CERN

European Organization for Nuclear Research
Organisation Européenne pour la Recherche Nucléaire

Symposium on physics of elementary interactions in the LHC era

Warsaw, April 21-22

CERN and Technology Transfer

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Fundamental Science and TT

Science leads to technology innovation.

High tech industry is becoming the backbone of economy.

Society relies on technology.

Discoveries alone are no longer sufficient to substantiate the investment level of MS in fundamental science.

High Energy Physics is required to demonstrate its importance to Society:

- Communication is key to reach this objective

High Energy Physics is required to demonstrate its usefulness to Society.

- TT is a key mean to reach this objective.

CERN as a source of technology & know-how

Large fundamental research apparatus not directly available from industry

CERN's purchasing requirements into 3 categories:

- Standard industrial products
- New high-tech products requiring a conceptual design phase
- Non-standard products which can be produced with existing manufacturing techniques and / or technologies

Long and Intensive R&D and Prototyping required

- Source of innovation
- Source of new technologies
- Existing technologies pushed to the limits
- Creation of know-how

Although developed for the purpose of fundamental research, many technology developments and know-how have strong impact to society

New products from Procurement

Industry acquires new technologies and know-how through procurement contract with CERN

Impact of procurement to industry (results of studies):

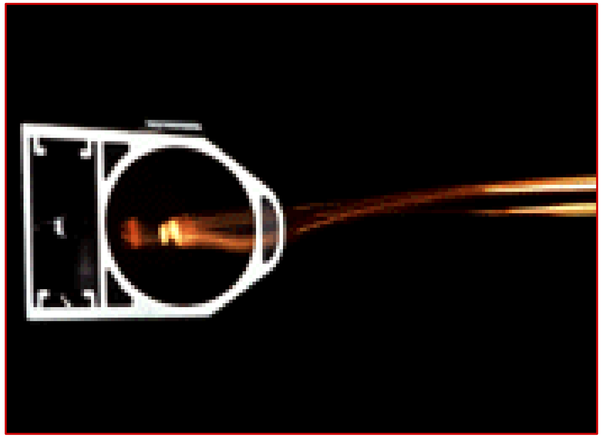
- Financial:

  For 1 Euro invested in purchasing technology goods, more than 3 Euros are generated in companies

- Knowledge transfer:

  Context: 629 High Tech supplier projects, ~1Bn Euros, 178 survey respondents, No companies with orders < 20 kEuros):

  Results:
  - 38% developed new products
  - 17% opened a new market
  - 14% started a new business unit



Vacuum chamber

Hood clamshell tool in elastomer

R&D contexts for PP and industry, impact on TT

Research: Open science

- ***Publication of discoveries & R&D results***
  - Scientific recognition
  - Value in copyrights
- ***R&D to meet scientific programme objectives***
  - Long-term
  - Best possible solution within budgetary constrains
- ***R&D results: Technology***
  - IP rights to use internally
- ***Highly collaborative***
  - Memorandum of Understanding (MoU)
- ***Unclear IP situation***
  - Joint ownership of R&D results
  - Complex dissemination
- ***Funding***
  - Public
  - Quality of research program

Industry: In/out sourcing technology

- ***Protection of innovations & know-how***
  - Required to facilitate industrial dissemination
  - Value in IP rights (patents, etc.)
- ***R&D to increase market share***
  - Short-term
  - Best cost-effective solution
- ***R&D results: Products (prototypes)***
  - IP rights to manufacture
- ***Highly competive***
  - Licence and/or partnership agreement
- ***Clear IP situation***
  - Clear ownership of R&D results
  - Dissemination based on manufacturing
- ***Financing***
  - Private with public support (EU, National funds)
  - Product market potential

From research to industry: Challenges

Finding an IP management strategy compatible with open science

- Possible limitation of dissemination of R&D results due to unclear IP situation

Finding the right balance between openness and the commercial exploitation

- Possible negative effects of IP protection on the willingness to share research results

Identifying market for CERN technologies

- Innovations in PP result from R&D programmes requiring non-commercially available products. Applications and markets identification outside PP requires dedicated efforts and understanding of potential application domains specific requirements

Funding the gap between public innovation and commercial application

- Firms are reluctant to invest in basic research; need for funds to support collaborative R&D with commercial aims and for early phases of start-ups promoting PP innovations

Collaborating with industry on basic technologies research while remaining compatible with CERN purchasing rules

- Basic technology developed in collaboration with industry may generate IP needed for future procurement contracts. Risk of monopolistic situations incompatible with purchasing rules

Impact of fundamental science to society

Generic technologies developed for accelerators, particles detection and data processing will find applications in many domains if:

- Match between technology offer and product needs
- Cost effectiveness of manufacturing products with technology
- Value of technology within product
- Acceptable product price with added features enabled by technology

Main domains:

- Health
- Information Technology
- Energy & Environment
- Industrial processes
- Security

The aims and objectives of TT

Aim: The CERN TT activities are aimed at the following:

- Maximizing the technological and knowledge return to the MS industry without diverting from CERN HEP mission.
- Promoting CERN's image as a center of excellence for technology.

Objectives: To steadily increase TT dissemination expressed in terms of R&D projects and commercial exploitation agreements:

- While securing external resources for such activities,
- So as to minimize their burden on the Organization's resources.

TT activities at CERN

Protect the interests of the Organization in Intellectual Property (IP) matters

Provide support to the Management in the protection, transfer, use, further development and dissemination of CERN's IP.

