# AWAKE Run 2c beamlines: status and requirements

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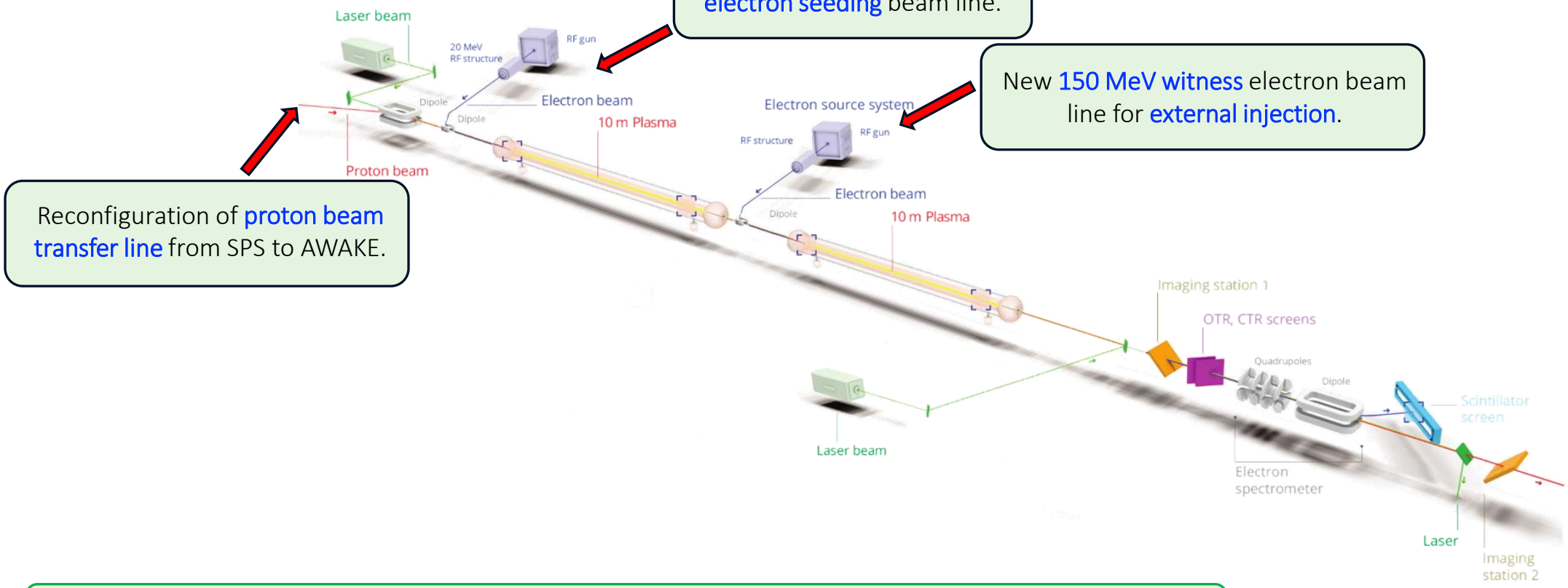
# Motivation

Run2c foresees several changes in experiment layout and beamlines configuration

Reconfiguration of 18 MeV electron seeding beam line.

New 150 MeV witness electron beam line for external injection.

Reconfiguration of proton beam transfer line from SPS to AWAKE.

