CLIC Drive Beam Injector study LEETCHI electron source

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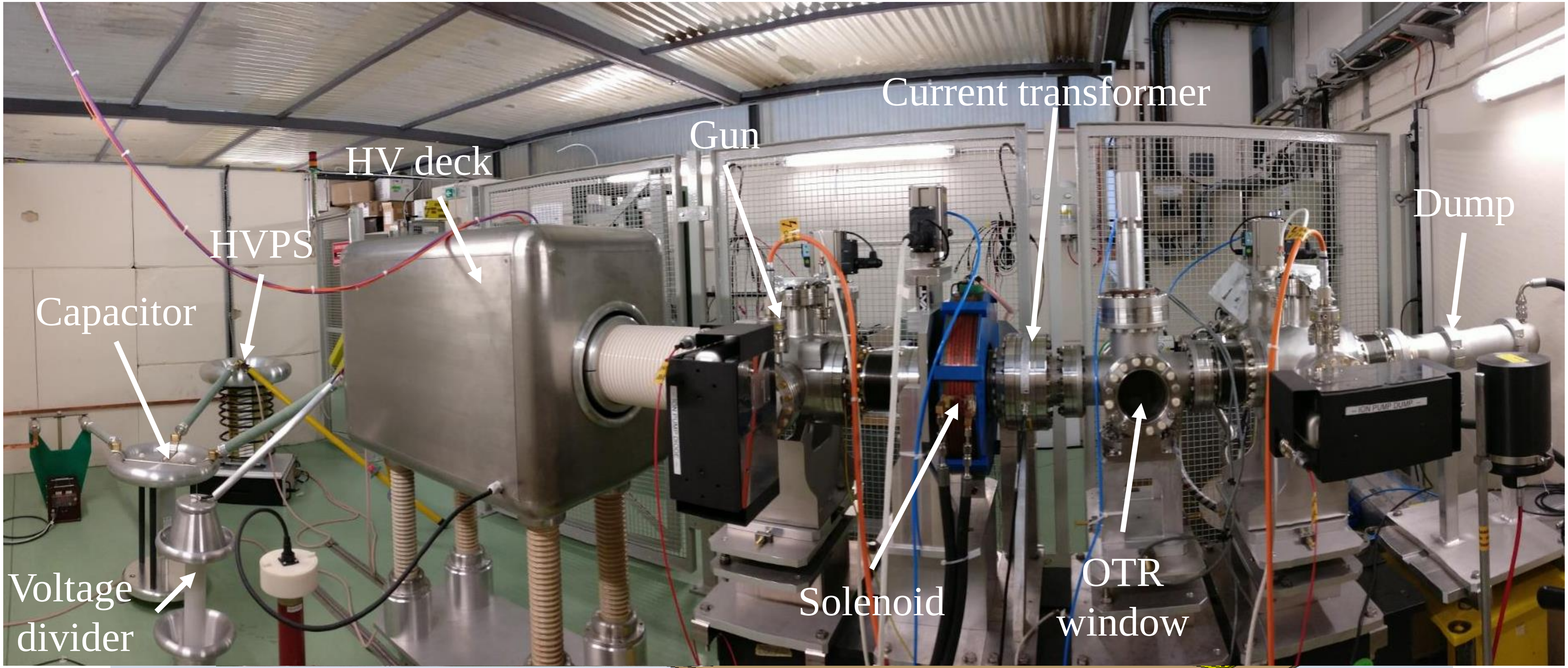
Electron beam parameters

CLIC drive beam electron source specifications

Parameters	Baseline
Beam energy	140 keV
Beam current	Up to 7 A
Pulse length	140 μs
Emittance (RMS)	< 20 mm mrad
Repetition rate	50 Hz
Beam power	Up to 6.9 kW
Shot to shot charge variation	0.1 %
Flat top charge variation	0.1 % after correction

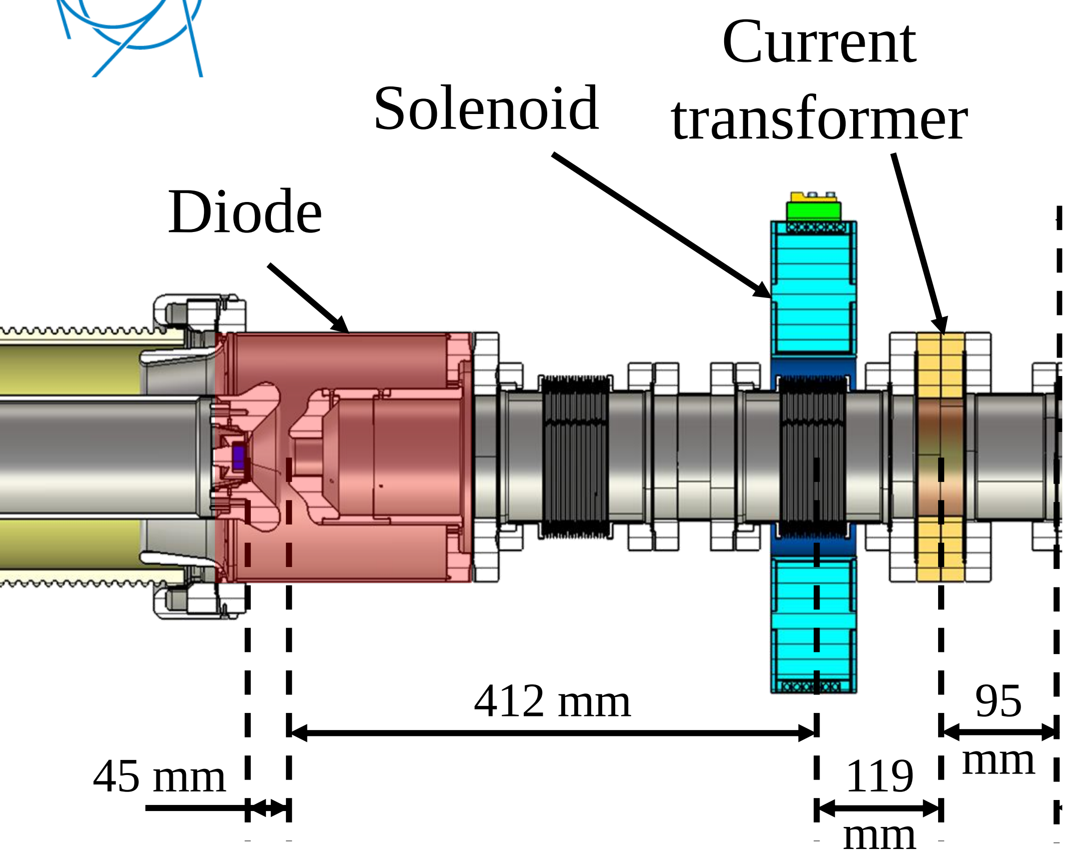
LEETCHI

Low Energy Electrons from a Thermionic Cathode at High Intensity



162/R-008 @ CERN

LEETCHI

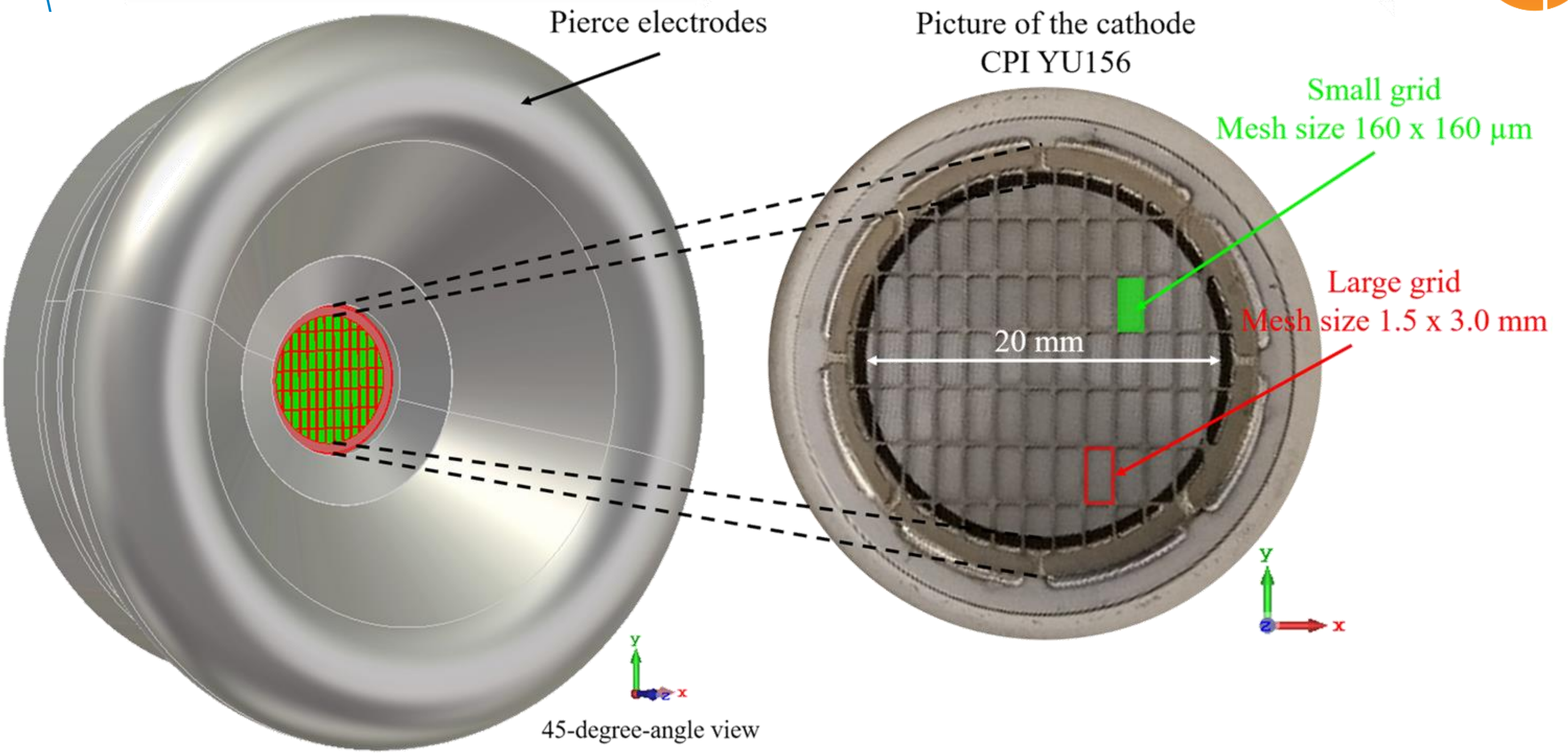


[illegible] mean power (no need for the water cooled beam dump) [illegible] characteristics under different conditions:

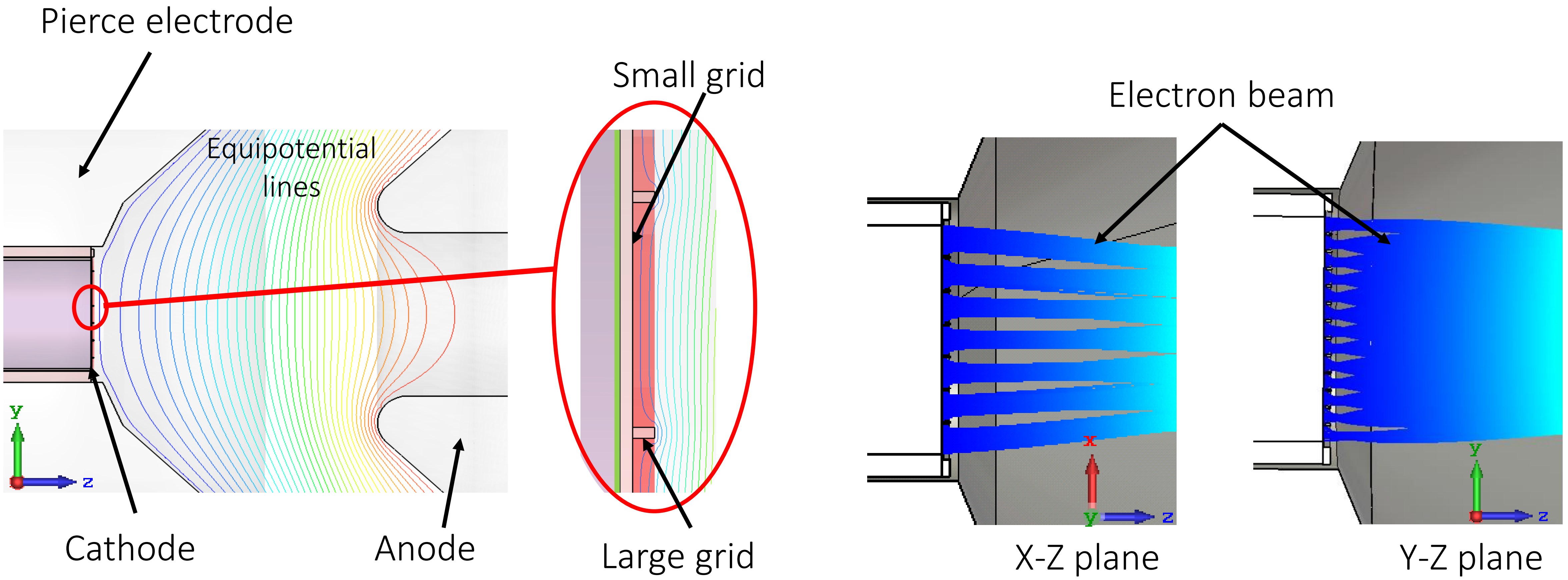
0.85 m for experiments with the beam dump

- I_{beam} from 0 to 4.5 A
- Magnetic field from 120 to 240 G
- d_{AK} by changing the spacer
- Cathodes: 2 cm² or 3 cm² area
- V_{HV} from 0 to 140 kV

