High Energy Circular and Linear Colliders

IPAC 上海 13
The 4th International Particle Accelerator Conference
第四届国際粒子加速器會議

Shanghai China
12-17 May 2013
Shanghai International Convention Center

IPAC13

Barbara Dalena,

CEA-Saclay DSM/Irfu/SACM

Outline

Accelerators for Particle Physics

- LHC $\Rightarrow$ High Luminosity LHC
- Beyond LHC:
  - ILC
  - CLIC
  - LHeC
  - Higgs Factories
  - Muon Colliders
  - Higher energies colliders
  - Super B factories
  - Accelerator neutrinos

2 interesting beam dynamics studies

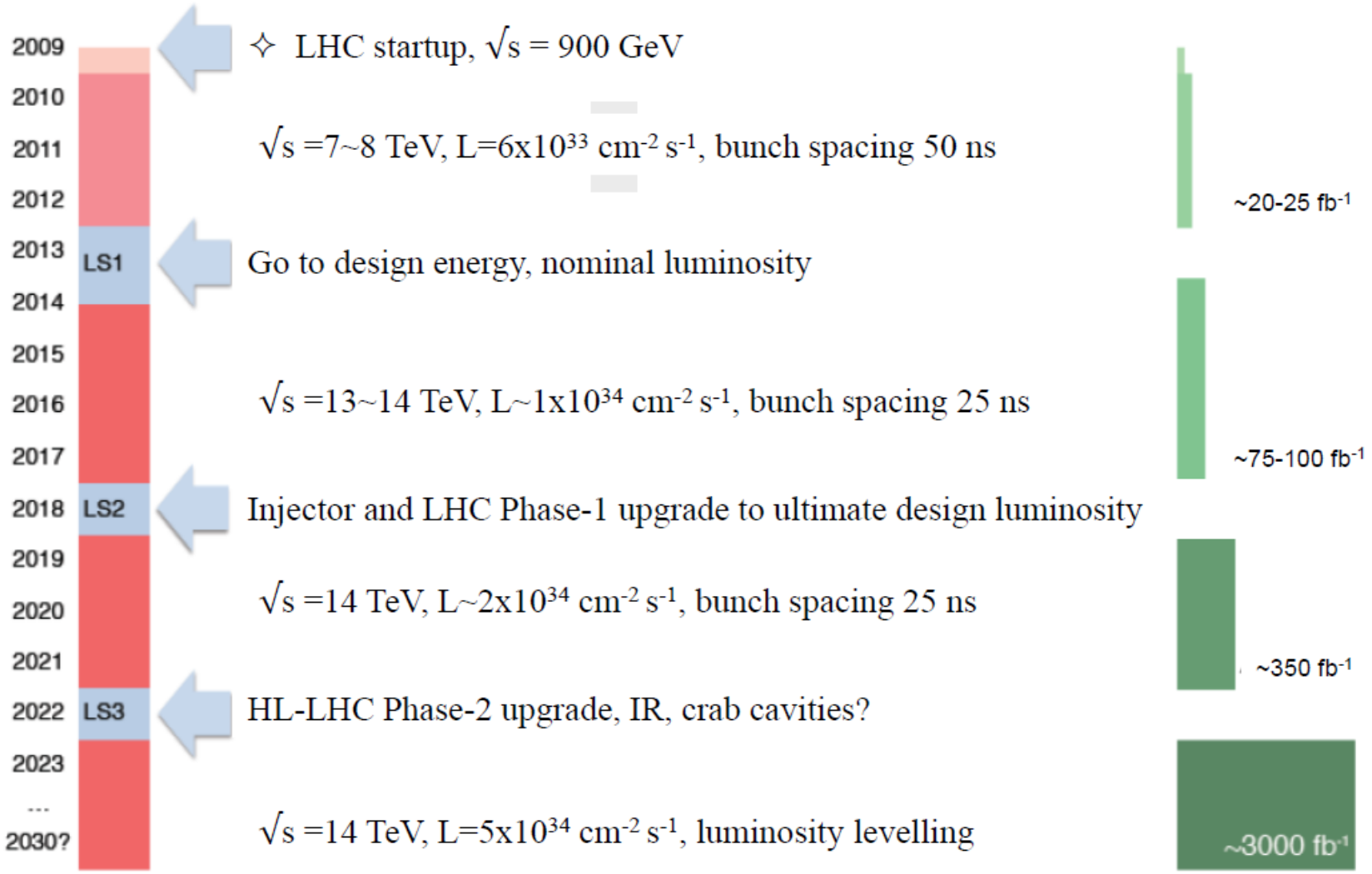
LHC

Peak performance through the years

	2010	2011	2012	Nominal
Bunch spacing [ns]	150	50	50	25
No. of bunches	368	1380	1380	2808
beta* [m] ATLAS and CMS	3.5	1.0	0.6	0.55
Max bunch intensity [protons/bunch]	1.2×10^{11}	1.45×10^{11}	1.7×10^{11}	1.15×10^{11}
Normalized emittance [mm.mrad]	~2.0	~2.4	~2.5	3.75
Peak luminosity [$cm^{-2}s^{-1}$]	2.1×10^{32}	3.7×10^{33}	7.7×10^{33}	1.0×10^{34}

