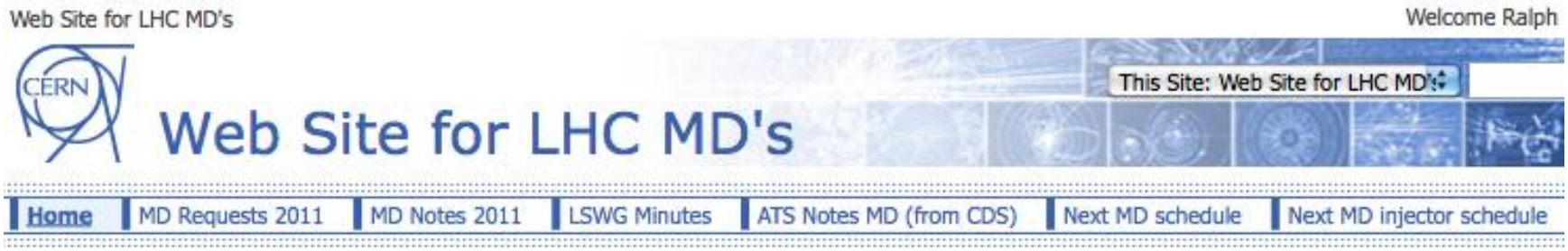
MD Plans in 2012

The LHC MD coordination team
R. Aßmann, Frank Zimmermann, Giulia Papotti

LHC Performance Workshop, Chamonix, 7.2.2012

http://www.cern.ch/lhc-md



LHC-MD web site holds detailed info, ATS MD notes by the teams, MD requests, LSWG minutes and presentations, ...

Here I will be generic, focusing on issues relevant for this meeting!

Achievements → 2011 MD Notes

BI MD studies on August 25th 2011, D. Belohrad et al, CERN-ATS-Note-2011-130 MD
End-of-fill study on collimator tight settings , R. Assmann et al, CERN-ATS-Note-2011-125 MD
Optics measurement and correction close to the half integer resonance, R. Calaga et al,CERN-ATS-Note-2011-124 MD. -2011.
Results of long range beam-beam studies and observations during operation in the LHC, Alemany et al, CERN-ATS-Note-2011- 120 MD
IR1 and IR5 aperture at 3.5 TeV, C. Alabau Pons,,CERN-ATS-Note-2011-110 MD
Beam parameters observations during a high pile-up collisions fill, G. Trad et al, CERN-ATS-Note-2011-105 MD
Longitudinal Oscillations with Batch Injection in the LHC, T. Argyropoulos et al, CERN-ATS-Note-2011-031 MD
Dependence of single beam lifetime on bunch length, P. Baudrenghien et al, CERN-ATS-Note-2011-083 MD
Tight collimator settings with beta* = 1.0 m, R. Assmann et al, CERN-ATS-Note-2011-079 MD.
R2E-related MD: slow controlled losses for RadMon/BLM cross-checks , M. Calviani et al, CERN-ATS-Note-2011-070 MD
BI MD Studies on June 29th 2011, D,Belohrad et al.CERN-ATS-Note-2011-069 MD
Quench Margin at Injection, W. Bartmann et al, CERN-ATS-Note-2011-067 MD
MKI UFOs at Injection, T. Baer et al, CERN-ATS-Note-2011-065 MD
MD on Injection Quality – Longitudinal and Transverse Parameters , L. Drosdal et al, CERN-ATS-Note-2011-063 MD
Improving LHC Collimator Setup Efficiency at 3.5 TeV, Assmann et al, CERN-ATS-Note-2011-062 MD
IR3 combined cleaning test at 3.5 TeV, R. Assmann et al, CERN-ATS-Note-2011-061 MD.
LHC Transvers Profile Monitors studies (MD on May 6th, 2011), E. Bravin et al, CERN-ATS-Note-2011-049 MD
Transverse coupled-bunch instability rise times in the LHC at injection and top energy, N. Mounet et al, CERN-ATS-Note-2011- 035 MD
Head-on beam-beam tune shifts with high brightness beams in the LHC, R. Alemany et al, CERN-ATS-Note-2011-029 MD
Test of luminosity levelling with separated collisions , R. Alemany et al, CERN-ATS-Note-2011-028 MD
50 and 75 ns operation in the LHC: Vacuum and Cryogenics observations, G. Arduini et al, CERN-ATS-Note-2011-046 MD
BPM Offset Determination by Sinusoidal Quadrupole K-modulation, T. Baer et al, CERN-ATS-Note-2011-043 MD
The Achromatic Telescopic Squeezing (ATS) MD part I, S. Fartoukh et al, CERN-ATS-Note-2011-033 MD
Summary of MD on nominal collimator settings, R. Assmann et al, CERN-ATS-Note-2011-036 MD
Un-squeeze to 90 m, H. Burkhardt et al, CERN-ATS-Note-2011-032 MD
Collimator losses in the DS of IR7 and quench test at 3.5 TeV, R. Assmann et al,CERN-ATS-Note-2011-042 MD
Studies of longitudinal single bunch stability, T. Argyropoulos et al, CERN-ATS-Note-2011-041 MD
TI8 shielding studies and angular alignment of TDI and TCDQ, W. Bartmann et al, CERN-ATS-Note-2011-040 MD

