Industry, RIs and the Economy

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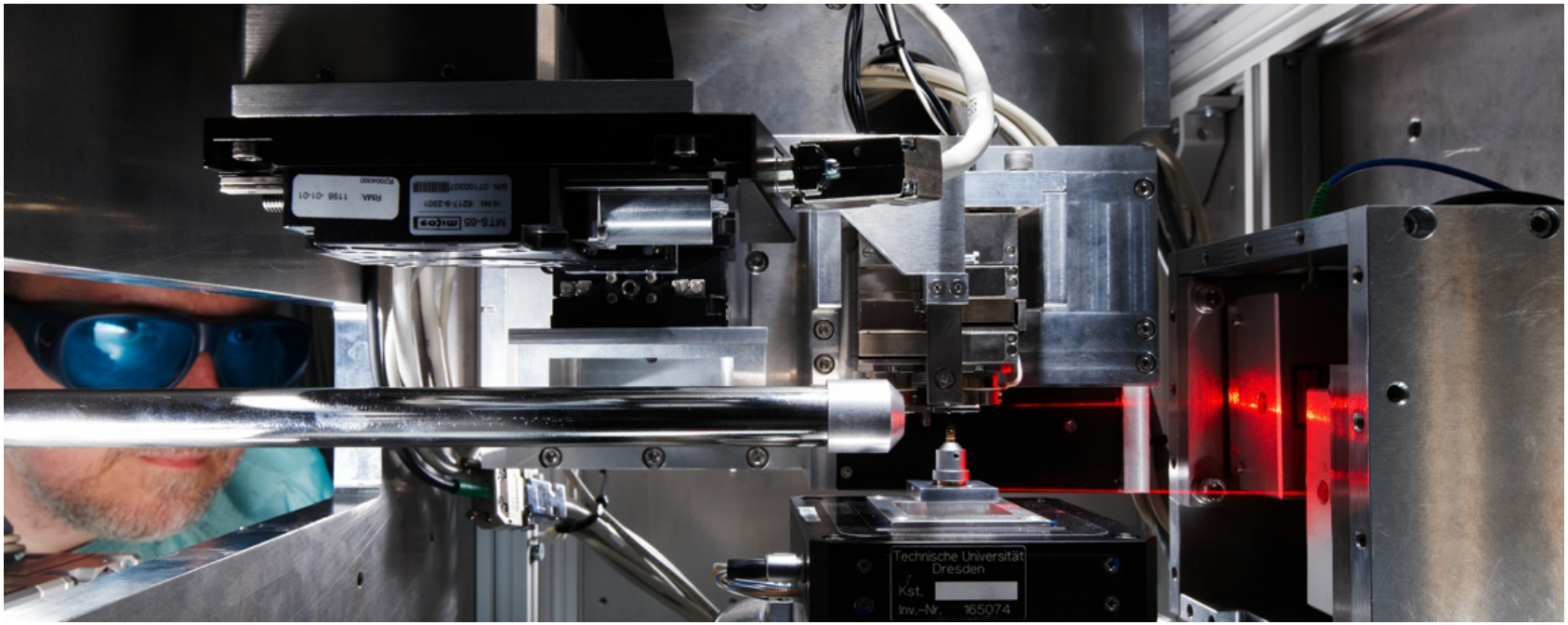
Overview of some previous studies, workshops – a personal view



