CLIC zero – use and users

- Selection of topics not fully covered but that could be considered (some far fetched and/or marginal but leave judgments for later – and not complete)
  - Particle and Nuclear Physics experiments
  - Test beam facility
    - For LC detector (and others), fairly low energy intense beam with relevant time-structure, any relevance for background studies at LC ?
  - Neutrons
    - The GELINA facility and ESS fundamental physics
    - Neutron photoproduction: flux and energy spectrum, applications (research, material analysis, active interrogation, …)
  - Combining laser with beam (gamma-gamma machine and/or physics measurements based on this)
    - Examples: Laser photon scattering on e- beam: QED test, non linear QED (non linear Compton scattering $e + n\omega \rightarrow e\,\gamma$), (electron positron pair creation $\gamma\, n\omega \rightarrow e^{+}e^{-0}$)
    - The ELI facility
    - Useful for studying pair background and gamma gamma -> hadrons ?
  - Others ?

Particle Physics/Nuclear Physics with beams

- JLAB (facility, physics) http://wwwold.jlab.org/div_dept/physics_division/GeV/collaboration.html

- NuPECC long range plan 2010 http://www.nupecc.org/lrp2010/Documents/lrp2010_final_hires.pdf mentions several lepton machines:
  - MAX-lab, Lund, Sweden
  - ELSA, Bonn, Germany
  - MAMI, Mainz, Germany
  - INFN-LNF, Frascati, Italy – ref earlier talk
- Future infrastructure of relevance: ELI, Bucharest, Romania (see later in discussion of electron machine with powerful laser)

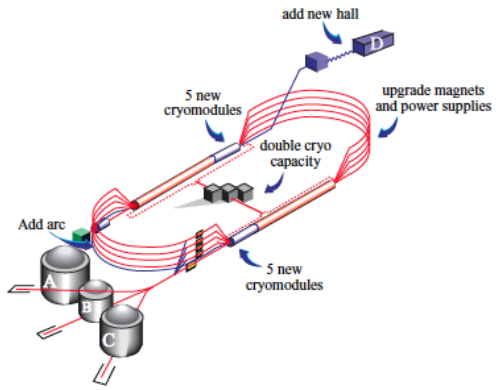


Figure 23: The configuration of the proposed 12 GeV CEBAF Upgrade.

Table 1: Selected key parameters of the CEBAF 12 GeV Upgrade

Parameter	Specification
Number of passes for Hall D	5.5 (add a tenth arc)
Max. energy to Hall D	12.1 GeV (for 9 GeV photons)
Number of passes for Halls A, B, C	5
Max. energy to Halls A, B, C	11.0 GeV
Max. energy gain per pass	2.2 GeV
Range of energy gain per pass	3:1
Duty factor	cw
Max. summed current to Halls A, C* (at full, 5-pass energy)	85 μA
Max. summed current to Halls B, D	5 μA
New cryomodules	10 (5 per linac)
Central Helium Liquifier upgrade	10.1 kW (from present 4.8 kW)

*Max. *total* beam power is 1 MW.

Gluonic Excitations and the Origin of Quark Confinement
Experiments and theory aimed at examining the fundamentally new dynamics that underpins all of nuclear physics: the confinement of quarks.

How are the Nuclear Building Blocks Made from Quarks and Gluons?
A program of measurements addressing the first question that must be answered in the quest to understand nuclear physics in terms of the fundamental theory of strongly interacting matter: quantum chromodynamics (QCD).

On the Structure of Nuclei
Three broad programs that take advantage of the precision, spatial resolution, and interpretability of electromagnetic interactions to address long-standing issues in nuclear physics. They aim to understand the QCD basis of nuclear physics through investigations
of the origins of the Nucleon–Nucleon (N –N) force and its short range behavior, and by identifying and exploring the transition from the meson/nucleon description of nuclei to the underlying quark and gluon description.

In Search of the New Standard Model
Experiments aimed at identifying physics beyond the Standard Model of electro-weak interactions through precision tests of its predictions, and by measuring low energy parameters of the theory to deepen our understanding of chiral symmetry breaking.

