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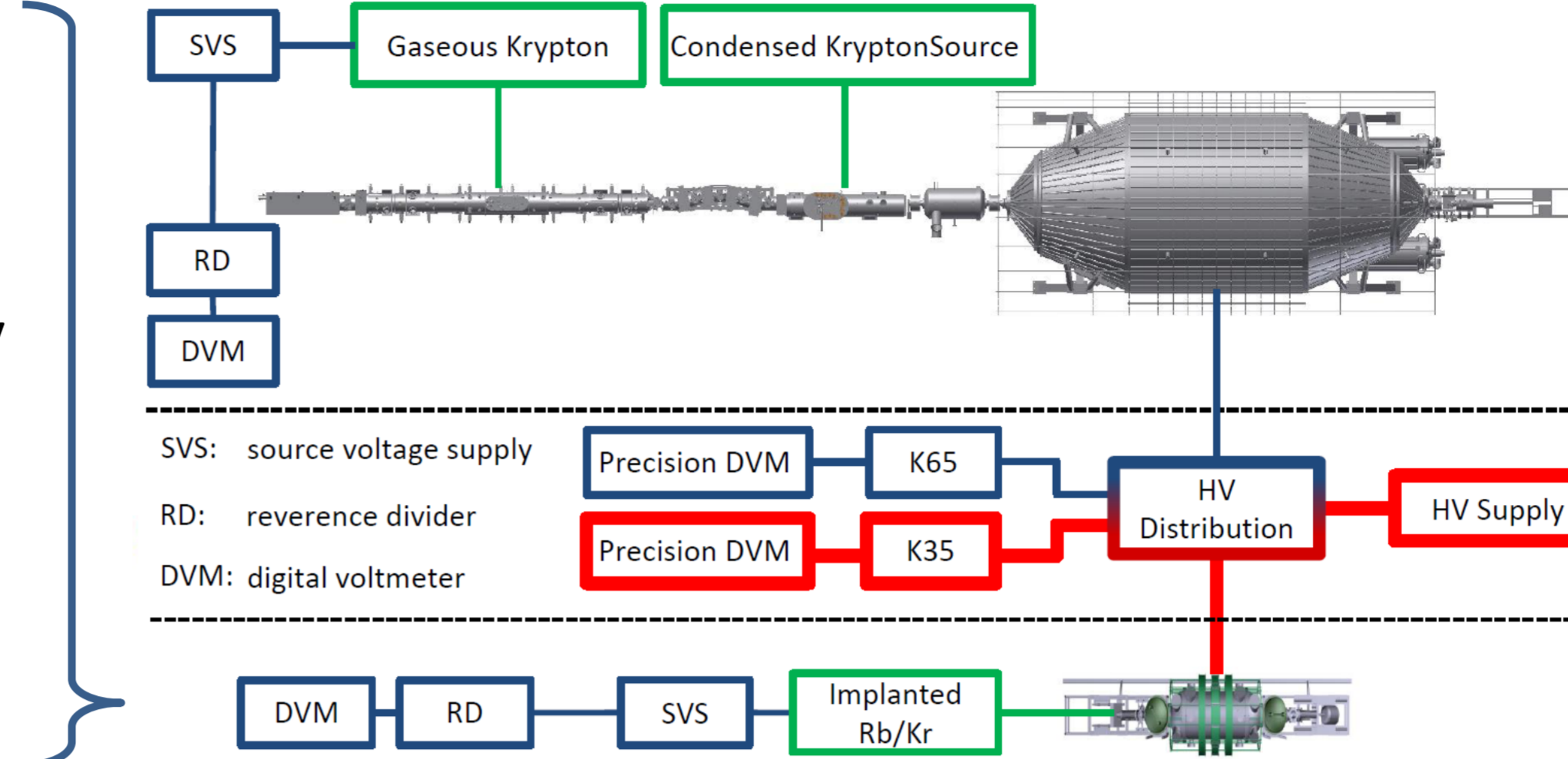
TECHNICAL CHALLENGE

sensitivity of 200 meV/c² (90% CL) on the effective mass of $\bar{\nu}_e$ from tritium β -decay

- high voltage (HV) stability within ≤ 60 mV @ 18.6 kV (3 ppm)
- continuous monitoring for a 2-month run

HIGH VOLTAGE MONITORING CONCEPT

Monitor spectrometer
conversion electrons with constant energy
HV instability
↕
shift of measured energy



