Advances in Ion Beam Manipulation at ISOLDE

Beam Switching and Beam Gating

Line Le

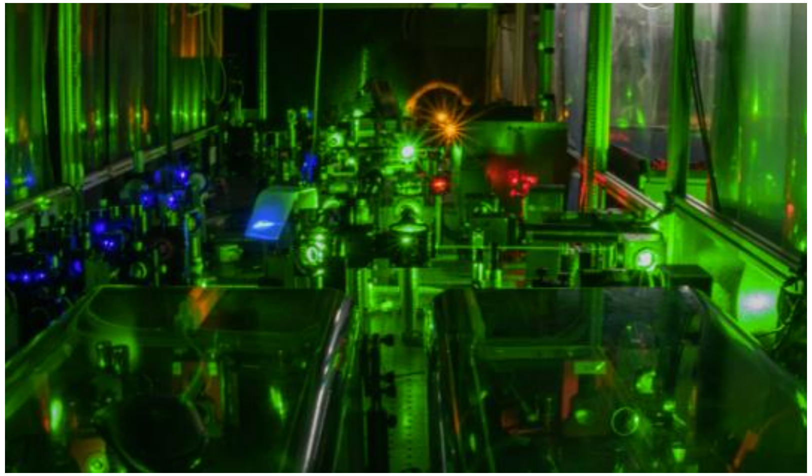
Ion Beam Manipulation

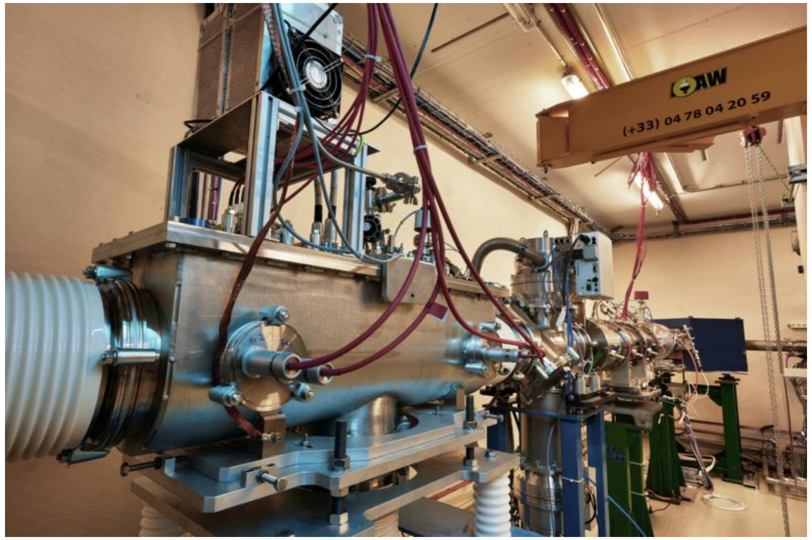
Ion Beam Manipulation

- Lasers & Photocathode section

  → now incl. ion-beam manipulation

- Radioactive ion beam purification
  - Molecular-beam extraction
  - Laser ionization & background suppression
  - Specialized systems
    - Fast beam gates, ion traps (RFQ, MR-ToF), advanced ion source

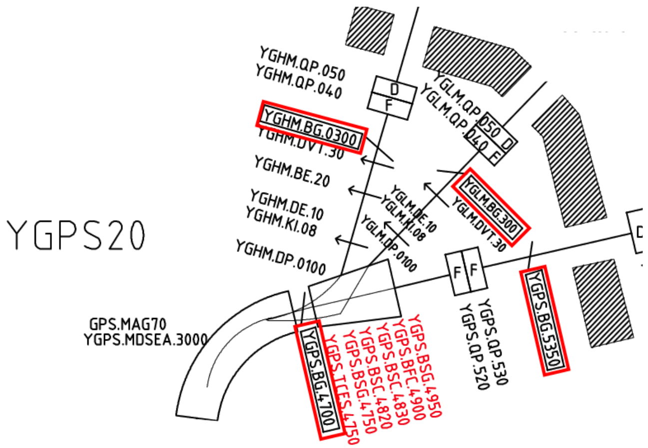


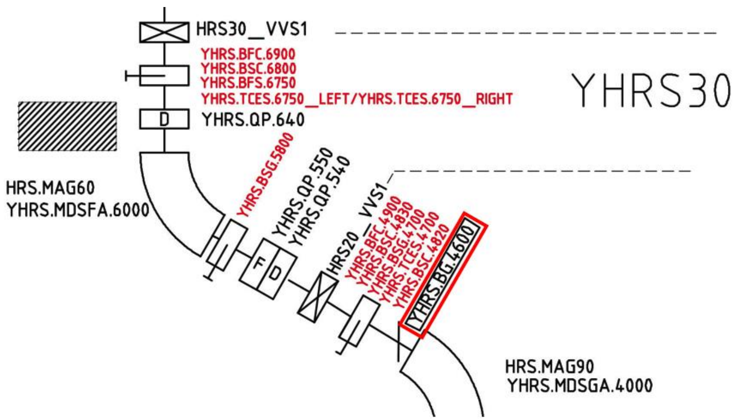


Beam Gating System

Introduction and Context

- Electrostatic plates controlling the passing of secondary RIBs
- 5 beam gates: 4 on GPS, 1 on HRS
- Prototype developed for HRS from January 2024
- Upgrades to control system and hardware



