CERN

Summary of Accelerator Physics presentations

Yannis Papaphilippou

Thanks to all the speakers for the material

Accelerator Physics presentations

Electron cloud effects: update (triplets, arcs, TDIS)	*Giovanni IADAROLA*	*Embassy Suites by Hilton Napa Valley*	08:30 - 09:00
Non-linear correction studies	*Frederik VAN DER VEKEN*	*Embassy Suites by Hilton Napa Valley*	09:00 - 09:30
Impact of 11 T field quality	*Pascal HERMES*	*Embassy Suites by Hilton Napa Valley*	09:30 - 10:00
Impact of field quality: single beam	*Dr. Yuri NOSOCHKOV*	*Embassy Suites by Hilton Napa Valley*	16:30 - 16:50
Impact of field quality in collision	*Dr. Yannis PAPAPPHILIPPOU*		
Observation of beam-beam effects in the LHC and projection to the HL-LHC performance	*Dario PELLEGRINI*	*Embassy Suites by Hilton Napa Valley*	10:20 - 10:50
BBLR Compensation in the LHC: test plan, outcome of the BBLR Workshop	*Ioannis PAPAPHILIPPOU*	*Embassy Suites by Hilton Napa Valley*	10:50 - 11:20
BBLR Compensation experiment at CERN: Simulations and obervables	*Alexander VALISHEV*	*Embassy Suites by Hilton Napa Valley*	11:20 - 11:50
BBLR Compensation HW status	*Adriana ROSSI*		
Impact of Noise on Beam Quality	*Ji QIANG*	*Embassy Suites by Hilton Napa Valley*	14:00 - 14:30
SPS Crab Cavity tests: preparation of the experiments	*Androula ALEKOU*	*Embassy Suites by Hilton Napa Valley*	14:30 - 14:50
Collimation with crab cavities in SPS	*Stefano REDAELLI*		
WBFS Review Results and Status	*John FOX*	*Embassy Suites by Hilton Napa Valley*	16:30 - 17:00
Next Generation WB Feedback Controller	*Ozhan TURGUT*	*Embassy Suites by Hilton Napa Valley*	17:00 - 17:30

- E-cloud
- Field quality and correction
- Beam-beam, BBLR compensation and noise
- Crab-cavities
- Wide-band Feedback

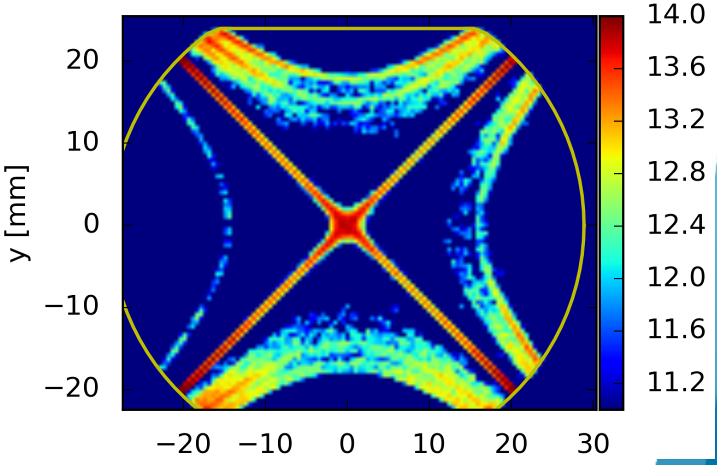
e-cloud – Inner Triplets

- Heat loads from e-cloud were estimated for the **Inner Triplet assemblies** in **IR1&5** and in **IR2&8**:
  - Included effect of the **entire cryogenic length:** dipoles (including correctors) and quadrupoles simulated with the relevant field configuration (higher order multipoles simulated as drifts, to be refined)
  - **Surface treatment** providing SEY<=1.1 **strongly reduces the heat loads**
  - If all **drifts outside the cold masses are left un-coated** (pessimistic) heat load increase is expected to be **less than 150 W/triplet**

Expected heat loads

	SEY = 1.3	SEY = 1.1	SEY=1.1 (cold masses) SEY=1.3 (elsewhere)
IR1&5	1.6 kW	170 W	300 W
IR2&8	1 kW	20 W	30 W

Quadrupole (IR8)

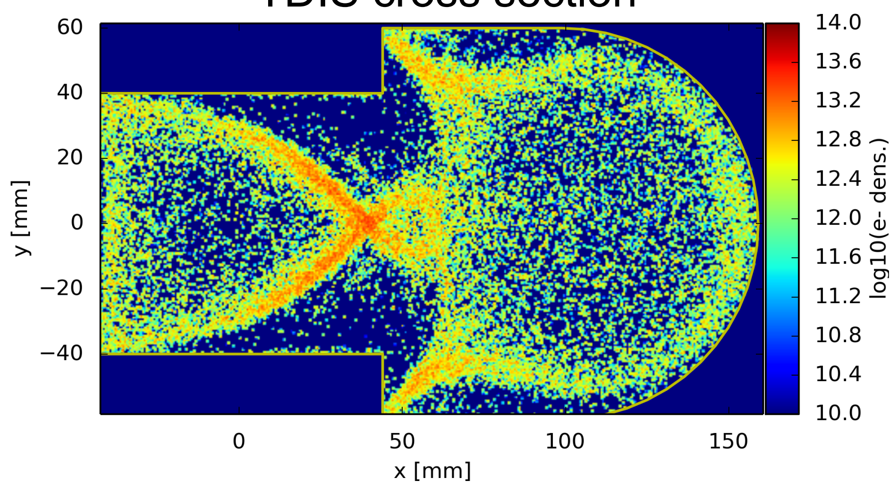


G. Iadarola

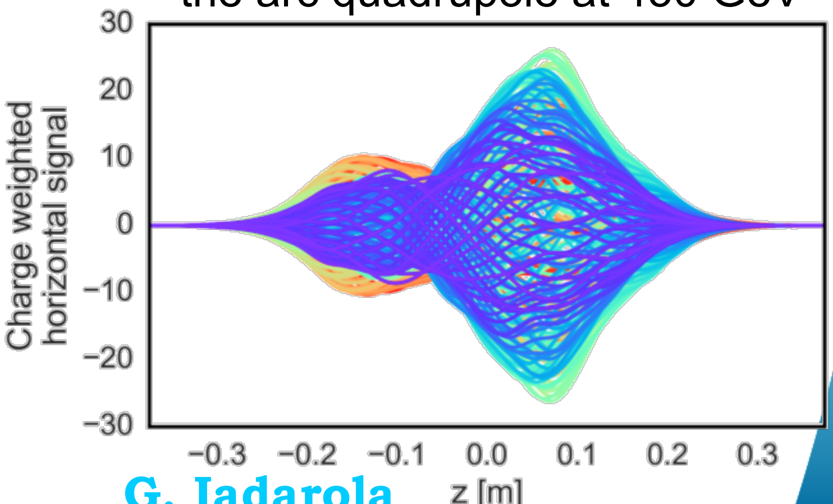
e-cloud – TDIS

- Buildup simulations have been performed for the **TDIS** injection dump:
  - e-cloud is **stronger when the jaws are open**
  - Multipacting **mainly on horizontal surfaces** of the jaws and the beam screen
  - After conditioning (SEY<=1.4), deposited **power should be well below 150 W**
- **Work is ongoing** to further refine the understanding of **e-cloud effects from the arcs**
  - Estimate heat load from **photoelectrons**
  - Include high order **multipoles** (code)
  - Study the impact on **beam stability**

TDIS cross section



Instability driven by e-cloud in the arc quadrupole at 450 GeV

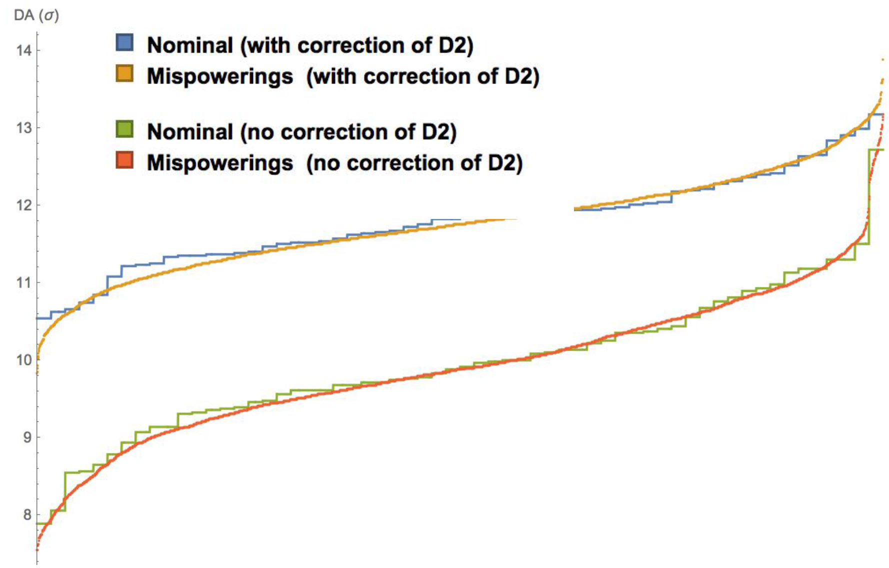


G. Iadarola

Non-linear correction studies

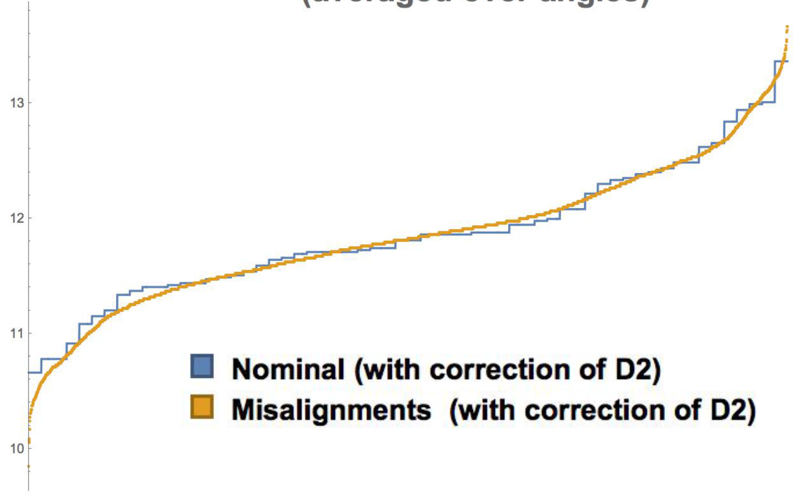
DA per mispowering and per seed

(averaged over angles)



