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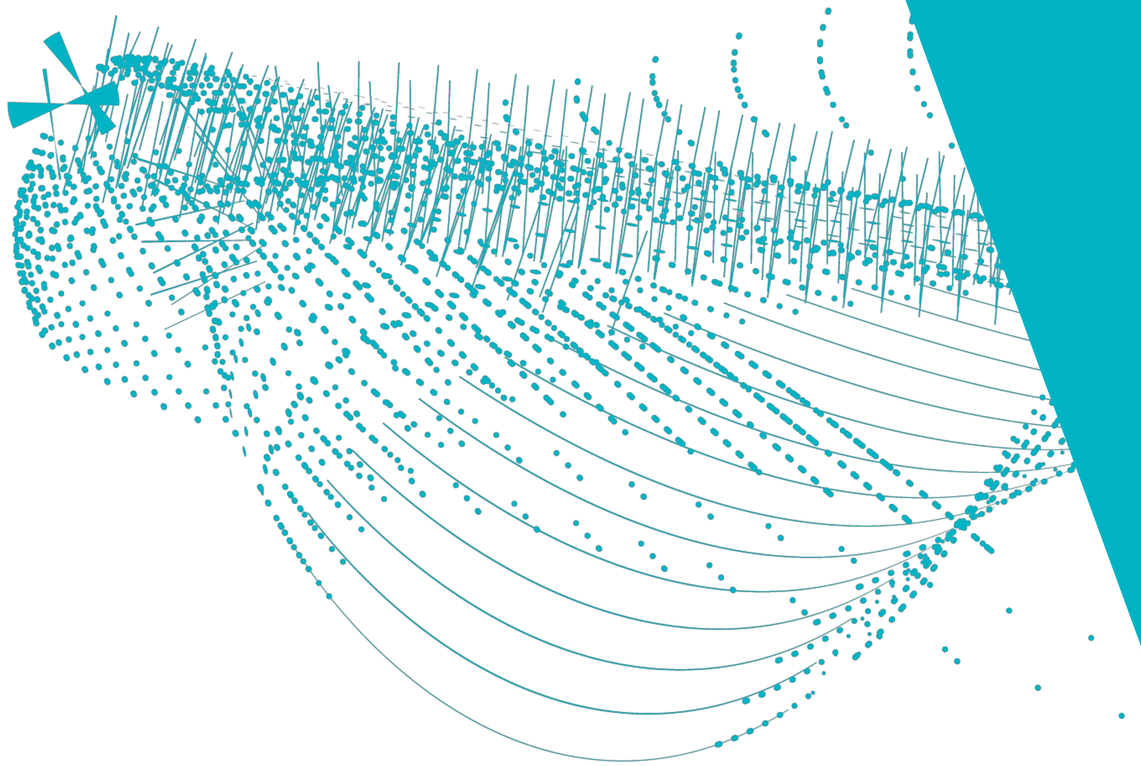
LOW-ENERGY PRECISION MEASUREMENTS



ELECTRON-EDM

Steven Hoekstra

electron-EDM program leader
Van Swinderen Institute for Particle Physics and Gravity
University of Groningen

THE ELECTRON-EDM PROGRAM

Low-energy precision measurements:

- Key contribution of Van Swinderen Institute for Particle Physics and Gravity within Nikhef
- University of Groningen joined Nikhef in 2016

Measuring the electron's electric dipole moment (eEDM):

- NWO funded program 2017-2023
- University of Groningen (RUG), Vrije Universiteit Amsterdam (VU)
- 7 staff, 7 PhD students, 2 postdocs
- Many master (1yr) and bachelor (3mo) students
- Building on existing expertise and infrastructure

