LHC Collimation Project CERN

SixTrack studies with DS collimators in nominal optics

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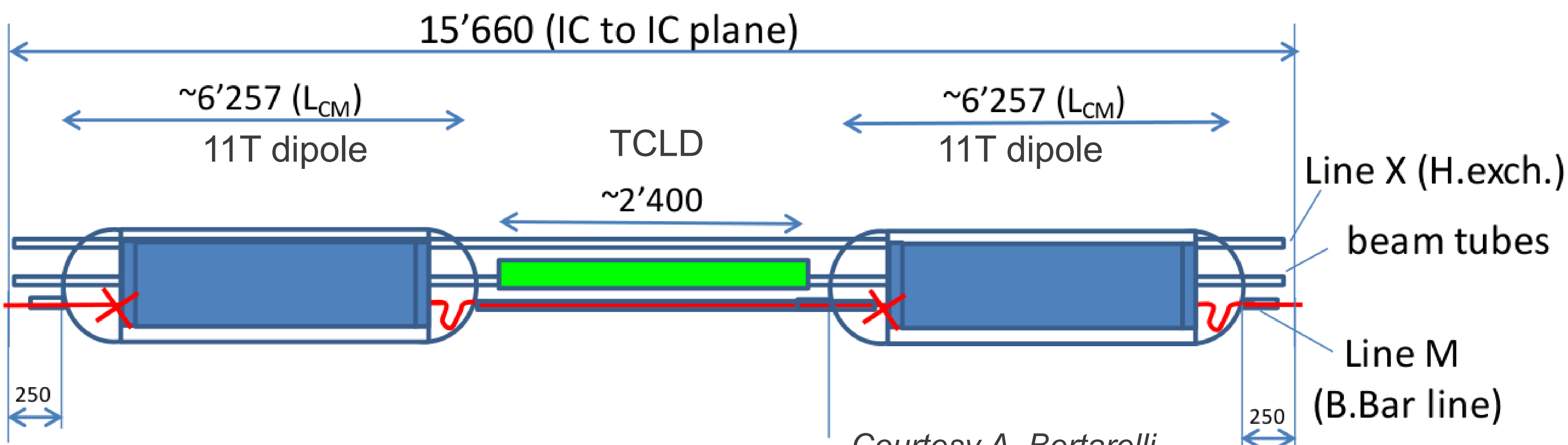
Acknowledgement: B. Holzer, M. Schaumann

Introduction to DS collimators

- IR7 dispersion suppressor (DS) is the limiting location in terms of collimation cleaning inefficiency
  - Dominating losses from protons that have undergone single diffractive scattering in TCP.
  - Energy offset large enough to hit the aperture in the arc, with high dispersion, but not large enough delta and betatron amplitude to hit the other collimators
- In the experimental IRs, off-momentum collisional debris lost in the DS. Maybe less critical (for protons – may still be needed for ions!) – considering presently only IR7 DS
- In both cases, the installation of additional collimators in the DS, TCLD, after the point where the dispersion is rising, could intercept these losses
- IR7 DS collimators are also beneficial for ions
- More background: see talks in collimation review 2013

Integration and layout

- Most promising layout option
  - replace an existing main dipole with two short 11T dipoles
  - Warm collimator installed in between the magnets
  - See talks V. Parma, A. Bertarelli in 2013 collimation review
- Considering a magnetic length of 5.5m (M. Karpinen) and an active collimator length of up to 1m