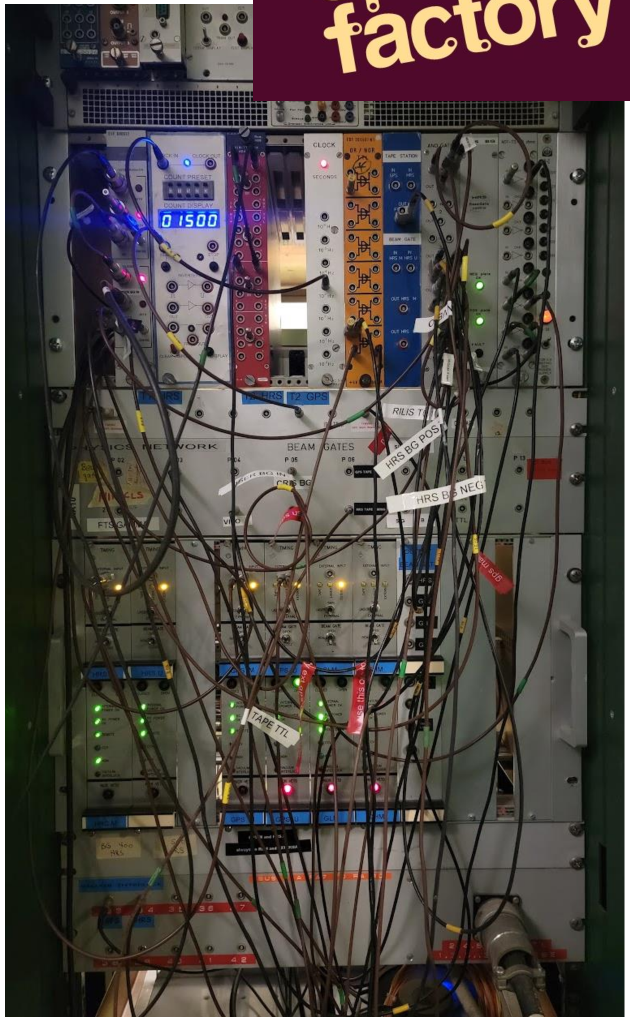


Introduction & Context

the old spaghetti factory

- ISOLDE's beam gates faced significant issues since 2021

- A new system was developed with an interim solution
  - **Aim:** To understand the workings of the old system while slowly introducing a new one
  - Ensure minimal disruption to ongoing experiments



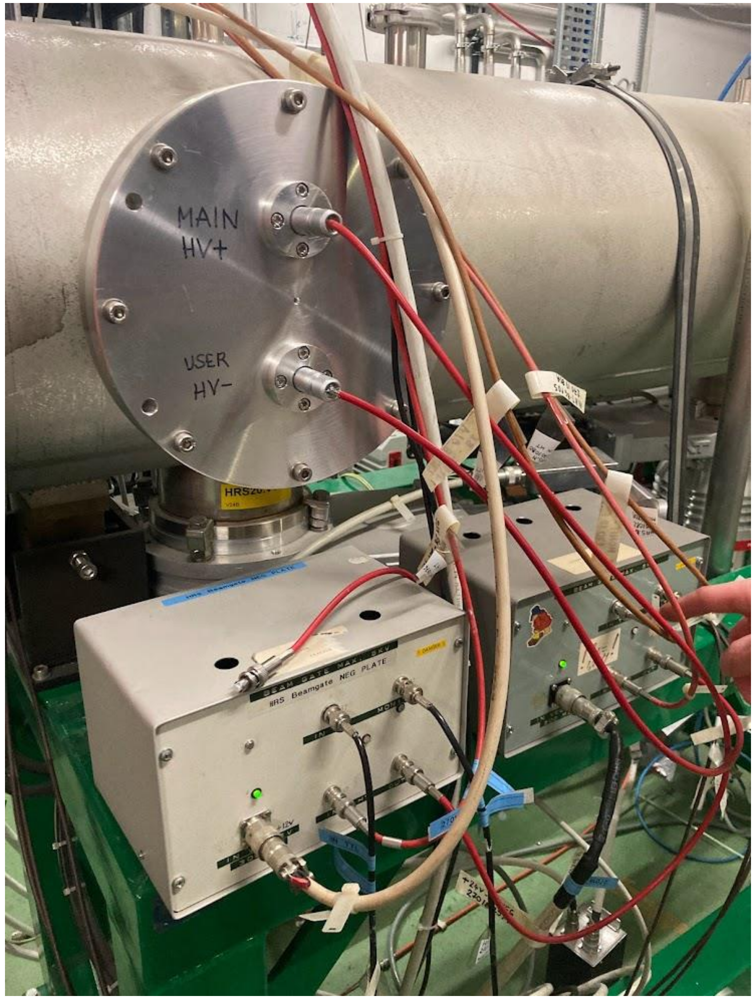
Reasons for Change

Problems

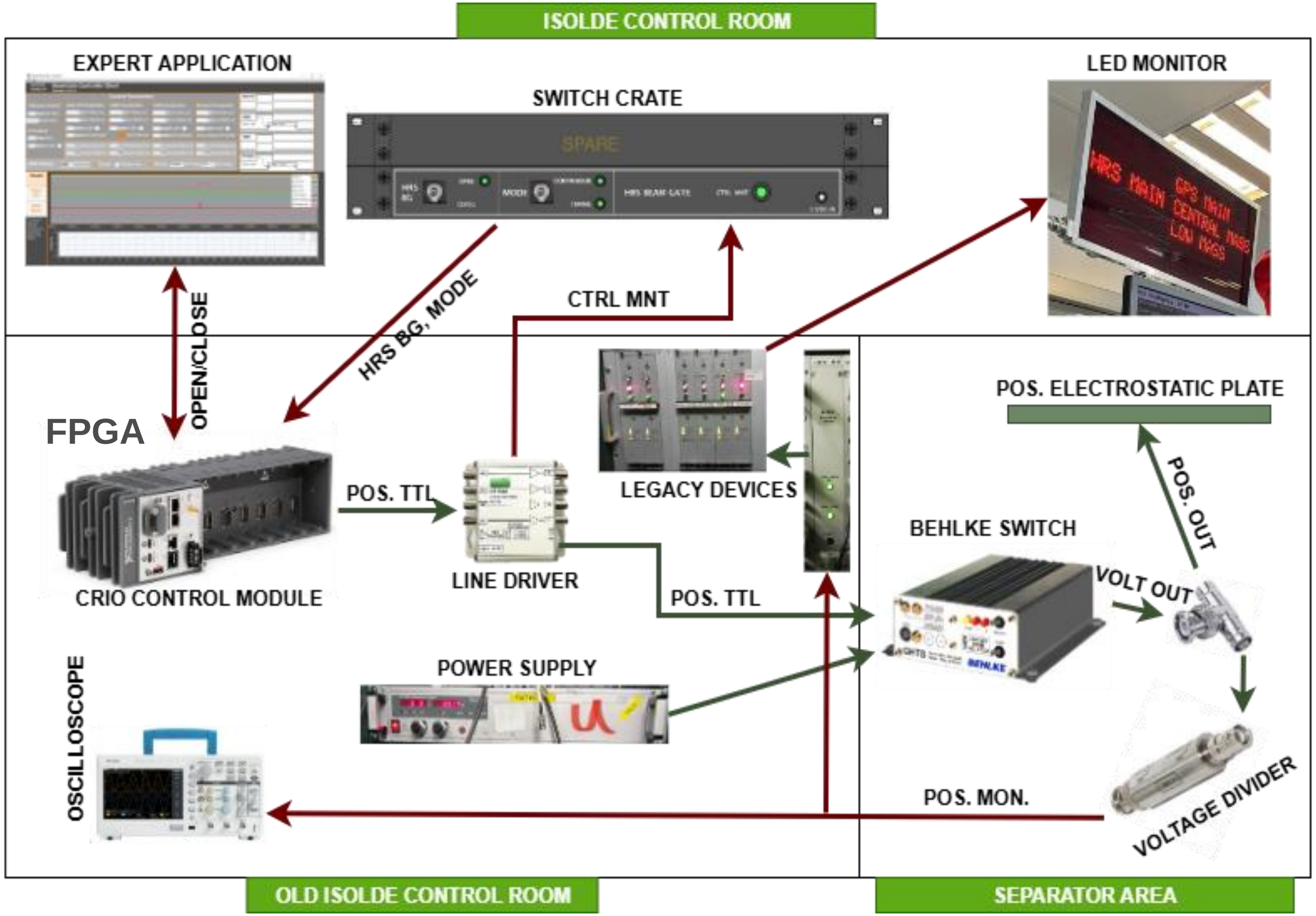
- Difficult to maintain
- Frequent failures during running periods
- Old hardware

