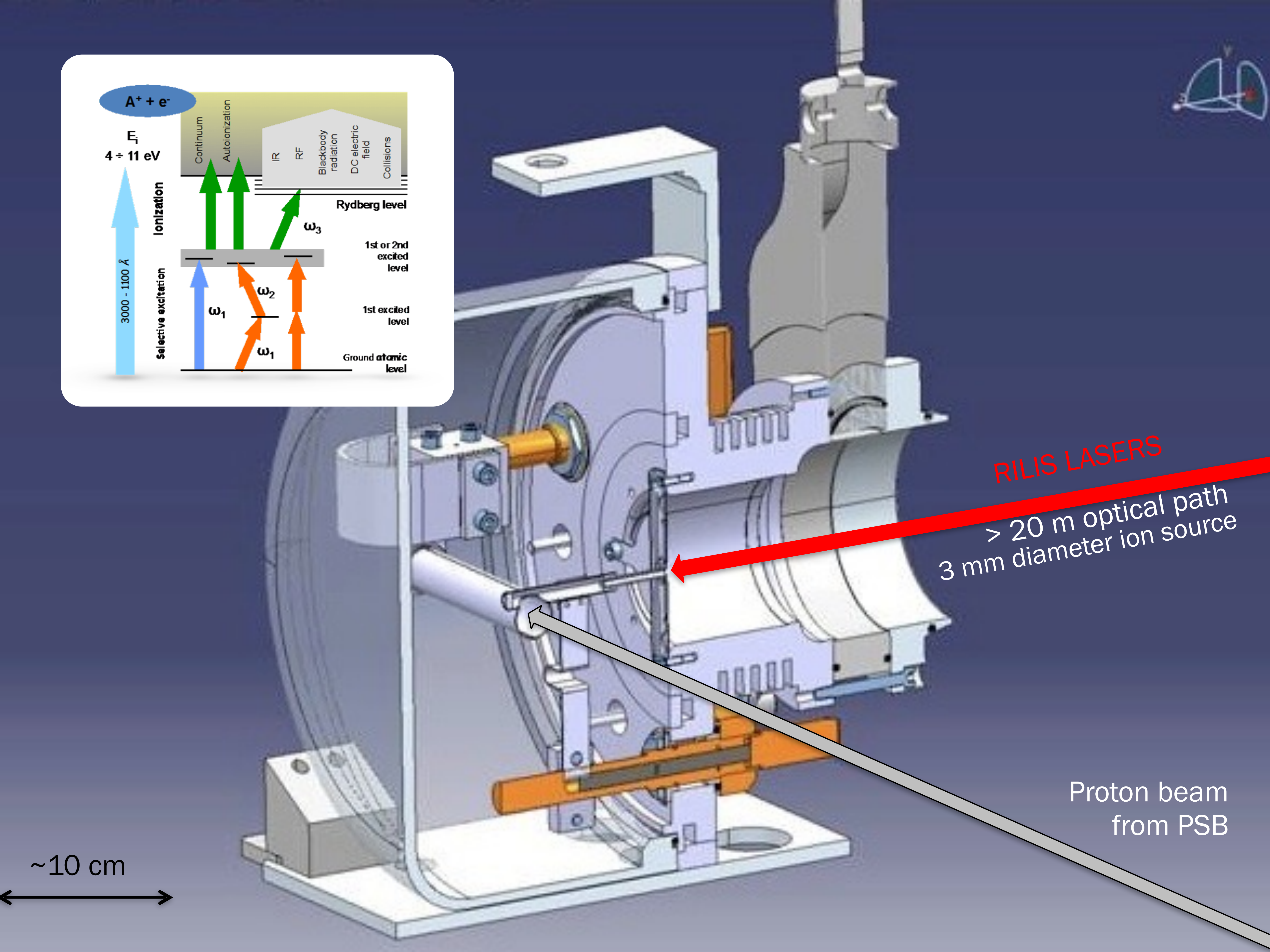
ECOS-EURISOL Town Meeting

IPN Orsay, 30 October 2014

The application of laser resonance ionization inside FEBIAD-type ion sources for ISOL facilities.

Bruce Marsh, *CERN EN-STI-LP*

EN STI

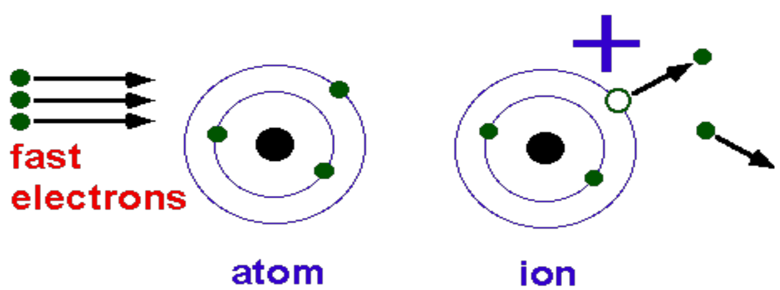


A+ + e-
Ei
4 ÷ 11 eV
3000 - 1100 Å
Ionization
Selective excitation
Continuum
Autoionization
IR
RF
Blackbody radiation
DC electric field
Collisions
Rydberg level
ω3
1st or 2nd excited level
ω2
ω1
1st excited level
ω1
Ground atomic level
RILIS LASERS
> 20 m optical path
3 mm diameter ion source
Proton beam from PSB
~10 cm

Drawbacks of hot-cavity laser ion sources

- Surface ionized contamination
  - *long standing issue but no universal solution has been found*
- Limited ion capacity (~ 1 uA)
  - *possible issue for EURISOL, ISOL@MYRRHA etc.*
- Not currently suitable for liquid targets
- Limited scope for non-standard RILIS applications

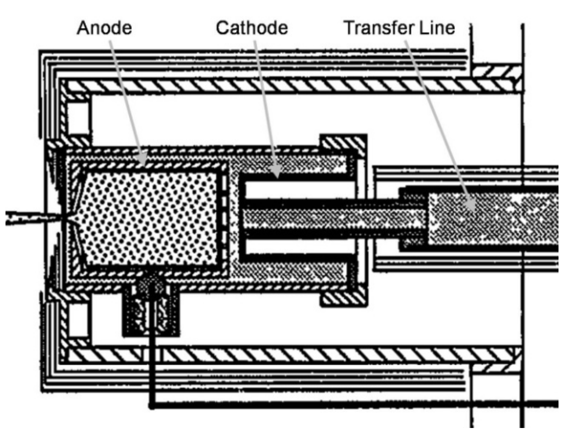
Using a FEBIAD as a laser/atom interaction region

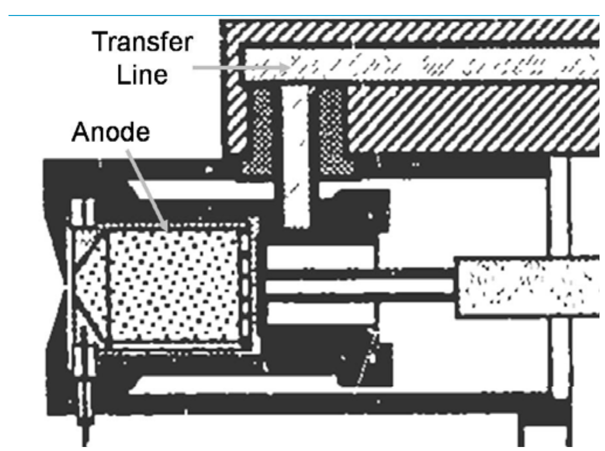


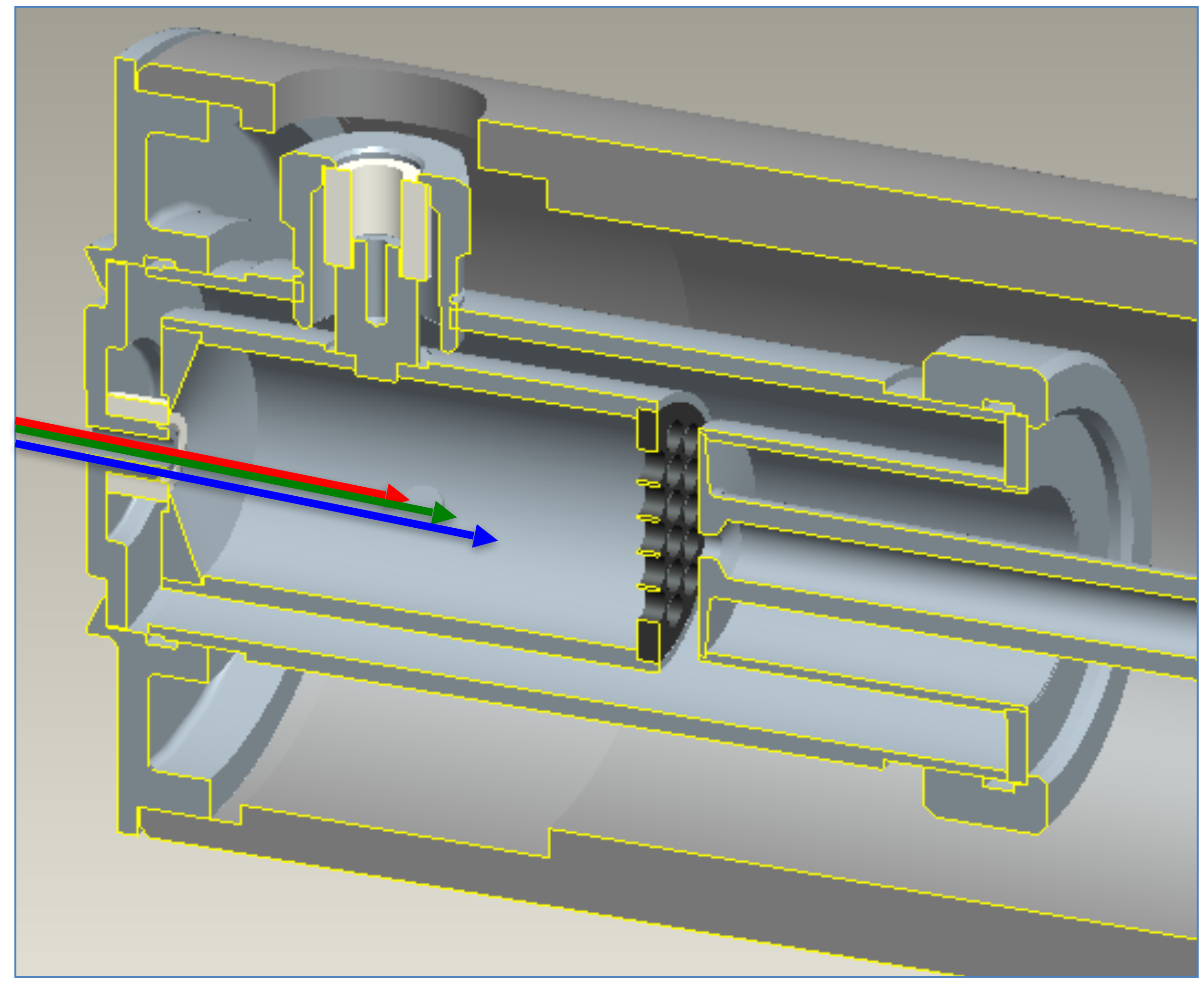
- Normally used for non surface-ionizing elements
- Ar or Xe plasma with 130 eV electrons

FEBIAD series:

MK5 and **MK7**







3D VADIS drawing taken from Alberto Andrighetto's talk

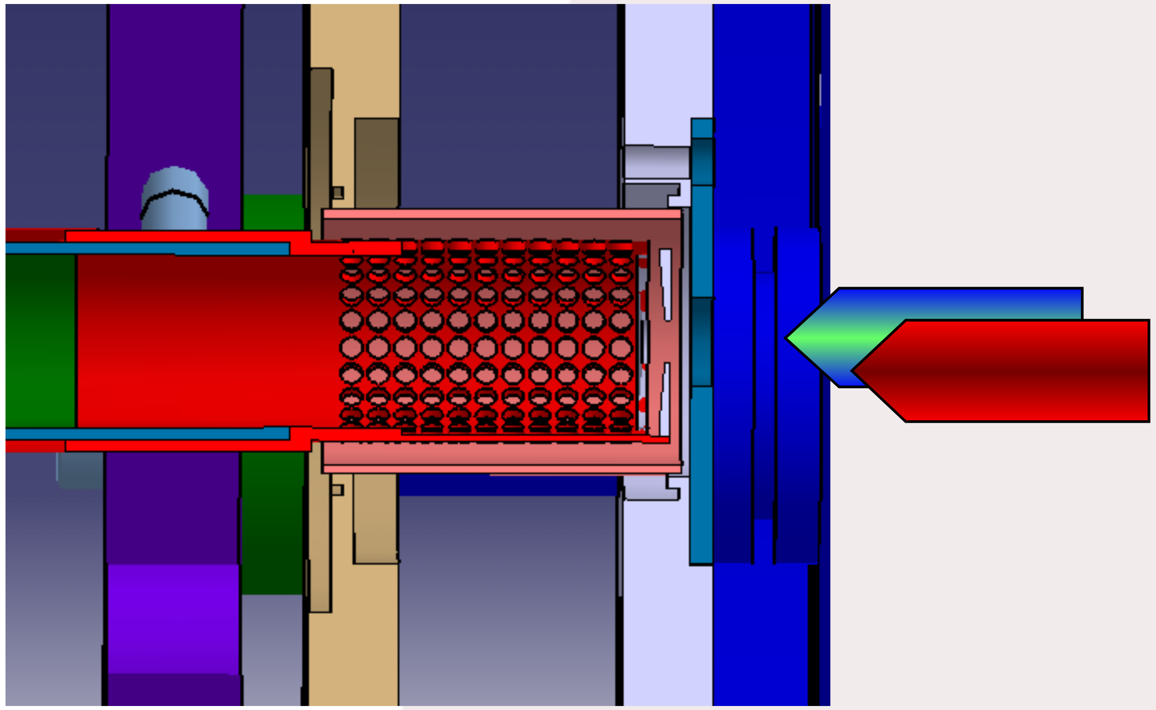
Cathi Meeting Sept '14

VADIS series:

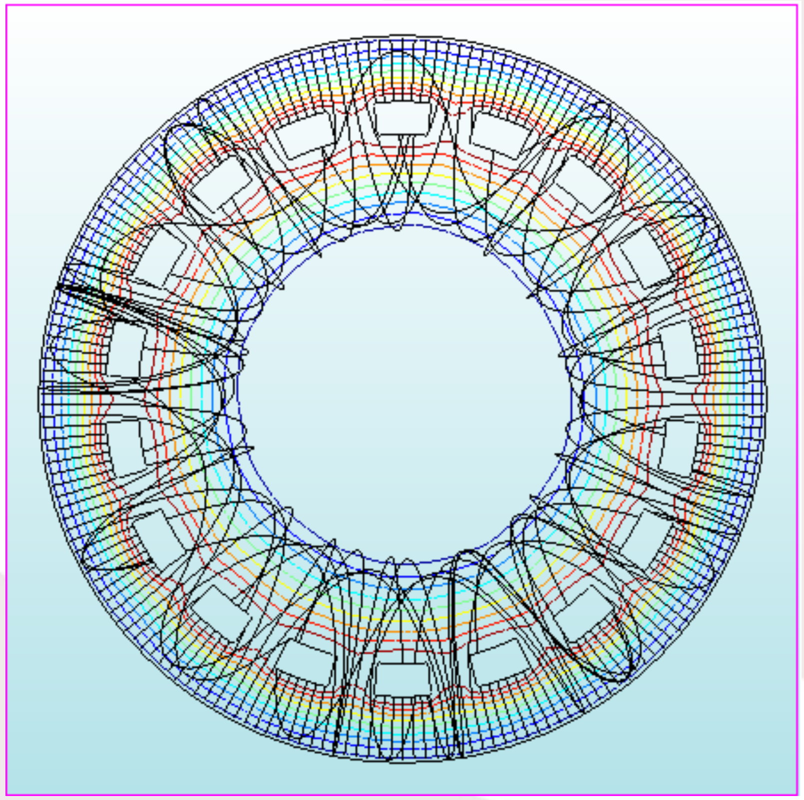
VD5 is identical to MK5 FEBIAD

but with **Mo** components to reduce contaminants

WP1: coupling of the IRENA radial-FEBIAD device and the laser ion source



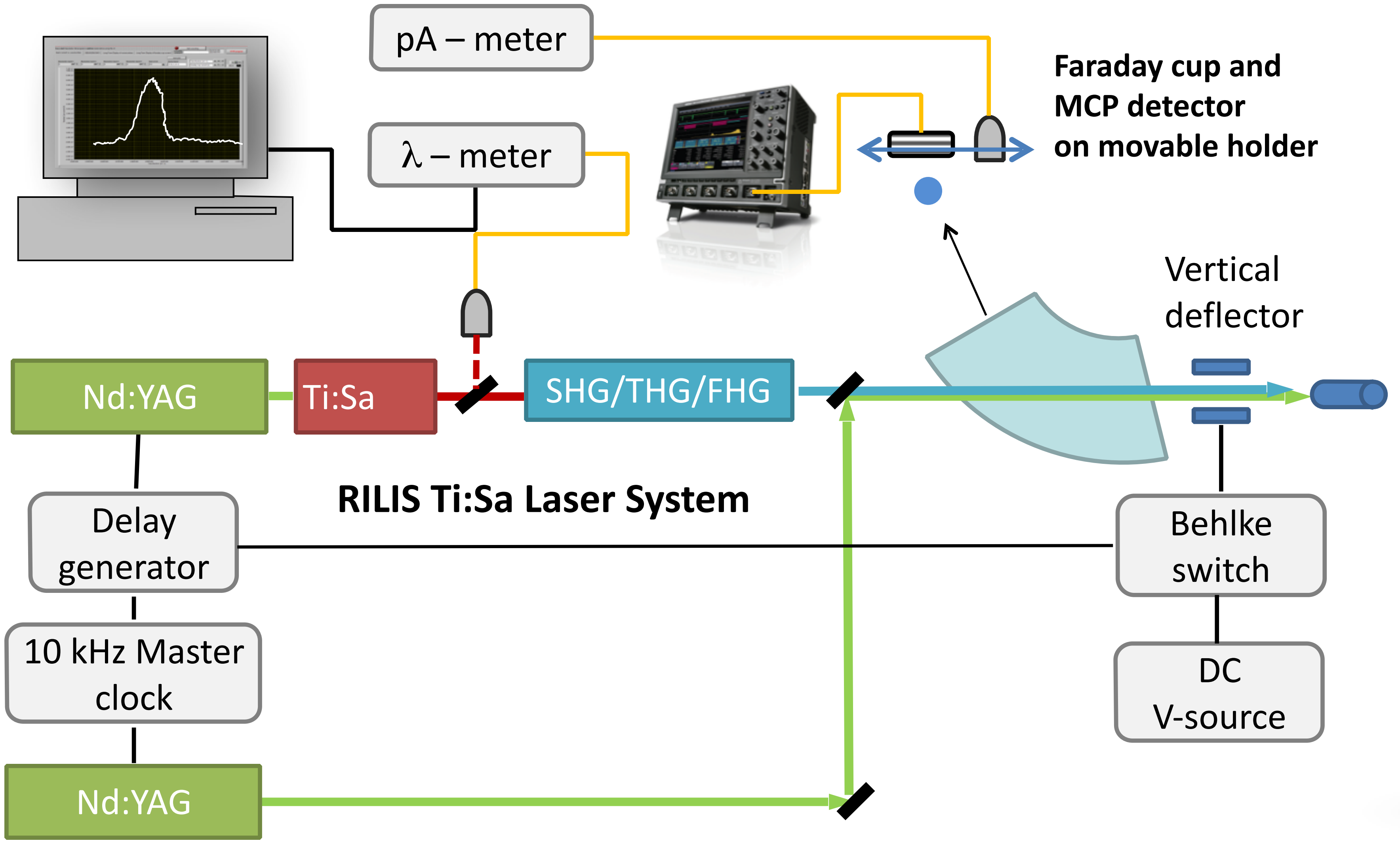
Partners	Requested budget	Responsable Labo
CERN	0 k€	B. Marsh
IFJ (Poland)	25 k€	R. Misiak
IPNO	210 k€	C. Lau
LNL-INFN	60 k€	A. Andrighetto
SLCJ (Poland)	25 k€	J. Choinski

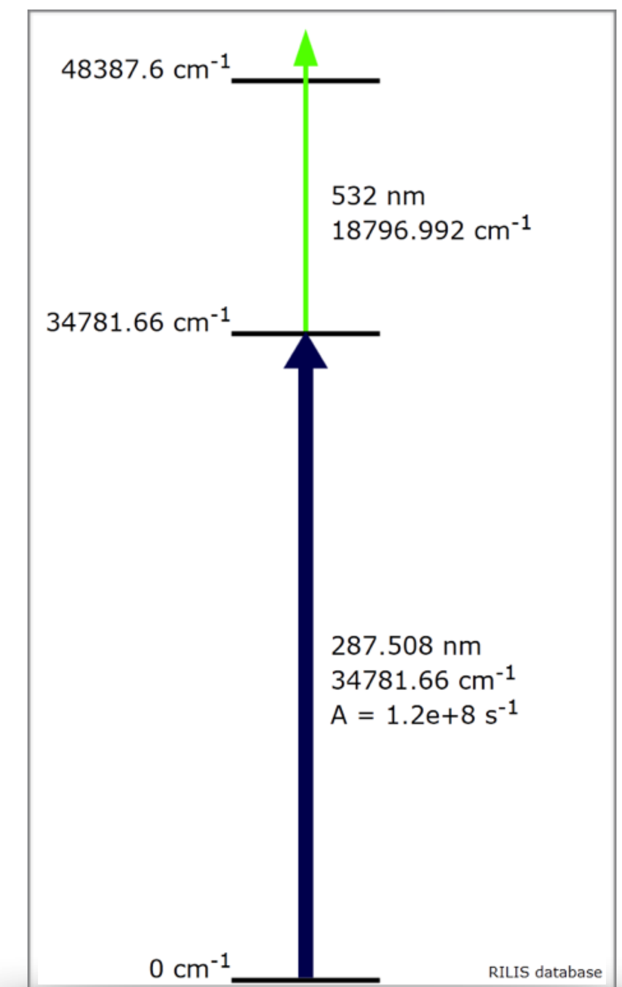


Work Package
Project coordination
WP1: IRENA device for the RILIS
WP2: Beam extraction
WP3: Physicochemical alteration
WP4: Material for selective regulation

