

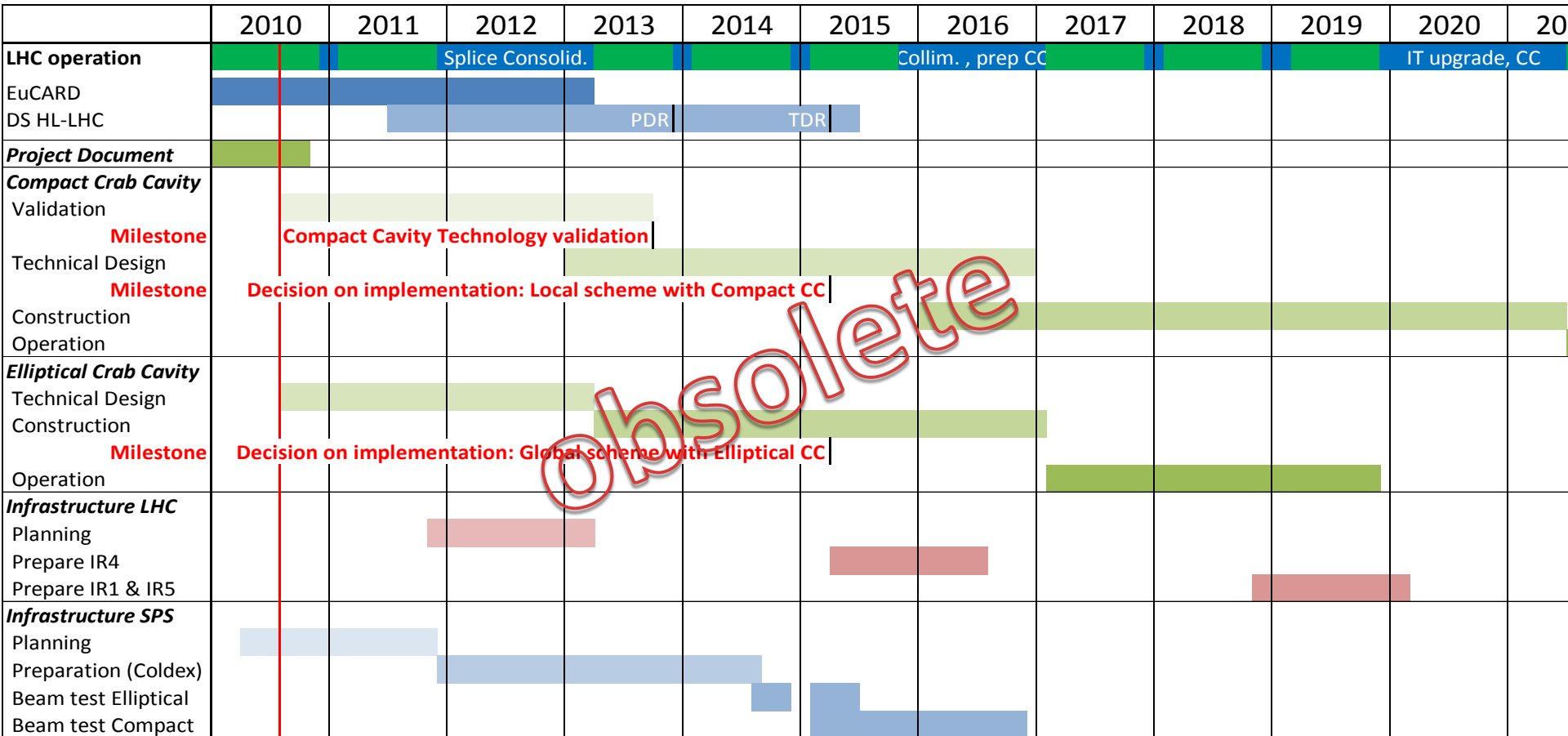


**High
Luminosity
LHC**

Overall Planning & HiLumi Meeting Highlights

E. Jensen/CERN

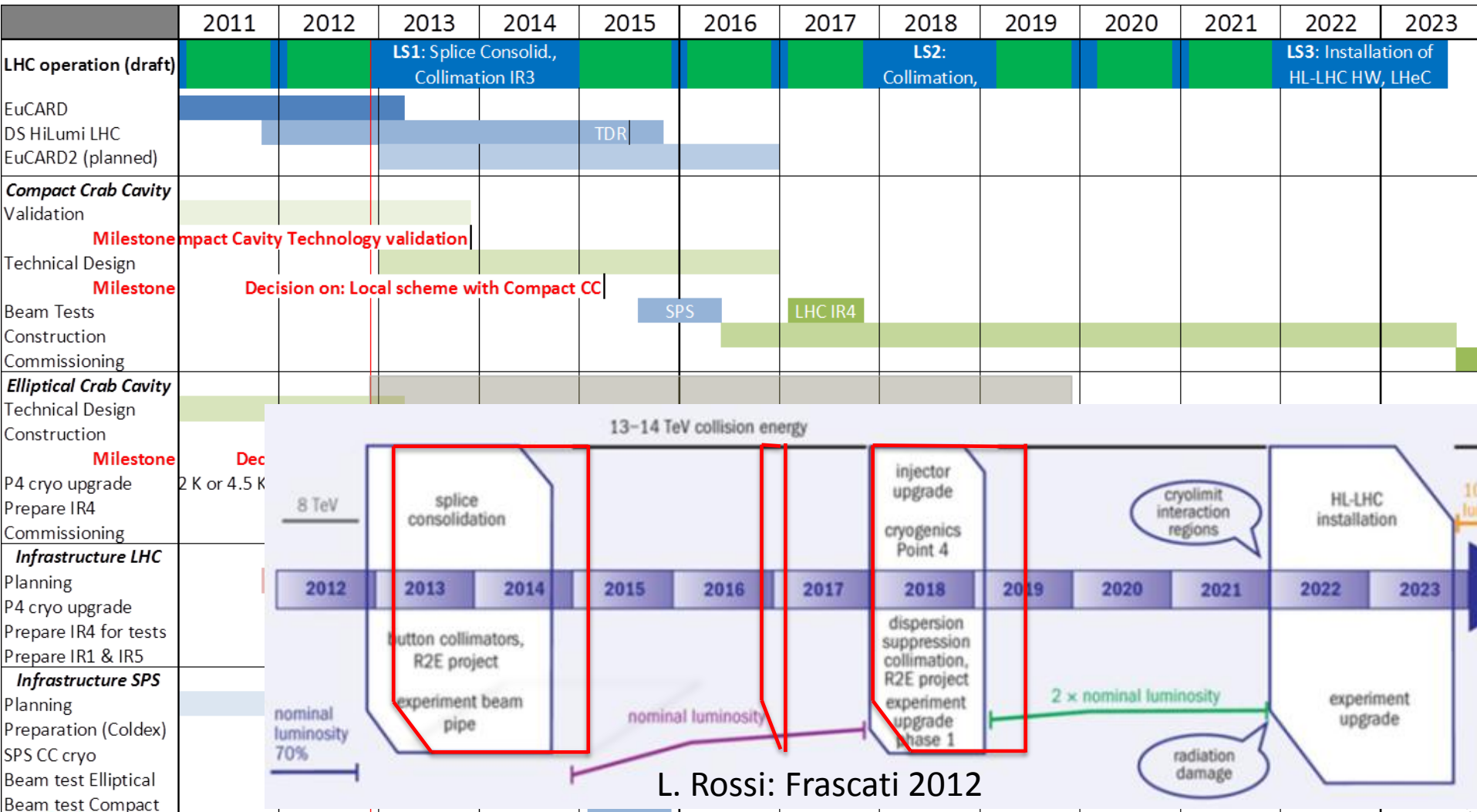
Reminder: What we planned in July 2010



obsolete



Present overall planning (Dec 2012)



L. Rossi: Frascati 2012



Overall planning – critical decisions (in reverse order)

