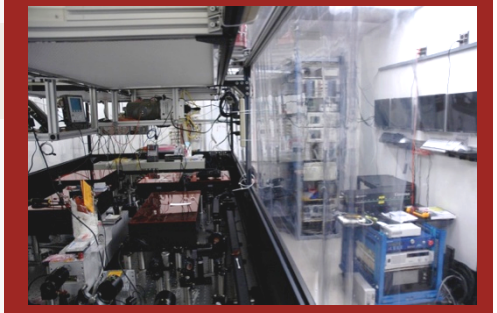
TRIUMF

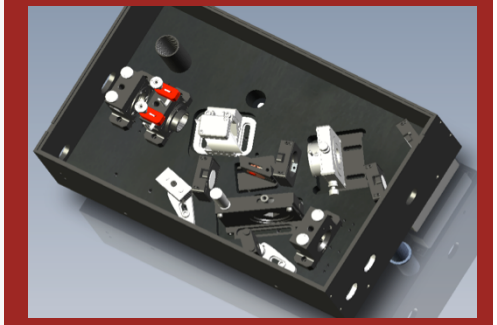
Laser Resonance Ionization @ TRIUMF spectroscopy tool & ion source for rare isotopes

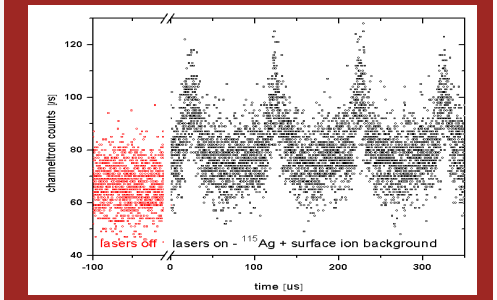
TRIUMF Resonant Ionization Laser Ion Source
In-source laser spectroscopy of rare isotopes

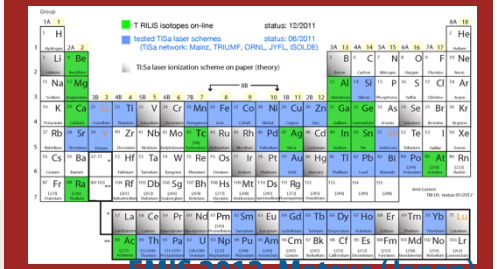
Jens Lassen | Research Scientist | TRIUMF Accelerator Division

EMIS 2012, Matsue (Japan)

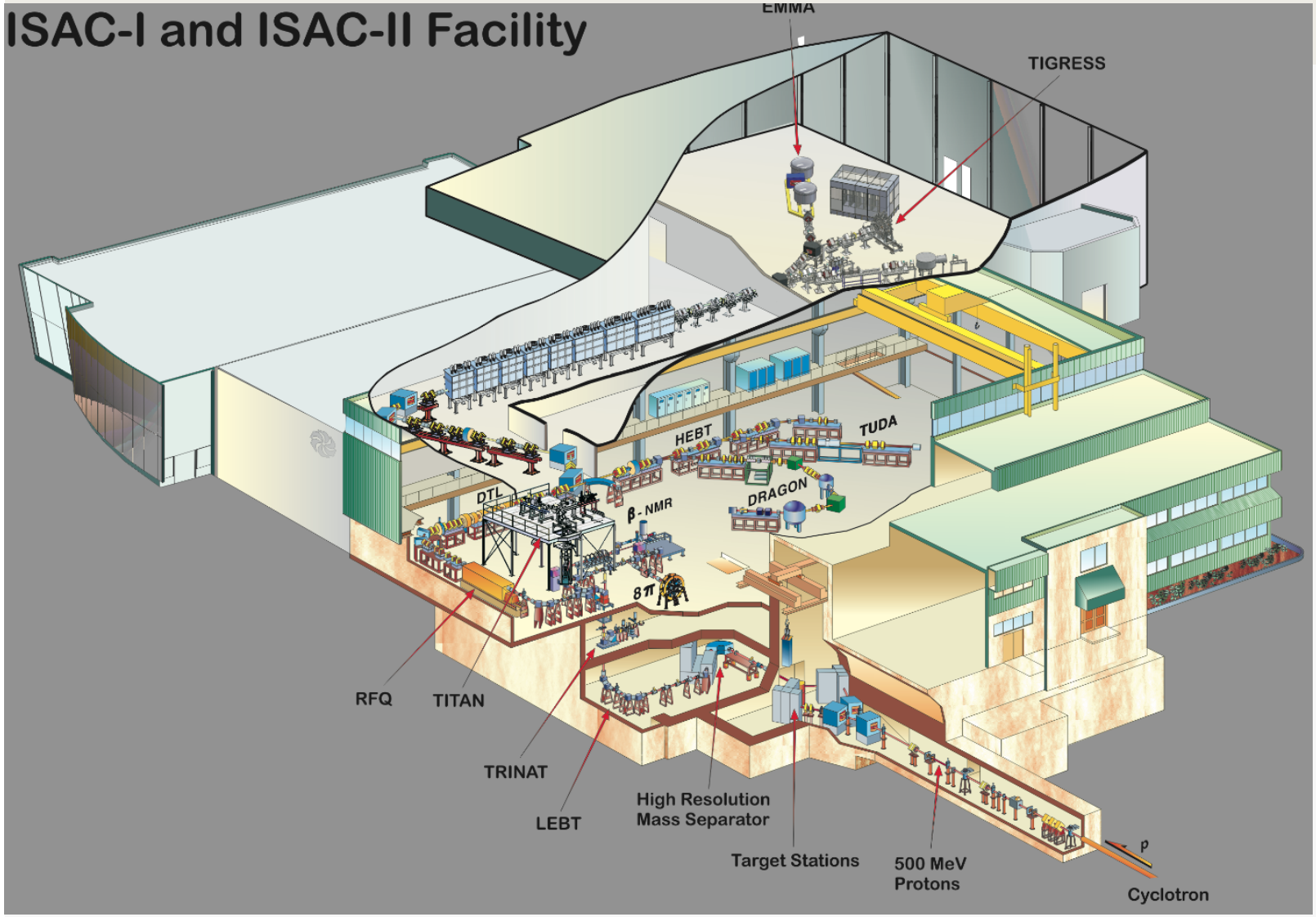








Radioactive Ion Beam Facility
Post Accelerated Beams up to 8MeV/u



ISAC isotopes delivered / measured (status 2012)

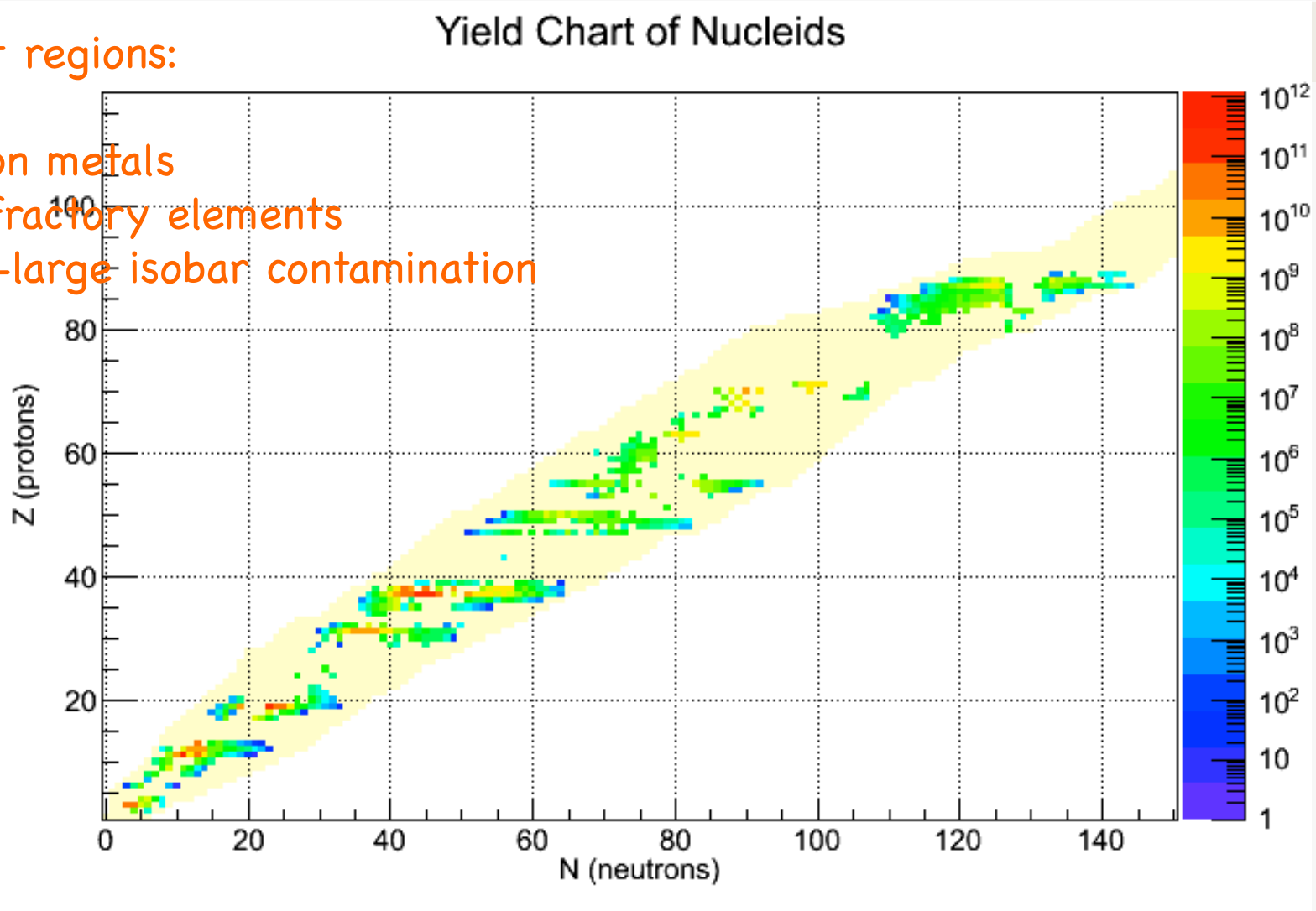
.isotopes from ISOL

the difficult regions:

-transition metals

-refractory elements

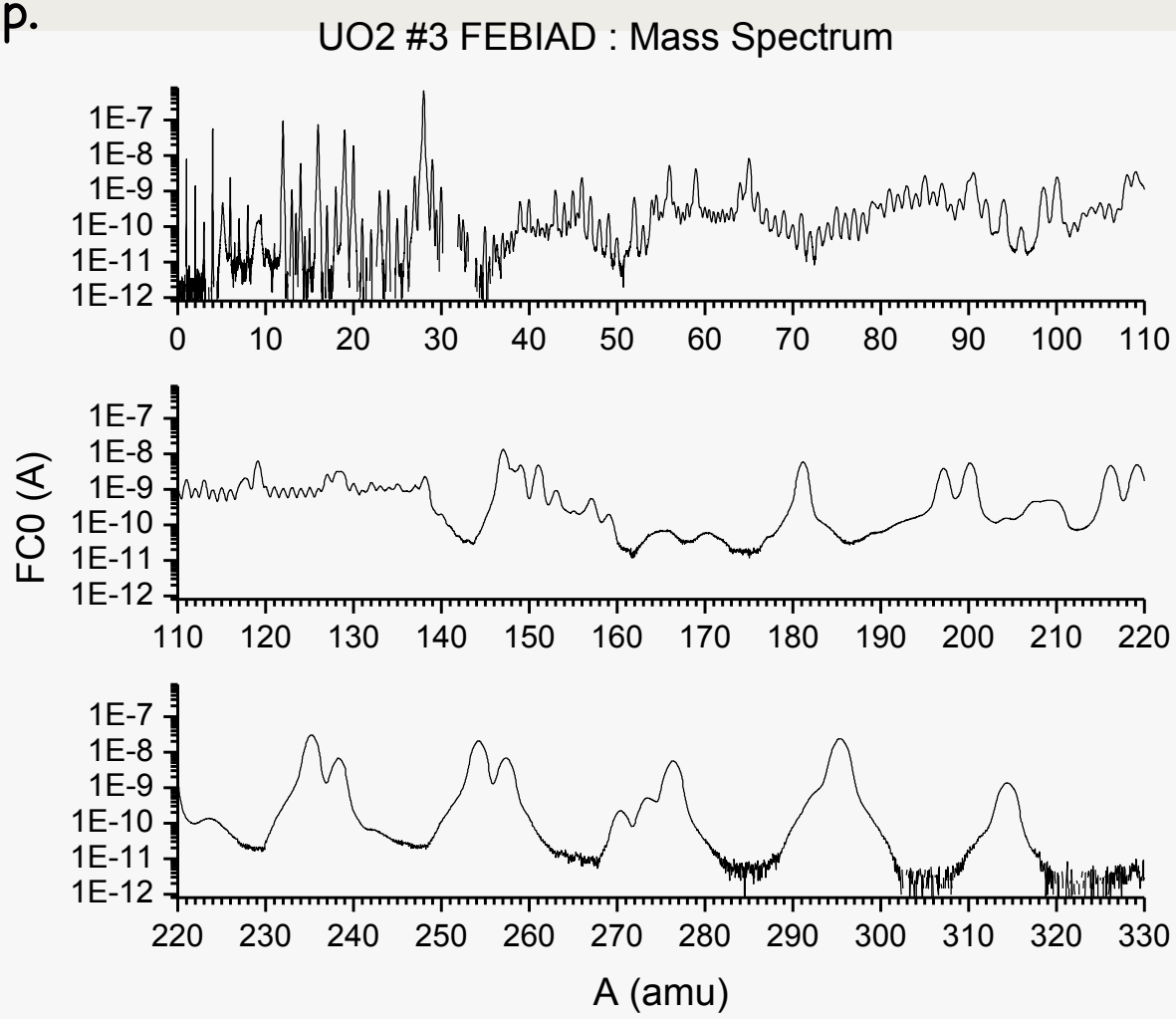
-large isobar contamination



UO_2 target with FEBIAD ion source @ 10 uA
-> cold transfer line
-> high resolution mass sep.

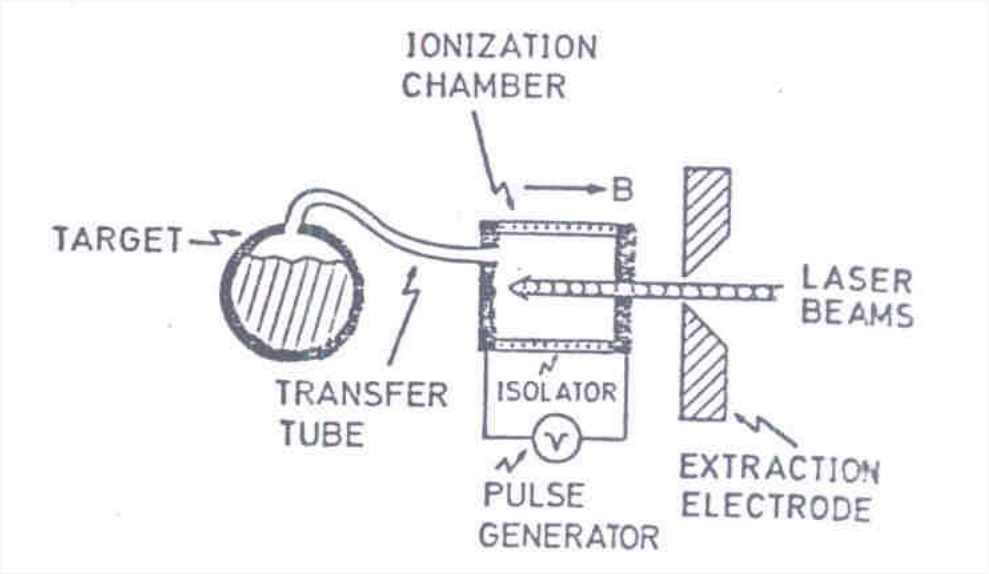
...or...

....element selective ionization...

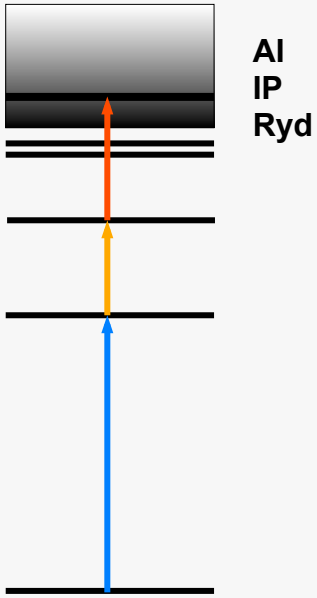


RILIS way back when … the role of workshops

"… Stepwise excitation by resonant laser radiation and photo ionization in the last transition can be used to ionize atoms selectively and efficiently in order to obtain a high performance laser ion source. …
For on-line isotpe separators the main advantages are the pulsed structure of the extracted radioactive beam and the reduction of isobaric impurites.
…
Ionization efficiencies of the order of 20 to 40% are expected for elements with one atomic ground state populated thermally. …"

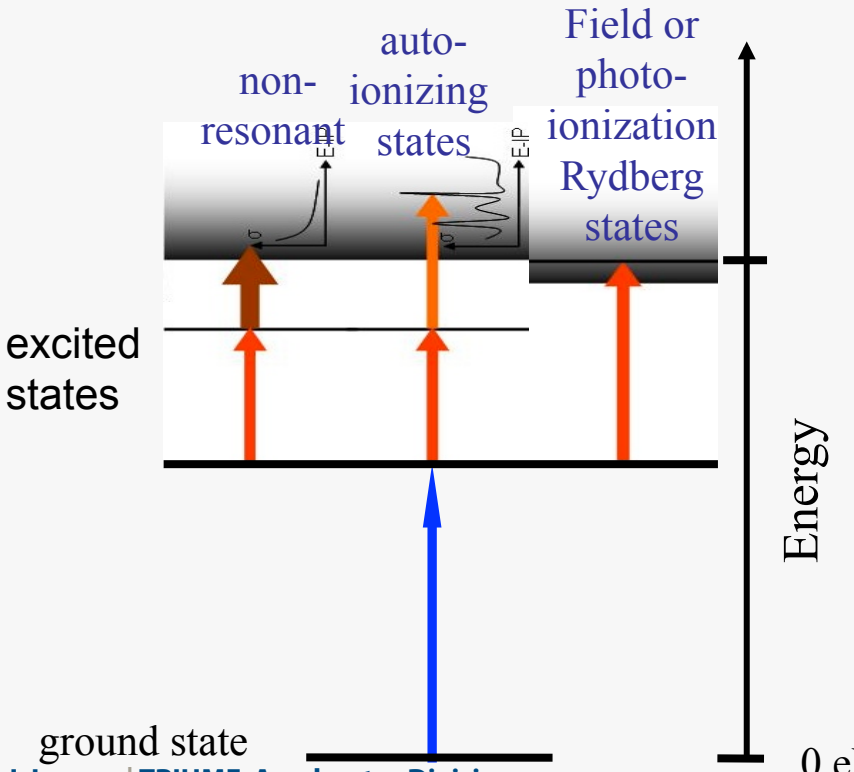


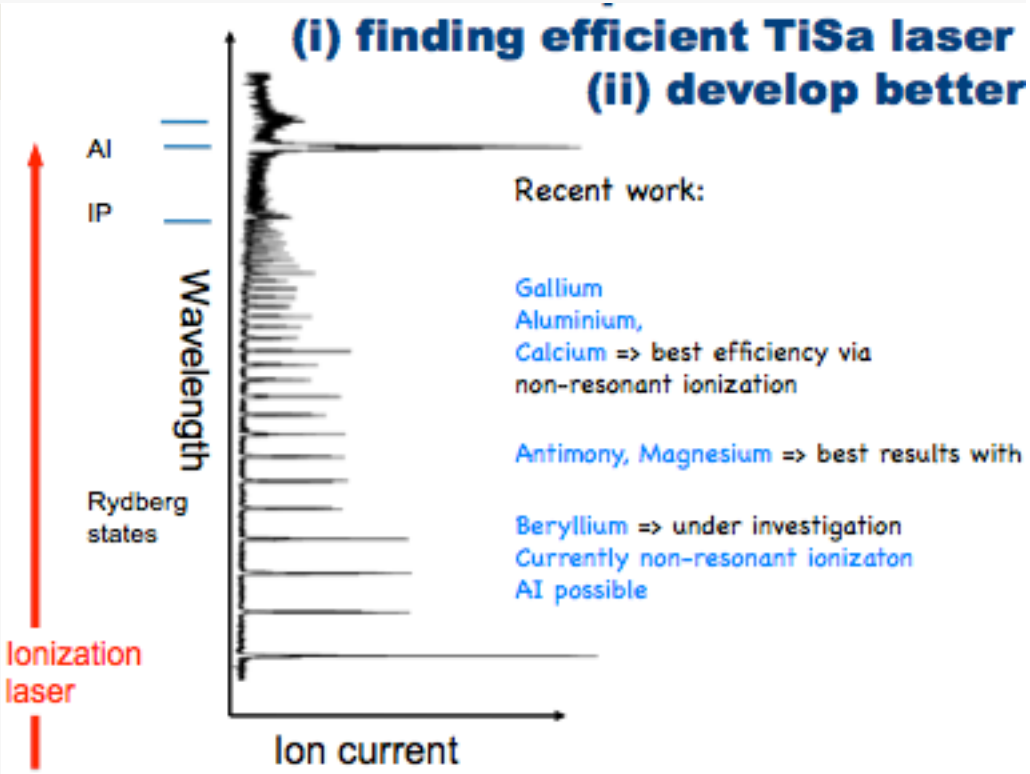
H.-J. Kluge, F. Ames, W. Ruster, K. Wallmeroth, Accelerated Radioactive Beams Workshop, Parksville B.C., Canada Sept 5-7 (1985)



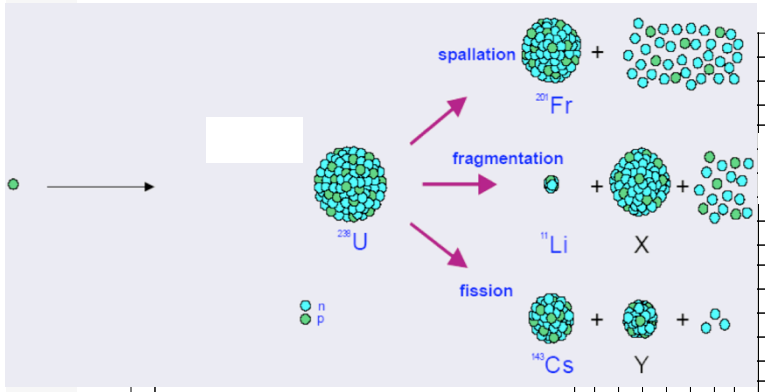
20 years back
"… ISOLDE, Mainz, Leuven, Gatchina, Dubna RILIS …"
copper vapor laser pumped dye lasers