Achievements → 2011 MD Notes

BI MD studies on August 25th 2011, D. Belohrad et al, CERN-ATS-Note-2011-130 MD
End-of-fill study on collimator tight settings , R. Assmann et al, CERN-ATS-Note-2011-125 MD
Optics measurement and correction close to the half integer resonance, R. Calaga et al,CERN-ATS-Note-2011-124 MD. -2011.
Results of long range beam-beam studies and observations during operation in the LHC, Alemany et al, CERN-ATS-Note-2011- 120 MD
IR1 and IR5 aperture at 3.5 TeV, C. Alabau Pons,,CERN-ATS-Note-2011-110 MD
Beam parameters observations during a high pile-up collisions fill, G. Trad et al, CERN-ATS-No
Longitudinal Oscillations with Batch Injection in the LHC, T. Argyropoulos et al, CE
Dependence of single beam lifetime on bunch length, P. Baudr
Tight collimator settings with beta* = 1.0 m, R. A
R2E-related MD: slow controlled
BI MD Studies
Quench
MKI UF
MD on
Improvi
IR3 com
LHC Trai
Transvers
2011- 035 MD

Acknowledgements to the many, many colleagues who proposed the MD's, performed them and analyzed results!

MD
ERN-ATS-Note-2011-063 MD
CERN-ATS-Note-2011-062 MD
al, CERN-ATS-Note-2011-061 MD.
(MD on May 6th, 2011), E. Bravin et al, CERN-ATS-Note-2011-049 MD
unch instability rise times in the LHC at injection and top energy, N. Mounet et al, CERN-ATS-Note-

Head-on beam-beam tune shifts with high brightness beams in the LHC, R. Alemany et al, CERN-ATS-Note-2011-029 MD
Test of luminosity levelling with separated collisions , R. Alemany et al, CERN-ATS-Note-2011-028 MD
50 and 75 ns operation in the LHC: Vacuum and Cryogenics observations, G. Arduini et al, CERN-ATS-Note-2011-046 MD
BPM Offset Determination by Sinusoidal Quadrupole K-modulation, T. Baer et al, CERN-ATS-Note-2011-043 MD
The Achromatic Telescopic Squeezing (ATS) MD part I, S. Fartoukh et al, CERN-ATS-Note-2011-033 MD
Summary of MD on nominal collimator settings, R. Assmann et al, CERN-ATS-Note-2011-036 MD
Un-squeeze to 90 m, H. Burkhardt et al, CERN-ATS-Note-2011-032 MD
Collimator losses in the DS of IR7 and quench test at 3.5 TeV, R. Assmann et al,CERN-ATS-Note-2011-042 MD
Studies of longitudinal single bunch stability, T. Argyropoulos et al, CERN-ATS-Note-2011-041 MD
TI8 shielding studies and angular alignment of TDI and TCDQ, W. Bartmann et al, CERN-ATS-Note-2011-040 MD

2011 MD Lessons

- Presented in various talks, so I do not repeat it here
  - see Monday + Tuesday sessions
  - A lot of “surprising” and “not surprising” good news identified.
- Example of lessons taken already during 2011 run:
  - Increase of bunch currents and decrease of emittance after review of MD results in “mini-Chamonix” meeting July 2011.
  - Decrease of beta* from 1.5m to 1.0m in early September 2011.
  - No full re-setup of collimation / MP during year, except IR changes.
  - Feed forward of MD results into operational settings (BI, RF, …).
  - Delay of LS1 collimation upgrade for the IR3 dispersion suppressors.
- Full safety guaranteed with up to 110 MJ beams – not a single close call or accident (not even accidental quench):
  - During MD execution.
  - For machine changes fed forward into operation.

