Lessons from Physics Runs

(and some proposals for 2010)

All for discussion.

- Spectrometer magnets (spectrometer = solenoid, toroid and dipole)
  - experience from 2009, improvements for 2010 operation
  - proposal for 2010 operation (including LHC ramp cycles)
- Experience with the handshake and BIS
  - injection handshake, PM, dump recovery, experiment protection
- Experience with *online* information exchange
  - DIP data (BCTs, Fill number and all that)
  - Longitudinal and transverse adjustments
  - Page1's and phone chats
- Experience with *offline* information exchange
  - LHC logging DB: tools for LHC data extraction from DB ? magnet polarities ?
  - fill schemes, nomenclature and documentation
  - run stats and book-keeping summaries

ACKNOWLEDGEMENTS

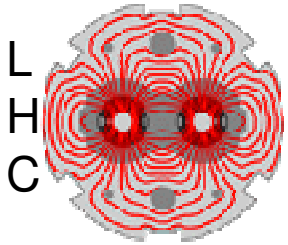
Many thanks to several people who helped me preparing this presentation:

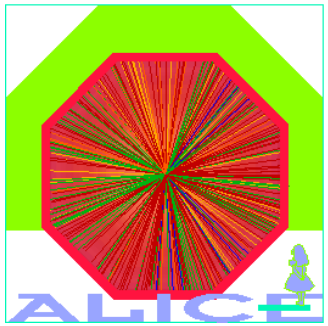
Tiziano Camporesi, Christophe Clement, Mario Deile, Benedetto Gorini, Richard Jacobsson, Daniela Macina, Jan Rak, Andreas Schopper.

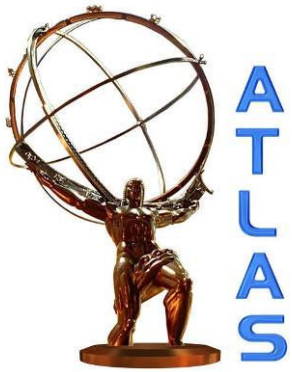
Many thanks also to Alick Macpherson, Helmut Burkhardt and all speakers and all participants of the joint LBS-LPC meeting of yesterday which most info in this talk was taken from.

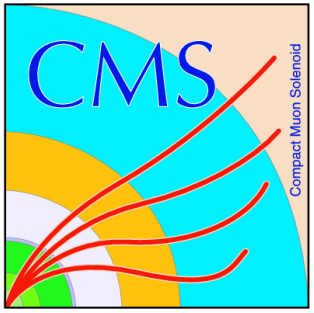
See

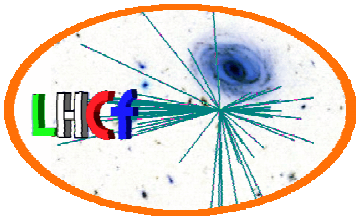
http://indico.cern.ch/conferenceDisplay.py?confId=77114



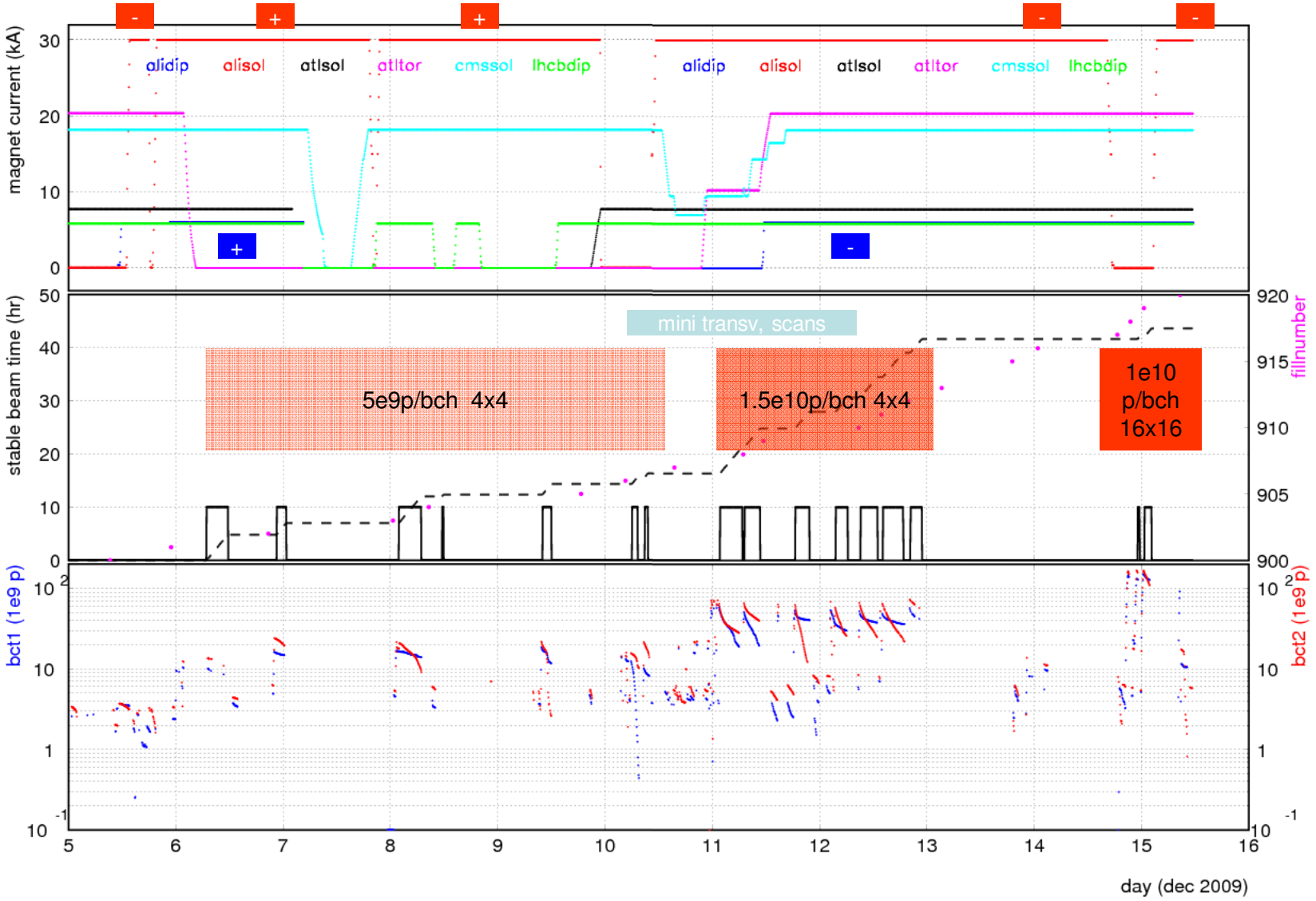








2009 Run overview



Stable beams summary

"stage"		Total hours
4x4	5e9 p/bch	16 hrs
4x4	1.5e10 p/bch	26 hrs
16x16	1e10 p/bch	1.5 hrs
		43.5 hrs

reason why some detectors did not take data at 1.18 TeV (safety!)

