Remembering and Celebrating James Stirling

As remembered by Steve Ellis

I was lucky enough to both overlap with and collaborate with James at many times and places - Seattle, Cambridge, Geneva, Santa Barbara & Durham.

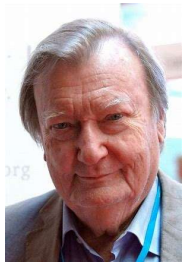
Here we will focus on his contributions during the exciting Monojet Era at CERN in the mid-1980's.

Summary:

- James was a truly outstanding physicist, colleague, and administrator. He demonstrated a remarkable ability to recognize times of revolutionary change in the science and then provide essential contributions to those changes: including understanding and using QCD, explaining Monojets, founding and directing the IPPP.

- James was also one of finest human beings that it was my honor and pleasure to interact with.

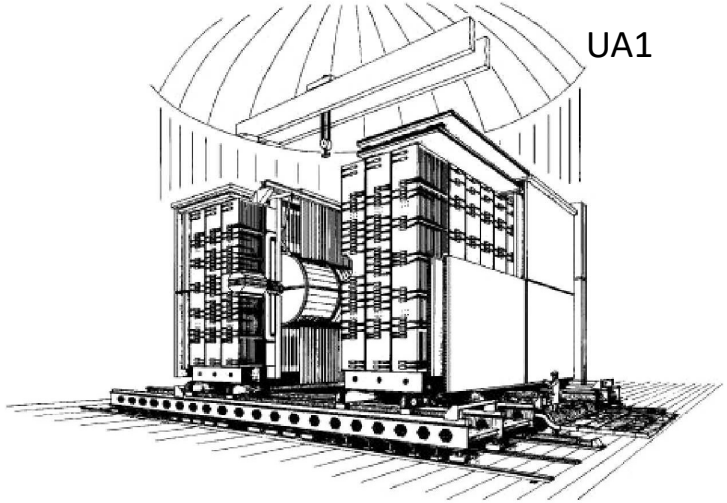
- My goal today is to share some of those experiences from an especially exciting and dramatic era at CERN. James, Ronald and I had the opportunity to work with (and around) a host of talented physicists.

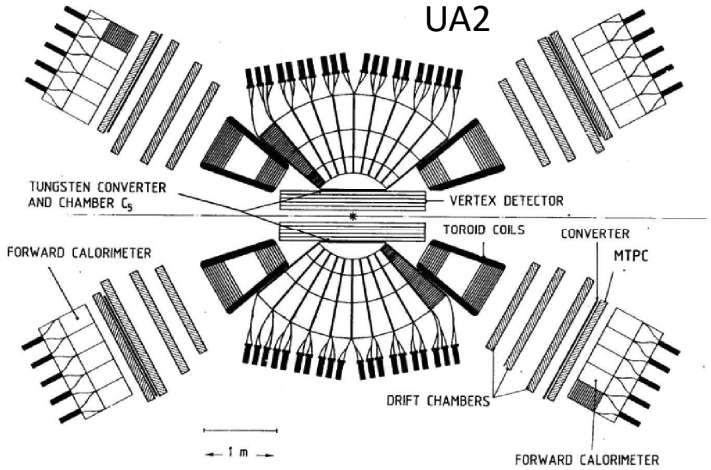


The setting – CERN: 1981 – 1986 – A Time of Revolution

- Thanks largely to the efforts of Carlo Rubbia and Simon van der Meer (1984 Nobel Prize winners) the S$\bar{p}$pS proton-antiproton collider was running at a large enough energy (initially 546 GeV, then 630 GeV) to produce W's and Z's.

- The two primary detectors, UA1 and UA2, were large acceptance ("nearly" 4π and "nearly" hermetic) detectors. This was in sharp contrast to previous hadron collision detectors, *e.g.*, at the ISR, dominated by single-arm, small acceptance detectors. So we needed to think about analyzing the *entire* event.





- The detectors could “see” the charged leptons from W/Z decays,

- especially after applying cuts.

