



Colorado
State
University

EXO barium tagging R&D: identification in solid Xe

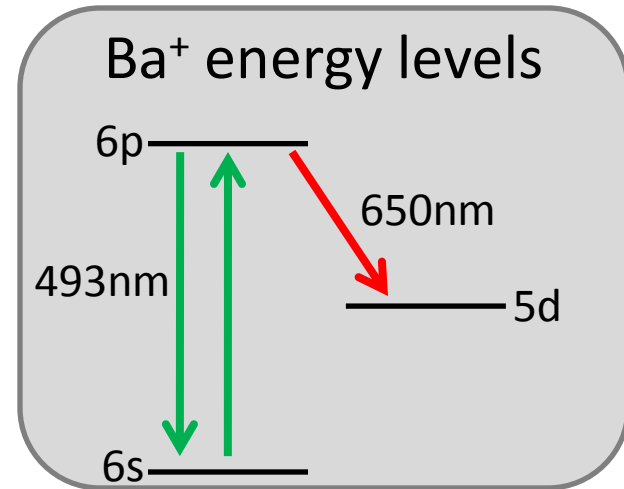
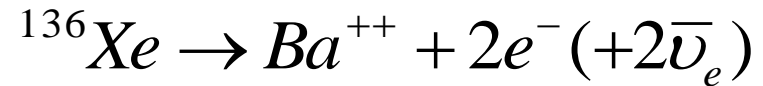
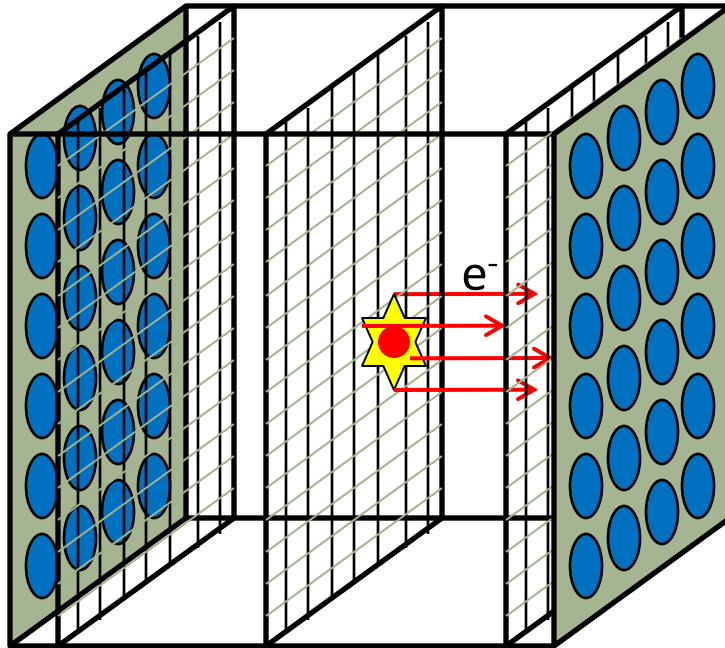
EXO Collaboration

