

The next AWAKE runs: technological advancements, scientific merit, and expected parameter reach

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FÜR PHYSIK

Summary & Conclusions

- **AWAKE is on schedule and achieved all milestones**
 - Run 1 - Run 2a programs complete
 - + many additional physics/technology studies performed
 - First promising results on Run 2b
- **AWAKE scientific results**
 - Impact the wakefield community
 - Lead to many publications in high impact journals
 - Almost all of them have early-career researchers as first authors

• **Self-modulator demonstrated** after Run 2b (2024)

Wakefield physics questions specific to the resonant excitation scheme

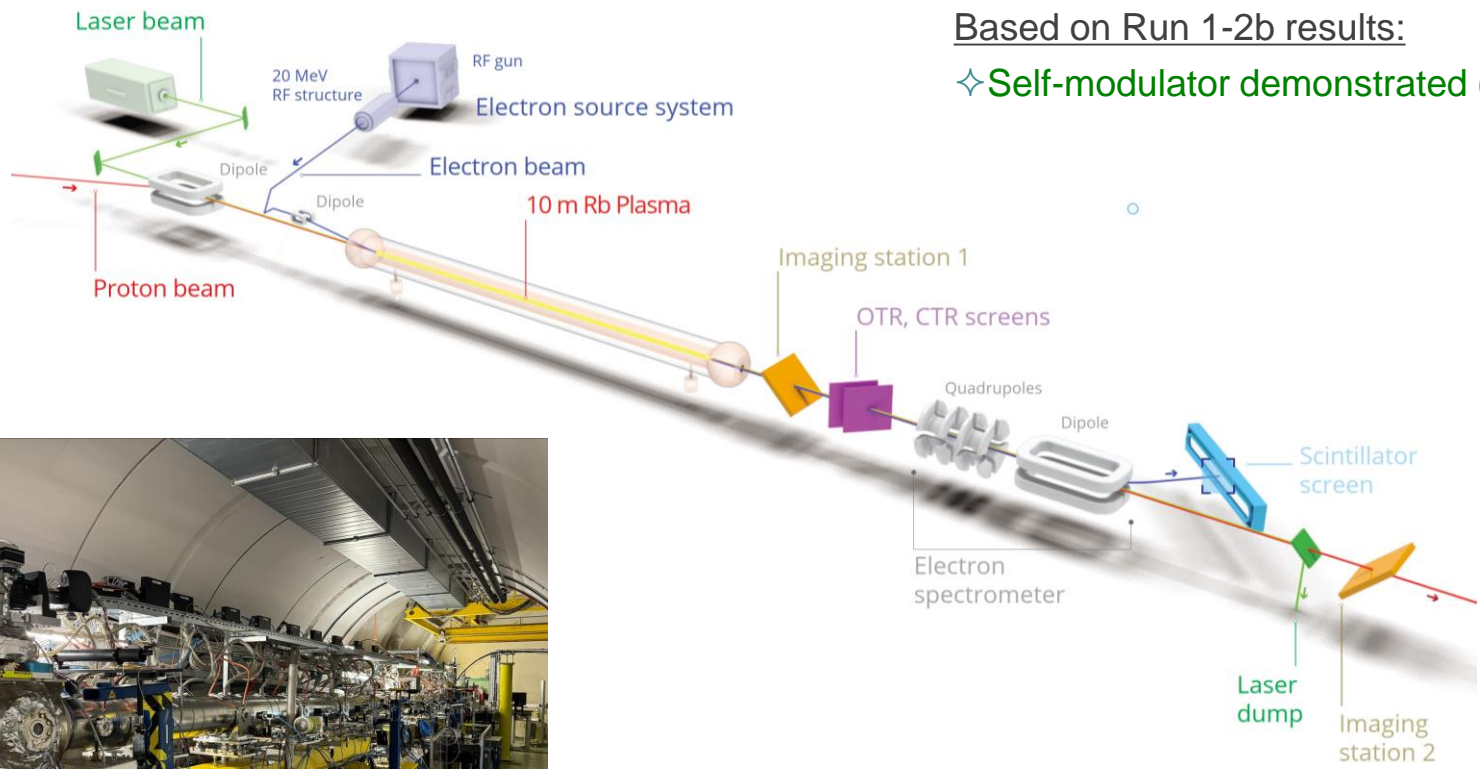
- **Driver preparation** → Self-modulation ✓
- **Wakefield control** → Seeding ✓
- **Witness acceleration** → External injection ✓
- **Maintain wakefields** → Density step

- **Quality** → can the quality of the accelerated bunch be controlled? → Run 2c
- **Scalability** → can the acceleration be scaled? → Run 2d

- ✧ Plan for Run 2c,d based on successful Run 1,2a,b results (Edda, Marlene)
- ✧ Clear and solid plan towards a scalable acceleration system
 - ✧ develop all technical components required
- ✧ Identify challenges:
 - ✧ baseline plan for Run 2c
 - ✧ explore options for Run 2d
- ✧ Plan:
 - ✧ ambitious and challenging, but no showstopper identified
 - ✧ includes numerous topics relevant to all plasma-based accelerators (HEP)
 - ✧ Includes technological developments
 - ✧ aim at parameters for fixed target experiments with e^-

- ✧ Goal: propose particle physics experiments in 2030's

RUN 1,2a,b: SELF-MODULATOR FOR RUN 2c,d

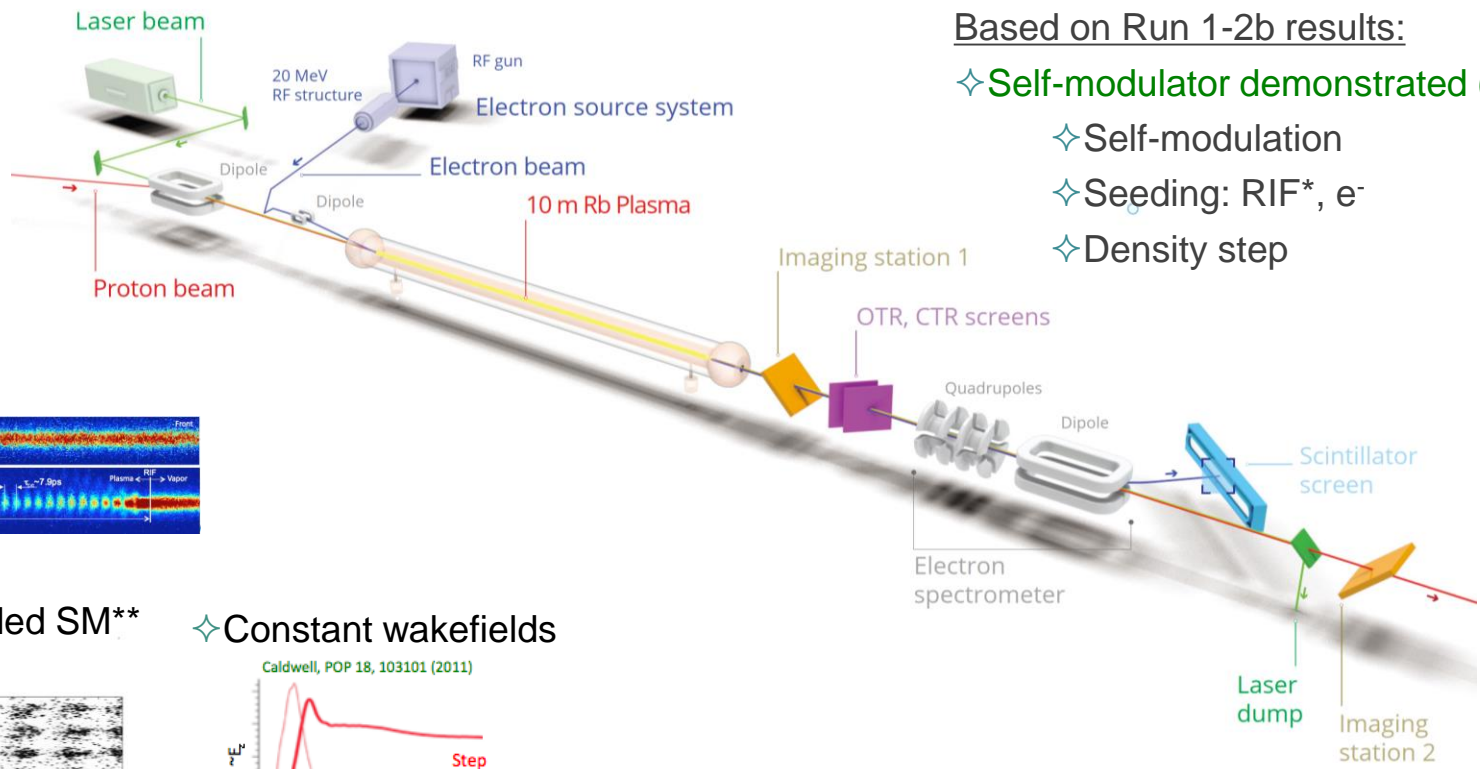


Based on Run 1-2b results:

✦ Self-modulator demonstrated (Marlene)

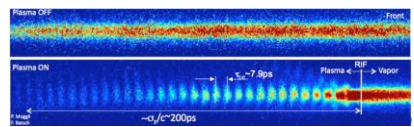


RUN 1,2a,b: SELF-MODULATOR FOR RUN 2c,d

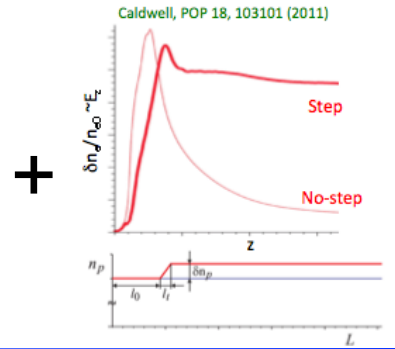
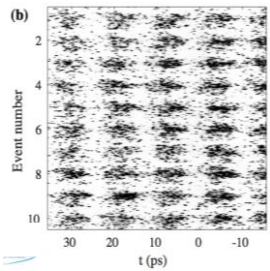


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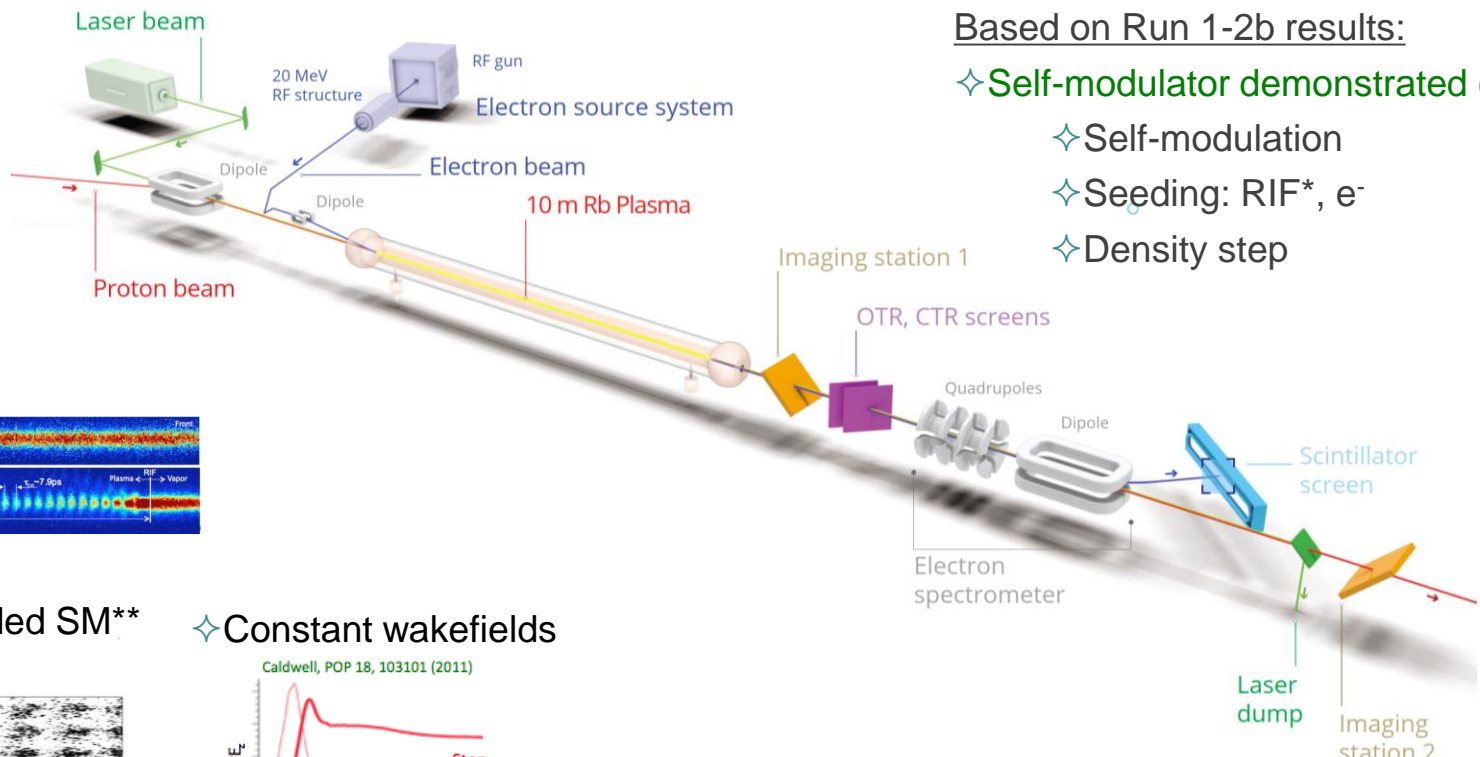
- ✧ Self-modulator demonstrated (Marlene)
- ✧ Self-modulation
- ✧ Seeding: RIF*, e⁻
- ✧ Density step



- ✧ Seeded SM**
- ✧ Constant wakefields

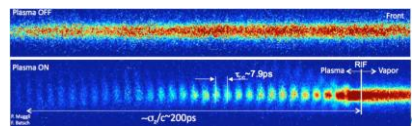


RUN 1,2a,b: SELF-MODULATOR FOR RUN 2c,d

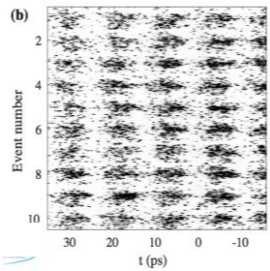


Based on Run 1-2b results:

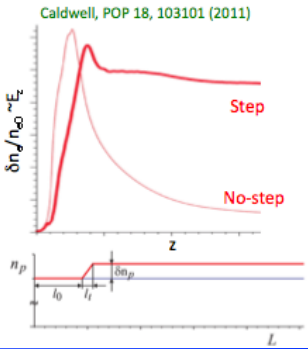
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- ✧ Density step



