FosterFest Oxford 11th September 2024

Brian and PETRA

First close encounter with
electrons and positrons

and with Hamburg

Albrecht Wagner, DESY and UHH

Leading up to PETRA

- While Brian was working on his PhD thesis……
- DESY, Frascati and the UK (RHEL) were competing as early as 1973 to build a large e+ e-/proton e- collider.
- On 30.11.1973 Herwig Schopper reported to the DESY Administrative Council, “that at the last meeting of the ECFA Working Group, which dealt with the long-term plans for new accelerators in Europe, plans were announced by RHEL and Frascati which aimed at building a large e+e-/pe- storage ring in these laboratories in the 1980s.“

1973 at DESY

- Schopper continued: “The conditions for the realisation of such a project are most favourable at DESY, especially as existing facilities would serve as part of the new project without any significant changes.
- The British are pressing ahead with their project with the aim that the decision on the location of a large e+e-/p e- storage ring, which would undoubtedly be made at a political level, will be taken in the course of next year.
- If DESY does not want to be eliminated from this competition from the outset, then the considerations for a long-term expansion of DESY in the 1980s must be continued. This would require a favourable statement from the Administrative Board.”

The UK Plans

- Norman McCubbin in his memoirs of Godfrey Stafford (RAL Director from 1969-1981):

"By the end of 1973 a very ambitious project had been conceived for the Rutherford site: a first phase would consist of an electron–positron collider of energy 14 + 14 GeV, to be followed later by a proton ring, of up to 200 GeV if superconducting magnets were available, for electron–proton collisions. The plan had a suitably ambitious name: Electron– Positron/Proton Intersecting Complex, EPIC. …."

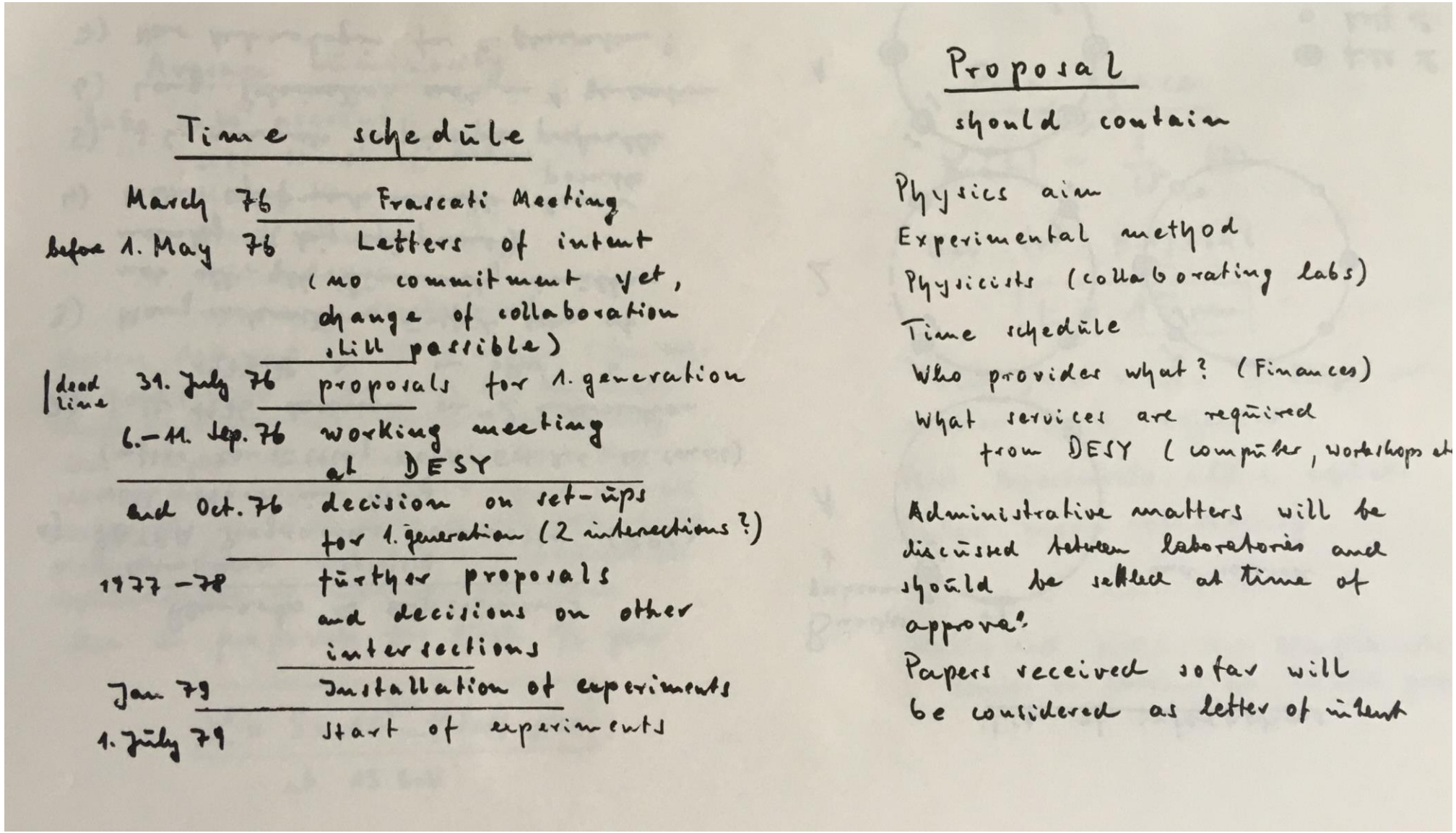
Europe and PETRA

- There was general agreement that **only one such facility should be built in Europe** and that the laboratory that took the first step in this direction would also create the best conditions for a later e-p project.”
- After J/Psi discovery in 1974 focus on e+e- storage rings

- DESY, with its experience from DORIS and the existing infrastructure, was chosen as site in 1975. That killed the EPIC proposal.
- At the same time, the international use of DESY as national lab was implemented with strong guidance from the German research ministry.

Frascati Meeting March 1976

Conclusions by
H. Schopper



Time schedule

	March 76	Frascati Meeting
before	1. May 76	Letters of intent (no commitment yet, change of collaboration still possible)
deadline	31. July 76	proposals for 1. generation
	6.–11. Sep. 76	working meeting at DESY
	end Oct. 76	decision on set-ups for 1. generation (2 intersections?)
	1977 –78	further proposals and decisions on other intersections
	Jan 79	Installation of experiments
	1. July 79	start of experiments

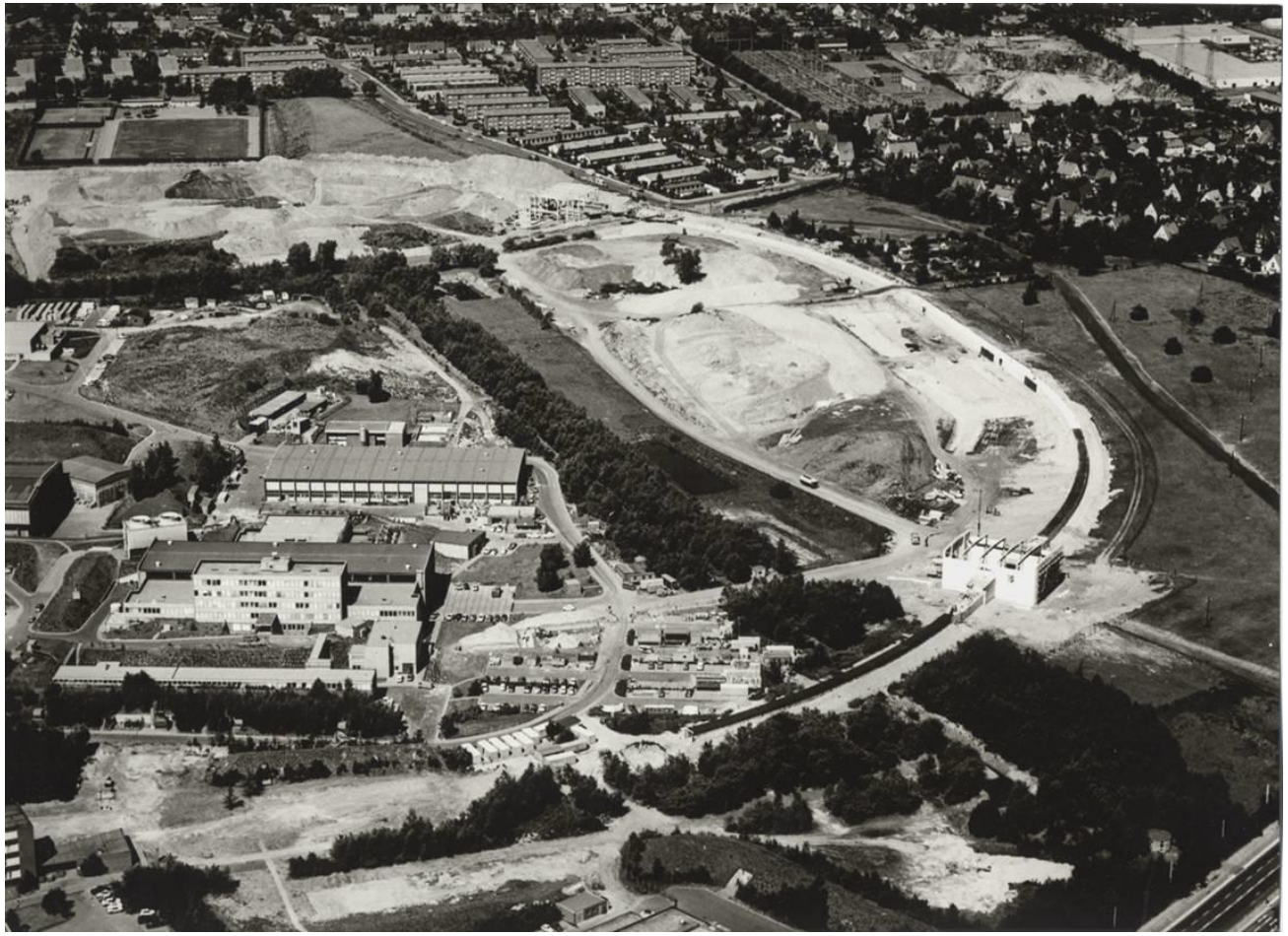
Proposal

should contain

Physics aim
Experimental method
Physicists (collaborating labs)
Time schedule
Who provides what? (Finances)
What services are required from DESY (computer, workshops et

