DE LA RECHERCHE À L'INDUSTRIE

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An In-Kind Partner Performing Off-Site Installations

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Overview

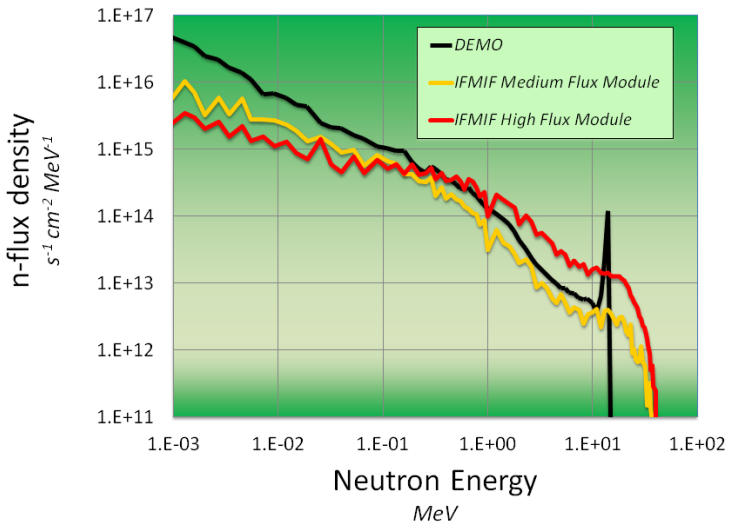
- Introduction: brief IFMIF presentation
- Preparation of Off-site Installation
  - Documents
  - Management of Interfaces
  - Transfer procedure
- Installation on Japanese site
- Few lessons from IFMIF - LIPAc Injector
- Conclusion

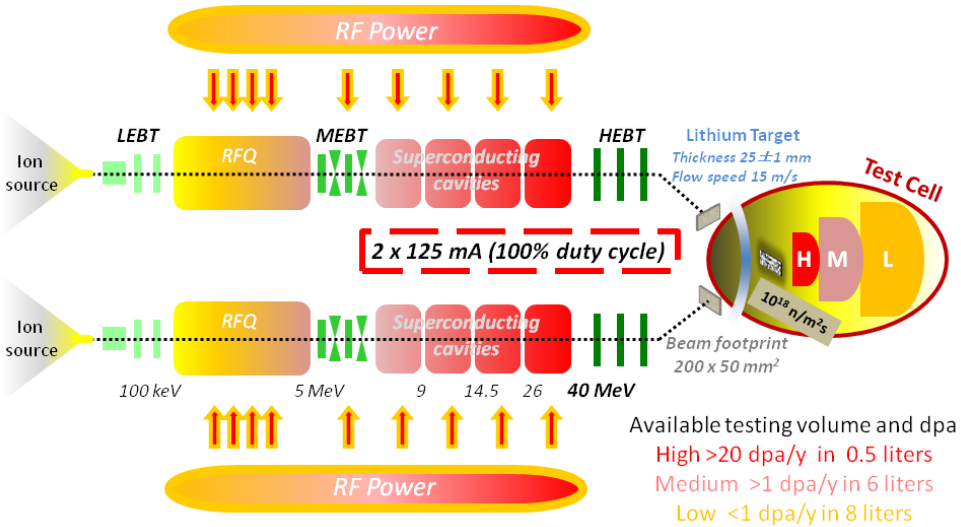
IFMIF PROJECT

(International Fusion Materials Irradiation Facility)

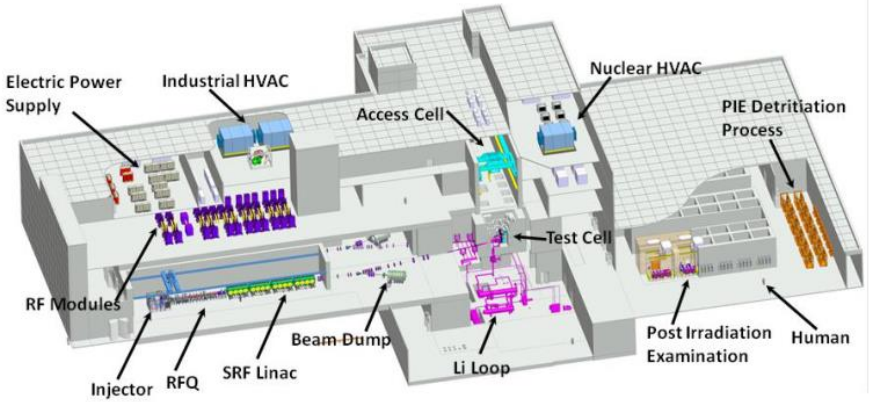
IFMIF aim is the production of a high neutrons flux (10^{18} n m^{-2} s^{-1}) with 14 MeV peak energy