TT activities are executed in a process composed of 3 sub-processes:

- Technology Assessment & IP Protection
- Promotion
- Dissemination
  - TT R&D Projects
  - Commercialization of IP

Dissemination principles

First option and favorable conditions to Member State industry

Equal opportunities for the commercial actors in the Member States

Dissemination Vs income

Market price

Military application are excluded

Networks to support TT activities

INET: Departmental Technology Liaison Officer (DTLOs)

- Liaise with TT Office
- IP disclosure & decisions

ENET: National Technology Transfer Offices (NTTO) (1 representative / MS)

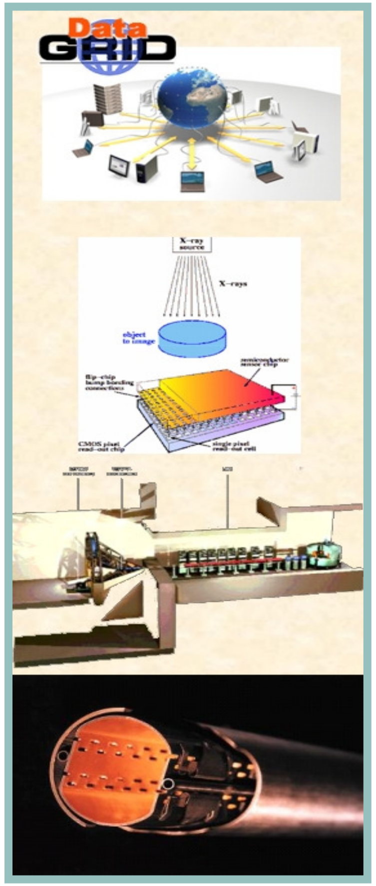
- CERN and National Industry Liaison
- Promotion of CERN technologies in MS

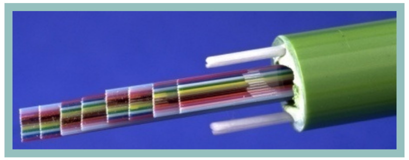
TTN: Technology Transfer Network of TT Offices of Research Institutes active in PP

- Enhance dissemination of results from Particle Physics program
- Tools:
  - IP charter to support dissemination in parallel with Open Science
  - Address IP pools (issues related to complementary/overlapping technologies)
  - Indicators to monitor dissemination
- Implementation

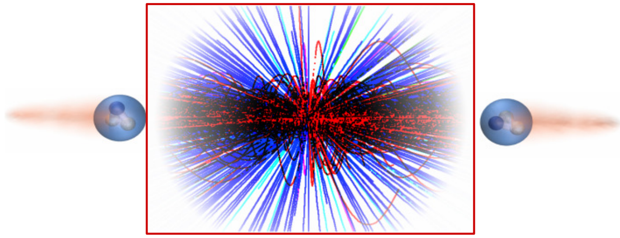
Potential of CERN technologies in non-HEP application domains

		Detectors	Electronics	IT	Accelerator	Magnets	Material	Mechanics
Health & Lifesc.	Detectors	✓	✓	✓				
	Electronics		✓	✓				
	Isotopes				✓	✓	✓	
Energy & Environment	Vacuum Technology						✓	✓
	Renewable Energy					✓	✓	
	Thermal Insulation					✓	✓	✓
	Nuclear Waste treatment				✓	✓		
Eng.	Material & Mechanics					✓	✓	✓

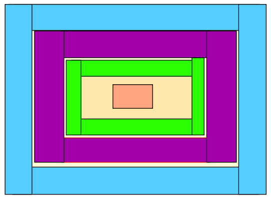


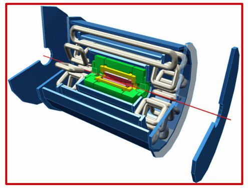


Scientific programme: The ingredients

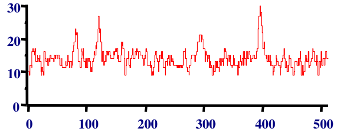


Accelerator

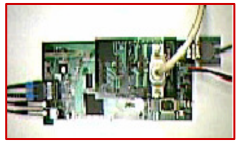


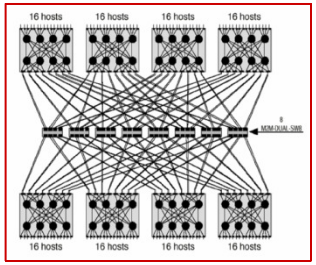


Experiments

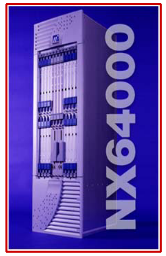


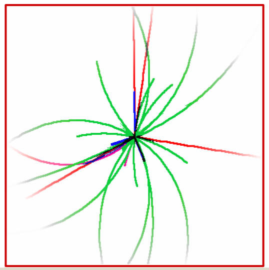
Measurements and selection

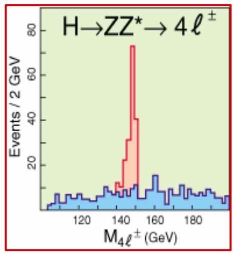




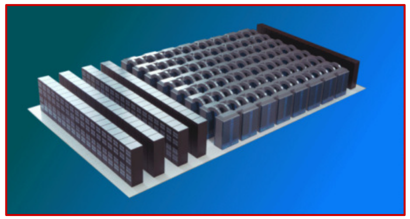
Data communication







Data processing



Applications of particle accelerators

CATEGORY OF ACCELERATORS	Number in use (2005)
High Energy acc. (E >1GeV)	**~ 120**
Synchrotron radiation sources	**> 100**
Medical radioisotope production	**~ 200**
Radiotherapy accelerators *	**> 7500**
Research acc. including biomedical research	**~ 1500**
Acc. for industrial processing and research	**~ 1500**
Ion implanters, surface modification	**> 7000**
Total	> 17500

*** Linacs used in radiotherapy represent 40% of all running accelerators:**
France, Germany, Italy: 4 units per million inhabitants
Switzerland: 11 units per million inhabitants
Finland: 14 units per million inhabitants

