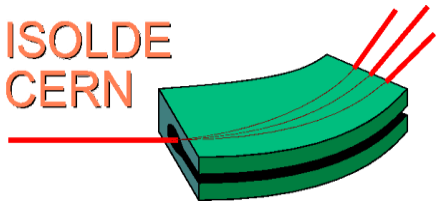


ISOLDE – Workshop 2016

Technical Session

"A fast recovery 60kV charging device for the ISOLDE target extraction voltage"

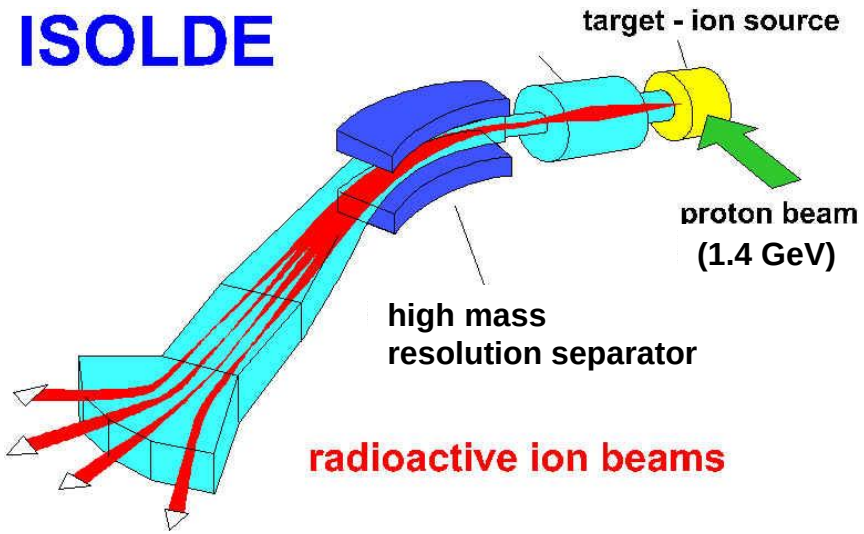
Contribution: by T. Fowler, J. Schipper, R. Barlow TE-ABT-EC

prepared by T. Gharsa (December 2016)

OUTLINE

- ISOLDE target high voltage
- Present modulator system
- Reasons for modulator upgrade
- New modulator system specification
- New fast recovery device design
- Prototype and test facility in B867
- Test in operation @ ISOLDE
- ISOLDE HT proposal upgrade
- HT consolidation status & budget
- Conclusions

ISOLDE TARGET HIGH VOLTAGE



ISOLDE FACILTY

The On-Line Isotope Mass Separator uses the 1.4GeV proton beam from the PS-booster at CERN to hit a target and produce a wide range of radioactive isotopes

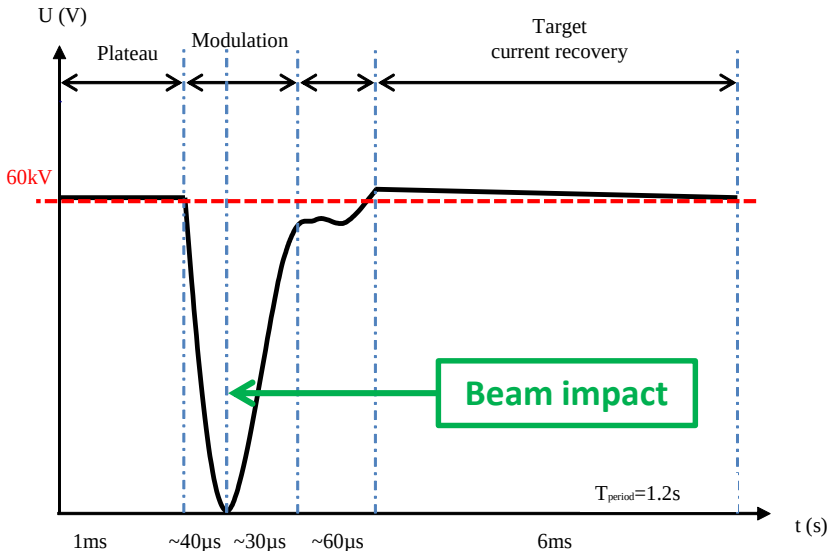
TARGET HIGH VOLTAGE

A high precision high voltage power supply provides up to 60kV for the target and should be held at a precise voltage with respect to a grounded electrode to allow extraction of radioactive ions at a well-defined energy before transport to the experimental area