C. Lau et al., EURISOL-NET, CERN 27 June 2011

RILIS R&D setup at ISOLDE off-line separator

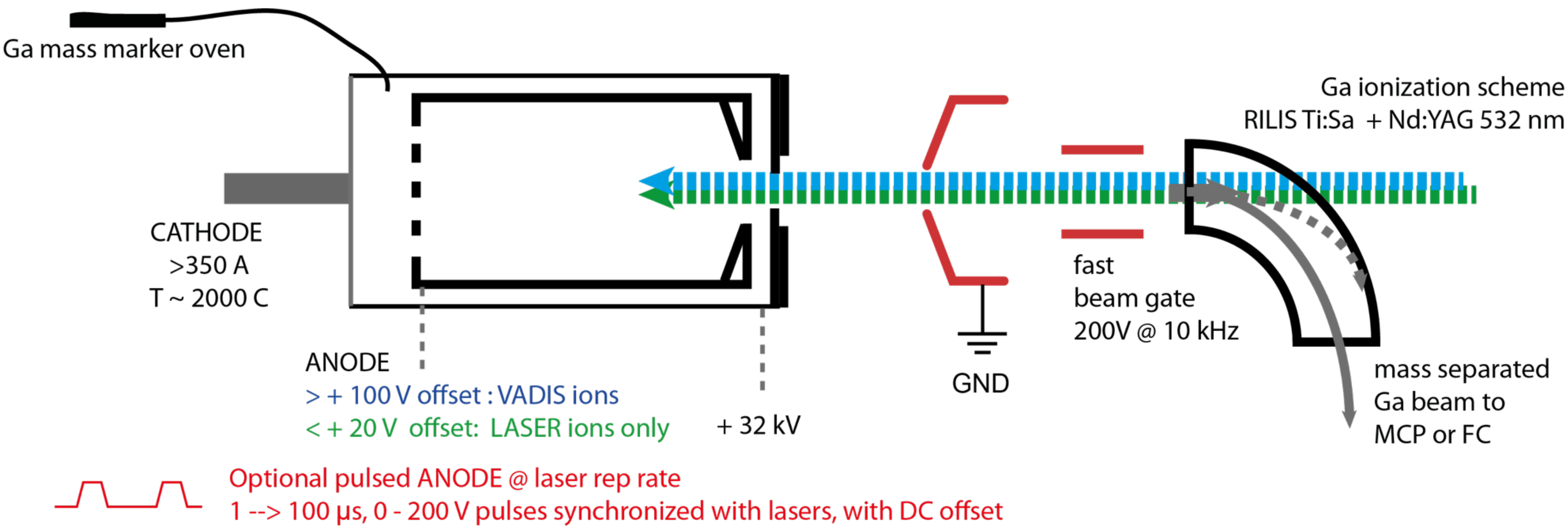




Ionization scheme for gallium

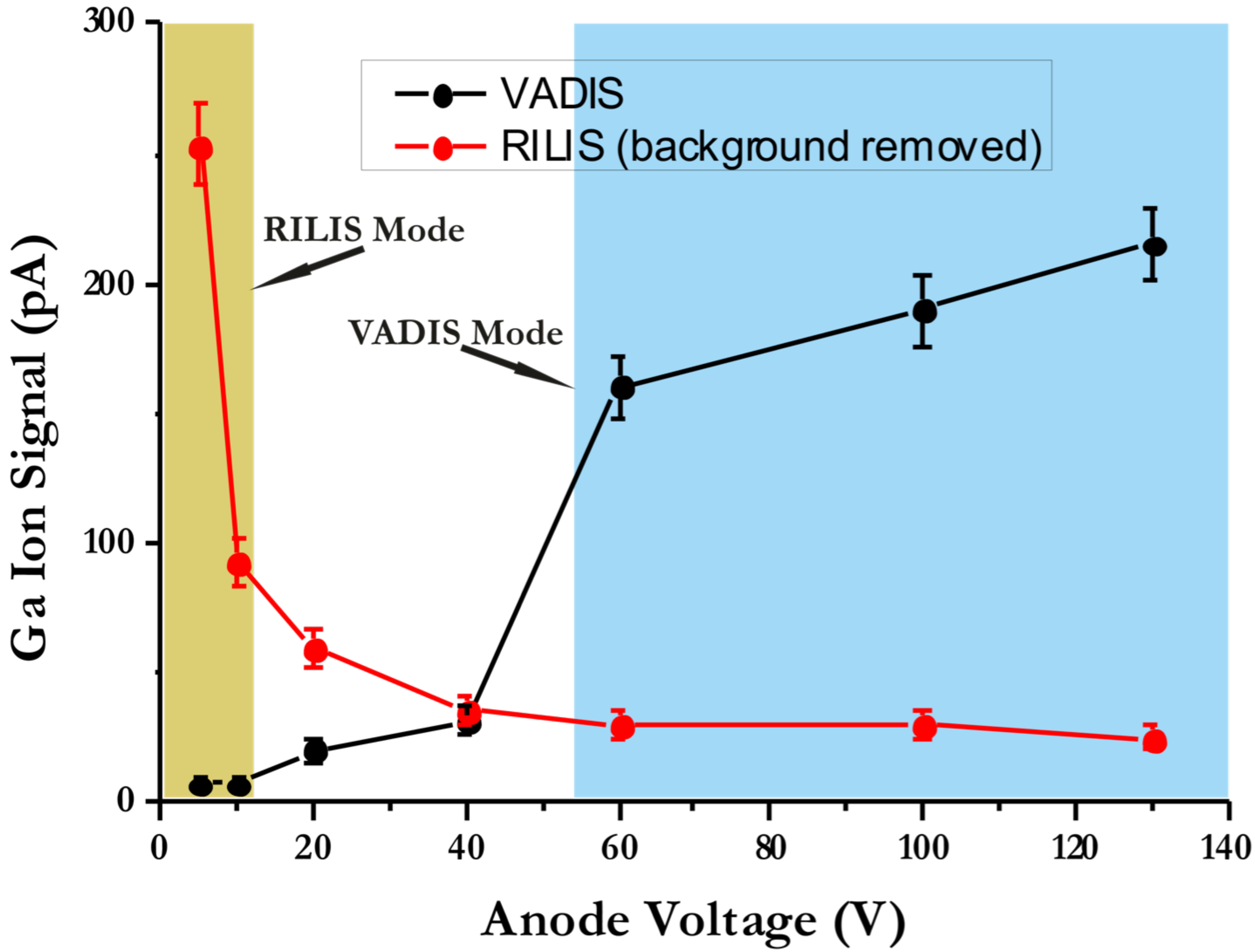
First Off-line test

Modified (2.5 mm diameter entrance aperture) VADIS + Ga mass marker

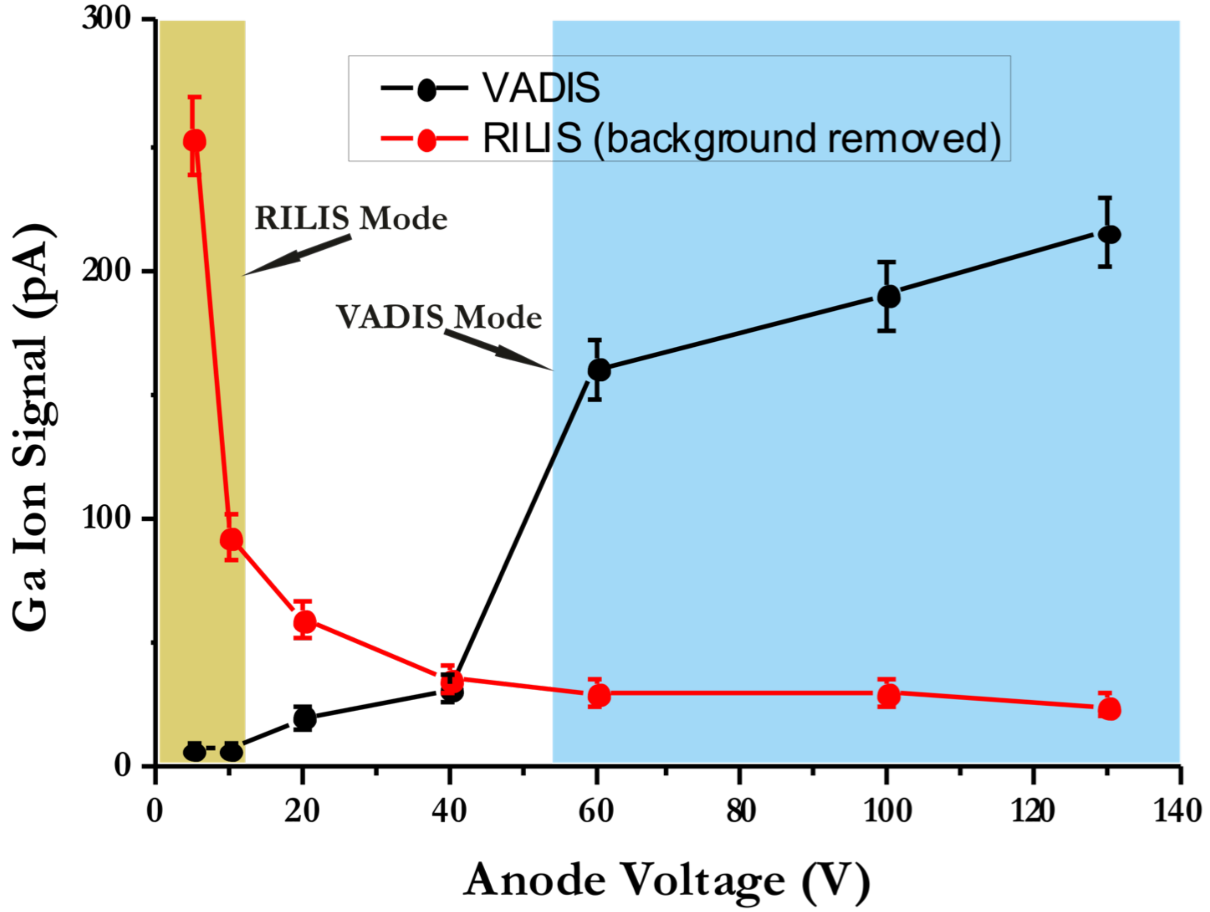


Tom Day Goodacre (CERN, Manchester) – PhD work

1) RILIS efficiency is comparable to VADIS efficiency

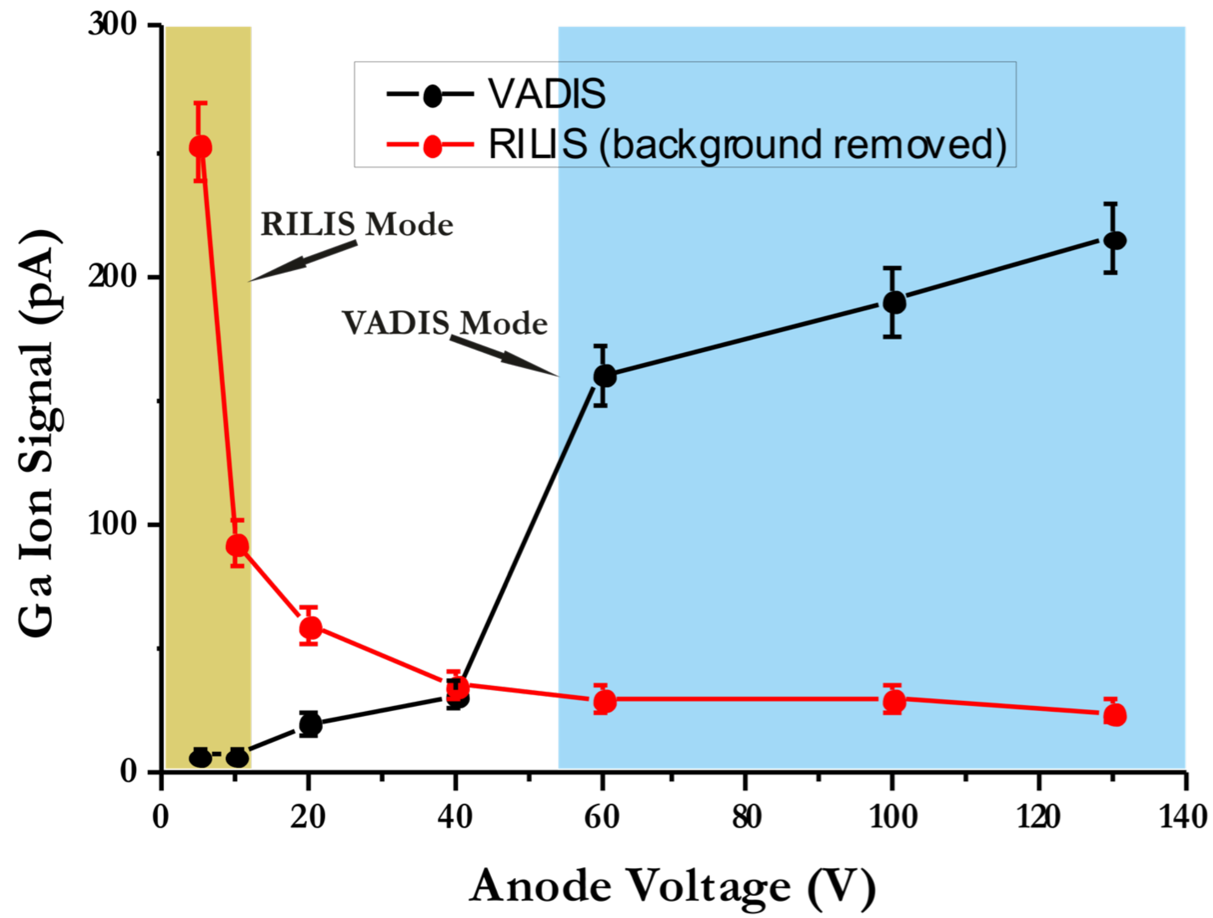


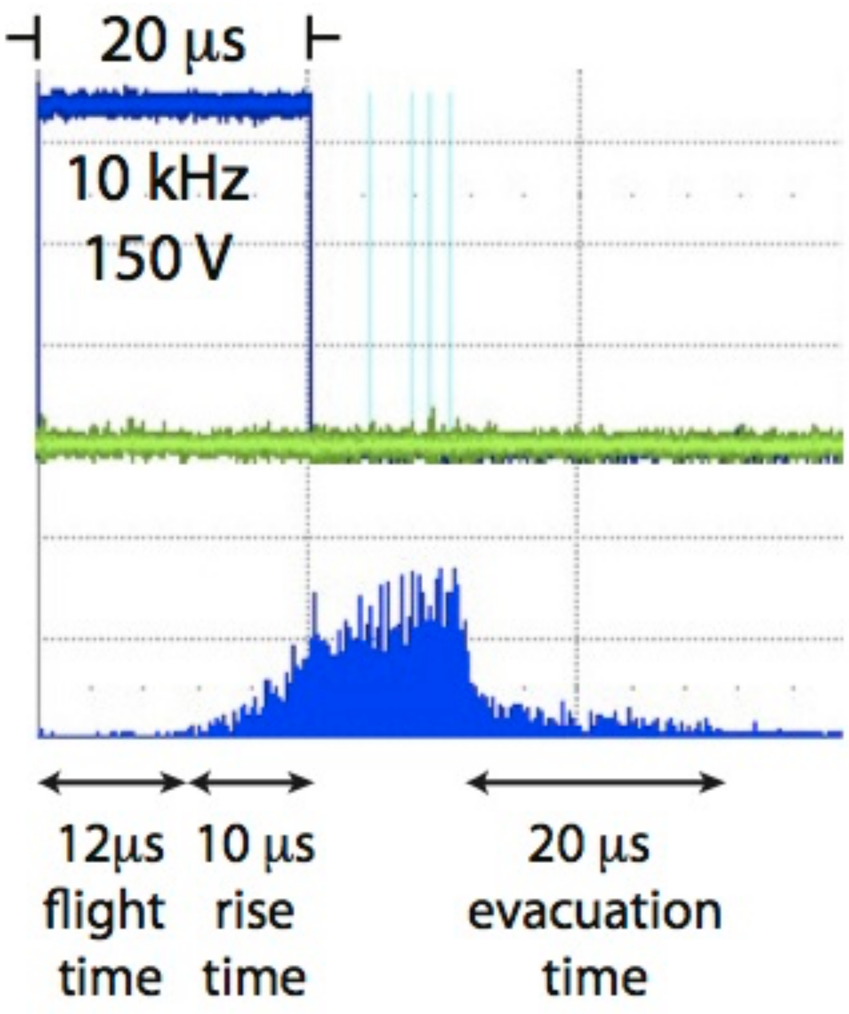
2) FAST switching between RILIS / VADIS modes



2) FAST switching between RILIS / VADIS modes

Laser pulse repetition rate of 10 kHz!