Brian Mong

Shon Cook

William Fairbank

Full EXO – with tagging

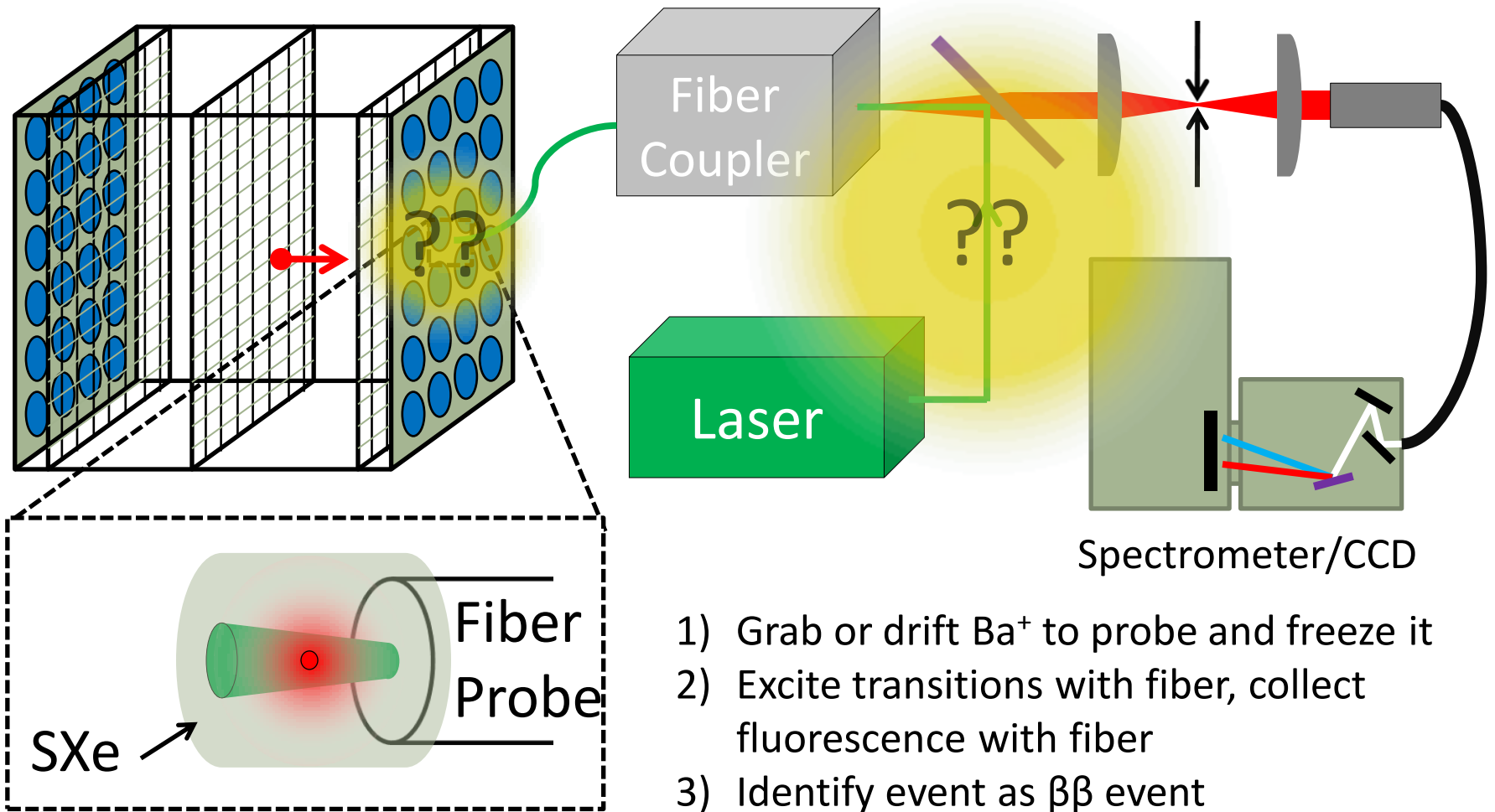


Case	Mass (ton)	Eff. %	Run Time (yr)	$\sigma E/E$ @ 2.5MeV (%)	$2\nu\beta\beta$ Background (events)	$T_{1/2}0\nu$ (yr, 90%CL)	Majorana mass (meV)	
							QRPA ¹	NSM ²
Conservative	1	70	5	1.6	0.5 (use 1)	$2 \cdot 10^{27}$	19	24
Aggressive	10	70	10	1	0.7 (use 1)	$4.1 \cdot 10^{28}$	4.3	5.3

1) Simkovic et al. Phys. Rev. C79, 055501(2009) [use RQRPA and $g_A = 1.25$]