- Ionisation around the target during and immediately after beam impact produces resistive loading on the power supply which reduces the target voltage level

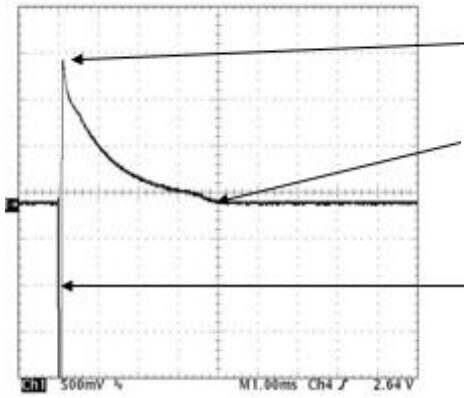
- To ensure extraction of short life-time isotopes this voltage is required to recover to its stable value to 10^{-5} within a few ms -> Very difficult. Not possible with simple D.C power supply

PRESENT MODULATOR SYSTEM



Present modulator characteristics

- A modulation system is used in which the charge on the effective target capacitance is resonantly transferred to a buffer capacitor during the heaviest ionisation period
- Modulation minimizes the target shunt loading when proton beam travels through air
- After the modulation, the power supply has to provide current for a further ~8ms to bring the target voltage back to the required ± 0.6 V tolerance



