The 600 MeV EUROTRANS Proton Driver Linac

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for the EUROTRANS WP1.3 Collaboration

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Overview

- EUROTRANS objectives and requirements
- Linac Reference Design
- Prototype Development
- Fault Tolerance
- Summary

EUROTRANS

Integrated Project on **EURO**pean **TRANS**mutation

145 nuclear power plants in EU → 2500 tons of spent fuel per year

Small fraction (minor Actinides) represents very problematic waste with respect to radio toxicity and life time

The most promising concept to reduce radio toxicity and life time is transmutation based on an Accelerator Driven System (ADS)

EUROTRANS

The main objective of EUROTRANS to work for a European Transmutation Demonstrator (ETD) using a two-step approach:

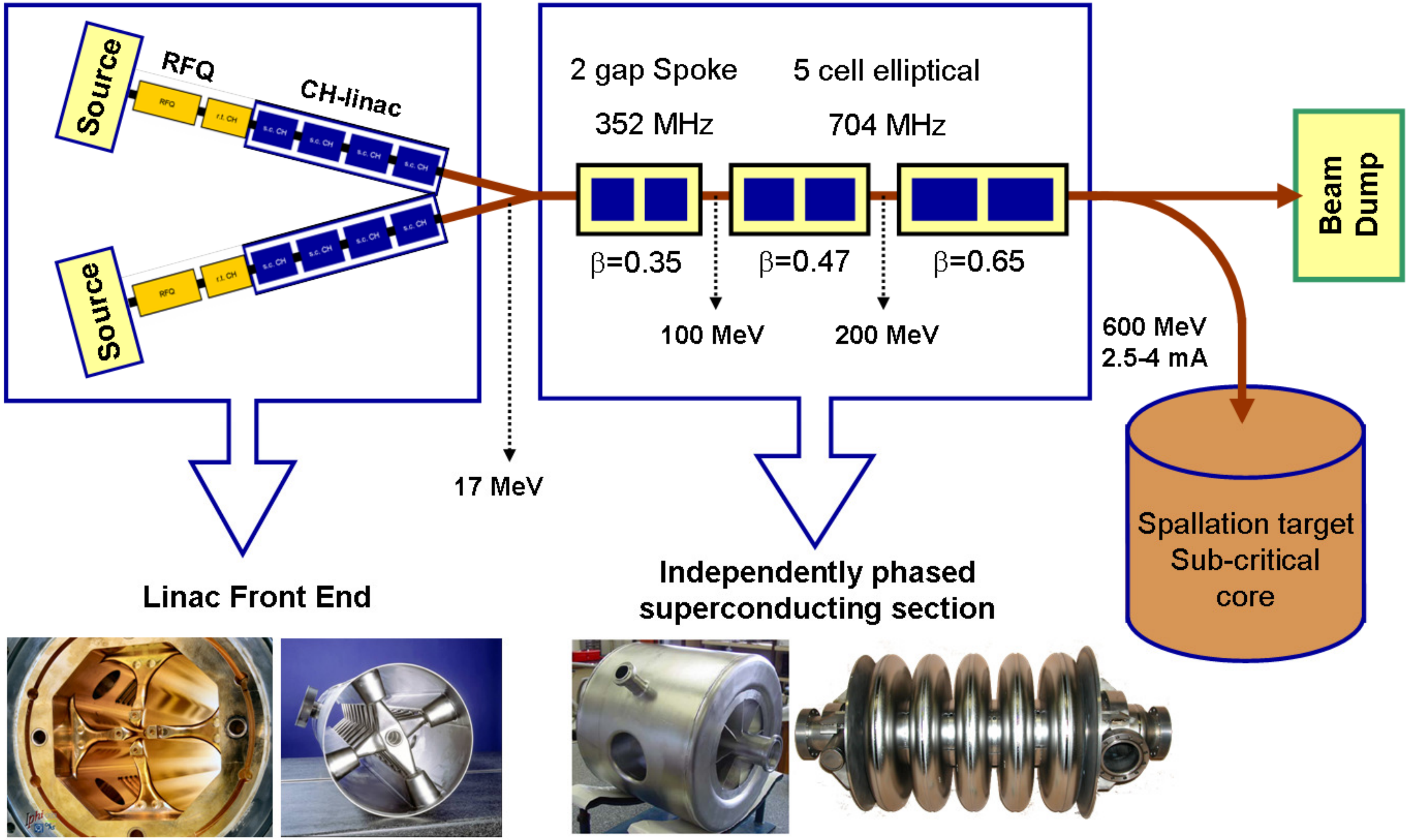
To provide an advanced design of all components of an experimental Accelerator Driven System (XT-ADS) at significant power levels (50-100 MWth) to be realized within 10-15 years (mid-term)

To provide a conceptual design of a European Facility for Industrial Transmutation (EFIT) with power levels of several 100 MWth (long-term)

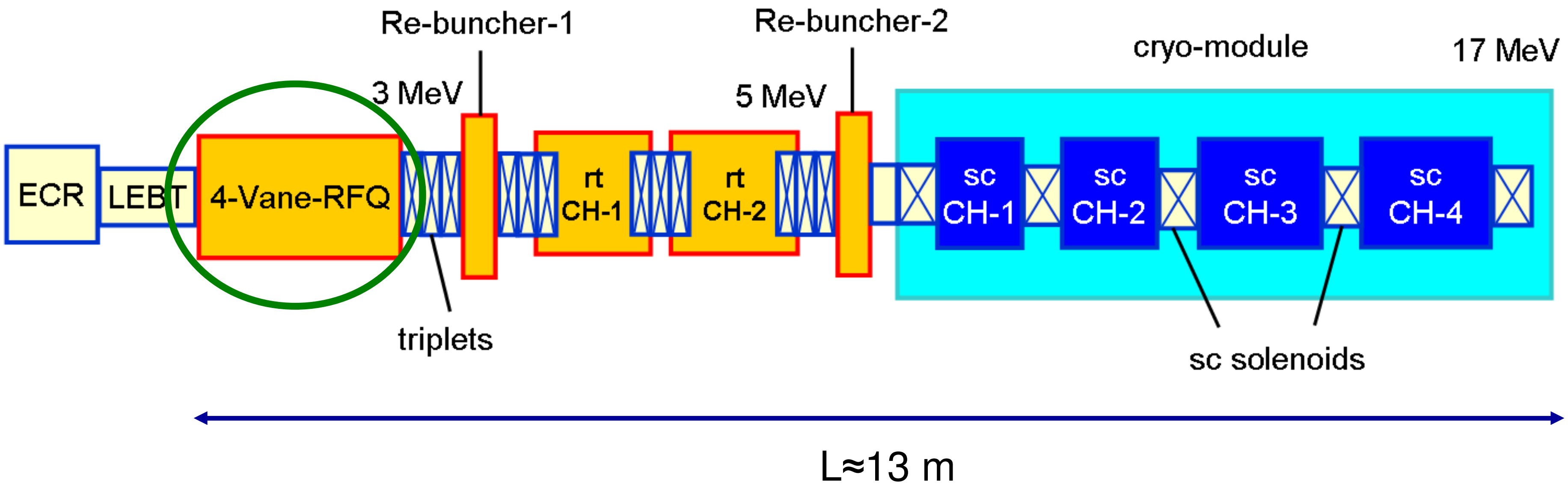
EUROTRANS

	XT-ADS (Demonstrator)	EFIT (Industrial)
Power (MWth)	50-100	Several 100
k_{eff}	0.95	0.97
Fuel	Highly enriched MOX	Minor Actinides fuel
Accelerator	Superconducting linac	Superconducting linac
Proton current (mA)	2.5-4	~20
Proton energy (MeV)	600	~800
Allowed beam trips per year t>1 sec	~10	~3
Beam time structure	Continuous wave (cw) with 200µs beam holes for sub-criticality monitoring	