p-p Peak Luminosity in 2011

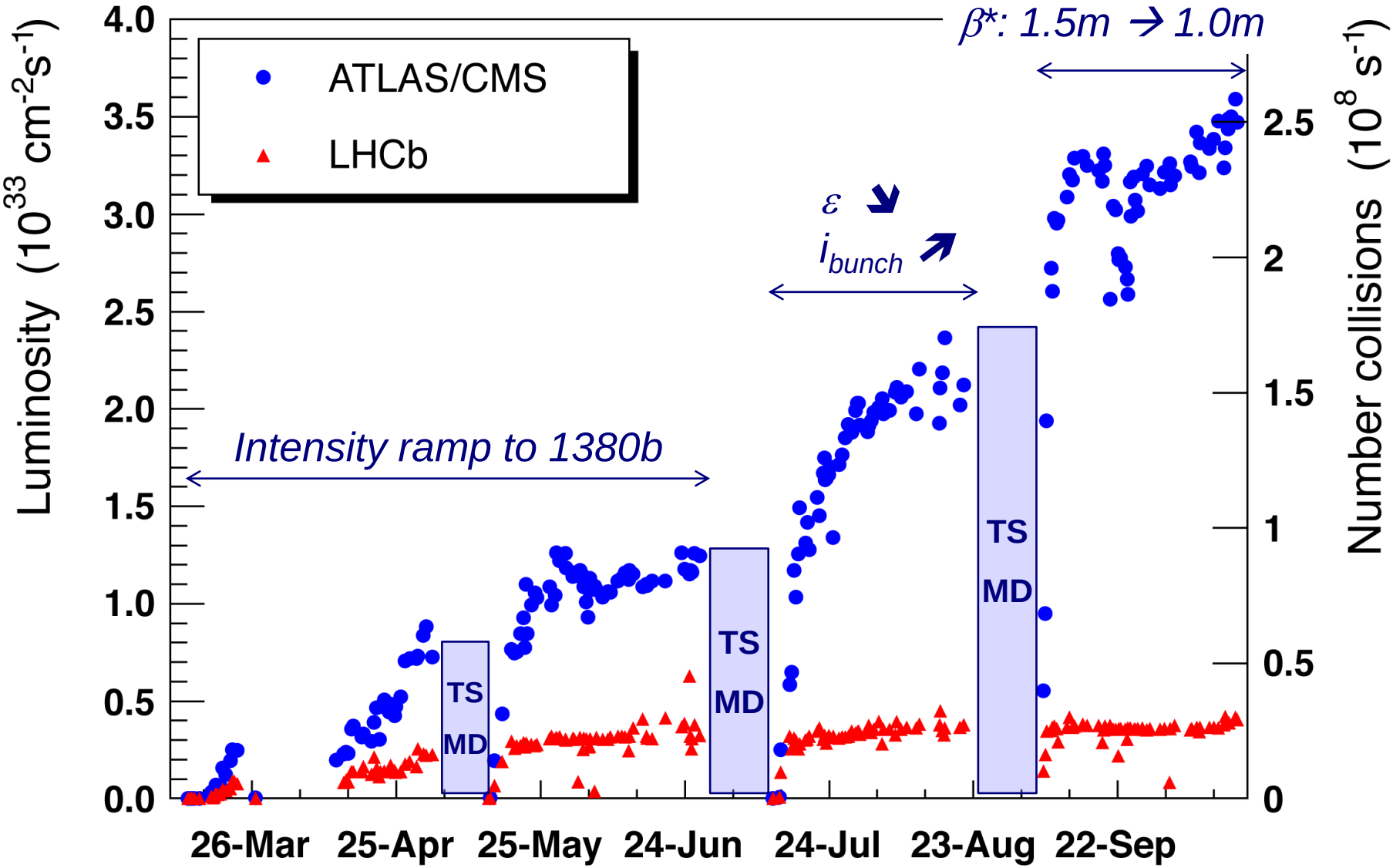


Figure Jörg Wenninger

p-p Peak Luminosity in 2011

There would have been much less integrated luminosity without machine improvements after we reached 1380b (end of June)

22 days of beam time for machine studies were well invested.

Thanks for support from all involved, including the LHC experiments.

