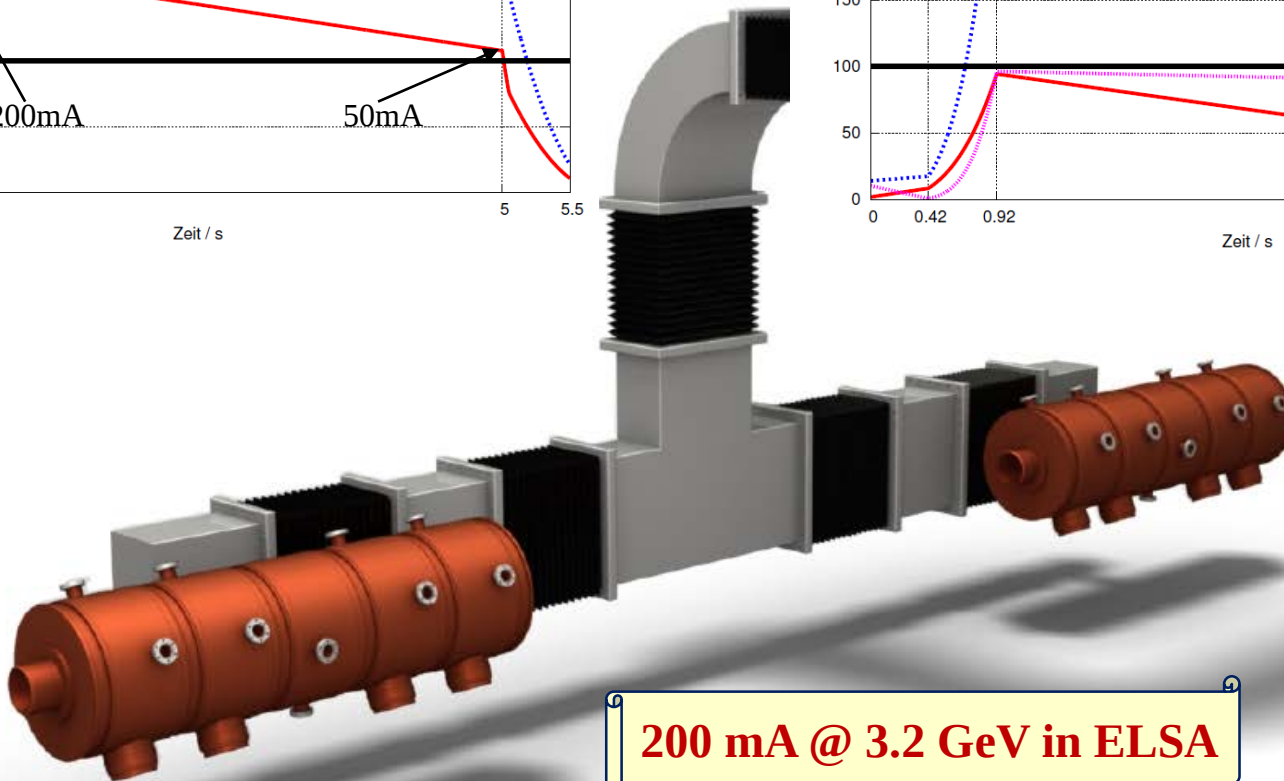
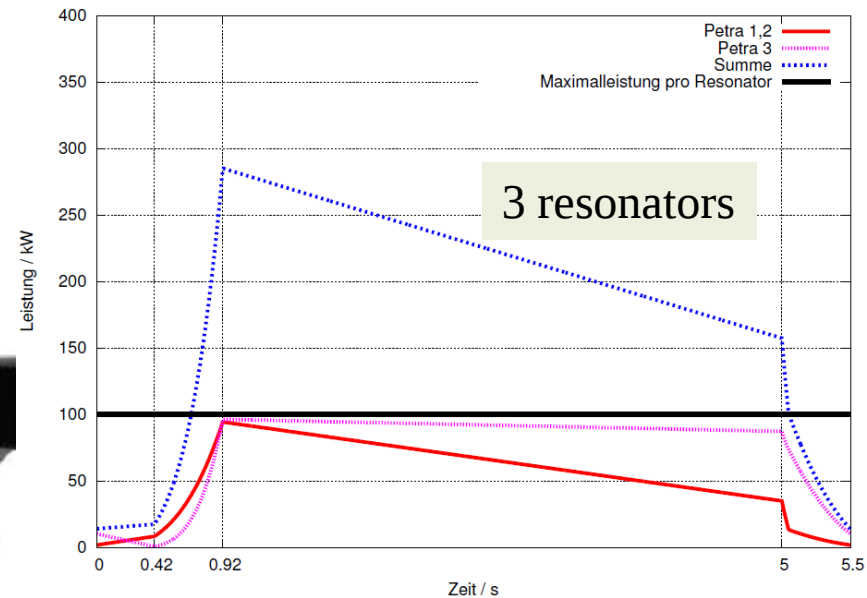
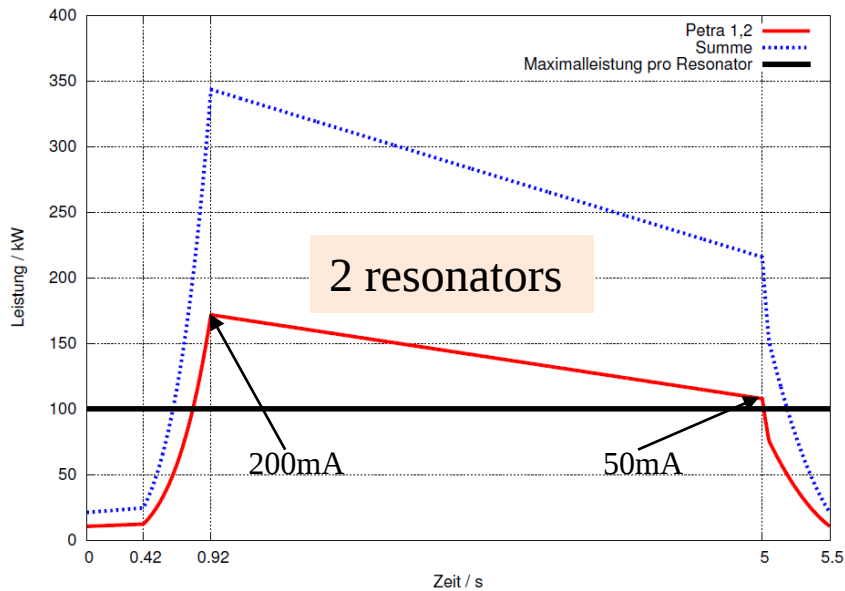


A simple approach for safely powering CW klystrons

Wolfgang Hillert
Andreas Dieckmann
Michael Humpert

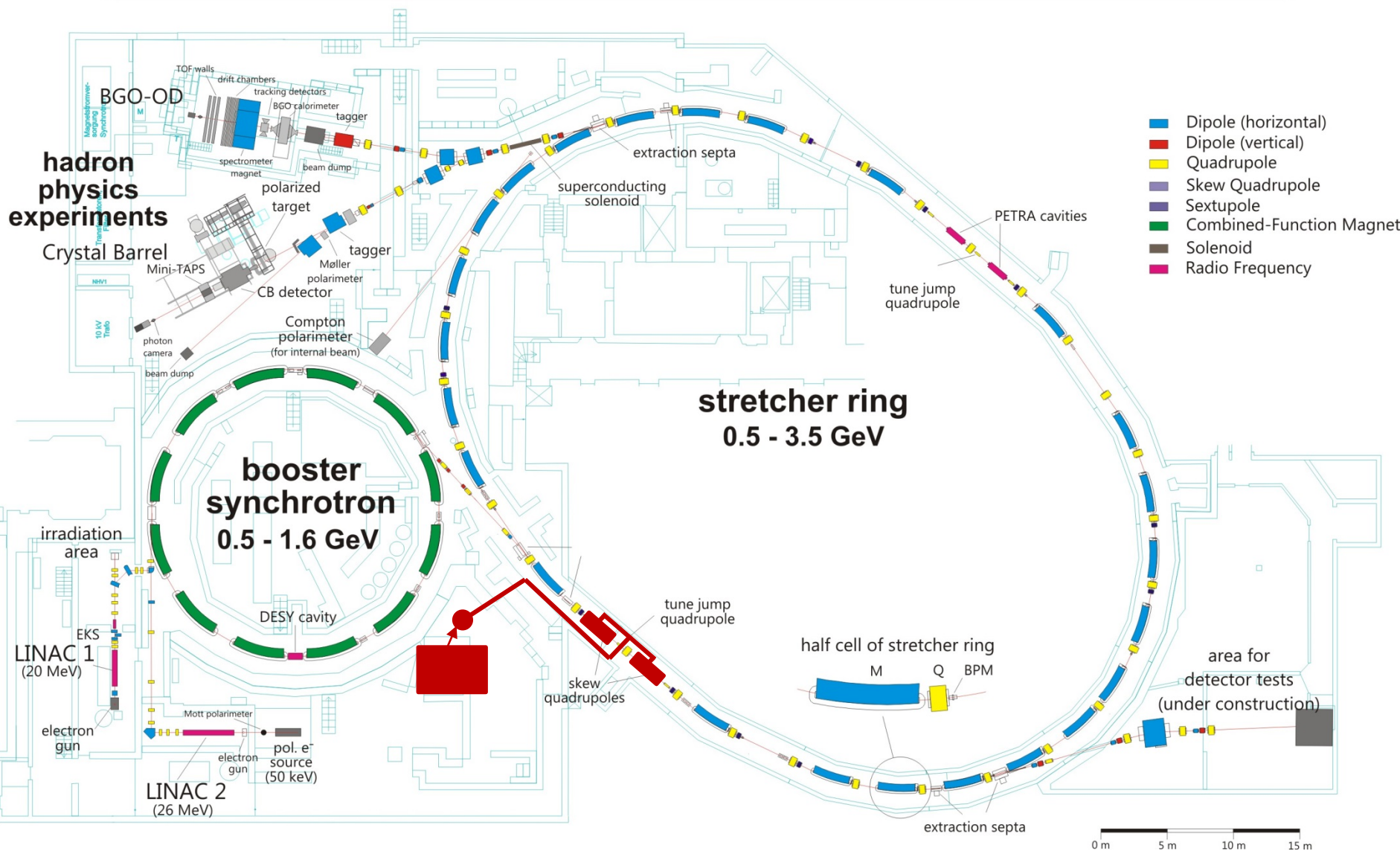


New RF System



200 mA @ 3.2 GeV in ELSA

Electron Stretcher Accelerator (ELSA)