Reference Design EUROTRANS Linac



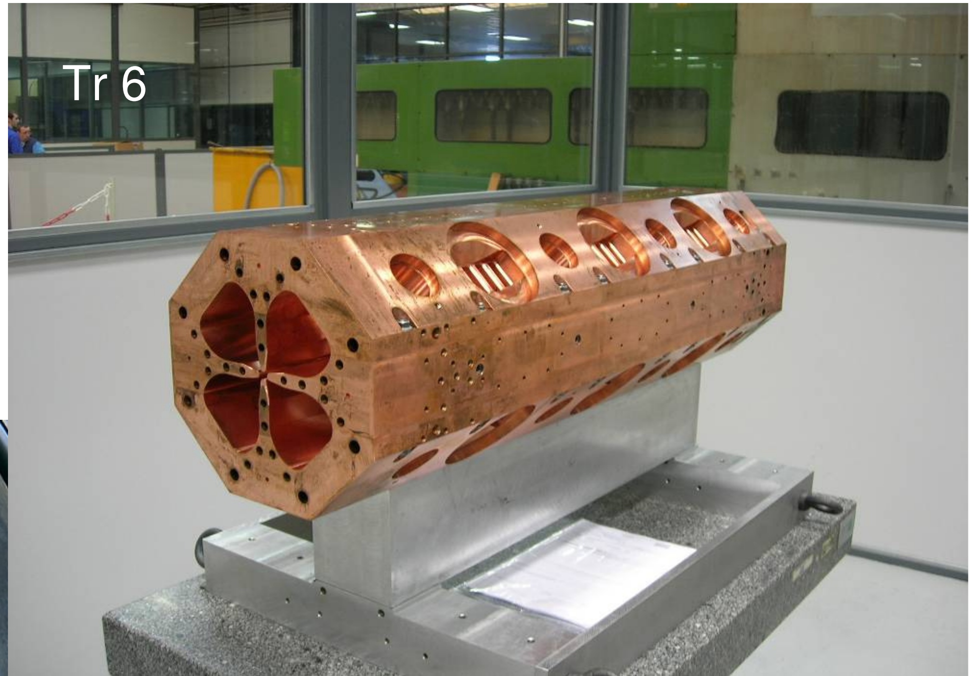
The EUROTRANS 17 MeV Front End

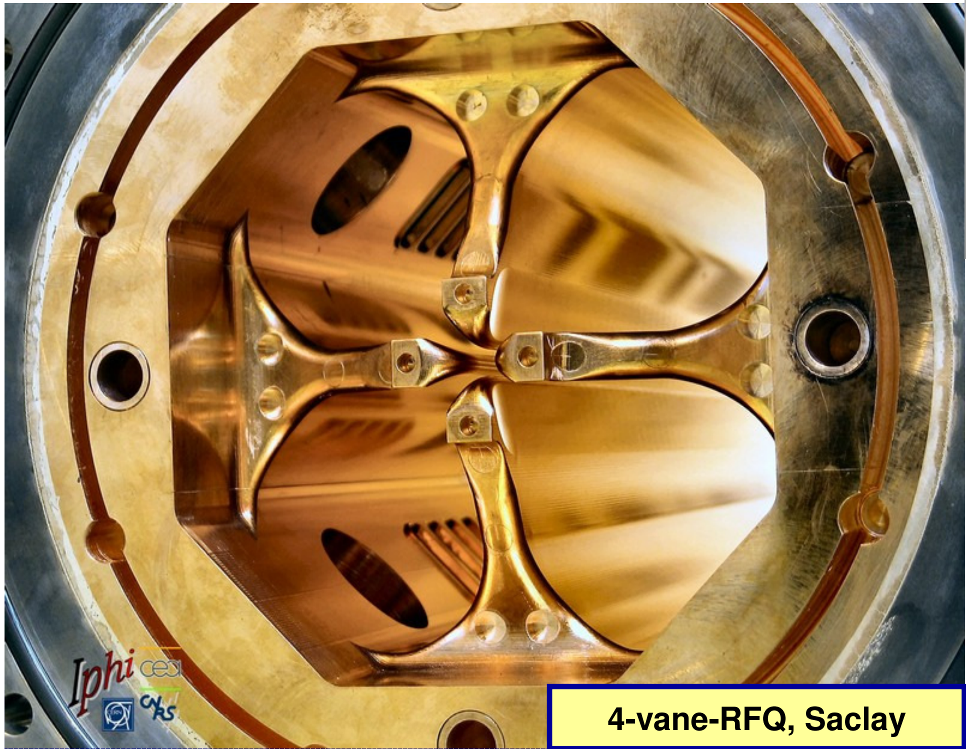


Radio Frequency Quadrupole (RFQ)

cw operation @352 MHz → 4-vane-RFQ

A 100 mA, 3 MeV RFQ under construction at CEA Saclay (IPHI)





4-vane-RFQ, Saclay

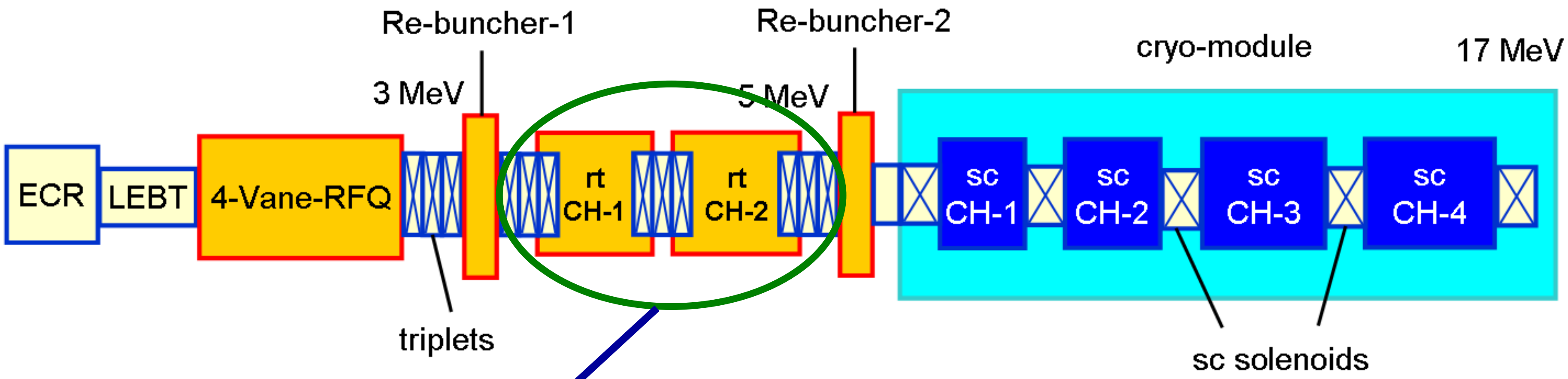
For EUROTRANS a dedicated design for lower beam current