Overshoot ~1.5kV

Recovery time depends on target leakage

Modulation to 0V during beam impact

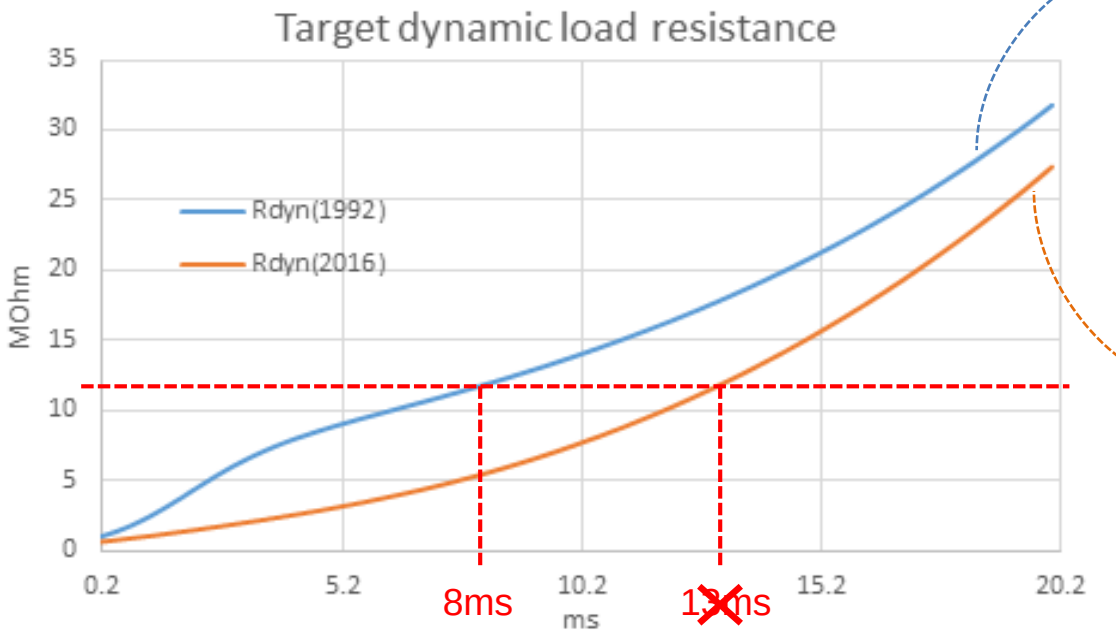
Modulator limitations

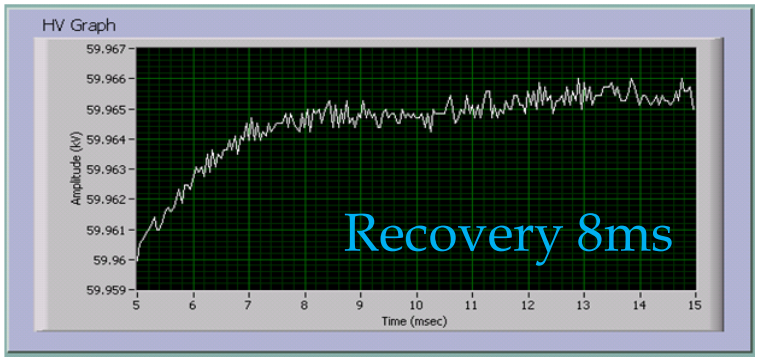
- The performance of the modulator in terms of stability and recovery time is to a large extend determined by the dynamic load in the few ms after beam impact
- By design target voltage remains in specification for up to ~5 mA change of target leakage
- The large overshoot of 1.5kV increases the risk of voltage breakdown at the ISOLDE front end (HT > 61.5kV)

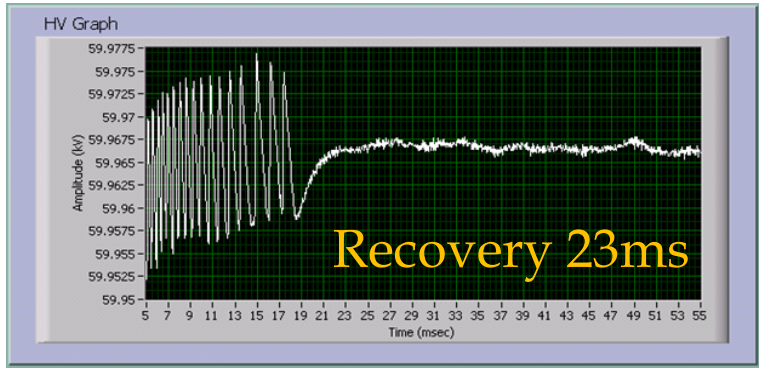
REASONS FOR MODULATOR UPGRADE

Recovery time on 2 different loads

~5 mA limit of target leakage







- Increasing ionisation in the first few milliseconds after beam impact due to new target configuration (converter) has stretched the limit of the voltage recovery time (>10ms).
- HIE-ISOLDE beam upgrade (post LS2) will also produce an increase of power on the target of a factor of 4, aggravating the recovery process even further.
- The original modulator components and ASTEC power supplies are more difficult to maintain and repair, and these are no longer manufactured.

NEW MODULATOR SYSTEM SPECIFICATION

New modulator specifications

- ❑ More robust device to sustain the increase of target leakage that is expected at (possible) higher energy (2GeV) and higher intensity beams for HIE-ISOLDE
- ❑ Faster recovery time to give improved possibilities for the detection of exotic isotopes with extremely short half-lives

HT pulsing

- ❑ Recovery time of < 2ms to within +/-1V (< 5ms with neutron converter target)
- ❑ Maximum voltage overshoot < 0.3% (~200 V)

HT source

- ❑ HT set-point from 10kV to 60 kV with 1V step resolution
- ❑ HT long term stability +/- 1V (external precision voltage divider (ROSS) with thermal stabilization)
- ❑ HT warm up delay < 5 min
- ❑ Due to non neglible long-term drift and aging effects, HT voltage dividers have to be recalibrated regularly

ROSS HT divider

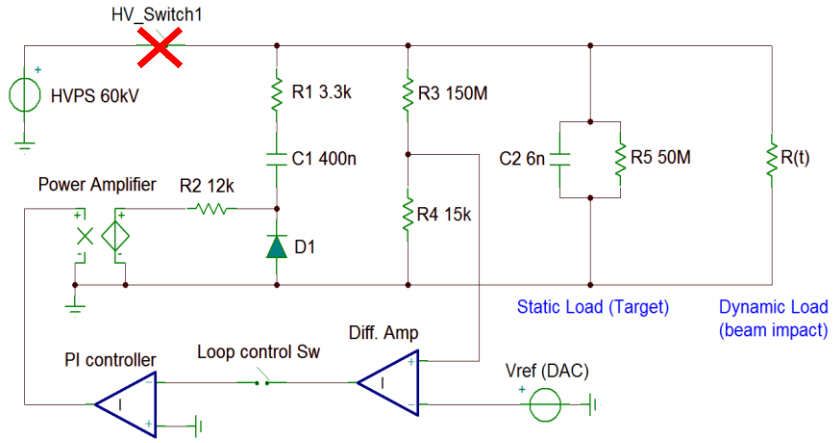
Monitored signals (required by operators)

