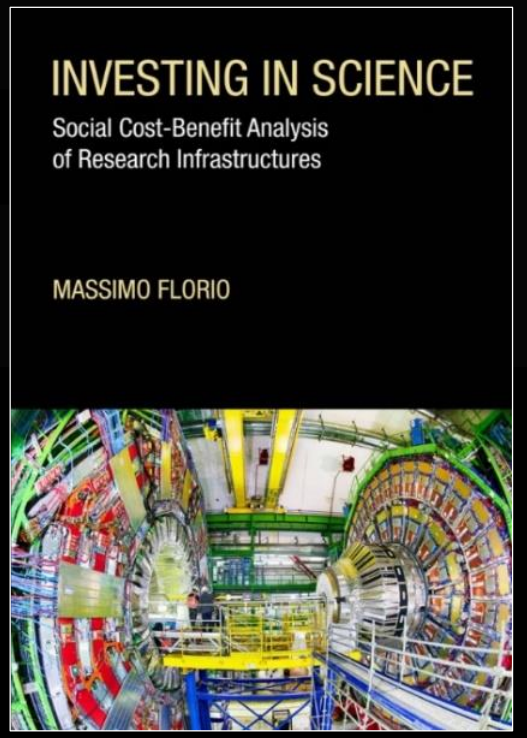
# Book launch

# INVESTING IN SCIENCE

**Tuesday 3 December 2019**
**CERN – Globe of Science and Innovation**




**Massimo Florio**
University of Milan

# THE USEFULNESS OF USELESS KNOWLEDGE

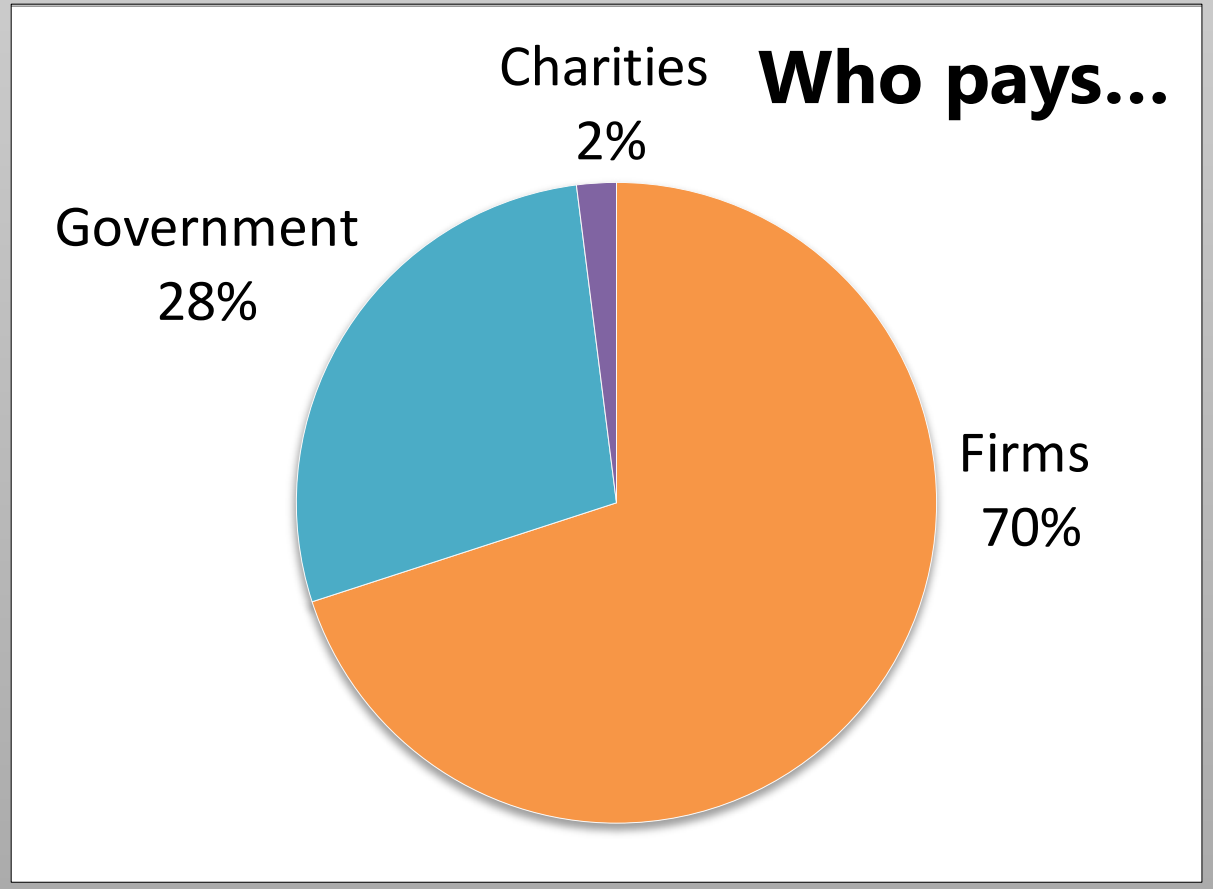
"From a practical point of view, intellectual and spiritual life is, on the surface, a useless form of activity… I shall concern myself with the **question of the extent** to which the pursuit of these useless satisfactions proves unexpectedly the source from which undreamed of **utility is derived**"

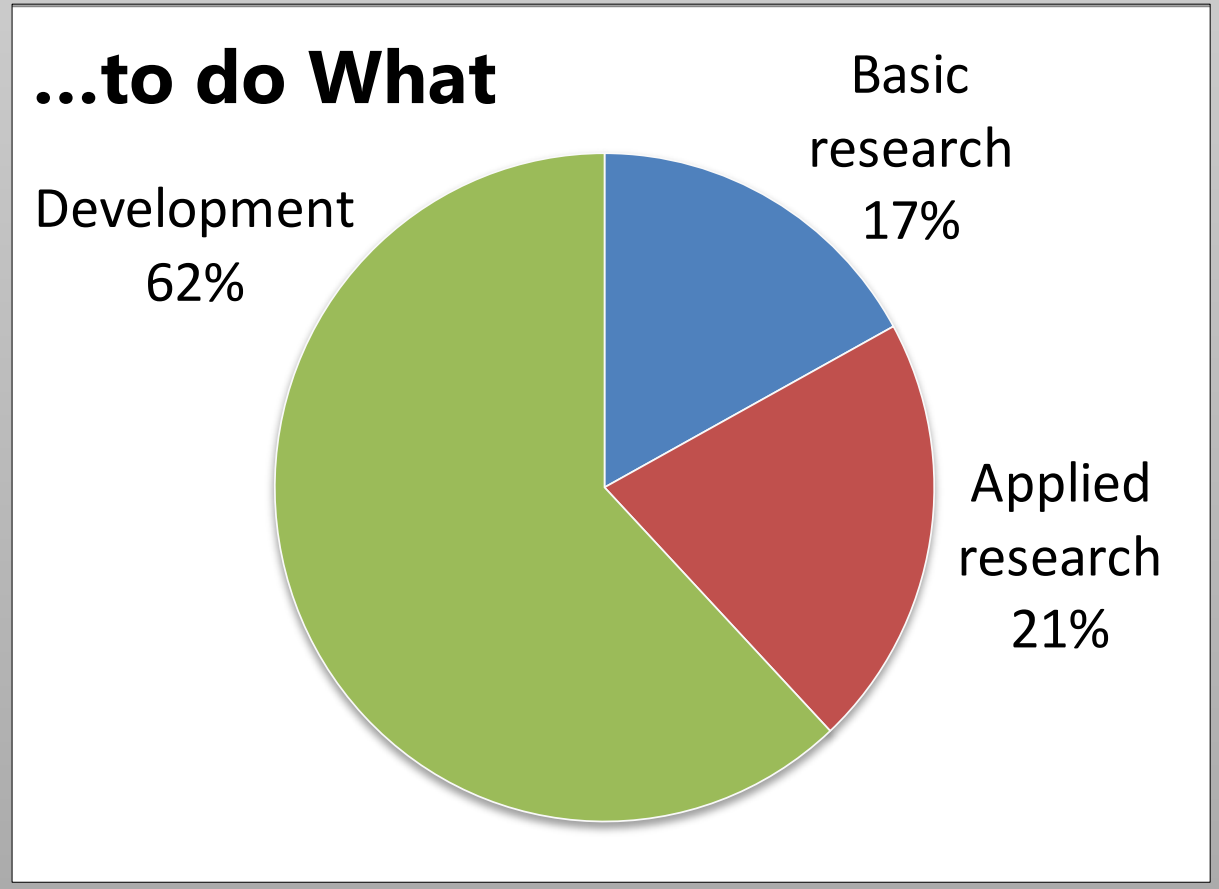
**Abraham Flexner**
Founding Director,
Institute for Advanced Study, Princeton
*The Usefulness of Useless Knowledge*
1939