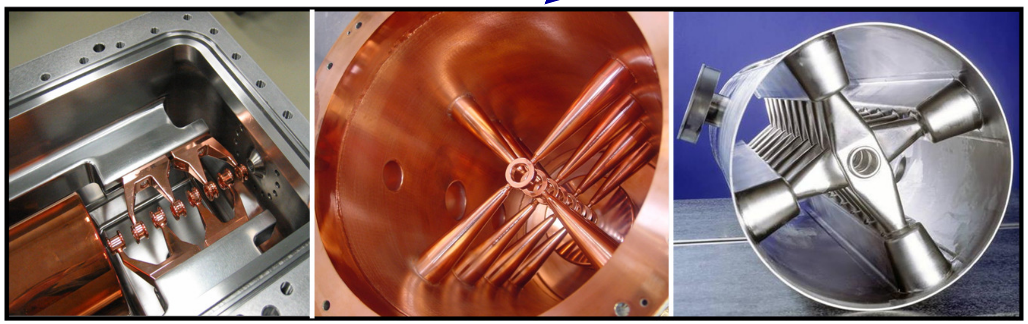
→ less RF power

→ shorter (L=4.3 m)

→ more reliable

The EUROTRANS 17 MeV Front End





CH-(Cross Bar)-H-mode cavities

H_{21}-Mode

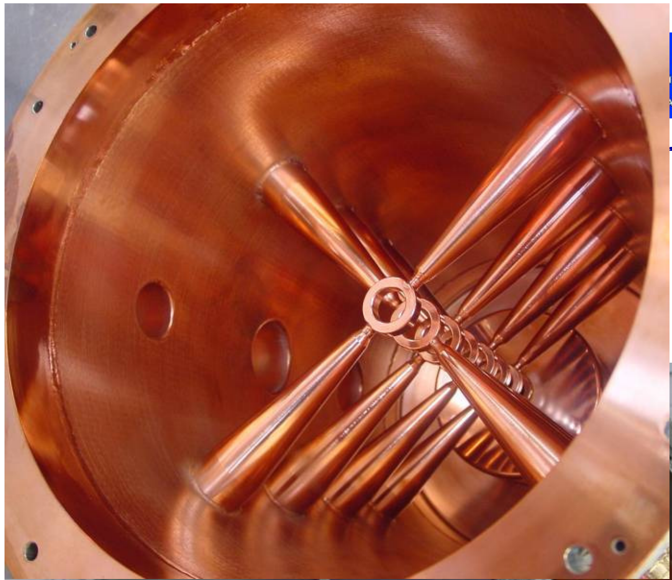
very efficient

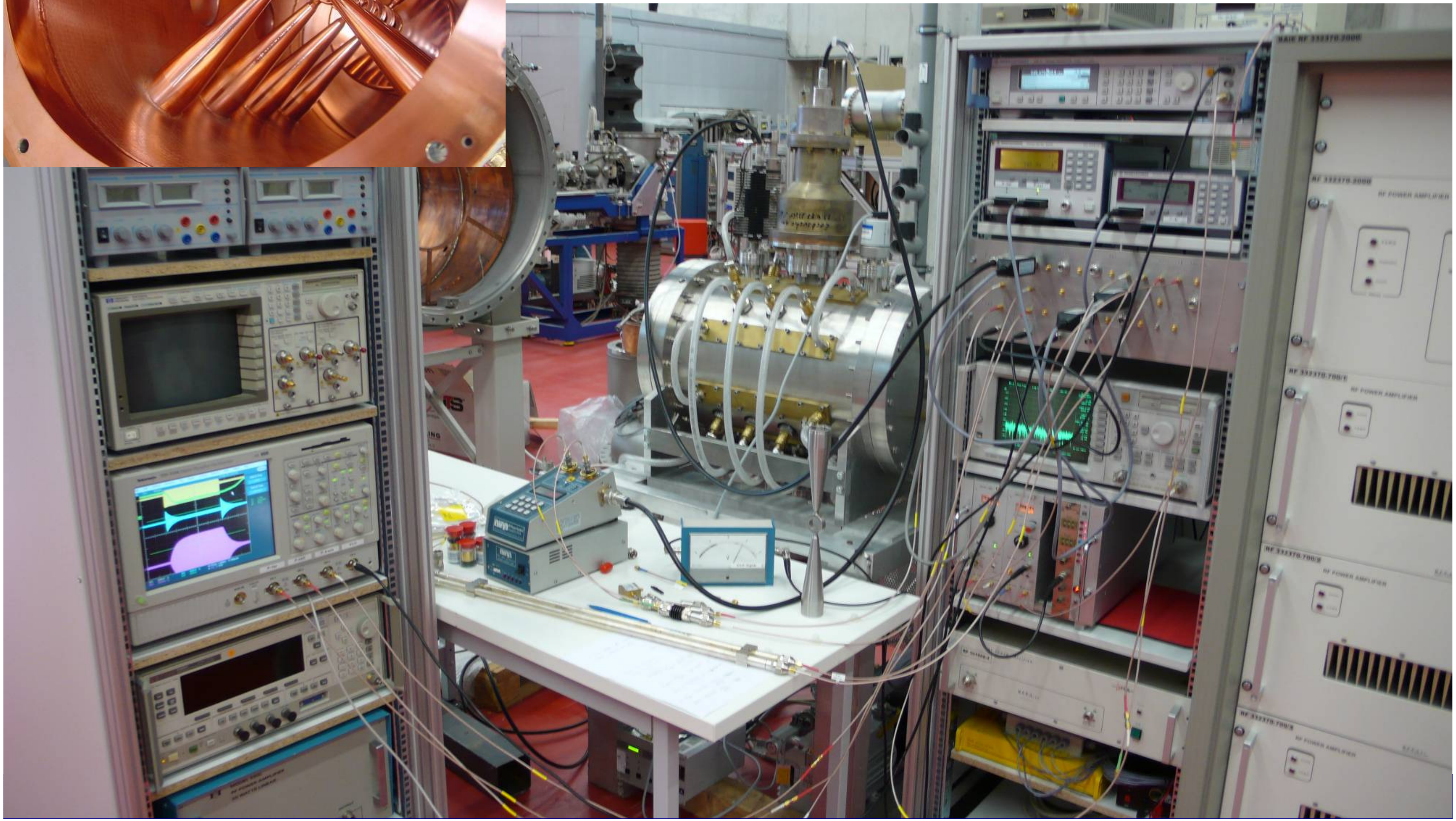
EUROTRANS

IAEA
International Atomic Energy Agency
Atoms for Peace

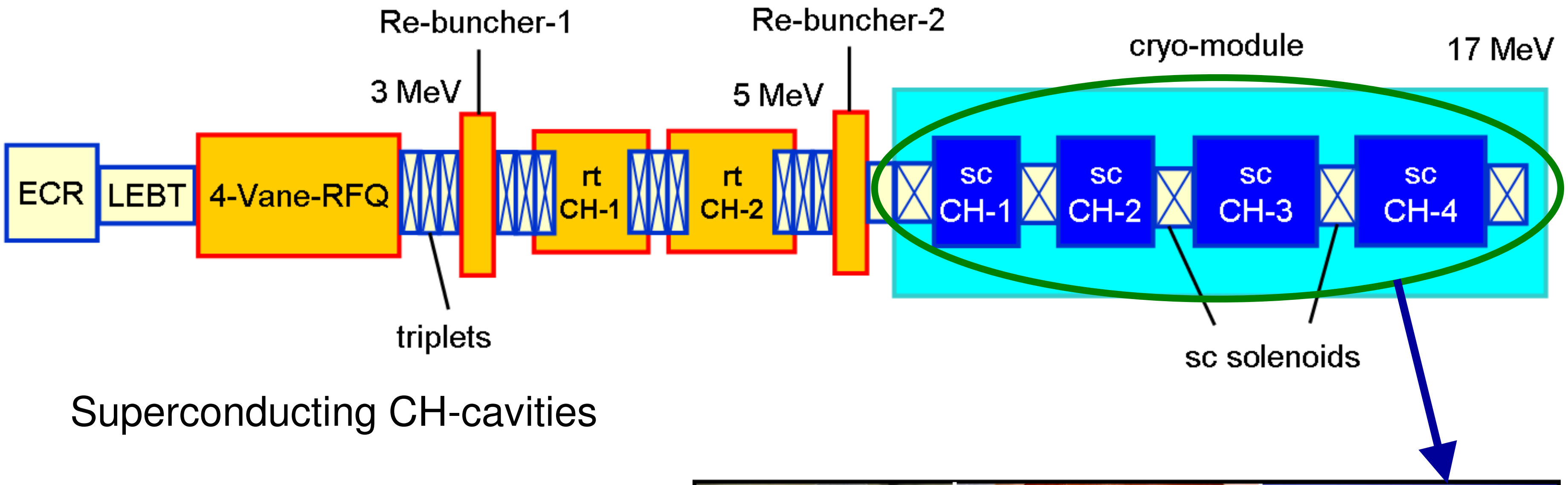