Cathode grid effects



Cathode grid effects

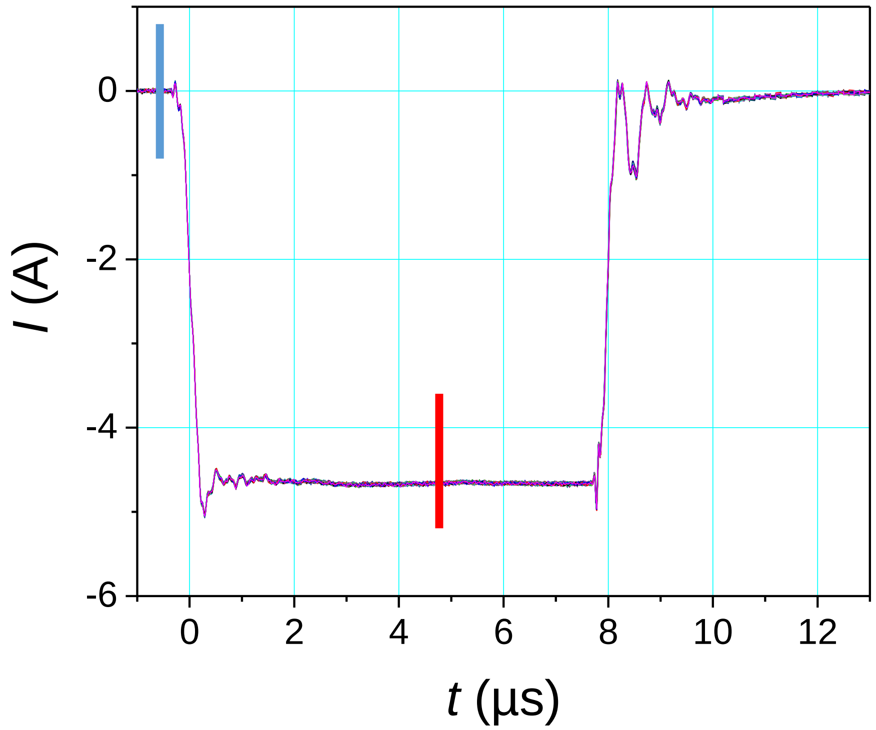


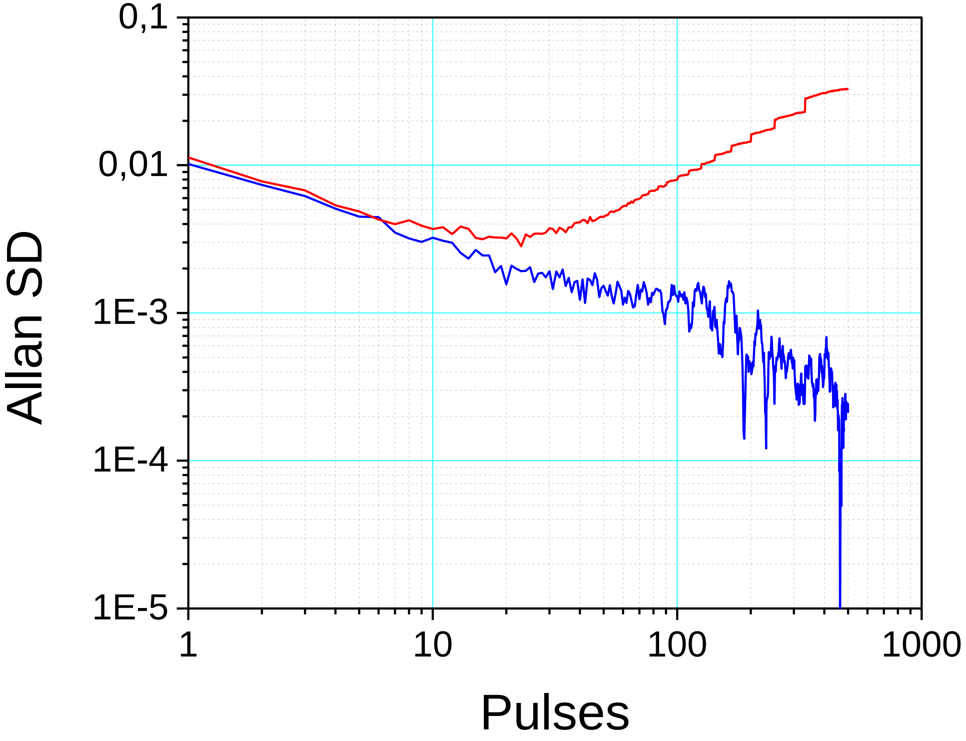
Experimental results

Pulse to pulse current stability

1000 shots @ 50 Hz, extracted from 180 000 shots (1 hour @ 50 Hz)

V_{HV} = 140 kV ; t = 8 µs ; I_B = 4.5 A





Measured pulse to pulse stability on beam current: 0.3-0.4 %

Allan Standard Deviation = A metric for stability = Two-sample Standard Deviation taken over variable interval of time or variable interval of pulses

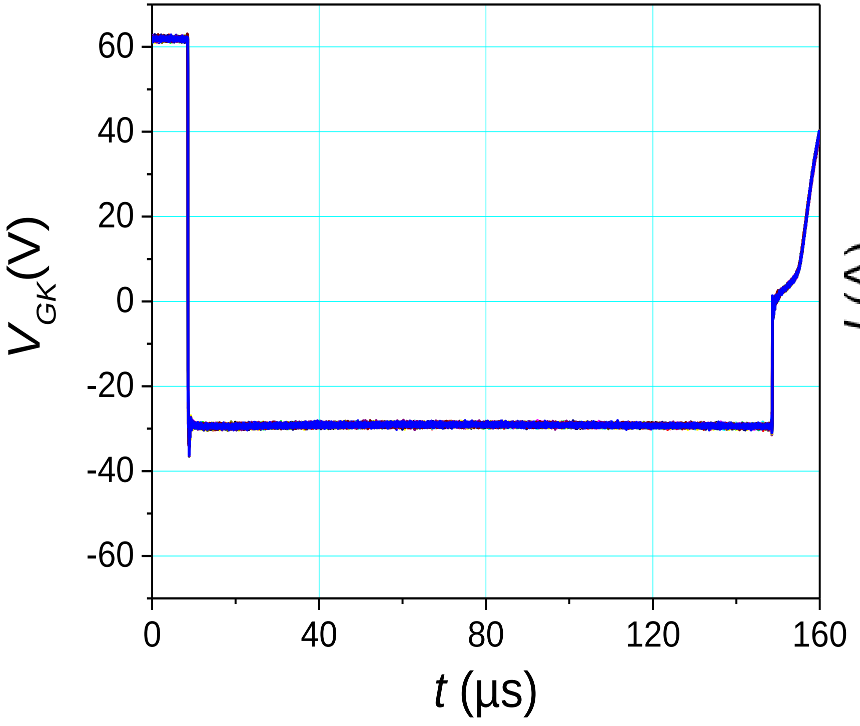
Experimental results

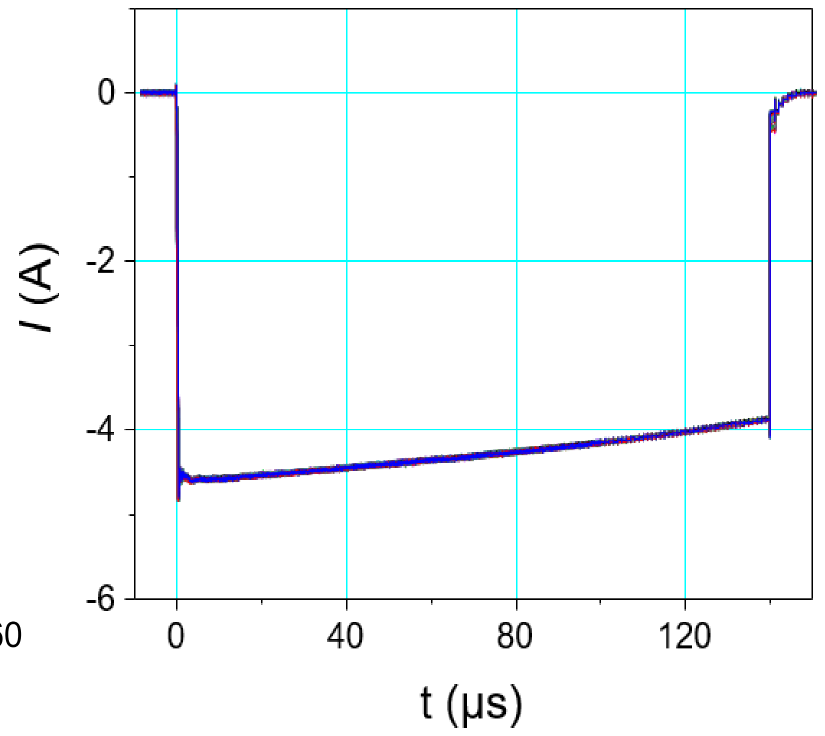
Pulse to pulse current stability

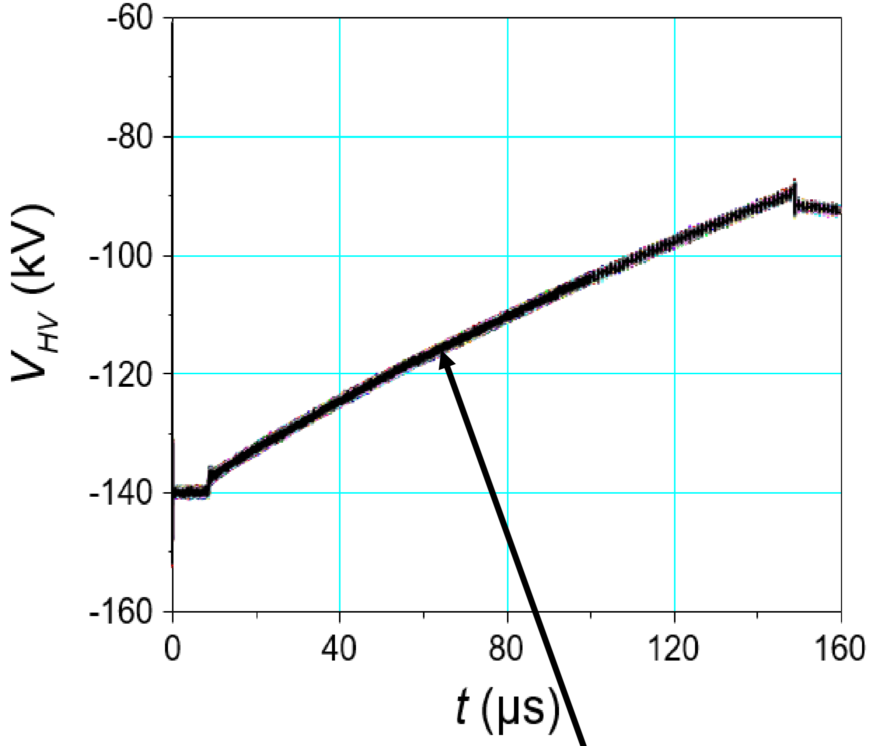
300 shots @ 6 Hz, extracted from 1800 shots (5 minutes @ 6 Hz)

