



**High voltage tetrode replacement
in the LHC klystron modulator**

Daniel Valuch

LHC RF

- The LHC has 16 RF stations, each powered by 300 kW / 400 MHz CW klystron
- Nominal DC working point of the klystron is 8.8 A @ 58 kV
- The cathode current could be controlled by a means of “modulation anode”

LHC RF

- With less intensity and only few bunches in the machine there is not need for the all available RF power and the full RF voltage
- At the moment LHC needs only 5-8 MV (out of 16 MV) per beam

LHC RF

ACS Summary Data

Last update = Sun Apr 25 16:40:27 2010

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RPTK.SR4.RA43U2.L4
ACSPowerConverterM1B1

RPTK.SR4.RA43U3.L4
ACSPowerConverterM2B1

RPTK.SR4.RA47U2.R4
ACSPowerConverterM1B2

RPTK.SR4.RA47U3.R4
ACSPowerConverterM2B2

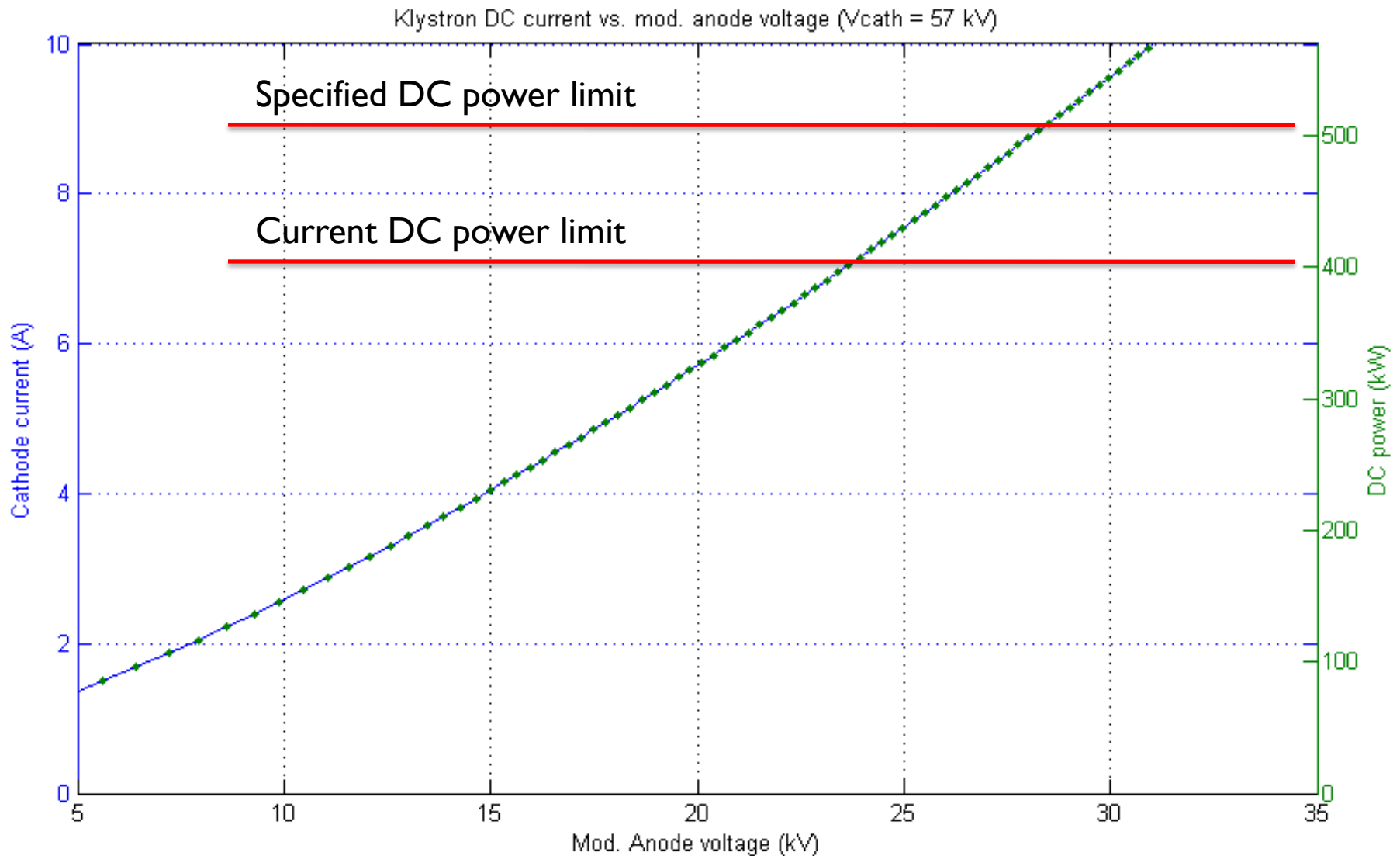
state	IDLE	state	IDLE	state	IDLE	state	IDLE
connected	ONLINE	connected	ONLINE	connected	ONLINE	connected	ONLINE
vMeas	50.20	vMeas	50.40	vMeas	49.53	vMeas	49.79
iMeas	22.96	iMeas	23.14	iMeas	23.40	iMeas	22.92

