Pulsed wire

Johann E. Baader, Sara Casalbuoni
Undulator Systems Group, European XFEL

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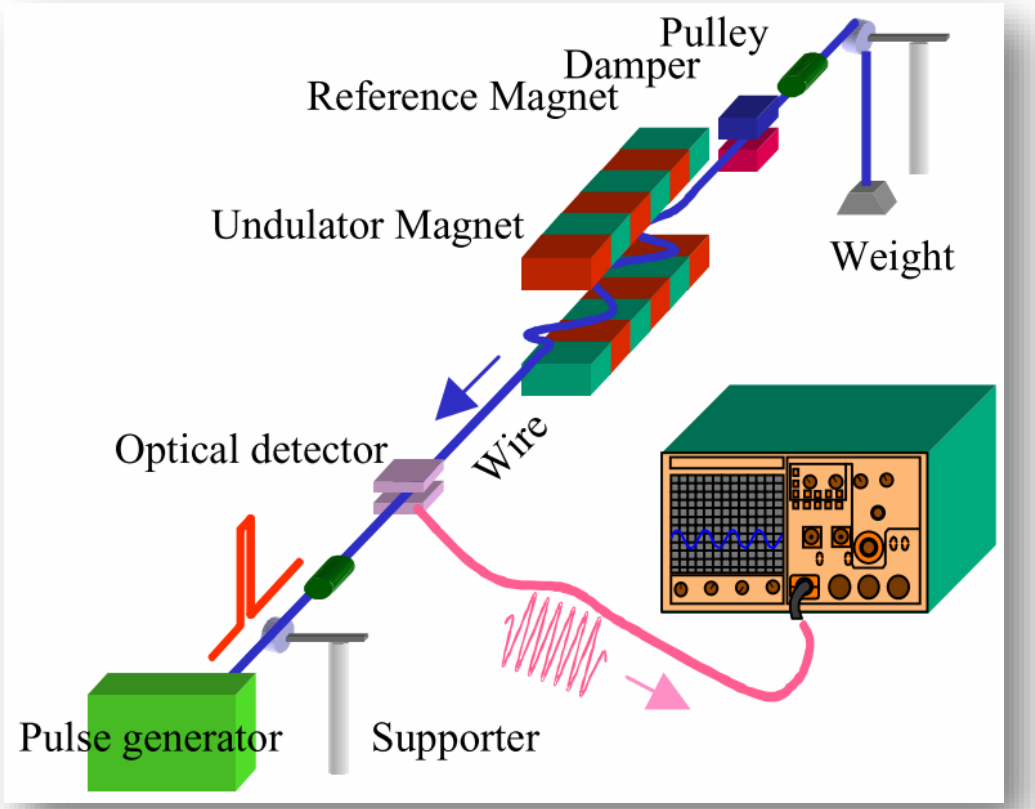
Key elements of the pulsed wire magnetic measurement system to characterize undulators

Undulators are complex accelerator magnets used to produce high brilliant photon beams. Its magnetic field characterization can be accomplished by applying a technique known as **pulsed wire**.

Pulsing an **electrical current** through a **wire** leads to its deflection along with the magnetic structure, according to the magnetic field strength of the individual poles of the undulator. Because of the restoring force, an acoustic wave travels through the tensioned wire, where an **optical detector** — commonly a combination of a **laser** and a **photodetector** — senses the wire displacement. The wire displacement as a function of time is properly scaled to represent the **magnetic field profile** as a function of the longitudinal position.



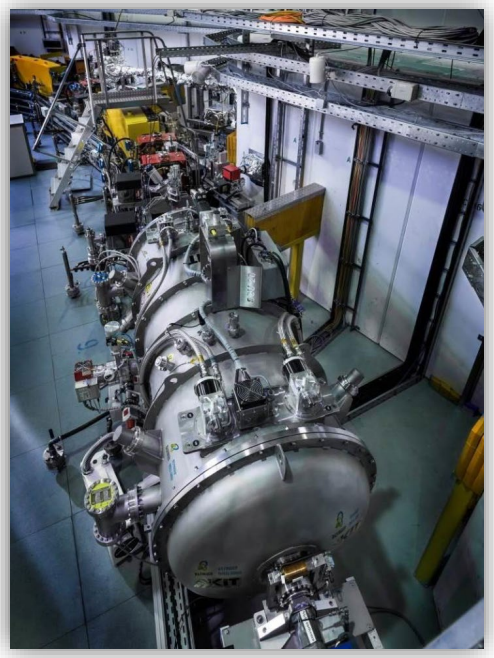
Simplified diagram of the pulsed wire system (T.C. Fan *et al.*, PAC2001, pp. 2775-2777).

