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**CHARITÉ**

MOPO011

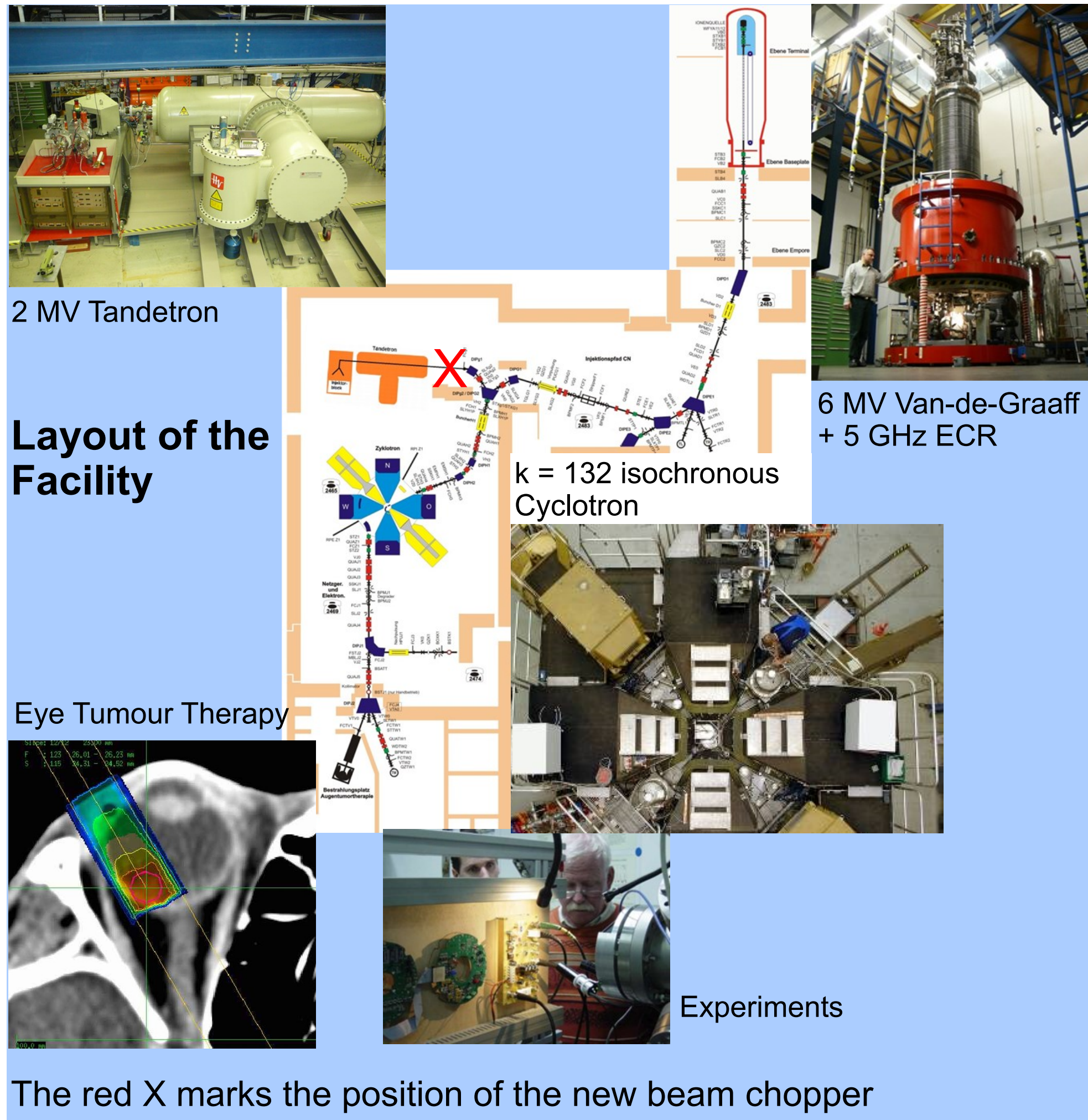# DESIGN AND OPERATION OF THE NEW FAST BEAM CHOPPER BETWEEN TANDETRON AND CYCLOTRON