DA per misalignment and per seed

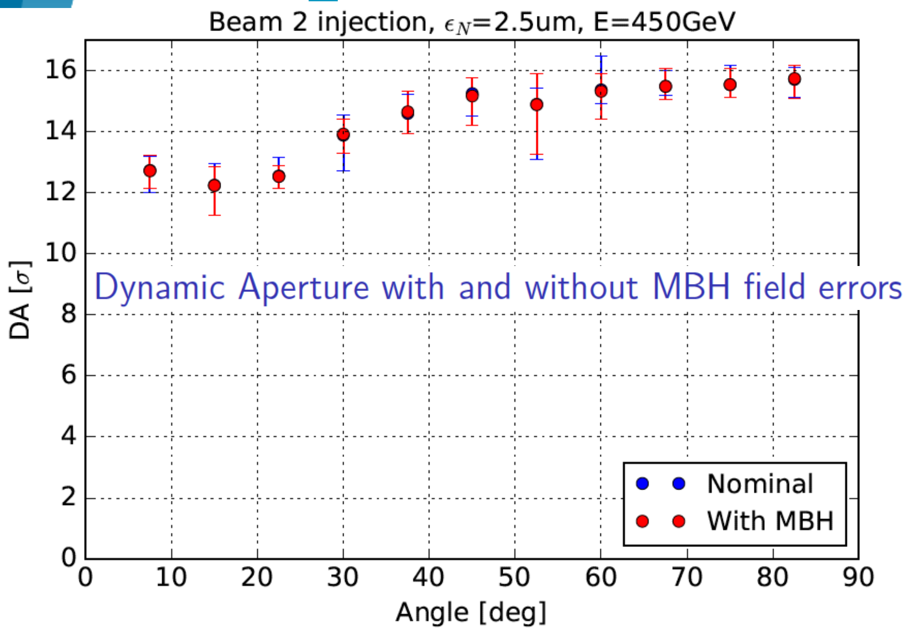
(averaged over angles)

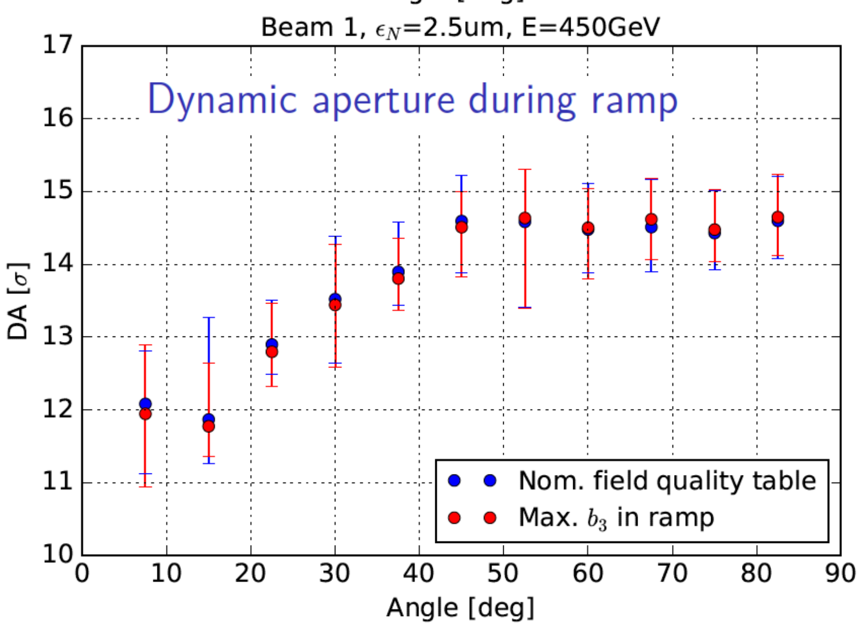


- **Correction algorithm** for b3 of D2 **works efficiently**
- More than enough **margin** in the **corrector strengths**
- System is very **resistant** for **mispowerings** and misalignments
  - Almost no shift in average DA, spread is under control
  - Even on seed-by-seed basis mispowering follows nominal
- Confirmation of usefulness of correcting D2

F. Van Der Veken

Impact of MBH field errors on DA



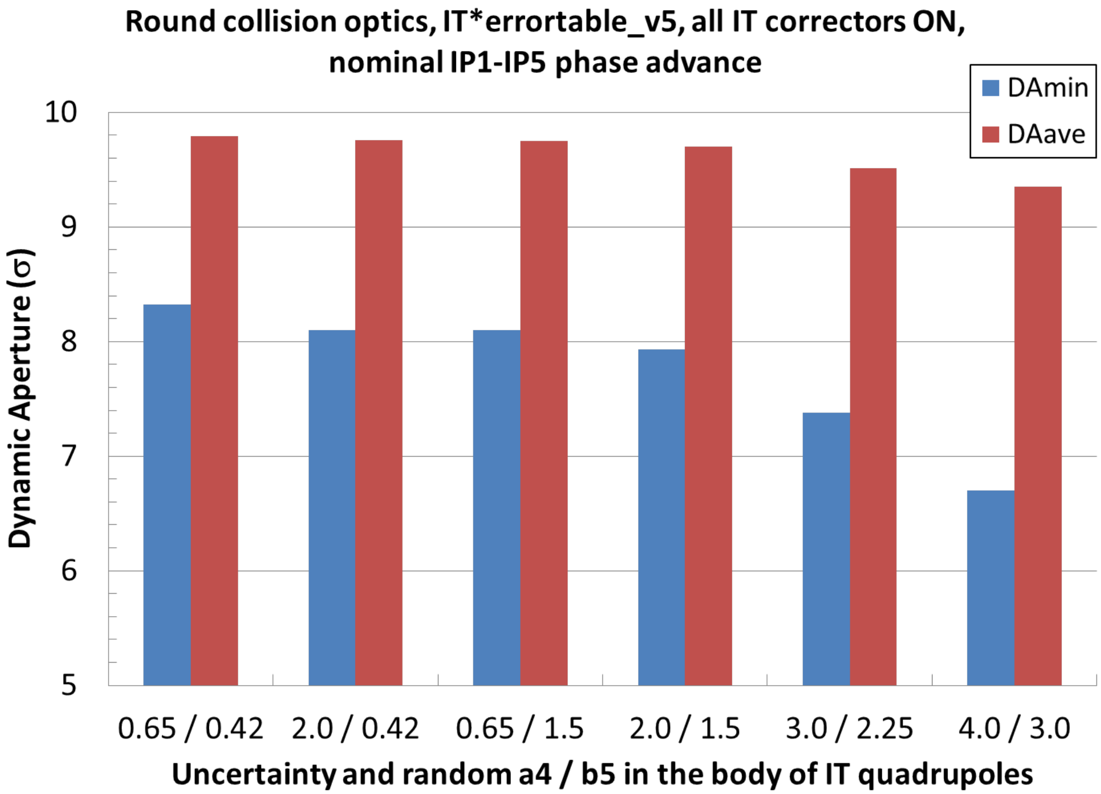


- b2 component at high field introduce **insignificant amount of β-beating**
- Small change of DA from all MBH field errors for both beams, injection and flat top
- Beam 1 **during ramp** with increased b3, b5, b7, (b9), provides **very small DA change** compared to injection