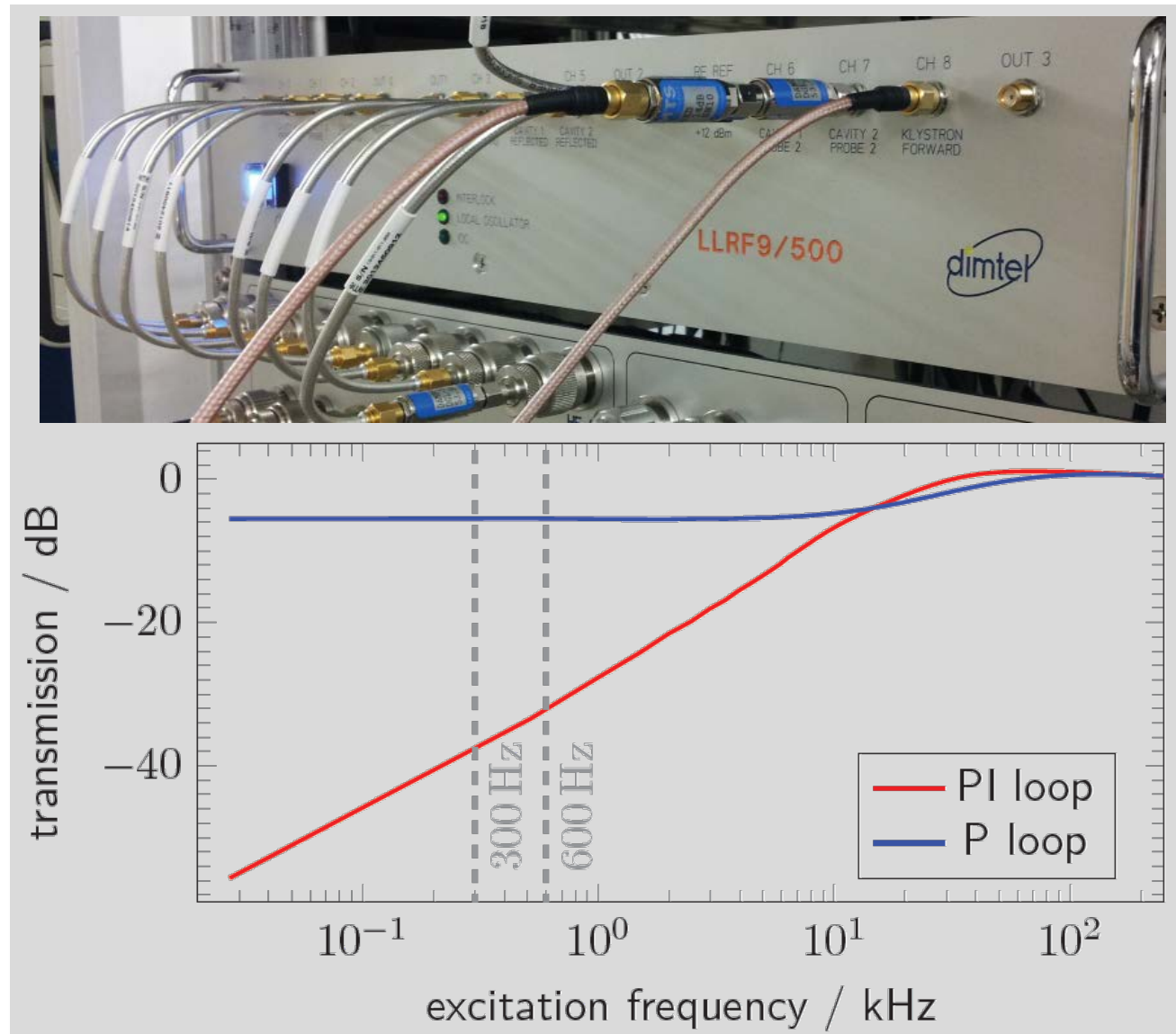


Error Rejection of new LLRF

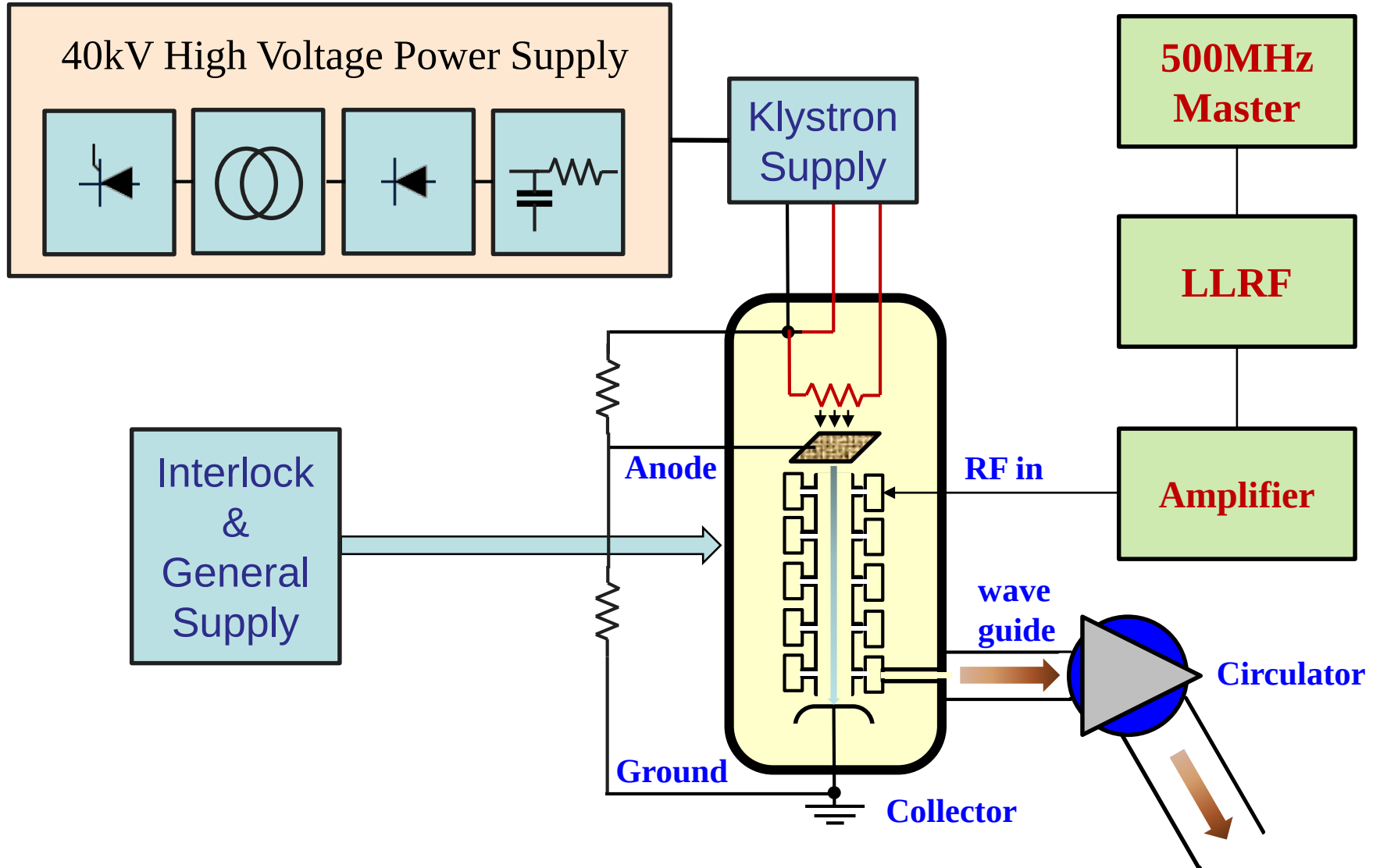
Effective
suppression
of low
frequency
contributions



