Chasing t – & finding g

Roger @ TASSO & PETRA – and a few other places

Cashmorefest

Oxford 30/6/2-15

Brian Foster

University of Oxford/DESY/Hamburg

Chasing t - & finding g

- Setting the scene
- Constructing TASSO
- Discovering the gluon
- Chasing the ephemeral
- Chasing the top - still
- “Here’s another fine mess ….”
- Final words

PETRA & TASSO

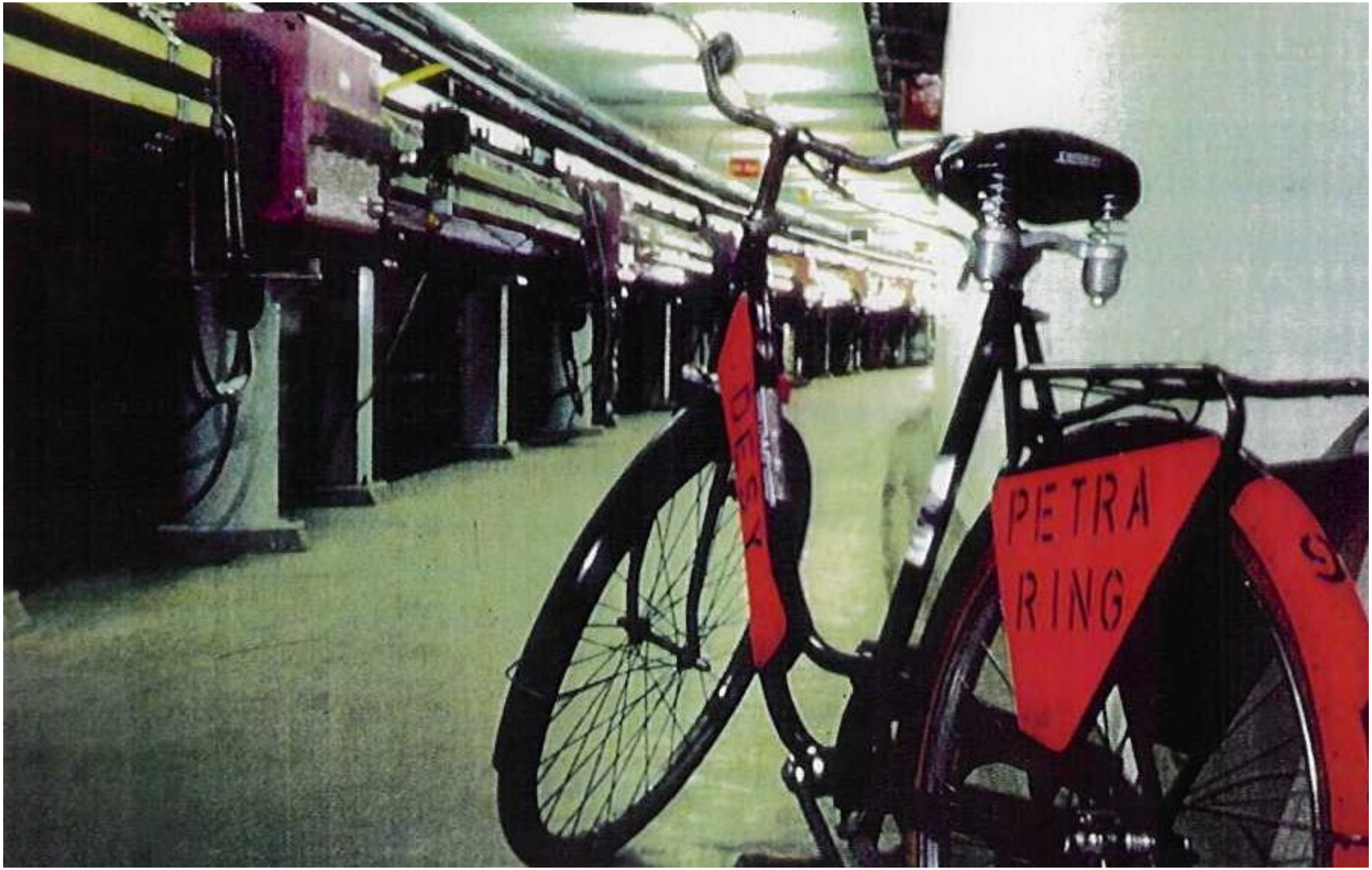
- ‘November revolution’ of 1974, work of experiments such as DASP etc and the observation of jets in e^+e^- collisions at SLAC in 1975, made existence of quarks as ‘real’ objects for first time part of particle physicists world-view.

- Before ANY of these developments, PETRA@DESY and PEP@SLAC conceived - end 73/start 74. Emphasis was on ep, with e^+e^- option - this quickly changed after 1974!

- Even after jets, J/ ψ etc., theoretical situation unclear: e.g. Cabibbo summary at 1976 Frascati meeting on PETRA detectors - list physics objectives as - R, mult. & scaling, jets (2 jets), new narrow resonances, heavy leptons, weak int., ‘something new’!

Building PETRA

Building PETRA



Building TASSO

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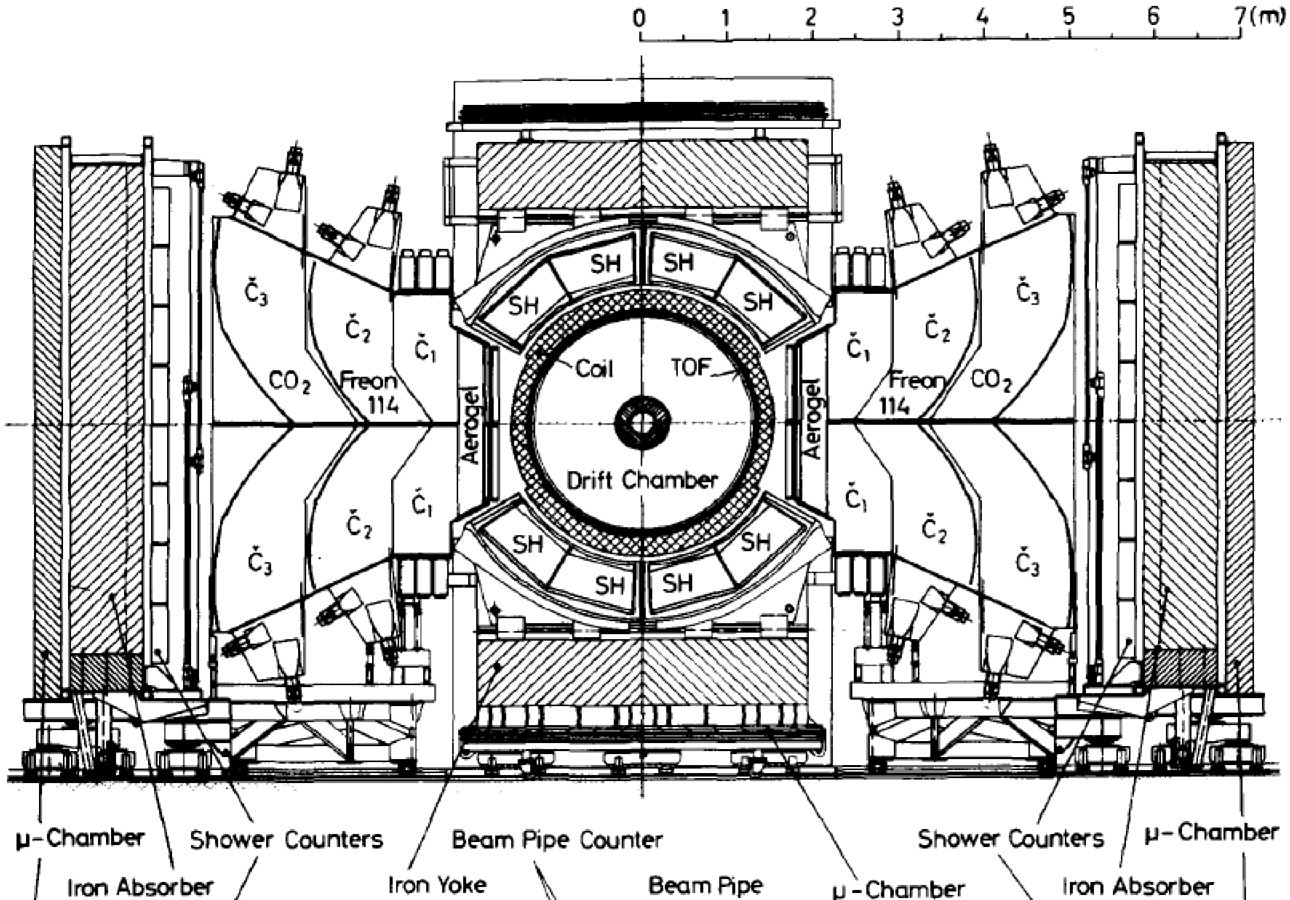
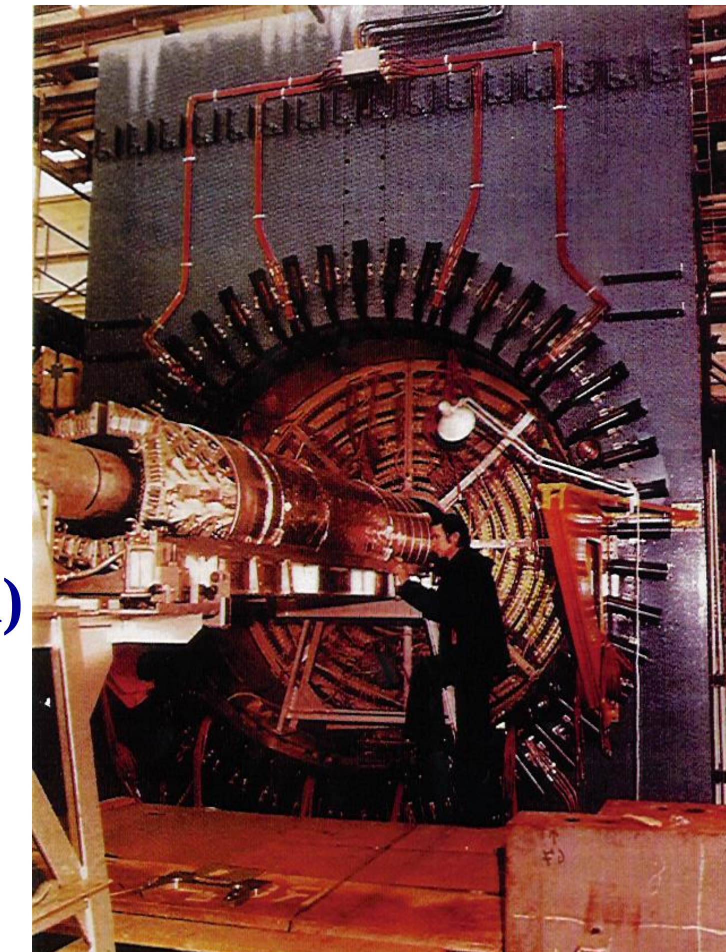
- Five experiments approved - CELLO, JADE, Mark J, PLUTO, TASSO = Aachen-Bonn-DESY-IC-Oxford-RAL-Wisconsin



UK in TASSO

- Roger, involved in ACCMOR, saw the potential of PETRA and got together a UK collaboration from “the south” – Imperial, Oxford & Rutherford
- Group leaders were
  IC: David Binnie & Peter Dornan
  Oxford: RJC
  Rutherford: David Saxon
- UK contributions:
  CPC (IC); ToF counters (RAL);
  DAQ (RAL); μ Chambers (Oxford)
- 1st entry in my TASSO logbook is measuring TOF HV bases; 2nd is summary of an RJC seminar!



