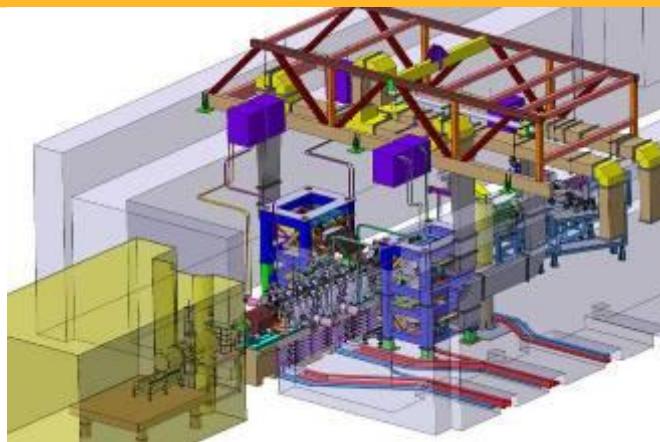
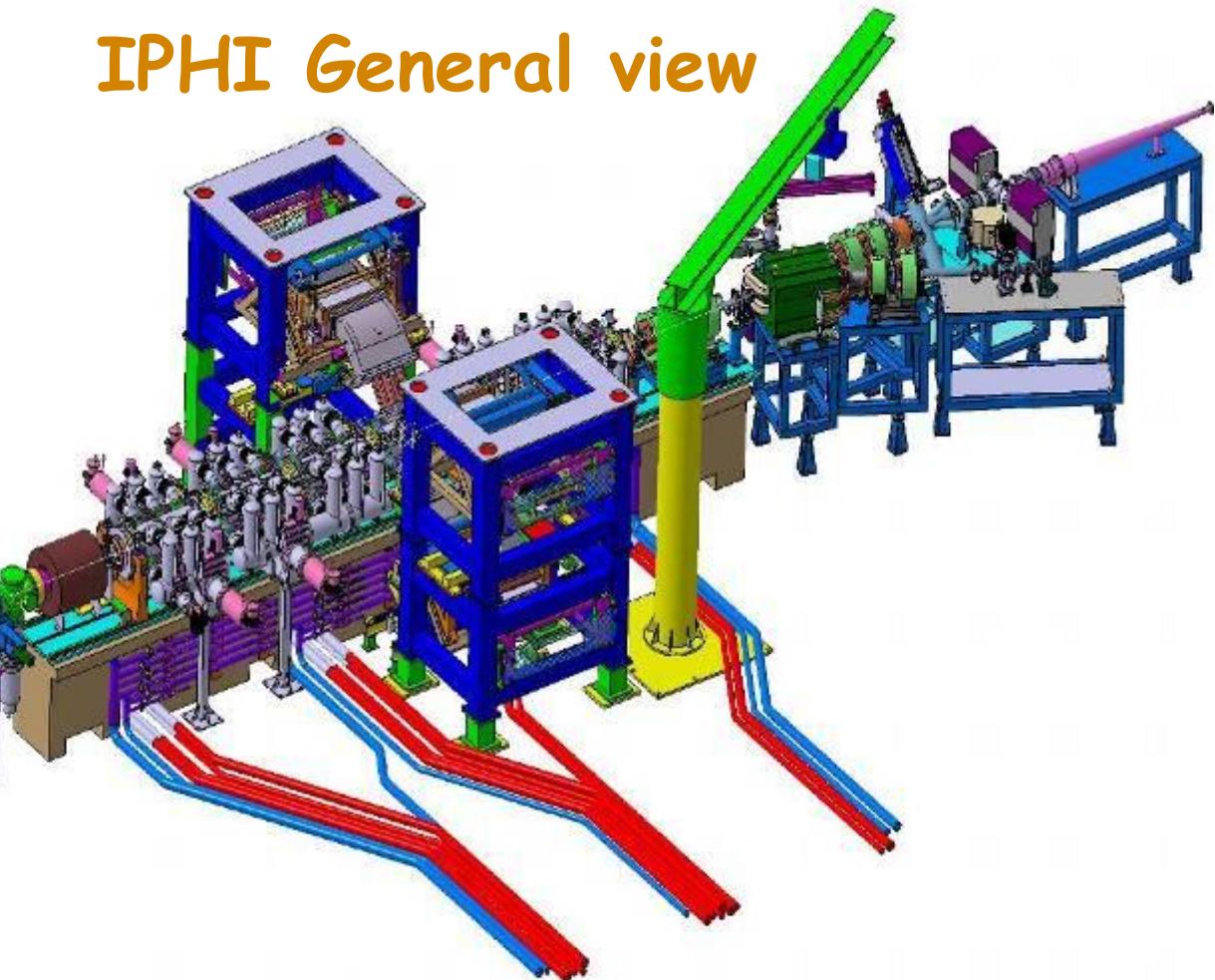
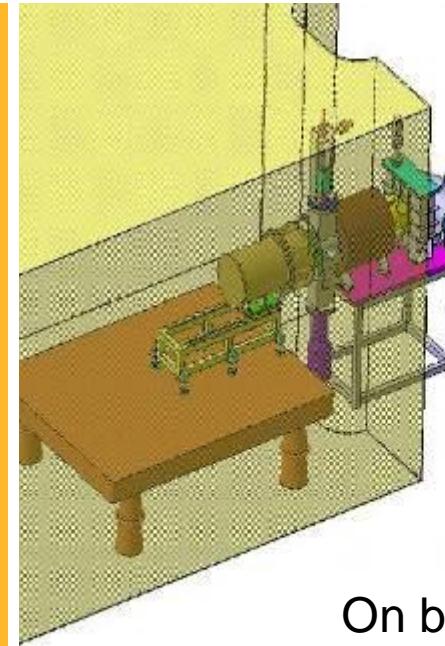


# The IPHI 352 MHz RF source at CEA/Saclay



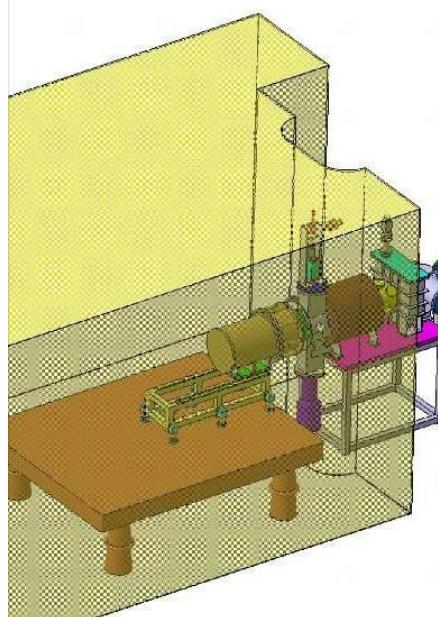
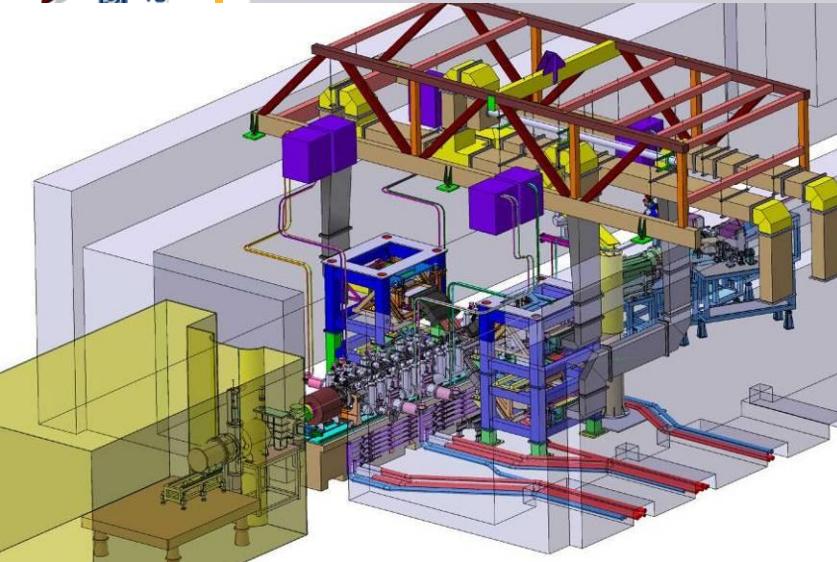
IPHI General view



