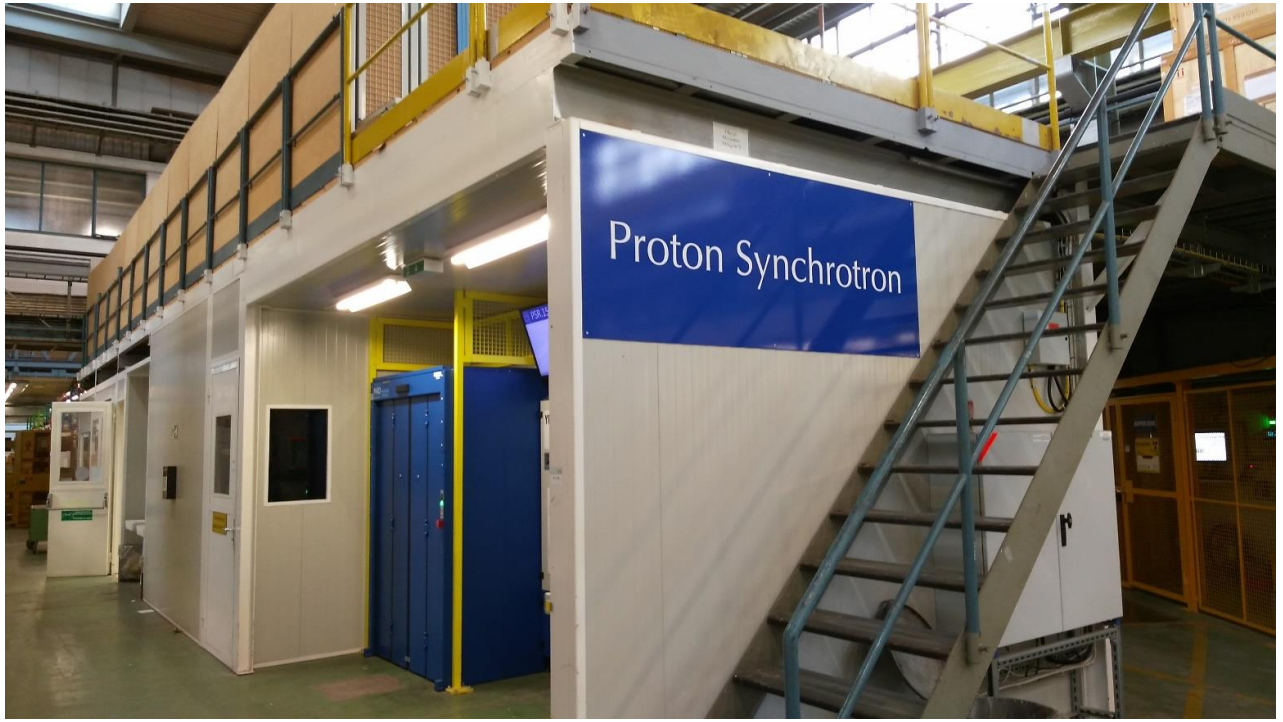
The LHC Beam and its Transverse Beam Profile

A short summary of my journey to CERN, the LHC beam, and my contribution to the new Beam Wire-Scanner.

How did I join CERN?

- I landed a one year internship as technical student (TS)

- Read my background story at CERN's career page: https://careers.cern/Ervin



A picture from my first tour at the Meyrin site.