Direct HV measurement

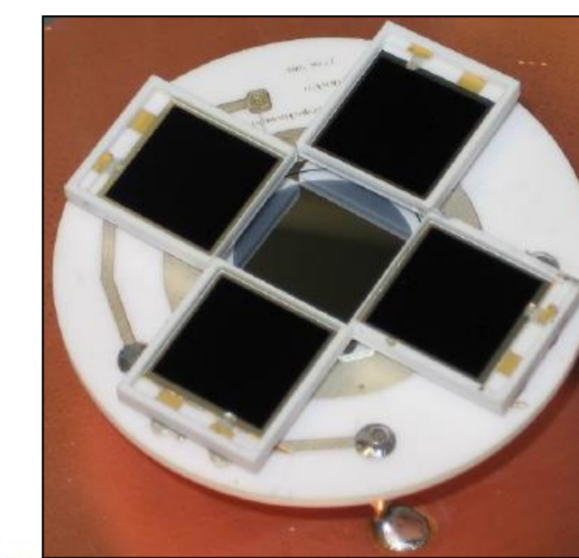
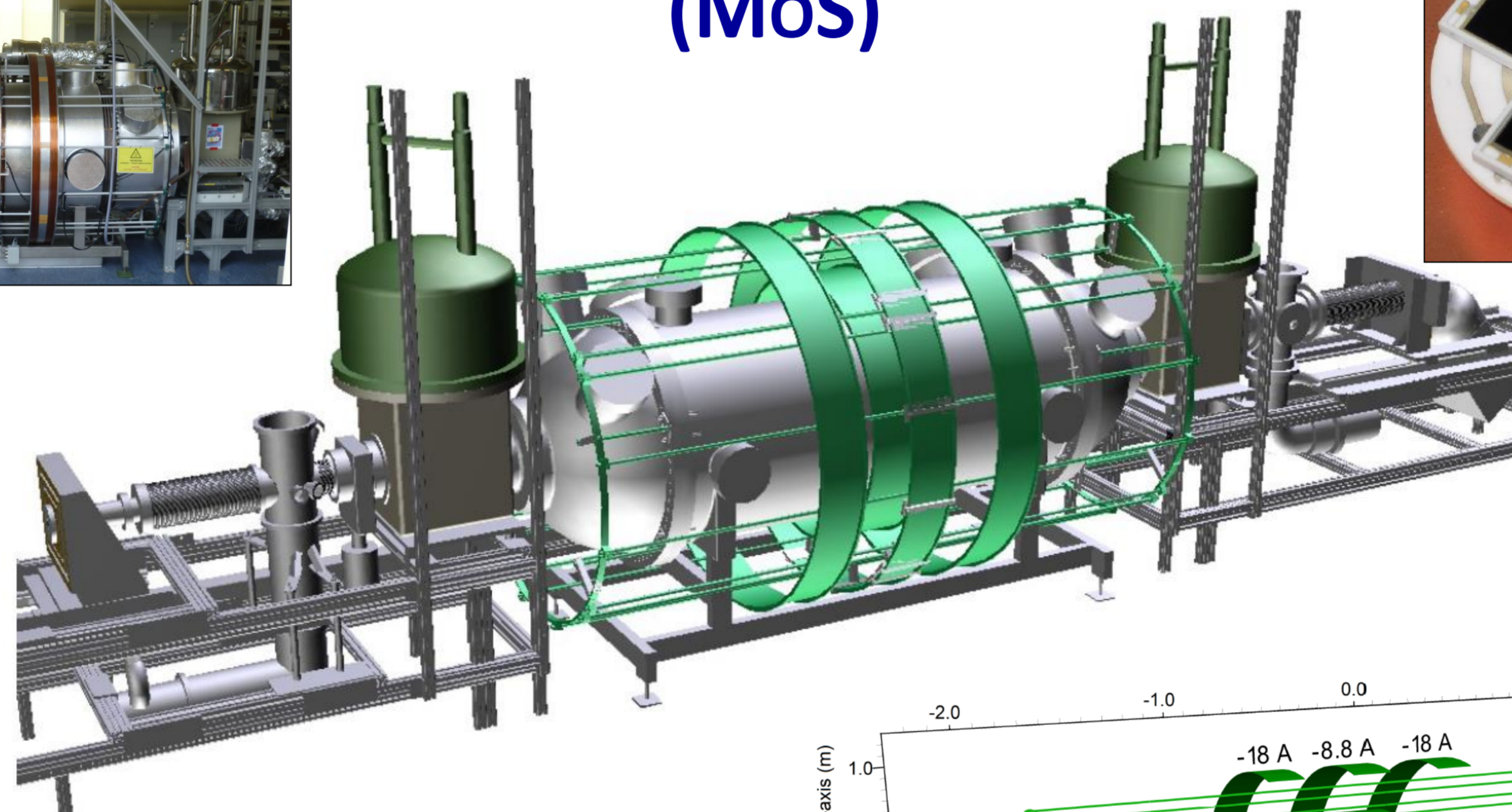
high precision HV-dividers K35 & K65 and precise voltmeters

