SPS Upgrade Proposals

Preliminary outcome of the Task Force on SPS Upgrades (TFSU)

V. Mertens
on behalf of the TFSU members

CERN-MAC, 26.4.2010

Outline:

TF mandate, organisation

Time frame for upgrades, motivation

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Recommendations, proposals

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Organisation:
The TFSU meets weekly (7 times so far + 2 joint mtgs with SUSG) + many side discussions

Thanks to:

The SPS Upgrade Study Team (SUSG)

The SPS impedance team

The contacted groups and individuals, including:
G.Arduini, R.Assmann, B.Balhan, M.Barnes, T.Bohl, J.Borburgh, F.Caspers, K.Cornelis, P.Costa Pinto, L.Ducimetière, M.Giovannozzi, J.-J.Gras, M. Gyr, W.Höfle, Rh.Jones, T.Linnecar, E.Montesinos, S.Rösler, I.Rühl, R.Steerenberg, Helmut Vincke

Apologies for any inadvertently missing or incorrect acknowledgements.

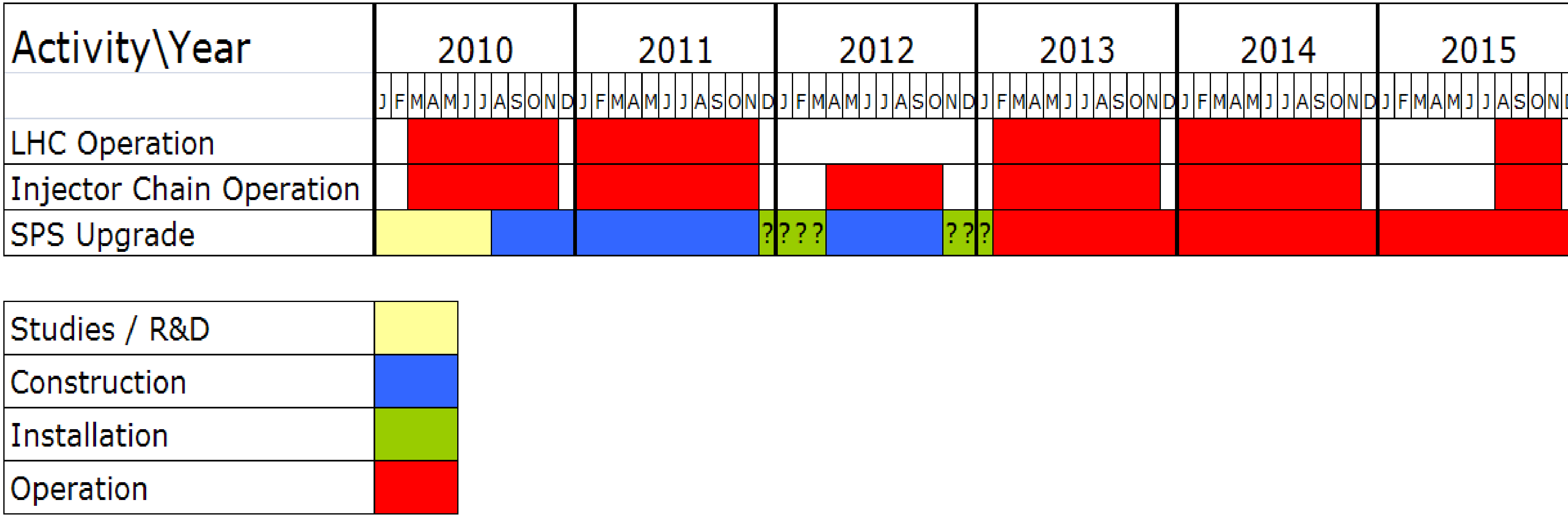
Mandate

Based on the work and results of the SPS Upgrade Study Group (SUSG) and in close collaboration with it the Task Force will:

- review the presumed most important hardware limitations in the SPS preventing it from delivering ultimate (1.7e11 p/bunch) and possibly higher intensities to the LHC;
- evaluate the relative merits of various technical approaches;
- identify areas where R&D on equipment and techniques are needed, and define development plans with the groups concerned;
- define beam tests to assess the feasibility and effectiveness of envisaged modifications, as applicable;
- propose further machine studies susceptible to increase the knowledge about the present and future intensity limits;
- propose hardware modifications required to overcome the limitations and compatible with the use of the SPS for the other physics programs, with cost and manpower estimates;
- propose action plans with time lines to implement these modifications, for different running/shutdown scenarios of the LHC and the injector complex; the work should be prioritized so as to mitigate against the most severe limitations in an evolutionary way.

The Task Force will be composed of members of the SUSG and experts from the different technical systems involved. Its membership may be adjusted as work proceeds, and also include outside experts. It will be assisted by an external advisory group, and report to the LMC.

<u>Indicative</u> time line:



Motivation:

Want possibility to go from 2013 onwards close to LHC design luminosity (“minimised collimation plan” [LMC49] is intended to allow nominal intensity by then).
Higher intensities needed early to probe LHC limitations and prepare counter-actions.
Need to provide flexibility in beam parameters, to see how to best operate LHC.

Time horizon for SPS upgrade was so far ~ 2018 (w PS2), with DR foreseen for 2011.
Need to speed up substantially now, and lift limitations much earlier.

Present and future SPS beams

Beam parameters		SPS at 450 GeV/c (maximum injected, after losses)					LHC ultim./+
		LHC	LHC	LHC	FT	LHC	LHC
Bunch spacing	ns	25	50	75	5	n.a.	25
Bunch intensity	10^{11}	1.2	1.2	1.2	0.13	**1.8**	1.9 (2.3)
Number of bunches		4x72	4x36	4x24	4200	1	288
Total intensity	10^{13}	**3.5**	1.7	1.2	**5.3**	0.02	5.5 (6.6)
Long. emittance	eVs	0.7	0.4	0.4	0.8	0.3	< 1.0
Norm. h/v emittance	µm	**3.6**	2.0* 1.1/1.4	2.0*	8/5	?	**3.5**

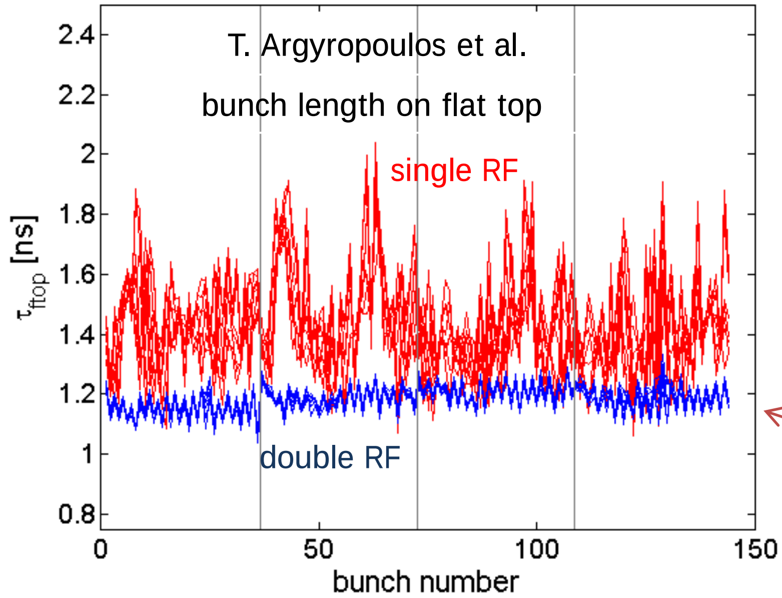
* single batch injection in PS

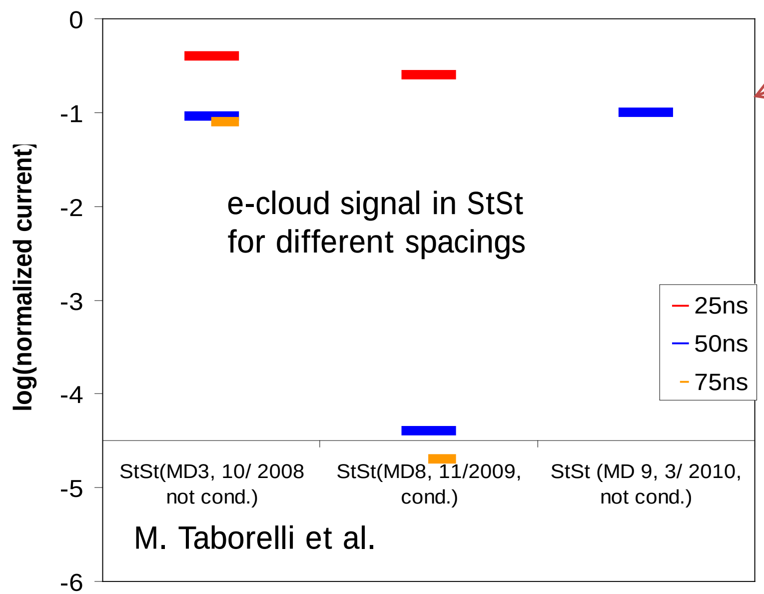
Intensity limitations (25 ns LHC beam)