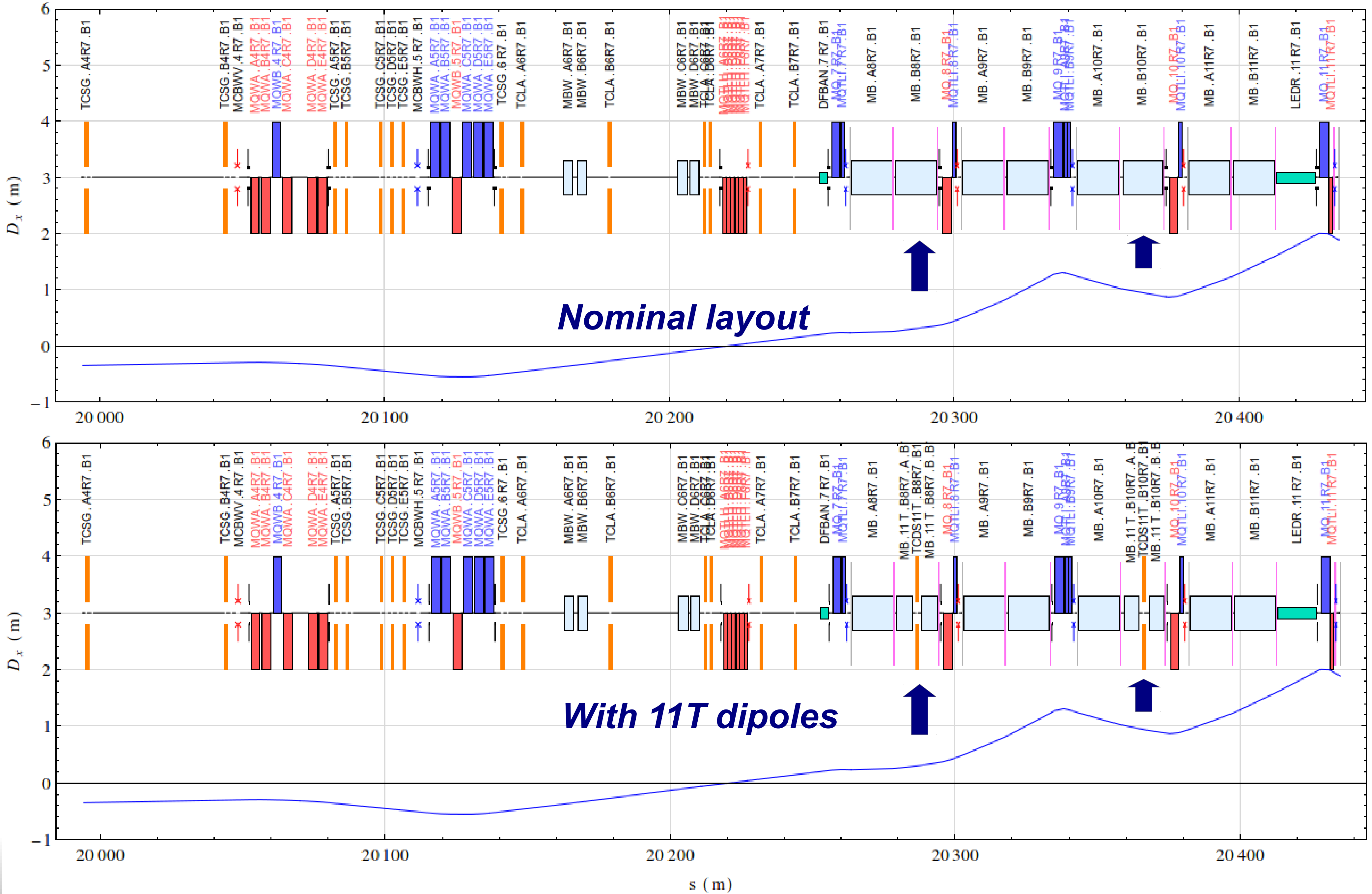


Courtesy A. Bertarelli

MAD/SixTrack implementation of DS collimators

- To quantify cleaning gain, need to simulate cleaning with SixTrack
- Previous simulations done with other layout options (shifting several magnets by up to 3m – see e.g. TH5PFP008, PAC09)
- New implementation based on 11T dipole layout
- In MAD lattice, exchanging existing dipoles in cells 8 and 10 in IR7 *(thanks to M. Schaumann and B. Holzer for input!)*
  - Installation done using thick lenses, before Makethin
  - Mathematica script to automatically generate the MAD input file and twiss, given the names of the dipoles that should be exchanged and a nominal twiss file
  - Thin sequences with 11T dipoles and DS collimators for SixTrack input created both for nominal optics and for ATS