- A revolution in event displays!

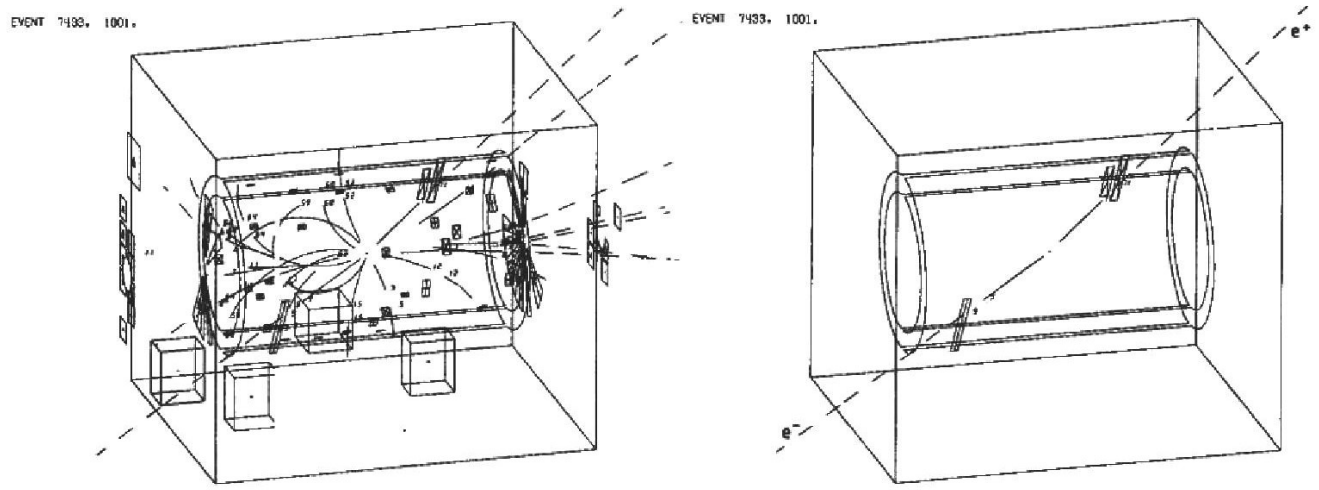


Fig. 15. One of the $Z \rightarrow e^+e^-$ events in UA1: (a) display of all reconstructed tracks and calorimeter hit cells; (b) only tracks with $p_T > 2\,\mathrm{GeV}/c$ and calorimeter cells with $E_T > 2\,\mathrm{GeV}$ are shown.

- Also, being “hermetic”, could infer (from transverse momentum conservation) the presence of “undetected” neutrinos or more exciting particles.

- Energies were also large enough that jets in the final state were clear to the naked eye (not requiring massaging the data as before). LEGO Plots became the event display of choice!
- Precision jet algorithms were still years away!

