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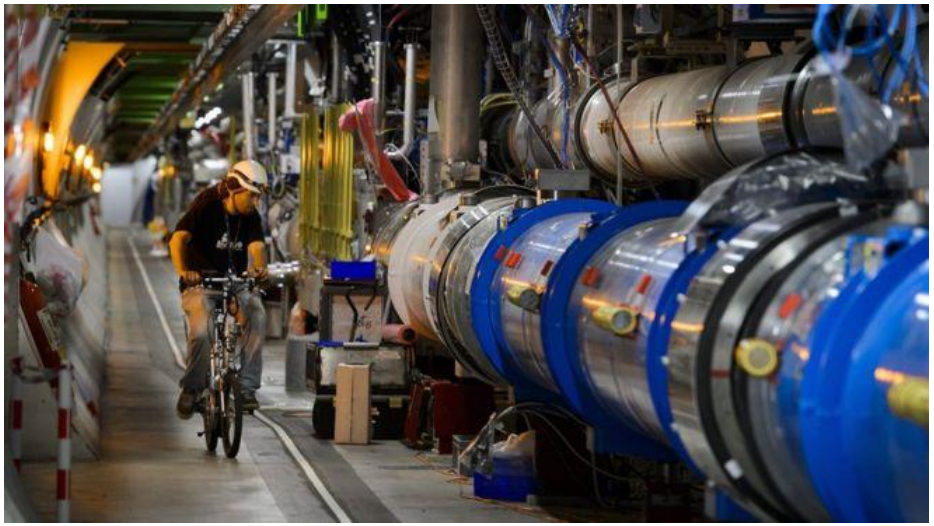
Industrial Applications of Particle Accelerators