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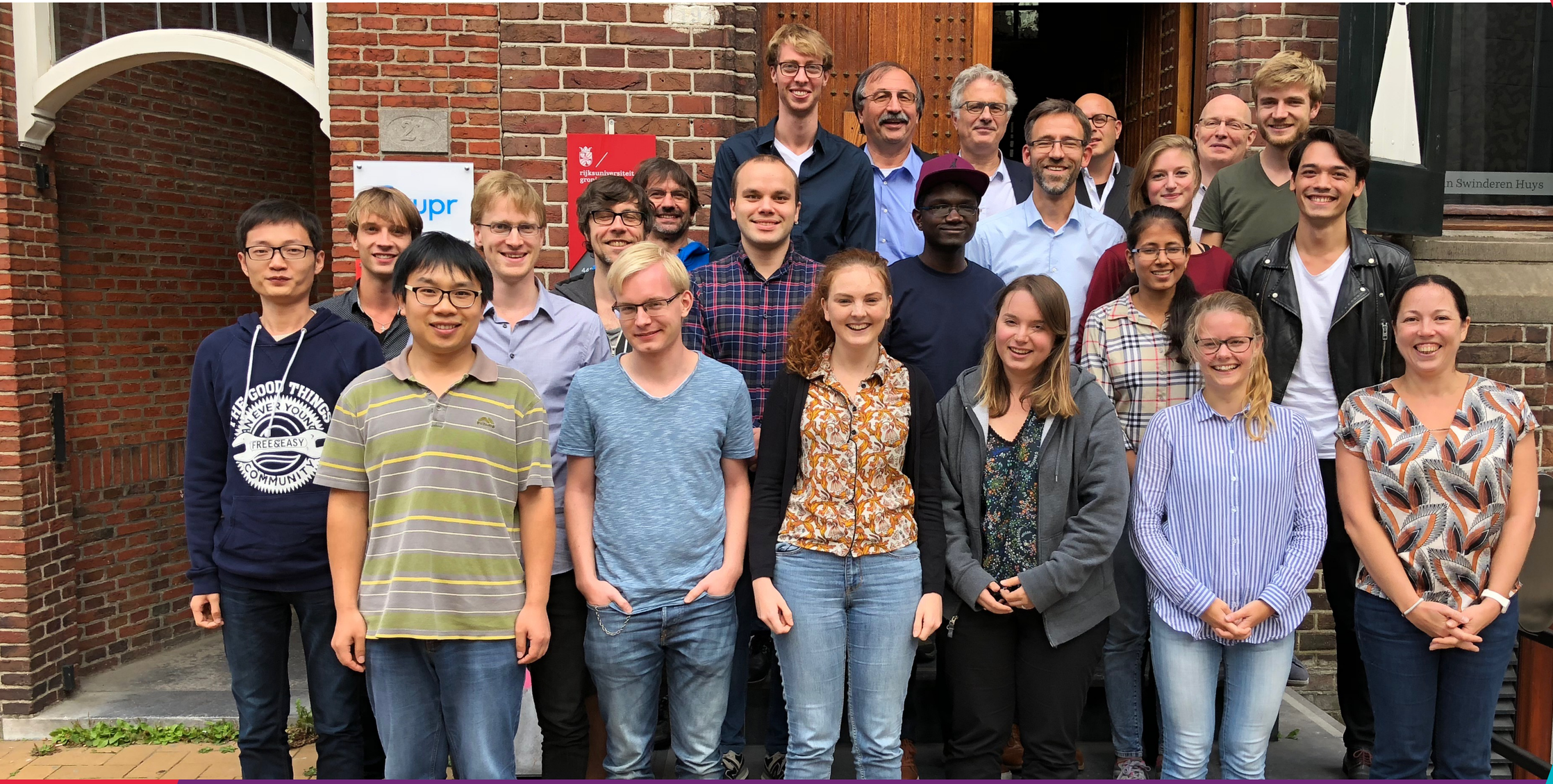
THE TEAM

ANNUAL MEETING SEPT 2018



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THE ELECTRIC DIPOLE MOMENT

Electron-EDM

- EDM arises from T-violating interactions with heavy particles in SM extensions
- A clean probe for new physics
  - EDM heavily suppressed in the Standard Model
- Current EDM sensitivity probes up to 30 TeV
  - Multihiggs, supersymmetry, leptoquarks, …

