ALEGRO 2018

Summary of Positron Sources and Positron LWFA Sessions

Working Group 8

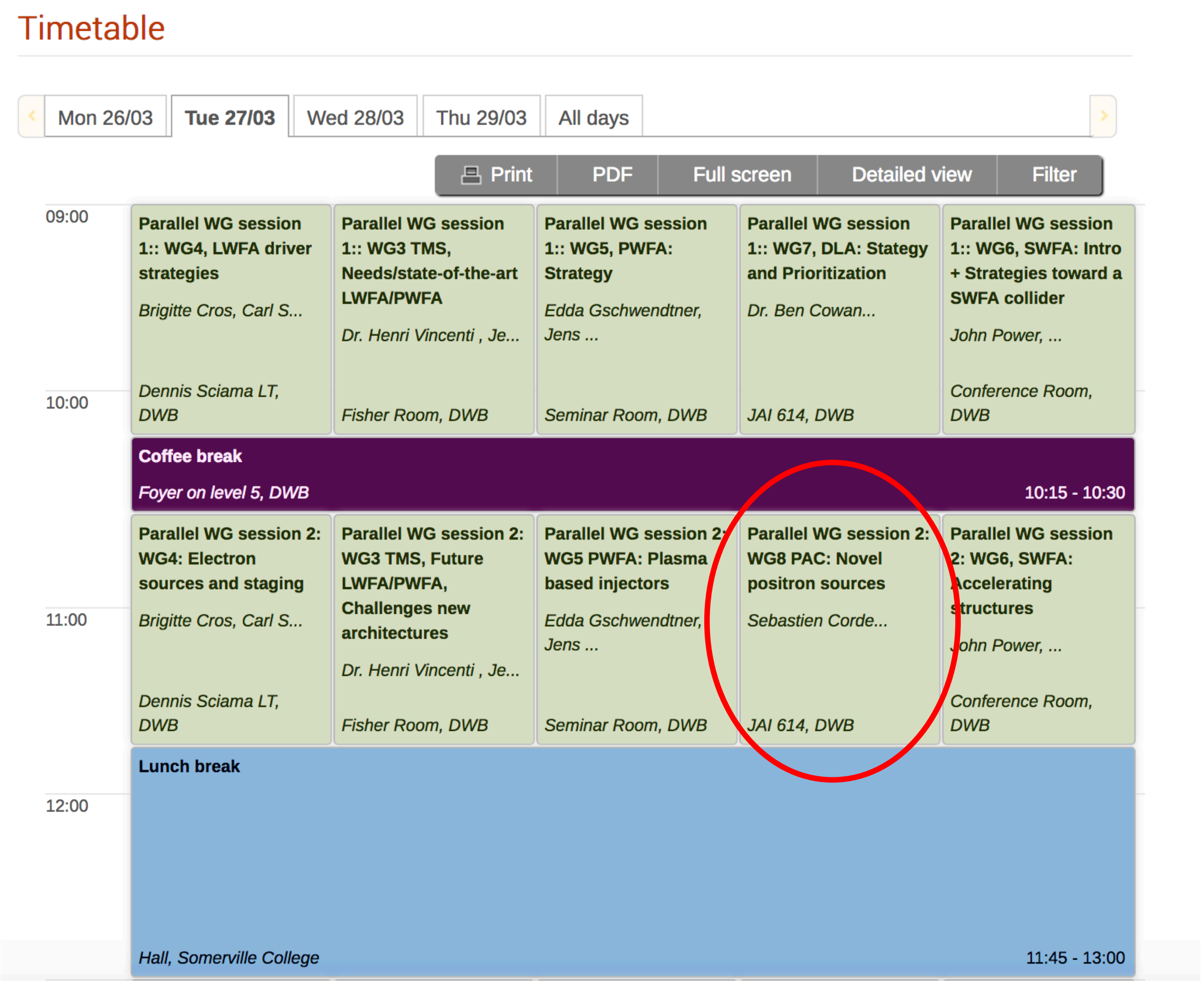
ALEGRO Workshop, Oxford
March 28th, 2018