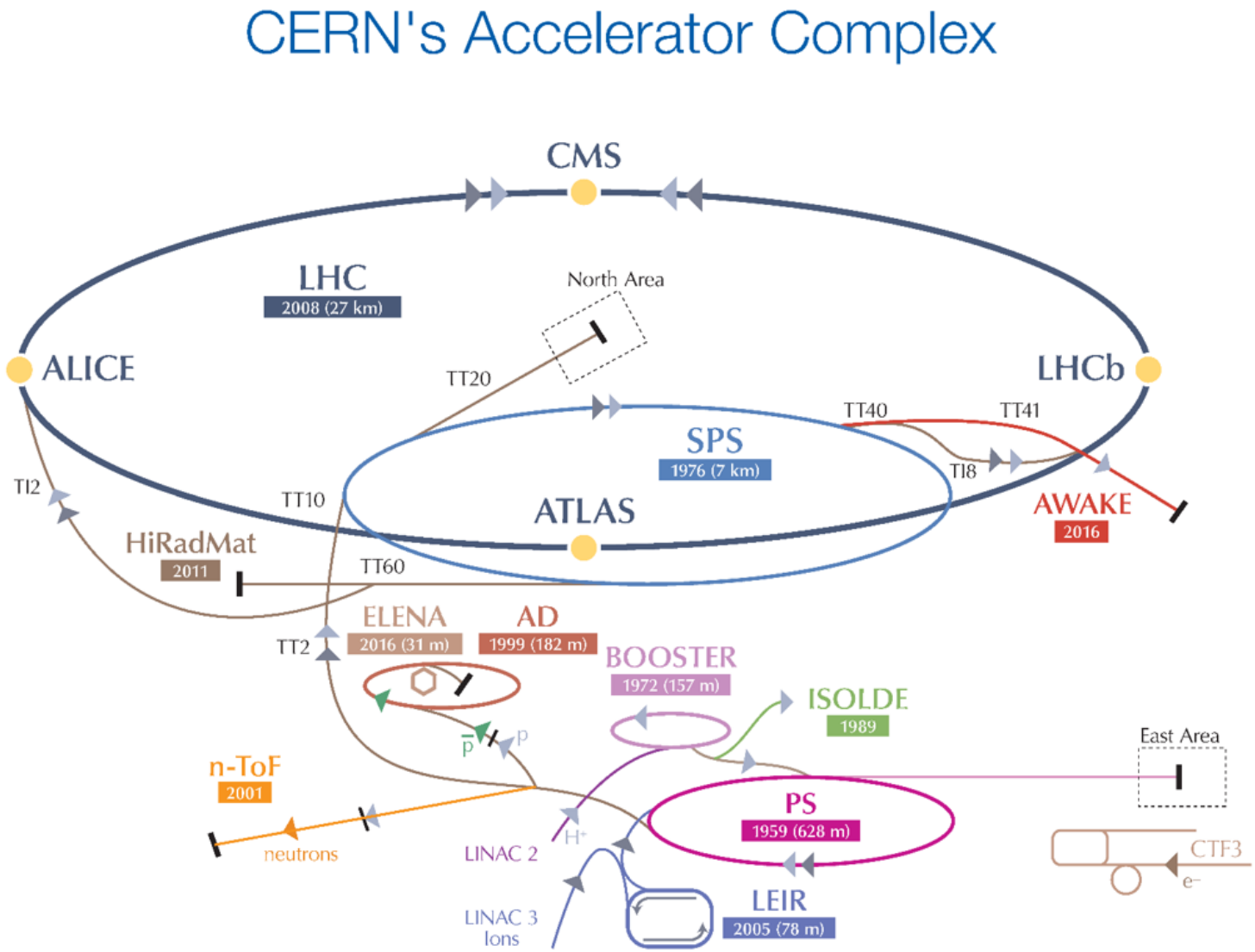
ARIES meets Industry, 1st January 2017

Prof Rob Edgecock / University of Huddersfield

Introduction

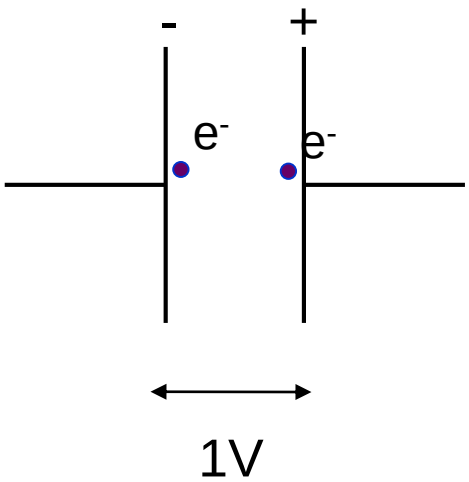


Introduction



Aside: beam energy

- Main accelerator parameter
- e.g. LHC is 7 TeV/beam



1eV

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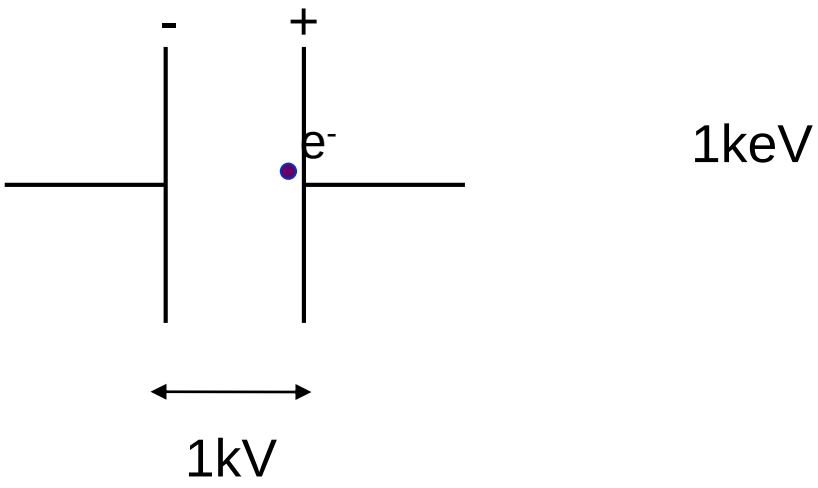

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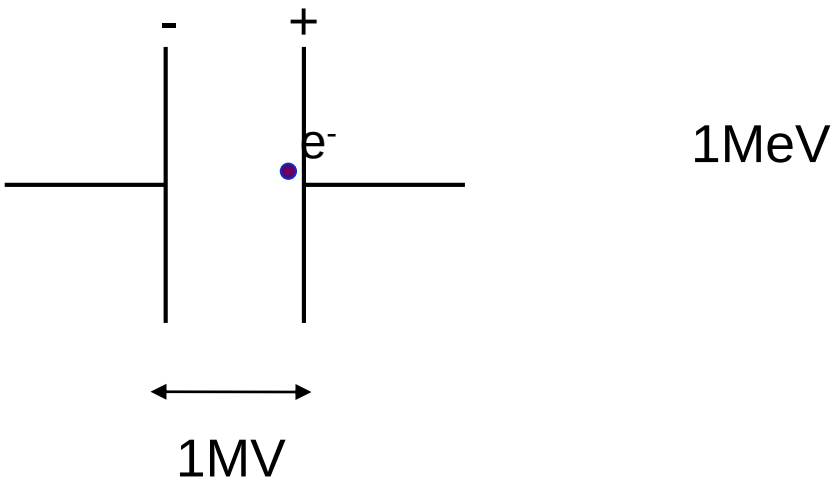


Introduction

- Nearly 40000 accelerators in the World
- About half < 5 MeV
- Nearly all the rest < 20 MeV
- About 2/3rd electrons, 1/3rd ions
- Used for a variety of every day applications:

- Energy	- few, developing
- Environment	- few, developing
- Health	- >15000
- Industry	- >21000
- Security	- ~1000

- Most of the accelerators: commercially manufactured
- Produce around $0.5T of commerce/year

Industrial Applications

- Big business
- Uses electron and ion/proton beams
- All < 10 MeV

Electrons

Effects of Electron Beam Interaction

Thermal Processes

Heat Production

Vacuum

- Evaporation
- Melting
- Welding / Joining
- Hardening
- Micro- structuring

Non-thermal Processes

Chemical Reactions

Atmosphere

- Curing
- Crosslinking
- Drying print-inks
- Surface modification (Grafting)

Biocidal Effects

Atmosphere

- Disinfection of animal feed
- Seed treatment
- Sterilisation of products
- Sterile packaging
- Inactivation of pharma waste

