HELMHOLTZ GEMEINSCHAFT

DESY

Injector Beamline Review

- Dark Current

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XFEL Beam Dynamics Meeting

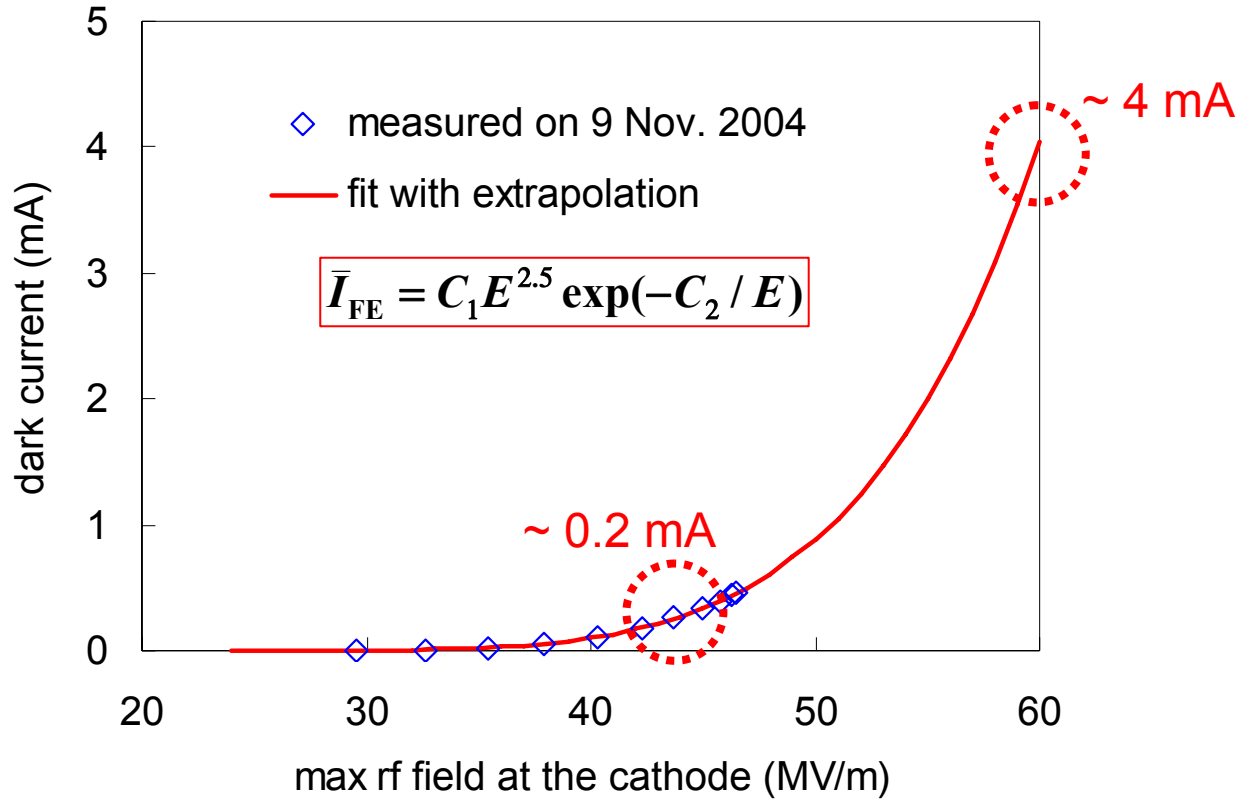
Questions

- At FLASH (~44 MV/m), dark current from the gun is already problem when long pulse operations
- 60 MV/m at the cathode, required for the XFEL beam quality

  → How much dark current?
- Field emission (dark current) suppression?
- Collimation at the injector?

