HL-LHC MD topics for the LHC I

★ $\beta^*$ leveling
★ Levelling by separation
★ ATS optics, round and flat $\beta^*$
★ Validation of DA models
★ IR non-linearities
★ e-cloud with 25ns and alternative schemes
★ Impact of noise on emittances, tails & lumi
★ Crystal collimation with protons & ions
★ Beam-beam head-on
★ Beam-beam long range: round and flat optics
★ Beam-beam long range compensation
HL-LHC MD topics for the LHC II

- Quench limits for protons and ions
- Mitigation of BFPP losses by bumps
- Halo control techniques
- RF Full detuning with currents above 0.5 A
- Longitudinal stability limits
- Longitudinal bunch flattening
- Transverse stability limits

Missing: Emittance blow-up at injection; Leveling with crossing angle; ?
MD333 20h CERN-ACC-NOTE-2016-0035
Crystal Collimation with protons at injection energy

MD304 12h CERN-ACC-NOTE-2016-0031
LHC Heavy-Ion Collimation Quench Test at 6.37Z TeV

MD453 5h CERN-ACC-NOTE-2016-0029
Effect of low frequency noise on emittance...

MD402 7h CERN-ACC-NOTE-2016-0023
Head-on limits. Separation leveling

MD754 8h CERN-ACC-NOTE-2016-0022
Instability Threshold for Train with 25ns Spacing

MD400 5h CERN-ACC-NOTE-2016-0020
Emittance growth with noise during collision

MD385 5h CERN-ACC-NOTE-2016-0019
Long range beam-beam interaction

MD382 10h CERN-ACC-NOTE-2016-0016 & 2016-0012
Beam Transfer Function and diffusion mechanisms
MD340 2h  CERN-ACC-NOTE-2016-0015
Collimation quench test with 6.5 TeV proton beams

MD284 8h  CERN-ACC-NOTE-2016-0010
Diffusion and Halo Population Measurements with coll.

MD312 16h  CERN-ACC-NOTE-2016-0009
Active halo control with the ADT

MD755 8h  CERN-ACC-NOTE-2016-0005
Instability threshold with smaller retraction in IR7

MD751 8h  CERN-ACC-NOTE-2016-0004
Train Instability Threshold

MD349 4h  CERN-ACC-NOTE-2016-0003
Impedance Localization with AC-dipole

MD346 5h  CERN-ACC-NOTE-2016-0002
Summary of single bunch instability threshold measurements

MD472 7h  CERN-ACC-NOTE-2016-0001
LHC Longitudinal Single-Bunch Stability Threshold
MD239 19h CERN-ACC-NOTE-2015-0043 & 2016-0018
Collide and Squeeze MD
MD380 11h CERN-ACC-NOTE-2016-0014
Nonlinear errors in the IRs

https://rtomas.web.cern.ch/rtomas/HLLHC_MD-Notes_Run2.html
20 MDs in 195h of beam time for HL-LHC over
55 MDs in 383h total in 2015
2016 commissioning and EoF

1st IR non-linear correction.
Overcompensation in IR5

1st IR non-linear trim with nominal bunch
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**MD1 schedule: the result**

- **00:00 - 02:00**
  - MD232 (ded): Longitudinal
- **02:00 - 17:00**
  - RF Cryo lost and RQDA45 earth fault
- **17:00 - 03:00**
  - MD1257 (ded): ATS
  - MD1257 (ded): DOROS BPMs for improved coupling
- **04:00 - 08:00**
  - MD1414 (ded): DOROS Longitudinal
  - MD1447 (ded): Beta* reach: IR7 Collimation Hierarchy Limit and Impedance
  - MD1442 (ded): Injection and emittance preservation of high intensity
- **08:00 - 13:00**
  - MD1268 (ded): MKI Pulse Length and ripple definition
  - MD1242 (ded): Active Halo Control
  - MD1444 (ded): Crystal collimation
- **13:00 - 21:00**
  - MD1429 (ded): Beta* Reach Long range limits Round optics
  - MD1429 (ded): Beta* Reach Long range limits Round optics
  - MD1414 (ded): Instability Studies with a Single Beam
- **21:00 - 07:00**
  - Cleanup
  - MD1447 (ded): Beta* Reach Long range limits Round optics
  - MD1429 (ded): Beta* Reach Long range limits Round optics

