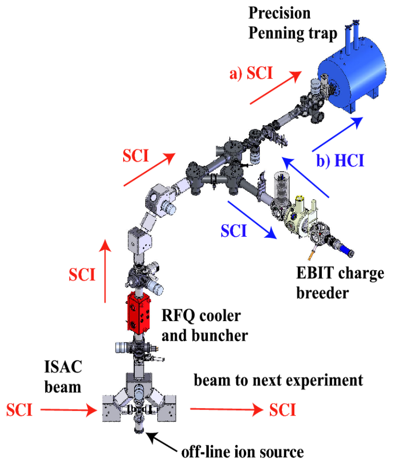
Technical developments : RFQ/Laser



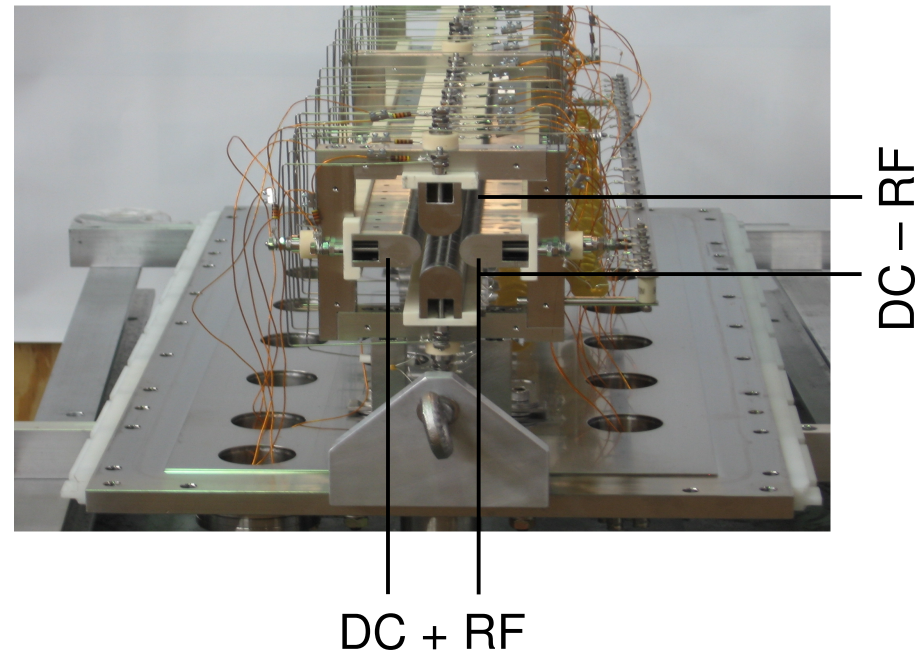
E. Mané

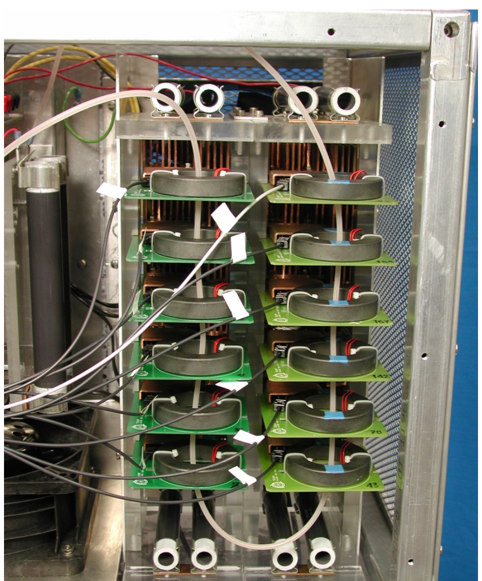
TITAN RFQ – A digital linear Paul trap

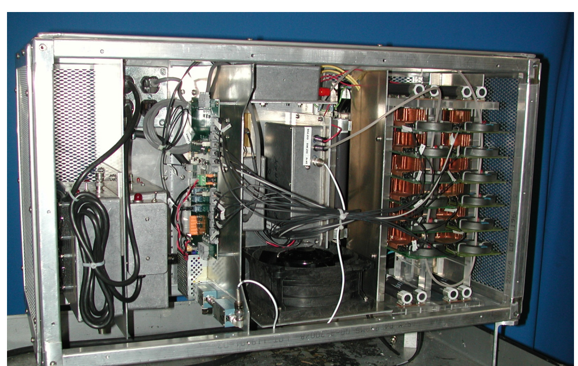
Quick facts and figures

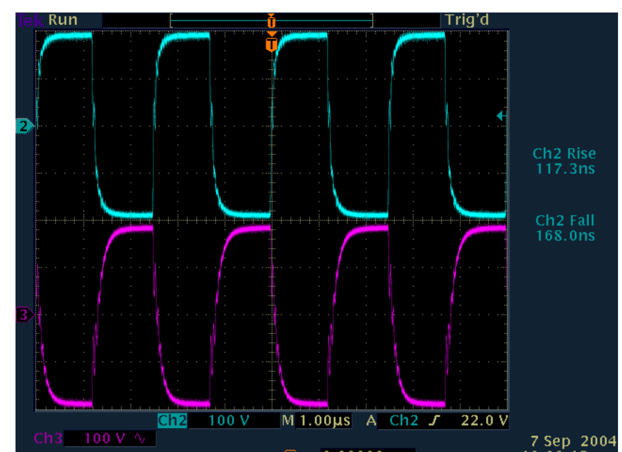
- 700 mm long, r_0 = 10 mm
- C ≈ 1500 pF
- Stack of optically triggered MOSFETs produces RF
- 200 kHz to 1200 kHz frequency range
- Amplitude up to 800 V_{PP}