GENERAL FEATURES

- integrating spectrometer
- high energy resolution **0.93 eV @ 18.6 keV**
- ultra-high vacuum 10⁻¹⁰ mbar
- 3D positioning of source and detector



MONITOR SPECTROMETER (MoS)

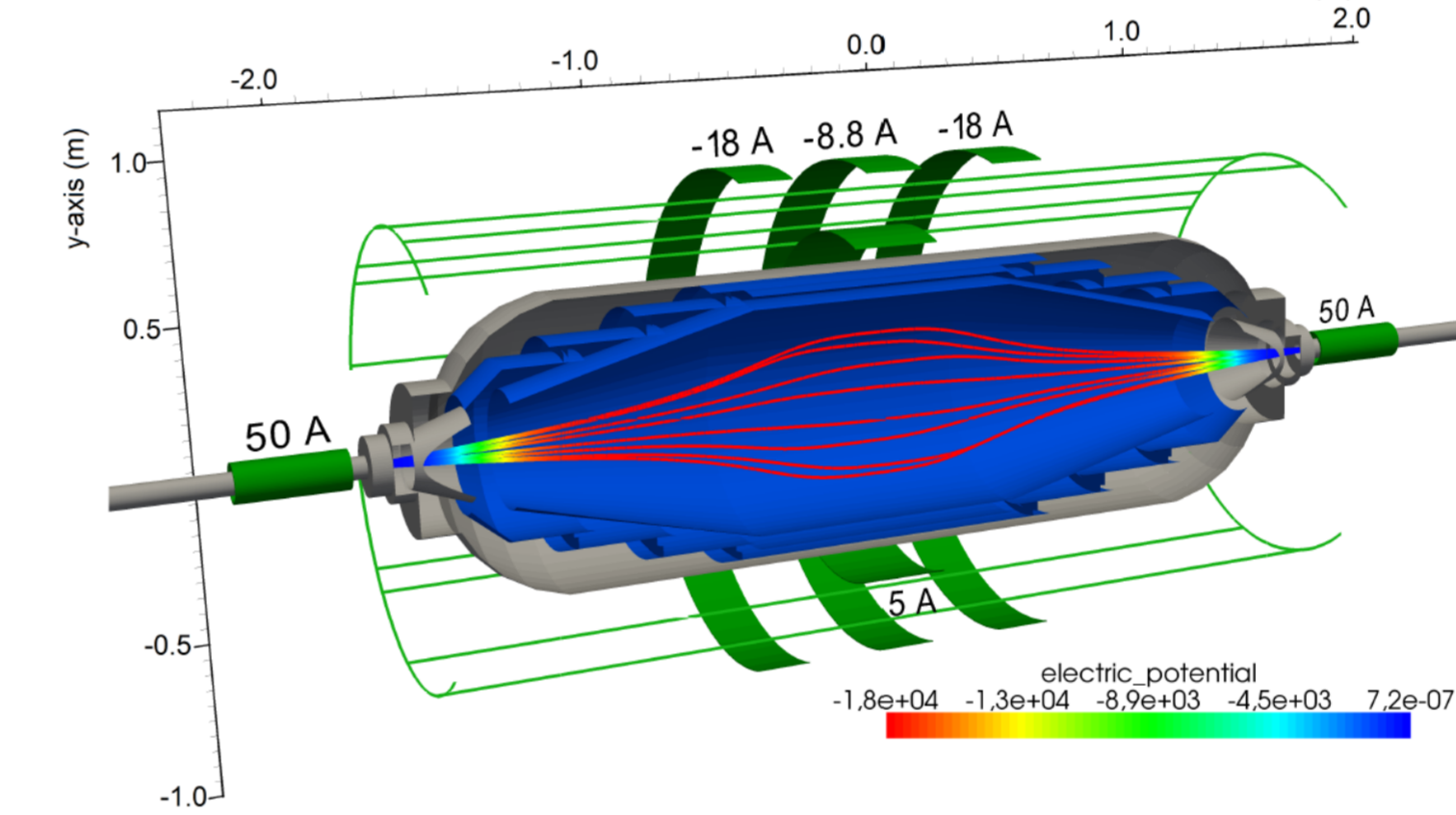
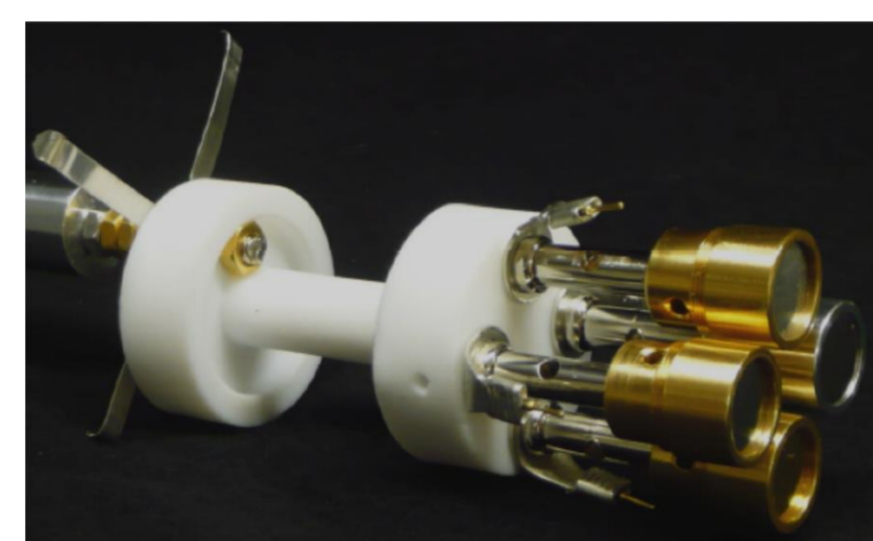
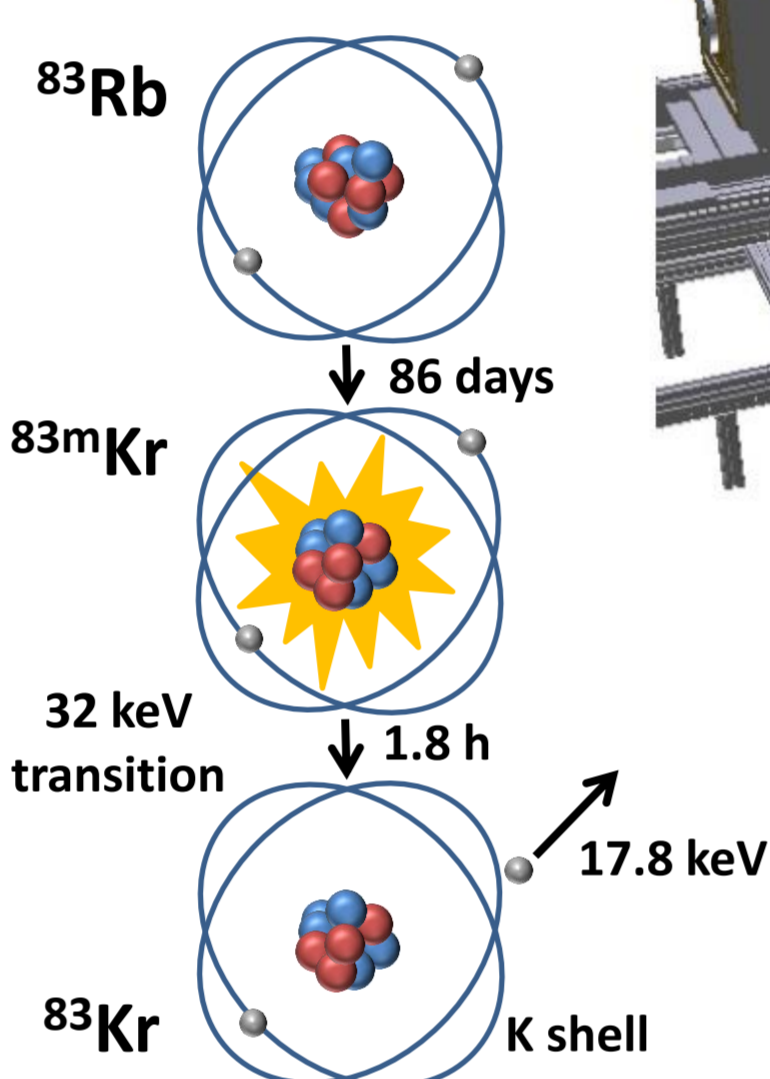


