Progress of a charge breeder for HIE-ISOLDE and TSR@ISOLDE

YEARS / ANS CERN

Andrey Shornikov

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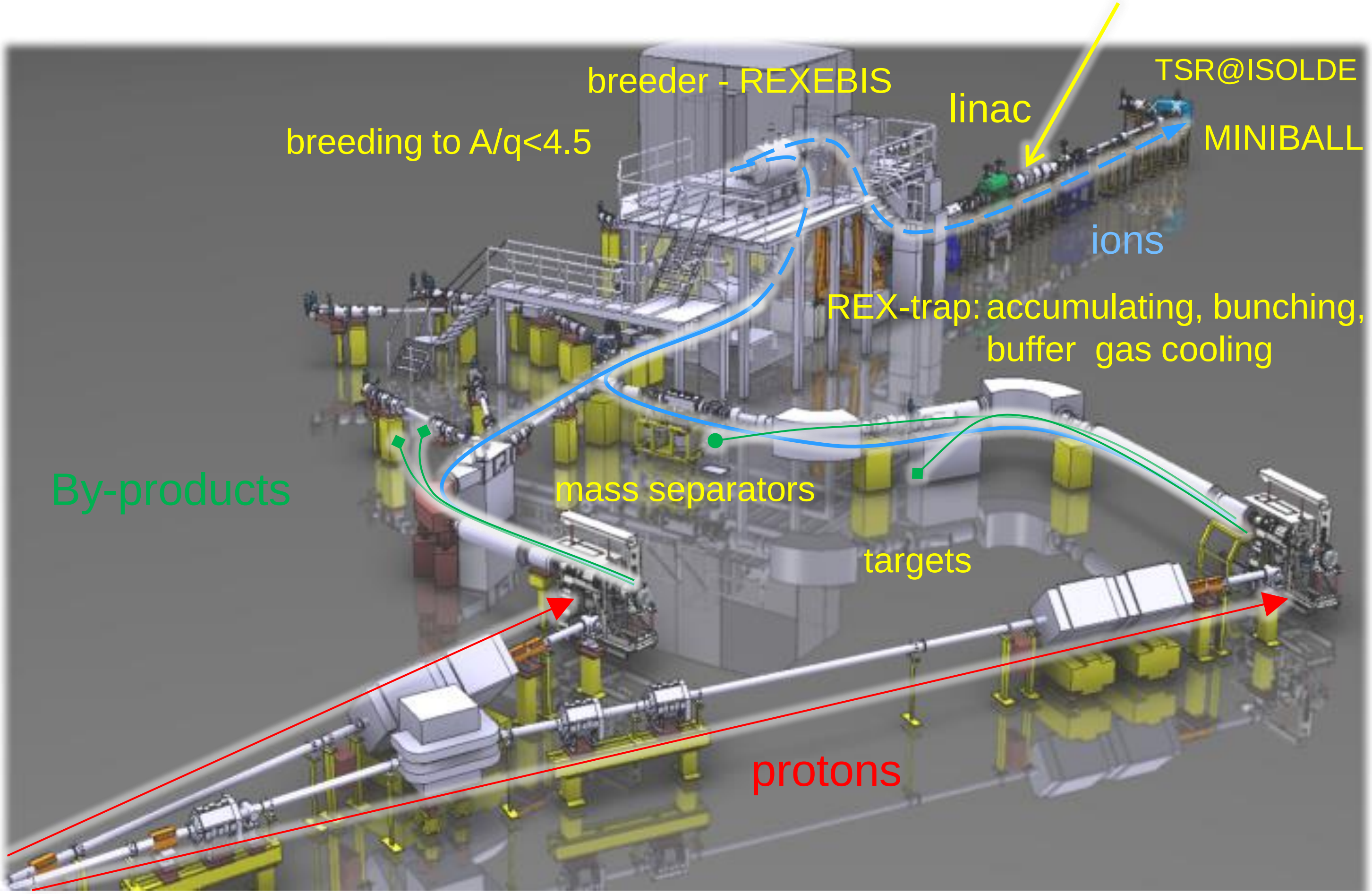
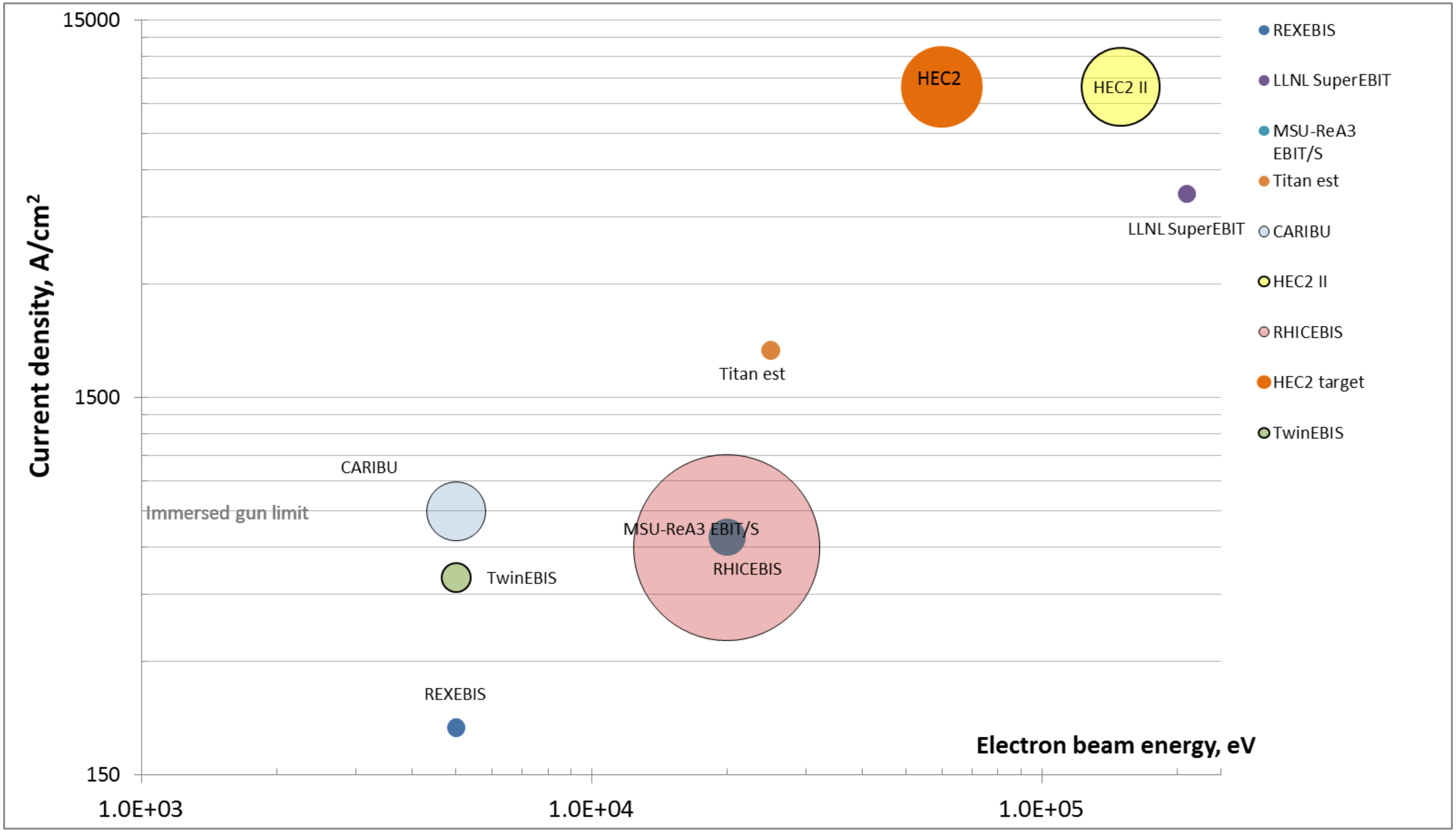
Hadron Sources and Linacs section
Beams department

