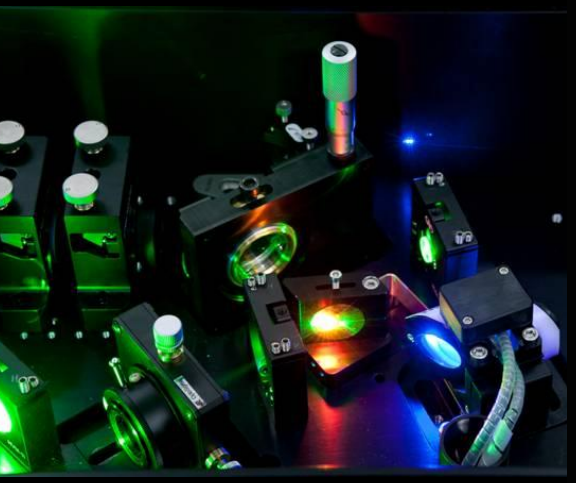
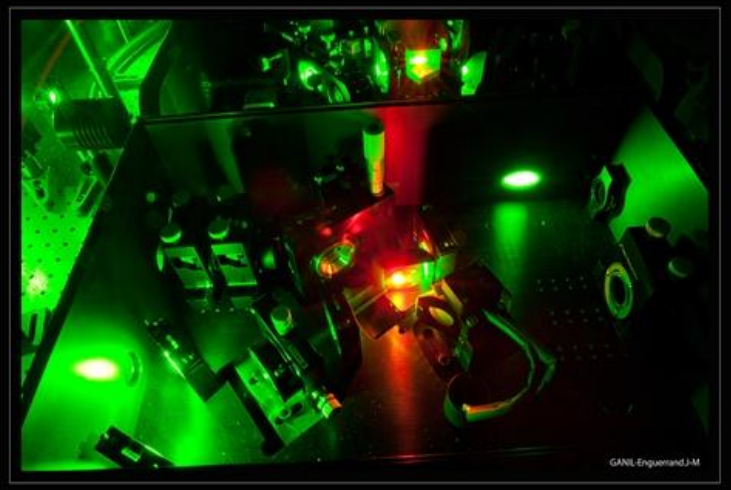



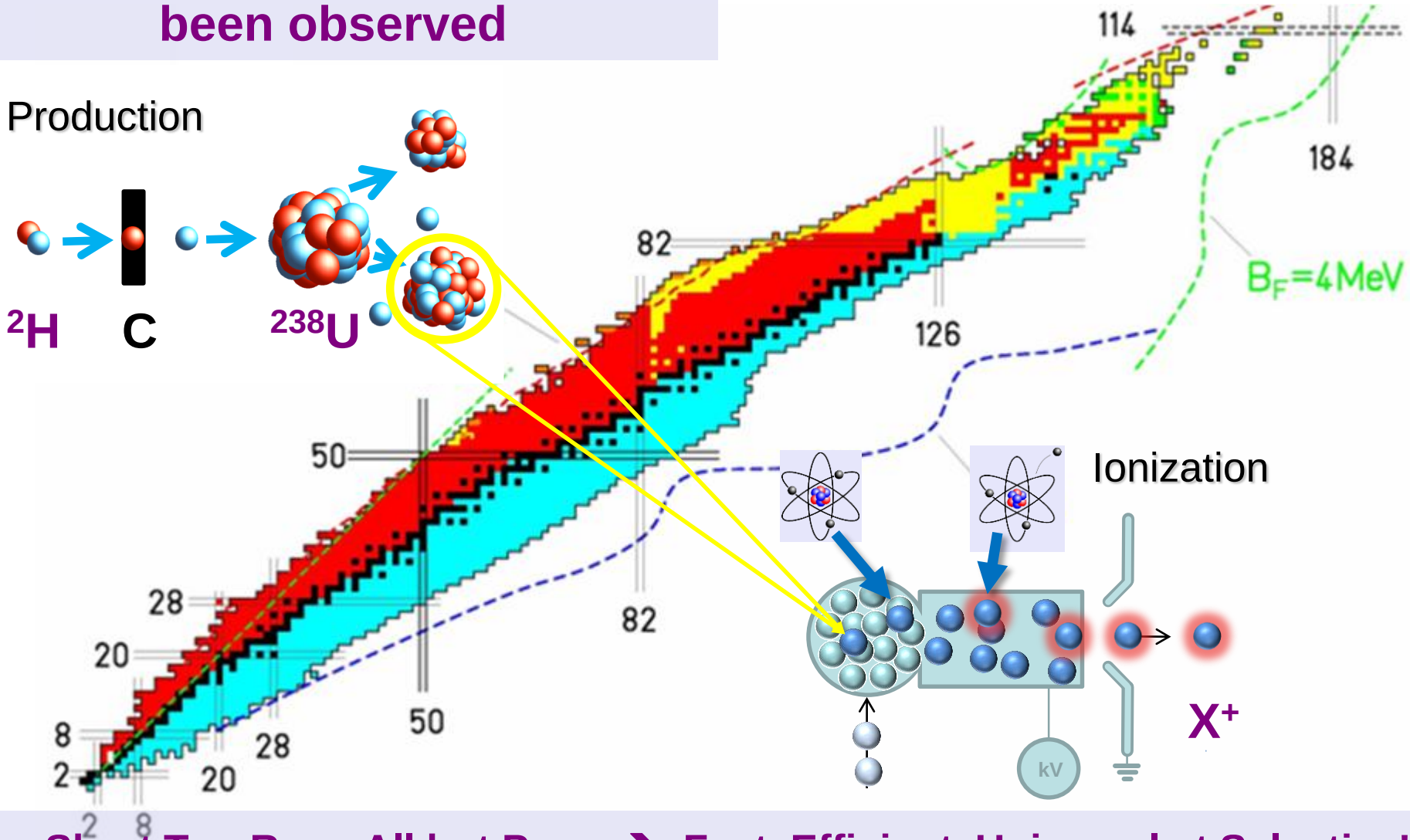
Ion beam and laser beam diagnostics for laser ion sources

Nathalie Lecesne

GANIL

Radioactive Ion Beam Production

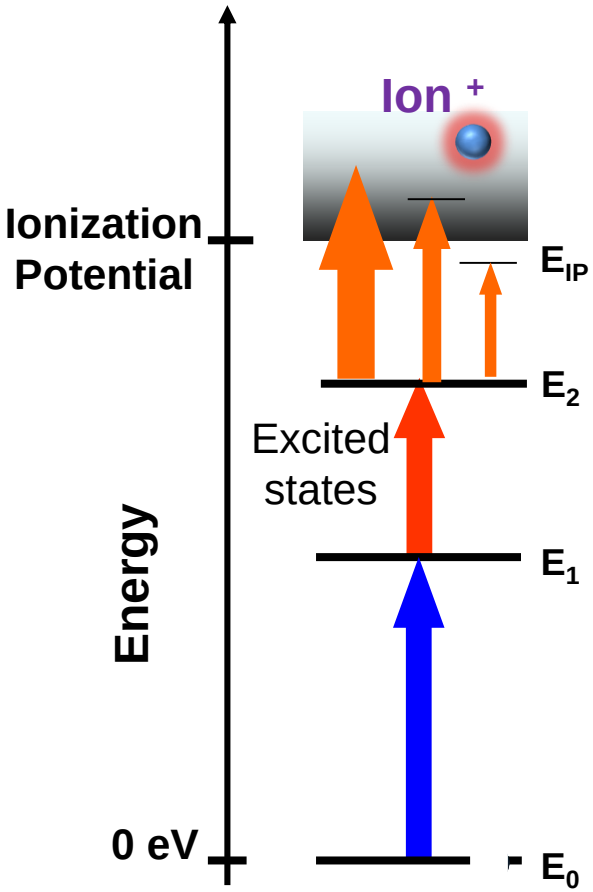
~3500 over >6000 nuclei have been observed

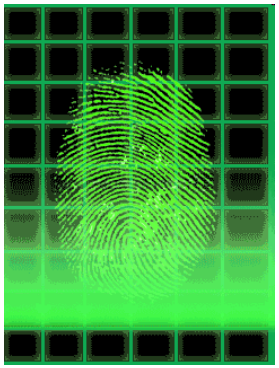


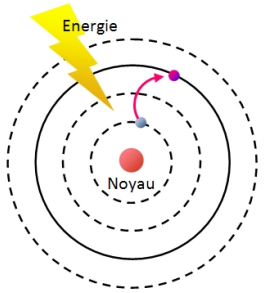
RIBs: Short $T_{1/2}$, Rare, All but Pure ➔ Fast, Efficient, Universal et Selective!

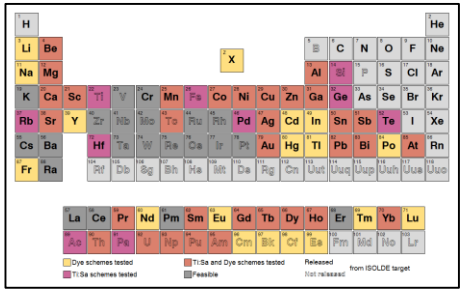
RILIS Principles

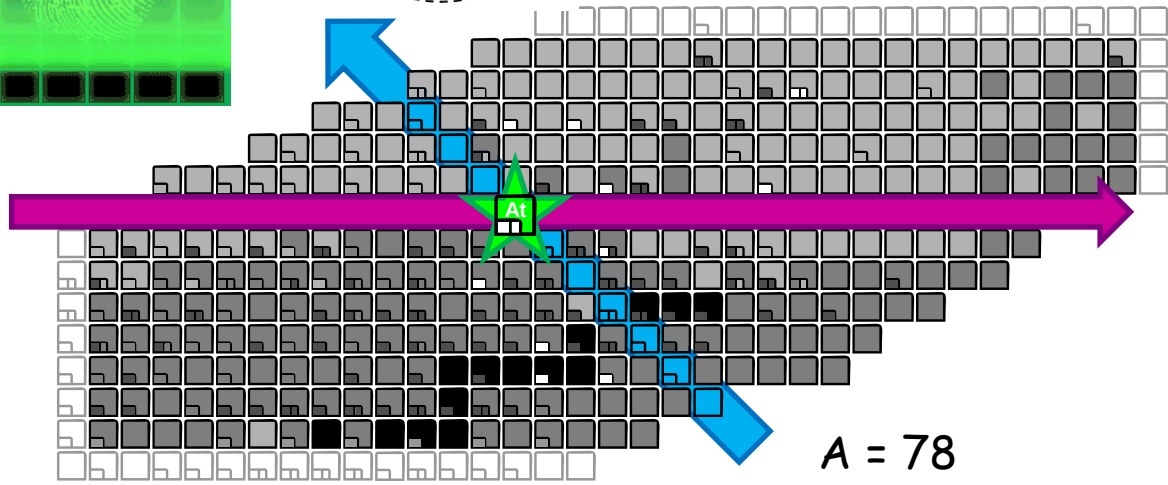
Resonant Ionization Laser Ion Source (RILIS)