Courtesy of @InstituteforAdvancedStudy

# THE COSTS & BENEFITS OF SCIENCE

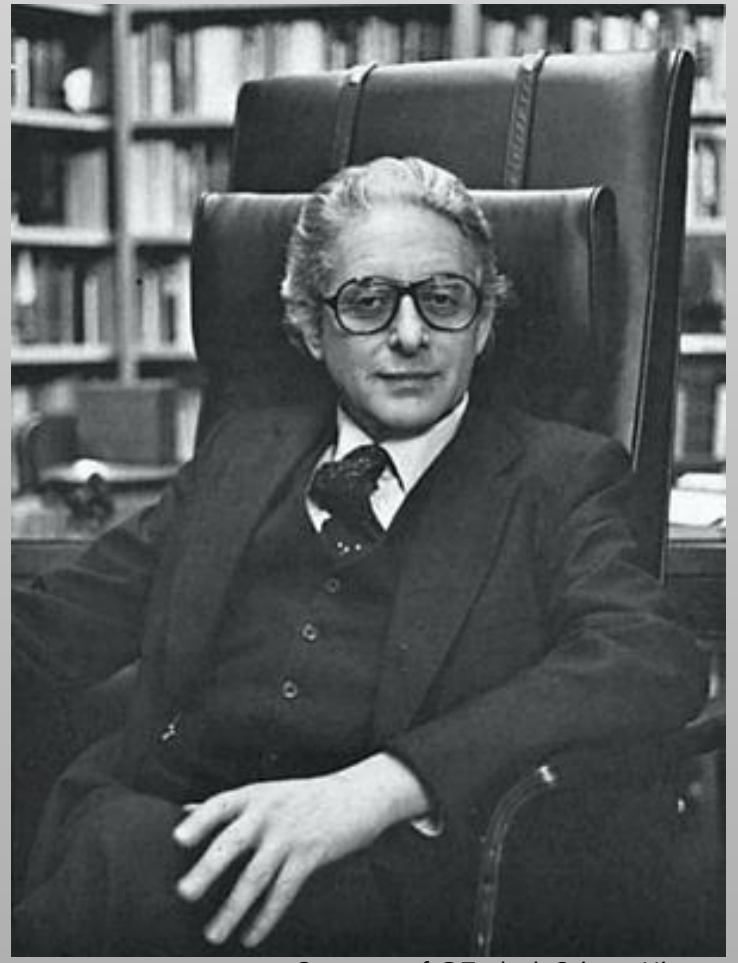
Costs: $315 billion per year → $250 per capita taxes (OECD)
Benefits: Wide → To be measured




- **Sources**: OECD data 2015-2017

# LITTLE SCIENCE, BIG SCIENCE... AND BEYOND

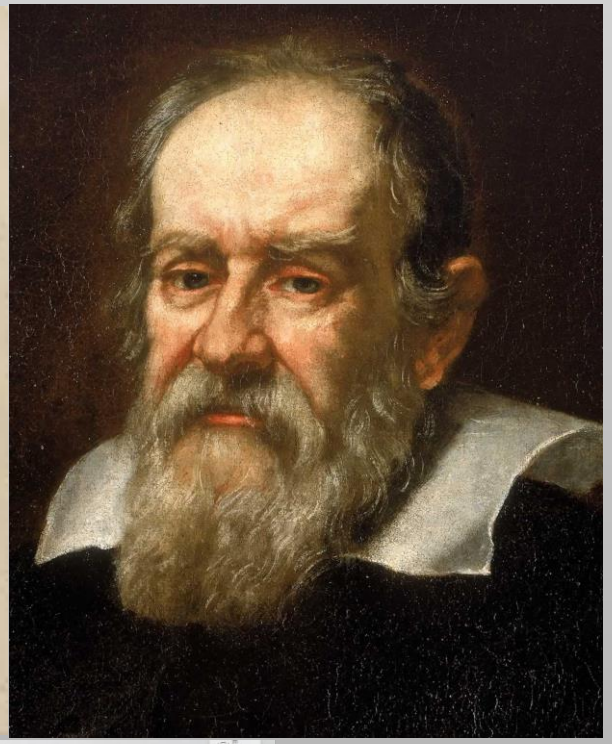
Courtesy of @TodayinScienceHistory

The 1962 Brookhaven National Laboratory Lectures by **Derek De Solla Price**, physicist and historian of science

# LITTLE SCIENCE: SMALL COSTS AND HUGE BENEFITS

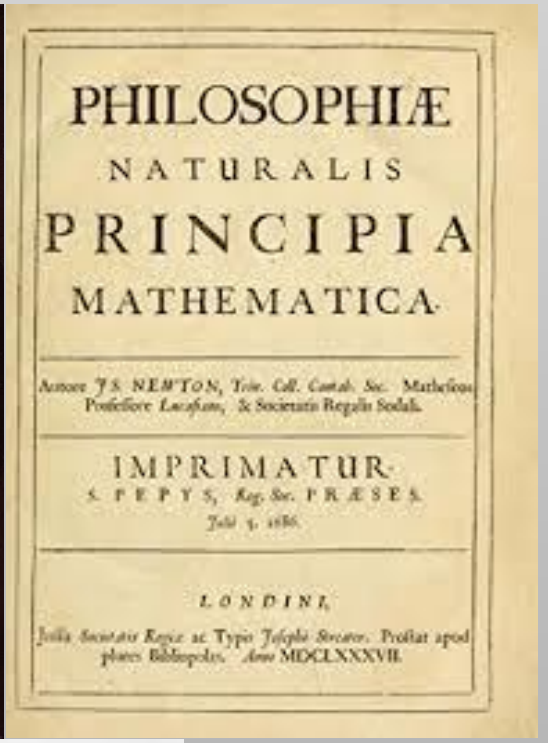
## Galileo Galilei


SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
GALILEO GALILEO
PATRITIO FLORENTINO
PERSPICILLI
QVATVOR PLANETIS
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.
VENETIIS,
M VIIII



1564-1642

## Isaac Newton


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA
Autore IS. NEWTON,
IMPRIMATUR
S. PEPYS,
LONDINI,