UK in TASSO

TASSO

Meeting

4.10.78

+ Notiz

D. Notz
4.10.78

Subject: Minutes of the TASSO Programming Meeting

Present: G. Wolf, H. Lynch, H. Kowalski, D. Notz, D. Pandoulas, S. Lloyd, R. Cashmore, R. Barlow, B. Foster, Ph. Woodworth, H.-U. Martyn, W. Koch, W. Rühmer, S.L.Wu, G. Mikenberg, Y. Eisenberg, M. Schliwa, D. Lüke, P. Söding, W. Chinowsky, K. Lübelsmeyer

Brian Foster and Willy Chinowsky were introduced.

The prototype of the IBM connection works. Hochweller has to test the multiplexing of two experiments. The cable bridge between Tasso Hall and control room is expected for the end of next week.

D. Quarrie reported about some timing measurements.

1 DMA (PROP 20words) + FORMAT TASK	183 Hz
3 DMA (PROP+MUON+PRFO 20words) + FORMAT TASK	150 Hz
3 DMA (" " " 500words) + " "	60 Hz

We run through the following list of activities to check where we are.

Start the Nord10 and RT TASSO

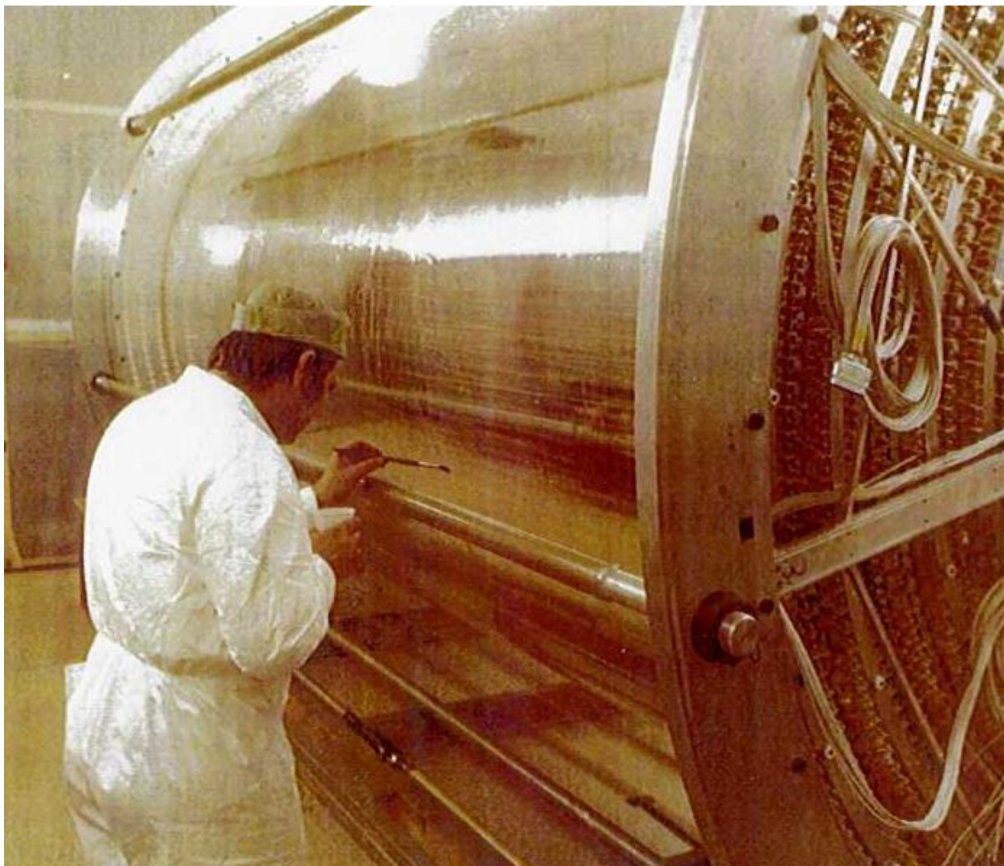
Activate DASSO	D. Quarrie
" Touch Panel	D. Quarrie
" Formatter	D. Quarrie, P. Dornan
" Input task	R. Bühring, D. Quarrie
MWPC	D. Quarrie
MUON	D. Quarrie
DRIFT	H. Hartmann
MONIKA	?
PU-ADC-TDC	R. Bühring
CAMAC: MAGNET DVM	?
CPC Processor	D. Pandoulas
Luminosity	D. Quarrie
" NORD50	D. Quarrie, M. Wollstadt
" Output task	D. Quarrie, D. Notz
" Histogram Display	D. Quarrie
" " Clear	D. Quarrie
" Event Display	W. Rühmer
" Status Display/Reporter	D. Quarrie
" Error "	D. Quarrie

All tasks are loaded and wait for events or interaction.
Before the first run is started, we have to run tests and look for calibration constants.

Driftchamber tests + calibration constants for TDCs	Th. Meyer, H. Hartmann
CPC tests	C. Youngman

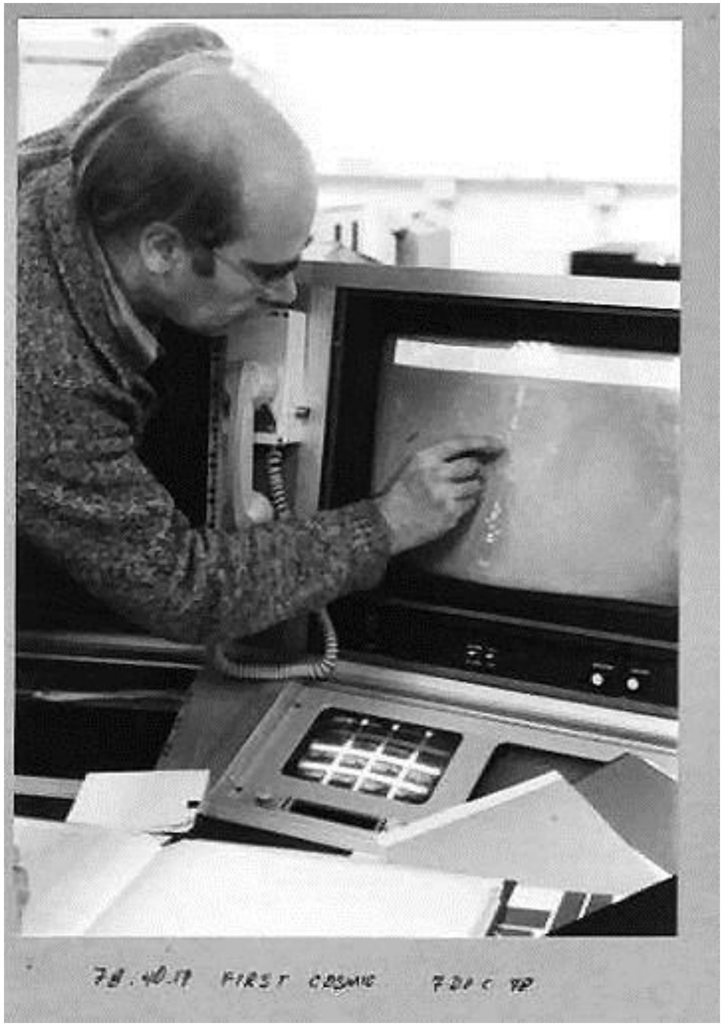
TASSO DC

- **Most important TASSO component was large volume drift chamber to detect charged particles - Bonn/DESY responsibility.**



First data

- **First cosmics & then beam data at end of '78**



TASSO

1. Schedule for parasitic shift, Friday 8.12., 16^{00} - 24^{00}

shift leader	NORD	CPC	DC	TOF	Forward	PETRA
Söding	Quarrie	Lloyd	Hartmann	Jaax	Hillen + Hartmann	Söding