**HL-LHC ≈ 80% thunderstorm**
Observed non-reproducible H blow-up at MKI pulse. Vertical emittance blow-up much larger than model.
Fixing D4L7 tilt to restore hierarchy, TCSGs at 6.5$\sigma$

First demonstration of $1\sigma$ retraction
Many loss maps with crystals (to be analyzed)
Reducing crossing angle from $12\sigma$ to $6.3\sigma$

Let’s increase luminosity!
(to be analyzed)
ATS optics ready for nominal beam

(AC dipole B1H broken)
Transverse instability MD

964 happy non-colliding bunches per beam with zero octupole current.
### MD2 Tentative Schedule

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- **07:00 - 17:00**
  - MD1669 (ded): Luminosity anti-leveling with crossing angle
- **09:00 - 11:00**
  - MD1271 (ded): Low frequency noise
  - MD1279 (ded): Bunch flattening by sinusoidal RF phase modulation
- **11:00 - 17:00**
  - MD1279 (ded): Active halo control with tune ripple
  - MD1407 (ded): Landau DAMping: Beam Transfer Functions and diffusion mechanisms
- **17:00 - 19:00**
  - MD1412 (ded): Non-linear coupling measurements at Injection
  - MD1415 (ded): Emittance growth limits from resonant excitation for HL-LHC
- **23:00**
  - MD1434 (ded): Head-on beam-beam limit separation levelling and pile-up

- **03:00 - 05:00**
  - MD1690 (ded): Control of losses during Off-momentum loss maps
  - MD1690 (ded): Control of losses during Off-momentum loss maps
  - MD1691 (ded): Bunch flattening by sinusoidal RF phase modulation

- **07:00 - 09:00**
  - MD1399 (ded): Dynamic aperture dependence on linear coupling
  - MD1690 (ded): Control of losses during Off-momentum loss maps

- **19:00 - 01:00**
  - MD1412 (ded): Non-linear coupling measurements at Injection

- **01:00 - 03:00**
  - MD468 (ded): Electron cloud for different beam parameters

**Mostly HL-LHC MDs**
## MD3 tentative schedule

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**02:00 - 10:00**
- MD249 (ded): ACS Cavity Voltage phase modulation

**10:00 - 12:00**
- ramp down

**12:00 - 20:00**
- MD1209 (ded): Orbit FB with MCBX correctors

**20:00 - 22:00**
- ramp down

**22:00 - 06:00**
- MD1446 (ded): Impedance contribution of primary collimators
- MD1182 (ded): Calibration of diamond particle detectors in IP6

**06:00 - ramp down**
- MD1182 (ded): Calibration of diamond particle detectors in IP6

**06:00 - 08:00**
- ramp down

**08:00 - 20:00**
- MD1257 (ded): ATS
- ramp down

**20:00 - 22:00**
- ramp down

**22:00 - 06:00**
- MD1446 (ded): Impedance contribution of primary collimators
- MD1182 (ded): Calibration of diamond particle detectors in IP6

Mostly HL-LHC MDs
# 2016 schedule

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- **July**
  - Technical stop (EYETS)
  - Scrubbing (indicative - dates to be established)

- **October**
  - Technical stop

- **November**
  - Machine checkout
  - Recommissioning with beam

- **December**
  - Special physics runs (indicative - schedule to be established)
  - Technical stop (EYETS)
  - Scrubbing (indicative - dates to be established)
Leveling with separation

Beam-beam head-on & long-range compensation:
- Linear part: MD979 $\rightarrow$ 2016
- Wire $\rightarrow$ 2017?
- Octupoles or IT corr: MD393 & MD449 $\rightarrow$ 2016?

Flat optics $\rightarrow$ 2017