- ❑ HT recovery time signal acquired and monitored
- ❑ HT long term stability acquired and monitored
- ❑ Post-impact target leakage current acquired and monitored (may be used as in-beam detection signal)

NEW FAST RECOVERY DEVICE DEVELOPMENT

New topology

- ❑ Differs significantly from previous modulator in that the target capacitance is not discharged prior to beam impact
- ❑ The target capacitor voltage is then allowed to decay due to beam impact and subsequent ionization losses
- ❑ The 60 kV is re-established on the target capacitor by a combination of recharge from a buffer capacitor and by charge injection from a fast linear power amplifier

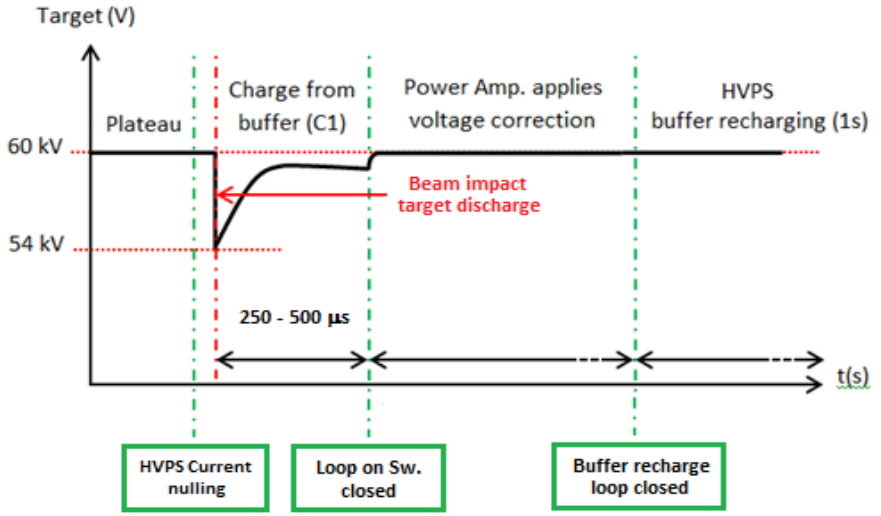


Initial circuit design modified

- ❑ Suppression of the BEHLKE HT switch due to excess of noise (voltage spikes induced by the internal gate refresh control)

Control upgraded to improve stability

- ❑ Control of the HV power supply in current mode to recharge the buffer capacitor while the power amplifier regulates the target voltage