Intensity /bunch	Origin	Leads to	Present/future mitigation measures
0.2×10^{11}	longitudinal coupled bunch instability due to longitudinal impedance	- beam loss during ramp - bunch variation on FT	(FB, FF, long. damper) - 800 MHz RF system - long. emit. blow-up → RF
0.3×10^{11}	e-cloud due to the StSt vacuum chamber (SEY=2.5, 1.3 is critical for SPS)	- dynamic pressure rise - transv. (V) emit. blow-up - instabilities - losses (via high chrom.)	- scrubbing run (→ SEY = 1.6) - high chrom. (0.2/0.4) - transv. damper (H) - (50/75 ns spacing) - a-C coating (→ SEY = 1.0)
0.5×10^{11}	not exactly known e-cloud + impedance (?)	- flat bottom/capture beam loss (10-15 %)	- (lower chromaticity) - WP, RF gymnastics - collimation to loc. losses
1.5×10^{11}	beam loading in 200 MHz RF system	- voltage reduction on FT - bunch phase modulation	- Feedback & FF - RF cavities shortening
1.6×10^{11} (?)	TMCI (transverse mode coupling instability) due to transverse impedance	- beam losses - emittance blow-up	- higher chromaticity - high voltage - high bandwidth transv. FB

E. Shaposhnikova

50 ns LHC beam





- small emittances (1.2×10^{11}/b):
  - transverse H/V:
    2.0 μm (single batch injection in PS)
    1.1/1.4 μm (double batch inj., E. Metral)
  - longitudinal: 0.4 eVs , 1.2 ns (FT)
    (stable in double RF system, BSM)
- small beam losses (< 5%)
- no e-cloud signal (only before scrubbing)
- 200 MHz beam loading limit: 3×10^{11}/bunch

→ For the same L single bunch effects become more important: TMCI, space charge (?), microwave instability (?)

Reminder: PS longit. limitation $\sim N_b/\varepsilon_L$
(H. Damerau et al.)

Situation in general

Complex interplay between effects, beam parameters, equipment properties.

→ Not straightforward to make precise predictions about the improvement supplied by each mitigation measure.

- Ongoing effort to understand + map impedance (simulations, measurements) – still not all known.
- Not everything can be entirely simulated (need to make assumptions, simplifications, single bunch vs. multi-bunch, …).
- Measurements (impedance, …) have errors.
- Beam studies sometimes hampered because of limited diagnostics and difficulty to compare between years (reproducibility of beam parameters, dependence on history of the machine: how long vented, which beam was used before, how much scrubbing was done, …).
- There might be unknown limitations which will only become visible once the known ones are lifted (some expectations based on scaling from present measurements).

Manpower limitations as well – to better assess the need, potential benefit and risk of certain modifications substantial study time is still needed, and the TF strongly advocates to allocate the necessary resources to support decision-making (manpower, money, and time for R&D, simulations, and MDs with high-intensity beam in 2010/11).

About the presented estimates …

The M, T, P resource estimates are **very preliminary** throughout ! They need to be refined and completed with profiles. Some of the estimates (only pre-studies, due to time available) have large error bars (> 1 MCHF) – even when made with the experience from other projects.

The convention for the specified time line was: Without “hard” reason (time to obtain civil engineering authorizations, mandatory prototyping phase, …) a planning is presented which is compatible with the given time frame. For some items the feasibility – technical + time-wise – needs to be confirmed with results from ongoing studies + R&D.

To respect the set time frame will require significant experienced manpower in the short term – its availability (through re-prioritising other work, optimal phasing of activities over time, external help, …) has not been addressed to this point.

Simultaneous high work load from concurrent activities (upgrades, other projects, consolidation, …) can generate additional resource needs (material, manpower) for specific teams (e.g. transport, radioprotection, vacuum, …) – this has not been taken into account.

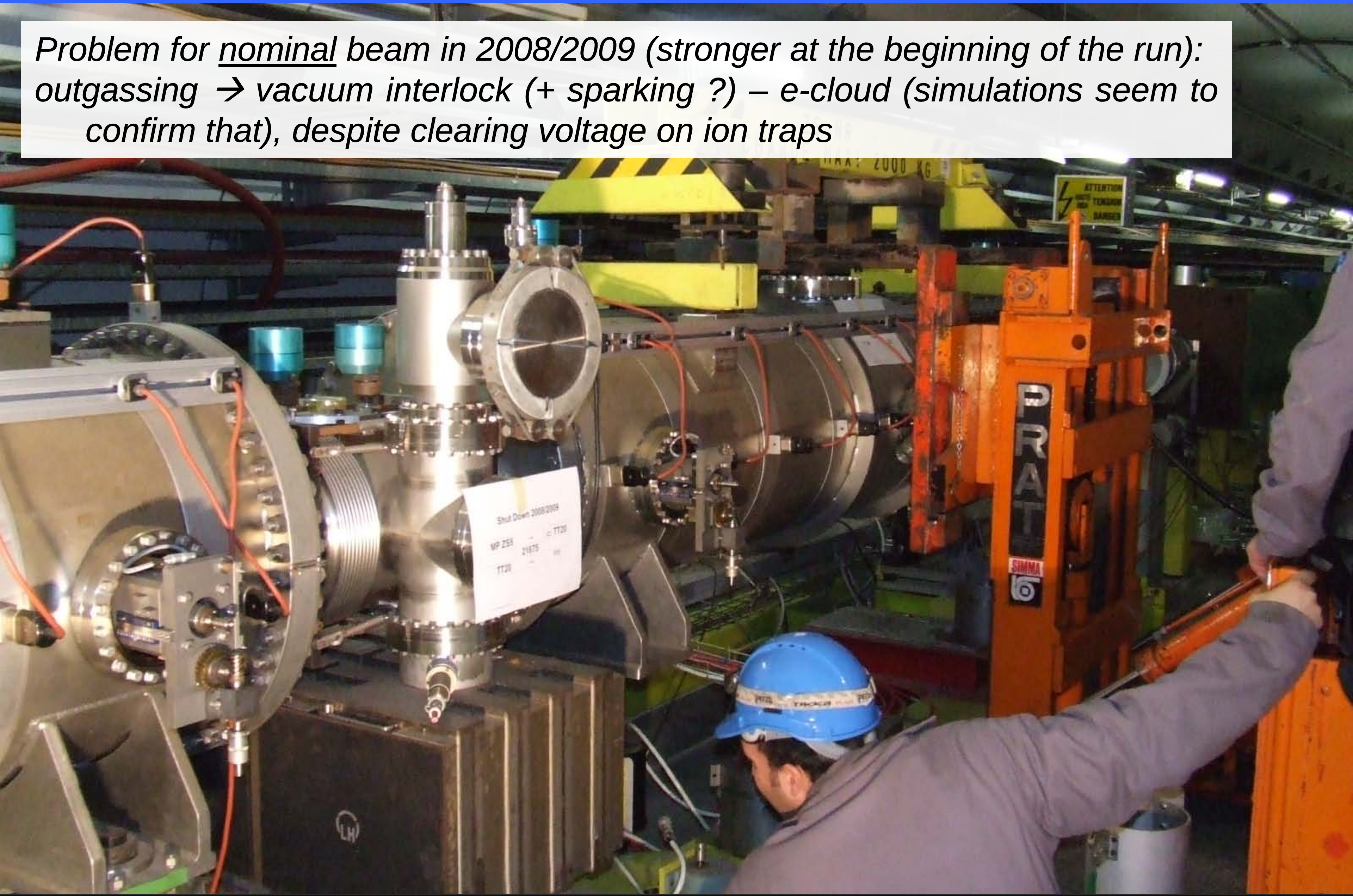
For some items the resource needs depend strongly on the adopted option and parameters. Depending on the general directions taken (e.g. the way and rate of coating) and various boundary conditions (concrete resource situation, concurrent workload for specific teams, external contributions, workshop space, …) the most appropriate option(s) need to be re-elaborated in detail, and the optimisation potential exploited.

