First simulation approach for Ar & Xe electroluminescence in the NIR region

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Purpose of the work

- Investigate Ar & Xe scintillation in the Near Infra Red (NIR) region
- Applications of noble gas NIR light:
  - Primary scintillation:

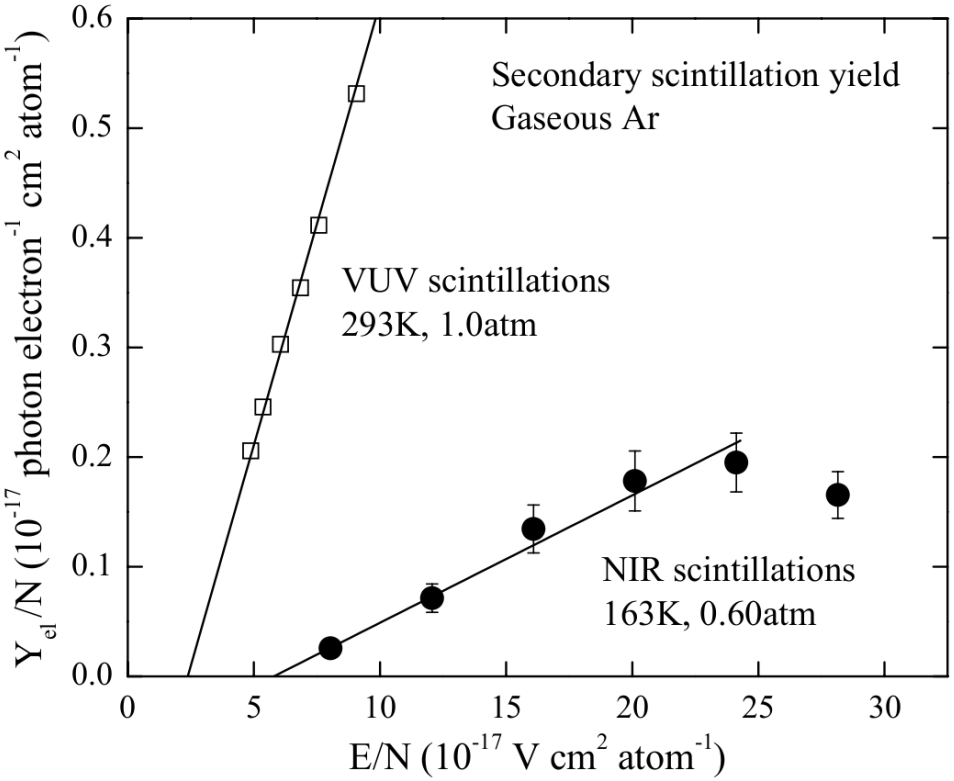
    Neutrino-nucleous scatering detectors

    Directional solar neutrino detection

    High energy calorimetry
  - Electroluminescence:

    Gaseous & dual phase Ar / Xe detectors

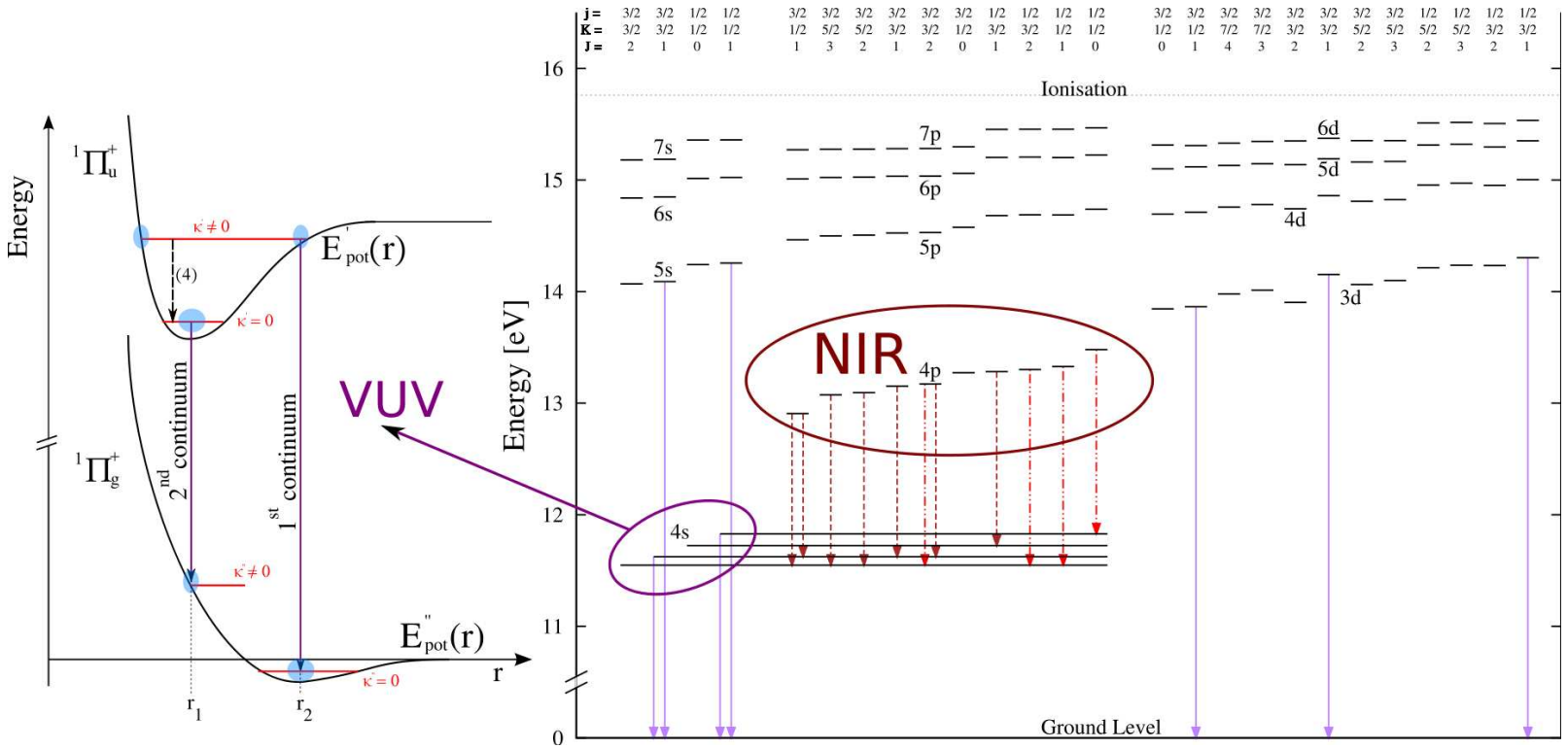
Purpose of the work



- *A. Buzulutskov et al* recently measured the absolute electroluminescence yield of pure Ar in the NIR region (**RD51-Note-2011-002**).
- Can *garfield*++ (& Magboltz 8.9.3) reproduce those results?