Administrative matters will be discussed between laboratories and should be settled at time of approval
Papers received so far will be considered as letter of intent

PETRA 1976 - 1986



Construction started in 1976

The project advanced very fast

Construction completed in 1978, > 12 months ahead of schedule (and 20 M under budget of 100 MDM)

First stored beam in July 1978

First Bhabhas seen end Nov. 78

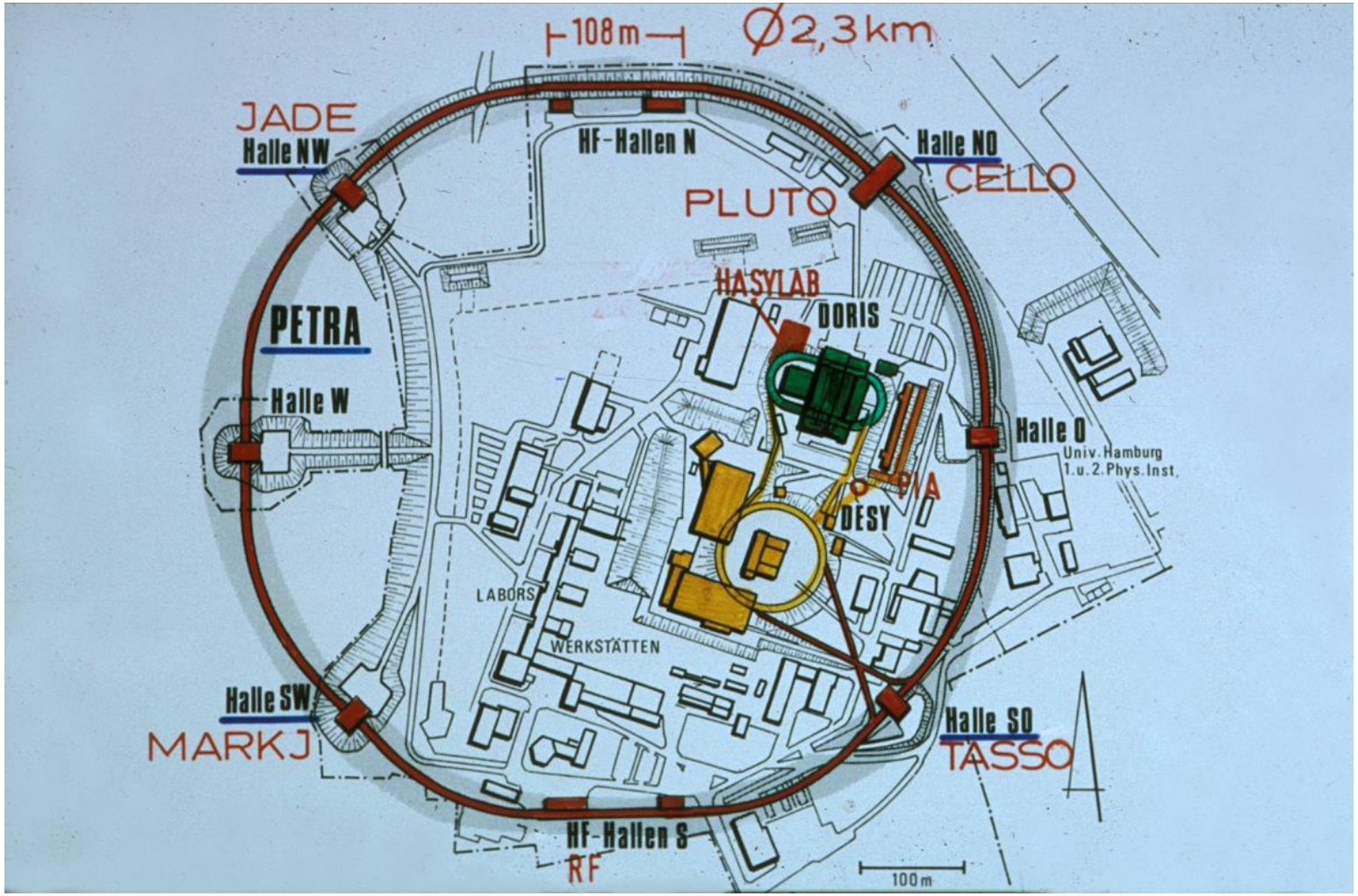
With PETRA DESY became international

The Experiments

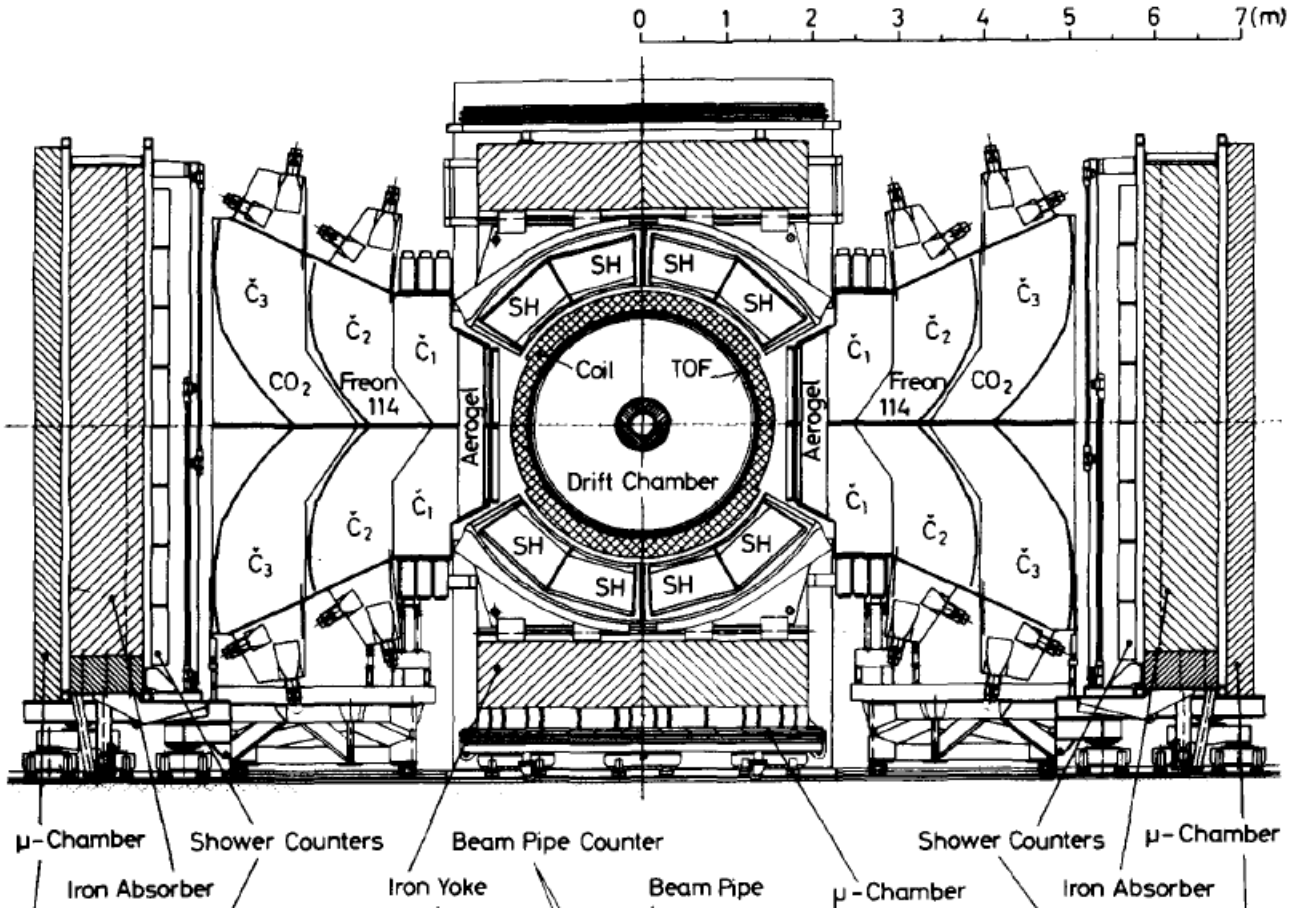
Five experiments approved
CELLO, JADE,
Mark J,
PLUTO, TASSO