DEVICES	status	detailedMode	mode	V cath [kV]	I cath [A]	Dc P [kW]	Coll TP [kW]	Drv fwd [W]	Kly fwd [kW]	Cav fwd [kW]	Field [MV]
ACSLine1B1	OK	ON	ON	50.21	8.03	403.38	316.90	8.72	88.08	96.93	0.82
ACSLine2B1	OK	ON	ON	50.25	7.78	390.77	288.71	12.21	71.96	105.51	0.83
ACSLine3B1	DISABLED	PC-POWERED	OFF	-0.05	-0.04	0.00	0.94	0.00	0.00	0.00	0.02
ACSLine4B1	OK	ON	ON	50.21	8.08	405.62	284.72	21.15	124.59	120.39	0.82
ACSLine5B1	DISABLED	PC-POWERED	OFF	-0.06	-0.05	0.00	5.80	0.00	0.00	0.00	0.02
ACSLine6B1	OK	ON	ON	50.12	8.09	405.26	276.71	27.66	115.22	135.11	0.82
ACSLine7B1	OK	ON	ON	50.55	8.02	405.25	312.58	18.69	111.52	123.85	0.83
ACSLine8B1	OK	ON	ON	50.47	8.04	406.00	321.29	12.28	97.28	90.82	0.82
ACSLine1B2	DISABLED	PC-POWERED	OFF	-0.11	-0.04	0.00	0.00	0.00	0.00	0.00	0.02
ACSLine2B2	OK	ON	ON	49.64	8.01	397.69	277.30	15.05	121.67	122.86	0.83
ACSLine3B2	OK	ON	ON	49.80	7.95	395.75	292.16	11.56	107.91	114.45	0.83
ACSLine4B2	OK	ON	ON	49.71	7.94	394.93	268.48	9.83	130.32	118.06	0.83
ACSLine5B2	DISABLED	PC-POWERED	OFF	-0.03	-0.04	0.00	-1.78	0.00	0.00	0.00	0.02
ACSLine6B2	OK	ON	ON	49.90	8.01	399.83	301.40	12.29	94.62	123.33	0.84
ACSLine7B2	OK	ON	ON	49.92	8.00	399.17	302.90	9.81	101.36	111.05	0.84
ACSLine8B2	OK	ON	ON	49.89	8.04	400.99	312.52	9.15	78.79	88.42	0.82

LHC RF

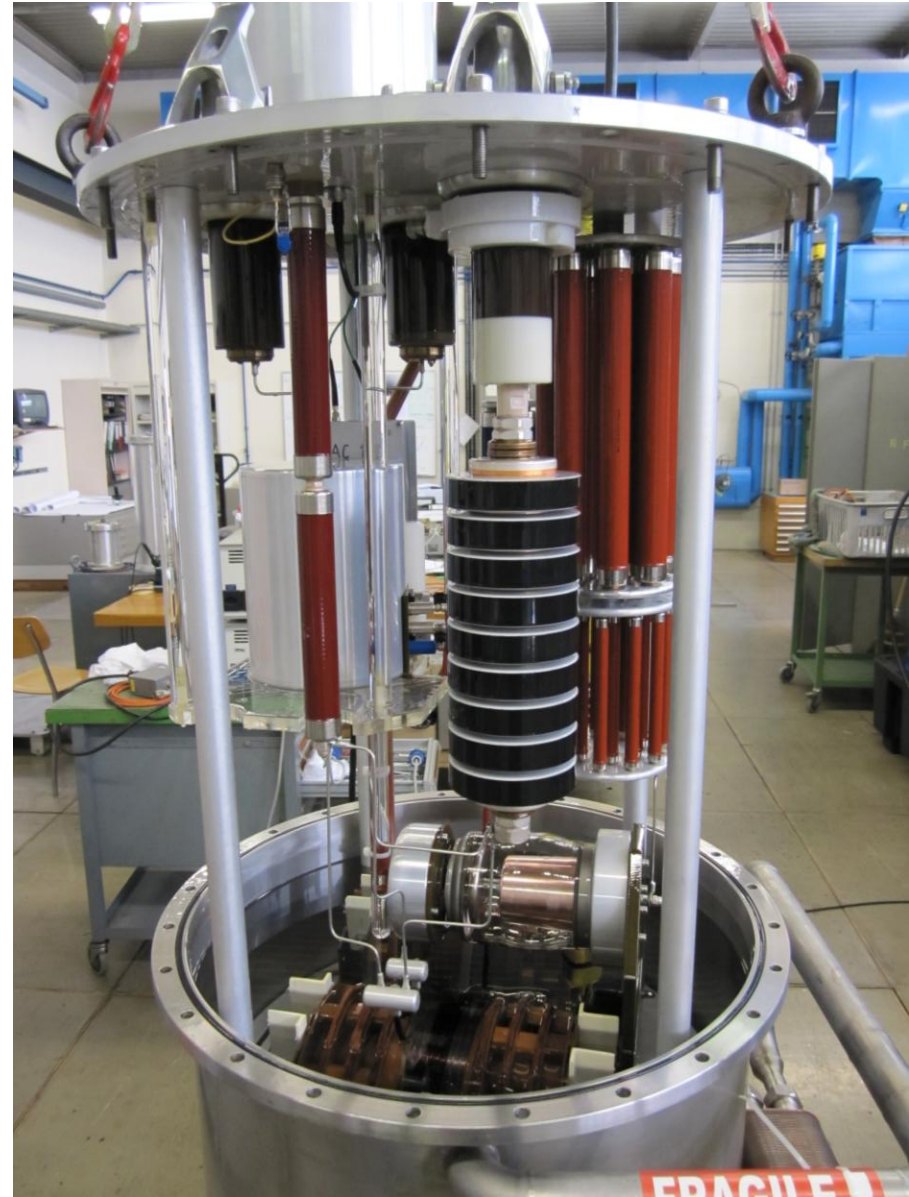
- Reduce the RF drive and hence the total RF power
- Reduce DC voltage by power convertor
- Reduce DC current by mod. anode and keeping the HV constant
- Run klystrons at full power and reduce number of powered cavities