2. Schedule for shifts Sat - Mo 7^{00} - 7^{00}

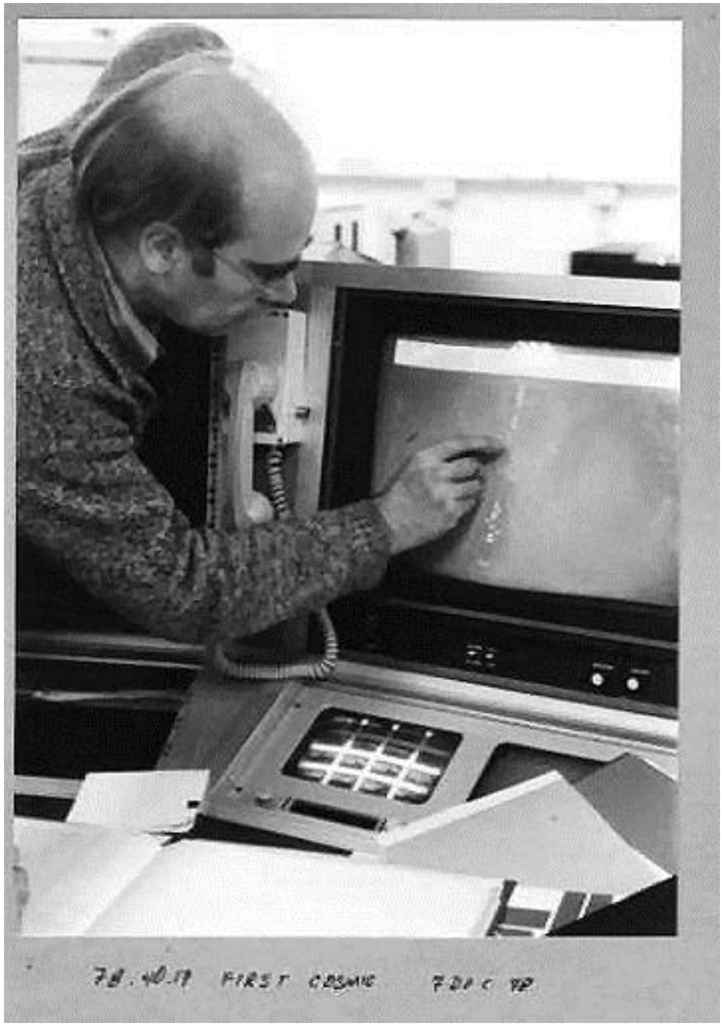
prime user: PLUTO

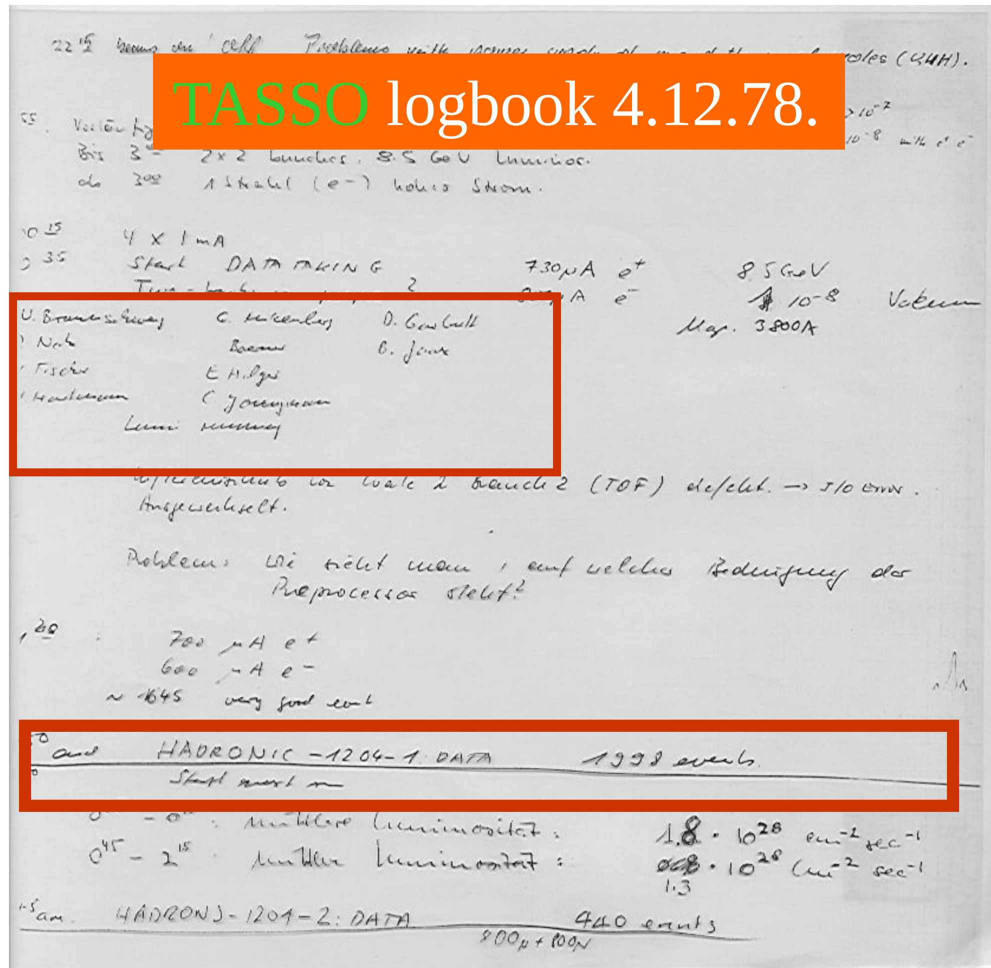
The last 4 hrs Mo 3^{00} - 7^{00} MARKJ may run with single beam, high current.

	shift leader	magnet	NORD	CPC	DC	TOF	μ chamber	forw. detector
Sat 7 - 15	Wolf	Mikenberg	Notz	Youngman	Börner	Jaax	Barlow	Hillen
15 - 23	Söding	Eisenberg	Bühring	Downie	Kötz	Martyn	Foster	Wedemeyer
Sun 23 - 7	Joos	Mikenberg	Quarrie	Lloyd	Wollstadt	Brandelik	Cashmore	Hilger
7 - 15	Wolf	Martyn	Notz	Pandoulas	Börner	Martyn	Barlow	Börner
15 - 23	Söding	Eisenberg	Quarrie	Downie	Hartmann	Jaax	Cashmore	Hartmann
Mo 23 - 7	Joos	Lübelsmeyer	Bühring	Pandoulas	Kötz	Lübelsm.	Foster	Hillen
7 - 15	Wolf			Youngman	Wollstadt			

First data

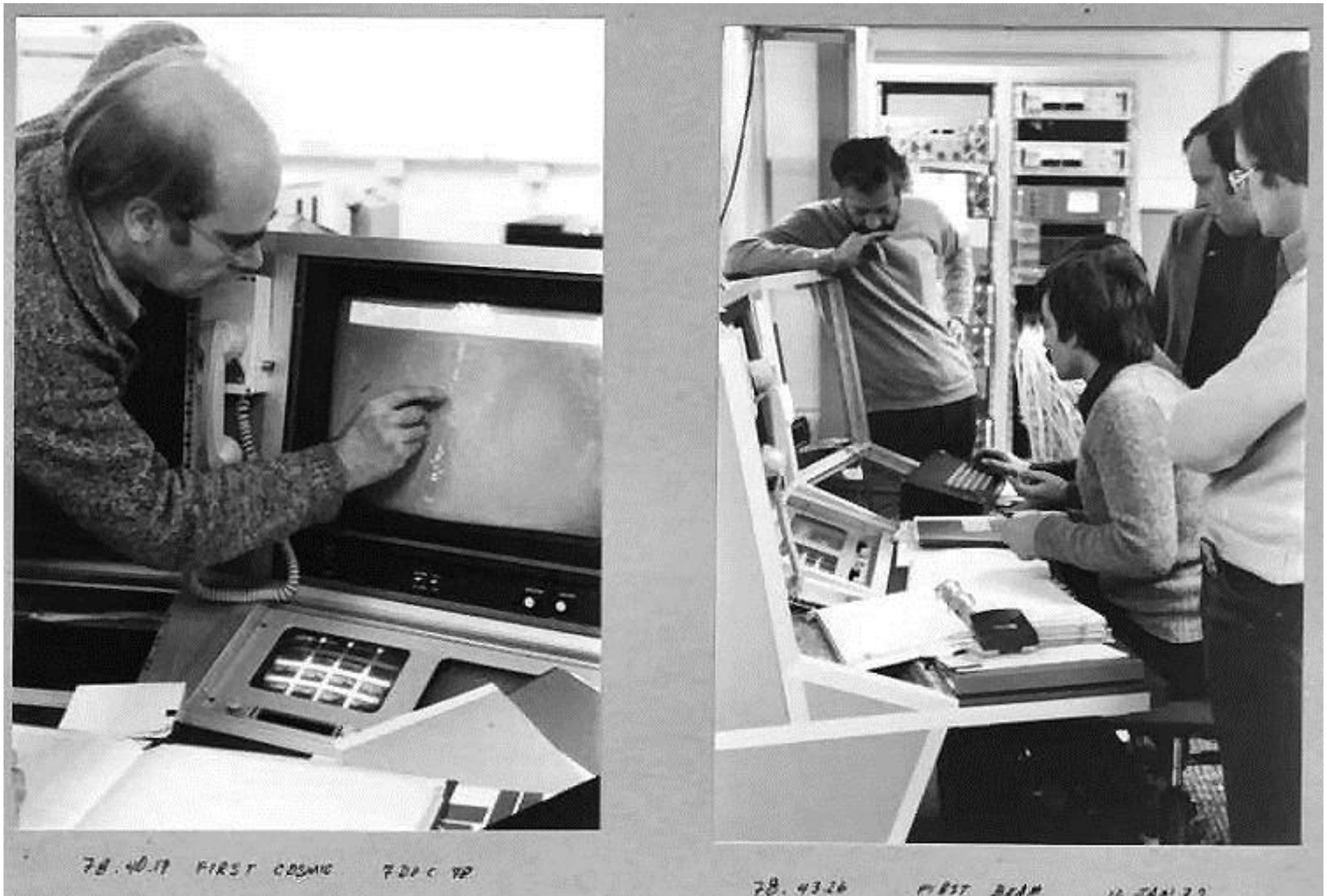
- First cosmics & then beam data at end of '78





First data

- First cosmics in Dec. ‘78, and then first runs began 12.1.79.



First data

- **So the data was coming in - what were the experimenters' priorities as to what to look for with it? (Ref "TASSO Physics Goals for 1979 run", TASSO Note 78, Feb. 1979.)**

  1. Top
  2. TOP
  3. T o p

  .
  .
  .

  n. Heavy leptons

- **Remember that jets were only 3 years old and QCD 1 year older - certainly QCD was far from being accepted as THE theory of strong interaction. Furthermore, the general feeling (Fluegge, Schladming '79) was that QCD would merely increase $\langle p_t \rangle$ with energy.**

Expectations

- However, it wasn't that the theory predictions didn't exist - they just weren't widely known/appreciated:
  Ellis, Gaillard & Ross '76 predicted "planar" events, growth in $\langle p_t \rangle$ and, at "sufficiently" high energy, explicit
  3-jet structure:
  amplified by several other authors in '78/79.

- At TASSO, exceptionally good contacts between theorists (Ellis, Gaillard, CHLS etc.) and experimenters (Wiik, Wolf..) meant that we were perhaps more aware than most of these ideas…Also, TASSO was optimised for hadronic final state & particle i.d. , so jets were central to our physics programme.