There were two UK teams involved involved:

South and North



The TASSO Detector Layout

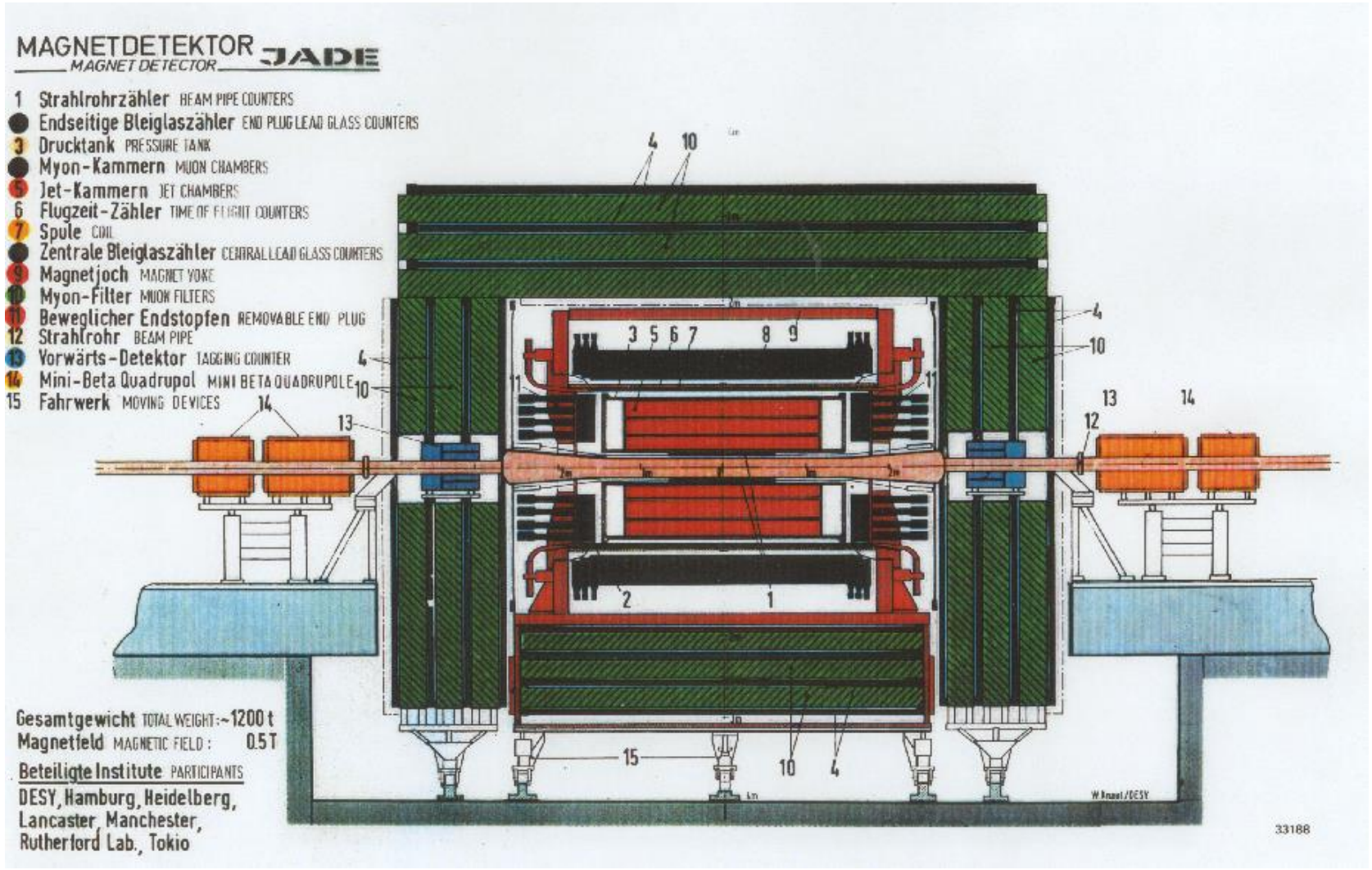


Essential features:
- Hadron arms
- Large solid angle
- Good tracking
- Muon detection

UK Groups

Imperial
Oxford
RAL

The JADE Detector Layout



Essential features:

- Large solid angle
- Excellent tracking
- Good energy measurement
- Muon detection

UK Groups

Lancaster
Manchester
RAL

Brian at PETRA - 1

- Brian, in 1978, having finished his PhD got a position for 3 years in the group of **David Saxon** at **RAL**

- In Nov 1978 he moved to HH, lived in the RAL flat at the DESY Guesthouse, it drizzled all the time

Brian at PETRA - 1

- Worked first on the TASSO hadron arms
- Moved in early 1979 on to online DAQ under David Quarry, with Chris Youngman with much time in control room
- Brian moved on to important Monto Carlo work, with Steve Lloyd, Ian Proudfoot, Chris Youngman, called “Simple”, originally designed for the drift chamber

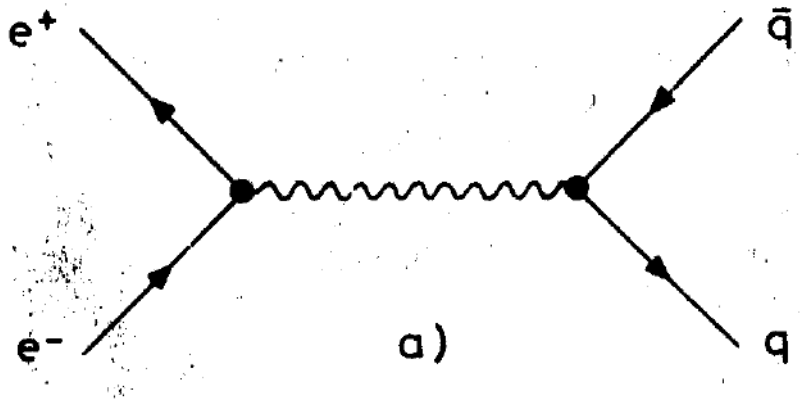
Physics: Proposed Programme at PETRA

- Measurement of magnitude and energy dependence of hadronic cross section
- Search for new quarks and leptons
- Measurement of magnitude of electroweak interference
- Study of hadronic final states, prove existence or non-existence of jets
- Is QED correct at high energies?
- Study decays of heavy quarks
- Study photon-photonon interactions

…but nothing about gluons

Predictions for e+e- -> Hadrons

In 1979 it was widely accepted that e+e- -> hadrons proceeded via



The final state hadrons would appear in two well collimated back to back jets of hadrons with small transverse momentum and growing momenta parallel to the jet axis

Discovery of Gluon

Nobody thought seriously of gluon jets until a seminal paper appeared:

J. Ellis, M. K. Gaillard and G. G. Ross, Nucl. Phys. B111 (1976) 253

First to suggest the existence of hard gluon bremsstrahlung leading to gluon jets:

“Motivated by the approximate validity of the naive parton model and by asymptotic freedom, we suggest that hard gluon bremsstrahlung may be the dominant source of hadrons with large momenta transverse to the main jet axes. This process should give rise to three-jet final states.”

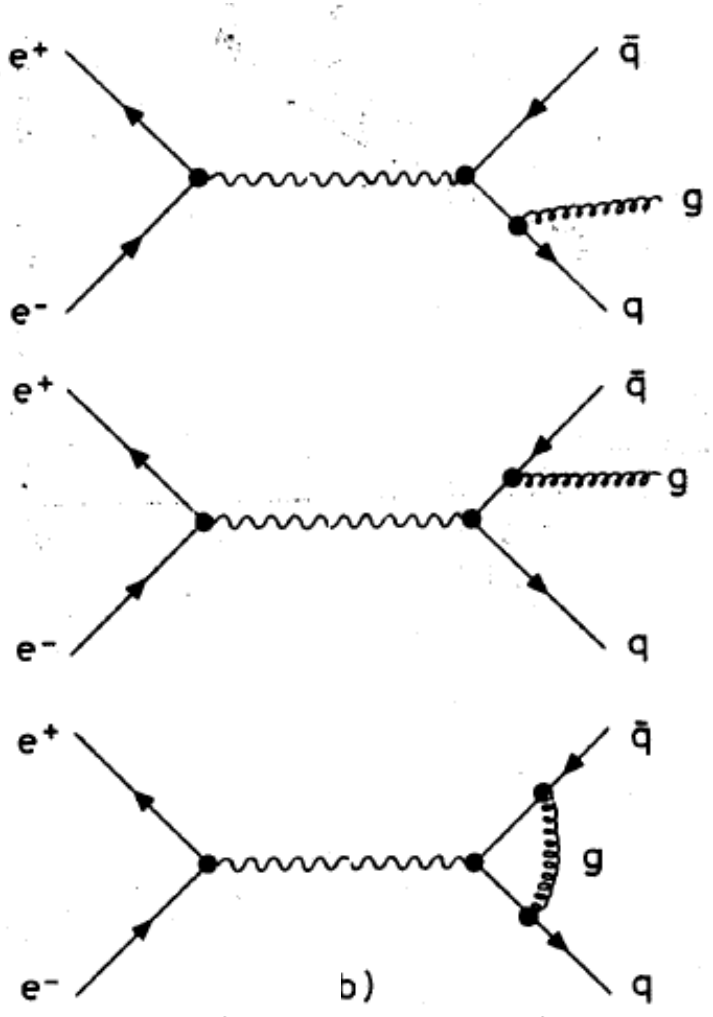
The title of this paper was:

“Search for Gluons in e^+e^- Annihilation” !