On behalf the IPHI team

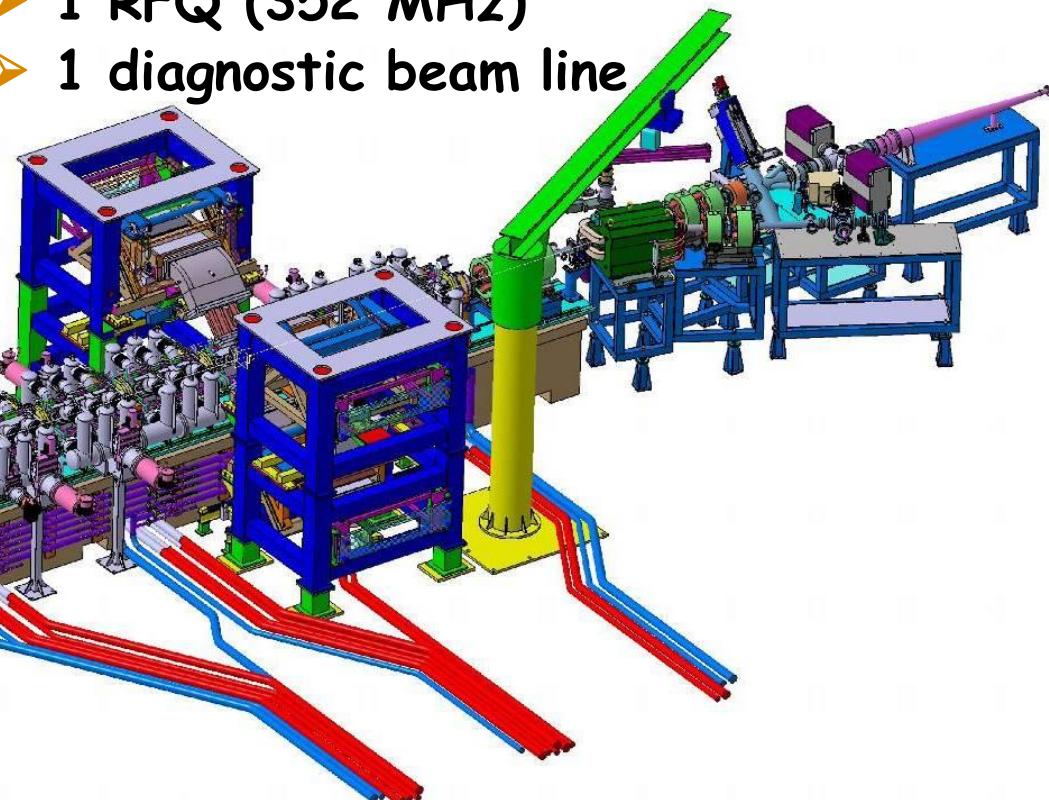
- IPHI general overview
- Injector : SILHI
- RFQ
- Beam Diagnostics
- RF Source
- Remote control
- TRASCO RFQ tests
- Prospects
- Conclusion

# IPHI General Overview



Injecteur de Protons à Haute Intensité  
**Composed of :**

- 1 ECR ion source
- 1 LEBT with 2 solenoids
- 1 RFQ (352 MHz)
- 1 diagnostic beam line



# Silhi source (1)

ECR Source → Resonance zone :  
 $\omega = e B / m$

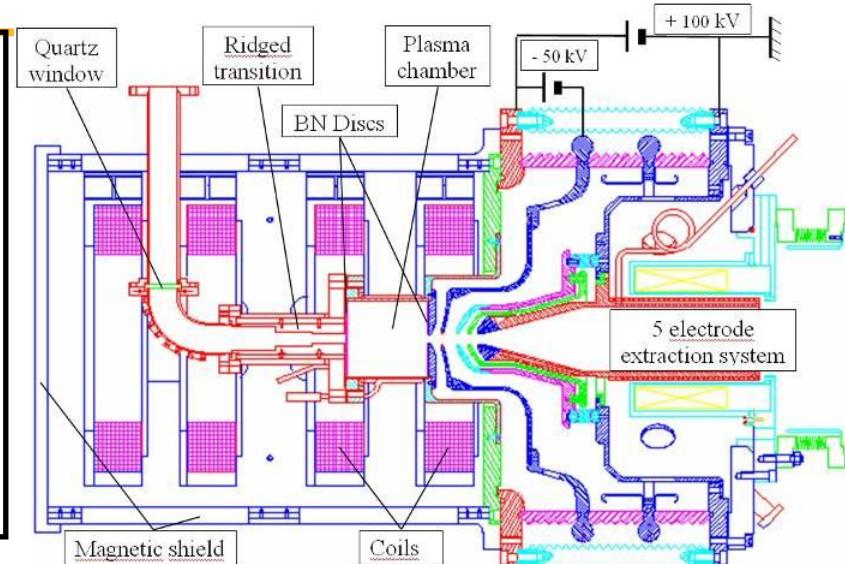
$\omega$ , pulsation

e, electron charge

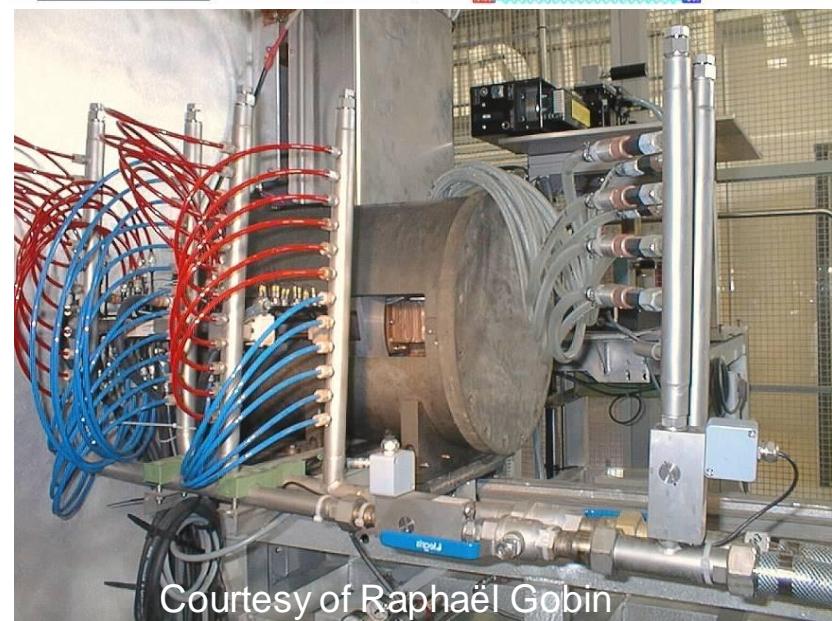
B, magnetic field

m, electron mass.

2.45 GHz → 875 Gauss



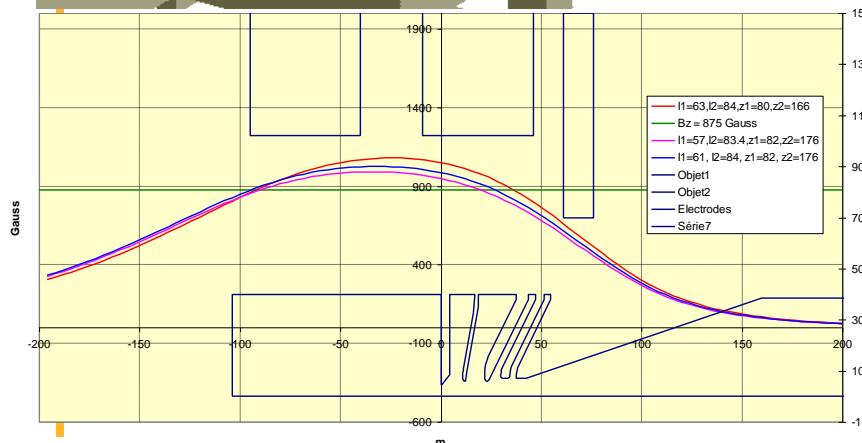
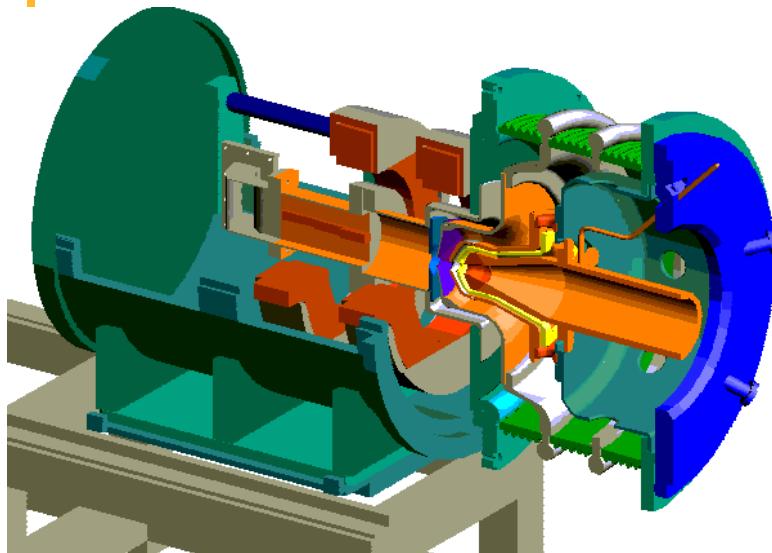
External Collaborations  
 CEA Grenoble,  
 IPNO, LANL, INFN, GSI, GANIL,  
 U. Frankfurt,  
 Industrial Companies  
 Students  
 Thesis or training sessions



Courtesy of Raphaël Gobin

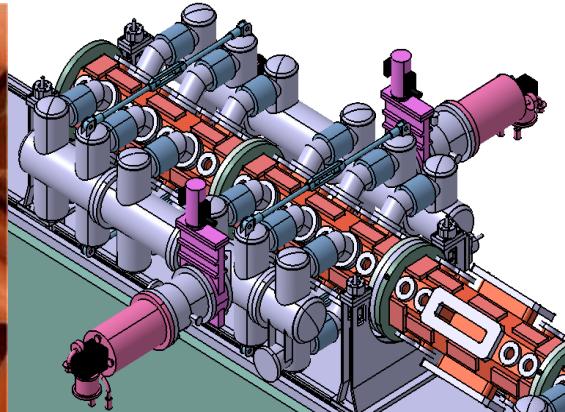
# Silhi source (2)

SILHI operates at 2.45 or 3 GHz  
 1 ECR zone at RF entrance  
 Pentode extraction system