Klystron DC power vs. V_{MA}



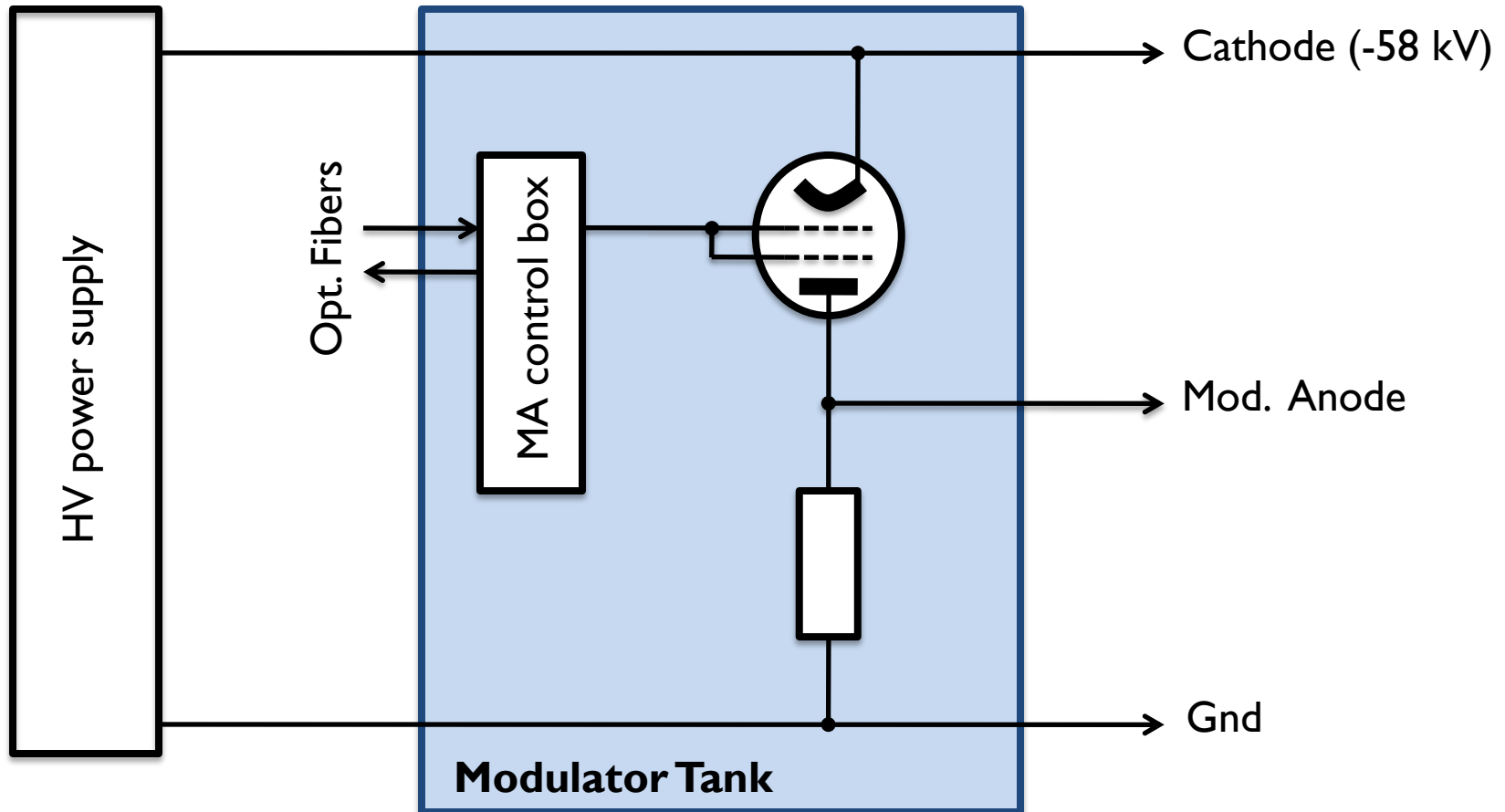
Klystron modulator tank

- The Klystron modulator tank (1 per klystron) contains:
 - Heater transformer
 - Modulation Anode voltage divider
 - Measurement and diagnostic circuitry