Re-acceleration branch – need to breed charges



Re-acceleration branch of ISOLDE. CB makes ions suitable for linac
A high performance breeder makes any ion a “light ion” for linac

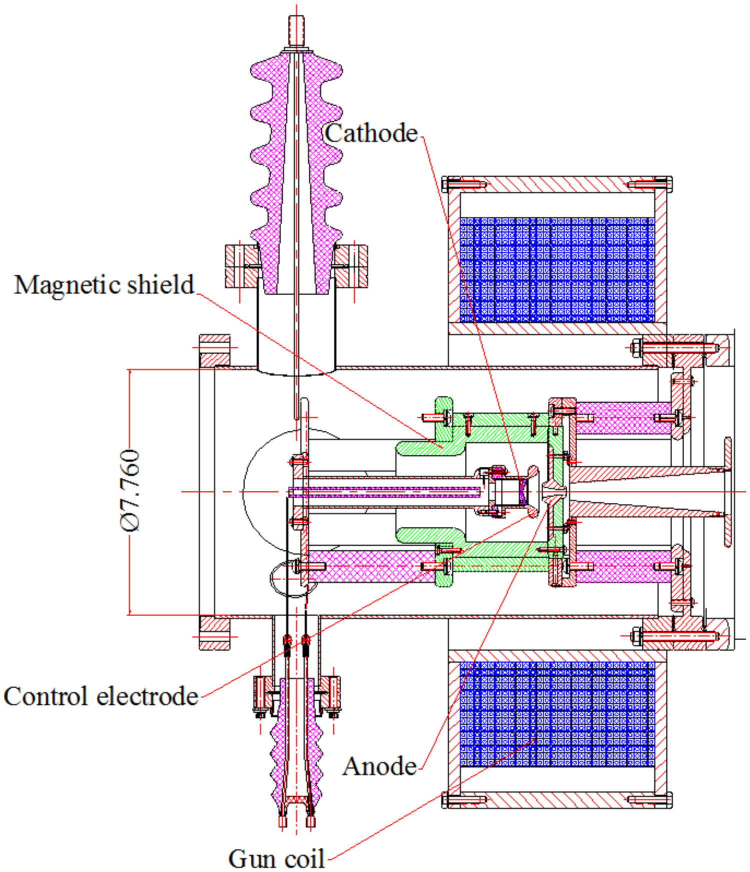
What is out there?



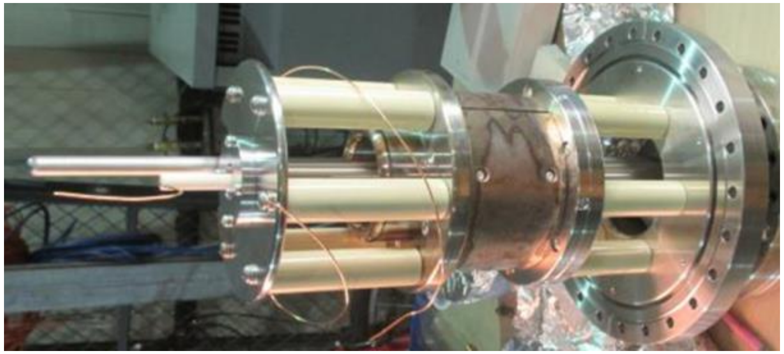
Bubble size represents electron current rep - reported, est - estimated, * - in commissioning phase † - discontinued

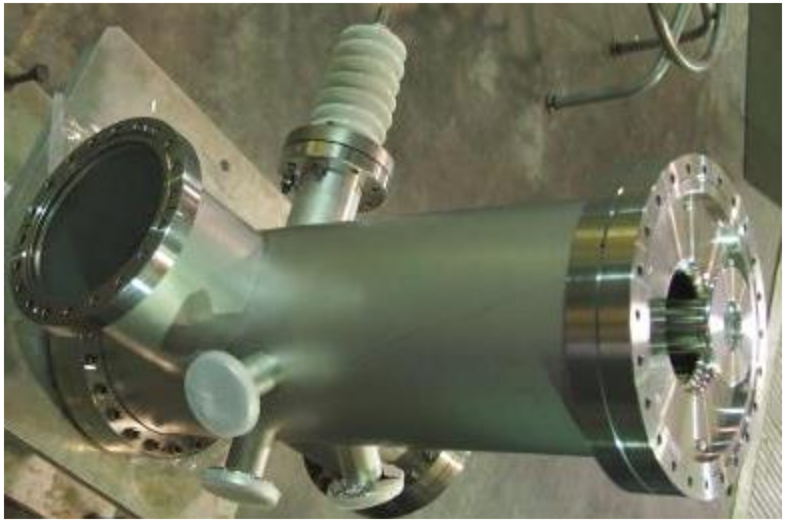
HEC^2 joint project by CERN and BNL

High Energy Current and Compression (HEC^2) electron beam for charge breeding



BROOKHAVEN NATIONAL LABORATORY Preliminary development





CERN 01-06.2013 manufacturing phase

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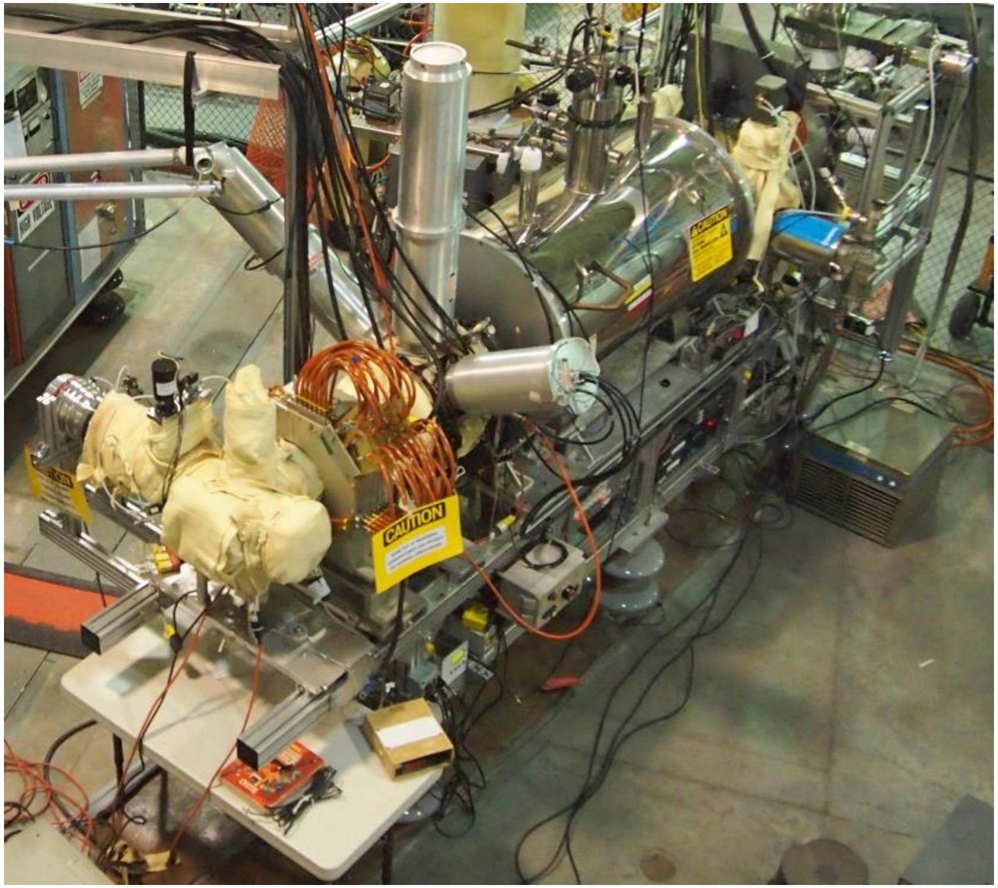
And test it at BNL

