LHeC Implementation Considerations

Presentation based on input from:

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Strategy for this presentation

- Collect critical time scales for the main LHeC components
  - ➔ Civil engineering and installation work
  - ➔ Magnet development & production
  - ➔ Cavity development & production
- Scale from experience with past projects
  - ➔ LEP, LHC and CLIC
  - ➔ Look at their need for prototyping and test stand and production time
- General considerations of LHC exploitation
  - ➔ Current schedule - planning
  - ➔ upgrade plans and LHC lifetime
- Compare LHeC timing needs with current LHC schedule

LHeC Components considered in this exercise

- Civil engineering:
  - ➔ 70 GeV Energy recovery linac
  - ➔ Bypass construction for the Ring-Ring option
- Main magnet system
  - ➔ Ring-Ring
  - ➔ Linac-Ring
- RF system
  - ➔ Parallel development of key components
  - ➔ Parallel construction
- Summary of experience from other machines

Civil Engineering Requirements

Numbers based on input from John Osborne

Energy recovery linac option for linac-ring design:

total tunnel length of ca. 14km (similar to 500 GeV CLIC option):

- ➔ 4 years for civil engineering
- ➔ 2 years of service installation (piping, cabling, EL general services)
- ➔ 2 years of actual machine installation
- ➔ Total of 6 years with partial overlap of some of these activities

Bypass for ring-ring option:

Total tunnel length of ca. 2km (ca. 500 on either side of experiment)

But also requires two access shafts (safety)

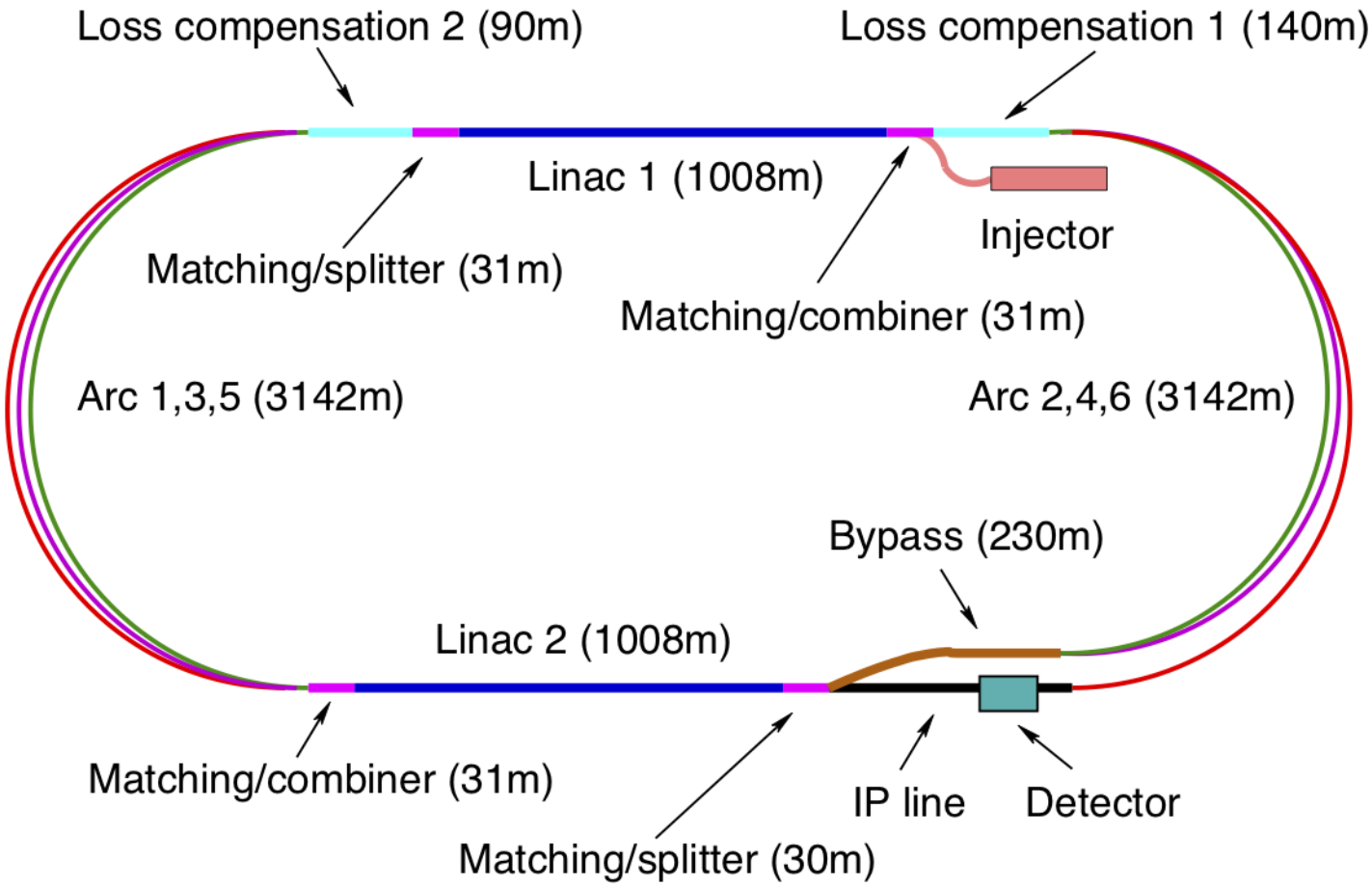
Requires dedicated alcoves for Klystrons and RF system

