BEAM PROFILE MEASUREMENTS FOR MAGNETIZED HIGH ENERGY COOLING DEVICES

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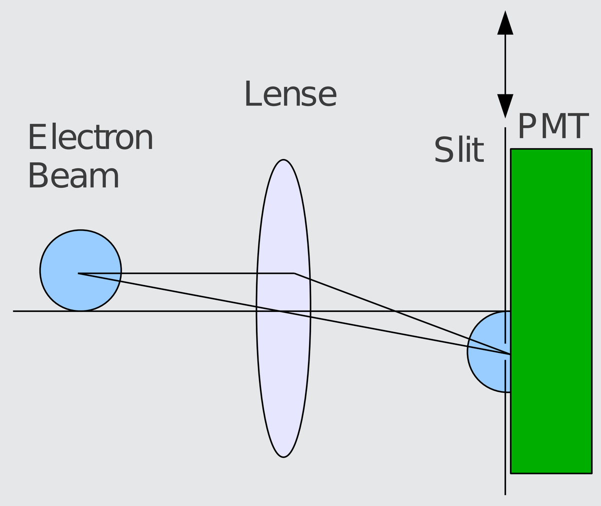
Motivation

- More high intensity electron beams available
  - Energy recovery linac
  - High energy electron cooling devices
- Both have special demands on the beam diagnostics
  - Low beam loss due to high voltage breakdown in cooling devices
  - Withstand high beam power
- Non destructive diagnostics necessary
  - Beam induced fluorescence (BIF) for beam profile measurements
  - Thomson laser scanner (TLS) for beam profile and energy measurements

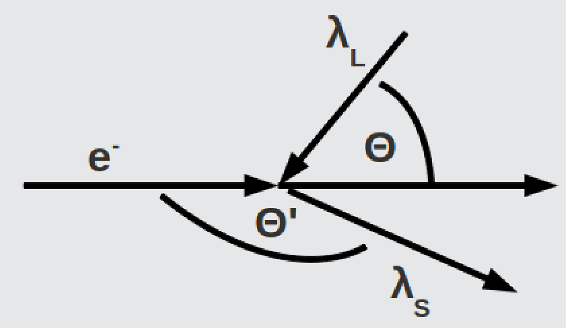
Non Destructive Diagnostic Methods

Principle of Scintillation Profile Monitor



- Beam excites residual gas atoms
- Excited atoms produce light
- Emitted light imaged on detector