Spencer Gessner, CERN
Sebastien Corde, EP

Session on Positron Sources

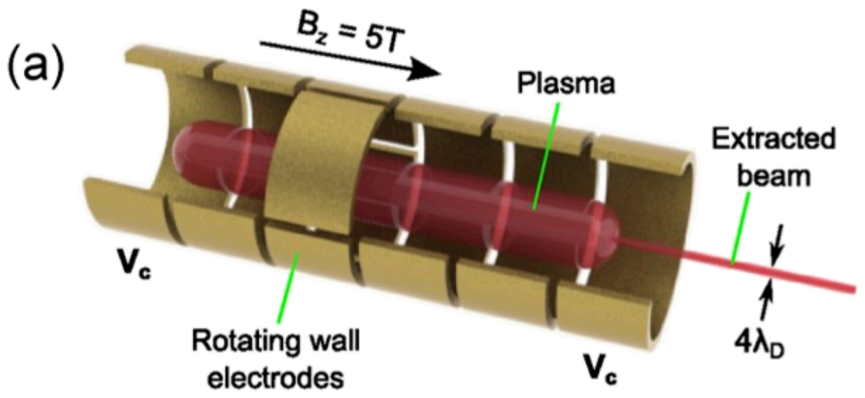
We discussed 5 topics:

1. Positrons generated from a high intensity electron beam for FACET-II.
2. Positrons generated from a high intensity proton beam for the AWAKE experiment.
3. "In-situ" positron generation.
4. Positron beams from electro-static traps.
5. Positron beams from a high-power laser.



Session on Positron Sources

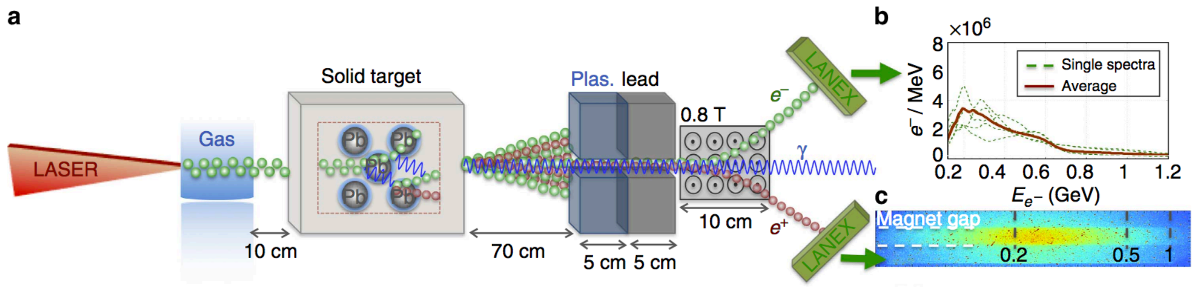
Positron beams from electro-static traps



Talk by R. Greaves, First Point Scientific:

- Ultra cold positron beams have excellent emittance.
- They are also very long. Existing bunch compression techniques are limited to about a nanosecond for low energy beams.
- Possibly interesting for multi-bunch acceleration.

Positron beams from laser-driven sources



Talk by G. Sarri, Queen's University Belfast:

- Positron beams produced in this manner are very short. Appropriate for LWFA/PWFA experiments.
- Excellent option for high-power laser laboratories.

