APPLICATIONS OF PARTICLE ACCELERATORS IN EUROPE

A. Faus-Golfe

on behalf of APAE committee

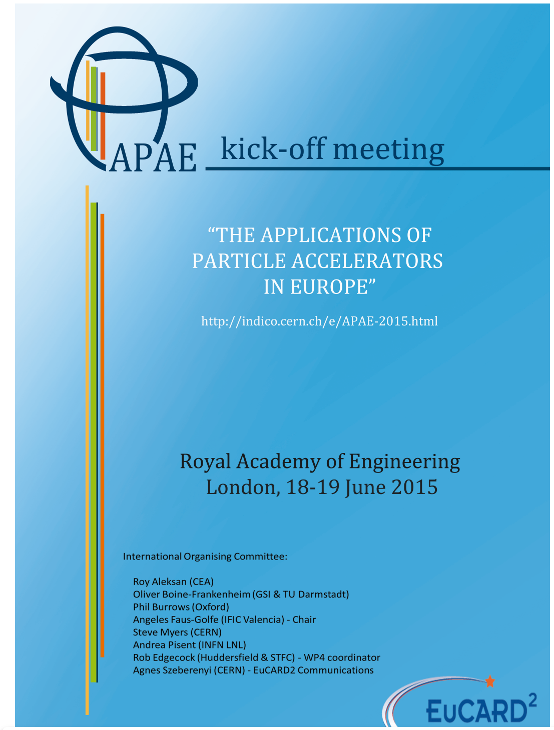
Outline

- APAE Project Objectives
- APAE Working group
  - APAE International Committee
  - Areas, Conveners and Roles
- Meetings and Highlights
  - Kick-off
  - Medium-term
- Future work

Key questions: what does the man in the street need?

More and better science – we all agree!
More and better life – we all agree, too…

WP4 Accelerator applications



People in the street need the LHC (and now the FCC…) but need as well more and better medical isotopes, better materials, better semiconductors, improved security, etc.

June 2015: Kick-off meeting of APAE: document for policy-makers on applications of interest in Europe and for which technology developed for research can have an impact.

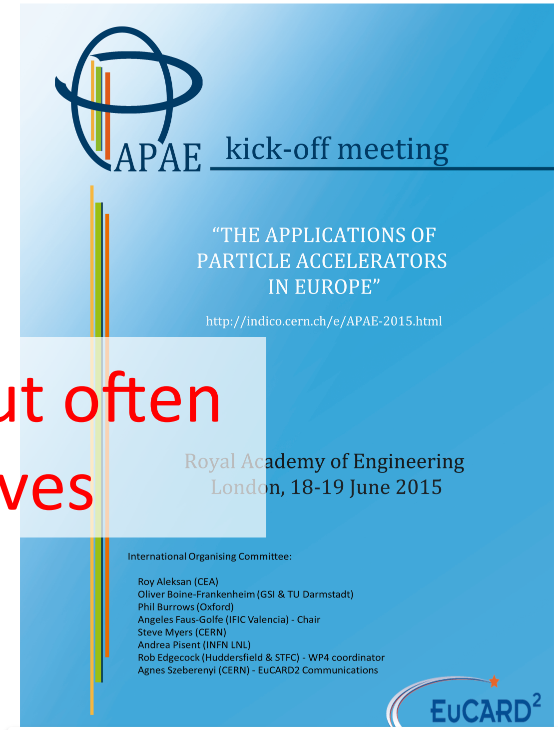
From M.Vretenar Eucard2 coordinator

Key questions: what does the man in the street need?

More and better science – we all agree!
More and better life – we all agree, too…

WP4 Accelerator applications

Accelerators have a very important, but often unseen, impact on our everyday lives


APAE kick-off meeting

"THE APPLICATIONS OF PARTICLE ACCELERATORS IN EUROPE"

http://indico.cern.ch/e/APAE-2015.html

Royal Academy of Engineering
London, 18-19 June 2015

International Organising Committee:

Roy Aleksan (CEA)
Oliver Boine-Frankenheim (GSI & TU Darmstadt)
Phil Burrows (Oxford)
Angeles Faus-Golfe (IFIC Valencia) - Chair
Steve Myers (CERN)
Andrea Pisent (INFN LNL)
Rob Edgecock (Huddersfield & STFC) - WP4 coordinator
Agnes Szeberenyi (CERN) - EuCARD2 Communications

EuCARD²

June 2015: Kick-off meeting of APAE: document for policy-makers on applications of interest in Europe and for which technology developed for research can have an impact.

People in the street need the LHC (and now the FCC…) but need as well more and better medical isotopes, better materials, better semiconductors, improved security, etc.

From M.Vretenar Eucard2 coordinator

Objectives

The aim of the project is to create a European document equivalent of the "Accelerators for America's Future" document (US focus, 5 years old)

The focus will be on **applications** of interest in **Europe** and for which technology developed for research can have an impact. The document will be entitled **"The Applications of Particle Accelerators in Europe"**

Objectives

It is intended for policy makers, as a result, it will be in two parts:

- Executive summary, focussing on the main issues for each country and in the correct language (International Committee)
- Supporting document in English (Conveners)

It is being organized by Work Package 4 of EuCARD²

Avoiding duplications with others existing docs in Europe such: the Nupecc report, but exploiting the complementarity and synergies on work already done in Europe:

- TIARA, Accelerators for Society
- CERN document
- Documents from various countries

Report will be finished by end of EUCARD2 April 2017

The Working Group

WP4:

- ✓ Rob Edgecock (WP4 coordinator)
- ✓ Agnes Szeberenyi, Jennifer Toes

International Organizing Committee:

- ✓ Roy Aleksan
- ✓ Oliver Boine-Frankenheim
- ✓ Phil Burrows
- ✓ Angeles Faus-Golfe
- ✓ Manjit Dosanjh (Steve Myers)
- ✓ Andrea Pisent

International Committee and Roles

International Committee charge is:

- Identify the areas and the conveners ✔
- Coordinate and support the different areas and conveners ✔
- Meeting organization: kick-off ✔
  mid-term and next ✔
- Responsible for writing of the Executive summary, focussing on the main issues for each country and in the correct language (French, Spanish, Italian, German, Swedish…)
- Ensure Main doc (English) is well balanced

Areas, Conveners and Roles

Energy	**Fission:** E. Mund, G. Van den Eynde **Fusion:** A. Mosnier **Accelerators:** J.L. Biarrott
Health	**Radiotherapy:** A. Mazal (M. Dosanjh) **Radionuclides**: O. Lebeda **Accelerators:** H. Owen
Industry & Environment	**Ion implantation and beam analysis**: M. Chiari **Low energy e^- beams**: A. Chmielewski **Very-low energy e^- beams :** F. Roegner
Security	G. Burt, J. O'Malley
Photonics	L. Rivkin, T. Garvey
Neutronics	M. Lindroos, E. Tanke (collaborators: P: Mastinu , M. Seidel, J. Thomason)