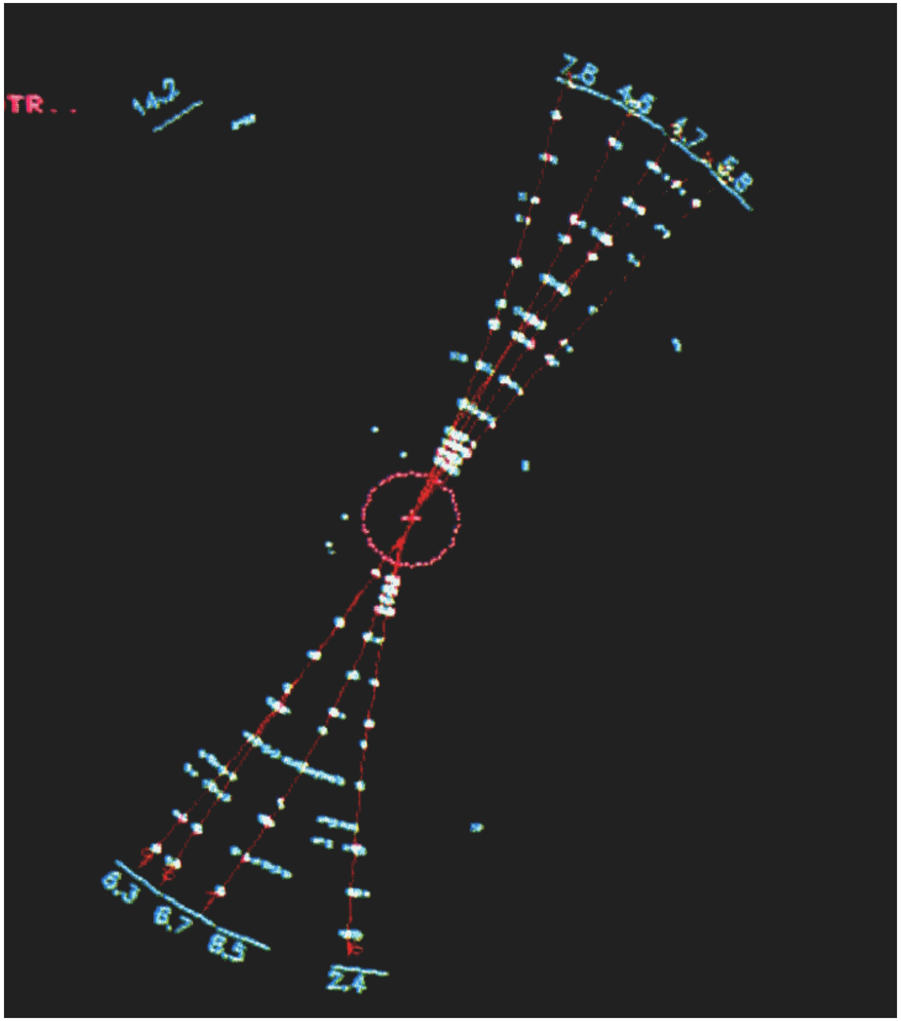
Gluon discovery

- A seminal work, certainly as far as TASSO was concerned, was Wu & Zobernig (1979) - which pointed out in practice the best way to observe 3-jet planar structures which were the “smoking gun” of the gluon. Since SPEAR had 7.4 GeV and resolved 2-jets, back-of-envelope + phase-space $\Rightarrow$~ 22 GeV required to see 3-jets. Method did not require all particles to be observed – charged tracks enough.

- From Jan- April, TASSO ran below 17 GeV. Clear two-jet structures, p_t distributions etc. measured. In late April more r.f. added and we started taking data at 27.4 GeV.

Gluon discovery

- Lots of events like this



Gluon discovery

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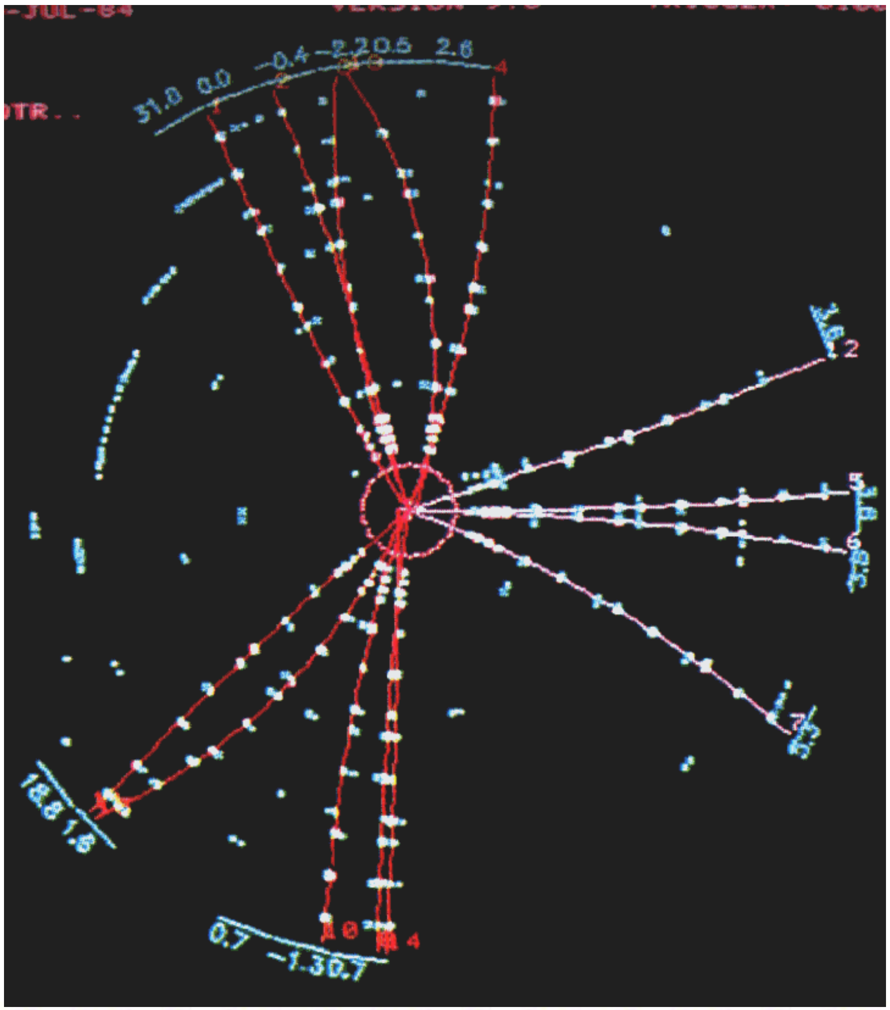
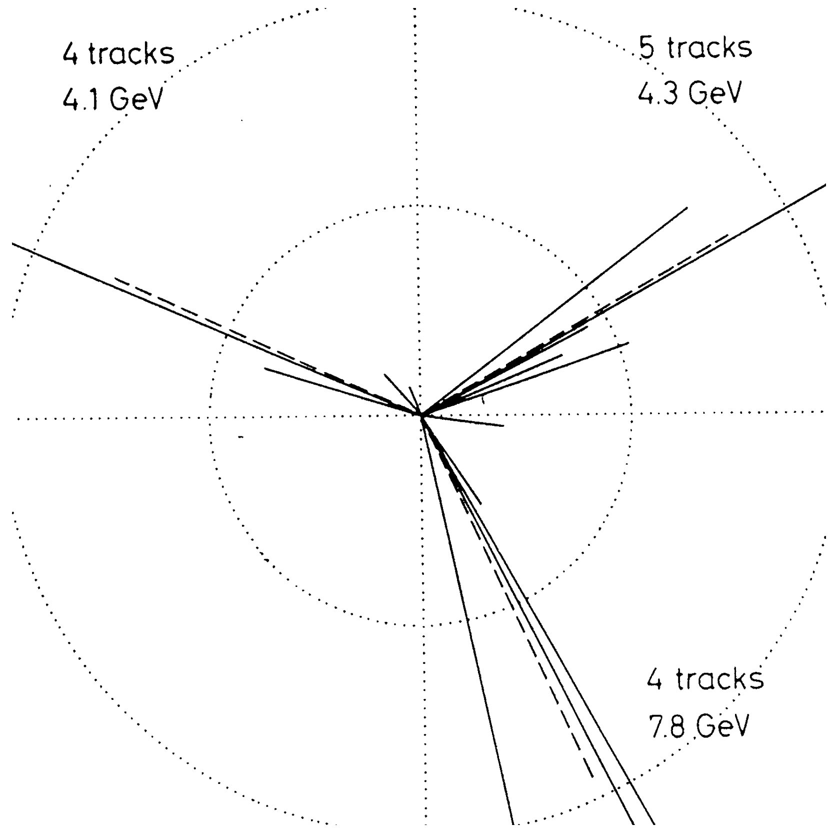
- And then one like this



- B. Wiik, Bergen, June 18th 1979



Gluon discovery

- A few days later, Paul Soeding showed 3 more events at EPS Geneva conference - with an estimated qq background of 0.3.
- He, with Wolf & RJC, showed a variety of plots which, taken together, were convincing evidence that the gluon had been discovered.

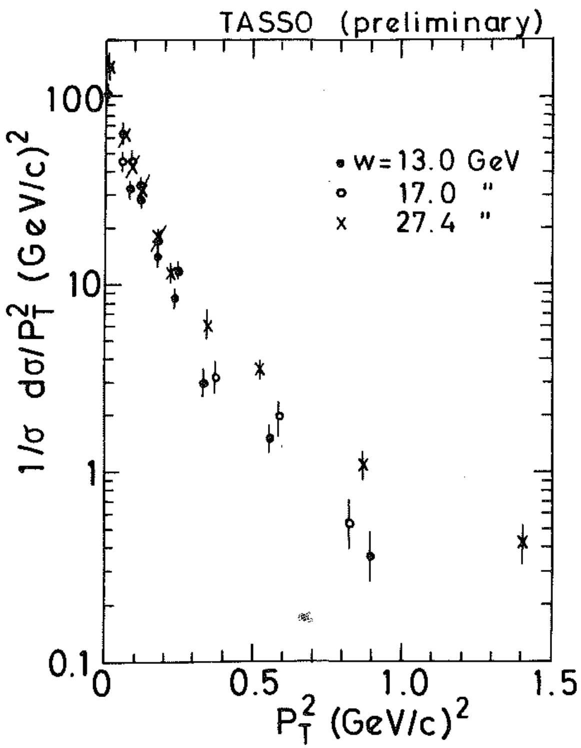
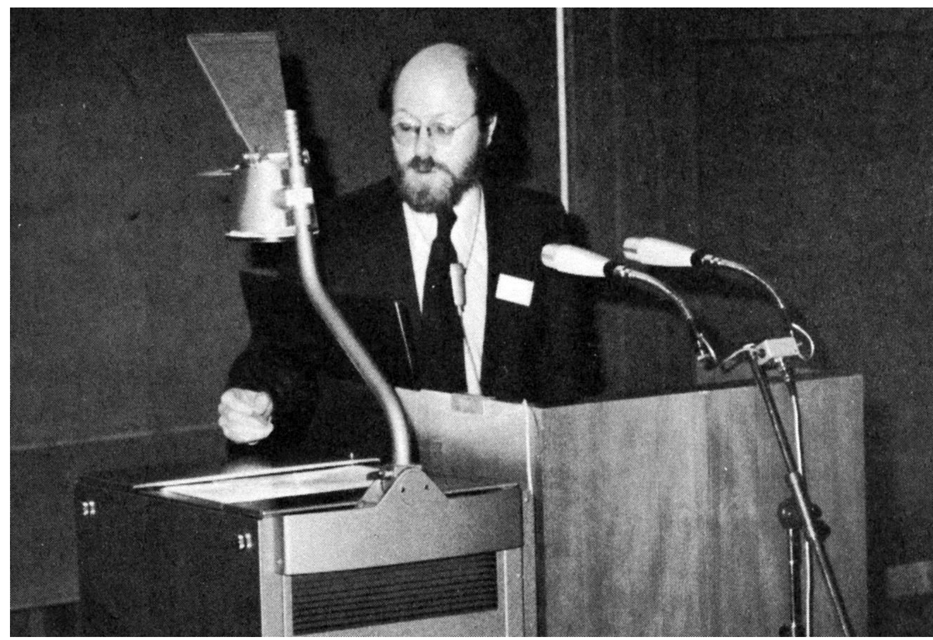


Fig. 3 The p_T^2 distribution measured relative to the spehericity axis.