M. Lamont http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/moyab101_talk.pdf

LHC, the next 20 years



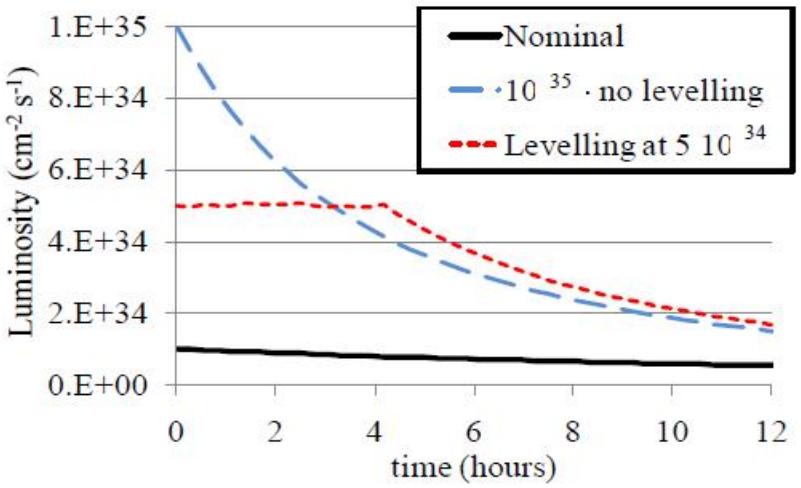
S. Bertolucci http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/fryba01_talk.pdf

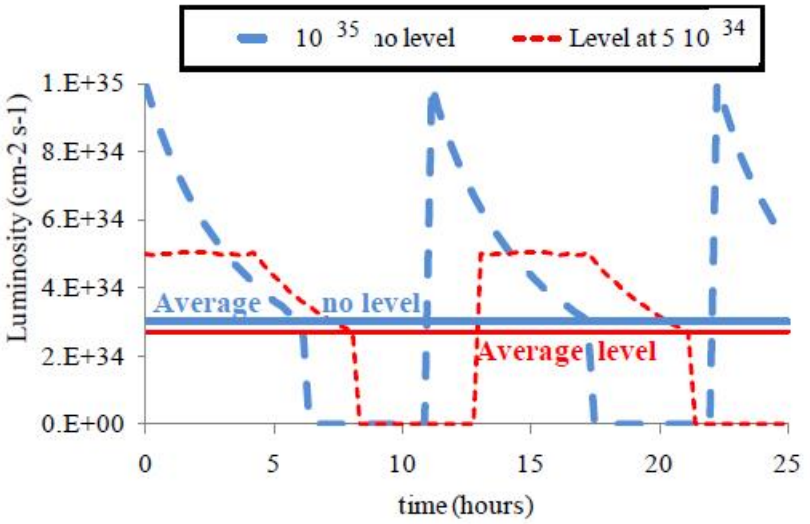
HL-LHC The Goal

The main objective of HL-LHC is to implement a hardware configuration and a set of beam parameters that will allow the LHC to reach the following targets:

- A luminosity of 5×10^{34} **cm^{-2}s^{-1} with leveling**
- Implies a "Virtual" peak luminosity of $>10^{+35}$ cm^{-2}s^{-1}
- An integrated luminosity of **250 fb^{-1}** per year, enabling the goal of **3000 fb^{-1}** twelve years after the upgrade.

Why Level?





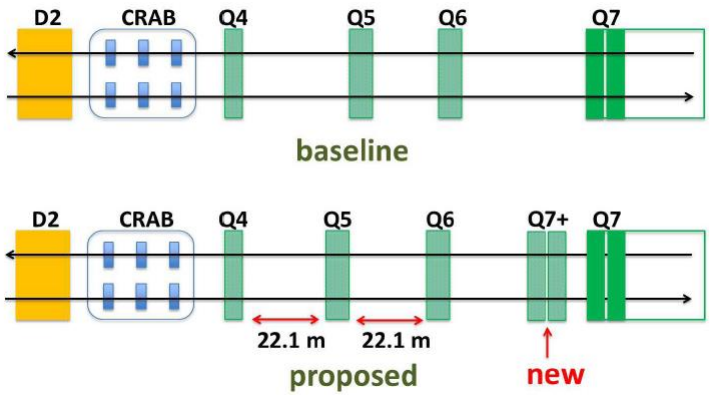
- ✓ Allow design integrated Luminosity for a lower peak L, and less pile up for the experiments
- ✓ Lower peak heat deposition in the magnets