Discovery of Gluon

The basis of the prediction was field theory, i.e. that the outgoing quarks radiate field quanta (gluons)

The probability for radiation is ~ $a_s(q^2)/p$, which at PETRA energy is ~ 10%.



Discovery of Gluon

Experiments were facing two major problems:

- How to distinguish gluon bremsstrahlung from the production of heavy quarks, which would be leading to jet broadening also.

- Even if this problem could be solved, would one be able to see and verify the perturbative QCD signatures directly, in view of the strong nonperturbative effects that had totally dominated all the measured distributions until then.

Discovery of Gluon

Among several important papers inspired by the ideas of Ellis et al, the following two were particularly relevant :

- *P. Hoyer, P. Osland, H. G. Sander, T. F. Walsh and P. M. Zerwas, Nucl. Phys. B161 (1979) 349*

-> produce detailed predictions of transverse momentum distributions and many other observables in e^+e^- -> hadrons.

- *S. L. Wu and G. Zobernig, Z. Physik C (Part. and Fields) 2 (1979) 107*

-> designed a fast algorithm to detect, present and investigate planar events and three-jet topologies in the data.

Experimental Implications of Gluon Bremsstrahlung

The average transverse momentum with respect to the jet axis should increase with energy. As $a_s(q^2) < 1$ at PETRA, only one jet should broaden

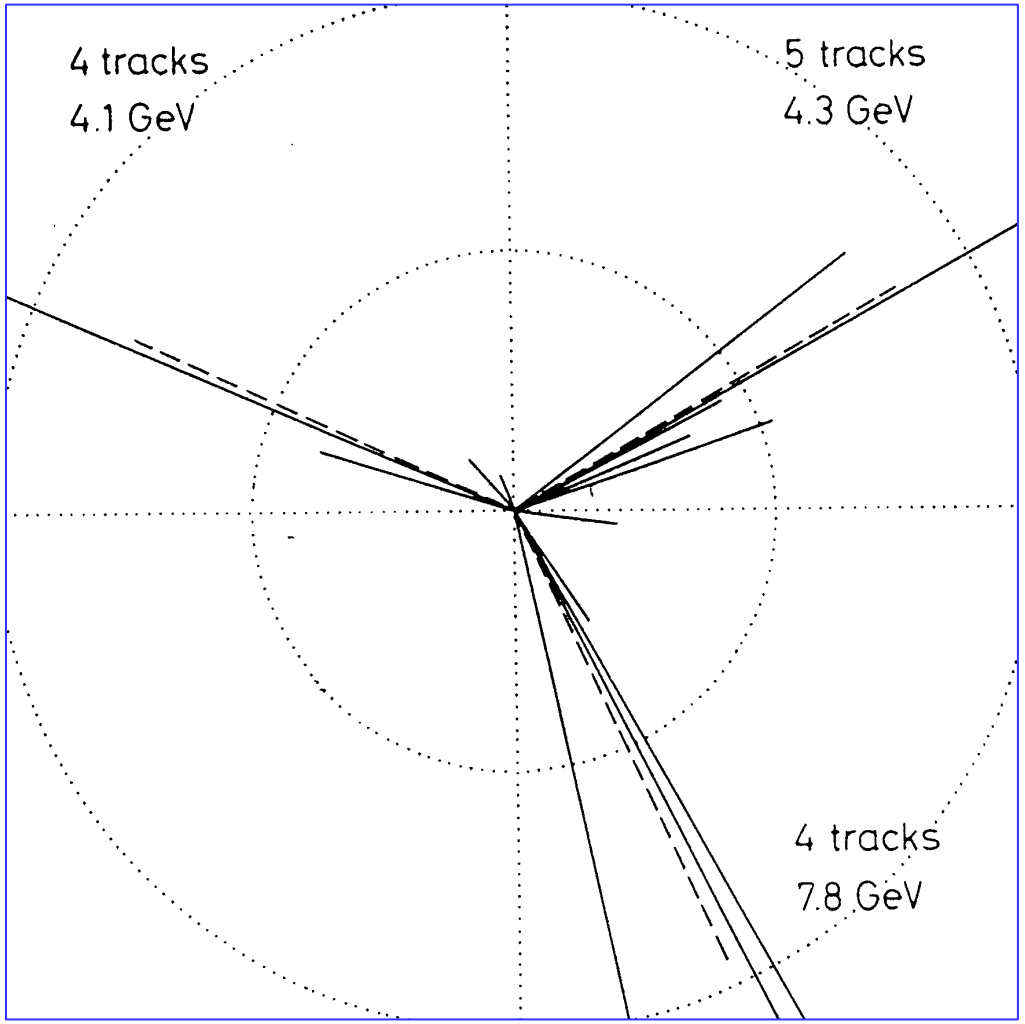
Hadrons from q-fragmentation should be uniformly distributed around the jet axis

The $q\bar{q}g$ topology defines a plane

Presumably also gluons fragment into hadrons with limited transverse momentum. Therefore the planarity is retained by the hadronic final state

-> One should observe planar events with small transverse moment in the event plane. A small fraction of events should have a three jet structure.