2 D^+ beams (40 MeV energy) will collide on a liquid Li target





Available testing volume and dpa
High >20 dpa/y in 0.5 liters
Medium >1 dpa/y in 6 liters
Low <1 dpa/y in 8 liters



IFMIF – Validation Phase
LIPAC
(Linear IFMIF Prototype Accelerator)

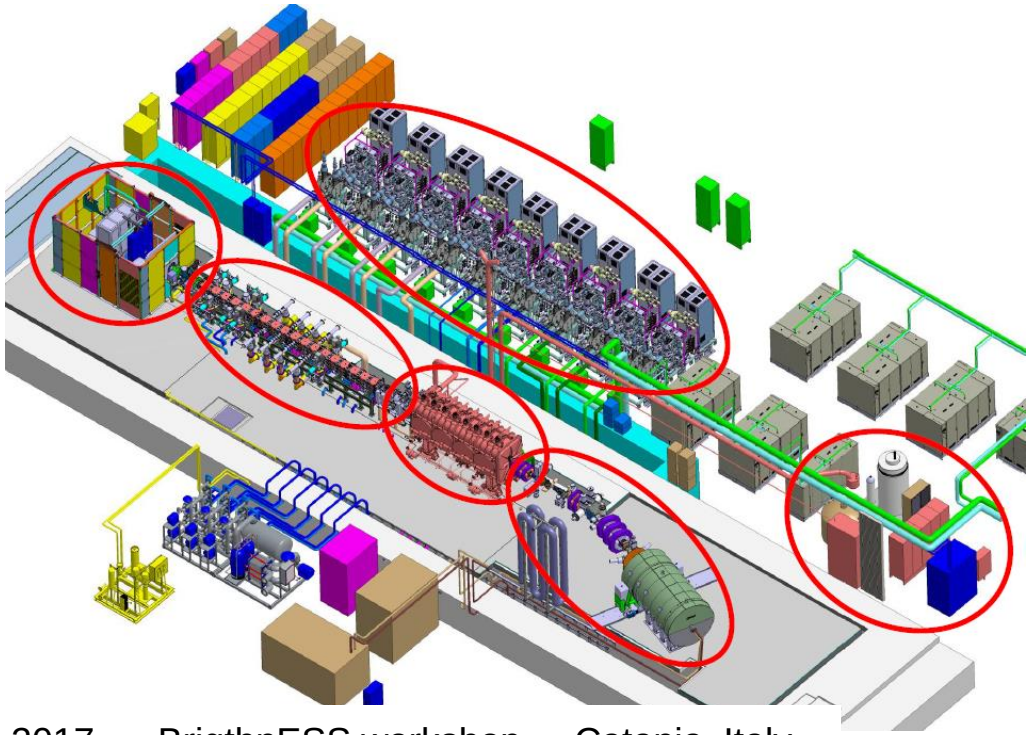
LIPAc = prototype of IFMIF Front End which includes all critical accelerator components to be tested at nominal beam current

