
ess
European
Spallation
Source

PLANNED ESS TEST ACTIVITIES

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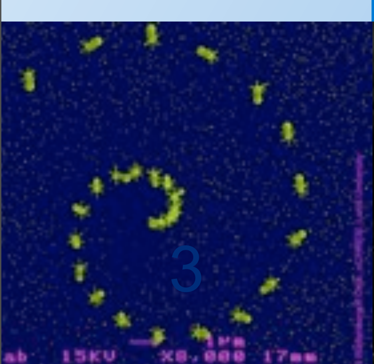
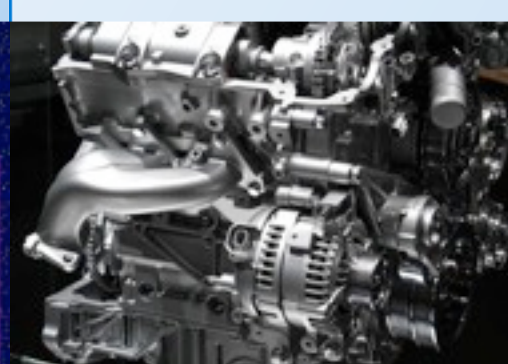
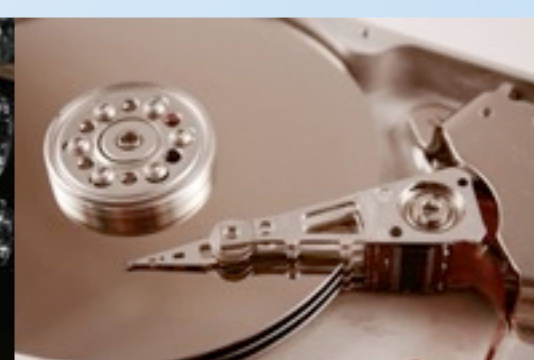
2010-03-29

EUROPEAN SPALLATION SOURCE

- ★A *joint european project* that will become a multi-science research facility.
  - -Material Science, chemistry, bio-science, medicine, energy, environment, climate, engineering, archeology, new materials....
- ★Neutrons are ideal for probing material:
  - -They are *neutral* and therefore highly penetrating
  - -Their *magnetic* moment can be used to study magnetic structures
  - -Neutrons have *spin* and can be formed into polarized beams
  - -The *energy* of thermal neutrons are similar to the energies of excitations in solids (vibrations, lattice modes, etc.)
  - -The *wavelength* of neutrons are similar to atomic spacing.
  - -Neutrons are sensitive to *light nuclei*.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NEUTRON SPALLATION

★A spallation source consists of three major parts:

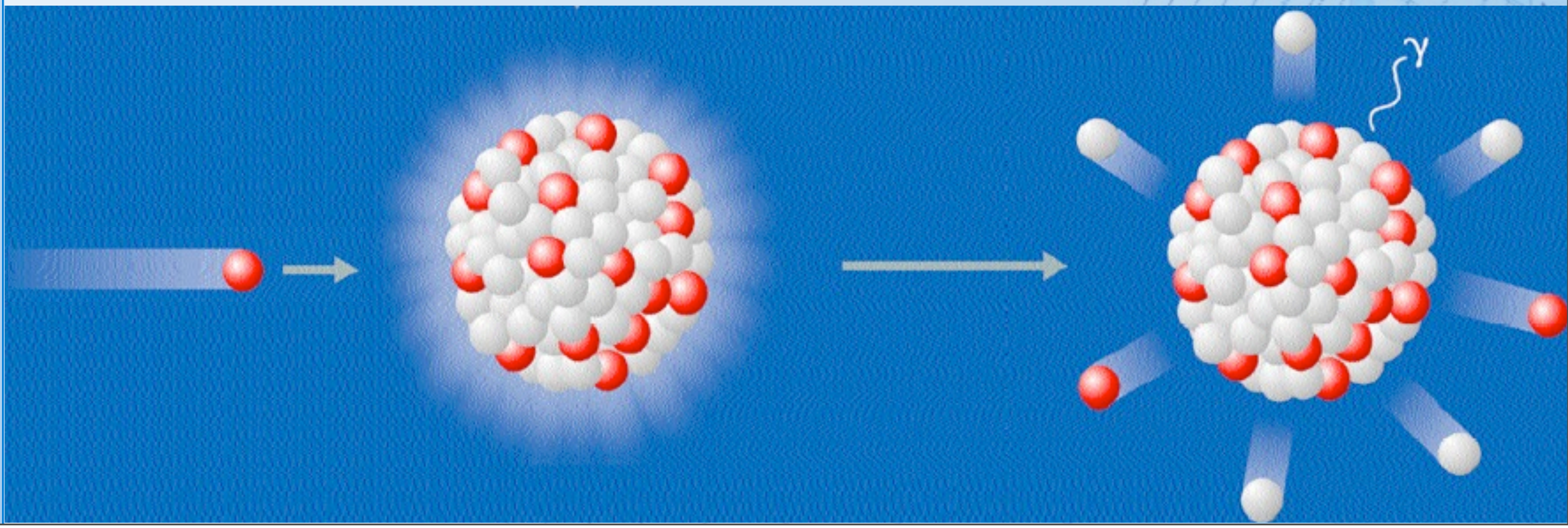
-A particle *accelerator* to create projectiles.

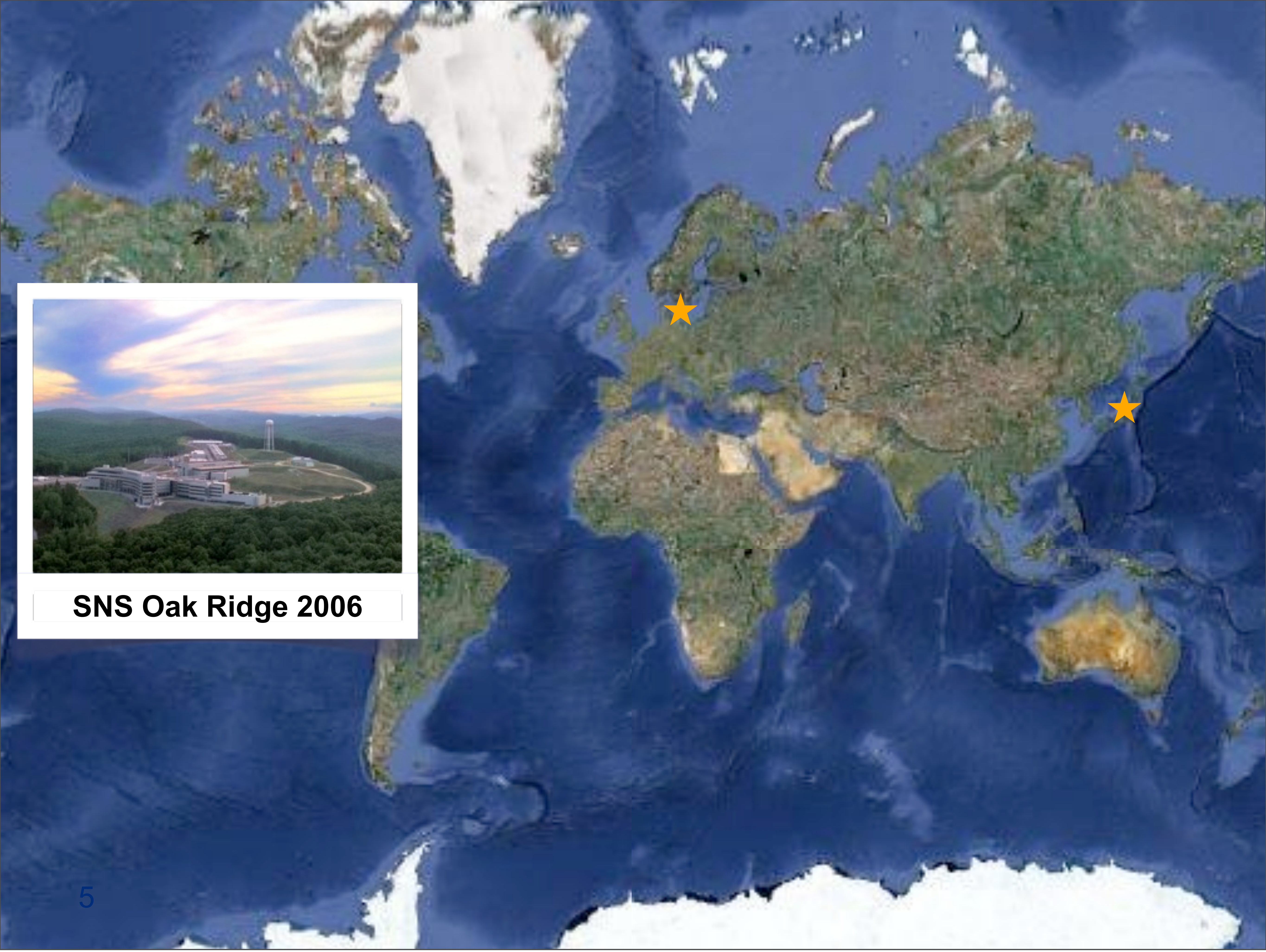
-A *target* where neutrons are spalled.

