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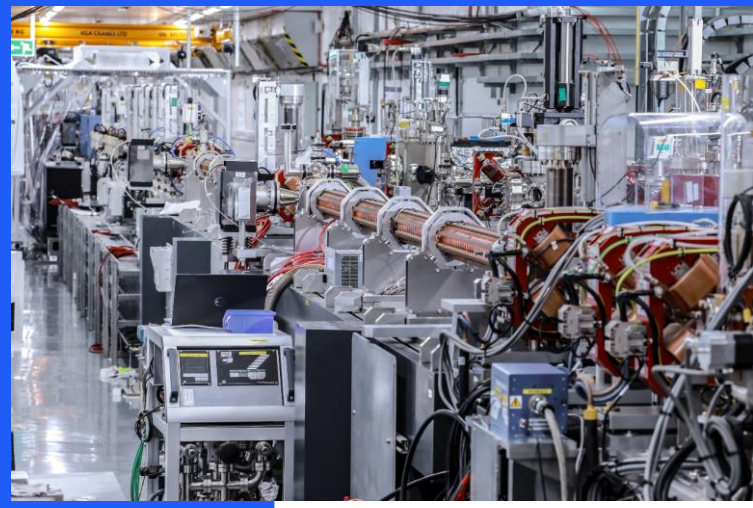
Making a brighter future through advanced accelerators

Prize Talk

Jim Clarke
STFC Daresbury Laboratory

PAB Conference June 2024

IOP Institute of Physics



The Brief…

- “Traditionally we do not impose any real constraint on the topic or content of the talk, save that it should be suitable to **entertain a room full of accelerator scientists for about an hour**, including time for any questions or discussion.”

My Brother Reads The Guardian…

- Or how I ended up at Daresbury …

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The Job Advert

- "…our group … is embarking on major new design initiatives … state of the art … **storage rings** and **free electron lasers**"

- "Advanced accelerators use high technology …particle beam design, major computer simulation, large electromagnets, high power RF systems, high-voltage pulse techniques, superconducting magnets, ultra high vacuum equipment, and other topics."

"So, have you applied for that job I sent you then?"

Physicists and Engineers

Particle Accelerator Development

We are looking for bright young physics and engineering graduates to join our team of particle accelerator experts.

Daresbury Laboratory in North Cheshire operates one of the world's leading high energy storage rings for provision of synchrotron radiation, which is used by a very large academic and industrial research community, including overseas scientists. There are a number of vacancies in our group, which is embarking on major new design initiatives aimed at advancing the state of the art in provision of synchrotron radiation from storage rings and free electron lasers.

We need people with drive and with ideas, who can innovate and who will quickly accept new responsibilities. Advanced accelerators use high technology, and you will work in such fields as particle beam design, major computer simulation, large electromagnets, high power radiofrequency systems, fast high-voltage pulse techniques, superconducting magnets, ultra high vacuum equipment, cryogenics, and other topics.

Recent honours graduates, including those graduating this year, or post-doctoral scientists and engineers, will find this an excellent opportunity to develop their careers in stimulating and varied work with international contacts. The existing Daresbury facilities provide first-class training for those without relevant experience.

Grading and a salary in the range £8,067 to £14,858 will be awarded according to qualifications and experience. Typically a good graduate could expect to start at £10,026 and further increments are available depending on performance. There is a flexible working system and non-contributory superannuation.

For further information contact Mike Poole (0925-603256) or Vic Suller (0925-603209). For application forms contact: The Personnel Officer, Daresbury Laboratory, Warrington WA4 4AD (0925 603467 – 24 hours). Please quote reference DL 99.

CLOSING DATE: 13th April, 1988.

Daresbury SCIENCE & ENGINEERING RESEARCH COUNCIL

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The Interview

- Travelling from Manchester the train was late…
- I received a warm welcome from the admin team - **“We don’t pay taxis!”**

DARESBURY
LABORATORY

DARESBURY WARRINGTON WA4 4AD. Telephone: 0925 603000. Direct Line: 0925 603___

-2 MAY 89

Mr J A Clarke
Moberley Tower
Burlington Street
Manchester
M15 6HR

Dear Mr Clarke

I am pleased to inform you, following your recent application for employment with the Council, that you have been selected to attend for interview for the post of Physicist, SO/HSO Ref. No. DL/99.

The interview will be held at Daresbury Laboratory on Monday 22 May 1989 at 14.15 pm. You should report to the Gate Lodge at least 10 minutes before the time of your interview; you will then be directed to the Personnel Office (Room A13).

A leaflet which explains how to get to the Laboratory is enclosed.

You will be entitled to a refund on account of travelling expenses necessarily incurred in connection with this interview. The refund of such expenses will normally be restricted to the cost of the journey by bus or second class rail fare. If you travel by private motor vehicle a car mileage allowance will be paid. Should you have any questions about method of travel please contact me beforehand.

Would you please let me know whether you are able to accept this invitation by completing and returning the enclosed acceptance form.

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The Offer

- Scientific Officer at a salary of £10,026

- When I received the offer I visited Daresbury again to learn a bit more about what the job actually was!
- Q “Can I do a PhD here?”
- A “No, it’s not possible to do a PhD in accelerators in the UK unfortunately”

- I was very unsure so said to myself I would give it two years…

DARESBURY
LABORATORY

DARESBURY WARRINGTON WA4 4AD. Telephone: 0925 603000. Direct Line: 0925 603___

E6 JUN 89

Mr J A Clarke
Moberly Tower
Burlington Street
Manchester
M15 6HR

Dear Mr Clarke

On behalf of the Science & Engineering Research Council (hereinafter referred to as the Council), I am pleased to offer you a permanent appointment as a Scientific Officer at the Daresbury Laboratory, subject to your producing evidence of qualifications of an acceptable standard.

Your employment with the Council will begin on the date on which you take up this appointment and your employment with your previous employer will not count as part of your continuous period of employment for the purpose of the Employment Protection (Consolidation) Act 1978.

Your terms and conditions of service are set out in the Council's Conditions of Employment Memoranda (CEMs) and General Notices issued from time to time, copies of which are available in the Laboratory's Library. Any significant changes will be notified by means of General Notices, Circulars etc.

Your attention is drawn to your rights as an inventor on entering the Council's service. Enclosed is a copy of the Council's regulations on this subject and an employee may not apply for nor obtain a patent except as laid down in those regulations. You are therefore required to sign the accompanying two copies of the Patent Rights Memorandum. One copy is for your retention.

The Group

- I joined the Accelerator Physics Group which sat within Synchrotron Radiation Department (the SRS user facility), Mike Poole was Group Leader and Vic Suller was Accelerator Division Head

The AP group (plus Mike Poole) in 1990

The AP group and Vic Suller in 1993 when John Lawson visited

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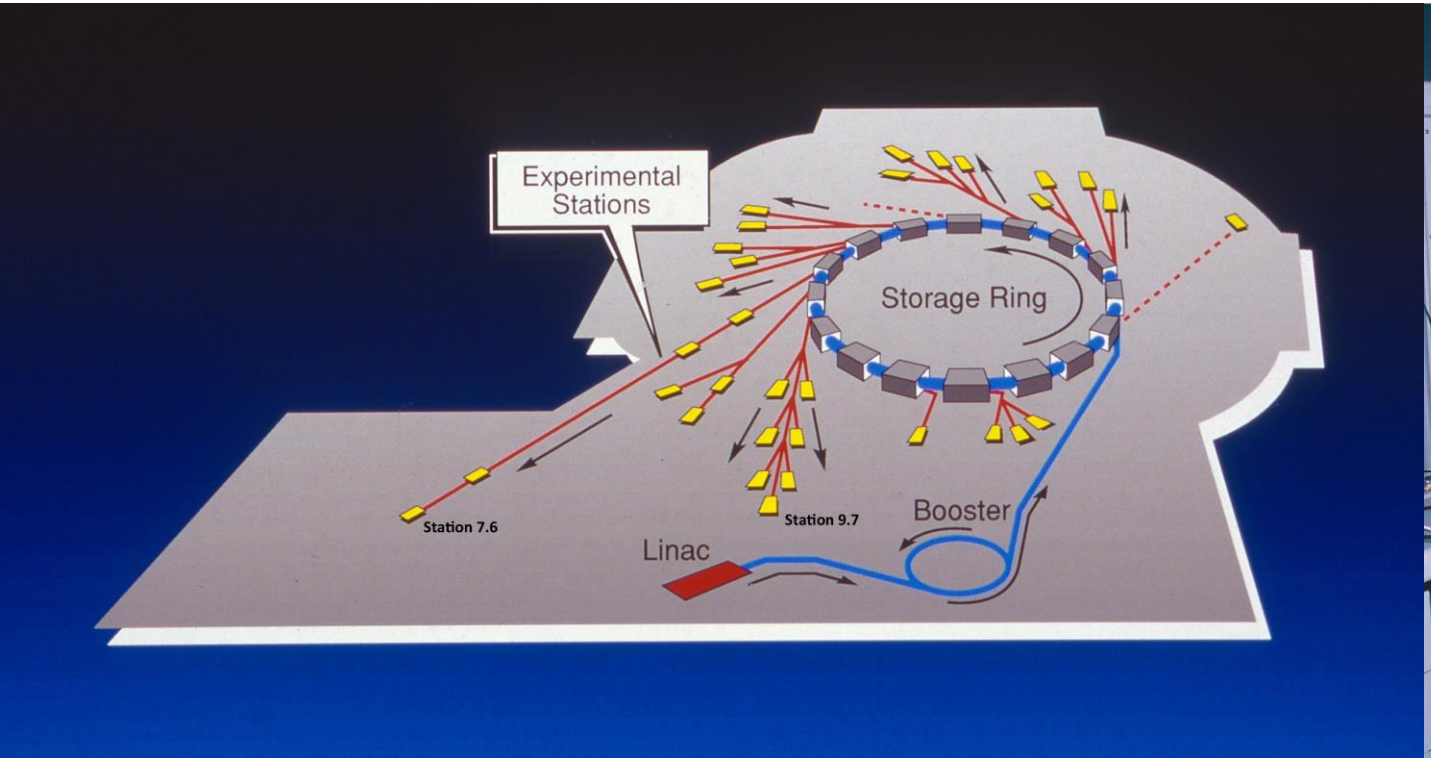
The SRS

- **We spent around two days per month on shift in the SRS Control Room to maintain and improve the performance of the accelerators, trying to understand the behaviour, and enabling and commissioning ongoing upgrades**

My first ever beam shift on the SRS
with Vic Suller and Jan Uythoven

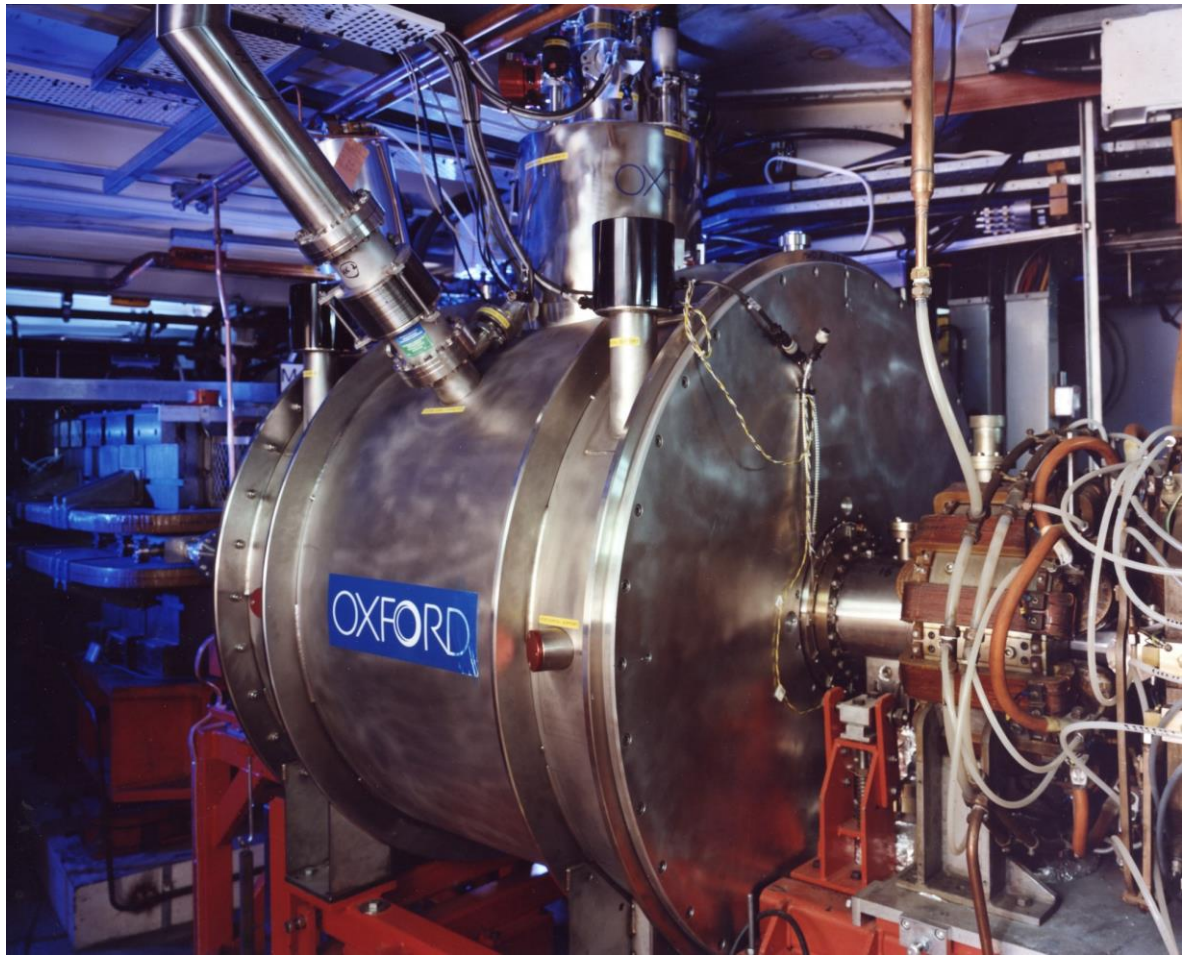


A Second Wiggler…

- The 7 hard X-ray end stations on the 5T wiggler were in very high demand and so funding was secured for **a second wiggler**, this time with 5 end stations
- This second superconducting wiggler was procured directly from industry (Oxford Instruments) and had a peak field of 6T
- The contract was placed in 1989 and the magnet was installed in 1991.

To physically make space in the straight section quite a few components had to be relocate and the injection elements were replaced.

