

IoP HEPG Meeting

Selling Particle Physics to The Treasury

Mark Lancaster - UCL



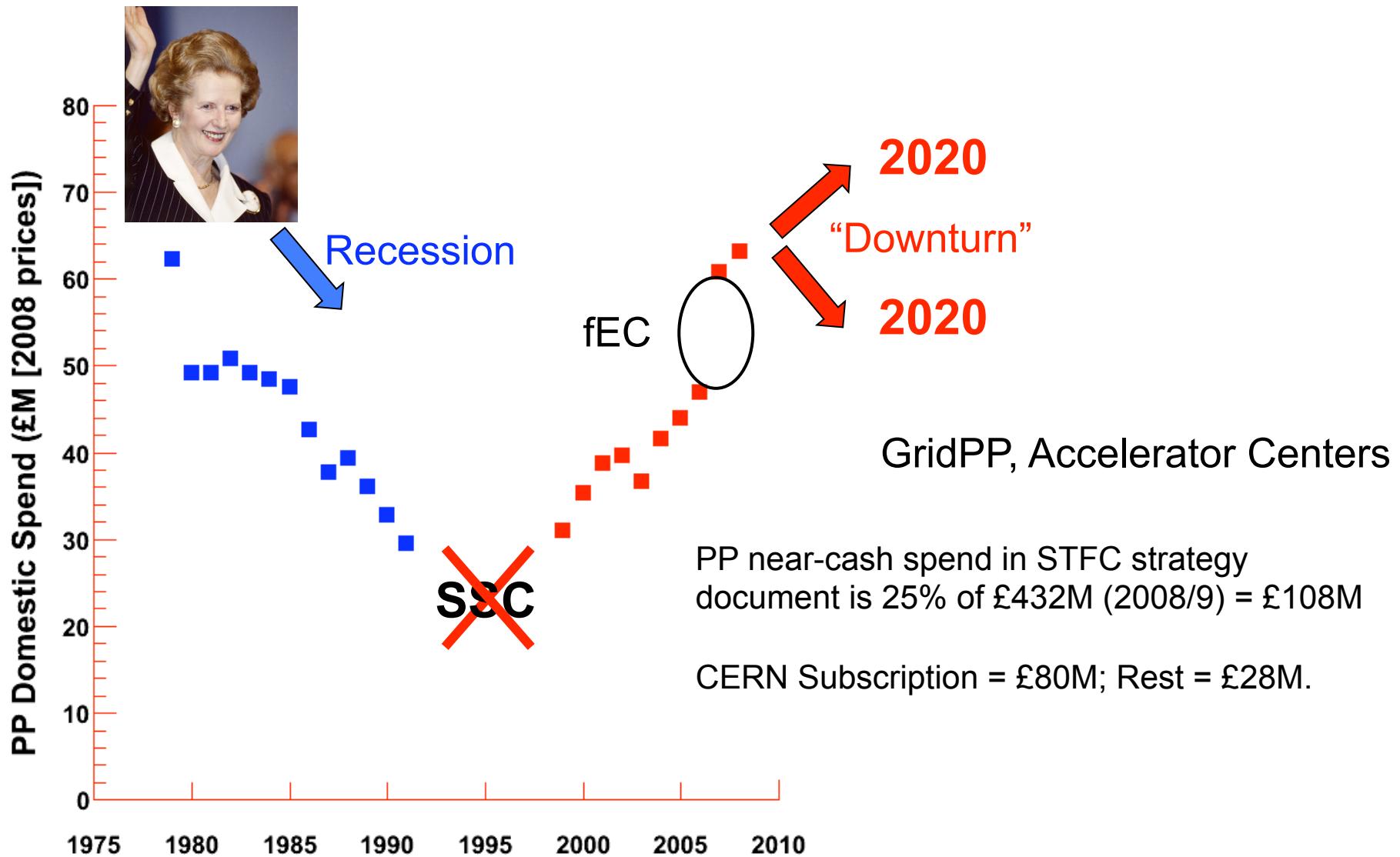
The Political Background To This Talk

Given increasing government emphasis that we communicate and quantify the impact of our research it was felt appropriate that one talk at the IoP meeting (& potentially also the old “RAL” annual PP report) should cover knowledge exchange.

Make people aware of what's going on for “elevator” pitches and to get involved.

Whether we like it or not – we will be judged by “impact” and it's up to us to define “impact” as best suits us.

Economic Background To This Talk



Many people are not disposed to Particle Physics...

STFC's slice of the RCUK pot diminished in CSR07.



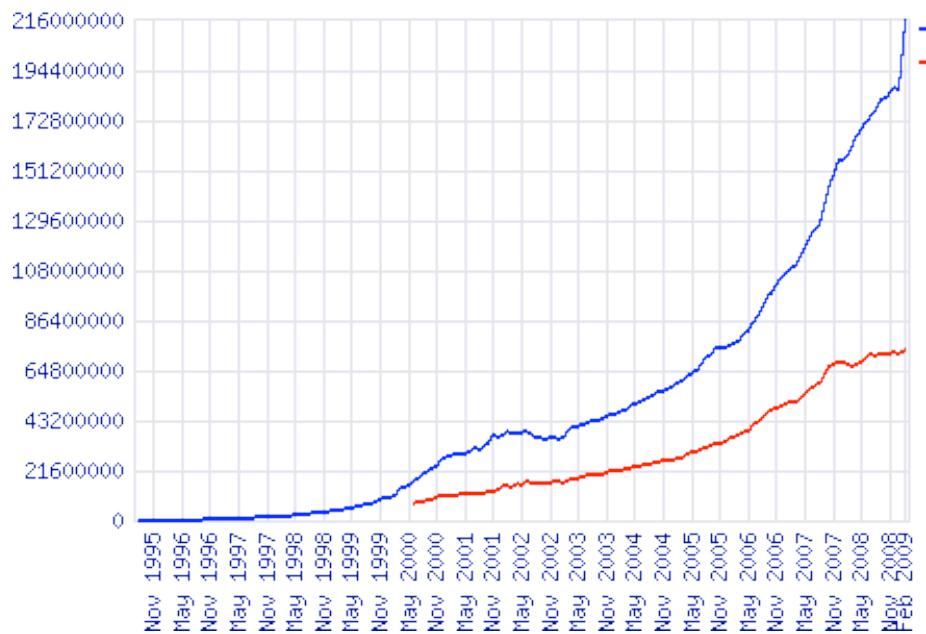
Sir David King

"It's all very well to demonstrate that we can land a craft on Mars, it's all very well to discover whether or not there is a Higgs boson; but I would just suggest that we need to pull people towards perhaps the bigger challenges where the outcome for our civilisation is really crucial."

"What if Tim Berners Lee had been working in a solar power laboratory? Perhaps he would have done it there as well. The spin-out would have come from the brilliant individual."

A view not shared by Tim BL

“A place like CERN, where enthusiastic experts congregate from all over the world, creates a unique, innovative atmosphere in which the boundaries of technology are pushed as a matter of course. **CERN's existence was critical to the start of the Web.**”



Government's Messages

Government message is mixed

“But, of course, any research base which does not include a substantial element of fundamental, curiosity-driven research conducted by researchers who simply want to know, will not be relevant economically in anything but the shortest of terms.

Knowledge for knowledge’s sake is also well worth having...

While the driver of fundamental research is curiosity, we shouldn’t, though, lose interest in its links with economic value.”

Government Line

“We can't give a little bit to everybody, that would be a derogation of duty. **We have got to make hard choices.....**”



“It can't be right to expect billions of pounds of funding and then **systematically deny the taxpayer any insight** into its potential applications to the economy, public policy or popular understanding..”

John Denham
Feb/Mar 2009

“.... This [economic impact] is a way of informing what will be funded.”

“In part it means undertaking the fundamental research which will inform our responses. But it's more than that.....”



The Next(?) Government



" For the last time Mother.No,I can't arrange to have you foceably returned to power ! "



The word “science” did not appear once in the Conservatives’ 2005 manifesto.



But

www.conervatives.com/pdf/stemreportfinal.pdf

The next(?) Government's Line

2006/7 – Ian Taylor

Cons.

"but scientists themselves were not the most helpful in persuading my fellow ministers. Scientists thought it was self-evident that they should remain immune to cuts, but too often failed to articulate how they could help the community through tough times. I accused one organization of "whingeing" on public radio, as that is how it sounded."

"creation of a powerful Innovative Projects Agency (IPA) alongside the Research Councils to refocus spending on innovation into areas of national interest

The IPA would recognize that **good work comes not just from university labs but from industry too** and would encourage collaboration and creative engineering.

This would mean a radical shift in the government approach to science funding..."

Cons.



2009 - Adam Afriyie – Shadow Science Minister

“Research councils have delivered well over the years and my preference is to preserve their critical independence.”

“But whether it’s an inquiry, commission or consultation, we need to resolve the uncertainty surrounding Haldane.”

“We must allocate tax-payers’ money effectively.
Part of the solution may be aligning public funds more closely with agreed national goals.”



Adam Afriyie – Shadow Science Minister

“We are committed to maintaining a world-class science base. And in some areas, **the case for public investment is strengthening.**”

“This is **especially relevant for basic research** in areas such as particle physics. The Diamond Light Source and **Large Hadron Collider** required investment that could only be sustained at national levels. In the short term, the return on investment is too unpredictable for commercial investors. But in the long term, **the benefits for humanity are transformative.**”

“**We must not sacrifice curiosity-driven research** in favour of applied science: there is an important role for both. We need a broad base of scientific research because we can never predict where the next breakthrough will emerge.”

