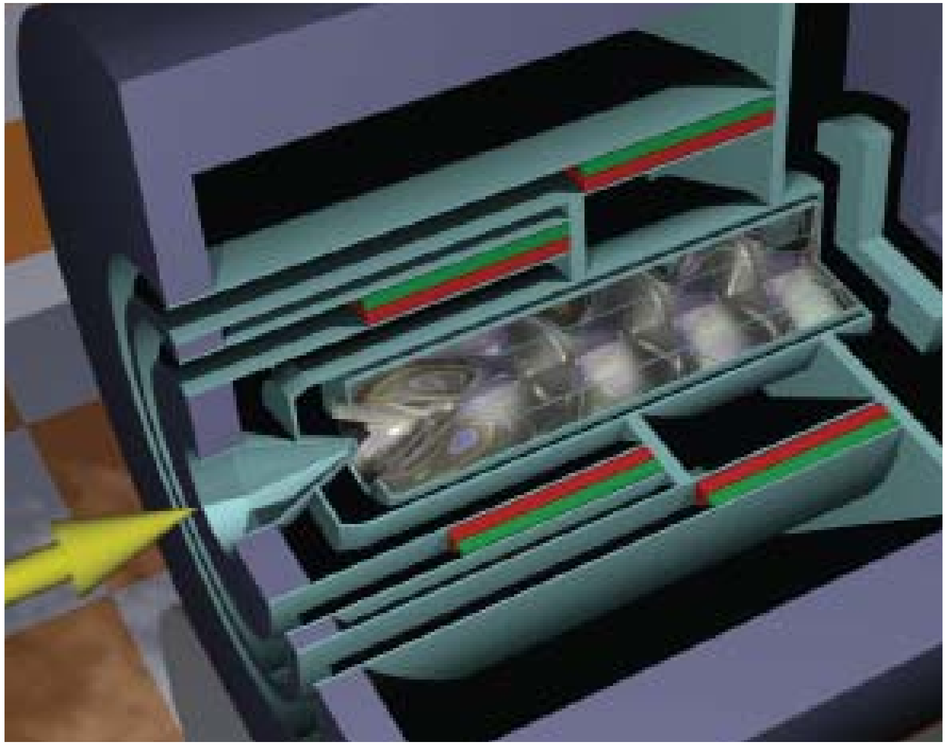
Studies for Developing the MW-station Ion Source

A compact and efficient design to get 10^{15} fissions/s



* Cylindrical liquid Hg converter (~10 l.)
* Surrounding annular fission target (~5 l.)

The annular fission target split up in 8 independent fission targets

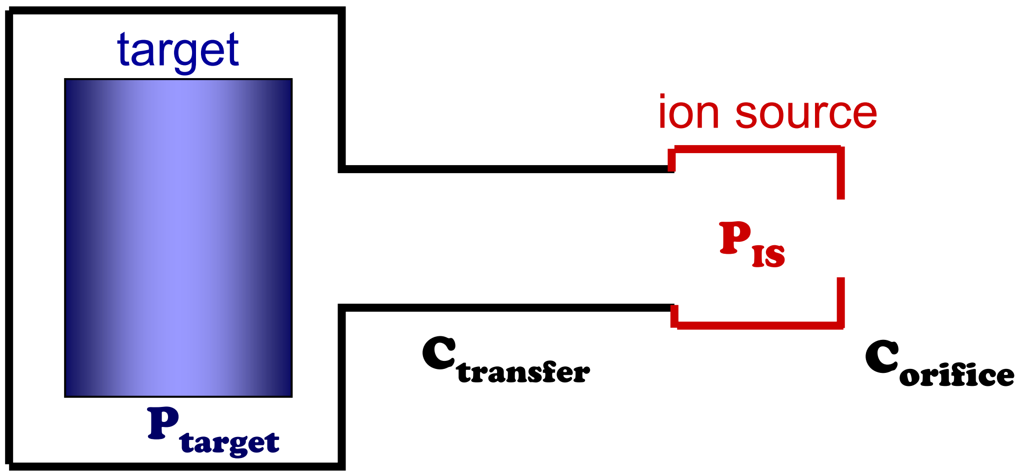
* 8 x 1,6 kg of Uranium
* standard UC_X (3 g/cm^3 of U).

Overall issues

- How to connect ion source to such a target system?
  - Multiple ion sources? Acceptable for the design of radioactive beam line?
  - Multiple transfer lines? Cf. Thierry STORA's presentation.

