Proposal for a "Progetto bandiera INFN"

Elementary Particles and Photon Physics Laboratory

M. Ferrario

on behalf of some INFN group (LNF, Tr, Fe, Rm1, Mi,….)

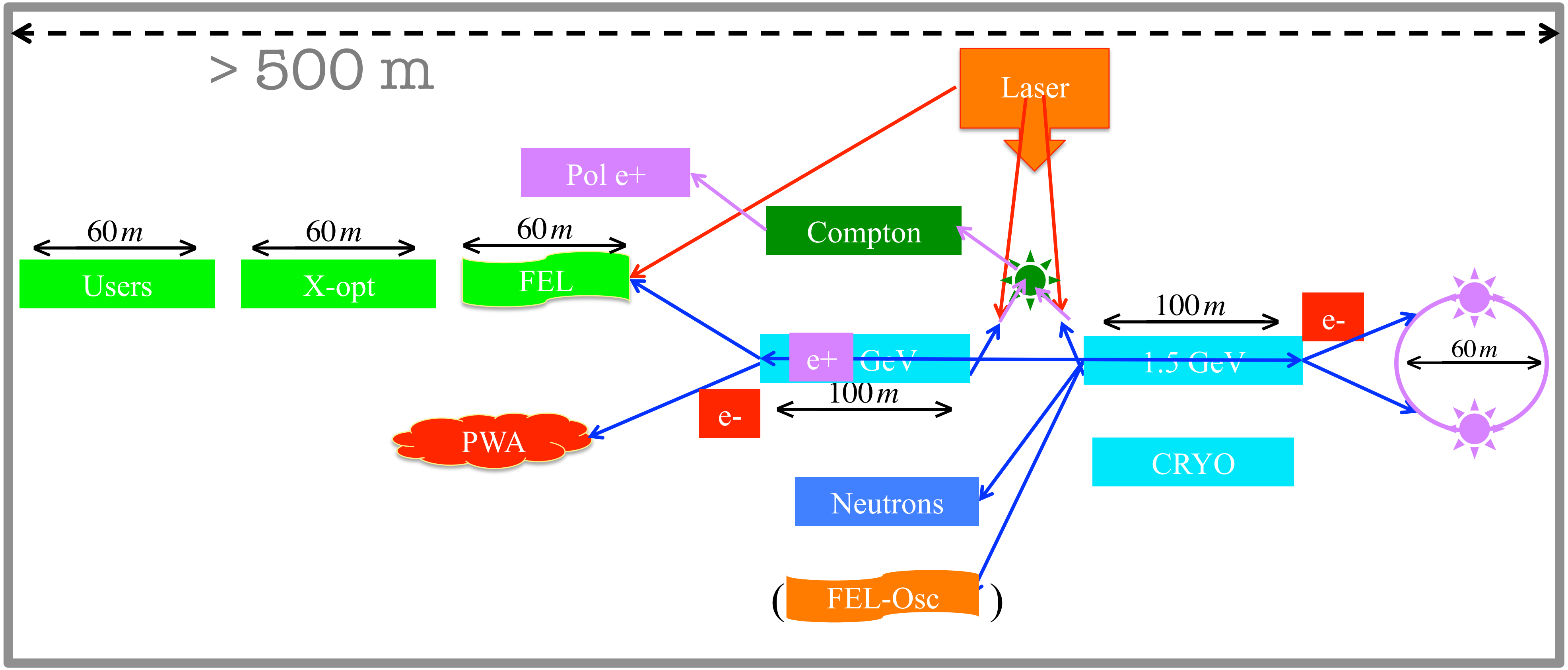
- e- γ and γ γ Low Energy Colliders
- Nuclear Photonics with Compton Back-scattering Source
- Science with X-ray FEL Source
- Advanced Neutron source by photo-production
- Detector development for X-ray FEL and γ γ Colliders
- Physics with High Power/Intensity Laser
- ILC technology implementation
- Polarised Positron Source
- Advanced Acceleration Concepts (PWA)
- R&D in accelerator technology and industrial spin – off
- Incorporate DAΦNE-VE