“And that’s why we are comfortable with dual support funding: block grants allocated for universities to invest over the long-term, alongside **more targeted allocations by research councils for individual projects.**”

Different Aspects to “Economic Impact”

Cultural Benefits

*“It has no security benefit except
to make the country worth defending”
- R. Wilson*

Education Training

*UK needs a 30% uplift in STEM graduates
in next 5 years to retain economic competitiveness*

There is no Knowledge Exchange
without knowledge

Technological Innovation
Enhancing Industrial
Capability

Not one single argument will win the day – need all three.

Should Sell Why We Are Different

We have to convince the Treasury we are doing our bit but also that we have unique selling points and not to be afraid to say that a discovery at eg the LHC could change the world.

Not New

Socrates: It amuses me to see how afraid you are, lest the people should accuse you of recommending useless studies
Plato, the Republic (380 BC)

Remind People How the Modern World Came About

“I have heard statements that the role of academic research in innovation is slight. It is about the **most blatant piece of nonsense it has been my fortune to stumble upon.**

Or whether, in an urge to provide better communication, one might have found electromagnetic waves. They weren't found that way. They were found by Hertz who emphasised the beauty of physics and who based his work on the theoretical considerations of **Maxwell**. **I think there is hardly an example of twentieth century innovation which is not indebted in this way to basic scientific thought.”**

H. Casimir – Research Director at Phillips

Arguments from 2008.....

We provide a lot of bankers



We have employed a number of PhDs in particle physics at aAIM and we have found them to be highly flexible and numerate, with an analytic mindset and the type of international experience which enables them to make a significant contribution very quickly. We would definitely like to see more people with this background becoming available for employment in the City."

Mark Tagliaferri – Chairmna aAIM Group

From [The Times](#)

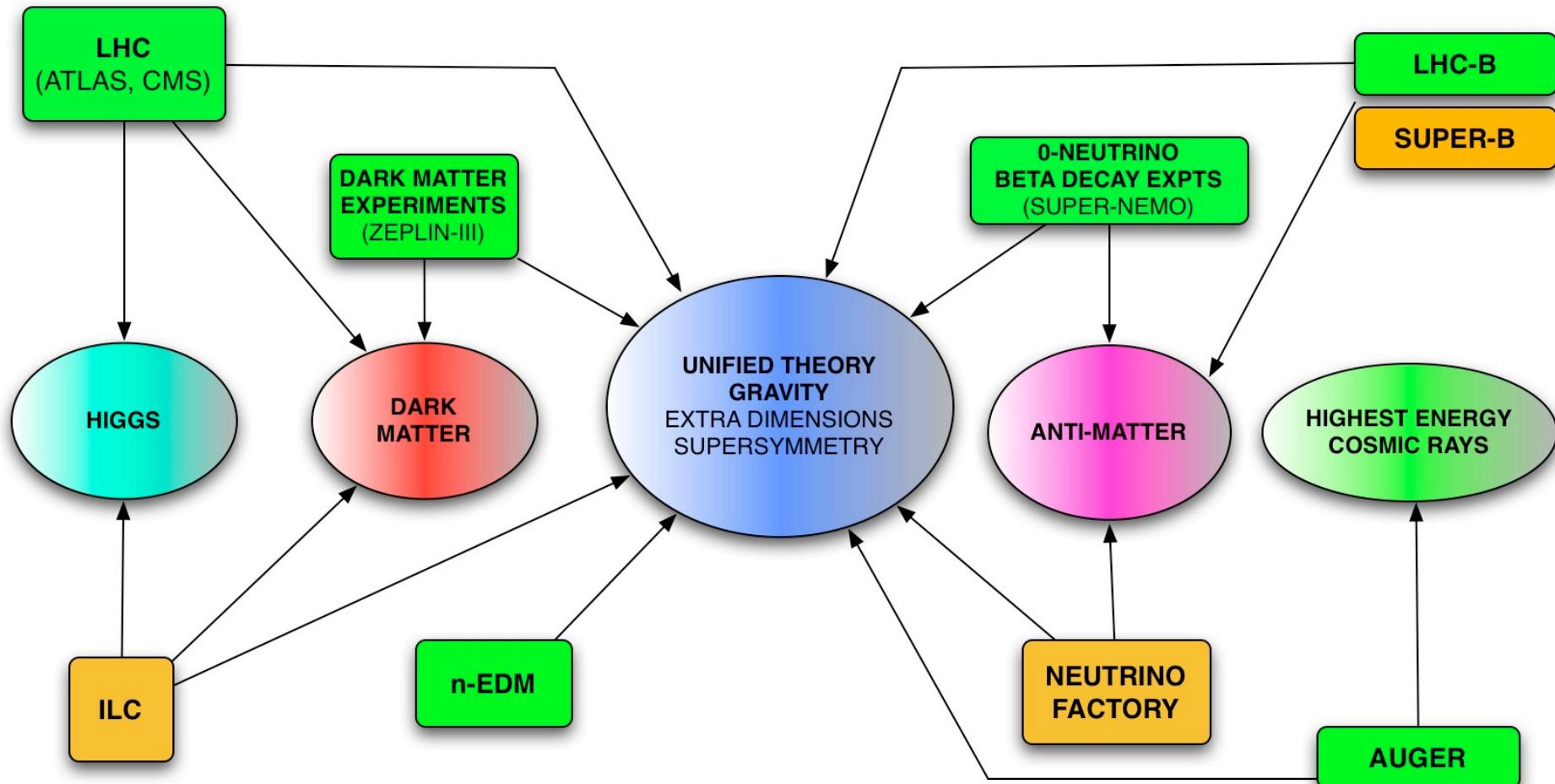
December 4, 2008

Celebrity crunch: property firm to the stars, aAim, goes bust

Cultural Benefits Stem From a Genuine Interest in PP Questions

25% of New Scientist feature questions below – when they do sales increase by 15%

Films, Books, Magazines etc



Education & Training

UG survey : 830 1st & final year students at 8 universities

1st Year Students – motivation for studying physics

90% expressed a significant interest in at least one STFC area

Only 37% expressed a significant interest in applied/medical physics

Final Year Students

71% had significant interest in at least one STFC science area

Particle Physics - lowest no interest and highest significant interest

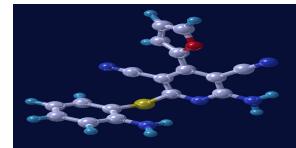
How about a survey of school-children/teachers ?

– quantify impact of LHC startup – uptake in A-level physics ?

The subject captivates the public and school-children
and draws students in to study physics.

This talk will highlight – latest applications

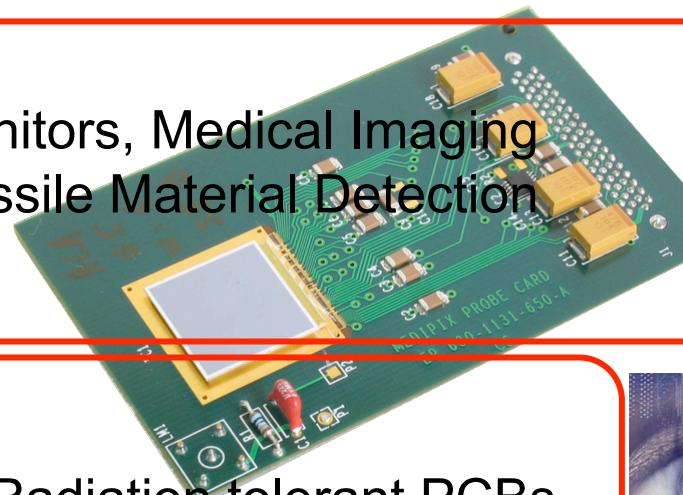
Accelerators



Cancer Therapy; Pharmaceutical Imaging
Food Sterilisation; Nuclear Waste Transmutation
Nuclear Thorium Reactors
Ion Doping of Semiconductors

Detectors

Radiation Dose Monitors, Medical Imaging
Cargo scanners, Fissile Material Detection



MicroElectronics

Eye Implants, Radiation tolerant PCBs
Pixel medical detectors

Computing

New drug simulations
Design of new medical treatments

New Technologies

In past five years ~ £20M spent on “KE” initiatives directly involving particle physicists (cf PP budget inc CERN = £120M/pa)
e.g.