- What kind of ion source?
  - Capable of operating under the vapour from the bulky target.
  - Capable of withstanding the level of radiation generated close to the target.

Basic scheme



[UC_2 @ 2000 °C] ~10^{-5} mbar

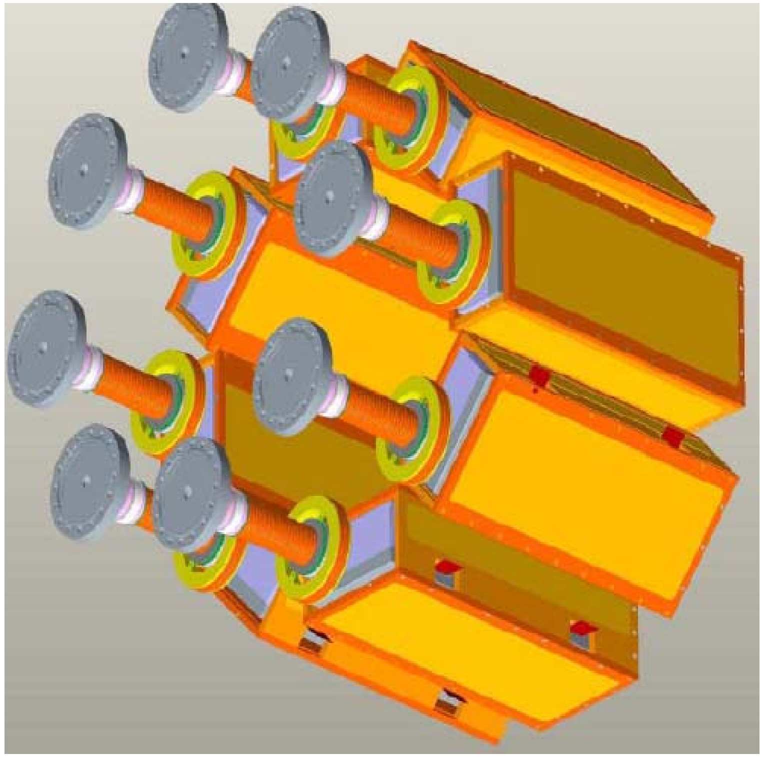
$Q = C \times \Delta P$ with **C** order of 1 l/s. (molecular flow)

~10^{-6} < P_{IS} < ~10^{-5} mbar → Q_{out} < ~10^{-5} mbar.l/s (negligible)

→ $P_{IS} \sim P_{target}$

If no specific device on transfer line, most target out-gassing goes into the ion source.

Vapour from the fission target



Considering a piece of 1/8 target
(1,6 kg of $^{nat.}U$):

- Overall radioactive nuclei production

  ~10^{16} nuclei/s in target; if 10% released

  → ~10^{15} nuclei/s ⇔ ~10^{-4} mbar.l/s

- Stable out-gassing

  UC_2 out-gassing is dominant (x100 larger than Ta out-gassing);

