Summary EAAC 2013

1st European Advanced Accelerator Concepts Workshop

Matthias Gross
EAAC2013 Summary
Zeuthen, 8 August 2013

HELMHOLTZ
ASSOCIATION

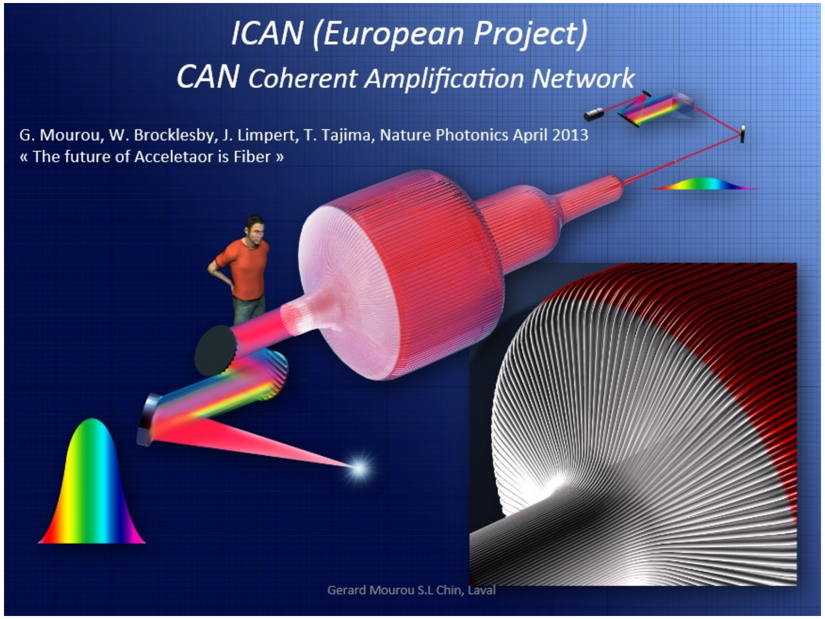
DESY

EAAC 2013

- June 2 – 7 2013 La Biodola, Isola d'Elba (Italy)
- Advanced Accelerator Concepts
- 150+ participants
- Talks in the morning, working groups in the afternoon
- June 7: EuroNNAc 2013 yearly meeting
- Topics:
  - Dielectric Structures
  - Novel schemes using advanced technologies
  - Plasma accelerators
  - etc.
- PITZ Contributions: Poster (Gaurav); Talk in working group (Matthias)
  - Workshop talks at: https://agenda.infn.it/conferenceOtherViews.py?confId=5564&view=standardshort

Gerard Mourou: Can the Future of Accelerators be Fibers?

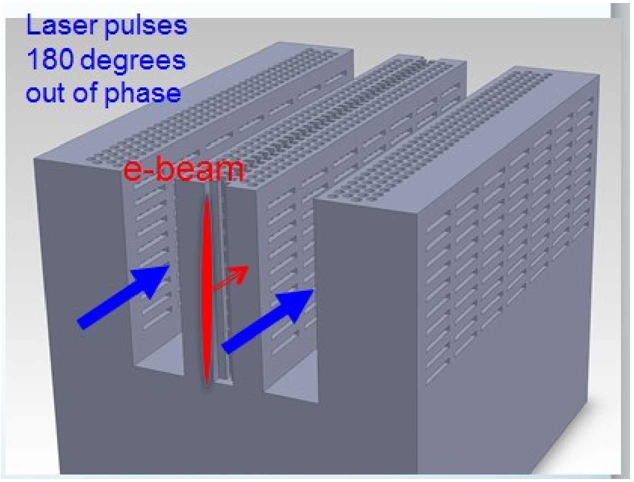
- Problem: Need PW+ peak power for laser plasma acceleration. Those lasers are extremely inefficient ($\eta \approx 10^{-4}$).