2) Menendez et al., Nucl. Phys. A818, 139(2009), use UCOM results

A detector probe concept

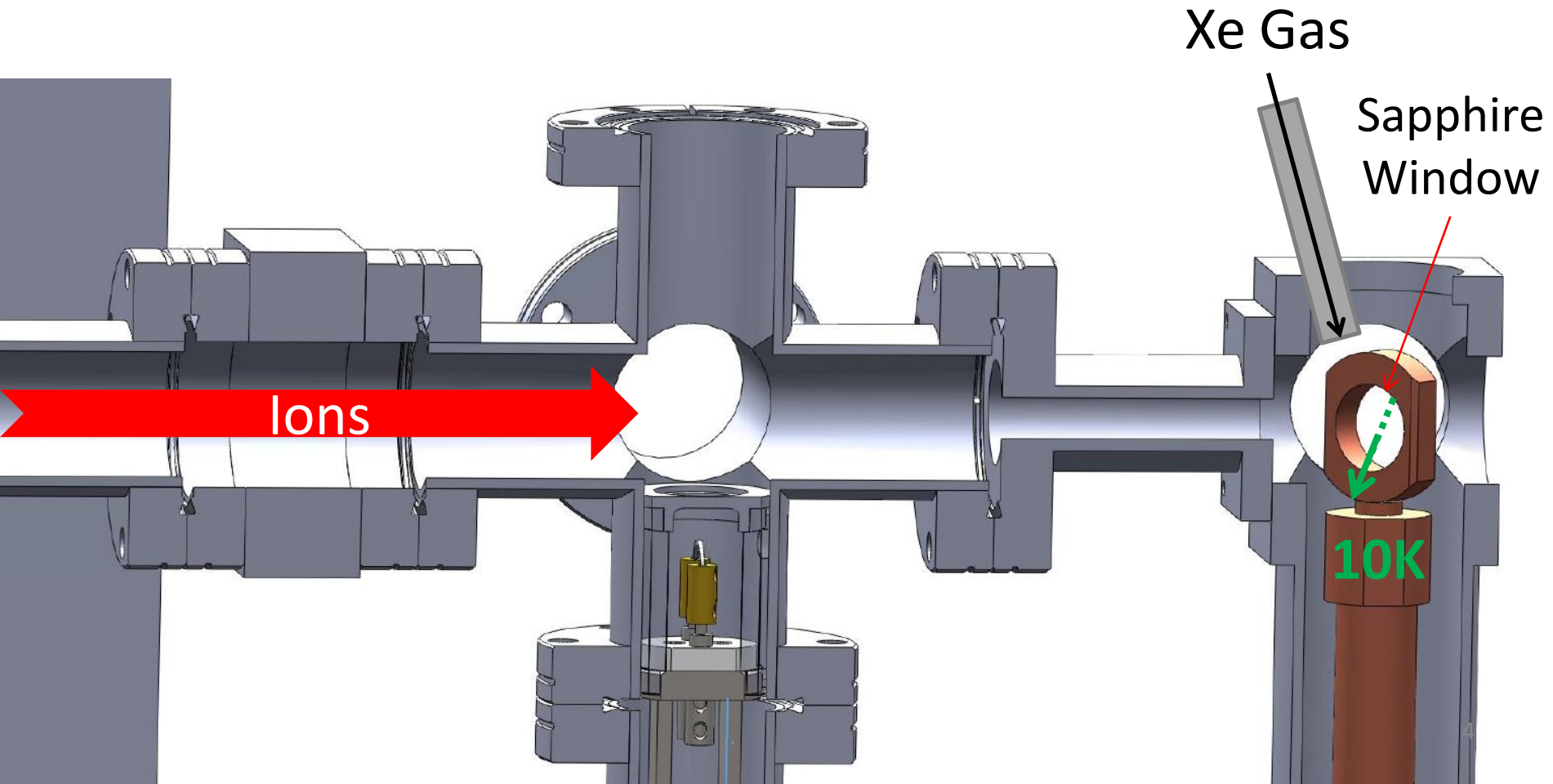


Breaking up the problem into **identification** and grabbing

Determining $\text{Ba}^+/\text{Ba}^{++}$ in SXe spectrum

(Making samples)