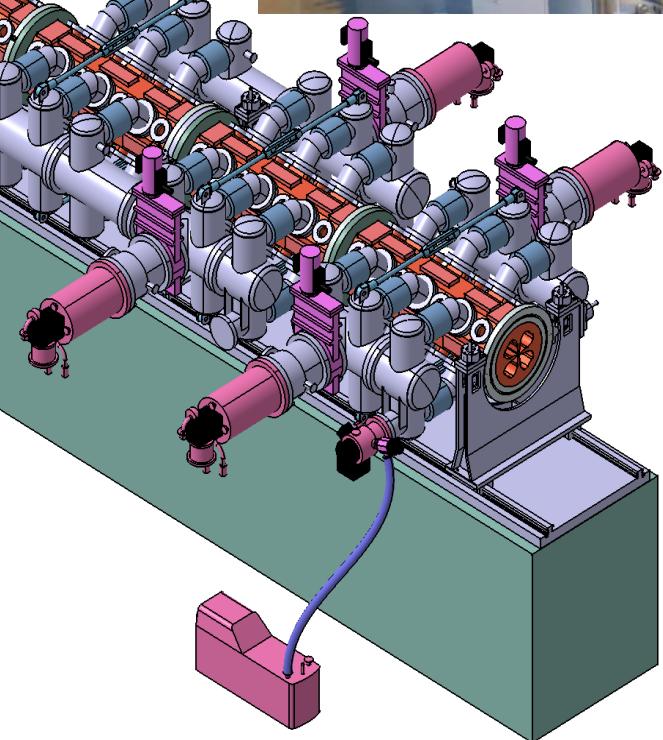


Since 1996, SILHI produces H+ beams with good characteristics:  
 H+ Intensity > 100 mA at 95 keV  
 H+ fraction > 80 %  
 Beam noise < 2 %  
 95 % < Reliability < 99.9 %  
 Emittance <  $0.2 \pi \text{ mm.mrad}$   
 CW or pulsed mode

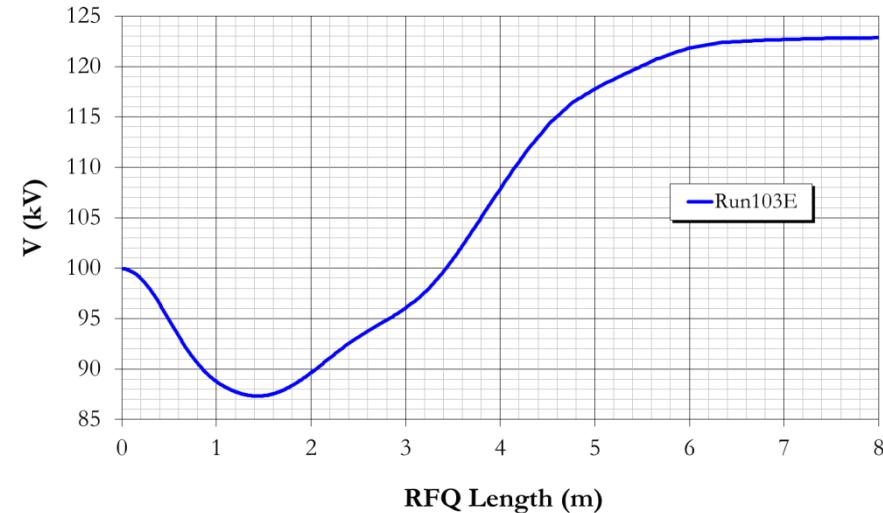
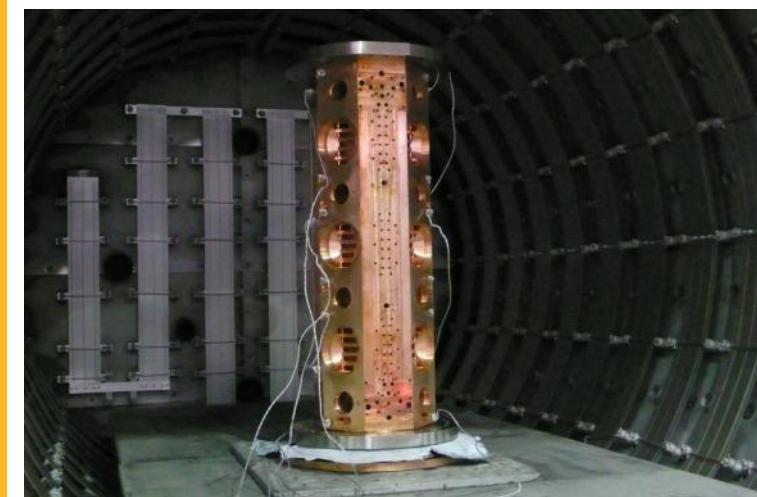




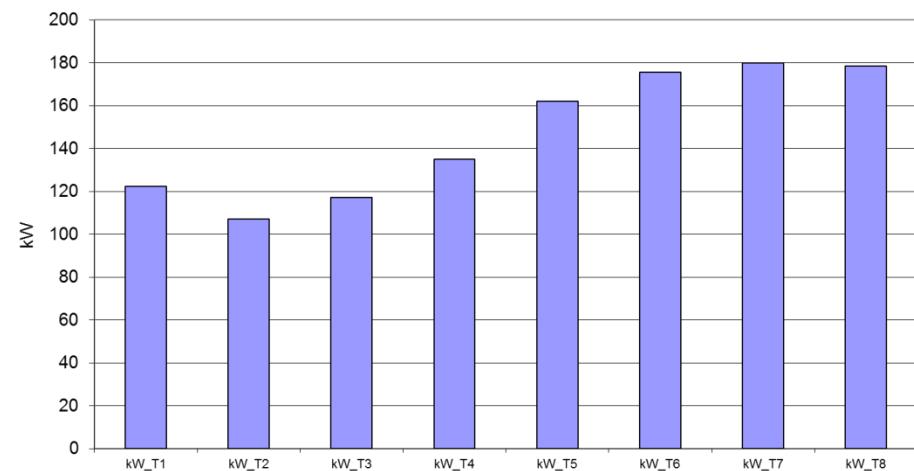
**6 sections**  
**900kW dissipated power**  
**300kW (100mA, 3MeV)**  
**2 end plates**  
**2 coupling plates**  
**60 pumping ports**  
**4 RF injections on 4<sup>th</sup> section**  
**96 RF stub tuners**  
**268 water cooling channels**



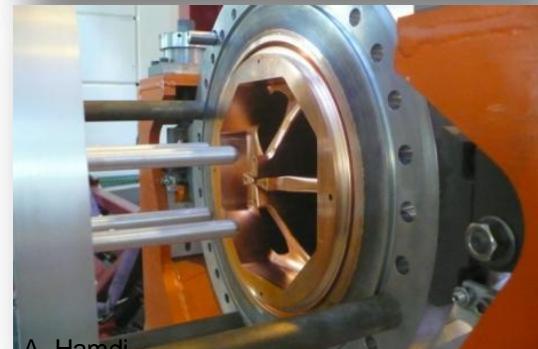
# RFQ : parameters



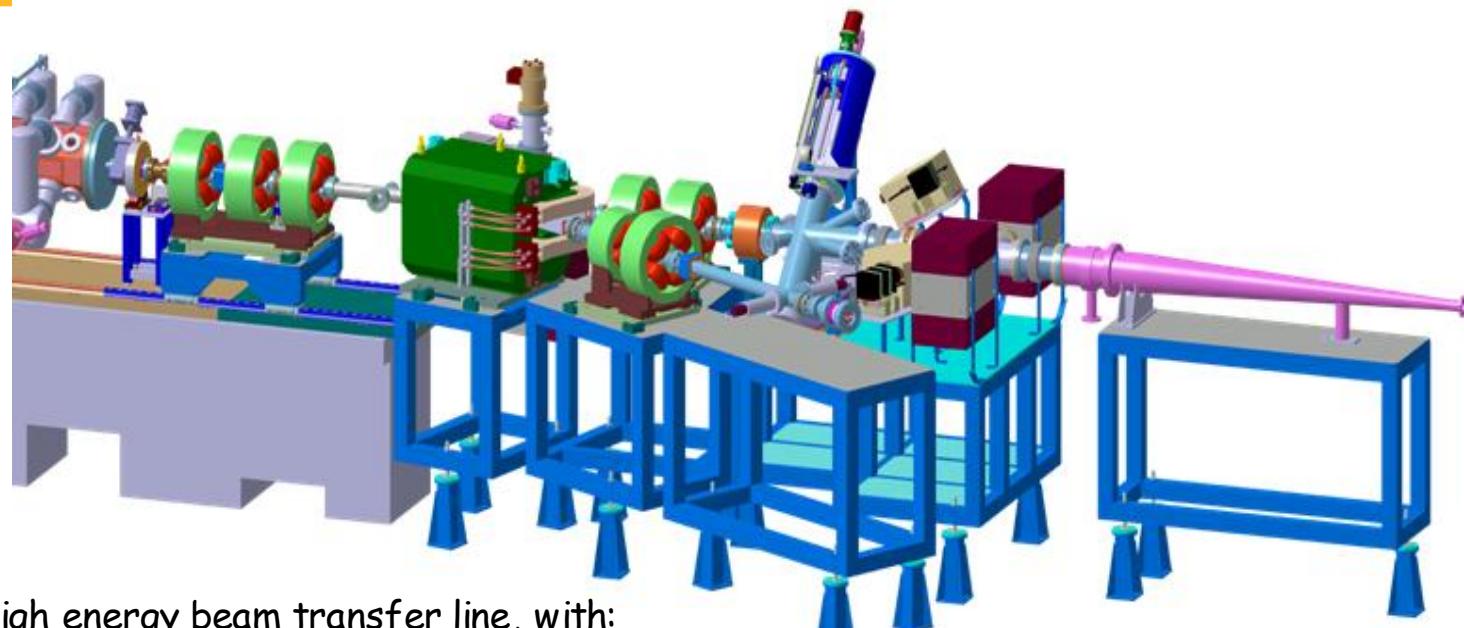
Dissipated power in sections  
( $P_{total} = 900$  kW) for 6 meters