TestEBIS – the cradle of all 4 highest current EBISes ever built



Jun-Aug 2013 HEC^2 moved to BNL, assembled, preparations of the Test EBIS started
Oct-Nov 2013 – first run with HEC2

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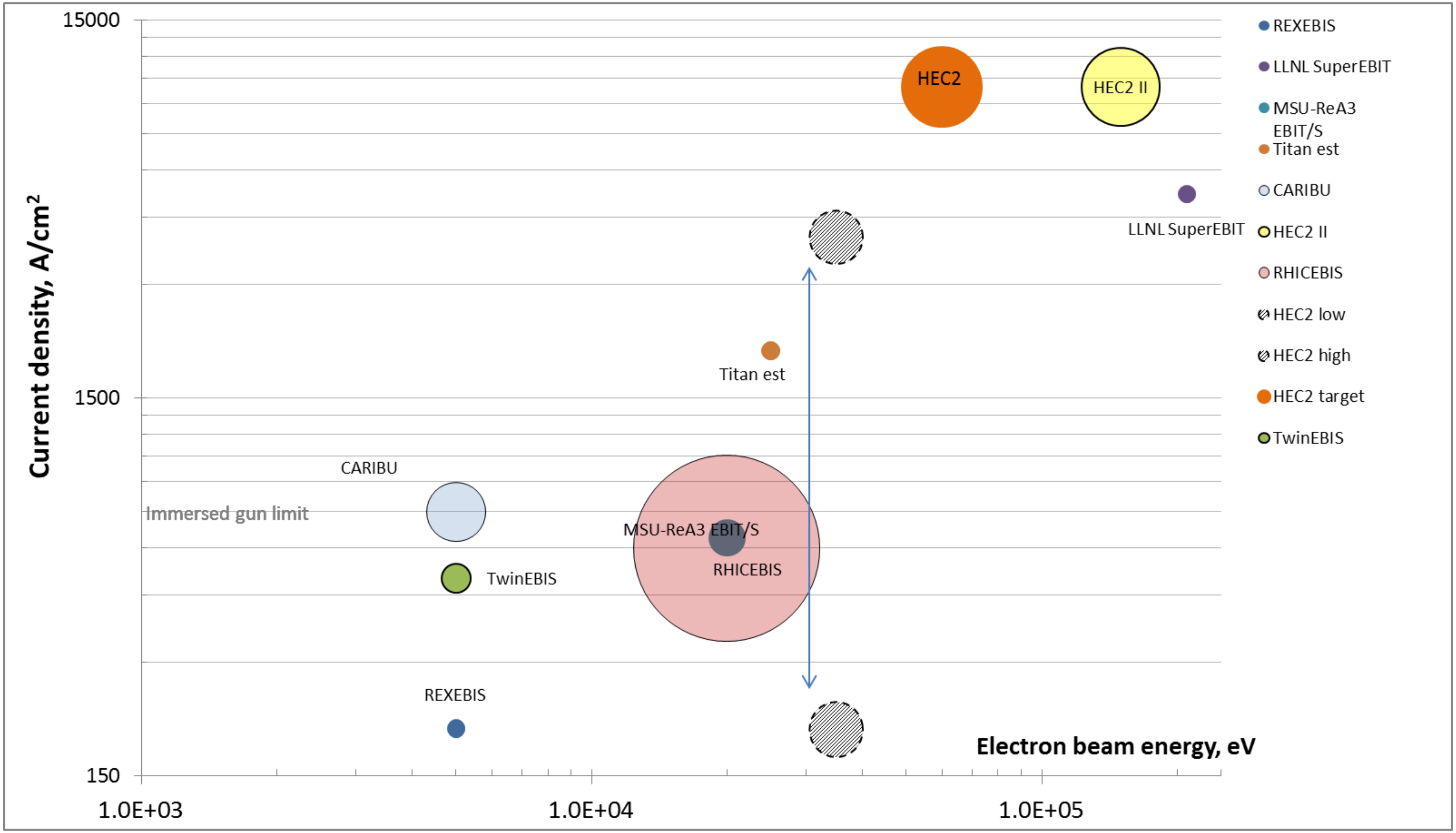
Where we are on the map?



Bubble size represents electron current rep - reported, est - estimated, * - in commissioning phase † - discontinued

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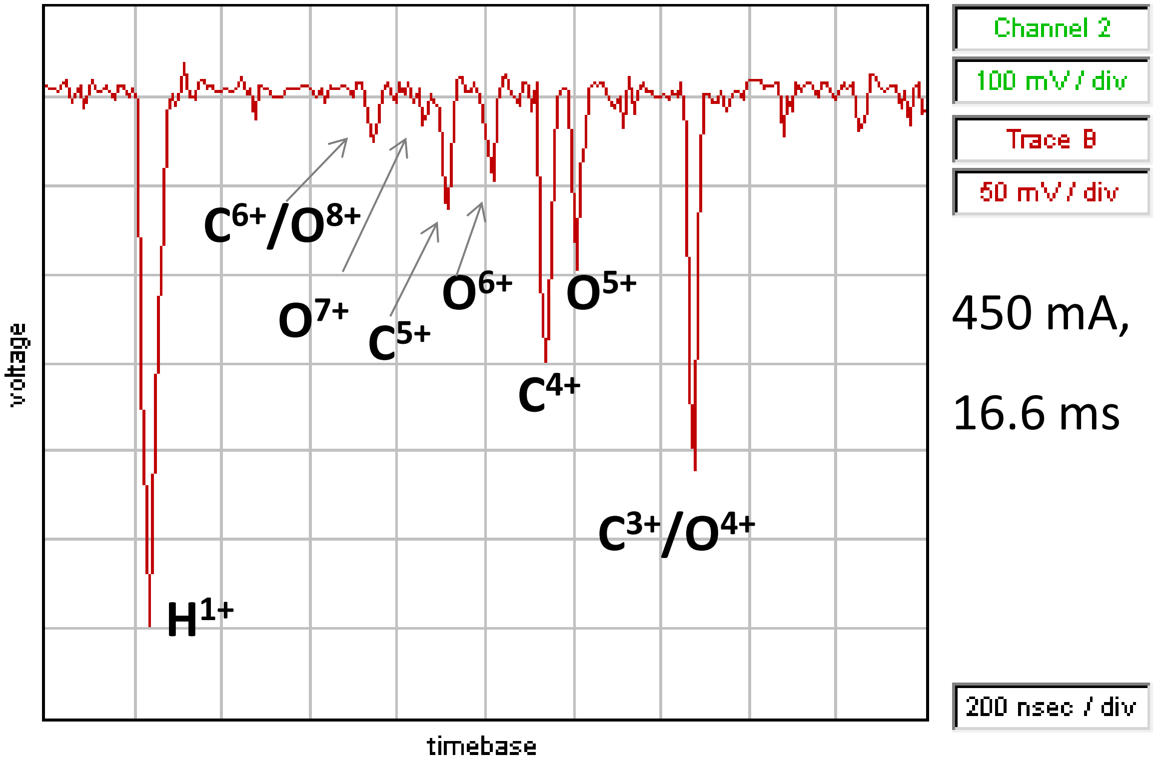
Follow up of the first run - Higher current, first HCI

