Polarized Atomic Physics Program at GSI/FAIR

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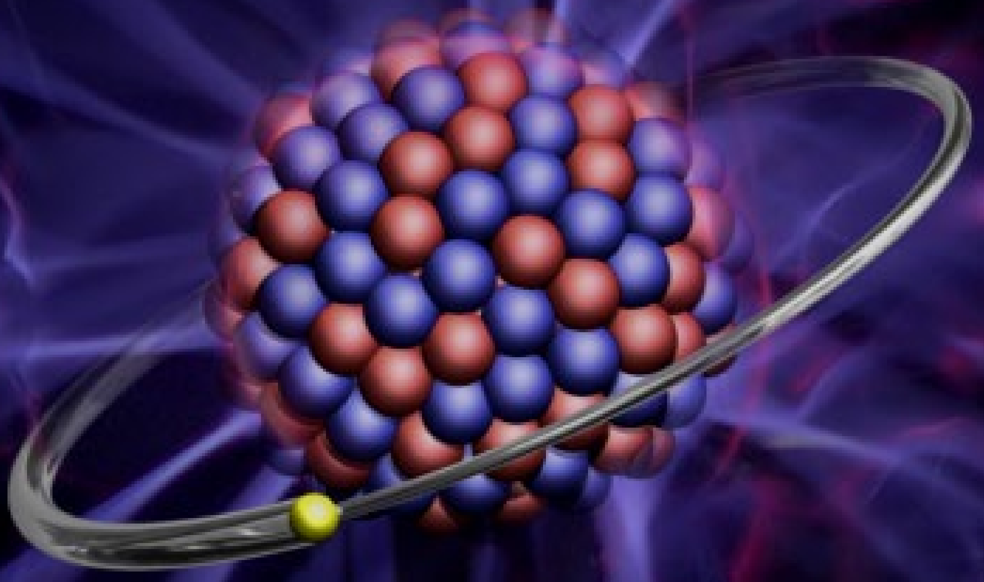
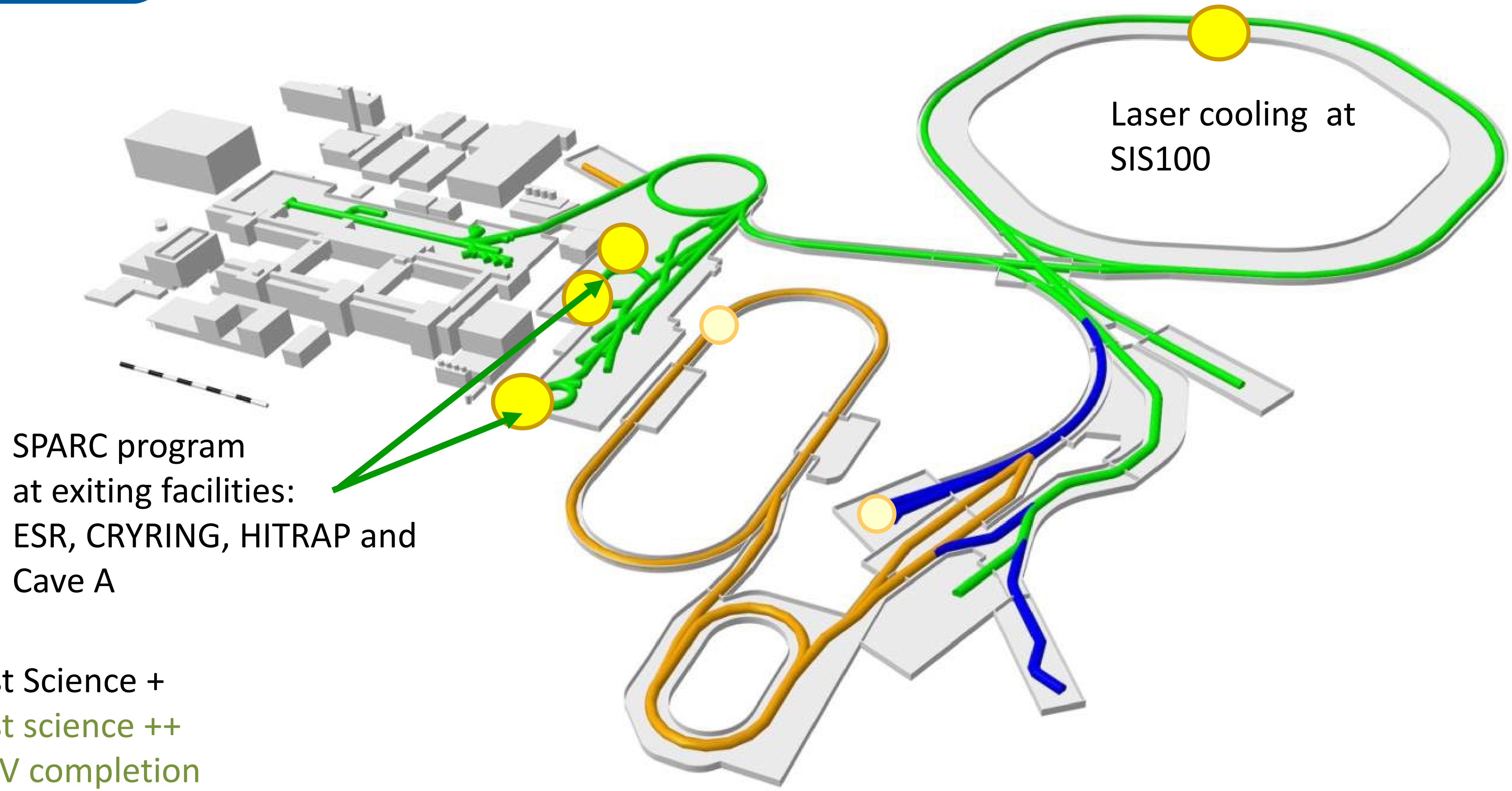
Electromagnetic Fields

- QED at the Schwinger-Limit
- Correlated multi-body dynamics
- Astrophysical phenomena involving exotic ions/nuclei
- Borderline between atomic and nuclear physics
- Fundamentals



FAIR: Civil Construction

SPARC at GSI/FAIR



First Science +

First science ++

MSV completion

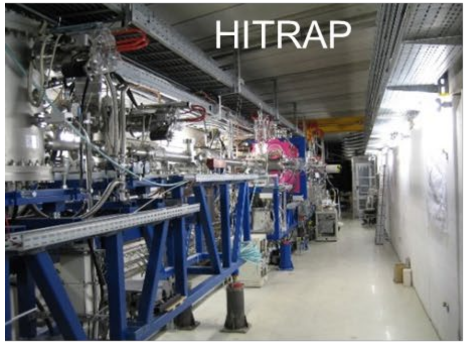
SPARC@FAIR FS

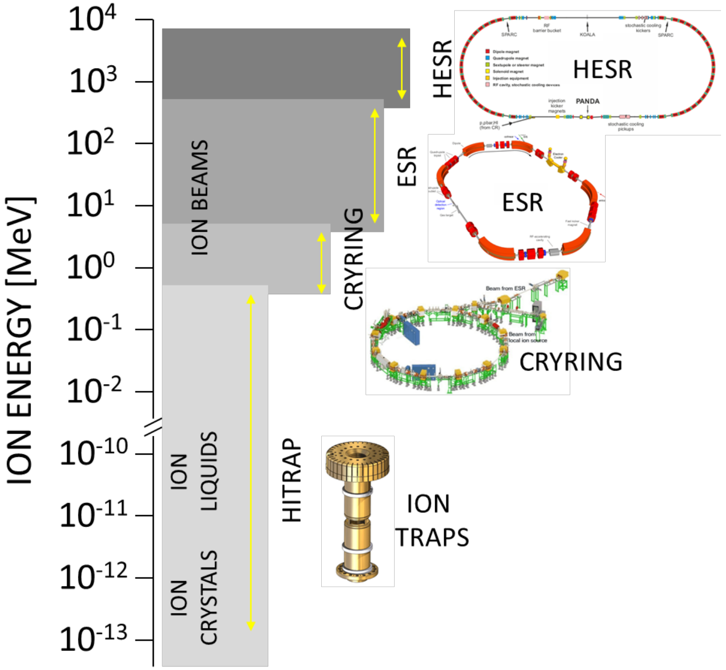
Precision Domain of FAIR: Trapping & Storage of HCI
Atomic, Quantum, and Fundamental Physics

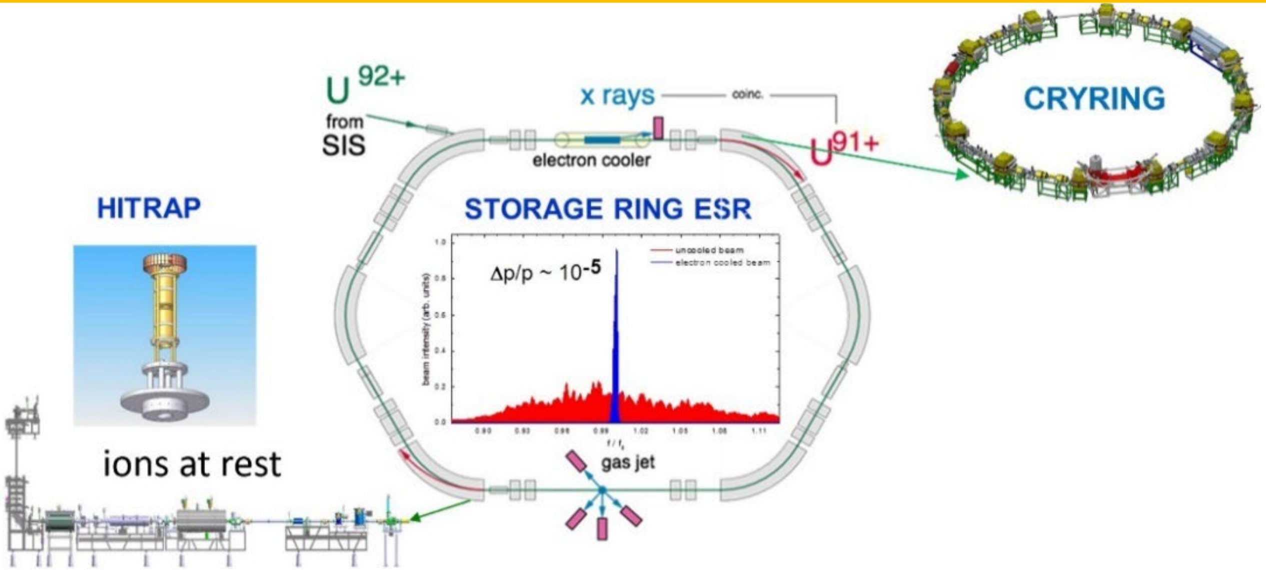
HITRAP, CRYRING@ESR, ESR: Existing Facilities of FAIR

FAIR Phase 0 Research Program

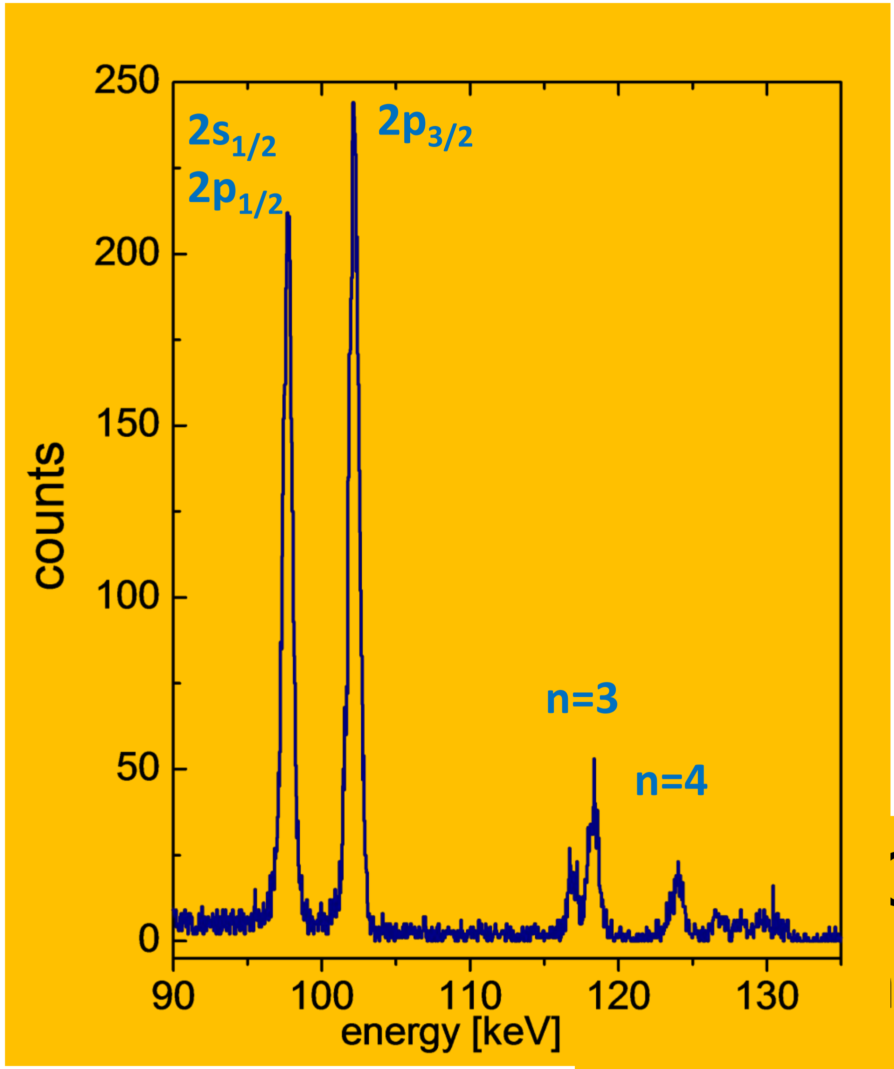
From rest to relativistic energies (up to 4.9 GeV/u)

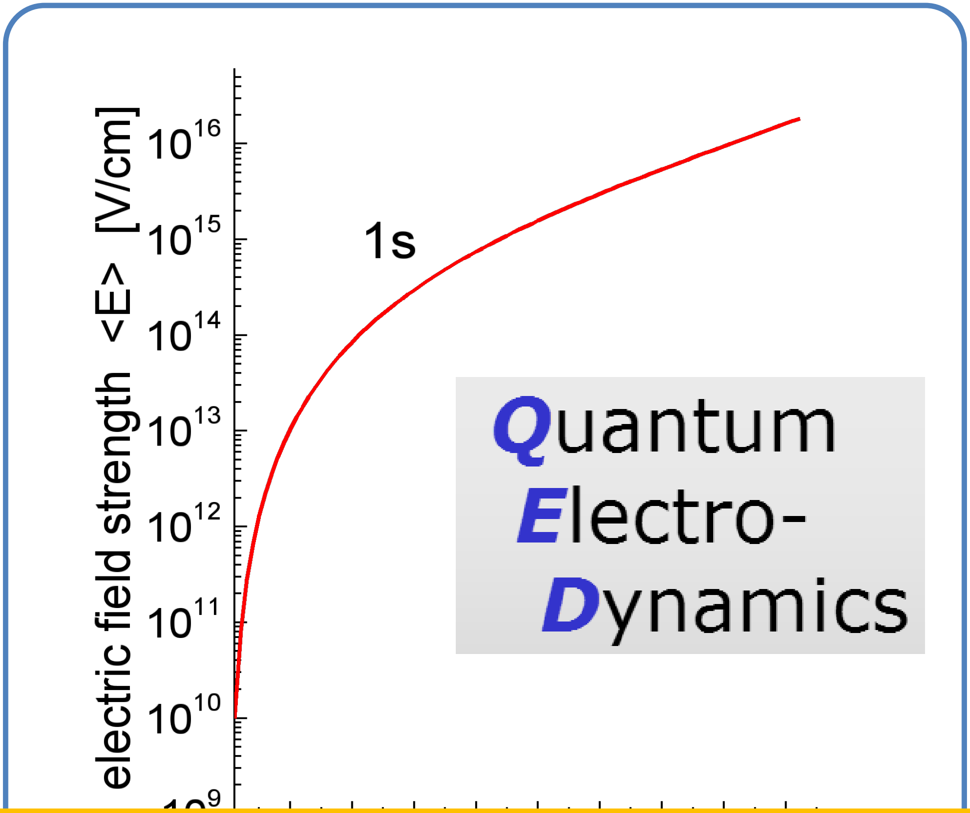






Structural properties of heavy ions





$\alpha Z \approx 1$

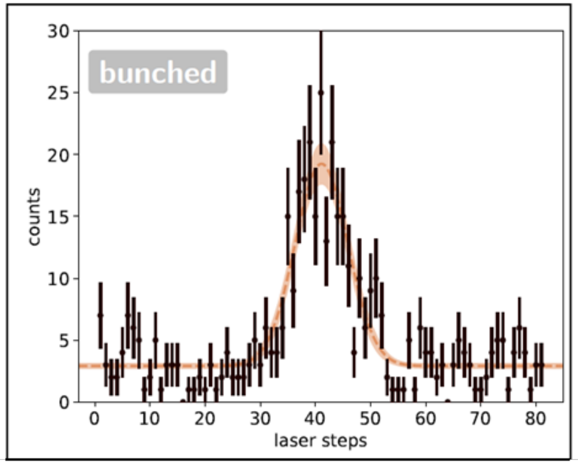
QED, the most precise theory
the non-perturbative regime
- not well-known up to now!

Laser Excitation of an Accelerator-Produced Isotope at the ESR

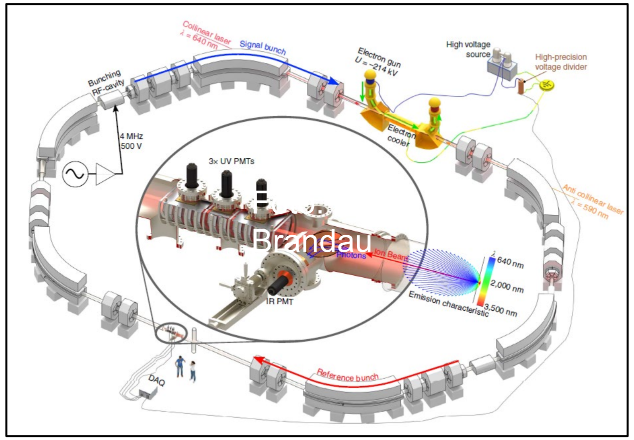
In ring laser experiments: a test of strong-field QED with 10^5 ions

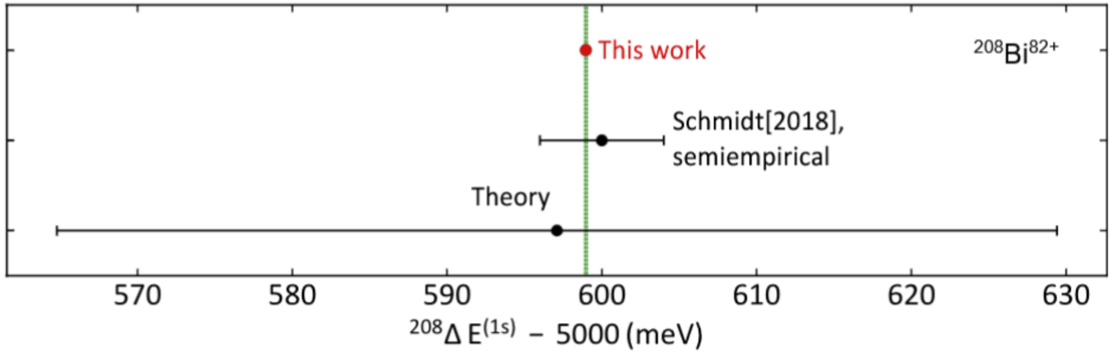
$^{208}Bi^{82+}$ (Z=83)

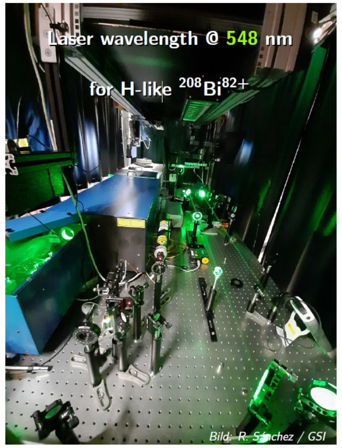
Due to high relativistic velocity ($\beta \approx 0.7$), substantial Doppler blue shift of laser light (factor $\approx$ 2.5). No VUV laser required.



Total accumulation time: 30 min



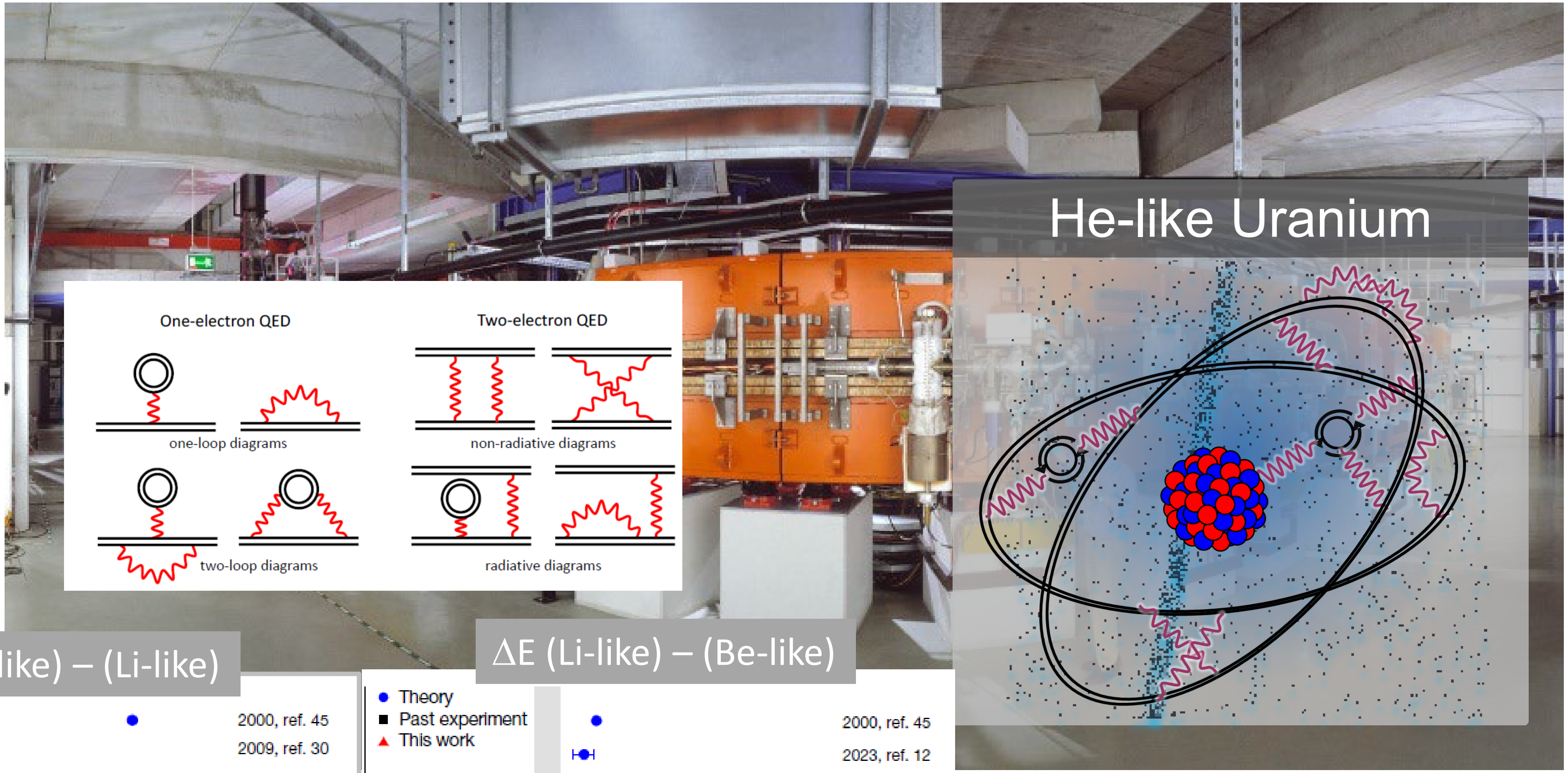




M. Horst et al., Nature Physics **21**, 1057 (2025)

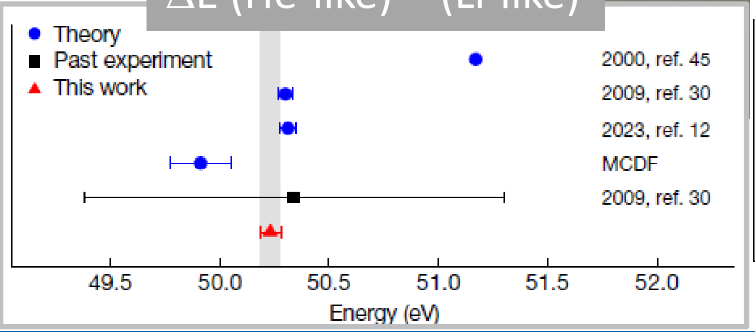
Testing quantum electrodynamics in extreme fields using helium-like uranium

Intrashell transition in He-like uranium

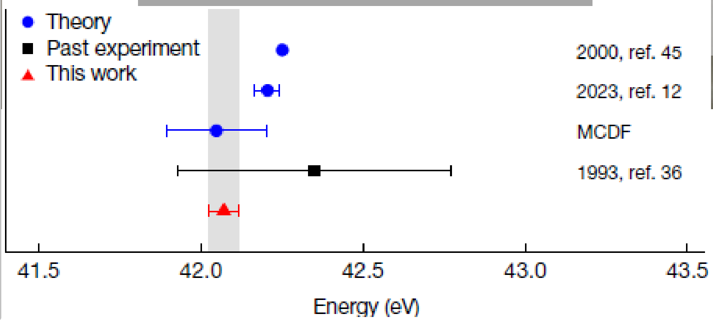


$\alpha Z \approx 1$

ΔE (He-like) – (Li-like)



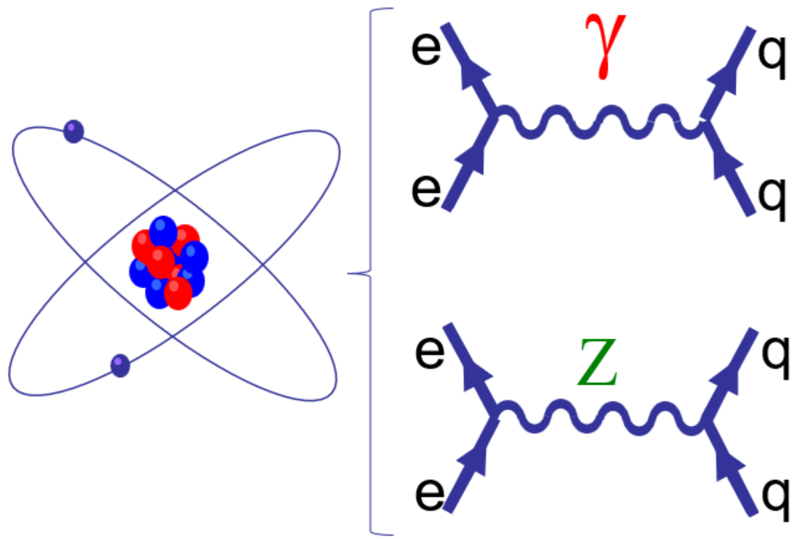
ΔE (Li-like) – (Be-like)