# RFQ: sections installation, coupling plates and segments



# Diagnostic beam line

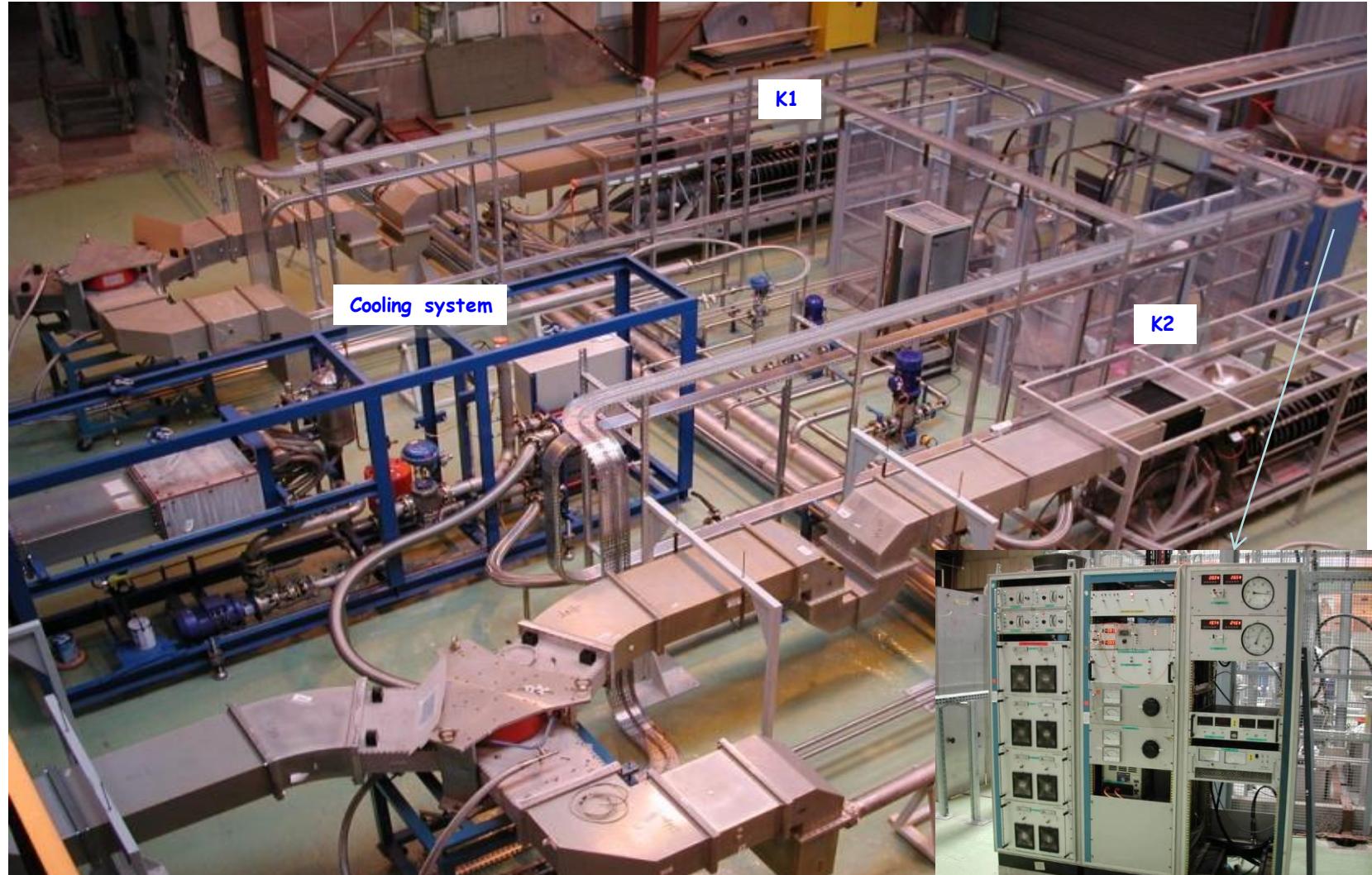


Dedicated High energy beam transfer line, with:

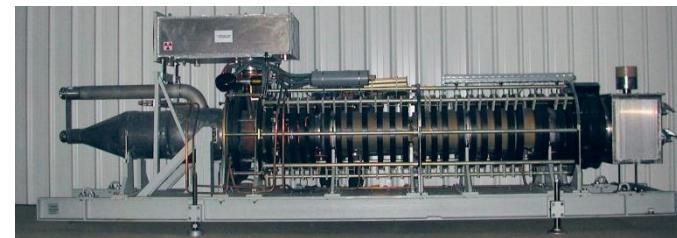
- Energy measurement
  - Time of flight (resolution  $10^{-3}$ )
  - Energy spread measurement (10keV to 20keV resolution)
- Beam Current measurement
  - ACCT : 5Hz-7MHz,  $10\mu A$  rms on test bench,
  - Bergoz DCCT,
  - beam stop (electric and power measurement)
- Profile / position measurement
  - Wire scanner for position and profile measurement (wire :  $33\mu m$  SiC, stroke 350mm, 2 planes)
  - 4 + 2 BPM for position measurement (dynamic 45dB).
  - back scattered proton measurement
  - Optical measurement with intensified CCD camera
- Emittance with wire scanner in pulse mode

# RF source (1)

2 klystrons from CERN: Thomson TH2089



# RF source (2)



## GENERAL CHARACTERISTICS

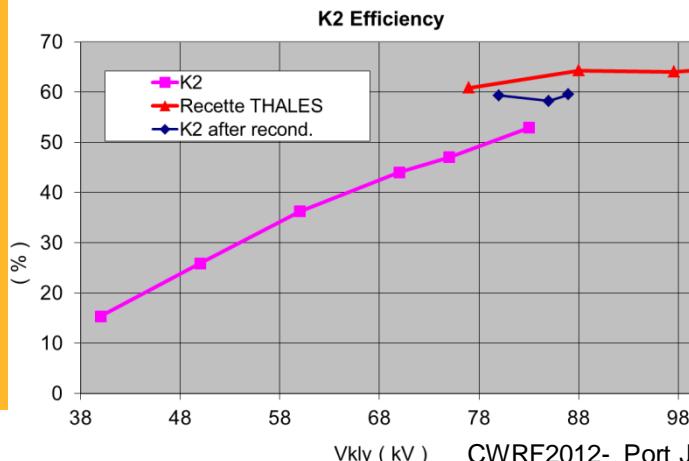
### Performance

Operating frequency (1) .....	352	MHz
Mechanical tuning range with respect to the center operating frequency .....	± 3	MHz
— 1 dB Instantaneous electronic bandwidth .....	± 0.8	MHz
CW output power, min. ....	1	MW
Drive power, max. ....	200	W
Gain, min. ....	40	dB
Gain, typ. ....	41	dB
Efficiency .....	65 to 70	%

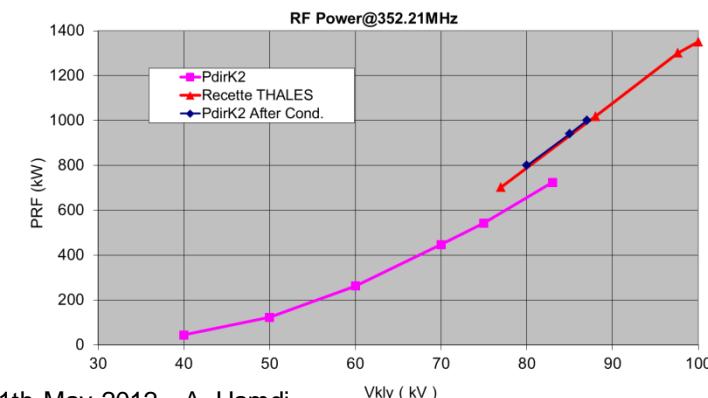
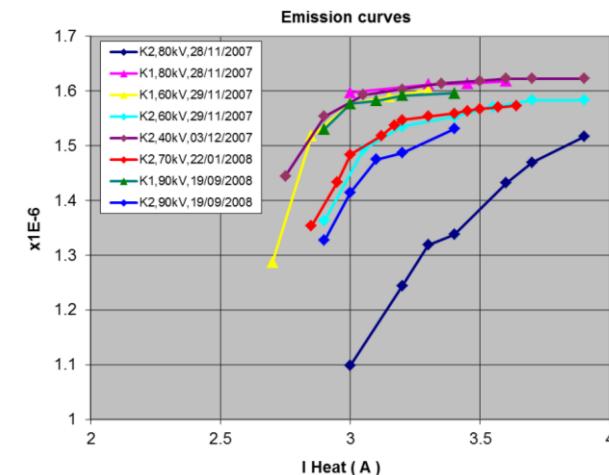
(1) The tube's center operating frequency can be set to any value desired between 345 and 360 MHz to be specified when ordering.

