Summary
LHC-CC status & review

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1. ***KEK-B achievements & crabs, Y. Funakoshi/KEK***
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3. ***Perspective from experiments, J. Nash/Imperial College***
4. ***HL-LHC design study & crab cavities, L. Rossi/CERN***

Workshop charges

- Important messages from the unique KEKB experience
- From LHC performance in 2010, what can be said about the upgrade.
- Requirements from experiments
- The HL-LHC Design Study: CC from R&D to project

KEK-B achievements & crabs,

Y. Funakoshi/KEK

- **Proof of crabbing principle:** done successfully for global electron crabbing and one experiment.
- **Performance reached**: 20% luminosity increase instead of 100% predicted; *probably specific to KEKB conditions with much stronger b-b effect.*
- **Timeline:**

1994-2007	13 years	R&D, manufacturing & installation
2007-2009	2.5 years	Restore former luminosity performance
2009-2010	1 year	Performance increased by CC

- **Beam dynamics features**: skew sextupole correction added, peculiar interaction between beam loading and b-b interaction suppressed by shifting the CC phase by 10 deg., 4 mm transverse beam needed in CC.

KEK-B achievements & crabs,

Y. Funakoshi/KEK

- **Reliability of CC:** Crab cavities demonstrated to be fully operational for years.
- **CC impedance:** non issue.
- **Phase stability:** better than 0.01 deg >1 kHz
- **Beam centering in CC**: tolerance 1mm, non issue
- **Voltage:** Drop from 1.9 KV (test stand) down to 1.3 KV with beam
- **RF trips**: from **12/day** down to 0.5/day (LER **0.1/day**) over 2 years, due to HER cavity quenches and LER discharges in couplers.

LHC luminosity achievements & limitations, *O. Bruening/CERN*

In one year, the LHC luminosity performance has increased from 10^{-7} to 10^{-2} of nominal performance at a pace mostly dictated by Machine Protection.

The nominal bunch current is reached, the emittance is 30% lower, beta* 7*nominal and the beam-beam tune shift reached 2 * nominal, i.e. the performance of SppbarS and TEV. The machine aperture is better than estimated. The beam instrumentation and correction toolkit are advanced and fully operational. 70% availability

Teething problems: higher secondary electron yield than anticipated (scrubbing needed), hump, UFO's: issues of the day, hopefully not relevant to the HL-LHC upgrade.

LHC luminosity achievements & limitations, *O. Bruening/CERN*

If it would be perilous to extrapolate performance when running at a % nominal performance level.
However, all signals show that the LHC has solid foundations and safety margins to be taken advantage off, and certainly no signal that would raise interrogations on the HL-LHC goals.

Caution: a low emittance option (/3) is "very difficult" [for collimation] . RA, 17-9-2009 LHC-CC09, perhaps not for CC configuration.

Perspective from experiments,

J. Nash

A common scenario of performance and calendar of shutdowns is essential. The existing one is consistent with the detector upgrade strategy pursued so far.

Lower pile-up is important.

CC's, by not requiring accelerator components in the detector area, are instrumental in preserving the physics reach of the detectors.

HL-LHC design study & crab cavities, *L. Rossi*

The baseline of the now official HL-LHC project (including the HiLumiLHC FP7 Design Study) is to reach its luminosity performance goal and carry out luminosity leveling with a local 400 MHz compact crabbing scheme without doglegs.

Unless showstoppers would be identified before, a validation in the LHC is needed by 2016, i.e. **in 5 years**.

Main conclusions

The experience in KEKB, the needs of LHC experiments and the LHC potential as evaluated today fully justify the HL-LHC baseline option of using crab cavities as the most suitable and versatile upgrade option.

The HL-LHC CC project is faced to a very challenging timescale (5 years instead of 13 years preparation for KEKB), and need be vigorous.

The hardware is not the only challenge. The KEKB experience shows a range of features, related to the increased complexity of the beam dynamics with crab crossing. For LHC, the challenges will be very different, and the simulations even more difficult and less predictive. *Appropriate* experiments will certainly pay off.