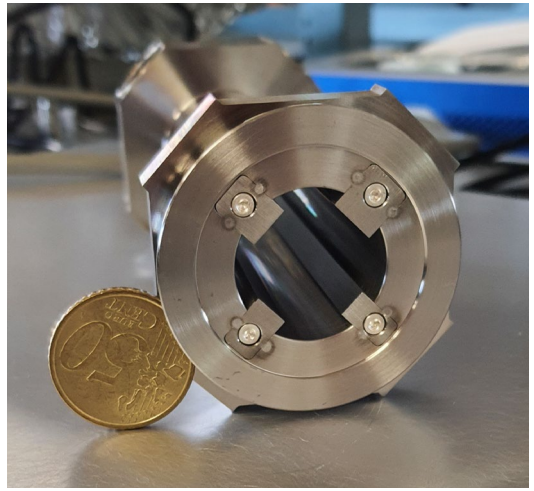
WA 10
Electron and photon beams diagnostics

Outline

- Electron diagnostics
- Photons and FEL beamline diagnostics (RC comments), more in F. Villa talk
- Virtual diagnostics

Striplines (WP14 Angelo Stella)

- A BPM prototype for bench measurements has been designed (WP13 & Vacuum Group) and built (CINEL srl)
- Sized to be inserted in Quad family 1.5T-3T but not in 7 Tesla family.
- Bench tests have been performed to verify :
  - Impedance matching of the striplines
  - BPM frequency response
  - BPM pulse response
  - and to select proper strip width to match Z_0=50 Ω characteristic impedance

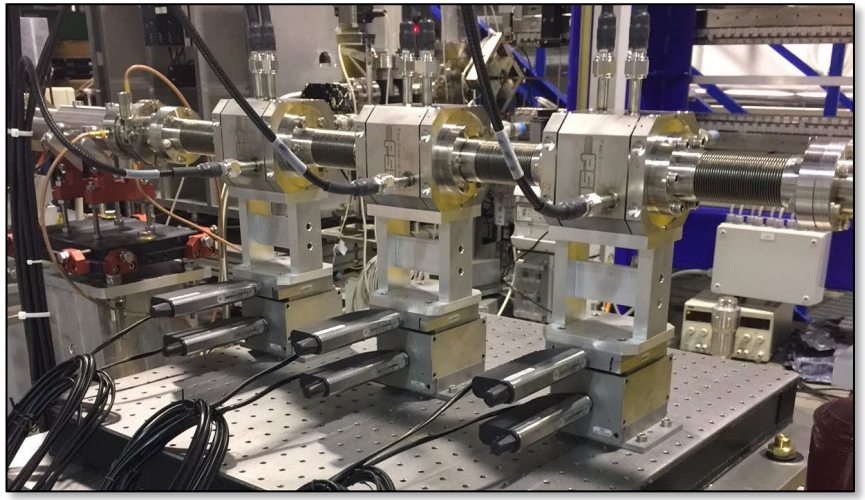


Next steps:

- Realization of a complete BPM suitable for beam tests
  - Updated Mechanical design to implement minor modifications resulted from bench tests and allow proper installation on a beam line
  - Vacuum feedthroughs procurement started (expected in early Sept.)
  - Tender for mechanical realization
  - Acceptance bench Tests
  - Beam Tests@ Sparc (hopefully this year)

Cavity BPM (WP14 G. Franzini)

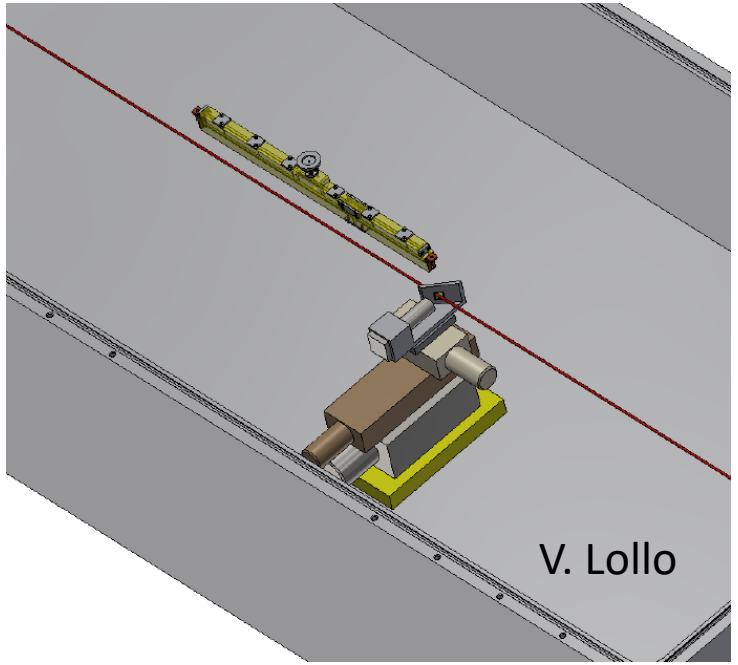
- Main goal of the measurements was to explore the limits and the features of the measuring system (cBPM + read-out electronics)
- The best resolution obtained was **1.5 µm** for bunch charges in the range of **10pC - 200pC**. We detected a dependency of the resolution on the measured position of the beam. This limits the achievable resolution and severely degrades it for beam far from the center (i.e. few mm).
- One possibility is that is caused by jitter-related noise introduced by the readout electronics. We are working closely with Instrumentation Technologies in order to identify the problem.
- We performed measurements also on different aspects of the cBPM's and the read-out electronics, such as long-term stability, cross-talk between X and Y measurements and gain differences between cBPM's.
- Open questions:
  - This Q is too low for our applications?
  - Different behavior in different data set still to explain
  - A set of fresh data will help

