Department of Physics

UNIVERSITY OF OXFORD

Commercialisation of Accelerator Technologies

John Adams Institute Course – 28 February 2024

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University of Oxford

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Benefits to Science - Benefits to Society

- Why Government fund science – where does £ come from

"We invest in research and innovation to enrich lives, drive economic growth, and create jobs and high-quality public services across the UK. We are transforming tomorrow together."

- £8 Billion

UK Research and Innovation

"STFC's mission is to deliver world-leading national and international research and innovation capabilities and, through those, discover the secrets of the Universe. Our major research and innovation campuses at Harwell, Daresbury and research facilities across the UK and overseas support fundamental research in astronomy, physics, computational science and space science."

- UK spend on CERN = ~£200M
- £500 Million+
- STFC funds at 80% cost…
- Rest decided by ranking in REF

Science and Technology Facilities Council

Research Excellence Framework (REF) – All university depts. reviewed and ranked

- "To provide accountability for public investment in research and produce evidence of the benefits of this investment.
- To provide benchmarking information and establish reputational yardsticks, for use within the Higher Education sector and for public information.
- To inform the selective allocation of funding for research."

REF 2021 Research Excellence Framework

Impact is 25% of score

UK Physics Dept Results

Institution	FTE entered	GPA	GPA 2014	Rank 2014	Research power (indexed)	RP rank	Market share (%)
University of Oxford	171	3.52	3.34	2	1000	1	8.6
University of Cambridge	148	3.63	3.29	=7	892	2	8.14
Imperial College London	130	3.45	3.26	10	744	3	5.97
University of Edinburgh	118	3.49	3.33	=3	683	4	5.6
UCL	113	3.38	3.12	=16	631	5	4.72

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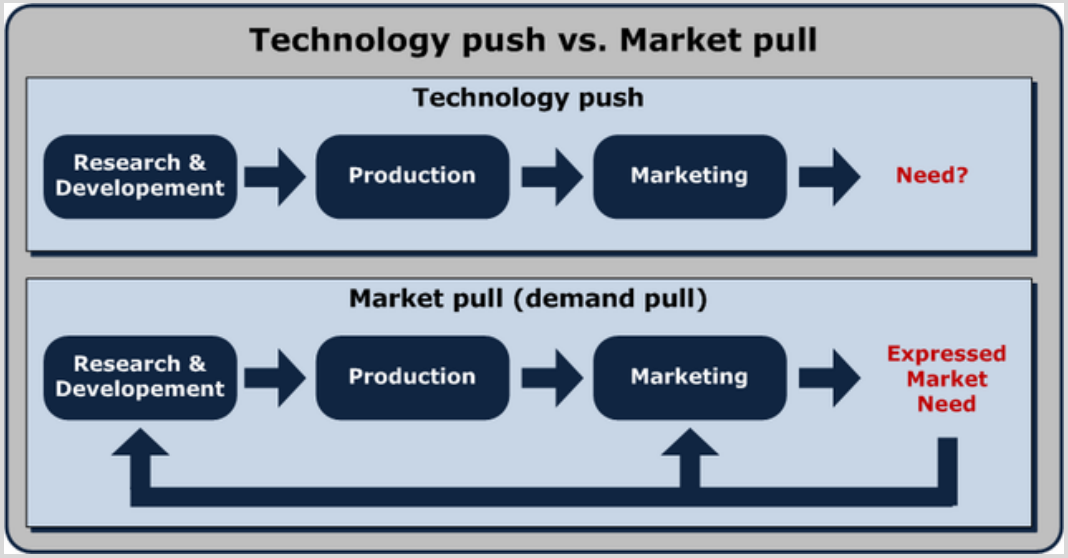
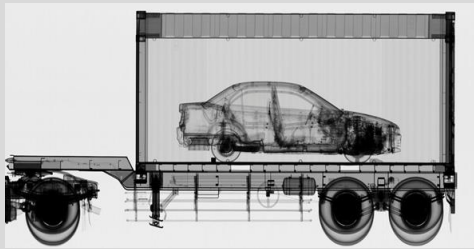
Impact of Accelerators – Innovation

