European Organization for Nuclear Research
Beams Department | Accelerators & Beams Physics

BNL-type source
&
Cesium laboratory

Linac4 ISWP review

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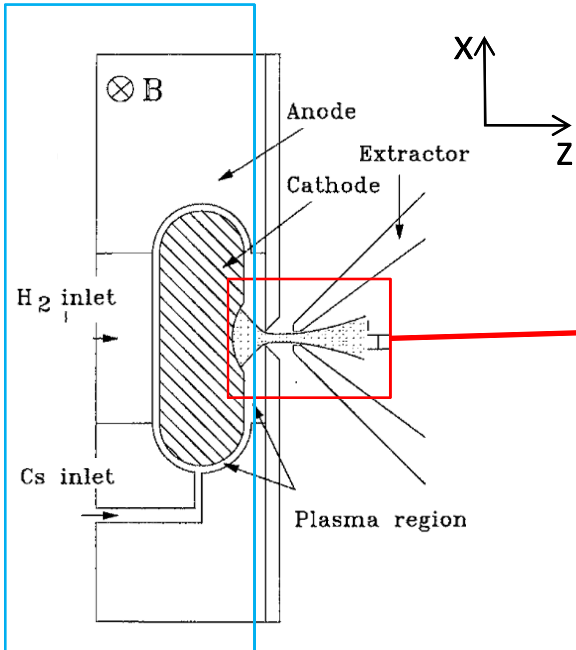
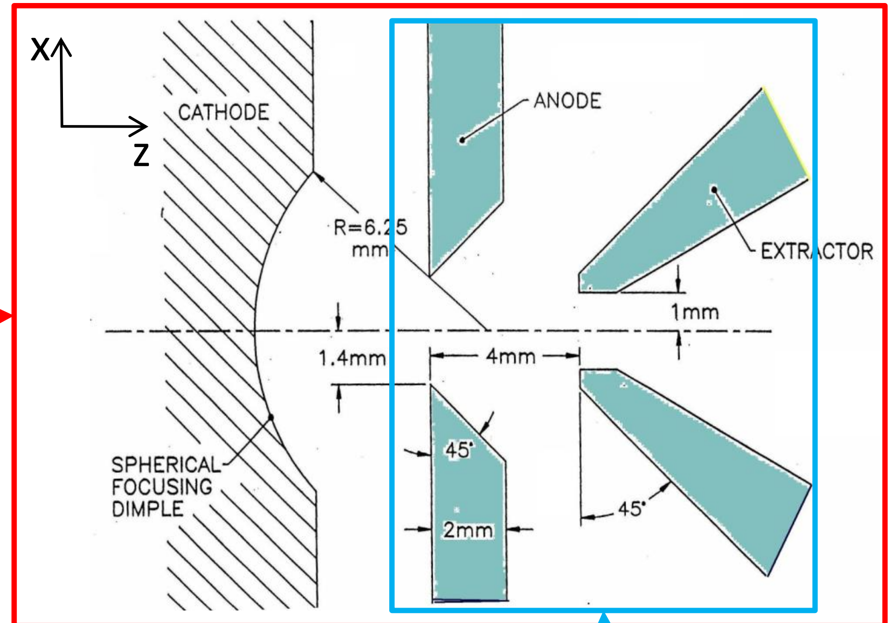
on behalf of the Linac 4 Ion Source team

June 7th, 2011

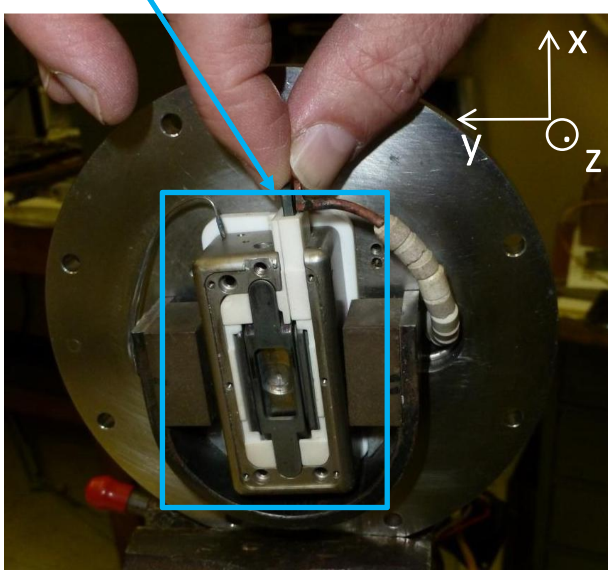
Contents

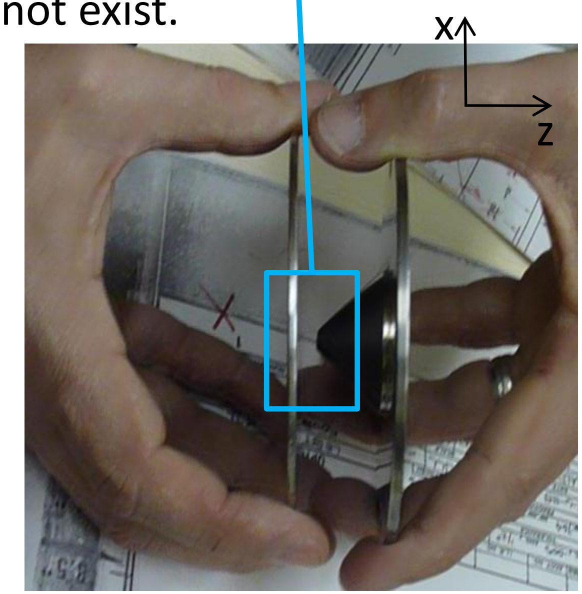
1. BNL source extraction





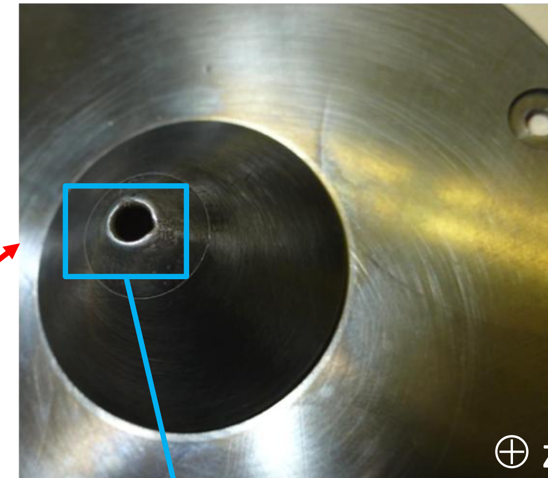
e^- dump does not exist.

