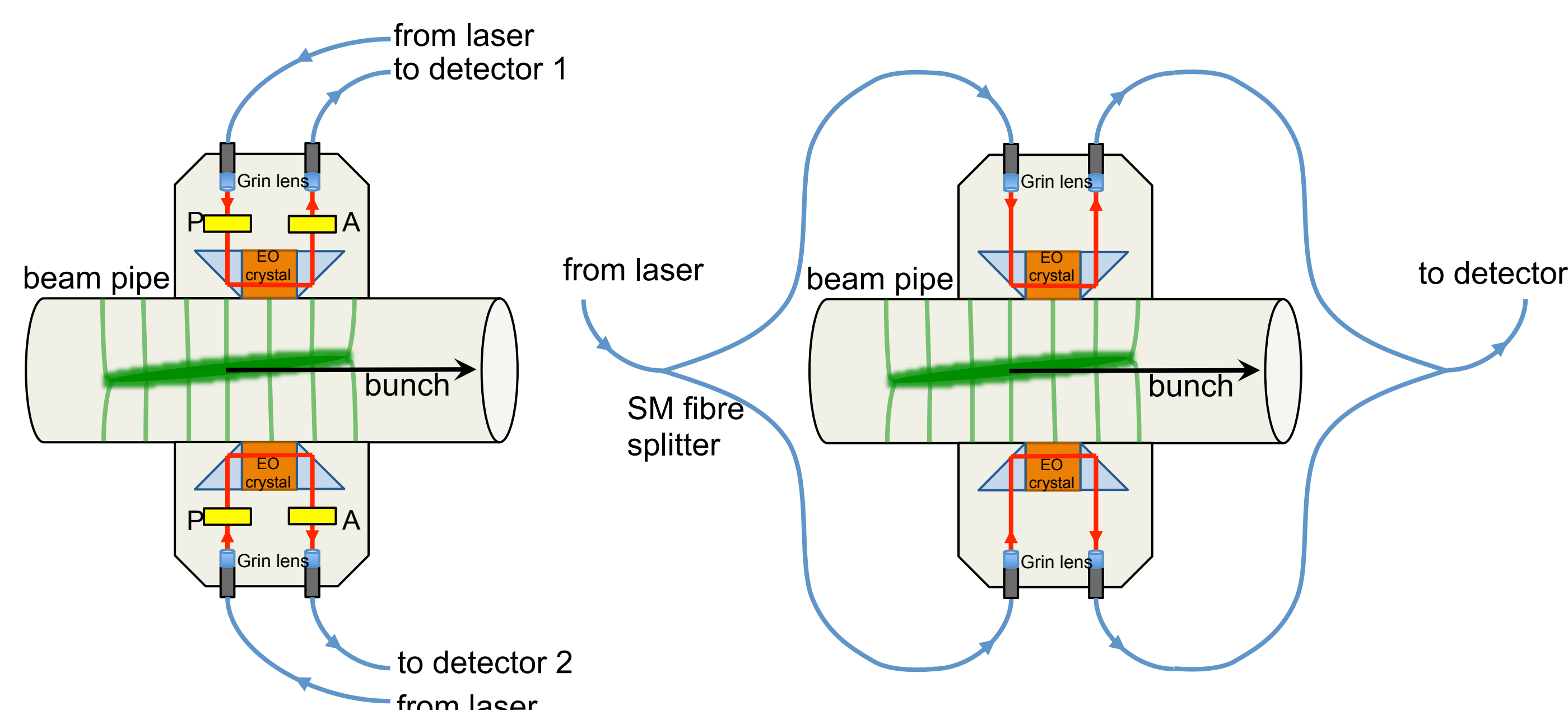


Motivation

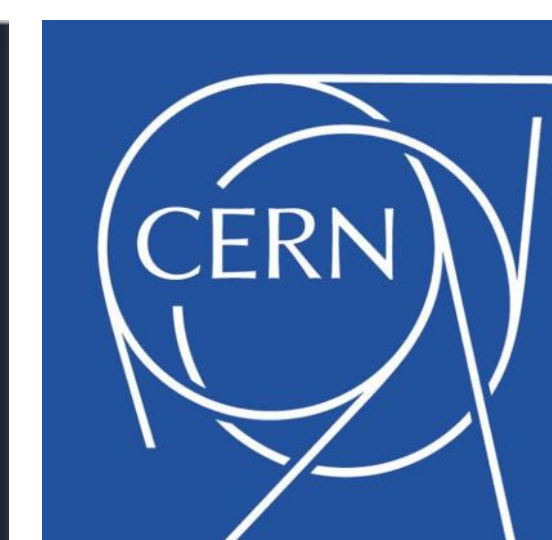
A novel **Electro-Optic Beam Position Monitor** capable of rapidly (< 50 ps) monitoring transverse intra-bunch perturbations is under development for the High-Luminosity Large Hadron Collider. The EO-BPM relies on the fast optical response of two pairs of **electro-optic crystals**, whose birefringence is modified by the passing electric field of a 1 ns proton bunch.