✧ Seeded SM**

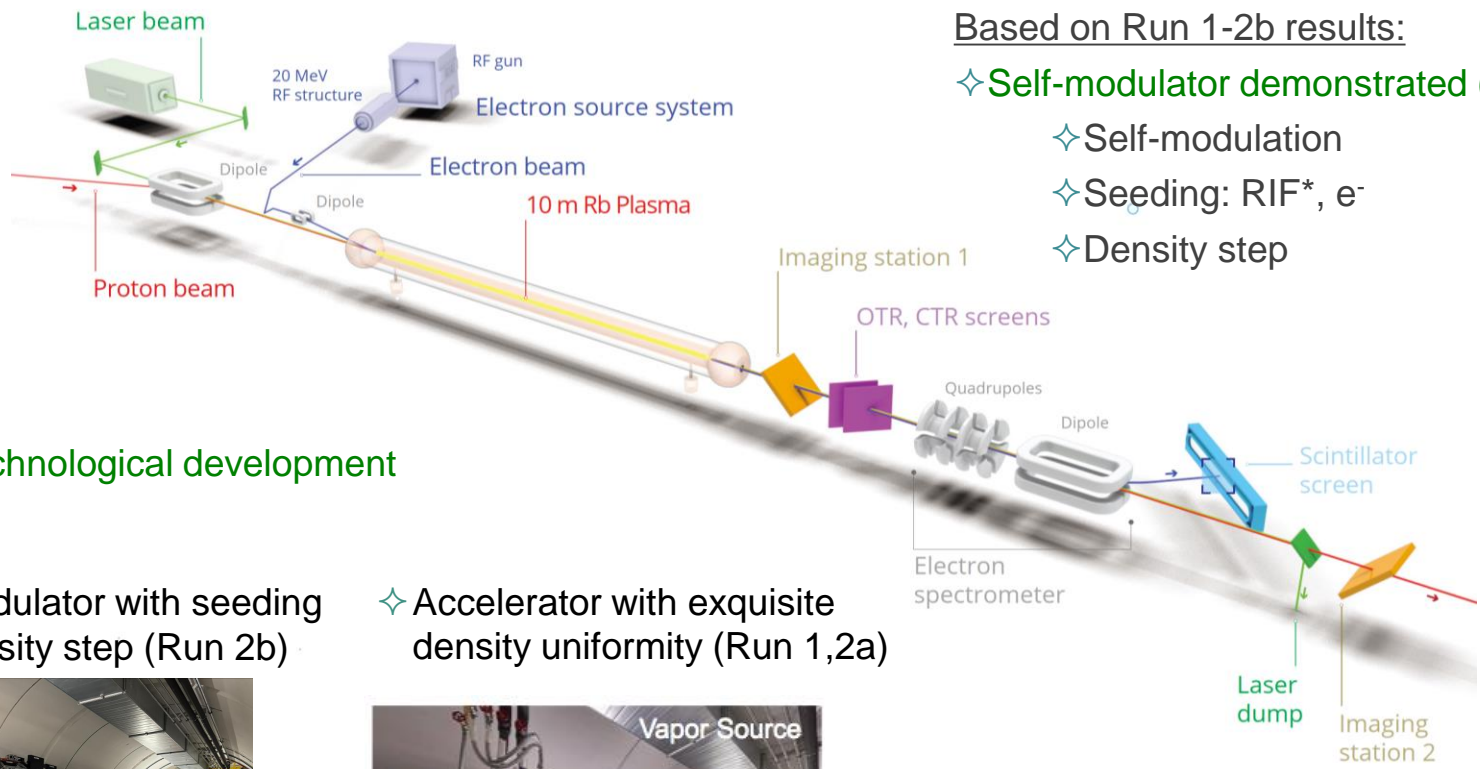


✧ Constant wakefields



- ✧ Self-modulated p⁺ bunch
- ✧ Driver for long accelerator
- ✧ Run 2c,d, applications

RUN 1,2a,b: SELF-MODULATOR FOR RUN 2c,d



Based on Run 1-2b results:

- ✧ Self-modulator demonstrated (Marlene)
- ✧ Self-modulation
- ✧ Seeding: RIF*, e⁻
- ✧ Density step

✧ Major technological development

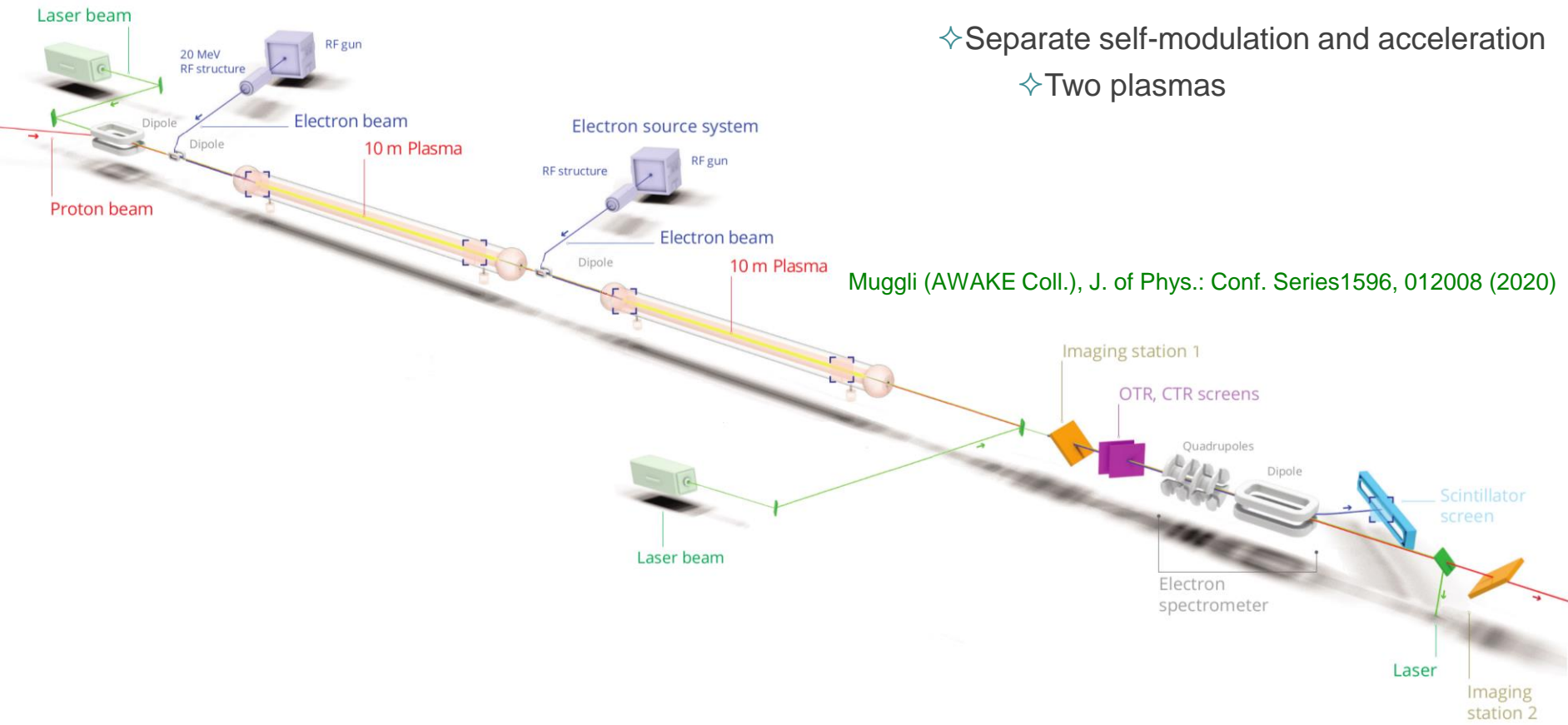
✧ Self-modulator with seeding and density step (Run 2b)



✧ Accelerator with exquisite density uniformity (Run 1,2a)



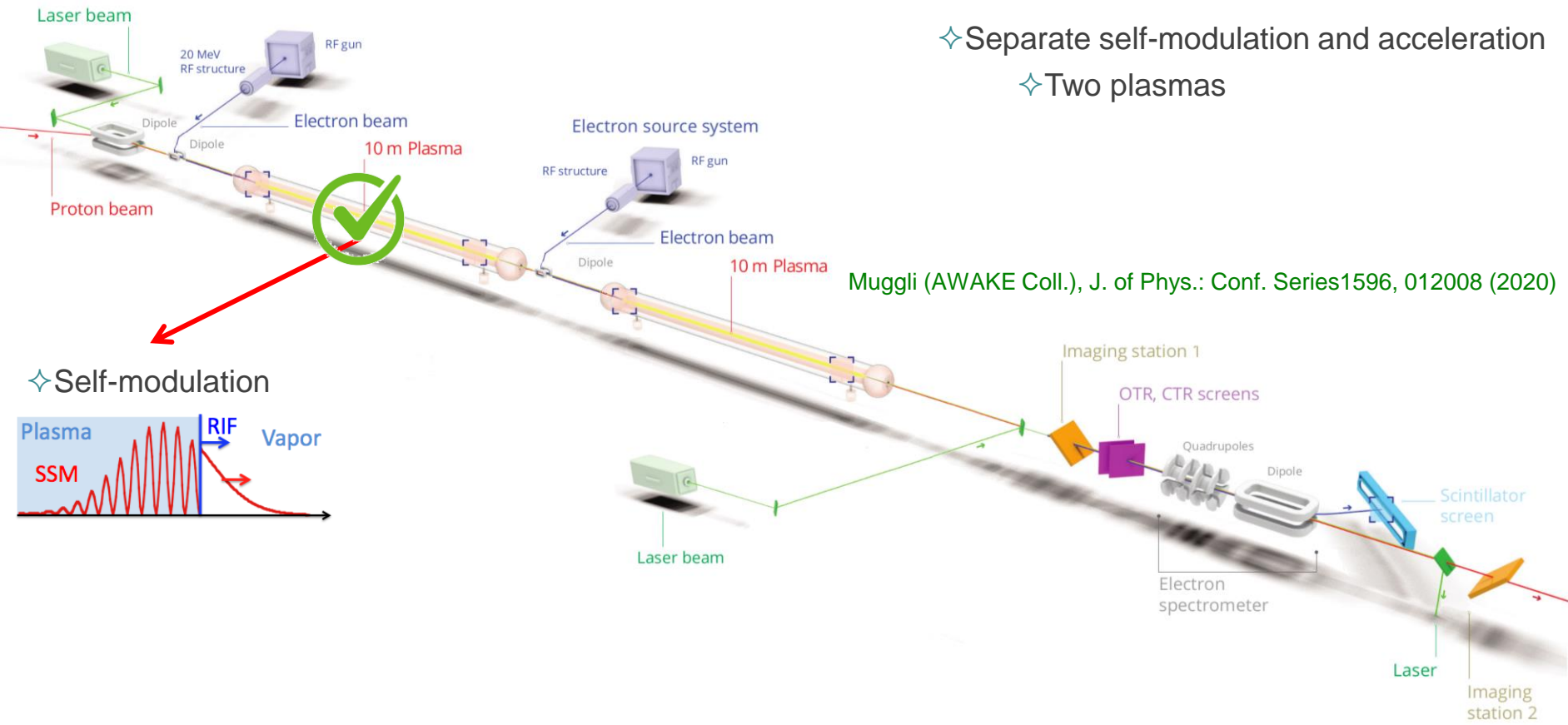
RUN 2c,d: ACCELERATE AN e⁻ BUNCH, QUALITY



- ✧ Separate self-modulation and acceleration
- ✧ Two plasmas

Muggli (AWAKE Coll.), J. of Phys.: Conf. Series 1596, 012008 (2020)

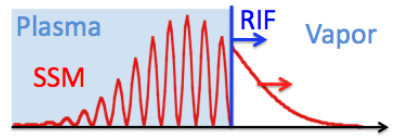
RUN 2c,d: ACCELERATE AN e⁻ BUNCH, QUALITY



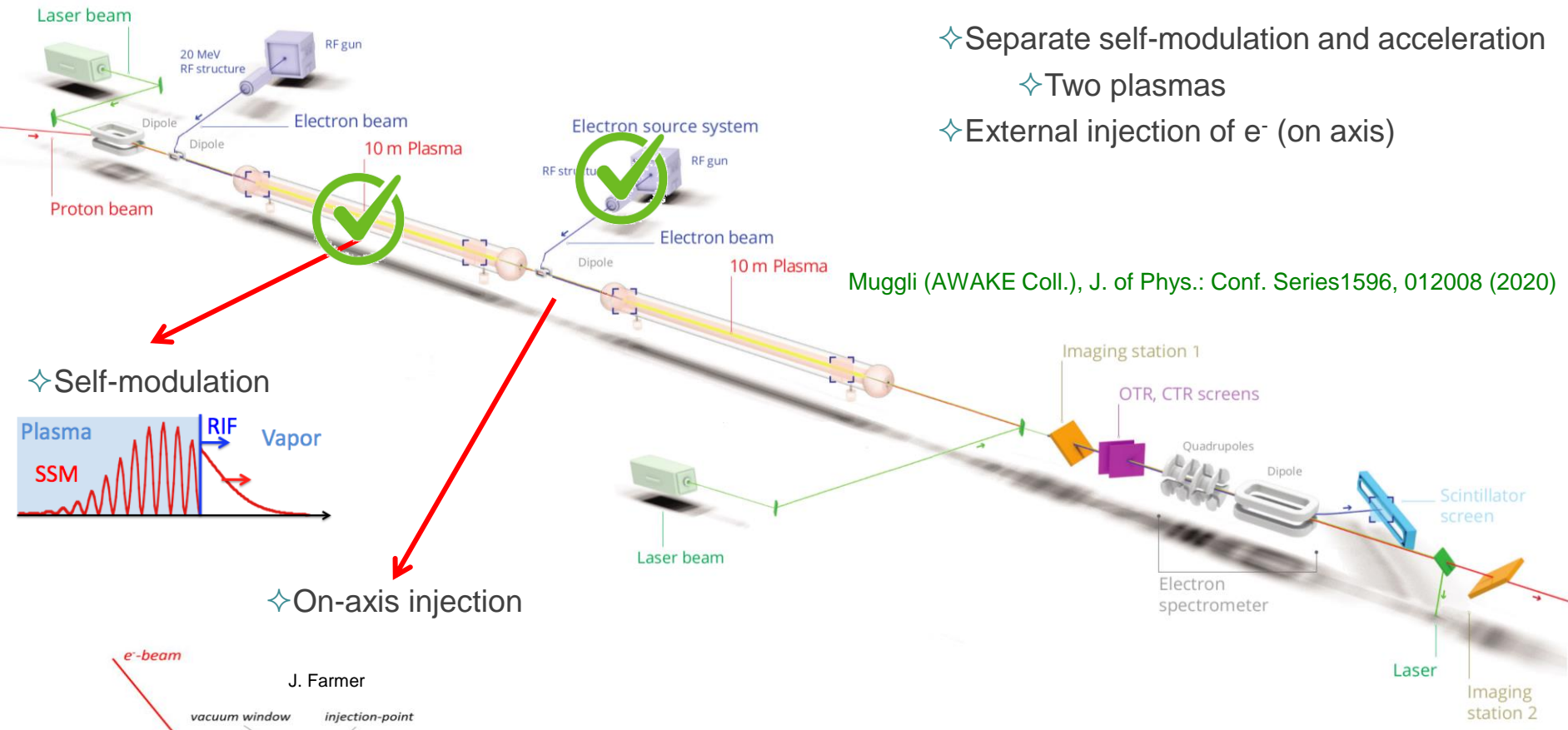
- ✧ Separate self-modulation and acceleration
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Muggli (AWAKE Coll.), J. of Phys.: Conf. Series 1596, 012008 (2020)

✧ Self-modulation

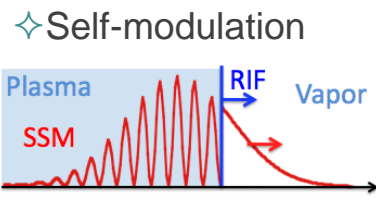


RUN 2c,d: ACCELERATE AN e⁻ BUNCH, QUALITY



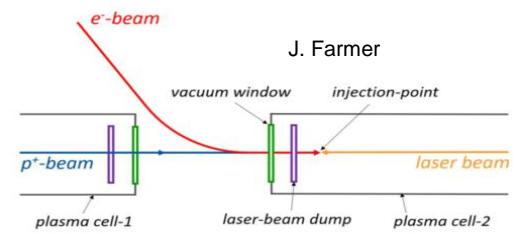
- ✧ Separate self-modulation and acceleration
- ✧ Two plasmas
- ✧ External injection of e⁻ (on axis)

Muggli (AWAKE Coll.), J. of Phys.: Conf. Series 1596, 012008 (2020)



✧ Self-modulation

✧ On-axis injection



J. Farmer

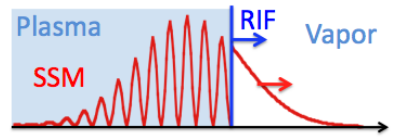
RUN 2c,d: ACCELERATE AN e⁻ BUNCH, QUALITY



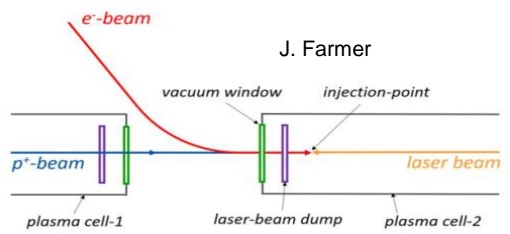
- ✧ Separate self-modulation and acceleration
- ✧ Two plasmas
- ✧ External injection of e⁻ (on axis)
- ✧ Bunch quality sufficient for applications

Muggli (AWAKE Coll.), J. of Phys.: Conf. Series 1596, 012008 (2020)

