

MAX-PLANCK-INSTITUT
FÜR PHYSIK



Run Coordination: preparation for Run 2b (2024)

Giovanni Zevi Della Porta

AWAKE Collaboration Meeting

March 11-13, 2024 — Liverpool, UK

<https://indico.cern.ch/event/1368982/>

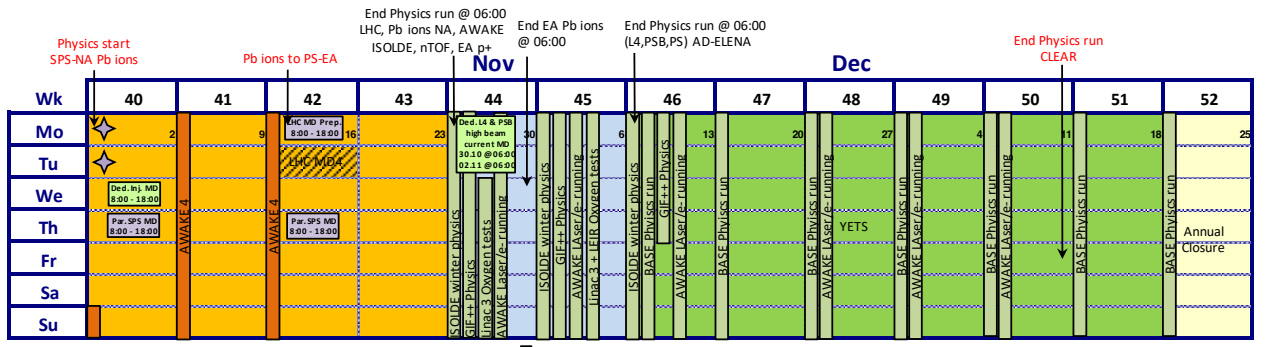
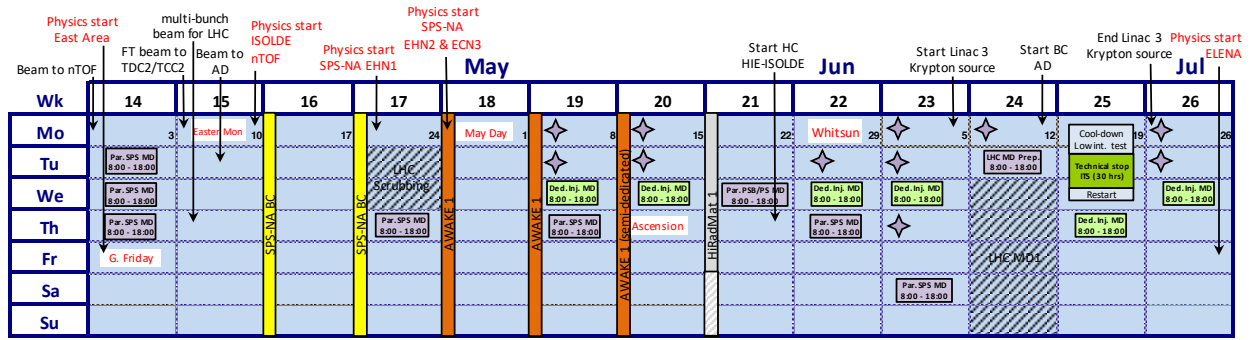
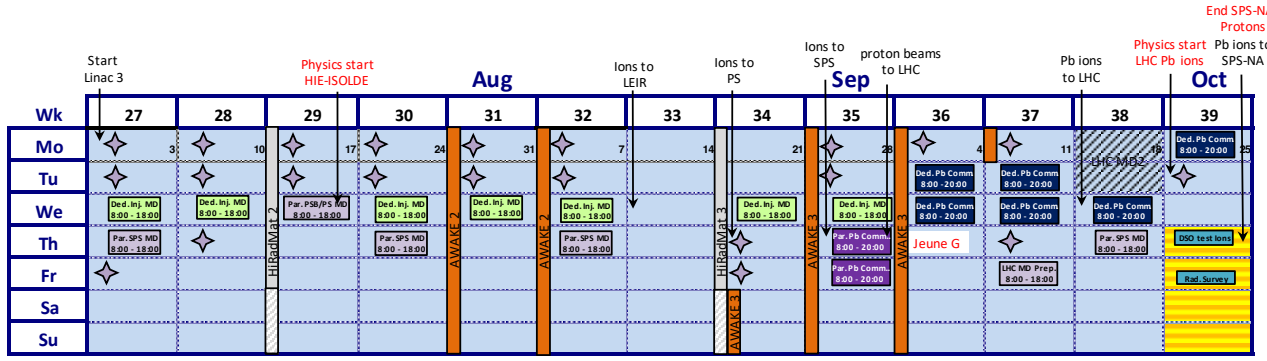
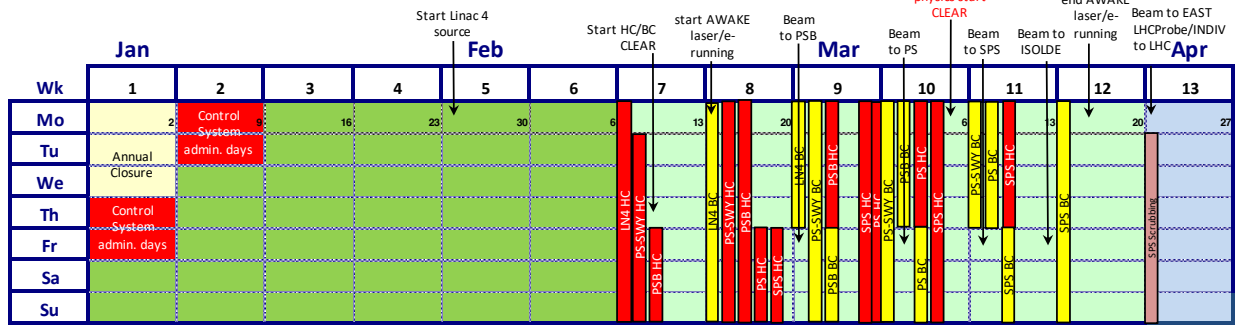
Outline

- The end of 2023, the start of 2024
 - October 2023: proton run
 - Winter (November-February) experiments: Laser and Electron
- Preparation for the 2024 proton run
 - Upgrades: what's new in 2024
 - Commissioning status for existing systems

Review of 2023

- 2023 was a very challenging year: tunnel activities worthy of a long-shutdown, on top of ~10 weeks of protons
- 4 proton runs: May, August, August-September, October
 - See last Collaboration Meeting for details of May-September runs
 - <https://indico.cern.ch/event/1329098/contributions/5608908/>
- 2 plasma sources: Discharge and Density Step

- Proton runs:
 - ✓ • May 1-21
 - ✓ • July 31 - August 13
 - ✓ • Aug. 26 - Sept. 11
 - ✓ • October 8-22



2023 Planned Activities

Run periods

- (laser) Align marker [and IR] on streak camera ✓
- (e) Estimate uncertainty from IN/OUT screen motion ✓
- (e) Commission orthogonal steering with new corrector ✓
- (p) Estimate position jitter on OTR screen ✓
- (e) Test 4D tomography of beam ✓
- (e) Commission optimizer to match beamline to injector ⚠
- (e) Test cycling (vs de-gaussing) for hysteresis ✓

