European Projects and Activities

TTC Meeting

Inter University Accelerator Center

New Delhi

October 20th-23rd 2008

H. Podlech

Institut für Angewandet Physik (IAP)

Goethe Universität Frankfurt am Main

Germany

Outline

PIAVE-ALPI (Italy)

SPIRAL-2 (France)

SARAF (ISRAEL)

IFMIF (?)

EUROTRANS (Mol, Belgium ?)

CW SHE Linac (GSI ?)

HIE ISOLDE (CERN)

EURISOL (CERN, ?)

FAIR Injector (GSI ?)

ESS (?)

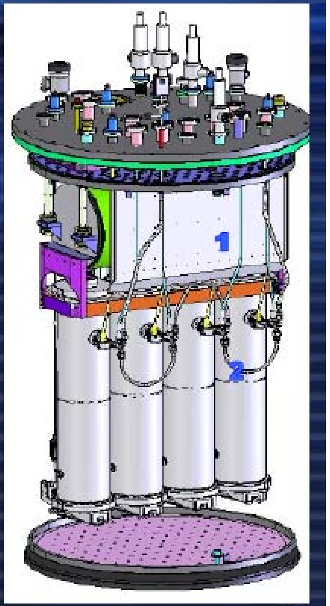
SPL (CERN ?)

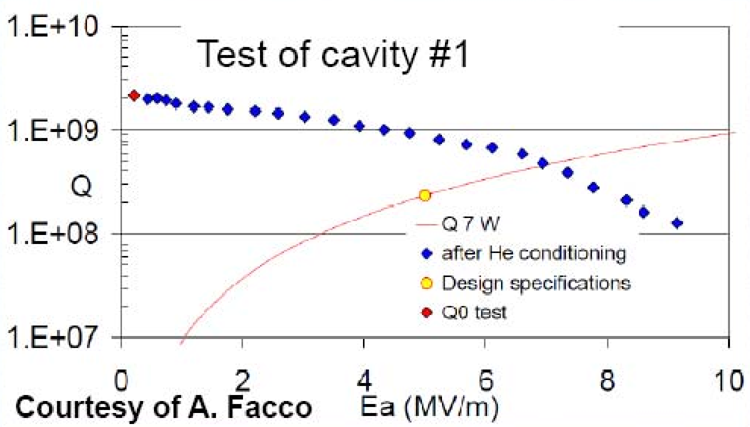
INFN-Legnaro

PIAVE-ALPI

MOP022 P.A. Posocco

- Upgrade of the existing 5 cryostats (housing 4 QWRs each) & addition of a new cryomodule (with 4 new QWRs)
→ Double the total voltage from 10 to 20 MV
  - Common vacuum & warm QP
  - New RF amplifiers and couplers to achieve the new design gradient: 5 MV/m (formerly, 3 MV/m for the 20 “old” QWRs)
  - 4 QWRs, beta 0.047, 80 MHz with also a new tuning system (modified ISAC-II tuner)





Courtesy of A. Facco

- Cavity #1 meet the specs
- Cavity #2 under test
- Cavities #3 & #4 are ready
- Validation of the new cryomodule: end of 2008
- Upgrade of the “old” cryostats (one by one) till the end of 2009

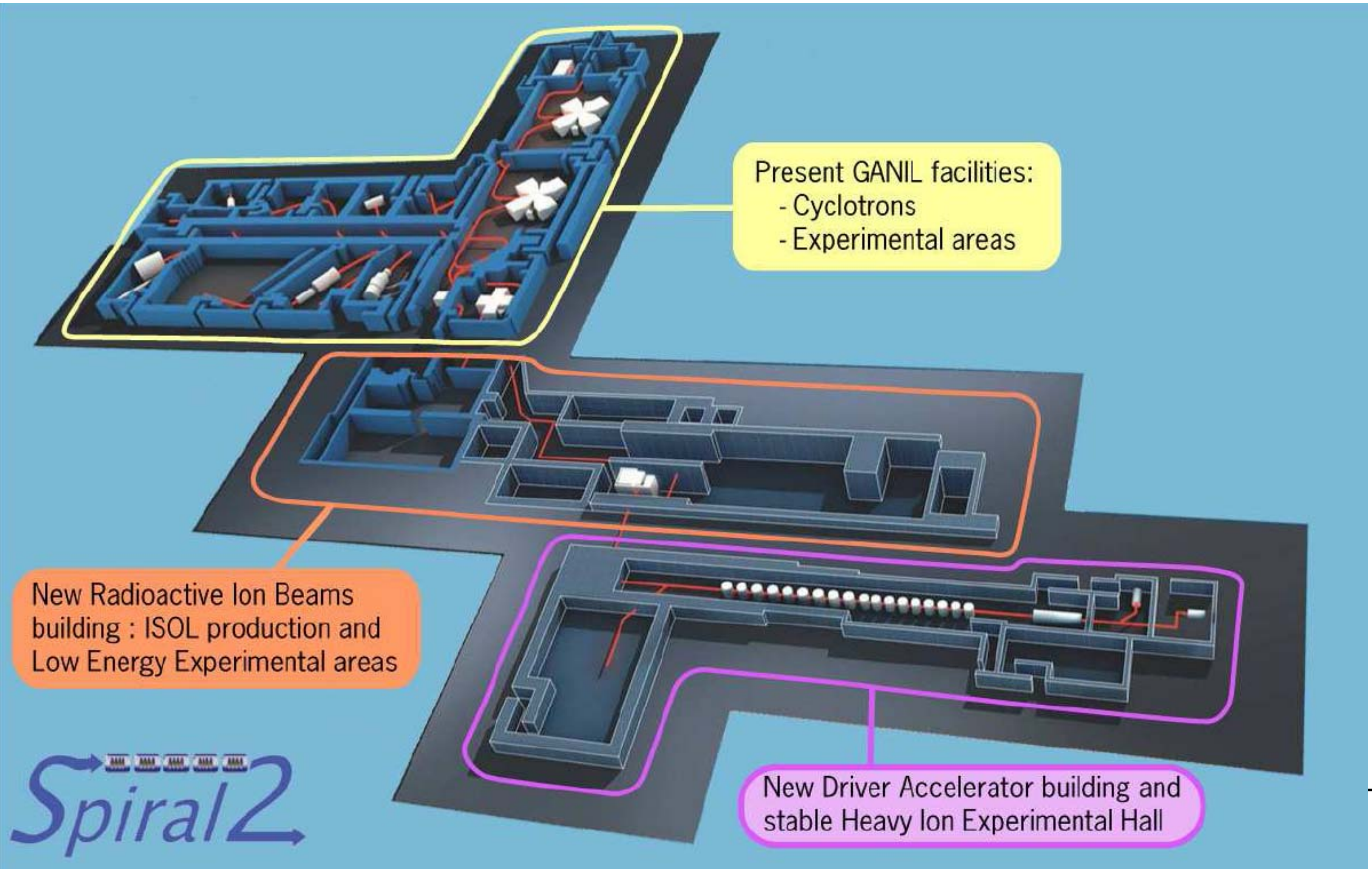
A. Facco, from G. Olry‘s talk at LINAC08

Spiral-2

Presently under construction at GANIL/France

Sc Driver accelerator A/q=3 (p, D, heavy ions), up to 200 kW cw

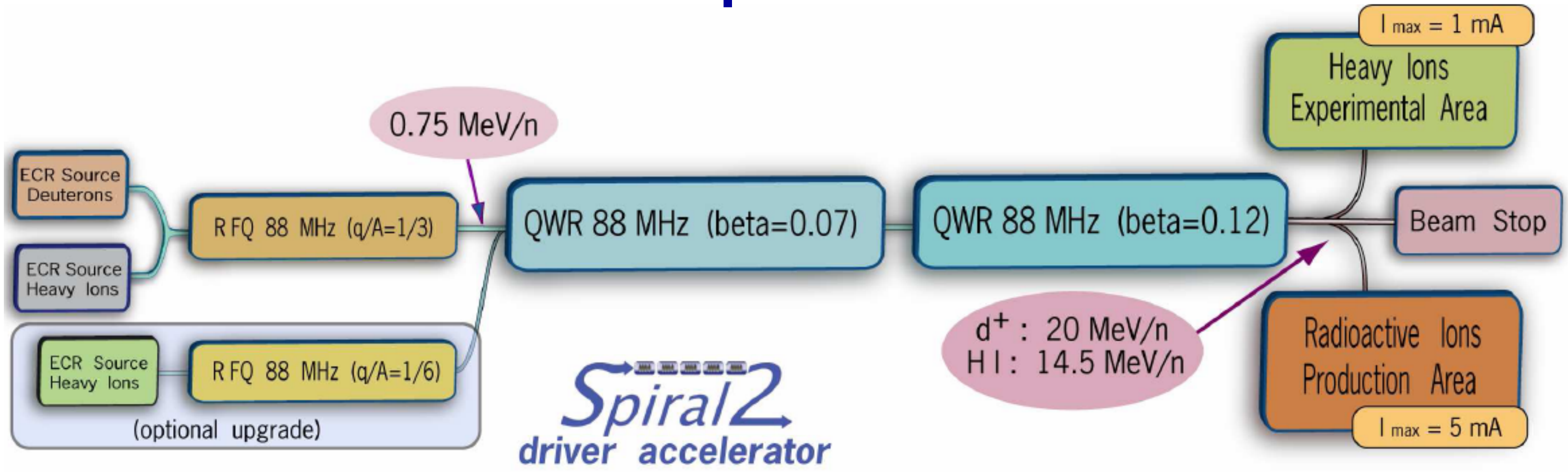
Neutron production with 5 mA D-beam via U-target



First beams in 2011

T. Junquera

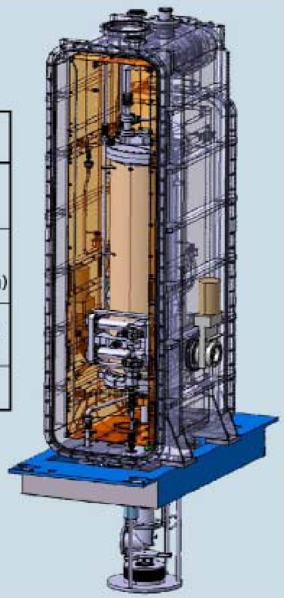
Spiral 2



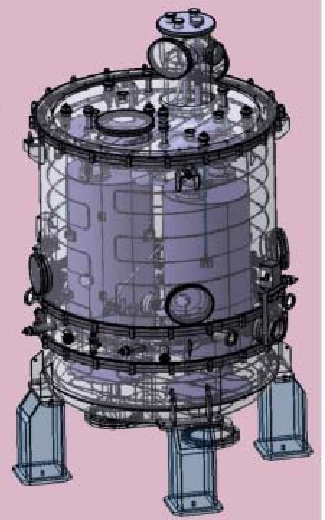
Energy Intensity	D^+ (1.5-40 MeV), H+ (33 MeV) Heavy Ions (2 - 14.5 MeV/A), bunched	I_{max}=5mA I_{max}=5mA I_{max}=1mA
Injector	D^+: ECR ion source Heavy Ions: ECR ion source (reference 0^{6+}) RFQ (1/1, 1/2, 1/3) 4 MEBT Bunchers	0.5-5 mA 1mA 113 kV, 160kW 165 kV, 8 kW
SC Linac	12 QWR beta 0.07 (12 cryomodules) 14 QWR beta 0.12 (7 cryomodules) Room Temperature Q-poles	E_{acc}^{max}= 6.5 MV/m «