LNF - 17 December 2012

Elementary Particles and Photon Physics Laboratory

Priorities and time modulation to be discussed depending on the available budget

3 GeV Linac	100 M€ - 4 y
HG FEL (1nm-3 Ang)	60 M€ - 2 y
Compton e-γγ ($10^{30,}$ 10^{27})	70 M€ - 2 y
Neutrons+PWA+FEL_{osc}	30 M€ - 2 y
DAΦNE-VE	100? M€ - 2 y
All Buildings	100 M€



Modules	M€
Injector 1	10
Injector 2	10
Linac 1 (1.5 GeV CW)	30
Linac 2 (1.5 GeV CW)	30
Cryo Plant and Modules Assembly	20
	100
FEL Undulators	20
FEL Optics and experiment	40
	60
FEL Oscillator	**10**
High Power Laser	15
Compton Beam Lines	30
Polarized e+	5
Detector e/γ γ/ γ	20
	70
PWA beam line	**5**
Neutron Beam Lines	**15**
DAΦNE_VE	**100?**
All Buildings	**100**

SPARC-BD-12/002
21 May 2012

A POSSIBLE HARD X-RAY FEL WITH THE SuperB 6 GeV ELECTRON LINAC

D. Alesini[1], M. P. Anania[1], P. Antici[2], D. Babusci[1], A. Bacci[3], A. Balerna[1], R. Bartolini[5], M. Bellaveglia[1], M. Benfatto[1], R. Boni[1], R. Bonifacio[8], M. Boscolo[1], B. Buonomo[1], M. Castellano[1], L. Catani[4], M. Cestelli-Guidi[1], A. Cianchi[4], R. Cimino[1], E. Chiadroni[1], S. Dabagov[1], A. Gallo[1], D. Di Gioacchino[1], D. Di Giovenale[1], G. Di Pirro[1], A. Drago[1], A. Esposito[1], M. Ferrario[1], F. Ferroni[2], M. Gambaccini[12], G. Gatti[1], S. Guiducci[1], R. Gunnella[9], S. Ivashyn[13], S. Lupi[2], A. Marcelli[1], M. Mattioli[2], G. Mazzitelli[1], A. Mostacci[2], M. Migliorati[2], E. Pace[1], A. Perrone[10], V. Petrillo[3], R. Pompili[4], C. Ronsivalle[6], J. B. Rosenzweig[11], A. R. Rossi[3], W. Scandale[7], L. Serafini[3], O. Shekhovt[13], B. Spataro[1], C. Vaccarezza[1], A. Vacchi[14], A. Variola[7], G. Venanzoni[1], F. Villa[1].

