Technical studies for the HIE-ISOLDE Frontend upgrade

Jacobo Montaño

Marie Curie Fellow; CATHI Project

The research project has been supported by a Marie Curie Early Initial Training Network Fellowship of the European Community's Seventh Programme under contract number (PITN-GA-2010-264330-CATHI)

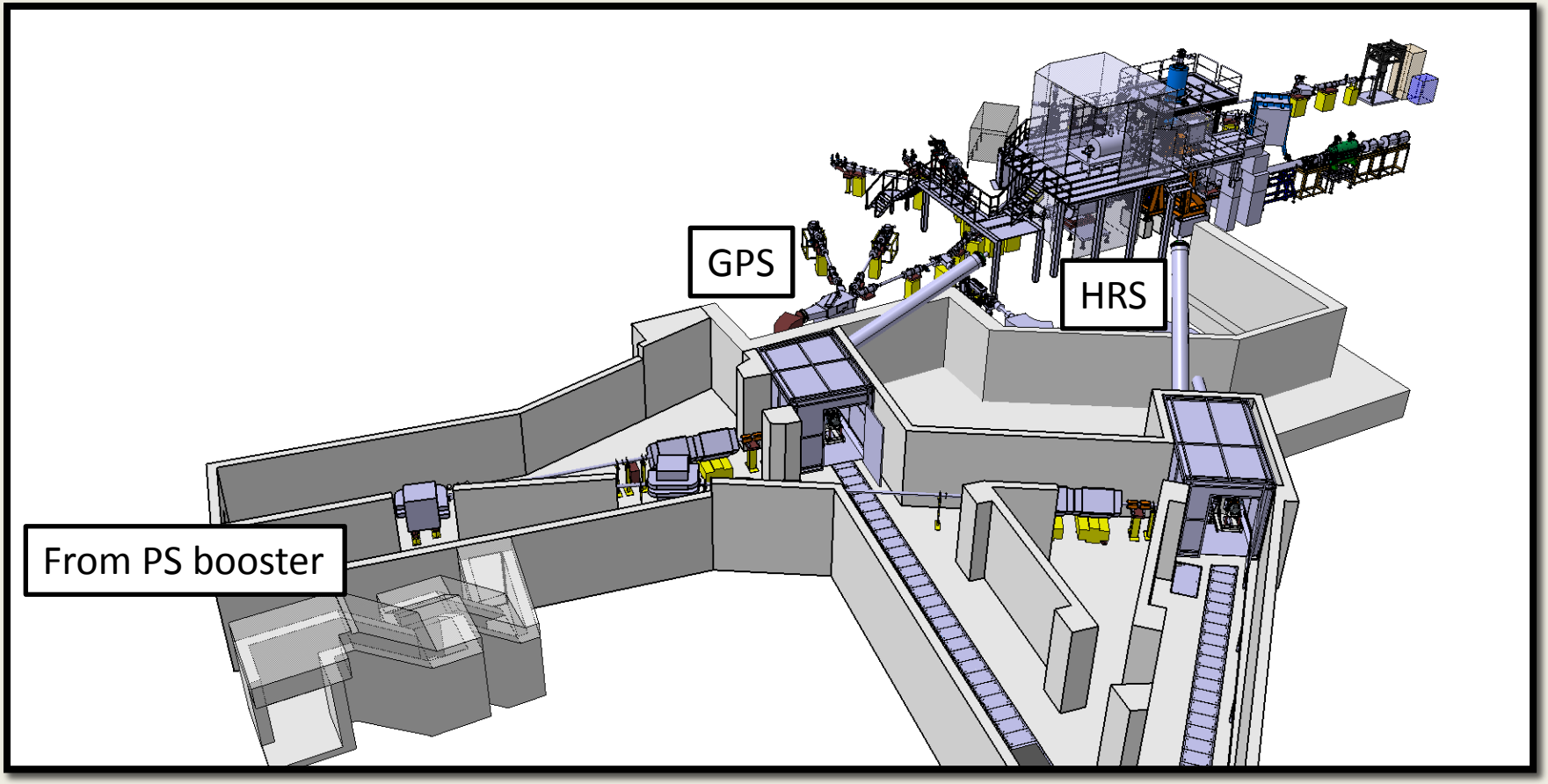
Outline

- **ISOLDE Target Area**
- **ISOLDE Frontend**
  - Current extraction system
  - Extraction optics
  - ISOLDE off-line labs
- **Two stage extraction**
  - Prototype
  - Thermal measurements
  - Ionized air conductivity measurements
  - Extraction efficiency measurements

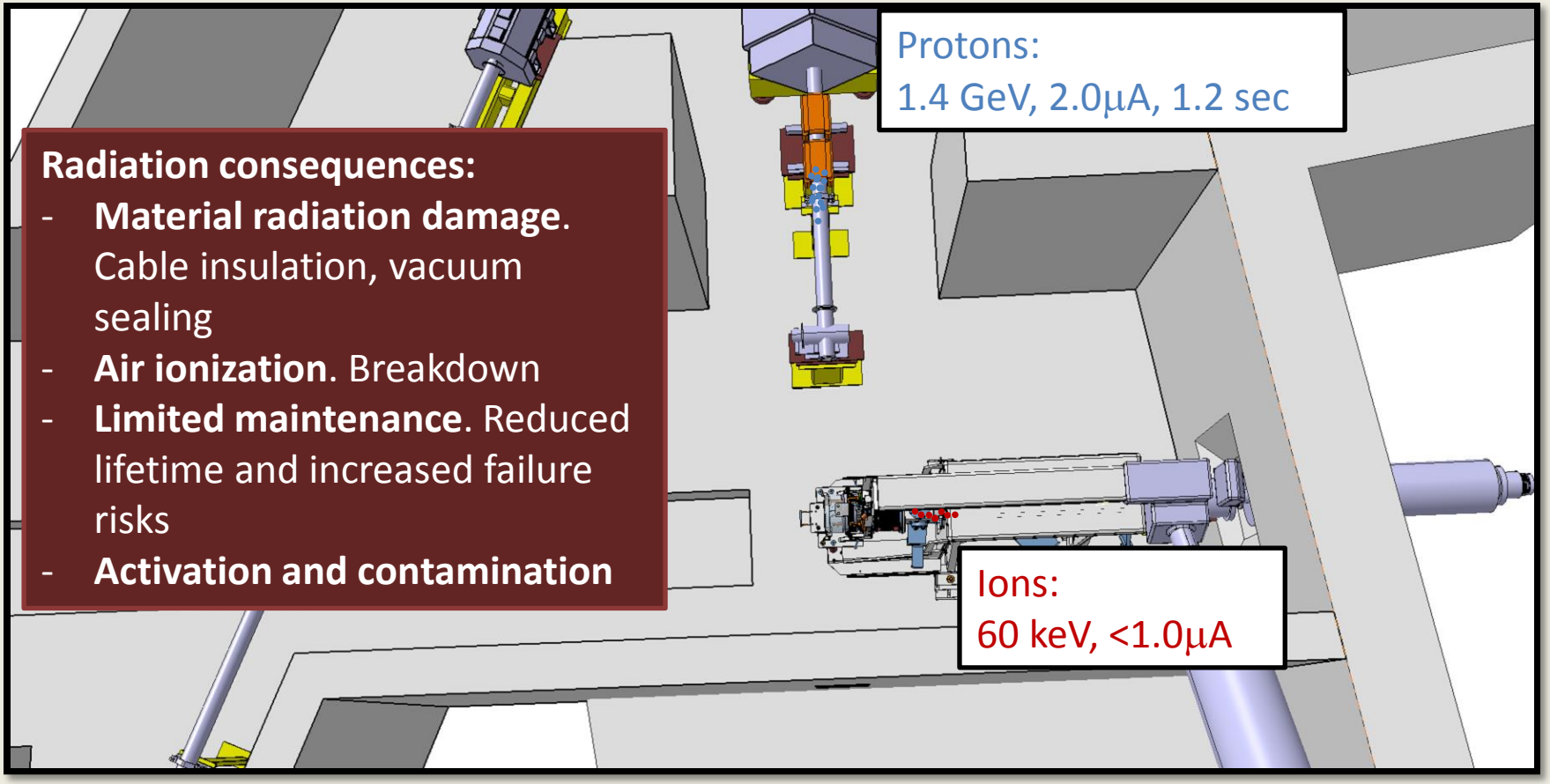
ISOLDE target area and frontend

- Target area
- ISOLDE Frontend
- Current beam extraction system

Target Areas and Mass Separators



Target Areas, Frontend (GPS)

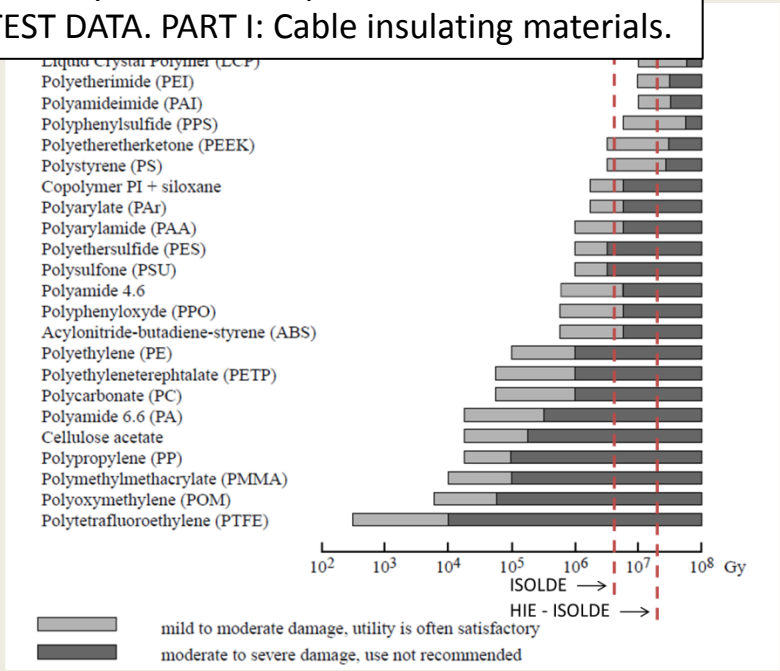


Requirements for HIE-ISOLDE

HIE-ISOLDE will bring an important increment in the radiation levels at the target area

Dose @0.5m from target:
6.3 MGy → **31.5 MGy**

H. Schönbacher, A. Stolarz - Iycka. CERN Report: COMPILATION OF RADIATION DAMAGE TEST DATA. PART I: Cable insulating materials.

