BBCW Collimation Scenarios for Run 4

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the collimation team

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Introduction

What settings are acceptable for the wire?

- Wires to be installed in shadow of IR1/IR5 TCTs
  → TCT settings define minimum wire setting

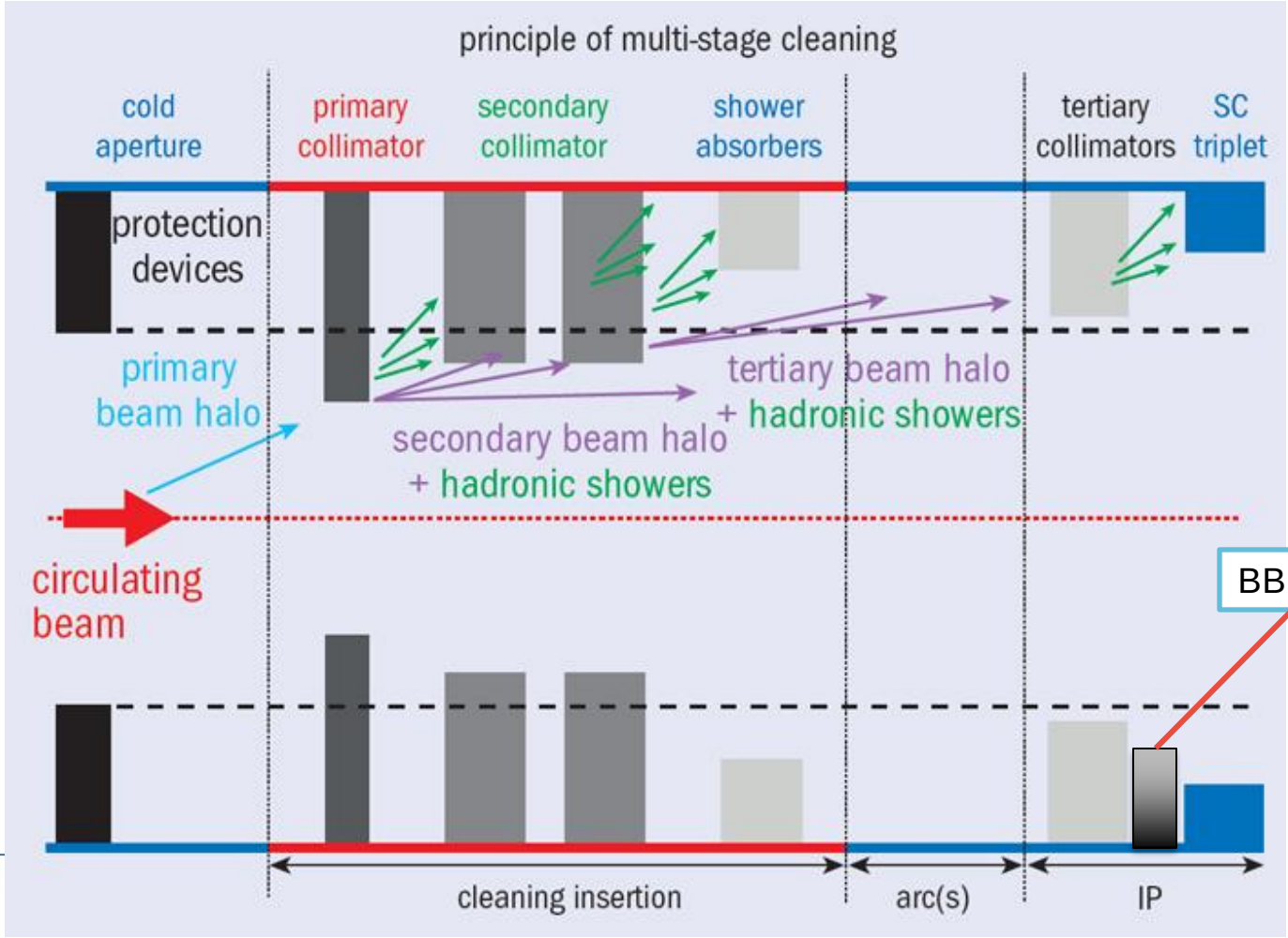
- For larger effect on the beam, desirable to bring wire closer to beam
  → Need to see what we can do about the TCT settings

