Thermal Simulations of Optical Transition Radiation Targets*

TUPP008

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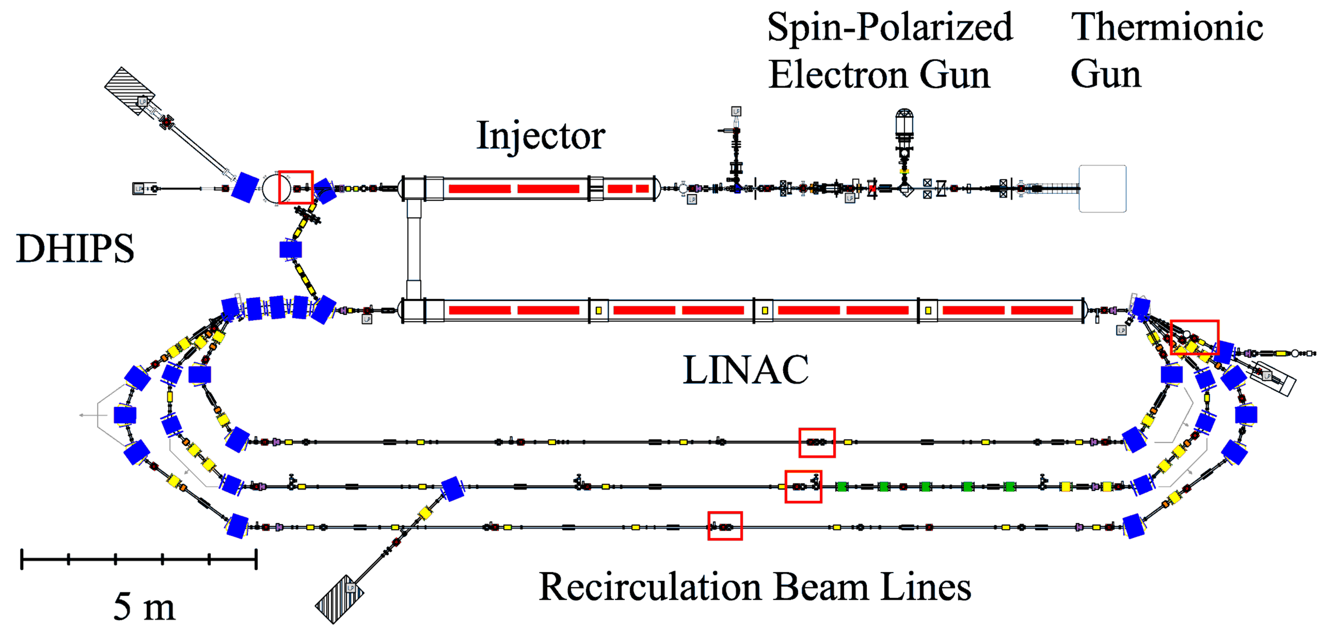
Abstract

The recirculating electron linac S-DALINAC [1] provides beams with currents up to 20 μA and energies up to 130 MeV. It is planned to extend the beam diagnostics by adding multiple emittance measurement systems in order to investigate the emittance evolution along the beam line. The emittance measurement is based on the quadrupole scan technique and utilizes the existing quadrupoles and newly built optical transition radiation targets. As the targets are heated by the beam and destruction must be avoided, simulations of the thermal behaviour of the target were conducted. In particular, the dependence of the target temperature on the target design, but also variable parameters as beam spot size and current were investigated. This contribution will present these parameter studies.