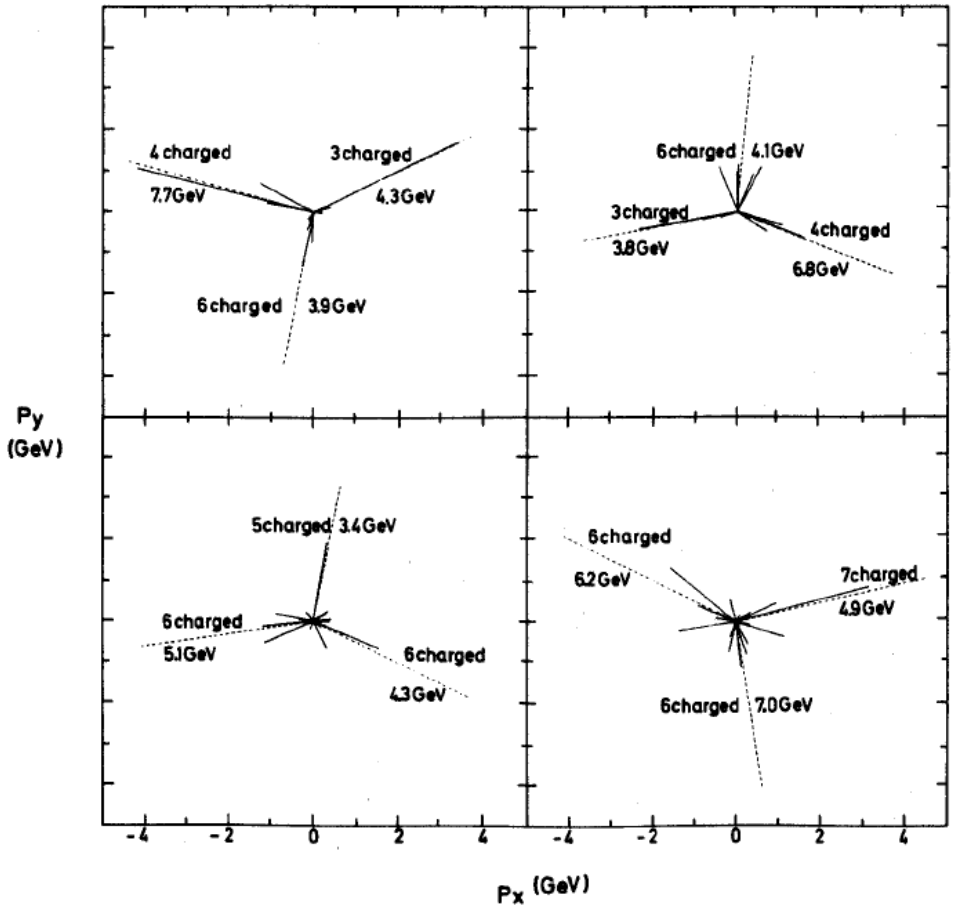
3-jet Events

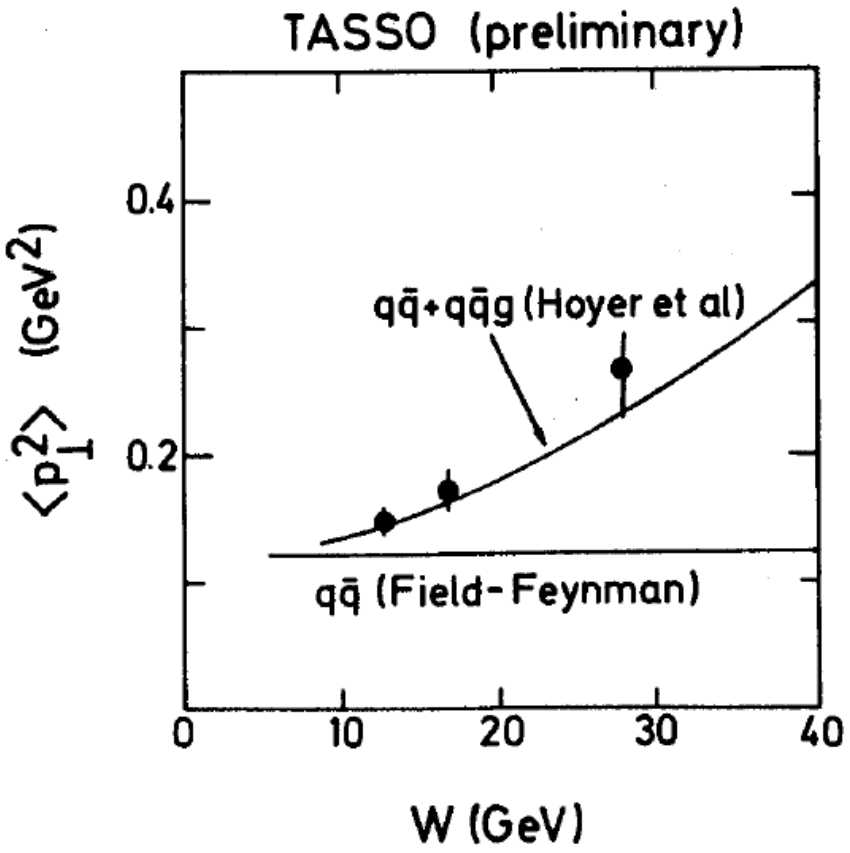


B. Wiik, Bergen, 18 June 1979

3-jet Events

More events at EPS Geneva conference - with an estimated qq background of 0.3.

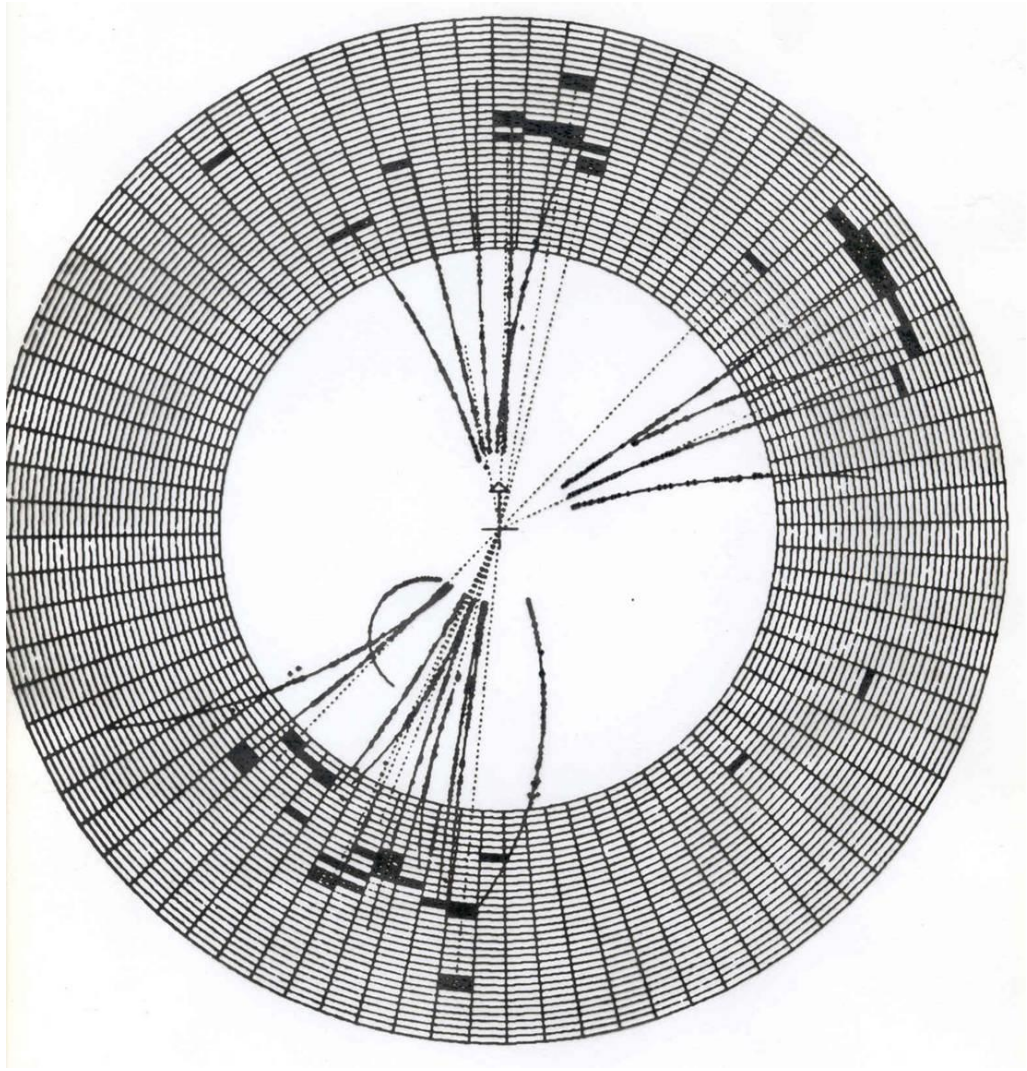




Paul Soeding, EPS Geneva conference, 27 June – 4 July 1979

Particle and Energy Flow

Jade Experiment



Lepton Photon Symposium 1979

Fermilab 23– 29 August 1979

The conclusion of all four PETRA experiments (JADE, Mark J, PLUTO and TASSO) was very similar.

To cite Haim Harari from his summary talk in 1979:

5.3. Gluons Exist

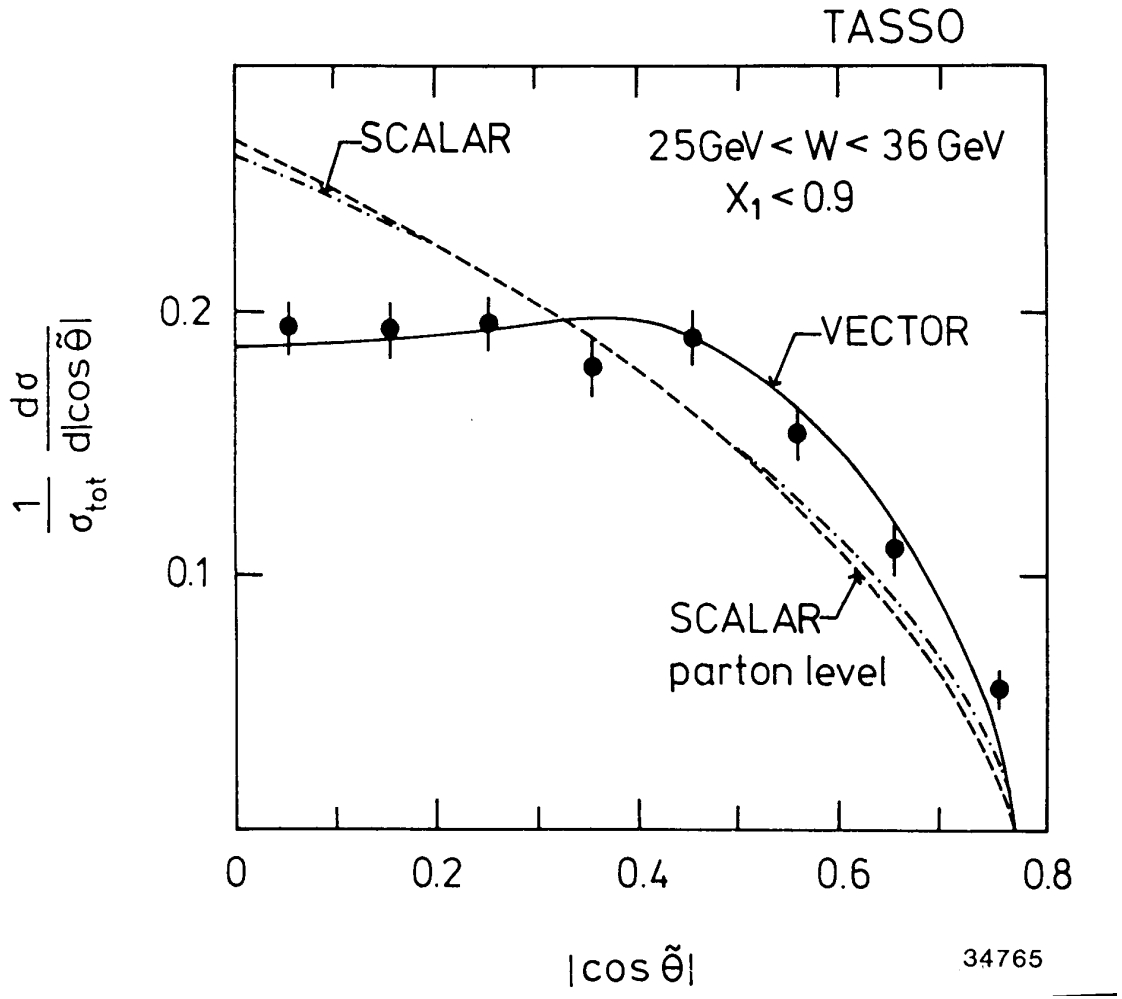
(a) Have we really seen three-jet events in e+e- collisions?