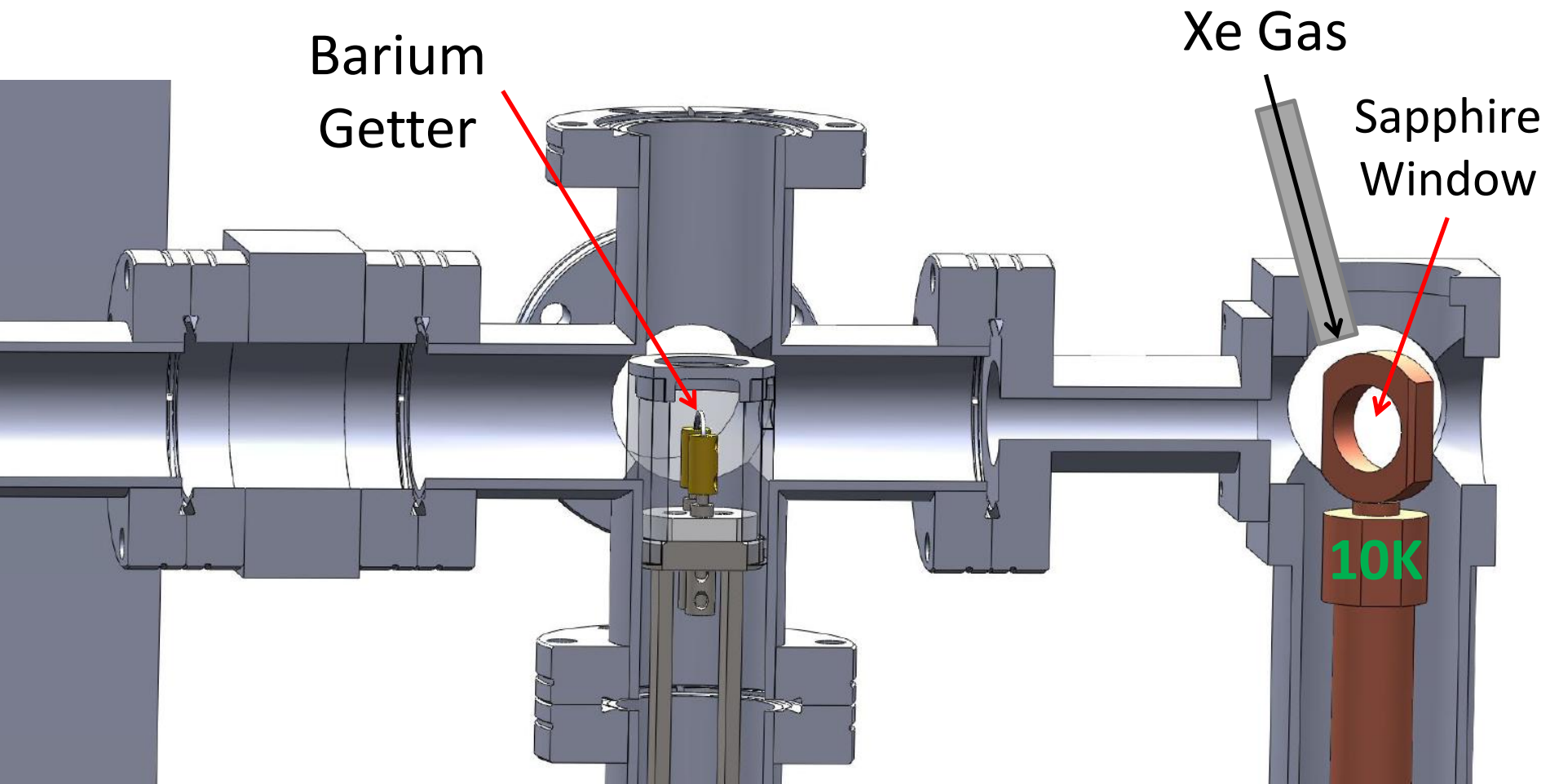
- 1) Xe leaked onto cooled sapphire substrate to form SXe matrix
- 2) Ions from an ion-beam are deposited at low energy (10-2000 eV settable)
- 3) Atoms excited by lasers emit fluorescence collected by spectrometer