New requirements

- High-frequency beam gates (10kHz) for laser-ion time-of-flight gating
- Microsecond beam gating
- Remote control and logging



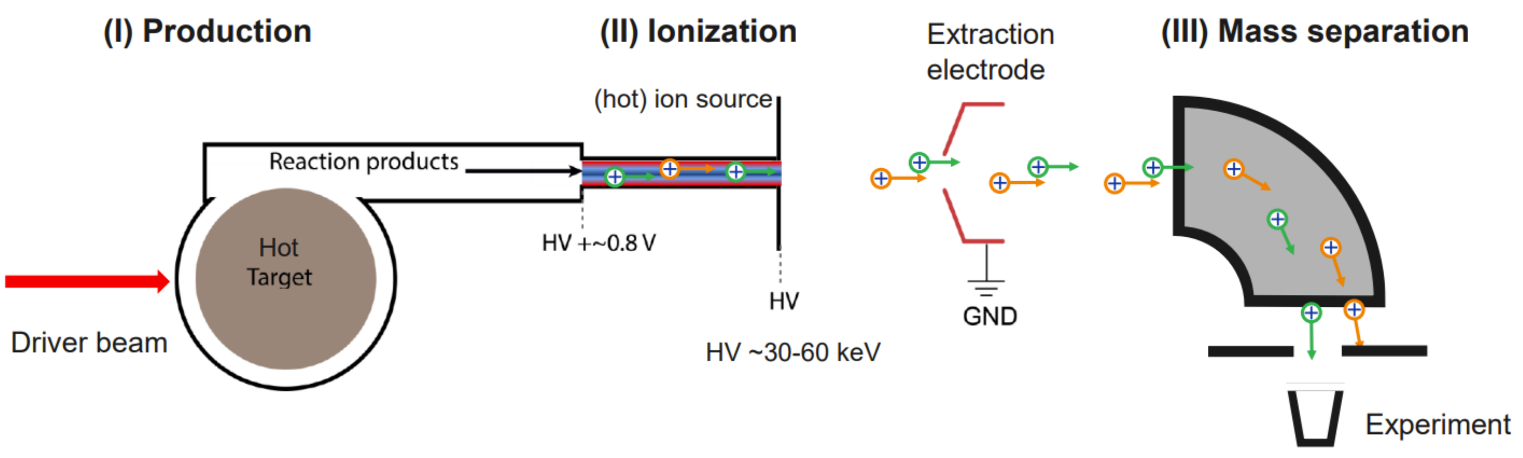
System Topology

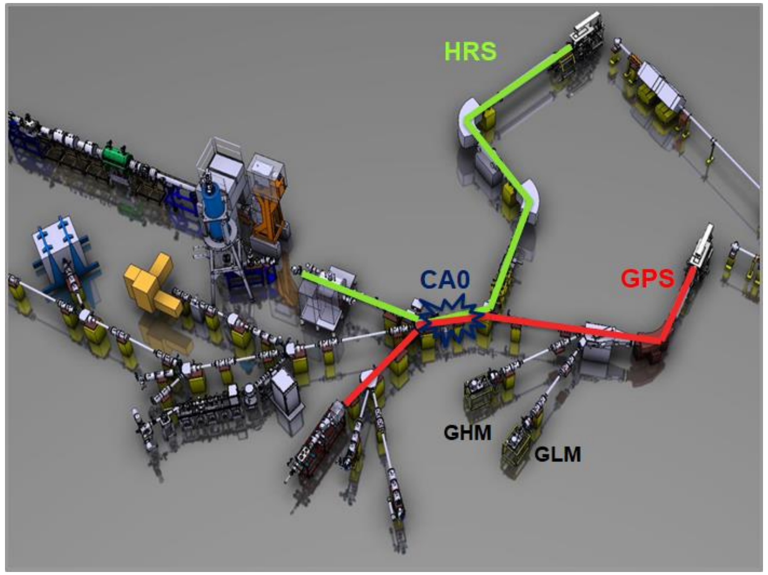


Neg. electrostatic plate controlled in parallel!

