

# Concept design of a high power Cyclotron for transmutation of radioactive waste.

*A proposal for call in  
EU2020  
Future Emerging Technology*

M.Losasso, CERN  
July 2016

# Meeting agenda

1. *Welcome and introduction by Project Coordinator*
2. *Brief Presentation of the Participants and Organizations involved*
3. *FET – Background – Status of the play*
4. *HPCYC proposal – WP sharing*
5. *Points to elaborate*
6. *Road Map to Proposal Preparation*

# Status of the play

- After the stop on last year, CERN management has agreed to let CERN coordinate a FET call on high-power cyclotron for radioactive waste transmutation.

*....Au vu de l'intérêt du projet, des technologies (même si le CERN n'a plus de cyclotron en opération), de la faible implication du CERN pour la préparation de l'offre (la contribution de Marcello Losasso) et de l'absence de fonds de contrepartie (financement de EU à 100% en cas de succès), nous sommes d'accord que le CERN joue le rôle de coordinateur pour cette proposition FET....*

*F.Bordry email on 24.06.2016*



# FET mission

- Future and Emerging Technologies activities help to create in Europe a fertile ground for responsible and dynamic multi-disciplinary collaborations on future and emerging technologies and for kick-starting new European research and innovation eco-systems around them. These will be the seeds for future industrial leadership and for tackling society's grand challenges in new ways.
- FET focuses on research beyond what is known, accepted or widely adopted and supports novel and visionary thinking to open promising paths towards radically new technological possibilities. In particular, FET funds interdisciplinary collaborations that seek genuine cross-fertilisation and deep synergies between the broadest range of advanced sciences (including the life sciences, social sciences and humanities) and cutting-edge engineering disciplines.

# FET program

The FET programme has three complementary lines of action to address different methodologies and scales, from new ideas to long-term challenges:

- © **FET Open** supports the early-stages of the science and technology research and innovation around new ideas towards radically new future technologies. It also funds coordination and support activities for such high-risk forward looking research to prosper in Europe.
- © **FET Proactive** addresses promising directions for research on future technologies in order to build up a European critical mass of knowledge and excellence around them.
- © **FET Flagships** are science-driven, large-scale, multidisciplinary research initiatives oriented towards a unifying goal, aiming at transformational impacts with substantial benefits for European competitiveness and for society.

# Call - FET-Open – Novel ideas for radically new technologies - H2020-FETOPEN-2016-2017

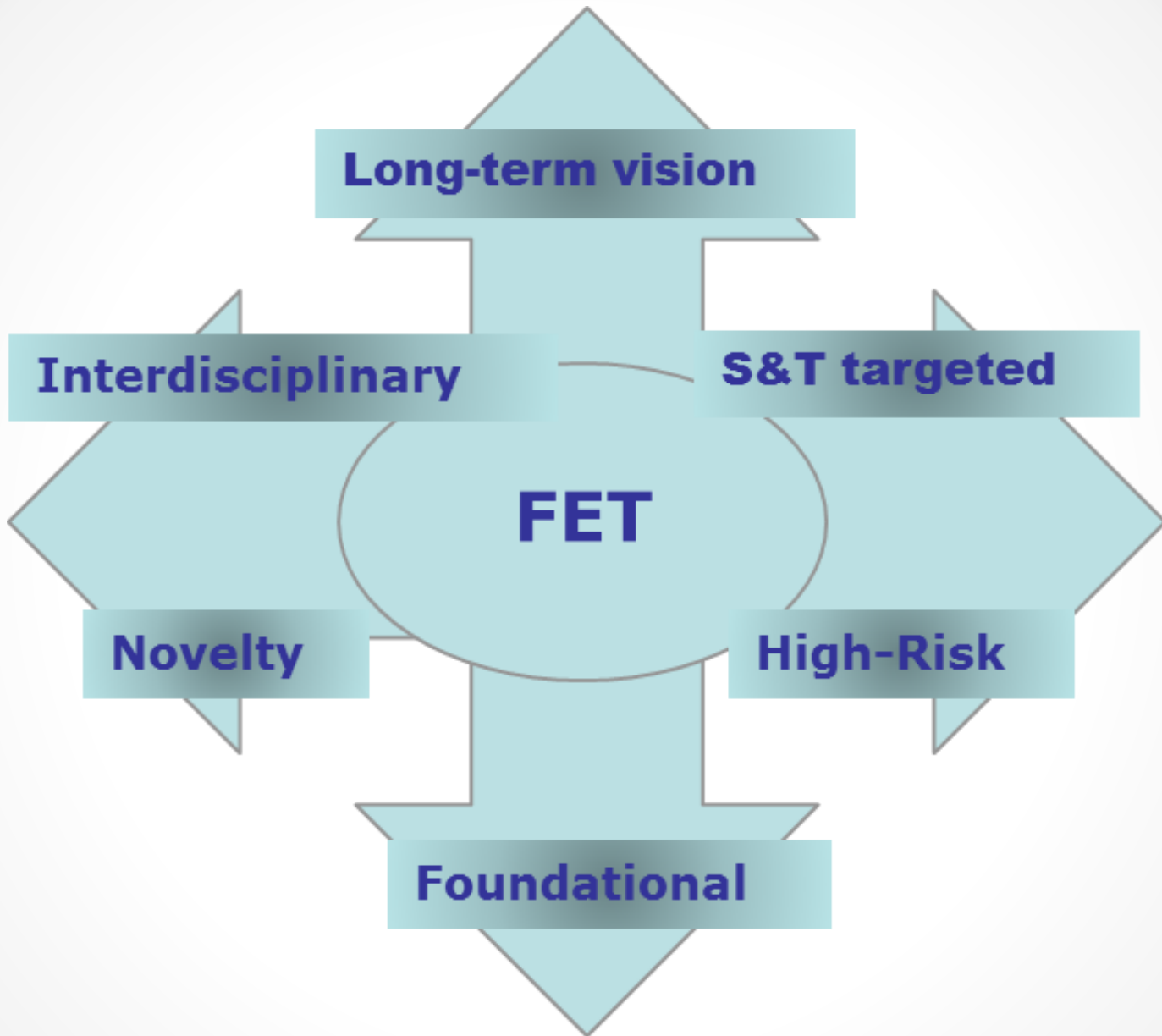
This call aims to support the early stages of joint science and technology research for radically new future technological possibilities. The call is entirely non-prescriptive with regards to the nature or purpose of the technologies that are envisaged and thus targets mainly the unexpected. A bottom-up selection process will build up a diverse portfolio of projects. In order to identify and seize opportunities of long-term benefit for citizens, the economy and society, the early detection of promising new areas, developments and trends, wherever they come from, will be essential.