Estimated numbers of pp interactions recorded by experiments

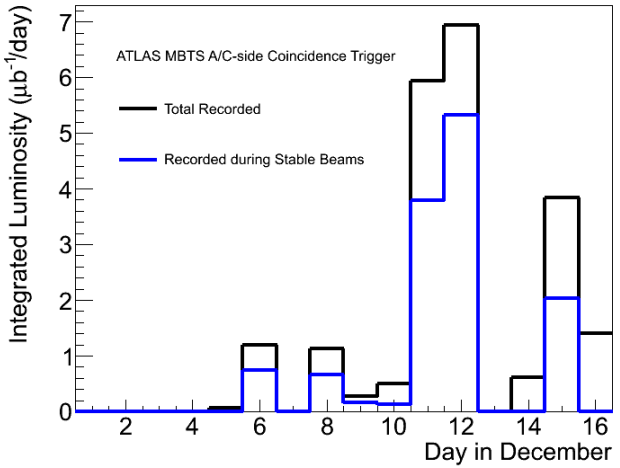
	NOT STABLE BEAMS (detectors partly on)		IN STABLE BEAMS (full detector on, with preliminary bkgd subtraction)
	450 GeV	1.18 TeV	450 GeV
ALICE:	40k	33k	~400k (13k +/+ 120k 0/- dip/sol 180k -/- 81k -/0)
ATLAS:	~320k	~34k	~540k (of which 220k not nominal fields)
CMS:	~110k	~18k	~410k (of which 60k not nominal field)
LHCb:		~40k	~320k (of which ~3k with dipole off)
LHCf:			~6k showers

TOTEM: with T2: 34 k at 450 GeV, 10k at 2.36 TeV , with RP: 2k halo at 450 GeV

Estimated 2009 integrated lumi at 450 GeV

- Approximate numbers
- Absolute normalisation yet to be checked
- Mostly using comparison to results from MC generator (physics, assuming “known cross section”) combined with detector simulation (acceptance)

- ALICE 18 ub
- ATLAS 13 ub (stable) 22 ub (total)
- CMS 9.5 ub (quiet or stable) 16 ub (total)
- LHCb 6.7 ub (stable)



- In addition, some 10% of that at 2.36 TeV “quiet” beam (depending on expt)

Experience with spectrometer magnets (normal operation)

=> See Werner's talk this session

- ATLAS, CMS, ALICE and LHCb magnets were successfully ramped up with circulating beam at 450 GeV
  - small corrections applied
- Both beams ramped successfully to 1.18 TeV **with all magnets on**
- Magnet effects on beams are small (as expected) and seem to be well under control
- All requests by experiments were fulfilled (and even more...)
  - tried to carefully consider and plan a number of spectrometer changes (trying to balance operational efficiency with physics needs)

- What strategy for 2010 ?
  - how big an impact on operational efficiency if an experiment requests a change of magnet state ? (change polarity or turn off a magnet)
  - can this be done with stored beams ? (any energy ?)
    - a fortiori: can it be done in stable beams ?

Experience with spectr. magnets (abnormal operation)

A few undesired events or features in 2009:

- ATLAS toroids turned off unwillingly
- *All* magnets (but ALICE sol) turned off unwillingly (power glitch)
- ATLAS toroids current leads issue
- CMS solenoid cooling circuit problem
- ALICE solenoid vs dipole polarity set wrong
- Control of magnets possible from several control rooms...
- Magnet polarity currently not saved in LHC logging DB
- Official documentation (from experiments) for operation not readily available for all spectrometer magnets

Experience with spectrometer magnets: improvements

Short description/operational notes available now for all magnets

- See http://cern.ch/lpc under “Magnets of Experiments”
- Please comment ! (notes can be updated)

RBAC rules (Steve Page)

- Since dec. 4, 2009, ATLAS and CMS magnets:
  - RBAC allows only experiments to control (read access OK for others)
- Since jan. 11, 2010, LHCb and ALICE magnets:
  - RBAC allows only LHC operator to control while not in shutdown. If ALICE or LHCb need to operate, a temporary operator control can be granted on request.
  - Change of RBAC rights to be done manually this year. Link to machine mode in the future ? (to be further discussed)

Exp. magnets “fixed display” (Markus Albert)

- State, current (scalar & graph) and polarity of the six expt magnets,
  - CCM: LHC Control - LHC Fixed Displays - LHC Experiments
  - Is that enough ?

Spectrometer magnets: proposal for 2010 operation

Proposals

- Keep all 6 spectrometer magnets ON at full field from start 2010
  - during the ramp studies (3.5 TeV) and subsequent flat top studies
  - only turn off if difficulties arise
- Changing state of a spectrometer magnet:

  Change of state between fills *or during circulating beam* (at injection or at flat top) and, in that case, even with stable beams ??
  - are all knobs available ? what about step between I_min and off ?
- Show *signed* value of 6 spectrometers in a vistar (LHC-OP vistar ?)
- Add polarity in LHC logging DB (sign the measured current value ?)

see also my second talk on Wed.

NB: warm spectrometer magnets:

- if machine stop >24h, there may be requests from ALICE and LHCb to turn off their magnets for economical (ecological ?) reasons (so, even if no access to UX)

Experience with handshake

- In general, worked nicely for a “first go”

- Some room for improvements on handshake:
  - handshake not always completed, or two handshakes going on
    - causes troubles in some expts, sometimes even unsafe detector state
  - handshake state and Beam Mode not always compatible
    - coupling of handshake, sequencer and Beam Mode are not automated yet
  - expts not always responding to handshake in a timely manner
    - in most cases due to a real “teething” problem. Still, should not happen...
  - LHCf: injection inhibit via DIP not always received OK by LHC
  - LHCf was asked to update only on change (now implemented)

- Some room for improvements on PM analysis and treatment:
  - some times, PM events arrived at unexpected moments ?
  - some times, long wait for beam permits re-arm from expts
    - PM analysis when not required ? (e.g. during inject_and_dump)
    - caution here: even in inject_and_dump, detectors must monitor what is happening and stop injection if bad conditions detected
  - some expts felt a bit “in the dark” after a dump. Lack of info.

Handshake: proposals for 2010

Proposals

- Automatized report from CCC after PM trigger ?
  - CCC is only place where all PM data arrive
  - why dumped ? who dumped ?
- Respect “time-outs” for all handshakes (expts !)
  - if an expt exceeds an agreed upon time-out, it must change its state to PROBLEM automatically
- Reduce manual action in sequencer/handshake/beam_modes, increase automatisation
  - avoid incomplete (or concurrent) handshake(s)
- Full system dry run at start-up (LHC with expts)

Experience with online information: DIP data

- Good start, in general
- Vital for expts:
  - BeamMode , CirculatingBunchConfig , IntensityPerBunch
    BPMs , beam sizes
- Some room for improvement:
  - Beam mode manually set (occasionally: not properly set)
    - automatise in sequencer ?
  - Server for FastBCT (beam current) going down ...
    - Restart of servers/publishers seemed not so obvious
    - How to automatise this ?
  - DIP publication of nominally filled bunches (CirculatingBunchConfig) initially was not working, but then promptly fixed...
    - Still manual ? requires EiC's discipline to update properly ?
  - Sometimes a DIP server crash was not noticed for long time