- Crab Cavities to be installed in LHC during LS3 (2022/23)
- Major preparations IP1/IP5 during LS2 (2018)
- CC must be tested in SPS/BA4 before LS2 (2016/17?)
 - What exactly is the scope of SPS test?
 - We have to respect certain constraints of the SPS, but not be dominated by them!
- Does a test in LHC/P4 add something? What will we not know by then that would justify the P4 test?
- Preparation SPS during LS1 (2013/14)

Imminent decisions (focus on SPS test)

- Constraints of SPS test:
 - Cryo (LHe volume, heat load, ...)
 - Geometry (Y-chamber, table, avail. space, distance of 2nd beam pipe, ...)
 - Power coupler ($R_i = 13.5$, $R_a = 31$ mm), connection, RF system
 - Pressure test values – compatible with safety regulations.
 - Tuner range – fast tuner?
 - We'll have those constraints frozen in January 2013

News from Frascati:

-  High Luminosity LHC
Europe/Zurich timezone
-  **LARP** 14-16 November 2012 INFN Frascati
- **2nd Joint HiLumi LHC-LARP Annual Meeting**
- Search
- <https://indico.cern.ch/conferenceDisplay.py?confId=183635>
- The parallel sessions on Crab Cavities can be considered “CC-12” Workshop.

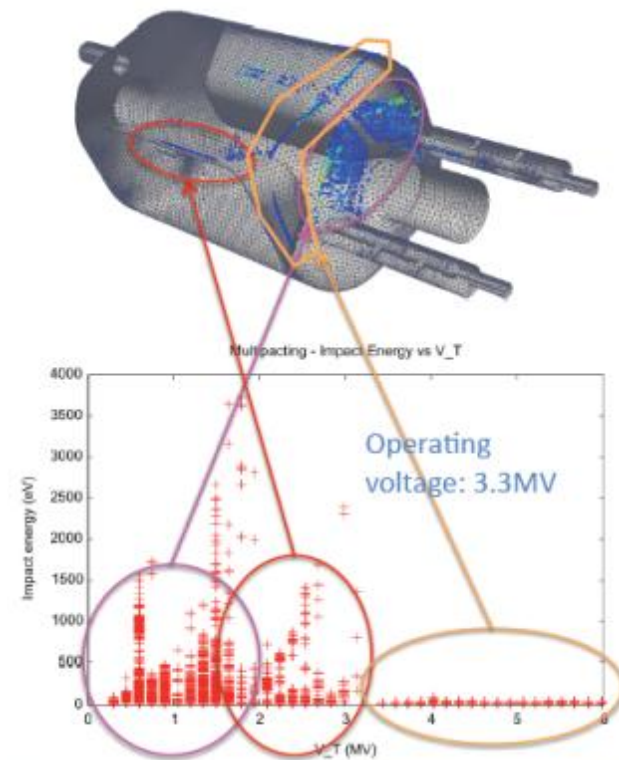
<https://indico.cern.ch/conferenceDisplay.py?confId=136807>

Reminder - Required kick voltage

- Design kick: 10 MV /side /IP /beam – this is reached with 3 cavities. Our reference numbers!
- Needed for full compensation: 11.8 MV ... 13.4 MV; this could be reduced to 8.2 MV with new Q7+ .
- Our reference remains 10 MV – the above is possible mitigation – but is this the overall optimum (cost!)?
- Let's see the prototype cavity performance and adapt design parameters then if needed. Keep engineering margin!
- Even with reduced voltage, we should stay with 3 cavities (to reduce impact of single cavity trip)

All 3 designs:

- Common numerical tools used for comparative studies: HOMs, MP (ACE3P, Z. Li), n -pole (HFSS, M. Navarro-Tapia)
- HOM damping: suppression below (demanding) CM18 numbers achieved – also thanks to newly designed coaxial high-pass filters and hook-shaped couplers.
- MP simulations indicate:
 - MP at low fields is “soft” – can be conditioned;
 - MP at high fields has low impact energy.