(1)



(2)

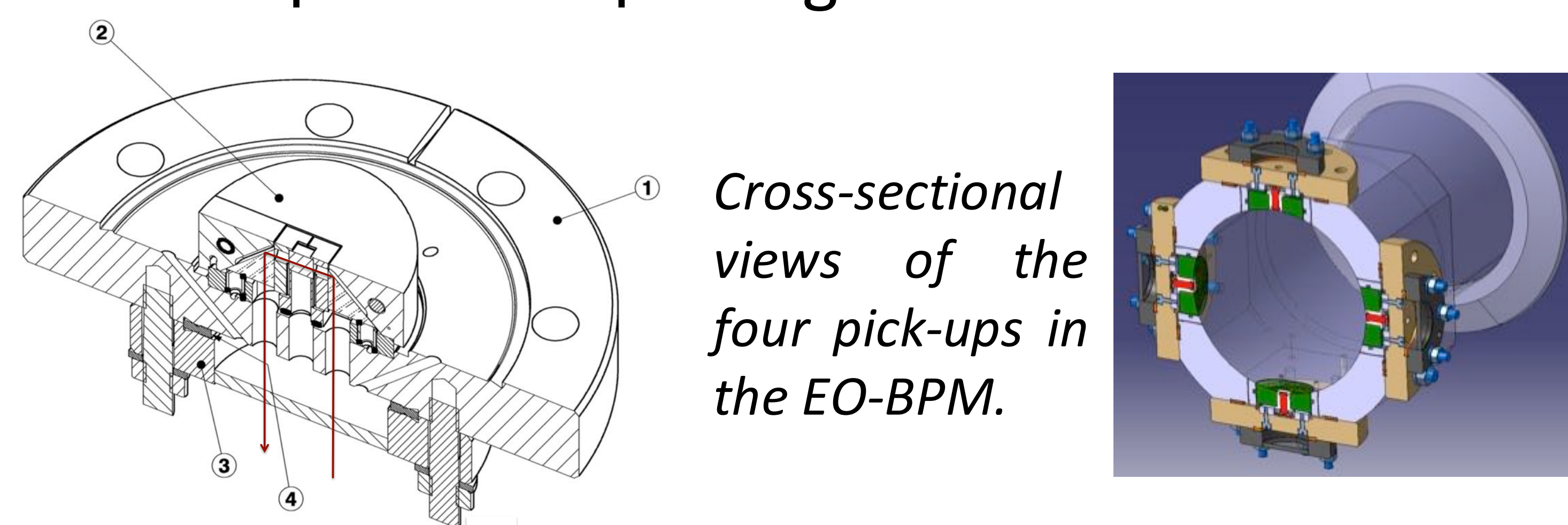


Electro-Optic Beam Position Monitor Concept

An EO-BPM is essentially a conventional button-BPM in which the pick-ups have been replaced with electro-optical crystals. Fibre-coupled polarized light is reflected through the crystal and emerges through an analyser (far left). The polarization state after the crystal is modified due to the Pockels effect induced by the passing bunch.