Principle of Thomson Scattering



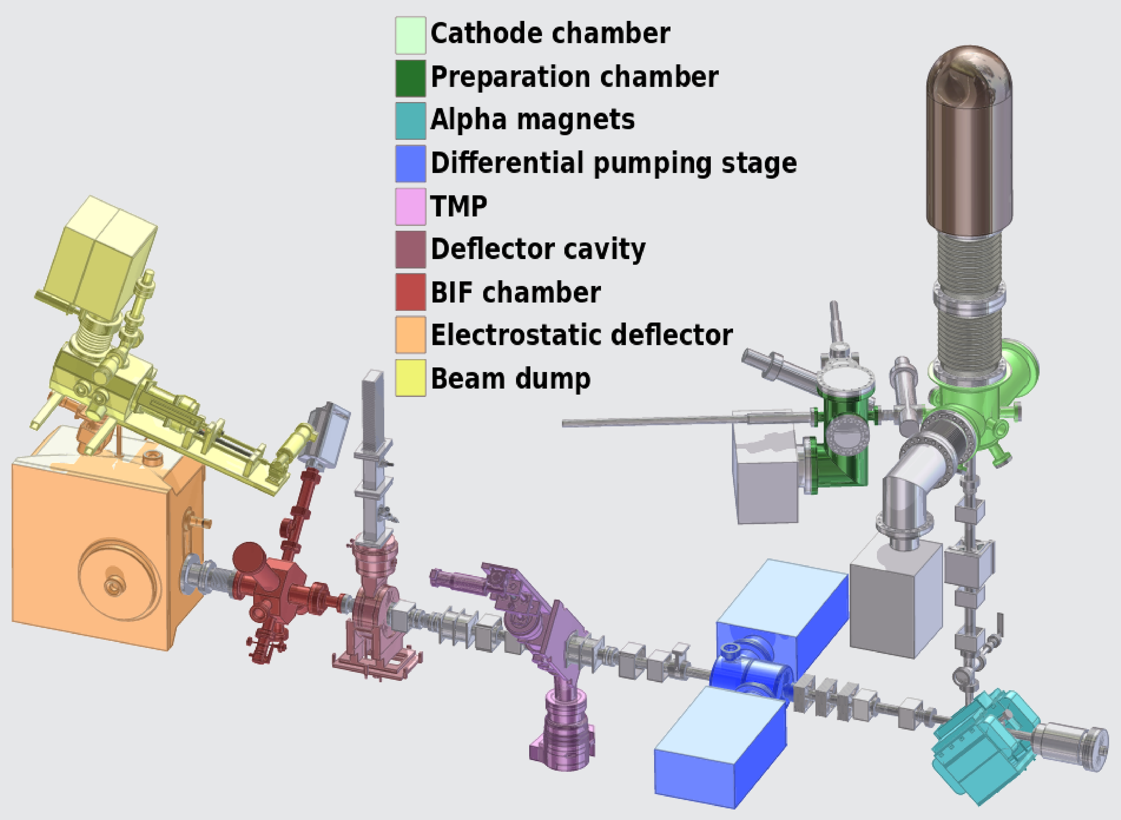
Wavelength shift

$$\lambda_S = \lambda_L \frac{(1+\beta\cos\Theta')}{(1+\beta\cos\Theta)}$$

- Laser field excites electron oscillations
- Electrons scatter photons
- Photons gain energy (Doppler shift)

Beam Induced Fluorescence (BIF)

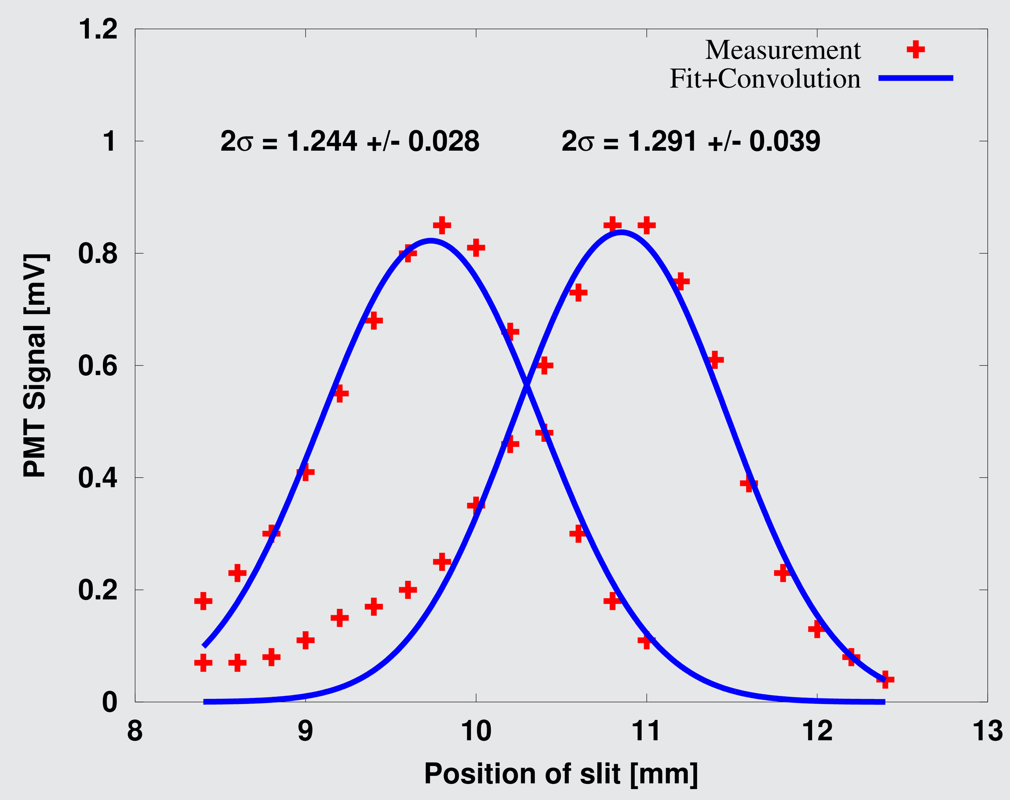
Polarized Test Source (PKAT)