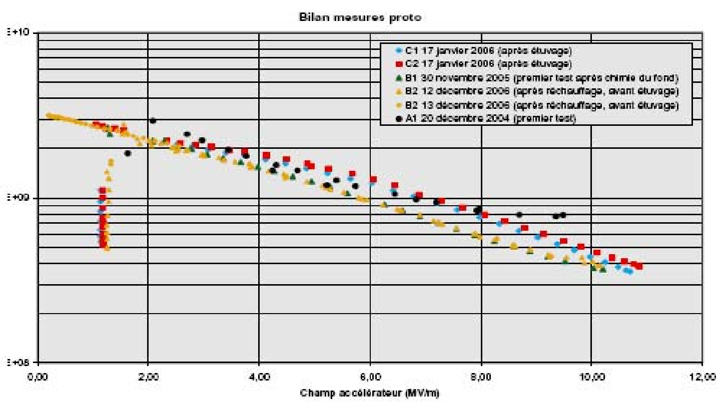
Vertical cold test results, T=4KQWR, 88 MHz, beta 0.07 & 0.12

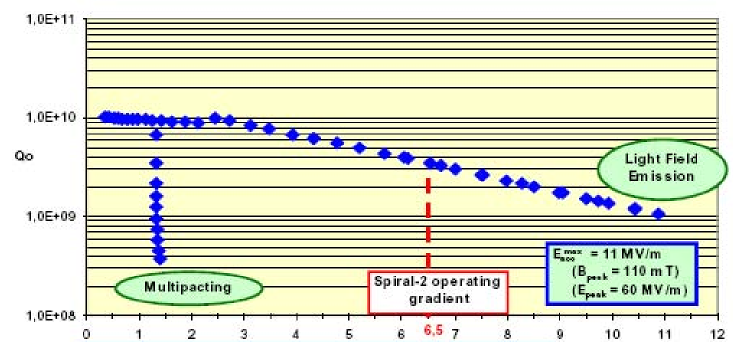
$\beta = 0.07$	
$\frac{E_{peak}}{E_{acc}}$	5.0
$\frac{B_{peak}}{E_{acc}}$	8.75 mT/(MV/m)
$\frac{R_s}{Q}$	632 Ω
$Q_0 \times 10^9$	2.2



$\beta = 0.12$	
$\frac{E_{peak}}{E_{acc}}$	5.5
$\frac{B_{peak}}{E_{acc}}$	10.1 mT/(MV/m)
$\frac{R_s}{Q}$	521 Ω
$Q_0 \times 10^9$	1.7







Design max. operating gradient: 6.5 MV/m
Results in both prototypes : (beta 0.07 and 0.12): 11 MV/m

G. Olry

SARAF @ SOREQ (ISRAEL)

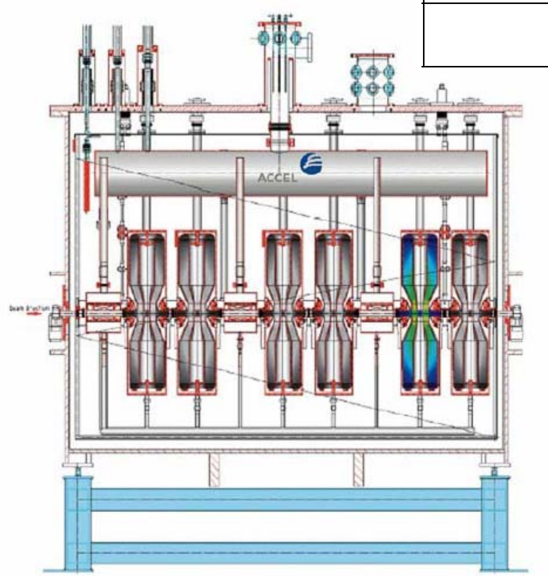
Soreq Applied Research Accelerator Facility

40 MV sc driver accelerator (p,d)
I=2 mA cw
1.5 MeV/u 4-rod RFQ (rt)
2 groups of sc HWR (β=0.09, 0.16) @176 MHz

Front end at SOREQ with IS, LEBT, RFQ

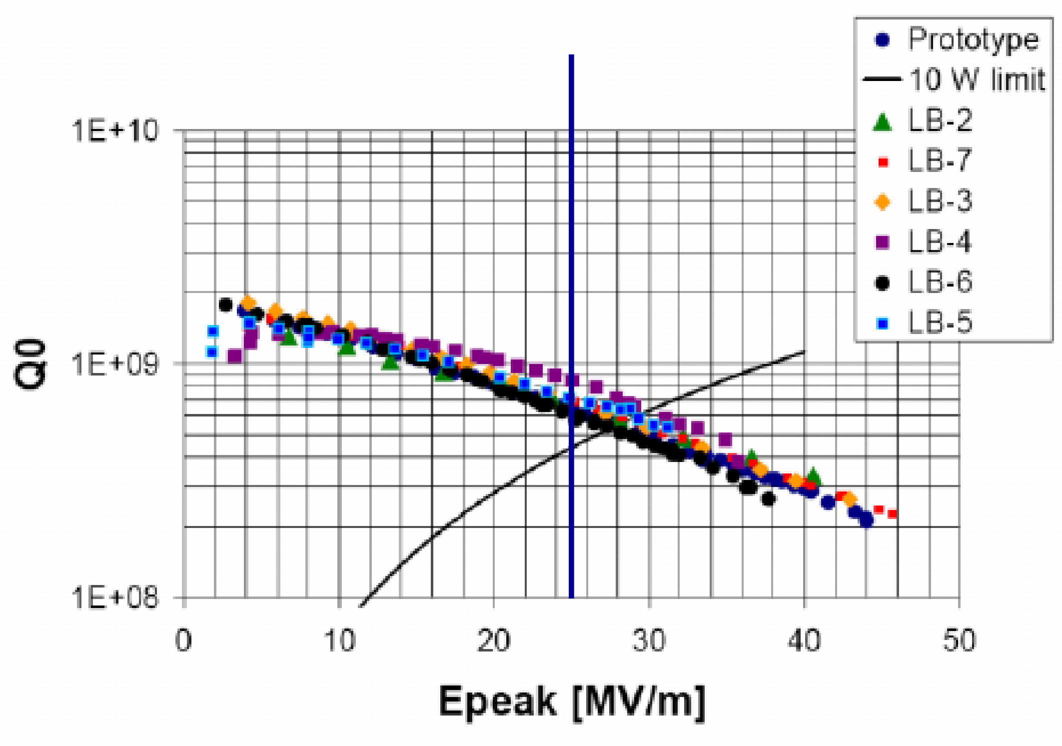
SARAF @ SOREQ

Operating pressure (temperature)	1.2 bar (4.4 K)
Beam pipe diameter	30 mm
Solenoid field	< 6 T
Cavity design gradient	Epeak = 25 MV/m
Bpeak@Epeak=25 MV/m	53 mT
Uacc@Epeak=25 MV/m	0.85 MV
Beam current	2 (4) mA
Coupler power	2 (4) kW cw
External Q	1.3×10^6
Cavity bandwidth	135 Hz



SARAF@SOREQ

Test results (4K) of β=0.09 cavities

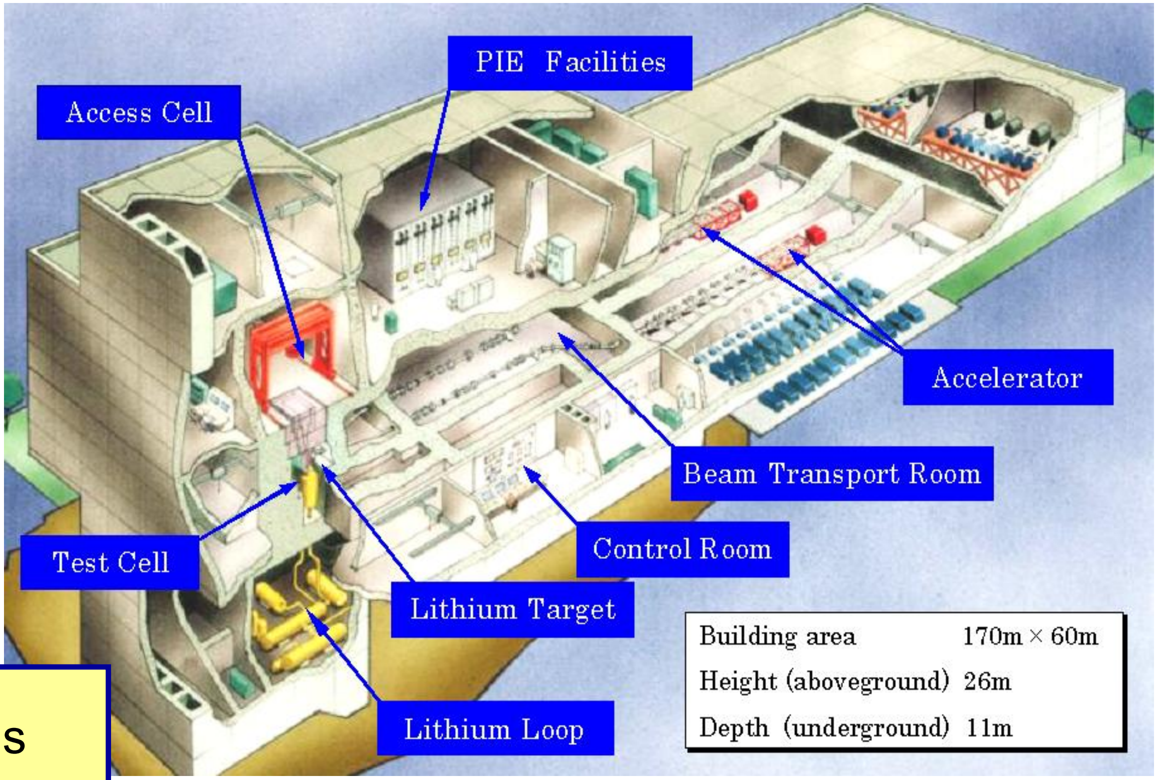


Design value: E_p=25 MV

IFMIF

International Fusion Material Irradiation Facility

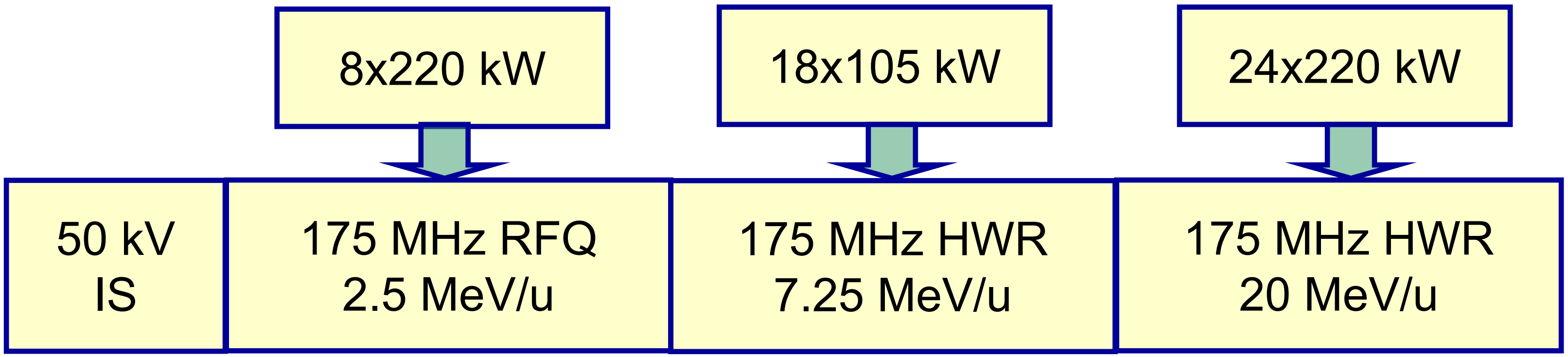
Recently switched from rt to sc!!



