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ESS - BILBAO, THE SPANISH CONTRIBUTION TO EUROPEAN RESEARCH EXCELLENCE

ESS bilbao

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ESS - BILBAO, THE SPANISH CONTRIBUTION TO EUROPEAN RESEARCH EXCELLENCE

ESS bilbao

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ess-bilbao research lines

The European Spallation Source (ESS) is Europe's next flagship facility for materials research. Spain has presented a very strong candidature to build the ESS in Bilbao in northern Spain.

The ESS- Bilbao consortium has been created to represent the Basque and Central governments, both of whom have a very strong commitment to the ESS project.

ESS- Bilbao Consortium team has designed a comprehensive, international and collaborative R&D programme which is already addressing some of the critical design challenges of the ESS and providing a collaborative platform for research efforts across Europe.

The three key characteristics of this R&D programme are as follows:

1. A **network** of **collaborators** who, together with the ESS-Bilbao consortium, will pave the way for the future knowledge community created around the construction of the ESS. This network will take advantage of the existing capabilities of Universities, Research Centres, Public Research Institutions and firms encouraging higher-level training oriented towards the creation of major research infrastructures.
2. **The definition of research lines** that will capitalise on the experience of our collaborators, and focus on the revision of the ESS design, which we aim to lead.
3. **The signing of international collaboration agreements** with the best-in-class research centres and infrastructures in order to ensure the transfer of knowledge to our community and secure a position as leaders in this field.

As said, ESS-Bilbao has endeavoured to pursue a coherent international R&D collaboration programme to meet the **design goals** of the European Spallation Source, **which covers**:

- The conceptual design of the accelerator in parametric from
- The construction of a Test Stand for accelerating structures
- The adaptation and prototyping of superconducting cavities
- Delivery of key components for accelerating structures and RF power distribution to international research infrastructures
- Liquid mercury target and rotating solid target developments
- Development of neutron instrumentation

The ESS-Bilbao strategy for fulfilling these lines of research has been based on international collaboration. ESS-Bilbao has signed or is in the process of signing technological **collaboration agreements with the following institutions**:

- ISIS - Oxford, United Kingdom
- SNS - Spallation Neutron Source, Knoxville, USA
- CERN, Genève, Switzerland
- IPN - Insititute for Nuclear Physics, Rusia
- INFN - Instituto Nazionale de Fisica Nucleare, Italy
- CEA/CNRS - France
- ILL - High Flux Reactor Source, Grenoble, France
- FZJ - Forschungszentrum Jülich, Germany
- PSI - Paul Scherrer Insititut, Switzerland

Within this framework, ESS-Bilbao is developing a range of projects that we are proud to show you in this publication.

ITUR: a Facility for Testing and Optimising Ion Sources

R. Enparantza[a], L. Uriarte[a], J. Alonso[a], I. Ariz[a], M. Egiraun[a], F. J. Bermejo[b], V. Etxebarria[b], J. Jugo[b], J. Lucas[c], J.M. Del Rio[d] , A. Letchford[e], D. Faircloth[e] and M. Stockli[f]

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ABSTRACT

The rationale behind the ITUR project is to perform a comparison between different kinds of hydrogen ion sources using the same beam diagnostics setup. In particular, a direct comparison will be made in terms of the emittance characteristics of Penning Type sources such as those currently in use in the injector for the ISIS (UK) Pulsed Neutron Source and those of volumetric type such as that driving the injector for the ORNL Spallation Neutron Source (TN, U.S.A.). The endeavour here pursued is thus to build an Ion Source Test Stand where virtually any type of source can be tested and its features measured and, thus compared to the results of other sources under the same gauge. It would be possible then to establish a common ground for effectively comparing different ion sources. The long term objectives are thus to contribute towards building compact sources of minimum emittance, maximum performance, high reliability-availability, high percentage of desired particle production, stability and high brightness. The project consortium is coordinated by ESS-Bilbao Consortium and composed by Tekniker-IK4 (research centre), Elytt Energy, Jema Group (industrial companies), the CSIC- Spanish Scientific Research Council and the University of the Basque Country (Spanish scientific institutions). The technical viability is guaranteed by the collaboration between the project consortium and several scientific institutions such as ISIS (STFC-UK), SNS (ORNL-USA) and CEA in Saclay (France).

INTRODUCTION AND OBJECTIVE

A test stand able to compare the emittance characteristics of $^-$H arc-discharge sources such as the Penning trap used at ISIS [2] and RF driven sources such as the multicusp $^-$H source being at present in use at SNS [3] is being built at the University of the Basque Country. In the future, other types of sources, even proton sources as the CEA-Saclay [4] will also be able to be mounted and measured in the test bench.

The strategic goal for the coming three years will consist on the construction of a complete accelerator Front-End Test-Stand able to diagnose ion beams generated by the set of ion sources referred to above. The ion source test stand is being built at the shop floor of the ESS Bilbao Consortium in the Bizkaia Technology Park (Zamudio), next to the proposed ESS site. At the moment, several of its main constituents are being designed, specified and some of them are already being built. It is expected that the test stand will be operative by the end of 2009. The expected beam features on the test stand are summarised in Table 1. It is considered that going beyond 65 mA would require a serious effort to compensate for the space charge effects [5].

TABLE 1. Beam features

Parameter	Value
Max Pulse $^-$H	65 mA
Max Pulse e-	1A
Pulse Frequency	50 Hz
Duty cycle	6 %

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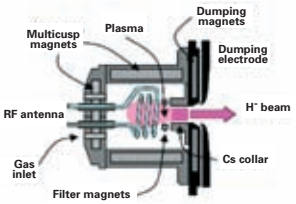
PENNING SOURCE (ISIS)

Presentation by Dan Faircloth in project ITUR meeting in TEKNIKER on

RF MULTICUSP SOURCE (SNS)



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THE FARADAY CAGE

Size	4,5 m x 6 m base and 3.5 m high
Material	Conducting aluminium
Purpose	To provide a stable environment to the main ion source components, so that the comparisons performed in the different kind of ion sources are reliable and not dependant on ambient conditions.

The Faraday cage allows for:

1. Isolate the ion sources from any type of electromagnetic interference
2. Screening the residual electric field of the HV platform so that it does not affect the rest of the components out of the cage.
3. Preventing human access to platform when in HV operation.
4. Protecting from X-rays or gamma rays, if required.

The cage is serviced from outside by the following supplies:

1. Hydrogen
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3. Power. 400V 200kW
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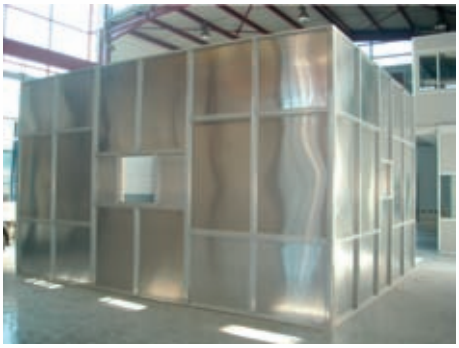
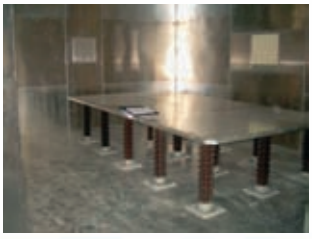


THE HV PLATFORM

Size	2,3 m x 4,3 m
Material	Conducting aluminium
Insulators	15 (800 mm high)
Voltage	100kV
Weight Cap.	4 kN/m²



THE POWER SUPPLIES

TABLE 2. Platform DC power supply

Parameter	Value
Maximum Voltage	100 kV
Intensity	120 mA
Drop	1 %
Precision	0.10 %
Electron return to extraction voltage	25 kV
Condensators capacitance	1 μF
Polarity change (manual)	Yes
Discharge time	2 s
Charging time	30 s

TABLE 3.1 Plasma formation power supply (Penning)

Parameter	Value
Input Voltage	400 V
Output Current Intensity	100 A
Frequency	50 Hz
Duty cycle	15 %
Precision	1 %
Output Voltage	0 to 80V
Regulation	Current

TABLE 3.2 Plasma maintenance power supply (Penning)

Parameter	Value
Input Voltage	400 V
Output Current Intensity	10 mA
Frequency	50 Hz
Duty cycle	85 %
Precision	1 %
Output Voltage	800 V
Regulation	Current

TABLE 4. Discharge power supplies (RF multicusp)

Type	Parameter	Value
Pulsed RF power supply	Power	80 kW
	Frequency	1.8-2.2 MHz
CW RF power supply	Power	300 W
	Frequency	13.56 MHz

TABLE 5. Extraction power supply (Penning)

Parameter	Value
Output Voltage	25 kV
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Curling in Voltage	1 %
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DIAGNOSTICS

TABLE 6 Diagnostics

Measurement	Component
Current	Slow Current Transformer
Current	Faraday Cup
Space charge effect	Buffer Gas delivery System, Flow controller
Emittance and profile	Scintillator, Interchangable Pepper Pot, CCD Camera
Degree of stripping	Diagnostic dipole
Energy spread	Retarding Potential Energy Analyser

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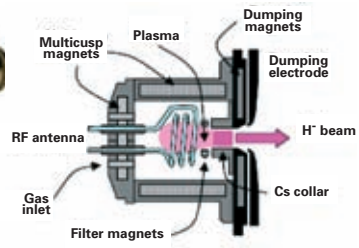

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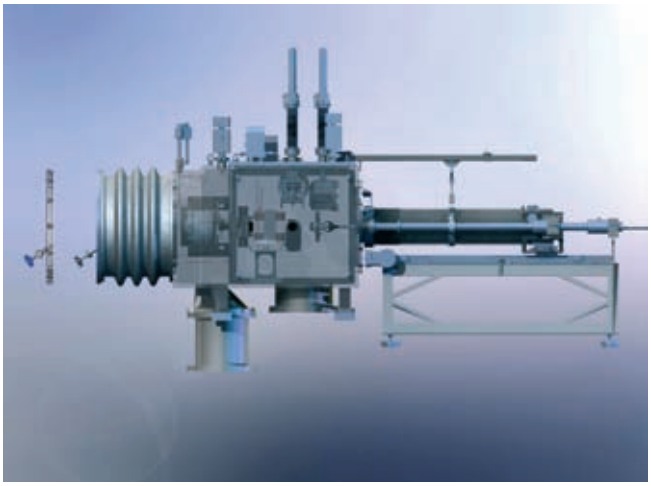

ETORFETS: a Front End Test Stand for ESS-Bilbao

L. Uriarte[a], R. Enparantza[a], J. Alonso[a], I. Ariz[a], M. Egiraun[a], F. J. Bermejo[b], V. Etxebarria[b], J. Lucas[c], J.M. Del Rio[d], M.T. Bustamante[e] and J. Eguía[f]

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ABSTRACT

The ETORFETS project aims at building a front end test stand as part of the R&D effort of the ESS-Bilbao Consortium. The main objective is to set up a facility to demonstrate experimentally the design ideas for the future ESS LINAC that are being proposed in discussion forums in the technical scientific community. In this sense, ETORFETS is centred in the first stage of acceleration of the linear accelerator, namely, that of the Radio Frequency Quadrupole and its pre and post beam transport systems.

