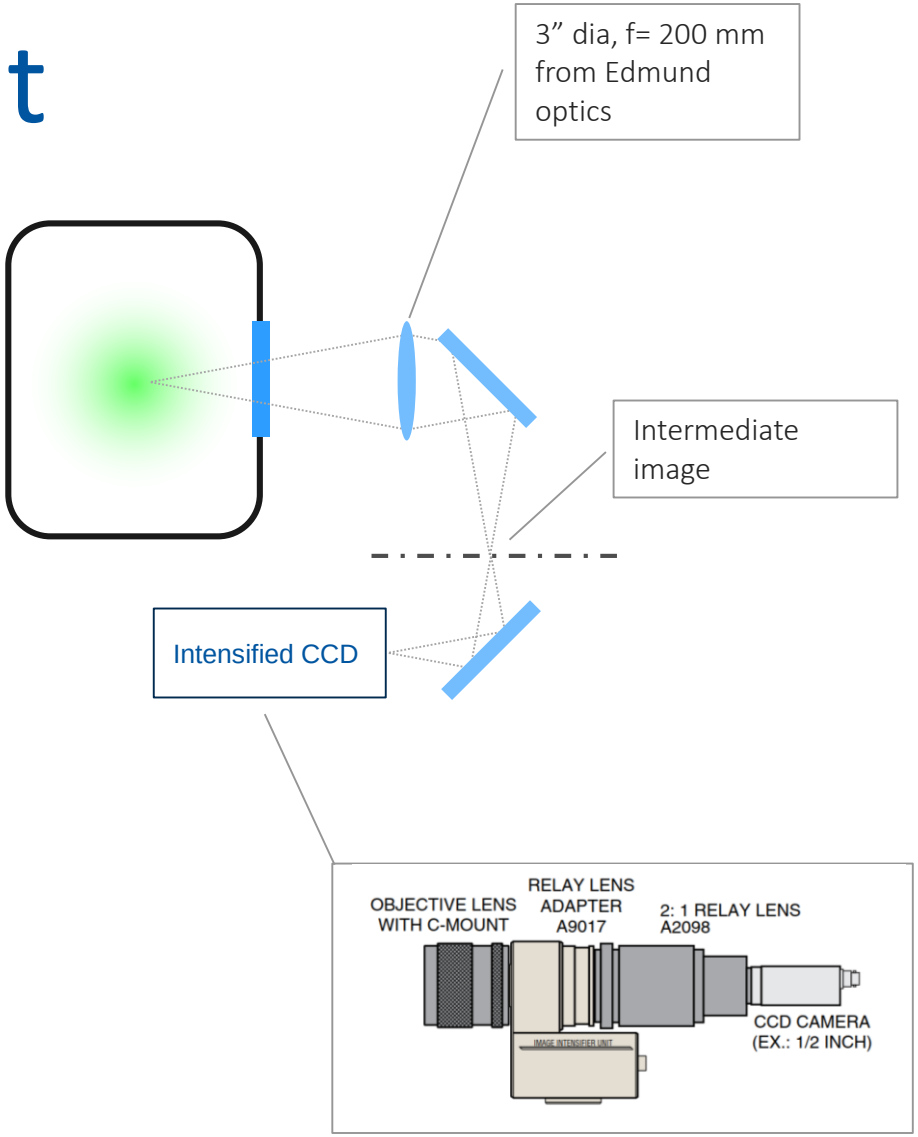
18/9/2017, HL-LHC WP13 meeting

LHC beam profile with residual gas fluorescence (Ne)

Optical instrument

- 3” achromat, 400 mm from source. Intermediate image at 1:1. Options: MCP at ii or camera lens (higher demagnification)
- Optical acceptance 2.7 x 10^{-2} Sr under the assumption that the lens is the entrance pupil.
- Intensified CCD assembly from Hamamatsu
- For simulation purposes: end magnification 2:1