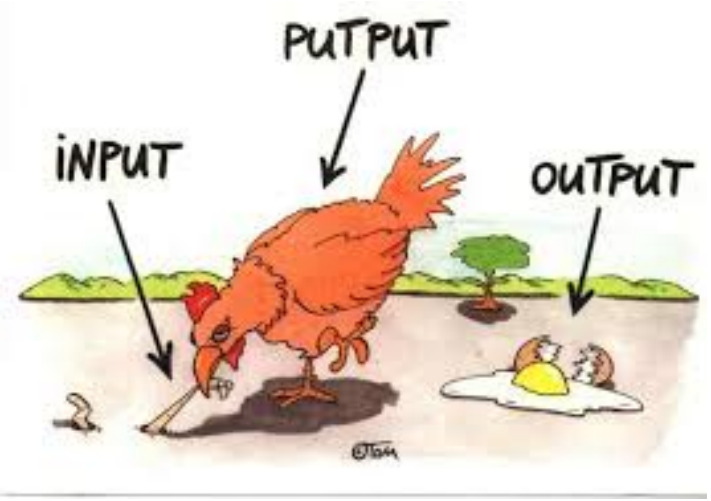
Frank Lehner, DESY
ERF Workshop
Trieste, 06 June 2013

HELMHOLTZ GEMEINSCHAFT

DESY

Outline

- What do we know about the economic impact of RIs?
- How do RIs interact with industry?
  - Demand side effects/Procurement/Market for instrumentation
  - Case: Industrial use at Synchrotron Radiation Sources
- What about socio-economic impacts of RIs?
- Towards a model of RIs as a learning environment for industry



What do we know about economic impacts of RI?

- Economic impact of the public research sector has been documented extensively
  - Increasing the stock of useful knowledge
  - Training skilled graduates
  - Creating new scientific instrumentation and methodologies
  - Forming networks and stimulating social interaction
  - Increasing the capacity for scientific and technological problem-solving
  - Creating new firms/Spin-offs
  - Direct technology stimulus for product development
- e.g. Salter, A. J., & Martin, B. R. (2001). The economic benefits of publicly funded basic research: a critical review. *Research policy*, *30*(3), 509-532. (cited in ~650 other articles)

Economic impacts of RIs

- However, much literature applies to „small science“ – still less is known on large scale RIs (although several I/O studies exist – starting from 70ies)
- RIs are notably a different source of knowledge transfer and industrial spillover than universities (from where most of the spin-offs are generated)
  - The scientific installations at RIs are large and technically complex with demanding engineering tasks, structures & schedule
  - Suppliers are exposed to highly diverse knowledge environment
  - There are matched technological competences

E. Autio et al.,
Research Policy 33 (2004) 107

- RIs offer fertile „learning environment“ & knowledge networks for industry to advance technologies/instrumentation at all stages of the innovation cycle …
- expect large benefits for industrial suppliers to RIs (instrumentation in widest context)
  - Well-known that important path for knowledge diffusion & innovation (D. Solla Price, N. Rosenberg)

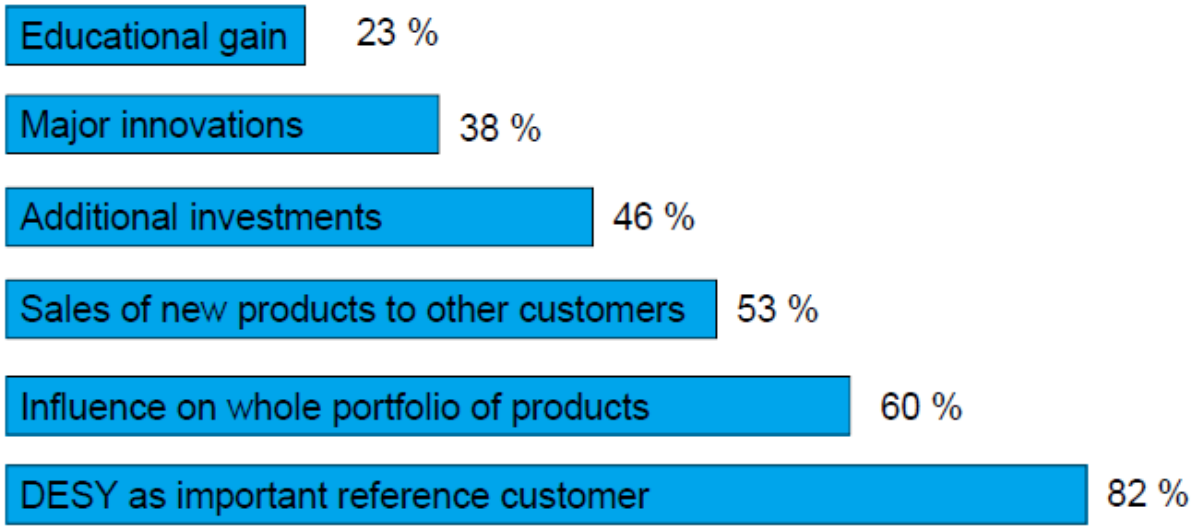
Markets/Demand driven effects/supplier survey

