FUTURE CIRCULAR COLLIDER

Updates on the FCC-hh collimation studies

A. Abramov, R. Bruce, M. Giovannozzi, G. Perez Seguarana, T. Rissellada

3rd FCC-hh Design Meeting – 16/03/2023

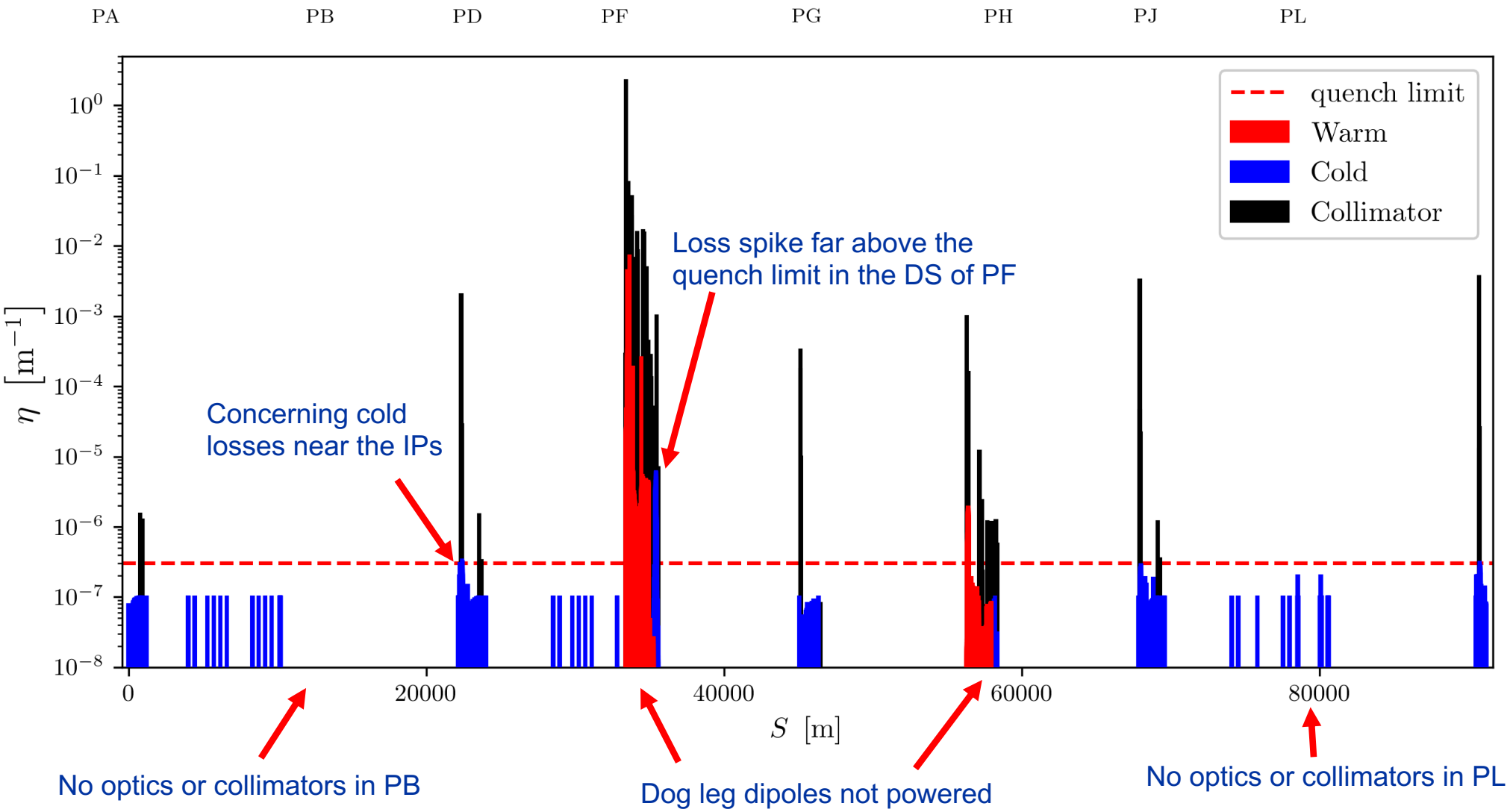
FCC-hh collimation studies

- **Collimation is one of the challenges for the FCC-hh**
  - The stored beam energy for proton beams reaches 8.3 GJ
  - Extensive work done for the CDR to study the collimation system performance
  - For details, see: FCC week 23 talk, R. Bruce

- **Update to PA31 and latest changes**
  - Address some of the points from the first iteration presented at FCC week 2022:
    - Dog leg dipoles powered
    - Dedicated optics in the injection and extraction insertion (PL and PB)
    - Collimators added in PB and PL
    - Decreased β* 55 cm -> 30 cm
    - Investigating optimizations of the collimation insertion settings