(b) If we did, does that confirm the existence of the gluon?

- Our answer to both questions is a cautious, qualified yes.
- Our tentative conclusion is that the experimental evidence for three jets is quite good
- The most likely explanation is the gluon.
- It is absolutely crucial to confirm the spin of the gluon.

"We believe, however, that five years from now, when we look back, we will all agree that the gluon was discovered in the summer of 1979."

Gluon Spin



TASSO: R. Brandelik et al, Phys. Lett. 97B (1980) 453:

(The data shown are from a later paper when higher PETRA energies were available.)

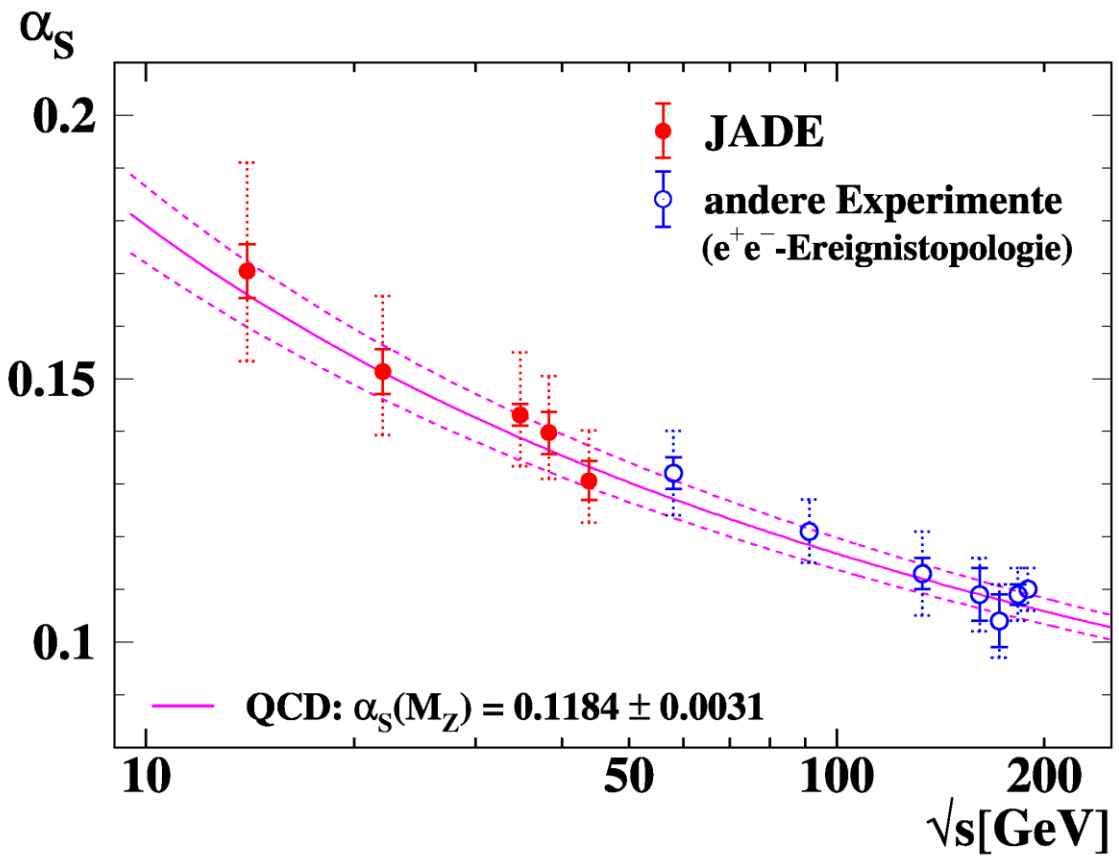
Determination of α_s (OPAL/JADE)

Study “event shapes”
in e^+e^- → hadrons

Compare with simulation
⇒ good agreement

Compare with QCD
prediction ⇒ $\alpha_s(\sqrt{s})$

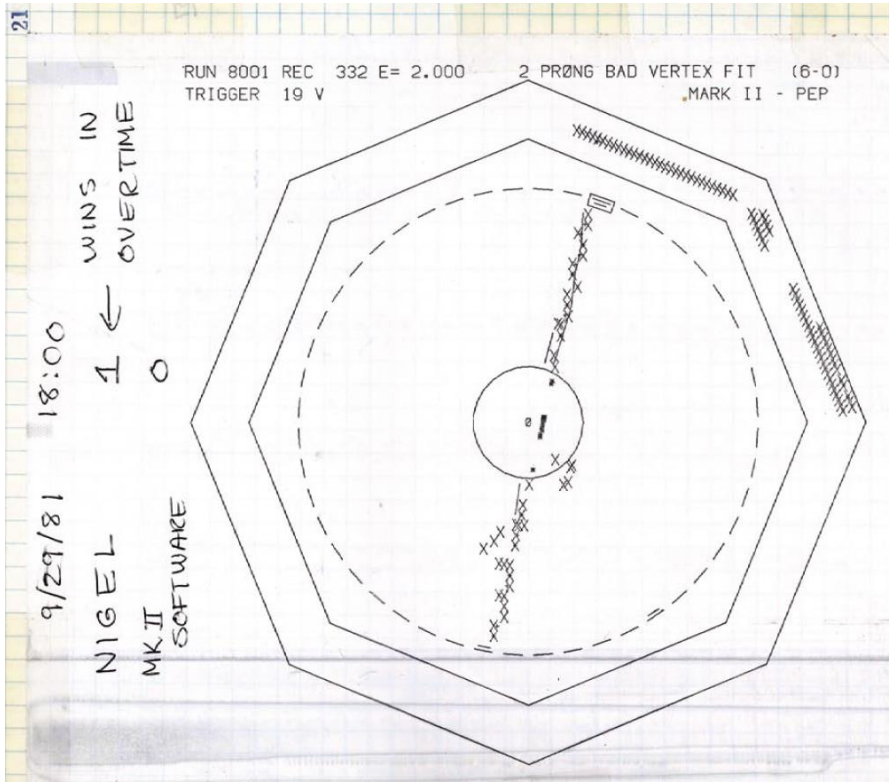
Compare $\alpha_s(\sqrt{s})$ with
QCD prediction for
running strong coupling



S. Bethke et al.

Brian at PETRA – Phase 2

- In 1982 Brian moved to **Imperial** for 2 years
- John Jaros at Mark II built vertex chamber (1980 - 1981) to detect heavy quarks and in particular to measure τ lifetime.
- Decision to build vertex detector for TASSO
- Built at **Imperial**, Brian worked first on the Monte Carlo, then became responsible.
- A few tiny obstacles…..



TASSO Vertex - Detector

Draft Proposal

1st draft

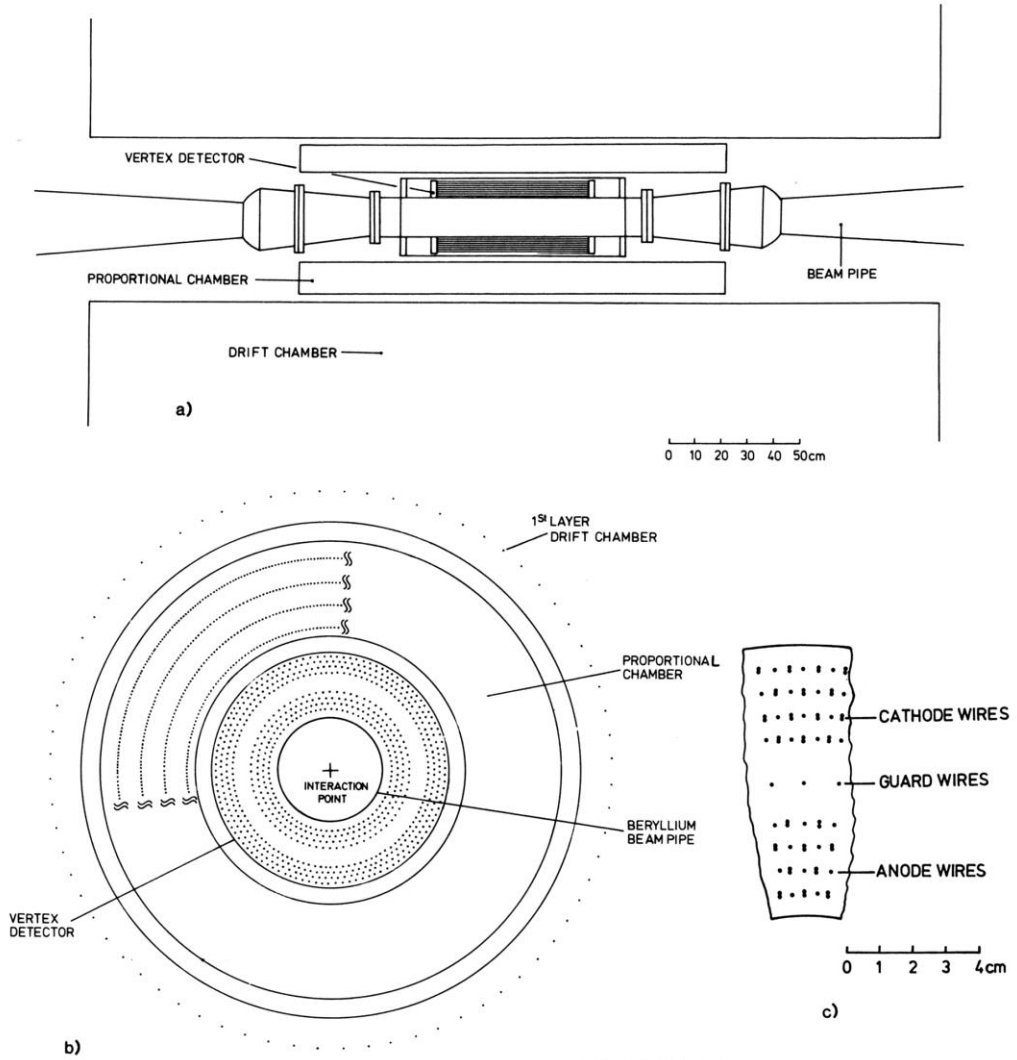
(1)