LIPAc building at Rokkasho site in Japan

Installation still in progress

International project

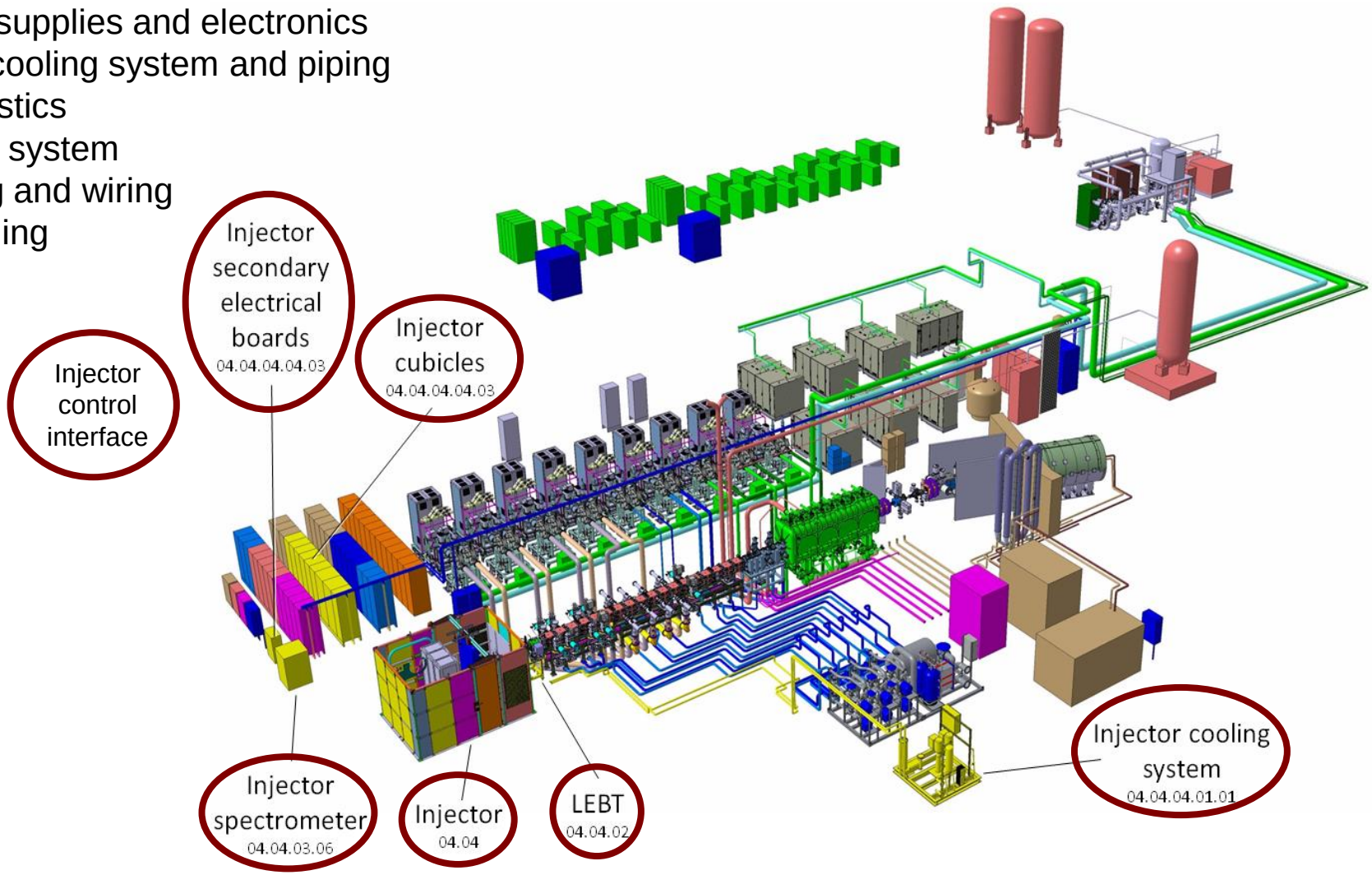
Injector (CEA France)
RFQ (INFN Italy)
Cryomodule (CEA France)
Diagnostics (CEA France, Ciemat Spain)
MEBT + HEBT + Beam dump (Ciemat Spain)
RF power, (Ciemat Spain, CEA France, SCK Belgium)
Cryoplant (CEA France)



Injector

The Injector is a multi-component system:

- Ion source + Beam line
- Power supplies and electronics
- Water cooling system and piping
- Diagnostics
- Control system
- Cabling and wiring
- Grounding