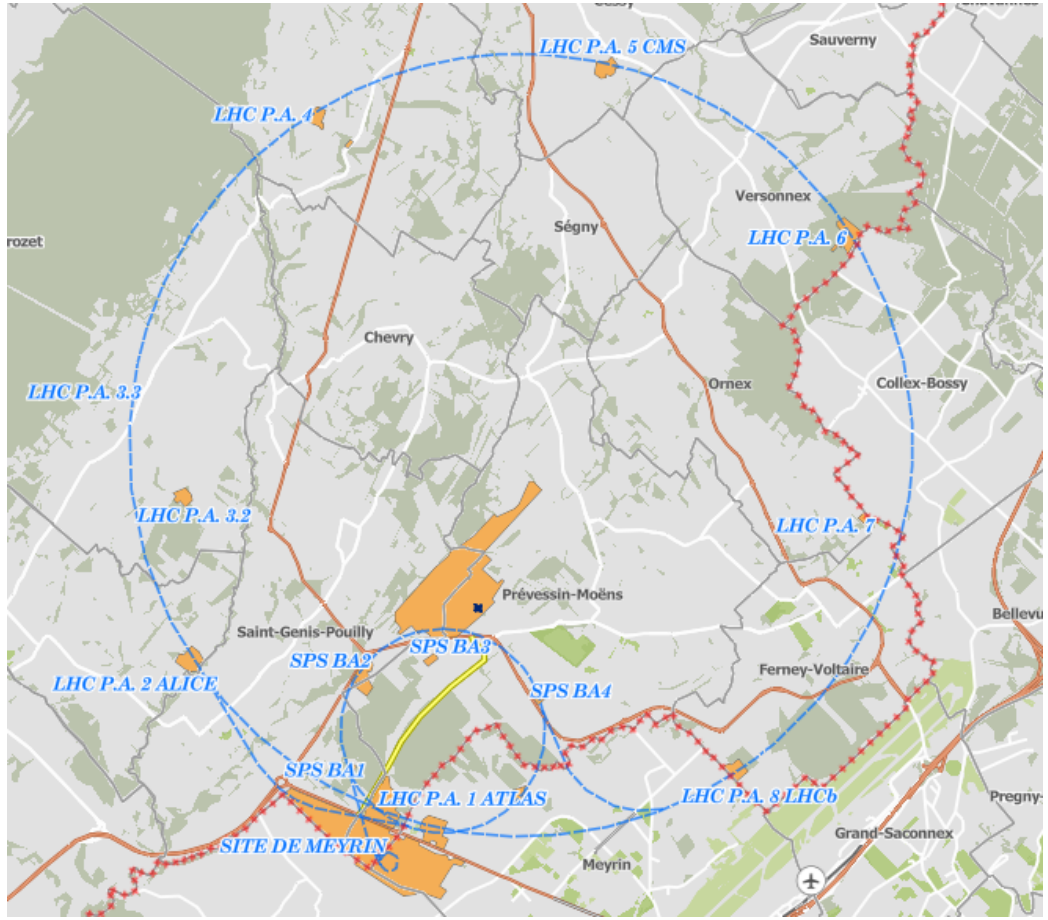
How can you join CERN?

- There are a lot of different programmes at CERN
  - Professionals
    - Experienced → staff
    - Entry-level → fellowships, trainings, …
  - Students
    - PhD
    - Technical Students → BSc/MSc
    - Administrative Students
    - Summer Student
    - OpenLab Summer Student

- Keep im mind
  - Staff positions are EXTREMELY hard to get.
  - Student positions much less.
  - In general time-limited contracts.
  - Students have 3.3k allowance.
  - Geneva region is expensive!
  - French side poor public transport (car recommeded).