BTVs and Streak Camera

- Complete commissioning of BI DAQ ✓
- Replace broken cameras: DMD1, 426.CORE ✓
- Move hardware IN position for CTR screen (avoid damage) ✓
- Align BTV lines ✓
- Align Downstream-to-Upstream line, marker laser line ✓
- Install OTR screen on BTV354 ✓
- Install new OTR screen at plasma exit ✓
- Improve imaging in optical line to upstream streak camera ✓
- Estimate noise on Basler cameras before/after run ⚠
- Install new server for additional cameras ✓

Rubidium

- Add automated warnings when Rb open

Other Instrumentation

- Fix BPM 412319 sending no data ✓
- Install additional channels to Oasis scope ✓
- Fix eBPM calibration signal
- Add proton/OTR light to DPS scope ✓
- Calibrate new BCT with pilot proton beam ⚠

Laser

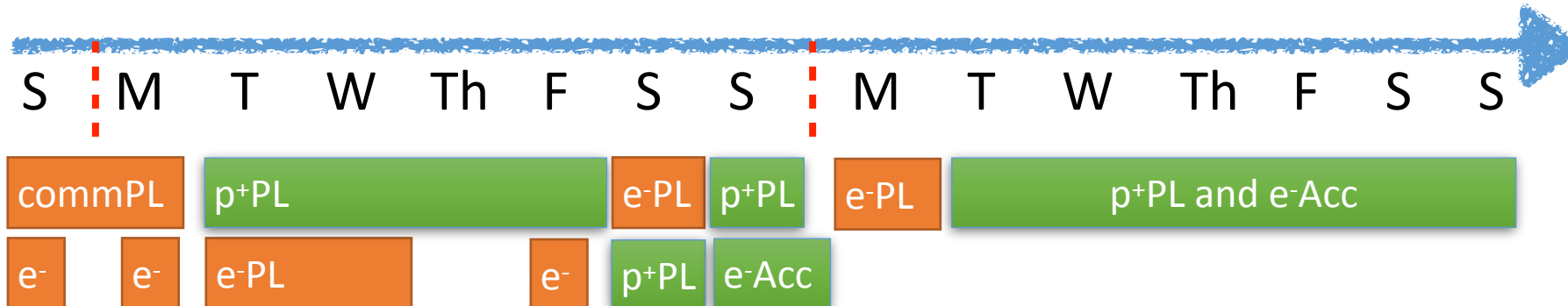
- Replace Energy Meter 4 (no longer needed)
- Set up remote locking to RF ✓
- Upgrade laser alignment, add diode laser to virtual line ⚠
- Reflective optics project ⚠
- Enable LBDP2 automatic movement ✓
- Add protection for BTV 412442 in interlock ✓
- Shift delay stage in TCV4 ✓
- Repair UV line optics causing dark area in beam profile ✓
- Produce new spare cathode ✓

Data Acquisition / Data Quality

- Stabilize slit scan GUI for streak camera ✓
- Plasma light not recorded in 1Hz EventBuilder ✓
- Add ICT to Event Builder (check synch at 1 Hz)
- Automated frequency plot from streak camera ✓
- Check DPS+DAQ with calibration trigger ✓
- Add PMT settings to Event Builder ✓

October 2024: Second Run with Density Step

- Another “commissioning+physics” run: several significant interventions in the week before the start of the run, only tested during proton time
 - Mu-metal to shield from Earth’s B field → New electron trajectories
 - Amplitude Laser intervention → New UV energy on photocathode → New electron beam optics
 - New plasma light diagnostics (10 digital cameras) → New trigger and alignment
- Ambitious commissioning+physics plan
 - Commission new plasma light diagnostics, first with laser, then protons **commPL**
 - Study electron trajectories in mu-metal in vacuum **e⁻**
 - Measure proton-driven plasma light vs density step **p⁺PL**
 - Study electron-driven plasma light to estimate electron trajectory **e⁻PL**
 - Measure electron acceleration vs density step **e⁻Acc**
 - → Progress and data taken on all the above. Scanned Rb density, density step height/position, RIF position



Preliminary results presented at SPSC and AWAKE Review

→ Preliminary results: see SPSC and Physics Board ←

Winter Experiments: Laser and Electrons

Lucas's talk

- Laser Physics: measurements of plasma column
 - Continue collaboration with Wigner team [[Lucas's TB slides](#)]
 - Transverse measurement: Schlieren imaging
 - Longitudinal measurements: back-propagating blue light
 - Simultaneous measurement of plasma light

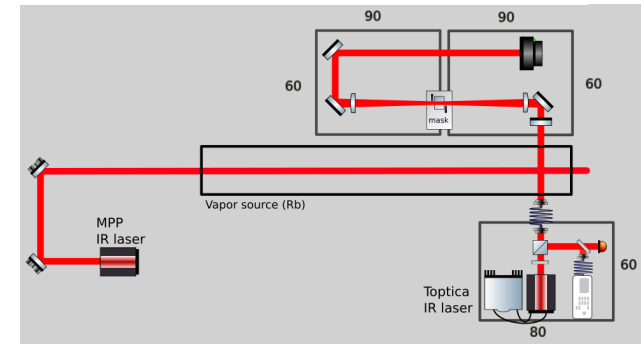
Nikita's talk

- Electron Commissioning:
 - Several measurements and tests planned
 - Timing: bunch length and timing jitter
 - Vacuum: characterize optics; explore trajectory 'ghost kick'

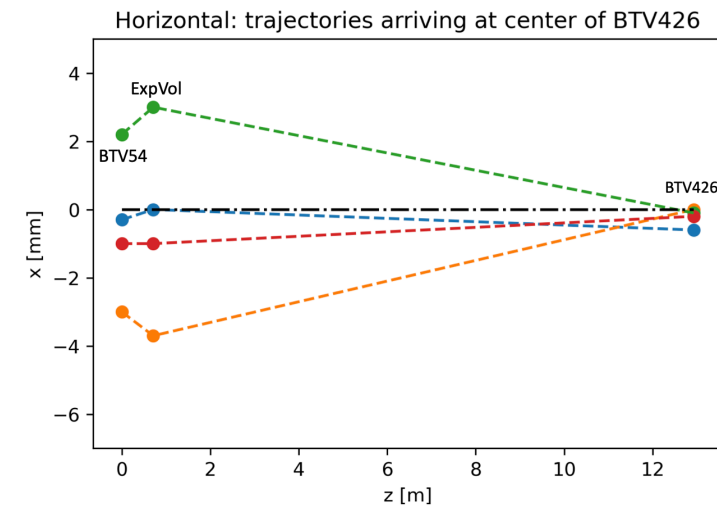
Fern's talk

- Spectrometer resolution measurements at CLEAR in December
 - Required for emittance measurement of accelerated bunch

Schlieren setup (transverse)