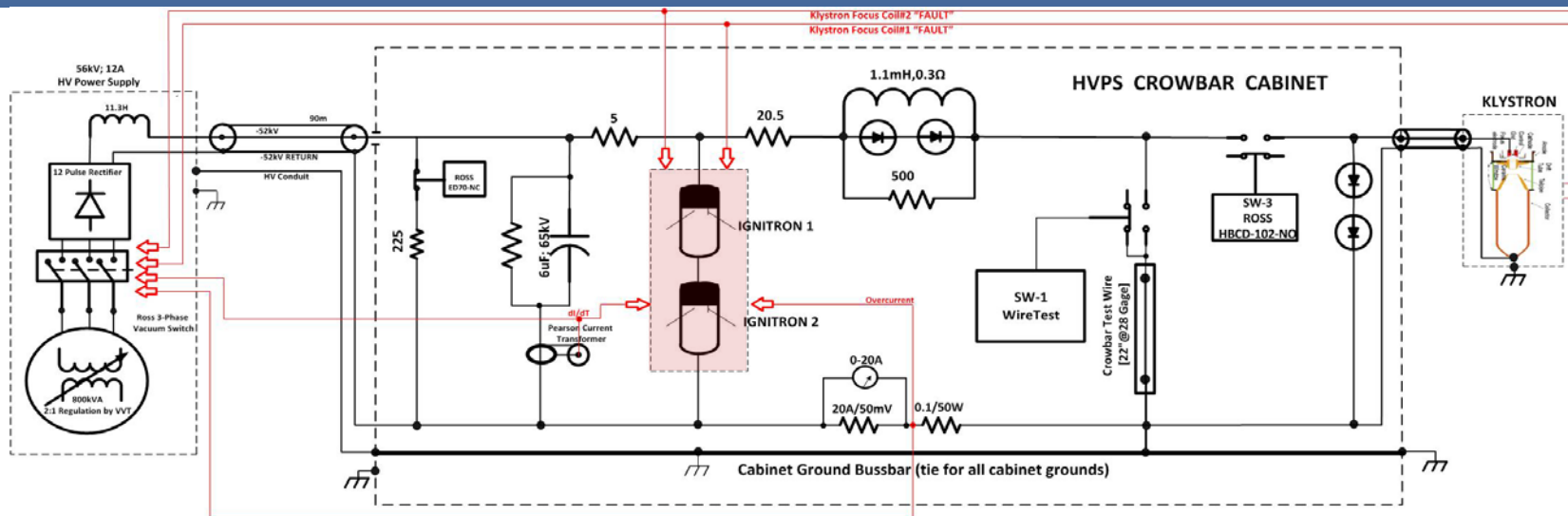
„High“
voltage
ripple
tolerable



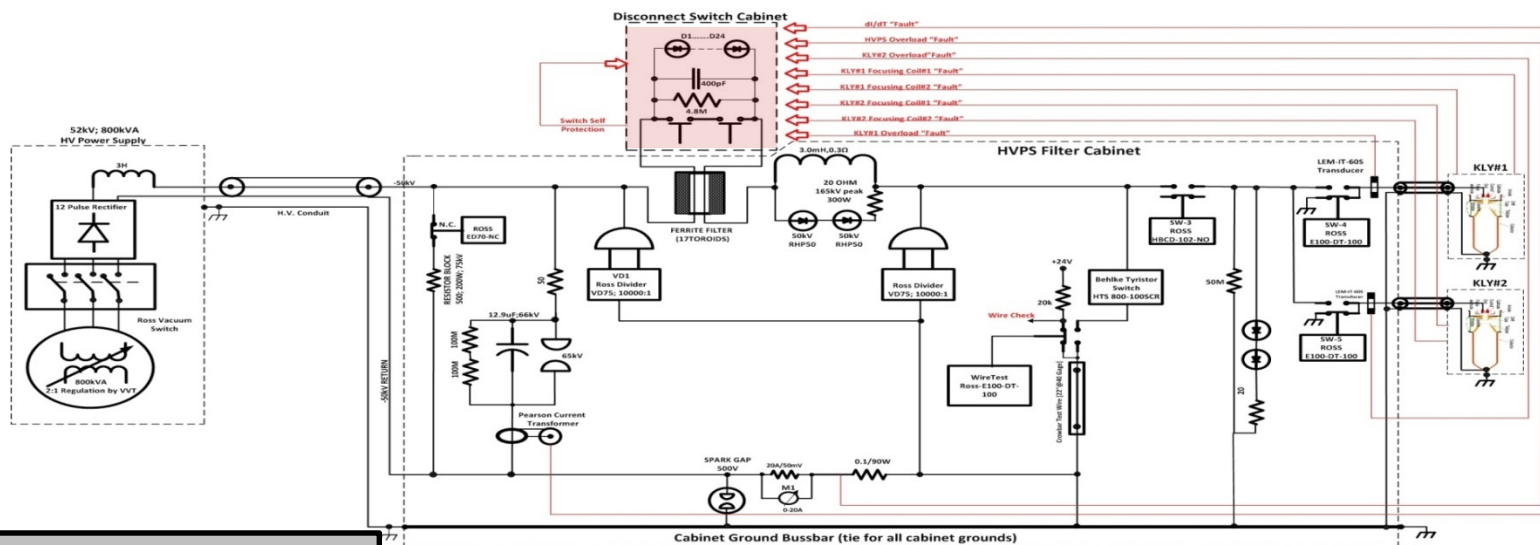
General Set-Up



Crowbar versus Disconnect Switch



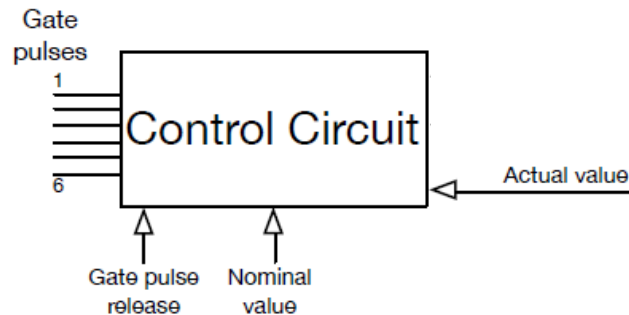
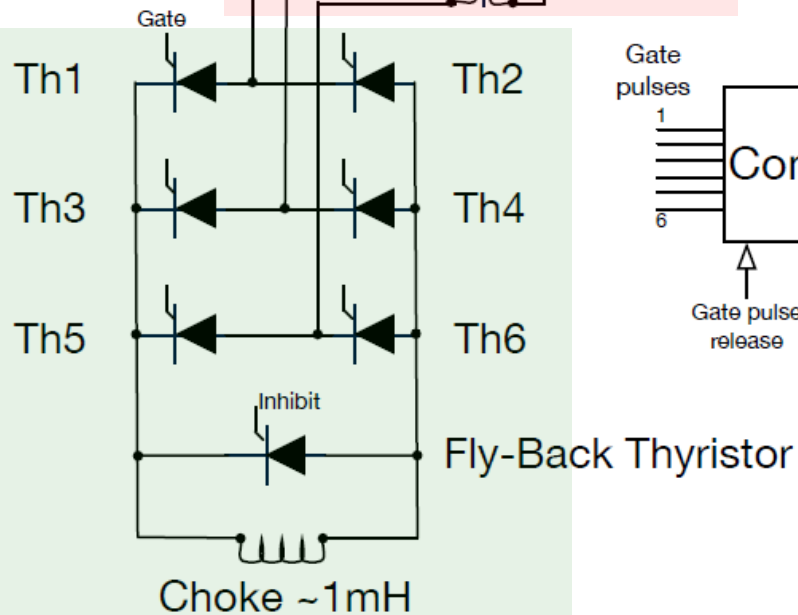
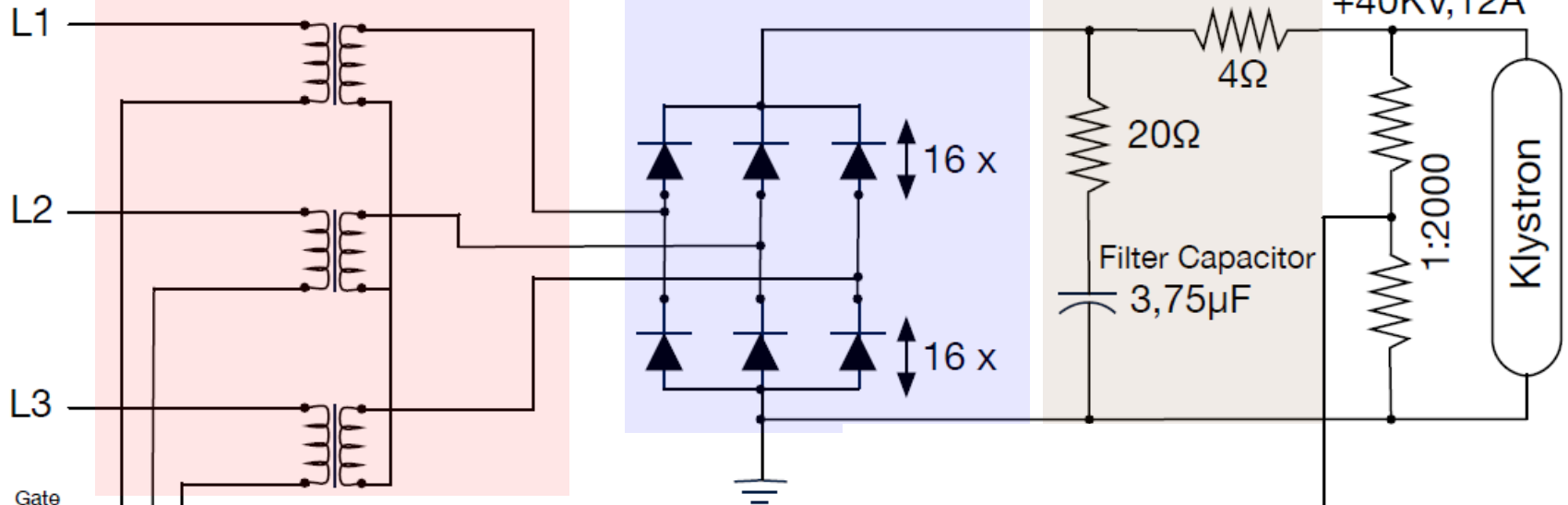
ALS HVPS with Crowbar protection circuit.



ALS HVPS with Disconnect Switch protection circuit.

Layout of the Klystron HVPS

Three - phase transformer
400V / 33KV



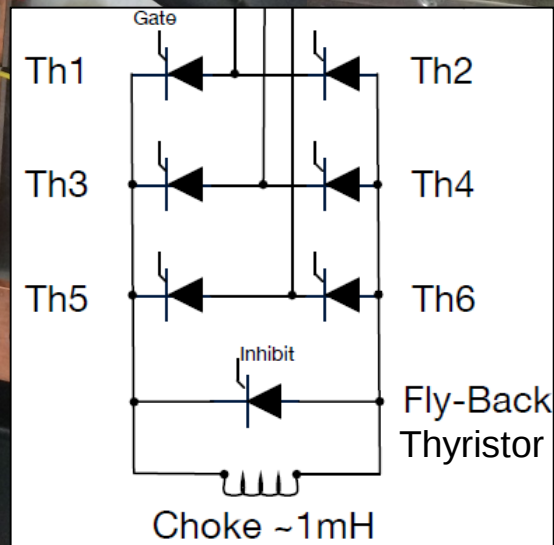
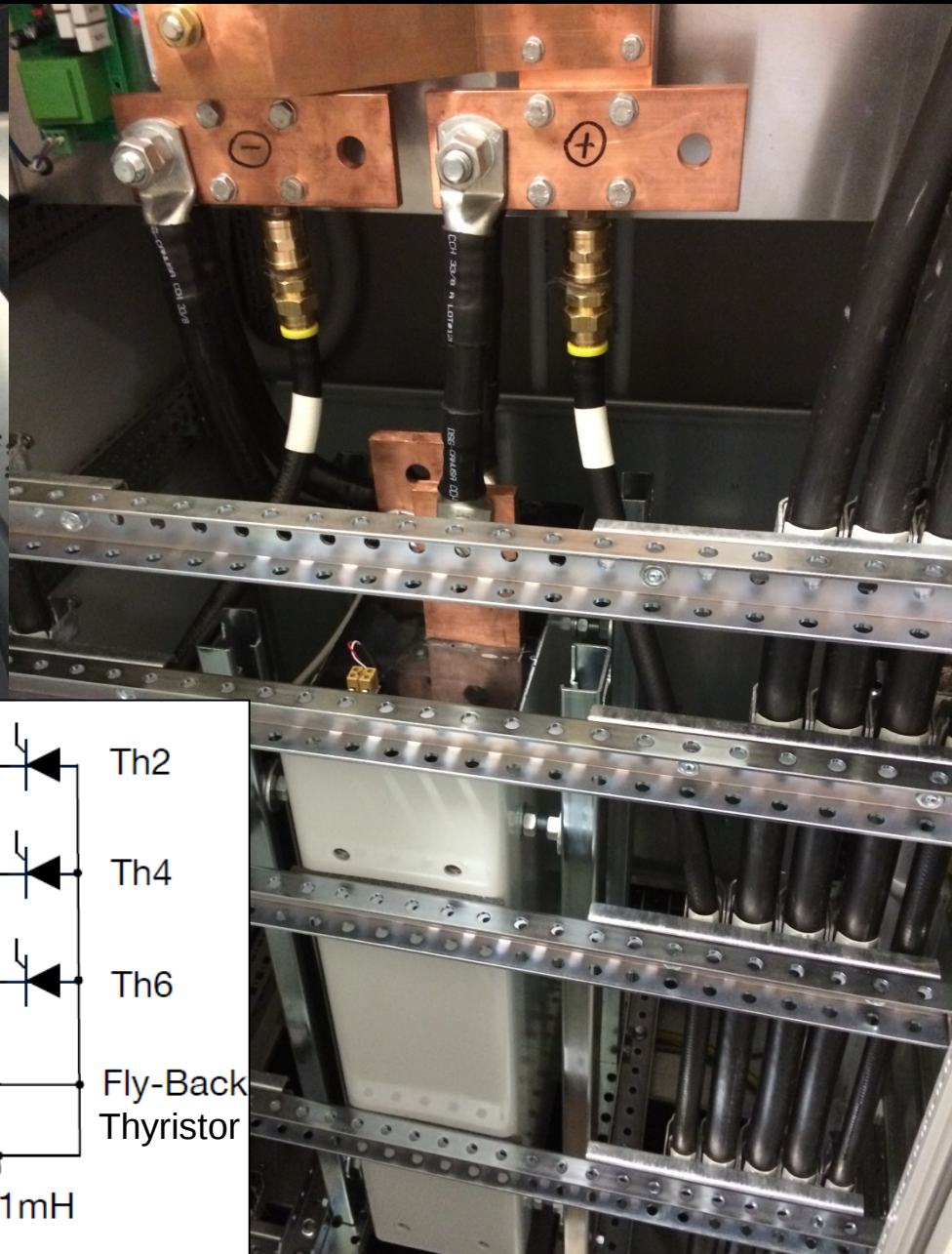
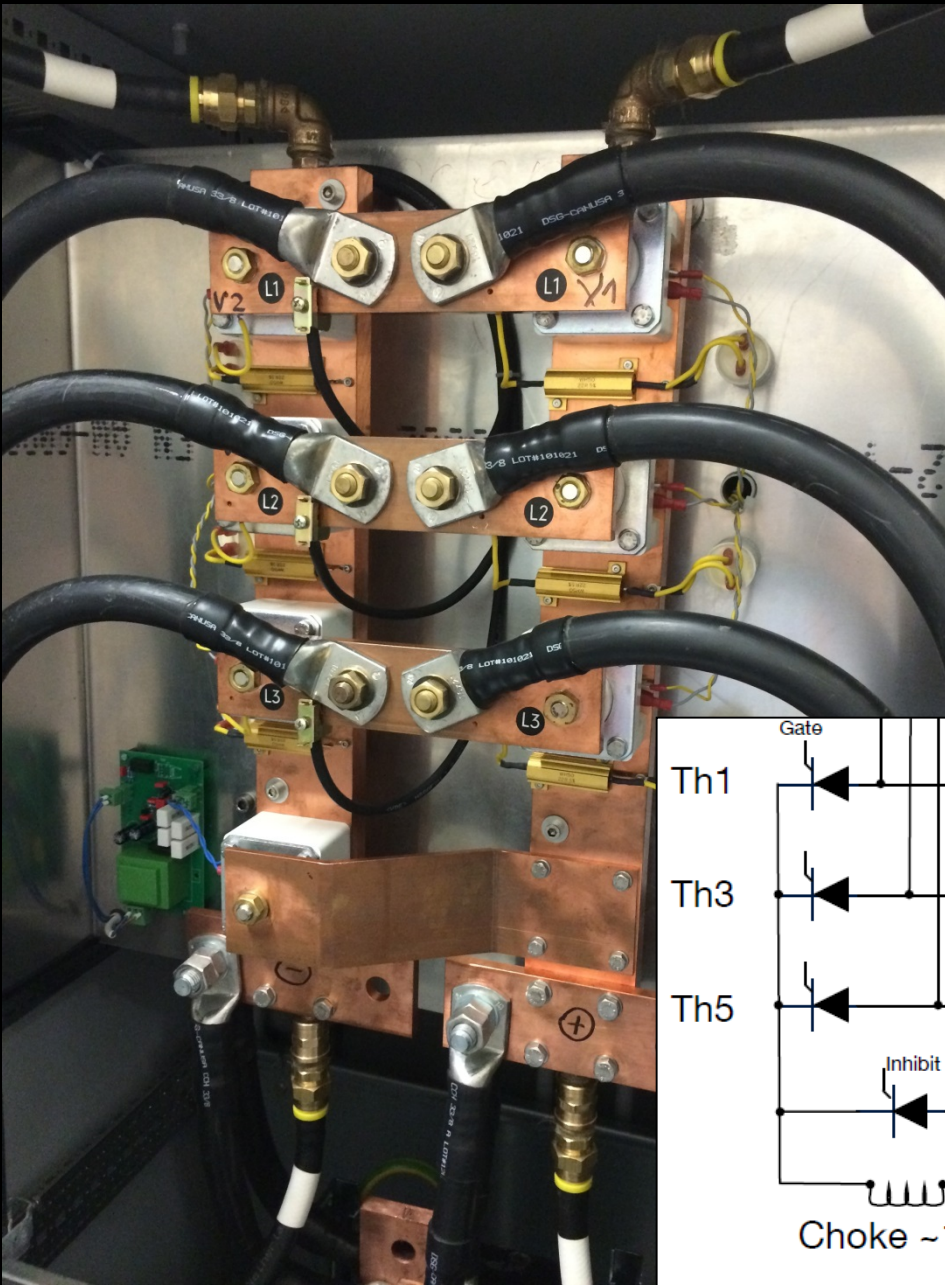
Important Parameters:

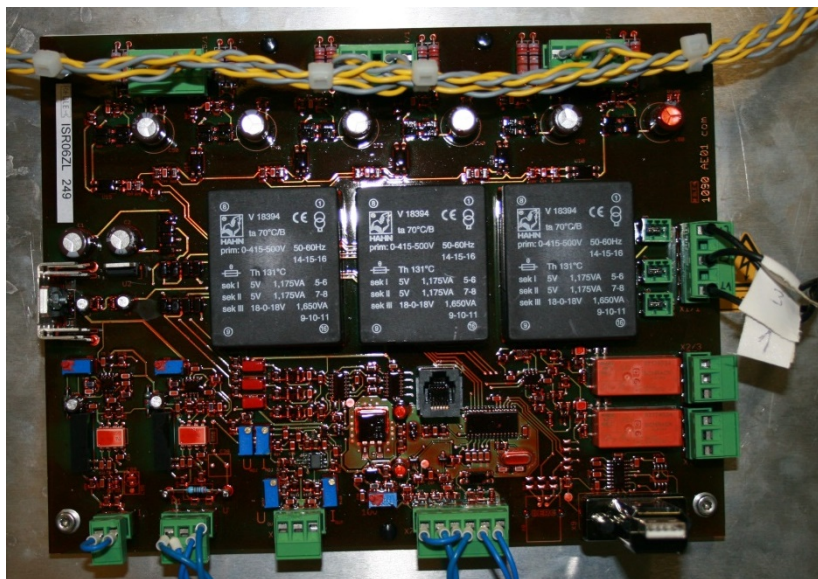
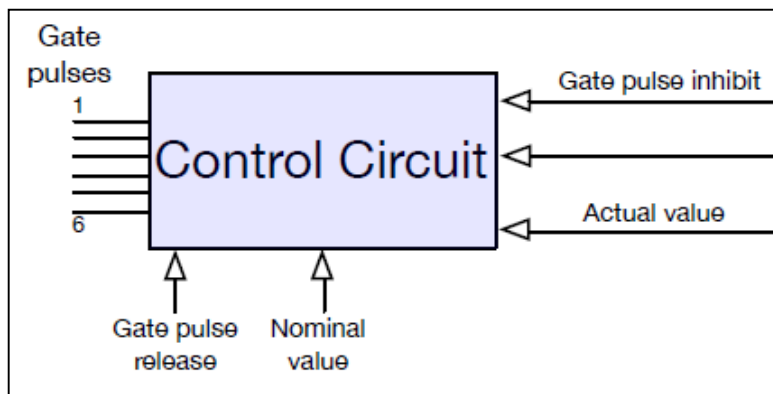
- damage threshold klystron: **20Ws**
- short circuit resistance: **0.1Ω**

Leading Edge Phase Control



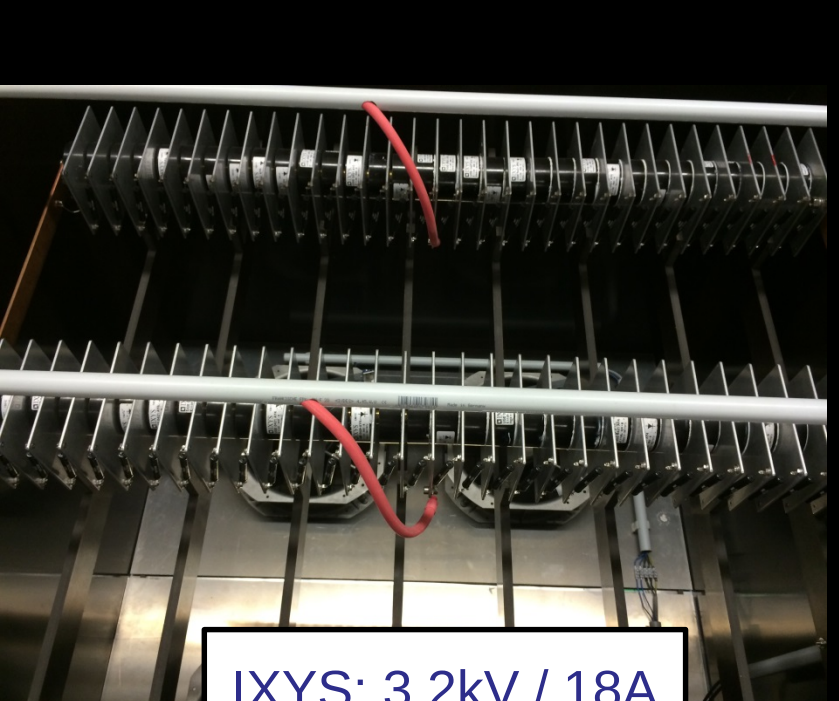
6-Pulse Bridge



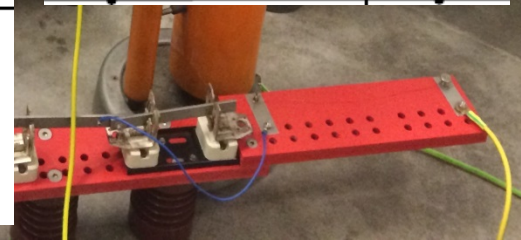
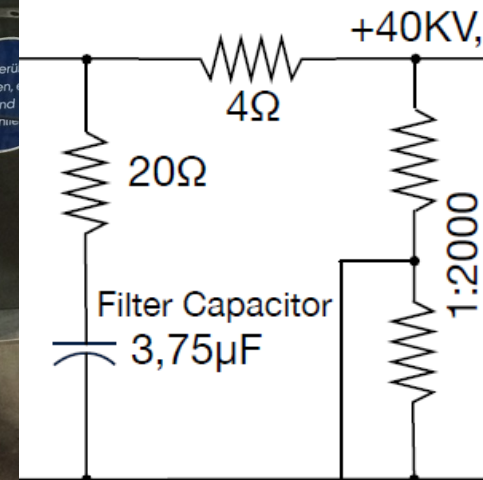
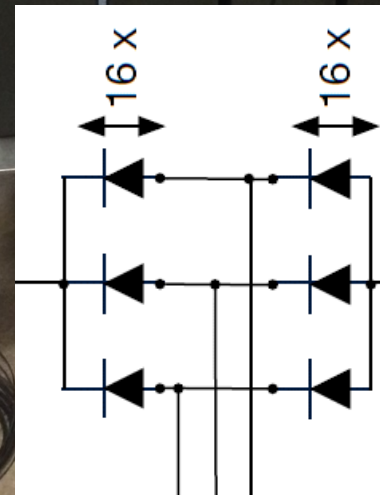
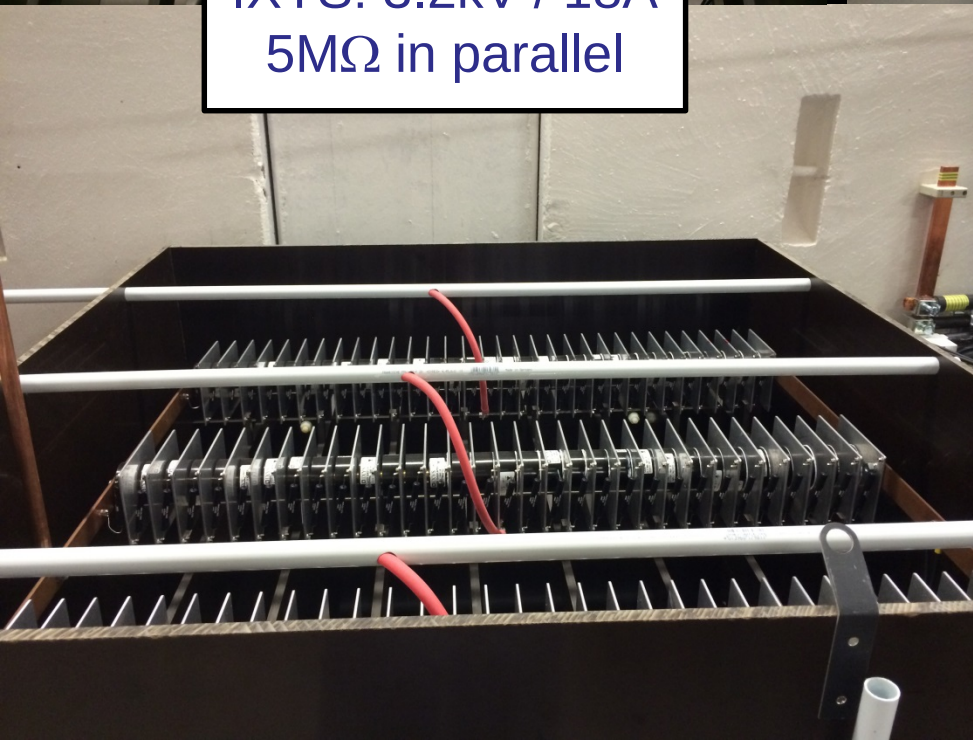


commercially available
($\approx$ 600 Euro)

