EUROPEAN SPALLATION SOURCE

Non-Invasive Beam Profile Measurement

Overview of evaluated methods

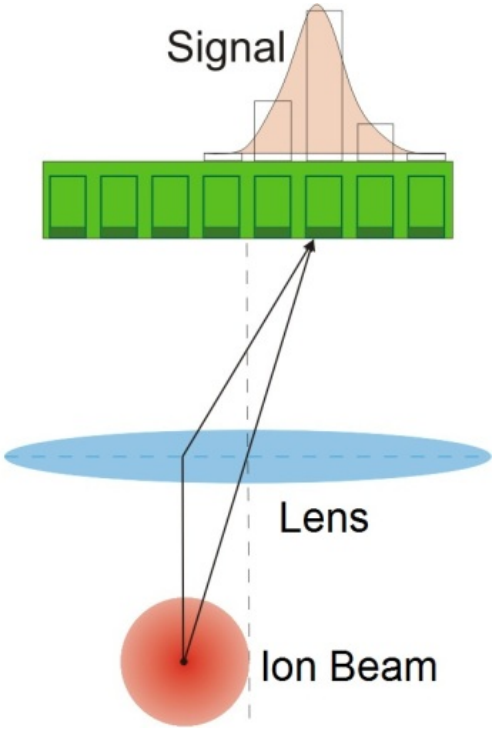
Goal

- Beam profile measurements, mainly in the high-energy part of the linac
- Requirements:
  - The beam profile should be measured within 10 % of nominal beam width
  - The beam profile might be measured over a beam pulse or even over several pulses combined

Methods in Evaluation

1. Residual Gas Luminescence
2. Residual Gas Ionization
   i. Detection of Ions
   ii. Detection of Electrons
3. Crossed Particle Beam Interaction
   i. Electron Beam
   ii. Ion Beam

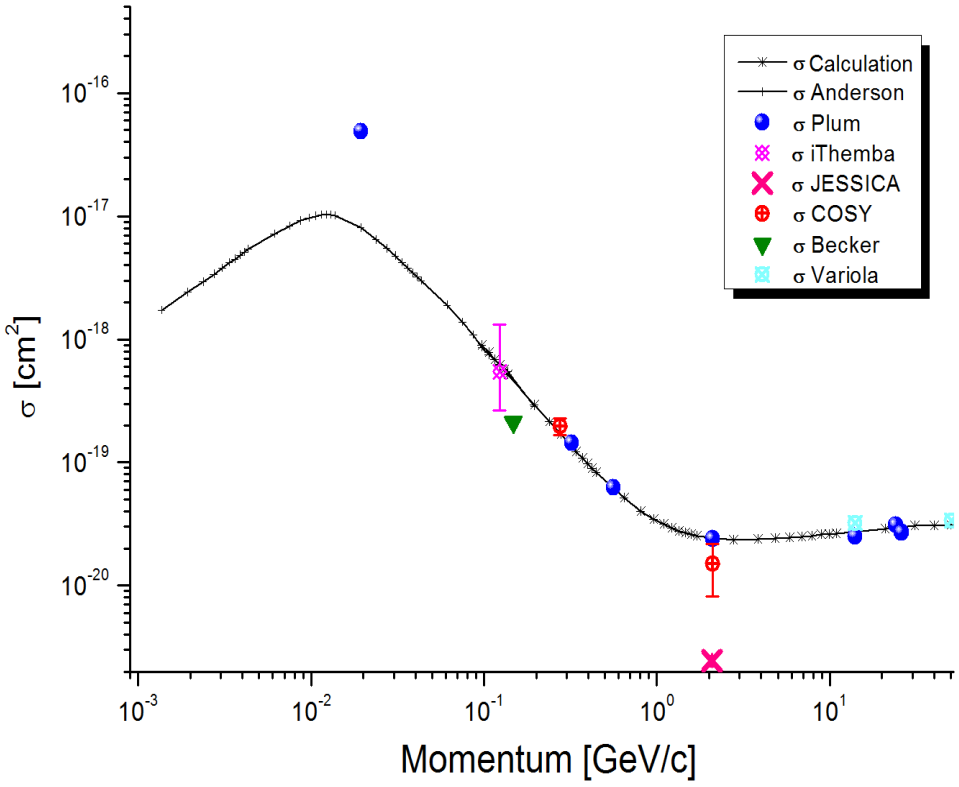
1. Residual Gas Luminescence



- Ion beam interacts with residual gas in a way that the gas emitts light
- This light is detected and a profile calculated

Picture: Balalykin, N. I. et al., *Development of beam position and profile monitor based on light radiation of atoms excited by beam particles,* Dubna, Russia: XIX Russian Particle Accelerator Conference, 2004.