Areas, Conveners and Roles

Conveners charge will be to:

- Identify the agenda and speakers for the appropriate session at the kick-off meeting ✔
- Invite participants to the meeting ✔
- Create a working group to deliver a chapter for the application area ✔
- Writing the chapter (first version provided)

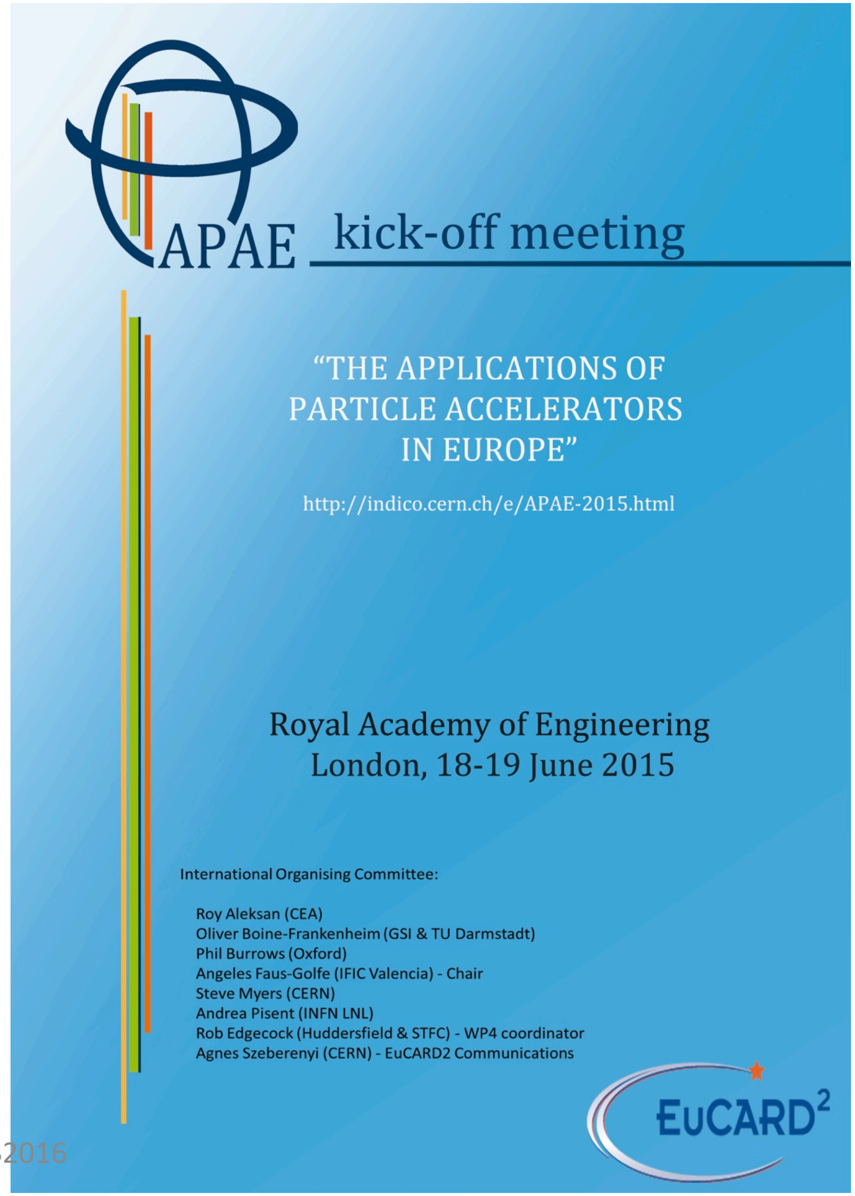
The main document: the chapters

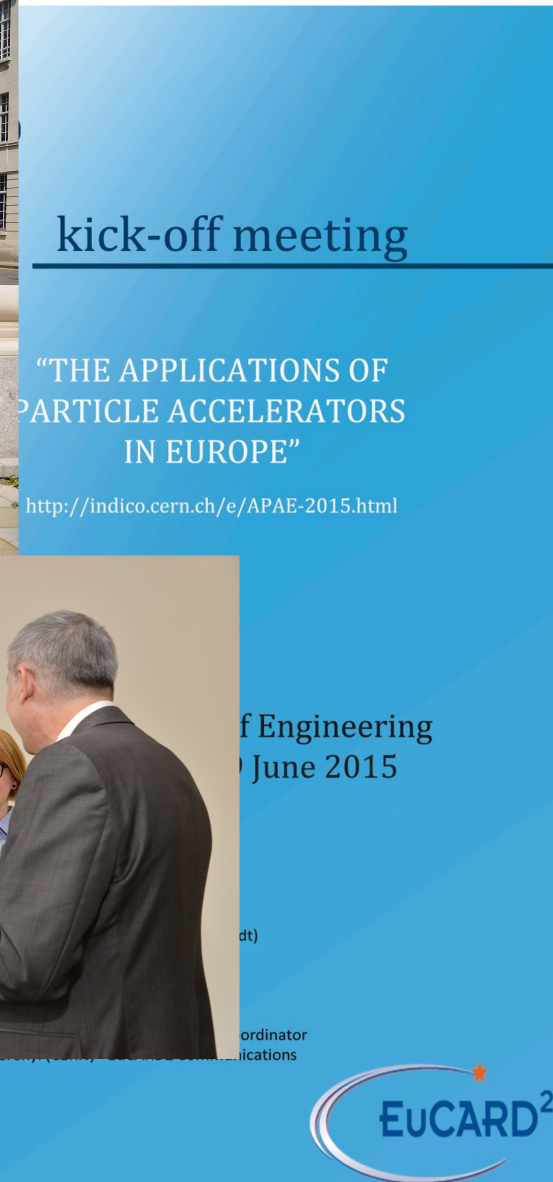
Each Chapter will have:

TABLE OF CONTENTS

Kick-off meeting

- Starting the APAE process
- Bring together people interested in the different application areas
- Initial discussion of what to include
- Existing and possible new applications
- Identification of the next steps




kick-off meeting
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http://indico.cern.ch/e/APAE-2015.html
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June 2015
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ications
EuCARD²

Kick-off meeting: the programme

APAE kick-off meeting:

"The Applications of Particle Accelerators in Europe"
Royal Academy of Engineering
London, 18-19 June 2015