### Electrical

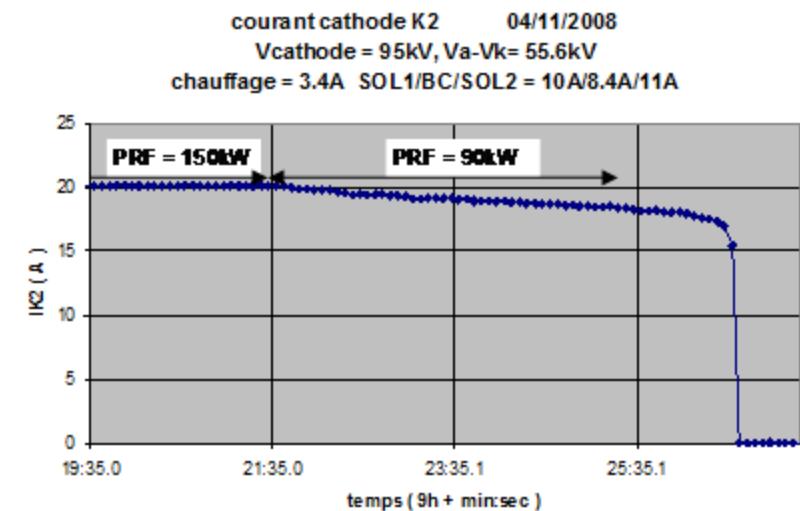
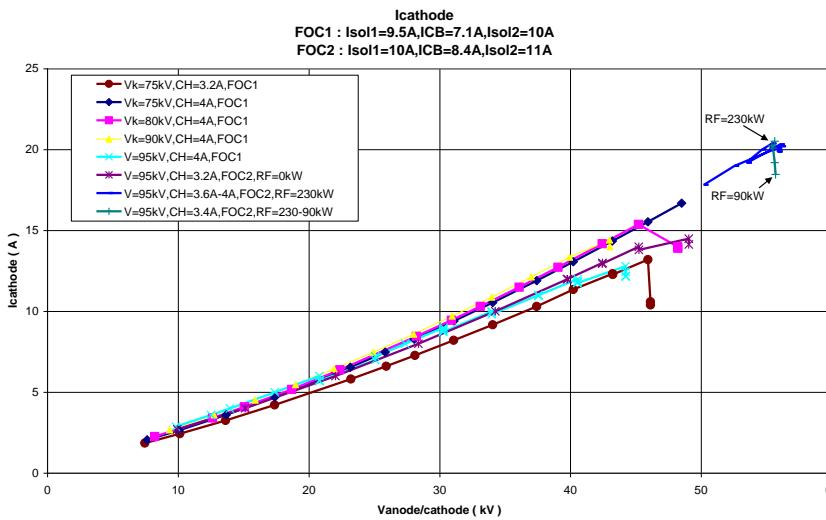
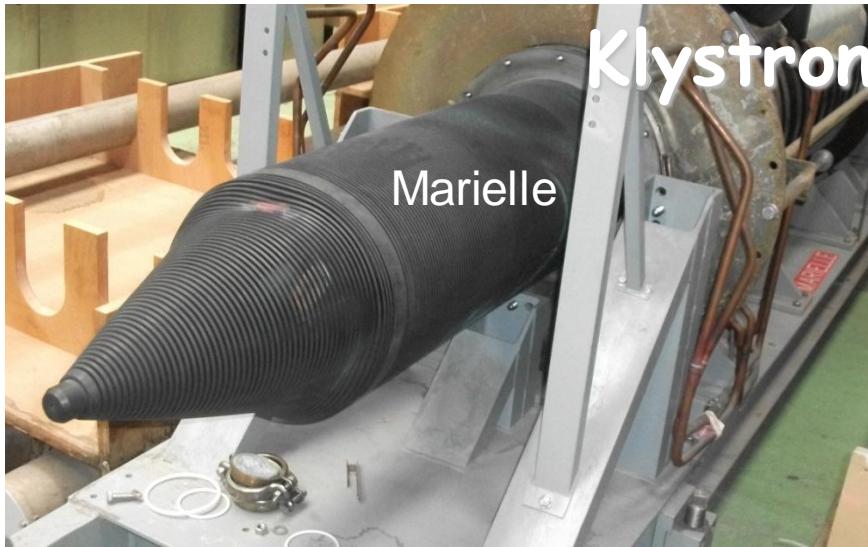
Beam voltage, max. ....	90	kV
Anode voltage, max. ....	90	kV
Beam current, typ. ....	18	A
Perveance ....	0.7 to 0.75	μperv
AC heater voltage, max. ....	24	V
Heater current, max. ....	30	A
Electromagnet voltage for each group of coils (2 power supplies), max. ....	300	V
Electromagnet current for each group of coils (2 power supplies), max. ....	12	A
Voltage supply for each of the two ion pumps ....	4.5 to 5.5	kV



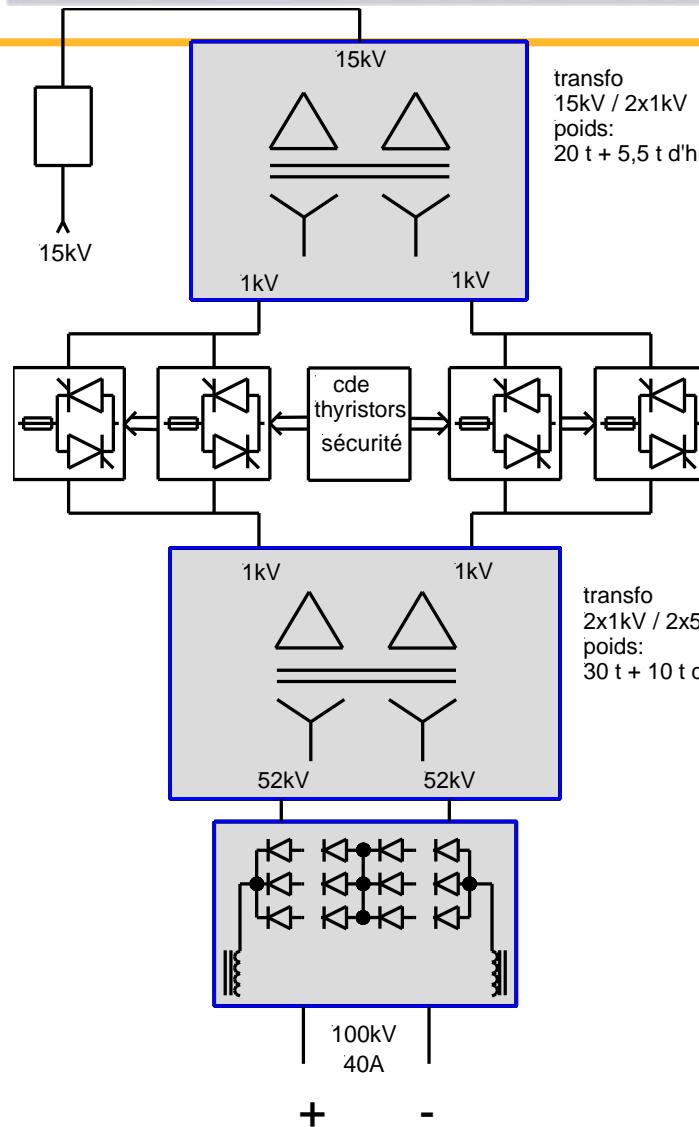
CWRF2012- Port Jefferson – 7-11th May 2012 - A. Hamdi