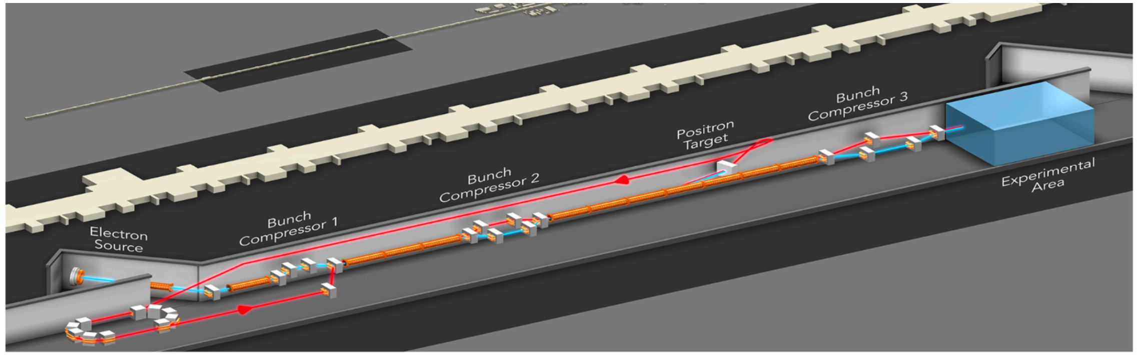
Session on Positron Sources

Concept	Beam Charge	Rep Rate	Emittance	Bunch Length	Energy Spread	Driver/Source	Facilities	Required Infrastucture	Comments
Positrons from high energy electron beams with damping ring	2 nC	5 Hz	6 mm mrad	8 um	<1%	10 GeV, 3 nC electron beam	FACET-II	2.9 meter diameter damping ring, modification to the return line, target infrastructure already exists.	Parameters come from FACET-II TDR. We take the optimistic values. SLAC is the only laboratory that has delivered positrons for PWFA experiments.
Positrons from high energy proton beams with damping ring	1 nC	0.033 Hz	6 mm mrad	8 um	<1%	400 GeV, 30 nC proton beam	AWAKE	Requires target and capture system, return line, damping ring, and beamline to the plasma.	Only a rough study has been done on this topic. We assume we can use the same damping ring design as FACET-II.
"In-situ" positron beam generation	10-100 pC	10 Hz	Large	8 um	100%	10 GeV, 3 nC electron beam	FACET-II	High-Z foil compatible with plasma oven	Cheap but messy solution.
Positron beams from electro-static traps	10 pC	0.1 Hz	Extremely small	10 cm	Small	Radioactive sodium		Positron trap ($0.5-1.0M) plus RF compression system	No systematic studies on this topic exist. Could be interesting for AWAKE which does not require ultrashort beams or a multi-bunch accelerator.
Positron beams from a high-power laser sources	OVERALL: 0.1 - 1 nC. 5% BW at 1 GeV: 1 - 10 pC	Existing: 10 Hz. Developing: 0.1 - 1 kHz	Geometrical emittance at 1 GeV ~ 0.01 mm mrad	micron-scale	100%	Ultra-relativistic electrons driven by a high-intensity laser	RAL, HERCULES, EuPRAXIA, ELI	Dedicated line and energy selection	Only drawback is the energy spread. Need precise energy selection and transport. Would be ideal to have a dedicated line (EuPRAXIA?) to use this source for post-acceleration and transport proof-of-concept studies

https://docs.google.com/spreadsheets/d/1aCRvU-clJM0HO9ABd5AzVqzthx5cyRd8YUylWuO1Qic/edit?usp=sharing