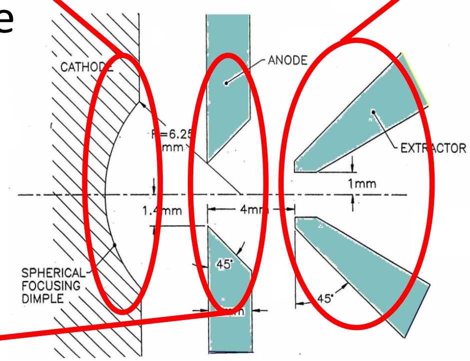




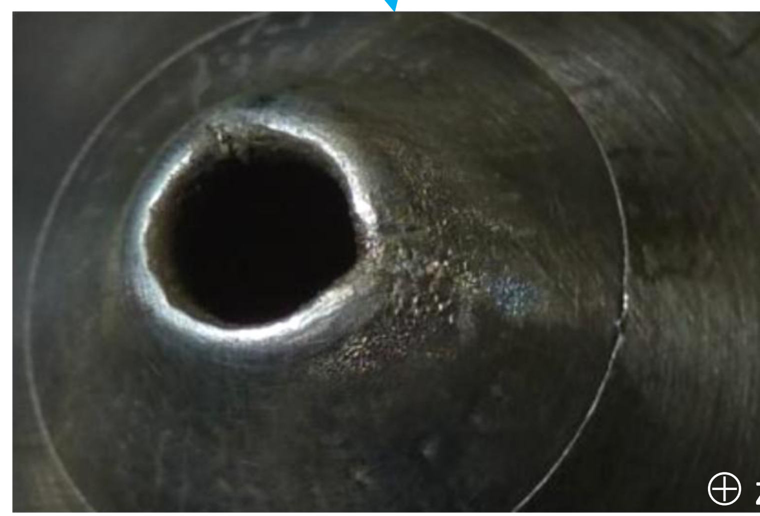
1.1. Extraction observations

Molybdenum cathode damage





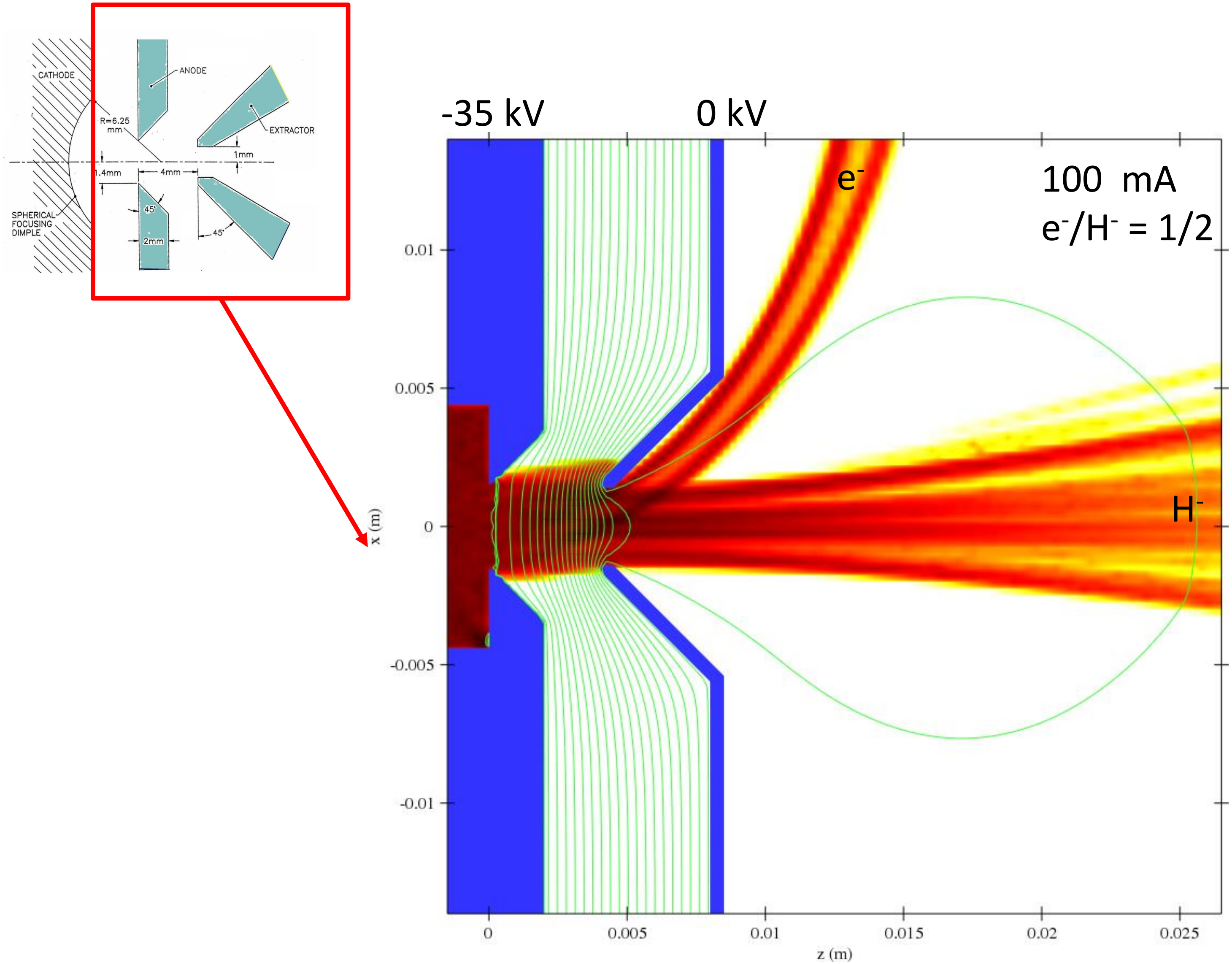
Anode damage



Tungsten puller electrode damage

⇒ **Visible damage does not compromise operation of the source.**

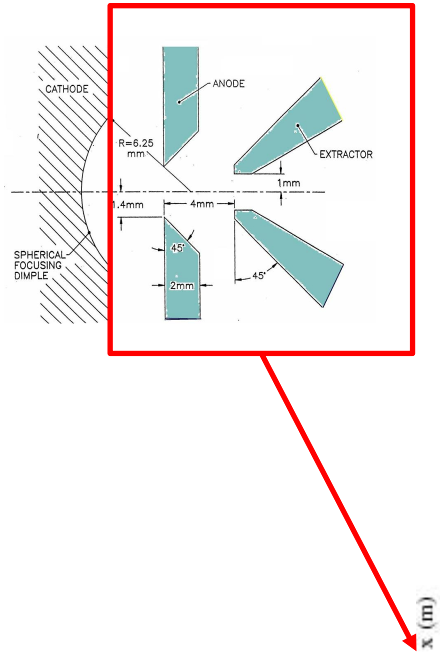
1.2. Extraction simulation at 35 kV