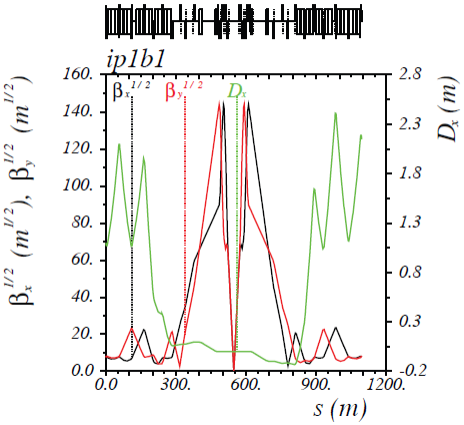
S. Bertolucci http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/fryba01_talk.pdf

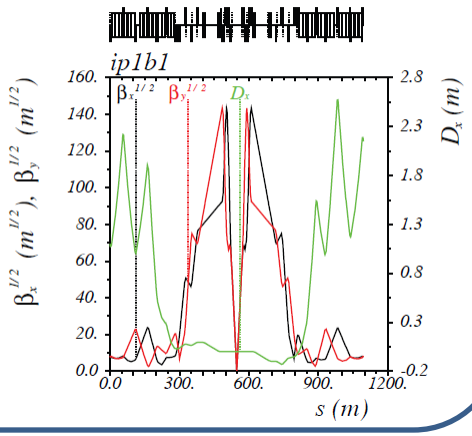
HL-LHC optics and tracking studies

1. R. De Maria et al. HLLHCV1.0: HL-LHC layout and optics models for 150 mm Nb3Sn triplets and local crab-cavities", TUPF014, IPAC'13
2. M. Korostelev et al. "Optics Transition between Injection and Collision optics for the HL-LHC Upgrade Project" , TUPFI051, IPAC'13
3. B. Dalena et al. (2013), "High Luminosity LHC Matching Section Layout vs. Crab Cavity Voltage", TUPFI001, IPAC13
4. Y. Nosochkov, et al. (2013), "Optimization of Triplet Quadrupoles Field Quality for the LHC High Luminosity Lattice at Collision Energy", TUPFI016, IPAC13
5. Y. Nosochkov, et al. (2013), "Evaluation of Field Quality for Separation Dipoles and Matching Section Quadrupoles for the LHC High Luminosity Lattice at Collision Energy", TUPFI017, IPAC13
6. M. Giovannozzi, et al. (2013), "Dynamic Aperture Performance for Different Collision Optics Scenarios for the LHC Luminosity Upgrade", WEPEA047, IPAC13
7. A. Bogomyagkov, et al. (2013), "Analysis of the Non-linear Fringe Effects of Large Aperture Triplets for the HL LHC Project", WEPEA049, IPAC13
8. …

Optimization of the matching section layout to reduce the crab cavity voltage: $V \propto 1/(\beta^*\beta)^{1/2}$



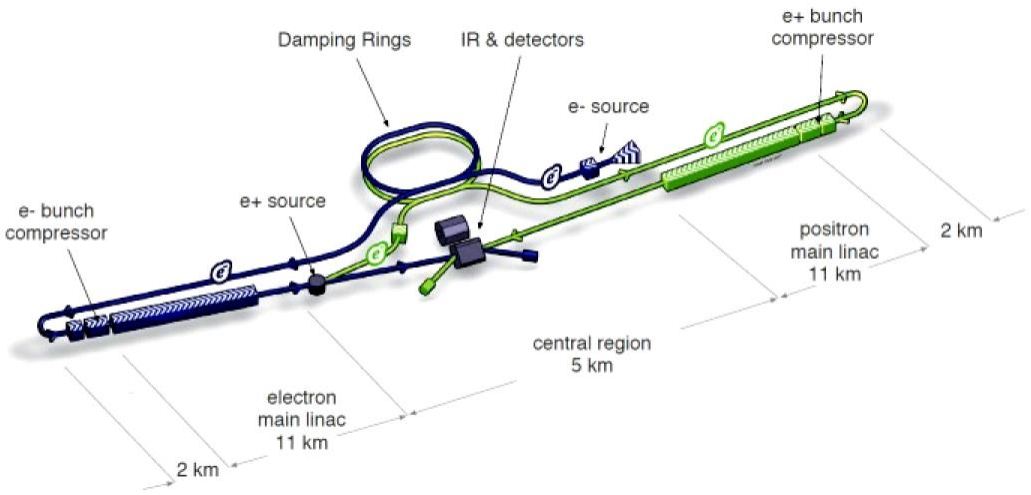




ILC

International Committee for Future Accelerators (ICFA) representing major particle physics laboratories worldwide.

- Chose ILC accelerator technology (SCRF)
- Determined ILC physics design parameters
- Formed Global Design Effort and Mandate (TDR)



B. Barish http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/tuyb102_talk.pdf

Best candidate: the International Linear Collider:

- Mature design
- TDR delivered
- Japanese community has submitted to the government a request to host it.