Gas-filled (He,H) linear Paul trap




Stack of MOSFETs

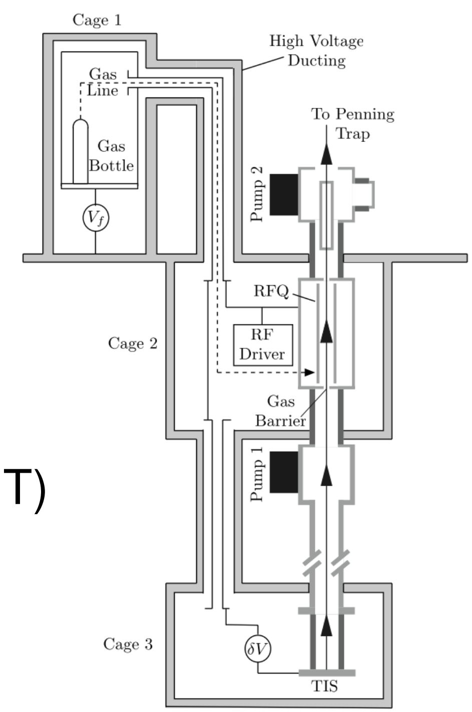

RF box



TITAN RFQ – Forward extraction

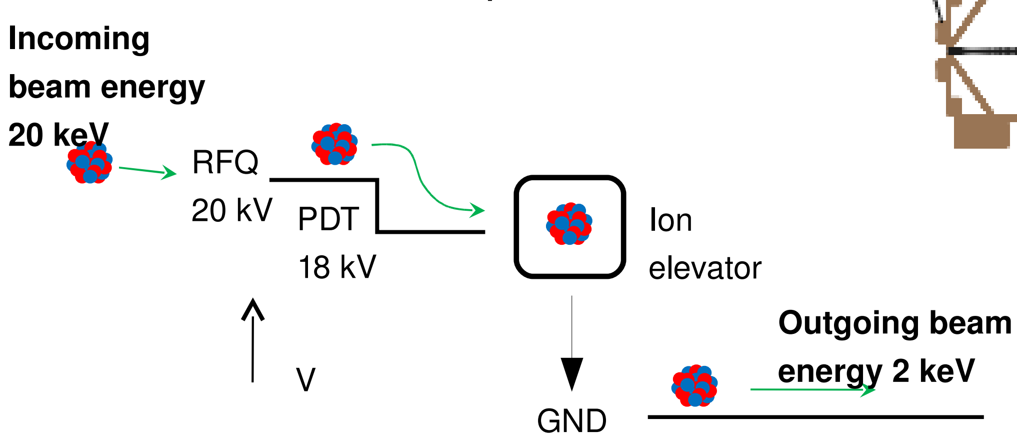
TITAN RFQ primarily needed to:

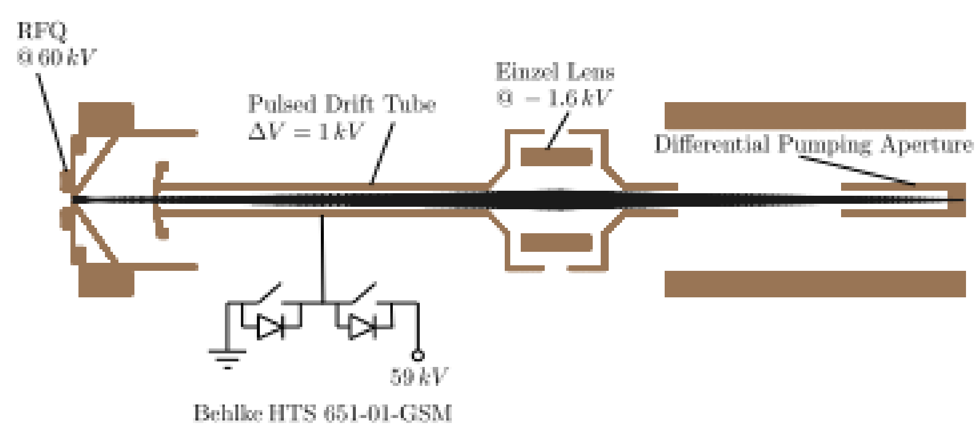
- Decelerate ISAC's beam from < 40 keV to 2 keV
- Cool the incoming beam (reduce the phase space volume)
- Bunch the incoming DC beam and send pulses to MPET (EBIT)



Pulsed drift tube

- Defines beam energy
- Switches ions to GND potential





Status (T. Brunner SMI '10)

- Fully operational at 20 kV (^{8}He beam time with 3 ions/minute at MPET MCP)
- Commissioned for 40 kV
- Frequency range from 250 kHz to 1200 kHz
- DC transmission of up to 80 % for Cs
- Broad mass range demonstrated for ion masses from 6 to 133
- Cooling with He and H possible
- Several online beam times with radioactive He, Li, K, Rb, Ca, In, Cs

Nim B. in preparation (T. Brunner et al.)

This is as far as forward extraction goes....

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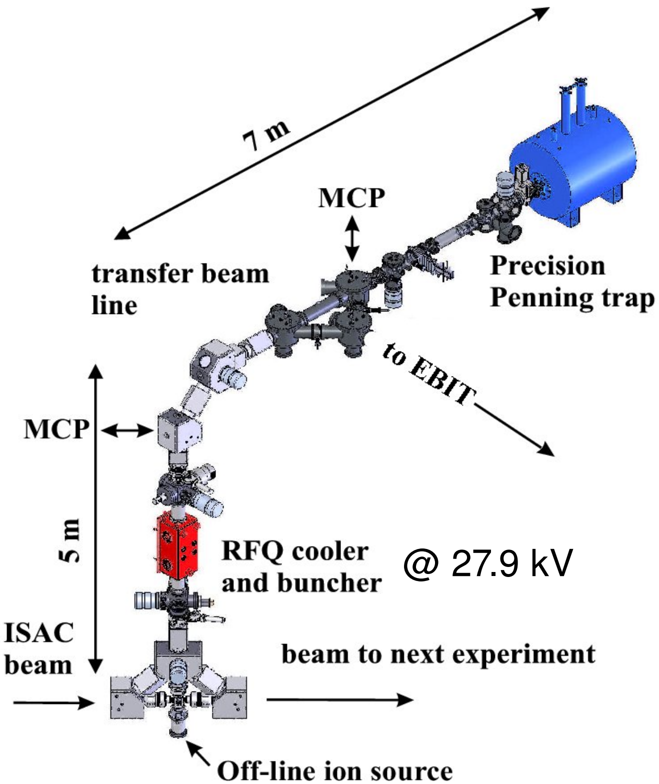
This is as far as forward extraction goes....

...this RFQ is also able to reverse-extract beams (demonstrated circa '06)

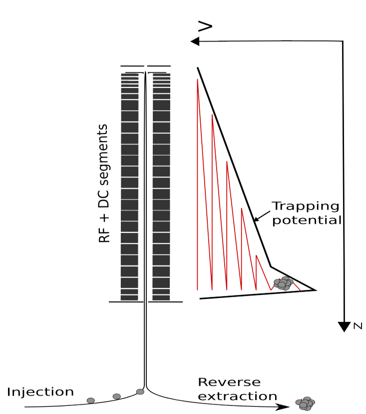
Which is very handy for laser spectroscopy :)