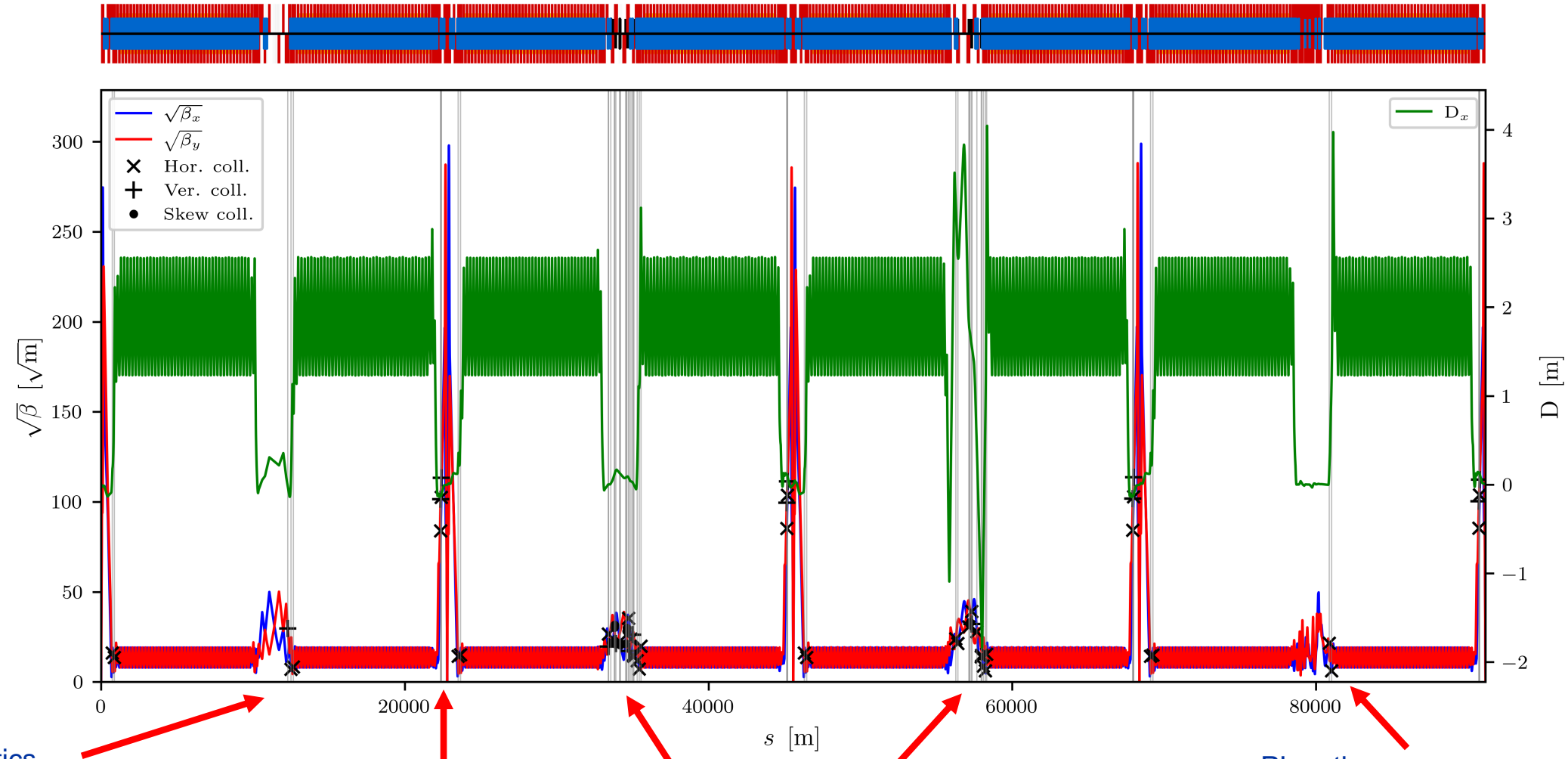
G. Perez Segurana, T. Risselada

PA31 layout loss maps from FCC week 2023



Updated collimation system

TCDQ still in the vertical? Location fixed?