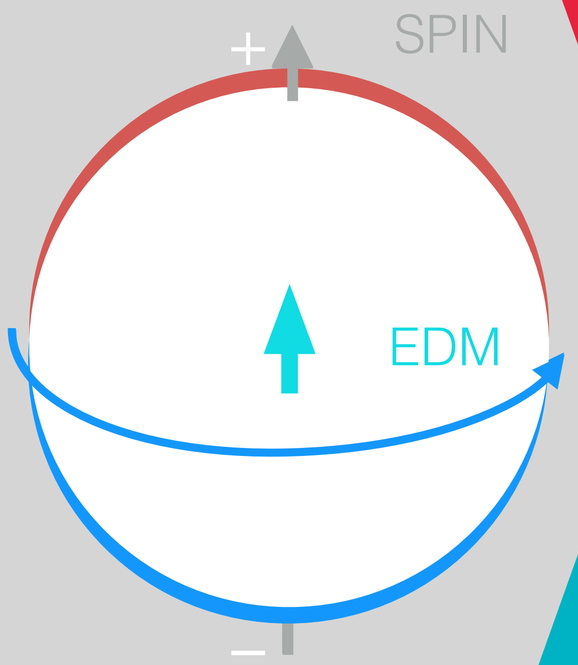
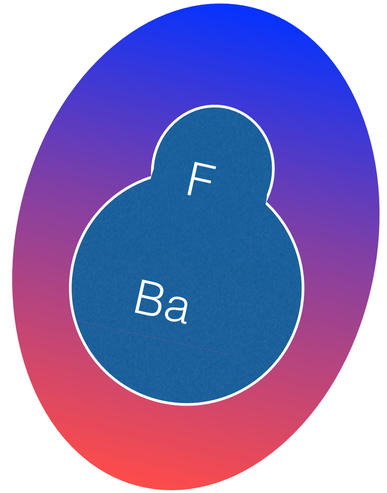


TABLE-TOP PARTICLE PHYSICS

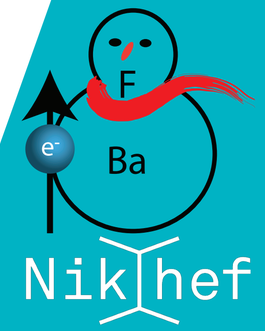
Exploit the extreme precision of atomic and molecular physics

- We can measure mHz shift (10^{-18} eV) of energy levels



Chose sensitive system and optimise techniques

- Use the electron in a heavy polar molecule: BaF
- 10^6 sensitivity enhancement through E-field inside polar molecule
- Exploit long interaction times for increased sensitivity



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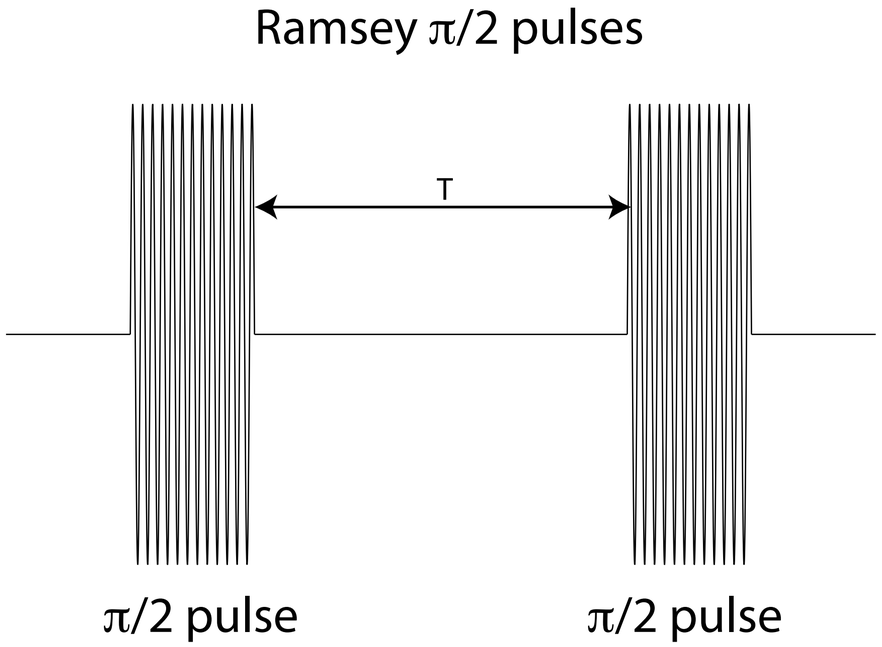
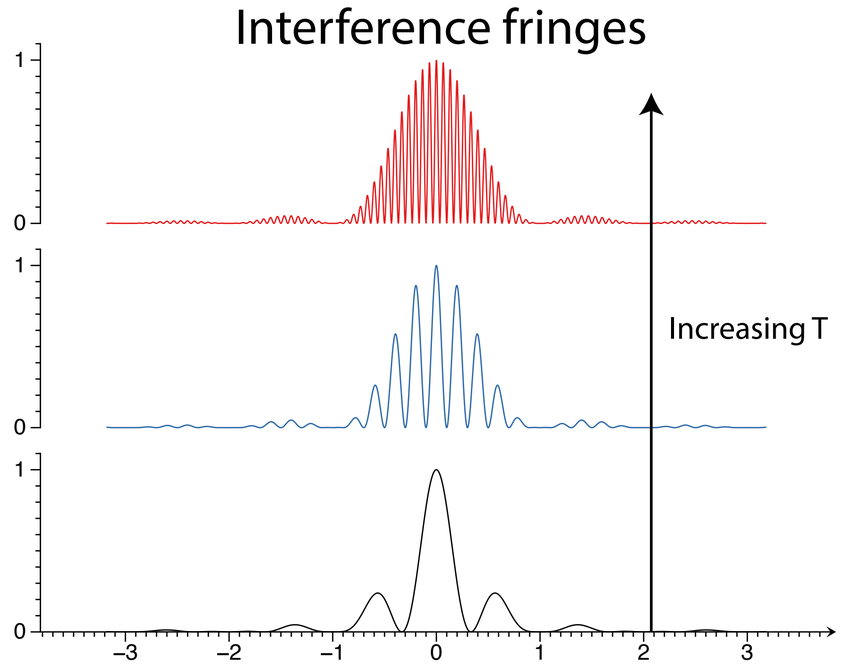
LONG INTERACTION TIME