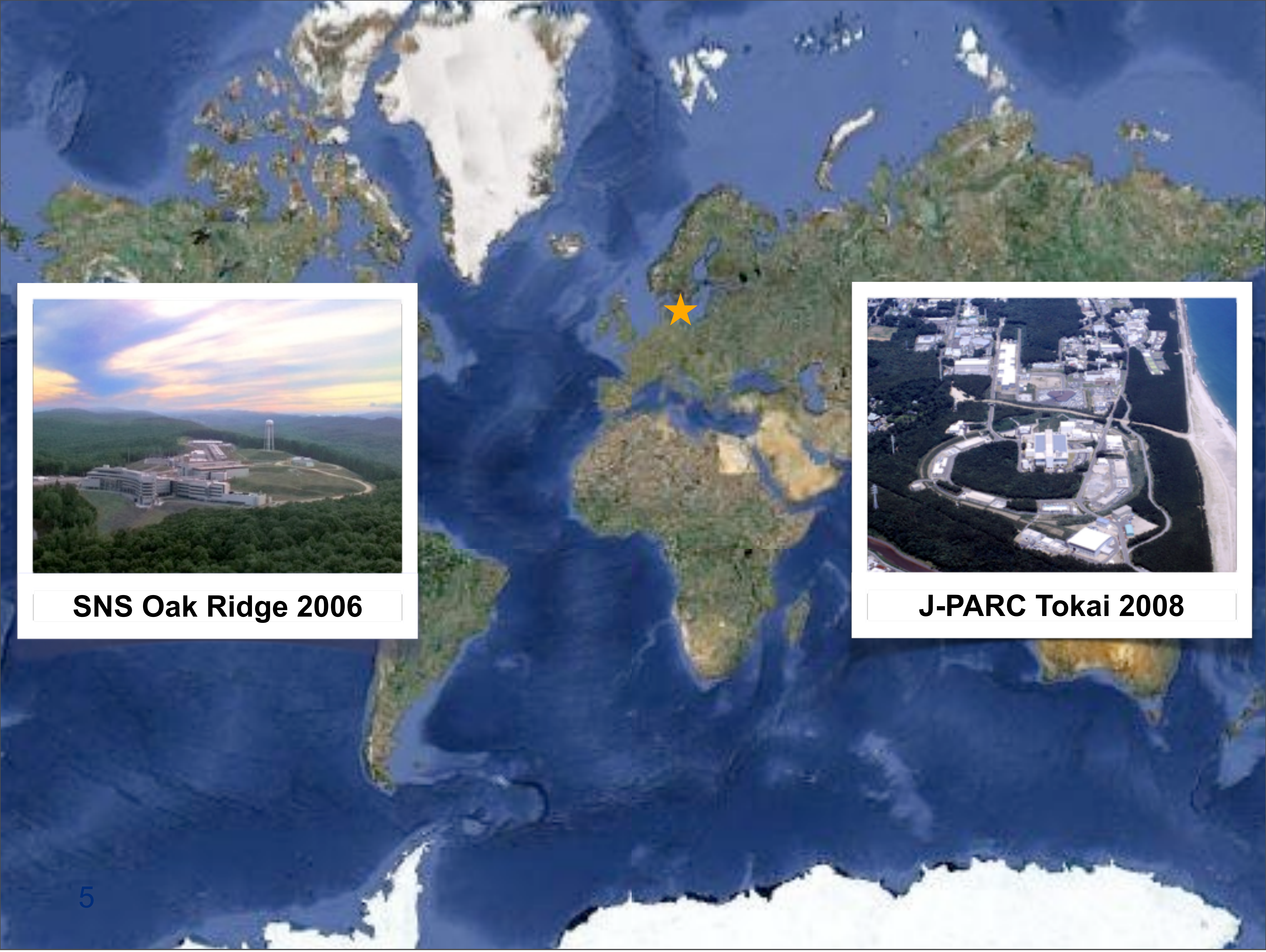
-*Instruments* (neutron guides and detectors) for the scientists.

★One high energy proton (2.5 GeV) gives many (~40) low energy neutrons

★Multiplication factor scales with energy




SNS Oak Ridge 2006



SNS Oak Ridge 2006
J-PARC Tokai 2008


SNS Oak Ridge 2006


ESS Lund 2019


J-PARC Tokai 2008

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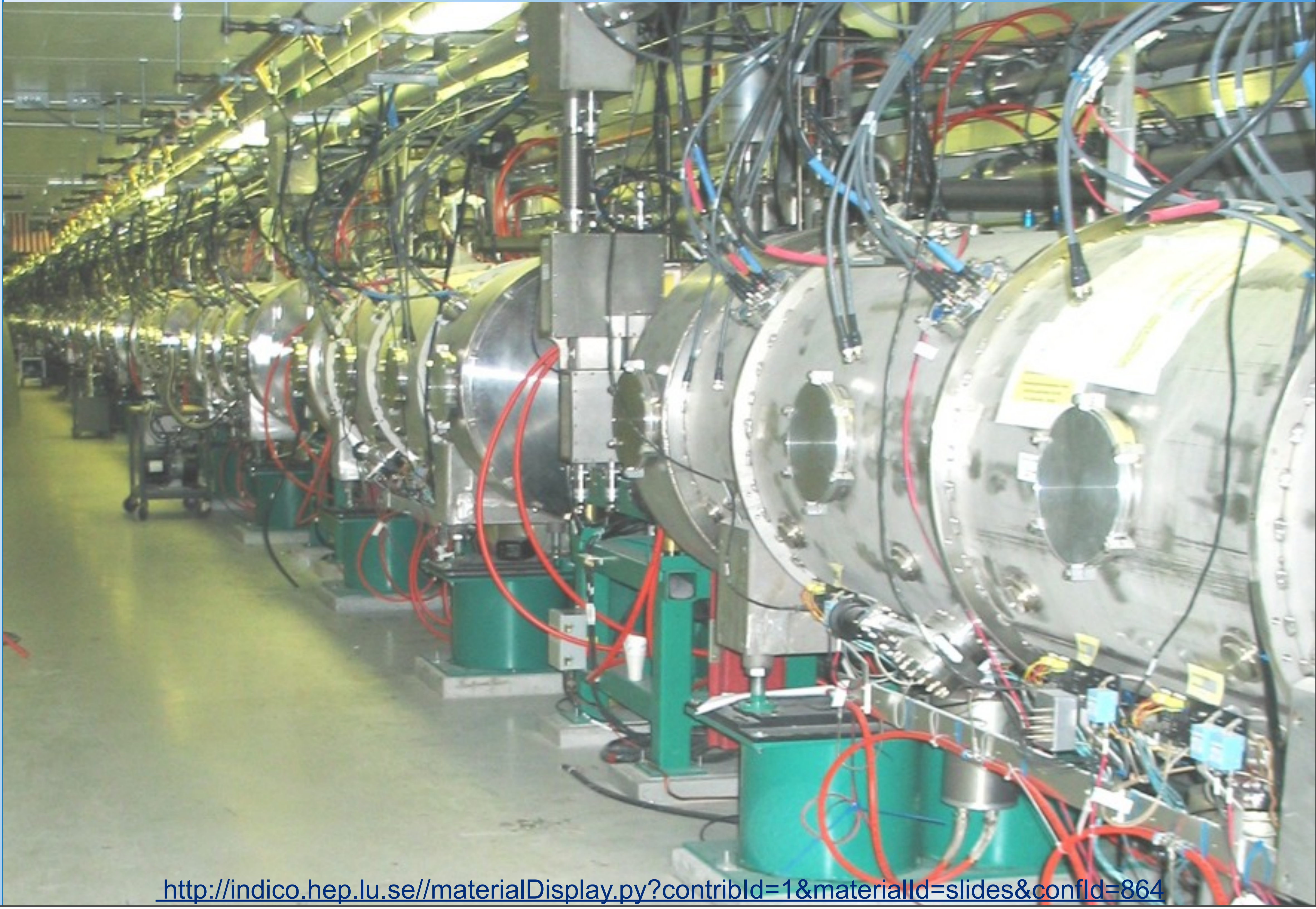
SUPERCONDUCTING LINAC

SNS Oak Ridge



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LIQUID METAL TARGET

SNS Oak Ridge

INSTRUMENTS
SNS Oak Ridge

STATUS

- ESS has a high priority on the ESFRI list
  - "To ensure that Europe has access to world leading facilities, the *European Spallation Source (ESS) is a high priority* together with the upgrade of the Institut Laue-Langevin (ILL)."

- Lund elected as the site for ESS at a Ministerial meeting in Brussels 28 May 2009
- ESS *Scandinavia*, ESS *Bilbao* and ESS *Debrechen* has become ESS, which now has 14 member states.
- First Steering Committee meeting in Copenhagen 22-23 October 2009
- New organization from April 1, 2010
- First neutrons for 2019 with full design specifications in 2023