RILIS – principle excitation paths





RILIS advantage in RIB production



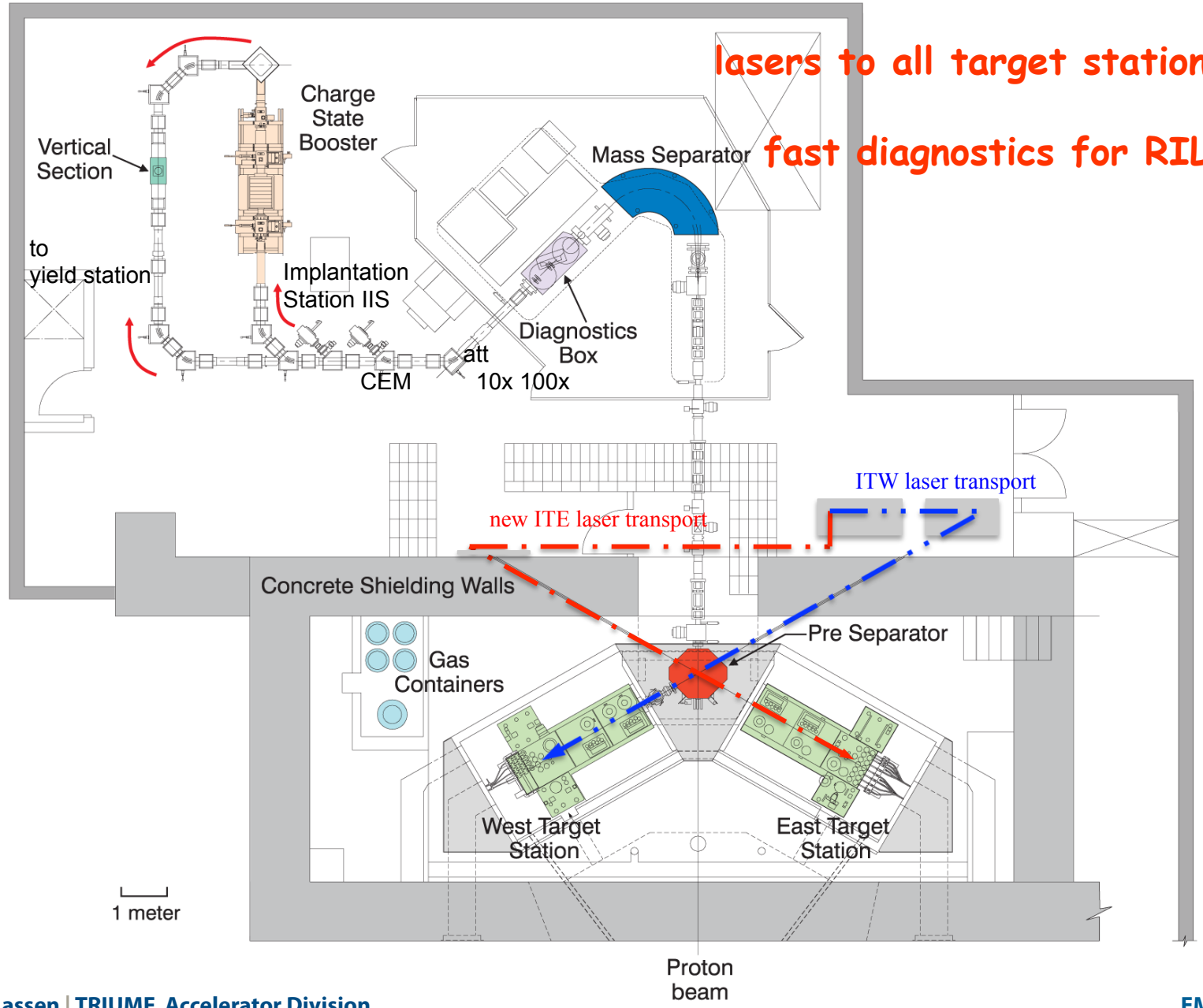
isobars (m=const.)

RILIS:
element selective
isotopes

RILIS
-> element selective
-> isobar free beams

-> improved beam quality
(emittance)

