# Wire Scanners for the 100 keV Polarized Electron Beam Line at the S-DALINAC*

TECHNISCHE UNIVERSITÄT DARMSTADT

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SFB 634




*Supported by DFG through SFB 634

# Outline

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- S-DALINAC
- Polarized Electrons
- Polarized Injector SPIN
- Wire Scanners
- Outlook

# S-DALINAC

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**Design values:**

| | |
|---|---|
| Max. energy: | 130 MeV |
| Energy spread: | $\pm 10^{-4}$ |
| Max. beam current: | 20 (60) µA |
| Duty cycle: | 3 GHz cw |

# S-DALINAC

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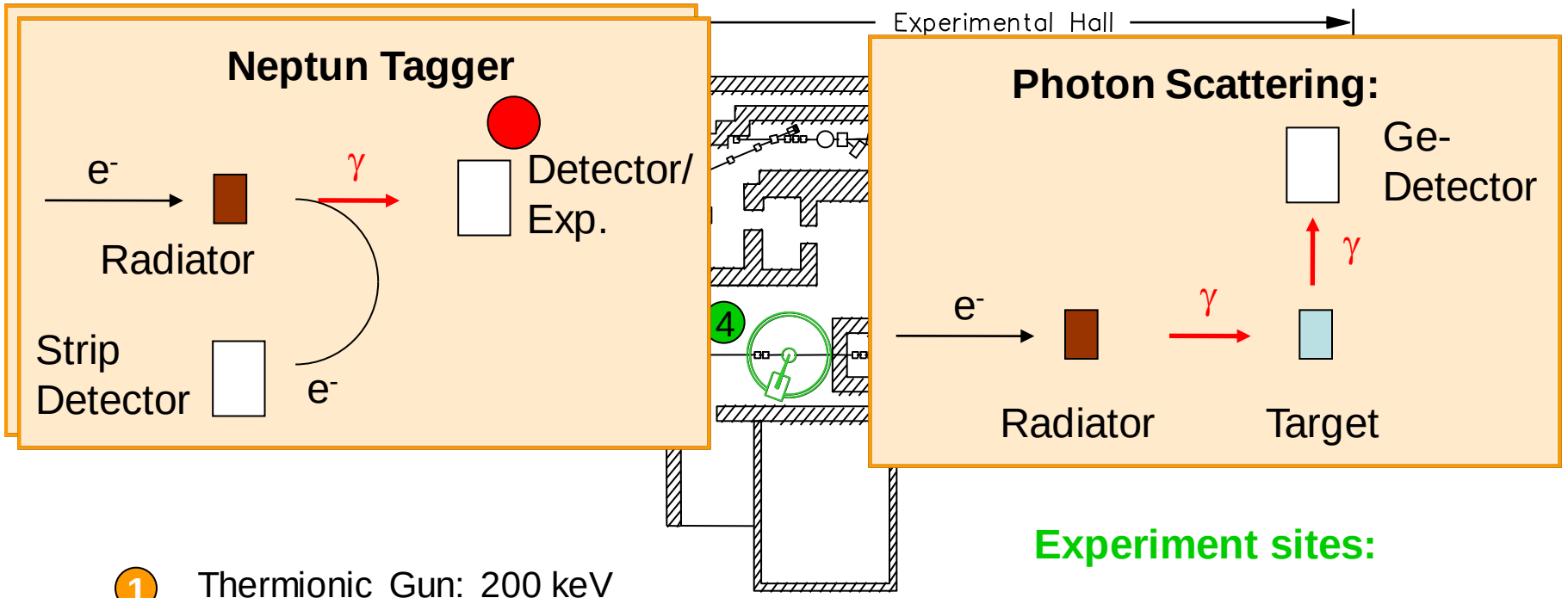


1. Thermionic Gun: 200 keV
2. Injector Linac: 10 MeV
3. Main Linac: 130 MeV (after 3 passes)

Polarized Source

**Experiment sites:**

1. Injector: Photon scattering
2. NEPTUN: Tagged Photon scattering
3. QClam spectrometer
4. High-resolution spectrometer

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# Planned Experiments

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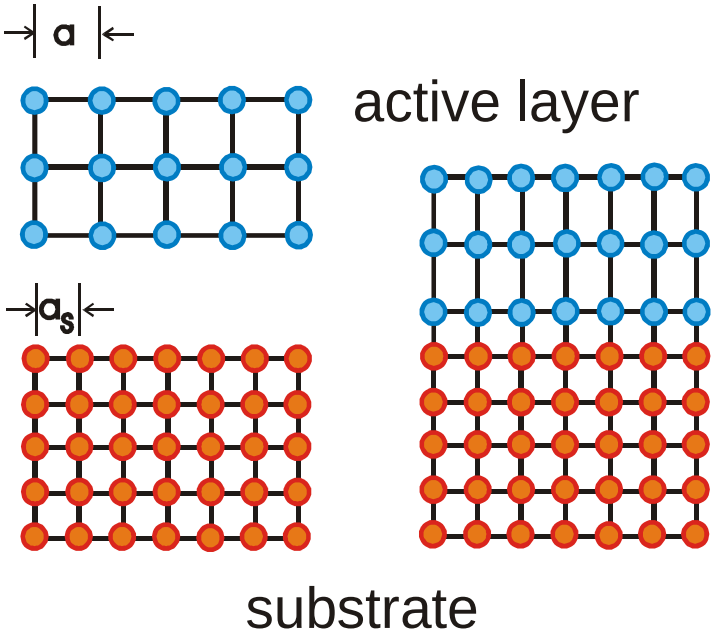
- Low-q (< 1 $fm^{-1}$) experiments with polarized beams
  → Completely unexplored field

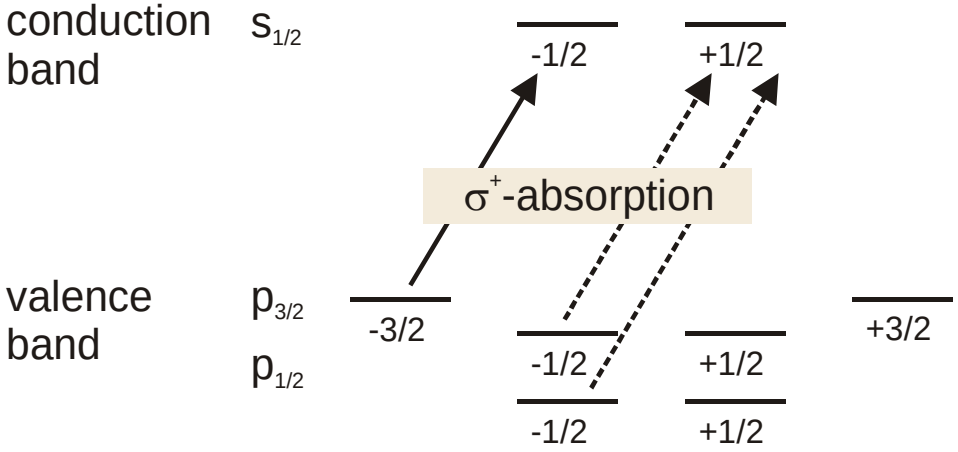
Polarized electron and photon scattering

- Parity-violation effects
  → Polarized bremsstrahlung

- Additional nuclear structure functions
  → Polarized electron scattering

# Strained GaAs




$P_{theo} = 100\%, \quad P_{exp} \approx 80\%$

Surface preparation: Negative electron affinity (Thin CsO layer)

# Test Stand

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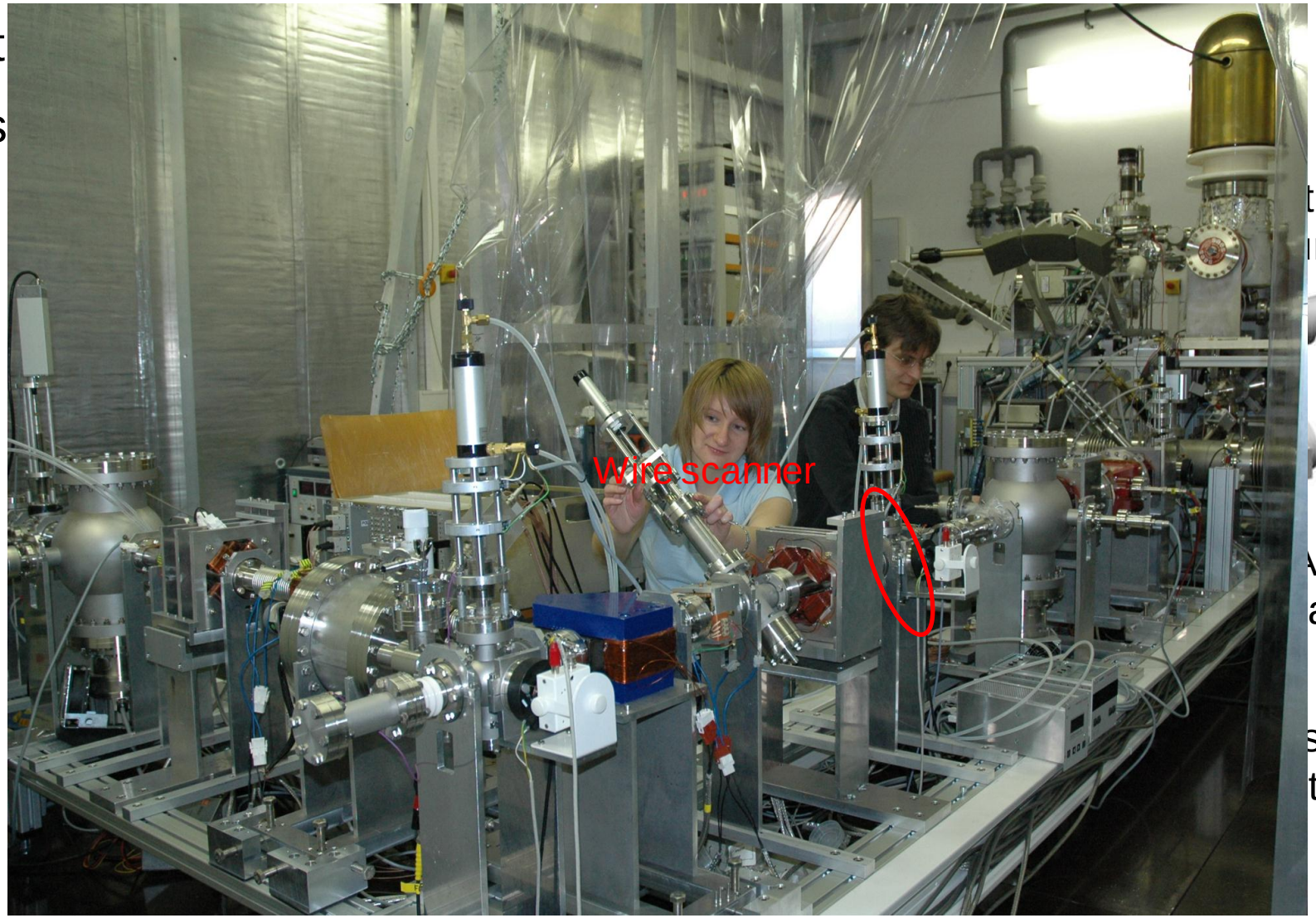
- Cat
- Las

