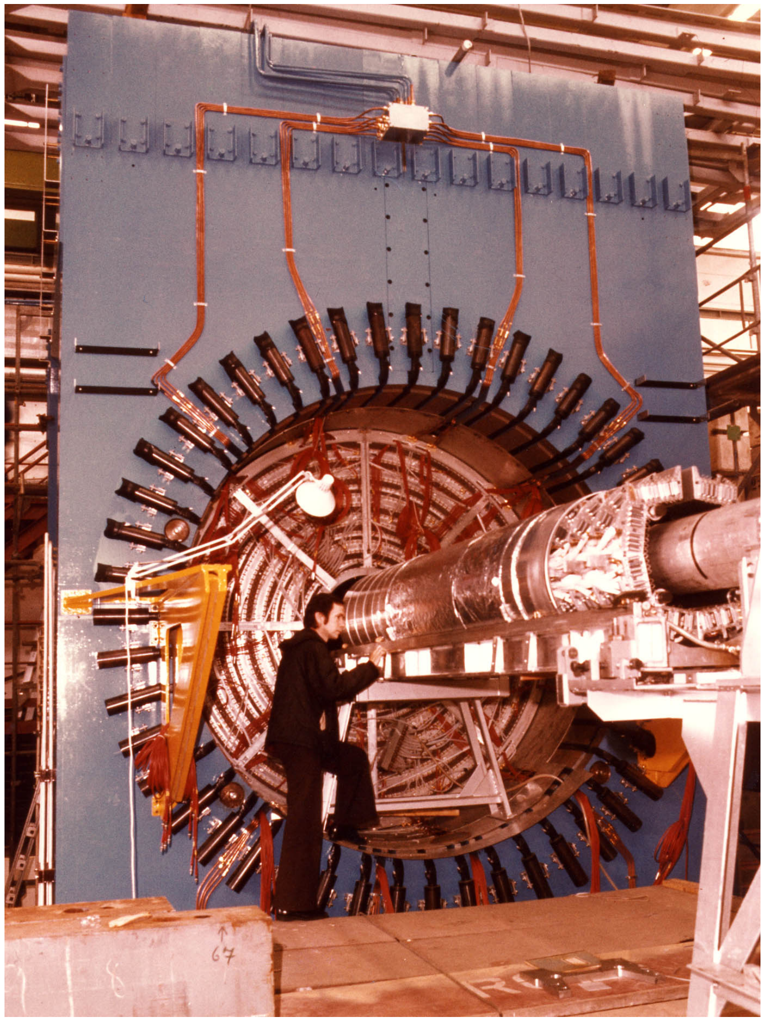
TASSO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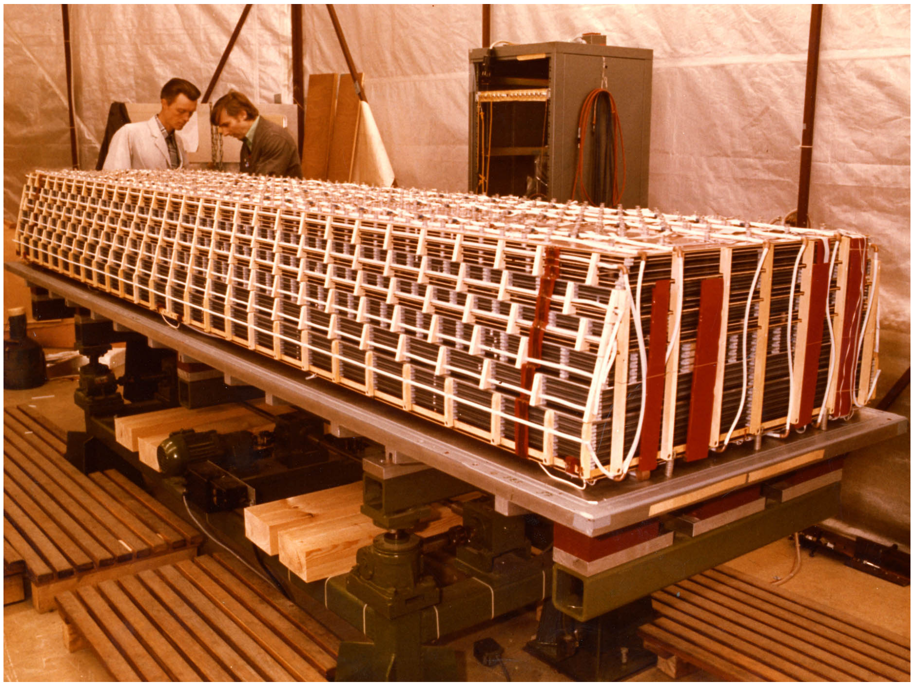
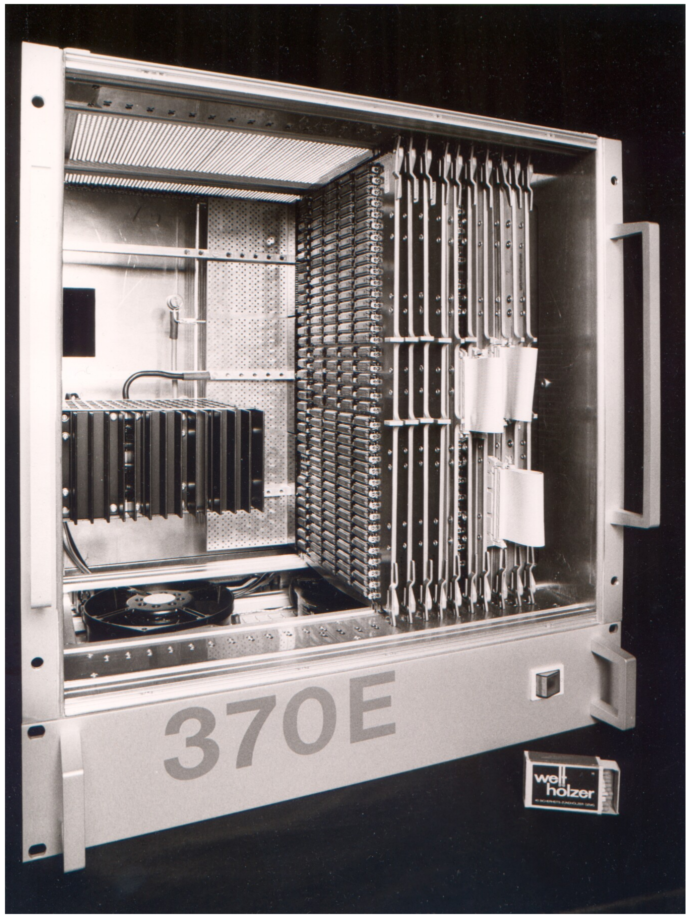