In an alternative interferometric layout, coherent light is exploited to optically suppress the common mode signal, such that the detector directly measures the difference signal between the two pick-ups.

Electro-optic Pick-up Design



Cross-sectional views of the four pick-ups in the EO-BPM.

Each prototype EO pick-up holds a 5 mm cubic, MgO_2 doped LiNbO_3 crystal in a ceramic holder, surrounded by two 45° prisms that reflect the incident polarized light from a fibre-coupled laser. An anti-reflection coated viewport provides the optical interface between the vacuum and the prototype free-space beam optics.

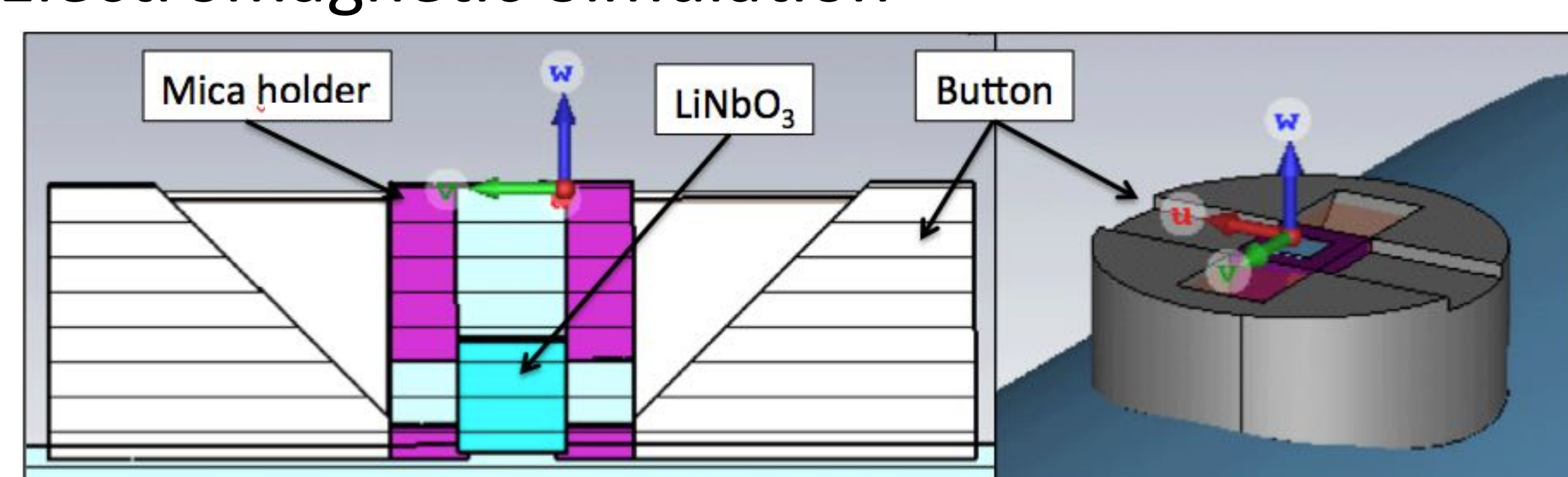


External view of pick-up in BPM body

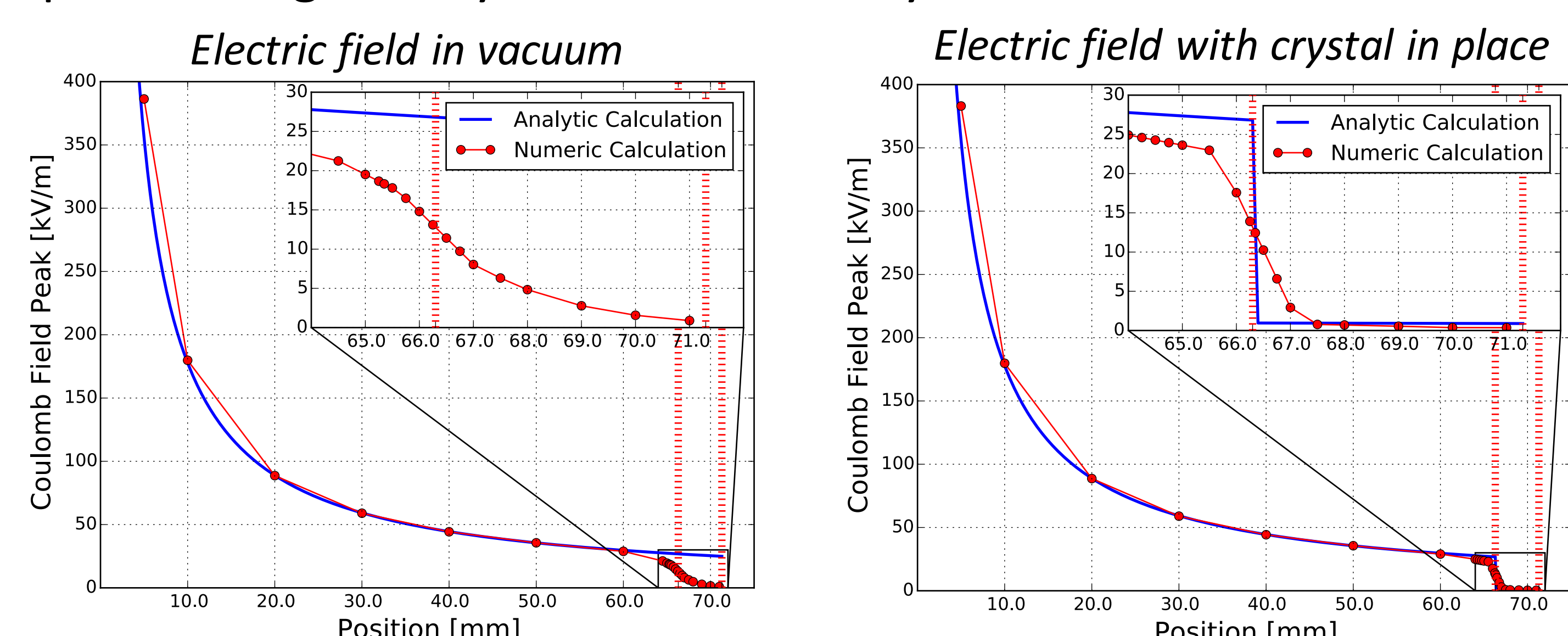
Pick-up components: ceramic holders, prisms, and crystal