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# Polarimetry: Mott Polarimeter

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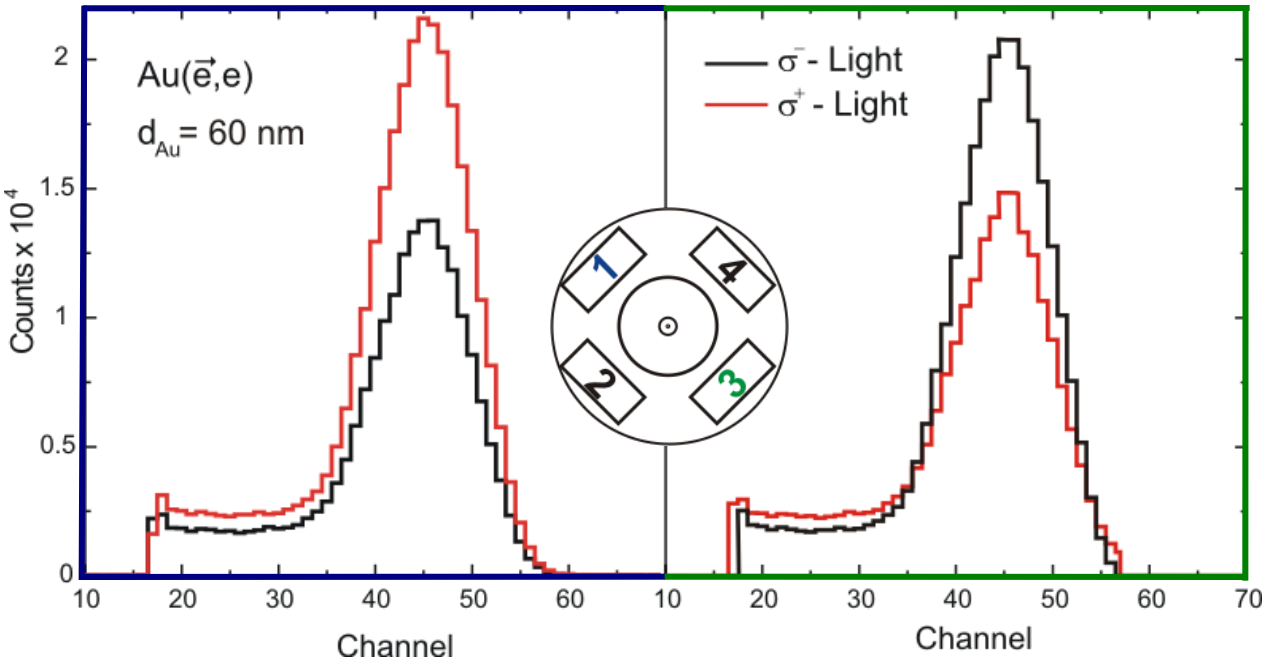
- Elimination of the instrumental asymmetry by helicity switching
- Foil thickness extrapolation – self supporting gold foils 40 - 500 nm




Bulk GaAs: **P = (35 ± 2)%**

Strained superlattice: **P = (86 ± 3)%** **(830 nm)**

# Wirescanner Unit

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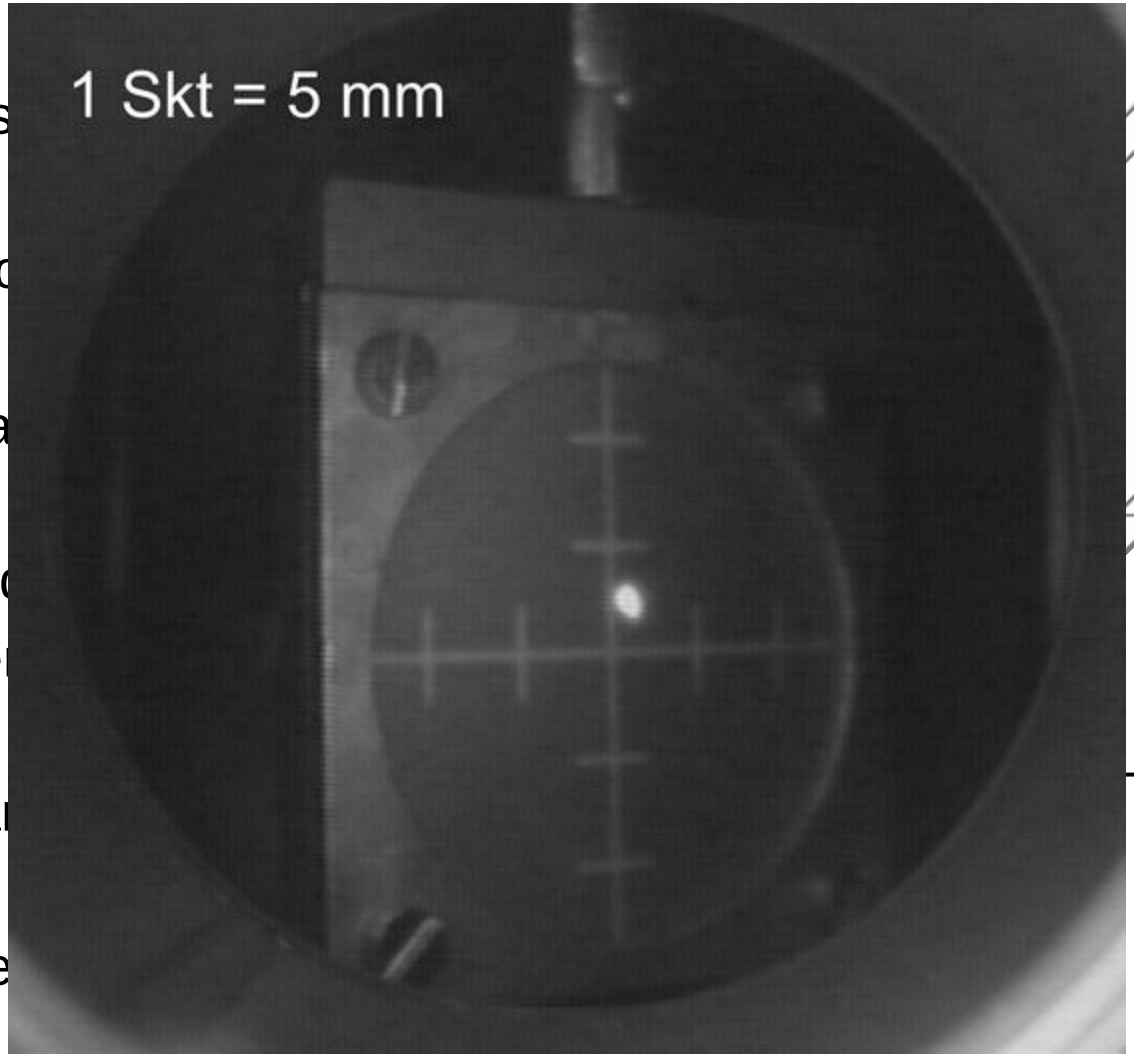
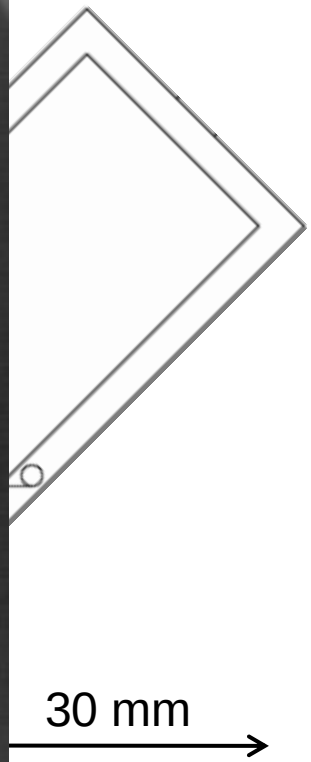
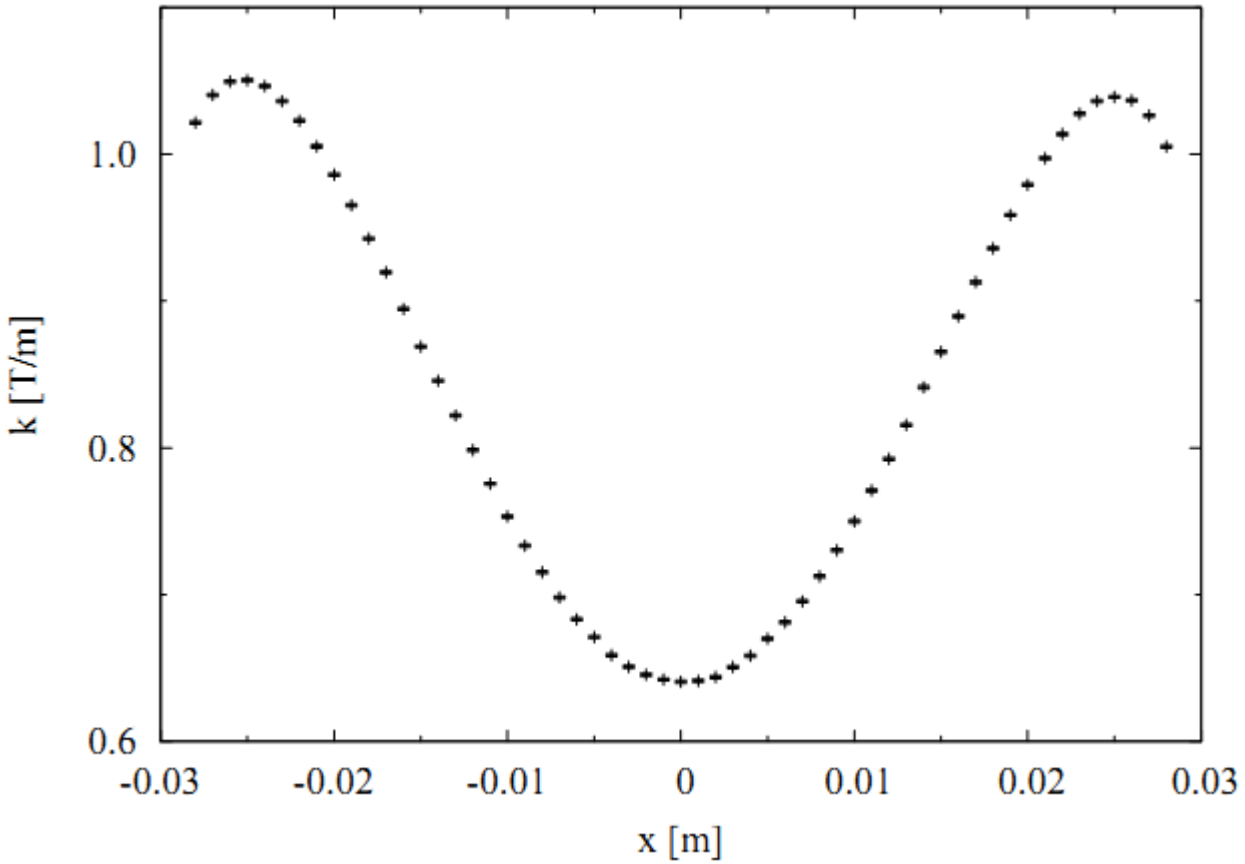
- 50 μm tungs
- Insulated mo
- Pneumatic a
- Position reac
  10 MΩ poter
- 24-bit 2-char
- Position - be