The current ETORFETS consortium is coordinated by ESS-Bilbao Consortium and is composed by TEKNIKER IK4 (research centre), ELYTT ENERGY and JEMA GROUP (industrial companies), The University of the Basque Country, CSIC–Spanish Scientific Research Council and CIEMAT (Spanish Scientific institutions).

" The technical viability is guaranteed by the collaboration between the project consortium and several scientific institutions such as CERN (Switzerland) and IN2P3 - Orsay (France)."

OBJECTIVE

The main objective is to develop FETS - Bilbao infrastructure, namely the elements and systems (building and services included) that generate, accelerate, guide, focus and chop ions, together with diagnostic instruments and final absorption and stop. At least a conceptual design phase will be carried out to define the sequence of room temperature and superconducting cavities of a complete LINAC. As a consequence of the development of the project specific technologies of particle accelerators are acquired

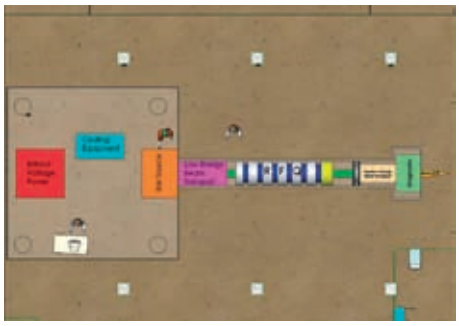
The objective of such a FETS is to demonstrate the production of chopped beams of hydrogen ions of high quality:

- 60 mA
- 3 MeV
- Up to 2 ms of pulse length
- Up to 50 pps of repetition rate

MAIN COMPONENTS OF THE FETS-BILBAO

There are several areas that can be defined in a Front End, corresponding to specific systems and technologies. Here is the full list:

- **Ion Source:** its mission is to obtain hydrogen ions, H- in the first approach and then also H+. requirements are minimum emittance, maximum performance, high reliability-availability, high % production of desired particles, stability and compacity of high brilliance (see ITUR poster)
- **Low Energy beam Transport (LEBT):** section where particles originated in the source are focused and directed to the following stages. It is fundamental to be well equipped with instruments, since the whole chain of subsequent acceleration systems depends on beam quality at the exit of this device.
- **Radiofrequency Quadrupole (RFQ):** it is responsible for grouping particle beams (bunching), focusing them and accelerating them. Its main requirements are high efficiency in bunching, low particle losses, reliability and compacity.
- **High Speed Chopper:** "tandem" type for fulfilling opposite requirements such as short ramping time (<2ns) and long permanence time (up to 100μs).
- **Beam Diagnostic Elements:** One of the key factors of the FETS facility is its instrumentation, since in order to characterise beam parameters, a series of measuring devices are required.
- **Beam-stop:** System for stopping, absorption and refrigeration of the beam.



THE LEBT

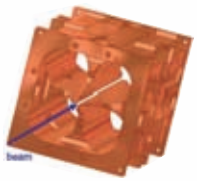
Focusing low a low energy particle beam is not an easy task. The LEBT has to compensate the space charge effect that pushes the beam to expand itself. Before the bema is driven to the first acceleration phase it needs to be "contracted". In order to do it a series of cylindrical magnets of considerable length have to be used (see the solenoids of the Figure). As the beam travels across the solenoids it is forced to follow a spiral movement. This movement not only keeps the beam on the right direction but also compresses its size so that it fits with the RFQ

It is possible carry out the same focusing operation by electrostatic methods. A study will be conducted in order to find out the most suitable method.

Solenoides for the ISIS FETS

THE RADIO FRECUENCY QUADRUPOLE (RFQ)

The radio-frequency quadrupole is the element responsible for "bunching" and accelerating the ions that come out of the LEBT by intense radiofrequency fields generated by klystrons or tetrodes. The RFQ "bunches" the ion flux softly and later it accelerates it. This soft bunching succeeds in keeping more than 95% of the ions and keep the beam quality. If bunching is performed in a more clumsy way, beam quality may deteriorate and lead to beam losses which radiate systems that come in subsequent phases.



Radio-frequency quadrupole of the ISIS FETS

MEDIUM ENERGY BEAM TRANSPORT AND CHOPPERS

Ions come out of the RFQ in bunches close to each other, separated by a few nano seconds. In some applications (Neutrino Factories, Spallation Sources, ADS), these ions experience several acceleration phases in drift tubes, superconducting cavities and other systems. In those applications where the shape of the pulse is important, each of these bunches is chopped by means of an electromagnetic device able to create a time gap, of just micro seconds, between bunches. This is achieved by the use of a line of "choppers". The chopper line of the MEBT consists of a series of quadrupole, RF rebunching cavities and the beam chopping system.

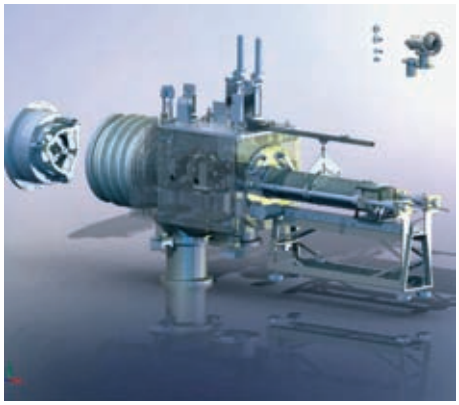
Choppers work by applying a high voltage on the beam, in order to remove part of it. The greatest challenge is for a Chopper is to be able to commute this voltage very quickly, that is, between ion bunches (just a few ns) and then keep it for a longer time (μs), so that the required gap is produced between bunches. This contradictory requirement is obtained by a double phase chopper, the fast phase and the slow one.

'Chopped' beam

DIAGNOSTICS

A set of instruments is required to measure beam parameters and evaluate the quality of the beam produced. Typical measurements include:

- Beam Current, with current transformers
- Emittance, with emittance scanners
- Beam profile, with Pepper-Pot type instruments
- Degree of stripping, with diagnostic dipoles
- Etc.



Diagnostic Vessel

BEAM STOP

In order to "dispose of" the beam a beam dumping system is required. These are usually called beam stops. The beam stop needs to have the following features:

1. Be made of a material that absorbs the radiation generated in the contact between the beam and the beam stop wall
2. Have a shape that optimised the heat spread on the beam stop wall. They are usually of conical or, even, ogive shape. This is important to reduce peak temperatures that may affect the mechanical properties of the beam stop material. In addition, refrigeration on its outside wall is usually required to evacuate the heat.
3. Be made of a material subjected to a treatment so that its mechanical properties withstand the mechanical, thermal and fatigue stresses generated on the beam stop surface due to the vacuum pressure inside, the refrigerant pressure outside and the temperature rise (made worse by a temperature change cycle in pulsed beams) by the heat transfer between the beam and the beam stop wall.

ISIS FETS beam stop in manufacturing phase

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The ETORFETS project aims at building a front end test stand as part of the R&D effort of the ESS-Bilbao Consortium. The main objective is to set up a facility to demonstrate experimentally the design ideas for the future ESS LINAC that are being proposed in discussion forums in the technical scientific community. In this sense, ETORFETS is centred in the first stage of acceleration of the linear accelerator, namely, that of the Radio Frequency Quadrupole and its pre and post beam transport systems.

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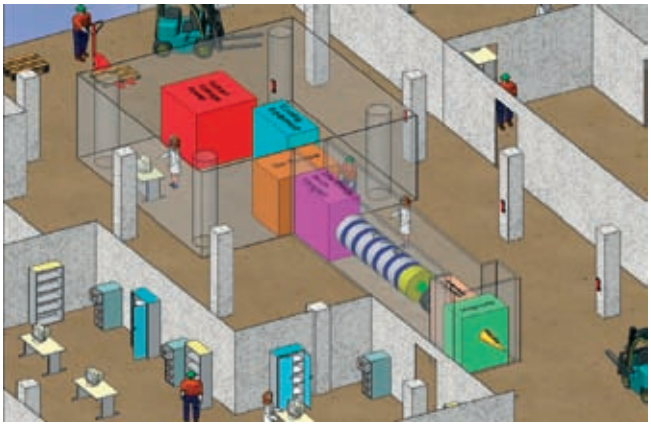

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- **Ion Source:** its mission is to obtain hydrogen ions, H- in the first approach and then also H+. requirements are minimum emittance, maximum performance, high reliability-availability, high % production of desired particles, stability and compacity of high brilliance (see ITUR poster)
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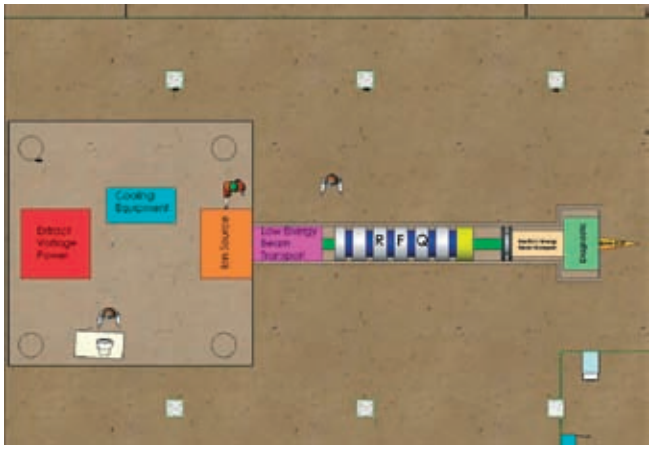
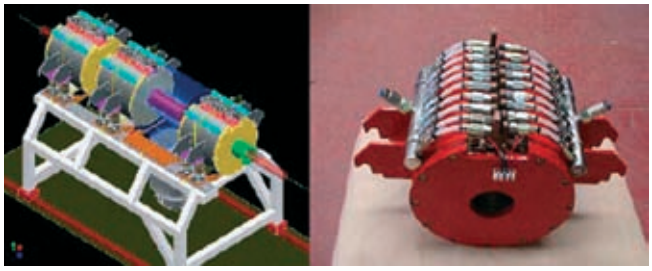
- **Radiofrequency Quadrupole (RFQ):** it is responsible for grouping particle beams (bunching), focusing them and accelerating them. Its main requirements are high efficiency in bunching, low particle losses, reliability and compacity.
- **High Speed Chopper:** "tandem" type for fulfilling opposite requirements such as short ramping time (<2ns) and long permanence time (up to 100μs).
- **Beam Diagnostic Elements:** One of the key factors of the FETS facility is its instrumentation, since in order to characterise beam parameters, a series of measuring devices are required.
- **Beam-stop:** System for stopping, absorption and refrigeration of the beam.