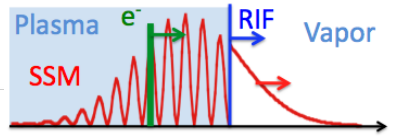
✧ Self-modulation



✧ On-axis injection

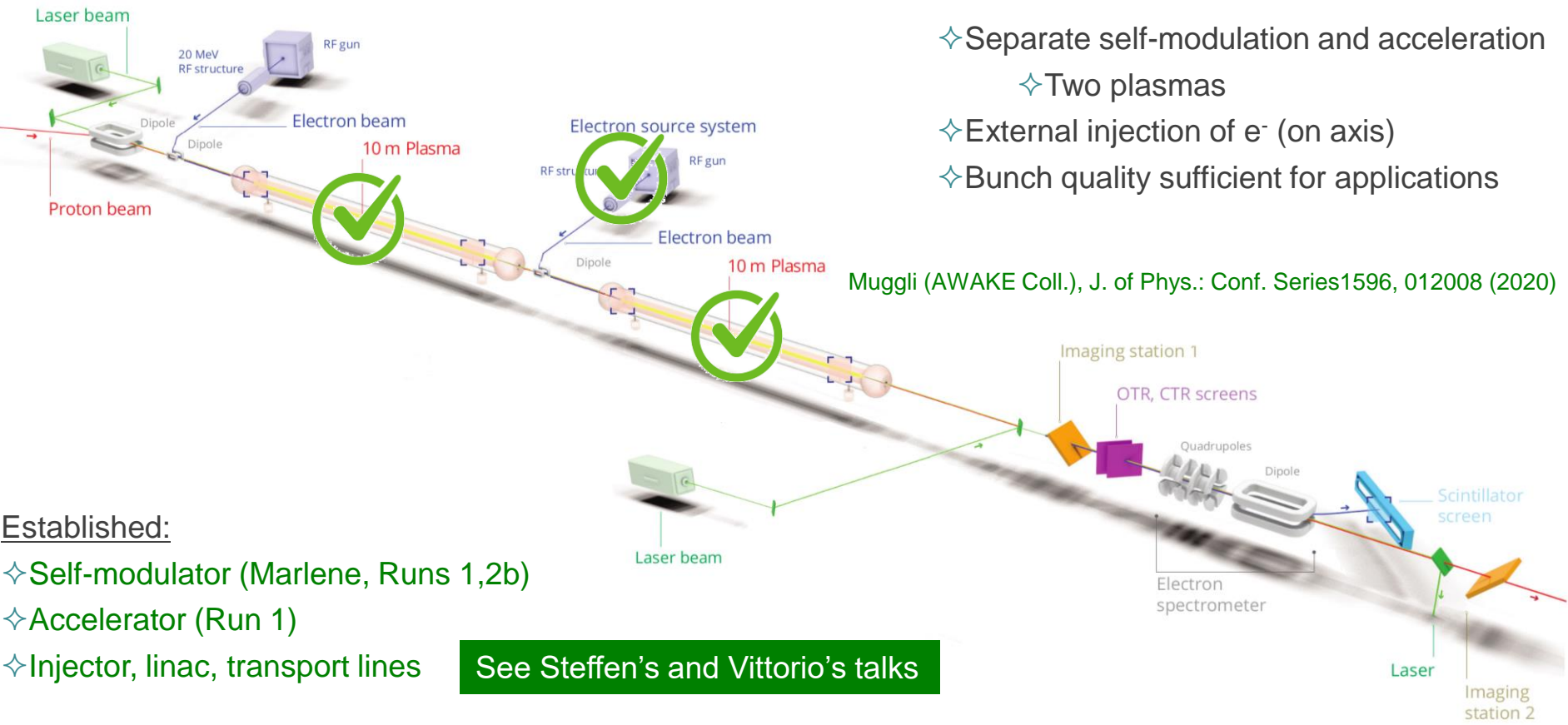


✧ Acceleration



✧ Quality

RUN 2c: e⁻-EXTERNAL INJECTION EXPERIMENT



- ✧ Separate self-modulation and acceleration
 - ✧ Two plasmas
- ✧ External injection of e⁻ (on axis)
- ✧ Bunch quality sufficient for applications

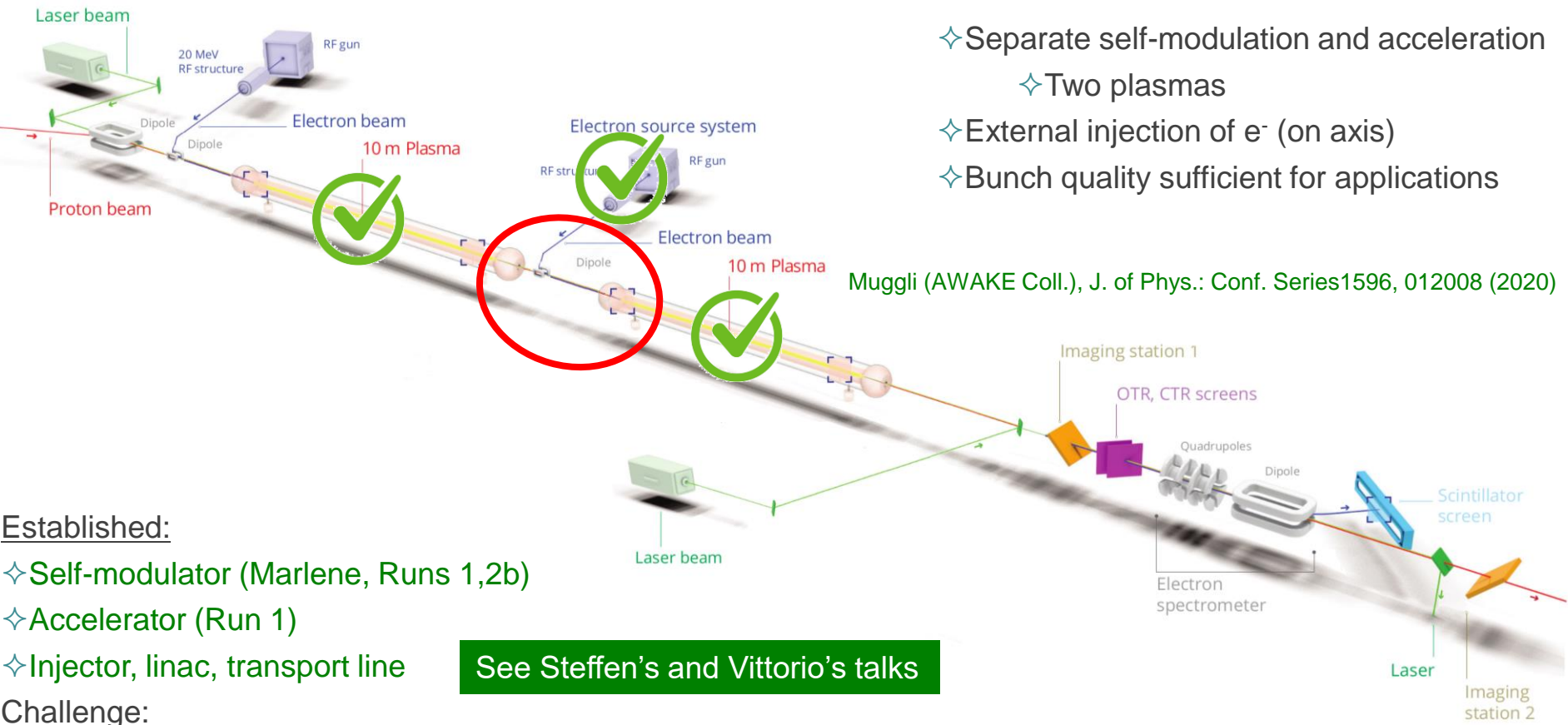
Muggli (AWAKE Coll.), J. of Phys.: Conf. Series 1596, 012008 (2020)

Established:

- ✧ Self-modulator (Marlene, Runs 1,2b)
- ✧ Accelerator (Run 1)
- ✧ Injector, linac, transport lines

See Steffen's and Vittorio's talks

RUN 2c: e⁻-EXTERNAL INJECTION EXPERIMENT



- ✧ Separate self-modulation and acceleration
- ✧ Two plasmas
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Muggli (AWAKE Coll.), J. of Phys.: Conf. Series 1596, 012008 (2020)

Established:

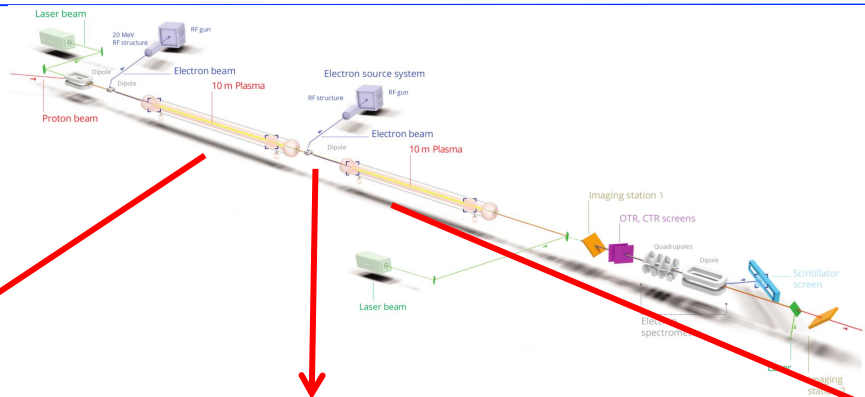
- ✧ Self-modulator (Marlene, Runs 1,2b)
- ✧ Accelerator (Run 1)
- ✧ Injector, linac, transport line

See Steffen's and Vittorio's talks

Challenge:

- ✧ Injection region
 - ✧ alignment, p⁺ and e⁻ beams

FUNCTIONS FOR RUN 2c,d



Self-modulator:

- ❖ Seeding of SM, reproducible
- ❖ Density step: $E_z(z)=\text{constant}$

Injection:

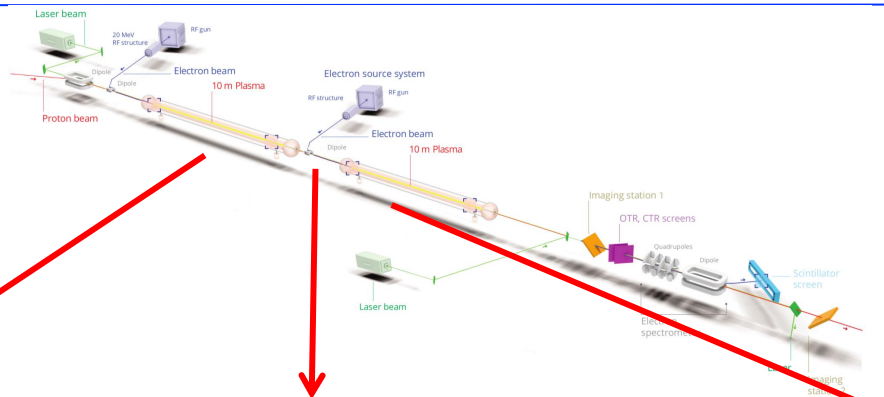
- ❖ Matching e-bunch to plasma focusing
 - ❖ Blow-out or quasi-linear
- ❖ Alignment e-/p+ beams

Accelerator:

- ❖ Density uniformity
 - ❖ $\Delta n_e/n_{e0} < 0.25\%$

Density tuning

RUN 2c BASELINE



Self-modulator:

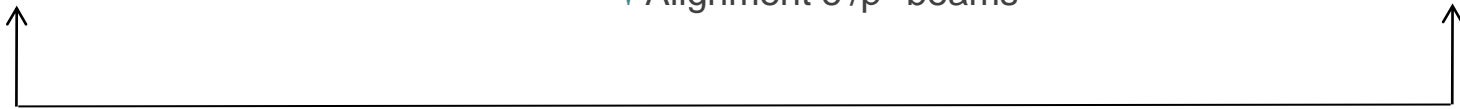
- ❖ Seeding of SM, reproducible
- ❖ Density step: $E_z(z)=\text{constant}$

Injection:

- ❖ Matching e-bunch to plasma focusing
 - ❖ Blow-out or quasi-linear
- ❖ Alignment e⁻/p⁺ beams

Accelerator:

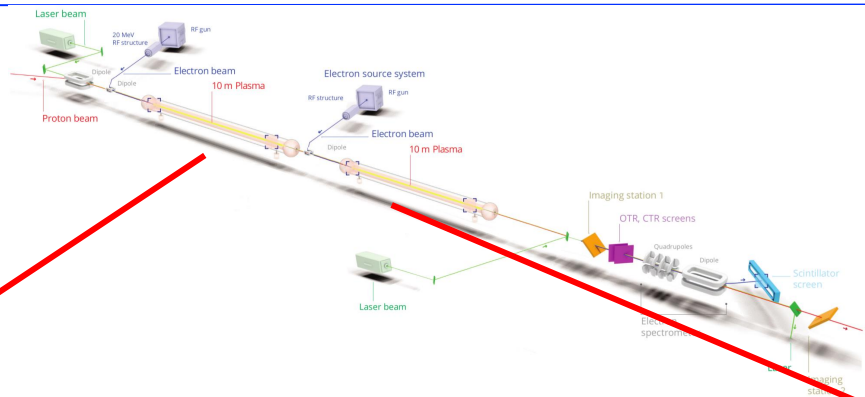
- ❖ Density uniformity
 - ❖ $\Delta n_e/n_{e0} < 0.25\%$



Density tuning



PARAMETERS RUN 2c: RUBIDIUM PLASMA



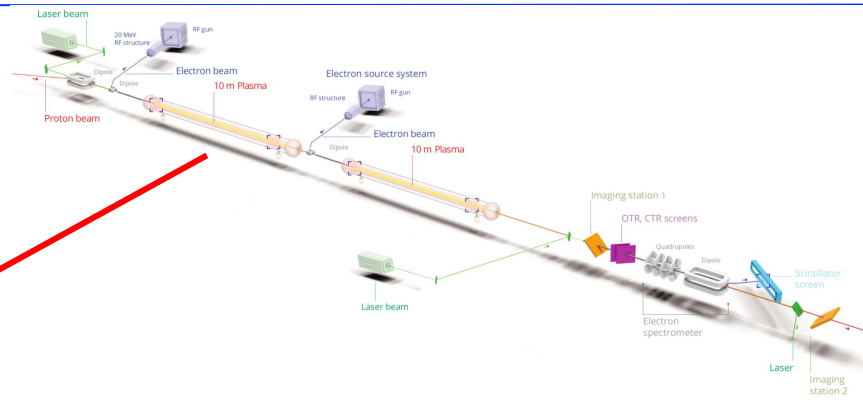
Self-modulator:

- ✧ Rubidium
- ✧ $L=10\text{m}$
- ✧ $n_{e0}=7 \times 10^{14} \text{cm}^{-3}$ ($\sigma_{r0}=200\mu\text{m}$)
- ✧ Seeding
- ✧ Adjustable density step z , $\Delta n_e/n_{e0}$
- ✧ Technological advancement

Accelerator:

- ✧ Rubidium
 - ✧ $L=10\text{m}$
 - ✧ $n_{e0}=7 \times 10^{14} \text{cm}^{-3}$, adjustable
 - ✧ Uniform ($\Delta n_e/n_{e0} < 0.25\%$)
 - ✧ Backward ionization
- ✧ Similar to Run 1,2a,b
 - ✧ Thermal systems for rubidium vapor n_{Rb}
 - ✧ $\Delta T_{\text{source}}(0.1-0.5)^\circ\text{C}$ @ 230°C or 500K
 - ✧ Laser ionization (100% $\text{RbI} \rightarrow \text{RbII}$)
 - ✧ $n_{e0}=n_{\text{Rb}}(T_{\text{source}})$
 - ✧ $\Delta n_{e0}/n_{e0} \sim 0.1\%$ (tunability)

PARAMETERS RUN 2c: SEEDING



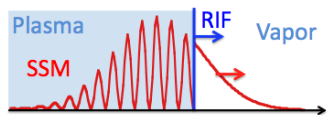
Self-modulator:

- ❖ RIF* seeding

- ❖ simple

- ❖ leaves head of the bunch un-modulated → unstable in ACC'or?