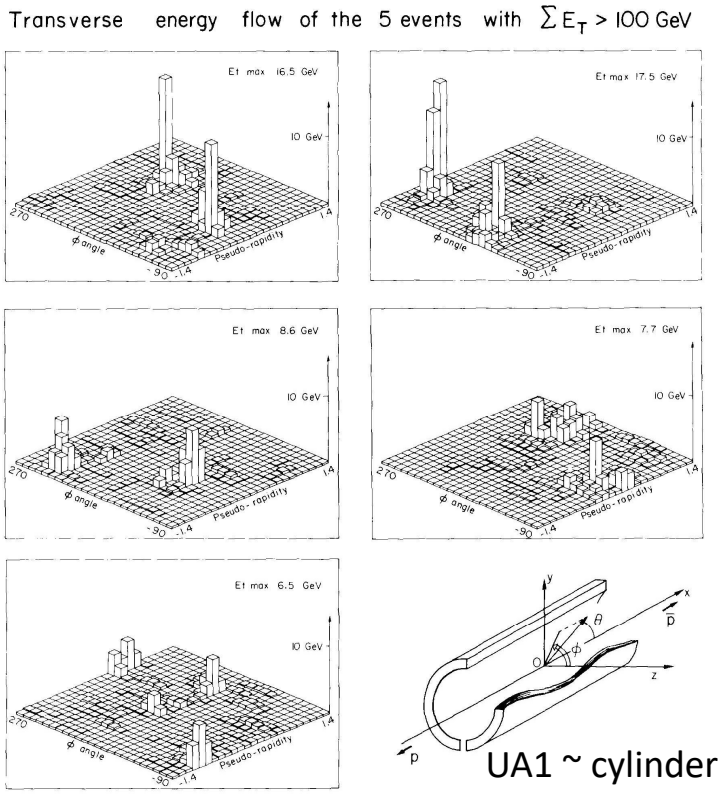


Fig. 3. Distribution of transverse energy versus azimuth ϕ and pseudo-rapidity η, for the five events with the highest ΣE_T.

The differences in geometry led to some differences in analysis.

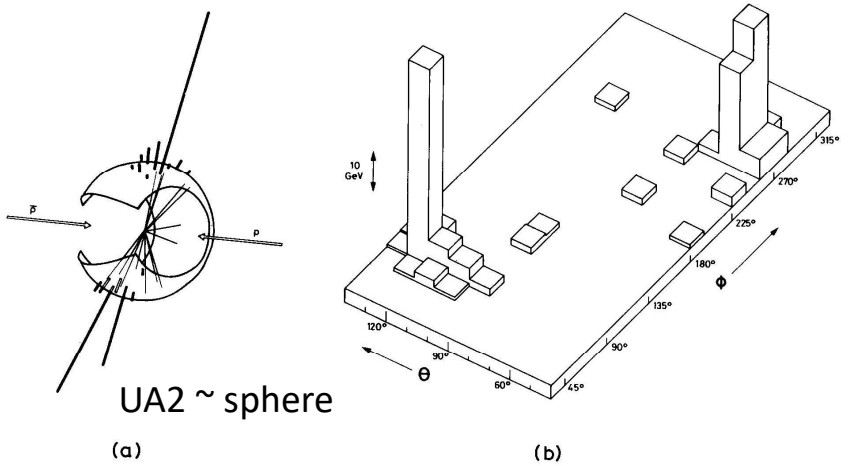


Fig. 4. Configuration of the event with the largest value of ΣE_T, 127 GeV (M = 140 GeV): (a) charged tracks pointing to the inner face of the central calorimeter are shown together with cell energies (indicated by heavy lines with lengths proportional to cell energies). (b) the cell energy distribution as a function of polar angle θ and azimuth ϕ.

- By the time I arrived for a sabbatical year at CERN in summer 1984 W's, Z's and jets were clearly being detected.

- Plus…. a new class of event was creeping into the data – the now famous Monojet Events wherein a jet with Large P_T (or E_T) was apparently recoiling against "nothing" – so also labeled Missing E_T Events.

- While neutrinos in W & Z decays could lead to this behavior, initial simple analyses suggested only fractions of an event per channel and these were largely ignored.

