EuCARD HE-LHC'10

AccNet mini-workshop on a „High Energy LHC"
14-16 October 2010, Villa Bighi, MALTA

Considerations about the injectors of the HE-LHC

R. Garoby

15 October, 2010

OUTLINE

1. Introduction
2. HE-LHC requirements
3. Possible solutions for the injectors
4. Summary

1. Introduction

Past...

- The injectors of LHC have already been the subject of investigation during past workshops, in view, at medium term, of the LHC luminosity upgrade and at long term, of a higher energy LHC:
  - LUMI06 [http://care-hhh.web.cern.ch/CARE-HHH/LUMI-06/default.html]
  - LER06 [http://ler06.web.cern.ch/LER06/]
- Outcome had materialized in the LP-SPL / PS2 / SPS proposal, as described in the LUMI08 workshop

  [http://indico.cern.ch/conferenceDisplay.py?confId=43275]
- However, as a result of the Chamonix2010 workshop [https://espace.cern.ch/acc-tec-sector/cham2010/default.aspx], the needs of the luminosity upgrade have been reduced and the decision taken to upgrade the existing injectors, instead of building new ones.

Present

- Matching the needs of the „High Luminosity LHC“ (HL-LHC) is the objective of the „LHC Injectors Upgrade“ (LIU) project

  [time period: ~2017 – 2030],

- The „High Energy LHC“ (HE-LHC) sets different requirements on the injectors, and with a different time-scale

  [time period: ~2030 – 2050],

- Past workshops (especially LER06 and LUMI06) are highly valuable sources of information.

2. HE-LHC requirements

Beam specifications

Derived from CERN-ATS-2010-177 [„First thoughts on a higher energy LHC“]

My guess...

Specific to HE-LHC

	Nominal LHC	HL-LHC	HE-LHC	
Beam energy [GeV]	450	450	> 1000	
Distance between bunches [ns]	25	25 (resp. 50)	50	
Bunch population* [10^{11} p/b]	1.2	~1.8 (resp. 3.6)	~1.4	
Transverse normalized emittance [μm]	3.75	≥ 2	3.75 (H) 1.84 (V)	2.59 (H & V)
Longitudinal emittance [eVs]	1	1	? (<4)	

* At LHC entrance, assuming 5% loss wrt to start of physics data taking at high energy

Comment: HE-LHC requirements are unlikely to be as well-defined as stated above...

3. Possible solutions for the injectors

Highest energy injector

Only requirement outside the capability of the existing injectors: need for > 1 TeV.

Two options:

1. In the SPS tunnel — **H. Piekarz, P. Spiller, P. Fabbricatore**
   - ⇒ New SPS (HE-SPS) with fast cycling sc dipoles
   - ⇒ Replacement of equipment in TI2 and TI8 transfer lines (sc magnets)

2. In the LHC tunnel — **H. Piekarz, K.H. Mess**
   - ⇒ No change to SPS and transfer lines
   - ⇒ Additional double aperture 27 km ring compatible with detectors
     - ⇒ Bypasses
     - ⇒ Passage through detectors' centres using fast deflecting magnets

Open technical issues for the highest energy injector

HE-SPS in the SPS tunnel	**Possibility to re-use existing magnets in accelerator and/or Xfer lines?**
	Injection energy in HE-SPS?
	Space for hosting the injector in the SPS tunnel?
	Magnet technology (if new magnets)?
LER in LHC tunnel	Space for hosting HE-LHC and LER in the LHC tunnel?
	Magnet technology?
	Solution for the IPs?
	Machine protection (Safe beam, beam dumps)?

HERA? TEVATRON?

Superferric?

Pipetron? Refurbishment of LHC magnets?

Bypass ? Through IP?

Lower energy accelerators (1/2)

As of today, the existing injectors meet the basic needs of HE-LHC.

But... How far can their lifetime be extended (e.g.: PS will be 70 years old in 2029)?

⇒ It is perfectly reasonable to plan for modern & optimized new low energy injectors for the HE-LHC which will operate until ~2045.

Since the injector complex will „live“ much longer than the HE-LHC, it should have the potential to serve more purposes, either in parallel with HE-LHC, or afterwards (possibly with upgrades).

⇒ Need to know about long term users‘ needs

⇒ Interest of building these new machines already during the lifetime of the LHC:

- ⇒ to get benefits for the LHC
- ⇒ to spread the construction effort of the HE-LHC over more years
- ⇒ to serve earlier other users and avoid a gap in data collection.

Lower energy accelerators (2/2)

(My) guess of the optimum set of low energy accelerators to:

- Optimize the complex (reasonable energy range in the different accelerators, minimum number of beam transfers, „safe“ technological choices)
- Have the potential to adapt to the requirements of a High Luminosity upgrade of the HE-LHC
- Serve the needs of the most demanding users known today (neutrino facility) simultaneously with HL-LHC and HE-LHC

⇓

Bmax~5 T
Bdotmax~2T/s

Bmax~4 T
Bdotmax~3T/s

Energy range	Machine	Other application
100 GeV – 1.2 TeV	HE-SPS	RIB acceleration?
~8 - 100 GeV	HE-PS	RIB acceleration ?
Up to ~8 GeV	SC linac	(+ 2 fixed energy rings) μ production for ν factory

Evaluation criteria

1. Beam dynamics / performance
   - Beam characteristics
   - Filling time/turn-around time
   - Performance margin
2. Risks
   - During construction (cost & performance)
   - During operation (MTTF & MTTR, personnel and environment)
3. Operational impact
   - During construction (compatibility with continuing physics)
   - During operation (flexibility/capability to adapt to changing needs, capability to simultaneously satisfy other users, exotic test beams...)
4. Cost (material and personnel)
   - During construction
   - During operation

4. Final words

Closing remarks

- A new >1 TeV synchrotron is necessary for the HE-LHC.
- For the lower energy accelerators, need to analyse (quantify) the advantages/drawbacks of keeping existing accelerators with respect to replacing them by a new optimized injector complex [level of acceptable risk of failure, manpower and material cost of maintenance/consolidation, reduction of environmental impact (electricity and water consumption)...].
- It would make sense to take into account additional needs. Which ones (High Luminosity HE-LHC, HE-LHeC, neutrino facility...)? When?
- Interest of making the new injectors available during the lifetime of HL-LHC.

THANK YOU FOR YOUR ATTENTION!