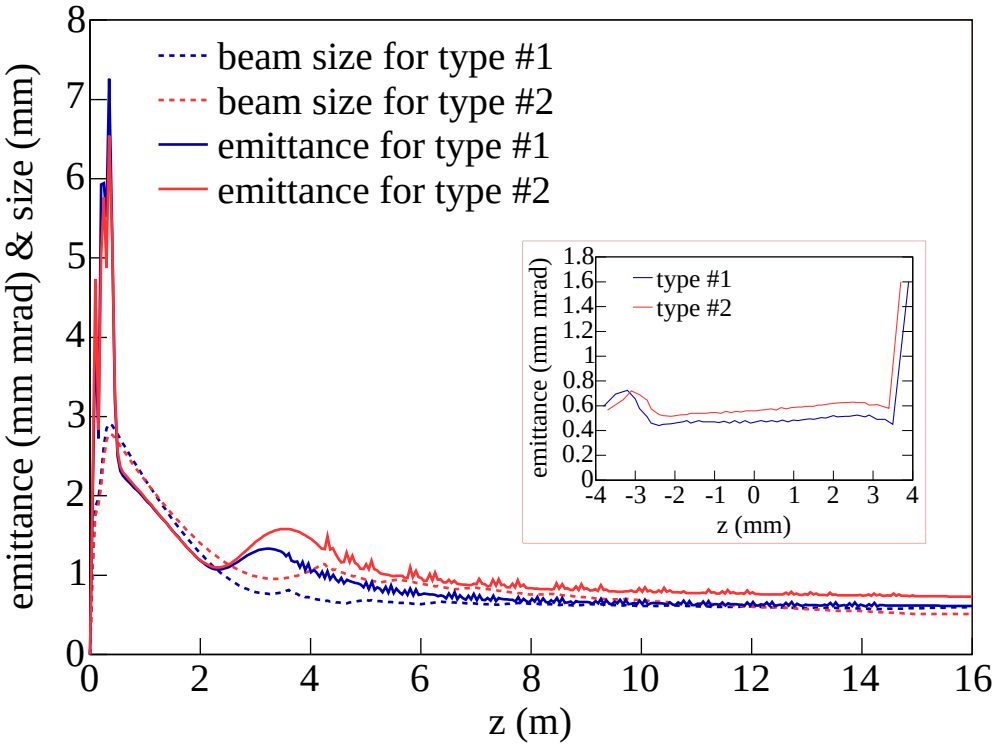
Operation at 60 MV/m (1)

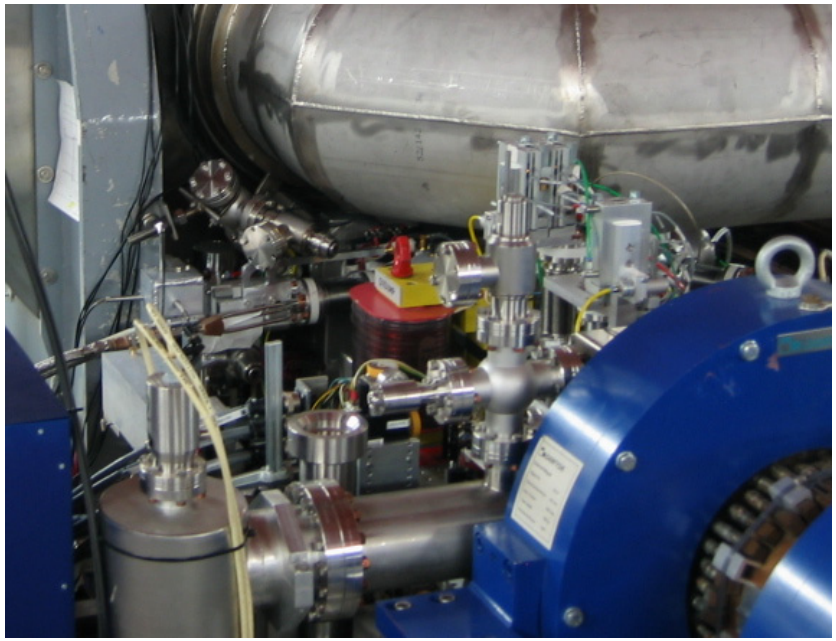
- More dark current generated



Operation at 60 MV/m (2)