S. Bertolucci http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/fryba01_talk.pdf

1 invited talk, 2 talk Special Session for Industry, 1 talk on ATF2, ~20 related posters

ILC

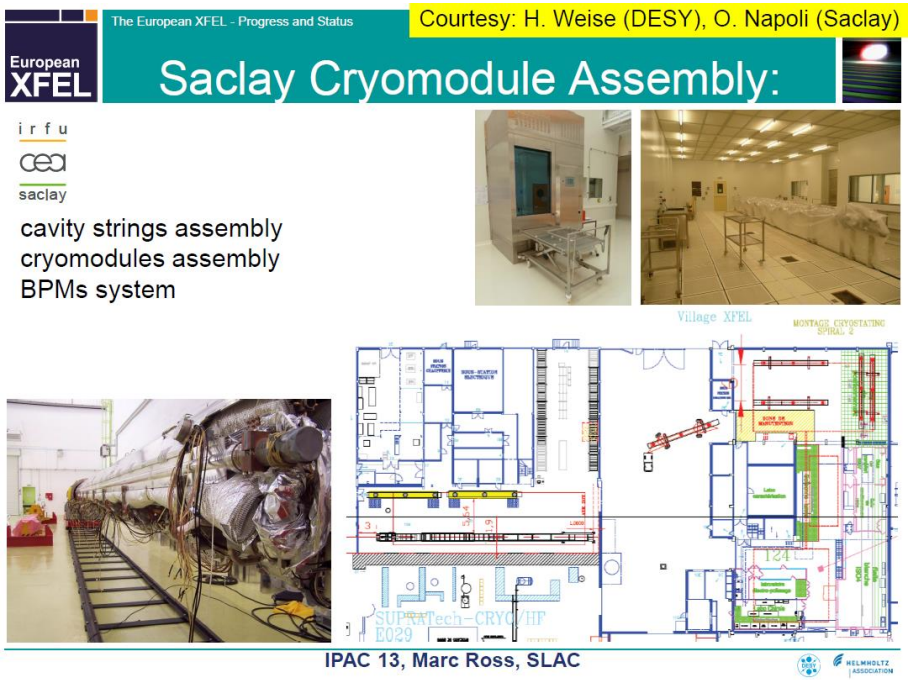
- small beam sizes and stabilization
  ATF/ATF2 facility
- cavity R&D (2010-2012 tests)

  15/16 > 28 MV/m
  12/16 > 35 MV/m

ATF / ATF2 Goals

- ❑ **Very small damping ring vertical emittance**
  - from ~10 pm → 4 pm (achieved !) → 1-2 pm
- ❑ **Small vertical beam size** *"goal 1"*
  - achieve σ_y ~37 nm (cf. 5 / 1 nm in ILC / CLIC)
  - validate "compact local chromaticity correction"
- ➔ ❑ **Stabilization of beam center** *"goal 2"*
  - down to ~ 2nm
  - bunch-to-bunch feedback (~300 ns, for ILC)
- ❑ **R&D on nanometer resolution instrumentation**
- ❑ **Train young accelerator scientists on "real system"**
  - maintain expertise by practicing operation

P. Bambade http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/tuocb203_talk.pdf

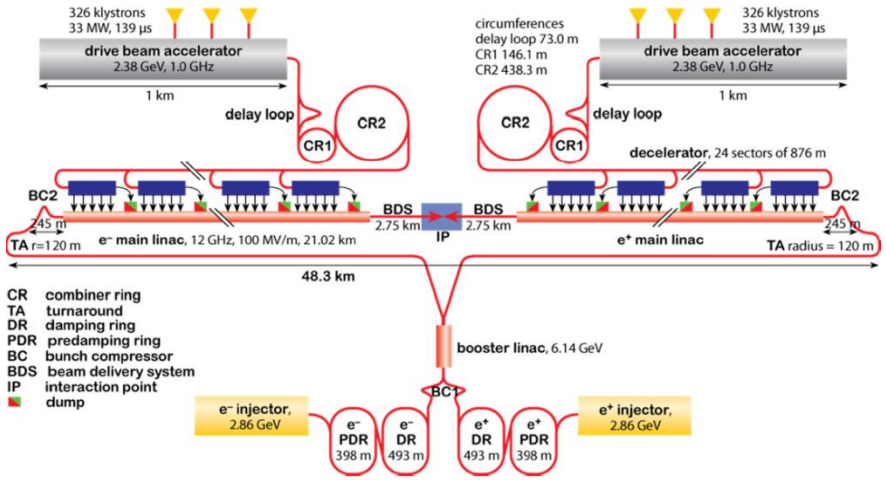


M.C. Ross http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/weib202_talk.pdf

CLIC & CTF3

Compact Linear Collider aka CLIC

TDR phase:
R&D programs in collaboration with several facilities around the world
ATF2, FACET, PSI, …

