Injector MD planning in 2012

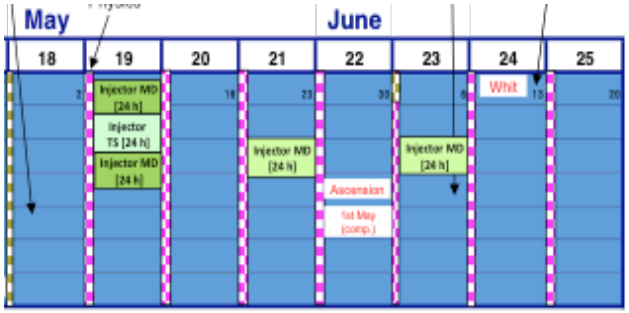
Giovanni Rumolo

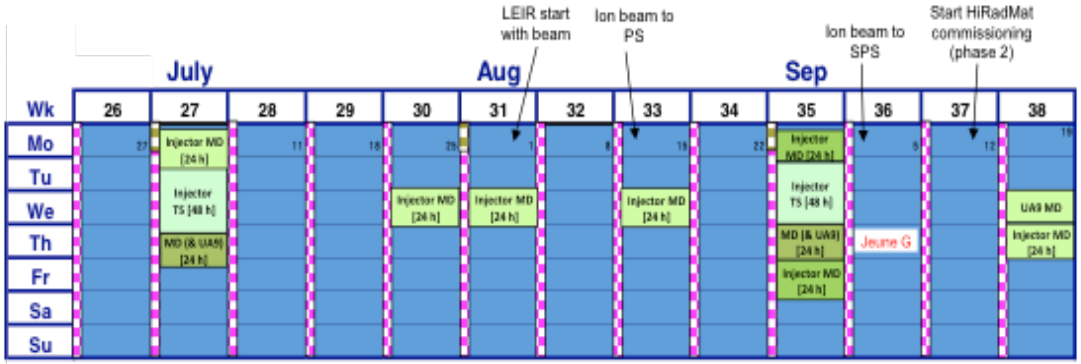
in *MSWG Meeting*, 17 February 2012

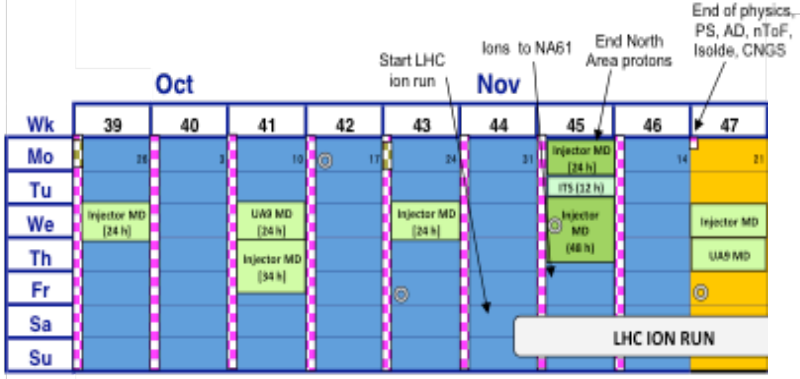
- Schedule: comparison with last year
- Last year's MDs vs. this year's requests (to date)
  - → Linac2 + PSB
  - → PS
  - → SPS
- Goals, priorities and logistics
- Concluding remarks

Overview 2011

- 2011 distribution of the MD days (priority to MDs in all machines)
  - → Floating MDs biweekly
  - → Long dedicated blocks during LHC TS (4x)
- Total number of available MD hours was 408 (434 on original schedule)
- Parallel MDs
  - → PSB + PS: at least one cycle per supercycle always available for MDs (or MTE)
  - → SPS: usually one parallel MD cycle available every week day for studies (some times used for set up)