GOETHE UNIVERSITÄT FRANKFURT AM MAIN

RF Power Test of rt CH-Cavity



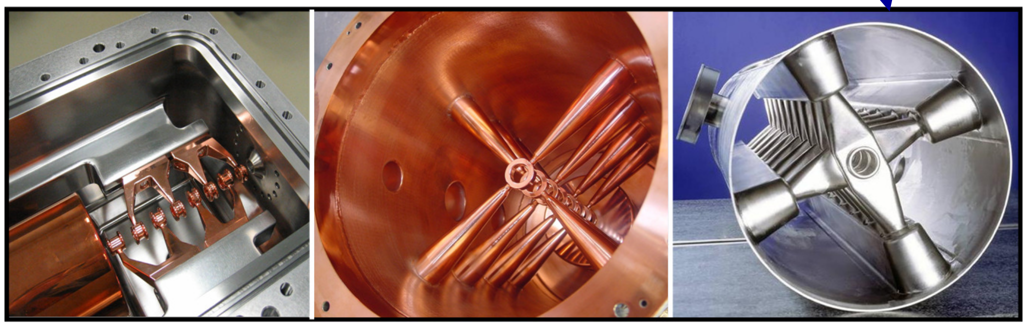


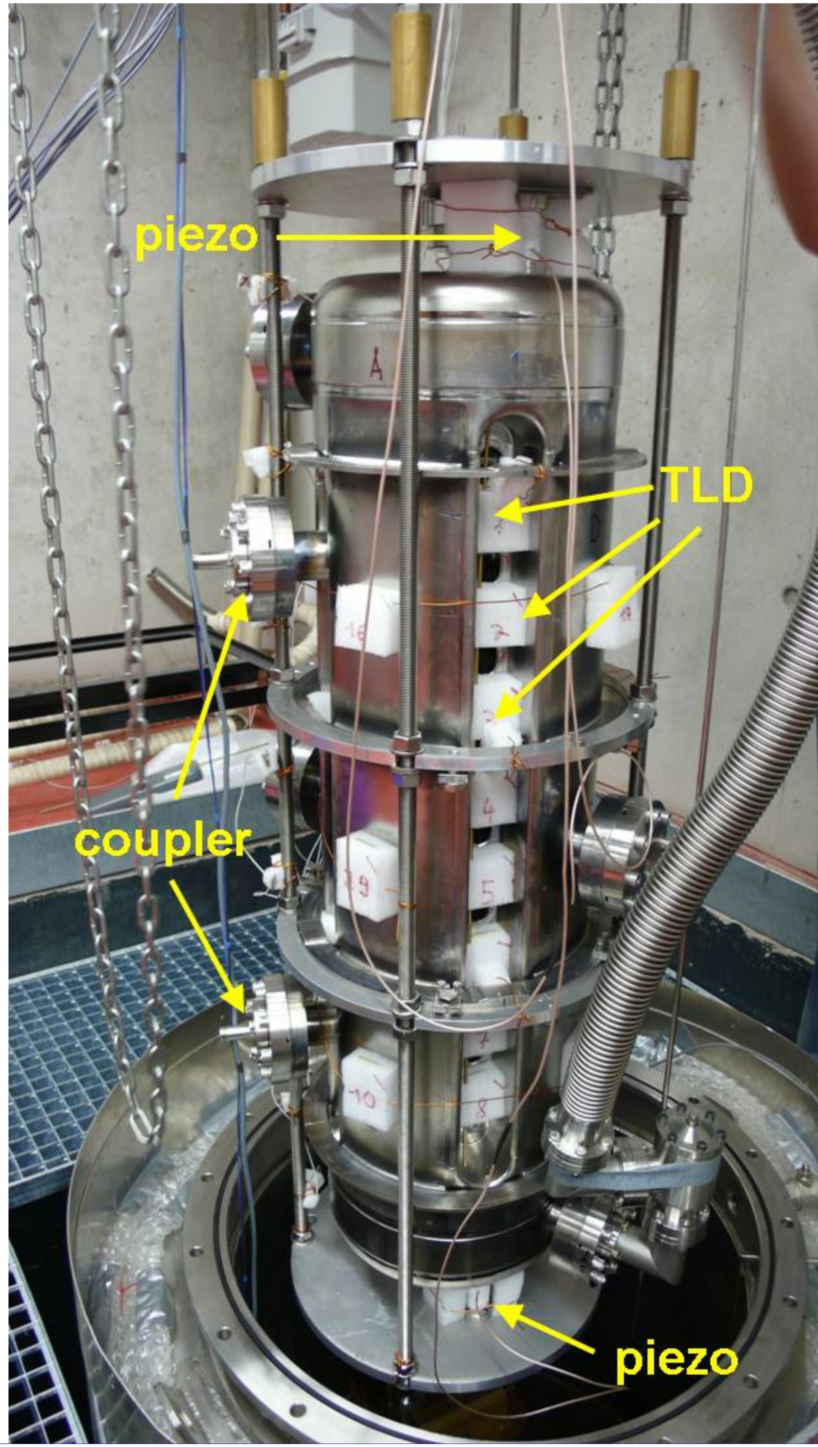
The EUROTRANS 17 MeV Front End



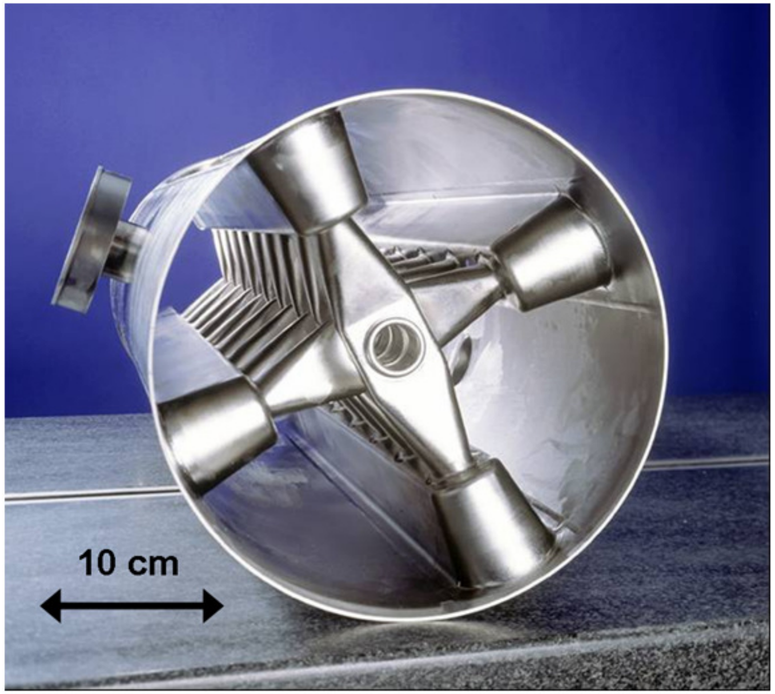
Superconducting CH-cavities

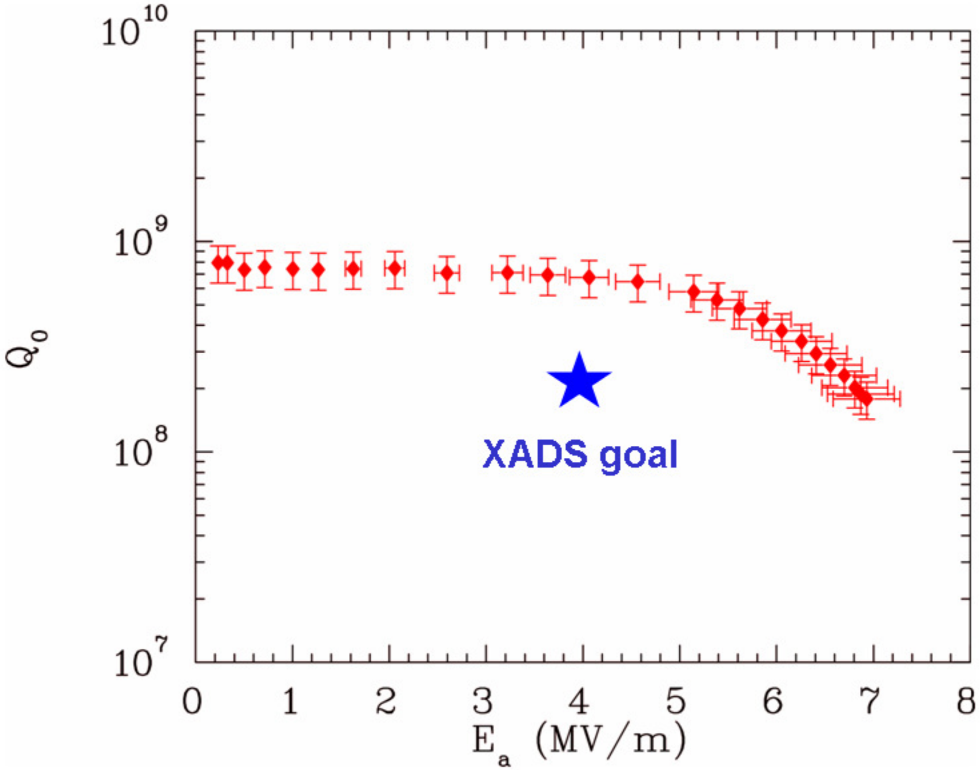
Frequency	352 MHz
Effective voltage	2.5-3.5 MV
Gradient	4 MV/m
Nr. of cells:	13-14
Focusing	Sc solenoids