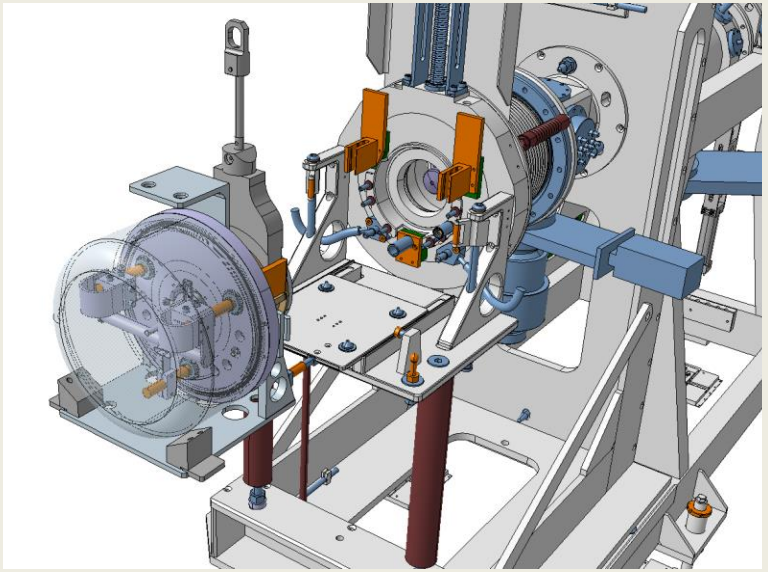


Only few polymers present a radiation hardness high enough to resist the HIE-ISOLDE expected doses

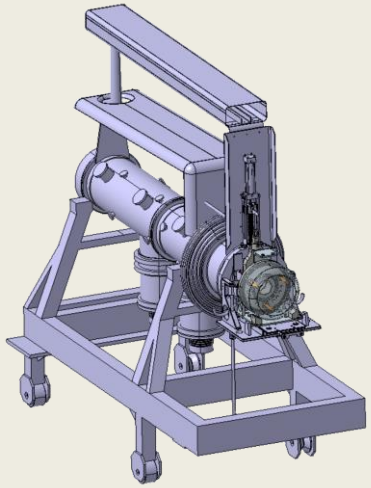
These materials are often essentials for **vacuum seals** as well as for **thermal** and **electrical insulations**

ISOLDE-Frontend

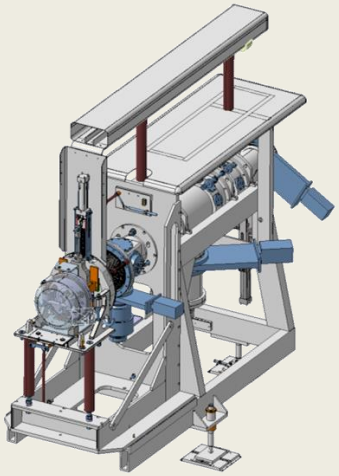
- For ISOLDE, the frontend is the machine that hosts the target unit and delivers the radioactive ion beams (RIB) to the mass separators
- ISOLDE uses two frontends ON-LINE for production



Frontends (1,2),3,4

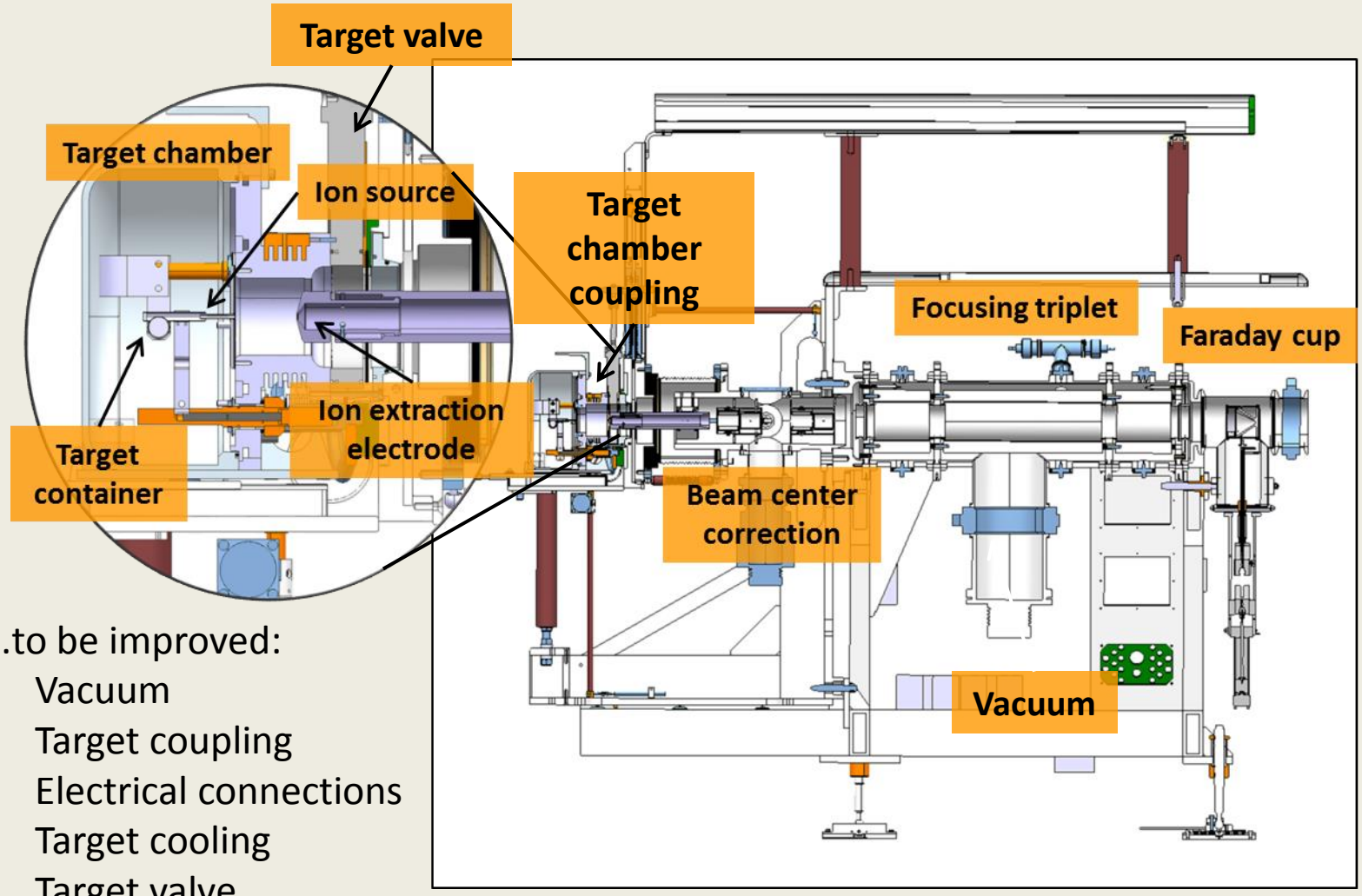


Frontends (5),6,7,8,9



Time for an upgrade!

ISOLDE-Frontend



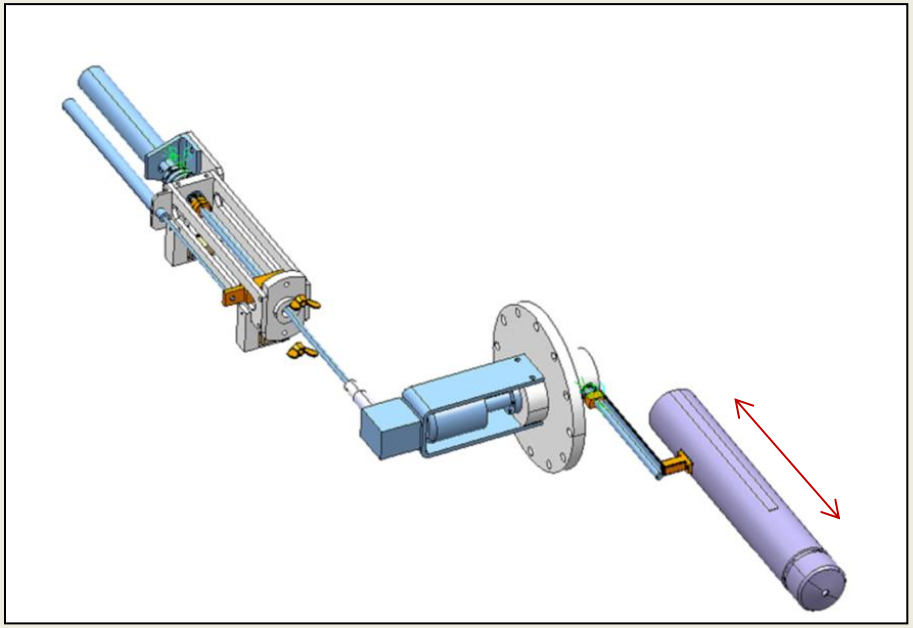
…to be improved:

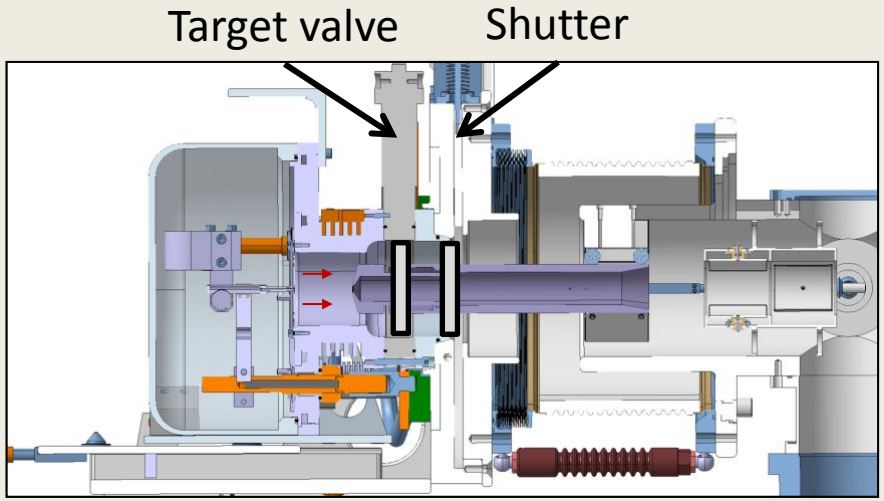
- Vacuum
- Target coupling
- Electrical connections
- Target cooling
- Target valve
- Ion extraction system

ISOLDE-Frontend

Ion Extraction System

- **Target valve** are closed during no operation
- On the long term **electrode tip**, neutral material condense



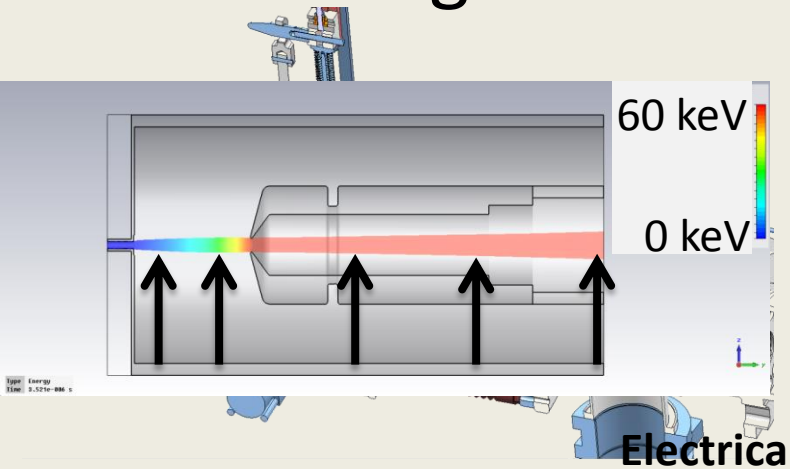


- A **mechanism** for electrode positioning
- **Mechanical failure risk** (possible to happen with a major impact)
- N**o fast valve closing is possible** in case of emergency

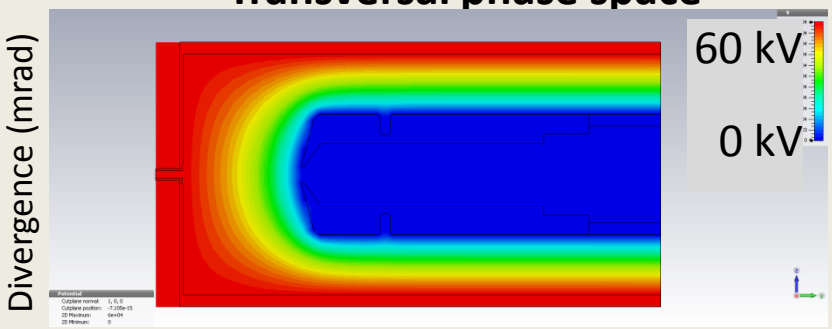
ISOLDE-Frontend

Extraction optics

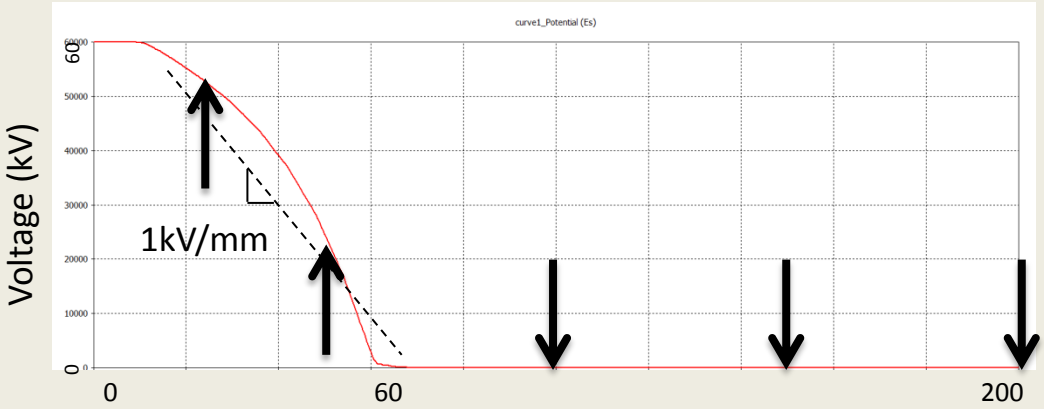
For a single electrode:



Transversal phase space

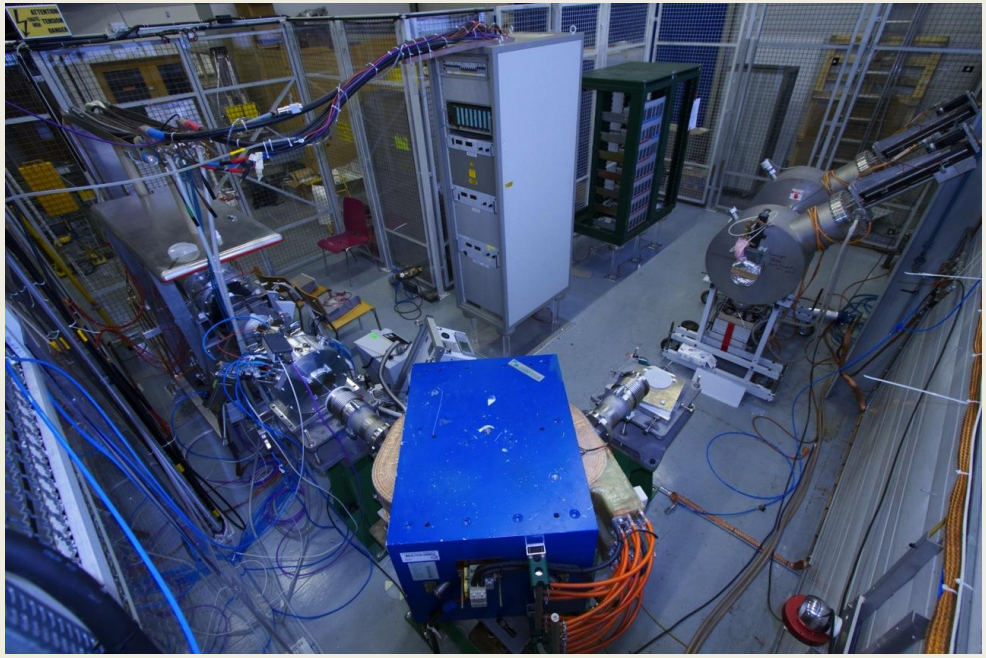


Electrical potential on axis



ISOLDE off-line Labs

- Extraction tests with different sources
- Mass spectrometer
- Faraday cup, beam monitor and emittance meter
- ISOLDE interlock system
- Test bench for prototypes (two stage extraction, coupling system, RFQCB…)



