

Photon Beams workshop

Padua
27-28 November 2017

introduction to ARIES
WP6
and workshop topics

Frank Zimmermann,
CERN



Padua Botanical Garden - Aula Emiciclo
27-28 November 2017

TOPICS

- ✓ Compton sources
- ✓ Laser-Compton collisions
- ✓ Gamma factories
- ✓ Low- and high-energy gamma-gamma colliders

Organising committee:

A. Bertolin, INFN
M. Morandin, INFN
M. Zanetti, INFN and University of Padua (chair)
F. Zimmermann, CERN (chair)

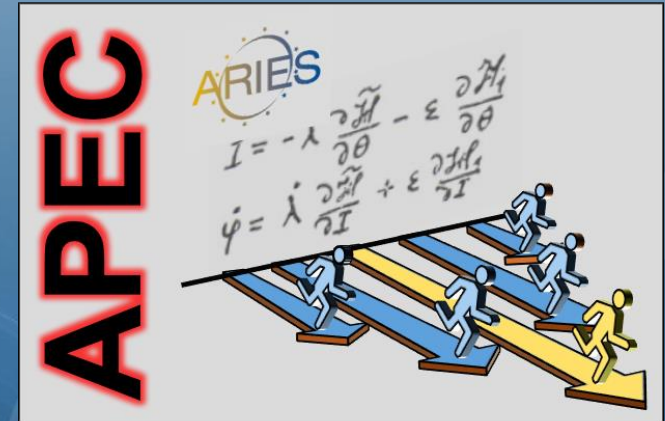
International advisory committee:

W. Chou, IHEP
A. Courjaud, Amplitude Systems
M. Ferrario, LNF
W. Krasny, LPNHE
M. Lamont, CERN
N. Sasao, Okayama
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Funded by the H2020
programme of the
European Union





G. Franchetti

improving Accelerator Performance and new Concepts – APEC (WP6)

Alessandro Drago (INFN-LNF), Giuliano Franchetti (GSI), Johannes Gutleber (CERN),
Klaus Höppner (HIT), Florian Hug (JGU), Mauro Migliorati (U. Roma Sapienza),
Marco Zanetti (INFN Padua), Frank Zimmermann (CERN)

APEC in a nutshell

5 scientific tasks with the goals

- to **improve the performance of the next generation of accelerators** (*MESA, FAIR, HL-LHC, ThomX...*) ,
- to **advance the design of the “next next” generation of accelerators** (*FCC, LHeC, ...*) , and
- to **investigate and rank accelerator options for the long-term future** (*photon colliders, muons, crystals, nanotubes, gravitational waves, ...*)