Gluon discovery

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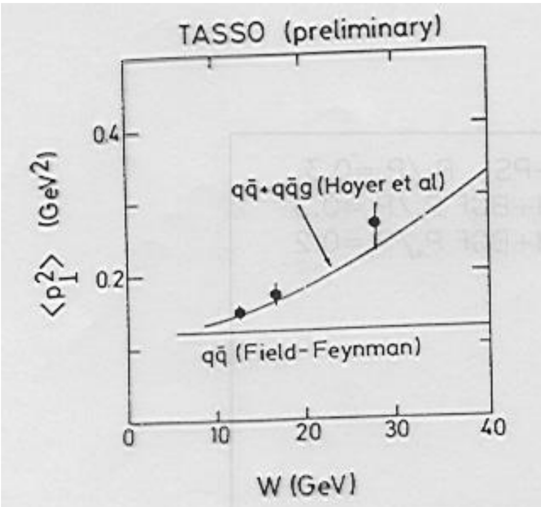


Fig. 4: Mean squared transverse momentum of the charged hadrons with respect to the jet (thrust) axis, as a function of the total e^+e^- cms energy W.

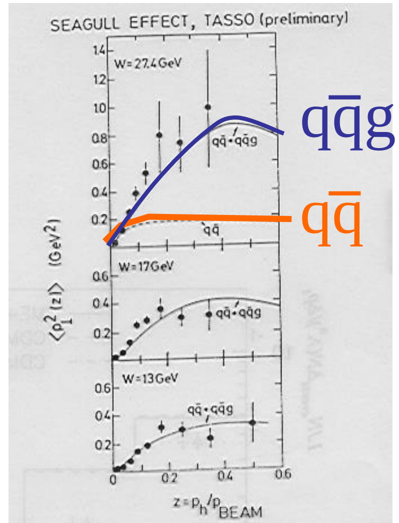
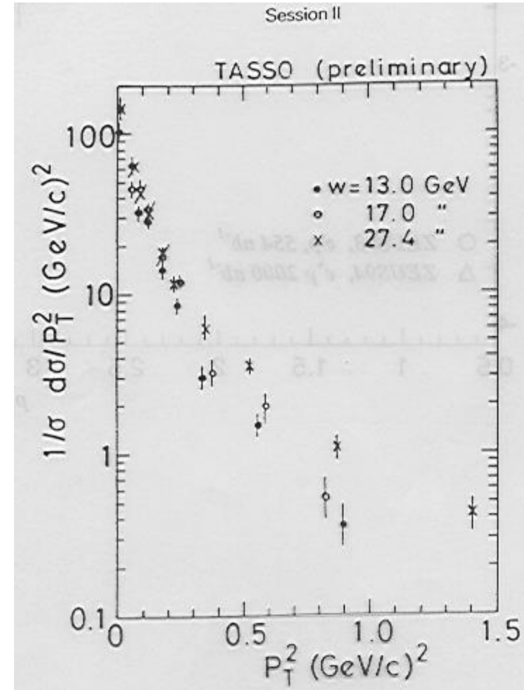


Fig. 5: Mean squared transverse momentum of the charged hadrons with respect to the jet axis as a function of fractional hadron momentum z, at different total e^+e^- cms energies W.



- **In the August Fermilab LPS, the other experiments also had evidence; the papers followed in September**

CERN Courier

From the archives

With PETRA running at total energies of around 30 GeV, the latest results on the jet analysis of hadron production in high-energy electron–positron annihilations were eagerly awaited at the Fermilab Lepton/Photon Symposium.

The big question was the existence of the sixth quark, but none of the four groups taking data at PETRA produced any evidence for a new quark-production threshold, either from the hadronic production rate or from the topology of the observed events.

However, jet analysis by the JADE, Mark-J, TASSO and PLUTO teams now confirms preliminary evidence presented at the Geneva conference in June.

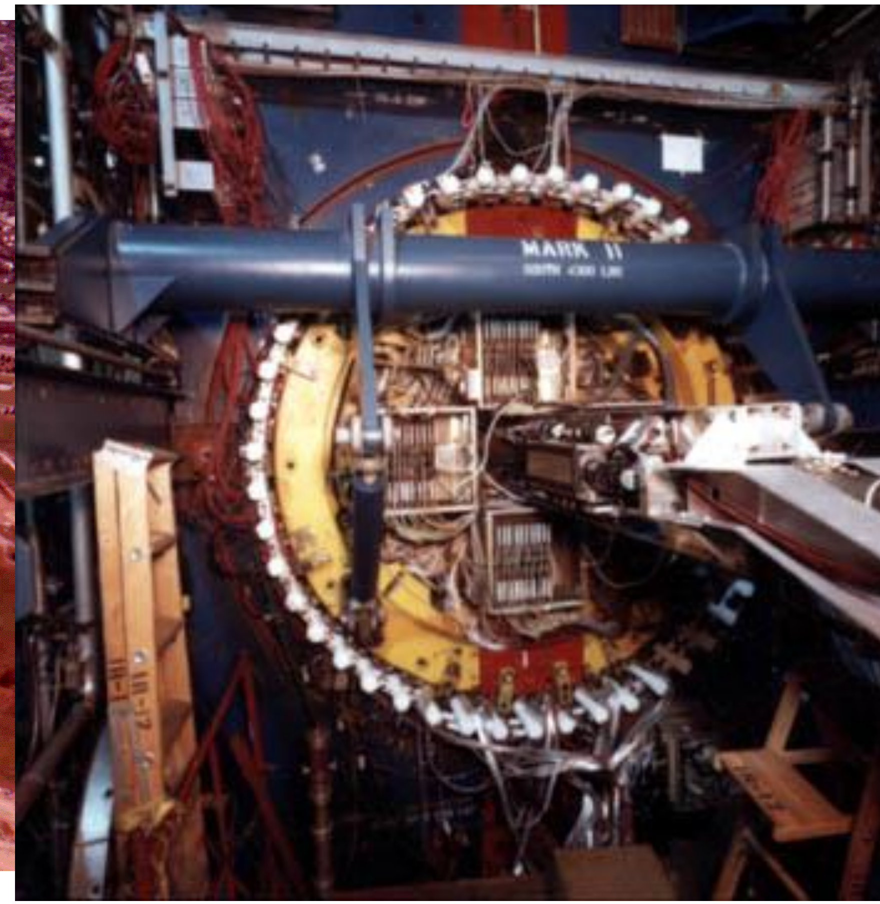
At 13 and 17 GeV-collision energies, the two-jet structure seen at lower energies is reproduced, indicating a quark and an antiquark emitted in opposite directions, producing back-to-back hadron fragments. At 30 GeV, another process becomes visible as one or other of the emitted quarks probably radiates a gluon (bremsstrahlung), which also fragments into hadrons.

- *CERN Courier* October 1979 p307 (extract).

EPS Prize

Short-lived particles

- **Although significantly behind PETRA, and missing out on the big gluon discovery, PEP got under way in 1980.**



Short-lived particles

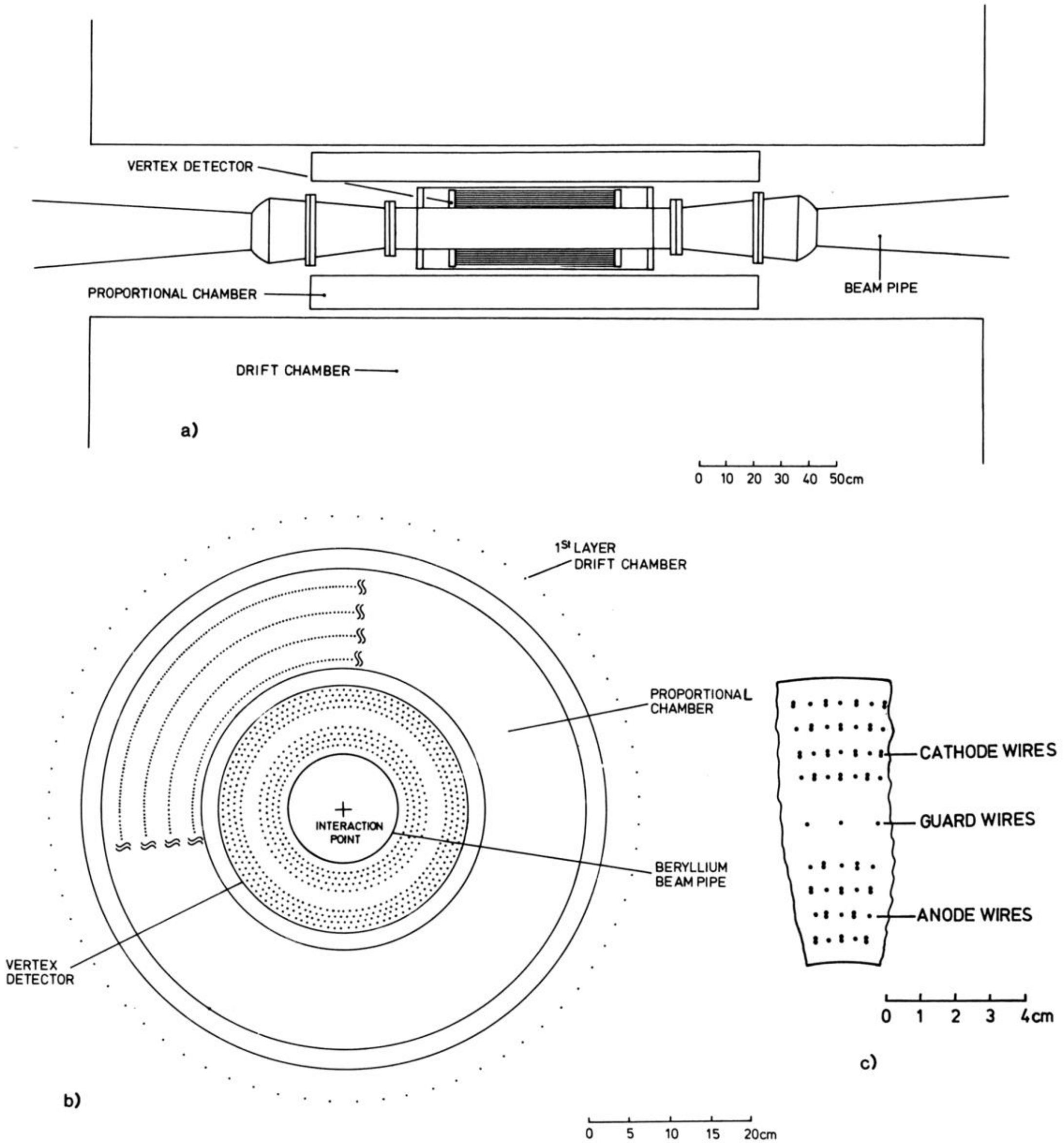
- Although PEP missed the gluon, it did some excellent work. In particular, exploiting the discovery of the b quark by Lederman et al in 1977 and the gradual realisation that it had a "long" (~10^{-12} secs) lifetime - some of the early measurements made at PETRA, including TASSO - made people think about possibility of "tagging" heavy quarks.
- More or less as soon as PEP turned on in Fall 79, John Jaros at SLAC began to design a very small, high-precision drift chamber close to IP to detect heavy quarks and in particular to measure τ lifetime.
- RJC had encouraged the UK postdocs (BF, Steve Lloyd, Jimmy Proudfoot, plus Chris Youngman) on TASSO to concentrate on tau analysis in addition to our hardware responsibilities. We produced a couple of papers in this area.