Motivation behind developing a magnetic measurement setup

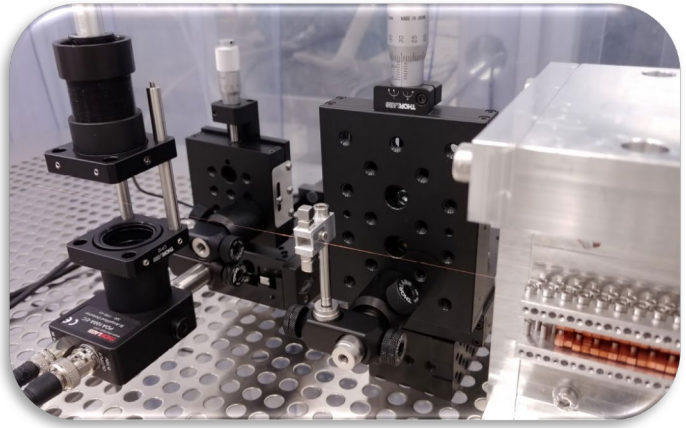
The **pulsed wire technique** could be used to perform ***quality assurance*** of magnets-based devices sold by companies, particularly when the region under characterization has limited access. Related applications include (but are not limited to):

- accelerator magnets (dipole, quadrupoles, sextupoles, undulators, etc.)
- nuclear magnetic resonance (NMR) instruments
- electrical devices for the industry (motors, generators, transformers, etc.)

In the context of **Storage Rings** and **Free-electron Lasers (FELs)**, magnetic field measurements are very demanding, and the pulsed wire technique is a promising solution to characterize small aperture devices, for example, **superconducting undulators**. The hardware side of the method has enormous room for growth: **wires with better homogeneity**, **higher voltage pulse generators**, and **faster/more sensitive photodetectors** are a few good examples. Such improvements would not only benefit the technique's quality itself but may also benefit the marketing that deals with similar components.



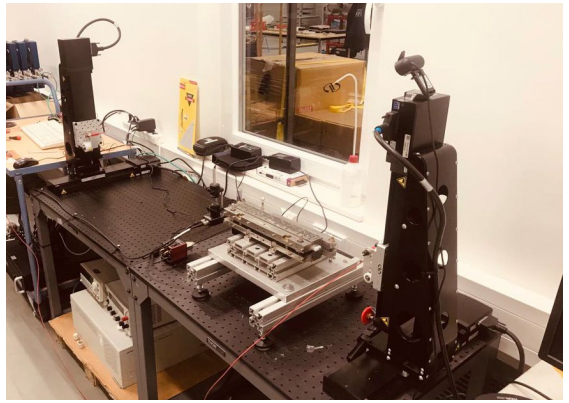
Superconducting undulator installed at KIT synchrotron (S. Casalbuoni *et al.*, Commissioning experience with commercial superconducting undulators, presented at the Beam Tests and Commissioning of Low Emittance Storage Rings Workshop, 2019).



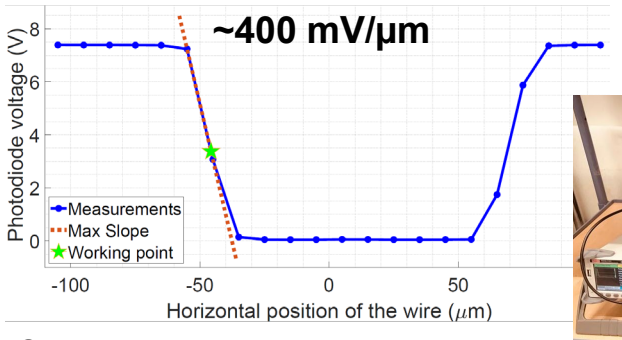
Example of a pulsed wire setup showing the optical detector and the wire used to measure an in-vacuum small gap permanent magnet undulator. Courtesy by Maximilian Trunk (Desy, UHH, LUX).