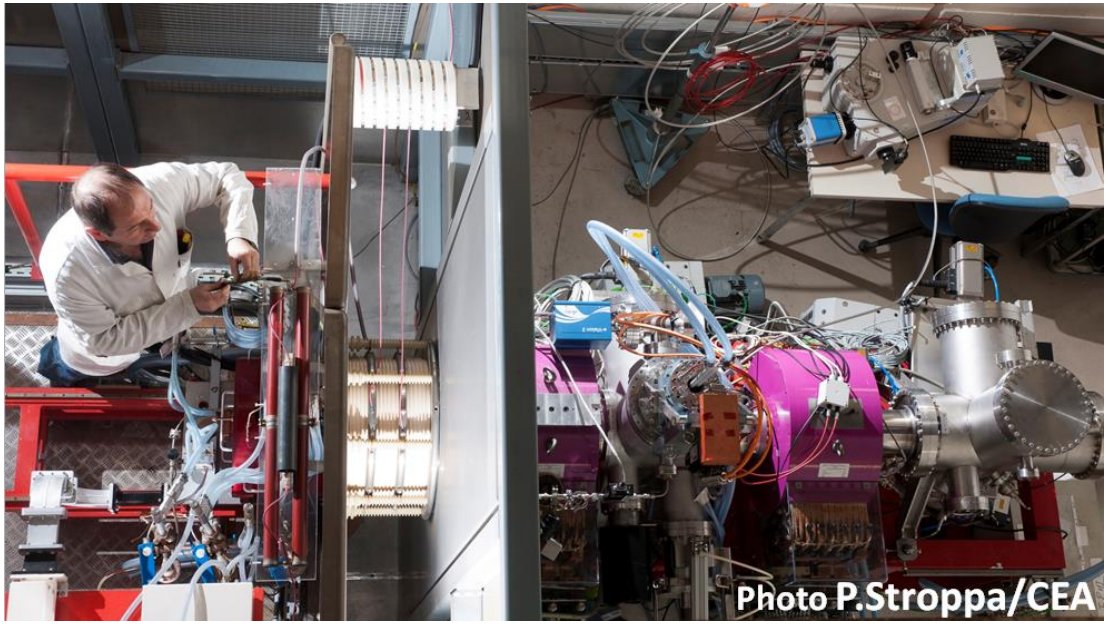
Before Injector Delivery

IFMIF is very challenging
and the challenge starts at the Injector level.

The aim of the injector is
to deliver 140 mA D+ beams
(in pulsed and CW mode)
at 100 keV.

Based on SILHI source,

IFMIF LIPAc Injector has been
designed, built and tested
at CEA/Saclay
before shipment
to Rokkasho site in Japan



Injector Documents

Documents which are part of the Delivery report :

- The **Injector Design Report**
- The **acceptance test report**
- The **assembly procedure**
- The Accelerator System **3D mock-up**
- The **Interface Management System sheets**
- The injector **re-assembly drawings**
- The injector **cabling folder**
- The **check-out procedure**
- The **commissioning procedure**
- The Injector **LCS user manual**
- The **maintenance procedure**

Numerous documents and meetings have to be managed in parallel with technical and scientific work … probably too much for R&D laboratory people

Additional Documents :

- The **minutes** of Injector meetings
- The Injector **LCS maintenance manual**
- The Injector **EMU user manual**
- The Injector **EMU maintenance manual**
- The Injector **PLC maintenance manual: Management of operation**
- The Injector **PLC maintenance manual: Management of vacuum groups**

And after beam production start:

- The Injector **beam switch off procedure**

Interface management

Interface management =

List of all interfaces between 1 sub-system and
- other sub-systems (upstream, downstream and others)
- common utilities (cooling system, electrical power distribution, control system…)
- building (positioning, alignment, anchoring, crane facility, …)