Example layout, IR7 DS, B1

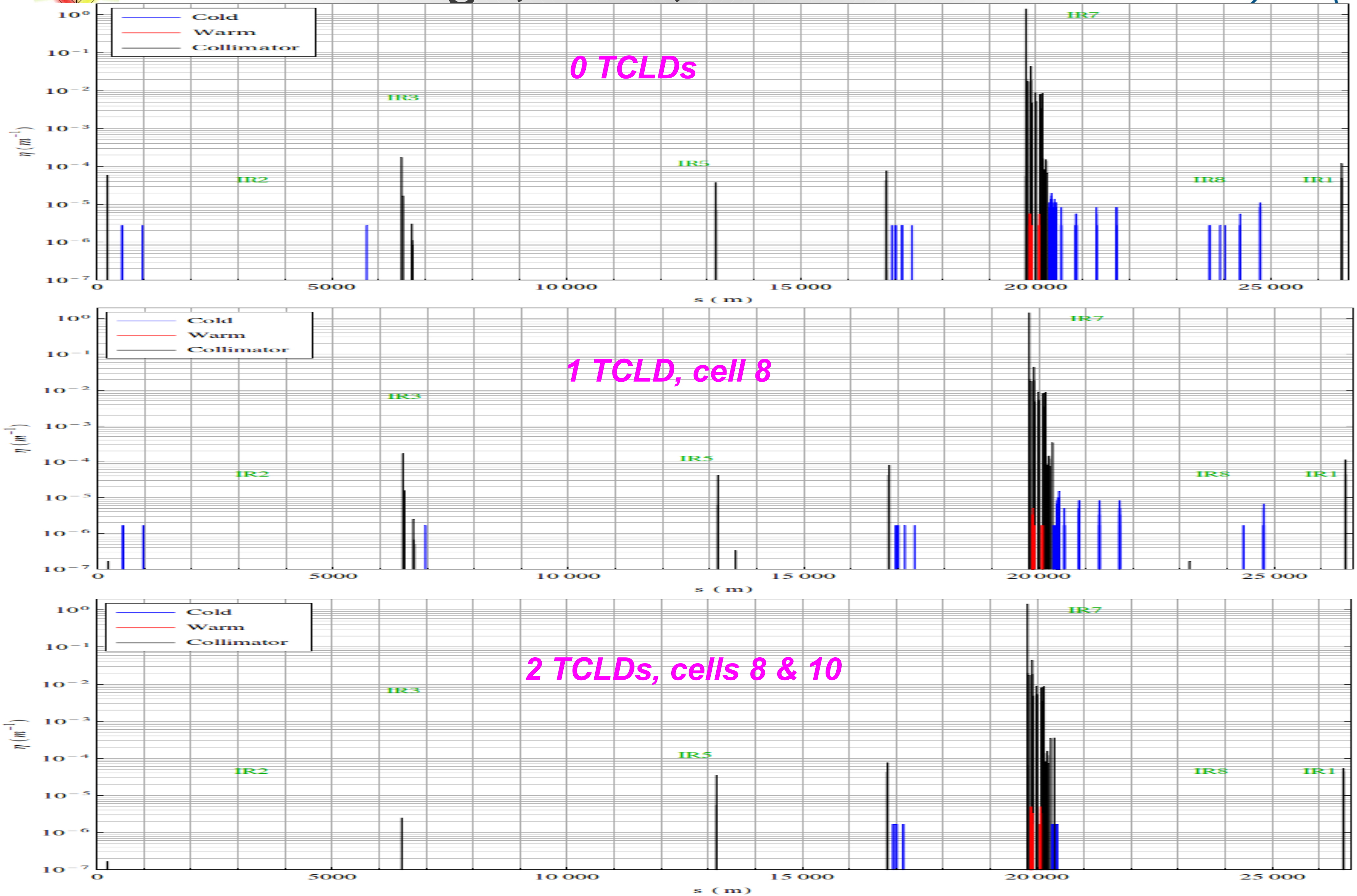


SixTrack simulation campaign

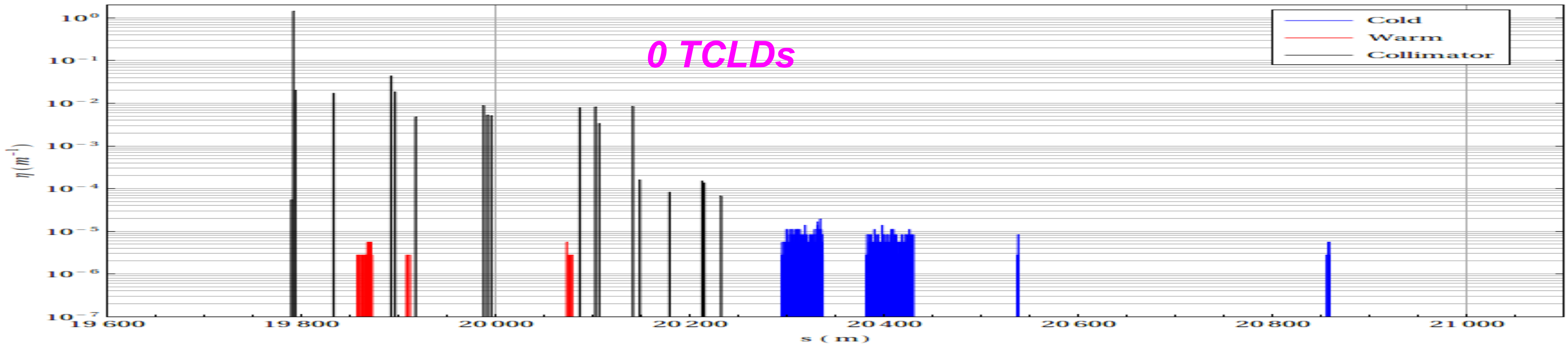
- Cleaning with DS collimators should be studied SixTrack for
  - Nominal optics (this talk).
    - Possibility of installing DS collimators before HL era
  - ATS optics (A. Marsili)
- For nominal optics (beta*=55cm), study:
  - 0, 1 or 2 DS collimators installed
