Experiments expectations

- Baseline conditions
  - Pileup, 25ns vs 50ns …
  - Heavy ion ops
  - Bunch length, beta*, flat beams …
- Special Runs and optics
  - Experiments requests

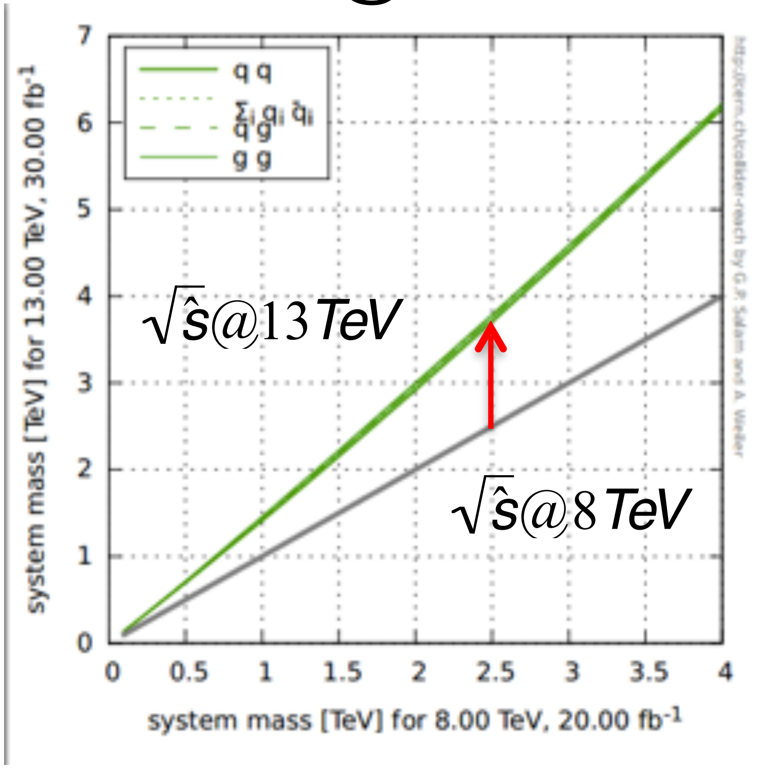
BASELINE CONDITIONS

Maximizing physics reach (stating the obvious….)

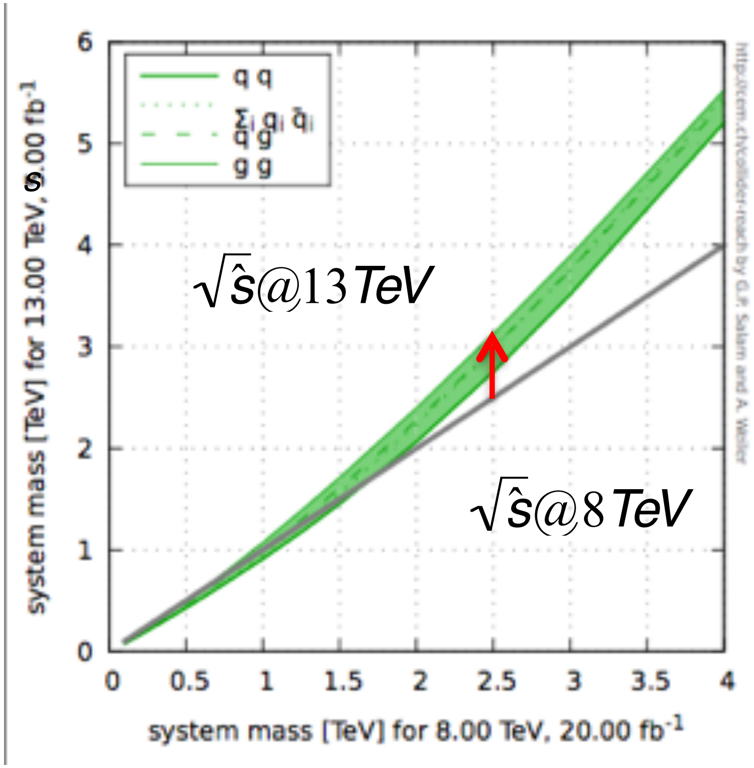
- Peak instantaneous luminosity is not everything…
  - Should not aim for higher values at the expense of stability
- Not even delivered integrated luminosity
  - Physics selection efficiency and background rejection depend on experiment resolution as a function of the physics and the pileup
  - Same delivered luminosity could result in different usable luminosity in different running conditions
- **Effective (i.e. usable for physics) luminosity is a key parameter**
- Effective integrated luminosity is the ultimate goal
  - Can be different for different analyses depending on type of final state and complexity
  - Challenge: find the best compromise for instantaneous luminosity and trigger for all analyses
  - Whichever mode of operation is chosen, the exact parameters are the ones which are optimal for the priority physics of the experiments