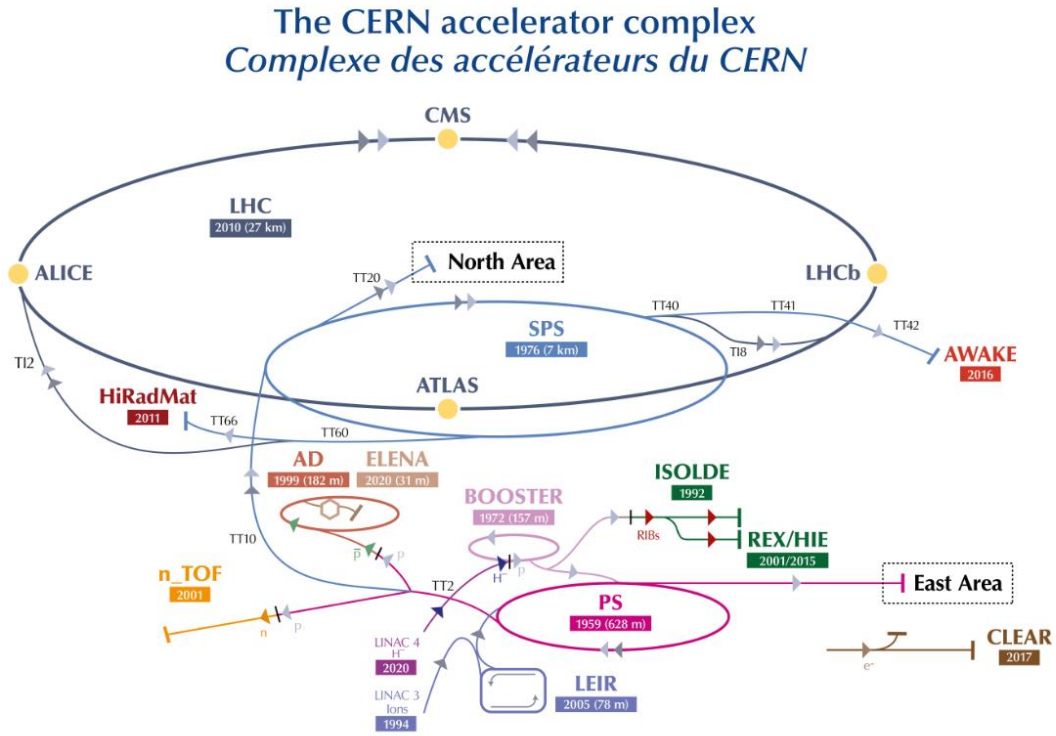
Where exactly was I at CERN?

- CERN is organized in many different departments with its groups and sections
- I was at BE-BI-PM:
  - Beams (department)
  - Beam Instrumentation (group)
  - Profile Measurement (section)
- CERN has two main sites
  - Meyrin (CH/F border)
  - Prévessin (F) ← I was here



CERN accelerator complex

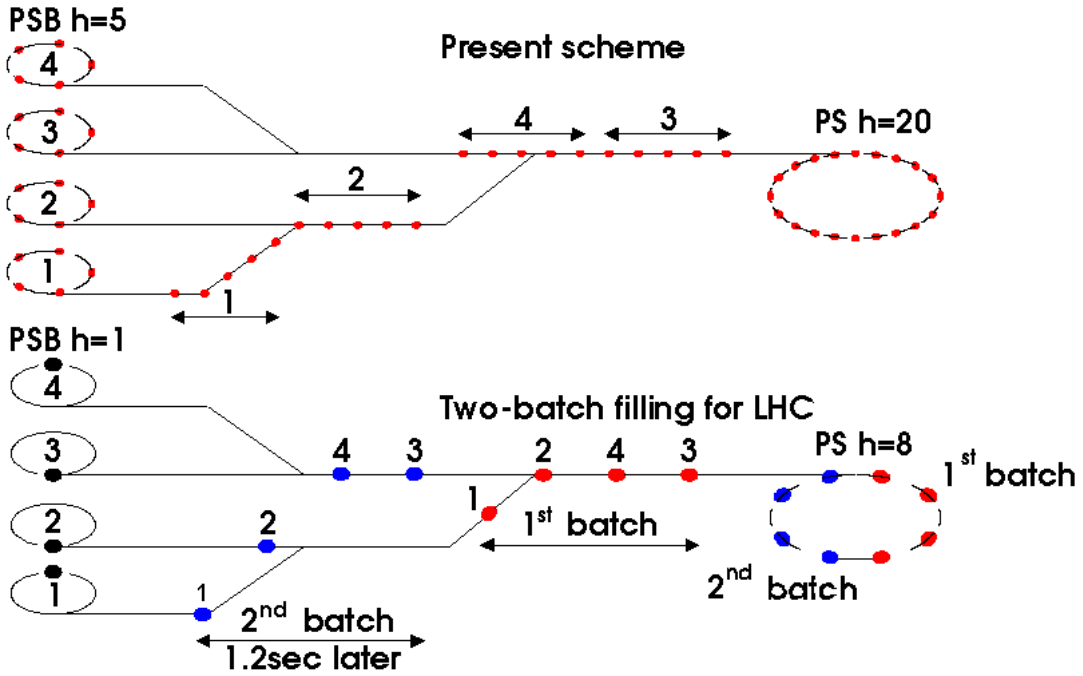
- There are many different accelerators and sections.
- My work focused on the LHC chain (start to end):
  - LINAC4
  - Proton Synchrotron Booster (PSB)
  - Proton Synchrotron (PS)
  - Super Proton Synchrotron (SPS)
  - Large Hadron Collider (LHC)