THE LEBT

Focusing low a low energy particle beam is not an easy task. The LEBT has to compensate the space charge effect that pushes the beam to expand itself. Before the bema is driven to the first acceleration phase it needs to be "contracted". In order to do it a series of cylindrical magnets of considerable length have to be used (see the solenoids of the Figure). As the beam travels across the solenoids it is forced to follow a spiral movement. This movement not only keeps the beam on the right direction but also compresses its size so that it fits with the RFQ

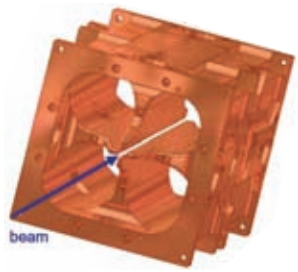
It is possible carry out the same focusing operation by electrostatic methods. A study will be conducted in order to find out the most suitable method.



Solenoides for the ISIS FETS

THE RADIO FRECUENCY QUADRUPOLE (RFQ)

The radio-frequency quadrupole is the element responsible for "bunching" and accelerating the ions that come out of the LEBT by intense radiofrequency fields generated by klystrons or tetrodes. The RFQ "bunches" the ion flux softly and later it accelerates it. This soft bunching succeeds in keeping more than 95% of the ions and keep the beam quality. If bunching is performed in a more clumsy way, beam quality may deteriorate and lead to beam losses which radiate systems that come in subsequent phases.



Radio-frequency quadrupole of the ISIS FETS

MEDIUM ENERGY BEAM TRANSPORT AND CHOPPERS

Ions come out of the RFQ in bunches close to each other, separated by a few nano seconds. In some applications (Neutrino Factories, Spallation Sources, ADS), these ions experience several acceleration phases in drift tubes, superconducting cavities and other systems. In those applications where the shape of the pulse is important, each of these bunches is chopped by means of an electromagnetic device able to create a time gap, of just micro seconds, between bunches. This is achieved by the use of a line of "choppers". The chopper line of the MEBT consists of a series of quadrupole, RF rebunching cavities and the beam chopping system.

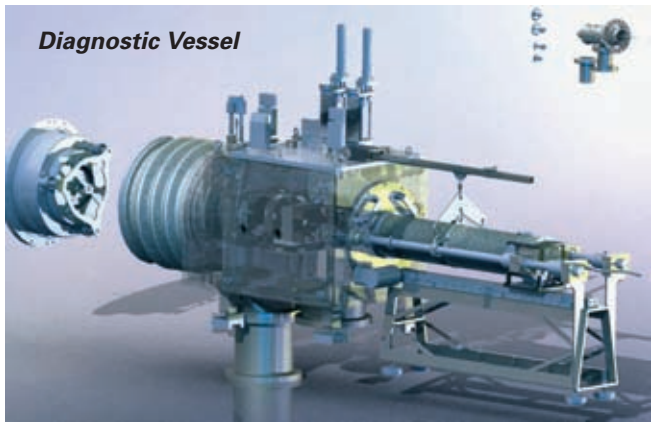
Choppers work by applying a high voltage on the beam, in order to remove part of it. The greatest challenge is for a Chopper is to be able to commute this voltage very quickly, that is, between ion bunches (just a few ns) and then keep it for a longer time (μs), so that the required gap is produced between bunches. This contradictory requirement is obtained by a double phase chopper, the fast phase and the slow one.

'Chopped' beam

DIAGNOSTICS

A set of instruments is required to measure beam parameters and evaluate the quality of the beam produced. Typical measurements include:

- Beam Current, with current transformers
- Emittance, with emittance scanners
- Beam profile, with Pepper-Pot type instruments
- Degree of stripping, with diagnostic dipoles
- Etc.

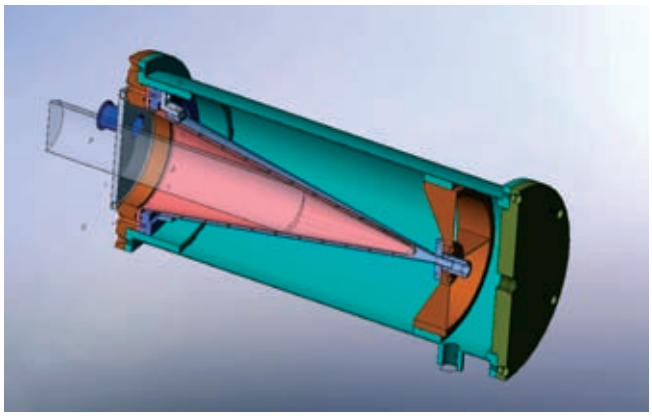


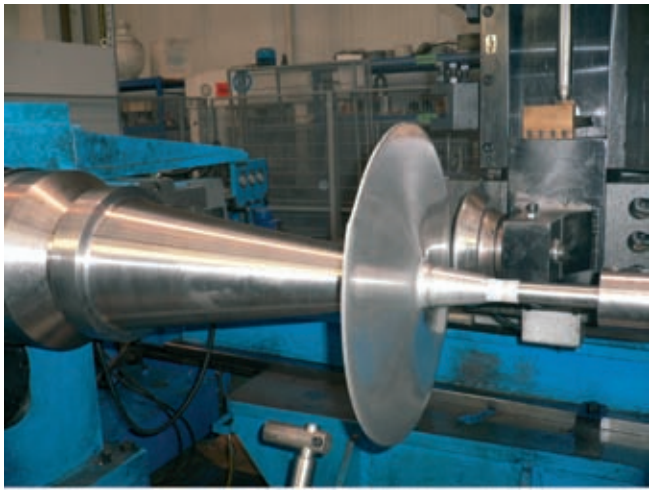
Diagnostic Vessel

BEAM STOP

In order to "dispose of" the beam a beam dumping system is required. These are usually called beam stops. The beam stop needs to have the following features:

1. Be made of a material that absorbs the radiation generated in the contact between the beam and the beam stop wall
2. Have a shape that optimised the heat spread on the beam stop wall. They are usually of conical or, even, ogive shape. This is important to reduce peak temperatures that may affect the mechanical properties of the beam stop material. In addition, refrigeration on its outside wall is usually required to evacuate the heat.
3. Be made of a material subjected to a treatment so that its mechanical properties withstand the mechanical, thermal and fatigue stresses generated on the beam stop surface due to the vacuum pressure inside, the refrigerant pressure outside and the temperature rise (made worse by a temperature change cycle in pulsed beams) by the heat transfer between the beam and the beam stop wall.





ISIS FETS beam stop in manufacturing phase

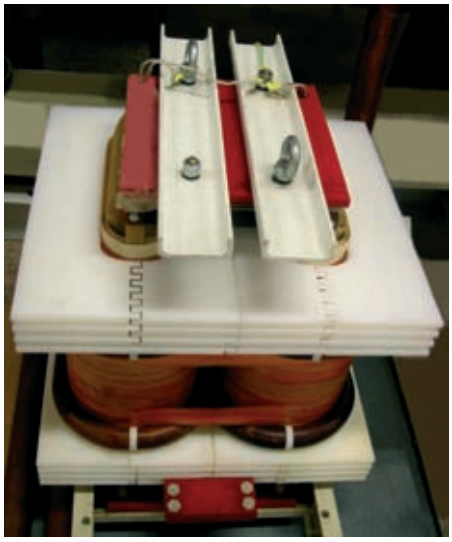
Klystron Modulators with High Frequency Transformers

Klystron Modulators with High Frequency Transformers

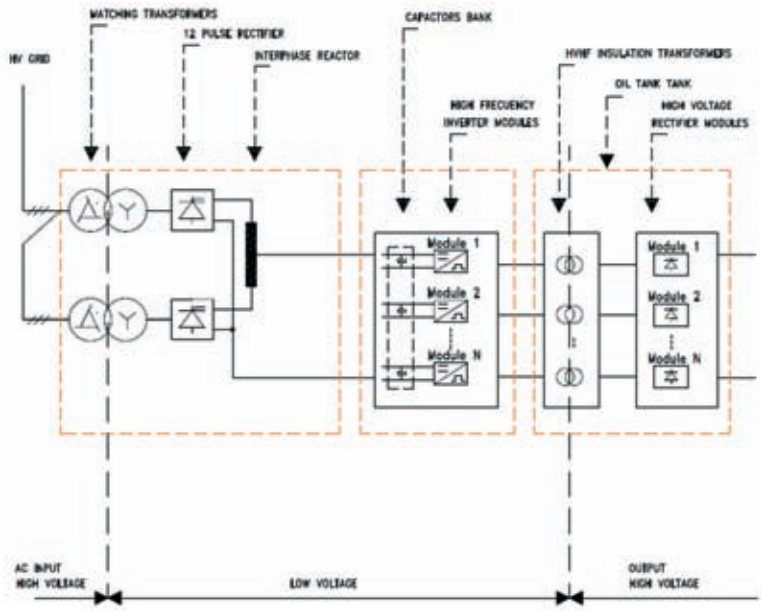
GENERAL DESCRIPTION

- Modulator is the specific name to the required high voltage pulsed power supply that drives a Klystron
- There are different Modulator solutions, one of them is based on the use of high frequency transformers (HFT). Its topology is composed of the following stages:

  - 50 Hz conventional transformer, HV input, LV output. Dimensioned for the modulator mean power (Pulse Power x Duty Cycle)
  - 6 or 12 pulse thyristor (or diode) rectifier
  - Intermediate capacitive bank referred to low voltage (where the energy required to perform the pulses is accumulated)
  - IGBT inverter modules. As a first approach, soft commutation should be used for working at high frequency
  - High frequency transformers. High isolation is require
  - Diode rectifiers at the high voltage side + Filter



HFT SINGLE LINE DIAGRAM



HFT MODULATOR CONFIGURATION MODES

The HFT Modulator works in two configuration modes

Configuration 1:

- Maximum Peak Power: Pmax = 11MW
- Maximum Reference Output Voltage: 140kVdc. Adjustable between 10kVdc and 140kVdc
- Maximum Output Current: 78A
- Duty Cycle: 1.35ms ON / 15.32ms OFF
- Output Voltage Ramp: Less than 100µs (from the beginning of the ramp until 90% of the voltage reference is reached)

Configuration 2:

- Maximum Peak Power: Pmax = 10MW
- Maximum Reference Output Voltage: 110kVdc. Adjustable between 10kVdc and 110kVdc
- Maximum Output Current: 90A
- Duty Cycle: 2.3ms ON / 17.7ms OFF
- Output Voltage Ramp: Less than 300µs (from the beginning of the ramp until 90% of the voltage reference is reached)

HFT MODULATOR PERFORMANCES

- Accuracy of the Output Voltage during the pulse: +/-1% of the rated voltage. Average value of the voltage, excluding ripple
- Maximum Output Voltage Ripple during the pulse: +/- 0.1% of the rated voltage
- Maximum Voltage Overshoot: 1% of the reference voltage. Stabilization to 0.1% in less than 50µs from the end of the ramp.
- Maximum shutdown time: 5µs
- Maximum energy delivered to the load in case of arc: 20J
- Input Grid Voltage: 30kV III
- 100% Solid State Technology
- Water Cooling of the semiconductors
- Climatic Conditions: 10ºC to 40ºC, 90% Maximum Humidity

HFT MODULATOR ADVANTAGES

Experienced and contrasted technology (for the low voltage stages only).