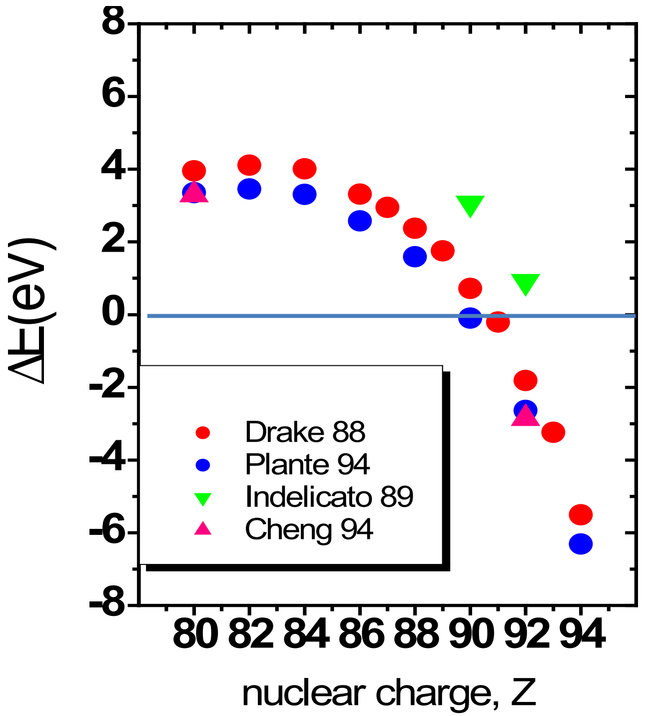


nature

R. Loetzsch et al., Nature 625, 673 (2024)

Parity violation in He-like uranium





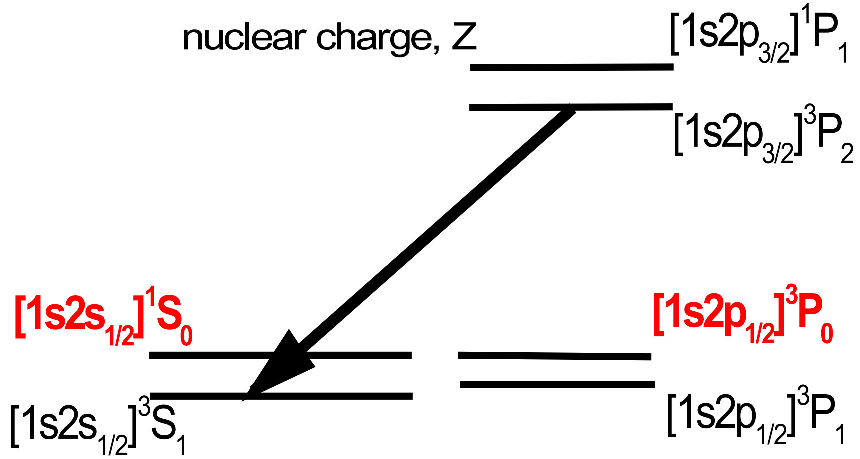
ΔE is very small at *Z*=92

$$\tilde{\Psi}_S = \Psi_S + \eta \Psi_P$$
$$\tilde{\Psi}_P = \Psi_P + \eta \Psi_S$$

- Mixing coefficient for the states with opposite parities:

$$\eta = \frac{\left\langle \Psi_S \left| G_F / 2\sqrt{2} \left(1 - 4\sin^2\theta_w - N/Z\right) \rho_{el}\, \gamma_5 \right| \Psi_P \right\rangle}{E_S - E_P}$$

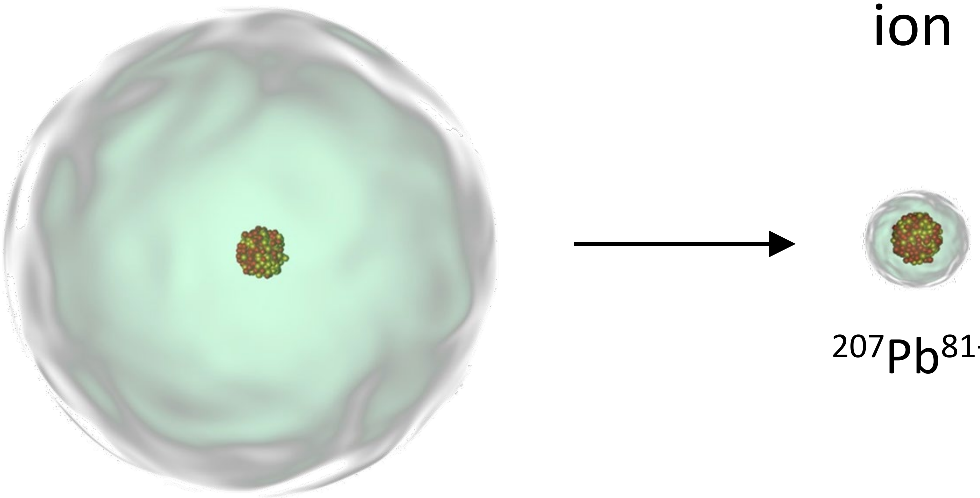
Energy splitting should be small!



Highly charged ions as probes for new physics

Neutral atom

Hydrogen-like ion



$^{207}Pb^{81+}$

- **Simple** ⇒ atomic properties accurately predicted
- High charge ⇒ **extreme electromagnetic fields**
  - **High sensitivity** to fundamental and unkown physics
  - **Robust** against external perturbations

Gross structure	Z^2
Fine structure	Z^4
Hyperfine structure	Z^3
QED Lamb shift	Z^4
Bohr radius	Z^{-1}

2^{nd}-order Stark shift	Z^{-4}
Black-body radiation shift	negligible
Electric-quadrupole shift	Z^{-2}
1^{st}-order Zeeman shift	Z^0
2^{nd}-order Zeeman shift	suppressed
Motional shifts	Z^0
Collisional shift	negligible

Z ... Proton number

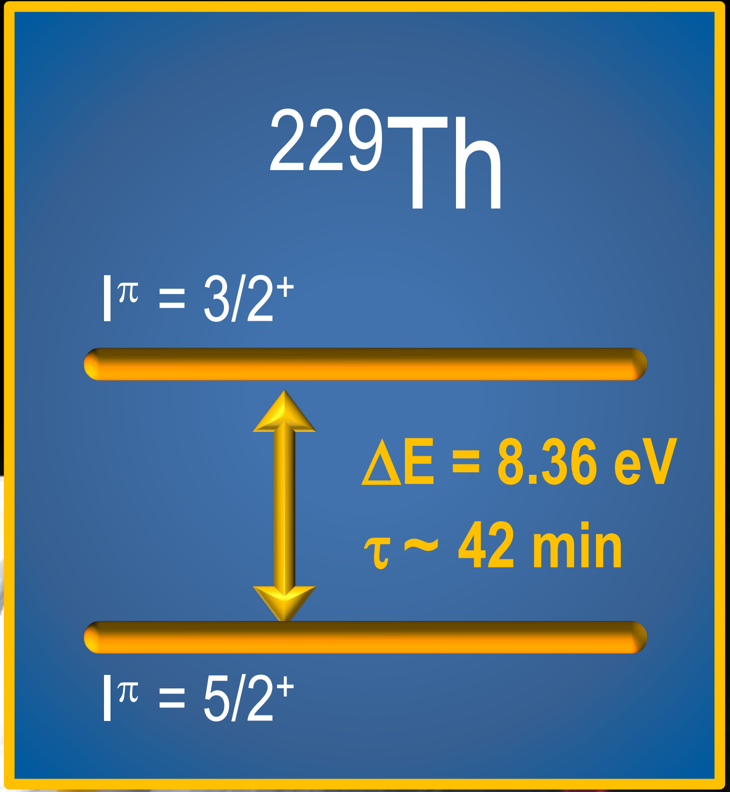
Kozlov et al., Rev. Mod. Phy. **90** (2018)

^{229}Th: A Unique Candidate for a Nuclear Optical Frequency Standard

The only known nucleus accessible with present lasers!

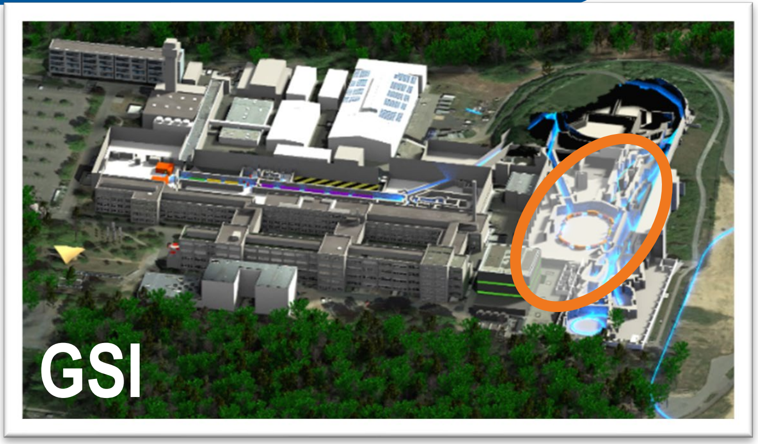
^{229}Th-clock idea: E. Peik and Chr. Tamm, EPL **61**, 181 (2003)

- **^{229}Th clock**
  - Frequency metrology to 19 digits
  - One order of magnitude better than best atomic clocks
- **Nuclear clocks:** Robust against external perturbations
- **Broad range of applications**
- **Nuclear clocks are ideal for the search of physics beyond the standard model**

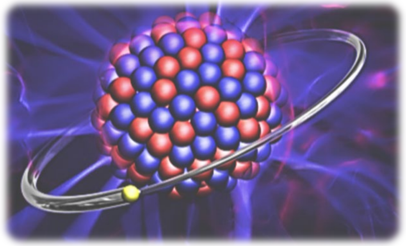


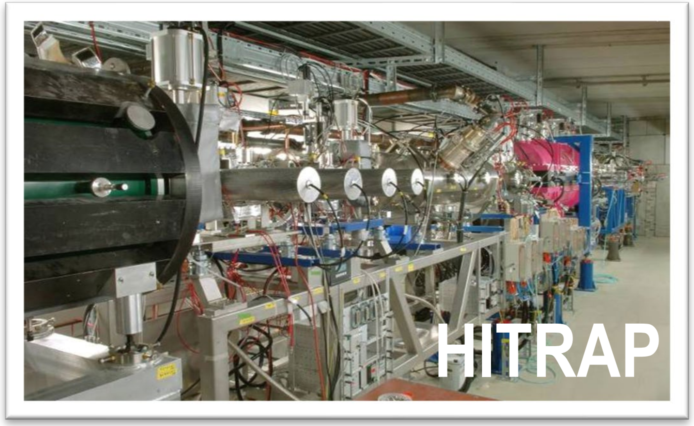
HiThor: Can Only be Realized at GSI – One-Electron $^{229}Th^{89+}$

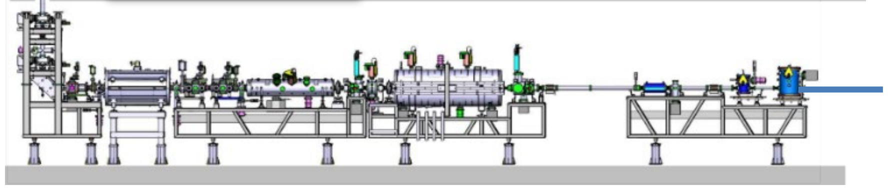
Ion storage ring and traps at GSI

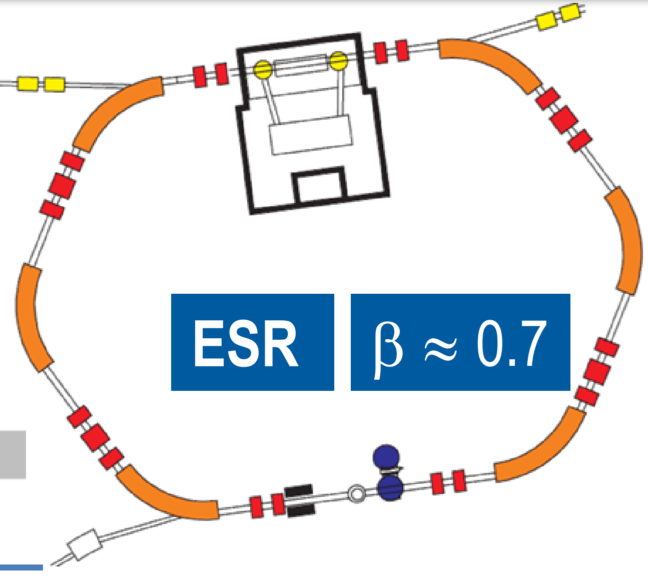


$^{229}Th^{89+}$





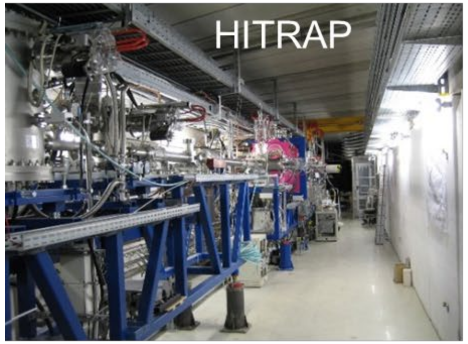


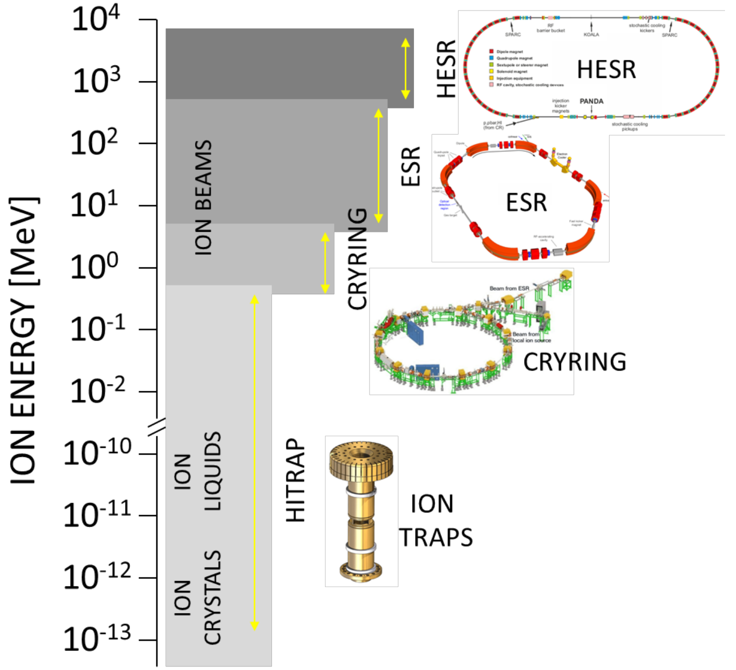


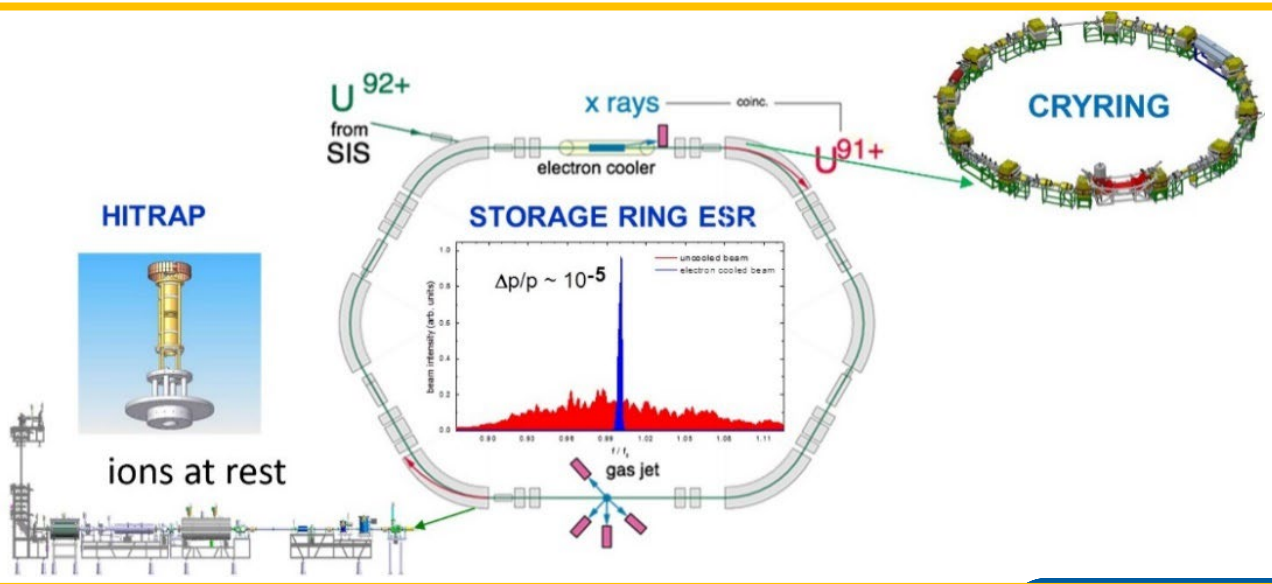
Precision Domain of FAIR: Trapping & Storage of HCI
Atomic, Quantum, and Fundamental Physics

HITRAP, CRYRING@ESR, ESR: Existing Facilities of FAIR

From rest to relativistic energies (up to 4.9 GeV/u)

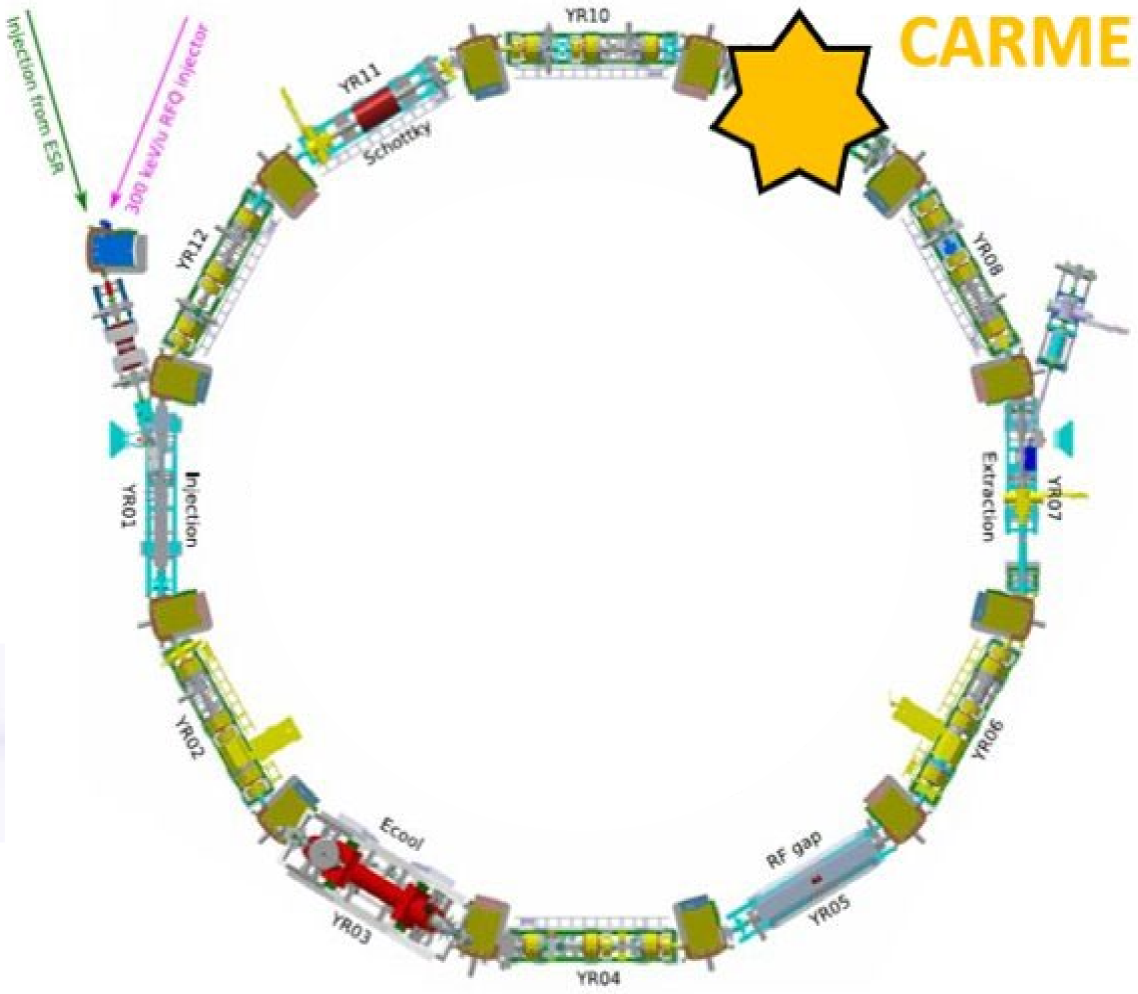






CARME@CRYRING – 2025 beamtime updates

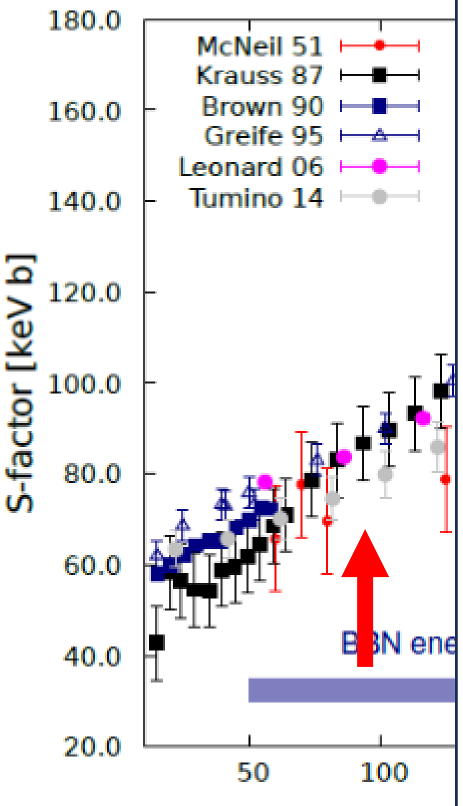
Jordan Marsh
University of Edinburgh

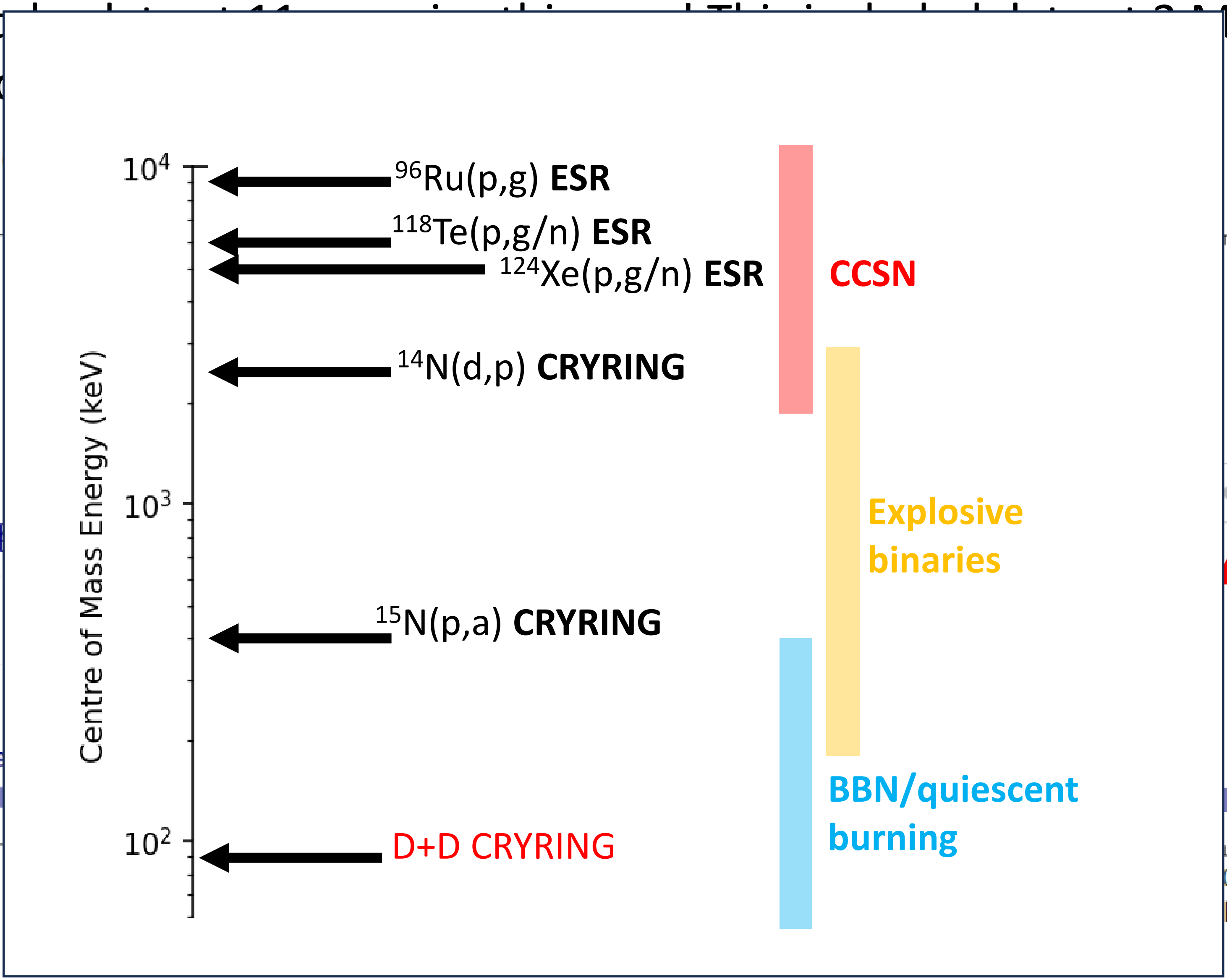


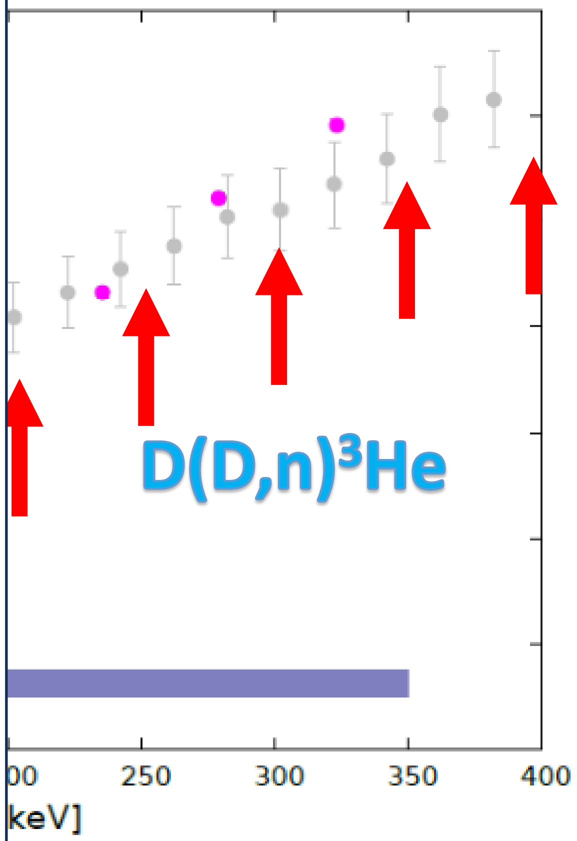
D+D

We managed to t … eV, 1.5 MeV, 1 MeV, 750 keV and

$$\sigma(E) = \frac{1}{E} e^{-2\pi\eta} S$$



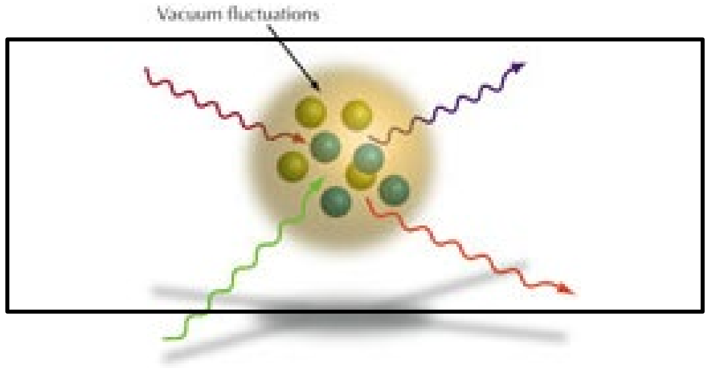


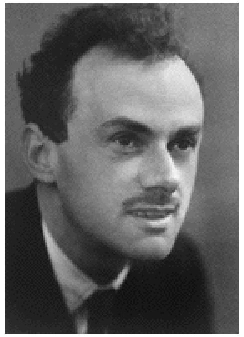


Observation of Vacuum Birefringence

Vacuum has a **structure** which can be observed by perturbing it and probing it!