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HORIZON 2020 - Work Programme 2016 -2017  
Future and Emerging Technologies

[http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016\\_2017/main/h2020-wp1617-fet\\_en.pdf](http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-fet_en.pdf)





# FET-Open

- <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/fet-open>
- FET Open calls for collaborative research and innovation actions that satisfy 6 'gatekeepers', which define the kind of research that FET is looking at:
  - **Long-term vision**
  - **Interdisciplinary**
  - **Novelty**
  - **Foundational**
  - **S&T targeted**
  - **High-Risk**
- Bottom-up, but targeted - not blue sky research
- Collaborative research
- All technologies, no thematic restriction

- **Long-term vision:** the research proposed must address a new, original or radical long-term vision of technology-enabled possibilities that are far beyond the state of the art and currently not anticipated by technology roadmaps.
- **Breakthrough S&T target:** research must target scientifically ambitious and technologically concrete breakthroughs that are arguably crucial steps towards achieving the long-term vision and that are plausibly attainable within the life-time of the proposed project.
- **Foundational:** the breakthroughs that are envisaged must be foundational in the sense that they can establish a basis for a new line of technology not currently anticipated.
- **Novelty:** the research proposed must find its plausibility in new ideas and concepts, rather than in the application or incremental refinement of existing ones.
- **High-risk:** the potential of a new technological direction depends on a whole range of factors that cannot be apprehended from a single disciplinary viewpoint. This inherent high-risk has to be countered by a strongly interdisciplinary research approach, where needed expanding well beyond the strictly technological realm.
- **Interdisciplinary:** the proposed collaborations must be interdisciplinary in the sense that they go beyond current mainstream collaboration configurations in joint science- and technology research, and that they aim to advance different scientific and technological disciplines together and in synergy towards a breakthrough.

- The Commission considers that proposals requesting a contribution from the EU of up to EUR 4 million would allow to address appropriately the scope.
- Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.
- **Expected Impact:**
  - ⊙ Initiating or consolidating a baseline of feasibility or a radically new line of technology and its future uses by establishing the essential proofs-of-principle and their foundational scientific underpinnings.
  - ⊙ Strengthening European leadership in the early exploration of visionary, new and emerging technologies, beyond academic excellence and with global recognition. This impact can be reinforced by involving also new high-potential actors such as young, both female and male, researchers and high-tech SMEs that may become the European scientific and technological leaders and innovators of the future.
  - ⊙ Impact is also sought in terms of the take up of new research and innovation practices for making leading-edge science and technology research more open, collaborative, creative and closer to society.