P. Hermes

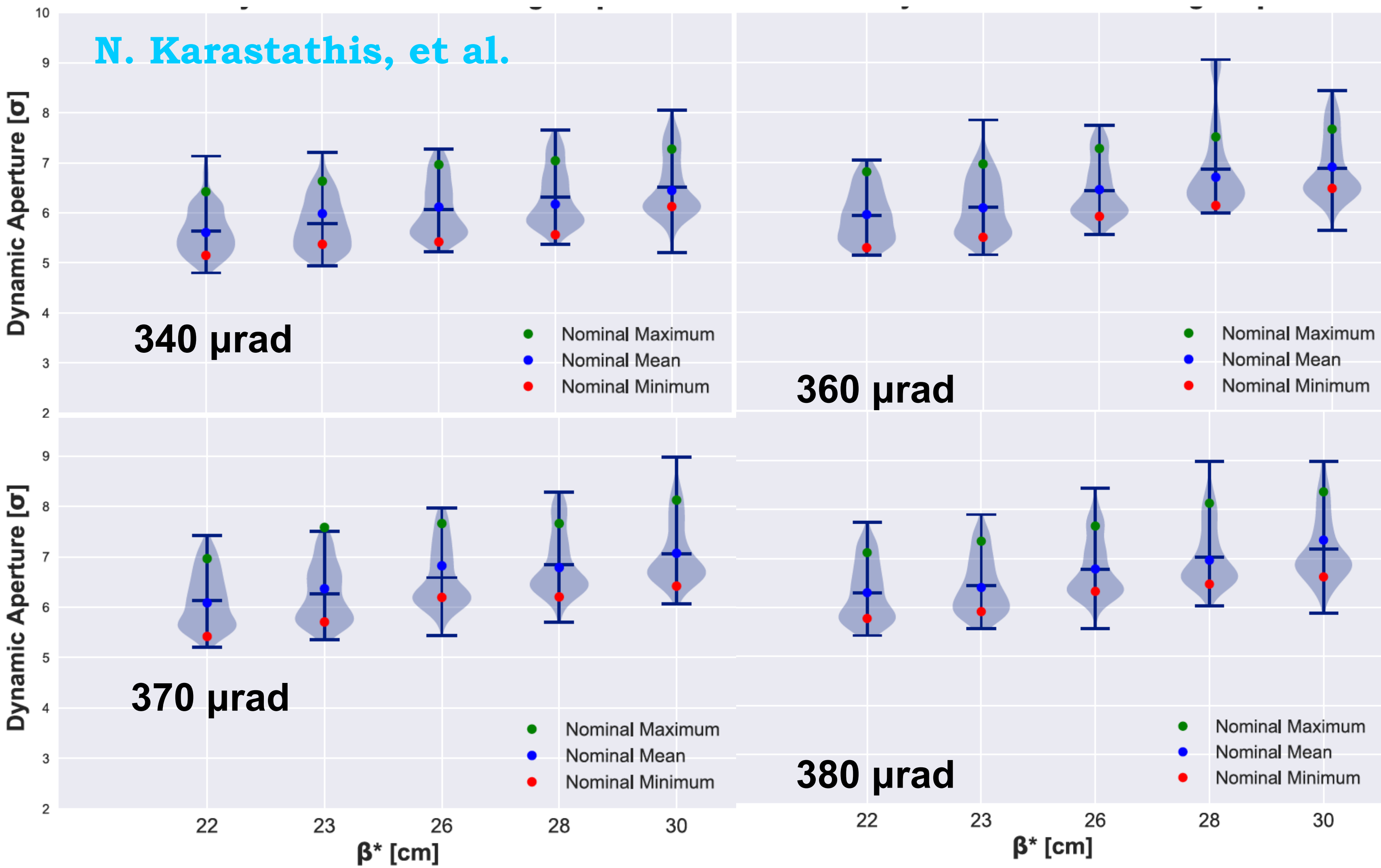
Using correctors to increase DA

- Use of a4 and b5 magnets to correct for observed larger-than-expected multipoles in the triplets.
- Very successful approach, but maximum correctors' strength may be reached



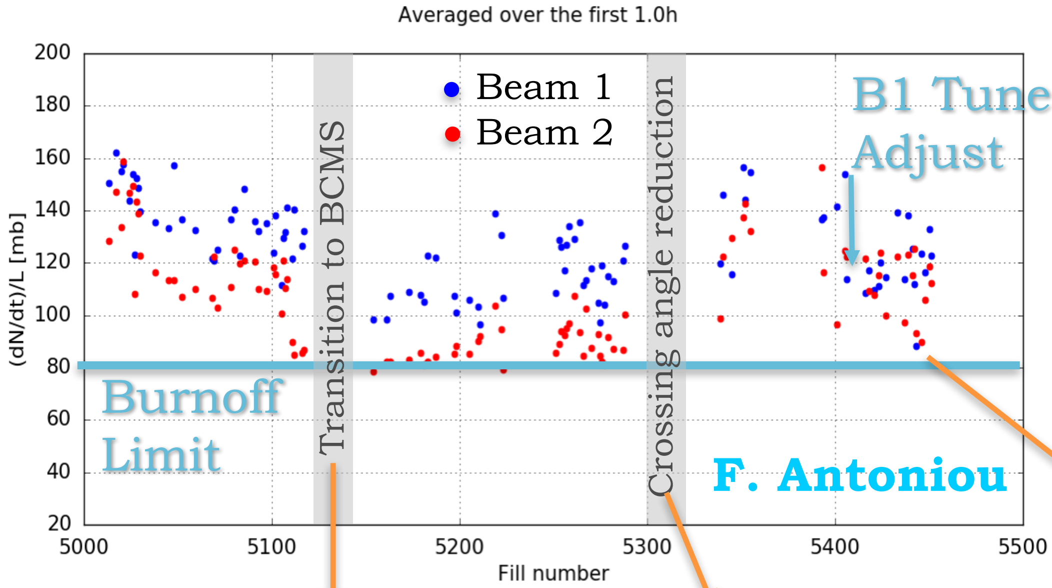
Y. Nosochkov

Impact of field errors with BB



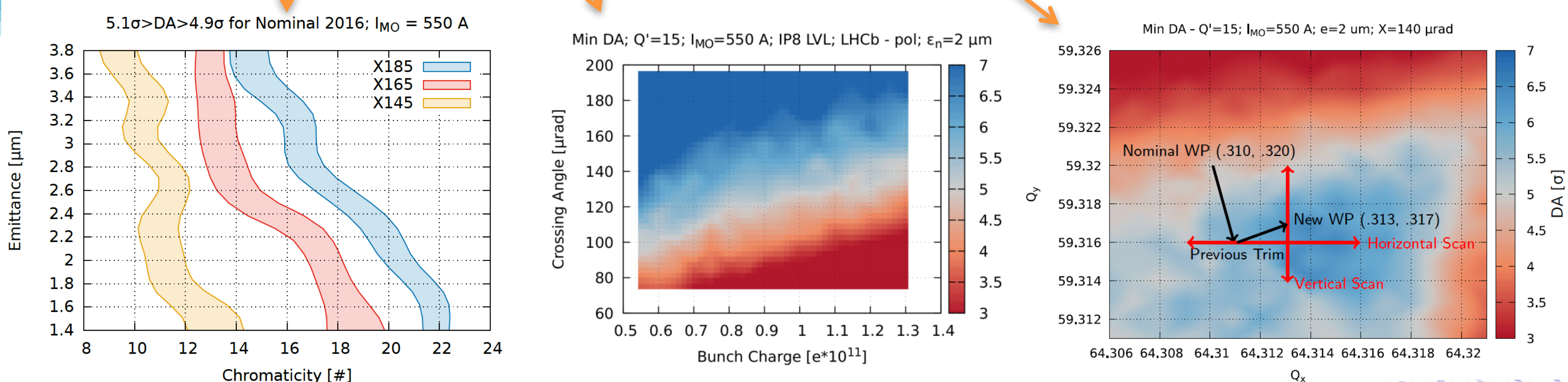
- Errors only slightly reduce minimum DA

Impact of DA on LHC Performance



D. Pellegrini

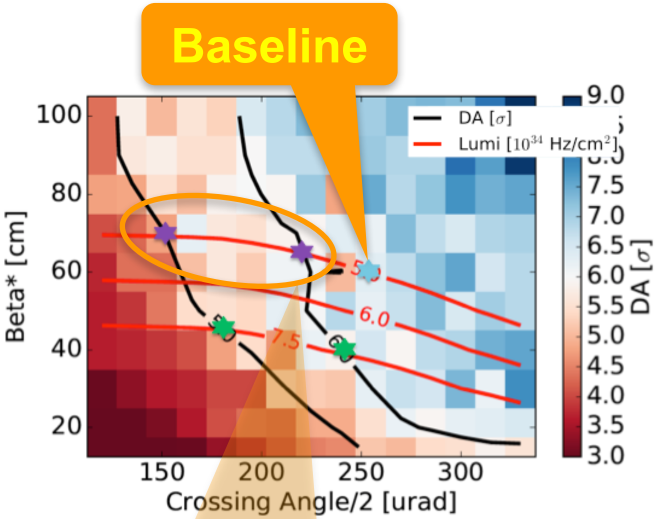
Integrated **luminosity loss** of **4%** can be considered from both emittance blow-up and beam losses, **81 mb cross section** and **50% availability** assumed.