- ➔ perhaps slightly shorter intervention time as for Linac-Ring options
- ➔ Total of 5 years with partial overall of some of these activities

(Civil engineering for injector complex not considered here)

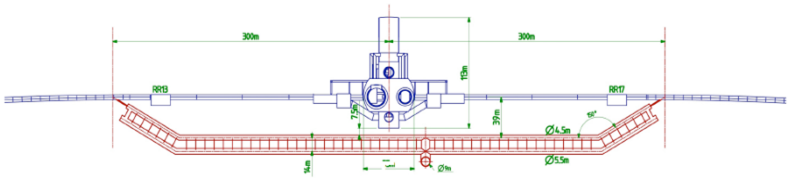
Energy-Recovery Linac Layout

Drawing from John Osborne



Overall Layout and Bypasses

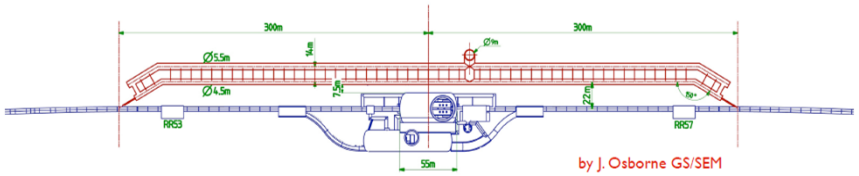
ATLAS (bypass inside): $\Delta = 39$ m



Properties (Version 6):

- estimate for additional synchrotron radiation losses: $\Delta P_W = 3.3$ MW
- separation $\Delta = 37.1$ m
- path length difference of $\Delta s = -5.46$ m