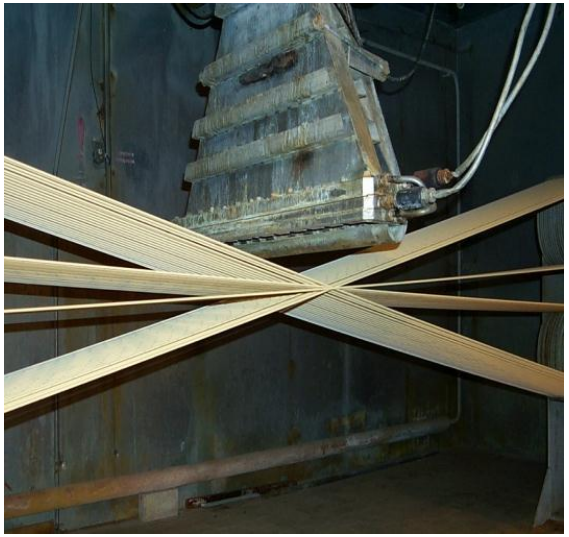
Polymer Cross-linking

92% radial tyres

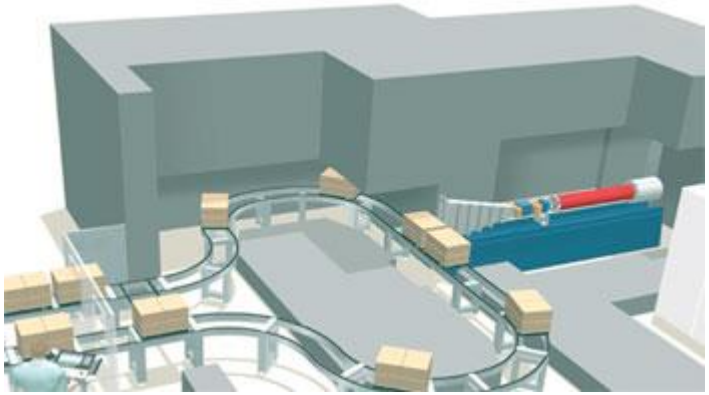
Nearly all wires/cables

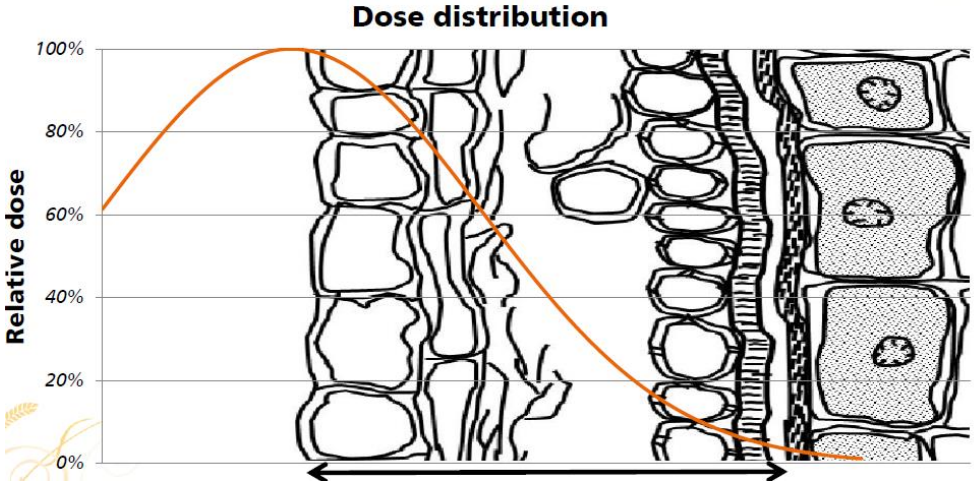
Most foam

Polymer Cross-linking



Sterilisation



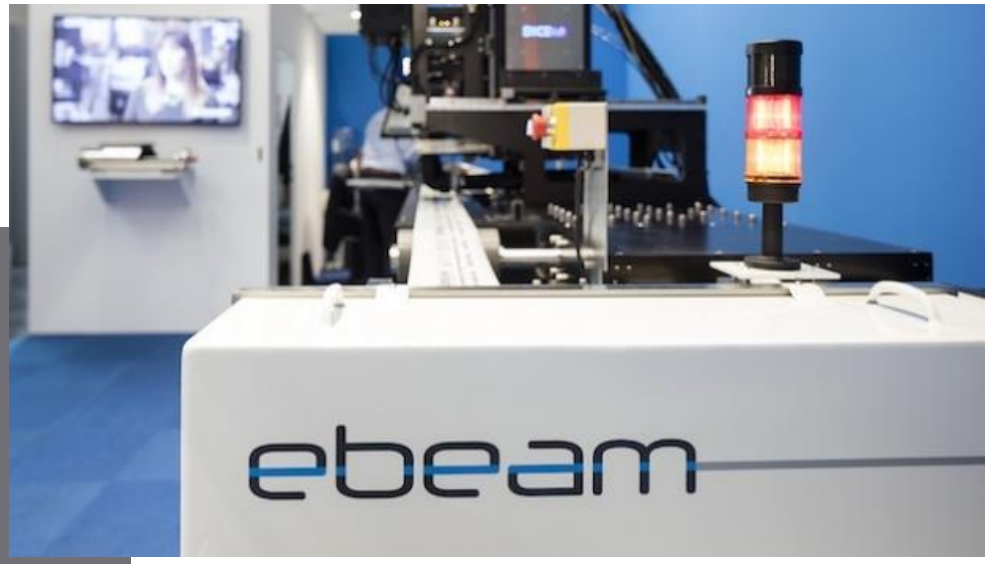


Gemstone enhancement

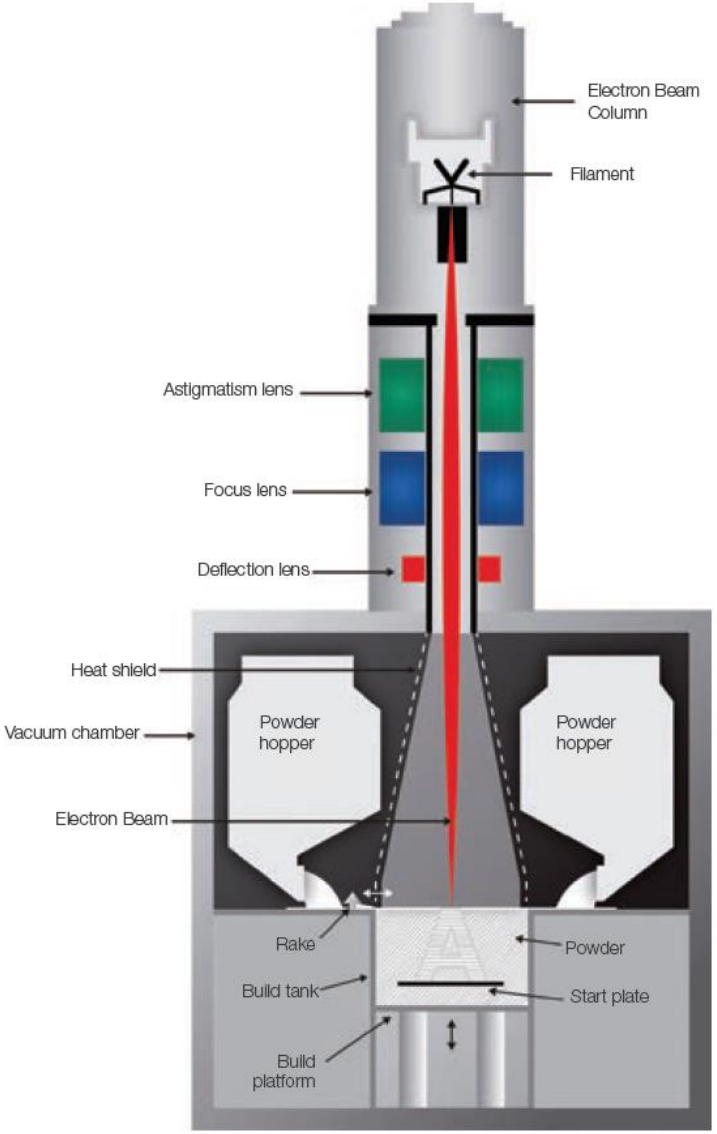
TABLE 2. Effects of irradiation treatment on various gem materials.[a]

Material	Starting color	Ending color
Beryl	Colorless Blue	Yellow Green
Maxixe-type	Pale or colorless	Blue
Corundum	Colorless Pink	Yellow Padparadscha
Diamond	Colorless or pale to yellow and brown	Green or blue (with heating, turns yellow, orange, brown, pink, red)
Fluorite	Colorless	Various colors
Pearl	Light colors	Gray, brown, "blue," "black"
Quartz	Colorless to yellow or pale green	Brown, amethyst, "smoky," rose
Scapolite[b]	Colorless, "straw," pink, or light blue	Blue, lavender, amethyst, red
Spodumene	Colorless to pink	Orange, yellow, green, pink[c]
Topaz	Yellow, orange Colorless, pale blue	Intensify colors Brown, blue (may require heat to turn blue), green
Tourmaline	Colorless to pale colors Blue	Yellow, brown, pink, red, bicolor green-red Purple
Zircon	Colorless	Brown to red