(1) INFN-LNF
(2) INFN and Universita' di Roma"La Sapienza"
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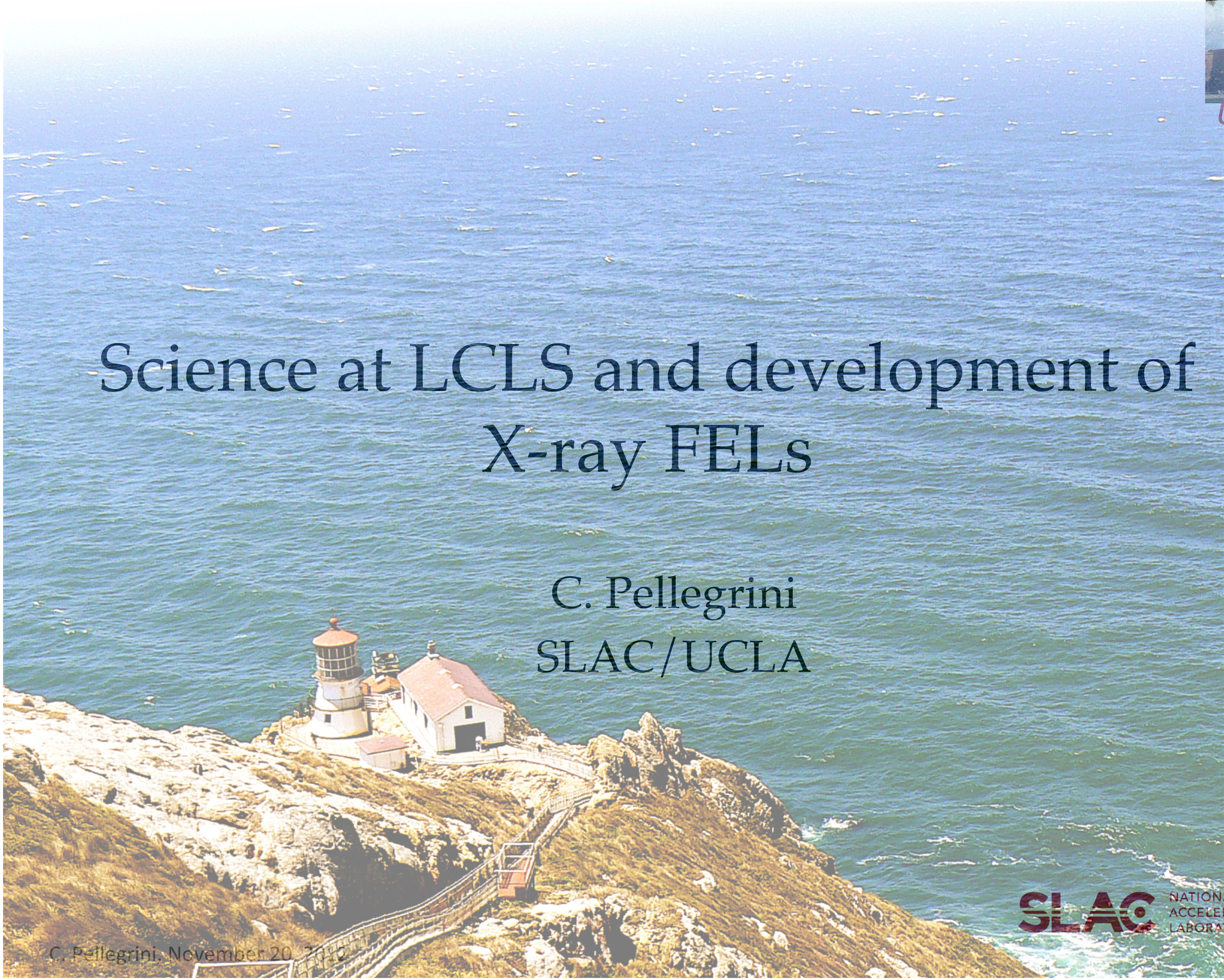
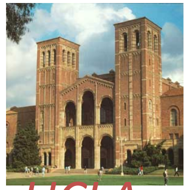
(4) INFN and Universita' di Roma"Tor Vergata"
(5) Diamond Light Source Ltd.
(6) ENEA, Frascati
(7) Laboratoire de l'Accélérateur Linéaire
(8) Universidade Federal da Paraiba, Brazil
(9) Universita' di Camerino
(10) INFN and Universita' del Salento
(11) UCLA, Los Angeles, USA
(12) INFN and Universita' di Ferrara
(13) ITP NSC KIPT, Kharkov, Ukraine
(14) INFN, Trieste