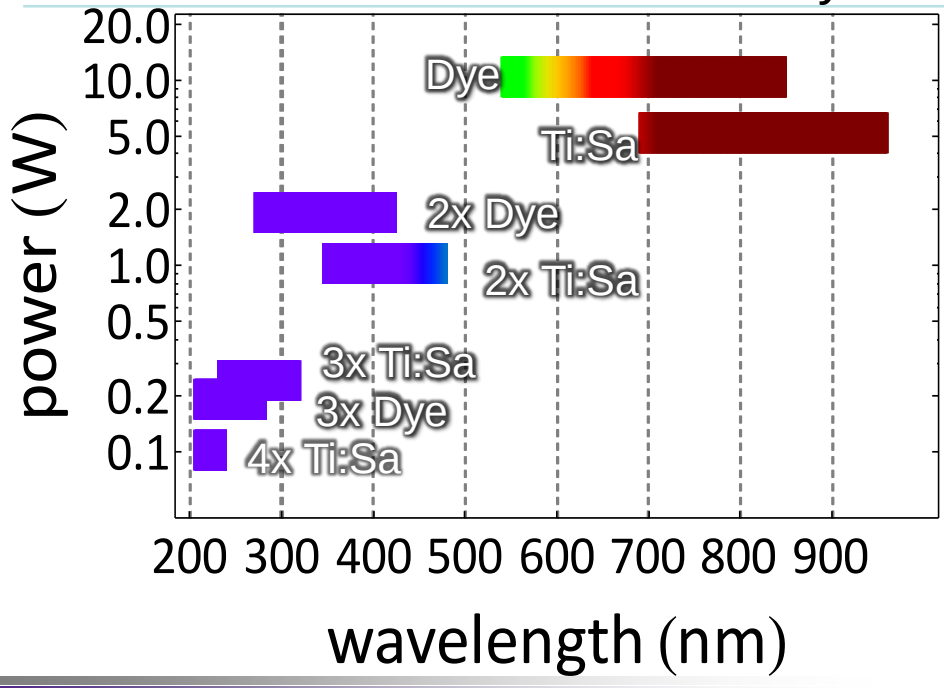


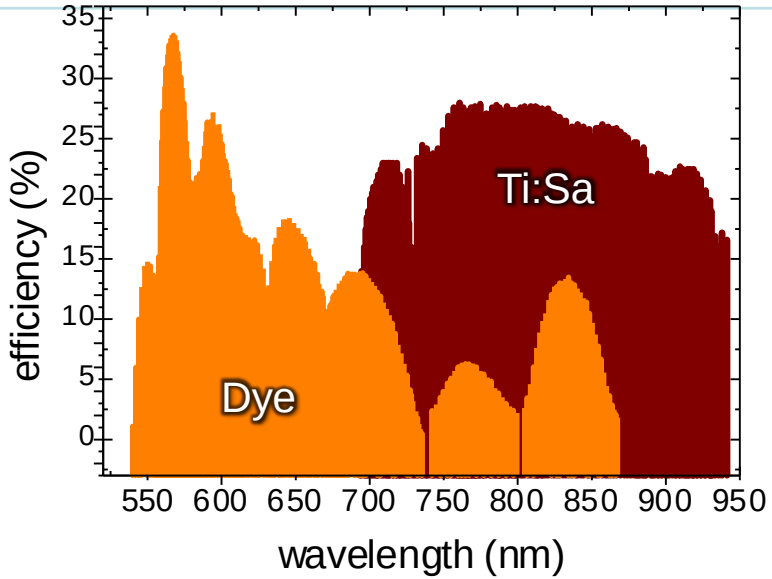
Chemical selectivity ➘ Isobaric contamination

Saturation ➔ Short pulsed laser (5-50ns with ~ 0.1-10mJ/pulse)

2 Tunable laser systems: Dye and TiSa

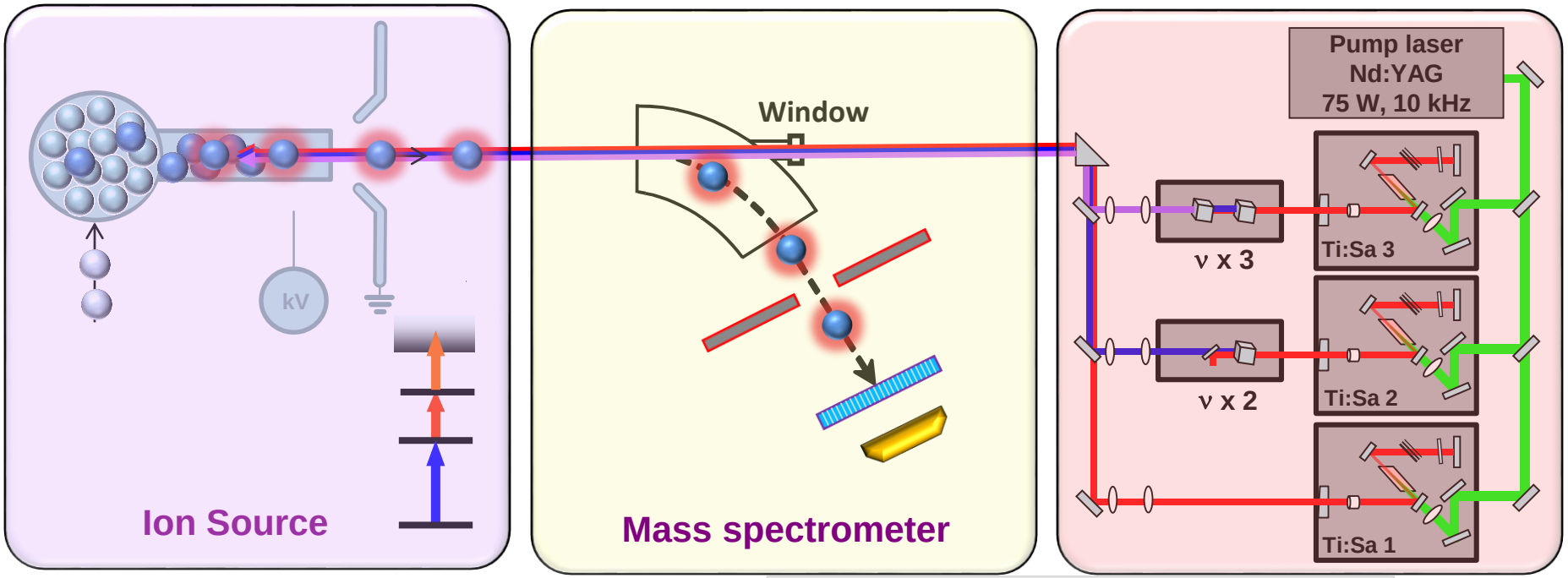
	Dye	Ti:Sa
Active Medium	> 10 different dyes	=1 Ti:sapphire crystal
condition of aggregation	liquid (org. solvents)	solid-state
Tuning range	540 – 850 nm	680 – 980 nm
Power	< 12 W	< 5 W
Pulse duration	~8 ns	~50 ns
Synchronization	optical delay lines	q-switch, pump power
# of schemes developed	47	37
Maintenance	renew dye solutions	~ none





Dye and Ti:Sa systems are complementary – ideally use BOTH!

RILIS in Radioactive Ion Beam Facilities



Tunable Laser System ➔ Wide λ range (200-1000nm), Dye or TiSa

Saturation condition: ➔ Short pulses (5-50ns) with ~ 0.1-10mJ/pulse

Duty cycle: ➔ 10kHz repetition rate

Hot Cavity (<2000° C) = Doppler shift: ➔ 6GHz laser line-width

Gas cell (500mbar) = pressure shift: ➔ 6GHz laser line-width

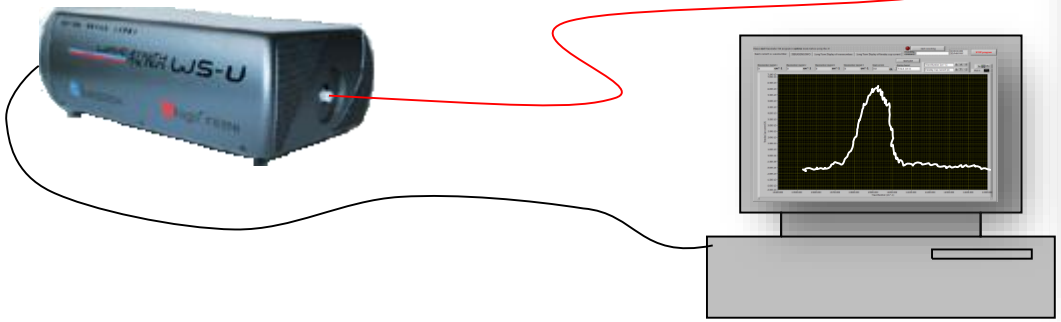
Laser beam diagnostics

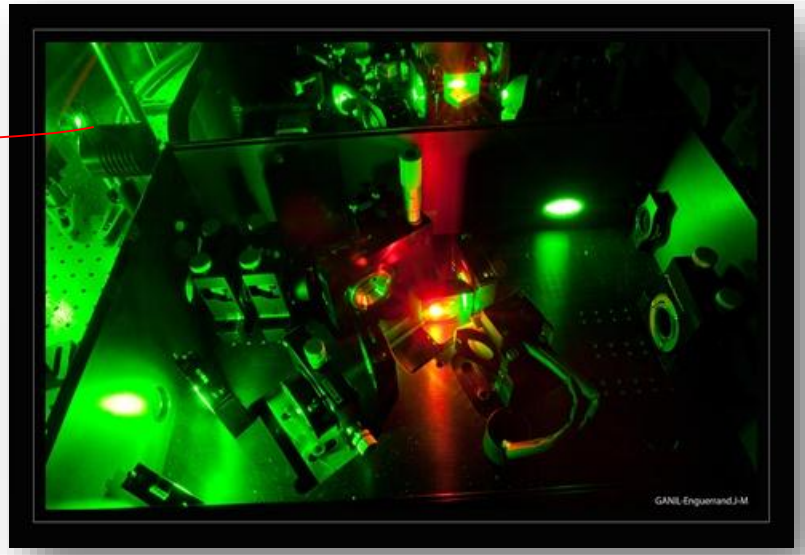
Wavelength measurement:

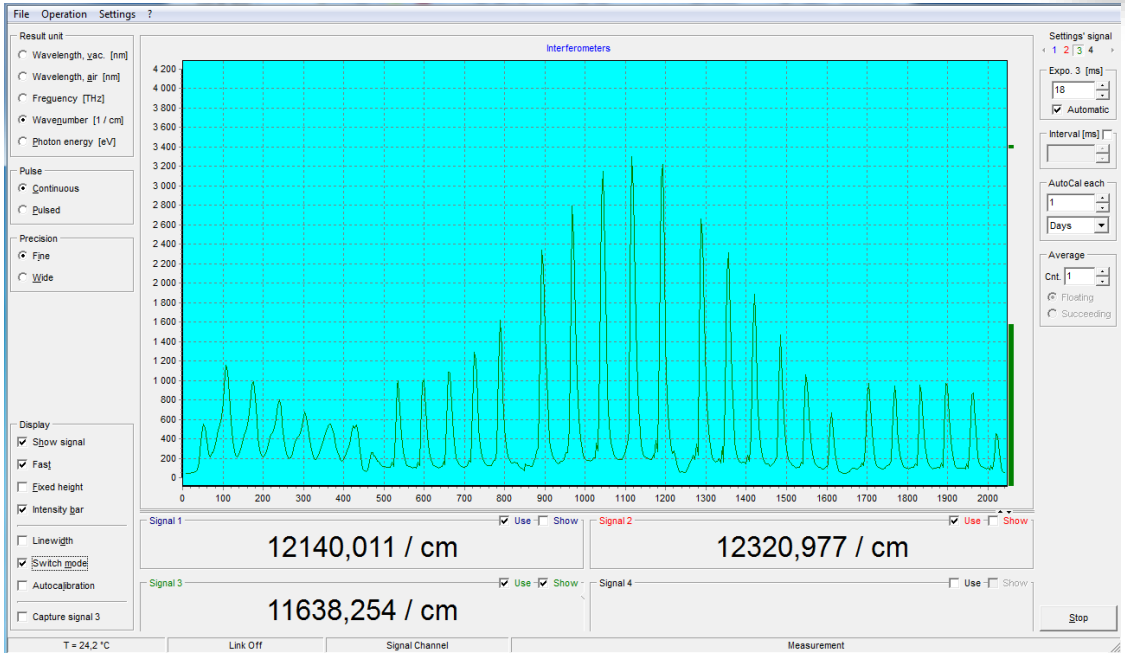
Lambdameter with switch mode: 4 λ

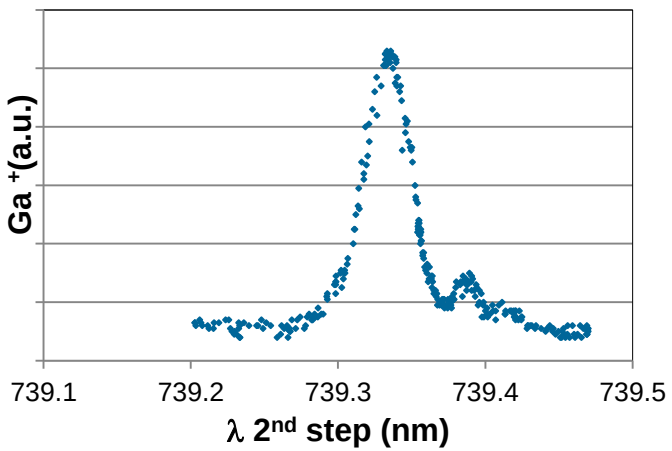
TiSa: 680nm < λ < 1000nm

Dye: 550nm < λ < 850nm





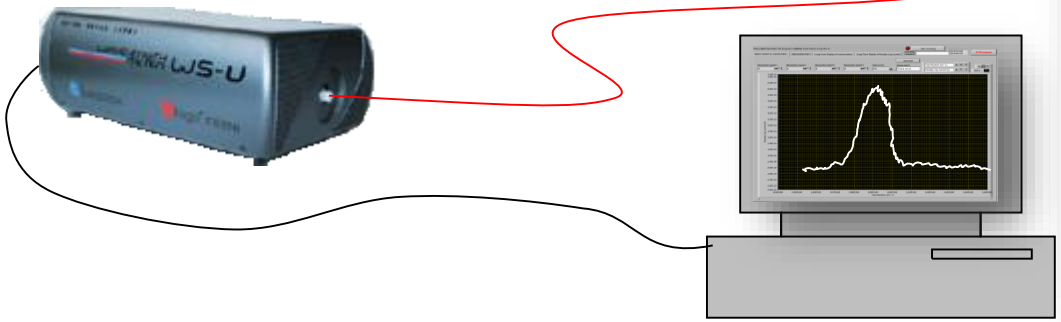


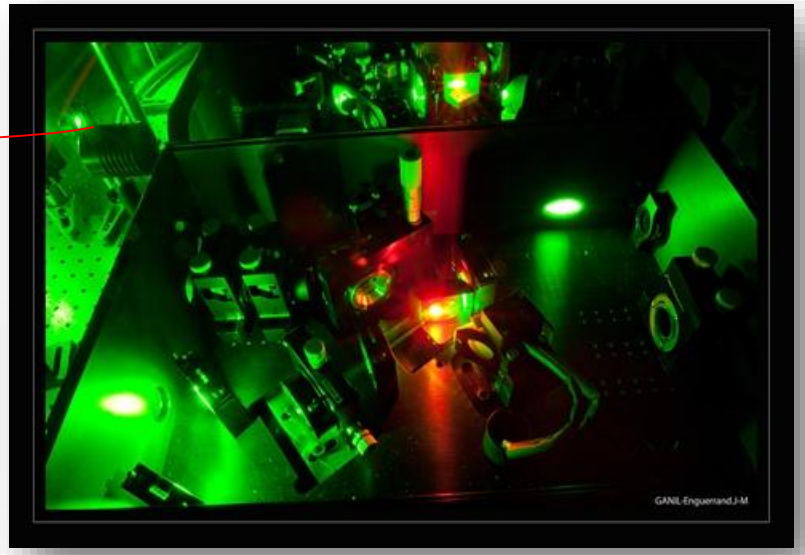


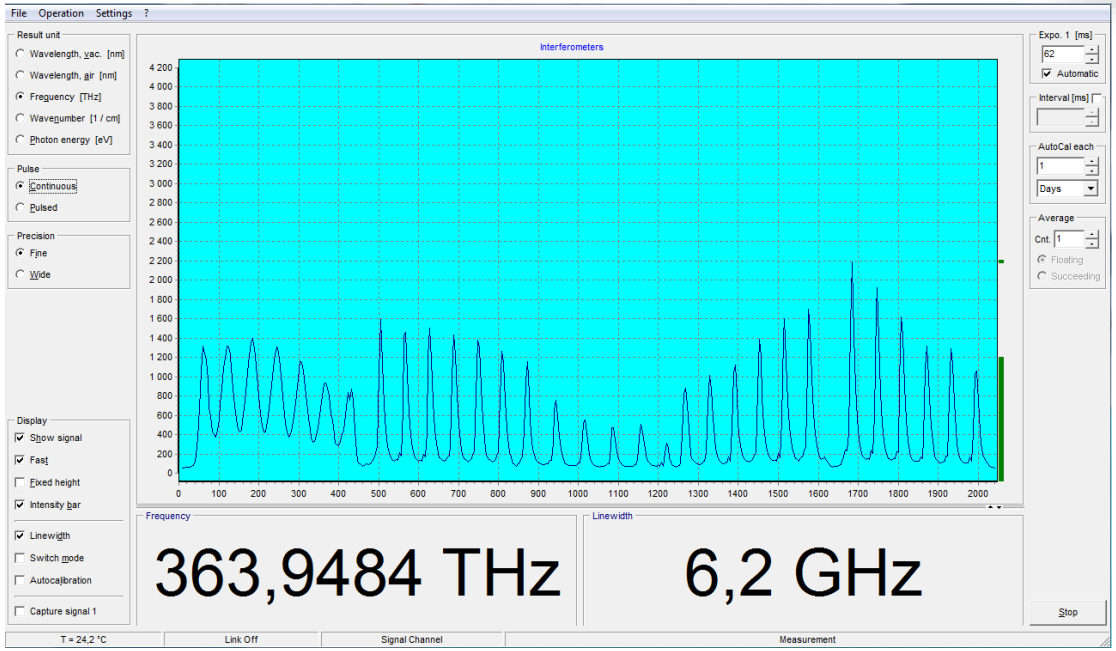
Laser beam diagnostics

Wavelength measurement:

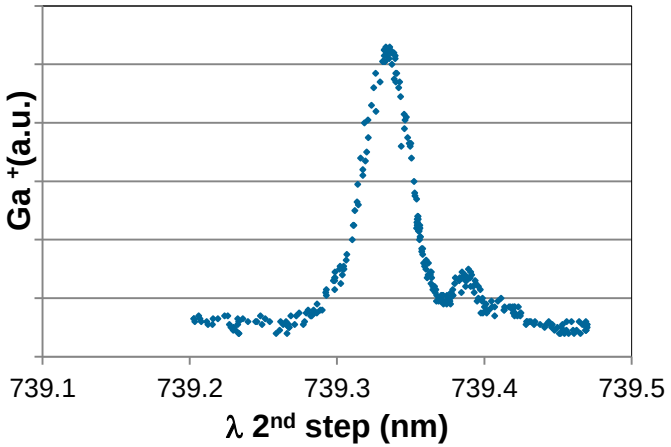
Lambdameter with linewidth option







Ga^+ Rydberg states



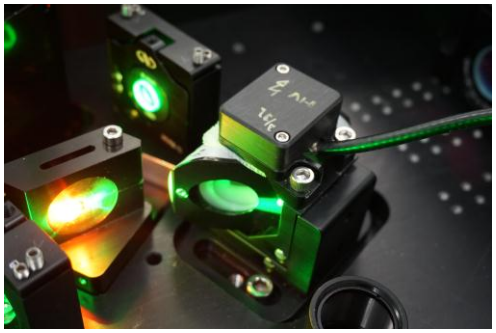
Laser beam diagnostics

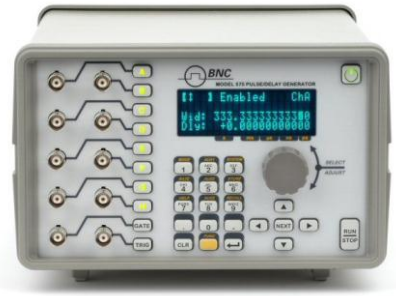
Laser beam synchronisation:

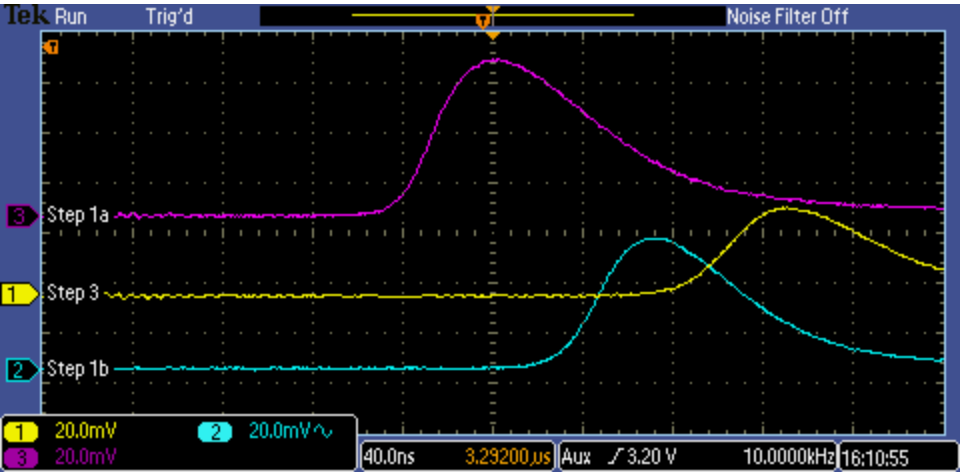
Photodiode + Oscilloscope

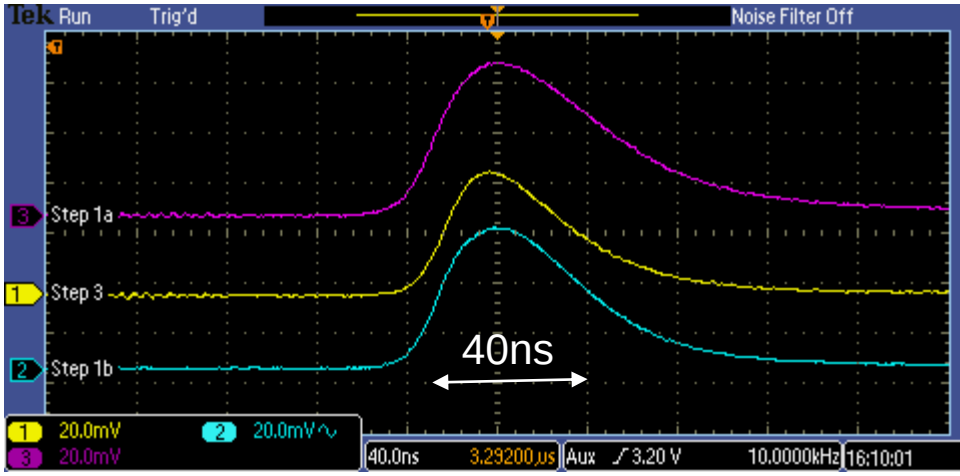
TiSa

Pockels cell + Master clock







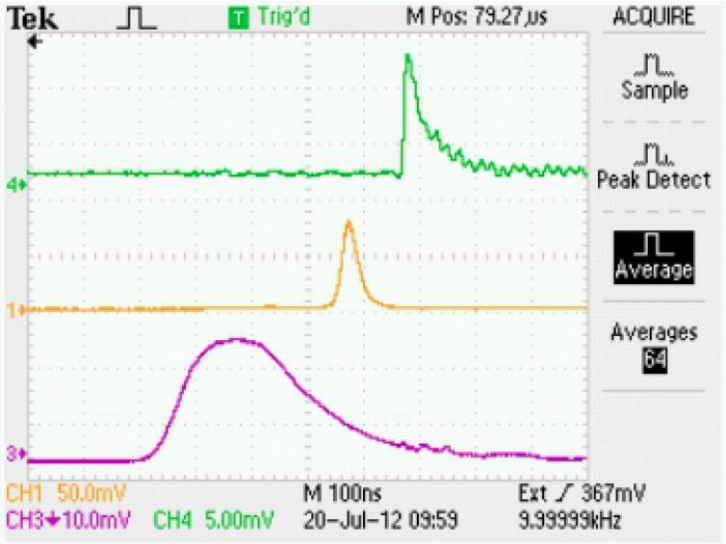


Overlap within few ns

Laser beam diagnostics

Laser beam synchronisation:

Photodiode + Oscilloscope

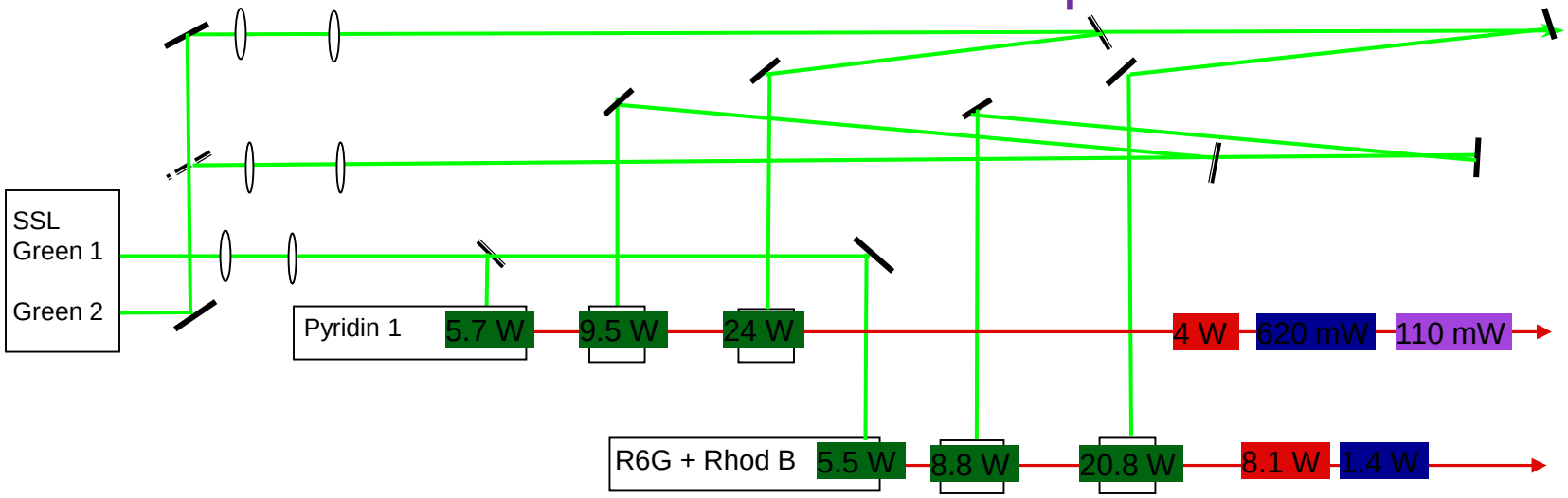


Dye

10ns -50ns pulse width

Overlap within ns

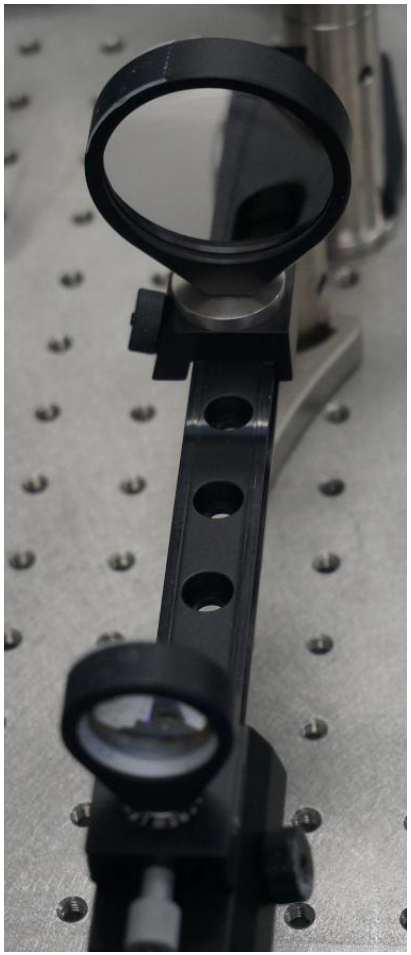
Optical delay lines:

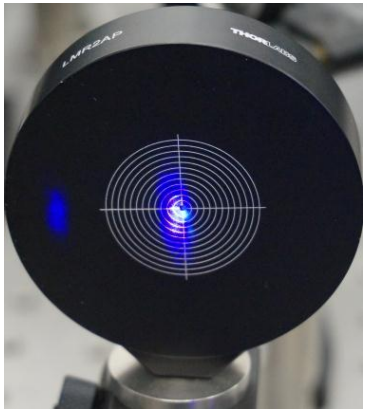


Laser beam diagnostics

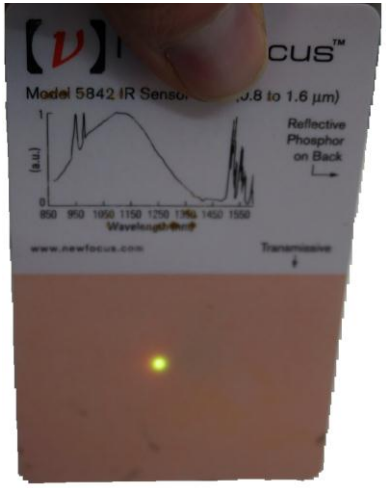
Laser beam alignment:

First: See the beam!

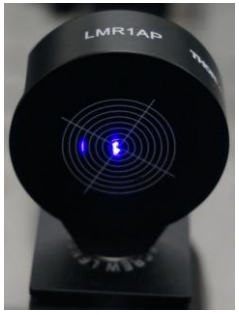


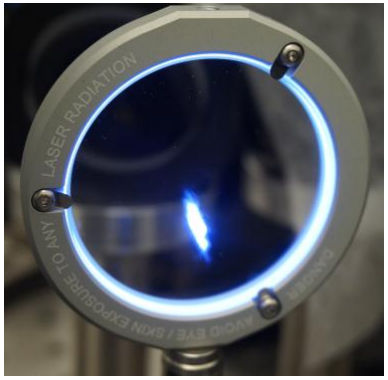


IR Viewer



IR Card



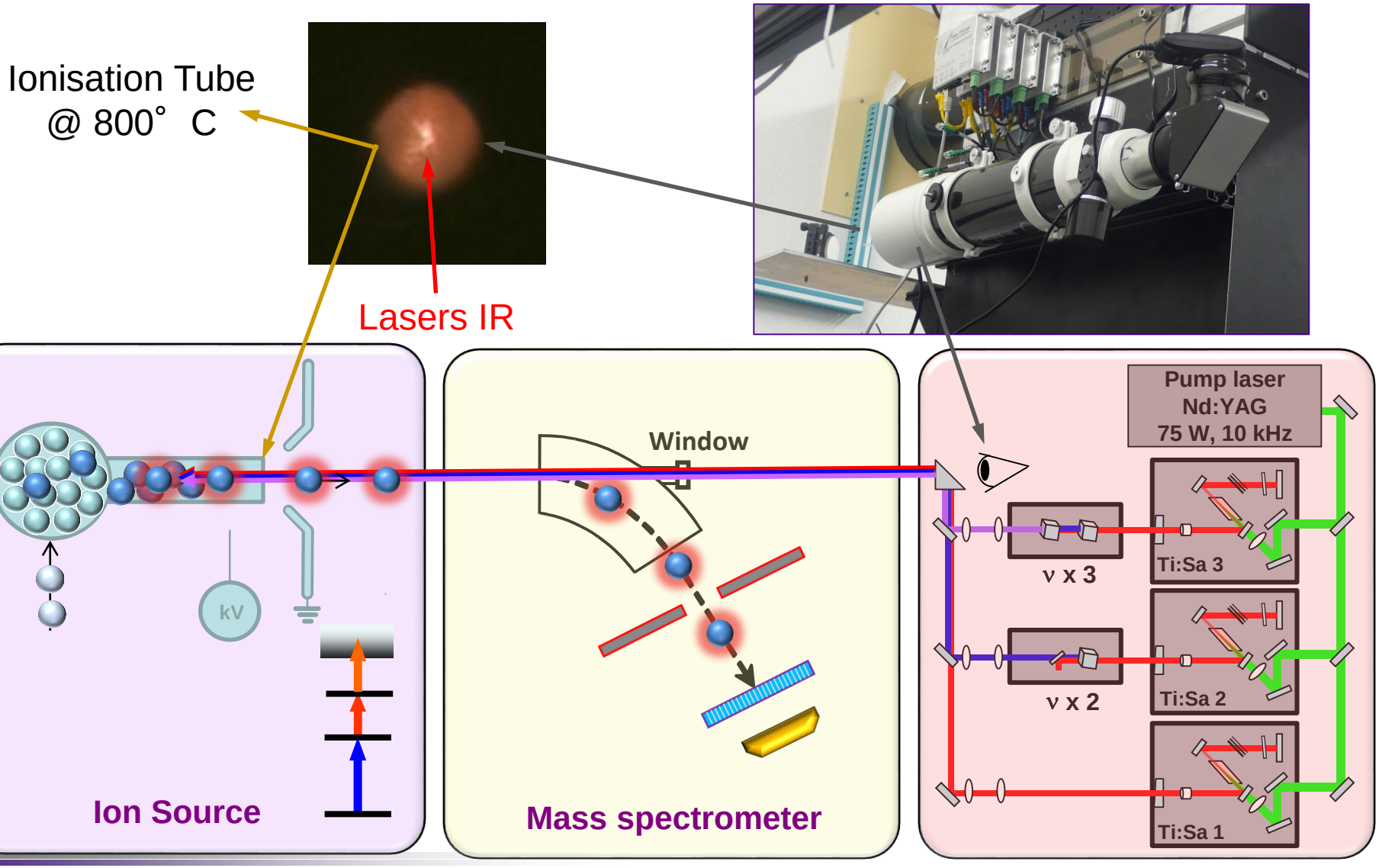


UV Viewer

Laser beam diagnostics

Laser beam position monitoring:

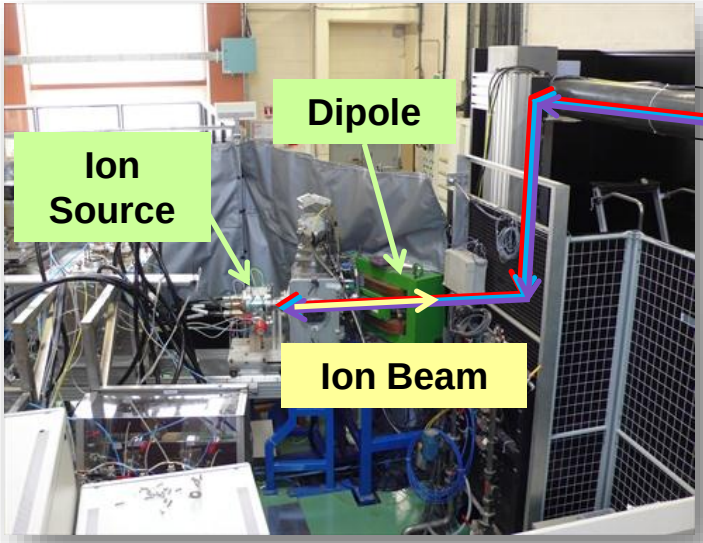
Laser Beam alignment into the ion source with telescope and camera



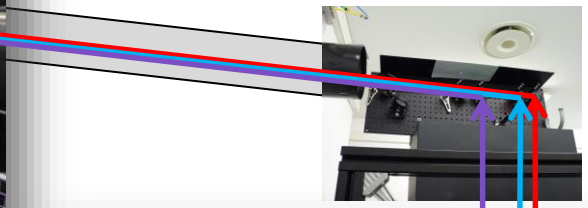
Laser beam diagnostics

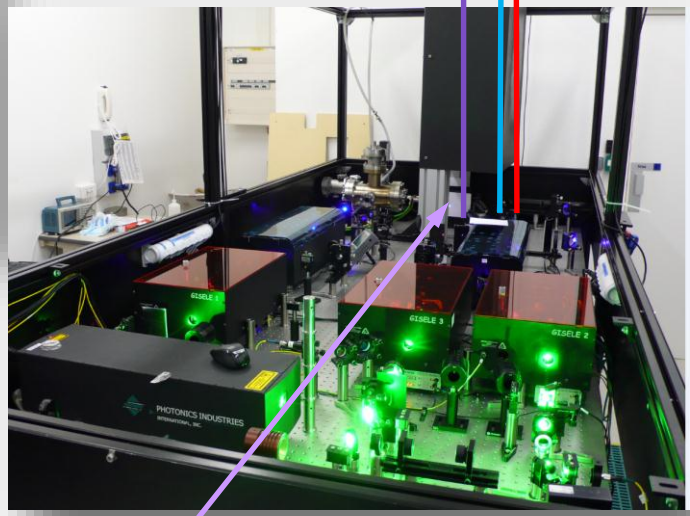
Laser beam position monitoring:

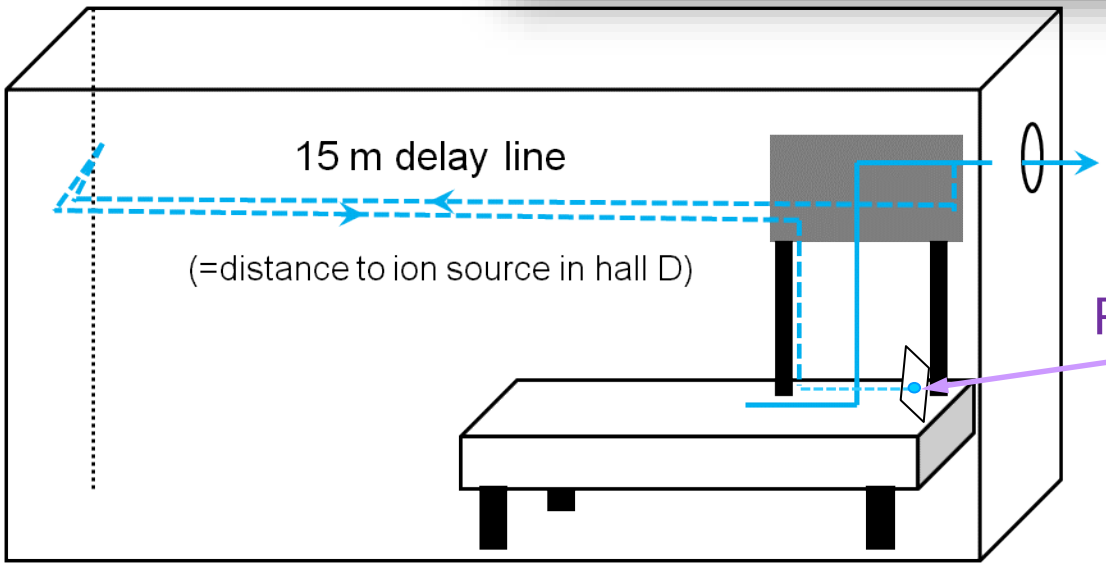
Reference point with manual alignment



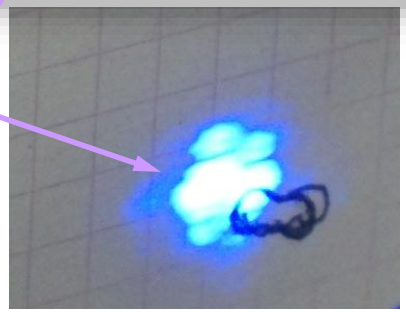
Off line test bench







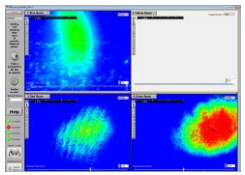
Reference Point

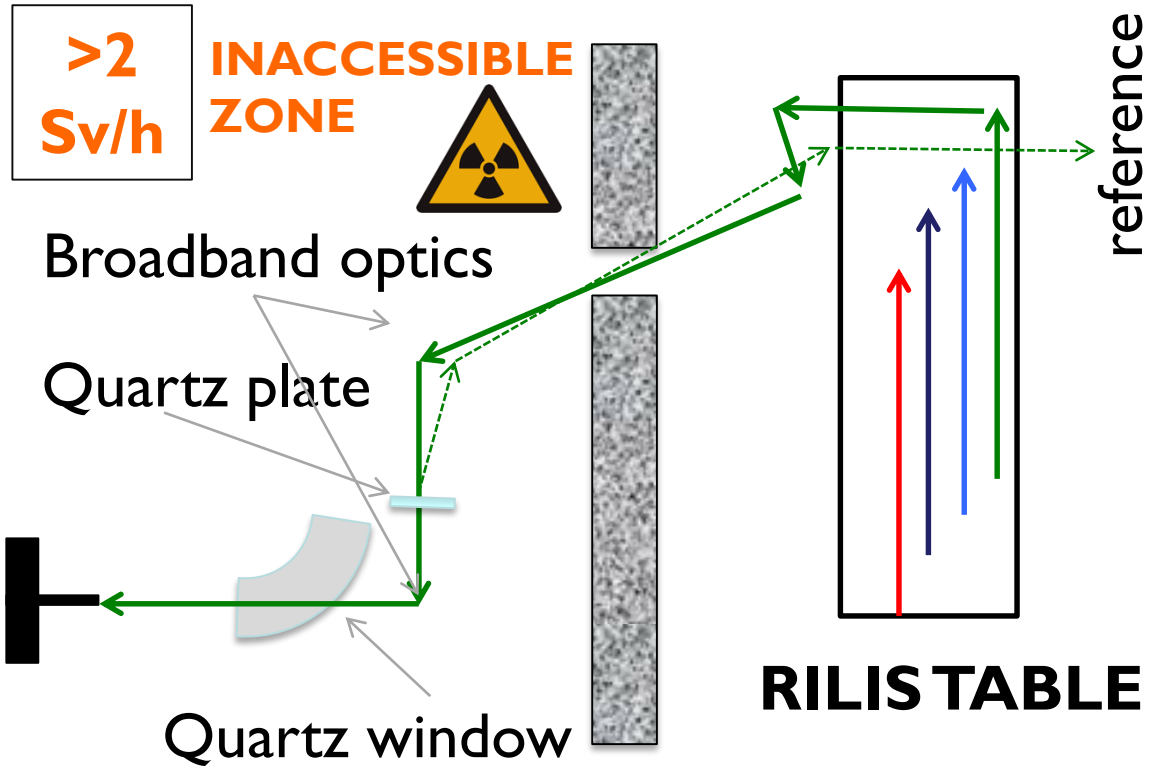


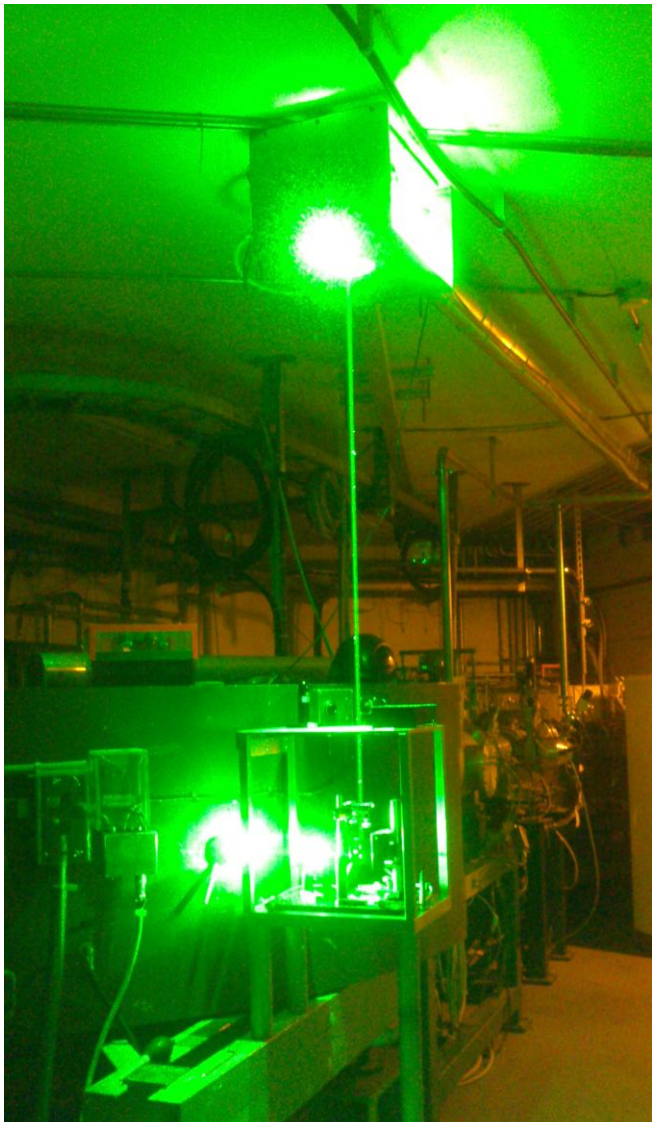
Laser beam diagnostics

Laser beam position monitoring:

Reference point in on line facility: ISOLDE

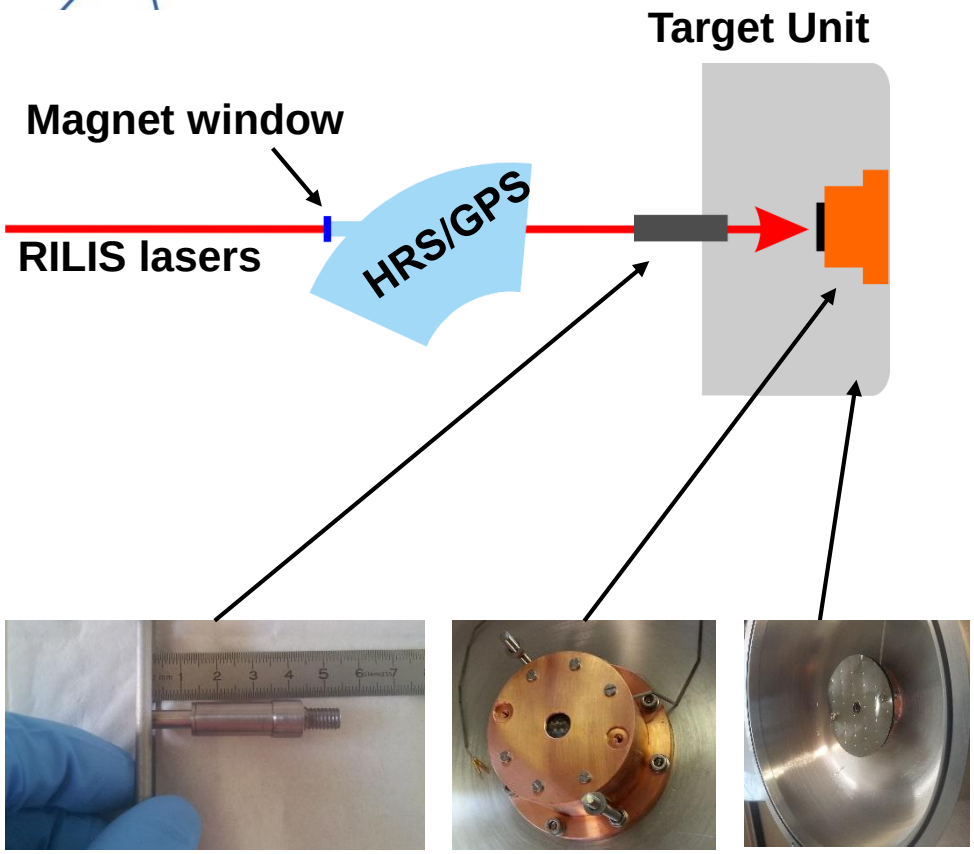






Courtesy B. Marsh

RILIS laser alignment target unit



Tungsten ionizer
acts as light source for pre-alignment after shutdown

Laser power meter
measures power delivered through ion source

readout via existing thermocouple infrastructure

Mounted as first target on HRS after LS1. Lasers successfully aligned. Unit functioning as expected.

→ facilitates laser alignment - normally only possible with ion beam

→ helps to clarify laser beam transport issues (thermal lensing)

→ enables remote check of status of magnet windows when in doubt, reducing interventions to separator areas

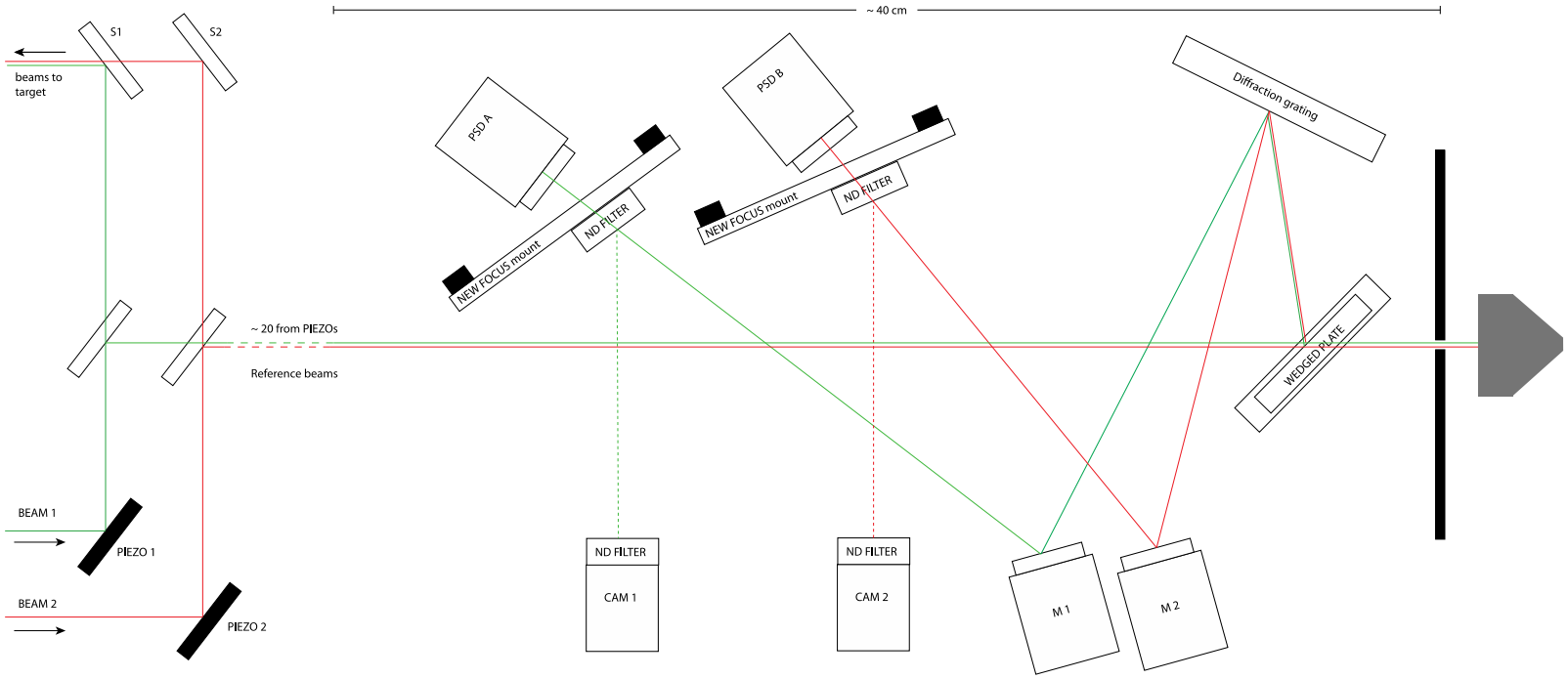
Thanks to: Bernard, Ermanno & our 2013 summer student Sasha