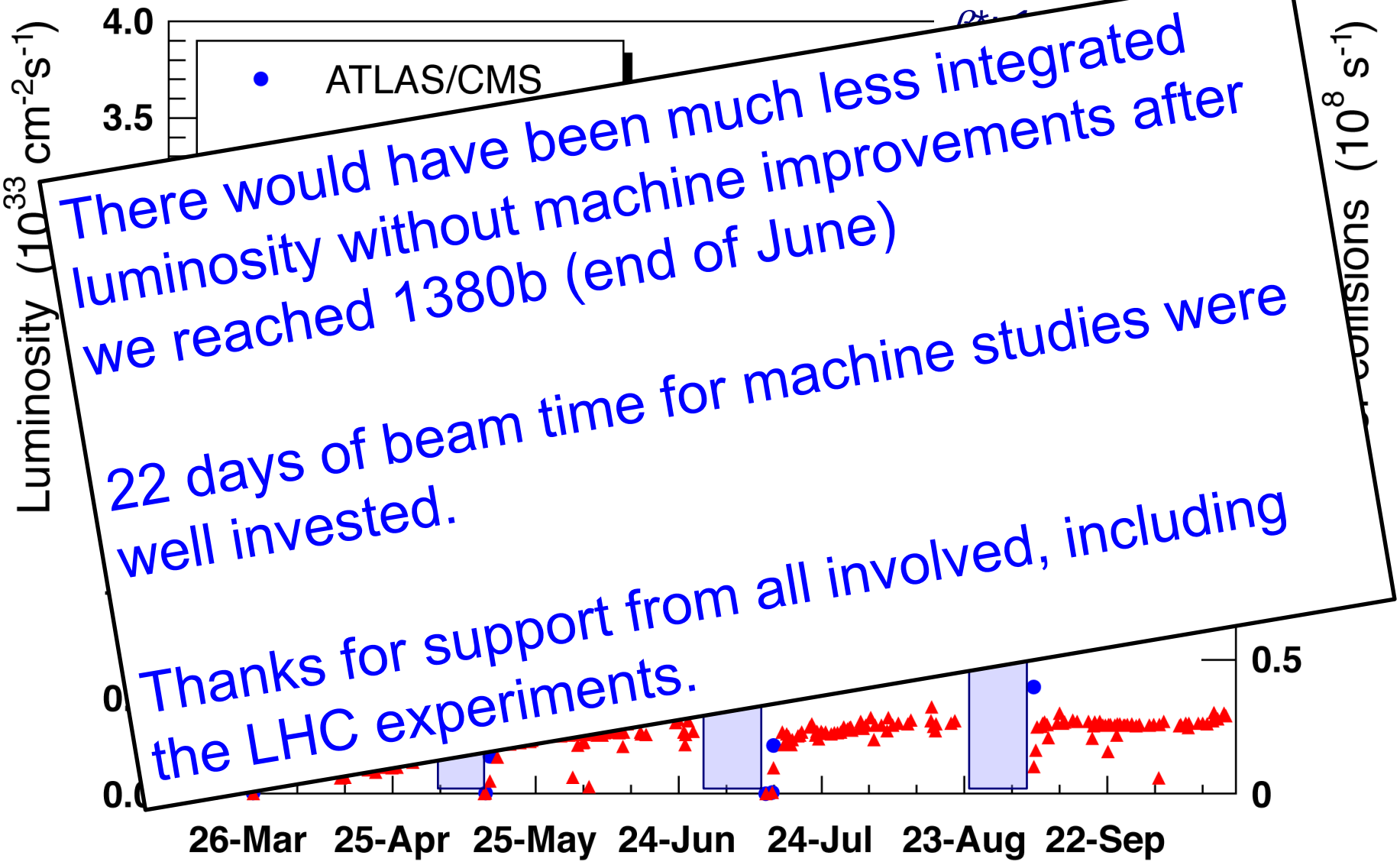
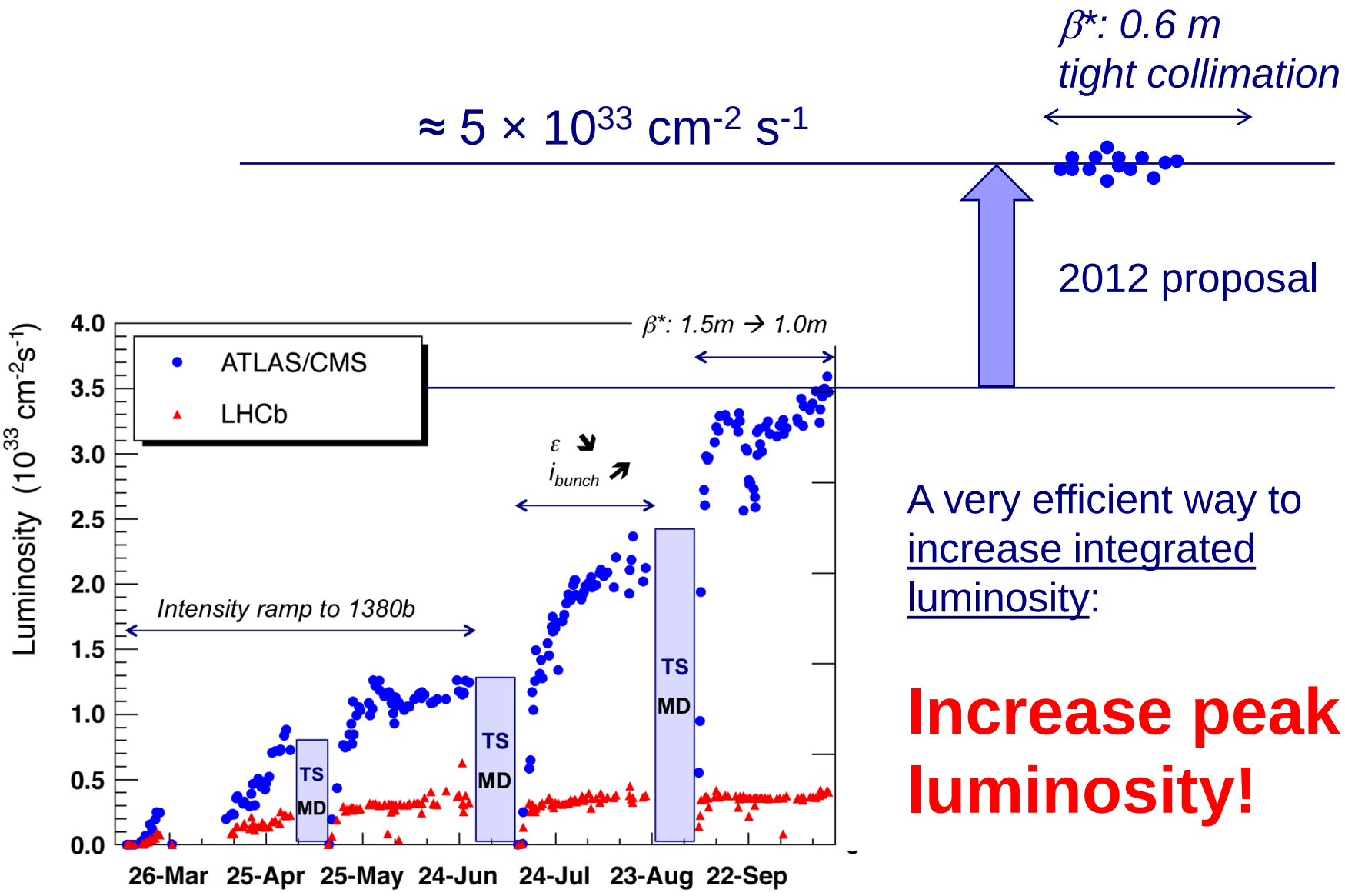


Figure Jörg Wenninger

…2012 even better (based on 2011 MD results)



A very efficient way to increase integrated luminosity:

Increase peak luminosity!