- Tech Push more than Market Pull (solution looking for problem)



Proton therapy



X-ray but moving to using neutrons and measuring gamma rays coming back

- SCAMPER
  - Substitute, Combine, Adapt, Modify, Put to other use, Eliminate, and Redesign

Impact of Accelerators – A brief history

- First accelerator (linac) built in 1928 by Rolf Wideroe in Aachen, Germany
- First Cyclotron in 1931 at Berkeley (cost $25)
- First electron synchrotron constructed was in the US at General Electric in 1945
- First modern Linac built after WW2 using microwave technology developed for radar
- First proton synchrotrons in the 1950's at Brookhaven and CERN
- First linear collider in 1989 at SLAC
- ~40k accelerators in operation in industry, hospitals, research institutions – most for seminconductors and healthcare

First Cyclotron

SLAC

Impact of Accelerators – Applications

- Linac – used for radiotherapy - low energy beams of electrons to produce X-rays targeted at tumour.

Radiotherapy linac

- Linear colliders – Technology developed for the Compact Linear Collider (to collide electrons and positrons), will allow very high-energy electrons (VHEE) to be used target tumours with FLASH therapy (quick burst of large dose) – collaboration between CERN, Lausanne Hospital with JAI (Prof Manjit Dosanjh).

VHEE & FLASH

- Cyclotron – radioactive isotopes for medical applications e.g. PET scans and radiotherapy treatment – need new versions

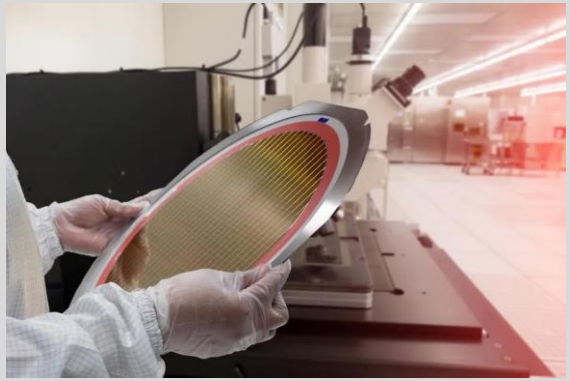
isotope production

Impact of Accelerators - Applications

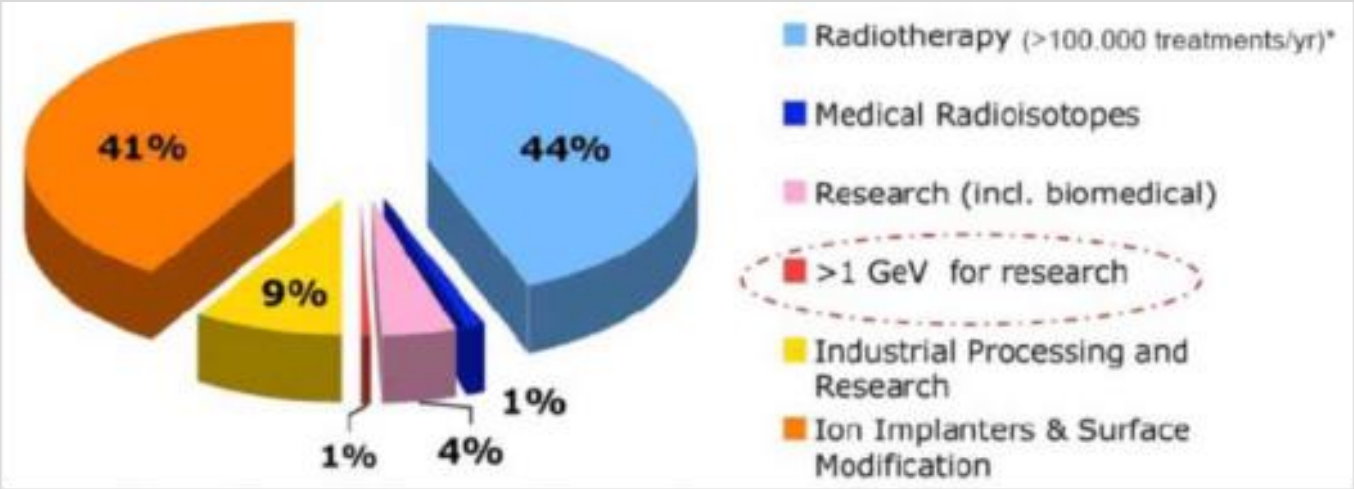
- Electron synchrotron – Lightsources – Diamond at Harwell, UK – intense beams of light (synchrotron radiation) used for material science, chemistry, molecular biology….