# TIMELINE of CALL-OFF

Topics (Type of Action)	Budgets (EUR million)		Deadlines
	2016	2017	
<b>Opening: 08 Dec 2015</b>			
FETOPEN-02-2016 (CSA)	3.00		11 May 2016
FETOPEN-01-2016-2017 (RIA)	84.00	110.50	11 May 2016 17 Jan 2017 27 Sep 2017

# Our proposed project:

**Concept design of a compact Cyclotron for transmutation of radioactive waste.**

# scope

- Starting from the current status of the technology and the market outlook, we want to define the requirements for a high-power, compact, cost effective and easy to operate, cyclotron for transmutation of nuclear waste.
- The objective is to deliver a conceptual design that is in principle adoptable by the market.
- We plan to demonstrate the main conceptual aspect of our design with prototypes and PoC demonstrators that are aimed to bridge the gap to industrialization.
- We plan to get a full understanding of the cost drivers that have made unacceptable this technology so far



# how

- By combining novel accelerator technologies, compact reactor concept, the use of MgB<sub>2</sub> superconductors and innovative design features that foresee a single stage accelerator and multiple sources for the injection, our objective is to produce a machine design that is highly reliable, and easily maintained and operated.
- We plan to use as much as possible the results of FP5 projects Europart and Eurotrans dealing with ADS design for transmutation, on all the issues already addressed of safety, radiation protection, transport, secondary waste, cost, scheduling.
- The long term vision of our project: higher reliability and simpler operation will make the unprecedented design ready for adoption in the frame of a larger program aimed to build an industrial machine crucial for the decarbonization of EU in the next decades.



# Evaluation criteria

## EXCELLENCE

Compliance with the FET-gatekeepers as described in the call:

- Clarity and novelty of long-term vision, and ambition and concreteness of the targeted breakthrough towards that vision.
- Novelty, non-incrementality and plausibility of the proposed research for achieving the targeted breakthrough and its foundational character.
- Appropriateness of the research methodology and its suitability to address high scientific and technological risks.
- Range and added value from interdisciplinarity, including measures for exchange, cross-fertilisation and synergy.
- Threshold: 4/5, Weight: 60%



# Evaluation criteria

## IMPACT

Contributions to the impacts listed under this topic in the workprogramme:

- Importance of the new technological outcome with regards to its transformational impact on technology and/or society.
- Impact on future European scientific and industrial leadership, notably from involvement of new and high potential actors.
- Quality of methods and measures for achieving impact beyond the research world and for establishing European though leadership, as perceived by industry and society.
- Threshold: 3.5/5, Weight: 20%

# Evaluation criteria

## IMPLEMENTATION

The following aspects are taken into account:

- Soundness of the workplan and clarity of intermediate targets.
- Relevance of expertise in the consortium.
- Appropriate allocation and justification of resources (person-months, equipment).
- Threshold: 3/5, Weight: 20%

A guide to evaluation of proposal is here:

[http://ec.europa.eu/research/participants/data/ref/h2020/grants\\_manual/pse/h2020-guide-pse\\_en.pdf](http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/pse/h2020-guide-pse_en.pdf)

# Project fits the scope of the call because:

- It will help Europe to grasp leadership into the area of management of radioactive waste, a sector where thousands ton of toxic materials are produced per year, without any yet accepted and adopted solution of definitive disposing **[from IAEA data Waste Counter: 29,620,000 m<sup>3</sup> in ~366 Facilities, Not including some countries]**
- It will bring closer science and society by finding a concrete technical solution for a grand society challenge
- The interdisciplinary action of superconductivity, accelerator technologies, new materials, environmental and nuclear sciences is expected to foster cross fertilization in many different areas, one example are accelerators playing a role in environmental conservation through their use in processing water and flue gases
- It will open a new line of market into the cyclotron business, with expected new jobs in Europe, addressing as well the challenges of next-generation reactors that burn non-fissile fuel, such as thorium, that can be burned with the use of particle beams. Both or either of these approaches could lead to an increase in power generation through greenhouse gas emission-free nuclear energy and could provide a long-term strategy for the energy supply.