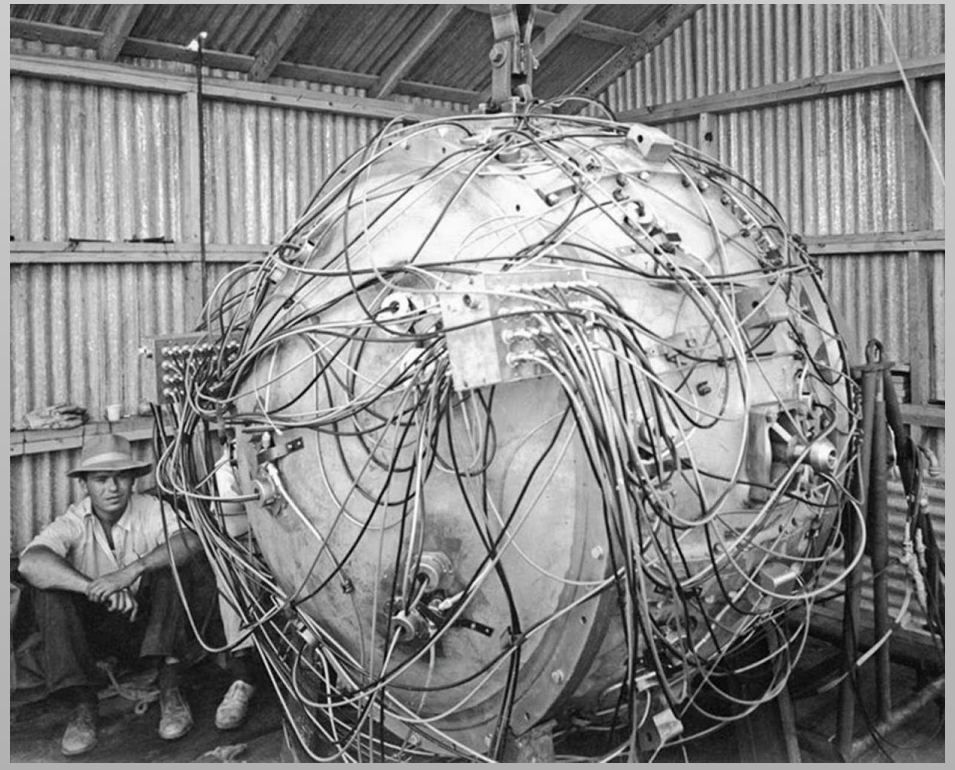
1642-1726


**No CBA needed**

# BIG SCIENCE FOR THE MILITARY: HUGE COSTS, UNCERTAIN BENEFITS

## The Manhattan Project

- Top-down
- Military-industrial complex
- National ownership
- Rigid mission and governance
- Political loyalty and secrecy



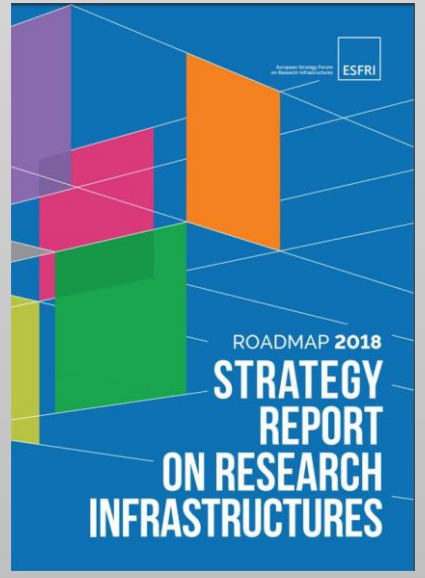
Courtesy of @RareHistoricalPhotos

Gadget, the world's first atomic bomb


Courtesy of @DennisD.McDonald'sWebSite

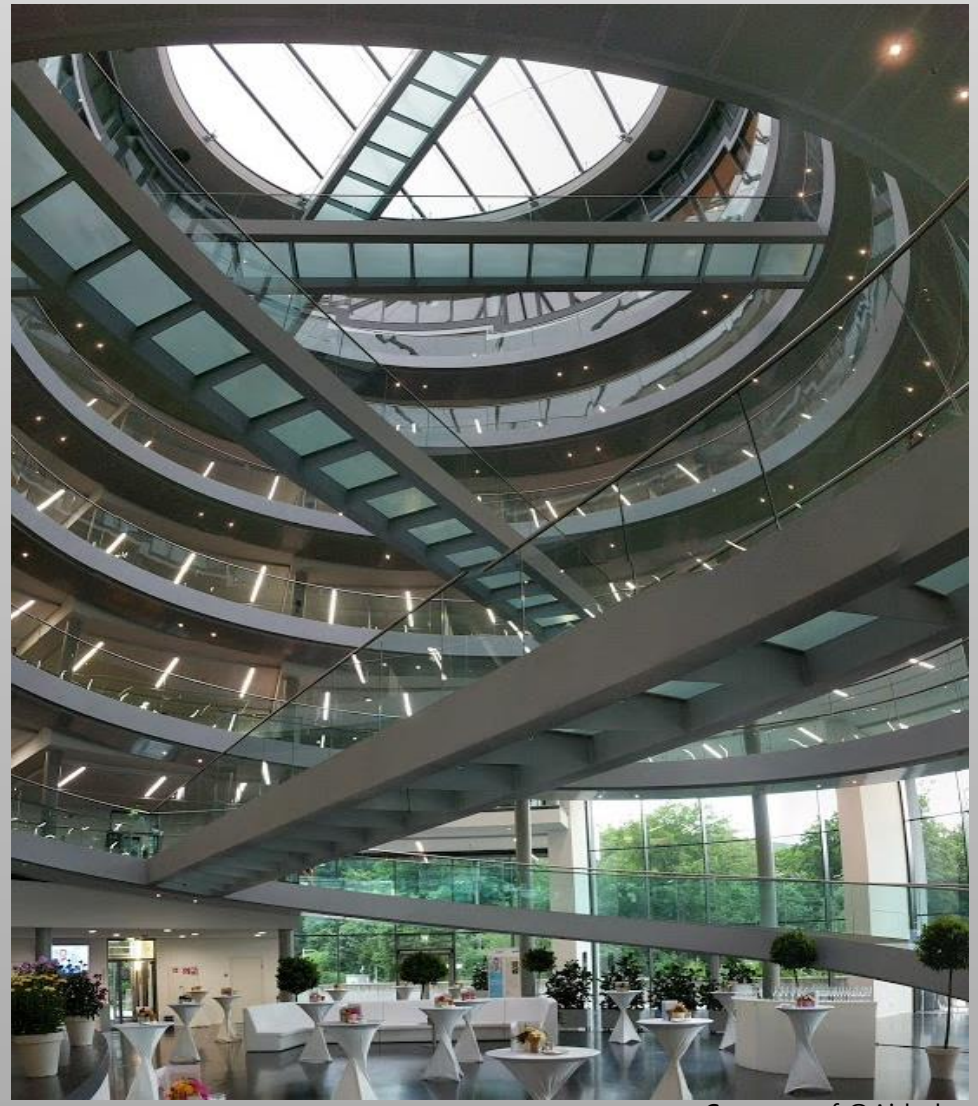
**CBA impossible**

# A NEW PARADIGM: RESEARCH INFRASTRUCTURES




**ESFRI**
Roadmap

- Bottom-up
- Scientific communities
- Open science
- International coalitions
- Multiple users and shared governance
- Cosmopolitan ecosystem