LHC Schedule 2012

MD Time Scheduled in 2012

- 22 days allocated to machine development in 2012.
- 4 long MD blocks to technical stops (executed just before):
  - 1 block of 3 days ➔ 9 shifts of 8h
  - 3 blocks of 5 days ➔ 45 shifts of 8h
- 2 blocks of floating MD's, not coupled to technical stops:
  - 2 blocks of 2 days ➔ 12 shifts of 8h

- Total available: **66 shifts** **~50-60 MD's**
  420 h (with 80% efficiency)

- Will continue the way we organized last year.
  - Make sure that this time is used efficiently and according to the priorities approved by the LHC Machine Committee (LMC).

2012 MD requests

	title	time [h]	energy	spacing [ns]	current	requestor	theme	MP class	
1	MKI UFO	8	450	25	high	Tobias Baer	after LS1	C	
2	ATS optics	16	4000	NA	low	Stephane Fartoukh	HL-LHC	A	
3	bb limit HO with unequal beams	16	450/4000	NA	medium	Herr / Papotti	HL-LHC	B	
4	bb limit, LR separation	24	4000	25+50	medium+	Herr / Papotti	HL-LHC	C	
5	bb limit, LR intensity	8	4000	50	medium+	Herr / Papotti	after LS1	C	
6	large Piwinski angle	16	450	NA	medium	Fartoukh / Zimmermann	HL-LHC	A	
7	BI MDs	91	450 & 4000	NA	medium	BI team	2012	B (and A)	
8	CaC	8	450	NA	medium	Assmann / Fartoukh	HL-LHC	A	
9	Transverse noide & coh. bb	16	4000	50	medium+	Herr / Papotti	2012	C	
10	bb emittance growth due to transv. noise	16	4000	NA	medium	Buffat et al	HL-LHC	B	
11	Source of transverse emittance blow up	16	450/4000	50	high	Arduini	2012	C	
12	LR beam-beam with flat beams	24	4000	50	medium+	Herr / Papotti	HL-LHC	C	
13	Tune close to 1/2 integer	16	4000	50	medium+	Calaga et al	HL-LHC	C	
14	High pile up	8	4000	NA	medium	Fartoukh	HL-LHC	B	
15	HV passive compensation	16	4000	25+50	medium+	Calaga et al	HL-LHC	C	
16	compensation of IR nonlinearities	12	4000	NA	low	Tomas	2012	A	
17	Quench margin at top energy	16	4000	50	medium+	Redaelli / Wollmann	after LS1	C	
18	Halo scraping	0.5	450/4000	50	high	Wollmann / Burkart	after LS1	C	EOF
19	Transverse emittance blow up at injection	10	450	50	medium+	Metral / Mounet	2012	C	
20	TCBI at flat top and octupole stabilization	20	4000	25+50	medium+	Mounet / Metral	after LS1	B/C?	
21	Impedance budget at injection	6	450	NA	low	Biancacci	2012?	A	
22	Multibunch tune shift at flat top	8	4000	25+50	medium+	Mounet / Metral	2012?	B	
23	Multibunch tune shift at injection	8	450	25+50	medium+	Mounet / Metral	2012?	B	
24	TCBI at flat top and octupole stabilization	1	4000	50	high	Mounet / Metral	after LS1	D	EOF
25	Beam losses at injection	16	450	25	medium+	Bartmann / Bracco	after LS1	B	
26	Probing the single bunch limits in LHC	6	450	NA	medium	Salvant	HL-LHC	B	
27	Quench limit investigation	16	450	NA	low	Bracco et al	2012	C	
28	Asynchronous dump in collimation set up	8	450	NA	low	Rossi / Lari / Cauchi	after LS1	C	
29	Scraping scans for beam shape	8	450/4000	NA	medium	Wollmann / Burkart	after LS1	B	
30	Protection from long devices	16	450/4000	NA	low	Bartmann / Bracco	2012	A	
31	LHC transverse impedance	10	450/4000	NA	medium	Redaelli / Salvant	2012	B	
32	Injection matching and emittance preservation	16	450	NA	low	Kain	2012	B	
33	Impedance and beam heating of long protetion devices	16	450	50	medium+	Goddard	2012	B	