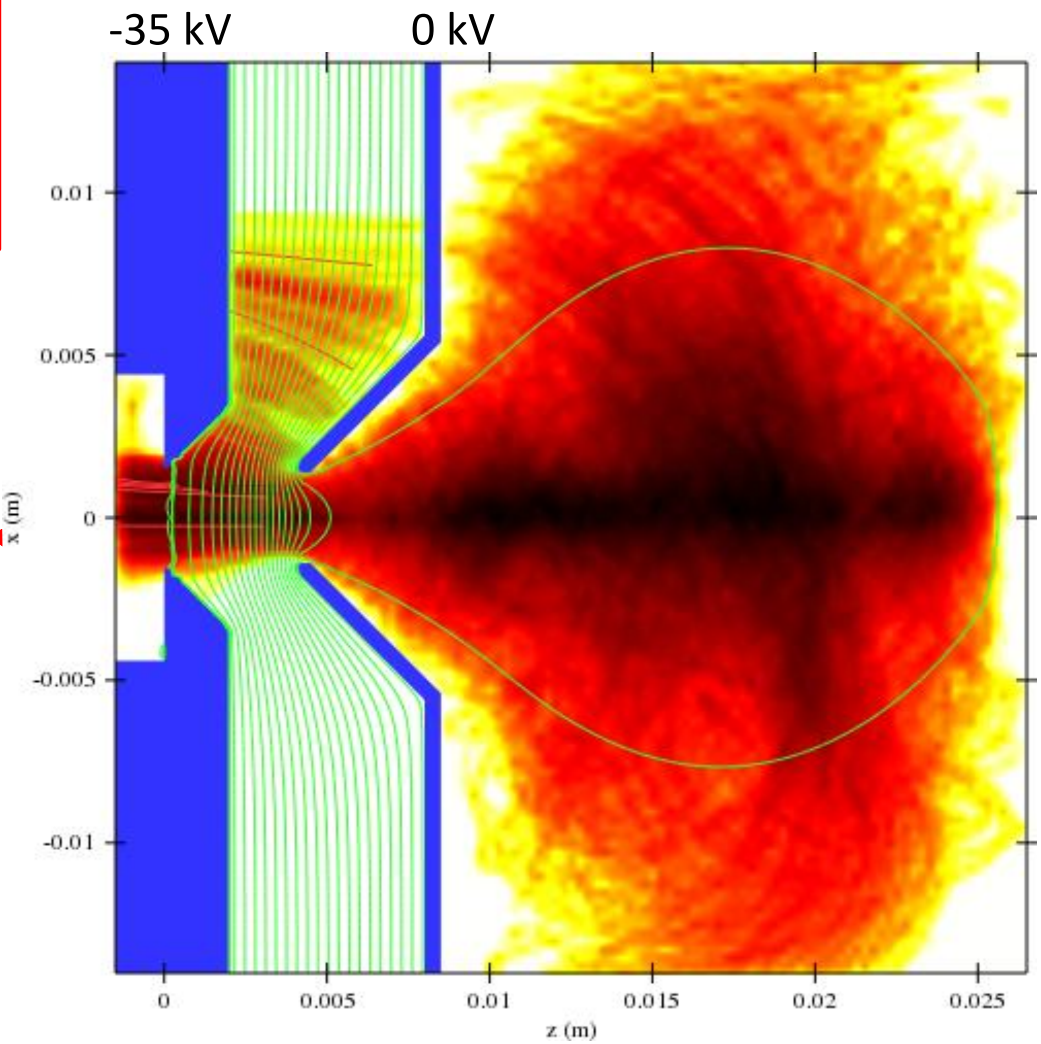


⇒ Simulation shows e^- partially dumped on the puller electrode.

1.3. Extraction simulation - positive ions

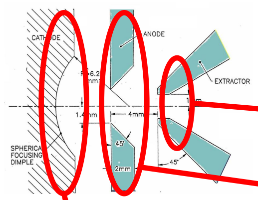
⇒ Positive ions are created from induced ionization of Cs atoms and rest gas.

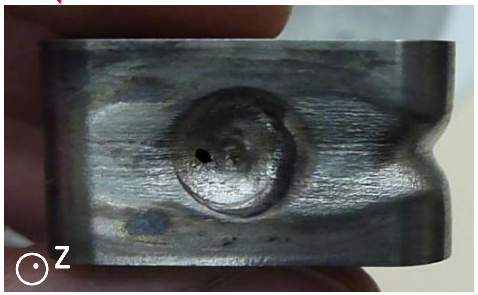




⇒ Simulation shows positive ions partially dumped on the cathode and anode.