- Longer distance to ACC1
  → more space for collimators



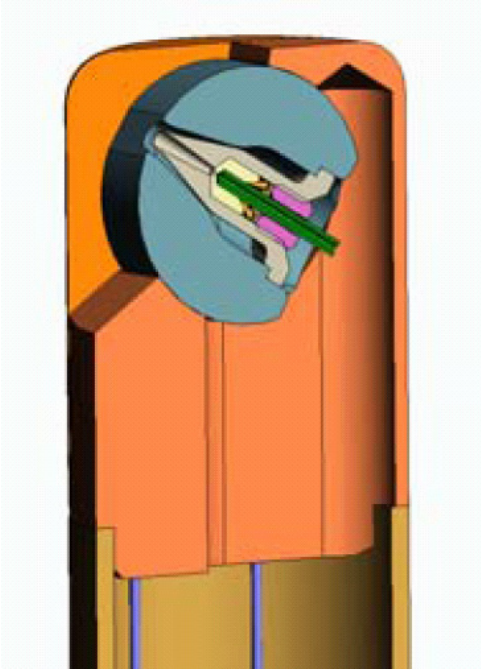


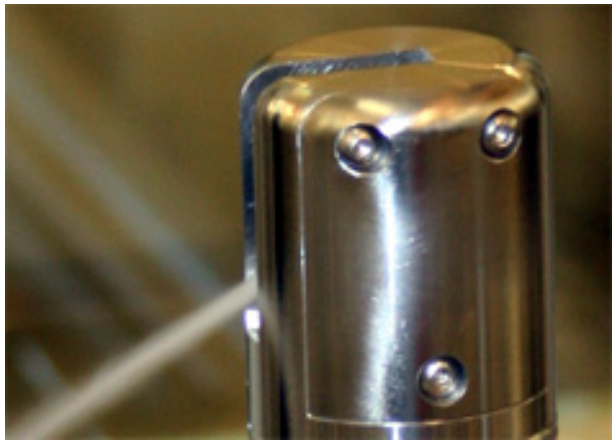
Han, FEL2006

Field emission (dark current) suppression

- RF conditioning at higher gradient may reduce the amount of field emission
- Dry ice cleaning for Cu cavity and Mo cathode plug – ongoing with Uni. Wuppertal
- Improved polishing of the front surface of the cathode plug – under first trial with Carl Zeiss
- New design of the cathode plug not to make new field emitters?

