The Information of profile width in Hybrid Ion Beam Tomography

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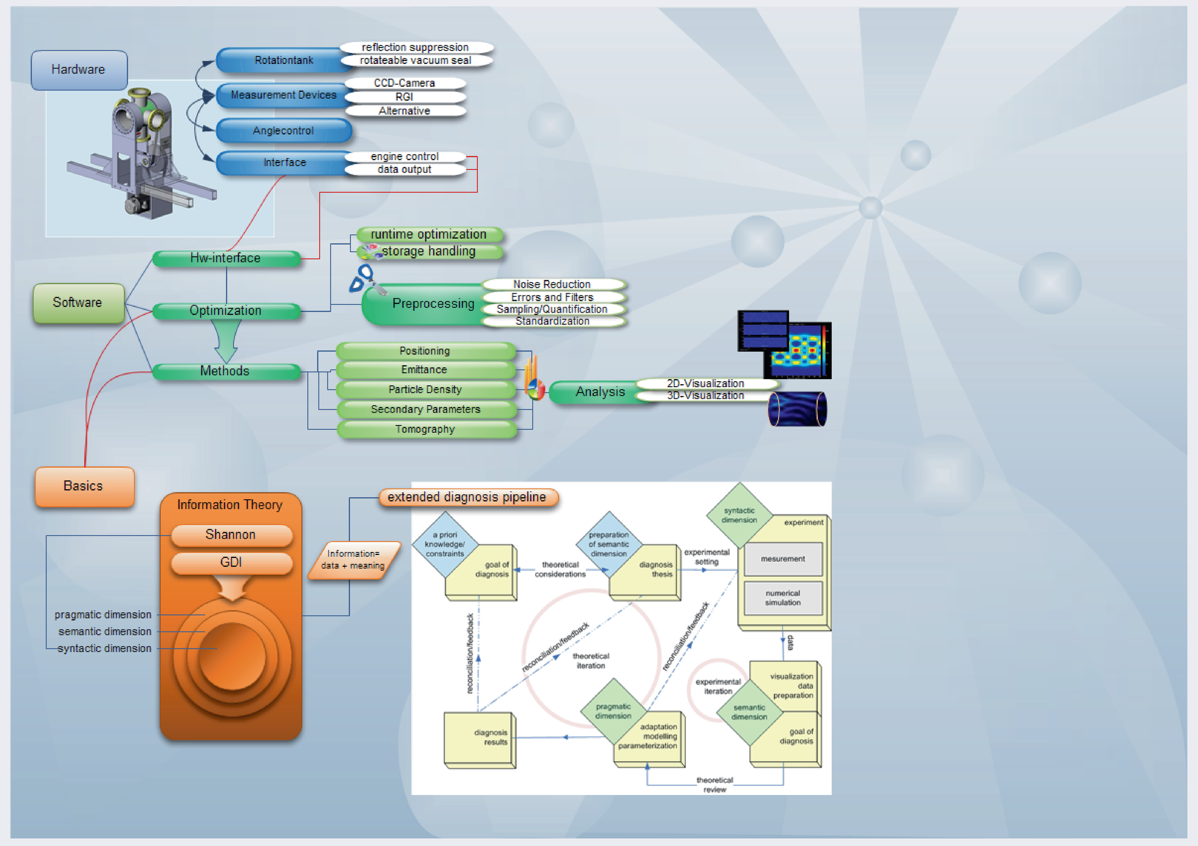
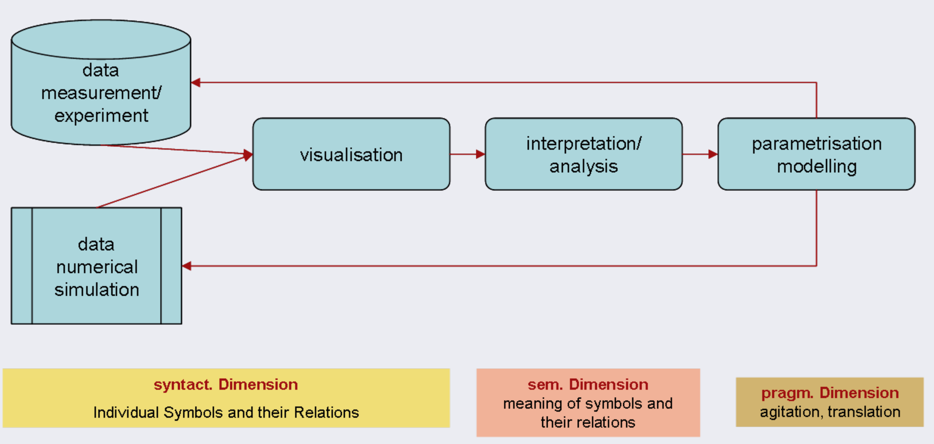
In beam diagnostics optical techniques had become increasingly important as they provide information with the advantage to have only minimal effect on the beam. The planned FRANZ (Frankfurt Neuron Source) will consist of a proton driver LINAC providing beam energies up to 2.0 MeV. The rotatable diagnosis tank HIBTT (hybrid ion beam tomography tank) will be placed at the end of LEBT (low energy beam transport) to provide beam tomography based on the visible radiation of the ion beam in front of the RFQ. The beam properties in this section will be 120keV and 200 mA. Additional to the CCD camera that takes optical data for the tomography, other non-interceptive devices could be used to gain additional information. The question behind this hybrid approach on non invasive beam diagnostics is: which and how much information can we extract from an ion beam without disturbing or destroying it. The actual contribution deals with the information of profile width in beam profile measurements. The presentation introduces a definition and information sensitive method for profile width determination and verifies them using experimental and equivalent numerical data.