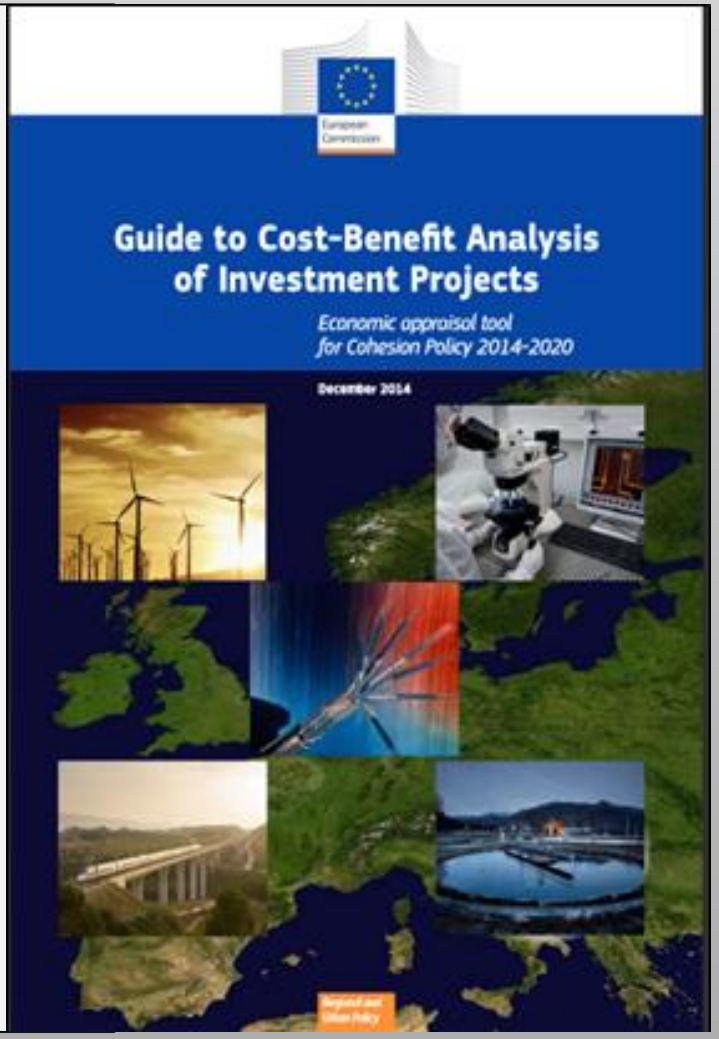
Courtesy of @Airbnb

The European Molecular Biology Laboratory (EMBL) *Heidelberg*

**CBA feasible and helpful**

# THE COST BENEFIT ANALYSIS MODEL

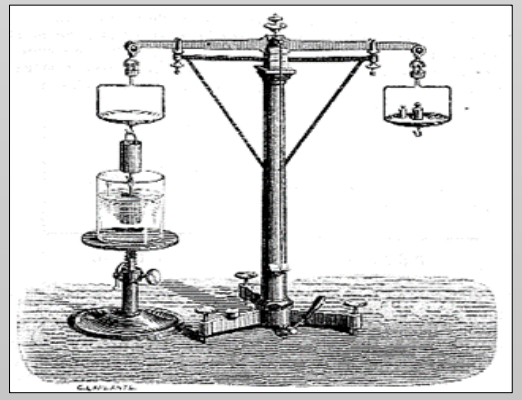
- The expected net present value of the RI
- over the time horizon
- is defined as the difference between expected benefits
- including the citizens' willingness to pay for knowledge
- and social costs
- valued at shadow prices
- discounted at the social discount rate



# MEASURING THE MEASURABLE

For example:

$$\sum_{j=1}^{J} \sum_{t=0}^{\mathcal{T}} s_t \cdot \Pi_{jt}$$



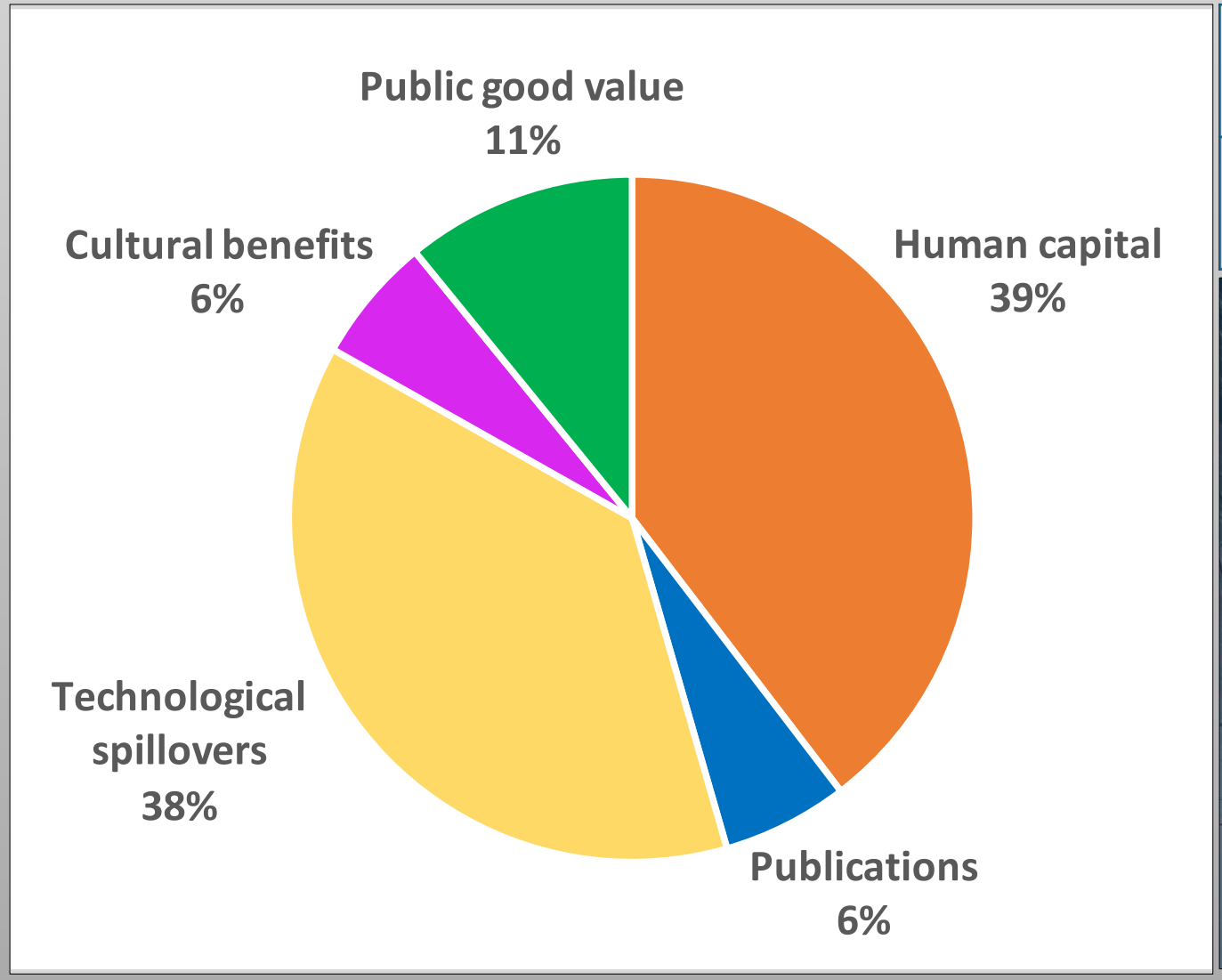
## BENEFITS

- Technological spillovers
- Scientific publications
- Human capital
- Benefits of innovation
- Cultural benefits
- Public good value

## COSTS

- Economic value of capital
- Labor cost of scientists
- Other staff costs
- Other operating costs
- Environmental impact