Dry Ice (CO_2) Cleaning

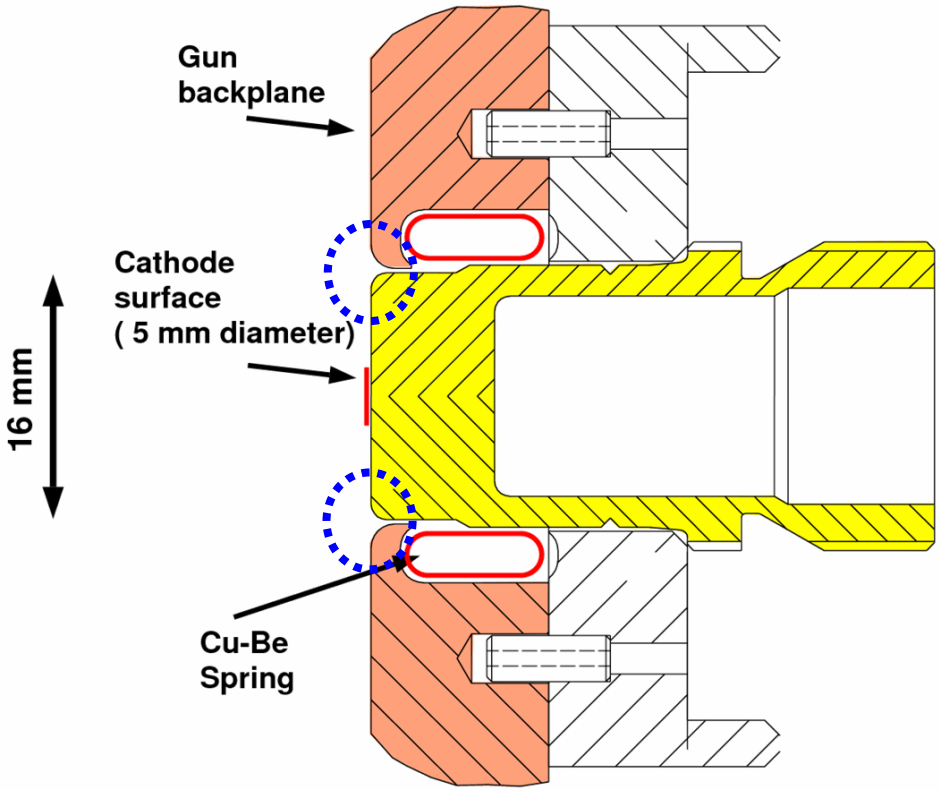




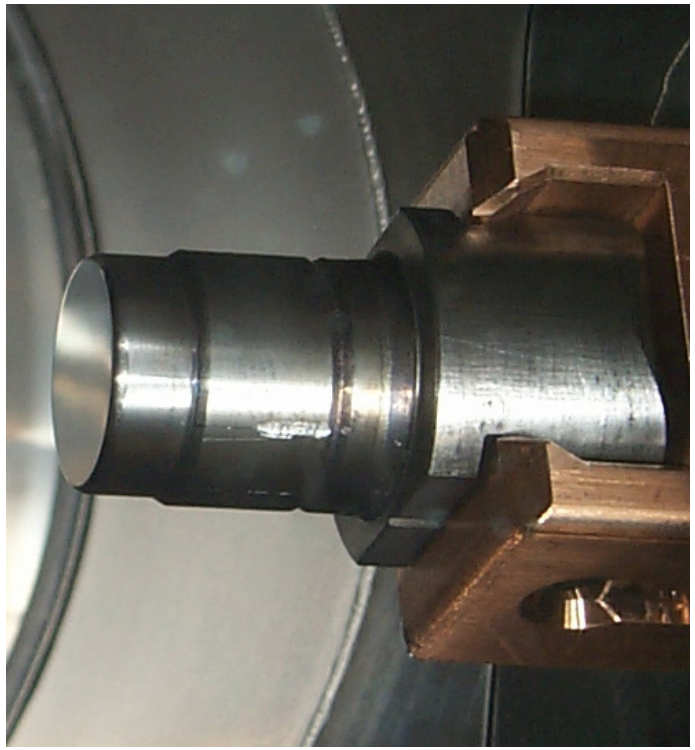
Moveable CO_2-Snow Nozzle by the Fraunhofer-Institut für Produktionstechnik und Automatisierung (IPA), Stuttgart