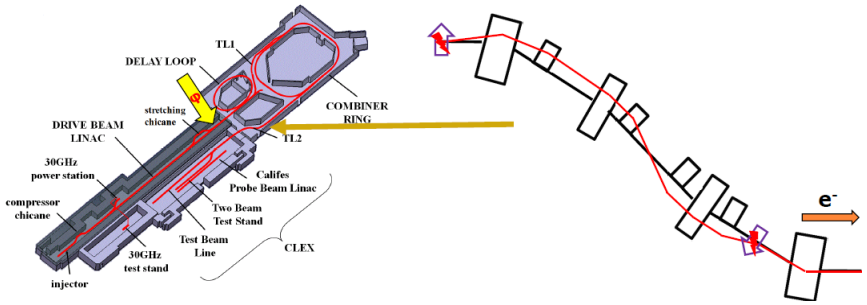


1 talk on CTF3

P. Skowronski http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/weobb203_talk.pdf

Phase Feed-Forward @ CTF3

- A prototype system implementation in CTF3
  - Prove its feasibility
  - Test area for the R&D
  - Ultimate goal: phase stabilization to 0.2 deg @ 12 GHz
- Phase measured before the Delay Loop with a dedicated monitor
- Correction in the **dog-leg chicane** after Combiner Ring using 2 kickers
- Verification with 2 monitors installed just before and after the dogleg
- 280 ns latency



~40 related posters

Proceedings of IPAC2013, Shanghai, China TUPME042

THE SPS AS AN ULTRA-LOW EMITTANCE DAMPING RING TEST FACILITY FOR CLIC

Y. Papaphilippou, R. Corsini and L. Evans, CERN, Geneva, Switzerland

LHeC

- Linac-Ring option:
  - -Installation decoupled from LHC operation and shutdown planning
  - -Infrastructure investment with potential exploitation beyond LHeC
  - -Challenge 1: technology ➔ high current, high energy SC ERL
  - -Challenge 2: Positron source
- Launch SC RF and ERL R&D and Establish collaborations:
  - -SC RF R&D has direct impact on cryo power consumption
    - -Synergy with HH RF for HL-LHC and TLEP!
  - -ERL is a hot topic with many applications
    - -Synergy with national research plans: e.g. JLab, BNL eRHIC and MESA
- Magnet R&D activities:
  - -Superconducting IR magnet design
    - ➔ Detailed magnet design depends on IR layout and optics
    - ➔ Optics & IR magnet design influence experimental vacuum beam pipe
  - -Normal conducting compact magnet design ✔

Baseline

Post CDR Plans

Oliver Brüning

http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/mozb201_talk.pdf

1 invited talk, 6 related posters

Proceedings of IPAC2013, Shanghai, China MOPWO054

THE LHeC AS A HIGGS BOSON FACTORY

F. Zimmermann, O. Brüning, CERN, Geneva, Switzerland; M. Klein, U. Liverpool, UK

ep option 60 GeV e-, 7 TeV p beam

$\gamma\gamma$ option 80 GeV e- /beam

Higgs factories

TUPME021 Proceedings of IPAC2013, Shanghai, China

OPTIMIZATION PARAMETER DESIGN OF A CIRCULAR e^+e^- HIGGS FACTORY*

50 Km ring, 120 GeV/beam

D. Wang#, J. Gao, M. Xiao, H. Geng, S. Xu, Y. Guo, N. Wang, Y. An, Q. Qin, G. Xu, S. Wang,
IHEP, Beijing, 100049, China

TUPME040 Proceedings of IPAC2013, Shanghai, China

TLEP: A HIGH-PERFORMANCE CIRCULAR e^+e^- COLLIDER TO STUDY THE HIGGS BOSON

80 Km ring, 120-175 GeV/beam

M. Koratzinos, A.P. Blondel, U. Geneva, Switzerland; R. Aleksan, CEA/Saclay, France; O. Brunner, A. Butterworth, P. Janot, E. Jensen, J. Osborne, F. Zimmermann, CERN, Geneva, Switzerland; J. R. Ellis, King's College, London; M. Zanetti, MIT, Cambridge, USA.

Proceedings of IPAC2013, Shanghai, China TUPME067

80 GeV/beam

DESIGN CONCEPT OF A γ-γ HIGGS FACTORY DRIVEN BY THIN LASER TARGETS AND ENERGY RECOVERY LINACS*

Y.H Zhang#, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA

Proceedings of IPAC2013, Shanghai, China TUPME031

CONSIDERATIONS FOR A HIGGS FACILITY BASED ON LASER WAKEFIELD ACCELERATION

S. Hillenbrand, KIT, Karlsruhe, Germany and CERN, Geneva, Switzerland
A.-S. Müller, KIT, Karlsruhe, Germany
R.W. Assmann*, D. Schulte, CERN, Geneva, Switzerland