Thursday 18 June 2015

09:00 09:30	**Registration and Coffee**	
09:30 10:00	**Welcome and Opening**	
10:00 11:15	**Security** G. Burt	
	Imran Tahir, Rapiscan Systems	Application of Accelerators in borders and homeland security
	Philippe Dethier, IBA	The Rhodotron used as an X-ray generator for next generation automated 3D Cargo Inspection System
	John O'Malley, AWE	Opportunities for accelerator driven radiation sources to support the detection of radiological and nuclear materials
	Slawomir Wronka	- Security applications development at NCBJ
	Discussion session animated by G. Burt: Present challenges for accelerators for Security, future needs in the next decades....	
11:15 11:30	**Coffee**	
11:30 13:00	**Industry and Environment: Ions** Roger Webb, Massimo Chiari	
	Russell Gwilliam	Ion implantation
	Franco Lucarelli	Ion beam analysis
	Graeme Taylor	Metrology and accelerator applications
	Discussion session animated by Franco Luc... Present challenges for accelerators for Industry ar... future needs in the next dec...	
13:00 14:00	**Lunch**	
14:00 15:00	**Industry and Enviro...** Andrzej Chmielews...	
	A. G. Chmielewski	Developme... ...accelerators and e/X systems en... ...plications of electron beams – ma... ...ization, food irradiation and ...vironment
	M. Fulop	... facility equipped in electron
	M. Dems...	...accelerators for radiation processing
15:30 16:00	**Tea**	
16:00 17:00	**...dustry and Environment: Electrons**	
		...wide sprayed field of application for low energy electron irradiation in European Industries
	...d	e-beam Goes Viral: "the pipeline of applications for compact, sealed, low-energy EB accelerators"
	Discussion session animated by F.H. Roegner: ...esent challenges for accelerators for Industry and Environment: Electrons, future needs in the next decades....	

APAE kick-off meeting:

"The Applications of Parti... ...n Europe"

Friday 19 June 2015

09:00 10:30	**Health** ... Dosanjh, O. Lebeda, H. Owen	
	P...	...iation Treatment
		...isotopes
		Accelerators
10:30 1...	**Coffee**	
1...	**Discussion** session animated by Manjit Dosanjh: ...esent challenges for accelerators for Health, future needs in the next decades....	
...	**Photonics** L. Rivkin	
	Gabriel Aeppli	Photonics applications: from beamline to industry
	Ian Robinson	Use of beam brilliance in imaging nanomaterials
	Discussion session animated by Leonid Rivkin: Present challenges for Photonics, future needs in the next decades....	
12:15 13:00	**Neutronics** M. Lindroos	
	John Thomason, ISIS	ISIS and future short pulse spallation sources in Europe
	Eugene Tanke, ESS	The first long spallation source (ESS) and continuous sources spallation sources (PSI
	Pierfrancesco Mastinu, LNL-	Compact neutron sources
	Discussion session animated by Eugene Tanke: Present challenges for Netronics, future needs in the next decades....	
13:00 14:00	**Lunch**	
14:00 15:30	**Energy** E. Mund, A. Mosnier, J.L. Biarrott	
	Alban Mosnier	FUSION: overview talk (fusion energy, ITER, IFMIF, accelerators status & challenges)
	Gert Van den Eynde	- FISSION: Transmutation issue, the GEN IV scenarios and the MYRRHA project
	Dirk Vandeplassche	- FISSION: ADS accelerator developments presently on-going for MYRRHA and possibly for the Chinese-ADS
	Discussion session animated by Jean Luc Biarrott: present challenges for accelerators for energy, future needs in the next decades....	
15:30 16:00	**General Discussion**	
16:00 16:30	**Tea** for the non conveners and organising committee	
16:00 17:00	**Closed session** with conveners and organising committee	

Mid-term meeting: only IOC and Conveners

Monday 8 February 2016

13:00 14:00	Registration and Coffee	
14:00 14:15	Welcome and Opening	
14:15 15:30	**Outline of the chapters:** Presentation by the conveners	
		Neutronics (30')
		Health (45')
15:30 16:00	Tea	
16:00 18:00	**Outline of the chapters:** Presentation by the conveners	
		Industry and Environment: Ions (45')
		Industry and Environment: Electrons (45')
		Photonics (30')

Tuesday 9 February 2016

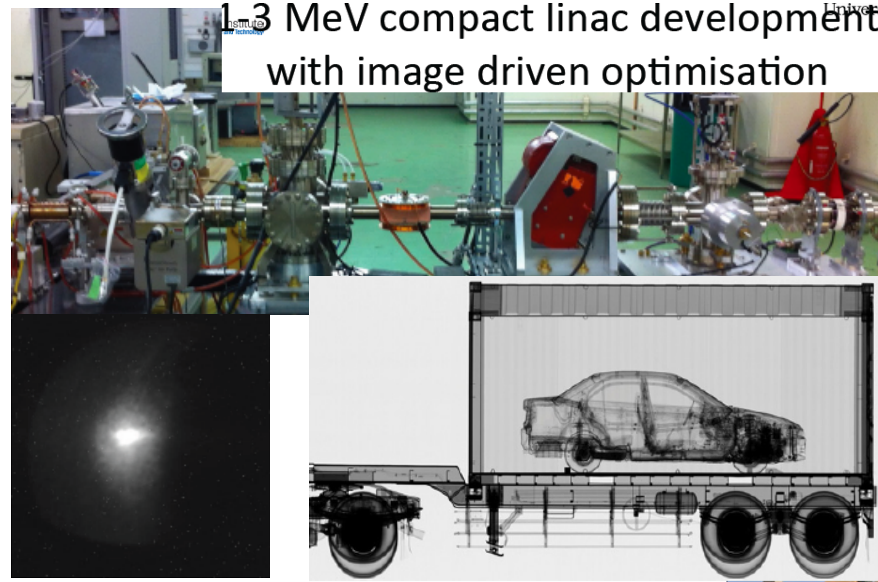
09:00 10:30	**Outline of the chapters:** Presentation by the conveners	
		Security (30')
		Energy (45')
	Summary (15')	
10:30 11:00	Coffee	
11:00 12:30	Organization of the chapter contents	
12:30 14:00	Lunch	
14:00 15:30	Executive summary and brochure	
	Technical Issues: Material sharing, template, professional help...	
15:30 16:00	Tea	
16:00 17:00	Concluding Remarks and Next steps	