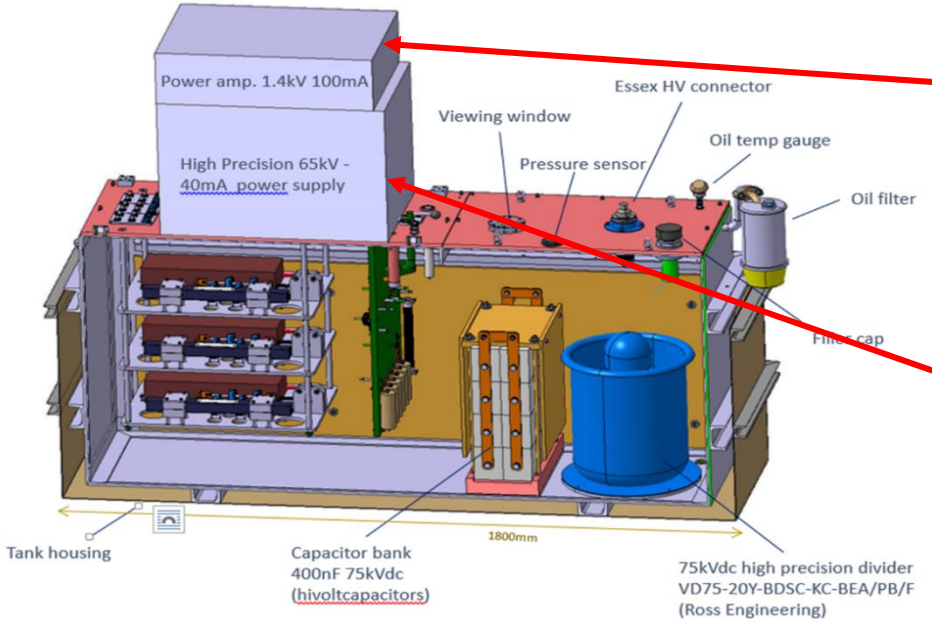
PROTOTYPE AND TEST FACILITY IN B867

Prototype for test and development

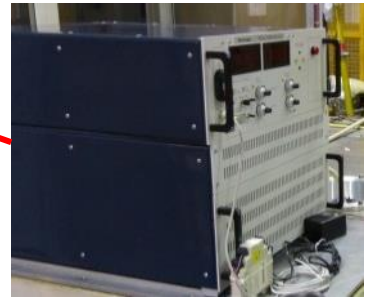
- ❑ Prototype is integrated in a dedicated HV tank in B867
- ❑ Contains the capacitor bank, HV precision divider, static and dynamic load
- ❑ Tests done up to 60 kV in a simulated operational environment
- ❑ Recovery time in accordance with the simulation

HT low level control implemented

- ❑ RT program running on the CPU in a PXIe controller
- ❑ FPGA program connected to the hardware
- ❑ Specialist tools for debugging and maintenance



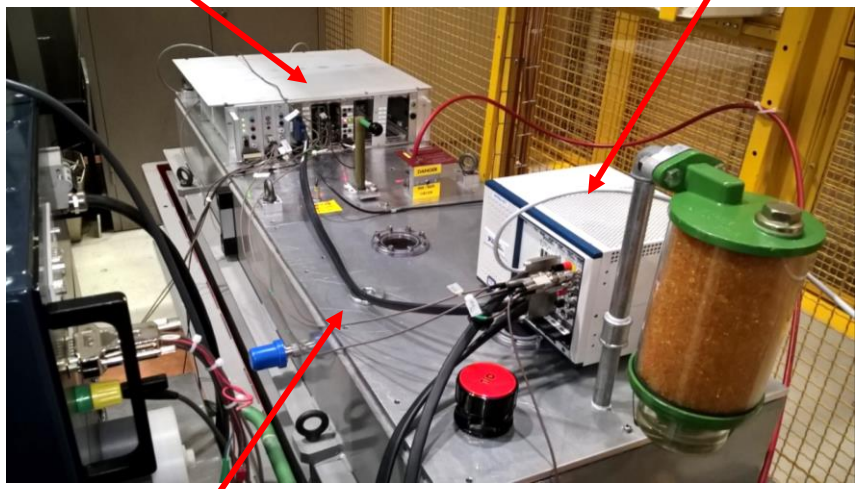
HV power amplifier



60 kV precision PSU

Analog linear controller

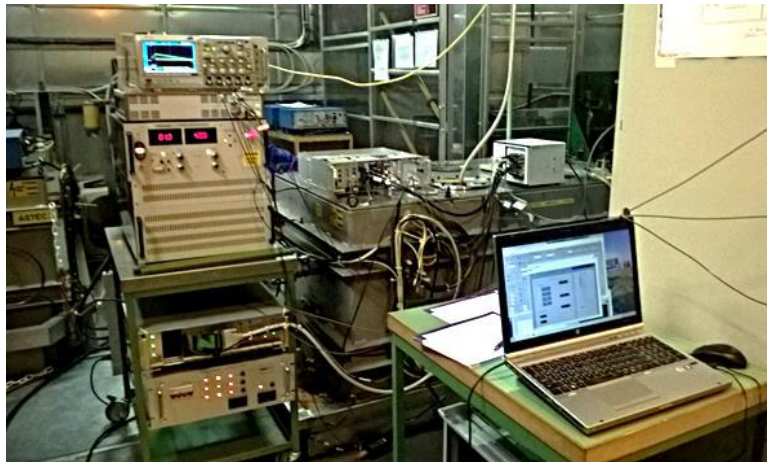
PXI controller



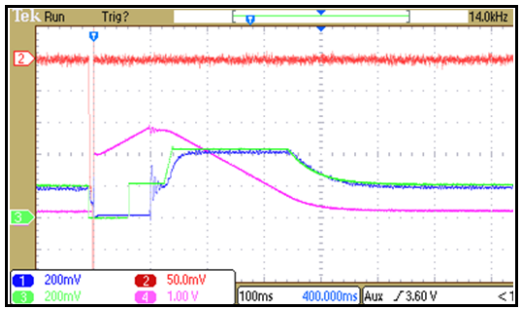
HV tank

TEST IN OPERATION @ ISOLDE

The prototype was installed at the ISOLDE facility during a dedicated MD (2016)



The fast recovery process performed as expected with presence of the proton beam at high pulse intensity and with the neutron converter type target:



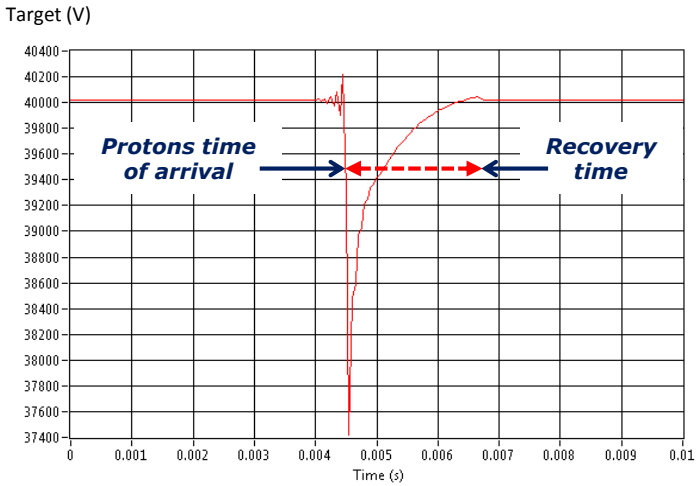
Control loop main parameters during the recovery process

Functionality demonstrated through testing over a limited range of operation due to the replacement of a broken amplifier by a spare unit with only half of the needed output voltage

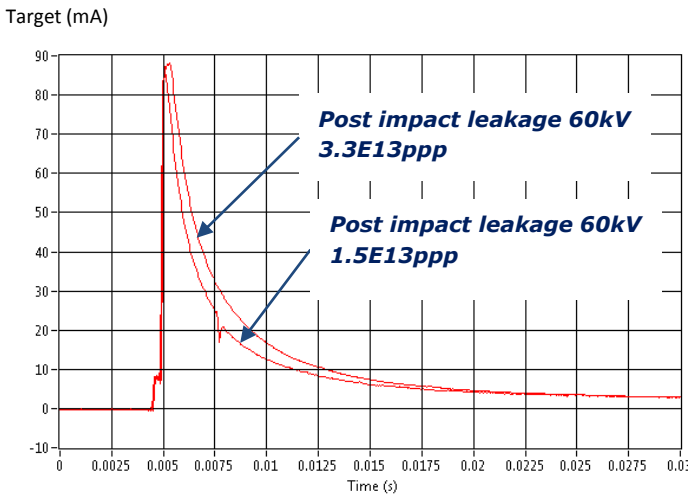
	High voltage recovery time		
Beam intensity	30 kV	40 kV	50 kV
1.5E13 ppp	1.2 ms	1.6 ms	2 ms
3.1E13 ppp	1.6 ms	2.5 ms	n.a.

Results from testing in operational environment

- The new system can provide a recovery time in the order of **2ms**, which makes a significant **improvement** by reducing the recovery time by a **factor of 5** over the actual modulator system.
- Monitored current signal that is related to post-impact target leakage, may be used by operators as a in-beam method to check alignment of beam on target



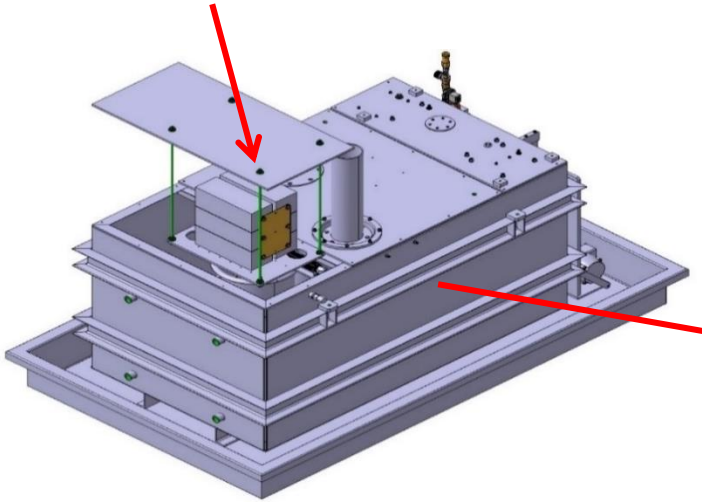
HV recovery signal (V) : 3.3E13ppp at 1.4Gev – HV = 40kV