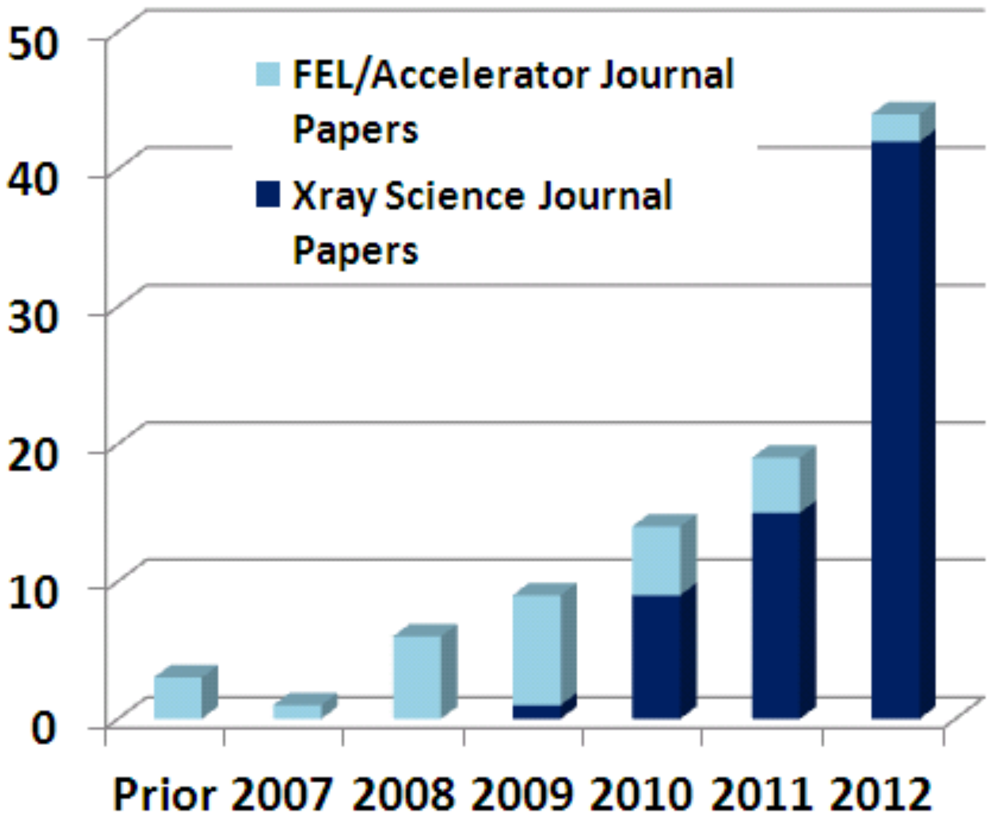


Science at LCLS and development of X-ray FELs

C. Pellegrini
SLAC/UCLA

LCLS is expanding our scientific knowledge in biology, chemistry and physics at an increasing rate





Publications using LCLS coherent photons: #/per year

~ 60% of papers in high impact journals, like Nature, Science, Physical Review Letters.

703 proposals (~15 scientists/proposal)

- 31 countries
- only 1 in 5 proposals receives beam time

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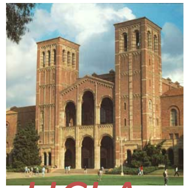
LCLS based publications: January/September 2012



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C. Pellegrini "The history of X-ray free-electron lasers" *Eur. Phys. J. H* **37** (2012)

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"Phase fluctuations and the absence of topological defects in a photo-excited charge-ordered nickelate" W.S. Lee et al., *Nature Communications* **3** 838 (2012) "

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"Temporal cross-correlation of x-ray free electron and optical lasers using soft x-ray pulse induced transient reflectivity" O. Krupin et al., *Optics Express* **20** 10, 11396-11406 (2012)

" Development and calibration of mirrors and gratings for the soft x-ray materials science beamline at the Linac Coherent Light Source free-electron laser " Regina Soufli et al., *Applied Optics* **50** 12, 2118 (2012)

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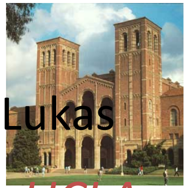

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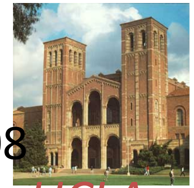

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Physics possibilities at a low energy e-γ collider

G. Venanzoni

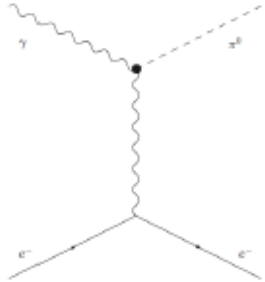
INFN/LNF Frascati

WORKSHOP ELI-NP-GS May 14-16, 2012, Milano, Italy

Physics case

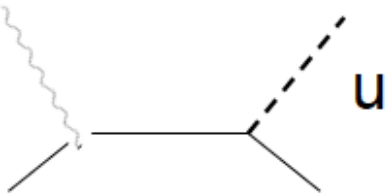
- High intensity electron-gamma interactions at low energy can be a valuable tool for precise tests of the **SM** and discovering physics **BSM**.
- At ELI-NP, with E_e=500-800 MeV and E_γ=10-20 MeV, the c.m. energy available is 140-250 MeV. This is just above the π^0 mass and therefore the $\Gamma(\pi^0 \rightarrow \gamma\gamma)$ can be precisely measured:

$$\gamma + e^- \rightarrow \pi^0 + e^-$$



- In addition possible searches for hypothetical light bosons (u bosons) can be done (for M_u<250 MeV):

$$\gamma + e^- \rightarrow u + e^-$$



- There are additional motivations (double and triple Compton, $\mu\mu$ production near threshold, etc…)