# RF source (3)



# RF source (5)



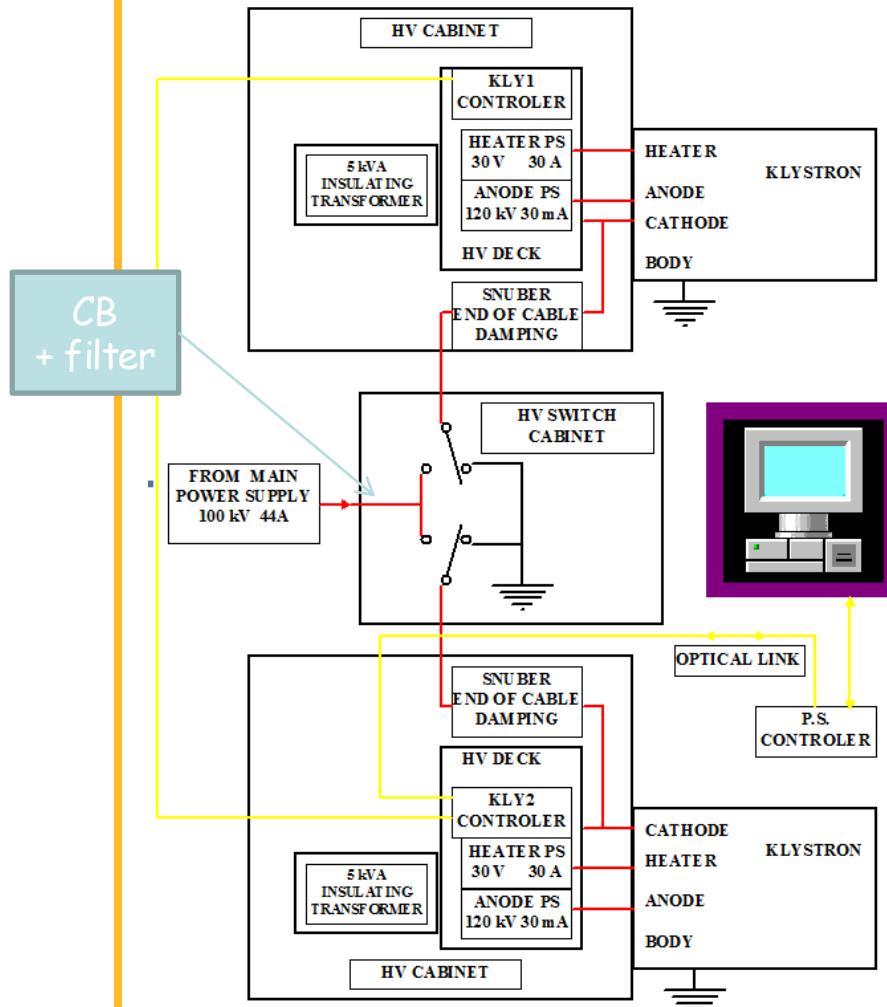
**HVPS 100kV 40A**



Courtesy of JL Jannin

# RF source (6)

## HV distribution



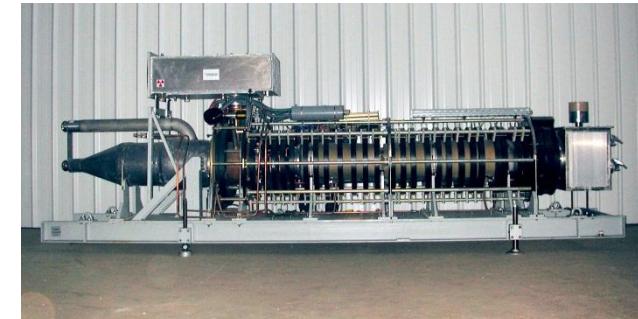
## KLYSTRONS AUXILIARIES

Klystron max energy: 20joules

Crowbar response time: 100ns

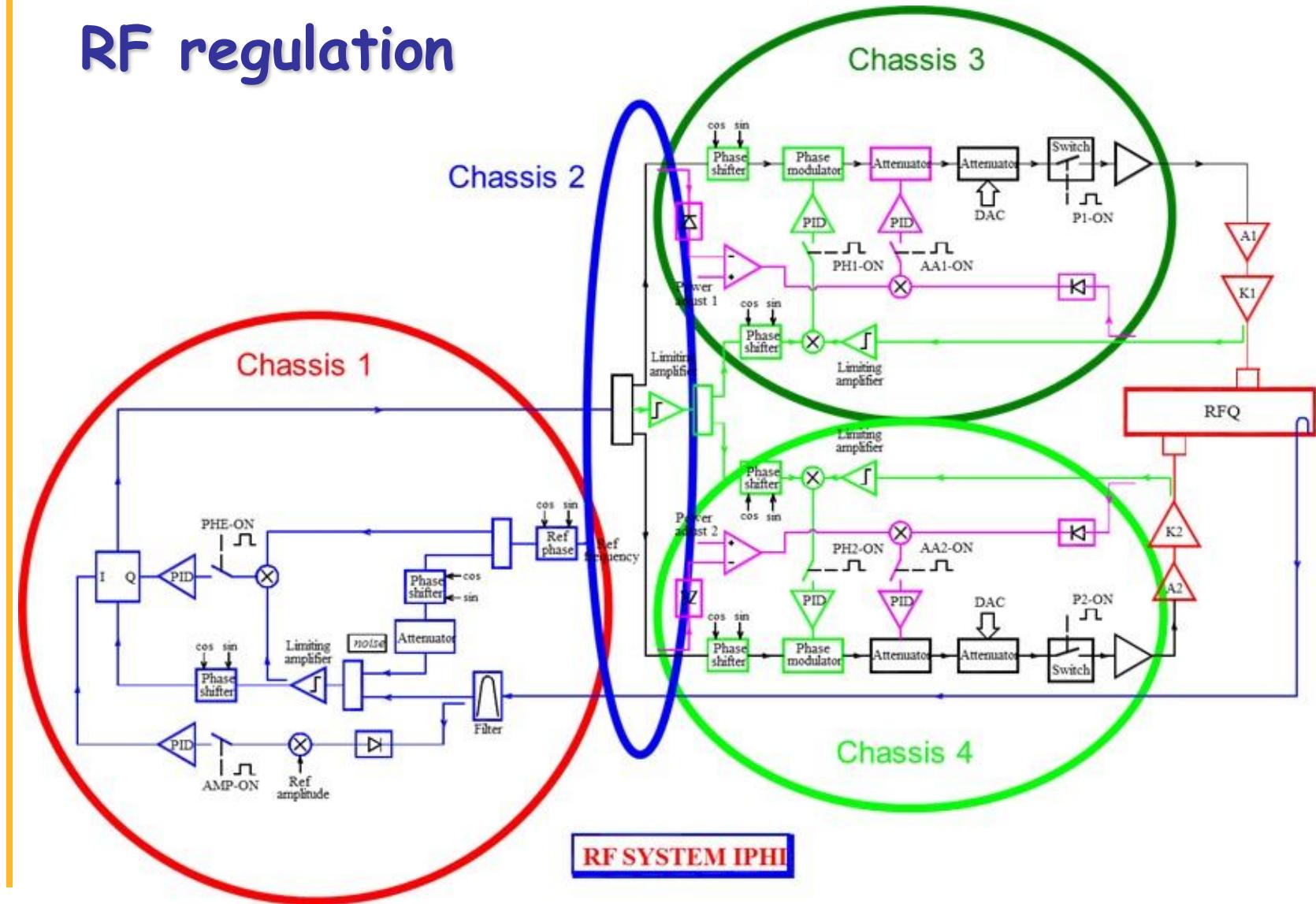
Anode Modulation  
120kV 10 mA

Heater  
30V 30A

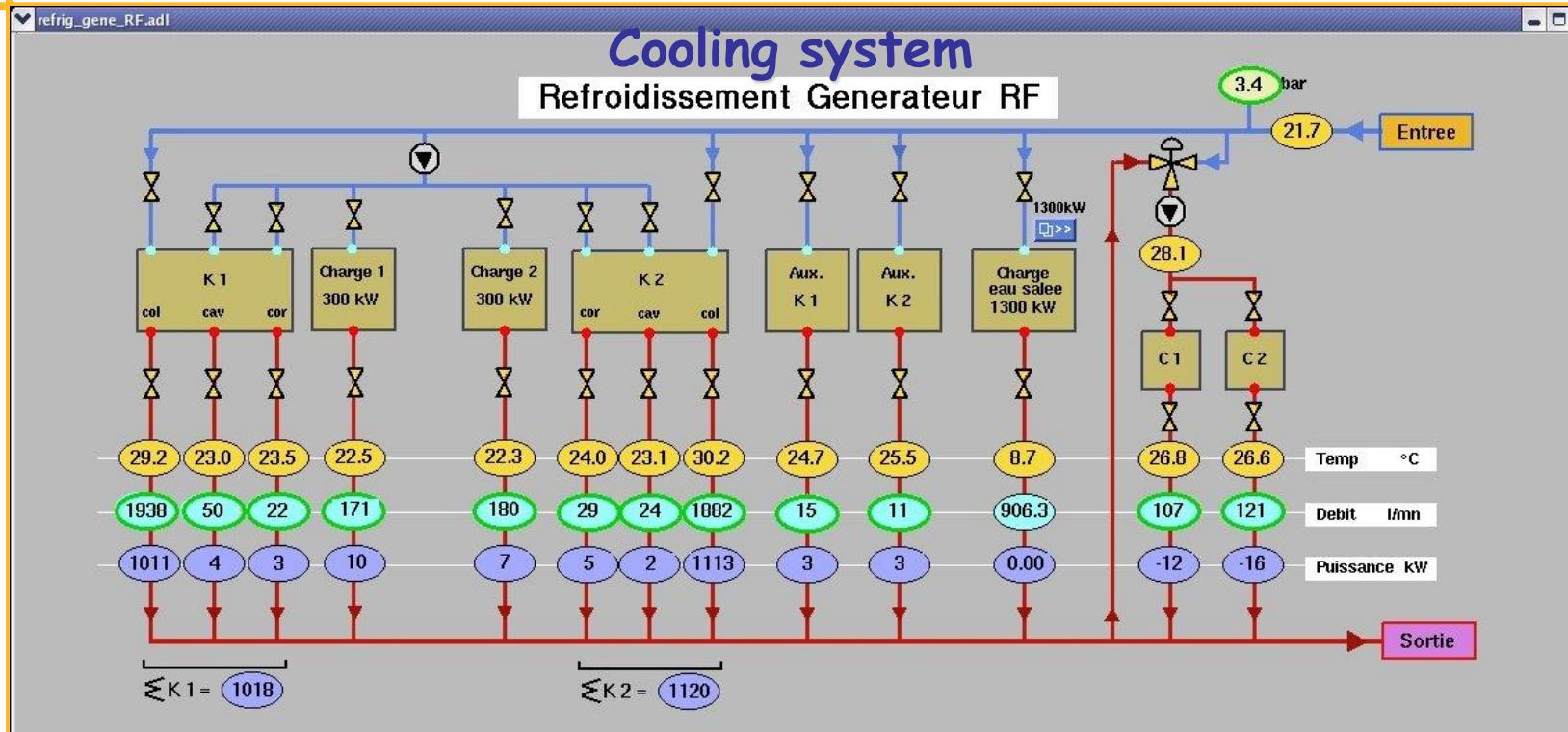


Focussing  
300V 15A

## RF regulation

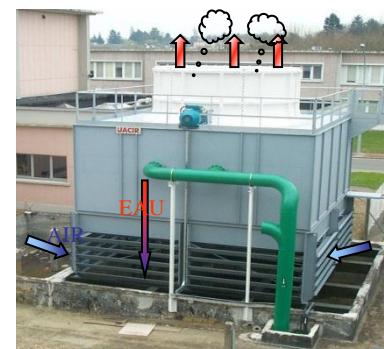


# RF source (8)



## GROUPES MOTOPOMPES

KSB Type : ETANORM C 100 - 200 C11 /  
ETANORM C 065 – 200 C11  
Puissance moteur : 45 kW / 22 kW  
Débit : 300 m³/h (2 RF circuits)  
100m³/h (charge à eau salée)  
Pression au refoulement: 4 Bars