Principle of measurement: Ramsey interferometer

- Create superposition state, accumulate phase difference, readout
- Sensitivity to small energy shift scales with coherent interaction time
- Therefore, use slow (30 m/s) and cold (100 μK) beam of molecules

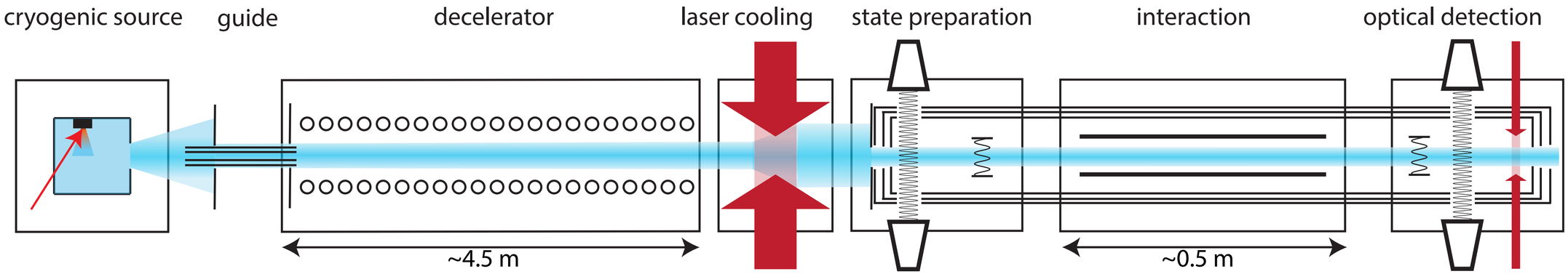