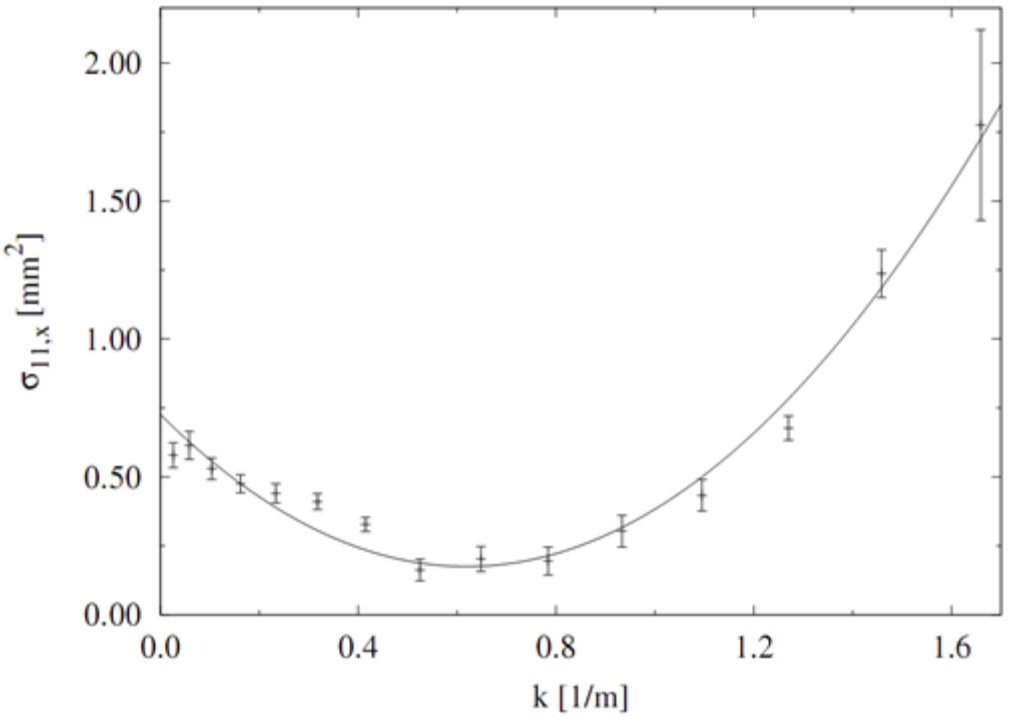



# Quadrupol Field Gradient




- Non-uniform field gradient complicates determination of emittance
- Double-Solenoid used for emittance measurement

# Emittance measurements




Laser diode @ 830 nm

Bulk GaAs

$\varepsilon_{n,x}$ = (0.14 ± 0.03) mm mrad

$\varepsilon_{n,y}$ = (0.19 ± 0.09) mm mrad

Strained GaAs

$\varepsilon_{n,x}$ = (0.13 ± 0.03) mm mrad

$\varepsilon_{n,y}$ = (0.18 ± 0.07) mm mrad

$$\sigma_{11}(k) = a(k-b)^2 + c$$

$$\varepsilon = \frac{\sqrt{ac}}{L^2}$$

# SPIN at the S-DALINAC

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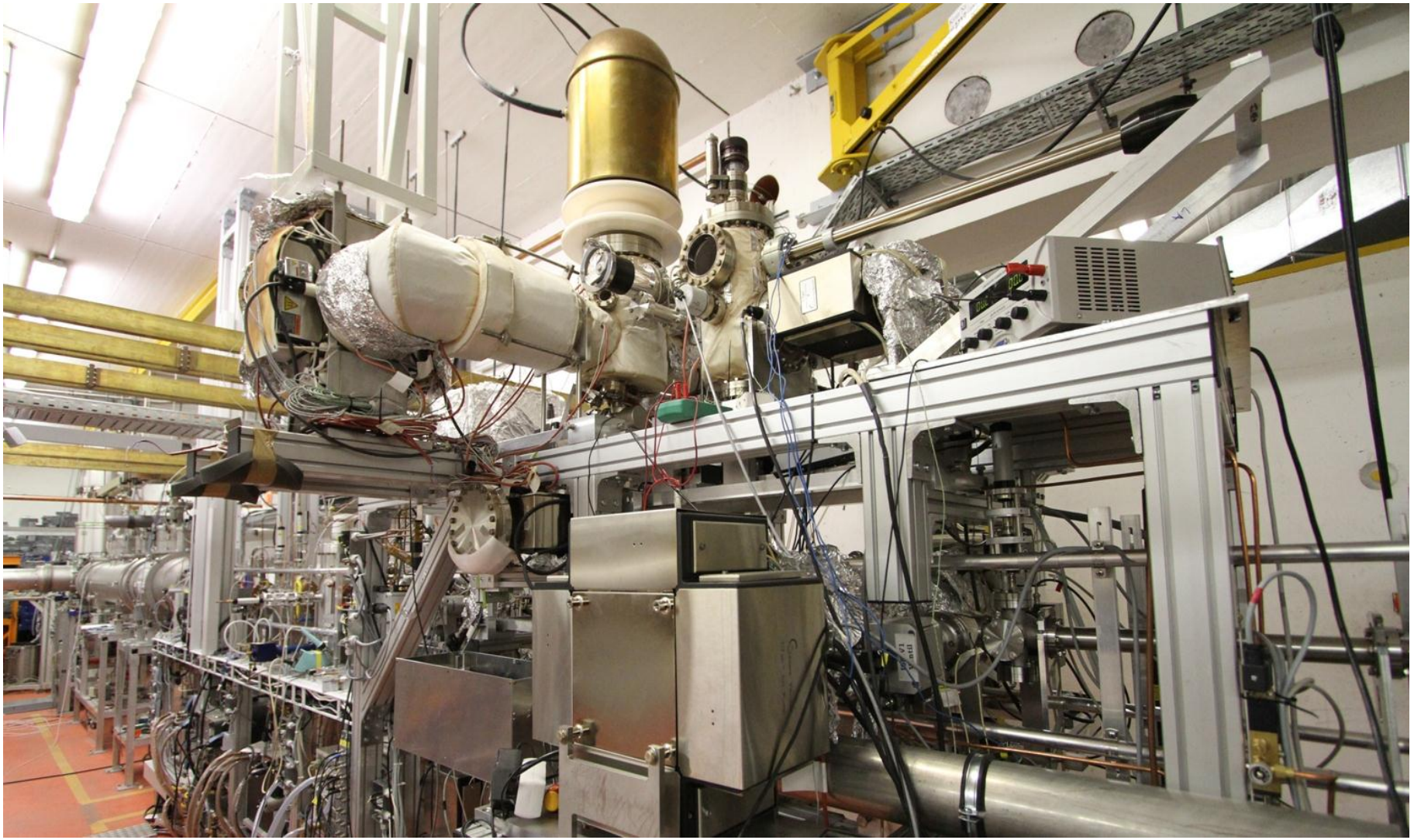
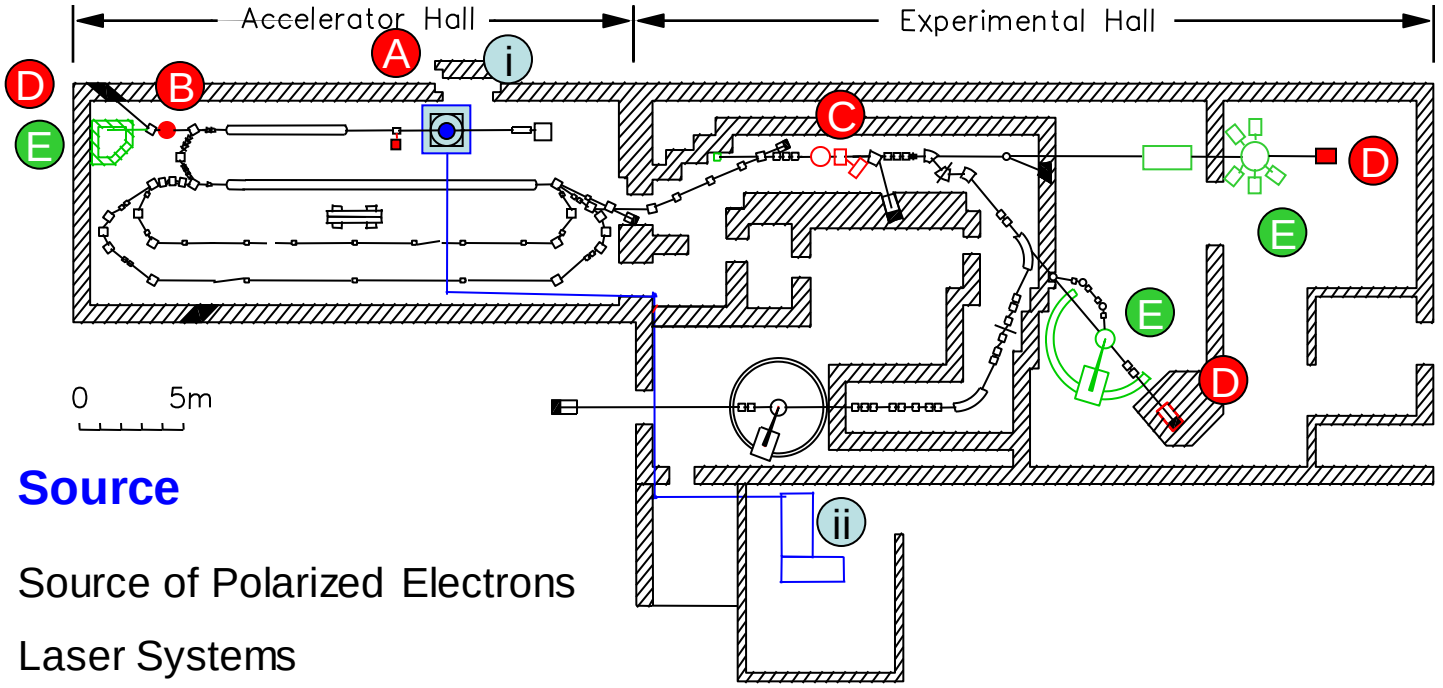