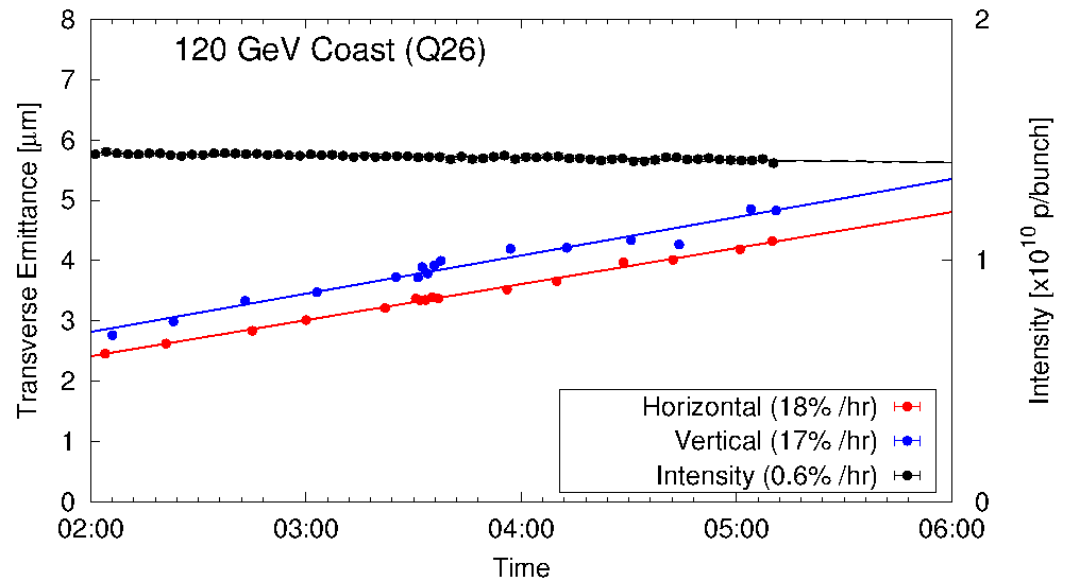
Z. Li

Getting ready for SPS tests

- SPS test is a must (LHC no best-bed!)
- Goal: Confirm that cavity can be made invisible; it would allow to try out operational scenarios.

SPS beam may be too noisy to test additional noise injected from CCs.

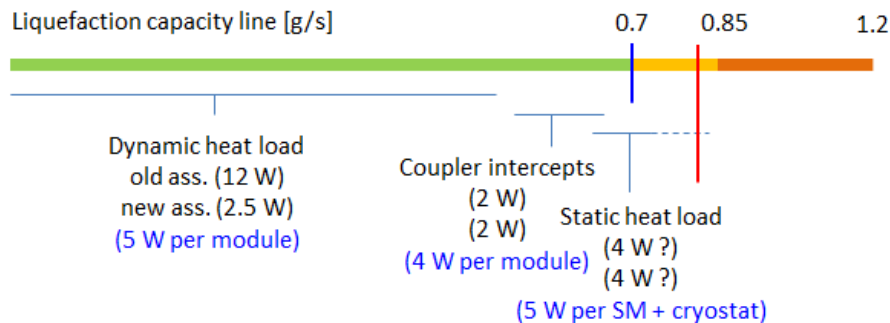
R. Calaga, A. Macpherson



- Schedule: Prepare during LS1 (RF power, cryo) – install cavities X-mas break 2015/16 – perform tests in 2016