Light Yield calculation

$$N_{ph} = N_p \sigma \rho_{N2} \frac{\Omega}{2\pi} \tau$$

N_{ph} photons per bunch per unit length

$N_p = 10^{11}$

$\sigma = 3.7 \times 10^{-20}$ [cm^2]

$\rho_{Ne} = 2.4 \times 10^{8}$ [cm^{-3}]

$\Omega = 2.7 \times 10^{-2}$ [Sr]

$\tau = 1324$

$$\tau = t Q_{pc} G_{MCP} G_{P43} C Q_{CMOS}$$

Where
t = 0.7 is the optical transmission of the line
Q_{pc} = 0.35 is the QE of the photocathode
G_{MCP} = 680 is the MCP gain at 880 V
G_{P43} = 53 is the efficiency of P43
C = 0.15 the coupling efficiency between P43 and CMOS
Q_{CMOS} = 0.7 the typical QE of the CMOS sensor

$$\rho_{Ne} = \frac{P N_A}{RT}$$

Where
P = 1E-08 mbar pressure
N_A = Avogadro number
R = 8.314 J/K*Mol, gas constant
T = 293 K temperature

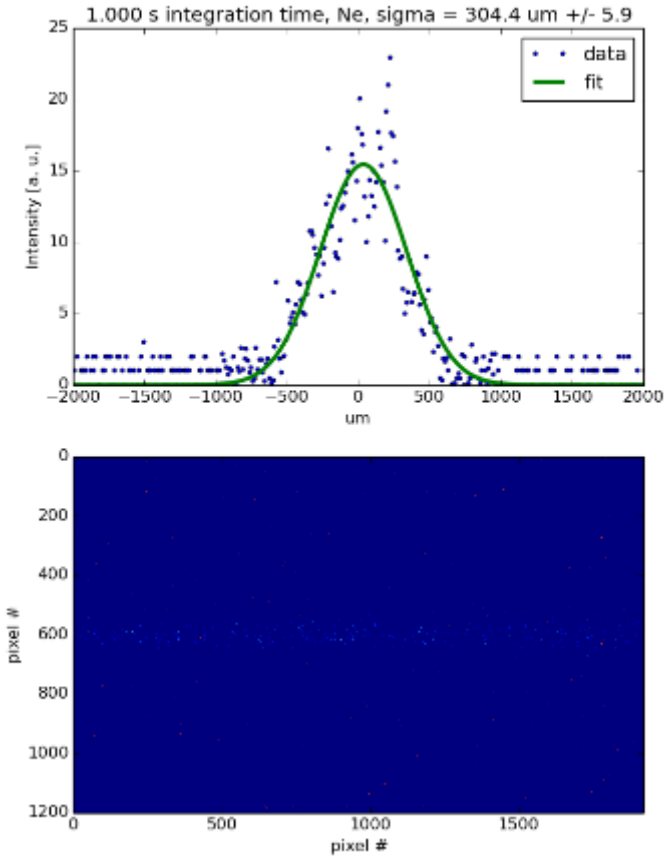
Distortion, noise, resolution

- Random displacement of Ne atom during fluorescence lifetime:

$$\Delta\vec{x} = \vec{s}(|\vec{v}\Delta t|, rand[0,2\pi]) \text{ where } v = \sqrt{\frac{3RT}{M}}, \quad \Delta t = exp - (t/\tau),\ \tau < 10 \text{ ns}$$