DIP data exchange: toward 2010

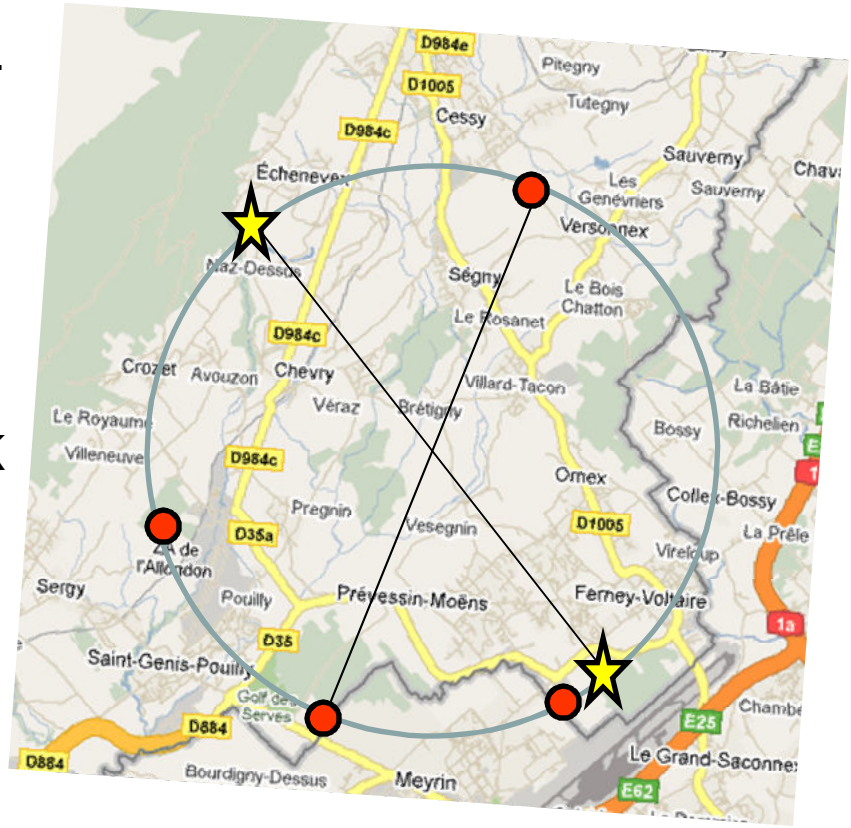
- Requests for additional info via DIP:
  - transv. beam emittances (from sync.light monitors and local optics)
  - bunch length
- Improving DIP server stability/reliability:
  - Implement a “heart beat” per server ?
  - Implement watchdog checking servers/clients supposed to be running ?
  - Improve documentation / instructions for restart of servers ?
  - DIP is not currently considered by IT as a critical resource. Perhaps this should be changed to request 24x7 interventions if required to maintain the service?
- Implement mechanism to allow expts to subscribe to each other’s DIP data servers

TO BE BETTER DEFINED AND AGREED UPON => LBS

Cogging and all that (behind the scenes...)

- At first, the crossings of buckets 1 were here...
  - Measured by 4 experiments using the beam pickups (BPTX), with single pass, single beam:

    DeltaT = -29.8413(1) us
- Cogging applied:
  - something like 11960 buckets of 2.4940786ns
- Verified with BPTXs & circulating beam(s): OK
- Fine adjusted: z_IP expected off by < 5cm
- Confirmed by vertex distribution!
  - z_IP ~ 1-2 cm clockwise



Special thanks to **Sophie Baron**, the "**RF guys**" and the **BPTX experts** in the experiments

- BPTXs proved to be a very useful tool:
  - ⇒ phase adjustment with rapid feedback (always on, <100 ps accuracy)
  - ⇒ check of bucket positions etc...

Experience with online information: clocks, phase and z_ip

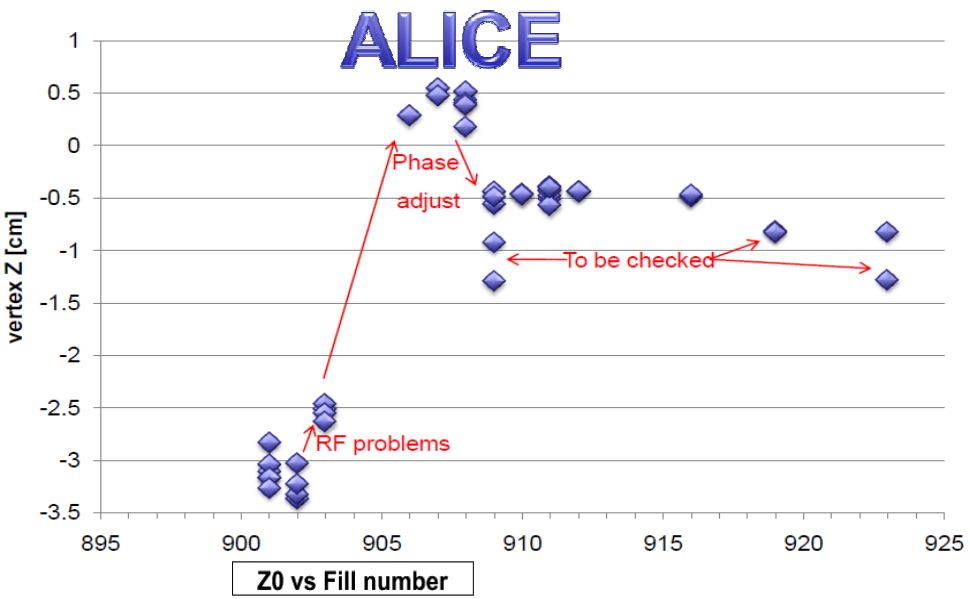
- This information exchange is important
- BPTX Delta_T from expts was added in DIP just in time for usage in 2009
  - very useful for phase monitoring
  - NB: if charge<5e9, no acq possible with BPIM board, no automatic publishing...
  - add this in FD per expt ?
- Tools developments (RF) for EiC/Operators in course of 2009 run?
- Resync: (expts wish to go to internal clock before a resync)
  - announced by phone and/or Page1. Improvement on this needed or not ?

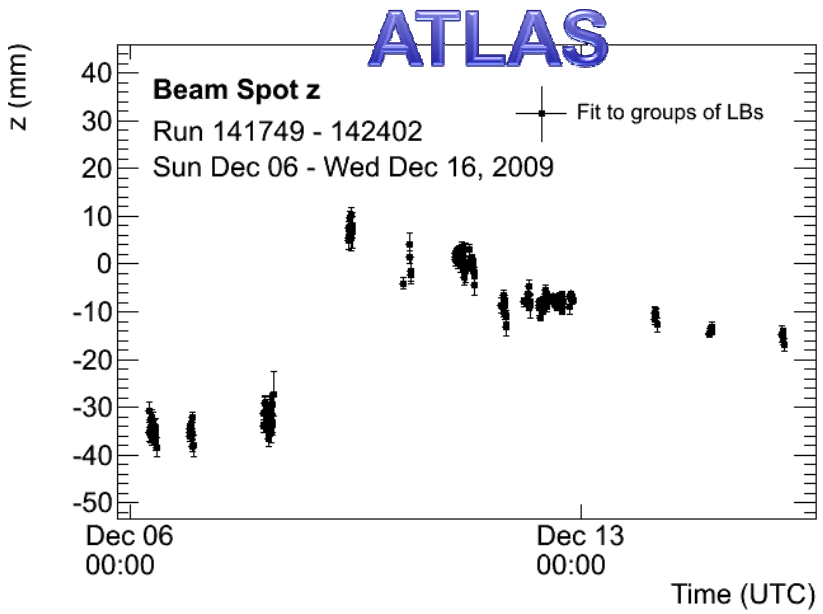
dedicated meeting in early Feb.