  Target surface at least x10 wider than standard

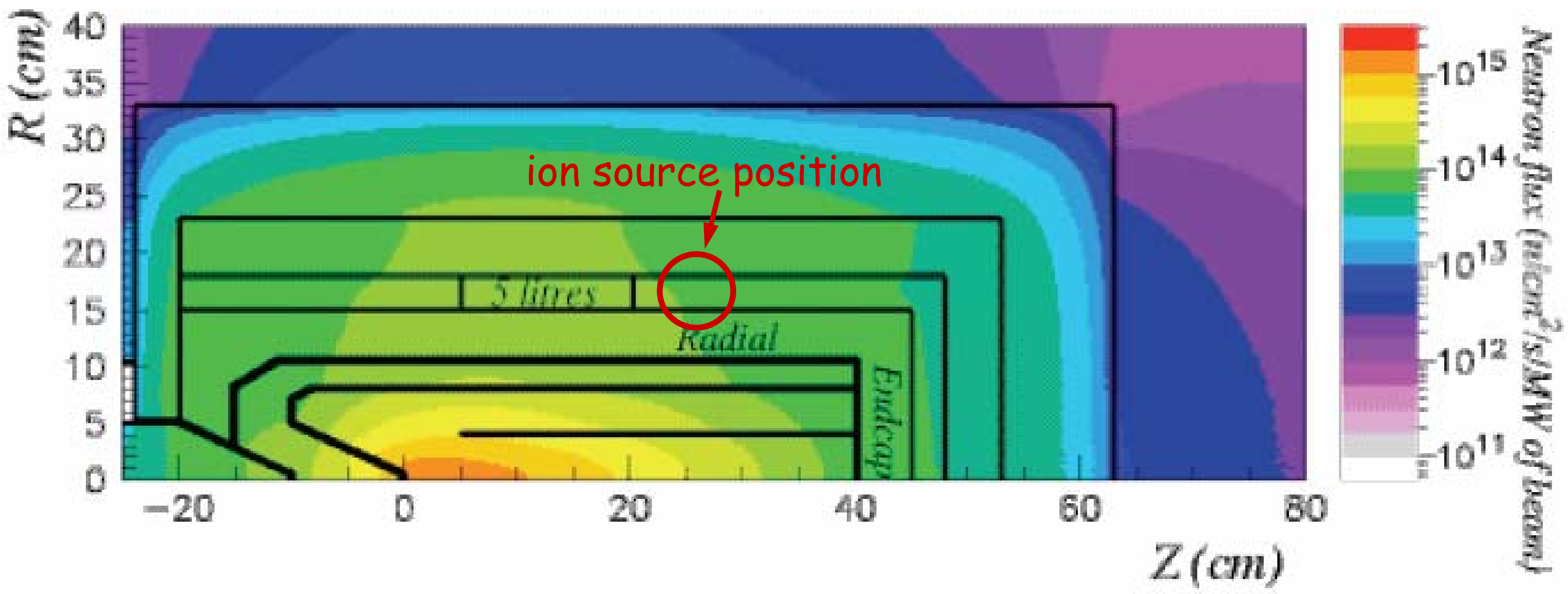
  → > 10^{-1} mbar.l/s (equilibrium) only a part reaches the ion source.

What kind of ion source?

- Target out-gassing surface is a few x10 wider than standard

→ **for efficient ion sources** (ε_{ion} ~ 1%): total extracted beam ~mA

- Ion source close to the target → 10^{14} neutrons/cm^2/MW of beam



A. Herrera-Martinez et al.

What about ECRIS?

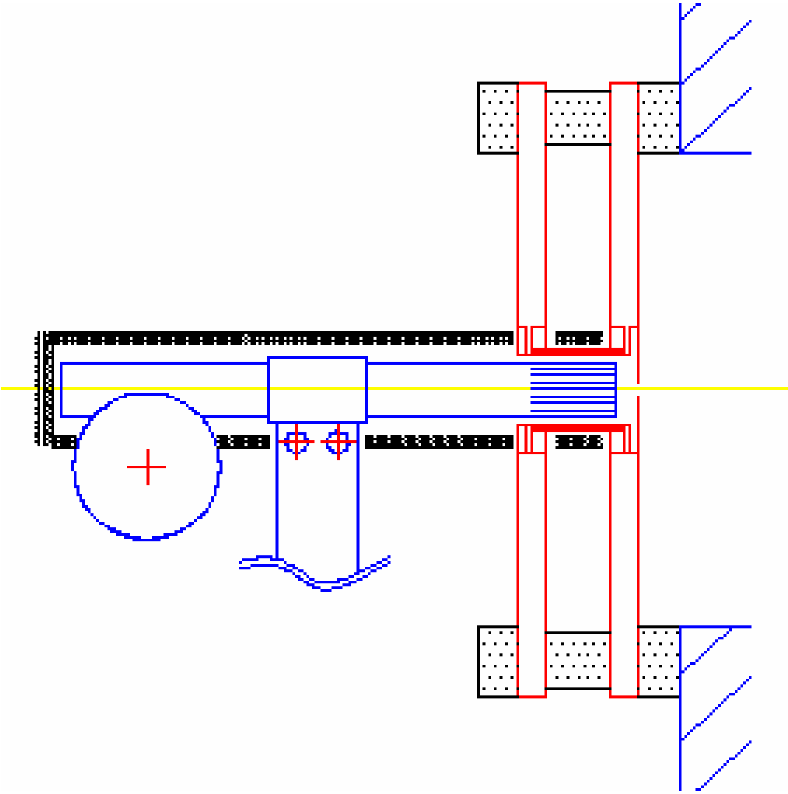
- OK for operating with such out-gassing conditions
- Possibility of transfer-line cooling to reduce metal vapours
- RF injection issue
- Radiation damage of magnetic confinement system:
  - Possibility of using coils instead of permanent magnets
  - Radiation damage of insulators? *e.g.* glass fibres ~10 MGy

Such studies are in progress for SPIRAL-2...