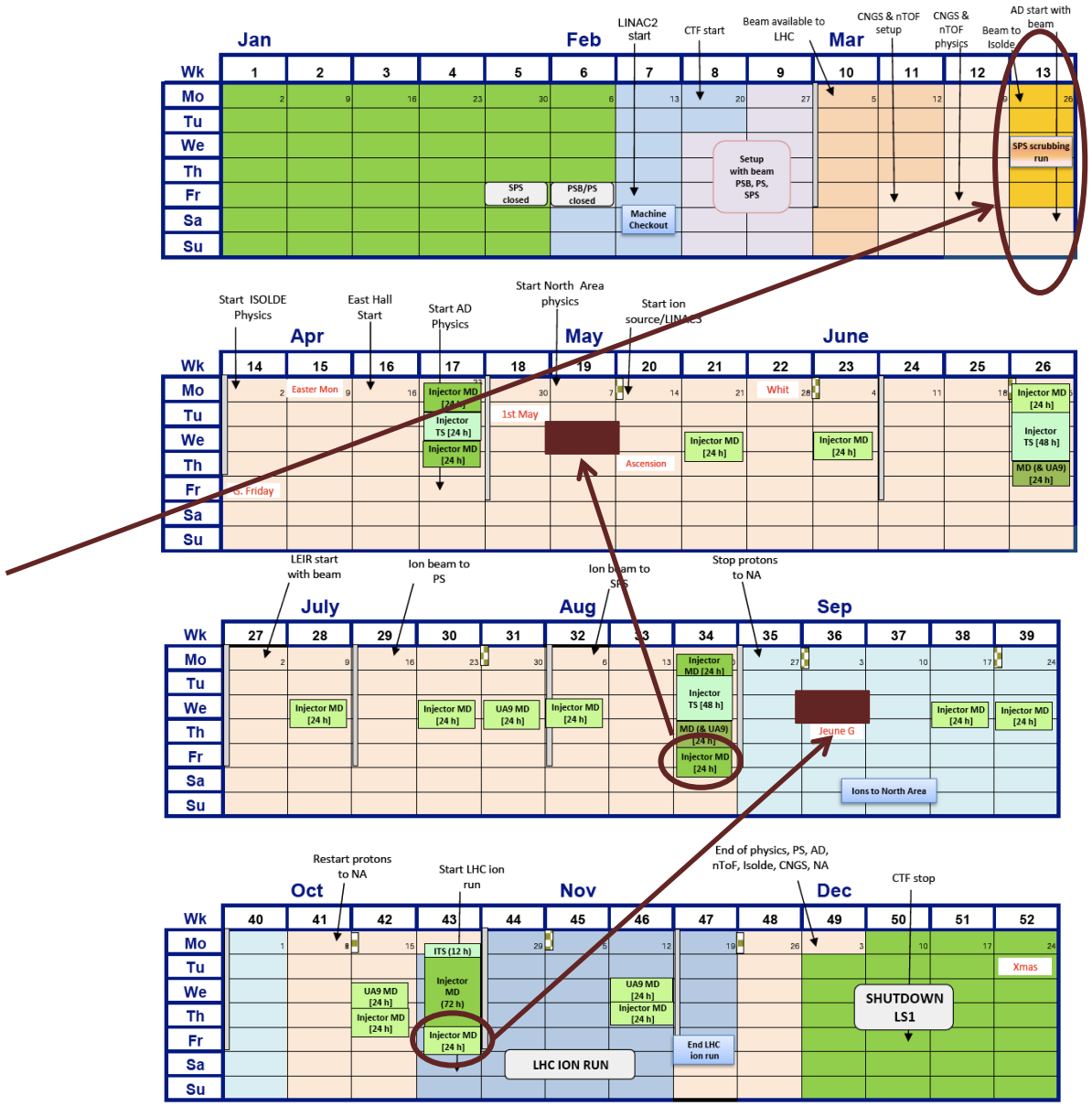


Some lessons from 2011

- The efficiency of the dedicated SPS MDs (real MD time vs. scheduled time) depends on the mode
  - The fully dedicated blocks (during LHC TS) had in general very high beam availability, above 90%
  - The floating blocks relied a lot on LHC being on store or injecting fast
    - Sometimes perfectly efficient or sometimes strongly perturbed
    - Global efficiency around 50%, or slightly higher
- Injector TS on Tuesdays (instead of Mondays)
  - Optimizes use of machine time in the 24h cool-down for high intensity users
  - Drawbacks for MDs are:
    - ✓ loss of 3h for general cool-down
    - ✓ limitations on amount of dumped beam if access to Sextant 1 needed during TS
    - ✓ no access before the first 24h MD
- More floating blocks instead of Friday MD during LHC set up after TS have proved more efficient
- Parallel SPS MDs were usually efficient, and frequently prolonged beyond the officially assigned day hours, physics permitting
- Most of the PSB and PS MDs could take place in parallel during physics operation and also profit from the priority given during the official MD time (however, problem with the users…)