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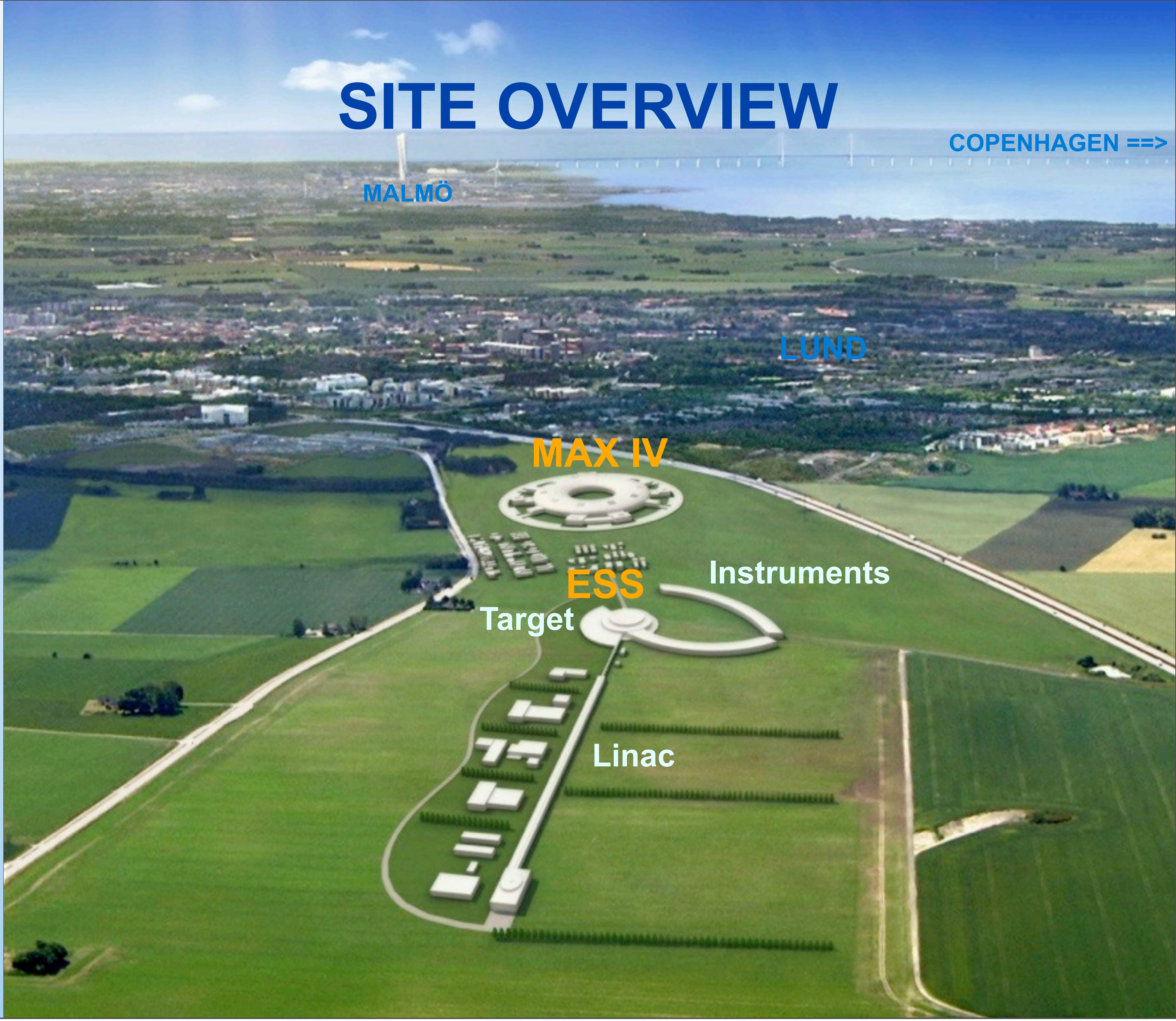
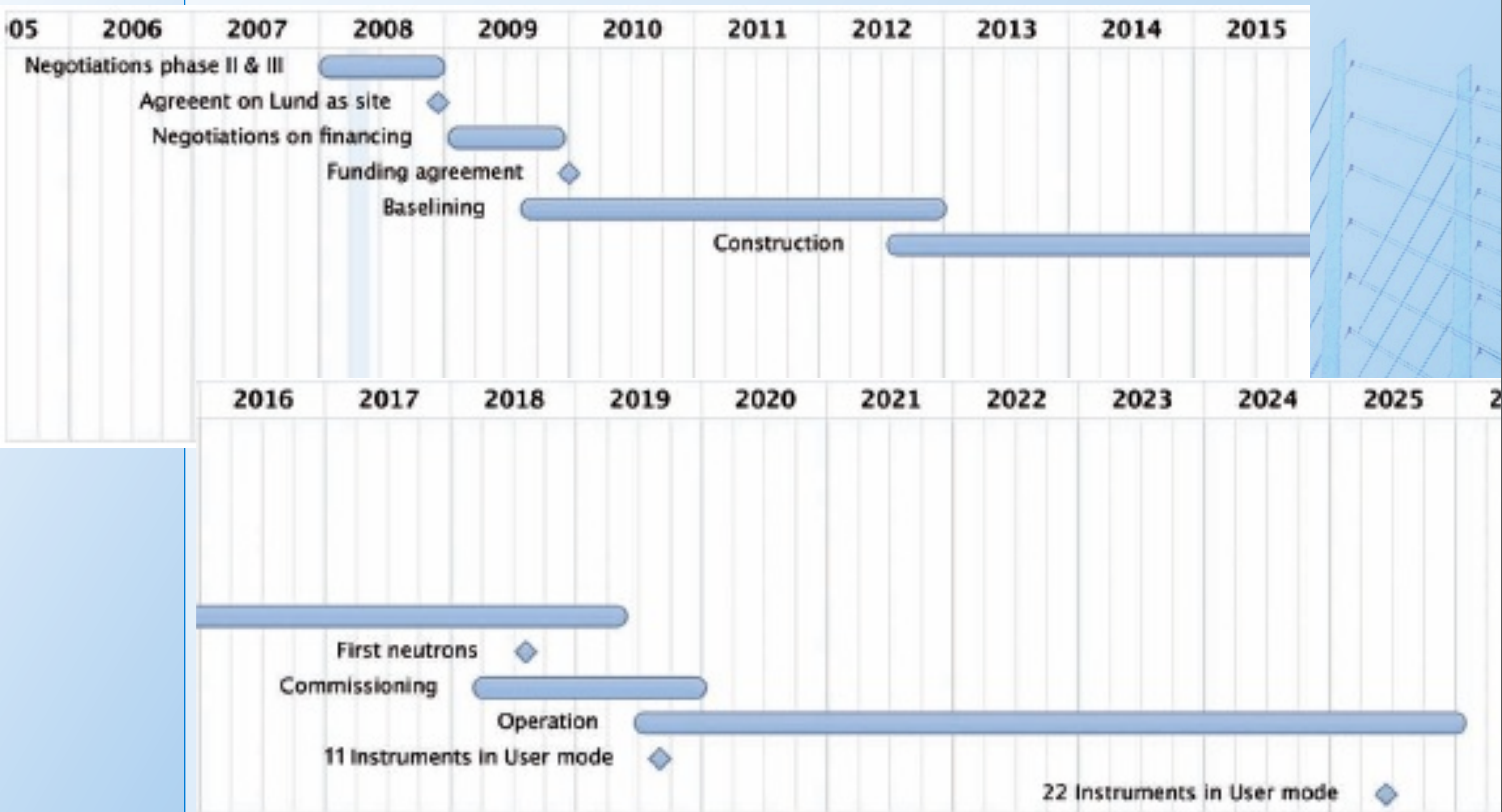
SITE OVERVIEW



TIME LINE

Ambitious goals requires ambitious planning



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ESS GUIDELINES

(Adopted by the ESS Steering Committee)

★ Starting point is the 2008 ESFRI Roadmap specification

★ Performance parameters
- -Neutron production 30 times SNS today
- -Peak neutron flux 30 times ILL´s average flux
- -Time-averaged flux equal to ILL

★ Electrical power supply 32 MW to 38 MW

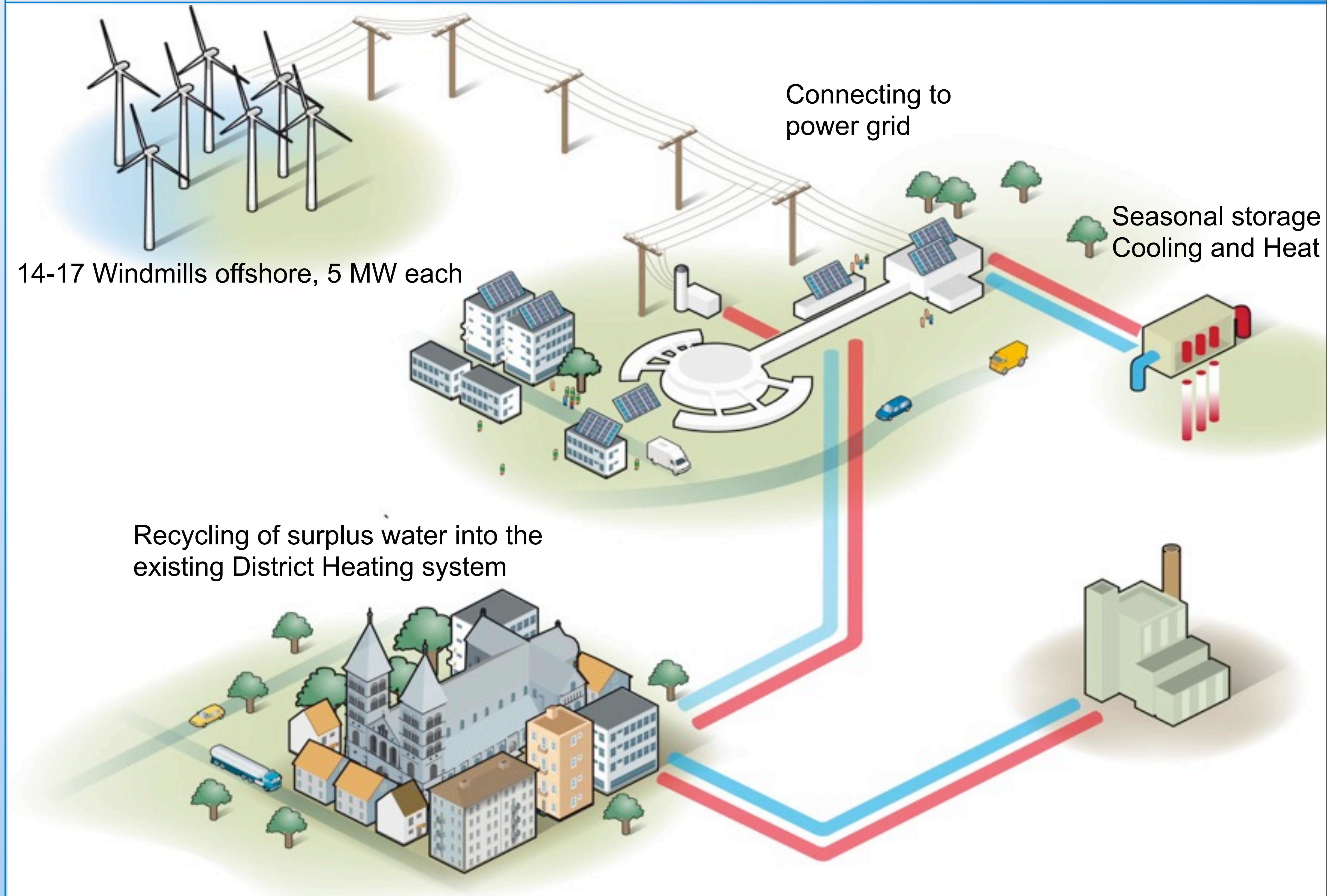
★ Accelerator key parameters
- -A proton linac
- -Proton energy range: 1 to 2.5 GeV
- -Pulse frequency range: 10 to 20 Hz
- -Pulse length range: 0.8 to 2 msec
- -Nominal beam power: 5 MW
- -Beam on target: > 95 % reliability
- -Beam loss: ~ 1 W/m

★ Target station key parameters
- -A single target station
- -Cold and cold-thermal moderators
- -A liquid metal target: mercury or lead-alloys, Solid rotating target as fall-back

★ 22 beam ports (11 North, 11 South)
- -or 11 beam ports South and 22 neutron guides North.