> There are clear benefits for suppliers of RIs / Technological learning through procurement

Main findings

- *38% developed new products as a direct result of the supplier project*
- *13% started new R&D teams because of the CERN project*
- *14% started a new business unit*
- *17% opened a new market*
- *42% increased their international exposure*
- *44% indicated technological learning*
- *36% indicated market learning*

CERN LHC study
CERN-2005-03



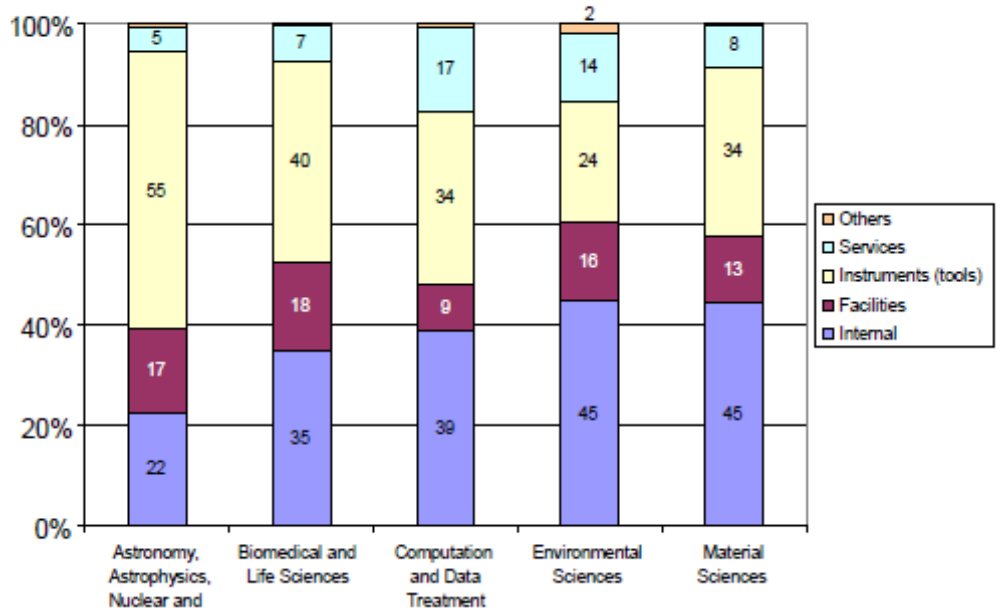
DESY Study
TTF/FLASH 1992-2004

Study of XFEL underway

What do we know about the Markets and demand driven effects?

- There is a large „research“ market for instrumentation for RIs
- ERID-Watch Market Survey (FP6, 2006-2008)):
  - Total annual budget European RIs €8-9bn (90% from national sources)
  - Total annual procurement for instrumentation: **~€4bn**