- ❖ Run 2 a,b: NO L. Verra et al., (AWAKE Collab.) Phys. Plasmas 30, 083104 (2023)

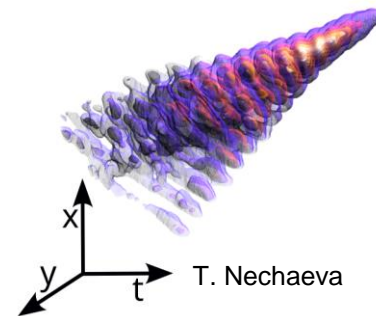
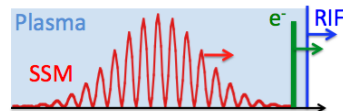


- ❖ e-bunch seeding

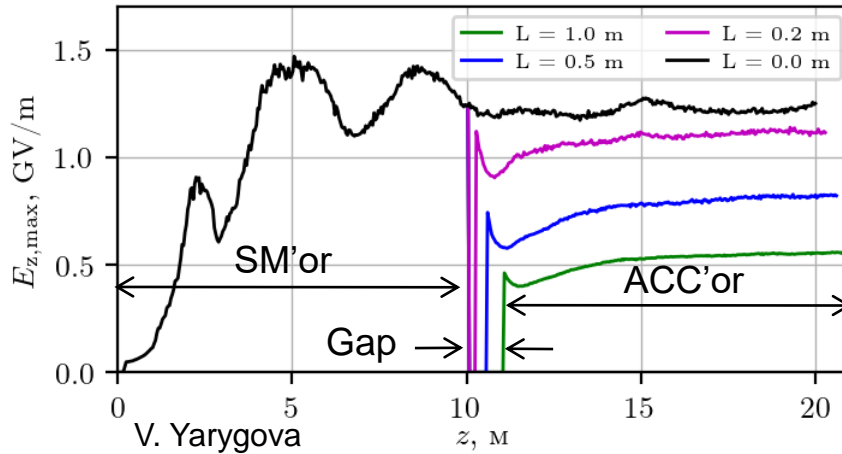
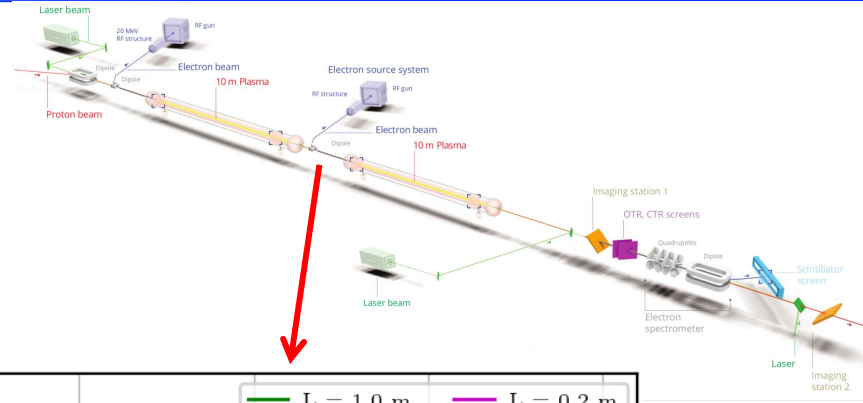
- ❖ entire p+ bunch self-modulated

- ❖ induces hosing when misalignment

T. Nechaeva et al., (AWAKE Collab.) accepted, Phys. Rev. Lett.



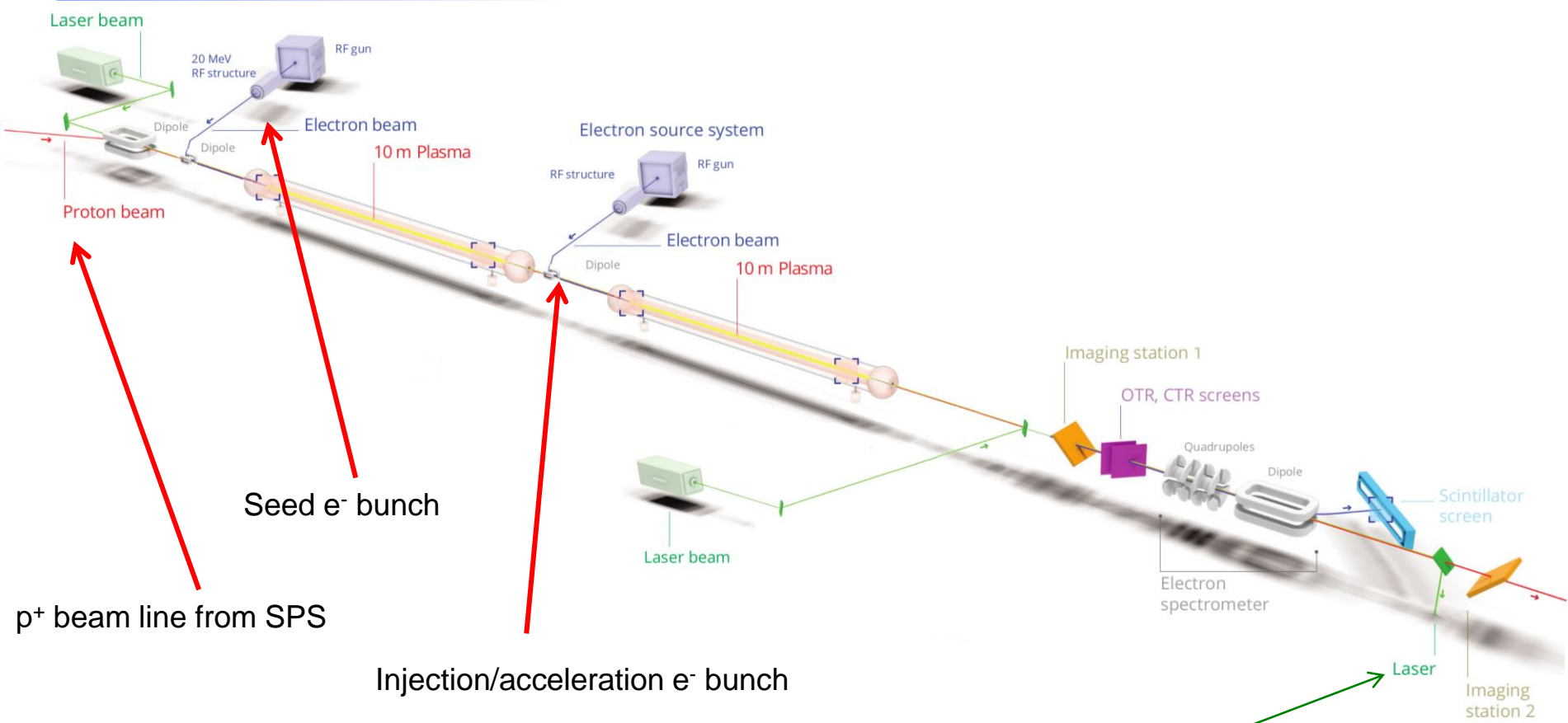
PARAMETERS RUN 2c: GAP BETWEEN PLASMAS



See John's talk

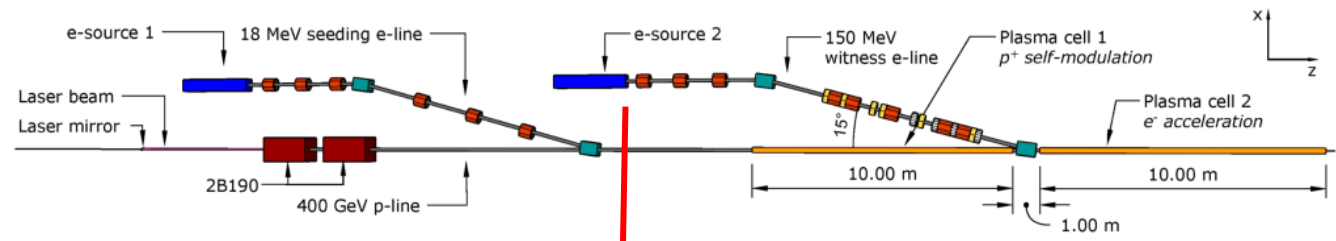
- ✧ Continuous transverse evolution of the p+ bunch in the (no plasma, vacuum) gap
- ✧ Must minimize gap length to maximize wakefields
- ✧ Integration

BASE LINE, RUN 2c: INJECTOR(S)



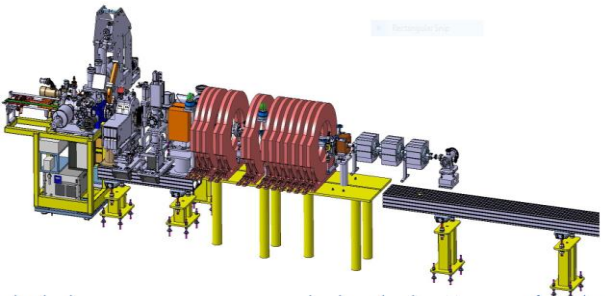
- ◇ All designed
- ◇ ... and laser beam lines ...E. Granados

BASE LINE, RUN 2c: INJECTOR(S), DESIGNED



Injector:

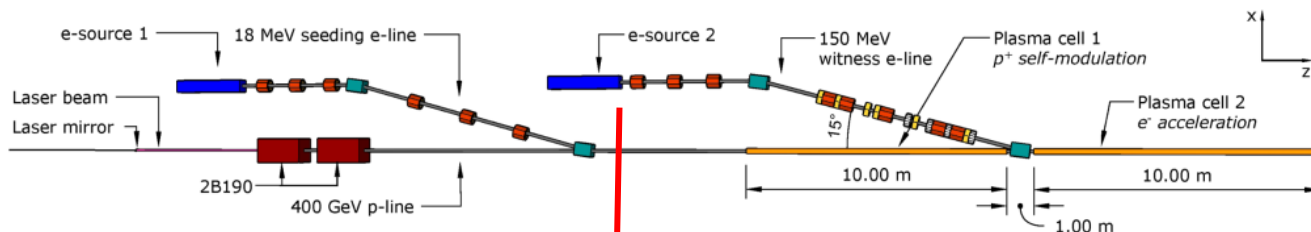
- ◇ RF-Injector + Transfer line
- ◇ Reproducibility
- ◇ Tunability
- ◇ Expertise at CERN
- ◇ Technological advancement
 - ◇ compact
 - ◇ high-gradient
 - ◇ other applications ...



In the lab!



BASE LINE, RUN 2c: INJECTOR(S), DESIGNED

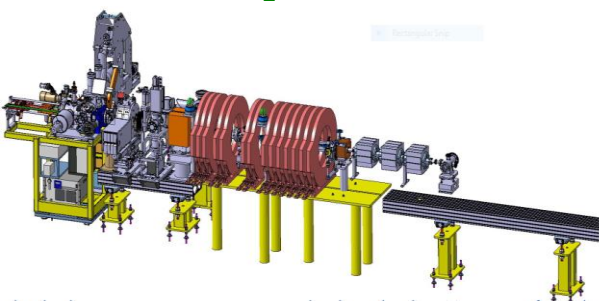


◇ Bunch parameters:

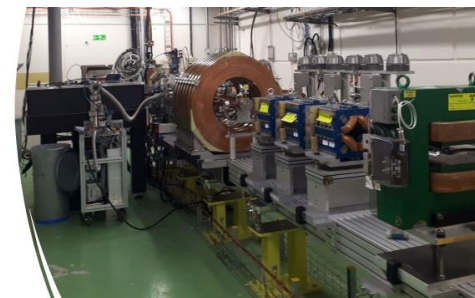
- ◇ $E=150\text{MeV}$
- ◇ $Q=100\text{pC}$
- ◇ $\epsilon_N=2\text{mm-mrad}$
- ◇ $\sigma_z=60\mu\text{m}$

◇ Injector:

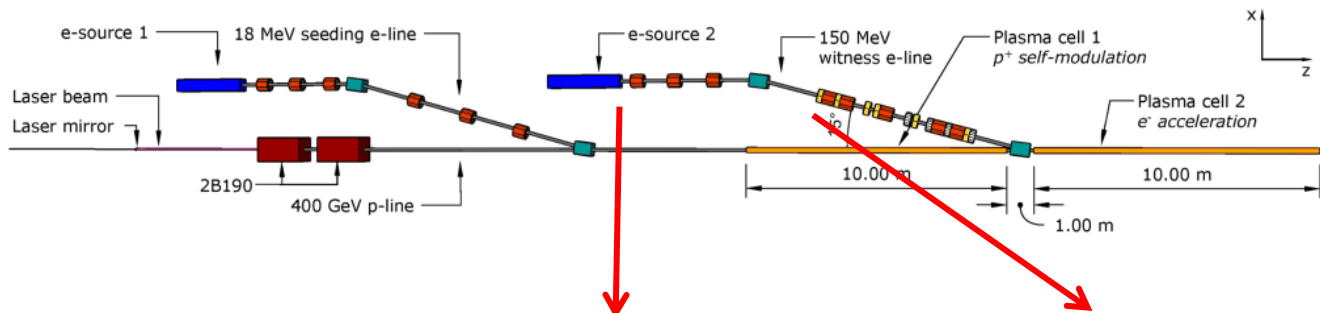
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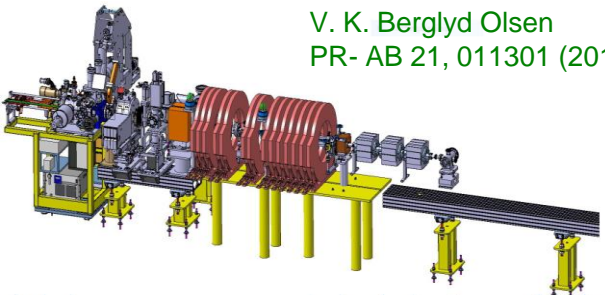
BASE LINE, RUN 2c: INJECTOR(S), DESIGNED



◇ Bunch parameters:

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V. K. Berglyd Olsen
PR- AB 21, 011301 (2018)



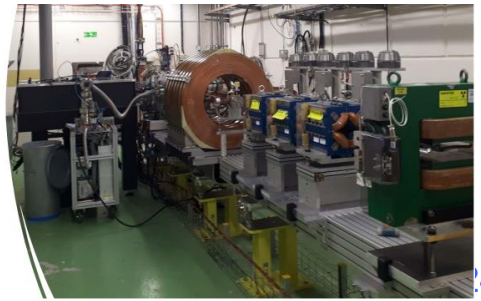
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Transport lines:

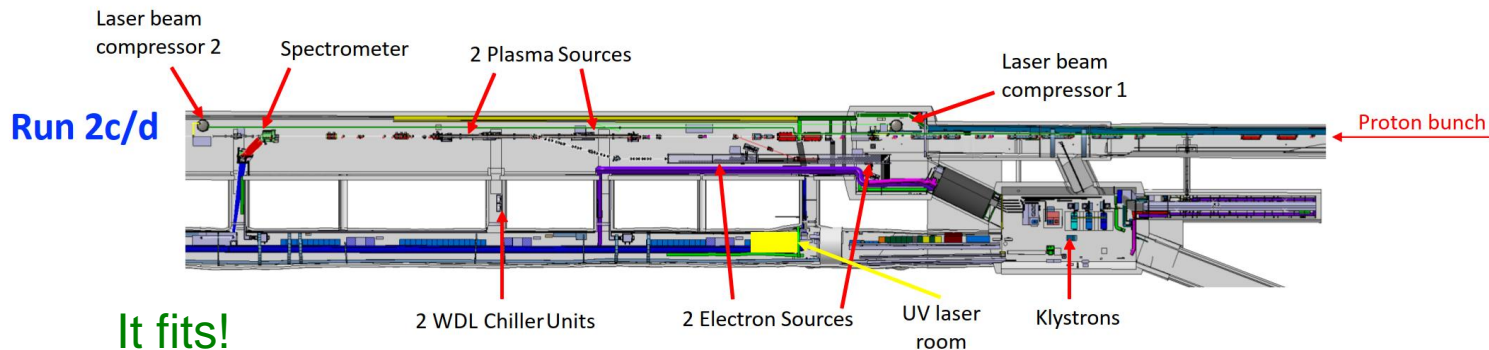
- ◇ p^+ , e-seed, e-injection
- ◇ Designed

In the lab!