1.4. Power density plots at 35 kV

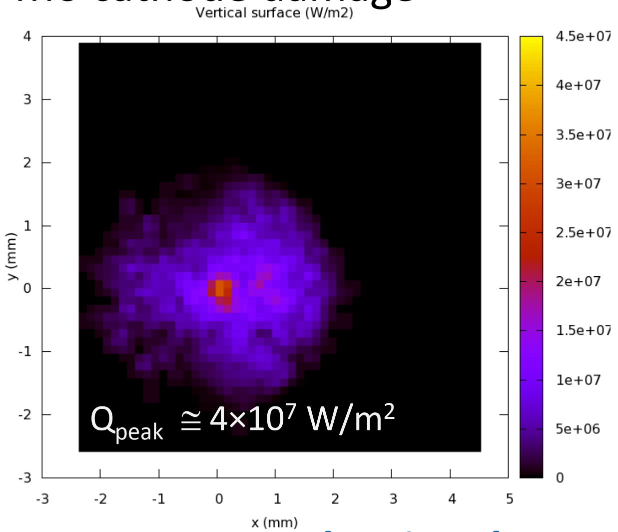


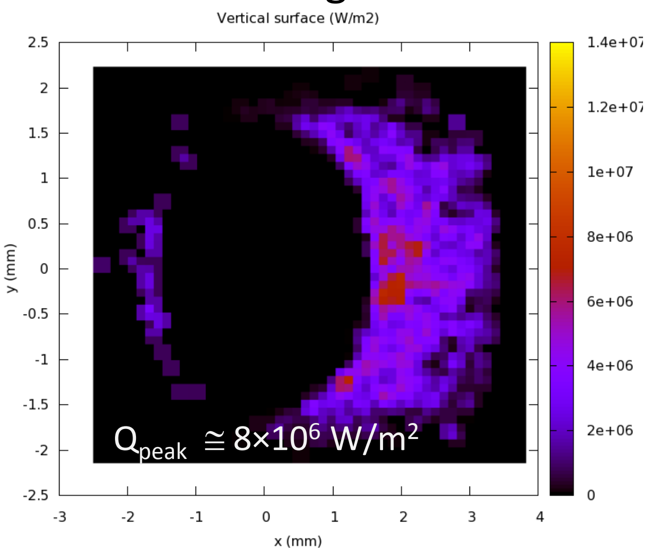


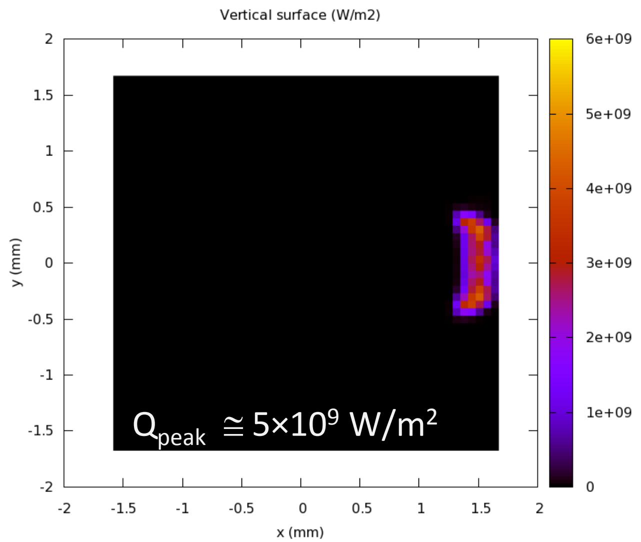
Mo cathode damage

Anode damage

W puller electrode damage

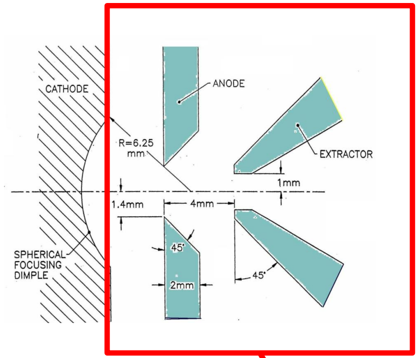


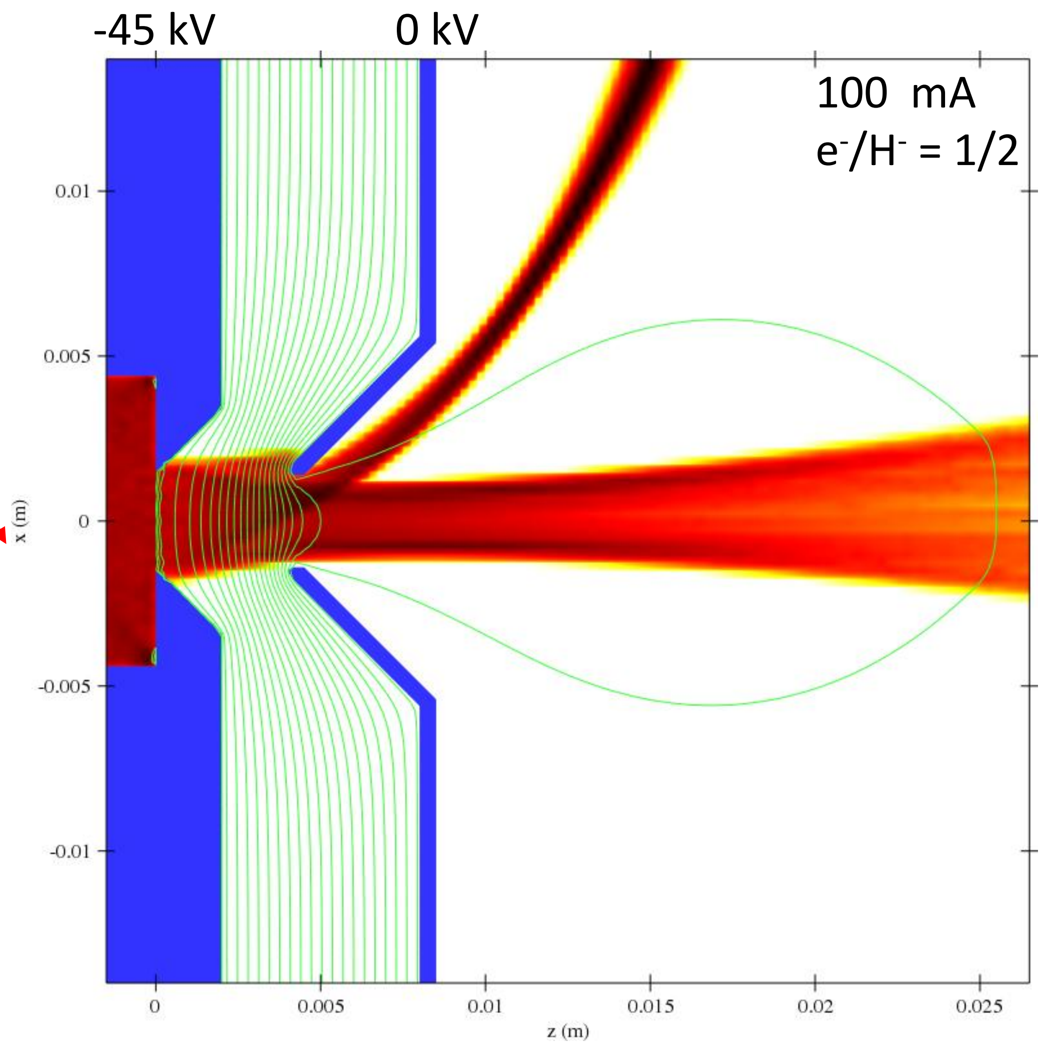




- ⇒ **Power density plots match the damage to the cathode, anode and puller electrode.**
- ⇒ **Sputtering will be studied.**
- ⇒ **Operation at 45 kV must be understood (are the same effects observed?).**