V_{HV} = 140 kV ; t = 140 µs ; I_B = 4.5 A

November 2016







Measured pulse to pulse stability on beam current: 0.3-0.4 %

Capacitor discharge during the pulse,
Marx-modulator under development

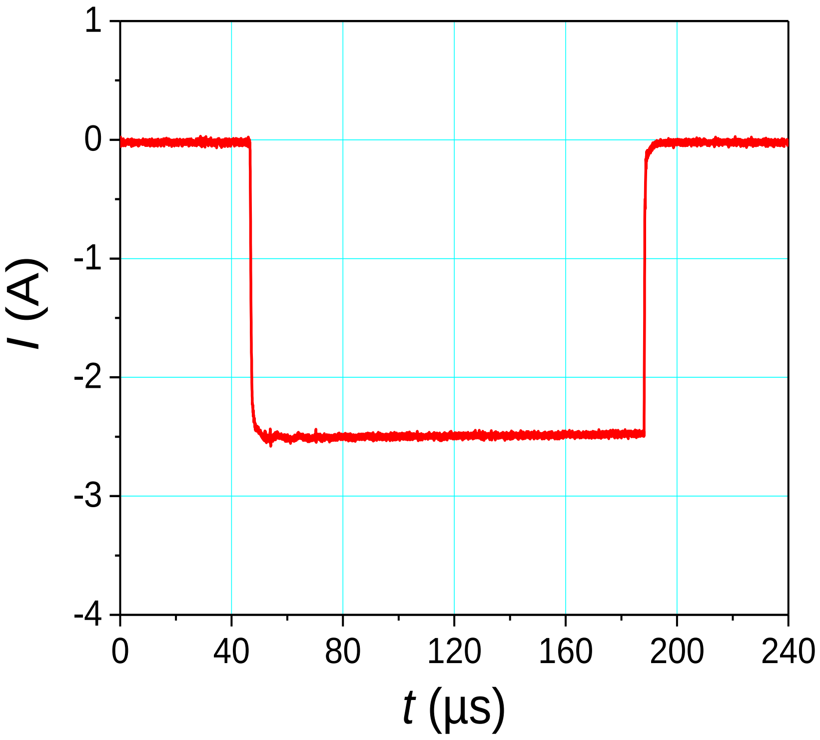
Experimental results

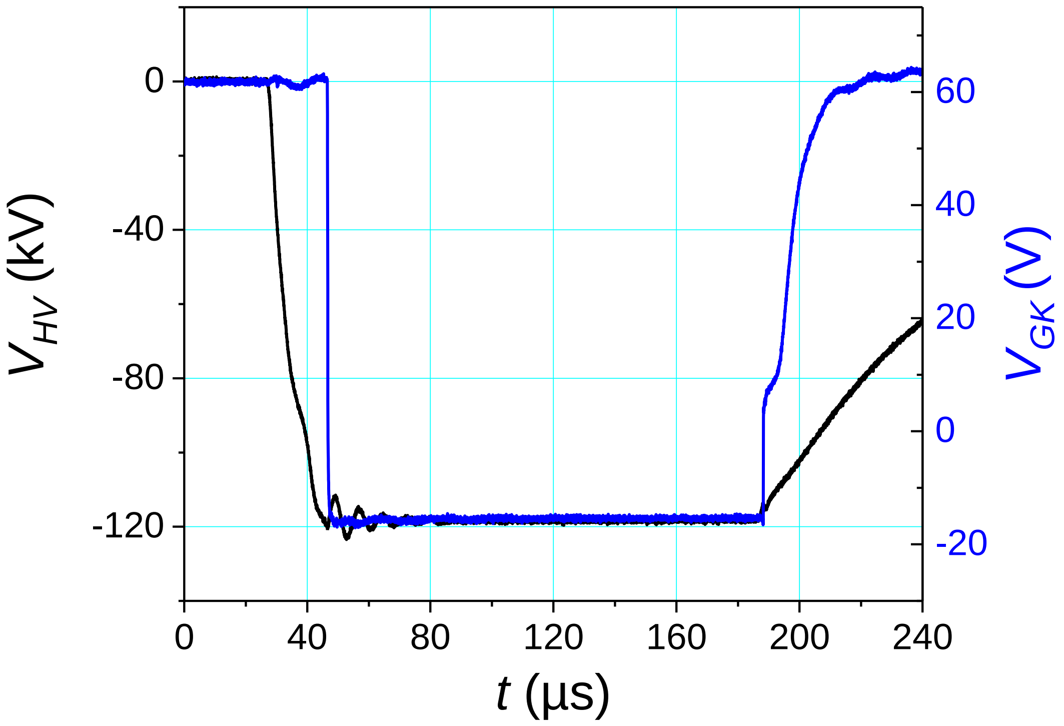
Marx-Generator

1 shot

V_{HV} = 120 kV ; t = 140 µs ; I_B = 2.5 A

November 2017
Preliminary
results



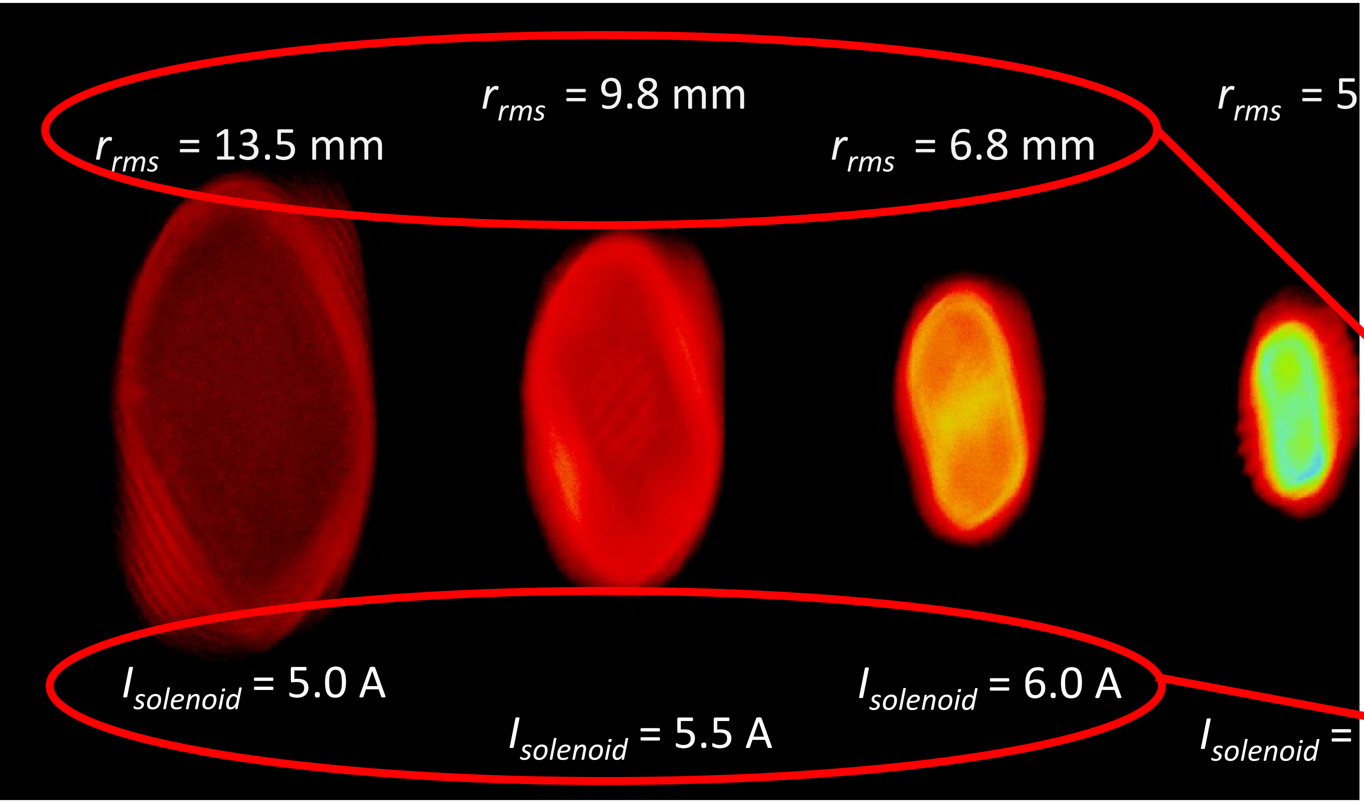


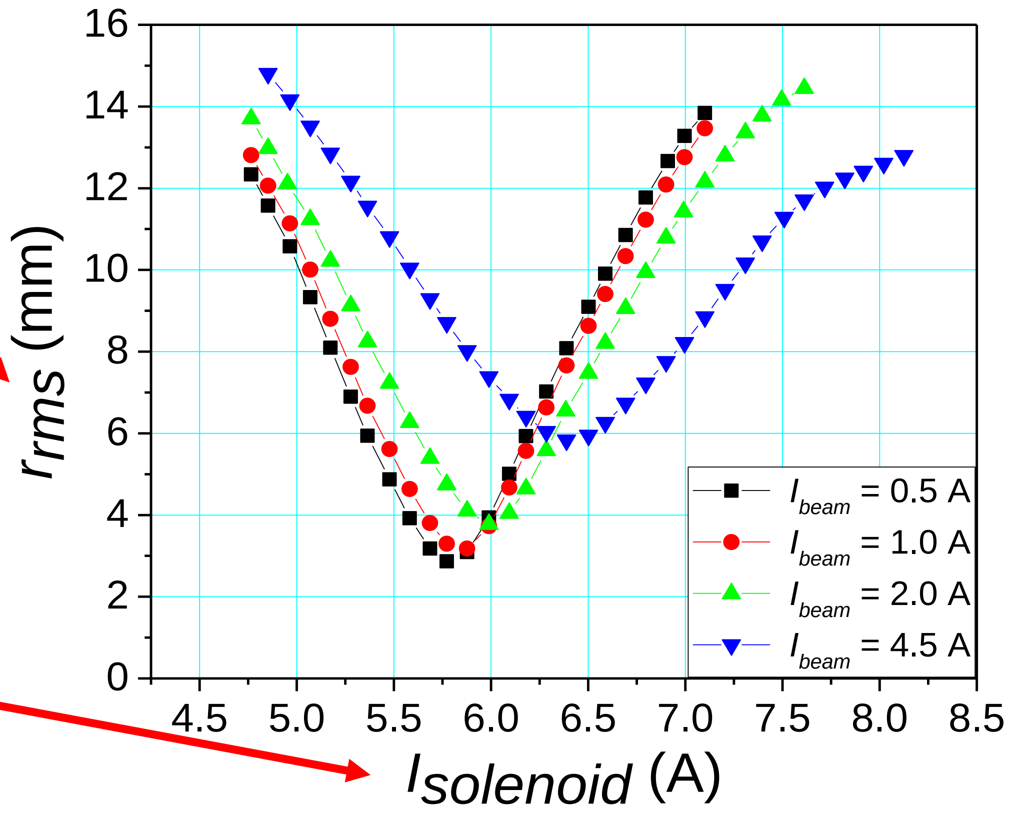
Good stability

Experimental results

RMS radius with OTR

t = 5 μs, I_{beam} = 4.5 A, E = 140 keV





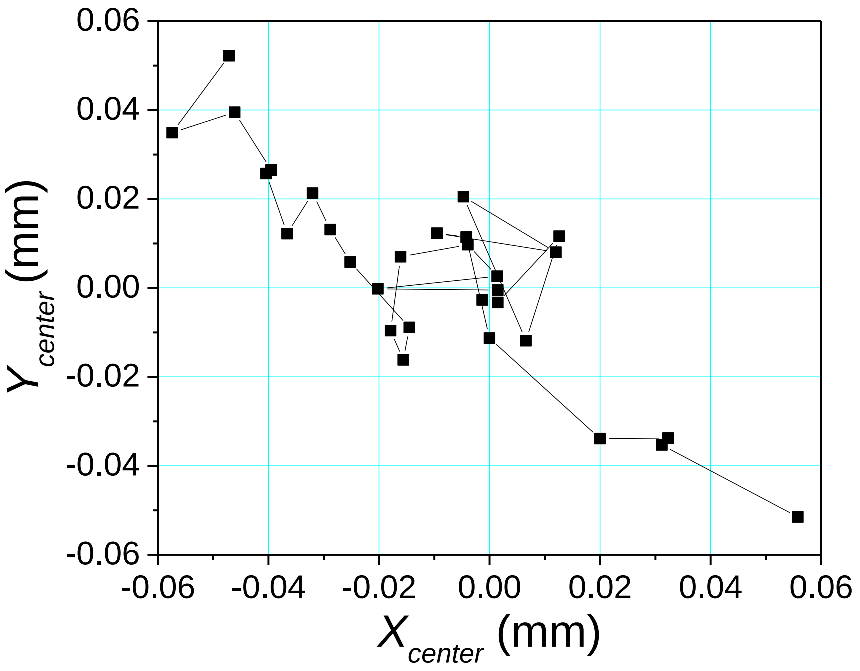
Magnetic field : 175 G

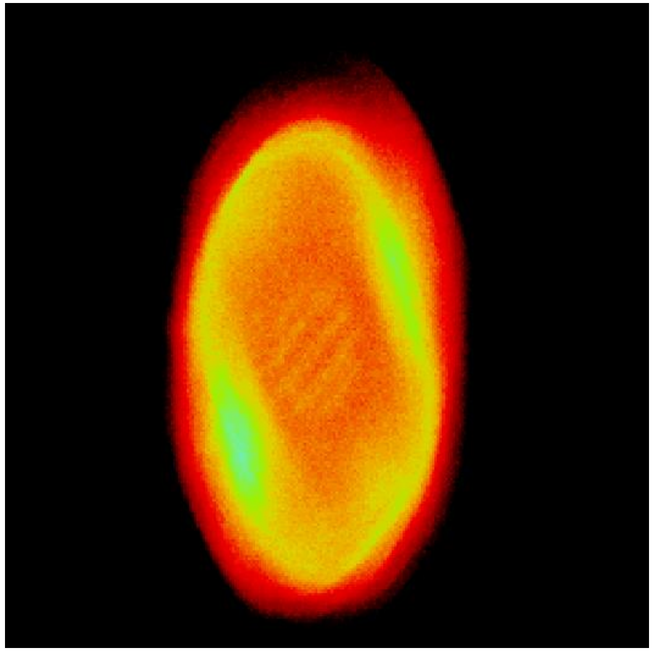
240 G

Experimental results

Beam stability with OTR

30 shots @ 1Hz, t = 3 µs, I_{beam} = 4.5 A, $I_{solenoid}$ = 5.5 A, E = 140 keV

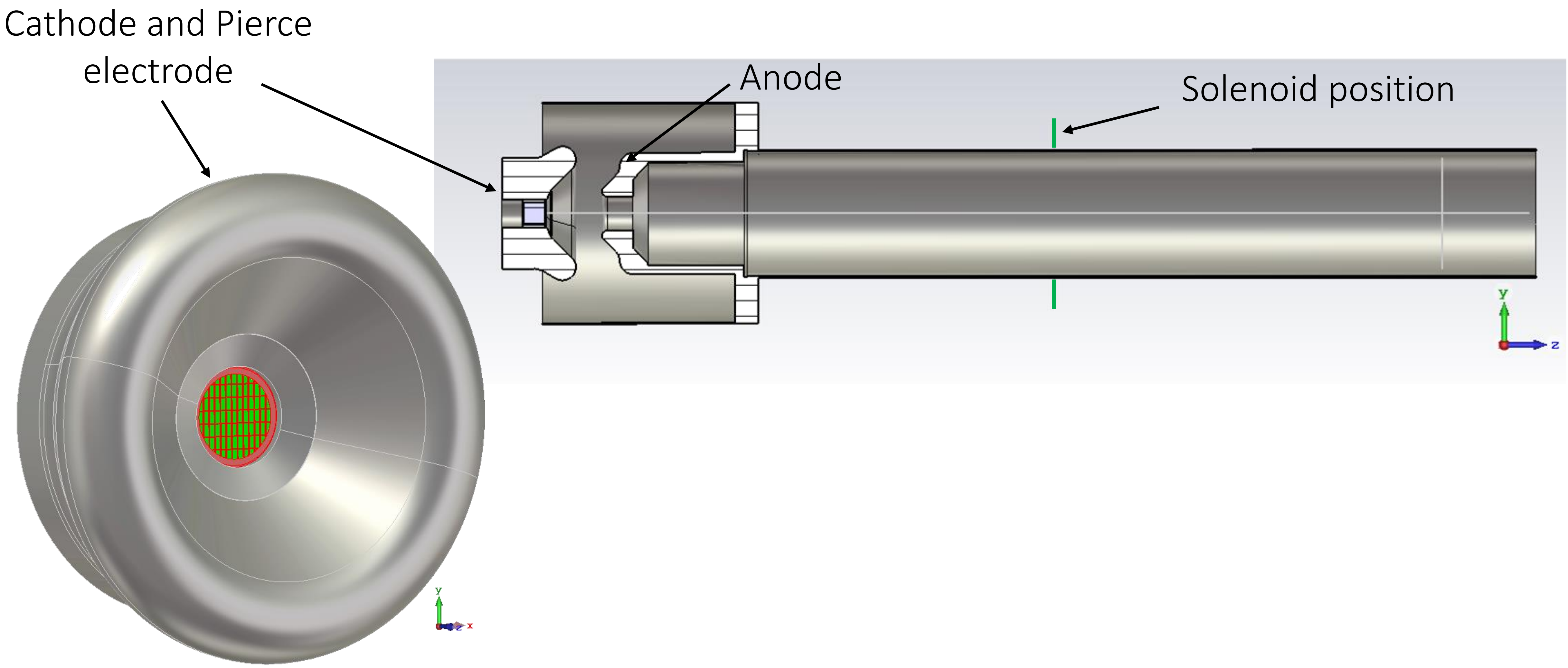




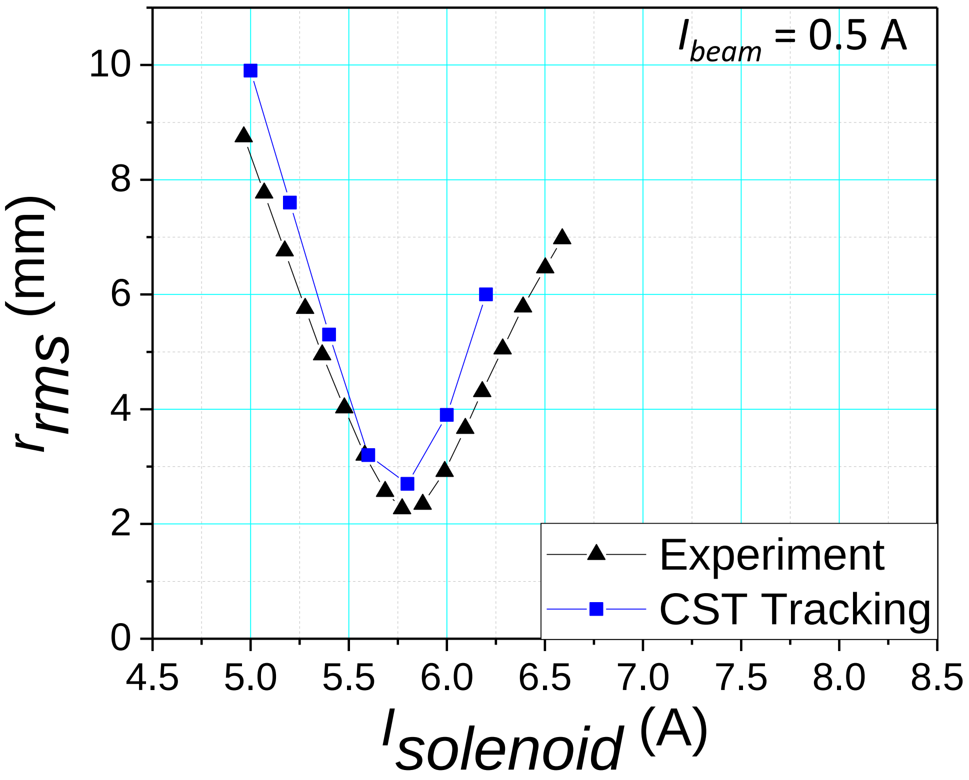
r_{rms} = 9.85 ± 0.022 mm
beam stability = 0.2%

