Photon Beams workshop

Padua
27-28 November 2017

introduction to ARIES WP6
and workshop topics

Frank Zimmermann, CERN

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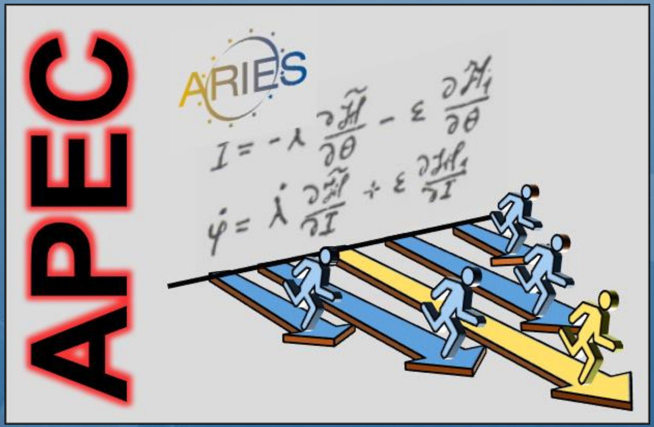

G. Franchetti

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)

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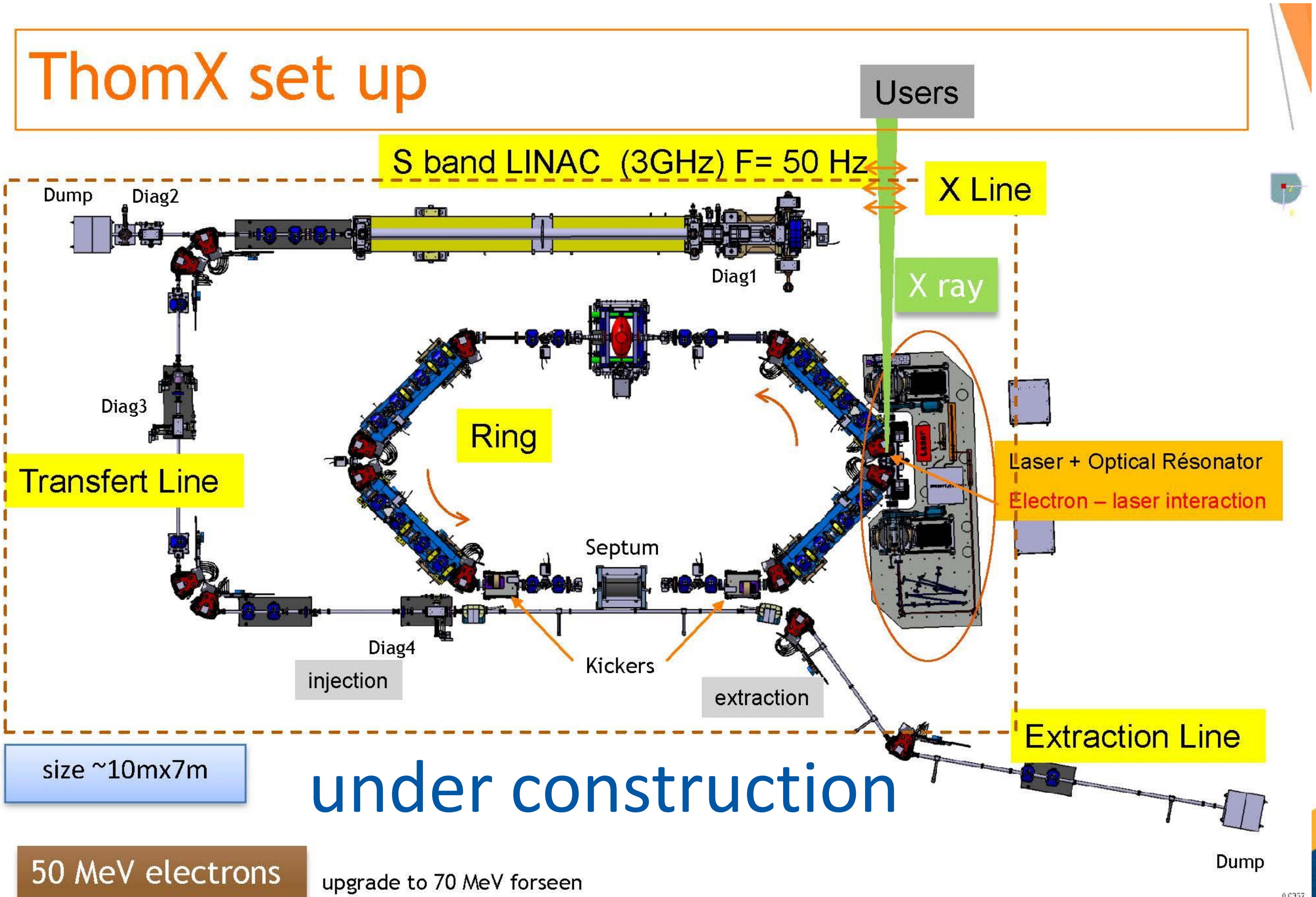
Task 6.6 Far Future Concepts & Feasibility