https://cds.cern.ch/record/2684277

The beam journey – Part I: LINAC-PSB-PS

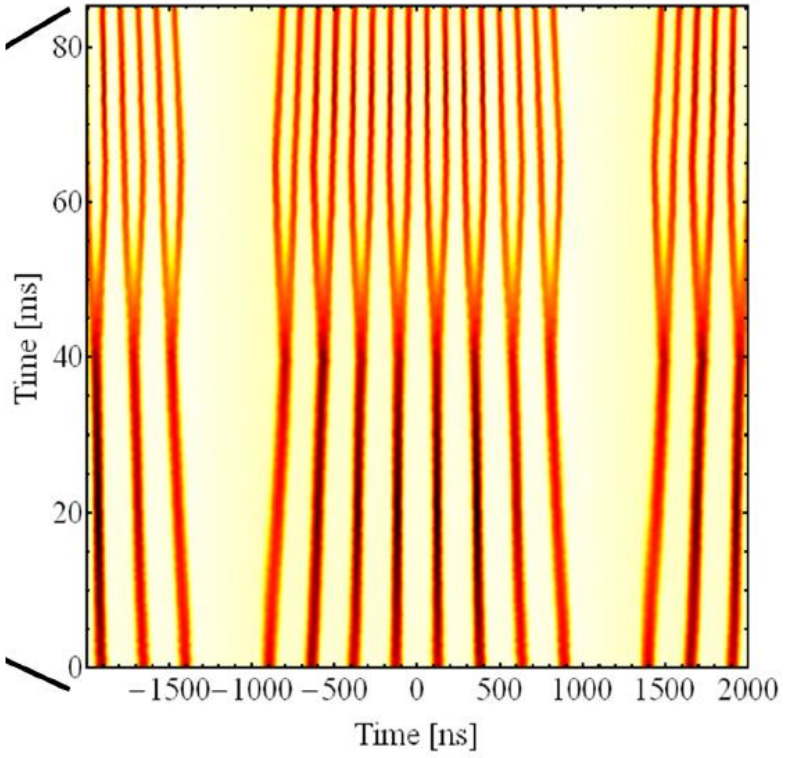
- The LINAC feeds the four strings of the PSB with particles
- The particle collection inside a PSB string is called «bunch» (b)
- A full «batch» of the PSB is thus 4 bunches (4 b)
- The PSB sends sequentially 6 b to the PS (1x full + 1x half batch)
- The PS captures the 6 b as buckets using ist RF cavities on h=7