- Solution: Use a lot of fiber lasers (high efficiency) in parallel.
- Challenge: Need exact phase and amplitude control.
  - Thermal effects, phase noise $\rightarrow$ control!
  - Micrometer precision assembly
  - Nonlinear effects
- ICAN: International Coherent Amplification Network – An enormous challenge that takes the world wide community
- Projected system cost for PW at 10 kHz: 70M€ ($P_{average}$=500kW, $\eta \approx 30\%$)
- Applications: Colliders etc, nuclear waste transmutation

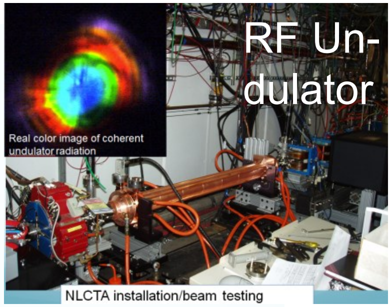
Jamie Rosenzweig: Dielectric Laser Accelerators

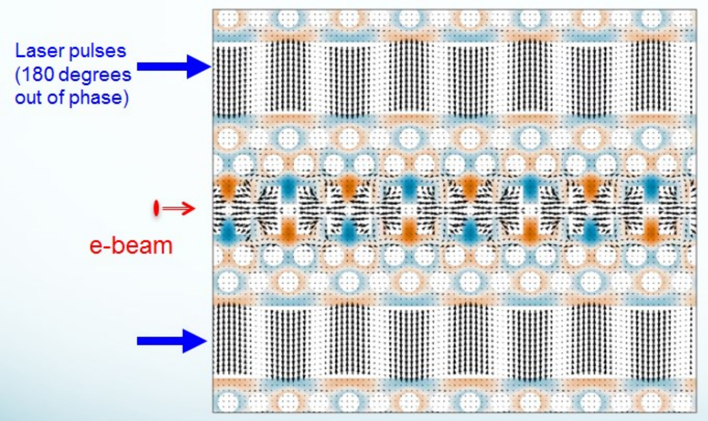
- 5th generation light source: Table top X-ray FEL
- Dielectric: Less dissipation or breakdown than metals
  - ≈proportional to bandgap
- GALAXIE at UCLA
  - Photonic bandgap structure

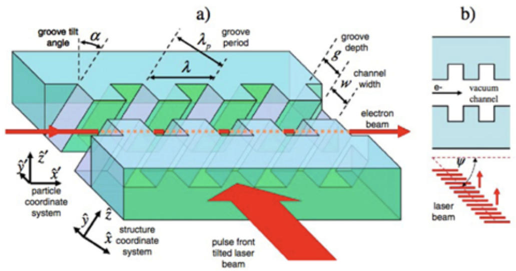


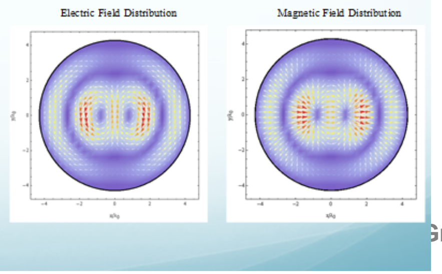
Optical Undulator

- Plettner-Byer scheme inspired field…
  - Slippage allows arbitrary wavelength
  - Problem: cancellation of E,B deflection
  - Quantum FEL effects at short wavelength!
- More promising: THz SW undulator (no E, B cancel)









Fernando Sannibale: High-brightness high-duty cycle electron injectors

- High rep rate (MHz, GHz), high brightness electron injectors are required!

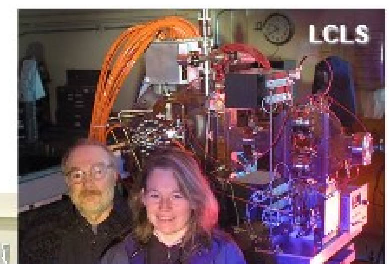
BERKELEY LAB

How to Generate High Brightness Electron Injectors?

High-brightness high-duty cycle electron injectors (F. Sannibale)

- The beams for such applications cannot be generated in damping rings and linear accelerators are usually required.
- In linear accelerators the ultimate brightness of the beam is defined at the electron injector and at the electron gun in particular.
- This has led to the development of a number of high-brightness electrons guns.