All active elements are in low voltage (easier fault finding and debugging). Improved maintainability.

Easier to maintain a stable voltage through the pulse and to give long pulses. No "droop" compensator is required.

Less active elements (IGBT's) are required. In principle, more reliable than a MARX modulator.

The energy is stored at low voltage: Improved security of the load (Klystron).

Some users consider this topology a less risky solution than a MARX modulator.

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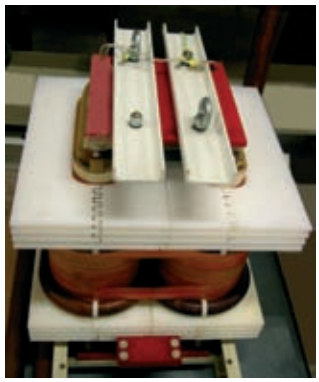

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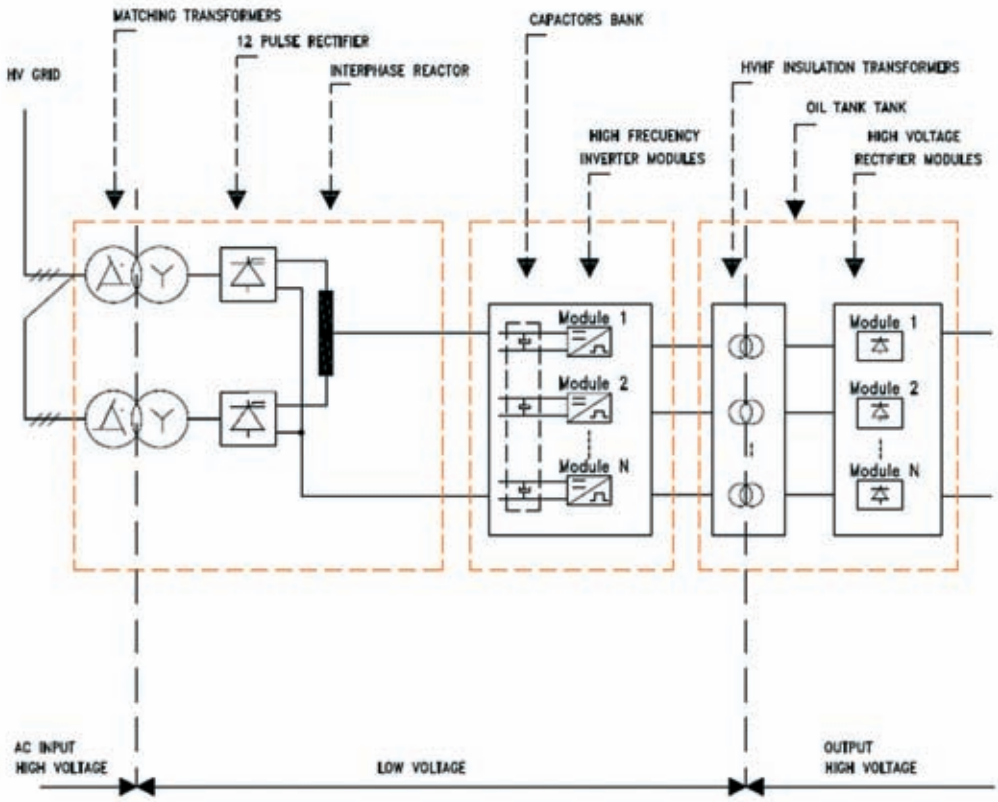

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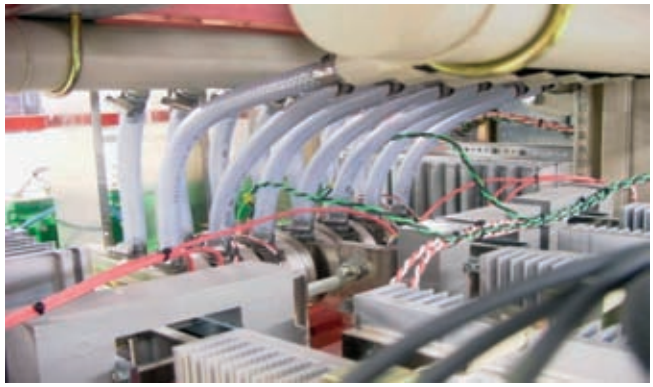

Accelerating Spoke Cavities for the ESS-Bilbao LINAC

Ibon Bustinduy[a], J. Lucas[b], Dong-o Jeon[c], F.J. Bermejo[d]

[a] ESS-Bilbao, Spain
[b] Elytt Energy, Spain
[c] SNS, USA
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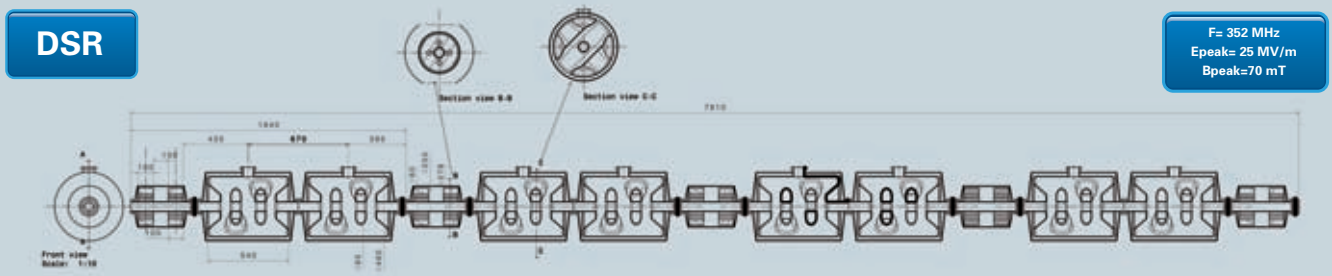
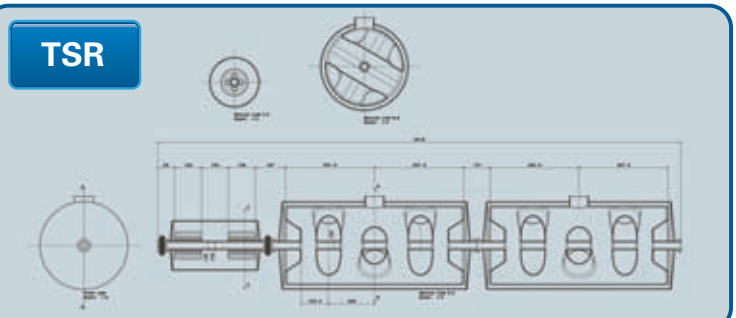
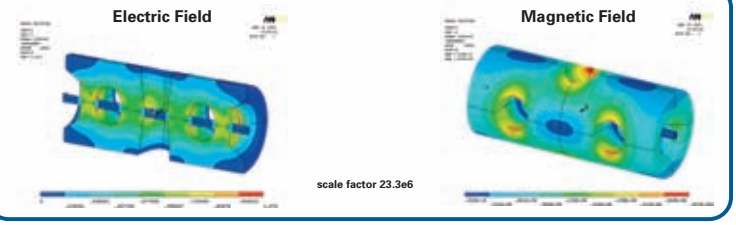
DSR



F= 352 MHz
Epeak= 25 MV/m
Bpeak=70 mT

TSR



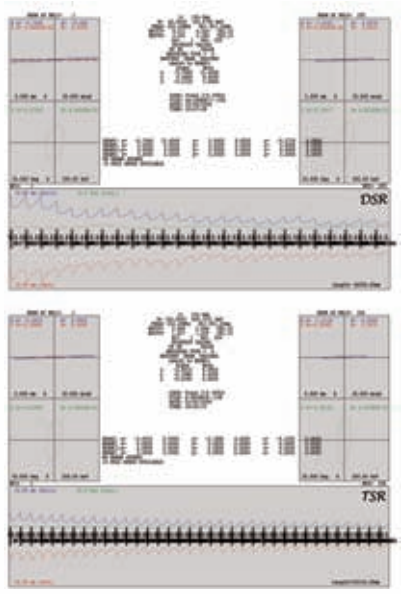


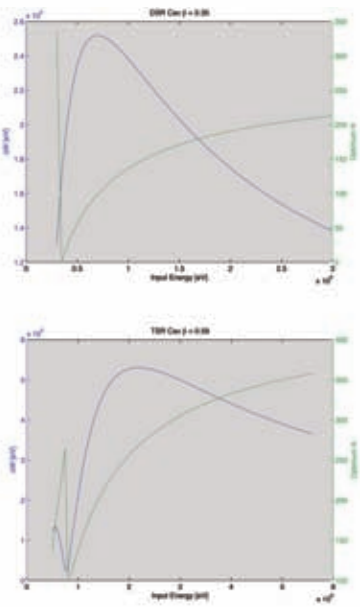
There has been considerable progress in the development of superconducting cavities for both low-to-medium and high ß regimes. Particularly important are developments concerning cavity technology for rather low (ß≤0.1) energies based upon spoke-half-wave-resonators or **CH** structures. The technology has already been developed, mostly geared towards applications within **IFMIF, EURISOL, EUROTRANS** and **SPIRAL2** projects and could provide a cost effective substitute for the copper cavities both in terms of fabrication and operation, since the total length of the accelerator would be significantly reduced. Our current design considers a transition into a SC section composed by low **ß=0.35** double-spoke cavities **(DSR)** and a mid **ß=0.65** Triple-spoke cavities **(TSR)** after reaching an acceleration within the normal conducting LINAC of **40 MeV**. Such transition does not represent a serious challenge.