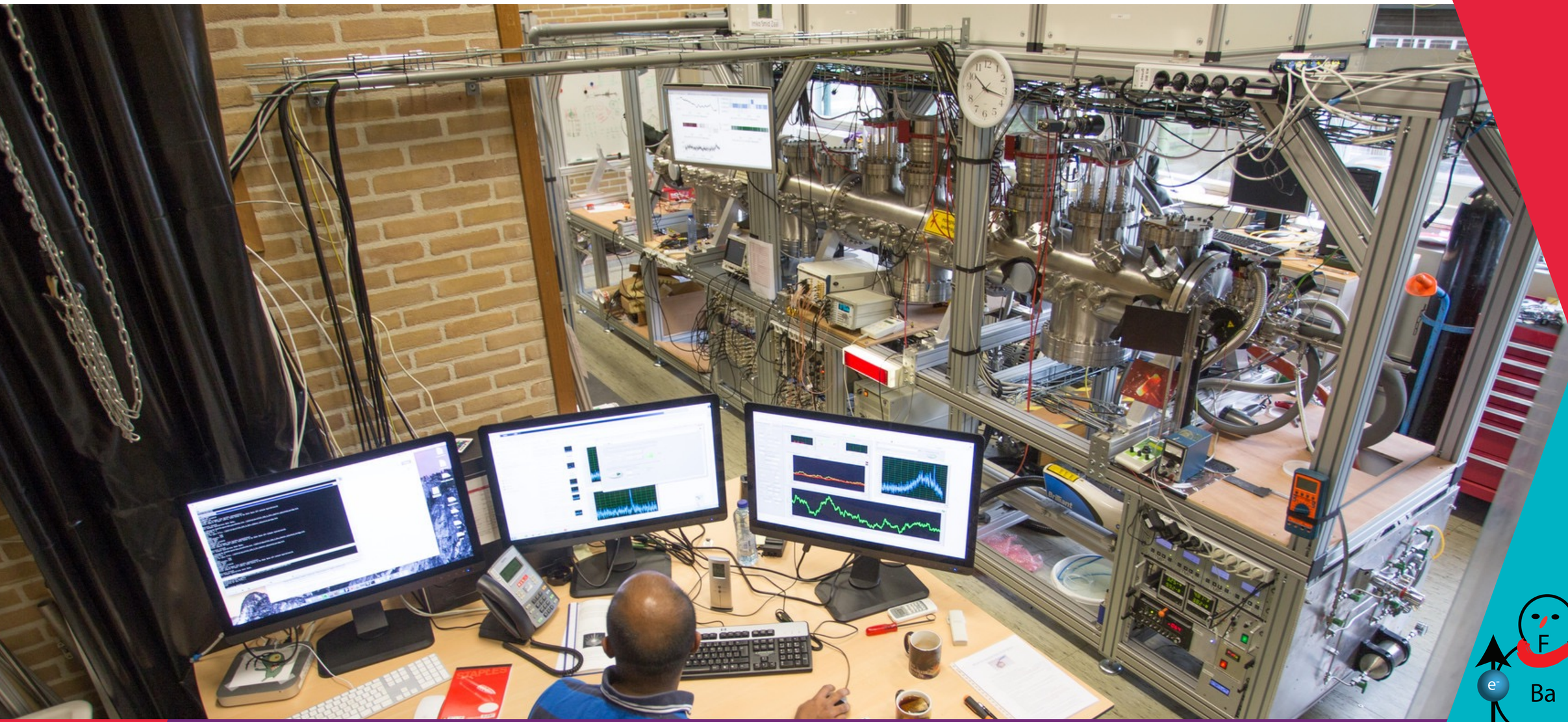
OUR APPROACH

Combine state-of-the-art techniques from AMO physics:

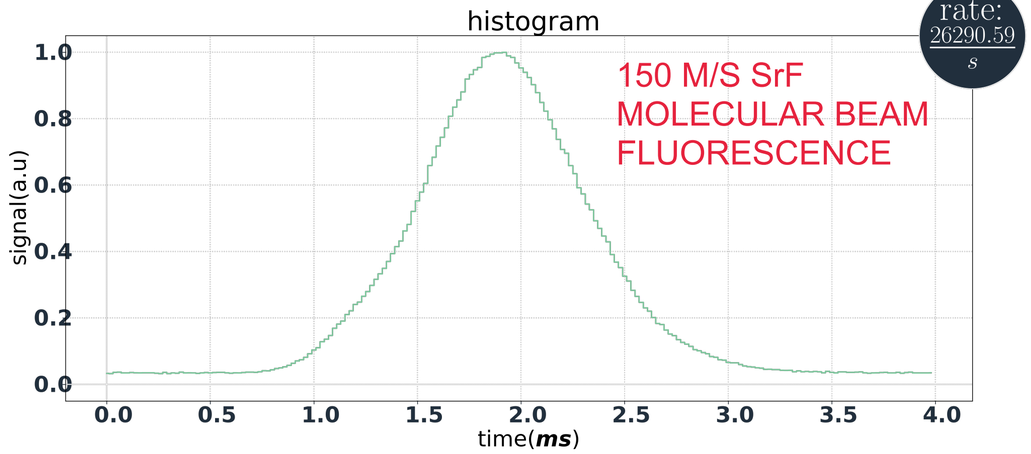
- Cryogenic buffergas molecular beam source
- Stark deceleration
- Molecular laser cooling
- Magnetic field shielding