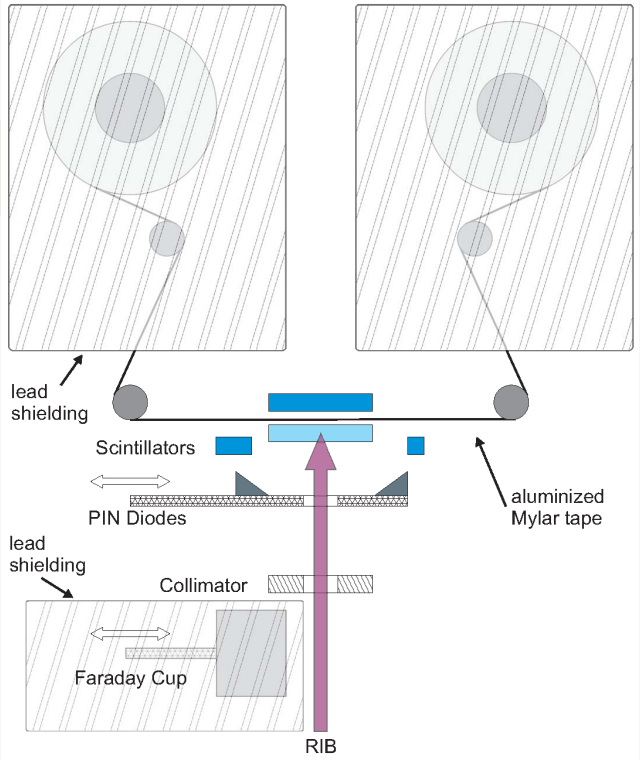
lasers on target & diagnostics

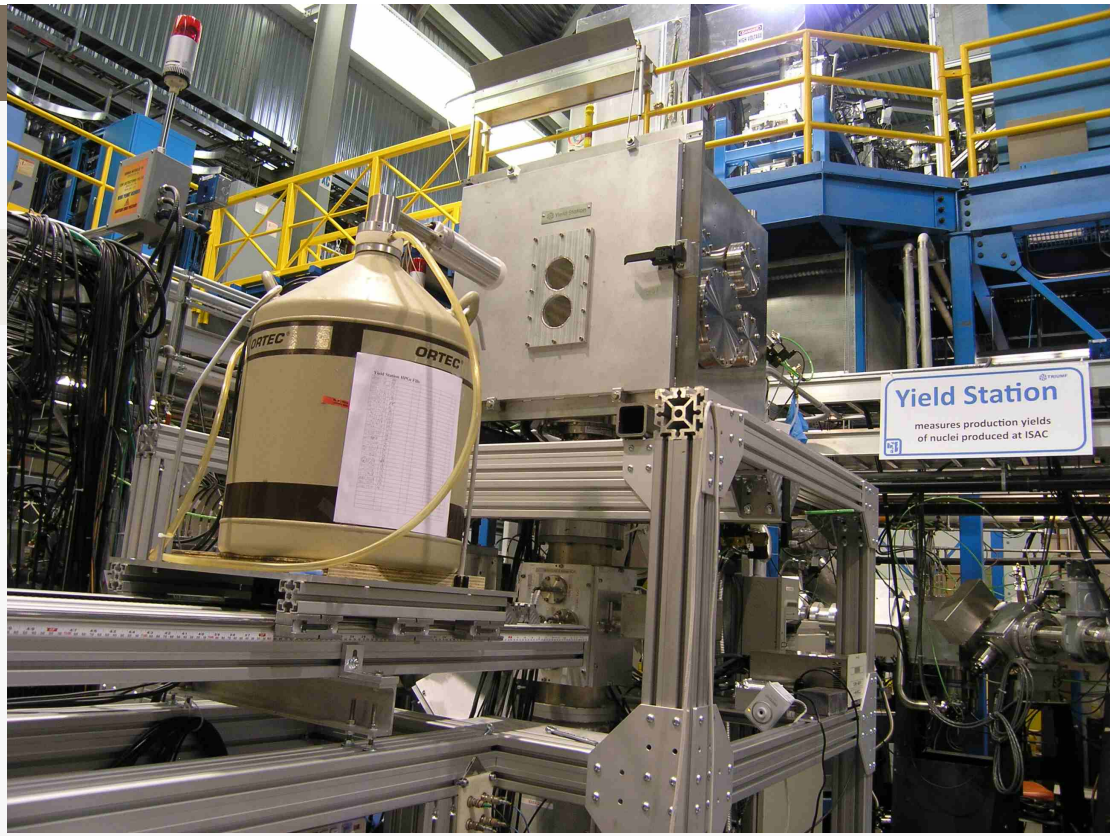


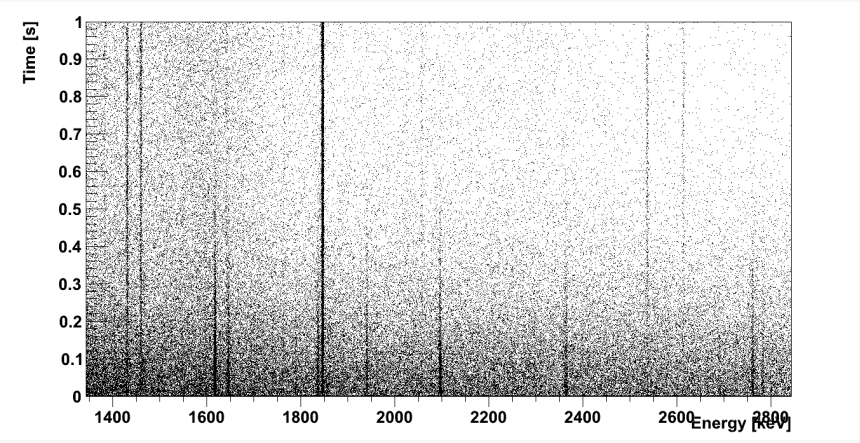
lasers to all target stations

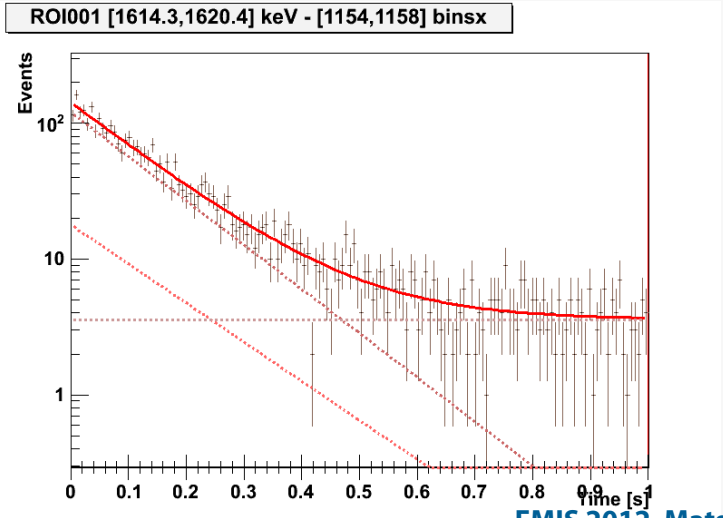
fast diagnostics for RILIS : CEM

Yield station



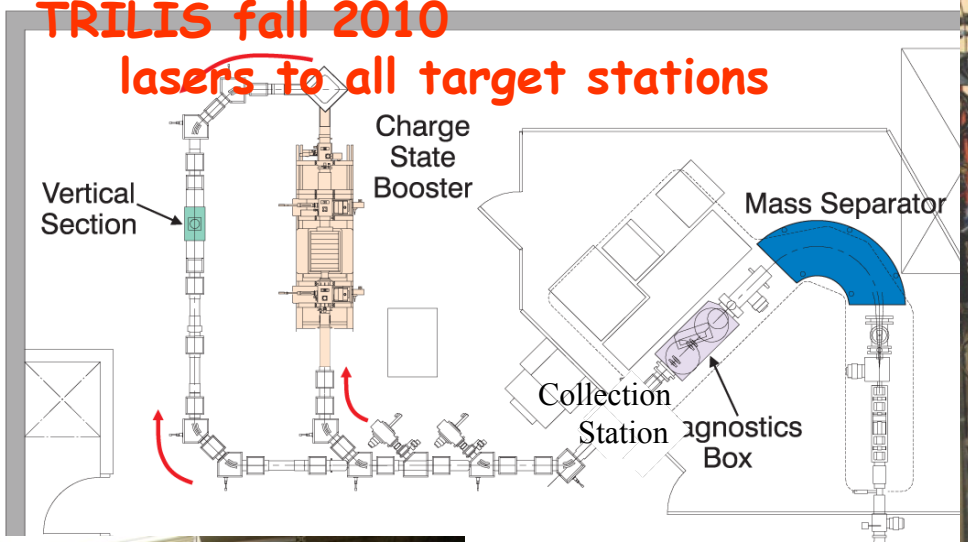


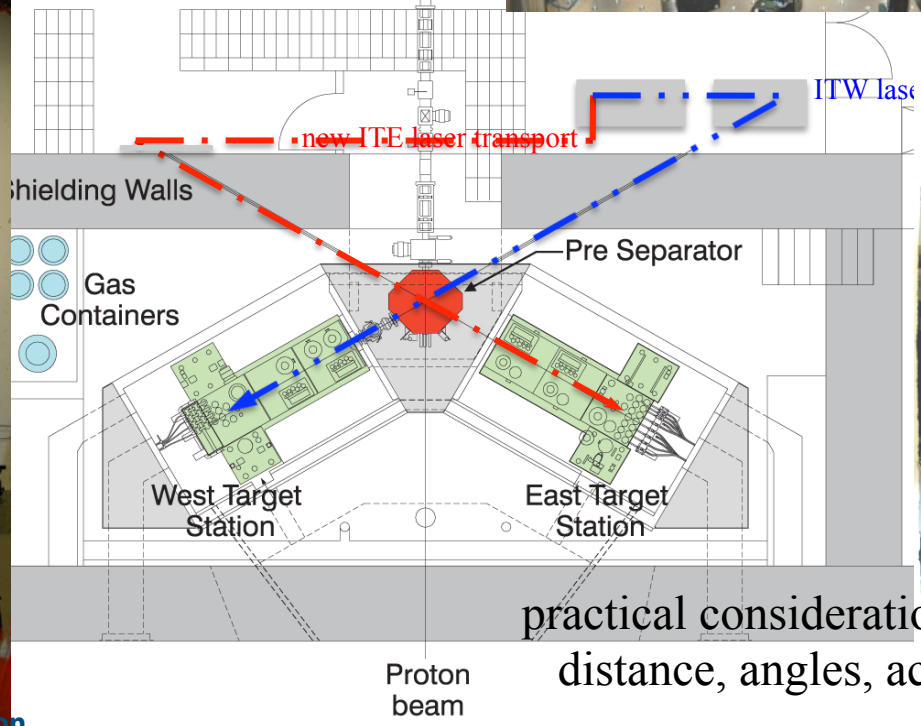




scheduling flexibility & doubling availability

TRILIS fall 2010
lasers to all target stations



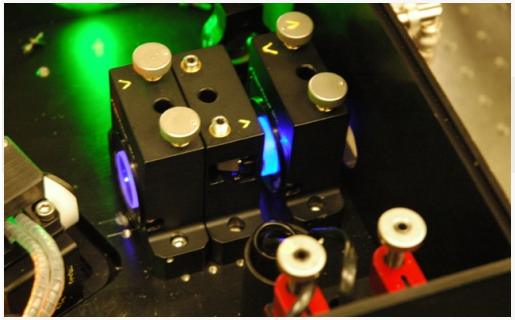


practical considerations:
distance, angles, access, service

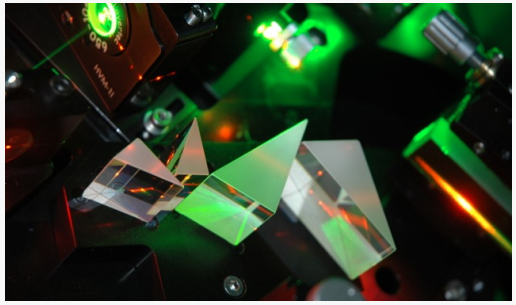
working the east & vertical

TRIUMF TiSa RILIS (T RILIS) in pictures

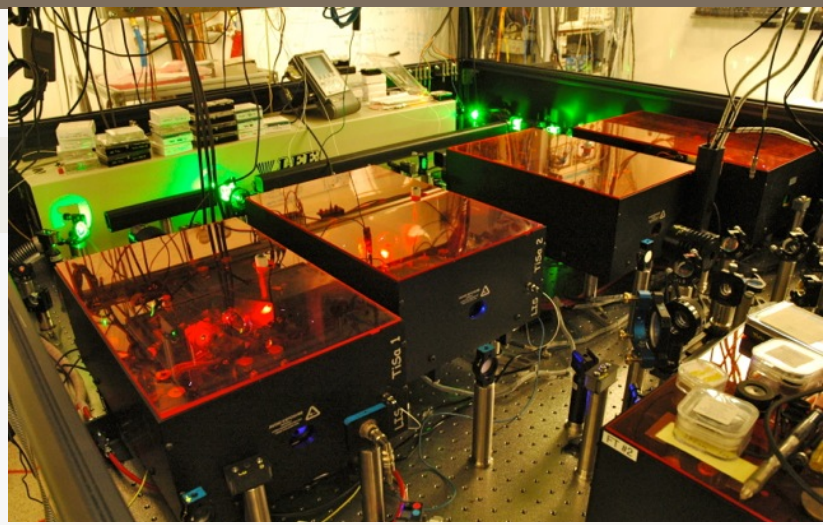
yield database: http://www.triumf.info/facility/research_fac/yield.php



Improved laser intensity (blue)
intra-cavity frequency doubling
-> Lanthanide RILIS scheme dev.



Grating tuned Ti:Sa laser
-> systematic searches for auto-ionizing states



MK3 TiSa lasers (on line)

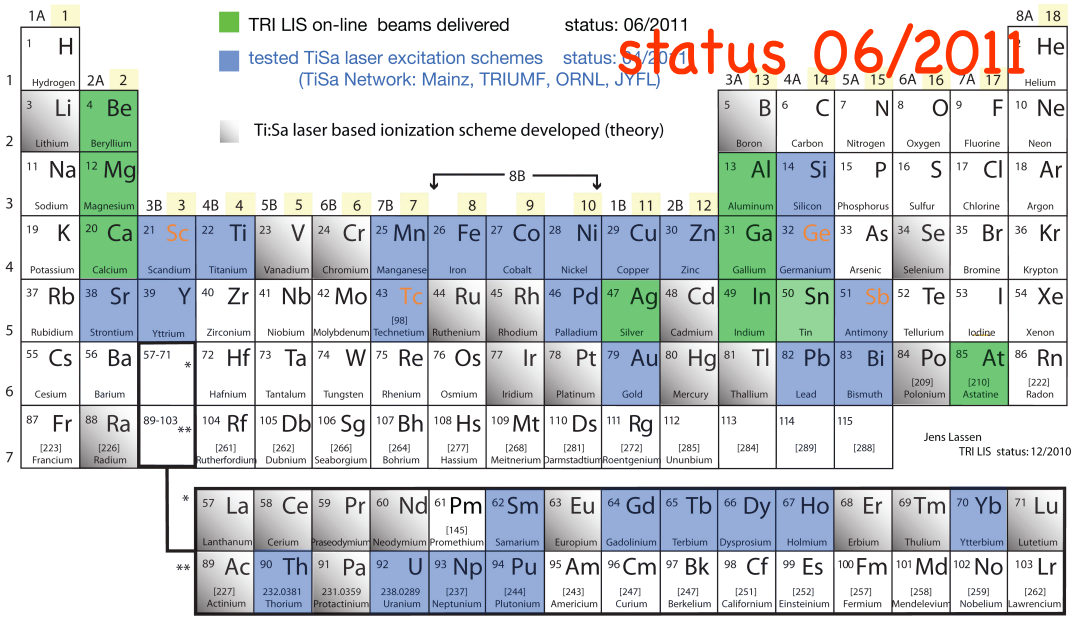
Specifications:
10kHz rep. rate, Q-switched
linewidth: < 5GHz (as low as 600 MHz)
wavelength: 690-990 nm
power: 2/5W IR @ 10/20W, 10kHz pump

Operational:

(2010) Full complement of TiSa lasers & full scheduling flexibility
(2009) NSERC funded
"in-source laser spectroscopy program"
(2011-2012) 1st schedule with 50^{+}% TRILIS shifts
T RILIS laser operation with GHz/wk stability

Development plans:
(2012-14) beam purity enhancements
e.g. RFQ-LIS, pulse structure (10kHz kicker) / spin isomer separation (e.g. Ag)
(2012-2015) cont'd laser development
in-source laser spectroscopy
development of TiSa RILIS schemes

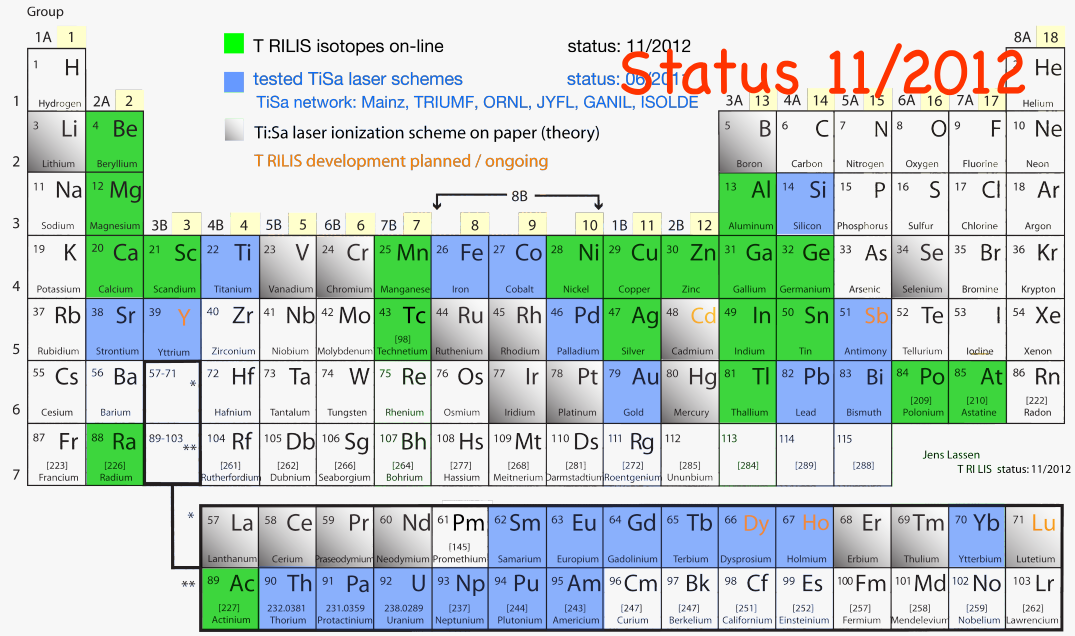
TRIUMF Ti:Sa RILIS (T RILIS) progress 2012 & plans 2013



yield database:
http://www.triumf.info/facility/research_fac/yield.php

(2010) full complement of TiSa lasers
LIS @ ITW & ITE -> full scheduling flexibility

(2011) full off-line development capabilities
1st schedule with 50%+ TRILIS shifts
laser operation with GHz/wk stability



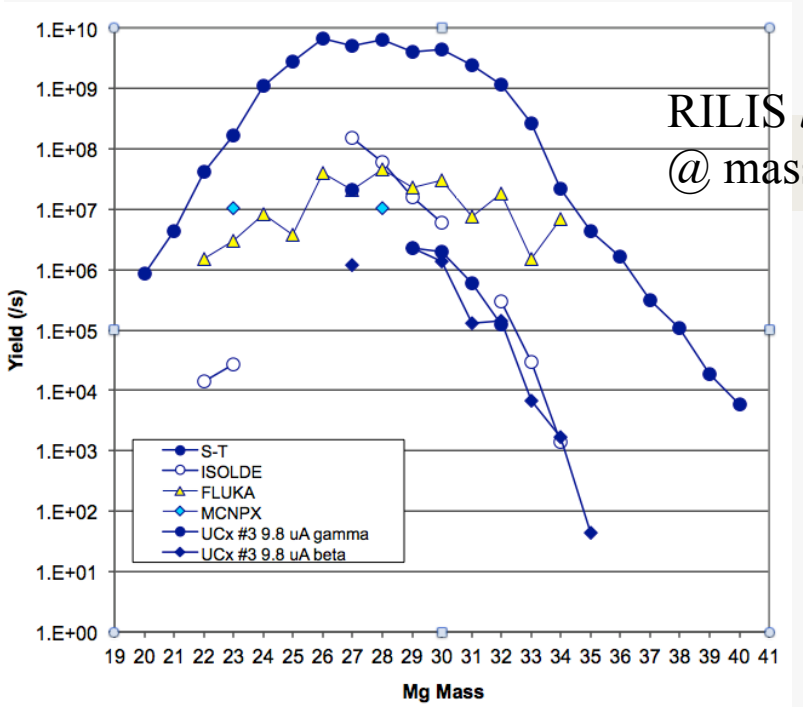
(2012) TiSa RILIS @ TRIUMF turns 20:
-> on-line development & delivery
Sc, **Mn, Ni, Cu, Zn**, Ge, **Tl, Po, Ra,** Ac

-> off-line "ion guide - LIS" (alias RFQ-LIS)
-> laser spectroscopy At (S1237), Ac
-> continued efficiency improvements
(auto-ionizing states)