Session on Positron Sources

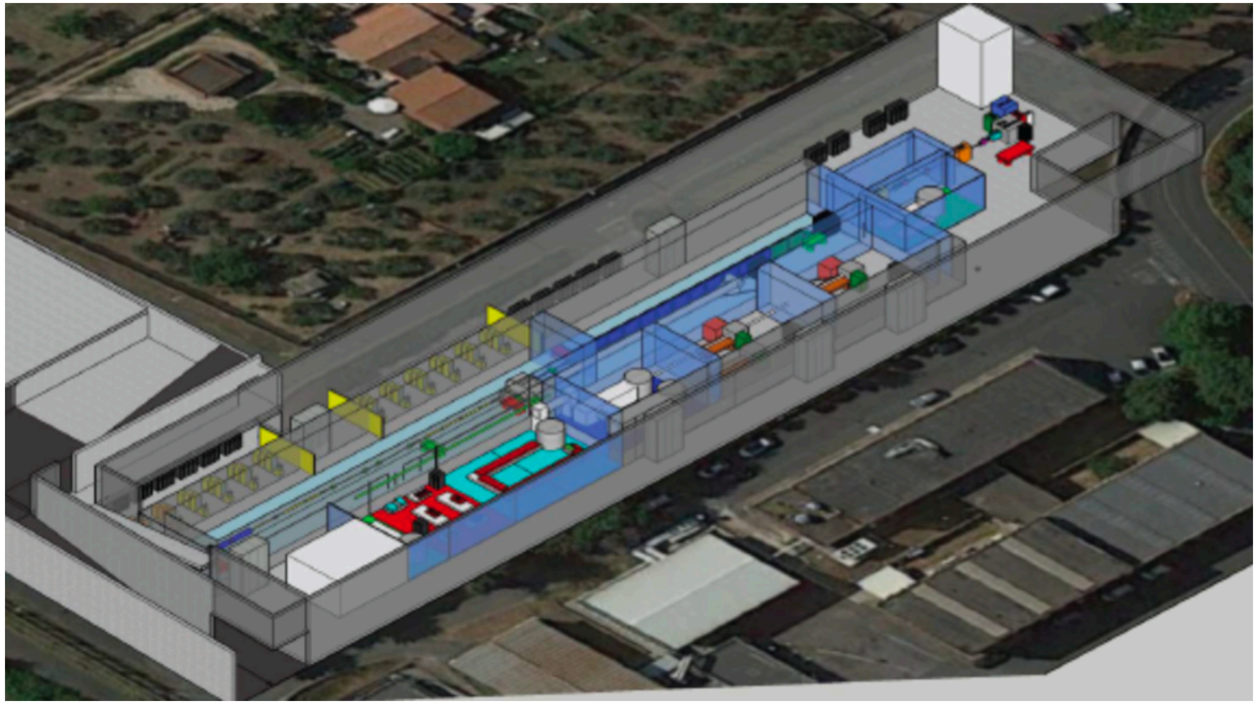
FACET-II @ SLAC



Electron Beam Parameter	Baseline Design	Operational Ranges	Positron Beam Parameter	Baseline Design	Operational Ranges
Final Energy [GeV]	10	4.0-13.5	Final Energy [GeV]	10	4.0-13.5
Charge per pulse [nC]	2	0.7-5	Charge per pulse [nC]	1	0.7-2
Repetition Rate [Hz]	30	1-30	Repetition Rate [Hz]	5	1-5
Norm. Emittance $\gamma\varepsilon_{x,y}$ at S19 [μm]	4.4, 3.2	3-6	Norm. Emittance $\gamma\varepsilon_{x,y}$ at S19	10, 10	6-20
Spot Size at IP $\sigma_{x,y}$ [μm]	18, 12	5-20	Spot Size at IP $\sigma_{x,y}$ [μm]	16, 16	5-20
Min. Bunch Length σ_z (rms) [μm]	1.8	0.7-20	Min. Bunch Length σ_z (rms)	16	8
Max. Peak current I_{pk} [kA]	72	10-200	Max. Peak current I_{pk} [kA]	6	12

FACET-II is the only facility that plans to provide positron beams for PWFA experiments. Contact M. Hogan for more information: hogan@slac.stanford.edu

EUPRAXIA @ LNF



The design for EUPRAXIA includes a user facility for positron beams. An exciting development! Contact R. Walczak for details: roman.walczak@physics.ox.ac.uk