Vacuum





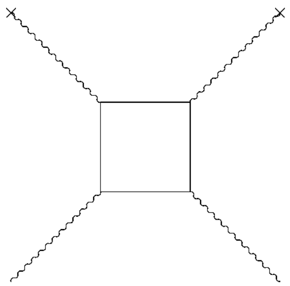
But: Euler and Heisenberg: „ *… even in situations where the photon energy is not sufficient for matter production, its virtual possibility will result in a ´polarization of vacuum´ and hence in an alteration of Maxwell´s equations*“ 1936

Strong electric field induced phase shift of a electromagnetic wave in birefrigent vacuum.

Effects of Vacuum Fluctuations

Elastic scattering between real photons and “virtual” photons of the nuclear Coulomb field

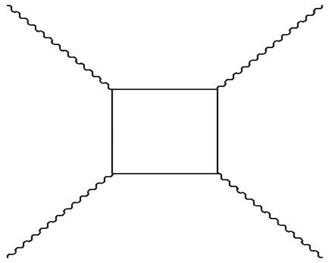
Delbrück Scattering in Nuclear Coulomb Fields



The crosses indicate the field of a heavy nucleus with (bismuth (Z=83), etc...)

Delbrück Scattering is still a challenge !

Photon – Photon Scattering



Not yet measured: Elastic scattering between real photons

Observation of Vacuum Birefringence

HI JENA
Helmholtz Institute Jena

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Eckhart Förster
Ingo Uschmann
Kai S. Schulze
Robert Lötzsch
Berit Marx-Glowna
Benjamin Grabiger
Annika T. Schmitt
Willi Hippler

Holger Gies
Felix Karbstein

European XFEL

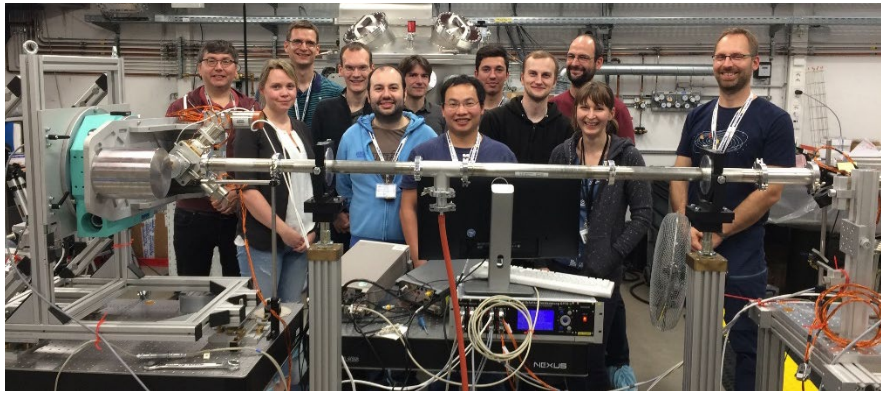
Ulf Zastrau
Zuzana Konopkova
Cornelius Strohm
Toma Toncian
Jan-Patrick Schwinkendorf

HZDR
HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Thomas Cowan
Hans-Peter Schlenvoigt
Lingen Huang
Alejandro Laso

DESY

Ralf Röhlsberger
Christian Schroer
Andreas Schropp



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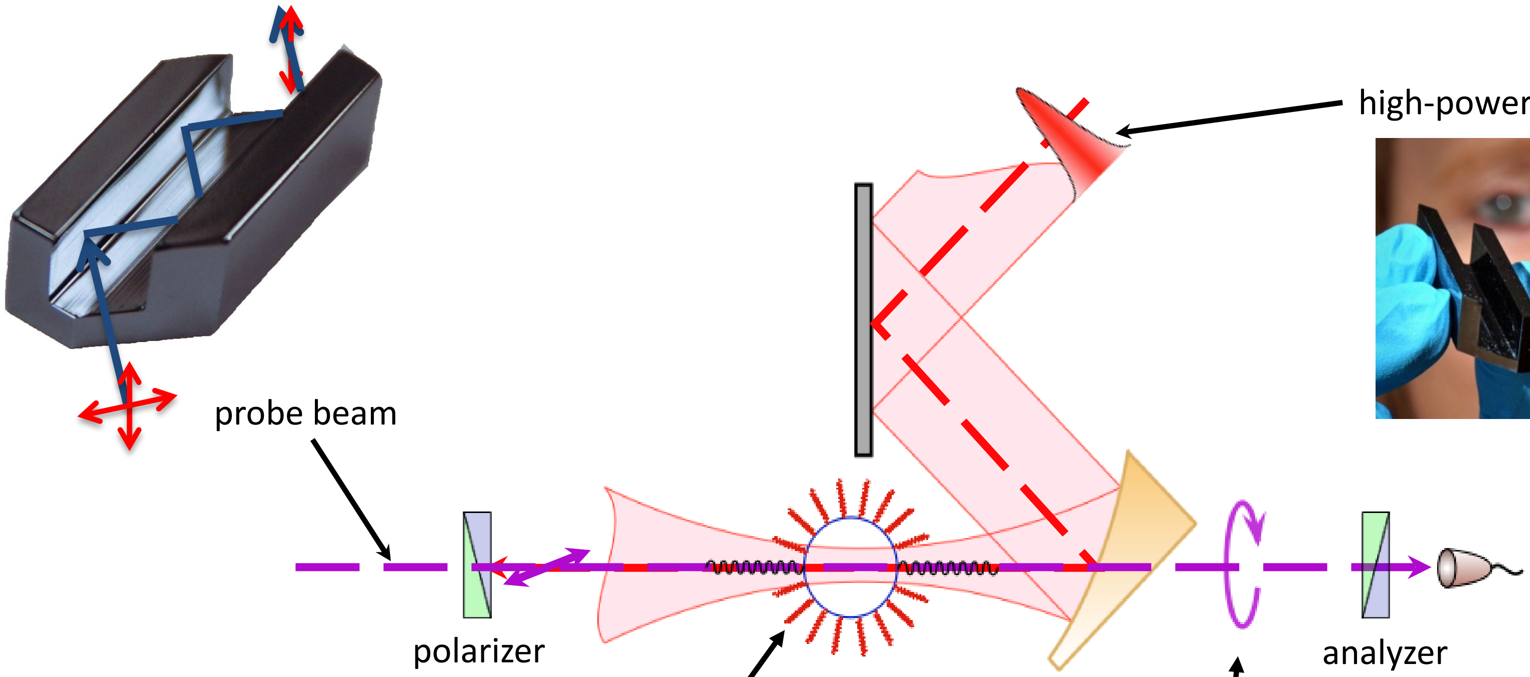
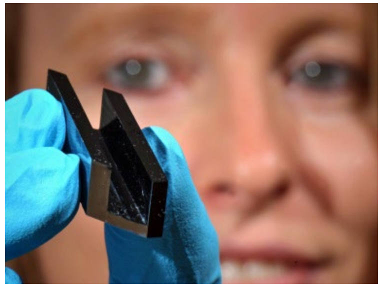
Federal Ministry of Education and Research

DFG Deutsche Forschungsgemeinschaft
German Research Foundation

Detection of vacuum birefringence

[T. Heinzl *et al.*, Optics Communications 267 (2006)]





W. Heisenberg, H. Euler, Z. Phys., 1936

Courtesy of Annika Tamara Schmitt

ellipticity: $\Delta\Phi^2 = \left(\frac{4\alpha \cdot z_0 \cdot I}{15 \cdot \lambda \cdot I_c}\right)^2$

α - fine structure constant

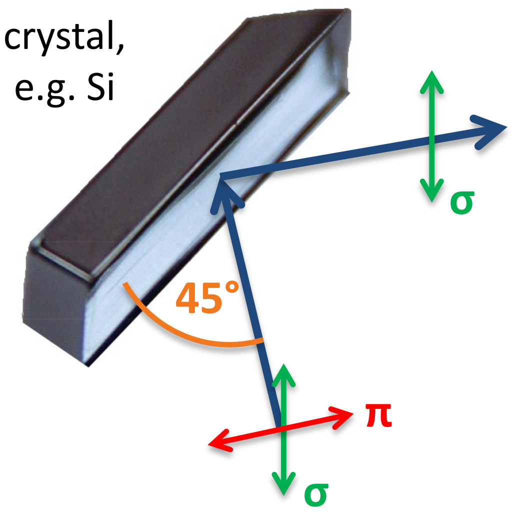
z_0 - interaction length

λ - probe wavelength

I - peak intensity

$I_c = 4.4 \times 10^{29}$ W/cm^2 - critical intensity

Polarizers based on Bragg diffraction close to 45°



Bragg condition

$2d \sin \Theta_B = \lambda$

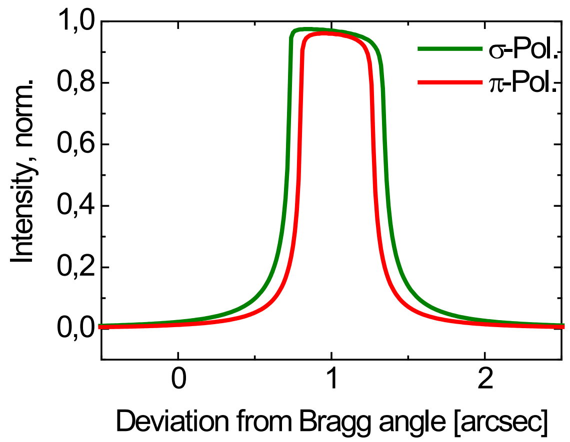
d … lattice distance

Θ_B … Bragg angle

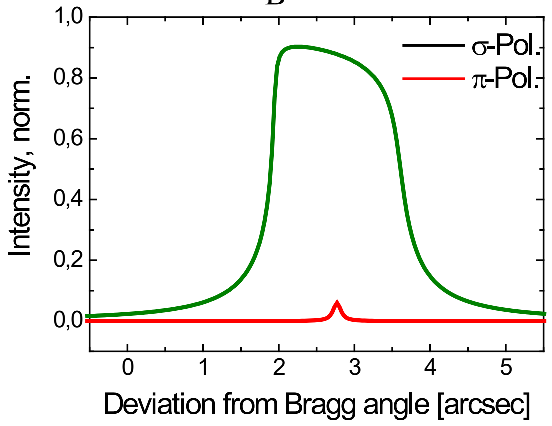
λ … wavelength

→π-component vanishes
at Θ_B = 45°

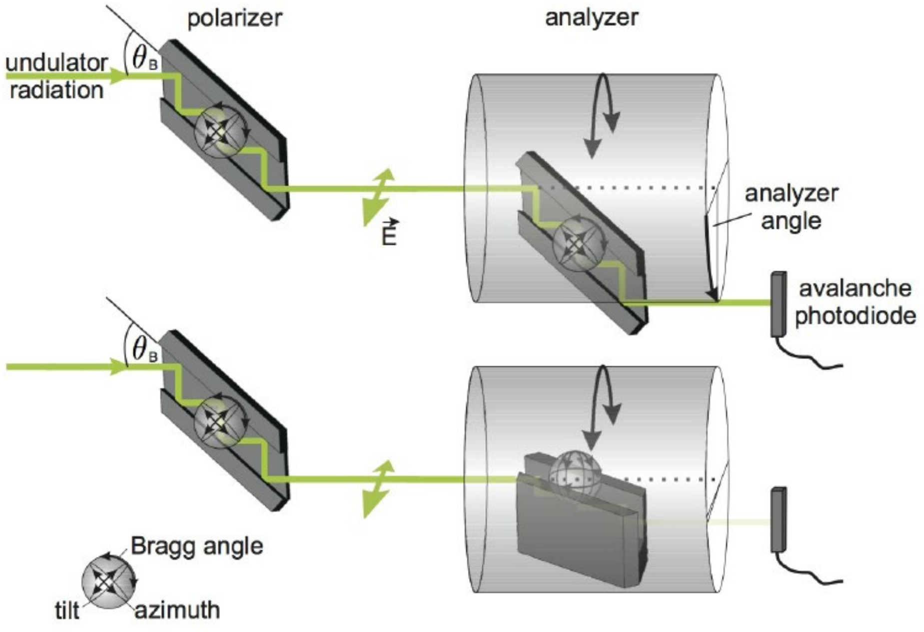
Θ_B=20°



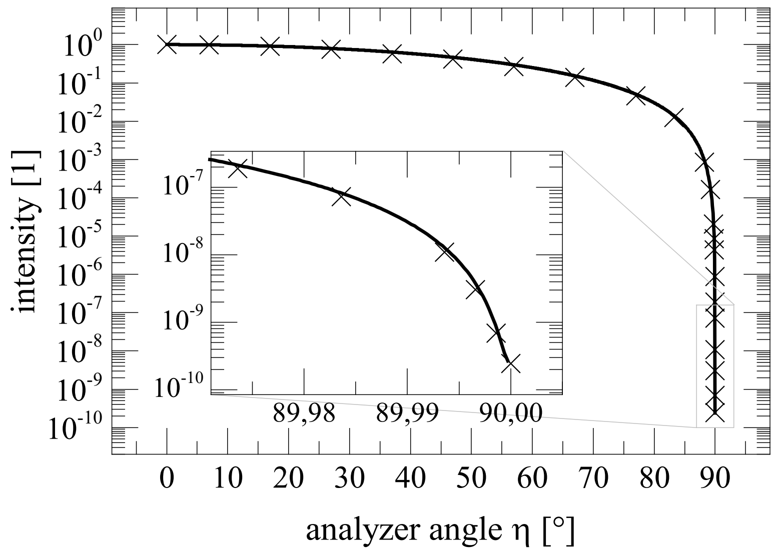
Θ_B=44°



Polarization purity of silicon polarimeter



measurement at ID06
with 6 reflections per crystal



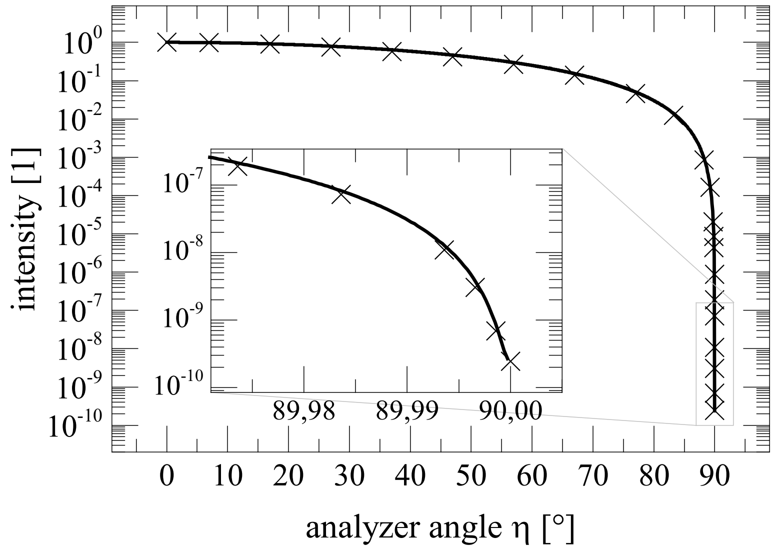
I_x/I_0 = 2.4 · 10^{-10} @ E_{ph}= 6457 eV, Si 400 Reflex

I_x/I_0 = 5.7 · 10^{-10} @ E_{ph}= 12914 eV, Si 800 Reflex

B. Marx, *et al.*, PRL 110, 2013

Experimental results limited by divergence and detour excitation!

Limitations of the polarization purity



$I_x/I_0 = 2.4 \cdot 10^{-10}$

@ E_{ph}= 6457 eV, Si 400 Reflex

B. Marx, *et al.*, PRL 110, 2013

$$\delta \geq \sigma_v^2 + \sigma_h^2$$

σ_v...vertical standard deviation of divergence
σ_h...horizontal standard deviation of divergence

synchrotrons (~10 µrad):

$\delta > 10^{-10}$

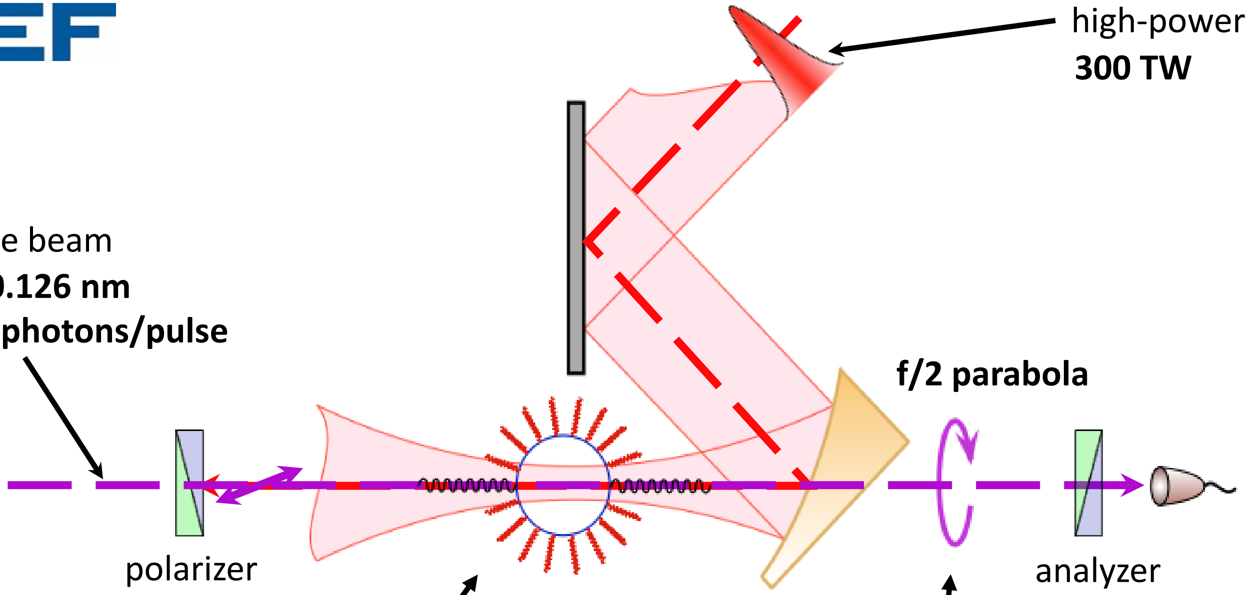
Europ. XFEL (~1 µrad):

$\delta > 10^{-12}$

K. S. Schulze, Fundamental limitations of the polarization purity of x rays, APL Photonics **3** (2018)

Detection of vacuum birefringence at HED of European XFEL

HIBEF



$w_0 \approx 1$ µm
$z_0 \approx 20$ µm
$I \approx 10^{21}$ W/cm²

α - fine structure constant
z_0 - interaction length
w_0 - waist
λ - probe wavelength
I - peak intensity
$I_c = 4.4 \times 10^{29}$ W/cm² - critical intensity

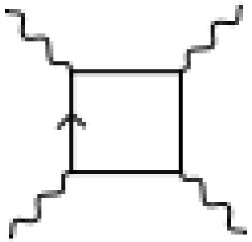
ellipticity: $\Delta\Phi^2 = \left(\frac{4\alpha \cdot z_0 \cdot I}{15 \cdot \lambda \cdot I_c}\right)^2 \approx 4 \times 10^{-12}$

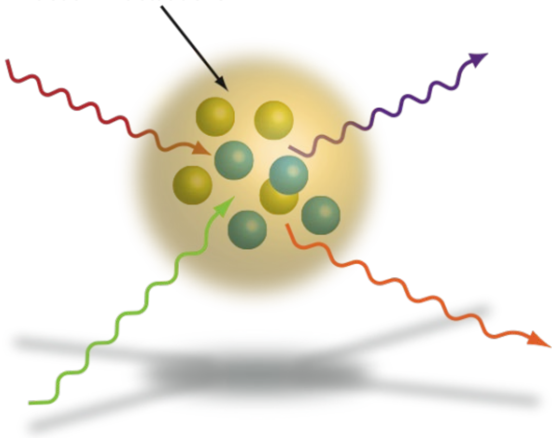
[F. Karbstein, Vacuum birefringence in the head-on collision of x-ray free-electron laser and optical high-intensity laser pulses, Phys. Rev. D 98 056010 (2018)]

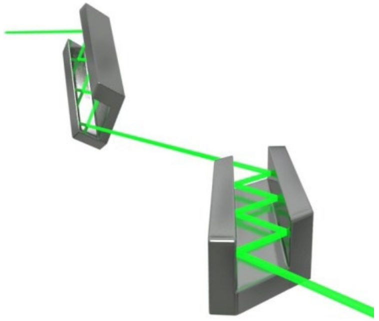
Why studying elastic x-ray scattering?

Elastic scattering of photons by a potential: fundamental 2nd order QED process

Vacuum birefringence: scattering from vacuum fluctuations induced by a strong laser field

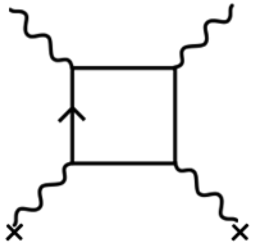




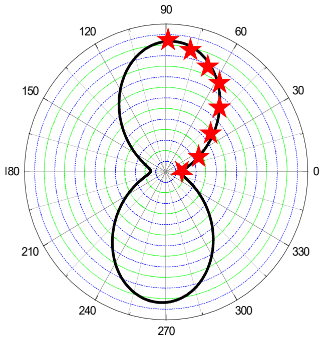


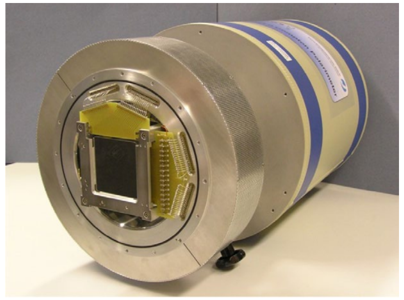
$$\hbar\omega \approx 10\,\mathrm{keV}$$

Delbrück scattering: scattering from vacuum fluctuations induced by the Coulomb potential of a nucleus



$$\hbar\omega > 1000\,\mathrm{keV}$$





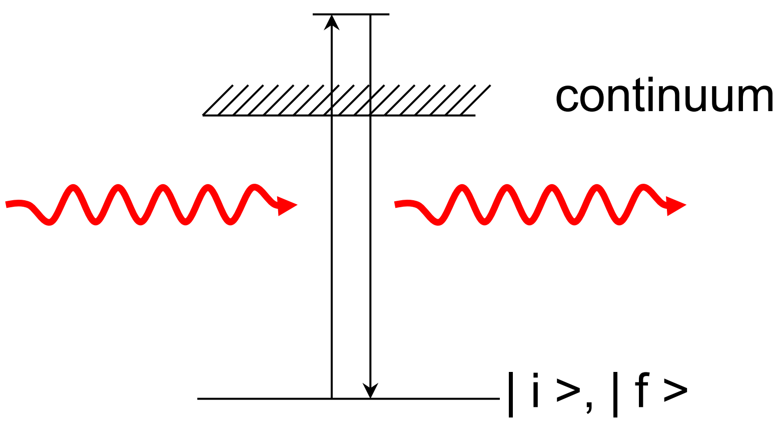
Rayleigh scattering: scattering from bound electrons

$$\hbar\omega \approx 10 - 1000\,\mathrm{keV}$$

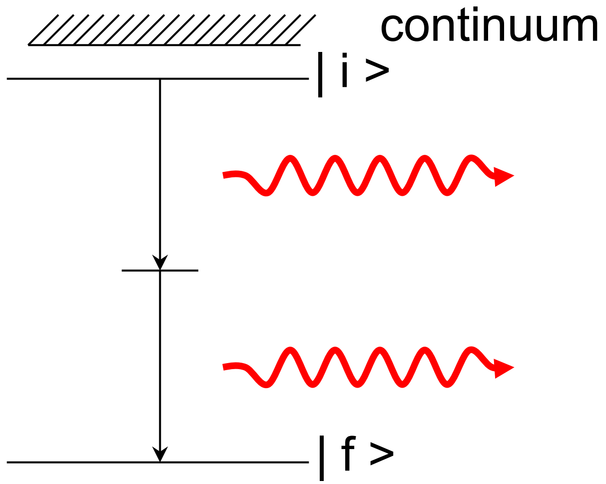
Rayleigh scattering and 2-photon decay: 2nd Order QED

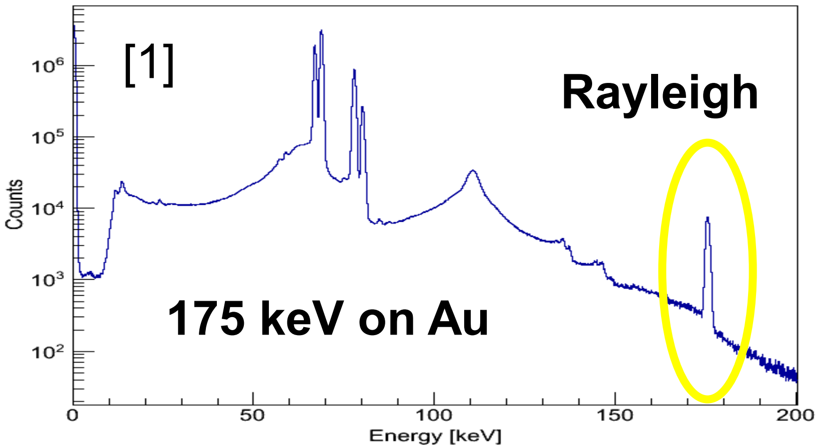
Both scenarios: Real state → photon → virtual state → photon → real state