I was responsible for measuring the magnetic fields of the new kickers and septum



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Measuring the Pulsed Magnets

- **Health and Safety in the 1990s…**
- Jim - “Is that live?”
- John (pulse power supply expert) flicks his hand onto the bus bars - “Yes”
- Jim - “OK, thanks” (in state of shock)

21st January 1991 SRS/TDN/92/01

SCIENCE AND ENGINEERING RESEARCH COUNCIL

DARESBURY LABORATORY

Magnetic measurement of the new SRS injection septum magnet

J. A. CLARKE

Introduction

With the installation of the second wiggler all of the pulsed injection magnets are to be changed. The magnetic measurements of the three new kickers has already been discussed in SRS/TDN/91/03, this note describes the measurements of the septum magnet.

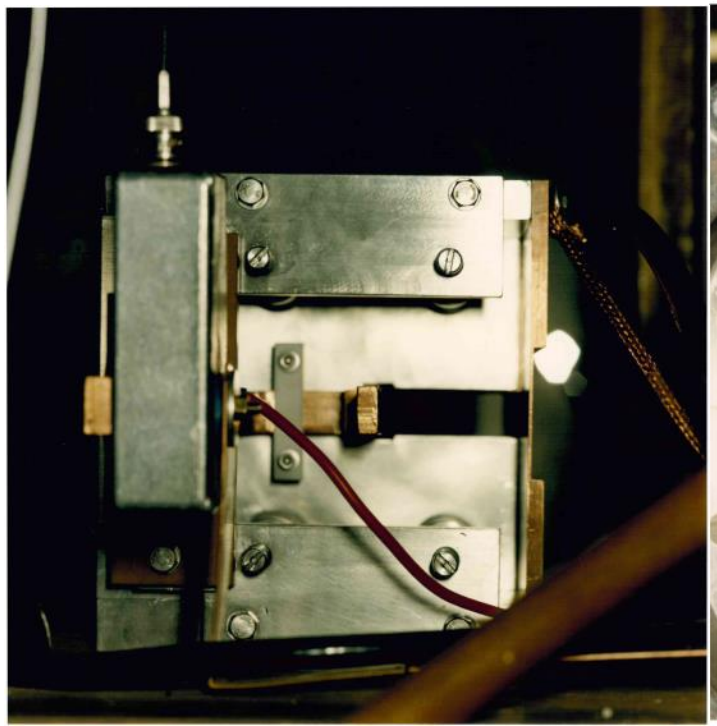
Apparatus

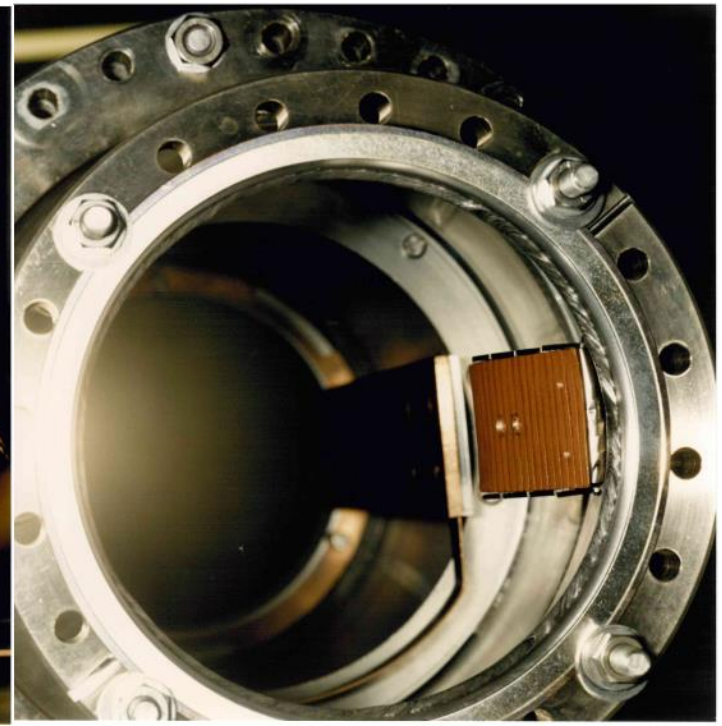
The measurement technique has been described in some detail in SRS/TDN/91/01. In order to measure $\int B.dl$, a long, single turn loop was used. The loop was produced using double sided circuit board. Copper was milled off both sides to leave a 2mm high strip of conductor on both sides. The two strips were connected by a short piece of copper sheet; a coaxial cable and connector were soldered onto the other end. The length of the loop was 915mm and the width 3.175mm. The septum magnet is in the shape of a dog leg, hence in order to get a true measure of the $\int B.dl$ the loop had to follow this geometry. The loop was scored at its centre and gently bent by hand to give an angular deflection of about 10^0. The integrity of the copper loop was not affected by this bending process. The magnetic length of the septum is around 800mm, so the loop extended by around 5cm at each end of the magnet. The magnetic gap between the laminations was 21mm.

Two RC integrators were used. The characteristics of each are given in the table below. The time constants of both integrators fell well below the calculated values, this is not yet understood. The values of the resistors were measured but the capacitors were taken as specified.

Integrator #	R kΩ	C nF	Calculated τ µs	Measured τ µs
6	68.0	4.7	320	245
7	100.2	4.7	471	339

The old septum power supply was used to provide a current of up to 7.5kA, the pulse length was 27µs. The output from both integrators were measured from 3kA to 7.5kA in 0.5kA steps.





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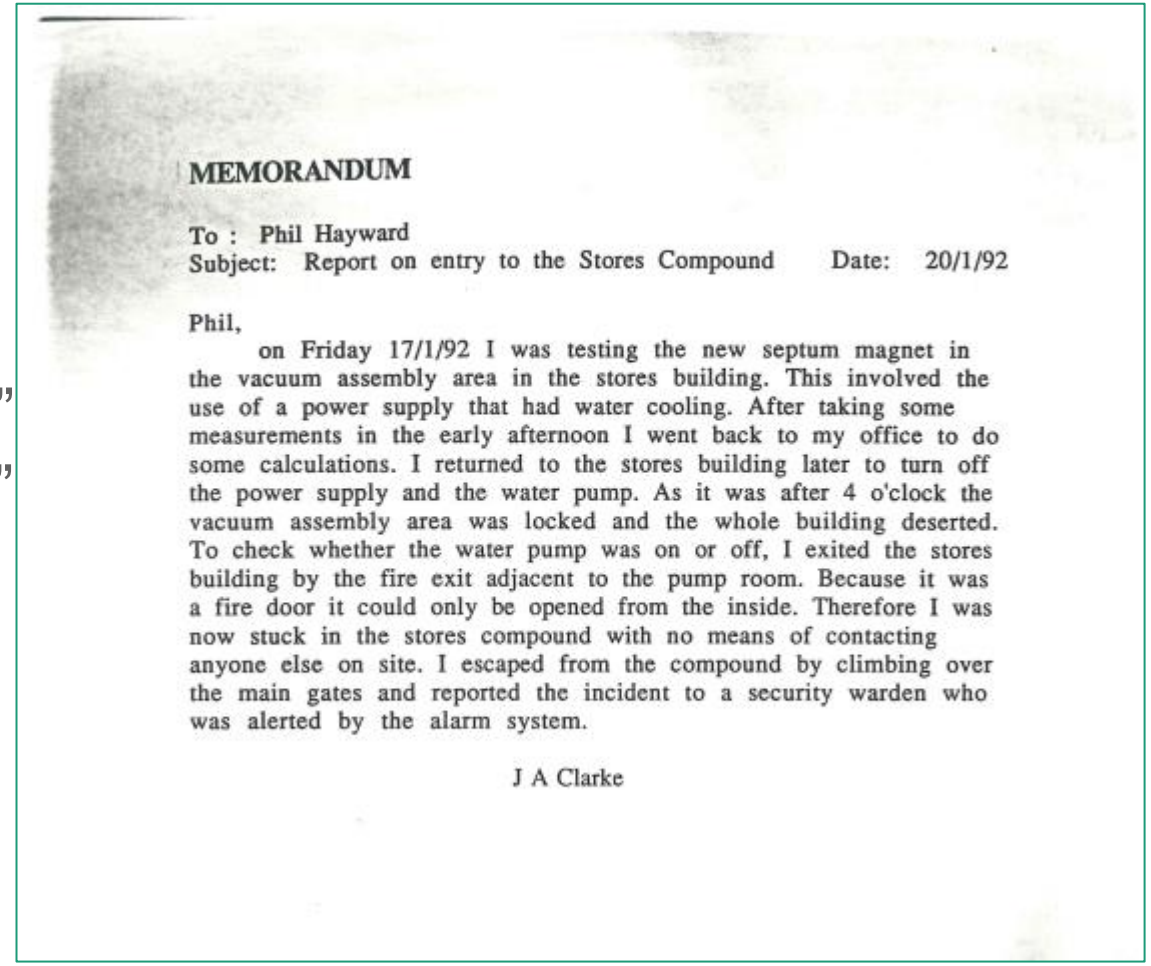
Measuring the Pulsed Magnets

- **Getting trapped in the Stores Compound…**
- "I was testing the new septum…"
- "As it was after 4 o'clock…the building was deserted"
- "I excited the Stores building by the fire exit…"
- "…it could only be opened from the inside"
- "I was now stuck in the Stores Compound"
- "I escaped by climbing over the main gates…"



MEMORANDUM

To : Phil Hayward
Subject: Report on entry to the Stores Compound Date: 20/1/92

Phil,

on Friday 17/1/92 I was testing the new septum magnet in the vacuum assembly area in the stores building. This involved the use of a power supply that had water cooling. After taking some measurements in the early afternoon I went back to my office to do some calculations. I returned to the stores building later to turn off the power supply and the water pump. As it was after 4 o'clock the vacuum assembly area was locked and the whole building deserted. To check whether the water pump was on or off, I exited the stores building by the fire exit adjacent to the pump room. Because it was a fire door it could only be opened from the inside. Therefore I was now stuck in the stores compound with no means of contacting anyone else on site. I escaped from the compound by climbing over the main gates and reported the incident to a security warden who was alerted by the alarm system.