"Proposal to upgrade TASSO by addition of a small, very high resolution drift chamber close to the interaction region"

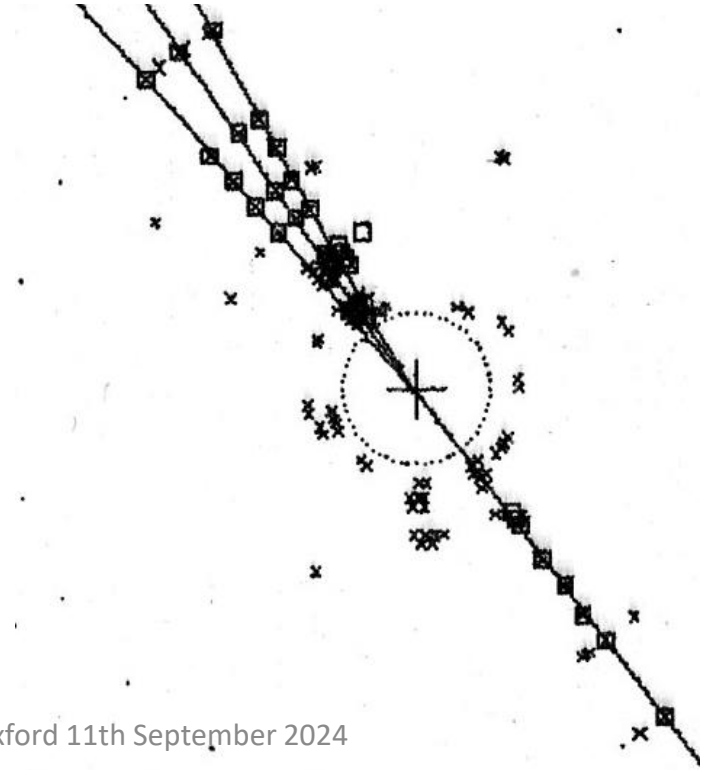
Review of TASSO operation, 1978-81.

Tasso has been operating successfully in the South ~~East~~ hall at PETRA since 1978. We briefly review below the main aims of TASSO and how they have been accomplished so far.

TASSO Vertex - Detector



- VXD installed inside TASSO and
- taking data by mid-December 1982 - less than 2 years since inception.



TASSO Vertex - Detector

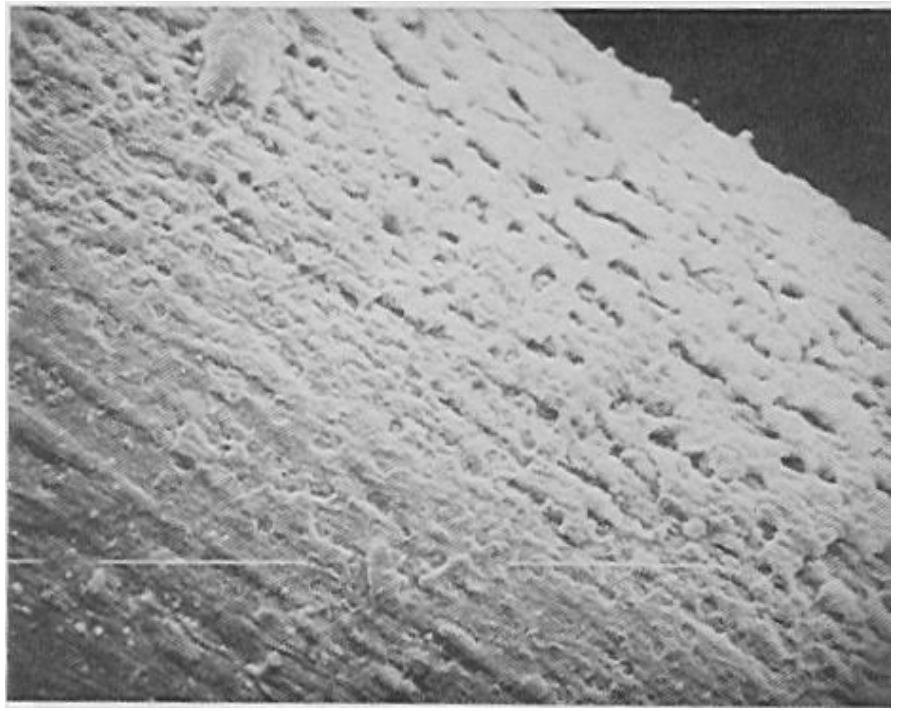
B.Foster
28.6.1983

Minutes of Vertex Detector Meeting - 7/6/83

Present: B.Foster, H.Hartmann, M.Hildebrandt, A.Ladage, B.Löhr, J.McCardle, R.Nowak, K.Rehlich, W.Schütte, G.Wolf

Hardware

B. Foster described the problems over the past few weeks with the detector. It seems as if we were having problems with a layer of insulator forming on the cathode wires which led to the ejection of electrons from the cathode and a "charging up" effect by which the chamber drew more and more current until it tripped. We have experimented with bubbling the chamber gas through both water and alcohol to try to alleviate the problem. Both seemed to cure it, and since we have evidence that alcohol can grow whiskers, we are running for the moment with water, since that is safer. We are all very thankful that this emergency procedure was a success!



Whisker growth: change gas from Argon-Ethane (50:50) to Argon-CO_2 (95:5) and add **water**

TASSO Vertex – Detector Results

DETERMINATION OF THE AVERAGE LIFETIME OF BOTTOM HADRONS

TASSO Collaboration

M. ALTHOFF, W. BRAUNSCHWEIG, F.J. KIRSCHFINK, H.-U. MARTYN, P. ROSSKAMP,
D. SCHMITZ, H. SIEBKE, W. WALLRAFF
I. Physikalisches Institut der RWTH Aachen, Germany [1]

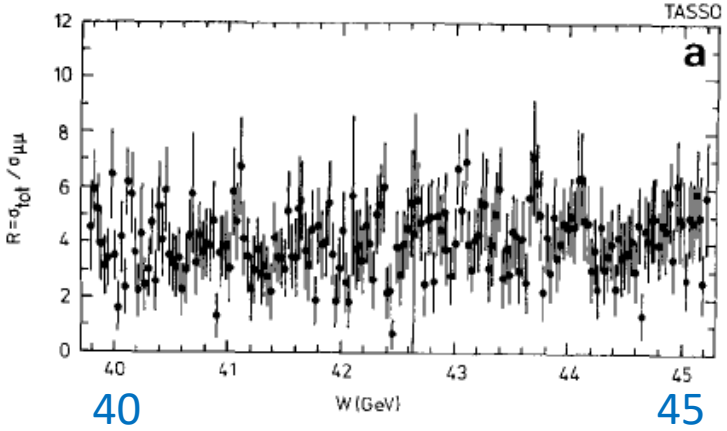
J. EISENMANN, H.M. FISCHER, H. HARTMANN, A. JOCKSCH, G. KNOP, H. KOLANOSKI, H. KÜCK,
V. MERTENS, R. WEDEMEYER
Physikalisches Institut der Universität Bonn, Germany [1]