2D printing



3D printing or additive manufacturing

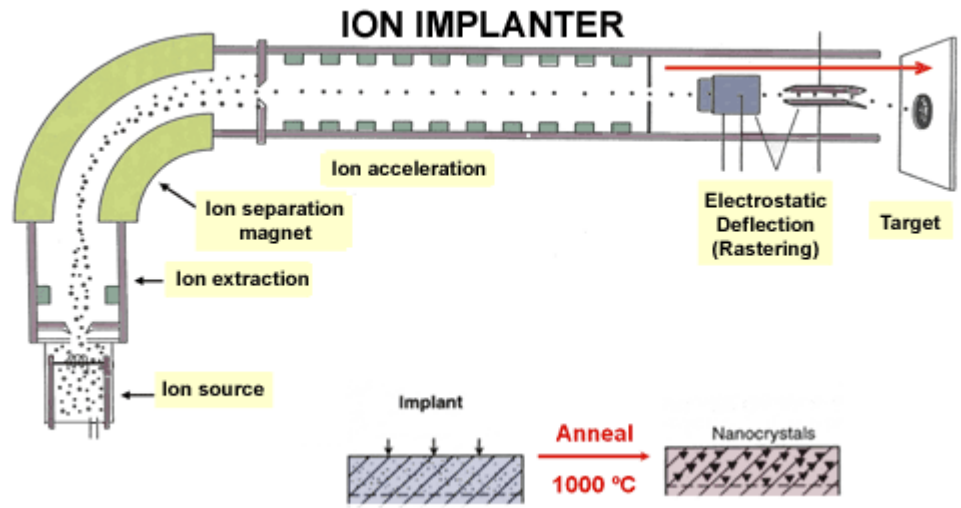


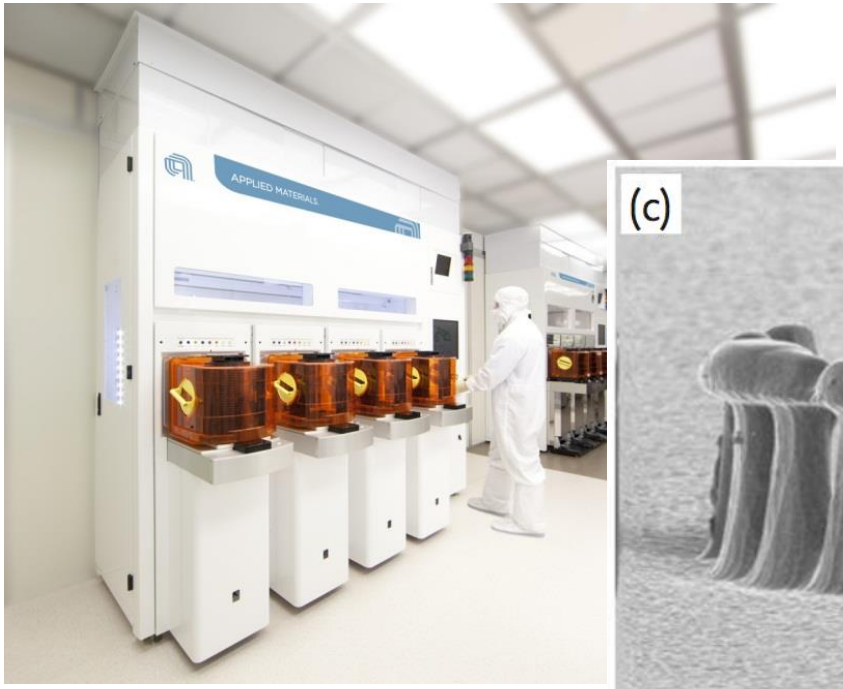
Arcam EBM® systems, schematic architecture.