1.5. Extraction at 45 kV



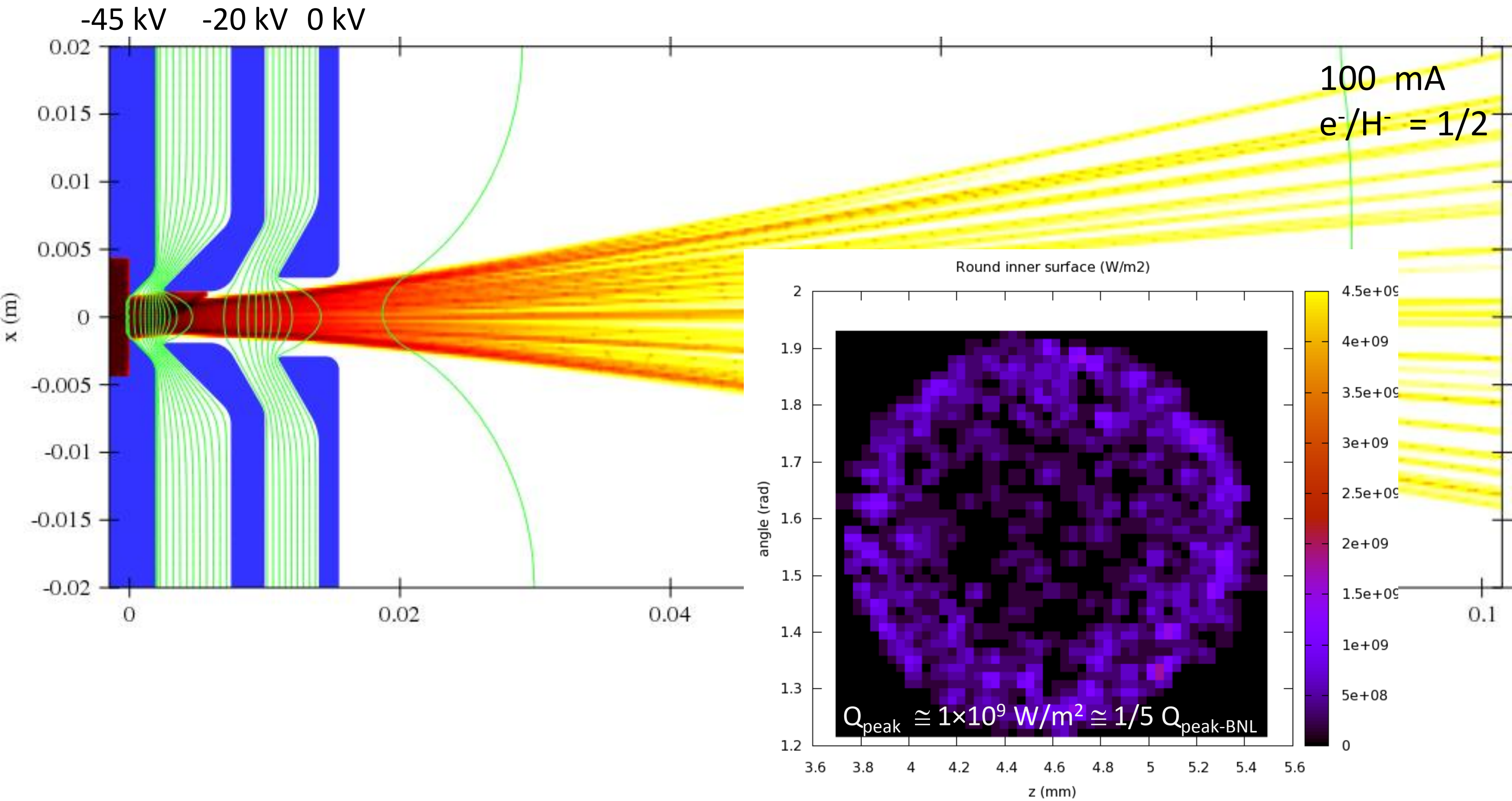


⇒ **At 45 kV the e^- are dumped on puller similar to the BNL case at 35 kV.**

⇒ **Same effects are expect, but further studies must be made.**

2.1 e^- dumping

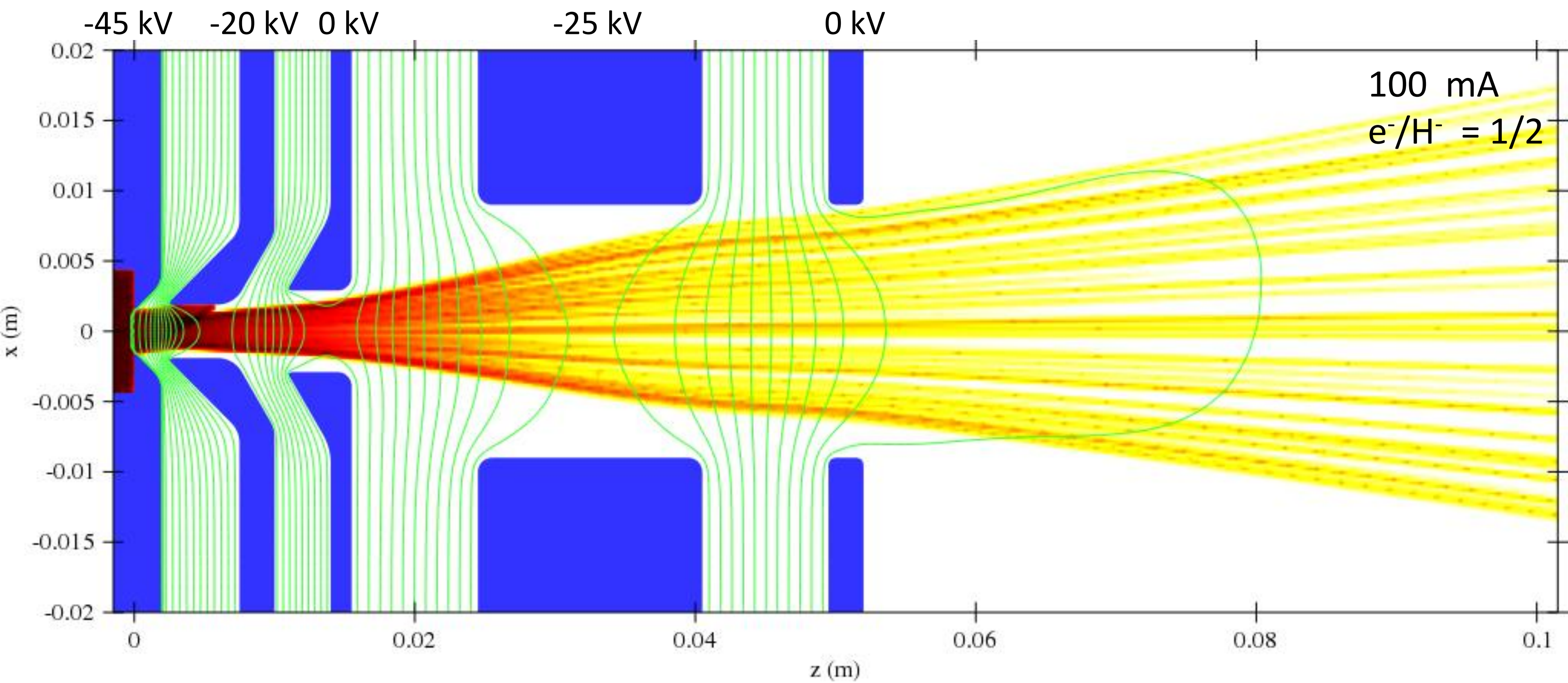
⇒ Insert dump electrode at a lower potential before puller.