'Ghost kick' vs initial trajectory



2024 Schedule

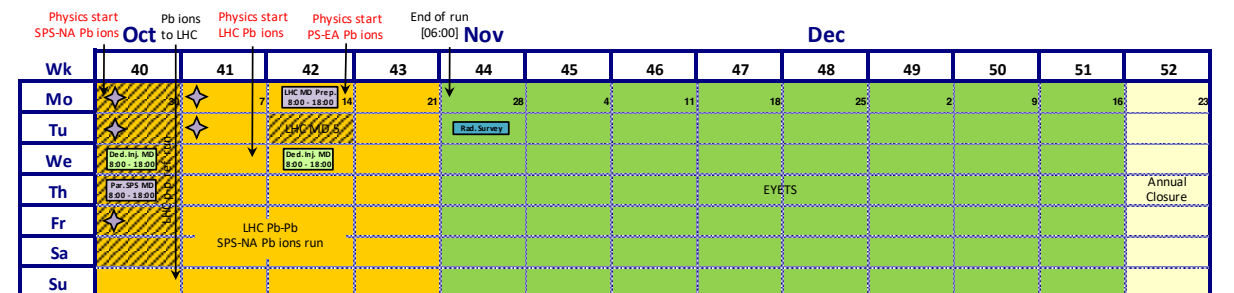
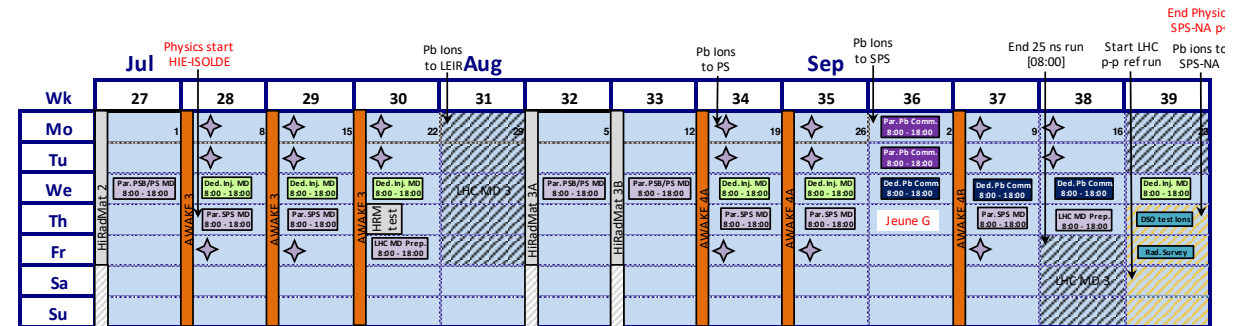
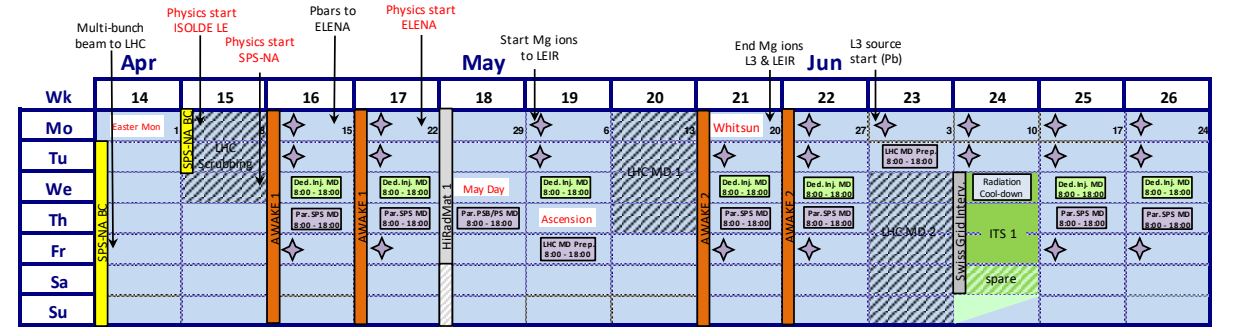
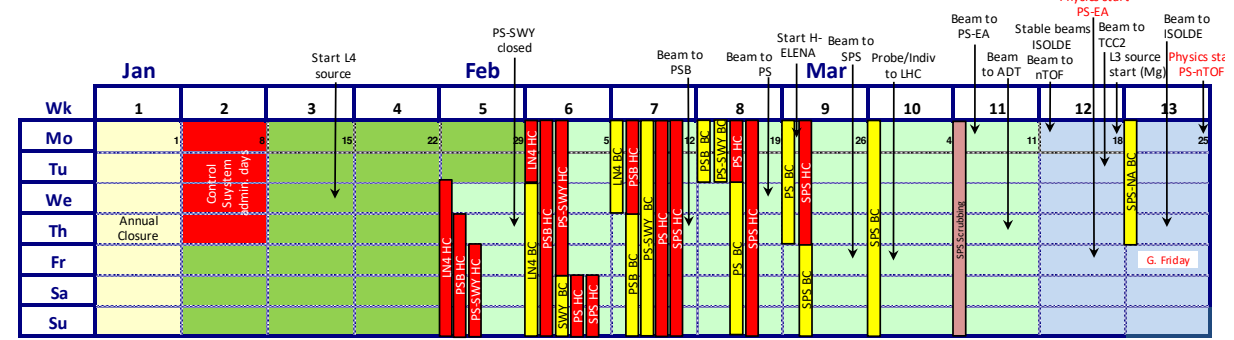
- Proton run:

- April 15 → September 15
- 10 weeks, spaced in 4.5 runs
- ≥ 3 weeks between runs

- Inter-run periods:

- May: Laser/plasma experiments
- June: Vapor source plungers installation

- October: begin CNGS work



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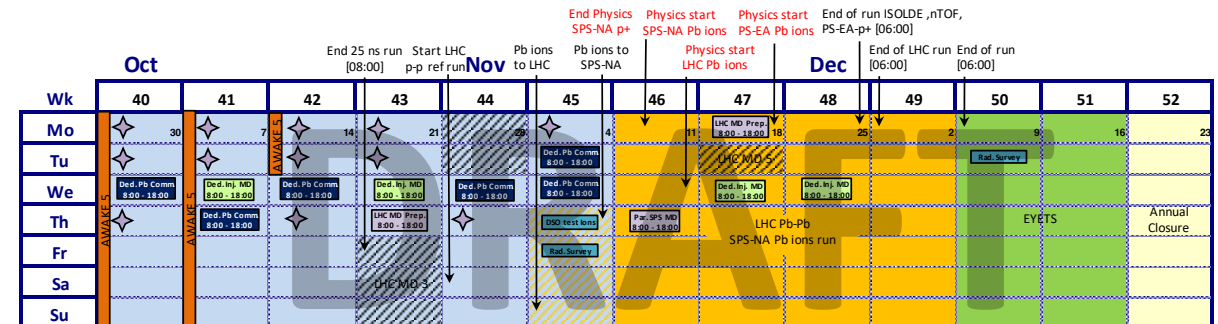
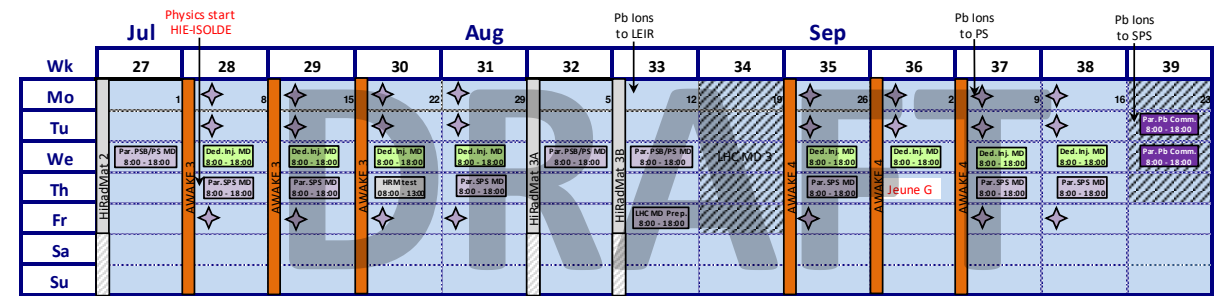
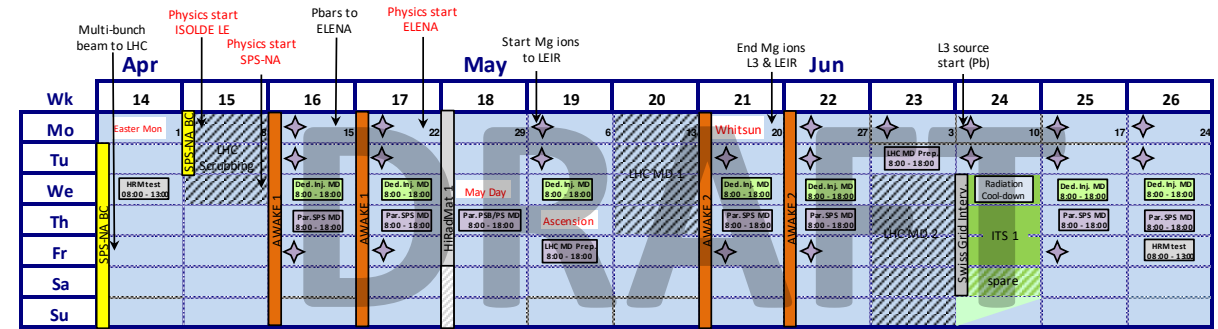
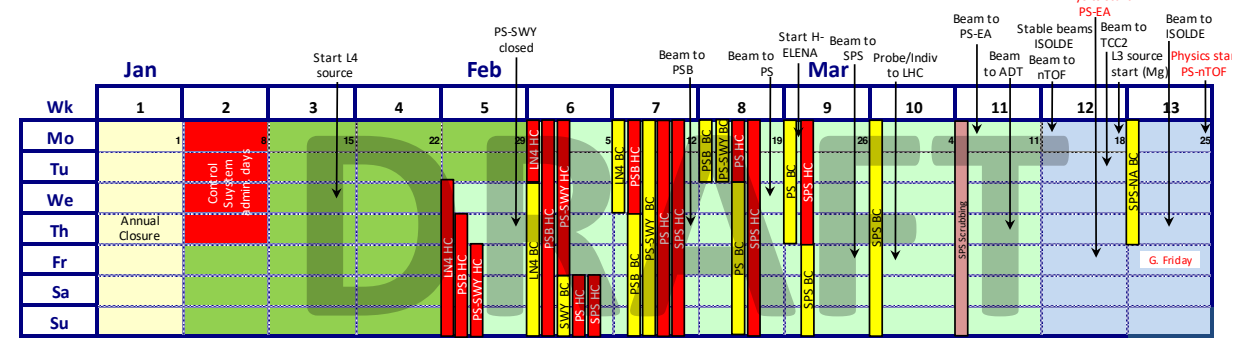
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- LATEST NEWS: 2 more weeks of protons?

- Injector schedule is under discussion and might be extended by 6 weeks, allowing for 2 weeks of protons to AWAKE in October
- Possible to shift CNGS dismantling



Maintenance and upgrades for 2024

- Most groups are focusing on maintenance and stability for 2024
 - Only one vacuum intervention still required before April run: replace laser beam dumps with clean foils (LBDP2/LBDP3).
- Most significant intervention: vapor source plungers
 - —> see Michele's talk
- Additional instrumentation is being considered/installed:
 - Schlieren imaging in plasma [installed in January]
 - New cameras for electron spectrometer [in progress] (see Collette's talk)
 - New streak camera optical line from Station 2 [in progress]

Commissioning Status: Instrumentation

	Hardware	Software	Electron/laser beam	Proton beam
eBPM	OK	Error in GUI (still usable)	OK	n.a.
pBPM and BCT	SPS responsibility		n.a.	
BTV Screens	OK	OK	OK	
BTV Cameras	OK (except Halo2 motors)	OK (missing some reference images)	OK	
XMPP Streak				
Upstream Streak	OK	OK	OK	
YMPP Streak				
Faraday Cup	OK	OK	OK	
Spectrometer	OK	OK	OK	
Rb Density	OK	OK	OK	
Plasma PMTs				
Photodiode @ CTR				

Commissioning Status: Beams

	Beam Created	Aligned and Propagated	Optics/Size	Intensity/Charge
Electrons	OK	OK (See Nikita's slides today)		
Laser (IR)	OK	OK	OK	OK
Laser (UV)	OK	OK	OK	OK
Laser (Marker)	OK			

Electron Controls

	Hardware	Software	Beam
Magnets	OK	OK	OK
Spectrometer Magnets	OK	OK	OK

Laser Controls

	Hardware	Software	Beam
Picomotors	OK	OK	OK
Filter wheels	OK	OK	OK

Commissioning Status: Alignment and DAQ

Alignment: optical lines, timing, synchronization

Photocathode UV translation stage photocatode: effect on e- trajectory	OK
Streak optical lines: align with HeNe or reference	Upstream OK.
Streak absolute time: find signal (electrons, IR or Marker) in all time windows	Upstream OK.
Beam synchronization: synch Marker+IR on Downstream streak	
Beam synchronization: synch Electrons+Marker on downstream streak	

Data Acquisition and Data Quality

Run Event Builder at 1Hz	OK
Run Event Builder with SPS calibration trigger	
Use Event Builder GUI to check which devices are not sending data	
Start DQM and verify that all data is processed	

Organization

- Starting a new job in April: new CMS tracker for HL-LHC
 - No immediate replacement for AWAKE
- Several months to prepare the transition: responsibilities to be shared among the Geneva-based team, with collaborators already heavily involved in these topics
 - Coordination of tunnel activities and access system outside proton run: Eloise
 - Operation of electron beam: Nikita, Fern, Vittorio
 - Run Coordination: Michele / Marlene
 - Data Acquisition and Data Quality: Lucas / Marlene
 - Control Room Tools: Lucas / Marlene