Reverse-bunched-beam laser spectroscopy

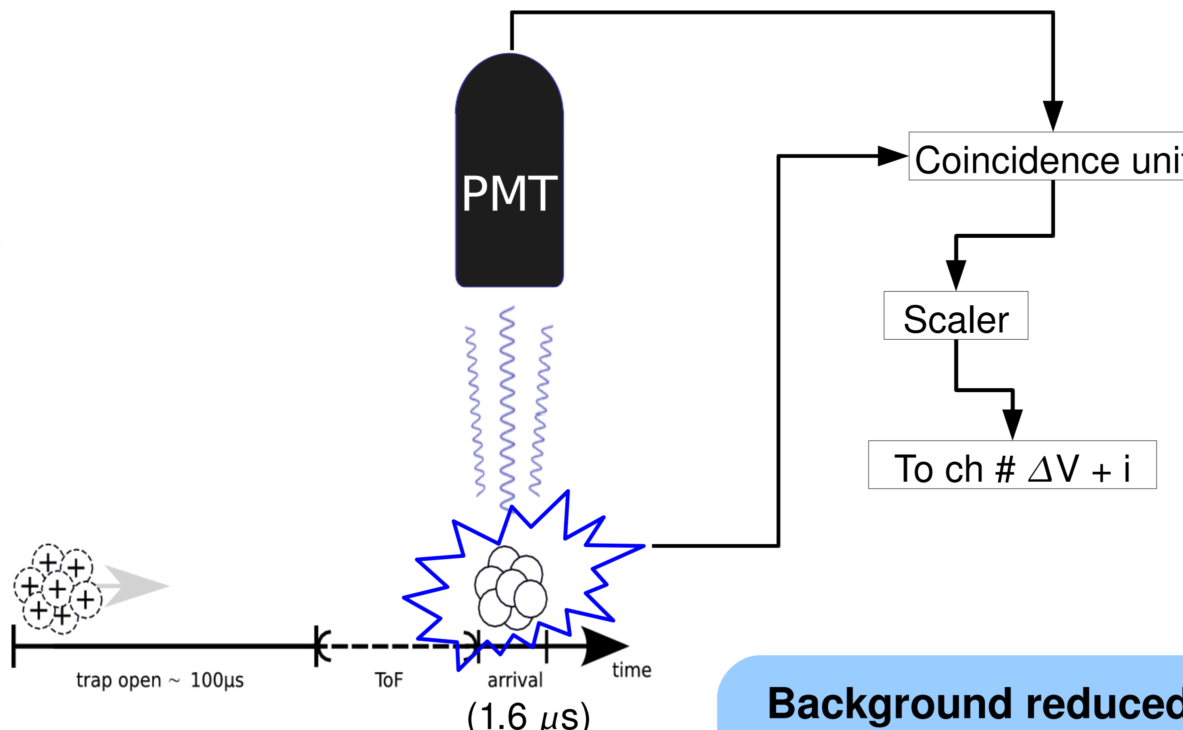
1) Cool, trap and reverse extract bunch



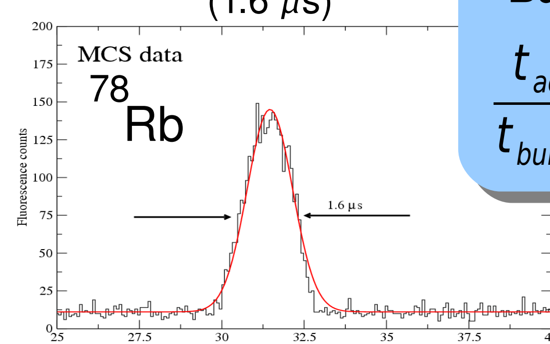
@ 27.9 kV



2) Only count when the bunch arrives



Fluorescence detection

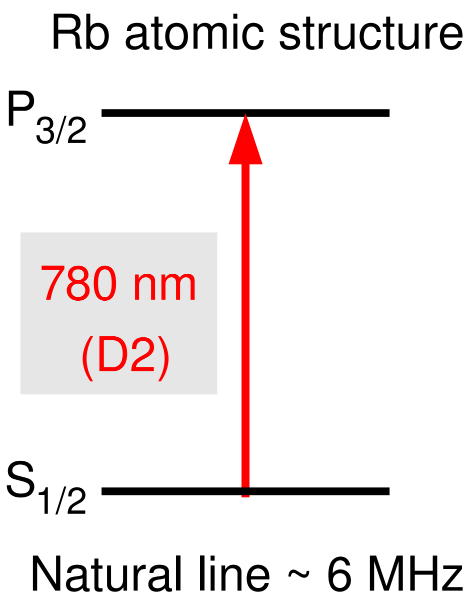


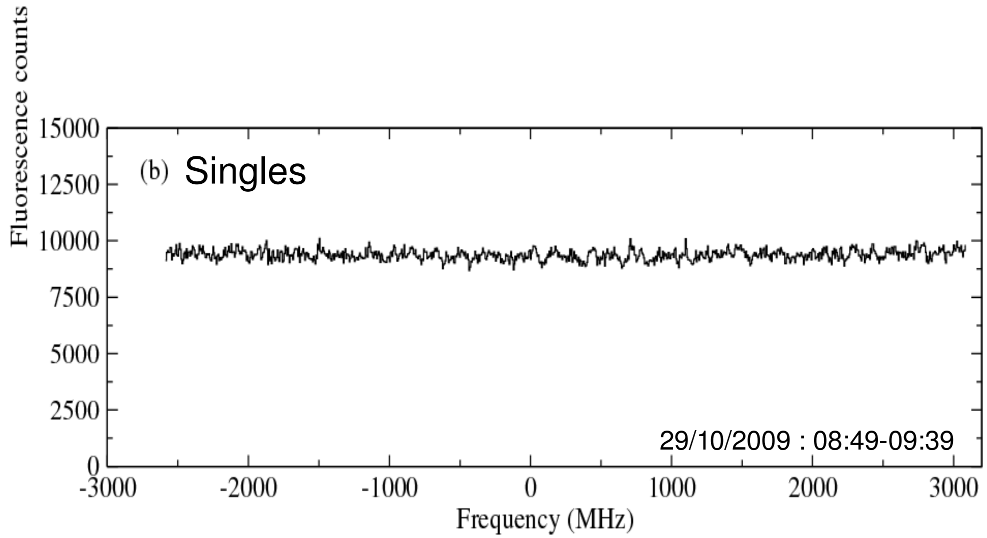
~ 10^5 ions (50 Hz cycle)

Background reduced by

$$\frac{t_{acc}}{t_{bunch}} \approx \frac{10\,ms}{1.6\,\mu s} \approx 6.25 \times 10^3$$

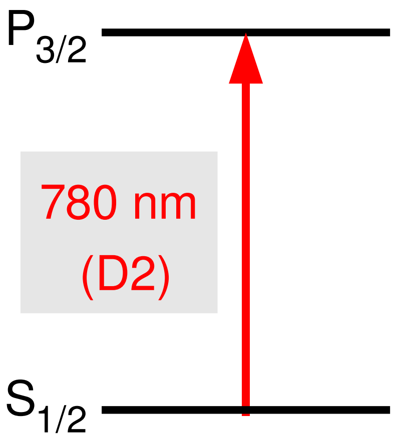
First on-line data on ^{78,78m}Rb (I=0,4), ~ 1pA