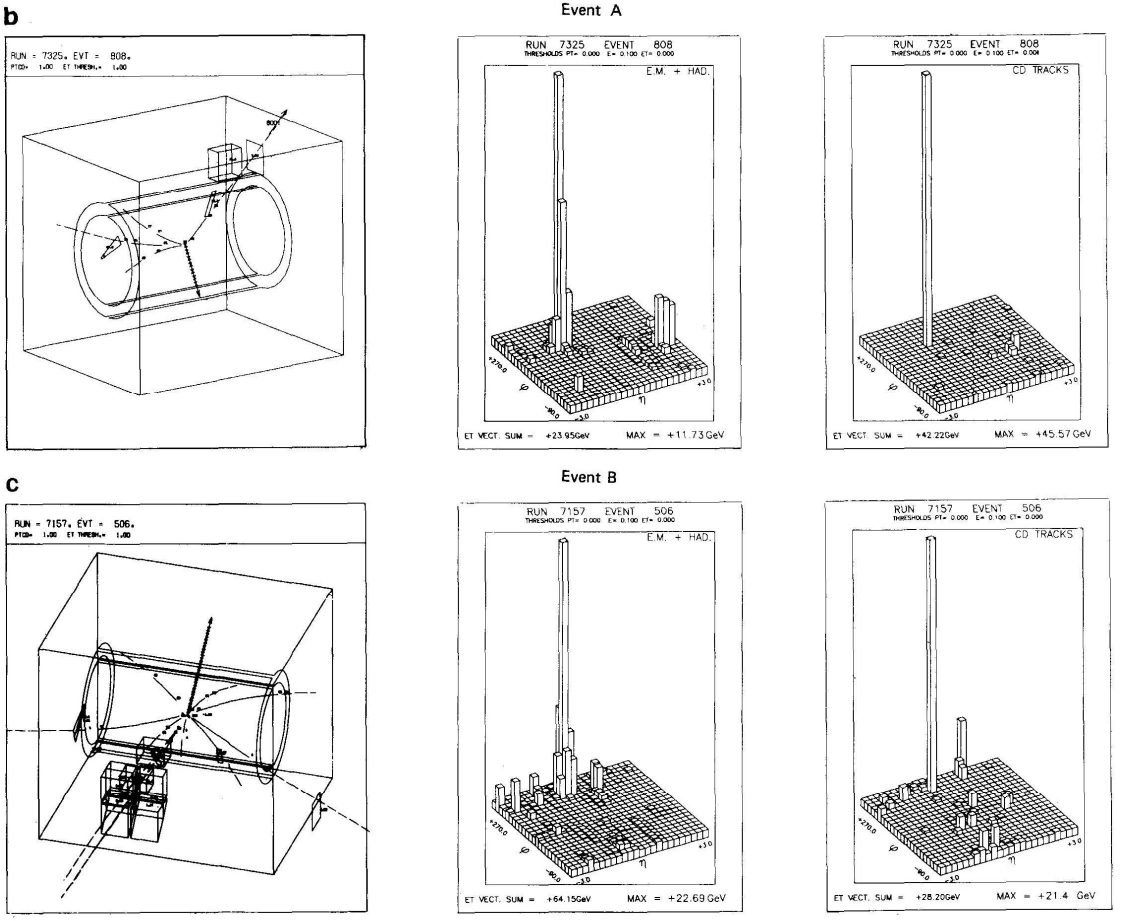


Fig. 7. Display of calorimeter cells and tracks with transverse energy greater than 1 GeV along with transverse energy flow (φ versus η) seen in calorimeters and in charged tracks for (a) event H, (b) event A, and (c) event B.

- Plus there was a strong SUSY “lobby” at CERN that *wanted* these events to be evidence for SUSY discovery (and for Carlo Rubbia to win TWO Nobel prizes).

- Clearly what was needed were better phenomenological tools, and luckily James and Ronald were already hard at work, using Ronald’s spinor techniques, to perform a more comprehensive analysis of the W/Z + jet(s) events.

- Also luckily I was able to beg my way into their collaboration.

ASIDE: The TH Christmas play in 1984 was Scarmen (a SUSY based opera) with me as the bull (as Carlo)!

The analysis:

- The idea was to perform a tree-level calculation of W/Z + jets production *including* the leptons from the decay. (Many final state fermions -> needed the spinor technology.)
- The experimental cuts could be applied directly to the "observed" leptons and jets (= 1 parton).
- This allowed a phenomenological description of *all* of the major components of the *entire* event.
- On the downside, there was uncertainty due to not including fragmentation or addressing the choice of scale issue, *i.e.*, just LO QCD.
- Still this was the most comprehensive analysis available and agreed (within uncertainties) with the experimental data.