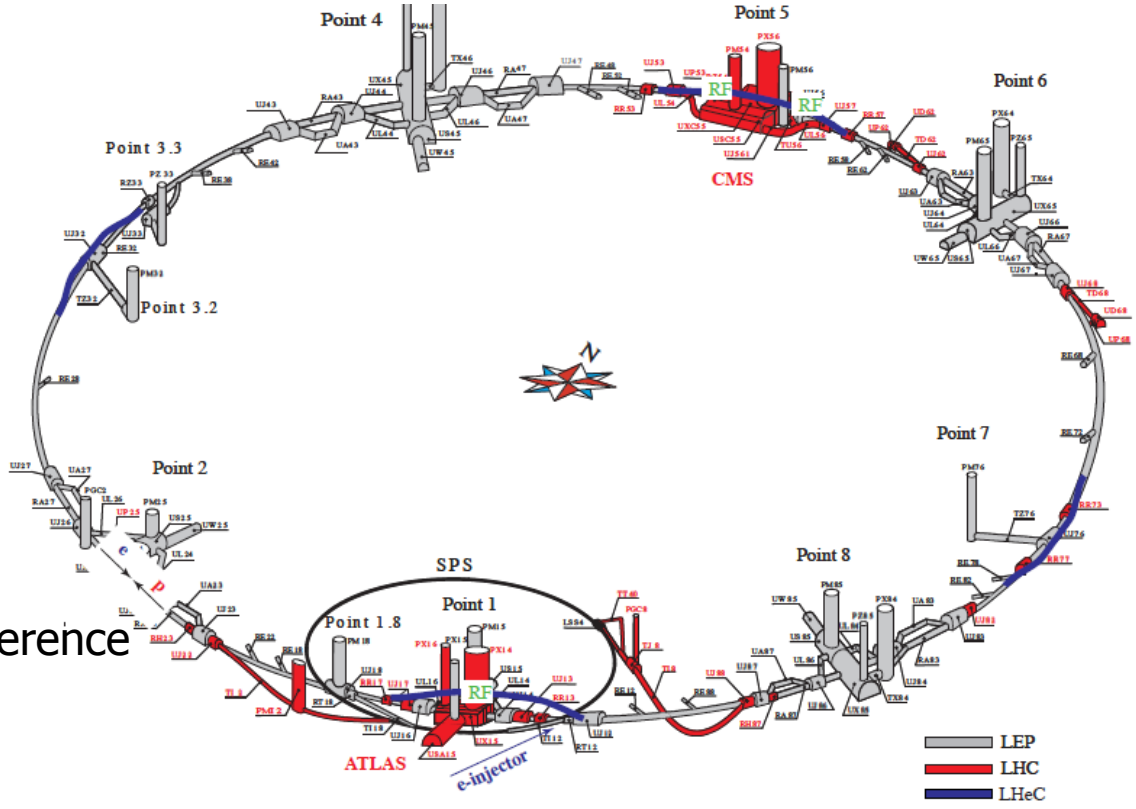
CMS (bypass outside): $\Delta = 22$ m



Properties:

- no additional synchrotron radiation losses
- separation $\Delta = 22.0$ m
- path length difference of $\Delta s = 2.25$ m

e-p/A experiment could be at IP2 (shown), IP8 or ...



Bypass design:

- shutdown time
- cost for tunnel
- match LHC and eRing circumference
- extra shafts being discussed

Main Magnet System

Based on input from V. Mertens, B. Godard, D. Tommasini, M. Fitterer

Magnet design and prototyping:

Conventional magnet technology – industrial experience:

➔ 2-3 years for generating specification for magnet production

Production time:

-Ring-Ring: ca. 4000 magnets (3000 dipole & 1000 quadrupoles)

-Dipole design could be optimized for 1500 11m long elements?

-Linac-Ring: ca. the same number of magnets for ER option!

➔ LHC transfer lines (ca. 6km); 350 warm magnets in 3 years (10/month)

➔ LHeC magnet production requires industrial production

➔ requires several contractors and production lines: pre-series and QA!

➔ assume 40 magnets / month (4 * TL) ➔ 8 years

➔ 1 year pre-series; 6-10 years production

Total of 10 to 15 years for magnet production time!!!

Energy-Recovery Linac Layout

Ring-Ring magnet numbers from Miriam Fitterer

10 GeV Linac + TL + 60 GeV Ring

	Dipoles				QF			QD		
	Number	*Radius*	*Field*	*Mag Length*	*Number*	*Gradient*	*Mag Length*	*Number*	*Gradient*	*Mag Length*
LINAC										
TL										
RING (total)	3080	curved	0.076	5.35	465	<17.5864	1	465	<11.6708	1
RING (Insertions+BP)					97	<17.5864	1	97	<11.6708	1
RING (ARC)					368	10.2807	1.000	368	8.39947	1.000

Units: meter (m), Tesla (T), T/m

Cavity Development & Production

Based on input from Edmond Ciapala

- Cavity design and prototyping:
  - ➔ 2-3 years for prototype development and testing?
- Test stand operation:
  - ➔ 4-5 years from LEP and LHC experience?
- Production time:
  - -LEP: 8 years from proto type to final installation of 73 4-cavity modules
  - -LHC: ca. 6 years from proto type to final installation of 4 modules
  - -LHeC ER linac requires ca. 2*80 modules of 6 700 MHz 5-cell structures
    - ➔ ca. 1000 structures; ca. 13 times the number of LEP structures
  - ➔ LHeC RF production requires industrial production: pre-series and QA!
  - ➔ requires several contractors and production lines: pre-series and QA!
  - Ca. 6 to 10 years for magnet production!!!