Highligths: Security

Security Applications of Accelerators

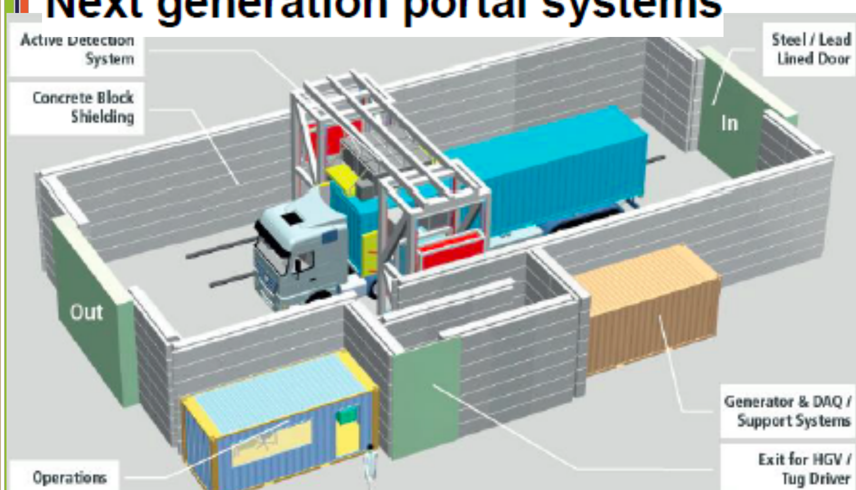
- X-ray cargo imaging (1-10 MeV electrons via linac or Rhodotron)
- Gamma's (10-20 MV) inducing resonances in nitrogen for explosives detection.
- Neutron cargo imaging for material discrimination (sometimes combined with photons)
- Active special nuclear material detection (neutrons or photons possible, some 10 MeV photons some 5 MeV D+ from RFQ to obtain gamma and neutrons)
- Flash radiography of Nuclear equipment (Electrostatic 10 MeV, ~kA ions)

1-3 MeV compact linac development with image driven optimisation



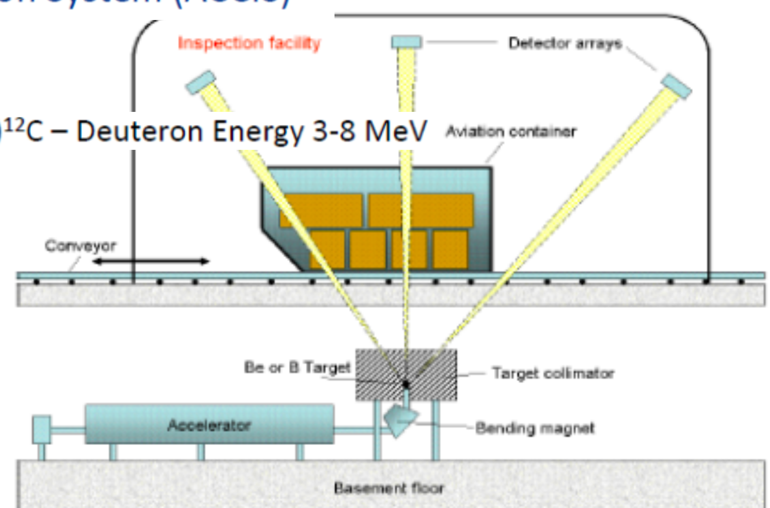
Active Fission Tecniques

Next generation portal systems



Automatic Cargo-Container Inspection System (ACCIS)

$^{11}B(d,n+\gamma)^{12}C$ – Deuteron Energy 3-8 MeV



Highligths: Security

Challenges

- More stable and repeatable dose from dual energy LINACs for improved and reliable material separation. That in turn requires better control of the magnetron RF output and High Voltage Pulse Forming Network

- More higher energy photons per incident electron in the LINAC output energy spectrum in order to achieve better penetration

- Reduction in undesired radiation from the accelerating structure by better design to achieve lighter weight shielding and smaller exclusion zone around the LINAC to suit busy port environment

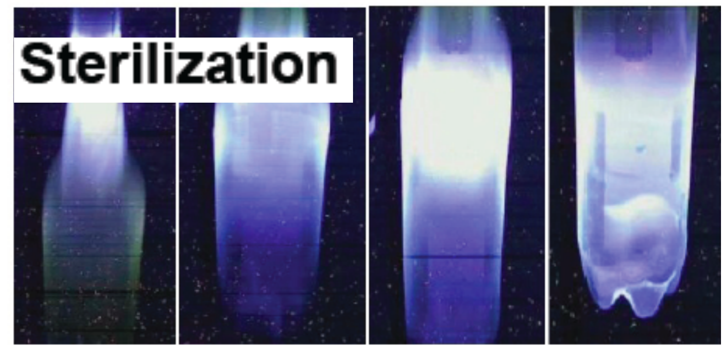
- Higher Pulse Repetition Frequency to achieve better image resolution

Highligths: Energy & Environment: very low energy e⁻

Effects of Electron Beam Interaction

Thermal Processes	Non-thermal Processes	
Heat Production	Chemical Reactions	Biocidal Effects
Vacuum	Atmosphere	Atmosphere
- Evaporation - Melting - Welding / Joining - Hardening - Micro- structuring	- Curing - Crosslinking - Drying print-inks - Surface modification (Grafting)	- Disinfection of animal feed - Seed treatment - Sterilisation of products - Sterile packaging - Inactivation of pharma waste

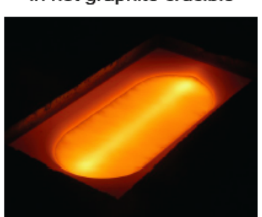
inside EB sterilizing of bottle preforms



Melting and Evaporation

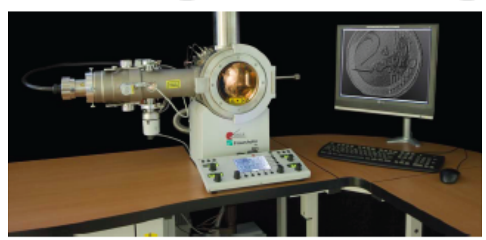
Aluminum melt (with slag) in cooled copper crucible

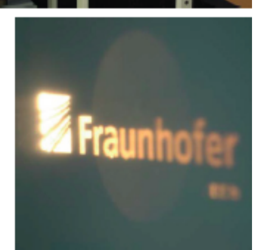
Silicon melt in hot graphite crucible



EB source ALD 400+
at test furnace EMO of Fraunhofer FEP

Welding and Joining





Disinfection of Seeds

Highligths: Energy & Environment: very low energy e^-

- **RESEARCH CHALLENGES**
  - Electron exit window limits actually the applicable power density
  - Very low energy application are requested (< 80 kV)
- **OTHER CHALLENGES**
  - Come to better familiarity with the technology in industry
  - Reduce mental reservations
- **PRIORITY AREAS FOR R&D NEEDED**
  - More cheap, compact and robust eb sources, easy to handle
  - Dosimetry for low energy electron applications
  - Online process control

Highligths: Energy & Environment: low energy e^-

BACKGROUND AND STATE OF ART

- Regarding synthetic polymers and rubber, the well established industrial technologies exist.
- Commercial radiation sterilization has been used for more than 50 years. The main market share is covered by gamma irradiators, but the situation may change soon , due to development of e/X systems.
- A joint FAO/IAEA/WHO Expert Committee approved the use of radiation treatment of foods up to 10 kGy dose in 1980.
- The number of electron accelerators used for these purposes is growing.
- Over the last few decades, extensive work has been carried out for utilizing electron-beam technology for environmental remediation. This includes application of this technology for flue gas treatment, purification of drinking water and wastewater, and hygienization of sewage sludge for use in agriculture.
- Protection of books, archives and artifacts from destruction caused by insects and microorganisms is one of the main aims of the cultural heritage objects conservation.The promising alternative for this technique can be ionizing radiation including electron beam for some applications.
- Special applications regard biological hazards. The units equipped in 10 MeV accelerators are in operation in the US.