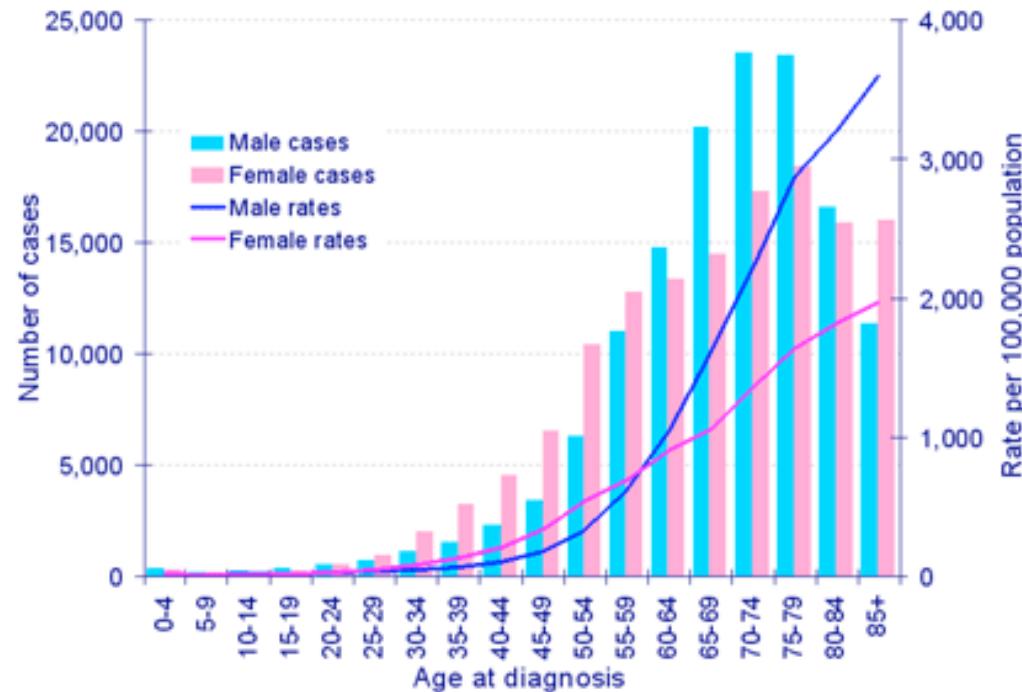
- EMMA : non-scaling FFAG accelerator
- MI3 : active pixel sensor consortium
- scintillators, PMTs
- grid / computing

All summarised in <http://www.pp2020.info>

Recent STFC pilot scheme for KE (health,security,energy)
Particle and Nuclear Physics Applied Systems (PNPAS)

FFAG / Accelerator Technology for Cancer Therapy

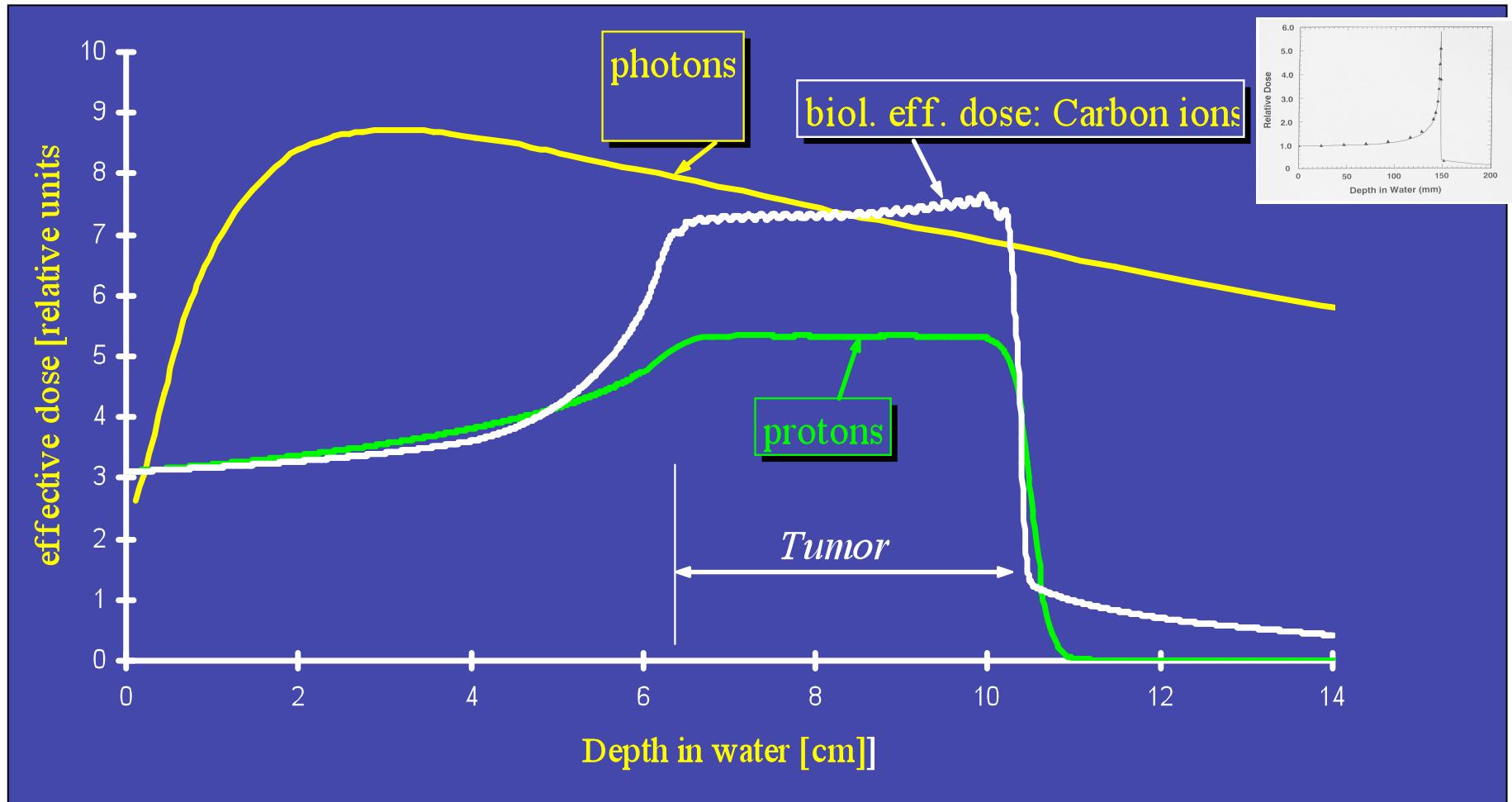
Richard Fenning, Akram Khan, Morteza Aslaninejad, Matt Easton, Jaroslaw Pasternak, Jürgen Pozimski, Alex Elliott, Cristian Bungau, Bob Cywinski, Becky Seviour, Roger Barlow, Sam Tygier, John Cobb, Mark Hill, Bleddy Jones, Gillies McKenna, Ken Peach, Suzie Sheehy, Boris Vojnovic, Holger Witte, Stephanie Yang, Takeichiro Yokoi, Elwyn Baynham, Rob Edgecock, Ian Gardner, Shinji Machida, Carl Beard, Neil Bliss, Neil Marks, Peter McIntosh, Hywel Owen, Mike Poole, Susan Smith, Stephan Tzenov, Charlie Jeynes, Karen Kirkby, Roger Webb



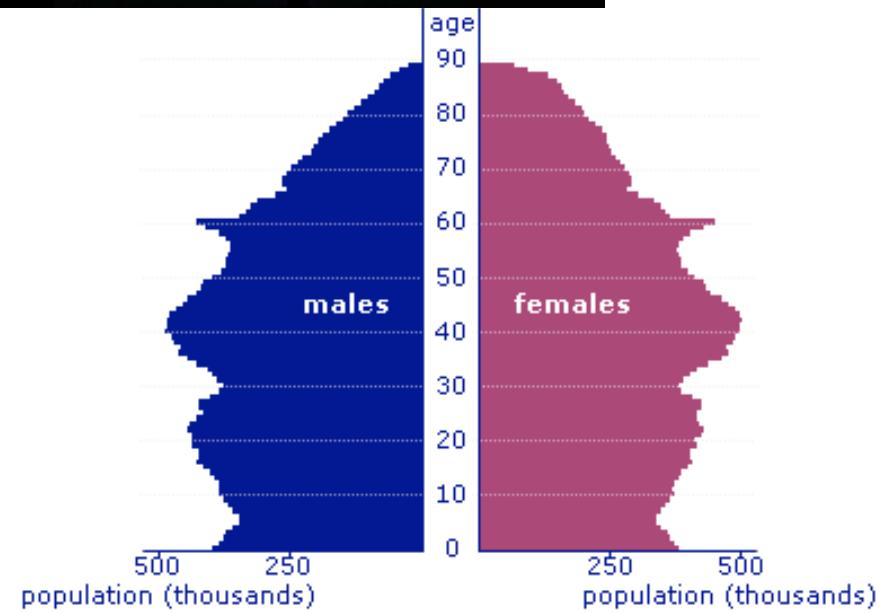
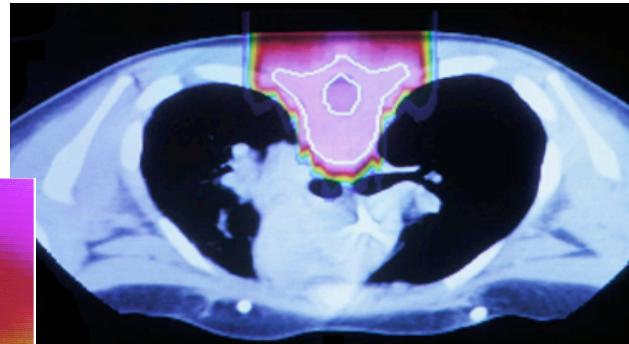
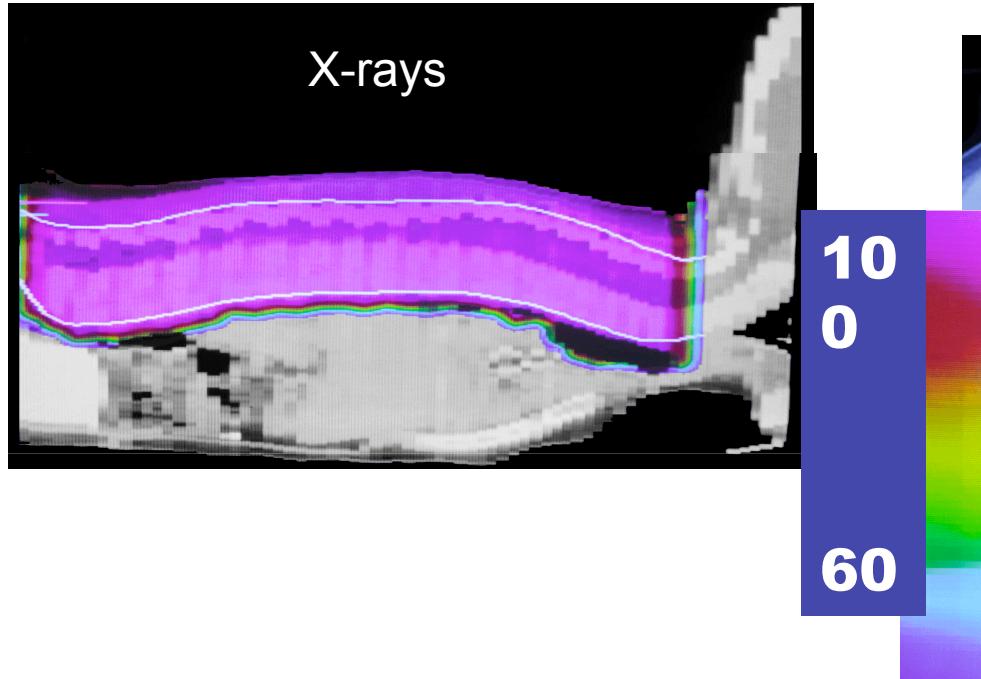
“Chemotherapy provides by far the smallest contribution towards cancer cure yet is much more expensive than radiotherapy and generates a disproportionately large research and media interest. “