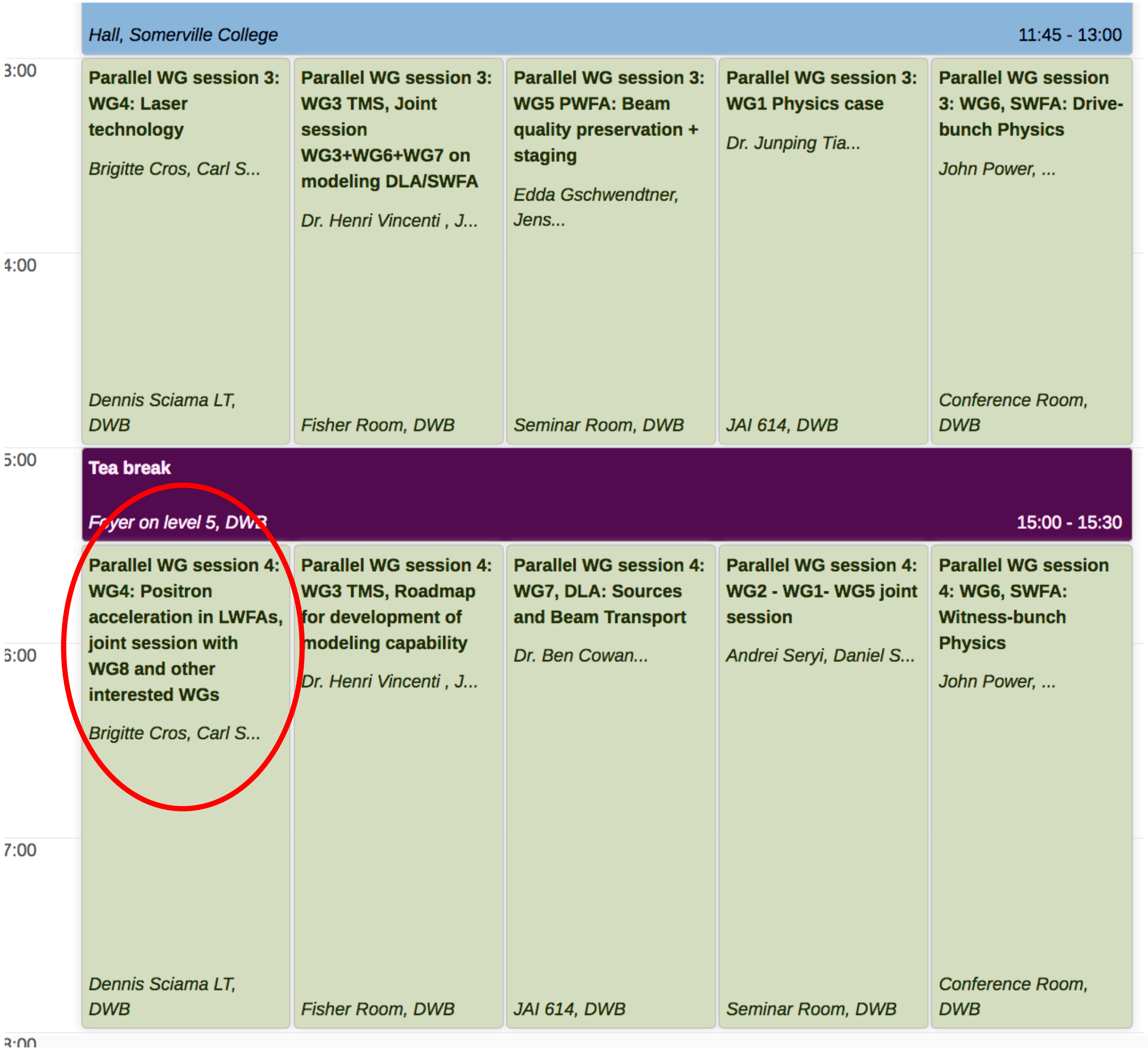
Joint Session on Positron LWFA with WG4

Our goal is to *identify the most promising paths forward*.

We considered several options:

- Nonlinear
- Quasi-linear (uniform)
- Quasi-linear (hollow channel)

The focus of the session was on hollow-channel acceleration of positron beams.