FEBIAD-type Ion Source?

- Not dedicated for operating with high vapour flow:
  - Standard FEBIAD operate up to 10^{-3} mbar.l/s
  - EBGP (radial type, by J.M. Nitschke) up to 10^{-4} mbar.l/s
- Nielsen and Nier-Bernas ion sources can operate:
  - e.g. beams of a few mA with an emittance of 20 π.mm.mrad @ 40 kV.
  - **But quick wearing of the cathode.**
- Radiation damage of the refractory insulators
  - {cathode/anode} → need of refractory insulators close to ionization chamber.

→ IRENA prototype



IRENA prototype based on EBGP (Nitschke, LBL 1985).

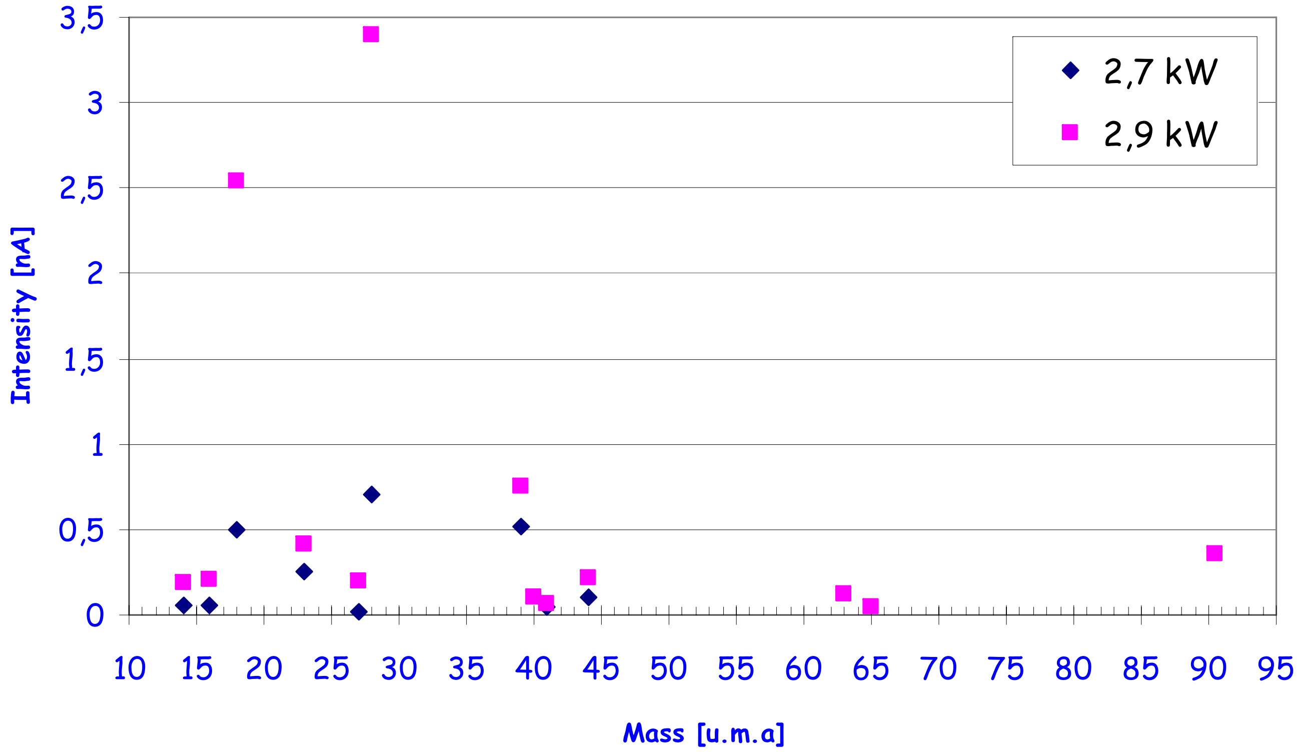
Main features:

- **Minimum of components (no magnet!)**
- **Insulators away from the ion. chamber**
- **Radial cathode more reliable**

Cathode Design

- ↘ hazard of cathode/anode short
- ↘ residual pressure in chamber
- strong e- emisssion required