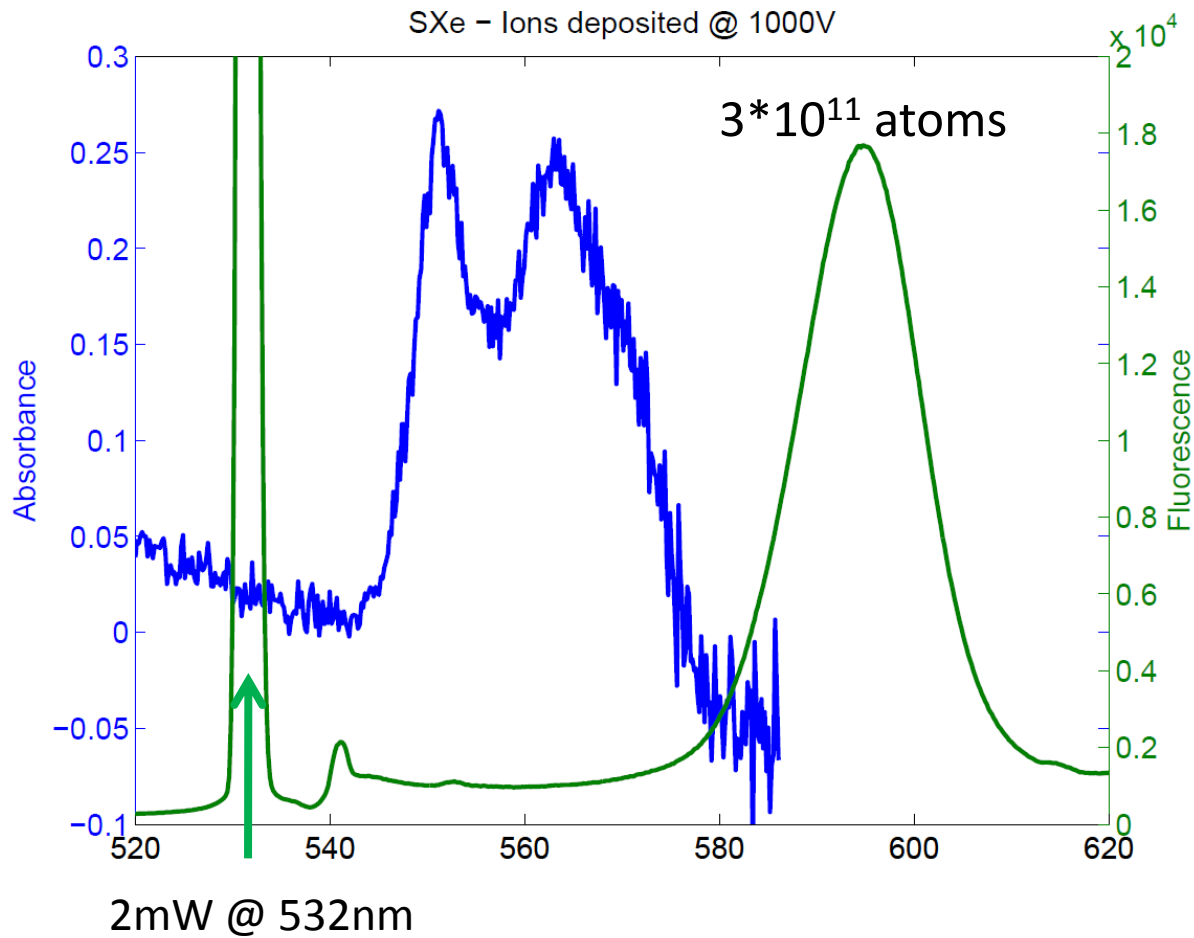
Determining Ba in SXe spectrum

(Making samples)

- 1) Xe leaked onto cooled sapphire substrate to form SXe matrix
- 2) Atoms deposited by Joule heating Ba-getter
- 3) Atoms excited by lasers emit fluorescence collected by spectrometer