# SPIN at the S-DALINAC




## Source

- i Source of Polarized Electrons
- ii Laser Systems

## Polarimeters

- A 100 keV Mott Polarimeter
- B 10 MeV Mott Polarimeter
- C Møller Polarimeter
- D Compton Transmission Polarimeter
- E Experiments with polarized electrons/photons

# Outlook

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- Measurements with pneumatic and electric manipulators
- Slit measurement for determination of beam pulse length
- Characterization of polarized injector SPIN
- Automatization of emittance measurements
- Preparation for first experiment:
  - Photofission on $^{238}U$ with polarized bremsstrahlung

# Collaboration

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## Institut für Kernphysik, TU Darmstadt

U. Bonnes,

R. Eichhorn,

J. Enders,

Y. Fritzsche,

M. Wagner

# Laser System

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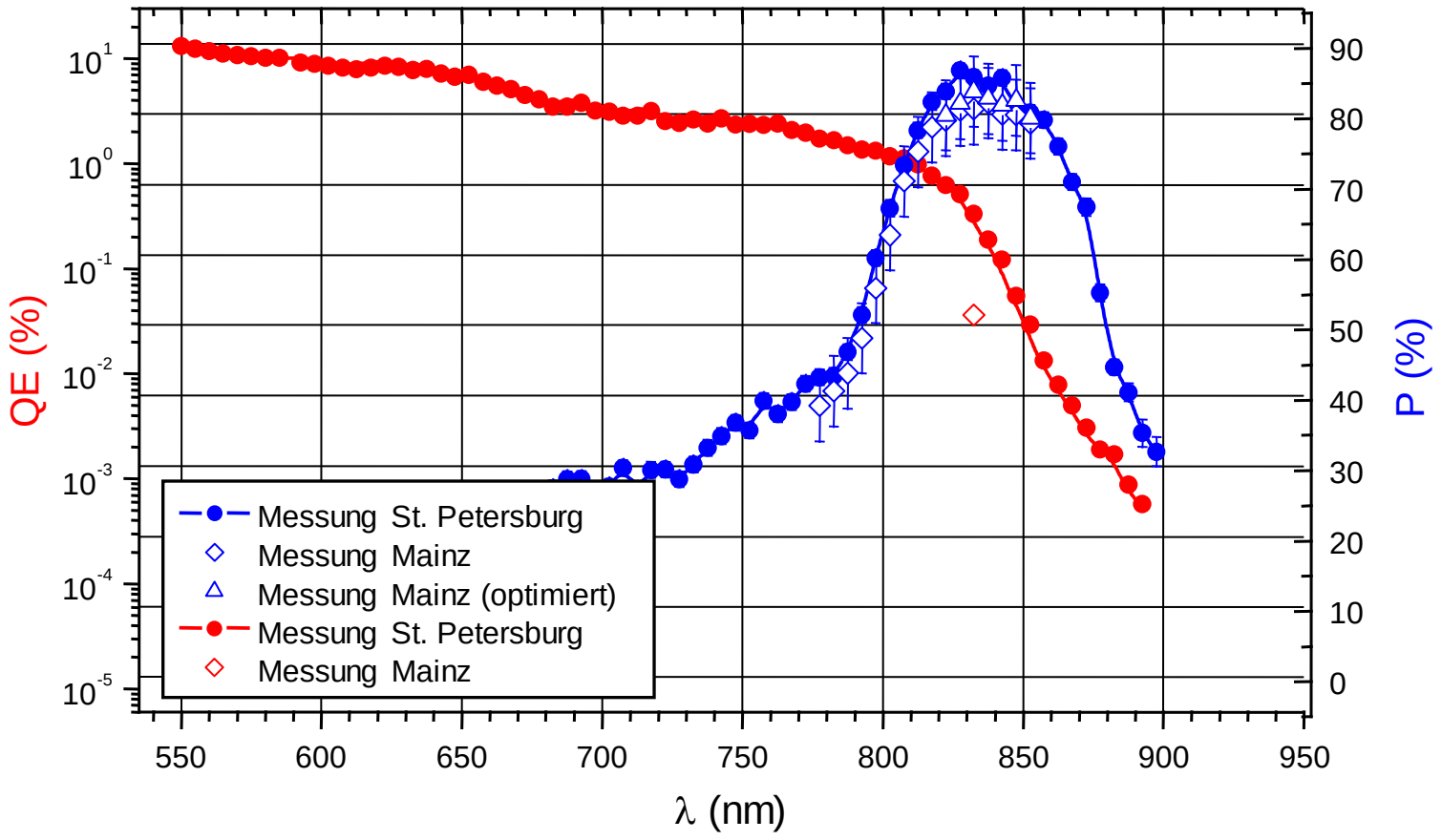
Titanium-Sapphire-Laser:

- possible wavelength 680…1000 nm
- currently 780 nm
- cw-operating at 3 W
- Soft aperture mode locked with repetition rate of 75 MHz, and pulse length of approximately 200 fs and power at 2 W
- Temperature stabilization, 4m m transfer line, acitve stabilization

Diode-laser (ECDL):

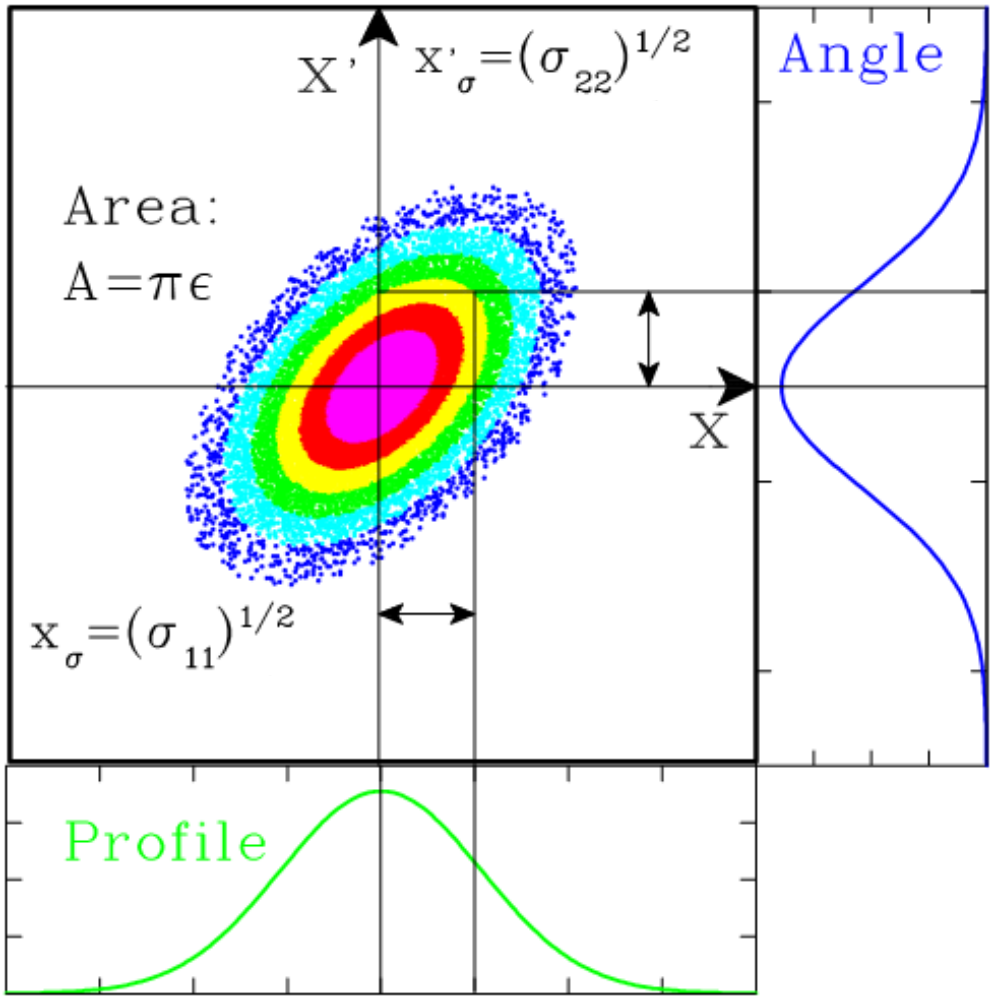
- wavelength variable between 780 and 788 nm
- cw-operating at 80 mW (without amplifier)
- pulse operating at 3 GHz with pulse length of 50 ps and average power 10 mW