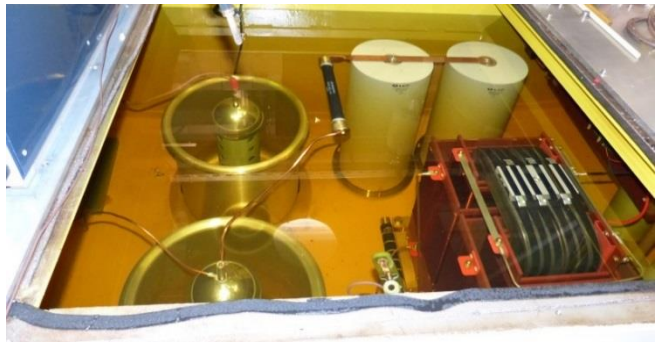


Target leakage current (mA) : 3.3E13ppp at 1.4Gev

ISOLDE HT PROPOSAL UPGRADE

New device sits
in existing housing

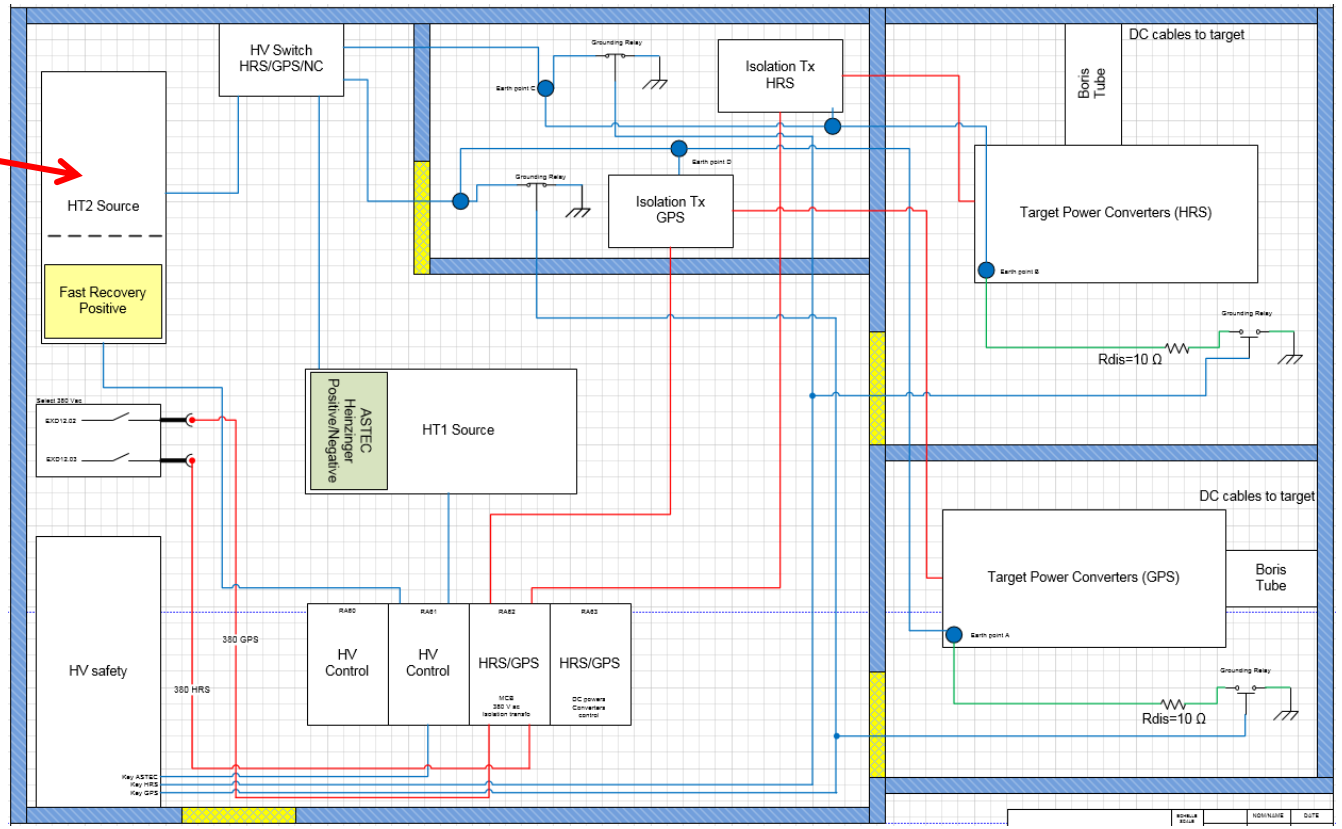




Re-use of the ROSS dividers

- Install the fast recovery system only on HT2 during YETS 2017/2018
- Easy reversal to present configuration system in case of major problems
- As a negative solution is not yet available, better to keep HT1 unchanged
- Full consolidation of both modulator during LS2 with positive and negative HT