⇒ **e^- are totally dumped on first electrode (damage still exists, further optimization required).**

⇒ **production of secondary e^- must be studied.**

2.2. Einzel lens



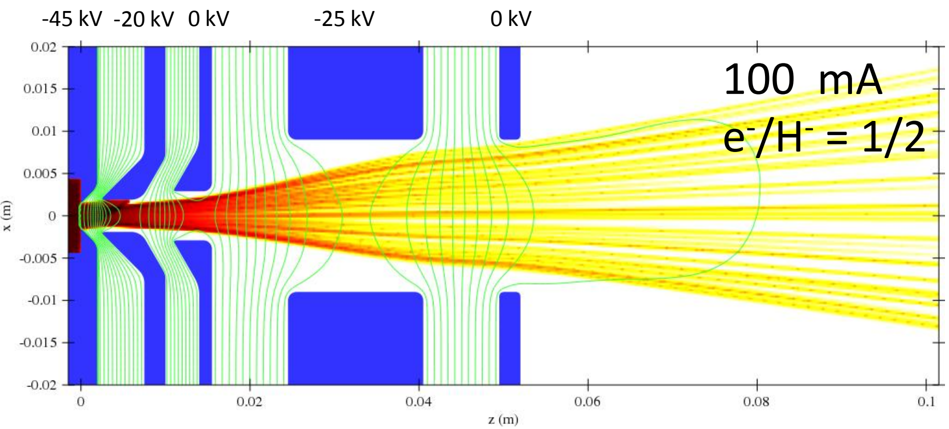
$\varepsilon_{xxLens} = .89\ \varepsilon_{xxNoLens}$

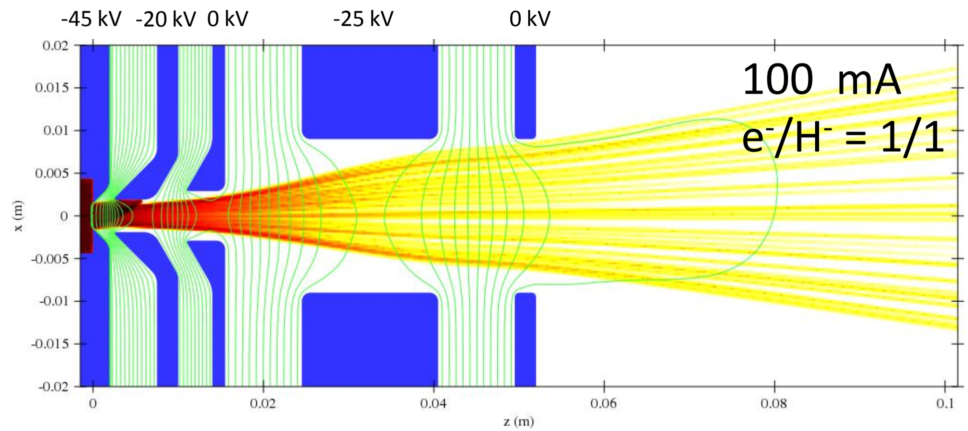
$\varepsilon_{yyLens} = .82\ \varepsilon_{yyNoLens}$