## Design of the New Beam Chopper



2 MV Tandetron

**Layout of the Facility**

6 MV Van-de-Graaff + 5 GHz ECR

k = 132 isochronous Cyclotron

Eye Tumour Therapy

Experiments

The red X marks the position of the new beam chopper

**Accompanying research includes beam delivery for Flash irradiation, thus it became necessary to set up a fast beam chopper**

- reliable and faster than the existing mechanical beam stop
- pulse widths down to 1ms at 1kV Amplitude
- fast deflection of the beam with a simultaneously low time delay
- fit in 1m beamline
- setup via a CAMAC Power Supply Controller and Beam control via FPGA and LabVIEW

**A half-bridge mosfet module from Behlke was chosen**

- True Square Wave
- Up to 3MHz switching frequency
- Peak current up to 30A
- Operating voltage up to 4kV
- Rise and Fall Time down to 8ns
- Liquid cooling

**Further necessary components**

- Processing and Control electronics
- Power supplies for the mosfet module
- HV power supplys for the deflection
- Liquid cooling and heat exchanger
- Deflection plates and vacuum chamber

### Operating principle
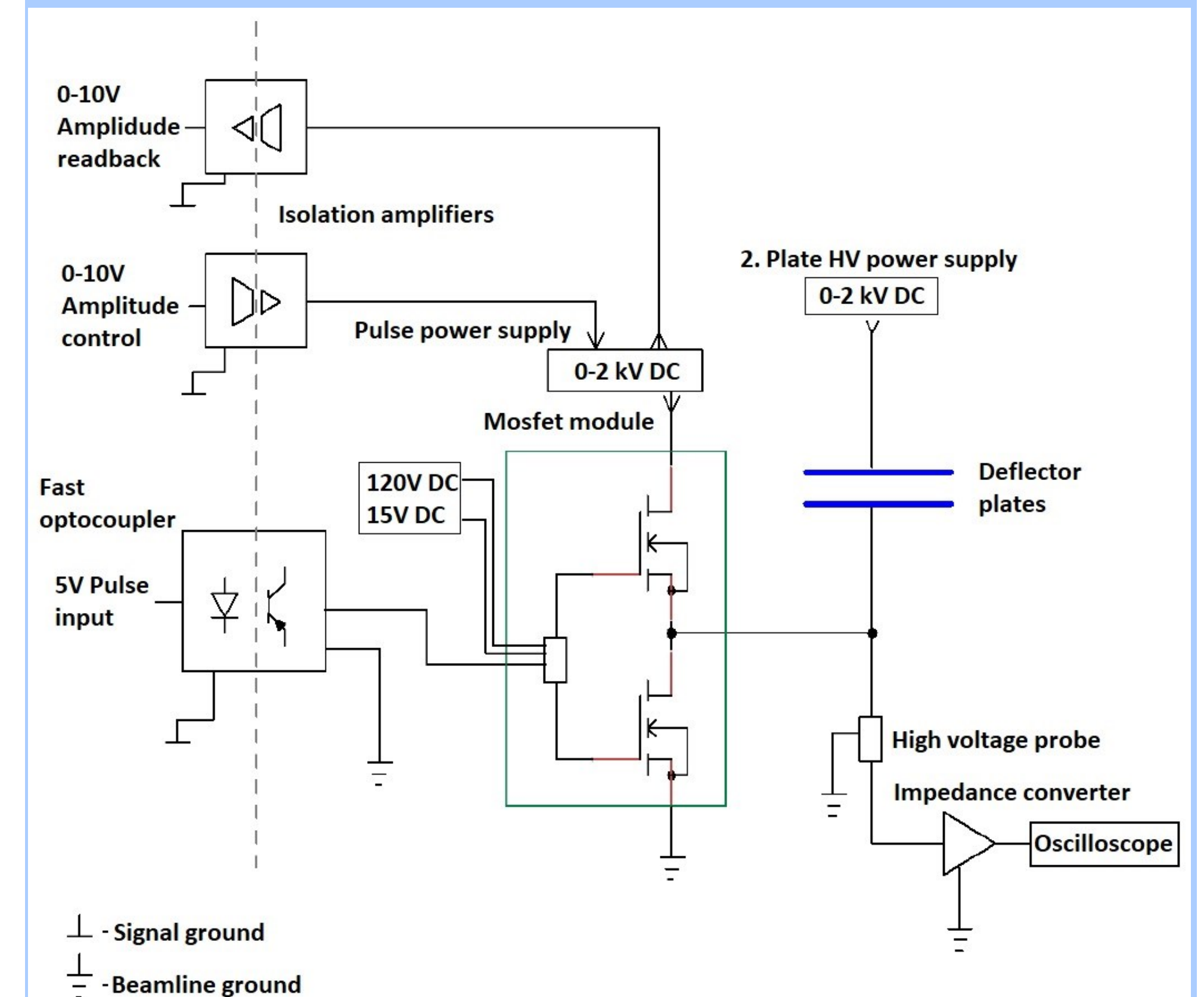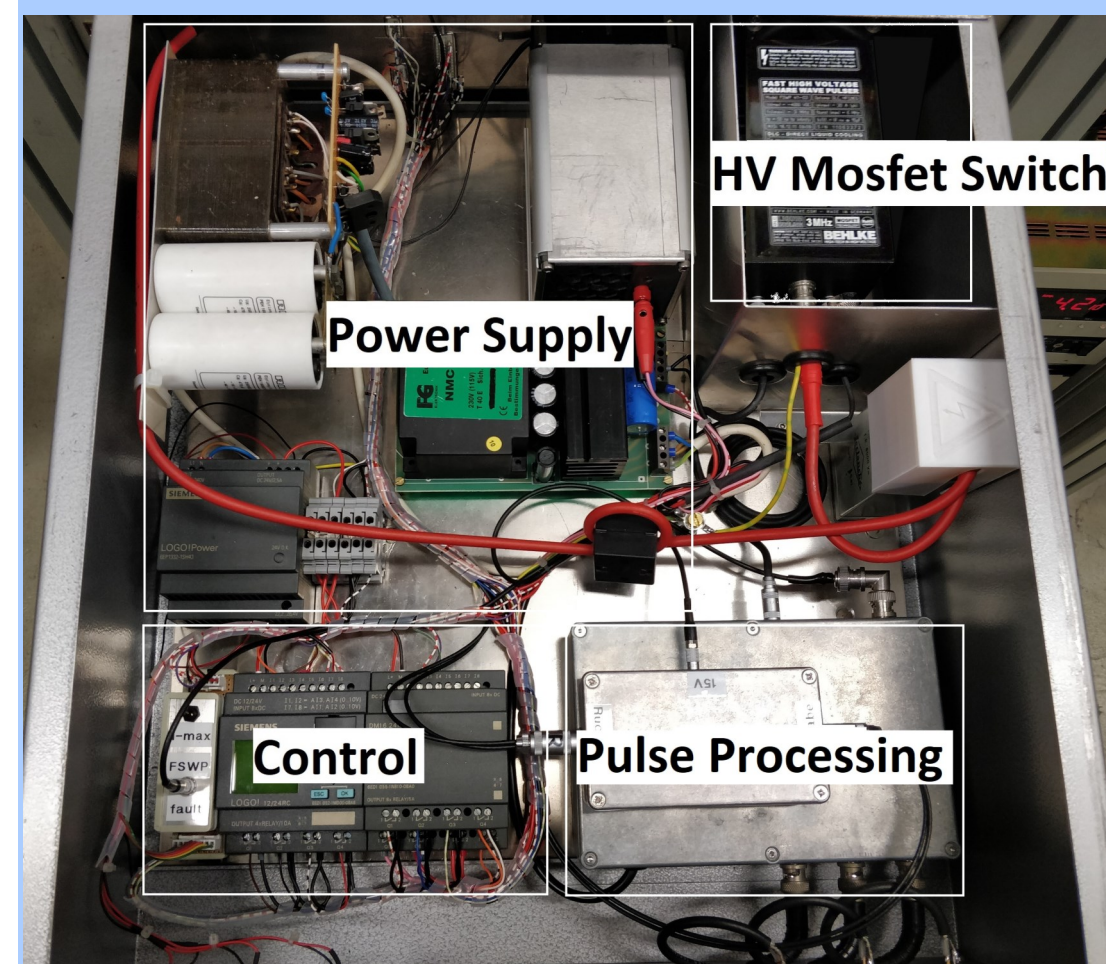


## Design of New Beam Chopper

### Pulser crates

- Pulse Electronics
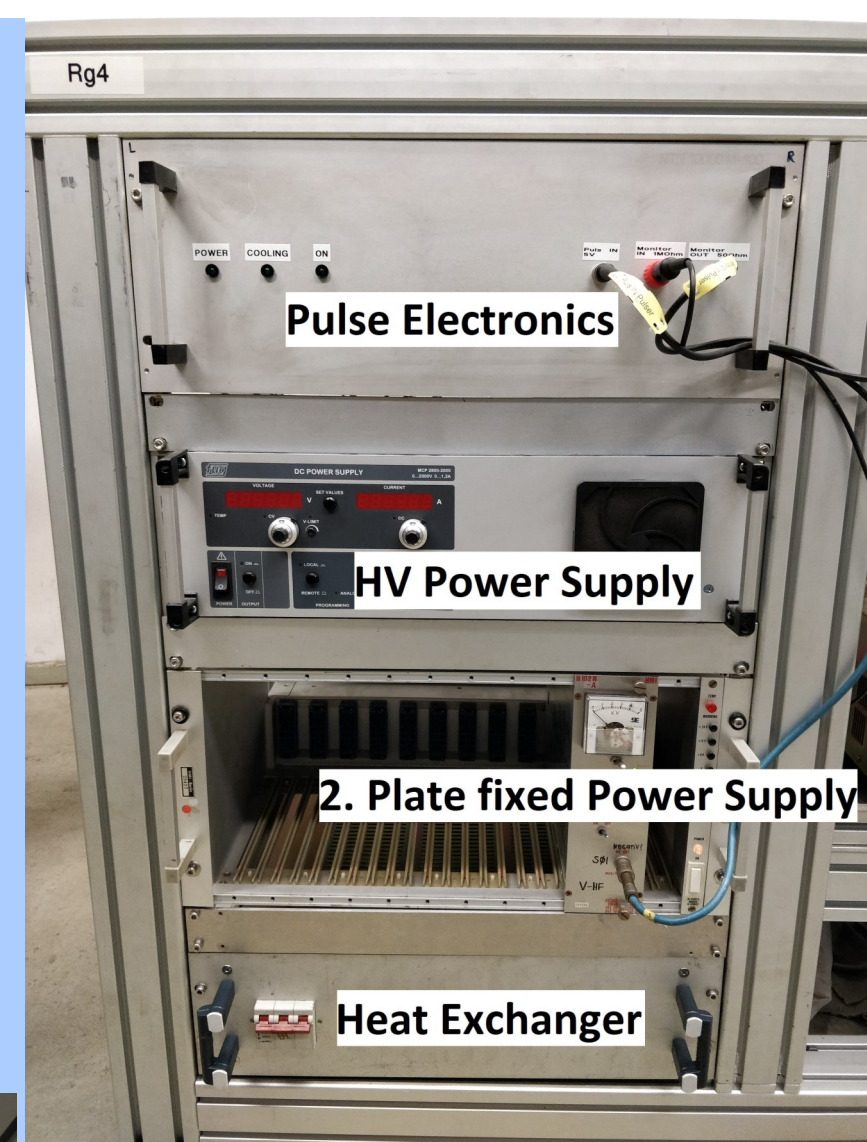- HV Power Supplys
- Heat Exchanger