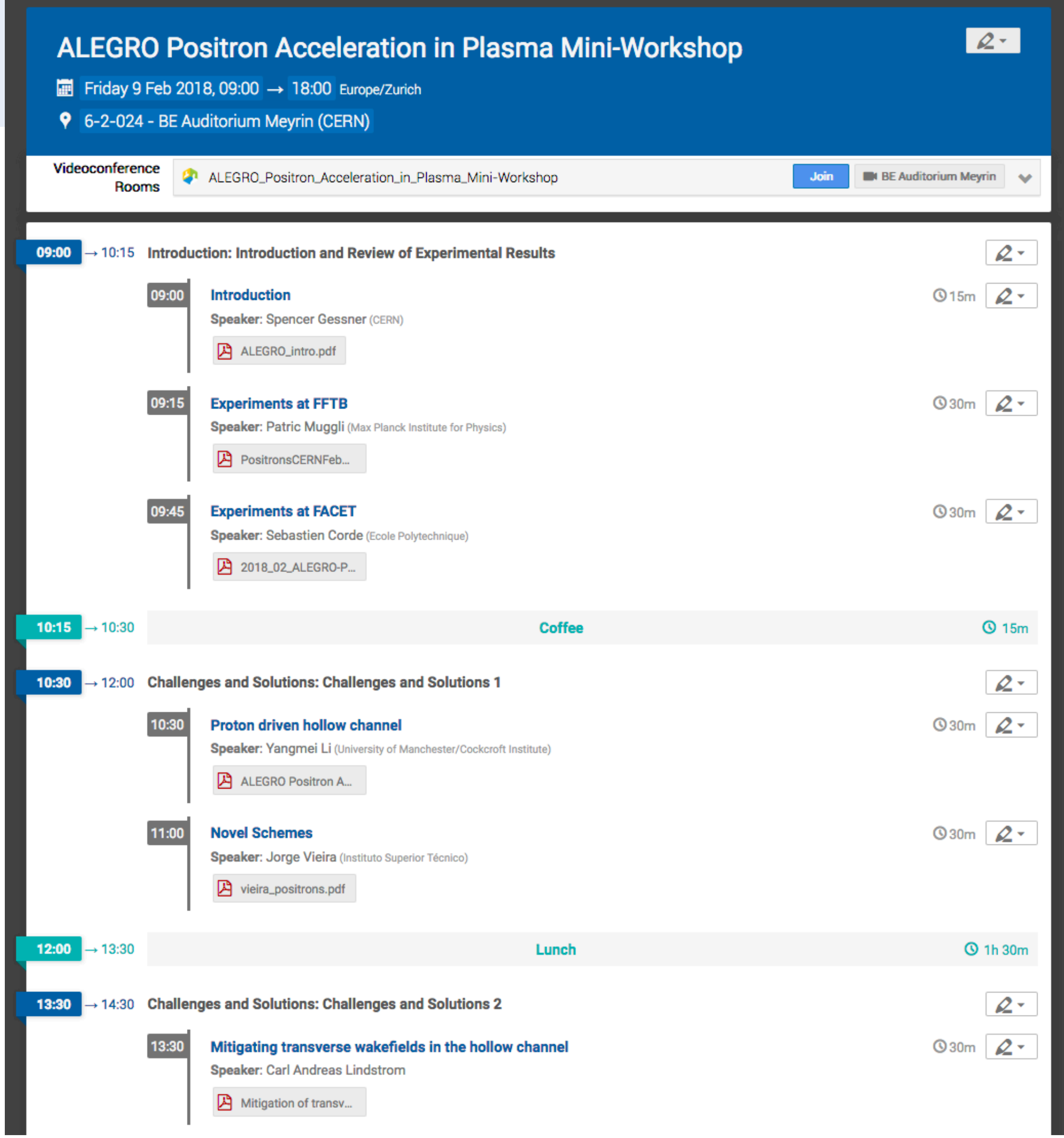


Recap of Mini-Workshop at CERN

We held a 1-day mini-workshop on positron acceleration in plasma at CERN on 9 February, 2018.

The goal of the workshop was to review the state of the field. It was essentially a *fact-finding mission*.

We had 11 presentations/speakers and 25 participants total.



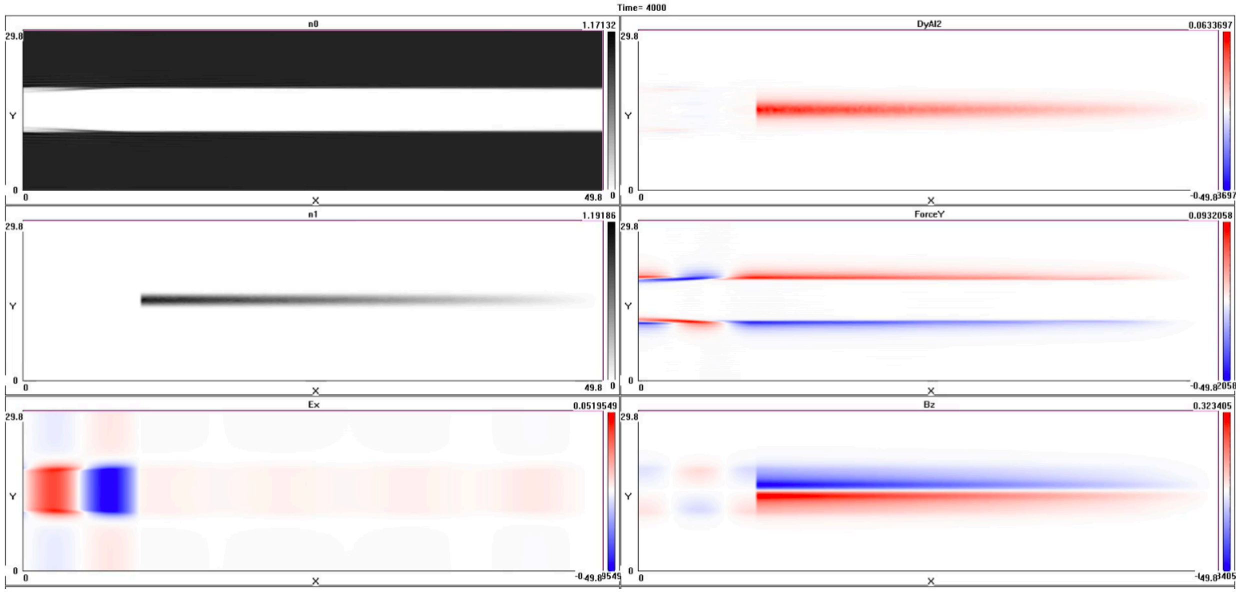
Link to full agenda and talks:
https://indico.cern.ch/event/702515/