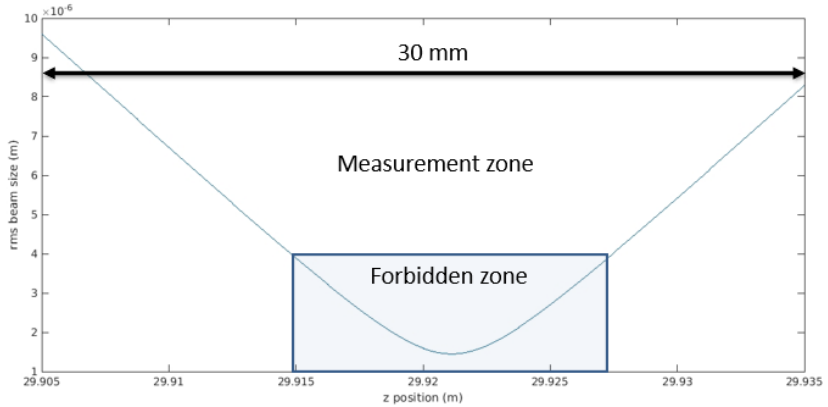


We plan to decide before summer the CBPM strategy, choosing between buying or replicate existing devices or designing a new one.

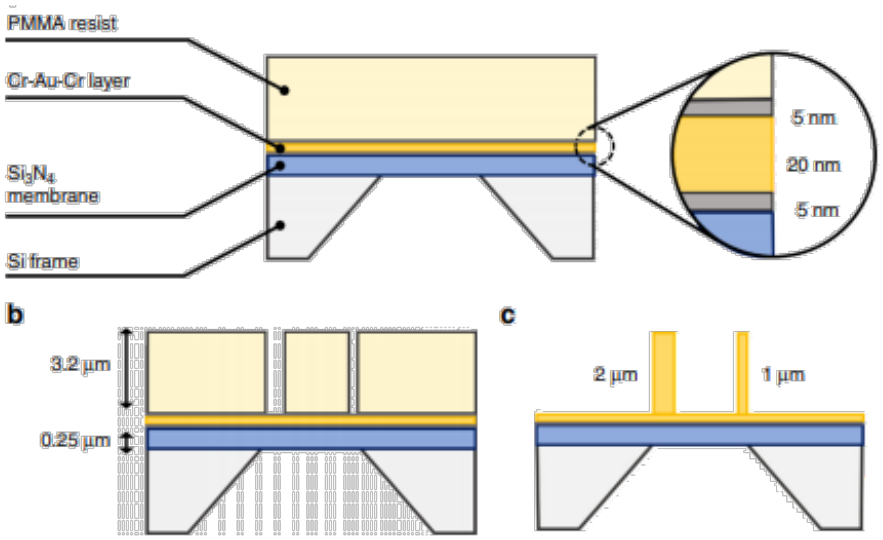
Micro-emittance meter

- Our concept is to move a screen in a 3 cm region centered around the capillary entrance.
- A microscope objective and a ccd in vacuum will move together with the screen
- We have to test ccd in vacuum and with the discharge to verify that there are not unpredicted problems
- Main problem so far is the CCD procurement. Basler has a big problem with components shortage.





Plan B



Borrelli, Simona, et al. "Generation and measurement of sub-micrometer relativistic electron beams." *Communications Physics* 1.1 (2018): 1-8.