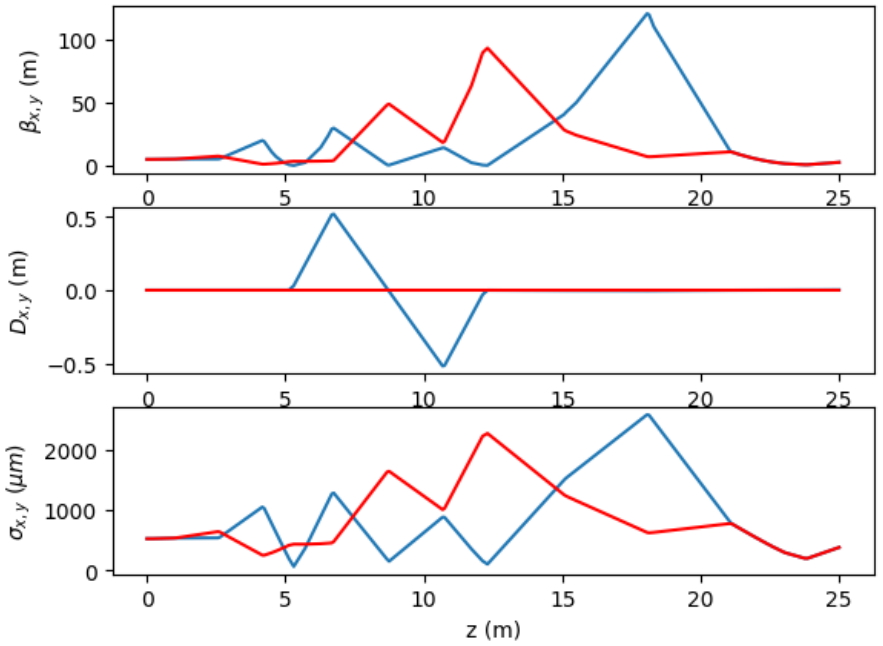



Design optimisation needed to match beam target experimental requirements

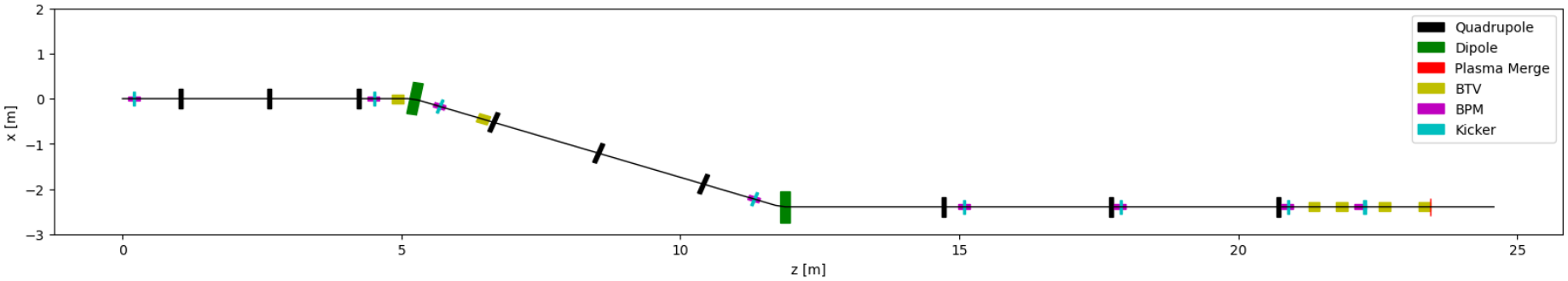
# 18 MeV electron line

Witness electron beamline would be used as seeding line for Run2c.

- New layout constrained by AWAKE tunnel geometry.
- Beamline design based on existing hardware.




| Parameter | Value |
|---|---|
| Momentum (MeV/c) | 18 |
| Rep. rate (Hz) | 10 |
| Bunch length (ps (mm)) | 4 (1.2) |
| Relative mom. Spread | 0.5 |
| Emittance r.m.s. norm. (mm mrad) | 2 |



# 18 MeV electron line

## Status

- Optics design finalized
- Layout integrated in 3D drawings
- Existing hardware ➔ No requirements for new developments

# 18 MeV electron line

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- Optics design finalized
- Layout integrated in 3D drawings
- Existing hardware ➔ No requirements for new developments