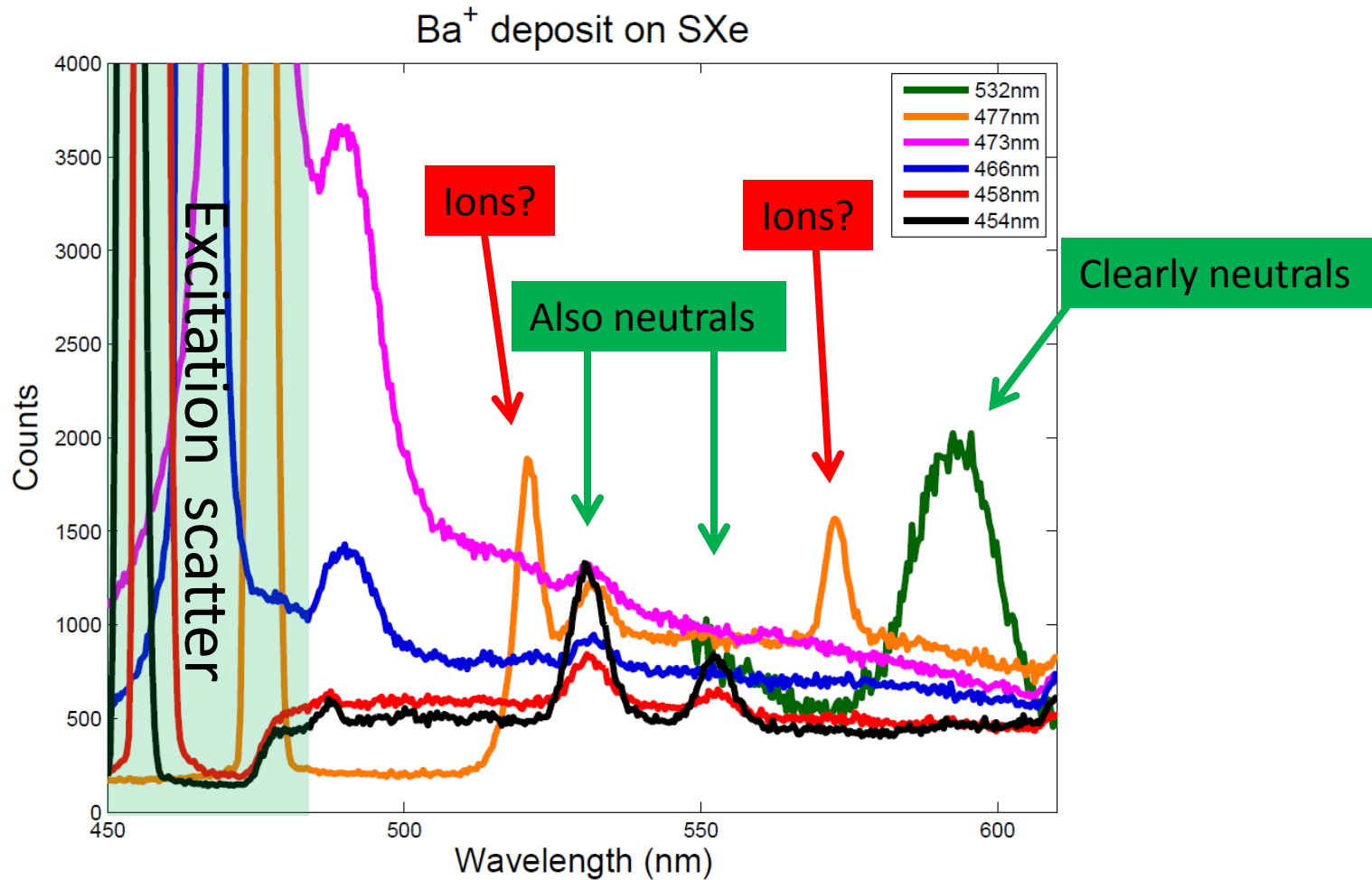


Spectroscopy – Neutrals



Neutral deposits show clear absorption and strong fluorescence

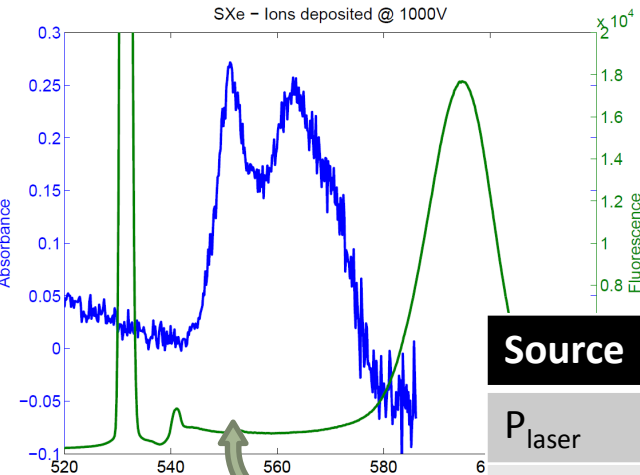
Spectroscopy – Ion deposit



Spectrum from ion deposit shows neutral lines and suspected ion lines

Neutrals – detection limit

SXe – Ions deposited @ 1000V

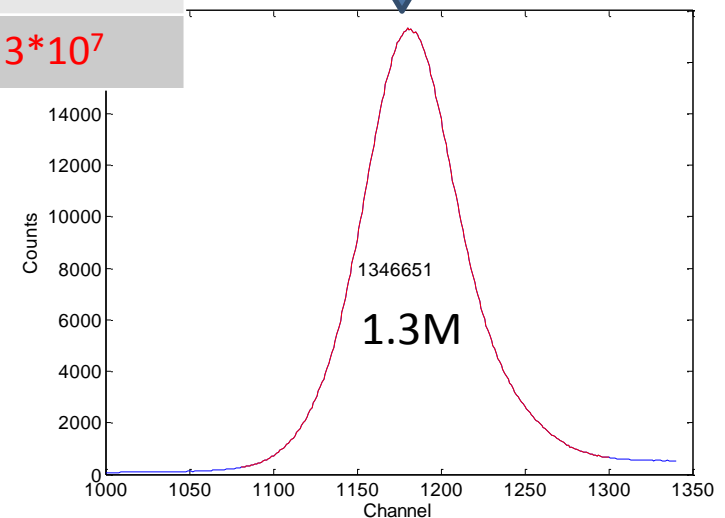


Excite with
dye-laser
 $\lambda = 550-560\text{nm}$
