The Contribution of the Wigner RCP to the CERN AWAKE Experiment

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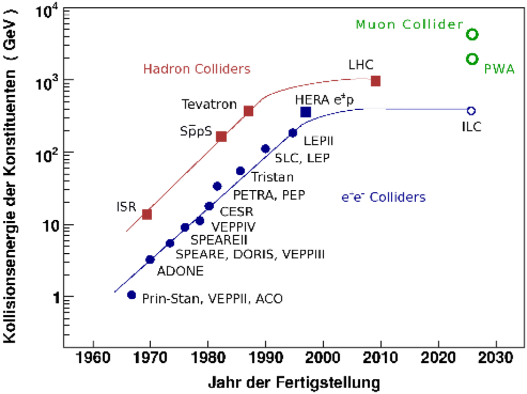
- Present State-of-the-Art technology: circular accelerator, 8.3 T, 14 TeV
- Limit: accelerating field $< 50\,\mathrm{MV/m}$ (in linear colliders $100\,\mathrm{MV/m}$).



How further → VLHC?
(Future Circular Collider Kick Off Meeting, February 2014, Geneva)

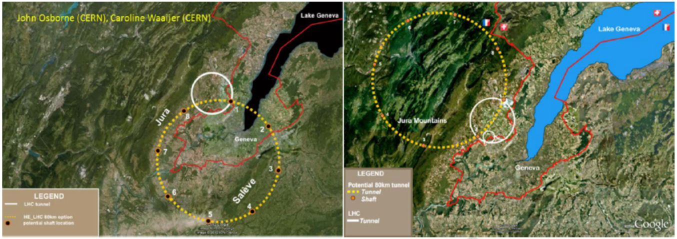


Figure 9. Two possible location, upon geological study, of the 80 km ring for a Super HE-LHC (option at left is strongly preferred)

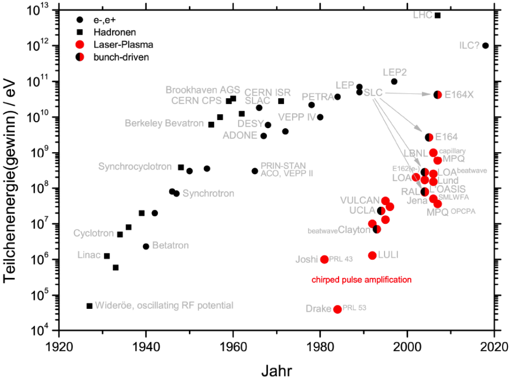
VLHC may provide:

- 80 km and 8.3 T $\rightarrow$ 42 TeV
- 80 km and 15 T $\rightarrow$ 80 TeV
- 80 km and 20 T $\rightarrow$ 100 TeV
- 100 km and 15 T $\rightarrow$ 100 TeV

VLHC requires the invention of 15 T and 20 T magnets.

Extremely expensive!

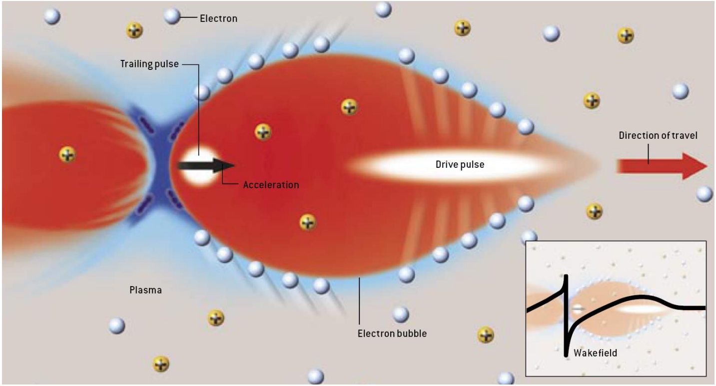
New, cheaper technologies are needed → Plasma based acceleration!