### Pulse Electronics

**Power Supply**

- 120V and 15V for mosfet module operation
- 24V for the Control module



HV Mosfet Switch

Power Supply

Control    Pulse Processing

**Pulse Processing**

- Galvanic isolation of the analog signals and the input pulse signal
- Input pulse signal conditioning

### Pulse Electronics

**Control**

- Connection between the CAMAC PSC interface, the HV power supply, the heat exchanger and mosfet module
- Fault detection

**HV Power Supplys**

- FUG MCP 2800-2000, 2kV 1.2A for Pulse Plate
- HMI N102N, 5kV 0.2mA for fixed Plate

**Heat exchanger**

- Galden® HT135 PFPE Fluid for Direct Liquid Cooling
- Behlke HE-10 Heat exchanger
- EHEIM universal 600 Pump
- Flowmeter UCC DFC.9000
- Main switch and fuse
- Mains power distribution
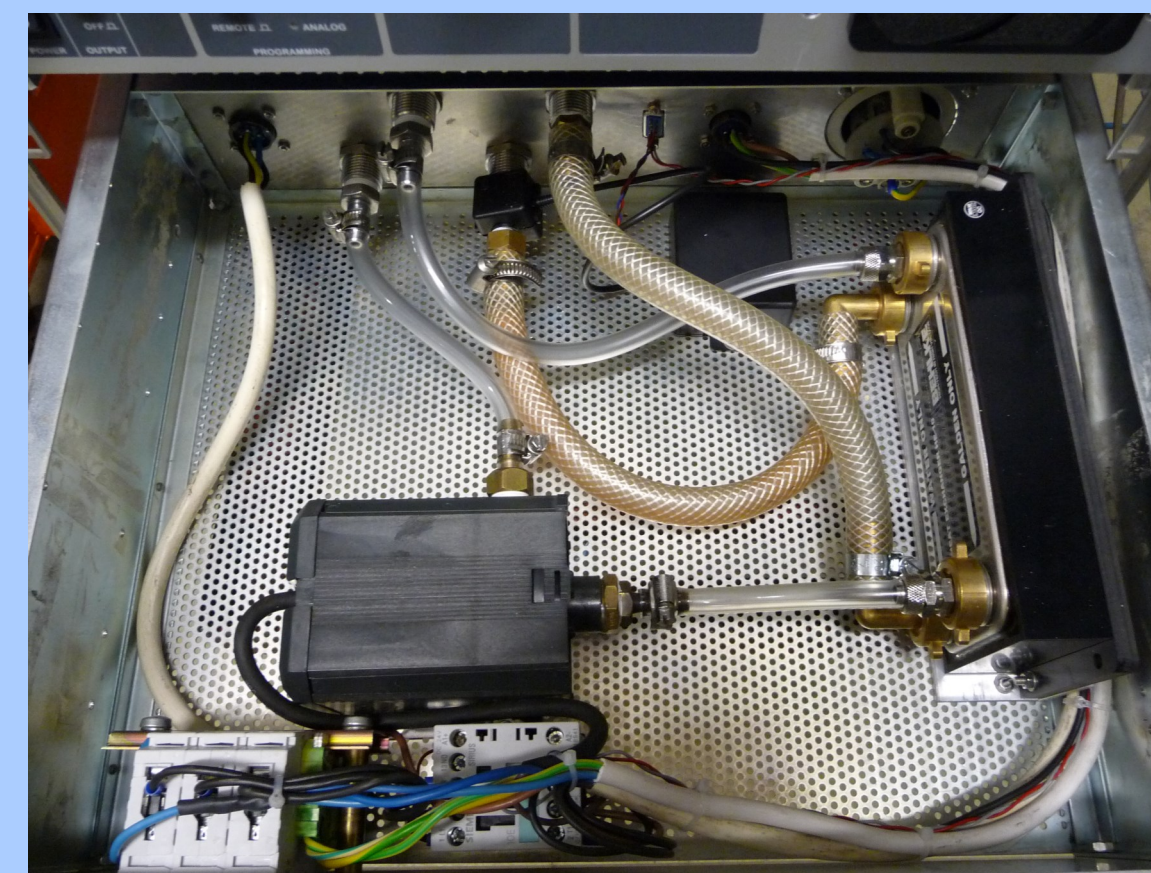