# THE NET BENEFITS OF HIGH LUMINOSITY LHC TO 2038



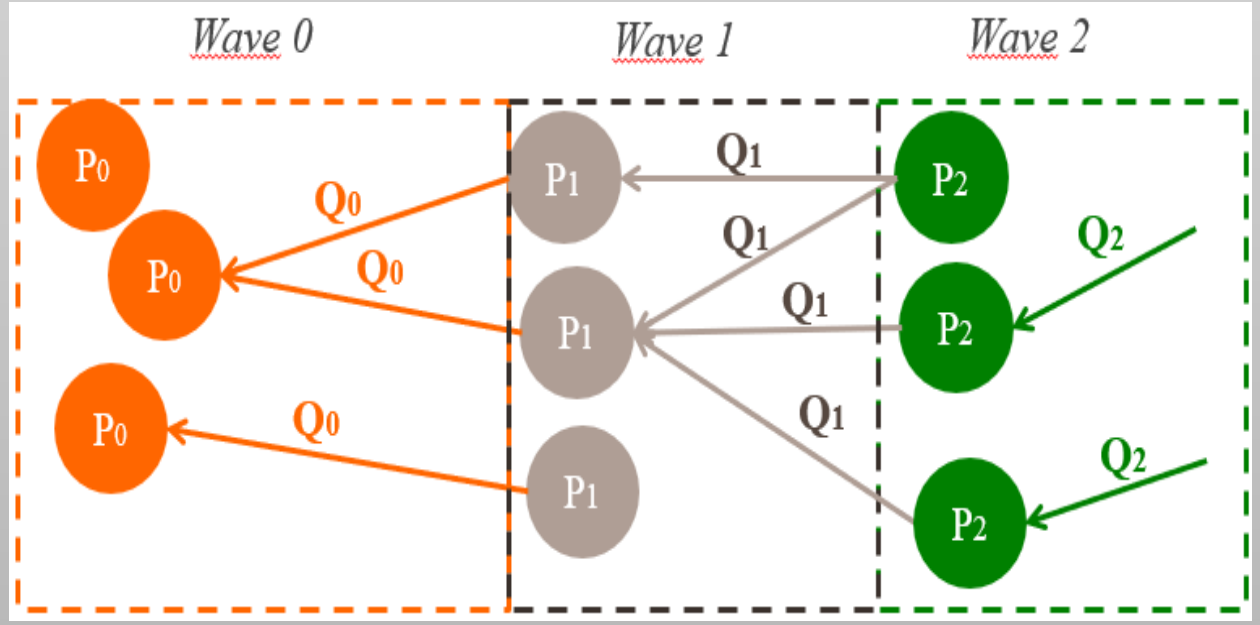

| | |
|---|---|
| Net Present Value | 2.2 |
| Benefit cost ratio | 1.8 |

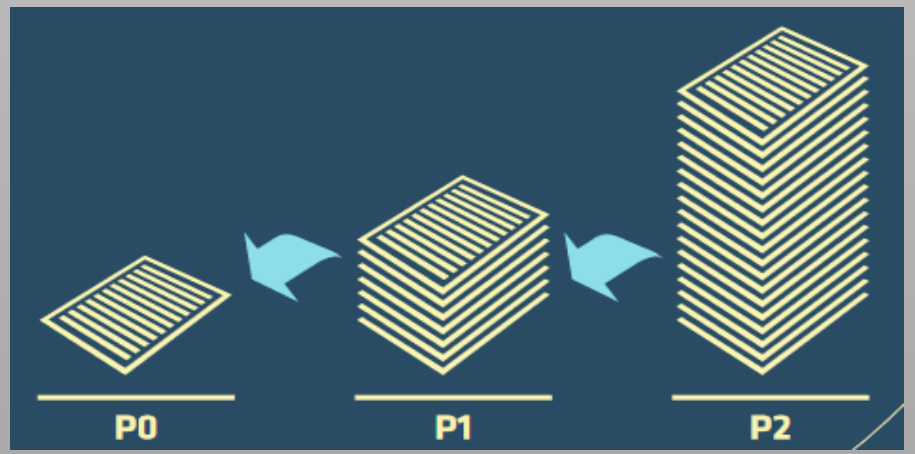
Courtesy of @CERN

Counterfactual: LHC without HL

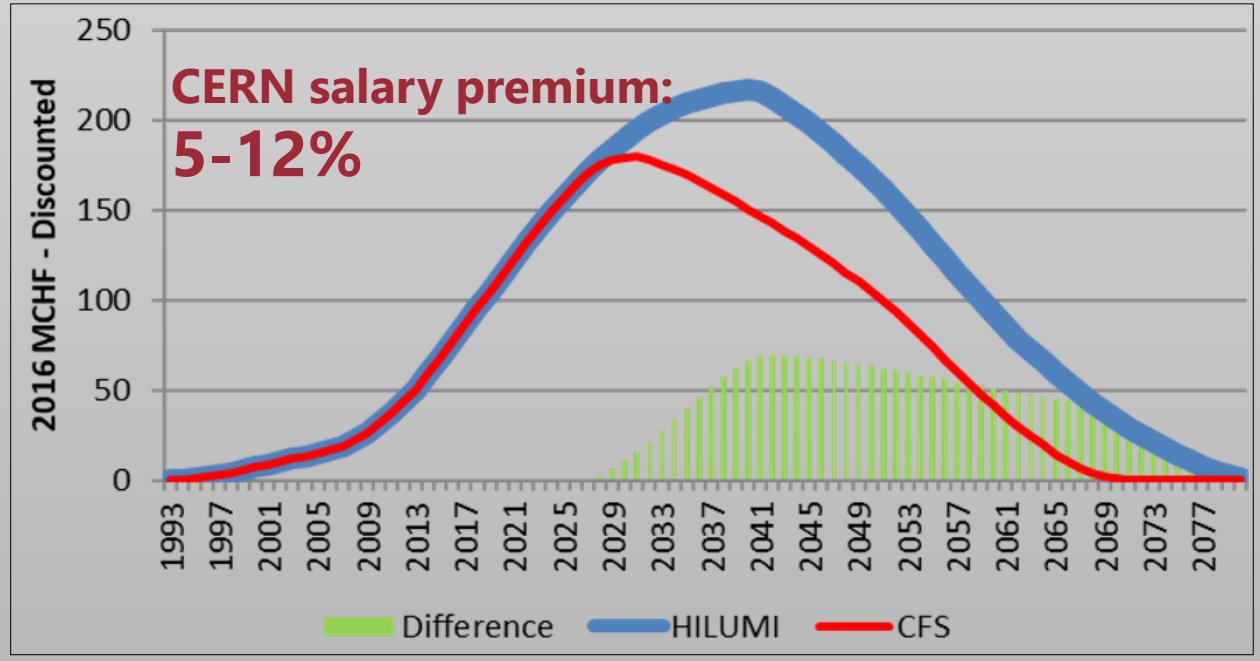
# PUBLICATION FACTORIES AND HUMAN CAPITAL