First on-line data on ^{78,78m}Rb (I=0,4), ~ 1pA

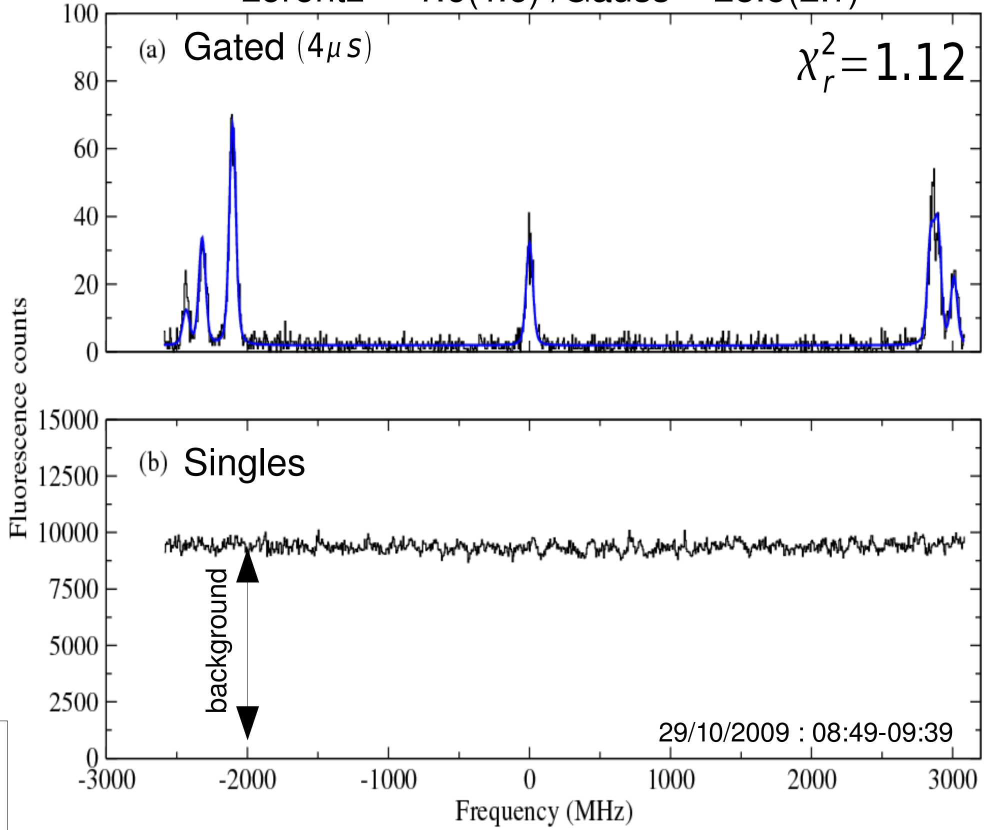
Rb atomic structure



Natural line ~ 6 MHz

Laser : 0.35 mW and Disp. ~ 6 MHz/V)

Lorentz = 7.6(1.6) /Gauss = 28.5(2.1)



Hyperfine structure: $F = I + J$

$$W_F = W_J + A\frac{C}{2} + B\frac{(3C/4)(C+1) - I(I+1)J(J+1)}{2I(2I+1)J(2J+1)}$$

$$A = \frac{\mu_I B_{el}}{IJ} \qquad B = eQ_s\left\langle \frac{\partial^2 V_e}{\partial z^2}\right\rangle$$

$$C = F(F+1) - I(I+1) - J(J+1)$$

Results (in MHz)

	$IS^{(78\text{-}78m)}$	$A(S_{1/2})$	$A(P_{3/2})$	$B(P_{3/2})$
This work	67.1 (2.1)	1184.4 (0.6)	29.5 (0.2)	77.1 (2.2)
Other work[1]	74.6 (2.2)	1186.8 (1.0)	29.4 (0.5)	76.5 (3.7)

[1] C. Thibault et al. PRC 23 6 (1981)

This is not enough (never is)...so we need to make improvements

Ars longa,

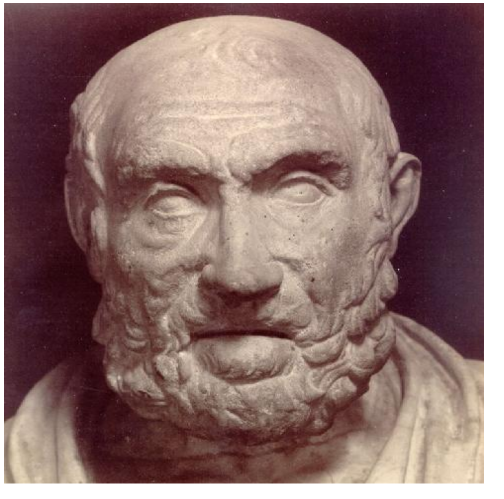
vita brevis,

occasio praeceps,

experimentum periculosum,

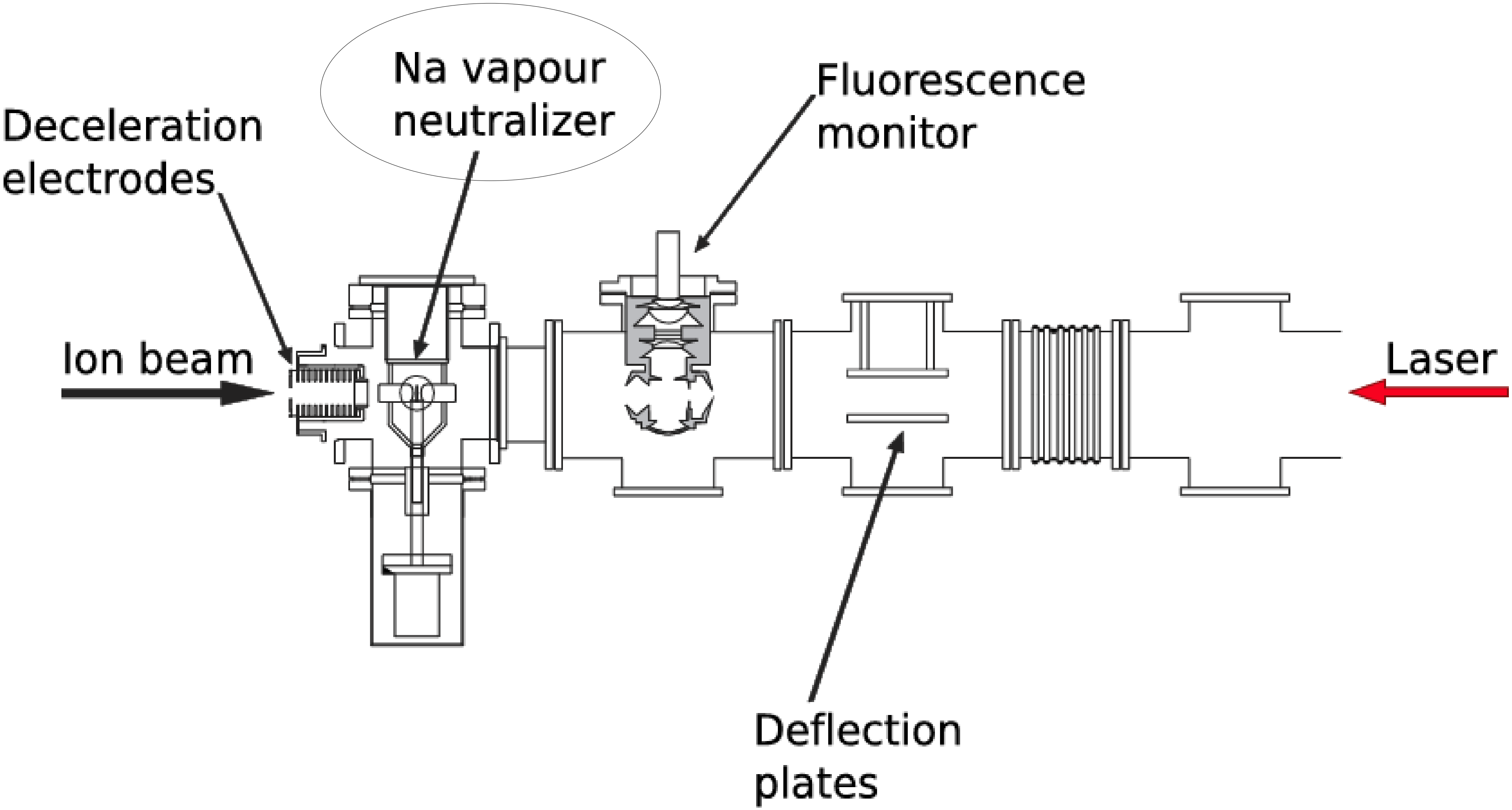
iudicium difficile.