# Data IAEA-TECDOC-1613, April 2009

## spent nuclear fuel from nuclear plant worldwide

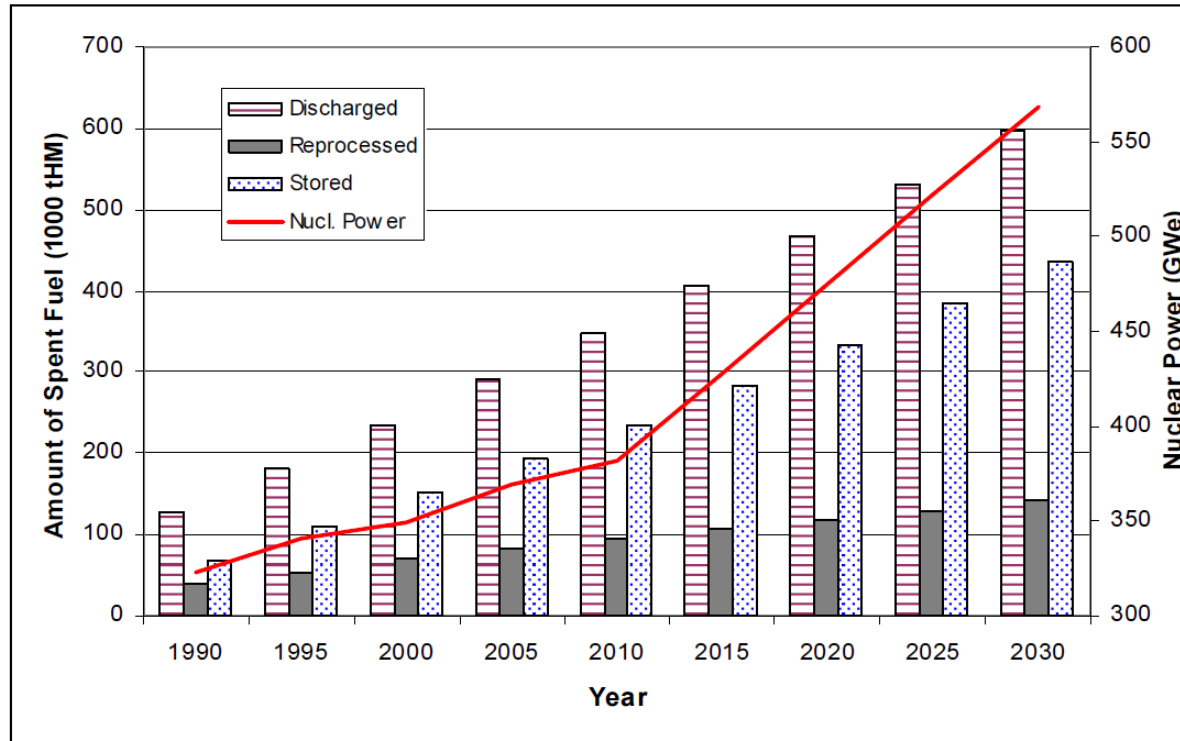


Fig. 14. Cumulative spent fuel discharged, stored and reprocessed from 1990 to 2030.

Even if nuclear would be phased-out tomorrow, the world still would need to address the safe, economic and definitive management of all the waste produced in the last 60 years.

# The project is innovative because:

- A key challenge facing the nuclear fuel cycle is reducing the radiotoxicity and lifetime of spent nuclear fuel. Partitioning or sorting of nuclear waste isotopes and accelerator-based transmutation combined with geological disposal can lead to an acceptable societal solution to the problem of managing spent nuclear fuel.
- The original idea of ADS has never been crossing the “death valley”
- Of the integration into the design of the machine of concepts never explored before in this context (High temperature superconductors, new design of cavity, SOC, for example) that will increase the reliability, reduce the cost, improve the simplicity of the operation.



# value chain and their actors:

- Technology designers → AIMA, ASG
- Design Integrators → CERN, iThEC, PSI
- Application Testing → AIMA, ASG, PSI
- System integrators → Hydromine Nuclear Energy
- Nuclear-21

# Proposed consortia is appropriate because:

- Each partner brings added value. In fact:
- AIMA is EU leader in cyclotron design
- ASG is EU leader into magnet manufacturing
- PSI is the world leader of the cyclotron operation
- CERN is the leader into particle physics and the site of the world largest accelerator, with consolidated experience of integration of research, researchers and technologies.
- Hydromine Nuclear Energy (represented by Ing. Cinotti), holds a large number of patents and invention in many field of nuclear applications
- Nuclear-21 is a Belgian based company specialized in nuclear science & technology services to governments, investors, utilities, industry, R&D-organizations and waste management agencies worldwide.
- ITHEC is a Geneva not-for profit based organization whose mission is to promote innovation into the field of Th, ADS and waste transmutation.