**Value = scientists' time**



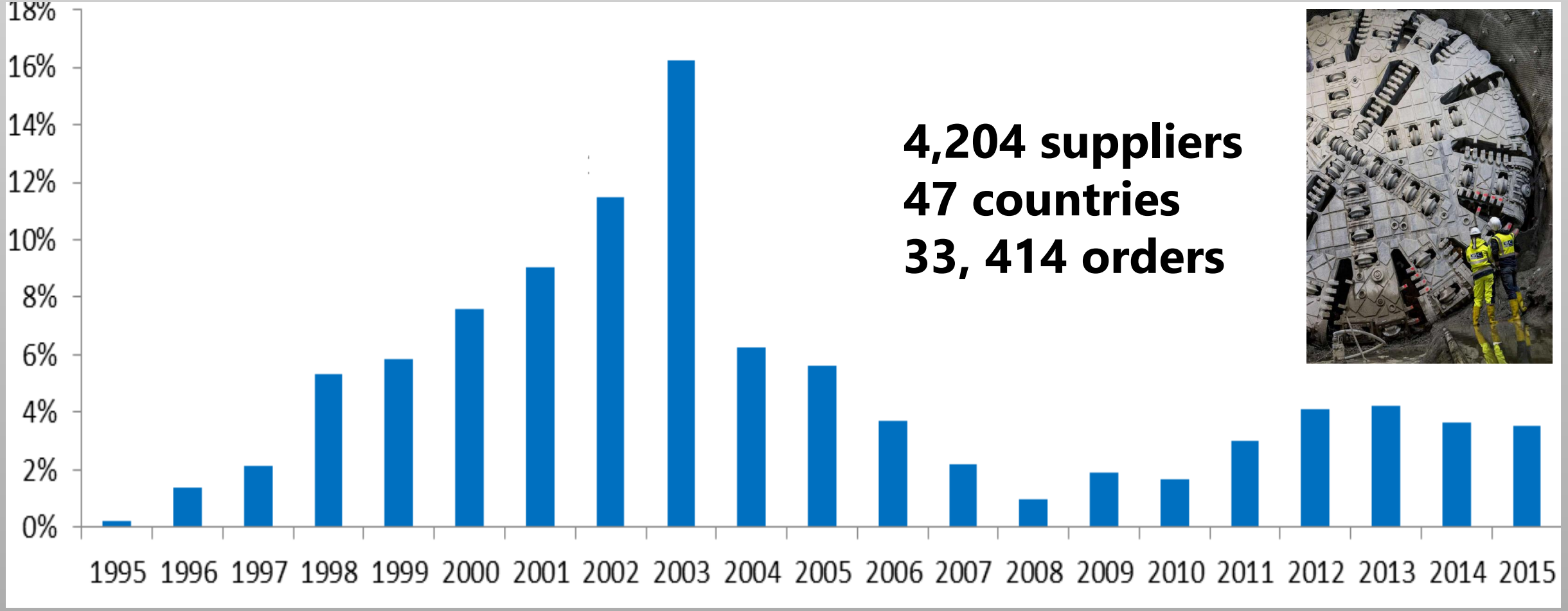

**Value = skills acquired by ESR**




Courtesy of @CERNCourier

# LEARNING HUBS FOR FIRMS

## The procurement activity of CERN 1995-2015




- Volume of the orders by year %; Orders > 10,000 CHF

# TECHNOLOGICAL SPILLOVERS

**Value = change of firms' economic performance**

**Procurement event**

↓

**R&D**

↓

**Innovations**

↓

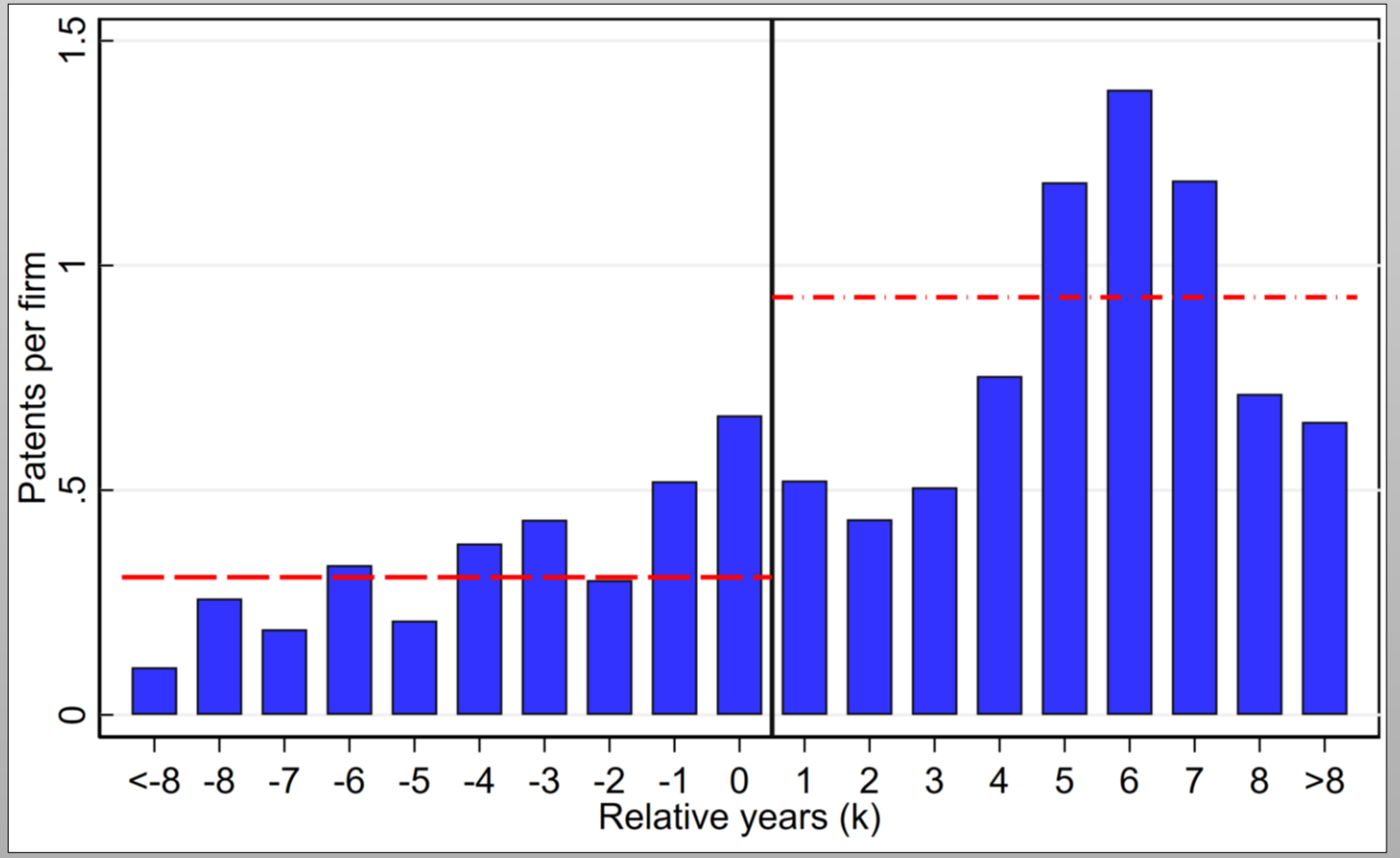
**Productivity**

↓

**Sales**

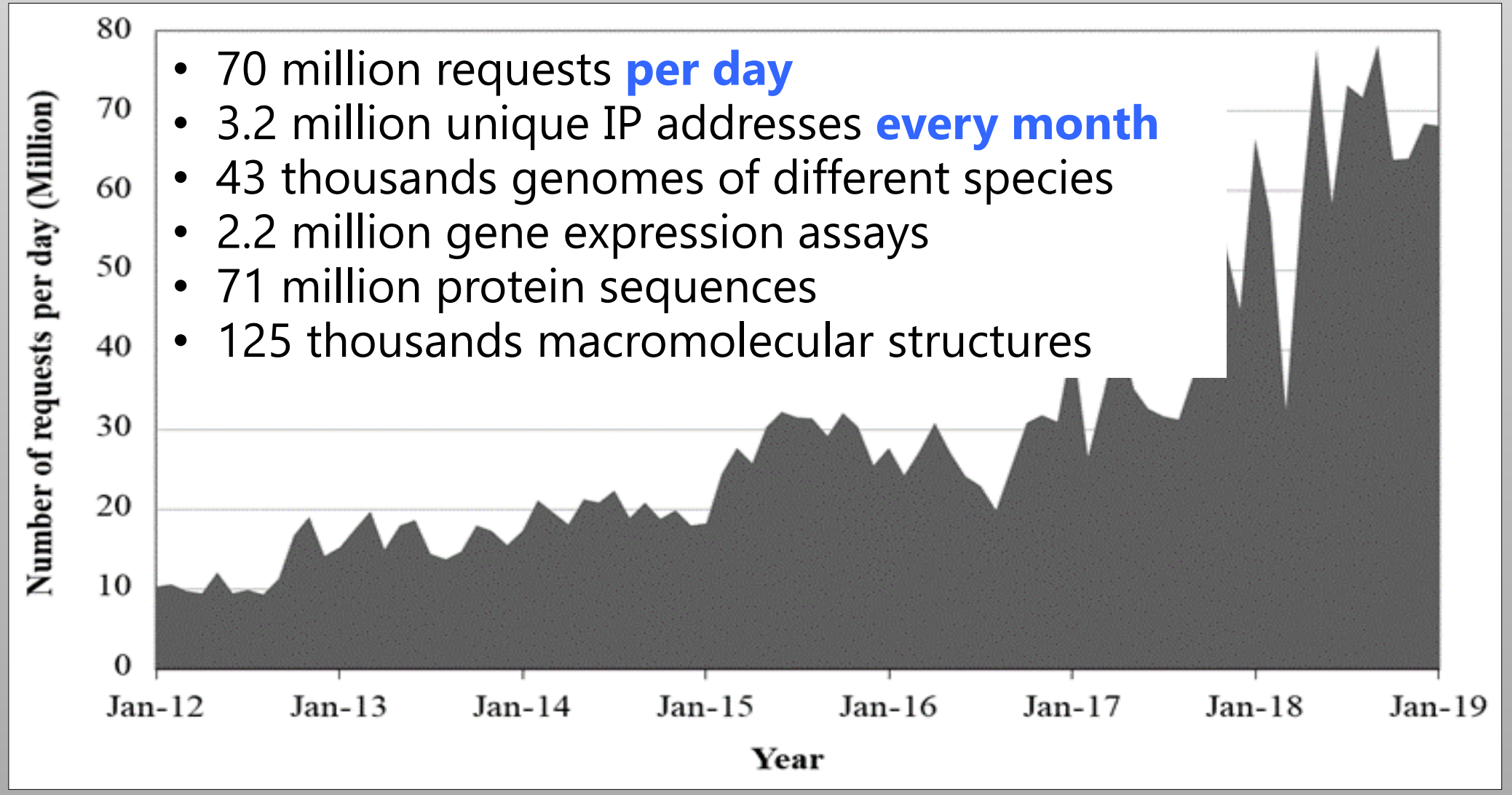
↓

**Profitability**



# TECHNOLOGICAL SPILLOVERS FROM BIG DATA

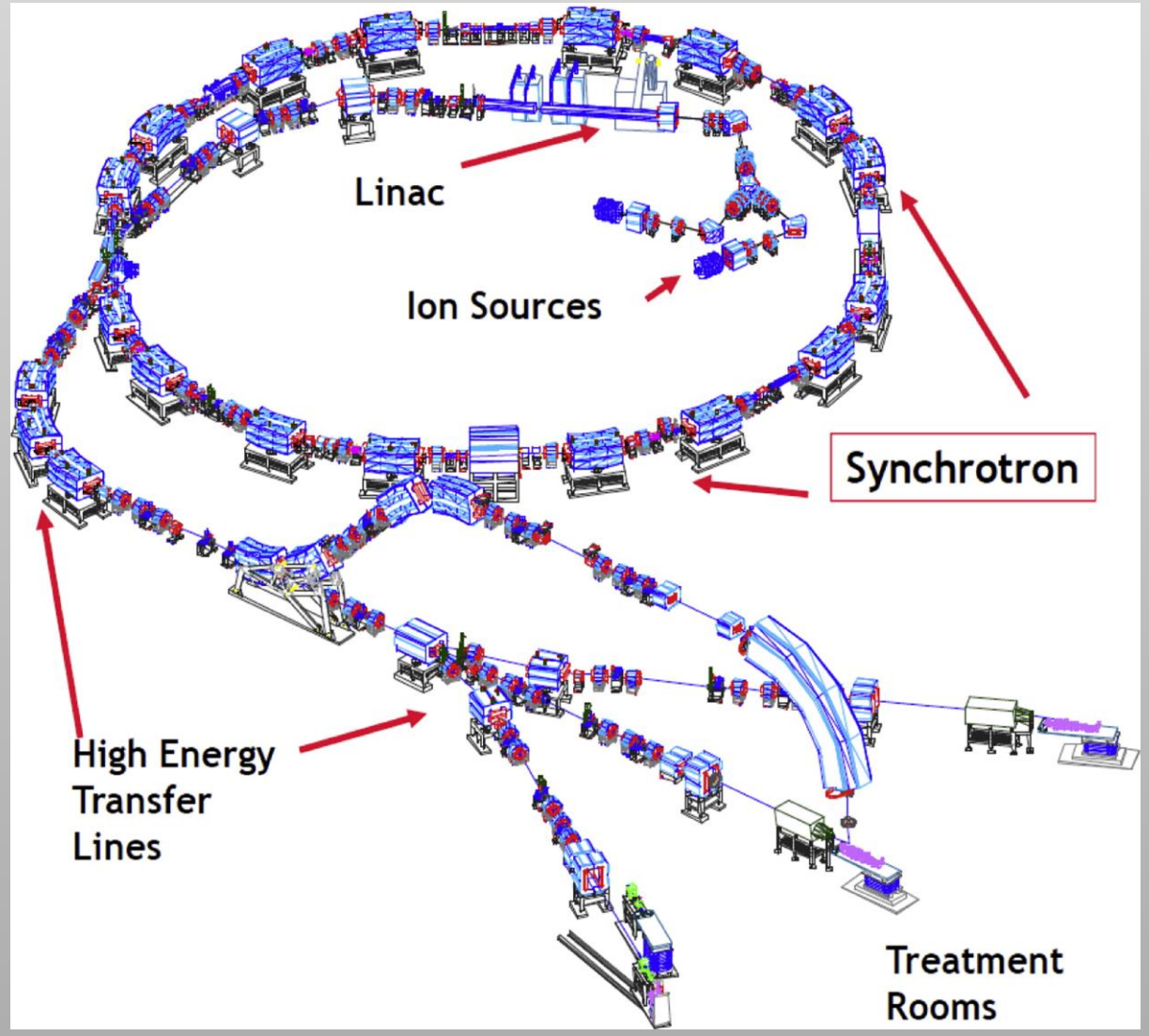
**Value = research time saved**




EMBL - European Bioinformatics Institute