Roger Dale, Hammersmith Hospital and Imperial College

Hadron Therapy



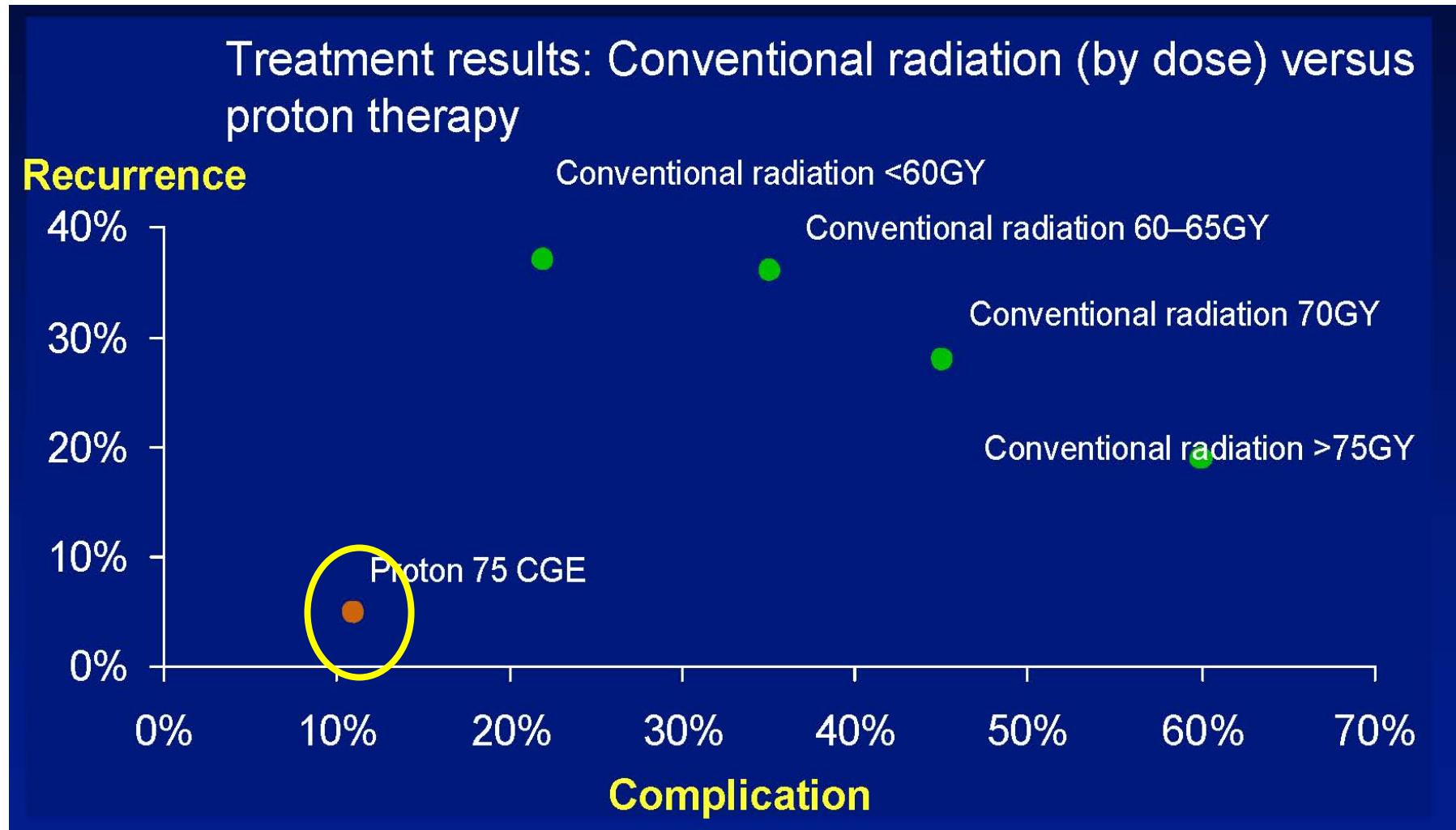
New Technologies



“When proton therapy facilities become available it will become malpractice not to use them for children [with cancer].”

Herman Suit, M.D., D.Phil., Chair, Radiation Medicine,
Massachusetts General Hospital

Proton Therapy – Prostate Cancer



New Technologies

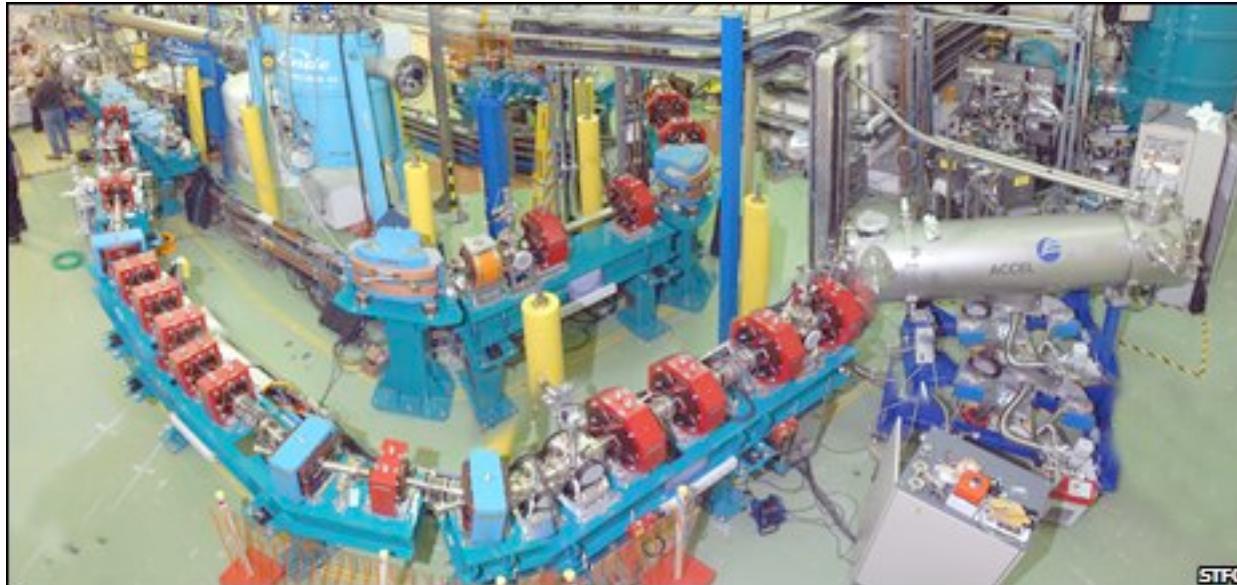
Studies suggest 1 hadron therapy center per 10M population.
UK has no center other than Clatterbridge (low E – eyes only)

There is still much to do

1. **Improved accelerator technology**
 - Improved patient experience, better control
 2. Improved beam delivery & instrumentation
 - Better control, reduced errors, lower dose to healthy tissue
 3. Improved understanding of the evidence
 - Better treatment planning, domains of applicability
 4. Improved treatment regimes
 - Finding the best way of delivering the lethal dose to the tumour
 5. Improved understanding of mechanisms
 - Better treatment planning, more effective outcomes
-
- **Improve patient experience**

FFAG for Hadron Therapy

FFAGs : various potential advantages, such as variable extracted energy and high repetition rates compared with cyclotrons, and simplicity of operation when compared with synchrotrons. Potentially also cheaper.



EMMA / PAMELA

THPMN076

Proceedings of PAC07, Albuquerque, New Mexico, USA

PAMELA – A MODEL FOR AN FFAG BASED HADRON THERAPY MACHINE

K. Peach, J. Cobb, T. Yokoi, JAI, Oxford, UK, Ian Gardner, STFC/RAL/ISIS, Chilton, UK, Rob Edgecock STFC/RAL/PPD, Chilton, UK, Mike Poole STFC/ASTeC, Daresbury UK, J. Pozimski, Imperial College, London, UK, Bob Cywinski, Leeds University, UK, Bleddyn Jones, Birmingham University, UK, Gilles McKenna, Oxford University, UK, Boris Vojnovic, Melvyn Folkard, Grey Cancer Institute, London, UK, Karen Kirkby, Roger Webb, Surrey University, UK, Roger Barlow, Manchester University, UK, Alex Elliott, Beatson Oncology Centre, Glasgow, UK.