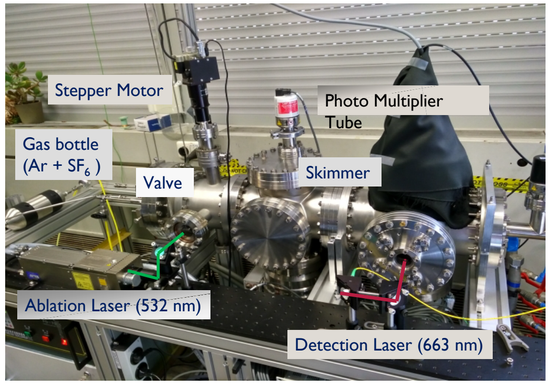
MOLECULE DECELERATOR

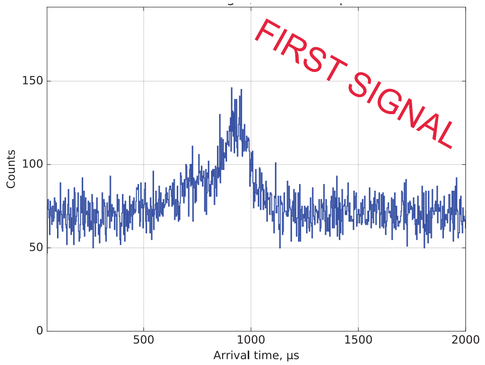


CURRENT STATUS

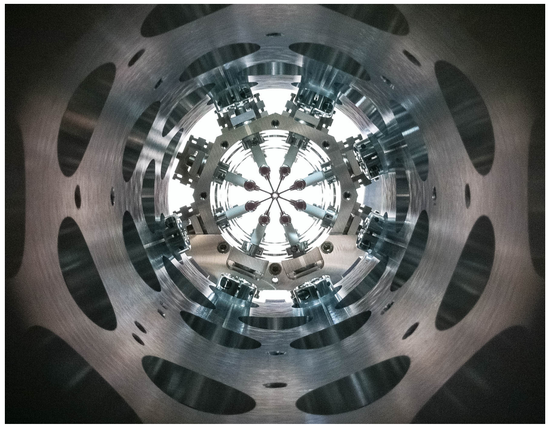


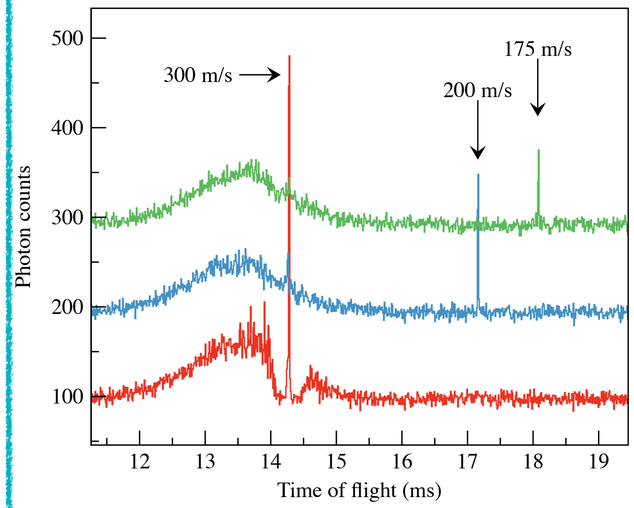
CRYOGENIC MOLECULAR BEAM SOURCE OPERATIONAL





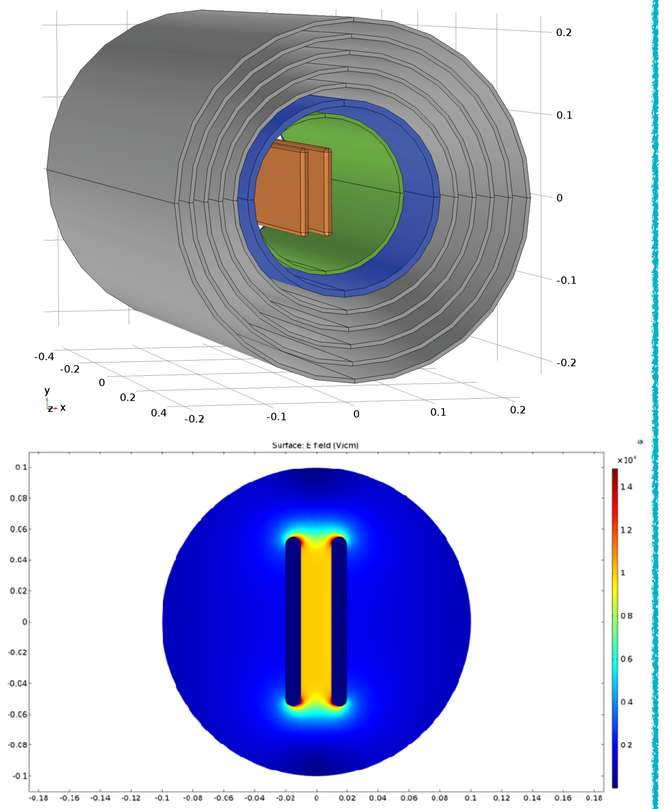
BaF BEAM AND LASERS OPERATIONAL



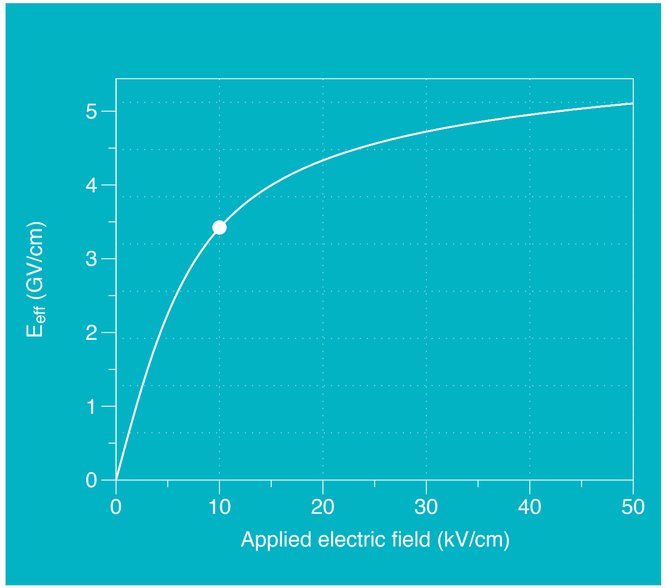


MOLECULE DECELERATOR OPERATIONAL

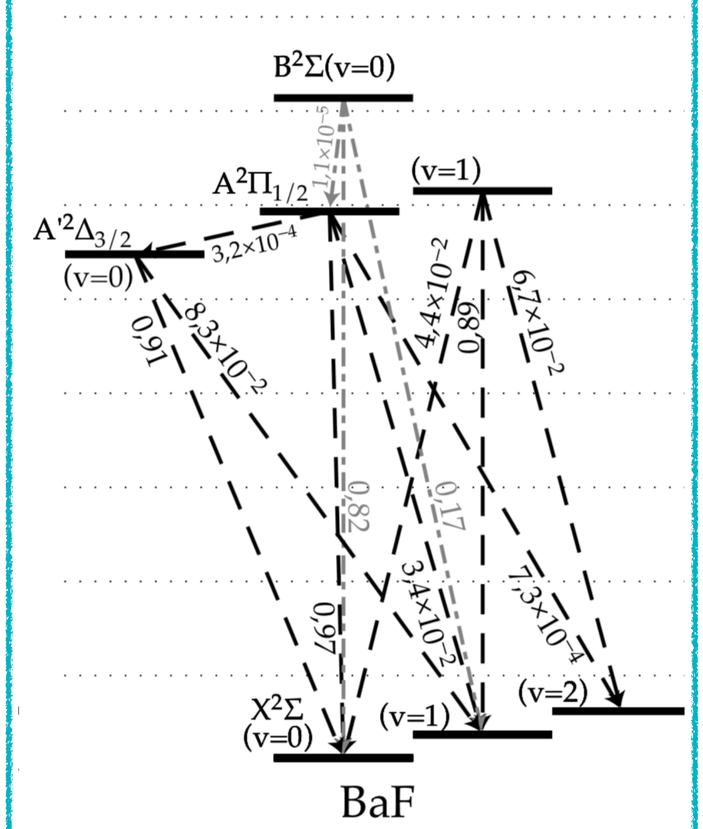
CURRENT STATUS



MAGNETIC SHIELDING DESIGN COMPLETED



EFFECTIVE ELECTRIC FIELD CALCULATED



BAF MOLECULAR STRUCTURE INVESTIGATED

CONCLUSION

Low-energy precision measurements

- Searching for new physics through a measurement of the electron-EDM with cold molecules

- Table-top particle physics with a potential for high impact

- Research program on track, first publications coming out

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