Overview 2012

- About same distribution of the MD days as in 2011
  - → Floating MDs biweekly
  - → Long dedicated blocks during LHC TS (4x)
- Total number of available MD hours is 432 (like in 2011)
- In addition, one dedicated week for scrubbing studies in W13
- Some changes we propose
  - → Redistribution of floating blocks
  - → Splitting of floating blocks into 12h blocks to guarantee more continuity in Q20 activities



Linac2 + PSB in 2011

- **Linac2 MDs**
  1. Remove hot spots found with the 2010 radiation survey
  2. Run with increased beam current (180 mA)

- **Types of PSB MDs**
  1. Prepare new beams, tune and check existing beams, for the downstream machines
  2. Define the limitations of the machine, improve the performance
  3. Specific machine studies in view of the future upgrades

Linac2 + PSB in 2011

– **Linac2 MDs**

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2. Run with increased beam current (180 mA)

Time, resources!

– **Types of PSB MDs**

1. **Prepare new beams, fine tune and check existing beams, for the downstream machines**
2. Define the limitations of the machine, improve the performance
3. Specific machine studies in view of the future upgrades

Linac2 + PSB (2012)

- **LIU-PSB activities in 2012 (RF, hardware)**

① Continue deployment of the digital RF control

① Test the newly installed Finemet prototype cavity hardware

- **Beam dynamics/performance MDs**

? Repeat tests with higher beam current from Linac2

⊙ Parameter dependence of the instabilities and identification of the impedance source (request also from V. Kornilov, GSI, to have ~1w for instability measurements at the PSB)

⊙ Determine resonance diagram with tune scans at 160 MeV to optimize placement of working point at injection with Linac4

⊙ Optics model based on turn-by-turn data from the available BPMs

⊙ Study the efficiency of the resonance compensation schemes

⊙ Space charge induced emittance blow up

⊙ Capture and acceleration in h=2

⊙ Equalization of transverse emittances across rings

⊙ Bunch lengthening at top energy for PSB-PS transfer (in view of 2GeV)

PS in 2011

Dedicated MDs

Parallel MDs

– **PS MDs**

- ☑ Space charge studies at 1.4 GeV and 2 GeV and tune diagrams
- ☑ Adjustment of working point at low energy with quads and PFW
- ☑ Qualification of dipole orbit corrector performances at 2 GeV
- ☑ RF gymnastics at 2 GeV (Triple splitting proven)
- ☑ PS-SPS longitudinal transfer optimization
- ☑ Fast instability at transition with TOF-like beams
- ☑ Tune shift with intensity at injection and extraction energy
- ☑ Electron cloud at flat top with 25 and 50ns beams
- ☑ Limitations from longitudinal coupled bunch instabilities during the ramp and flat top
- ☑ Batch compression scheme h=9 → 10 → 20 → 21
- ☑ One-turn feedback with C11
- ☑ Production of 100ns beams for p-Pb scenario

PS in 2012

- **PS machine studies requested in 2012**

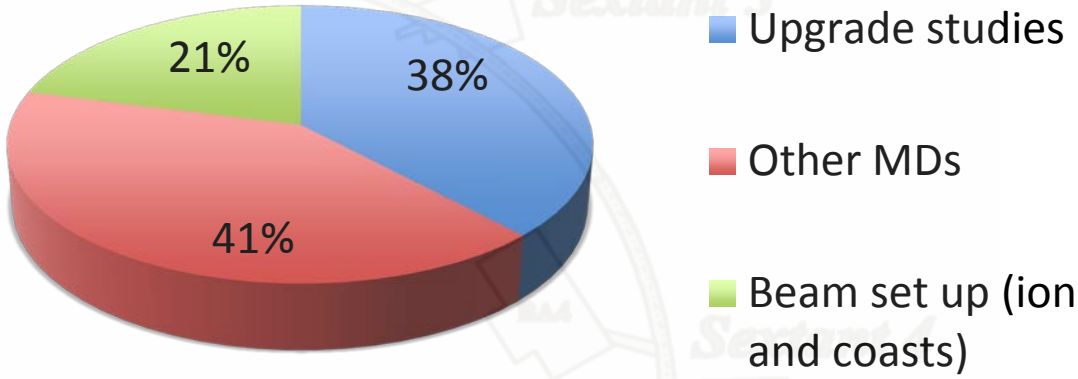
- Space charge studies: is 0.26 the limit for the PS?
- Additional feedback against longitudinal CBI (should extend the intensity reach for 50 and 25ns beams!)
- Batch compression scheme h=9 → 10 → 20 → 21, acceleration, transfer to SPS
- Batch compression + bunch merging scheme
- One-turn feedback against transient beam-loading
- Electron cloud measurements in presence of B field and with double step bunch rotation
- PS-SPS transfer studies (SPS capture loss maps as a function of PS bunch rotation timings)
- Commissioning of transverse feedback system
- Head-tail instabilities on the flat bottom (V. Kornilov, GSI)
- Transverse instabilities of short intense bunches at flat top
- Impedance identification for modeling
- Miscellaneous injection studies and optics model at different energies
  - ✓ Tuning of working point from injection in 5 CM
  - ✓ Tests of low energy elements
  - ✓ Acceleration-deceleration for double batch transfer