WP6 APEC tasks

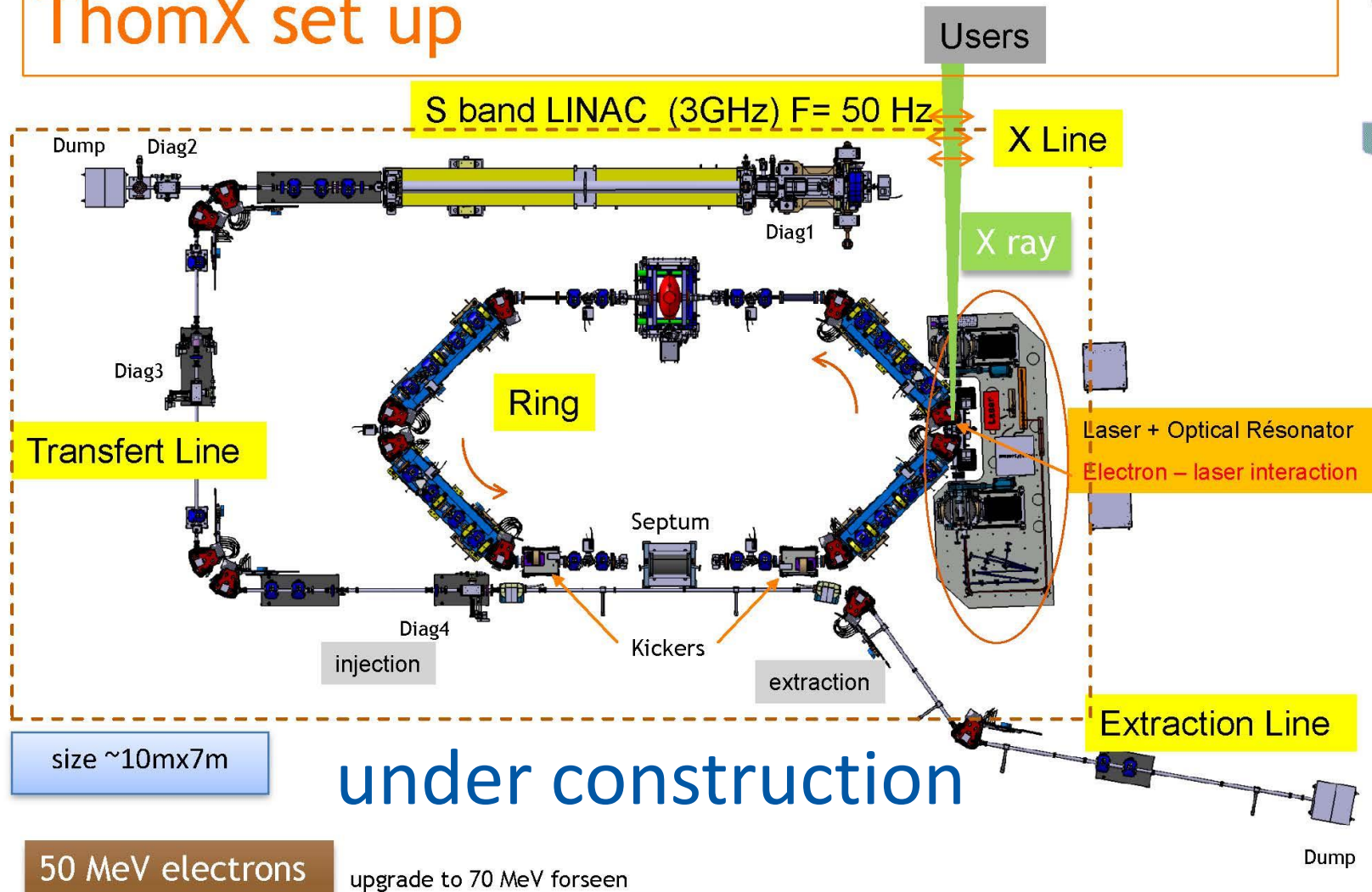
- Task 6.1. Coordination and Communication
(F. Zimmermann, CERN; G. Franchetti, GSI)
- Task 6.2. Beam Quality Control in Hadron Storage Rings and Synchrotrons (G. Franchetti, GSI; F. Zimmermann, CERN)
- Task 6.3. Reliability and Availability of Particle Accelerators
(J. Gutleber, CERN; K. Höppner, HIT Heidelberg)
- Task 6.4. Improved Beam Stabilization
(M. Migliorati, La Sapienza/INFN; A. Drago, INFN-LNF)
- Task 6.5. Beam Quality Control in Linacs and Energy Recovery Linacs (F. Hug, JGU Mainz)
- Task 6.6. Far Future Concepts & Feasibility
(M. Zanetti, Padova/INFN; F. Zimmermann, CERN)

Task 6.6 Far Future Concepts & Feasibility

- Analysis of the potential of **crystals** for charged-particle bending or particle acceleration
- Development of advanced **photon colliders**, including gamma-gamma and photon-nucleon colliders
- Assessment of **advanced muon-collider concepts** without ionization cooling
- Assessment of the potential use of large storage rings for **gravitational wave detection or generation**
- **Assessing and ranking a basket of future concepts with regard to “future feasibility” and physics cases**
- **White list of ranked future options**

ThomX at LAL – commissioning in 2018

ThomX set up



ELI-NP in Magurele



- high intensity laser system, with two 10 PW laser arms able to reach intensities of 10^{23} W/cm² and electrical fields of 10^{15} V/m
- intense (10^{13} γ/s), brilliant γ beam, ~ 0.1 % bandwidth, with E_{γ} up to 19.5 MeV, which is obtained by incoherent Compton back scattering of a laser light off a very brilliant, intense, classical electron beam (E_e up to 720 MeV) produced by a warm LINAC

gamma-gamma colliders – a long history

some references from the last 35 years

I.F. Ginzburg, G.L. Kotkin, V.G. Serbo and V.I. Telnov, “Colliding γe and $\gamma\gamma$ Beams Based on the Single-Pass $e^{\pm}e^{\mp}$ Colliders (VLEPP Type),” Nucl. Instr. and Meth. 205 (1983) 47.

I.F. Ginzburg, G.L. Kotkin, S.L. Panfil, V.G. Serbo, and V.I. Telnov, “Colliding γe and $\gamma\gamma$ Beams Based on Single-Pass e^+e^- Accelerators II. Polarization Effects, Monochromatization Improvement,” Nucl. Instr. and Meth. 219 (1984) 5-24