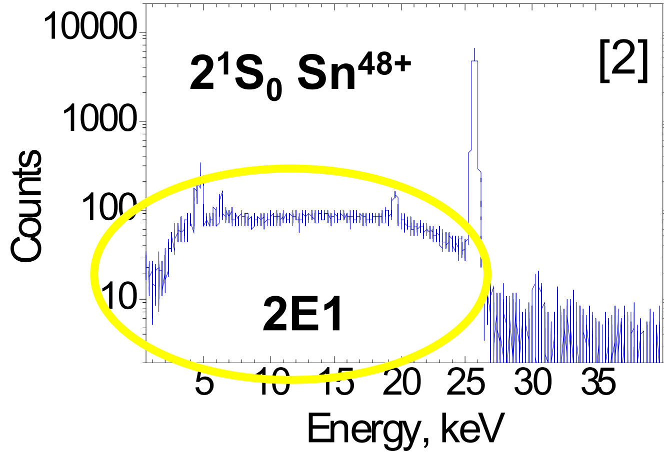
Rayleigh scattering



2-photon decay



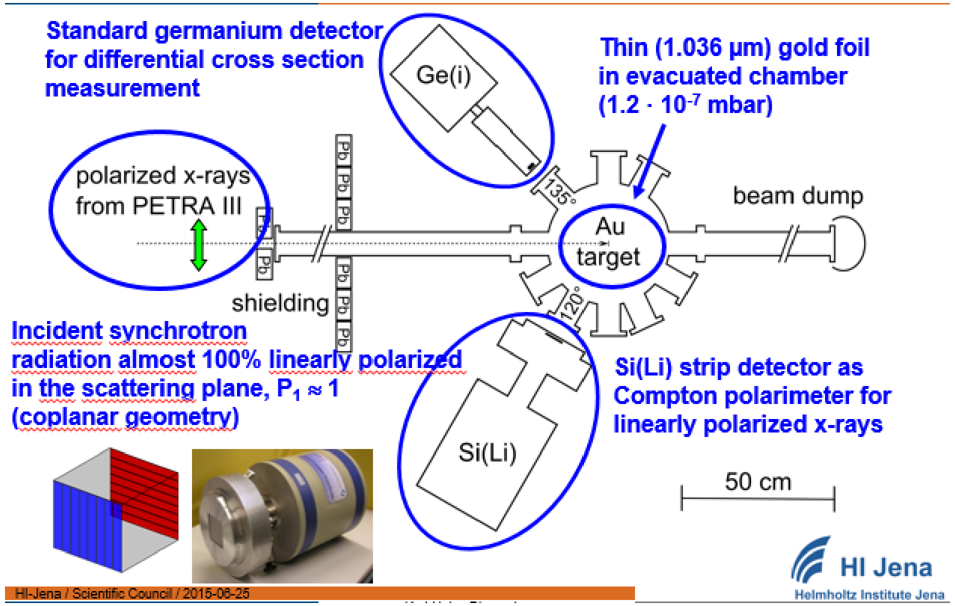


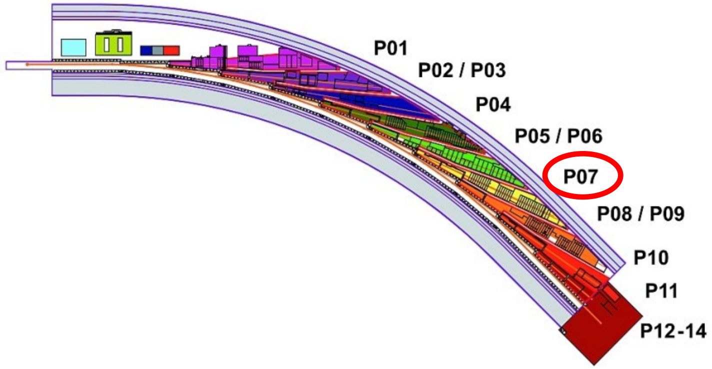


[1] This work, to be published
[2] S. Trotsenko et al., *Phys. Rev. Lett.* **104** 033001 (2010)

Polarisation Measurements on Rayleigh scattering for highly polarized x-ray at PETRA III at DESY

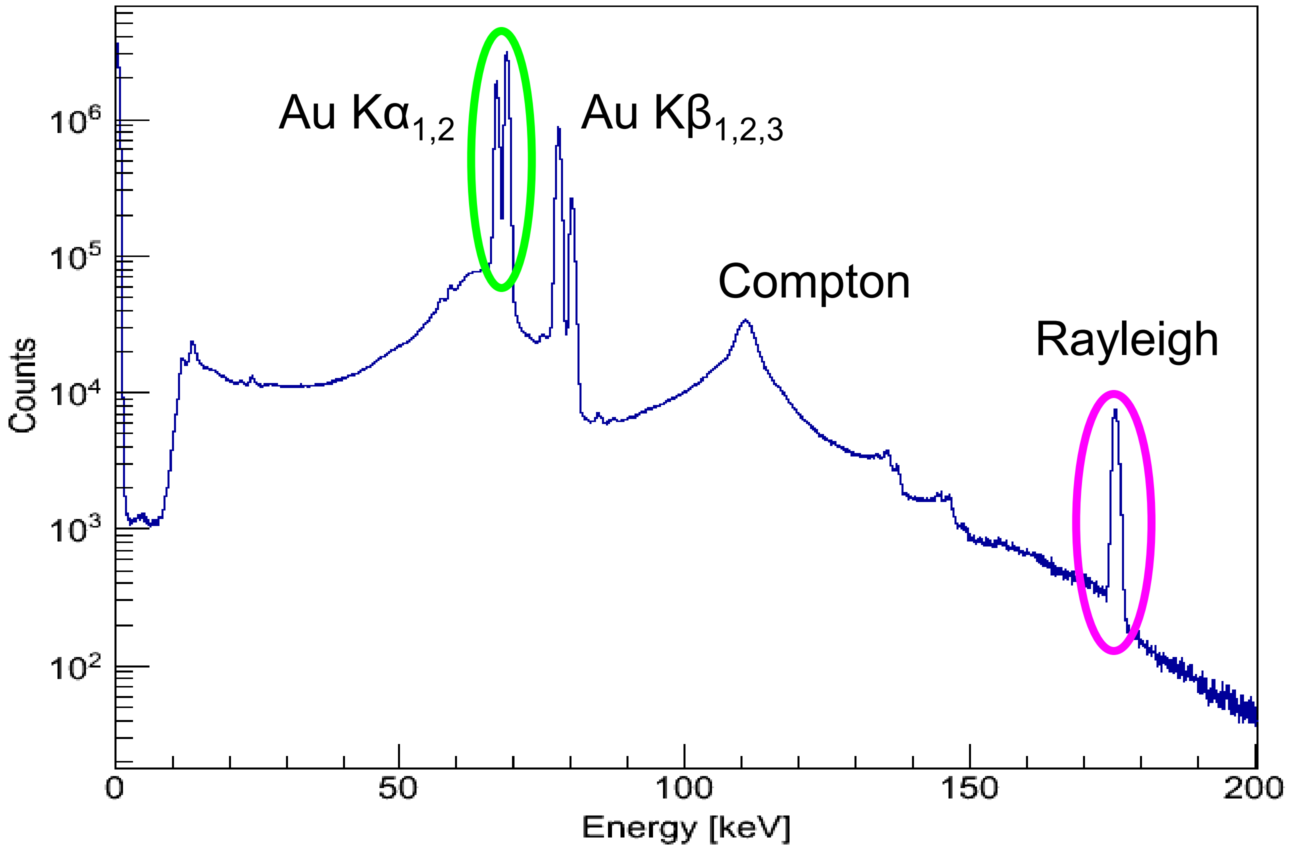
PETRA III: 3rd generation synchrotron light source



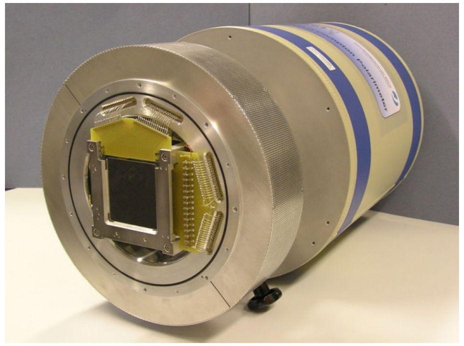


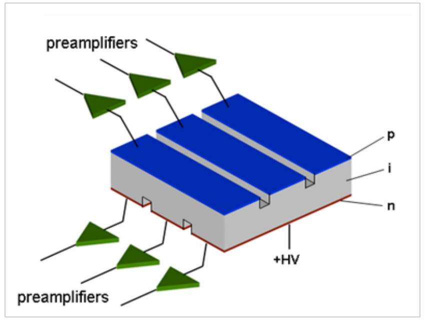
Differential cross section determination

Relative cross section measurement: Rayleigh / Kα_1

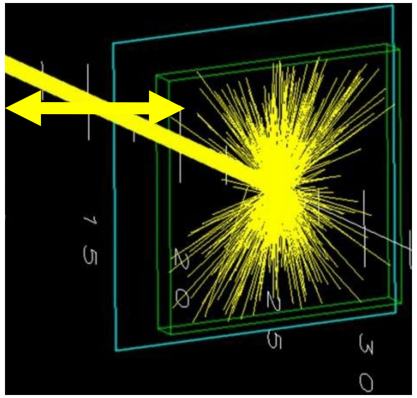


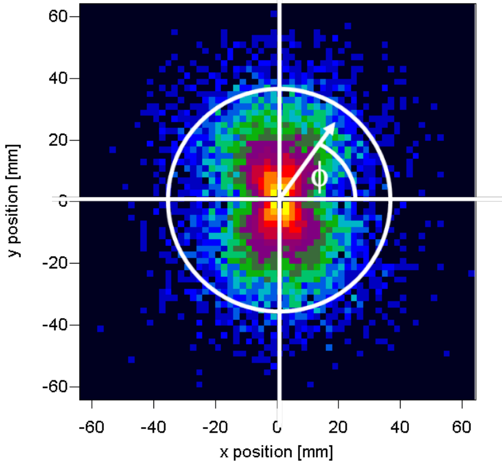
Position sensitive x-ray detectors (> 50 keV)

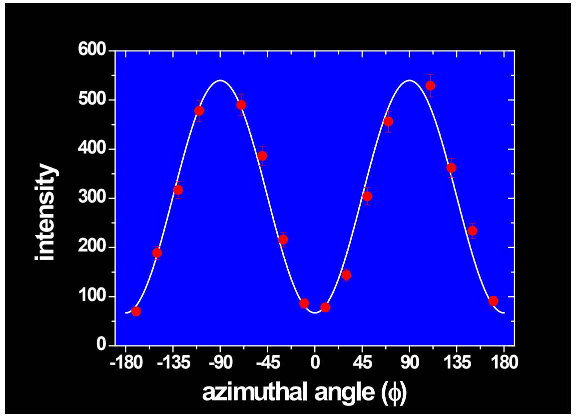




Compton imager for hard x-rays: hard x-ray polarimetry







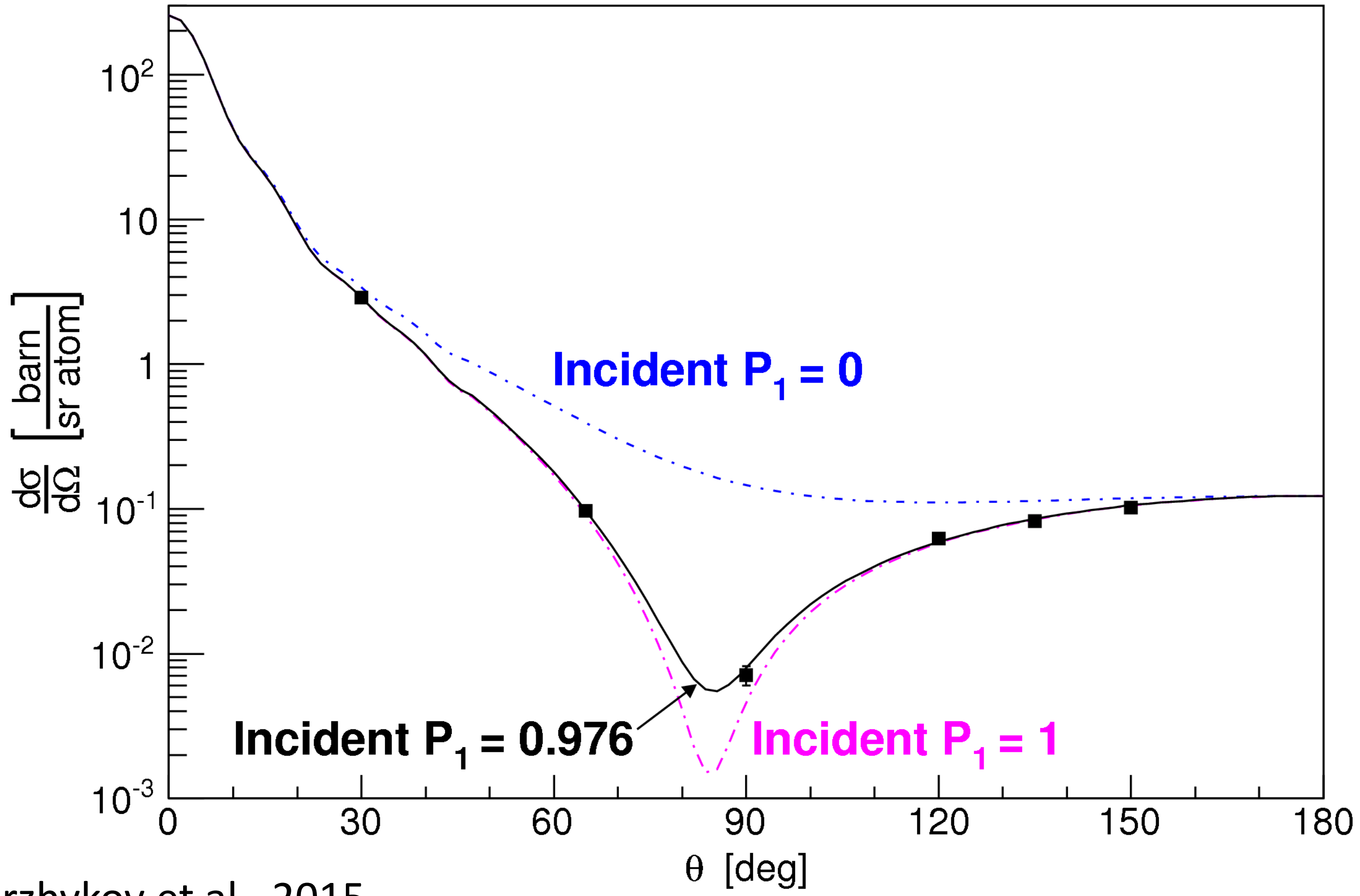
Simulation:
linearly polarized x-rays

2D image (experiment):
Compton distribution

Azimuthal intensity distribution

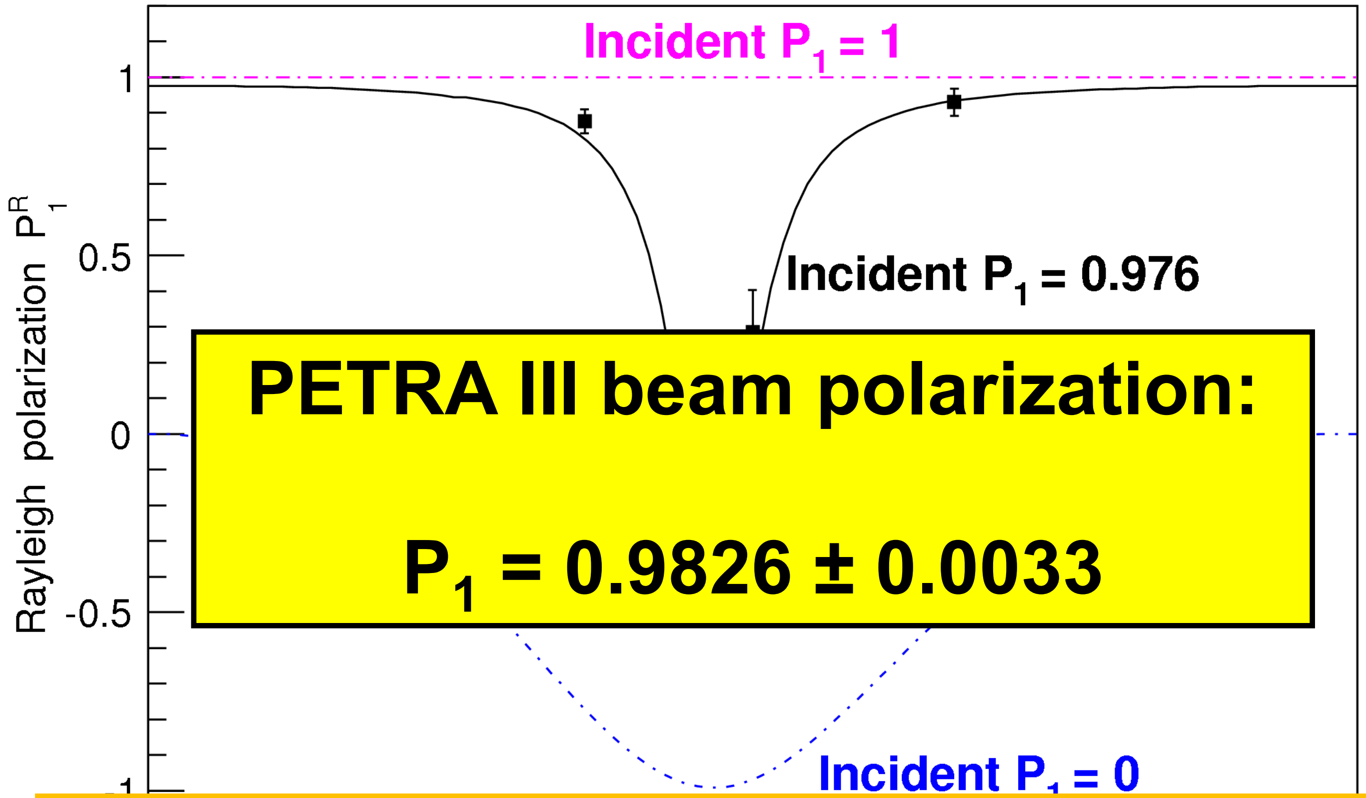
Rayleigh differential scattering cross-section

P1: linear polarization (Stokes paramter)



Theory: Surzhykov et al., 2015

Rayleigh photon polarization



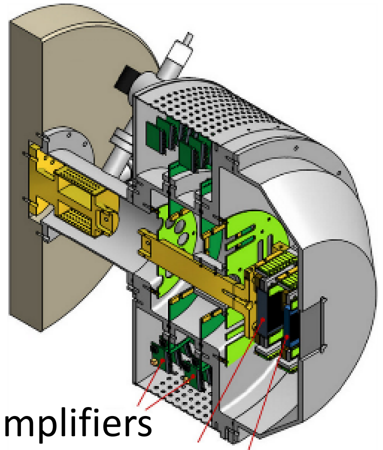
PETRA III beam polarization:

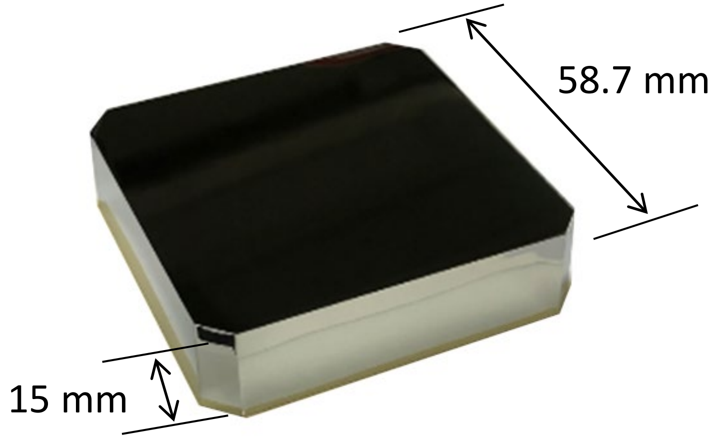
$P_1 = 0.9826 \pm 0.0033$

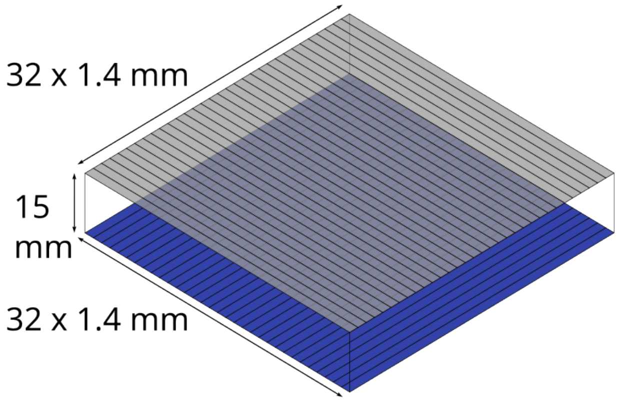
Next step (in preparation): Polarization studies of Delbrück scattering !

K. Blumenhagen et al., 2015

New Telescope Structure







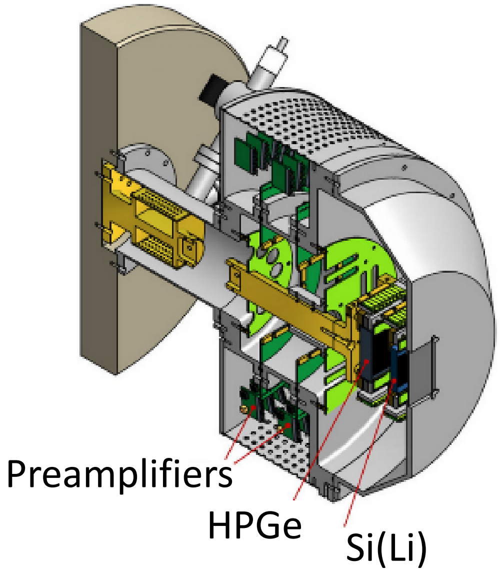
→ 1024 Quasi-Pixel

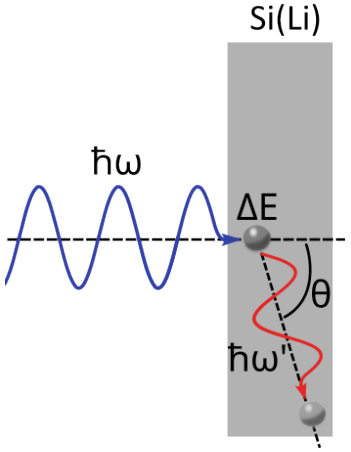
- Additional HPGe crystal next to Si(Li) crystal installed
- Ge has a higher absorption probability for high energy photons

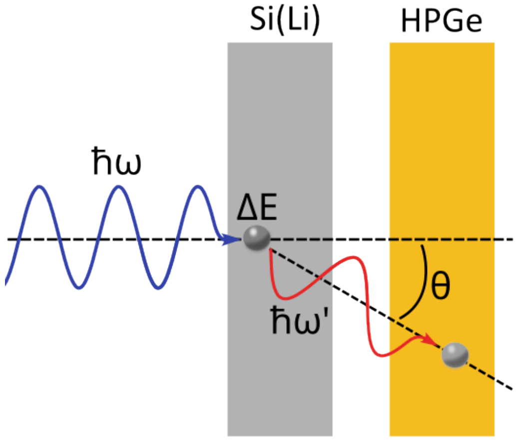
- Possible Compton events in HPGe and Si(Li) + HPGe
- Increases efficiency at higher energies

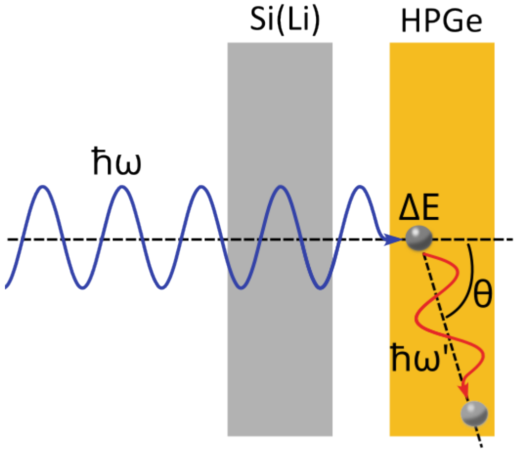
Effective energy range between 10s of keV up to several 100s of keV