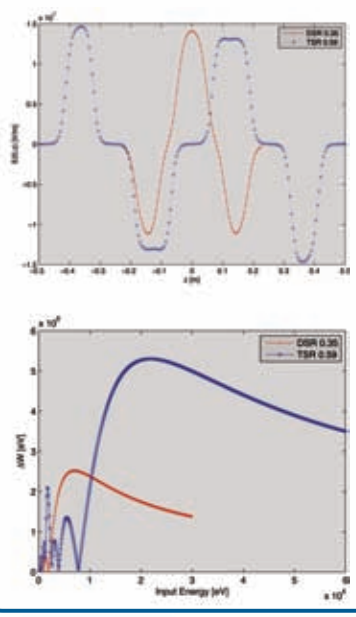
In fact some current designs such as that for **EURISOL** contemplate a series of half-wave resonators with ß=0.09 and ß=0.15 right after the **RFQ**, followed by a set of **TSR** cavities with ß=0.3 which have an incoming beam of **60 MeV.**

In the velocity range from ß=0.4 to ß=0.7 spoke resonators provide:

- High cavity quality factors and which enable the use of high accelerating gradients.
- Excellent mechanical stability, allowing easy tuning and phase control in the presence of microphonics or and dynamic Lorentz detuning
- High shunt impedance and reduced cryogenic load
- Large longitudinal acceptance, reduced sensitivity to phase errors
- Low shunt impedance for higher-order-modes (HOM)







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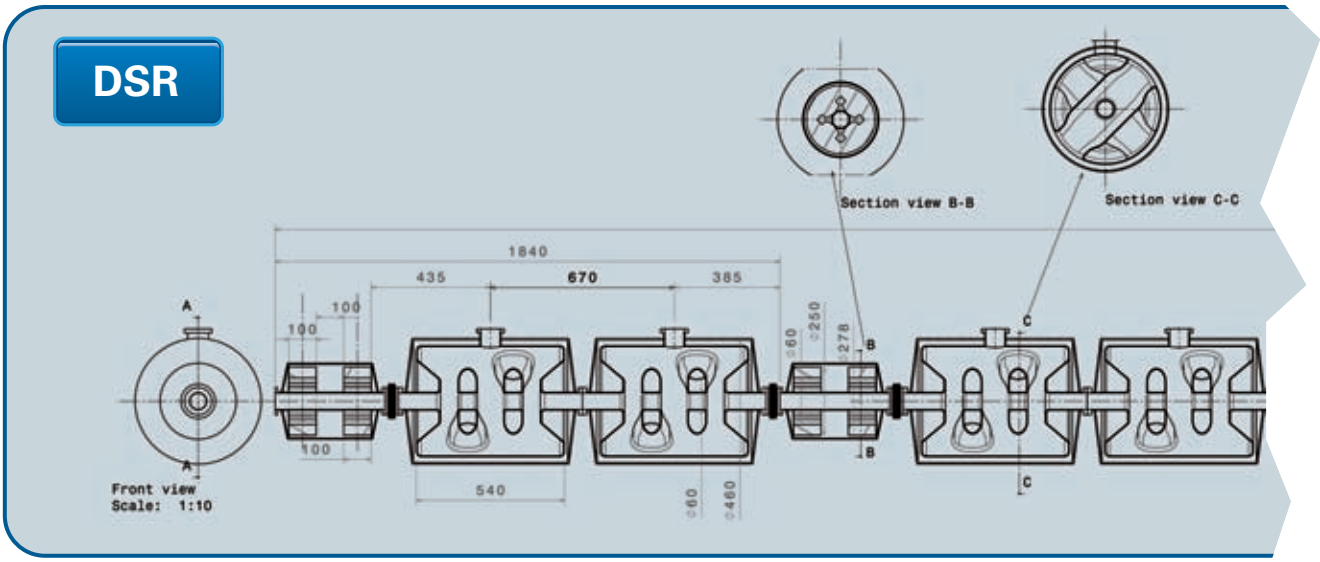
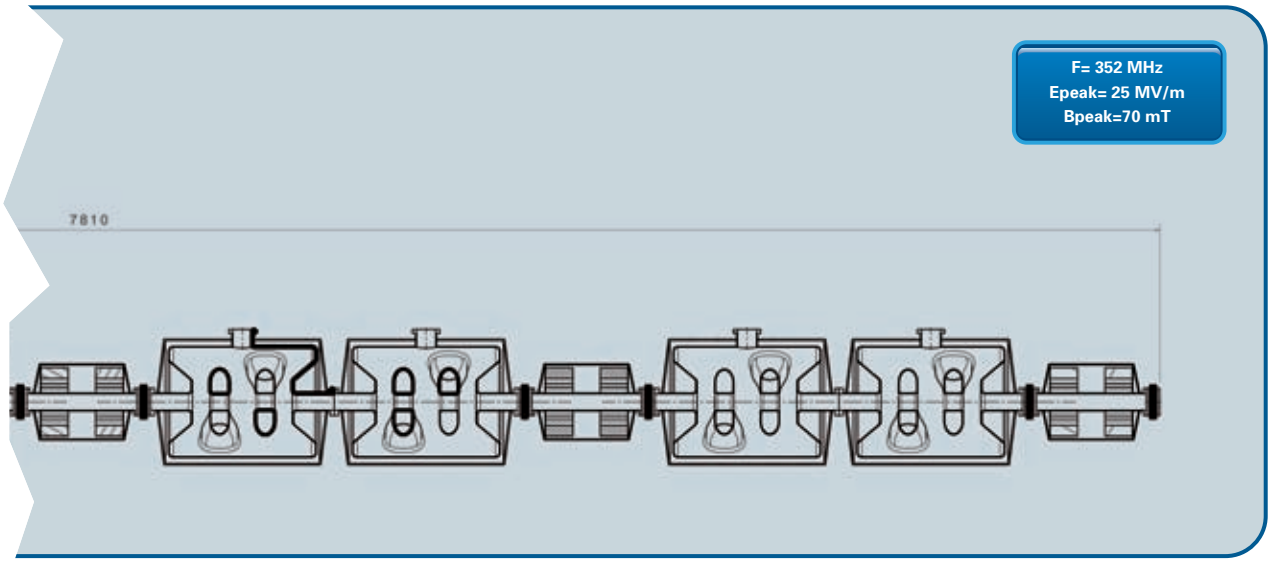
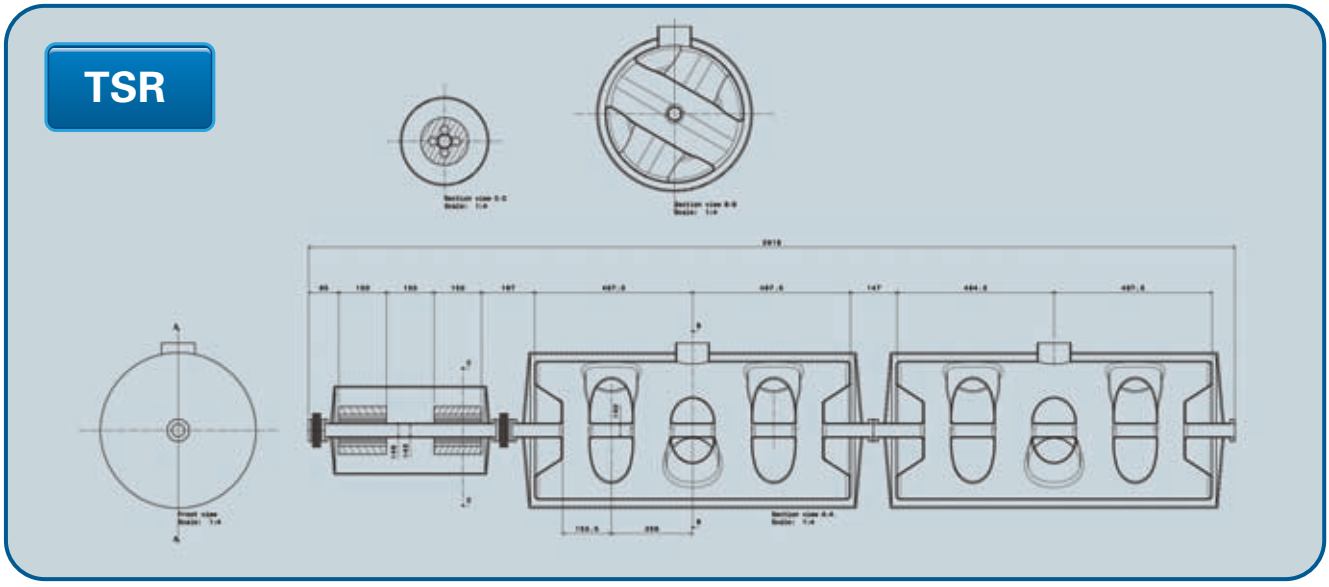
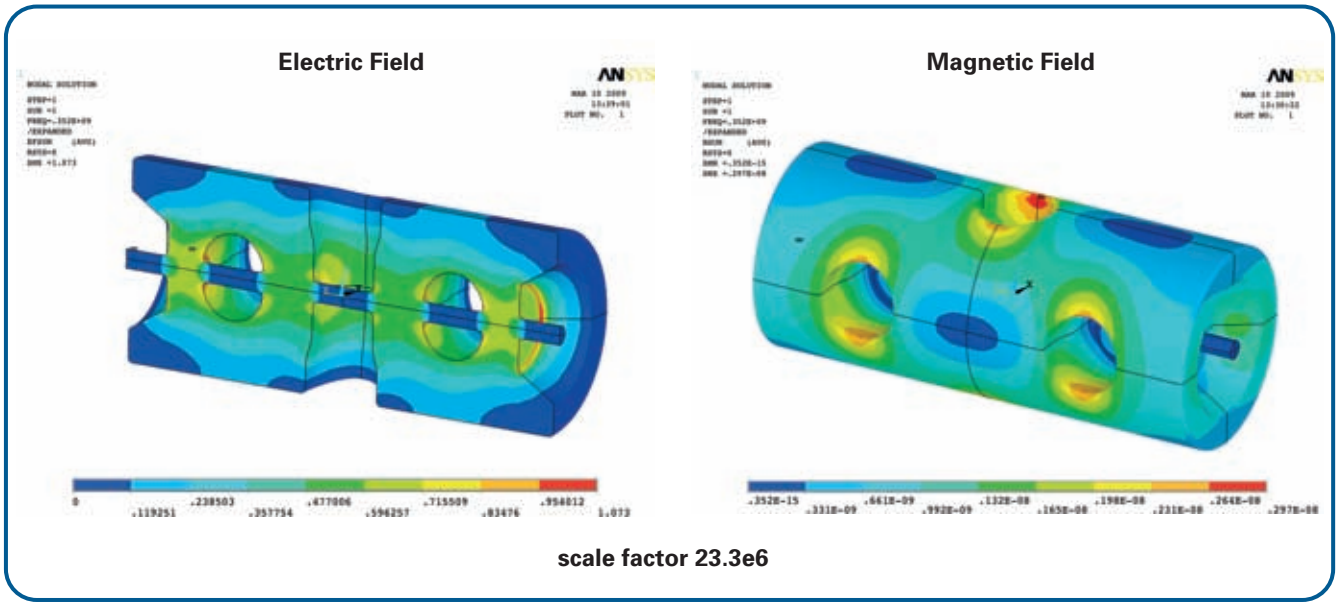
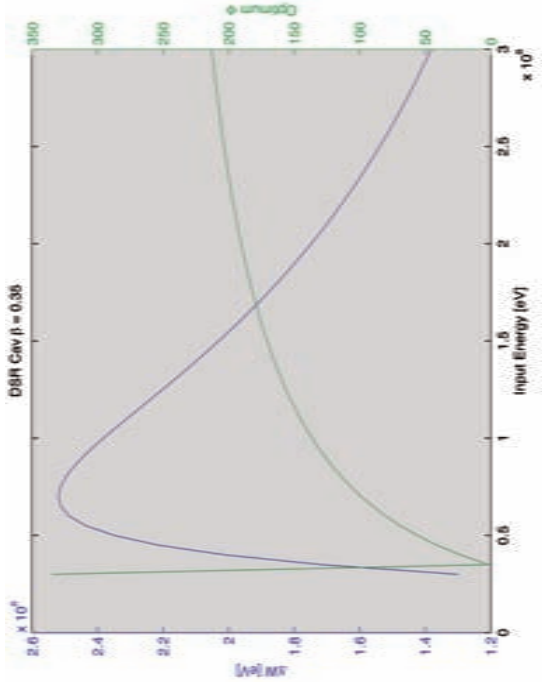
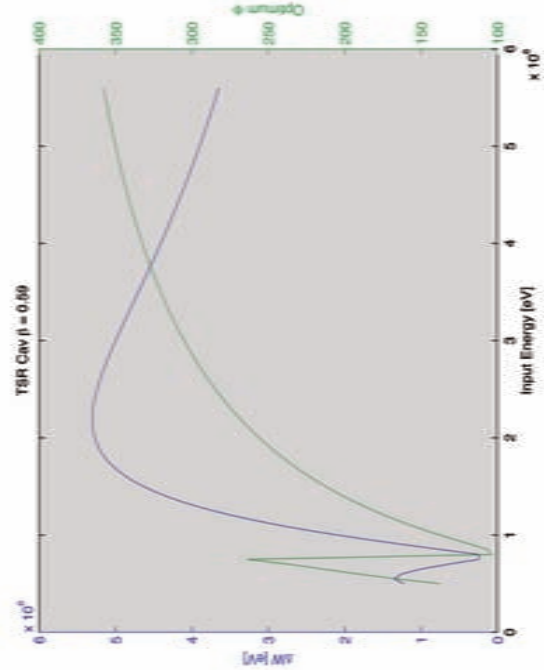