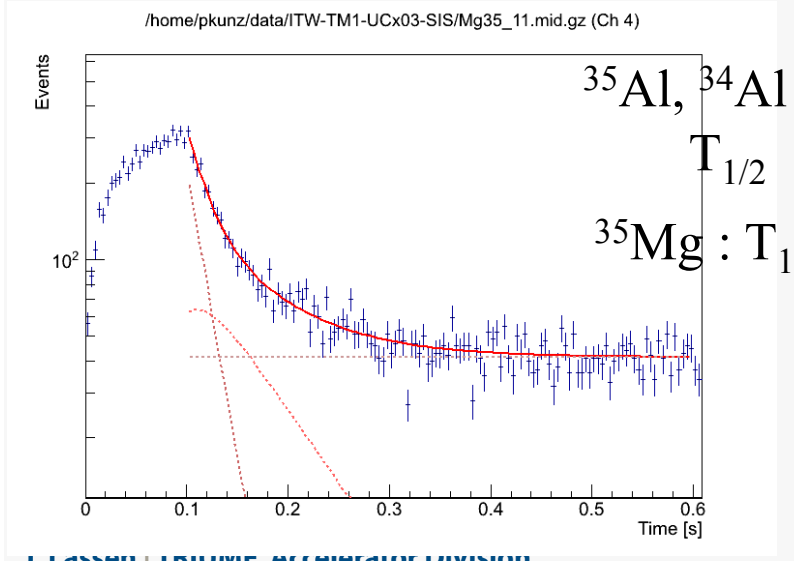
(2013) T RILIS plans:

-> IG-LIS: At, **Cd**, Ca, Mg, Al
-> T RILIS post irradiation **Ho, Dy**

neutron-rich Mg from UC2 target #3

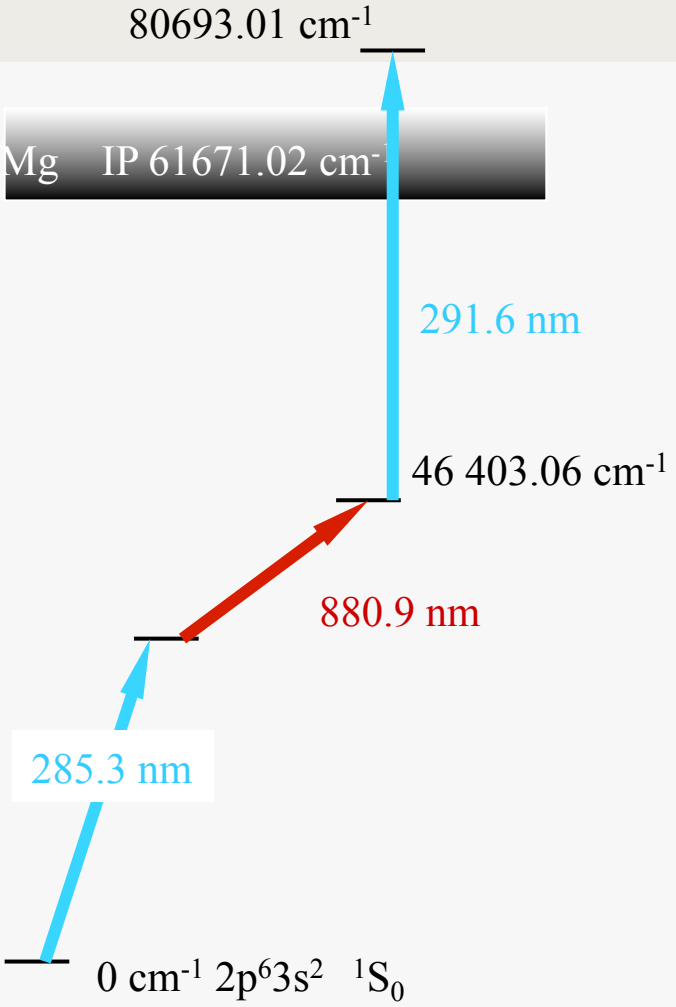


RILIS *laser on/laser off* 10^4 @ mass 33

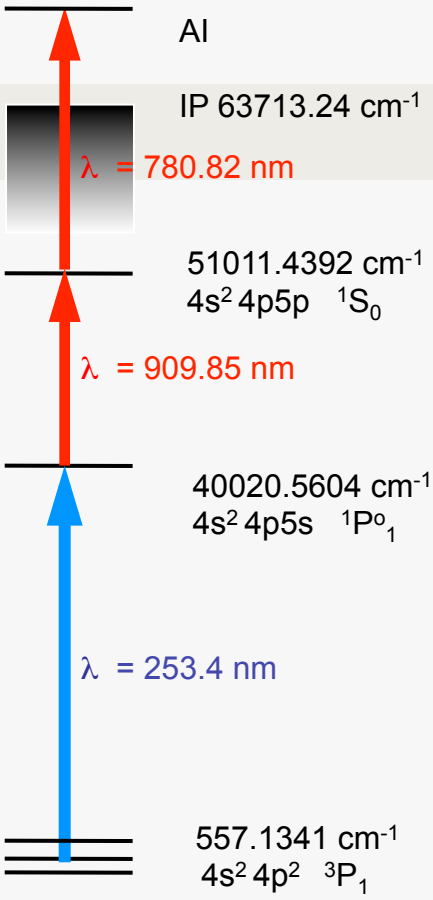


^{35}Al, ^{34}Al : $T_{1/2}$

^{35}Mg : $T_{1/2}$



laser on/off technique



Ta#36 50mA p^+

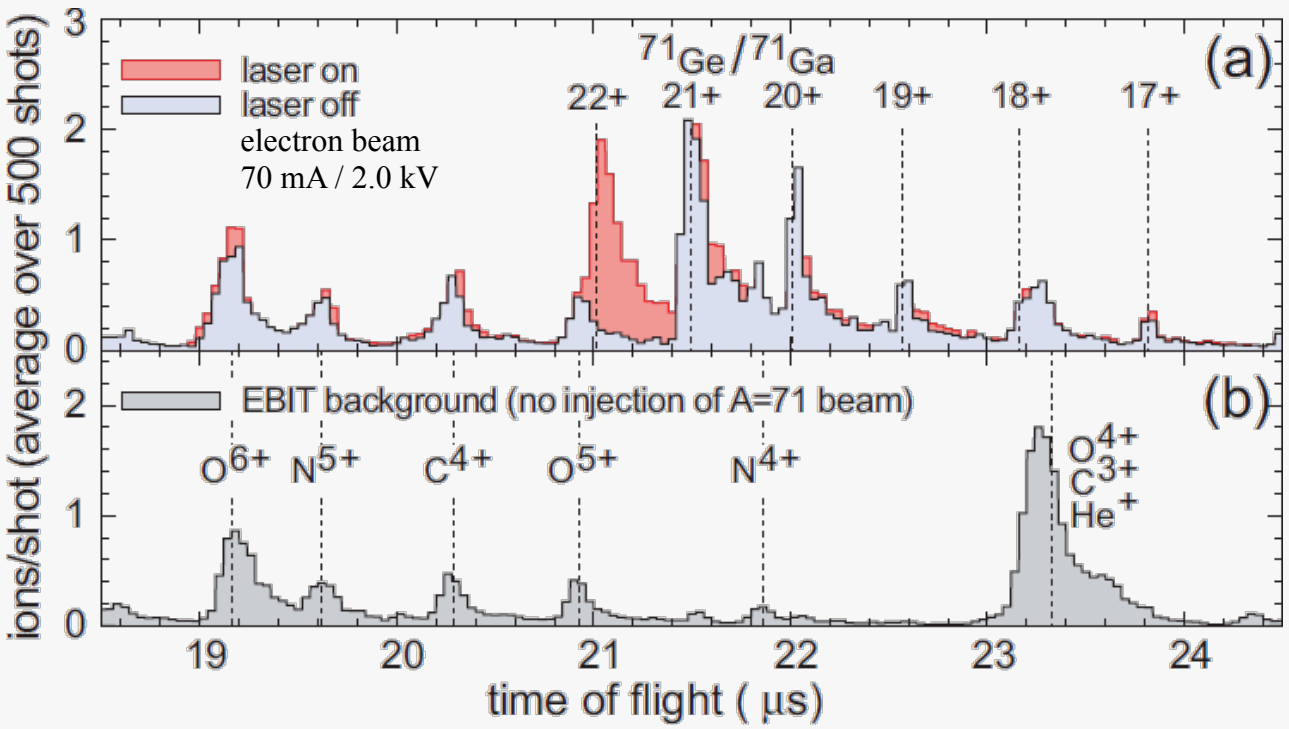
surface-ionized Ga & ^{67}Ge 1.2*10^4 /s

^{71}Ge 1.8*10^7 /s

^{76}Ge 3.3*10^4 /s

⇒ GaGe – TITAN mass measurement $^{76}Ge^{22+}$ / $^{76}Ga^{21+}$

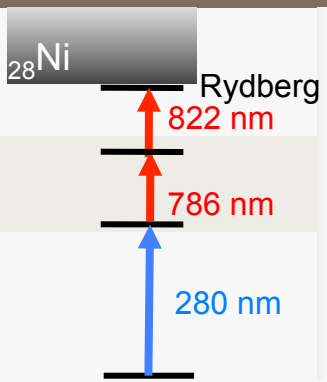
⇒ by threshold charge breeding

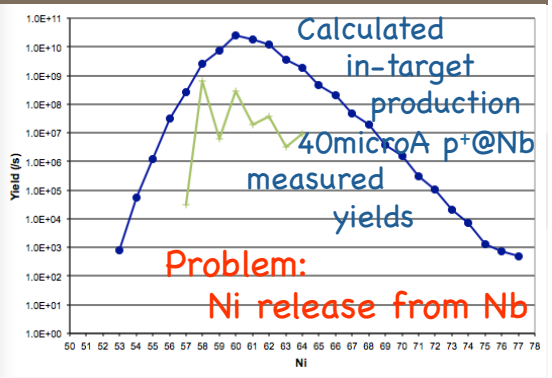


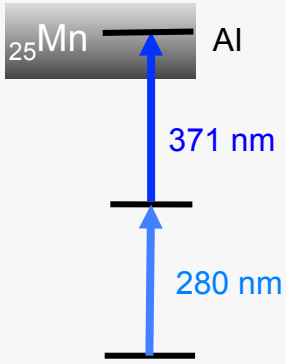
M.C. Simon *et al.*, RSI **83** (2012) 02A912, D. Frekers, M.C. Simon, *et al.*, submitted to PRL

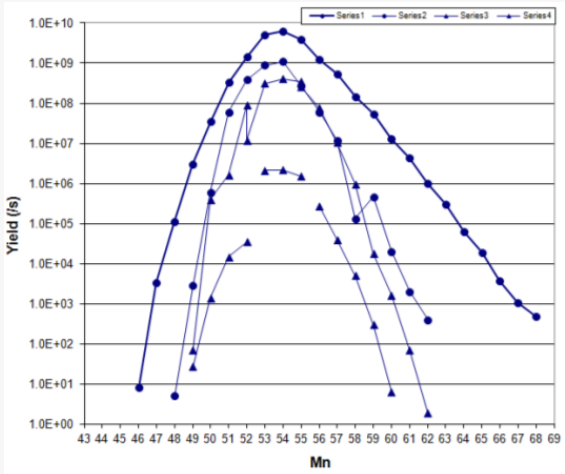
From Ania Kwiatovski -> TITAN presentation