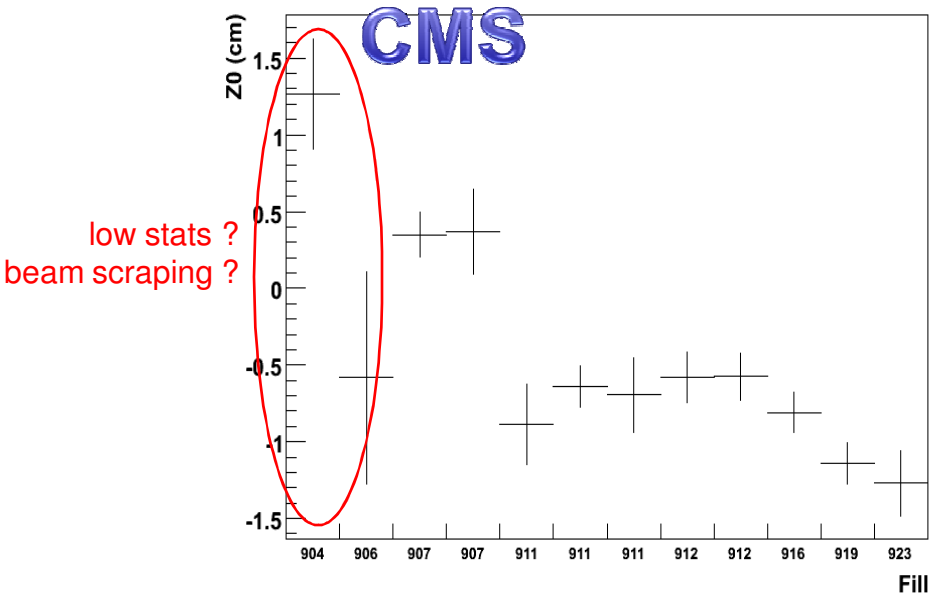
Clocks and phase: Outlook for 2010 ?

- no fixed BCREF clock yet, use either BC1 or BC2 => ok for expts
- NB: Expts can live with a z_ip displacement of up to ~1cm, but <5mm should be easily feasible
- In-run fine phase adjustments will be needed
  - in stable beams or not ?
- Tools for phase adjustement and monitor available to EiC/Operators ?
- Issue of “request for switching to internal clock” from CCC: expts should be disciplined and just switch to internal clock during agreed upon periods

Longitudinal position of IP (z_IP)







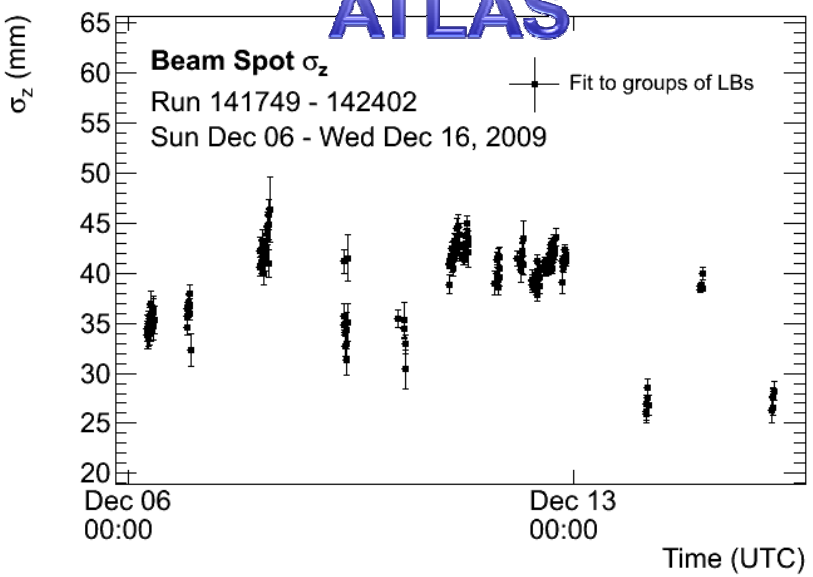
- coherent results
- to be compared with RF adjustments

Longitudinal size of beam spot (sigma_z)

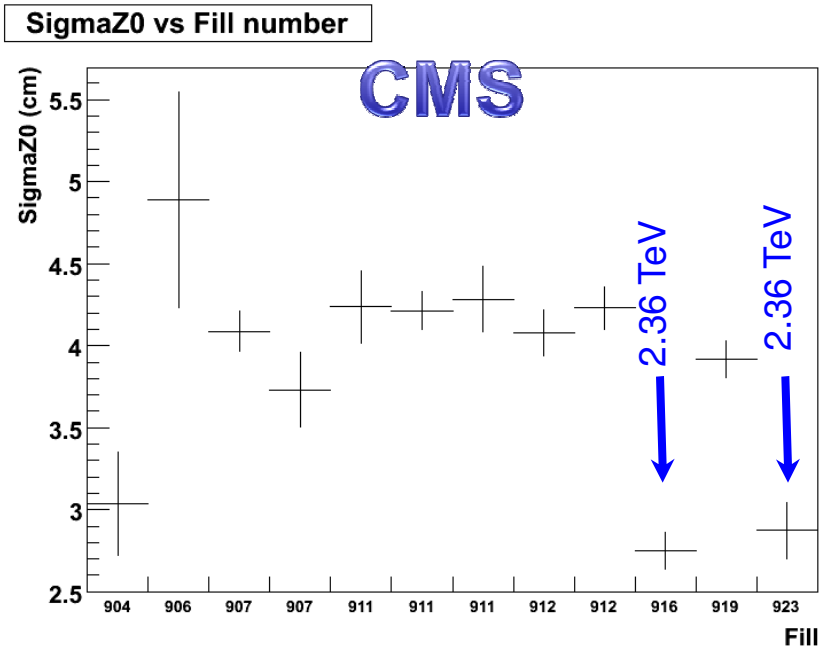
ALICE

Z	104030 - 104157	104321 (Full statistic)	104775	104800-104801	104452
SIGMA (cm)	3.7	4.4	4.3	4.5	4.1

ATLAS



CMS



LHCb

15 dec: 36 +/- 0.3 mm

- sizes substantially smaller than "nominal"
  - no problem at these lumis
- due to reduced long. emittance
- compare numbers!