B. FOSTER
H.H. Wills Physics Laboratory, University of Bristol, Bristol, UK [2]

$$\tau(\tau) = (3.18^{+0.59}_{-0.75} \pm 0.56) \times 10^{-13}\ \text{s}.$$

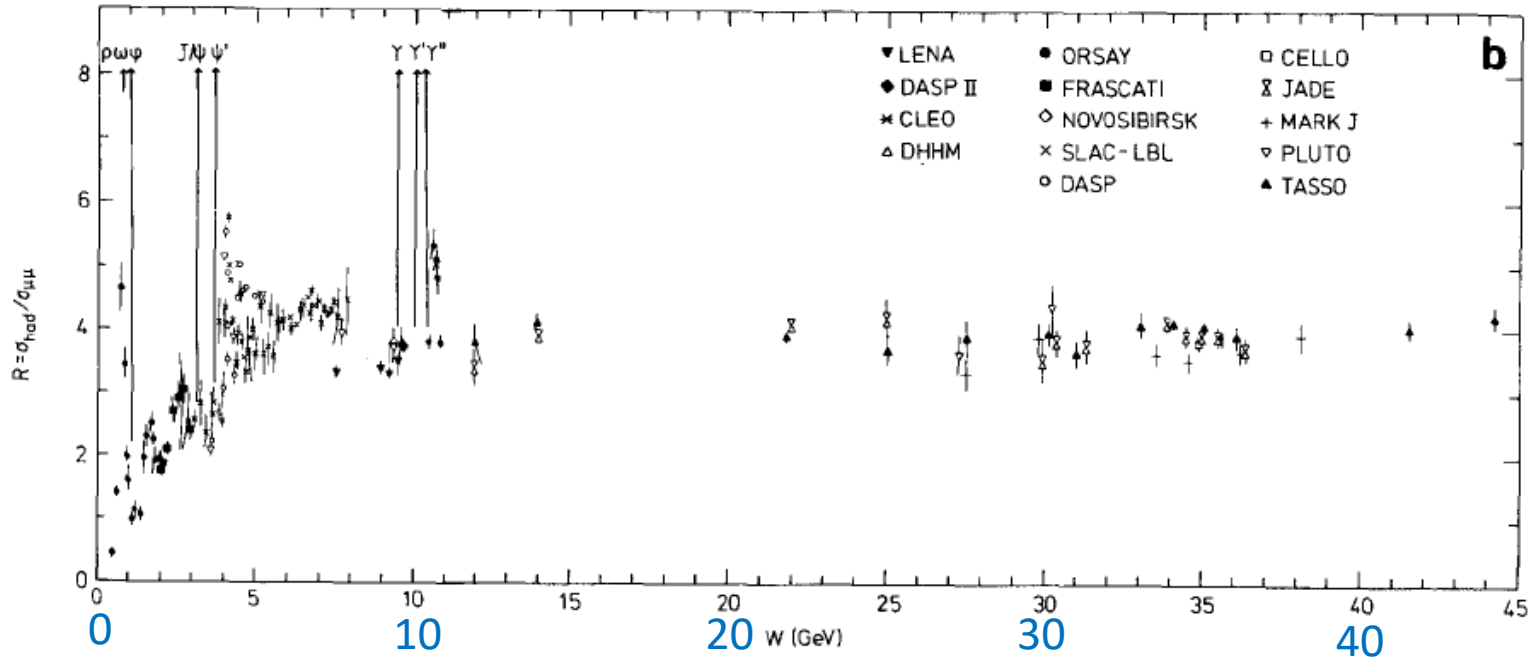
$$\tau_B = \left(1.83^{+0.38+0.37}_{-0.37-0.34}\right) \times 10^{-12}\text{s}.$$

The Elusive Top



R = σ(tot)/σ(μμ) as function of enery

Fig. 1. (a) The ratio $R = \sigma_{tot}/\sigma_{\mu\mu}$ measured in the scanning mode between 39.8 and 45.2 GeV. (b) The ratio $R = \sigma_{tot}/\sigma_{\mu\mu}$ as measured by this and other experiments (cited in ref. [5]). Only statistical errors are shown.



Electroweak Effects

R = σ(tot)/σ(μμ) as function of energy, including TRISTAN

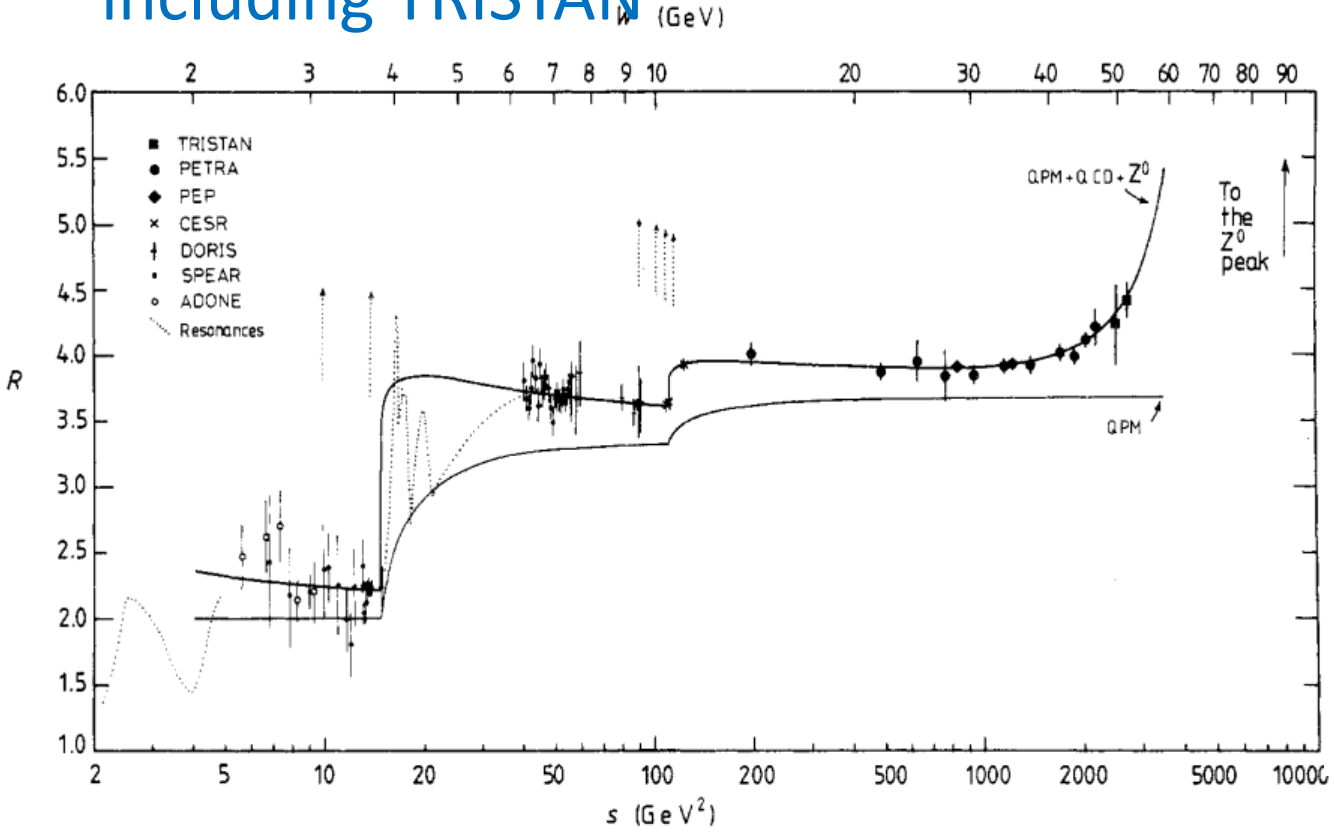
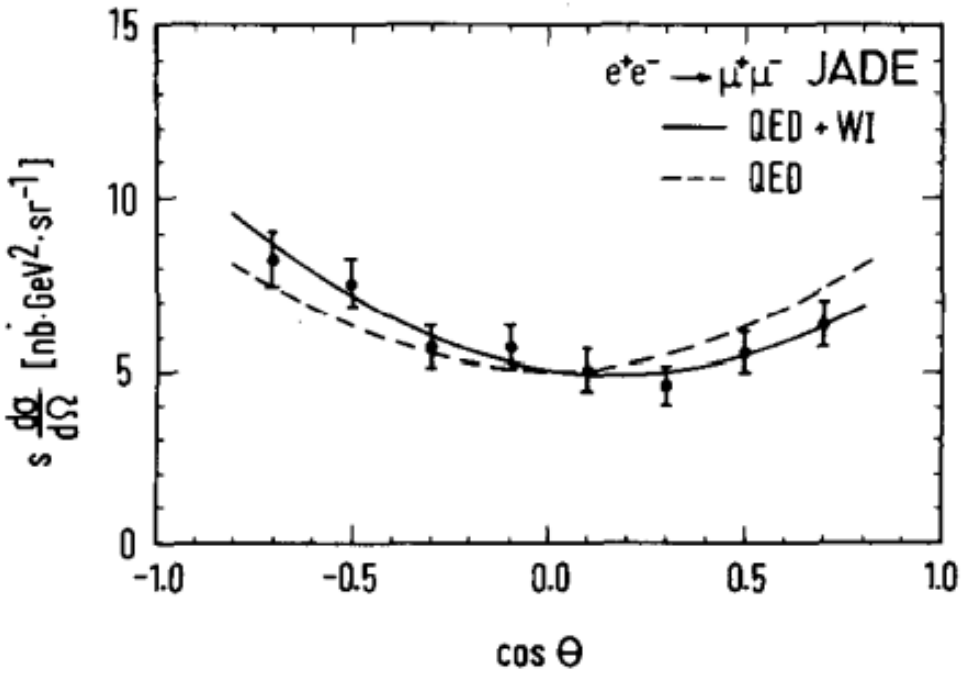


Figure 8. A comparison of R measurements with global fit.

Forward-backward asymmetry in muon production



Brian at PETRA – Phase 3

- 1983 appointed as Lecturer at Bristol (on tenure track)
- In parallel simulation for Electra at LEP (82-83) and SSC in parallel

First Close Encounter with Hamburg

DESY Open Day

Meeting Sabine

1983

Brian and Music

Brian, like Einstein,
loves playing his violin

In Hamburg,
Brian was a member of
the DESY orchestra

Since 2005:

Brian and Jack Liebeck
toured the world with

„Einstein and music“

Birthday Wishes

A firework of talks reminding you of your highly productive past

A brilliant time with your old friends

A day with no „nugatory toil“

And an inspired future with lots of music