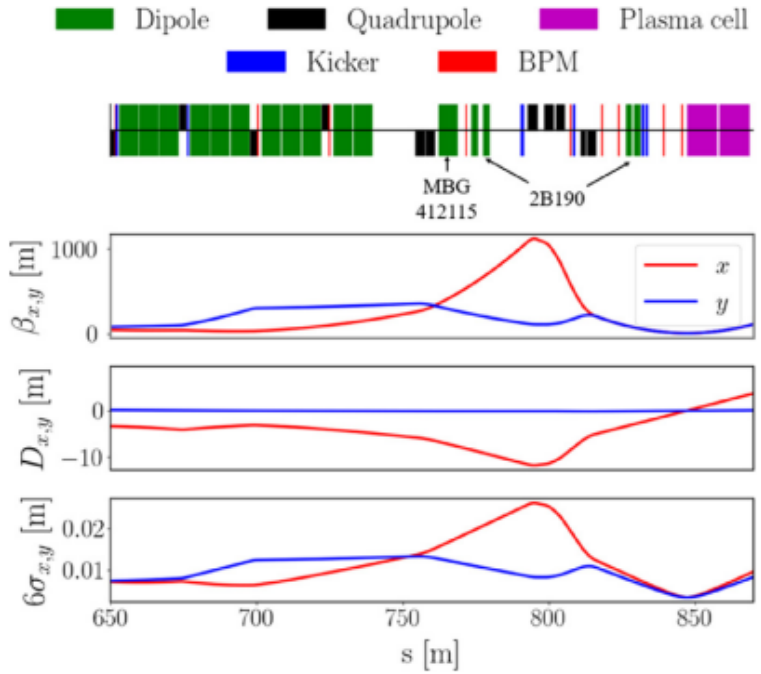
Requirements (PLAN Activity: 13958)

- **Vacuum (TE-VSC-IVO):** design, installation and commissioning of vacuum pipes and pumps for new configuration (same specs as existing line)
- **Vacuum (TE-VSC-ICM):** Procurement of vacuum controls
- **Cabling (EN-EL)**: New DC cables to connect to magnets in new positions.
- **Controls (BE-CEM-IN):** Update control system to include new functional positions.
- **Beam instrumentation (BI):** Move existing instrumentation
- **Survey and alignment (BE-GM-ASG):** Reference point definition
- **Magnets (TE-MSC):** Same magnets will be used. Need to manage the transport and re-installation
- **Supports and design office (EN-MME):** design new supports (height of beam line will be considerably different from present one)
- **Transport and handling (EN-HE-HH):** hardware transport.

# Proton line (TT41)

New experimental layout requires reconfiguration of proton transfer line

- Plasma cell position will be shifted of 40 m
- Design relies on existing magnets, to be re-organized to fit the new layout




| | Specifications | x-plane | y-plane |
|---|---|---|---|
| $\sigma_{x,y}$ $[\mu m]$ | 200 | 200.6 | 200.1 |
| $\beta_{x,y}$ $[\mu m]$ | 4.9 | 4.9 | 4.9 |
| $\alpha_{x,y}$ | 0.0 | 0.0 | 0.0 |
| $D_{x,y}$ $[m]$ | 0.0 | 0.0 | 0.0 |


[3] Ramjiawan, R., et al. "Design of the proton and electron transfer lines for AWAKE Run 2c." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 1049 (2023): 168094. (https://www.sciencedirect.com/science/article/pii/S0168900223000840)

# Proton line (TT41)

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- Optics design finalized
- Layout integrated in 3D drawings
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# Proton line (TT41)

Status

- Optics design finalized
- Layout integrated in 3D drawings
- Existing hardware ➔ No requirements for new developments

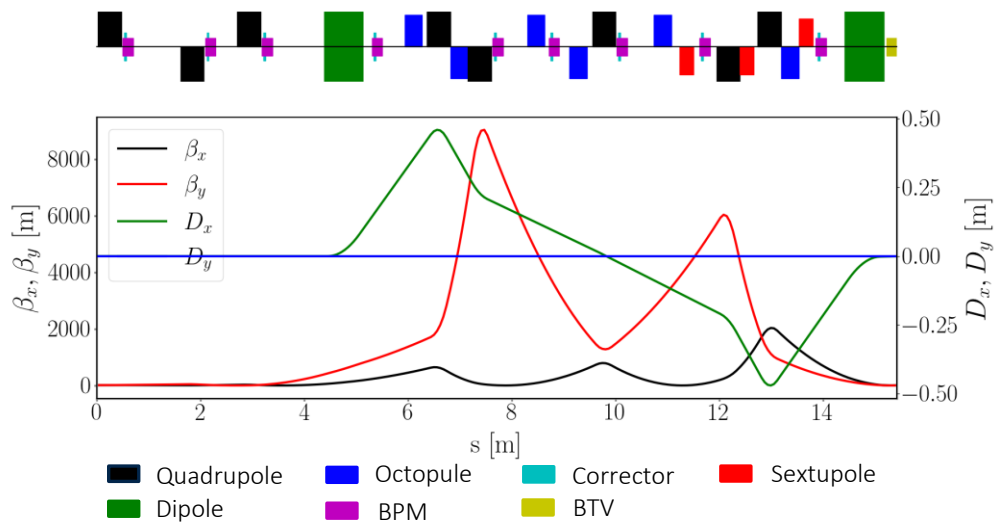
Requirements (PLAN Activity: 13964)