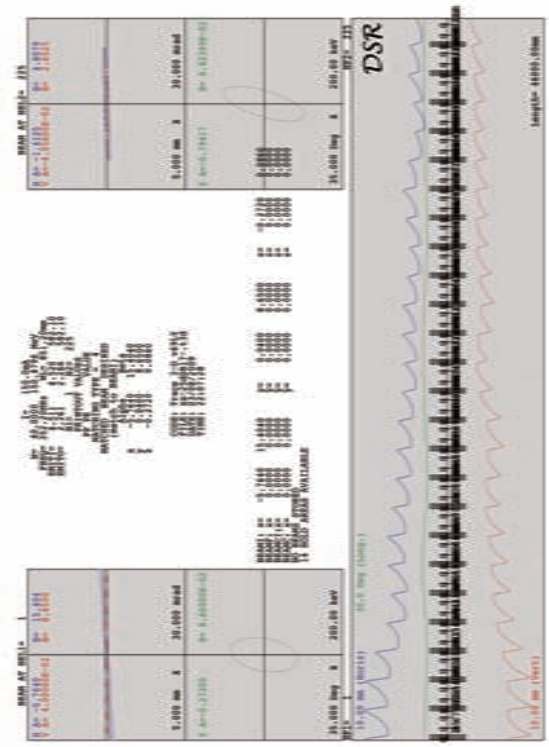


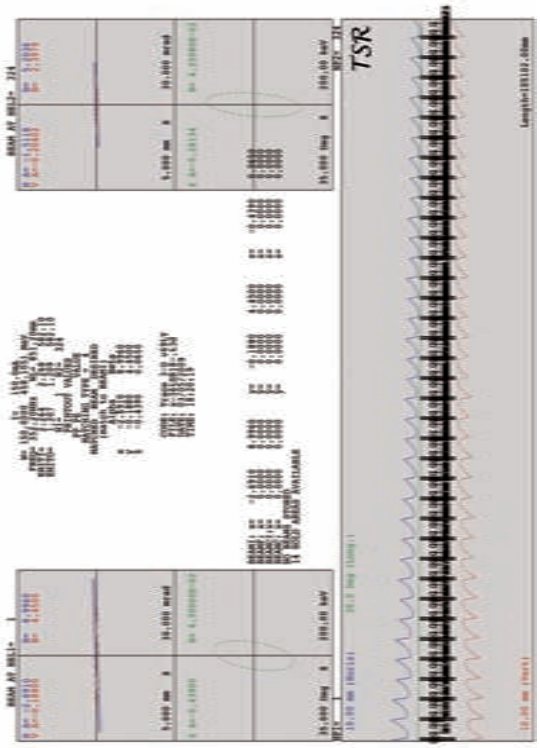

TSR

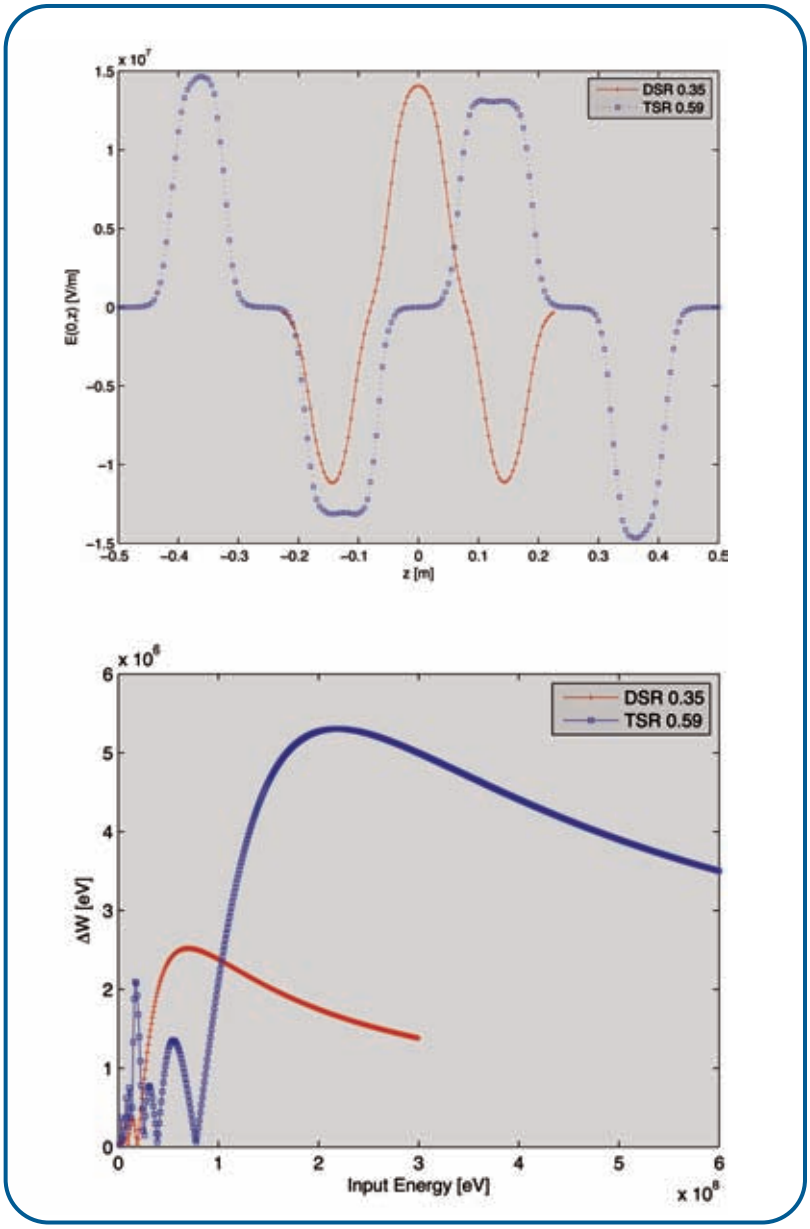

Electric Field
Magnetic Field
scale factor 23.3e6


DBR Cav β = 0.35
Input Energy [eV]
x 10^6
Optimum Φ


TSR Cav β = 0.69
Input Energy [eV]
x 10^6
Optimum Φ


DSR


TSR


x 10^7
DSR 0.35
TSR 0.59
E(0,z) [V/m]
z [m]
x 10^8
DSR 0.35
TSR 0.59
ΔW [eV]
Input Energy [eV]
x 10^8

ESS Bilbao - Target

ESS Bilbao – Target

ESS BILBAO - TARGET PREPARATORY WORKS

Preparatory works are being carried out in two parallel lines in order to minimise project risk. Following the recommendation of the ESS TAC of developing a rotating disk backup alternative, the aim is to develop both options (liquid mercury and rotating solid target) to an equivalent level so as to make a comparative cost and project risk assessment.