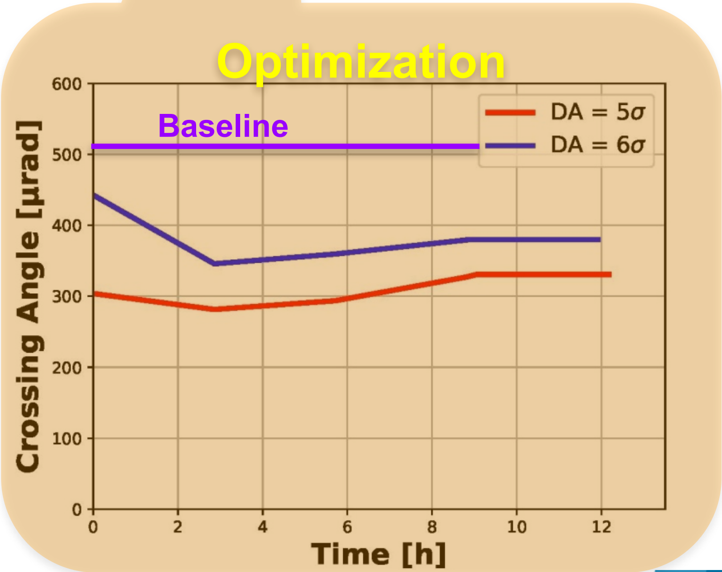
- DA target of **6 σ** is comfortable (good lifetime, mild losses at beginning of Stable Beam)
- **5 σ** comes with stronger losses, but additional mitigation measures can be available to restore **lifetime** (even during levelling)

HL-LHC Performance Optimization

- Performance extrapolation based on:
  - Experience from **2016 run**
  - Simulation work with **parametric scans**
- **Adaptive crossing** folded in the **β* levelling**:
  - increased leveling time → increase **integrated luminosity** (1-2 %); reduction of **PU density** (~10 %)
- **Levelling by separation** also investigated:
  - Need **high x-angles** for **high-intensity**
  - needs validation for **higher intensities** (after LS2)
- Continue **machine studies** and observations
  - Test of **x-angle variation** in LHC in 2017
  - Demonstrate **levelling** with **β*** and **adaptive x-angle**
  - Proof-of-principle for critical **lifetime improvement methods**, in particular **BBLR compensation**
  - Understand-eliminate other performance **limitations** (e.g. emittance blow-up, losses at the beginning of collisions)

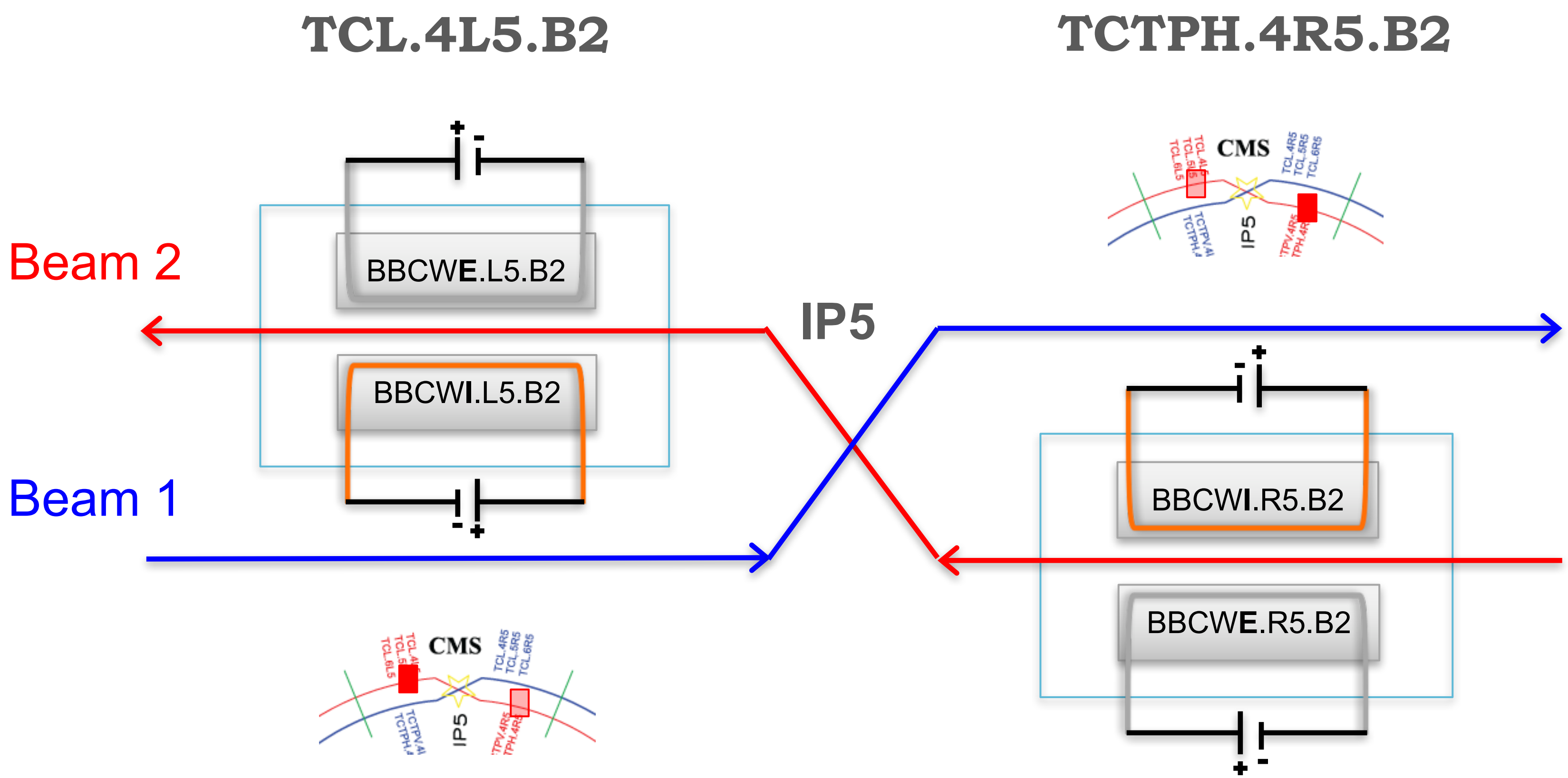


Nominal and ultimate scenario (2.2e11p/bunch).



D. Pellegrini

Wire collimators for 2017 tests

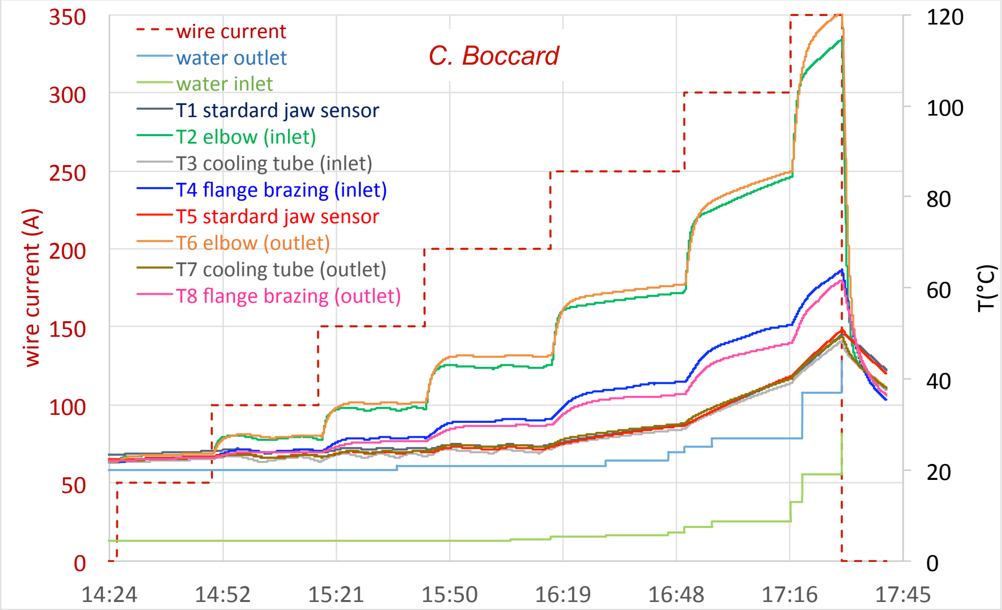


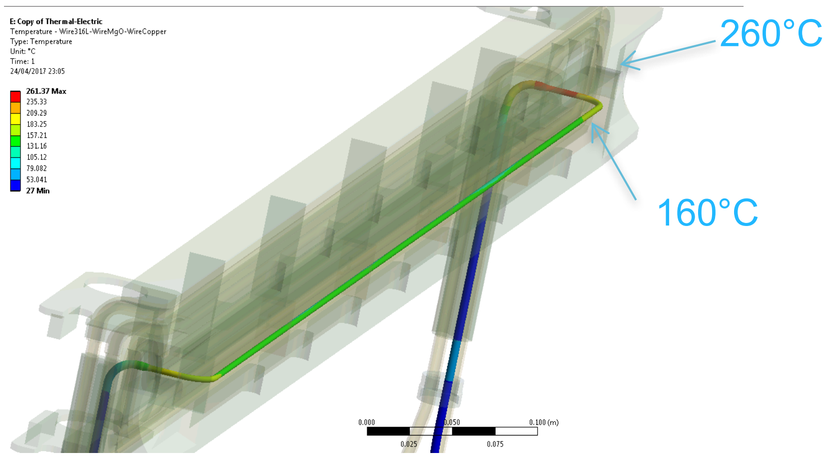
- TCTW-H installed in slots TCTPH.4R5.B2 and TCL.4L5.B2. Can be used for round/oval beam (for H crossing).
- 350A wire moving in x-plane and perpendicular (5^{th} axis)