Max current ramped to 1.7 A, still limited by loss current



450 mA,

16.6 ms

courtesy E. Beebe

Ions extracted, O^{6+}/O^{5+} and C^{5+}/C^{4+} give too big error bars to define J_e

Limiting factor – 20 mA on the anode

- 20 mA = 2% losses, too high for an EBIS.

- 20 mA x 12 kV = 240 W heating on the anode, too high for high duty factor and good vacuum.

- In experiment – 20 mA trips the power supply.

Where 20 mA come from?

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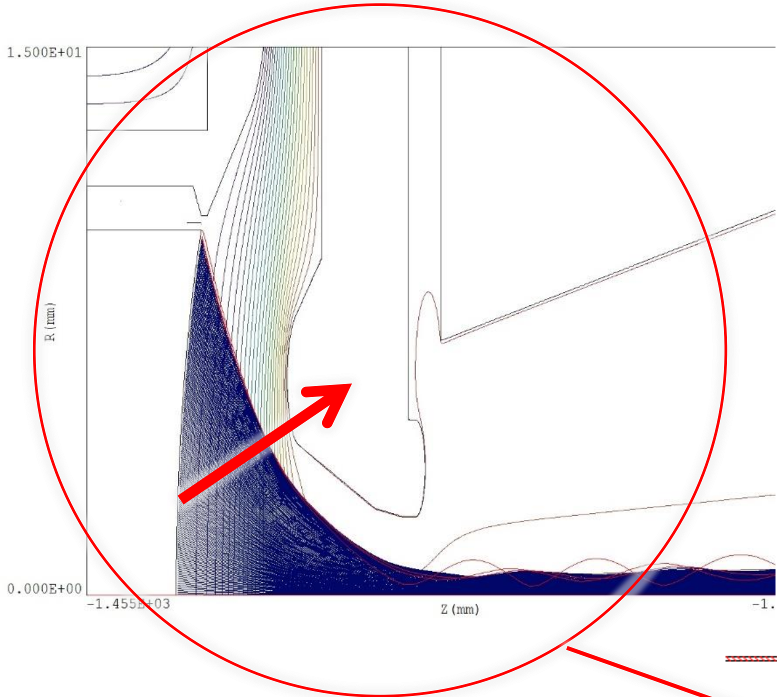
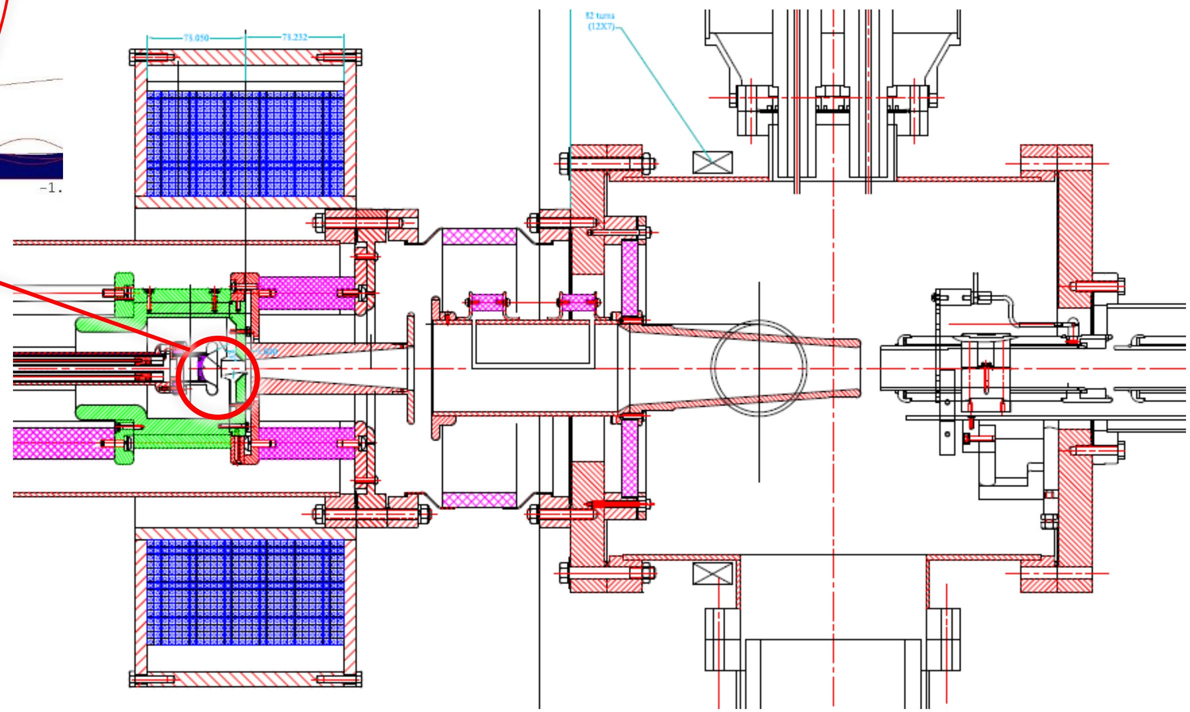
Where 20 mA come from?



Simplest answer is the wrong one



How do we know that?