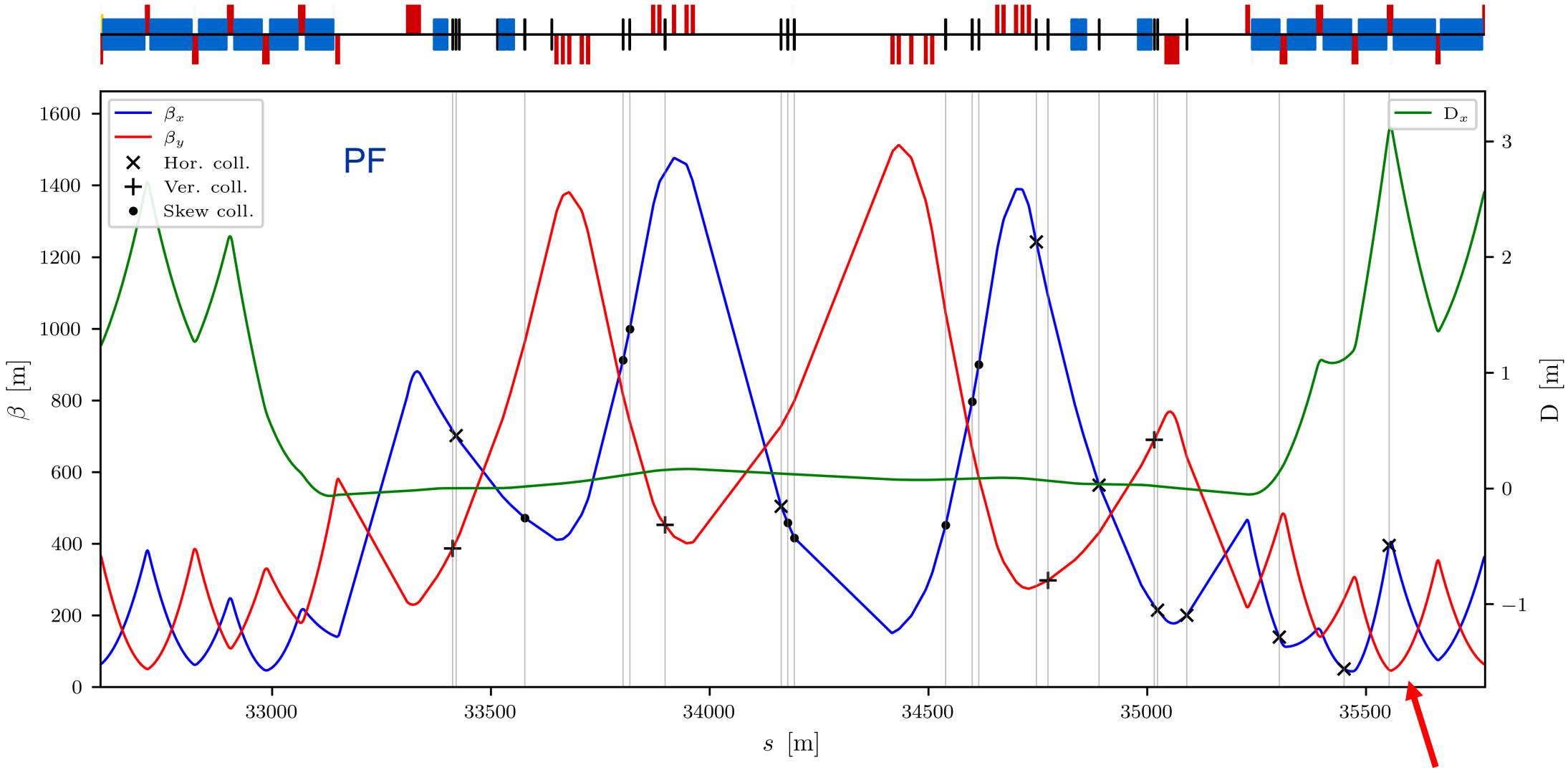
PB optics,
Async. Dump (TCDQ),
DS collimators (TCLD)

Squeezed β* at all IPs

Dog leg dipoles on

PL optics,
DS collimators (TCLD)

Betatron collimation insertion (PF)

