Measurements and modeling at the PSI-XFEL

500 kV low-emittance electron source

T. Schietinger, A. Adelmann, Å. Andersson, M. Dietl, R. Ganter,
C. Gough, C.P. Hauri, R. Ischebeck, S. Ivkovic, Y. Kim, S.C. Leemann,
F. Le Pimpec, K. Li, P. Ming, A. Oppelt, M. Paraliev, M. Pedrozzi,
V. Schlott, B. Steffen, A.F. Wrulich,
Paul Scherrer Institut, CH-5232 Villigen, Switzerland

PAUL SCHERRER INSTITUT

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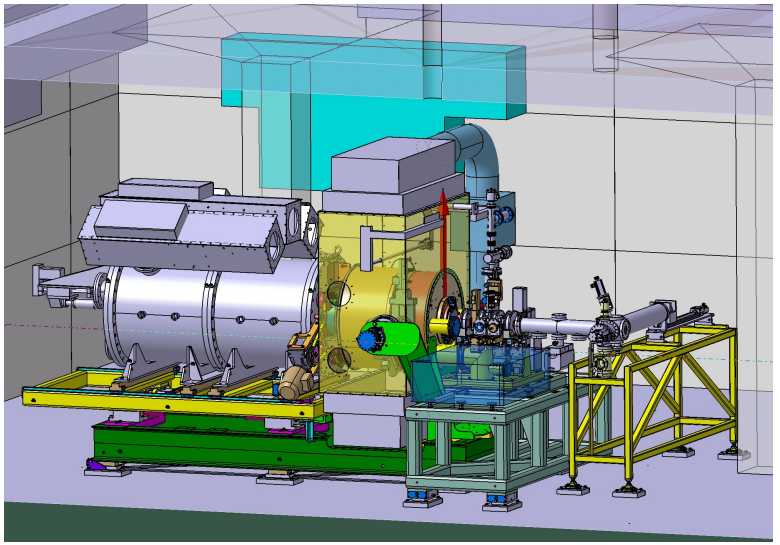
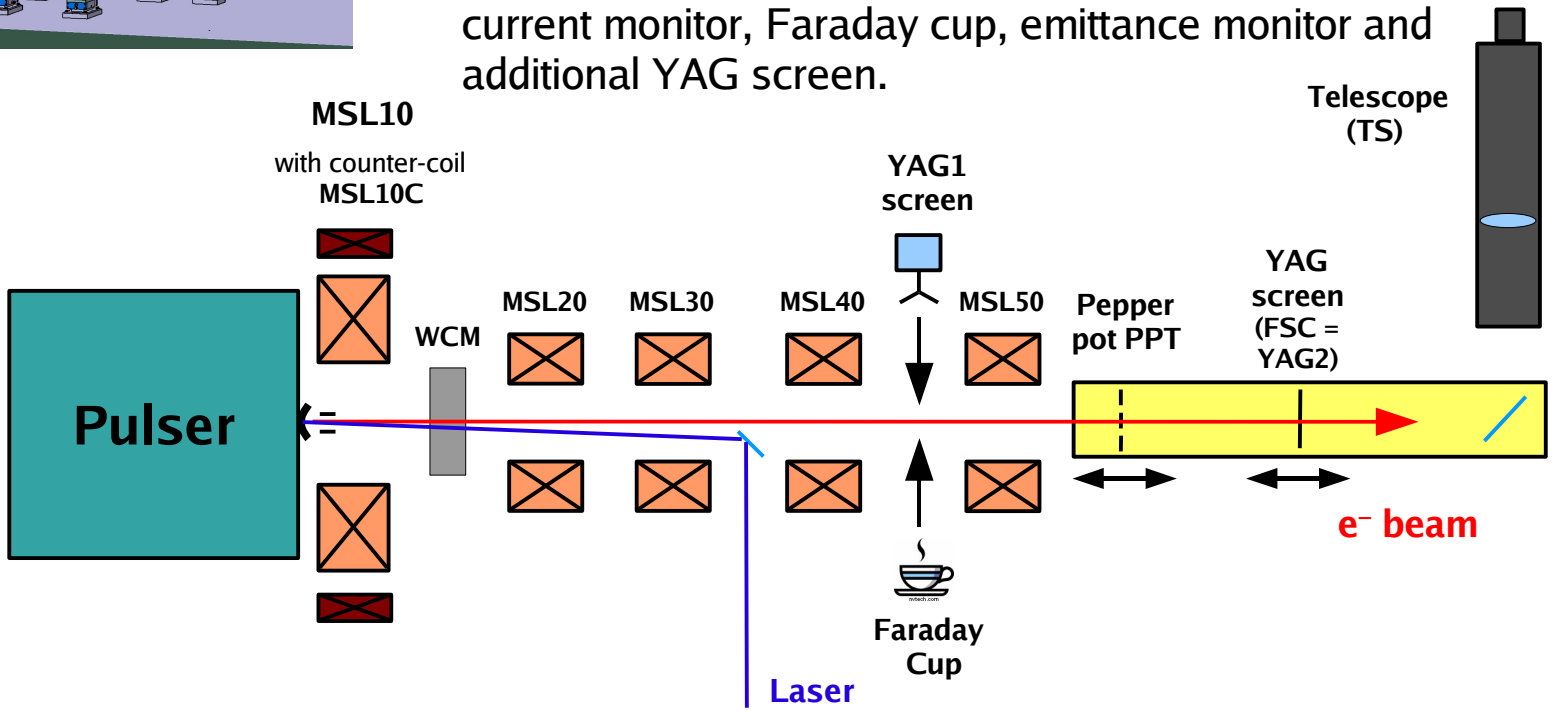
The Goal:

- Development of a low-emittance gun for the PSI-XFEL project
- Evaluation of:
  - emission processes (photo emission, field emission)
  - Cathode materials/concepts (metals, needles, field emitter arrays)

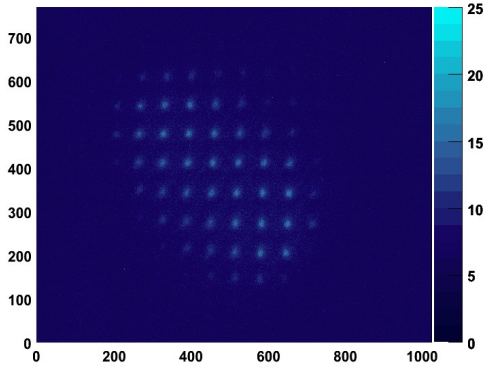


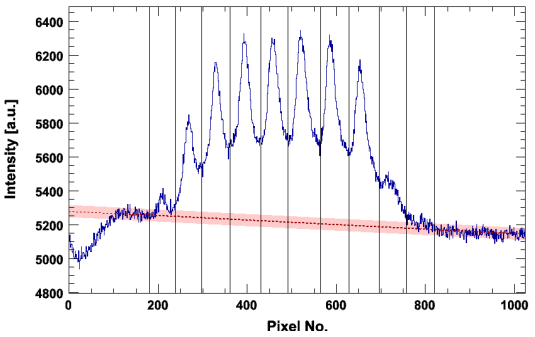
Experimental Setup:

- **High-voltage pulser** delivering 250 ns pulses of up to 500 kV amplitude to an adjustable diode (stainless steel or other material)
- 266 nm UV **laser** (Nd:VAN) illuminating the cathode during pulse (~4 µJ)
- **Diagnostic beamline** consisting of 5 solenoids, wall current monitor, Faraday cup, emittance monitor and additional YAG screen.



Emittance measurement:

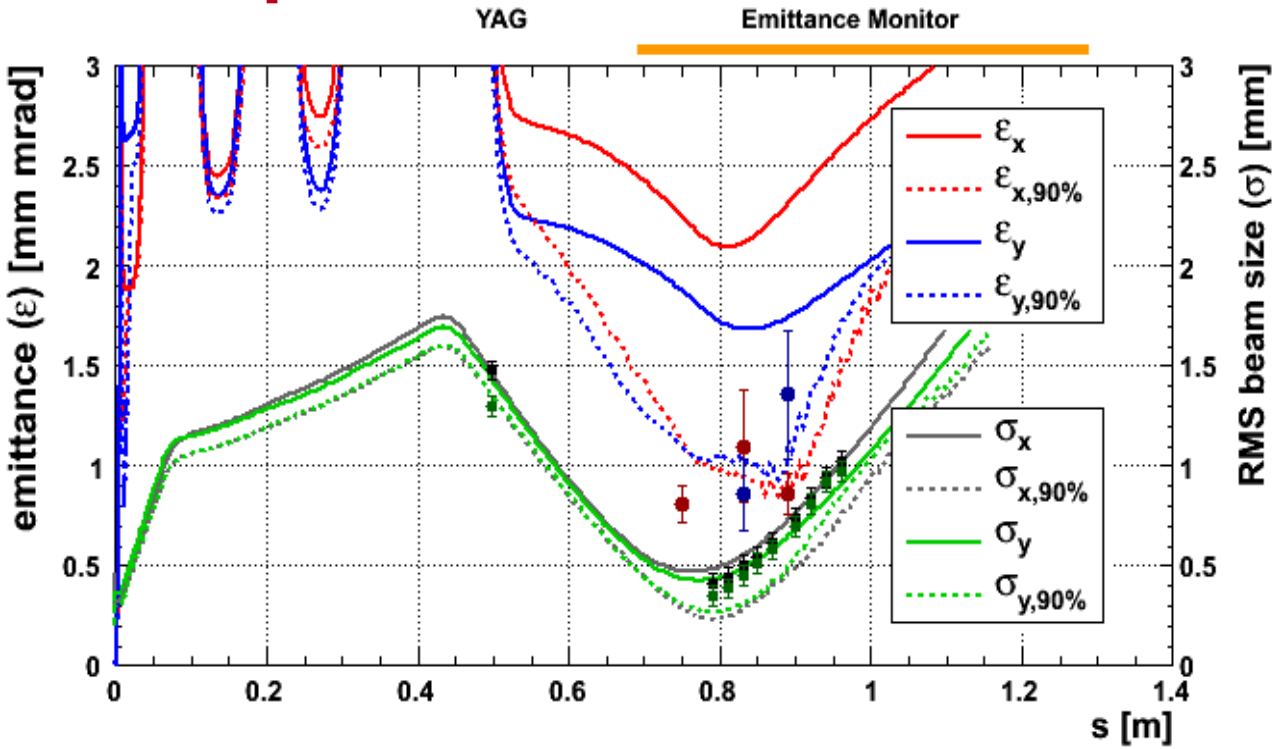




Simulation:

- **OPAL: Object-oriented parallel accelerator library**
- C++ framework developed at PSI (A. Adelmann)
- **OPAL-T:** (one of several flavors of OPAL)
  - Time-dependent parallel particle-in-cell code
  - Space-charge solver based on integrated Green function (similar to IMPACT-T)
  - We track 10^6 macro-particles on 32×32×64 mesh.
  - Currently run on 4–8 processors.

Comparison:



Issues:

- (Too?) Large emittance in simulation.
- Can be traced back to a large but faint halo (in the simulated beam) – not observed in measurement.
- Strategies (under study):
  - Only consider central 90% of particles in simulation (left)
  - Modify initial distribution on cathode (tails are not very well known).
  - Aperture from anode iris?