Atomic and molecular transitions

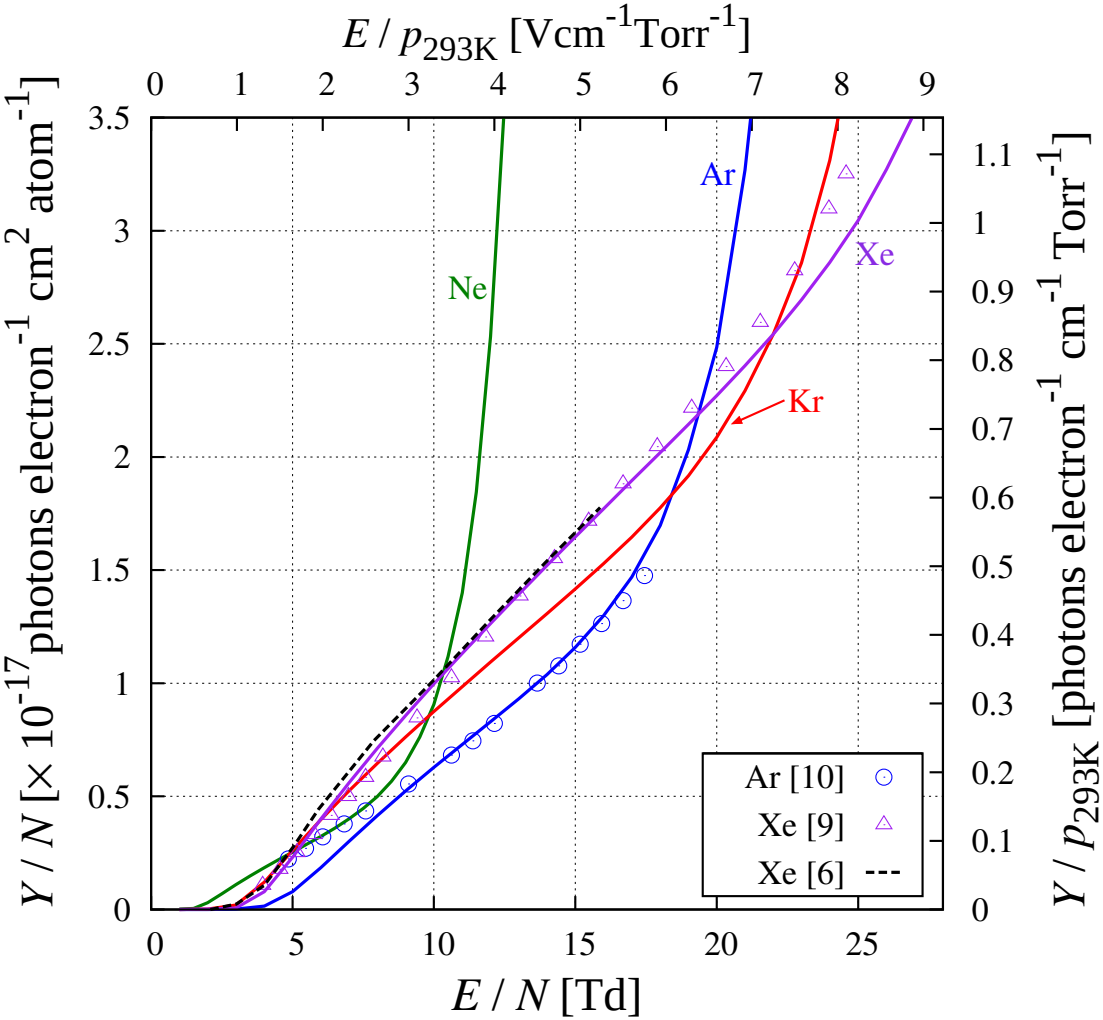
NIR & VUV



- 4s (75-90%) $\rightarrow$ excimers $\rightarrow$ VUV γ
- 4p (5-13%) $\rightarrow$ decay to 4s (NIR γ)$\rightarrow$ excimers $\rightarrow$ VUV γ
  (1 4p state $=$ 1 NIR γ + 1 VUV γ)
- higher levels (1-12%) $\rightarrow$ decay to 4p (J.W. Keto, J.Chem.Phys. 74 (81) 6188) $\rightarrow$ decay to 4s (NIR γ) $\rightarrow$ excimers $\rightarrow$ VUV γ (1 higher state $=$ 1 NIR γ + 1 VUV γ)

VUV yield

Uniform field



[6] Monte Carlo - F. P. Santos et al., J. Phys. D. Appl. Phys. 27 (1994) 42.

