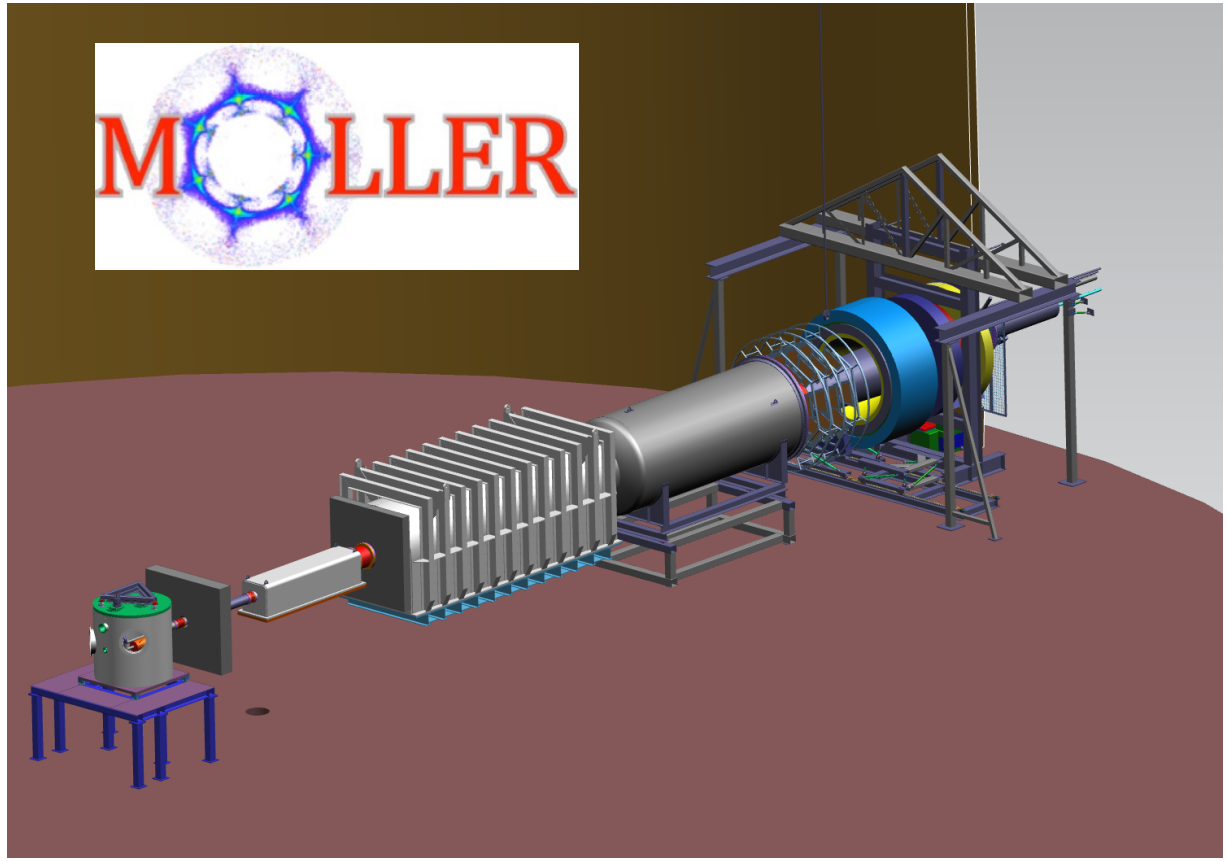
MOLLER Beam Monitoring Update

MOLLER Collaboration Meeting

June 22, 2022



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Outline

- Reminder of MOLLER Incoming Beamline Functional and System Requirements
- MOLLER Incoming Beamline Status
- Phaseout of ”SEE electronics”
- Unser requirements for MOLLER

MOLLER Incoming Beamline: Functional Requirements

From MOLLER Functional Requirements document Rev. 0:

3.6 BEAM DIAGNOSTICS AND MONITORING

The beam intensity and trajectory must be measured continuously with sufficient precision and accuracy to be able to make corrections to the detector response for both random and helicity-correlated jitter at the polarization flip frequency. Specific requirements and specifications include:

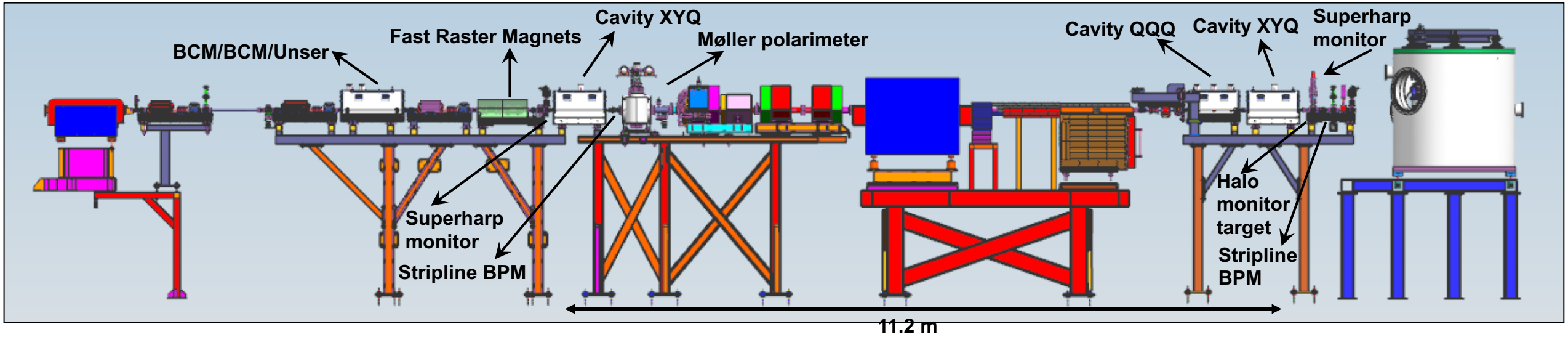
- Capability to measure relative beam intensity and position values for 960 Hz window-pairs (1.92 kHz data-taking rate) to a precision of 10 ppm and 3 μm, respectively, for high current beam.

Need redundant measurements with Beam Charge Monitors (BCM) and Beam Position Monitors (BPM)

- System capable of inducing small changes to the beam trajectory/energy with a specified time dependent pattern (harmonic frequencies ≤ 125 Hz) in order to measure the response of the detector system to beam parameter variations.

Need a beam modulation system with air core corrector coils

MOLLER Incoming Beamline: Final MOLLER Incoming Beamline Design

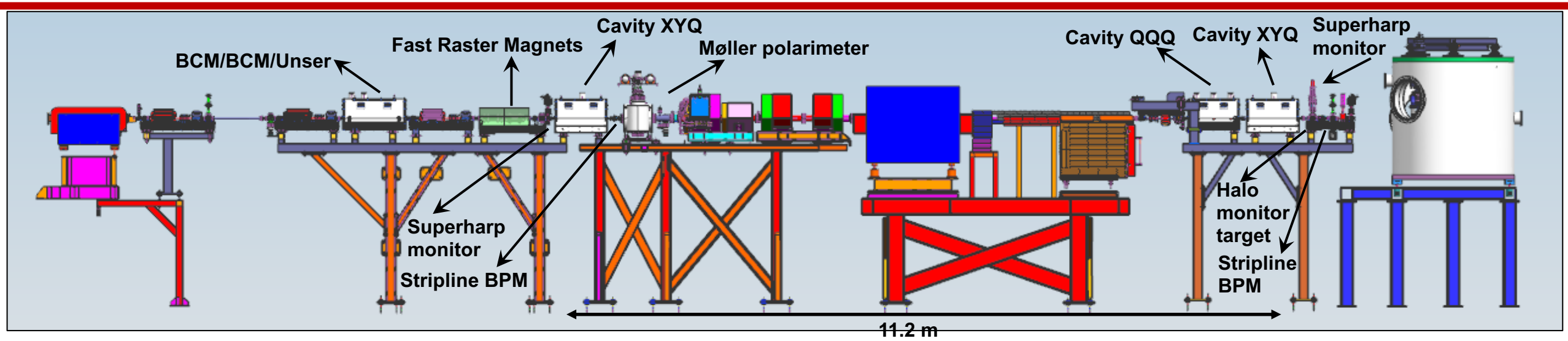


The final MOLLER incoming beamline design was designed by Jay Benesch and verified with beam optics calculations by Yves Roblin (*J. Benesch and Y. Roblin JINST 16 T12007 (2021)*)

It allows for:

- Movement of MOLLER hydrogen target 4.5 meters upstream of nominal Hall C target position
- Necessary beam instrumentation and controls to achieve physics requirements