Discovery Potential

30 fb^{-1} @ 13 TeV



5 fb^{-1} @ 13 TeV



- 20 fb^{-1} @8TeV vs X fb^{-1} @13 TeV
  - Parton-parton system mass at which we get the same number of events
  - Nota bene: only scaling of partonic luminosities
  - assuming (conservatively) that analysis acceptance and efficiency are the same at 13 TeV and 8 TeV

Views on beam energy

- At the mass scale of 1 TeV the cross section for production of new particles is ~10 times higher at 13 TeV relative to 8 TeV
- However:
  - Minimum-bias cross-section increases by O(15%)
  - Expected overall multiplicity increases O(10%) at $|\eta|<2.4$, O(20%) in LHCb
  - At equivalent number of bunches and luminosity, events get O(25%) busier in ATLAS/CMS and up to O(40%) in LHCb
- Target energy value for Run 2
  - Obviously higher energy implies higher reach but this has to be weighted against the need of fixing the energy early enough to allow MC production
  - Assumed hereafter that 6.5 TeV will definitely be the initial energy (after this Chamonix final decision) and NOT changed in 2015
    - We accept the risk that results from late quench tests could force to run at lower energy
  - In the long run:
    - **step increases towards ultimate energy should be avoided**
    - Ideally if changed must be, it should only be at YETS

Effects of Pileup and bunch spacing

- Obviously, 50ns gives roughly twice the in-time pileup for the same luminosity
- Higher pileup has several negative implications on:
  - Detector
    - E.g. event size and bandwidth limitations in inner detectors readout)
  - Trigger efficiency
    - Higher fake rates make it difficult to keep current thresholds
  - Online and offline CPU resource requirements
  - Reconstruction & Analysis efficiency
- Not a sharp threshold but rather a constant degradation with pileup
  - Moreover the pileup effects are analysis-dependent
- A **maximum** pileup of ~50 is considered to be acceptable for ATLAS and CMS
  - For higher values a levelling mechanism should be considered
  - It is important to note though that physics with μ=50 is challenging and **in the case of levelling to a constant value we should aim for a lower figure**

Recap of 25ns vs 50ns

- Running at 25 ns is considered of paramount importance by all experiments to maximise ultimate physics reach
- 50 ns for luminosity production should only be considered in case of major showstoppers
  - Leveling would be needed in IP1&5
  - We feel that it is premature and not appropriate to discuss criteria that would suggest to fallback to the 50 ns scheme
  - But it is not premature to discuss a “plan B” in case we have to
- Commissioning at 50 ns will be needed but should be kept to the absolute minimum required to establish readiness for 25 ns
  - A strategy for intensity ramp-up should be formulated with experiments to maximise the usefulness of this phase
  - Assuming a delivered luminosity of order 1 fb^{-1}
  - Not to be forgotten: some colliding bunches for ALICE (2011-like) during 50 ns
- No specific optimisation is requested at 50 ns
  - Except as needed to speedup 25n s commissioning
- **It is accepted that running at 25 ns could result in lower delivered luminosity in 2015 compared to a 50 ns scenario**
  - Longer commissioning plus longer scrubbing period

Bunch Length, Luminous Region, Crossing angles etc.