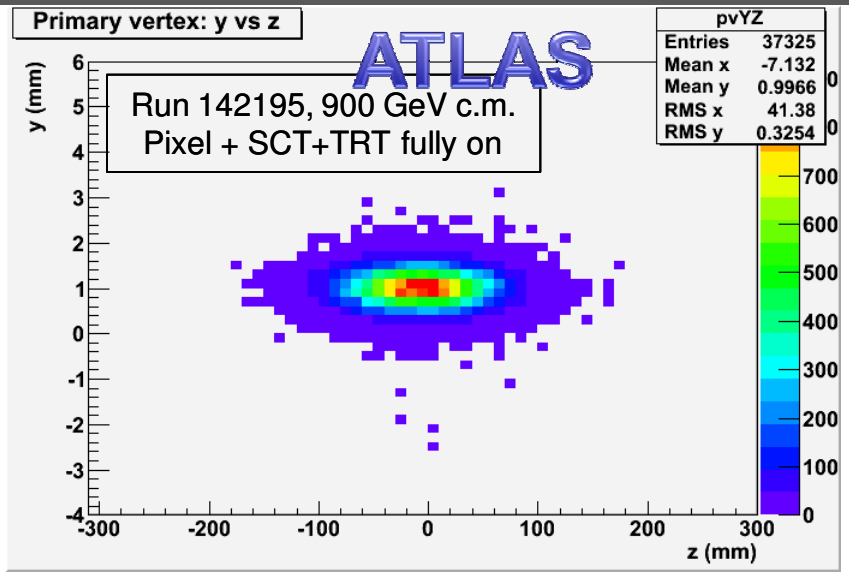
Transverse size

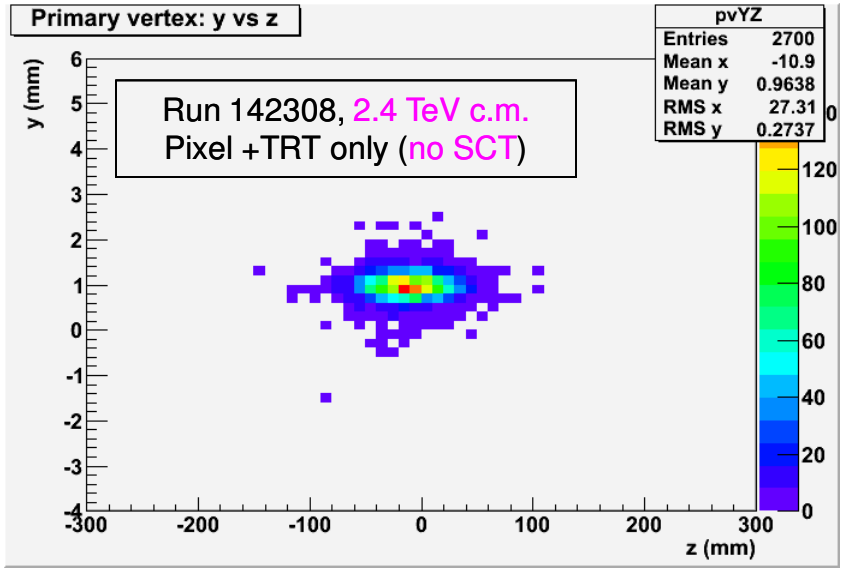
- Many results available (or being finalized) from the expts
  - see joint LBS-LPC meeting, jan. 18 2010: http://indico.cern.ch/conferenceDisplay.py?confId=77114

- Results to be compared with measurements of transverse emittances and beta*

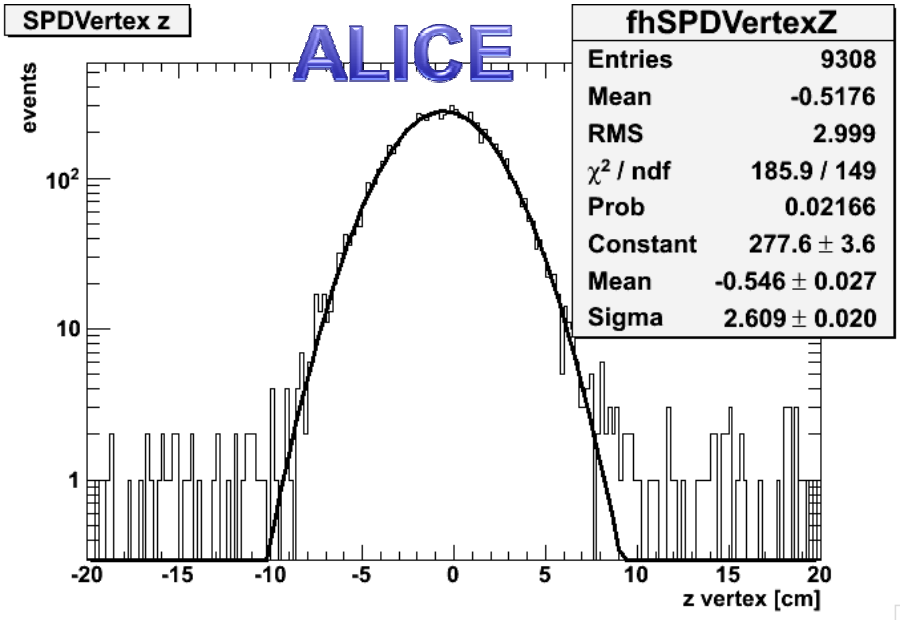
- ATLAS: observed growth (shrinkage) of y (x) size, by about 20% over 4 hours of a fill (12 dec, 13:30-17:30) TO BE CONFIRMED