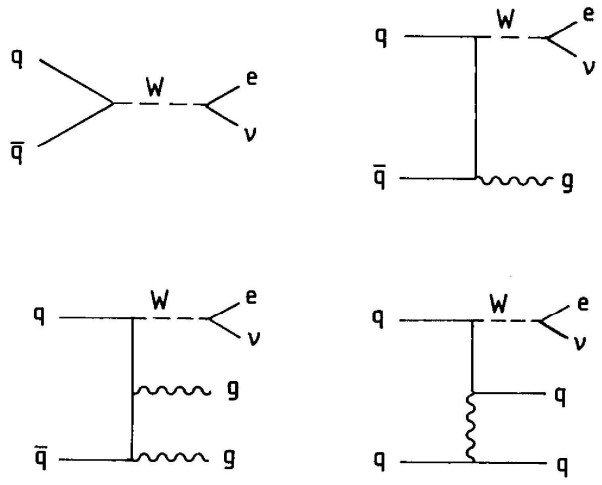
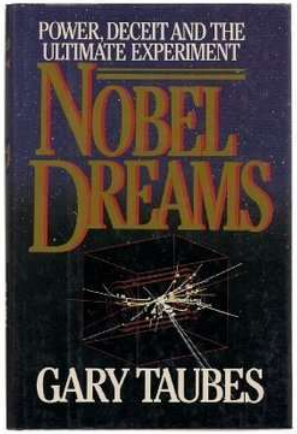


Fig. 1: Examples of Feynman diagrams contributing to the processes $p\bar{p} \to W(e\nu) + 0,1,2$ jets.

- And, with a quantitative description of the "observed" W's and Z's, we could proceed to "accurately" estimate the SM "unobserved" events – the Monojets.

The level of drama increased as the Particle Physics Community (~220 people) headed to Saint-Vincent in the Aosta Valley in late February 1985 to hear about Monojets at the *5th Topical Workshop on Proton-Antiproton Collider Physics*!

- The drama was heightened as Carlo now had his own writer, Gary Taubes, to record the events. See Chapter 15 of *Nobel Dreams*!



- On day 2 the UA1 and UA2 Missing E_T results (Monojets, Dijets, Trijets and 1 Quadjet), were "reviewed" (somewhat misleadingly) by Carlo.
- Then John Ellis, Gordie Kane and Alvaro DeRujula offered "competing" SUSY explanations differing primarily on the mass of the purported gluino.
- Guido Altarelli offered, in his typical colorful style, his suggestion that many channels (including "cracks" in the detector) might each be making small contributions that summed could explain the observations – the "Altarelli Cocktail".
- Day 3 was about upgrades and lower energy results leading many to shop or ski.

- By the afternoon of day 4 Carlo had left for Geneva and then the fun started. First was a talk by James Stirling – "a dapper Englishman, in his mid-thirties"* who spoke about QCD in W and Z physics (largely ignoring monojets).

"He had a soft British accent, and he worked calmly, letting the calculations speak for themselves, building up his case step by step. For every one of his theoretical deductions, he would check back with the experimental data to prove that the deduction had been valid."

Even with the theoretical uncertainties the Standard Model seemed in agreement with the identified W/Z events with jets, including the large p_T tail. For example, the fraction of events with a specific number of jets matched the UA1 data.