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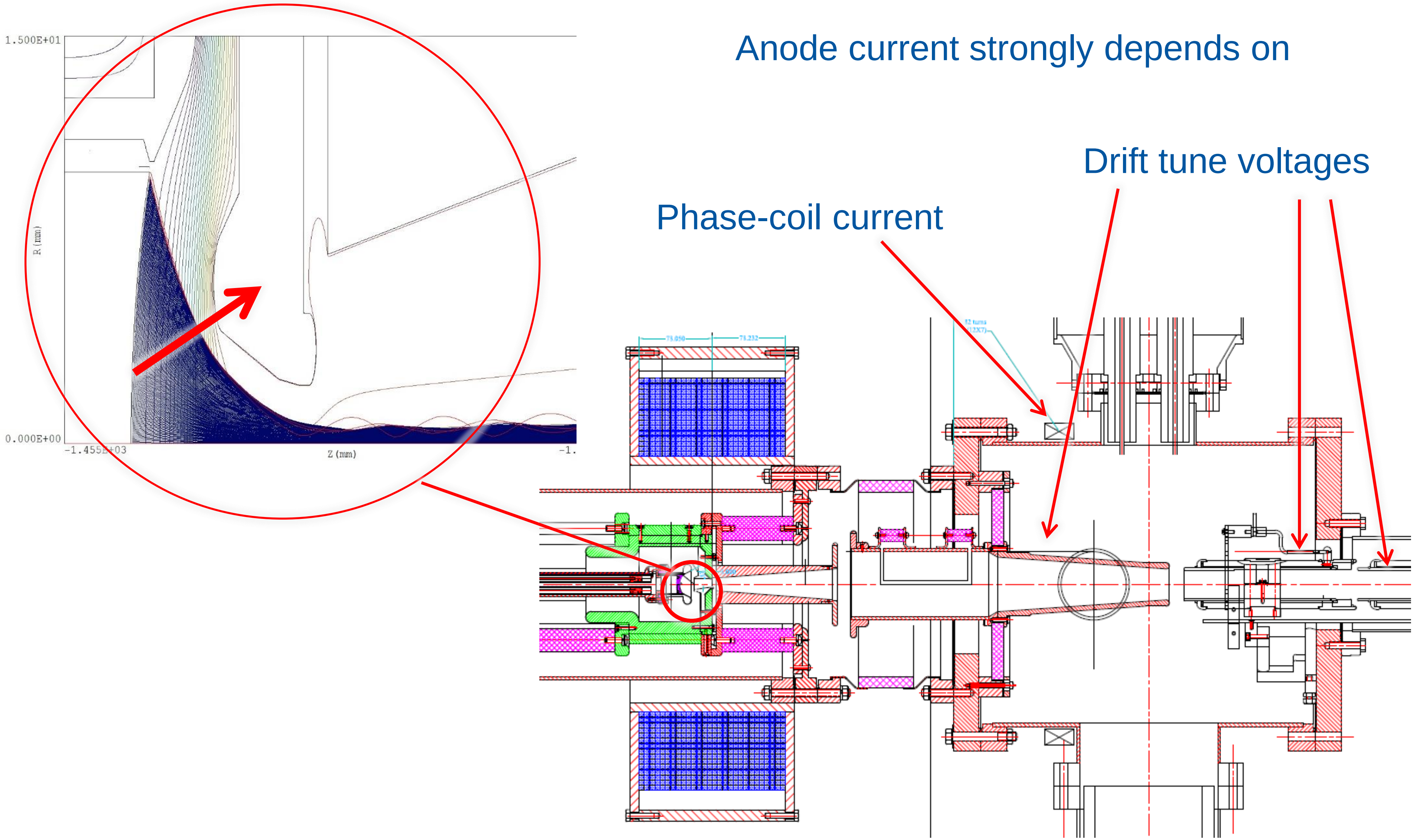
How do we know?

Anode current strongly depends on



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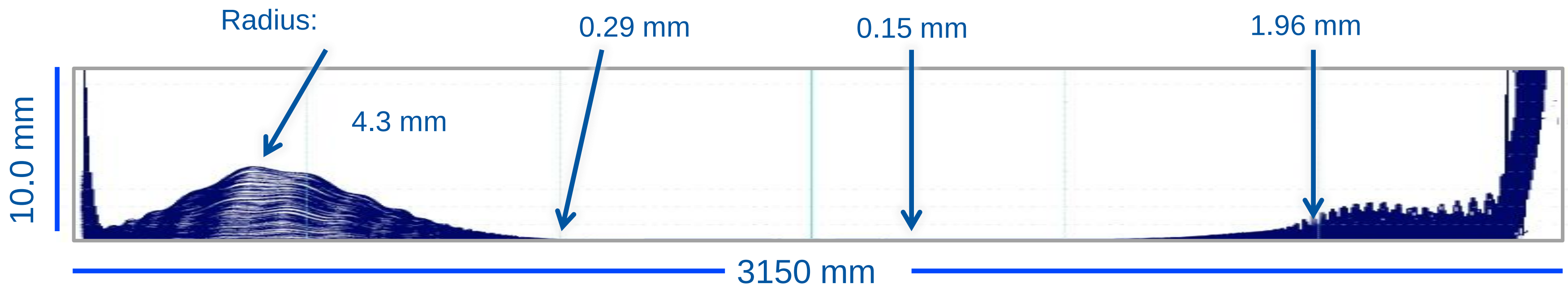
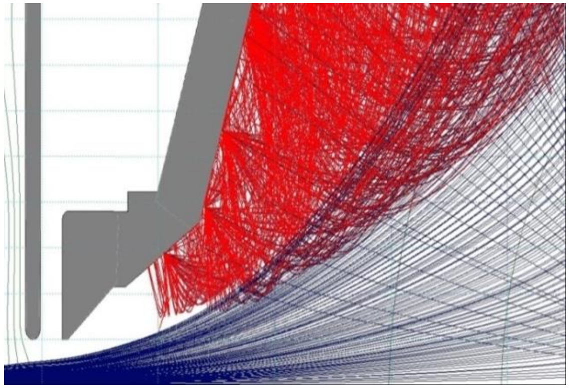
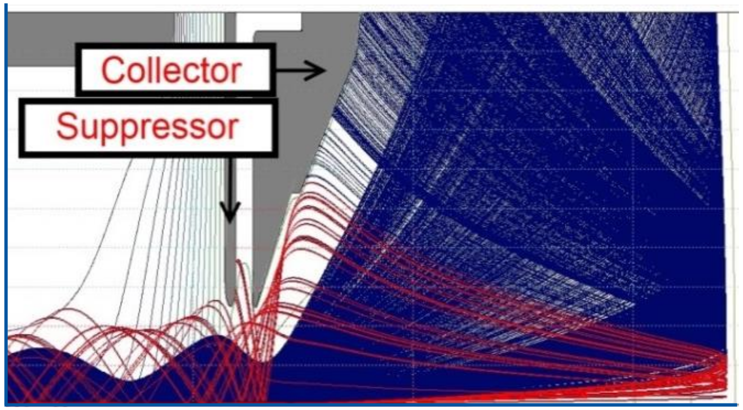
Back from where, who they are

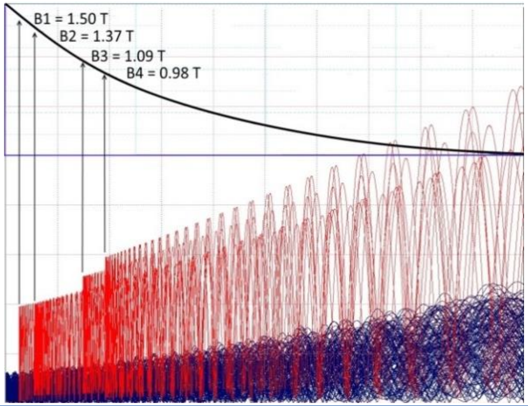




Backscattered electrons from collector?