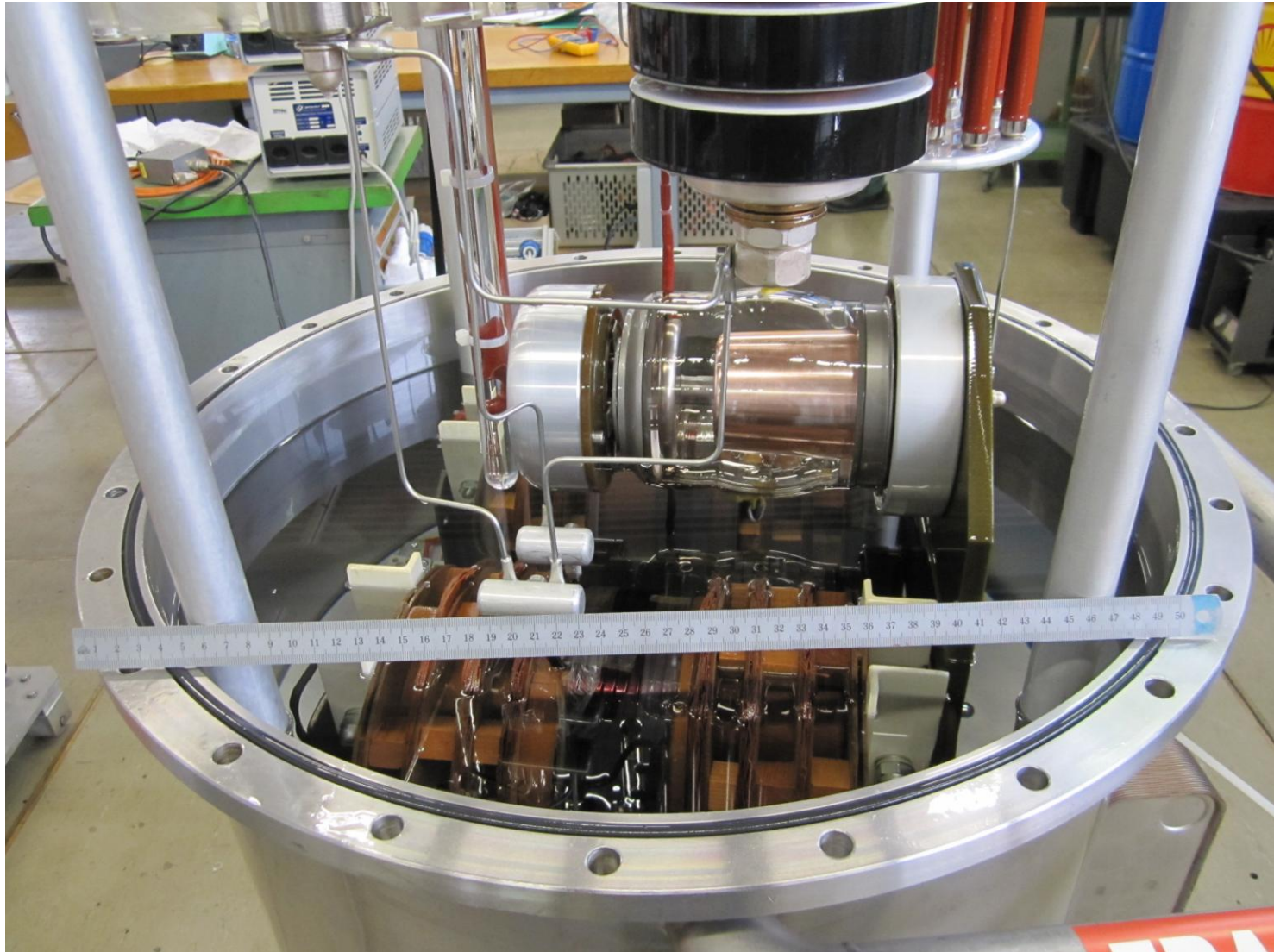


Current MA source