Hadron Therapy

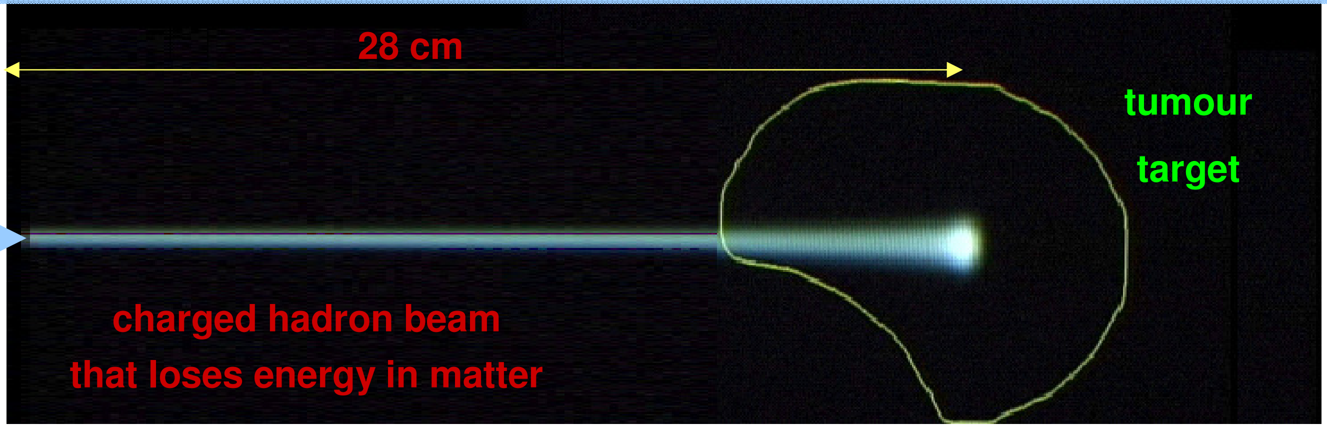
Loma Linda(p)-US; PSI(p)- CH; Heidelberg, Pavia-CNAO (C), Lyon-Etoile (all C ions, p), Medastron (C)

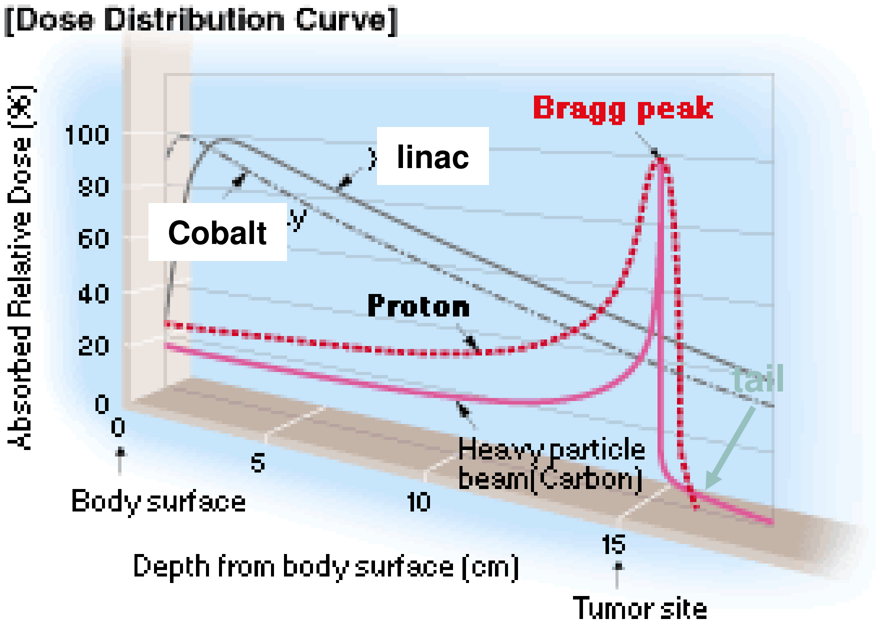
200 MeV protons

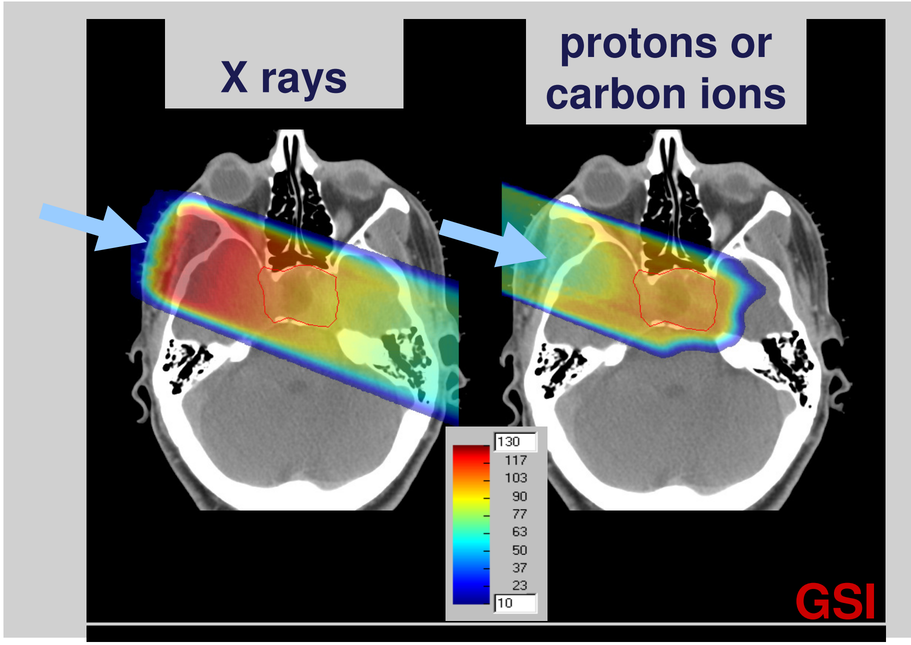
480 MeV carbon ions

which control radioresistant tumours

(G. Kraft)