Plasma wakes accelerate particles. Plasma wakes are driven by either laser pulses or particle beams. Possible methods (Tajima and Dawson, Phys. Rev. Lett. **43**, 267 (1979), E. Esarey *et. al:* Rev. Mod. Phys. **81**, 1229 (2009) etc.):

- **LWFA:** Short ($\approx 1\,\mathrm{ps}$), ultra-intense $I \geq 10^{18}\mathrm{W}\cdot\mathrm{cm}^{-2}$ pulse. $L = c\tau_p \approx \lambda_p = 2\pi c/\omega_p$, $n = 10^{15}\,\mathrm{cm}^{-3}$.
- **PBWA:** Beat-wave of two pulses, $\omega_1 - \omega_2 \sim \omega_p$, $n = 10^{16} - 10^{17}\,\mathrm{cm}^{-3}$. An alternative for LWFA.
- **Self-modulated LWFA:** LWFA by higher plasma densities. $n = 10^{19}\,\mathrm{cm}^{-3}$, $I \approx 10^{19}\,\mathrm{W}\cdot\mathrm{cm}^{-2}$, $L > \lambda_p$. A train of pulses with pulse length $L = \lambda_p$ is formed.
- **Beam-driven:** a short (few hundred microns at most) particle bunch is capable to drive plasma wakes.
- **Multiple pulses or bunches:** plasma waves with greater amplitude via resonant excitation.

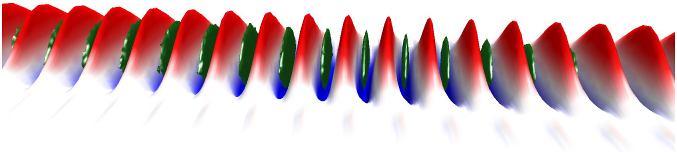
Electron-Driven Plasma Wakefield Acceleration:



AWAKE: Proton Driven Plasm**a Wake**field Acceleration (PDPWFA).

The key point is the **Self-Modulation Instability** (the SPS beam is around 20 cm long).

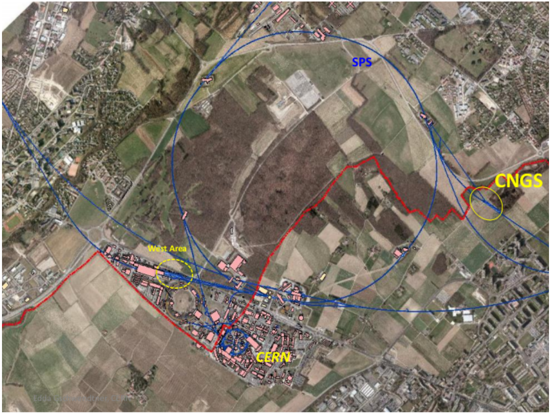
Electrons injected between the short bunches.



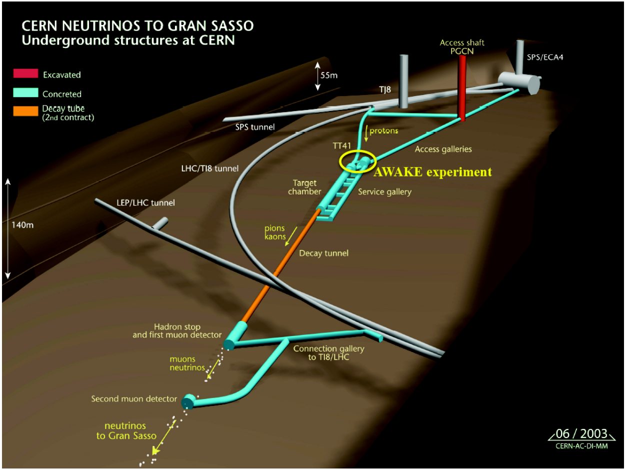
(Required) properties for Rb the plasma:

- $T_{\mathrm{melt}} = 38.89\,^{\circ}\mathrm{C}$
- $T = 180 - 220\,^{\circ}\mathrm{C}$, $\delta T \leq 0.25\%$ that is $\Delta T < 0.5\,\mathrm{K}$
- $l = 5 - 10m$
- $n = 7 \cdot 10^{14}\,\mathrm{cm}^{-3}$, $\delta n < 0.2\,\%$
- $100\,\%$, single ionisation.