(now working)

Source	Current	Expected	Increase
P_{laser}	2mW	20mW	10
$\lambda_{\text{laser}}/\lambda_{\text{abs-peak}}$	1/30	1	30
CCD Counts	10^6	10^2	10^4
Exposure	1s	10s	10
Total			$3 \cdot 10^7$

Collecting fluorescence
in 219 \rightarrow 4 channels
with hardware binning

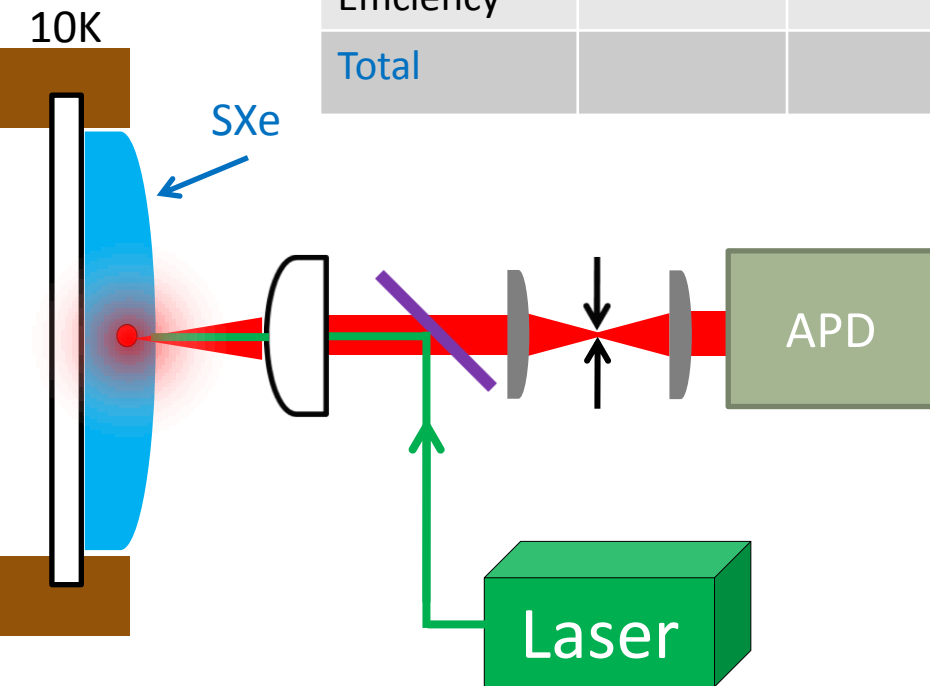
$$\frac{3 \cdot 10^{11} \text{ atoms}}{3 \cdot 10^7} \Rightarrow 10^4 \text{ atoms}$$