Elastically reflected paraxial electrons?





courtesy R. Mertzig

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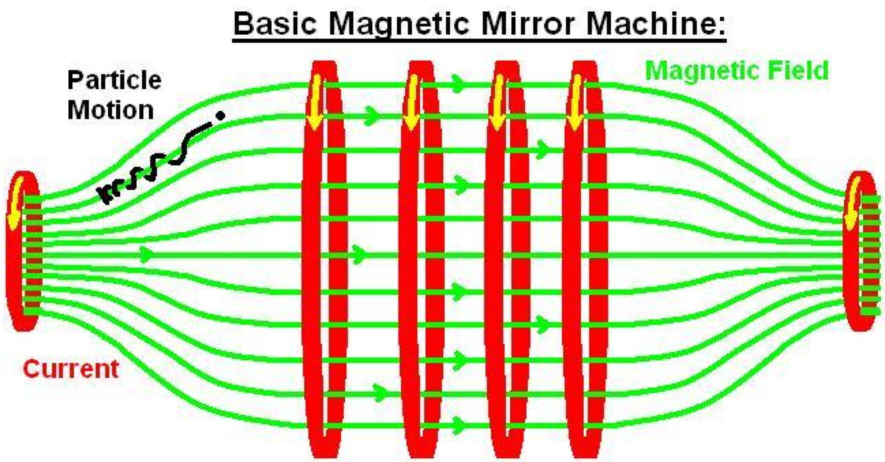
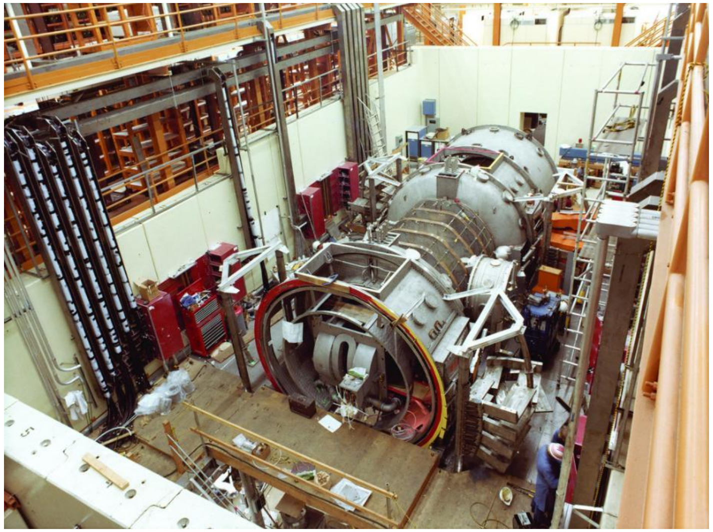
Magnetic bottle stops bad electrons



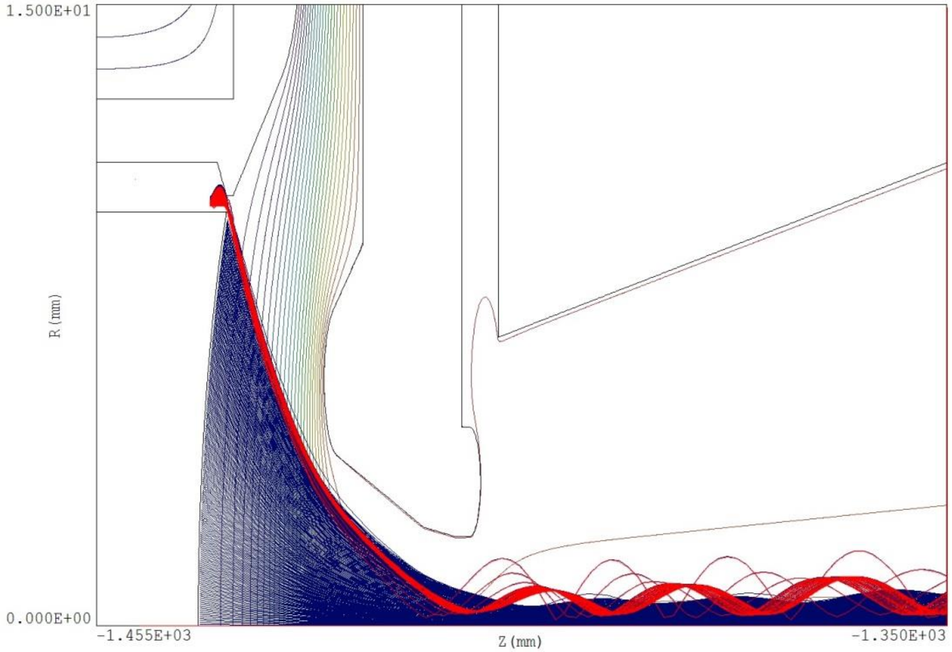


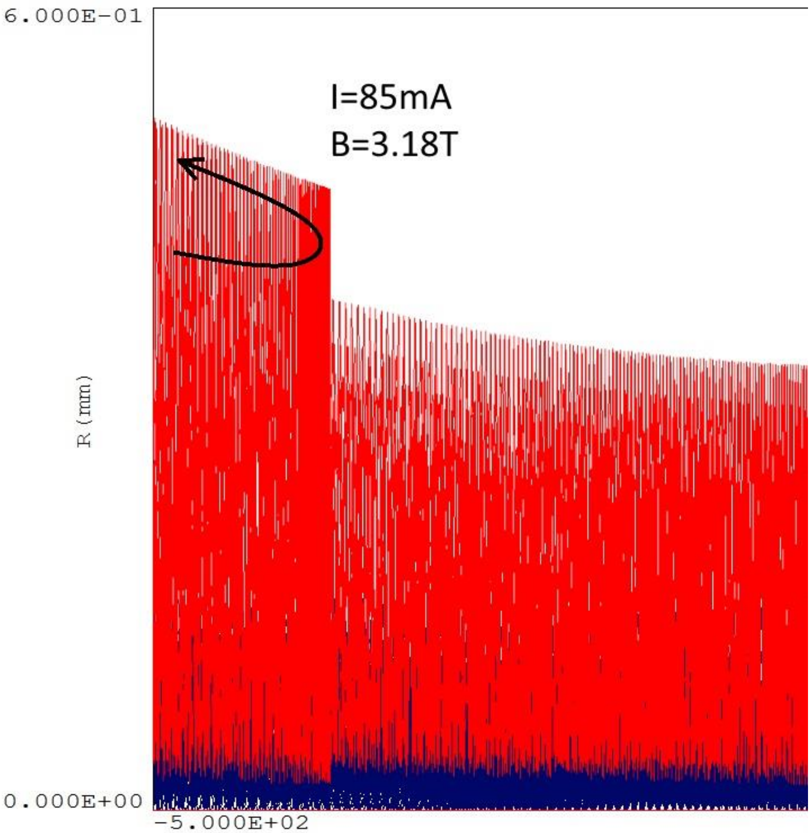
Tandem Mirror eXperiment (TMX 1979)
Lawrence Livermore National Lab

Mirror ratio $R = \frac{B_{max}}{B_{min}}$

Reflection condition $\frac{v_\perp}{v_\parallel} = \frac{1}{\sqrt{R}}$

Where bad electrons come from?





courtesy R. Mertzig

General approach to suppress this effect

A. Reduce mirror ratio, keeping current density
B. Increase electrostatic compression
C. Reduce low-quality beam component