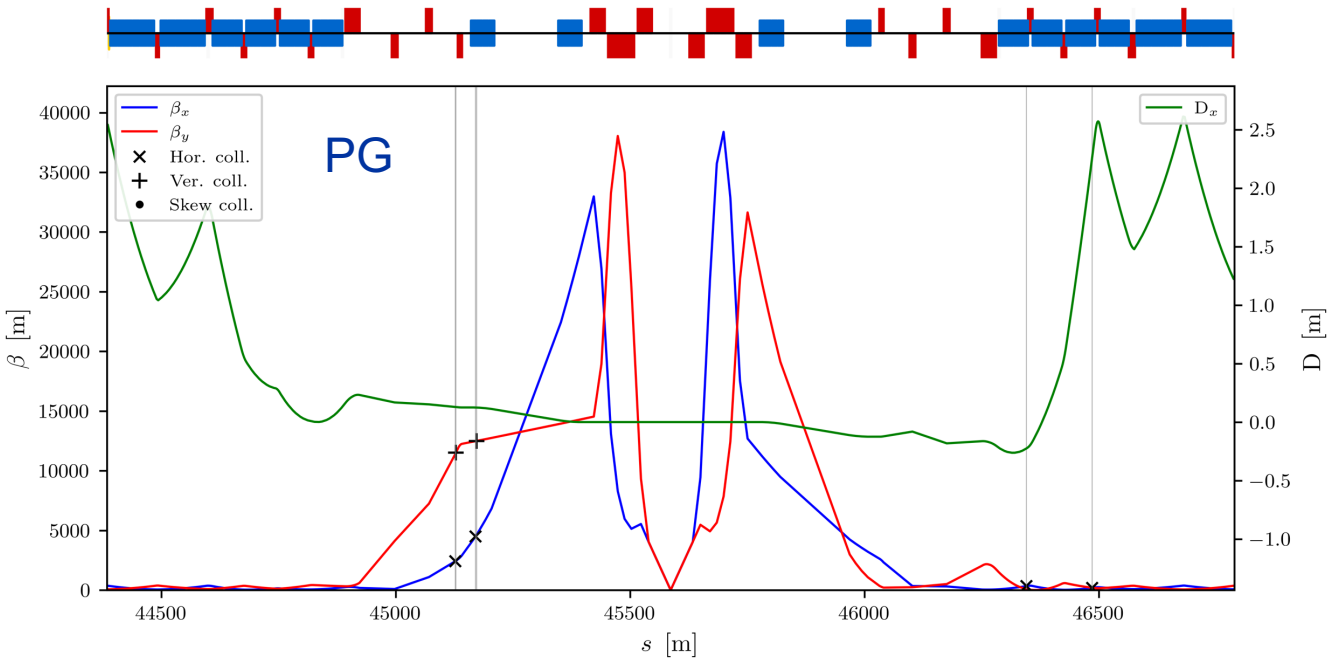


DS collimators (TCLD) must be adjusted

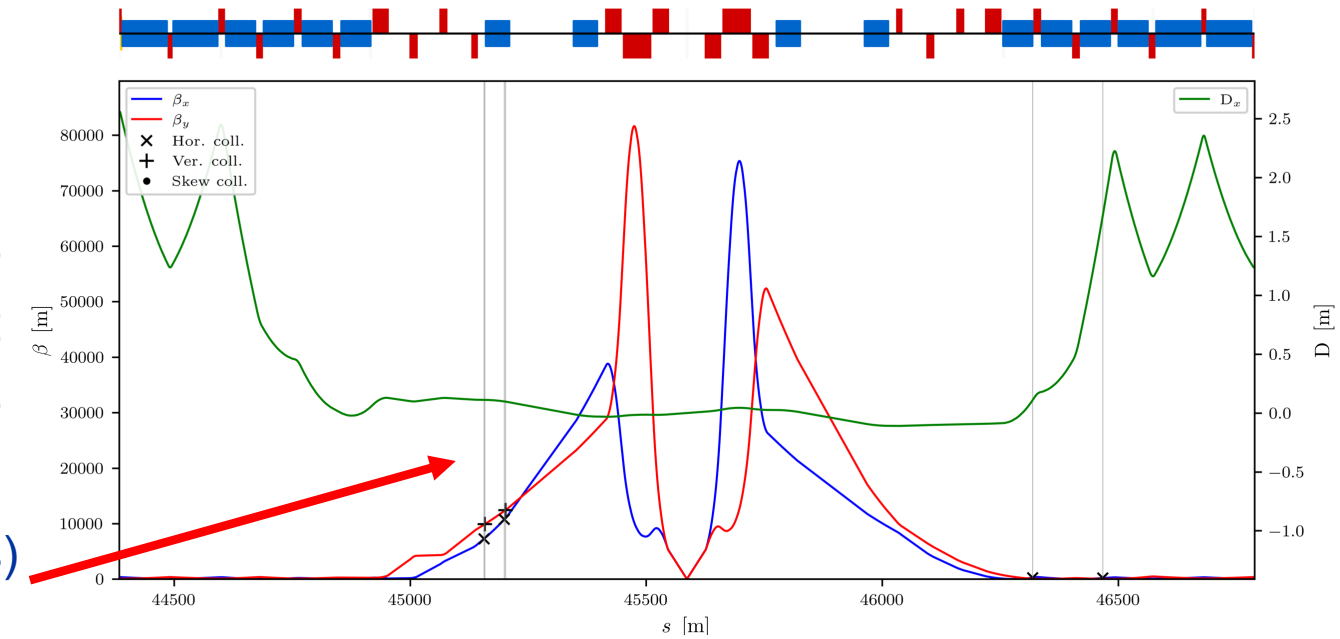
Experimental insertions

- **β* pushed from 50 to 30 cm**
- **This can be problematic:**
  - IR losses close to limit already at 50 cm
  - No detailed studies of the beam stay clear for this lattice
  - The inner triplets are the aperture bottlenecks at top energy
  - Need to make sure IR aperture is protected