Diamond Lightsource

- Ion implantation - firing a beam of ions at a material - used for doping silicon for making semiconductors for computing industry.



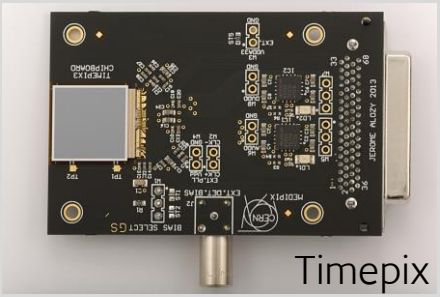
Impact of Accelerators – Applications



- Market $3B and $5.5B by 2027 - Future growth due to:
  - increasing access to cancer treatments
  - production of semiconductors
  - investment in science facilities in China
  - development and adoption of compact, portable, affordable accelerators – e.g. smaller Free-Electron laser (FEL) and Laser Wakefield for materials industry

Major companies – Elekta (Sweden), General Electric (US), Toshiba (Japan), Mitsubishi Heavy Industries (Japan), Siemens Healthcare (Germany), Varian (US), Shinva (China)

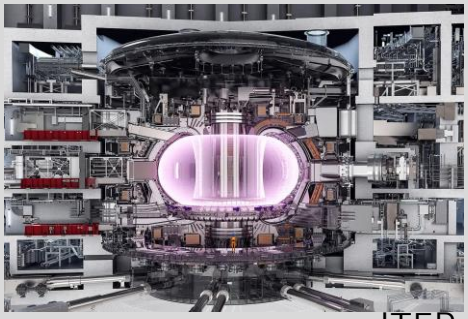
Impact of Accelerators – Applications of related technologies


Timepix

- Particle Detectors – photon counting and particle tracking technology from CERN (Medipix / Timepix collaboration) – dosimetry, life sciences, material analysis (licensed by CERN)

- Computing
  - WWW invented at CERN in 1989
  - Optimisation algorithms developed for analysing data from particle detectors now being used by companies looking to reduce energy demands of smart devices and AI capabilities

- Materials – Superconducting magnets (e.g. MRI), Cryogenic equipment, Vacuum systems used throughout industry–
  - CERN (hardware and control software) shared with ITER and companies inc. Tokamak Energy to pursue Fusion.


ITER

- Are these Tech Push or Market Pull?
- Were they invented by SCAMPER – smaller, new use, adapted?

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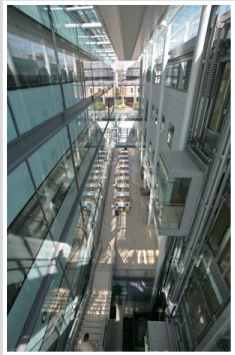
Role of Academia to Innovate – Motivation

- Further academic career
- New collaborations
- Access to further funds
- Attract wider range of researchers to group
- Solving societal problems

- Create careers for students
- Learn transferable skills (being a group leader is like a CEO of a small company)
- Money for living
- Career options
- Creative outlet


University culture




Industry, business & the wider world

As inventors of creative solutions, is it your duty to identify opportunities to use technology to make the world better and work with industry to make it happen?

What is Intellectual Property (IP)

The World Intellectual Property Office has defined IP it as "*any creations of the mind*".

Inventions & literary and artistic works

Symbols, names, images used in commerce

IP Rights (patents) can give £ value to your idea but which IP is worth protecting

Where is the value?

The clever and unique bits…

Branding

- Made by Apple
- Logo
- Product “iPad”
- Software “iOS”

Written & drawn content

- Instruction manual
- Packaging artwork

Hardware & Design

- Form of the device
- The case
- The border around the screen
- Semiconductor circuits

Software

- Data processing methods
- User interface

Intellectual Property Rights (IPR)

Why protect? Is it protection needed?