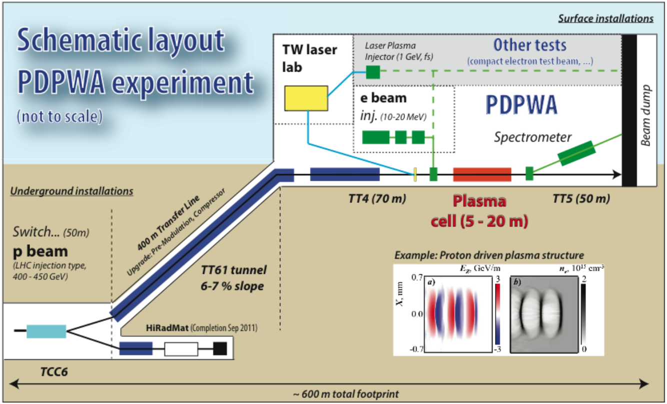
Birdeye View of the CNGS—AWAKE Spot



The CNGS Area

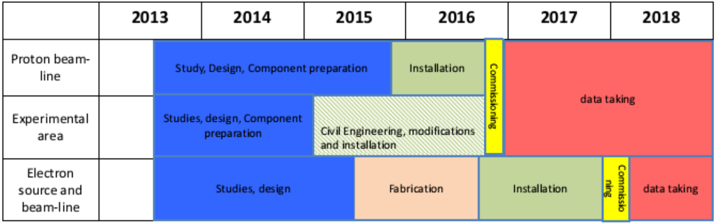


Schematic View of the Experiment



Time-Scale as in the CERN Medium-Term Plan

Time-scale for AWAKE in the MTP



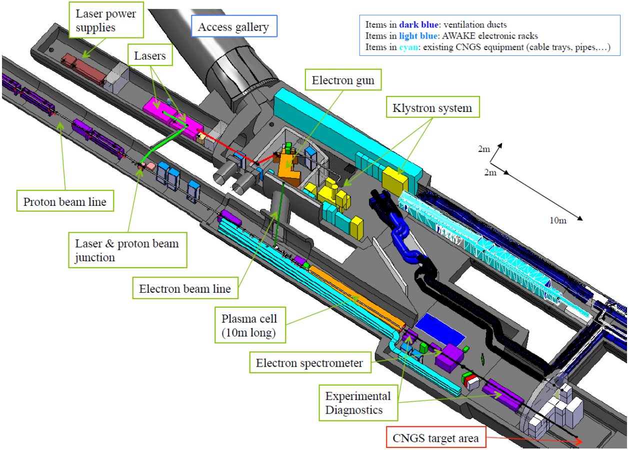
Needed CERN resources:

Costs: 8.5 CHF

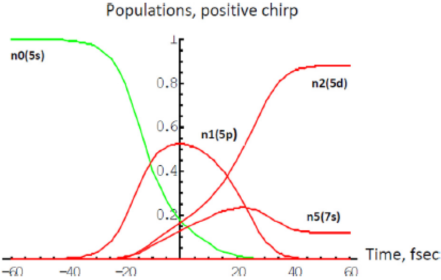
Person-Years: 34.2 PY

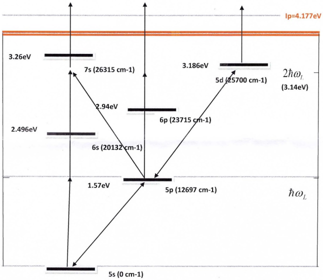
→ **Budget and manpower profile for 5 years**