See Steffen's and Vittorio's talks

BASE LINE, RUN 2c: INJECTOR(S), DESIGNED

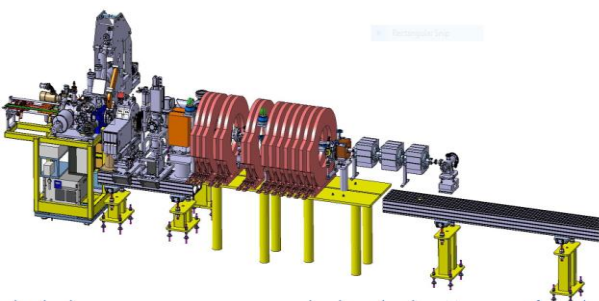


Injector:

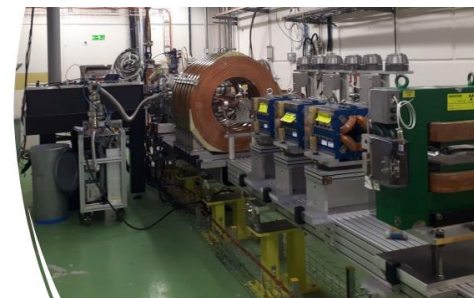
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Transport lines:

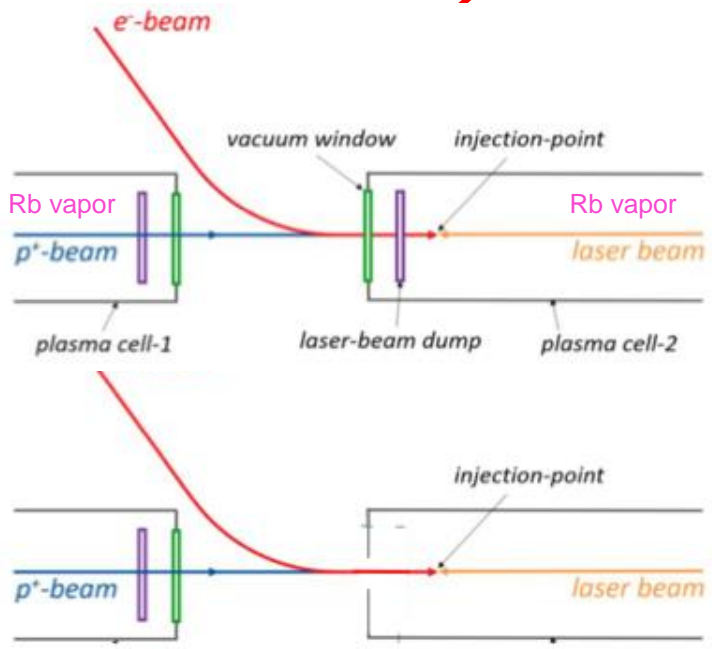
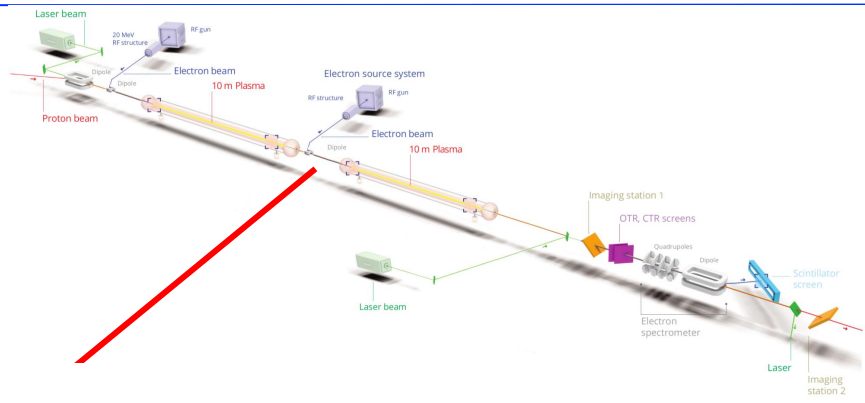
- ◇ p⁺, e-seed, e-injection
- ◇ Designed



In the lab!



RUN 2c: INJECTION REGION



❖ Foils

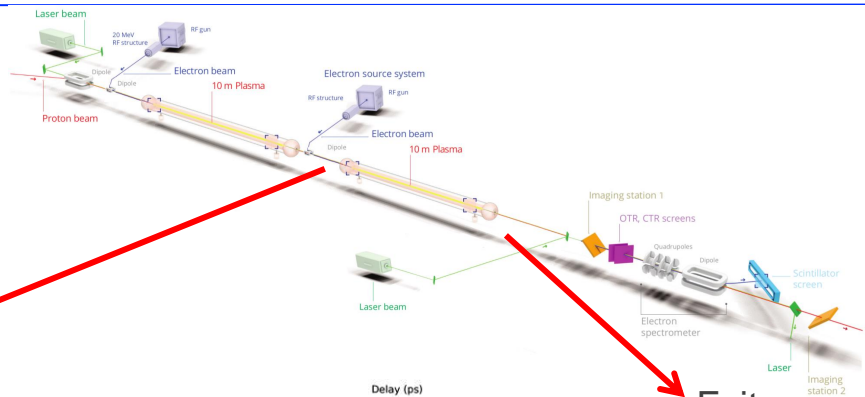
❖ emittance growth, $\epsilon_N=2 \rightarrow 16 \text{mm-mrad}$

❖ No foil

❖ expansion volume

❖ no emittance growth, $\epsilon_N=2 \text{mm-mrad}$

PARAMETERS RUN 2c: INJECTION/ACCELERATION ATWAKE



Entrance:

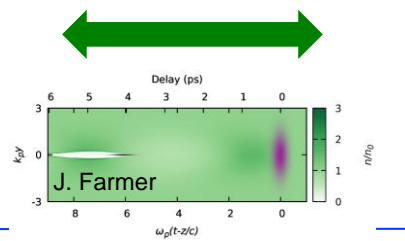
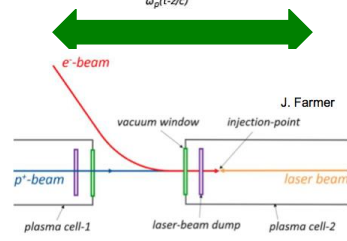
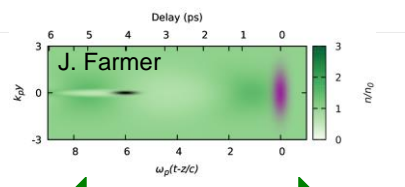
✧ $E=150\text{MeV}$, $\sigma_z=60\mu\text{m}$, $Q=100\text{pC}$

✧ “High emittance”, foils

- ✧ $\epsilon_N=16\text{mm-mrad}$
- ✧ $\sigma_{r,\text{matched}}=26\mu\text{m}$

✧ “Low emittance”, no foil

- ✧ $\epsilon_N=2\text{mm-mrad}$
- ✧ $\sigma_{r,\text{matched}}=6\mu\text{m}$



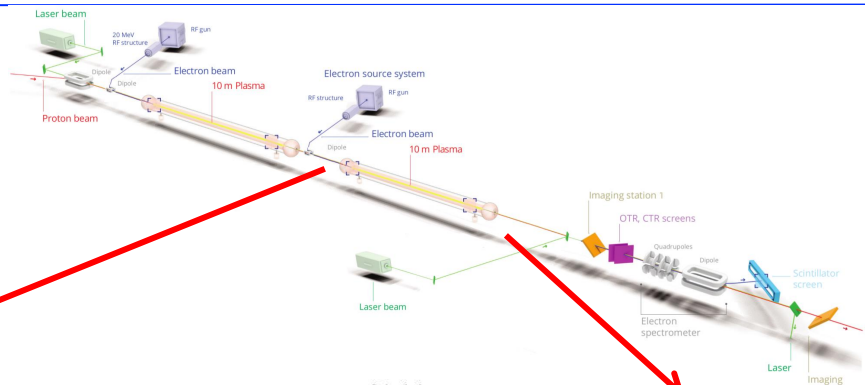
Exit:

- ✧ $L=10\text{m}$, 1m gap
 - ✧ $\epsilon_N=17\text{mm-mrad} \Leftrightarrow$ quasi-linear
 - ✧ $E=4\text{GeV}$
 - ✧ $\Delta E/E=8\%$
 - ✧ $Q=100\text{pC}$
- Farmer, arXiv:2203.11622 (2022)

- ✧ $\epsilon_N=2\text{mm-mrad} \Leftrightarrow$ blow-out
- ✧ $E=4\text{GeV}$
- ✧ $\Delta E/E=5\%$
- ✧ $Q=100\text{pC}$

V. K. Berglyd Olsen
PR- AB 21, 011301 (2018)

PARAMETERS RUN 2c: INJECTION/ACCELERATION ATWAKE



Entrance:

✧ $E=150\text{MeV}$, $\sigma_z=60\mu\text{m}$, $Q=100\text{pC}$

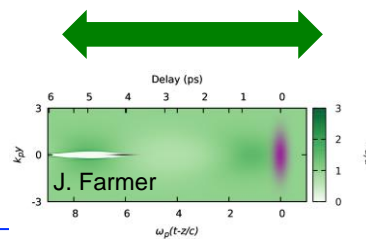
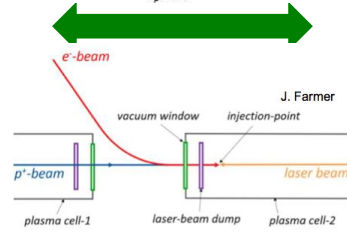
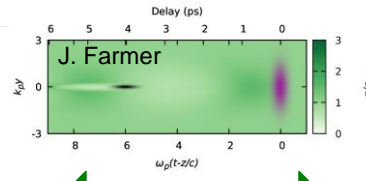
✧ “High emittance”, foils

- ✧ $\epsilon_N=16\text{mm-mrad}$
- ✧ $\sigma_{r,\text{matched}}=26\mu\text{m}$

✧ “Low emittance”, no foil

- ✧ $\epsilon_N=2\text{mm-mrad}$
- ✧ $\sigma_{r,\text{matched}}=6\mu\text{m}$

See John's talk



Exit:

- ✧ $L=10\text{m}$, 1m gap
- ✧ $\epsilon_N=17\text{mm-mrad}$ → quasi-linear
- ✧ $E=4\text{GeV}$
- ✧ $\Delta E/E=8\%$
- ✧ $Q=100\text{pC}$

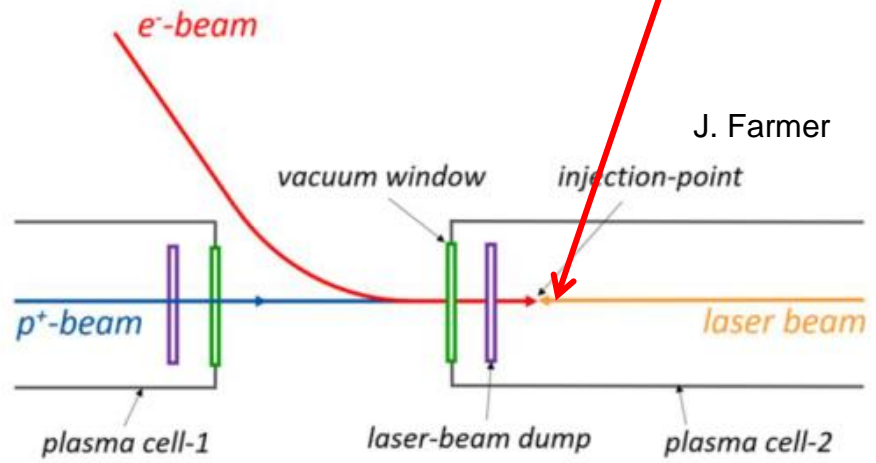
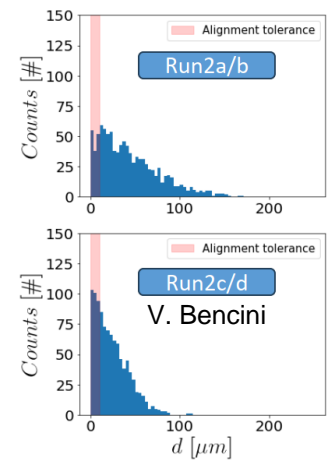
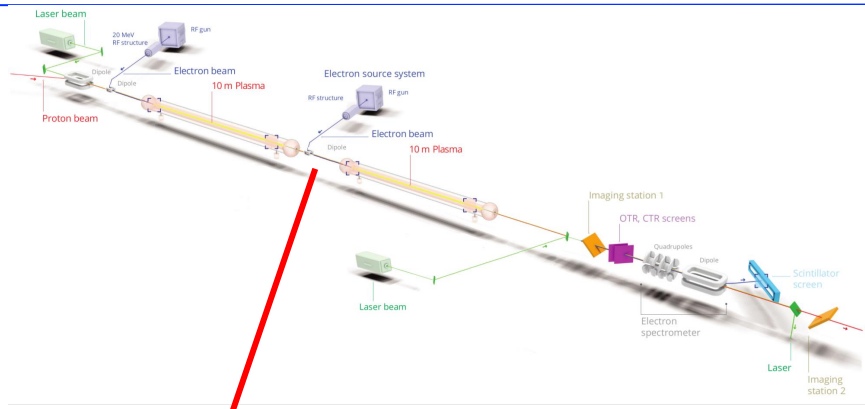
Farmer, arXiv:2203.11622 (2022)

Emittance Control!

- ✧ $\epsilon_N=2\text{mm-mrad}$ ⇔ blow-out
- ✧ $E=4\text{GeV}$
- ✧ $\Delta E/E=5\%$
- ✧ $Q=100\text{pC}$

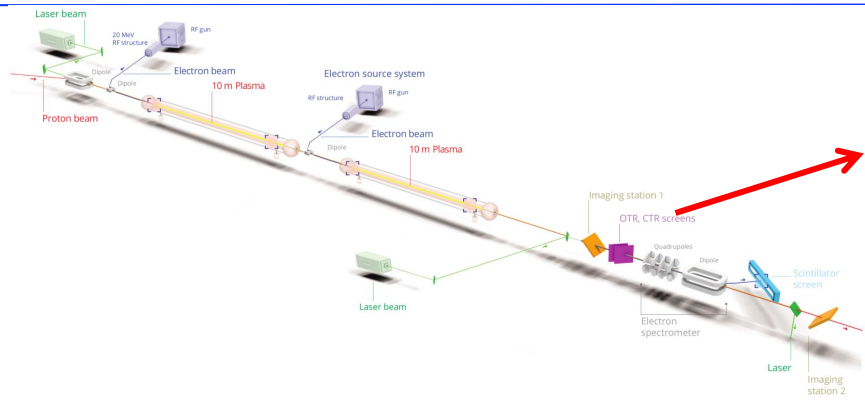
V. K. Berglyd Olsen
PR- AB 21, 011301 (2018)

RUN 2c: INJECTION ALIGNMENT/DIAGNOSTICS



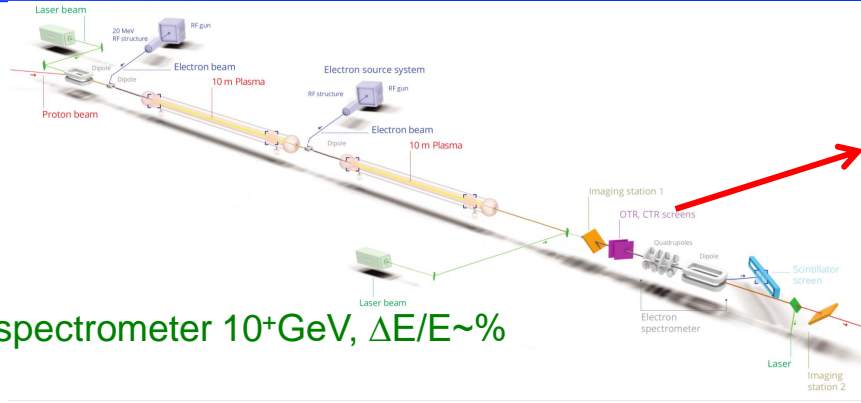
- ✦ Align (position, pointing) two beams with:
 - ✦ $\beta_{p^+} \sim m, \sigma_r > 200 \mu m$
 - ✦ $\beta_{e^-} \sim mm, \sigma_r \sim 5-20 \mu m$
 - ✦ include relative jitter Vittorio's talk
 - ✦ Timing synchronization e-laser pulse $< 100 fs$
 - ✦ $< T_{pe} = 4.3 ps$ ($n_{e0} = 7 \times 10^{14} cm^{-3}$)
- ✦ Diagnostics TBD
- ✦ Tested screen @ 200°C @ CLEAR
- ✦ Tested screen in rubidium

DiAGNOSTiCS: e⁻ BUNCH



Typical parameters

- ❖ $\epsilon_N = (2-30) \text{ mm-mrad}$
- ❖ $Q = 100 \text{ pC}$, $N_{e^-} \sim 6 \times 10^9 e^-$
- ❖ $\Delta E/E = 5-8\%$
- ❖ $E \sim 4-10^+ \text{ GeV}$