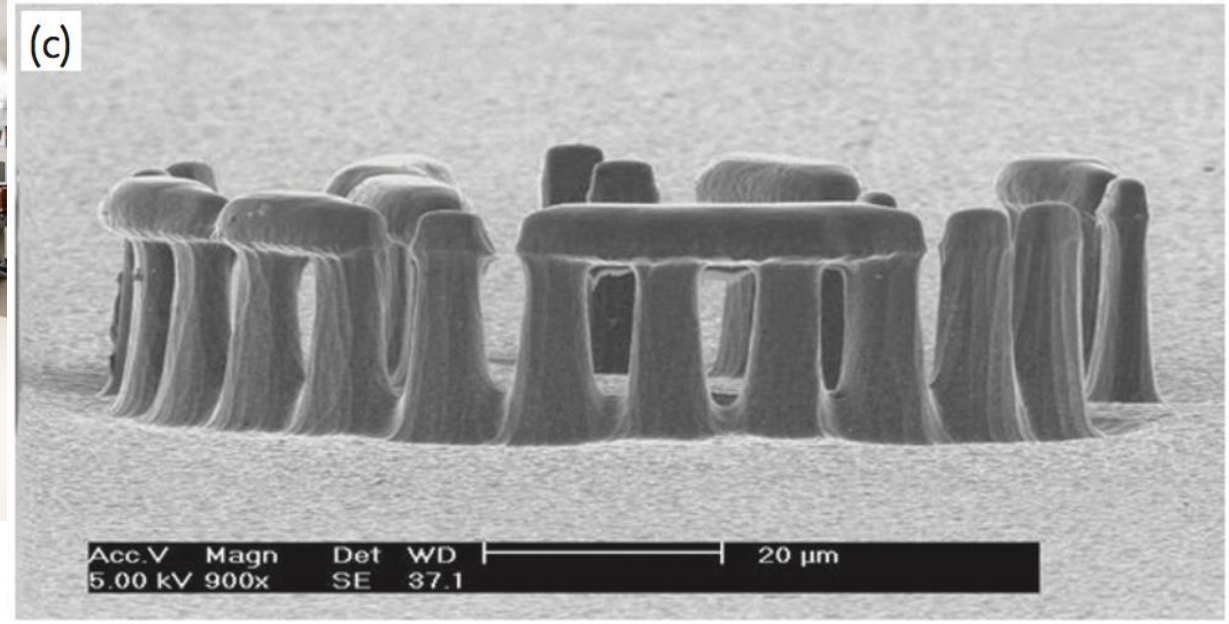
Ion Implantation

Ion implantation - >10000

Used extensively and all digital electronics ion implanted

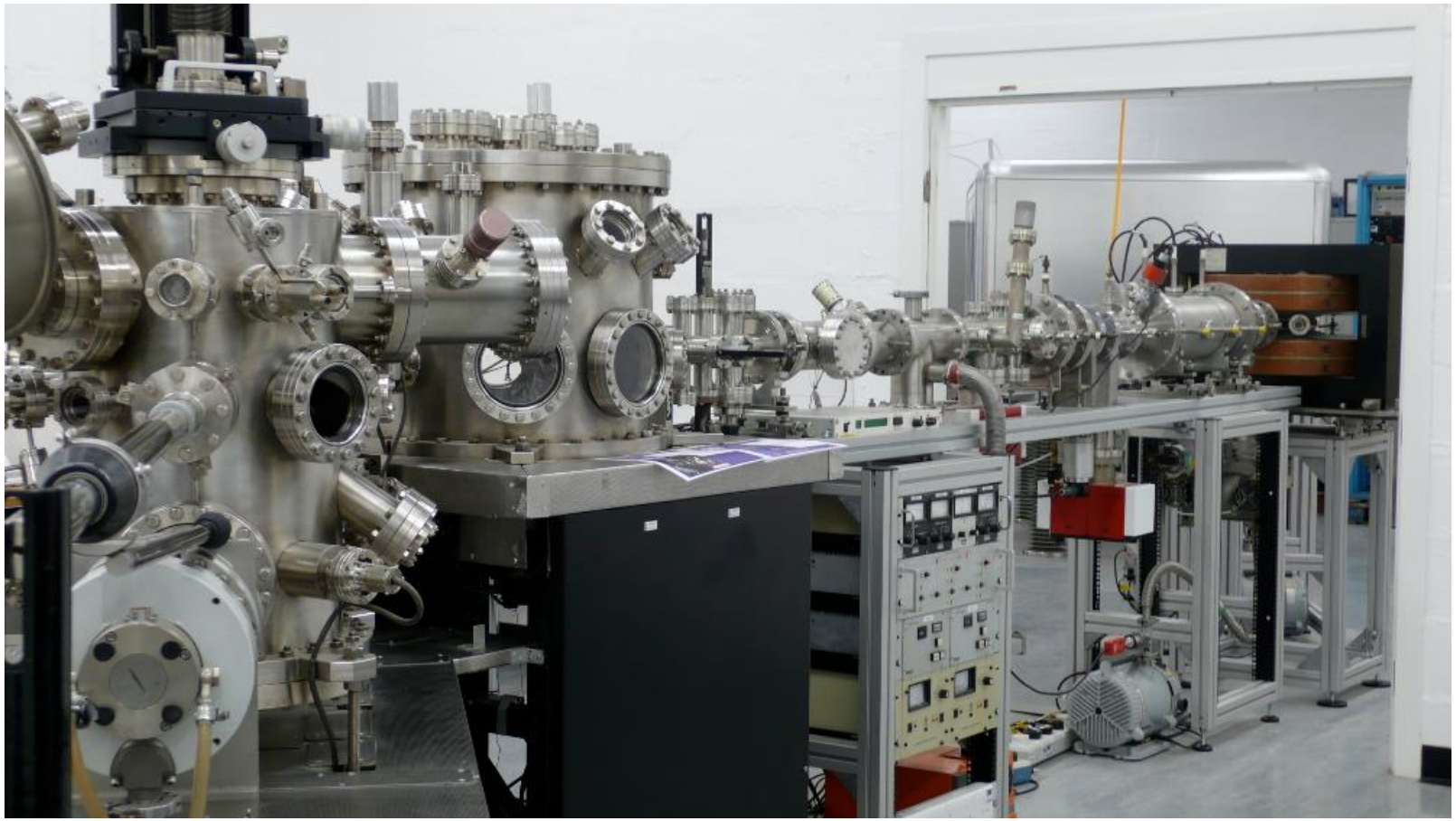




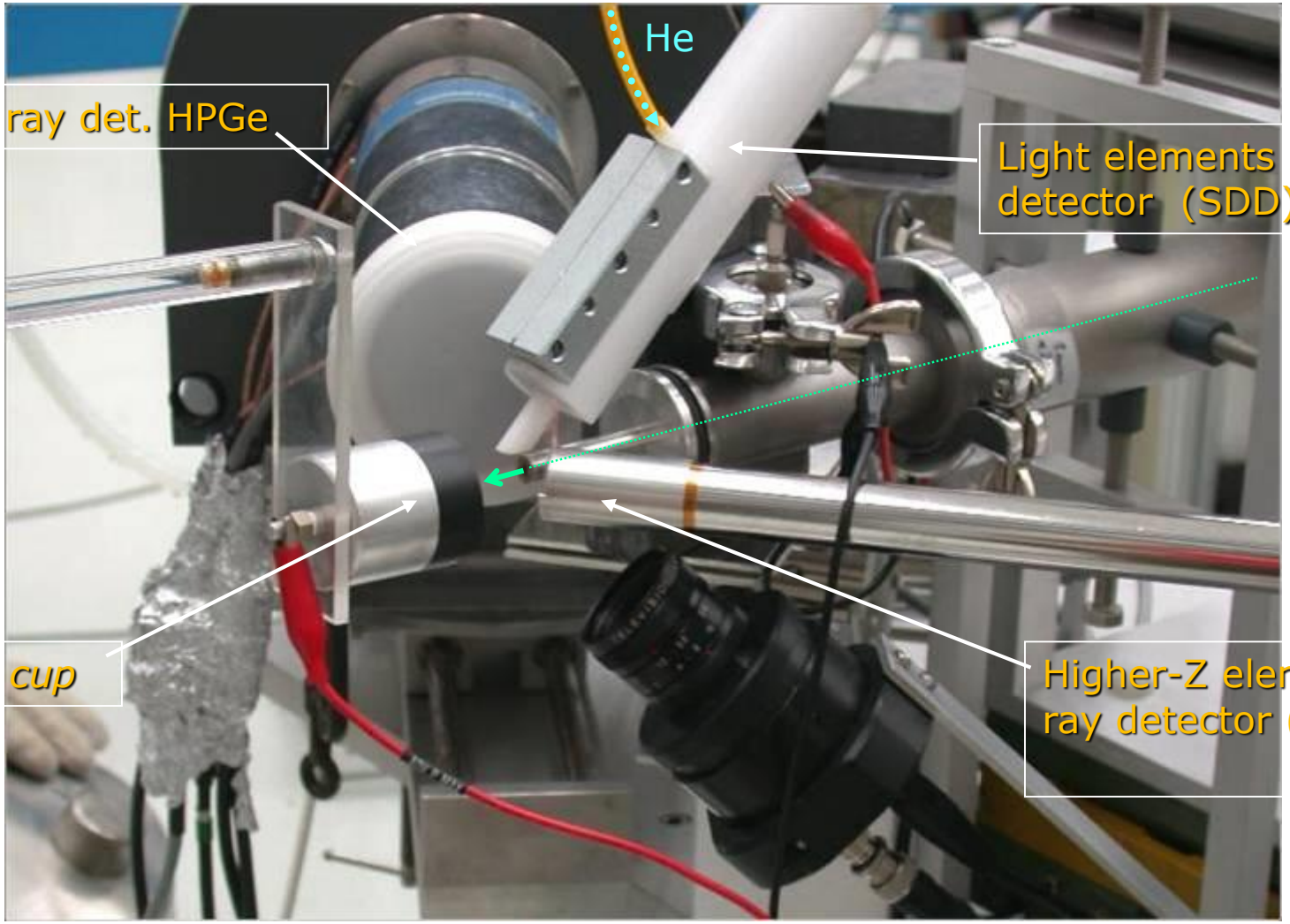


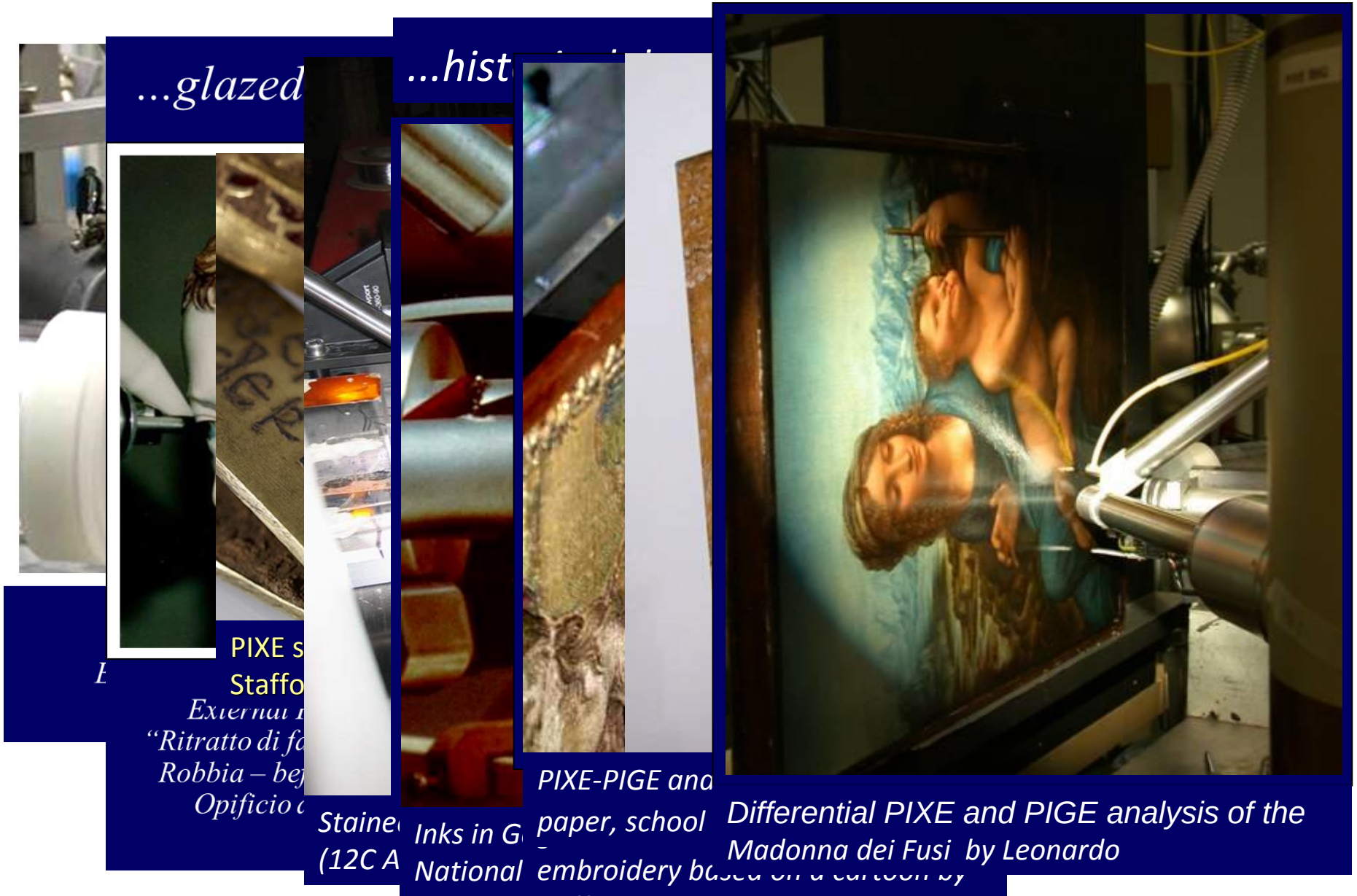
Ion Beam Analysis

Ion beam analysis: determining material structure and composition
>1500



Ion Beam Analysis

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Robbia – bej
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(12C A