http://ps-div.web.cern.ch/LHC-PS/LHC-PS.html

The beam journey – Part II: PS beam spacing

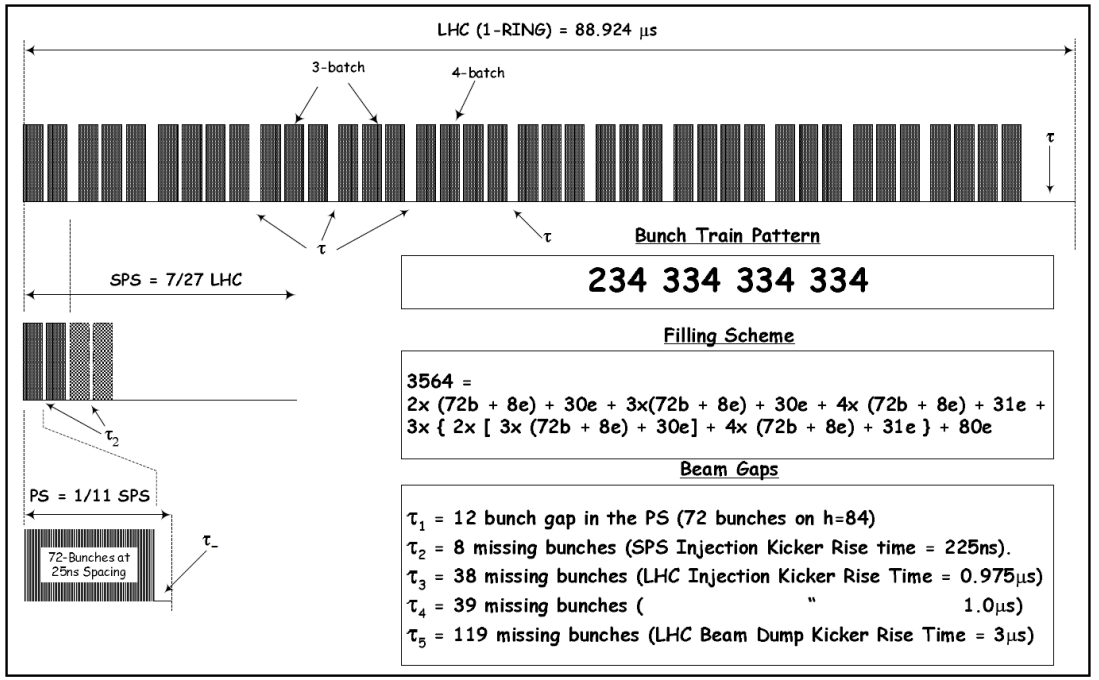
- On h=7 there are 7 buckets
  - 6 are filled with particles
  - 1 is empty (e) → kicker slot
- The PS is used to «reshape» the beam (longitudinal)
- Example (HL 25 ns scheme):
  - Start with h=7: 300 ns (1 e)
  - 3x → h=21: 100 ns (3 e)
  - 2x → h=42: 50 ns (6 e)
  - 2x → h=84: 25 ns (12 e)



Example of a «reshape» for h=9, 2x:
https://cds.cern.ch/record/2674118/files/664.pdf

The beam journey – Part III: PS-SPS-LHC

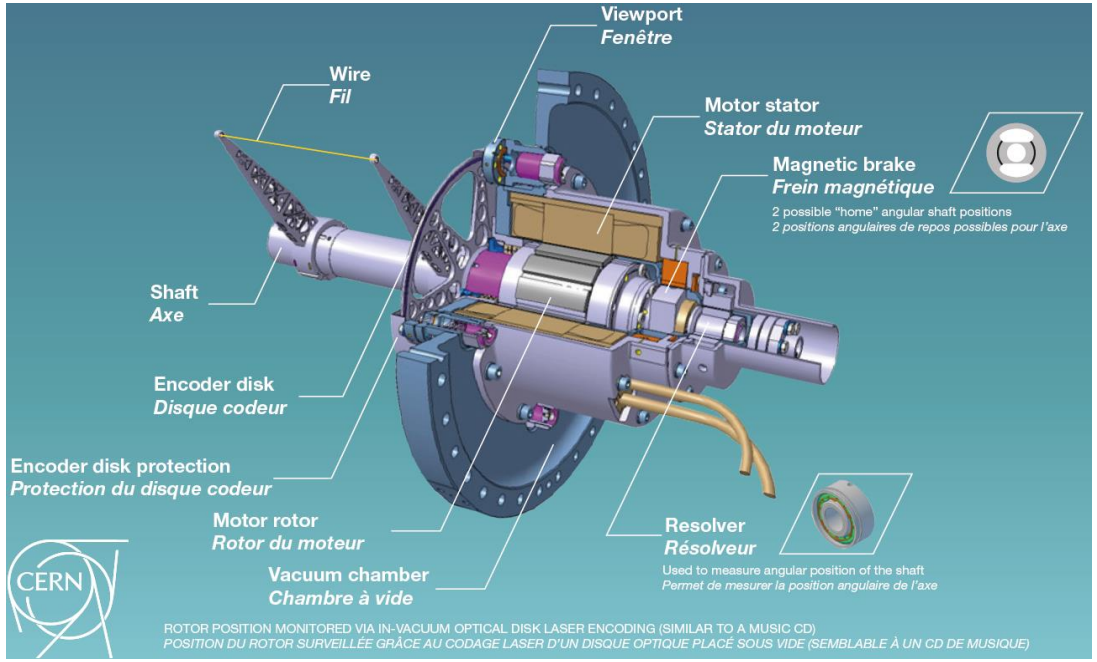
- The PS batch is injected to the SPS (72 b + 12 e).
- The SPS «compresses» the PS batches by reducing 12 e to 8 e.
- The SPS can take up to 4 batches from the PS.
- For HL the SPS is filled as follows
  - 1 x {2, 3, 4} followed by 3 x {3, 3, 4}
- These are injected to the LHC (HL 25 ns filling scheme)



https://cds.cern.ch/record/691782/files/project-note-323.pdf

What project did I join?