- High flux source of fast neutrons
- Development of new material for fusion reactors
- Up to 100 dpa/fpy
- Liquid Li target

- Beam: 40 MeV Deuterons
- Beam current 2x125 mA
- Beam power: 10 MW
- Duty cycle 100%

IFMIF



2 cryo modules

2 cryo modules

2 groups of HWR: β=0.094 and 0.166

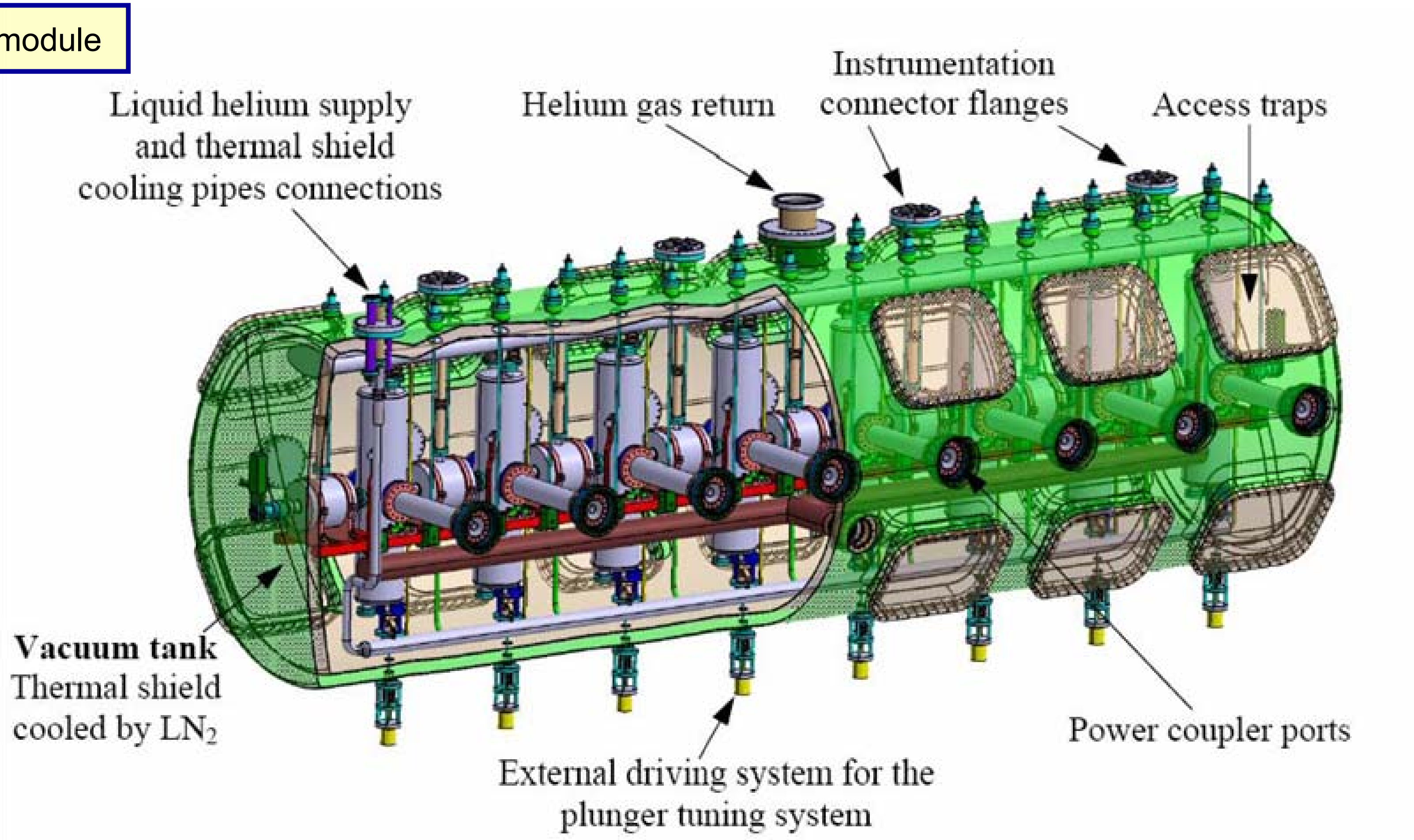
42 cavities in total (18+24)

E_a=4.5 MV/m

Cryomodules	1	2	3 & 4
Cavity β	0.094	0.094	0.166
Cavity length (mm)	180	180	280
Beam aperture (mm)	40	40	48
Nb cavities / period	1	2	3
Nb cavities / cryostat	1 x 8	2 x 5	3 x 4
Nb solenoids	8	5	4
Cryostat length (mm)	4.64	4.30	6.03
Output energy (MeV)	9	14.5	26 / 40

CEA Saclay

β=0.094 cryo module



During EVEDA-phase:
Build and test front end (IS, RFQ, 1. cryo module)
up to 4.75 MeV/u with full beam

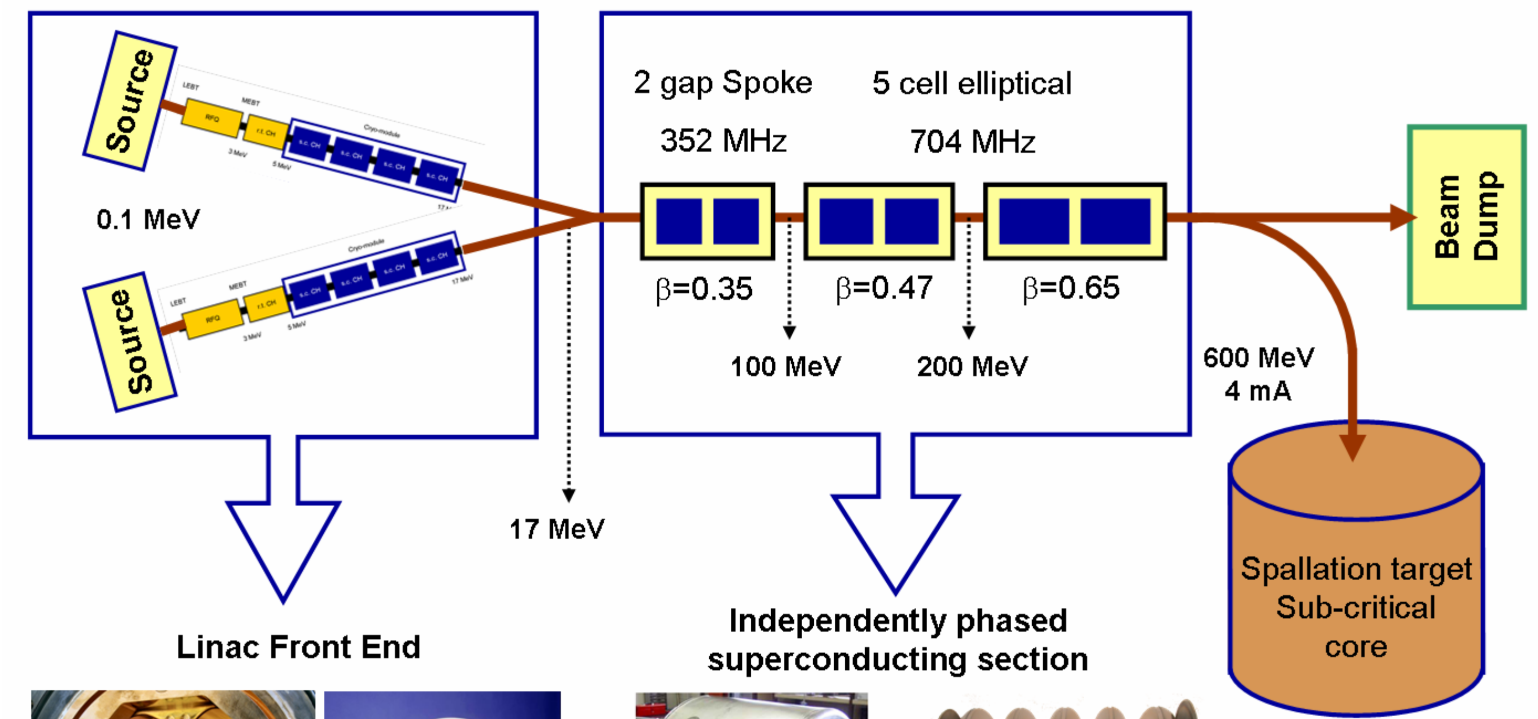
CEA Saclay

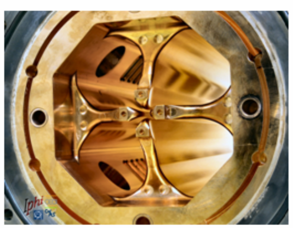
EUROTRANS (Nuclear waste transmutation) ADS=Accelerator Driven System

IP-EUROTRANS
- INTEGRATED PROJECT ON EUROPEAN TRANSMUTATION -

Beam: protons
Beam current: 2.5-25 mA (EUROTRANS, EFIT)
Energy: 600-800 MeV
Power: 1.5-20 MW/ (Reactor 20-300 MW_{th})
Duty cycle: 100%
Accelerator: Superconducting linear accelerator
Frequency: 352-704 MHz
Beam stability: 2% power
Maximum 3-10 beam trips per year >1 s !!!
Transmission: 99.999%
Losses: 1 W/m