# Quantum Efficiency and Polarisation



# Emittance ε : A definition

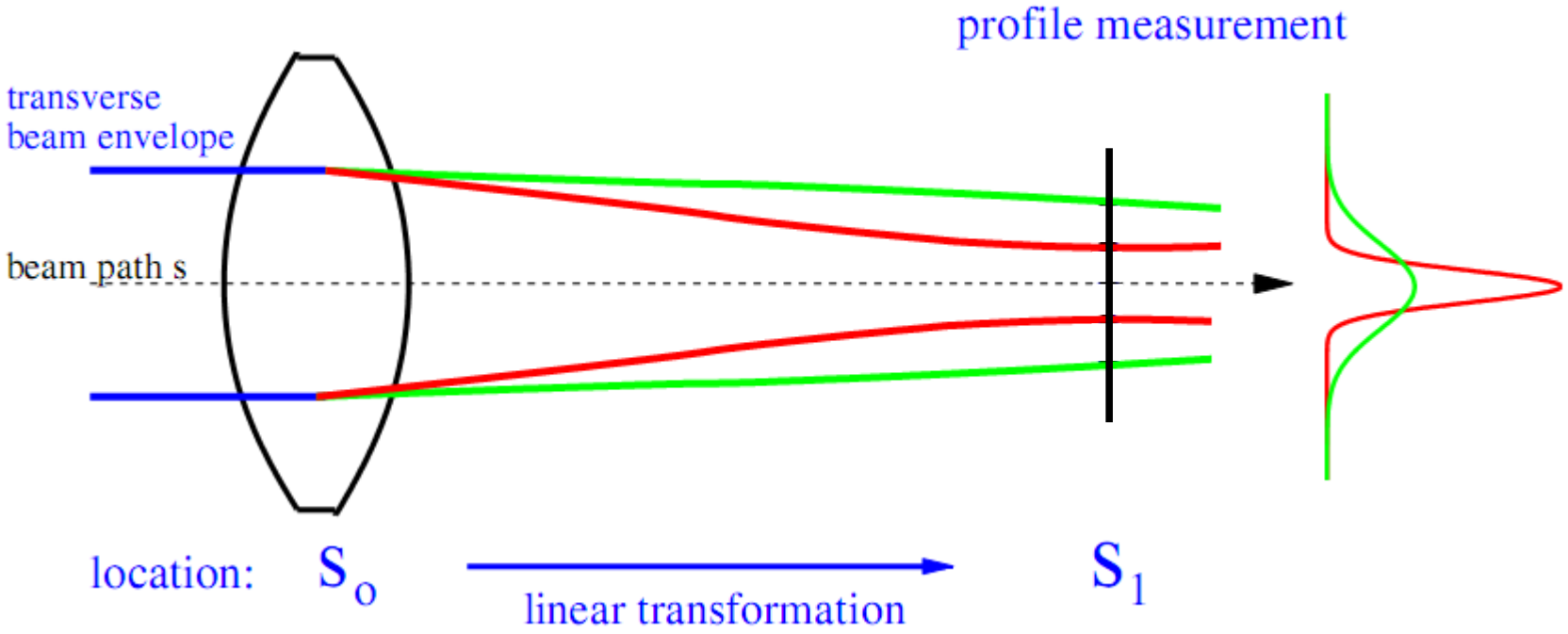
- 2-dim phase space
- Beam matrix
- Emittance
- Normalized emittance




( P.Forck, Lecture Notes, JUAS, 2007 )

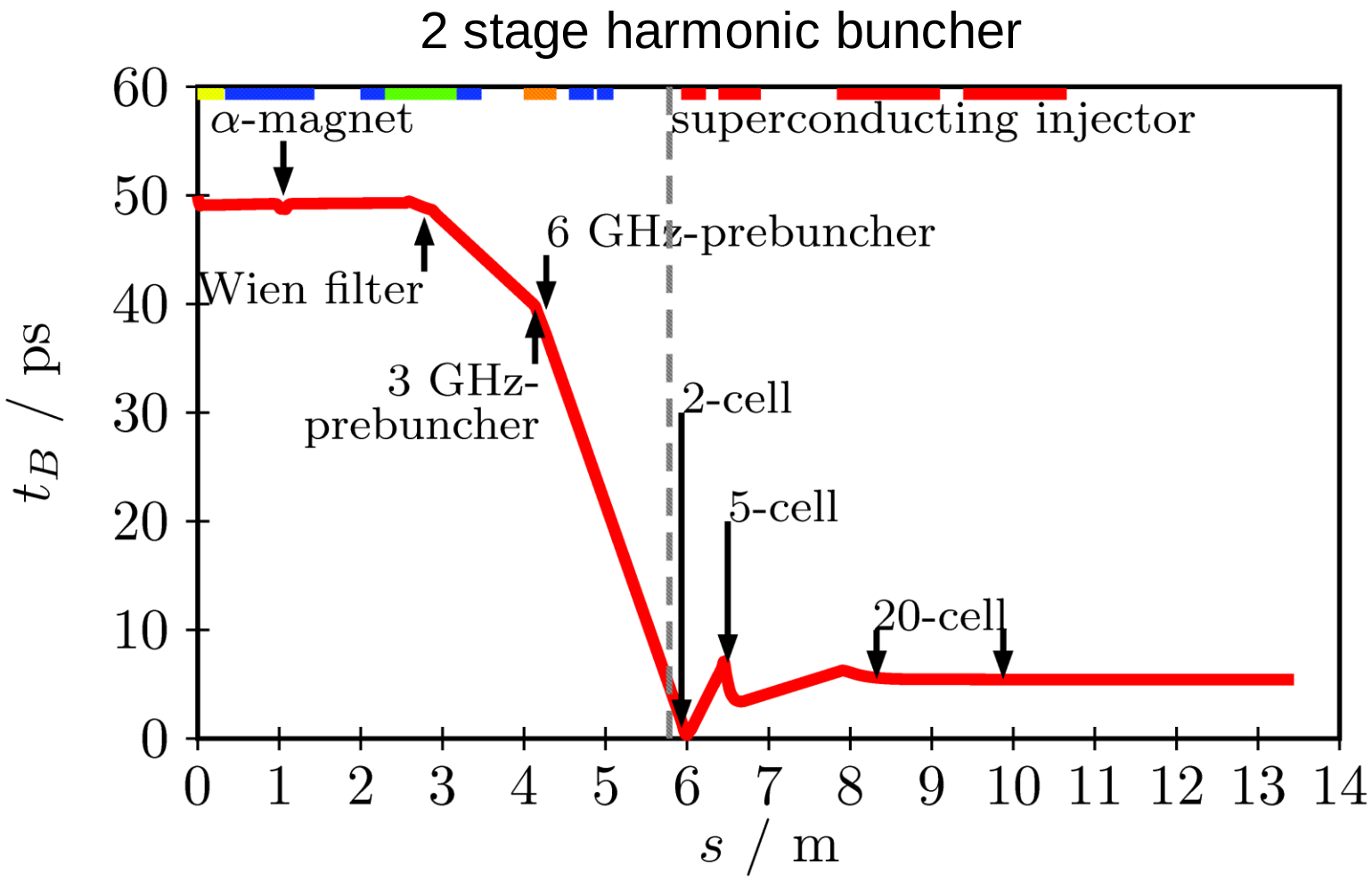
# Profile Measurement

- Several beam profile measurements at different refraction strength
  - Fit Gaussian model distribution to acquired data points




( P.Forck, Lecture Notes, JUAS, 2007 )

# Bunch Length



# Electron energy

- 100 keV injection energy to the superconducting Linac
- 2-cell capture structure necessary

**Injection energy:**

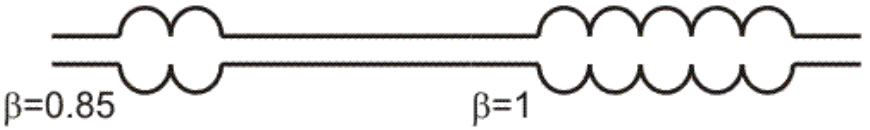
Thermionic gun:

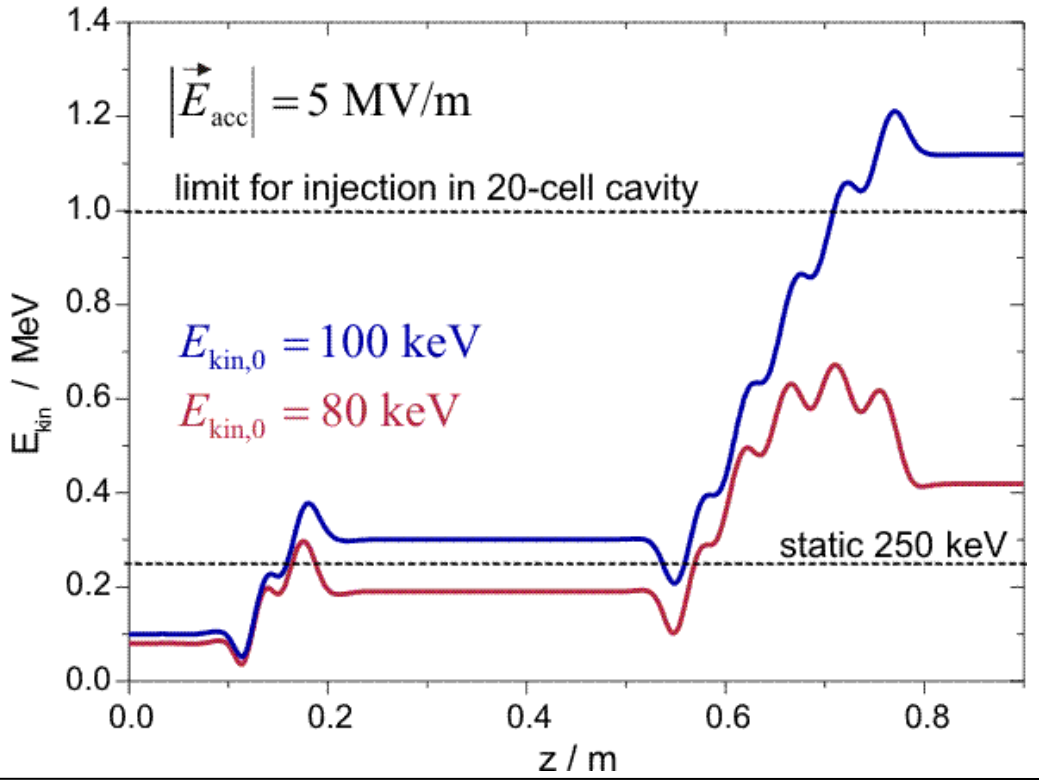
200 keV

Polarized gun:

100 keV

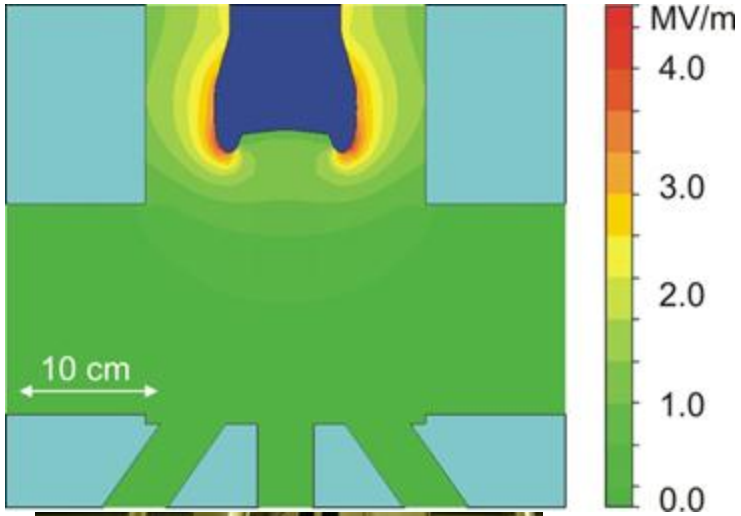
V-Code simulations

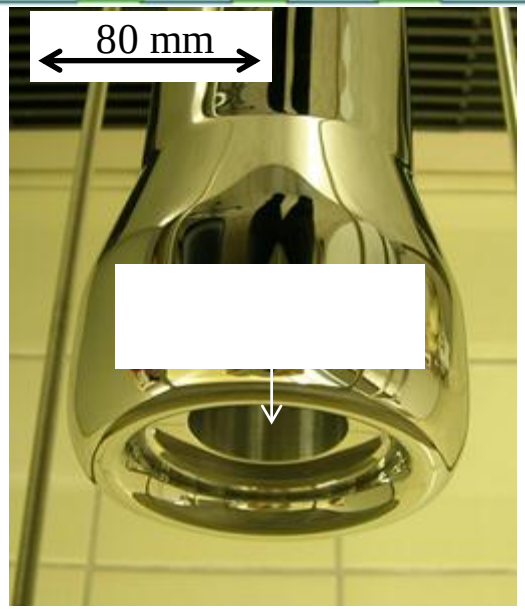



V-Code:
M. Krassilnikov, A. Novokhatski, T. Weiland,
W. Koch, P. Castro, ICAP2000, Darmstadt (2000)

# Electrode

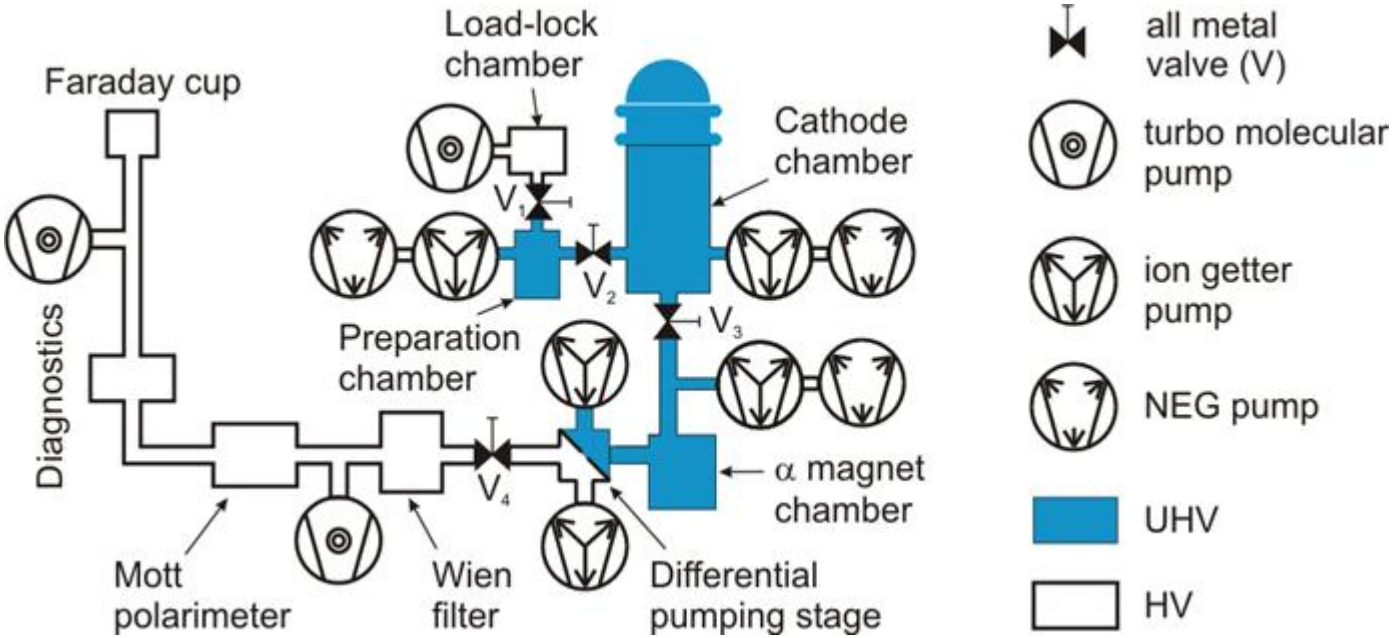



- Cathode surface:
  E = 0.85 MV/m
- Edges:
  E = 4 MV/m

- Material 1.4429-ESU (316 LN)
- High polished surface

# Vacuum System




Achieved vacuum pressure (after 12 days bake out @ 220° C ):

- Cathode and preparation chambers: < $1.8 \cdot 10^{-11}$ mbar (detection limit)
- HV beam line after DPS: $6.0 \cdot 10^{-9}$ mbar

Cathode lifetime ~ 250 h, further bake out cycle planned

# Spin Manipulation and Polarimetry

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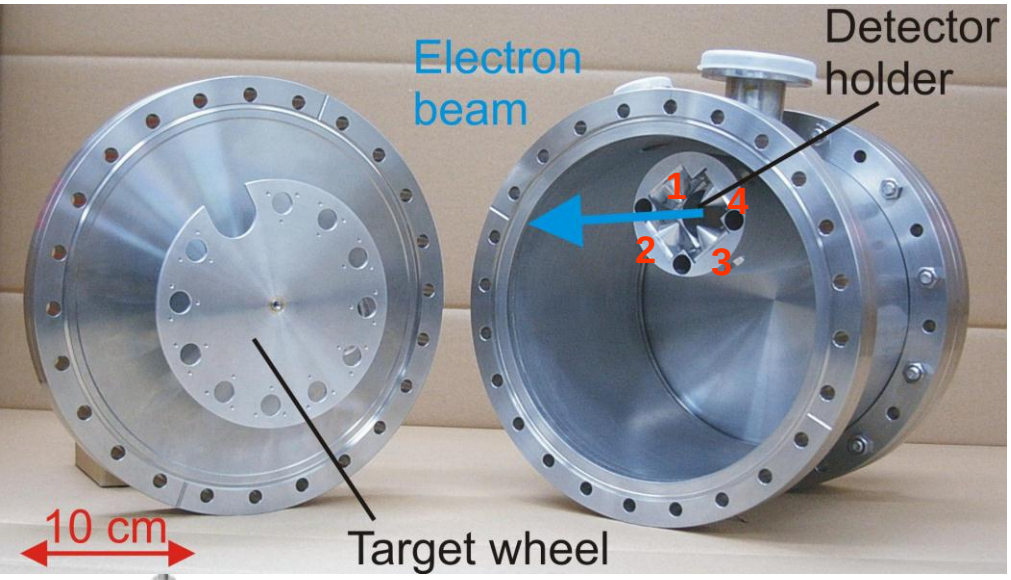