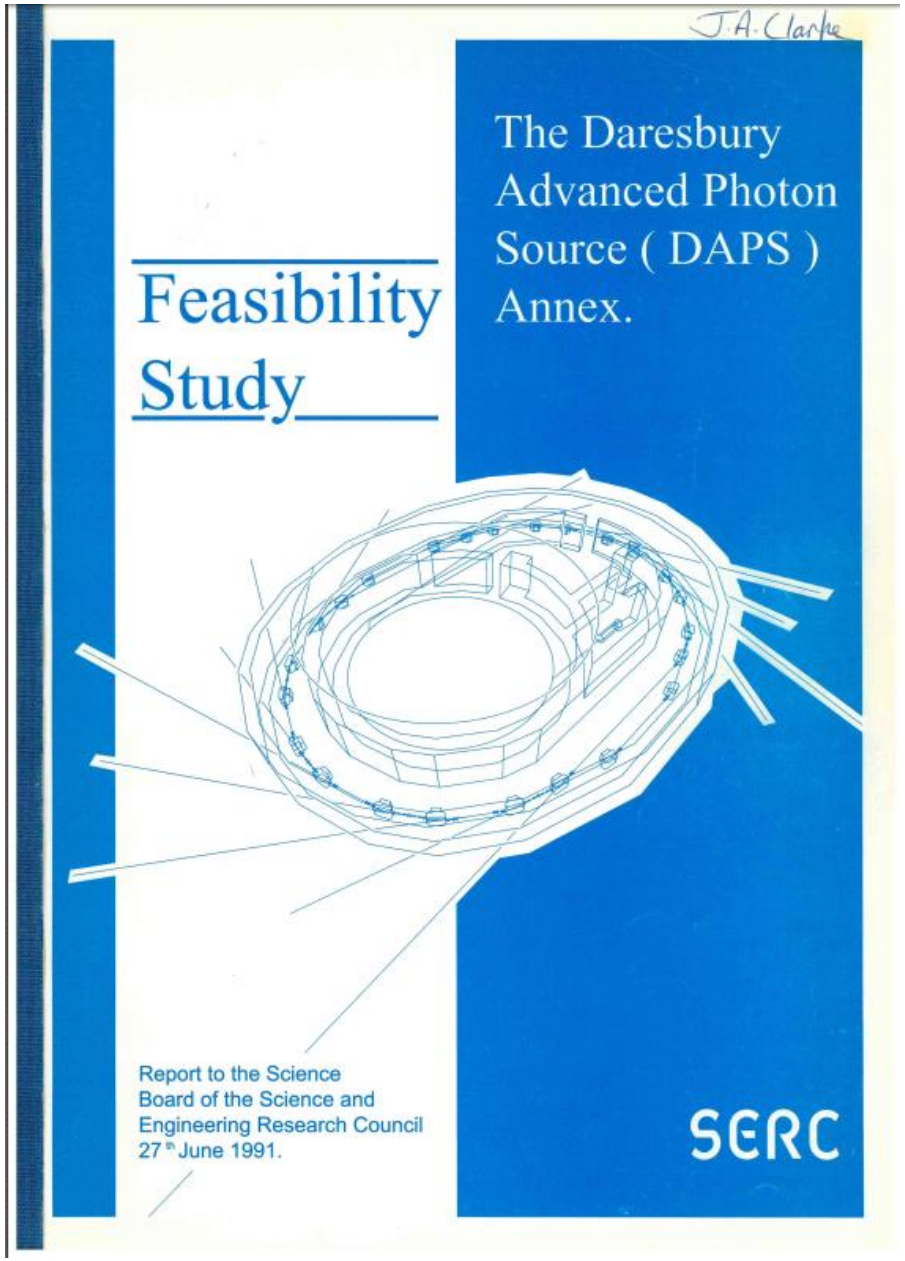
J A Clarke

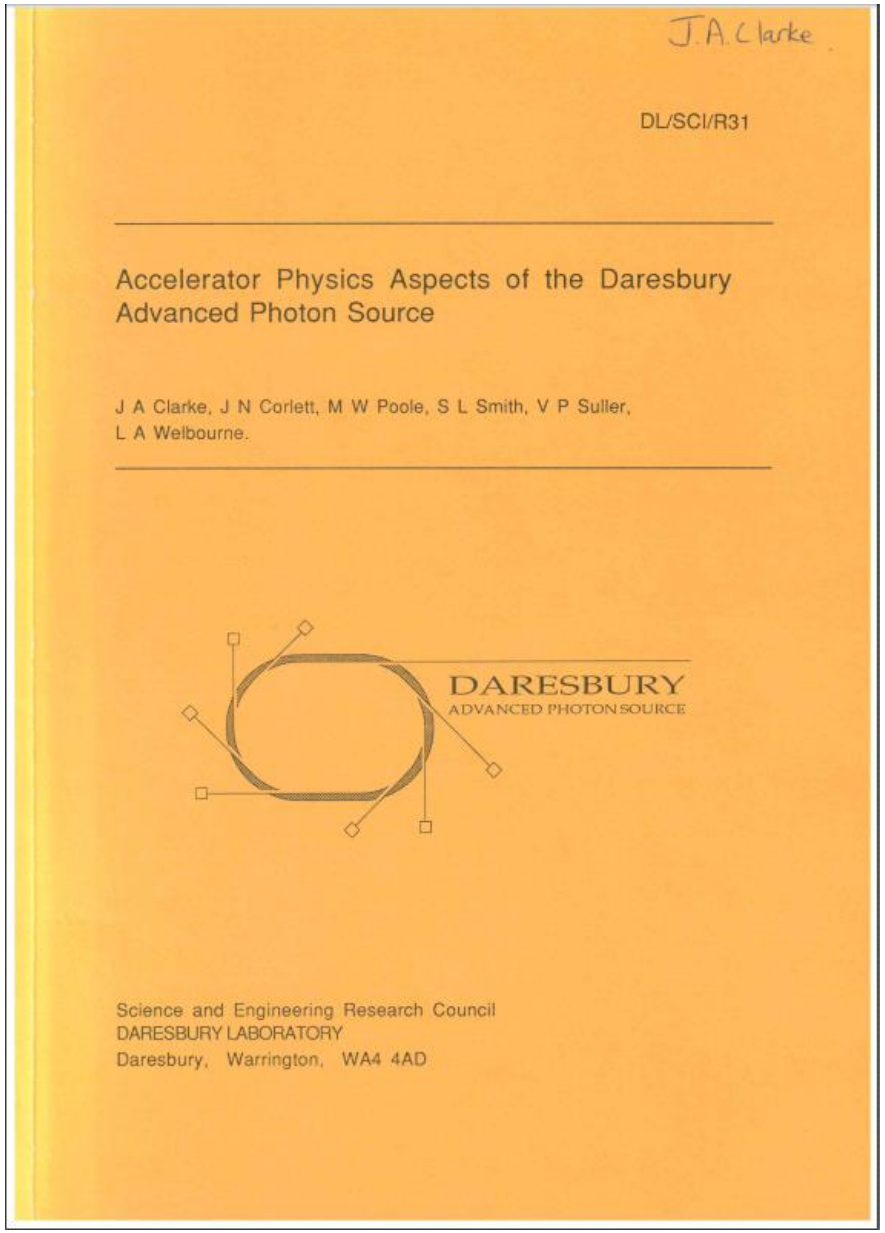
Designing a New Storage Ring Light Source

- **As well as working on the SRS my activities were focussed on designing a storage ring to complement the SRS and the newly operational ESRF in Grenoble – this was the so-called "three ring scenario for the UK"**
- The idea was that there should be a *low energy storage ring* to serve the longer wavelength users (VUV/SXR), *a replacement for the SRS* covering X-rays and *ESRF* for the harder X-rays

- **This new low energy light source was called The Daresbury Advanced Photon Source (DAPS)**
  - **This is the first of many accelerator based facilities that I have helped to design that have yet to be built…**
  - **[some have been built though! ☺]**

DAPS





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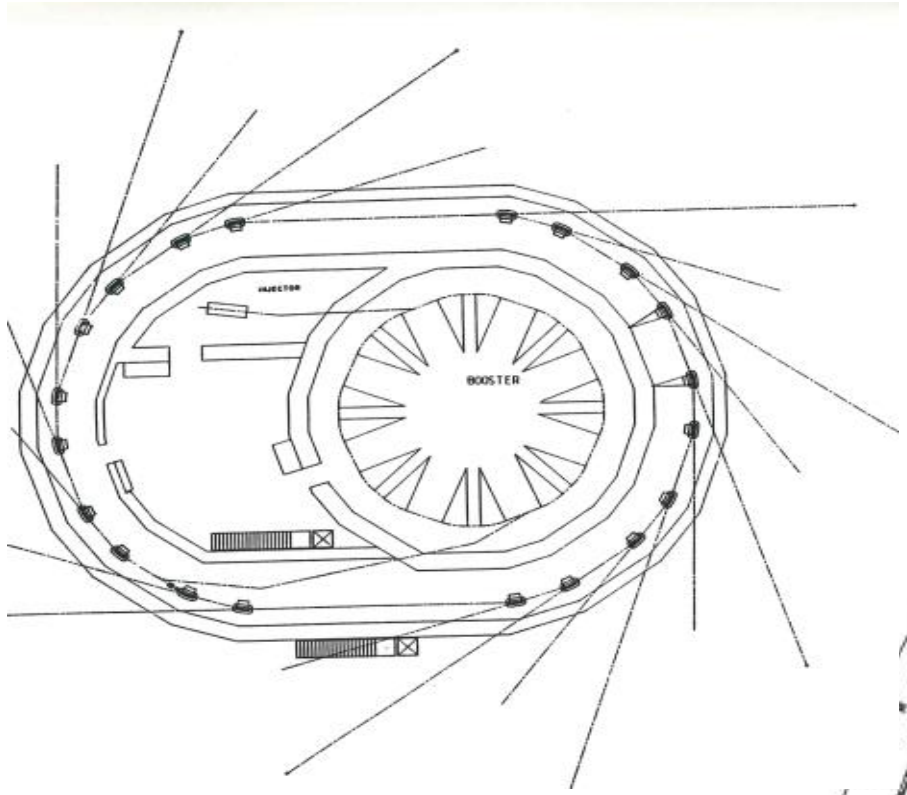
DAPS



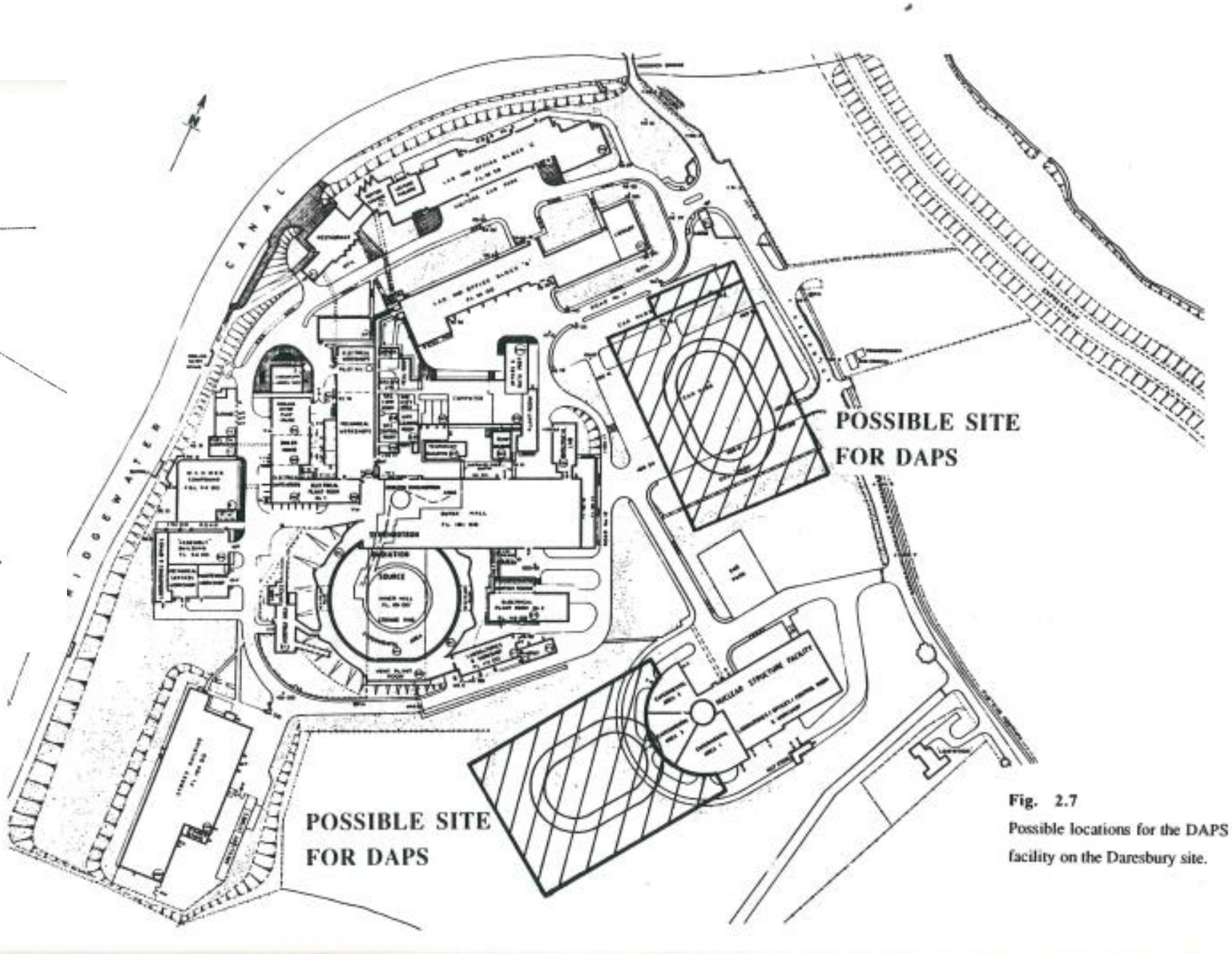


Fig. 2.7
Possible locations for the DAPS facility on the Daresbury site.

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Moving on from DAPS…

- The DAPS feasibility report was published June 1991 and by May 1992 we had shifted away from DAPS to some reshaped three ring scenario

Minutes of the New Machines Lattice Working Party Meeting held on 13/5/92 [I was secretary]

Present:

V P Suller
L A Welbourne
J A Clarke
M W Poole
S L Smith

The low energy ring was now scaled back to 700 MeV from 1.2 GeV and the SRS replacement was set at 3 GeV

VPS summarised the conclusions of the **SR Review panel meeting** at the end of April. They are interested in a **high energy x-ray source on a green field site and a low energy VUV source** either in an existing building or on a green field site, possibly with the high energy source. The first draft of the feasibility report on these options is to be completed by the end of '92, to go to the review panel at the end of January '93. J Bordas is organising 3 Town meetings to specify the user case for both machines in mid-July.

SINBAD and DIAMOND

- By the end of August 1992 both new machines had names…

Minutes of the New Machines Lattice Working Party Meeting held on 23/8/92

Present: V P Suller
M W Poole
S L Smith
L A Welbourne
J A Clarke

SINBAD – Source of INtense Brightness At Daresbury
DIAMOND – DIpole And Multipole Output for the Nation at Daresbury

The chairman reported on the conclusions of the Town meetings organised by J Bordas. The low energy machine photon range was extended from 10 - 100 eV to 5 - 200 eV. It was confirmed that 3 GeV was more desirable than 2.5 GeV for the high energy machine and an overlap in the photon ranges of the two machines would be useful.

I remember the conversation around the name for **Diamond**, which took place over coffee with the above. We wanted a name we weren't embarrassed by since we all thought SRS was an awful name and the interim name for the 3 GeV ring had been MEXS (medium energy X-ray source). The French had picked SOLEIL which we all envied as a good pick.
So we picked a name that had a D in it, was something **bright, hard, and expensive** – Diamond was the obvious choice! What the letters actually stood for came the next day

SINBAD and DIAMOND

- By the end of 1993 Diamond had clearly emerged as the priority over SINBAD

Notes of the New Machines Lattice Working Party Meeting held on 19/11/93

Present:

V P Suller
S L Smith
M W Poole
J A Clarke

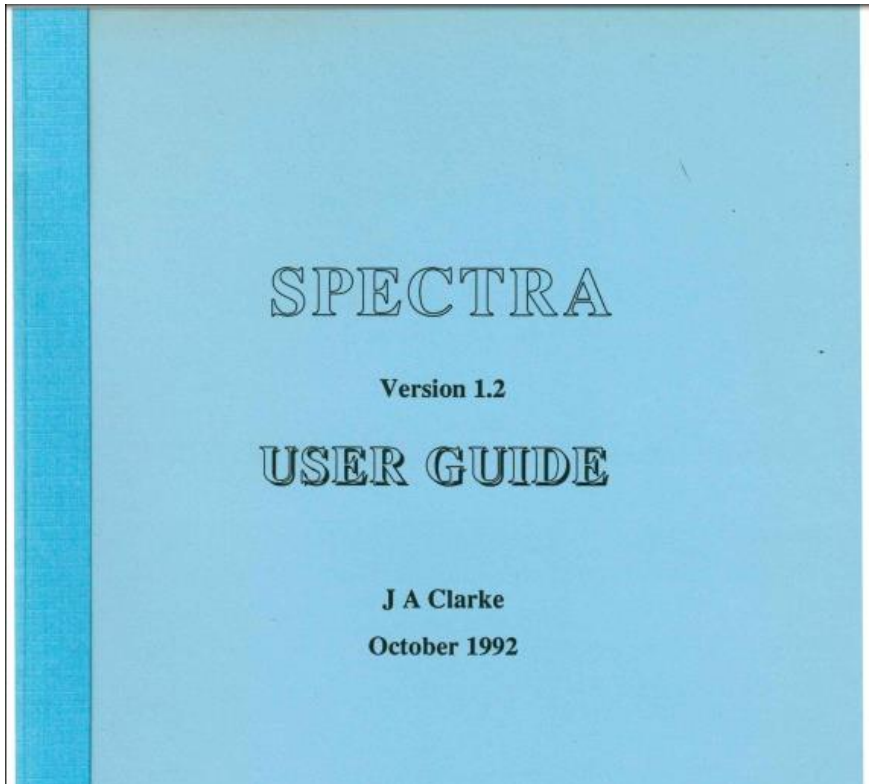
STATUS

VPS discussed with the group the current status of the new machines. Firstly, there was no change to **SINBAD which is still unsupported**. Science Board had been presented with the following cost information concerning DIAMOND:

£57M using SRS resources
£71M in total (8 lines)
£90M if built at DL with 20 stations.