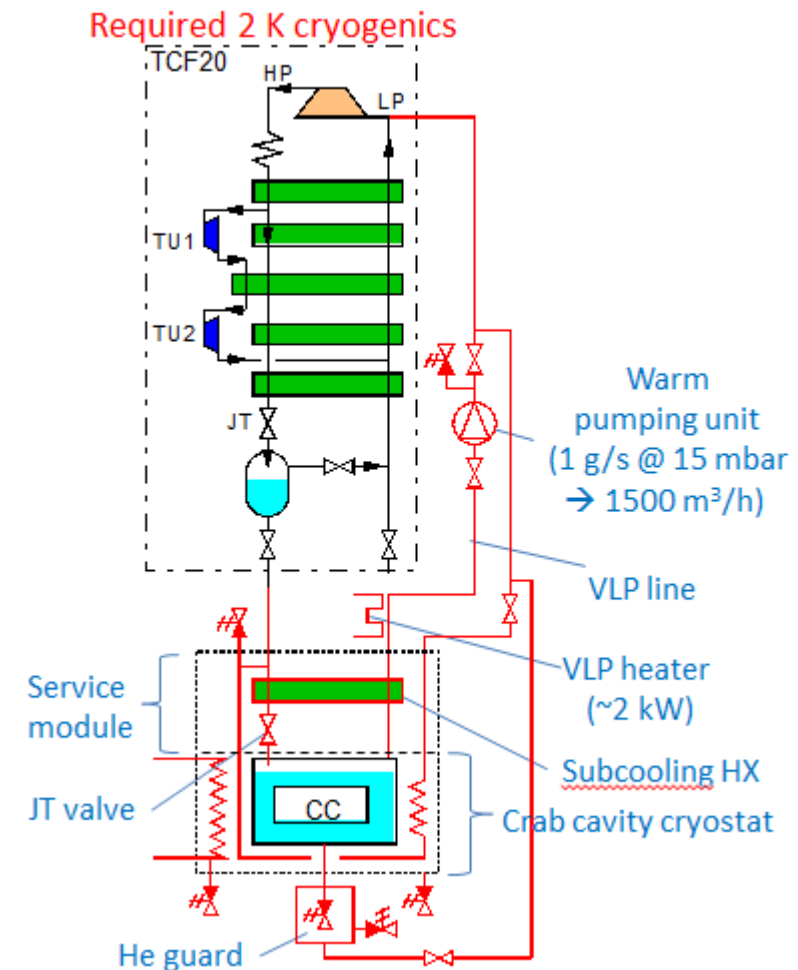
Cryo preparation for SPS tests

- Existing TCF20 should do, but liquefaction test must be done before 15-Jun-2013.
- Dynamic heat load assumed: 2.5 W/module.



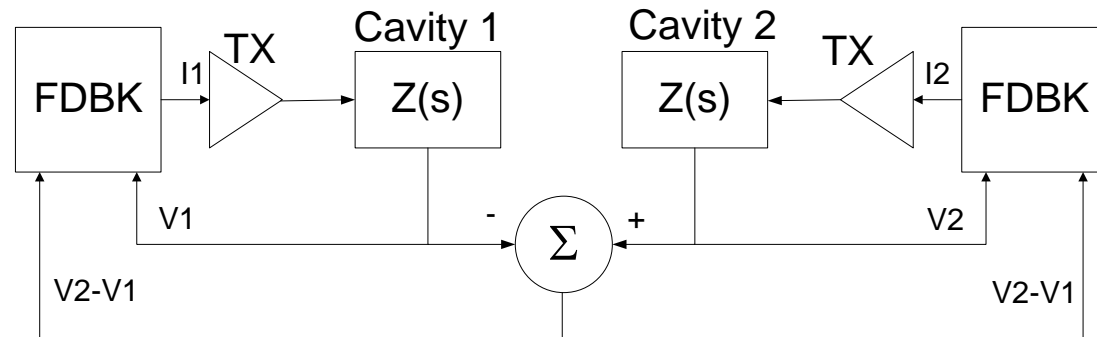
- Upgrade to 2 K during LS1.