Compton Telescope for $\hbar\omega > 200$ keV

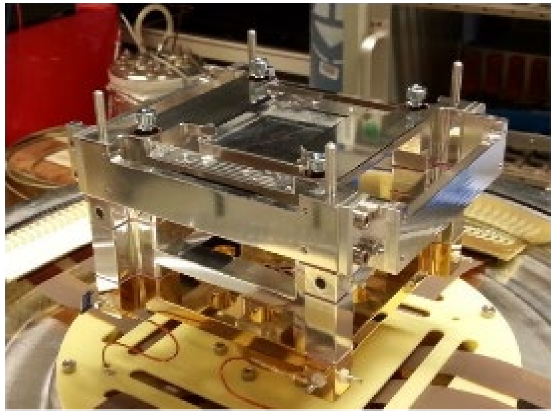




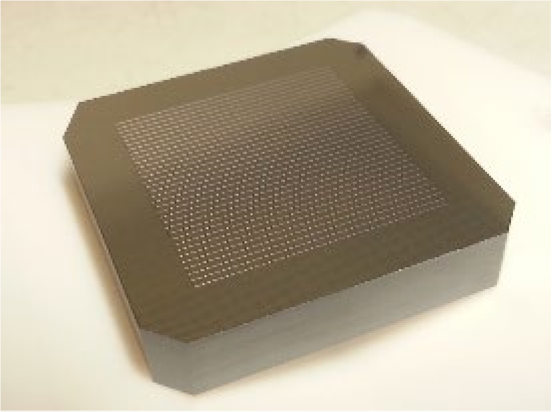




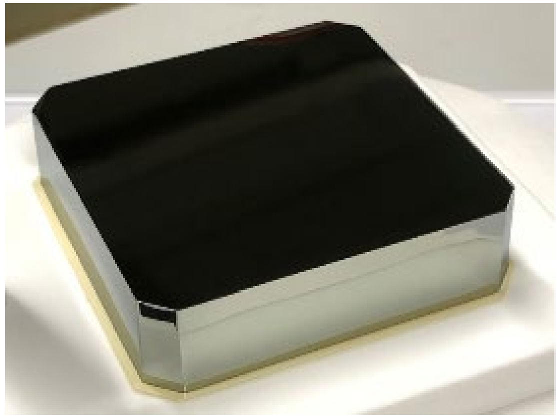
Compton Telescope



Crystal placement

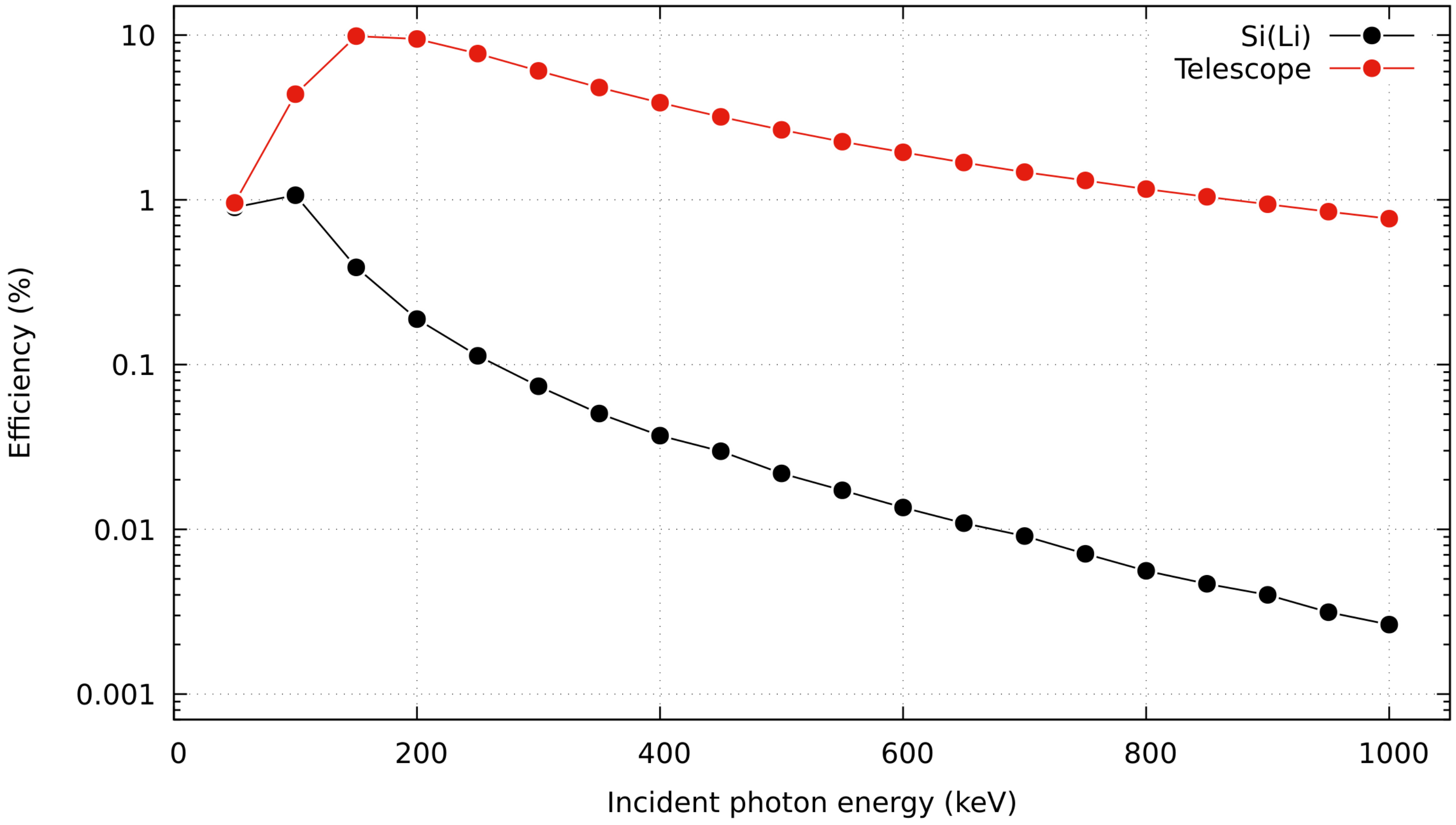


Si(Li) crystal



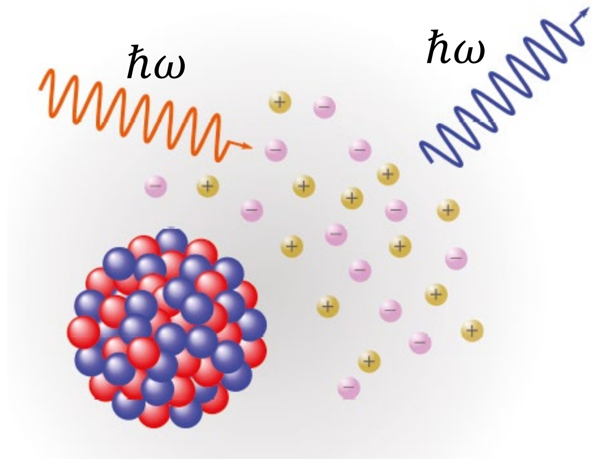
HPGe crystal

Efficiency Improvement



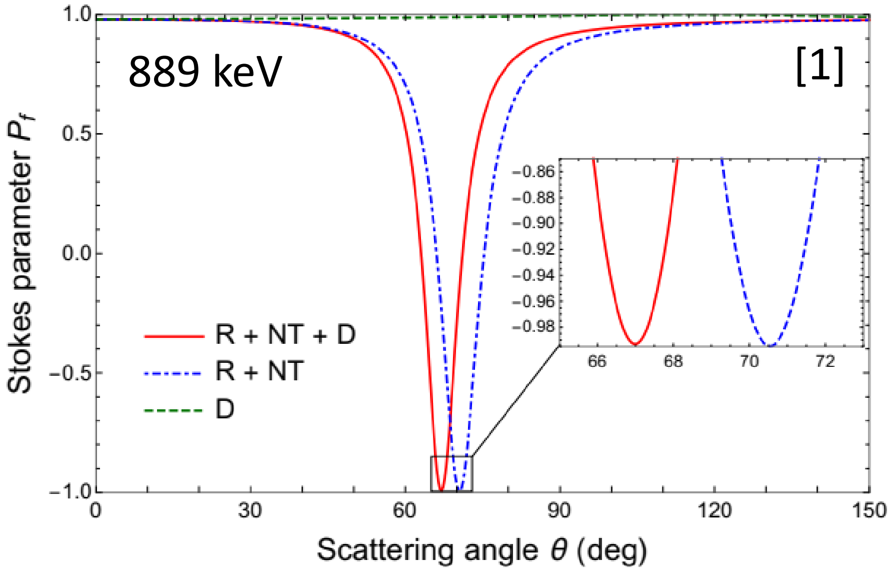
Probing the Contribution of Delbrück Scattering

- Highly linearly polarized incident radiation
- Experiment with photon energies significantly above 500 keV
- Incident photons scatter off an atomic target



- Delbrück contribution results in distinct modification of elastic scattering features

→ **Shift in linear polarization**



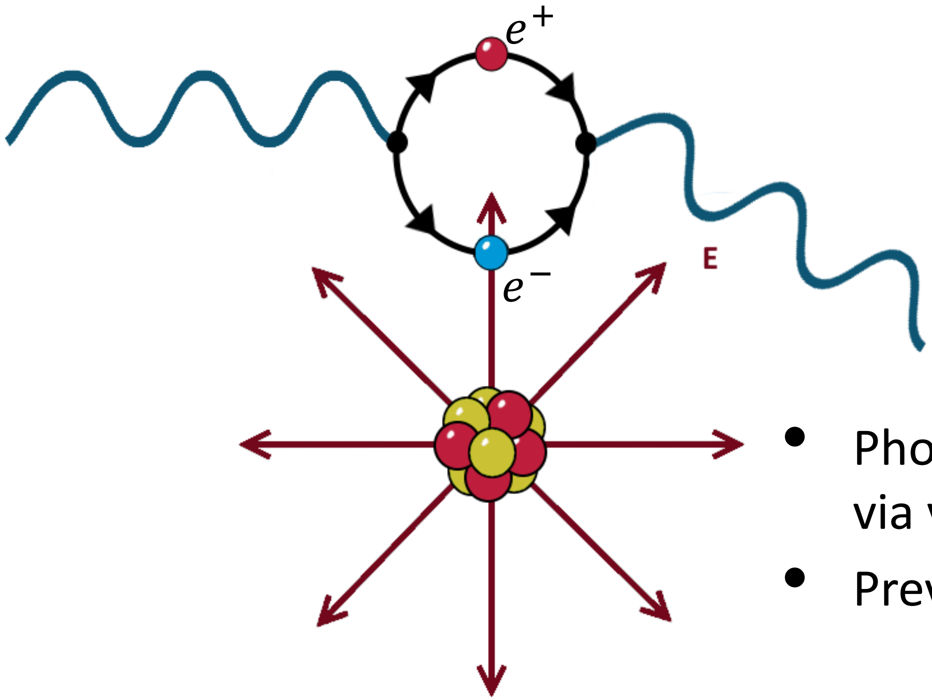
[1] J. Sommerfeldt et al, Phys. Rev. A **108**, 042819 (2023)

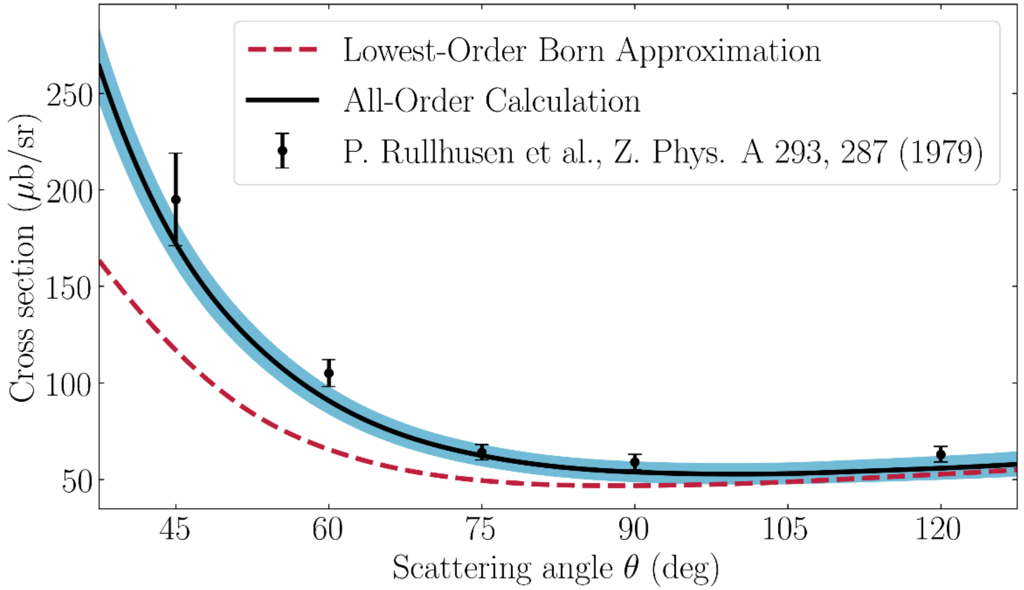
Delbrück Scattering

PHYSICAL REVIEW LETTERS **131,** 061601 (2023)

Editors' Suggestion | Featured in Physics

All-Order Coulomb Corrections to Delbrück Scattering above the Pair-Production Threshold





- Photons are elastically scattered by the electric field of an atomic nucleus via virtual electron-positron pair creation
- Previous calculations were done in the lowest-order Born approximation.

Physics See Synopsis:

“Quantum Deflection Unraveled“, *Physics* 16, s114

J. Sommerfeldt *et* al., Phys. Rev. Lett. **131**, 061601 (2023)

Technische Universität Braunschweig PTB GSI

PROCEEDINGS OF SCIENCE

Towards experiments with polarized beams and targets at the GSI/FAIR storage rings

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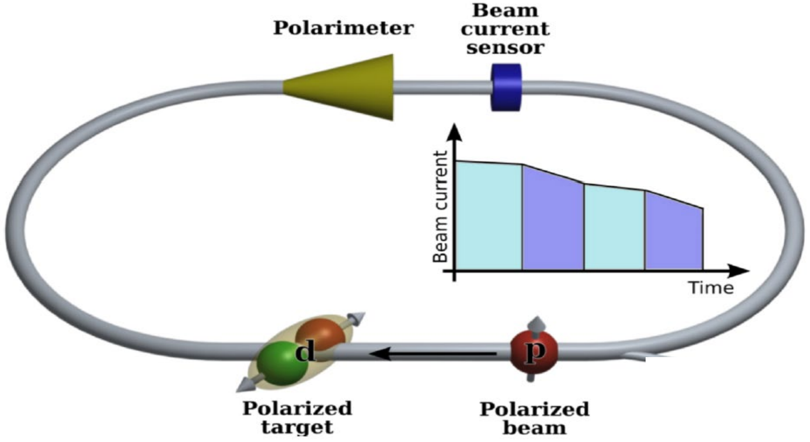
E-mail: pretz@physik.rwth-aachen.de, t.stoehlker@hi-jena.gsi.de



GPAC 2022:
LOI0073 ✓

Step 1: Diagnostics
- electron spin dependent x-ray radiation
- neutrino recoil for bound-state beta decay

Step 2: Spin preservation
- absolute capture cross-section / photon emission (Pauli blocking)

Step 3: Spin-transfer to nuclei
- ions with magnetic moment ⇔ spin transfer to the nucleus)

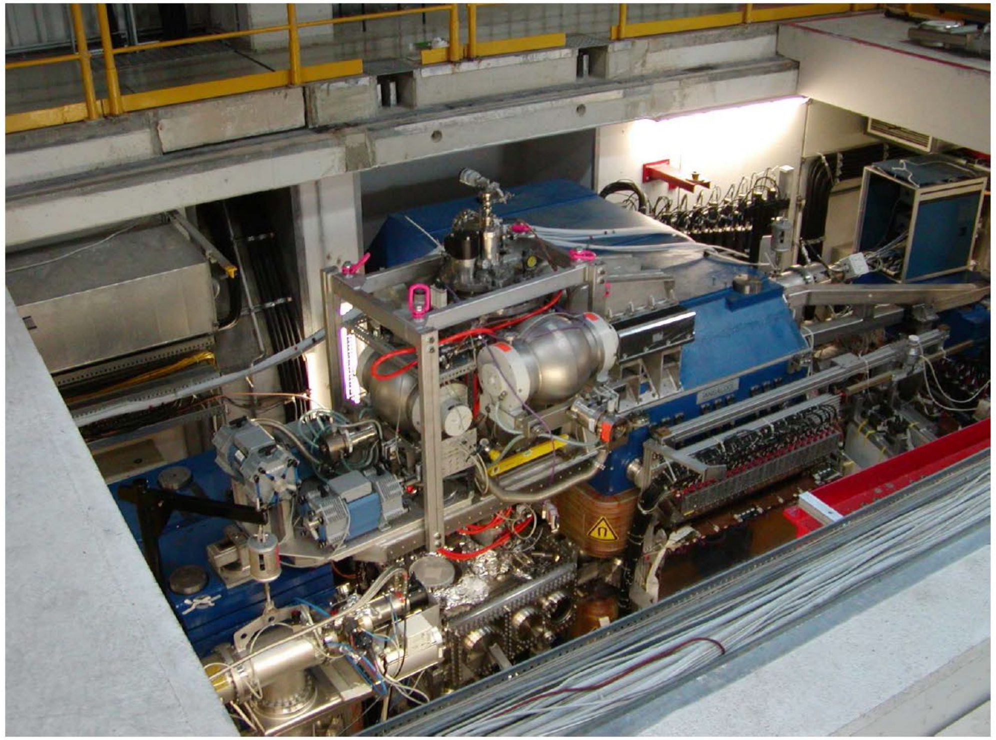
Goal: Experiments with spin-controlled stored particles

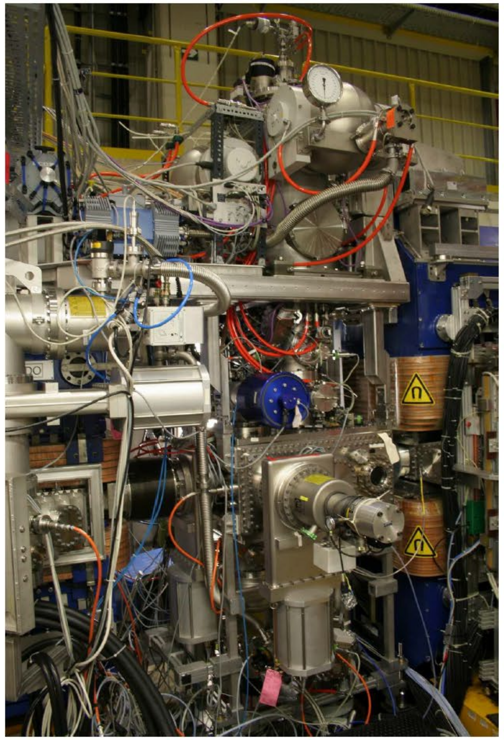
Search for physics beyond the SM
- EDM / Axion search
- Atomic PNC experiments at high-Z

S. Karanth et al., PRL X in press, https://arxiv.org/abs/2208.07293

A state of the art ABS used at ANKE at COSY

Idea: Radiative electron capture of polarized electrons into heavy bare ions



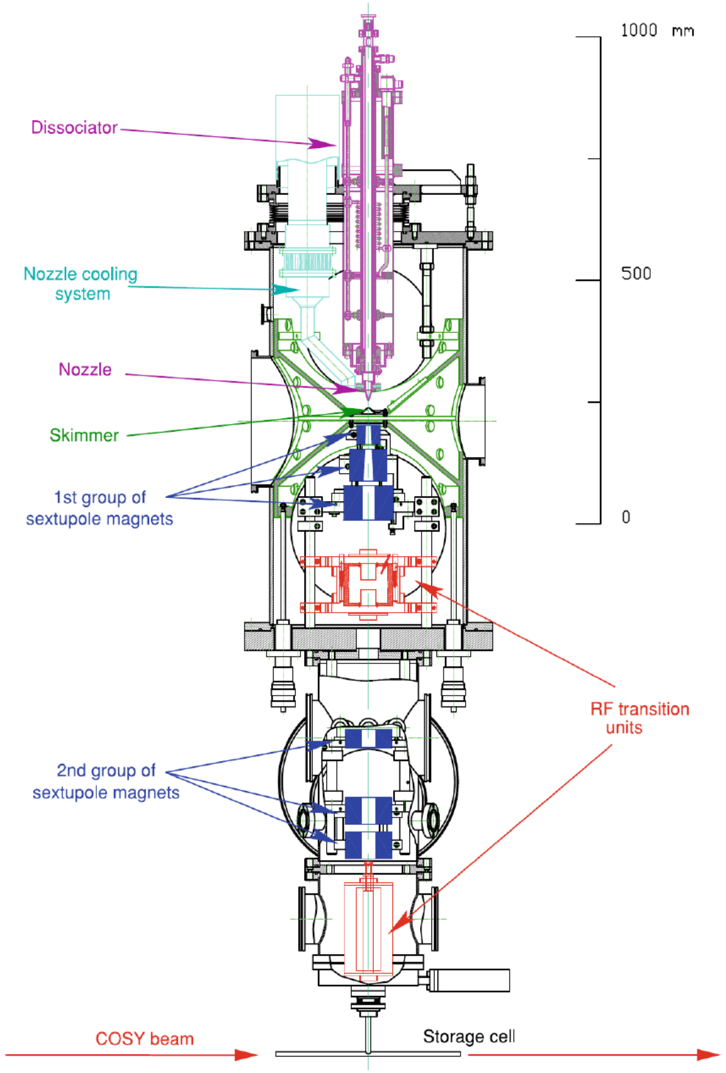


A state-of-the-art ABS used at ANKE at COSY

Idea: Radiative electron capture of spin-polarized electrons into heavy bare ions

Polarized source and target:

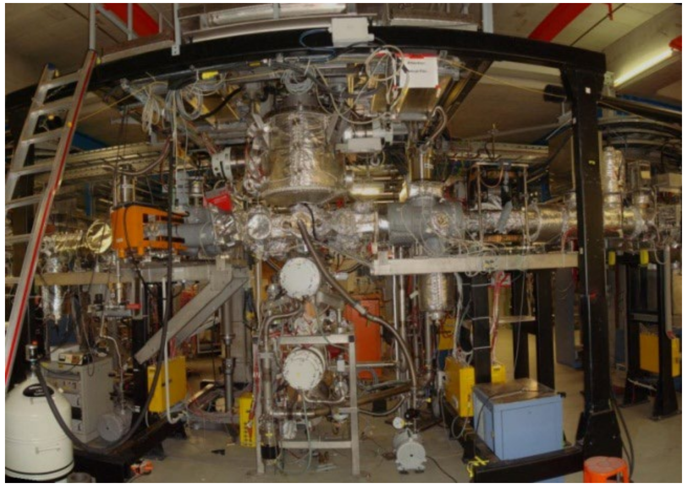
- routinely operated at many facilities around the world.
- employed as a target inside a storage ring, or after ionization, as used a beam
- polarized sources generate a flux of about 1 × 10^{17} atoms/s, which translates into a target thickness of 1 × 10^{12} atoms/cm^2.
- employing a suitable cell, target densities of 1 × 10^{14} atoms/cm^2 can be achieved.
- nuclear (or electron) polarizations of neutral H^0 (D^0) atomic beams, typically exceeds P = 0.9.

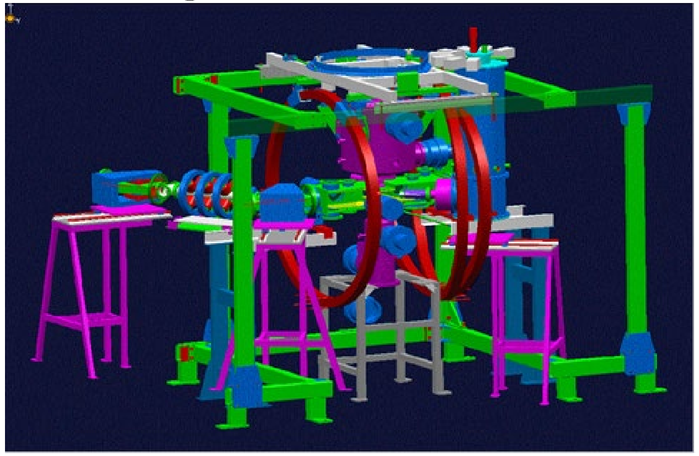


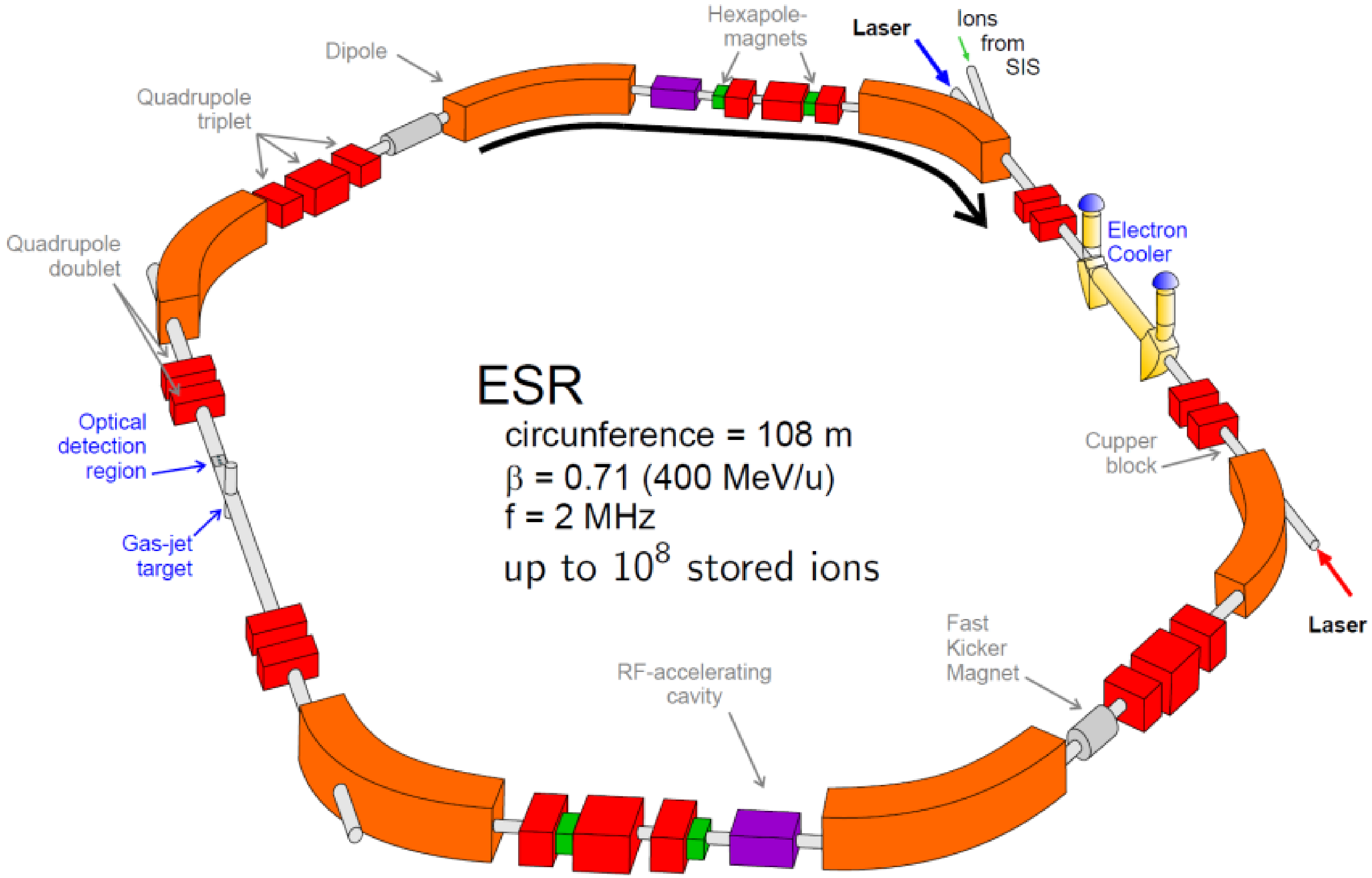
Polarized targets
Physics and techniques of atomic beam sources (ABS) available at COSY

The ESR Storage Ring

Internal target section

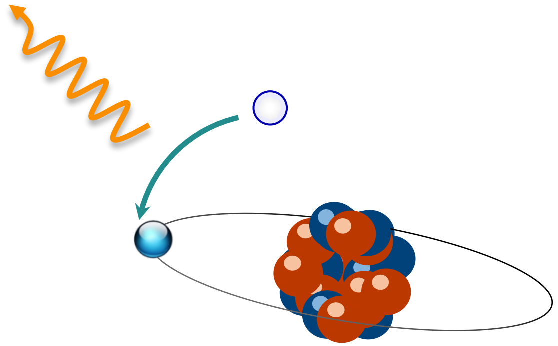


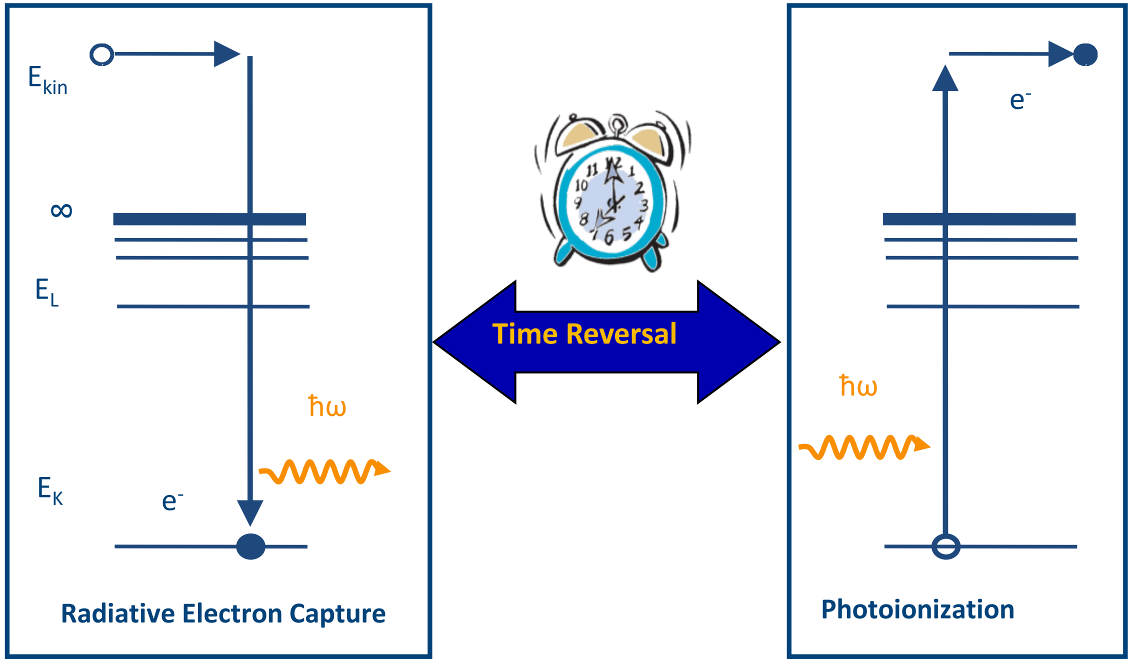




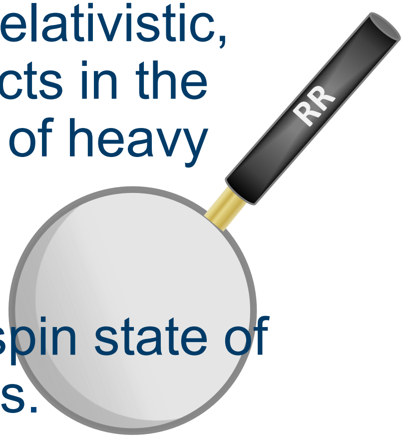
Radiative Recombination of Highly Charged Heavy Ions

RR is one of the dominant processes in relativistic ion–electron as well as ion–atom collisions at storage rings.

