

# LASer techniques for Exotic nuclei Research (LASER)

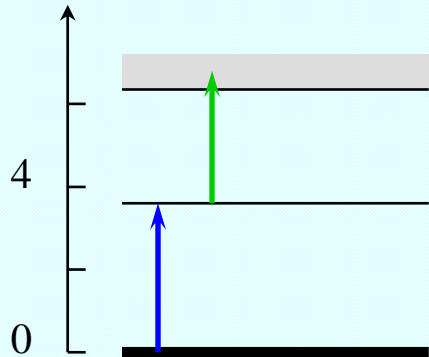
Develop tools and perform R&D for the Resonance Laser Ion Source (RILIS):

- Production of **extremely pure** ground-state and isomeric beams of exotic nuclei
- **Accumulation, cooling, bunching and polarization** of clean radioactive ion beams

(Institutes: K.U.leuven, GSI, JYFL -Jyväskylä, ISOLDE, U-Mainz, U-Manchester, INP-Orsay)

## Resonant Laser Ionization

Energy (eV)



Increase of  
ionization efficiency

Increase of  
ion beam quality  
- purity  
- emittance  
- time structure

- More efficient use of ISOL beams
- New exotic (polarized, isomeric) RIB
- Optimization of RIB time structure
- Easy injection into ion traps
- Determination of radii, spins and moments using in-source spectroscopy
- Reduction of background in collinear spectroscopy

# Research program

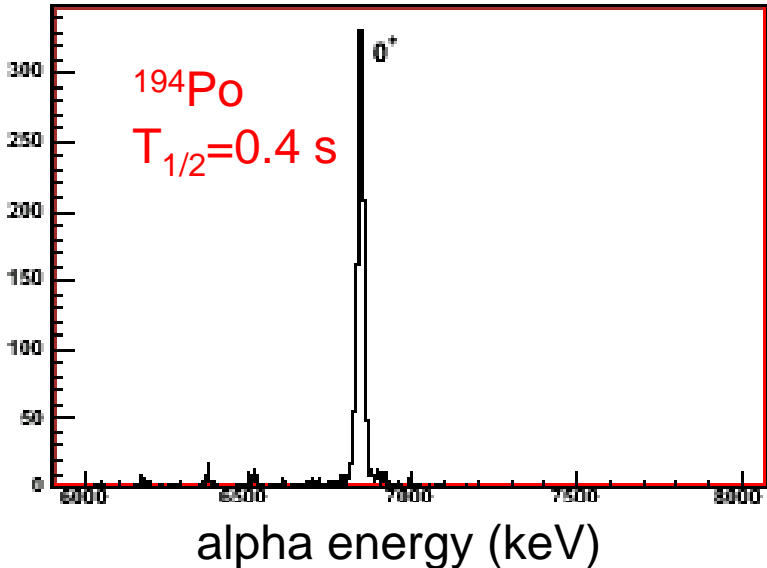
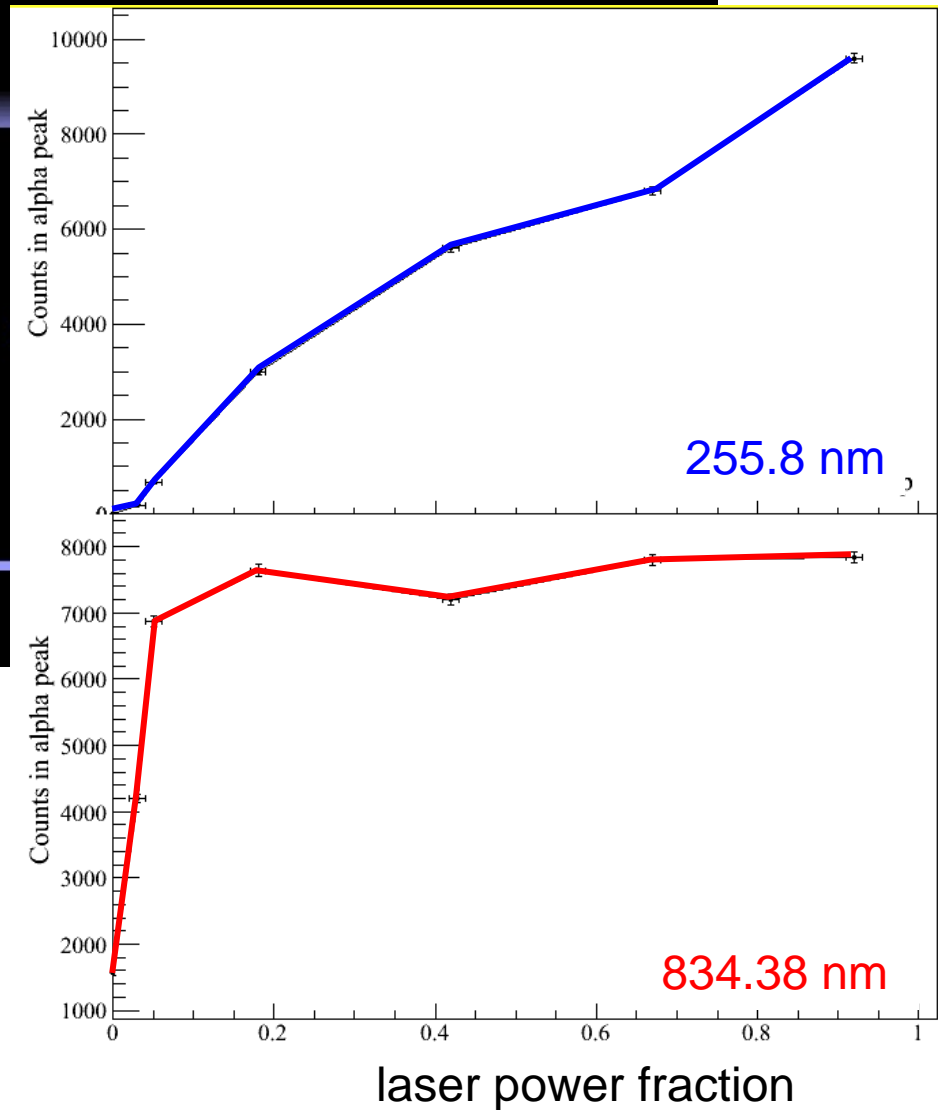
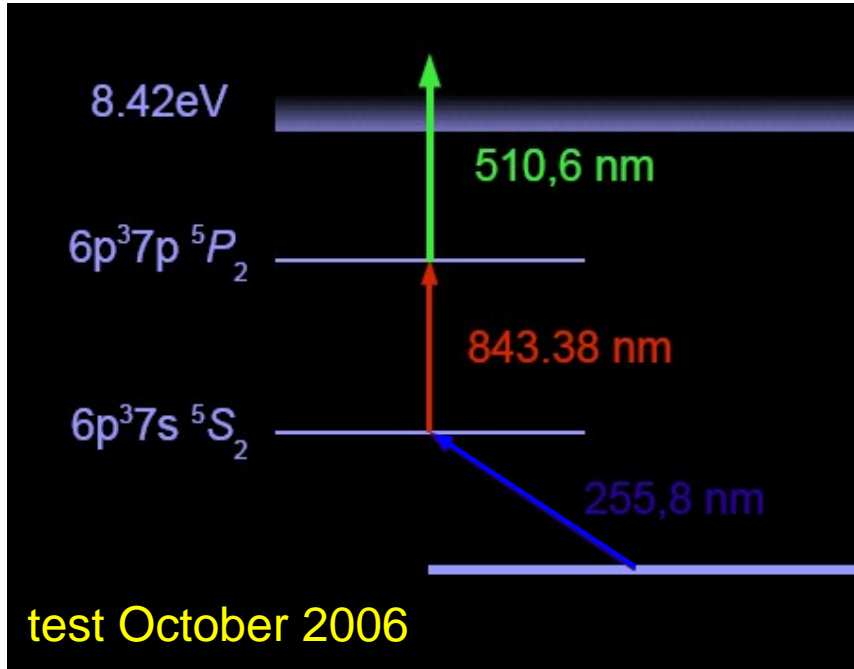
## Description of work:

Task T-J08-2: New laser ionisation schemes and new beams

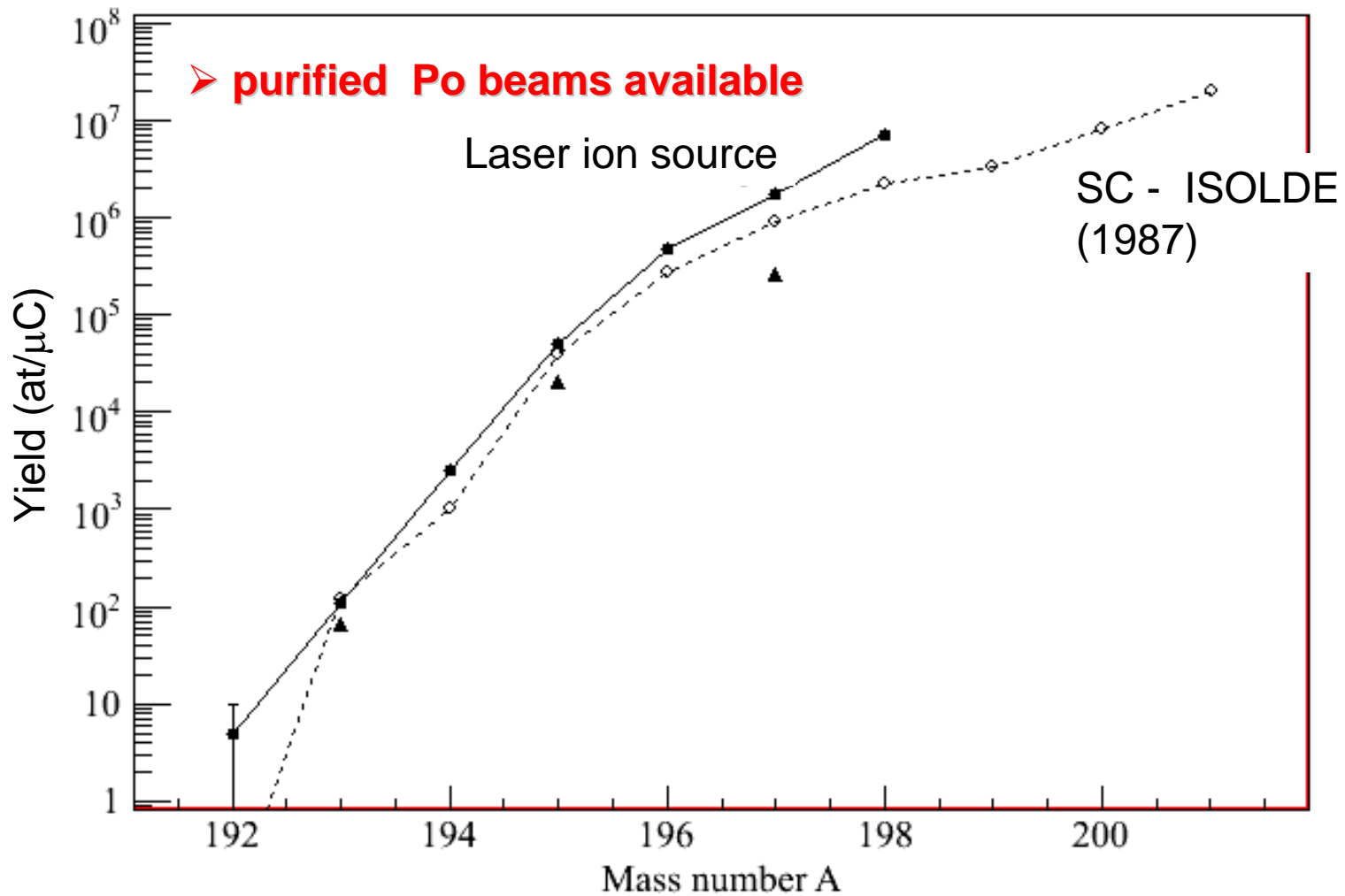
Task T-J08-3: Prototype LIST system

Task T-J08-6: Feasibility study to polarize exotic nuclei with lasers

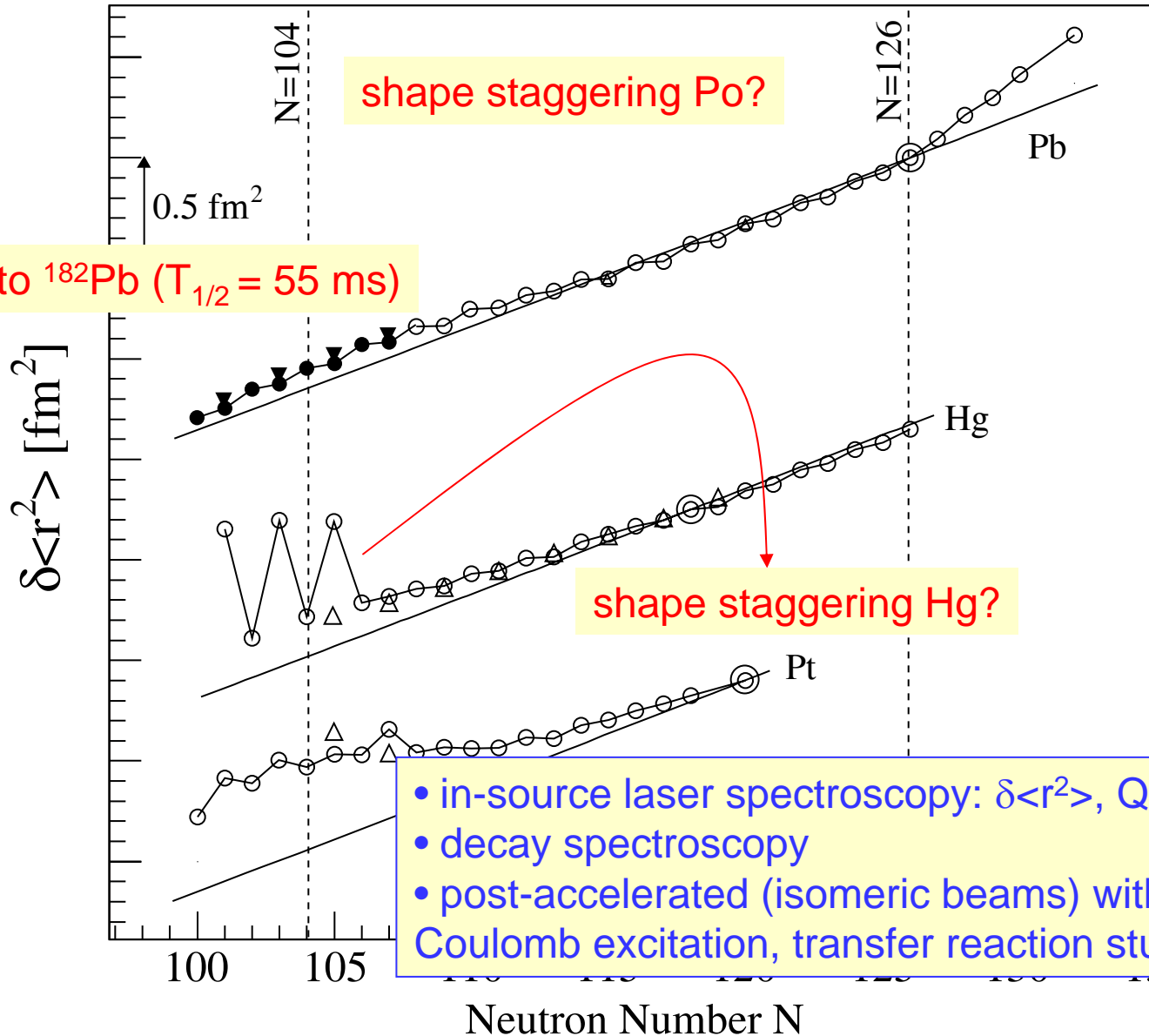
- **On-line** test of a new laser ionization scheme for polonium at ISOLDE (ISOLDE, K.U.Leuven, INPO-Orsay, U-Mainz)