SUSTAINABLE RESEARCH CENTER

Responsible-Recyclable-Renewable



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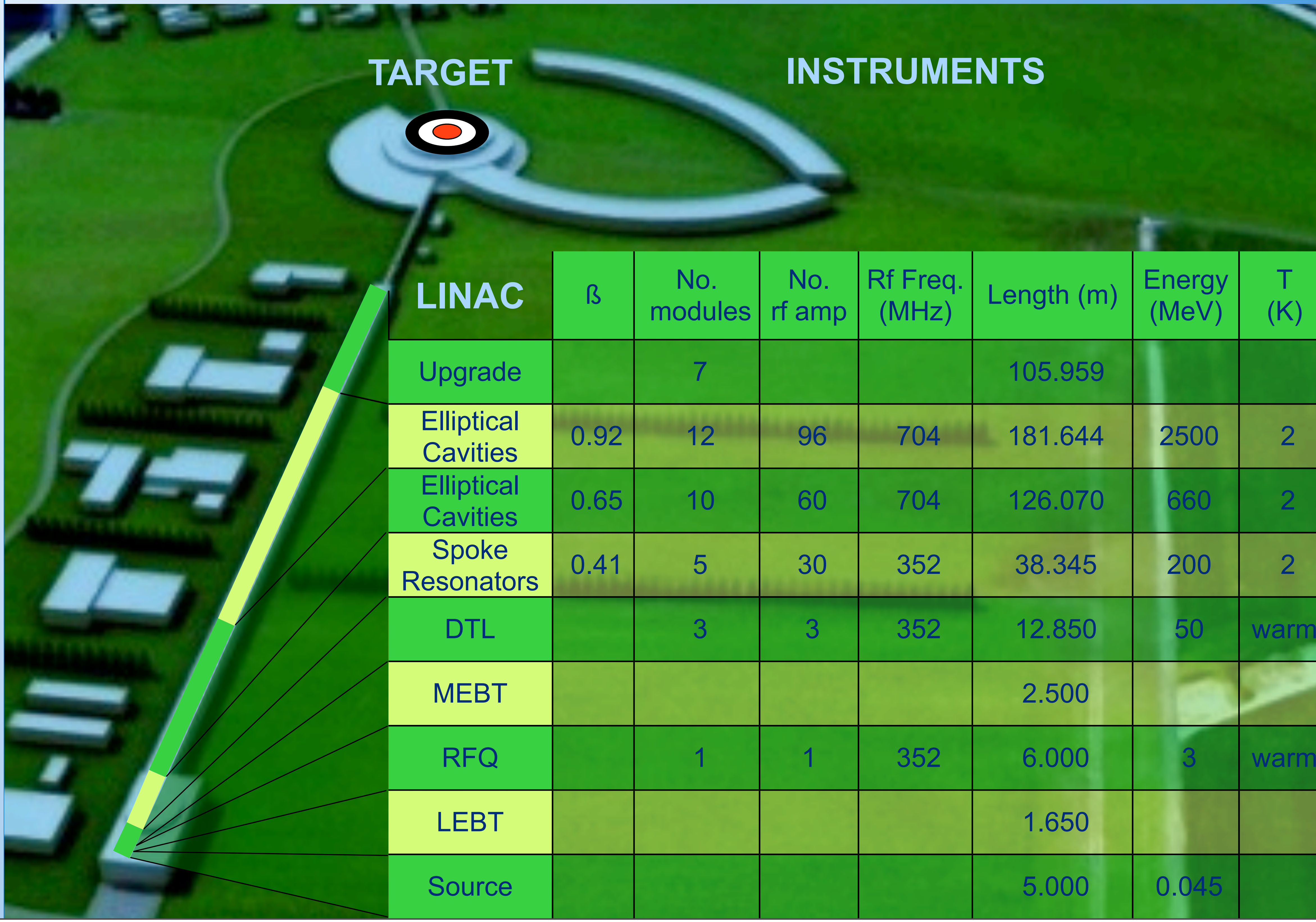
LINAC OVERVIEW



LINAC	ß	No. modules	No. rf amp	Rf Freq. (MHz)	Length (m)	Energy (MeV)	T (K)
Upgrade		7			105.959		
Elliptical Cavities	0.92	12	96	704	181.644	2500	2
Elliptical Cavities	0.65	10	60	704	126.070	660	2
Spoke Resonators	0.41	5	30	352	38.345	200	2
DTL		3	3	352	12.850	50	warm
MEBT					2.500		
RFQ		1	1	352	6.000	3	warm
LEBT					1.650		
Source					5.000	0.045	

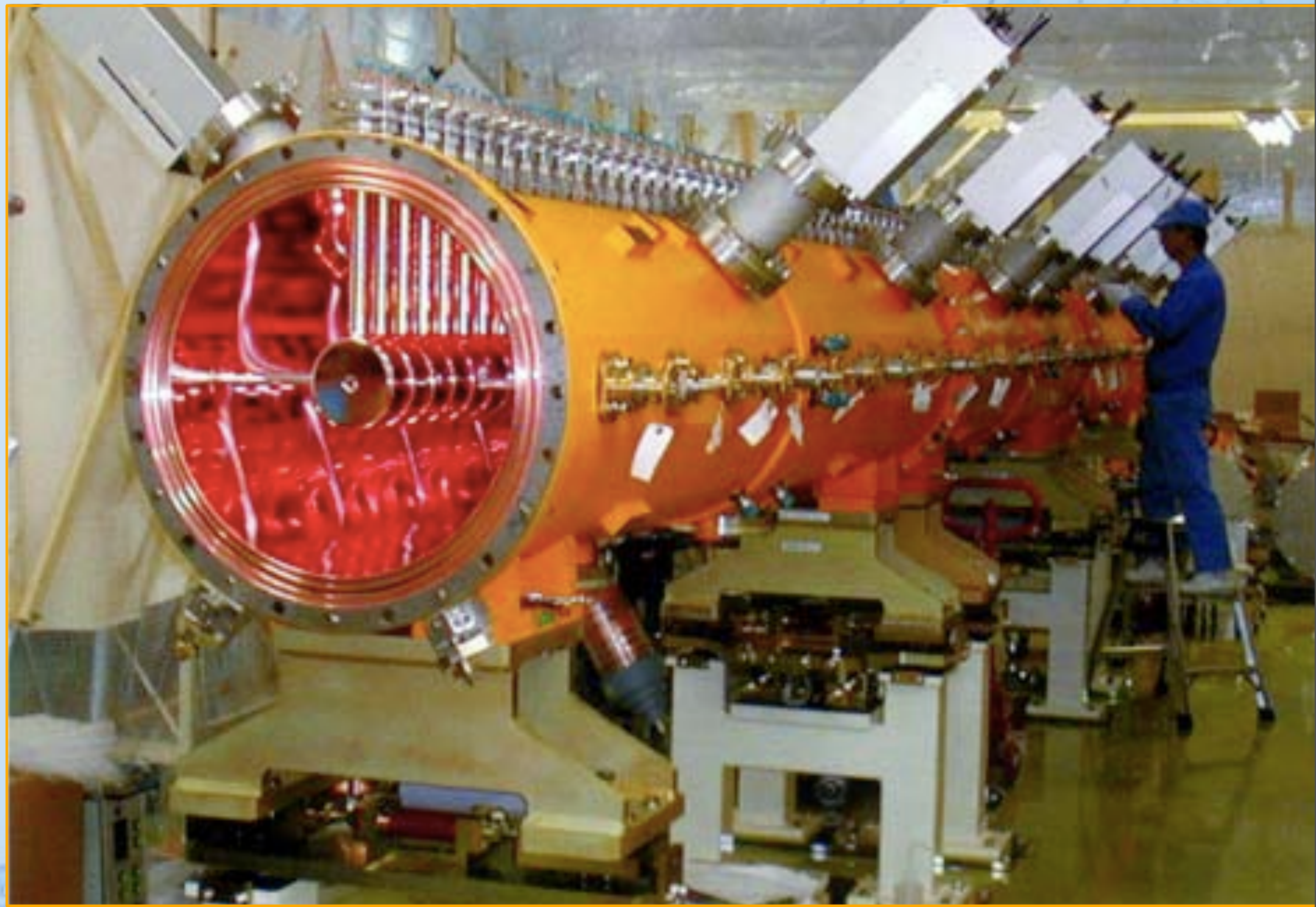
WORK PACKAGES

1. Management and Coordination
2. Accelerator Science
3. Infrastructure Services
4. SCRF Spoke cavities
5. SCRF Elliptical cavities
6. Front End and NC linac
7. Beam transport, NC magnets and Power Supplies
8. RF Systems

FRONT END & NC LINAC
WP 6

★Work units of WP6:

1. Planning of the activities
2. Source and Low Energy Beam Transport (LEBT)
3. RFQ
4. Medium Eenergy Beam Transport (MEBT)
5. NC Linac



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SOURCE AND LEBT

★SILHI:

-H+ Intensity > 100 mA at 95 keV

-H+ fraction > 80 %

-Beam noise < 2%

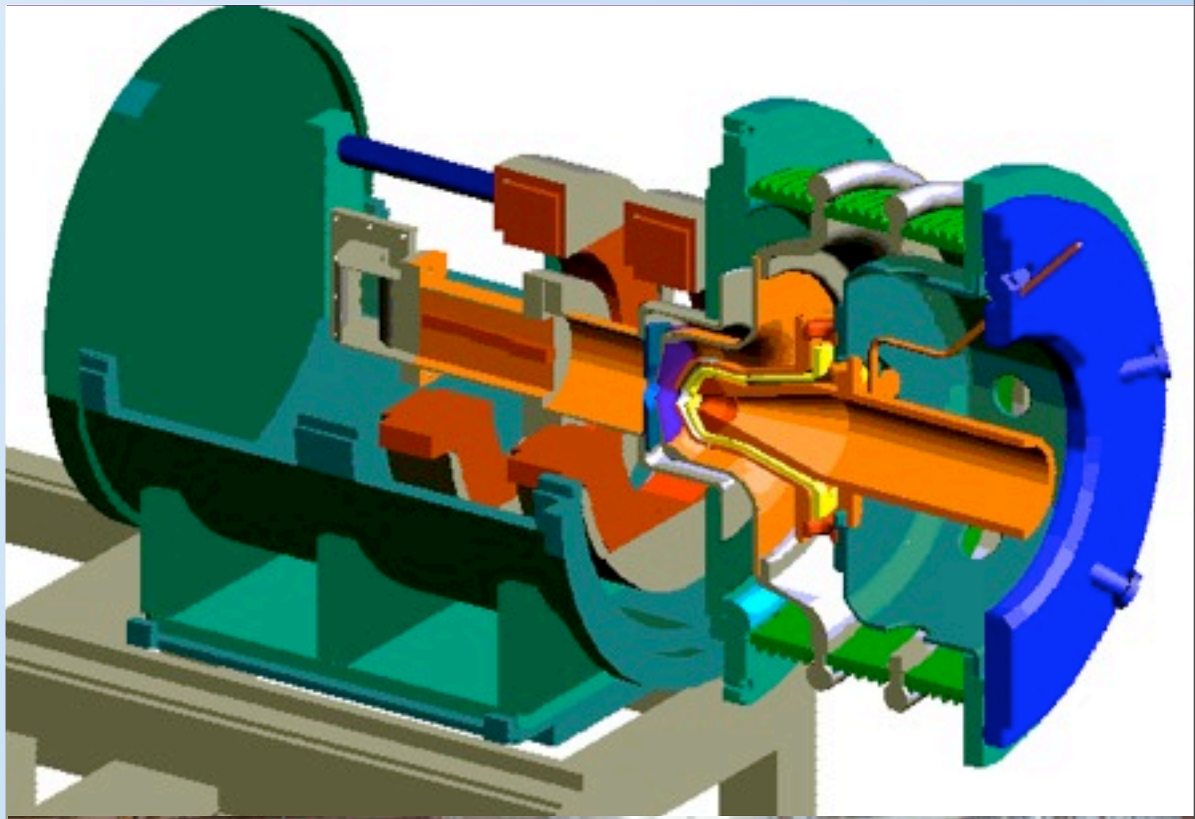
-95 % < Reliability < 99.9 %

-Emittance < 0.2 π mm.mrad

-CW or pulsed mod

★Study of pulsed operation with existing sources at INFN-LNS and CEA-IRFU

★Study of matching with RFQ

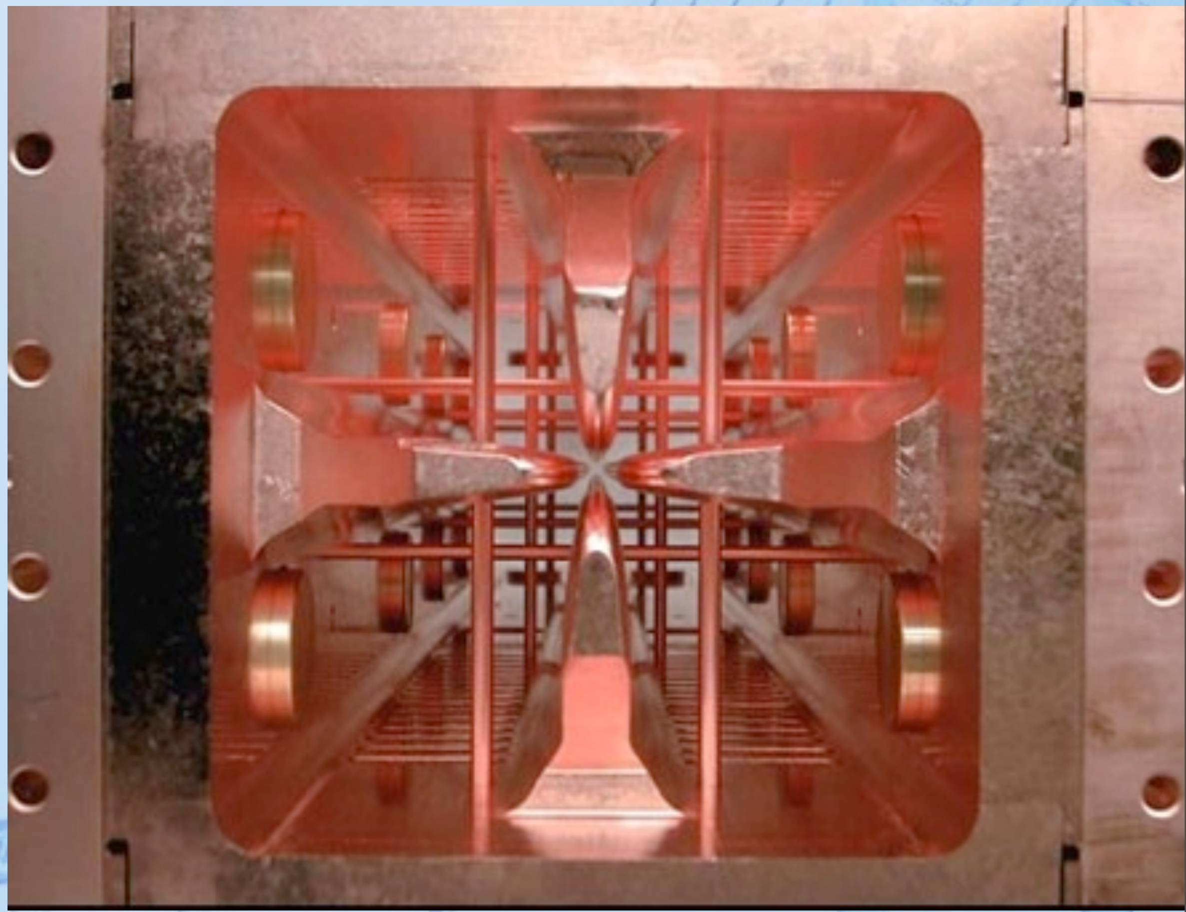


WHO MASTERS RFQ?

★SNS: problem with the tuning during operation.

★J-PARC: high sparking rate, they are replacing it and are switching to a 4 vanes structures

★Study of operations with exiting RFQ at CEA-IRFU



http://commons.wikimedia.org/wiki/File:SNS_RFQ.jpg

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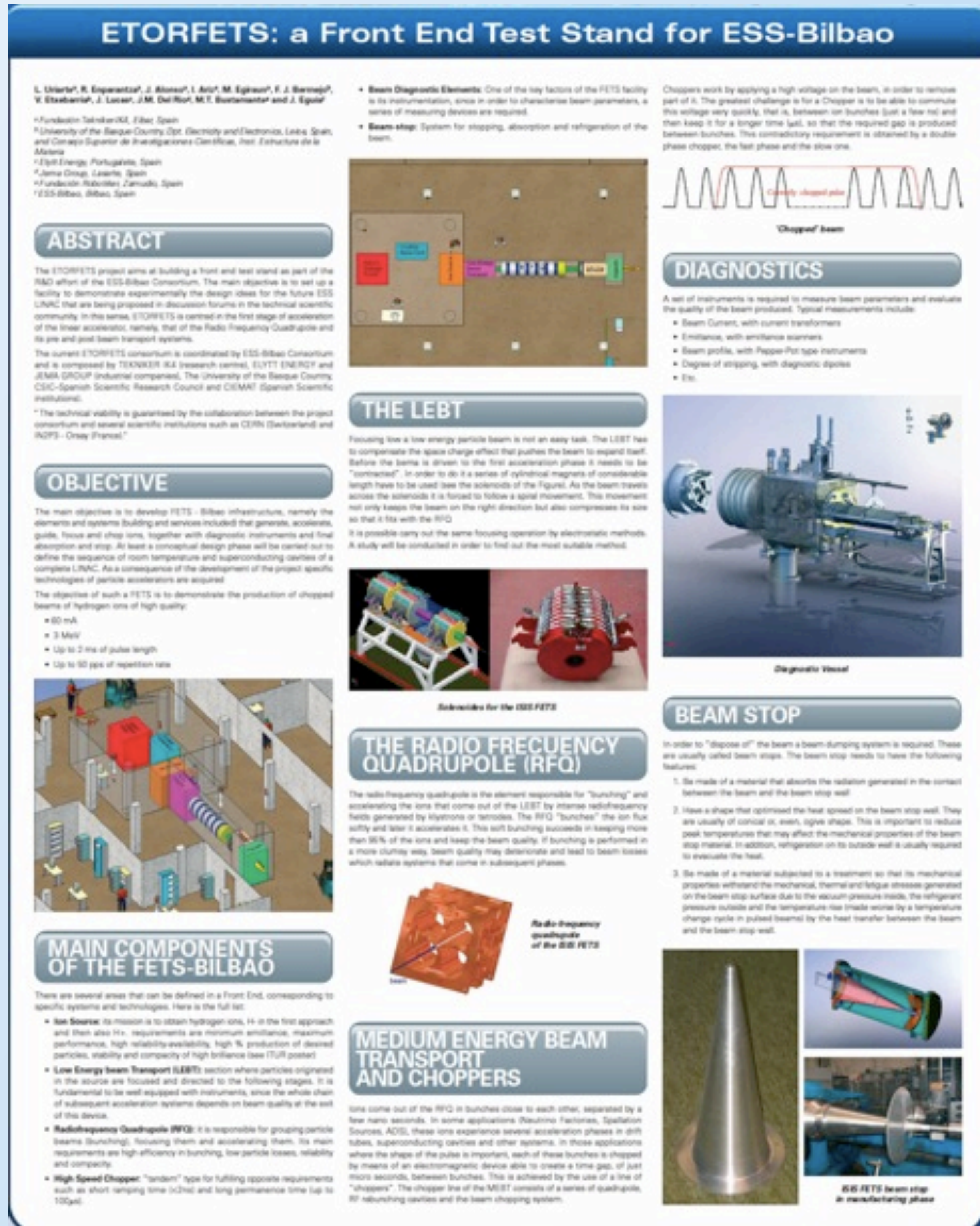
BILBAO TEST STAND