PA31 June 2022



PA31 current



Tertiary collimators (TCTs) must be adjusted

Collimator settings

- **The current collimator settings are taken directly from the CDR**

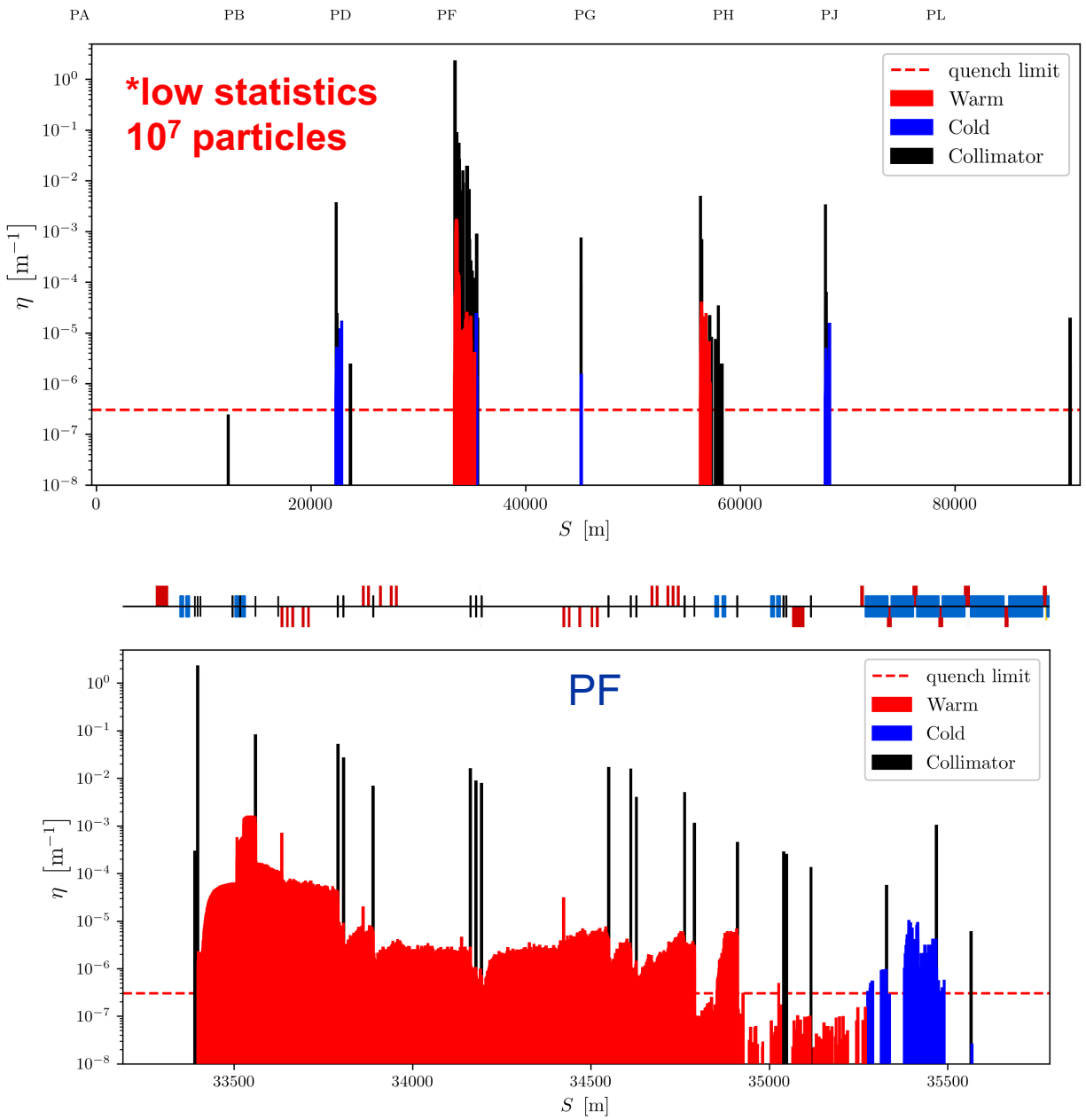
Collimator	Material	Number	Injection ($n\sigma$)	Collision ($n\sigma$)
β TCP	CFC	2	7.6	7.6
β TCSG	CFC/MoGr	11	8.8	8.8
β TCLA	W	5	12.6	12.6
β TCLD	W	3	21.0	35.1
δ TCP	CFC	1	10.8	18.7
δ TCSG	MoGr	4	13.0	21.7
δ TCLA	W	5	14.4	24.1
δ TCLD	W	4	21.0	35.1
TCT	W	12	14.0	10.5
Experiment TCLD	W	8	21.0	35.1
TCDQ	CFC	1	9.8	9.8
Extraction TCLA	W	2	11.8	11.8
Extraction TCLD	W	1	21.0	35.1

Table from the long CDR

First run of the new setup

- **Similar losses in PF to previous baseline**
  - Still a large loss cluster in the DS
  - Need to adjust the TCLD collimators

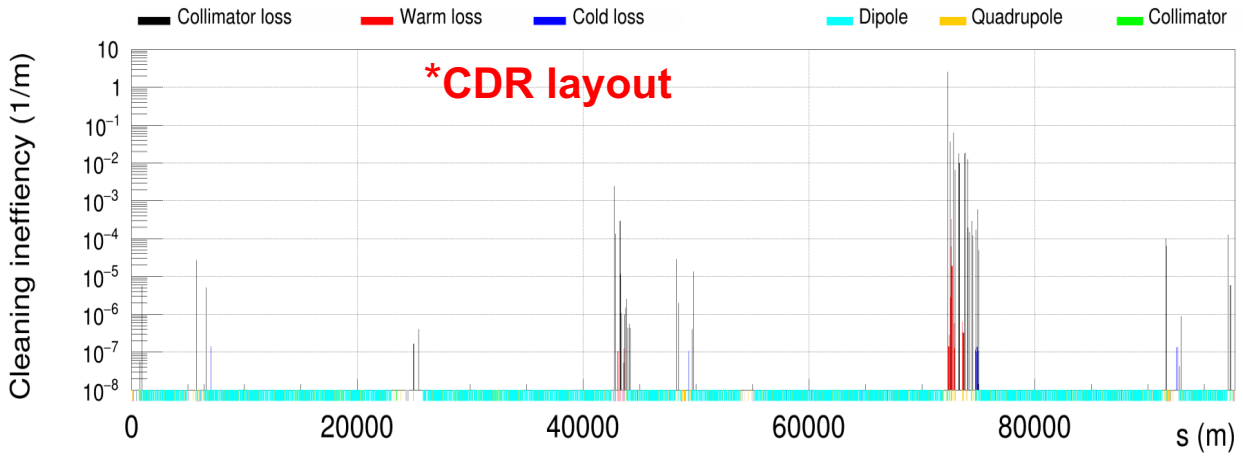
- **Much worse cold losses in the IRs:**
  - Higher losses on the tertiary collimators (TCT)
  - Higher cold losses downstream of the TCTs
  - Cold loses above the estimated quench limit
  - No clear solution to those losses