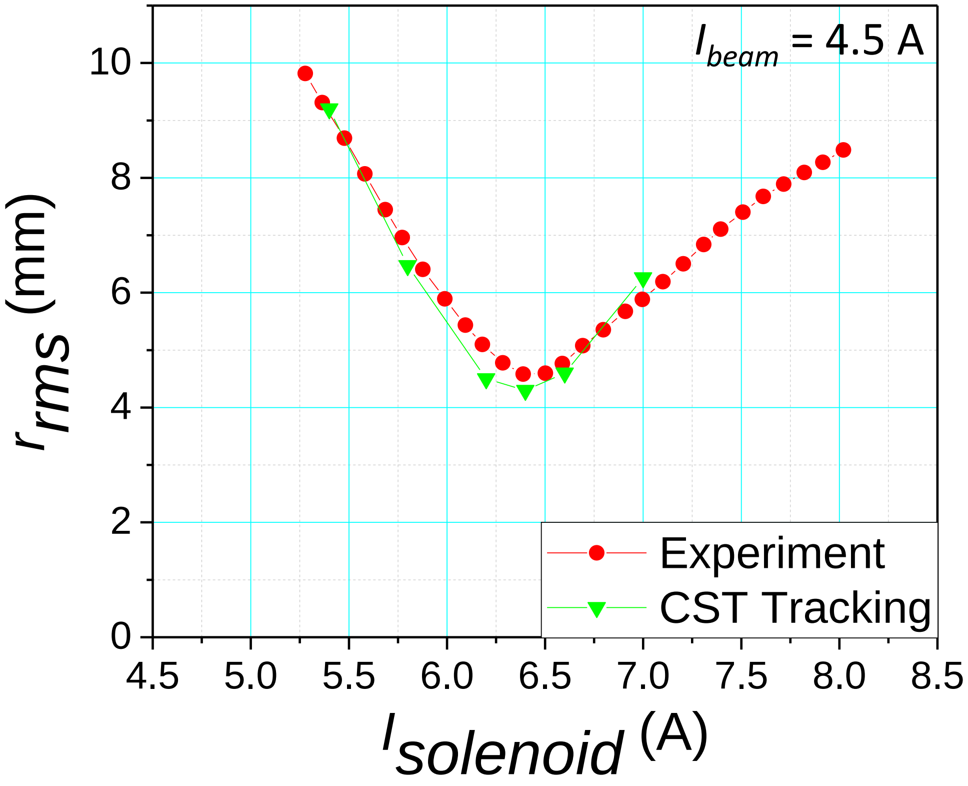
1 pixel = 0.12 mm

CST simulations

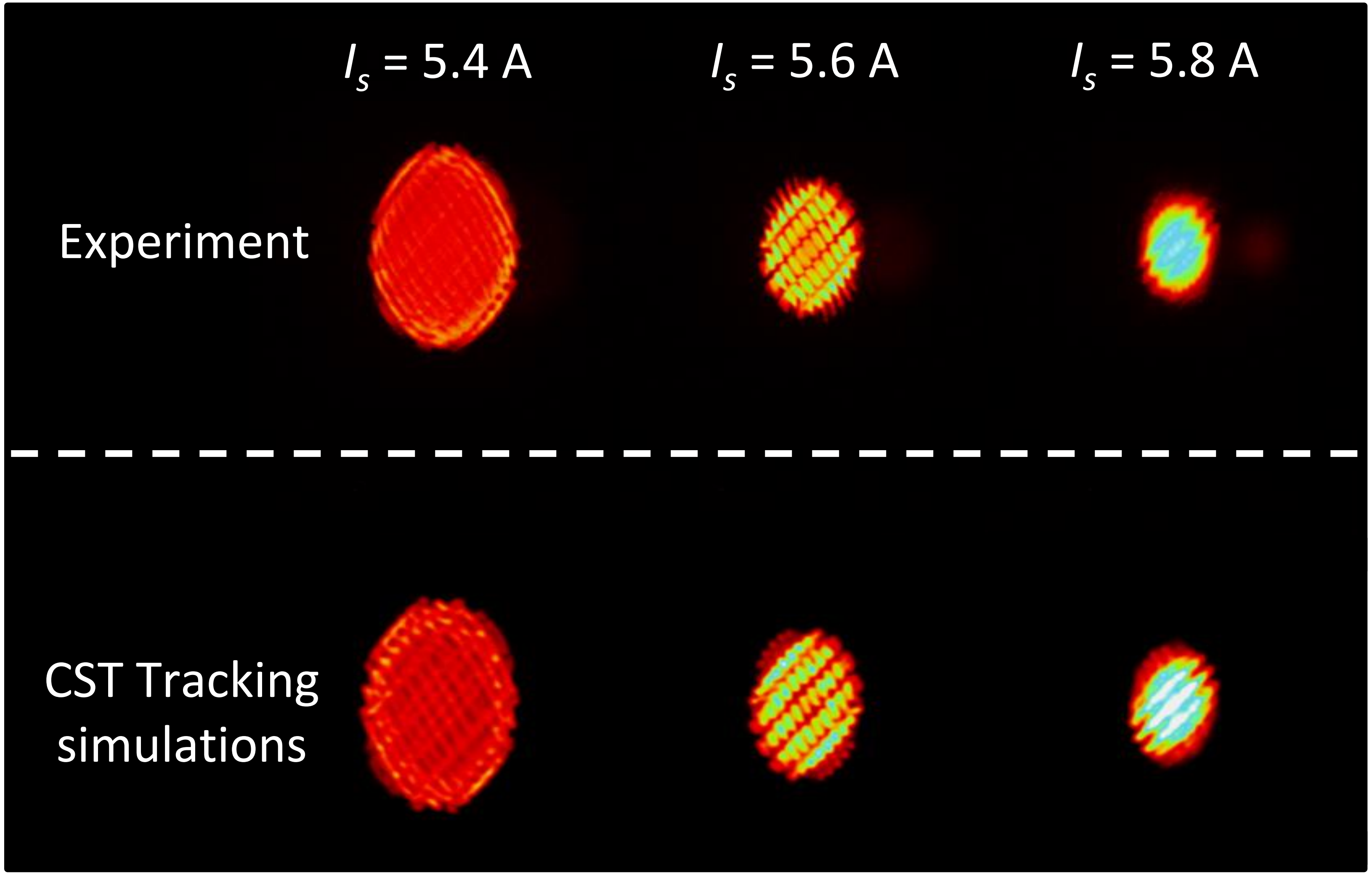


Comparison between experimental results and simulations

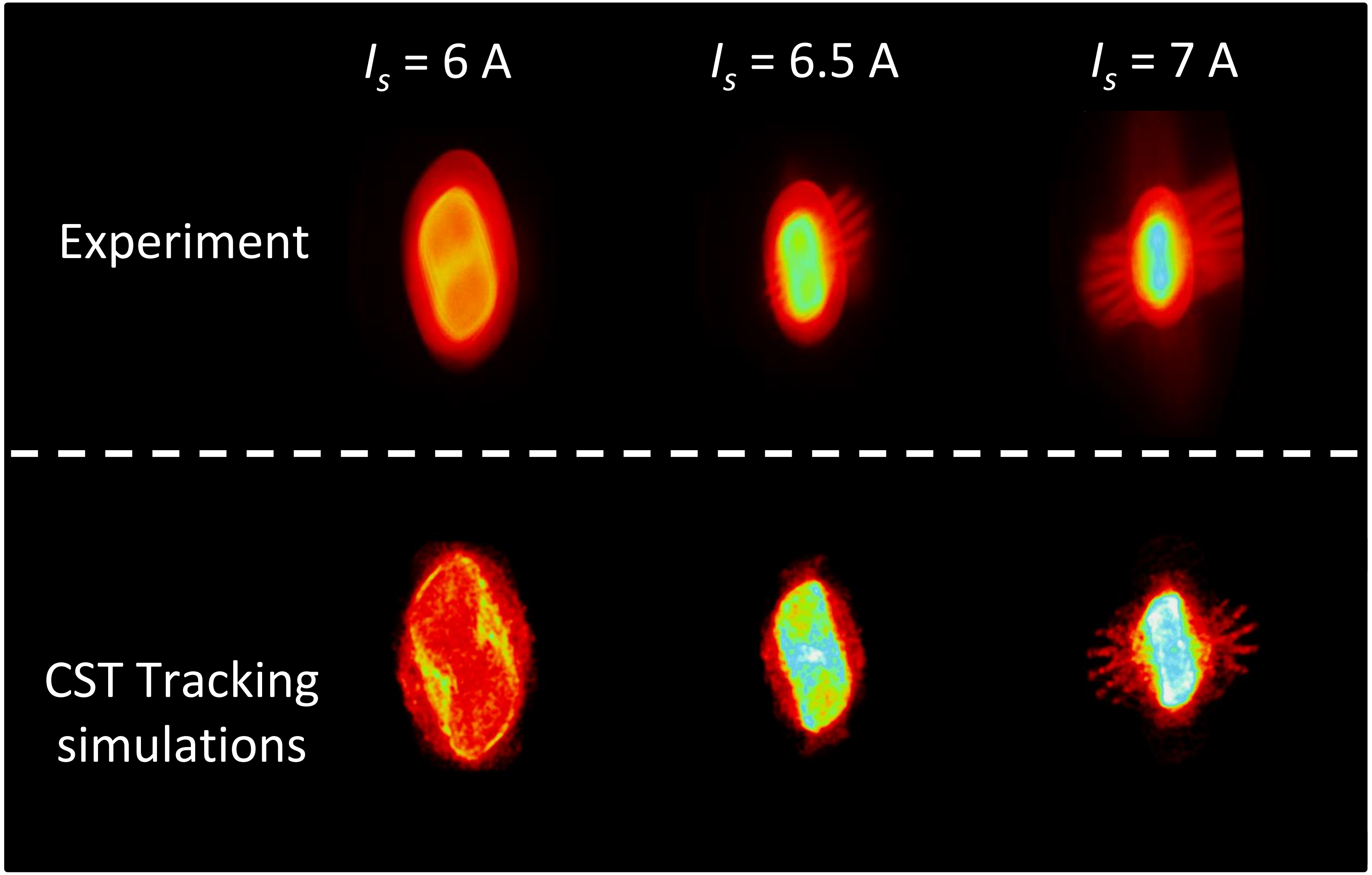




Comparison between experimental results and simulations @ 0.5A

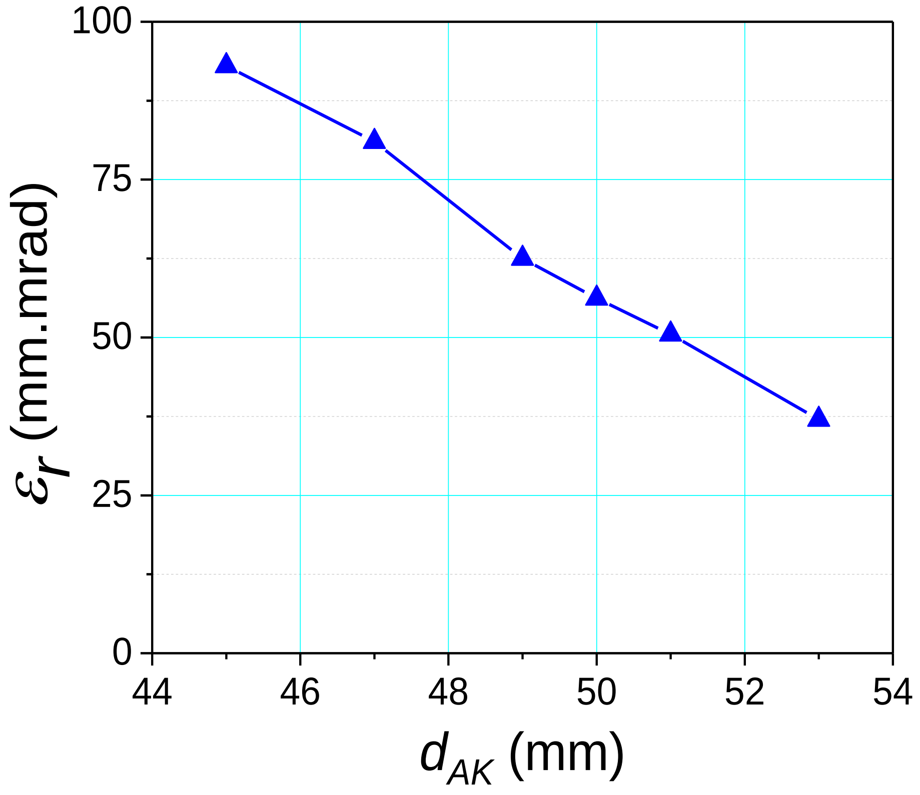


Comparison between experimental results and simulations @ 4.5A

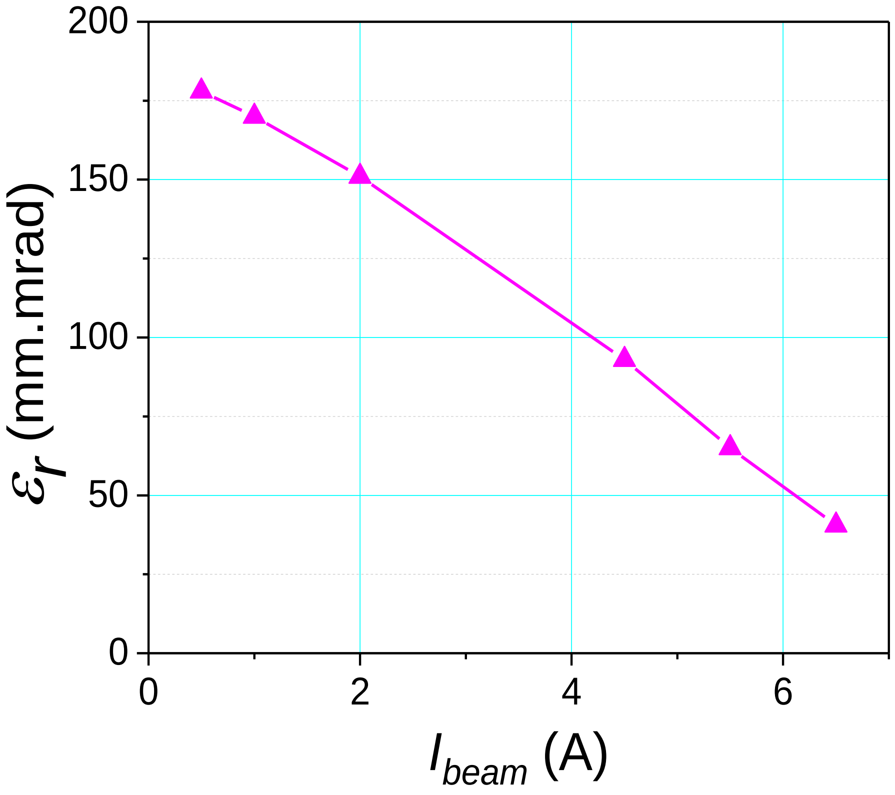


Emittance estimation

Emittance as function of d_{AK} for I_{beam} = 4.5 A



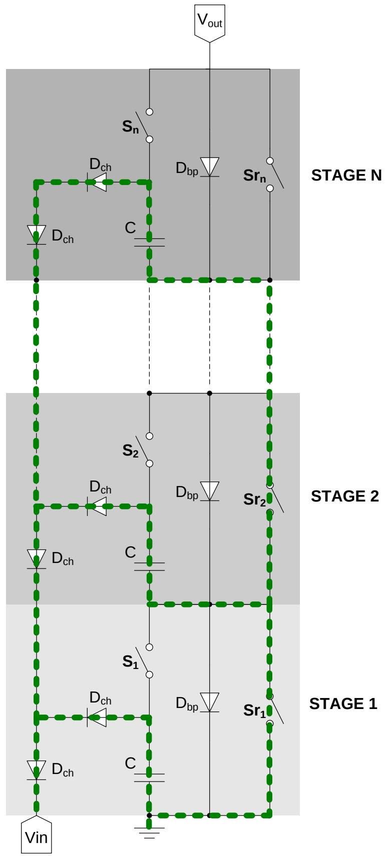
Emittance as function of I_{beam} for d_{AK} = 45 mm



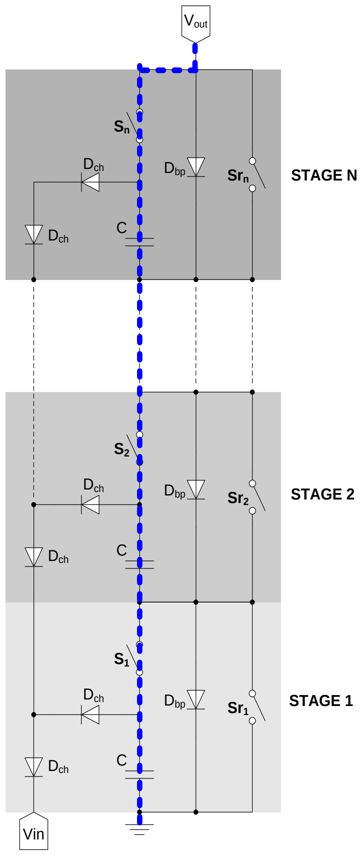