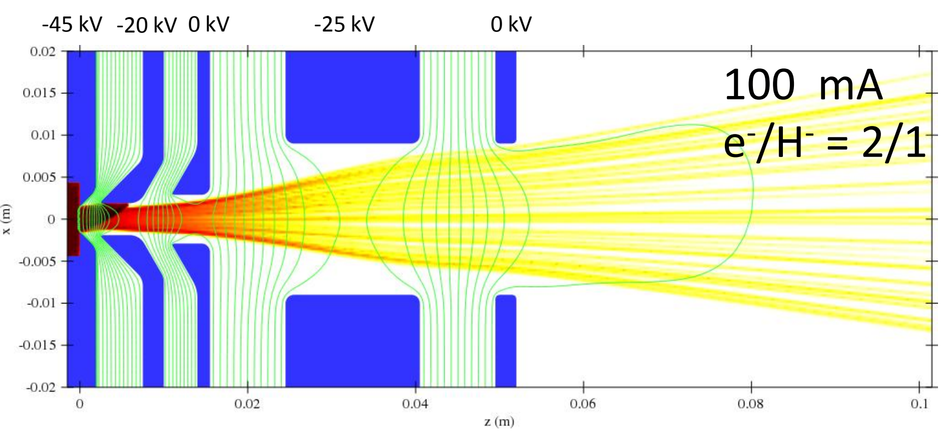
⇒ Einzel lens improves beam focusing.

2.3. e$^-$/H variation

⇒ Test same configuration with different e$^-$/H$^-$ ratio.







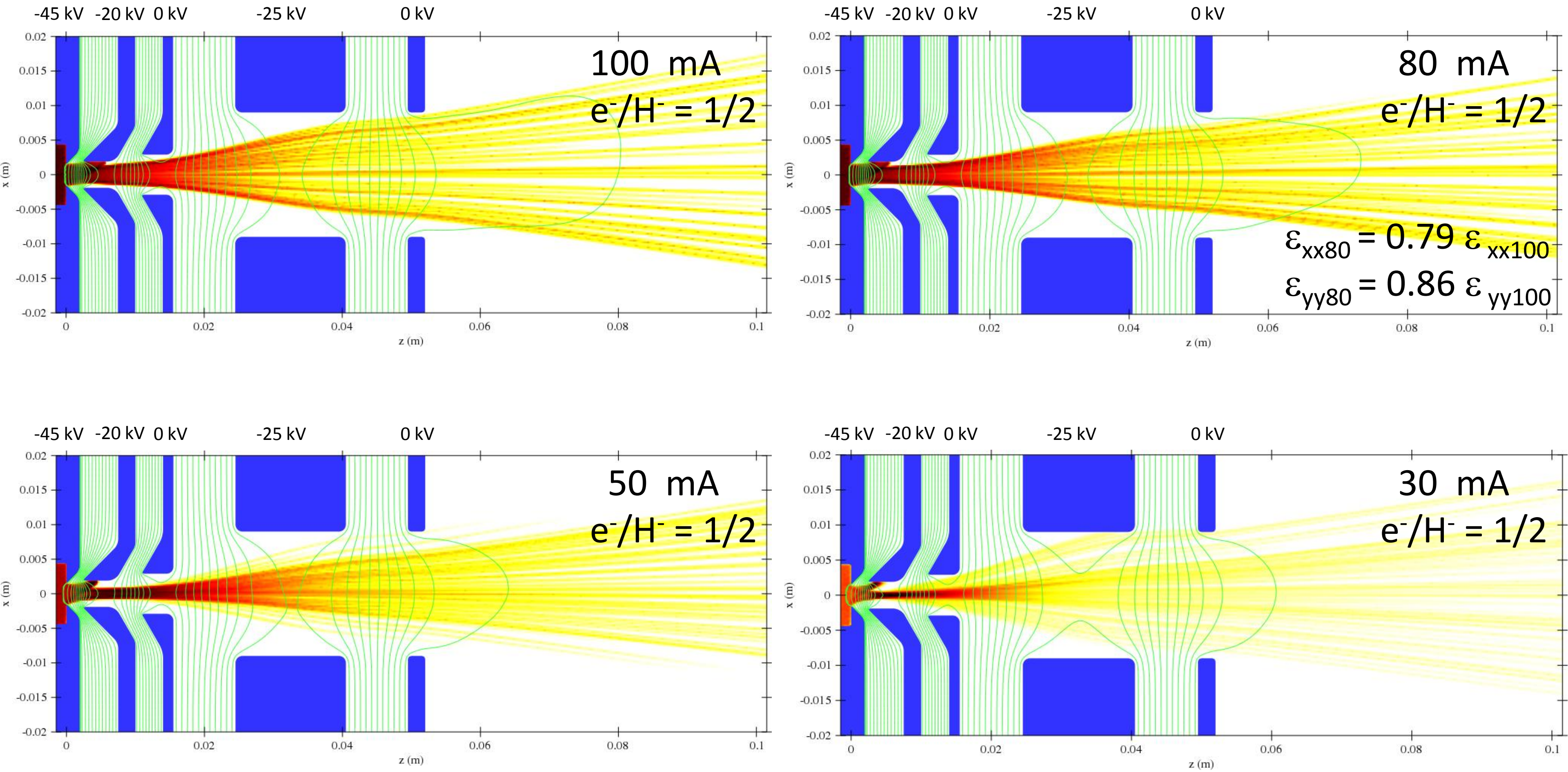
$\varepsilon_{xx1/1} = 1.00\ \varepsilon_{xx1/2}$
$\varepsilon_{xx1/1} = 1.01\ \varepsilon_{xx1/2}$

$\varepsilon_{xx2/1} = 1.02\ \varepsilon_{xx1/2}$
$\varepsilon_{xx2/1} = 0.99\ \varepsilon_{xx1/2}$

⇒ **Small increase of e$^-$/H ratio has no strong influence for tested cases.**

2.4. Beam current variation

⇒ Test same configuration with different beam currents.



⇒ For 80 mA the emittance is improved.

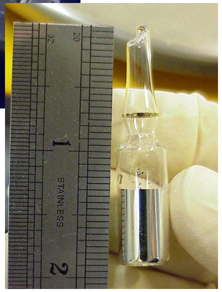
⇒ Further beam current decrease implies new design optimization.

3. Cesium laboratory

- **Cesium-coated metal surfaces**:
  - have considerably **low work function**;
  - **increase the conversion yield** of negative ions from plasma.