DETECTOR

- central** – circular Si PIN-diode, area 1.5 cm²
➤ for counting electrons
- auxiliary** – PIN-photo diodes
➤ for alignment
- cooled to ≈ -45 °C with LN₂

CONVERSION ELECTRON SOURCE

- K-32 electrons of ^{83m}Kr **800 eV below tritium β -spectrum endpoint**
- ⁸³Rb implanted into solid substrate (Pt, HOPG) @ ≤ 30 keV

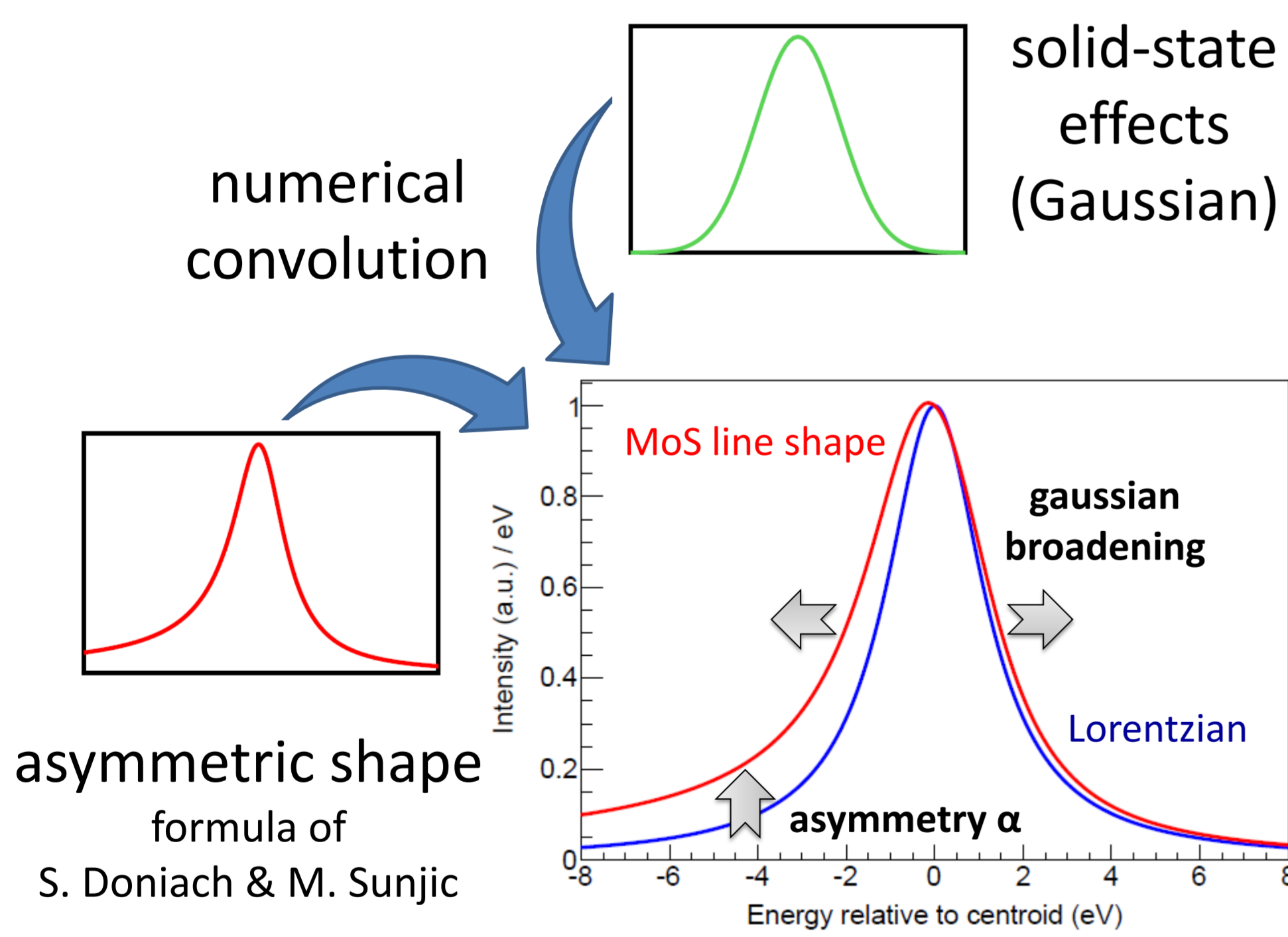


MAC-E FILTER

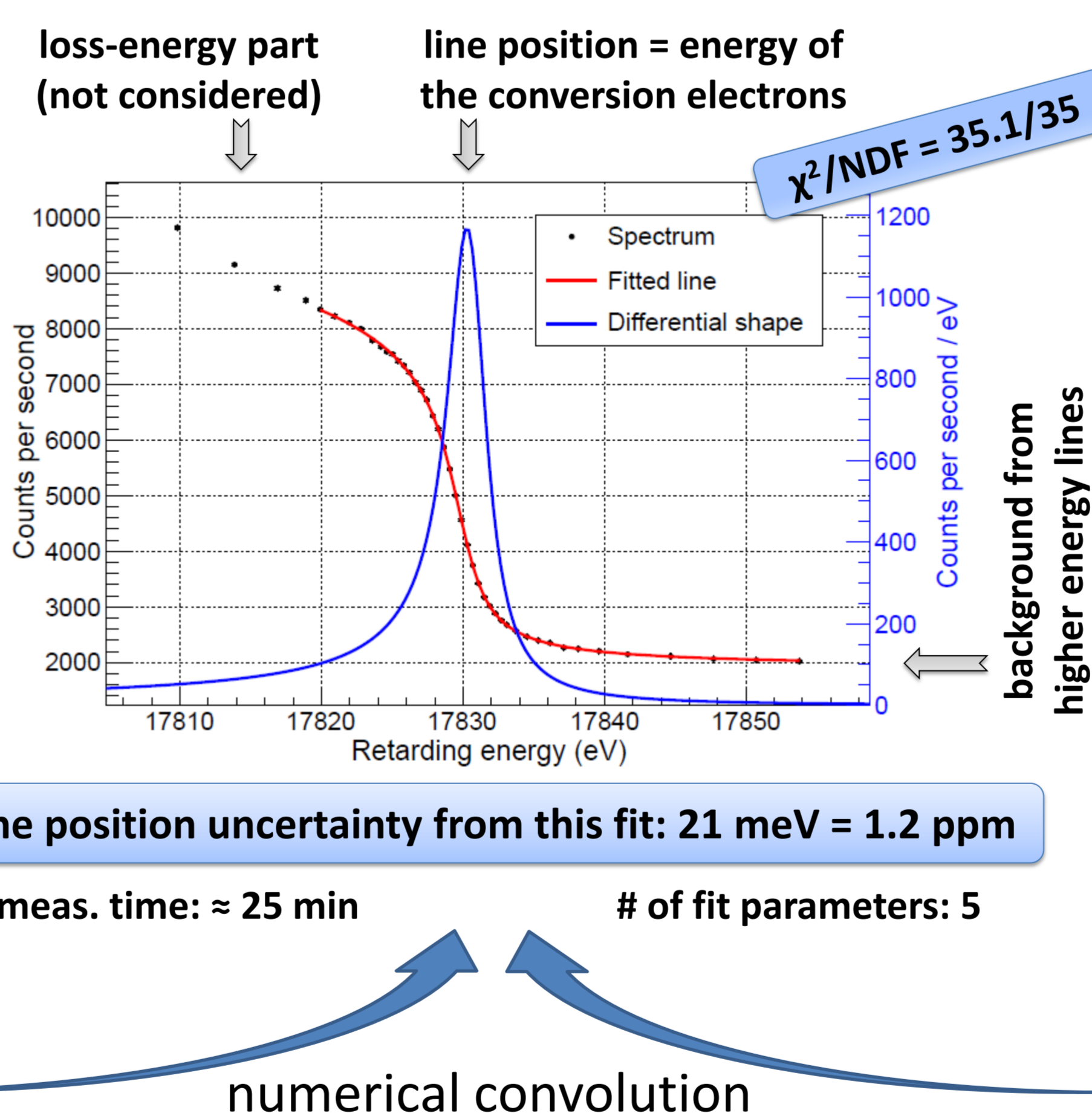
- magnetic adiabatic collimation with electrostatic filter
- electron orbital magnetic moment constant
➤ electron energy analysed in the center (analysing plane)