SPS in 2011

Dedicated MDs
39%
(very high efficiency ~95%)

Floating MDs
61%
(efficiency slightly above 50%)

Distribution of SPS MDs in 2011



– **Upgrade studies included**

→ Push the SPS performance with the present 25 and 50ns beams, as well as with single intense bunches (up to 4 x 10^{11} ppb)

→ Development of low gamma transition optics (Q20)

→ Electron cloud studies (mitigation, wide band feedback)

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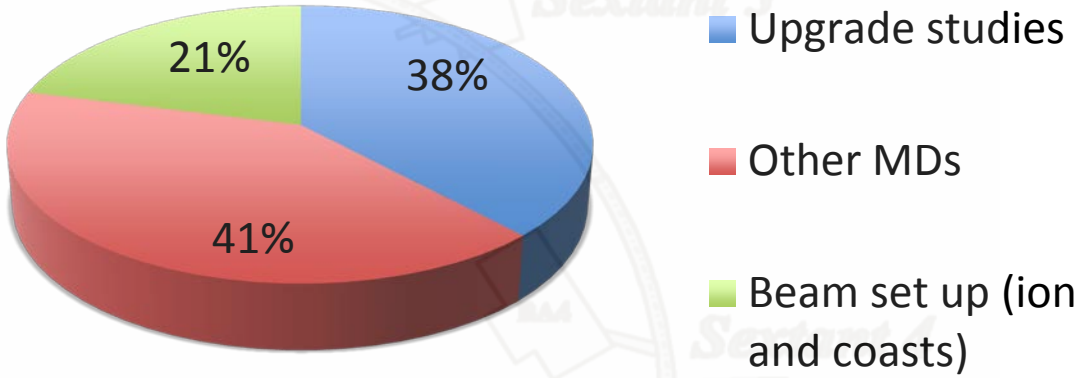
Distribution of SPS MDs in 2011



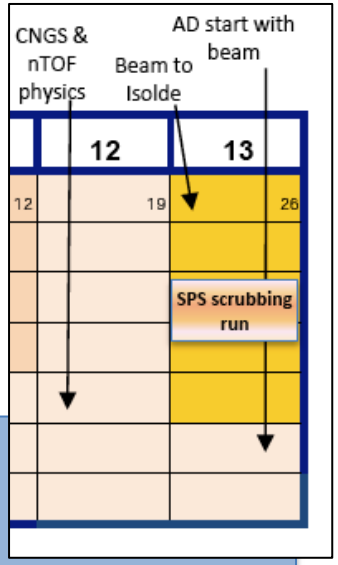
– **Other MDs included**

→ LHC collimator prototype tests, outgassing measurements
→ Emittance growth studies in coasting mode in the frame of the crab cavity studies for HL-LHC
→ TT20 steering tests for NA61
→ BI tests (e.g. fastBCT: dependence on bunch position/length, profile measurements)
→ **No** BBLR tests, although planned a few times

SPS: electron cloud, scrubbing or coating?

– **Electron cloud in 2011**

1. Effects on the nominal 25ns beam have become less evident from the start
2. Mitigation techniques (clearing electrodes, C coating)
3. Progress on the high bandwidth feedback system



– **2012 studies**

1. Scrubbing in W13
   - ☹ Beneficial effects on the beam ?
   - ☹ Most interesting scrubbing techniques not possible for now (5ns or 10+15ns spacings from PS)
   - ☺ Testing efficiency of scrubbing with uncaptured beam
   - ☺ Monitor and qualify beam induced scrubbing under different beam/chamber conditions (beam observables, direct electron cloud observables)
   - ☺ Validate simulation models on scrubbing times (like for LHC)
   - ⟶ Program details to be worked out in the next SPS-BD meeting
   - ⟶ Questions: which beam will LHC take? Will CNGS run in parallel?
2. New setups for validation of a-C coating