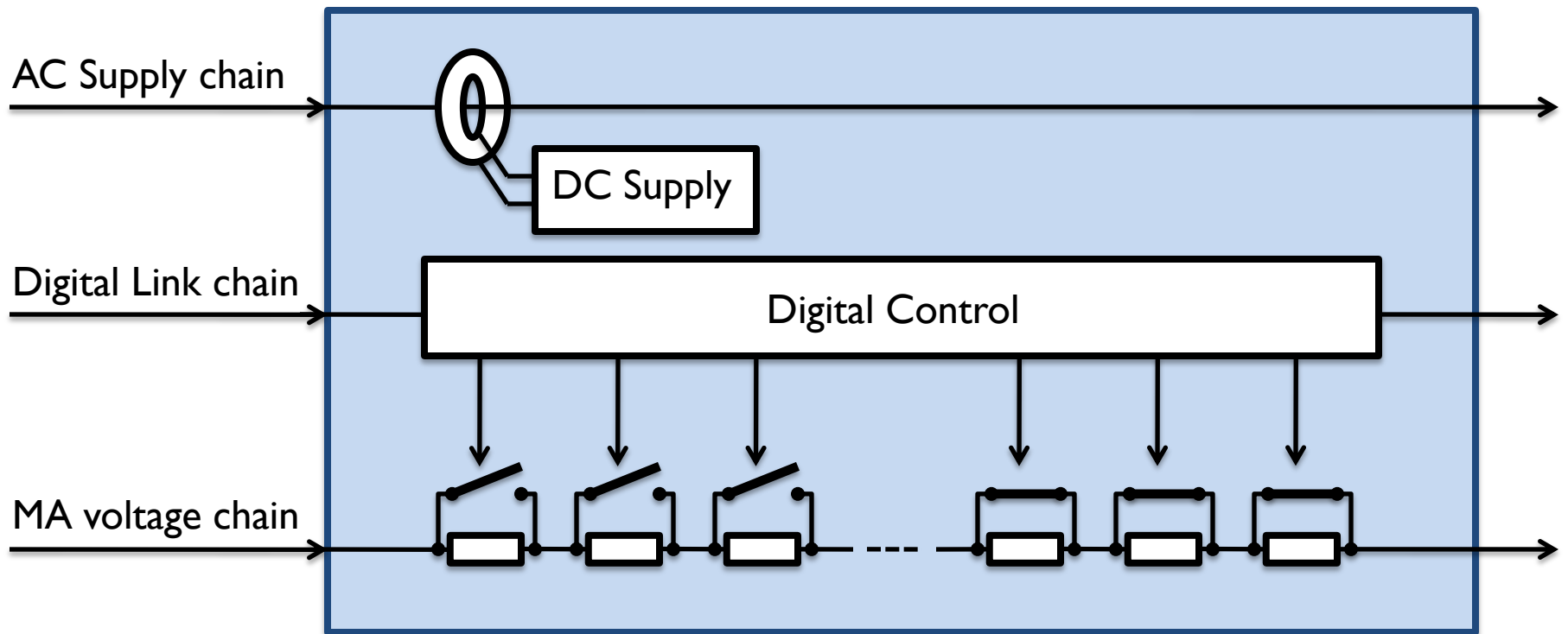
- The current MA source uses the TH5186 tetrode