- WP2 requested to relax the collimator settings due to impedance concerns

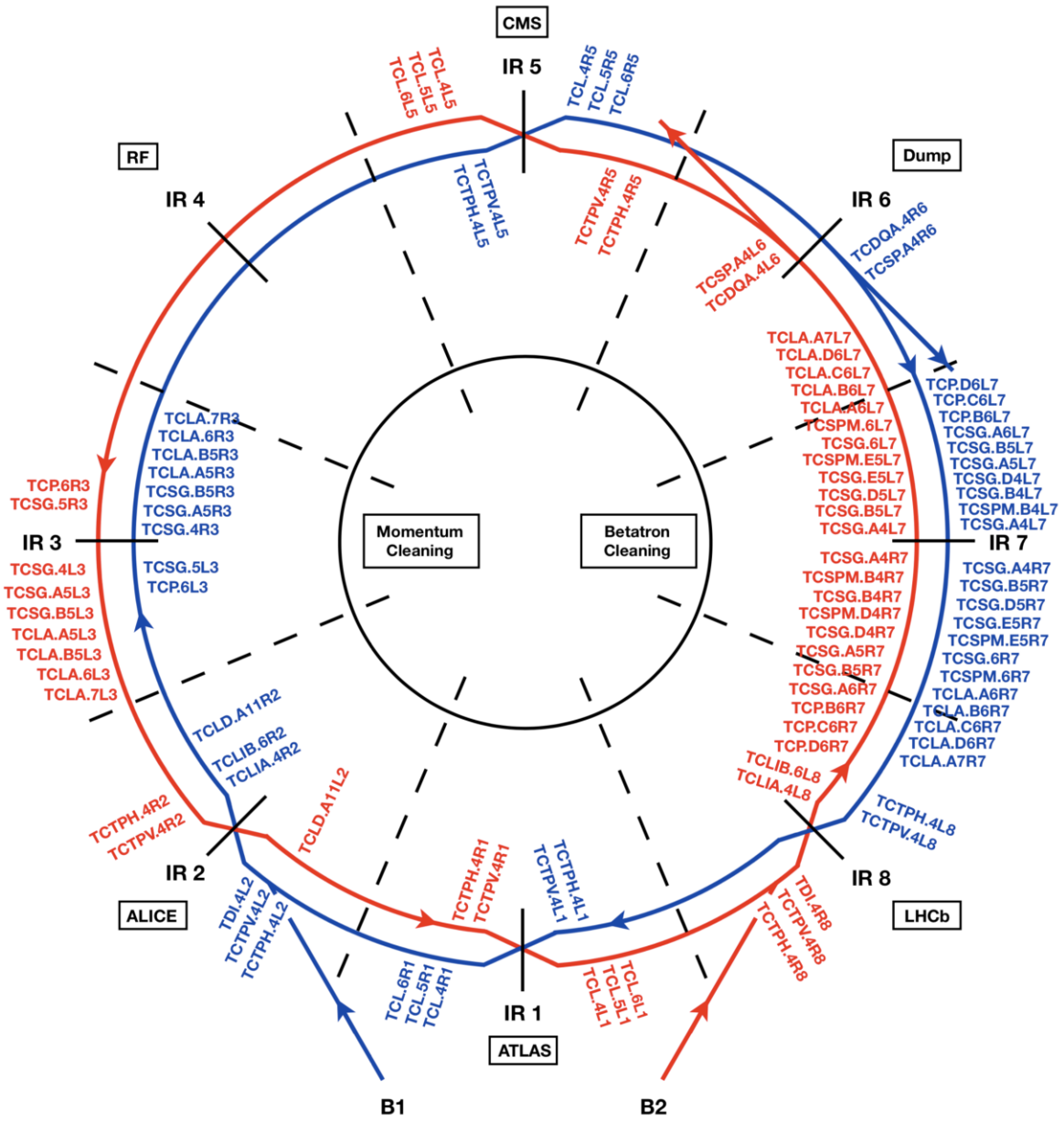
- Assumption: wires are movable stand-alone objects not incorporated into the TCTs. In Run III they are embedded in the TCTs.

LHC collimation hierarchy

TCT upper limit determined by aperture
lower limit determined by retraction to secondaries, as well as other constraints (e.g. asynch dump) such that TCTs are not exposed to dangerously high losses