Neutrons

Gelina:
http://irmm.jrc.ec.europa.eu/about_IRMM/laboratories/Pages/gelina_neutron_time_of_flight_facility.aspx

- The GELINA neutron source is based on a linear electron accelerator producing electron beams. A typical beam operation mode uses 100 MeV average energy, 10 ns pulse length, 800 Hz repetition rate, 12 A peak and 100 µA average current. With a post-acceleration pulse compression system, the electron pulse width can be reduced to approximately 1 ns (FWHM) while preserving the current, resulting in a peak current of 120 A. The accelerated electrons produce Bremsstrahlung in an uranium target which in turn, by photonuclear reactions, produces neutrons. Within a 1 ns pulse a peak neutron production of 4.3 x 10^{10} neutrons is achieved (average flux of 3.4 x 10^{13} neutrons/s).
- The neutron energy distribution emitted by the target ranges from subthermal to about 20 MeV, with a peak at 1-2 MeV. To have a significant number of neutrons in the energy range below 100 keV, a hydrogen-rich moderator is added. The partially moderated neutrons have an approximate 1/E energy dependence plus a Maxwellian peak at thermal energy. By using collimators and shadow bars moderated or unmoderated neutron beams are selected for the twelve neutron flight paths. Further tailoring of the spectral shape is done with movable filters.
- The up to 400 m long flight paths, symmetrically arranged around the uranium target, lead to experimental locations at distances of 10, 30, 50, 60, 100, 200, 300 and 400 m. These experimental stations are equipped with a variety of sophisticated detectors, and data acquisition and analysis systems. GELINA is a multi-user facility serving up to 12 different experiments simultaneously. The facility is operated in shift work on a 24 hours/day basis, for about 100 hours per week.

ESS organized a 3-day workshop in December 2009 in Lund on the broader physics programme at ESS. The workshop was named Neutron, Nuclear, Neutrino, Muon and Medical Physics at ESS or simply 3N2MP at ESS:
http://www.hep.lu.se/staff/christiansen/proceeding.pdf

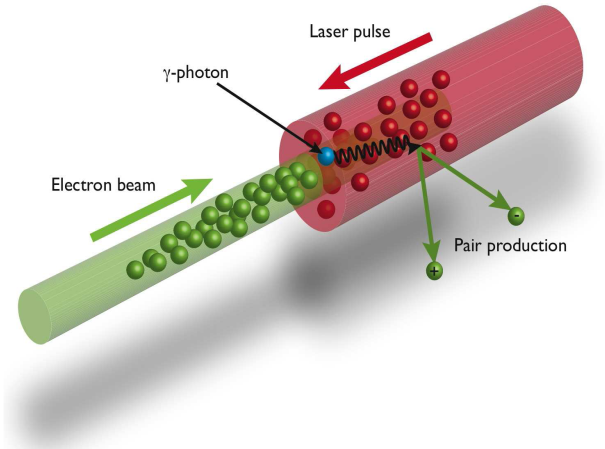
- Have not evaluated if and how these topics could be of relevance to us

Neutron photoproduction facilities:
(example LNF-BTF beam energy 510 MeV)

For fluxes below ~10^{16} n/s, photoproduction preferable to spallation sources
Applications:

- Irradiation facility for detector R&D with broad energy spectrum (for SLHC highest n fluence is 10^{15} 10^{16} n cm^{-2});
- Test stand to study neutron production in beam dump of LC
- Research in boron neutron capture therapy (BNCT) (low energy beam)

Combining electrons and laser - 1



e^- laser collisions for QED studies and LC background characterisation

QED and NL-QED with e^-g

Figures of merit adiabaticity: $h = eE_{rms} / mw_0c$ and $U = E_{rms}/E_{crit}$

Study spontaneous pair creation from vacuum induced from external field ("break down of the vacuum" probing strong field regime):

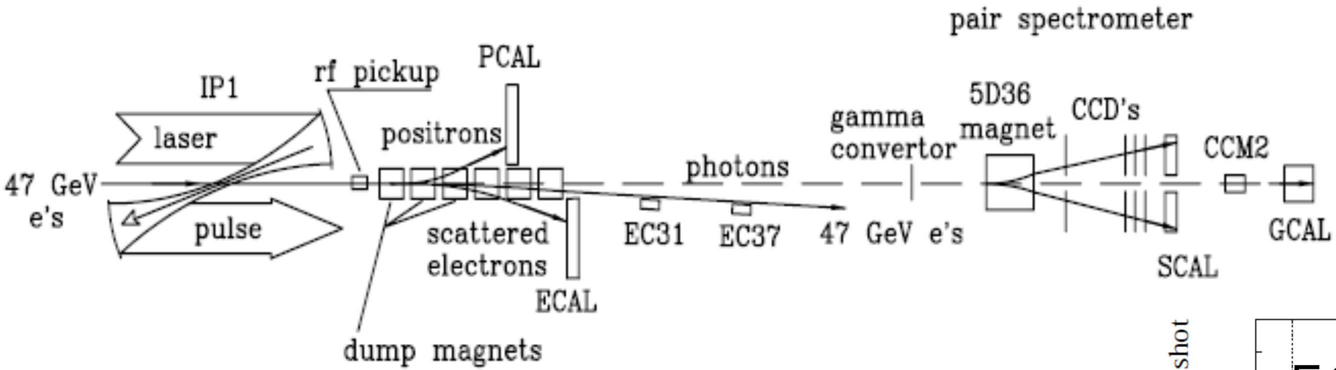
pair creation at the overlap of electron beam and laser beam
($\gamma\ n\omega \rightarrow e^+e^-$)

non linear Compton scattering ($e + n\omega \rightarrow e\ \gamma$),

Combining electrons and laser - 2

e^- laser collisions for QED studies

Examples:
SLAC E144 at FFTB (E_e = 46-49 GeV, TW Laser, h ~ 0.4, Y ~ 0.25) [completed]