Top view shows reflected path through the crystal

Electromagnetic Simulation

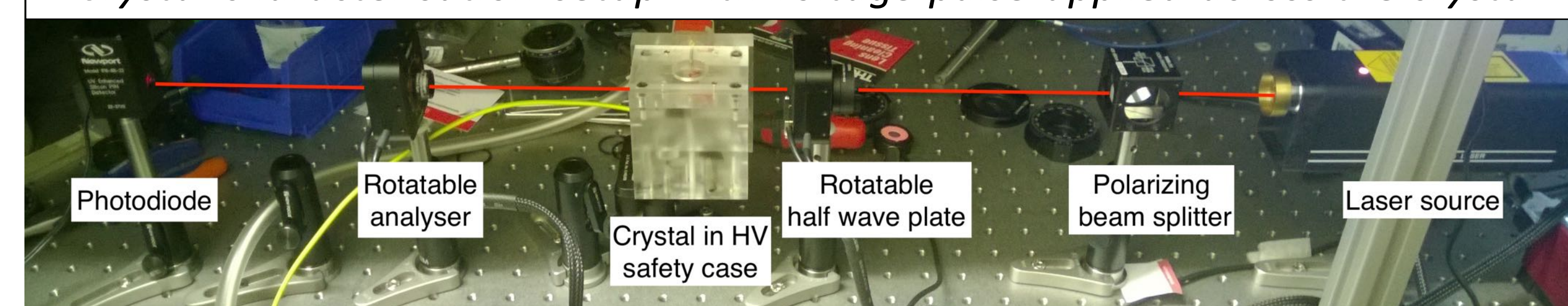


An EM simulation of a $4\sigma = 1$ ns Gaussian bunch passing a simplified geometric model of the EO pick-up. The Coulomb field penetrating the crystal is modified by the dielectric constant.