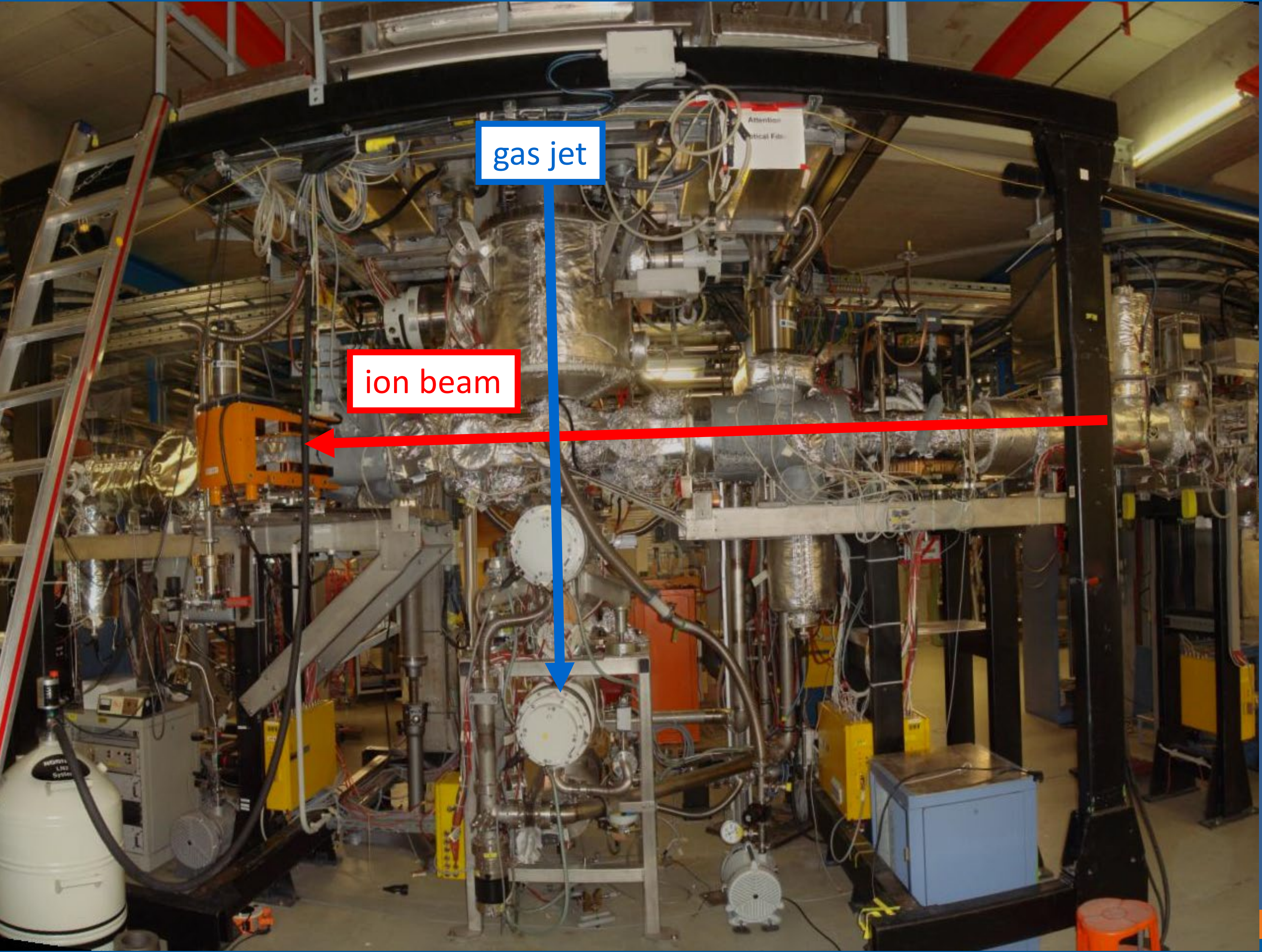




- ✓ we can study RR by measuring emitted X-rays.
- ✓ is very sensitive to the relativistic, magnetic and QED effects in the structure and dynamics of heavy atomic systems.
- ✓ is very sensitive to the spin state of ions and target electrons.



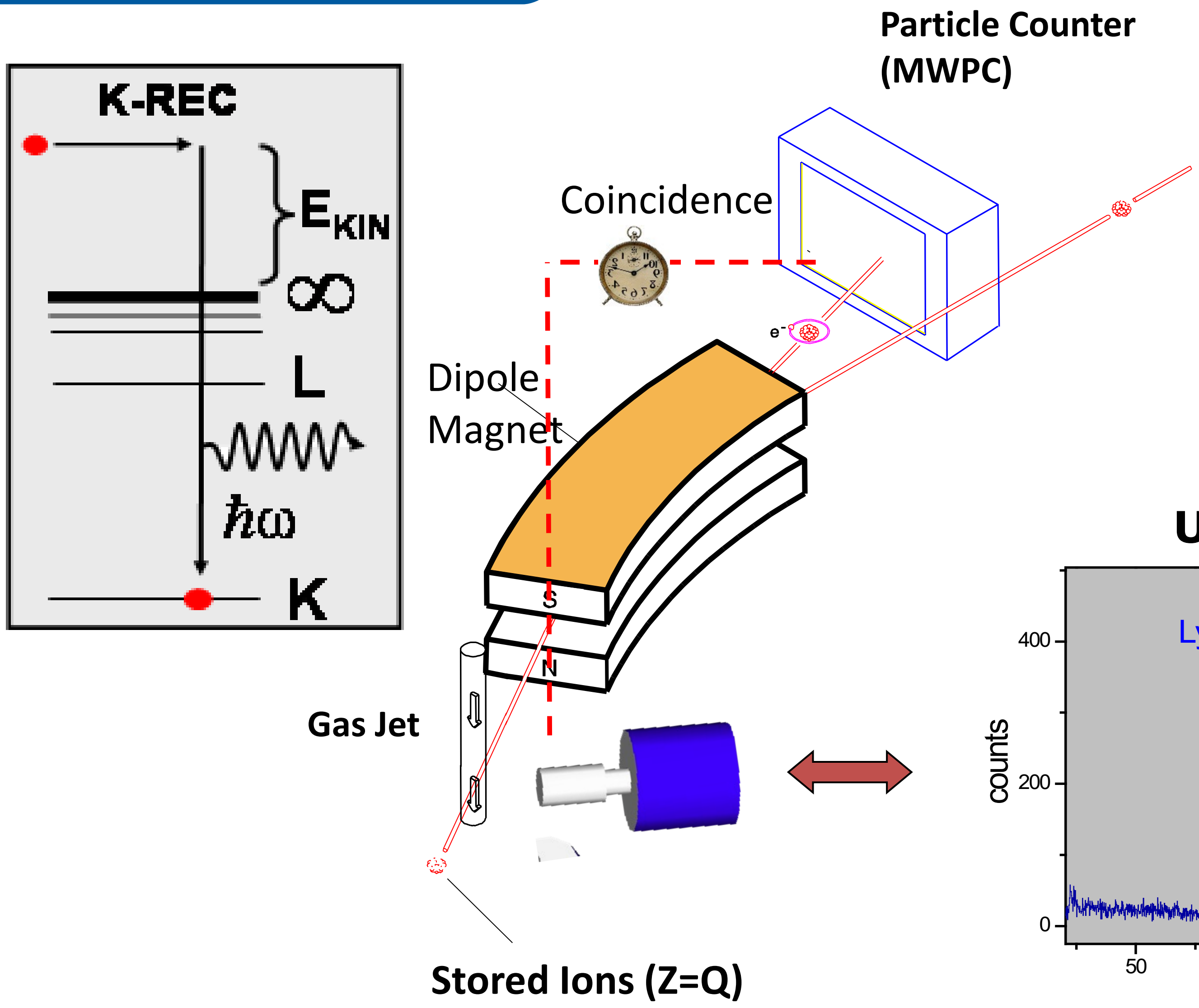
Internal Target



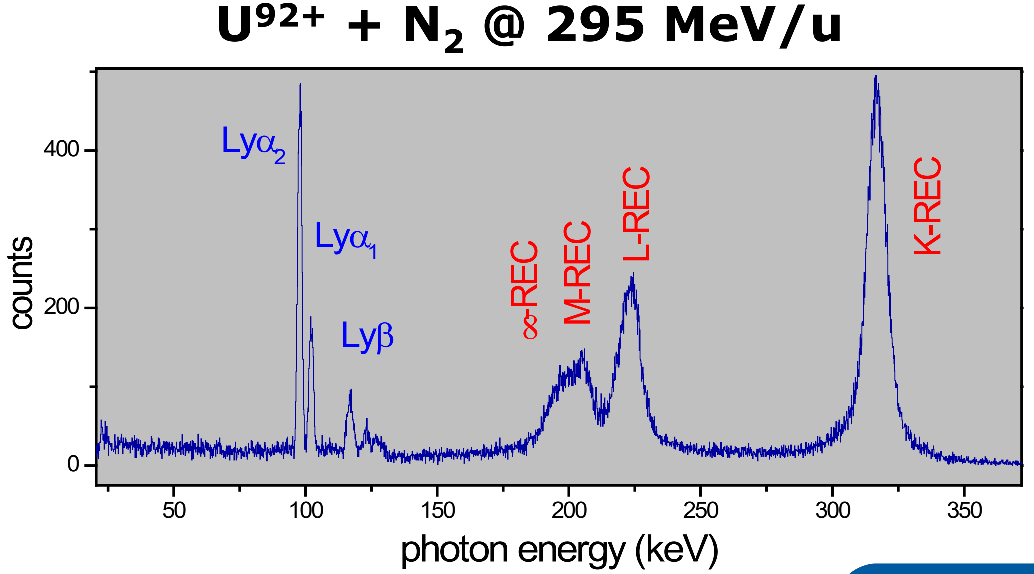
Hydrogen H_2 (droplet)
also N_2, Ar, Kr, Xe …

- Areal density $\approx 10^{13}$ T/cm^2
- Jet target $\approx$ 5 mm
- Cooling $\approx$ 30 K – 35 K

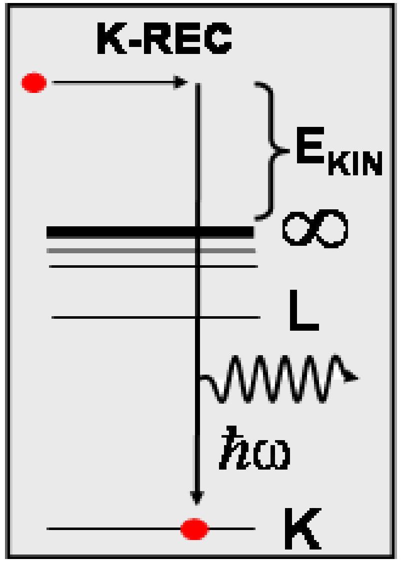
Experimental REC-Spectra

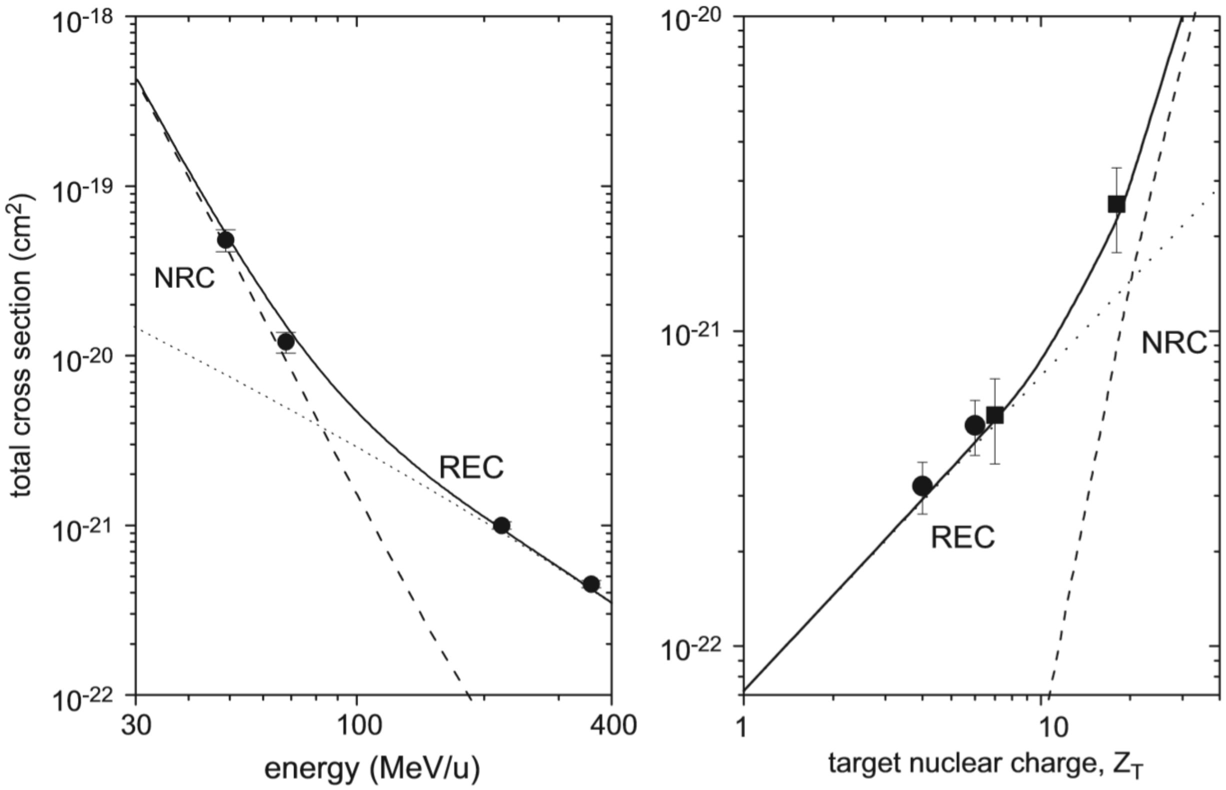


$$Z^{Q+} + e^- \rightarrow Z^{(Q-1)+} + \hbar\omega + \ldots$$



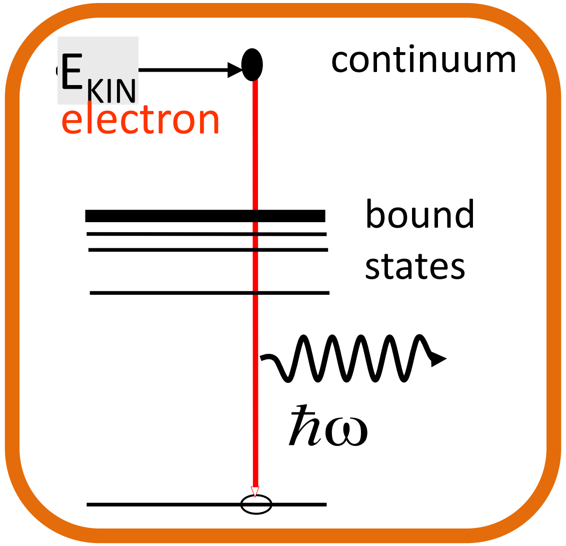
Electron Capture Processes: Bare Uranium





- REC is most important at high beam energies.
- At high-energies, NRC plays basically no role.

Dynamics in Strong Fields: Radiative Processes



Radiative Recombination

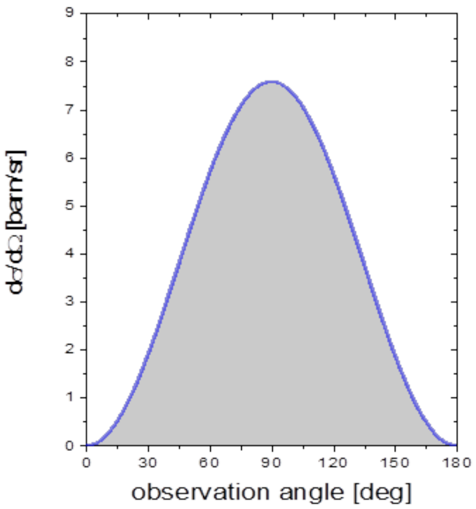
Electron capture into a bound ionic state by emission of a photon

$$\hbar\omega = E_B + E_{KIN}$$

Time-reversed photoionization

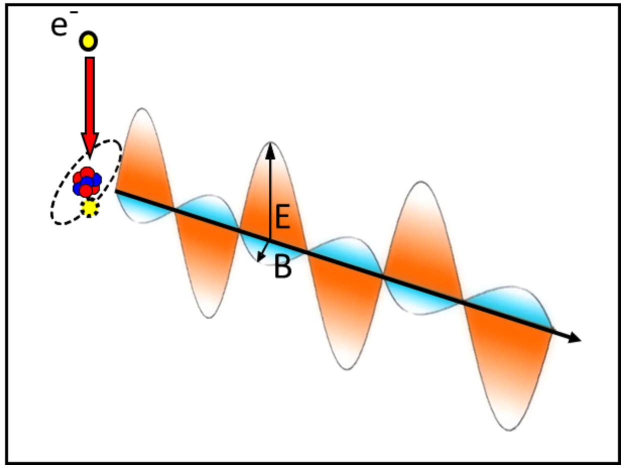
Schnopper et al., PRL 29, 898 (1972)

angular distribution

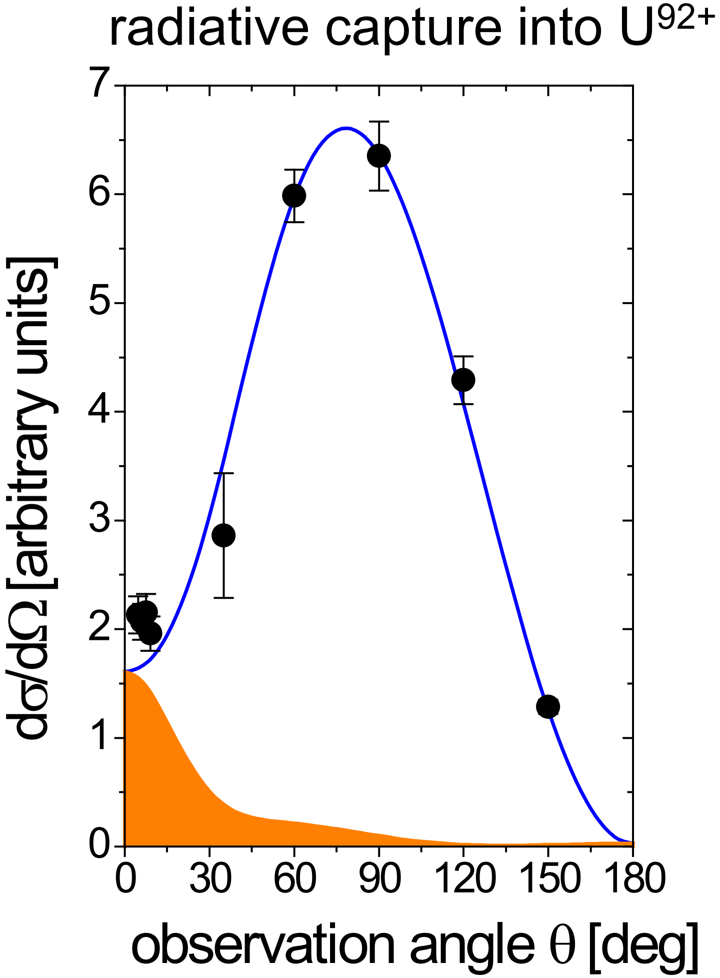


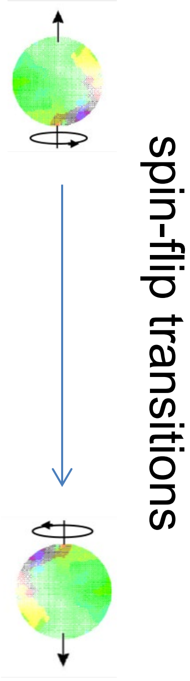
Spindler et al., 42, 832 (1979)

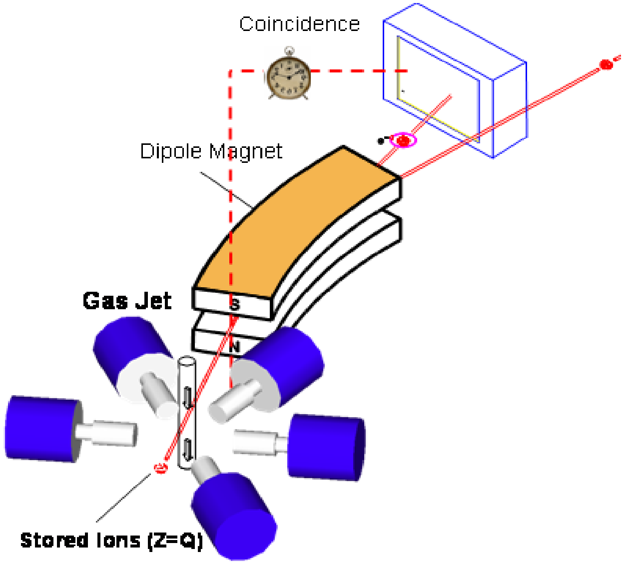
Polarization



Photon angular distribution for REC into the K-shell (U^{92+}, 310 MeV/u)





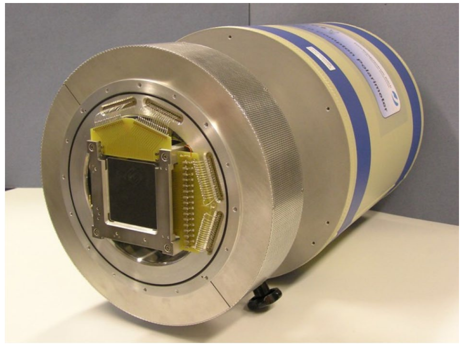


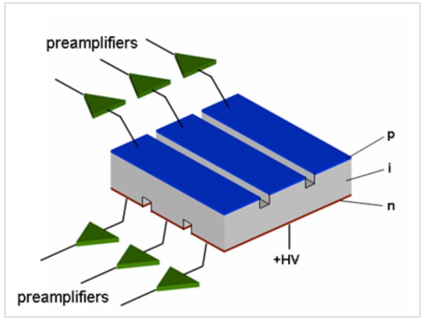
At high-Z, the coupling of the magnetic moment of the electron to the radiation field leads to spin-flip transitions
→ 0 deg emission

observation at 0 deg allows for a kinematical identification of spin-flip transitions

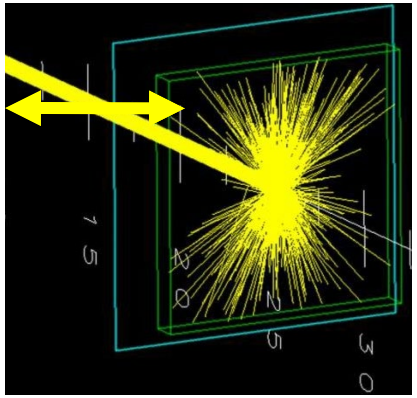
Position sensitive x-ray detectors (> 50 keV)

IKP/FZJ

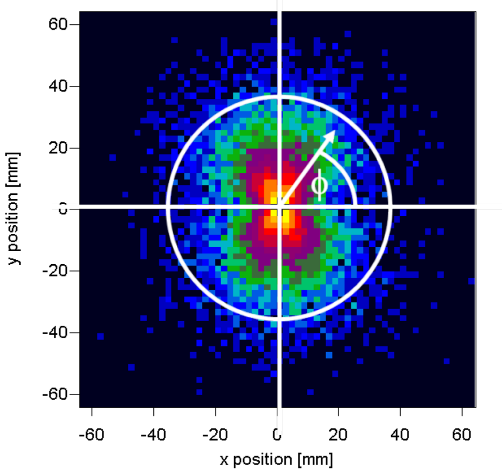




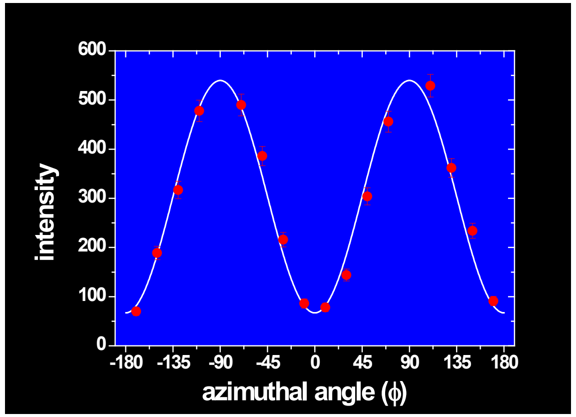
Compton imager for hard x-rays: hard x-ray polarimetry



Simulation:
linearly polarized x-rays



2D image (experiment):
Compton distribution



Azimuthal intensity distribution

REC/Radiative Recombination: Source of Intense, Monoenergetic, Almost Completely Polarized Hard X-Rays in Ion-Atom Collisions

Xe^{54+} => H_2, 155 MeV/u

Degree of linear Polarization:

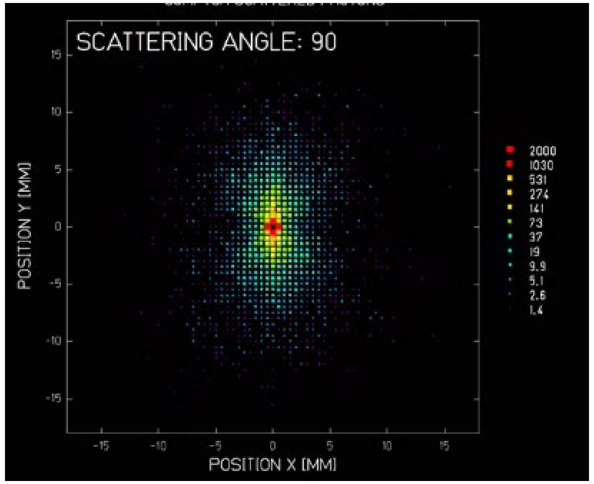
98 ± 1 %

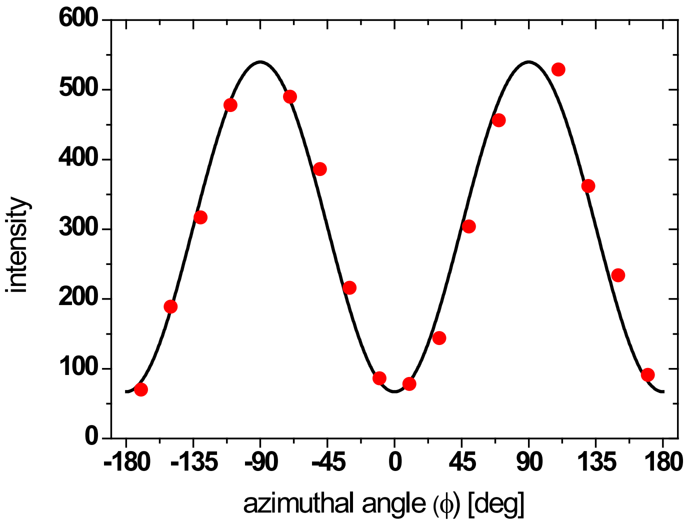
Xe^{54+} => H_2, 30.9 MeV/u

Degree of linear Polarization:

$99.9^{+0,1}_{-1,5}$ %

Compton Scattering Distribution



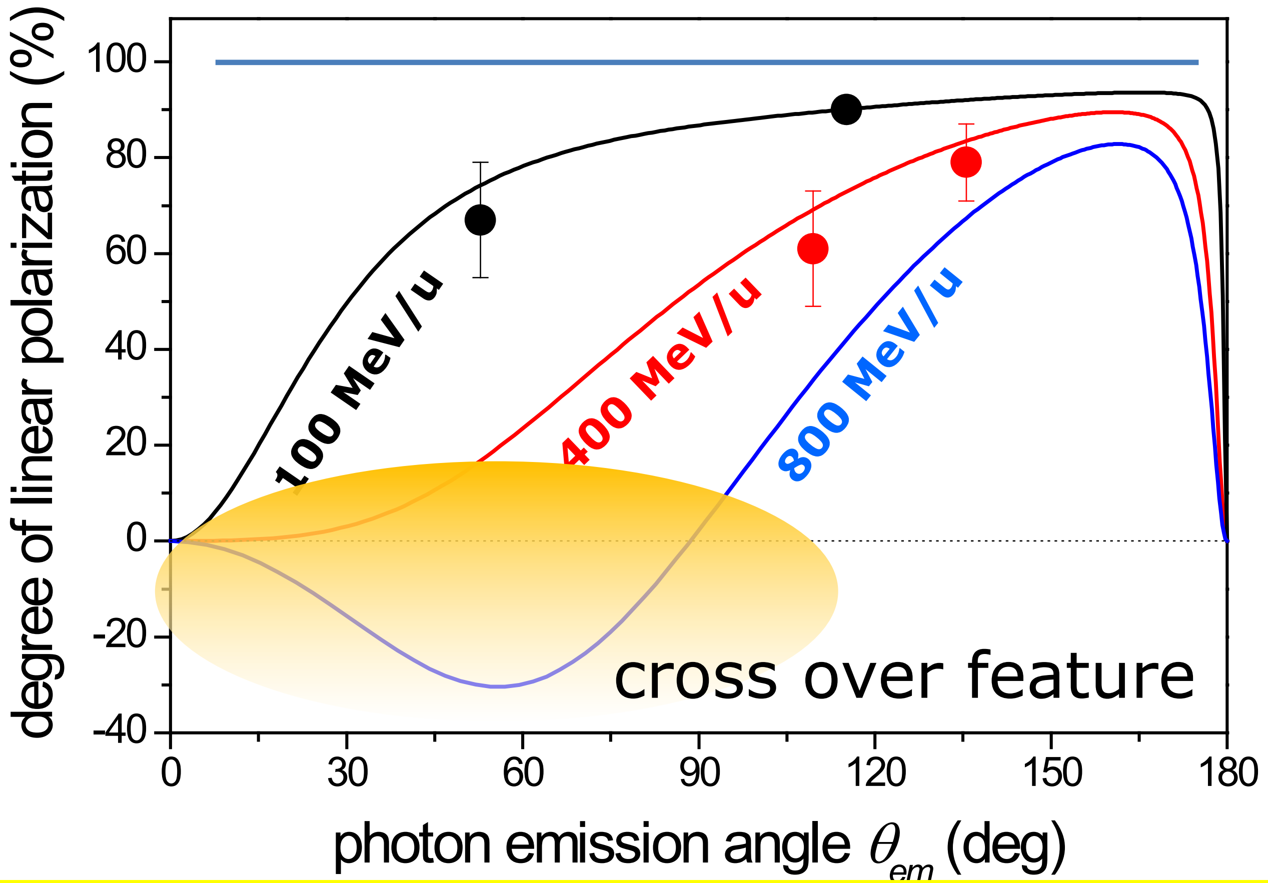


155 MeV/u: S. Hess, PHD thesis

30.9 MeV/u: M. Vockert, PhD thesis; PRA 99, 052702 (2019)

Comparison of xenon and uranium proofs the importance of the nuclear charge for the higher-multipole contribution, leading to a depolarization of the RR photons.

Linear Polarization study for Radiative Recombination Into Bare uranium



S. Tashenov et al., PRL 97, 223202 (2006)

G. Weber et al., PRL 105, 243002 (2010)

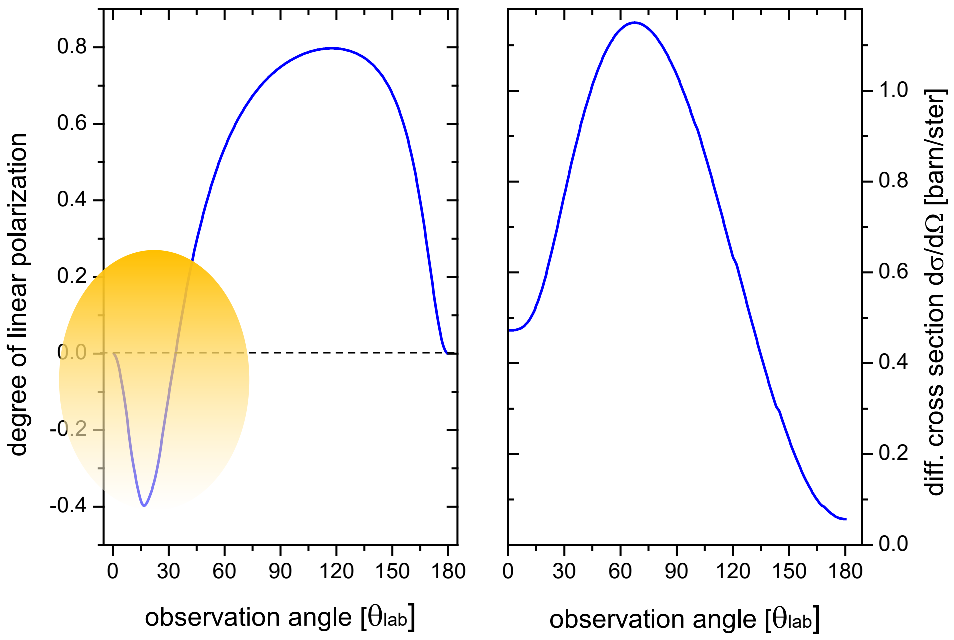
Theory:
J. Eichler and A. Ichihara, Phys. Rev. A **65**, 052716 (2002)

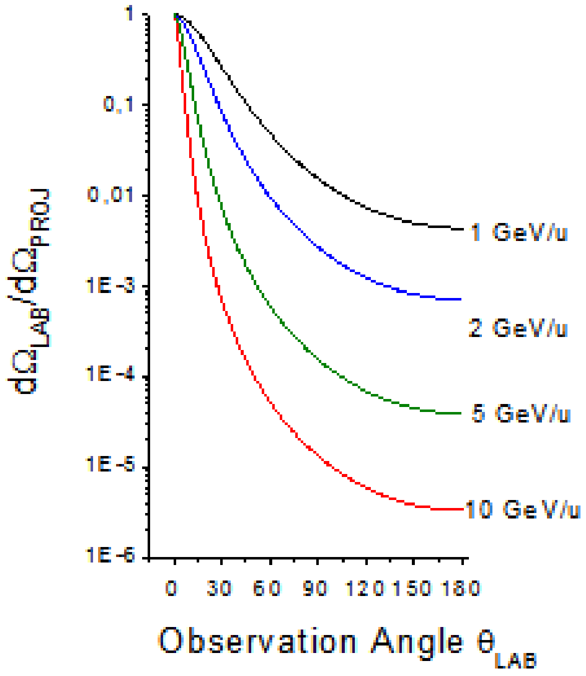
A. Surzhykov et al., PRA 68, 022710 (2003)

Linear polarization studies are a very sensitive probe for the occurence of higher-multipole components and spin-effects. At high energies theoretical results are still puzzling.

Ideal Conditions for the Clear Identification of „Cross-Over Effect“

1 GeV/u; U^{92+} + e^-





Despite relativistic solid angle transformation, recombination and bremsstahlung transitions are predicted to be an intense radiation source at backward angles in the lab frame.

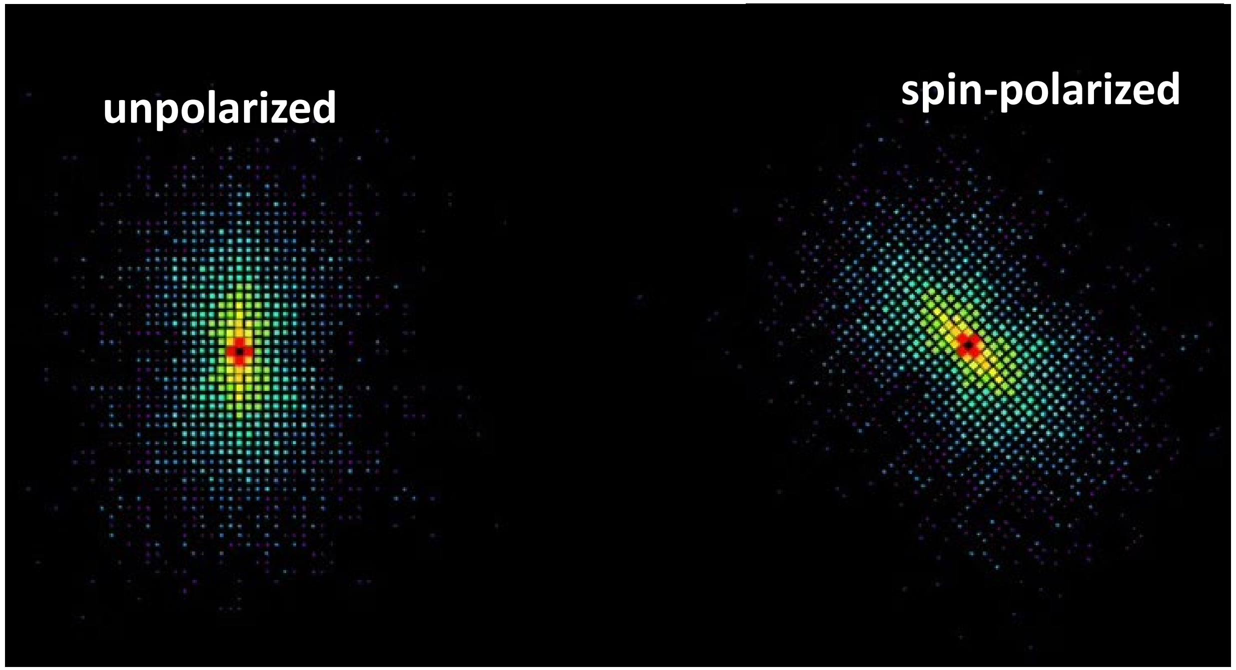
Recombination: spin polarized particles beams (ions or electrons)

Spin Polarized Ion Beams

for spin polarized ions, the polarization plane and scattering plane are not equal.

A.Surzhykov et al.,
PRL 94, 203202 (2005)

R. Pratt, R. Levee, R. Pexton, and
W. Aron, Phys. Rev. **134**, A916 (1964)
“polarization transfer for the photoeffect“

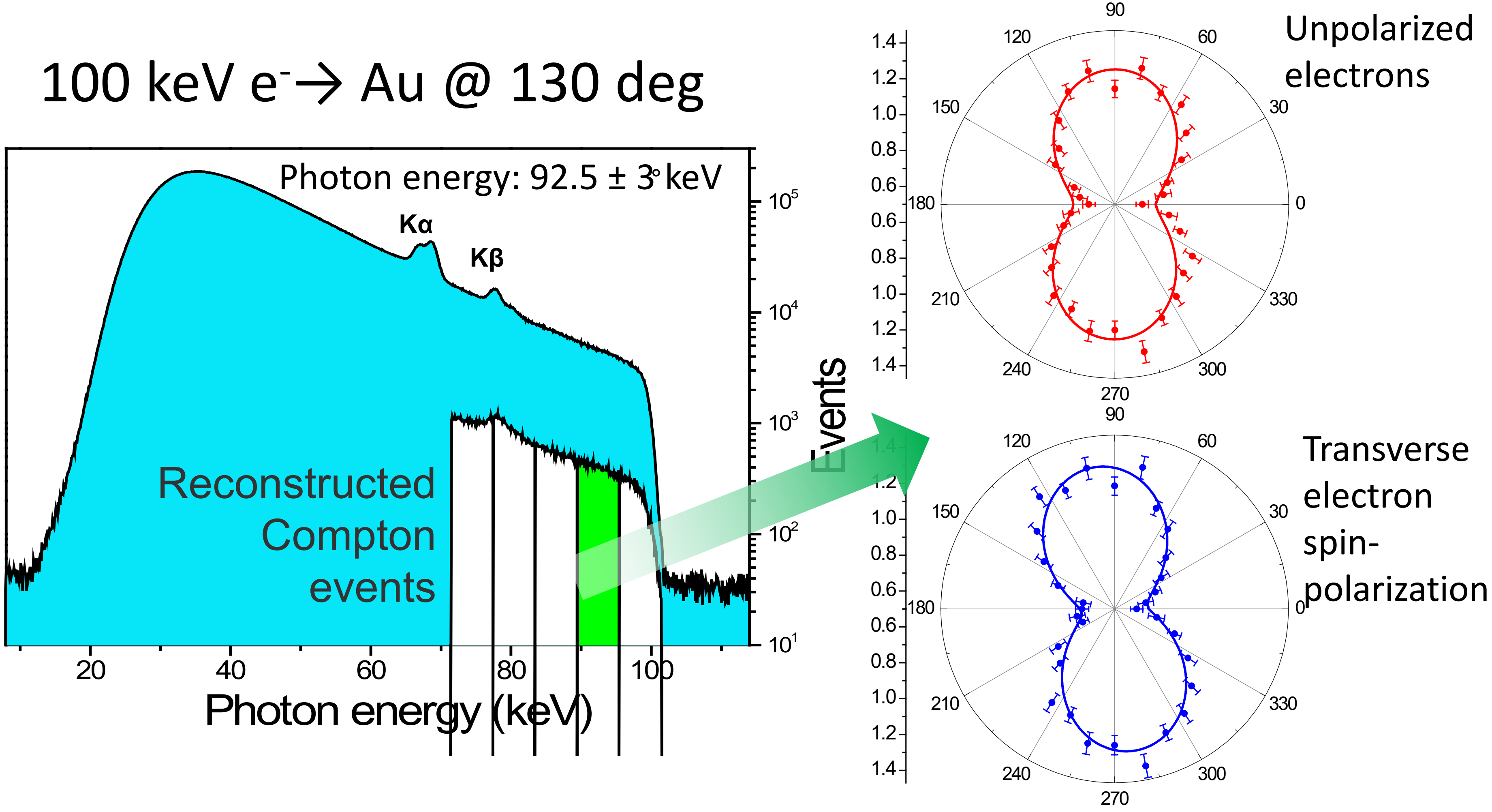


Control over the spin-polarization of stored ions:
required for the search of the electric-dipole momentum of elementary particles and for atomic PNC experiments.

REC/Recombination would be a possible tool:
Polarization transfer from the particles to the photons

Bremsstrahlung of spin-polarized electrons

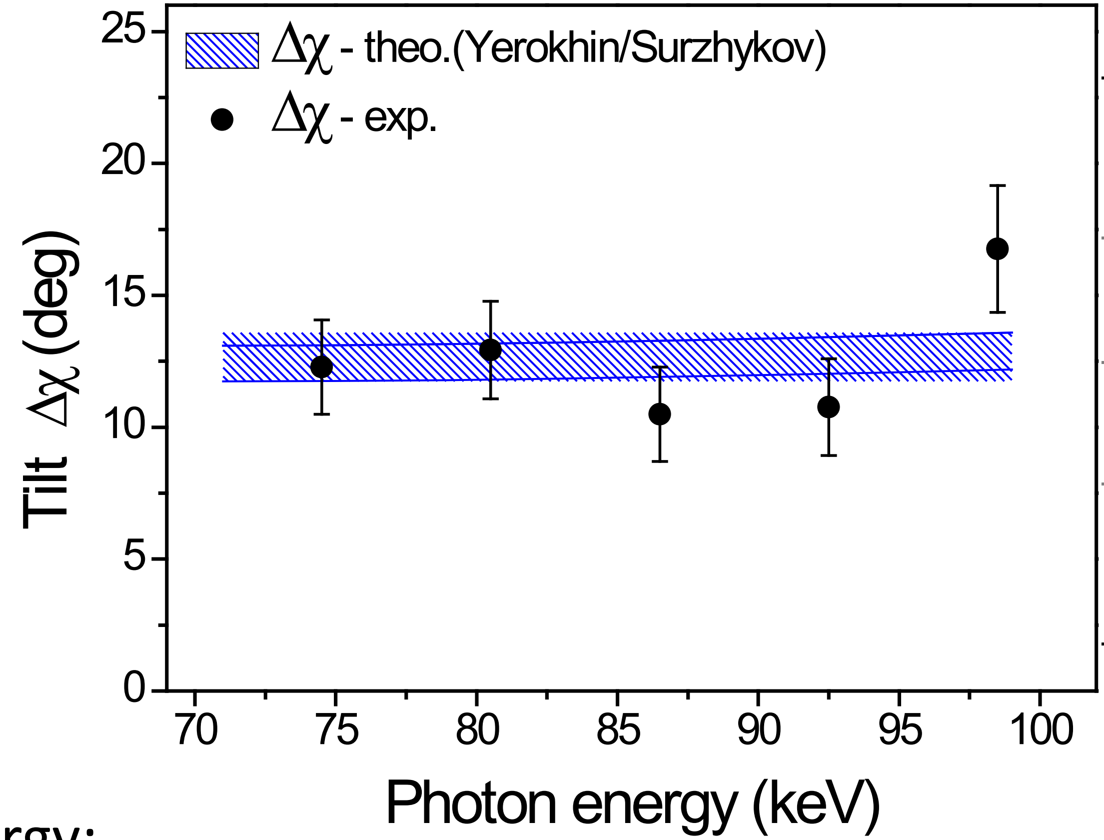
100 keV e⁻→ Au @ 130 deg

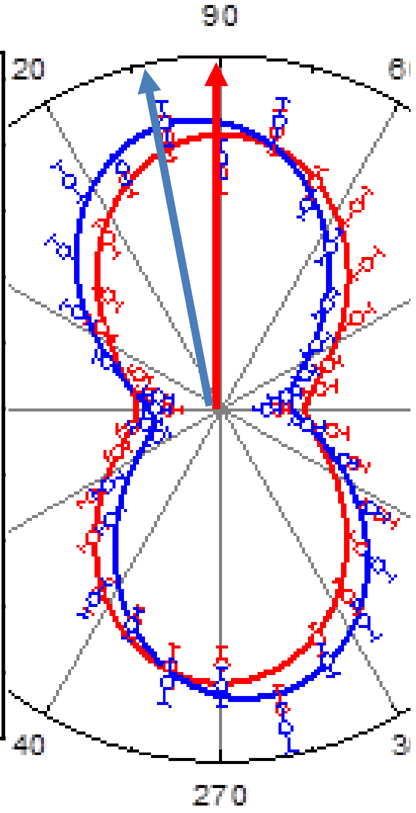


Experiment done at the spin-polarized electron source at TU-Darmstadt

R. Märtin et al., PRL 2012

Bremsstrahlung of spin-polarized electrons





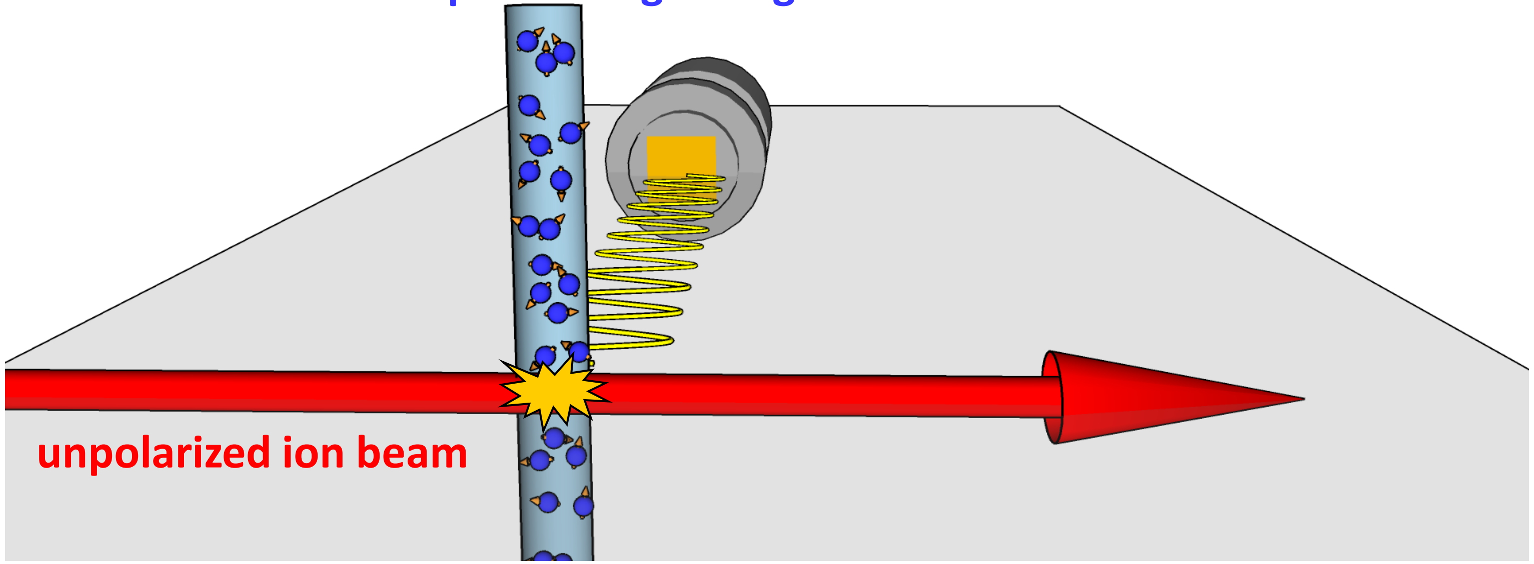
Experiment:
76 ± 5 %
transversal
polarisation
in the reaction
plane

R. Märtin et al., PRL 2012

Photon energy:
92.5 ± 3 keV

V. A. Yerokhin and A. Surzhykov, Phys. Rev. A 82, 062702 (2010)
R. Pratt, R. Levee, R. Pexton, and W. Aron, Phys. Rev. **134**, A916 (1964) „ polarization transfer for the photeffect“

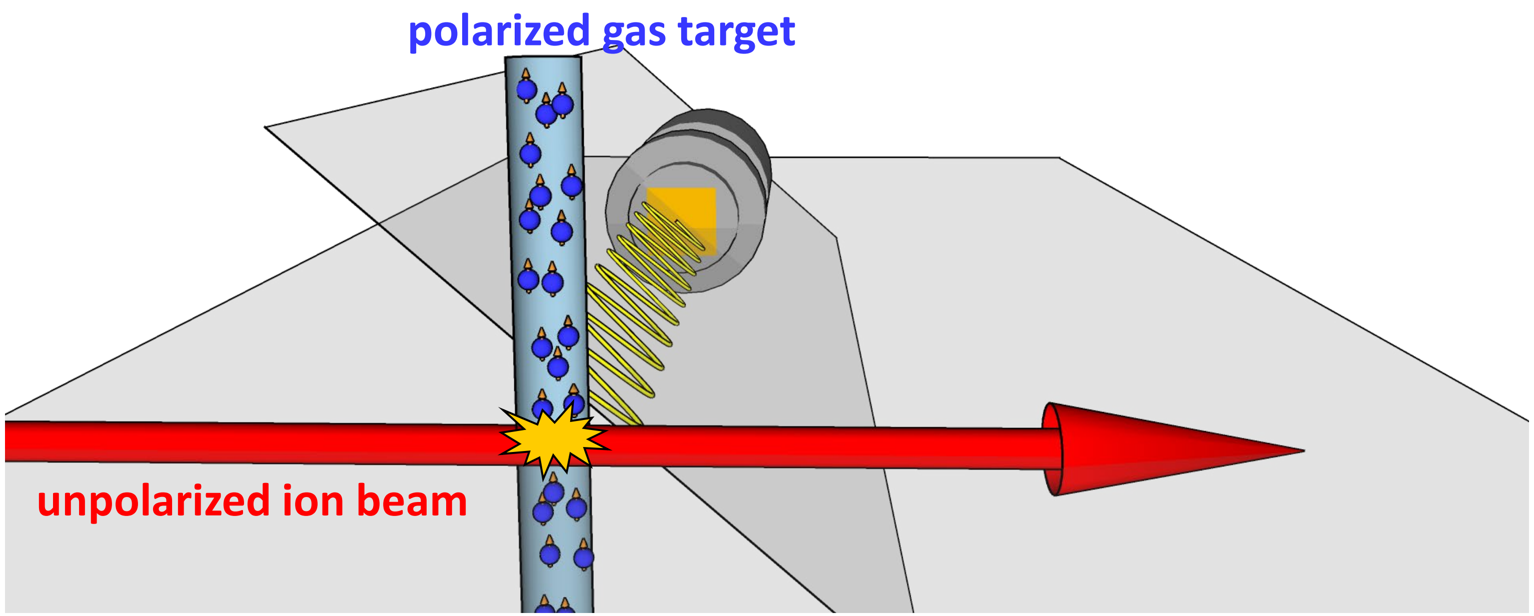
REC: spin polarization of particles beams (ions or electrons)



Unpolarized collision system:

Emitted photons are polarized along the reaction plane.