- **Source:** Courtesy of ©EMBL-EBI

# BENEFITS FROM INNOVATION: AN EXAMPLE




National Centre For Oncological Hadrontherapy (CNAO)

**Value = statistical lives saved**

**Tumor and other diseas treated:**


*Source*: Courtesy of ©CNAO

# CULTURAL BENEFITS

## Value = travel cost method

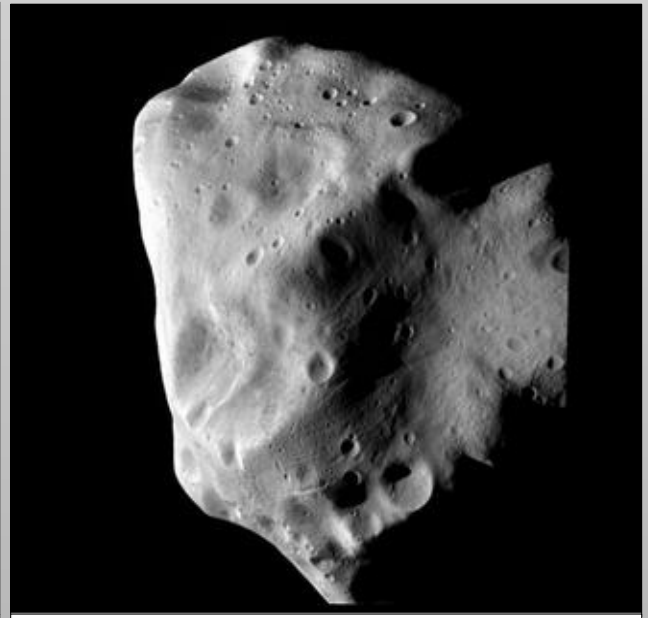

Courtesy of @KennedySpaceCenter

**The NASA Kennedy Space Center**

## Value = opportunity cost of time

**INVADER ID**

Help us track changes in coastal environments by identifying marine invertebrates.



**HUBBLE ASTEROID HUNTER**

Help us find asteroids in images from the Hubble Space Telescope!