For example:



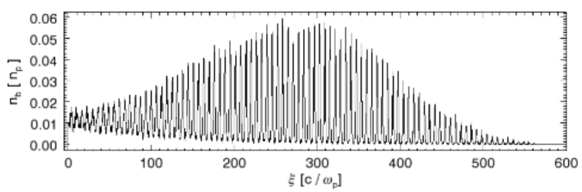
- Most of such sources operate at low duty cycle with repetition rates ranging from few Hz to few hundred Hz.

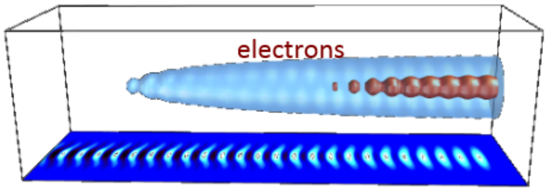
Guoxiang Xia: A proposed plasma wakefield acceleration experiment using CLARA beam

- CLARA: beam line in Daresbury (UK)
- Possible contributions:
  - Two bunch experiment for energy doubling of CLARA beam
  - High transformer ratio
  - Self modulation of long beam
  - etc.
- Simulation:

Self-modulation

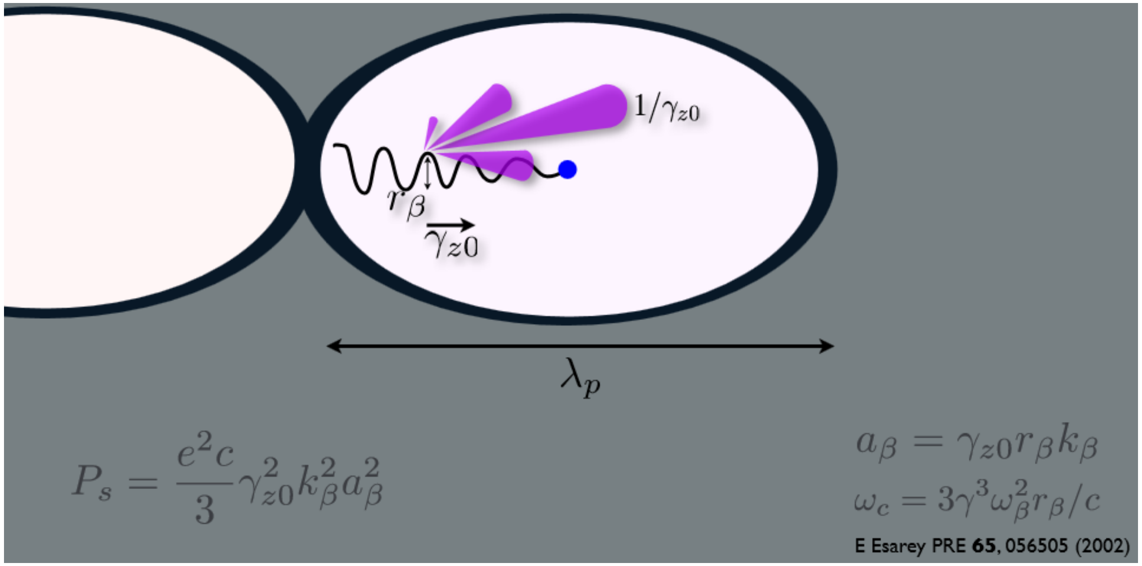
- Long bunch gets modulation in the wakefield excited by itself (bunch head).
- Many ultra-short bunch slices (scale of a plasma wavelength) are produced and then excite the wakefield and add up coherently to a high amplitude (AWAKE experiment at CERN).
- CLARA beam has a similar gamma factor (gamma ~ 500) as SPS beam, many plasma-beam dynamics could be similar and could be tested here at PARS.