$$\langle \varepsilon_r \rangle = 2.0\sqrt{\langle r^2\rangle[\langle p_r/p_z\rangle^2 + \langle p_\theta/p_z\rangle^2] - \langle rp_r/p_z\rangle^2 - \langle rp_\theta/p_z\rangle^2}$$

Measurements to verify prediction started

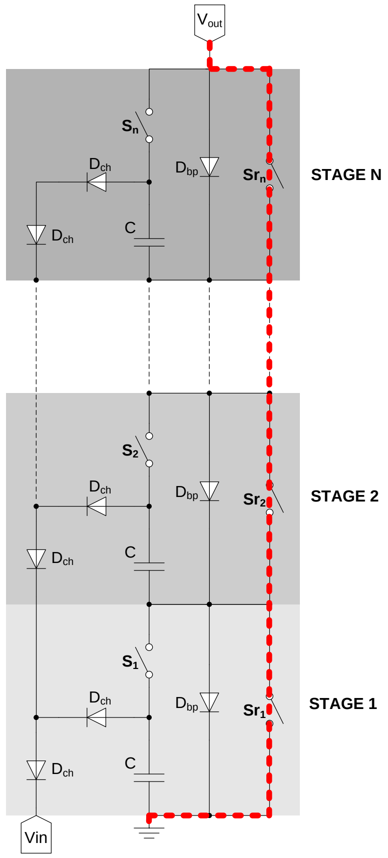
Solid State Marx Modulator



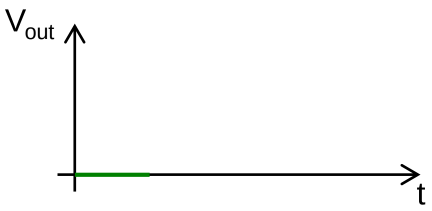
Charge

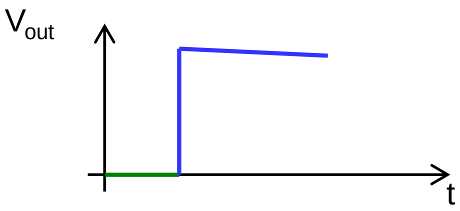


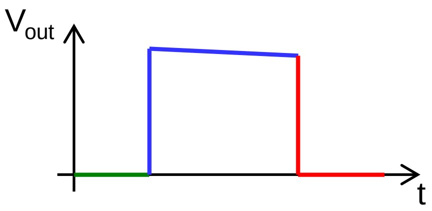
Discharge



Optional Crowbar



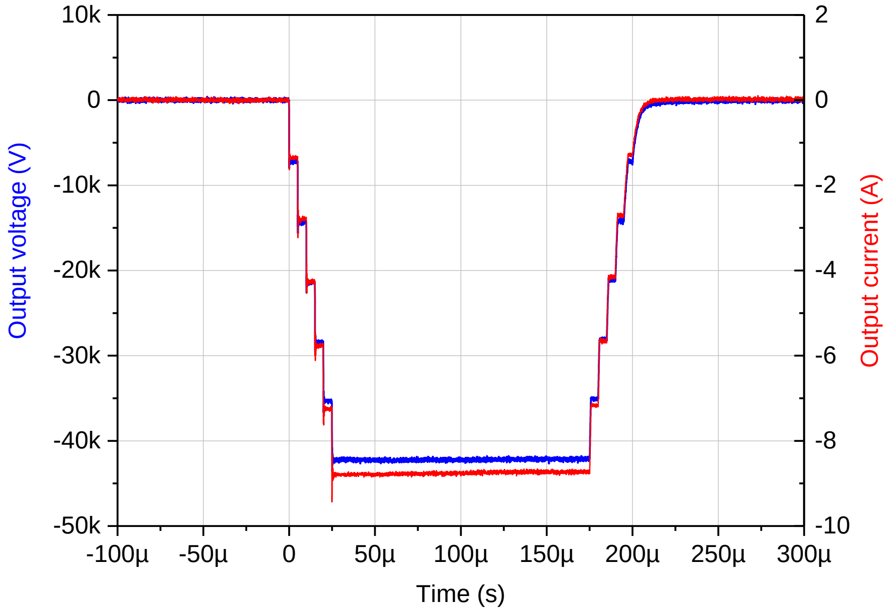


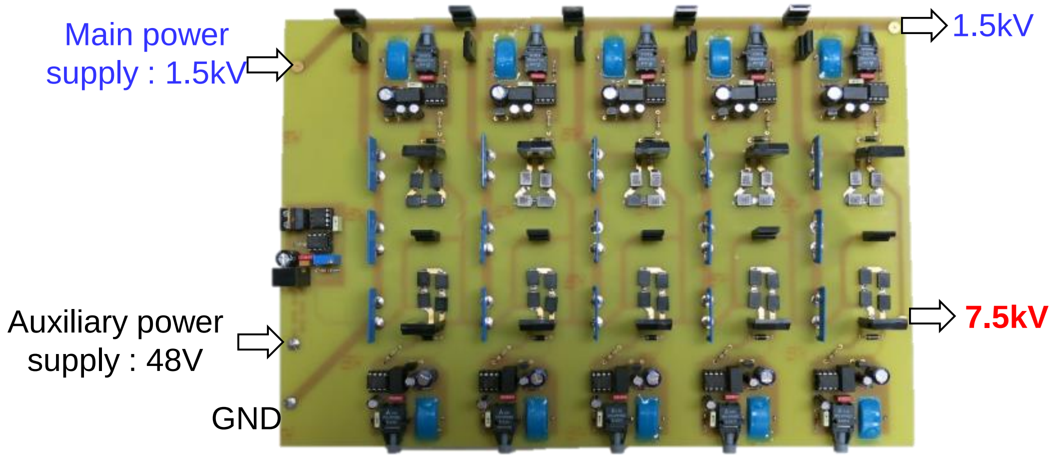


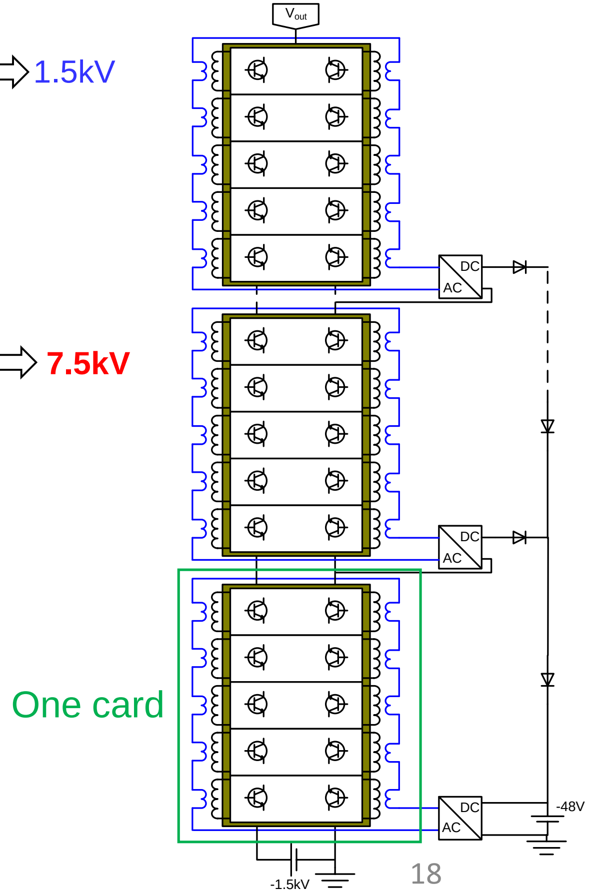
Previous results (obtained at CESTA)