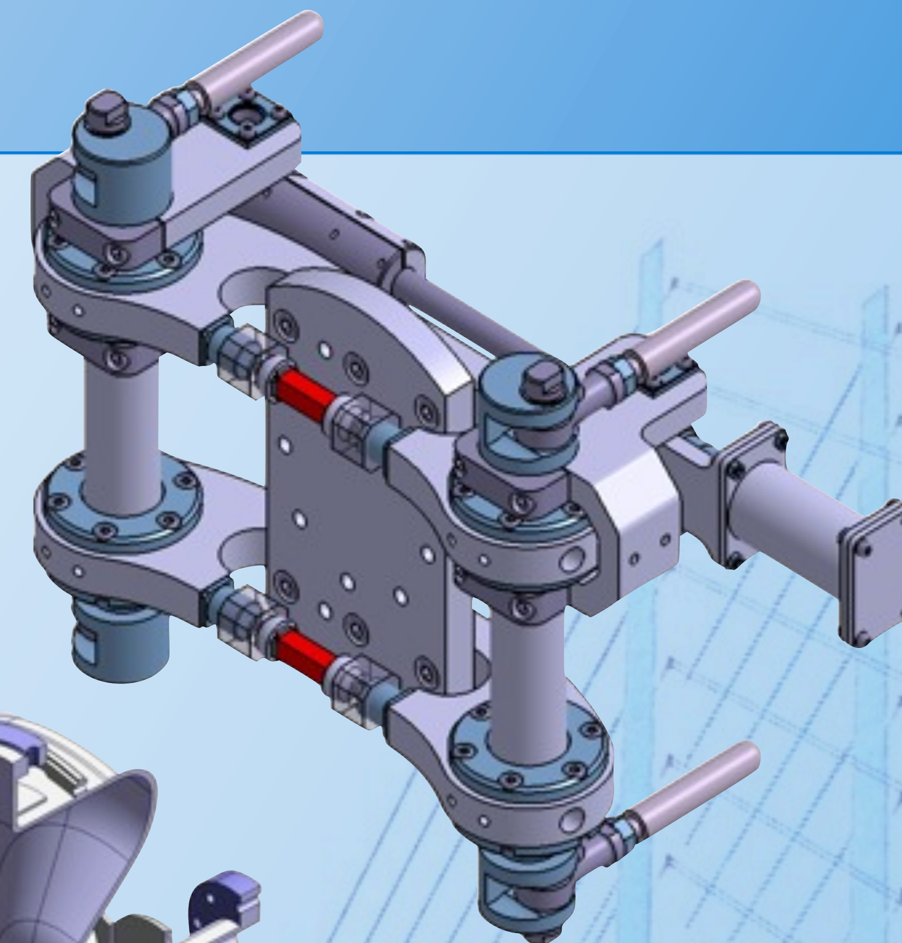


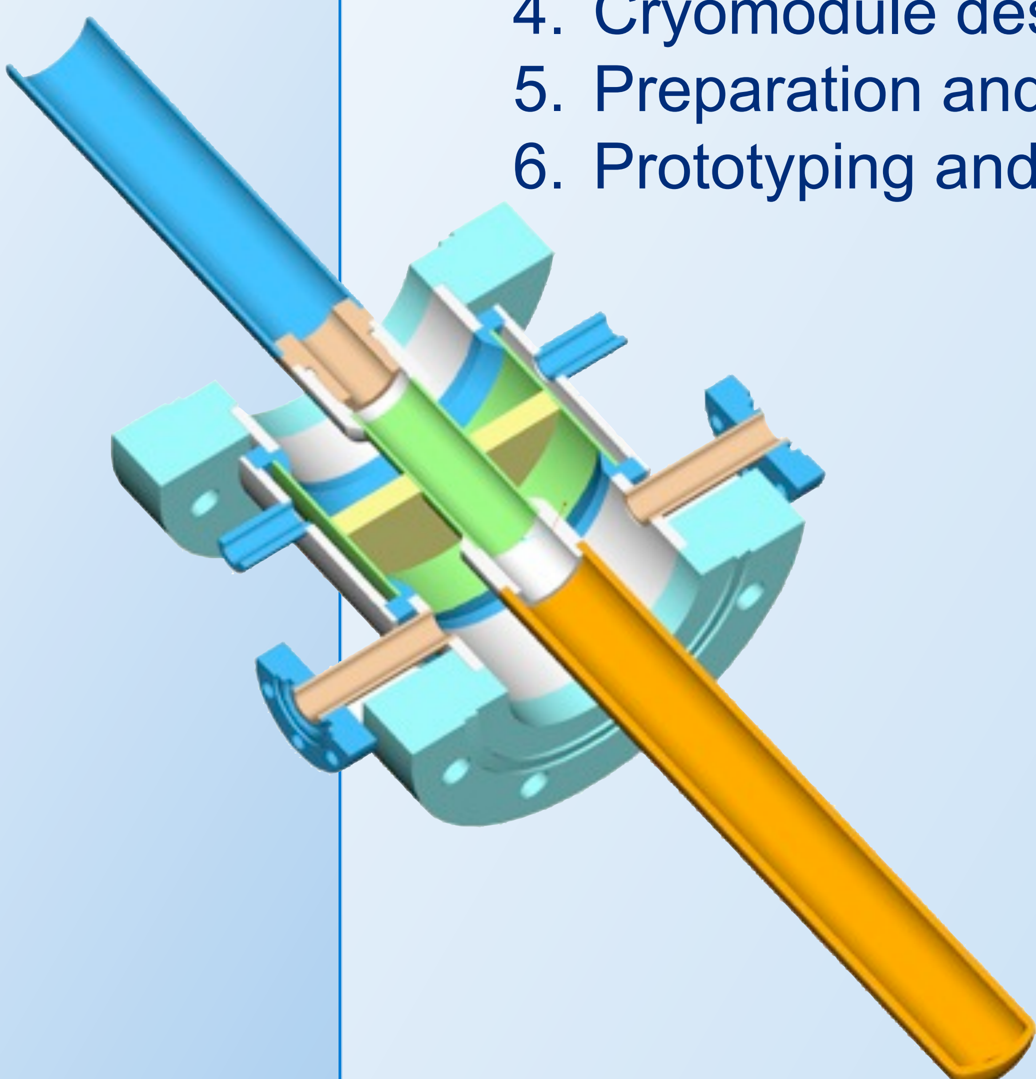
http://www.essbilbao.com/Descargas/etorfets.pdf

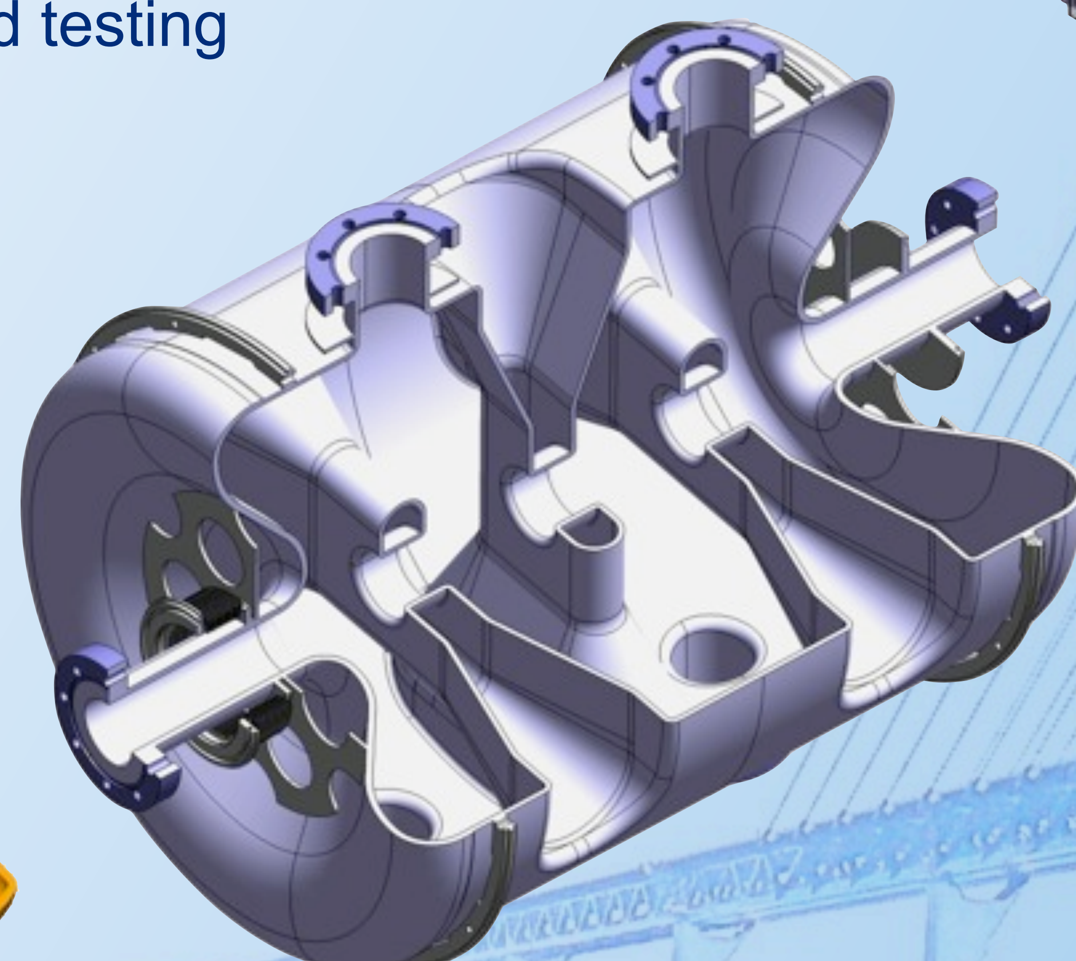
SCRF SPOKE RESONATORS
WP 4

★Work units:

1. WP management and TDR preparation
2. Spoke cavity design
3. Fundamental power coupler design
4. Cryomodule design
5. Preparation and conditioning procedures
6. Prototyping and testing







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http://www.workshop2009.essbilbao.com/cas/wshopdoc/12.pdf

SCRF SPOKE RESONATORS
WP 4

★One of the highest risk components of the ESS Linac
- -High priority to the non-beam testing of early SR Prototypes
- -2 spoke prototypes, one for each beta,
- -Bare cavities (maybe not fully optimized in terms of mechanical behaviour).
- -Test at least one cavity with the other beta, but only in a vertical cryostat.