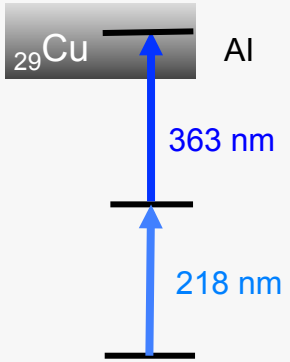
recent developments

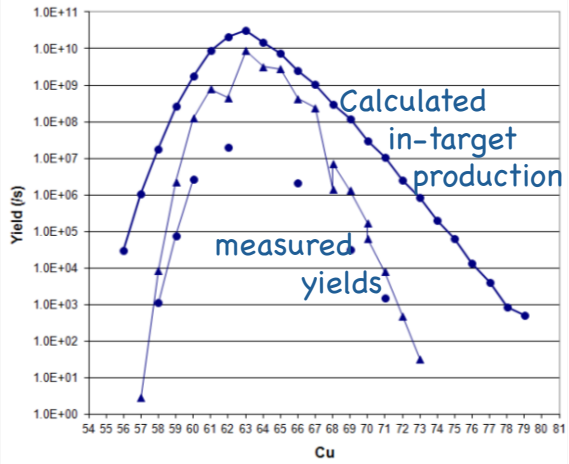


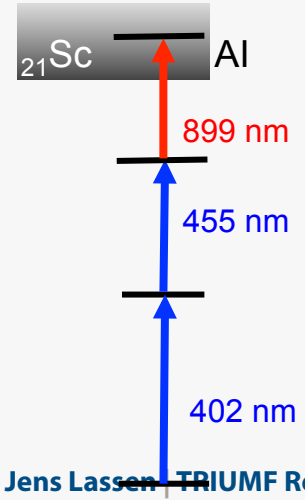


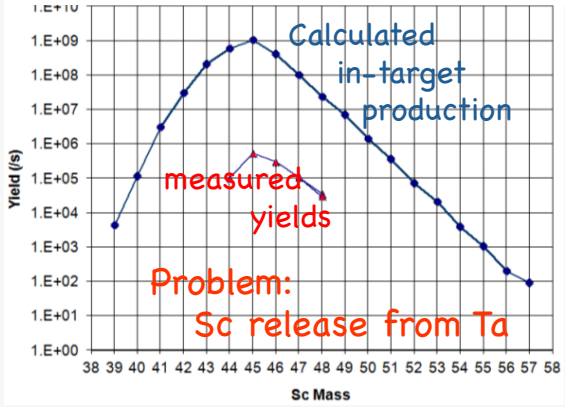


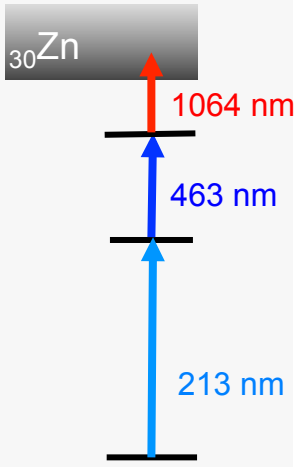


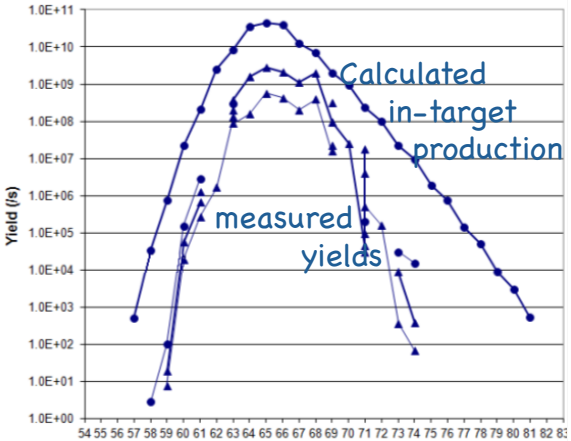




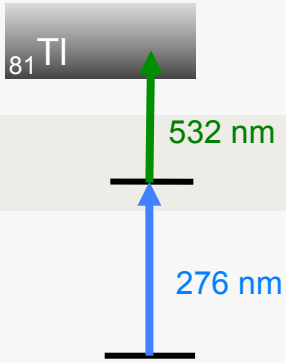


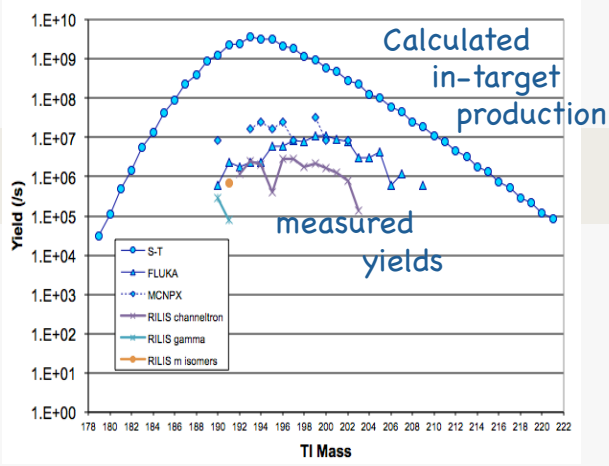


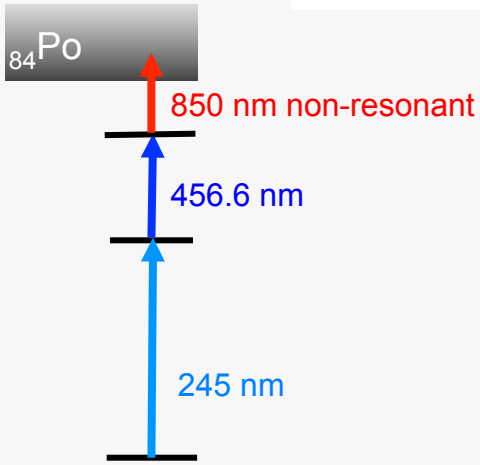


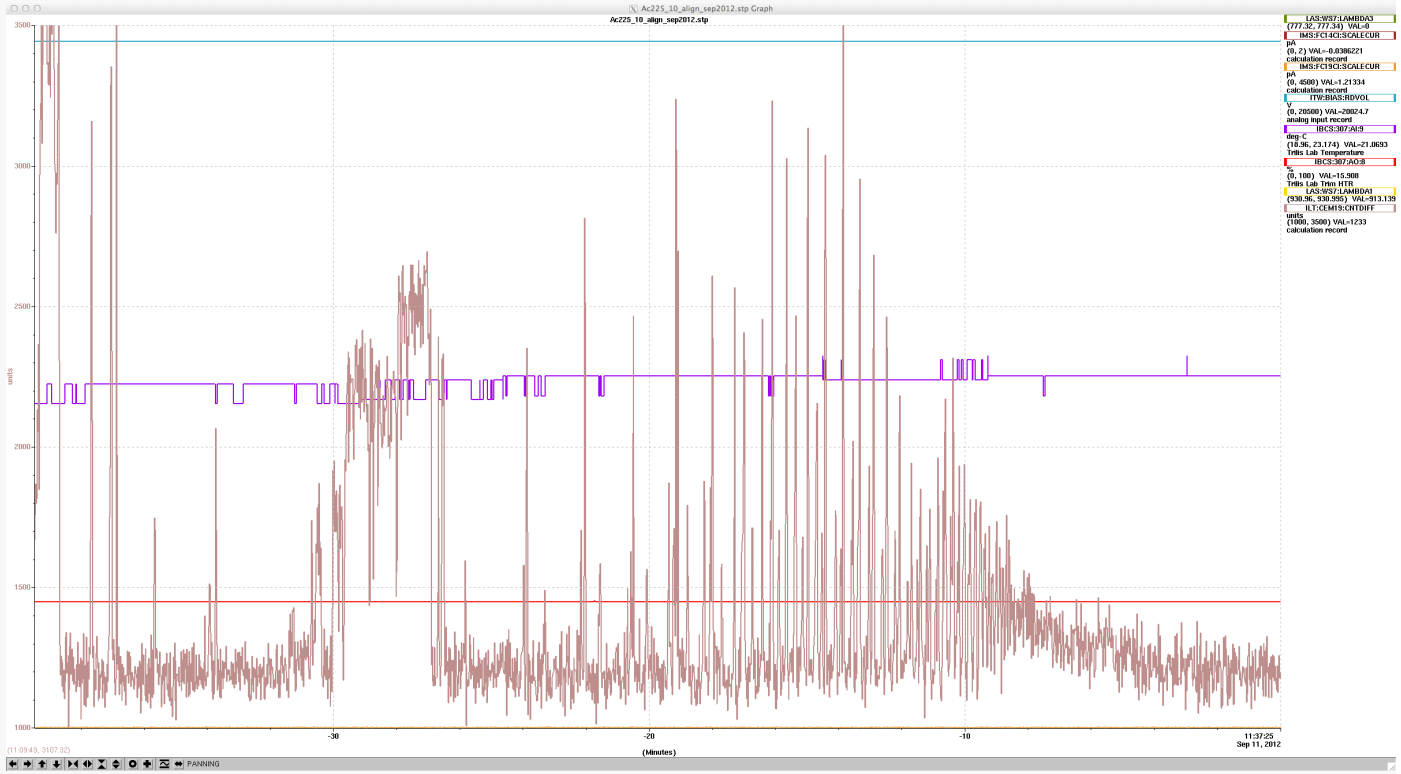


recent developments

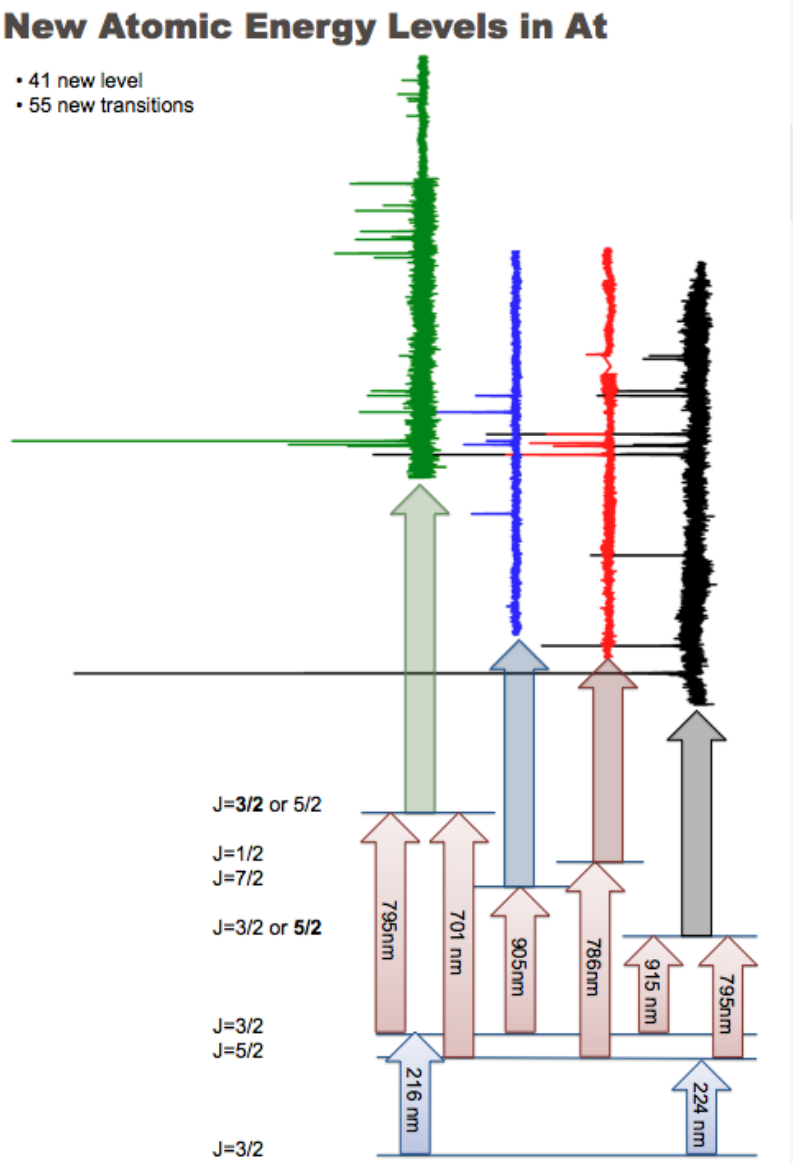


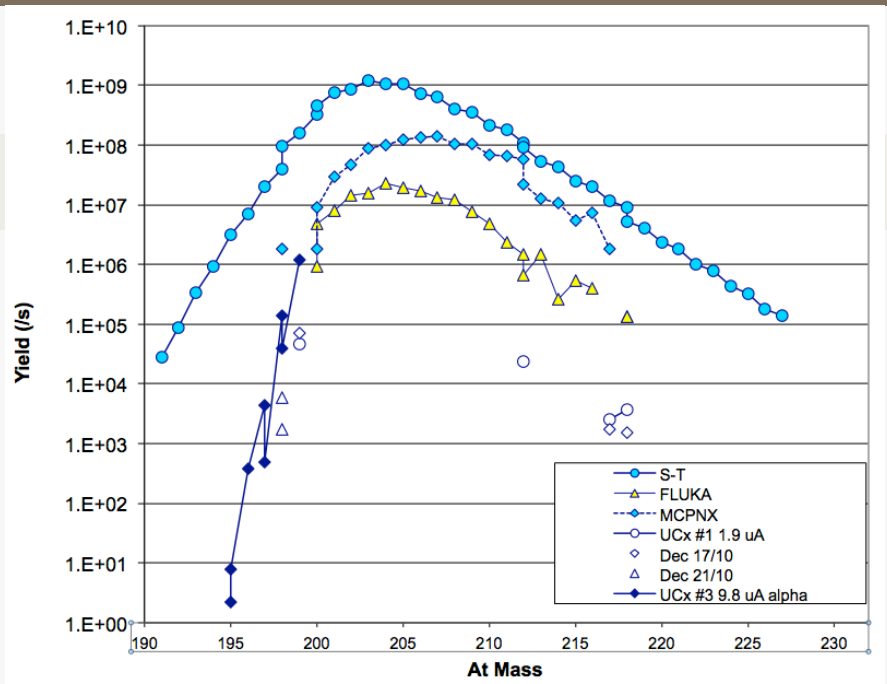


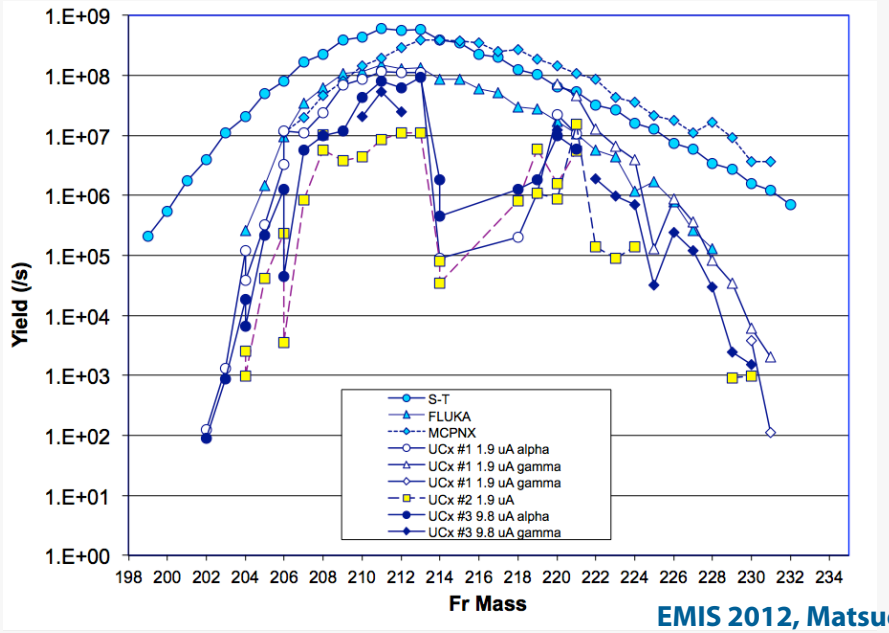




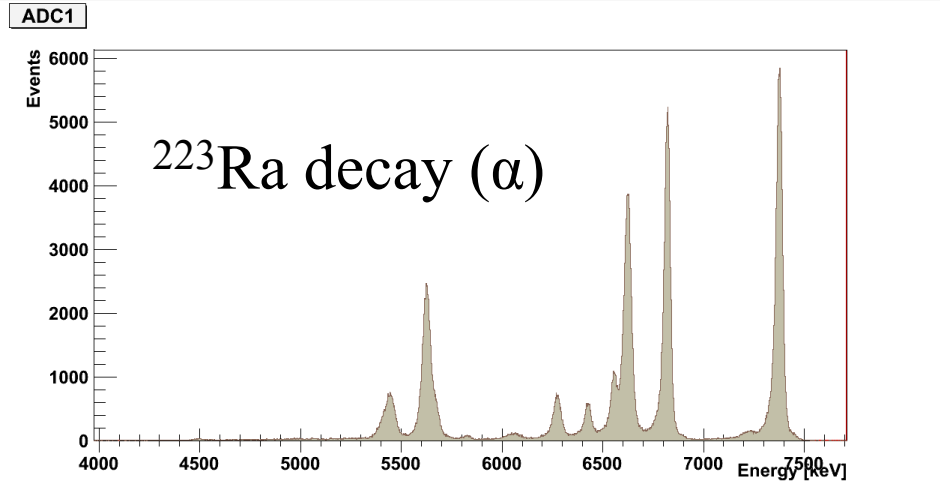
recent developments T RILIS @ UCx

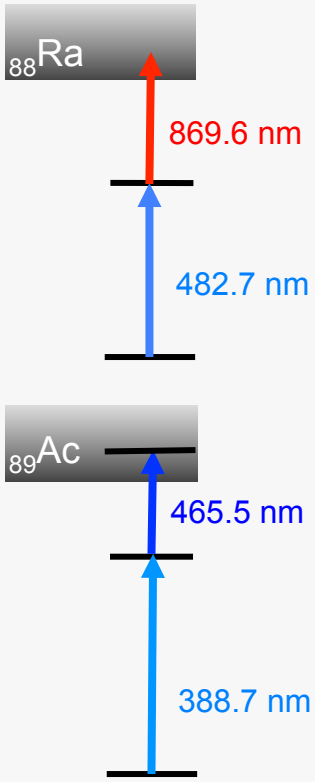






S1237 in-source laser spectroscopy
Astatine: 41 new atomic energy levels,