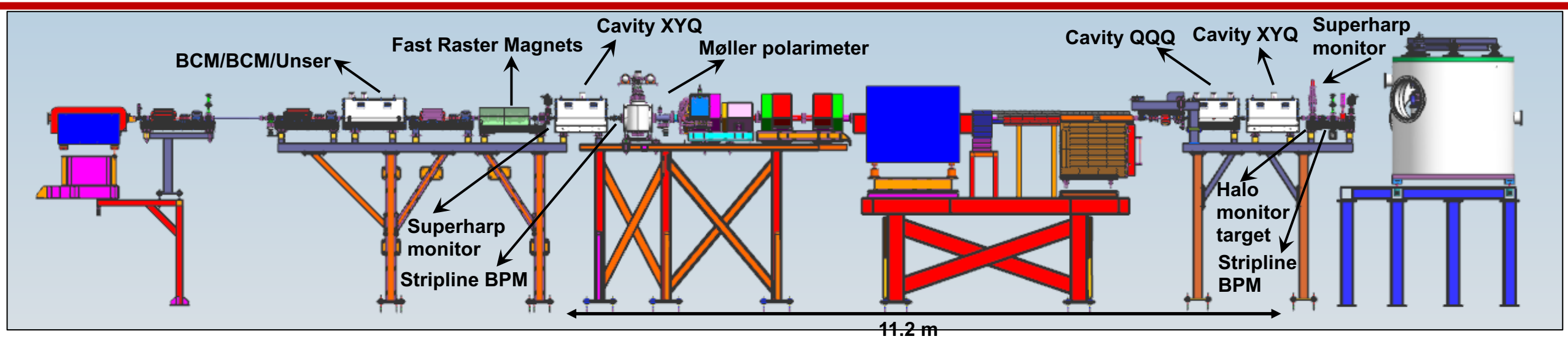
MOLLER Incoming Beamline: System Requirements



Design documented in MOLLER Incoming Beamline System Requirements document (Rev0-Final)

- Moller polarimeter magnets unmoved from current location, but with fully degaussed quads/dipoles during production running
- Redundant position/angle measurements with thin-wire “stripline” and microwave cavity position monitors separated by > 10 m
- Fast feedback will work independent of anything downstream of the Hall A arc
- Adequate quad count for envelope matching at Compton and Moller polarimeters and physics targets
- Independent slow orbit locks available before and after Compton polarimeter
- Phase advance from beam modulation correctors to BPMs is > $\pi/6$
- Moller polarimeter target is moved 30 cm upstream from its current location
- Faster raster system capable of 5.0 mm x 5.0 mm spot at MOLLER target (assuming square pattern)
- Microwave cavity (QQQ and XYQ) monitors should be electrically isolated from beamline

MOLLER Incoming Beamline: Status



See Robin Wines infrastructure talk for more complete details

- The full 3D model is finalized and all design drawings detailed; presented by Chase Dubbe to June 2022 Preliminary Design Review committee
- PDR recommended early installation and subsequent testing of the “prototype” entrance beamline about one year in advance of start of MOLLER installation in 2024. The “prototype” includes:
  - New raster girder and girders with new stronger MCG dipole correctors and quadrupoles
  - Møller polarimeter target moved upstream by 30 cm

  → Opportunities for operations to test aspects of the new optics and MOLLER to study the Møller polarimeter target being moved upstream

Phaseout of SEE Electronics

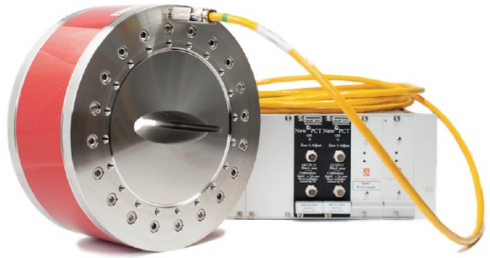
- Beamline readout covered in Paul King's DAQ talk
- The SEE (Switched Electrode Electronics) that have been used with "thin-wire" stripline BPMs for all prior JLab PVES experiments are being phased out (parts obsolete). They are being replaced with JLab digital receivers.
  - Concern: Lots of experience with the existing electronics; replacing with new can introduce new issues
  - Opportunity: Existing SEE system always had concerns with multiplexed readout; new system may allow removal of the multiplexing and increase of sample frequency
- We will require (in update to the beam requirements document) that we need to be able to test the new receivers in parallel with the existing SEE systems on some critical devices such as the last two BPMs in Hall A

Hall A Unser Replacement for MOLLER

- For electrical isolation reasons, a new 2 BCM + Unser box will be made with the Unser electrically isolated from the 2 BCMs
- Requested to provide requirements for the new Unser for MOLLER – need linearity at < 0.5% over the 15 – 75 uA range – we use the Unser to properly measure the pedestals for the cavity charge monitors that become non-linear at low beam currents
- Jim Fast and others have identified a commercial unit that appears to satisfy the requirements, and it is being purchased

bergoz INSTRUMENTATION

NPCT – New Parametric Current Transformer



DC beam current non-destructive measurement

Four ranges ± 20mA, ±200mA, ±2A and ± 20A
<0.5uA/√ Hz noise, i.e. resolution, on option
DC to 10 kHz (-3dB) frequency response
< 0.1% linearity error
NPCT package includes spares for all electronics

The New Parametric Current Transformer is the latest evolution of the Unser Transformer, commonly called DCCT, developed at CERN in 1966 by Klaus B. Unser.