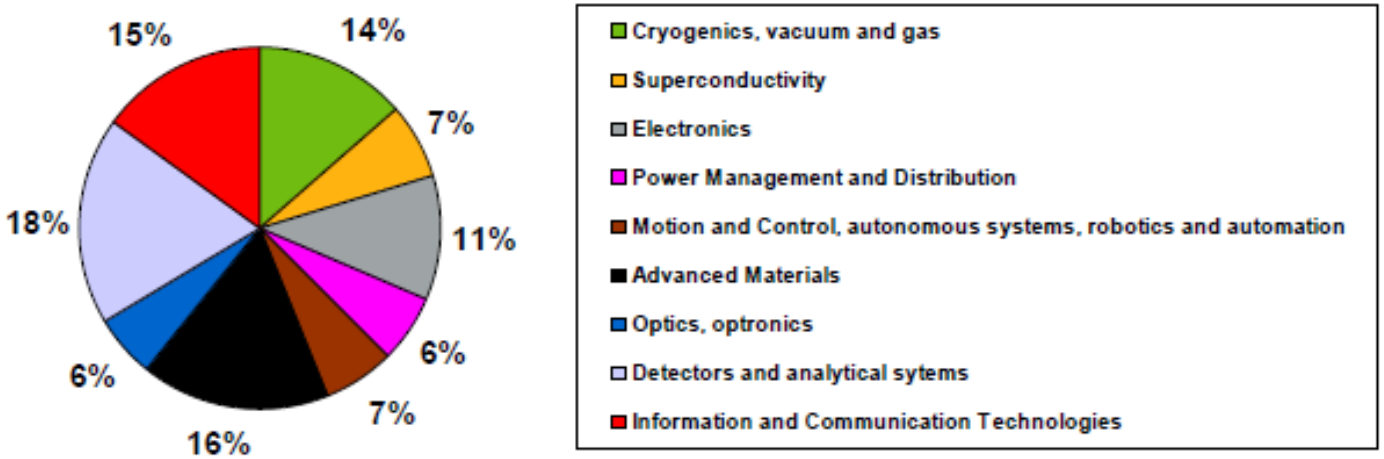
The expenditure patterns across different scientific domains:



Markets/Demand driven effects/ERID-Watch Study

- RIs constitute a premium segment of the “research market” as the requirement of the sector is demanding and challenging, often basis for innovative solutions. **Almost two out of three companies (62%) report that they have been able to move into additional markets**

According to the classification below, the sample interviewed breaks down as follows*:

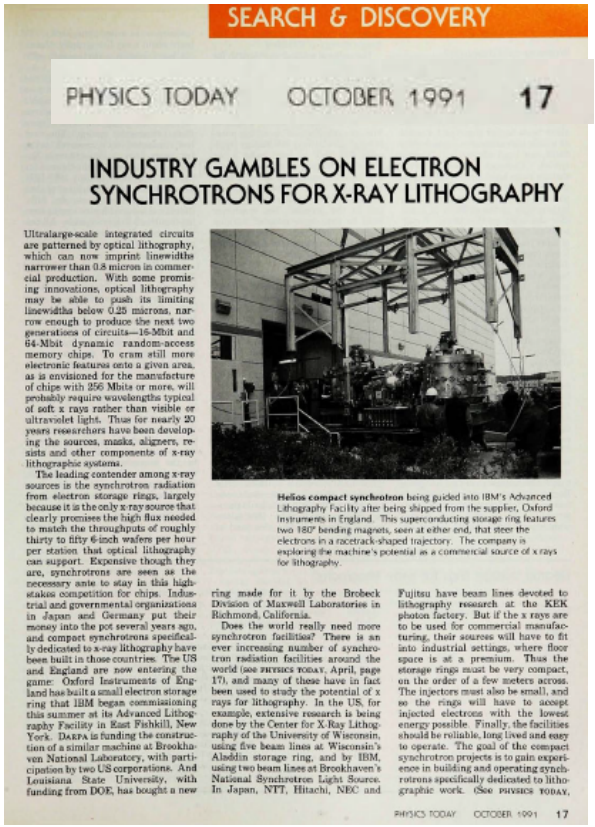


EIRISS study confirms this …

- European Industrial and RI Interaction and Support Study – FP7 2011/2012 – Activities:
  - Review ERID-Watch results, industrial interaction policies and case studies of current RI instrumentation development
  - Pan-European study of instrumentation market
  - Study financial mechanisms in support of instrumentation firms – key to innovation and commercialization
- Results from ERID-Watch ~stable, procurement landscape ~similar
- Three main findings from case studies/surveys:
- Visibility of the opportunities for interactions between industry and RI has to be improved
  - Mapping out future technology needs at RIs
  - Actively managed opportunity portal for calls, tenders, etc.
- Develop targeted funding support mechanisms for collaborative R&D
- Best practice in procurement and knowledge transfer

What do we know about the industrial use at light sources?