The Experiment Area



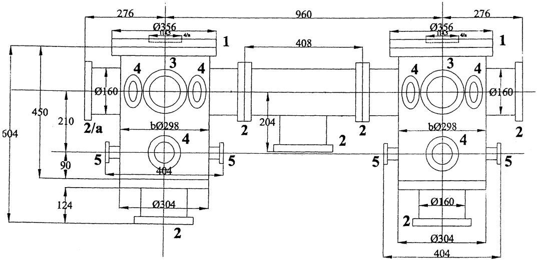
Theoretical contribution: resonant pre-excitation of the Rb vapour could improve the experiment. (M. Aladi *et. al*, Nucl. Instr. Meth. Phys. Res. A **740**, 203–207 (2014))





Experimental Contribution:

- Production of homogeneous Rb plasma (75 cm) long
- Plasma diagnostics

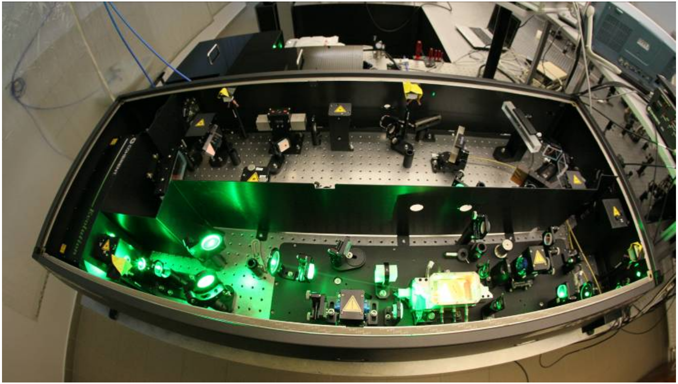


1. Melléklet
VÁKUUMEDÉNY SZERKEZETI RAJZA

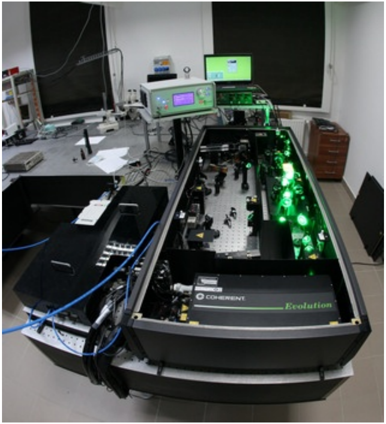
Laser parameters:

- 806 nm Mean Wavelength
- 4.1 W Average Power
- 9 mm Beam Diameter
- Linear, Vertical Polarization
- 1 kHz Repetition Rate
- 35 fs Pulse Duration
- 4.2 mJ Pulse Energy

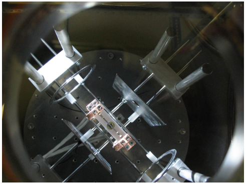
HELIOS Laser in the Wigner RCP

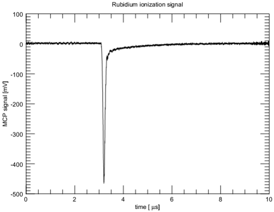


HELIOS Laser in the Wigner RCP



Present Setup and Recent Results:





The signal of the MCP was closed with 50 Ohm in the oscilloscope, the noise was filtered with a 11 point smoothing algorithm, saturated ionisation current is measured.

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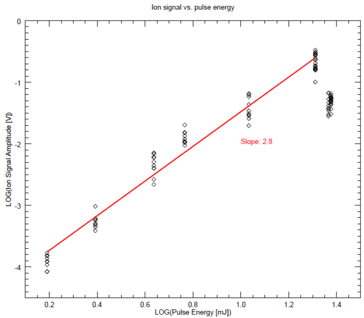

The three-photon ionisation process has been almost measured!

Further work (both experimental and theoretical):

- Building the 75 cm long plasma source
- Plasma Diagnostics (temperature, density, homogeneity)
- Theoretical Description of the Ionisation Process, "Extending" the PIC Simulations

Thank You for Your Attention!