IRENA 1st prototype: First results (1)

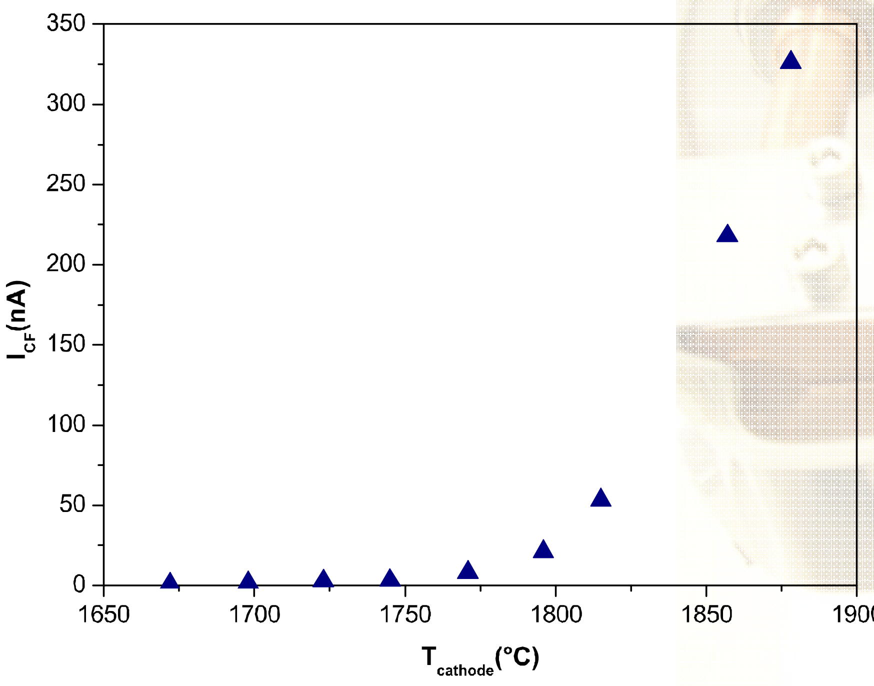


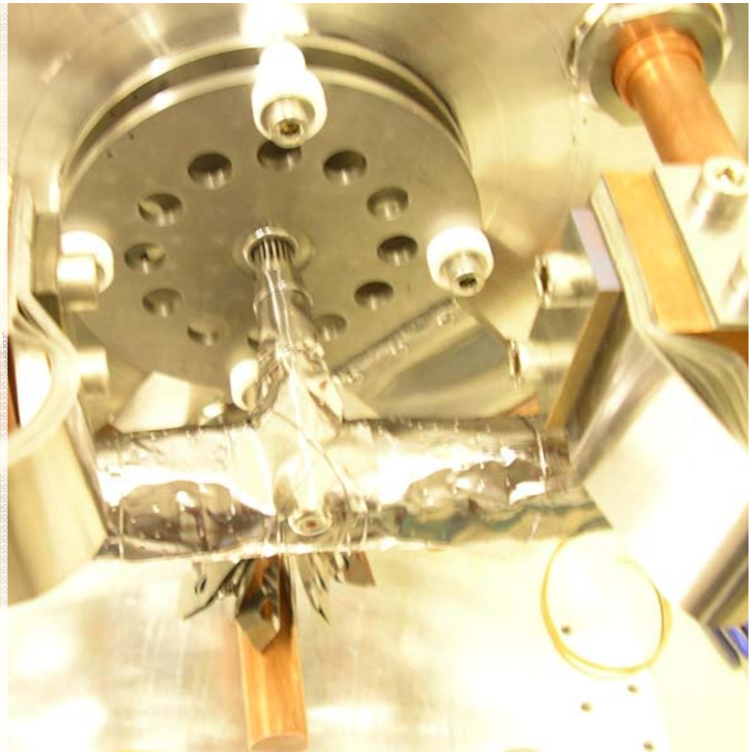
Optimal conditions not yet reached: ionization efficiency (Kr): 0.03 % @ 2.10^{-5} mbar.

Tests interrupted in March 06; to be pursued with a prototype supplied by NIPNE.

IRENA 1st prototype: First results (2)

Total beam extracted @ 10^{-5} mbar as function of cathode heating.