K. Flöttmann

Cathode Geometry at FLASH



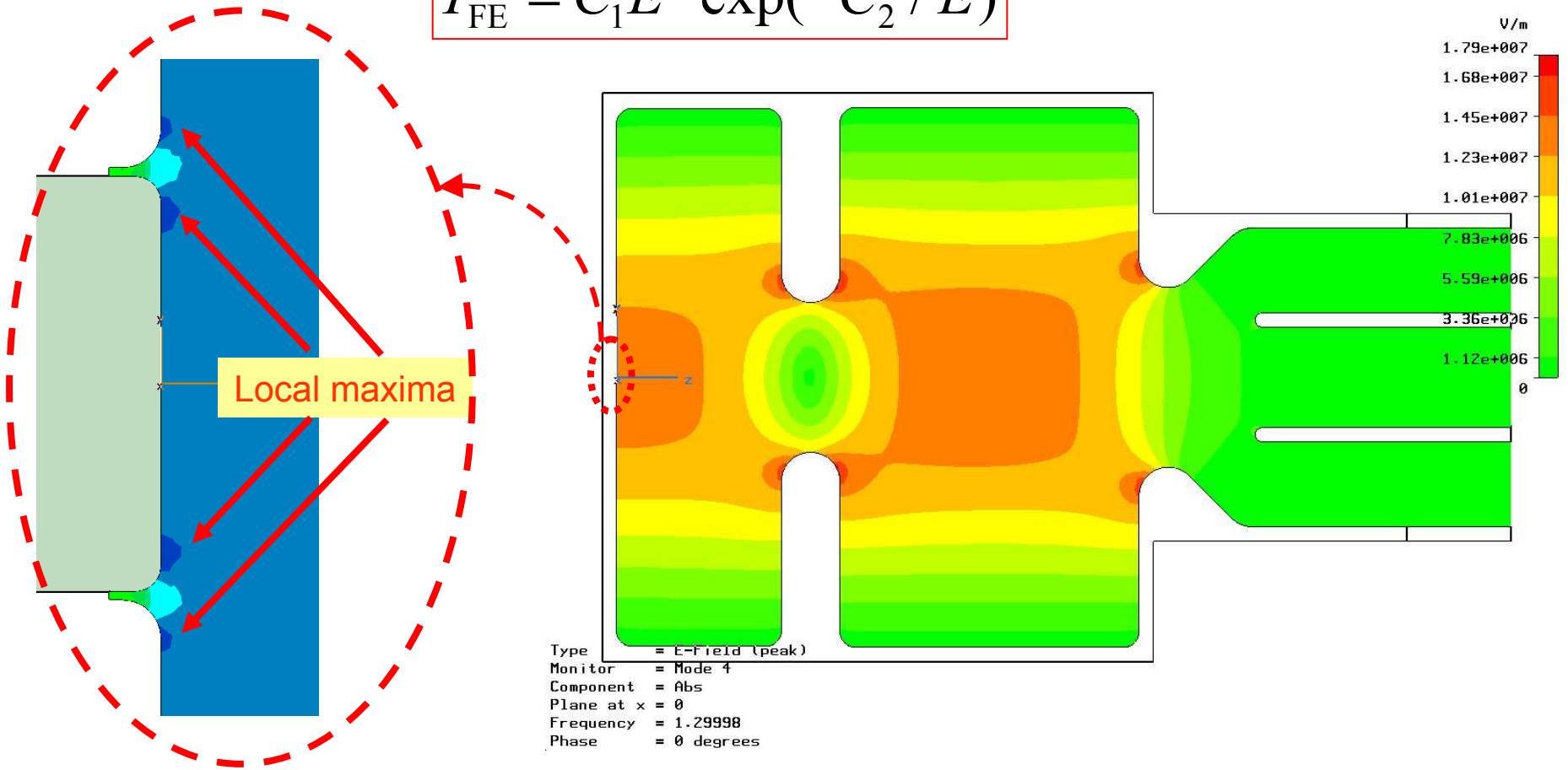
Drawing by S. Schreiber



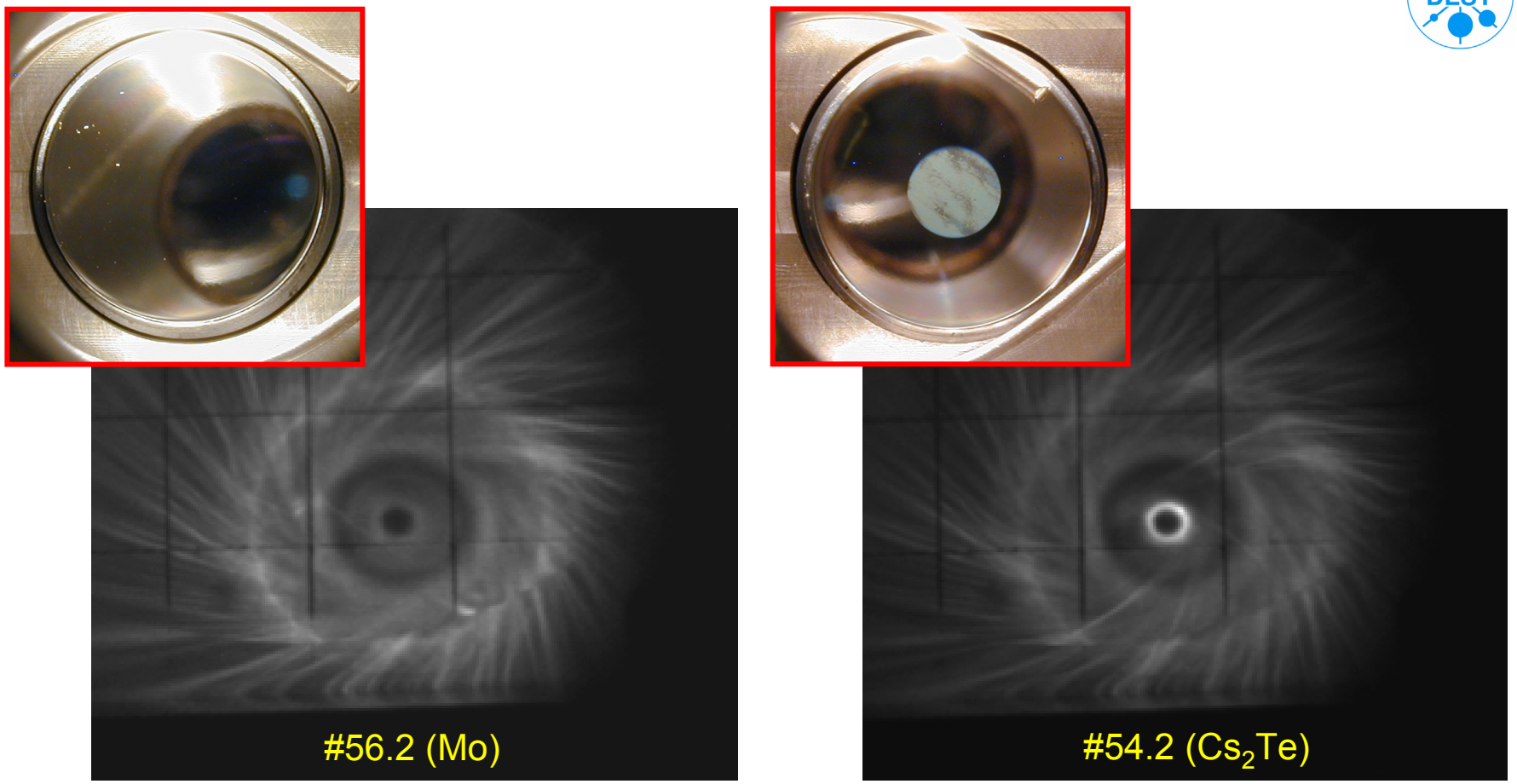
RF Field Profile

Field emission strength