Design parameters being formalised and will be refined based on results from EMMA tests later in the year.

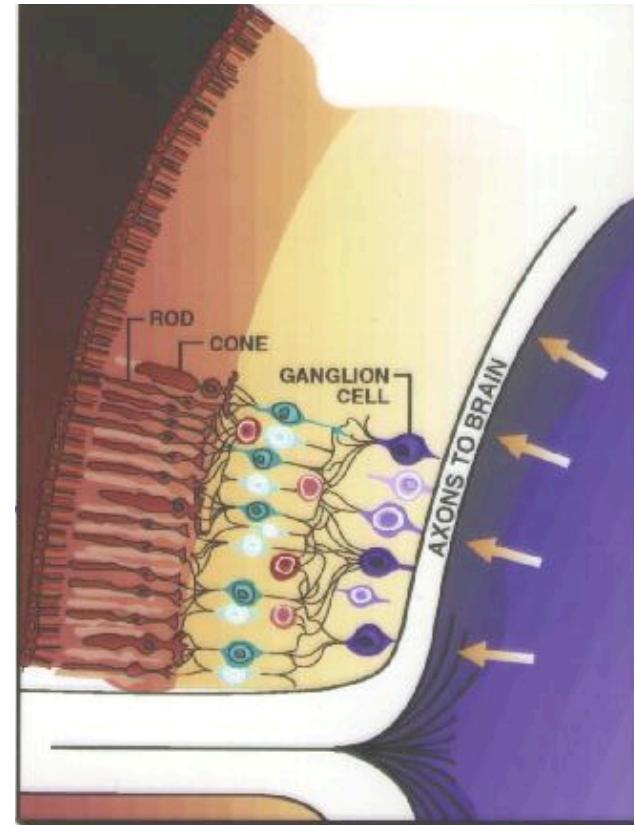
RETINAL IMPLANTS

Age-related macular degeneration(AMD)

- Most common cause of blindness in the developed world, 1 in 30 people affected.
- Dry form of AMD has no effective treatment.

Retinitis Pigmentosa (RP)

- RP affects approximately 1 in 3000 people worldwide.
- There is a progressive loss of rods until only the central retina is functional : tunnel vision
- Again significant survival rate amongst remaining neurons.

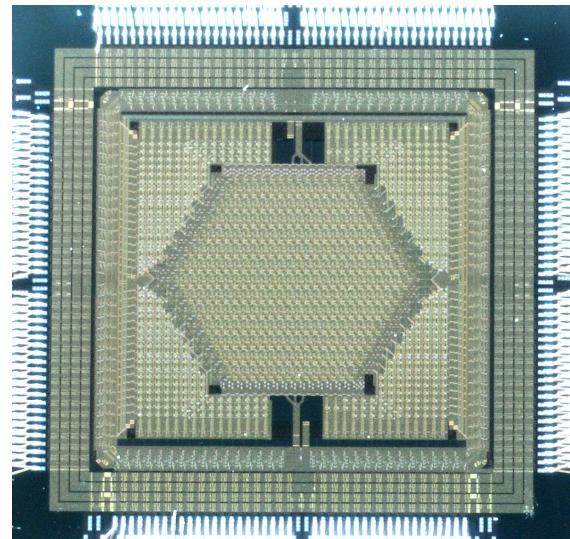


Study Signal from Retinal Cells

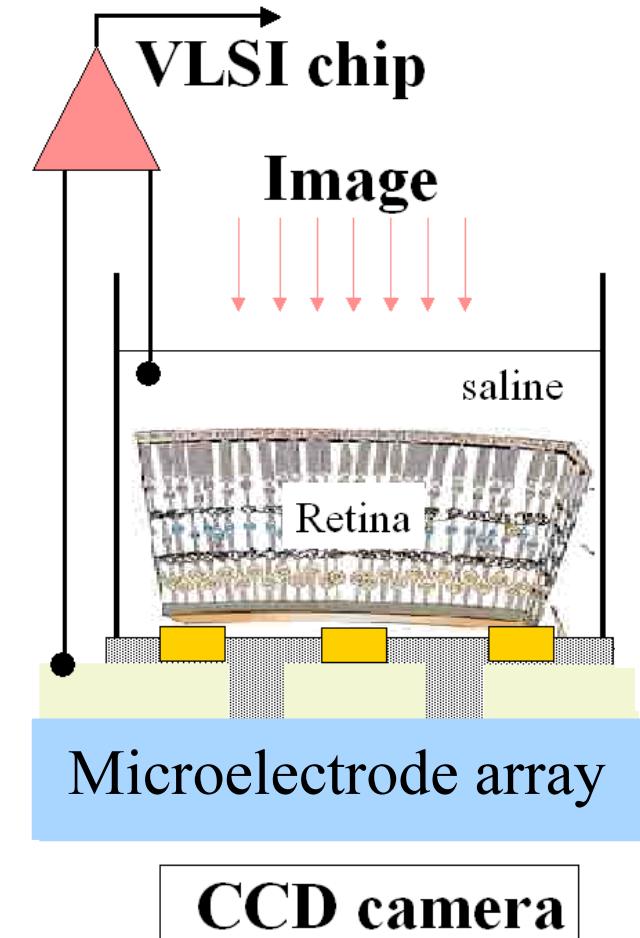
Study the signals from retinal cells

Mimic signal from retinal cells

Stimulate retinal cells



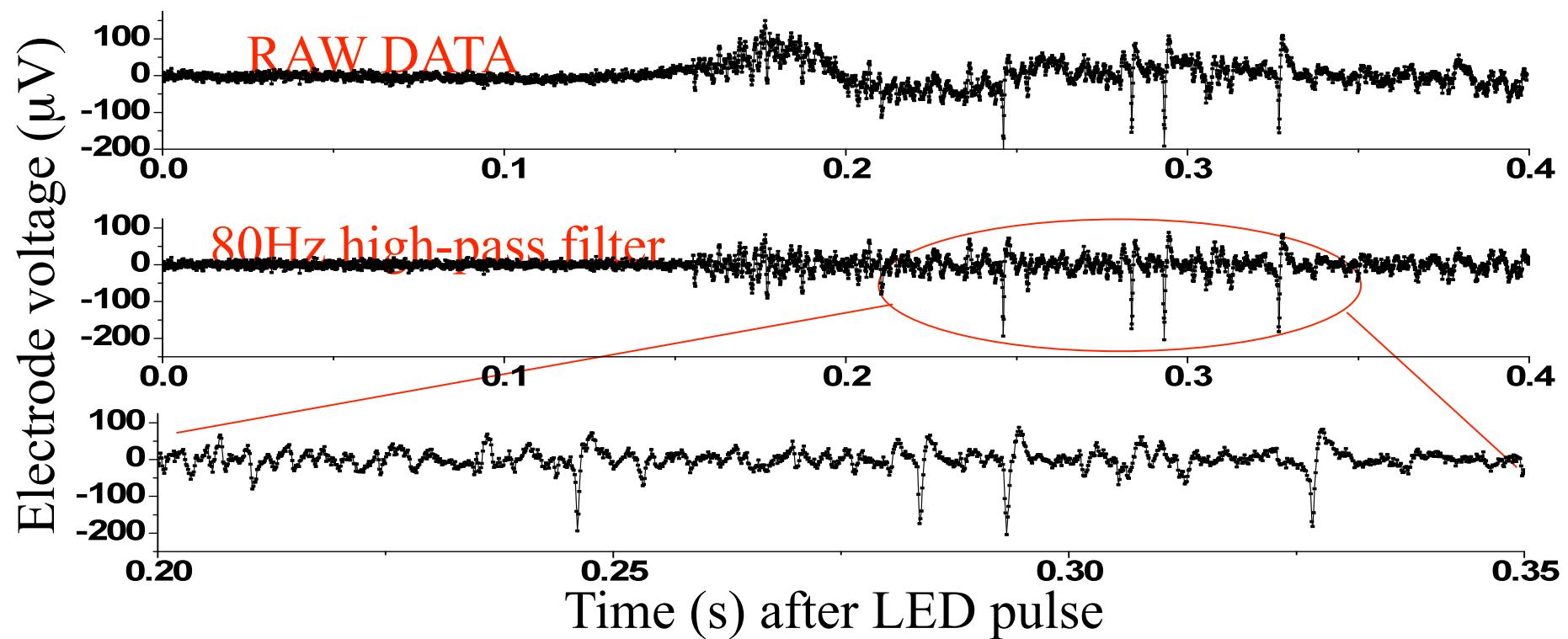
547 independent pixels



Glasgow & STFC

K.Mathieson,D. Gunning, D.
Murdoch, J.D. Morrison, A.R. Moodie,
M.L.Prydderch,M. Hart

Study Signal from Retinal Ganglion Cells (Frog)