A. Rossi

Status of the BBLR compensator HW

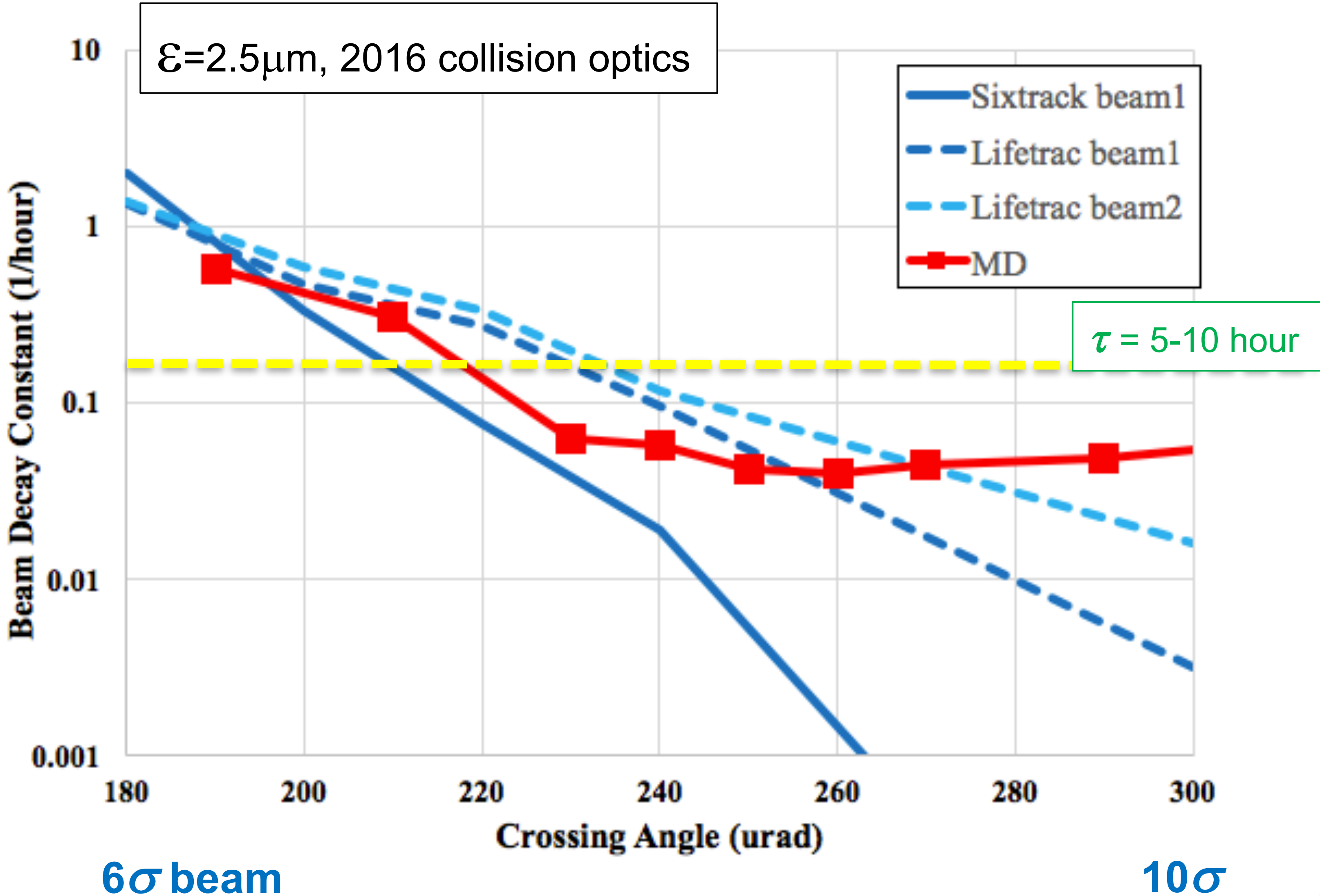
- Wire tested in prototype jaw to define interlocks
- TCTWs tested on surface successfully
- In IR5:
  - TCTWs fully commissioned (including HW interlocks)
  - Wire control and SW interlock to be finalized
  - Upgrade foreseen to allow bipolarity
- Plans for 2018: install TCTW-V left and right of IP1, in TCTPH.4R1.B2 and (tbc) TCL.4L1.B2 or behind Q4.