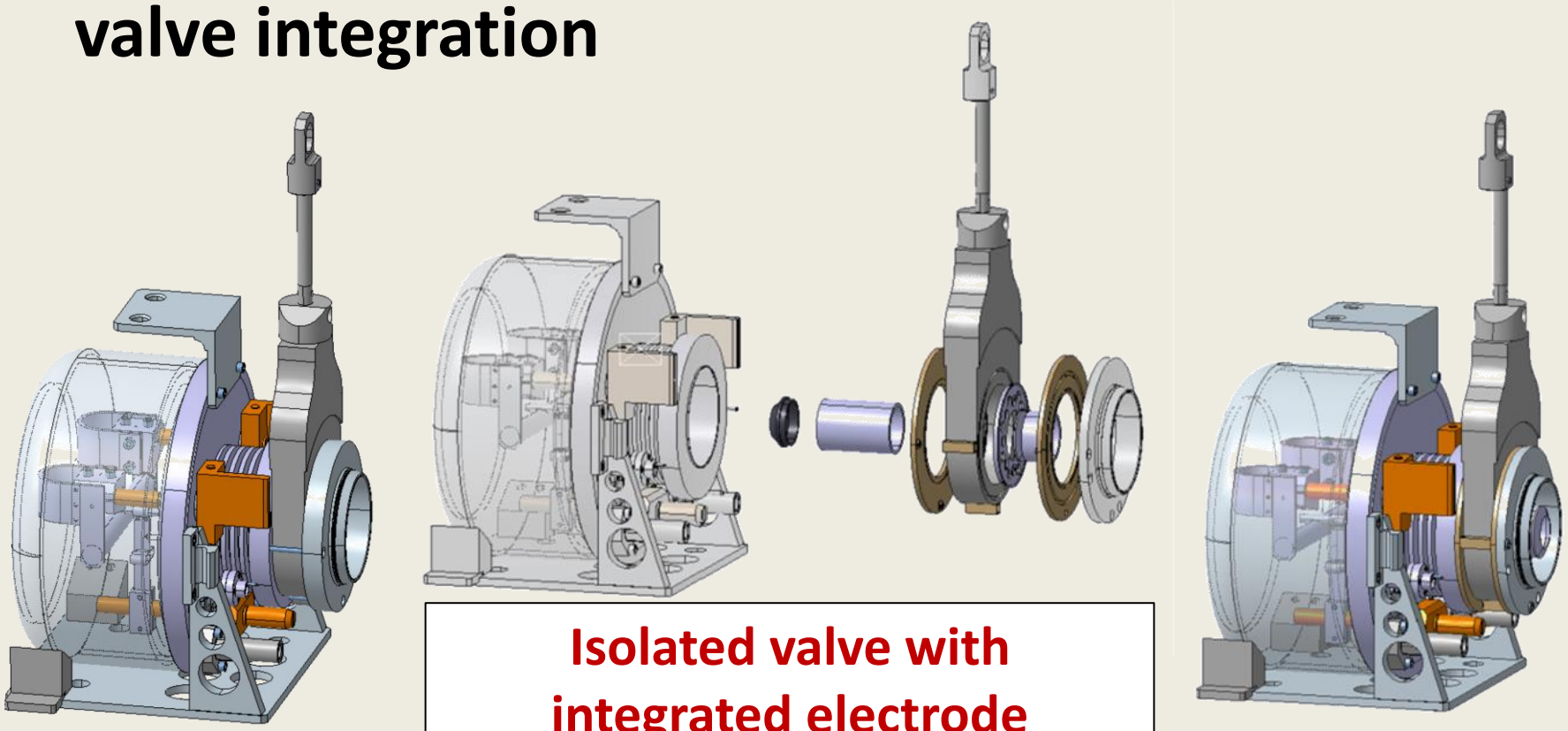
Courtesy of M. Augustin

Two stage extraction

- Prototype
- Thermal characterization
- Beam optics characterization
- Ionized air conductivity

Two Stage Extraction

A prototype has been designed, constructed and assembled. The main idea: **Electrode – valve integration**

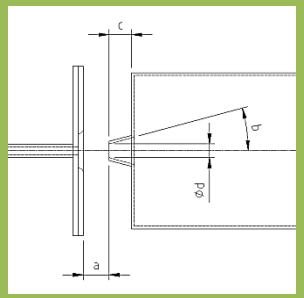


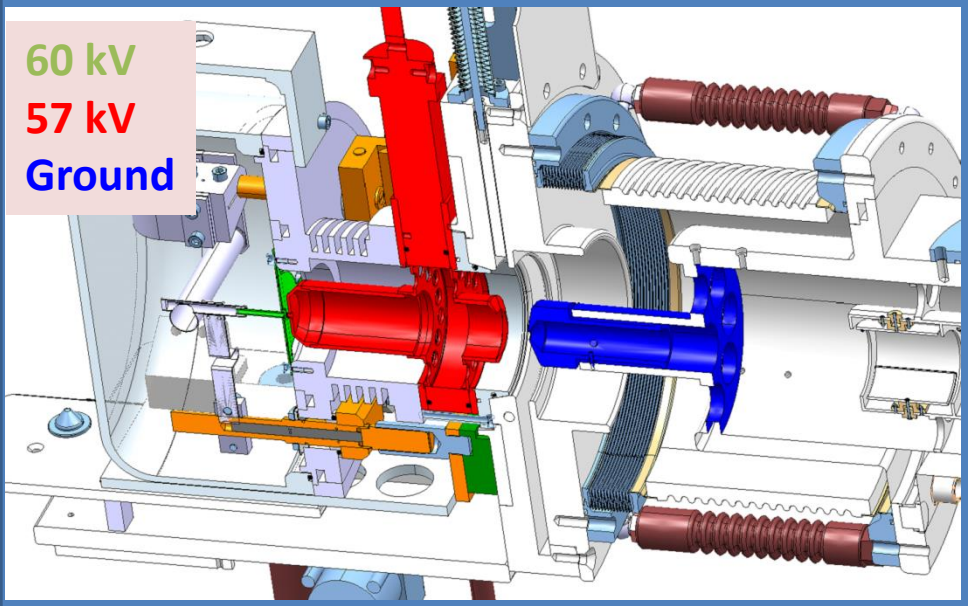
Isolated valve with integrated electrode

Two stage extraction

Few geometrical parameters are studied in order to find an optimum electrode design:

- **Aperture**
- **Acceleration gap**
- **Tip shape**





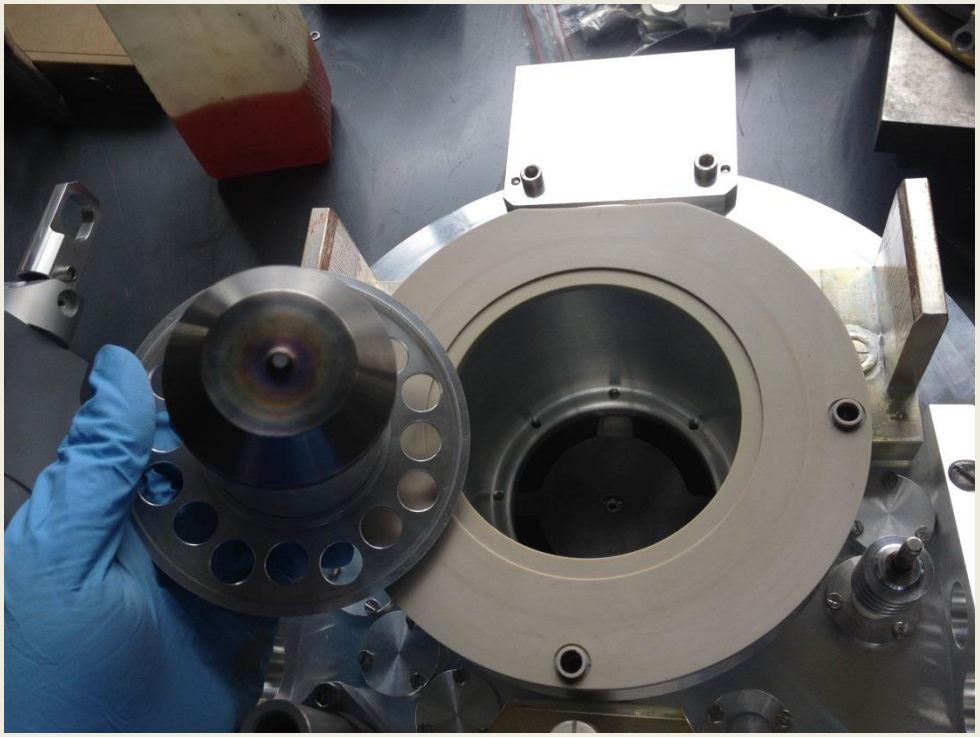
For determining the optimum intermediate electrode configuration:

- **Thermal tests and simulations with ion source @2000°C**
- **HV insulation tests up to 5kV with respect the ion source**
- **Extraction efficiency measurements**
- **Ionized air conductivity measurements**
- **Acceleration gap pressure measurements**

Two stage extraction

Thermal characterization

- Electrical insulation implies also thermal insulation from cooling
- Intermediate voltage means closer gaps
- Electrons can be emitted at high temperature from the electrode…