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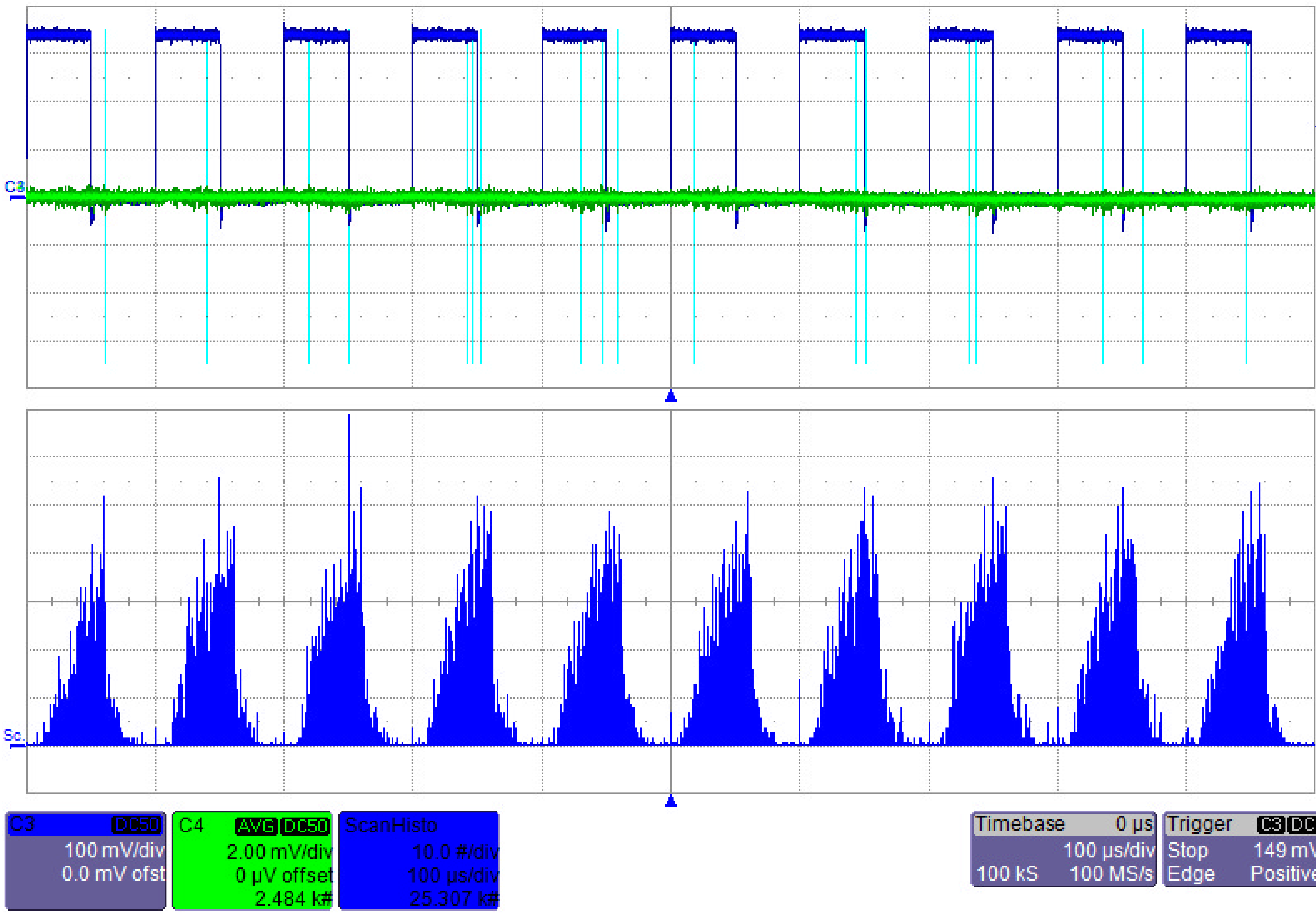
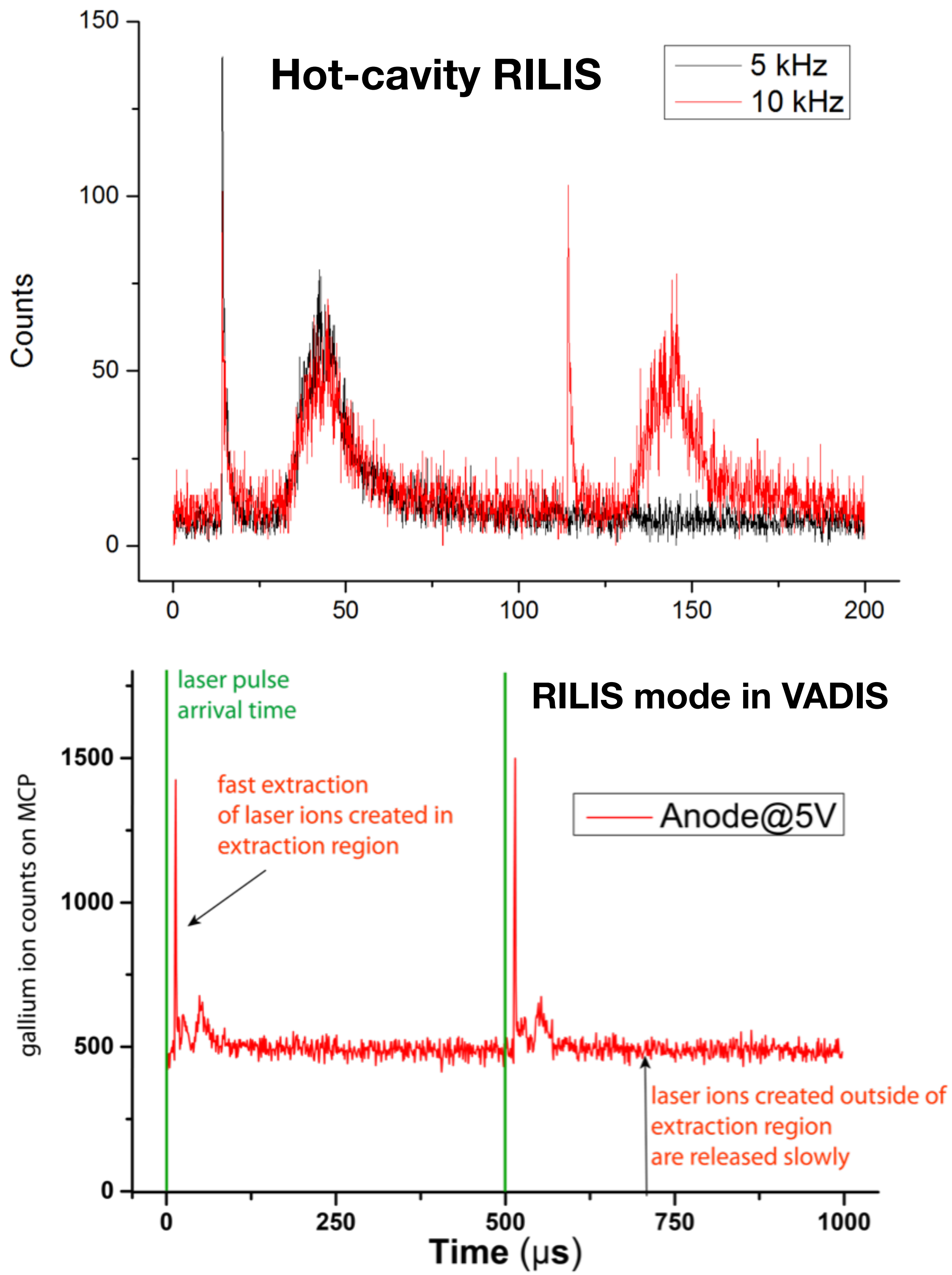


3) Long residence time of ions wrt. hot cavity

Modified VADIS + Ga mass marker



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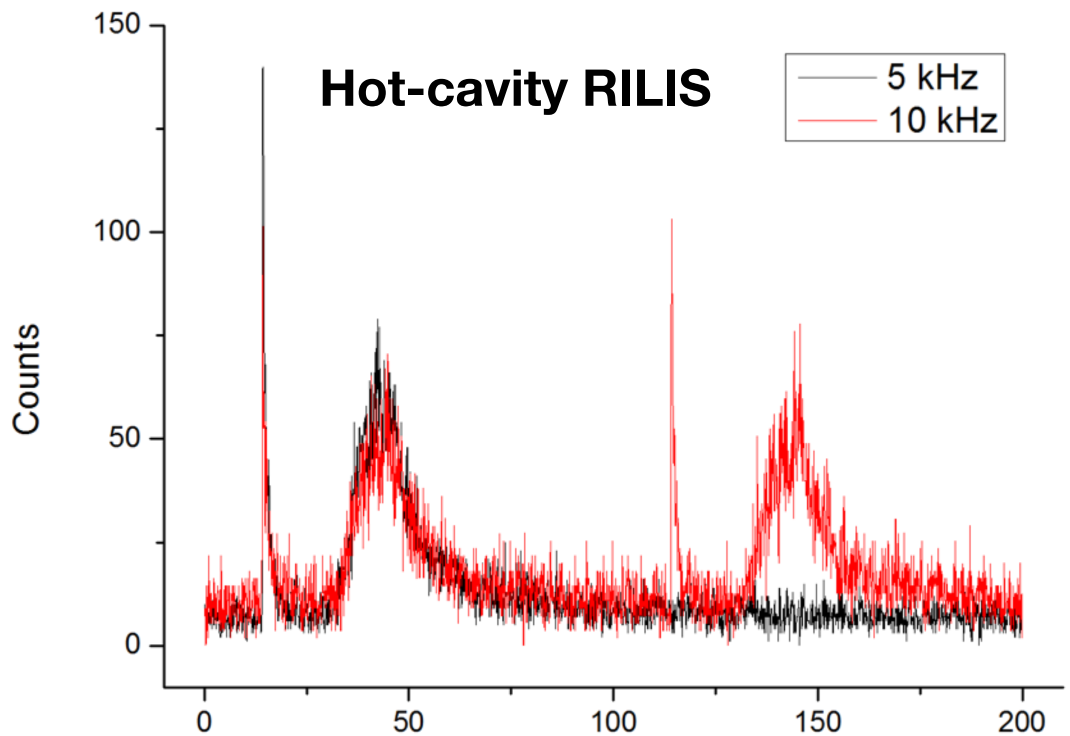