A. Rossi

BBLR lifetime simulations

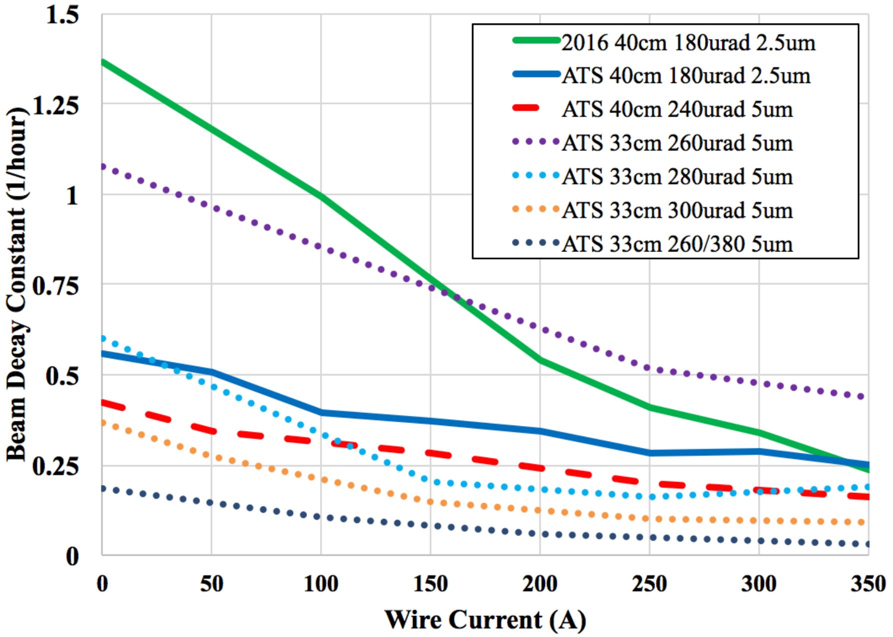


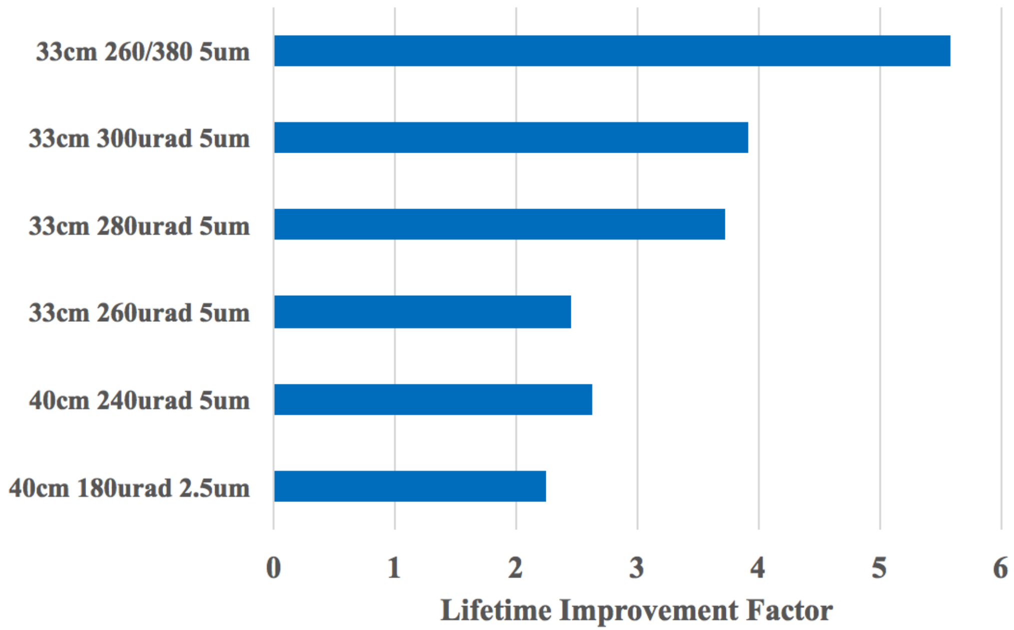
HiLumi HL-LHC PROJECT

LARP

S. Valishev

BBLR compensation simulations



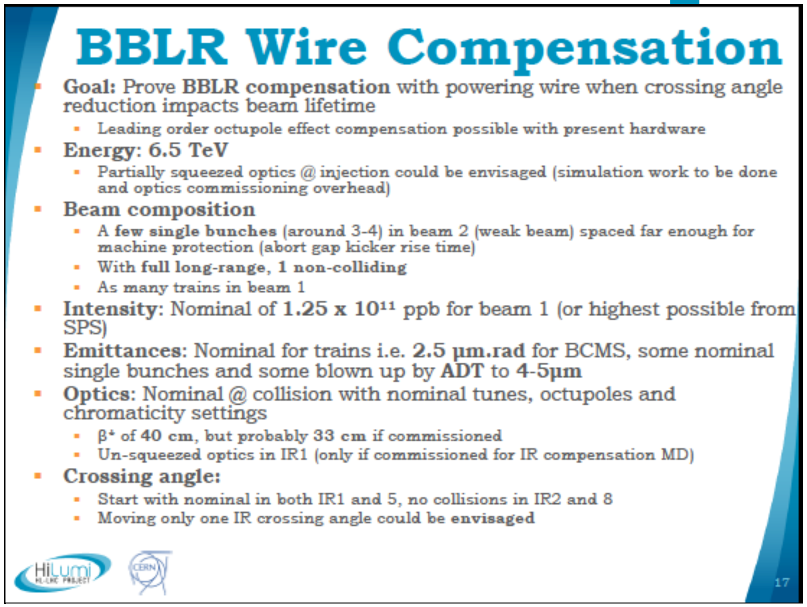


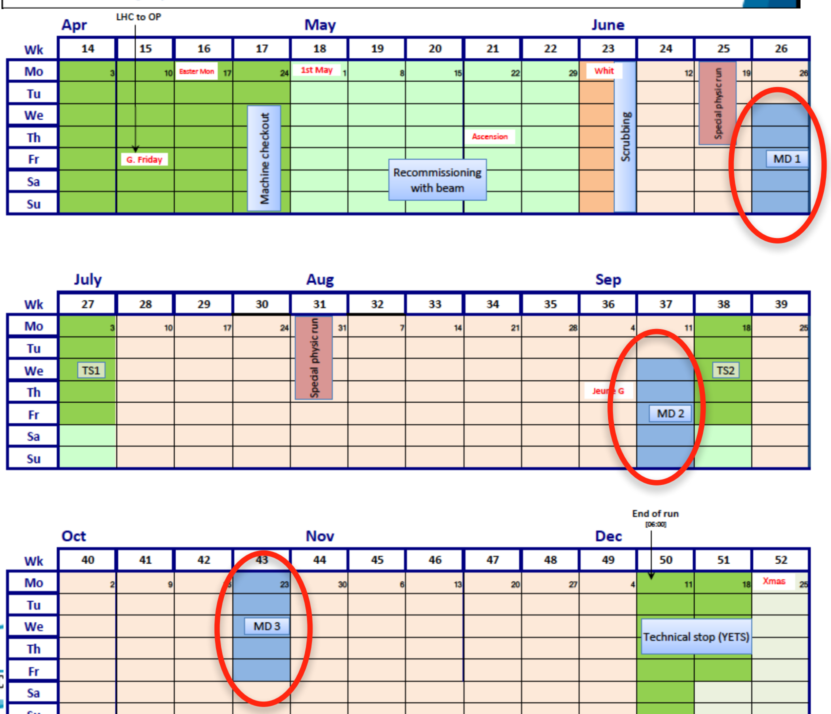
- Severe beam lifetime degradation due to long-range begins at separations of $<6\sigma$.
- Even with a 2-wire scheme and HW constraints can show **measurable benefit to lifetime**
  - **2x** in β^* = 40 cm ATS optics, ε = 5 μm and θ = 240 μrad
  - **4x** in β^* = 33 cm ATS optics, ε = 5 μm and θ = 300 μrad
  - **5x** in β^* = 33 cm ATS optics, ε = 5 μm and θ = 380/260 μrad
  - Important to control machine parameters (tune, chromaticity) with/without wire during MD

HiLumi HL-LHC PROJECT CERN

S. Valishev

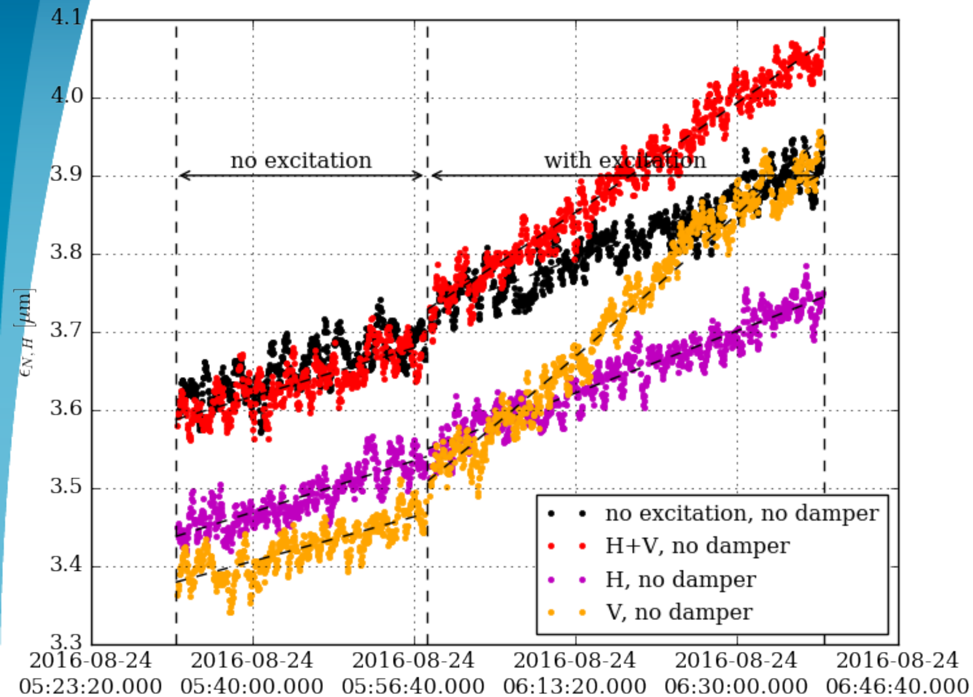
BBLR compensation MD plans



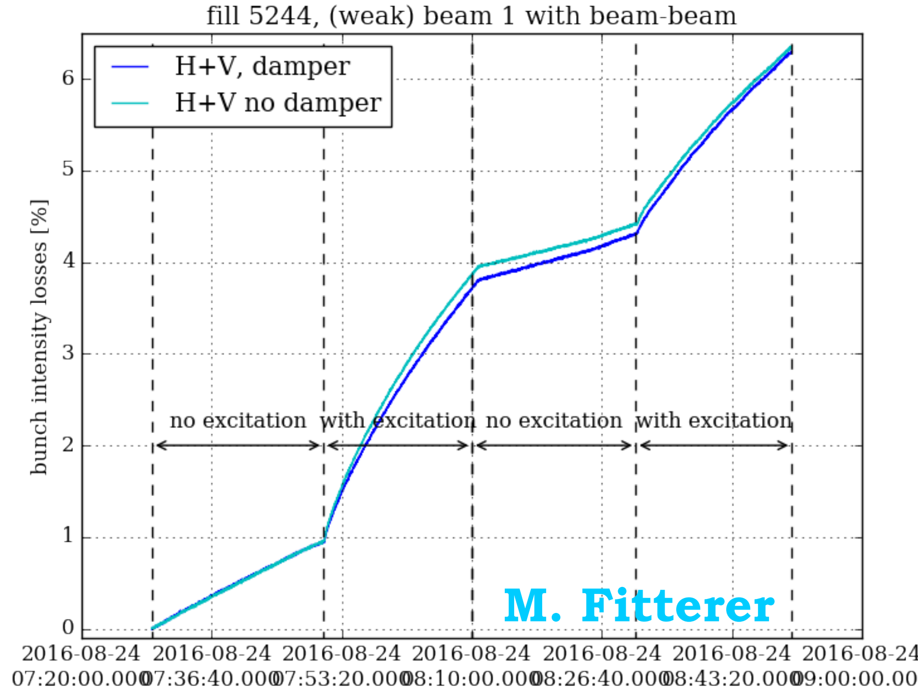


- Devised detailed procedure for wire **callibration**, **preparation** and actual compensation MDs
- Only 15 MD block days
  - MD1 may be moved towards mid-July
  - Possibility for additional days after TS2 if LHC lumi goal reached
- Wire calibration will profit from **commissioning** time in May (2x8h)
- X-angle scan may profit from **intensity ramp-up** (1x8h)
- Wire compensation MD requests **3x8h** for strict minimum
- Ideally would like to profit already from the **1st MD block** and use **each other block** for complementary measurements