- Design & Choice of components :
  - 1700 V IGBT, Capacitors, Diodes, Power supply
  - Hybrid auxiliary power supply

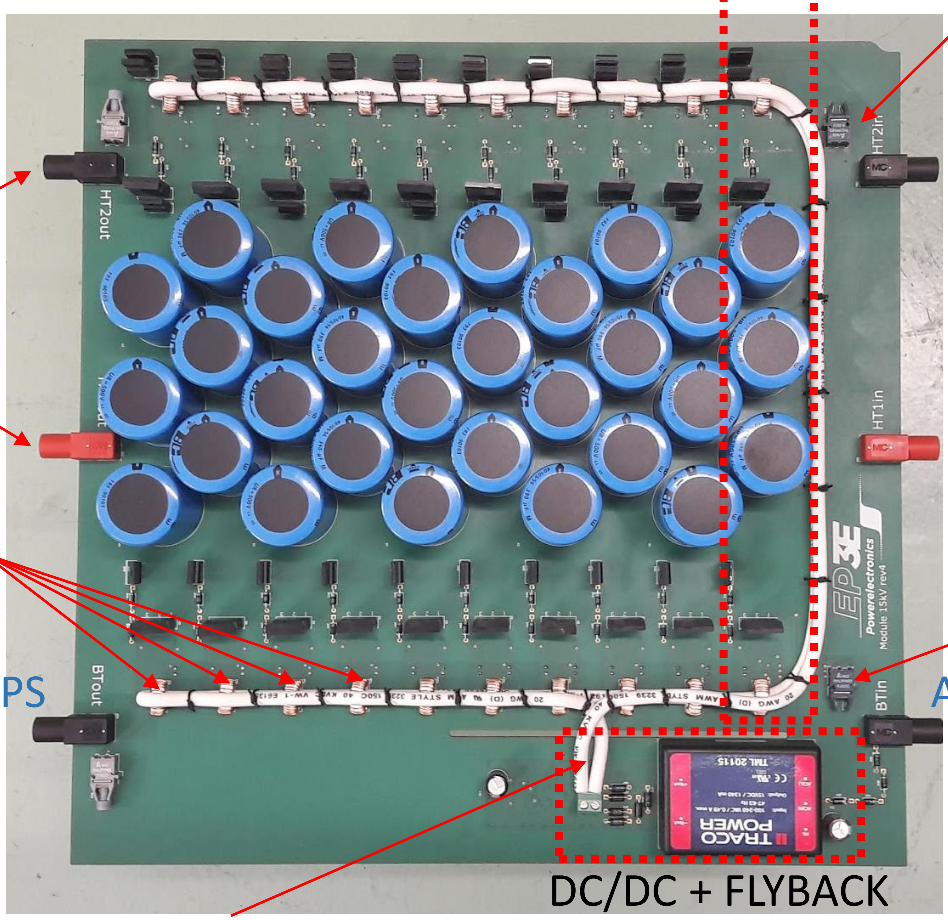
- Tests with 30 stages (6 cards)



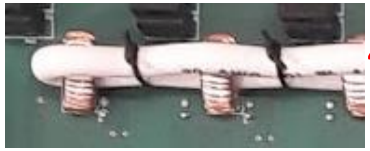




Details

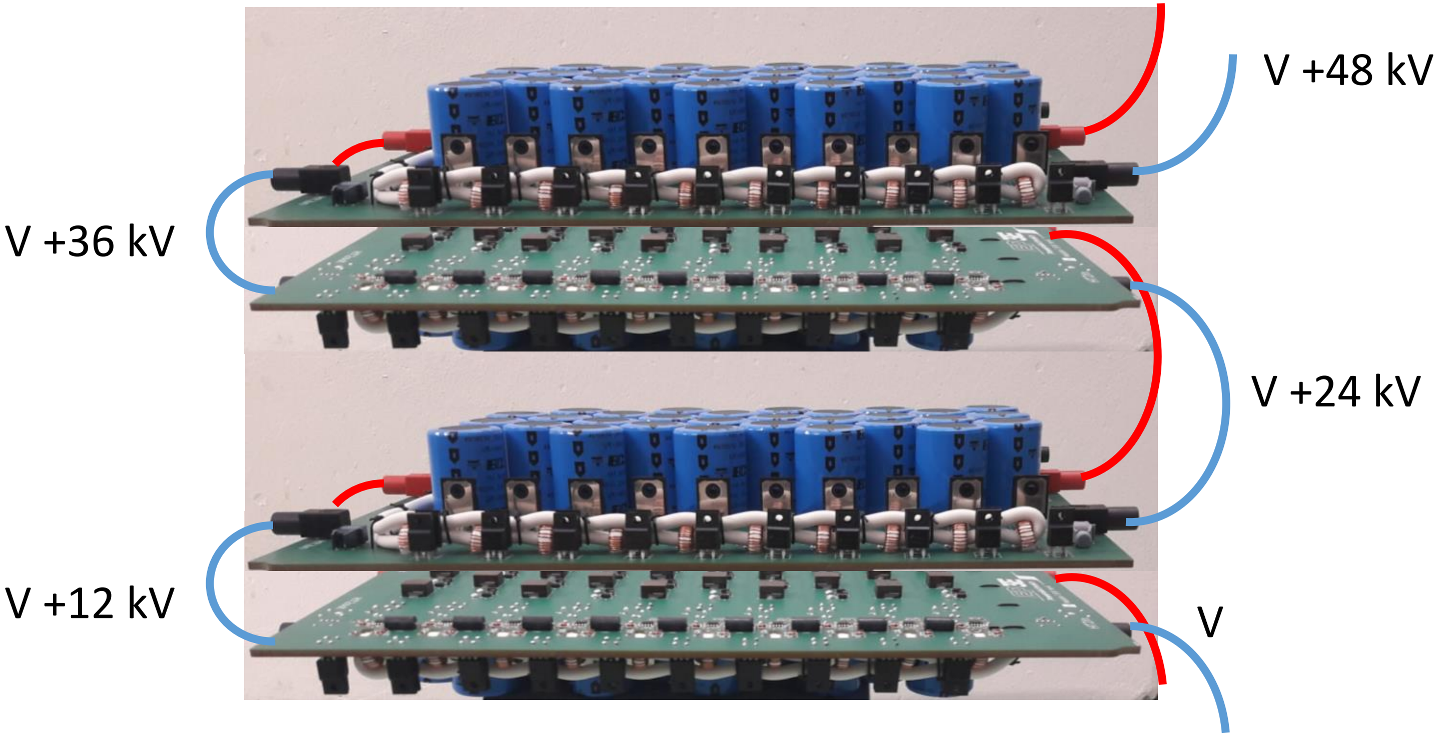


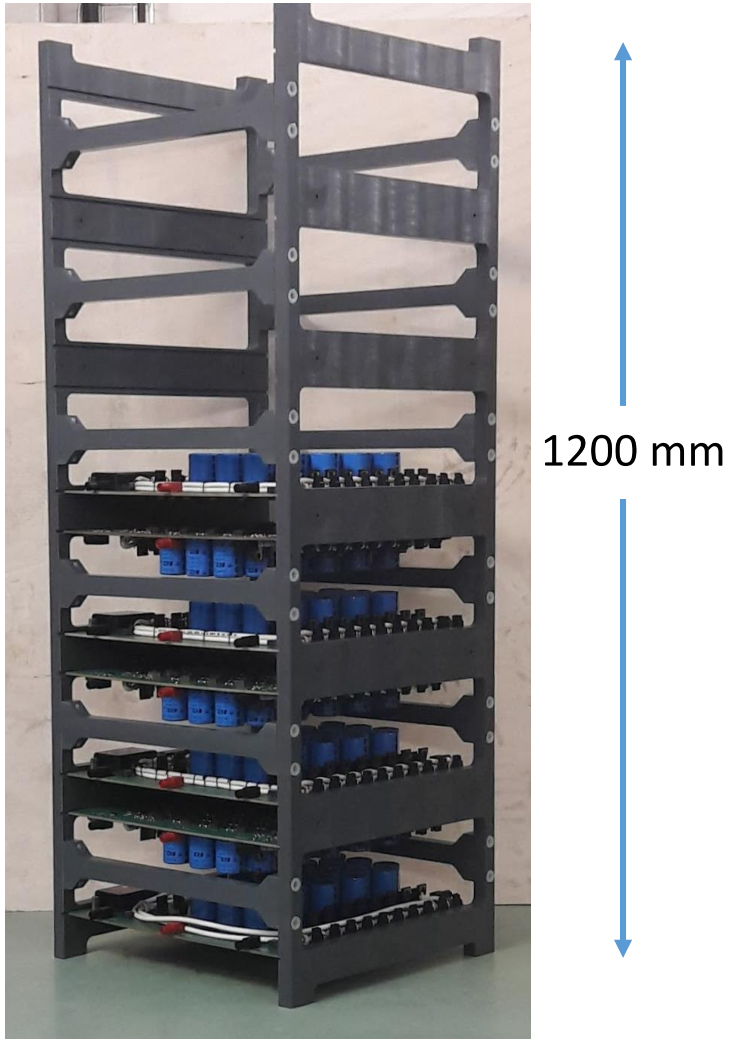
1ST STAGE
FIBER OPTIC RECEIVER (CHARGE)
CHARGING OUTPUT TO NEXT CARD
CHARGING INPUT FROM PREVIOUS CARD
40 SECONDARY WINDINGS
FIBER OPTIC RECEIVER (DISCHARGE)
AUXILIARY PS OUTPUT
AUXILIARY PS INPUT
DC/DC + FLYBACK
FLYBACK PRIMARY WINDING
HT2out
HT2in
HT1in
BTout
BTin
TRACO POWER



Mechanical integration

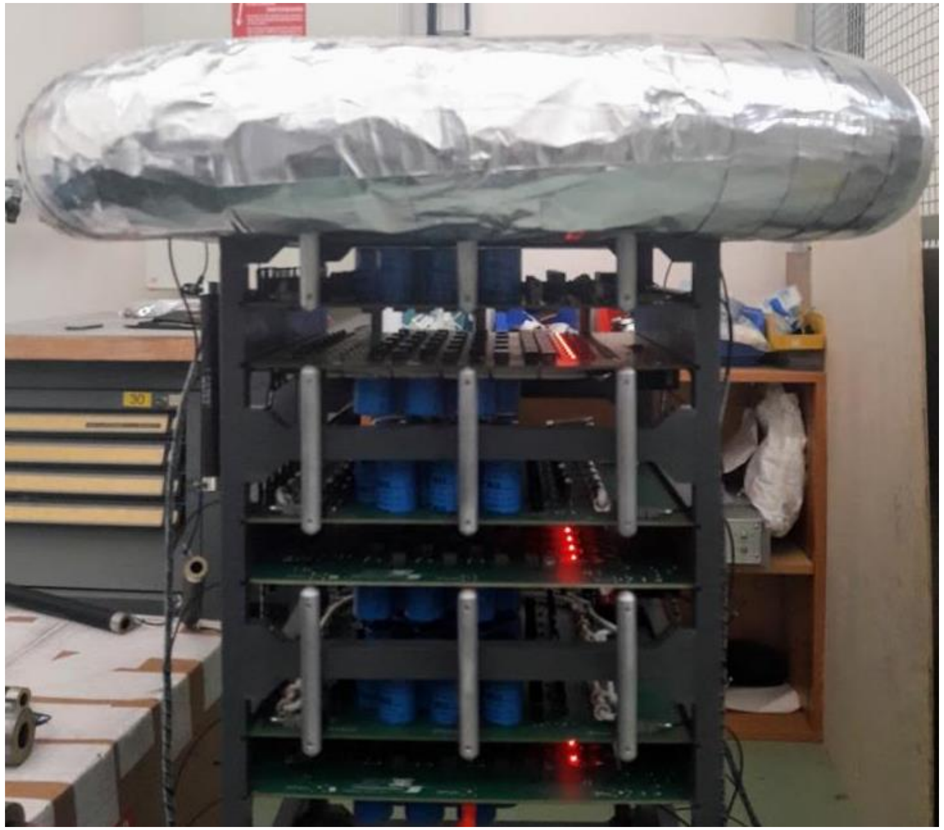
- Mechanical integration is ongoing.