55 new transitions



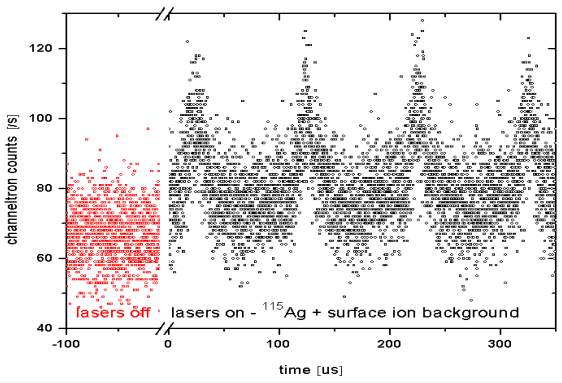


^{223}Ra	10^8/s
^{224}Ra	10^7/s
^{225}Ac	10^7/s

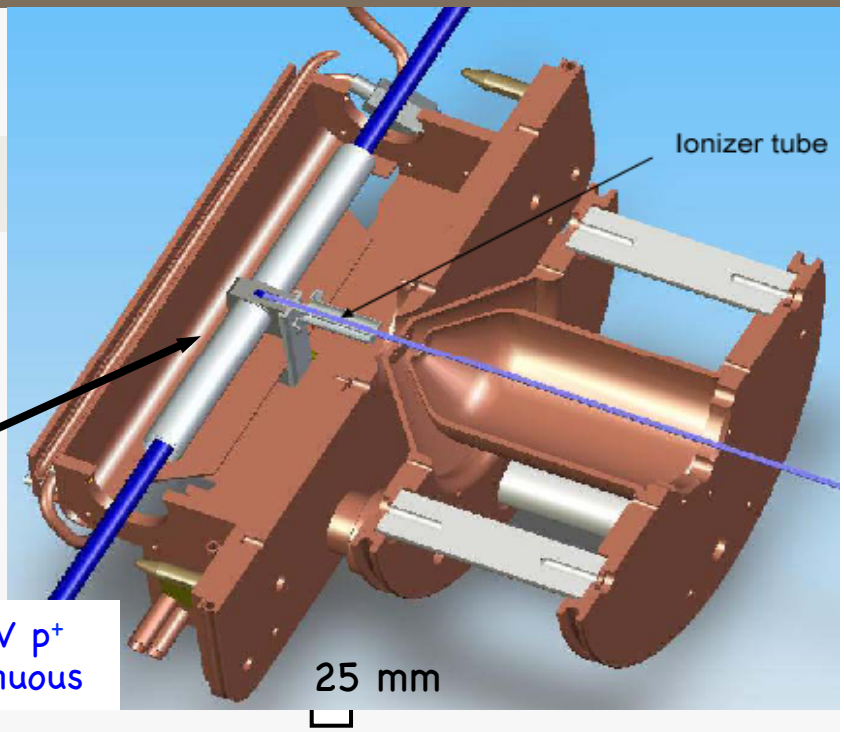
laser on/laser off=25

spectroscopy -> Leuven

towards isobar-supression: beam gating & RFQ-LIS



Pulse structure of RILIS ions



500 MeV p^+ continuous

(2012-13) fast kicker (beam gating), complement laser transport optics

(2013-14) RFQ LIS on-line (isobar free beams), laser trigger

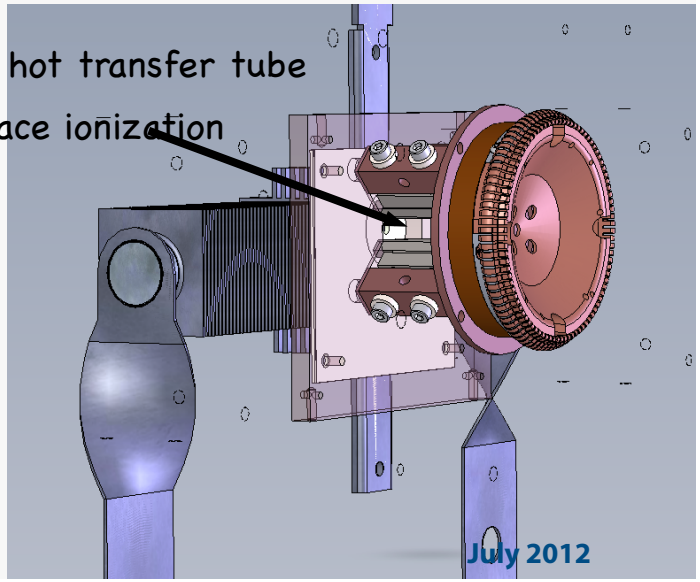
(2013-16) 15kHz rep. rate laser operation

(2014-17) multiple beams & ARIEL lasers, Doppler free spectroscopy control system integration

RFQ-LIS

cold RF-ion guide replaces hot transfer tube

-> eliminates residual surface ionization



T RILIS off-line developments:

(2012-2017) 2 new elements/y (Y, Cd, Sb, Lanthanides, etc.)