XADS/EUROTRANS





CEA Saclay

IAP Frankfurt

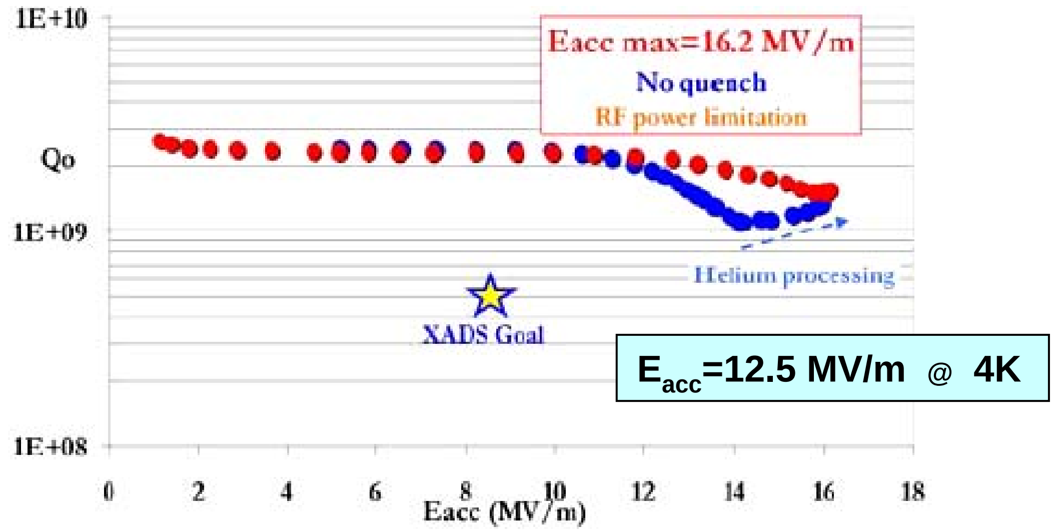
IPN Orsay

INFN, CNRS

Frozen design
Until 2010

Spoke (β=0.35), 352 MHz at IPN Orsay

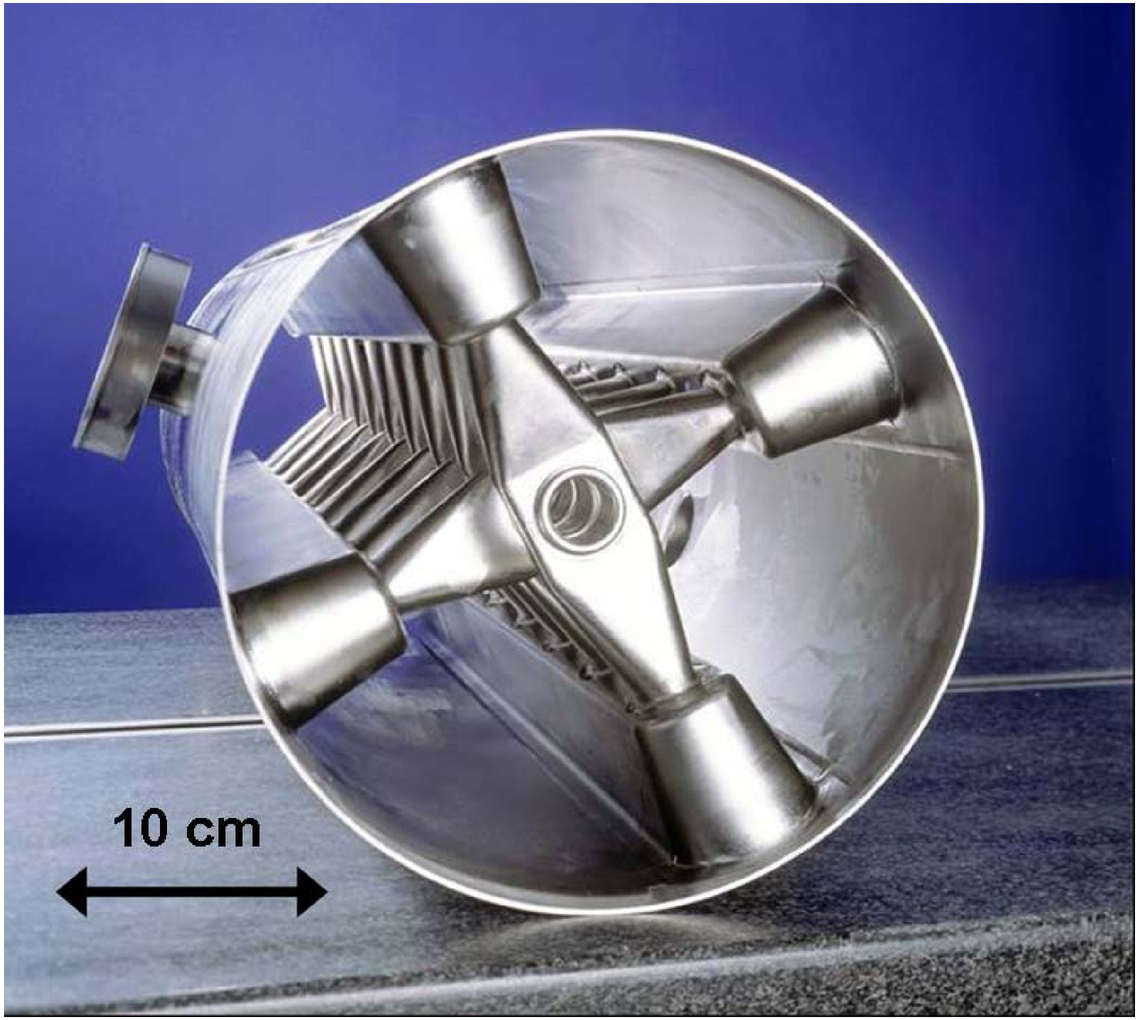
β = 0.35 Prototype



J.-L. Biarrotte, Orsay

CH-Cavity Development at IAP Frankfurt

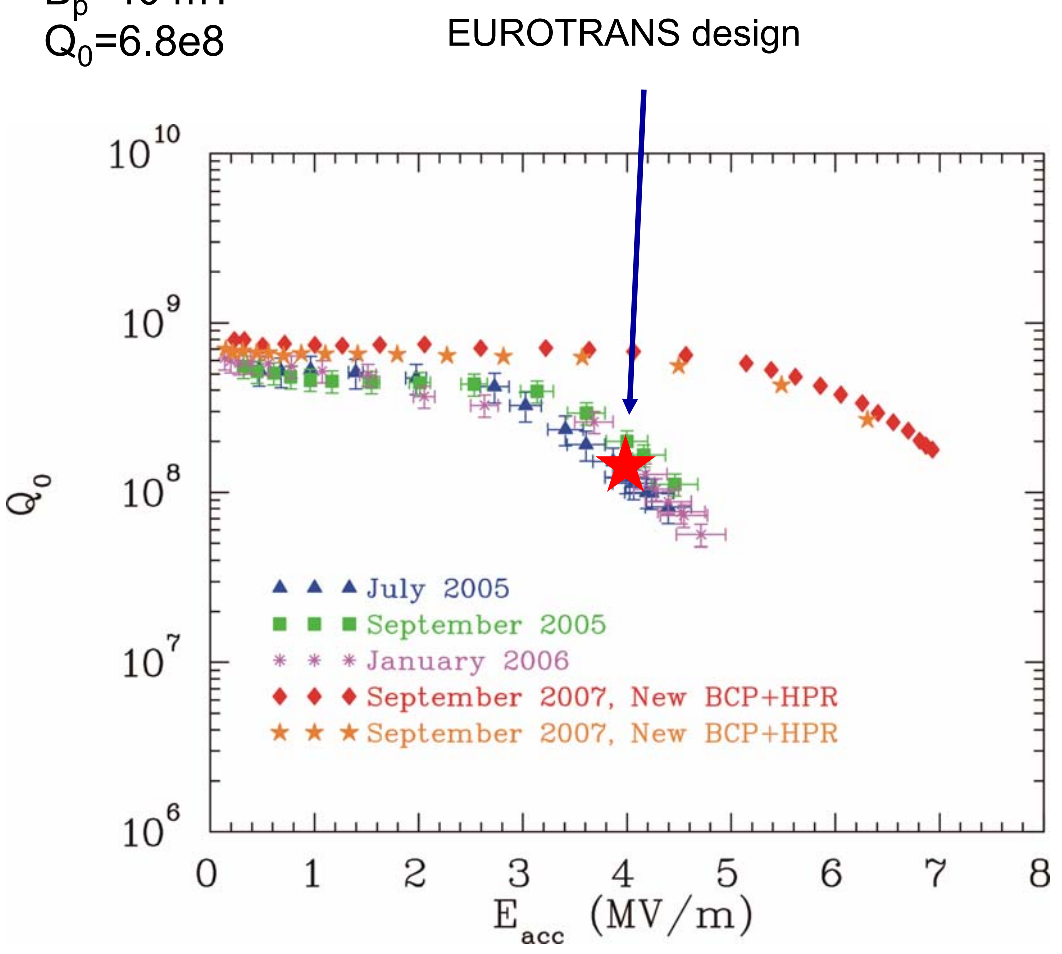
Gap number	19
Length (mm)	1048
Frequency (MHz)	360
β	0.1
E_p/E_a ($\beta\lambda$-definition)	5.2
B_p/E_a [mT/(MV/m)]	5.7
$G=R_sQ_0$ (Ω)	56
R_a/Q (Ω) (T incl.)	3180
$(R_a/Q)G$ (Ω^2)	178000
Q_0 (BCS, 4.2K, 360 MHz)	1.5×10^9
Q_0 (total R_s=150 nΩ)	3.7×10^8
W [mJ/(MV/m)^2]	92