Science to Health: Hadron Therapy

Technology

Complex accelerator technology in combination with precise imaging systems developed for PP constitute the infrastructure for hadron therapy centers.
(ex. PIMMS Design Study (published in 2000))

Health care

- Protons and ions have proved to be extremely efficient to treat deep seated tumors without damaging healthy tissue.
- Effective also for radio resistive tumors

Impact

- **29 centers have treated 48 000 patients to date, many of them being PP centers** (1)
- **5 dedicated hadron therapy facilities are being constructed. In 10 years up to 30 is forecasted** (2). **CERN is contributing to the construction of CNAO (Italy) and MedAustron (Austria) (Former members of the PIMMS study group).**
- **Epidemiological data suggest one center per 10M inhabitants** (3)
- **Construction costs for the infrastructure of such center is approximately 120 Million EUR. Annual running costs 15 Million EUR.**

Sources: (1) ***Particle Therapy Co-Operative Group***, (2) ***Siemens, (3) TERA***

Accelerator technology (Vacuum) for renewable energy

Description

Thin film coatings to achieve and obtain ultra-high vacuum at low temperatures based on the Non-Evaporable Getter (NEG). Coating applied by sputtering. Recovery of chemical reactivity (i.e. pumping function) by heating at temperature as low as 180^0 C

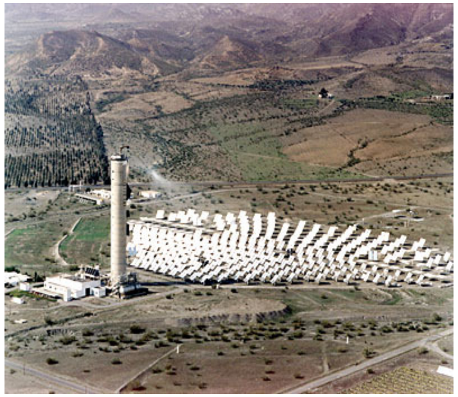
Applications

- Improvement of vacuum pumps
- Electron and cathode tubes
- Vacuum thermal insulation at high temperature (solar thermal applications)
- Micro-Electro-Mechanical Systems (MEMS)

Solar technologies

Thermal

Concentration



Trough

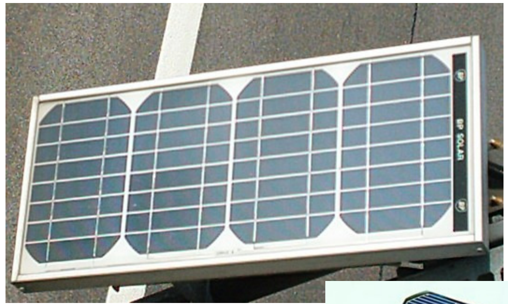
Diffused light

Flat panel

Evacuated tubes

CERN: Evacuated flat plate solar collector

Photovoltaic



Direct
photon->electron Conversion
Private installations
Plants connected to grid
Total peak power of installed solar photovoltaic arrays worldwide was around 5.3 GW at the end of 2005;