Synchrotron Radiation Calculations

- **For all of these new light source options someone had to start calculating the SR output to make comparisons to show to the users**
- At the time I was running the Synchrotron Light Monitor which was a dedicated end station on the SRS which used the visible SR for all sorts of electron beam diagnostics and so I was given the job of **writing some software and generating all of the comparison curves**…



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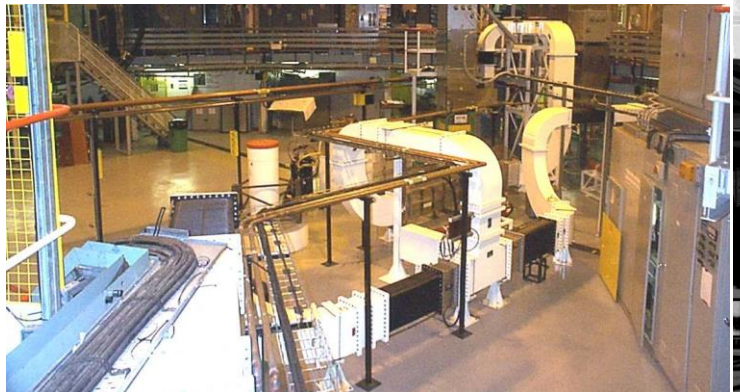
Upgrading the SRS

- **In the mid 1990s we were asked by the SR science leaders whether we could install anymore insertion devices into the SRS**
- The initial reaction from the accelerator team was that it would be really challenging (“No Chance!”) as every straight section (each only ~1.2m long) had equipment in it but it was agreed to take a look
- Finding space for the photon beamlines and end stations would also not be easy
- A viable solution was proposed to **move three of the four RF cavities** and to consolidate other components to free up space – **9 of the 16 straights had to be rebuilt**

- I didn’t play any part in this assessment but I was really impressed by the attitude of the team to find a solution and also that without the challenge from outside of the accelerator team we would never have proposed such an upgrade



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Upgrading the SRS

- **My role in the upgrade once it was clear that two straight sections could be made available was to work with the researchers to define what should actually go in them**
- The demand for hard X-rays was very strong and so it was very clear that multipole wigglers would be the device of choice as undulators would not be feasible

The selected MPW was a permanent magnet/steel pole hybrid with a peak field of 2T, a period of 200mm and 9 full strength poles

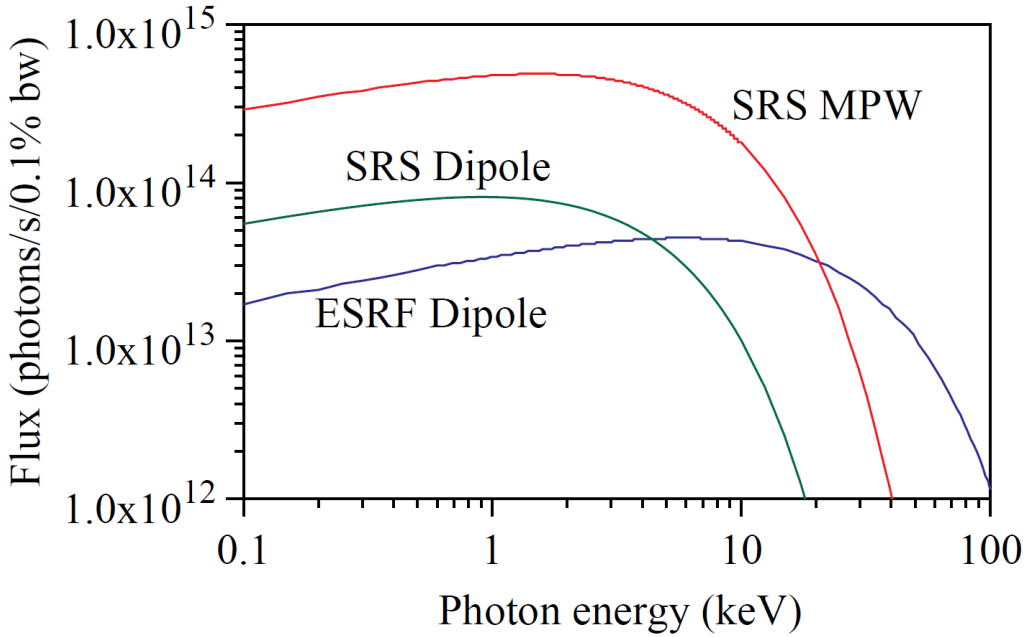


Figure 3. Comparison of photon fluxes from the SRS and ESRF dipoles and the proposed MPW.

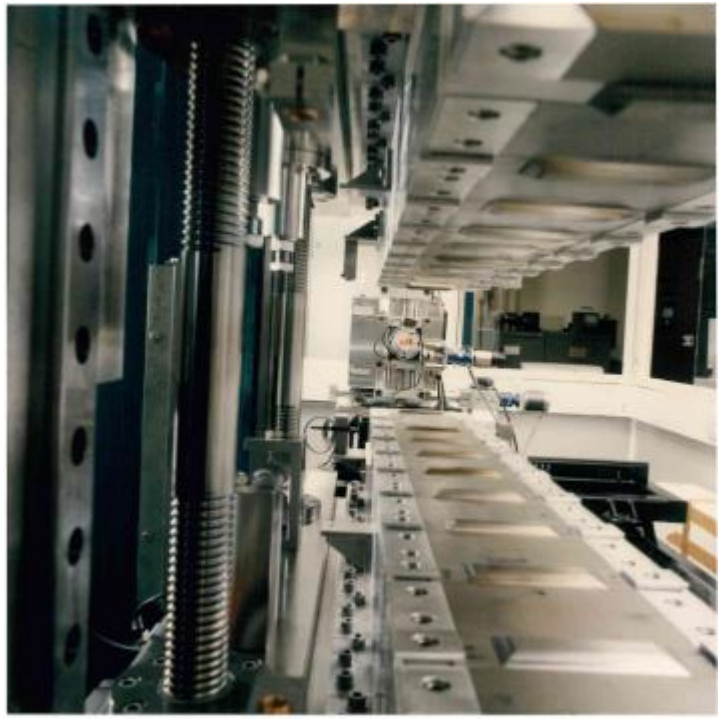
Two 2 T Multipole Wigglers

- **The funding agencies (EPSRC, BBSRC and MRC) agreed to the proposal to fund the two MPWs, photon beamlines and end stations**
- I then was tasked with carrying out a full 3D magnet design for the first time which was a bit daunting
- Working with the engineers to turn my physics simulations into something that could be built and operated was very rewarding – a first for me

- Handling such strong permanent magnet blocks was a skill that did not exist at Daresbury so we decided to buy fully assembled magnet arrays built to our design – Sincrotrone Trieste (aka Richard Walker) won the contract and also the separate one for the support structures

Two 2 T Multipole Wigglers

- **So, two identical very high field MPWs were delivered and I looked after the magnet measurements, setting up a short Hall probe bench for the purpose**
- The measurements matched expectations – a great relief !



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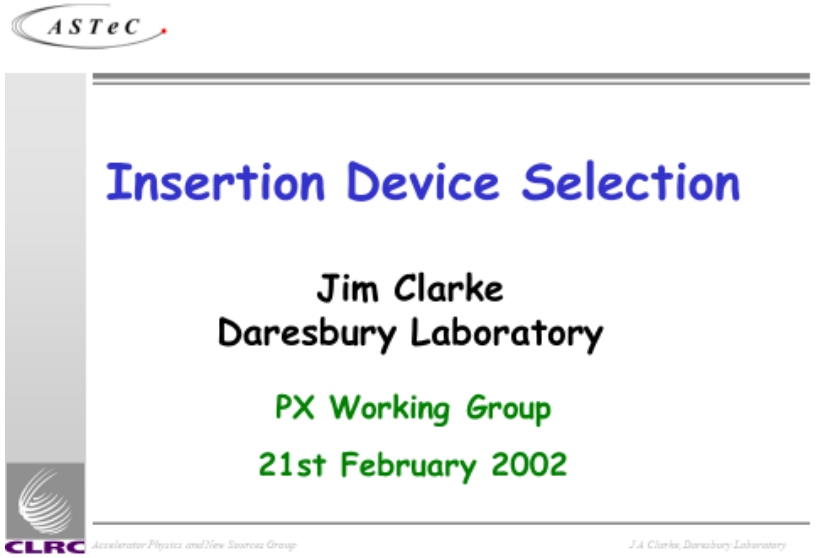
Two 2 T Multipole Wigglers

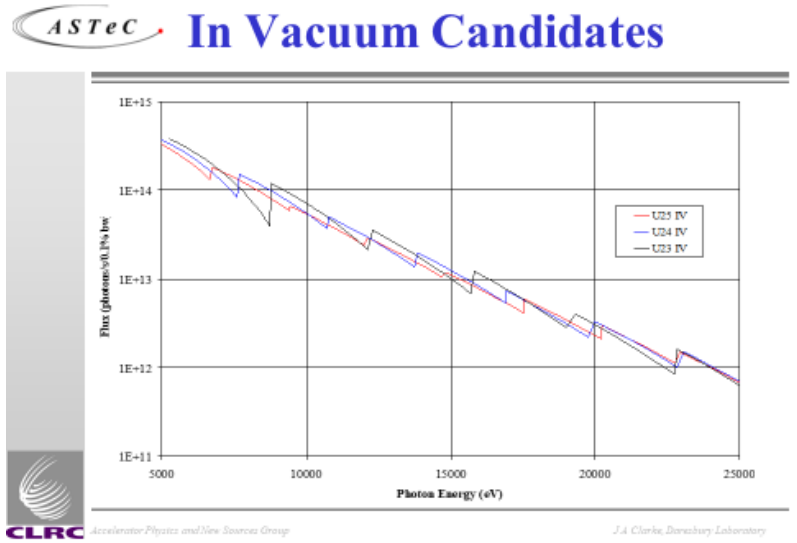
- **They were installed into the SRS successfully and were very popular with the users. There was though a sting in the tale!**
- The funding agencies didn't decide what exactly the beamlines would actually be used for until we were well into the project, and they did this through some sort of peer review call
- One was selected for hard X-ray based science as expected
- BUT the other beamline selected was optimised to work in the **XUV region** of the spectrum (40 – 350 eV), whereas the MPWs were optimised for multi-keV!
- **This was brushed under the carpet as it was embarrassing and the beamline was still far better than any other similar ones on the SRS – it just could have been better!**

- This was another important lesson for me in how not being joined up as a complete facility project can lead to poor outcomes
- **It's essential to have an ongoing dialogue between the users and the accelerator team**

DIAMOND

- **Whilst working on this upgrade of the SRS we were continuing to develop the design for Diamond. SINBAD was quietly dropped (if I remember correctly)**
- All through the 1990s we were frustrated at the lack of funding to build Diamond, other countries were building their equivalent facilities and although, looking back, it was an obvious decision to replace the SRS with a next generation light source, there were a lot of doubts at the time that it would ever happen
- My work was almost completely focussed on the synchrotron radiation side of things – comparing characteristics of various undulator and multi-pole wiggler options.





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Diamond Funding

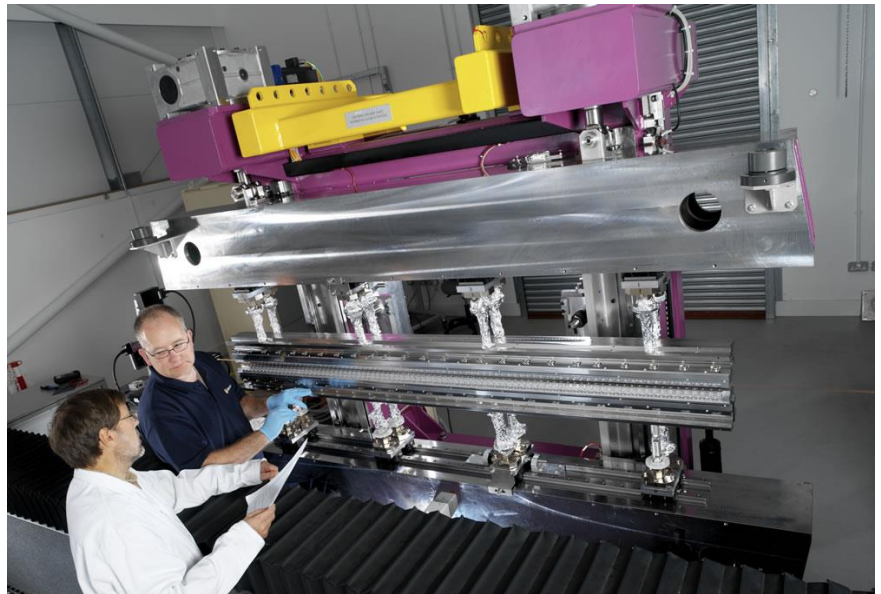
- **Funding was finally approved for Diamond in 1998**
- Then the arguments started about where it would be sited, with Harwell finally being confirmed some time later – **this was a low point for Daresbury and for me**
- I don't intend to dwell on the rights and wrongs of the decision but it certainly made it clear to me that my world view was somewhat naïve - decisions like these are not black and white and involve a much bigger picture than I appreciated – they are truly political decisions.

- What is clear though looking back is that this was a momentous decision which had unintended positive consequences for the UK accelerator community and my career !

- **Of all the things that have influenced my career this is the one I was most upset about, since I was so invested in the project, and the one which turned out to be the most positive!**

Diamond Insertion Devices

- **I was responsible for the first 7 insertion devices, which were funded in the construction phase of the project**
- It was fun working much more closely with the various user interest groups and beamline scientists and learning about what mattered to them
- This time the process was very sensible, with the beamlines being allocated up front to particular priority disciplines/techniques and then for each one I worked closely with the user group to optimise the insertion device to their needs
- **The final selection included in-vacuum undulators, a variable polarisation undulator, and a superconducting multi-pole wiggler – all new technologies to me**