The Tasso control room



The gluon discovery

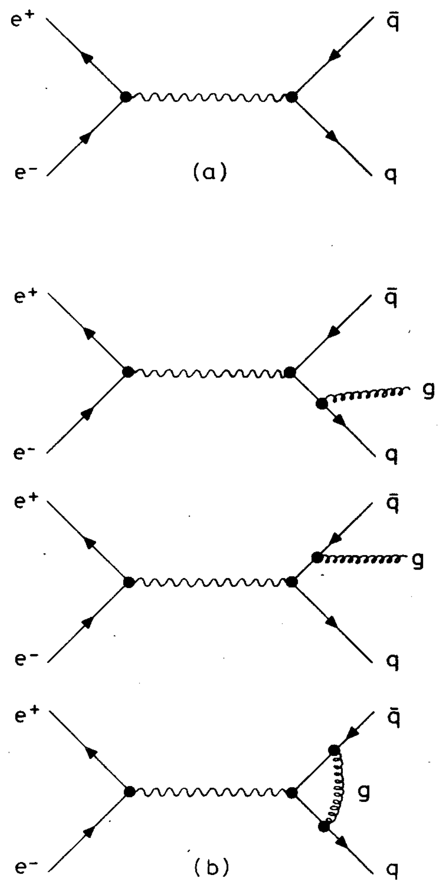


Fig. 1

J.Ellis, M.K.Gaillard and G.G.Ross

P.Hoyer et al.