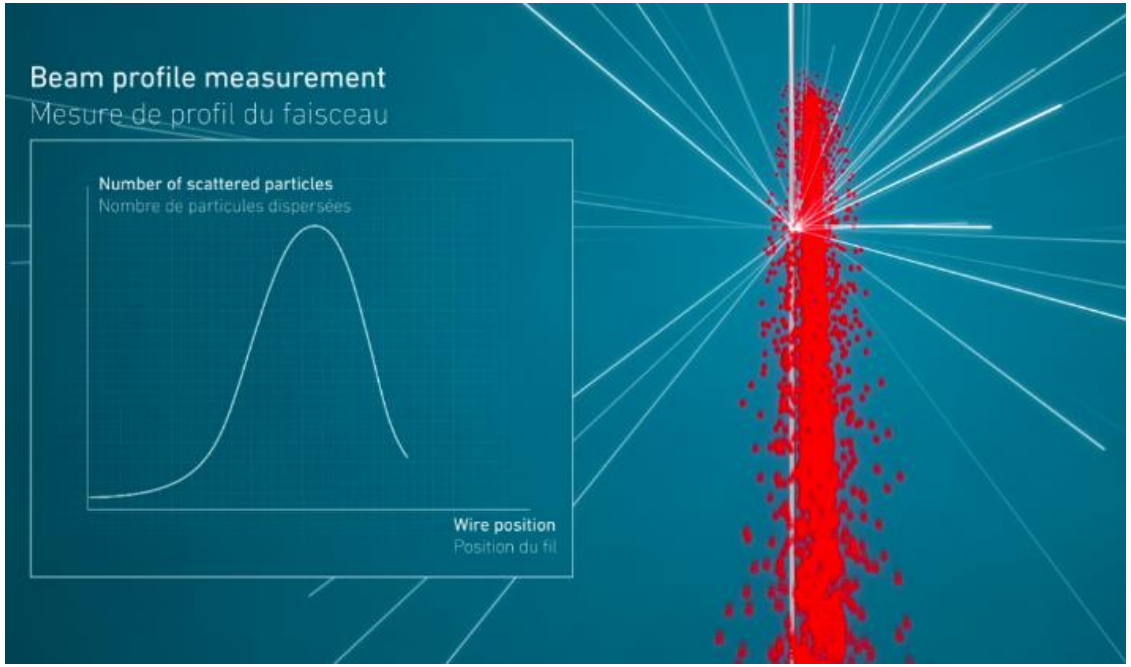
- Particle beams have many different properties that have to be measured
- I worked on the new high speed «Beam Wire-Scanner» (BWS)
- The BWS measures the transverse beam profile
  - Beam travels in *s* direction
  - The transverse beam profile is orthogonal to *s*, i.e. (*x*, *y*)-plane