# Yield curves - Po isotopes



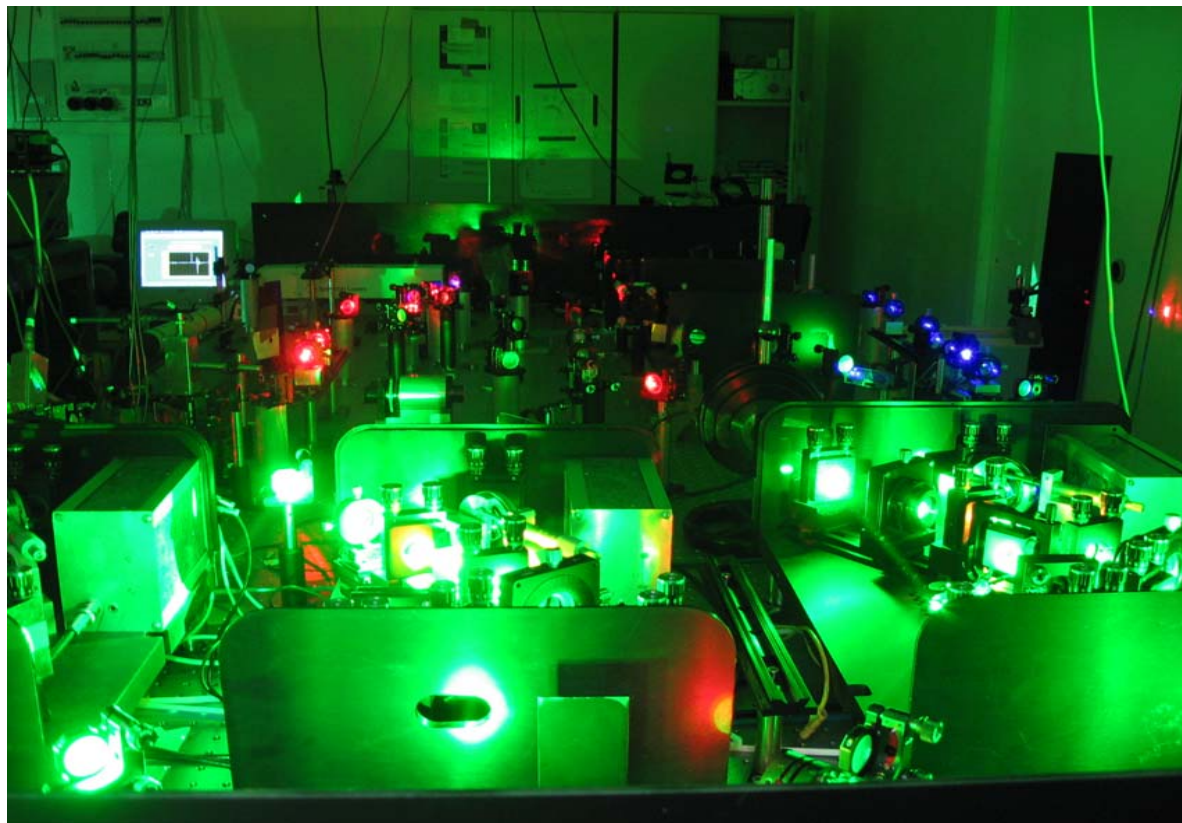
# Mean square charge radii



new down to <sup>182</sup>Pb (T<sub>1/2</sub> = 55 ms)

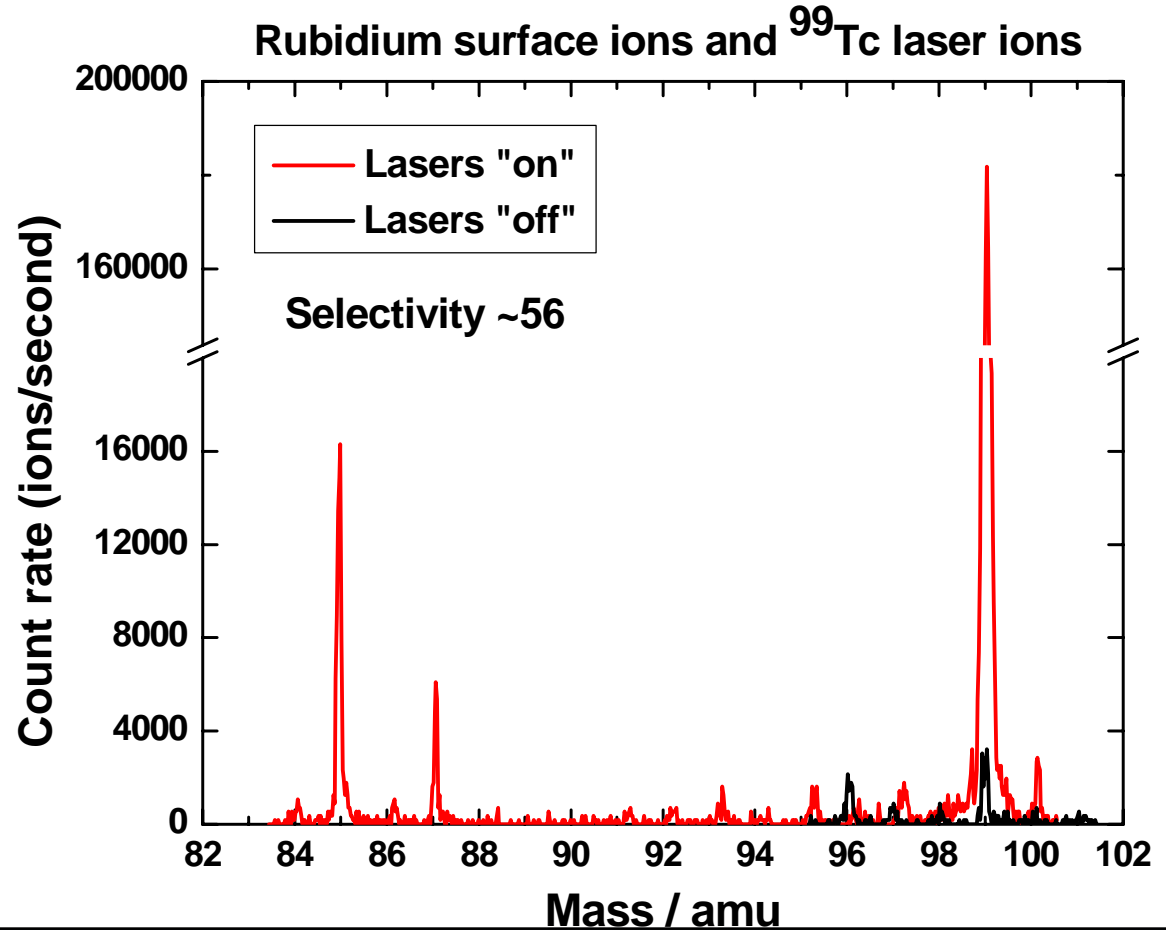
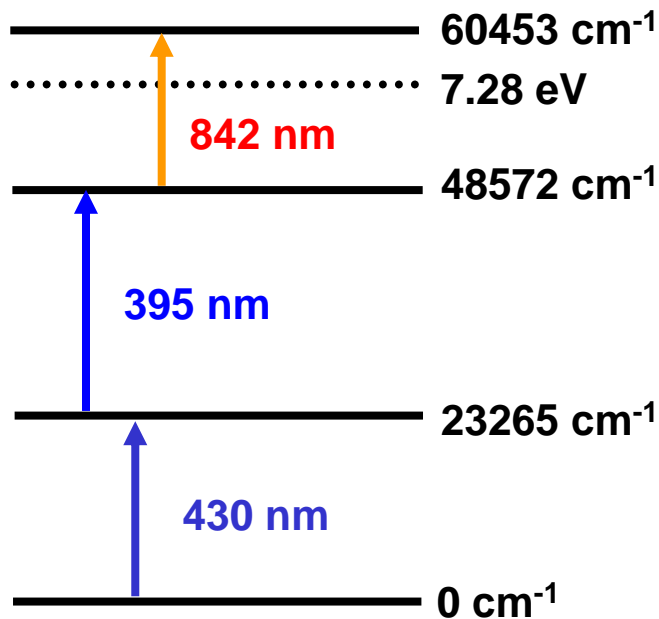
- Lasers for radioactive ion beam production and research