V. Telnov, “Principles of Photon Colliders,” Nucl. Instr. And Meth. A 355 (1995) 3-18

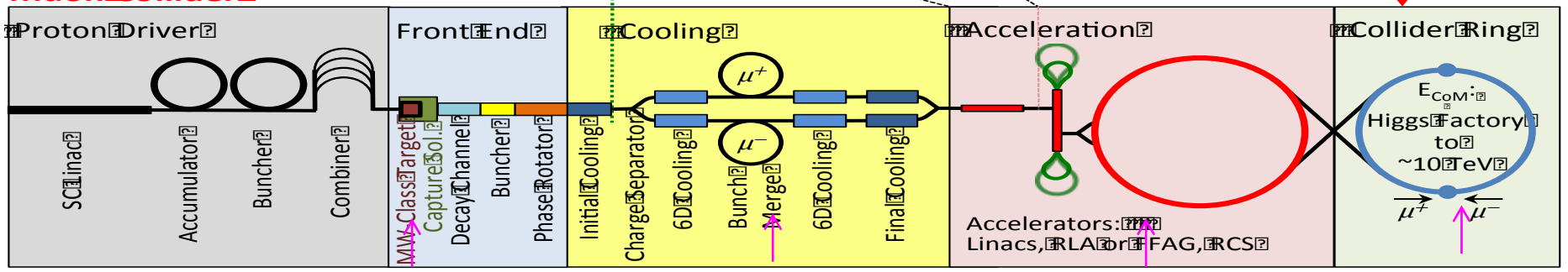
K.-J. Kim, A. Zholents et al., “NLC ZDR Appendix B Second Interaction Region For Gamma-Gamma, Gamma-Electron and Electron-Electron Collisions,” SLAC SLAC-R-474, LBL-PUB-5424, LBNL-PUB-5424, UCRL-ID-124161 ... (1996)

V. Telnov et al., “The Photon Collider at TESLA,” Int. Journal of Modern Physics A Vol. 19, No. 30 (2004) 5097–5186

S. A. Bogacz, J. Ellis, L. Lusito, D. Schulte, T. Takahashi, M. Velasco, M. Zanetti, F. Zimmermann, “SAPPHiRE: a Small Gamma-Gamma Higgs Factory,” arXiv 1208.2827 (2012)



from US-MAP (2015) to Italian μ -collider (2017)



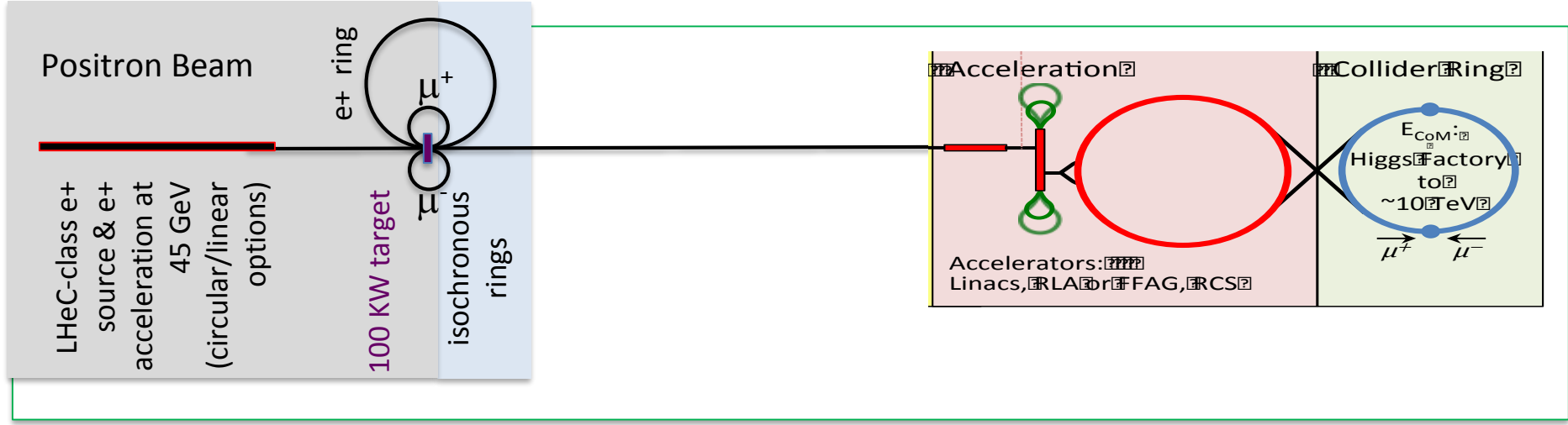
key challenges

$\sim 10^{13}-10^{14}$ μ / sec
tertiary particle
 $p \rightarrow \pi \rightarrow \mu$:

fast cooling
($\tau=2\mu s$)
by 10^6 (6D)

fast acceleration
mitigating μ decay

background
from μ decay



key challenges

$\sim 10^{11}$ μ / sec from $e^+e^- \rightarrow \mu^+\mu^-$

key R&D

10^{15} e+/sec, 100 kW class target, NON destructive process in e+ ring

M. Boscolo

threshold e^+ energy for μ production in e^+ annihilation on static e^- :

$$E_{e^+, \text{thr}} = \frac{4m_\mu^2 c^4 - 2m_e^2 c^4}{2m_e c^2} = 43.7 \text{ GeV}$$

→ we could use the FCC-ee e^+ ring (or the FCC-ee top-up booster, or a LEP3,...) as internal target ring for μ production!