(Hippocrates)



A closer look at the polarizer line

P. Levy improved the design > lifetime



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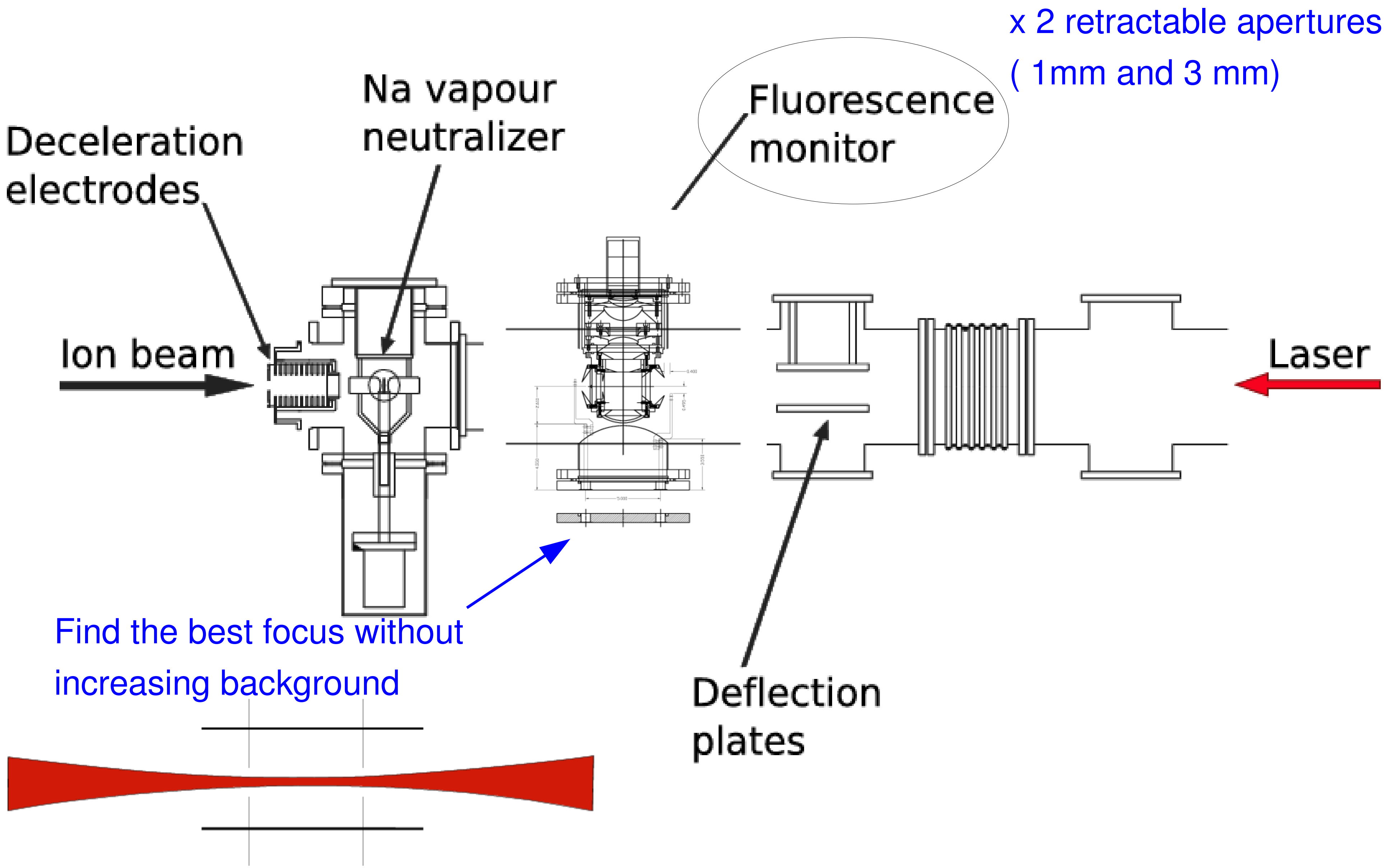

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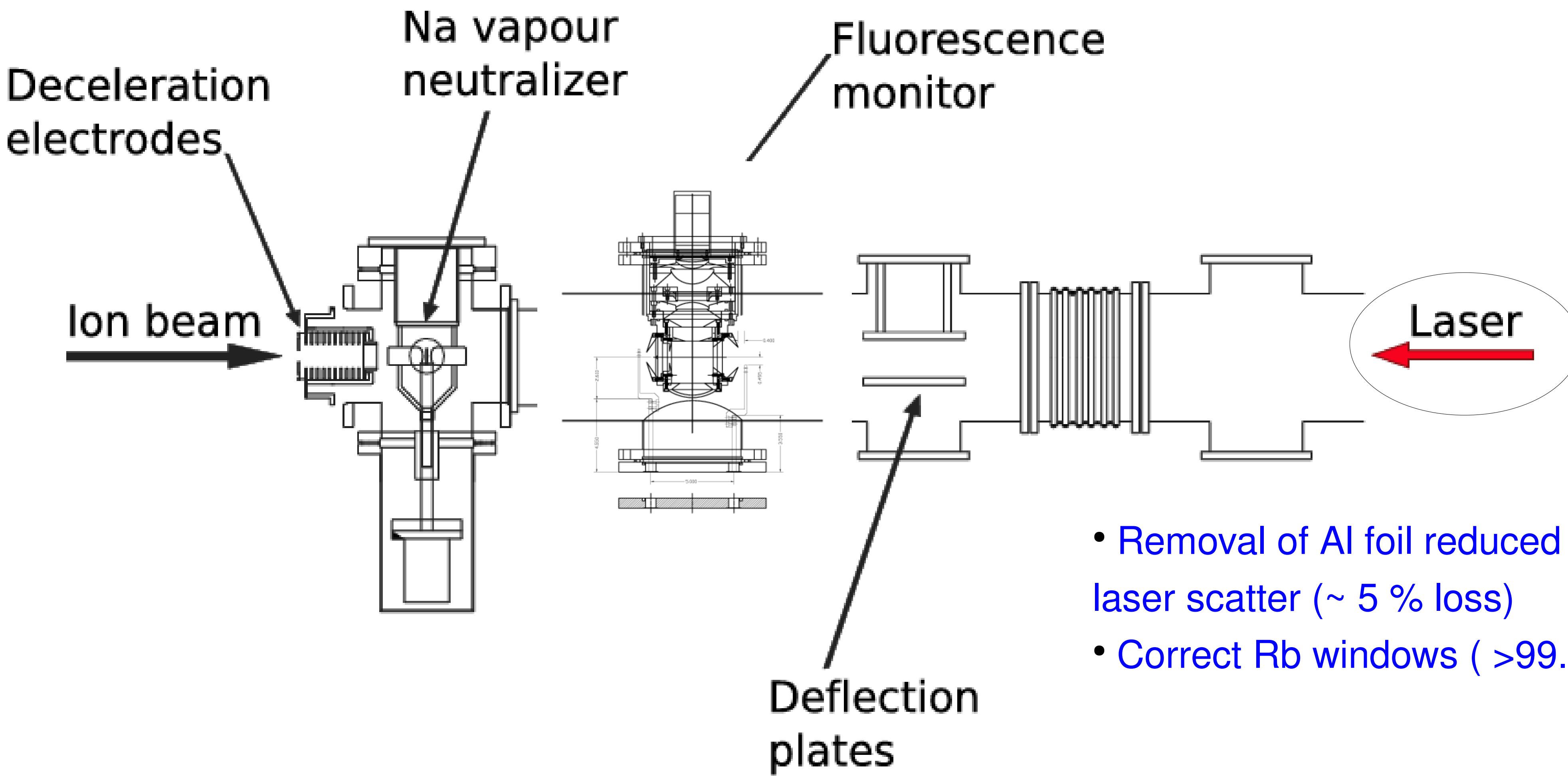
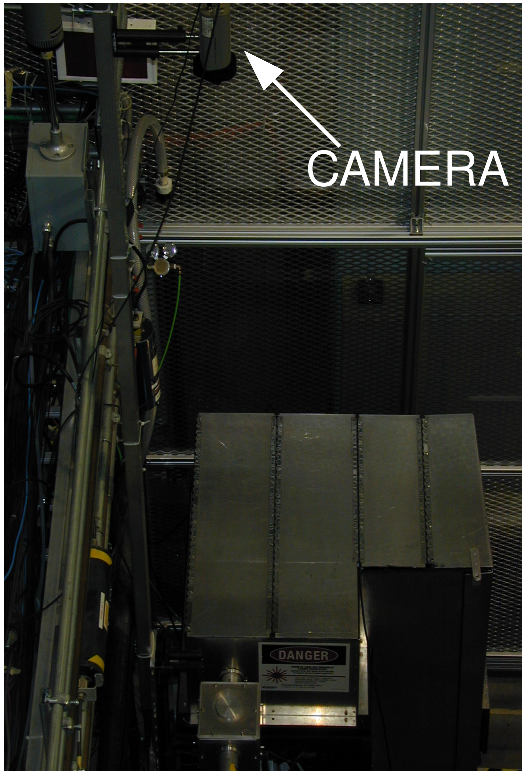