- ISOLDE - CERN: operational, laser system upgrade
- LISOL - Louvain la Neuve: operational
- JYFL - Jyvaskyla: installed and operational
- ALTO - Orsay: installation of laser system 2007

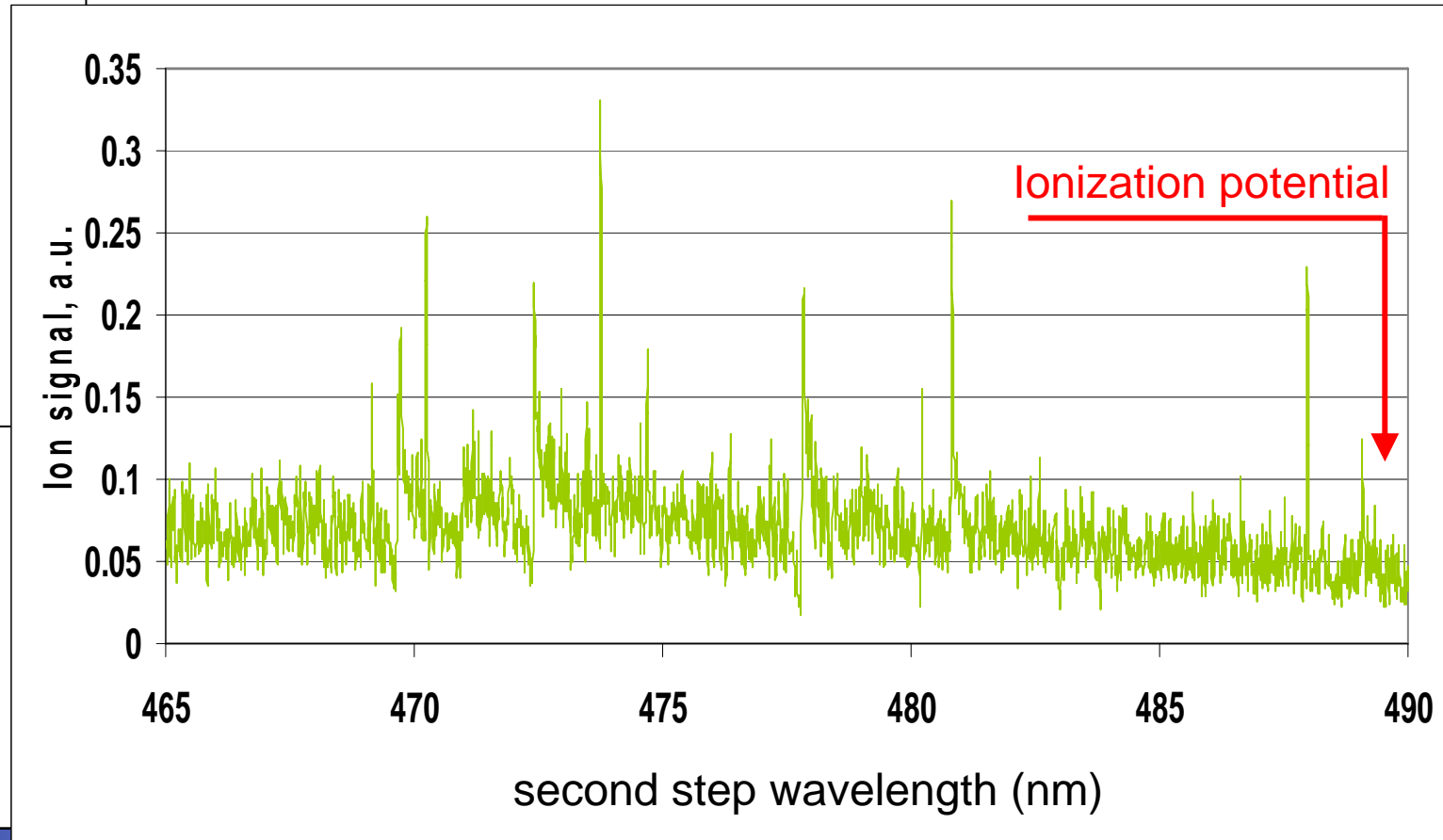
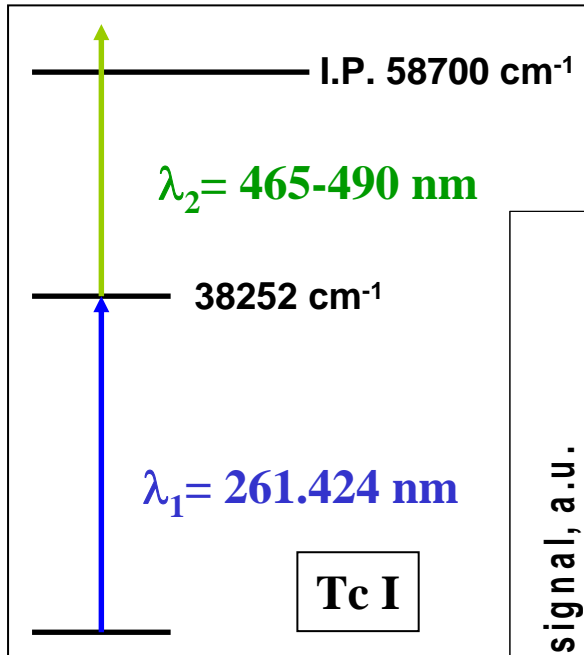


- **Off-line** laser ionization of Tc  
(JYFL, Mainz, Manchester, K.U.Leuven)

- $10^{14}$  atoms of  $^{99}\text{Tc}$  ( $t_{1/2} = 2.1 \times 10^5$  years) on Re filament (Mainz)
- 3-step laser ionization scheme using Nd:YAG pumped Ti:Sapphire lasers (JYFL)



- 2-step laser ionization scheme using excimer pumped dye lasers via auto ionizing states (LISOL)



# Ti:Sa Laser Ion Source

Titanium:sapphire laser excitation schemes accessible .....

1H																	2He
3Li	4Be											5B	6C	7N	8O	9F	10Ne
11Na	12Mg											13Al	14Si	15P	16S	17Cl	18Ar
19K	20Ca	21Sc	22Ti	23V	24Cr	25Mn	26Fe	27Co	28Ni	29Cu	30Zn	31Ga	32Ge	33As	34Se	35Br	36Kr
37Rb	38Sr	39Y	40Zr	41Nb	42Mo	43Tc	44Ru	45Rh	46Pd	47Ag	48Cd	49In	50Sn	51Sb	52Te	53I	54Xe
55Cs	56Ba	57La	72Hf	73Ta	74W	75Re	76Os	77Ir	78Pt	79Au	80Hg	81Tl	82Pb	83Bi	84Po	85At	86Rn
87Fr	88Ra	89Ac	104Rf	105Ha	106	107	108	109	110	111	112	113					

- ..with fundamental & frequency doubling.
- ..with frequency tripling.
- ..with frequency quadrupling.
- ..successfully tested.