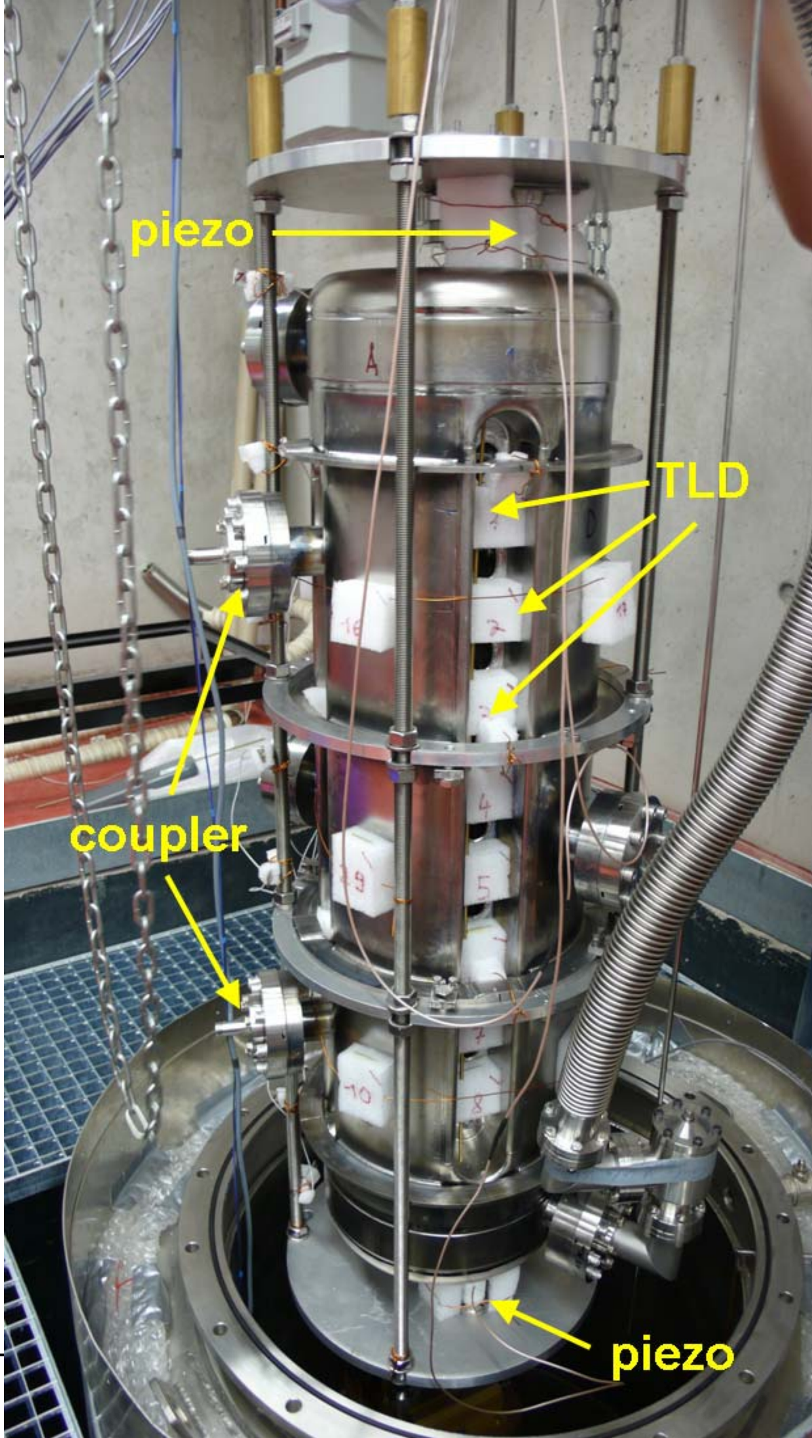


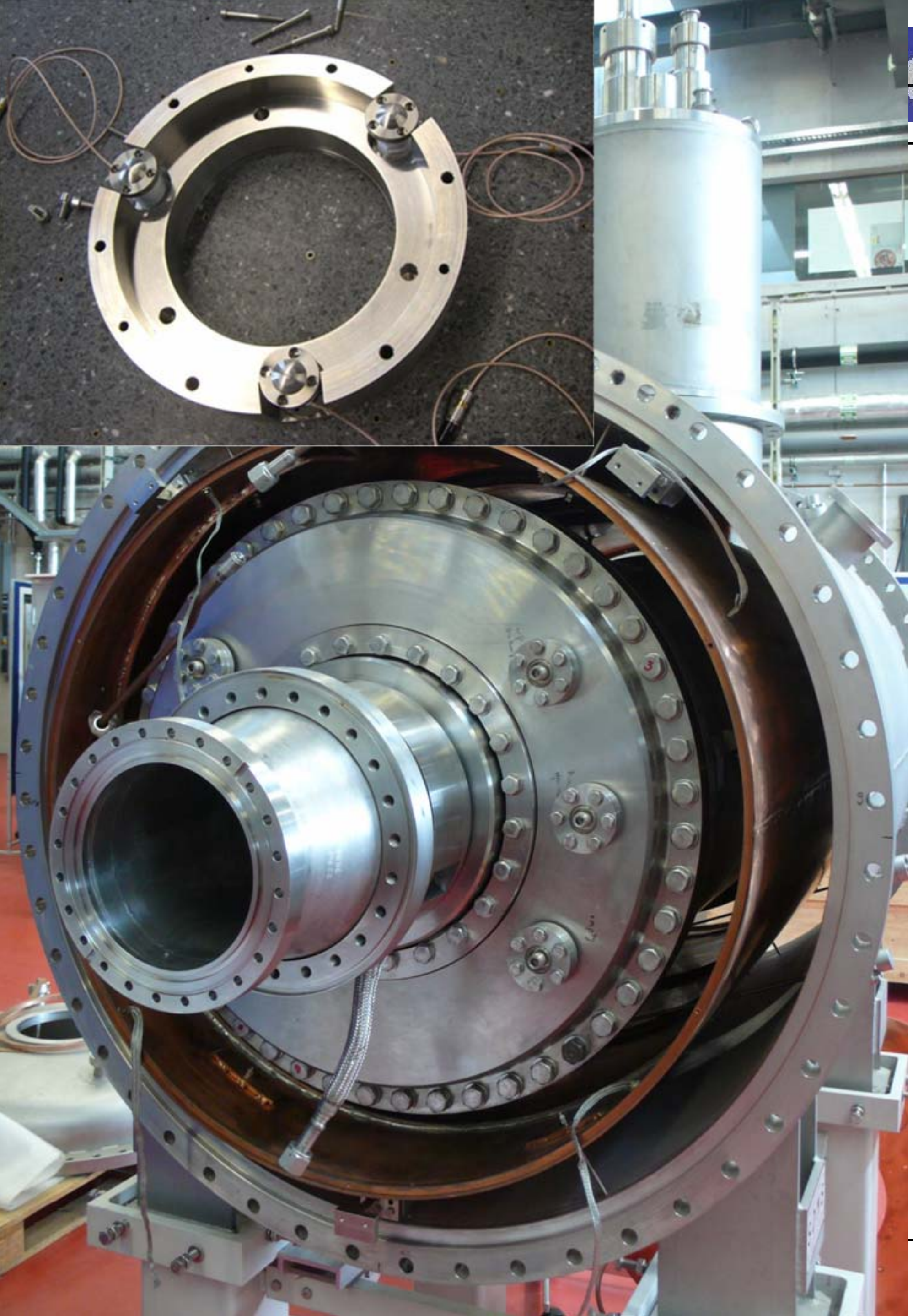
IAP Frankfurt
LINAC AG

Cavity performance

E_a=7 MV/m
B_p=36 mT
E_p=36 MV/m
B_p=40 mT
Q_0=6.8e8

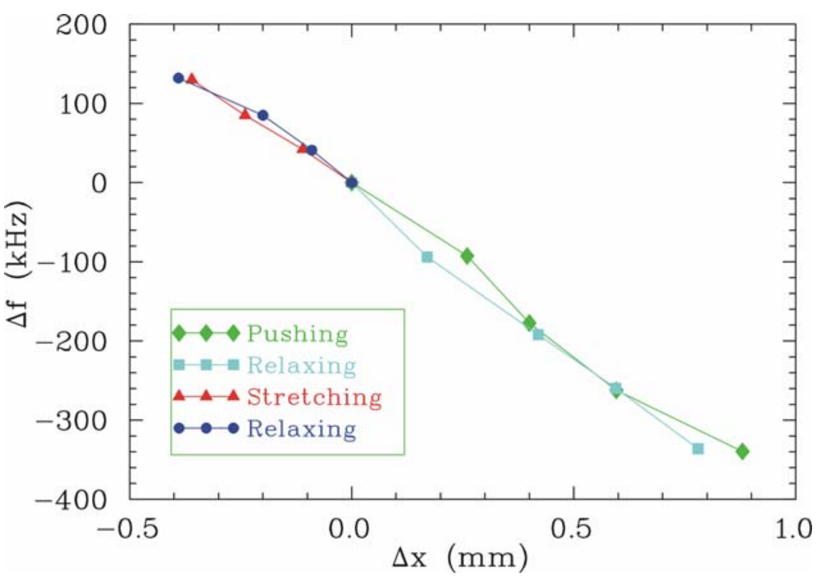






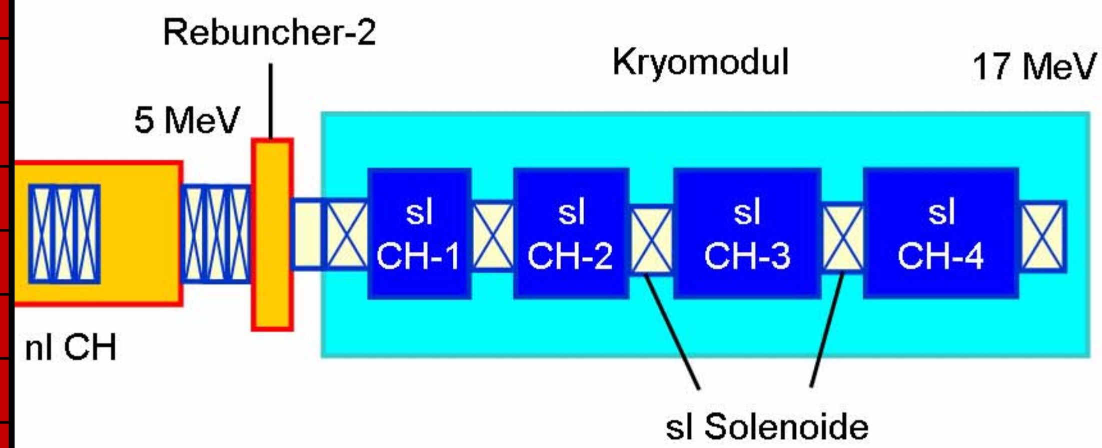
Horizontal Test

Planned for beginning of 2009 with slow and fast tuner



CH-linac layout for EUROTRANS

Particles	Protons
Current	2.5-4 mA
Duty cycle	100%
Frequency	352 MHz
Energy range (sc)	5-17 MeV
Nr. sc CH-cavities	4
E_a	4 MV/m
E_p	<22 MV/m
B_p	<40 mT
P_{beam} per cavity	7-13 kW



Effective gradients in the s.c. CH-cavities: 4 MV/m (βλ)

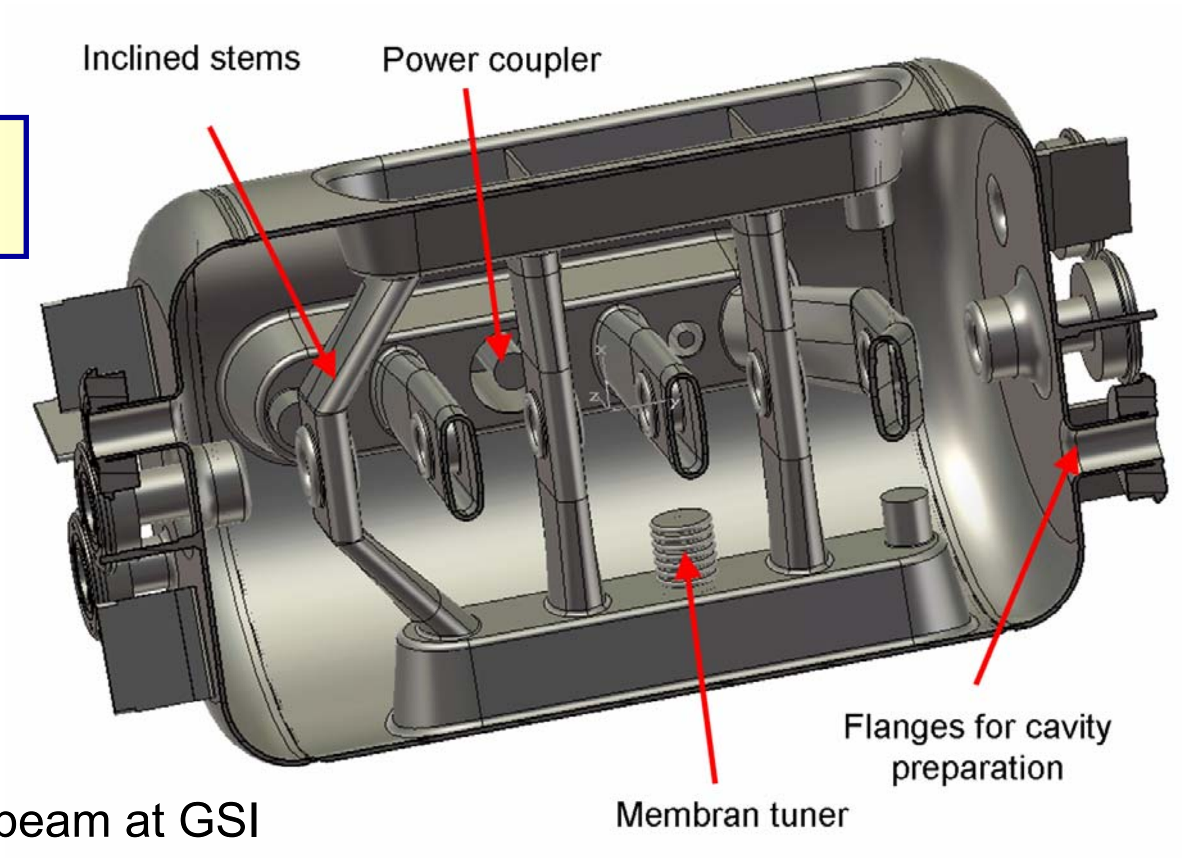
→ Electric peak fields ≈ 20-23 MV/m
→ Energy gain per cavity ≈ 3 MeV