- 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



under construction

50 MeV electrons

upgrade to 70 MeV forseen

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H. Monard

ELI-NP in Magurele

- high intensity laser system, with two 10 PW laser arms able to reach intensities of 10^{23} W/cm^2 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±e− 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

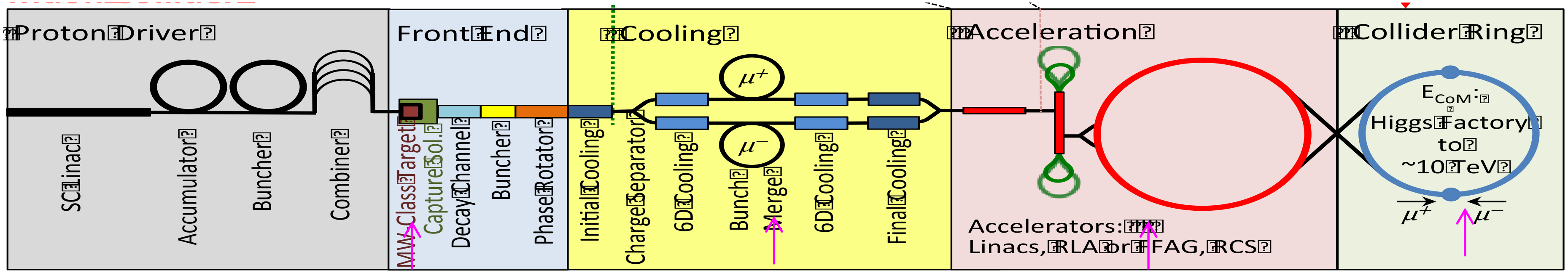
K.-J. Kim, A. Zholents et all., “NLC ZDR Appendix B Second Interaction Region For Gamma-Gamma, Gamma-Electron and Electron-Electron Collisions,” SLAC SLAC-R-474, LBL-PUB-5424, LBNL-PUB-5424, UCRL-ID-124161 ... (**1996**)

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**)

EuCARD SAPPHiRE Day 2013, https://indico.cern.ch/event/231263

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



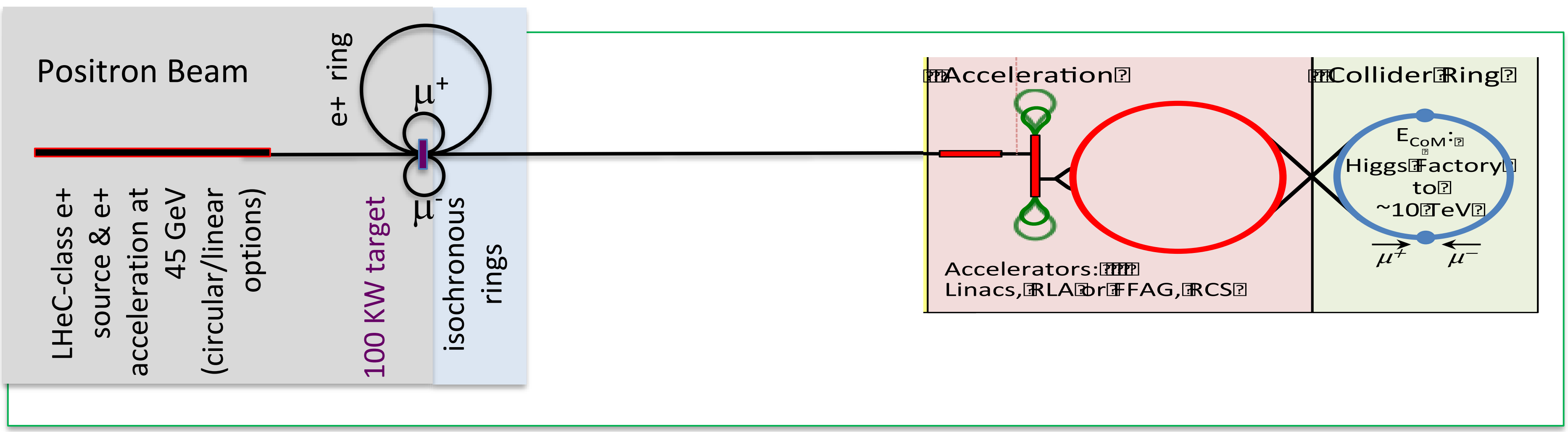
key challenges

~10^{13}-10^{14} μ / sec tertiary particle *p→π→μ:*

fast cooling (τ=2μs) by 10^6 (6D)