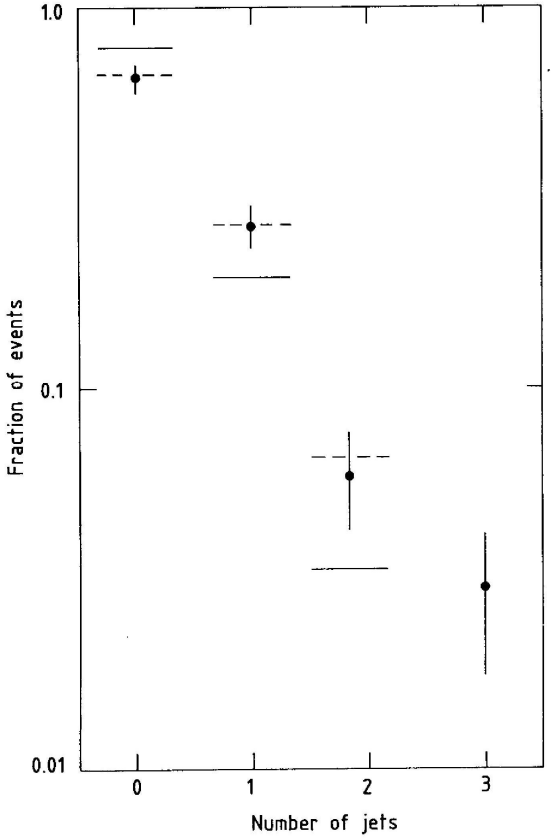


Fig. 3: Jet multiplicity distribution for W → eν events. The data are from the UA1 collaboration reported at this workshop[3]. The two sets of theoretical results, shown as horizontal lines , are explained in the text.

- I gave the next talk, concerning events without identified W's or Z's.

*Liberal quotations from *Nobel Dreams*, p. 228-230.

- Ellis's "lecture style was half comedian and half television sports announcer".

- Following Altarelli the talk's subtitle was "The Many Roads to Paradise".

- With uncertainties expect between 4 and 11 events with $E_T^{miss} > 40$ GeV.

- The UA1 result for $E_T^{miss} > 40$ GeV was less that 12 events.

- I concluded "I am not at all sanguine that a large fraction of that [monojet] signal is not just plain old W and Z decay."

- Within a few months, using more detailed tools, UA1 and UA2 confirmed the Standard Model Interpretation.

TABLE

Specific contributions of the various "roads" in picobarns for $E_T^{miss} > 40$ GeV. The numerical uncertainty in the individual numbers varies from less than 1% for the largest values to about 20% for the smallest. The total result is estimated to have a numerical uncertainty of about ± 0.03 pb. The two jet contributions are divided according to whether (a) the lower P_T jet has P_T in the range 6 GeV/c < P_T < 10 GeV/c or (b) P_T > 10 GeV/c.

Channel	1 Jet	2 Jets (a)	2 Jets (b)	Total
$Z \to \nu\bar{\nu}$	2.89	0.68	1.17	4.74
$W \to \not{e}$	1.34	0.21	0.29	1.84
$W \to \not{\mu}$	0.03	0.008	0.005	0.04
$W \to \tau \to \not{e}$	0.35	0.10	0.15	0.60
$W \to \tau \to \not{\mu}$	0.12	0.03	0.05	0.20
$W \to \tau \to h$	1.61	0.31	0.57	2.49
TOTAL	6.34	1.34	2.23	9.91

A Summary of James' Many Contributions to this Era

- Geer & Stirling, Phys. Lett. 152B, 373 (1985); "*JET ACTIVITY ASSOCIATED WITH W AND Z ° PRODUCTION*"
- Ellis, Kleiss & Stirling, Phys. Lett. 154B, 435 (1985); "*W's, Z's AND JETS*"
- Ellis, Kleiss & Stirling, Phys. Lett. 158B, 341 (1985); "*MISSING TRANSVERSE ENERGY EVENTS AND THE STANDARD MODEL*"
- Ellis, Kleiss & Stirling, Phys. Lett. 163B, 261 (1985); "*W +W - PAIR PRODUCTION IN HIGH ENERGY HADRONIC COLLISIONS: SIGNAL VERSUS BACKGROUND"*
- Ellis, Kleiss & Stirling, Phys. Lett. 167B, 464 (1986); "*MONOJETS IN THE STANDARD MODEL*"
- Ellis, Kleiss & Stirling, Aosta Talk, CERN-TH.4185/85; "JET ACTIVITY IN W, Z – A THEORETICAL ANALYSIS"
- Ellis, Kleiss & Stirling, Aosta Talk, CERN-TH.4170/85; "THE STANDARD MODEL AND MISSING ET OR THE MANY ROADS TO PARADISE"
- Ellis, Kleiss & Stirling, Comp. Phys. Comm. 40, 359 (1986); "*A NEW MONTE CARLO TREATMENT OF MULTIPARTICLE PHASE SPACE AT HIGH ENERGIES*" (i.e., *RAMBO*)

This was a remarkably productive (and fun) year for all of us, and all because of James!