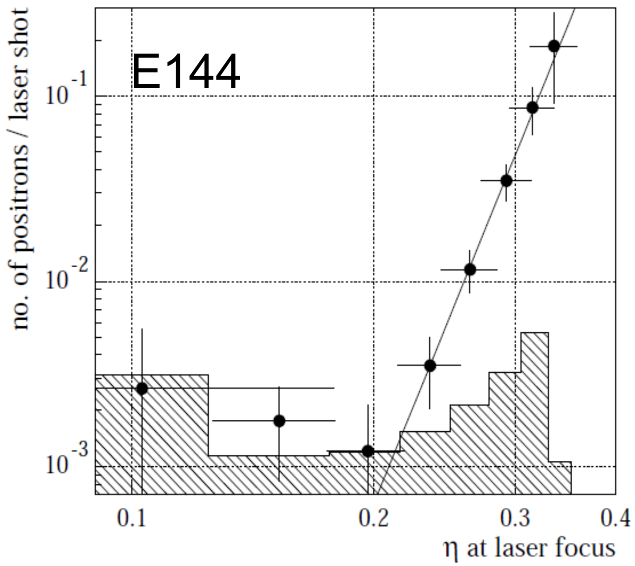


DESY XFEL (Ee ~10 GeV, PW Laser, h ~ 15) [proposec

BELLA at LBNL (E_e = 10 GeV, PW Laser) [proposed]

Such studies are also part of the future ATF programme

PW laser to probe large h
Large electron energy (and thus scattered photon energ
to enhance emission rate)



ELI-Beamlines Facility

In the **Czech Republic**, Prague, the ELI pillar will focus on providing ultra-short energetic particle (10 GeV) and radiation (up to few MeV) beams produced from compact laser plasma accelerators to users.

ELI-Attosecond Facility

In **Hungary**, Szeged, the ELI pillar will be dedicated to extremely fast dynamics by taking snap-shots in the attosecond scale (a billion of a billion of second) of the electron dynamics in atoms, molecules, plasmas and solids. It will also pursue research in ultrahigh intensity laser.

ELI-Nuclear Physics Facility

In **Romania**, Magurele, the ELI pillar will focus on laser-based nuclear physics. For this purpose, an intense gamma-ray source is forseen by coupling a high-energy particle accelerator to a high-power laser.

ELI-Ultra High Field Facility

The **highest intensity pillar location** will be decided in 2012. The laser power will reach the 200 PW or 100 000 times the power of the world electric grid. It will depend, among other things, on the laser technology development and validation. It could be built on one of the existing three sites or in a new country. With the possibility of going into the ultra-relativistic regime, ELI will afford new investigations in particle physics, nuclear physics, gravitational physics, nonlinear field theory, ultrahigh-pressure physics, astrophysics and cosmology (generating intensities exceeding 10^{23} W/cm^2).

ELI

- It consists of two parts, a laser facility (two 10 PW lasers) and the gamma source, which was the topic of the meeting.
- The gamma beam facility consists of a ~600 MeV e- beam on which a high power laser beam is Compton-scattered, producing high brilliance gamma beams up to 19 MeV. The parameters still vary a lot and are probably not yet fully consistent.
- Two proposals are presently on the table to provide the complete facility including photo injector, linac, laser and interaction region:
- a) a copy of the Mega-ray facility being built by Lawrence Livermore labs in the moment. LLNL would purchase all components, test them in Livermore, then ship them to Romania and install them. It is based on X-band technology from SLAC. The beam will be generated in an X-band photo gun. The linac is based on eight T53 structures at 75 MV/m as well as XL4 klystrons from SLAC
- b) a proposal from INFN. It is based on C-band technology as developed for Frascati.

Summary

- Several facilities with parameters not too different (but have made no attempt to qualify this statement), but obvious to see physics cases at the level that CERN should engage (again not well qualified statement)

- No obvious connections to CLIC zero except a significant potential/ international interest in combined experiments with electron beams and laser – for accelerator R&D and physics, and possibly background studies
  - The possible uniqueness of a future CERN installation need to studied

- Testbeam and irradiation capabilities should be considered