- Critical parameter: luminous region (not bunch length) and density of interactions
  - Luminous region will be smaller in 2015 due to larger crossing angles
- Shorter luminous region gives higher vertex density
  - more difficult to identify primary vertex
  - for high vertex density tracking more difficult
- Longer luminous region benefits tracking and vertexing…
  - at the price of possible loss of acceptance
  - for particular physics channels it may entail a loss of resolution
- As usual, variations of order 10% are acceptable, an early decision eases the task of preparing MC samples
- The possibility of varying the bunch length during a fill as a mean to recover instantaneous luminosity has been discussed
  - ATLAS/CMS are not against this possibility provided it doesn't increase peak pileup density - more details needed
  - LHCb view: not specifically concerned by peak pileup, but would require more specific parameters to plug into a simulation to check the systematics

Views on optics options

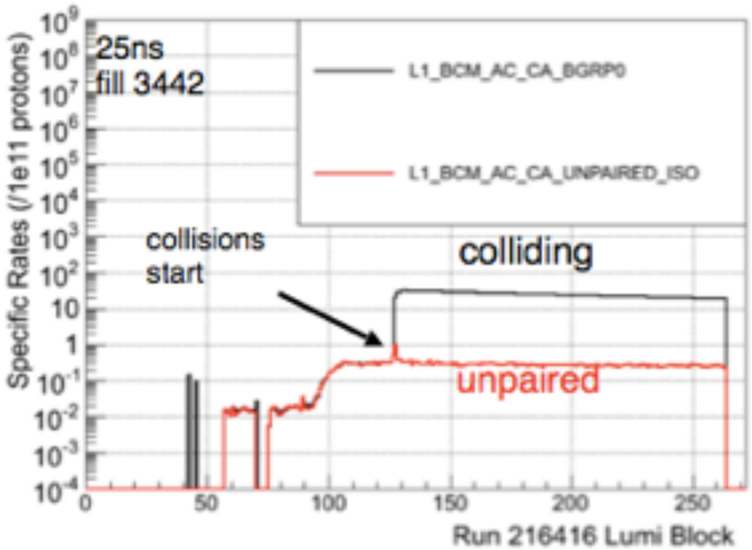
- Injecting at a different β^* is generally agreed to be OK (although it is currently no longer considered for the restart)
- Special optics will be required for VdM scan (and LHCf run, see later)
- As far as we understand, "flat beams" are no longer being considered for the startup
- At any rate, experiments indicated no evident showstopper from the latter
  - Final decision will depend on accurate study based on actual value of $\beta_{x/}\beta_y$ ratio
- Possible "intermediate" optics are assumed to have no influence on experimental IPs
- Assume conservative β^* (80 cm ?), with option to move to smaller value later
  - Obviously will affect final integrated luminosity

Filling schemes

- Several fill schemes prepared for 2015
  - 25ns_2748b_2736_2452_2524 (standard booster extraction)
  - 25ns_2508b_2496_2108_2204 (BCMS / 5 PS trains per SPS batch)
  - 25ns_2604b_2592_2288_2396 (BCMS / 6 PC trains per SPS batch)
  - 25ns_1968b_1960_1163_1868 (e-cloud moderating scheme, 8b+4e)

- Beware that all schemes have 12 initial bunches not colliding in IP1&5
  - These are of paramount importance for background studies
  - Eliminating them would leave the experiments "blind" to beam-gas

Online beam-gas monitoring



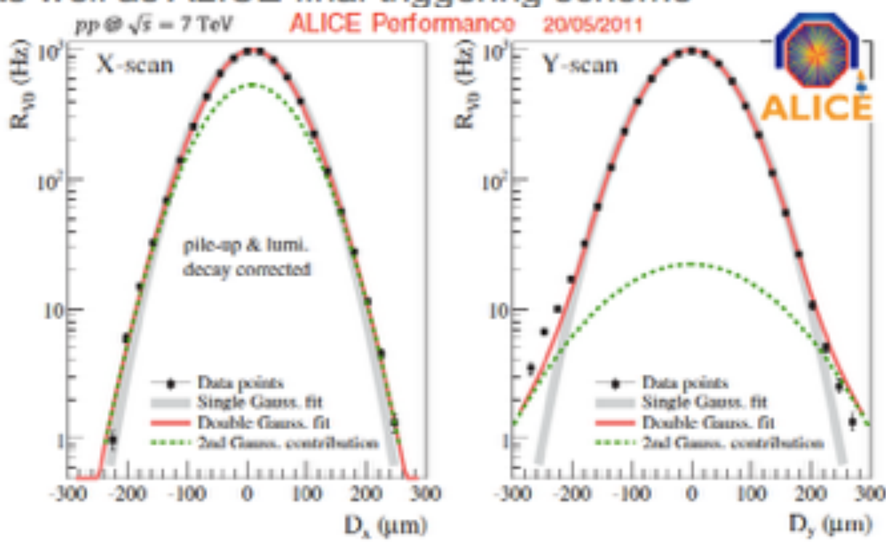
Levelling and crossing in LHCb

- tilted crossing in IP8 not proven to reduce systematics, can be abandoned
- Difference between angles in UP/DOWN should however be minimized
- Regular polarity switch for reduction of systematic error in precision measurements are still required
  - Every ~100 pb^{-1} collected
  - One polarity switch will be necessary also during the 50 ns phase to make data useful for physics (a good occasion to commission the switch under better known conditions)