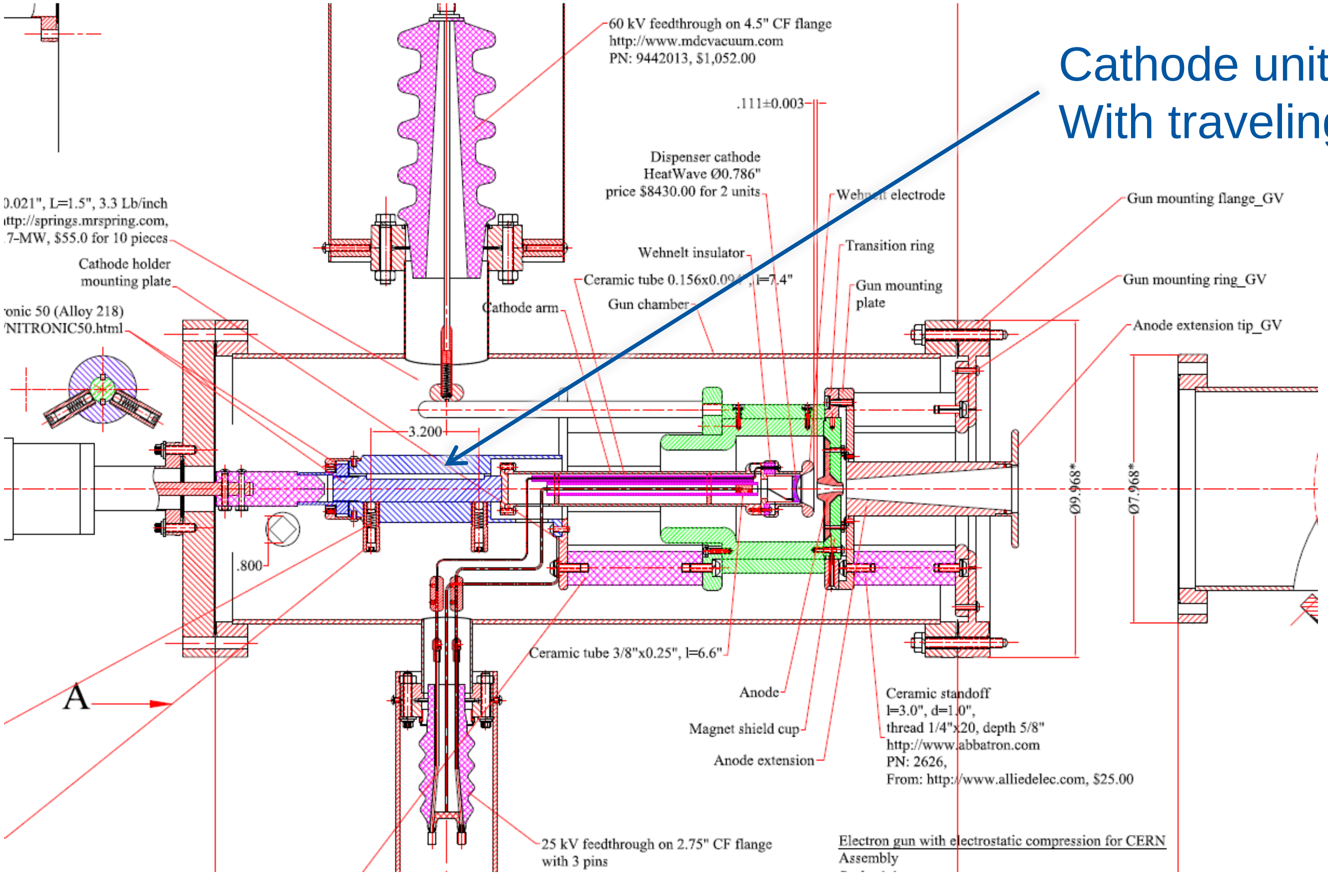
Requirements

A: Increase injection magnetic field
B: precise control of the gun geometry, low aberations
C: Passivate side surfaces (workaround – use focusing electrode)

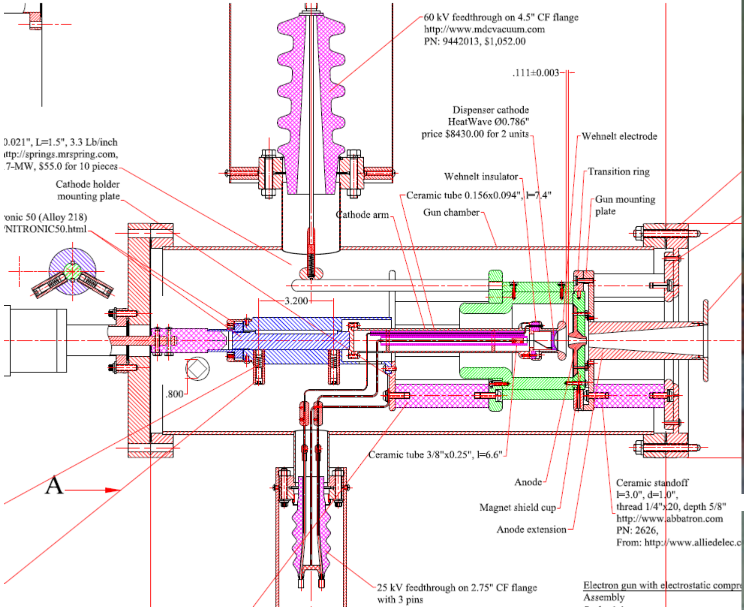
Actions taken

A: ramp injection field – 300 A gun coil PS prepared at BNL to replace 120 A PS
R will be reduced (now –R=16 ~(3.3 T), in 5T present optics R=25, new R=12.5)

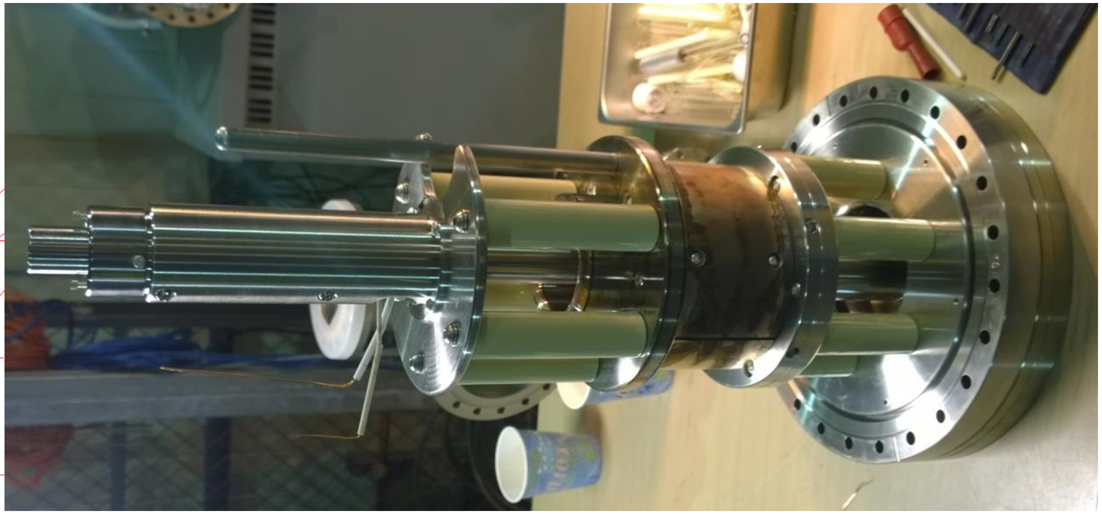
B: precise control of the gun geometry, low aberations adjustable gun optics