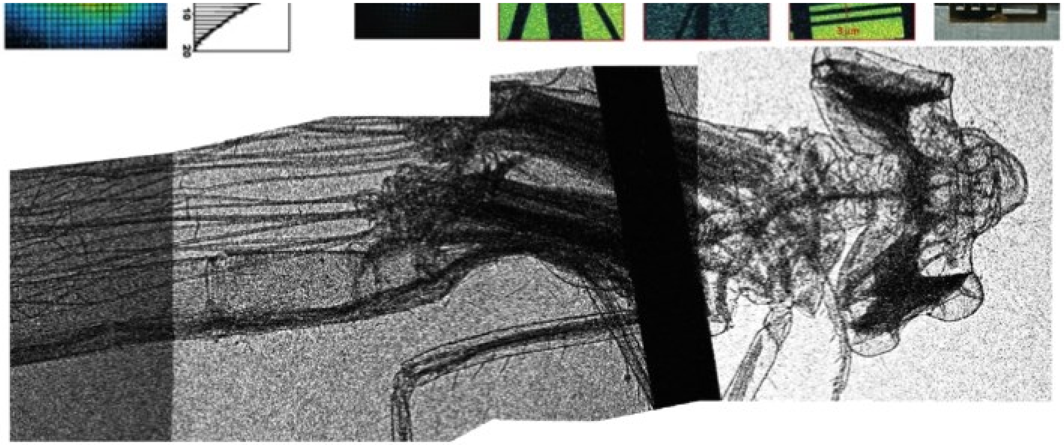
Zulfikar Najmudin: Review on Plasma Accelerators Driven by Laser Beams

- Electron motion in plasma bubble: betatron oscillation → X-ray source!



Experimental observation:

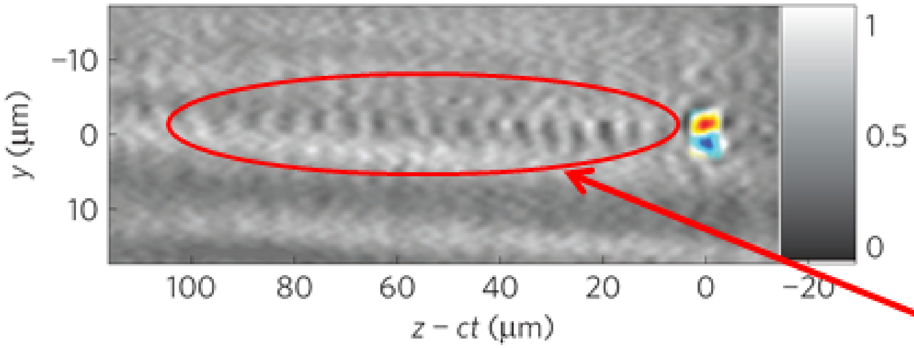
Structural Imaging:



Kneip, S., C. McGuffey, F. Dollar, M. S. Bloom, V. Chvykov, G. Kalintchenko, K. Krushelnick, et al. "X-ray Phase Contrast Imaging of Biological Specimens with Femtosecond Pulses of Betatron Radiation from a Compact Laser Plasma Wakefield Accelerator." *Applied Physics Letters* 99, no. 9 (2011): 093701.

Malte Kaluza: Optical Diagnostics for Laser-Driven Plasma Accelerators

Shadowgraphy with 8.5 fs @ LWS 20



- Polarimetry:
  visualize e-bunch via associated B-fields

- change delay between pump and probe
  ⇒ movie of e-bunch formation

- observe e-bunch formation on-line!

- Shadowgraphy:
  visualize plasma wave

- change electron density ⇒ change plasma wavelength

A. Buck *et al.*, Nature Physics **7,** 543 (2011)

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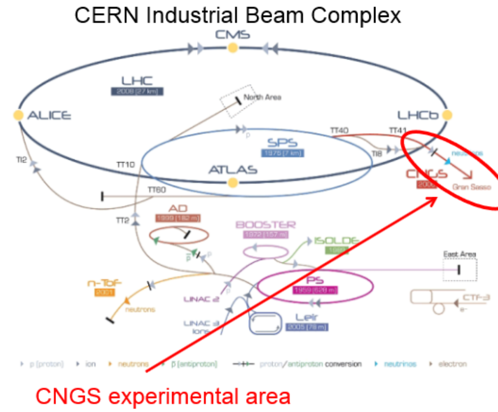
Patric Muggli: AWAKE: A Proton-Driven Plasma Wakefield Experiment at CERN