Main actors: Japan, Germany and US

Accelerator Vacuum technology to Solar Energy

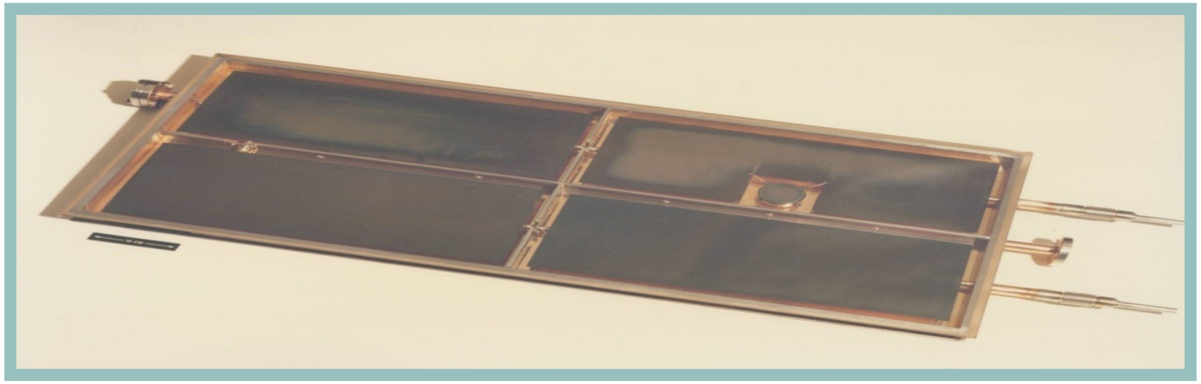
Flat evacuated solar collectors

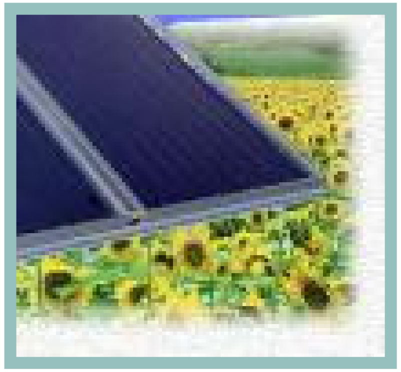
Advantages

- Diffused light
- 350^0 C
- Easy to produce
- High performance

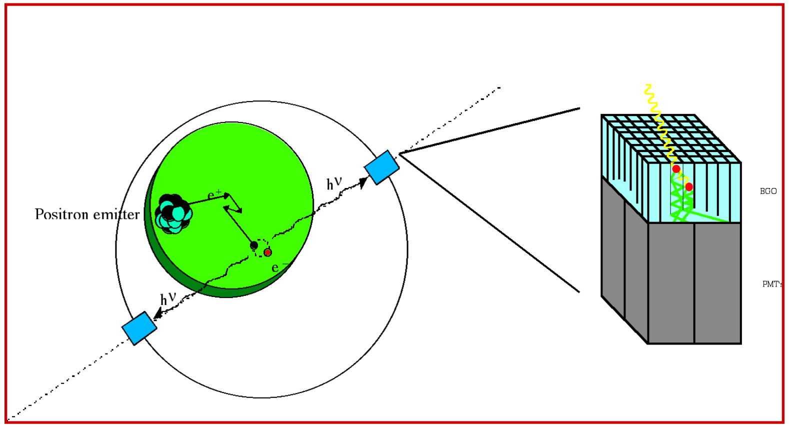
Applications

- **Heating and cooling**
- **Electricity production**
- **Agriculture (i.e. crop drying)**
- **Desalinisation**