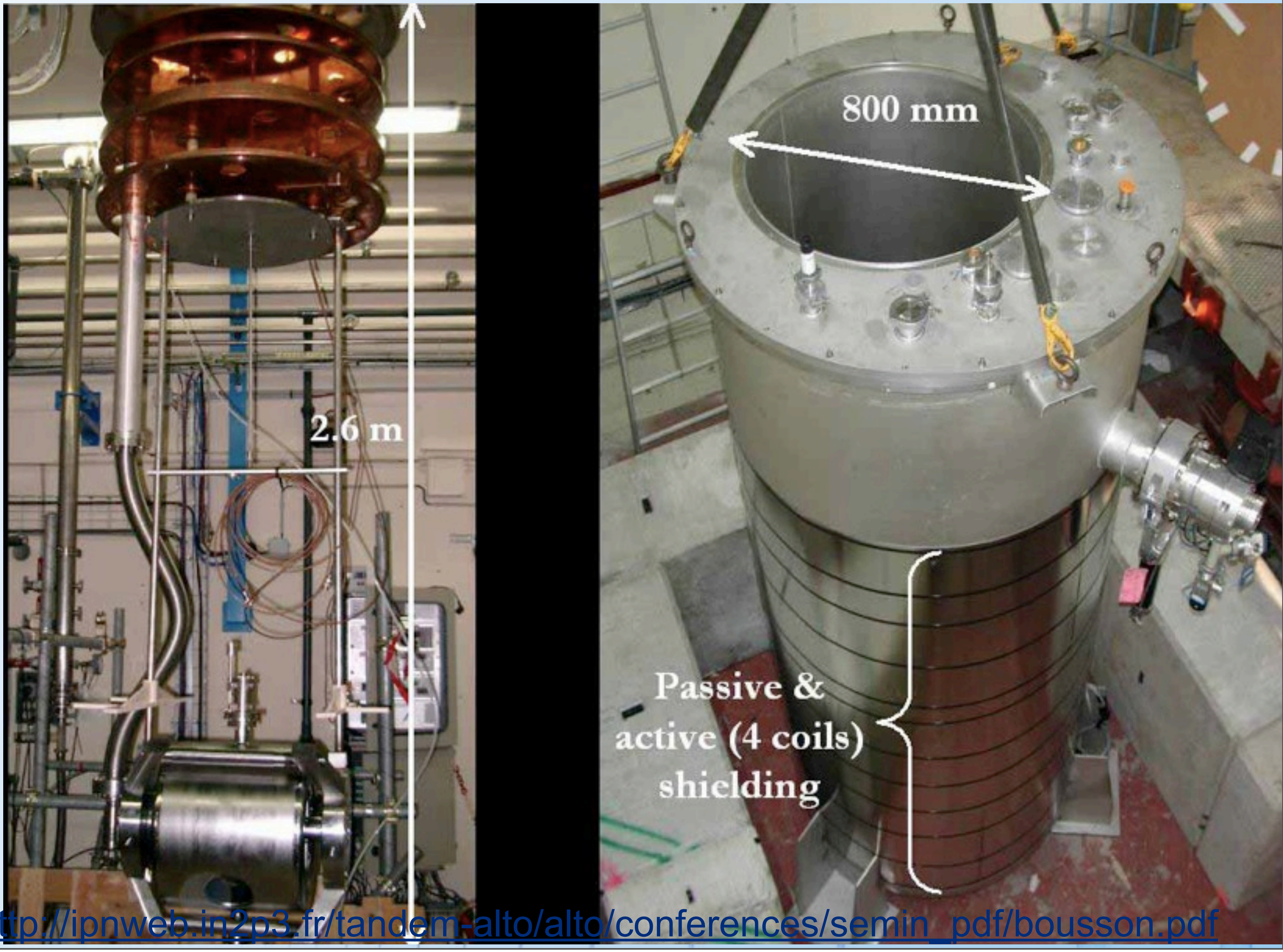
★Baseline temperature is 4K, but 2K option will be studied.
- -2K cryogenics will be available at ESS.
- -Fabricated and tested cavities at low power in VC at 4k and 2K

★2 prototype power couplers, fabricated and characterized

★No appropriate full cryomodule test stand currently exists.
- -Key element that has to be fabricated and tested before construction is a complete spoke cryomodule prototype (7-8 cavities).
- -Should be tested at low temperature, with the nominal RF power on at least one cavity at a time.

VERTICAL TEST STAND

CNRS Orsay

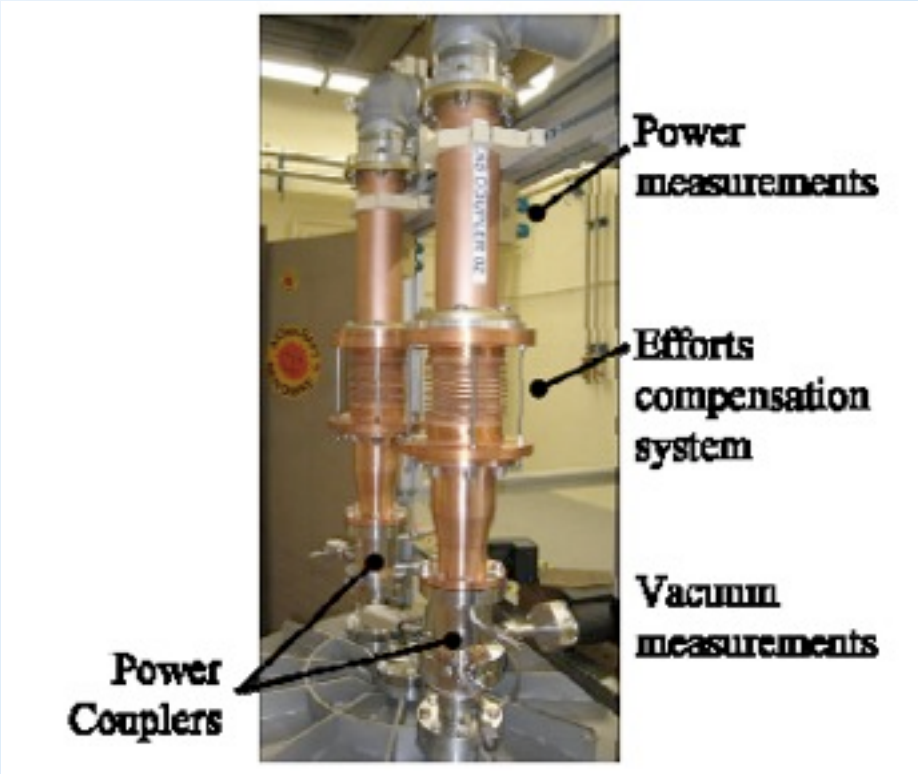


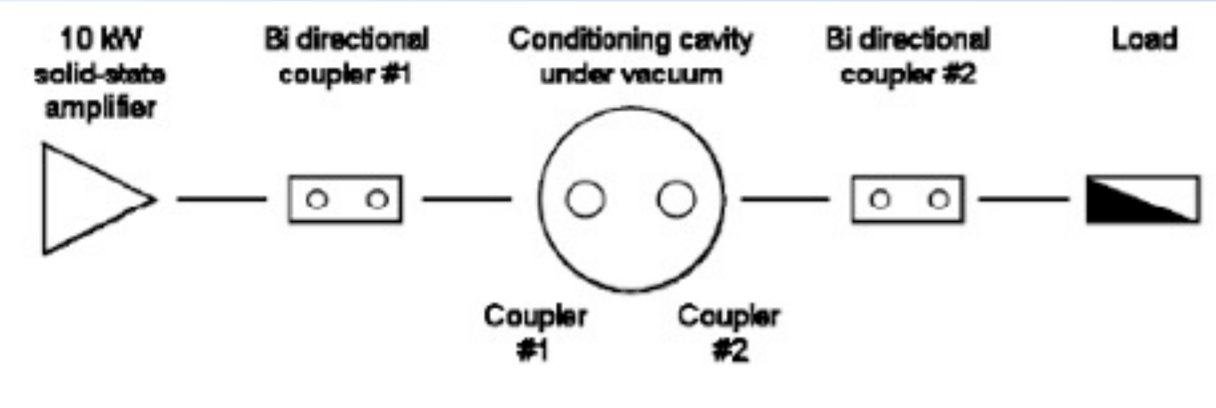
http://ipnweb.in2p3.fr/tandem-alto/alto/conferences/semin_pdf/bousson.pdf

CAVITY PROTOTYPING OUTCOMES

- ★Assess the fabrication procedure, and evaluate the tuning procedure, check the capability of reaching the desired frequency, evaluate the major difficulties during fabrication.
- ★Assess the preparation procedure (chemistry, baking, clean room assembly)
- ★Test in vertical cryostat (at 4K and 2K) and assess the cavity performances (accelerating field, Lorentz forces detuning coefficient, dissipated power) at the two temperature

CONDITIONING TEST STAND
CNRS Orsay





http://trshare.triumf.ca/~pac09proc/Proceedings/papers/we5pfp029.pdf

POWER COUPLERS PROTOTYPING OUTCOMES

- ★ Assess the fabrication procedure, evaluate the major difficulties during fabrication.
- ★ Measure the couplers main parameters
  -f, S-parameters...
- ★ Assess the preparation procedure
  -cleaning, clean room assembly