CH-linac layout: new sc CH-cavity

Goal: Design optimized for applications like EUROTRANS/IFMIF

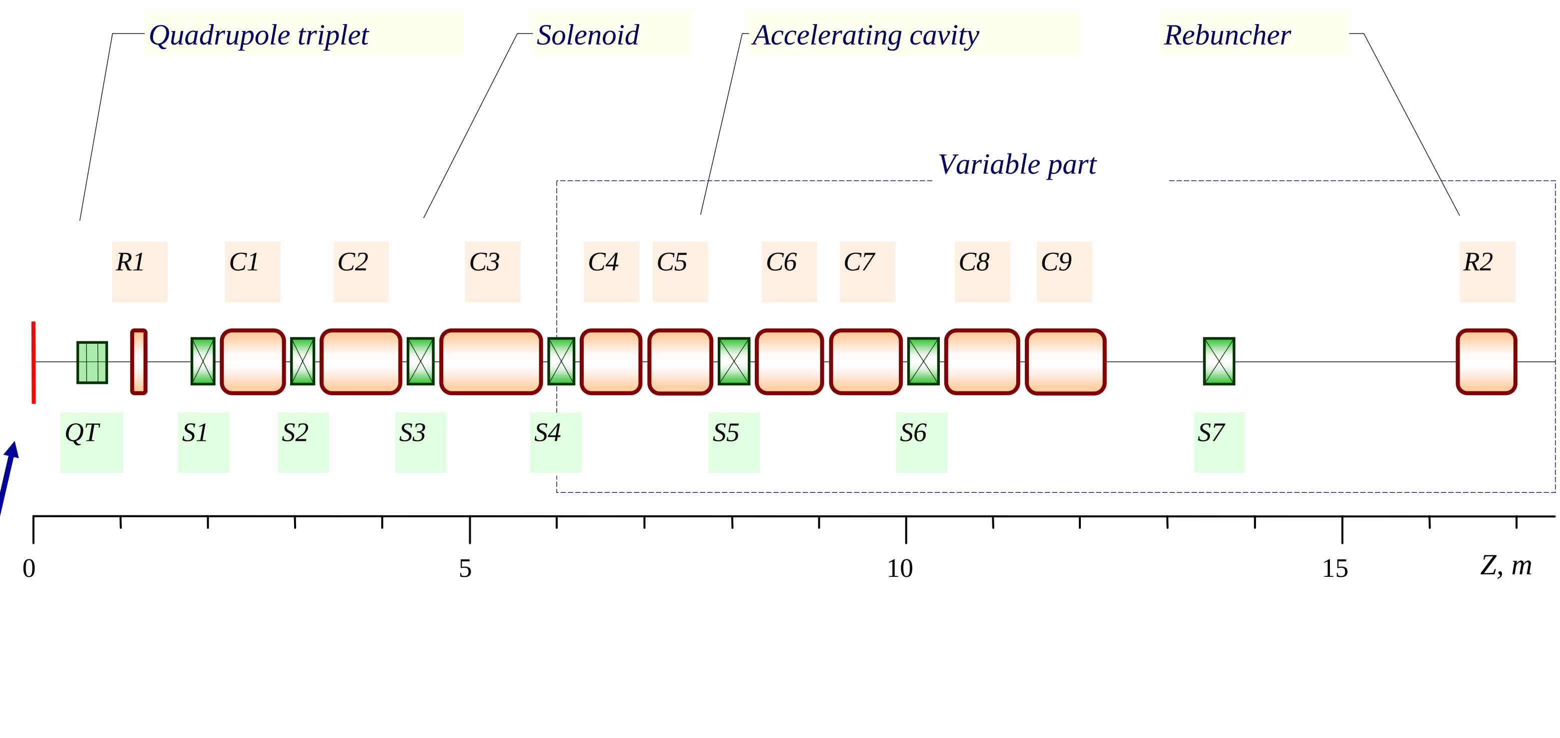
As realisitic as possible

f=325 MHz
β=0.15



Test with beam at GSI

SC CW-Linac at GSI for SHE



Front part: High Charge Injector at GSI, 108 MHz

W_{max}=7.5 MeV/u
f=216 MHz
A/Q=6.5

Each cavity powered by 5-10 kW solid state amplifier

(REX)-ISOLDE Upgrade

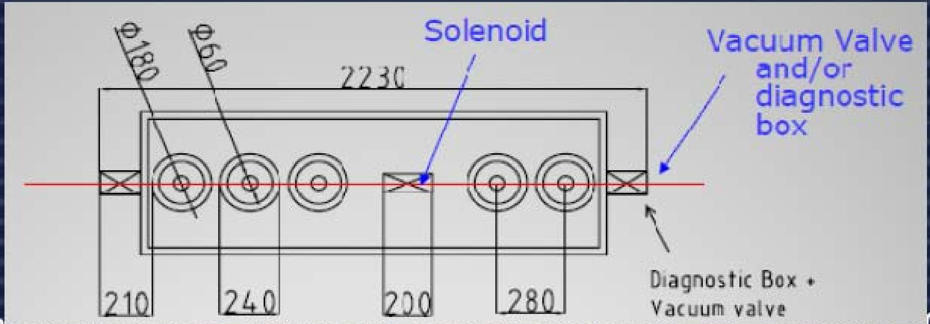
CERN

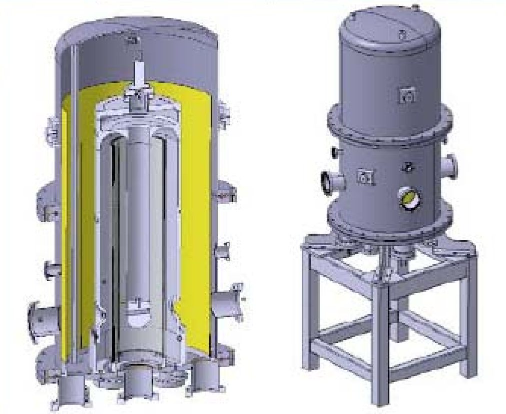
HIE-ISOLDE

MOP028 M. Pasini

- Stage 1: final energy up to 5.5 MeV/u with 10 QWRs, beta 0.12, 101 MHz
- Stage 2: final energy up to 10 MeV/u with 10 QWRs, beta 0.075, 101 MHz & 5 more QWRs, beta 0.12, 101 MHz
- 5 cavities & 1 SC solenoid/cryomodule (common vacuum)
- Nb/Cu sputtering technology
- 1 copper model of the 'high' beta 0.12 ready by the end of October 2008
  - Drift tubes faces modified for steering compensation