K. Brodzinski



LLRF

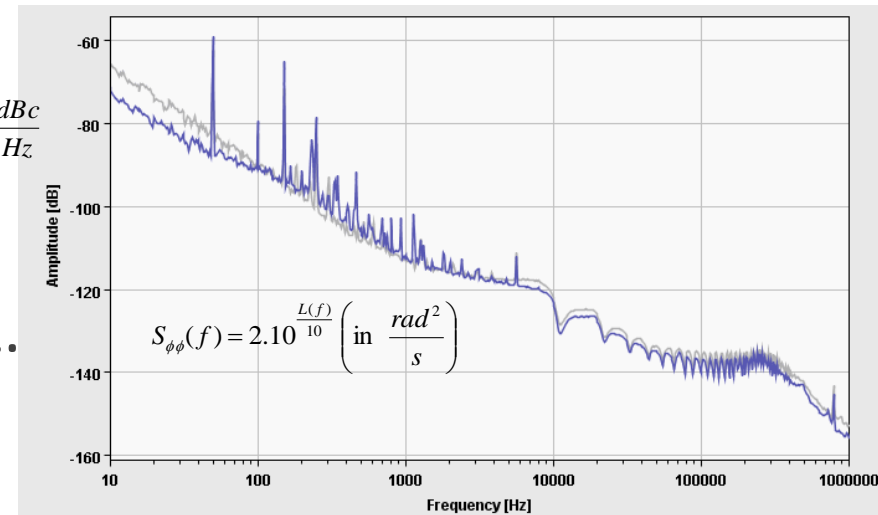
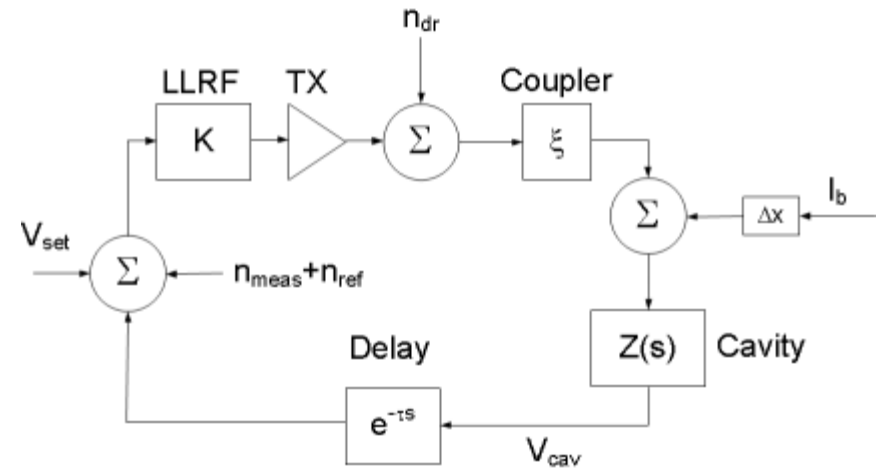
- Active feedback (as used in many modern RF systems) is key. It can reduce Z by loop gain. Limit: $R_{min} = \frac{R}{Q} \omega_0 \tau_g$.
For CCs approx. 50 dB.
- Large feedback gain increases BW. Trade off against noise!
- Coupled feedback interesting and challenging – required to minimize impact of single cavity failure.



P. Baudrenghien

RF Noise

- Different noise sources have different spectra;
- 1st betatron SB 3 kHz off – dominated by TX noise.
- Tetrode/IOT advantageous. $L(f)$ in $\frac{dBc}{Hz}$
- Scaling from ACS: expected 0.01 ° rms φ noise @ 400 MHz. This looks OK.



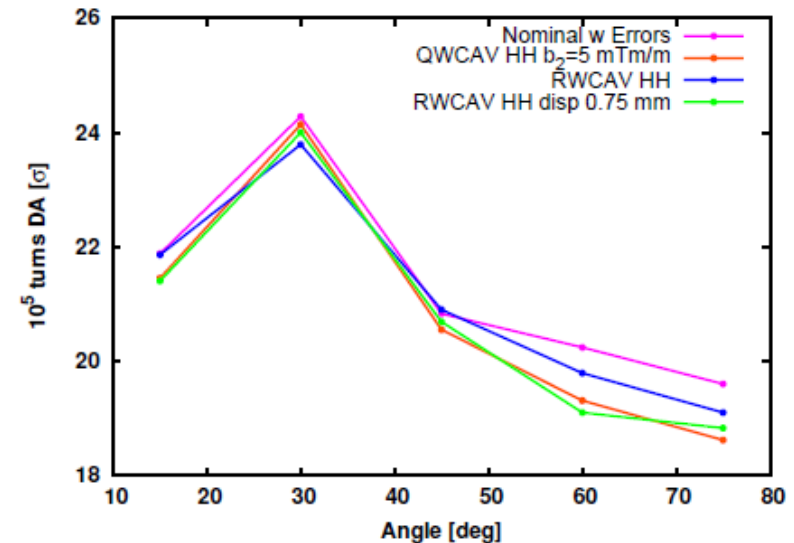
- Idea for noise measurement: excite on betatron SB.