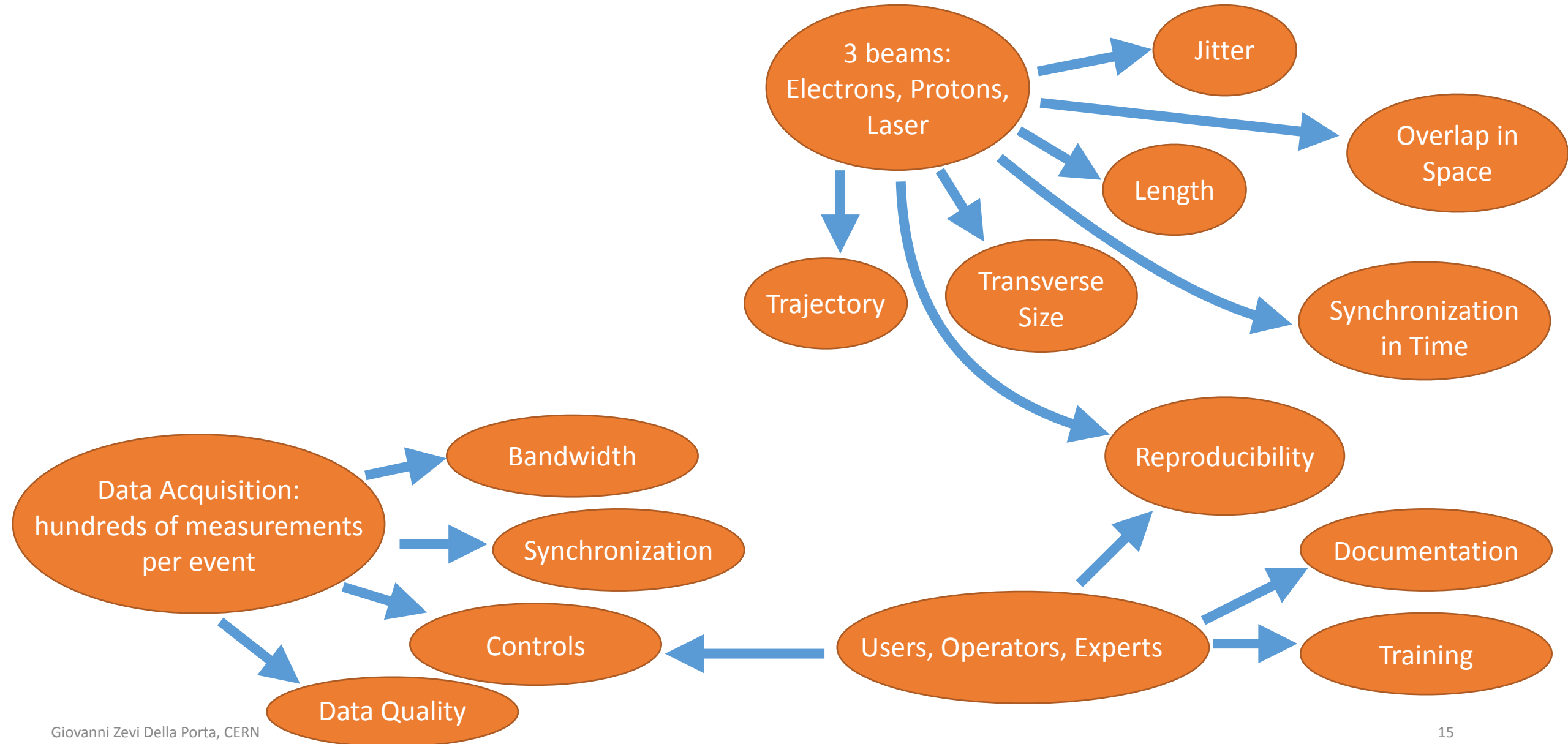
AWAKE: a learning experience

15 October 2019: the start

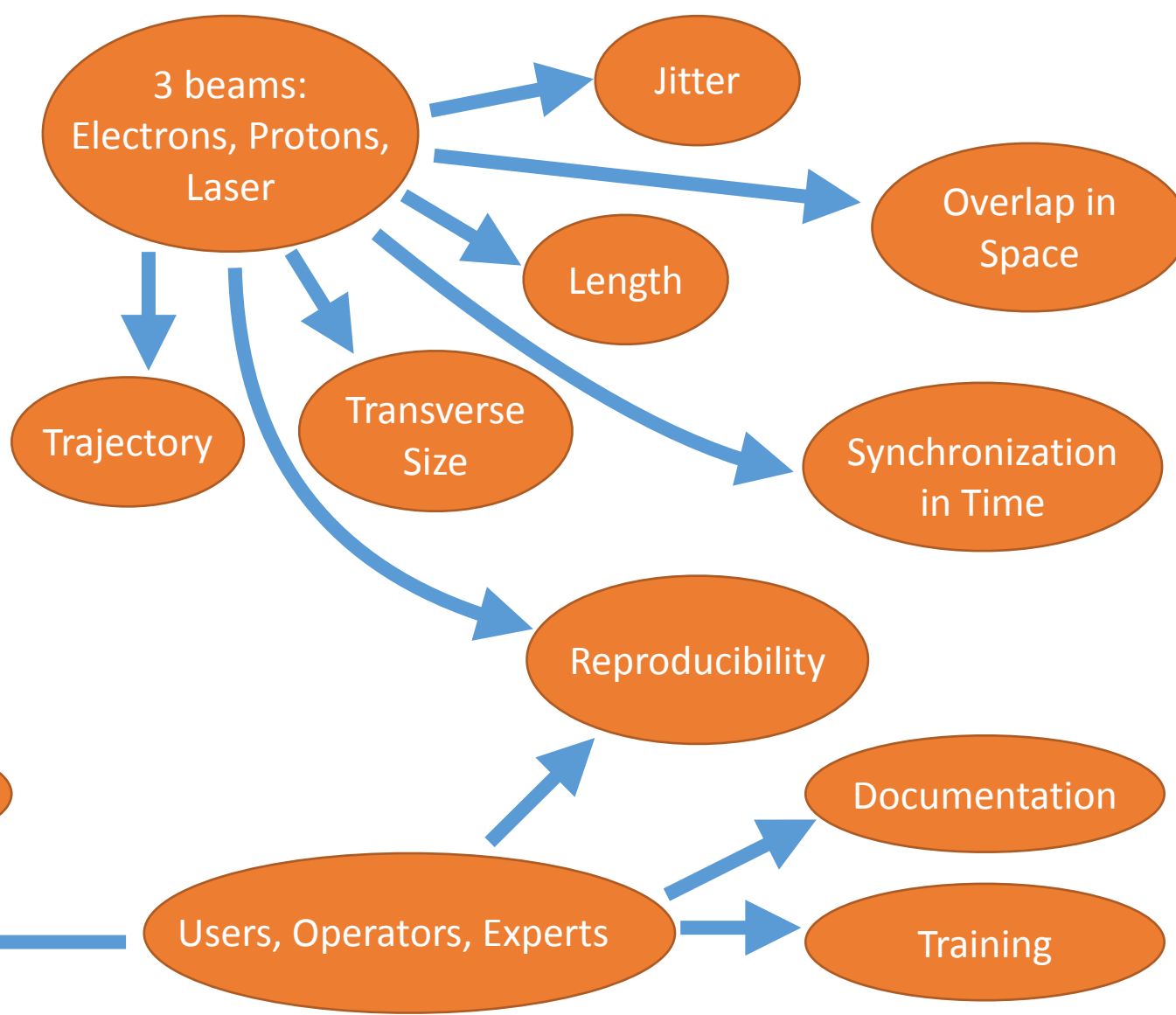
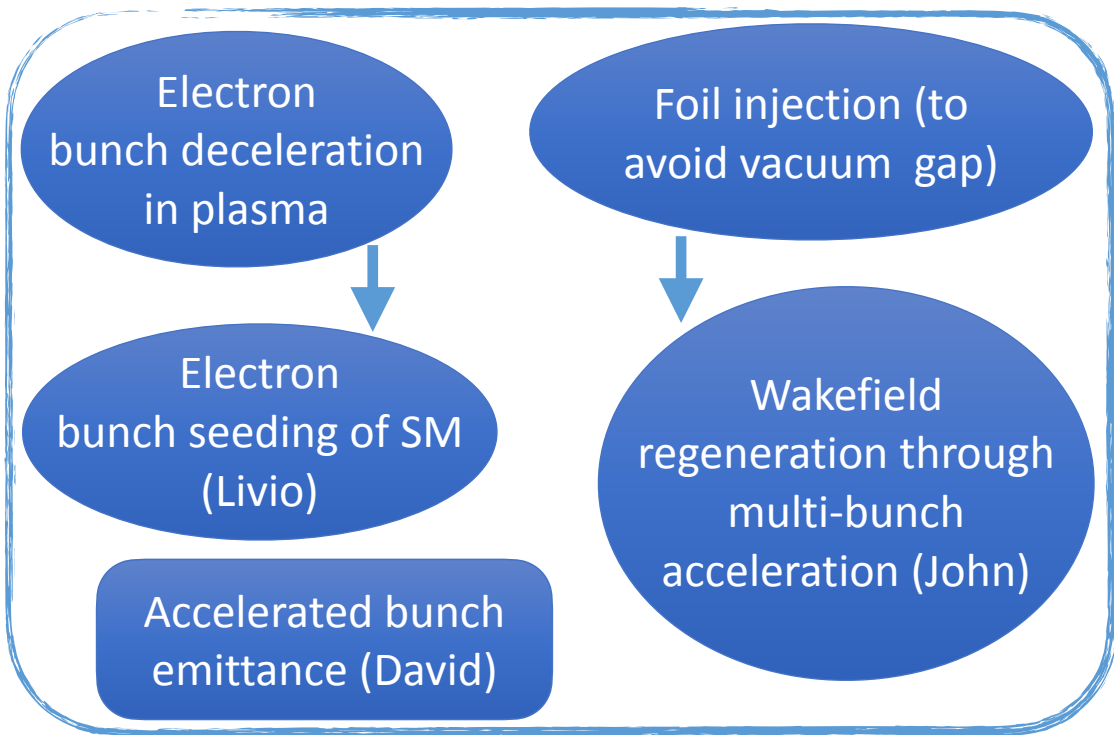