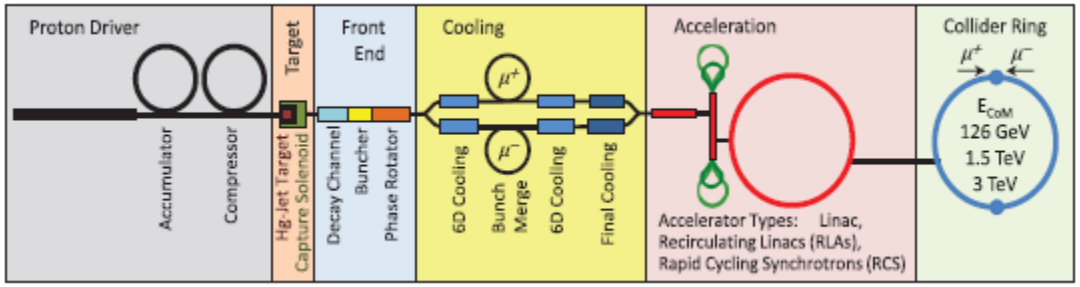
Muon Colliders

~25 related posters

TUPFI056 Proceedings of IPAC2013, Shanghai, China

A MUON COLLIDER AS A HIGGS FACTORY*

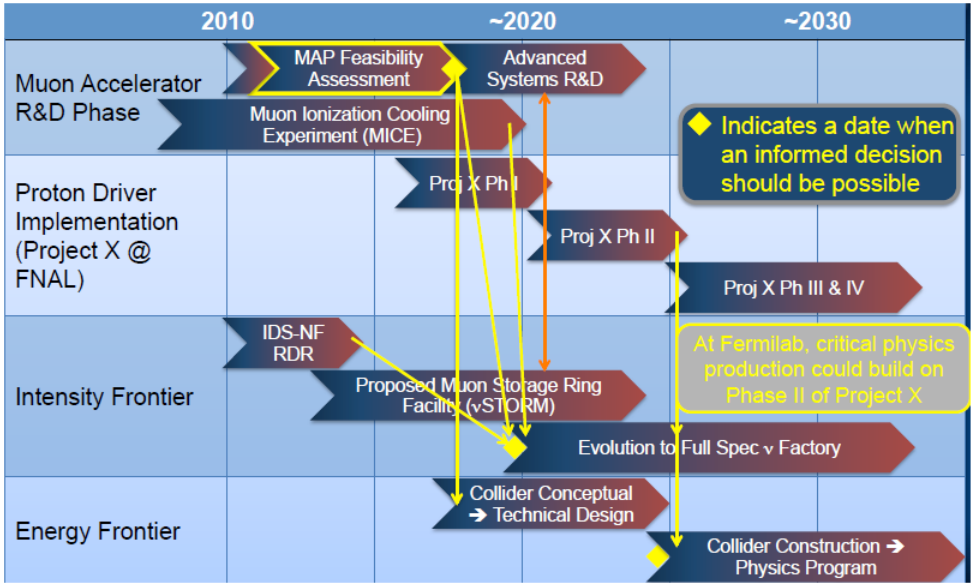
D. Neuffer#, M. Palmer, Y. Alexahin, Fermilab, Batavia IL 60510, USA, C. Ankenbrandt, Muons, Inc., Batavia IL 60510, USA, J. P. Delahaye, SLAC, Menlo Park, CA 94025 USA



Proceedings of IPAC2013, Shanghai, China TUPFI057

MUON ACCELERATORS FOR THE NEXT GENERATION OF HIGH ENERGY PHYSICS EXPERIMENTS *

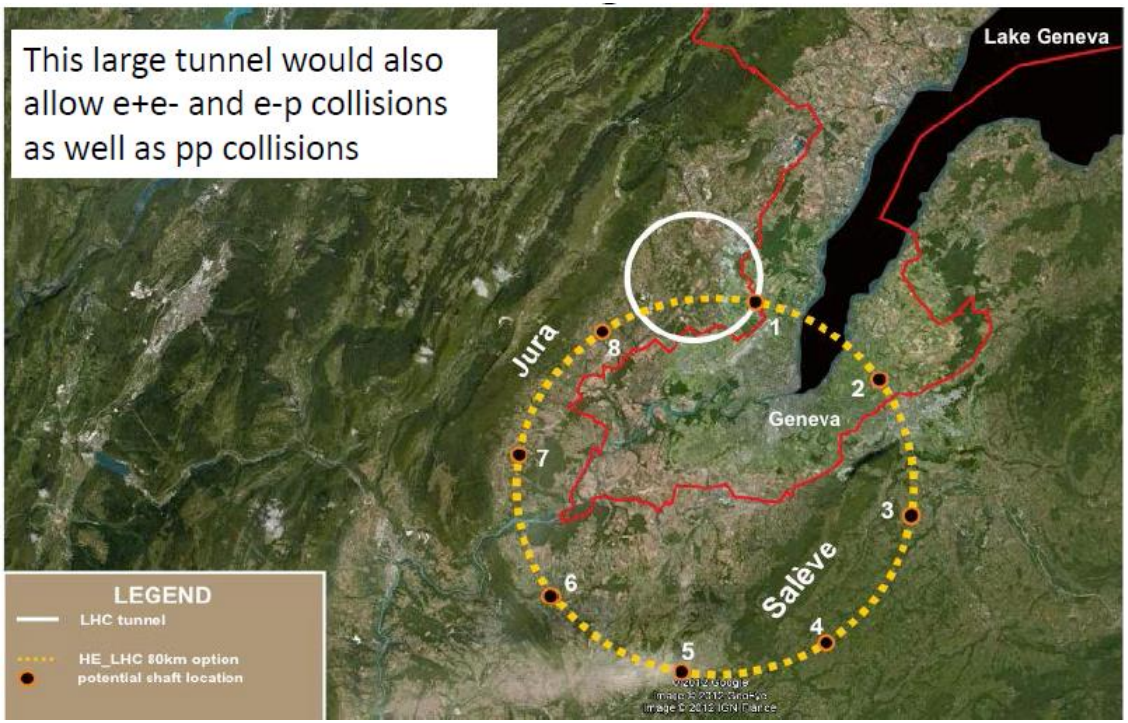
M.A. Palmer#, S. Brice, A.D. Bross, D. Denisov, E. Eichten, R. Lipton, D.V. Neuffer, FNAL, Batavia, IL 60510, USA
H. Kirk, R. Palmer, BNL, Upton, NY 11973, USA
D.M. Kaplan, P. Snopok, Illinois Institute of Technology, Chicago, IL 60616, USA
A. Bogacz, JLAB, Newport News, VA 23606, USA
R. Ryne, LBNL, Berkeley, CA 94720, USA
C. Ankenbrandt, Muons Inc., Batavia, IL 60510, USA
J-P. Delahaye, SLAC, Menlo Park, CA 94025, USA
P. Huber, Virginia Tech, Blacksburg, VA 24061, USA
for the MAP Collaboration