Definition of the interfaces with owners, drawings, documents, etc…

Definition of approval procedure

Interfaces with Injector

System A	System B	Assembly	Title		
Accelerator common utilities	Injector	JAEA or JAEA contractor	Injector cables coming from Injector skid are plugged on the common secondary electric board in the Hex & water cooling area.	Injector provides	
Accelerator common utilities	Injector	JAEA or JAEA contractor	Connection of Injector LVPS cooling pipes on ACU (Accelerator Common Utilities) cooling pipes coming from common skid in the RF area.	ACU provides a a quarter turn va flange bolted to flanges.	
Accelerator common utilities	Injector	JAEA or JAEA contractor	Connection of Injector flexibles on the compressed air networks in the vault.	Injector provides Accelerator Con compressed air n and female coup	
Accelerator common utilities	Injector	JAEA or JAEA contractor	Connection of cable coming from the primary board on the Injector secondary board (PU1)	Building delivers the cable. Injector delivers the secondary electric board with breakers and connectors.	Approved
Accelerator common utilities	Injector	JAEA or JAEA contractor	Grounding of Injector equipment	ACU delivers the grounding network in the vault. Injector delivers cables and associated fixing system (screws, bolts...) between its equipment and the grounding network.	Approved
Injector	RFQ	JAEA or JAEA contractor	Mechanical interface betwen LEBT and RFQ flange in the vault	Injector provides the LEBT flange with its associated Helicoflex joint and screws. RFQ provides the RFQ flange.	Approval Validated
Injector	RFQ	JAEA or JAEA contractor	Electron repeller on the RFQ flange in the vault.	Injector provides the electron repeller with its associated screws, ceramic spacers, the HV cable, the connector and the CF feedthrough. RFQ provides the RFQ flange equipped with the CF16 flange.	Approval Validated

04-05-001 IFMIF-EVEDA/LIPAC Interface Record *(at 06/06/17 11:44*

System A	Injector	System B	RFQ	Assembly
Title	Mechanical interface betwen LEBT and RFQ flange in the vault			
Sharing	Injector provides the LEBT flange with its associated Helicoflex joint and screws. RFQ provides the RFQ flange.			
Part A	Flange DN100 with 8 holes phi8,5 at D=130.3	Model A	Helicoflex ring HN200 - lining material in aluminu	
Part B	Flange DN100 with 8 M8 at D=130.3 for Helicoflex	Model B		
Standard	ISO			
Size: Field 1		Field 2		Field 3
Comment	1- Waiting the update of the RFQ flange mock-up to generate the updated drawing			
References	BA_D_23PUKT - Injector+LEBT vs RFQ			
TRO Support	System A	System B	Assembly	
Overall Status	Approval Validated			

Transport from Eu to Japan

The IFMIF LIPAc injector has been disassembled and packed at Saclay,

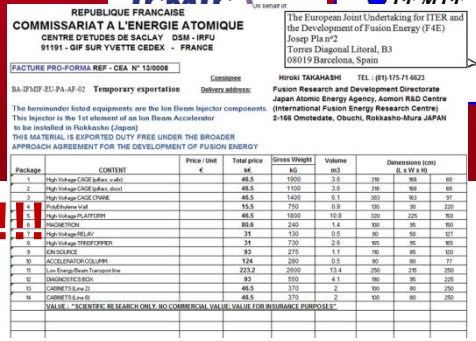
shipped to Hacchinoe port

delivered on the Rokkasho site

Before transfer, preparation of :

- **Transport definition and needed documents**
- **Packaging**
- **Insurances**
- **Customs procedures**
- **Precise list of transferred components**
- **Transfer of property**

Transport from Eu to Japan



REPUBLIQUE FRANCAISE
COMMISSARIAT A L'ENERGIE ATOMIQUE
CENTRE D'ETUDES DE SACLAY DSM - IRFU
91191 - GIF SUR YVETTE CEDEX - FRANCE

The European Joint Undertaking for ITER and the Development of Fusion Energy (F4E)
Josep Pla nº2
Torres Diagonal Litoral, B3
08019 Barcelona, Spain

FACTURE PRO-FORMA REF - CEA N° 13/0008

Consignee: Hiroki TAKAHASHI TEL : (81) 175-71-6623
BA-IFMIF-EU-PA-AF-02 Temporary exportation
Delivery address: Fusion Research and Development Directorate
Japan Atomic Energy Agency, Aomori R&D Centre
(International Fusion Energy Research Centre)
2-166 Omotedate, Obuchi, Rokkasho-Mura JAPAN

The horoinunder listed equipments are the Ion Beam Injector components.
This Injector is the 1st element of se Ion Beam Accelerator
to be installed in Rokkasho (Japan)
THIS MATERIAL IS EXPORTED DUTY FREE UNDER THE BROADER
APPROACH AGREEMENT FOR THE DEVELOPMENT OF FUSION ENERGY