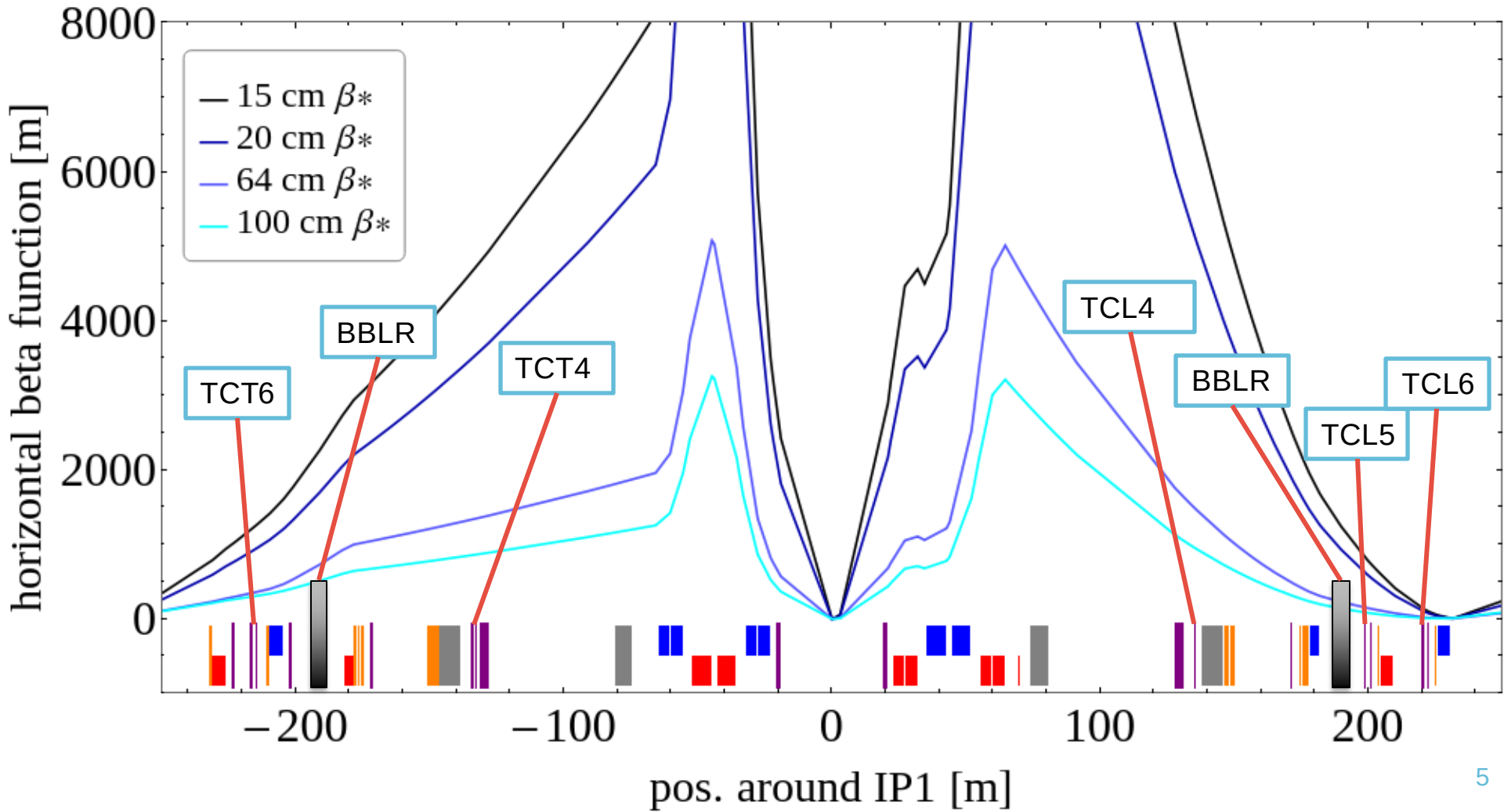
LHC collimation layout



Beta functions

- During the squeeze, beta functions change in IP1/IP5
- Strategy for TCTs and TCLs is to fix the gap in mm
- Consequently the effective setting in σ changes

optics:
/afs/cern.ch/eng/lhc/optics/HLLHCV1.5/scenarios/run4



Collimator Settings ($\epsilon_n = 2.5\mu m \cdot rad$)

	TDR Baseline (tight settings)	Relaxed Settings		
	15 cm β*	15 cm β*	20 cm β*	100 cm β*
TCP IR7	**6.7**	**8.5**	8.5	8.5
TCS IR7	**9.1**	**10.1**	10.1	10.1
TCLA IR7	**12.7**	**14.0**	**13.7**	**13.7**
TCLD IR7	**16.6**	**n/a****	n/a**	n/a**
TCP IR3	17.7	17.7	17.7	17.7
TCS IR3	21.3	21.3	21.3	21.3
TCLA IR3	23.7	23.7	23.7	23.7
TCS IR6	**10.1**	**11.1**	11.1	11.1
TCDQ IR6	**10.1**	**11.1**	11.1	11.1
TCL IR1/5	14.2	14.2*	**16.4***	**38 – 44***
TCT IR1/5	**10.4**	**11.4***	**13.2***	**23 – 35***
Prot. Aperture IR1/5	**11.8**	**12.8**	**14.6**	**>24.4**
TCT IR2	43.8	43.8	43.8	43.8
TCT IR8	17.7	17.7	17.7	17.7
TDIS	park	park	park	park
TCLD IR2	park	park	park	park