Highligths: Energy & Environment: low energy e⁻

RESEARCH CHALLENGES

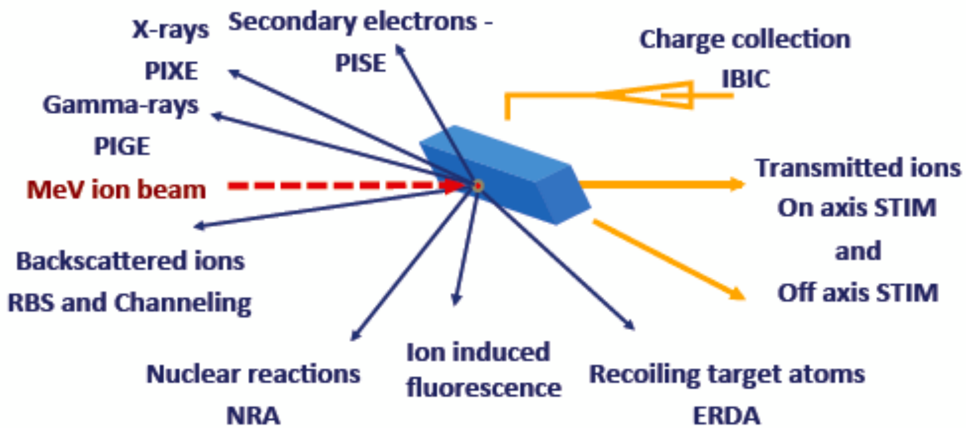
- The development of nanostructures and nanocomposites including graphene is a new field of research and applications.
- The other important field of research are environmental applications in the field of gaseous and liquid effluents treatment. The research concern solid waste treatment as well.The field require development of low cost realiable accelerators.
- The possibility of cultural heritage objects conservation has to be studied more intensively. The wider use of this technique requires conclusively establishing that irradiation doses not lead to unacceptable changes in the functional or decorative properties of the artefact and its authenticity not compromised.

EAS FOR R&D NEEDED

- New developments require the industrialization of new solutions, like superconducting RF cavities, magnets, and other accelerator components such as cathodes, klystrons, advanced material windows etc The more efficient for generating of x-rays on e/X systems should be investigated.
- Further fundamental research into the physical, chemical and biological effects of radiation should be continued. It should concern application of eb in biological systems (sterilization, biohazards, waste) and materials (nanotechnology, grapheme, nanocomposites etc).

Highligths: Energy & Environment: IBA

Ion Beam Analysis are a suite of analytical techniques that exploit the interactions of rapid (~MeV) charged particles with matter to determine the elemental composition and structure of the surface regions of solids inferred from measured quantities such as X-ray, gamma-ray and charged particle spectra



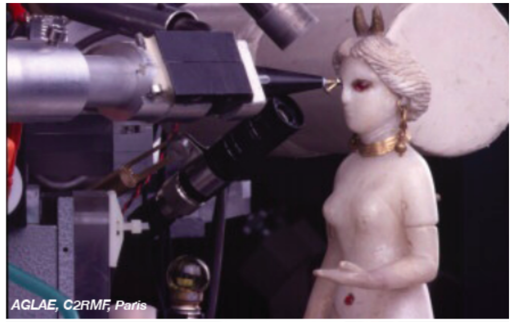
- Multi-elemental (from H to U)
- Non-destructive
- Sensitivity to trace elements (µg/g)
- Highly quantitative (few %) and traceable

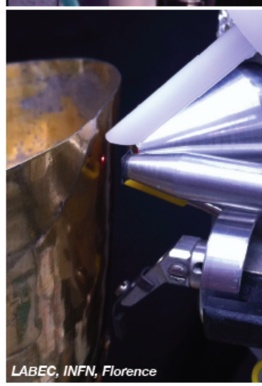
- Concentration profiles
- Surface analysis (up to 1-30 µm)
- Microanalysis (lateral resolution <1 µm)
- 2D mapping

Highligths: Energy & Environment: IBA

IBA for Cultural Heritage

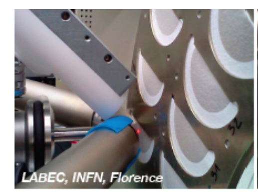
- What IBA can do in cultural heritage studies?
  - Materials identification (analysis of major elements)
  - Materials provenance, sources of raw materials and trade routes (analysis of trace elements)
  - Manufacture technology (microanalysis and depth profiling)
- Information can be obtained in a fully non-destructive way, thanks also to the use of particle beams "extracted" from the accelerator beamline into the external atmosphere.

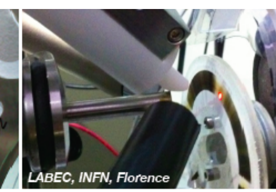


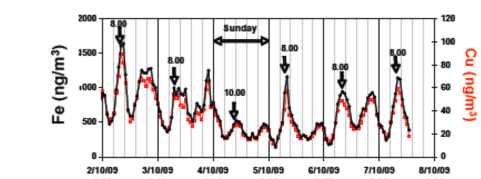


IBA for the Environment

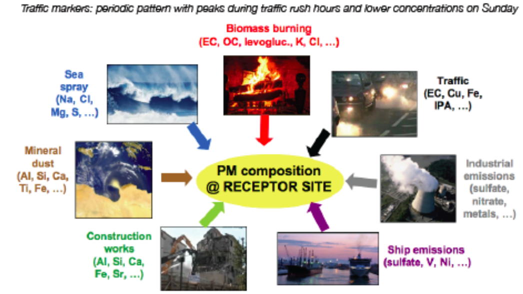
- Fine particle air pollution impacts human health, affects climate, travels large distances across international borders.
- IBA techniques can produce large databases of elemental concentrations (daily and with high time resolution) from the small samples coming from air pollution.
- IBA techniques provide quantitative source characterisation and identification, extremely useful to environmental pollution agencies and policy makers.