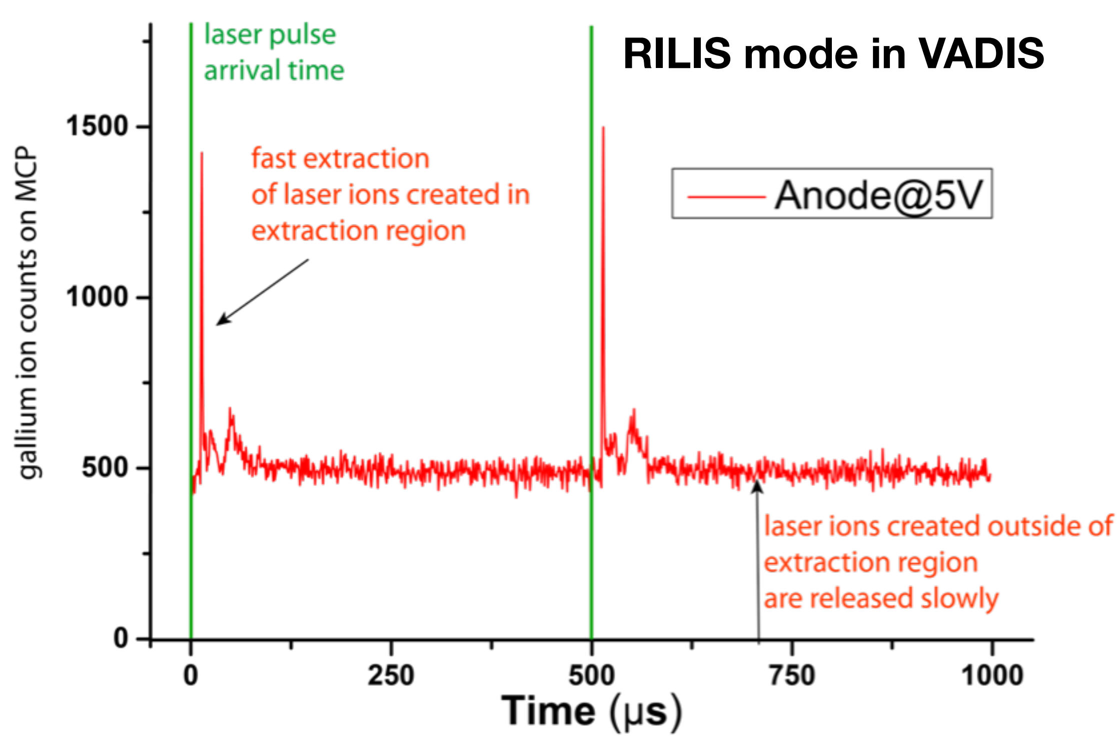

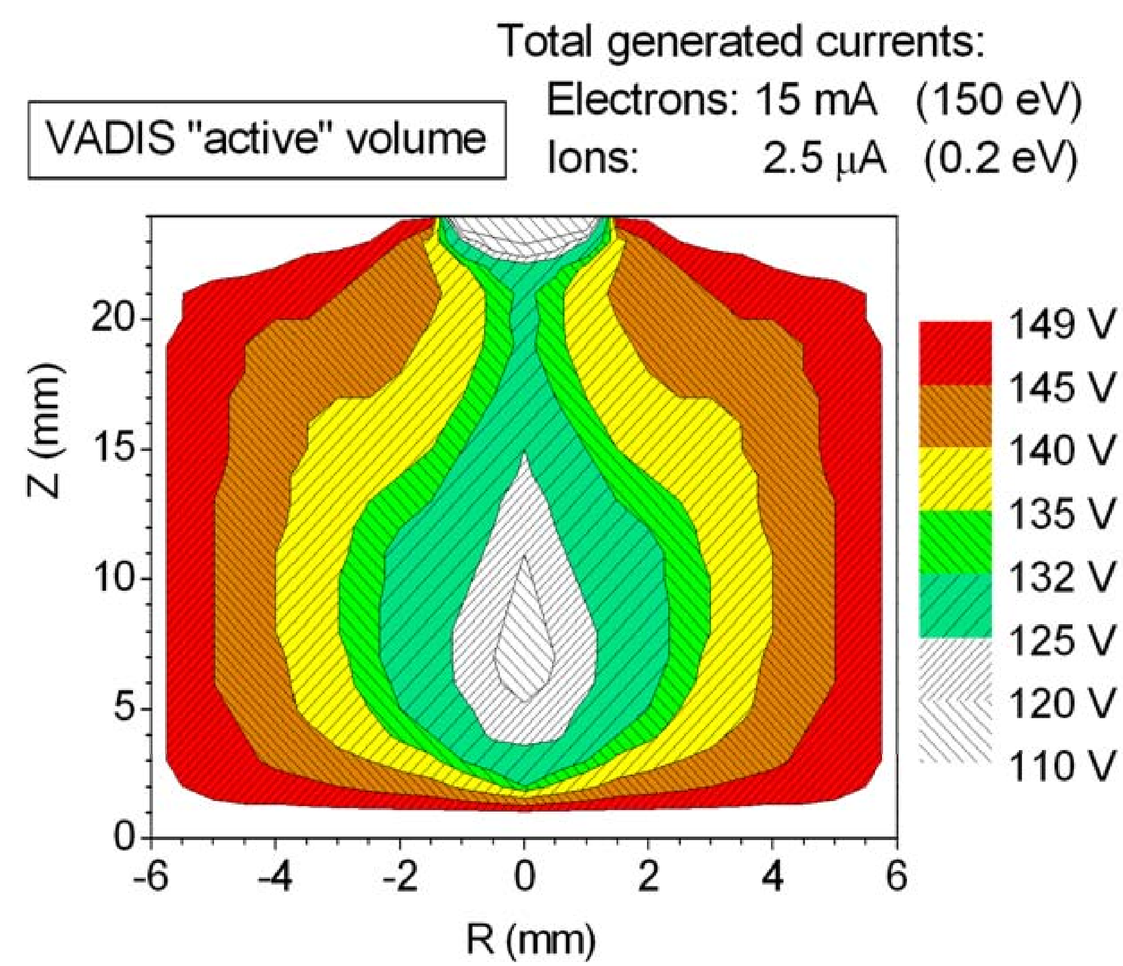

AIP Review of Scientific Instruments

Development of high efficiency Versatile Arc Discharge Ion Source at CERN ISOLDE

L. Penescu, R. Catherall, J. Lettry, and T. Stora

Citation: Rev. Sci. Instrum. **81**, 02A906 (2010); doi: 10.1063/1.3271245

View online: http://dx.doi.org/10.1063/1.3271245

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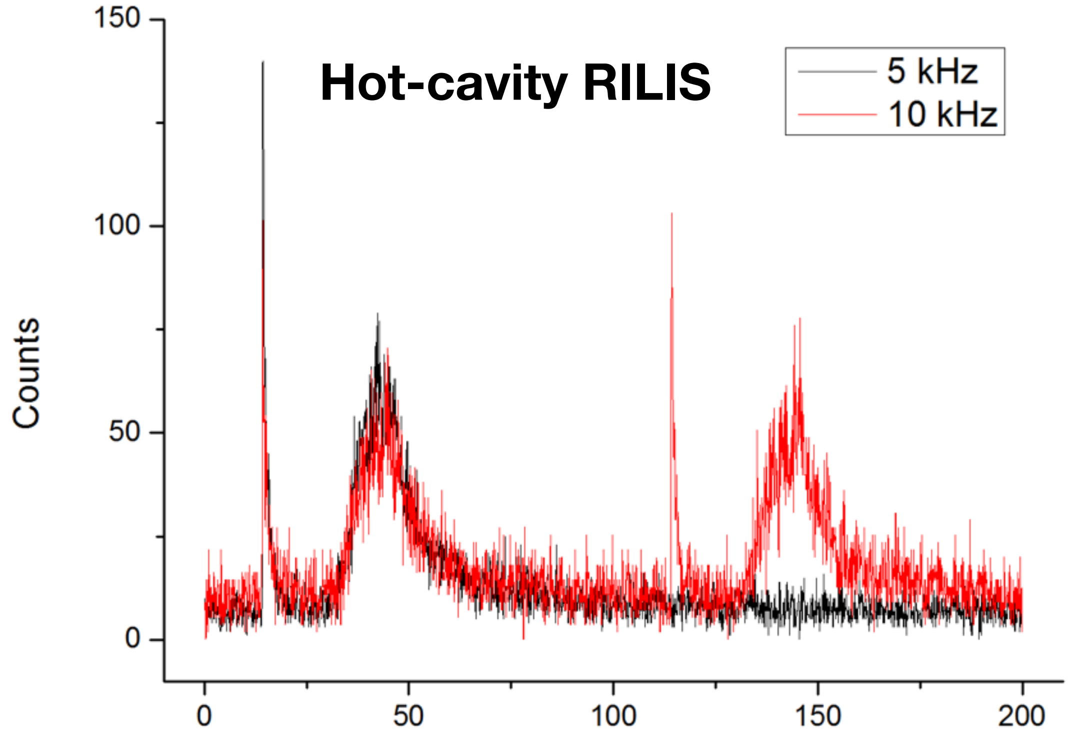