* gap in mm is set to final (15 cm) value and kept constant throughout squeeze
** likely n/a for runIV, status for runV to be confirmed

Wire position

- Wire position depends on the beta functions, and the endpoint TCT setting
- Endpoint TCT setting depends on collimator settings (tight / relaxed) and final β* (20 cm here)

TCT endpoint setting [σ]	BBLR IR1L pos [mm]	BBLR IR1R pos [mm]	BBLR IR5L pos [mm]	BBLR IR5R pos [mm]
12.0 tight	8.9	7.0	6.3	9.4
13.2 relaxed	9.7	7.6	6.9	10.3

- Retraction from the TCTs is not defined yet,
  example for roman pots, three sigmas+300µm but would have to be studied

Potential options for moving wire closer (1/6)

- Keep TCTs at constant sigma settings from FT (tight or relaxed settings)
  - Wire is closer at beginning of collisions
  - Wire moves out during levelling
  - TCTs are more exposed with the higher beam current at FT, in particular for asynchronous dump failures (phase advance conditions to be verified)
  - Note that copper diamond TCTs have been removed from baseline. They would have been more robust against beam losses.

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d, retraction from TCT, to be defined

relaxed, 13.2σ β* [cm]	BBLR IR1L pos [mm]	BBLR IR1R pos [mm]	BBLR IR5L pos [mm]	BBLR IR5R pos [mm]
20	9.8 + d	7.6 + d	7.0 + d	10.3 + d
64	6.4 + d	3.8 + d	3.5 + d	6.9 + d
100	5.4 + d	3.0 + d	2.7 + d	5.7 + d

tight, 12.0σ β* [cm]	BBLR IR1L pos [mm]	BBLR IR1R pos [mm]	BBLR IR5L pos [mm]	BBLR IR5R pos [mm]
20	8.9 + d	7.0 + d	6.3 + d	9.4 + d
64	5.8 + d	3.5 + d	3.2 + d	6.3 + d
100	4.9 + d	2.7 + d	2.5 + d	5.1 + d

Potential options for moving wire closer (2/6)

- Use tighter TCT settings
  - Wire is closer throughout levelling
  - TCTs are more exposed
  - More leakage to experiments
  - Note that copper diamond TCTs have been removed from baseline. They would have been more robust against beam losses.

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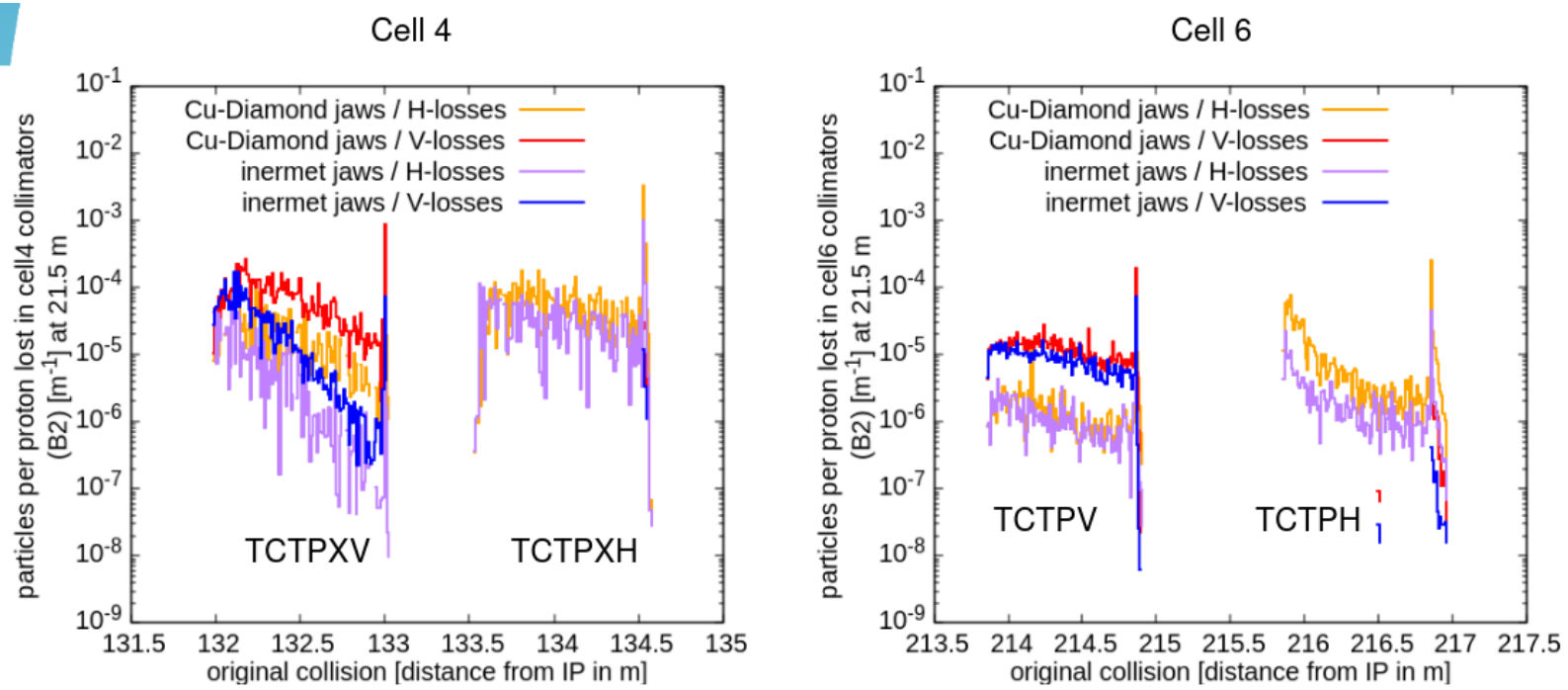
  - Note that copper diamond TCTs have been removed from baseline. They would have been more robust against beam losses.
  - Most leakage to experiments from TCTs in cell 4, one could possibly adjust the relative settings of the TCTs to mitigate the leakage