LHC Schedule and Upgrade Plans

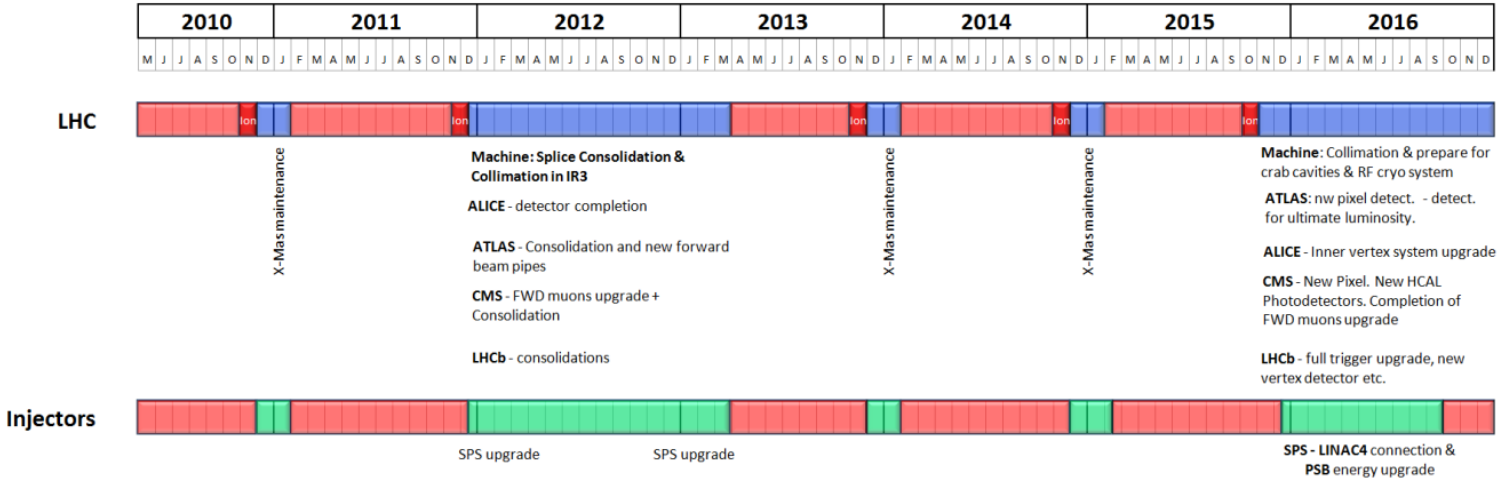
- Initial LHC commissioning (now to 2013):
  - ➔ commissioning and operation at 3.5 TeV from 2010 until 2011 (2012?)
  - ➔ 1 year shut down for splice consolidation
- Nominal exploitation (2013 to 2020):
  - ➔ commissioning and operation at 3.5 TeV from 2010 until 2011 (2012?)
  - ➔ 1 year shut down for splice consolidation
  - ➔ commissioning to 7 TeV and L production
  - ➔ 1 year shut down for LINAC4 connection and experiment upgrade
  - ➔ operation until performance plateaus (expected around 2020)
- High Luminosity operation:
  - -1 year shutdown for LHC upgrade to $L = 5\ 10^{34}\ cm^{-2}\ sec^{-1}$
  - -aim for 250 fb^{-1} per year during high luminosity production operation
  - -goal of 3000 fb^{-1} per year can be reached between 2030 and 2035