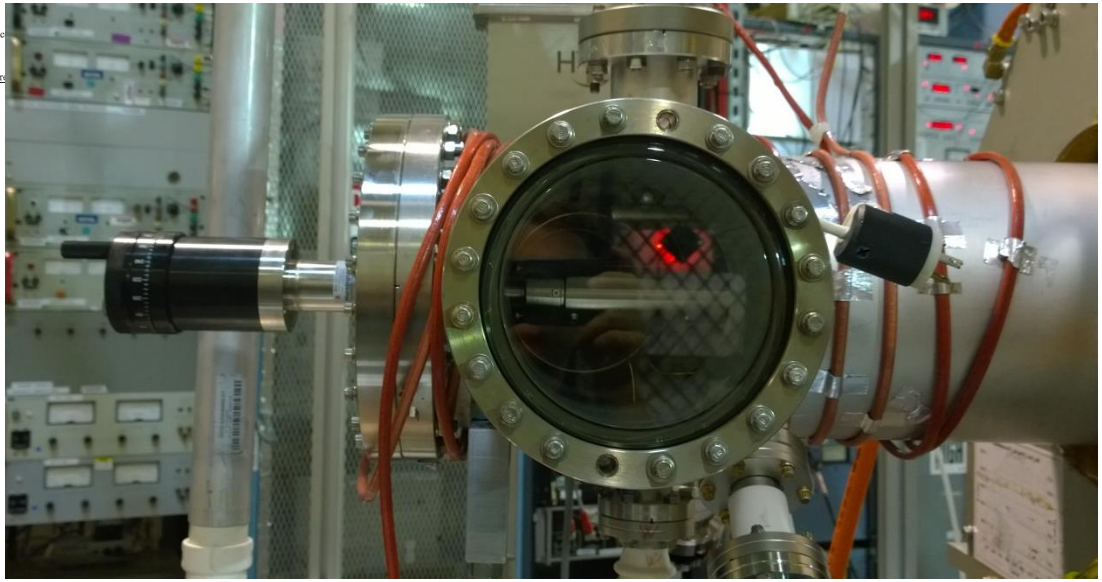


Actions taken



courtesy A. Pikin

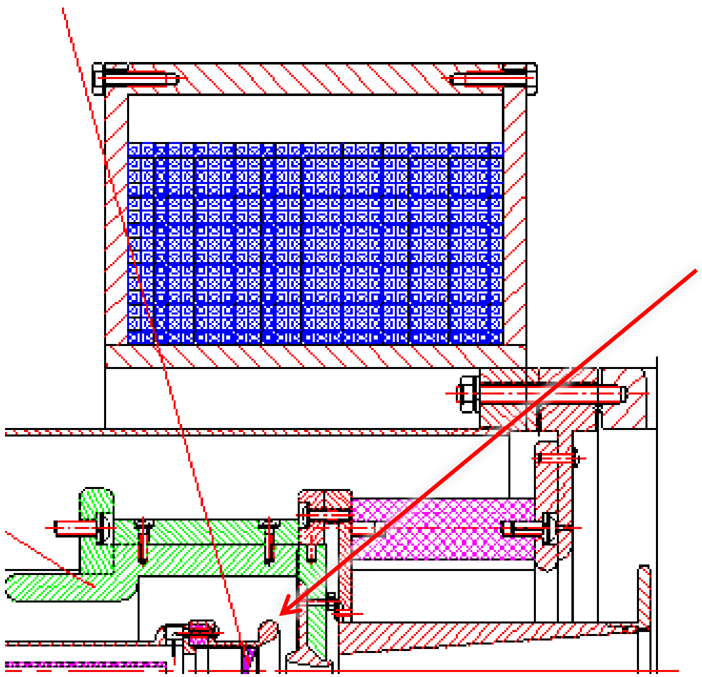


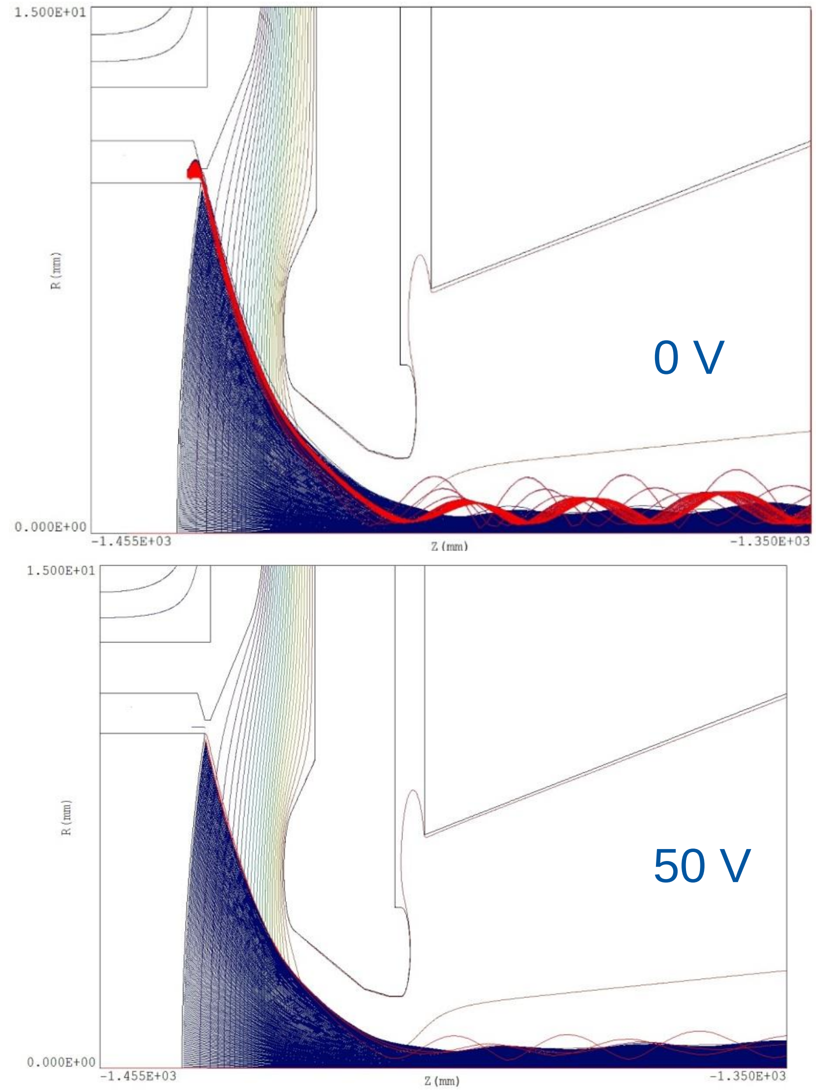


Positioning system installed,
Gun perveance changed
In range 0.6-0.92

Tests Nov-Dec 2014

Actions taken





Using workaround with focusing potential
Experiment showed reduction of anode current
Need more robust Wehnelt electrode

courtesy R. Mertzig

Longer term vision

Strategy 1 (currently pursued)

- ❑ Method : Improve optics and quality of the beam with low mirror-ratio optics
- ❑ Goal: attain non-compromised design parameters

Strategy 2 (a back-up)

- ❑ Method : Deal with symptoms, use workaround for each one (focusing, interceptors, cooled anode…)
- ❑ Goal: attain parameters as close to design as practically possible

The transatlantic HEC^2 team

A. Shornikov (coordination, QA, on-site commissioning)
R. Mertzig* (simulations, on-site commisioning)
F. Wenander (supervision at CERN)
E. Barbero (manufacturing, post-production)

A. Pikin (chief designer, BNL supervision, EBIS)
E. Beebe (operation of EBIS)
R. Schoepfer (operation/commissioning support)
D. McCafferty (operation/commissioning support)

our supporters

R. Catherall, Y. Kadi, R. Scrivens, J. Alessi,

funding bodies

* Visit poster session for more details on simulations