piezo
TLD
coupler
piezo

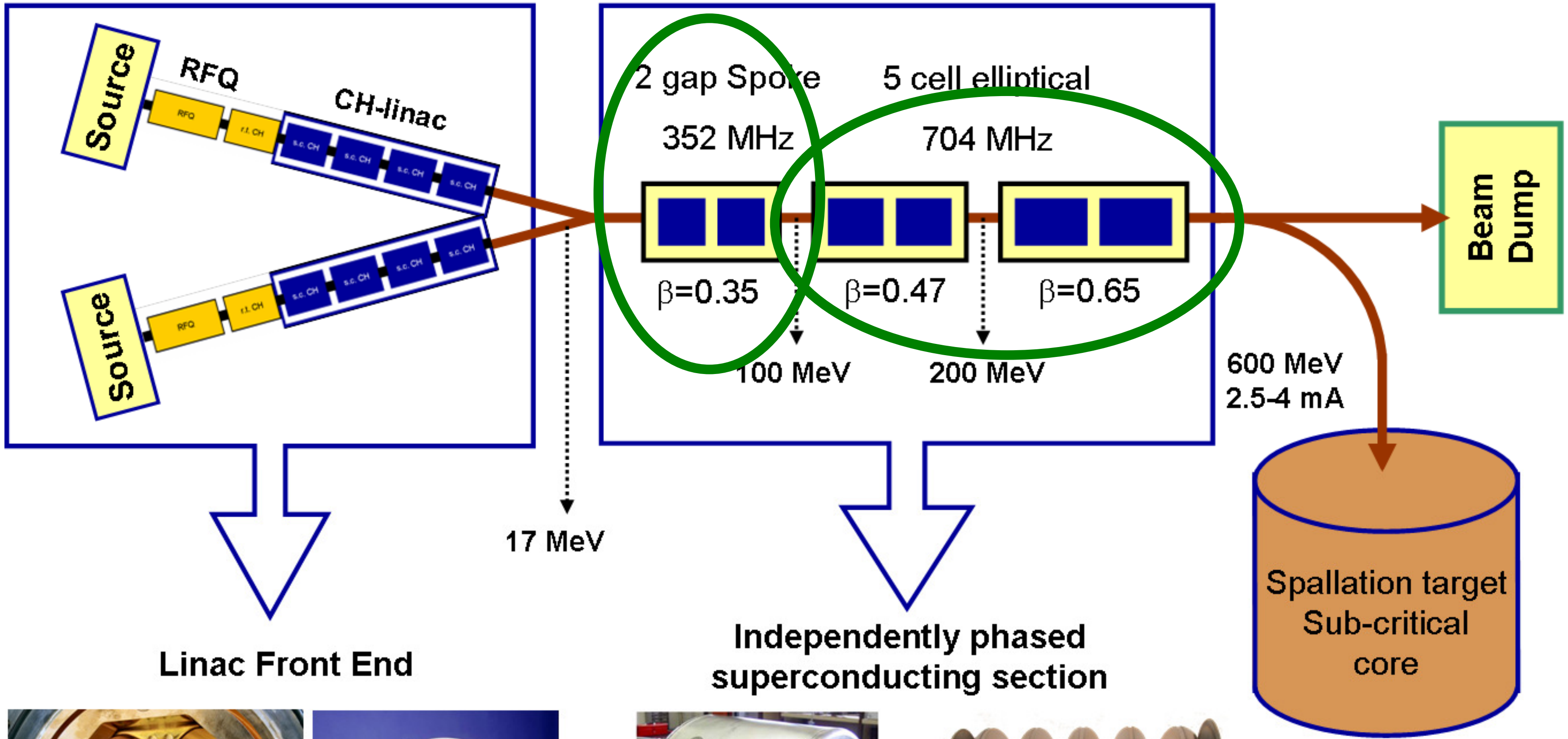
Experimental Results Superconducting CH-Cavity