Courtesy of M. Pasini

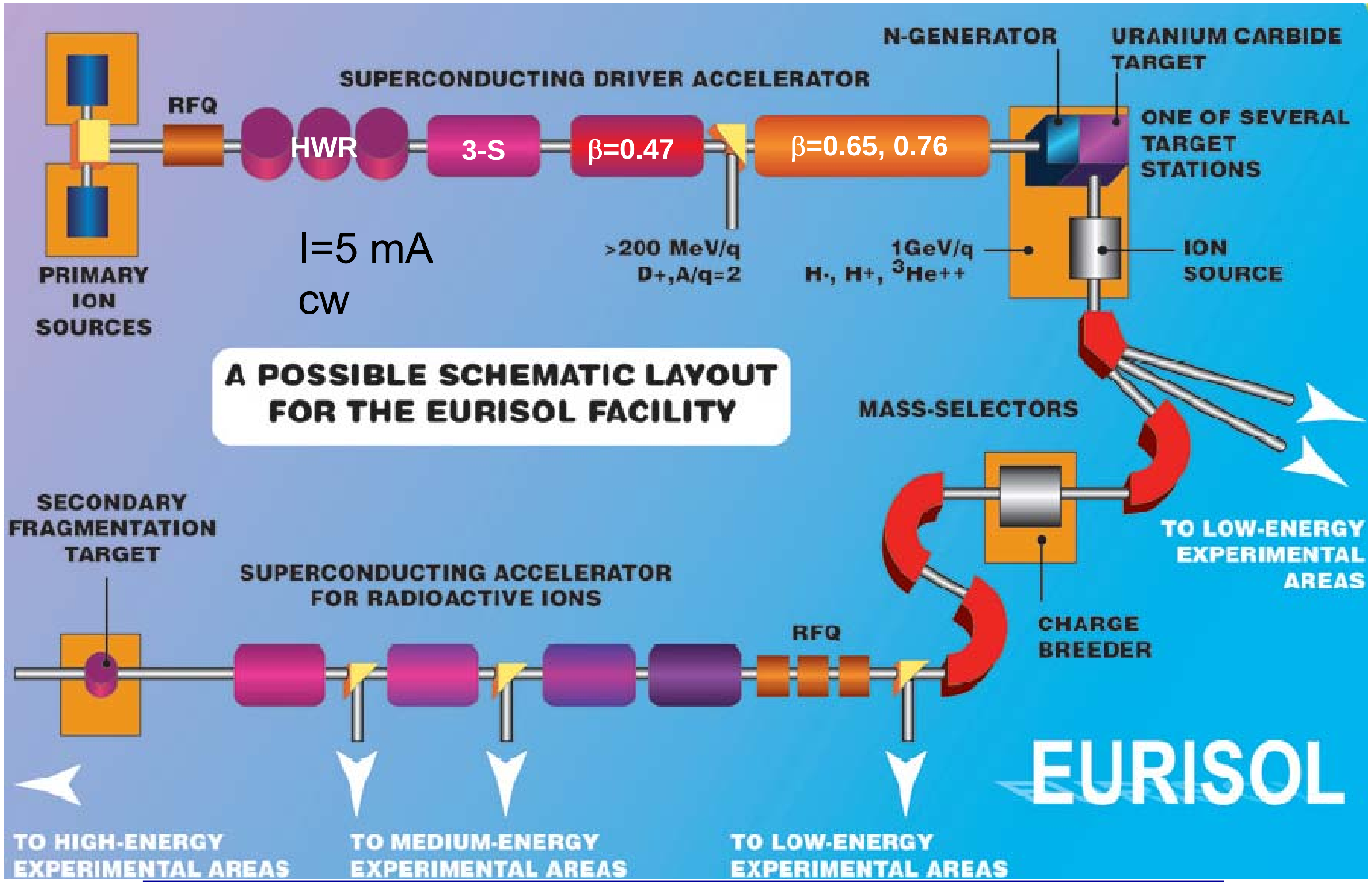




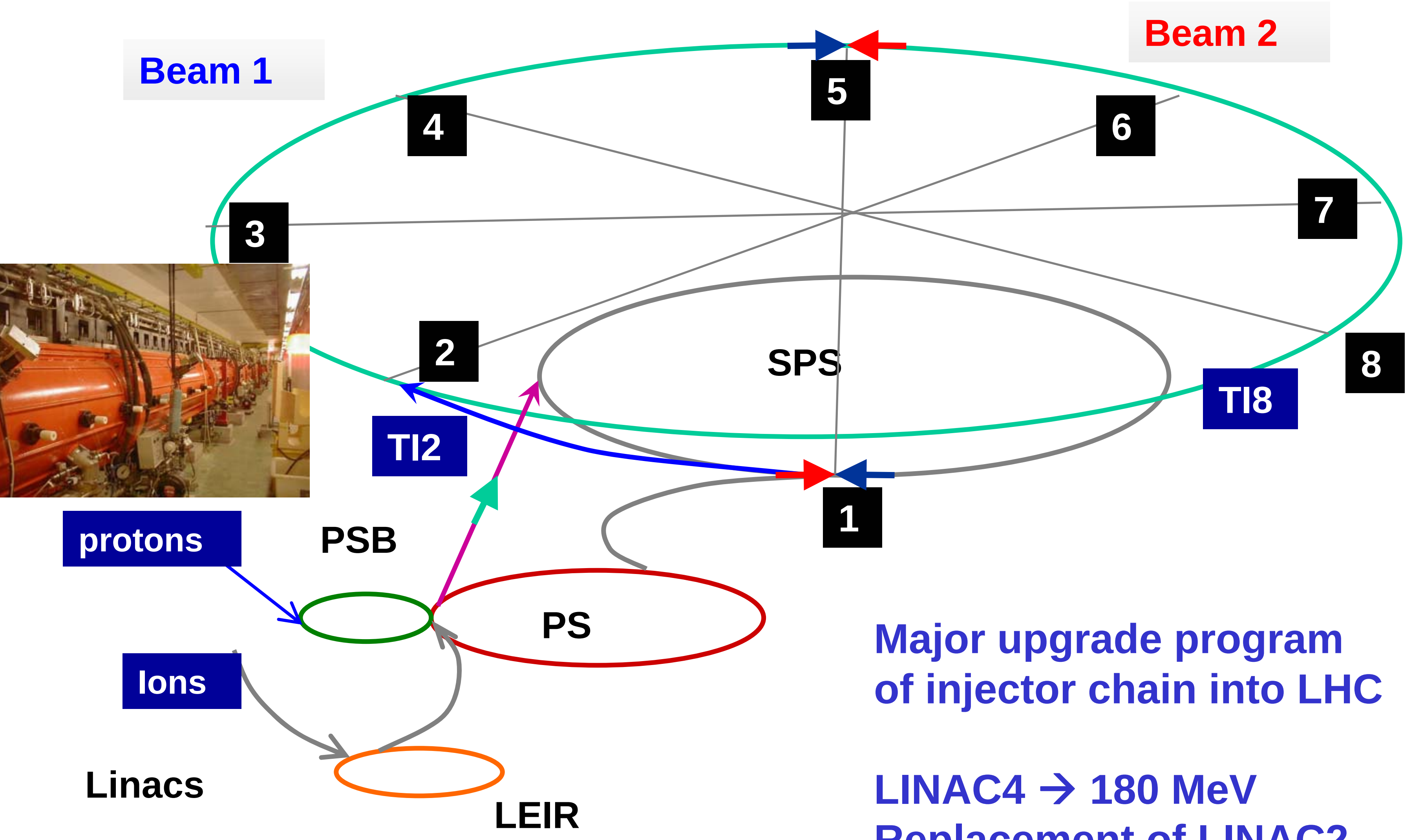
Sputtering chamber

M. Pasini

Layout EURISOL



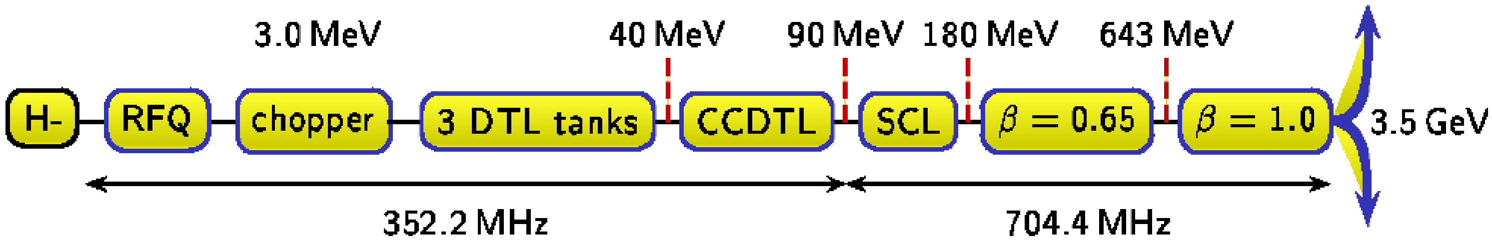
Low beta cavities: 176 MHz HWR (INFN), 352 MHz triple spoke (Orsay)



Major upgrade program of injector chain into LHC

LINAC4 → 180 MeV Replacement of LINAC2

SPL at CERN



Section	E [MeV]	Cavit.	$\hat{P}_{RF}$ [MW]	Klystr.	l [m]
Source	0.095	–	–	–	3
RFQ	3	1	1.0	1	6
Chopper	3	3	0.1	–	3.7
DTL	40	3	3.8	5	13.6
CCDTL	90	24	6.4	8	25.5
SCL	180	24	15.1	5	34.9
$\beta = 0.65$	643	42	18.5	7	86
$\beta = 1.0$	3560	136	116.7	32	256
Total	3560	233	161.6	58	429

Multi purpose machine

- LHC injector (direct injection in PS)
- υ-factory driver
- EURISOL driver

Superconducting 5-cell cavities

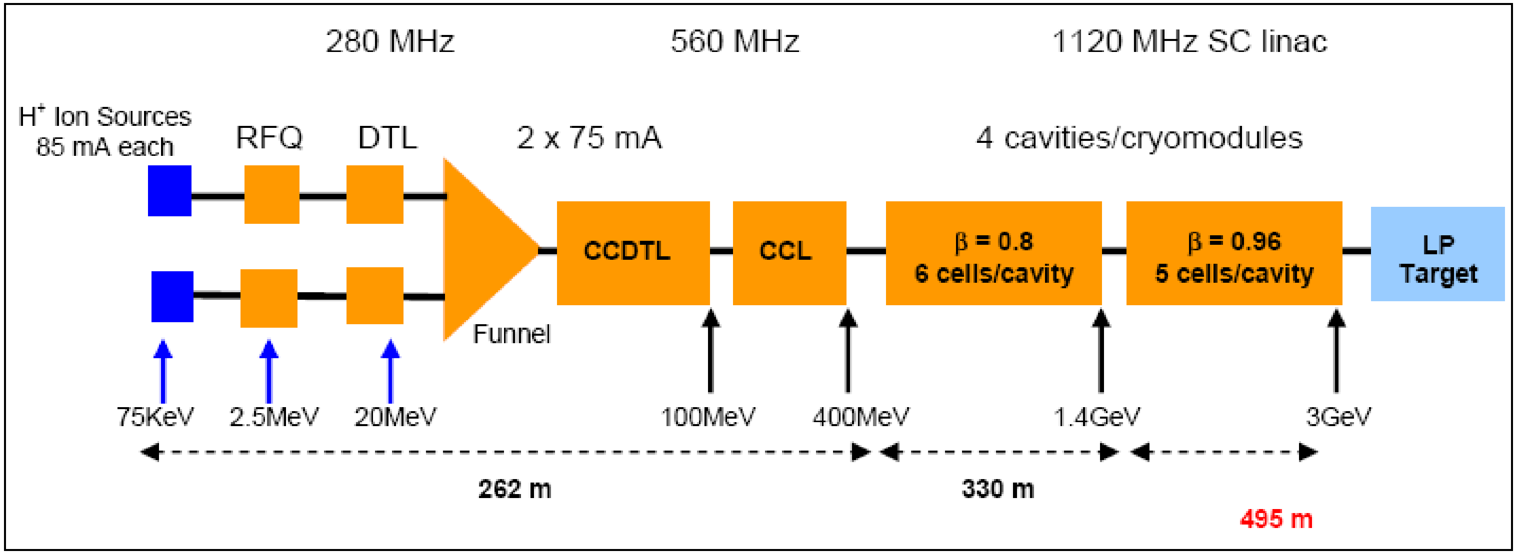
β=0.65 and 1.0

f=704 MHz

E_a=19 and 25 MV/m

P_{beam} up to 5 MW

ESS (old)

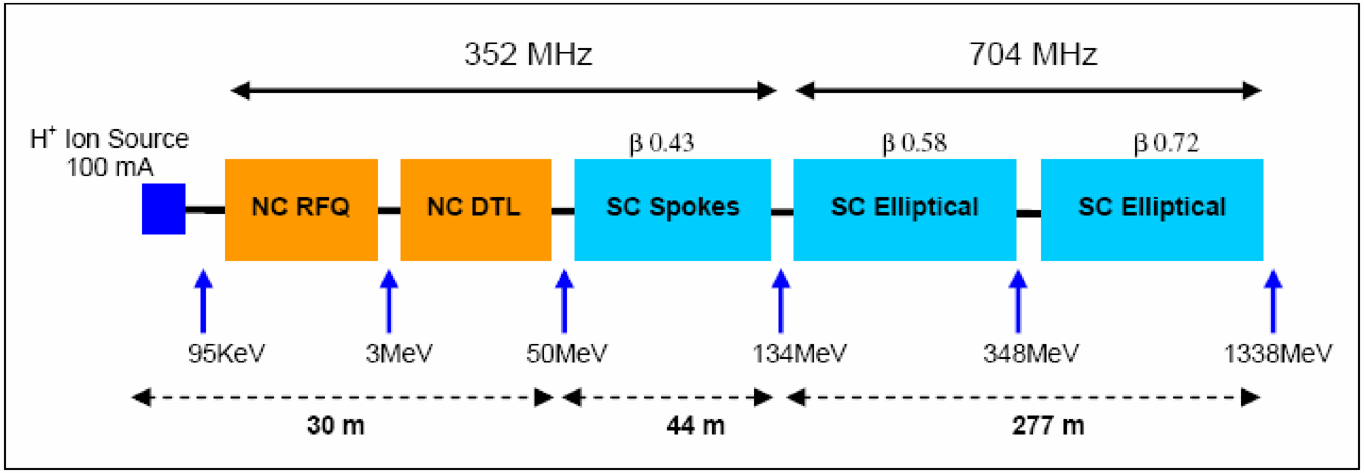


Design published 2003
High transition energy rt-sc
Funneling

ESS (Bilbao)

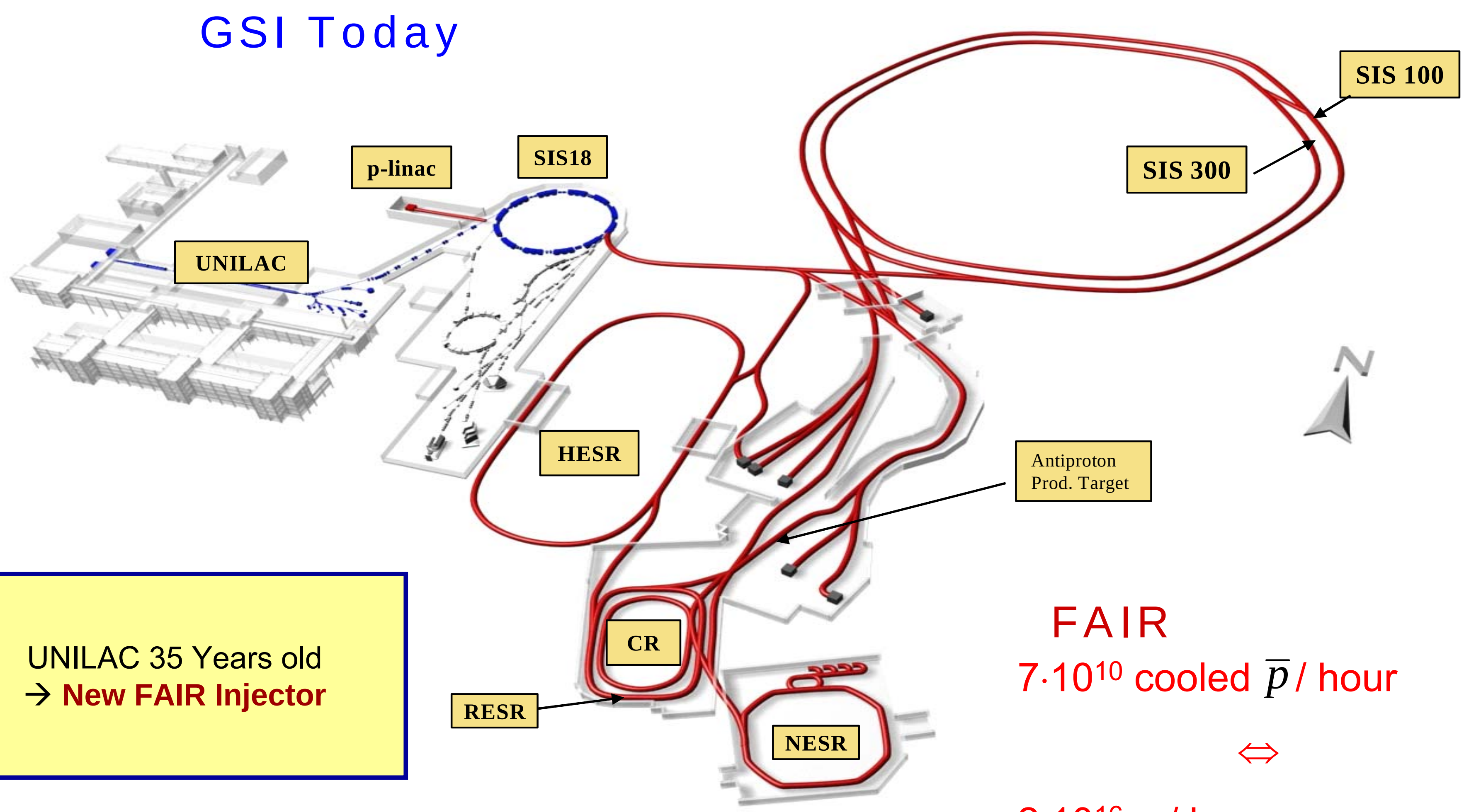
Recently launched new programs for an ESS