Silicon probes for studying brain slices – D. Gunning

High density array of electrodes capable of penetrating into brain tissue

Electrode separation

= 60 μm

Electrodes at tip

$\sim 5 \mu\text{m}$



Thorium Reactors

Bob Cywinski, Roger Barlow, Cristian Bungau, Bill Nuttall, Geoff Parkes

Thorium as fuel

Advantages

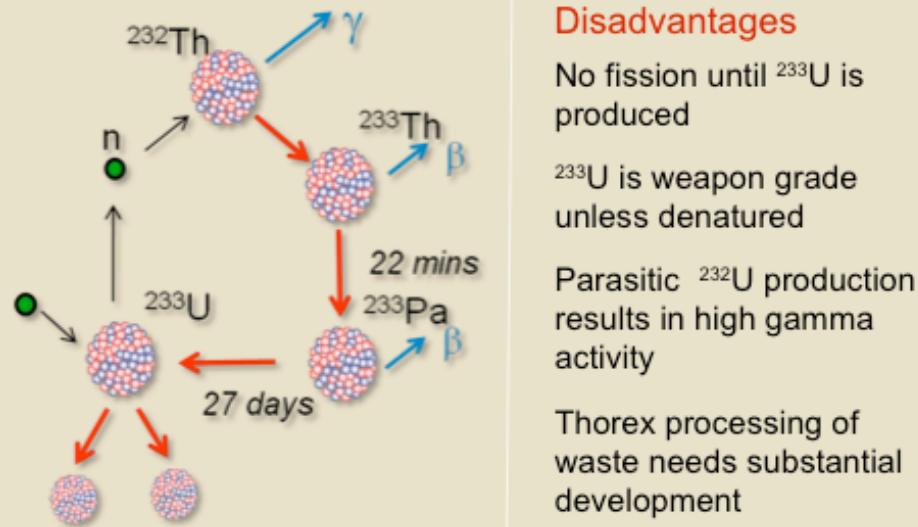
Thorium supplies plentiful

Robust fuel and waste form

Generates no Pu and fewer higher actinides

^{233}U has superior fissile properties to ^{235}U and ^{239}Pu

Proliferation resistant



Disadvantages

No fission until ^{233}U is produced

^{233}U is weapon grade unless denatured

Parasitic ^{232}U production results in high gamma activity

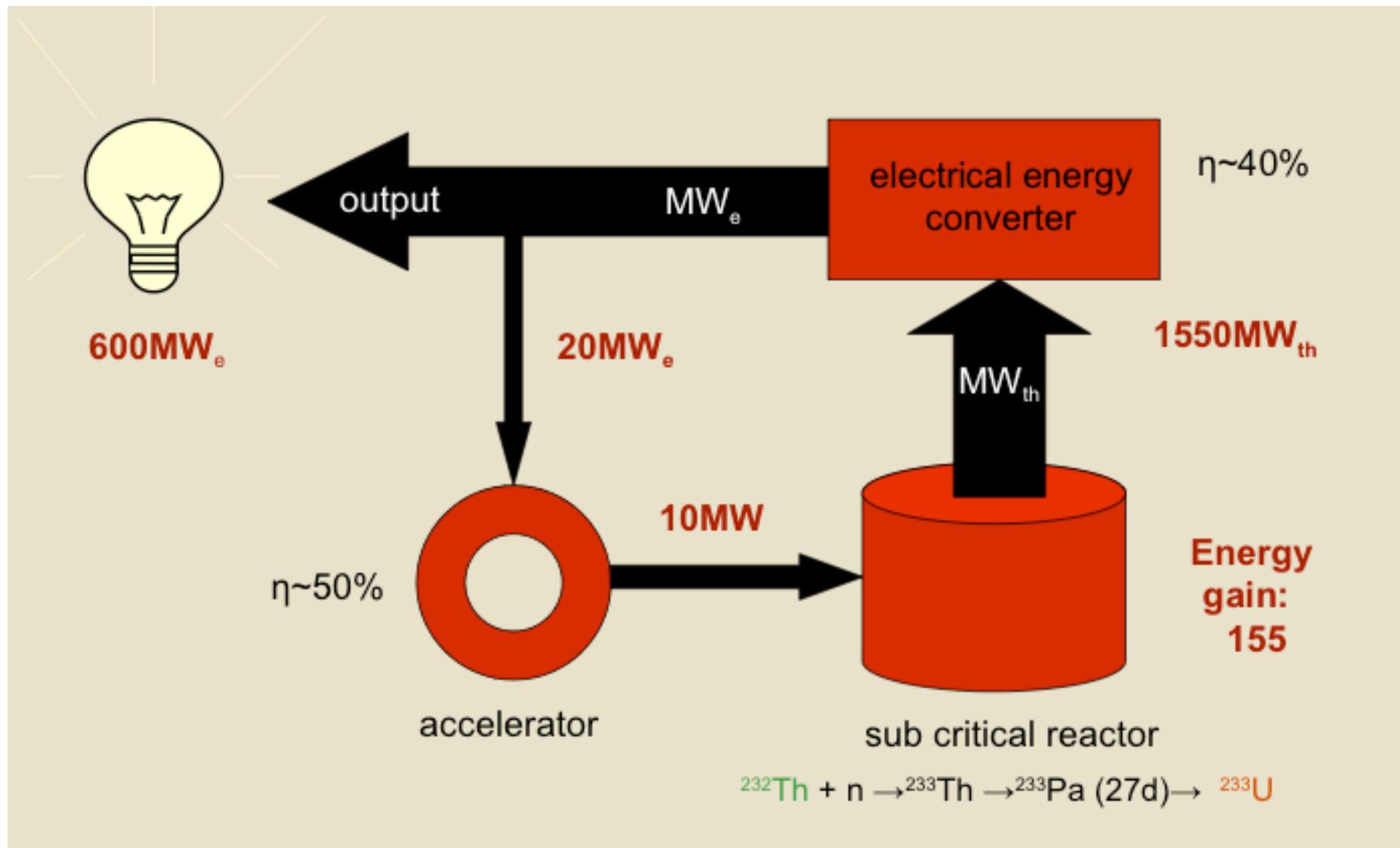
Thorex processing of waste needs substantial development

It is generally considered that the neutrons necessary to produce ^{233}U from ^{232}Th must be introduced by seeding the Th fuel with ^{235}U or Pu for a conventional reactor, or

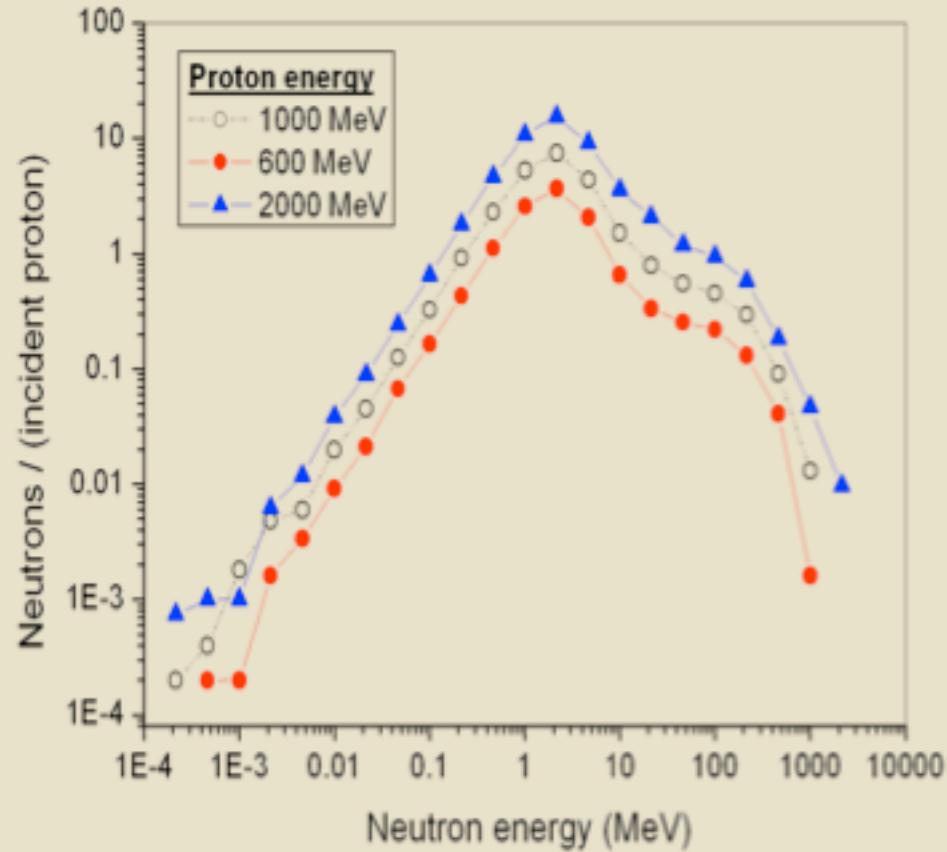
Butcan we dispense with U and Pu altogether ?

- Need 10 MW proton source (for neutrons)