Typical parameters

- ✧ $\epsilon_N = (2-30) \text{ mm-mrad}$
- ✧ $Q = 100 \text{ pC}$, $N_e \sim 6 \times 10^9 e^-$
- ✧ $\Delta E/E = 5-8\%$
- ✧ $E \sim 4-10^+ \text{ GeV}$

✧ Energy:

- ✧ Imaging magnetic spectrometer 10^+ GeV , $\Delta E/E \sim \%$

✧ Emittance ($\epsilon_N = 2-30 \mu\text{m}$)

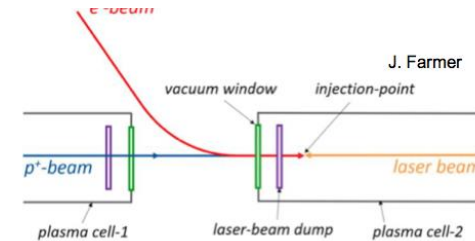
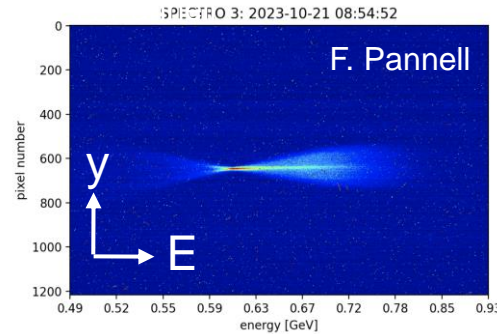
- ✧ butterfly method
- ✧ micro-lens array (optical pepper-pot)

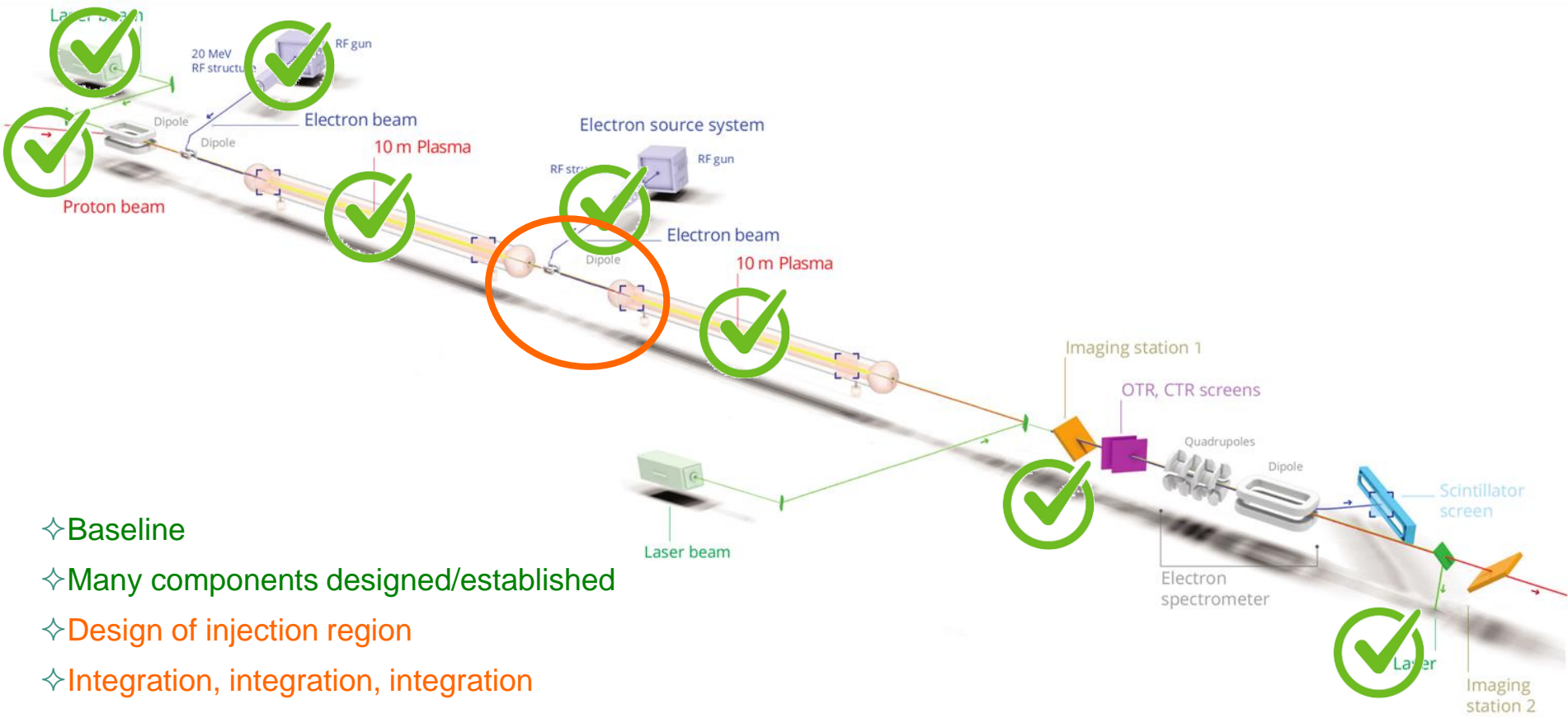
✧ Bunch length ($\sigma_z = 60 \mu\text{m}$)

- ✧ OTR + streak camera (200fs)
- ✧ electro-optical sampling (EOS)
- ✧ time-deflecting cavity (TDC)
- ✧ coherent emission (relative)

✧ Focal size, alignment, position & pointing

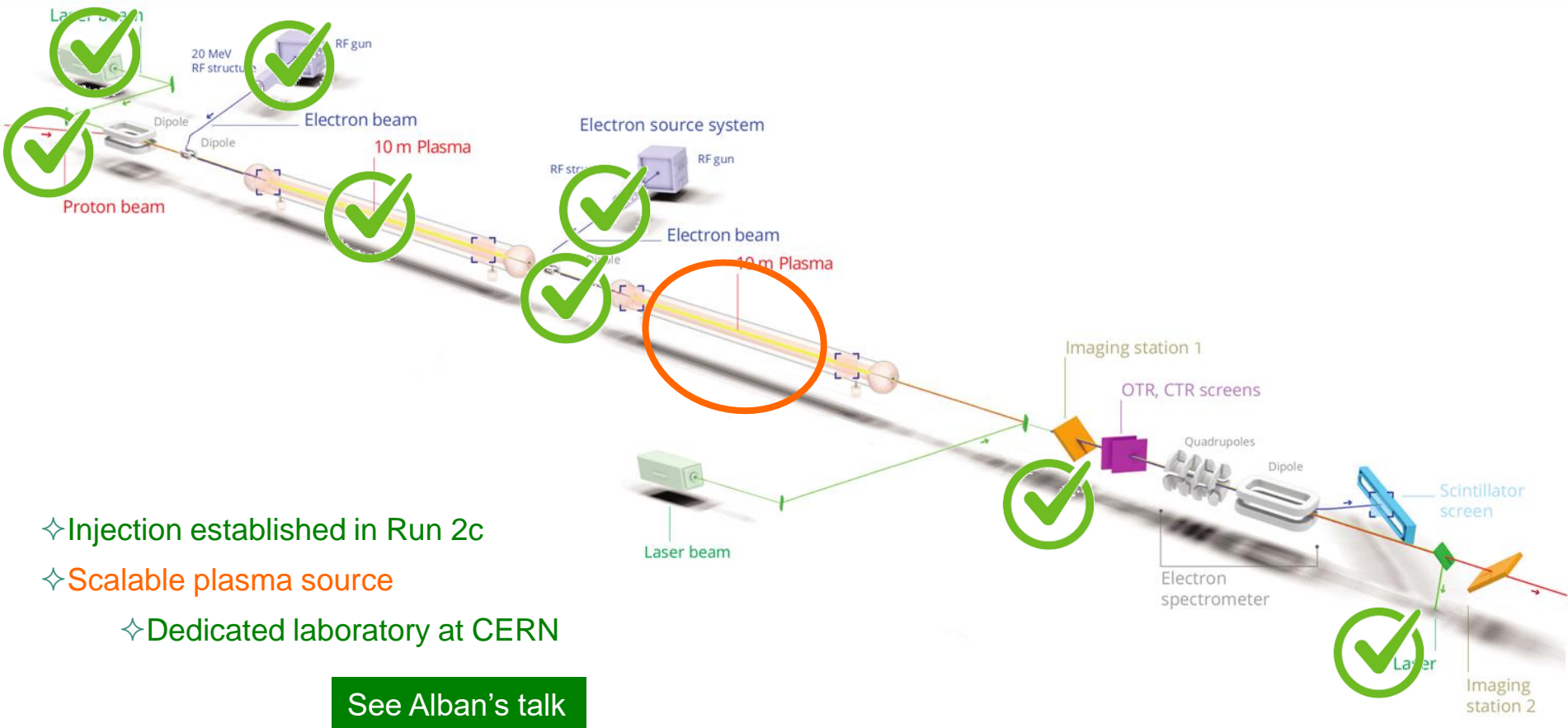
- ✧ Imaging, YAG screen
- ✧ synchrotron radiation (relative)





- ✧ Baseline
- ✧ Many components designed/established
- ✧ Design of injection region
- ✧ Integration, integration, integration

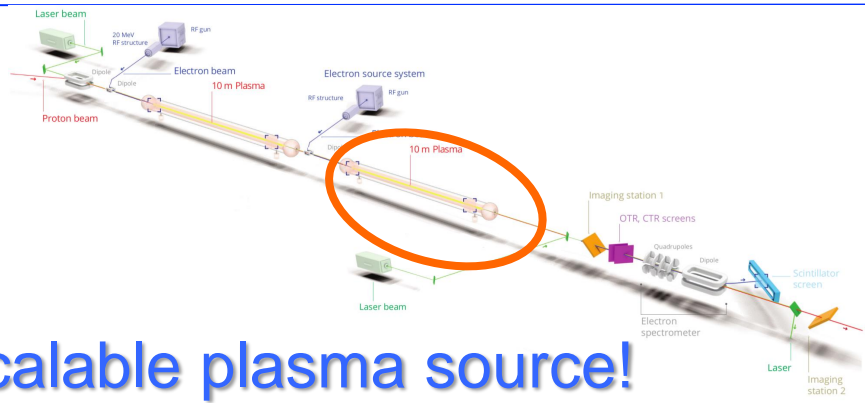
RUN 2d: DESiGN



- ✧ Injection established in Run 2c
- ✧ Scalable plasma source
- ✧ Dedicated laboratory at CERN

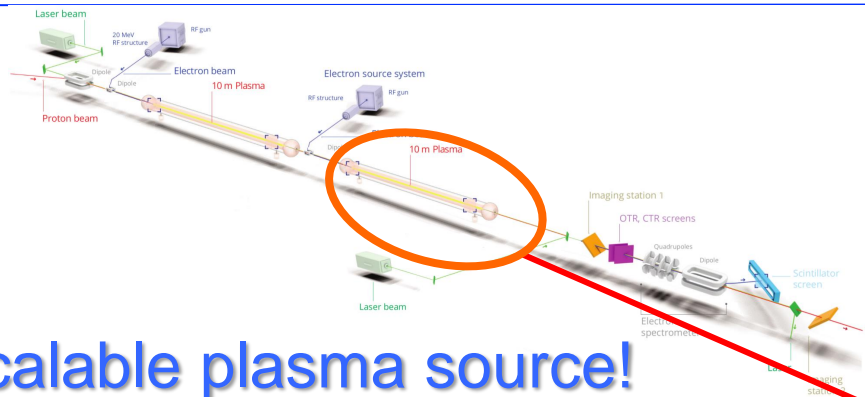
See Alban's talk

CHOICE FOR RUN 2d



Accelerator: scalable plasma source!

CHOICE FOR RUN 2d

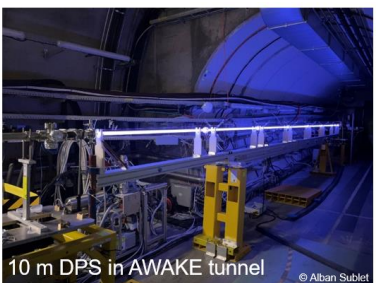


Accelerator: scalable plasma source!

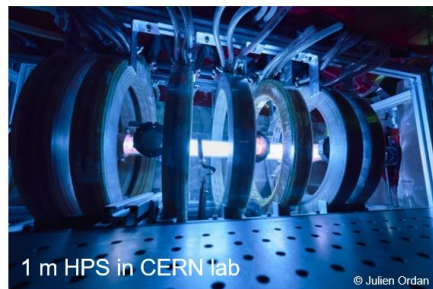
- ❖ Discharge Plasma Source (DPS)
- ❖ Helicon Plasma Source (HPS)

Accelerator:

- ❖ DPS*, HPS**
- ❖ Density uniformity
- ❖ Tunability
- ❖ Reproducibility

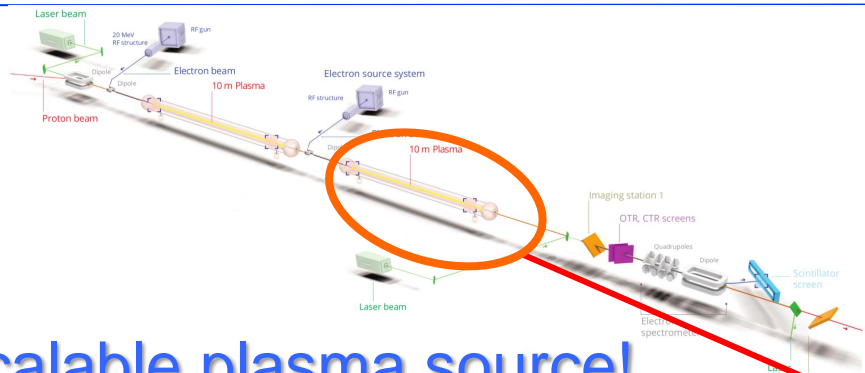


10 m DPS in AWAKE tunnel © Alban Sublet



1 m HPS in CERN lab © Julien Ordan

CHOICE FOR RUN 2d

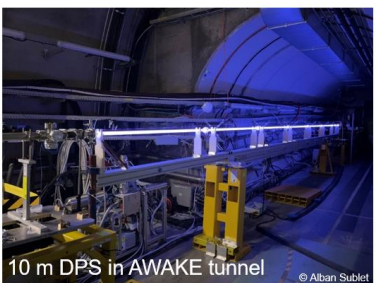


Accelerator: scalable plasma source!

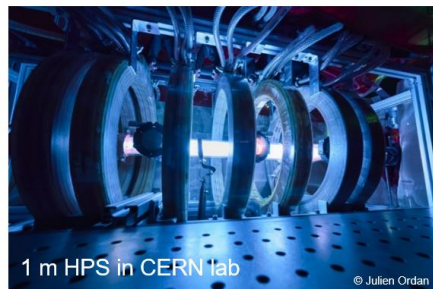
- ✦ Discharge Plasma Source (DPS)
- ✦ Helicon Plasma Source (HPS)

Accelerator:

- ✦ DPS*, HPS**
- ✦ Density uniformity
- ✦ Tunability
- ✦ Reproducibility



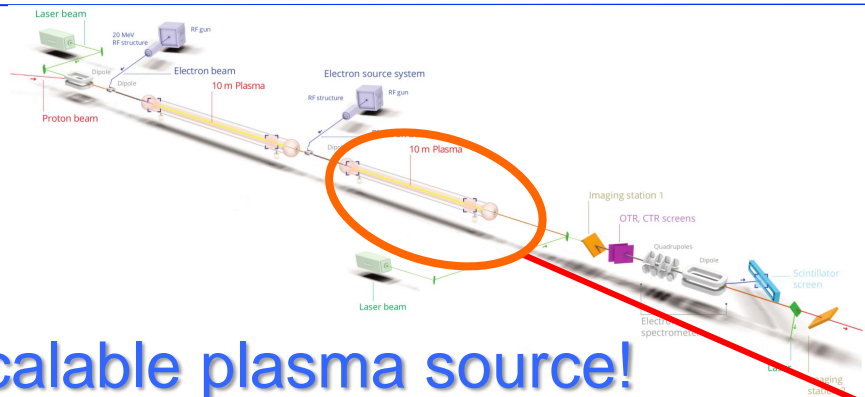
10 m DPS in AWAKE tunnel © Alban Sublet



1 m HPS in CERN lab © Julien Ordan

- ✦ Dedicated laboratory plasma source at CERN
- ✦ ESSENTIAL for the success of Run 2d and for applications
- ✦ Development that applies to other accelerators (parameters)

CHOICE FOR RUN 2d



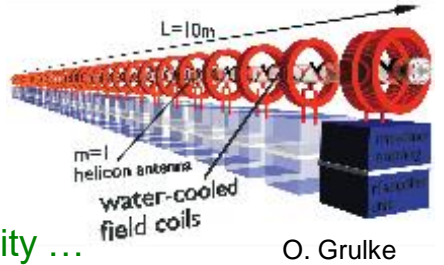
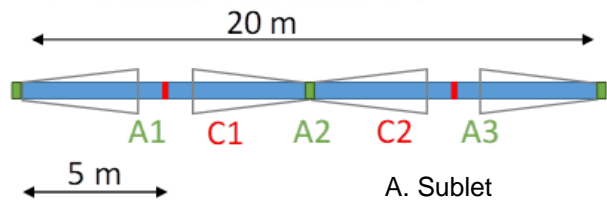
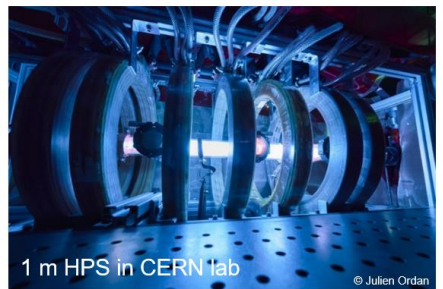
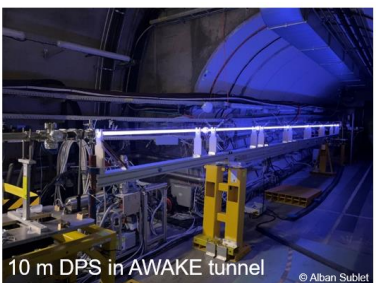
Accelerator: scalable plasma source!