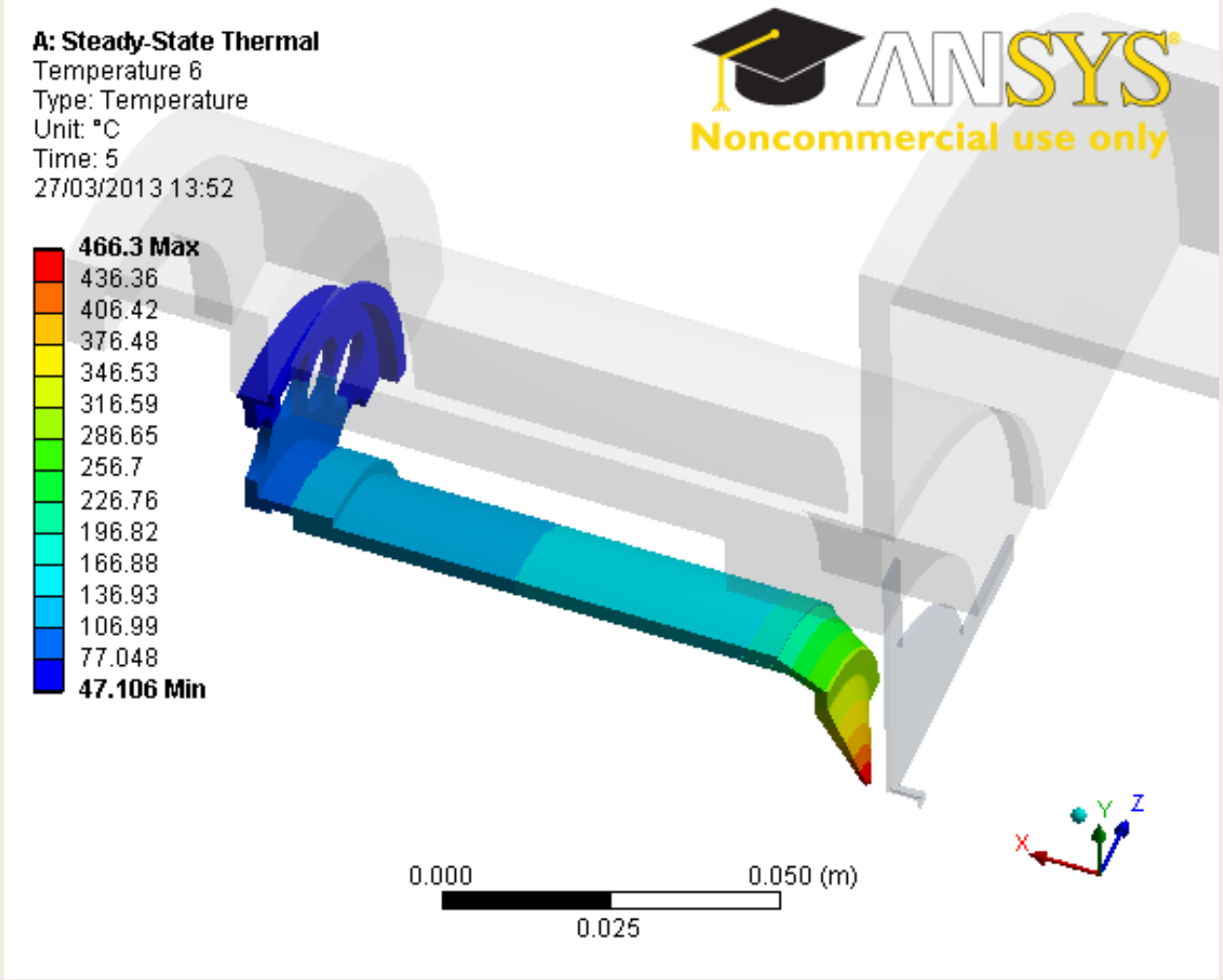


A THERMAL CHARACTERIZATION IS REQUIRED

Two stage extraction

Thermal characterization

Thermal simulations

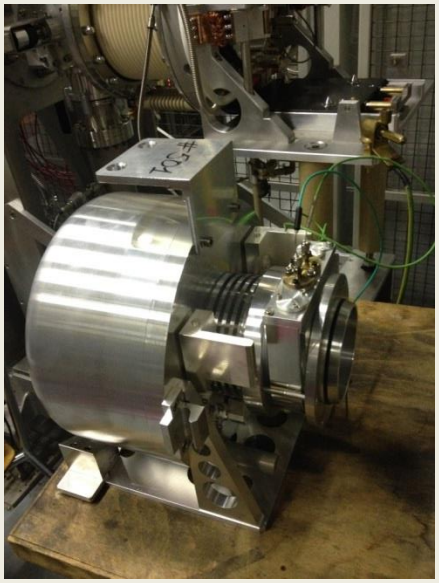


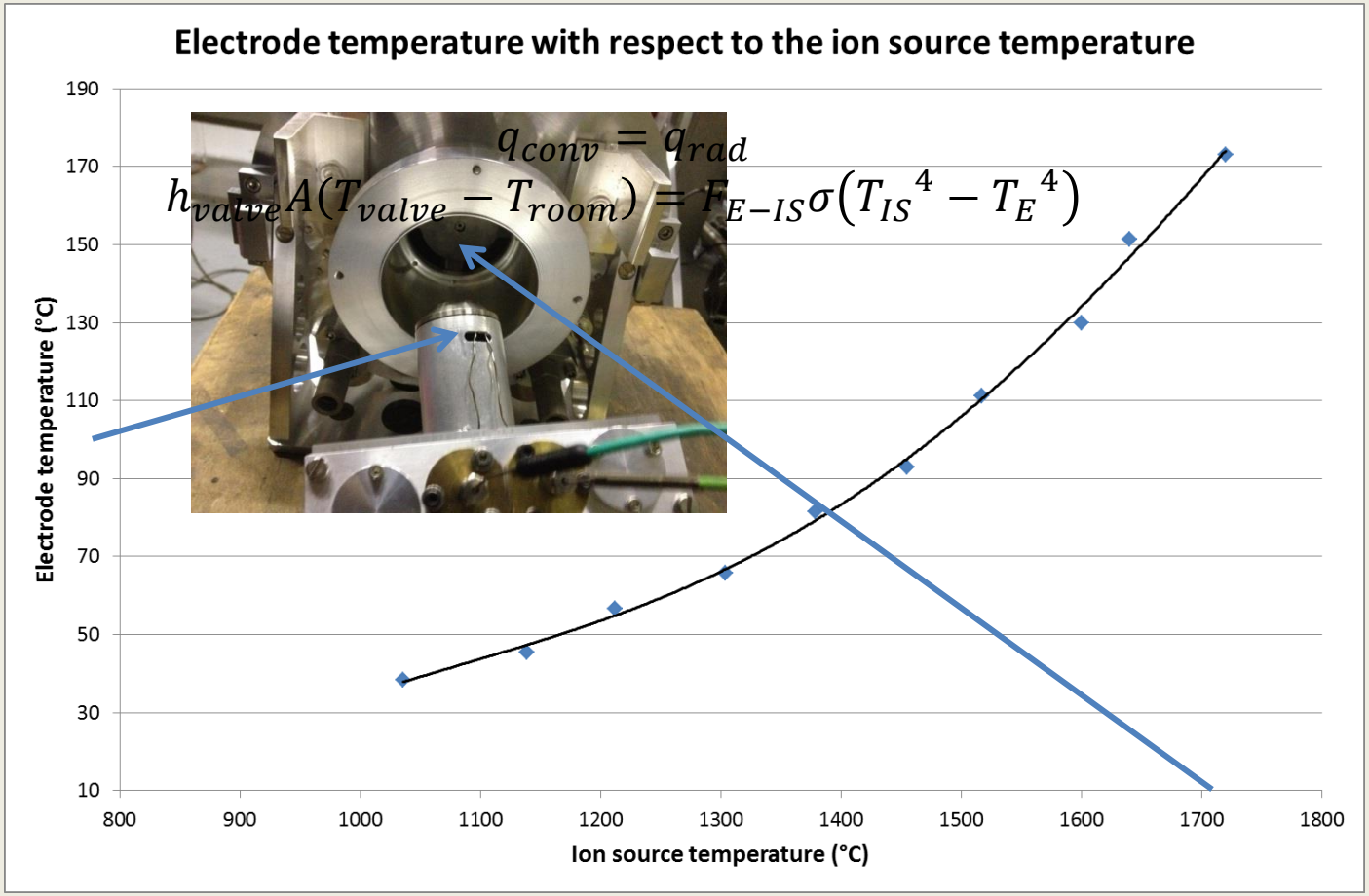
- Ion source simulated at 2000 °C
- Electrode cooled by air convected valve

Two stage extraction

Thermal characterization

Thermal measurements

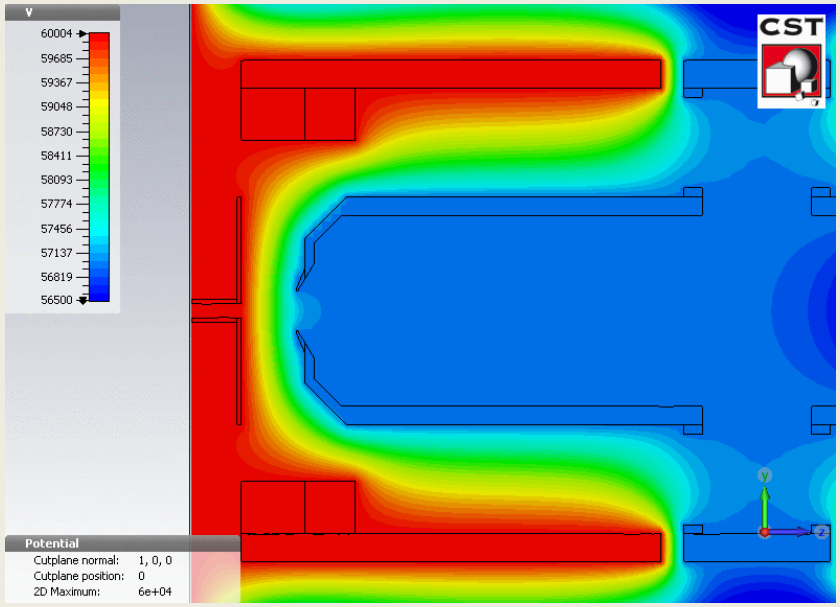


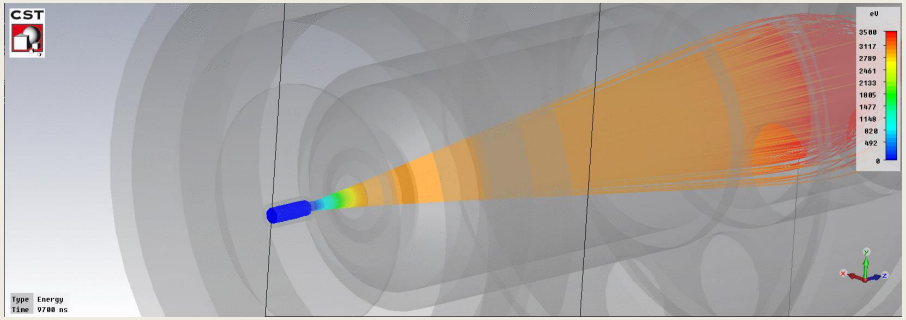


Two stage extraction

Extraction optics

Electrostatic and beam simulations (first gap)