beam spot: 900 GeV vs 2.36 TeV



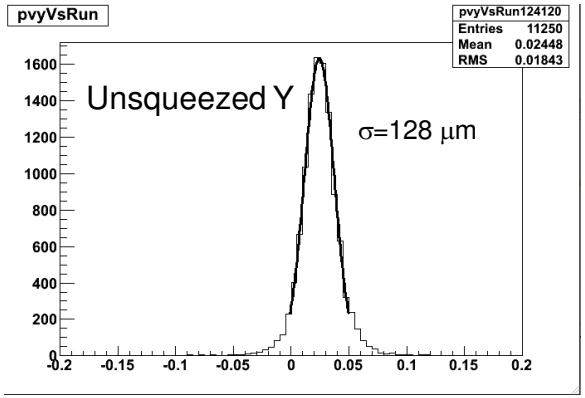


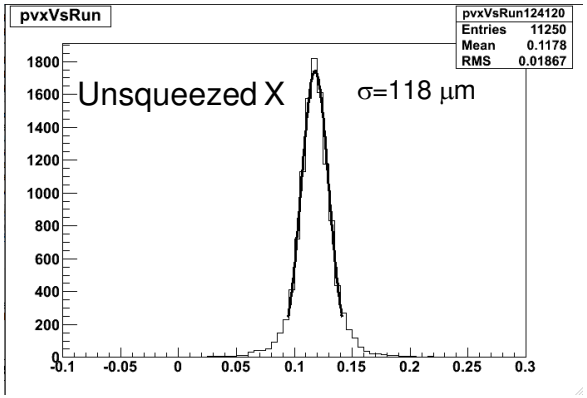
- CMS also around 27 mm in sigma_z

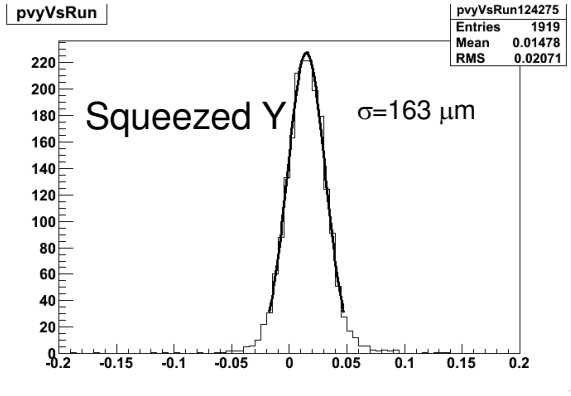


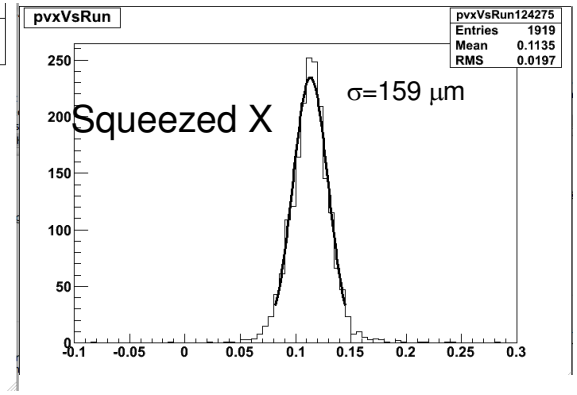
Squeezed beam spot ? (2.36 TeV) CMS

After reprocessing it looks like the size of the beam spot for the squeezed run is not smaller than the unsqueezed (2 independent analysis based on vertex fits and distant of closest approach confirm this)









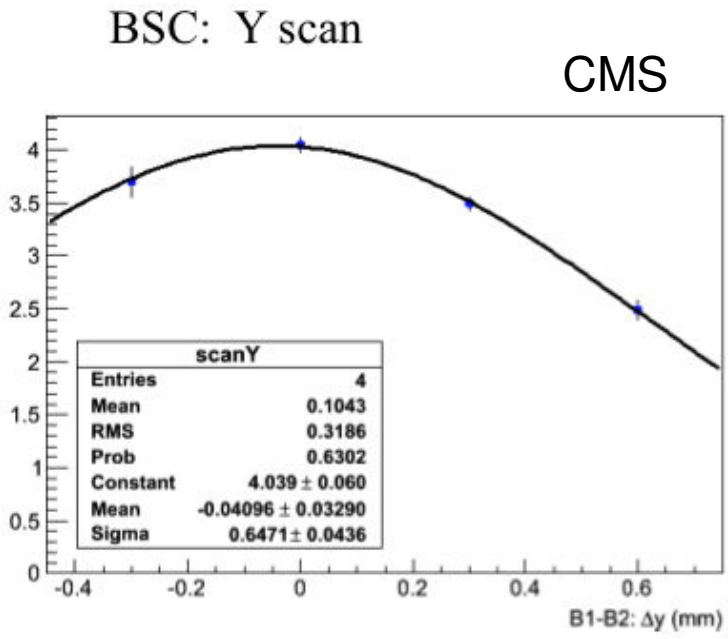
beam sigma should have decreased by factor ~0.8

emittance growth ?

Experience with (mini) transverse scans

=> See Simon's talk in session 2

- Transverse scans were very useful !
  - after adjustments based on BPM only, beams were off by typically +/- 1σ
  - mini scans increased rates by factor up to 3, depending on IP
    - IP1: ~ 1 (already optimal...)
    - IP2: ~ 1
    - IP5: ~ 3
    - IP8: ~ 1.5



- Important learning step for future lumi scans
- However, allowed windows were tight (needed to be adjusted, expert intervention...) and rates were marginal
  - should naturally get better at higher energies...
  - 2010: try to work with rates >10 Hz and larger windows (at least 4σ full range ?)
  - at top energy, after reaching some reasonable lumi, plan in the real lumi scans
    - expert needed ? or tools/instructions available to EiC ?

Experience with online information: Vistars

- Page 1 “LHC”:
  - some occasional collapse of server causing much increased phone load on the EiCs and operators
  - Maximum age of last post should be ~ 1 hour (better if less!)
    - was the case most of the time in 2009
  - Why not couple message posting to direct OP-elogbook entry ? (as a “Page1 msg”)
    - would avoid sometimes double typing
    - would allow tracking of messages posting
- Page 3 “LHC-OP”:
  - sometimes stuck as well
  - bkg numbers not trusted ? (hence, not looked at ...)
    - expts: sort out/implement normalisations
- Per expt FD: not yet all finalized (hence not deployed, not used)

Experience with offline information: filling schemes

- Used schemes in 2009 (in just a few weeks):
  - 1x1_a (IP1/5), 1x1_b (IP2), 1x1_c (IP8), levi's 505 (or 1x1_a')
  - 2x2_a, 4x4_a, 4x4_b, 4x4_c ...
  - 16x16_a
  - with <1e10 p/bch: used unshifted schemes
  - with >1e10 p/bch: used the shifted schemes (+1 pilot)
- The number of schemes "will increase..." (sic)
- Limitations due to abort gap window mismatch: in 2009, maximum acceptable filled RF bucket were 30986 (B1) and 30950 (B2).
  - Will be removed for 2010 ?
  - else it will impose more and more tortuous gymnastics as the number of bunches incresases...