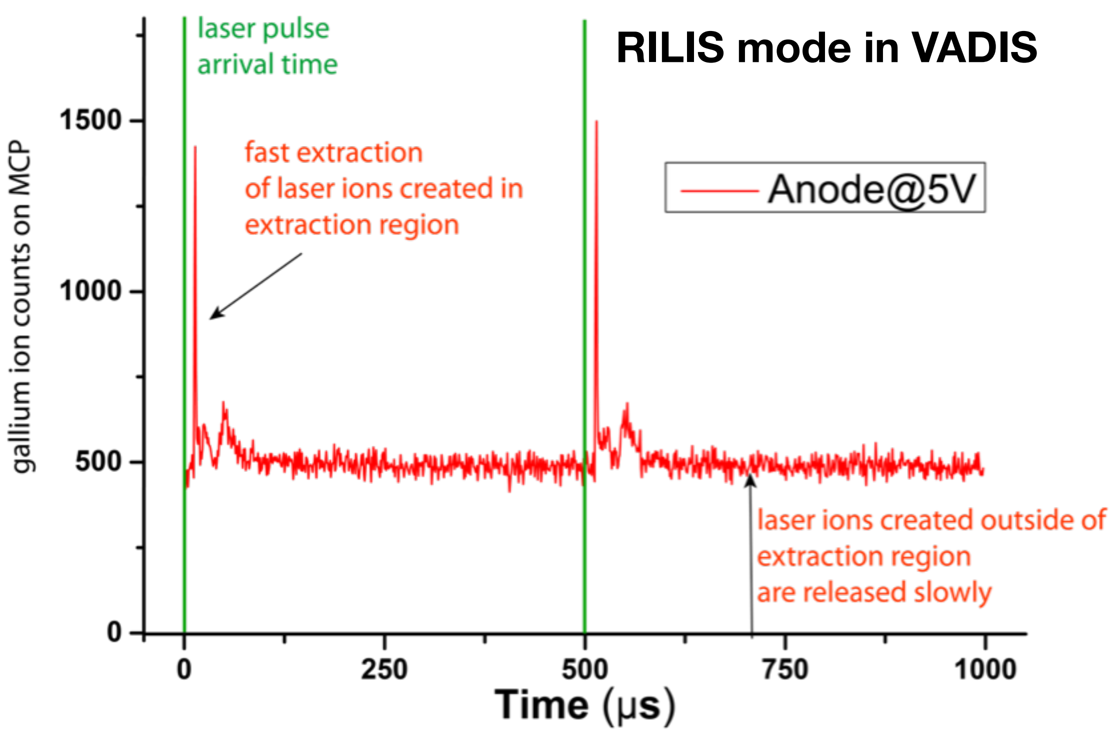

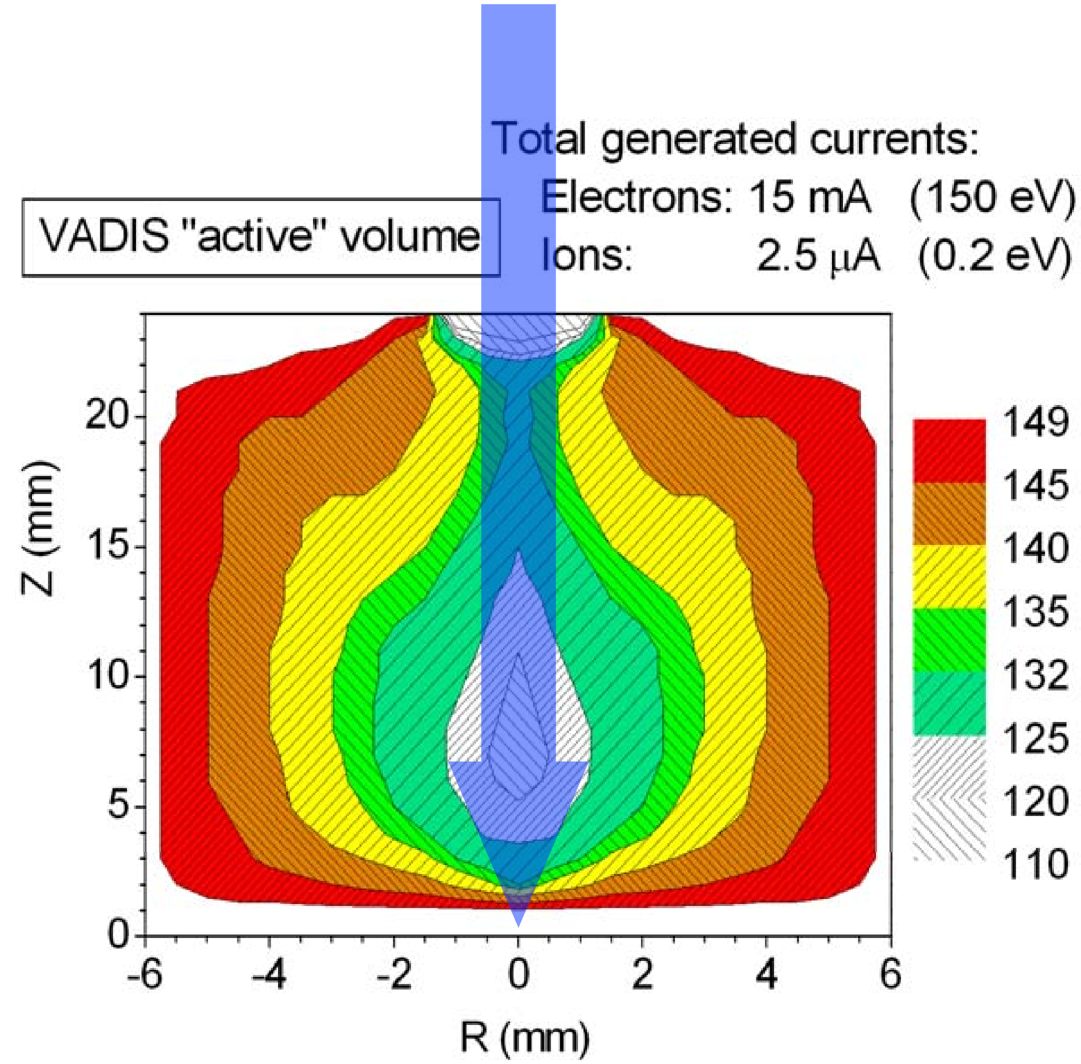

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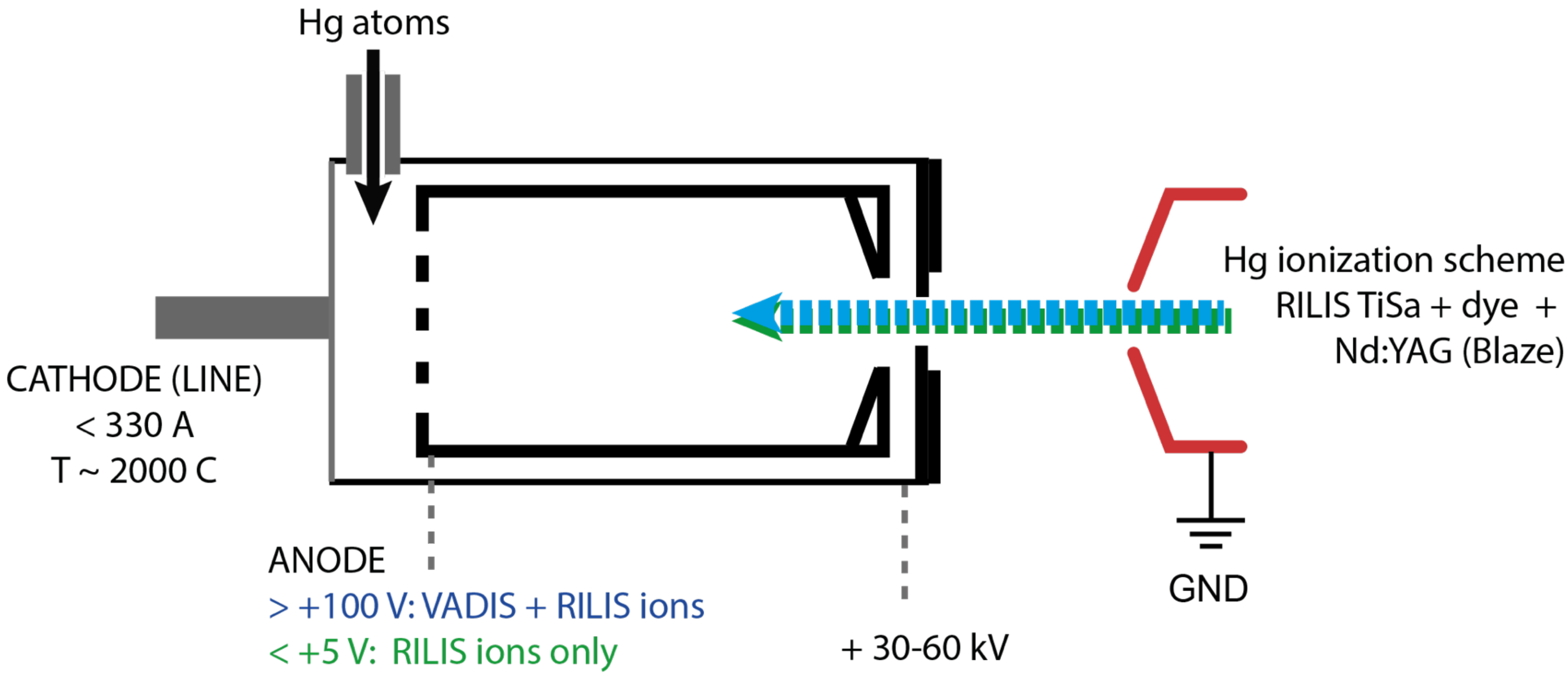
First On-line test

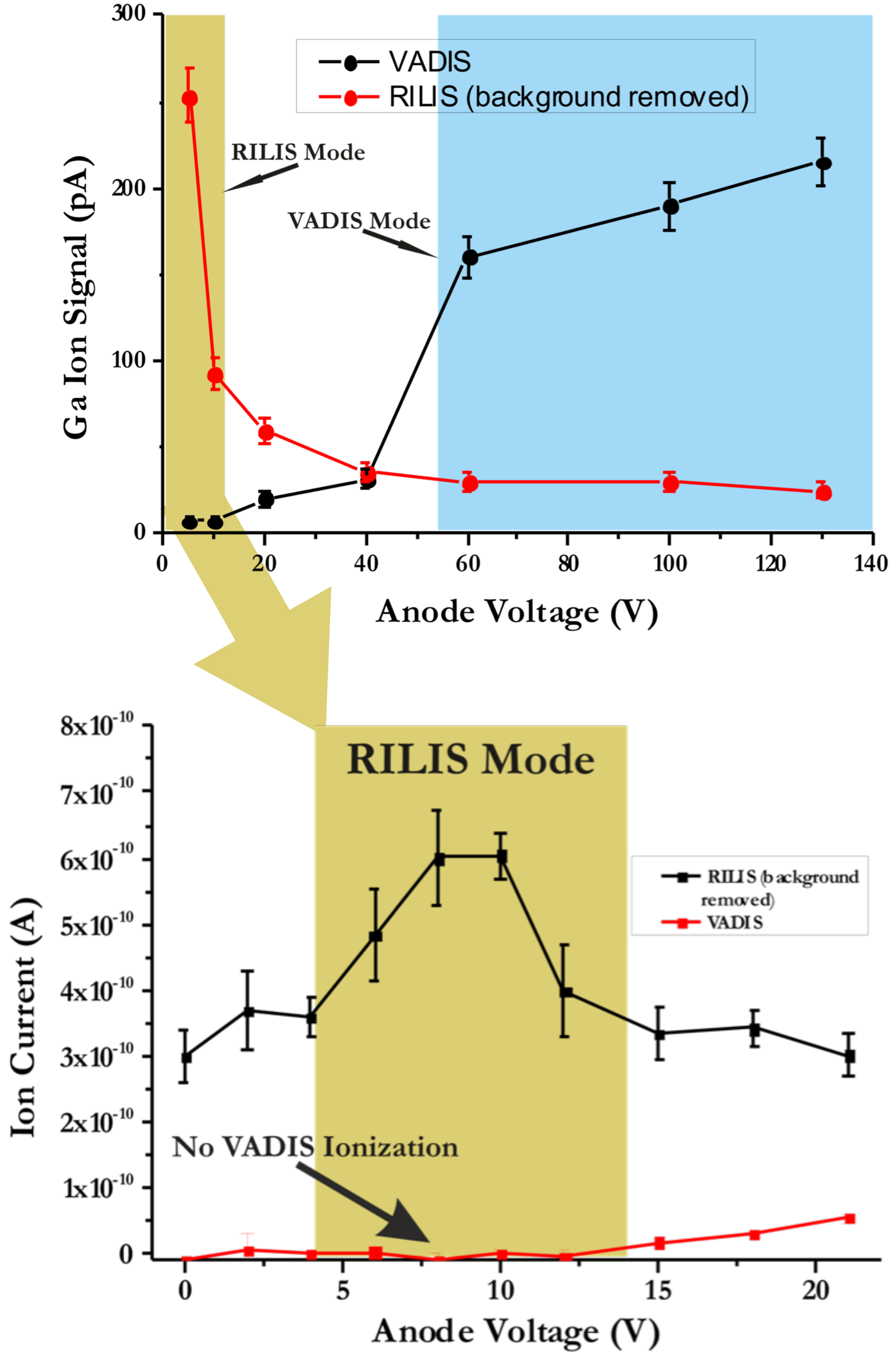
Standard VADIS + liquid Pb target @ ISOLDE