Operational scenario revisited

- Strong RF feedback on at all times!
- To keep CCs invisible during fill & ramp, detune but keep small voltage (active tuning) – dephase 3 cavities 120° to cancel. RF feedback provides add'l stability.
- On flat top, reduce detuning keeping V set-point small – RF feedback compensates BL. Once detuning is zero, synchronously change voltage on all CCs to desired kick.
- Much of this can be tried out, commissioned and verified in SPS tests!

n -pole errors

- For the first time, SixTrack simulations could study the effect of n -pole errors on beam. Results can give also tolerable misalignments:
 - These studies were done with older versions of the cavities.
 - n -pole fields with latest versions of cavities indicate globally even smaller errors.
- QWCAV (only HV) $|d_{x,y}| < 2$ mm
 - RWCAV (HH or HV) $|d_{x,y}| < 0.75$ mm
 - 4RCAV (HH or HV) $|d_{x,y}| < 2.7$ mm



J. Barranco, M. Navarro-Tapia

Frascati Discussions/brain storming

- Lots of productive/critical discussion throughout – this was really a “work”-shop. (pretty much like this one!)
- What instrumentation do we need for CCs – head-tail monitors, streak camera to measure remaining non-closure? What instrumentation do we need to make the SPS test a success?
- We need fast BLMs for MP (diamond?)
- We still need better understanding of possible (ultra) fast failure modes – cavity tests and in particular SPS tests will help this understanding.

HL-LHC – HiLumi LHC

Definition:

HL-LHC: the overall project for Luminosity upgrade

HiLumi LHC: FP7 Design Study, co-financed by EU, Grant Agreement 284404



The screenshot shows a web browser window with the URL hilumihc.web.cern.ch. The page features the High Luminosity LHC logo and the title "HL-LHC: High Luminosity Large Hadron Collider". Below the title are three images: a cross-section of a superconducting magnet, a long section of the LHC tunnel, and a 3D simulation of the particle beams. A navigation menu includes links for HOME, ABOUT HL-LHC, ACTIVITIES, NEWS, EVENTS, and RESULTS. The main content area is titled "The next step for the Large Hadron Collider" and contains text about the LHC's history and the HL-LHC upgrade. A sidebar on the right includes an "INTRANET" section with links for "Member registration" and "LATEST NEWS", which lists several recent articles with dates and titles.

HL-LHC: High Luminosity Large Hadron Collider

[HOME](#) [ABOUT HL-LHC](#) [ACTIVITIES](#) [NEWS](#) [EVENTS](#) [RESULTS](#)

The next step for the Large Hadron Collider

The Large Hadron Collider (LHC) is the largest scientific instrument ever built. It has been exploring the new energy frontier since 2009, gathering a global user community of 7,000 scientists. It will remain the most powerful accelerator in the world for at least two decades, and its full exploitation is the highest priority in the European Strategy for Particle Physics, adopted by the CERN Council and integrated into the ESFRI Roadmap.

To extend its discovery potential, the LHC will need a major upgrade around 2020 to increase its luminosity (rate of collisions) by a factor of 10 beyond its design value. As a highly complex and optimized machine, such an upgrade of the LHC must be carefully studied and requires about 10 years to implement.

The novel machine configuration, called High Luminosity LHC (HL-LHC), will rely on a number of key innovative technologies, representing exceptional technological challenges, such as cutting-edge 13 Tesla superconducting magnets, very compact and ultra-precise superconducting cavities for beam rotation, and 300-metre-long high-power superconducting links with zero energy dissipation.