Information Mining in Beam Diagnostics

- getting the general concept of HIBT -



Beam diagnosis systems that provide knowledge about beam properties and behaviour of an ion beam, serve as a source of potential controllability through attained information. Based on a theory of information an extended diagnosis pipeline was derived that forms the fundament for the beam diagnostic system HIBT (hybrid ion beam tomography), consisting of a flexible measurement device and an associated, modular software agent. This approach is chosen to explore what one could actually learn about an ion-beam or rather, which and how much information can be extracted, without disturbing or destroying it.



GDI (General Definition of Information)

by Floridi and Mingers:

„σ is an instance of information, understood as semantic content, iff:

GDI1) :

σ consists of n data(d) for n≥1

GDI2):

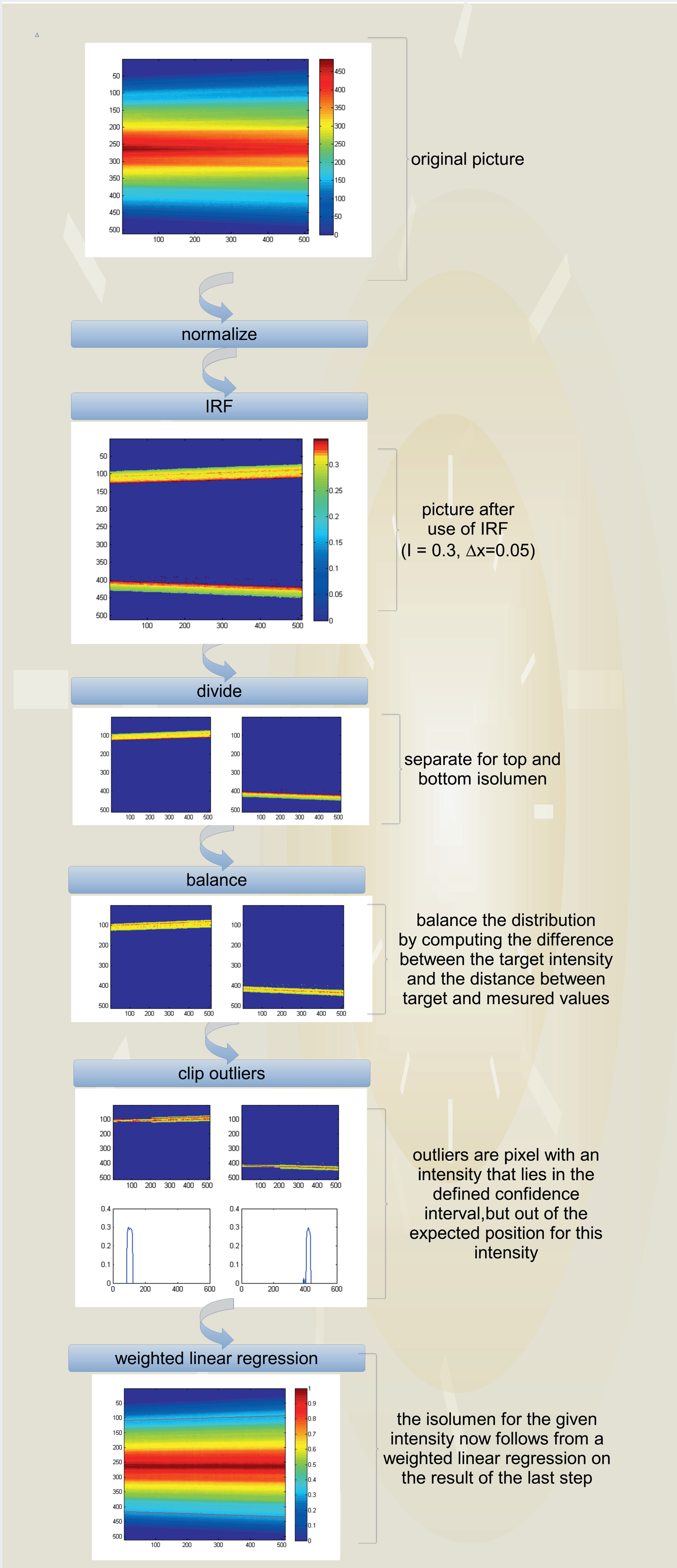
d is well-formed (wfd)

GDI3):

the wfd are meaningful (mwfd = δ)“

Determination of profile width

- saving information in beam profile measurements -



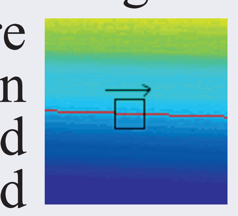
Several optical methods for the determination of emittance use the parameter of profile width. The error propagation of this methods is seriously influenced by the exactness with that the profile width could be specified. By a simple smoothing of the whole data by filtering, e.g. with a gaussian filter, inclosed information will be erased or blurred. Therefore an information sensitive filter will be introduced.

The profile length at position x $x_{prof}(x)$ in an optical beam measurement P is defined as:

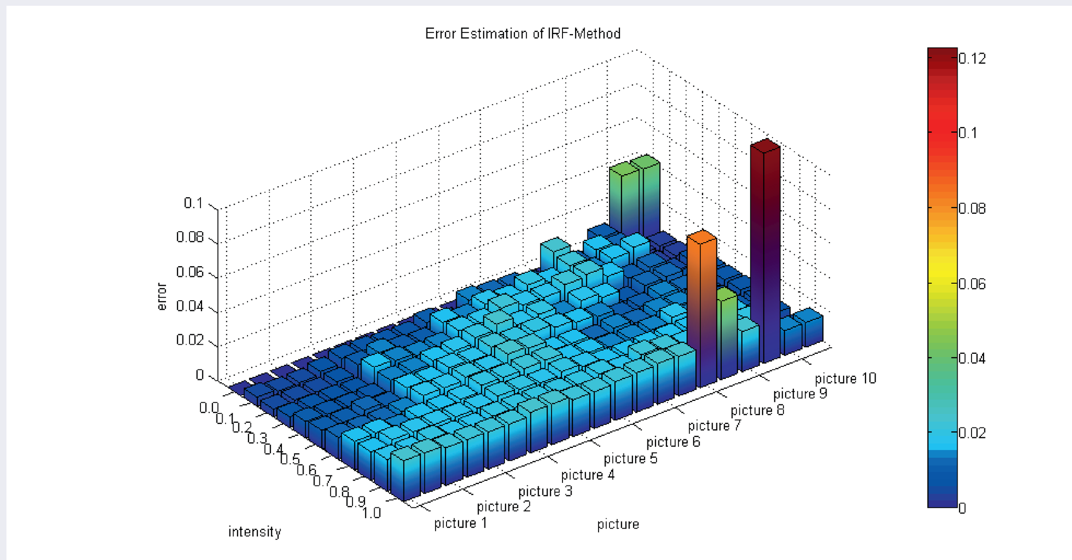
$$x_{prof}(x) := |g_1^{I_l}(x) - g_2^{I_l}(x)| \cdot \frac{l}{N}$$