The first RILIS ionized isotopes from a liquid target

Tom Day Goodacre (CERN, Manchester) – PhD work

Establishing modes of operation



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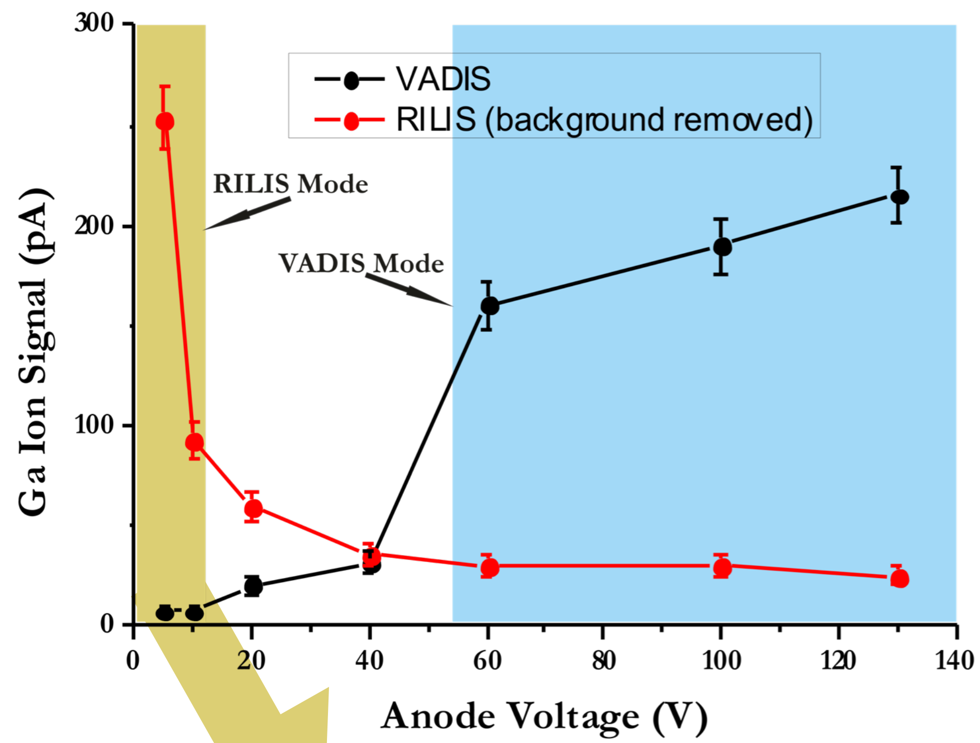
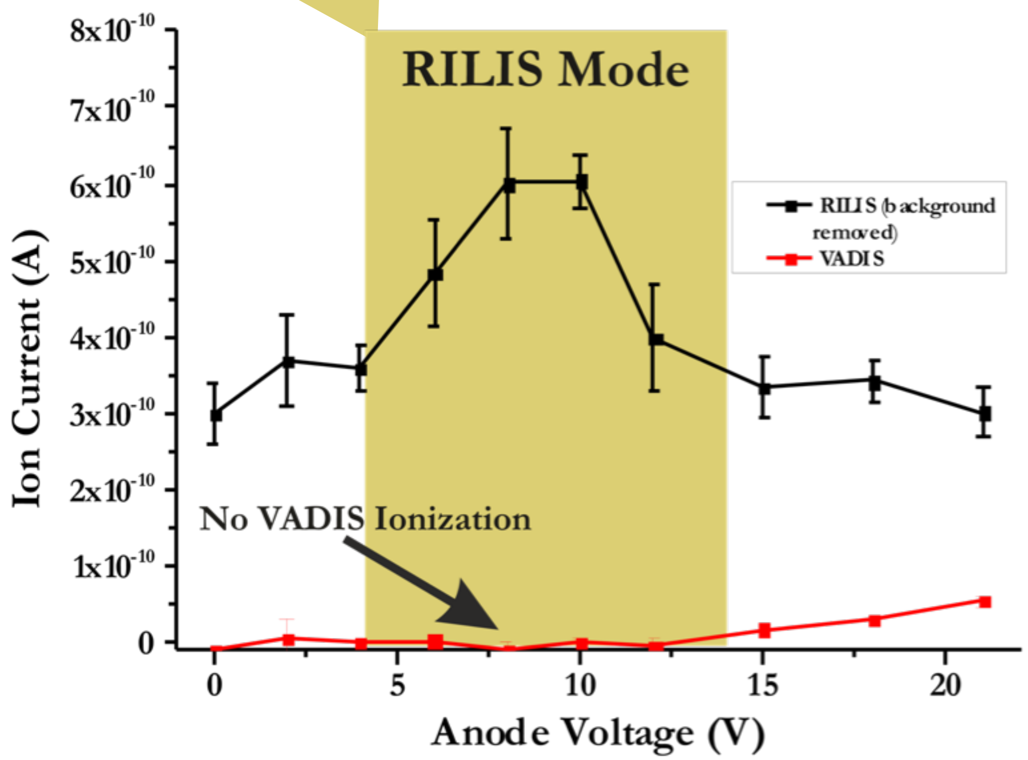
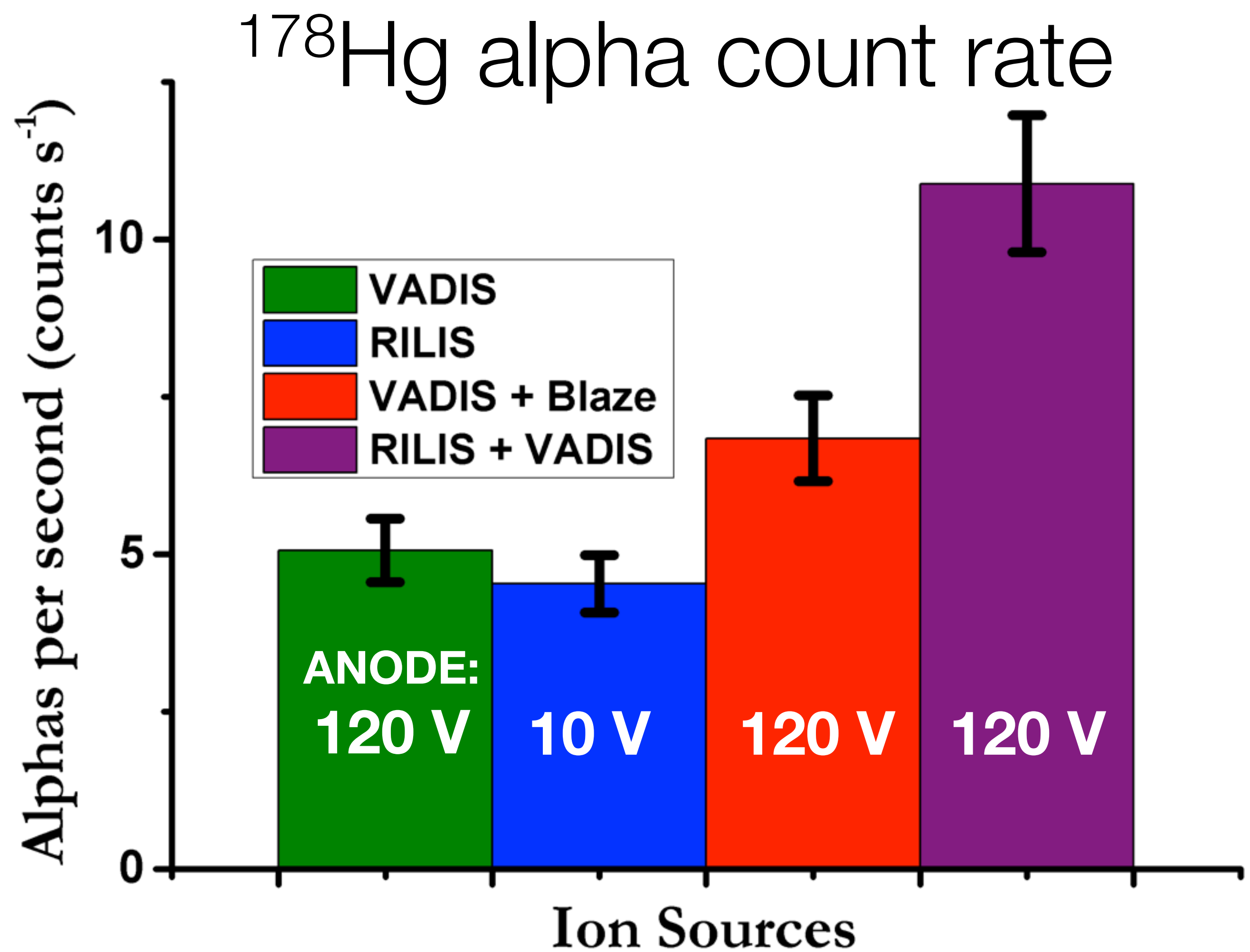
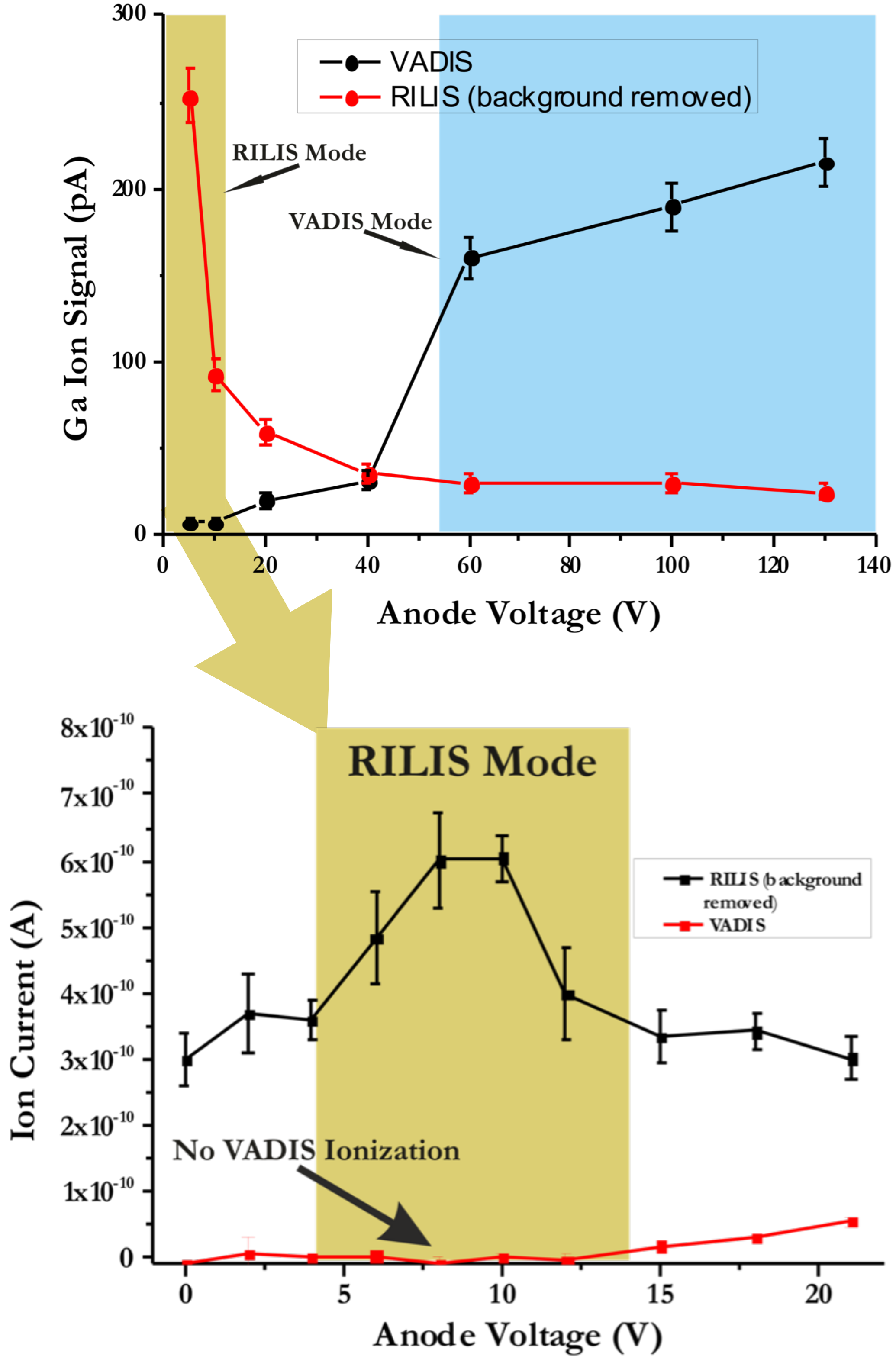
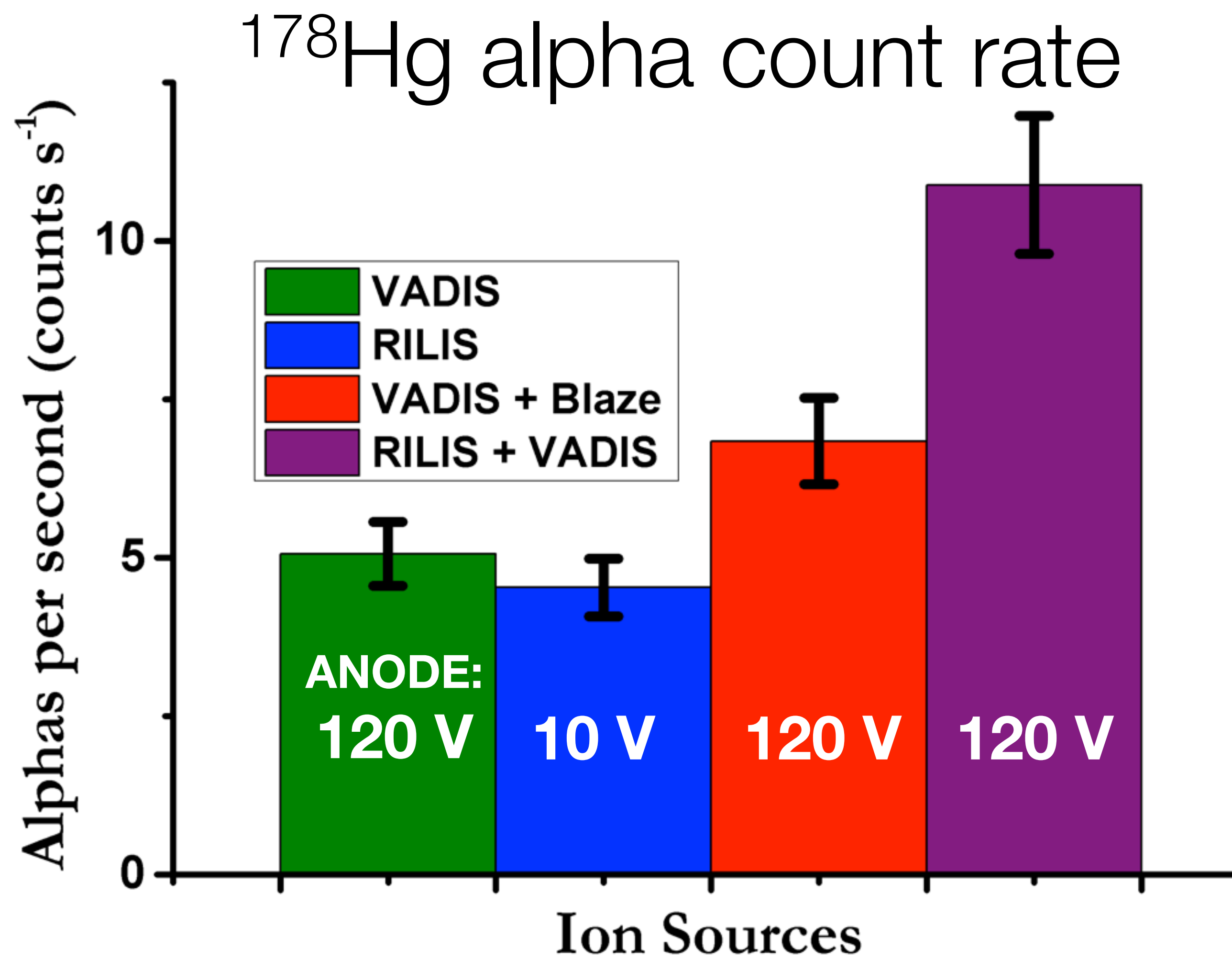






Establishing modes of operation





These measurements were obtained with a standard VADIS under normal operating conditions
- lots of room for optimization!

Proposal for 1st physics application

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

In-source laser spectroscopy of mercury isotopes

October 10, 2014

L. P. Gaffney[1], T. Day Goodacre[2,3], A. N. Andreyev[4], M. Seliverstov[5,2], N. Althubiti[3], B. Andel[11], S. Antalic[11], D. Atanasov[10], A. E. Barzakh[5], K. Blaum[10], J. Billowes[3], T. E. Cocolios[3], J. Cubiss[4], G. Farooq-Smith[3], D. V. Fedorov[5], V. N. Fedosseev[2], R. Ferrer[1], K. T. Flanagan[3], L. Ghys[1,12], C. Granados[1], A. Gottberg[2], F. Herfurth[8], M. Huyse[1], D. G. Jenkins[4], D. Kisler[10], S. Kreim[10,2], T. Kron[7], Yu. Kudryavtsev[1], D. Lunney[13], K. M. Lynch[1,2], B. A. Marsh[2], V. Manea[10], T. M. Mendonca[2], P. L. Molkanov[5], D. Neidherr[8], R. Raabe[1], J. P. Ramos[2], S. Raeder[1], E. Rapisarda[2], M. Rosenbusch[9], R. E. Rossel[2,7], S. Rothe[2], L. Schweikhard[9], S. Sels[1], T. Stora[2], I. Tsekhanovich[6], C. Van Beveren[1], P. Van Duppen[1], M. Veinhard[2], R. Wadsworth[4], A. Welker[14], F. Wienholtz[9], K. Wendt[7], G. L. Wilson[4], S. Witkins[3], R. Wolf[10], K. Zuber[14]

[1] *KU Leuven, Belgium*; [2] *CERN-ISOLDE, CH*; [3] *The University of Manchester, UK*; [4] *The University of York, UK*; [5] *PNPI, Gatchina, Russia*; [6] *CENBG, Bordeaux, France*; [7] *Johannes Gutenberg University of Mainz, Germany*; [8] *GSI, Darmstadt, Germany*; [9] *Ernst-Moritz-Arndt Universität Greifswald, Germany*; [10] *Max-Planck-Institut für Kernphysik, Heidelberg, Germany*; [11] *Comenius University, Bratislava, Slovakia*; [12] *SCK•CEN, Mol, Belgium*; [13] *CSNSM-IN2P3-CNRS, Orsay, France*; [14] *Technische Universität Dresden, Germany*;

Spokespersons: Liam Paul Gaffney [Liam.Gaffney@fys.kuleuven.be],
Thomas Day Goodacre [Thomas.Day.Goodacre@cern.ch],
Andrei Andreyev [Andrei.Andreyev@york.ac.uk],
Maxim Seliverstov [Maxim.Seliverstov@cern.ch]
Contact person: Bruce Marsh [Bruce.Marsh@cern.ch]

First off-line demonstration

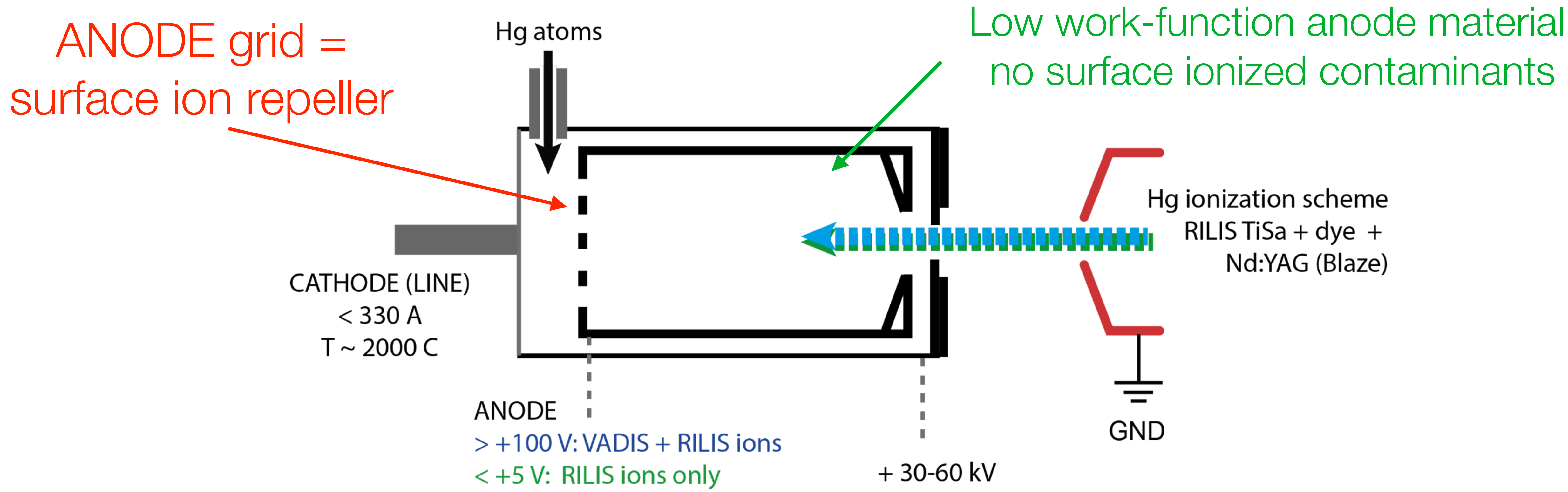
First on-line test

Physics proposal

< 6 months!