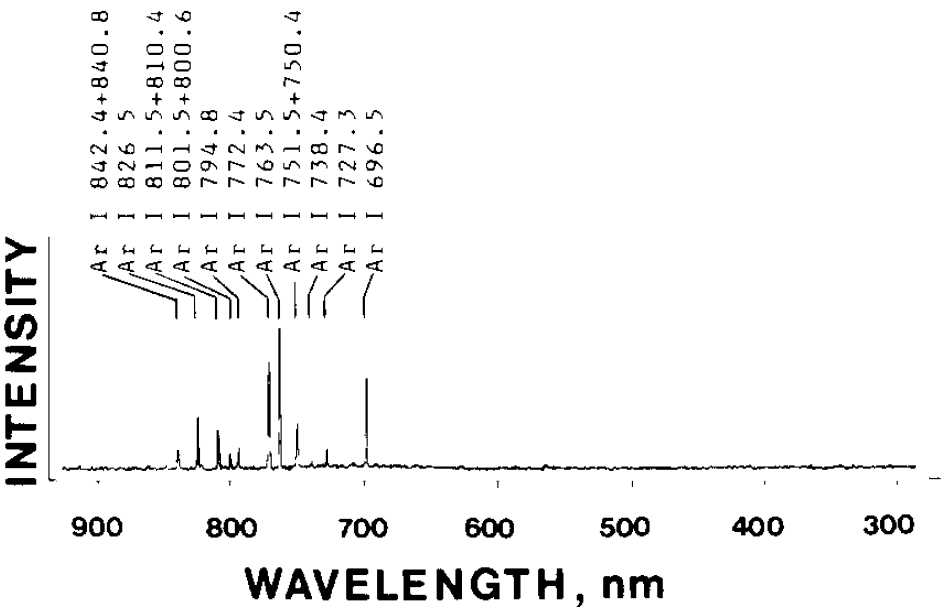
[9] Experimental - C.M.B. Monteiro et al., J. Instrum. 2 (2007) P05001

[10] Experimental - C.M.B. Monteiro et al., Phys. Lett. B 668 (2008) 167

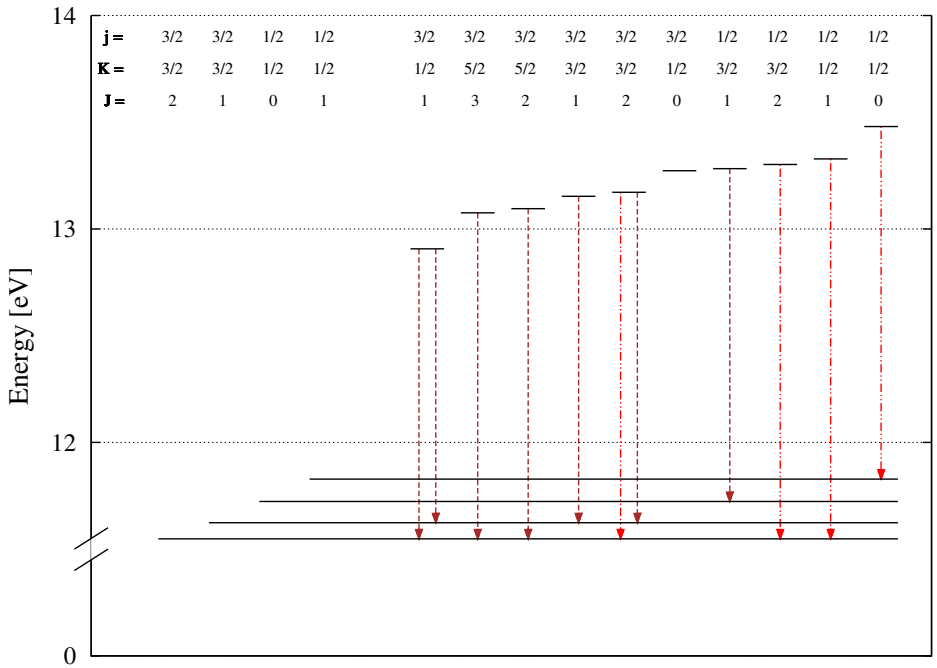
- 1 excited state (in any level) $\rightarrow$ 1 VUV γ
- Good agreement with experimental data (Ar & Xe)
- Toolkit validated
- Submitted to Phys. Lett. B