[1] N. Pietralla, Nuclear Physics News, Vol. 28, No. 2, pp. 4-11 (2018)

S-DALINAC



Beam current:	up to 20 μA	Frequency:	2.997 GHz
Duty cycle:	cw	Max. energy:	130 MeV

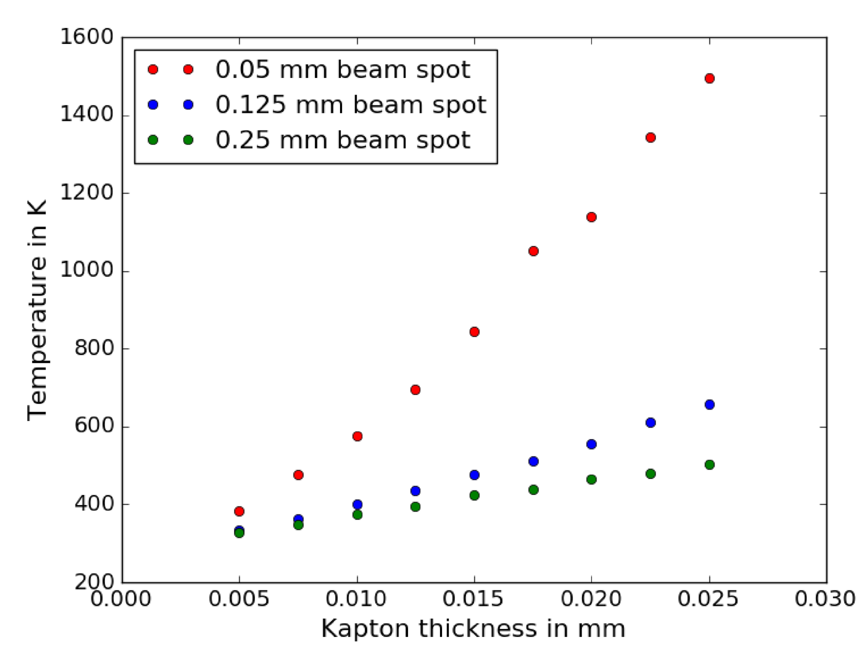
Red boxes: new diagnostic stations after each acceleration

Diagnostic Stations

- Based on optical transition radiation (OTR) targets
- Existing quadrupoles allow for emittance measurements by quadrupole scan
- Targets observed by circuit board camera
- Alternative: CMOS camera observing target via mirror
  → Allows more shielding, camera out of accelerator plane

Target Design

- Beam current down to 100 nA
- 7.5 μm Kapton foil coated with aluminium; diameter 25 mm
- Aluminium: high plasma frequency (15 eV)
  → high OTR yield
- Kapton can be stretched
  → flat surface
- 7.5 μm Kapton results in acceptable heating even for maximal current and small beam spot



Conclusion

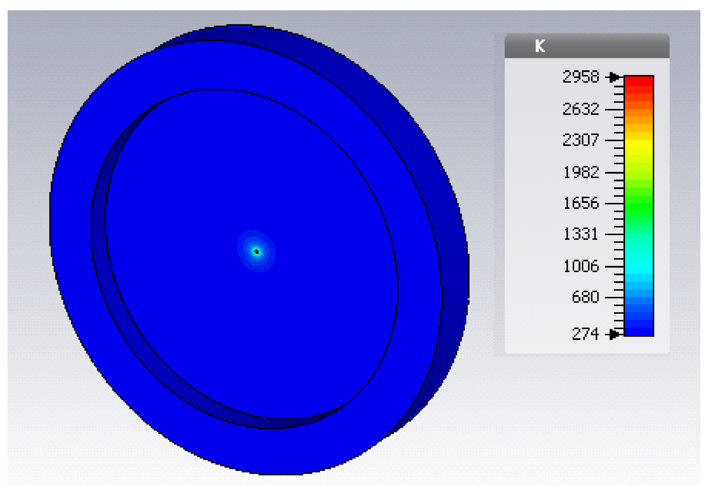
- Targets: 7.5 μm Kapton coated with aluminium
- Overheating possible only in extreme cases for beam current and size
- OTR targets constructed and installed
- Successful demonstration with only 100 nA beam current [3]
- Ready for emittance measurements