- Initial Goal: ≈GeV gain by externally injected e^-, in 5 to 10m plasma in self-modulated p^+ driven PWFA

PROTON BEAMS @ CERN

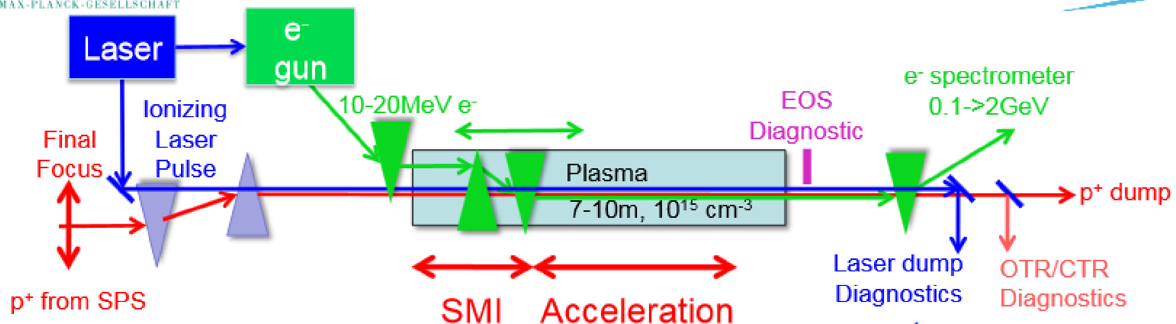


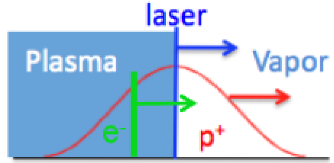
Parameter	PS	SPS	SPS Opt
E_0 (GeV)	24	450	450
N_p (10^{10})	13	10.5	30
$\Delta E/E_0$ (%)	0.05	0.03	0.03
σ_z (cm)	20	12	12
ε_N (mm-mrad)	2.4	3.6	3.6
σ_r^* (μm)	400	200	200
β^* (m)	1.6	5	5

n_e~7×10^{14}cm^{-3} ($k_p\sigma_r$≈1)
λ_{pe}~1.3mm<<σ_z
f_{pe}~240GHz
L_p~5-10m

P. Muggli, 06/04/2013, EAAC 2103

BASE-LINE EXPERIMENTAL SETUP





✧Laser ionization of a metal vapor (Rb), 7-10m plasma, $n_e=10^{14}$-10^{15}cm^{-3} (E. Oz poster)

✧Injection of 10-20MeV test e- at the 3-5m point (SMI saturated, $v_\varphi=v_{p+}$~c)