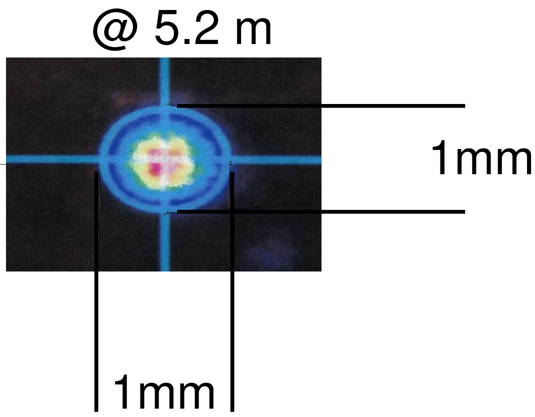
- Removal of Al foil reduced laser scatter (~ 5 % loss)
- Correct Rb windows (>99.8%)

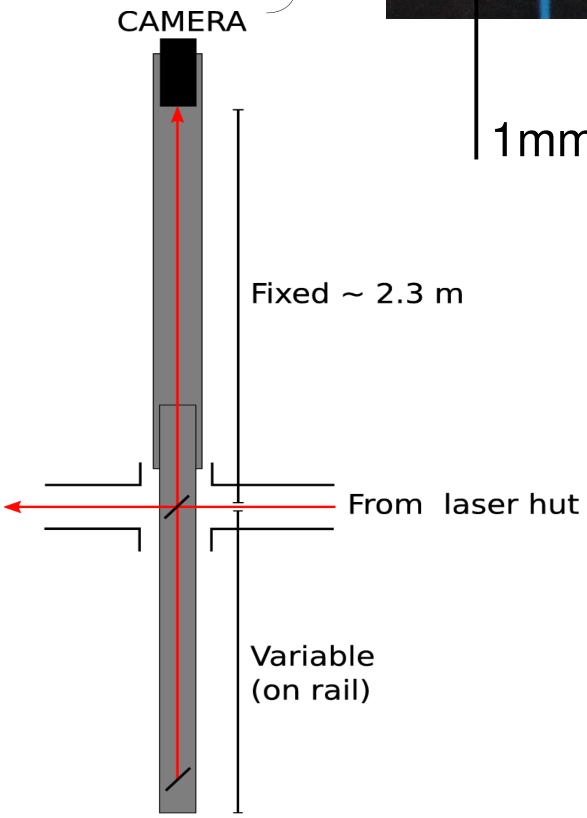
Seeing the laser mode at the interaction region

Coherent CCD camera + beam analyser resurrected:

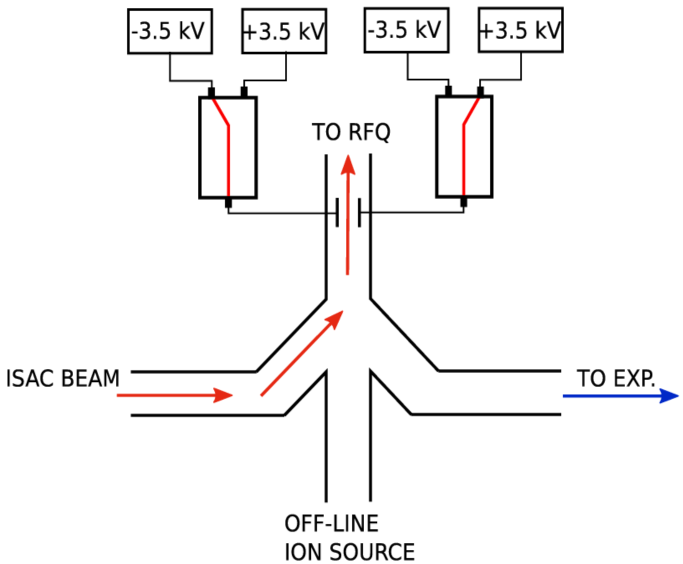
- Test made with 670.9 nm (camera is ok for 780 nm)
- > 90 % of the laser mode within in 1mm