CONVERSION LINE SHAPE

- naive expectation: symmetrical Lorentzian function
- observed:

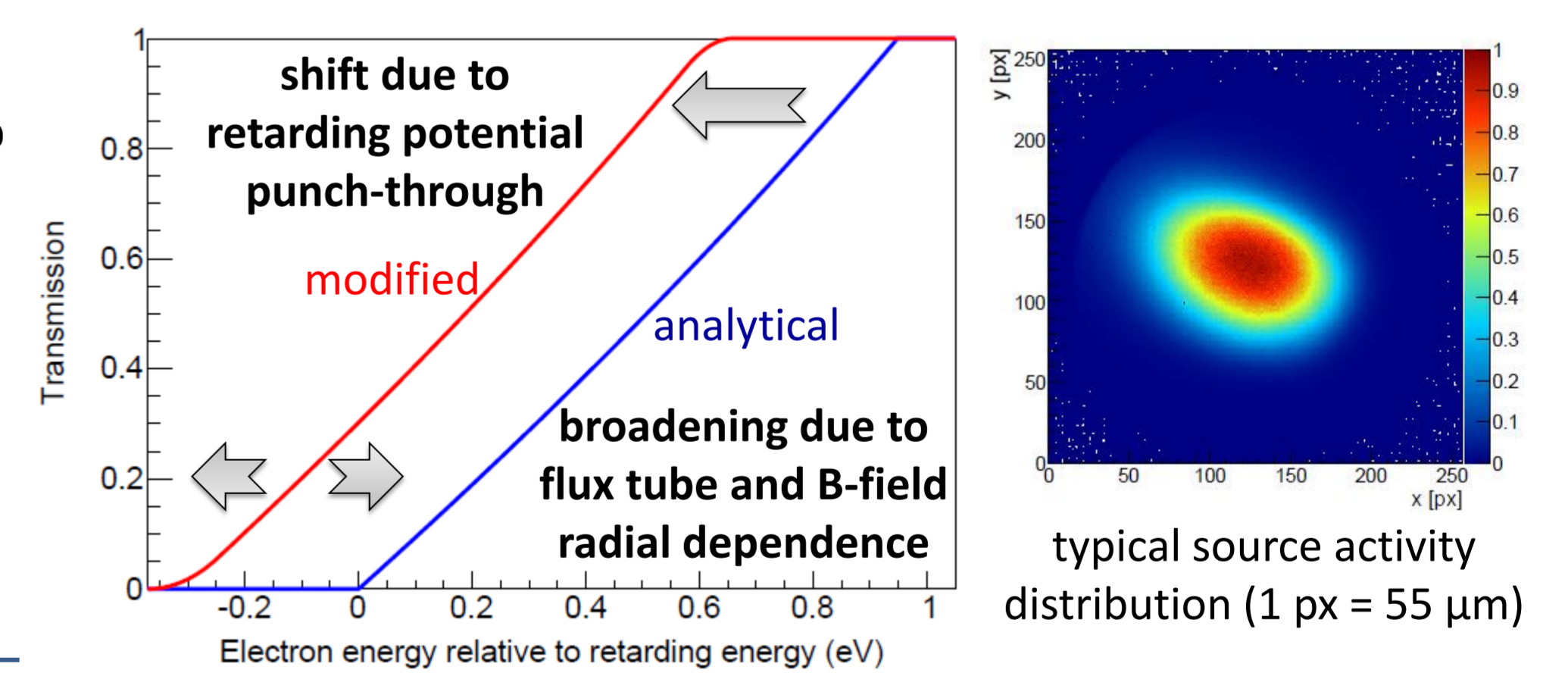


ANALYSIS OF MOS ELECTRON SPECTRUM



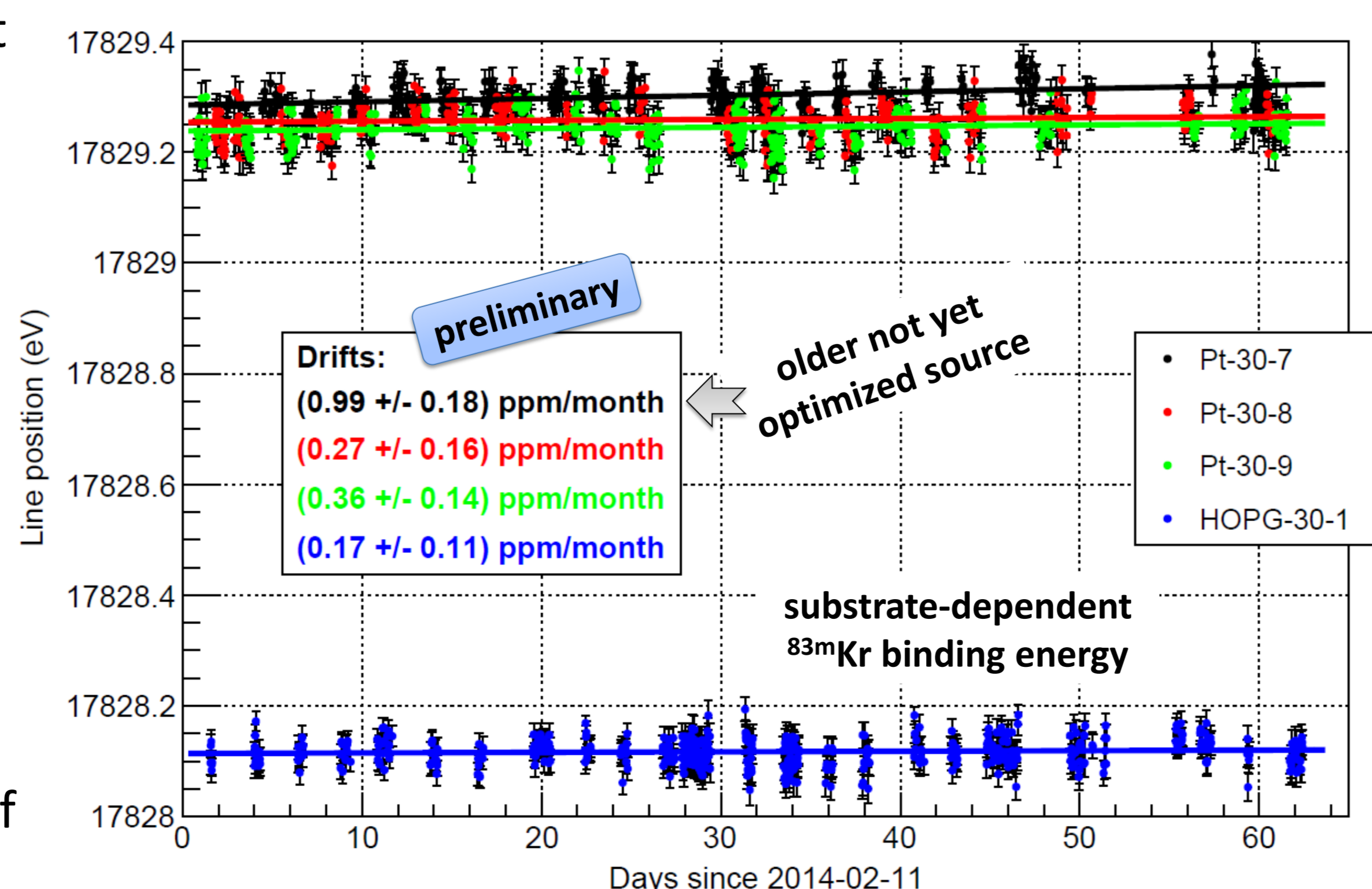
TRANSMISSION FUNCTION

- analytically: ideal MAC-E filter, point-like source
- in reality: source with finite dimensions, inhomogeneous activity distribution
➤ non-trivial electron flux tube over the analyzing plane



EXPERIMENTAL PROOF OF K-32 ENERGY STABILITY

- series of measurements at the standalone MoS
- optimization
 - substrate
 - implantation dose
 - implantation energy
 - beam contamination
- reproducibility
- stability
- latest results: K-32 line position stable at the level of **0.3 ppm/month**



CONCLUSION

The monitor spectrometer will serve as a powerful and independent tool for continuous monitoring of the high voltage stability in the KATRIN experiment.

REFERENCES

- KATRIN collaboration, *KATRIN design report 2004*, Karlsruhe (2005), <http://www.katrin.kit.edu/>.
- M. Erhard et al., *High-voltage monitoring with a solenoid retarding spectrometer at the KATRIN experiment*, accepted in *J. Instrum.* (2014).
- M. Slezák et al., *Electron line shape of the KATRIN monitor spectrometer*, *J. Instrum.* **8**, T12002 (2013).

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