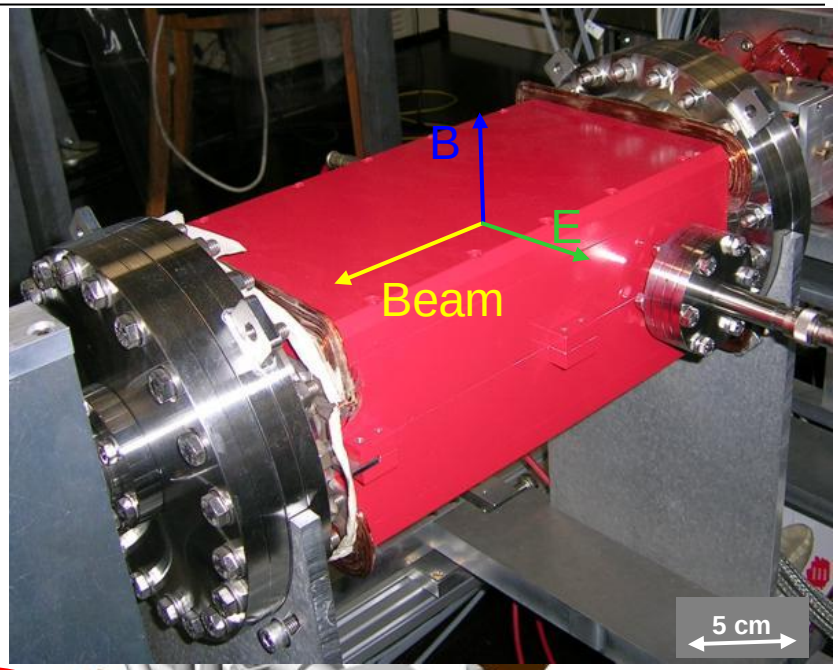


# Progress of Implementation

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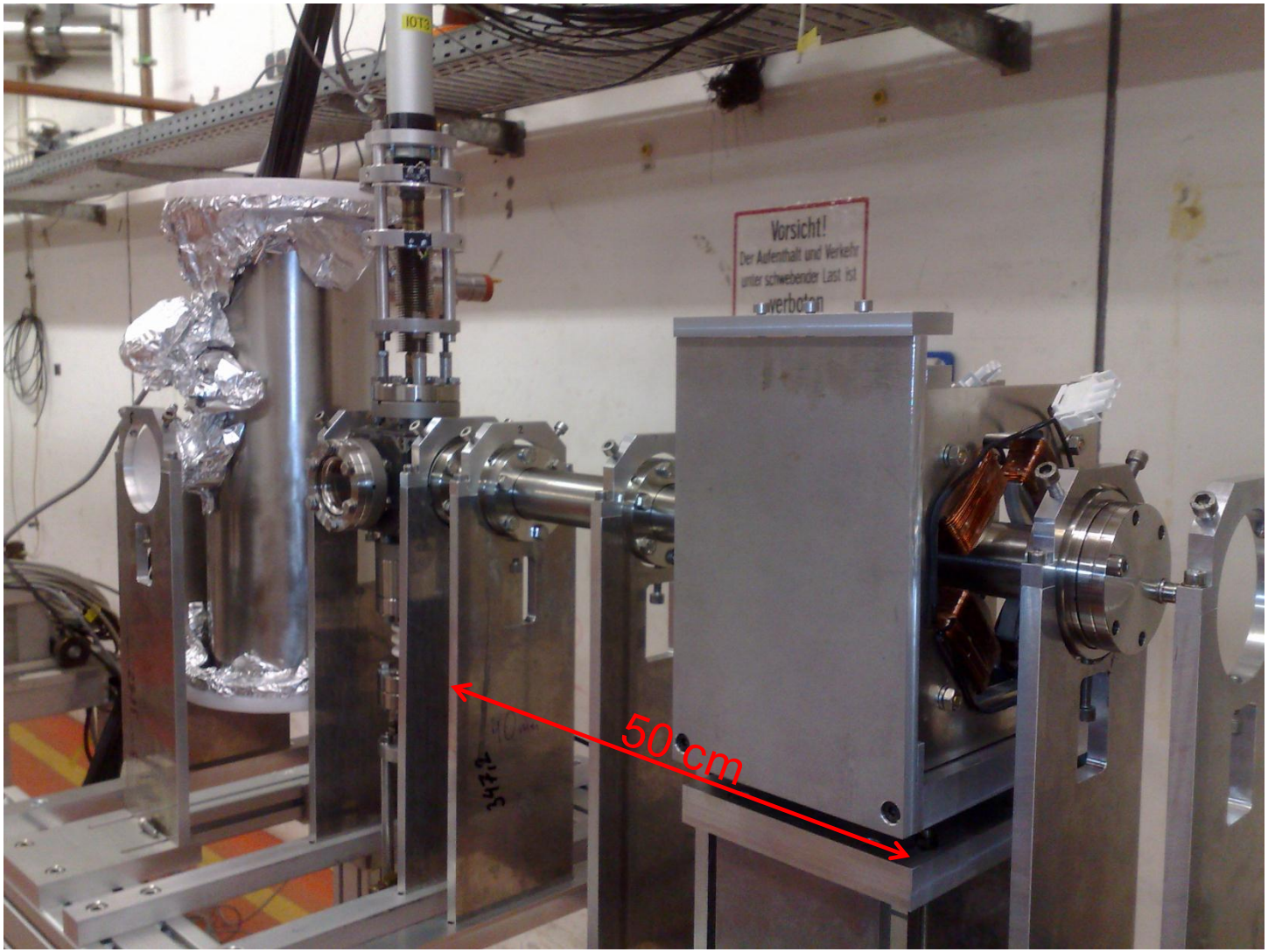
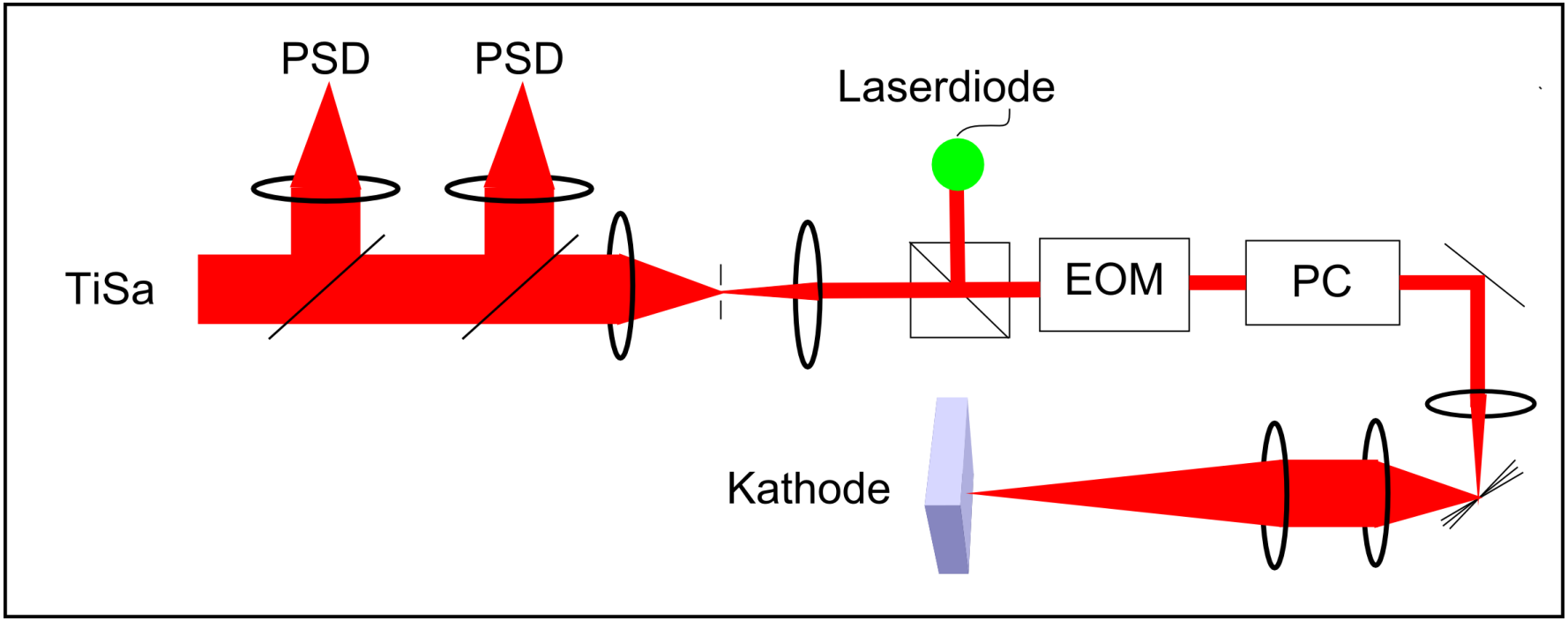


# Laser Beam Line: 40 m




- Intensity stabilization → Electro optical modulator
- Polarization → Pockels cell (PC)
- Telescope → small focus → Small emittance

# Photofission Experiments

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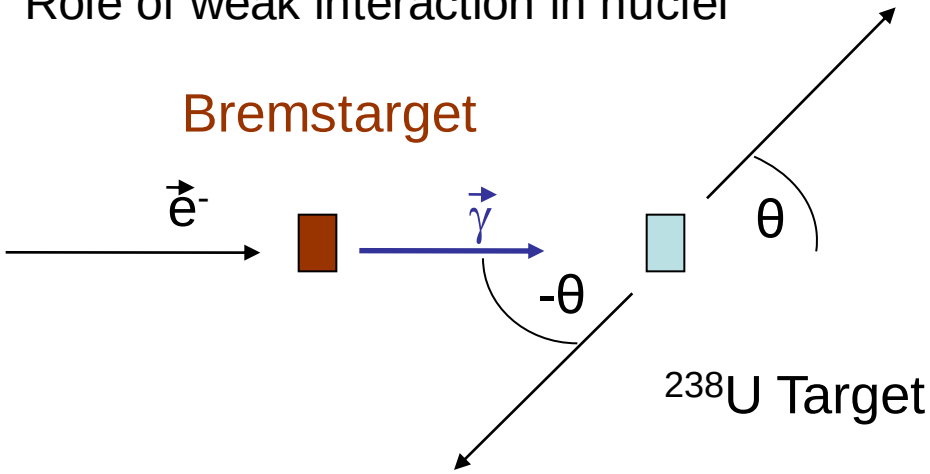
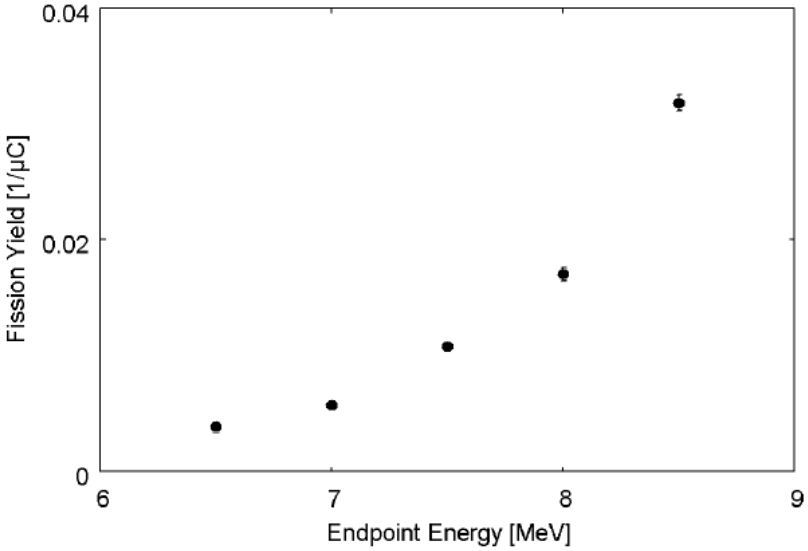
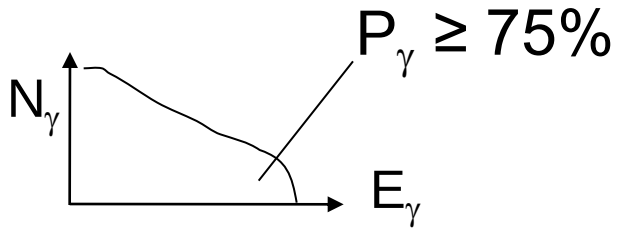
Role of weak interaction in nuclei