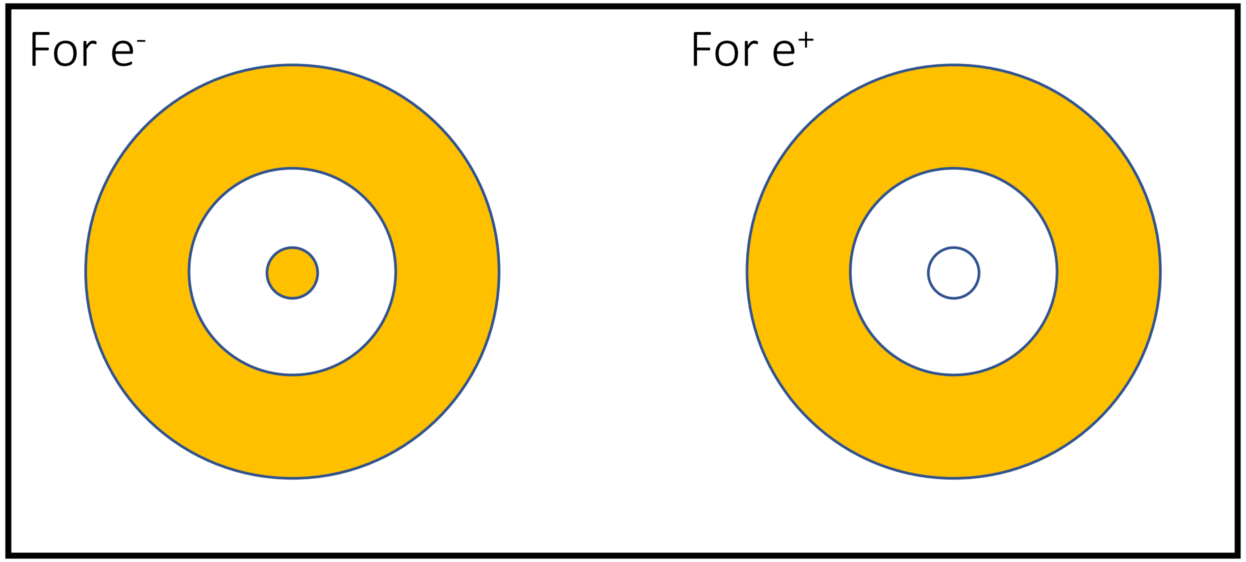
Hollow Channel Acceleration

There is a consensus that without a BBU suppression mechanism, the hollow channel does not work.

One idea is BNS damping with 10% energy spread, but this passes on the problem to the focusing system.

Another idea was presented by A. Pukhov: The "Co-axial hollow channel". In this scenario, there is a filament of plasma on axis to provide focusing and suppress BBU.