Package	CONTENT	Price / Unit €	Total price k€	Gross Weight KG	Volume m3	Dimensions (cm) (L x W x H)		
1	High Voltage CAGE (pillars, walls)		46.5	1900	3.6	318	168	68
2	High Voltage CAGE (pillars, door)		46.5	1100	3.6	318	168	68
3	High Voltage CAGE CRANE		46.5	1400	6.1	383	163	97
4	PolyEthylene Wall		15.5	750	0.9	130	30	220
5	High Voltage PLATFORM		46.5	1800	10.8	320	225	150
6	MAGNETRON		80.8	240	1.4	100	95	150
7	High Voltage RELAY		31	130	0.5	80	50	127
8	High Voltage TRNSFORMER		31	730	2.6	165	95	165
9	ION SOURCE		93	275	1.1	110	85	120
10	ACCELERATOR COLUMN		124	280	0.5	80	80	77
11	Ion Energy Beam Transport line		223.2	2600	13.4	250	215	250
12	DIAGNOSTICS BOX		93	550	4.1	190	95	225
13	CABINETS (Line 2)		46.5	370	2	100	80	250
14	CABINETS (Line 8)		46.5	370	2	100	80	250
	VALUE : "SCIENTIFIC RESEARCH ONLY. NO COMMERCIAL VALUE. VALUE FOR INSURANCE PURPOSES"							

Do not forget the customs procedures !

And document for the transport:

- **Pro forma invoice**
- Document of **Transfer of ownership** between CEA-F4E
- **Transport** document (to be attached on the packages)
- **Precise list** of elements in each package. Japanese colleagues controlled each package content (and counted the precise number of the provided elements…)

		Project: IFMIF INJECTOR	Dim EXT cm			Volume total m3	Net Weight total kg	Gross Weight total kg
N°		CONTENT	Length	Width	Height			
1	1	High Voltage CAGE (pillars, walls)	318	168	68	3.6	1650.0	1900.0
2	1	High Voltage CAGE (pillars, door)	318	168	68	3.6	850.0	1100.0
3	1	High Voltage CAGE CRANE	383	163	97	6.1	1140	1400
4	1	PolyEthylene Wall	130	30	220	0.9	710	750
5	1	High Voltage PLATFORM	320	225	150	10.8	1450	1800
6	1	MAGNETRON	100	95	150	1.4	160	240
7	1	High Voltage RELAY	80	50	127	0.5	80	130
8	1	High Voltage TRNSFORMER	165	95	165	2.6	600	730
9	1	ION SOURCE	110	85	120	1.1	200	275
10	1	ACCELERATOR COLUMN	80	80	77	0.5	210	280
11	1	Transport Beam LINE	250	215	250	13.4	2245	2600
12	1	DIAGNOSTICS BOX	190	95	225	4.1	380	550
13	1	CABINETS LET2	100	80	250	2.0	250	370
14	1	CABINETS LET8	100	80	250	2.0	200	370
15	1	CABINETS SCE1	100	80	215	1.7	200	300
16	1	CABINETS SCE2	100	80	215	1.7	500	600
17	1	CABINETS SCE3	100	80	215	1.7	200	300
18	1	CABINETS LET5,6,7	200	100	270	5.4	900	1120
19	1	POWER SUPPLIES (soft)	110	110	235	2.8	800	940
20	1	POWER SUPPLIES (soft2)	110	110	235	2.8	800	940
21	1	High Voltage POWER SUPPLIES	140	100	230	3.2	900	1050
22	1	RACK 1	118	88	92	1.0	230	300
23	1	RACK 2	115	78	73	0.7	170	220
24	1	CABLES	178	148	107	2.8	730	830
25	12	WATER COOLING PIPES	6000	7.6	7.6	3.0	250	250
26	1	WATER COOLING SKID	250	265	260	17.2	1900	2350
27	1	ALIGNEMENT SYSTEM	158	58	72	0.7	140	200
28	1	PRIMARY PUMPS	118	68	67	0.5	215	270
29	1	TURBOPUMPS	133	78	117	1.2	235	310
30	1	CONE	73	68	47	0.2	50	70
31	1	FARADAY CUP	113	48	57	0.3	60	100
32	1	BEAM STOPPER	40	40	50	0.1	55	50
33	1	OPTICAL DIAGNOSTICS + COMPUTERS	208	108	137	3.1	290	150
34	1	DIVERS packages (ELECTRONICS and Optic fibers)	128	88	117	1.3	130	200
35	1	Electrical Distribution	203	98	72	1.4	210	300
		TOTAL					19098.0	23345.0