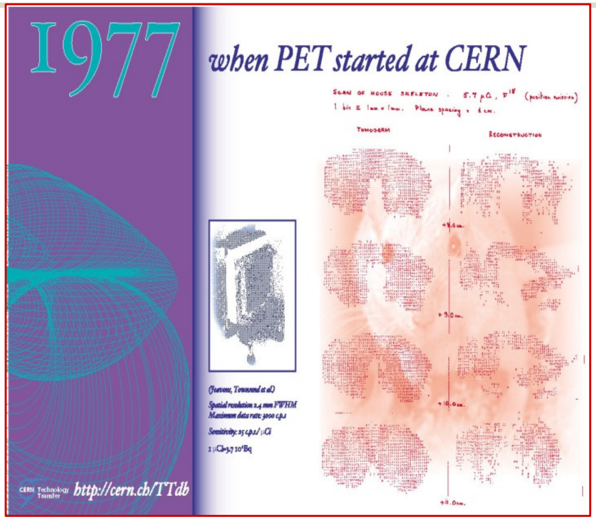




Science for Health: Imaging



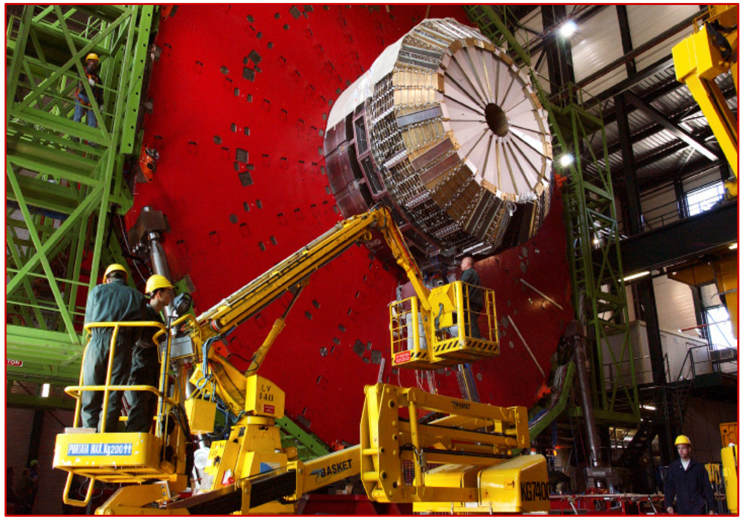
Brought the idea of PET

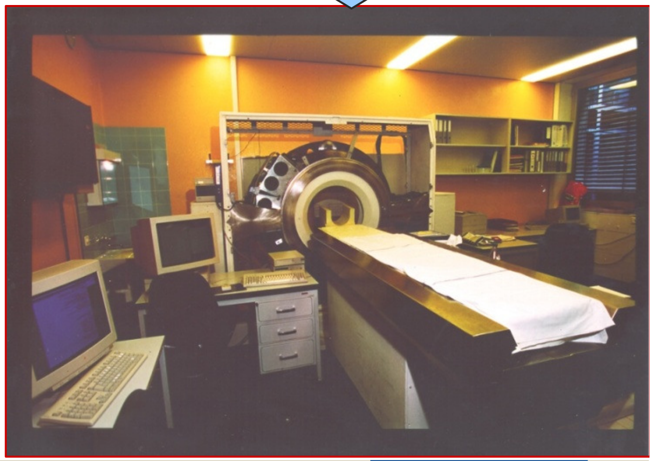


Photon detection used for calorimetry

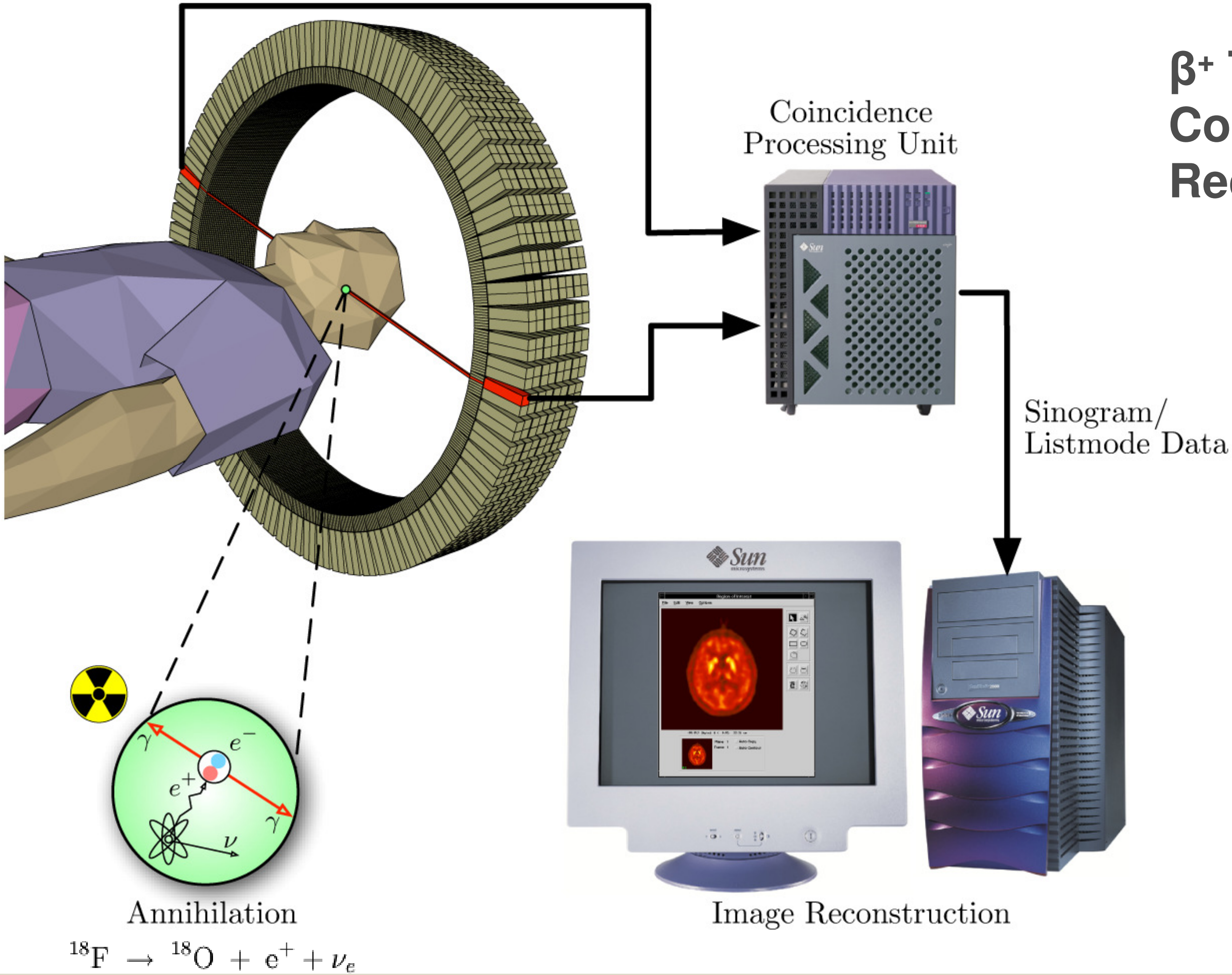
PET today

CMS calorimeter





PET Systems



β⁺ Tracer
Coincidences
Reconstruction

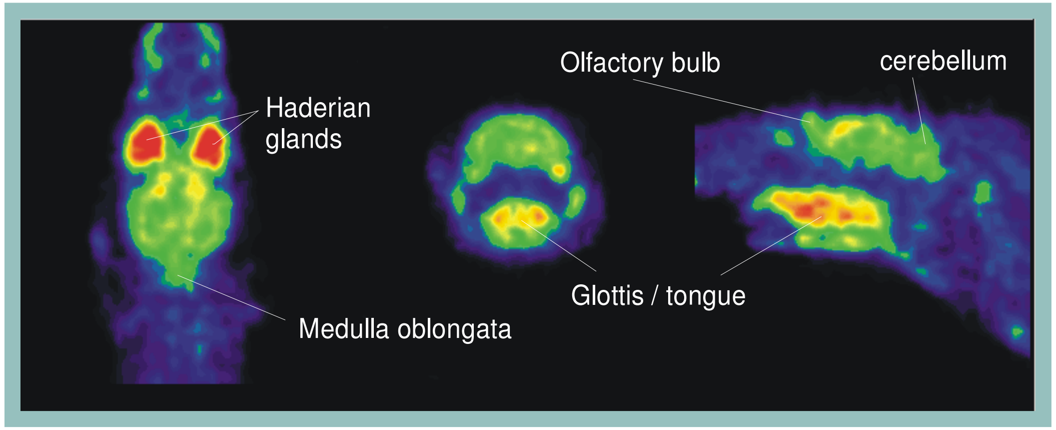
Science to Health: Imaging (2)

How PP bridges the gap to imaging industry: Ex. PET technology

Attractive market perspectives for whole body PET/CT's:

- Generalized use of PET technologies across multiple domains of medical diagnostics
- Attractive opportunities for dedicated PET also in niche markets:
  - Small animal PET's (Drug discovery)
  - Mammography, Brain devices

Year	Mio $
2004	880
2005	985
2010 (est.)	1870



Crystal Clear Collaboration: Small animal PET for in-vivo drug screening

X Ray imaging: Novel Particle detector electronics

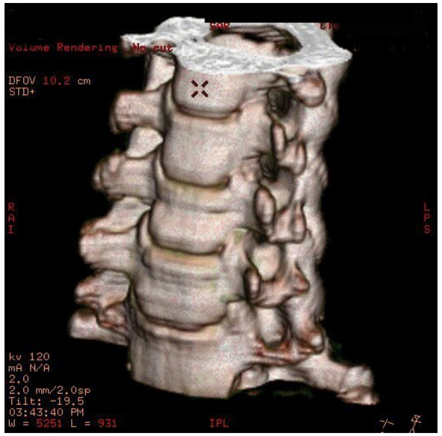
A paradigm shift: current to counting mode