34	LHC transfer line stability	16	450	50	medium+	Kain	2012	B	
35	Wire scanner quench test at flat top	8	4000	50	medium+	Sapinski	2012	C	
36	Optimization of ADT in the ramp	12	450/4000	50	high	Hofle	2012	B	
37	Noise properties of ADT with FB on and off	6	450	25+50	medium+	Hofle	after LS1	A	
38	Residual tune signal in damper signal	6	450	25+50	medium+	Hofle	after LS1	A	
39	ADT Q/Q' diagnostics possibility	6	450/4000	50	high	Hofle	2012	B	
40	Collimation studies with different settings	24	4000	50	medium+	Assmann	after LS1	B	
41	Quench test at injection energy	8	450	NA	medium	Priebe	2012	A?	
42	Loss maps with transverse damper	8	450/4000	50	medium+	Salvachua	2012	B or C	
43	Collimation with beta*=40 cm	8	4000	NA	medium	Bruce	HL-LHC	B	
44	Fast collimator setup at 3.5 TeV	8	4000	NA	medium	Valentino	2012	B	
45	intensity limitations for 25 ns operation	24	450/4000	25	medium+	Arduini	after LS1	B	
46	Operational development MD	48	450/4000	NA	low	Wenninger	after LS1	A or B	
47	Quench test at nominal energy	8	4000	NA	medium	Priebe	2012	C	
48	Scraping with tune excitation	16	450/4000	NA	medium	Bruce	HL-LHC	A or B	
49	Nonlinear beam dynamics	12	450	NA	low	Giovannazzi et al	HL-LHC	A	
50	Transfer & injection of high brightness bunches w SPS Q20	16	450	50	medium+	Bartmann et al	after LS1	C	
51	Single bunch parameter evolution	?	4000	50	high	Papotti	2012	A	
52	Effective longitudinal broadband impedance	6	450	NA	medium+	Shaposhnikova	after LS1	B	
53	Movements IT with beam at injectior	8	450	NA	low	Wenninger	2012	A	
54	Sensitvity of QPS thresholds to FB systems	8	4000	50	high?	Denz et al	after LS1	A	
55	Loss of Landau damping during ramp	6	4000	NA	medium+	Shaposhnikova	2012	B	
56	Ion collimation loss mitigation	16	4000	100 or 200	medium+	Jowett	2012	C	
57	Proton lead intensity limit	16	450/4000	100 or 200	medium+	Jowett	2012	C	
58	Proton collimation loss mitigation	16	4000	50	medium+	Jowett	after LS1	C	
59	De-squeeze to beta*=500	8	4000	NA	low	Burkhardt	2012	A	
60	Scraping to 1 micron emittance at to energy	8	4000	NA	medium	Burkhardt	2012	A	
61	RF cavity non-linearities	16	450/4000	NA	medium	Calaga	HL-LHC	A	
62	Longitudinal blow up studies	16	450/4000	50	medium+	Baudrenghien	2012	B	
63	RF feedback optimization with circulating beam	4	450/4000	50	medium	Baudrenghien	2012	B	(EOF)
64	Commissioning of longitudinal damper	16	450	50	medium+	Baudrenghien	2012	B	
65	Commissioning of p-Pb rephasing using p	8	450	50	medium+	Baudrenghien	2012	B	
66	Longitudinal stability for batch	16	450	50	medium+	Baudrenghien	after LS1	B	
67	Voltage modulation to minimize klystron power	16	450/4000	50	medium+	Baudrenghien	after LS1	B	
68	Longiudinal stability of batch	16	450	50	medium+	Baudrenghien	after LS1	B	
69	Aperture measurements at 3.5 TeV w ADT blow up	8	4000	NA	medium	Redaelli	2012	B	
70	Collimation cleaning during the ramp w ADT blow up	8	4000	NA	medium	Redaelli	2012	B	
71	Fast beam losses at the collimators	8	450/4000	NA	medium	Redaelli	2012	B	
72	Combined ramp & squeeze	8	450/4000	NA	low	Redaelli	after LS1	A	
73	Luminosity leveling with dynamic beta* change	8	4000	NA	medium	Redaelli	after LS1	C	
74	LHC linear chromaticity	6	450	NA	low	Tomas	2012?	A	