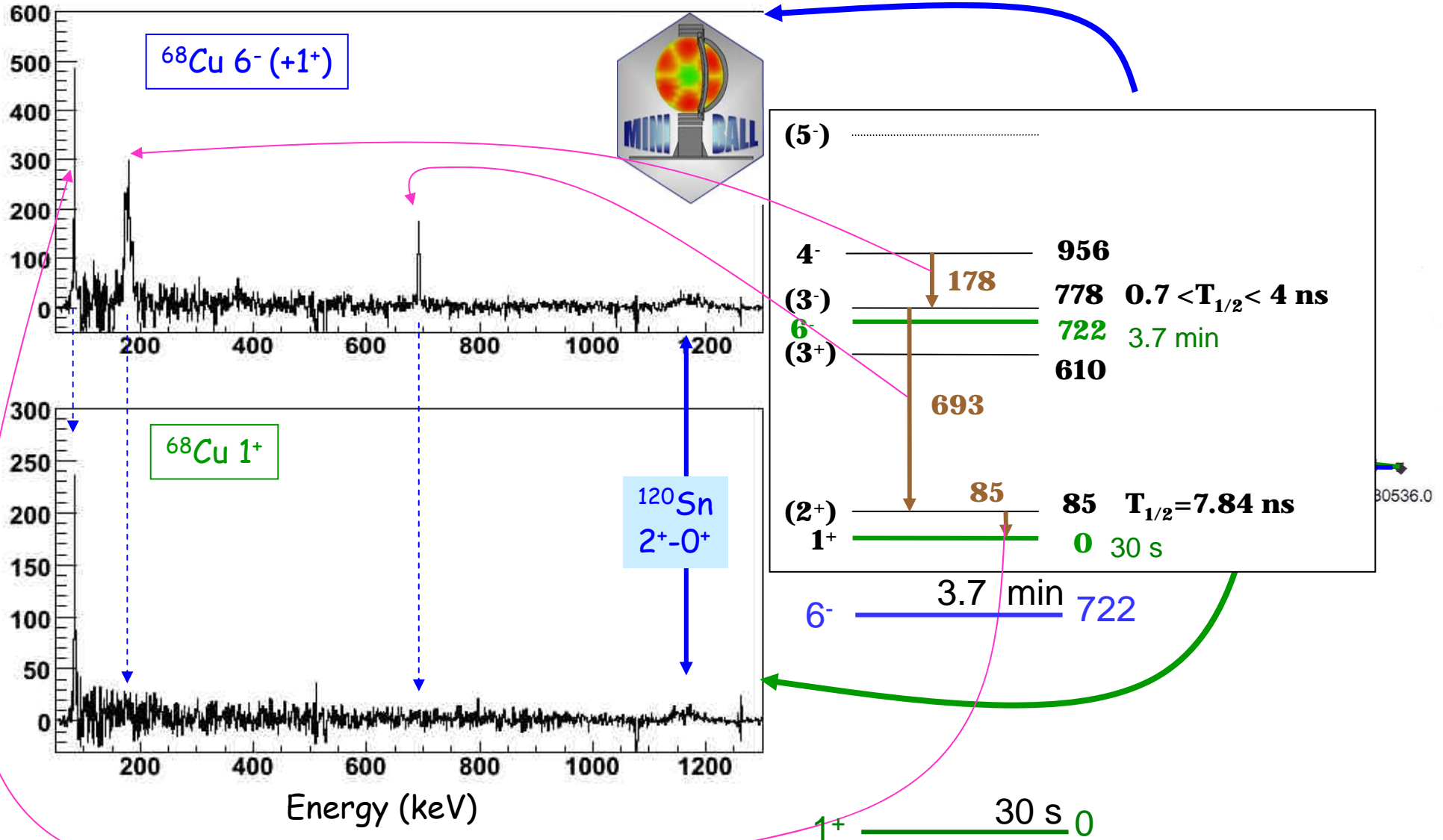
58Ce	59Pr	60Nd	61Pm	62Sm	63Eu	64Gd	65Tb	66Dy	67Ho	68Er	69Tm	70Yb	71Lu
90Th	91Pa	92U	93Np	94Pu	95Am	96Cm	97Bk	98Fm	99Es	100Md	101No	102Lr	



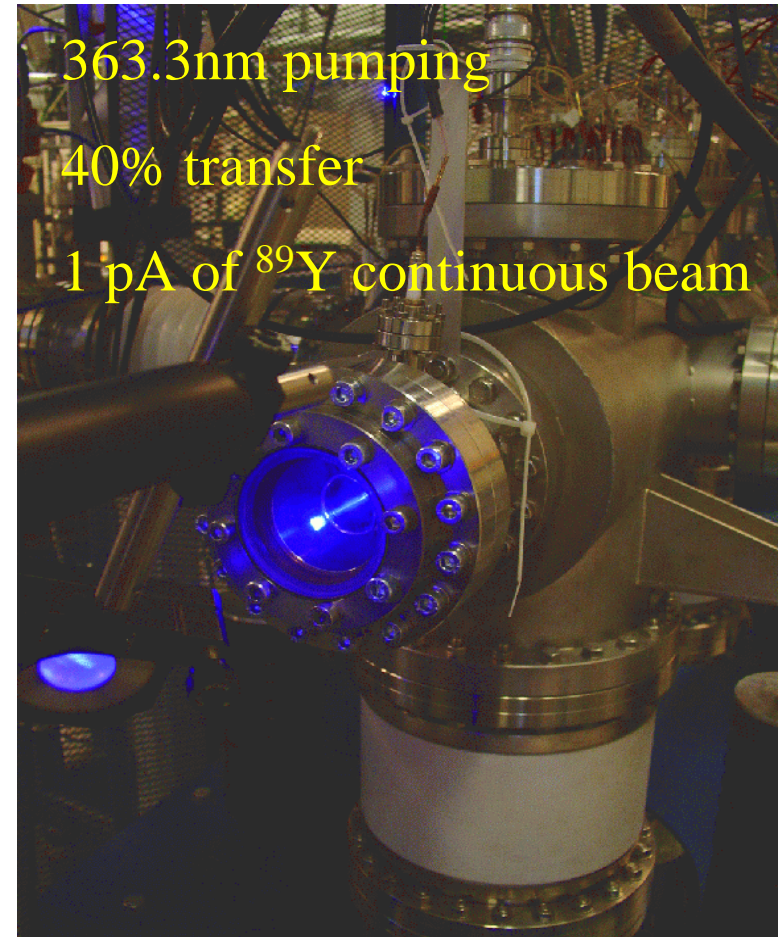
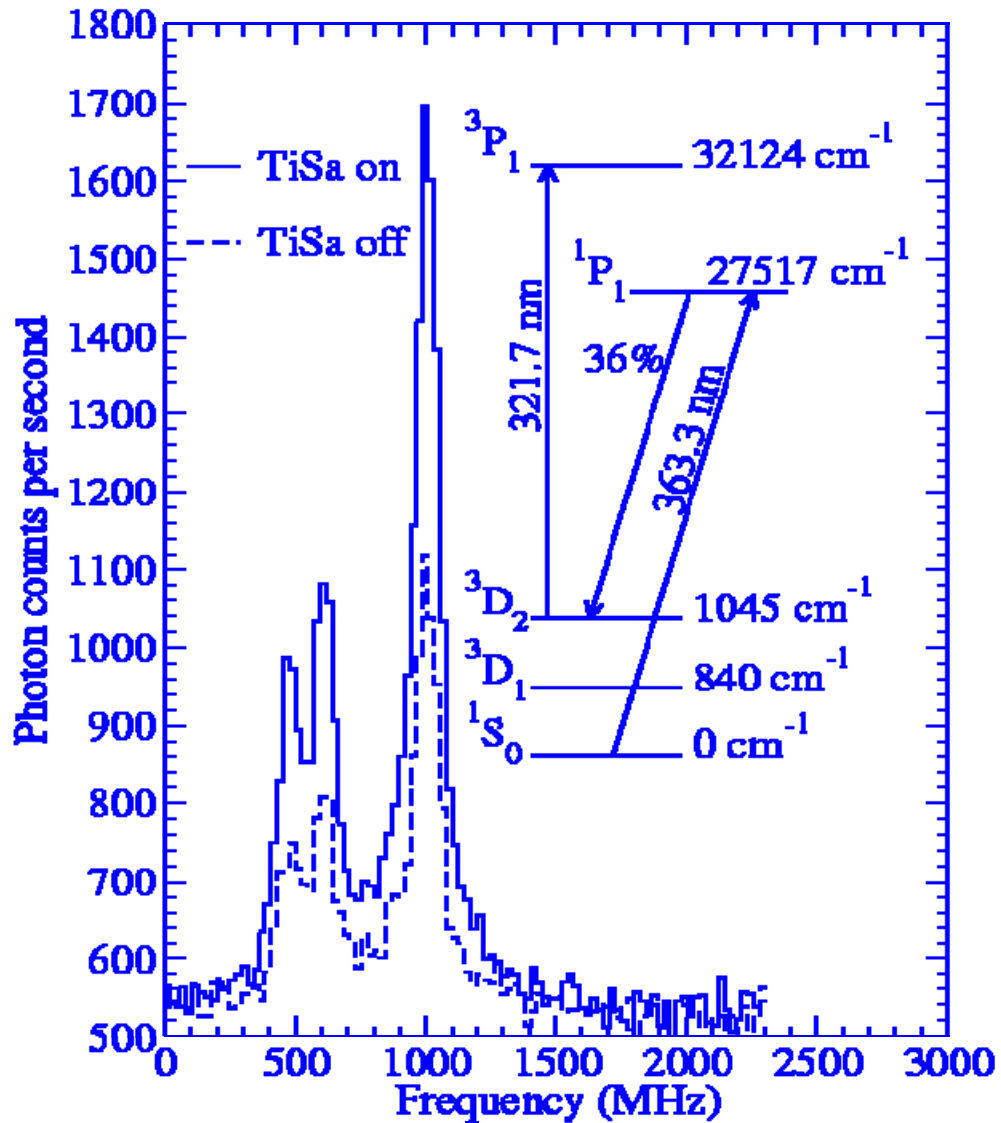
- New ionization schemes: Al, Ca, Fe, Ni, Cu, Ga, Zn, Ge Tc, Pd, Sn, Gd, Yb,.....  
(on-line experiments)