Introducing new RILIS + FEBIAD opportunities

- **New option for surface ion reduction**
- Easy and fast ‘switch on/off’ of non-selective ionisation / electron impact effects
- Immediately compatible with liquid targets
- Greater ion capacity is expected (> 100 uA) - High-power target application?
- New opportunity for 2-photon spectroscopy
- RILIS ionized non metals and noble gases?
- Ideal 2+ RILIS ionization environment?
- Towards RILIS ionized refractory metal beams at thick-target facilities?



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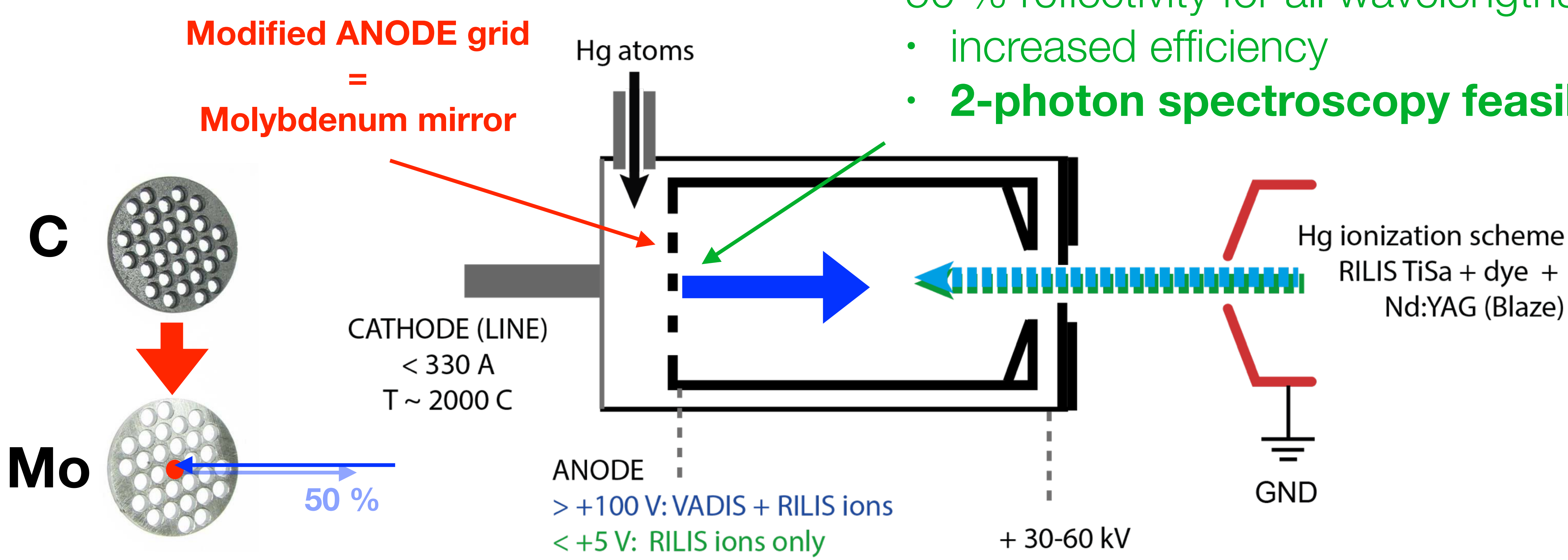
50 % reflectivity for all wavelengths
- increased efficiency
- **2-photon spectroscopy feasibility?**



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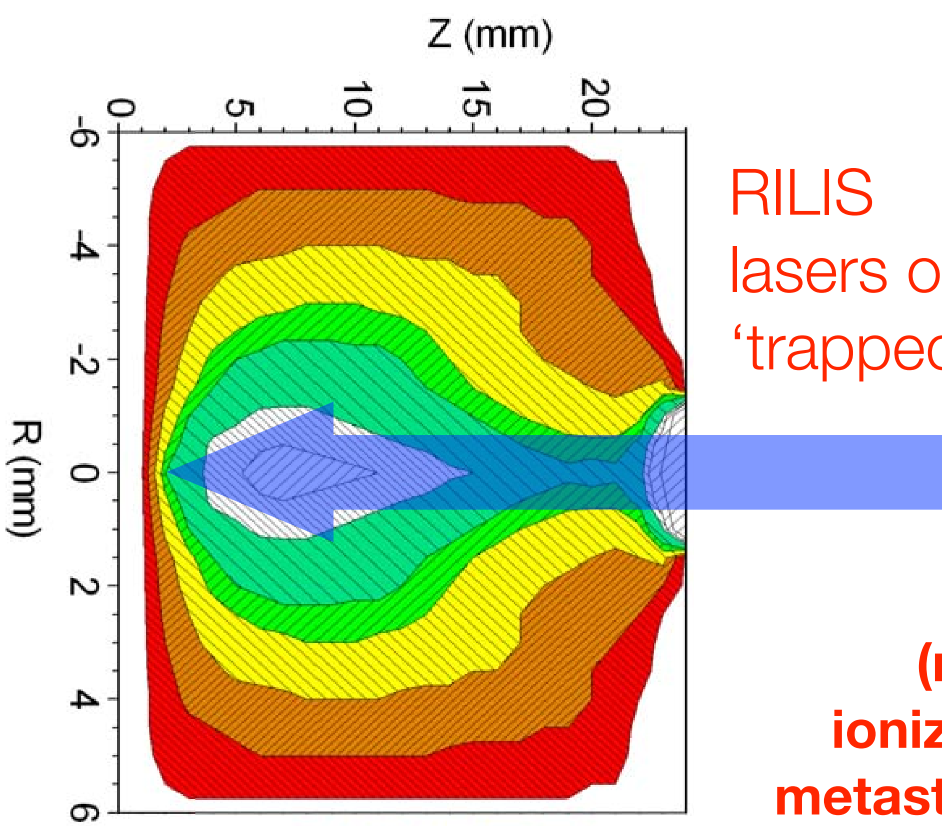
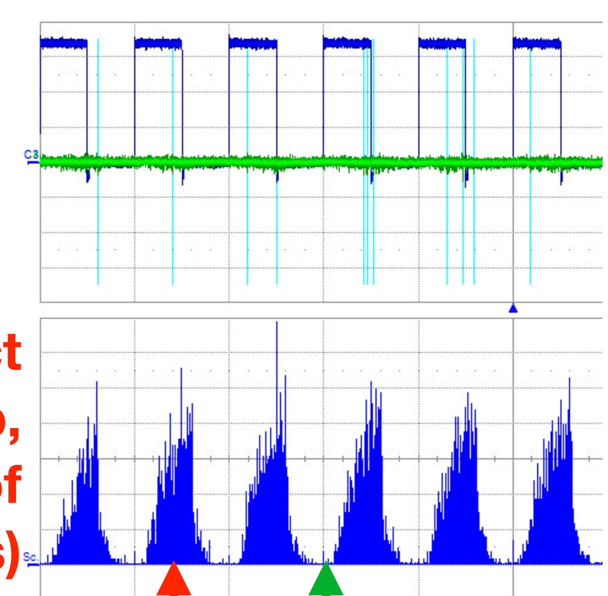
- **RILIS ionized non-metals and noble gases or optical pumping of ions?**
- **Ideal 2+ RILIS ionization environment?**
- **Towards RILIS ionized refractory metal beams at thick-target facilities?**



RILIS
lasers overlap with
'trapped' ions

Synchronized laser + **anode**
pulsing operating cycle



electron impact (molecular breakup, ionization, excitation of metastable atomic levels)

Background-free RILIS ionization

Introducing new RILIS + FEBIAD opportunities

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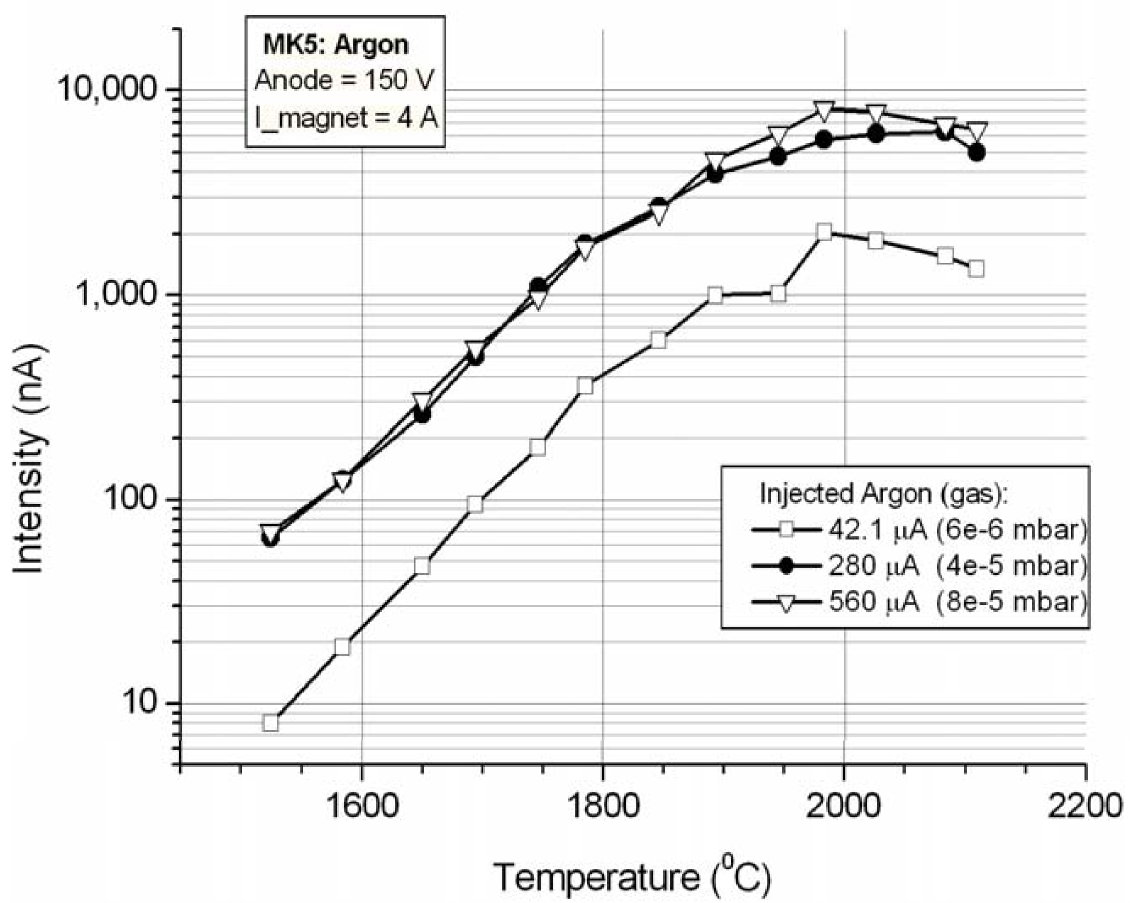

Outlook

- RILIS inside a standard VADIS/FEBIAD works extremely well
- RILIS, VADIS and VADLIS operating modes are tested on-line
- This open the doors for promising new R&D for many RILIS applications
- Much more needs to be understood about the ion dynamics inside the VADIS cavity - Simulations (CPO and VORPAL)
- So far we have only tested 'standard' FEBIAD cavities: we can expect that there is a lot of room for improvement through optimisation of the cavity design for RILIS use.

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Acknowledgements

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Petersburg Nuclear Physics Institute

LA³NET

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A. Gottberg
T.M. Mendonca
J. P. Ramos
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