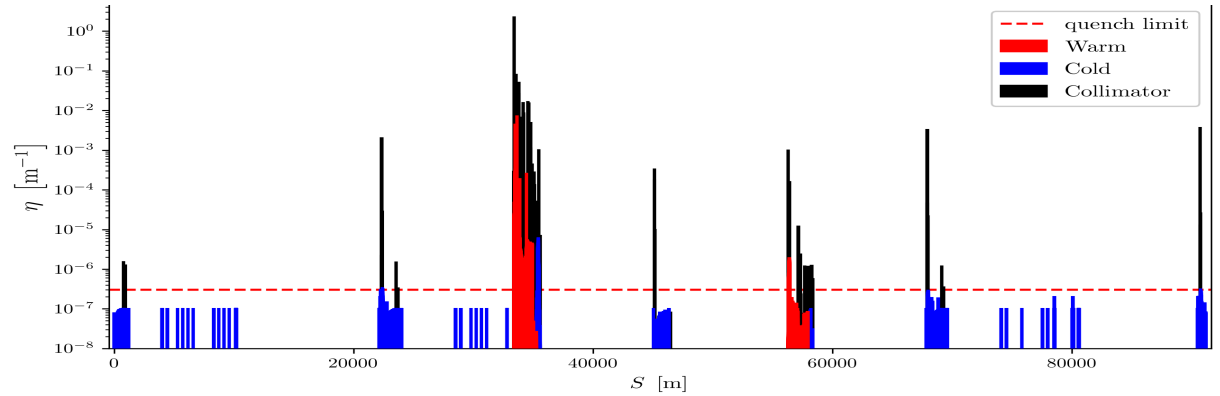
Comparison of IR losses

- For the CDR layout, IR cold losses remained around 10^{-7} m^{-1}
- For the 2022 PA31 lattice, it reached a few 10^{-7} m^{-1}
- For the current lattice, the losses reach 10^{-5} m^{-1}
- Quench limit assumed is $3x10^{-7}$ m^{-1}
- This is posisbly an effect of the decreased β*, but must be addressed
- Can we consider going back to the 55 cm β*?
  - Note: The CDR setup used 30 cm for the two main experiments

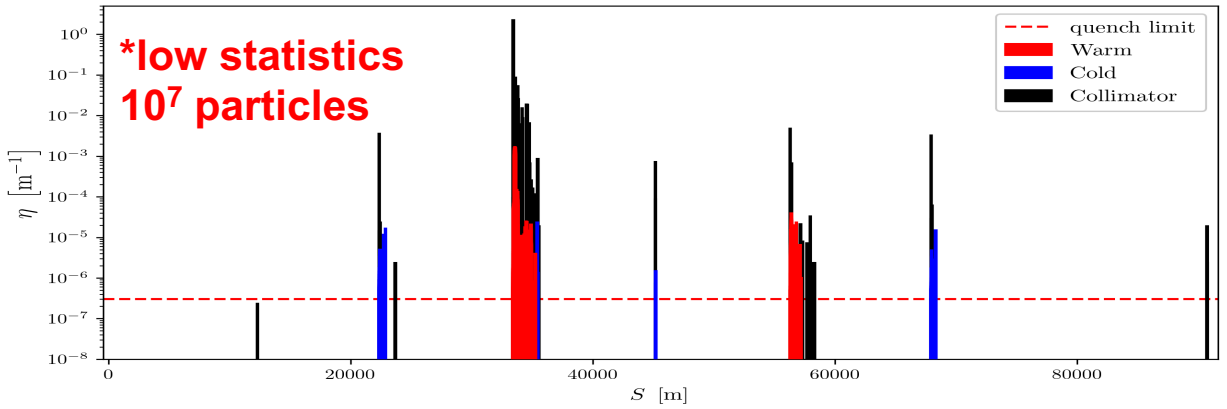
CDR lattice (J. Molson, talk)



PA31 2022 (talk FCC week)