• Post-accelerated isomeric Cu beams @ ISOLDE (ISOLDE, IPN-Orsay, K.U.Leuven)

➤  $^{68m,g}\text{Cu}$  (2.86 MeV/u,  $3 \cdot 10^5$  pps, 74% pure) @  $^{120}\text{Sn}$  (2.3 mg/cm<sup>2</sup>)

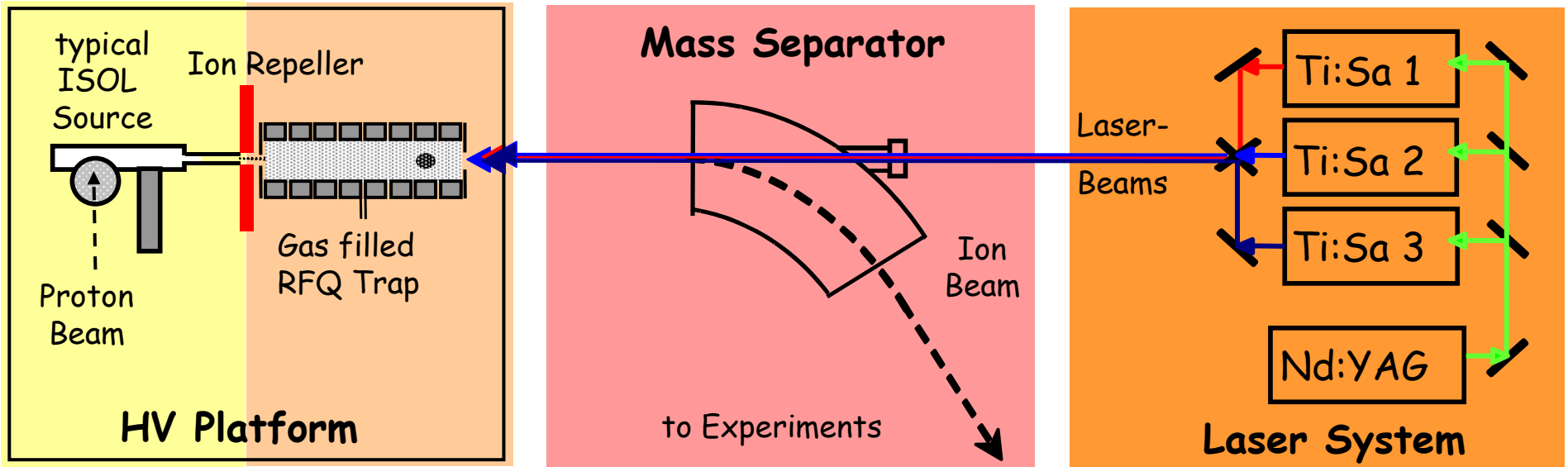


- Optical pumping in the RFQ cooler (JYFL - Manchester)



• Laser Ion Source Trap - LIST  
(GSI - Mainz - JYFL - Manchester)

Production of isobarically pure ion beams with optimum spatial and temporal ion pulse control using a gas-filled RFQ structure



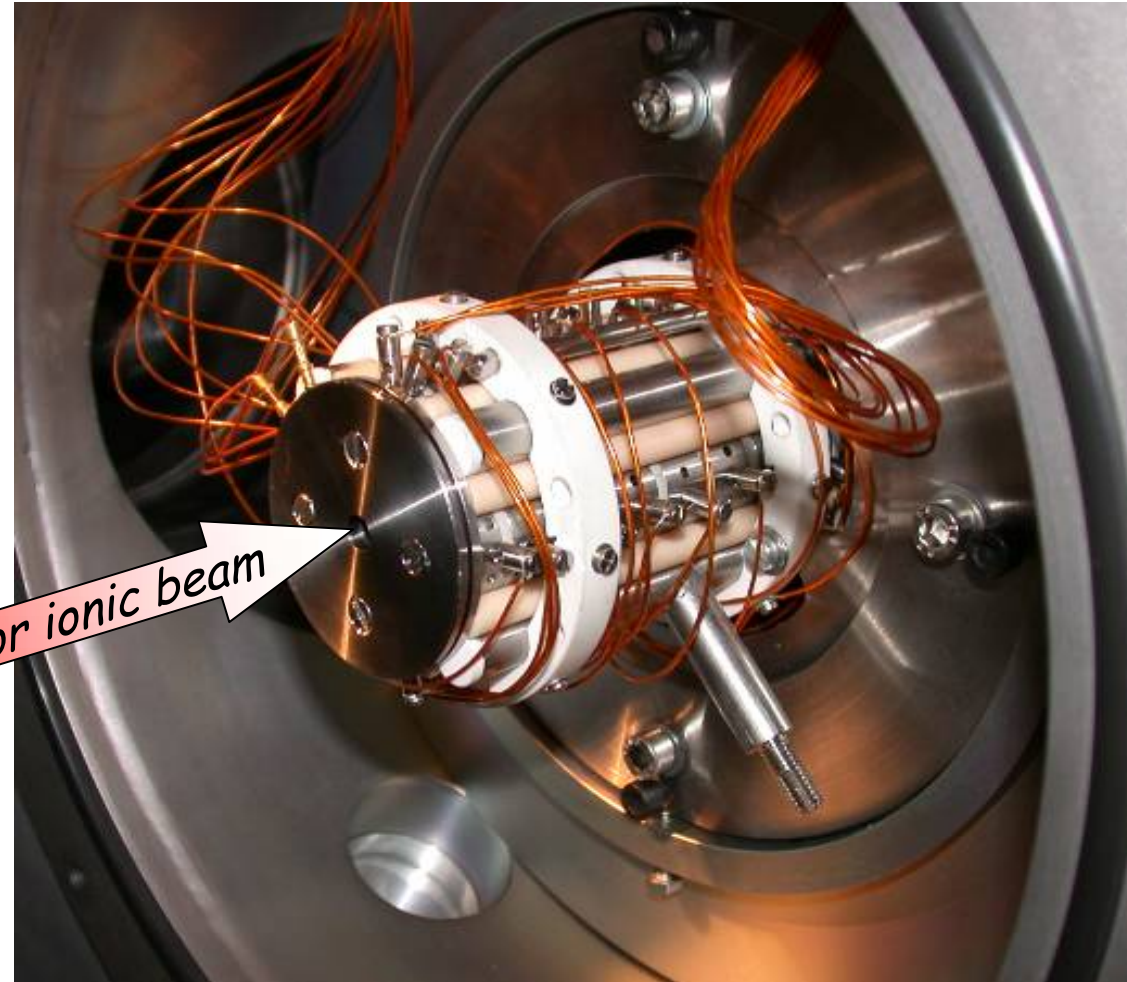
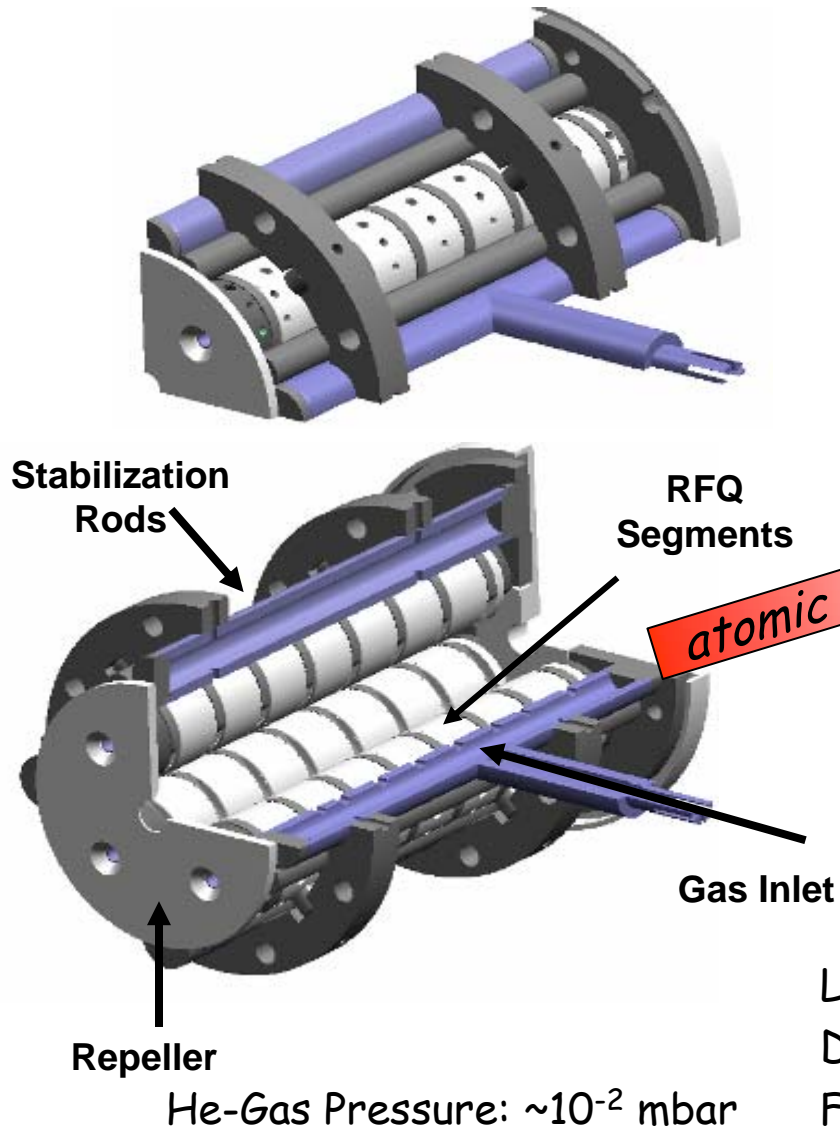
1. Atomic Beam Source with Surface Ion Reppeller - Gas cell