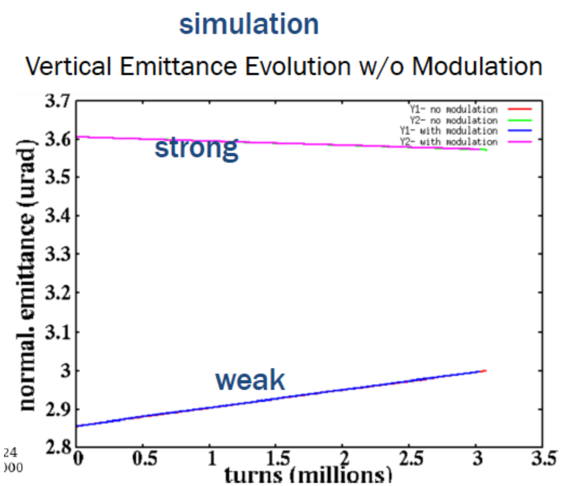
Low Frequency Noise studies



Injection 1, non-colliding, H. emit. growth



Injection 2, losses for exc. in H+V and V for colliding and non-colliding



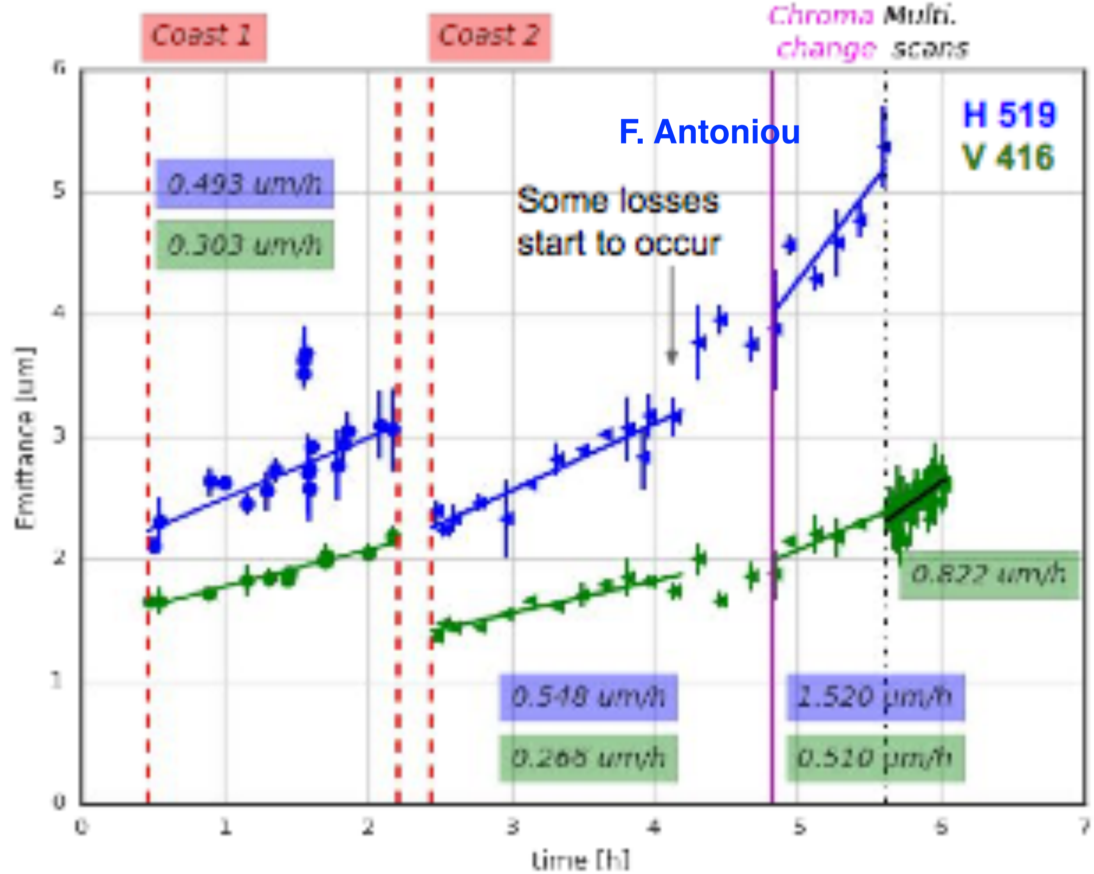
No Damper, No Machine Nonlinearity

- Continuous effort in simulations and measurement to understand impact of low frequency modulation (triplet eigen-frequencies) to emittance

J. Qiang

Preparation of SPS CC tests

- No difference between the two intensities (coast1: 0.42e11, coast2: 0.16e11)
- Clear correlation with chroma
- No clear correlation between the emittance increase and the number of wire-scans

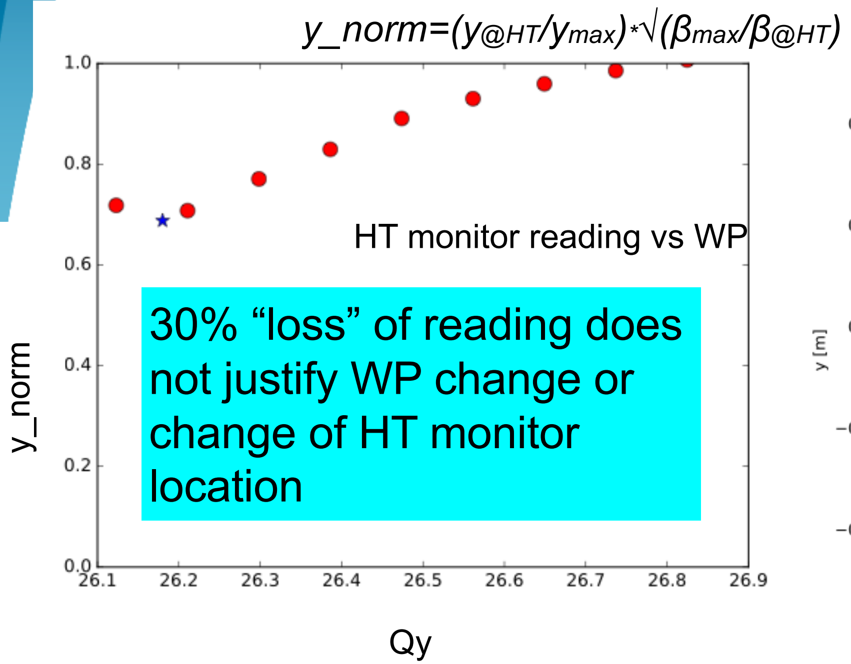


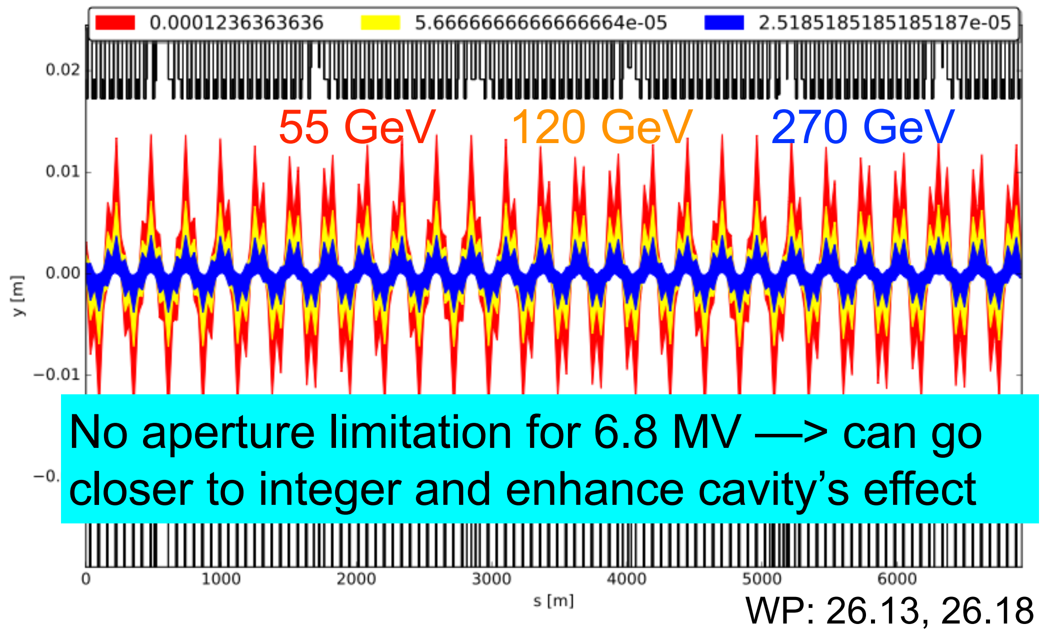
Future MDs:

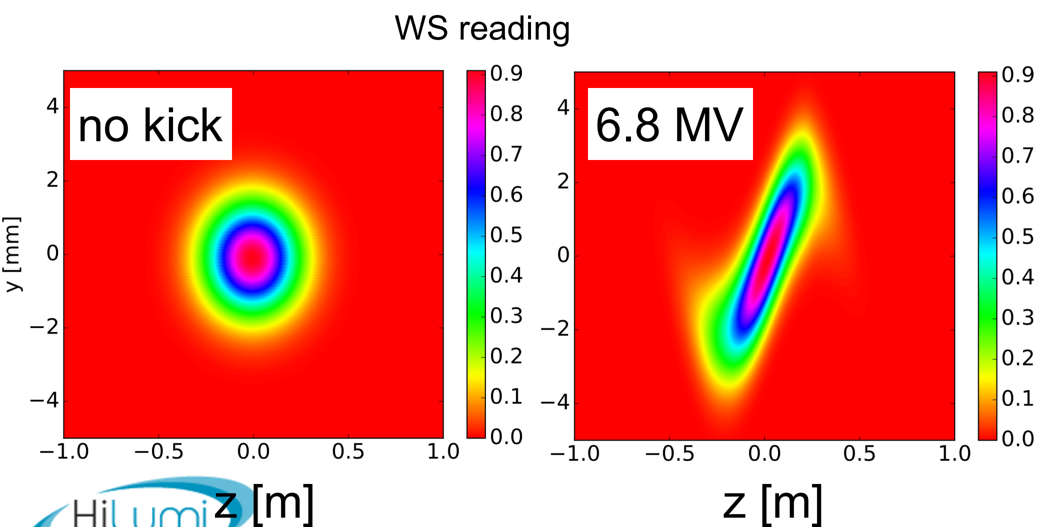
- Emittance evolution in coast
  - with worse vacuum levels, BGI monitors, multiple WS, different intensities, etc
- Head-Tail monitor resolution
- CO correction, <5mm
- Collimation studies, system verification
- Shorter bunch length, NL of RF curvature