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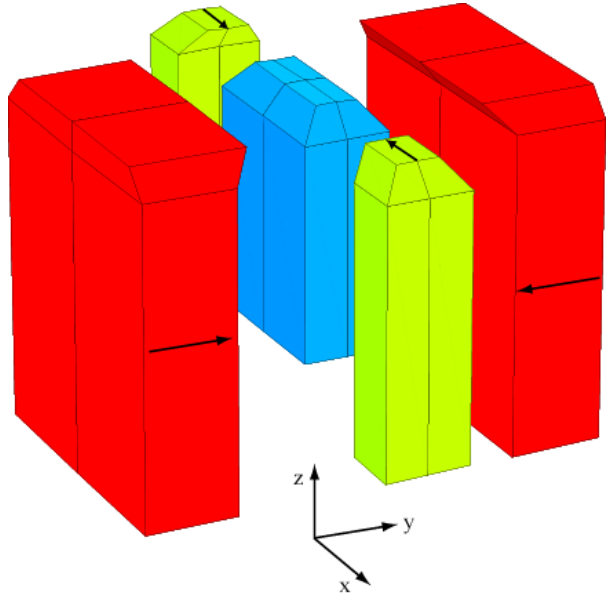
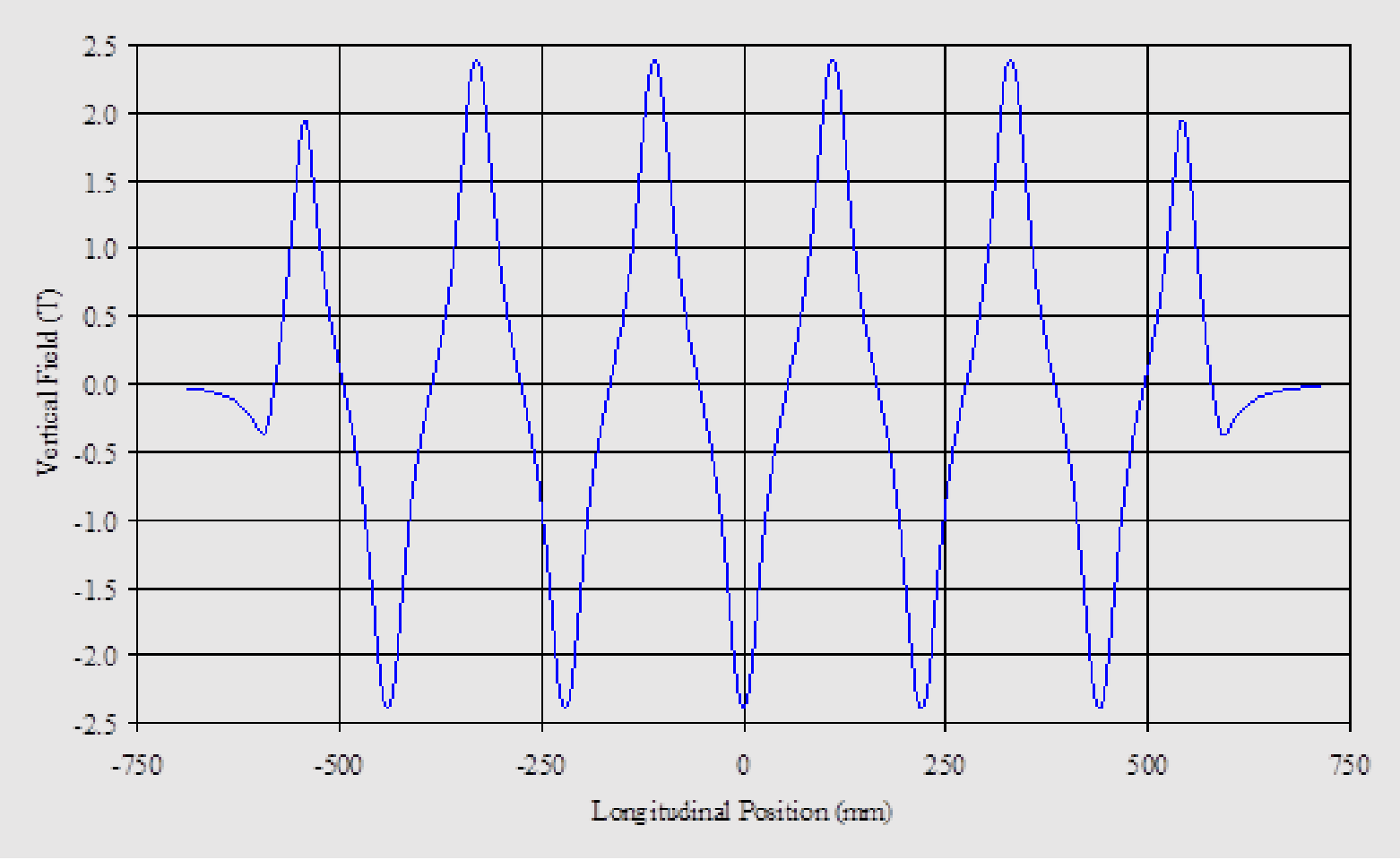
Another multi-pole wiggler for the SRS

- **The two MPWs were so popular that a case was made successfully to add a third one to the SRS**
- Somehow we found space for one more in the storage ring
- The user case for this one was based on hard X-rays so I was asked to optimise the output for 5 to 13.5keV
- Starting from lessons learnt from the 2T versions and just a bit more experience, and a similar device that had been built at the ESRF, I re-optimised the design by shaping the permanent magnets around the steel poles so they were not cuboids anymore
- In this way I was able to achieve **2.4 T with a period of 220mm which was a world record** and I think still is!
- The engineers and technicians had also learnt a lot from the other two MPWs so they were happy to take responsibility for designing and building the device in-house



Another multi-pole wiggler for the SRS

- **The regret I have with this magnet is that since it was a bit special I opted to publish it in a journal instead of a conference proceedings but despite starting to draft the paper I never managed to finish it so you will not find any publications about this magnet anywhere – a big regret!**



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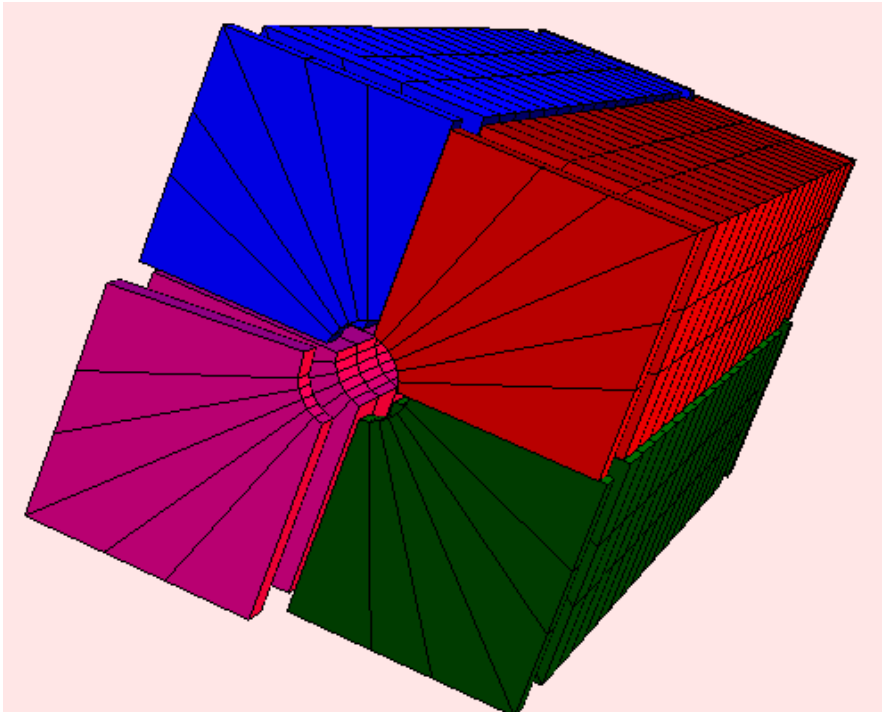
A Variably Polarizing Undulator for the SRS

- **At about the same time, funds for swapping out the original SRS undulator, which had been installed before I had started at Daresbury, were also secured**
- **This time the case was made for a soft X-ray variably polarizing undulator**

- The three MPWs and this new undulator were all loaned out to various light sources after the SRS closed (Diamond, ANKA (KIT), and Thailand Light Source)

Another regret is that we painted them all the same colour so they all look the same!



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The Original Undulator

The first undulator built in the UK was installed in October 1984

- The SRS was not intended to have undulators installed but despite this an undulator was designed and built at Daresbury and installed into the storage ring
- It was a 10 period device , built using permanent magnets, and was one of the early examples
- The engineering was very simple and the **magnet gap was controlled with a simple switch** from the Control Room.
- There was no control of the gap it was either fully closed or fully open!
- Occasionally the operating team forgot to flick the switch and the users would phone the control confused about not seeing any SR – the crew would ‘offer’ to re-optimise the undulator and then just close the gap – the users were always amazed and extremely grateful at how quickly the crew were able to sort out the problem!

Science and Technology Facilities Council

ASTeC

4GLS & Free Electron Lasers

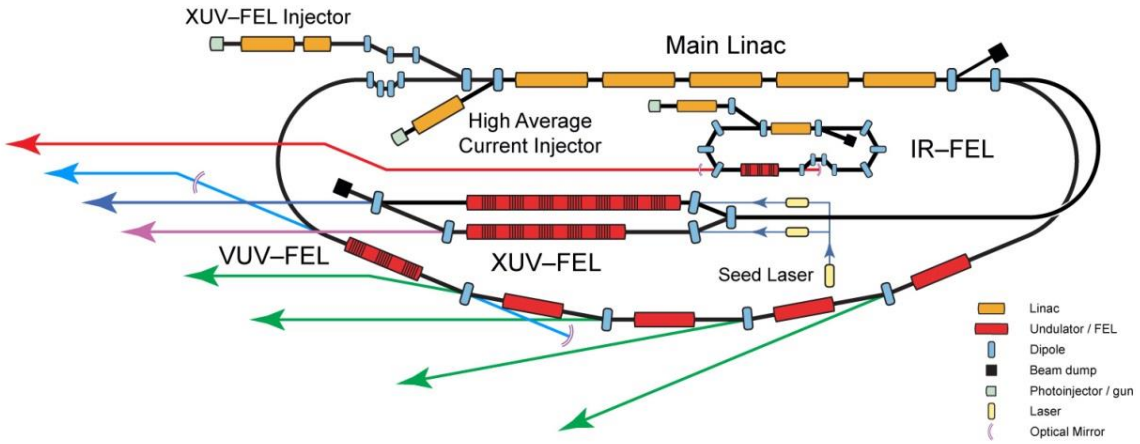
- **With Diamond being built at Harwell it was time start planning a future for Daresbury**
- With the encouragement of the government we started thinking about a low energy light source again
- We started from SINBAD but knew we needed to spice it up a bit so we did two things:
  - Decided that the source should be a mix of spontaneous sources and FELs
  - Dropped the storage ring approach and picked an Energy Recovery Linac solution instead

- The facility was called 4GLS (4th Generation Light Source)

4GLS & Free Electron Lasers

- **My responsibility in the conceptual design was for the undulators and FELs this time**
- We had helped to develop the oscillator FEL on the Elettra storage ring in Trieste by this point (an EU funded project) but hadn't seriously worked on single pass FELs at all
- This was a steep learning curve for me and my group but thanks to direct support from Brian McNeil my team rapidly became proficient and started publishing new concepts, especially for generating ultrashort attosecond pulses

4GLS was a CW-ERL driven XUV/VUV/IR light source that still looks state of the art today



Science and Technology Facilities Council
ASTeC

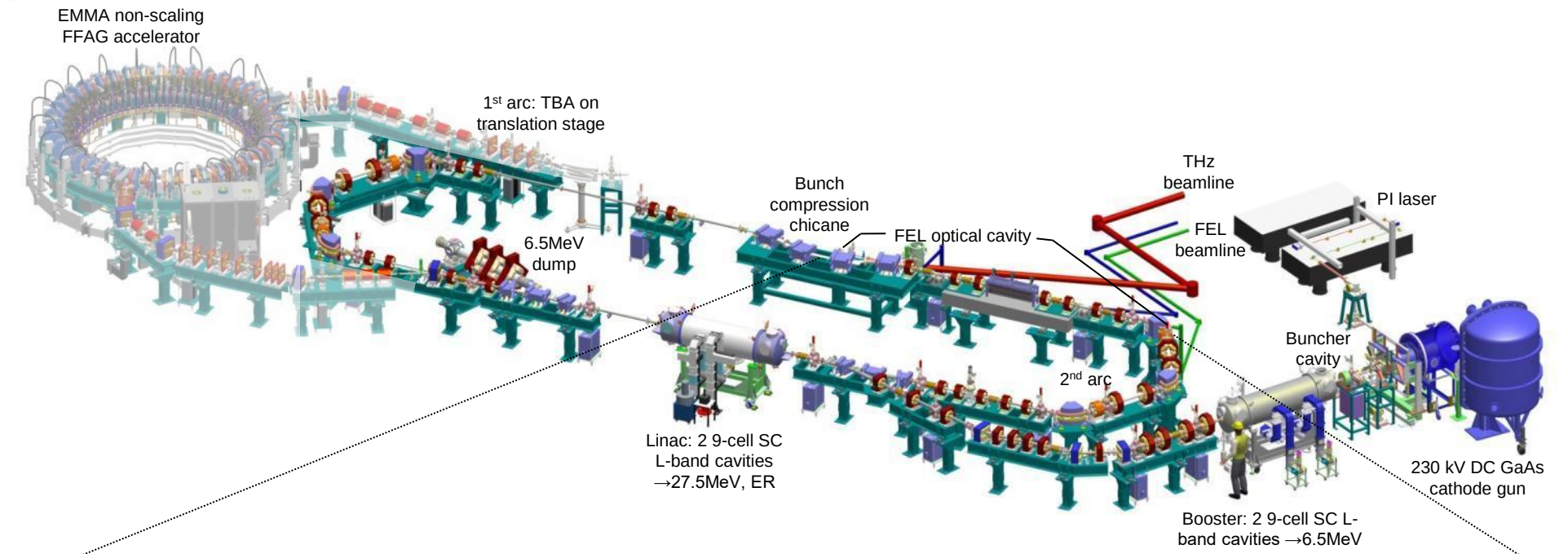
ALICE

- **Modern ERLs had received a big boost from superconducting RF improvements with Jefferson Lab leading the way**
- We were supported by JLab very much and when an opportunity for some funding arose we bid for an ERL test facility to develop the skills and experience that we lacked – this was initially called ERL Prototype (ERLP) but soon became known as **ALICE** (Accelerators and Lasers in Combined Experiments)
- An infra-red **oscillator FEL was included** in ALICE from the start, again to develop skills and experience
- Although 4GLS was stopped in 2008, ALICE continued to receive support and we demonstrated energy recovery in the same year