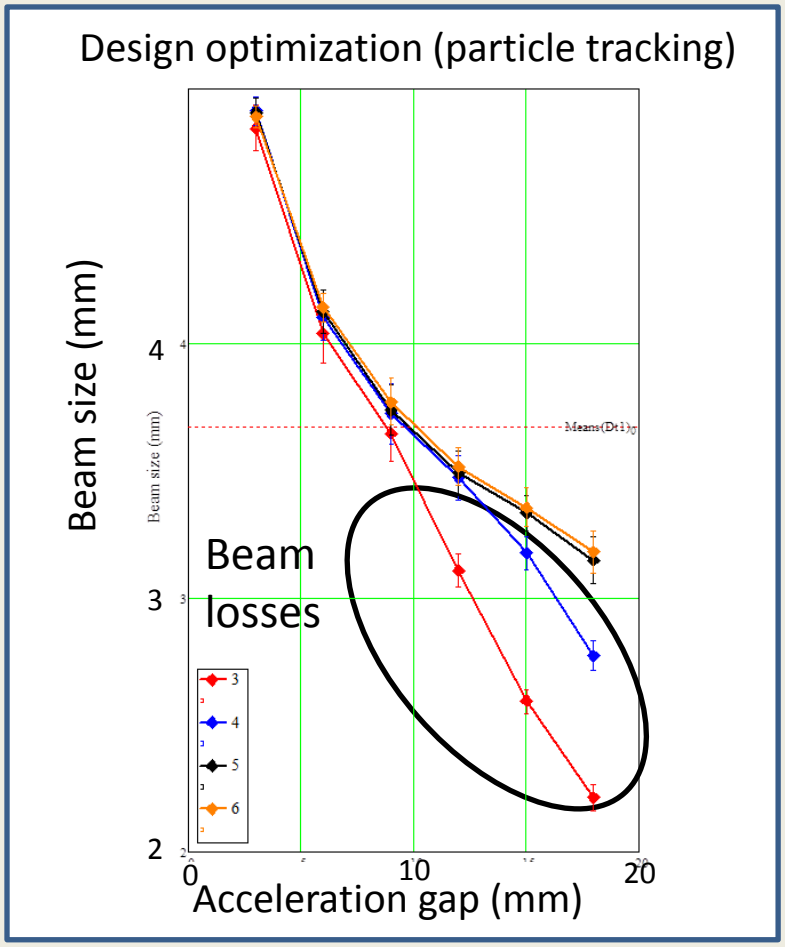


- The particle tracking shows the primary effect of the geometrical parameters over the beam
- Complex phenomena like electron emission, breakdown, realistic particle distribution or scatter due to neutral particles requires experimental measurements

Two stage extraction

Extraction optics

Particle tracking, parameter optimization (first gap)

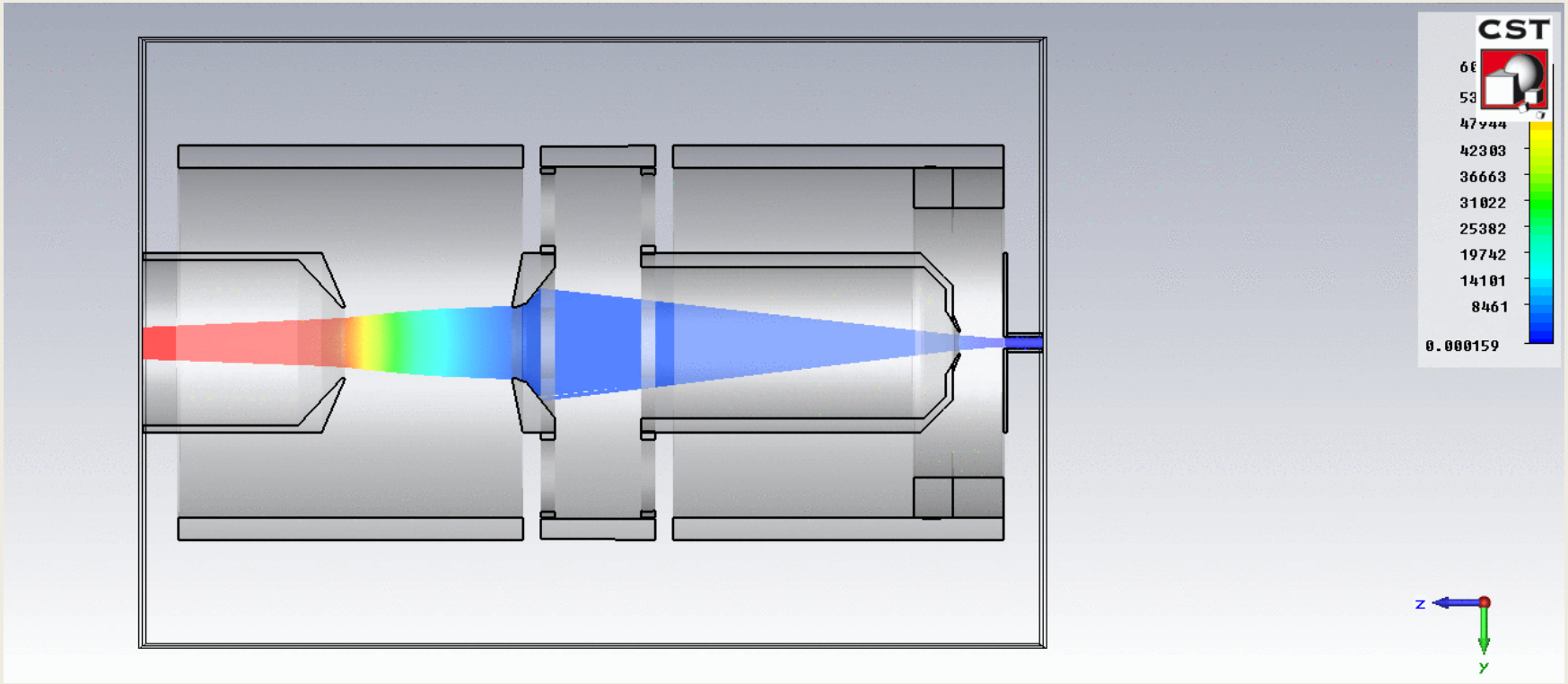


With numerical simulations, some geometrical configurations can be **discarded** for the experimental measurements

Two stage extraction

Extraction optics

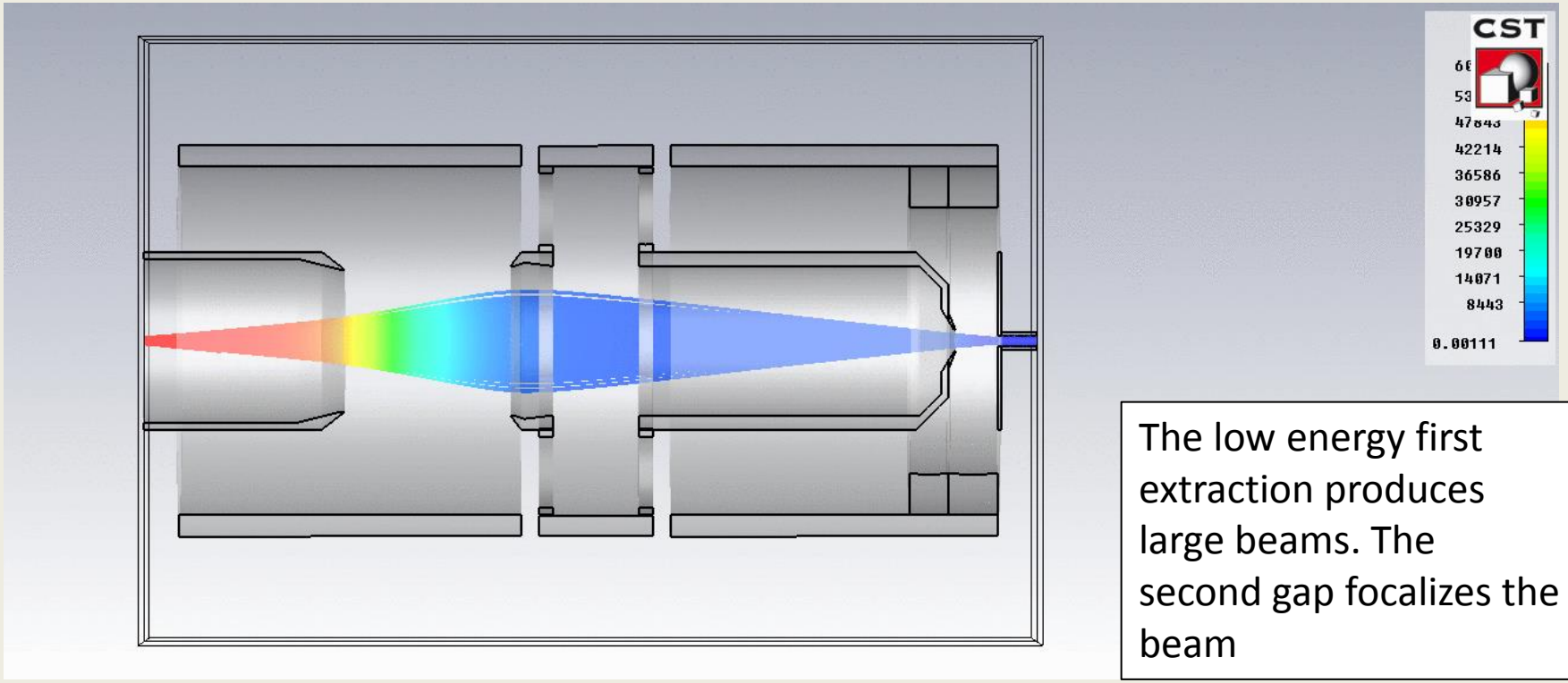
Particle tracking (second gap)