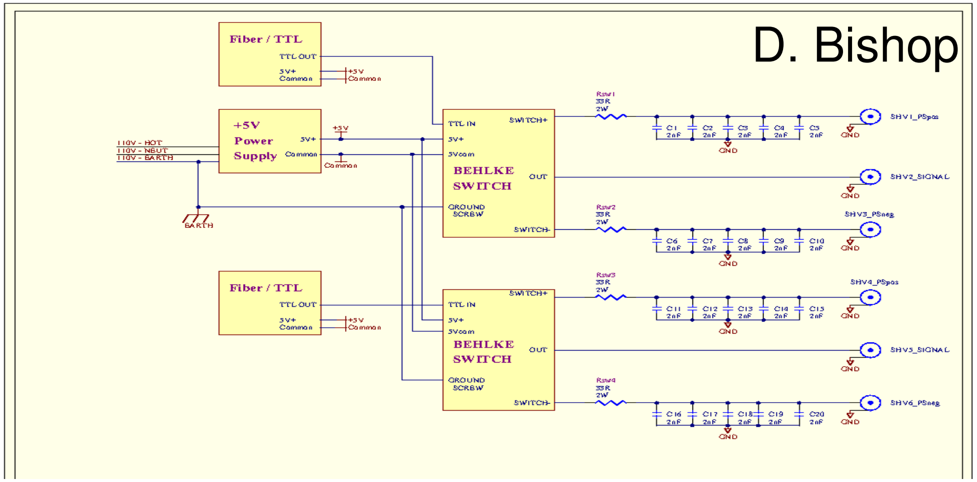


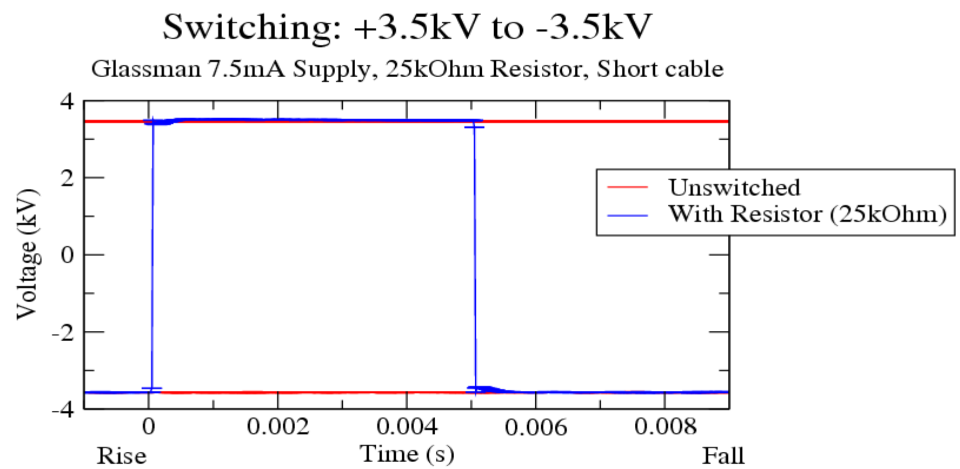


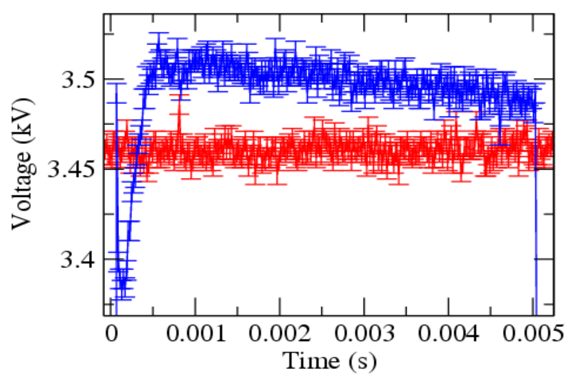


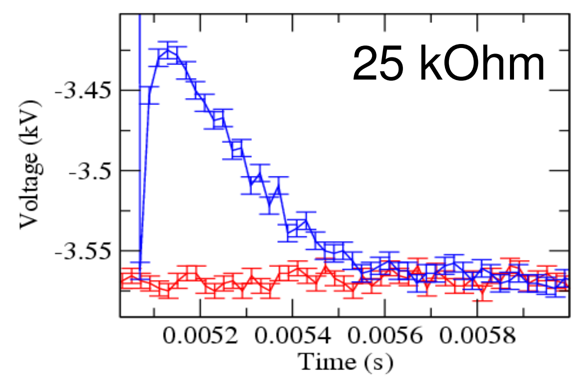
TITAN switch yard – 100 Hz rep. rate







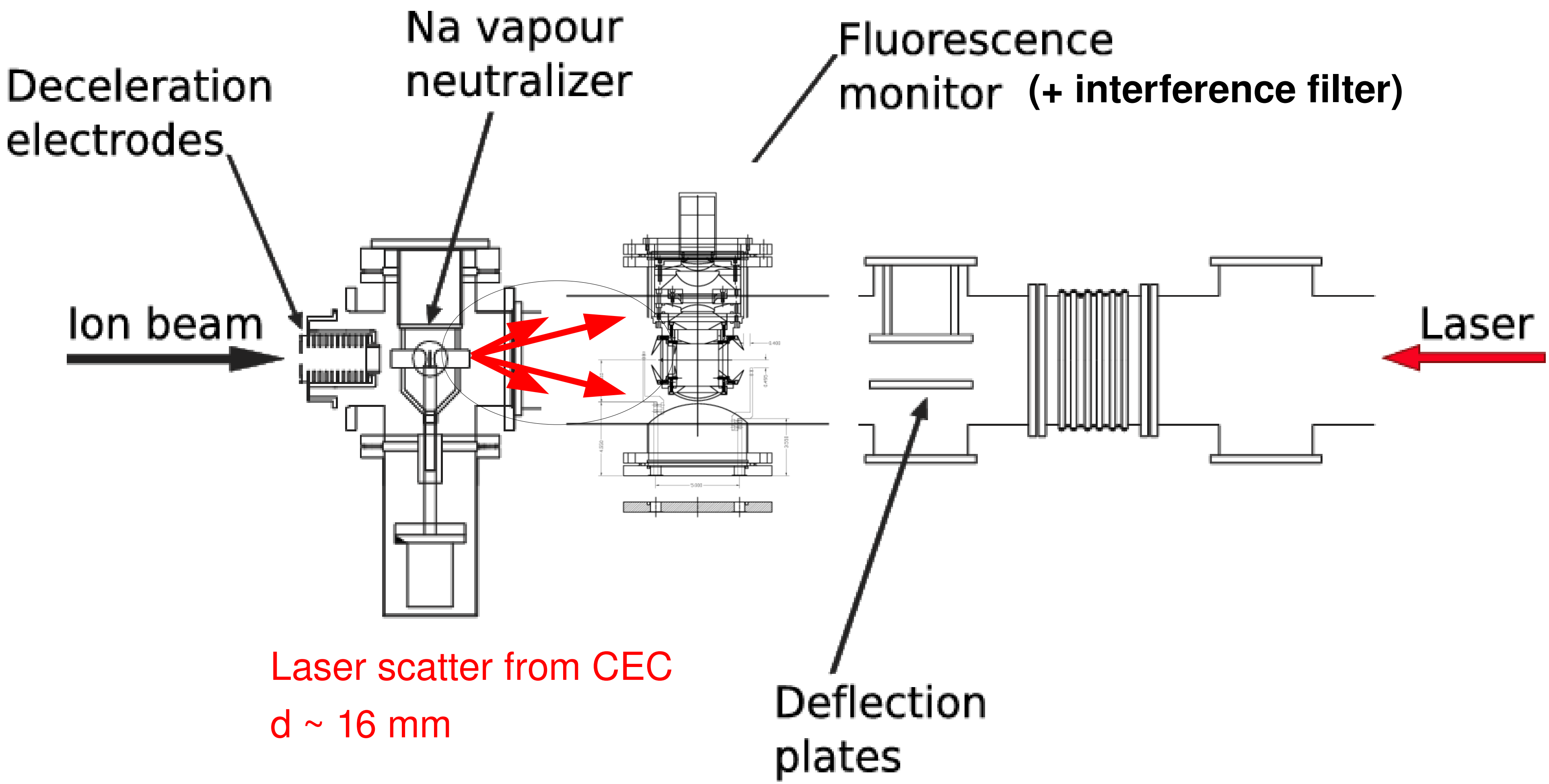




- > 1ms settling time achieved*
- 4 x Glassman 7.5 mA supp required
- Integration with EPICS
- 20/80 duty cycle