Obtaining IP protection will not guarantee commercial success

IP protection can be a bargaining tool and a source of revenue

- You still need a unique value proposition and without that the IP is of less value and not worth even protecting.

IPR can be:
Sold ('assigned')
Rented ('licensed')

Intellectual Property Protection

Different forms of intellectual property rights

Patents	Copyright	Design rights
Trade marks	Know-How	Trade secrets

What is a Patent?

–An agreement

Public disclosure of your invention

Government grants exclusive but temporary monopoly rights

Protects inventions

from making, using or selling your invention without permission (rent or buy patent)

Lasts 20 years

Enough time to make back more than R&D cost of invention

Must be applied for

Patents

Key criteria

Novel

Not in public domain anywhere in the world

Inventive

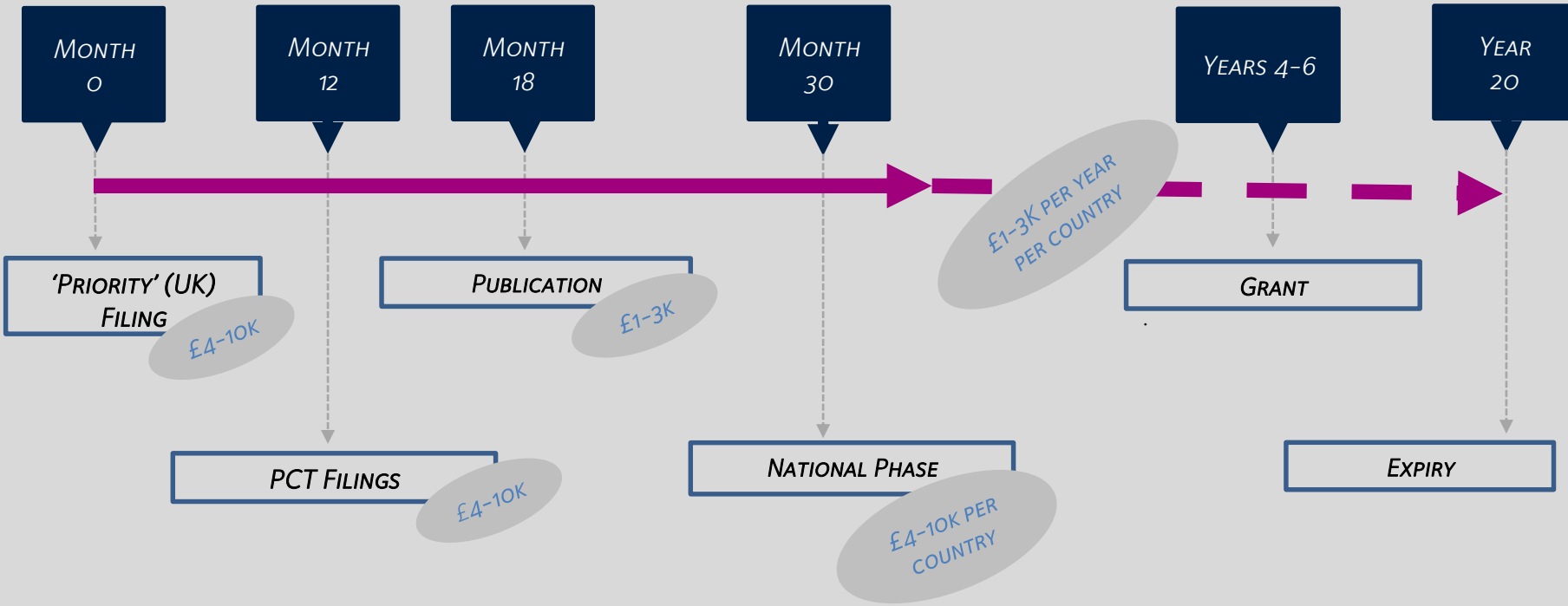
non-obvious improvement of what is already known