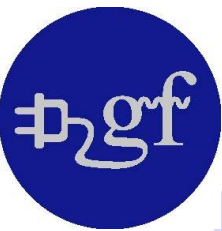
e^+ production rates achieved (SLC) or needed

	S-KEKB	SLC	CLIC (3 TeV)	ILC (H)	FCC-ee (Z)	Italian μ collider
10^{12} e^+ / s	2.5	6	110	200	5	1000

x 18 **x 33** **x 165**

The diagram shows green arrows and brackets indicating multiplication factors between the values in the table. An arrow points from 2.5 to 110 with 'x 18' written above it. Another arrow points from 6 to 200 with 'x 33' written above it. A third arrow points from 5 to 1000 with 'x 165' written above it.

LHC based Gamma Factory could provide 100x more e^+ / s than needed

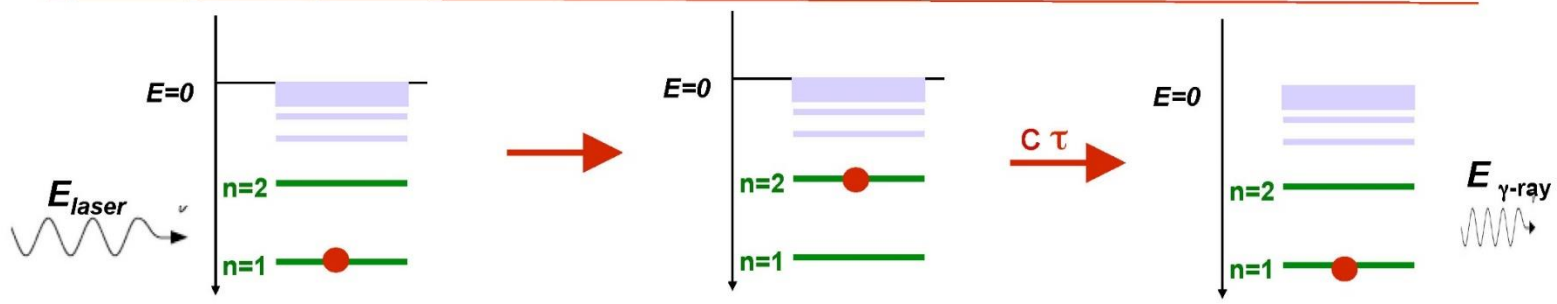
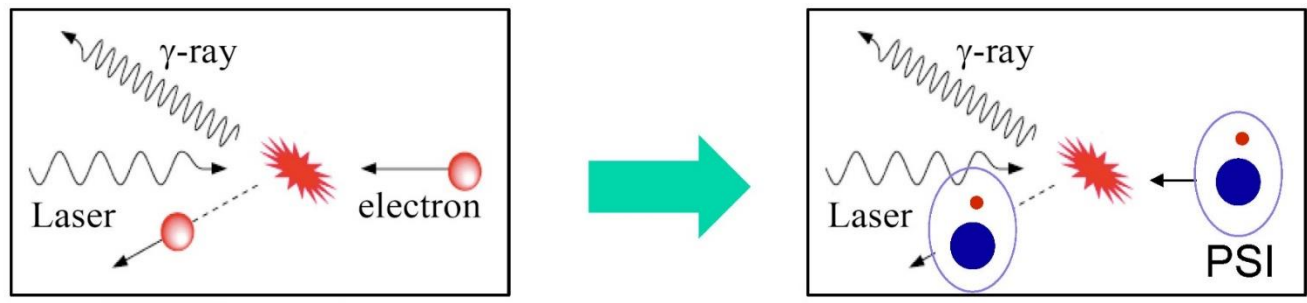


"Gamma Factory" based on "PSI"

Compton back scattering at LHC or FCC



Simple Idea: replace an Electron beam by a Partially Stripped Ion (PSI) beam



$$E_{laser} = 1Ry (Z^2 - Z^2/n^2)/2\gamma_L$$

$$E_{\gamma-ray} = E_{laser} \times 4\gamma_L^2 / (1 + (\gamma_L \theta)^2)$$

Note: $(E_{laser} / m_{beam}) \times 4\gamma_L \ll 1$

high photon energies,
high cross section

Workshop themes:

- recent and future facilities, Thom-X, ELI, far future
- photon-beam collision schemes and hardware
- laser technologies
- laser-based photon-beam collisions
- FEL based approaches
- Compton sources, gamma-gamma colliders, gamma factories
- Gamma Factory R&D program



wishing us a creative and most stimulating workshop!