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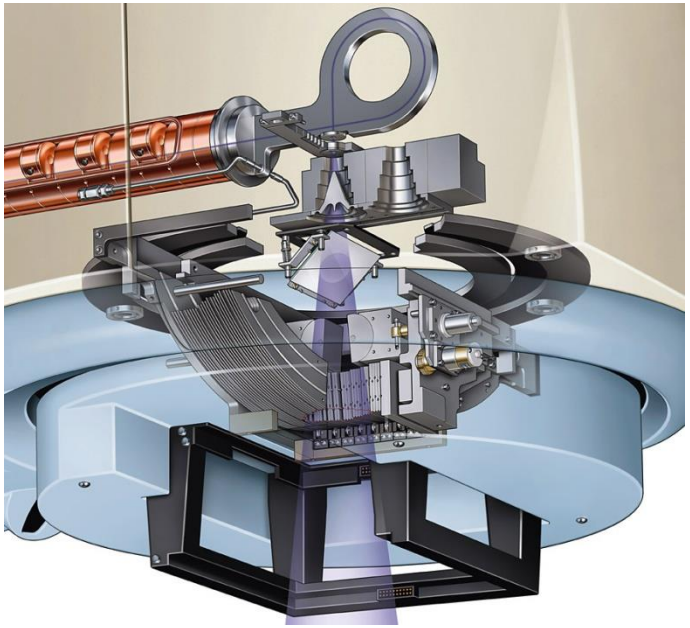
PIXE
PIXE-PIGE and
paper, school
embroidery based on a cartoon by
Raffaellino del Garbo
Differential PIXE and PIGE analysis of the
Madonna dei Fusi by Leonardo

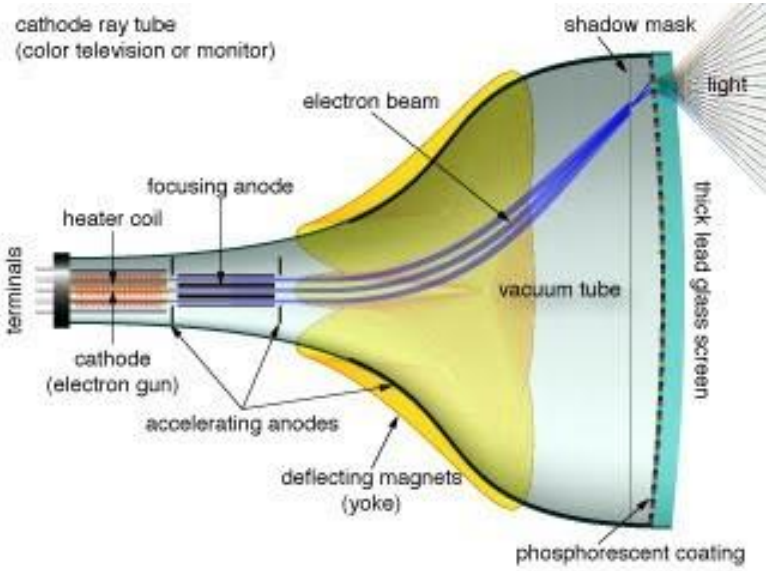
Health: Radiotherapy

- Most radiotherapy uses X-rays for cancer treatment
- Created using electron linear accelerator
- Commercially manufactured
- Energy ~4-20 MeV
- >13000 systems in the World



Conclusions (part 1)

- Particle accelerators are not just the LHC
- Extensively used in industry
- Mainly industrially manufactured
- Reliable
- Relatively easy to use



Conclusions (part 2)

- ARIES WP3
- Industrial and Societal Applications of accelerators
- Studying improvements in technology
- Investigating new applications
- Many experts in the field involved
- More partners are welcome!

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