Applicable

useful and industrially applicable

Patent Application Process

Getting a Patent Granted is SLOW and Expensive



Patents still helpful before being granted

Intellectual Property Protection

Different forms of intellectual property rights

Patents	Copyright	Design rights
Trade marks	Know-How	Trade secrets

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Copyright – The Basics

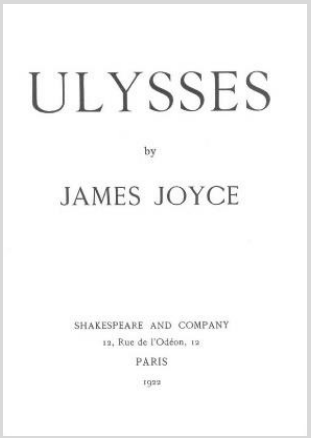
Criteria
the expression of ideas (not the underlying ideas themselves)

Generation
Automatic

Timeline
50-70 years (UK)

Examples

software, music, artwork, literature



Legal right that grants the creator of an original work exclusive right for its use and distribution.

Intellectual Property Protection

Different forms of intellectual property rights

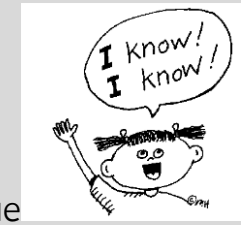
Patents	Copyright	Design rights
Trade marks	Know-How	Trade secrets

Know How & Trade Secrets

The Basics

- Protects a **method, technique, ingredient, idea** etc.
- Value is obtained through limited people knowing
- Not held in a register or similar.
- No protection from reverse engineering

Know How



- Owned by an individual and travels with them.
- Often may be licensed to others to gain revenue

Trade Secrets

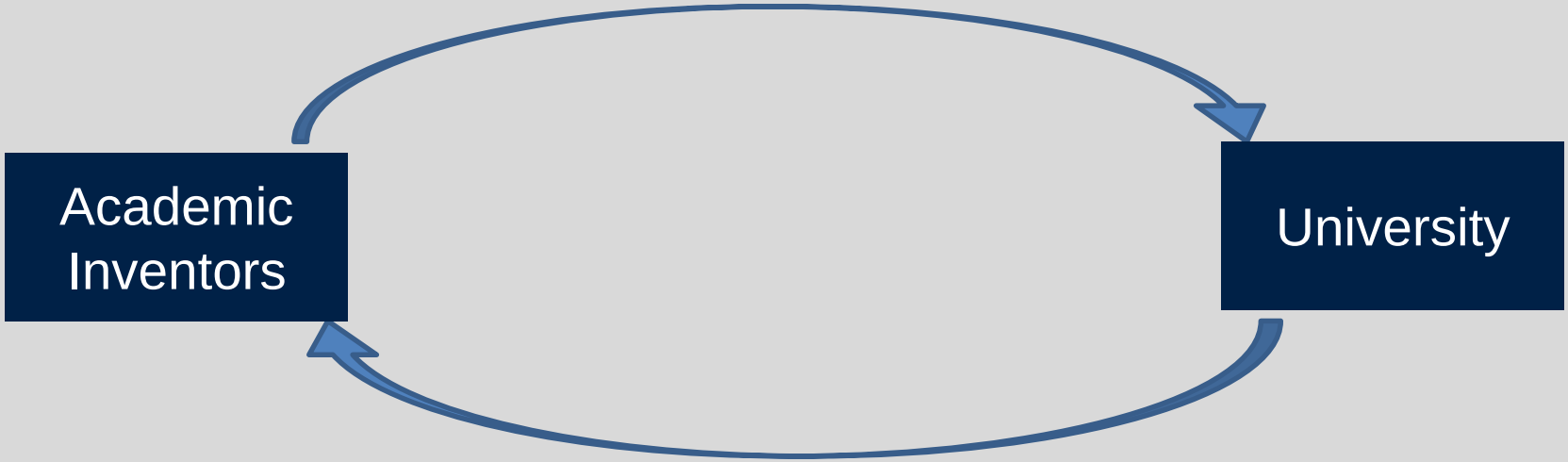
- Held within a company
- Employees/individuals are contractually bound to secrecy
- Bound within the organisation until it is in the public domain

method or technique of how to make your invention work

IP Ownership

Ownership transferred:

- under University rules of Oxford / Imperial / RHUL
- If the IP was created as part of your studentship



In return:

- IPR costs paid (e.g. patenting)
- revenue shared (see later)
- supported through process by your Tech Transfer Office (TTO)

Contents

In Practice

Steps to Protection

IDENTIFY *PROTECT* *TRANSLATE* *MARKET* *LICENSE/ SPINOUT*

Essential Ground-Work

Who?