IFMIF LIPAc

PA-AF02
Injector

GEODIS WILSON SPAIN, S.L.U.
Ibañez de Bilbao, 3 -2ª Centro
48001 Bilbao-Spain

Task order number N°1

Consignee
Fusion Research and Development Directorate Japan Atomic Energy
Agency, Aomori R&D Centre
(International Fusion Energy Research Centre)
2-166 Omotedate, Obuchi, Rokkasho

Departure Address
COMMISSARIAT A L'ENERGIE ATOMIQUE
CEA / SACLAY DSM
IRFU / SACM Hall bat. 126
91191 Gif sur Yvette France

Package N°	System	weight (kg)	length (cm)	width (cm)	height (cm)
9	Source	275	110	85	120

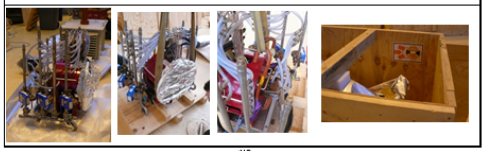
Details of any hazardous contents: *(radioactive, poisonous, corrosive, oxidising, asphyxiating, flammable, explosive, pressurised or otherwise potentially harmful)*

Special requirement for Handling and OPENING:
First OPEN BY THE TOP using a dedicated NAIL EXTRACTOR

Captor sensors:

Type	Number	Requirem ent	Comments
Shockwat ch	2	outside and inside	
Tiltwatch	1	outside	

Pictures:



IFMIF LIPAc

PA-AF02
Injector

GEODIS WILSON SPAIN, S.L.U.
Ibañez de Bilbao, 3 -2º Centro
48001 Bilbao-Spain

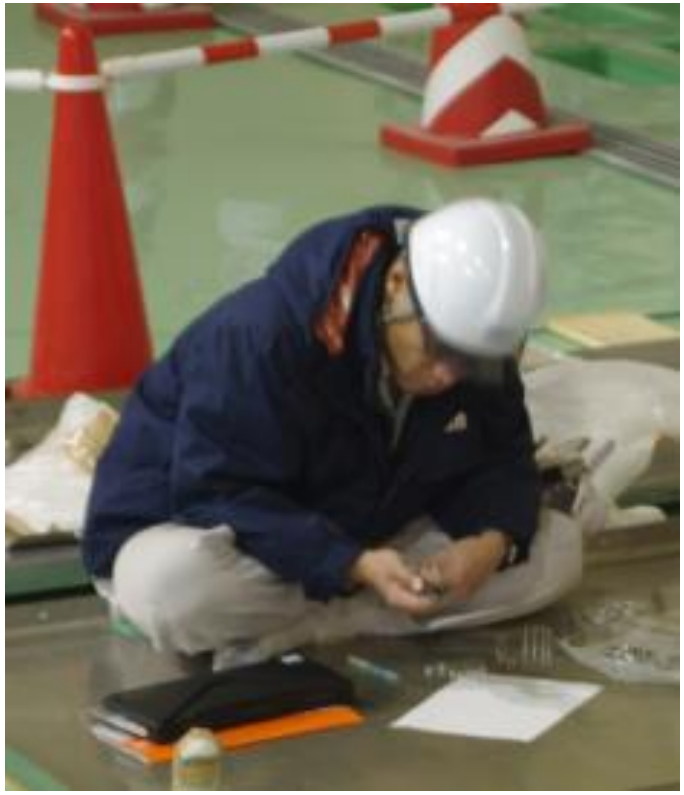
Task order number N°1

Description of contents:

Designation	Quantity	Comments
		HS Code
Lifting loop ESM 18-012-16	4	7326
Quick Link ESM 18-311-14	8	7326
Clevis-end turnbuckle ESM 18-411-16	4	7326
AU4G wedges for LEBT feet	6	7616
CF 250 flanges (SS 304 L)	2	7326
SS M 8x70 H-H Screws	65	7318
SS M 8x55 H-H Screws	100	7318
SS M 8x30 H-H Screws	32	7318
SS M 4x20 H-H Screws	19	7318
SS M6x30 C-H-H Screws	36	7318
SS M6x25 C-H-H Screws	50	7318
SS M4x12 C-H-H Screws	39	7318
SS M4x16 C-H-H Screws	20	7318
M4x16 C-H-H Screws	21	7318
SS Washer phi 4	100	7318
SS Washer phi 6	50	7318
SS Washer phi 8	200	7318
SS nuts phi 4	100	7318
SS nuts phi 6	50	7318
SS nuts phi 8	200	7318
Length of string	20 m	

Detailed inventory

Important to quantify precisely the number of different elements...