Atomic transitions from 4p states

NIR



P. Lindblom, Nuc. Instrum. Methods A 268 (1988) 204



Dipole-allowed transitions (NIST Atomic Spectra Database)

Atomic transitions from 4p states

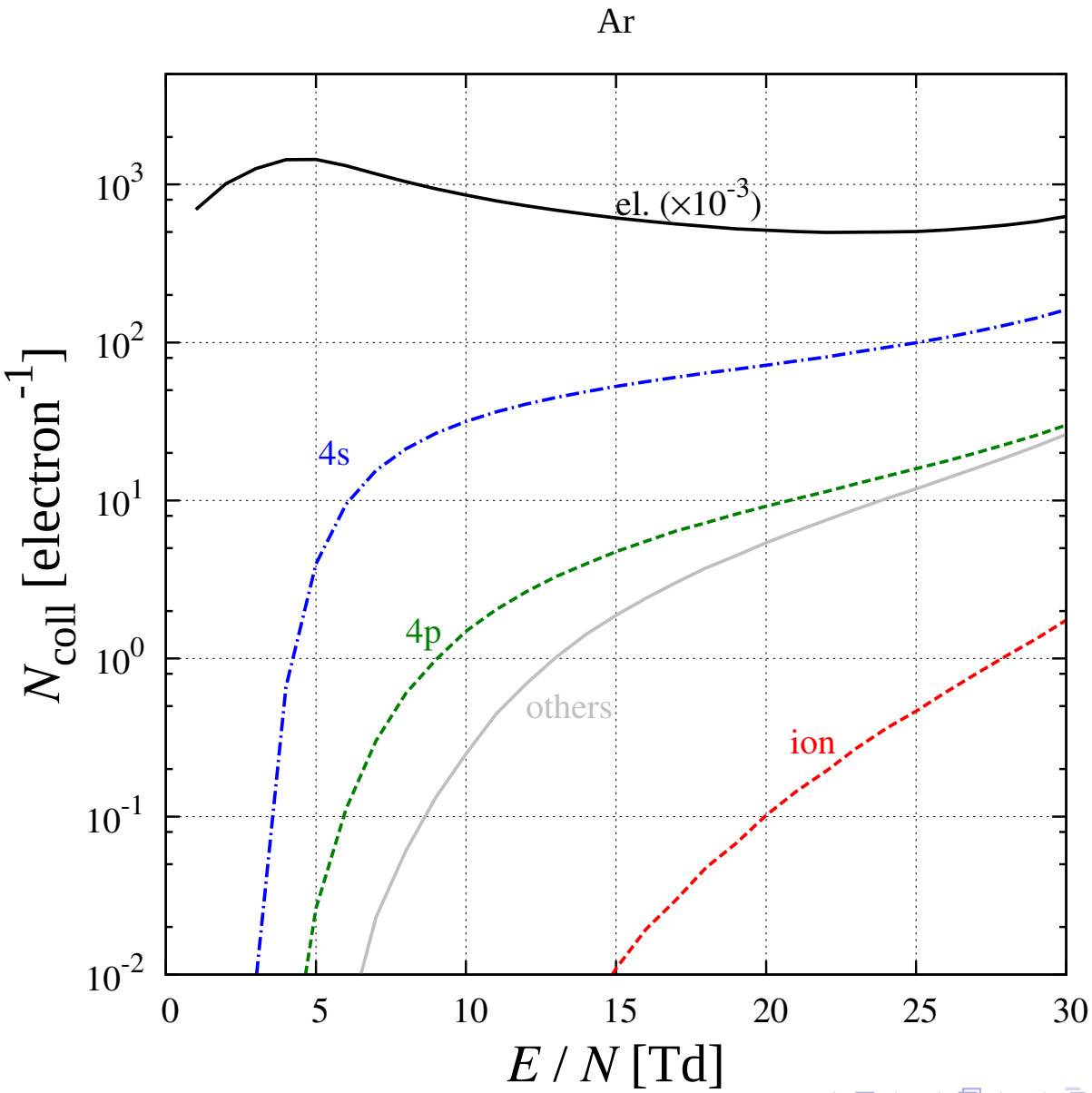
NIR

NIST				P. Lindblom	
Source	Final	ΔE[eV]	λ[nm]	λ_{agree}[nm]	$\lambda_{\text{don't\_agree}}$[nm]
4p'$[1/2]^{\text{o}}_1$	4s$[3/2]^{\text{o}}_2$	1.7795025	696.7	**696.5**	
4p'$[3/2]^{\text{o}}_2$	4s$[3/2]^{\text{o}}_2$	1.7538723	706.9		727.3
4p'$[1/2]^{\text{o}}_0$	4s'$[1/2]^{\text{o}}_1$	1.6518156	750.6	**751.5**	
4p$[3/2]^{\text{o}}_2$	4s$[3/2]^{\text{o}}_2$	1.6234232	763.7	**763.5**	
4p'$[3/2]^{\text{o}}_1$	4s'$[1/2]^{\text{o}}_0$	1.5594786	795.0	**794.8**	
4p$[3/2]^{\text{o}}_2$	4s$[3/2]^{\text{o}}_1$	1.5481849	800.8		738.4
4p$[5/2]^{\text{o}}_2$	4s$[3/2]^{\text{o}}_2$	1.546518	801.7	**801.5**	
4p$[3/2]^{\text{o}}_1$	4s$[3/2]^{\text{o}}_1$	1.529551	810.6		772.4
4p$[5/2]^{\text{o}}_3$	4s$[3/2]^{\text{o}}_2$	1.5273612	811.8	**811.5**	
4p$[1/2]^{\text{o}}_1$	4s$[3/2]^{\text{o}}_2$	1.3586608	912.5		826.5
4p$[1/2]^{\text{o}}_1$	4s$[3/2]^{\text{o}}_1$	1.2834225	966.04		842.4

- NIST - used in the simulation model
- P. Lindblom - used in the experimental measurement by Buzulutskov et al