Current

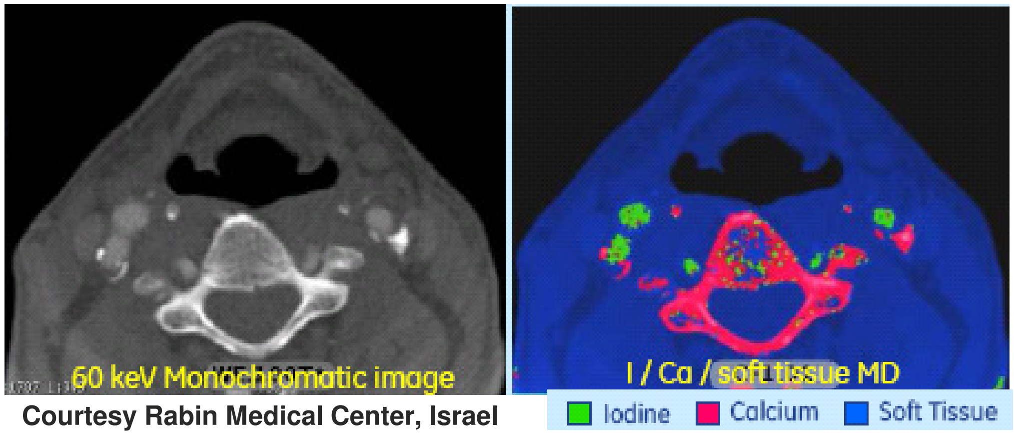
- Limited contrast
- High dose
  - Restricted use for screening
  - Limited access to preventive health care market

Counting

- High contrast
- Colour mode possible
- Lower dose (factor of 10)
  - Opportunity for screening
  - Access to preventive health care



Courtesy GE



Courtesy Rabin Medical Center, Israel

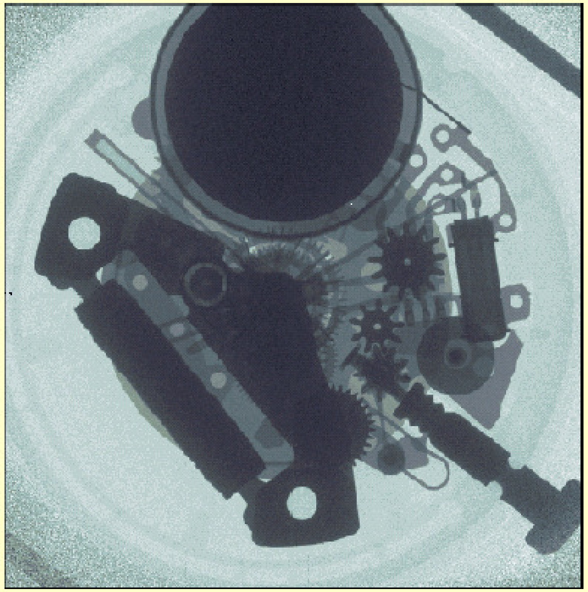
- **Computed tomography (CT)**
  - **Low-cost, high-reliability, high-speed, true-colour / higher-quality imaging and less patient radiation exposure**
- **Industrial process: Digital X-Ray camera**

Semiconductor detectors - Medipix

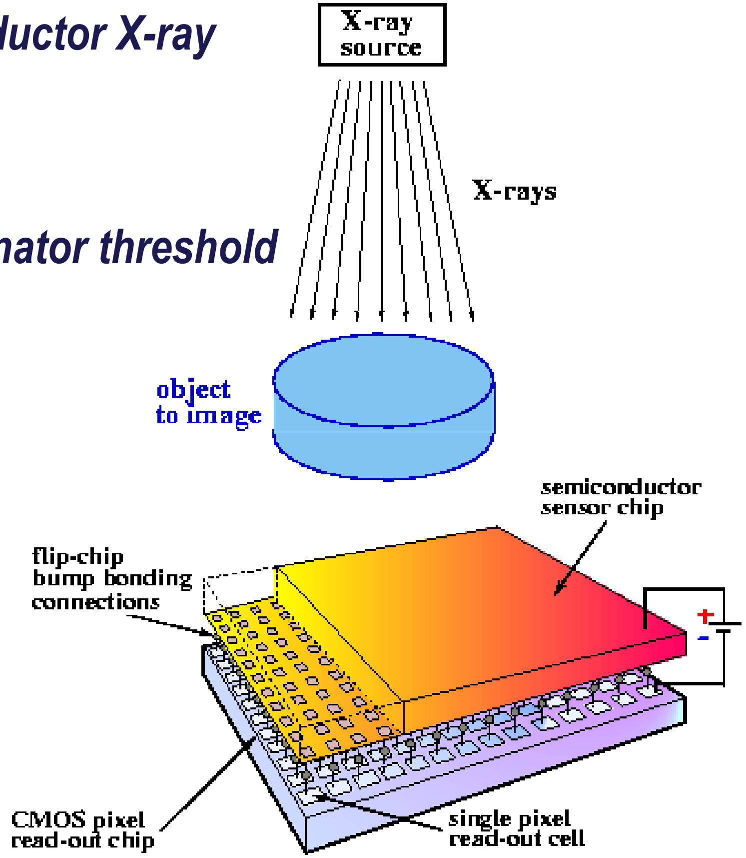
High contrast, high spatial resolution single photon counting(256x256 pixels)

Suitable for direct X-ray conversion in various semiconductor X-ray converters connected through bump bonding

55x55 um cell size with individually adjustable discriminator threshold



5 frame/sec. Limited by DAQ software

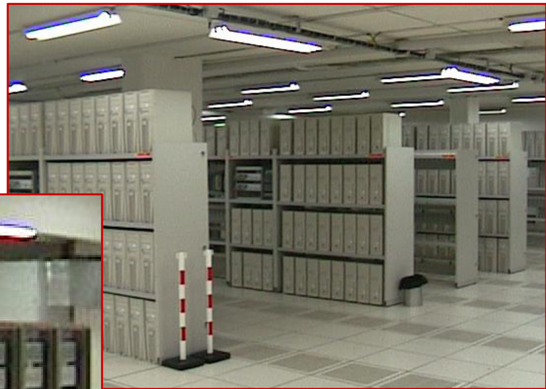


Science for society: ICT*

Scientists deployed the Internet Infrastructure

CERN invented the World Wide Web

Scientists are developing the Grid computing



Web infrastructure

Internet infrastructure

World wide distributed computing

* Information & Communication Technology

Technology Transfer

Science to e-Society: WWW

Physicists needed to share computer-stored information to answer tough questions about the Universe and to network within the R&D community