Updates

- First measurements of a 30cm long, 5mm period, 1.6mm gap undulator
  - Improved the sensitivity of the technique (detects a wire displacement of 0.1 μm)
  - Enabled the simplification of the generator from a commercial solution
- Mohammed Ebbeni *et al.* (MAX IV) proposed an approach to correct the pulse shape
- Procurement of UHV translation stages from **SmarAct** and vacuum chambers from **CECOM** ➔ to measure SCU modules (**Bilfinger Noell**)
- Currently setting up the U40 undulator (5m long, 40mm period) undulator for pulsed wire measurements

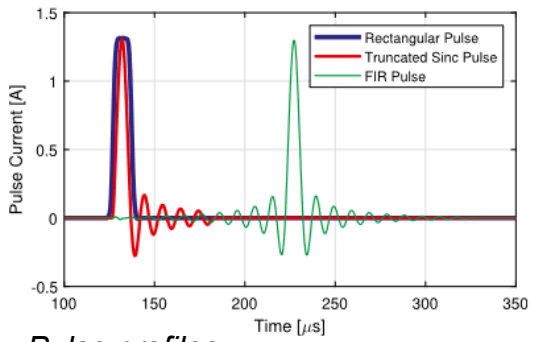


Preliminary setup

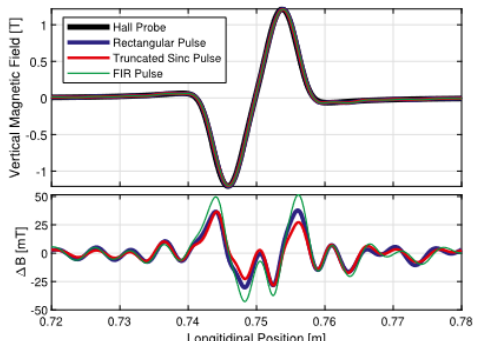


Sensitivity measurements

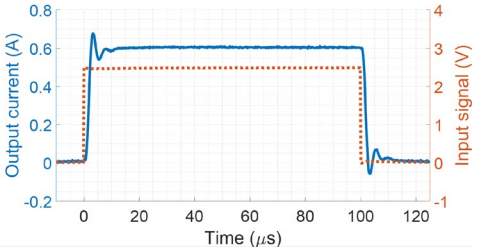
Pulse generator scheme



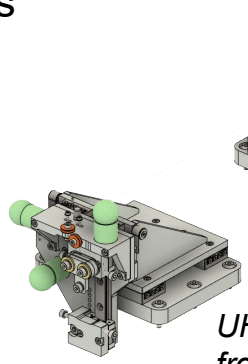
Pulse profiles (MAX IV)



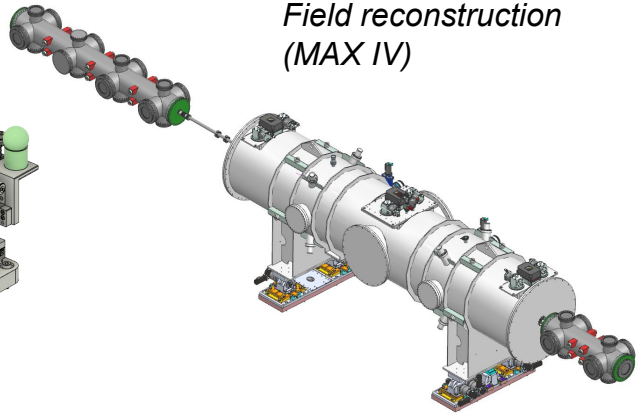
Field reconstruction (MAX IV)



Output current measurement



UHV translation stages from SmarAct



Vacuum chamber (CECOM) and SCU module (Bilfinger Noell)

U40 undulator at EuXFEL