2. Gas filled RFQ Trap Section for Bunching and Cooling

3. Mass Separator

4. Laser System

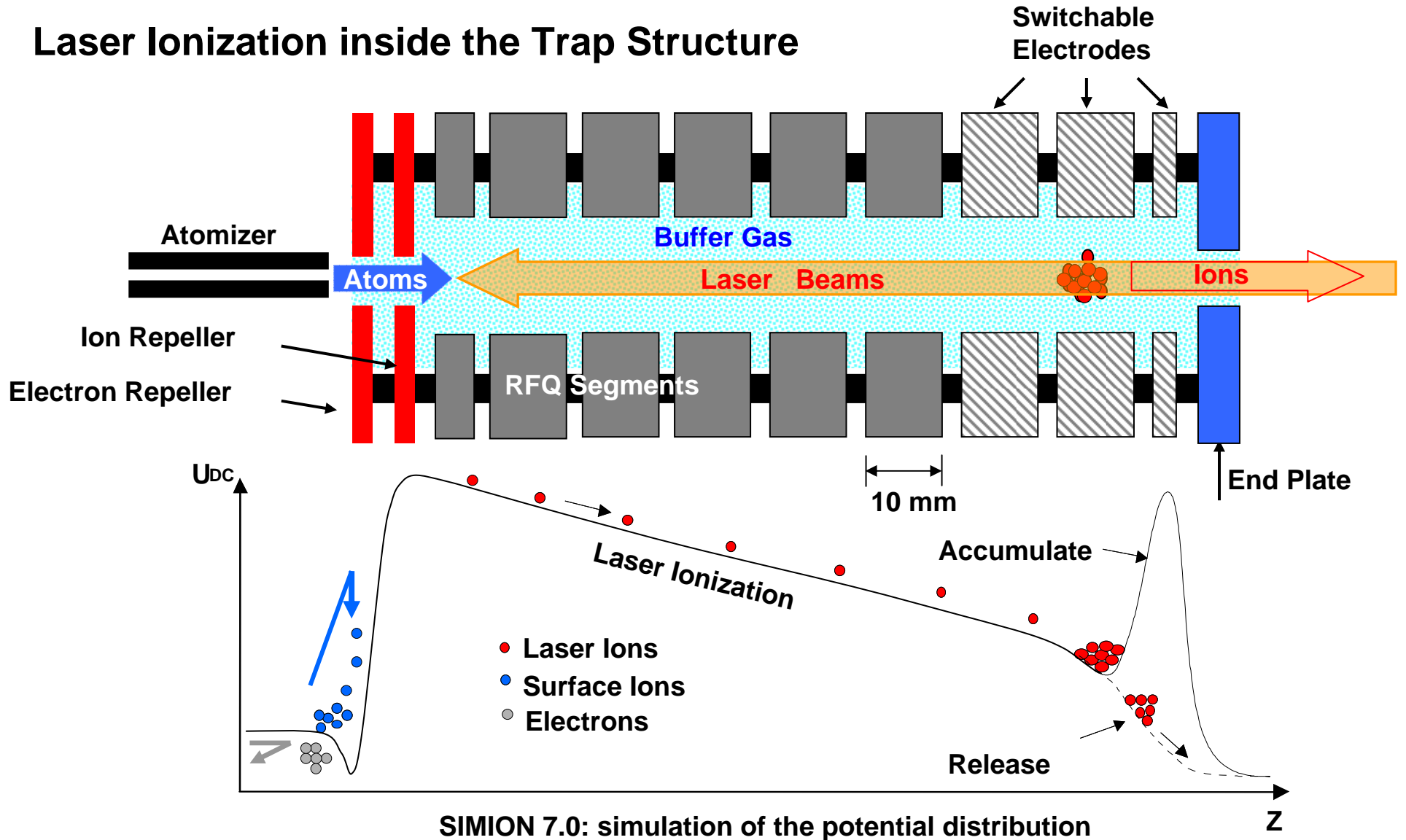
# The RFQ-Trap: Design & Realization



Length: 106 mm	Distance to RILIS: 2 mm
Diameter: 70 mm	Entrance & Exit: 6 mm
Field radius: 12 mm	Radio Frequency: 1 MHz