- ✦ Discharge Plasma Source (DPS)
- ✦ Helicon Plasma Source (HPS)

Accelerator:

- ✦ DPS*, HPS**
- ✦ Density uniformity
- ✦ Tunability
- ✦ Reproducibility

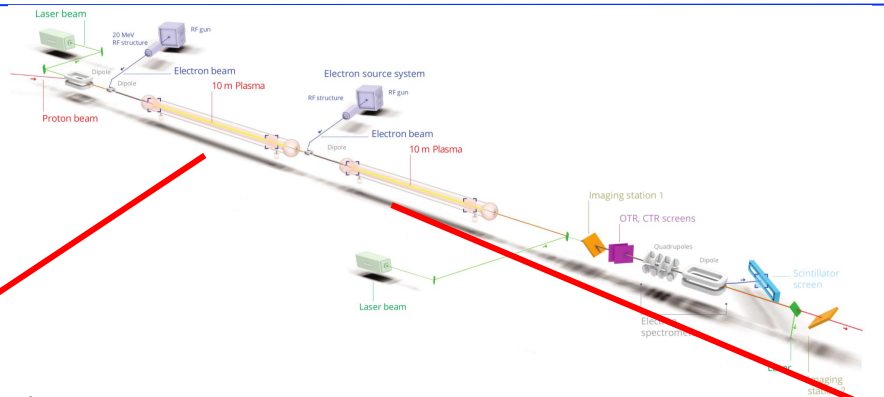
See Alban's talk



✦ Scalability ...

- ✦ Dedicated laboratory plasma source at CERN
- ✦ ESSENTIAL for the success of Run 2d and for applications
- ✦ Development that applies to other accelerators (parameters)

OPTIONS FOR RUN 2d



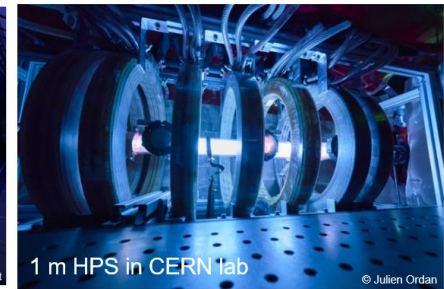
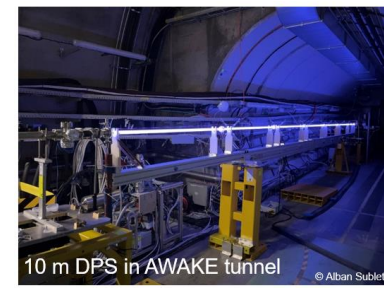
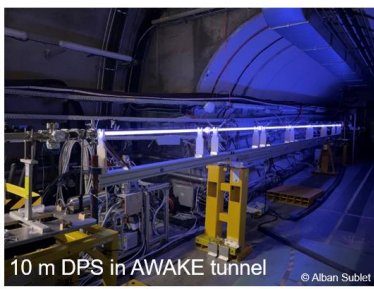
Self-modulator (default: Rb):

- ❖ DPS*, Argon
- ❖ Simplicity
- ❖ e-seeding
- ❖ Density step
- ❖ e⁻ bunch seeding

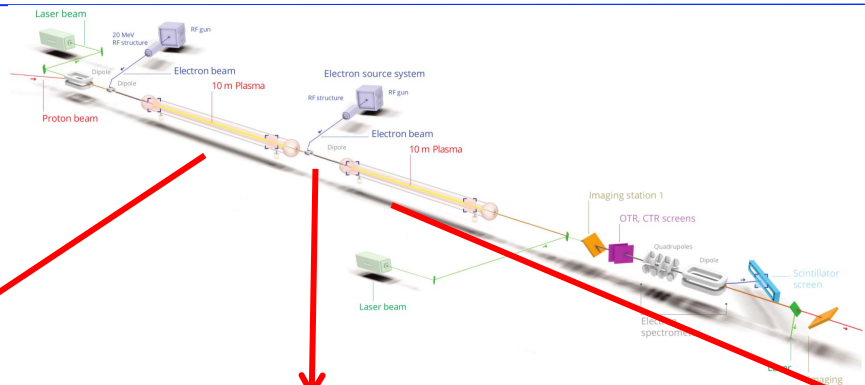
❖ Plasma sources: major technological development that applies to other accelerators (parameters)

Accelerator:

- ❖ DPS*, HPS**
- ❖ Density uniformity
- ❖ Tunability
- ❖ Reproducibility



OPTiONS FOR RUN 2d



Self-modulator (default: Rb):

- ❖ DPS*, Argon
- ❖ Simplicity
- ❖ e-seeding
- ❖ Density step
- ❖ e- bunch seeding

Injectors (default: RF):

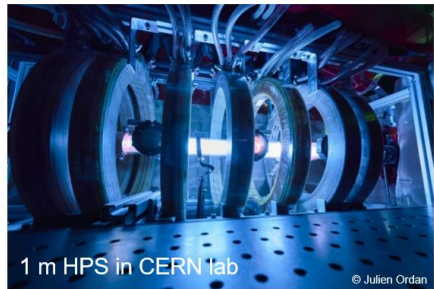
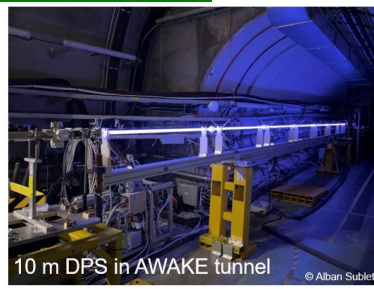
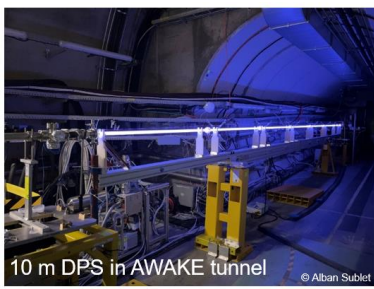
- ❖ LWFA (EARLI Project)
- ❖ Novelty
- ❖ Reproducibility
- ❖ Tunability
- ❖ Foil injection
- ❖ no gap

See John's talk

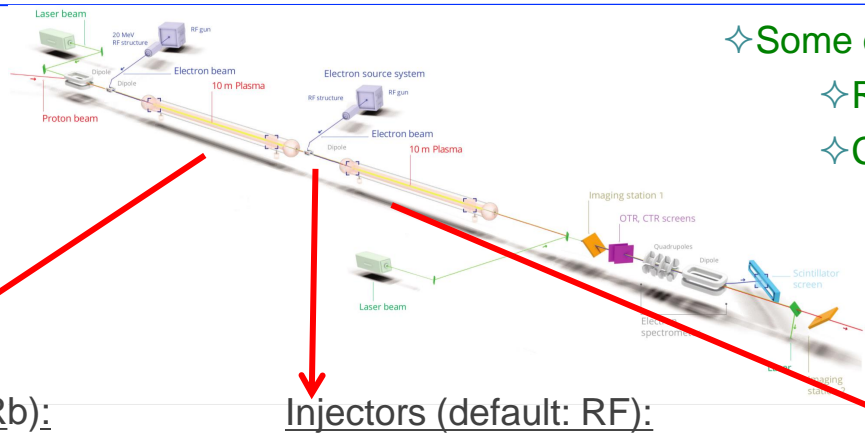
Accelerator:

- ❖ DPS*, HPS**
- ❖ Density uniformity
- ❖ Tunability
- ❖ Reproducibility

❖ LWFA injector: technological development that applies to other accelerators (parameters)



OPTiONS FOR RUN 2d



Some options for Run 2c?

- Ready
- Cheaper, easier

Self-modulator (default: Rb):

- DPS*, Argon
- Simplicity
- e-seeding
- Density step
- e⁻ bunch seeding

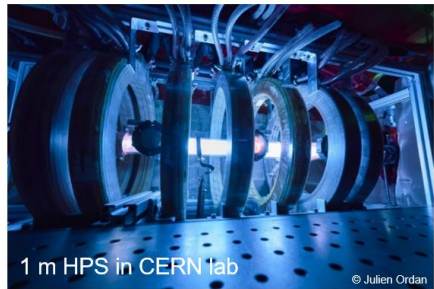
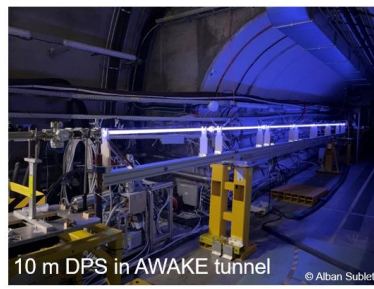
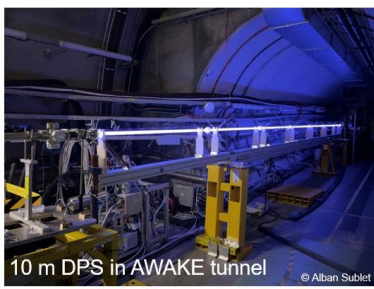
Injectors (default: RF):

- LWFA (EARLI Project)
- Novelty
- Reproducibility
- Tunability
- Foil injection
- no gap

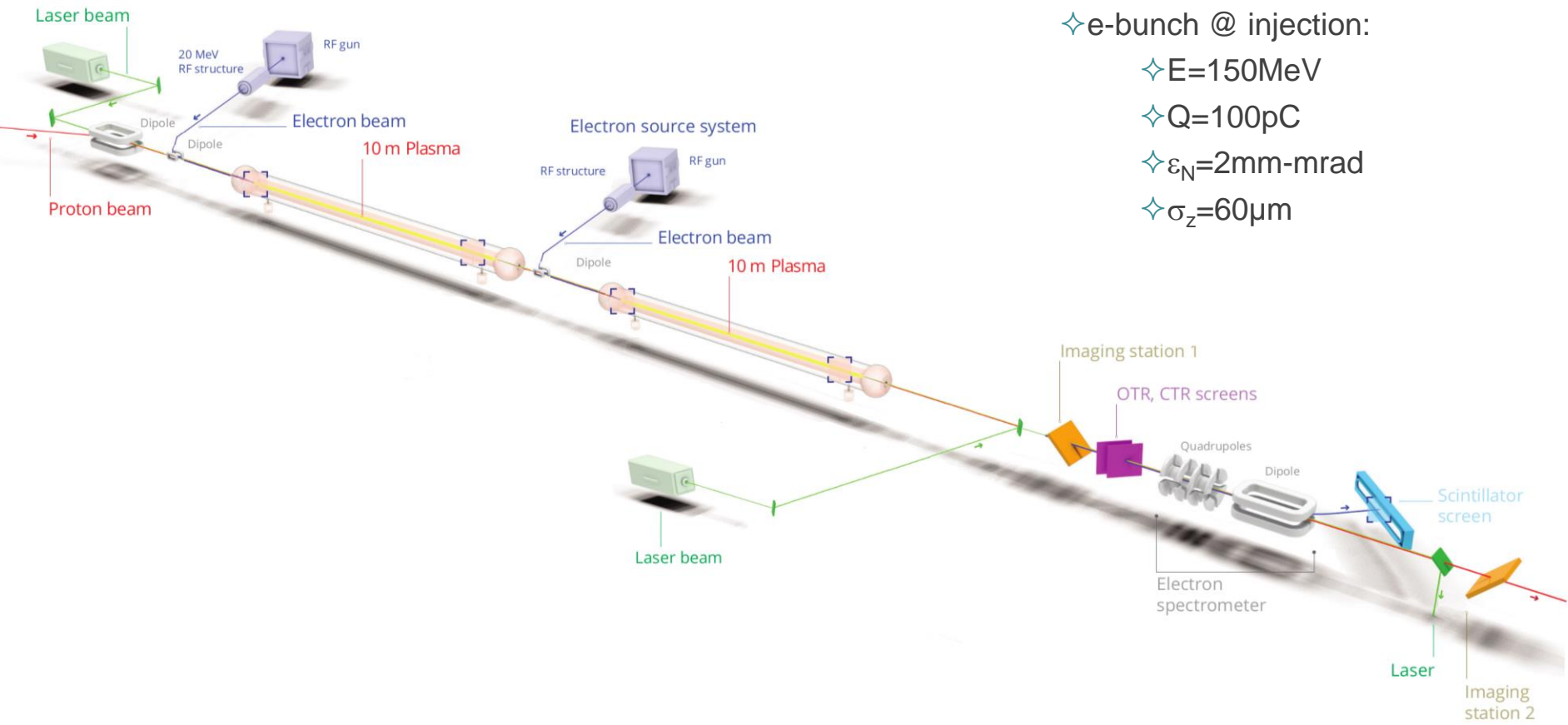
Accelerator:

- DPS*, HPS**
- Density uniformity
- Tunability
- Reproducibility

LWFA injector: technological development that applies to other accelerators (parameters)



RUN 2c,d: EXPECTED PARAMETER REACH



✧ e-bunch @ injection:

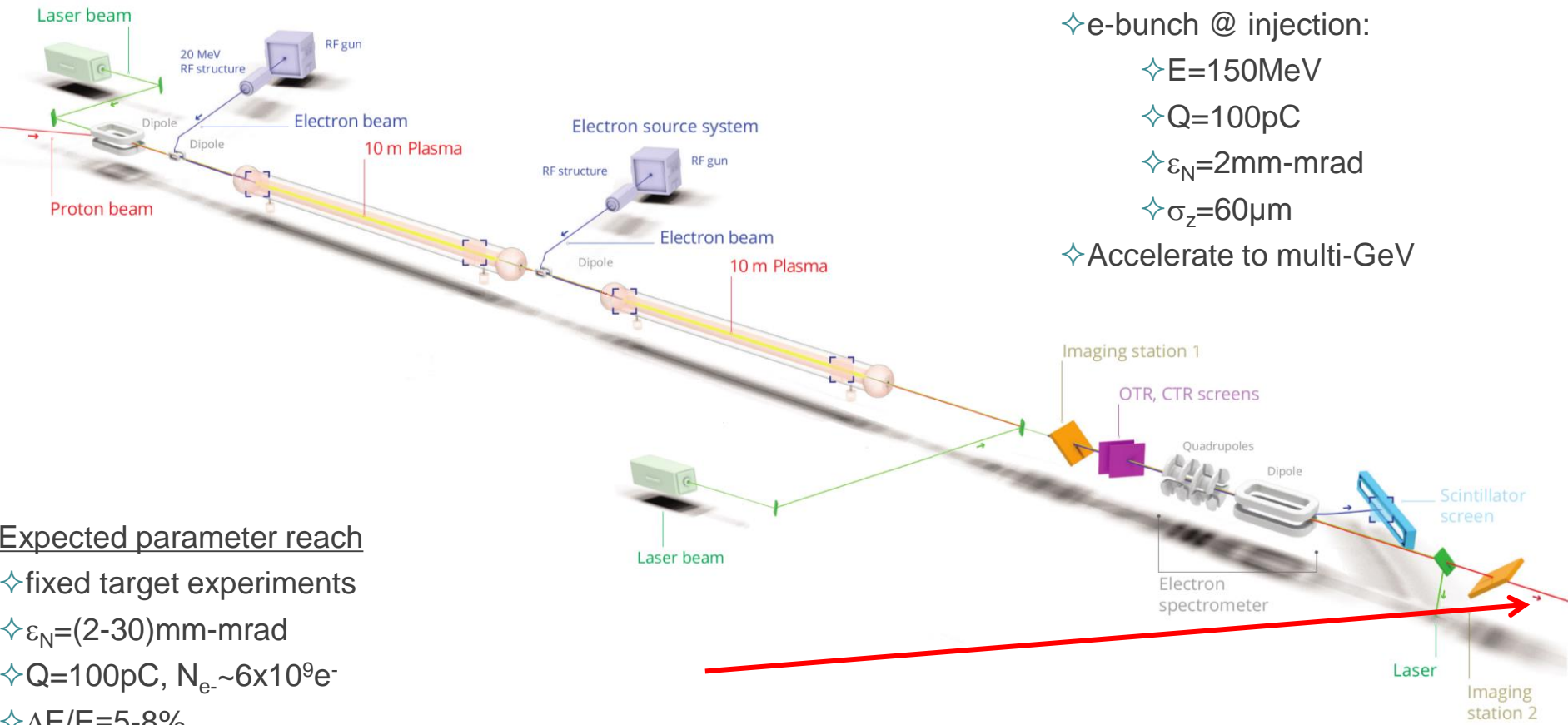
✧ $E=150\text{MeV}$

✧ $Q=100\text{pC}$

✧ $\epsilon_N=2\text{mm-mrad}$

✧ $\sigma_z=60\mu\text{m}$

RUN 2c,d: EXPECTED PARAMETER REACH



- ✧ e-bunch @ injection:
 - ✧ $E=150\text{MeV}$
 - ✧ $Q=100\text{pC}$
 - ✧ $\epsilon_N=2\text{mm-mrad}$
 - ✧ $\sigma_z=60\mu\text{m}$
- ✧ Accelerate to multi-GeV

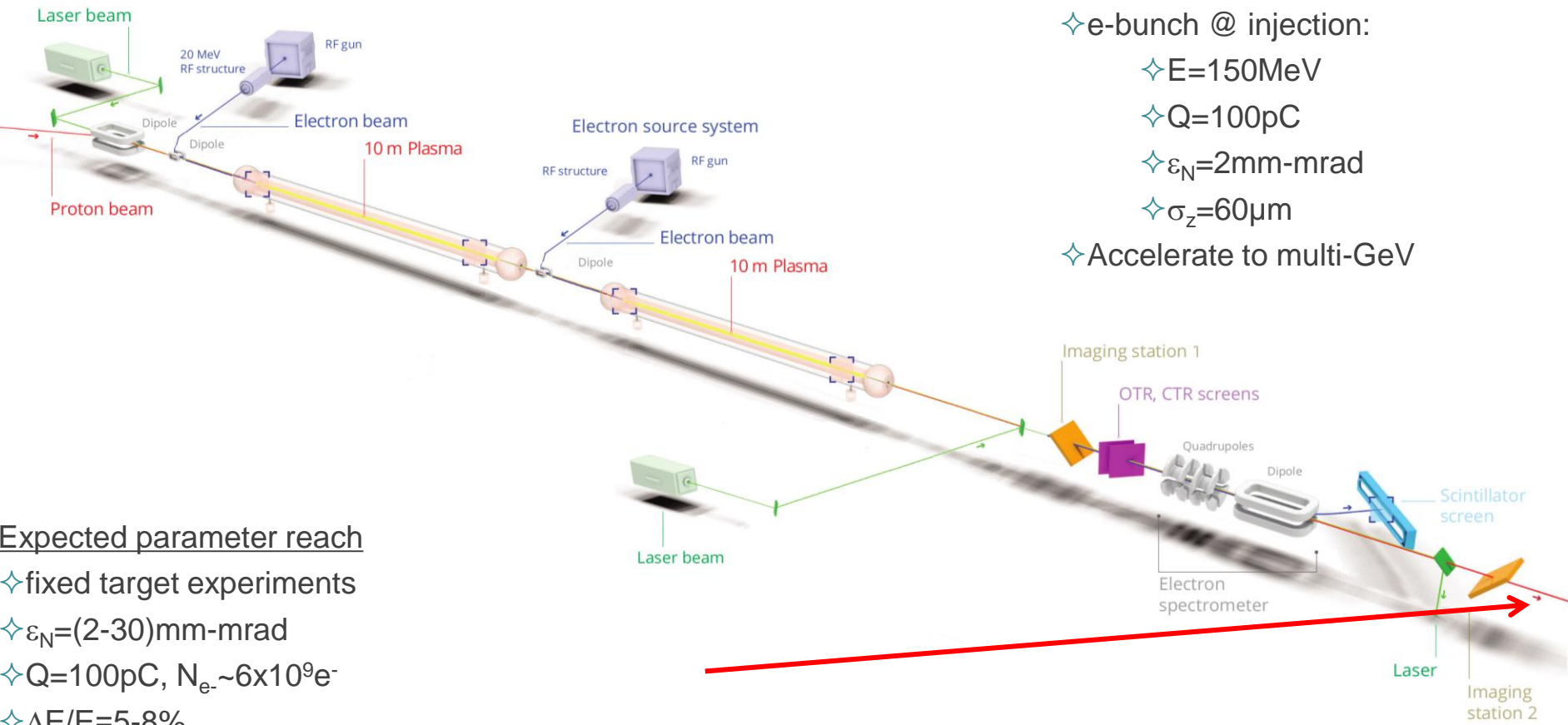
Expected parameter reach

- ✧ fixed target experiments
- ✧ $\epsilon_N=(2-30)\text{mm-mrad}$
- ✧ $Q=100\text{pC}$, $N_{e^-}\sim 6\times 10^9 e^-$
- ✧ $\Delta E/E=5-8\%$

- ✧ Run 2c: $E\sim 4-10\text{GeV}$, 10m
- ✧ Run 2d: $E>10\text{GeV}$, 10^+m , scalable

See John's talk

RUN 2c,d: EXPECTED PARAMETER REACH



- ✧ e-bunch @ injection:
 - ✧ $E=150\text{MeV}$
 - ✧ $Q=100\text{pC}$
 - ✧ $\epsilon_N=2\text{mm-mrad}$
 - ✧ $\sigma_z=60\mu\text{m}$
- ✧ Accelerate to multi-GeV

Expected parameter reach

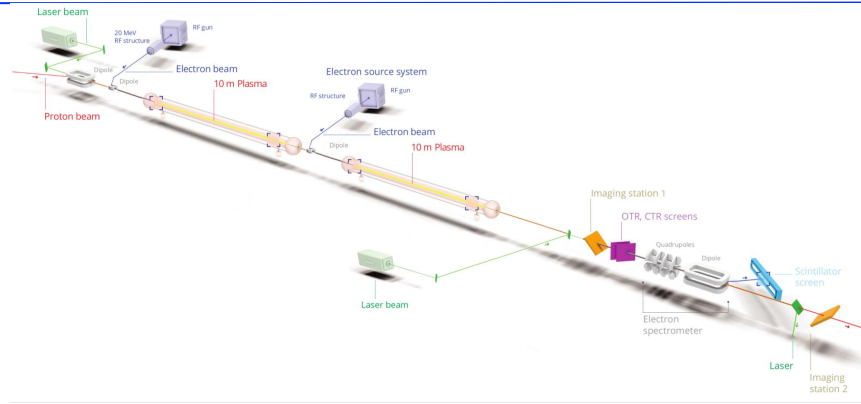
- ✧ fixed target experiments
- ✧ $\epsilon_N=(2-30)\text{mm-mrad}$
- ✧ $Q=100\text{pC}$, $N_{e^-}\sim 6\times 10^9$
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- ✧ Run 2c: $E\sim 4-10\text{GeV}$, 10m
- ✧ Run 2d: $E>10\text{GeV}$, 10^+m , scalable



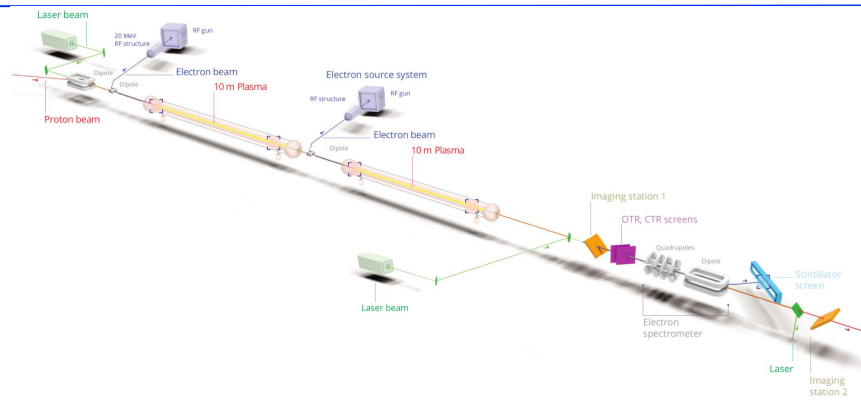
✧ Application: $\sim 50\text{GeV}$

RELEVANCE TO OTHER ADVANCED ACCELERATORS AWAKE



Developments shared with other plasma-based accelerators:

- ❖ Externally inject an e^- bunch ⇔ injection, staging
- ❖ Acceleration to multi GeV level ⇔ large energy gain
- ❖ Control e-bunch quality: E , $\Delta E/E$, Q , ϵ_N ⇔ quality!!
- ❖ Plasma source: length, density uniformity, reproducibility, tunability ⇔ staging, >1 plasma
- ❖ Development of diagnostics: plasma density, bunch parameters (ϵ_N) ⇔ quality



Technological developments

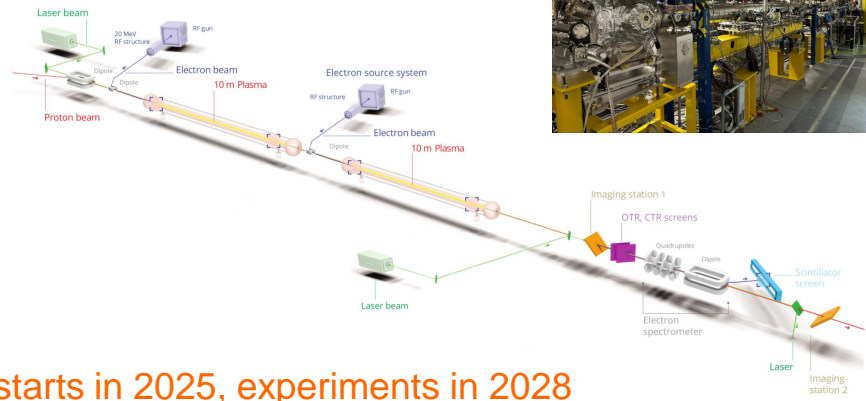
- ❖ Plasma sources
 - ❖ rubidium, discharge, helicon
 - ❖ parameters
 - ❖ reproducibility, tunability, uniformity, etc.
- ❖ Injectors/injection
 - ❖ RF-based, LWFA, ...
 - ❖ parameters
 - ❖ reproducibility, tunability, uniformity, etc
- ❖ Diagnostics

Scientific merit

- ❖ Edda's, Marlene's talk
 - ❖ publications
 - ❖ education, prizes
- ❖ Understanding plasma-based accelerators
 - ❖ and more ...

SUMMARY

- ✧ AWAKE: high-energy e^- for application to particle physics
- ✧ Solid plan based on results of successful Run 1,2a,b
 - ✧ Demonstrated baseline self-modulator for Run 2c,d
- ✧ **Baseline for Run 2c: external injection experiment**
 - ✧ Rb self-modulator plasma
 - ✧ Rb accelerator plasma
 - ✧ RF-based e-bunch injector (CERN)

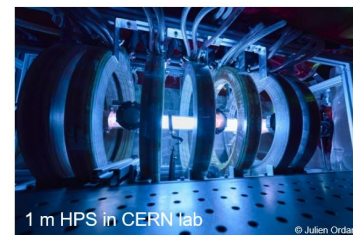
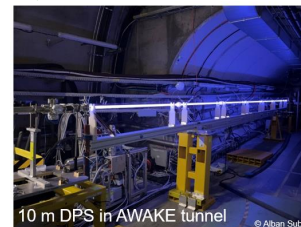


- ✧ Design/construction has started, **design of injection zone starts in 2025, experiments in 2028**
- ✧ Most topics addressed for Run 2 c,d are relevant for other plasma-based accelerators
- ✧ Technological developments: plasma source, injector, ...
- ✧ Scientific merit: publications, invited presentations, PhDs, Masters, prizes, ...

- ✧ **Run 2d: acceleration experiment in scalable plasma source**
 - ✧ Preparation has started, plasma source lab at CERN

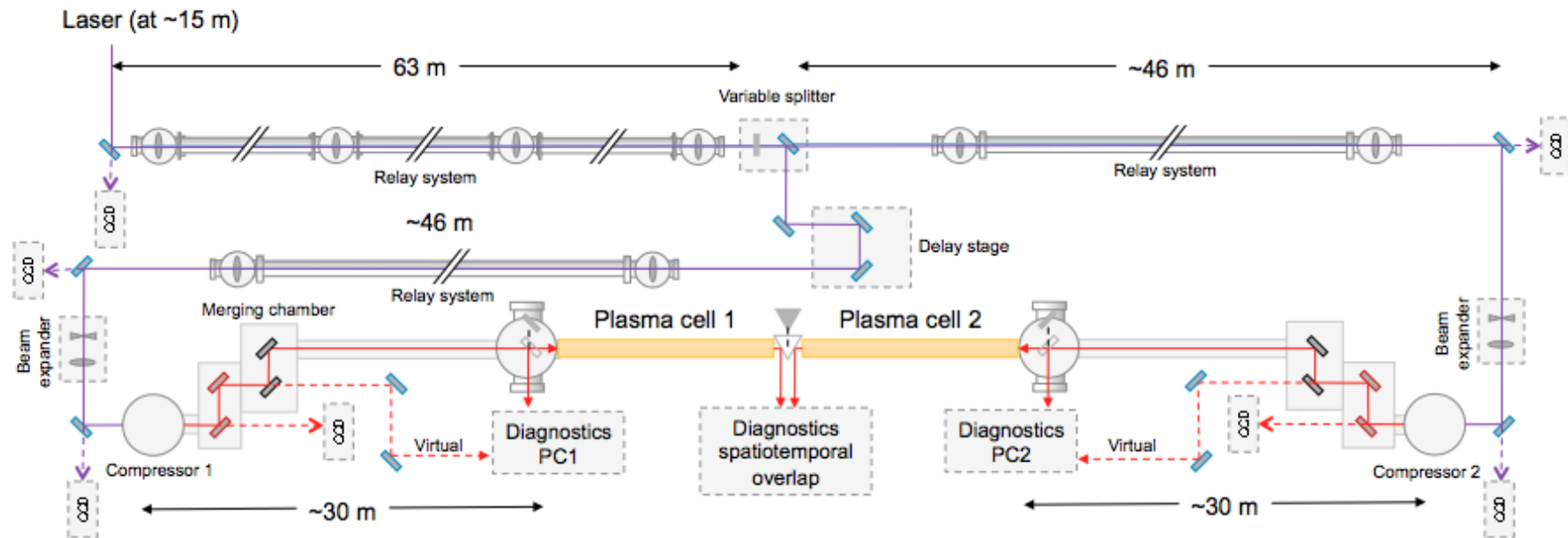
- ✧ No showstoppers identified

- ✧ Can produce parameters for first particle physics applications in early 2030's



IONIZING LASER: LAYOUT

IR beams delivery to plasma cells, relays



- Stretched pulse
- Compressed pulse
- - - Mirror leak

- Relay imaging systems require only low-level primary vacuum, blue mirrors are “in air”
- Focusing on plasma cell attained by mismatching beam expanders
- Content of diagnostics sets still to be determined, location of safety devices, etc...

E. Granados

/24