Summary:

- James was a truly outstanding physicist, collaborator, administrator and human being.

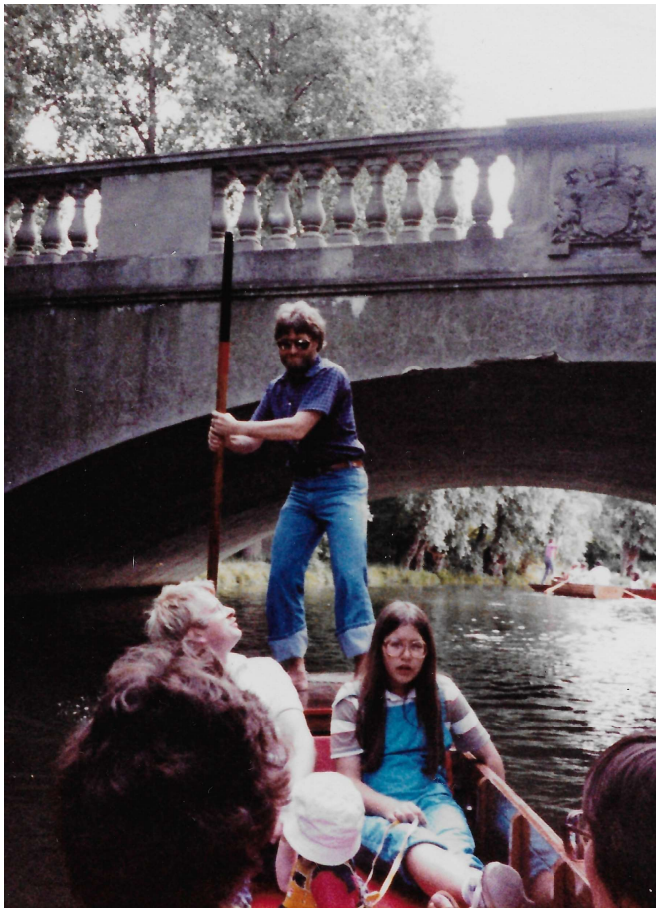
- It was my honor and pleasure to experience James in all of these roles during the several times that we were in the same location and worked together.

- I hope my shared experiences illustrate James's special talents as a physicist and as a human being. He had a extremely positive influence on the lives of many of us and he will not be forgotten.

EXTRA: Historical photos & video:
1979 - 1990

Seattle: 1979 - 1981

Cambridge: 1982 (James teaches me how NOT to fall in the Cam)