Slide: S.Rothe, EN-STI-LP, CERN

Tom Day Goodacre

Beam monitoring and stabilization

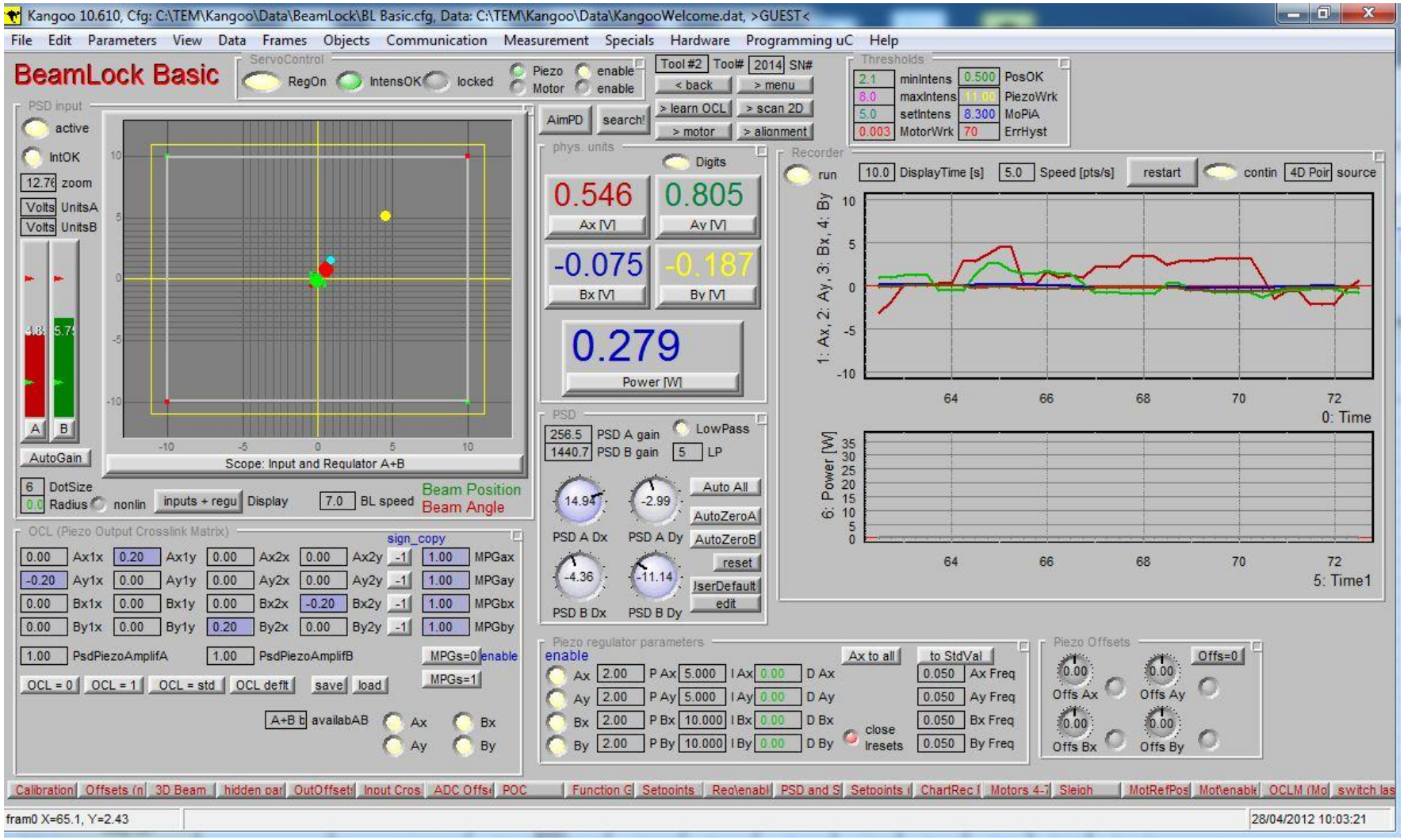
Stabilization of high and low frequency beam fluctuations
Piezo actuators for fast frequency beam fluctuations
Currently capable of stabilizing up to two beams



http://www.tem-messtechnik.de/MainPages/en/productsfs.htm

Courtesy B. Marsh

Beam monitoring and stabilization



http://www.tem-messtechnik.de/MainPages/en/productsfs.htm

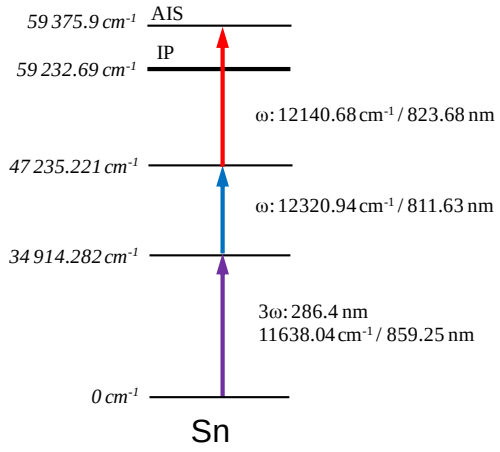
Courtesy B. Marsh

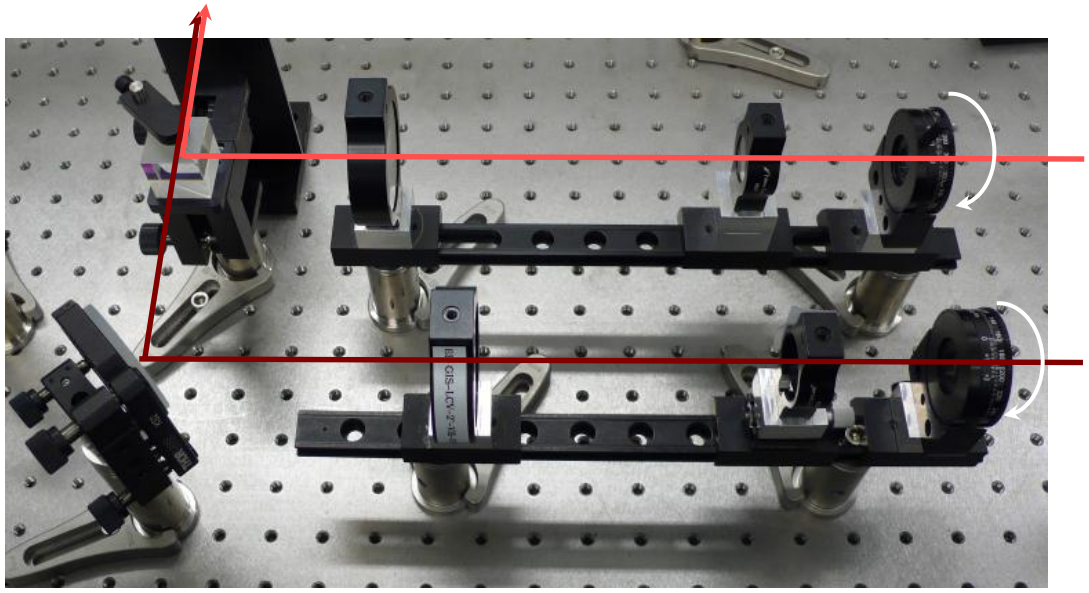
Laser beam diagnostics

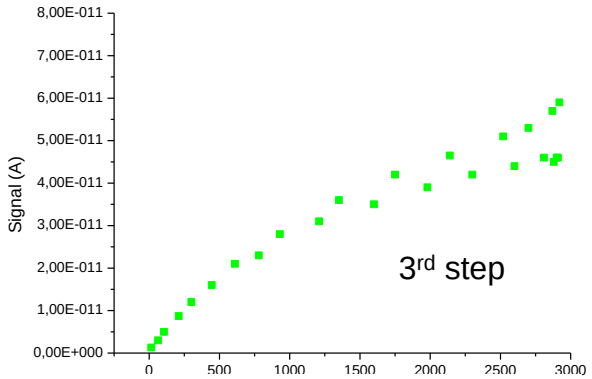
Laser beam power measurement:

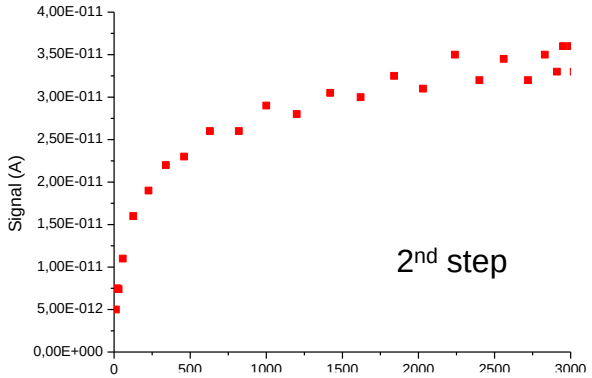
Laser beam power: from mW to 100's W

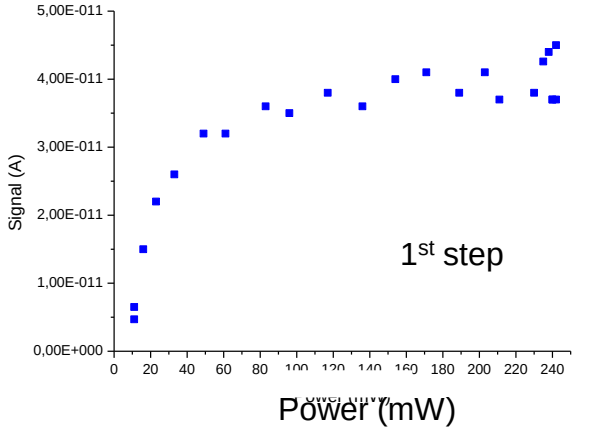
100 µW for monitoring



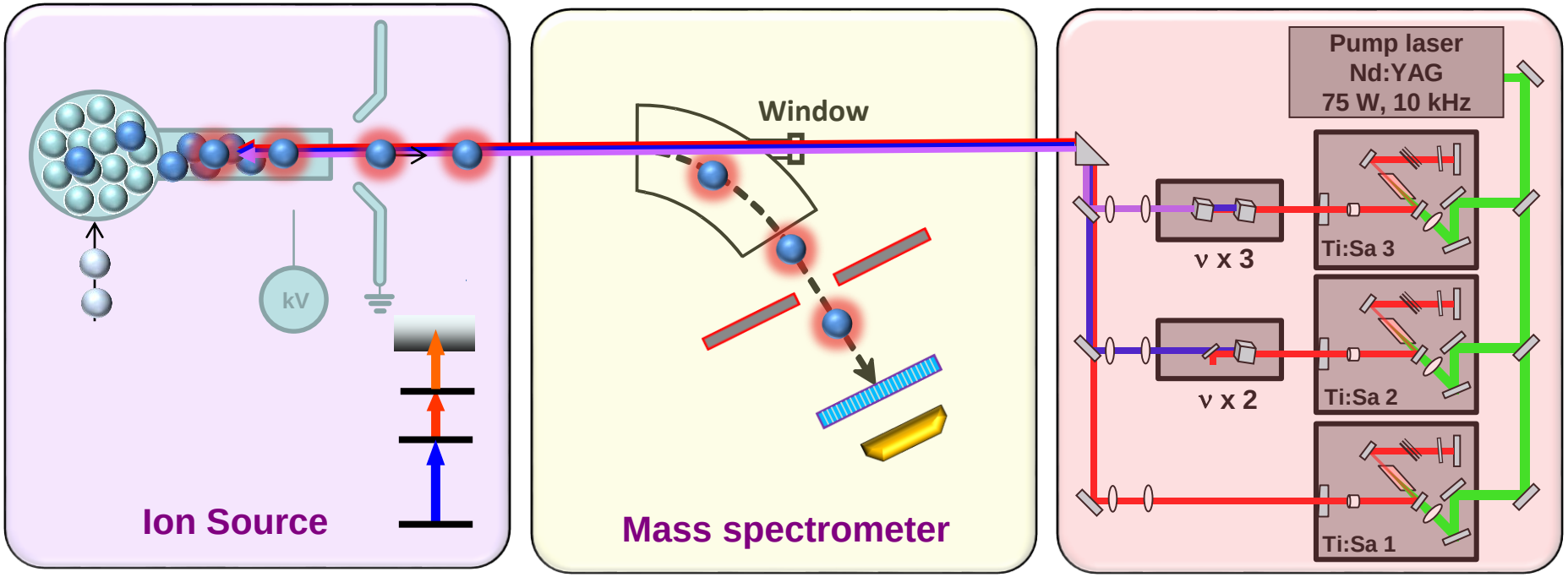








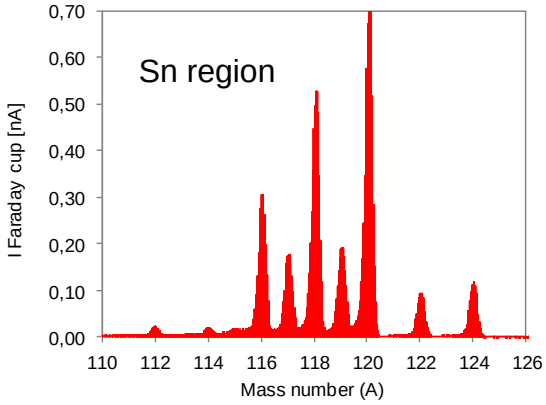
Ion beam diagnostics



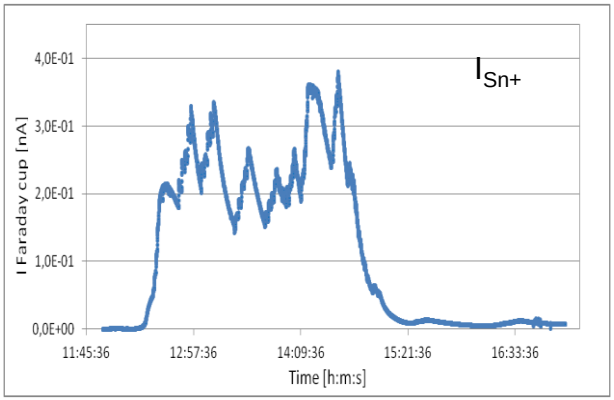
Ion beam diagnostics

Low intensity measurement of stable ion beams :

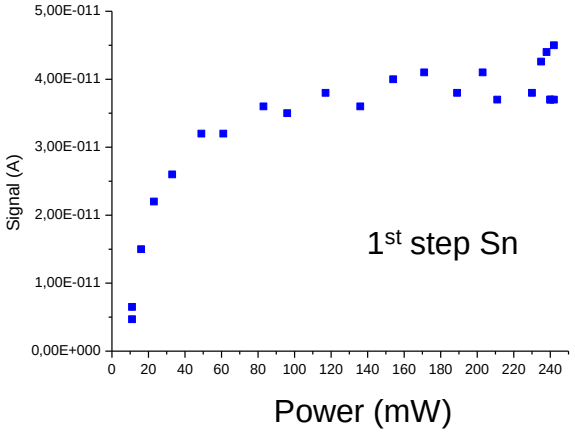
Ion beam intensity: from pA to 10's nA



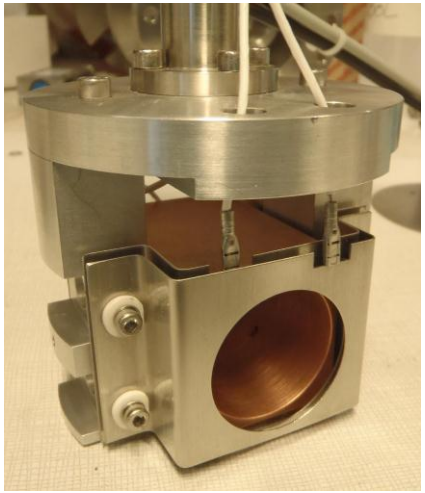
Mass scan

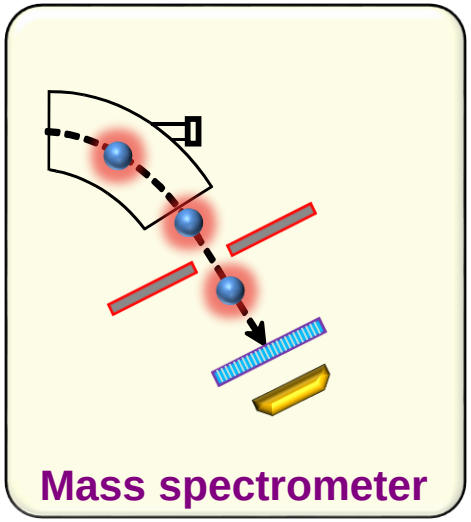


Efficiency measurement



Saturation curve





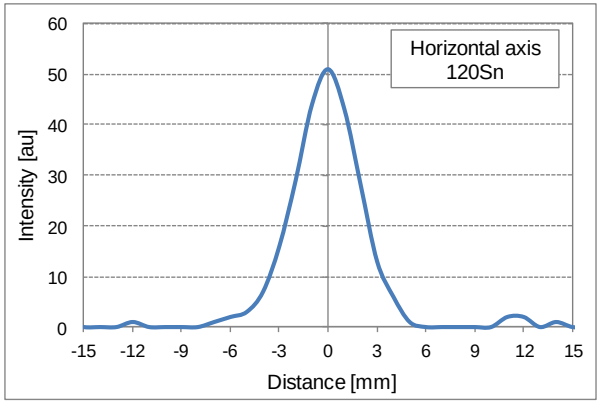
GANIL low intensity FC :
~10pA to 1µA

PhD J.L. Henares

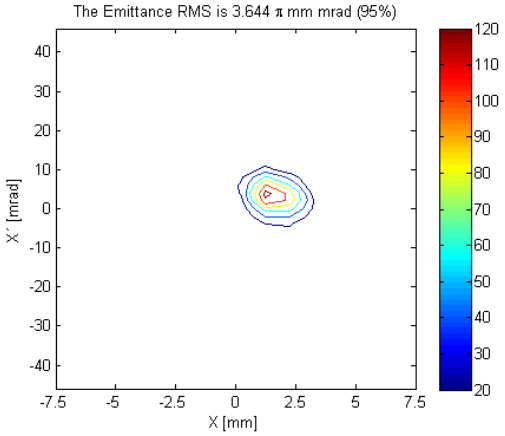
Ion beam diagnostics

Beam profile measurement :

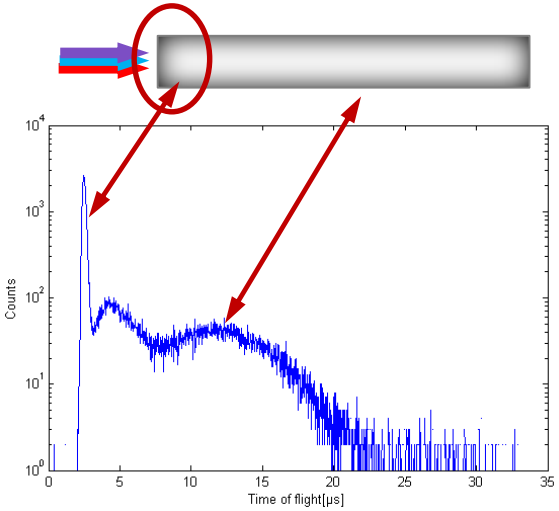
Ion beam intensity: from pA to 10's nA



Ion Beam profile

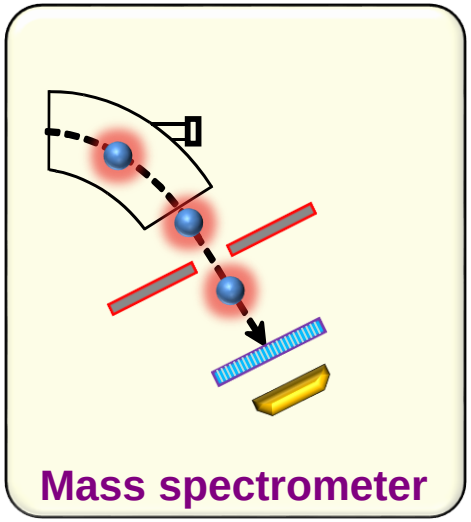


Emittance measurement



Time Profile Structure

J.L. Vignet et al, Proceedings of IBIC2013, Oxford, UK



GANIL EFM
(Emissive Foil Monitor) :
⊂ Micro Channel plate
~pps to 10's nA
5keV/u to 25MeV/u

See J.L. Henares's talk on Wednesday

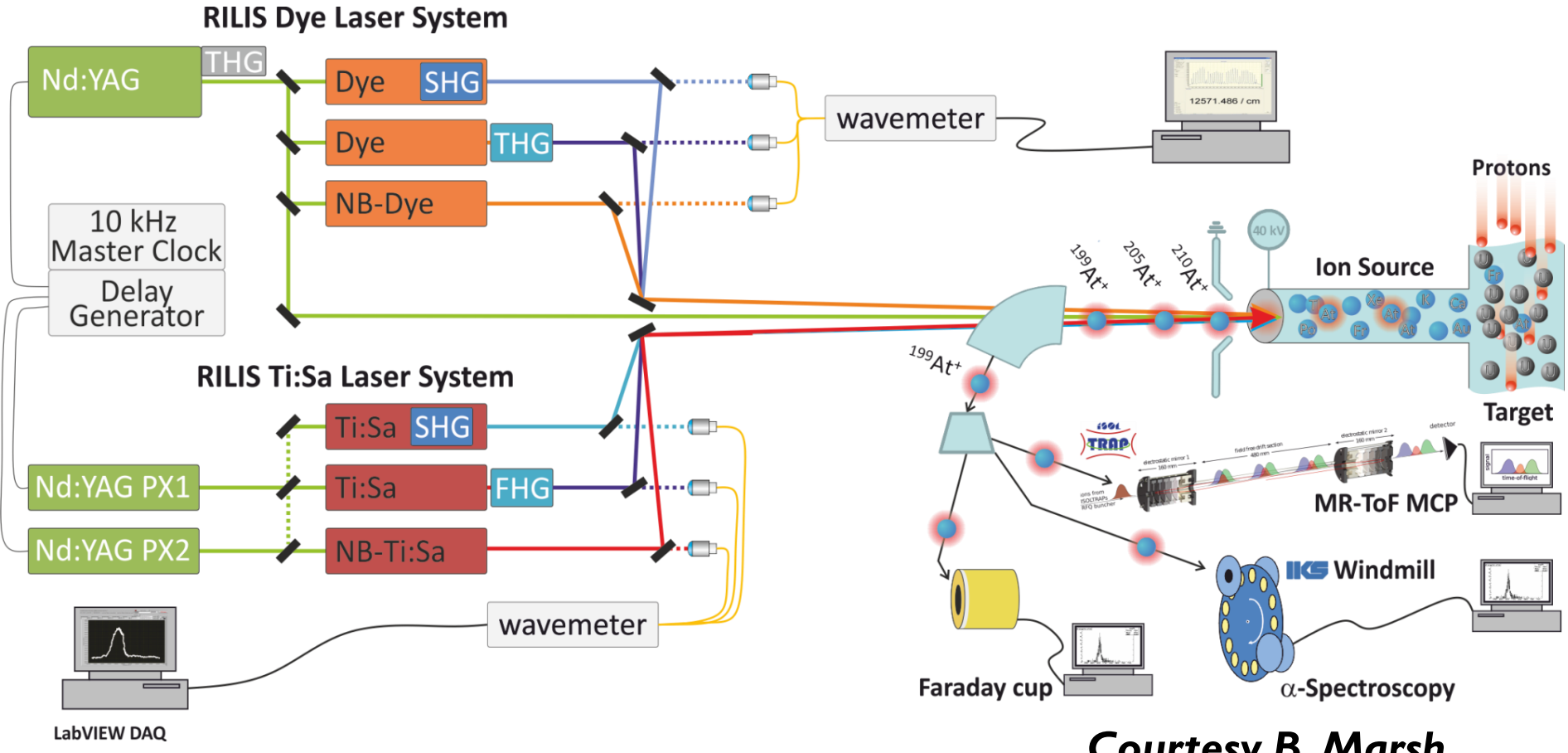
Ion beam diagnostics

Very Low intensity radioactive ion beams:

Ion beam intensity: from few pps to pA

Faraday cup and/or Micro Channel Plates

γ, β, and α counters



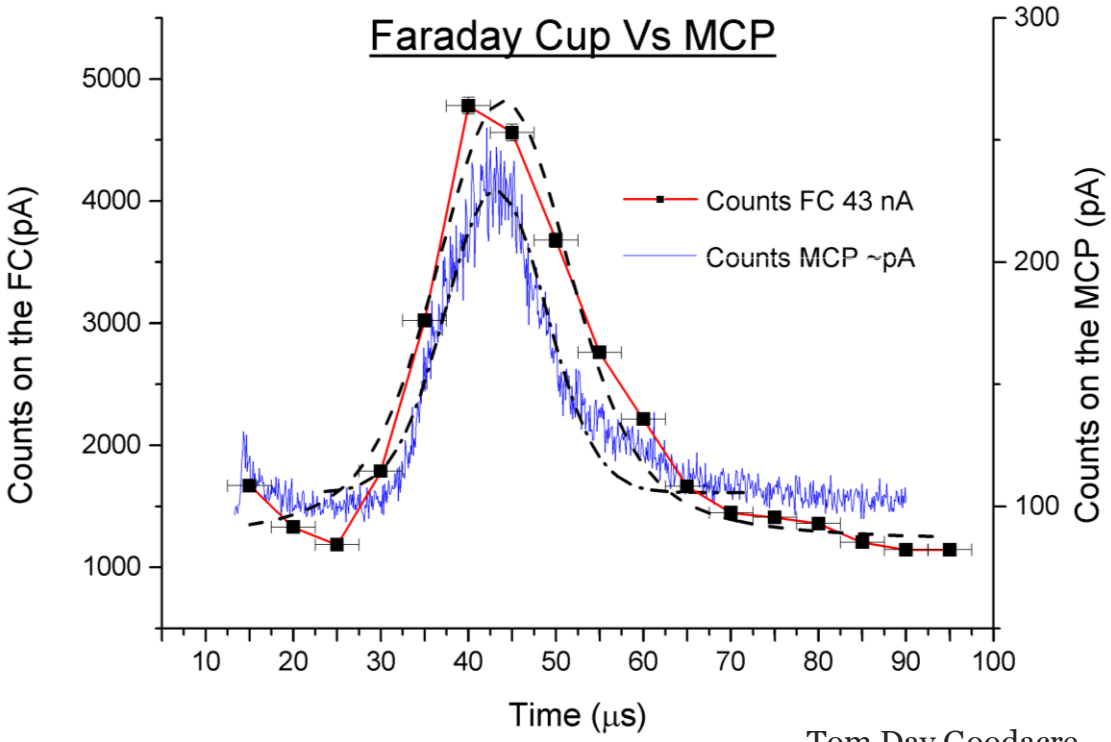
Courtesy B. Marsh

Time structures from µs beam gating

µs beam gating enabled time structure measurements with nA beam currents and a standard Faraday Cup.

Measurements of the ion beam current were made during 5 µs windows (pulsed at 10 kHz) at intervals across the 100 µs gap between laser pulses

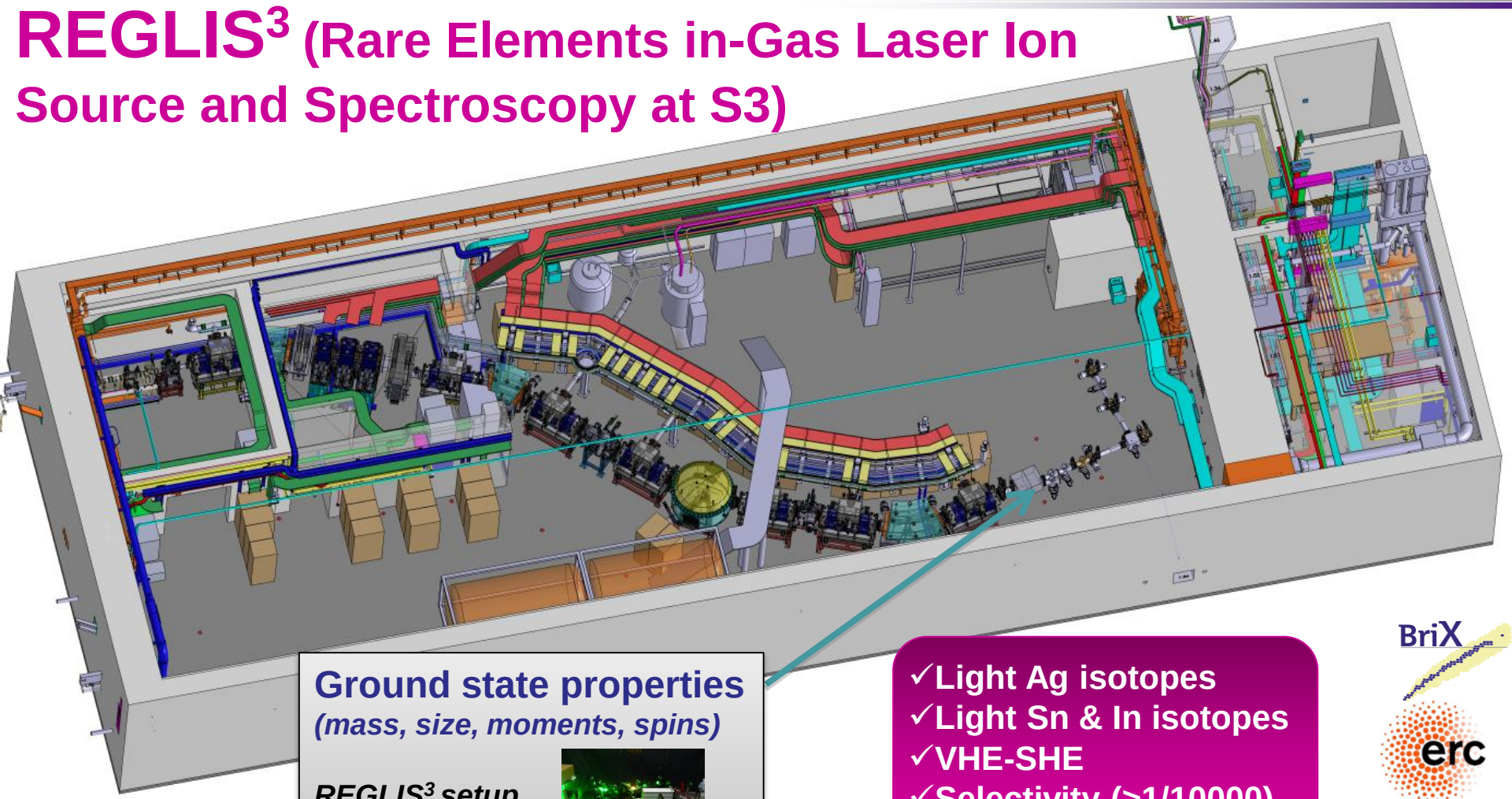
See T.D. Goodacre's talk on Wednesday



Tom Day Goodacre

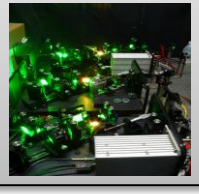
LISOL+ for S3 @ SPIRAL2 Phase 1

REGLIS3 (Rare Elements in-Gas Laser Ion Source and Spectroscopy at S3)



Ground state properties
(mass, size, moments, spins)

REGLIS³ setup
Low Energy Branch



- ✓Light Ag isotopes
- ✓Light Sn & In isotopes
- ✓VHE-SHE
- ✓Selectivity (>1/10000)

Low Energy Branch @ S³

Collaboration

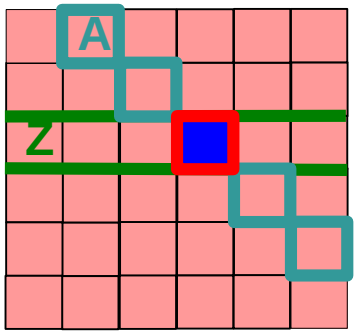
IPN INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY (Gas cell)

lpc caen (RFQs)

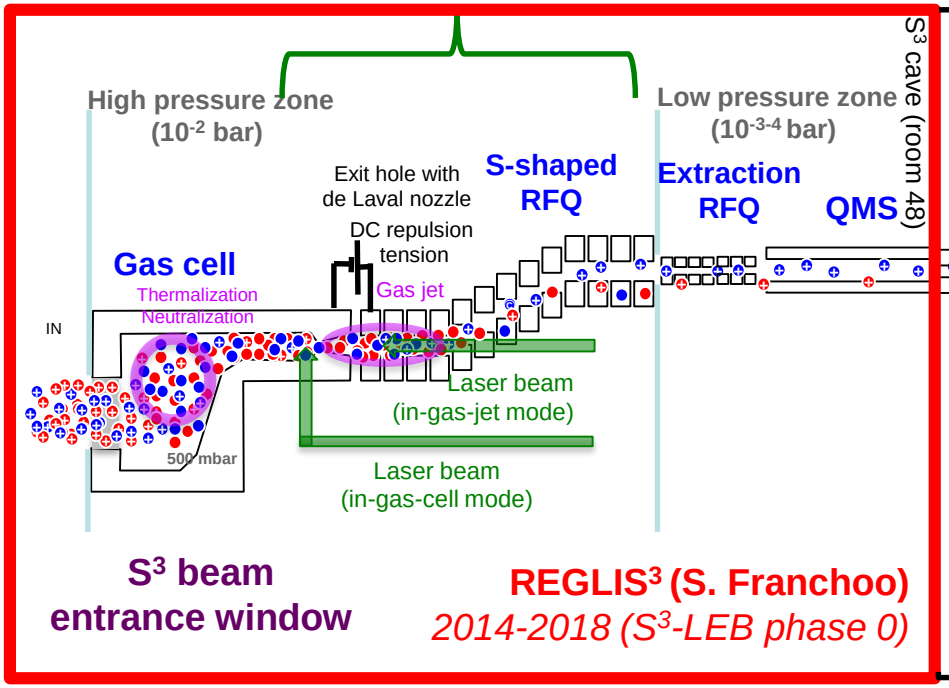
KU LEUVEN (Gas cell, laser system)

GANIL spiral2 laboratoire commun CEA/DSM CNRS/IN2P3 (mr-TOF-ms, laser system infractructure, safety, RFQs)

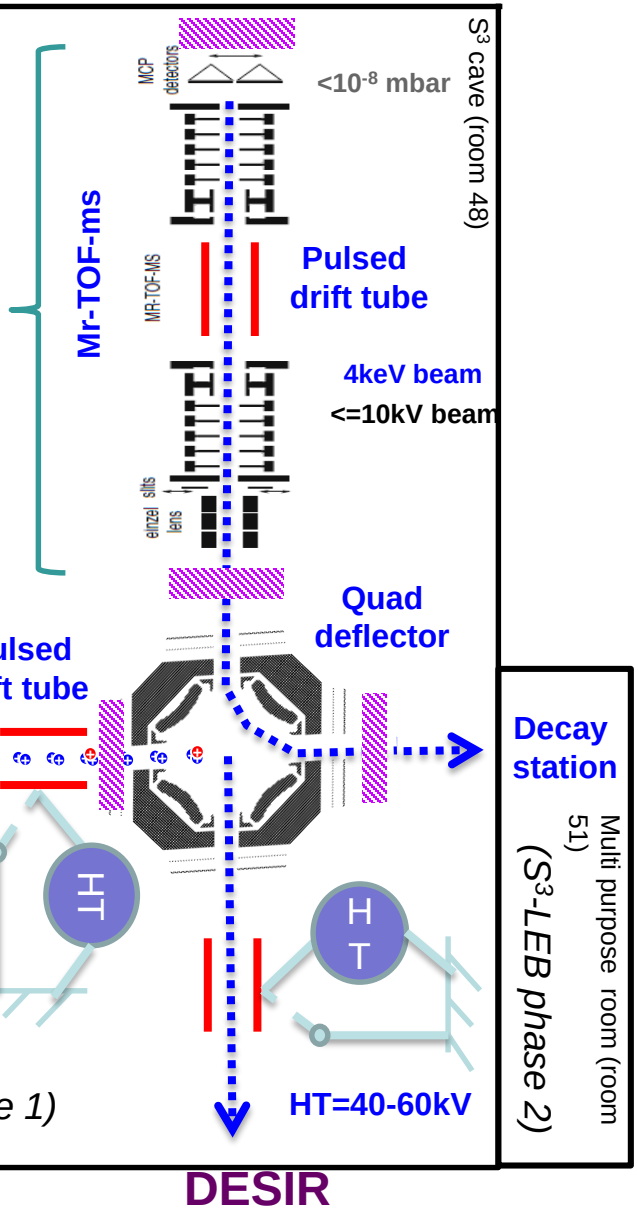
Pure beam



Isotopic selection (Z)



Isobaric purification (A)



Thank you for your attention