- importance of SR for basic & applied research has greatly improved over last decades
- many industrial applications at SR sources
  - for production, quality control and R&D
  - life science/pharmaceuticals, energy/chemicals/catalysis are main applications
- Industrial usage early recognized with high hopes, but real developments are still disappointing, e.g. X-ray lithography
- most SR sources have industrial usage ~few %
- annual turnover <3% of budget



SEARCH & DISCOVERY

PHYSICS TODAY OCTOBER 1991 17

INDUSTRY GAMBLES ON ELECTRON SYNCHROTRONS FOR X-RAY LITHOGRAPHY

Ultralarge-scale integrated circuits are patterned by optical lithography, which can now imprint linewidths narrower than 0.8 micron in commercial production. With some promising innovations, optical lithography may be able to push its limiting linewidths below 0.25 microns, narrow enough to produce the next two generations of circuits—16-Mbit and 64-Mbit dynamic random-access memory chips. To cram still more electronic features onto a given area, as is envisioned for the manufacture of chips with 256 Mbits or more, will probably require wavelengths typical of soft x rays rather than visible or ultraviolet light. Thus for nearly 20 years researchers have been developing the sources, masks, aligners, resists and other components of x-ray lithographic systems.

The leading contender among x-ray sources is the synchrotron radiation from electron storage rings, largely because it is the only x-ray source that clearly promises the high flux needed to match the throughputs of roughly thirty to fifty 6-inch wafers per hour per station that optical lithography can support. Expensive though they are, synchrotrons are seen as the necessary ante to stay in this high-stakes competition for chips. Industrial and governmental organizations in Japan and Germany put their money into the pot several years ago, and compact synchrotrons specifically dedicated to x-ray lithography have been built in those countries. The US and England are now entering the game: Oxford Instruments of England has built a small electron storage ring that IBM began commissioning this summer at its Advanced Lithography Facility in East Fishkill, New York. DARPA is funding the construction of a similar machine at Brookhaven National Laboratory, with participation by two US corporations. And Louisiana State University, with funding from DOE, has bought a new

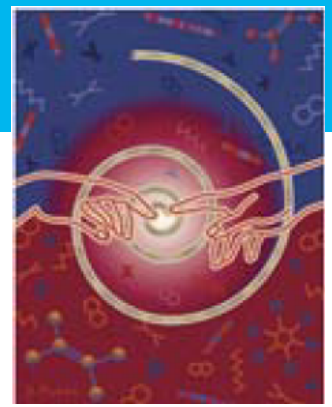
Helios compact synchrotron being guided into IBM's Advanced Lithography Facility after being shipped from the supplier, Oxford Instruments in England. This superconducting storage ring features two 180° bending magnets, seen at either end, that steer the electrons in a racetrack-shaped trajectory. The company is exploring the machine's potential as a commercial source of x rays for lithography.

ring made for it by the Brobeck Division of Maxwell Laboratories in Richmond, California.

Does the world really need more synchrotron facilities? There is an ever increasing number of synchrotron radiation facilities around the world (see PHYSICS TODAY, April, page 17), and many of these have in fact been used to study the potential of x rays for lithography. In the US, for example, extensive research is being done by the Center for X-Ray Lithography of the University of Wisconsin, using five beam lines at Wisconsin's Aladdin storage ring, and by IBM, using two beam lines at Brookhaven's National Synchrotron Light Source. In Japan, NTT, Hitachi, NEC and Fujitsu have beam lines devoted to lithography research at the KEK photon factory. But if the x rays are to be used for commercial manufacturing, their sources will have to fit into industrial settings, where floor space is at a premium. Thus the storage rings must be very compact, on the order of a few meters across. The injectors must also be small, and so the rings will have to accept injected electrons with the lowest energy possible. Finally, the facilities should be reliable, long lived and easy to operate. The goal of the compact synchrotron projects is to gain experience in building and operating synchrotrons specifically dedicated to lithographic work. (See PHYSICS TODAY,