Sau Lan Wu and G.Zobernik

The publication

Volume 86B, number 2 PHYSICS LETTERS 24 September 1979

EVIDENCE FOR PLANAR EVENTS IN e^+e^- ANNIHILATION AT HIGH ENERGIES

TASSO Collaboration

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Received 29 August 1979

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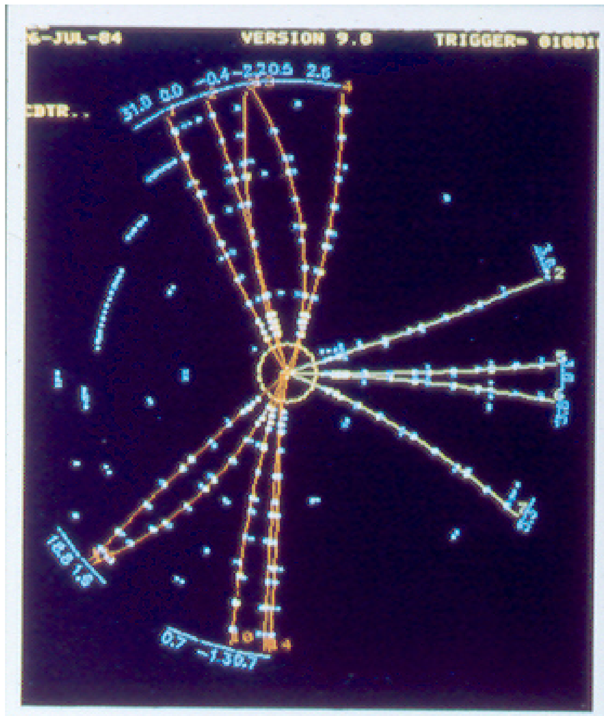
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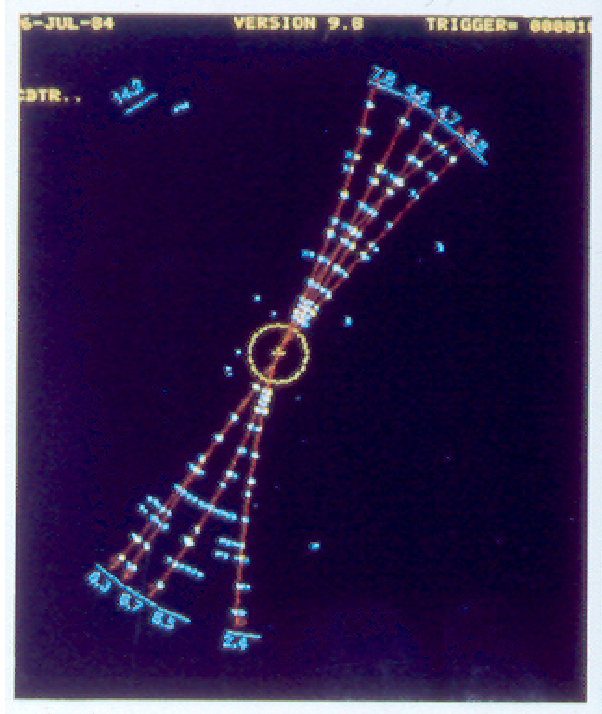
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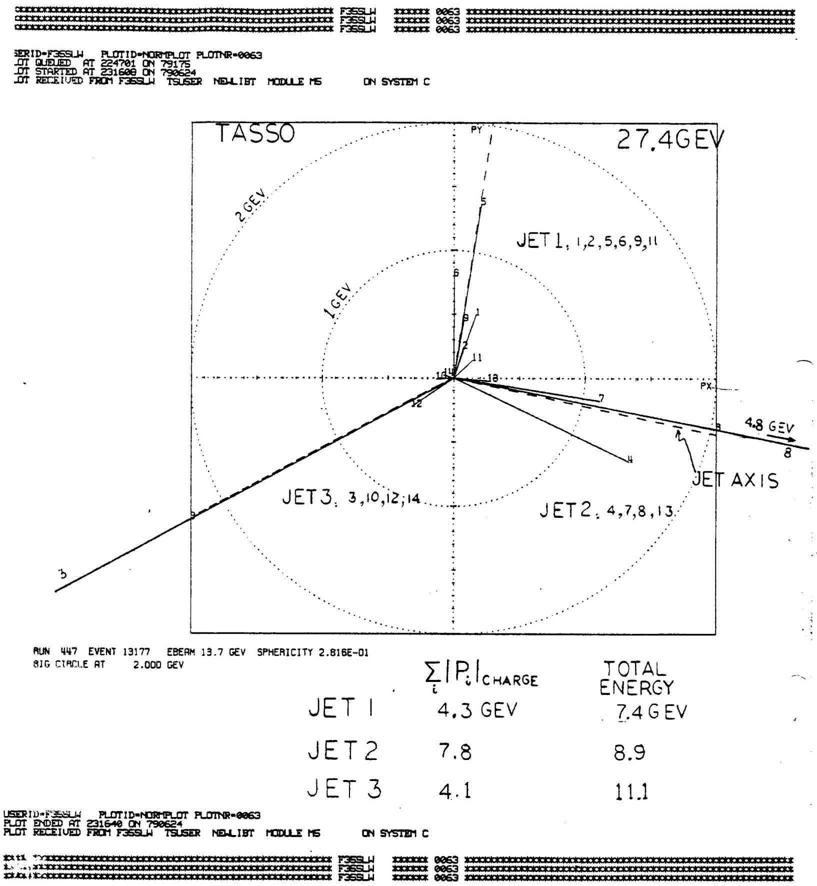
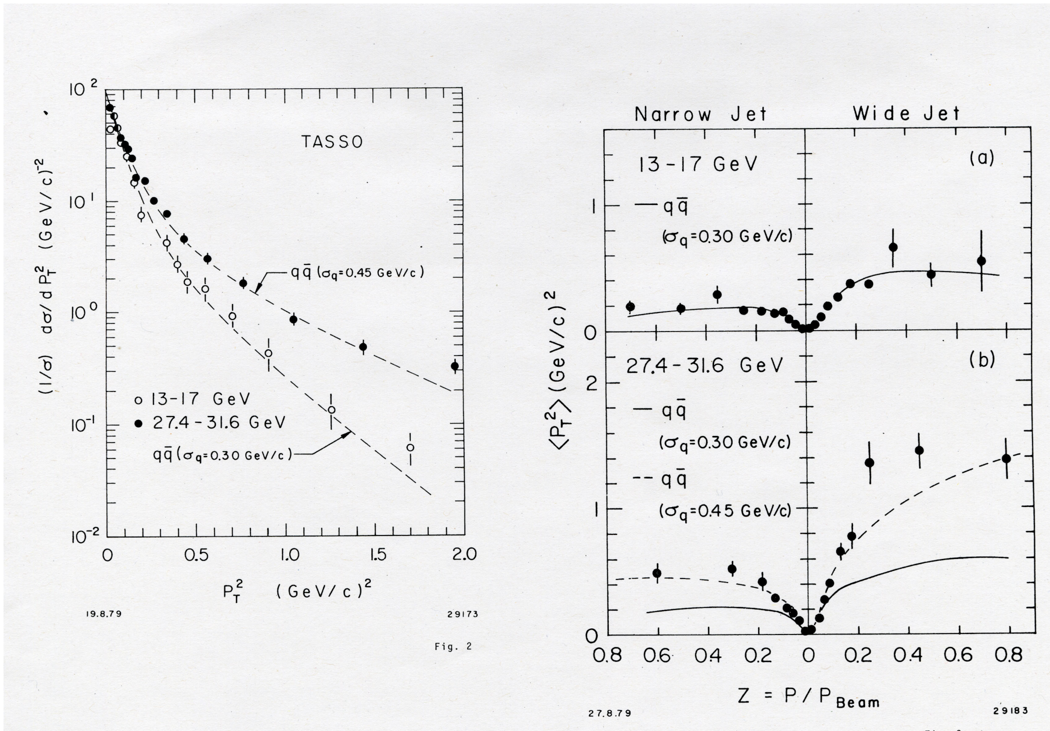
VERSION 9.8
TRIGGER=
CDTR..