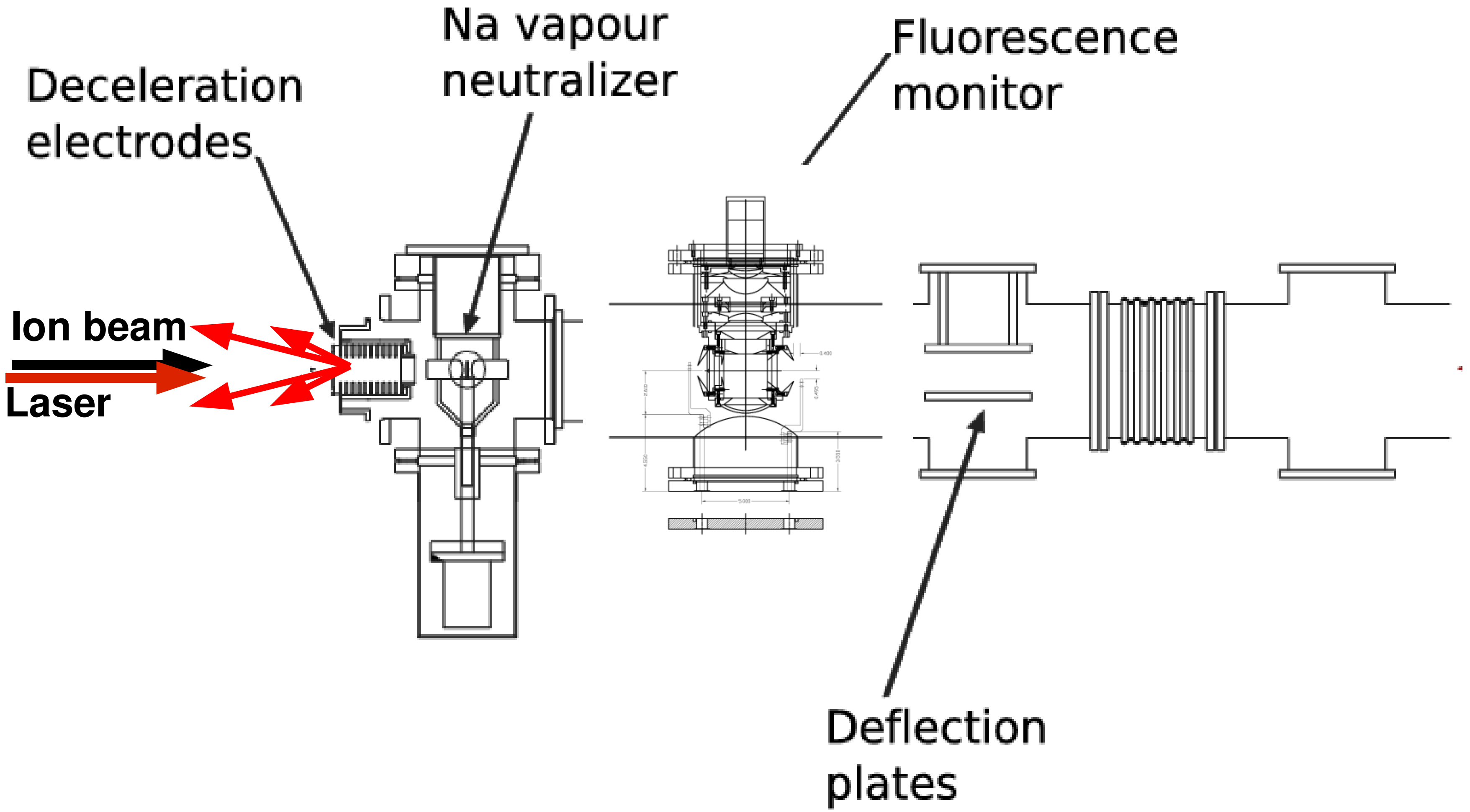
* Supplies 1.5 m away from switch box

Another look at the polarizer line



- Doppler shift for 78Rb @ 28 KeV ~ 0.7 nm
  -> Background reduced only by a factor of 2...
- Might also be throwing away signal... (ang. dependence of interference filter)

Another look at the polarizer line



- **Less background and no need of interference filter**
- **...but solution requires fibre coupling!!**

My wish list

- **Measure the beam emittance (longitudinal and transverse) at the polarizer line <u>before and after RFQ</u>**
- **Voltage stability of RFQ (measure hfs over long t)**
- **Space-charge limit**
- **Optimal settings for operation (cooling time, RF, etc)**
- **Investigate double trap issue...**

For that we need OLIS

OLIS beam time essential for the laser programme :

- Find tuning that works best to maximise transport and laser /ion overlap
- **<u>Efficiency measurements for Rb experiment (laser co and counter propagating)</u>**

Timeline for 2010

Plan for activities TITAN 2010 - > RFQ

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SETUP CHANGES											
~~Switch box for ISAC beamgate~~	■	■	■	■	■						
~~Switch box for RFQ pulsed drift tube (PLT)~~			■								
a) investigate current setup (including a test-setup for the switch)			■	■							
b) upgrade to 60 kV											■
~~Replace RFQ PLT feed-through (Mel Good)~~	■	■									
Upgrade RFQ to 65 kV										■	■
Make RFQ bakeable (sealing?) (Mel Good)										■	■
Try to send Rb, Na , Kr, Ne through RFQ (beam from OLIS)		■	■								
Try to achieve 200 Hz repetition rate			■	■					■	■	
Voltage divider to measure HV											
EXPERIMENTS											
Kr						■					
Rb (Reverse extraction bunched collinear laser spectroscopy), MPET									■	■	
MEASUREMENTS (DC, FORWARD, AND REVERSE EXTRACTION)											
Cooling time X TOF distribution with RFQ=2 kV, avoid PLT (for Thomas)	■	■									
Efficiency in AC with preamp on Faraday cup (for Thomas)	■	■									
Investigations of space charge limit (with laser + OLIS)		■							■		
Emittance & energy spread (Emittance meter, laser + OLIS)		■									
Optimal parameters (trap potential, RF, gas) for different masses		■	■	■	■	■	■	■	■	■	■
Investigation for reason of "sub-trap" in reverse extraction	■	■									

A closer look at the 78Rb spectra