Two stage extraction

Extraction optics

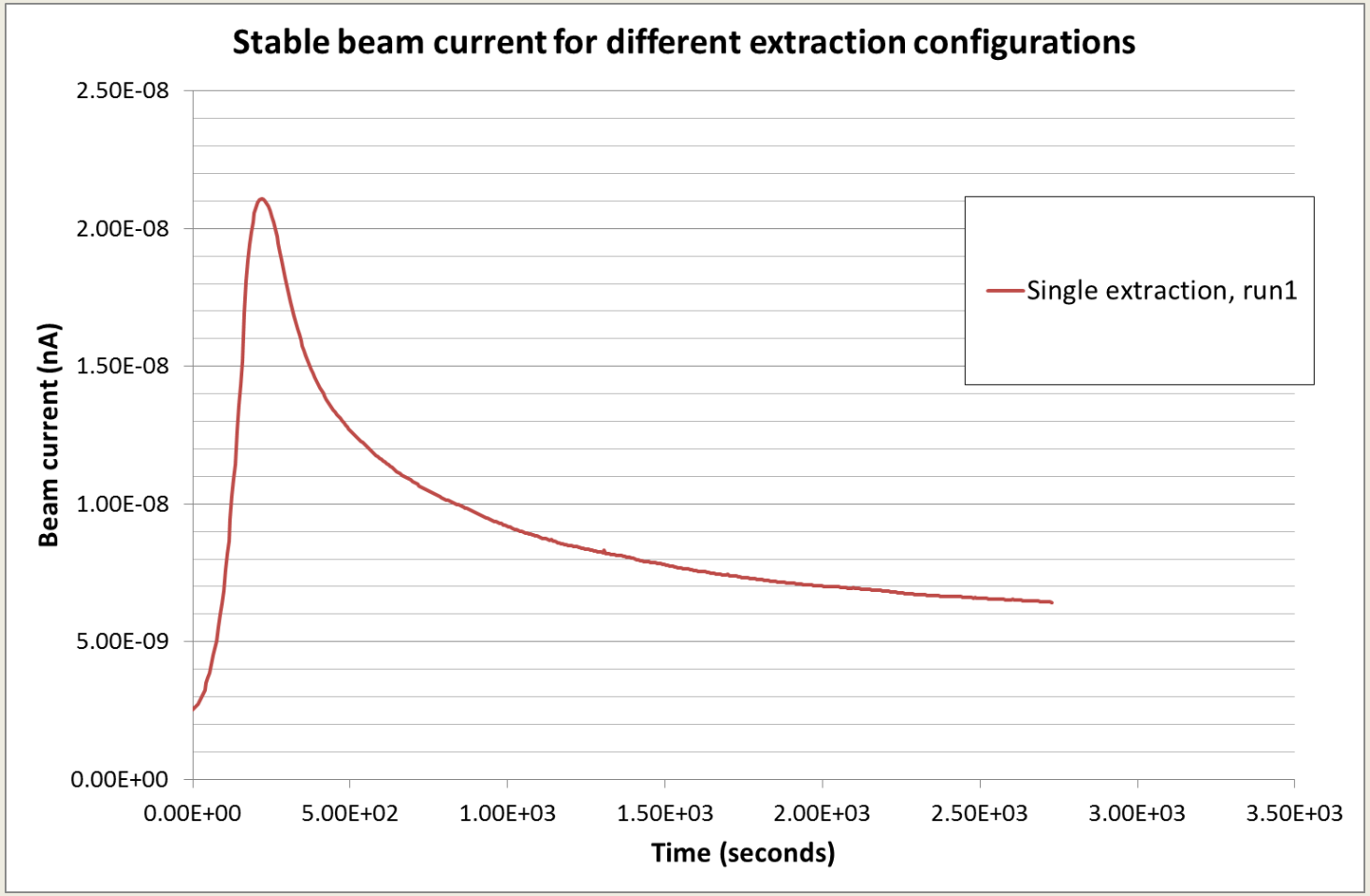
Particle tracking (second gap)



The low energy first extraction produces large beams. The second gap focalizes the beam