The original 3-jet event





Haim Harari at the 1979 International Lepton-Photon Conference at FNAL: 'Have we really seen 3-jet events and does that confirm the existence of the gluon? ... when we look back five years from now, we will all agree that the gluon was discovered in the summer of 1979'.

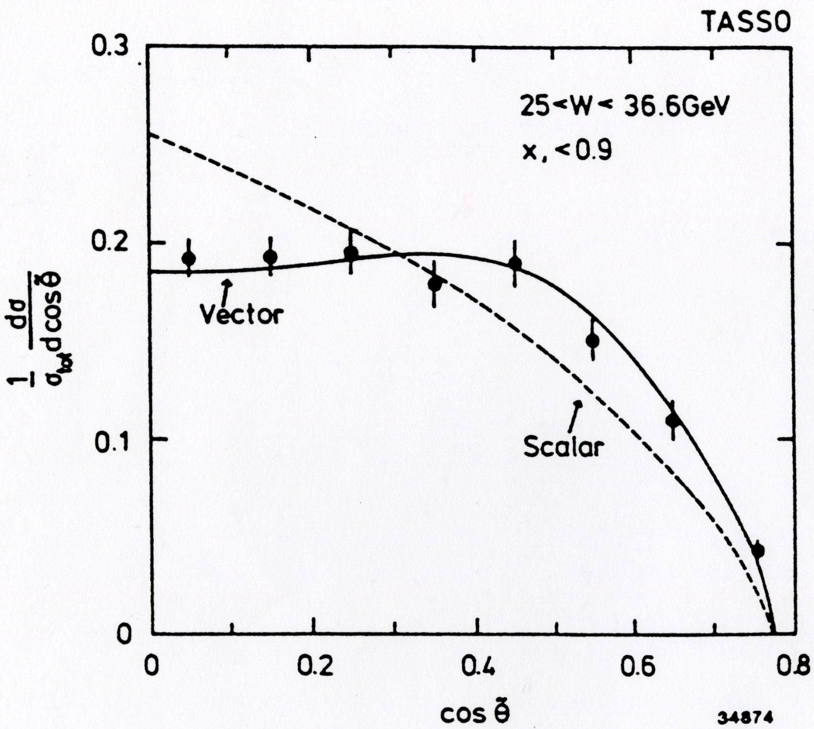


Abbildung 3: Ellis- Karliner angle

Gluon spin

Tasso has demonstrated

charge and color of quarks from total cross section.

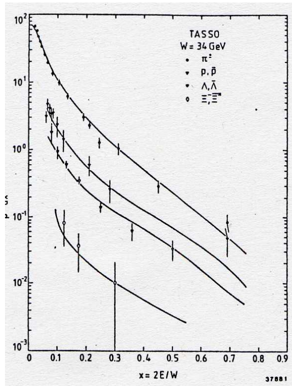
spin 1/2 of quarks from $(1 + cos^2\theta)$ distribution of 2-jet events.

existence and spin of gluon.

Measurement of the strong coupling constant.

It is proportional to the relative frequency of 3-jet events.

Result: $\alpha_s =$ **0.17** ± 0.02 ± 0.03 **(SM 0.14)**



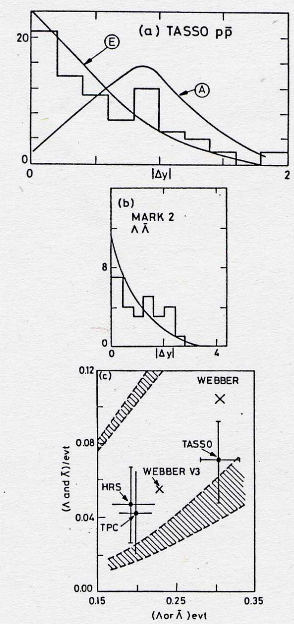


Fig 19. Meson and baryon energy spectra compared.
Fig 20. (a) Rapidity gap - $p\bar{p}$ (0.4< p< 1.2 GeV/c) compared to models (A) and (E)
(b) $\Lambda\bar{\Lambda}$ rapidity gap
(c) $\Lambda\bar{\Lambda}$ single and pair rates. Lower shaded band - no flavour correlation. Upper band - 100% correlation. Lund predictions (not shown) can be made near the data.

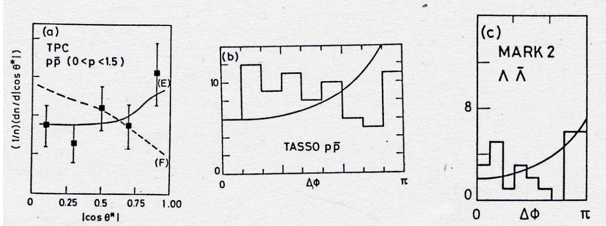


Fig 21. (a) $p\bar{p}$ correlations. Ang dist of pair wrt jet axis in pair cm (b,c) azimuthal distributions around jet axis. Curves - Model E without any mesons associated with $B\bar{B}$ pair.

D.H. Saxon, Rapporteur Talk on Jet Fragmentation at the Int. Europhysics Conf. on High Energy Physics, Bari 1985.

Vertex detector

Large contribution of UK.