Science and Technology Facilities Council

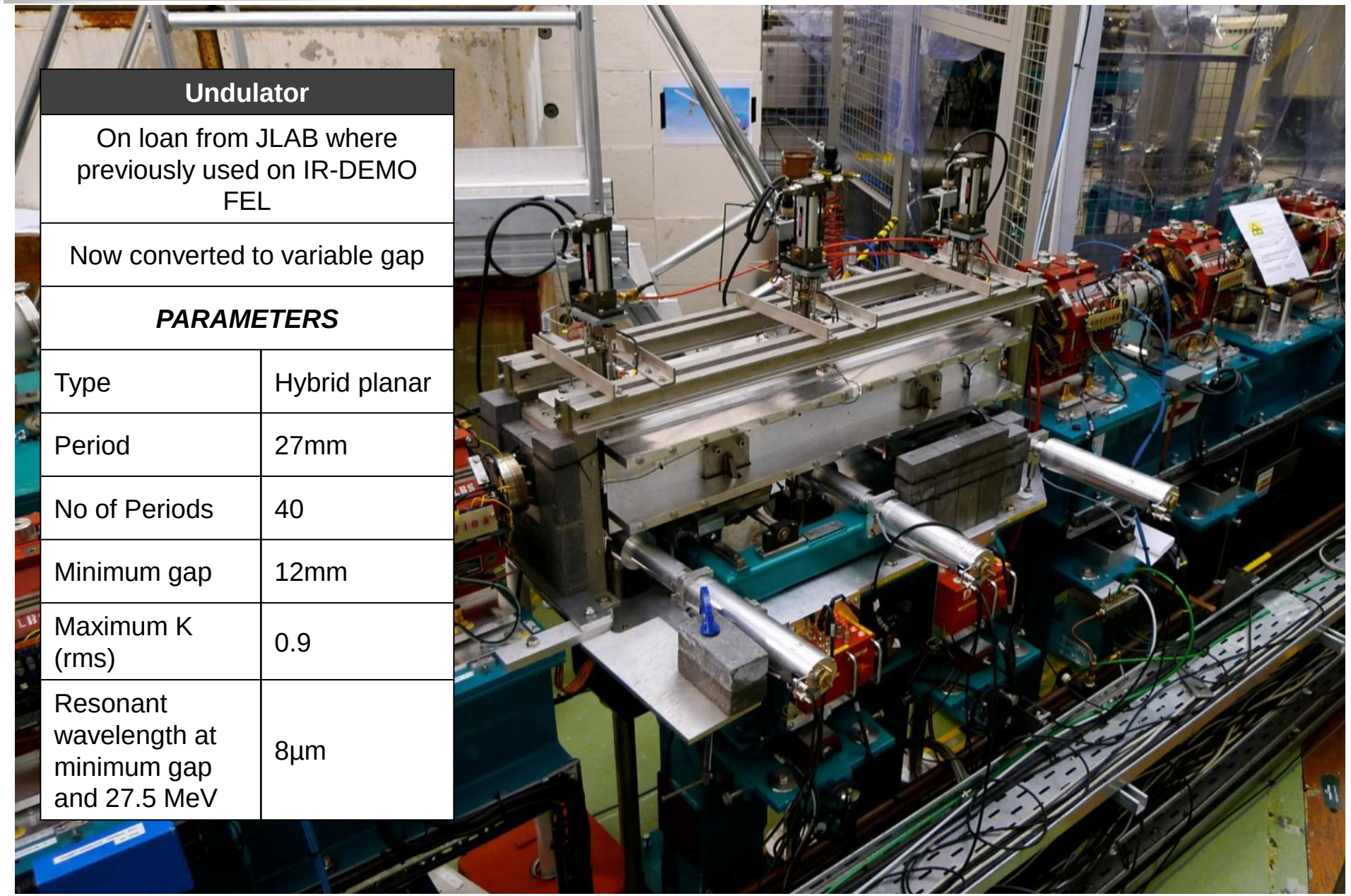
ASTeC

ALICE accelerator and FEL layout



Dave Dunning

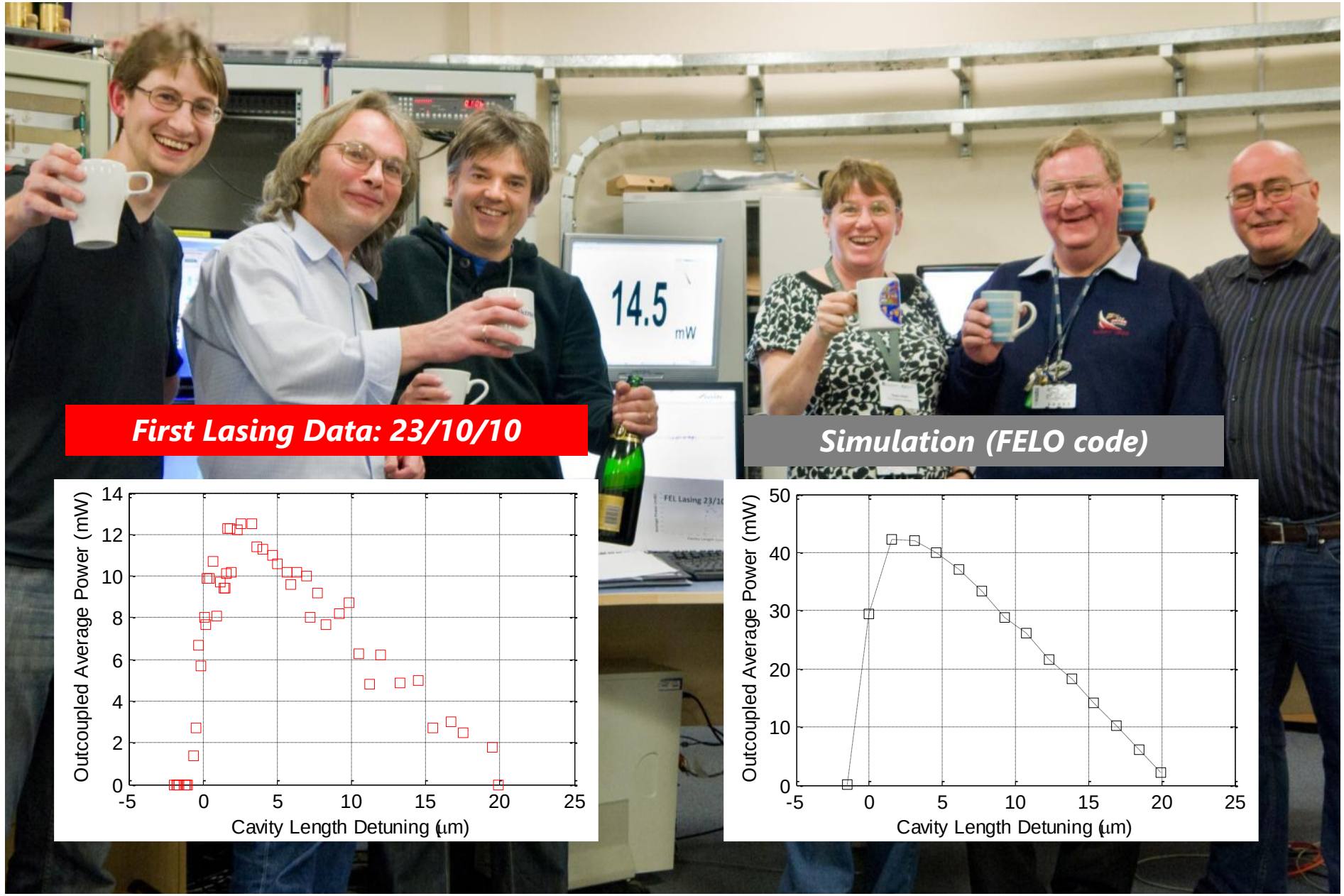
Undulator



Undulator	
On loan from JLAB where previously used on IR-DEMO FEL	
Now converted to variable gap	
PARAMETERS	
Type	Hybrid planar
Period	27mm
No of Periods	40
Minimum gap	12mm
Maximum K (rms)	0.9
Resonant wavelength at minimum gap and 27.5 MeV	8µm

Dave Dunning

23rd October 2010: ALICE FEL First Lasing



It took a while to achieve first lasing but once the electron bunch charge was pushed up to 100pC it was really easy, in fact it was hard not to lase afterwards, even at lower charges!

The IR from the FEL was used for several years on cancer diagnosis research by a team led by Peter Weightman from Liverpool but once the funding for this dried up we took the decision to close ALICE and concentrate our resources on CLARA instead – more on that later

Dave Dunning

CAAST

- **In the meantime, it was decided that the accelerator part of the SR Department should spin out and stand alone as a new ‘Centre’**
- This was originally going to be called **CAAST** – The Centre for Advanced Accelerator Science and Technology

- The proposed name wasn’t very popular with the troops, me included, so over coffee time one day we brainstormed new ideas and **ASTeC** emerged the winner – **Accelerator Science and Technology Centre**

ASTeC

- **Splitting off from a department whose prime mission was to operate a user facility had really long reaching implications for us**
- We were able to choose what we worked on, as long as there were the funds to support it !
- Over previous years we had been held back from taking on many non-light source opportunities, now we really felt like we had been given our freedom!
- Soon we were working on accelerator R&D for particle physics, neutrino factories and linear colliders in particular, but also with industry as well

When ASTeC was set-up in 2001 there were three groups and 19 staff members

Today there are three divisions, eight groups and ~115 staff, apprentices and students

CLRC

SYNCHROTRON RADIATION DEPARTMENT

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Fax +44 (0)1925 603124

Mr V P Suller
Associate Director,
Head of ASTEC
Tel: 01925 603209 (Direct)
Tel: 01925 603212 (Secretary)
e-mail v.p.suller@dl.ac.uk
http://www.dl.ac.uk/

12 April 2001

Dear Jim

Welcome to the Accelerator Science and Technology Centre (ASTEC)

You have probably seen CLRC Notice 1021001 announcing the 3 technology centres which have been set up. These are an important step in CLRC's strategy for ensuring that, as an organisation, it is effectively structured to provide unequalled support for advanced science based facilities both now and in the future.

I am very pleased that I have been given the task of leading ASTEC, because I believe that accelerator technology is an indispensible skill upon which CLRC's future depends and that I have the right background and experience to develop this.

Equally I am very happy that you will be a member of the ASTEC team, because with your skills and experience you will be able to contribute most effectively to the existing and new accelerator activities in which ASTEC will be engaged.

A full list of ASTEC staff at Daresbury is attached to this letter. It is also the intention to create a branch of ASTEC amongst ISIS staff at RAL, but the details have not yet been agreed. For the time being your line management arrangements will not change. There are however, agreed vacancies within ASTEC and once these have been recruited it may be appropriate to fine-tune the structure.

I will shortly arrange a meeting for all ASTEC staff where I can go into further detail about how I see things developing in the future and will answer any questions you may have.

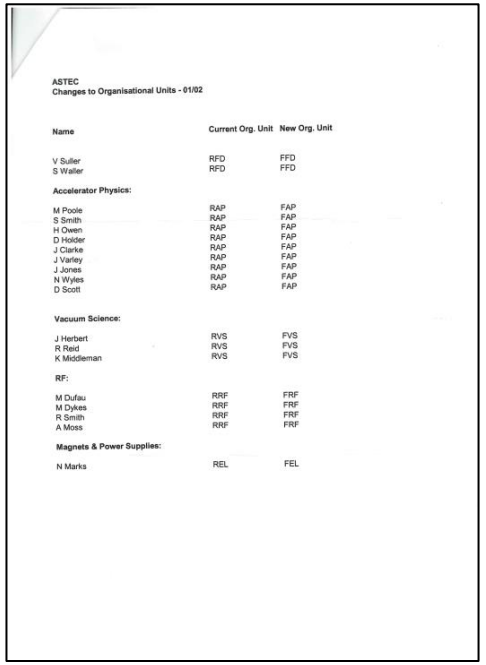
Looking forward to an interesting and challenging future of working together.

Yours sincerely

V P Suller

Vic

COUNCIL FOR THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS



ASTEC
Changes to Organisational Units - 01/02

Name	Current Org. Unit	New Org. Unit
V Suller	RFD	FFD
S Waller	RFD	FFD
Accelerator Physics:		
M Poole	RAP	FAP
S Smith	RAP	FAP
H Owen	RAP	FAP
D Holder	RAP	FAP
J Clarke	RAP	FAP
J Varley	RAP	FAP
J Jones	RAP	FAP
N Wyles	RAP	FAP
D Scott	RAP	FAP
Vacuum Science:		
J Herbert	RVS	FVS
R Reid	RVS	FVS
K Middleman	RVS	FVS
RF:		
M Dufau	RRF	FRF
M Dykes	RRF	FRF
R Smith	RRF	FRF
A Moss	RRF	FRF
Magnets & Power Supplies:		
N Marks	REL	FEL

The Universities

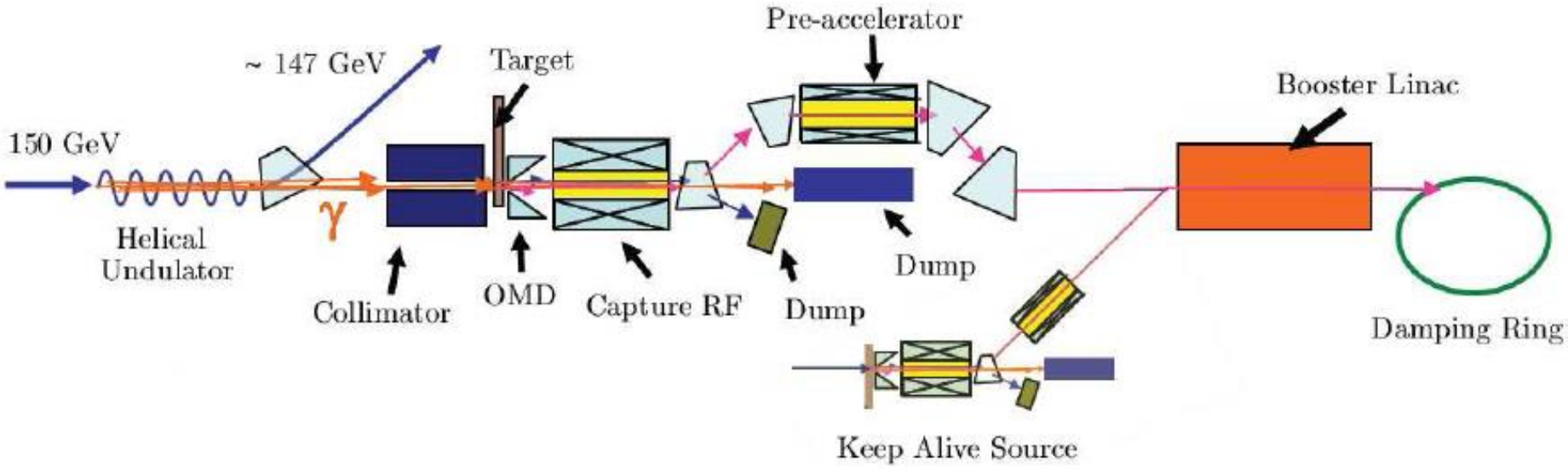
- **At around the same time that ASTeC was being set-up PPARC took the strategic decision to help develop the UK capability in accelerators – in the universities as well as the labs!**
- This was the impetus that was needed for the UK universities to really take an interest again in accelerator R&D, especially for particle physics

- A few years later it was agreed to establish the two accelerator institutes – CI and JAI

- **Suddenly it was possible to study for a PhD in accelerators in the UK again!**
- **Good Times!**

Positron Source for the ILC

- **I was asked to lead a UK activity in the positron source for the International Linear Collider since one of the main options for achieving the very high bunch charges required was undulator based**
- The undulator solution had the big advantage that **polarized positrons** could be generated using **circularly polarized gamma rays**
- This was a very challenging and interesting technical problem and after building permanent magnet and superconducting magnet prototypes we selected to focus on helical superconducting undulator solutions