The scientific case for a photon-photon collider

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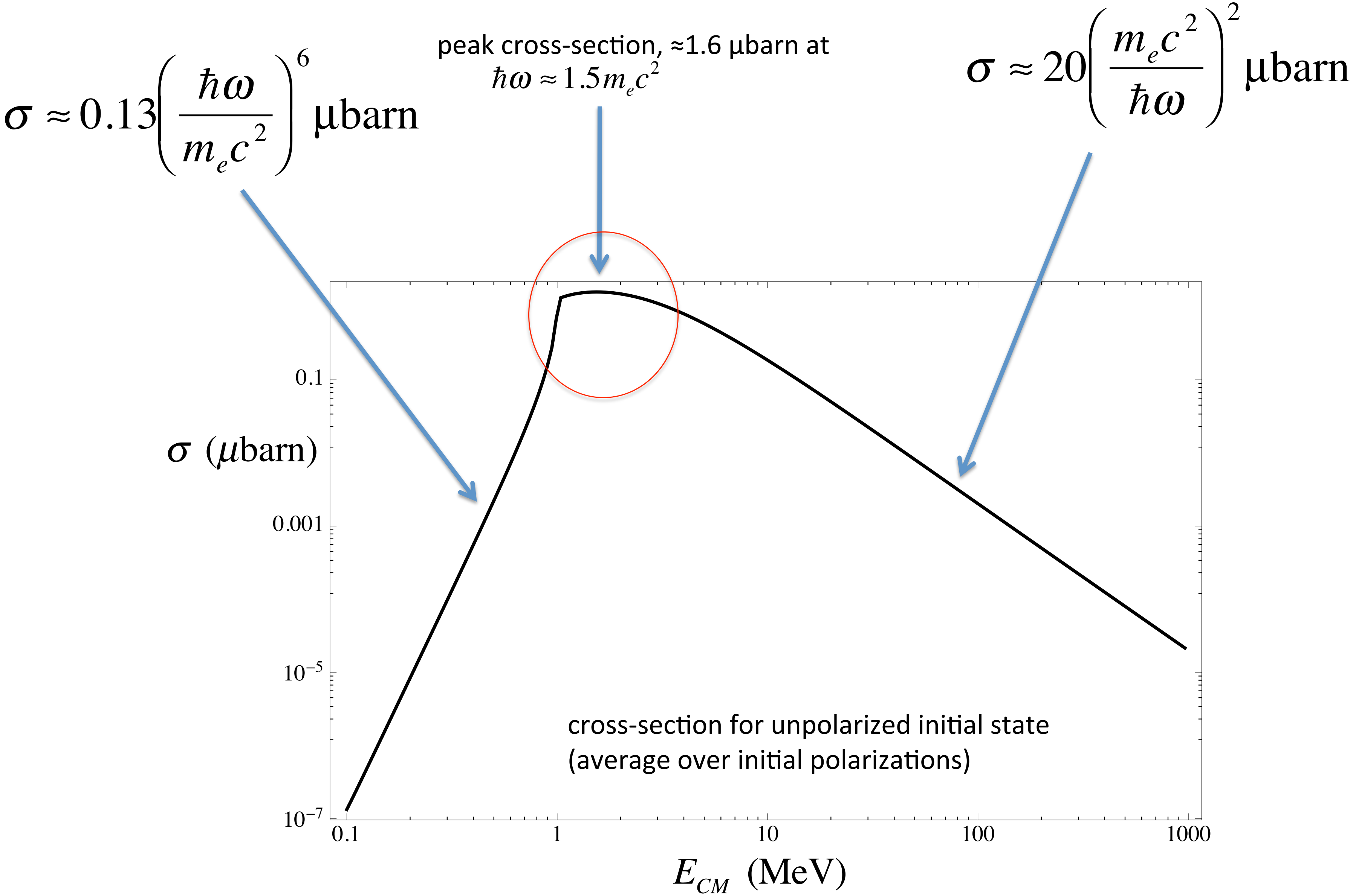
LNF – 14/12/2012