Vertex Detectors

- In Jan. ’81 we were measuring τ and b lifetimes using only the TASSO DC + CPC - the resolution at vertex was cm, but we managed! Guenter came into the TASSO control room and asked me why we couldn’t build a VXD like MARK I’s?

- Alfred Ladage had idea to construct a VXD made of straws with central anode. UK groups led by David Binnie had more “conventional” design with drift cells. Both were at 4 bar pressure.

TASSO VXD


VERTEX DETECTOR
PROPORTIONAL CHAMBER
BEAM PIPE
DRIFT CHAMBER
a)
0 10 20 30 40 50cm
1st LAYER
DRIFT CHAMBER
PROPORTIONAL CHAMBER
INTERACTION POINT
BERYLLIUM BEAM PIPE
VERTEX DETECTOR
b)
0 5 10 15 20cm
CATHODE WIRES
GUARD WIRES
ANODE WIRES
0 1 2 3 4cm
c)

VXD Planning

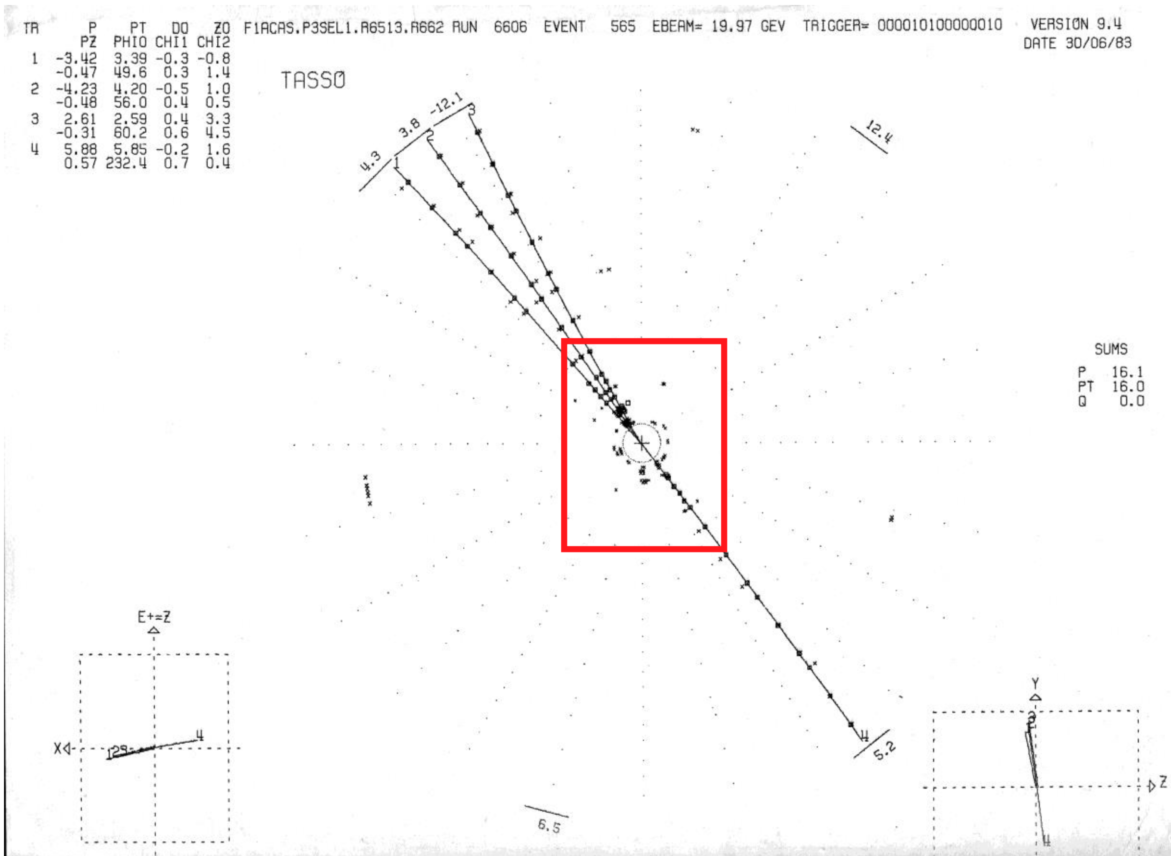
Foster

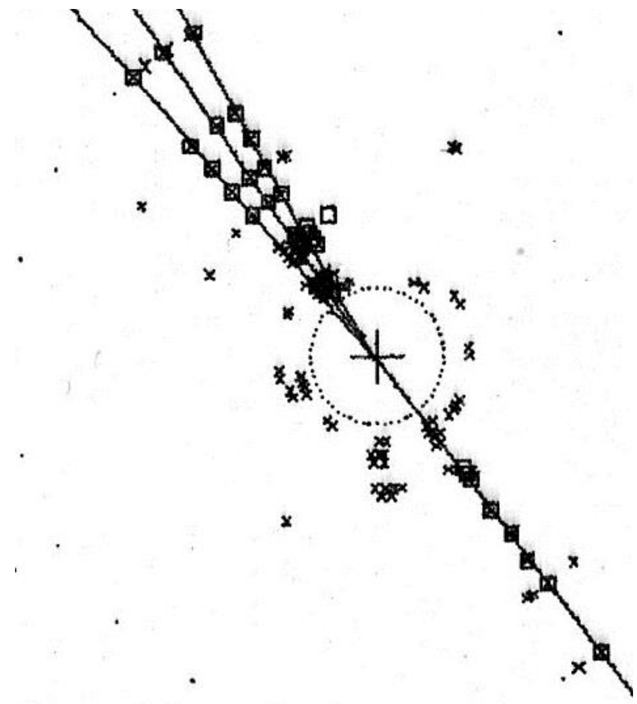
III
9.8 – 4.10.82
version as of 1.9.82

	wer	wann	August 9–15.8	16–22.8	23–29.8	30.8–5.9	September 6–12.9	13–19.9	20–26.9	27.9–3.10	October 4.–10.10
cabling east	UK	1/2.9				—					
move beam pipe west	He/Hu	3.9 10[illegible]				—					
put cables in west	UK	3/5.9				—					
install cone west	He/Hu	6/9.					—				
vac. test	"	6/7.9.					—				
cables in final tray + gas pipes	UK	7/8.9. Speed.					—				
move beam pipe east	He/Hu	8.9.					—				
8.9? install cone east + vac. test	He/Hu	9/10.9.					—				
9.[illegible] cables in final tray + gas pipes	UK	10–13.9					—				
beam pipe final position survey	He/Hu Weiss	14.9						—			
final gas connections	F52	14.9						—			
how we do cabling there — close end cap	MEA	15.9						—			
after 15.9 run proper gas	F1/12/35 52/UK	24.9.							—		
take cosmics magnet off	"	27–29.9								—	
" " " on (note: field direct. reversed)!		30.9–4.10.								—	—

VXD Installation

- **VXD installed inside TASSO and taking data by mid-December 1982 - less than 2 years since we had first begun to think about it.**