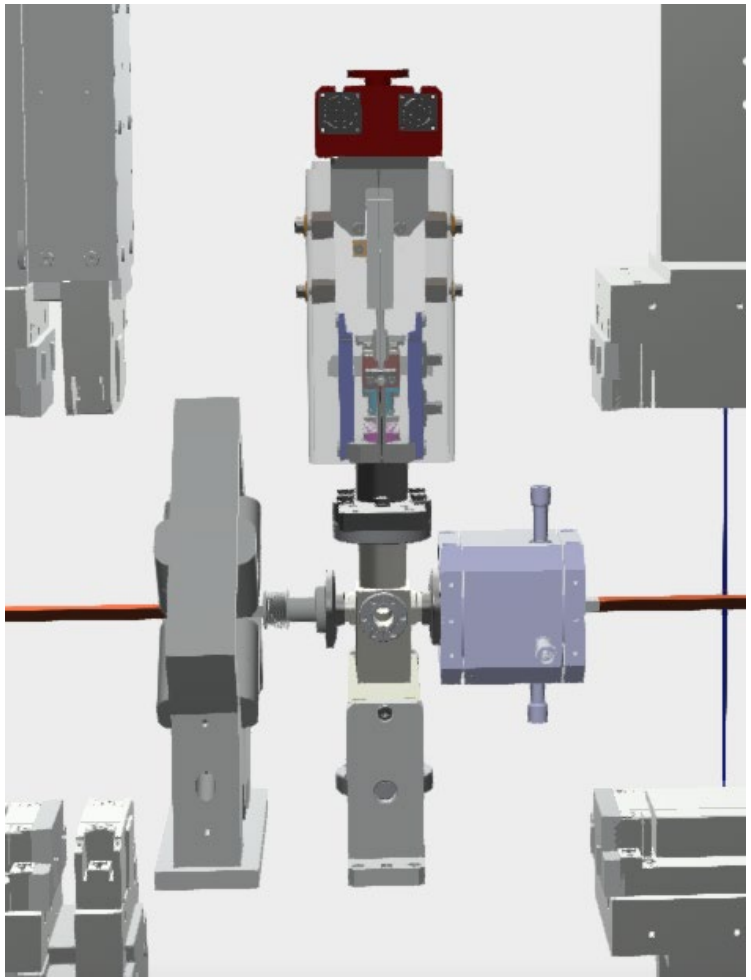
- Free standing gold wire
- Sub-um resolution
- 1-D measurement
- Not single shot
- Proved up to 200 pC
- Collect the produced shower (maybe problem of space occupancy downstream the plasma capillary)
- It is a possible solution if others will be not available

Review Committee

- No details were given about instrumentation of the beamline along the undulators.
  - Indeed, this beamline requires BPMs with 1-2 µm resolution and **quadrupoles on remotely adjustable movers**.
- In general, there were no additional information about diagnostics for the FEL beamline presented to the RC
- Considering the importance of these topics, the RC would like to see the development of all diagnostics along the FEL electron beam line, but also along the photon line to be pushed forward and presented at future meetings

Intraondulator diagnostics

- In the current configuration at SPARC_LAB we cannot test view screen+cavity BPM between undulator modules
- There is not enough space for transitions between different pipes
- There are constrains that prevent to increase this space, for instance moving the undulator modules
- We can test just the view screen alone or the cavity BPM alone.
- The space between undulator modules is strongly affected by the quadrupole length. There is not even a preliminary design yet.



E. Di Pasquale

Photons diagnostics

- Following the RC indications, we have included photons diagnostics in WA scope of the work.
- Synergy with EuAPS (CNR role to be increased)
- Positive experience in CompactLight project
- Meeting with CNR on April 27th (More on F. Villa talk)

ML and Virtual Diagnostics

- Starting June 22
  - ❑ RF Gun Solenoid scan (master thesis)
  - ❑ Beam Energy at RF Gun exit (master thesis)

→

- Optimize Neural network
- Study training set batch size vs prediction performances

Elettra Sincrotrone Trieste

- Starting November 22
  - ❑ Quadrupole scan

→

- Test-drive with time tagged data
- Verify the ML tool portability

Beam loss monitor (S. Pioli)

- We plan to test BLM fiber based on TeX facility
- Procurement done for test setup (digitizer + mppc + fibers)
- Next steps:
  - RADFET procurement
  - Test at TeX
  - Test at Sparc (before 6/23)

Timeline electron diagnostics

WA.10	DIAGNOSTICS	106,8 w	01/06/21	19/06/23
WA10.0100	e-beam diagnostics design	10 mons	03/12/21	09/09/22
WA10.0101	High precision charge measurements	6 mons	03/12/21	20/05/22
WA10.0200	Compact diag. chamber design	12 mons	01/06/21	03/05/22
WA10.0201	Compact diag.chamber prototyping	10 mons	03/05/22	07/02/23
WA10.0300	BPM design	8 mons	01/09/21	13/04/22
WA10.0301	BPM prototyping	6 mons	13/04/22	28/09/22
WA10.0400	BLM design	8 mons	03/01/22	15/08/22
WA10.0401	BLM prototyping	6 mons	15/08/22	30/01/23
WA10.0501	ML data taking test	6 mons	02/01/23	19/06/23
WA10.0601	CCD Test in vacuum & under discharge	3 mons	10/10/22	30/12/22
WA10.0701	Design of micrometer resolution diagnostics	5 mons	12/01/23	31/05/23
M10.1	Diagnostic prototyping validation	0 w	24/04/23	24/04/23
M10.2	Final e-beam diagnostic design	0 w	09/10/23	09/10/23
M10.3	ML data taking final design	0 w	06/11/23	06/11/23

done
done
done
done
done

- It is worth mentioning that there are many other WAs that can impact on diagnostics, for instance machine layout, quadrupole development, plasma chamber and so on…
- From the point of view of diagnostics right now we are on schedule

Photon diagnostics main milestone

- *30/06/24 Preliminary Technical Design of the diagnostics*
  - *Now feasible with collaboration with CNR and internal LNF resources*