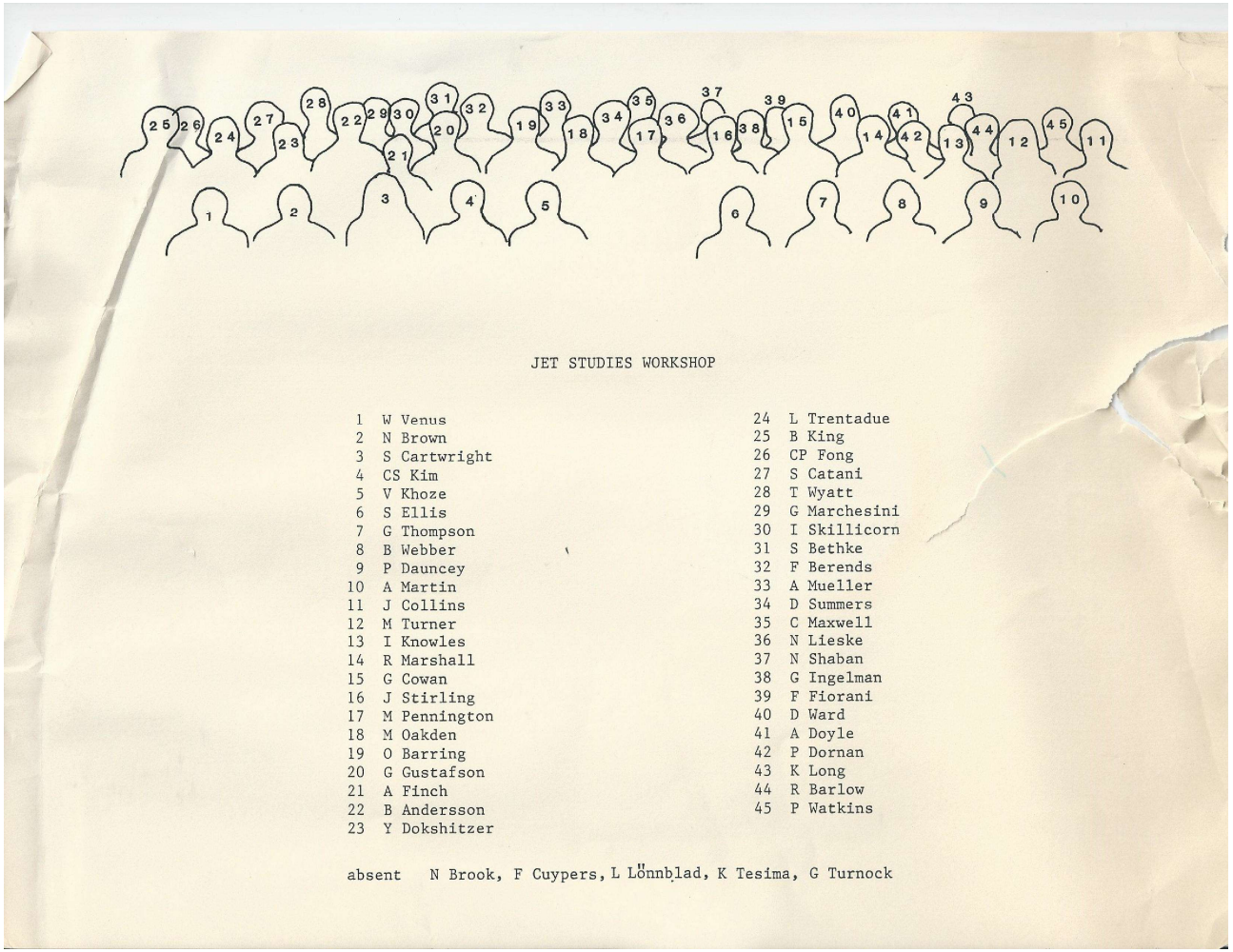
Santa Barbara (ITP): 1988

- Video file removed due to size constraints.

Durham:1990

JET STUDIES WORKSHOP
ST. JOHN'S COLLEGE, DURHAM.
DECEMBER 1990

Names



JET STUDIES WORKSHOP

1	W Venus	24	L Trentadue
2	N Brown	25	B King
3	S Cartwright	26	CP Fong
4	CS Kim	27	S Catani
5	V Khoze	28	T Wyatt
6	S Ellis	29	G Marchesini
7	G Thompson	30	I Skillicorn
8	B Webber	31	S Bethke
9	P Dauncey	32	F Berends
10	A Martin	33	A Mueller
11	J Collins	34	D Summers
12	M Turner	35	C Maxwell
13	I Knowles	36	N Lieske
14	R Marshall	37	N Shaban
15	G Cowan	38	G Ingelman
16	J Stirling	39	F Fiorani
17	M Pennington	40	D Ward
18	M Oakden	41	A Doyle
19	O Barring	42	P Dornan
20	G Gustafson	43	K Long
21	A Finch	44	R Barlow
22	B Andersson	45	P Watkins
23	Y Dokshitzer		

absent N Brook, F Cuypers, L Lönnblad, K Tesima, G Turnock