Thinking BIG

- HE-LHC dipole design will piggy back on the high gradient quadrupole R&D needed for HL-LHC
  - Would allow an increase in energy by factor of 2-2.5

- SHE-LHC (??SSC) needs a 80km tunnel
  - In conjunction with the high field magnets would allow a factor of (2-2.5)x(80/27) = 6-7.5 times LHC (42-52 TeV/beam)



S. Bertolucci http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/fryba01_talk.pdf

Super B Factories

Summary

- Construction of SuperKEKB is underway, and the commissioning is scheduled early 2015. Finalizing the design is also in progress for the most critical region, in particular for the IR.
- SuperB has been cancelled due to budget issues, but a design for a τ/charm factory has started, based on the previous work done for the SuperB.

K. Akai http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/tuyb101_talk.pdf

1 invited talk, ~14 related posters

Short/Long/Medium accelerator neutrinos

1 talk, ~15 related posters

Future

	Beam power(MW)	Baseline (km)	Detector	Start time
NOVA	0.7	810	14 kt Iron calorimeter	2015
HyperK	0.75	295	560 kt Water Cerenkov	~ 2022
LBNE	0.7 ➔ 2.3	1300	10 kt➔ 35kt Liquid Ar TPC	~ 2022 ➔ ?
LBNO	0.75 ➔ 2.0	2300	20 kt LAr TPC + 35 kt MIND	?

if HyperK/LBNE/LBNO do not find CP

Below in-elastic threshold: **~ 300 MeV ➔ baseline = 150 km**

Low energy ➔ cheaper

Europe efforts: Super-beams

- **CERN HP-SPL**
  - 4.5 GeV proton driver, 4 MW power
  - Baseline: 130 km to Frejus
- **European Neutron Spallation Source at Lund (ESS)**
  - 2.5 GeV, 5 MW Superconduction Linac
  - Baseline: 260 km up; 540 km Garpenberg Mine ?

Efforts in IHEP: DYBIII

- **A proton LINAC for ADS is now under development in China**
- **If R&D is successful, a CW Linac based ~15 MW proton driver can be used for neutrino beams**
- **Shoot towards the Daya Bay II detector ? (150 km from CSNS site to DYBII)**

Phase IV (2023-

Y. Wang http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/fryca01_talk.pdf

Beam Coupling impedance localization technique validation and measurements in the CERN machines

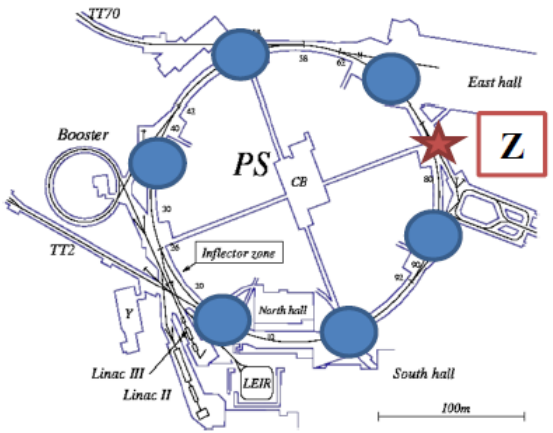
Motivation: Increasing the beam intensity, detrimental effects like beam instabilities and beam losses may arise due to the beam coupling impedance. Need impedance quantification!