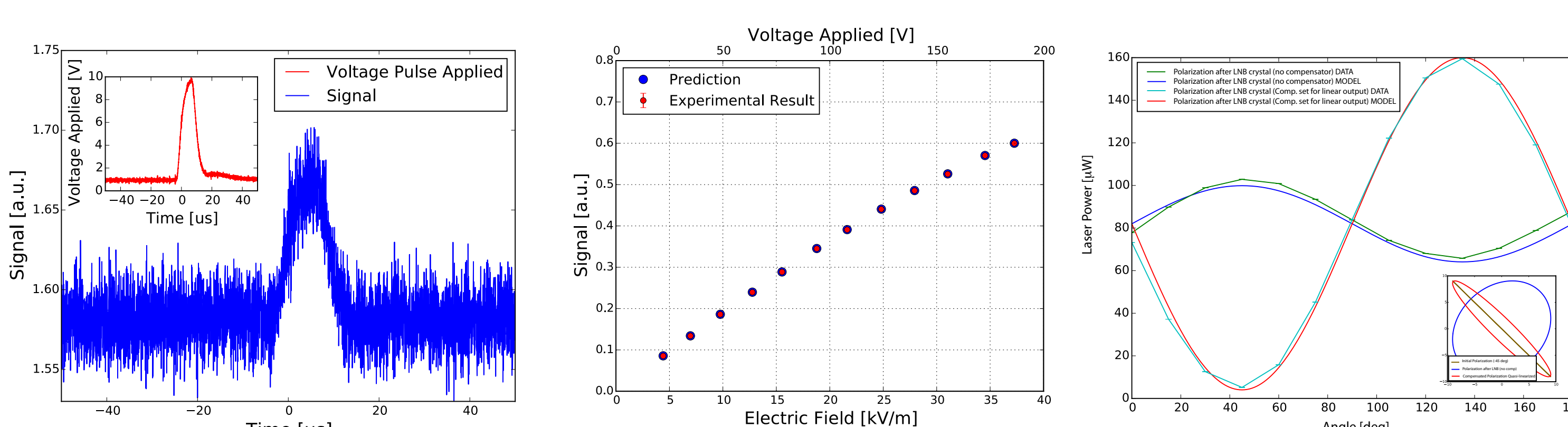


Laboratory measurements of crystal response

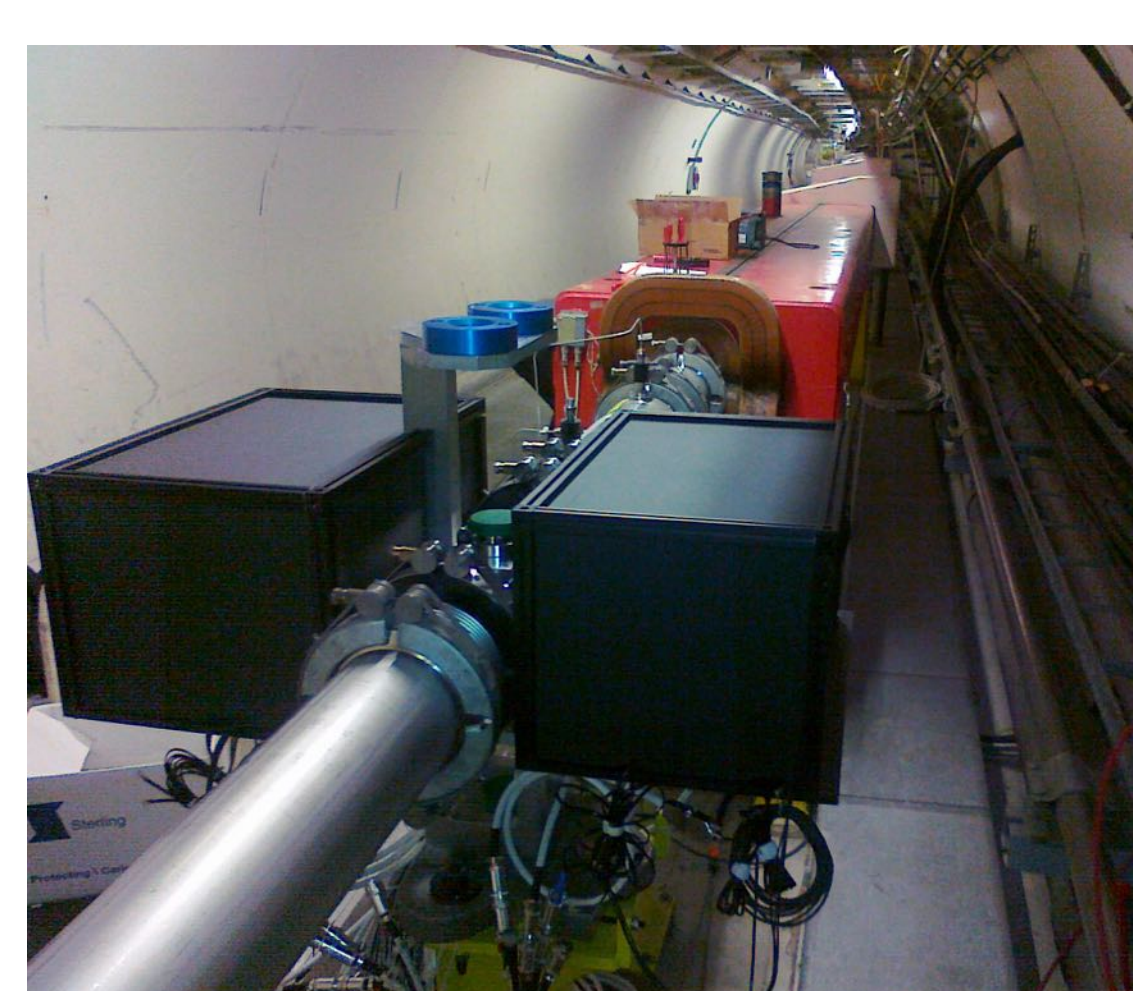
Crystal characterisation setup with voltage pulse applied across the crystal