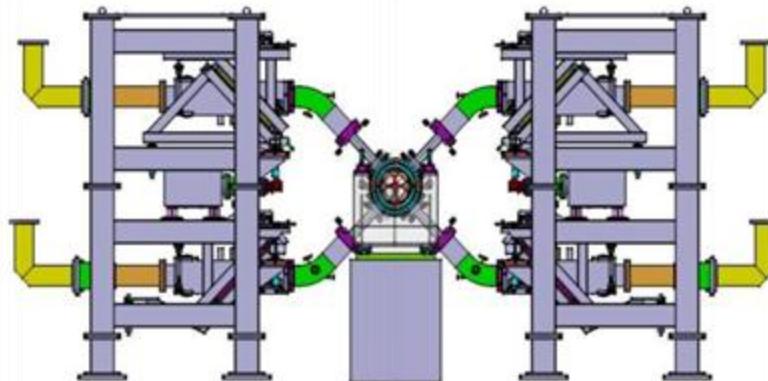
- Cooling Tower (power capability 8 MW)

## AEROREFRIGERANT

JACIR Type : KOMPACT Série : GM KA-3540-QK-750  
Puissance calorifique éliminée : 6 888 000 kcal/h = 8MW  
Débit d'eau : 640m³/h  
Refroidissement eau (HR : 45%, TH : 21°C, Tair : 30°C ) : 40 à 24 °C  
Evaporation : 11.2 m³/h  
Puissance absorbée moteur : 77/25 kW  
Vitesse de rotation ventilateur : 313/208 tr/mn  
Diamètre ventilateur : 3.66 m  
Niveau sonore à 20 m : 72 dBA env.

# RF source (9)

4 RF windows



Conditionning of RF windows

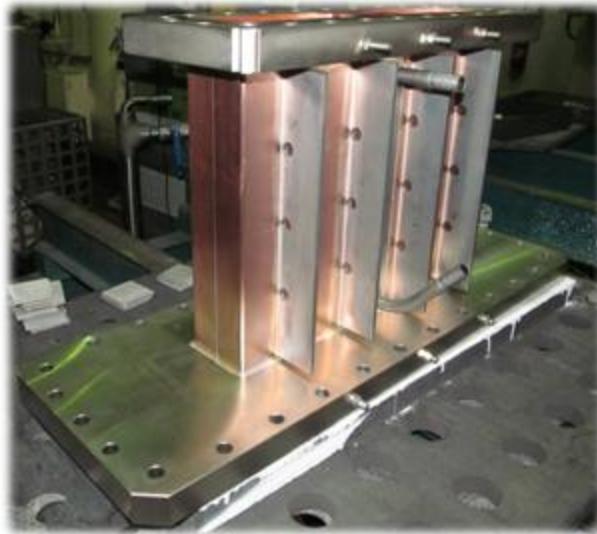
WG distribution to  
the RFQ (a)

Waveguides  
Circulators  
300 kW Water cooled loads  
1.3 MW Salted water cooled load  
for Klystron tests

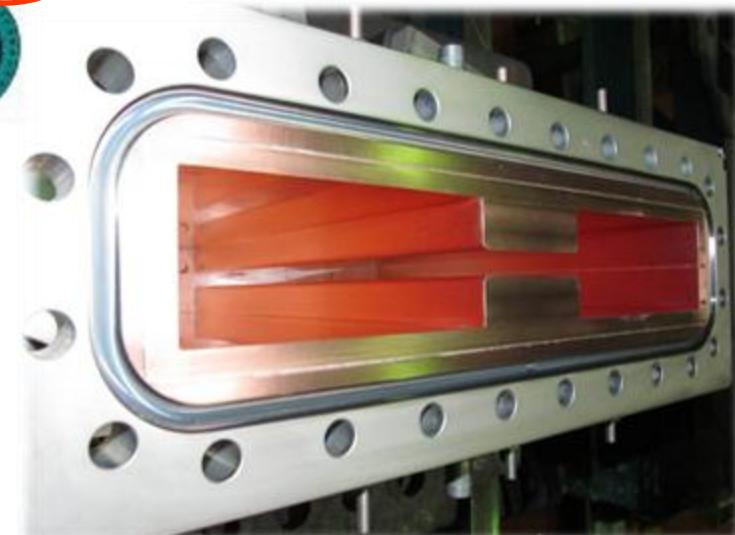
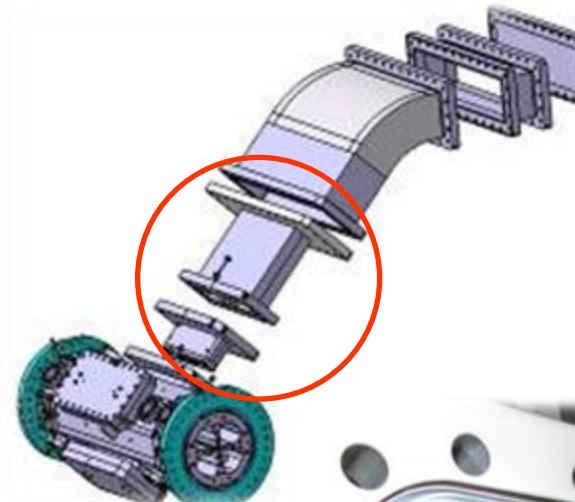


## RF source (10)

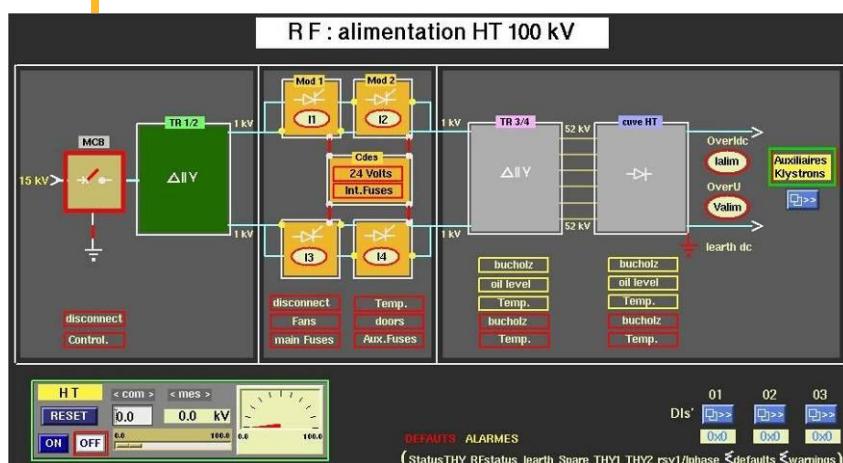
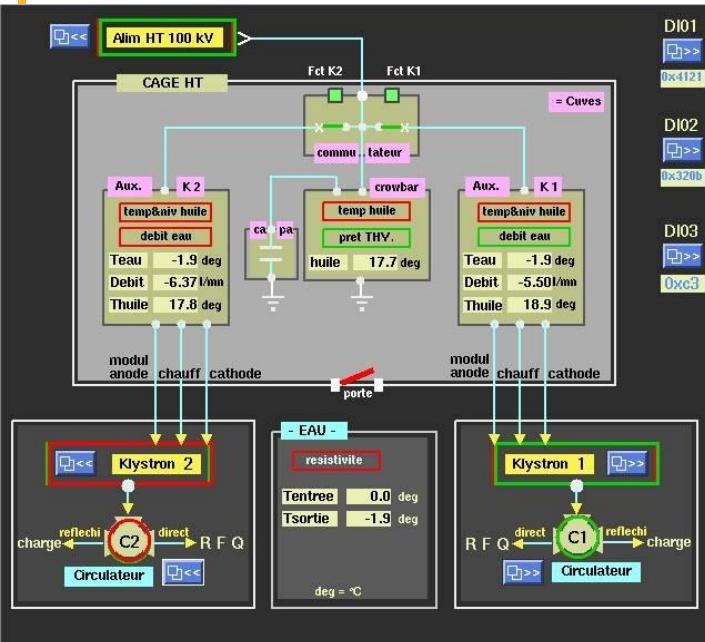
- Transitions  $\frac{1}{4}$  wave in CuC2



WG distribution  
to the RFQ (b)



# RFQ environment : remote control



- EPICS linked to different subsystems (CAN, GPIB, Field Point) has been chosen as control system,

- Industrial PLC (SIEMENS™):

- Source and LBE Vacuum,
- RFQ Vacuum,
- LHE Vacuum,
- Safety rules,

- Already working (SILHI/LBE, low level RF,...)