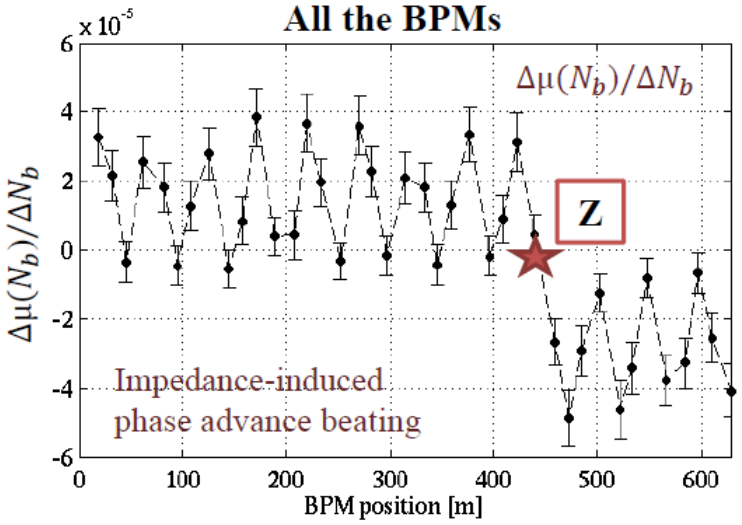
Global machine impedance measurements: The imaginary part of the total transverse beam coupling impedance can be estimated from the tune shift with intensity.

$$\Delta Q(N_b)/\Delta N_b \propto Im(Z_{\perp,eff}^{tot})$$

Local machine impedance measurements: The local contribution may be estimated with different methods using distributed BPMs:

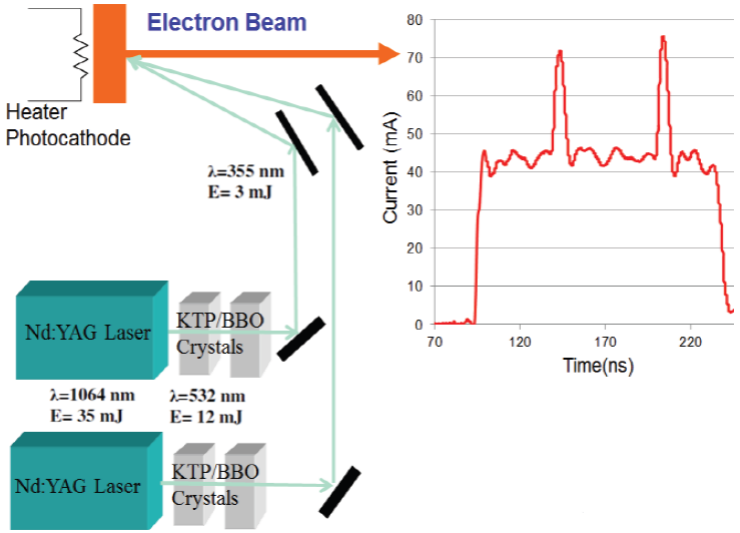
1. Impedance-induced orbit shift with intensity.
2. **Impedance-induced phase advance beating with intensity.**
3. Others?

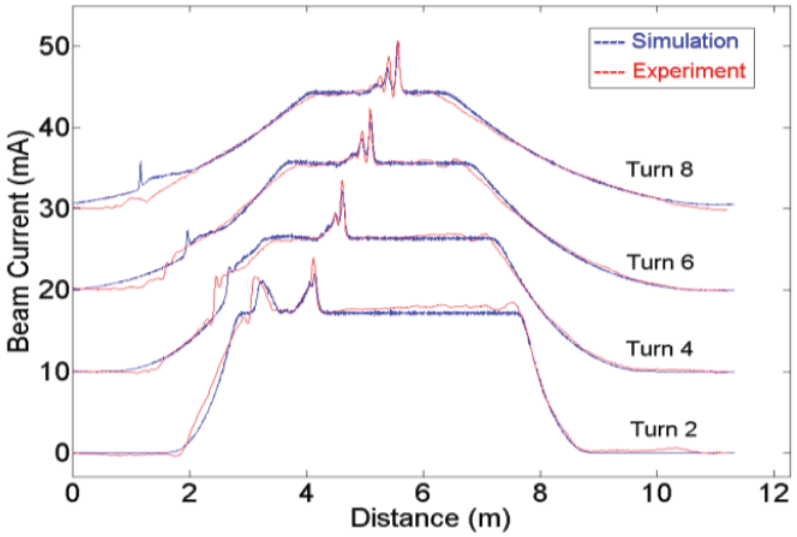




N. Biancacci http://accelconf.web.cern.ch/accelconf/IPAC2013/talks/thobb102_talk.pdf

Experimental studies of soliton wave trains in intense electron beams





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Experimental Observations of Soliton Wave Trains in Electron Beams

Y. C. Mo, R. A. Kishek, D. Feldman, I. Haber, B. Beaudoin, P. G. O'Shea, and J. C. T. Thangaraj*
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(Received 7 November 2012; published 20 February 2013)

Y.C. Mo http://accelconf.web.cern.ch/accelconf/IPAC2013/papers/tupwa058.pdf