- Leveling to 4-6x10^{32} $cm^{-2}s^{-1}$ will be needed
  - Minimum β* = 3m, leveling by separation the default
  - LHCb still interested in serving as "guinea-pig " for leveling by β* (combined with separation) should it be considered later on
    - Would require separation no larger than 1σ
  - **only if beneficial or of no significant impact on physics time**

Running conditions for ALICE in p-p periods

- ALICE plans to run in minimum-bias conditions
  - Luminosity range $5x10^{29}$ - $2x10^{30}$ $s^{-1}cm^{-2}$
  - Actual set point depending on final running conditions
    - TDI vacuum and beam-gas background level as well as ALICE final triggering scheme
- Luminosity reduction must be obtained by separation only
  - No main-satellite scenario available for 25ns
- Data from 2011 VdM show a drop of rate of only about 300 (Y-scan) to10^3 (X-scan) at the limit of VdM separation range (~5-6 sigmas?)



- Points to be addressed:
  - The reduction of luminosity requested is at the limit of what can be attained by separation
  - Lumi fluctuations might be significant in this regime
  - A strategy is being discussed to avoid risks of beam dump at the removal of the separation bump in P2

Quick view on Heavy Ion Operations after LS1

- 4 weeks of Ion operation
- Baseline: PbPb @ 5.1 TeV
  - max inst. luminosity: 3-4 10^{27} $cm^{-2}s^{-1}$
  - 1-1.5 nb^{-1} expected to be delivered
- Energy of 5.02 would be considered preferable **ONLY** if the additional cost in commissioning is negligible
- Luminosity leveling, at least in ALICE, will be required
  - ALICE will operate at 8 kHz
  - alternative leveling scenarios including the 3 experiments are under evaluation based on the machine potential for peak luminosity and turnaround times
- Reference pp sample at equivalent energy ($\int Ldt$ (pp) = 3-4 $10^4 \times \int Ldt$ (PbPb))
  - Exact schedule for commissioning and running the latter TBD
  - Commissioning shall be scheduled before the run period

Commissioning phase

- Experiments express no concern with the initial commissioning plan, in particular the plan and schedule of checkout and sector test is monitored to make sure the collaborations can comply to the machine requirements
  - **Important**: schedule dry run to test VdM scan application
  - Transfer line test TI2&8 now in week 47 should include “TED shots” for both experiments (alignment) and system tests including BIS (injection and beam)
  - https://lhcsectortest2014.web.cern.ch/content/schedule-num-2

- Both ATLAS and CMS explicitly **request ~20 beam splash per beam** (other detectors are probably interested too)
- Stable colliding beams, with pilots, as early as possible are paramount to commission detectors and trigger systems that have in many cases undergone major maintenance or upgrades in LS1
- Unsqueeze for VdM and LHCf should be part of initial commissioning as needed (see below)
- Consider performing ALFA and TOTEM alignment and loss maps for RPs as part of the initial commissioning