Traffic markers: periodic pattern with peaks during traffic rush hours and lower concentrations on Sunday



Highligths: Neutronics

Background

- Neutron beams are being used extensively in science and industry to investigate the properties of matter
- Neutrons can also be used for cancer therapy, for radioactive waste transmutation and Accelerator Driven nuclear power systems, as well as measurements of nuclear data for fundamental physics, medical and energy physics
- Research reactors, which traditionally have been the major source of neutrons for research, require fissile material handling, potentially a major constraint for both handling and licensing

- A majority of these reactors will be phased out over the coming ten years
- The spallation process is the most practical and feasible way of producing neutrons for a reasonable effort (or simply cost) of the neutron source cooling system
- Spallation sources come in at least three types:
  - short pulse sources (a few μs)
  - long pulse sources (a few ms)
  - continuous sources

Highligths: Neutronics

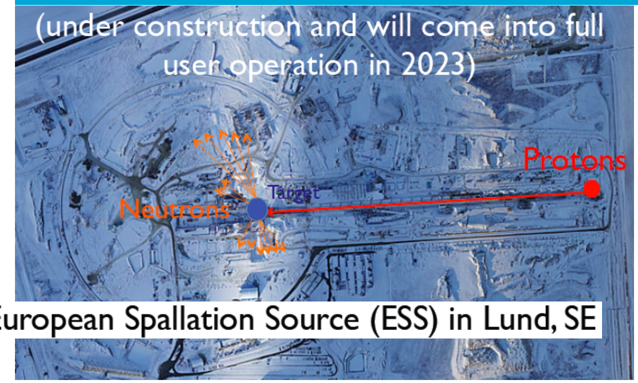
State of the art

Short pulse source in Europe

ISIS in Harwell Oxford, UK (operational)

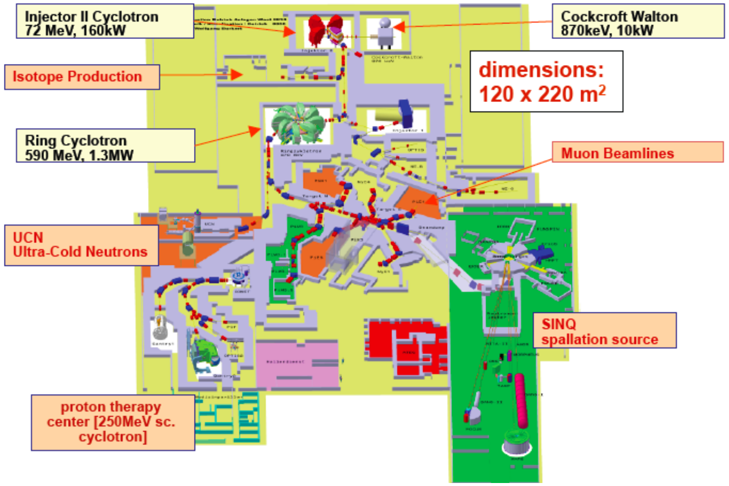
Long pulse source in Europe

(under construction and will come into full user operation in 2023)



European Spallation Source (ESS) in Lund, SE

Continuous source in Europe



Swiss neutron source at PSI in Villigen, CH (operational)

- Compact sources producing neutrons using a smaller and cheaper accelerator below the spallation energy threshold
  - ➢ Feasible for use at a hospital for e.g. cancer therapy, in industry for specific material studies and imaging or at universities or smaller labs for training and quick and cheap service to private companies
  - ➢ In Europe today, the RFQ based FRANZ CNS in Frankfurt, Germany and the LENOS CNS in Legnaro, Italy are under construction and other countries are planning for such facilities

Highligths: Neutronics

Research challenges

- High availability and high intensities of neutrons required to reach a neutron flux equal to or better than what research reactors deliver
  - ➢ accelerator availability and efficiency can be improved through e.g. research on high quality factor cavities, cheaper manufacturing technologies, reliable and robust tuner design and improved cryomodule design
- Keeping beam loss below the 1 W/m required for hands-on maintenance (especially for multi-MW facilities)
  - ➢ Understanding and measuring beam loss

- Cheaper, more compact and more energy efficient RF sources for linacs as these drive cost both for the capital investment and the operation of the facility
- Grid to beam energy conversion efficiency is an issue for all accelerator concepts
- For synchrotrons and FFAG accelerators the injection is usually the limiting factor together with space charge limitations
- For cyclotrons clean extraction with electrostatic elements is optimized by maximizing turn separation and by minimizing generation of tails from space charge effects; H_2^+ acceleration and stripping extraction is a new concept being explored
- For CNS, simple operation, low cost and low energy consumption is very important. The major beam physics issues arise at the early stage of acceleration where spatial charge confinement is challenging

Highligths: Photonics

Background and state of the art

- Accelerator based photon sources
  - Historical evolution
    - rotating anodes
    - parasitic use on HEP synchrotrons
    - dedicated synchrotron radiation storage rings (bending magnets)
    - Insertion device dominated storage rings
    - Linac based light source (SASE FEL's)

- Other accelerator based light sources
  - Compton back-scattering
  - Energy Recovery Linacs
  - FEL Oscillators (mainly IR)

X-ray / VUV FEL projects around the world

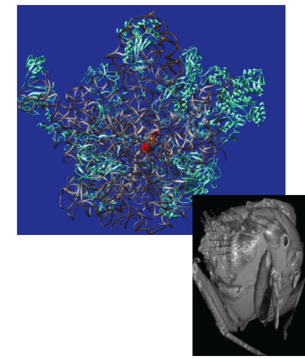
B2016

Hard X-Rays: imaging and diffraction

- Phase contrast imaging, ptychography
- Element specific, very high resolution
- Bulk material can be probed with high energy photons in transmission

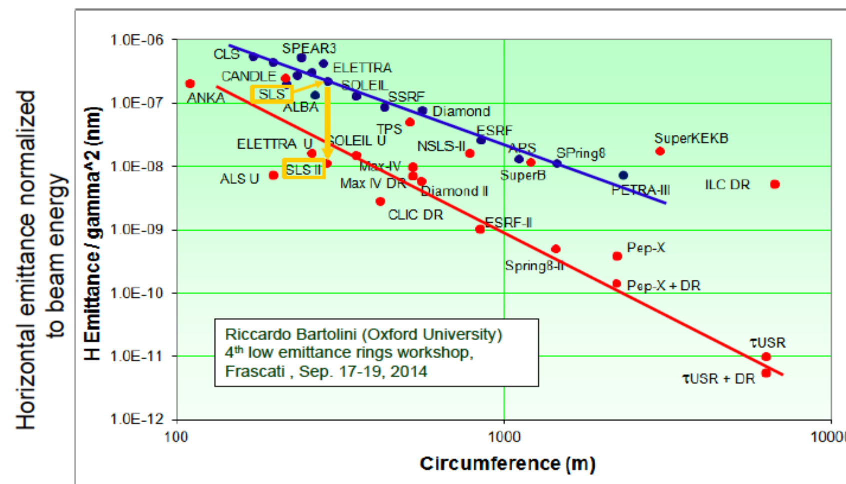
Bio-imaging

- High resolution, high speed tomography
- Mammography: hospital tests
- Neurological applications