[3] F. Hug et al., Journal of Physics: Conference Series 1067 (2018) 032021

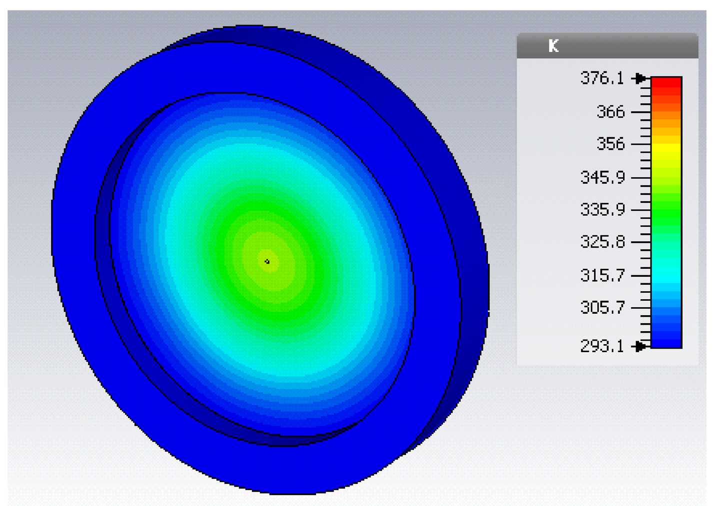
Thermal Simulations

- Estimate target temperature with beam heating, conduction, emission
- Simulations in CST MPhysics Studio [2]
- Target frame as heat reservoir
- Beam heating uniformly distributed

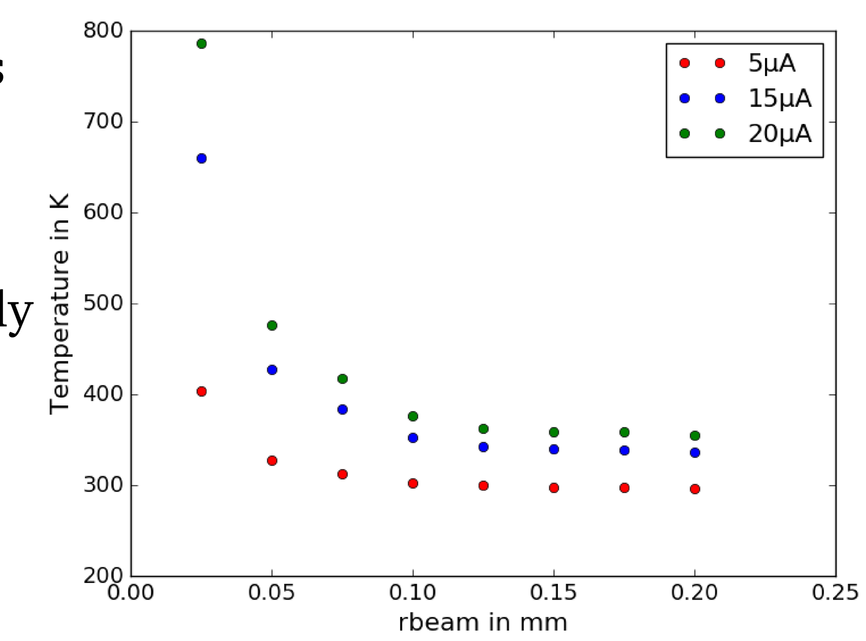
- Temperature distribution of pure Kapton target, beam current 20 μA, beam spot size 0.1 mm
- Heat only in beam spot
- Overheating, destruction of target



- Temperature distribution of Kapton target with aluminium coating, beam current 20 μA, beam spot size 0.1 mm
- Aluminium has high conductivity
- Heat distributed over large volume
- Acceptable temperature increase



- Max. target temperature varies with beam properties
- Typical beam current of 5 μA results in acceptable temp.
- At max. current targets can only be used if beam spot size is large enough



[2] Dassault Systemes: CST – Computer Simulation Technology AG: CST Studio Suite. Version 2016. http://www.cst.com/