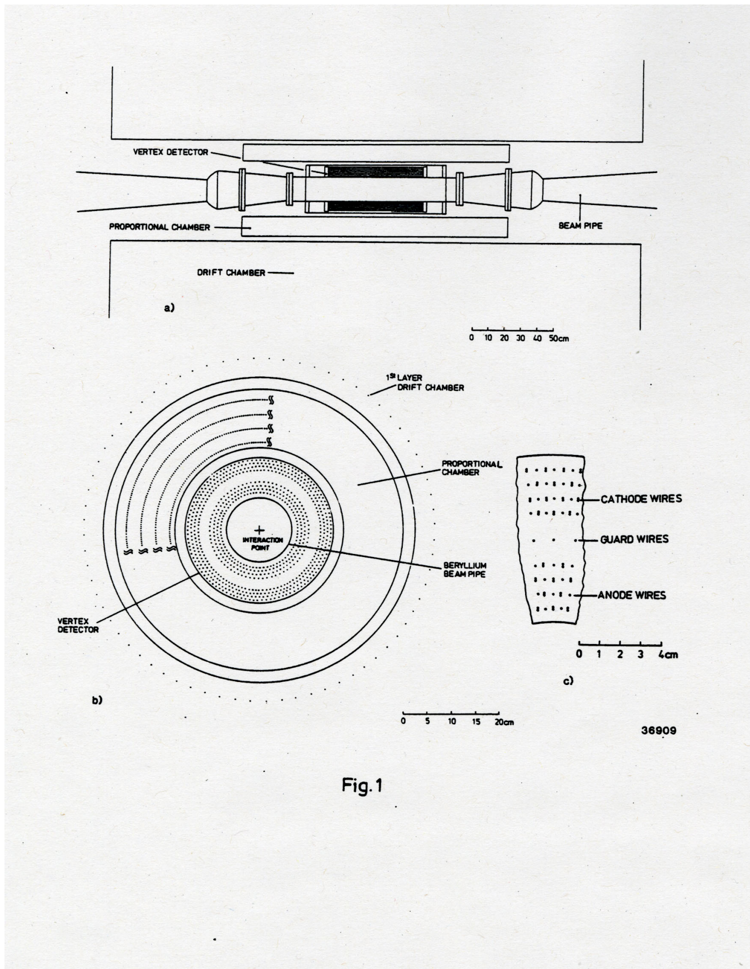


Abbildung 4: Vertex detector

Nuclear Instruments and Methods in Physics Research A234 (1985) 258–266
North-Holland, Amsterdam

THREE-DIMENSIONAL TRACK AND VERTEX FITTING IN CHAMBERS WITH STEREO WIRES

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Received 2 May 1984 and in revised form 10 September 1984

A formalism has been developed, and used in the TASSO experiment, for track fitting and geometrical vertex fitting in a uniform magnetic field. A two-dimensional fit, suitable for many detectors, has been extended into three dimensions in the case of cylindrical drift chambers with small-angle stereo measurements. Error matrices are calculated which are suitable for input to subsequent calculations. Multiple scattering is approximated by a model.

1. Introduction

In a previous paper, we have described three-dimensional track and vertex fits suitable for use in a detector with parallel measuring planes, in the presence of a very inhomogeneous magnetic field [1]. In this work, some of the techniques developed there are used in a simpler but more common situation, an array of drift and proportional chambers in a uniform magnetic field parallel to the sense wires, where the third-dimension information is provided by small angle stereo layers. This method has been applied to the TASSO detector [2], in particular to the measurement of the tau lifetime [3].

With the precision achieved in the TASSO vertex detector ($\lesssim 100$ μm) [3,4] it is necessary to take some account of multiple scattering in vertex fits. This was done by means of a simple model, in which the material of the detector was lumped together into a single scattering cylinder. The validity of the derived error matrix was checked by Monte Carlo methods and by studying distributions of the data.

The three-dimensional treatment is particular to the use of small angle stereo cylinders. The two-dimensional treatment is more general.

2. The detector elements

The TASSO detector is described elsewhere. The relevant elements for this work are the tracking chambers, inside the solenoid, of inner radius 135 cm and length 440 cm, which produces a field of approximately 0.5 T. Field inhomogeneities are ignored in this work.

The innermost measurements come from the vertex detector [4,5]. This surrounds a beam pipe of radius 6.5 cm, constructed of 1.8 mm thick beryllium (0.5% radiation length), to minimise multiple scattering, coated with a 15 μm thick copper layer (to reduce the synchrotron radiation background). Eight measuring layers are located at radii between 8.1 and 14.9 cm with a total of 720 channels of single hit readout. Running with an Ar/CO_2 95/5 mix at 3 bar, a precision of 90–100 μm has been obtained on isolated tracks. The total thickness of the beam pipe and detector is 0.011 radiation lengths, with an additional 0.017 radiation lengths in the outer wall. The vertex detector provides information on track azimuths (by measuring drift times) and z-coordinates (by current division). Only the azimuthal measurements from the vertex detector have been used in this work.

The cylindrical proportional chamber surrounds the vertex detector. We have used the measurements from the four anode layers located at radii of 17 to 29 cm. The wire spacing of about 3 mm results in a position accuracy of ~ 870 μm. The total material is 0.033 radiation lengths.