- You
- Supervisor
- Postdoc
- Funders
- Collaborators
- Sample providers

What?

- Patent
- Know How
- Software

When and where?

What is already publicly known?

- Publications
- Patents
- Open source code

What is the timescale for the publication of the work?

- Already submitted
- Imminent publication
- Impending deadline

Contact your Technology Transfer Office (TTO)

Invention Record

- Idea evaluation
- Starting point for patent drafting
- Info for due diligence by University

IP forms

- Audit of funding background
- Comply with terms of funding
- Agree revenue share

Translation

Basic science to practical applications

Valley of death – time taken to prove an idea in your lab is ready to be taken up a company (your spinout).

What is the killer experiment needed to convince a company/investor?

Translational funding sources

Translational Research Grants | Proof-of-Concept Funds | Seed Funds | Competitions | Angel Investors | Venture Capital

University Ecosystem

- Impact Accelerator Accounts (IAA)
- TTO Innovation Funds

Funding Councils

- UKRI Science and Technology Facilities Council
- UKRI Engineering and Physical Sciences Research Council
- The Royal Society
- Royal Academy of Engineering

Sources for Spinouts

- Angel & VC Investors
- Bank
- Friends & Family

IDENTIFY — *PROTECT* — *TRANSLATE* — *MARKET* — *LICENSE/ SPIN-OUT*

Licensing Agreements

"renting out your IP"

Why license

- To recoup R&D costs
- To collaborate on the R&D
- To bring a product to market
- To incorporate the technology into company product

How to choose licensing partner

- Right Resources?
- Intent to develop technology into a product?
- Can they sell it?
- Appropriate Experience?

Licence Agreement Terms

What to include?

Commercially:

- Exclusivity
- Territory & field of use
- Upfront payment
- Patent costs
- Milestone payments
- Royalties, reporting, audit
- Development plan

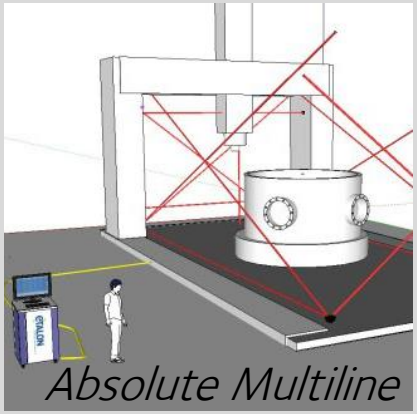
Legally:

- Patent management
- Infringement
- Warranties
- Protect right to publish
- Reputation of University
- Licence back for non-commercial (research) use

Licensing JAI Case Study

Absolute Multiline

- JAI (Armin Reichold) developed and patented advanced Frequency Scanning Interferometry (FSI). Initially for ATLAS detector and ILC.
- Commercialised through collaboration with Etalon, who licence, make and sell the *Absolute Multiline* product for industrial and scientific applications with sales ~£4M.
- Companies use Absolute Multiline for improved machining – knowing where all your machine tools are 0.5 µm per meter uncertainty.
- The data acquisition elements have been further developed in collaboration with VadaTech UK, who now licence and make the DAQ (Data Acquisition) system - with MicroTCA-based (Micro Telecommunications Computing Architecture)
- Also deployed at national standards laboratories (NPL, PTB, le cnam, INRiM), helping organisations around the workd by improved calibration.