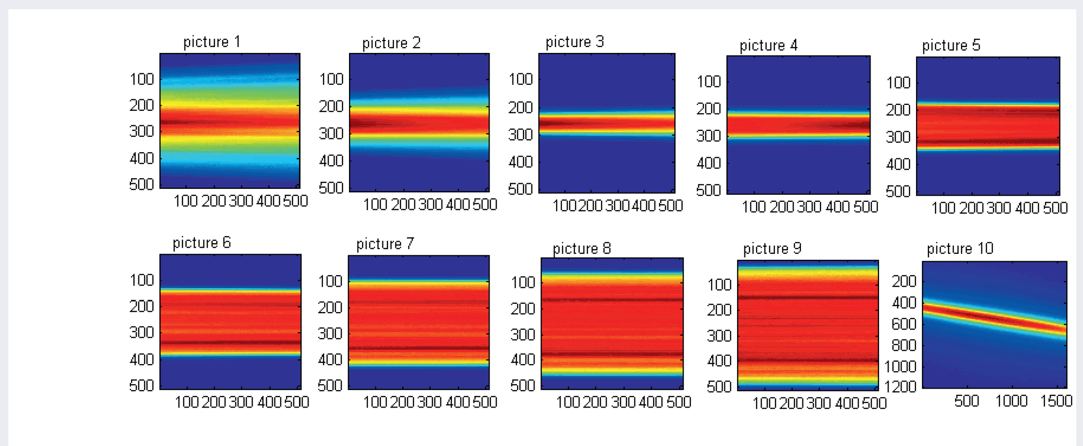
where l is the width of P in [mm] and N the width of P in pixels.

Two lines g_1 and g_2, are called isolumen for an intensity I_1, iff they fit in the area along an optical beam measurement P, where the mean over all distances between the mean intensity of the defined neighborhood around g_1, g_2 and intensity I_1 is minimal.