**Zooniverse**

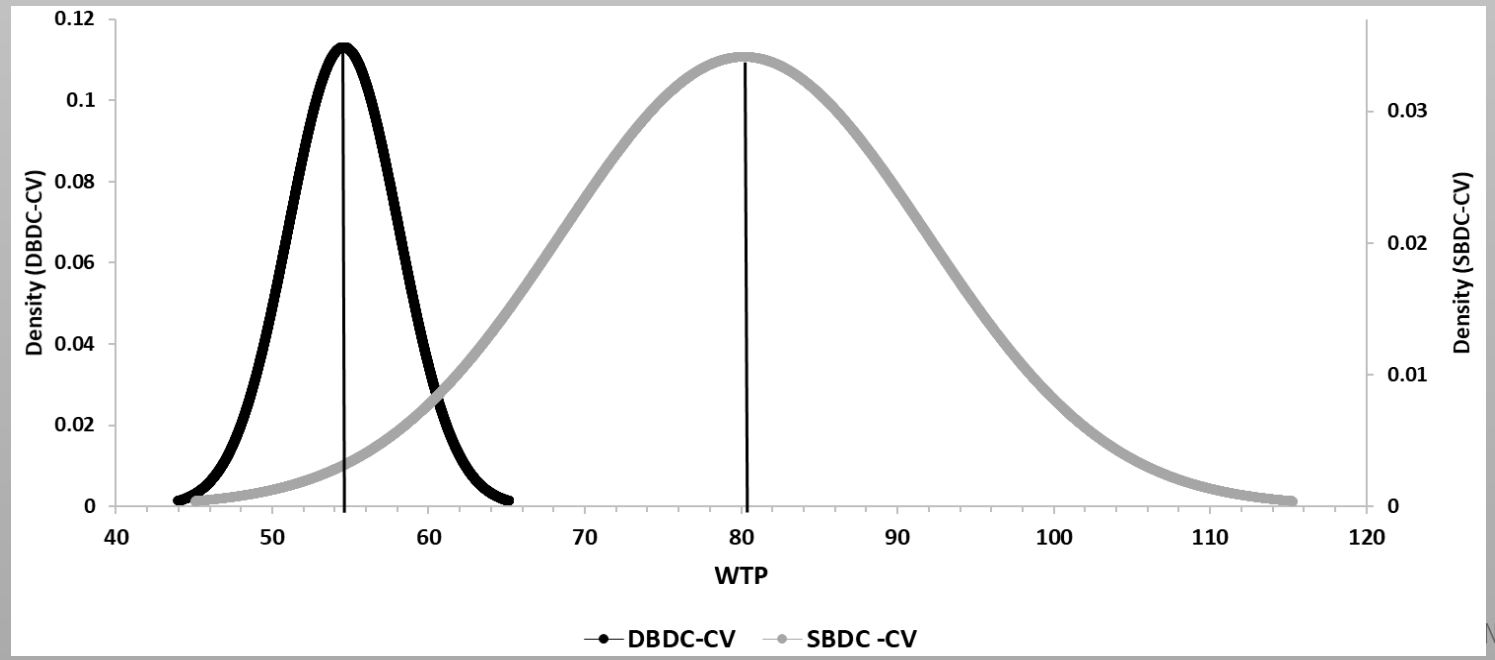
# PUBLIC GOOD VALUE

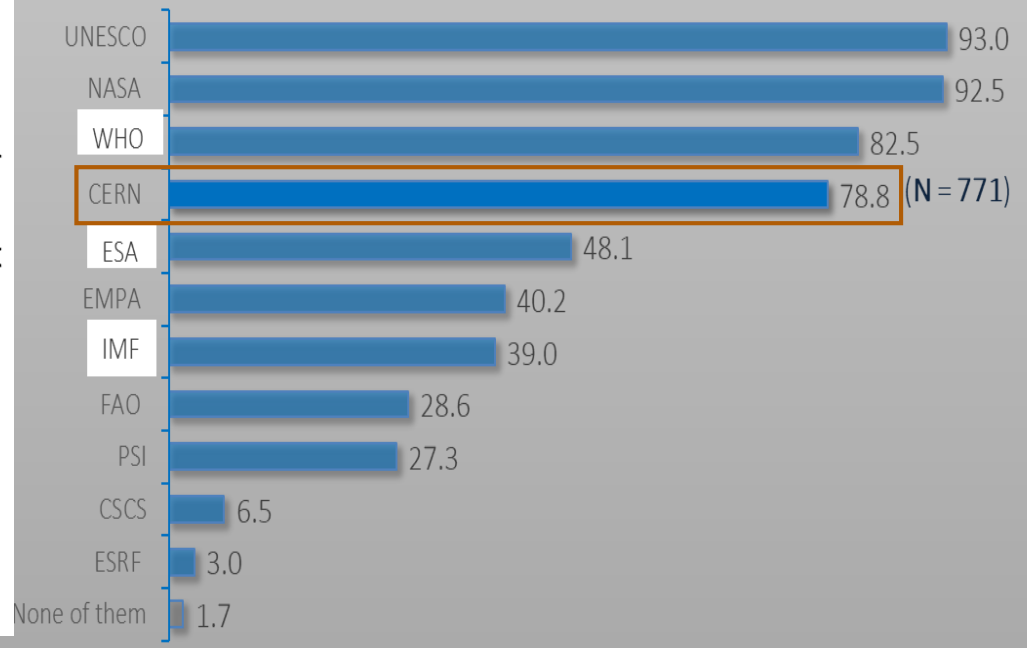
## Value = Contingent Valuation Experiment

- CV experiments about CERN future accelerators
- Representative samples of citizens
- France: 1000 interviews
- Switzerland: 1000 interviews
- **Willingness-to-Pay CHF 54 > implicit taxation CHF 6**

Ethics Committee

Swiss Federal Act on Data Protection

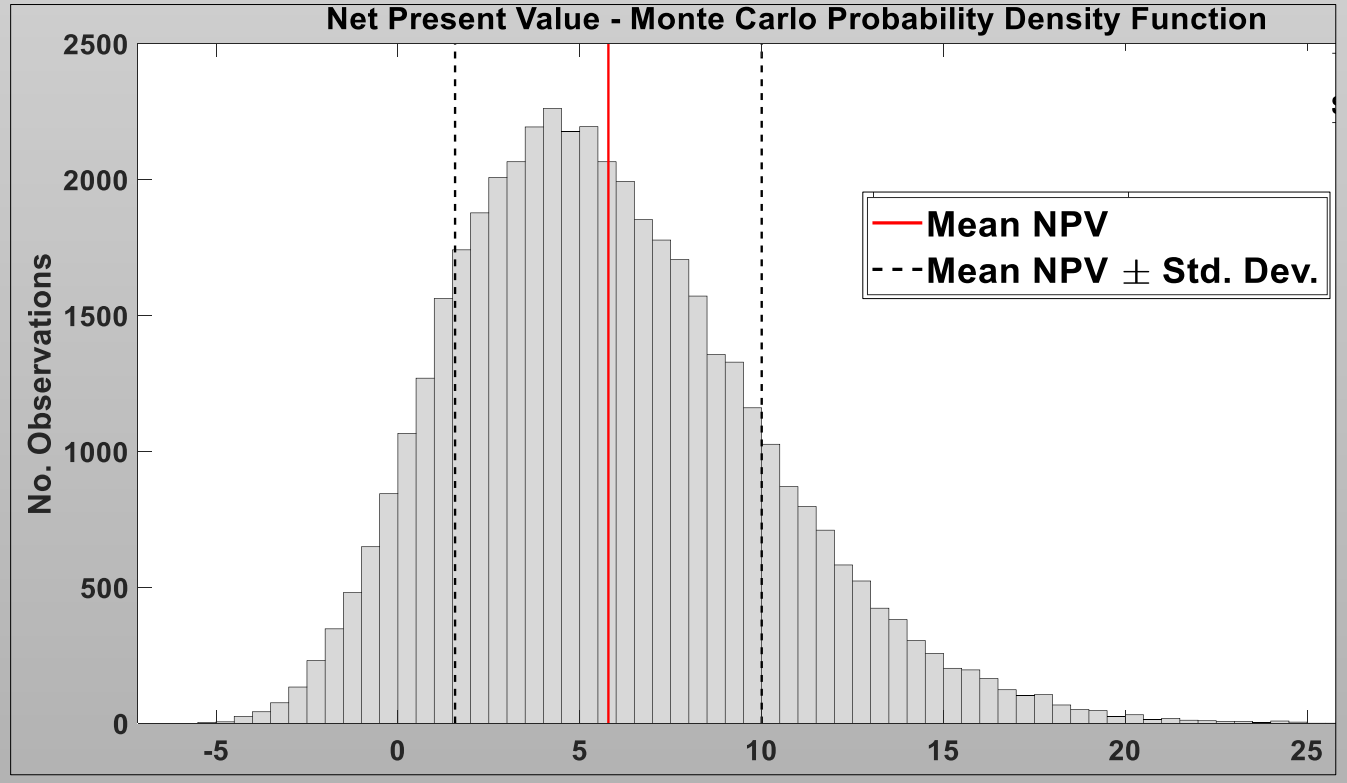


# SUMMING UP: BENEFITS AND COSTS

## Stochastic Net Present Value of LHC + High Luminosity LHC

| | |
|---|---|
| **Benefits** baseline | **25.6** |
| Scientific publications | 0.6 |
| Human capital | 8.4 |
| Technological spillovers | 10.2 |
| Cultural benefits | 3.3 |
| Public good value | 3.1 |
| **Costs** baseline | **22.3** |
| **Net Present Value** baseline | **3.3** |




Source: Bastianin, Florio (2018); Florio, Forte, Sirtori (2016)

# CONCLUSIONS

- A new paradigm of science production
- Are Social Benefits > Costs?
- B>C possible, even for basic research
- Measurable benefits:

**Technological Spillovers**
**Human Capital**
**Cultural Goods**

Courtesy of @SKA

- Unmeasurable benefits: “Useless” Knowledge
- A gift from the current to the future generations
- We invest today in science
- They will discover tomorrow its use and value

Courtesy of @Societàitalianadipediatria

# THANK YOU TO RESEARCH TEAM AND MANY OTHERS…

**1200 university undergrad students in four countries**

**120 scientists and experts**
**650 firms**
**400 PhD and post-docs**
**330 team leaders**

**1000 French citizens**
**1000 Swiss citizens**

**4700 interviews**

**CASE STUDIES:**
ALBA
CERN
COPERNICUS-SENTINELS
COSMO-SKYMED – ASI
DoE NATIONAL LABORATORIES
ELIXIR
EMBL-EBI
NATIONAL INSTITUTES OF HEALTH
SKA
**and others**

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S. Forte (UNIMI/INFN)
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**and others**

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