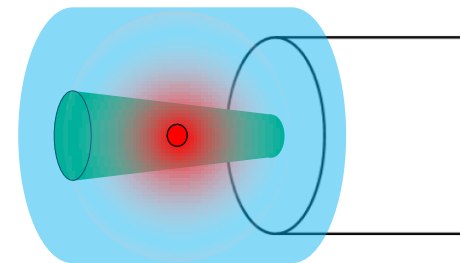
Increasing sensitivity to single Ba

Source	Current	Expected	Increase
Focus Laser (intensity)	1mm	30 μ m	10^3
Collection Efficiency	10^{-5}	10^{-3}	10^2
Total			10^5

10^{-4} atom sensitivity
 $\times 10^5$ increase in S/N
 \rightarrow Single atom detection

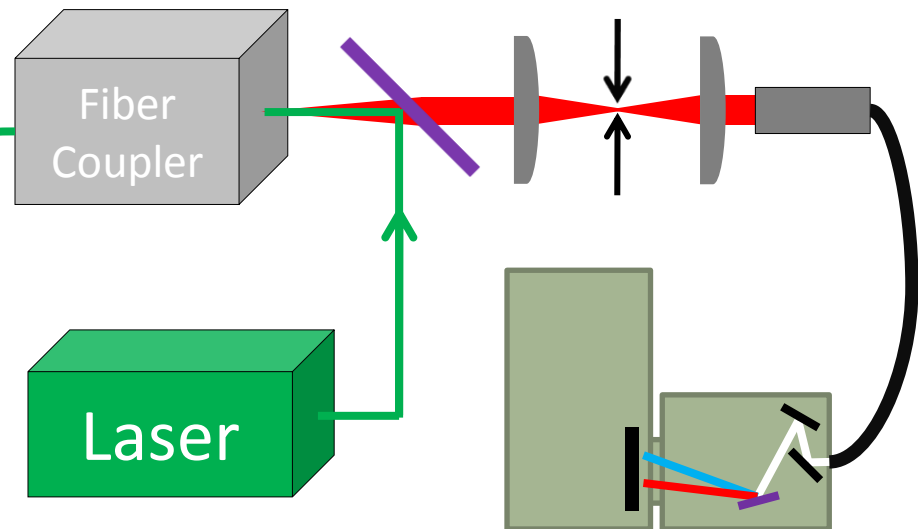
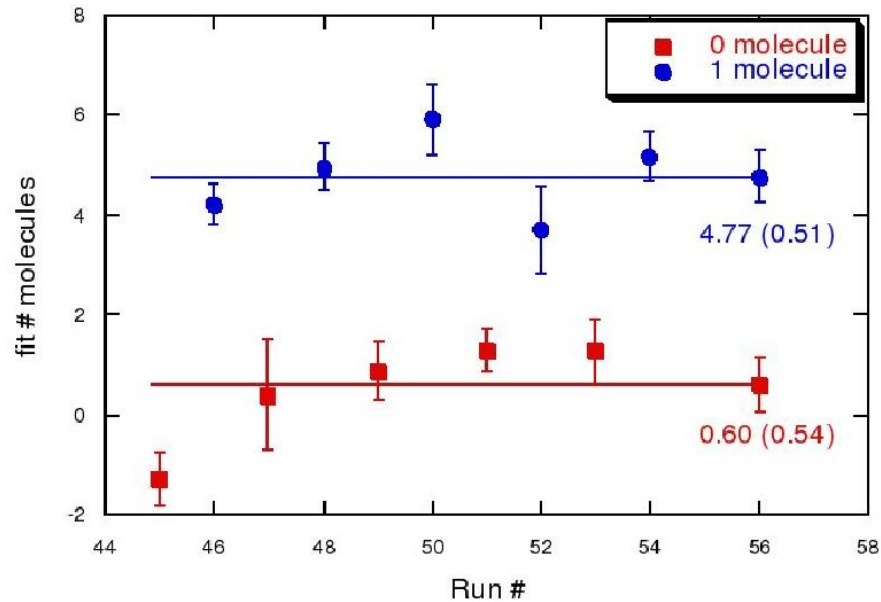


Confocal Spectroscopy



Single Mode Fiber Optic

Dye molecule analogue demonstrates single molecule sensitivity with fiber



EXO Collaboration

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