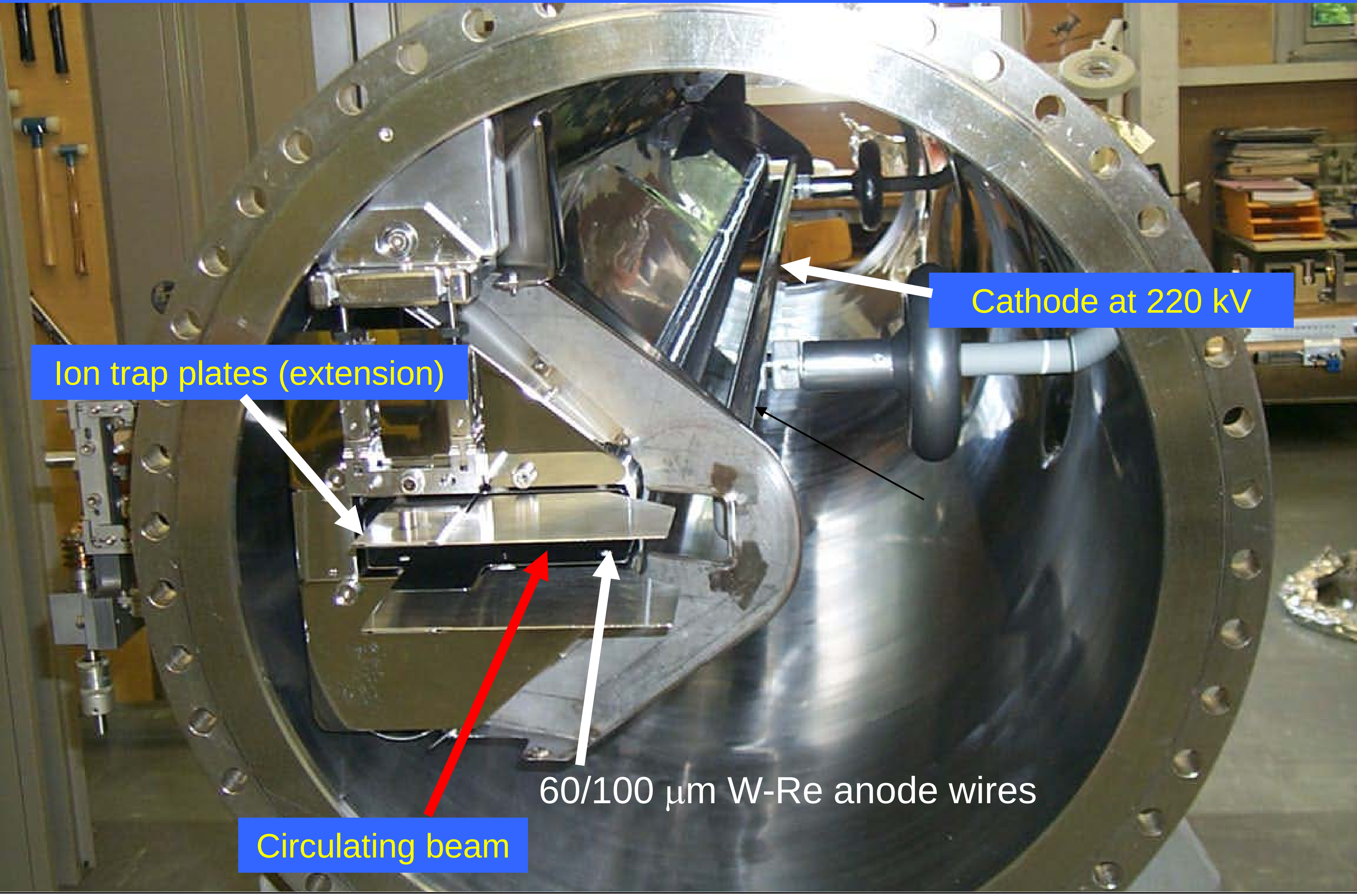
Situation/proposals for:

ZS
e-cloud (coating)
Beam loss
Collimators
Impedance
High BW feedback
200 MHz RF
Beam instrumentation
New dump system (?)
New extraction kickers (?)

ZS (electrostatic septa) with pumping modules, LSS2

Problem for <u>nominal</u> beam in 2008/2009 (stronger at the beginning of the run): outgassing → vacuum interlock (+ sparking ?) – e-cloud (simulations seem to confirm that), despite clearing voltage on ion traps



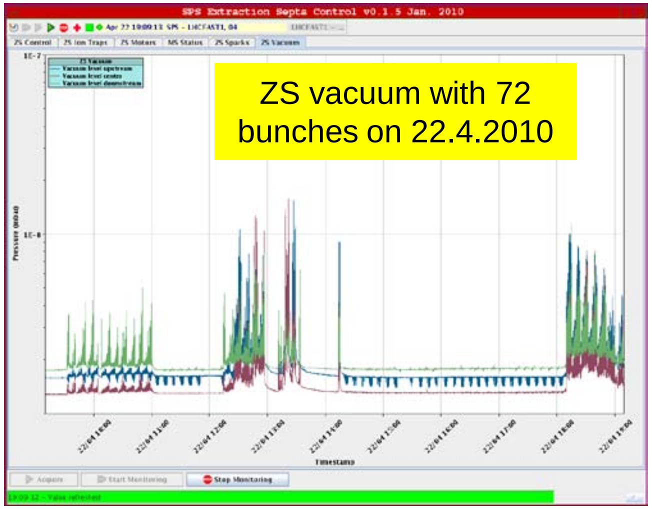

Cathode at 220 kV
Ion trap plates (extension)
60/100 μm W-Re anode wires
Circulating beam

ZS - proposals

B.Balhan
J.Borburgh
B.Goddard
K.Cornelis

ZS very performant and delicate devices.
Need further insight before applying potentially risky techniques.

- Intensify MD studies (imminent !), study dependence on beam parameters, assess impact on LHC production beam
- Launch e-cloud (first round done – G.Rumolo) and impedance simulations
- Measure ZS and pumping port impedance
- Install test bed of 2 ZS in LSS6 (in SD 2010/11, if sufficient time) and continue studies on these
- Apply modifications identified as found useful in tests:
    - o improve ion trap supply circuitry ?
    - o add more direct measurements
    - o improve ZS tank shielding ?
    - o shield inter-ZS pumping modules ?
    - o test solenoidal field ?
      (simulations show 30-50 G are efficient, but can cancel effect of ion trap voltage (G.Rumolo, SUSG, 22.4.2010))



Time line: **2010-2012**, cost (incl. shielded TPSN): **0.3 MCHF**, staff manpower: **1.4 m-y**
Complete new ZS development not considered here.

e-cloud mitigation

Active damping system in V plane (W.Höfle et al., US-LARP collaboration) → *see below*
- o feasibility (instability growth rate, frequency, large bandwidth)
- o incoherent effects (emittance blow-up)

Clearing electrodes all along the beam pipe (F.Caspers et al.)
- o fixing (needs 600-800°) → magnet opening
- o impedance, aperture ?

Altering the surface exposed to the beam – requirements:
Low SEY (1.3 is critical), no activation needed, no long outgassing, no ageing, no aperture reduction, …

• Coatings (M.Taborelli et al.)
- o amorphous carbon (a-C), SEY < 1 – considered "today's best offer"
- o "microscopically rough" surfaces – 2 step process, more studies needed

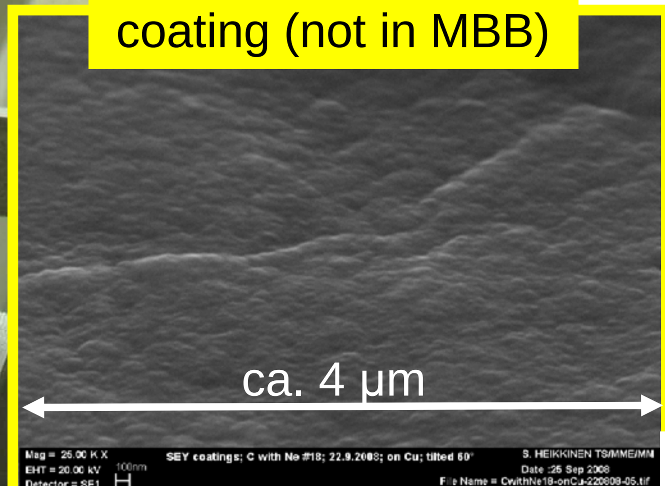
• "Grooves" (M.Pivi et al., SLAC collaboration)
- o manufacturing, aperture, impedance, vacuum