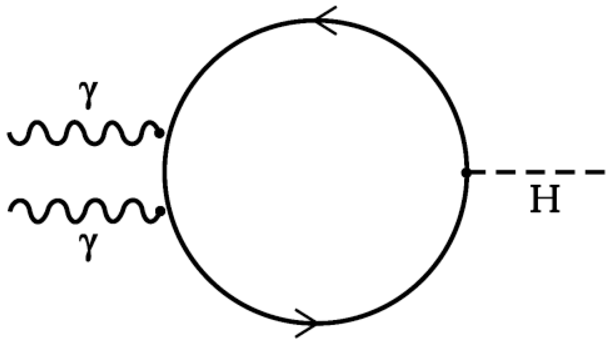
$\sigma \approx 0.13\left(\frac{\hbar\omega}{m_e c^2}\right)^6$ μbarn
peak cross-section, ≈1.6 μbarn at
$\hbar\omega \approx 1.5 m_e c^2$
$\sigma \approx 20\left(\frac{m_e c^2}{\hbar\omega}\right)^2$ μbarn
0.1
0.001
10^{-5}
10^{-7}
σ (μbarn)
0.1
1
10
100
1000
E_{CM} (MeV)
cross-section for unpolarized initial state
(average over initial polarizations)

Final comments

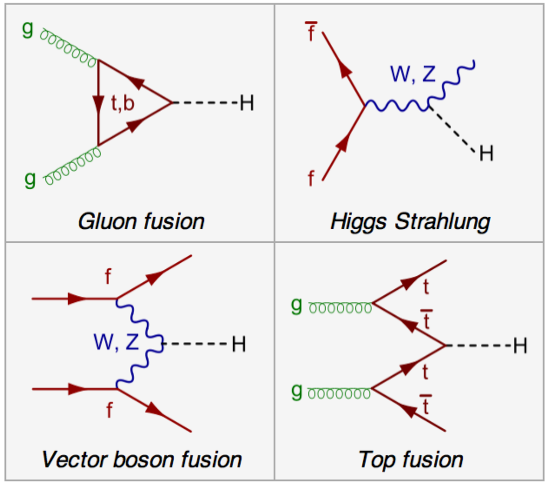
- a high-energy photon-photon collider is an ideal tool to search for new physics by exploiting the reaction

$$\gamma + \gamma \rightarrow H \rightarrow \text{final state}$$

- such a machine is highly efficient at this task, because it requires less energy and the cross-sections are higher than those in electron machines



vs.



- a high-energy machine works in a “discovery mode”

- by contrast, a low-energy machine verifies the fundamental tenets of the theory, and helps us reexamine the foundations of QED and QFT

- in my opinion, this “foundational mode” is quite important, and is an irreplaceable companion of the “discovery mode”.

People do not seem to realize that they are really departing from the original Heisenberg theory ...
Indeed there is some justification for that because rules can be set up to remove the infinities. This is the renormalization process.

It turns out that, sometimes, one gets very good agreement with experiments working with these rules. In particular if one has charged particles interacting with the electromagnetic field, these rules of renormalization give surprisingly, excessively good agreement with experiments.

Most physicists say that these working rules are, therefore, correct. I feel that this is not an adequate reason.”

P.A.M. Dirac: "The inadequacies of quantum field theory", 1984

LNF–10/ 25 (IR)
December 21, 2010

A HIGH-LUMINOSITY $e^+ e^-$ COLLIDER FOR PRECISION EXPERIMENTS AT THE GeV SCALE

G. Venanzoni[1], D. Babusci[1], M. Bertani[1], C. Bloise[1], F. Bossi[1], A. Clozza[1], A. Drago[1], A. Gallo[1], G. Isidori[1], C. Milardi[1], M. Mirazita[1], D. Moricciani[2], A. Passeri[3], M. Preger[1], P. Raimondi[1], C. Sanelli[1], B. Spataro[1], S. Tomassini[1], M. Zobov[1], *et. al*.