PHYSICS TODAY OCTOBER 1991 17

ERID-Watch Study (2006-2008)



- European Research Infrastructure Development Watch
  - Part of FP6
  - Case study on industrial usage of synchrotron radiation sources
- 11 interviewed Synchrotrons (10 in Europe, 1 in the US)
  - All of them are opened for industrial usage
  - Distinction between published and proprietary research, dedicated pricing systems for proprietary research
  - Number of commercial users from 4 to 50 p.a., most of them visit more than once a year
  - Average number of industrial users is 27
  - Usage spans from 0.2% to 12%

http://cordis.europa.eu/documents/documentlibrary/125670151EN6.pdf

- Other finding:
  - All Synchrotrons want to increase usage and expect this in the next years
  - Most customers from Life Sciences (Pharmacy) and Chemistry & Energy
  - Most common method: XRD
  - All European Synchrotrons offer rapid access

Barriers and limitations for industrial use at SR

- **limited awareness** within industry of the capabilities & analytical tools at SR (“gap”)
- large expenses, large distances: travel, hotel, equipment & beamtime
- often a **lack of confidence** from industry to invest time & resources in synchrotrons. On the SR side, risk aversion is observed against investing time and staff in building relations with industry
- bottlenecks in SR operation, which are set up for academic scientific excellence rather than the needs (such as rapid access, confidentiality, full service, standardization, quality control of beamline) of industrial R&D. **Industry is process & product oriented, RI interested in methods and fundamental understanding**
- When opportunities do arise to develop both turn-key solutions and longer-term flexible R&D partnerships with industry, they can be difficult to implement as, until now, working with industry was **not seen as a core mission of synchrotron sources**, which often hesitate to divert resources towards R&D services to industry

E. Mitchell (ESRF) at el., SRN 24, 2011
Al. Molenbroek (Haldor Topsoe), Talk at ERF Workshop, Lund 2010
K. Kroschewski et al., Materials Science Forums Vols 638(2010)2493
J. Hormes, NIM A467(2001)1179

What about socio-economic impacts of RIs?

(ERF workshop, May 2012 at DESY)

- Impacts studies can serve various purposes depending on stakeholders,
  - Governments & funding agencies are requesting more and more proof of evidences of returns for (large) science investments
  - Narratives on «success stories» nice, but less and less easy going….in times of financial restrictions…. need to evolve to quantifying/documenting impacts and evidences wherever possible
- Methods: need to develop standardized methodologial tools & guidelines to be adapted to each particular objective. Need conceptualization of all types/dimensions of impacts
- Open-access@RIs: good long-term investment for science, economy & society, but need a strategy to demonstrate overall impacts
- Social & Human Capital and their build-up at RI are most important cornerstones in knowledge transfer

http://erf.desy.de/workshop

What about socio-economic impacts of RIs?

