SPIRAL II HIGH INTENSITY RADIO FREQUENCY COOLER

a.k.a. SHIRaC

STATUS REPORT
SHIRAC COLLABORATION

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OUTLINE

• DESIR@SII

• Why/how cooling?

• Status and recent results

• 2010

• Conclusion
Why & How Cooling the beam?

COOLER and HRS are « part » of SPIRALII Phase II and included in the production building.
WHY & HOW COOLING the beam?

• Requirements for High Resolution Spectrometer (HRS):
  low emittance to reach best performances

  HRS needs ~1 \( \pi \) mm mrad
  Ion source (ECS) ~ few 10 \( \pi \) mm mrad

• BUFFER GAS TECHNIQUE + RF for beam guiding
  (R.B. Moore O. Gianfrancesco NIM B 204 203) Many running around the world

• The new challenge: Cooling of high intensity beams (\( \mu A \))
  with high transmission
Beam emittance and resolving power

Calculation by T. Kurtukian Nieto
(With OLD HRS configuration)

\[ R \approx 22000 \quad \text{and} \quad R \approx 14400 \]
Work achieved in 2009-2010

- Last tests on the modified prototype I (transmission & emittance measurements)
- Manufacturing of New Cooler
- Improved RF system
- Slow control
- New Cooler set up at LPC
- Since SII week set up at LPC, new design for breakdowns, simulations for coupling with HRS
Last Tests with SHIRAC I (PhD Thesis F. Duval 2009)

Alkali Ion gun 3keV  
I = 25 nA  
RF: 1800 Vpp @5MHz  
He : 0.5 Pa  
HT = 2900V

- very promising results (to be confirmed with prototype II and higher intensity)  
- good agreement with simulations (space charge & Microscopic approach)  
- simulations show that the transmission is limited by the acceptance ($r_0$)

$\varepsilon = 2 \pi \text{mm mrad} @ 60 \text{ keV}$  
$\Delta E = 0.145 \text{ eV}$  
Transmission = 25%
New cooler manufacturing and assembling (end 2009)

Simulated with SC & Microscopic approach

→ Requirements: 700 mm long
    R₀=5 mm
    10 MHz RF
    10 kV<sub>ptp</sub>
RF system layout

- Resonance Frequency tunable via adjustable capacitor
- No ferrite cores for the inductive coupling with amplifier
- DC potentials for the segments guided inside the coils (no HV filters)
- Asymmetries compensated mechanically by translation of middle point

\[ L_{tot} \sim 6\mu H \ @ \ 1MHz \]
\[ R_{tot} \sim 0.03 \ \text{Ohms} \]
\[ Q \sim 10^3 \ @ \ 1MHz \]
High Voltage RF Developments

- Resonant circuit with Inductive coupling (no ferrite cores)
- Tunable capacitor for broadband use
- 500 W amplifier
- 2 loops
RF performances and limitations

- 9 MHz 5.8 KV 2 loops secondary
- 6.5 MHz 8 KV 5 loops secondary
- Highly Harmonic

Present limitations:
→ INSULATOR Breakdown at ~8 kV...

Investigations underway → improved design and new materials needed (PEEK)
Insulator burning VRF~8 kV

New design larger gap/frame for higher HV
Open frame for better RF coupling
Very few data in this range of RF voltage
Other material PEEK (Poly Ether Ether Kepone) will be tested
Slow Control (vacuum system, RF, DC, gas...)
To be done...
  • Completed in July 2010
  • Test with high intensity beams soon
other studies

Because of gas flow Extraction and Injection region are critical. Simulations show that under $10^{-4}$ mbar T>65%
Additional pumping and by passes added in these regions to decrease gas diffusion

For $5 \times 10^{-2}$ mbar in the cooler injection and extraction ~$5 \times 10^{-5}$ mbar

Coupling with HRS Simulations of EINZEL lens located at 1 m from the extraction
Different designs give parralell or focused beam 1 m away

Work underway...
Nuclear environment

Cooler should be the most irradiating part in the yellow zone

Mechanical design for confinement
→ double valve OK
→ anti sismic frame OK

Maintenance: minimize part failure, internal electronics simplification
Segmented rod → one single resistive rod?

Gas: recycling Helium?

Two identical coolers?
Work on a 1st prototype
Emittance within requirements
Transmission (25%) limited by acceptance

- RF system ~ OK, higher HV and RF requires new design and new materials
- Construction of SHIRaC, mechanics, slow control, vacuum system, safety, RF system...

- Setup completed in JULY 2010
- Couplings with HRS underway
- Cooling of μA beams For HRS requirements to be confirmed in 2010-2011
- Nuclear environment
THANK YOU FOR YOUR ATTENTION