Outside this is the large cylindrical drift chamber [6]. This has 15 layers of cells at radii between 30 cm and 130 cm with a cell size of 3.2 cm and single hit readout with an accuracy, after corrections depending on the angle of incidence of each track, of about 220 μm. Nine of the layers have wires parallel to the beam direction (the z-axis) and six have wires at small skew angles (typically 3°). This causes the "stereo" layers to have a hyperboloidal shape,

$$r^2 = r_0^2 + z^2 \tan^2\alpha, \qquad (1)$$

where r is the (x, y) radius, r_0 the radius at $z = 0$ and α the stereo angle.

The overall length of the drift chamber is 323 cm, so that tracks at more than 38° to the beam direction go through all the layers and have up to 27 point measurements, including 6 stereo layers.

The drift chamber material is dominated by the

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(North-Holland Physics Publishing Division)

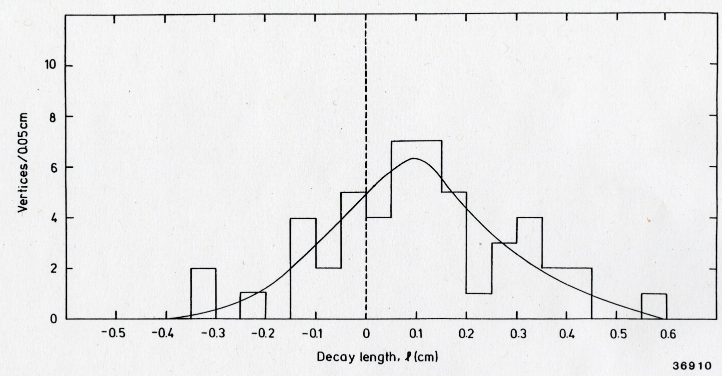
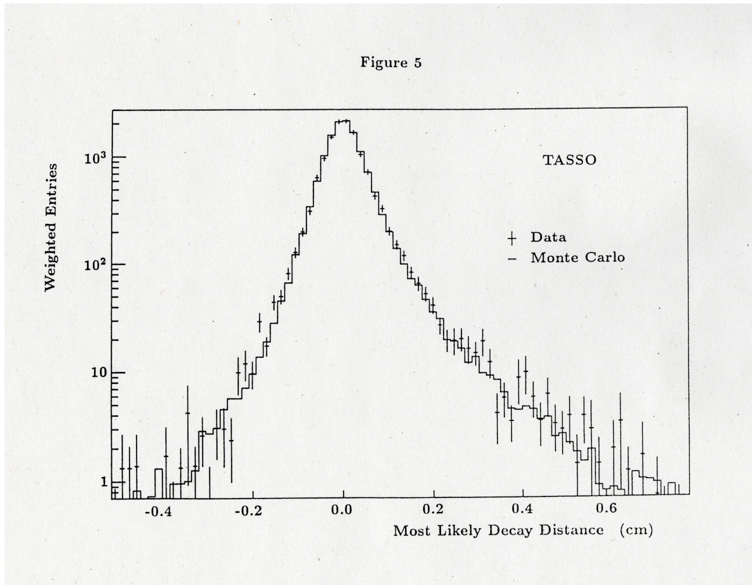


Fig.8

$$\textbf{tau lifetime} = (3.18^{+0.59}_{-0.75} \pm 0.56) \cdot 10^{-13}\ \mathbf{s}$$



b lifetime = $(1.35 \pm 0.1 \pm 0.24)$ **ps**

Testing QED and Electroweak Theory.

D.H.Saxon, Invited Talk at the IX Warsaw Symposium on Elementary Particle Physics 1986.

$e^+e^- \rightarrow \mu^+\mu^-, \tau^+\tau^-$

Interference with Z^0 Boson.