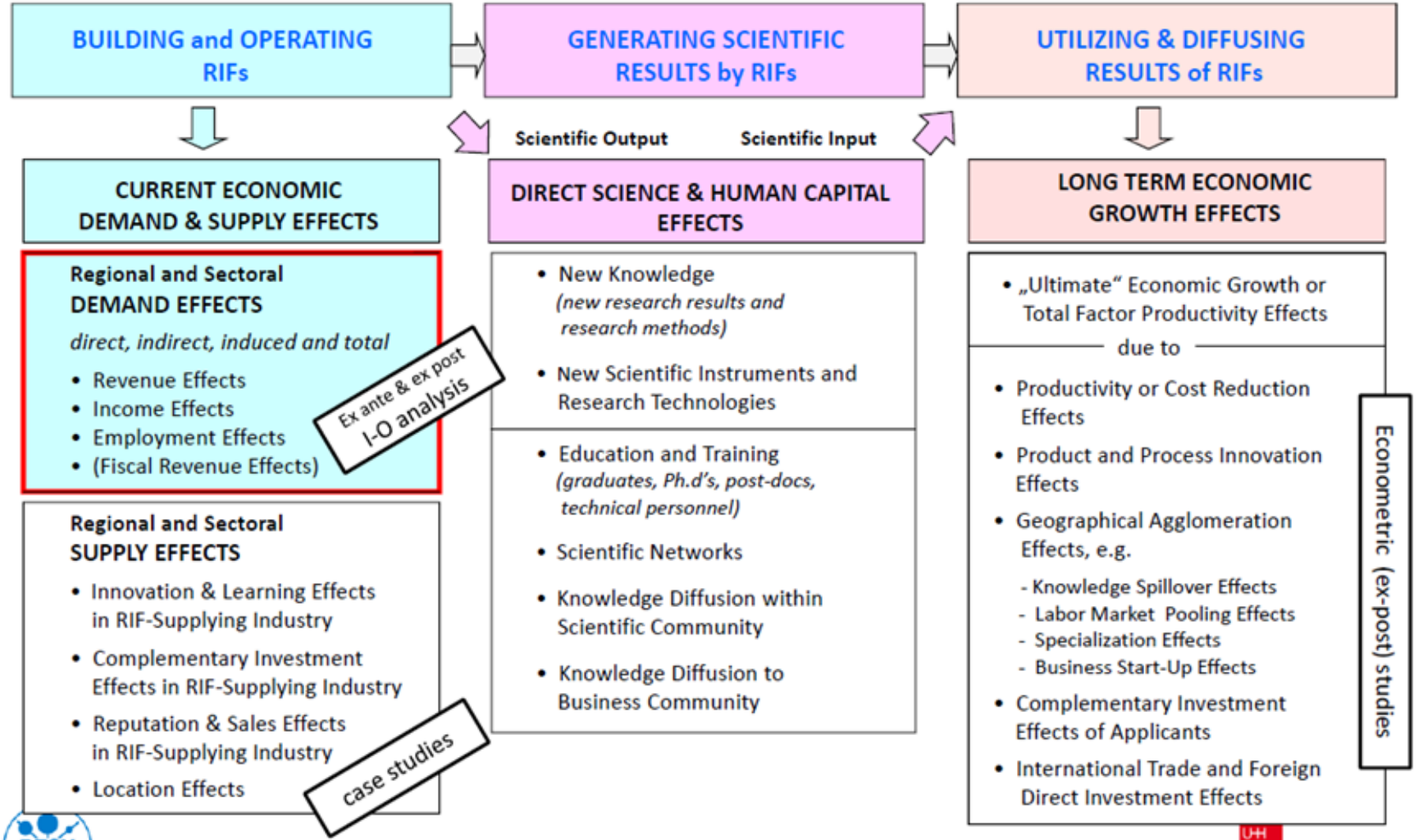
(ERF workshop, May 2012 at DESY)

- Innovation: RIs are a tool and driver for innovation and offer fertile „learning environment“ for industry (supplier and customers) at all stages of the innovation chain
- A better understanding and clear demonstration of the (long-term) learning mechanisms & effects and on the RI-industry interactions in general are needed
  - Should not treat RIs solely as a „black box“ with input/output relations
  - Important to demonstrate best practice cases how

    RIs act as important first customers for emerging technologies
    RIs can be leveraged in all phases of the innovation cycles
    RIs can be leveraged for advancing development projects in industry
    Industry projects with RIs might not be financially lucrative, but technological learning benefits outweigh the financial ones
    Long-term benefits through knowledge diffusion
  - To improve, foster and maximillay utilize relationships RI/industry

Backup

Socio-Economic Effects of RIs (W. Pfähler)



The many dimensions of impacts and stakeholders

Carlo Rizzuto, ERF May 2012

A vast amount of literature and studies