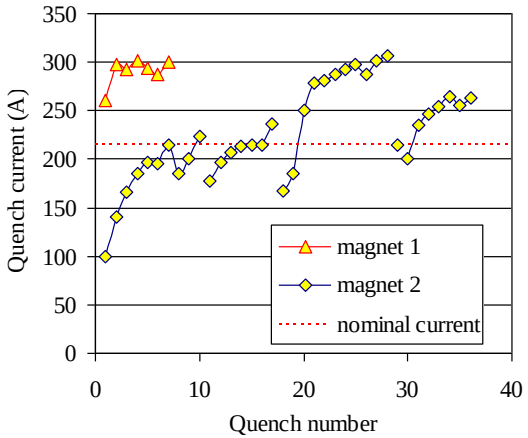
Science and Technology Facilities Council
ASTeC

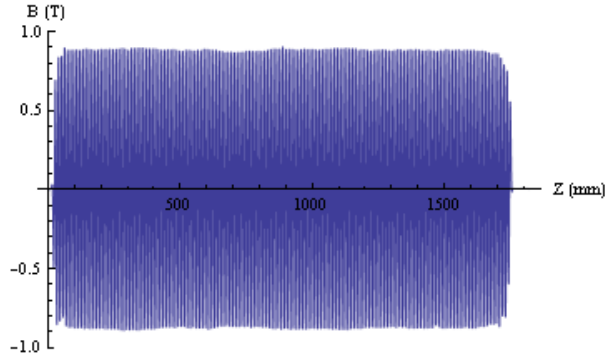
Positron Source for the ILC

- **I really enjoyed working in a truly global collaboration for the first time**
- I quickly realized that not just the positrons were polarized but also the people proposing the alternative solutions for creating them in the first place
- The US (and European) members were pro undulator and the Japanese were pro conventional positron source (electrons into a target)
- **Because of this it was one of the most controversial parts of the design which often led to heated arguments**
- As there were particularly strong feelings in the US and Japan it was agreed that a European person should run this part of the ILC design and so I took over the leadership for several years
- **This really helped me work on my diplomatic skills!**
- Eventually we were asked to pick a baseline solution and **the undulator based one was selected** – all the work that had been carried out in the UK and elsewhere in the meantime had systematically addressed many of the concerns raised and the physics advantage of polarized positrons tipped the balance

Helical Superconducting Undulator for the ILC

- **My personal technical involvement was in the R&D for the SCU**





- A 4m module containing 2 x 1.75m helical undulators (11.5 mm period) was constructed and tested at RAL
- Closed loop cryo system with cryocooler
- **I think this is still the baseline for the ILC**

Science and Technology Facilities Council

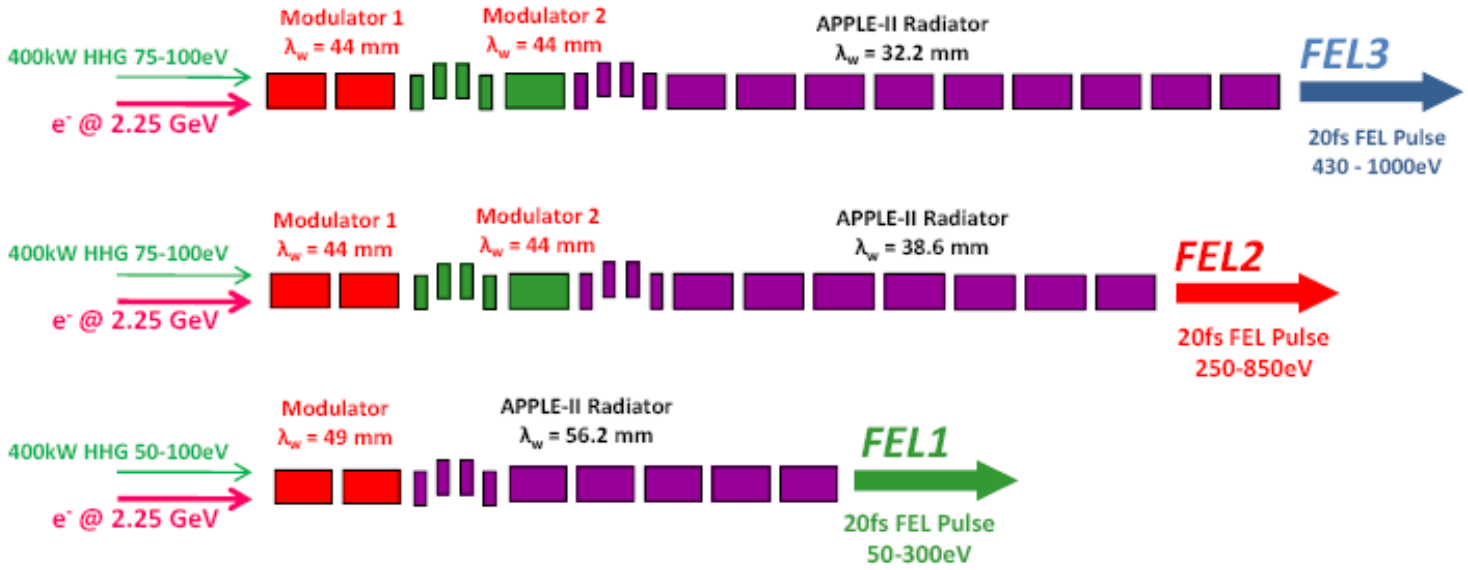
ASTeC

New Light Source

- **Although 4GLS was stopped in 2008 there was strong interest in the UK SR user community in continuing to explore the potential for FELs**
- **A Science Case for NLS was drafted and well received and so it was full steam ahead on another FEL light source design study!**
- The Science Case made it clear that we needed to push the output **into the soft X-ray region** and so we picked a single pass FEL for the NLS concept – this was before any X-ray FEL had even lased
- **Sadly the NLS was a victim of the financial downturn and was told to go away and come back in a few years!**

UKRI Science and Technology Facilities Council

ASTeC



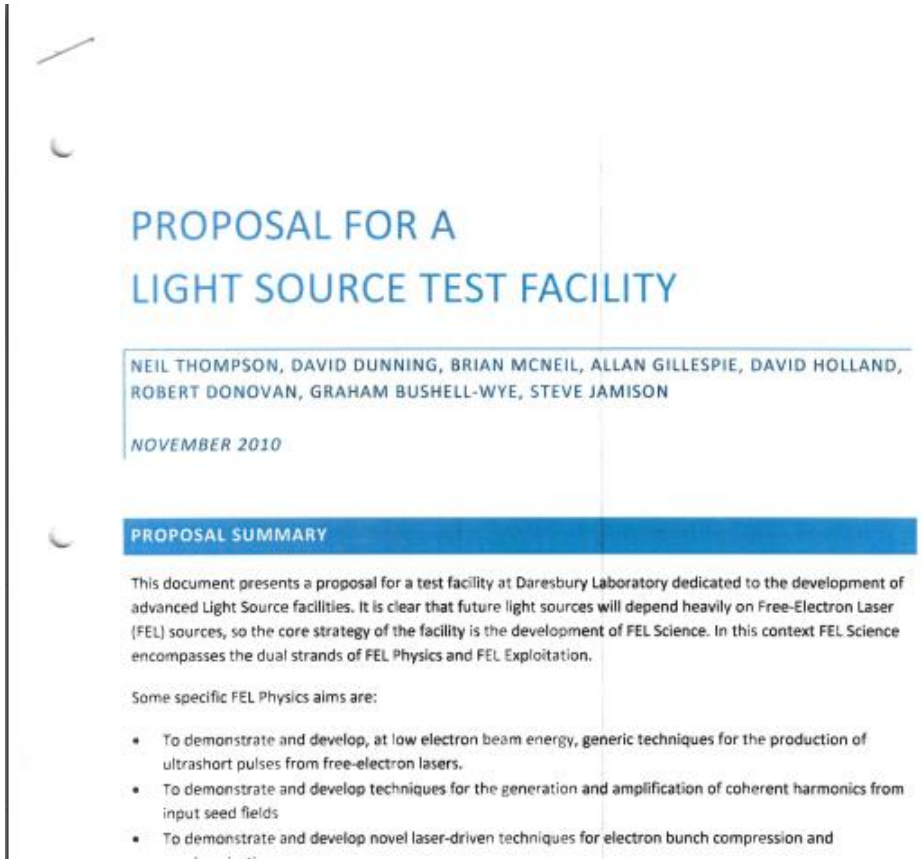
DELTA

- **The NLS project did convince me and others in ASTeC that single pass FELs, based upon linac technology (not ERL), was the future and so we started thinking about a test facility in late 2010 to demonstrate some of the new concepts that my team and others had generated – codename DELTA**

Development of ELectron Test Accelerators (DELTA) in the Outer Hall: Agenda

Wednesday 9th Feb, 15.00, S16

1. Introduction – JAC
2. NCAA Outline Business Case
   a. Feedback from Review – SLS/PAM
   b. SCRF Facility – PAM
   c. Injector Development Facility – BLM
   d. Photonic Development Facility – SJ
3. Light Source Test Facility – NRT
4. Laser Wakefield R&D – SJ
5. Others
   a. Security Futures Lab
   b. Antiproton Ring
   c. ...
6. Building Layout – NB



PROPOSAL FOR A
LIGHT SOURCE TEST FACILITY

NEIL THOMPSON, DAVID DUNNING, BRIAN MCNEIL, ALLAN GILLESPIE, DAVID HOLLAND, ROBERT DONOVAN, GRAHAM BUSHELL-WYE, STEVE JAMISON

NOVEMBER 2010

PROPOSAL SUMMARY

This document presents a proposal for a test facility at Daresbury Laboratory dedicated to the development of advanced Light Source facilities. It is clear that future light sources will depend heavily on Free-Electron Laser (FEL) sources, so the core strategy of the facility is the development of FEL Science. In this context FEL Science encompasses the dual strands of FEL Physics and FEL Exploitation.

Some specific FEL Physics aims are:

- To demonstrate and develop, at low electron beam energy, generic techniques for the production of ultrashort pulses from free-electron lasers.
- To demonstrate and develop techniques for the generation and amplification of coherent harmonics from input seed fields
- To demonstrate and develop novel laser-driven techniques for electron bunch compression and

CLARA

- I proposed a list of names to Susan Smith for this new test facility
- Susan came back with **CLARA** (the Compact Linear Advanced Research Accelerator)
- John Womersley, STFC Chief Exec, then gave a staff talk in which he expressed support for CLARA, the **Compact Linear Accelerator for Research and Applications** – I agreed with Susan that this was much better so we have stuck with this ever since!

My suggestions at the time

BETA – Bright Electron Test Accelerator

STELLA – Synchronised Test Electron Linac and LAsers

BELLA – Bright Electron Linac and Lasers

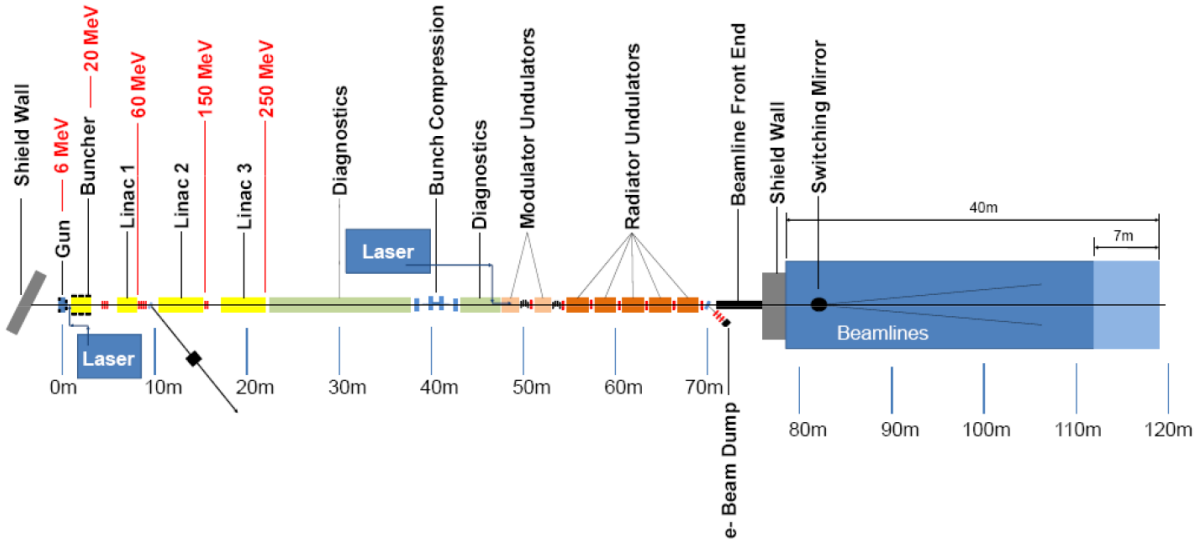
CALISTA – Compact Advanced Light Source Test Accelerator

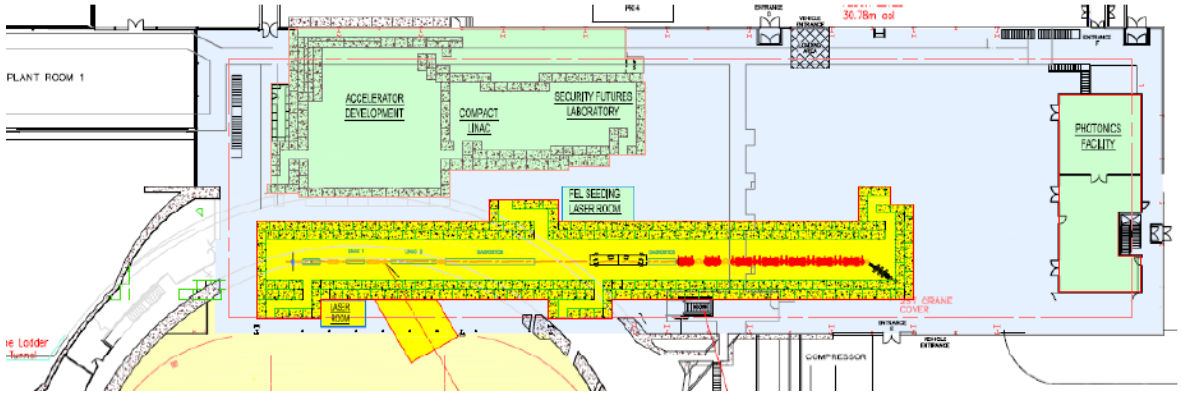
PETULA – Photoinjector Electron Tests for the ULtimate Accelerator

TESSA – Test Electron Source for Synchronised Acceleration

ABACUS – Advanced Bright Accelerator Creating Ultra Short pulses

LEWIS – Lasers and Electrons Working in Synchronism





CLARA

- **Although STFC supported CLARA, it wasn't able to find the budget so it could be delivered as a simple one off project**
- Instead we received an annual allocation which certainly made it very hard to manage and forced us to break the project down into phases
- Finally, after several years me and Susan persuaded STFC to allocate the remaining funds across multiple years which made the Phase 2 procurement and management a bit easier
- Originally CLARA was foreseen as a single pass FEL Test Facility but we are still not there yet!
- The space is still reserved for a FEL but the motivation (& funds) will need to come from UK XFEL