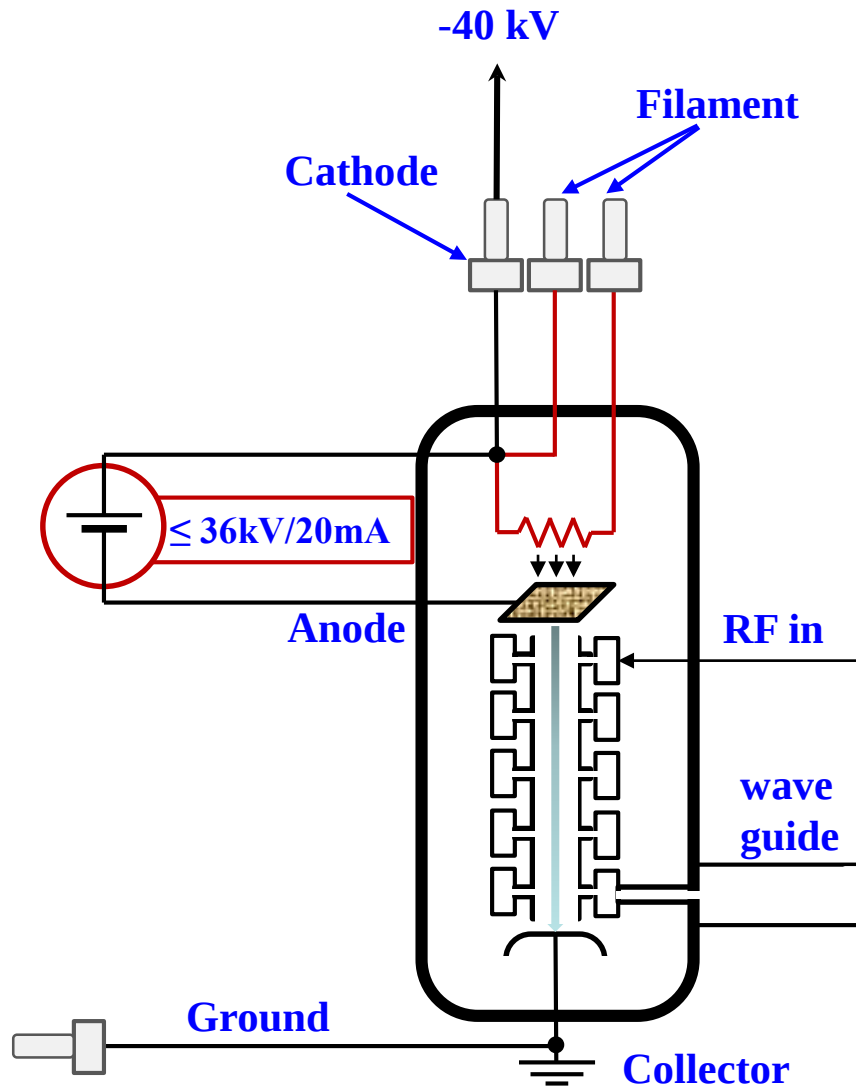




IXYS: 3.2kV / 18A
5M Ω in parallel



Emission Control



No phase shift control → low ripple

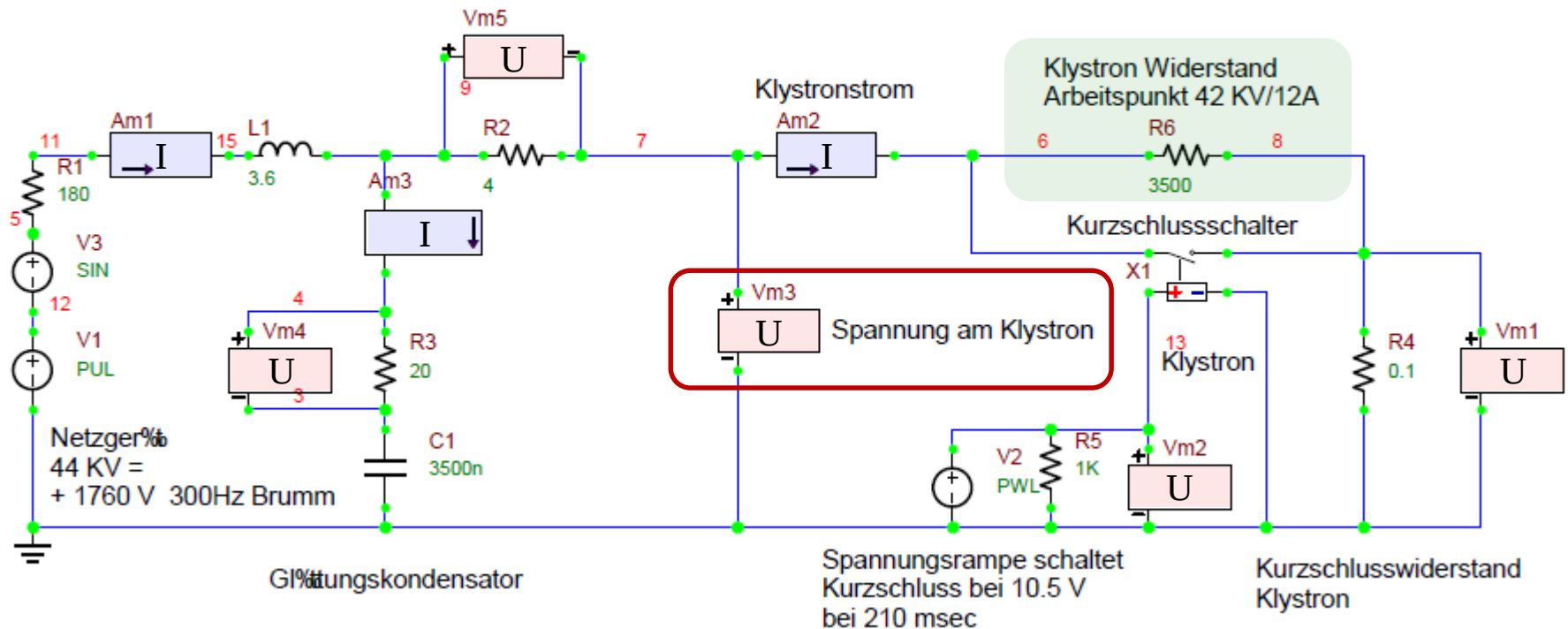


fug
50kV / 40mA

Spice Simulation

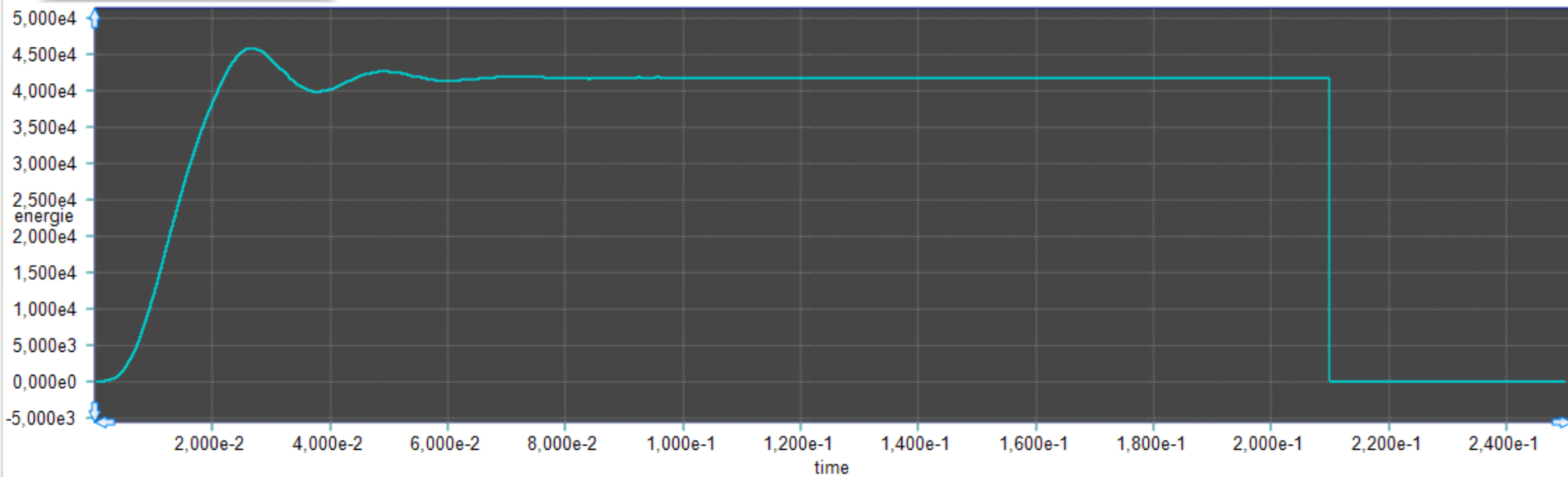
Simulation of the HVPS

1. **Voltage ripple**
2. Short at Klystron

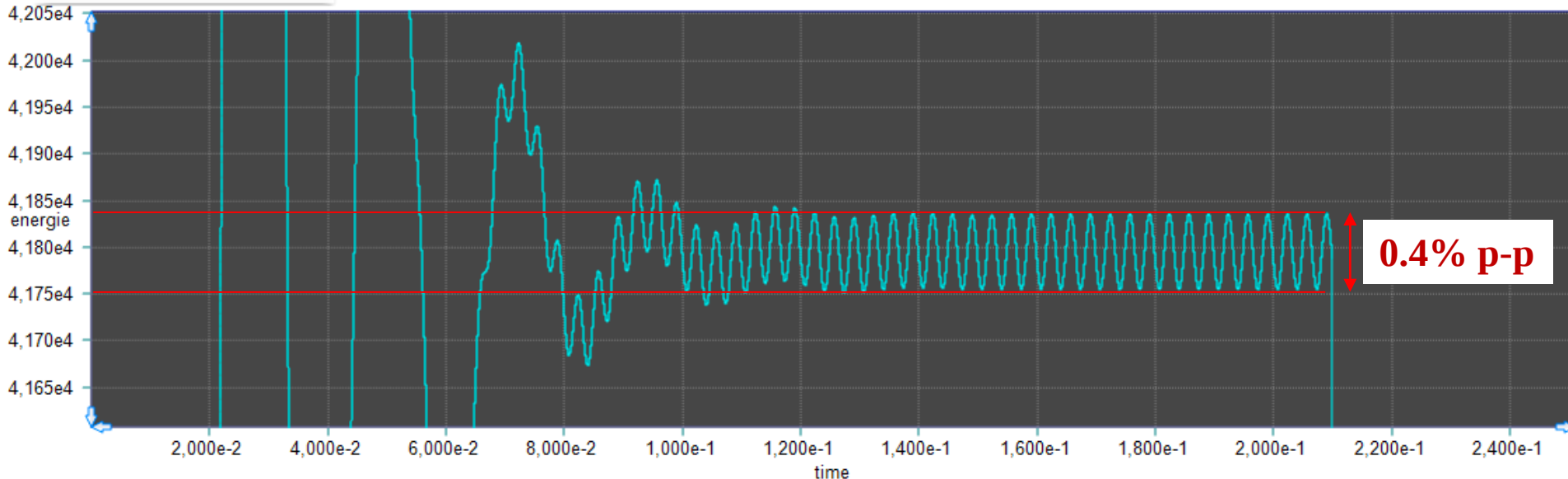


Voltage Ripple (Simulation)