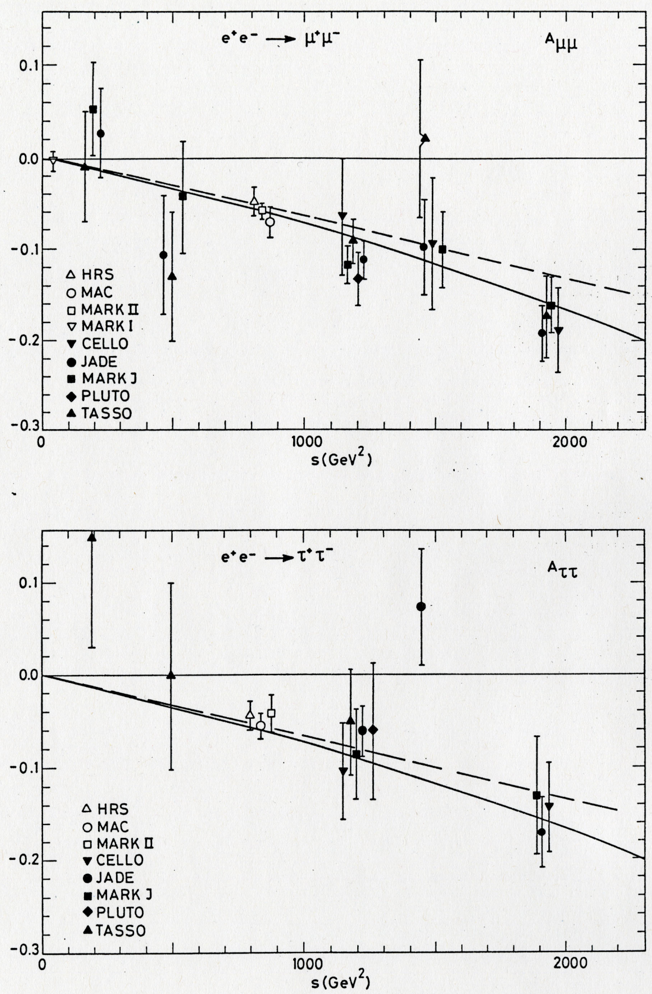


Figure 8 Measured asymmetries. Dashed line shows WS prediction for pointlike process ($m_z = \infty$). Solid line shows predictions for $m_z = 93$, $\sin^2\theta_w = 0.22$.

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Abbildung 5: Angular asymmetries as function of s

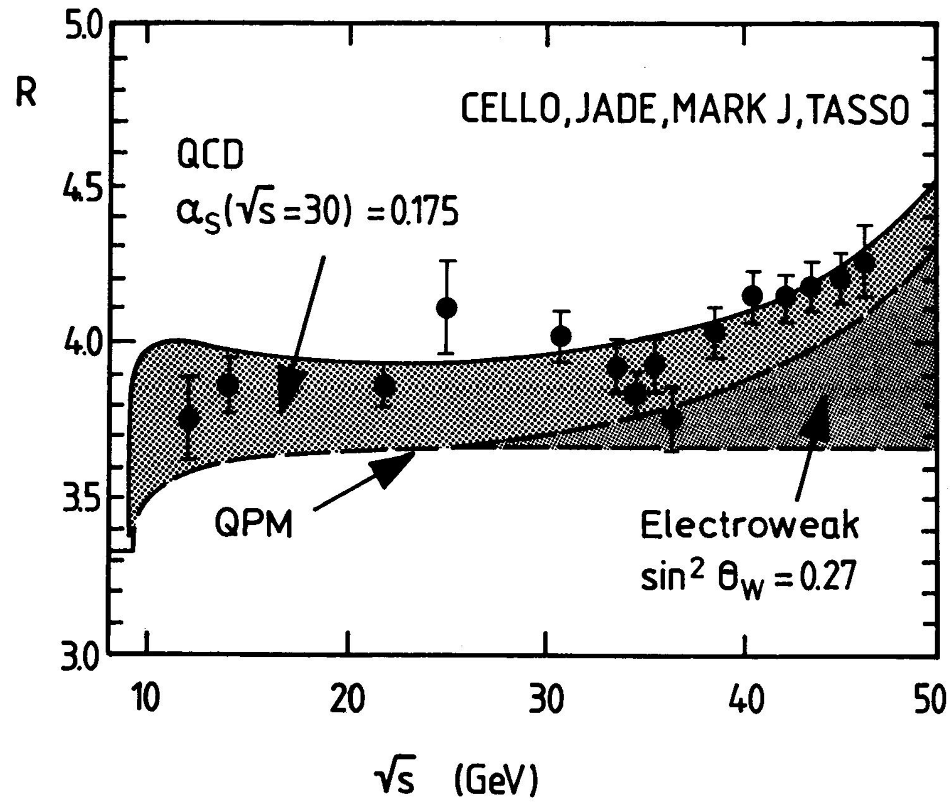

Abbildung 6: Total cross-section as function of CM energy

Most accurate test of QED to date.

Clear evidence for electroweak interference terms.

Evidence for the Z^0 Boson, 63 $< M_Z < 101$ GeV (95 % c.l.)

$g_v^2 = 0.08^{+0.07}_{-0.04}$, $g_a^2 = \mathbf{0.26} \pm 0.01$