European support for a worldwide project

INTRANET

[Member registration](#)

LATEST NEWS

29 Aug: Article featured on PhysOrg: *Small but powerful* [Read more >>](#)

27 Aug: Project featured in CERN Bulletin: *Warmer amps for the LHC* [Read more >>](#)

11 Jul: Fermilab Today features the project in *A new generation of magnets for accelerators, MRI's* article. [Read more >>](#)

HiLumi Intranet: <https://espace.cern.ch/HiLumi/default.aspx>

The screenshot displays the HiLumi Intranet interface. At the top, there is a dark navigation bar with 'Site Actions', 'Browse', and 'Page' options, and a user profile for 'Erk Jensen'. Below this is the 'High Luminosity LHC' logo and the title 'High Luminosity LHC Project Intranet (incl. HiLumi LHC FP7 Design Study)'. A secondary navigation bar includes links for 'Home Public Site', 'Home Intranet', 'Indico Meetings', 'EDMS Portal', 'E-groups', and 'LIU Project', along with a search bar and a help icon. A left sidebar lists various sections: 'General Information', 'Management Bodies', 'HiLumi Members List', and 'HiLumi Calendar'. The main content area features a central diagram with a blue LHC logo at its core, from which lines radiate to 16 Work Packages (WP1-WP16) arranged in a circular pattern. Each WP is accompanied by a brief description.

WP1 Project Management and Technical Coordination

WP2 Accelerator Physics and Performance

WP3 Magnets for Insertion Regions

WP4 Crab Cavities

WP5 Collimation

WP6 Cold Powering

WP7 Machine Protection

WP8 Collider-Experiment Interface

WP9 Cryogenics

WP10 Energy Deposition & Absorber

WP11 11-T Dipole Two-in-One for DS

WP12 Vacuum

WP13 Beam Diagnostics

WP14 Integration & (De-)installation

WP16 High-Energy LHC – Studies

HiLumi Description (excerpt)

HiLumi LHC started 1-Dec-2011 to run 48 months (until Nov. 2015)

Beneficiaries: CERN, CEA, CNRS, STFC, ULANC;

Associated partners: KEK, BNL, FNAL, LBNL, ODU, SLAC (US-LARP).

Tasks (see right) now revised to adapt to planning and needs (Task 4.4 to disappear).

Please register to allow use of Sharepoint site! This will allow coordination and communication!

I uploaded the “Intermediate Activity Report” there.

Task 4.1. Coordination and Communication.

- Coordination and scheduling of the WP tasks
- Monitoring the work, informing the project management and participants within the JRA
- Follow up the WP budget and use of resources

Task 4.2. Support studies

- Tunnel preparation SPS and LHC
- Local IR layout and spatial integration
- Effect of phase noise, LLRF system conceptual design
- RF power system specification
- Operational aspects (how to commission/make invisible)
- Interlocks and fast Feedback

Task 4.3. Compact Crab Cavity Design

- Complete cavity and cryomodule specifications
- Design optimisation for novel schemes
- Conceptual design of SOM, HOM and LOM couplers
- Conceptual design of helium tank and cryostat
- Multipacting simulations on cavity & couplers
- FEM simulations: mechanical & thermal aspects
- Initial down-selection of the CC options
- Completion of a full technical design on the initial down-selected options, with mechanical drawings and specification.
- Design of tooling, dies and cavity fabrication equipment

Task 4.4. Elliptical Crab Cavity Technical Design

- Coupler development and testing
- Tuner design and mock up on copper models
- Study of mechanical effects: resonances, microphonics.
- Cavity performance with couplers and horizontal cryostat
- Performance difference between 2 K & 4 K
- Cryostat and He Tank Design
- Complete the full technical design

Task 4.5. Compact Crab Cavity Validation Prototyping

- Procurement / fabrication of tooling, dies and equipment
- Construction of models (in copper initially) to refine manufacturing techniques and tooling.
- Fabrication of prototype niobium cavity
- Cleaning and electro-polishing on the bare niobium cavity. (i.e. no couplers, antennas or other accessories), including cavity surface inspection
- Development and procurement of all test equipment and instrumentation
- Low power tests and measurements on the bare cavity in a test cryostat to test for compliance with design gradient and other cavity performance specs.
- Make the final CC design down-selection

Thank you very much!