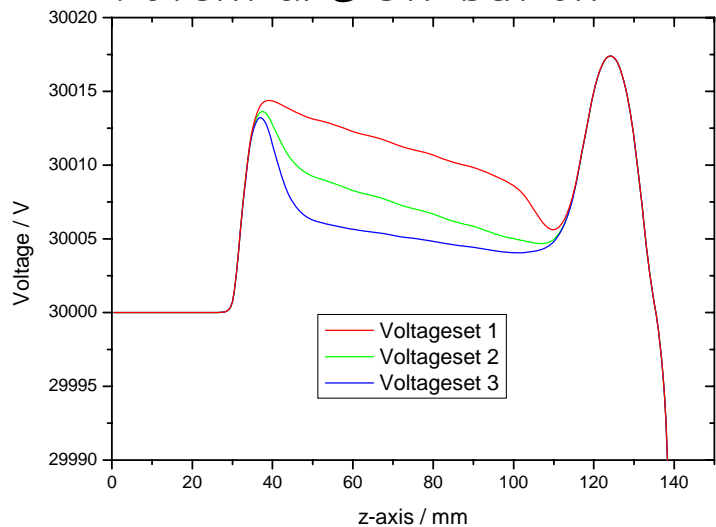
# The Gas Filled Linear RFQ-Trap

## Laser Ionization inside the Trap Structure

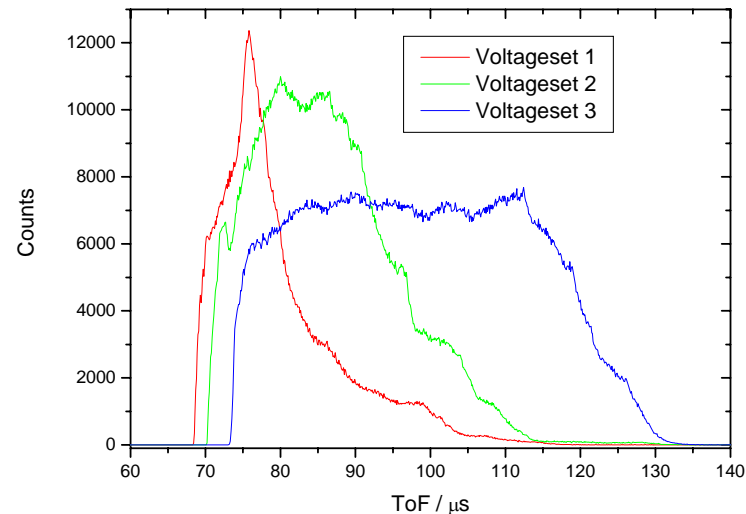


# Experimental Time Structures

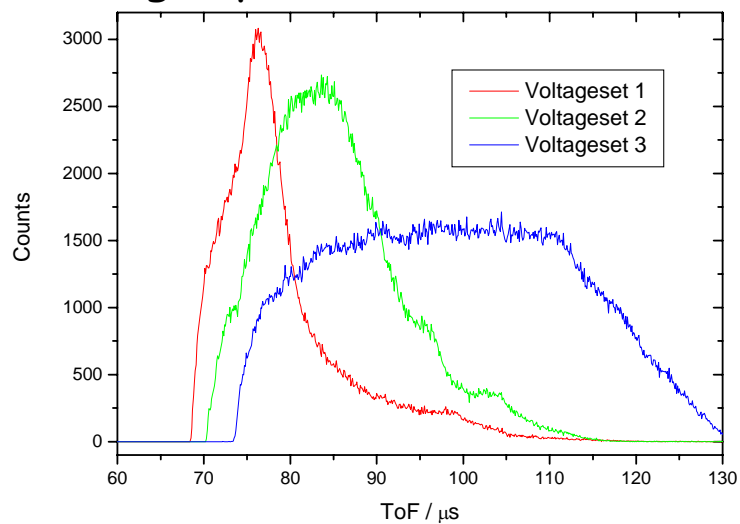
## Potential Distribution



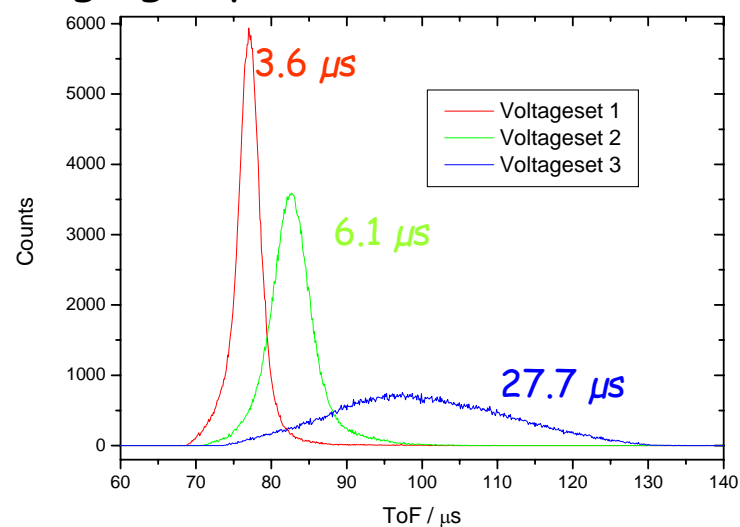
## without buffergas ( $4 \cdot 10^{-7}$ mbar)



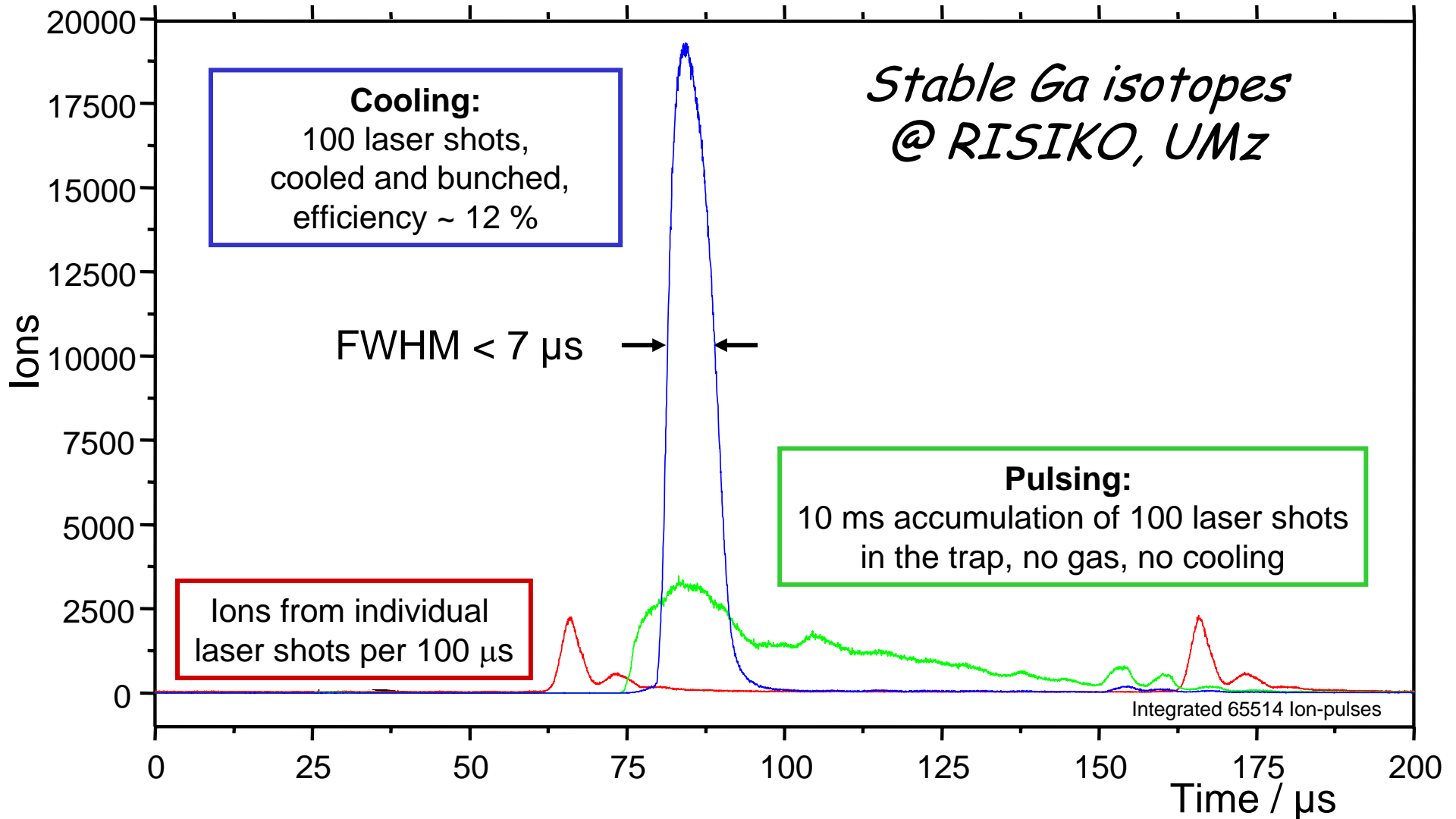
## low gas pressure ( $6 \cdot 10^{-5}$ mbar)



## high gas pressure ( $2 \cdot 10^{-4}$ mbar)



# Pulsed & Cooled Beams from LIST





## LASer techniques for Exotic nuclei Research (LASER)

- Most milestones on track
- Associated partners: ORNL Oak Ridge, TRIUMF Canada, Gatchina Russia
- April 2007, Joint workshop LASER – TRAPSPEC: Finland

Radioactive Ion Beam facility

**RILIS**

- selectivity, efficiency, time structure
- isomeric beams
- management of the radioactive inventory