**And thanks to Spencer
for teaching me way more
than I could handle!!**

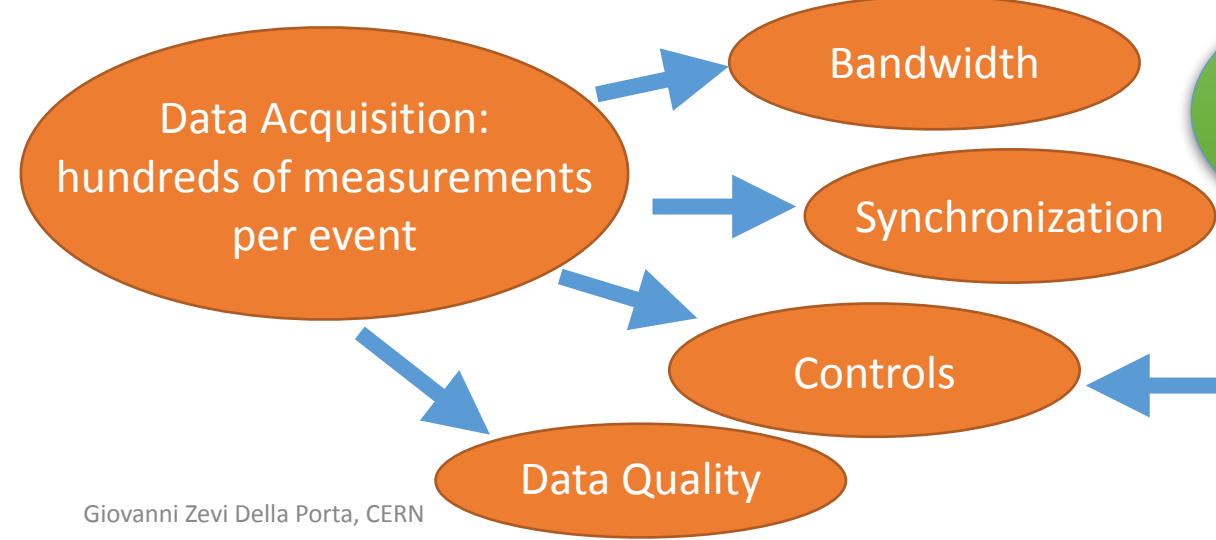
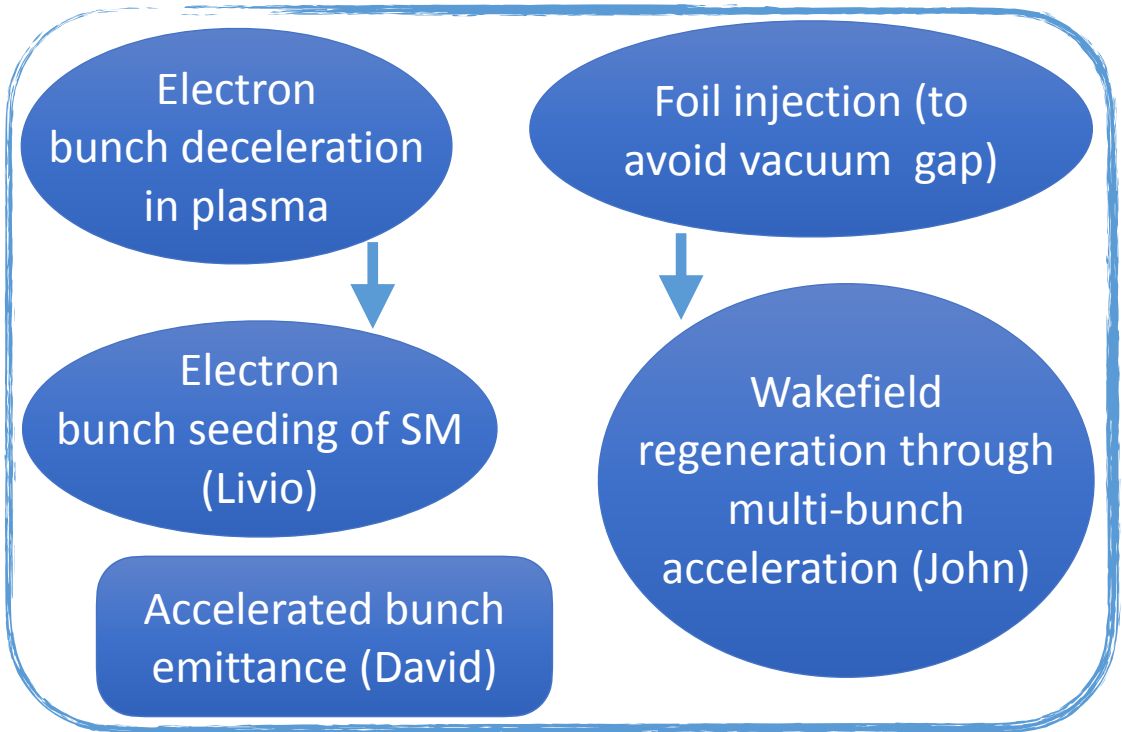
AWAKE: a learning experience



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AWAKE: a learning experience



Special thanks to:

Edda, Patric, Allen, Matthew

Spencer, Marlene, Josh, Michele, John, David, Lucas, Eloise, Vittorio, Rebecca

Stefano, Ans, Eduardo, Steffen, Francesco, Alban, Verena, Ben, Athanasios

Livio, Anna-Maria, Fabian, Jan, Tatiana, Mariana

Arthur, Fern, Nikita, Jan²

... and to everyone who has helped to keep AWAKE running since 2019!!