Also plans in Scandinavia for an ESS



Still unclear: transition energy rt-sc

FAIR: Facility for Antiproton and Ion Research



UNILAC 35 Years old
→ **New FAIR Injector**

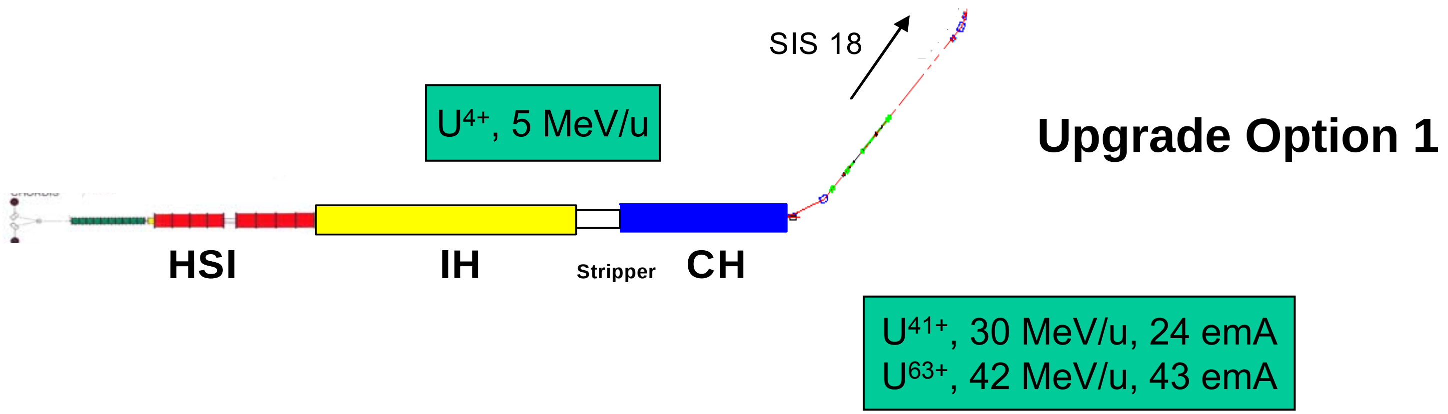
FAIR

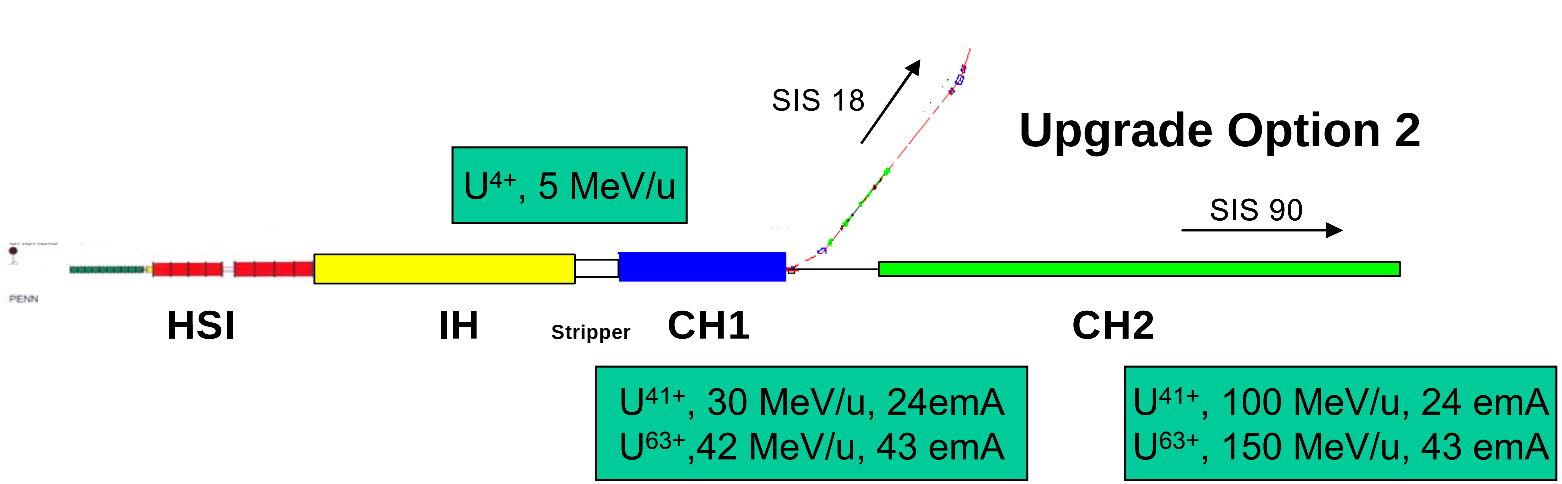
$7 \cdot 10^{10}$ cooled $\overline{p}$ / hour

⇔

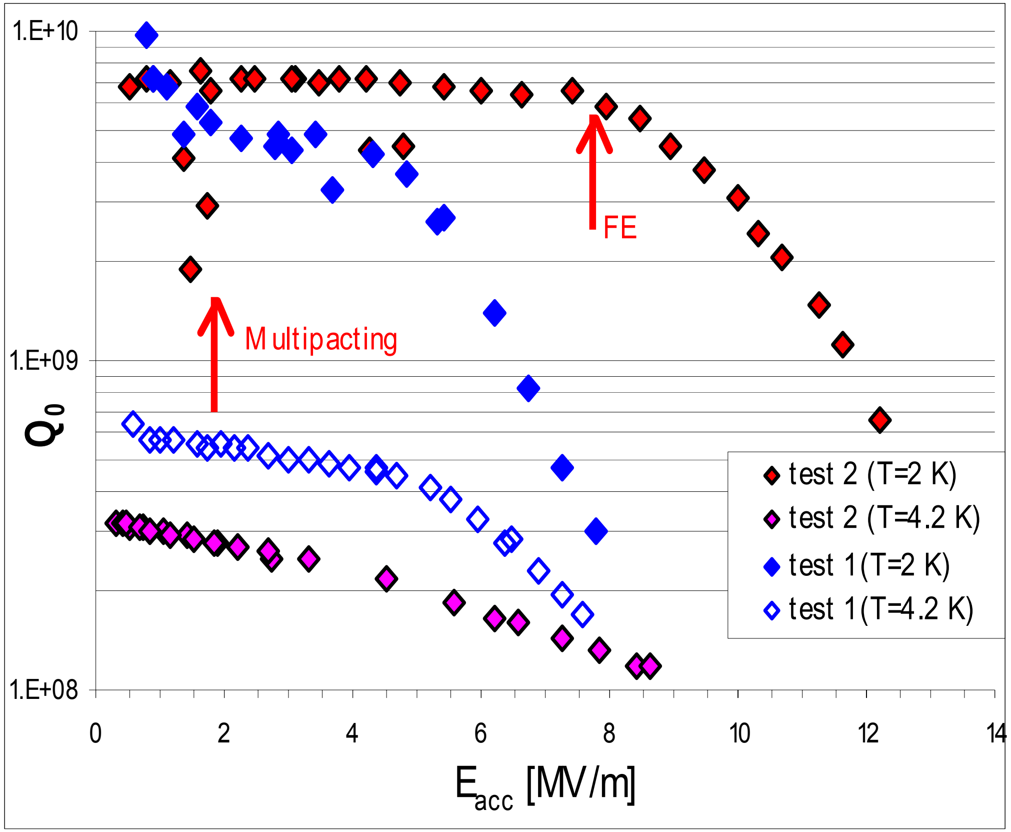
$2 \cdot 10^{16}$ p / hour

Design Study for a Novel Compact Injector for FAIR





JLAB test results, Jülich Triple Spoke



FZJ - 760 MHz, β=0.2

After test 1 the cavity was warmed up, disassembled, degreased and heat treated at 600 C for 10 hrs. After furnace treatment, degreased and bcp with 1:1:3 in steps of 5 min each (on sample app. 0.9 microns/min); total time of bcp 30 min; then HPR in 2 locations axially with cavity rotating, app. 30 min each, R@D hpr system. Cavity dried in class 10 clean room over night and assembled next morning (PK); attached to test stand and evacuated; prior to cooldown, p~ 1.2e-8 mbar, cont'd next day after Helium top off

E. Zaplatin

Jülich Triple Spoke, β=0.5, f=352 MHz

E. Zaplatin

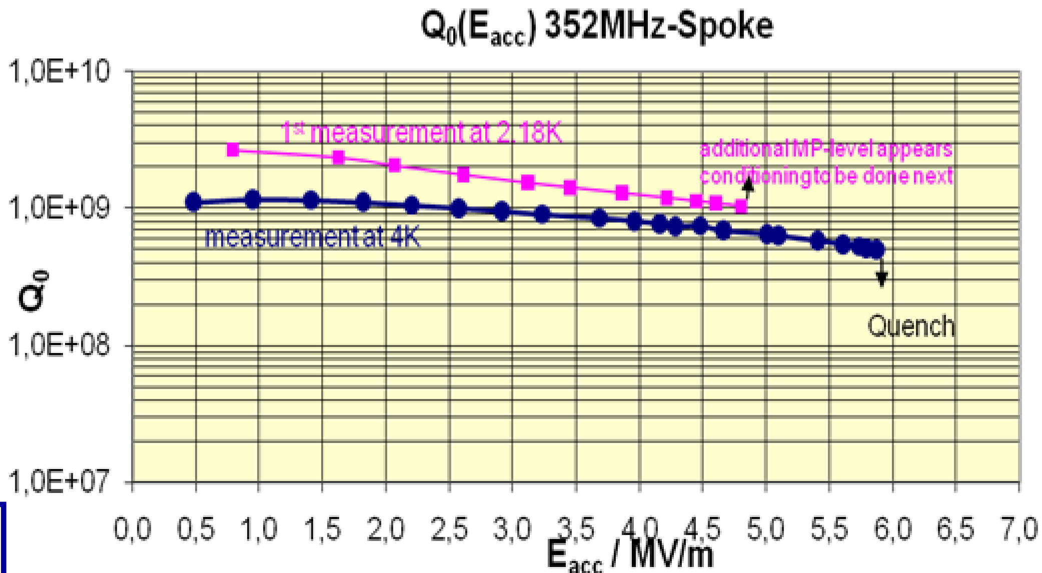
Status at 12-Sept-2008:

E_{acc} = 5.8 MeV/m , stoped by quench (4 K)

E_{acc} = 4.6 MeV/m , stoped by MP (2 K)

experiment will be continued in November

df / dp [Hz/mBar]		K_L [mT/(MV/m)**2	
calc	exp	calc	exp
-21.43	-31.86	-4.1	-5.5



Thanks to all collegues providing information

T. Junquera, J.-L. Biarrotte, G. Olry: IPN Orsay
A. Mosnier: CEA Saclay
A. Facco: INFN Legnaro
J. Zaplatin: FZ Jülich
M. Pasini: ISOLDE/CERN