https://cds.cern.ch/record/2693990/files/Poster-2019-888.pdf

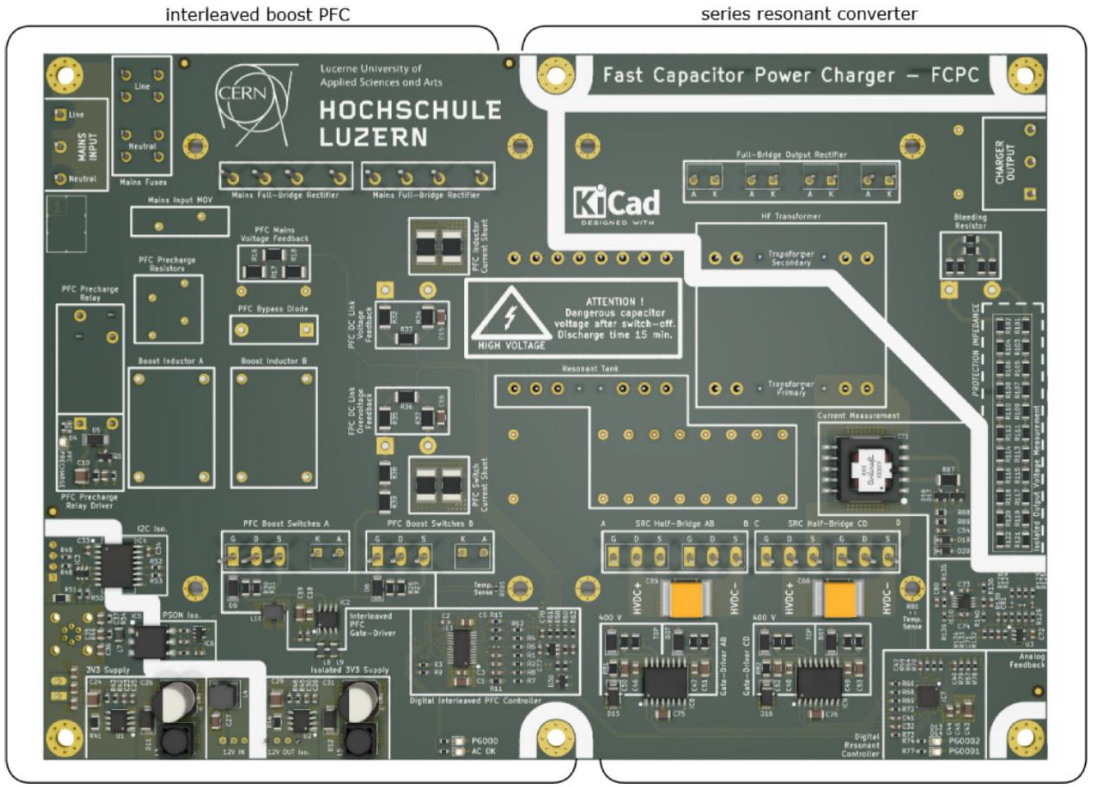
How does the BWS work?

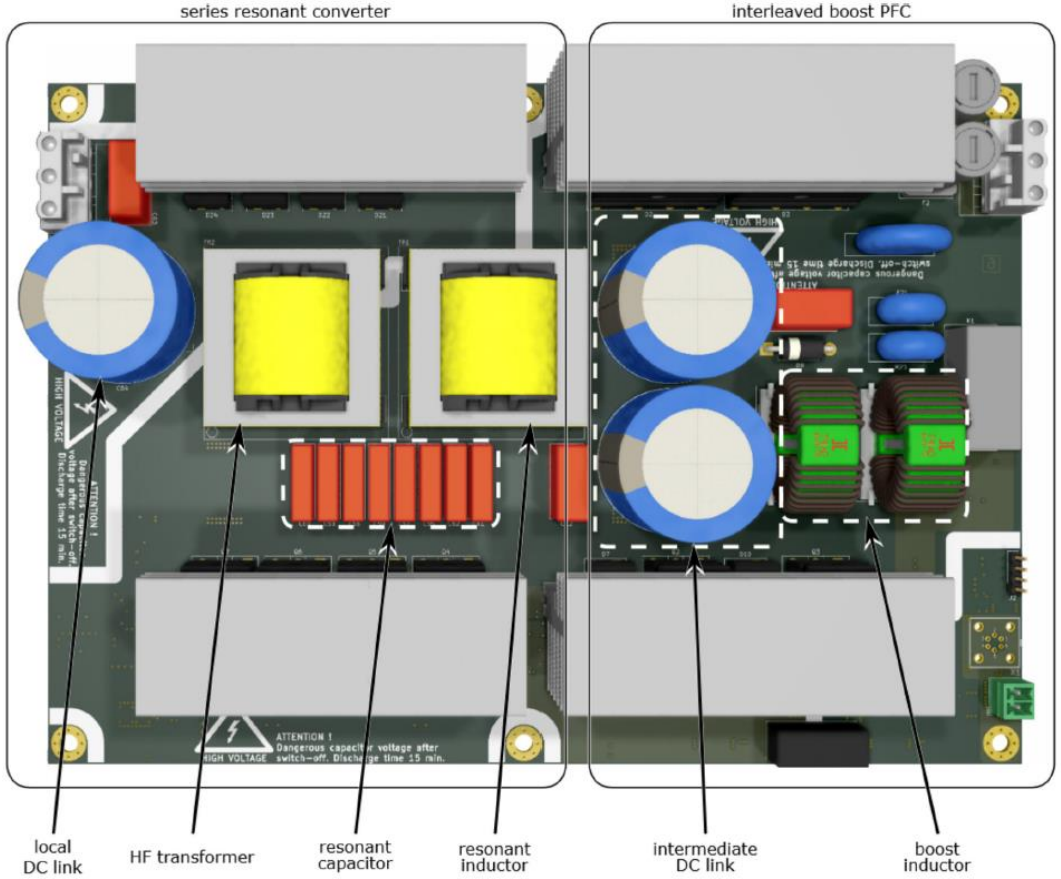
- The BWS sweeps a thin carbon wire (30 um) through the beam.
- The beam-wire interaction generates a particle shower.
- The particles are detected with scintillators.
- By correlating the wire position and the intensity of the beam interaction, the transverse beam profile can be calculated.