1989 - Sir Tim Berners - Lee created an information management system using hypertext to share data, documentation and news to help the Physicists community

World Wide Web	
Web pages in the publicly indexable web (1)	11.5 billion
Number of World Internet Users (2)	1.04 billion
New hostnames/month - 1st quarter 2006 (average) (3)	2.75 million
Total hostnames from Jan.1994 – Jan.2006 (4)	450 million
Domains currently registered on the Internet (.Com/.Net/.Org) (5)	76.10 million

(1) - As of Jan.2005, Wikipedia, September 7, 2006
(2) - World Internet Usage and World Population Statistics, June 30, 2006
(3) - NetCraft (http://news.netcraft.com/), September 12, 2006
(4) - Internet System Consortium (ICS), September 7, 2006
(5) - Domaintools (http://domaintools.com/internetstatistics), September 12, 2006

E-business related revenue expected to reach $ 3 trillion by 2006, protecting the flow of credit cards, financial transactions, and all forms of commerce across the Internet;

E-business spending $ billion.
Products $ 11.7 billion.

Hosting Service $ 12.5 billion.
US spending $ 24.2 billion.

Conclusions

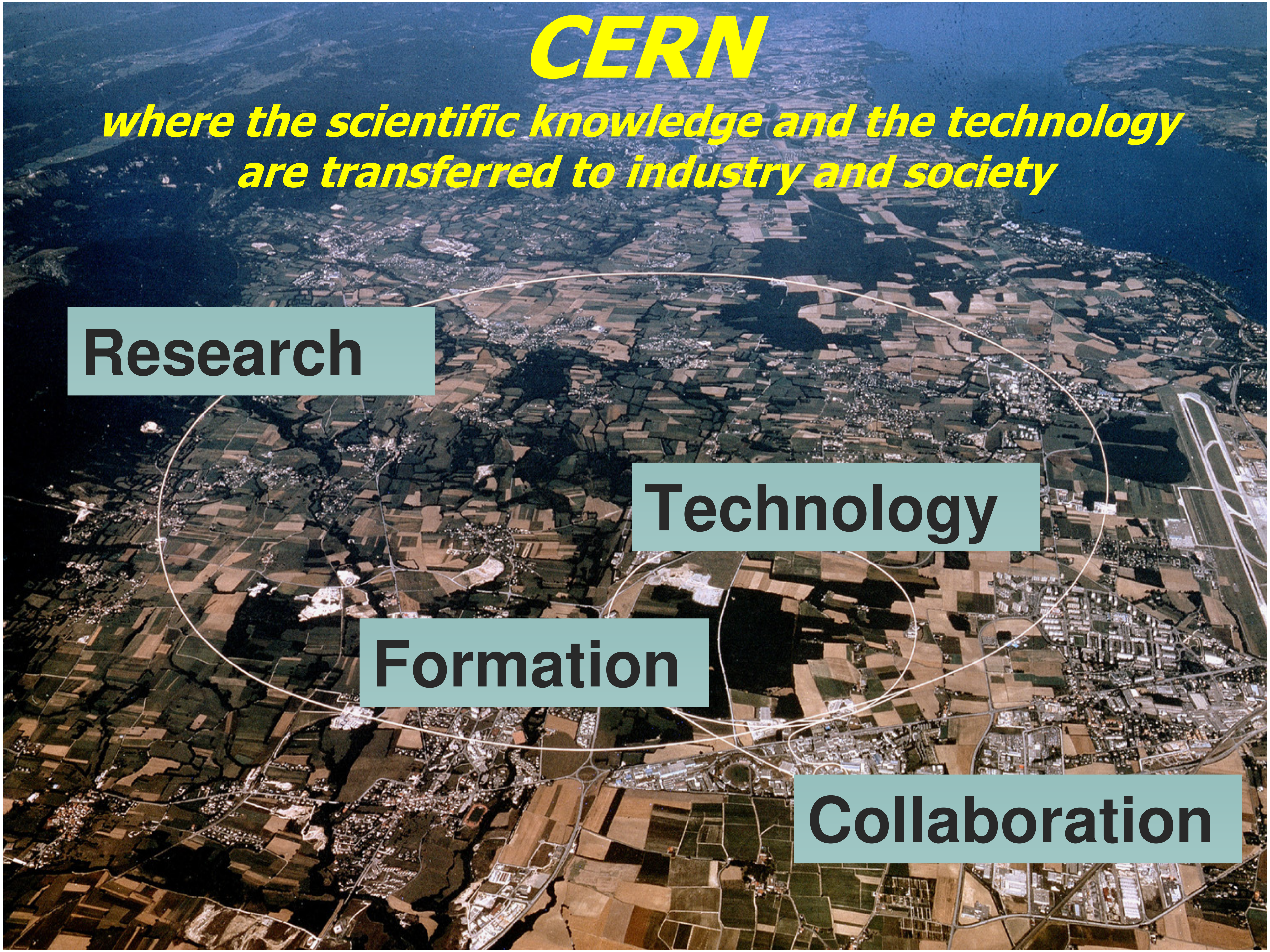
Basic research has a strong impact on technology developments and innovation

Technology developed for science have major repercussions on the global community

Technology developed for science is a source for Industry that leads to important business prospects

Fundamental science accelerates the industrial process and improves daily life

Many issues, including funding are limiting the impact of public research to industry and society


CERN
where the scientific knowledge and the technology
are transferred to industry and society
Research
Technology
Formation
Collaboration