And still looking for top…

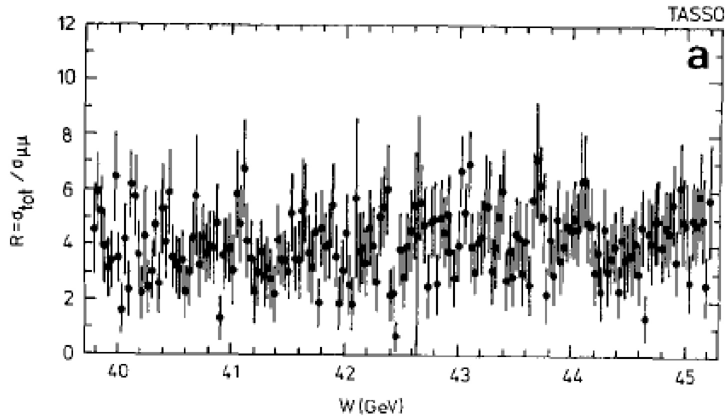
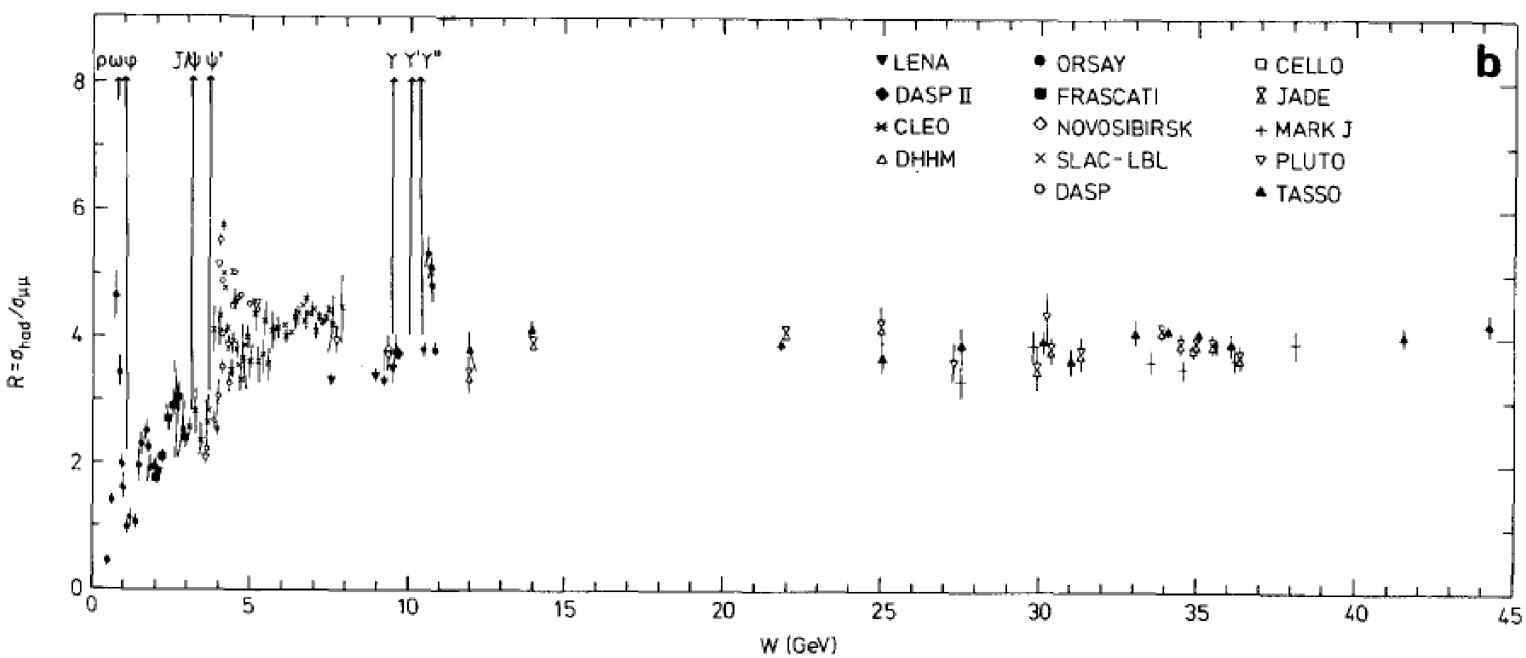


Fig. 1. (a) The ratio $R = \sigma_{tot}/\sigma_{\mu\mu}$ measured in the scanning mode between 39.8 and 45.2 GeV. (b) The ratio $R = \sigma_{tot}/\sigma_{\mu\mu}$ as measured by this and other experiments (cited in ref. [5]). Only statistical errors are shown.



TASSO Collaboration

Electra

L.E.P.C./L.I.(5
82-7

LETTER OF INTENT TO STUDY e+e-

ELECTRA

The ELECTRA Collab

Aachen, Belgium, Cambridge, CERN, C
Hamburg, Imperial College, LAPP, Li
Oxford, Queen Mary College, Rome, Ru
Tel Aviv, Vienna, Weizmann

(31 January 19

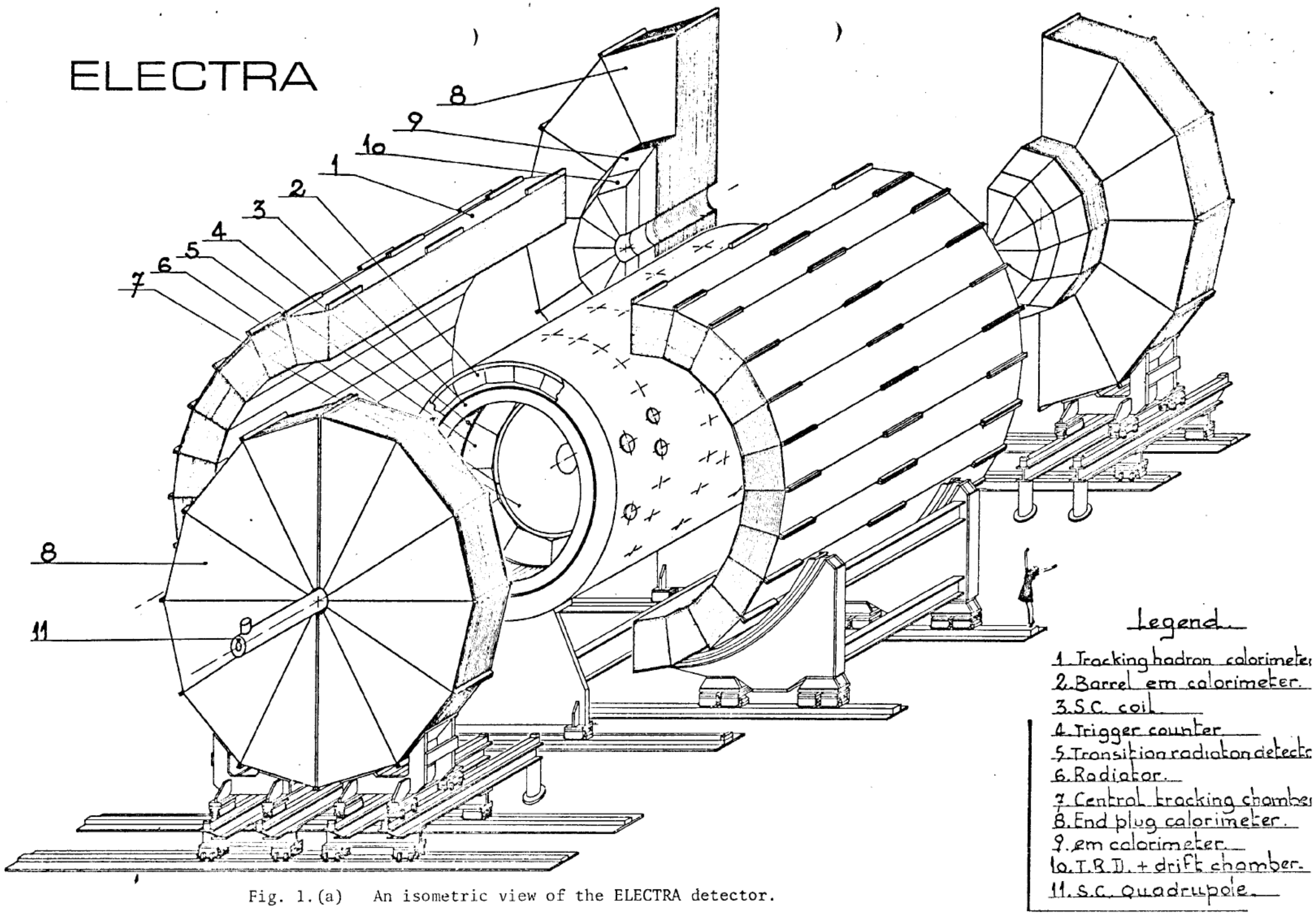


Fig. 1.(a) An isometric view of the ELECTRA detector.

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* The names of the participants are contained in the Appendix.

Electra

Appendix

Participants

Spokesman - R.J. Cashmore, Oxford

Austria
Institut für Hochenergiephysik
der Österreichischen Akademie
der Wissenschaffen, Vienna

W Bartl
G Leder
F Mandl
W Mitaroff
G Neuhofer
M Pernicka
+ 6 others

(ii) Tel Aviv University

G Alexander
G Bella
J Grunhaus
A Levy
+ 1 other

(ii) Imperial College, London

T C Bacon
R Beuselinck
W Cameron
P J Dornan
A Duane
J G McEwen
G Hall
W G Jones
S L Lloyd
J K Sedgbeer
I Siotis
D M Websdale
A P White

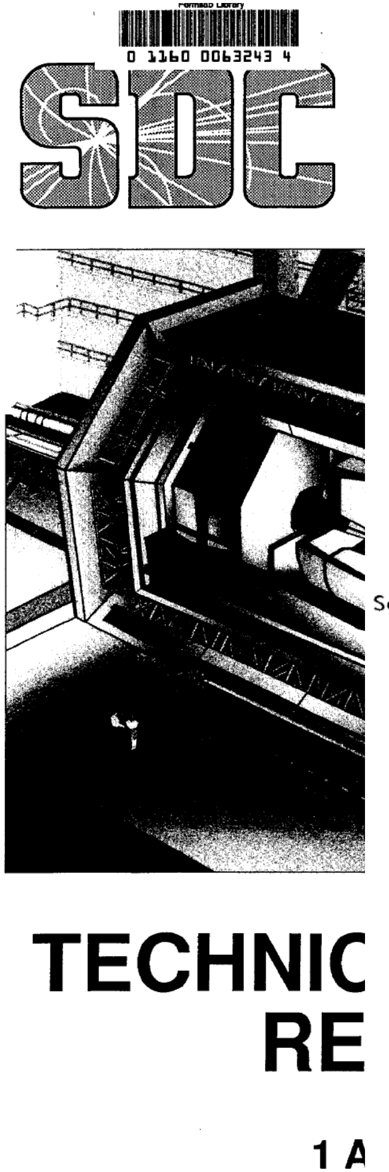
(vi) Rutherford Appleton Laboratory

P T Clee
B Foster
J C Hart
J Proudfoot
D H Saxon
P L Woodworth
+ 2 others

(iv) Oxford

M G Bowler
R J Cashmore
R C Devenish
P Grossmann
J G Loken
R Mount
P Renton
G L Salmon
W S C Williams
C Youngman