See the full BWS animation video here:
https://videos.cern.ch/record/1750707

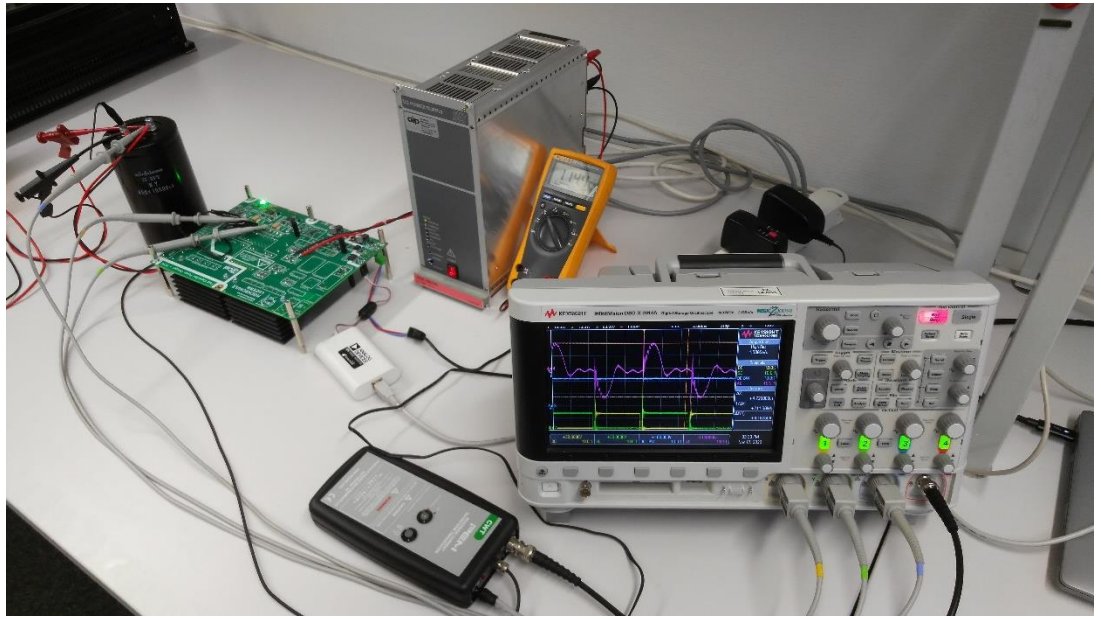
Master Thesis – Fast DC Link Charger for BWS





Master Thesis – Fast DC Link Charger for BWS

- I developed a new DC link charger for the BWS to boost its performance and flexibility
  - Faster startup (60 s → 3.36 s)
  - Faster recharge (12 s → 672 ms)
  - High RR (80 mH → 1.49 Hz)
  - Lower cost (- 40 %)
  - Remote control (now robust)
  - Telemetry (new)
  - Software configuration (new)



First prototype setup of the fast DC link charger.

Questions?