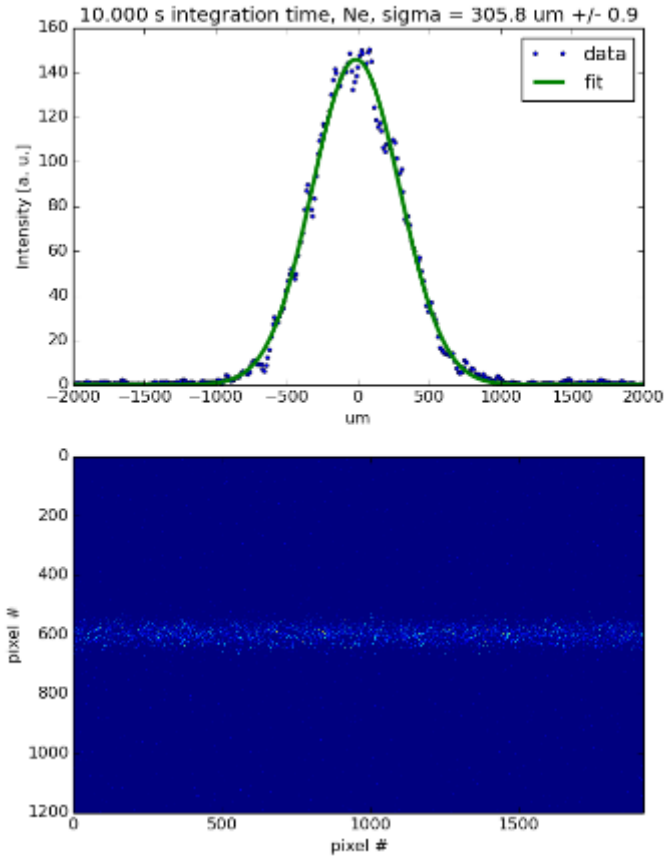
- Intensifier dark noise: 1000 photons/sec typical (from experience)
- CMOS Poisson noise
- Image resolution: typical 50 um on the ii plane > convolution with Gaussian of 25 um FWHM.

Beam profiles



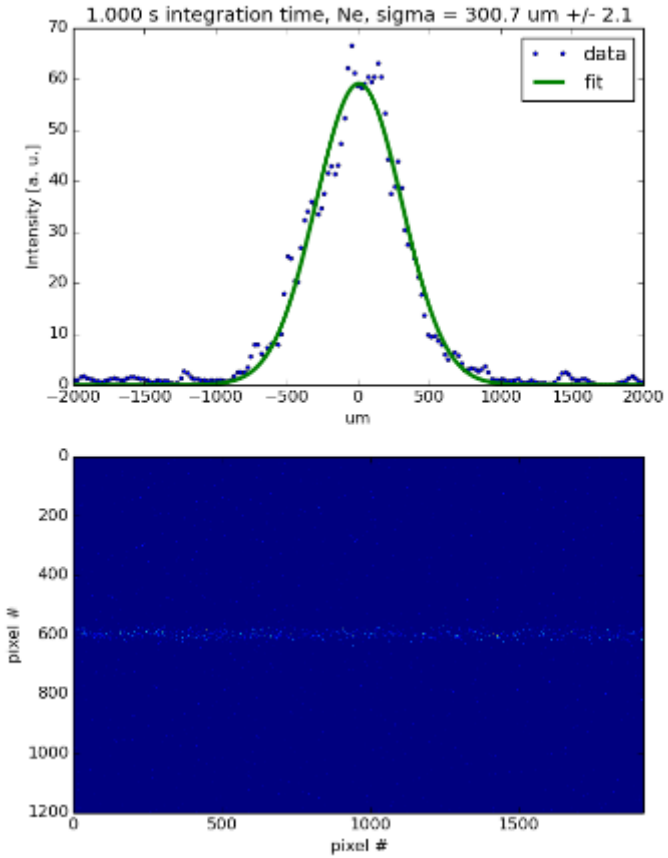
1 sec integration time, approx. 500 photons
Relative error on sigma 3% to be confirmed