Absolute Multiline

JAI Collaboration with Business Case Study

- Cavity Beam Position Monitors (BPMs) developed by JAI RHUL (Stephen Gibson) and commercially licensed to FMB-Oxford, with customers including ELI Beamlines.
- Sensitivity allows high resolution measurements to be realised at low bunch charge and/or short bunches, making Cavity BPMs a highly useful tool in FELs.
- RHUL also collaborated with Ion Beam Applications on gantry design for radiotherapy.
- JAI (Phil Burrows) has collaborated with TMD Technologies, a UK manufacture of RF systems, in the design and operation of future accelerators and upgrade work at current accelerators. Multiple JAI PhD Students (STFC CASE) involved. No licensing.
- Following collaboration, TMD has won a large contract to fabricate RF cavities for Compact Linear Collider (CLIC), opening up additional markets in radiotherapy (VHEE).

FMB OXFORD

Cavity BPM

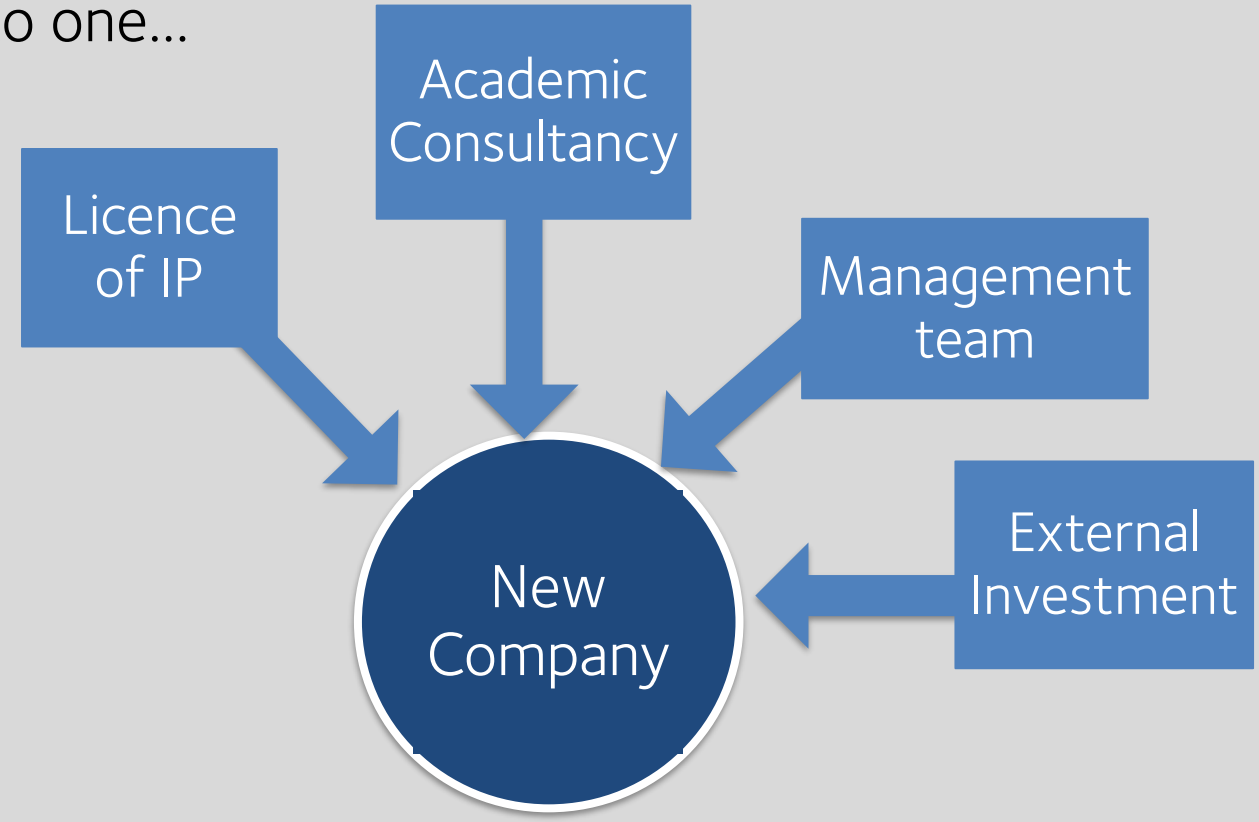
iba

TMD

RF accelerating cavities

Spinout Companies

What goes into one...