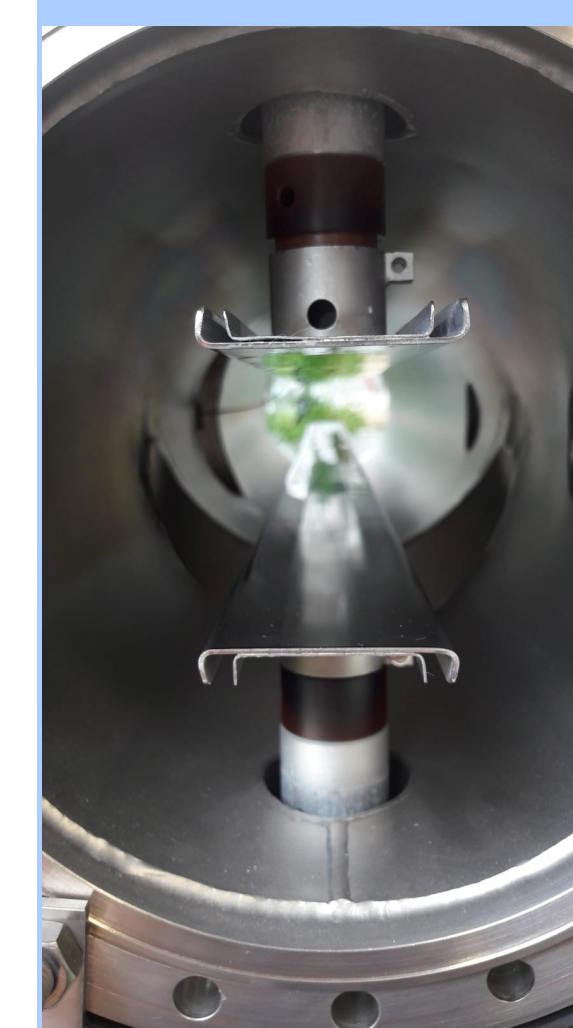### Vacuum chamber and Deflection plates

**Vacuum chamber**

- 94cm long with DN 160 CF Flange
- One DN 200 CF Flange for a Getter pump
- Two ports for electrical connection of the plates
- Four Adjustment knobs for the Plates
- A supporting frame made of item profiles