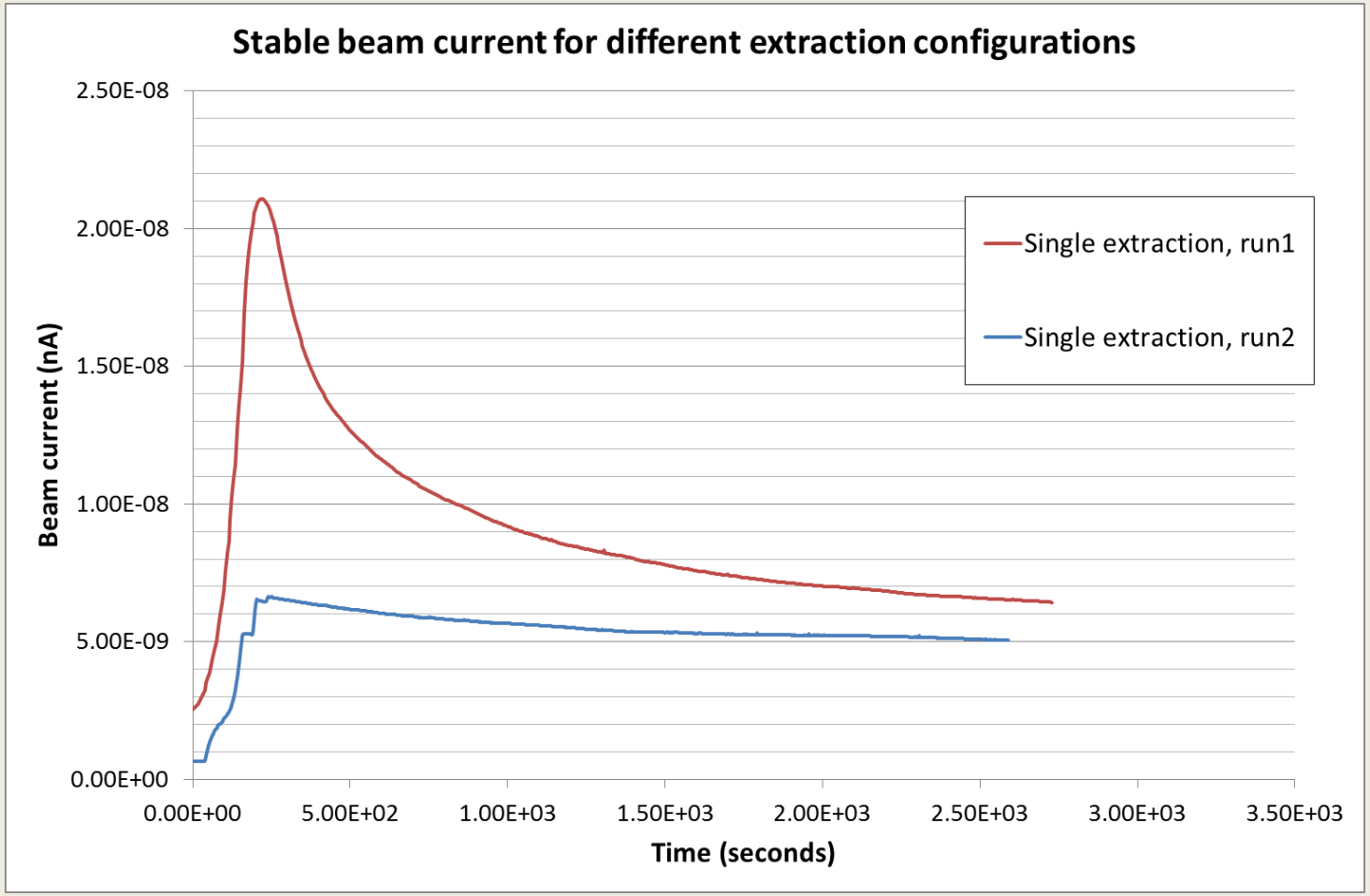
Two stage extraction

Extraction performace measurements



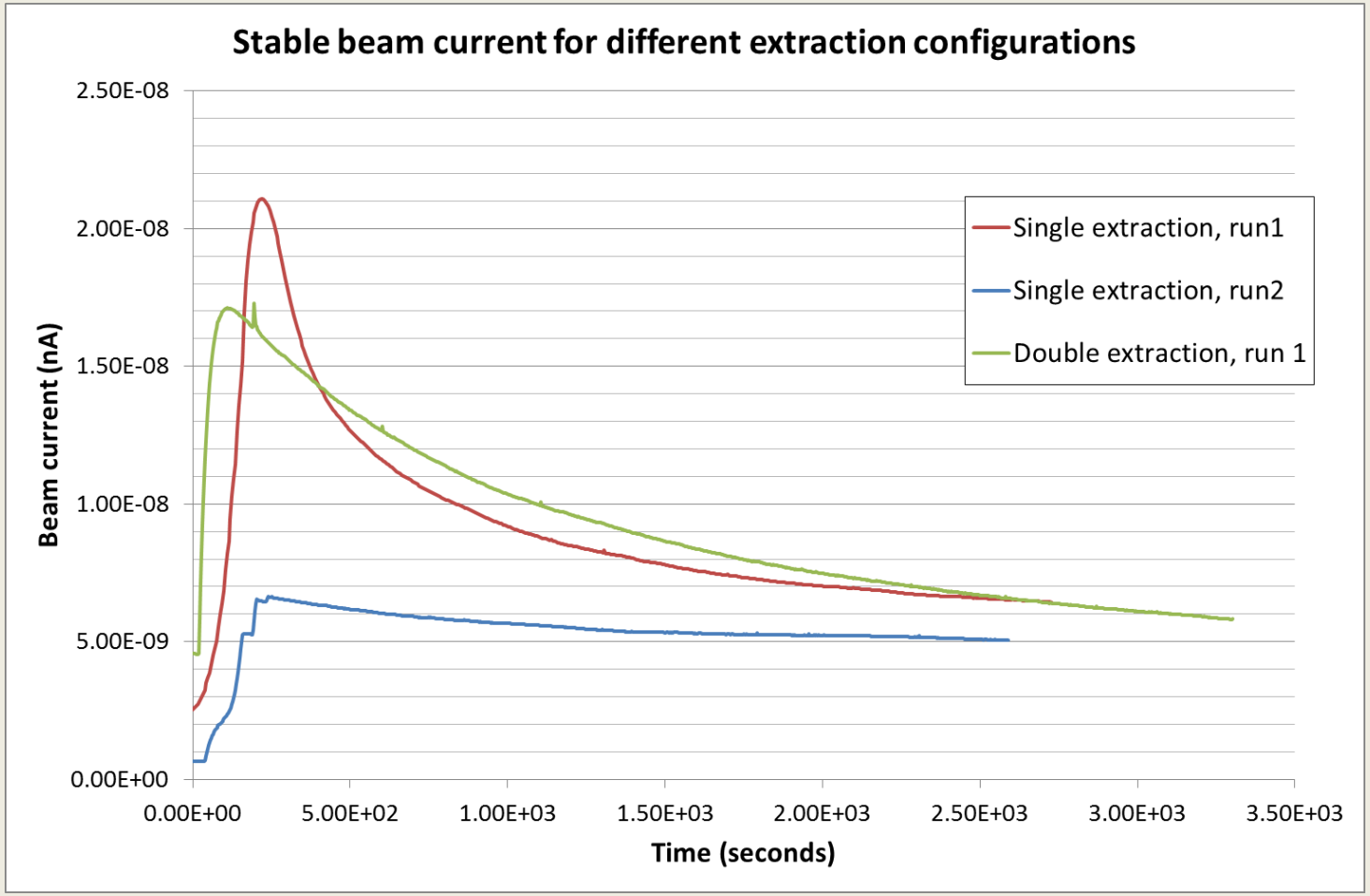
Two stage extraction

Extraction performace measurements



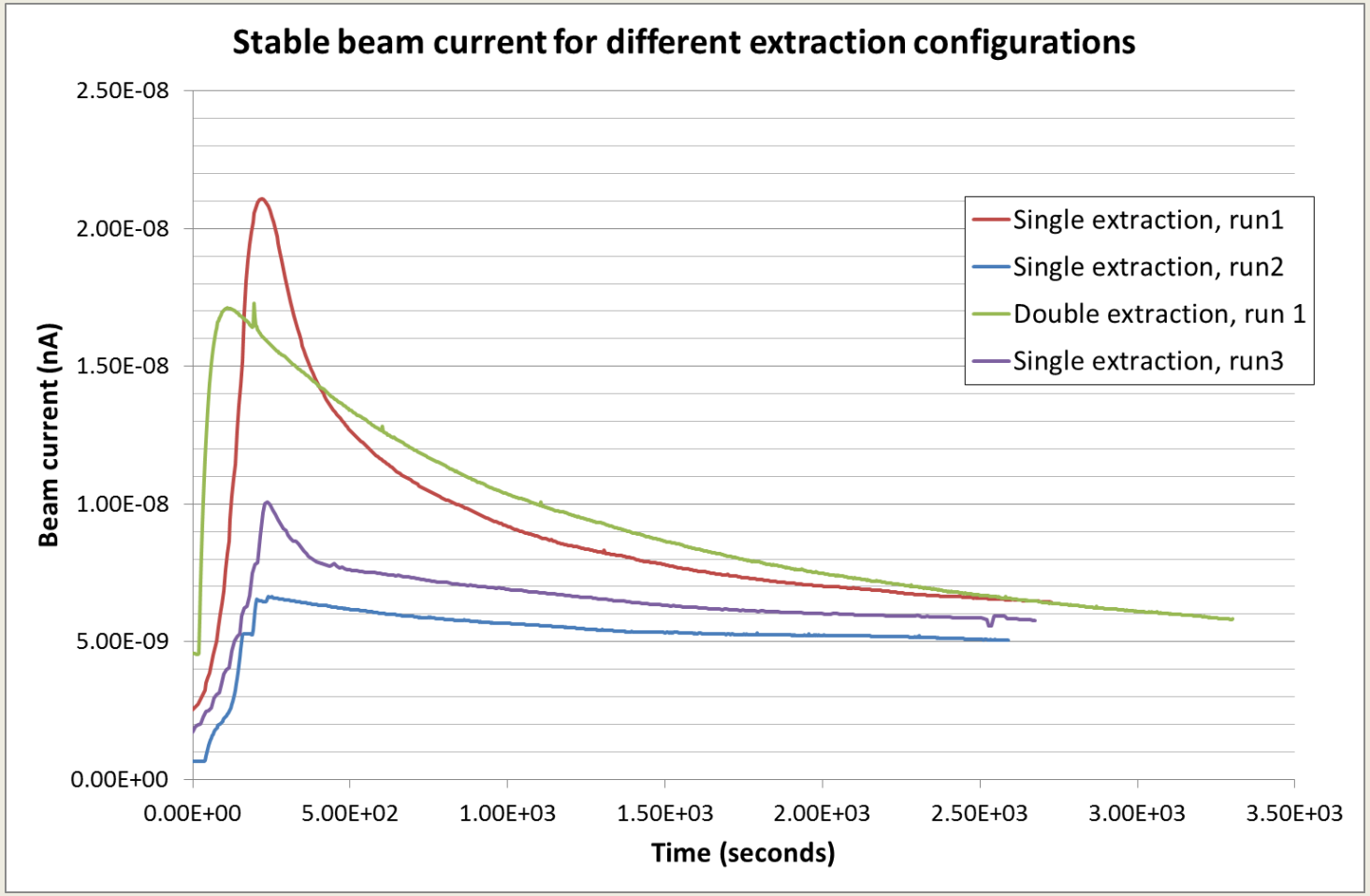
Two stage extraction

Extraction performace measurements

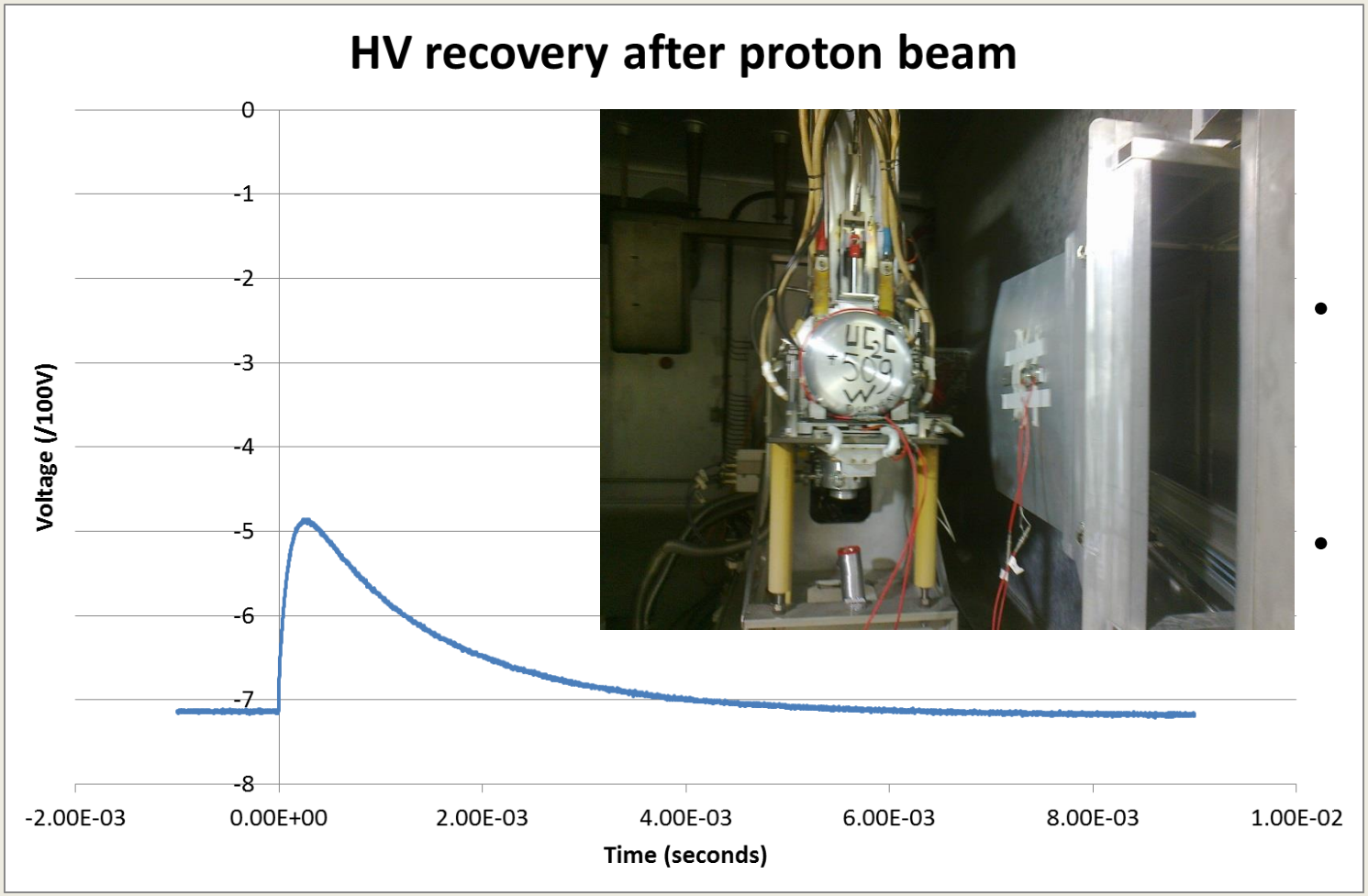


Two stage extraction

Extraction performace measurements



Ionized air conductivity measurement



- Breakdown induced between 0.5 mm gaps
- Electric field threshold measured $< 800V \times mm$

Summary

- For HIE-ISOLDE, a frontend upgrade is required
- A new two stage extraction system has been prototyped and characterized
- A model adapted to be tested online should be produced

Many thanks!

Questions?