Beam profiles



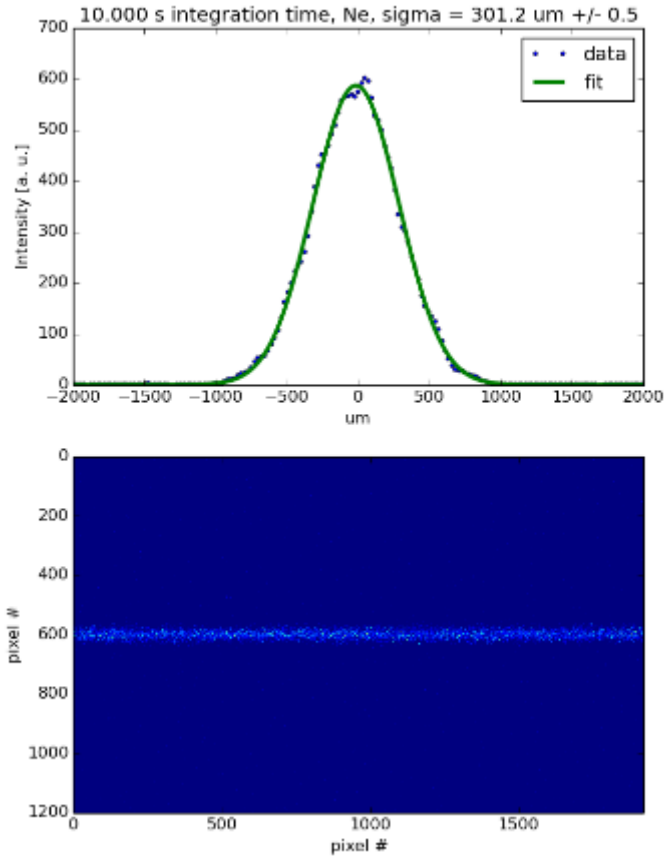
10 sec integration time
Relative error on sigma 1% to be confirmed

Beam profiles



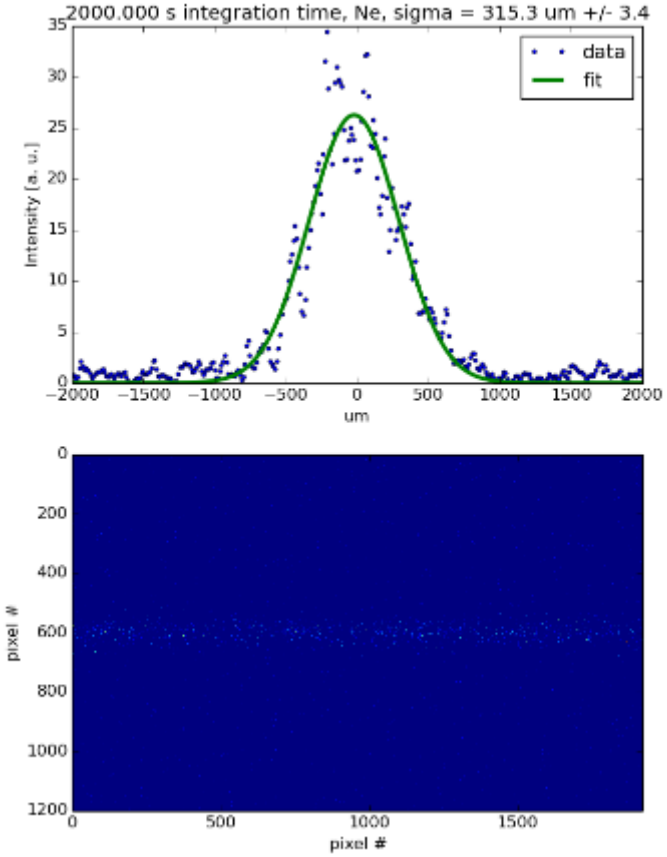
1 sec integration time. Magnification 0.25
Relative error on sigma 3% to be confirmed

Beam profiles



10 sec integration time. Magnification 0.25
Relative error on sigma 1% to be confirmed

Beam profiles, no intensifier



2000 sec integration time = 1 s with physics fill
800 photons, 2.5% error to be confirmed