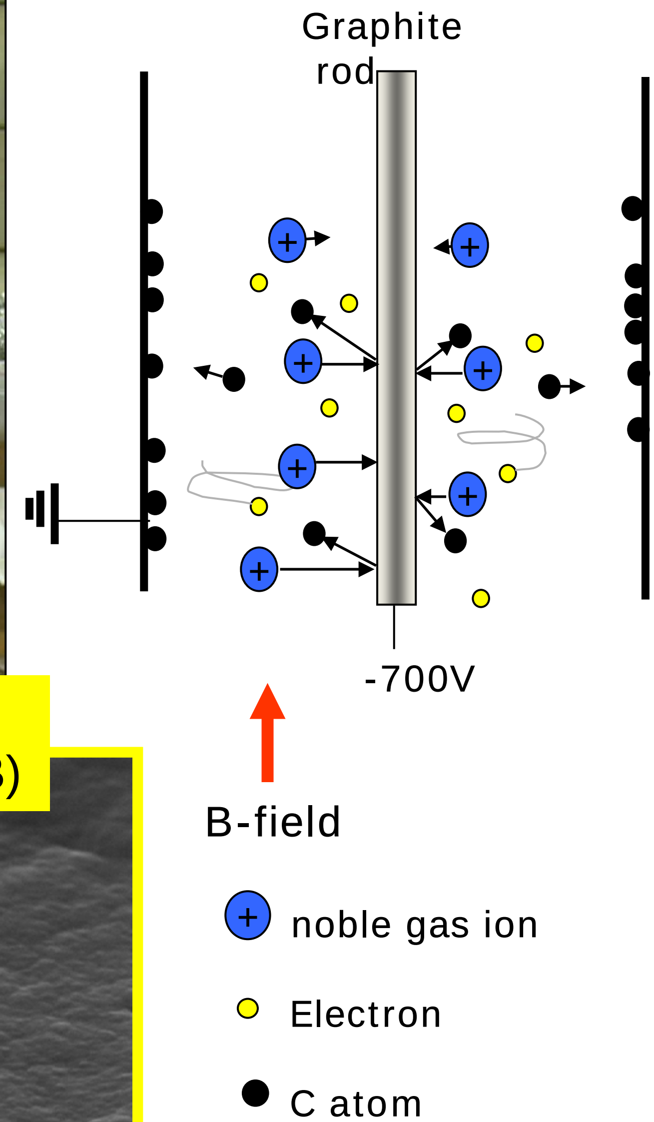
If aperture reduction allowed → more options possible
e.g. NEG coating as in LHC – requires activation 24 h at 180 , heating/insulation layer (3.7 MCHF + 0.5 MCHF/yr), higher vacuum sectorisation, no more "simple venting", …
Re-investigate potential/impact of higher inj. energy for FT/CNGS beam, lower γ_T …

Coating vacuum chambers

dipole coating test bench

SEM image of coating (not in MBB)

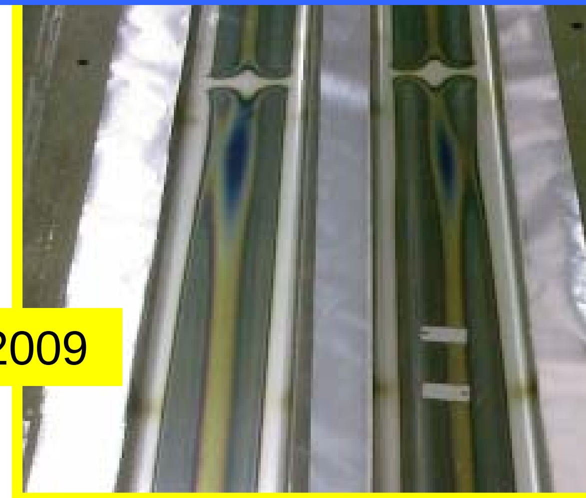




thickness 50 – 1500 nm

a-C coating tests, proposals

Since 2008: Experimental setup in the SPS (4 e-cloud monitors)
-no ageing after venting and beam exposure for “laboratory coatings”
Since 2009: 3 (now 2) MBB magnets coated using their dipole field
- no e-cloud signal (microwave transmission)
- outgassing, no reduction in pressure rise
- some ageing (SEY = 1.3)
- quality ? →



MBB chamber tested in 2009

Statements collected (for a-C coatings done so far):

Can in principle confirm absence of e-cloud in coated magnets
Yet tests presently not fully conclusive (beam + venting history ?, lack of refer. measurements, …)
Not sure about the quality (normally the coating sticks well; a 1 cm^2 flake came off once)
(work done in a rush, with little resources; could do better after more R&D)
Not sure about ageing/long-term behaviour (ok for > 1 yr in e-cloud monitor)
Not sure about impact for ions (test in May in Linac3)
Not sure about impact from heating during coating process on nearby magnet coils
(could cool the coils with water but not good for coating result)

Proposals (short-term):

Continue R&D with more manpower, help from external experts
Coat small section (4 magnets) in good conditions (lab.) + install w comprehensive
diagnostics in summer 2010 (?) (2 w/o air exposure = “ideal”; 2 w air exp.)
Do int. MD studies in remainder of 2010 as basis for decision in late autumn 2010
Elaborate in detail how to apply coating to large series, with optimisation

Coated new MBB profile

Large-scale coating – 2 specific proposals

The following bulk action is not recommended before the previous steps !
Lots of options and parameters (where to coat, how many benches, how many shifts, split over shutdowns, …), with strong impact on cost + time line – constraints (space, time available) to be checked out, as well as logistics details, radiation, safety aspects, ….

J.Bauche, D.Tommasini

744 MBA/MBB to coat
Not included: preparatory R&D + qualification effort, radioactive waste treatment
Not included: 216 quadrupoles (using pre-coated replacement chambers), pumping ports, …
Not included: other consolidation work (water manifolds, coil repl.), ideally done in combination

A) a-C coating (single-layer) of chambers inside magnets: **for 2013, 4.2 MCHF, 13 m-y**
Assuming 8 magnets/d, 800 m^2, 2 shifts, incl. ramp-up/-down → 26 wks (+ 4 wks for "split")
Not so well controlled process (cleaning, sputtering) + radioactive cleaning waste (liquid ?)
B) a-C coating (single-layer) of new chambers: **for 2015, 17.3 MCHF, 25 m-y**
Assuming 8 magnets/d (as of 2012/13 or later), ~2500 m^2, 2 shifts
Implies opening of magnet (is done on ~ 15 magnets/year), but overall better result
Needs magnetic measurement/adjustment – how far will the machine be different afterwards ?

With A) doing the whole machine for 2013 is not excluded (**but t.b.c.**) – certainly a "crash program"
Prediction is: at least 2-3 sectors need to be coated to see an effect on the beam

Recommendation from VSC team to preserve quality of coating is
to blank off coated parts during interventions + do rough pump-down (1e-2...-3 mbar)
*) a-C can be removed "without traces" by plasma etching in O2 atmosphere (reverse process)

Relative beam loss (flat bottom + capture) increasing with intensity
- understand origin of beam loss (needs more MD and simulation)
- e-cloud mitigation (coating)
- impedance reduction (after identification)

Collimation system:
- Presently only a scraper in LSS5 (already problematic for single bunches)
- Most large accelerators have a collimation system: Tevatron, RHIC, …
- Main motivation (not only for LHC beam): loss and radiation localisation (less irradiation around the ring, higher components lifetime + easier equipment maintenance elsewhere), passive and active machine protection, help control beam quality during the cycle, more “contained” scraping, …
- Recommendation: make study, taking into account future intensities, # of cycles, loss assumptions, make radiation analysis, look at maintenance scenarios.

- Idea: classical 2-stage system - total of 9 + 1 spare p + 1 spare s = 11
- Jaw speed ~ 5 mm/s (LHC: 2 mm/s); 5-10e5 cycles/year (LHC: 30 k over lifetime !)
- Cost (ballpark figure) = **4 ± 2 MCHF** (incl. additional sector valves, bake-out gear)
- Simulations already set up (since benchmarking LHC collimator prototype in SPS)
- System could be ready (assuming manpower) for use in **2013**
  (could be installed in steps, as collimators get ready)

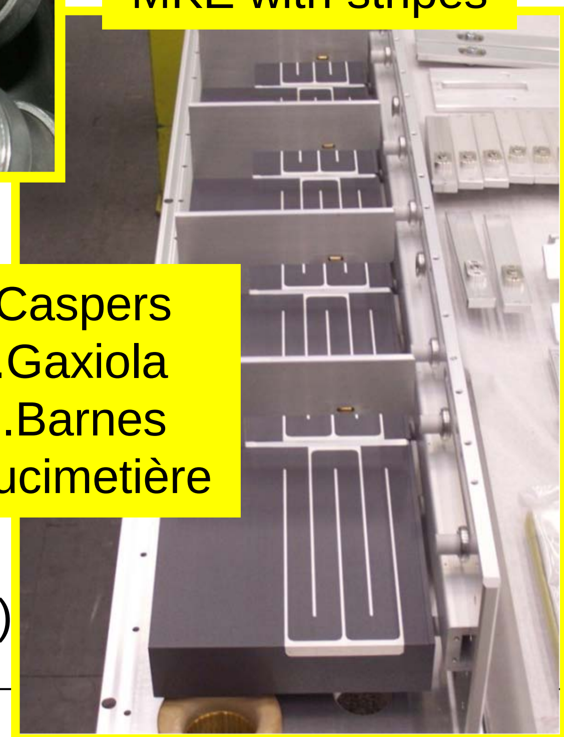
R.Assmann

Impedance – situation and proposals

Reduce known high impedances (leading to loss of Landau damping, eqp't heating)

- Fast extraction kickers MKE: serigraphy – 3 done, 5 last in 3 next longer stops – transverse impedance issue – new design ? *(see below)*
- Beam dump kickers MKDV, MKDH:
  - complete transition pieces between magnet and tank (heating, outgassing)
  - MKDH uses laminated steel yokes – new dump system ? *(see below)*
- 800 MHz TW cavities: active damping → new FB and FF (2011)
- 200 MHz TW cavities: reduction by 20 % when modified *(see below)*
- Enameled flanges ?