# The proposed work package distribution

- WP0 (**CERN**) → coordination Management, integration, dissemination.
- WP1 (**iThEC**, all) → Identification, definition and integration of machine parameters
- WP2 (**AIMA**, CERN, PSI, ASG) → Novel Cyclotron Design
- WP3 (**Hydromine Nuclear Energy**, iThEC) → Spallation Target design & Beam transport
- WP4 (**iThEC**, CERN, PSI) → Transmutation analysis
- WP5 (**nuclear-21**, all) → Life Cycle Analysis
- WP6 (**ASG**, AIMA) PoC prototypes



WP0 (CERN): coordination Management, integration, dissemination, tech and financial monitoring, coordination of governance committees

WP1 (iThEC):

1. identification of requirements
2. definition of machine parameters
3. integration

WP4 (iThEC):

1. transmutation analysis

WP2 (AIMA): design of novel cyclotron

1. Magnetic design
2. Mechanical design
3. Cryogenic design

WP5 (nuclear-21): life cycle analysis

1. cost/benefit balance for transmutation
2. Socio-political sustainability vs. technical-economic challenges
3. larger economic benefit of this transmutation, e.g. radioisotopes production and separation

WP3 (Hydromine Nuclear Energy): spallation target design & beam transport

1. Interface cyclotron/reactor
2. Adaptation of innovative reactor designs to ADS

WP6 (ASG):

1. Proof of Concept
2. Prototypes

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# proposed way to go:

- July 2016 : Agreement on the consortia composition and work packages distribution
- August 2016 : consolidate partners information ( mail to the project coordinator):
  - Preliminary description of work packages: overall scope, tasks distribution in WPs.
  - General info, administrative data
  - Contacts
  - Draft budget per WPs.
- September. 2016 : VC is arranged with all partners. -→ *fix the date already now: Monday September 12 is ok? In alternative 22 or 23 September?*
- October 2016 : in person meeting. The coordinator edits a first draft for circulation to the partners; internal review with CERN EU experts to address issues in the call preparation
- → *fix the date already now: October 10, Monday, is ok? In alternative all that week is fine with me.*
- November 2016: second draft preparation and approval of the partners
- December 2016: in person meeting, proposal submission. Resolution of issues. Discussion and draft of consortium agreement.

We have to prepare a 16 A4 page document, plus adm info

**⚠ Page limit:**

**The part B (cover page and sections 1, 2 and 3) is strictly limited to 16 A4 pages and shall consist of:**

- A single A4 title page with acronym, title and abstract of the proposal.**
- Maximum 15 A4 pages consisting of an S&T section (section 1), an Impact section (section 2) and an Implementation section (section 3).**

**All tables in these sections must be included within this limit. The minimum font size allowed is 11 points. The page size is A4, and all margins (top, bottom, left, right) should be at least 15 mm (not including any footers or headers).**

**⚠ A proposal that does not comply with these page limits will be declared ineligible.**

# FET open

We have to prepare a 16 A4 pages document, plus adm info

## **Success rates\* for the 1st cut-off date of FET Open call**

RIA: 24 / 643 (3.7%) CSA: 4 / 31 (12.9%) Of note, number of proposals below threshold(s): 385 (RIA) and 10 (CSA) (\*) Number of proposals retained for Grant Agreement preparation / Number of submitted proposals

To increase our chances:

we have to clearly set the appropriate TRL and the ambitions we have for concrete technology transfers

we have to highlight value chain concepts and cross sectorial impact

- **COVER PAGE**

- **Title of the Proposal:**

- **Acronym: HPCYC**

- **List of Participants**

- **Participant No**

- **Participant organisation name Country**

- 1 (Coord) European Organization for Nuclear Research - CERN

- International European Interest Organisation

- 2
- 3
- ...
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- **Abstract:**

- The HPCYC will tackle a societal issue by delivering a novel technical solution to the radioactive waste management. The present solutions for the radioactive waste storage and disposal are not considered satisfactory, and even in the 100% phased out nuclear scenario on a planet scale, the waste is estimated to increase in the next decades to unacceptable levels. The proposed technology will combine status-of the art particle accelerator know-how with new material developments and simulation advances to allow the transmutation of nuclear waste and the reduction of its volume. By delivering PoC prototypes the project will demonstrate the technical and economical viability of the concept, and it will dramatically open the way to new applications for a carbon-free economy and also for HEP.

## Section 2: Impact

2.1 Expected impacts:

## Section 3: Implementation

3.1 Project work plan:

GANTT chart

Work Package description

Pork Package number	1	Start date				
WP title						
Participant no						
Short name						
Person/months						

WP Objectives, Deliverables, Milestones....

WP Description of work.

discussion