Beam Switching System

Introduction & Context

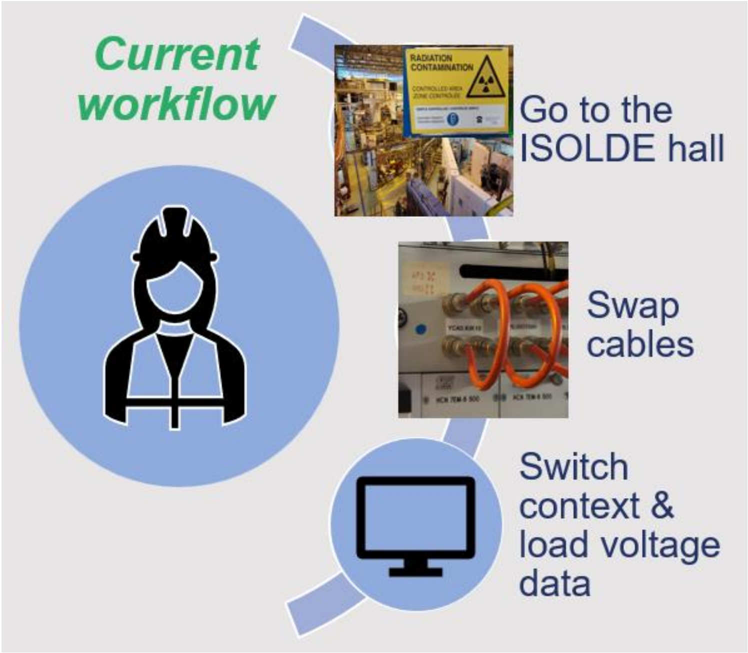




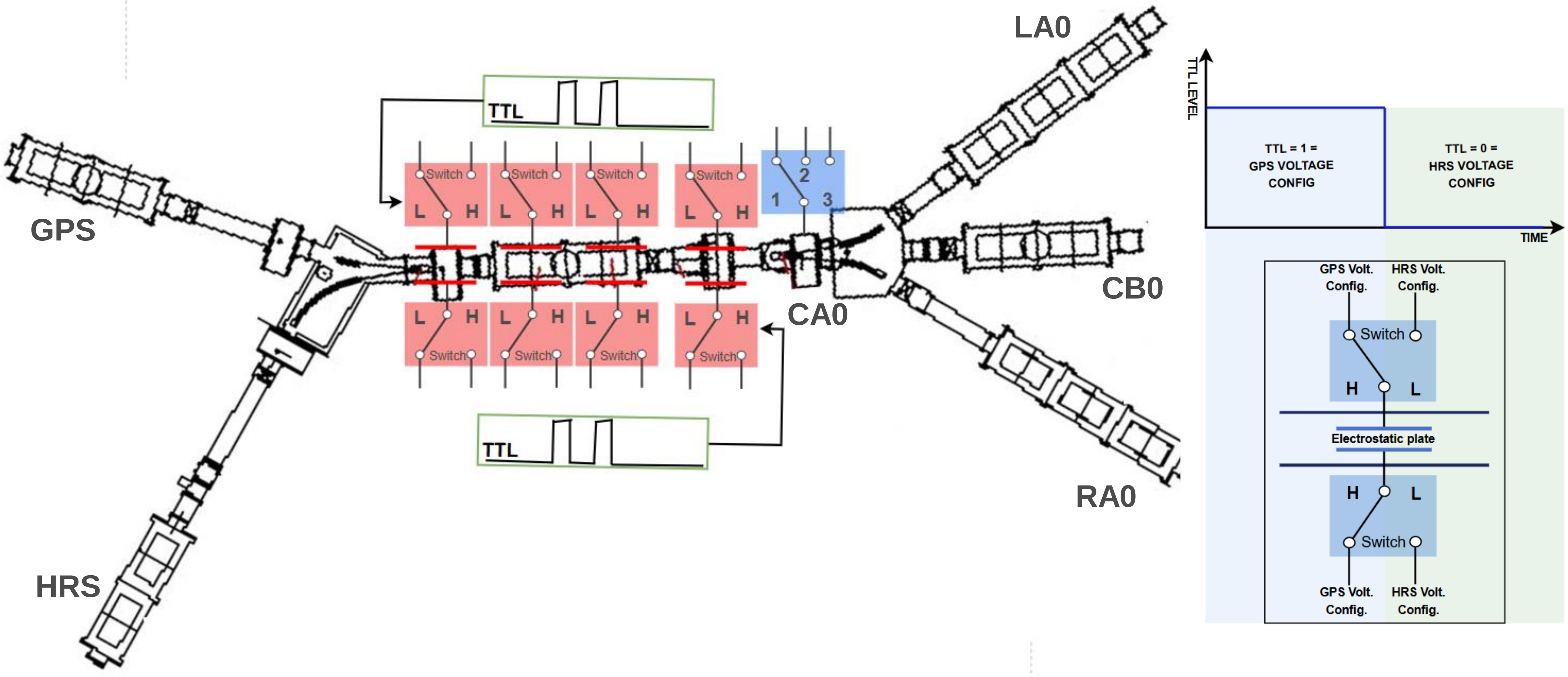
- The isotope-separation on-line (ISOL) method
  - Proton beams from PS Booster hits front-ends
  - Radioactive ion beams (RIB) produced and separated at HRS or GPS
  - RIBs travel through shared CA0 beamline before reaching experiments

Introduction & Context

- **Current limitation:**
  - Both GPS & HRS beams delivered via **single central beamline (CA0)**
    - If CA0 occupied by HRS → GPS limited to upstream lines (GHM, GLM)
    - If CA0 occupied by GPS → HRS cannot run at all
  - Beam switching between target stations is done manually
- **Parallel operation proposal:**
  - First suggested in 2006 (ref. link)
  - **Pulse-to-pulse switching** between GPS and HRS
  - Beam sharing – gain of 1 day per week of operation