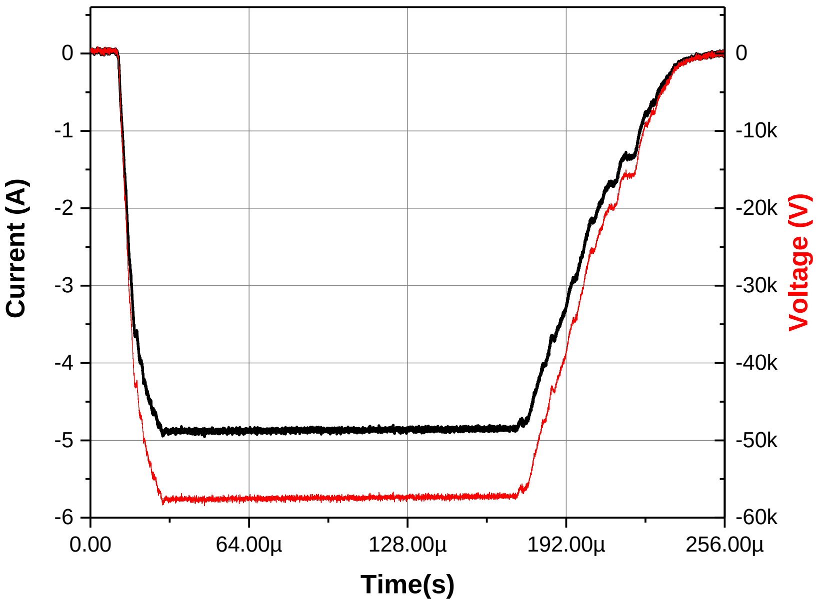




SUPPORTING STRUCTURE
WITH 7 CARDS

Mechanical integration & test

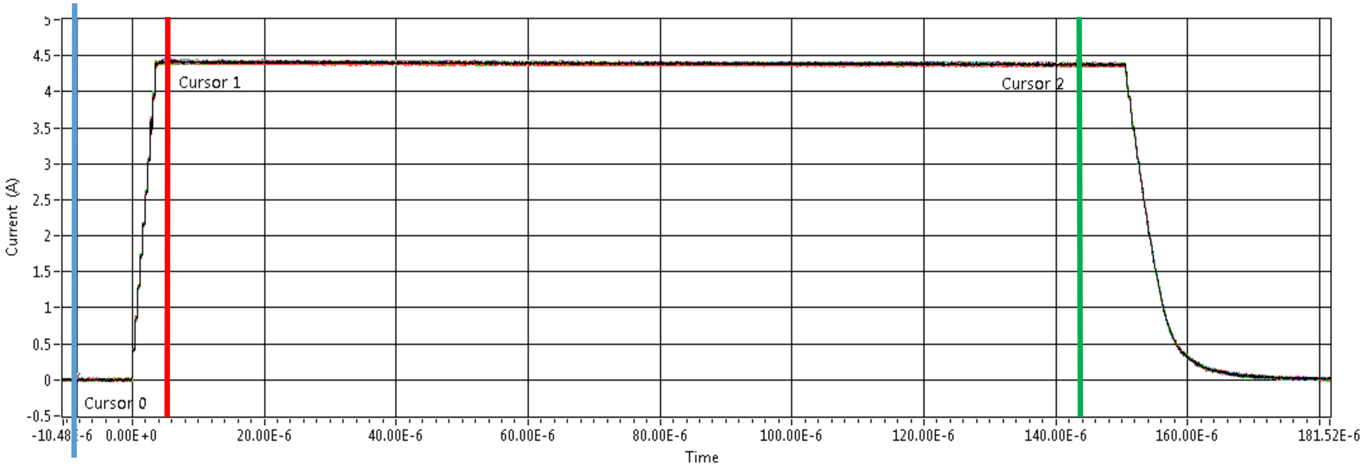




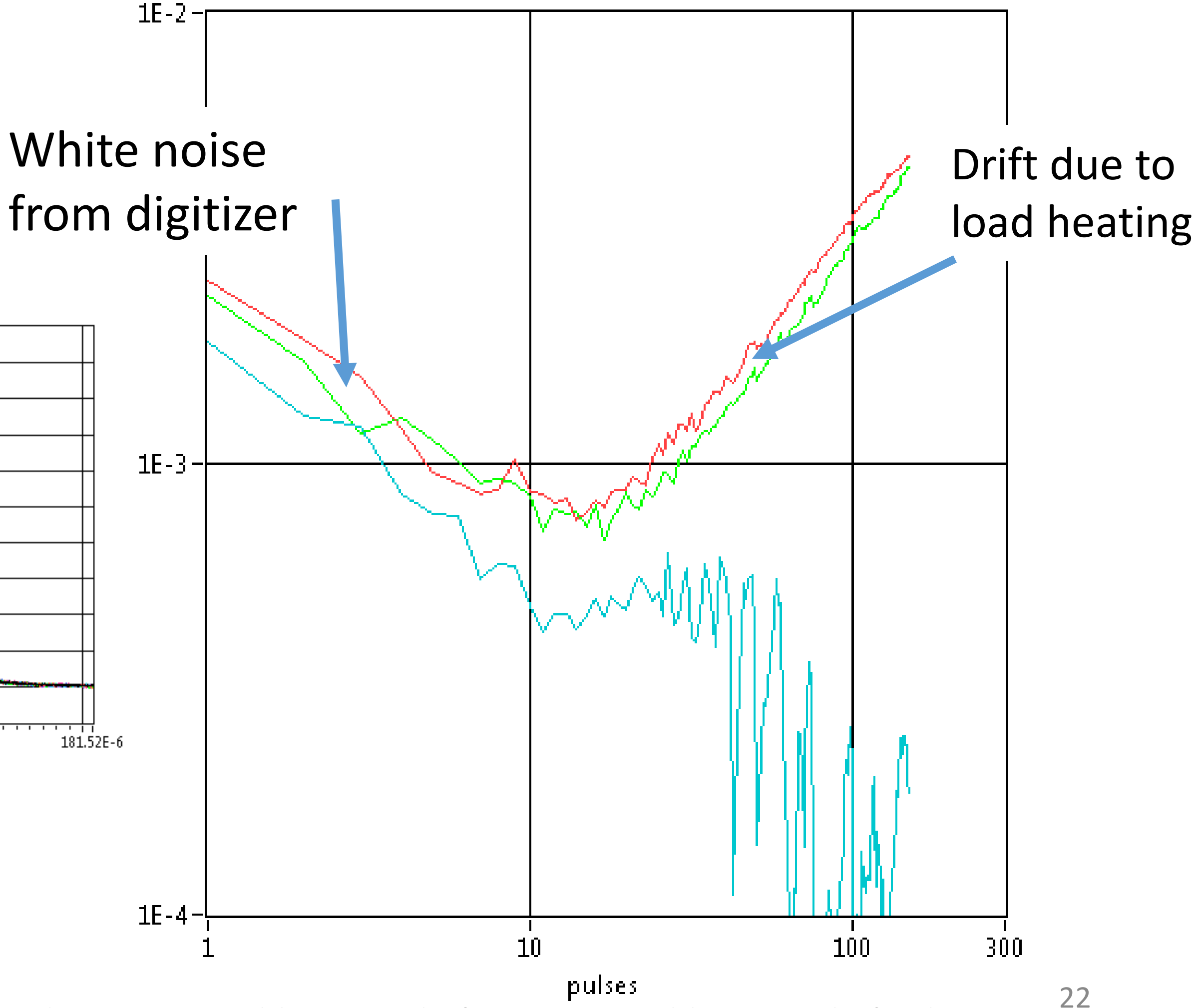
Very first result 70 stages,
70% charging voltage (880 V)
on 11.8 kΩ load

Results: Pulse to pulse variation

- One card test
- 300 pulses on 1.8 kΩ resistive load
- 50 Hz Rep. Rate

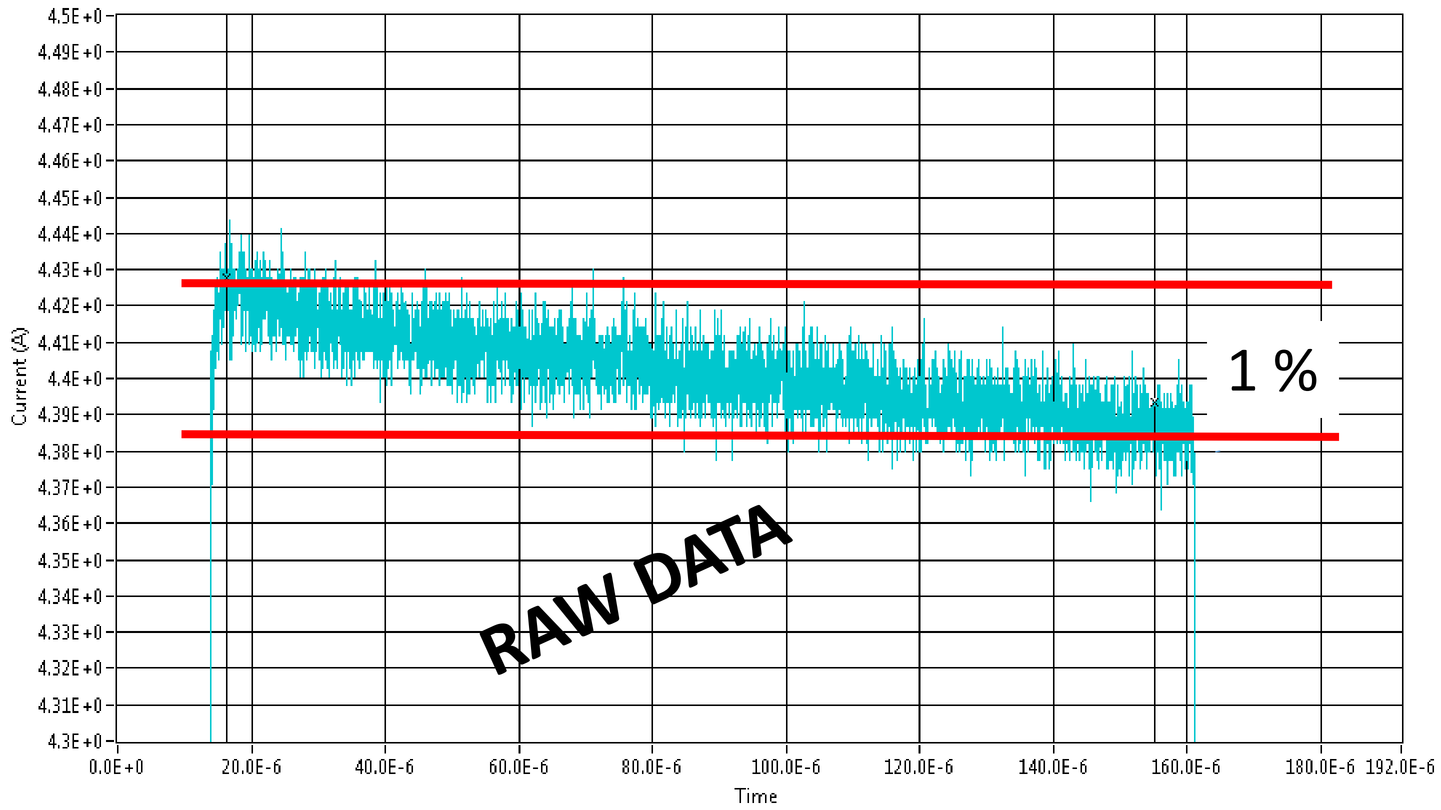


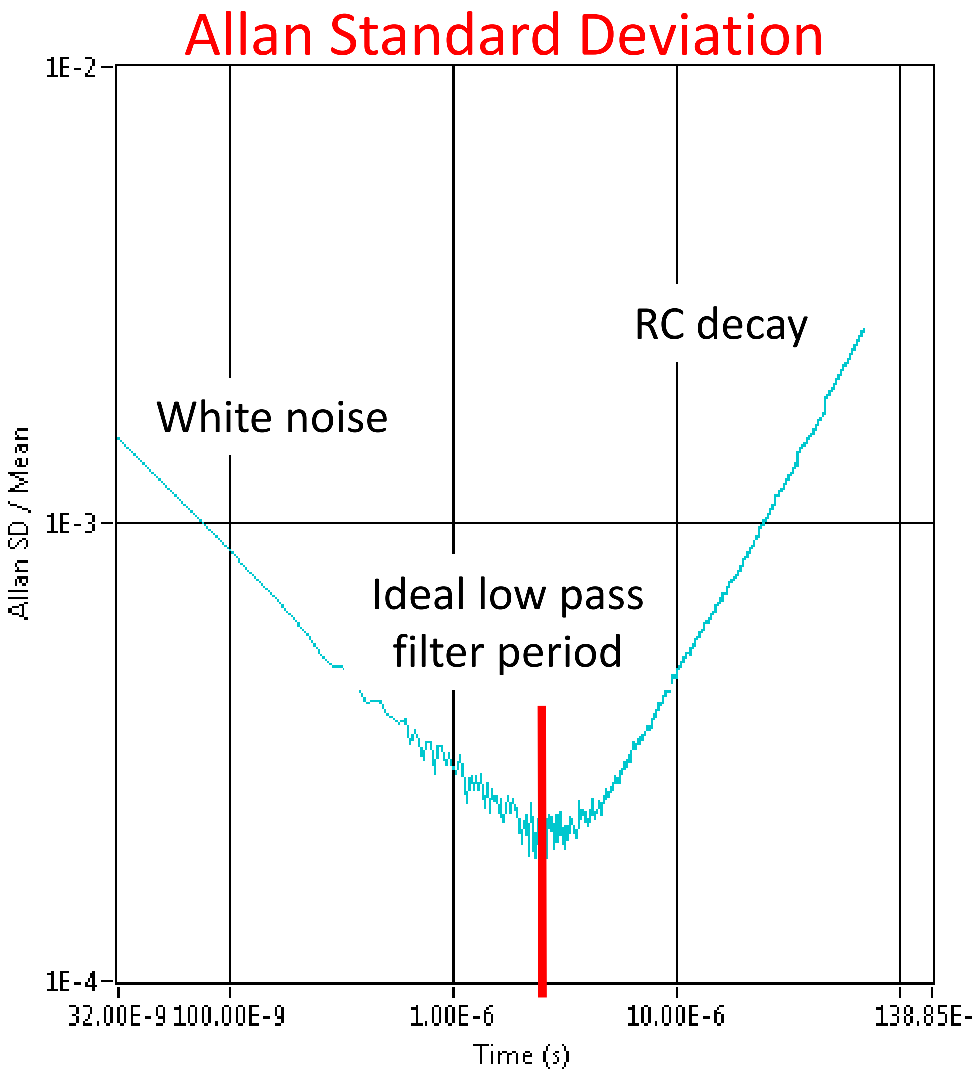
Allan Standard Deviation



Allan Standard Deviation = A metric for stability = Two-sample Standard Deviation taken over variable interval of time or variable interval of pulses