SDC @ SSC



SDC-92-0201

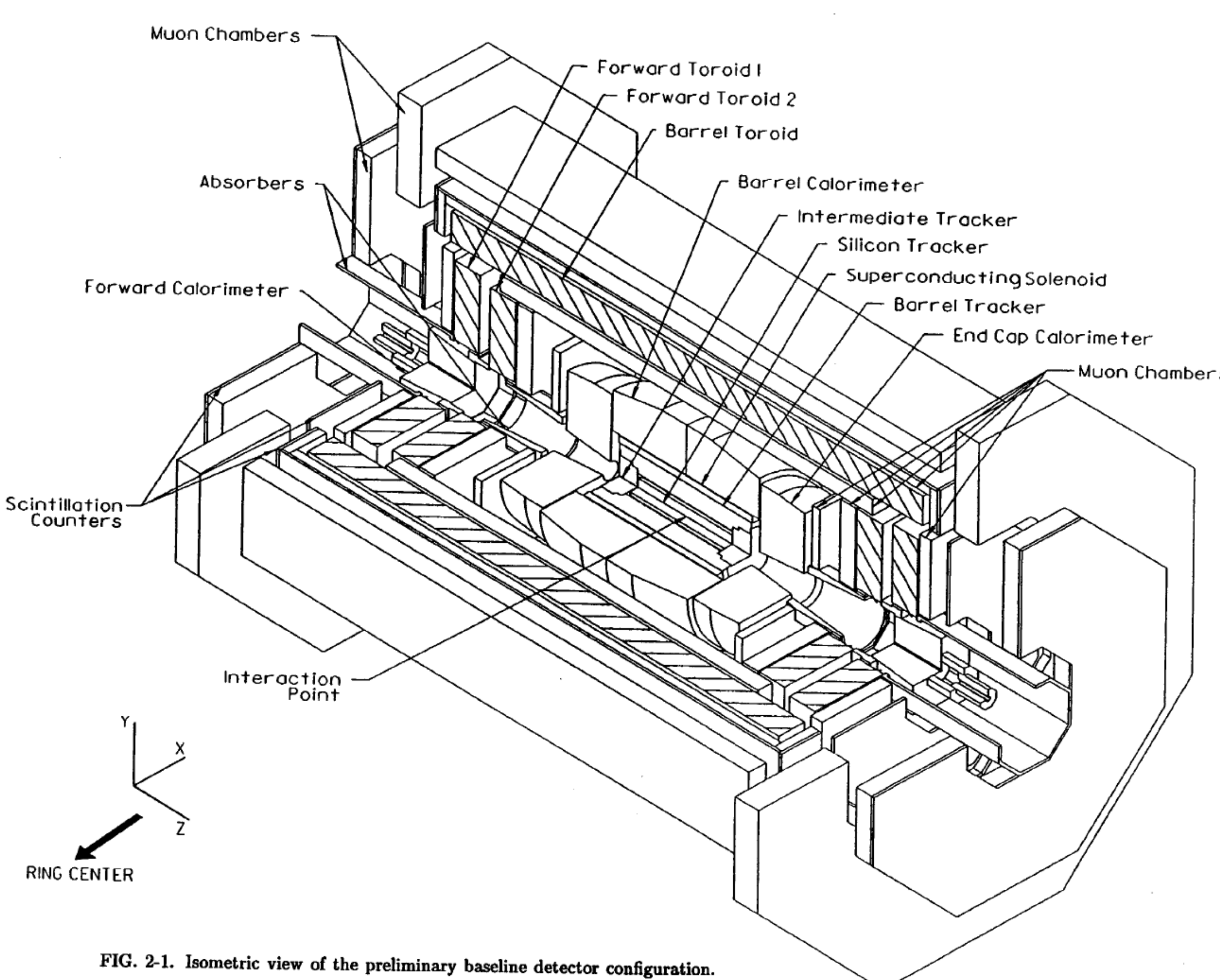


FIG. 2-1. Isometric view of the preliminary baseline detector configuration.

SSC site

SDC

Members of the Solenoidal Detector Collaboration

Argonne National Laboratory: E. L. Berger, R. E. Blair, J. W. Dawson, M. Derrick, T. H. Fields, V. Guarino, N. F. Hill, P. K. Job, T. B. W. Kirk, E. N. May, J. Nasiatka, L. J. Nodulman, L. E. Price, J. Proudfoot, H. M. Spinka, R. L. Talaga, D. G. Underwood, R. G. Wagner, A. B. Wicklund

University of Arizona: K. A. Johns

Beijing University, China: He Yu Ming, Lai Chu Xi, Liu Hong Tao, Liu Song Qiu, Lou Bing Qiao, Yang Ji Xiang, Yao Shu De, Zhang Re Ju

Institute of High Energy Physics, Beijing: H. Cui, C. Gao, M. Gao, W. Gao, S. Gu, H. Hu, D. Huang, W. Li, N. Liu H. Mao, H. Ni, N. Qi, G. Rong, H. Shi, S. Tang, P. Wang, T. Wang, X. Xie, S. Xue, W. Yan, M. Ye, Ge. Zhang, W. Zhao, L. Zheng, Y. Zhou, Q. Zhu, Y. Zhu

Brandeis University: S. Behrends, J. R. Bensinger, P. Kesten, L. Kirsch

Bratislava State University, Czechoslovakia: P. Povinec, P. Strmen

University of Bristol: B. Foster, G. P. Heath

Lawrence Berkeley Laboratory: G. S. Abrams, H. Aihara, A. Barbaro-Galtieri, R. M. Barnett, L. P. Bautz, C. J. Bebek, R. N. Cahn, A. Ciocio, C. A. Corradi, C. Day, S. Dow, A. Dubois, P. H. Eberhard, W. R. Edwards, K. Einsweiler, T. Elioff, R. Ely, G. Gabor, M. G. D. Gilchriese, W. Greiman, D. E. Groom, C. Haber, C. Hearty, I. Hinchliffe, M. Hoff, R. Jared, R. W. Kadel, J. A. Kadyk, F. Kirsten, I. Kipnis, S. Kleinfelder, M. E. Levi, A. Lim S. C. Loken, N. Madden, O. Milgrome, J. Millaud, Y. Y. Minamihara, T. L. Moore, D. R. Nygren, E. Oberst, W. L. Pope, M. Pripstein, J. Rasson, D. Santos, B. Schumm, M. Shapiro, D. Shuman, H. G. Spieler, R. Stone, M. Strovink, W. Thur, G. H. Trilling, R. C. Weidenbach, W. A. Wenzel, S. Wonduke, M. Wong

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SDC

University of Oxford: J. Bibby, R. J. Cashmore, N. Harnew, R. Nickerson, W. Williams

Tel Aviv University: J. Grunhaus, R. Heifetz, A. Levy

SDC – 92 – 171
Report To Kondo Committee
January 20th, 1992

Intermediate angle Track Detector
Conceptual Design Report

SDC ITD GROUP

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Carleton University

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CRPP

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T. Jones, S. Kiourkos, S.J. Maxfield, J.M. Morton, G.D. Patel
Liverpool University

L. Hamel, J.P. Martin, L. Martinu, P. Taras, M.R. Wertheimer
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M. Edwards
Rutherford Appleton Laboratories

E. Barasch, R. Gaedke, P. McIntyre, Y. Pang, H.-J. Trost
Texas A&M University

R. Henderson, M. Salomon
TRIUMF

Some people never learn

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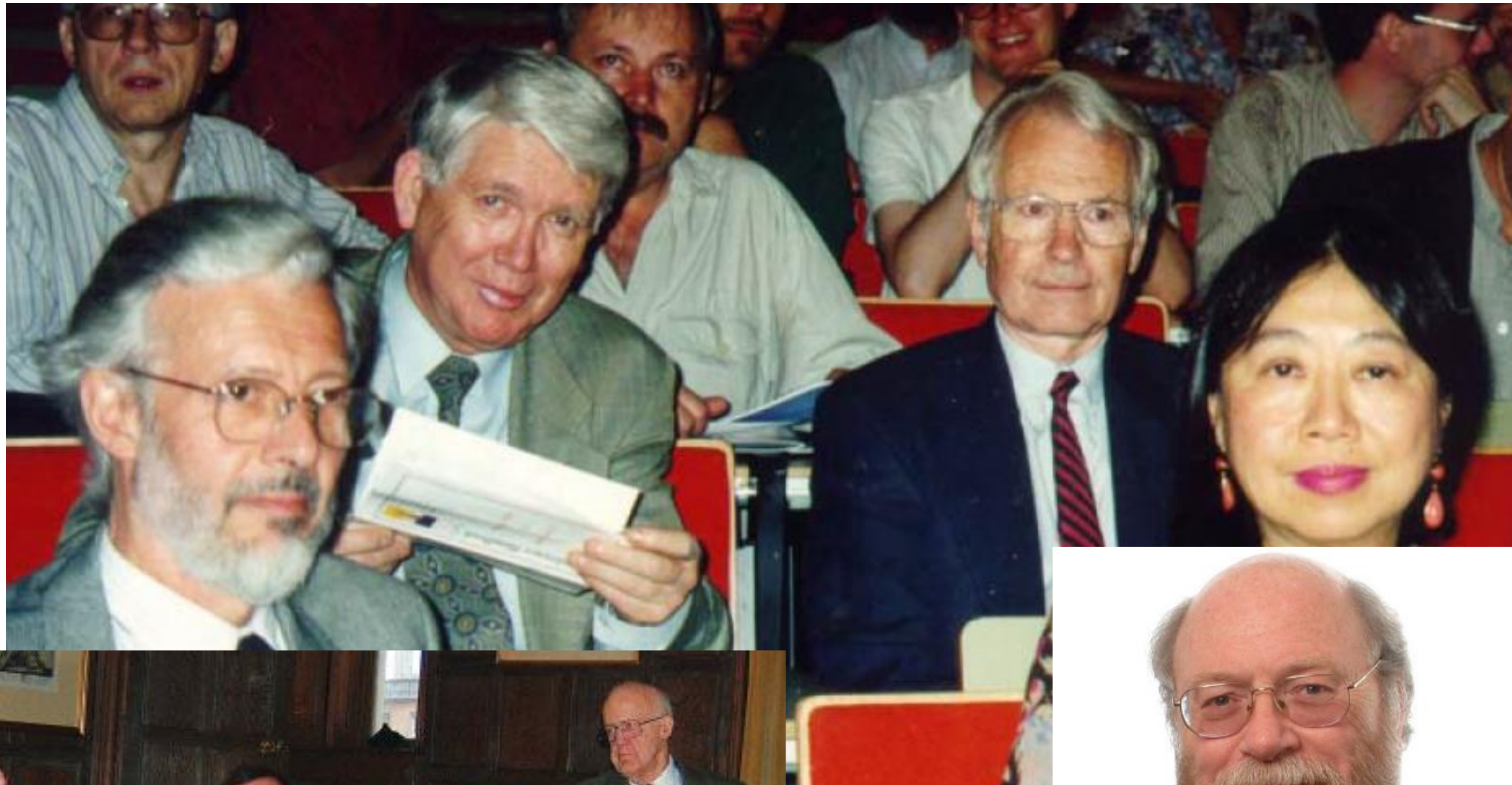
In summary….



In summary….

Thank you Roger for almost 40 years of physics – and fun!