$$I_{FE} = C_1 E^2 \exp(-C_2 / E)$$

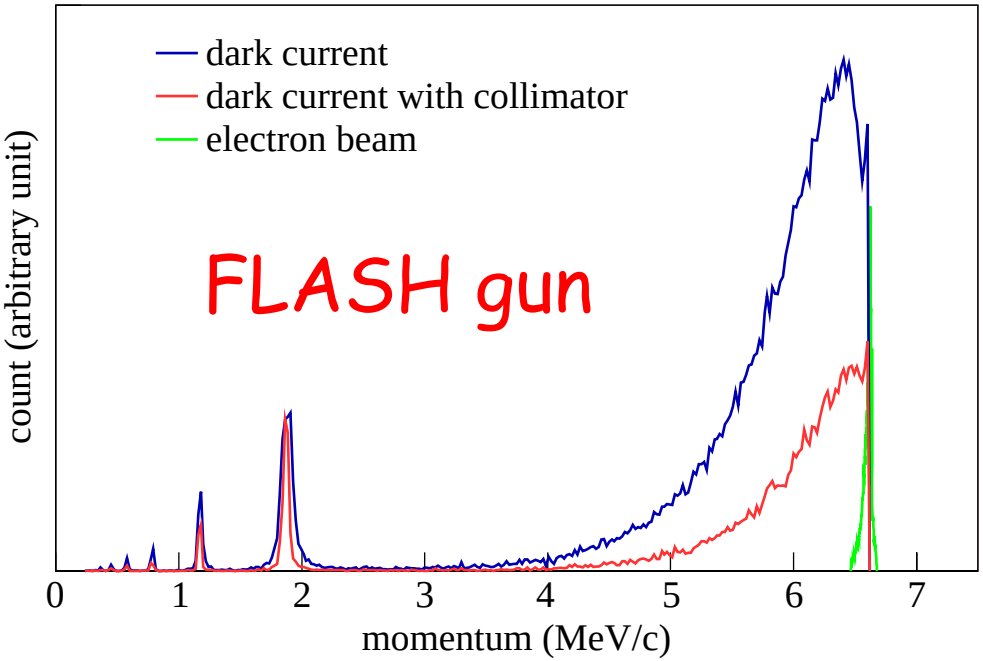


Dark Current Image



Larger diameters of the plug and the Cs_2Te film
→ better separation of beams and dark current