Bonus: surface control room for April run

- There will be no elevator for the April proton run
 - Control room is 19 floors underground
- CMS Executive Board has allowed exceptional usage of their Meyrin Control Centre for the April run
 - 8 computers, ~20 screens, next to Building 6 cafeteria



Backup

Issues in October run

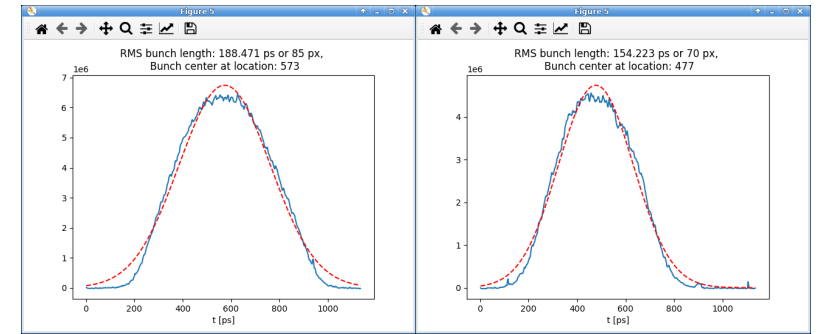
- SPS Proton Beam:

- Ion run: good rate (3 extractions in 50 seconds), but more interruptions for LHC fills
- RF instabilities (event-to-event and day-to-day)
 - Observed on October 10 and October 20-21
 - Solved by experts, but investigation of root causes is ongoing
 - Upcoming presentation at SPS Machine Performance Committee
- Fast Magnet Current Monitors (FMCM) for SPS septum (MSE) (also had issues in September run)

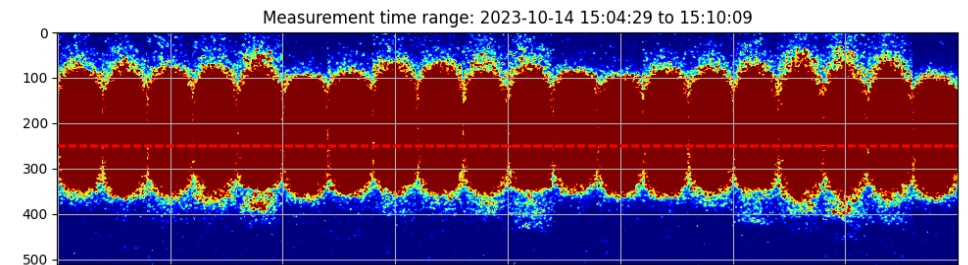
- AWAKE Experiment

- No more OTC issues in vapor source: problem solved by WDL!
- No more contrast/prepulse issue in Laser!
- New energy of UV on photocathode resulted in great charge but suboptimal electron beam parameters —> Solved after the end of the run with an intervention
- Failed PMT scope card —> Replaced
- Three plasma light cameras died and required replacement —> Potential link to BTV54 motion (protons scattering on screen holder) —> New procedure: stop extractions when moving BTV54

Avg. bunch z profile: Oct 19 and Oct 21



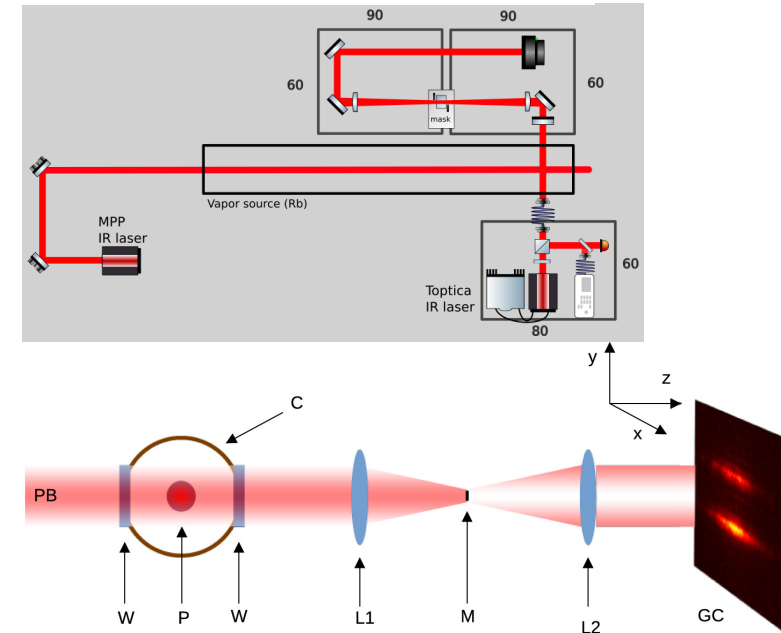
Bunch z profile changing from event to event



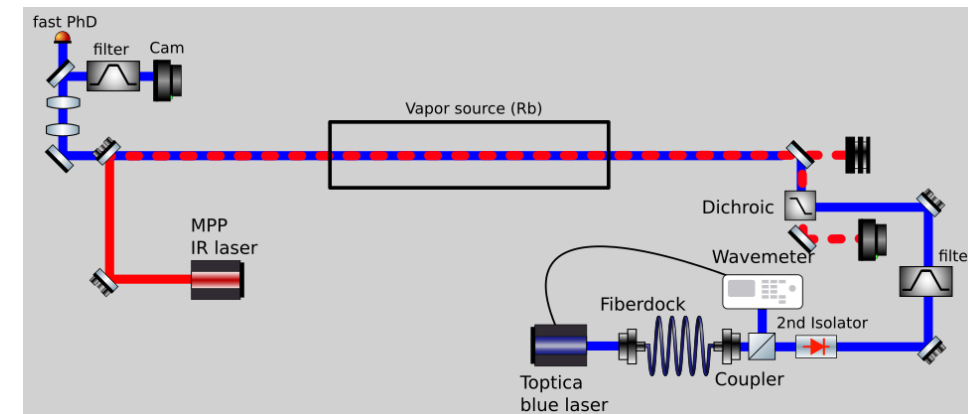
Laser studies during YETS

- During the year, laser work has focused on IR and UV delivery
 - Many new tools for alignment, interlock mode change, automatic counting of shots on beam dump
 - Tuning for IR prepulse/contrast and UV energy
- Use the YETS to study the physics of ionization
 - Continue collaboration with Wigner team
 - Optics & Laser Technology, Volume 168, January 2024, 109921
 - Phys. Rev. A 104, 033506
 - Different measurements of plasma:
 - Transversely, using Schlieren imaging
 - Longitudinal, using blue light (plasma is transparent)
 - Plasma light
- Status:
 - Setting up for physics program started in November
 - Schlieren setup complete and data taking started
 - Plan to continue in January, also adding blue light