SCRF ELLIPTICAL CAVITIES

WP 5

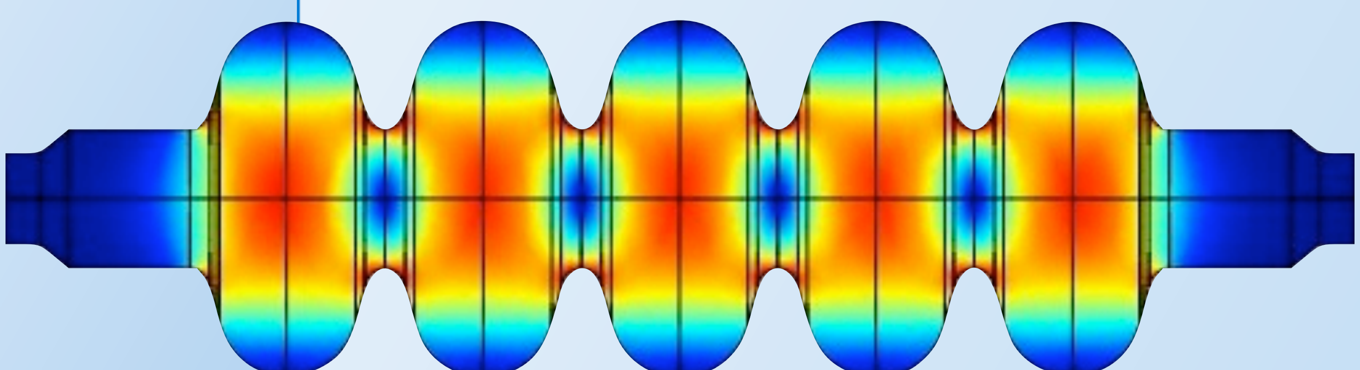
★Components:

-Cavity incl. power coupler,He vessel, HOM dampers, Tuners
-Intercavity elements
-Thermal and magnetic shields
-Internal supporting and alignment
-Internal cryogenic distribution
-Vacuum vessel

★Interaction with similar developments

ELLIPTICAL CAVITIES

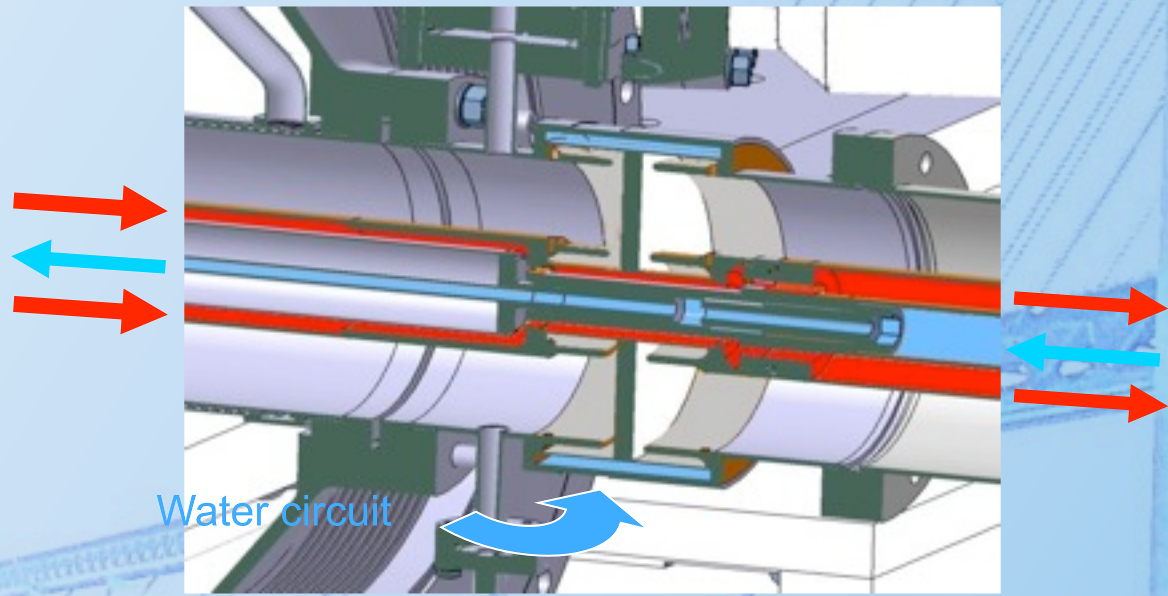
- ★704.4 MHz
- ★Two geometrical structures
  - -β=0.65
  - -β=0.92
- ★ESS and SPL and eRHIC: five cell cavity



eRHIC 704MHz cavity, β=1
(AES brookhaven)

POWER COUPLERS

- ★ Simple design for reliability and cost reduction.
  - -Not adjustable impedance antenna.
  - -No mechanical movements allowed.
- ★ One coupler per cavity to avoid cross talk
- ★ Matched only when the cavity is fully loaded (beam and rf)
- ★ 704 MHz
- ★ Design power:1.2 MW



http://indico.cern.ch/getFile.py/access?contribId=77&sessionId=10&resId=0&materialId=0&confId=63935

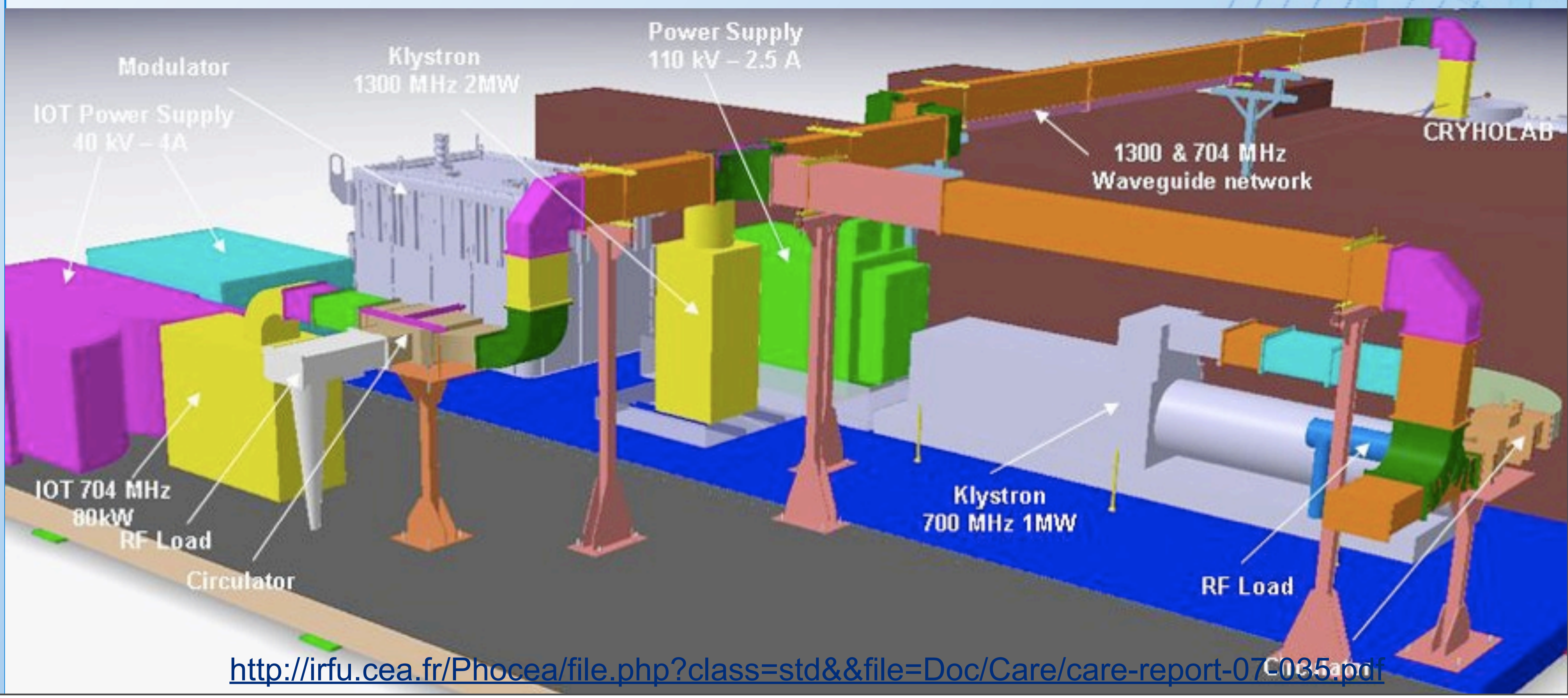
TEST STAND AT CEA-SACLAY

★704 MHz, 1 MW vertical test stand for qualification of:

-superconducting cavities

-power couplers

-tuning systems



http://irfu.cea.fr/Phocea/file.php?class=std&&file=Doc/Care/care-report-07-035.pdf

CERN SM-18 TEST FACILITY

★Discussions of joint prototype testing of a full high beta cryomodule for ESS and SPL by the end 2012.
-8 cavities for β=0.92

★Further development for ESS is needed:
-No real estate gradient crisis -- moderate requirement on gradients
-On the other hand, very high power requirements

RF SYSTEMS
WP8

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WORK UNITS
WP8

1. Coordination and communication
2. Low level RF system
3. RF power generation
4. RF power distribution
5. RF test facility

TEST FACILITY IN UPPSALA

- Ongoing discussions for building a test facility for the rf source and distribution system with emphasis on
  - -reliability
  - -losses
  - -power consumption
  - -overall costs
- Examples:
  - -Development of klystron modulators with variable pulse length
  - -Optimize droop compensation of modulator pulse
  - -Optimize LLRF system in the spirit of mobile telephone r&d
  - -Active amplifiers for vector modulators to splitting rf power to β=0.65 cavities

EXAMPLE:
β=0.92 geometry

★1 MW at power coupler requires

-1.5 MW klystron (5% losses + 30% margin for LLRF)

-2.5 MW klystron modulator (62% klystron efficiency)

★13 MW power consumption averaged over year

-96 Klystrons, 85% modulator efficiency, 4.6 % duty cycle (2.3 ms pulses and 20 Hz repetition rate) and 4800 + 480 hour operation per year (including start up and r&d)

★R&d on the rf systems is important

-Increase reliability

-Minimize beam losses

-Reduce power consumption


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