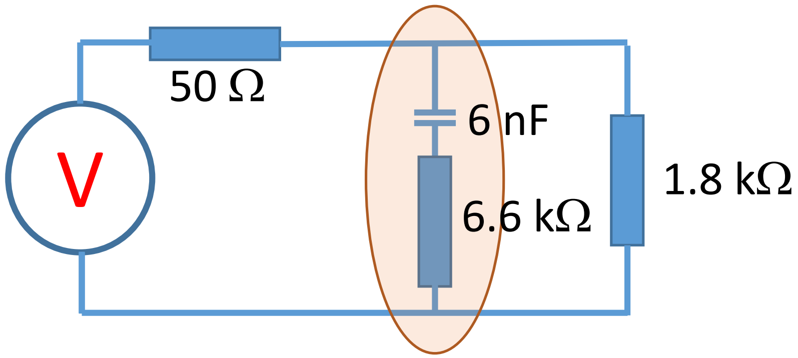
Results: Flatness

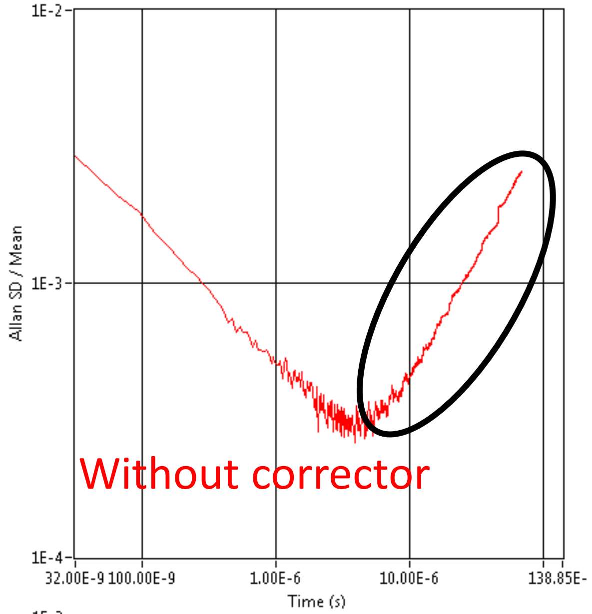


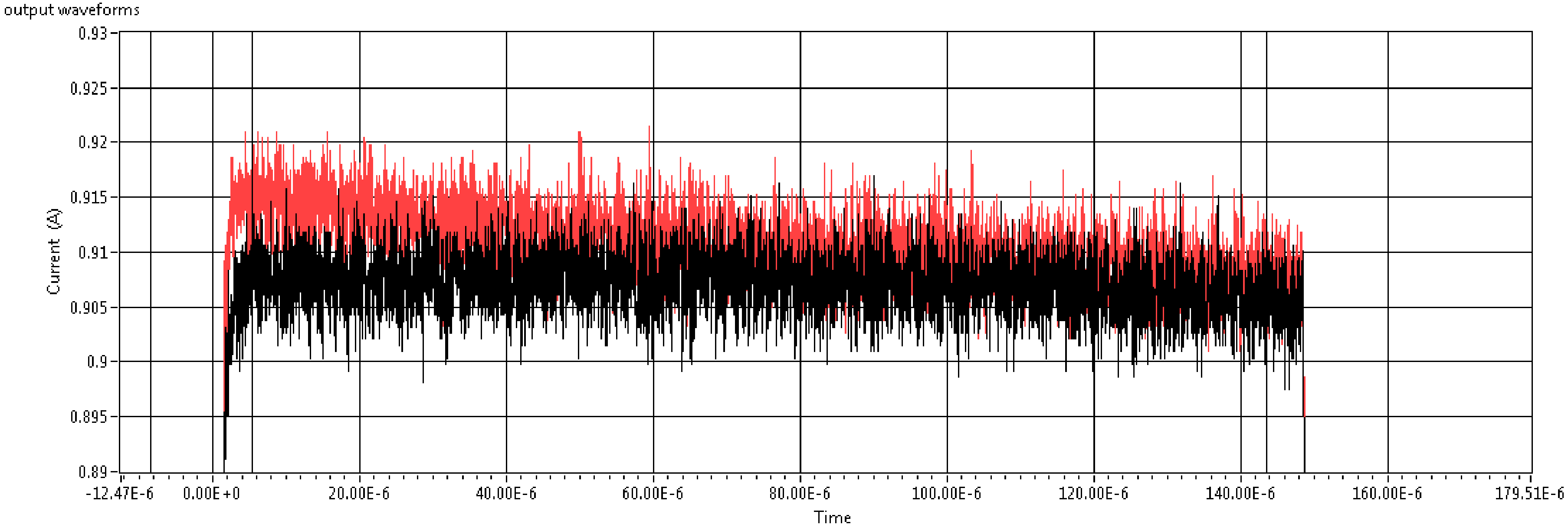


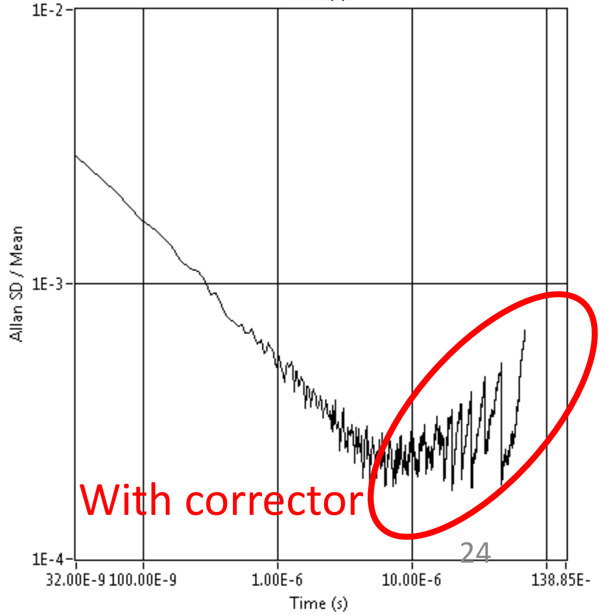
RC corrector

- RC in parallel with the load in order to absorb ~1% of the energy during the first half of the pulse.

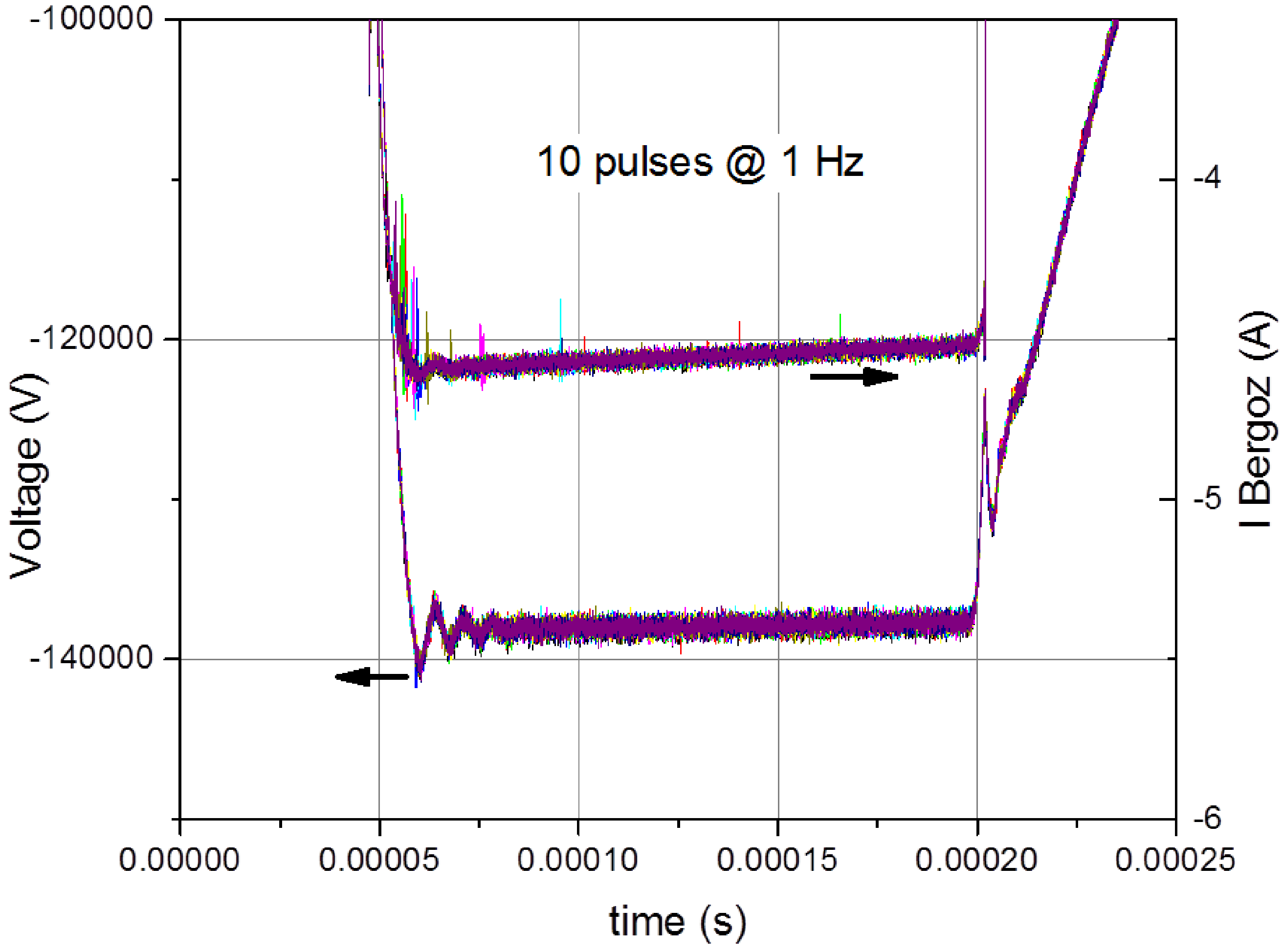


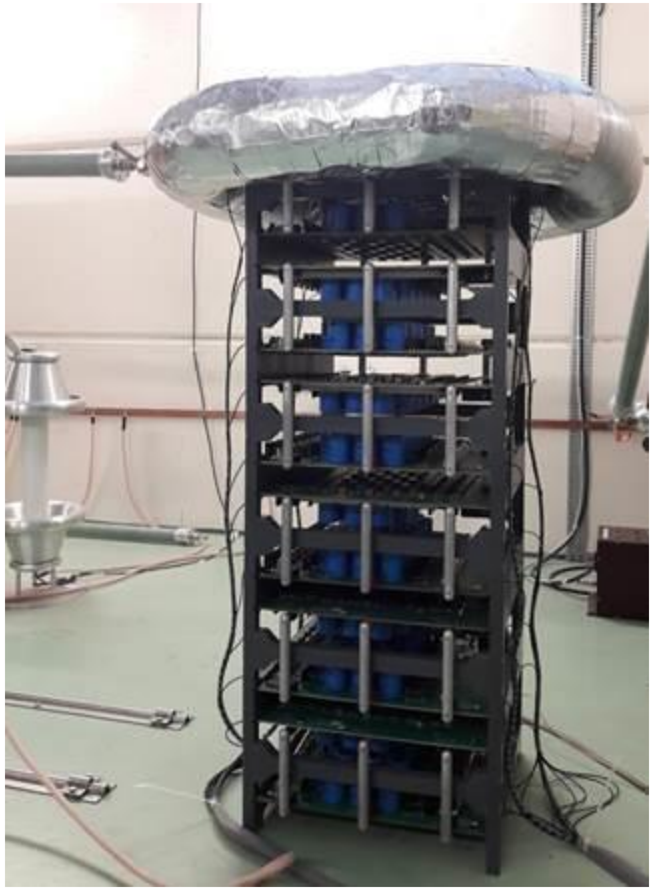






Latest Results (Nov 2017)





Marx-Modulator connected to the gun producing beam at nominal parameters

Outlook

- Kevin and Bruno left us, new fellow start in February, CEA collaboration continues
- Continue measurements, mainly beam stability and emittance
- Test Marx-Modulator to full average power
- Found interesting science and applications around our project
  - Emittance due to the grid
  - Terahertz generation, Smith-Purcell
- Intends to operate LEETCHI at least until 2019

Thank you for your attention