Klystr1_Transient_0_Graph



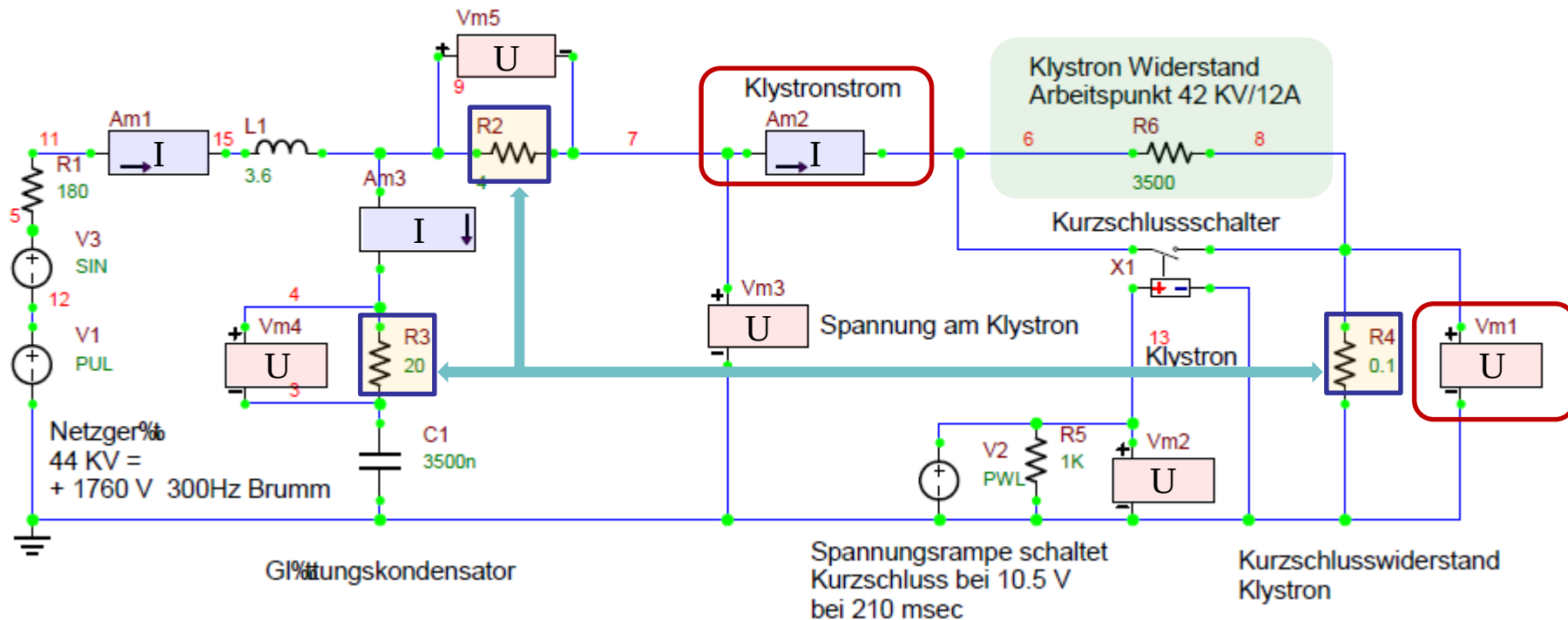
Klystr1_Transient_0_Graph



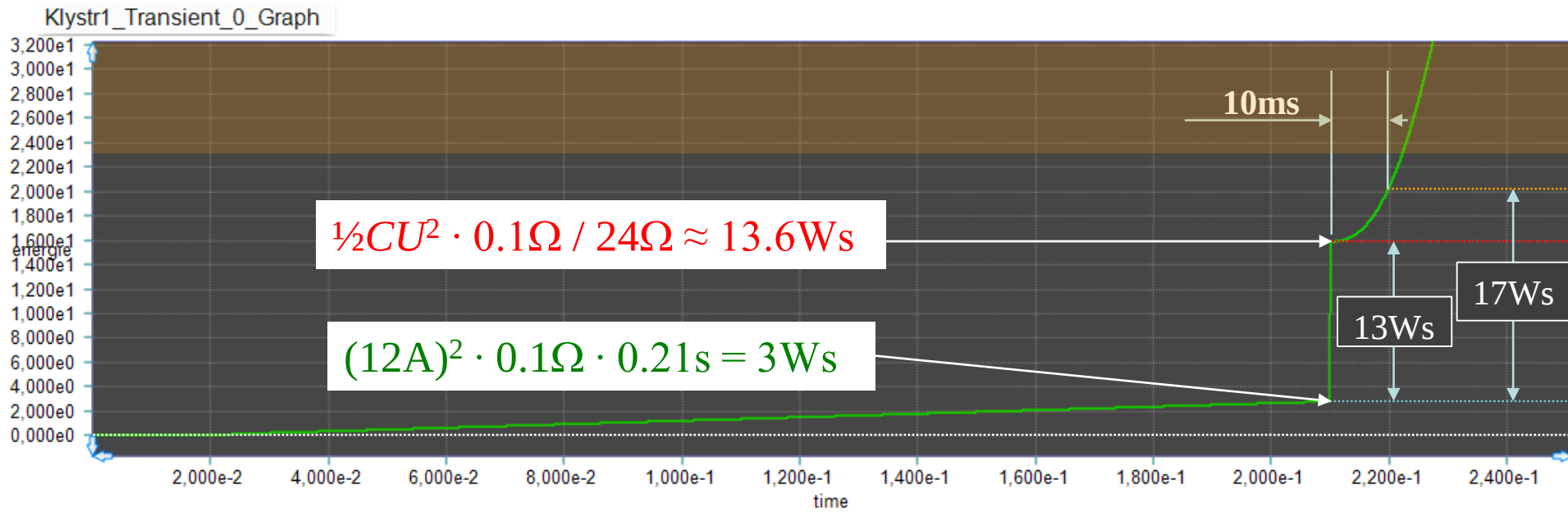
Spice Simulation

Simulation of the HVPS

1. Voltage ripple
2. **Short at Klystron**

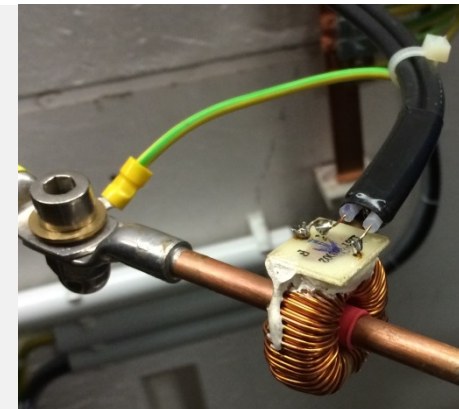
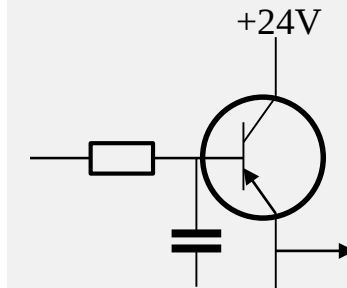
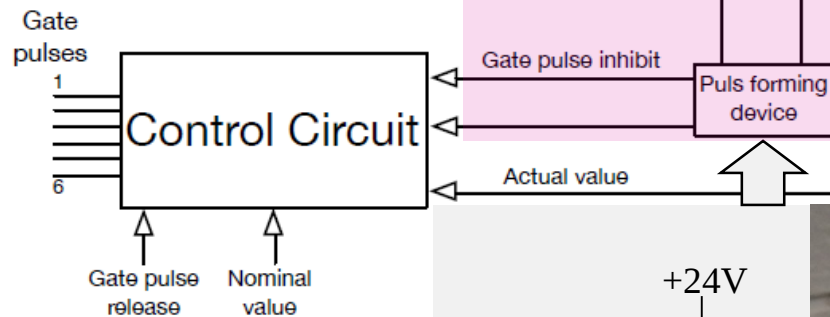
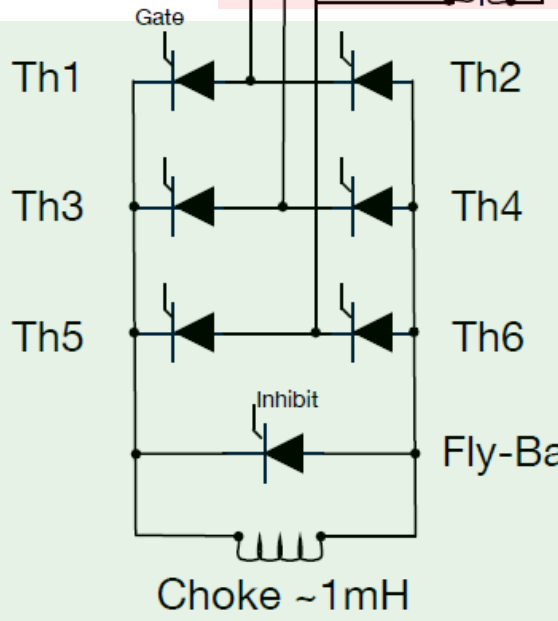
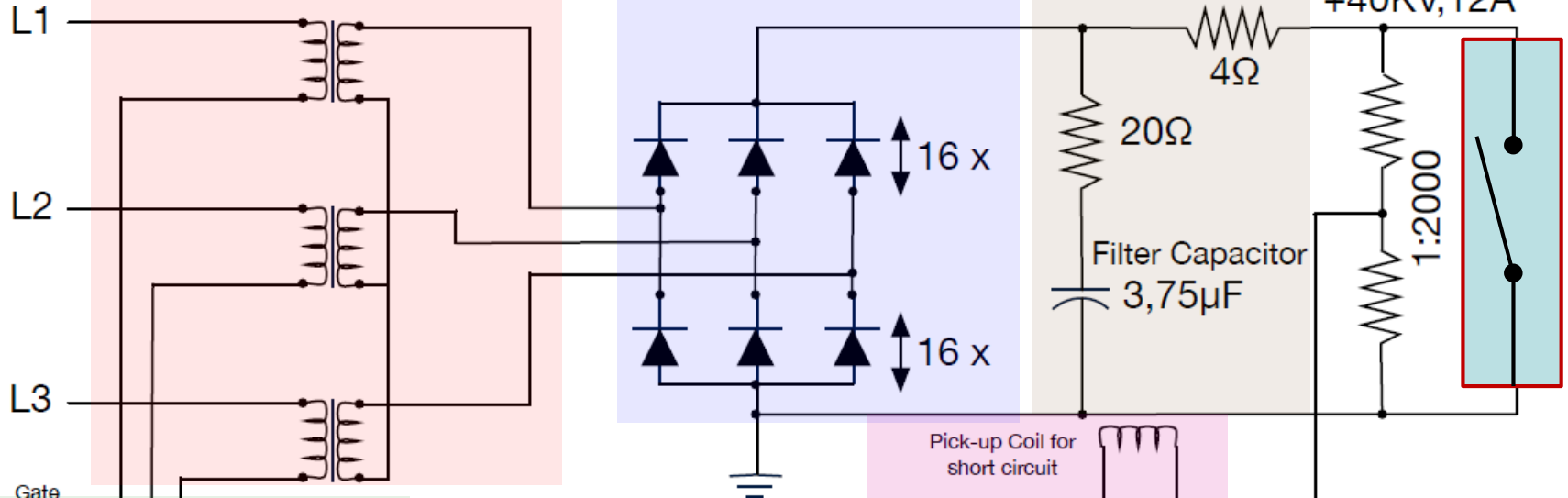