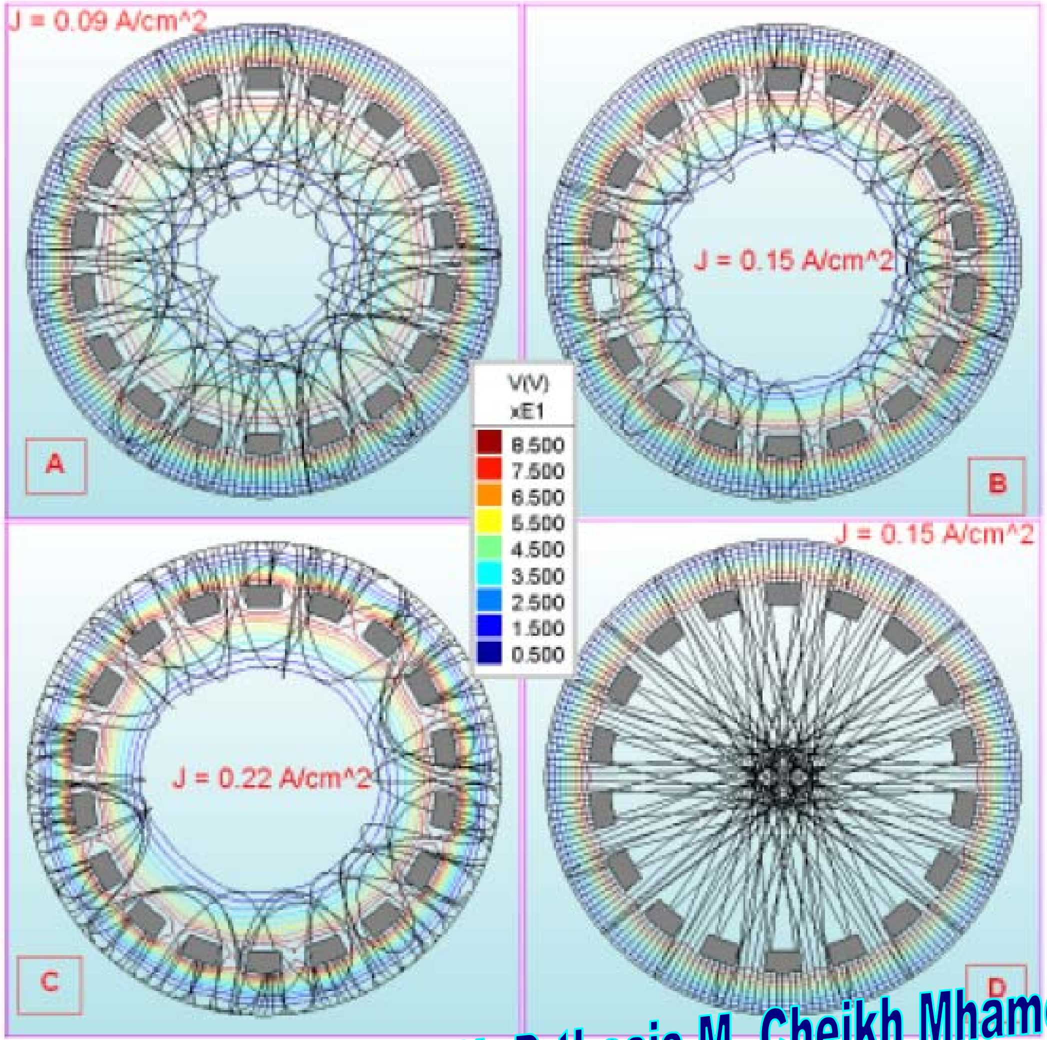




Total beam intensity comparable to EBGP (~µA) expected by 2000 °C within these operation conditions.

Christophe Lau et al.

Optimizing IRENA design



Ph.D thesis M. Cheikh Mhamed

Increasing e- emission by 10^3 to get a prototype working with MW-target out-gassing.

→ Another cathode material or cathode surface x10^3

(the ionization chamber may reach the typical size of **ECRIS**)

Further studies using IES Lorentz code planned in 2007.

What about RILIS?