Offline information: fill schemes, work for 2010

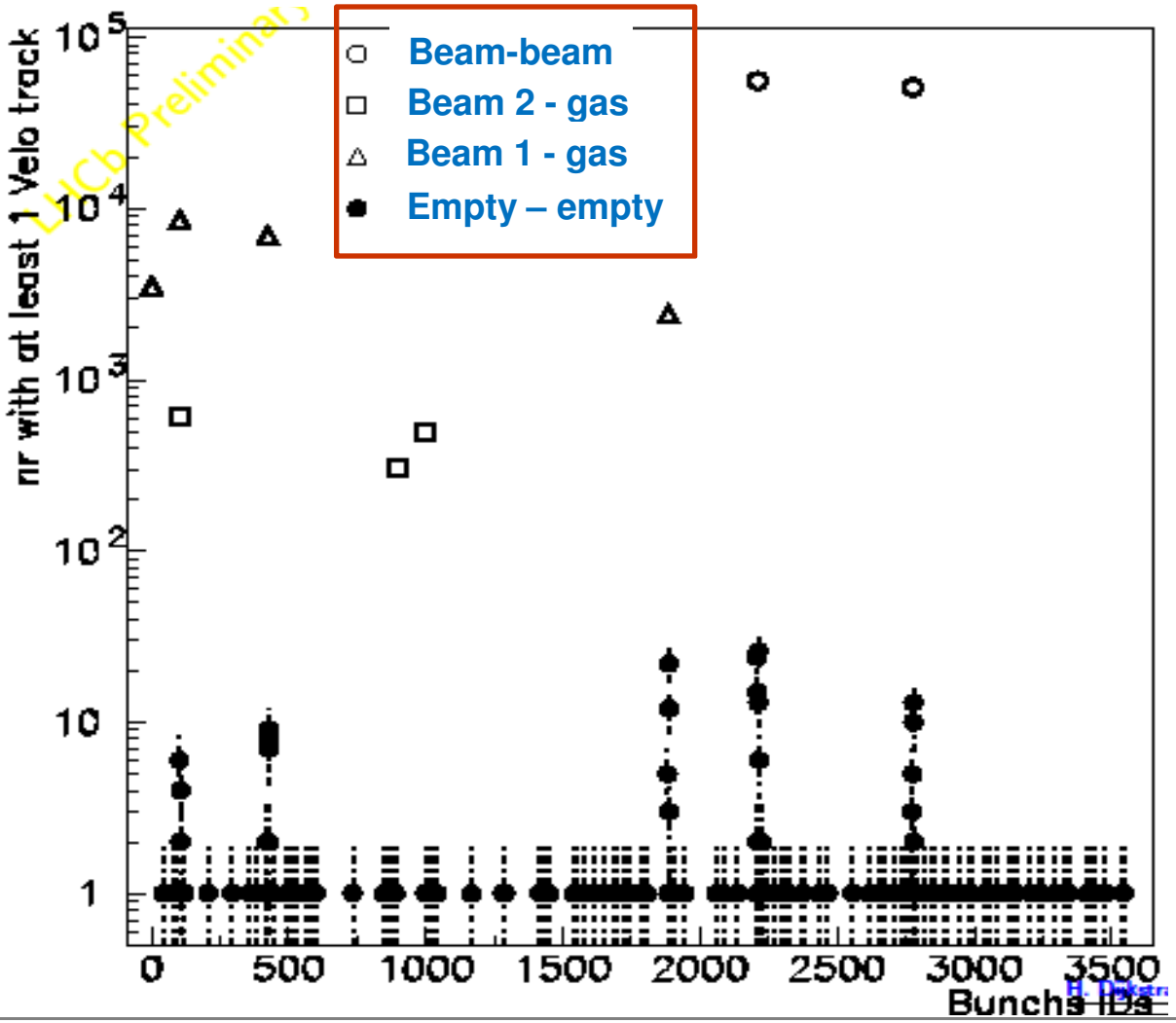
Giulia Papotti
& Delphine Jacquet
(and of course support from Werner Herr)

Proposal

- Develop nomenclature and documentation
  - define a naming scheme for fill schemes
    - ex (α=0): <num>x<num>_<ip15>.<ip2>.<ip8>_<codeletter>
      - 4x4_2.2.2_c , 16x16_8.8.8_a , 43x43_43.4.19_a
    - or ($\alpha \neq 0$): <num>_<spacing>ns_<ip15>.<ip2>.<ip8>_<codeletter>
      - 144_50ns_144.4.138_a , 288_50ns_288.4.276_a
    - name bijectively associated with a two-beam fill pattern (but independent of expected bunch charges ?)
  - publish current scheme name on Page1 and DIP => online info!
  - save fill scheme name to logging data base (like the fill number)
  - web site with list of defined fill schemes with more information, like
    - full list of filled RF buckets for each beam (with expected charge)
    - injector fill sequence
    - list of pairs crossing per IP (at collision point)
    - longitudinally displaced crossings inside IR (if any), with expected transverse separation

Note in passing: Ghost bunches@450 GeV (LHCb)

- Fill 907 - 912: Current in <empty – empty>/<beam 1 – empty> ~ 1.5 ± 0.1%
  - Detector timing checked



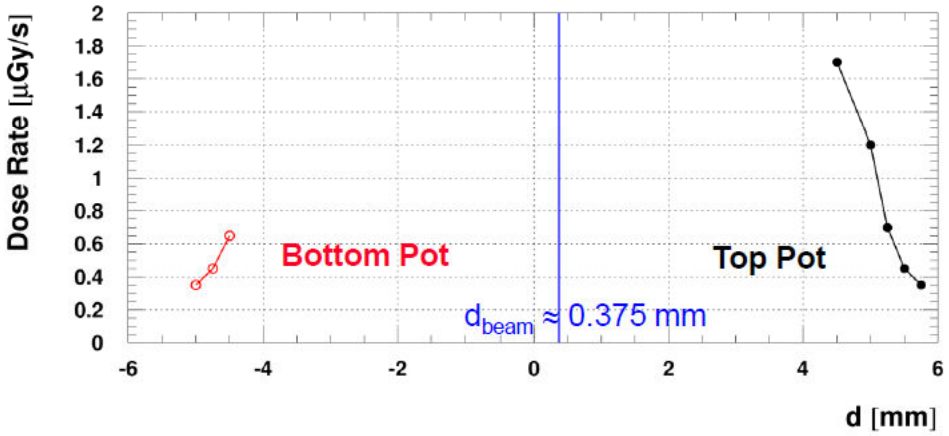
Also seen in SPS ?

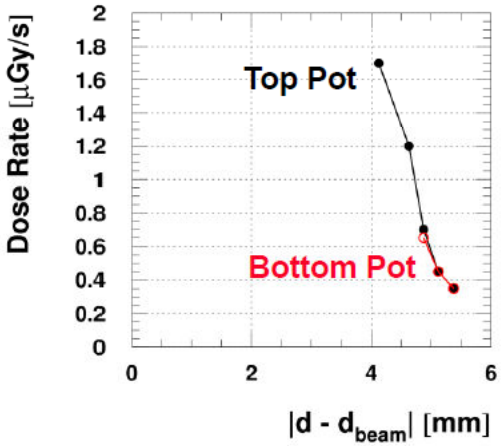
Alignment Studies by Scraping

Final procedure:
move top and bottom RPs toward beam in very small steps until first BLM spike
→ RPs at same normalised distance from beam centre as the collimators
→ absolute calibration between RP mechanics and collimators
and absolute calibration of BPM mounted on RP

work in progress !

Tentative analysis approach for the first data (step size 0.25 mm):
exploit the equilibrium BLM levels after the spikes as halo estimate





Beam position from this test: +0.375 mm
BPM measurement: -0.8 mm
(in agreement with global orbit fit)

} Discrepancy under investigation
(betatron beat ? mechanical offset ?)

During technical stop: new geometrical survey of RP + BPM, new motor calibration
Then: more scraping studies needed

Mario Deile – p. 5

Experience with offline information: tools for LHC data

- Reminder:
  - DIP is used for online info exchange and (rapid) online data retrieval in the expts.
  - No need to duplicate databases => expts do intend to use LHC logging DB for offline analysis => we should work together

- Important offline data:
  - beam positions at IPs, emittances, beta*'s
  - beam and bunch charges versus time: used for rates normalisation
    - remember: different bunch pairs collide in different IPs and bunch pairs can have quite different charge product !

- Are there tools for extracting the LHC data ? (script-based, for prompt or batch jobs)
  - now using timber (with many clicks...)

Experience with offline information: run stats and results

- Run measurements of beam parameters (important for expts):
  - xy beta*, xyz emittances, xy crossing angles, individual bunch charges
  - All vs time, whenever applicable
  - more ???
- Run stats and book-keeping summaries
  - hours of machine available, of beam available, of stable beams
  - delivered lumi (stable beams) per IP, per fill
  - more ???
- Who ? How ? In what form ?