RFQ LIS optimization & reliability

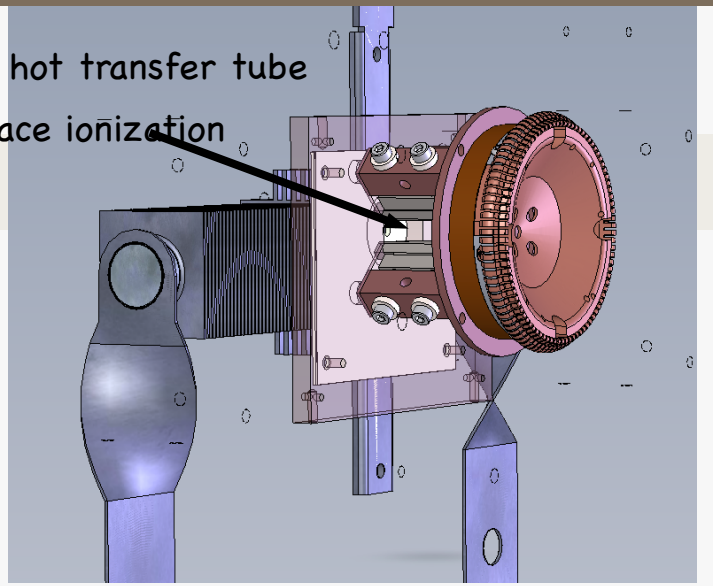
laser source reliability improvements

laser developments for select elements (RILIS schemes)

RFQ-LIS

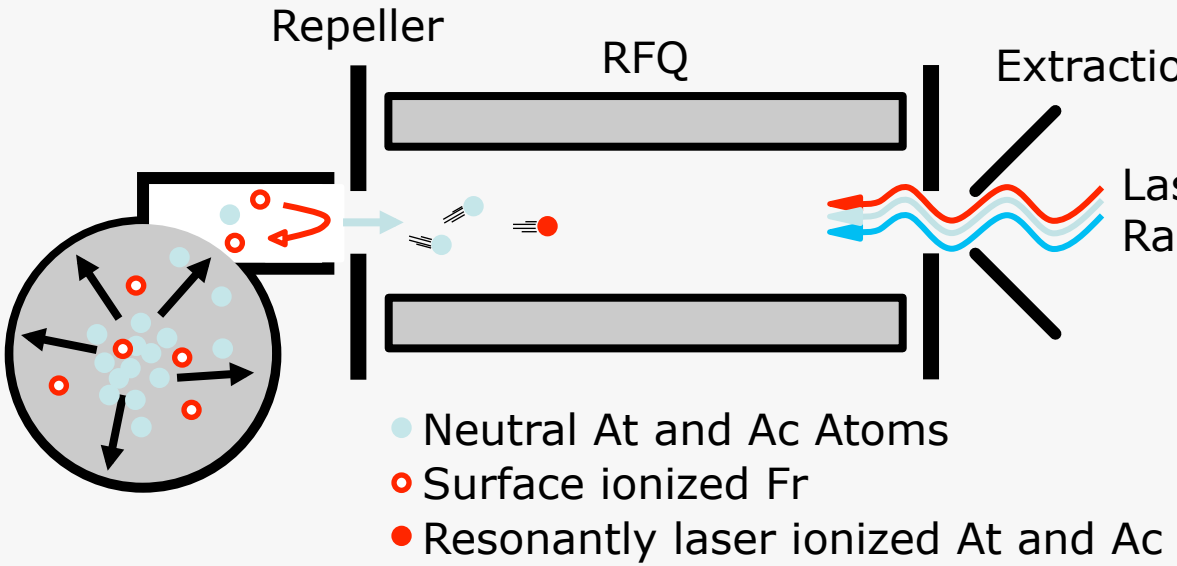
cold RF-ion guide replaces hot transfer tube

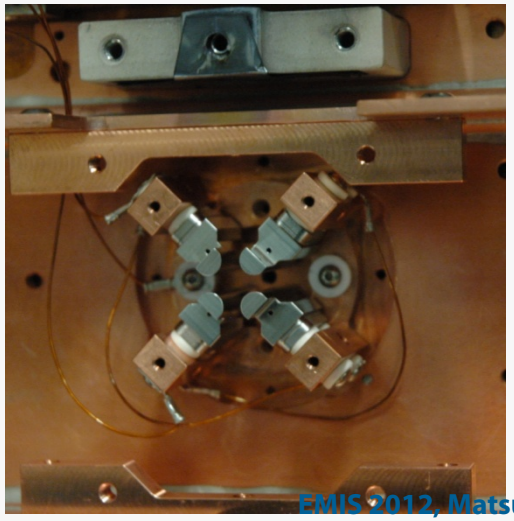
-> eliminates residual surface ionization



currently off-line testing

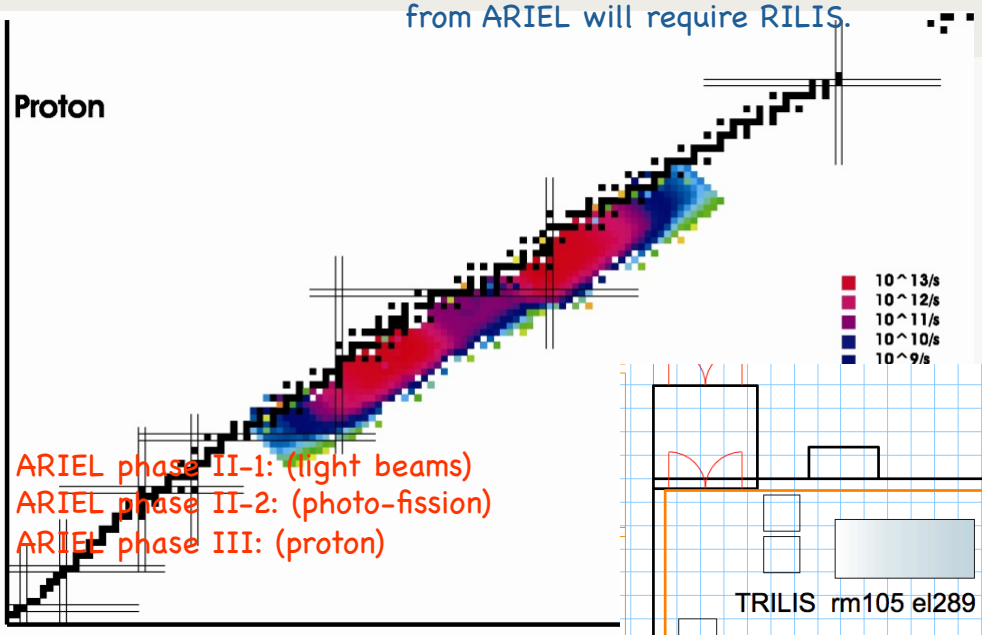
spring 2013 first on-line tests

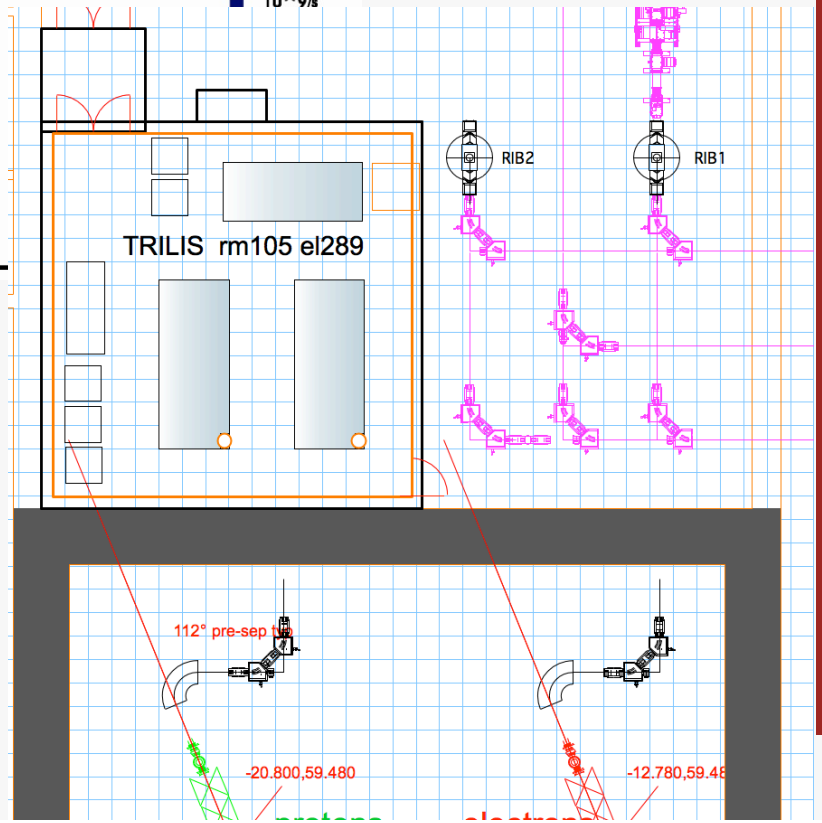


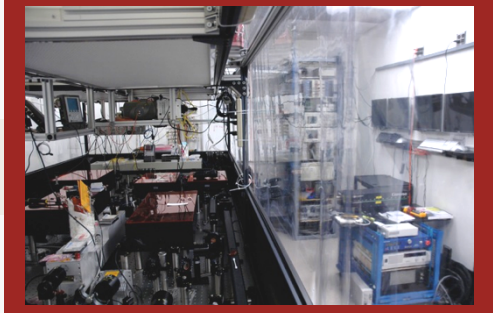


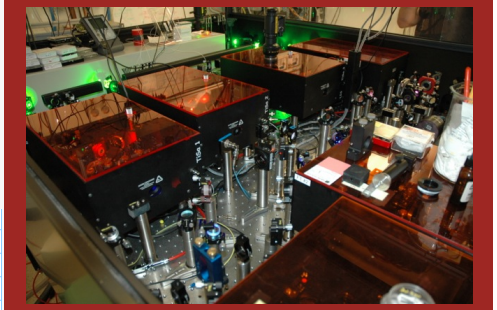
far out (2014-2020) ARIEL laser ion source

The unique ARIEL isotope production spectrum demands highest isobar selectivity. A resonant ionization laser ion source (RILIS) is uniquely in its ability for element selective ionization. It is expected that more than 50% of all rare isotope beams delivered from ARIEL will require RILIS.





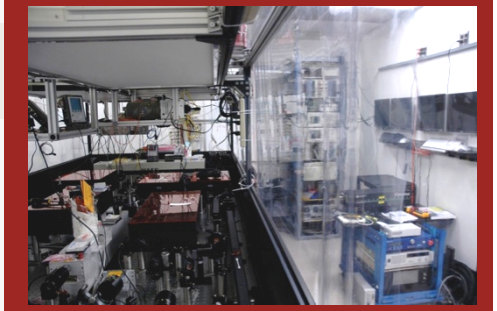




TRIUMF

Canada's National Laboratory for Particle and Nuclear Physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

Laser Resonance Ionization @ TRIUMF
spectroscopy tool & ion source for rare isotopes



principles, application,
TRIUMF Resonant Ionization Laser Ion Source
In-source laser spectroscopy of rare isotopes

Jens Lassen, A. Teigelhoefer, S. Raeder, R. Li, H. Heggen, T. Menke, L. Suen, P. Kunz, F. Ames | TRIUMF Accelerator Division

thank you very much

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TiSa Network

.and colleagues from around the world, who in the background support our work

TRIUMF: Alberta | British Columbia | Calgary Carleton | Guelph | Manitoba | McMaster Montréal | Northern British Columbia | Queen's Regina | Saint Mary's | Simon Fraser | Toronto Victoria | Winnipeg | York

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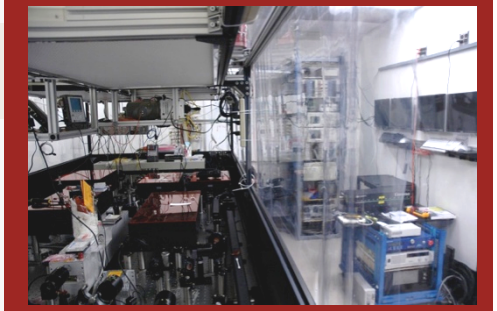
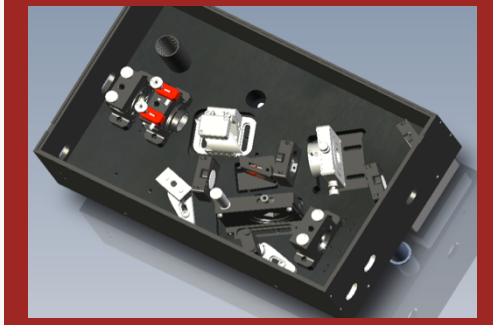
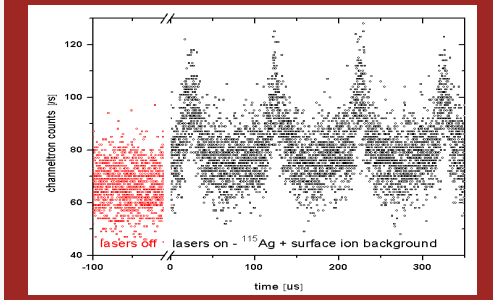
Laser Resonance Ionization @ TRIUMF spectroscopy tool & ion source for rare isotopes

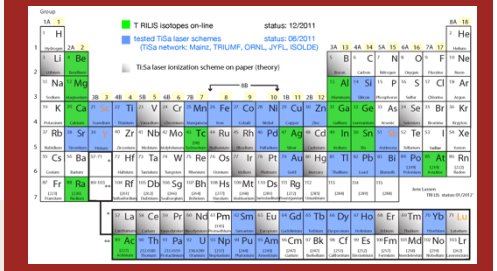
TRIUMF Resonant Ionization Laser Ion Source
In-source laser spectroscopy of rare isotopes

Jens Lassen | **Research Scientist** | **TRIUMF Accelerator Division**









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