SPS in 2012

– **SPS machine studies in 2012**

- ZS studies
- Tests with increased peak RF power
- Q20 optimization
  - ✓ Longitudinal stability and quality at extraction
  - ✓ Injection tests into LHC
  - ✓ Transverse emittance preservation and single bunch limits
  - ✓ Nonlinear optics model
  - ✓ Split tunes (20, 26), coupling correction
  - ✓ Instabilities (TMCI, ECI)
  - ✓ Extension of Q20 to fixed target physics cycles
- PS-SPS transfer studies (see PS)
- Terminate phase (1) for high bandwidth feedback studies (i.e. close feedback loop and prove damping of head-tail modes)
- Impedance identification

- Tests of the collimators with integrated BPMs
- Emittance growth studies in coasting mode
- Ion MDs (usually second part of the run)
  - ✓ Set up of cycles for NA + LHC filling
  - ✓ Dispersion of bunch parameters
  - ✓ Preparation of primary ion beams for NA with use of new hardware, firmware, software and a new SPS magnetic cycle.
- BBLR excitation/compensation, BI specific studies (MOPS upgrade, detection of ghosts/satellites, HT Monitor upgrade)

SPS in 2012

– **SPS MD cycles in 2012**

- Q20 optics
  - ✓ Short MD1 cycle and LHCfast type
  - ✓ Long cycle (4 injections) for 25 and 50ns beams
  - ✓ Coastable at 120 and 270 GeV/c
  - ✓ CNGS type ?
- Nominal optics
  - ✓ Short MD1 cycle and LHCfast type
  - ✓ Long cycle (4 injections) for 25 and 50ns beams
  - ✓ Coastable at 120 and 270 GeV/c (UA9?)
  - ✓ MD1-type cycle with long flat bottom
- Cycles for the set up of the ions (later on during the run): standard cycles for NA + LHC filling & new magnetic cycle for NA

Some suggestions to improve the efficiency?

- Presently 24h floating blocks ~2 weeks apart
  - O.k. for set up and subsequent use of coasts
  - Would be better **12h blocks during daytime** every week for Q20?
    - ✓ More continuity for optimization and fine tuning
    - ✓ Avoids lengthy checks and set up every time that the cycle is re-loaded (typically every 1-2 months)
    - ✓ Ensures the presence of experts when needed
    - ✓ At least in the second part of the run?

- Q20, electron cloud: **MD wrap-up and preparation meetings** to be held before each new session to encourage timely data analysis and steer the next steps (will be organized in the frame of the SPSU-BD meetings, on Tuesdays?)