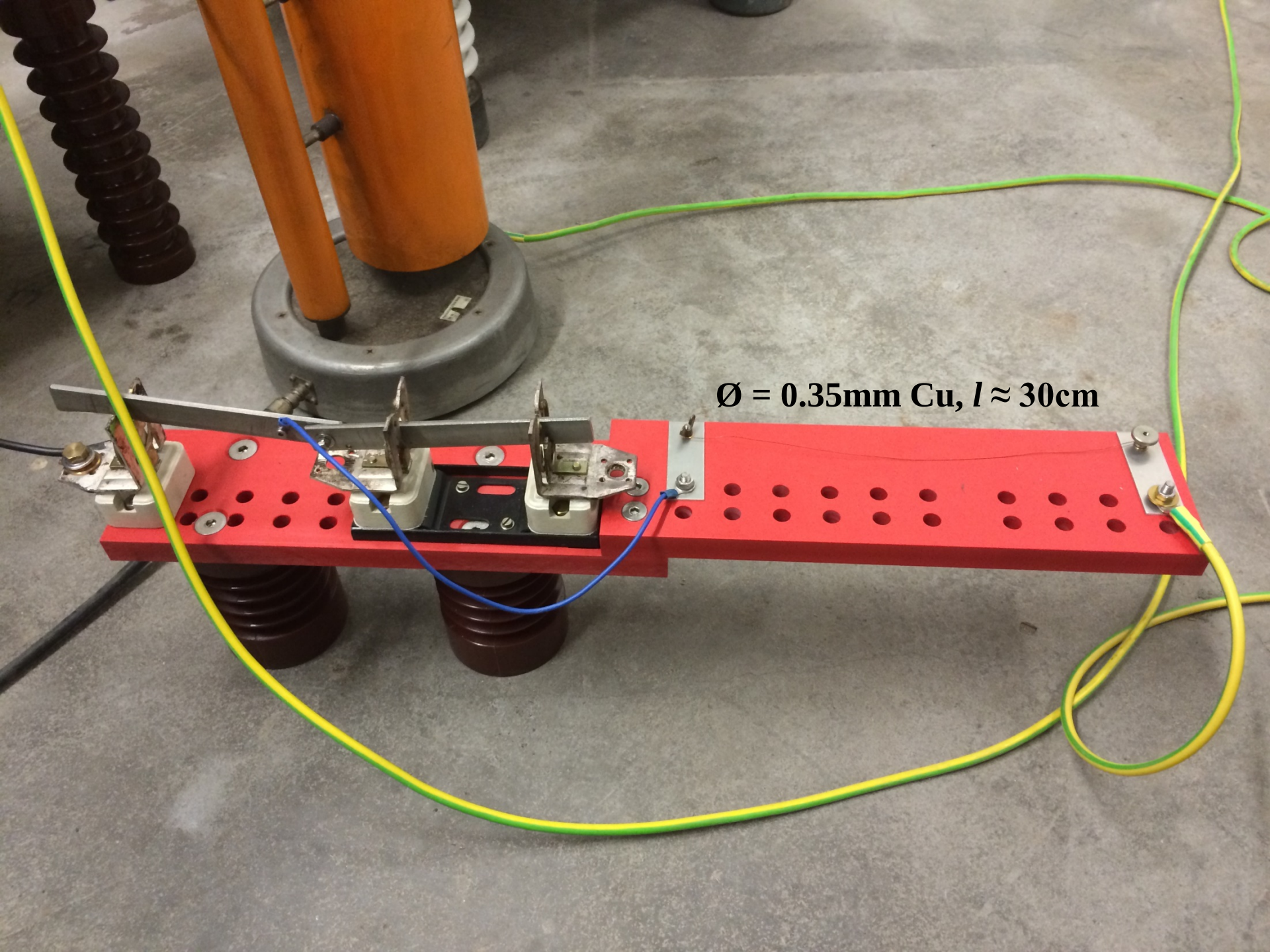
Energy Deposit to Klystron at Short



Layout of the Klystron HVPS

Three - phase transformer
400V / 33KV



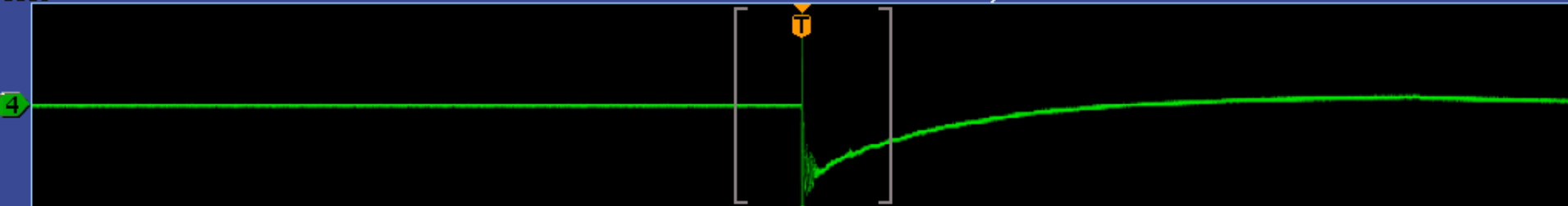


$\varnothing = 0.35\text{mm Cu}, l \approx 30\text{cm}$

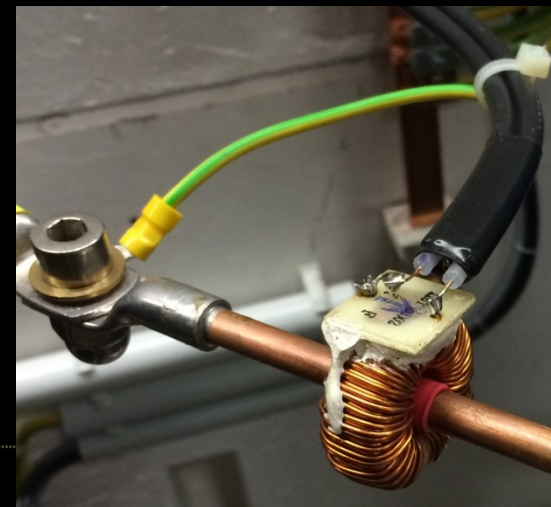
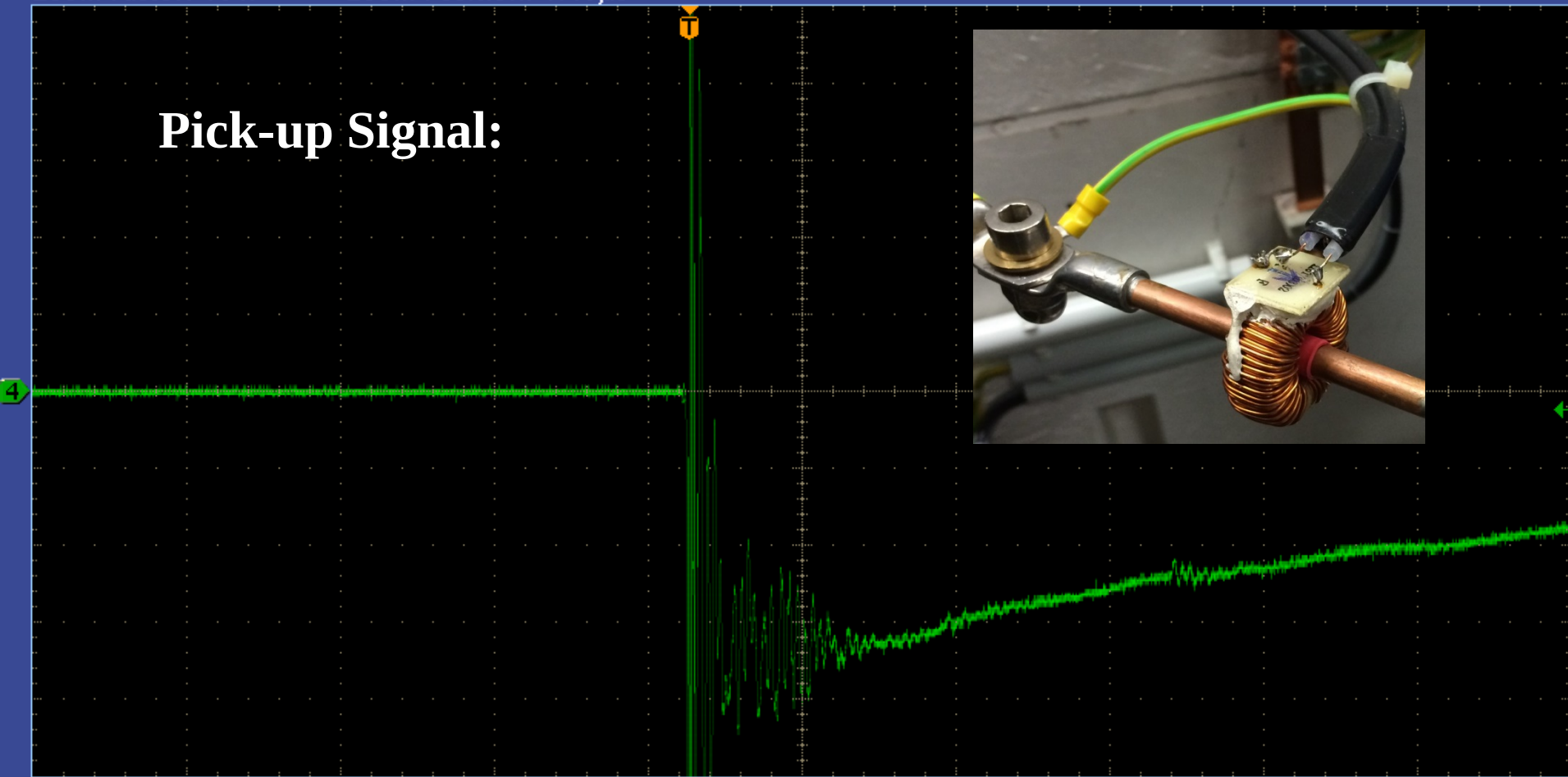


Wire Tests





Pick-up Signal:

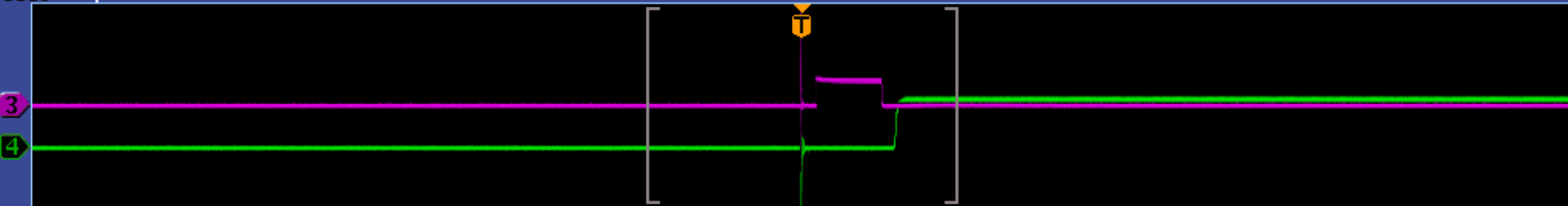


4 50.0 V

Z 2.00 μ s
I $\rightarrow$ ∇ 0.00000 s

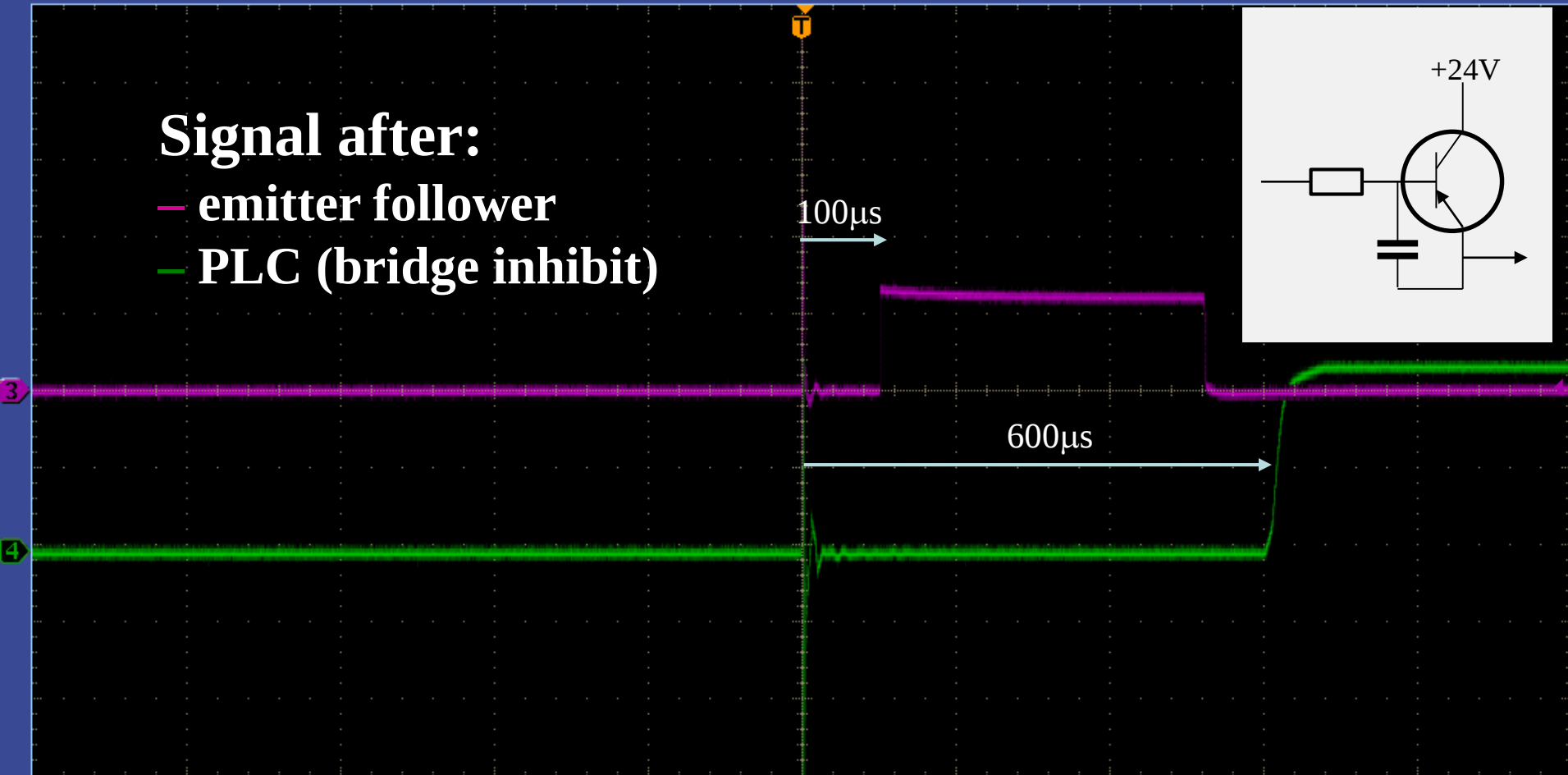
500MS/s
100k points

4 $\int$ -12.0 V



Signal after:

- emitter follower
- PLC (bridge inhibit)



3

20.0 V

4

10.0 V

Z 200 μ sI $\rightarrow$ 4.00000 μ s100MS/s
1M points

3

800mV

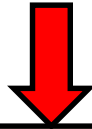
Type
EdgeSource
3Coupling
DC

Slope

Level
800mVMode
Normal
& Holdoff1 Sep 2014
11:42:56

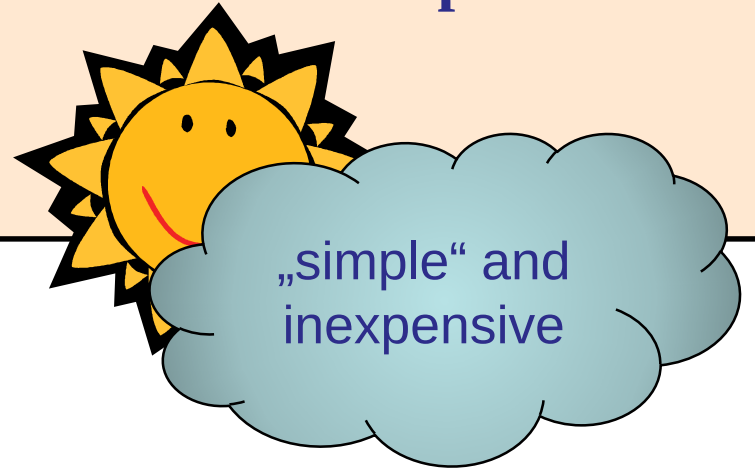
Conclusions

Error rejection capabilities of state of the art LLRF systems and considerably low klystron voltage



High voltage klystron power supply without crowbar protection:

- Spice simulation promising
- First wire tests very convincing

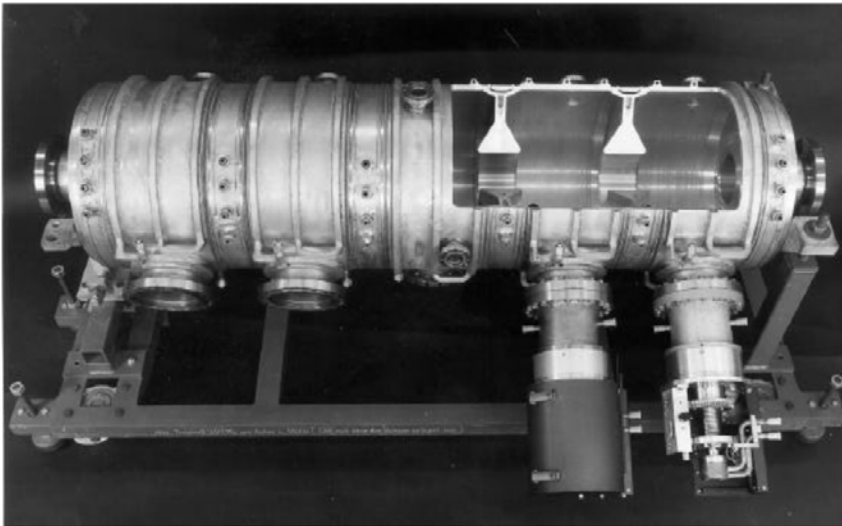


Ongoing work:

- Installation and cabling of klystron
- High power tests
- Installation of 7-cell PETRA and waveguides in ELSA tunnel

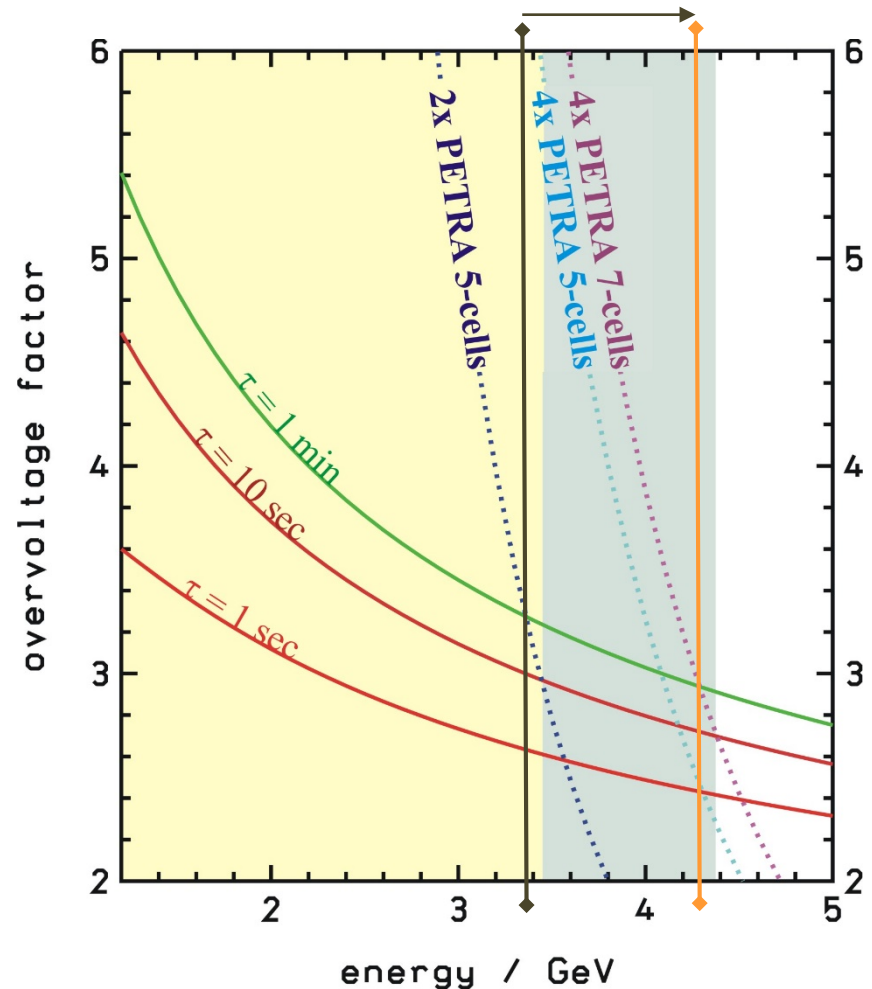
Spares

Accelerating Voltage



n.c. resonators type PETRA:

- 5-cells: $Q_0 \approx 10^4$, $R_S \approx 12 \text{ M}\Omega$
- 7-cells: $R_S \approx 17 \text{ M}\Omega$
- Input-Coupler: $P_{\max} \leq 120 \text{ kW}$



with four 7-cell resonators $E \leq 4.3 \text{ GeV}$ @ $\tau = 1 \text{ min}$