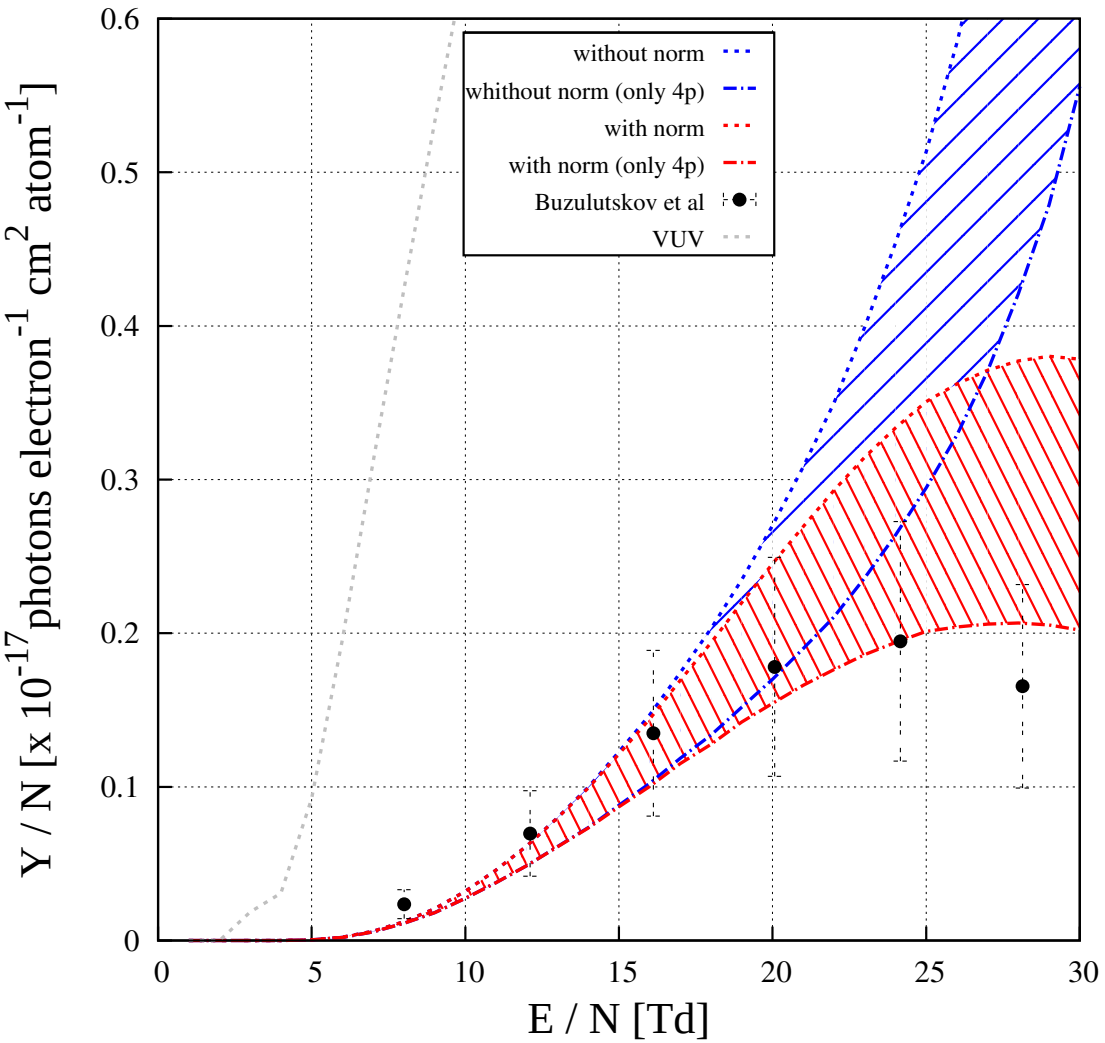
Population of excited states

Ar @ 0.6 atm 163 K | 2 mm of drift



NIR yield

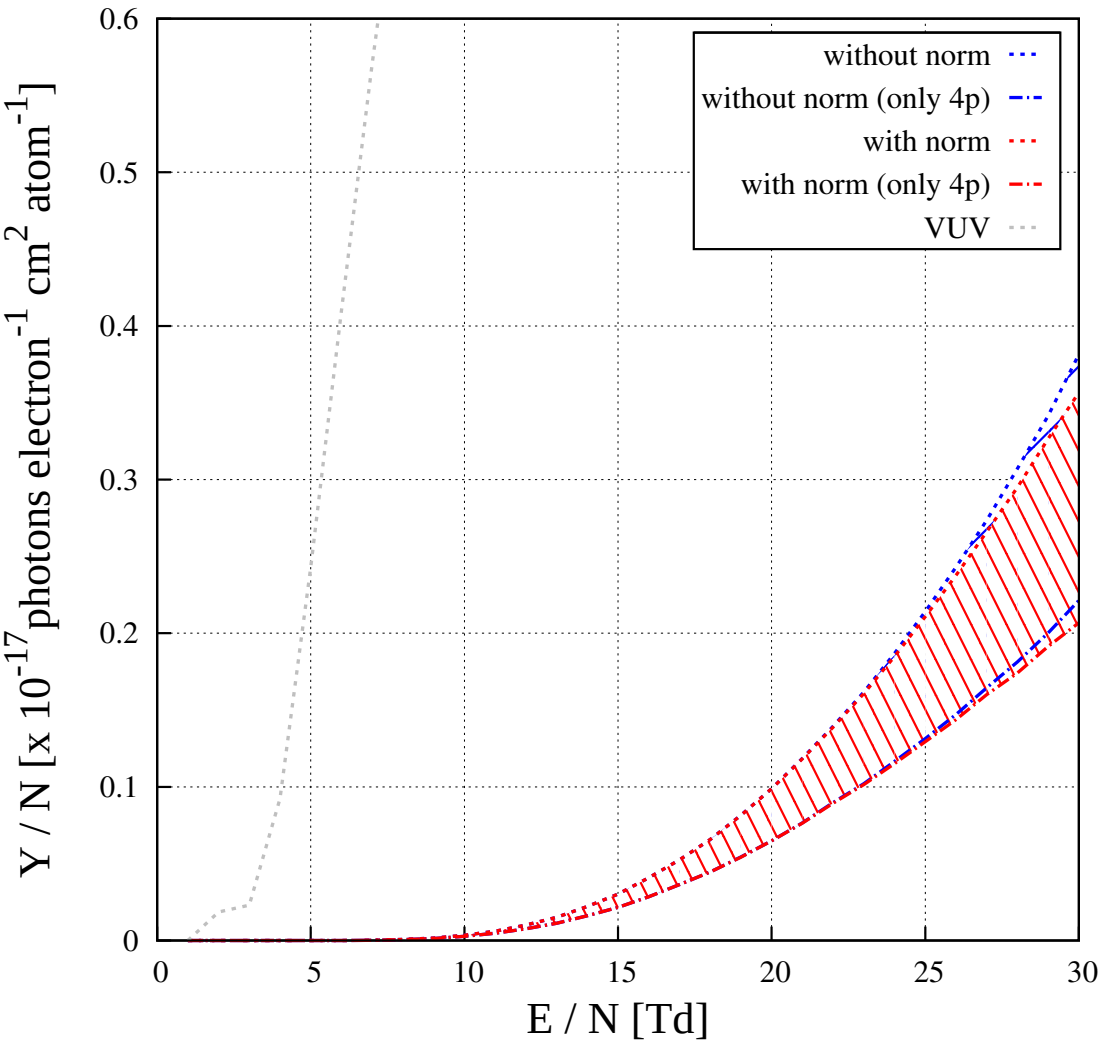
Ar - Uniform field



- Fair agreement between experiment & simulation for $E/N < 16$ Td
- Differences for $E/N > 16$ Td being analysed
- $\alpha_{\text{ion}} > 0.01 \text{ions cm}^{-1}$ for $E/N > 13$ Td

NIR yield

Xe - Uniform field

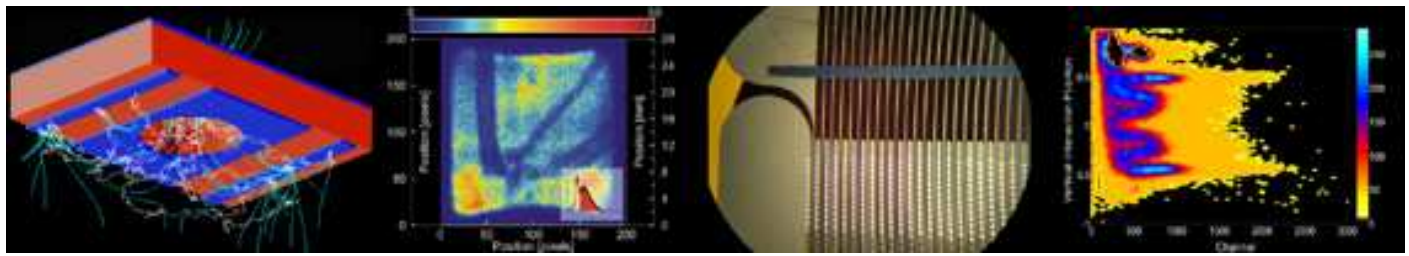


- $\alpha_{\text{ion}} > 0.01 \text{ions cm}^{-1}$ for $E/N > 21$ Td

Current and future work

- The toolkit has been validated for VUV Electroluminecence in pure noble gases.
- Electroluminescence in the NIR region can in principle be simulated.
- Fair agreement between experiment & simulation in Ar for $E/N < 16\,\mathrm{Td}$
- The decay cascade from levels higher than 4p is being studied in order to implement a more realistic model

Thank you!!



DRIM - Radiation Detection & Medical Imaging