BIF Profile Measurement Conditions

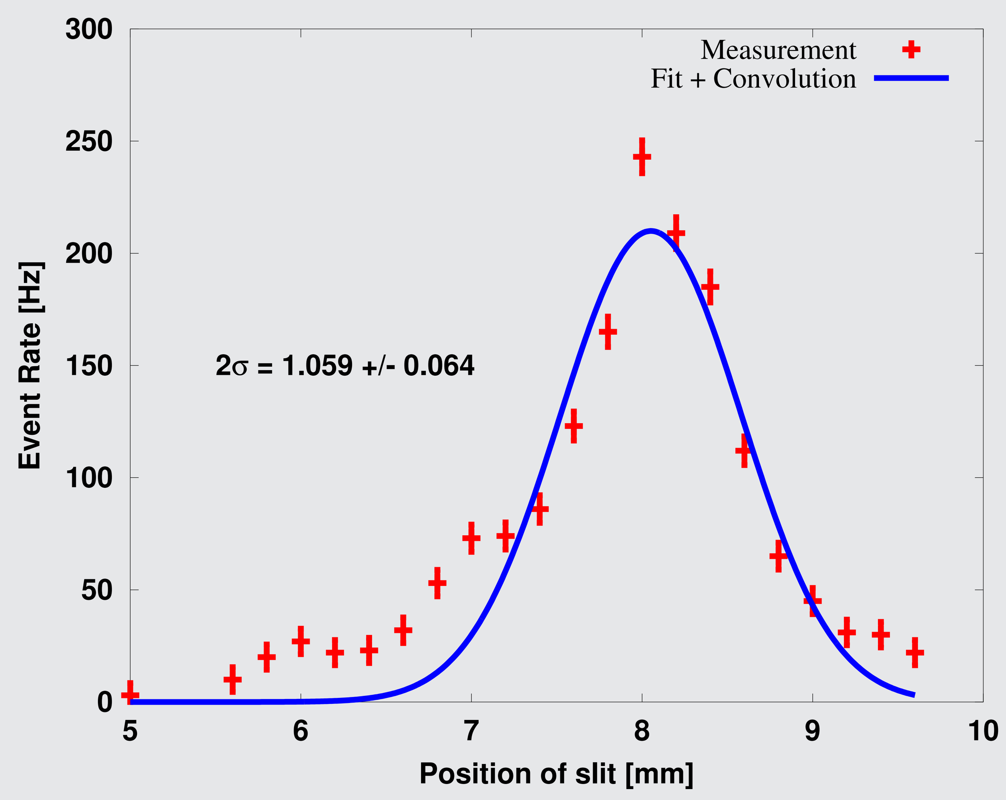
Beam energy	100 keV
Pressure	10^{-5} mbar
Slit width	0.2 mm

Analog Measurement Mode



- 100 μA beam current
- PMT signal amplified by 10^5 V/A
- 30 s integration time
- Same event rates for an ERL with 100 mA and 10^{-8} mbar