SPECIAL RUNS / SPECIAL OPTICS

Overview of special runs in 2015

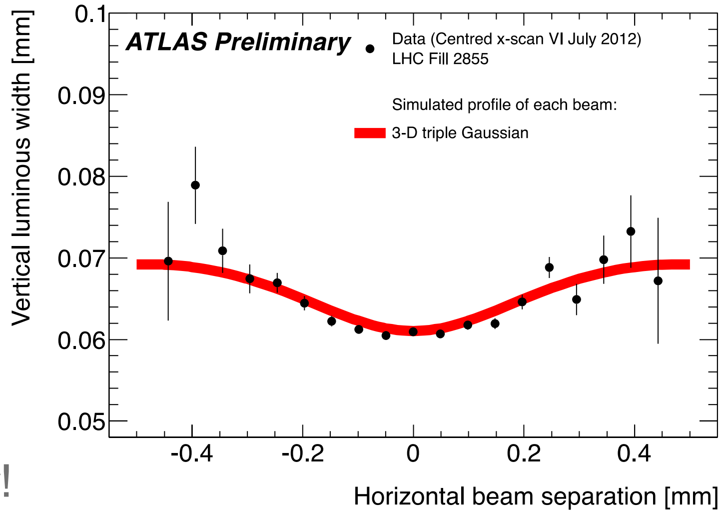
- 2015 p-p period will require a longer commissioning for 25 ns ops.
- The rest should essentially be dedicated to collect data at 13 TeV
- Few exceptions are considered
  - Low pileup and unsqueezed optics for LHCf
  - Run at high β^* (90m) for TOTEM/ALFA
  - VdM scan(s)

LHCf run

- Ideal beam conditions:
  - β* = 19m , optics commissioned for VdM scan as well
  - Half crossing angle of 145 urad
  - isolated bunches with some non-colliding (no trains)
  - very low pileup
  - L ~ 5×10^{28} $cm^{-2}s^{-1}$
  - Goal: collect 5-20 nb^{-1}
- Constraints:
  - The run must be taken before 500 pb^{-1} of delivered luminosity in IP1
    - Beyond that LHCf will suffer from radiation damage even it is kept in garage position

Luminosity Calibration: VdM scans

- 2012 campaign showed that the non-linear x-y beam correlations are a dominant source of uncertainty in the luminosity calibration
  - Non-factorization @ IP 1, 5,8 can be studied quantitatively only by fitting the evolution of the beamspot position & luminous width during scans
    - Possible only if the vertex resolution does not dominate the luminous width
  - The problem:
    - σ_b scales like $\sqrt{(\beta^*/E_b)} \Rightarrow$ naturally smaller beamspot in 2015
    - The vertex resolution won't get any better!



- Hence VdM scans cannot be performed at injection optics but need a dedicated optics:
  - $\beta^* \sim$ 19 m (IP1 & 5), 30-40 m IP8
  - $\varepsilon \sim 3\ \mu$m,
  - $\theta_{Xing} = 0$ and ($\beta_x = \beta_y$)

Planning of LHCf run and VdM

- Efficiently combine LHCf run and a first VdM scan (commissioning a single optics) in the first days of running
  - Experiments require a minimum initial exposure of their luminosity detectors (order of 10 pb^{-1} for detector conditioning and/or calibration of luminometers)
  - Bunch intensities for VdM of order $7x10^{10}$ ppb
  - Provide low-pileup to LHCf by separation

- For efficiency use same optics for both to combine commissioning
  - This implies that the first VdM will have $\theta_{1/2xing}$ = 145 μrad
  - This is considered acceptable for a first calibration of the luminometers
- remember to provide colliding bunches to LHCb throughout (and external crossing angle)
- Will use early runs with very few nominal bunches to calibrate afterglow
- If possible, define a proper filling scheme to provide enough collisions to LHCf during IP2 & IP8 scans
  - With caveat to stay in proper DCCT range

- A second "precision" VdM is foreseen for the second part of the program
  - No θ_{xing} for this one

High β* runs

- ATLAS/ALFA and TOTEM have both expressed interest in a run at β* = 90 m
- At the moment, ATLAS/ALFA only request is for a short run with few low-intensity bunches (~3 bunches, mu~0.03, .7E10 ppb)
- TOTEM specific request aims at collecting ~10 pb^{-1} for central diffraction physics
  - This can be achieved with a large number of relative low-intensity bunches (7 x 10^{10} ppb) at a pileup of order 10% and L ~ 10^{31} $cm^{-2}s^{-1}$
  - Requires development of enhanced setup with crossing angle
  - Consider injection at higher β* only if commissioning cost is worth it
  - would require ~two weeks of data taking, possibly in two separate slots
- ATLAS/ALFA would join this run but is not requesting a specific duration at this time (a specific request will be considered later this year as part of the ATLAS soft QCD program)
  - ALFA upgraded trigger will allow running with up to 600-700 bunches
- Low β* insertion tests are requested for TOTEM (in conjunction with CMS/PPS) and should be carried out at end of fills