Therapy

- Radiotherapy: new dimensions
- Micro-beams, cyberknife

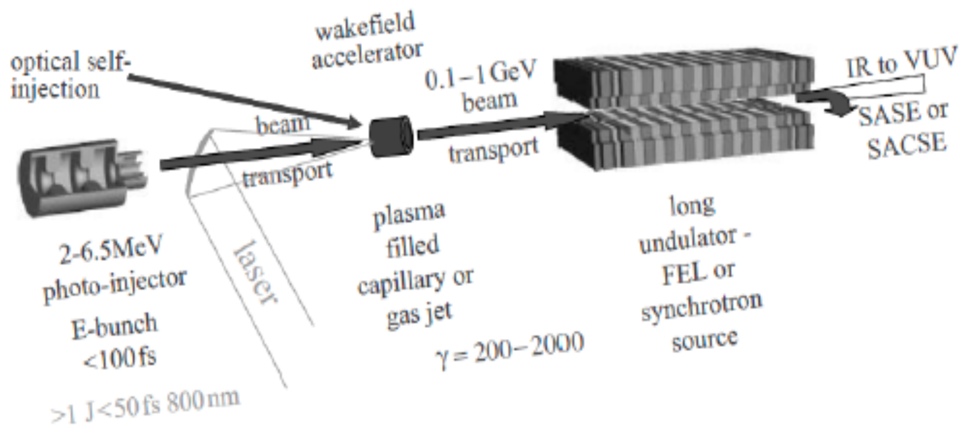


Storage rings in operation (•) and planned (•).
The old (—) and the new (—) generation.

Highligths: Photonics

Research challenges

- Higher brightness storage rings – multi-bend achromat designs
- Seeding for increased temporal coherence of short wavelength FELs
- High Gain High Harmonic Generation
- «Table-top» (plasma) light sources - many technological challenges !

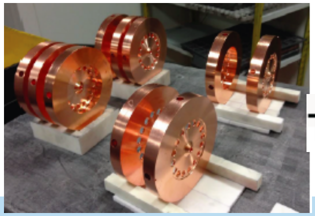


- Synchronisation - Femtosecond → attosecond and diagnosis

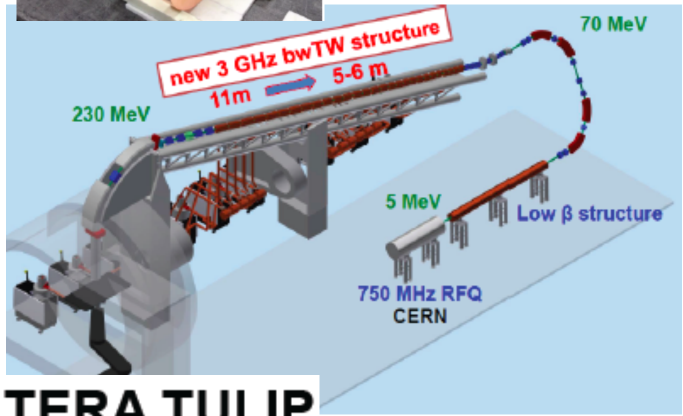
Highligths: Health accelerators

Research Challenges – Proton Therapy

- Trends
  - >100,000 patients now treated with protons/ions
  - >50 centres in operation, ~20 under construction
  - Spot scanning + gantries seen
  - >10 companies active commercial suppliers
- Technical Innovations:
  - SC cyclotrons, esp. isochronous
  - Compact synchrotrons
  - High-gradient RF systems
  - FFAGs
  - Novel beam delivery
  - Imaging methods
- Research challenges
  - Low-cost systems. esp. SC cyclotrons
  - High dose-rate systems
  - Access to higher energies for imaging
  - Novel technologies for scanning and delivery, e.g. achromatic gantries, SC magnets in gantries
- SC magnet technology a key technology driver
- High-gradient linacs a potential disruptive technology
- FFAGs not yet implemented
- Laser-plasma not demonstrating its potential

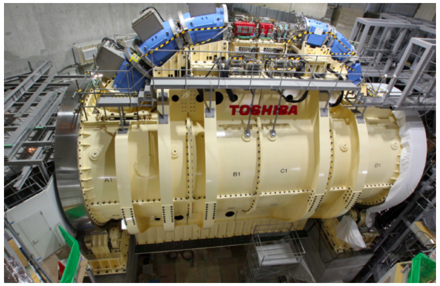


TERA 3 GHz SCL



TERA TULIP

Gantries



NIRS SC

HIT C^{6+}

Research Challenges – Ion Therapy

- Trends
  - Clinical centres now in operation around globe
  - USA case building for ion therapy provision (following early pioneering work)
  - UK interest in ion therapy
  - Initial EU centres have proven viability of technology
- Technical Innovations:
  - SC gantries will be key to near-term growth
  - Many technical innovations, but unproven in clinic
- Research challenges
  - Unclear best technical route to future ion therapy – cyclotron, synchrotron, linac, FFAG all possible
  - Use of hybrid systems?
- SC magnet technology a key technology for delivery
- Alternatives to carbon?
  - 11C, 10C, He

Highligths: Health accelerators

Research Challenges – Radiotherapy

- Conventional X-ray very well established
  - Cost reductions and innovation primarily in commercial sector
  - Opportunity for research?

- Electron therapy gaining niche interest
  - Relies on laser-plasma or high-gradient

- BNCT/neutrons
  - Likely to remain niche area

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Dedicated talk tomorrow morning (MUNES project)