PA31 current



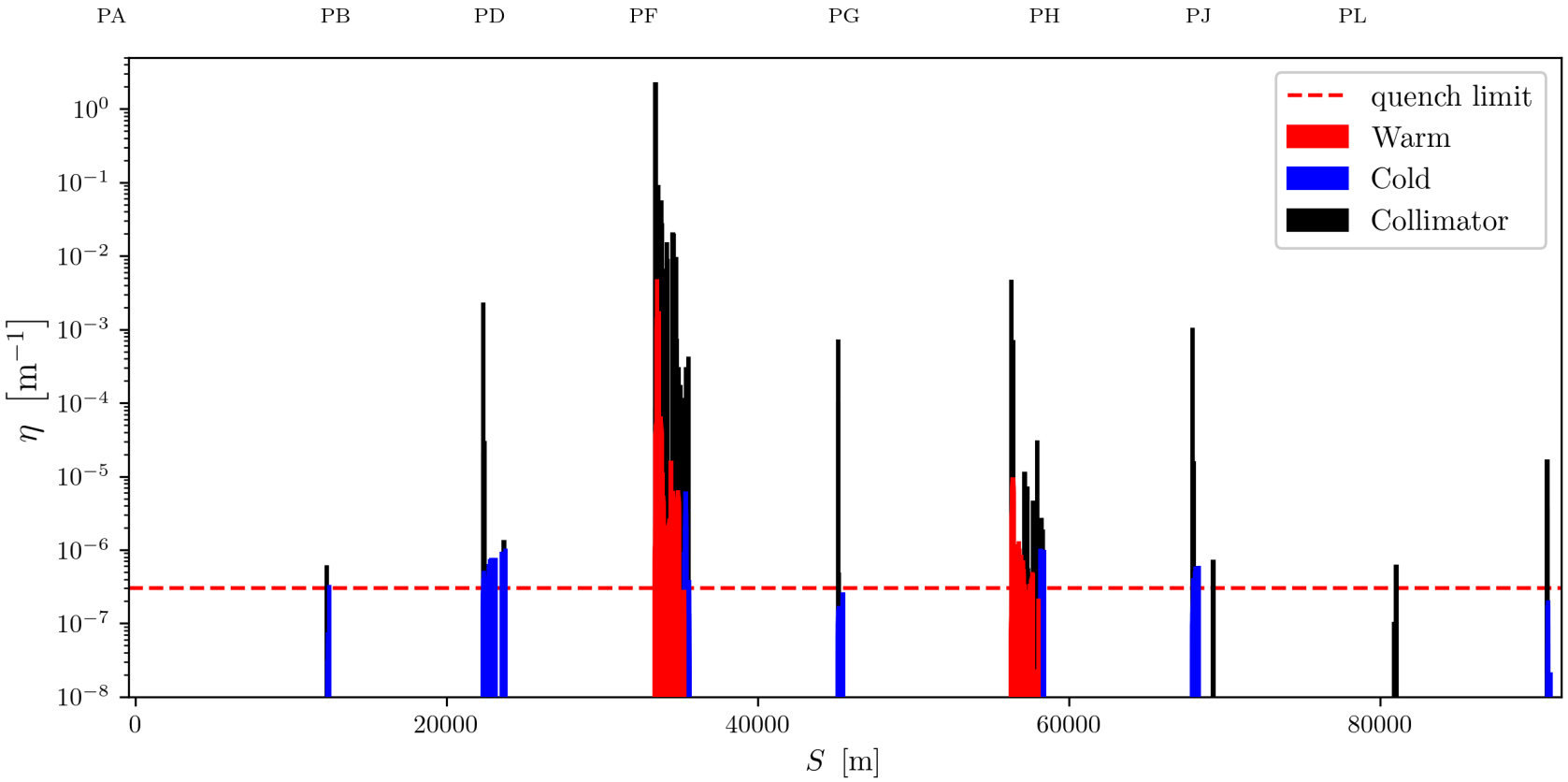
Mitigation attempt #1

- Introduce some adjustments in an attempt to reduce cold loss clusters
  - Close PF secondary collimators (TCSG) by 0.2 sigma
  - Reposition the first 2 PF TCLDs to better match peaks
  - Close the PF TCLDs by 1 sigma
  - Open the TCTs by 0.2 sigma

- Caveats
  - This is a first guess
  - Changing settings requires detailed investigation
  - Beam stay clear, collimation hierarchy, impedance, and power loads, must be checked