**Deflection plates**
- 90x4cm
- with a set distance of 2cm
- made from V4A steel

## Installation and Operation Experiences of the first 2 years

### Installation

- took place in 2020
- installed directly behind the Tandetron
- 1m beamline which was previously only used for Steerer tests
- The flat beam profile in Y-direction in this area perfectly matched with the deflector plates
- Mechanically aligned with the beam axis
- Mains connection with 3x400V and 16A
- Connection to the control system via a CAMAC PSC interface
- for FLASH operation the pulse input signal comes from a FPGA
- for continuous pulse operation the input signal comes from a devider which is triggered by the cyclotron frequency
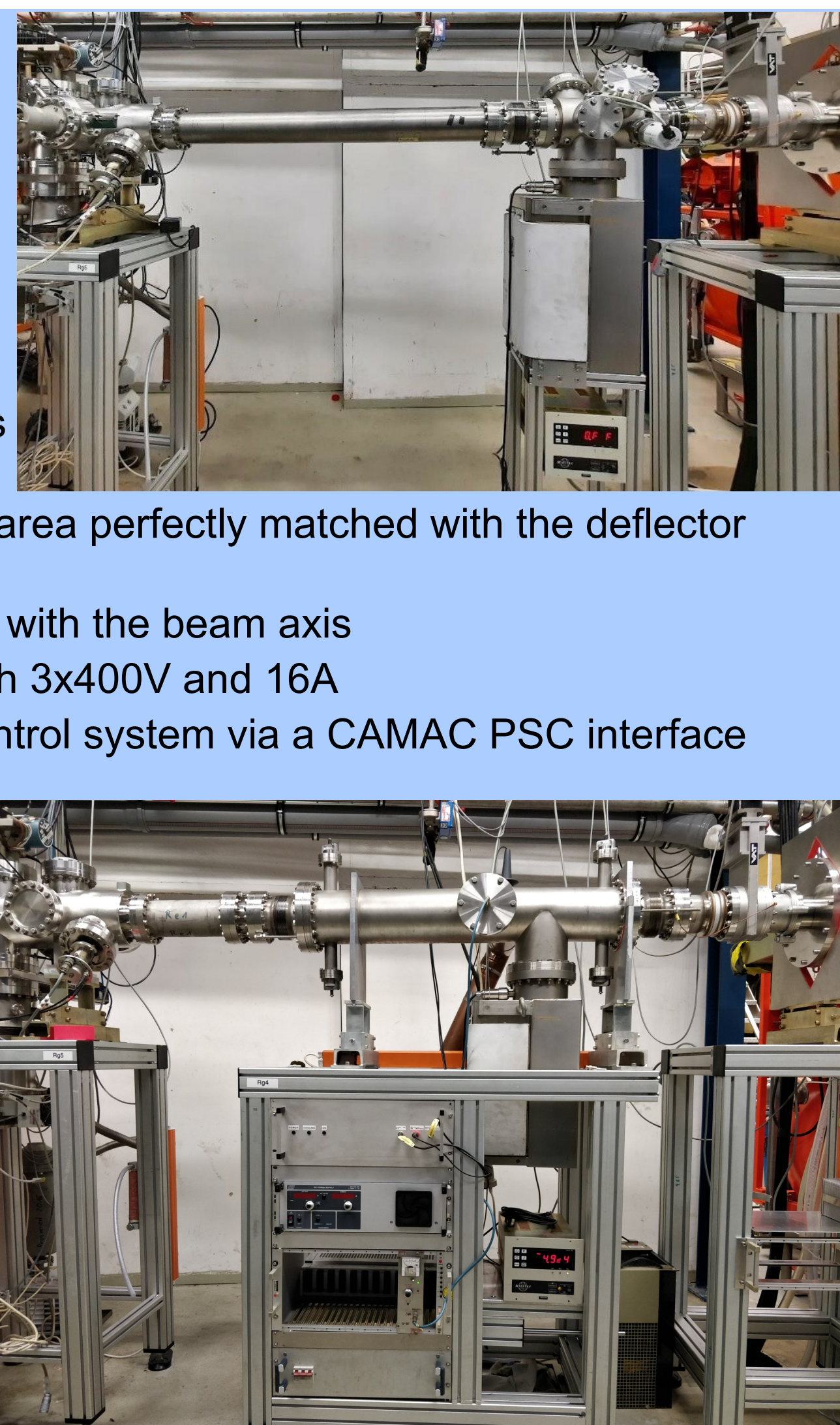


### Two years of Operation

- For the 3.6MeV proton beam from the Tandetron an amplitude between 0.7k-1kV is needed to deflect the beam
- Operation up to 2.4MHz repetition frequency is possible
- The minimum pulse width is 70ns with Rise and fall time down of 18ns