In collaboration with SNS

Works on both target options are being developed in collaboration with SNS. As part of this collaboration ESS Bilbao is participating in the full-scale prototyping and testing of the SNS rotating target design.

Mercury liquid target

Works focused on the analysis of the thermal and pressure stresses on the vessel beam window in the case of a 5MW long pulse. Although risk for cavitation damage is much lower than in the case of the short pulse, cavitation mitigation techniques will be developed as a safe-guard.

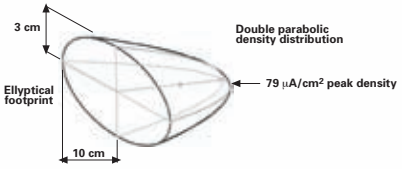
Rotating solid target

Works comprise the thermohydraulic design of the disk and the cooling system, the mechanical design of the target and drive modules, the study of the maintainance/handling requirements, and other assessments such as the activation of the surrounding target station components.

NEUTRONICS

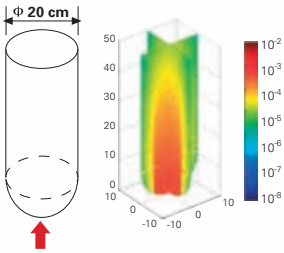
ESS beam profile: 1.3 GeV protons, 5 MW, f=16 2/3 HZ, 2 ms pulse.

- Heat deposition in a Hg liquid target and a W solid target calculated for the thermo-hydraulics studies.
- Neutron production performance, radiation in the target station components and decay heat studies will be carried out in order to assess both target alternatives.



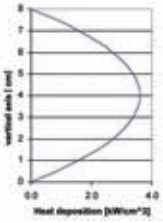
Mercury liquid target

Heat deposition on a hemispherical specimen and in the target module

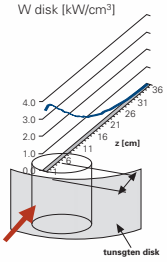


Tunsgten solid target

Heat deposition in the critical rod [kW/cm³]



Heat deposition along the W disk [kW/cm³]



ANALYSIS OF THE THERMOHYDRAULIC PERFORMANCE OF A LONG PULSE MERCURY LIQUID TARGET FOR ESS

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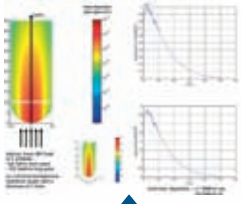
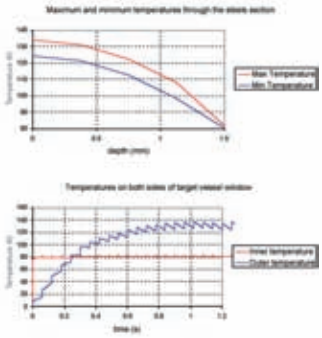
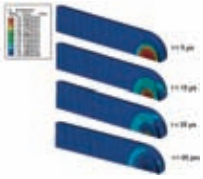


stress caused by temperature pulses on steel



mercury pressure wave impact on steel



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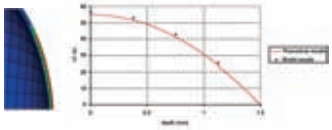

ROTATING TARGET THERMO-HYDRAULIC DESIGN

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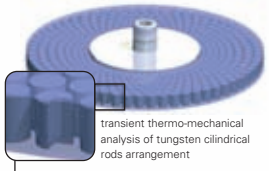

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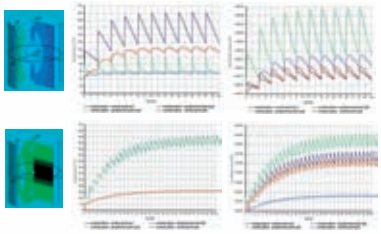

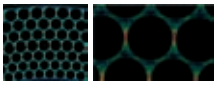

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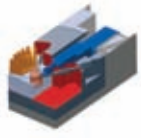

ESS Reference Design. Mercury liquid target & trolley

ESS Reference Design. Target Station

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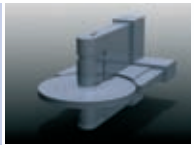
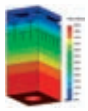
Disk formed by tungsten bricks with involute fins for the attachement to aluminium cold plates under study.

Elements suited to radioactive environments needed for the drive system.





Rotating disk design study. Temperatures on a tungsten brick

Rotating disk design study. Brick disk with horizontal insertion

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Rotating disk design study. Stress analysis on a tungsten brick

TARGET MODULE FOR THE SNS FULL-SCALE ROTATING TARGET MOCKUP

ESS Bilbao is designing and fabricating the target module of a full-scale rotating target mockup for SNS.

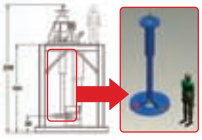
The purpose is to test the basic drive configuration. The main elements to be evaluated are:

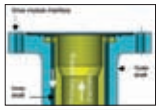
- Manufacturability
- Assembly
- Water seals

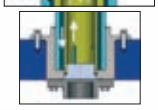
The target mockup is basically composed of two concentric stainsteel shafts to create the cooling channels, and a massive disk to achieve the target inertia characteristics. The target will be assembled to the SNS drive module through the outer shaft flange.

Rotating target module mockup - Characteristics

Mass, m:	2240 kg
Rotational speed, n:	20-60 rpm
Max. system temperature, T:	100°C
Max. Delta temperature Inner-outer shafts, ΔT:	40° C
Water pressure, p:	7 bar







ESS BILBAO - TARGET PREPARATORY WORKS

Preparatory works are being carried out in two parallel lines in order to minimise project risk. Following the recommendation of the ESS TAC of developing a rotating disk backup alternative, the aim is to develop both options (liquid mercury and rotating solid target) to an equivalent level so as to make a comparative cost and project risk assessment.

In collaboration with SNS

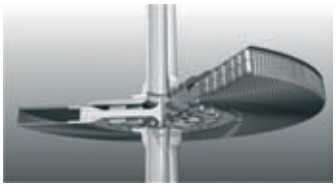
Works on both target options are being developed in collaboration with SNS. As part of this collaboration ESS Bilbao is participating in the full-scale prototyping and testing of the SNS rotating target design.

Mercury liquid target

Works focused on the analysis of the thermal and pressure stresses on the vessel beam window in the case of a 5MW long pulse. Although risk for cavitation damage is much lower than in the case of the short pulse, cavitation mitigation techniques will be developed as a safe-guard.

Rotating solid target

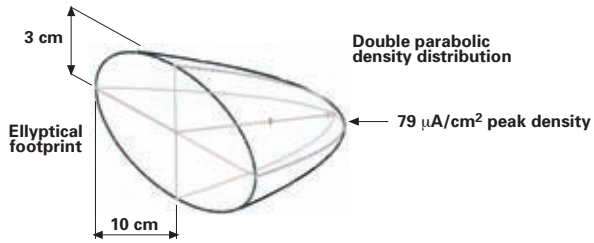
Works comprise the thermohydraulic design of the disk and the cooling system, the mechanical design of the target and drive modules, the study of the maintainance/handling requirements, and other assessments such as the activation of the surrounding target station components.



NEUTRONICS

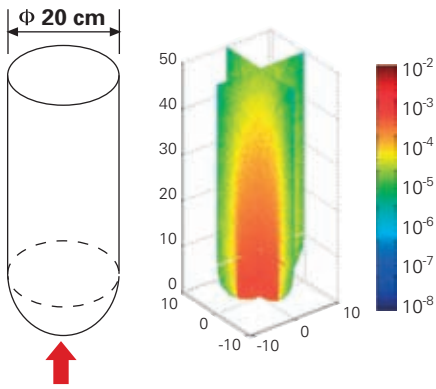
ESS beam profile: 1.3 GeV protons, 5 MW, f=16 2/3 HZ, 2 ms pulse.

- Heat deposition in a Hg liquid target and a W solid target calculated for the thermo-hydraulics studies.
- Neutron production performance, radiation in the target station components and decay heat studies will be carried out in order to assess both target alternatives.



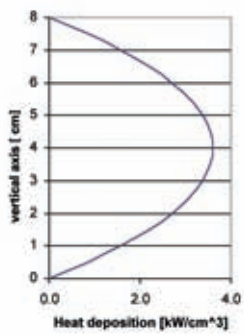
Mercury liquid target

Heat deposition on a hemispherical specimen and in the target module

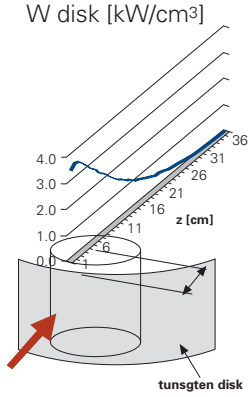


Tunsgten solid target

Heat deposition in the critical rod [kW/cm3]



Heat deposition along the W disk [kW/cm3]



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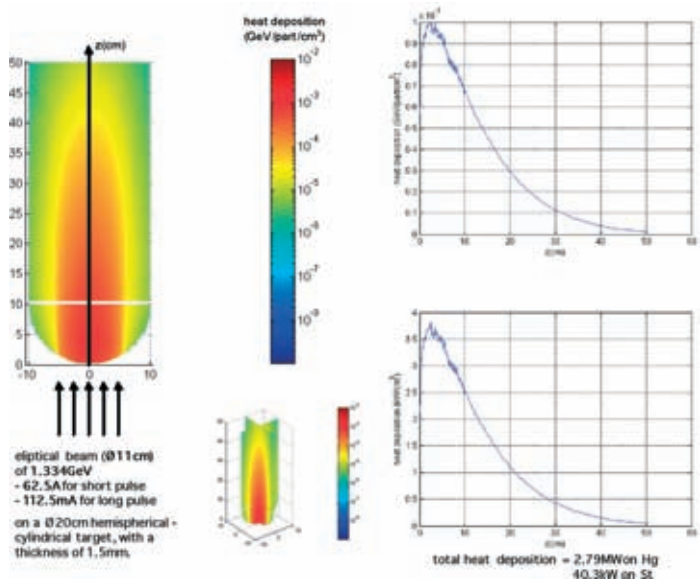

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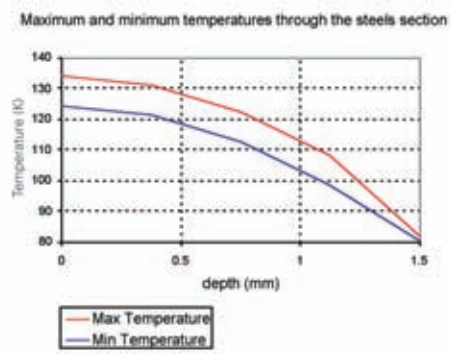