  Check how many still around …



F.Caspers
E.Gaxiola
M.Barnes
L.Ducimetière

Search for unknown impedances:

- transverse (broad-band and narrow-band):
  only 60% known → TMCI
- longitudinal (narrow-band - HOMs)
  → coupled-bunch instability
- Continue and intensify simulations and MD
  to better localise impedance sources
- Foster systematic modeling + simulation of machine
  elements ("impedance catalogue")
- Continue measurements of hardware elements (as possible)

W.Höfle et al.

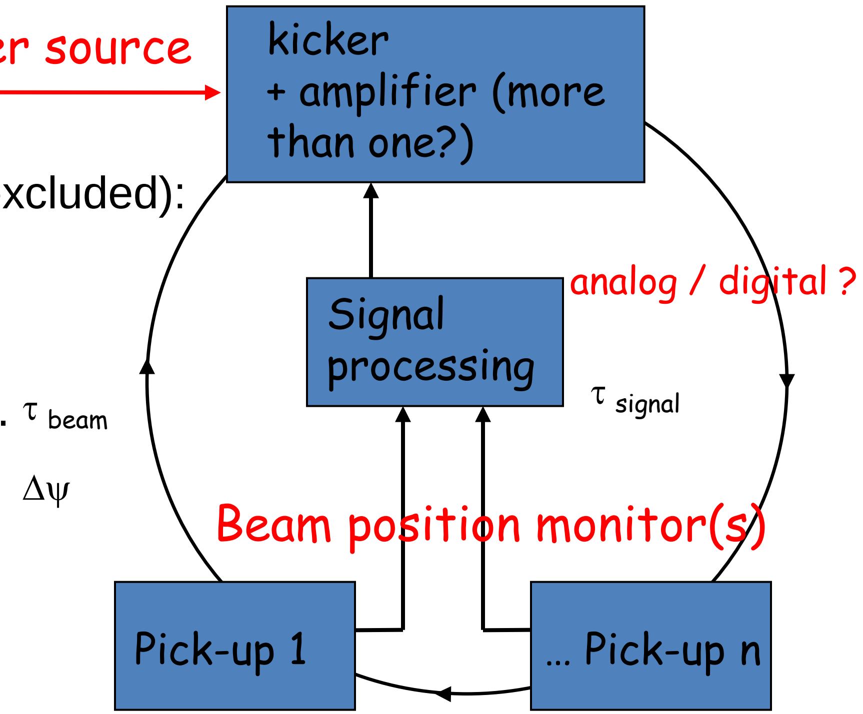
New high-bandwidth transverse feedback system

Ongoing collaboration (US-LARP)
Initiated against e-cloud –
extended to look into single-bunch TMCI

Maybe difficult for e-cloud (although not plainly excluded):

- Emittance growth possibly dominated by incoherent effects which cannot be damped
- High power needed due to fast growth rate
- Delicate adjustment of phase delays during accel.
- Possibly mix-up with longitudinal motion if bunches are not stable longitudinally

"Cautiously optimistic" for TMCI:
700 – 800 MHz bandwidth
Needs high-precision pickups and stripline kicker,
Fast signal processing, kW solid state amplifiers, …
First measurements done with existing PU
Simulations done for e-cloud instabilities at fixed energy

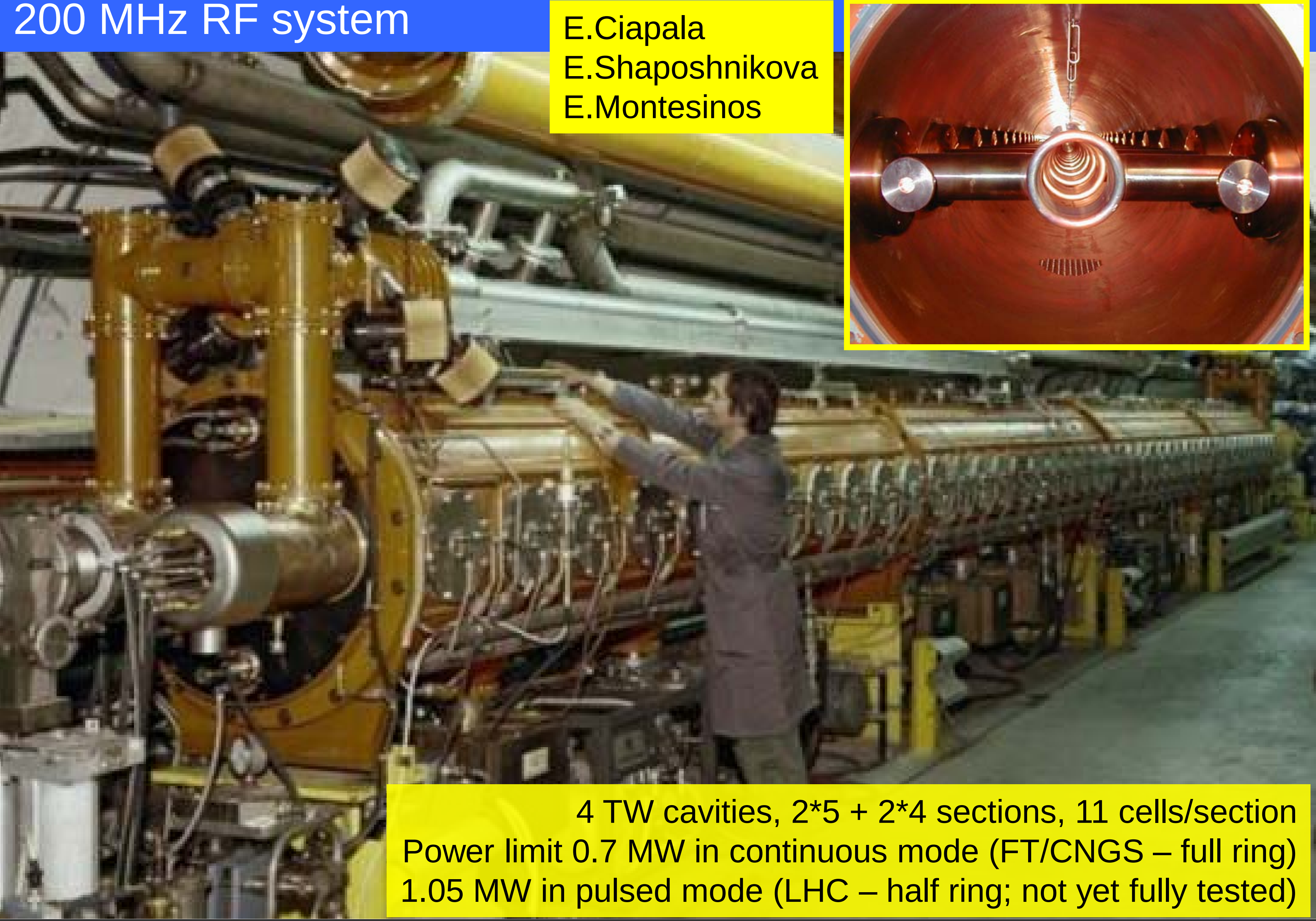


Looks interesting – might remove or delay need for other measures if could be made to work but requires manpower-intensive R&D and studies (TMCI) – big step up needed to advance

"Aggressive" timescale (if manpower available): ready for use in **mid 2013**.
Very preliminary cost estimate : **1.8 MCHF** (w/o corrector system, assuming installation in Pt 3 (preferred, else more infrastructure work and cabling), w/o US-LARP part)
Very preliminary manpower estimate: **5 m-y** (w/o US-LARP part)

200 MHz RF system

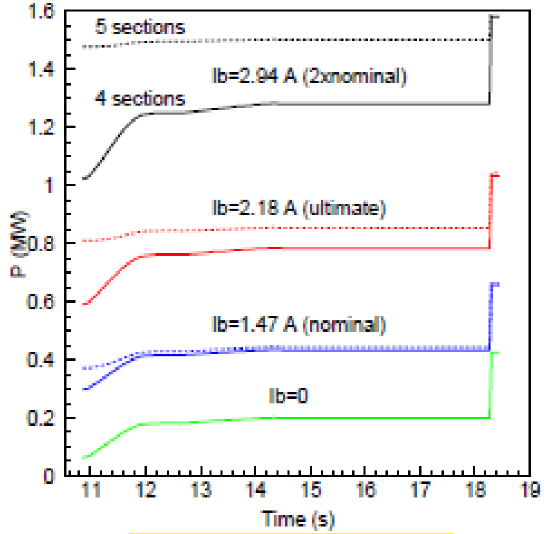
E.Ciapala
E.Shaposhnikova
E.Montesinos



4 TW cavities, 2*5 + 2*4 sections, 11 cells/section
Power limit 0.7 MW in continuous mode (FT/CNGS – full ring)
1.05 MW in pulsed mode (LHC – half ring; not yet fully tested)