Here is not a set of...

Here are:

- n_1 bolts (l = X mm, d = X mm)
- n_2 washers (d = X mm)
- n_3 screws (d = X mm)

Here is :

- 1 LEBT...

That's all!

Missions on site

Before each mission on site, CEA Injector manpower has to :

- deliver a document describing the expected activities with possible risks
- deliver an itinerary table and a Visitor form

When arriving on site:

- follow safety training once a year
- deliver a radioprotection shuttle form
- deliver a medical certificate of less than 6 months

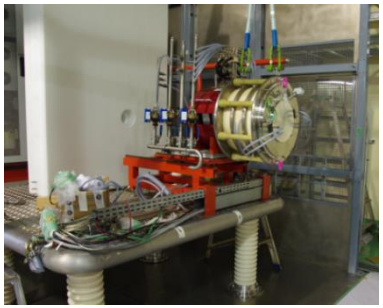
During the mission on site

- Participate to the weekly meeting each Monday morning
- Participate to the daily meeting each morning for a summary of previous work and for pointing out the risks due to co-activities

Installation on site



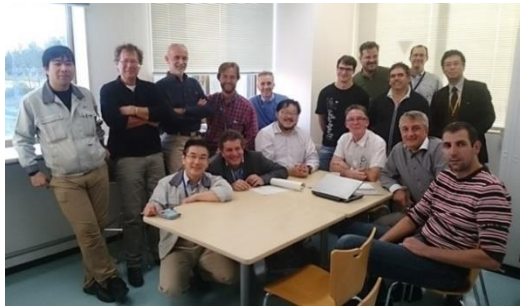
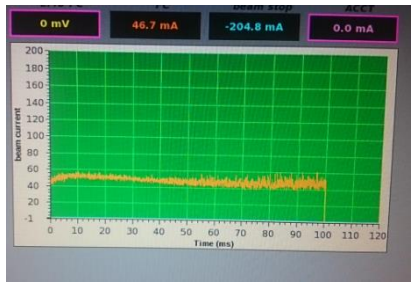










Several Lessons from LIPAc (1)

- Never start construction without consolidated guidelines

- Perfect agreement between guidelines, design report and technical specs has to be verified before starting the realization

- Importance of prerequisites and interface management

- Security and safety have to be clearly defined and spread before starting installation on site:
  - instructions readable by everybody
  - attitude in case of accident,
  - who can do what,
  - problem of co-activities,

- Need experienced manpower with particle accelerator skills on site

Several Lessons from LIPAc (2)

- Site must be well equipped with workshops and spaces with adapted tools for technical activities (mechanics, cabling and wiring, electronic board inspection and repair, etc…)

- Pressure due to POLITICAL Milestones is not beneficial to the project:
  - Not enough time to perform the needed commissioning in Europe
  - Loss of time on final site before starting installation
  - Issues of missing manpower on site to complete the commissioning

- CEA Injector group manpower was needed largely more than planned on site

- **Largely more people on the photos for 1st beam than at work for installation**

Conclusion (1)

For LIPAc Injector

- Installation and check-out of the LIPAc injector took … **11 months,** from package opening to the 1st plasma

- Commissioning of the Injector is not completed yet, **4 years after the delivery** on site

- Protection of background knowledge is important
  → Issues transfering detailed drawings when repair is needed

- Final cost for CEA is largely higher than estimated
  lots of unexpected missions + work from Saclay

Conclusion (2)

Few personal comments:

→Difference of culture could lead to unexpected difficulties

→Experienced manpower with accelerator technical skills is essential on site

→R&D laboratories delivering "FORMULA 1" sub-systems are not industrial companies

→An HPPA is not a "coffee machine" with On/Off button

Thank you for your attention

View of LIPAc Injector H^+ beam

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