1. Residual Gas Luminescence

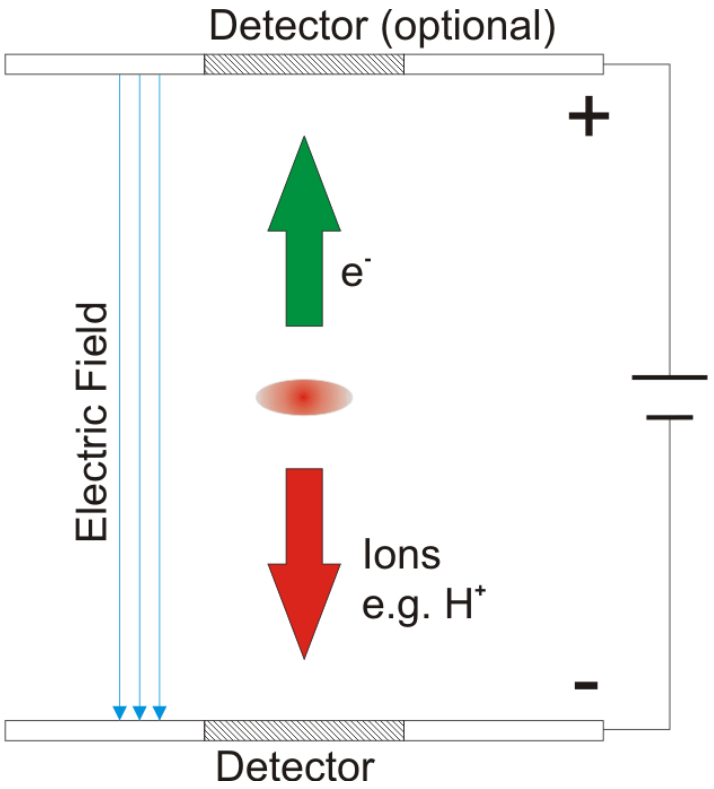


- Problem of this method: small cross section
- Estimated photon count in ESS cryogenic section (without additional gas): <10/s

1. Residual Gas Luminescence

- Preferred method because of simple setup
- Low predicted countrate might render this method impossible in cold section
- Non-desturbing adding of gas (gas jet) has to be investigated
- At warm sections this method might be still preferred for online profile measurement
- Planned to test predictions of cold section at SNS in summer 2012

2. Residual Gas Ionization



- Ion beam interacts with the residual gas in a way that the gas gets ionized
- Ions and/or electrons* are accelerated by an electric field towards a detector

2. i. Residual Gas Ionization

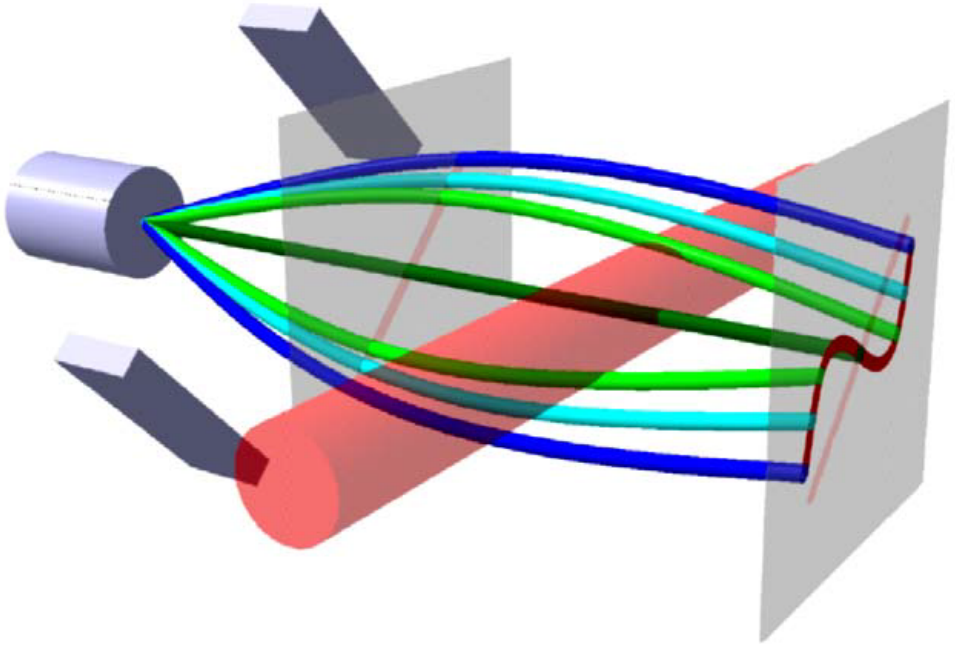
- Estimated countrate <450/(s*cm)
- Using MCPs limits operational lifetime
- Method without MCP in investigation
- Beam space charge might influence the beam imaging process
  - First simulations showed about 2.5 % beam broadening at 600 kV/m
  - Still, beam shape might be influenced

2. ii. Residual Gas Ionization

- For use of electrons a magnetic field must be overlayed
- This field must be in the region of 0.03 T
- Steering magnets within the quadrupoles might be used to correct beam
- Beam physics must be evaluated

3. Particle Beam

- A particle beam (electrons, ions) is sent perpendicular to the ion beam
- Due to coulomb interaction the particle beam is deflected
- This deflection can be used to calculate the beam profile



Picture: Peter Forck, Minimal Invasive Beam Profile Monitors for High Intense HadronBeams, IPAC 2010 Kyoto

Conclusion

- Luminescence might be hard to achieve for cold part, maybe useful at other positions (warm section, target), or might need gas jet to increase vacuum level
- Particle beam interaction is only used at one other lab, still highly experimental
- Ionization gives a fair countrate with a proved method, because of space charge the use of electrons (adding magnets) might be necessary