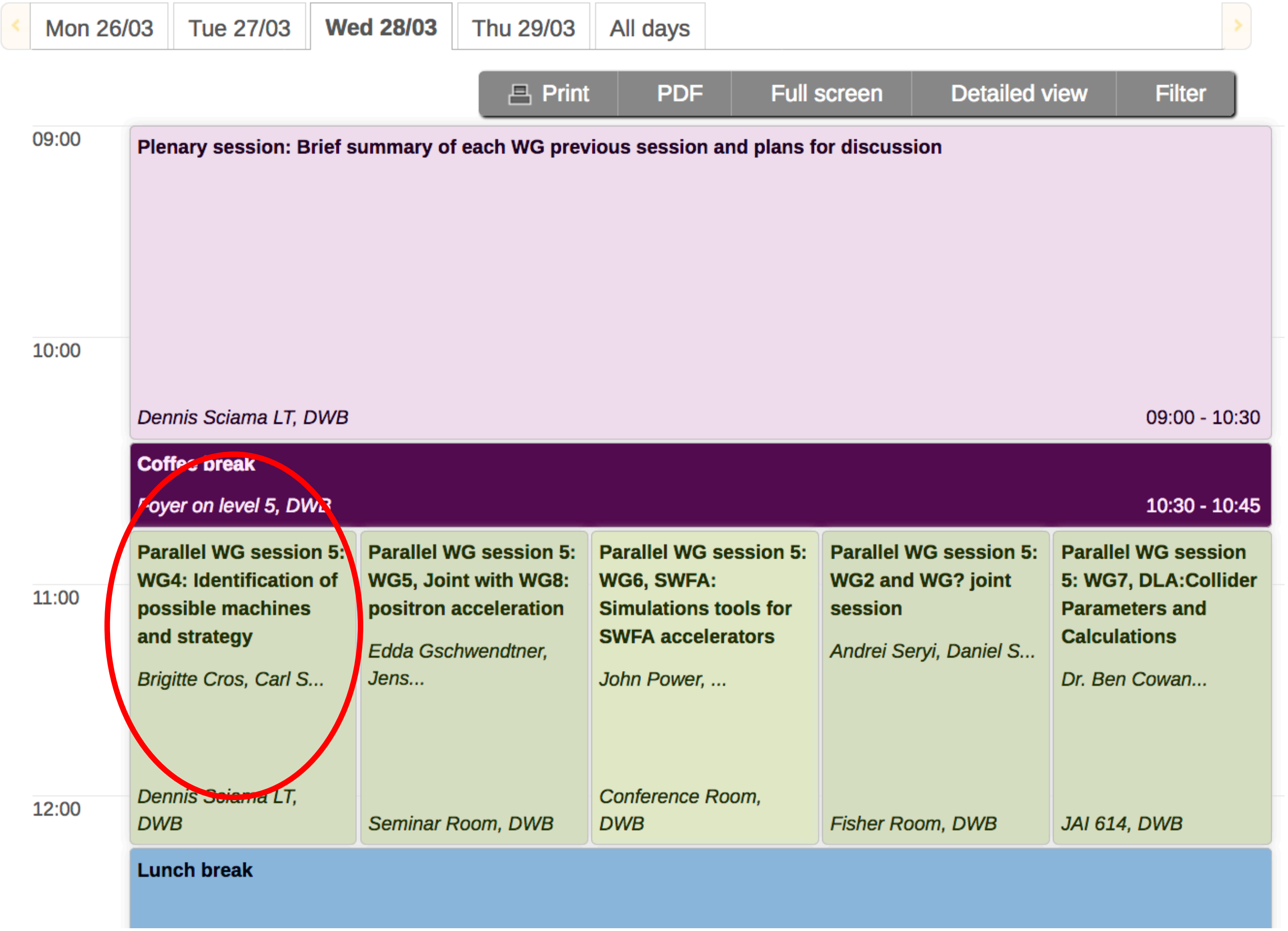




Today: Joint Session on Positron PWFA with WG5

After this session, we will discuss options for PWFA, including an afterburner for the ILC/CLIC.

We will also hear from C. Lindstrøm on hollow channel based linear colliders.



Input to ALEGRO document

At minimum, we will request strong support for facilities that can provide positrons for LWFA/PWFA facilities.

We would also like to make concrete suggestions on positron R&D. More discussion with WG4 and WG5 is needed.