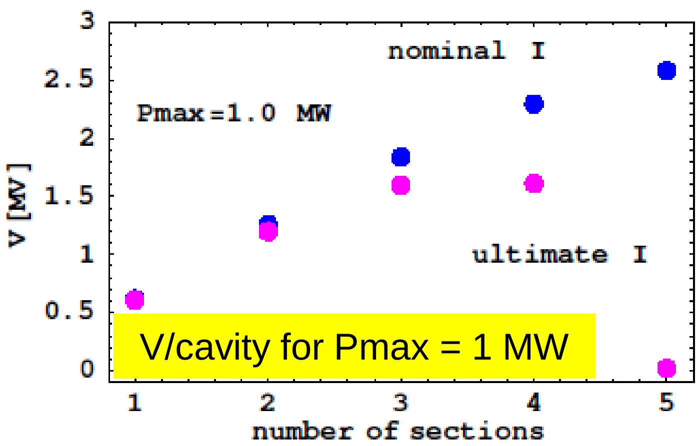
Instability threshold (during acceleration) for bunches with small long. emittance ~ 1/5 of nominal
Counteracted by FB, FF, dampers, 800 MHz + controlled emittance blow-up 0.42 → 0.65 eVs

If larger emittance needed for higher intensities (to keep beam under control) → problem to transfer to LHC 400 MHz system
(total RF voltage needed > voltage limit (8 MV))

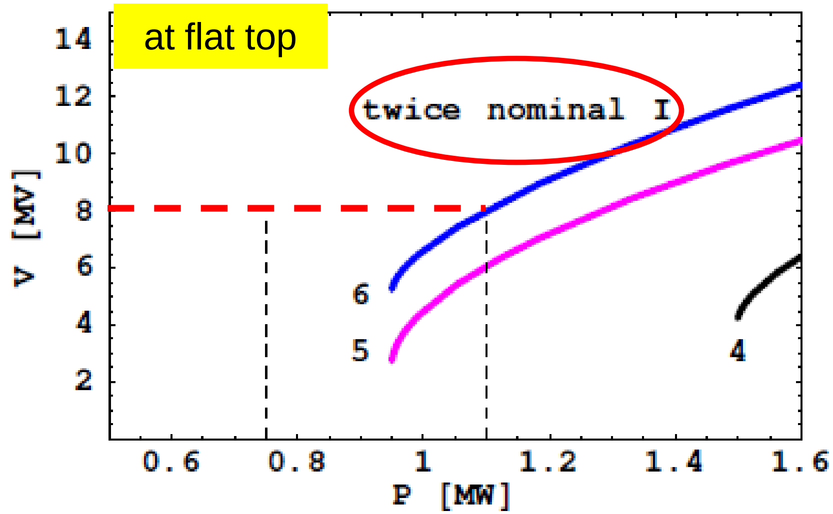


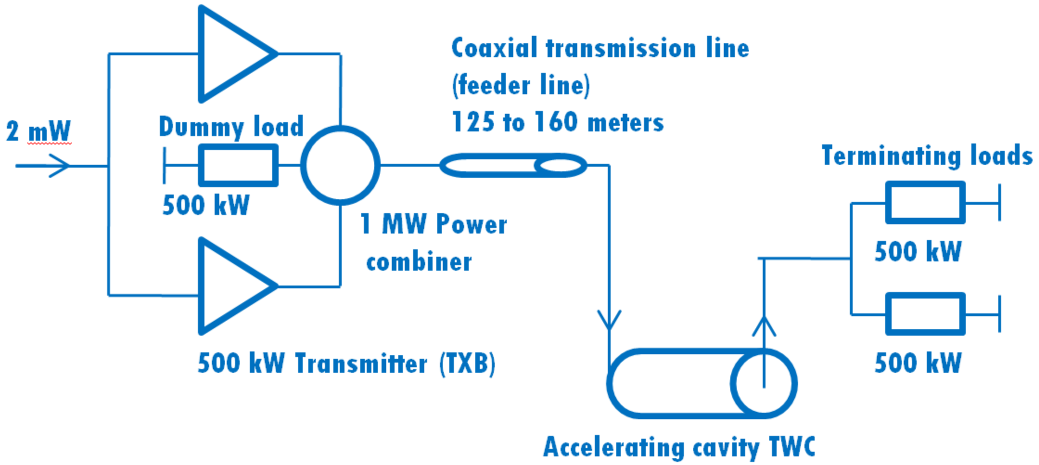
LHC cycle
7.5 MV at flat top

2 possibilities:
- Install 200 MHz system in LHC (higher impedance, no access during operation, reduces reliability, still need to transfer to LHC 400 MHz)
- re-arrange SPS 200 MHz system
(e.g. 6 cavities of 2*4 + 4*3 sections, using 2 spare sections)
+ additional power plants 2*1.1 MW peak power
(will also reduce impedance (!) by ~ 20 %)
Assuming 6 cavities with 1.1 MW peak power each --> 8 MV at flat top for 2 x nom. beam



More cavities give also a significant improvement for FT/CNGS beam which is presently at voltage/power limit.





Some BIG work: ~ **26.3 MCHF**, **10.5 my**, but technically quite straightforward.

If launched now could be ready for **2015**.

Work not reasonably stageable.

Preferably at Point 3, otherwise additional infrastructure and cabling work
Timeline dominated by CE study/authorisation + building construction

present feeder lines

Rh.Jones, J.-J.Gras

Beam instrumentation

BI most likely no real limitation, but improvements could help to better diagnose/localise limitations

BPM:

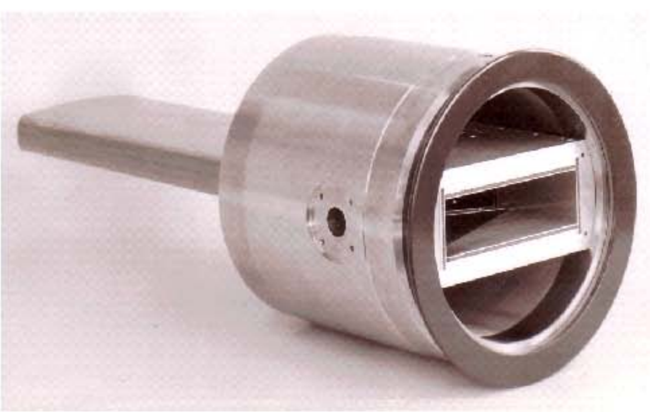
• Renovation of MOPOS electronics + software already approved and budgeted under the existing consolidation project (1.2 MCHF, 7.5 my up to 2013).

• <u>Recommendation: </u>The future beam requirements (LHC + other) should be updated and included in the Functional Specification for this system.

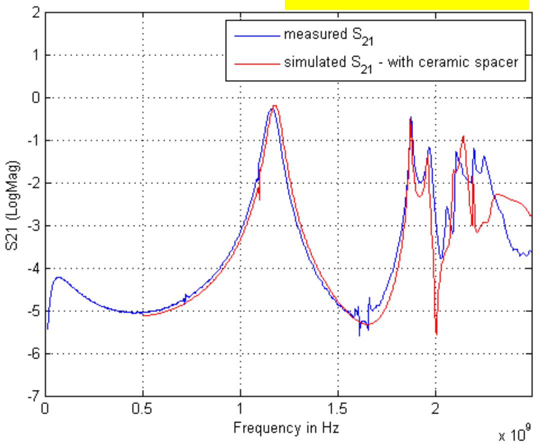
• What about the impedance of the BPM bodies ? B.Salvant looks into this. New BPM bodies would cost **1.6 MCHF** + **2.5 my**.

• Adding dual-plane readout (e.g. to better localise imp. sources) would imply new bodies and more electronics than foreseen in above consolidation. Decision required in 2010 before foreseen renovation passes into production stage. The additional cost for the electronics would be **500 kCHF**.

• The new electronics is presently scheduled to be ready in 3-4 years – without heavy requirements for installation time slots.



B.Salvant



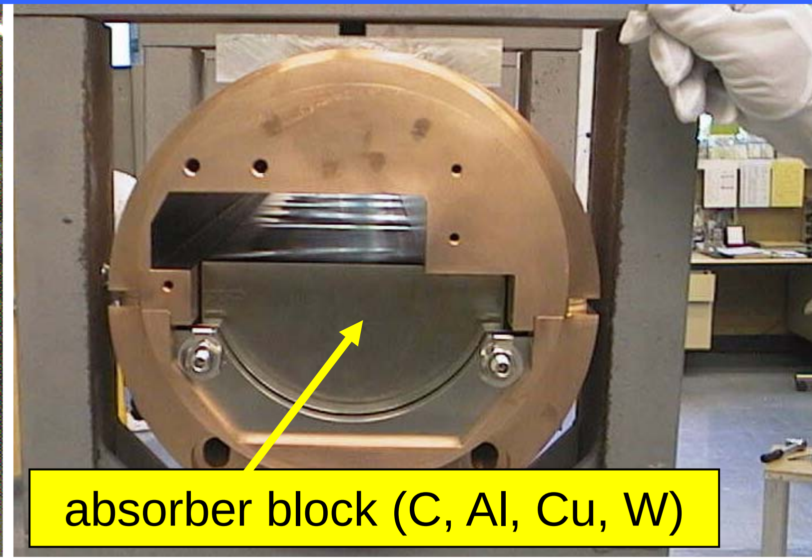
BCT:
DC and fast BCT ready for ultimate LHC beam.
Update planned for 2011/12 – required for and funded by NA61 (400 kCHF + 1.5 my).
Will be developed to cope with the SPS upgrade scenarios.