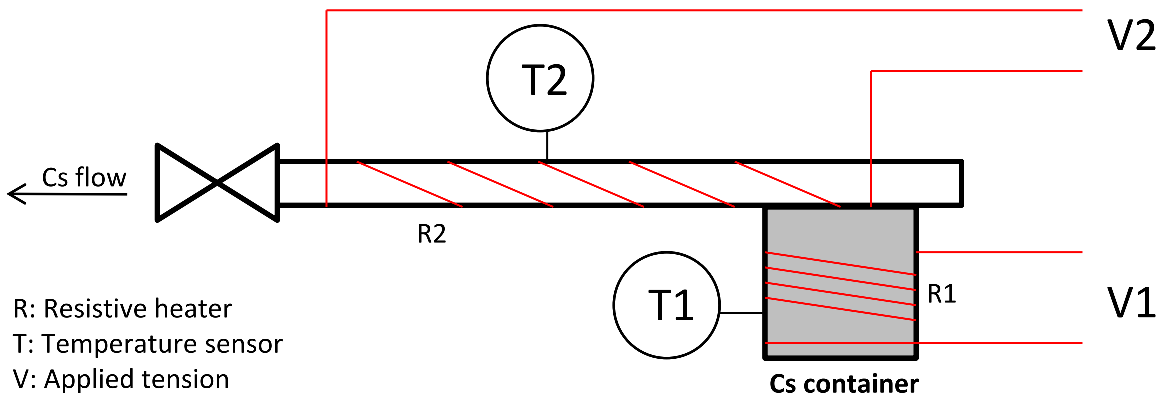
⇓

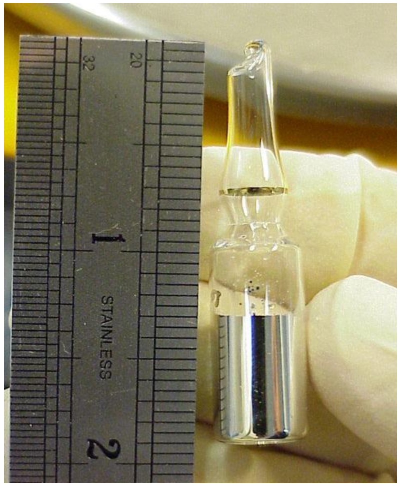
- Build and test a **cesium oven**:
  - **store and handle** cesium;
  - **transport** cesium and cesium oven;
  - **assemble** test stand;
  - **clean** cesiated elements after test.



3.1. Cesium oven and dispenser

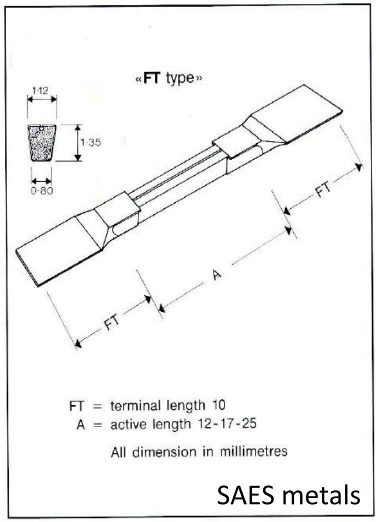
- **Elemental Cs** oven:

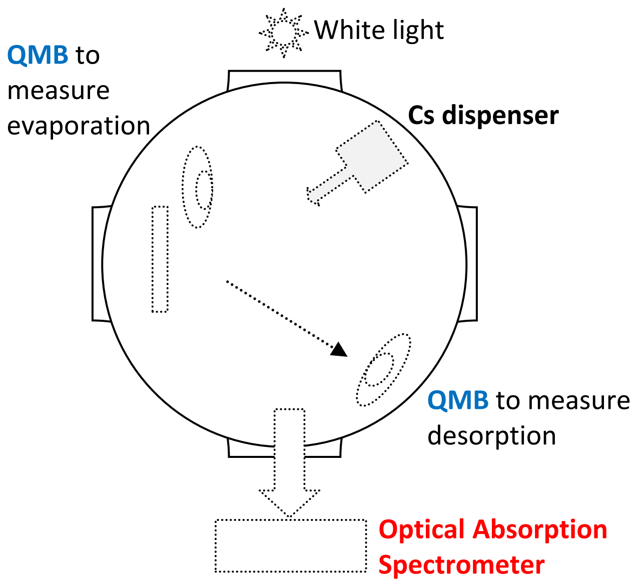




Cs glass ampoule.

- **Cs Dispenser**:






QMB: quartz micro balance; Cs layers are deposited on a quartz detector plate covered by Au.

3.2. Schedule and cost

- **Schedule** and **manpower**:
  - Source **extraction simulation**: 6-8 months
  - Source **thermal analysis**: 6-8 months;
  - **Laboratory** and **test stand** assembly: 6-8 months;
  - Test stand source **measurements**: 6-8 months.
  - ⇒ **Manpower: 2-3 FTE** over 2 years.

- **Costs** (kCHF):
  - Cesium **test stand** for Cs oven: 126;
  - **Storage, handling and safety**: 90;
  - **Cleaning system** for cesiated elements: 20.
  - ⇒ **Total = 236 kCHF**

Cesium test stand	
Cesium	10
6-way cross vacuum chamber	3
Flanges & other material	5
Power supplies	10
Rack and cabling	5
Vacuum pumps	6
Fabrication and design	60
Quartz Micro Balance	14
Optical Absorption Spectrometer	15
Storage, handling and safety	
Cs and Cs chromate storage	1
Flammable liquids storage	1.5
Argon box	33
Fire protection	3
Ventilation system and refurbishing	50

Conclusion

1. **BNL source**

    - Extraction damages cathode, anode and puller electrode.

    - Simulated extraction results reproduce experimental data.

2. **Modified BNL-type source at 45 kV**

    - Extraction for a modified BNL–type source at 45 kV is modeled

    - A draft e-dump is proposed and simulated.

    - Further parametric studies (2nd electrons, rest gas ionization) must be peformed.

    - Study thermal behaviour at low repetition rates mandatory.

3. **Cesium laboratory**

    - Create laboratory and assemble a test stand to acquire Cs behaviour.

    - 2-3 FTE over 2 years;

    - 236 kCHF.