fast acceleration mitigating μ decay

background from μ decay



key challenges

~10^{11} μ / sec from $e^+e^- \to \mu^+\mu^-$

key R&D

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

M. Boscolo

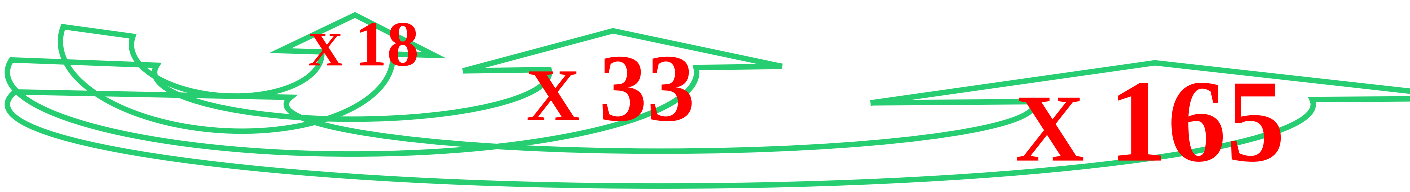
threshold e^+ energy for μ production in e^+ annihilation on static e^-:

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

→ 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

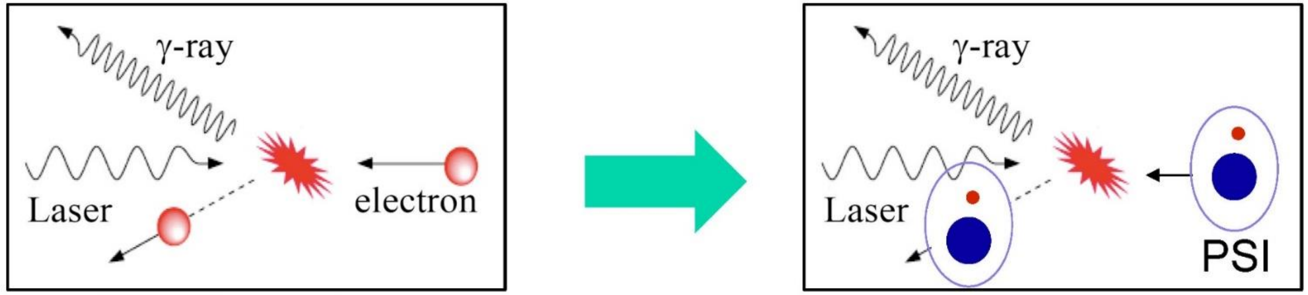
	S-KEKB	SLC	CLIC (3 TeV)	ILC (*H*)	FCC-ee (*Z*)	Italian μ collider
10^{12} e^+ / s	**2.5**	**6**	**110**	**200**	**5**	**1000**

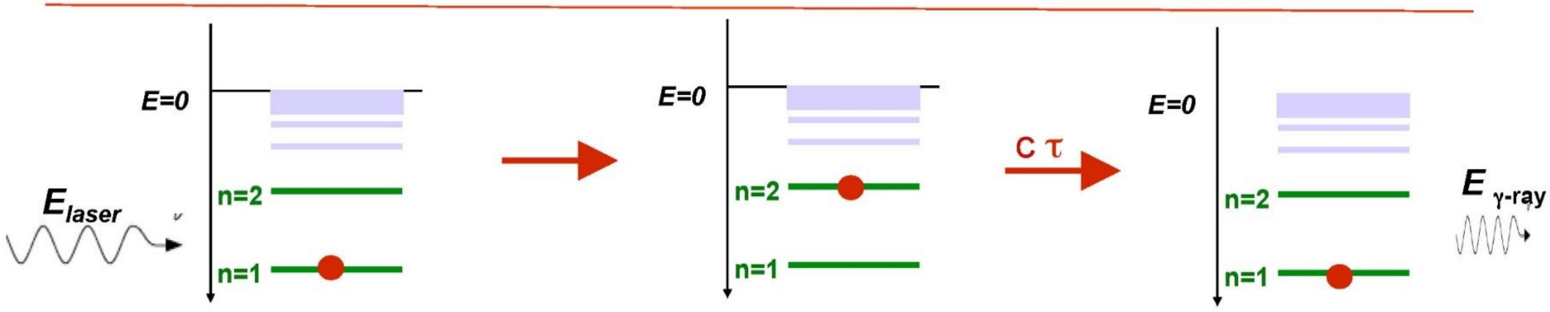


LHC based Gamma Factory could provide 100x more e^+/s than needed

"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





$E_{laser} = 1Ry\,(Z^2 - Z^2/n^2)/2\gamma_L$ → $E_{\gamma\text{-ray}} = E_{laser} \times 4\gamma_L^2/(1+(\gamma_L\theta)^2)$

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

high photon energies,
high cross section

W. Krasny

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!