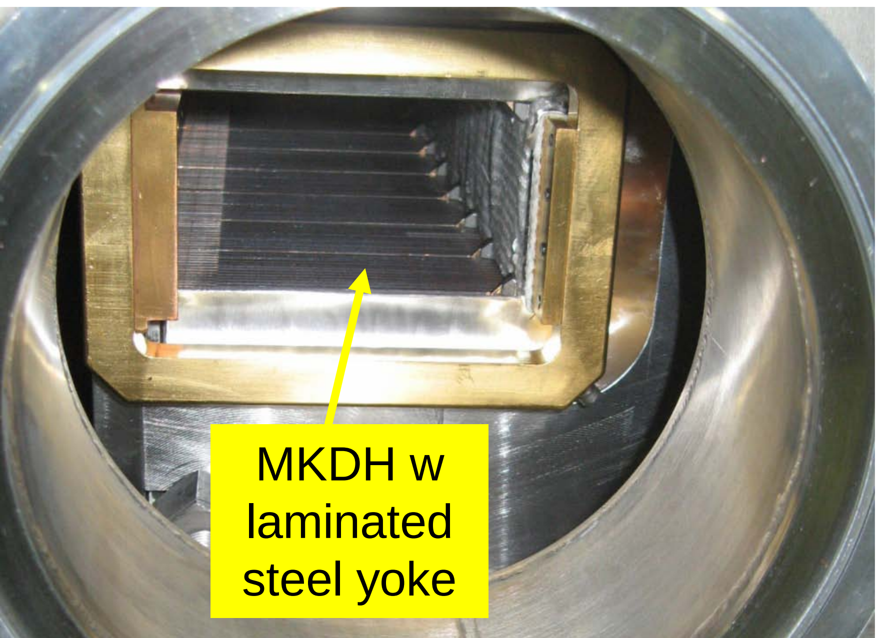
BWS/BGI:
BWS ok for ultimate LHC beam – work to be invested for BGI.
Update and standardisation of electronics planned for 2011/12 .
New BWS are planned to be ready for 2015 (standard for PS, SPS, LHC).
Cost: **600 kCHF** to be requested from the injector consolidation programme + **1.5 my**.

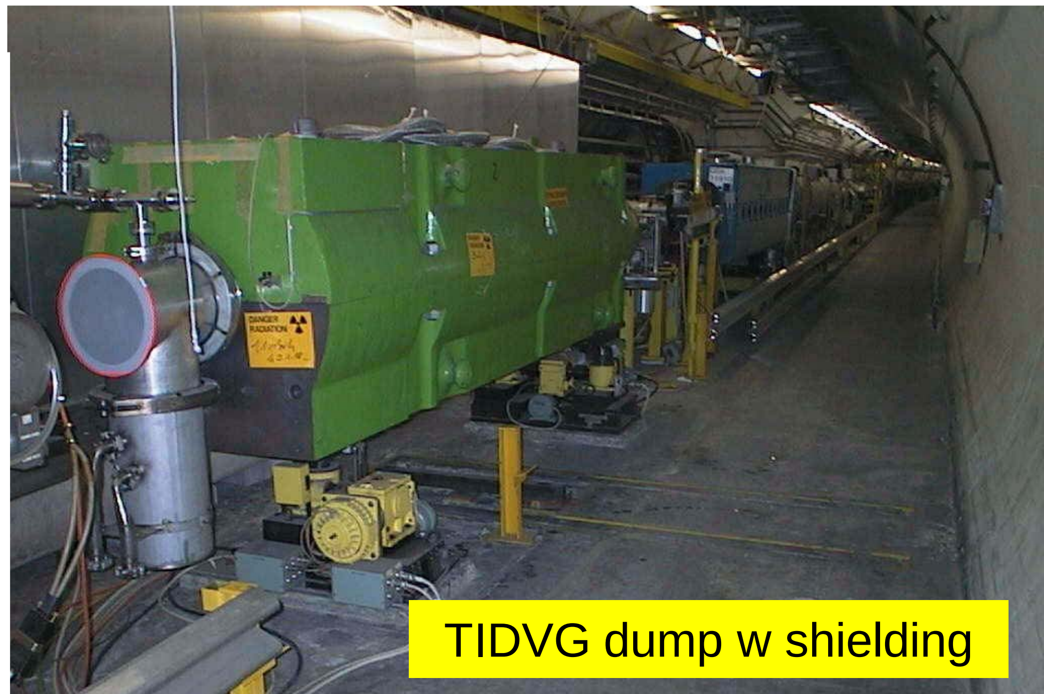
BLM:
There are already plans to consolidate the existing system – to be ready for 2015.
Cost: **580 kCHF** to be requested from the injector consolidation programme + **3.5 my**.
This will take into account parameters for an eventual SPS upgrade.
A future collimator system will probably require special BLM for fast losses.

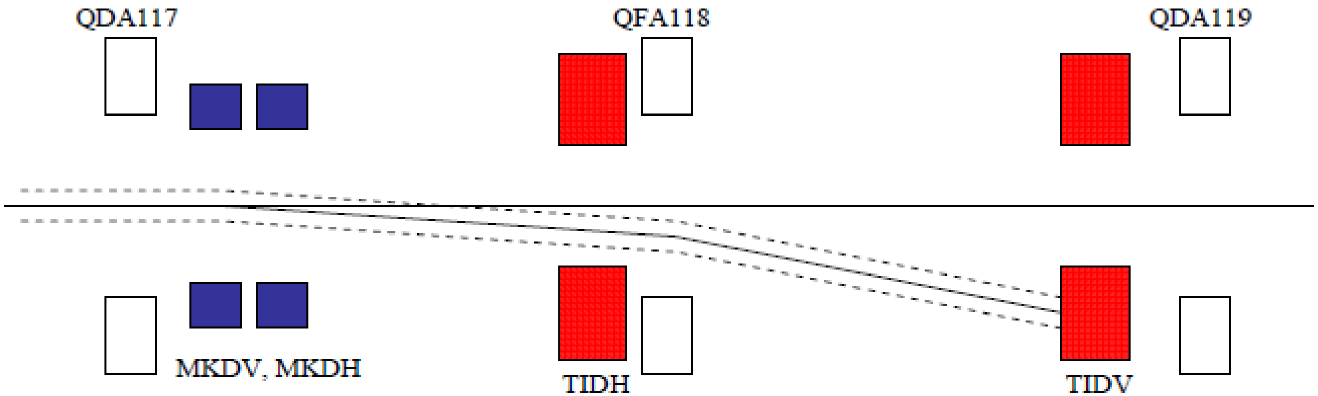
Ideas for further instrumentation – not yet estimated, but should be discussed
- longitudinal tomography
- bunch-by-bunch transverse measurements
- bunch-by-bunch loss monitoring
- ionisation profile monitors (online monitoring of transverse emittance evolution)

New dump system ?









Operational limitations and potential improvements:

2 blocks → depending on energy – for 30 – 100 GeV (fractions of) beam land on SPS aperture – future system could possibly be made to avoid this.

MKDH have in-vacuum steel laminations – not good for impedance – future system to use ferrites – MKDH/V with proper beam screen – needs more length because of larger gap.

Outgassing of TIDVG graphite core (mainly a concern for adjacent MKP) – assembly in air and only 150° C bakeout – spare now using an improved procedure – add valves around to preserve conditioning during nearby vacuum interventions.

Totally new absorber design ~ **3 years** + **1 - 1.5 MCHF**.

Relocation of dump system elsewhere (LSS5 ?) – could be combined with collimation system – ventilation/radiation an issue, to be studied – cost **1.5 – 2 MCHF** ?

Best option: completely new design (including new kickers (~ **4 years** + **2 MCHF** ?), new absorber, in a different LSS) – could then be built while the old one remains operational. Could be ready for **2015** – total cost ~ **5 MCHF** (manpower not yet estimated).

External dump even better – to be studied (if feasible, significantly more expensive).

B.Goddard

Existing kicker systems, observations and actions

"In 2006 the sum of all kickers contributed to ~40 % of the vertical tune shift."