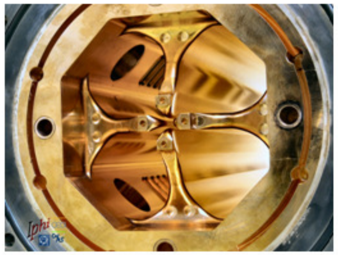




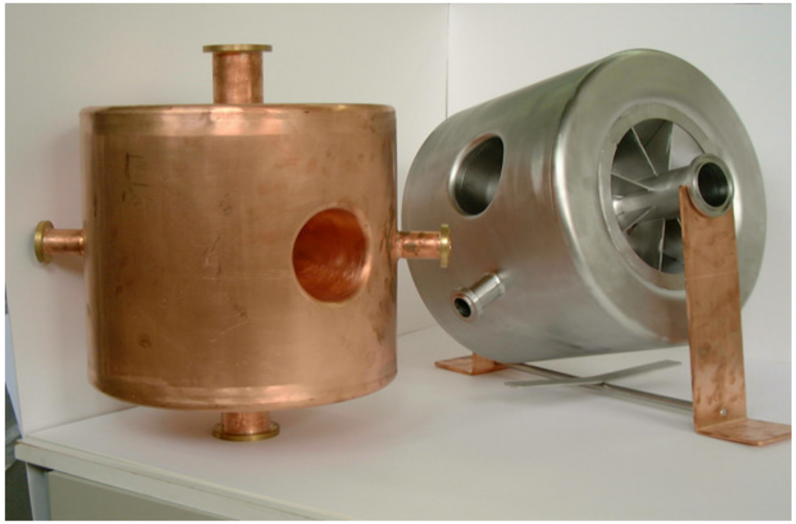
Gradient based on βλ-definition

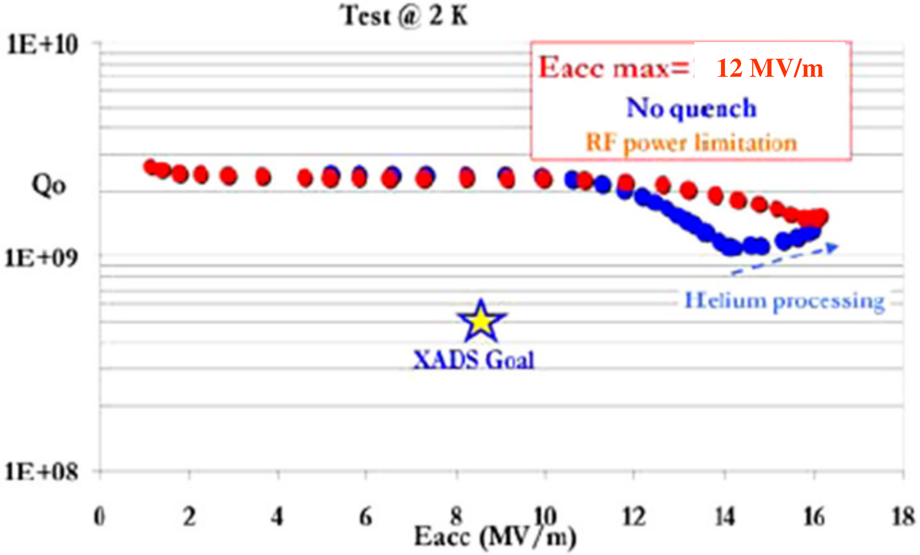
Reference Design EUROTRANS Linac





Superconducting β=0.35 Spoke Cavity





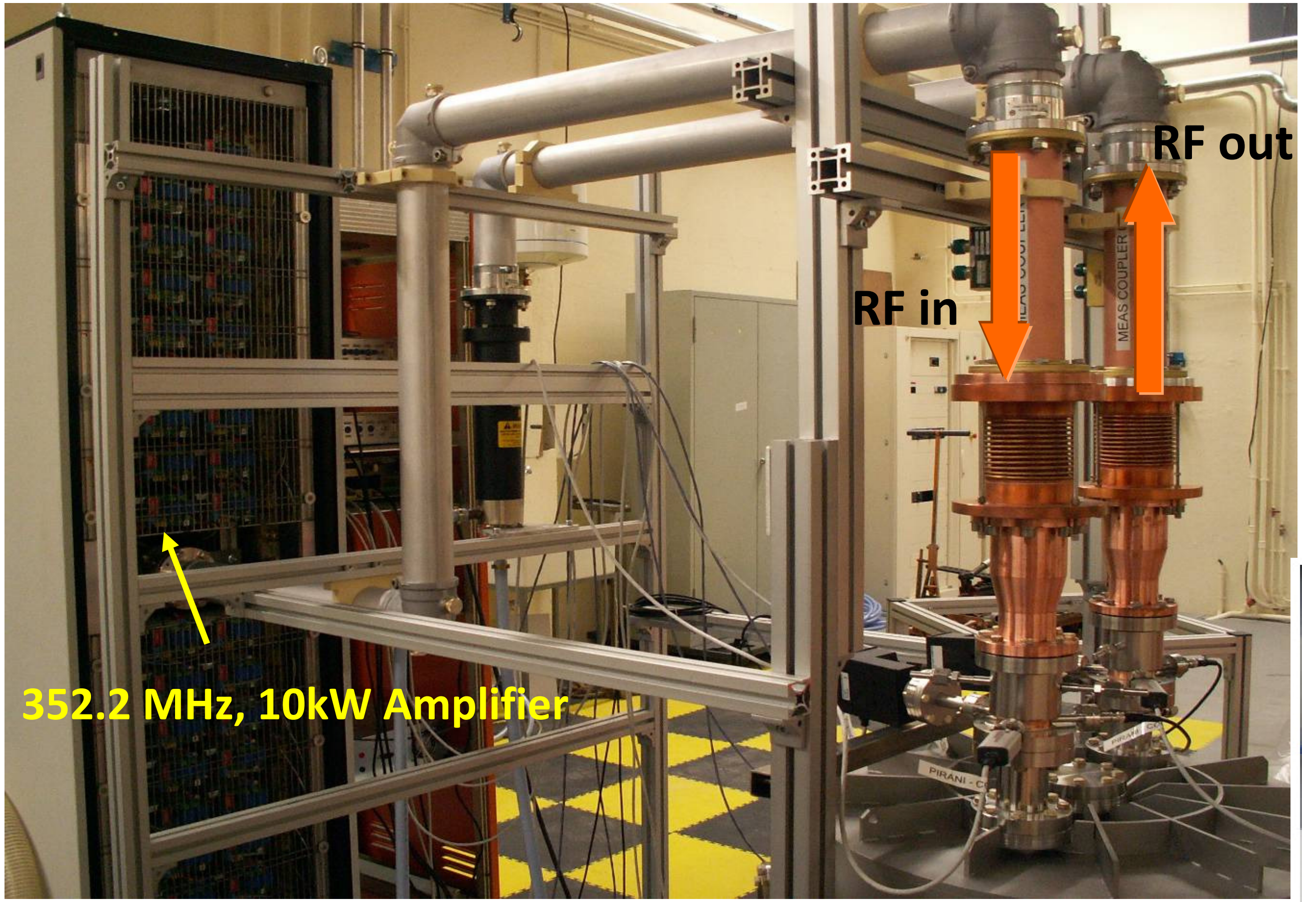
Gradient based on βλ-definition

Frequency	352 MHz
Effective voltage	0.6-1.5 MV