- New realization in progress (RFQ/LHE Vacuum, safety)

# TRASCO RFQ tests



RFQ tests

- Conditionning OK until 220kW CW
- X measurements at 80kV never exceed the noise level of the detectors
- To realize those tests, we used our analogical LLRF, this enable us to see the LLRF improvements to do

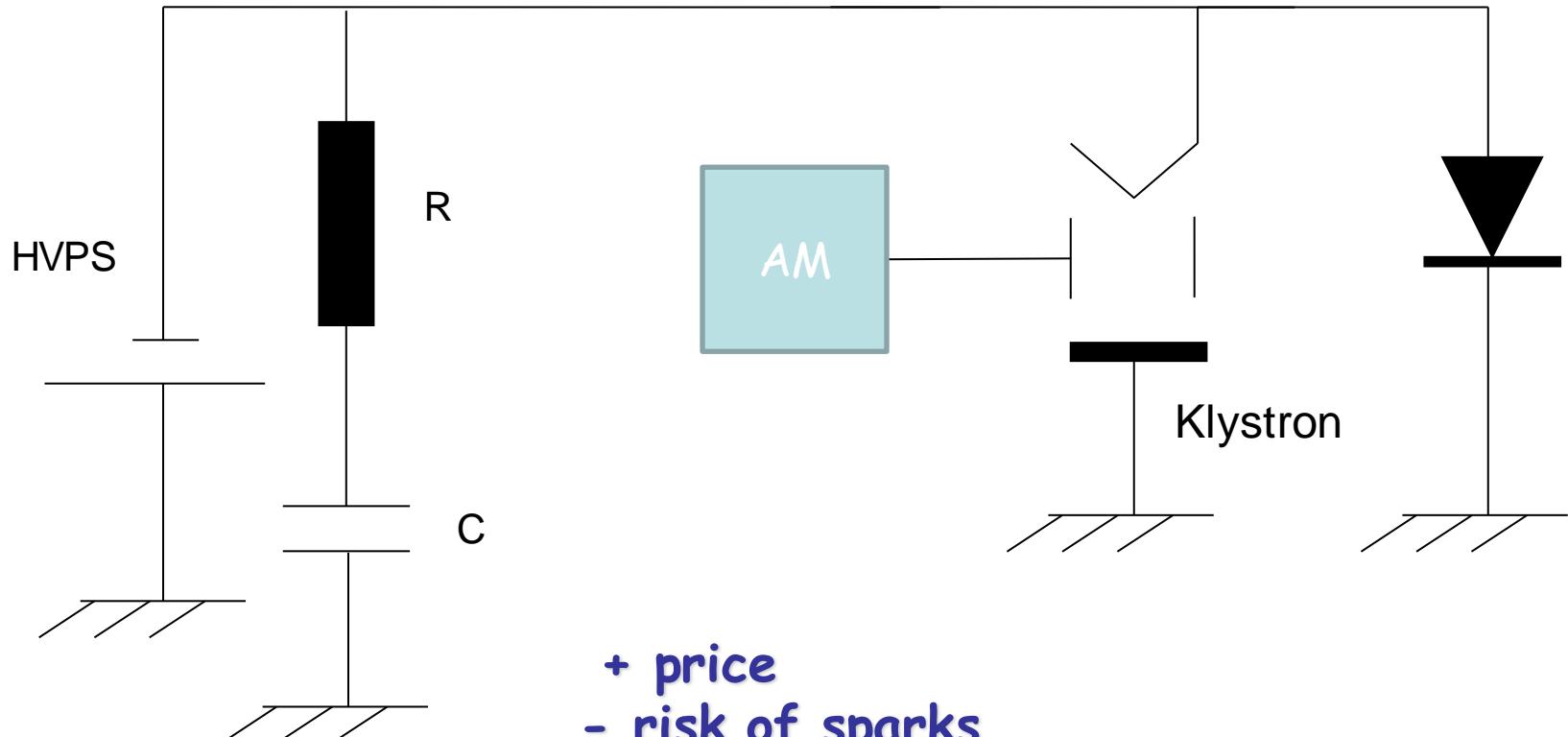


Test done on a separate cavity to allow conditionning of 2 couplers

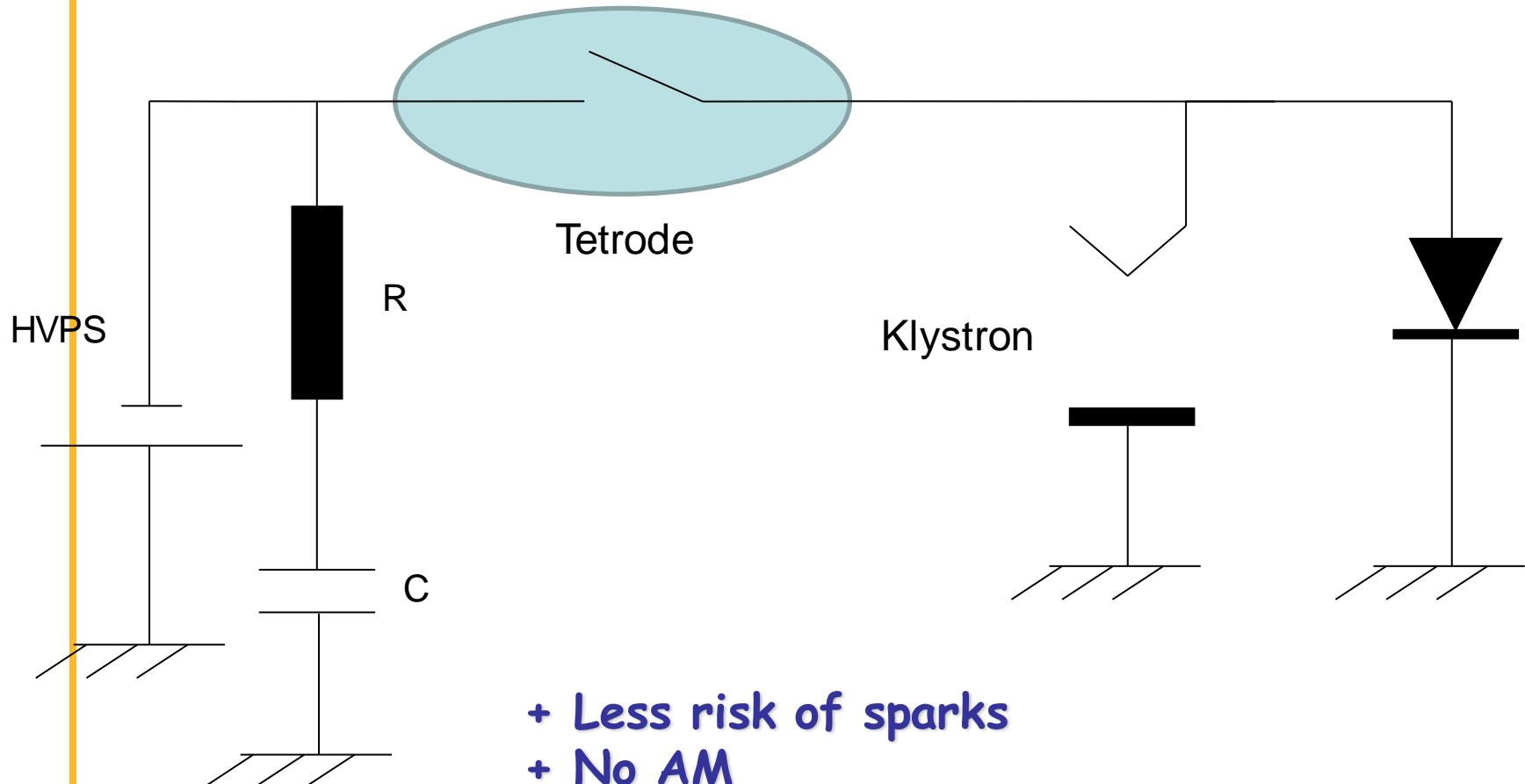
- Windows conditionning OK until 150kW peak at 75% of duty cycle
- Windows conditionning OK until 120kW CW

# Prospects (1)

## Anode Modulation re-designed for pulsed mode



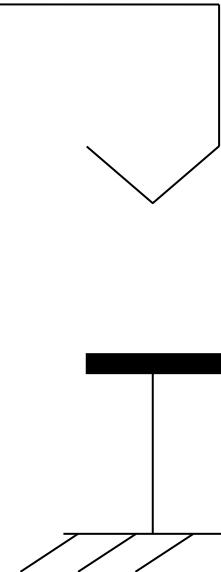
# Prospects (2)



## Prospects (3)

Pulsed  
SS  
HVPS

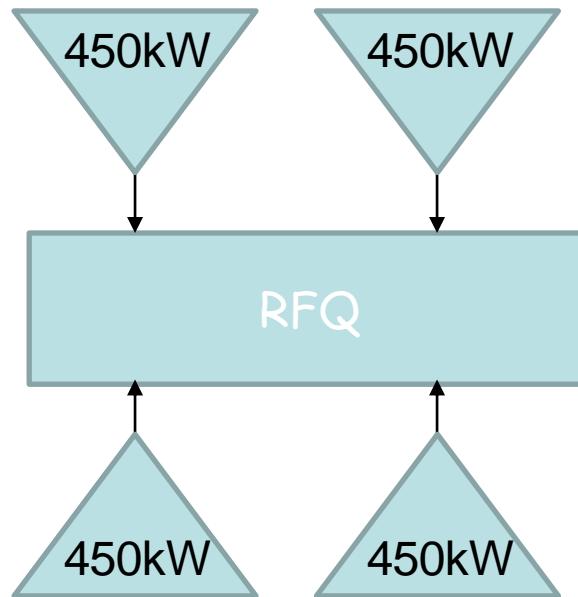
Klystron



- Price
- + efficiency
- + availability

## Prospects (4)

**SSA**



- + better reliability
- + No HV
- + Pulse mode/CW ability
- Price
- Size
- LLRF

# Conclusion

The installation IPHI (will) provide:

IPHI beam (CW or pulsed)

3 MeV - 100 mA: 300 kW

RF power of the platform IPHI

352 MHz up to 2 MW CW, need to be improved for pulsed operation and better reliability

A facility for high intensity accelerators and for ADS

## Acknowledgements

- To the whole IPHI team and particularly to Michel DESMONS, Raphaël GOBIN, Jean-Luc JANNIN, Francis BALLESTER, Bruno POTTIN and Gilles BOURDELLE
  
- To the CWRF and BNL organizers

# Thank you!