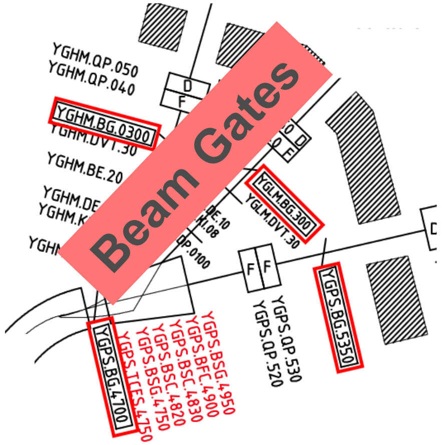


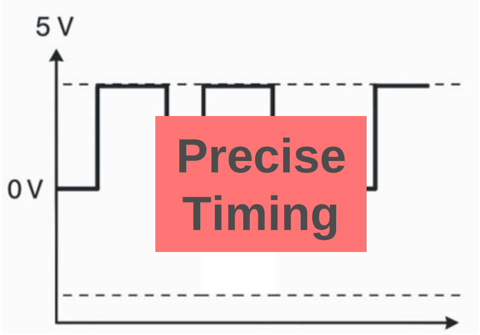
Switching Implementation



Suggested Solution

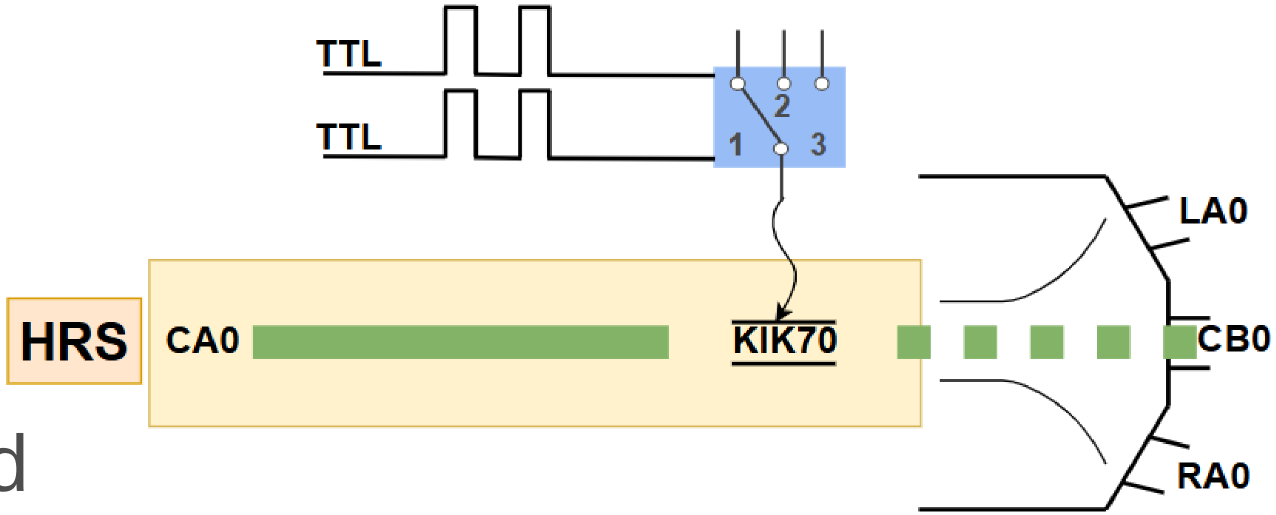
- Alternating mode: no structural changes
  - New control system & additional hardware
- Switch HRS and GPS FEs every basic period (1.2 s)
  - Minimal beam interruption: <10 ms per switch (beam downtime <1%/cycle)
- Out-of-scope: **Alternating operation downstream** for more parallel experiments



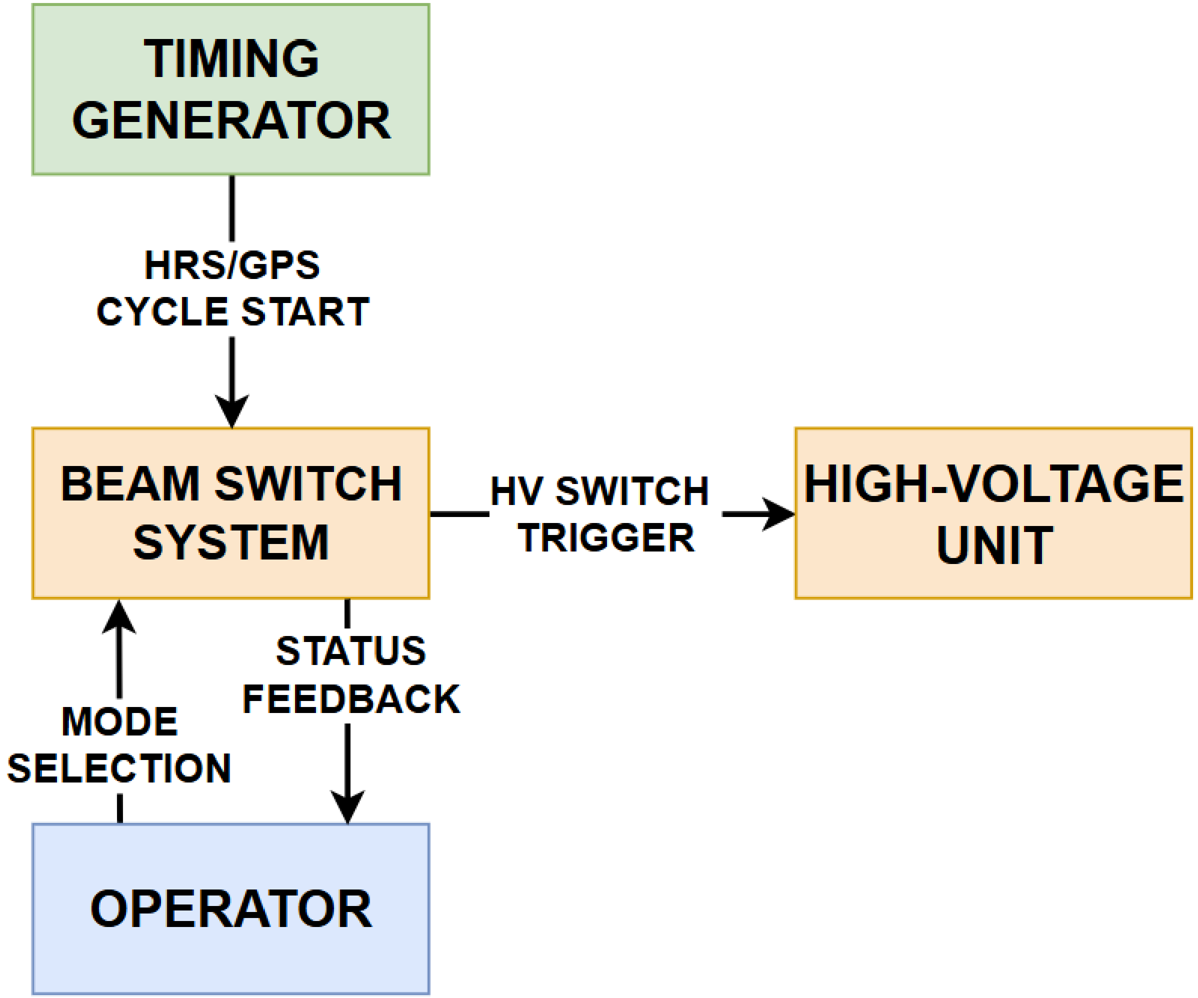


Sharing Mode with KIK70

- Last element in CA0: KI70
- Directs beam to CB0, LA0, or RA0
- Functionality:
  - Default: beam continues straight
  - Apply voltage → electrostatic field → deflects beam left/right
- Pulsed operation allows rapid alternation/beam sharing between experiments