- Now the focus has shifted to CLARA being a user facility for research that requires access to a high energy, bright electron beam – we have already fitted in two user periods which have been highly successful and these have helped persuade STFC to further invest in a 120TW laser and FEBE (the independent end station)

- **I'm very much looking forward to seeing CLARA generate 250 MeV electron bunches and welcoming users onto site again**

Science and Technology Facilities Council

ASTeC

CLARA First Beam Celebration

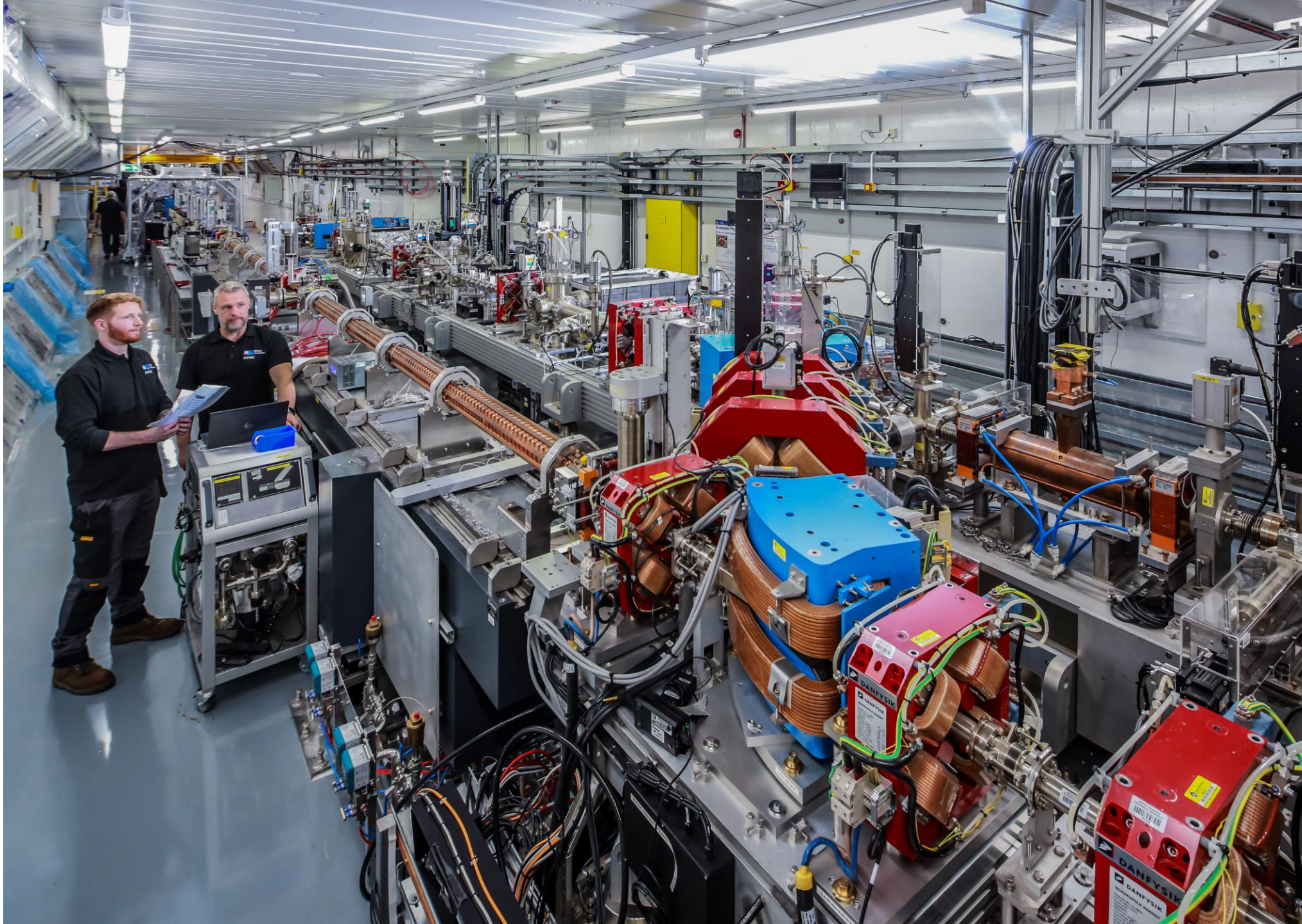
We did manage to persuade STFC to pay to upgrade the Electron Hall so we could control the temperature at the levels required by CLARA

I was given the privilege of picking the colour scheme

So after a quick call to Leicester City Football Club to find out the exact shade of blue they use for their shirts…

Science and Technology Facilities Council

ASTeC



UKRI Science and Technology Facilities Council

ASTeC

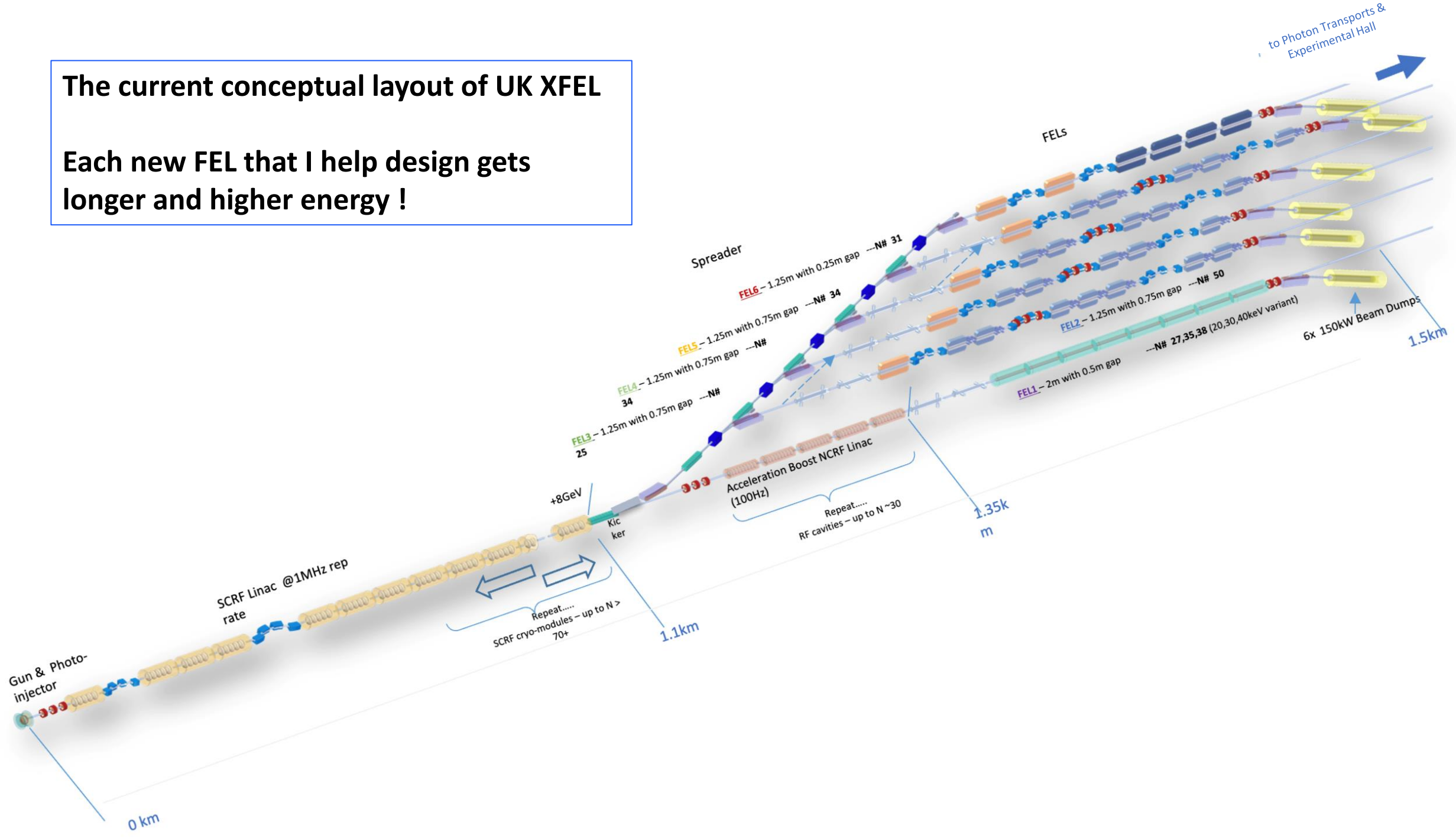
UK XFEL – 3rd time lucky?

- **Since the NLS time, five XFELs have begun operations around the world, with many UK researchers benefitting from access to carry out their research**
- STFC recognised this and so solicited the community to reassess the user case
- A compelling science case was published and the demand for **hard X-rays** (as well as the other parts of the spectrum) clearly emerged

- We are now developing the conceptual design for a possible new national facility – UK XFEL, as well as looking at alternative options for meeting UK user needs, such as major investments in existing overseas XFELs

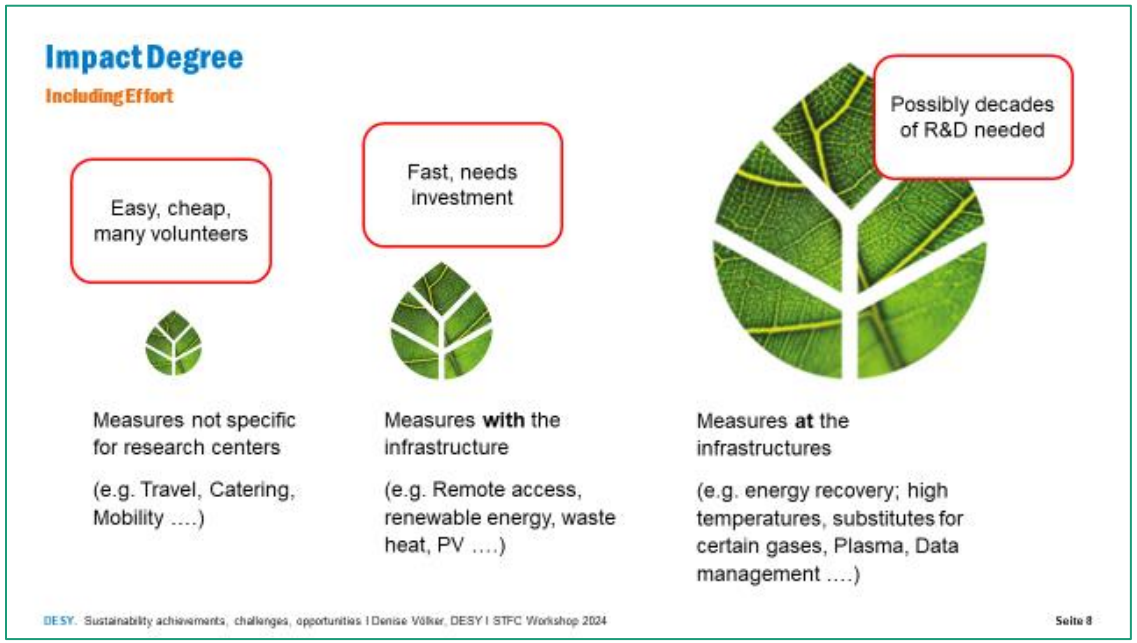
The current conceptual layout of UK XFEL

Each new FEL that I help design gets longer and higher energy !



Sustainability of Accelerators

- **I want to play my part in making current and future accelerators more sustainable**
- **On the technical side I helped develop the first ZEPTO permanent magnet quadrupoles and dipole**
- **My only patents !**
- Now, I am concentrating my efforts on making sure that the UK accelerator community is properly funded to lead the way globally in some key technologies, not least because we have a pipeline of new accelerator projects that absolutely must be much more sustainable than present day technology allows – e.g. ISIS-2, UK XFEL, FCC, …



Denise Völker, Head of Sustainability at DESY
Sustainable Accelerator Workshop, Harwell
23rd May 2024

ZEPTO quad installed on Diamond

Back to the Job Advert

- "…our group … is embarking on major new design initiatives … state of the art … storage rings and free electron lasers"
- "Advanced accelerators use high technology …particle beam design, major computer simulation, large electromagnets, high power RF systems, high-voltage pulse techniques, superconducting magnets, ultra high vacuum equipment, and other topics."

It's taken a long time but I have worked on most of the topics listed now, just two more to go!

Physicists and Engineers

Particle Accelerator Development

We are looking for bright young physics and engineering graduates to join our team of particle accelerator experts.

Daresbury Laboratory in North Cheshire operates one of the world's leading high energy storage rings for provision of synchrotron radiation, which is used by a very large academic and industrial research community, including overseas scientists. There are a number of vacancies in our group, which is embarking on major new design initiatives aimed at advancing the state of the art in provision of synchrotron radiation from storage rings and free electron lasers.

We need people with drive and with ideas, who can innovate and who will quickly accept new responsibilities. Advanced accelerators use high technology, and you will work in such fields as particle beam design, major computer simulation, large electromagnets, high power radiofrequency systems, fast high-voltage pulse techniques, superconducting magnets, ultra high vacuum equipment, cryogenics, and other topics.

Recent honours graduates, including those graduating this year, or post-doctoral scientists and engineers, will find this an excellent opportunity to develop their careers in stimulating and varied work with international contacts. The existing Daresbury facilities provide first-class training for those without relevant experience.

Grading and a salary in the range £8,067 to £14,858 will be awarded according to qualifications and experience. Typically a good graduate could expect to start at £10,026 and further increments are available depending on performance. There is a flexible working system and non-contributory superannuation.

For further information contact Mike Poole (0925-603256) or Vic Suller (0925-603209). For application forms contact: The Personnel Officer, Daresbury Laboratory, Warrington WA4 4AD (0925 603467 – 24 hours). Please quote reference DL 99.

CLOSING DATE: 13th April, 1988.

Daresbury SCIENCE & ENGINEERING RESEARCH COUNCIL

Science and Technology Facilities Council

ASTeC

Acknowledgements

- **I am particularly indebted to three mentors that I was lucky enough to work with for large parts of my career – Vic Suller, Mike Poole, and Neil Marks**
- **They were all brilliant and inspiring to work with in their own distinctive ways!**

- Also, all of the activities and projects that I have mentioned were carried out as part of a team of other experts from multiple disciplines and I would have achieved very little without them!

- I am extremely grateful to everyone who I have worked with along the way and apologies for not listing you all here, I'm bound to forget someone inadvertently!

- **Thanks again to the IOP PAB for the prize, it's a great honour and a surprise and very much appreciated!**