- High pressure in the hot cavity

    → Larger production of non-selected positive ions

    → Deterioration of the plasma conditions in the cavity

- Possible remedy

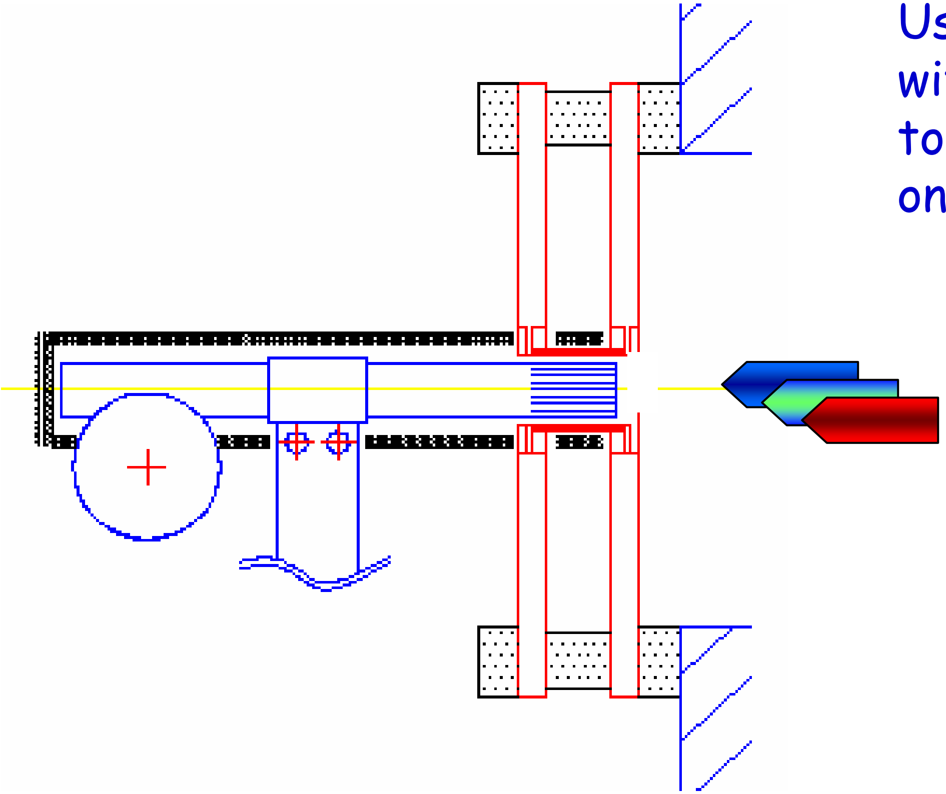
    - Increasing cavity diameter (keeping $\varnothing/L^2 \sim$ constant)

        → larger conductance and larger surface for increasing e- emission.

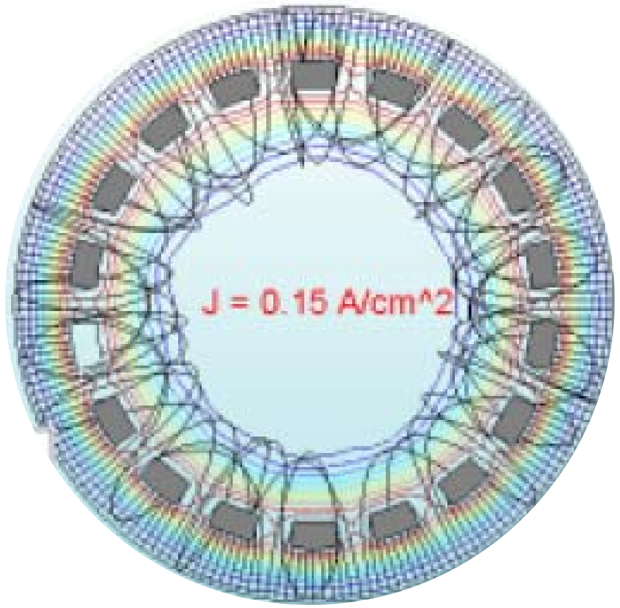
    - Changing cavity material to increase e- emission.

    - Or…

a plasma confinement structure



Using IRENA radial structure
with low voltage
to generate lots of radial electrons
only for confinement



Resume

- Important to minimize target size as much as possible

  Cf. also D. Ridika's poster

- To get beams from Multi-MW target, many aspects have to be considered: specification on transfer tube, beam extraction, beam contamination etc.

- Some possibilities for developing MW-station ion sources but requires important R&D works → need for support

Acknowledgment:

Many thanks to all collaborators, special thanks to R. Catherall, V. Fedoseev, A. Herrera-Martinez, Y. Kadi, J. Lettry, D. Ridikas, T. Stora, F. Wenander)