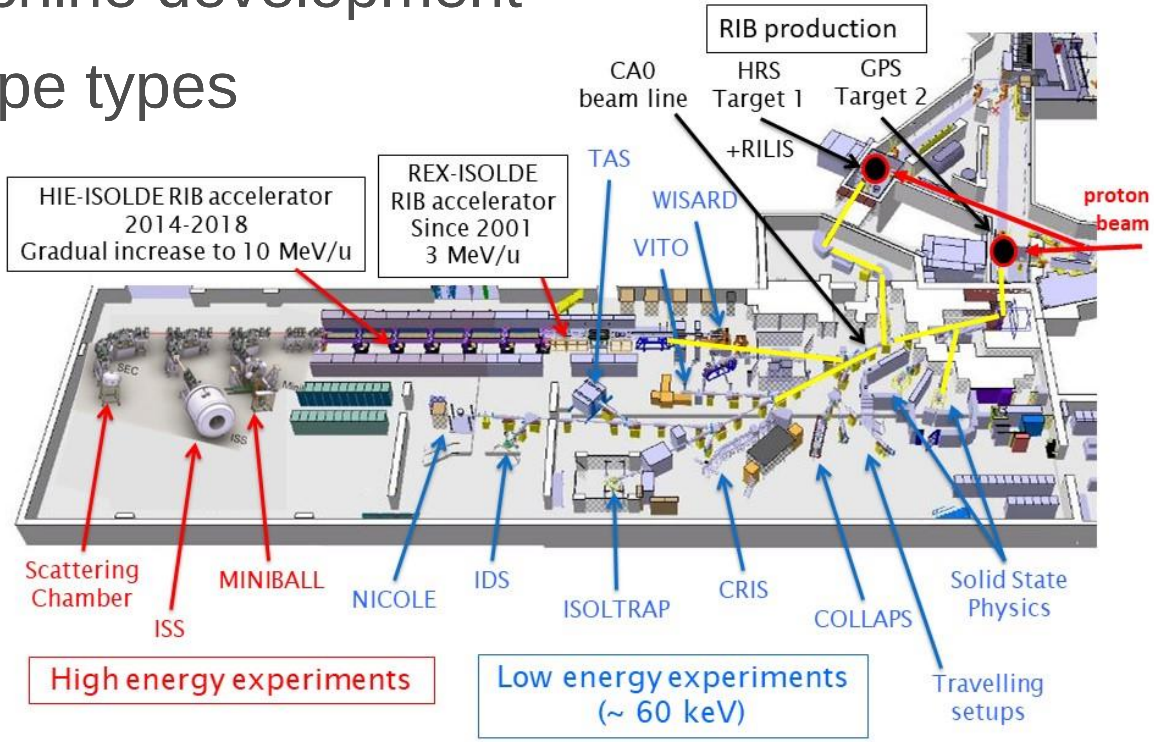


System Topology

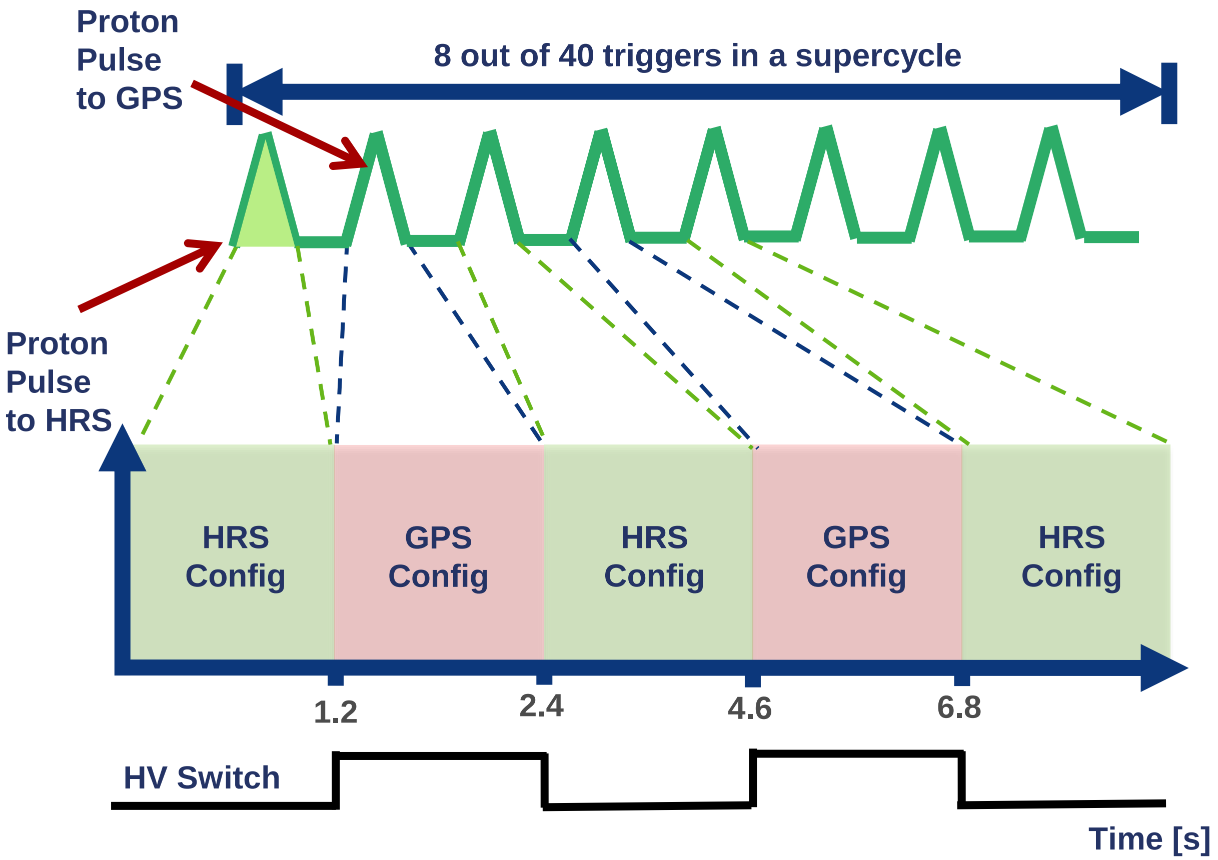


Applications

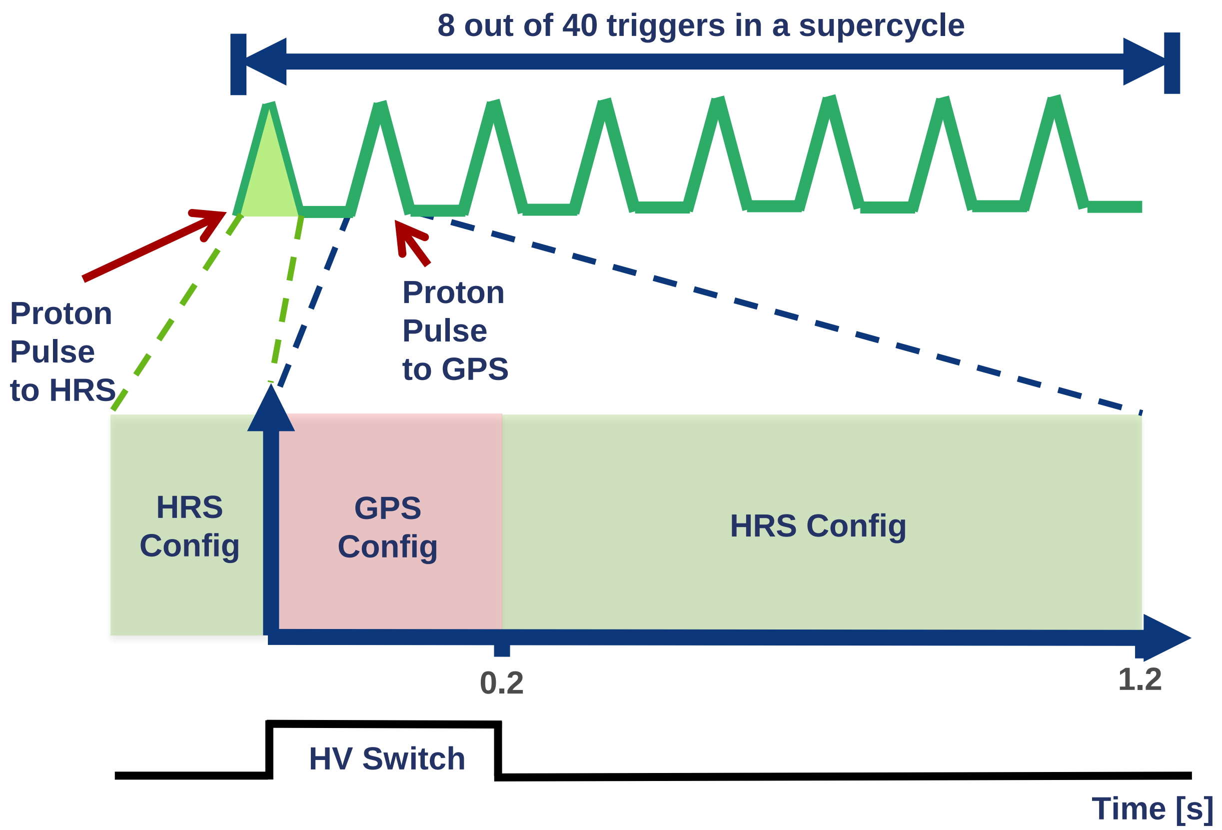
- Fast switching between CA0 source and destination
- Beam delivery to tapestation from either FE during experiment
- Opportunity for low-priority tests and machine development
- Simultaneous operation of different isotope types
  - Stable beam during other operations
  - Fast/fast pulses
    - E.g. 500ms/500ms pulses
  - Fast and slow released species
    - DC beam interrupted by slow released species