Gradient	4 MV/m
geometrical β=v/c	0.35
Nr. of cavities	60

INP Orsay

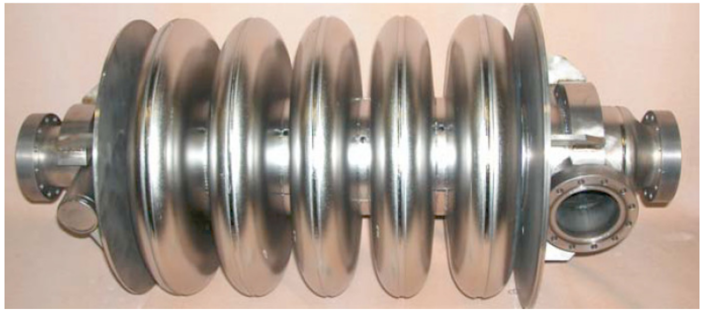
RF Tests of Power Couplers

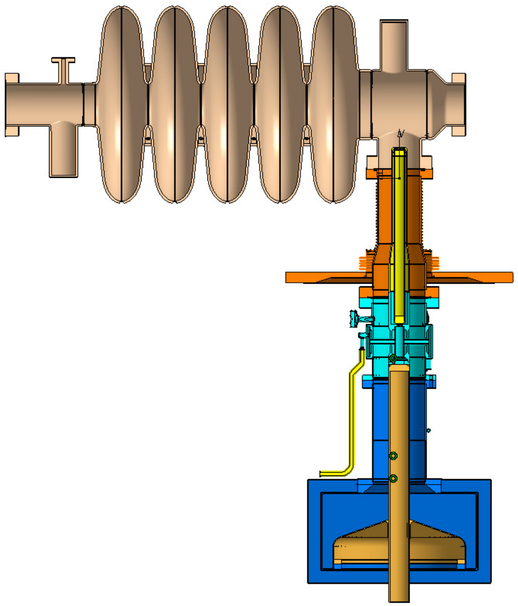
INP Orsay



Power couplers successfully conditioned
February 2009

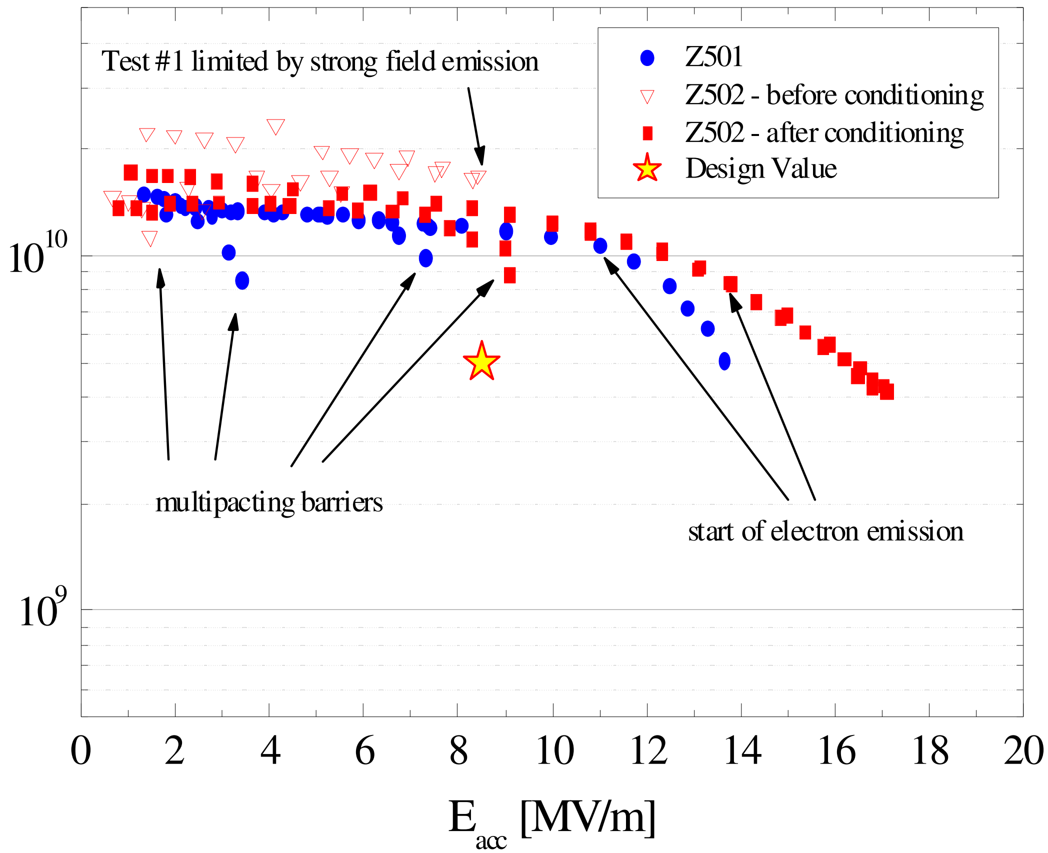
Superconducting 5-Cell Elliptical Cavities