LHC DB: archive centrally DIP data from expts ?
Proposal by Alick, to be discussed => LBS

Remarks in passing:

- fill number not updated at every fill... Makes cross comparison of experimental results more painful
- Can fill Nr be automatically updated in sequencer ? At every start of injection ?
- stable beam flag: HX:SMP1_STABLE and HX:SMP2_STABLE
- beam mode not saved in DB as an integer ? (code number for beam mode)

Exple: bch chge data from fast BCT 11 dec 2009 morning

Data from TIMBER

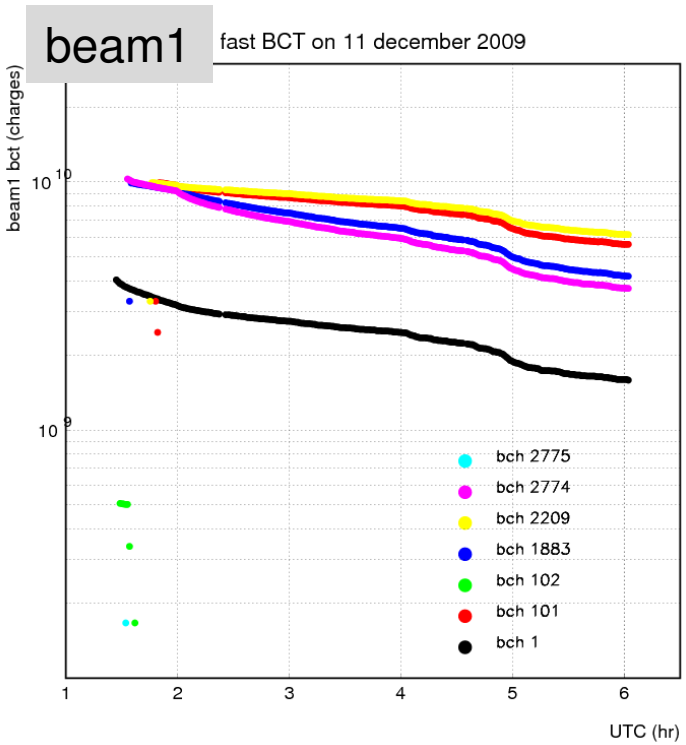
Expected 25ns buckets:

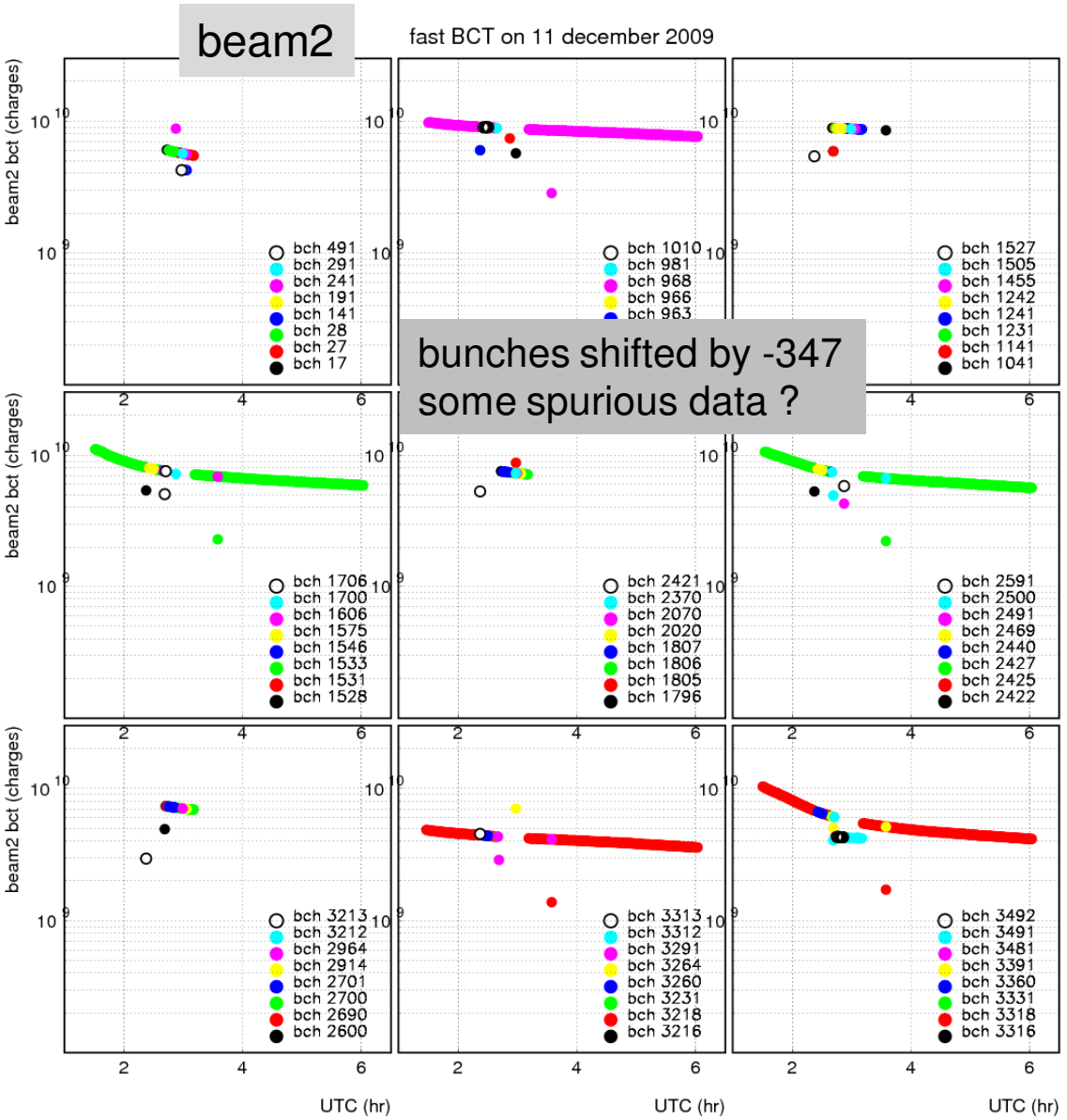
beam1: 1*-101- 883-2209-2774

beam2: 1*-101-1315-1880-2774

* pilot

=> Problems with beam2 data





bunches shifted by -347
some spurious data ?

Offline information: proposal

Proposal

- Per subject:
  - Analysis done by/with LHC expert (avoid duplication of work)
  - Publish data files with results in a central place for use by everybody: "official release" (can be versioned, if needed)
  - Complement with an LHC performance note

- A typical example: applies also to xy beta*, xyz emittances, xy crossing angles

  FastBCT individual bunch charges for 2009
  - calibration needs to be worked out (offsets ? scale ? non-linearity corrections ?)
  - some data are missing
  - some data are displaced (wrong buckets), needs to be corrected
- Natural to expect that a BI expert does this, but there are many eager clients for these data (some even ready to offer manpower for help)

Summary & outlook

- Very successful 2009 LHC run
- Identified some items where there is room for improvements
- A number of proposals made, to be further discussed (here and in the various “study groups”)
  - too long list for here...
- Wish an equally brilliant success with 2010 commissioning/operation