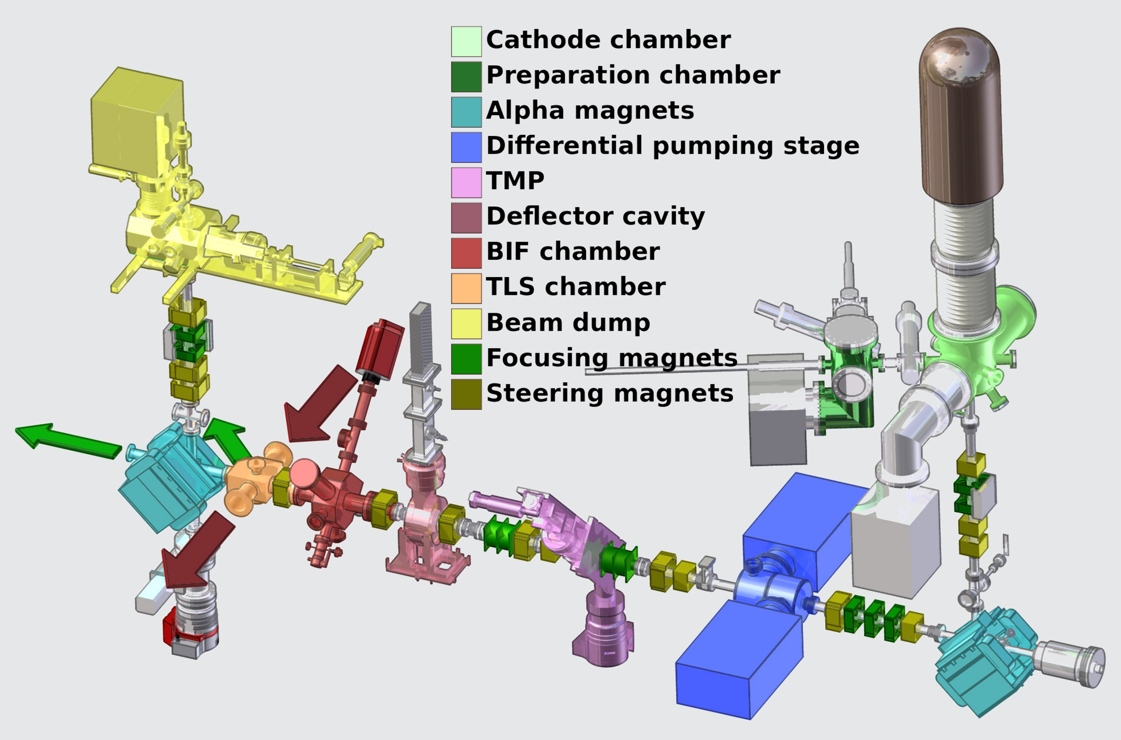
Counting Mode



- 500 μA peak current, duty cycle of 0.1
- S/N $\approx$ 1 limited by PMT thermal noise
- Statistical errorbars only
- Same event rates for an electron cooler with 1 A and 10^{-9} mbar

Thomson Laser Scanner (TLS)

Present Diagnostic Setup at PKAT



PKAT Modifications

- Electrostatic deflector replaced with alpha magnet to deflect electrons
- TLS chamber with possible detector positions at $\Theta' = 135°$ and $\Theta' = 180°$ (green arrows) installed
- Red arrows indicate Thomson laser beam line
- Quadrupole doublet for focusing beam onto beam dump
- YAG screens integrated in BIF and TLS chamber

Laser System for Thomson Scattering

- Pulsed beam necessary because of limited HV power supply
- Synchronization between electron and laser beam essential
- Green laser for electron beam generation
- IR laser with high power ($\geq$ 100 W) for Thomson scattering
- Synchronization with variable delay of both lasers within 1 ns to compensate for the time of flight of the electrons
- High repetition rate (150 kHz) prevents beam line elements from being damaged due to lower peak power, compared to low rep. rate laser systems

Laser Parameter

	Green	IR
Wavelength	516 nm	1032 nm
Power	10 W	150 W
Pulse duration	20 ns	20 ns
Rep. rate	150 kHz	150 kHz

Estimated Event Rates for Several Setups

Beam energy	$\lambda_L/\mu m$	λ_S/nm	Event rate $/s^{-1}$
100 keV (PKAT)	1.03	630	14
2 MeV (COSY)	10.6	220	$6.1 \cdot 10^2$
4.5 MeV (HESR)	10.6	50	$1.2 \cdot 10^3$
8 MeV (ENC)	10.6	20	$2.1 \cdot 10^3$

- Electron beam current 60 mA and diameter 2 mm for pulsed beam
- Electron beam current 1 A and diameter 3 cm for DC beam
- Average Laser power 100 W
- Detector system efficiency 0.2
- Solid angle 100 msr
- $\Theta' = 135°$

Wavelength analysis of scattered photons grants access to further observables like:

- Electron energy
- Longitudinal electron temperature
- Space charge effects