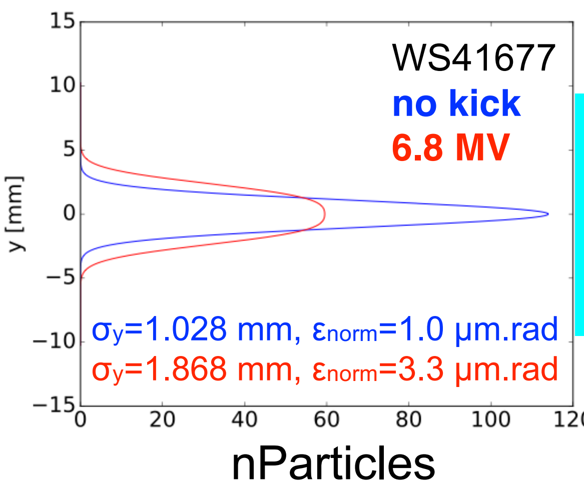
A. Alekou

Preparation of SPS CC tests







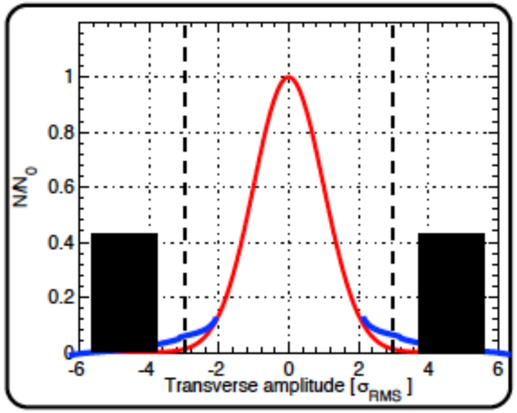


ϵ_{norm} triples, σ_y change can be measured in SPS MD

HiLumi HL-LHC PROJECT

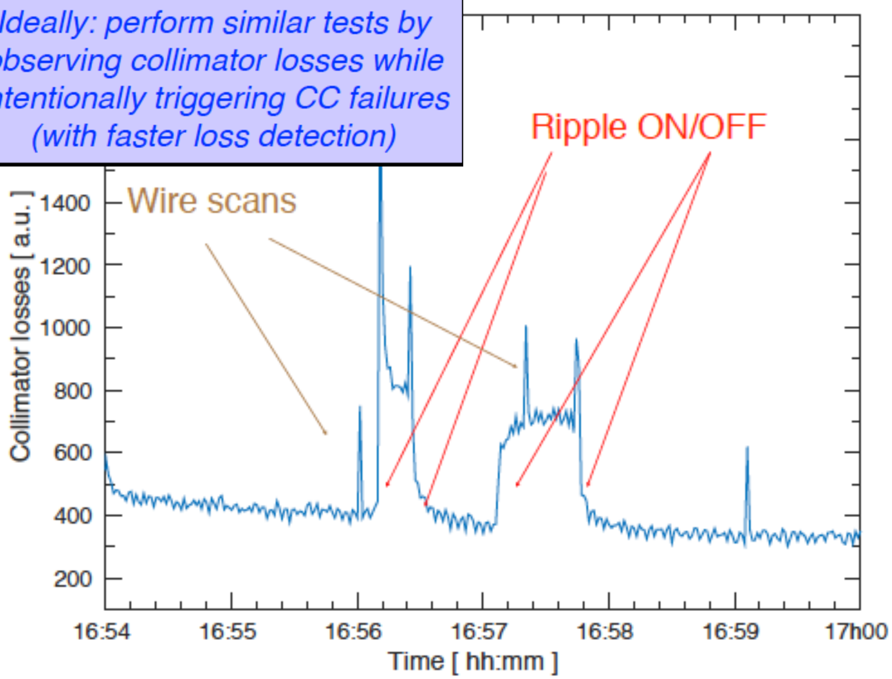
A. Alekou

Collimation with crab cavities at the SPS



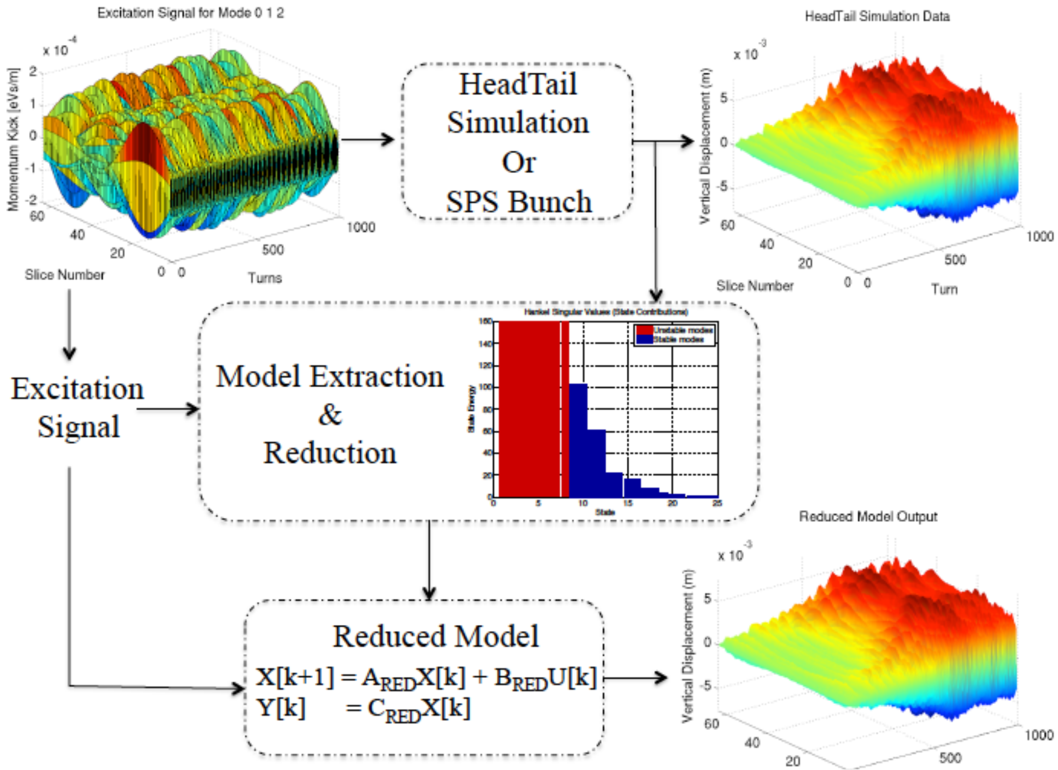
SPS tune ripple: 0.5 A at 1kHz
(Tested in beam tests on Aug. 3rd)

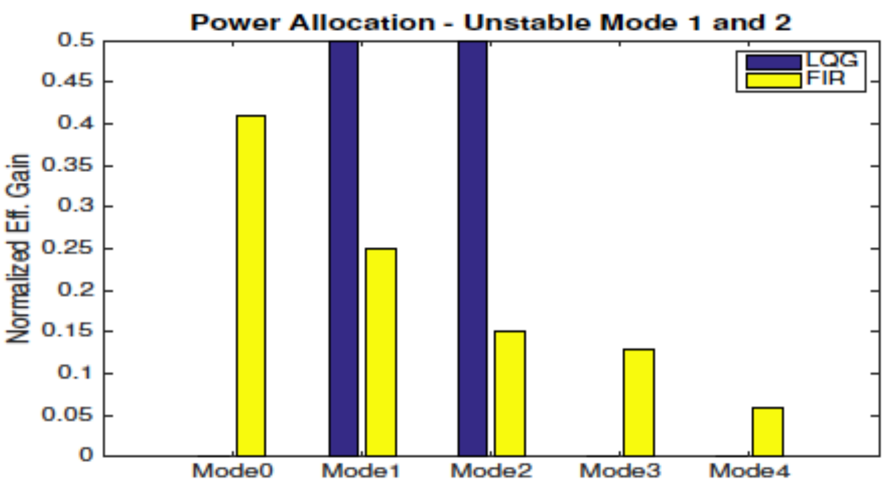
Ideally: perform similar tests by observing collimator losses while intentionally triggering CC failures (with faster loss detection)



- CC's in the SPS opens a way for many **exciting beam tests**
- From collimation side, key priority will be to **assess beam losses** in various relevant scenarios
  - Highest interest lay in the assessment of **time profile of losses during failures, loss patterns** and **collimation hierarchy**
- A lot can be done in the SPS, thanks to a **well-equipped LSS5**
  - Building on experience with the existing test stand, operated since 2004
- A number of preliminary tests can start in 2017 already!

Next Generation WFB Controllers





- Diagonal FIR **successfully implemented** and **demonstrated intra-bunch instability control** at SPS
- **More MD studies** needed to understand the limits of control of higher currents and HL-LHC style beams
  - New slotline kicker can double the bandwidth
- Developed multiple intra-bunch mode reduced order linear **MIMO model**
  - Powerful tool to benchmark beam dynamics using **data** from **measurements** and **simulations.**
- Although more complicated in computation, **MIMO controllers** use the available control power much more effectively.
- Ready to support more MDs in SPS for **Q22 experimental studies**

Wide-band feedback support

LIU-SPS Wideband Feedback Review 20-21 September 2016:
Conclusions and Recommendations

Comments
There is an enormous investment and availability of expertise in the SLAC team. This could be lost if WBFB development is not continued at an appropriate level.

Recommendations

In the committee's opinion a full wideband feedback system for the SPS is feasible.

Support levels and potential results

- Hospice 1 FTE, new Fellow ($475K plus Fellow support)
  - Model - minimal support, goal is to transition expertise to CERN
  - Maintain existing Demo system, existing control functionality (requires J. Dusatko)
  - No expansion of Demo functionality for more trains, new control methods, increased dynamic range
  - limited Q22 MD studies, data analysis jointly with CERN
  - allows transfer of skills before end of SLAC program
- Life Support 1.35 FTE, new Fellow ($650K plus Fellow support)
  - Model - modest support, goal is to validate Q22 control per CERN Memo
  - Upgrade existing Demo system, control functionality (energy ramp, expanded dynamic range)
  - Commissioning of SPS slot line kicker
- Minimalist per-Plan 1.75 FTE, 2 new Fellows ($800K ,2 Fellows)
  - Model - fund at historical support level,
  - Upgrade existing Demo to 8 GS/sec system, control functionality (energy ramp, expanded dynamic range, two pickups, or Δ Σ, MIMO)
  - Design studies 4 GHz LHC slot line
- All assume Travel costs for MD studies and collaboration supported by CERN
- US-Japan funding can support modest technical components
- Collaborative SLAC/CERN engineering and MD studies, transition expertise to CERN

- **WBFS highly ranked** by Multiple Reviews
- 2017 LARP funding to less **50%** of 2016 level (loss of expert skills)
- CERN has requested "high priority" support (**Q22**) to complete MD studies up to LS2, i.e. 2017-2018
  - Need activity and **investments** at least at **2016 level**
  - Risk of **loss** of previous **investment**
- Support must include mix of Engineering, Modeling and Experimental work

Thank you for your attention