MD requests for 2012 submitted in November & December 2011

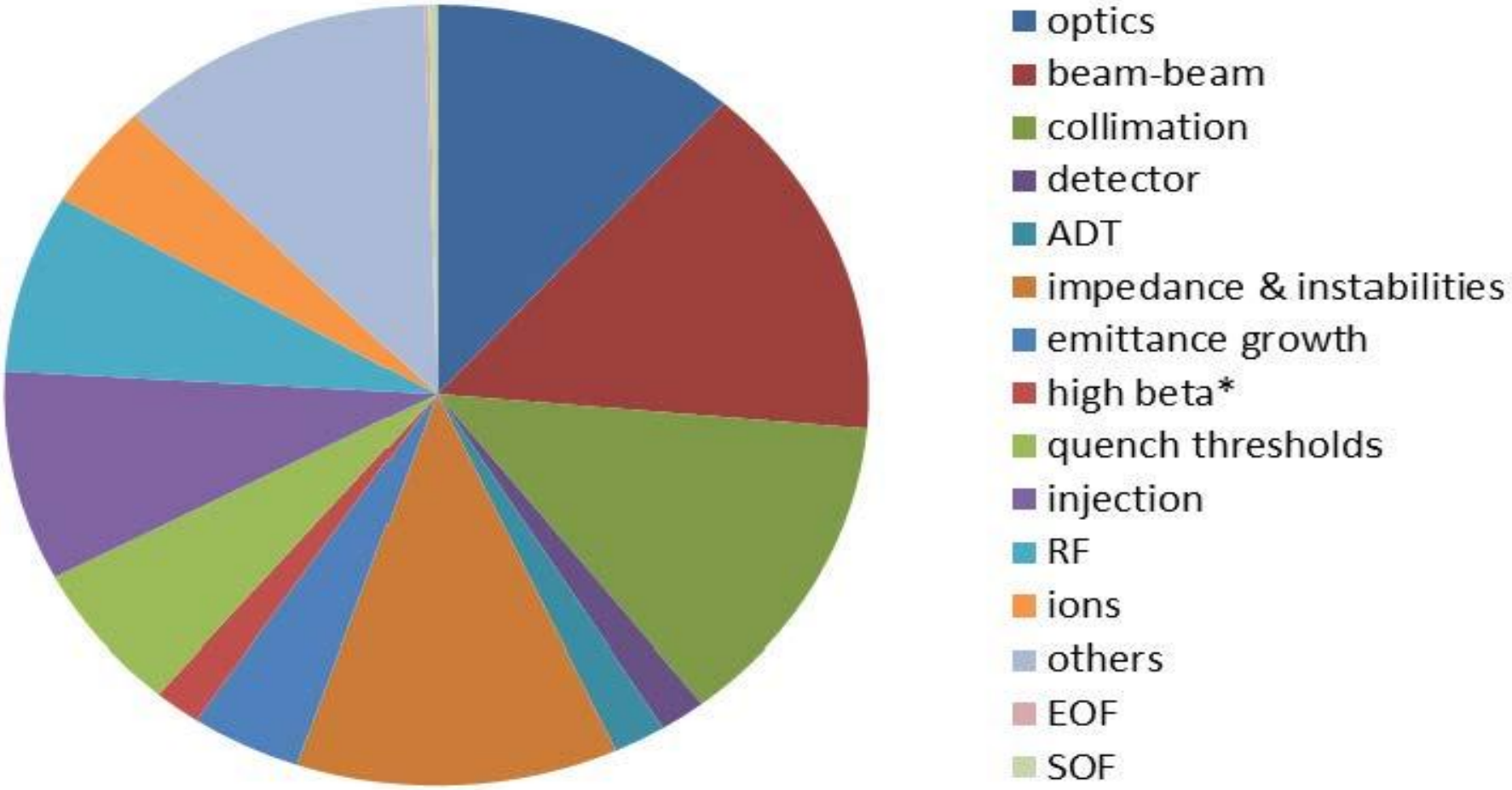
76 requests in total

total time requested: 913.5 h

available time: 420 h

Slide Frank Zimmermann, Evian 2011

Distribution of MD Requests



Slide Frank Zimmermann, Evian 2011

Limiting Time Availability and Priorities

- Not enough MD time to do everything in 2012.
- In the following propose a list of MD goals for 2012 that we ask comments and feedback on:
  - Has been discussed in LHC Study Working Group
  - What is missing? What should be removed? Input on priorities?
- Three categories:
  - MD's for operation and physics.
  - MD's for future running.
  - MD's with lower priorities (scheduled if time allows).
- This is still preliminary!

Operation & Physics I

1. Understand **beam heating** effects around the LHC ring.
   a) Establish limits for safe intensity without hardware damage.
   b) Requires identification of critical locations → see report by Vincent Baglin.
   c) Requires temperature sensors at critical locations.

2. Understand & optimize **transverse emittance growth**:
   a) Measure beam-beam emittance growth due to transverse noise.
   b) Noise properties of transverse damper (ADT): FB on and off.
   c) Optimization of ADT in ramp.

Operation & Physics II

3. Demonstrate RF setup for **proton-lead physics**:
   a) → Ramp many bunches.
   b) → Prepare ion physics run at end of year.

4. Establish an LHC optics with a **beta* of 500 m**.
   a) Depends on physics priorities.
   b) Prepare for small angle physics runs after LS1.

Operation & Physics III

5. Understand and optimize **longitudinal beam dynamics** in LHC:
   a) Understand longitudinal impedance in LHC.
   b) Study voltage modulation (→ minimize transient power loads)
   c) Optimize bunch length blow-up (→ minimize heating effects).
   d) Set up longitudinal damper.

6. Establish **automatic and very fast collimator setup**:
   a) Setup rate should reach 9 Hz (~10 times faster).
   b) Hope to achieve maximum during commissioning.

Operation & Physics IV

7. Calibrate and optimize LHC **beam instrumentation**:
   a) Special fills (MD) for cross-calibration

8. Compatibility **tune and ADT**:
   a) Establish residual tune signal in damper signal and provide to tune feedback.
   b) ADT Q/Q' diagnostics compatibility.

9. Equalize beta* in ATLAS and CMS:
   a) Automatic K modulation for beta*.

Future Running I

1. Characterize future **operation with 25ns**:
   a) Establish reliable nominal injection with 288b batches.
   b) Establish nominal intensity of 2808 bunches with 25ns at injection: 2808 x 1.2e11 (if safe for beam heating)
   c) Ramp as many batches as possible: ramp at least 288b (25ns) for peak current within 3 μs → demonstrate the safe RF operation with 200 kW klystron power.
   d) With ramp of 25ns batches determine UFO scaling.
   e) Understand LR beam-beam limit for 25ns: reduce crossing angle for 25ns fill, observe losses.