Schlieren setup (transverse)



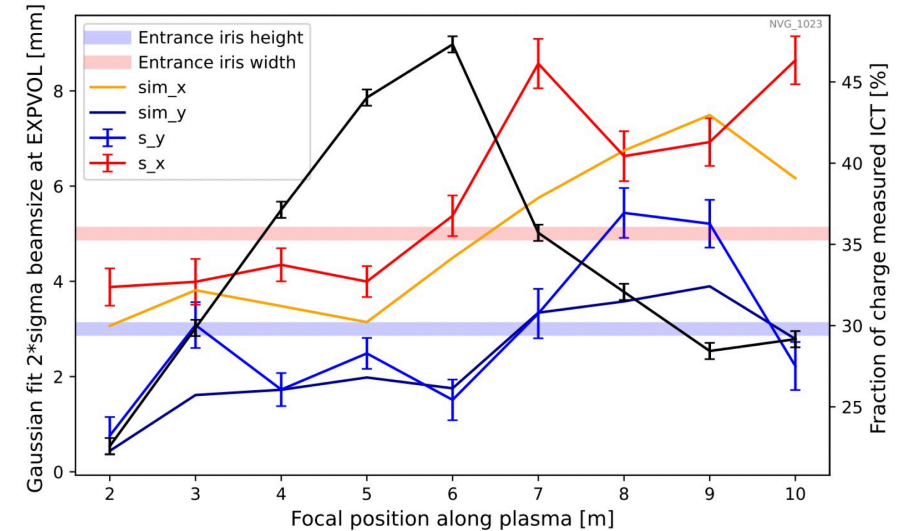
Blue light setup (longitudinal)



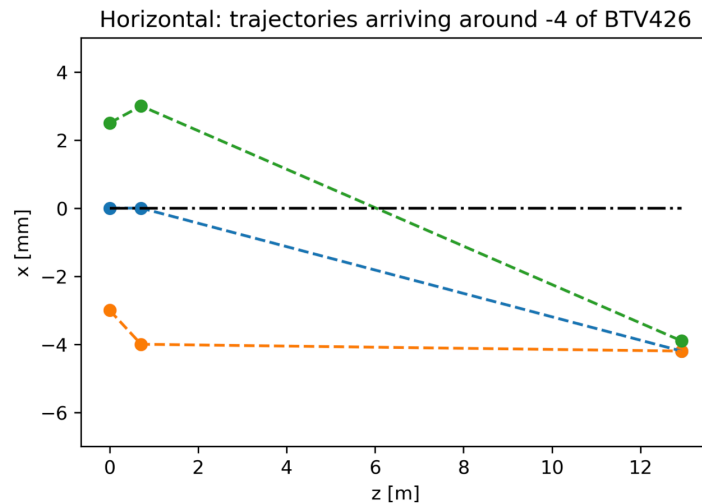
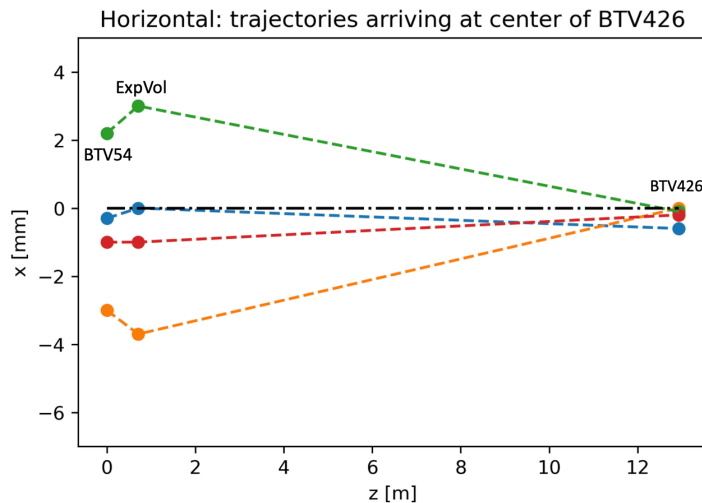
Electrons studies during YETS

- Only ~2 weeks dedicated to electron studies in 2023
 - Focus on Trajectory/Optics before vapor source
 - Reproducible steering
- YETS allows for dedicated studies including vapor source
 - Propagation as a function of optics
 - Electron-driven plasma light for trajectory control
 - BTV before/after vapor source for trajectory control
- Plan to continue studies in February and March

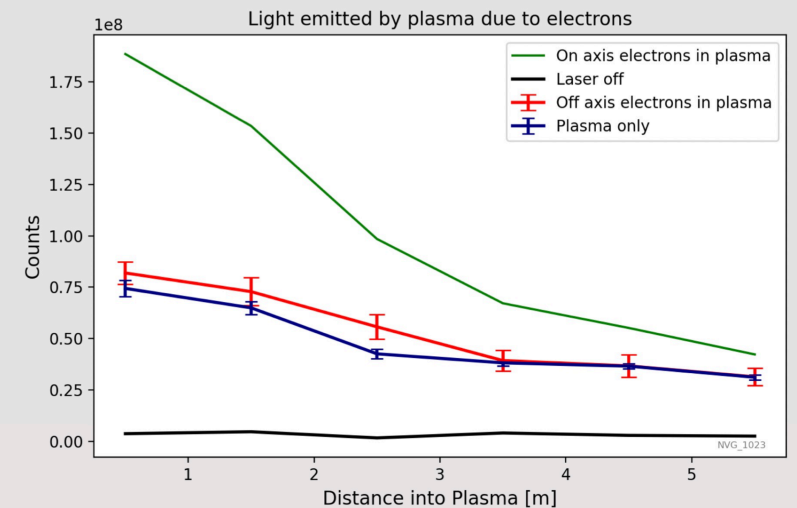
Propagation as a function of optics



Electron trajectory in vacuum



Plasma- electron crossing



Possible Improvements to the Experimental Setup

Streak Cameras

Goal: Simultaneous measurement of proton bunch modulation and electron acceleration.
→ transporting light emitted by screen downstream of the spectrometer

Schlieren Imaging

Goal: Determine plasma radius evolution during p^+ operation.

Plasma Length

Goal: change plasma length by stopping the ionizing laser pulse.
This could be done in principle by inserting screens that would be thick enough to block the laser pulse, but thin enough to let through high-energy electrons through.

Larger Plasma Radius

Goal: larger plasma radius to increase alignment tolerances.
Laser pulse focusing system uses transmissive optics
→ limits the fluence on compressor gratings
Upgrade: use of reflective optics (off-axis parabolas) after the compressor allowing for larger plasma.

Upgrade during the YETS

Highlights of October Run

- From Marlene's SPSC talk: <https://indico.cern.ch/event/1337721/>