All the machines

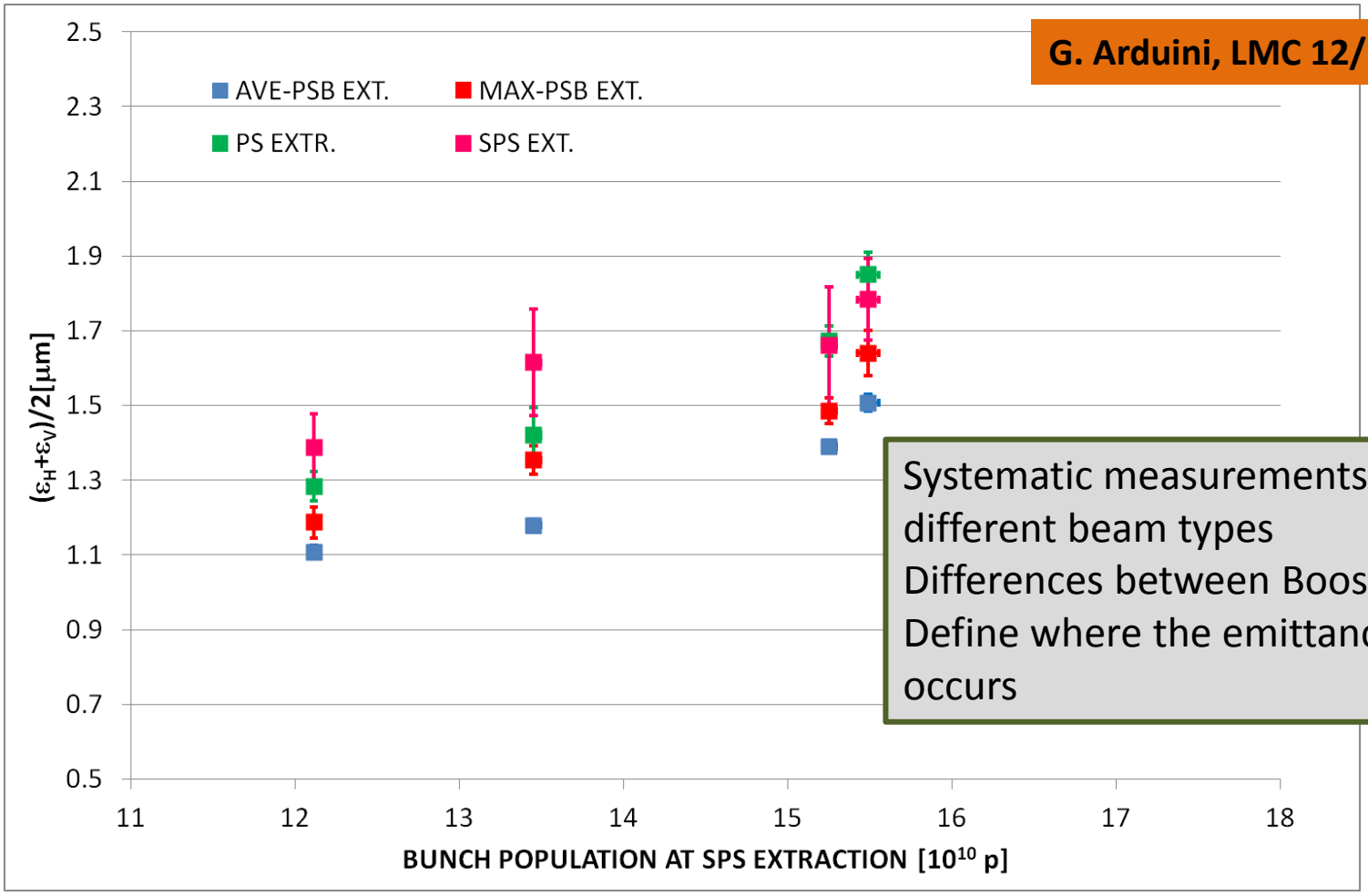
– **Preparation of beams for the LHC MDs**

From FOM 2011, G. Papotti, GR

TIME	MD TITLE	EN.	LHC BEAM	PPB	TRANSV. EMIT.	LONG. EMIT.	PSB USER	PS USER	SPS USER	MMI TARGET
06:00	Head-on beam-beam + data taking	3.5TeV	indiv	>2e11	<2um		MD4	LHCINDIV	LHC4	LHCMONO
13:00	*Ramp down*									
15:00	Optics for β*=1m	3.5TeV	pilot	1e10			LHCPROBE	LHCPROBE	LHCPILOT	LHCPILOT
19:00	*Ramp down*									
21:00	Long bunch length	3.5TeV	op 50 ns				LHC_MD_A + LHC_MD_B	LHC_MD	LHC1	LHC50NS
			indiv	1.3e11			LHCINDIV	LHCINDIV	LHC4	LHCMONO
03:00	*Ramp down*									
05:00	Beam Instrumentation	450GeV	indiv	>2e11	<2um		MD4	LHCINDIV	LHC4	LHCMONO
			Indiv	1.2e11			LHCINDIV	LHCINDIV	LHC4	LHCMONO
		3.5TeV	op 50 ns				LHC_MD_A + LHC_MD_B	LHC_MD	LHC1	LHC50NS
13:00	*Ramp down*									

All the machines

- Preparation of beams for the LHC MDs
- **Emittance preservation across the injector chain**



In summary

First MD requests have been submitted for PSB/PS/SPS, but the list is not yet exhaustive to date

- **PSB** → More resources desirable for the key studies
  - → Resonances at 160 MeV
  - → Origin of instabilities, efficiency of transverse feedback in the enlarged parameter range
- **PS** → Important questions
  - → Space charge limit at injection
  - → Feedback against CBI
  - → Alternative production schemes – like batch compression
- **SPS** → Redistribution of the MD time + MD follow up meetings in the frame of SPSU-BD WG in 2012 recommended
  - → More frequent – and shorter – MD blocks to allow for more continuous effort on Q20 optimization (with experts available)
  - → 3 to 5-day dedicated block for scrubbing studies

Thanks to all those who help with the coordination and/or already submitted their MD requests

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