Thorium Reactors : Energy Amplifier



Thorium Reactors



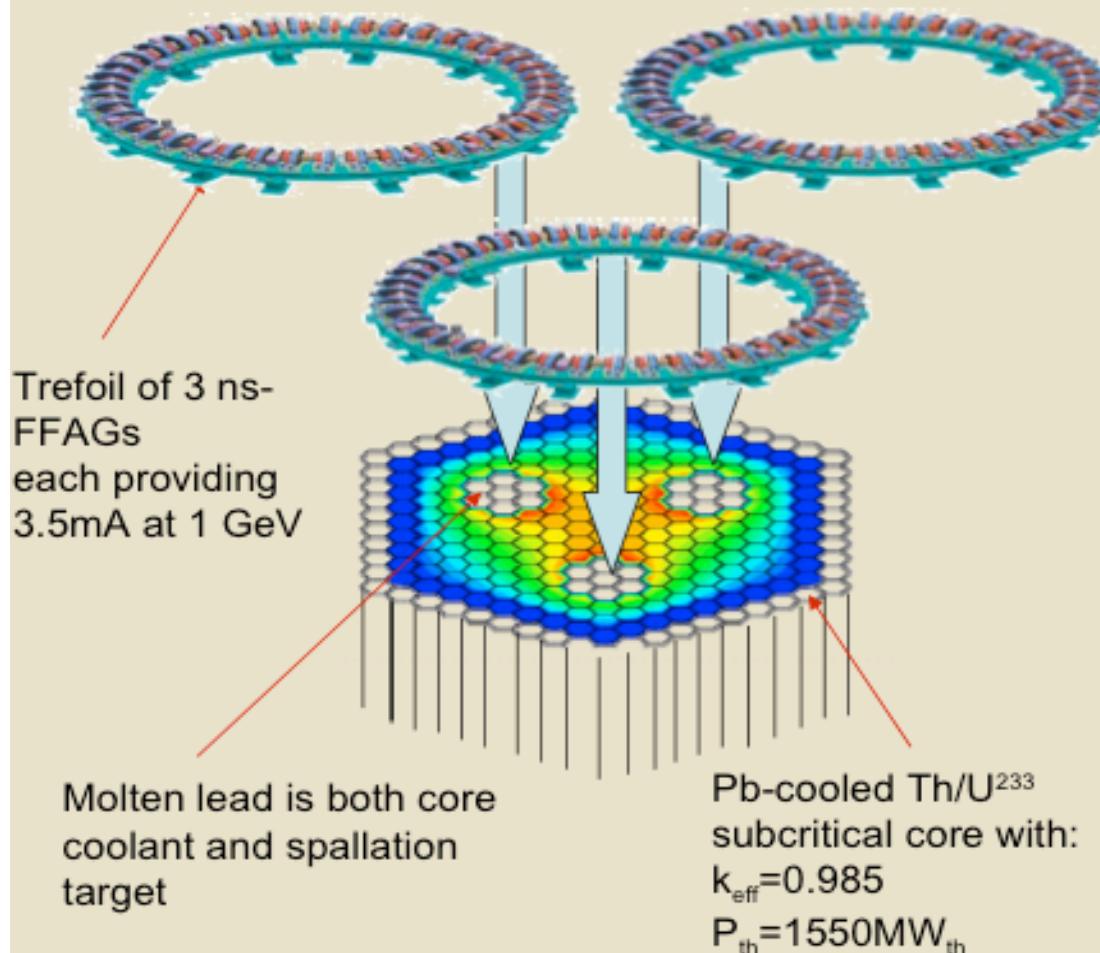
The energy spectrum of the spallation neutrons at different incident proton energies.

The target is a lead cylinder of diameter 20 cm

At 1 GeV, approximately 24 neutrons per proton are produced

Thorium Reactors : FFAGs again...

Triple target FFAG-driven ADSR



Power density distribution
(W:cm³) in a lead-cooled
ADSR with Th:U²³³ fuel.

The three beams with buffer
zones are described by seven
lead-filled fuel element
positions.

The over-all power distribution
is satisfactory.

Three ns-FFAG drivers should
be no more expensive than a
single conventional driver....

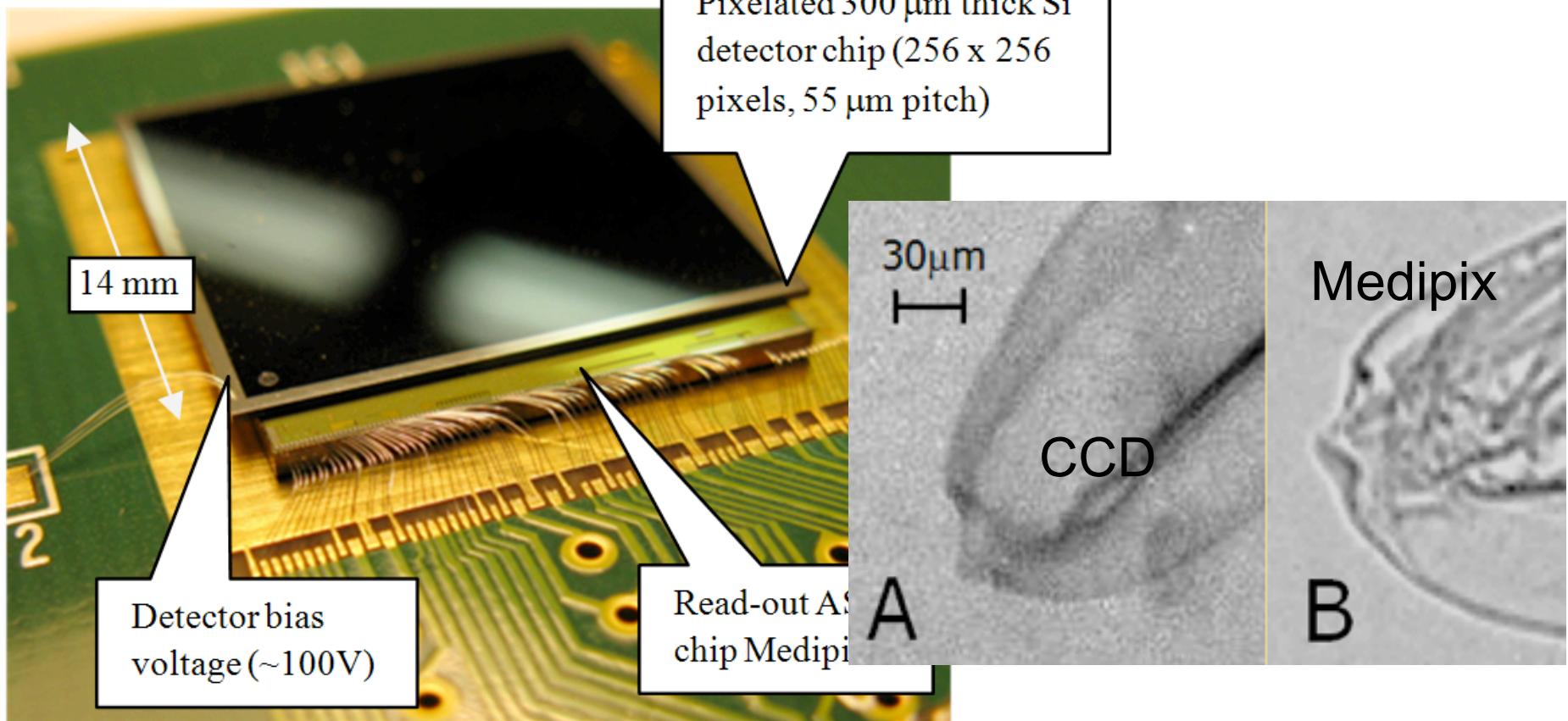
.....and will provide the required
reliability margin

Medipix / TimePix Photon Counting Pixel Detectors

Val O'Shea et al (Glasgow)

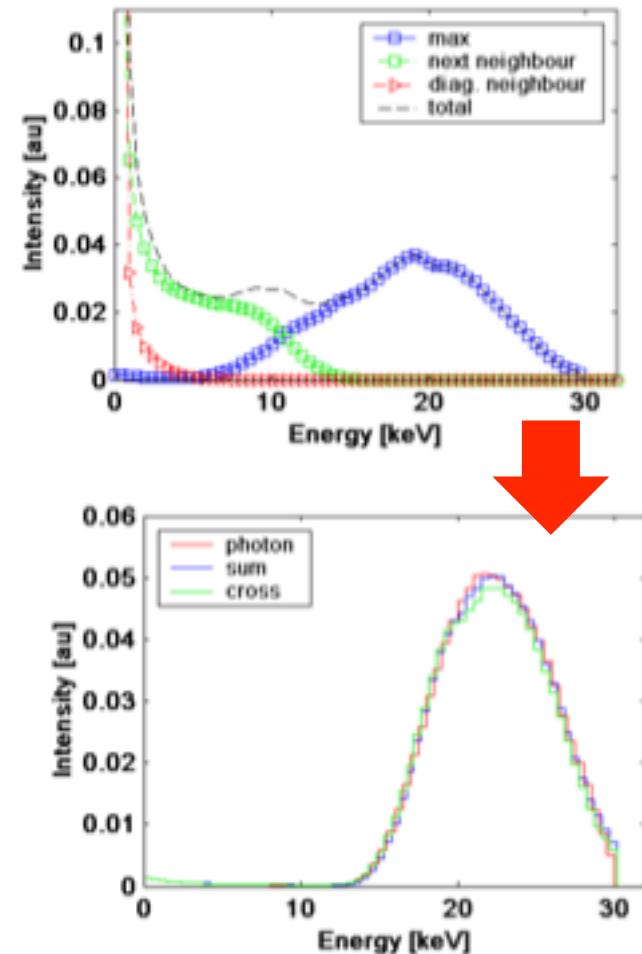
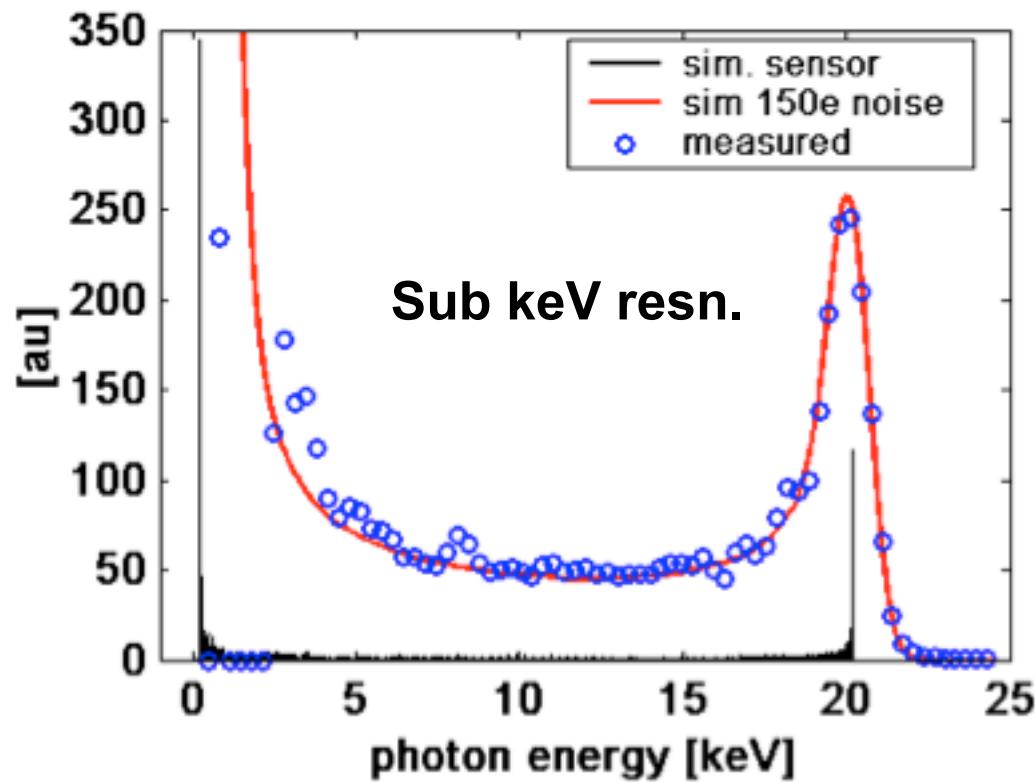
Now on 3rd Generation