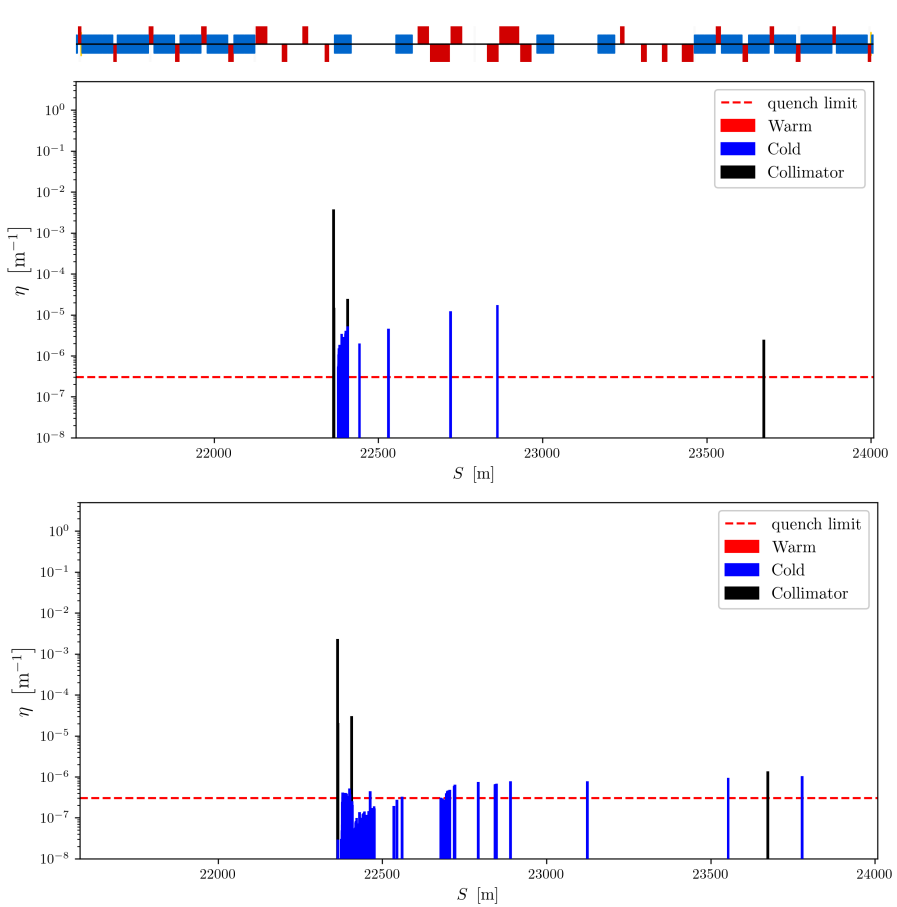
Mitigation attempt #1

- The losses in the IRs are significantly reduced, but still above the quench limit
- The losses in the PF DS are still high – likely leakage from the TCLDs themselves
- Must be studied in more detail

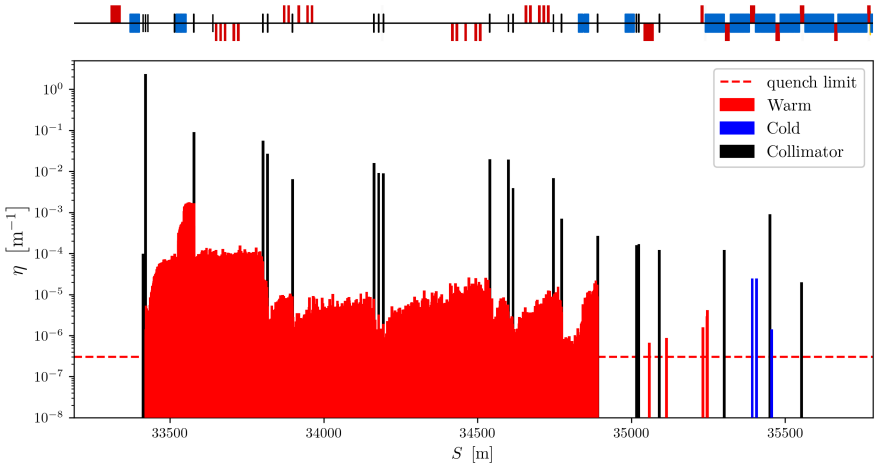


Mitigation attempt #1

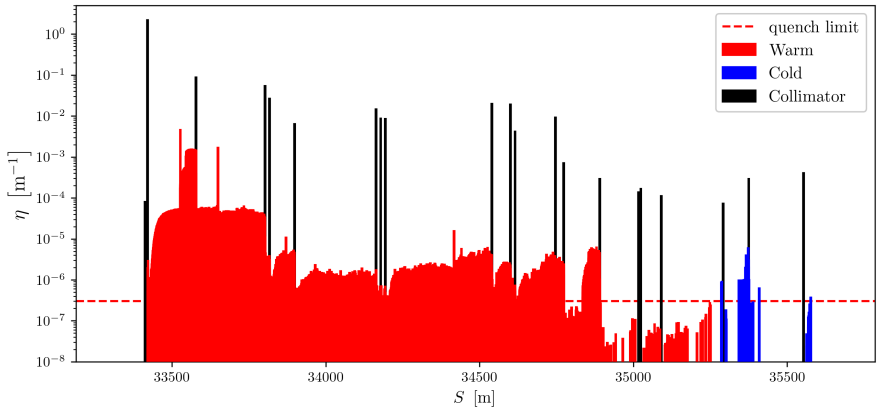
- Peak losses in PD go from **1.5x10^{-5} m^{-1}** to **1.0x10^{-6} m^{-1}**
  - Factor 15 improvement, but still factor 5 above the quench limit
- Peak losses in PF go from **2.5x10^{-5} m^{-1}** to **6x10^{-6} m^{-1}**
  - Factor 4 improvement, but still factor 20 above quench limit



Base



Mitigation #1



Future work

- **Optimize the locations of the TCLD collimators in PF to mitigate the DS loss cluster**
  - Check the momentum cut at the collimators
  - Consider other mitigations – adjusting TCSG and TCLA settings, longer collimators

- **Resolve the issues with cold losses in the lrs**
  - Perform aperture studies with the new layout
  - Investigate possible collimator setting optimizations (time consuming)
  - Relax the β*

- **Include the remainder of the CDR collimators in the model:**
  - Injection protection collimators
  - Physics debris absorbers (TCLs)
  - These collimators are not needed for the basic studies at top energy, could postpone the installation

Future work

- **Optimize the locations of the TCLD collimators in PF to mitigate the DS loss cluster**
  - Check the momentum cut at the collimators
  - Consider other mitigations – adjusting TCSG and TCLA settings, longer collimators

- **Resolve the issues with cold losses in the lrs**
  - Perform aperture studies with the new layout
  - Investigate possible collimator setting optimizations (time consuming)
  - Relax the β*

- **Include the remainder of the CDR collimators in the model:**
  - Injection protection collimators
  - Physics debris absorbers (TCLs)
  - These collimators are not needed for the basic studies at top energy, could postpone the installation