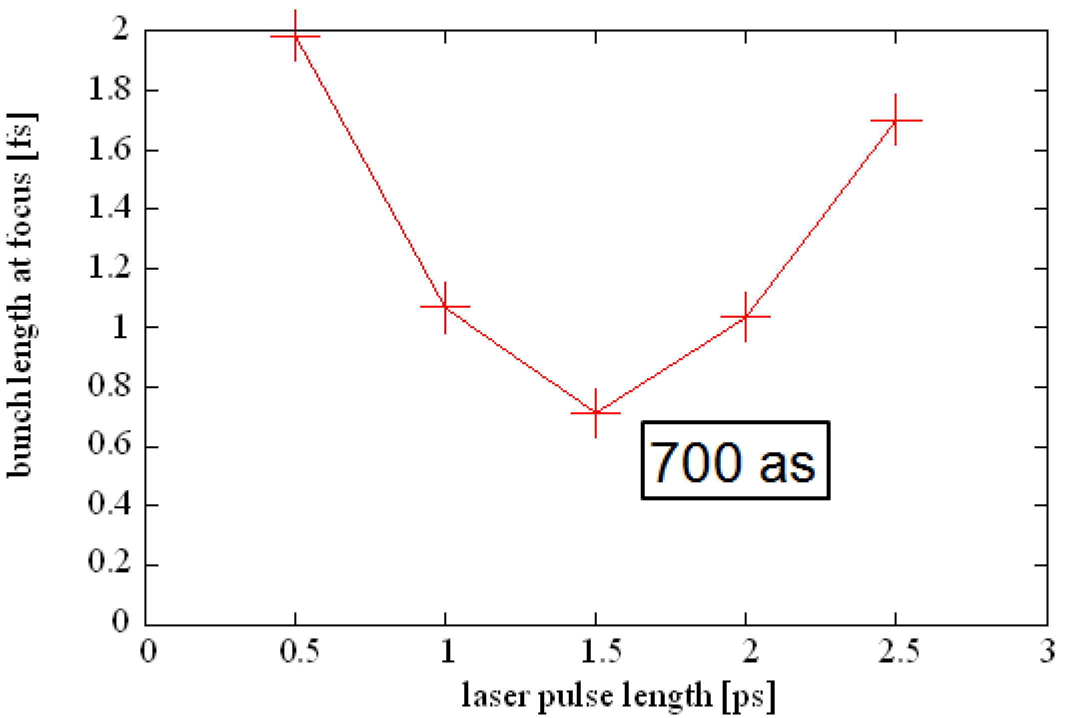
P. Muggli, 06/04/2013, EAAC 2103

Klaus Flöttmann: Shortest Possible Beams from Conventional Accelerators

> Sub fs pulse length possible with ellipsoidal photocathode laser pulse

- Simulations based on REGAE

minimal bunch length as function of emission time



LAOLA.

Klaus Floettmann | laola.desy.de | EAAC | June 2013 | Page 31

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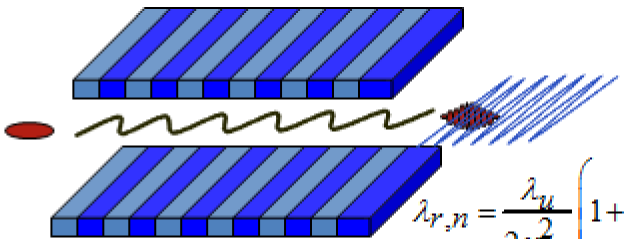
Pietro Musumeci: Inverse Free Electron Lasers for Advanced Light Sources

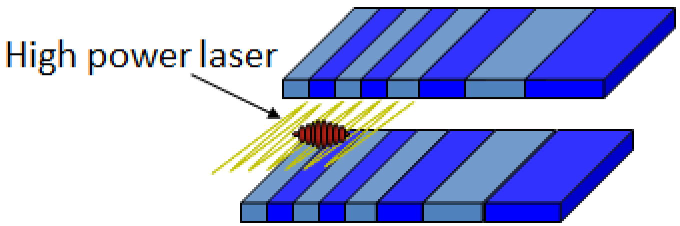
IFEL Interaction

In an FEL energy in the e-beam is transferred to a radiation field



$$\lambda_{r,n} = \frac{\lambda_u}{2\gamma^2 n}\left(1+\frac{K^2}{2}\right)$$

In an IFEL the electron beam absorbs energy from a radiation field.



What you should know about IFELs ?

- IFEL scales ***ideally well*** for mid-high energy range (50 MeV – ***up to few GeV***) due to
  - high power laser wavelengths available (10 um, 1 um, 800 nm)
  - permanent magnet undulator technology (cm periods)

- Simulations show high energy/ high quality beams with gradients >500 MeV/m achievable with current technology!
  - 70 MeV/m gradient already demonstrated at UCLA
  - 70 % trapping already demonstrated at BNL.
  - ***Preservation of e-beam quality/emittance*** and high capture.

> RUBICON experiment at UCLA: Use helical undulator → electrons always moving in helix so always transferring energy