M. Sabaté-Gilarte, 114th LBS, https://indico.cern.ch/event/1195003/

Potential options for moving wire closer (3/6)

- Use tight collimator settings throughout cycle
  - Wire is closer from beginning of collisions (n.b. wires positions are fixed at the mm settings corresponding to their end-point sigma setting)
  - Bunch instabilities might occur from impedance

  - Recent MD results* indicate that a lower octupole current is needed than initially foreseen, still to be understood, but would give more margin and allow for tighter settings
  - If limited in intensity by electron clouds, we can tighten the collimator settings

* L. Giacomel, Impedance measurements, LHC-MDs,
12th HL-LHC Collaboration Meeting, https://indico.cern.ch/event/1161569/contributions/4921657/

Potential options for moving wire closer (4/6)

- Bring in collimators (including TCP) during collisions as bunch intensity drops
  - Wire is brought closer as intensity drops
  - Impedance remains good when there is a large beam intensity
  - Moving the TCPs in with full intensity beams is tricky and has not been done operationally. Will provoke loss spikes, in particular without the electron lens

  - Note that electron lens has been removed from baseline

Potential options for moving wire closer (5/6)

- Keep TCPs at tight settings from FT and then bring in TCS/TCT during levelling
  - No TCP movement
  - Wire is brought closer as intensity drops
  - Impedance remains good when there is a large beam intensity
  - Large retraction of TCS to TCP – worsened cleaning. Unlikely to work unless positive surprises on beam life time.

Potential options for moving wire closer (6/6)

- Put wire closer to beam than TCTs
  - Wire is closer from beginning of collisions
  - Wire exposed to secondary halo
  - Horizontal wires exposed to asynchronous dump failures
  - Cleaning performance could be negatively affected

Potential studies

- Instability simulations / MDs / follow-up on previous MD results
  → to better understand impedance limitations
  (see talk by B. Salvant, this meeting)
- MD on tightening the whole IR7 hierarchy during levelling
  → to understand feasibility of moving, in particular the TCPs, inwards with high-intensity beams
- Study wire exposed to secondary halo/asynch dump (SixTrack/FLUKA)
  → to understand if one could allow a hierarchy breakage (wire vs TCT) and what retraction margin to use
- Study cleaning performance with tight TCP and relaxed TCS/TCT (simulations and MD)
  → to quantify worsening of cleaning

- Further studies will require discussion on available manpower

Potential methods to move wires further in

- Keep TCTs at constant sigma settings from FT (tight or relaxed settings)
  - Wire is closer at beginning of collisions
  - Wire moves out during levelling
  - TCTs are more exposed with the higher beam current at FT, in particular for asynchronous dump failures (phase advance conditions to be verified)
- Use tighter TCT settings
  - Wire is closer throughout levelling
  - TCTs are more exposed
  - More leakage to experiments
- Use tight collimator settings throughout cycle
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Extra slides

Beta functions

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