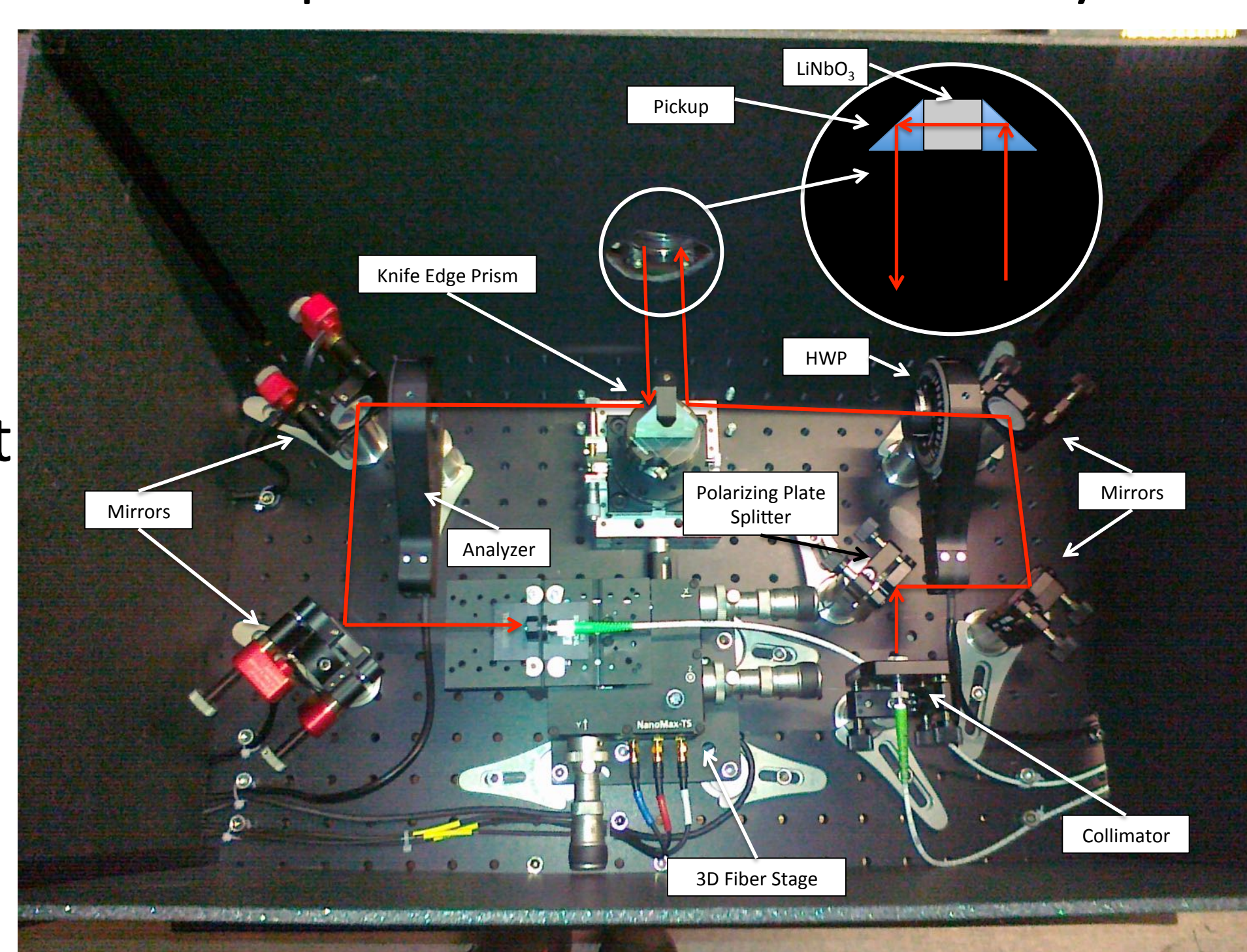
A pulse of only 10 V peak applied across 5 mm thick LiNbO_3 crystal induces an observable signal in the polarization state.



Installation in CERN SPS



A prototype EO-BPM was recently installed in the CERN SPS, initially equipped in the horizontal plane with two breadboards, each containing remote-controlled polarization state, analyser and fibre coupling optics. The prototype setup enables flexible online reconfiguration and investigation of the polarization state via the crystal.



160 m of PM fibre conveys polarized light from a 780 nm laser to the collimator shown. A knife edge prism diverts light into and out of the EO-pick-up. The modified polarization state is analysed, fibre coupled, and monitored by a distant fast photo detector.

Summary and Outlook: A prototype electro-optic BPM has been designed and was recently installed at the CERN SPS, with remote controlled, fibre-coupled polarization and analyser optics. The strength of the electric field penetrating the crystal has been evaluated by electromagnetic simulations. Optical measurements of the crystal response confirm applied voltage pulses of the expected field strength are detectable. The installation of the ancillary laser and detection equipment will be completed in the coming months.

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