Unpolarized test experiment



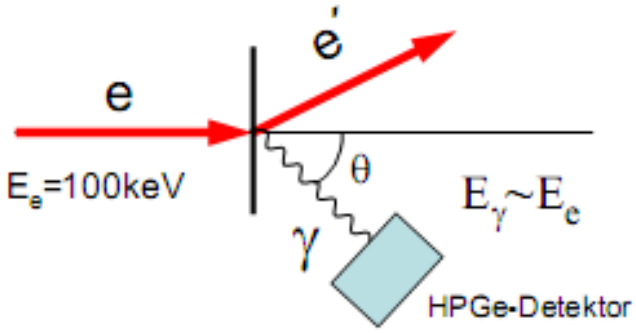

Bremsstrahlungspectrum

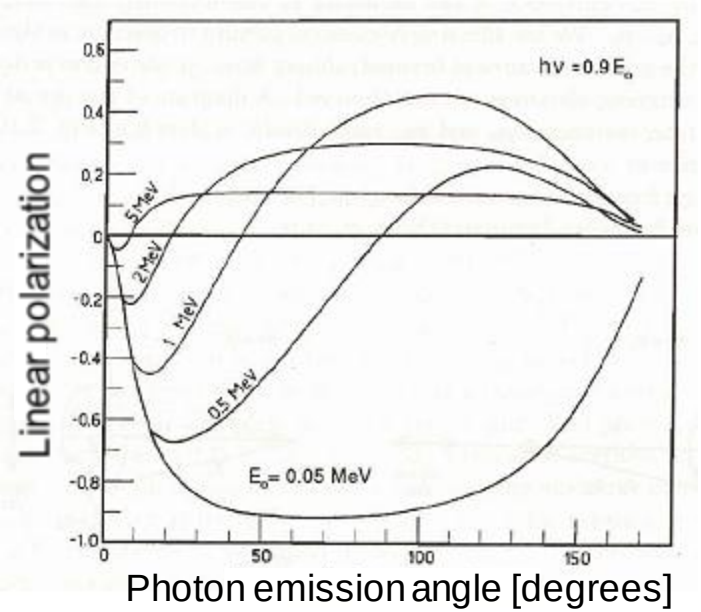



Sensitivity $A \approx 10^{-3}$
Expected $A \approx 10^{-4}$

→ Active Target

# Polarized Bremsstrahlung



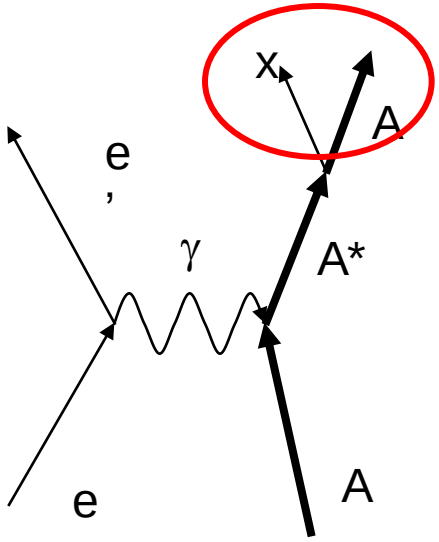

J.W. Motz and R.C. Placius, Nuovo Cimento 15 (1960) 571

Theory: H.K. Tseng and R.H. Pratt, Phys. Rev. 7 (1973) 1502
Exp.: No exp. results for long. pol. Electrons
Collaboration: KTH Stockholm, GSI, Universität Heidelberg

# (e,e´x) Experiments

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma}{d\Omega}\bigg|_{Mott} \left(v_L W_L + v_T W_T + v_{LT} W_{LT} + v_{TT} W_{TT} + v_{LT'} W_{LT'} + v_{T'} W_{T'}\right)$$

- Inclusive electron scattering
  - two structure functions: longitudinal/transversal
- Exclusive electron scattering
  - interference terms: L, T, LT, TT
- Polarized electron scattering
  - parity violation, final state interaction
- Polarized electrons and polarized targets
  - polarization transfer



# „Fifth Structure Function“

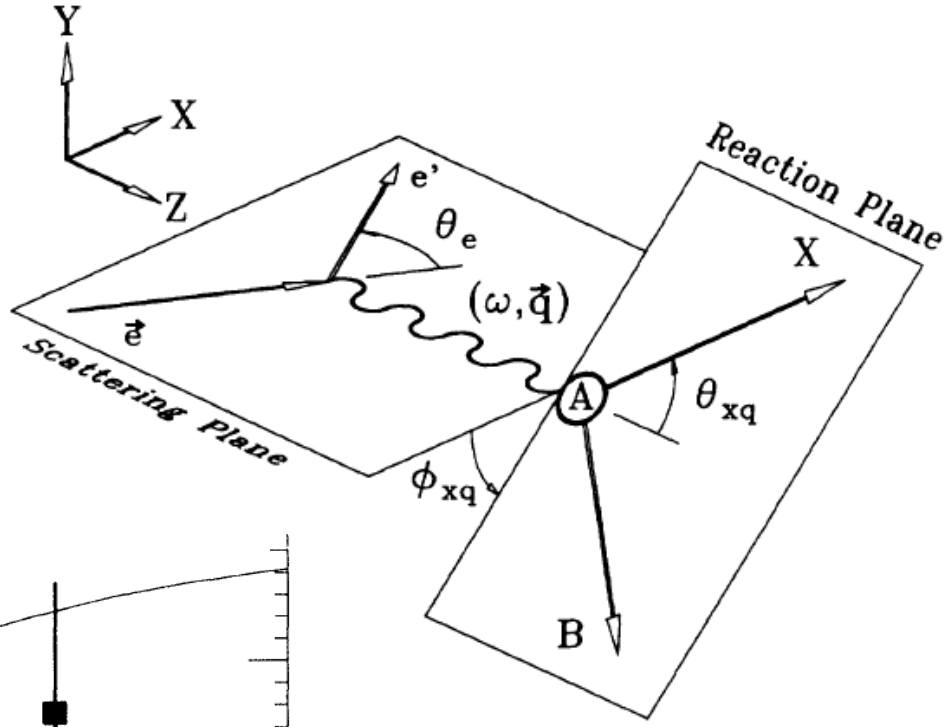
- Only two data sets:

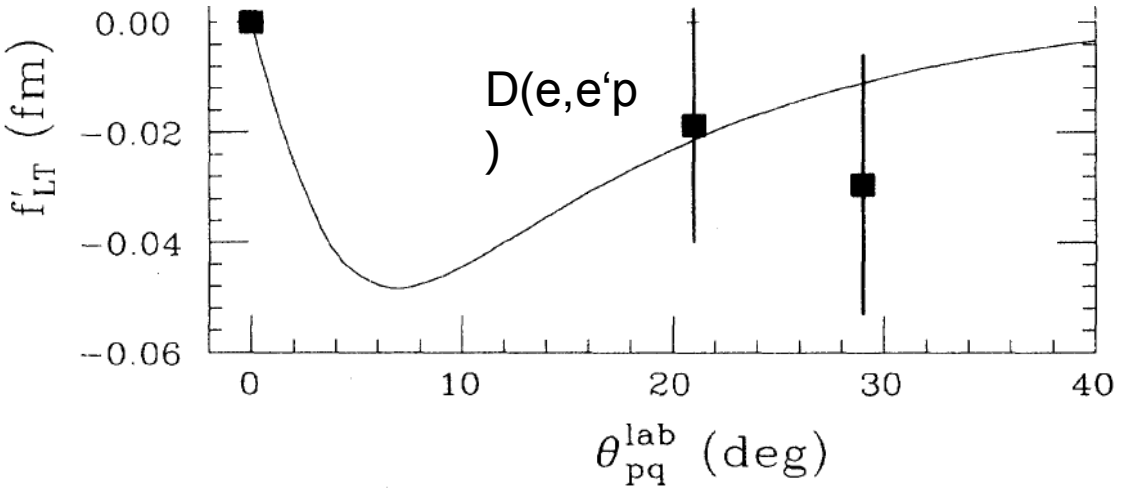
$^{2}$D(e,e’p)

$^{12}$C(e,e’p)

- S-DALINAC

Low momentum transfer



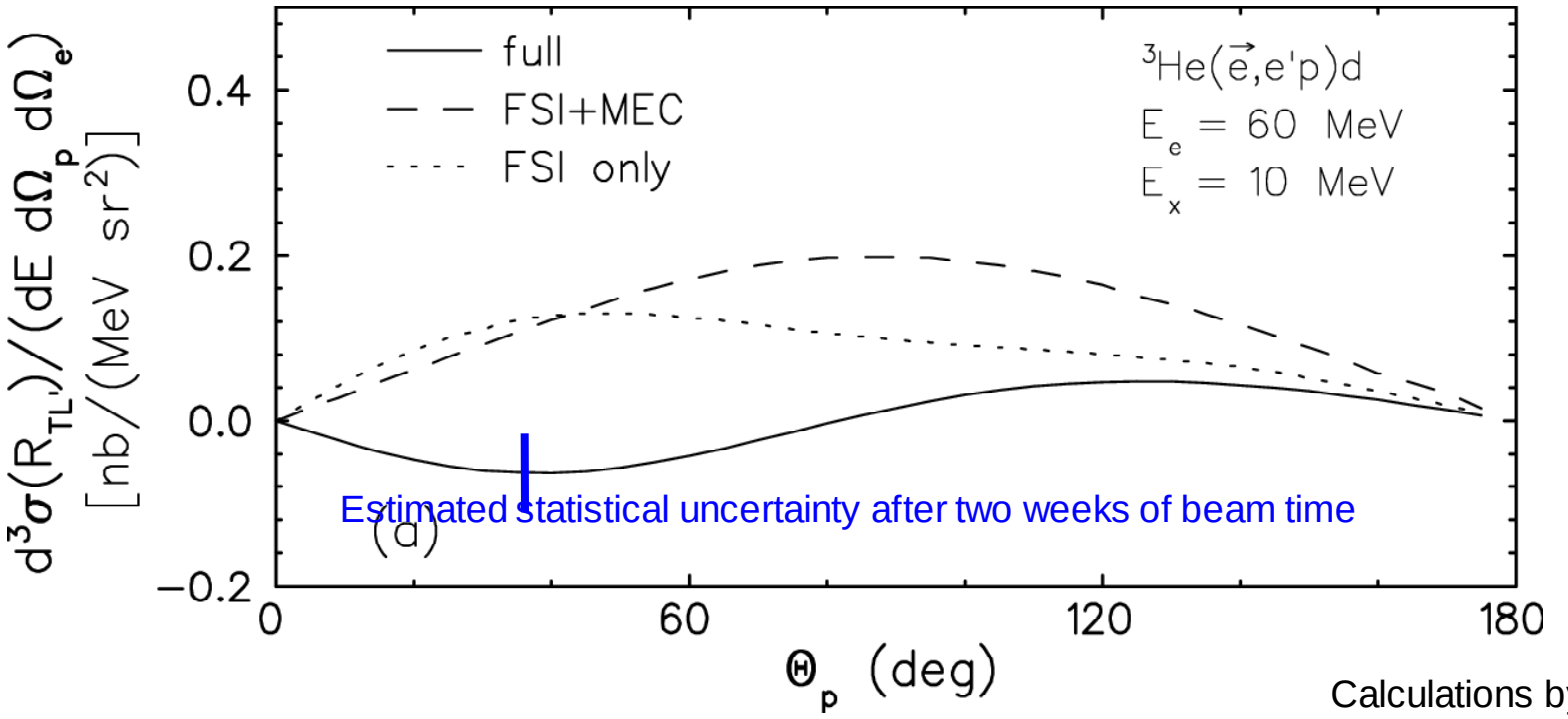




S. Dolfini et al., PRC 60 (1999) 064622

# 3He Break-Up Reaction

Three-Body-Force investigation

No data at low momentum transfer




Calculations by
J. Golak, Crakow