Dark Current Collimation



Dark current at the entrance of the 1st module

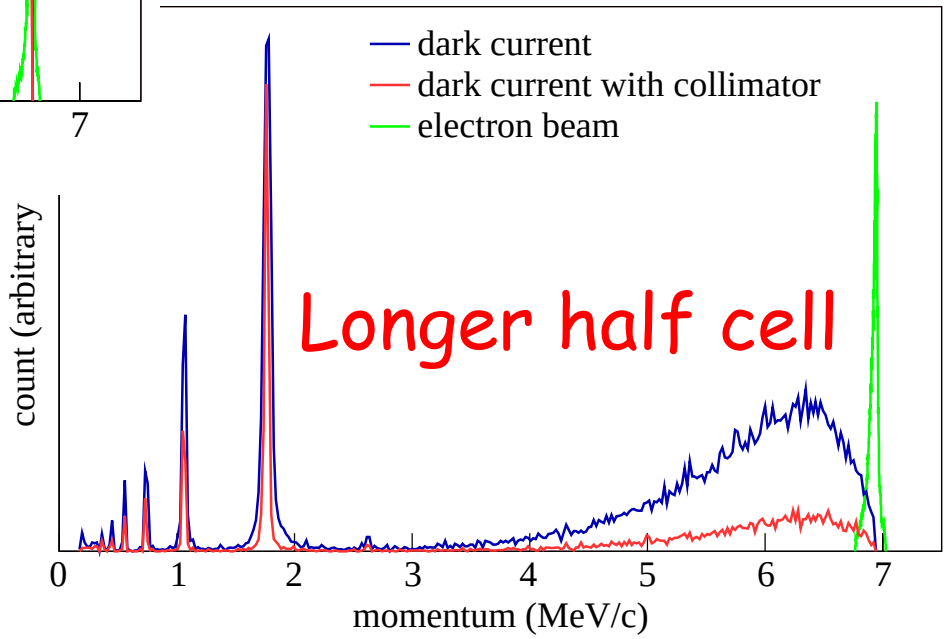
10 mm ϕ collimator 2.2 m from cathode (1.2 m upstream of the 1st module)
Dark current reduced by 66%

Large overlap of the dark current & the beam in the momentum spectra

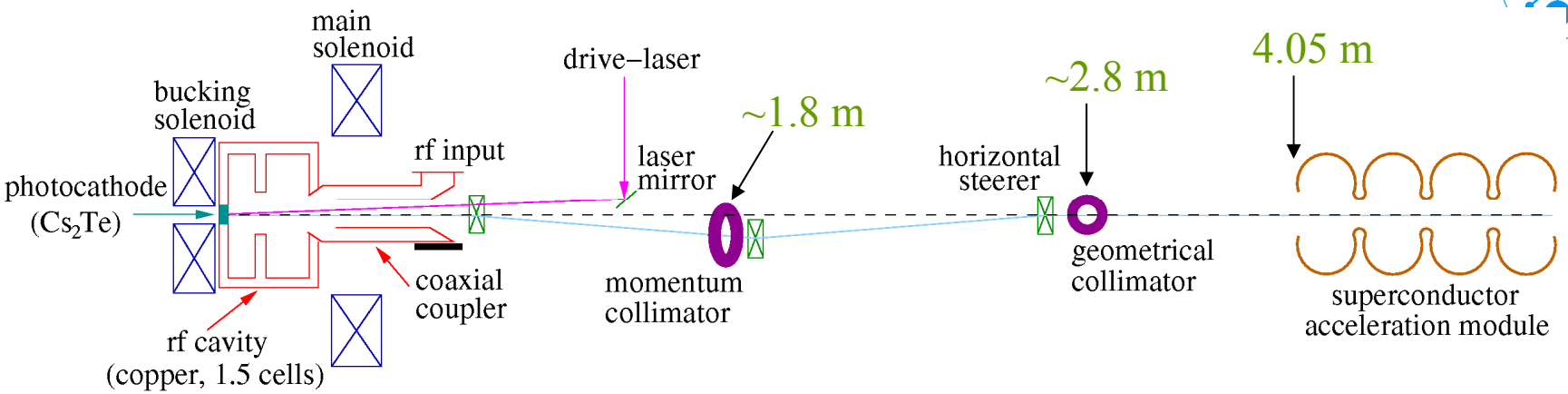
Dark current reduced by 63% without collimator

10 mm ϕ collimator 2.8 m from cathode
Dark current reduction by 70% especially near the beam

Very small overlap in the momentum spectra



Collimators at the XFEL



Momentum collimator with elliptical shape

- Minor axis (vertical) by the bunch size
- Major axis (horizontal) by the momentum distribution and the size

→ Further simulation study required (optimum size, wakefield, material)

	Type #1	Type #2
At module entrance	100% (z = 3.43 m)	37% (z = 4.05 m)
+ geometrical collimator	34% (10 mm ϕ at 2.2 m)	11% (10 mm ϕ at 2.8 m)
++ momentum collimator	**26% (> 5.9* MeV/c)**	**3% (> 6.2* MeV/c)**

* 10% lower than the mean momentum of the beam

Summary and Outlook

- Field emission is stronger at higher gradient
- More care required to suppress field emission from the cavity and the cathode plug
- Advantage in dark current collimation at the XFEL
- With changing gun geometry, dark current surviving until ACC1 can be reduced. But new machine parameters should be found with an optimization