[1] *Laboratori Nazionali di Frascati dell'INFN, Frascati, Italy*
[2] *Università "Tor Vergata" and Sezione INFN, Roma, Italy*
[3] *Università "Roma Tre" and Sezione INFN, Roma, Italy*

Brainstorming on photon-photon scattering experiment

Scaling Laws for Photon Fluxes, Bandwidths, Luminosity, etc, and a look at the interaction point (e-γ with primary and secondary electron beams)

Can we get up to L= 10^{27} $cm^{-2}sec^{-1}$??
N_{ev} = 1 μ*barn10^{27} = 1 ev/hour**

L. Serafini - INFN-Milan

First we produce Gamma photons (0.5-1.5 MeV) with 2 Compton Sources (similar to ELI-NP), then we collide the 2 counter-prop. gamma photon beams, focused to μm spot size

Luminosity in collision

$$L[cm^{-2}s^{-1}] = \frac{N_\gamma N_\gamma}{4\pi\sigma_0^2} f_{RF} n_b$$

$$N_e = 3\cdot 10^9\ ;\ N_\gamma = 1\cdot 10^9\ \left(\frac{\Delta\nu_\gamma}{\nu_\gamma} = 10\%\right)$$

$$f_{RF} n_b = 100x1 \Rightarrow L[cm^{-2}s^{-1}] = 1.0\cdot 10^{27} \Big/ \left(\sigma_0[\mu m]\right)^2$$

to get up to $L = 10^{27}\ cm^{-2}s^{-1}$ *we need* $\sigma_0 = 1\ \mu m$

achieve 10 events/day

Cost (Meuro): 2 x (laser 5 + linac 15) = 40

Energy available W in the center of mass

$$W[MeV] = 2\sqrt{T_e \cdot h\nu_\gamma} \quad ; \quad T_e = (\gamma - 1)mc^2$$

1 GeV electron against 10 *MeV* gamma -> *W=200 MeV*

Luminosity in collision

$$L[cm^{-2}s^{-1}] = \frac{N_e N_\gamma}{4\pi\sigma_0^2} f_{RF} n_b$$

$h\nu_\gamma$ = gamma photon energy [MeV] ; T_e = colliding electron energy [MeV]
σ_0 = electron bunch (and gamma photon beam) spot size at collision point
N_e = # electron in bunch ; N_γ = # gamma photons in burst
f_{RF} = RF rep rate ; n_b = # electron bunches per RF pulse

$$ex.\ ELI-NP\ beams: N_e = 2\cdot 10^9 ; N_\gamma = 3\cdot 10^8 \ (\frac{\Delta\nu_\gamma}{\nu_\gamma} = 10\%)$$

$$f_{RF} n_b = 100x100 \Rightarrow L[cm^{-2}s^{-1}] = 4.8\cdot 10^{28} \Big/ \left(\sigma_0[\mu m]\right)^2$$

$$to\ get\ up\ to\ L = 10^{30}\ cm^{-2}s^{-1}\ we\ need\ \sigma_0 = 0.22\ \mu m$$

Possibili applicazioni di fasci di neutroni da fotoproduzione

Antonino Pietropaolo

ENEA-Centro Ricerche Frascati

Laboratorio Tecnologie Nucleari

Possibili applicazioni dei fasci di neutroni

- **Neutron Resonance Capture Analysis* (fascio incidente)**
- **Diffrazione* (fascio diffuso)**
- **Bragg edge transmission* (fascio incidente)**

- **Radiografia (fascio incidente)**
- **Tomografia (fascio incidente)**
- **Chip Irradiation (fascio incidente)**

- **R&D su rivelatori di neutroni (3He replacement etc) e strumentazione (training)**

* **Tecnica del tempo di volo**

R&D e training

- **Strumentazione e componenti:**
  - **linee di fascio, guide di neutroni, rivelatori (3He replacement, neutroni veloci)**
- **Target station:**
  - **targhetta di produzione, sistemi di moderatori/ riflettori/liner e shielding, tailoring dei fasci per avere spettri atmospheric-like**
- **Uso delle tecniche neutroniche descritte**

Possibili soggetti interessati

- **Operatori museali e archeologi**:
  - NRCA, BET, Diffrazione, radiografia e tomografia
- **Università ed Enti di Ricerca** :
  - training e R&D
- **Industrie a livello nazionale e internazionale**:
  - Danneggiamento dei materiali
  - Danneggiamento di componenti elettronici

- **Medicale**:
  - Boron Neutron Capture Therapy
  - Altro ?