IDENTIFY PROTECT TRANSLATE MARKET LICENSE/ SPINOUT

Spinout Companies – Business Plan

Who is going to own it

What funding is needed

How investors will make a return on their money

What will be sold

Who is going to do the selling

How will it sell the product / service

Where is the funding going to come from

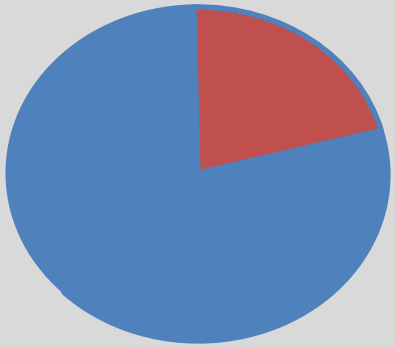
What is the company going to do

And much more

Spinout Companies

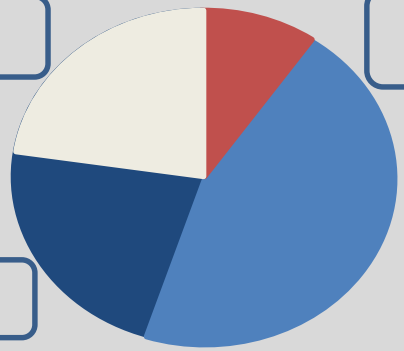
Equity and Equity Split

Basic Split:
(Founders) 80:20 (University)



Equity = the book value of a company

Investors



Founders and University diluted

External CEO

Same number of shares

But shares gain value

University Spinout Policy

Academic Founders of a spinout receive:

- 80% founding shares in spinout, 20% to the university
- Opportunity for Academic Consulting to spinout (30 days+)
- Opportunity to convert equity to cash
- Royalty returns on IP licensed to spinout

Total net revenue	Researcher(s)	University	Department(s)
Up to £50K	85.7%	14.3%	0%
£50K to £500K	45%	30%	25%
Over £500K	22.5%	40%	37.5%

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Machine Discovery

QUANTUM DICE

Living Optics

IDENTIFY PROTECT TRANSLATE MARKET LICENSE/ SPINOUT

Contents

Benefits to Science – Benefits to Society
- Why Government funds science – where does £ come from

Impact of Accelerators
- Innovation
- Applications past & present

Role of Academia to Innovate
- Motivation
- Intellectual Property

Pathways to Commercialisation
- Translation / Licensing / Collaboration / Spinouts

Next steps
- Future / Support / Training

Future Commercialisation of Accelerators?

Diamond, UK

More compact accelerators for all industry applications

- Compact = more portable allowing new applications
  - What new applications could there be?
  - What innovation is needed? – smaller superconducting components, laser wakefield?

- Compact = more affordable allowing new users
  - Smart Technologies to Extend Lives with Linear Accelerators (STELLA)

  - Radiotherapy in low/middle income countries often poor – high cost of radiotherapy linac, and difficulty operating/servicing/maintain equipment

  - CERN, JAI, Cockcroft and others formed STELLA – develop novel medical linac technology, improving efficiency, reliability, serviceability of radiotherapy treatment in LMICs

First Radiotherapy linac in Cameroon

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University Commercialisation Support

Imperial Enterprise Lab

Institute for Deep Tech Entrepreneurship

https://www.imperial.ac.uk/enterprise/students/

OXFORD UNIVERSITY INNOVATION

UNIVERSITY OF OXFORD

OXFORD SCIENCE ENTERPRISES

https://innovation.ox.ac.uk/university-members/for-students/

ROYAL HOLLOWAY UNIVERSITY OF LONDON

The Knowledge Exchange and Enterprise Team

https://royalholloway.ac.uk/about-us/more/collaborate-with-us/innovation-enterprise/

Or me

Entrepreneurship for Physicists Training (Oxford-only for now)

Developed with Business School to give you know-how to transform your inventions into businesses.

Trialled with PhD & Undergraduates

Fully deployment coming soon – watch this space

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Saïd Business School

1st Success! Ricardo Wölker (2020 cohort) from Particle Physics sub-dept has now started the company Cogram – A ML company helping business be more efficient.

Thank you

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Questions?