- **Vacuum (TE-VSC-IVO):** design, installation and commissioning of vacuum pipes and pumps for new configuration (same specs as existing line)
- **Vacuum (TE-VSC-ICM):** Procurement of vacuum controls
- **Cabling (EN-EL)**: Extension of DC cables to match new magnets positions
- **Beam instrumentation (BI):** Move existing instrumentation
- **Survey and alignment (BE-GM-ASG):** Reference point definition
- **Magnets (TE-MSC):** Same magnets will be used. Need to manage the transport and re-installation
- **Supports and design office (EN-MME):** design new supports (height of beam line will be considerably different from present one)
- **Transport and handling (EN-HE-HH):** hardware transport.

# 150 MeV line

New witness electron beamline will be used to perform external injection in second plasma.

- Beam requirements at the forefront of technological state-of-the-art.
- Design involved a combination of advanced numerical optimization techniques. [2]
- Sextupoles and octupoles essential to compensate for high order effects and achieve design parameters.
- Space charge and synchrotron radiation effects considered in simulation. [3]




| | Specifications | x-plane | y-plane |
|---|---|---|---|
| $\sigma_{x,y}$ $[\mu m]$ | 5.75 | 5.62 | 6.15 |
| $\sigma_z$ $[\mu m]$ | 60 | 58.96 | |
| $\varepsilon_{x,y}$ $[\mu m]$ | 2 | 2.2 | 2.3 |
| $\alpha_{x,y}$ | 0.0 | 0.0 | 0.0 |
| $D_{x,y}$ $[m]$ | 0.0 | 0.0 | 0.0 |


[2] Ramjiawan, R., et al. "Design and operation of transfer lines for plasma wakefield accelerators using numerical optimizers." *Physical Review Accelerators and Beams* 25.10 (2022): 101602. (https://journals.aps.org/prab/abstract/10.1103/PhysRevAccelBeams.25.101602)
[3] Ramjiawan, R., et al. "Design of the proton and electron transfer lines for AWAKE Run 2c." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 1049 (2023): 168094. (https://www.sciencedirect.com/science/article/pii/S0168900223000840)

# 150 MeV line – status

Status

- Optics design finalized, but:
  - Possible integration issue may require to reduce the bending angle from 15 to 13.8 degrees to accommodate safety passage in the tunnel. Second option under study
  - Details about the plasma cells and the injection region have still to be defined. This could affect the final design.
- Layout integrated in 3D drawing ongoing.

# 150 MeV line – requirements

Requirements (PLAN Activity: 13958):

- **Vacuum (TE-VSC-IVO):** design, installation and commissioning of vacuum pipes and pumps for new configuration (same specs as existing line)
- **Vacuum (TE-VSC-ICM):** Procurement of vacuum controls
- **Power converters (SY-EPC):** brand new power converters (MEXICO family).
- **Cabling (EN-EL):** DC cables, AC distribution, control cables (tickets open)
- **Controls (BE-CEM-IN):** control infrastructure to be developed. A total of ~30 magnets to be controlled
- **Beam instrumentation (BI):** Request for screens, BPMs (40 mm and 60 mm), bunch length monitor, 1 high resolution screen (~5um beam size measurement)
- **Survey and alignment (BE-GM-ASG):** static alignment 50/100 um (to be verified). Need for mechanical movers
- **Movers (BE-GM-HPA):** UAP system to move each magnet separately with 1 um accuracy and step
- **Magnets (TE-MSC):** Quadrupoles, octupoles, sextupoles, dipoles, correctors to be designed.
- **Supports and design office (EN-MME):** design new supports (height of beam line will be considerably different from present one).
- **Transport and handling (EN-HE-HH):** hardware transport.