500ns Pulse
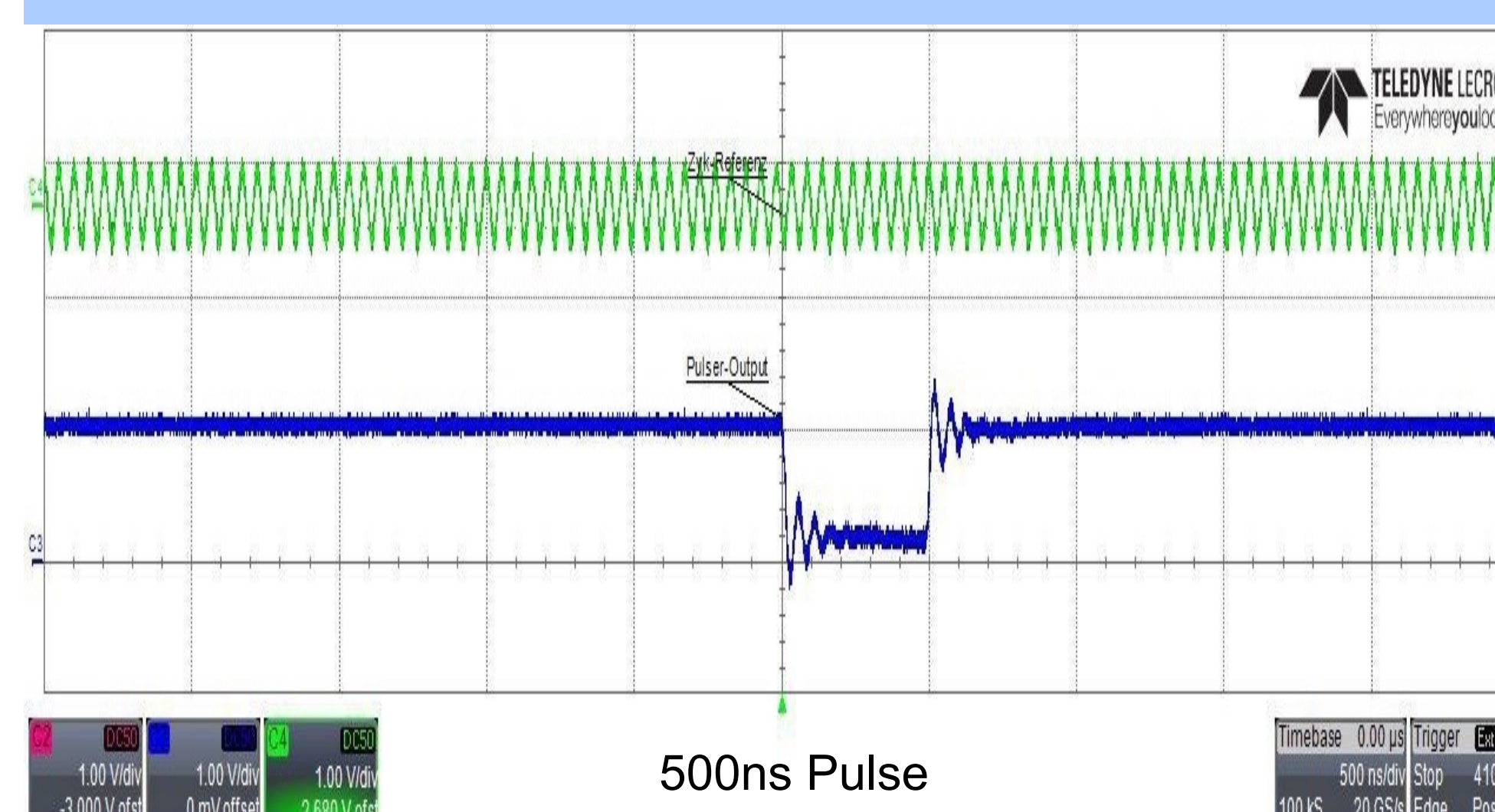
- For the flash experiments only pulse widths between 1-100ms are needed
- The new beam chopper is more reliable and faster than the previous mechanical beam stop
- Only minor problems with coolant leaks and TVS diodes were encountered.

### Conclusion

- The available area behind the Tandetron was large enough for the mechanical setup.
- The flat beam profile at this point allows a small plate spacing of only 20mm and thus a deflection amplitude of less than 1kV
- The achievable pulse frequencies and pulse widths are far better than needed for flash irradiations
- For experiments, pulses synchronized to the cyclotron frequency with repetition rates up to 2.4 MHz and pulse widths down to 70 ns can be obtained with both the bunched CN beam and the DC beam from the Tandetron.

### Outlook

- Automatic grounding of the plates when the Chopper is not in use
- Better monitoring of the coolant level
- Timely procurement of spare parts due to supply difficulties by Covid 19