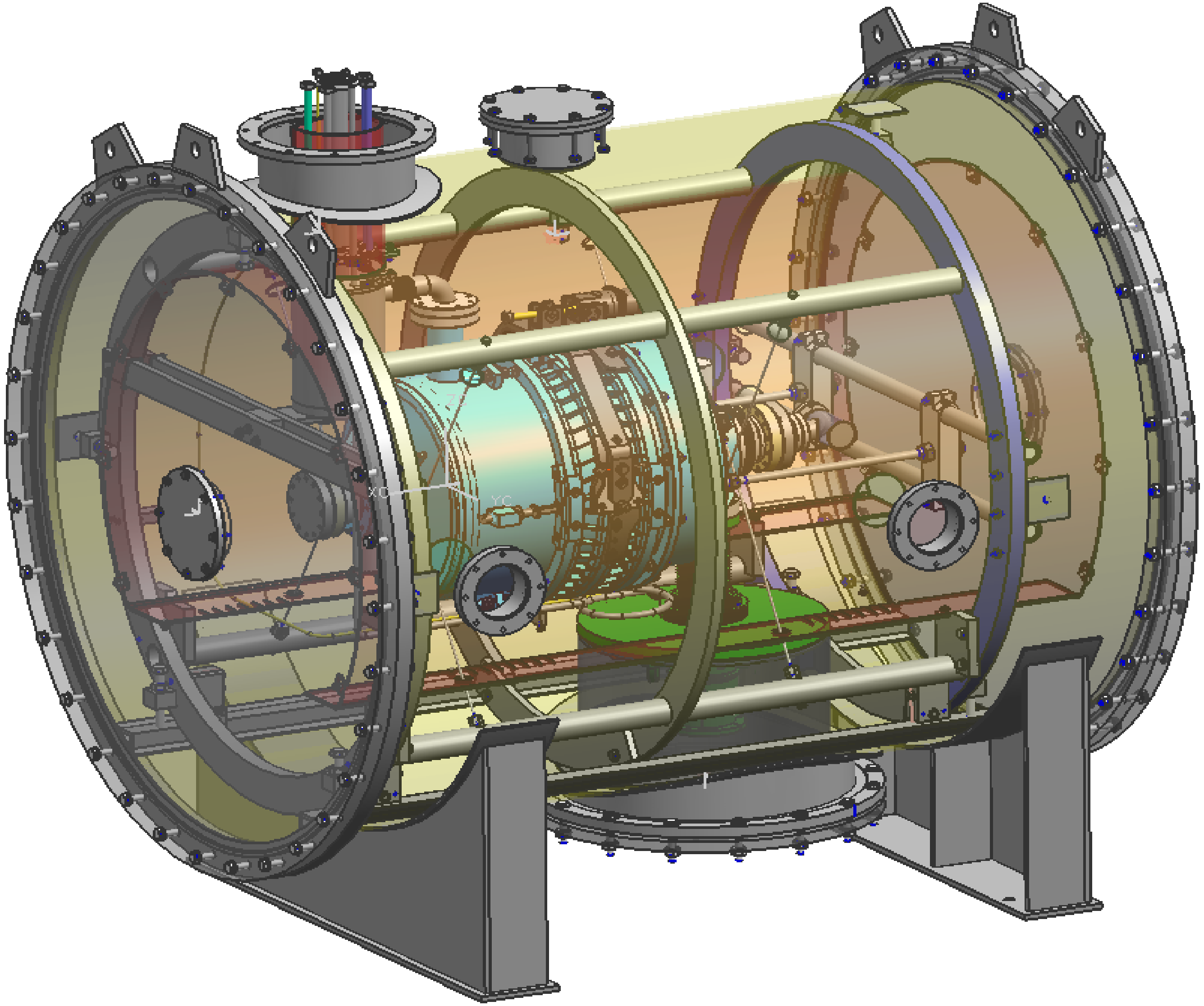
High power test foreseen in 2010

INFN Milano



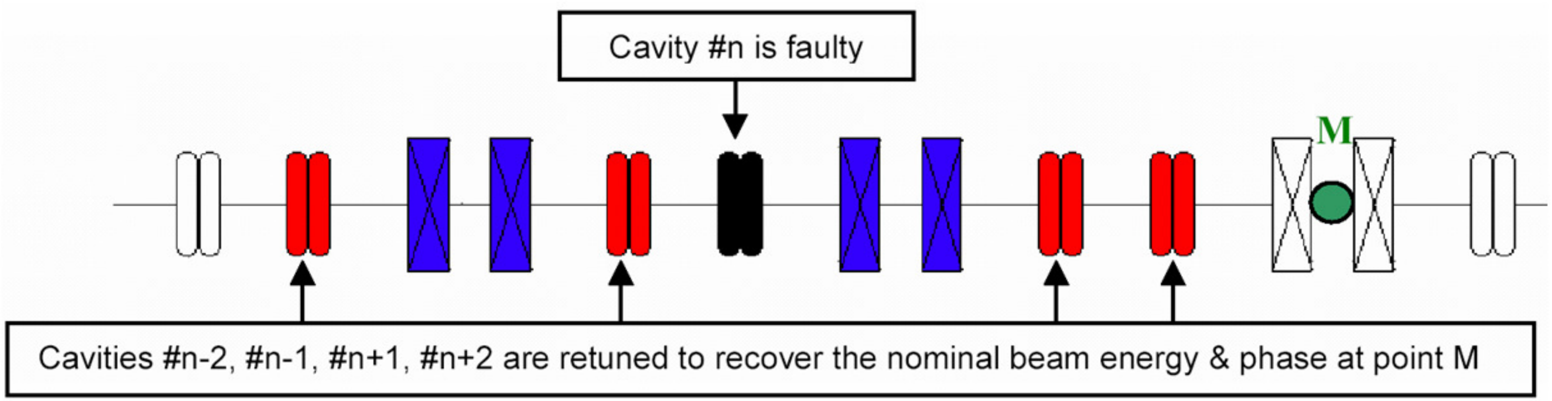
Gradient based on βλ-definition

Superconducting 5-Cell Elliptical Cavities



Fault Tolerance

Dynamic Compensation of RF Cavity Faults



- Detection of an RF fault
- Change RF phase in neighbouring cavities
- Increase RF field in neighbouring cavities

Increase of 25% field level

→ 50% power margin required

Summary

- EUROTRANS (XT-ADS) requires a powerful proton Driver Linac (600 MeV, P_{beam}=1.5 MW)
- Linac has to be extremely reliable
- Preferred solution is superconducting because of cw operation (cost and reliability)
- Reference design (Double injector, independently phased sc cavities)
- Prototype development: All prototypes have shown an excellent performance (typically twice as required)
- Fault tolerance of the linac by dynamic RF fault compensation possible