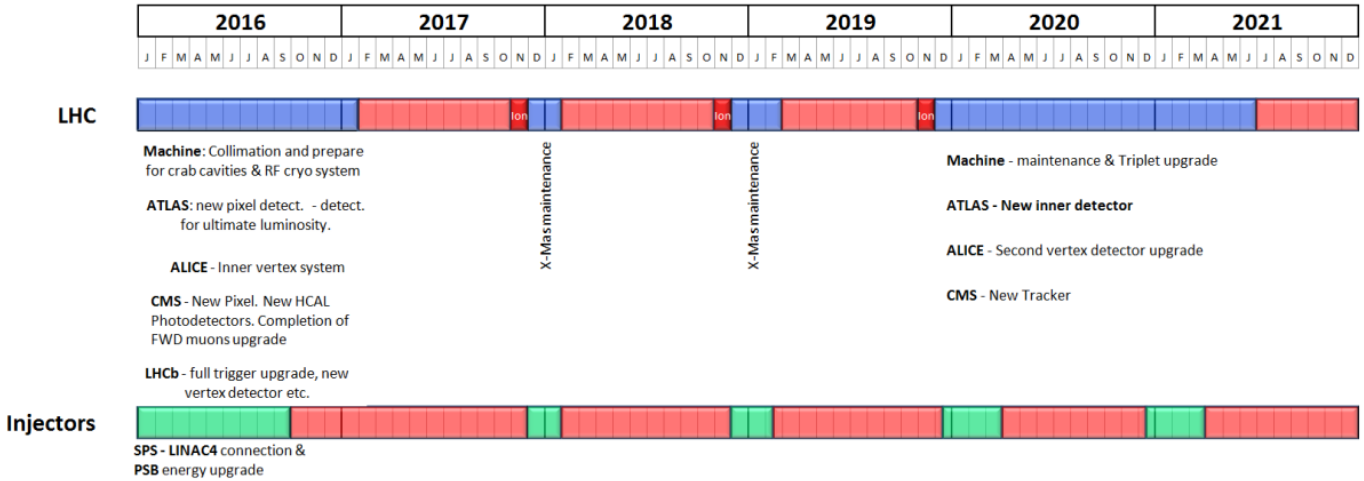
LHeC Requirements

- LHeC installation should be compatible with 5-10 years operation:
  - ➔ assume LHC end of lifetime reached in 2030-2035 (radiation damage)
  - ➔ LHeC operation start required by 2025 (at latest)
  - ➔ start production of key components (magnets & RF) by 2015
  - ➔ prototype development (magnets & RF) launched by 2012

- LHeC installation time:
  - ➔ Magnet installation for Ring-Ring option only possible during long LHC shutdown ➔ 2016, 2020, (2025?)
    LEP installation into empty tunnel took ca. 1 year!
  - ➔ Only one scheduled long shutdown if LHeC can not profit from 2016 shutdown

CERN plan for coming years





Stop INJ in 2012
No shutdown in 2015 to maximize Physics

Nobody will be surprised if instalaltion of HL equipment will shift 1 year…

Not Considered here

- Kicker and dump development:
  - ➔ required 50 MW beam dump for both options
  - ➔ rough estimate of 10 years for design & production (B. Goddard)
- Injector complex:
  - ➔ LEP: 6 years from ground breaking to operation 1989 (H. Burkhardt)
  - ➔ LIL: 7 years from construction (surface) to operation in 1986 (Rinolfi)
  - ➔ Assume that installation is in the shadow of the main LHeC systems
- Sources for the Linac-Ring option:
  - ➔ required challenging development and test stands
  - ➔ Assume development can be done in the shadow of the main systems
- Vacuum:
  - ➔ 50 MW of synchrotron radiation in ring-ring
  - ➔ ion instabilities for linac-ring option
- Cryogenics:
  - ➔ Linac-Ring requires ca. 30 MW cryo power for 2 linacs with total length of 2 km (comparable to LHC cryo system)

Conclusion

- Keeping an LHeC option open for the LHC requires:
  - ➔ launch of R&D and design activities for key components (magnets, RF) needs to start very soon
  - ➔ planning the installation of the ring-ring option requires careful synchronization with LHC operation schedule (assume minimum of two long shut downs for installation)
  - ➔ Civil engineering must start before 2018

- Requirements:
  - ➔ The above work can not be done with the current arrangement and requires a focused team and sufficient resources

- Conclusion:
  - ➔ Decision on LHeC option should be taken by 2012