Operational limitations & questions:

MKDV outgassing and heating with LHC beam, for 50 ns worse than for 25 ns

New MKDV1 (baked ferrites, transition pieces) better in 2009 – not clear if good enough …

MKDH have laminated steel cores – deemed not good for impedance

All 3 MKE in LSS6 equipped w stripes, 5 in LSS4 to do

MKE w/o stripes heating – only for short bunches, during scrubbing (a real issue ?)

MKE w stripes heat less – good enough ?

Serigraphy not applicable on MKD (too short cells → HV problems)

Proper beam screen (a la MKI) means new design – huge effort (+ to check if rise time ok)

MKQH: fitted ceramic plates are not ideal (HV, rise time)

Short-term proposals:

Do systematic + comprehensive measurements for all kickers in or leaving lab (MKP, MKDH)

Add transition pieces (in lab) where still missing (MKDH)

Analyse previous MD results and make further MDs to get more complete picture

Measure MKE4 and 6 waveforms with beam

Medium-term proposals (2-3 years):

Make simulations of all kicker impedances, w benchmarks where possible (ABP – MKE started, MKP to come)

Complete impedance measurements where feasible (help from US-LARP ?)

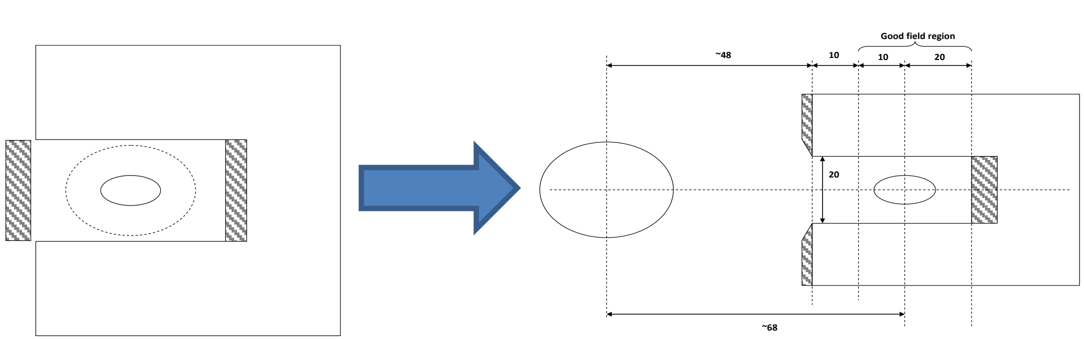
Equip remaining 5 MKE with stripes

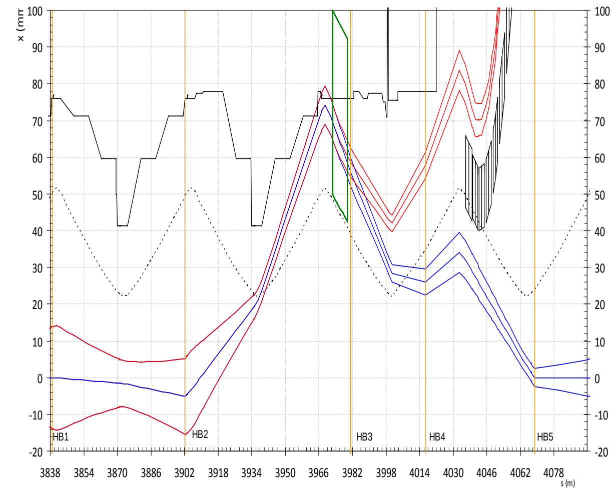
Redesign MKQH shielding

B.Goddard, M.Barnes, J.Bauche,
J.Borburgh, M.Gyr

New fast extraction kickers ?

Paper study for a new fast extraction concept
w C-shaped kickers + bump just ms before extraction





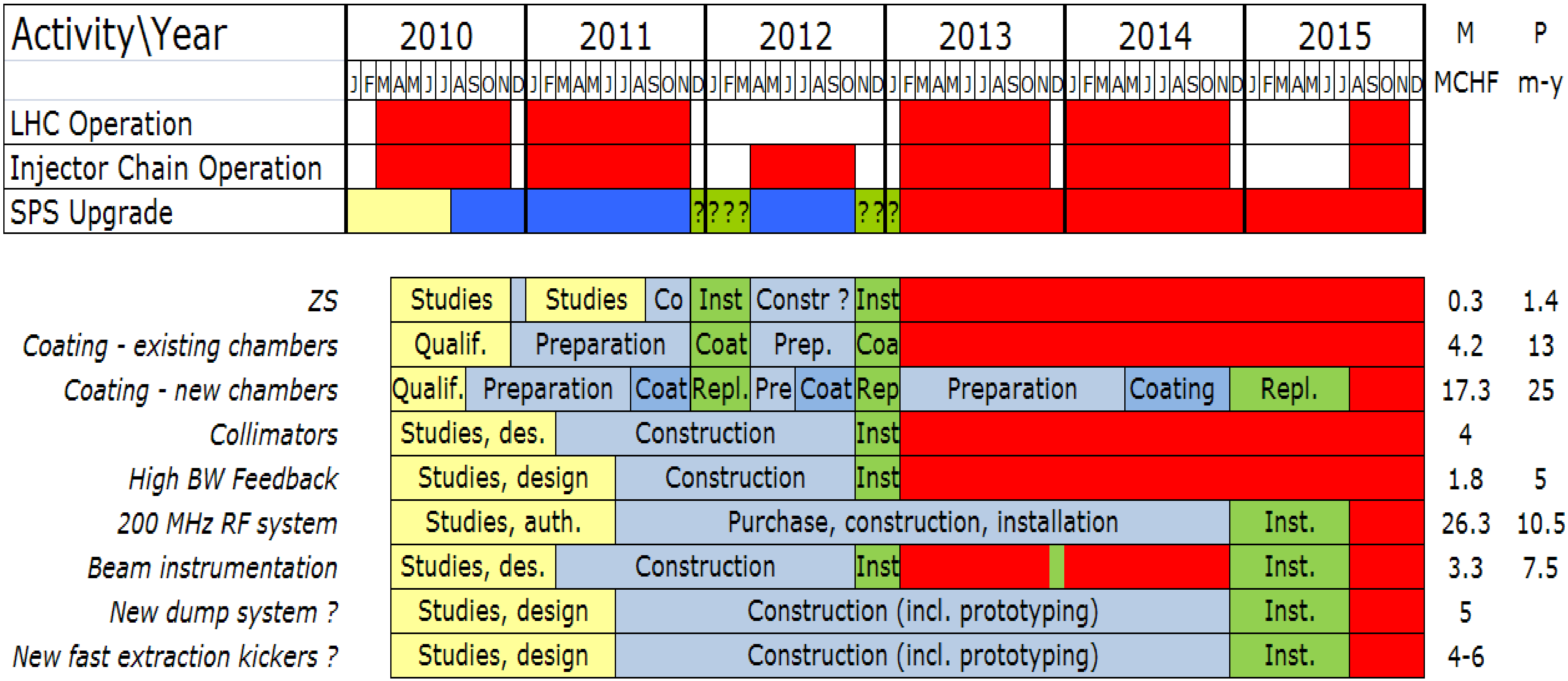
Many things still to be checked in detail.

Would need (other than 6 kickers) a couple of enlarged quads and new fast bumpers.
Very rough cost estimate ~ **4 - 6 MCHF** for both LSS4 and 6 (manpower not estimated).
Could be ready (after prototyping) for startup **2015.**

Could be elaborated further if clear evidence of benefit
(a priori also possible for new injection kickers but yet more involved).

Summary (M, P, time lines)

Phases and overall time lines indicative; cost + manpower estimates very preliminary.
Assuming t_0 = NOW, with allocation of experienced manpower.



Suggestions for US-LARP involvement:

ZS, kickers: MD preparation + analysis, impedance measurements, simulations

Coating: R&D, production setting up, help during bulk work

Impedance (ongoing): localisation of sources

High BW feedback (ongoing): FB algorithms, signal processing, stripline kickers, pickups

Collimators (?): simulations, design

Conclusions

Concrete candidate actions for implementation in time for operation in 2013 and 2015 have been identified, with preliminary resource estimates (the feasibility is conditioned by – among other – the availability of experienced manpower in the short term). Candidate areas for US-LARP involvement have been identified.

To better assess the need, potential benefit, risk and impact of certain modifications a substantial amount of studies is still needed, and the TF strongly advocates to allocate the necessary resources to support decision-making (manpower, money, and time for R&D, simulations, and MDs with high-intensity beam in 2010/11).

To meet the given time scale some decisions are needed before the studies can be completed; some risks cannot be completely excluded.

Alternatives to produce luminosity (e.g. using 50 ns beam) need to be considered in the overall picture, for the case certain measures will not get completely ready in time.

In taking a “fresh look” at the situation the TF also re-opened some questions, mostly already addressed in the past. The time scale prevented going to great detail; some aspects might be interesting to follow further in the strive to find the overall best solution.

A coherent approach across the injector complex will allow to see where the limitations are best removed, and the resources invested in the optimum way.