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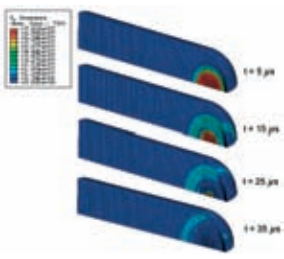

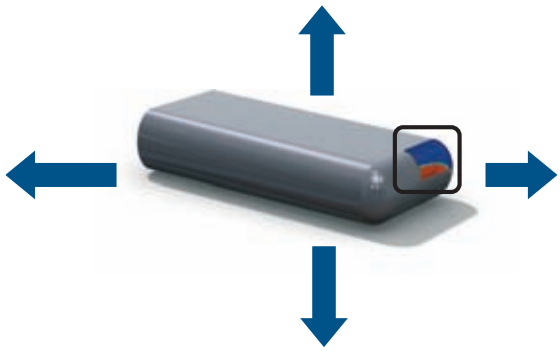

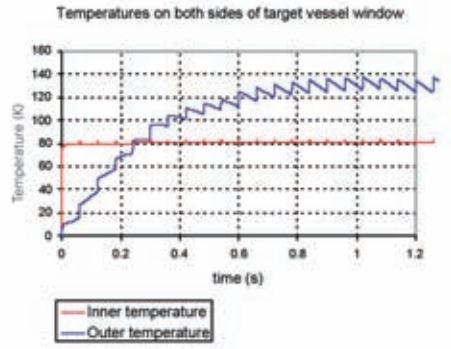

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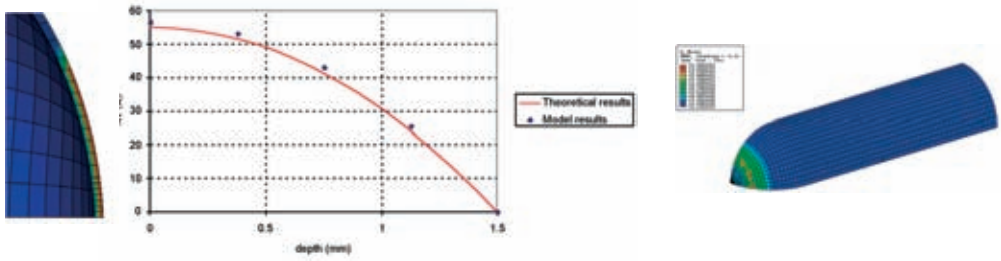

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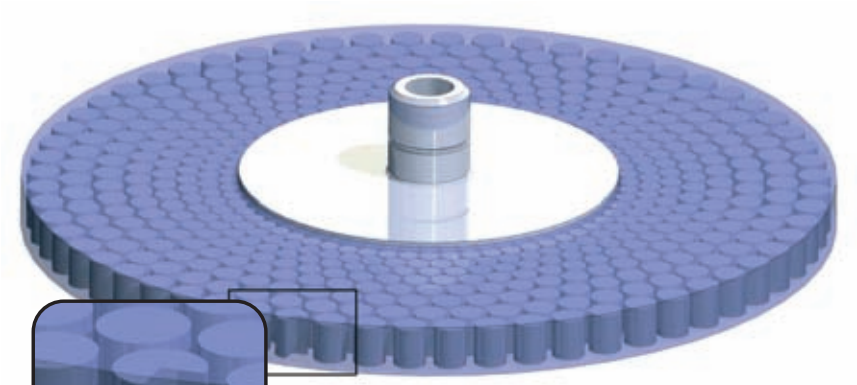

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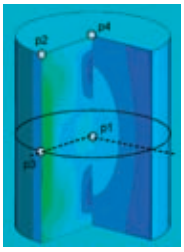

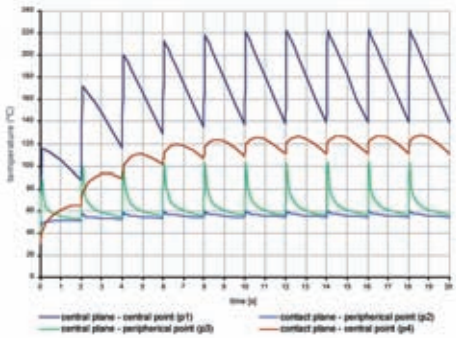

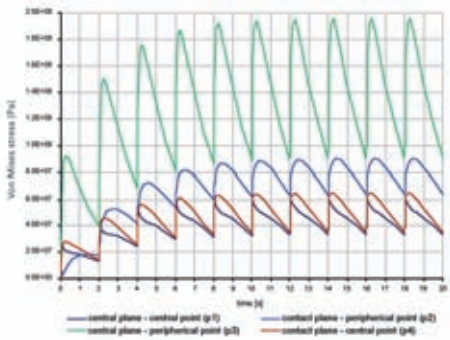

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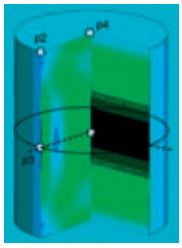

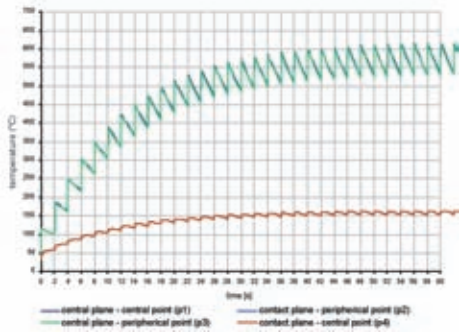

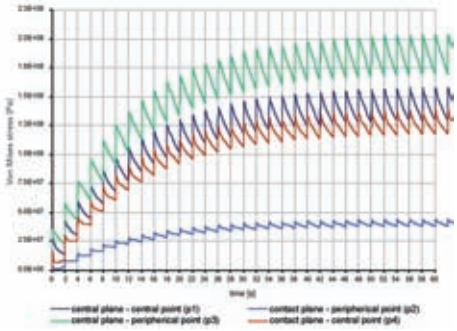

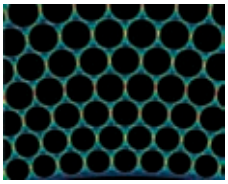

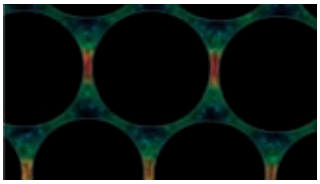

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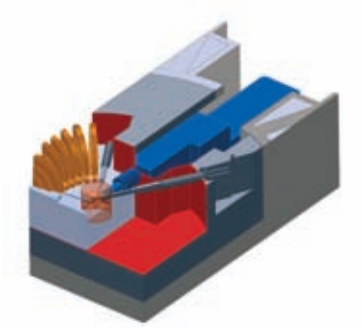

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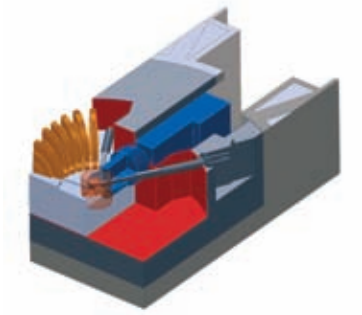

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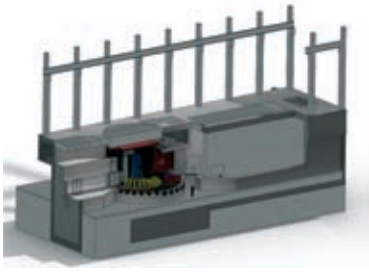

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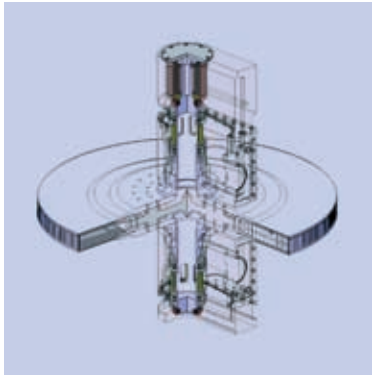

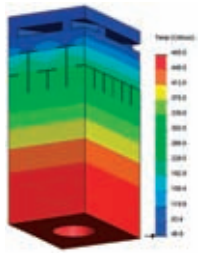

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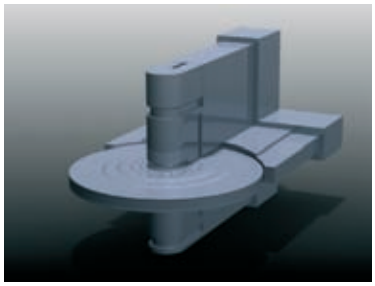

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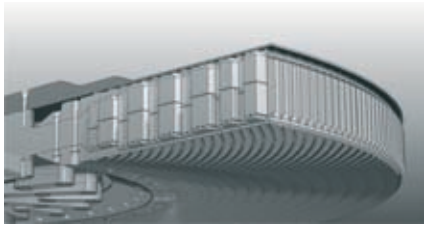

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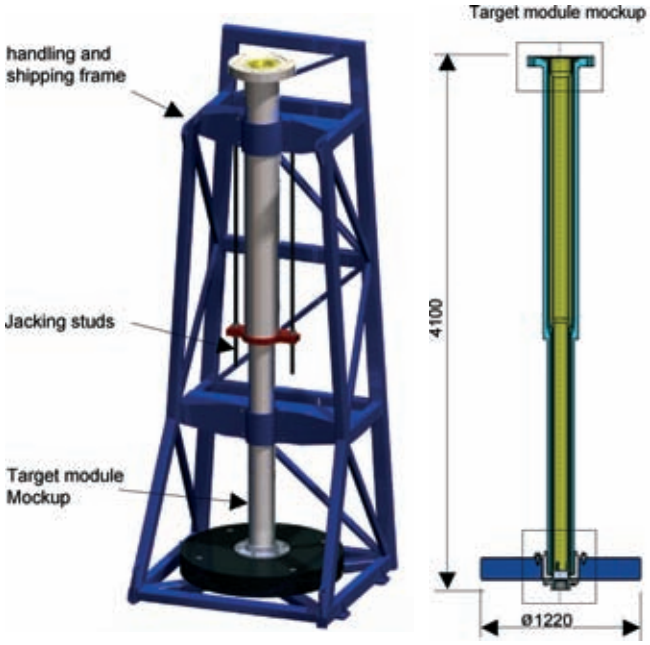

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