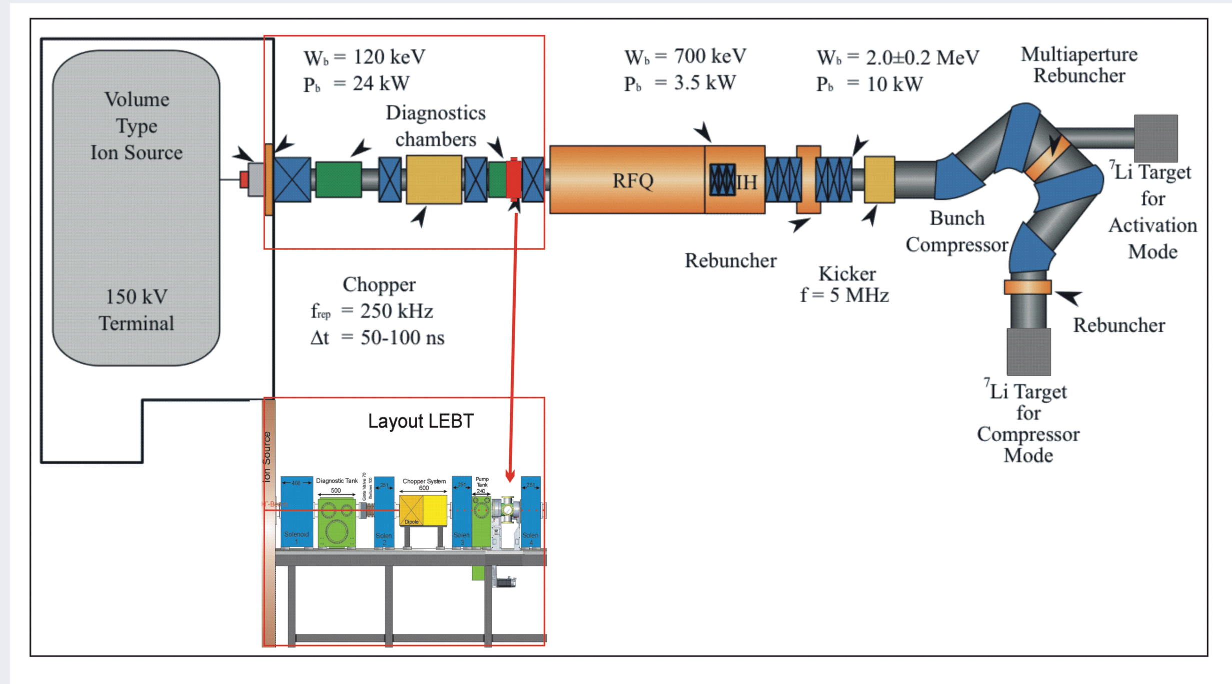
Error Estimation





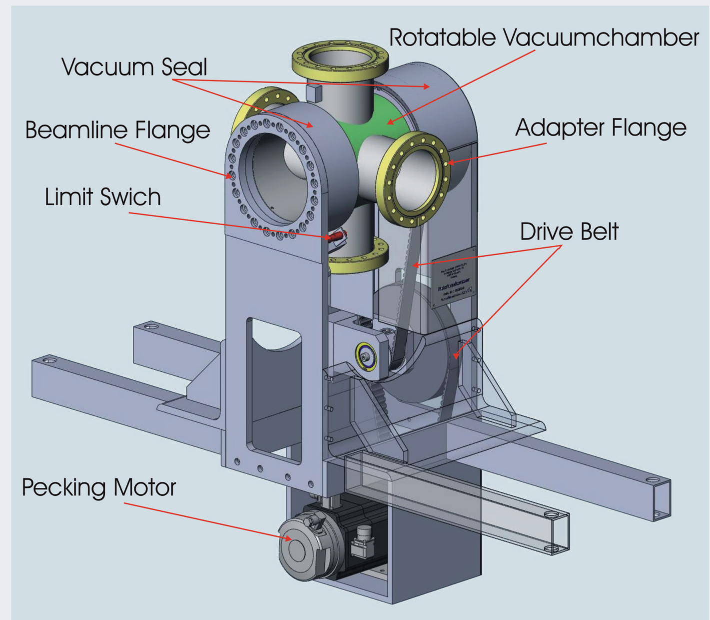
HIBTT - Hybrid Ion Beam Tomography Tank

- a multi measurement approach to beam diagnostics -



HIBTT (HIBT-Tank) is a rotatable vacuum tank with a 270° angular freedom and that is designed for vacuum pressure up to 10^{-7} mbar. It will be integrated in the LEBT section of FRANZ (Frankfurt Neuron Source) which is an intense neutron source that consists of a proton driver LINAC providing beam energies up to 2 MeV (picture FRANZ/LEBT with marker for HIBT) In the LEBT section a beam with 120keV energy and a 200mA beam current is planned.

HIBTT will first be fit with a CCD Camera pco.1600s with 1600 x 1200 pixel/14 bit, 5µs up to 60s shutter speed, a field viewing angle of 14° and a quantum efficiency of 55% for optical measurement.



Technical Data HIBTT

Physical Dimensions:
length: 351.2 mm (along beam line)
height: 1147 mm
width: 334 mm

4 Adapter Flanges 100 mm
Beamline Flanges 150 mm

Angle Encoding:
position indicator swiches: 2
max. angle: 270°
5000 - 10000 steps

Seal:
threefold viton seal with ball bearing
possible vacuum pressure : 10^{-7} mbar

CCD-Camera:
1600 x 1200 px/14bit
5 µs - 60s shutter speed
Peltier Cooling
320 nm - 1000 nm wavelength sensibility
quantum efficency 55%
14° viewing angle