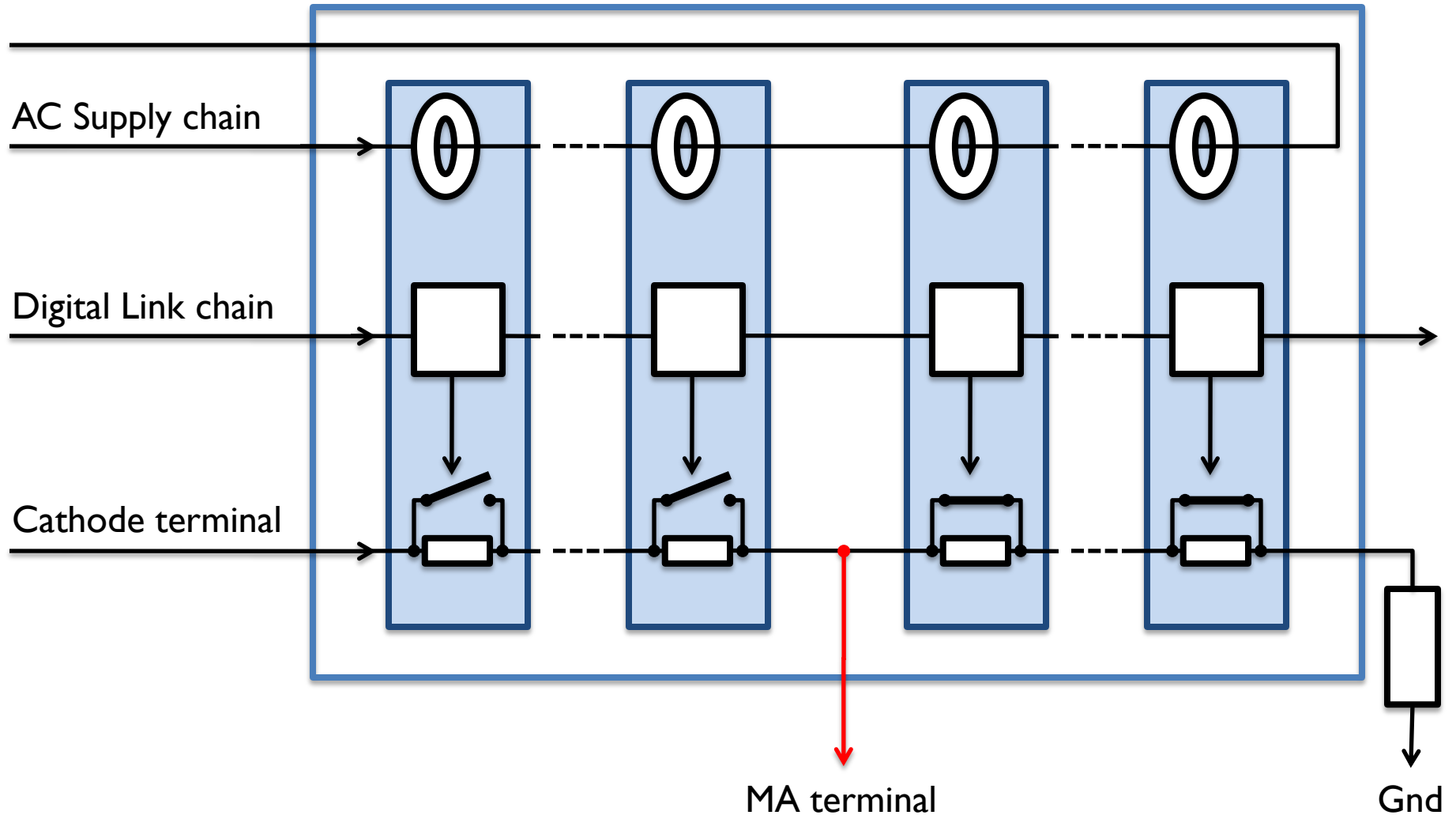
Current MA source



New MA source

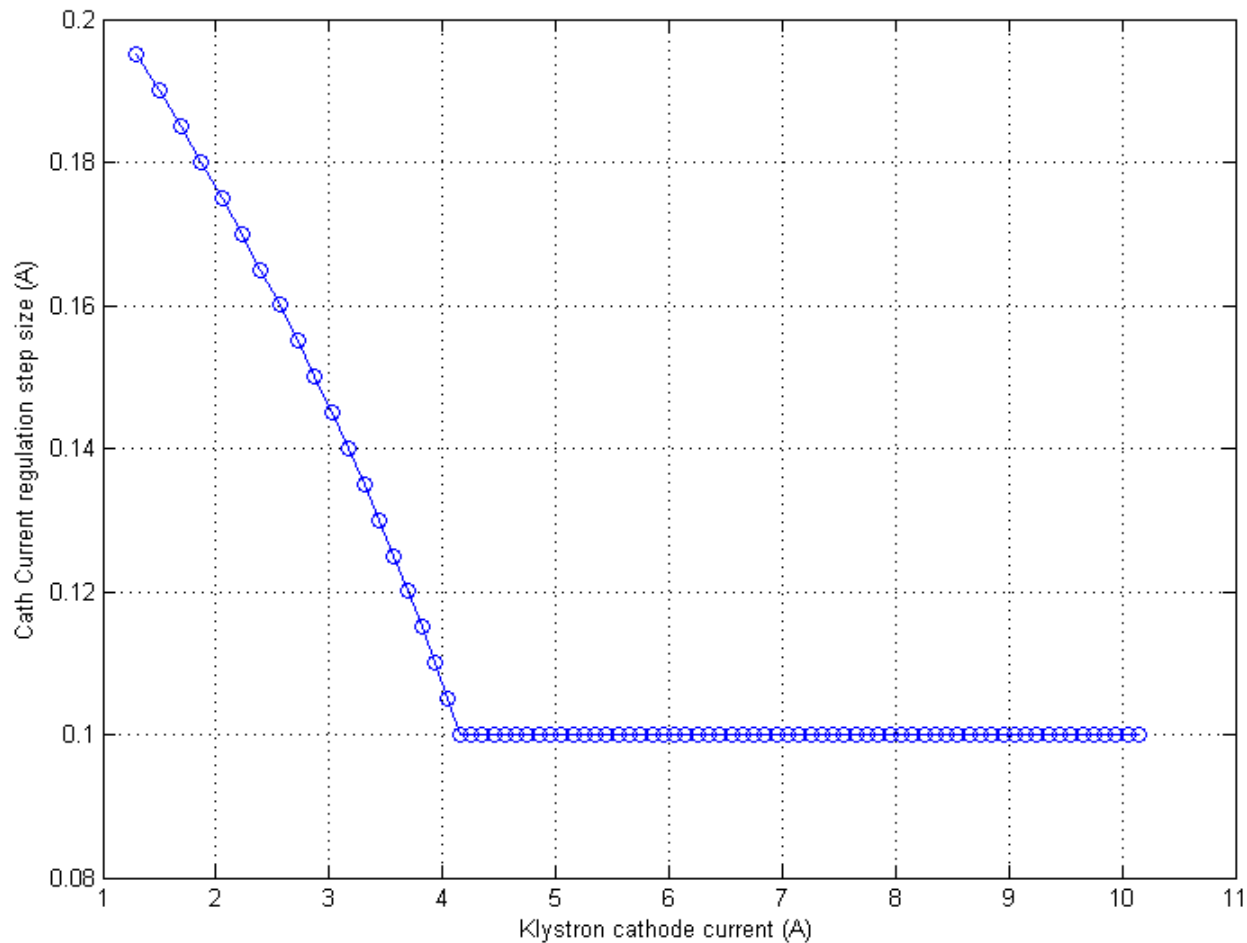


New MA source



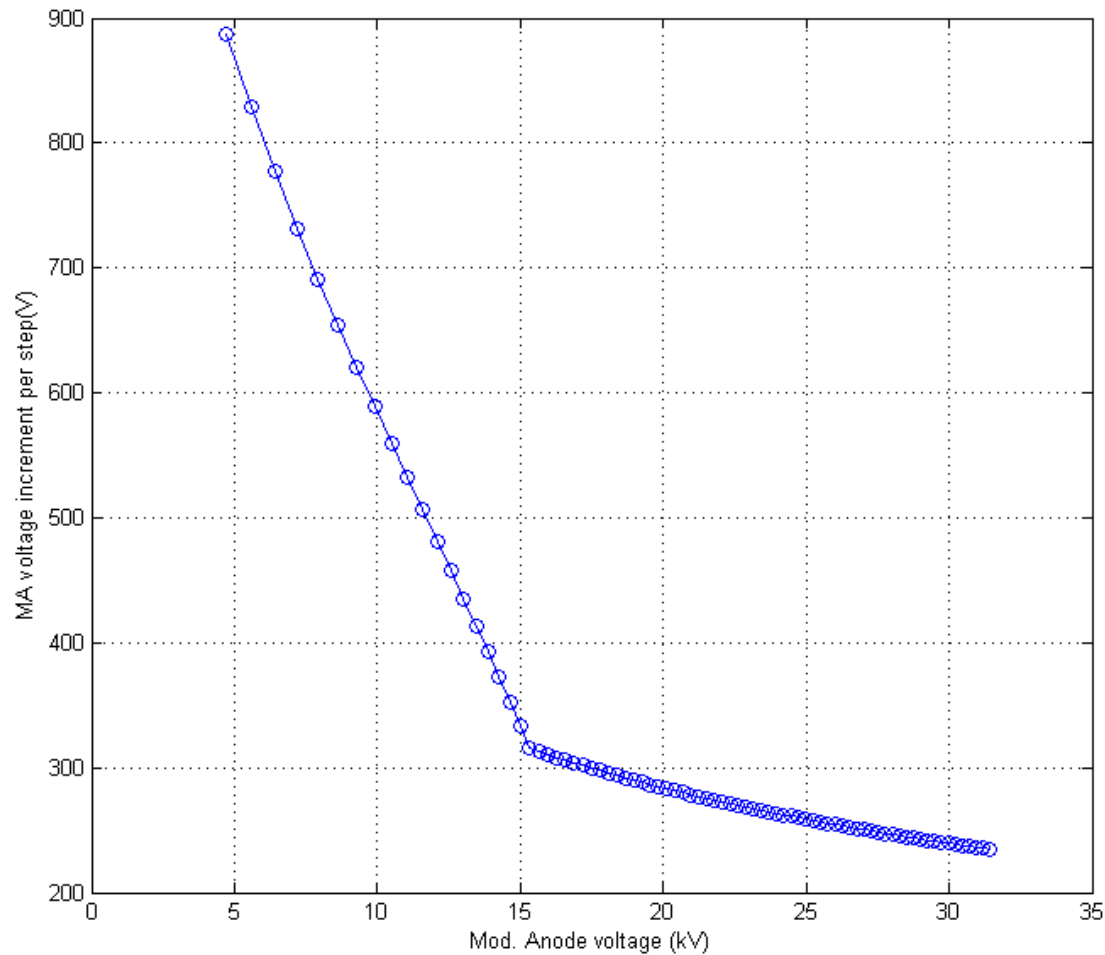
New MA source

- Klystron current regulation granularity



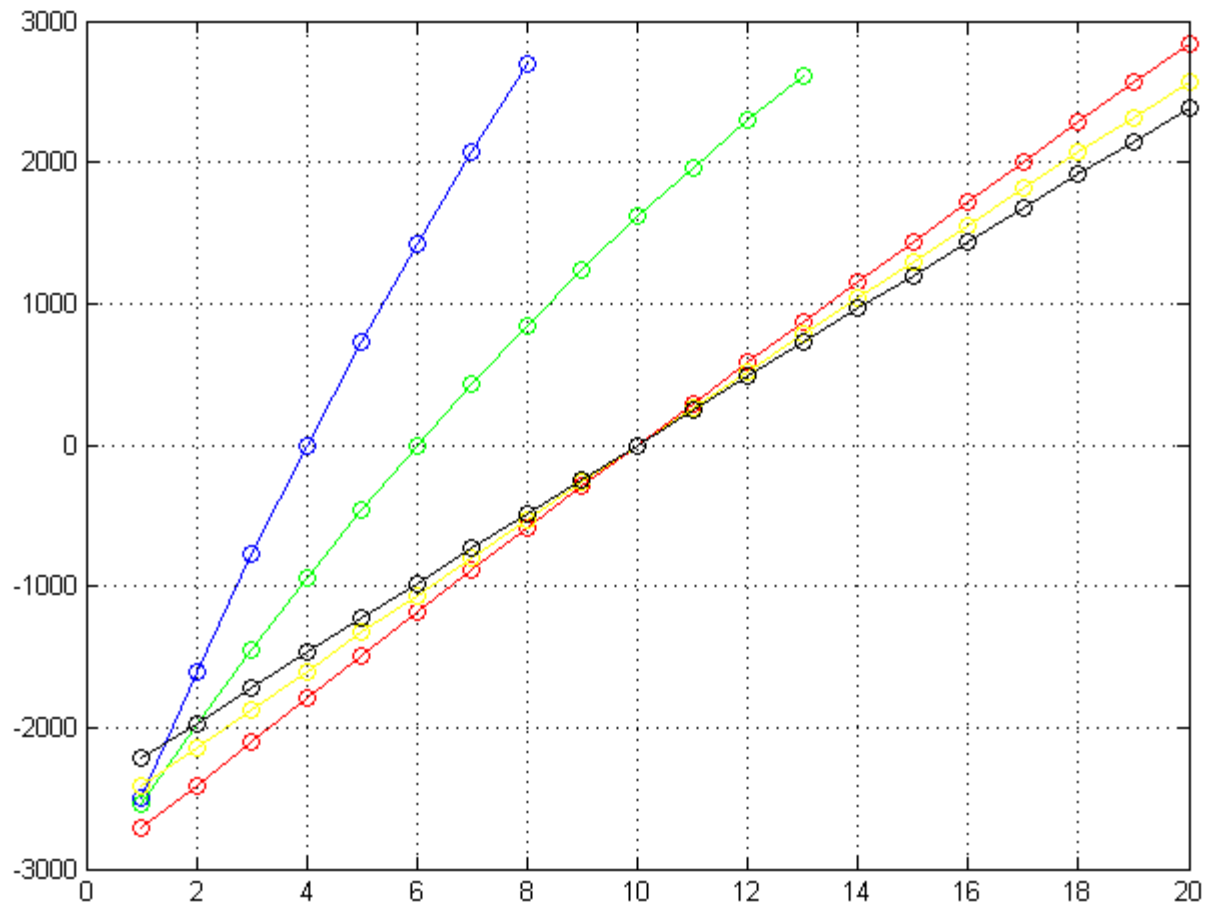
New MA source

- Klystron MA voltage granularity



New MA source

- Reed switch voltage loading



Summary

- The new MA source should replace the current tetrode based modulator by a “solid-state” solution
- The digital control will provide 0.1 A cathode current regulation steps in the active region (~100 reed relays)
- Serial digital link will give us much better access to the “hot side” measurements (heater current and power, cathode current, MA current)
- A prototype unit is currently being developed, it should occupy not more volume than the currently used tetrode