Beam Sharing Basic Scenario



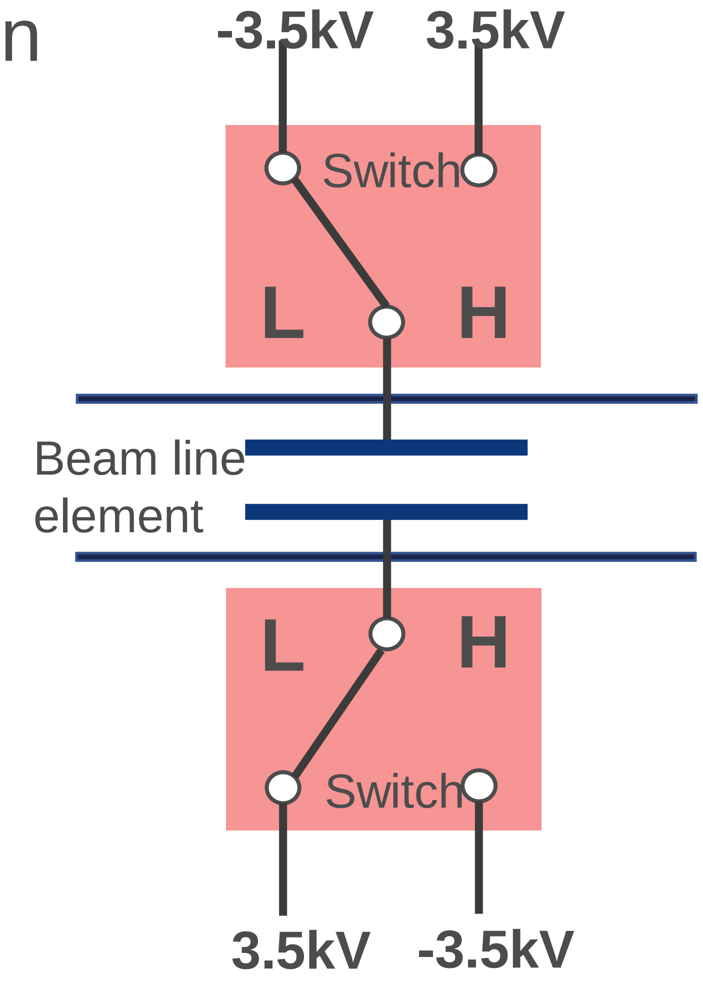
Beam Sharing – Stable Beam Scenario



Beam Switching Project Status

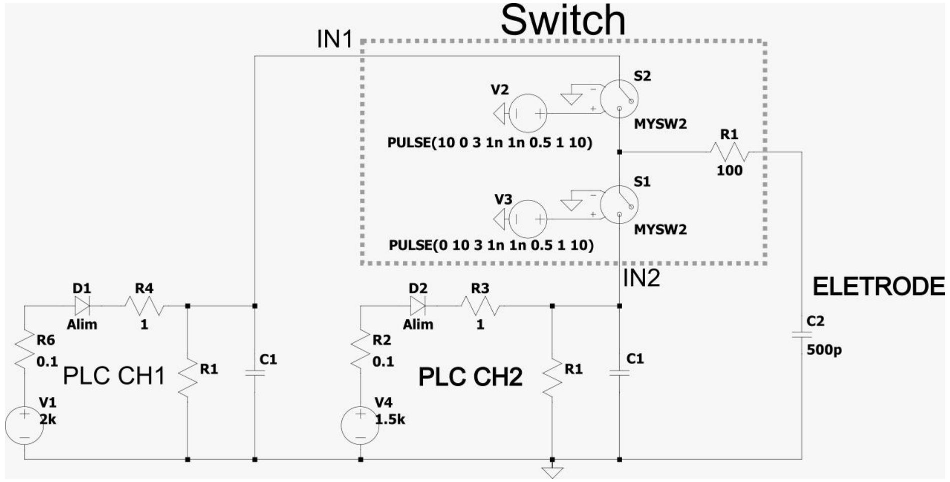
- Initial work funded by the ISOLDE Collaboration
- Functional Specifications
  - Will be shared soon with the user community
- Done a “market survey”
- Identified suitable hardware
- Tested and validated prototype switches

- New funding line in ISOLDE Improvement Program (IIP)

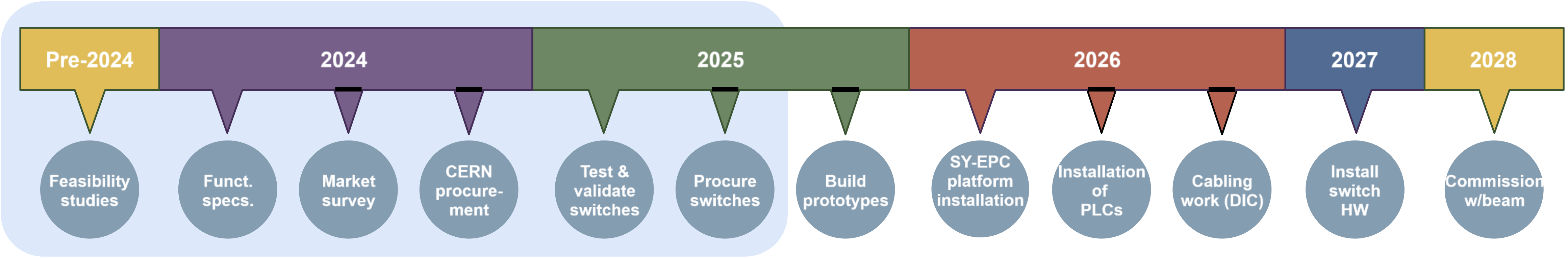


Solid-State Switches

- Decision for solid-state switches after feasibility studies
  - Relay vs. Solid-state switches
- Offline testing (YOL2)
  - 2-state and 3-state switch + auxiliary hardware
- Key results:
  - Possible to operate with duty cycles of 0.1%-99.9% for individual frontend
  - A 10–90% rise time of 200 ns



Timeline of Beam Switching Project



Short-term considerations

- Replace the entire beam gate system (GPS and HRS)
- CERN Timing System
  - Similar system as the PS Booster timing
  - BE-CSS (Software)
  - BE-CEM (Timing)
  - BE-OP + SY-STI (Top-level application)

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FUNCTIONAL SPECIFICATION

PROPOSAL FOR A NEW GENERAL TIMING SYSTEM AT ISOLDE

ABSTRACT:

Due to the ever-increasing demands and the interconnectedness of the different machines operating at ISOLDE, a general timing system is proposed for the facility to synchronize the operation for the different sub-systems. First, the different sub-systems of the machine requiring a new timing system or a timing system consolidation are described, followed by a summary of the different triggers that will be needed to operate synchronously. Lastly, an abstract layout for the realization of such timing network is proposed.

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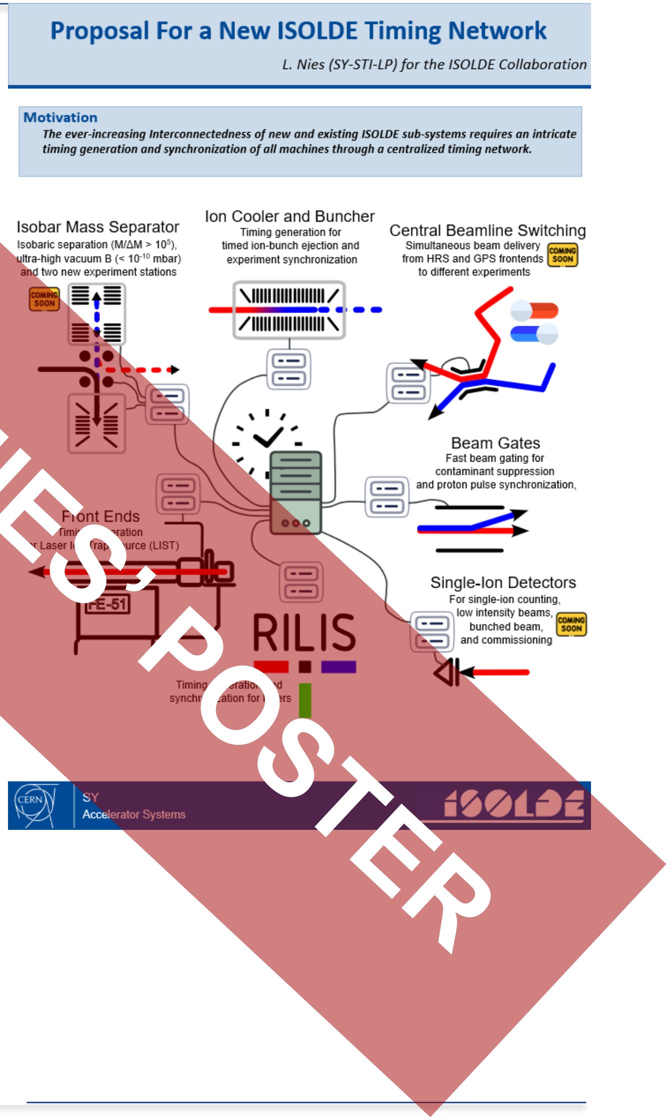

Thanks to…

- Target team
- Laser team
- Operators
  - Erwin!
- CRIS, IDS, ISOLTRAP, ISS for allowing us to test our system and giving us time at the start of their experiments.