Future Running II

2. Quantify required tolerances for **non-linearities** in LHC:
   a) What do we really need for upgrade specifications (e.g. for 11T dipoles)?
   b) Minimize cost of upgrades by only asking for required features.

3. Show feasibility **very small beta* / very high pile-up**:
   a) Test ATS optics to 10 cm beta*
   b) Set up collimation for beta*=40 cm and flat machine (ATS pre-squeeze).
   c) Demonstrate pile-up of 90-110.
   d) Establish chromatic limits in LHC collimation and MP: When do we need an ATS optics?
   e) Test Large Piwinski Angle.

Future Running III

4. Verify and check the **transverse impedance** limits of the LHC:
   a) Impedance from the machine parts (collimators etc…)
   b) Limitations in octupole and ADT stabilization (profit from much more correcting power at 3.5 TeV) for acceptable emittance growth.
   c) Verify 7 TeV collimation settings ("super-tight")

5. Show feasibility of **flat beam optics** in the LHC:
   a) With standard or ATS optics.
   b) Option to **increase luminosity and to reach 5e34 lumi after LS1 at 6.5 / 7 TeV**, before HiLumi upgrade?

Future Running IV

6. Establish benefits of the **½ integer tune working point**:
   a) Demonstrate more room for LR beam-beam → lower crossing angle → lower beta*.

7. Study and improve LHC **injection limitations**:
   a) Check solutions for transfer line stability.
   b) Injection into LHC with Q20 optics in the SPS.

Proposed Criteria for Lower Priority

- Sufficiently conclusive results in 2011.
  - e.g. collimation efficiency
- MD studies that are becoming operational tools for 2012 commissioning.
  - e.g. aperture
  - e.g. ADT blow-up
- Studies on damaged devices.
  - e.g. TDI impedance, of course assuming full commissioning of these critical devices.
- Studies without impact on 2012 performance, that can be performed efficiently at 6.5 / 7 TeV in 2014.
  - e.g. detailed study of 7 TeV quench margin and required BLM thresholds.

Lower Priority MD's I *(schedule as time permits)*

1. Additional data for **UFO's at MKI's** at injection energy:
   a) MKI has minor influence on UFO extrapolation to high energy. Triggered by injection pulsing…
   b) Hardware investigations ongoing.
   c) Better to focus on UFO's in arcs and other locations?

2. Experimental **benchmark on 7 TeV quench limits**:
   Quench test on C14R2 at 4 TeV and in DS's.
   a) Several tests performed and data is on disk.
   b) No issues in operation so far.
   c) For adjusting BLM thresholds for 6.5/7 TeV: Possibly more efficient to do direct measurements after LS1 (with improved interconnects)?

Lower Priority MD's II *(schedule as time permits)*

3. **Proton performance reach** from beam losses:
   a) Several conclusive tests performed on collimation performance and losses in cold magnets.
   b) Collimation upgrades in DS's of IR3 delayed as a result.
   c) No limitation in sight for 4 TeV physics.
   d) Extrapolate results to nominal/ultimate performance at 7 TeV.

4. Understand **Pb intensity and luminosity limitations** and mitigation (orbit bumps).
   a) Several conclusive tests performed on collimation performance and losses in cold magnets.
   b) Achieved very high ion losses in some cold magnets, much higher than physics induced losses.
   c) Comfortable…

Lower Priority MD's III *(schedule as time permits)*

5. LHC **aperture** measurements:
   a) Will be used as operational technique in commissioning.

6. Studies on **TDI impedance**:
   a) We know that impedance deteriorated.
   b) We know that there is hardware damage.
   c) Lessons are of limited value.
   d) Include as a priority into general survey of beam-induced heating.

7. Controlled beam **blow-up with ADT**:
   a) Will be used as operational technique in commissioning.

Summary MD Plans (for discussion)

Operation & Physics: 9 major MD goals proposed.

1. Understand **beam heating** effects around the LHC ring.
2. Understand & optimize **transverse emittance growth.**
3. Demonstrate RF setup for **proton-lead physics.**
4. Establish an LHC optics with a **beta* of 500 m**.
5. Understand and optimize **longitudinal beam dynamics** in LHC.
6. Establish **automatic and very fast collimator setup.**
7. Calibrate and optimize LHC **beam instrumentation.**
8. Compatibility **tune and ADT.**
9. **Equalize beta*** in ATLAS and CMS.

Future running: 7 major MD goals proposed.

1. Characterize future **operation with 25ns.**
2. Quantify required tolerances for **non-linearities** in LHC.
3. Show feasibility **very small beta* / very high pile-up.**
4. Verify and check the **transverse impedance** limits of the LHC.
5. Show feasibility of **flat beam optics** in the LHC.
6. Establish benefits of the **½ integer tune working point.**
7. Study and improve LHC **injection limitations.**

Reduced priority MD's: 7 goals. To be scheduled as time allows.