REC: spin polarization of particles beams (ions or electrons)

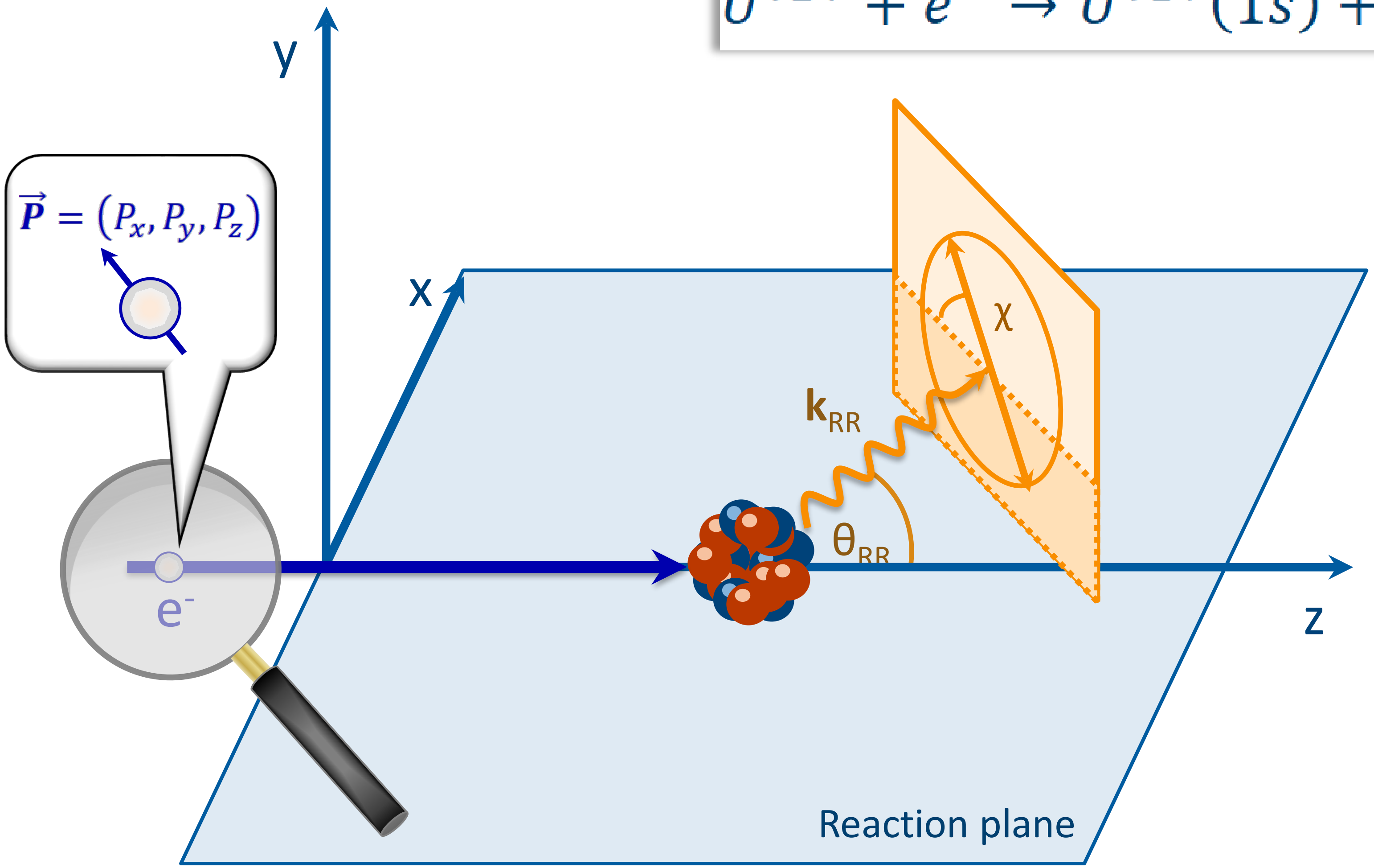


Polarized collision system:

Orientation of photon polarization depends on the spin polarization of the colliding particles. → Polarization transfer from particles to photons → Spin diagnostic!

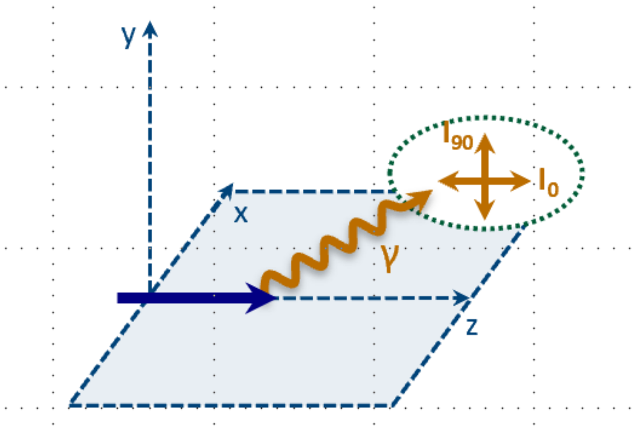
Geometry

$U^{92+} + e^{-} \rightarrow U^{91+}(1s) + \gamma_{RR}$



Stokes parameters of light

$$P_1 = \frac{I_{0^\circ} - I_{90^\circ}}{I_{0^\circ} + I_{90^\circ}}$$



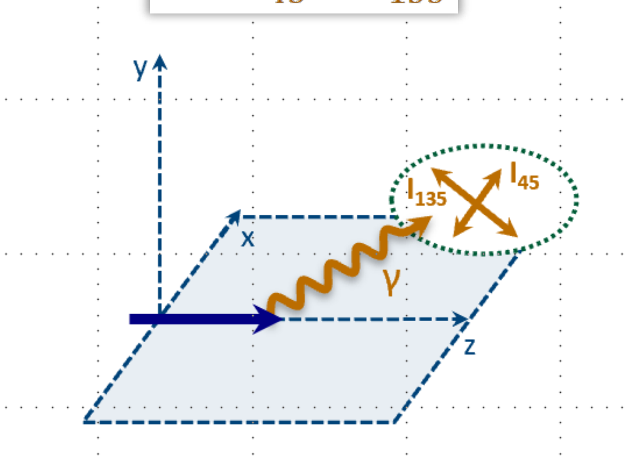
P_L Degree of Polarization

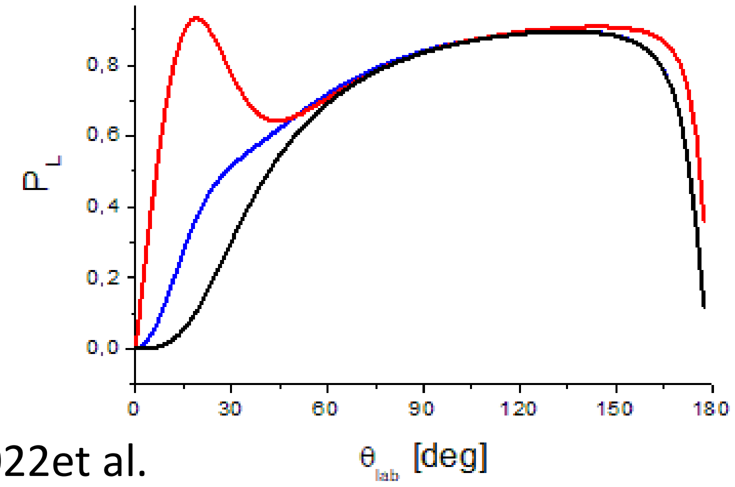
$$P_L = \sqrt{P_1^2 + P_2^2}$$

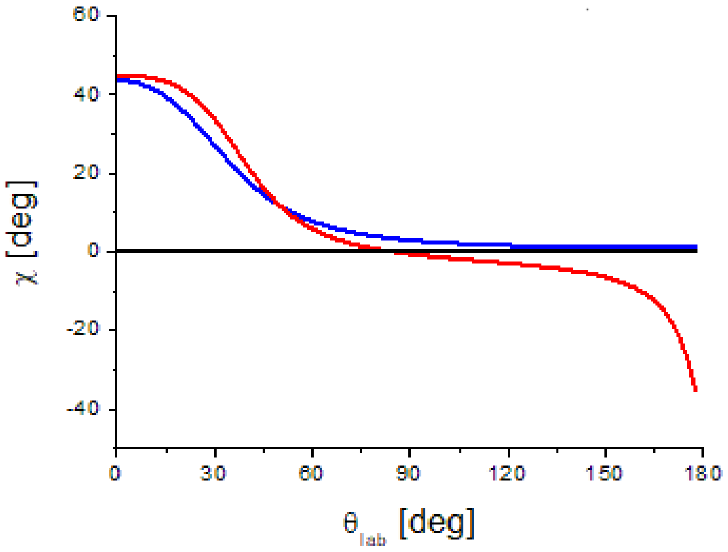
χ tilt angle of scattering elliipse

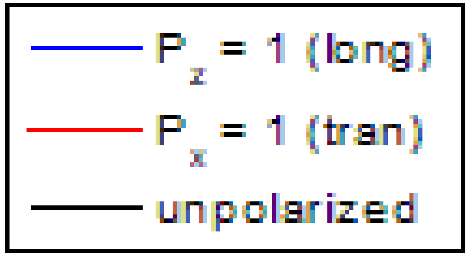
$$\tan 2\chi = \frac{P_2}{P_1}$$

$$P_2 = \frac{I_{45^\circ} - I_{135^\circ}}{I_{45^\circ} + I_{135^\circ}}$$





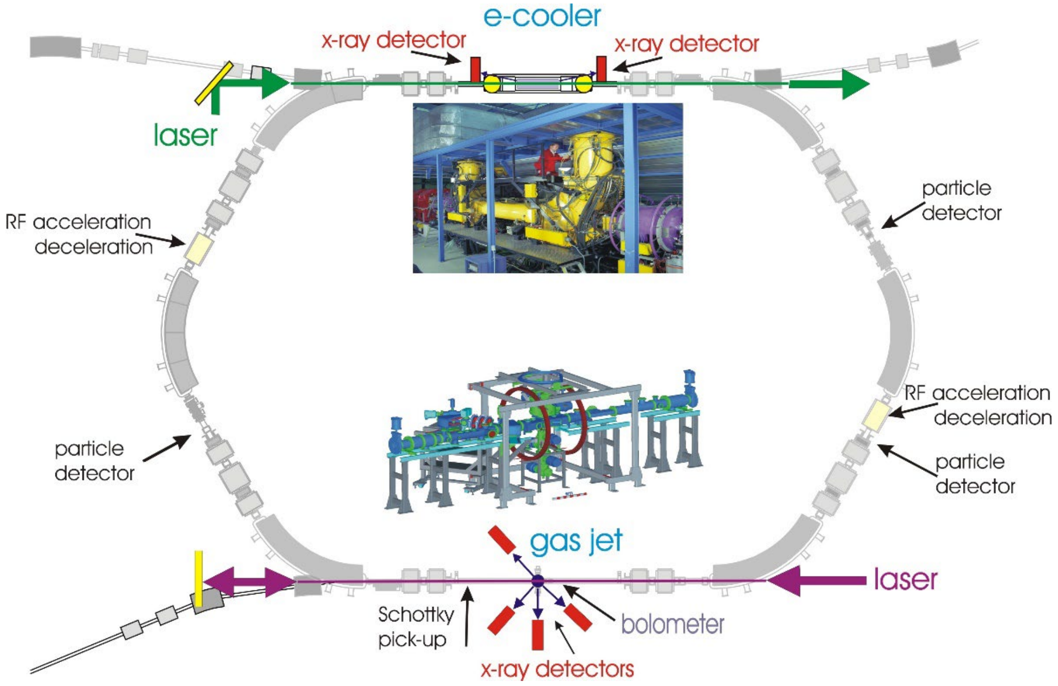




Theory: A. Maiorova 2022et al.
PRA 107, 042814 (2023)

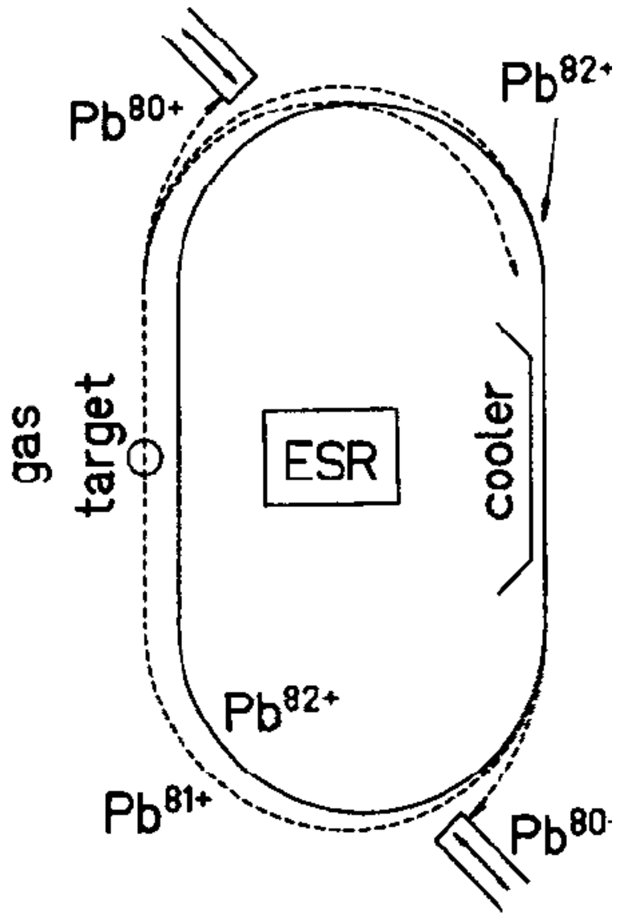
Preservation of the polarization in the ESR

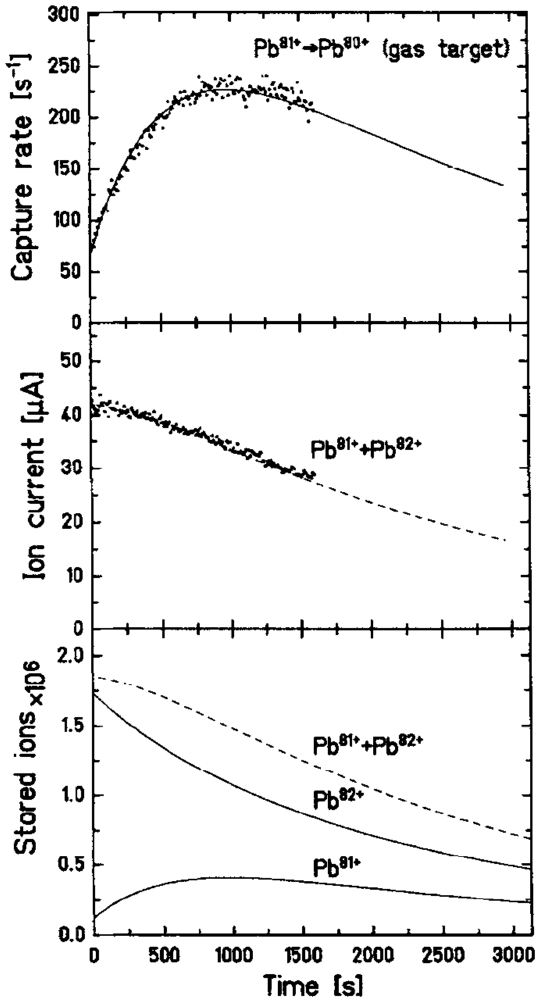
ToDo



The preservation of the polarization in the ESR is a prerequisite to this, but depolarization effects in storage rings are well understood, and can be well controlled by spin tracking calculations. Possible processes for buildup of polarization need to be identified and studied.

Also an Option: Charge State Breeding





Alternative to the electron cooler one may use stochastic cooling at 400 MeV/u

Experiments at the ESR
(at 400 MeV/u Stochastic Cooling)

Application of spin-polarized targets: R&D projects with large discovery potential

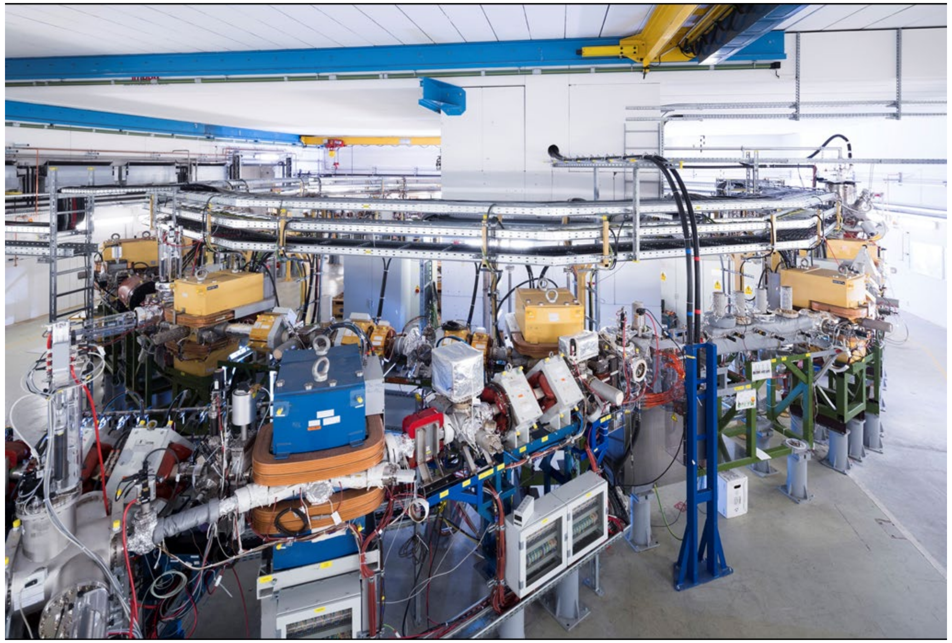
- Step 1: Simple start
  - electron spin dependent RR radiation characteristic
  - detection of neutrino recoil for bound-state beta decay

- Step 2: Test of preservation for stored polarized ions
  - Test of polarization transfer via total capture cross-section / photon characteristics (Pauli blocking)

- Step 3: Spin-transfer to nuclei: e.g. $^{209}Bi^{82+}$ (ions with large magnetic moment ⇔ spin orientation transfer to the nucleus)

- Step 4: Experiments with spin-controlled stored particles

CRYRING@ESR (in operation since 2020)

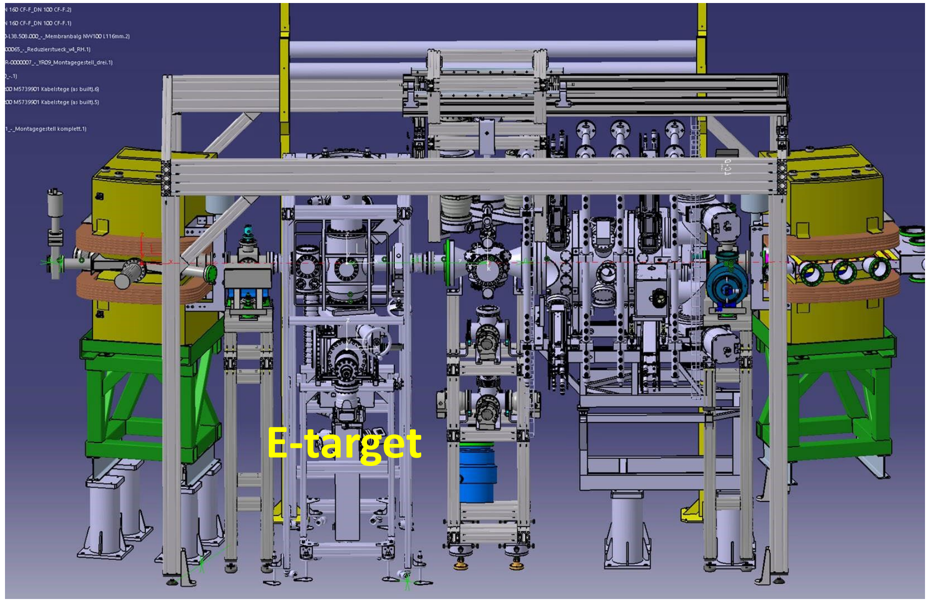


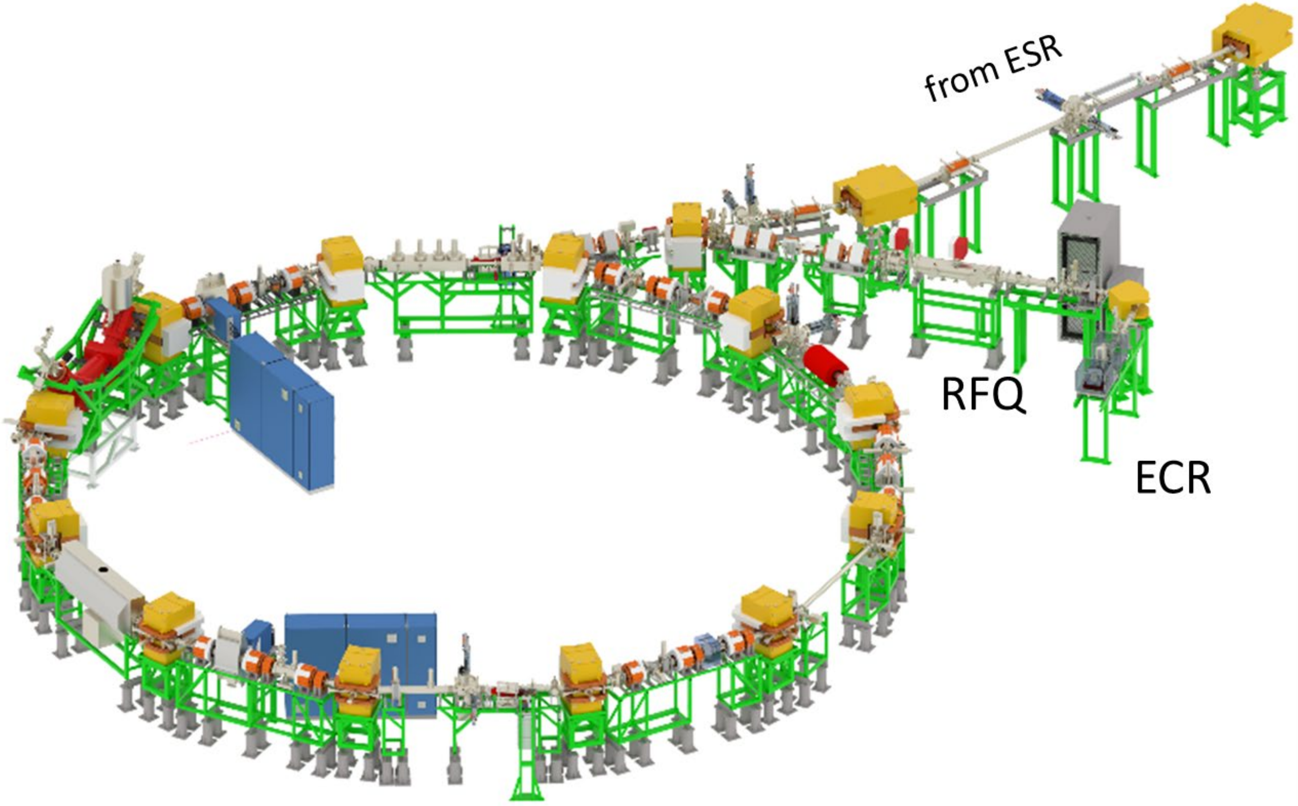
Key features: CRYRING@ESR

- Low-energy and electron cooled beams
- Electron cooling with adiabatic expansion -> ultra-cold e-beam
- High-luminosity for in-ring experiments
- Very fast deceleration 7 T/s
- Internal gas-jet and electron targets
- Slow and fast extraction

- CRYRING@ESR: Swedish in-kind contribution to FAIR with substantial contributions of the SPARC collaboration
- first physics production runs with beams from ESR in 2020
- Experiments with local injector and ion source possible

CRYRING@ESR (in operation since 2020)

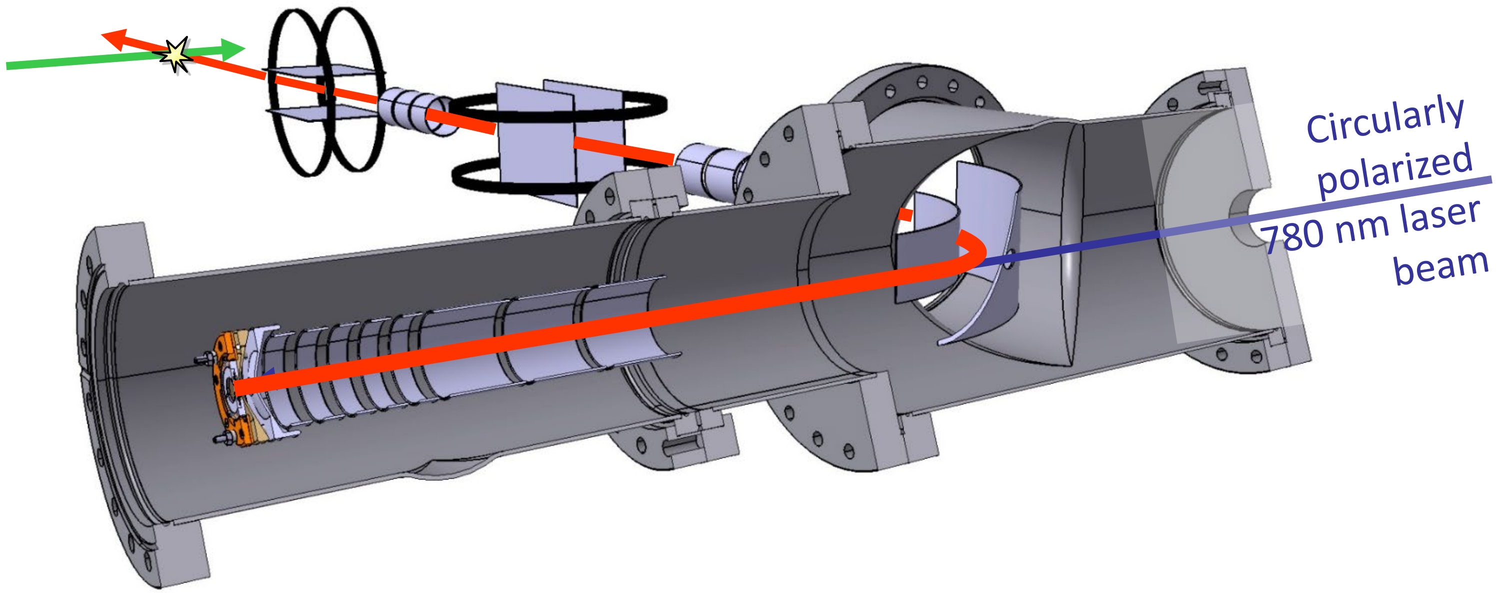




Options:
Spin-polarized electron target
Polarized ion source

Polarized electron target (PEGASUS)

- GaAs photocathode established technique for spin-polarized electrons
- Beam optics optimized for high intensities in simulations (SimIon)
- Test setup available at GSI



M. Lestinsky et al.

Summary

PROCEEDINGS OF SCIENCE

Towards experiments with polarized beams and targets at the GSI/FAIR storage rings

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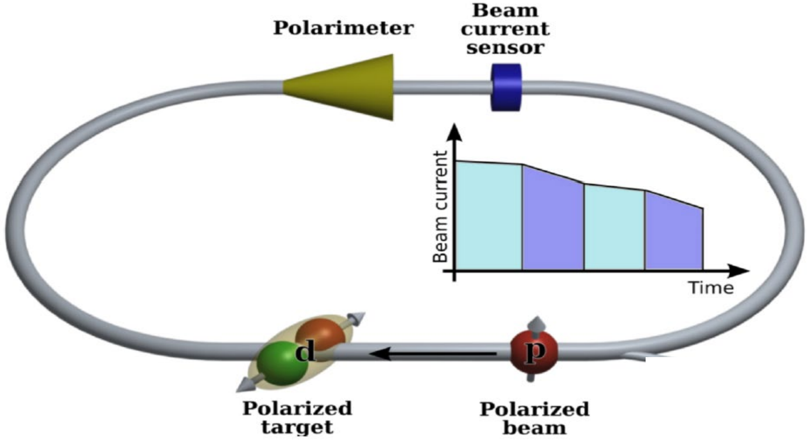

GPAC 2022: LOI0073 ✓

Step 1: Diagnostics
- electron spin dependent x-ray radiation
- neutrino recoil for bound-state beta decay

Step 2: Spin preservation
- absolute capture cross-section / photon emission (Pauli blocking)

Step 3: Spin-transfer to nuclei
- ions with magnetic moment ⇔ spin transfer to the nucleus)

Goal: Experiments with spin-controlled stored particles

Search for physics beyond the SM
- EDM / Axion search
- Atomic PNC experiments at high-Z

S. Karanth et al., PRL X in press, https://arxiv.org/abs/2208.07293

Thank you for your attention !

Grenoble | Mainz | Paris | Frankfurt | Heidelberg | MPIK | Darmstadt

IMP Lanzhou | Caen | Darmstadt | Jülich | Cracow | Berlin | Gießen | Münster

FIAS | Jena | Greenbelt | Stockholm | Gießen | Braunschweig

Thank you for your attention