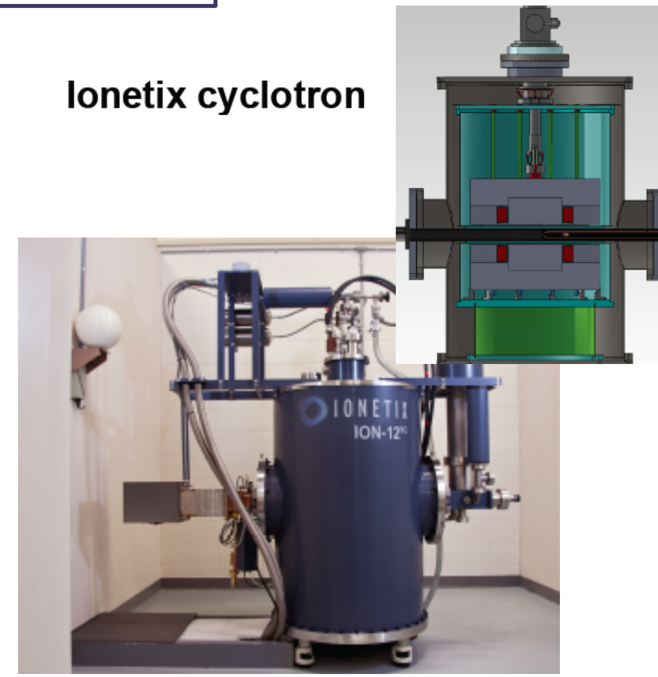
Highligths: Health accelerators

Research Challenges – Medical Isotopes

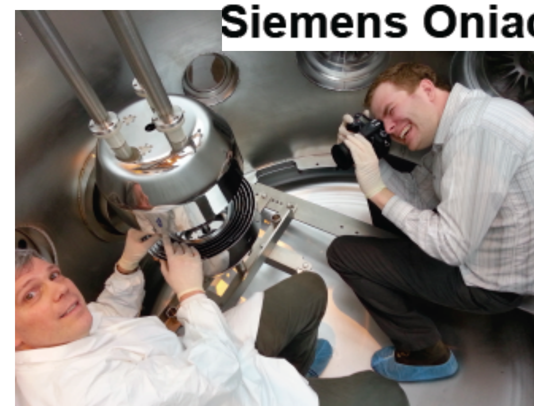
- 99mTc and 18F workhorses of nuclear medicine
  - 99mTc not yet produced significantly with cyclotrons
- Primary production route through high-current p+ cyclotrons from 10-30 MeV
- Trends in production technology
  - Very high current machines, e.g. c.1mA ACSI TR-24
  - Very compact cyclotrons, incl. SC machines
  - Novel acceleration routes: RFQs, DC, laser
  - Novel methods for 99mTc: p+ 24 MeV, e- 25 MeV e/g, D-T>n
  - MEDICIS and MEDICIS-like facilities/methods

- Trends in isotope demand
  - 99mTc slow growth, potentially displaced by PET
  - Novel isotopes for molecular imaging/targeted therapy: 64Cu, 124I, 223Ra, 225Ac
  - Candidates: 44Sc, 45Ti, 67Cu, 211At etc.
- Challenges
  - 99mTc complex in EU; UK/ French differences
  - Significant opportunity in novel isotopes

Ionetix cyclotron



Siemens Oniac



Compact isotope RFQ system

Production for PET scans of ^{18}F and ^{11}C

Highligths: Health accelerators

Research Challenges – Medical Isotopes

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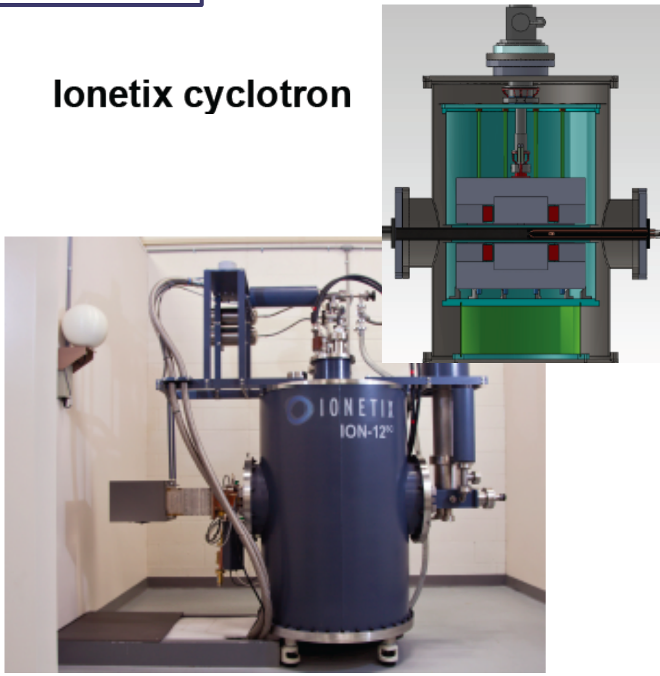
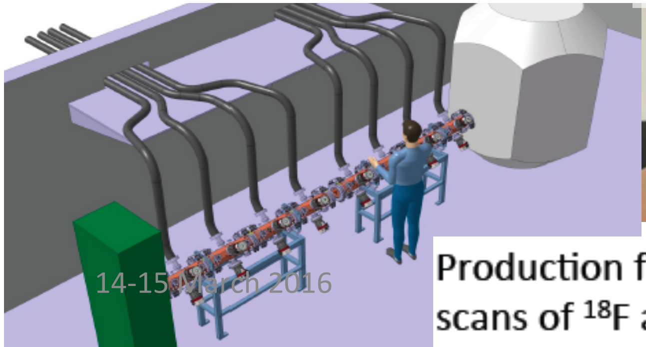
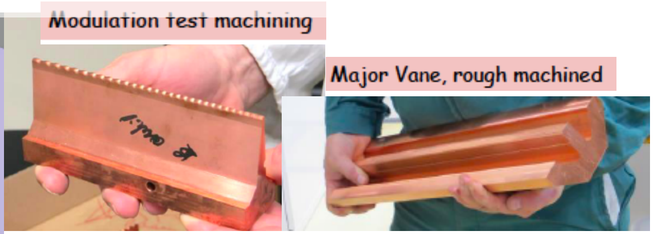


Siemens Oniac

Dedicated session tomorrow morning

Compact isotope RFQ system





Production for PET scans of ^{18}F and ^{11}C

Next steps and actions

- **APAE web page** http://apae.ific.uv.es/apae/

will be updated:

  - home page with contents and pictures
  - info of the meetings and material private area
  - ….

with the help of A. Szeberenyi and Jennifer Toes

- **Deadlines for full document**:
  - end February: all chapters finished
  - end March: 1st version of complete document for comments by conveners
  - end April: deadline for comments
  - end May: final version for comments by conveners, IOC, working groups, …
  - end July: deadline for comments
  - end December Printing the document

"google docs" platform will be use for the interchange of different versions and revision

Next steps and actions

- **Deadlines for brochures**
  - beginning August: final version of full document send it to professional writer (Nina Hall) for extracting the brochure
  - mid September 1st version in English for IOC revision
  - mid October approval and final version in english, send it to IOC for translation to the different languages:
    - French (R. Aleksan)
    - Spanish (A. Faus-Golfe)
    - German (O. Boine-Frankenheim)
    - Italian (A. Pisent)
    - Polish (A. Chmielewski)
    - Swedish (M. Lindroos)
    - Hungarian (A. Szeberenyi)
    - Belgium (G. Van den Eynde)
    - Dutch (E. Tanke)
    - Russian (L. Rivkin) …
  - end December final version in different languages and printing

Next steps and actions

- We have asked the **TIARA support,** a presentation of the project will be made in the next TIARA meeting on 6-7 June 2016 in Madrid

- **Other characteristics for full document**:
  - Few hard copies, number has to be determined depending on cost, A. Szeberenyi will ask for a cost estimation
  - A pdf copy will be available in the APAE webpage, we will ask for mobile compatibility and electronically digital reading availability

- If **necessary a meeting** will be hold at **CERN mid-September**

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The work is in progress but a lot of work has to be made until the end of 2016. Document has to be finished in April 2017.

Thanks to all the IOC and the conveners for their collaboration

Contact: Angeles.Faus-Golfe@uv.es