2nd : ATLAS dosimeters, Philips Healthcare, Panalytical



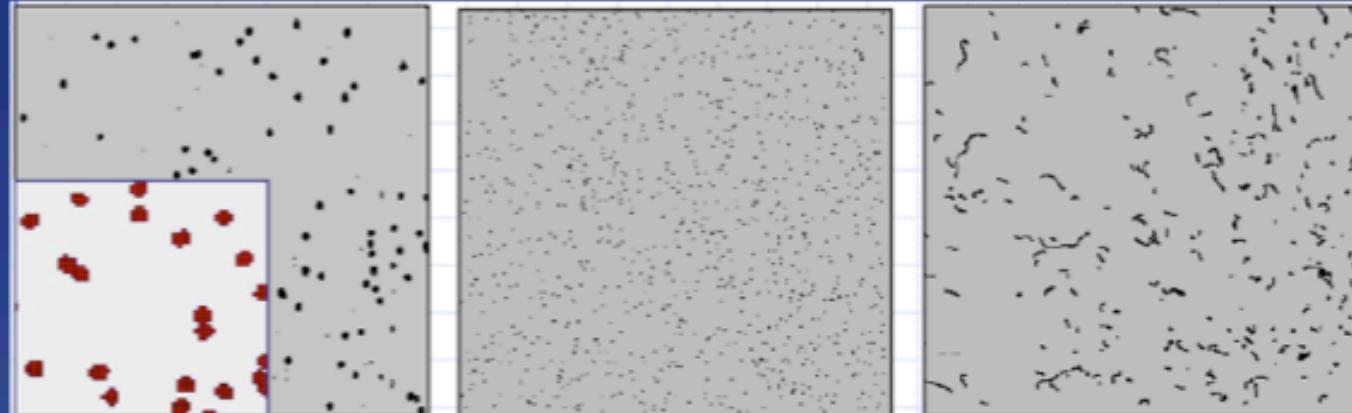
Medipix / TimePix Photon Counting Pixel Detectors

Mitigate against charge sharing; colour images;
simultaneous read/write – 1086 transistors per pixel



Medipix Pixel Detector

Quantum Dosimetry



Identify each hit by radiation type and energy from track/cluster shape

Method, Apparatus and Computer
Program for Measuring the Dose,
Dose Rate and Composition of
Radiation

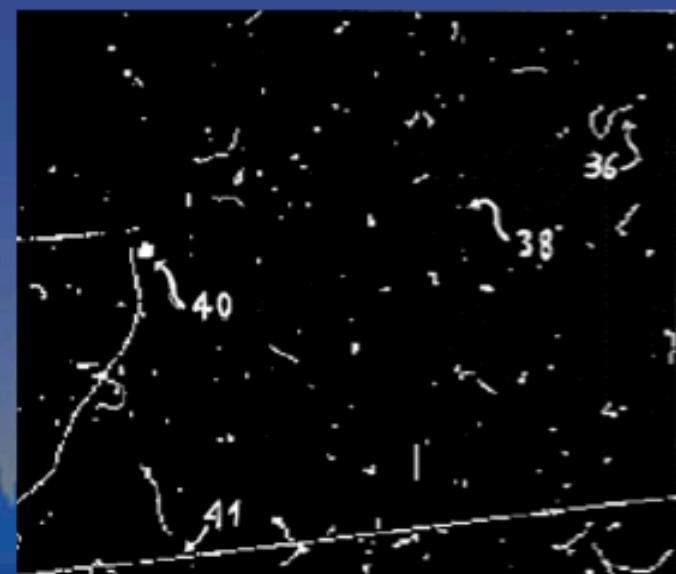
Patent submitted 09/03/'07

36 Electron

38 Photon

40 Neutron

41 Muon



Thermal Neutron Detectors

John McMillan, Neil Spooner, Graeme Hitchen, Ed Marsden

Aim is large area BUT low cost neutron detector for security
Optimising materials e.g. use of Boron for neutron capture

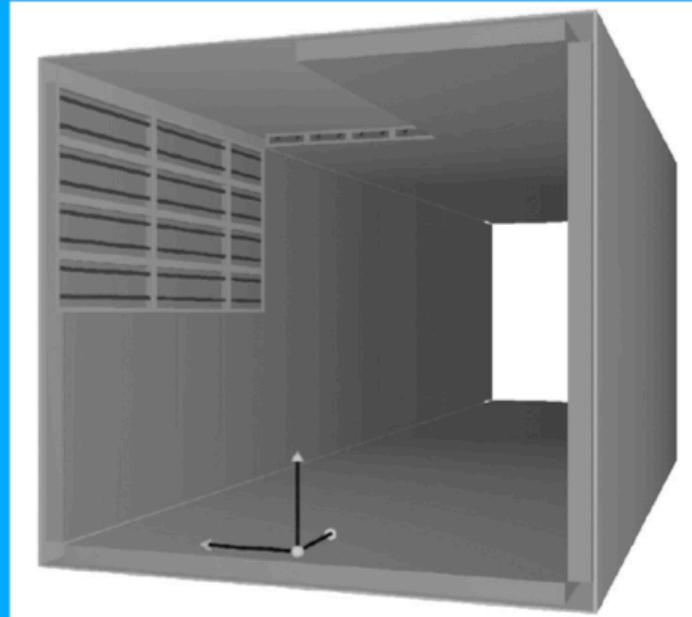


Neutron box counter

640 ^3He tubes
Surround truck
or ISO container.

13% efficient.

Simulations indicate
detection of 25kg
HEU at 3sigma
in 180s



PP2020 – “Particle Physics : It Matters”

To be launched by IoP on back of “Angels and Demons” Film Launch (May 15).

1. The field has a bright future beyond the LHC
2. It is people's interest in the science that motivates them to innovate in technology.
 - we need to counter the argument that if we are so good at useful technology why don't we just concentrate on that
3. The research requires paradigm shifts in technology
 - the electric light bulb didn't come from incremental R&D in candles.
4. The research inspires young people to study physics and this continues to PhD level

Engaging Other Supporters

Getting other scientists & industrialists to make our case is crucial

“Every program in super-conductivity that there is today owes itself in some measure to the fact that Fermilab built the Tevatron and it worked” : Robert Marsh US Nb-Ti manufacturer.

“We remain concerned, however, that **the correct balance be maintained** between the current emphasis on the industrial relevance of research and the pursuit of new knowledge which is not perceived to be of immediate application. World class excellence in Science and Engineering has been a central feature in our national culture for more than two centuries and **we urge that fundamental research should continue to be accorded the highest priority** as we move towards the new Millennium” : Oxford Instruments.

Summary

Don't get depressed – it's always been like this !

But we are in competition for funds and we need to have the arguments ready and for more people to be versed in them for the elevator pitch.

If you're interested in helping to sell "PP2020" – get in touch.

www.pp2020.info

End

CASIMIR RANT

“I have heard statements that the role of academic research in innovation is slight. It is about the most blatant piece of nonsense it has been my fortune to stumble upon.

Certainly, one might speculate idly whether transistors might have been discovered by people who had not been trained in and had not contributed to wave mechanics or the quantum theory of solids. It so happened that the inventors of transistors were versed in and contributed to the quantum theory of solids.

One might ask whether basic circuits in computers might have been found by people who wanted to build computers. As it happens, they were discovered in the thirties by physicists dealing with the counting of nuclear particles because they were interested in nuclear physics.

CASIMIR RANT

One might ask whether there would be nuclear power because people wanted new power sources or whether the urges to have new power would have led to the discovery of the nucleus. Perhaps - only it didn't happen that way.

One might ask whether an electronic industry could exist without the previous discovery of electrons by people like Thomson and H A Lorentz. Again it didn't happen that way.

One might ask even whether induction coils in motor cars might have been made by enterprises which wanted to make motor transport and whether then they would have stumbled on the laws of induction. But the laws of induction had been found by Faraday many decades before that.

Or whether, in an urge to provide better communication, one might have found electromagnetic waves. They weren't found that way. They were found by Hertz who emphasised the beauty of physics and who based his work on the theoretical considerations of Maxwell. I think there is hardly an example of twentieth century innovation which is not indebted in this way to basic scientific thought."

End