ISOLDE HT room - Building 170



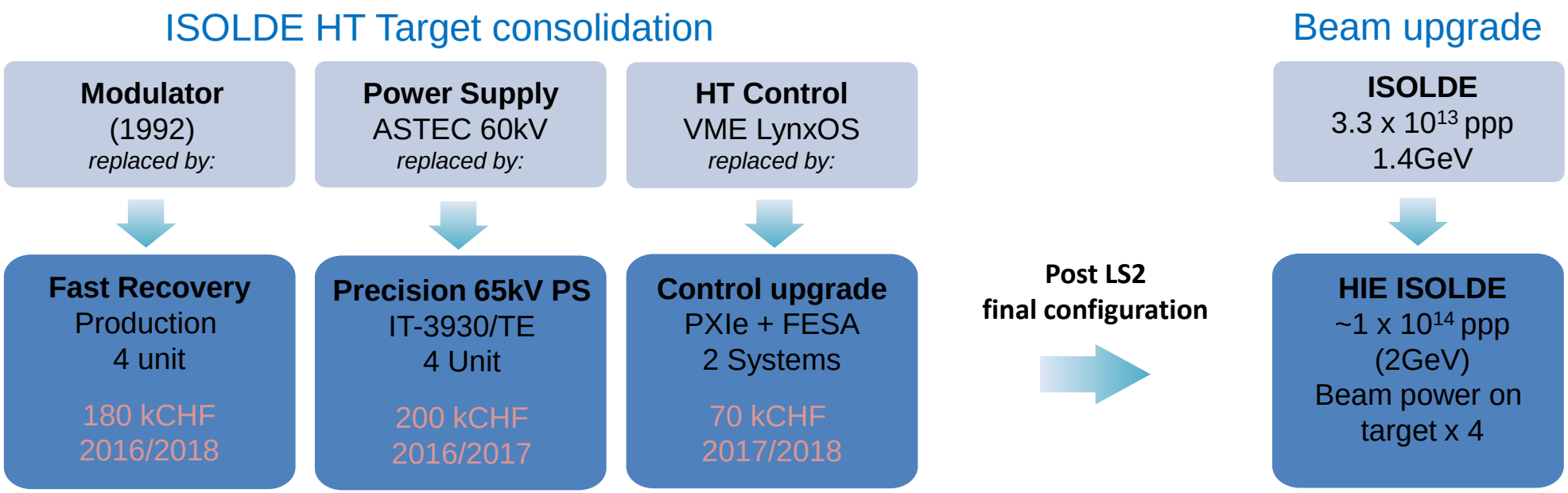
HT CONSOLIDATION STATUS & BUDGET

Upgrade ISOLDE 60 kV Target modulators (TE-ABT consolidation work unit, BC 99306)

- Production of 4 **fast recovery systems** with positive and negative configuration, timescale 2016-2018
- ISOLDE HRS and GPS **HT control upgrade**, including 2 PXI controllers for the HT low-level control
- Budget *allocated* 200 kCHF – Budget *needed* 250 kCHF – Budget *missing* ~50 kCHF

Upgrade ISOLDE Target D.C Power Supply (TE-ABT consolidation work unit, BC 99224)

- 4 new 65kV **high precision power supplies**, IT-3930/TE started, first unit expected in ~June 2017
- Budget 200 kCHF



CONCLUSIONS

- The consistent performance of the fast recovery system has been investigated over a wide range of operational conditions, with the worst case scenario concerning the target leakage with the neutron converter target
- By adding a second power amplifier in parallel, the output current will be doubled, and will allow similar performance at 60kV
- The new system can provide a recovery time in the order of 2ms along with in-beam detection methods that will greatly contribute to the measurements of exotic short-lived isotopes
- HT control and monitoring instrumentation will be upgraded for ease of operation of the system from the user standpoint
- Maintainability and repair will be simpler with the new HT systems
- The changing of the polarity of the system will take less time, reducing the impact on the physics schedule
- Adaptable to further (future) target loading simply by increasing amplifier output current