  - With a tungsten TCLD of 80cm or 1m
  - With relaxed or nominal settings
  - For B1 and B2
- In total 16 simulations – but not all cases simulated
- Studying 7 TeV

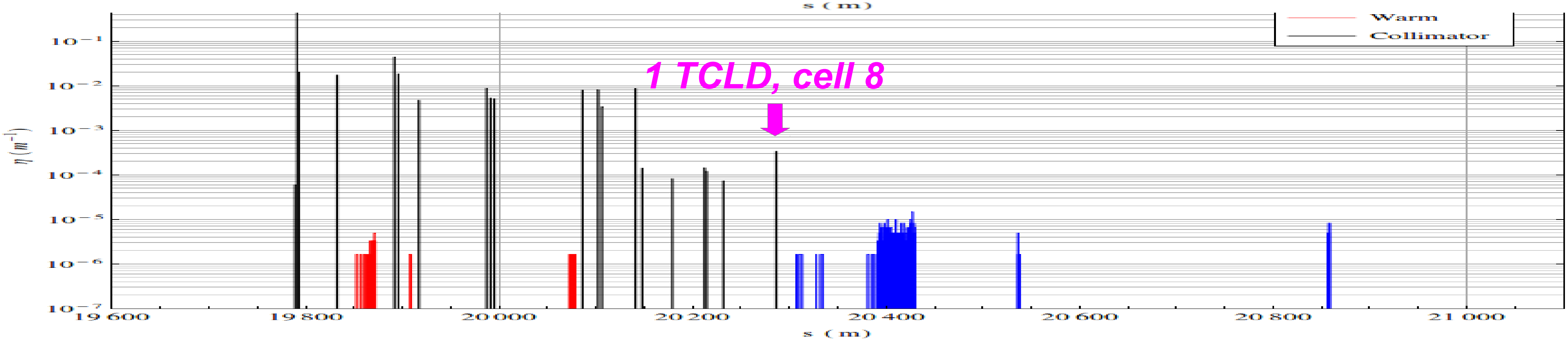
Settings in sigma (3.5 um emittance)	Relaxed (20% larger gap than 2012)	nominal
TCP7	7.0	6.0
TCS7	10.3	7.0
TCLA7	13.0	10.0
TCLD	**13.0**	**10.0**
TCSG6	11.0	7.5
TCDQ6	11.6	8.0
TCT	13.2	8.3

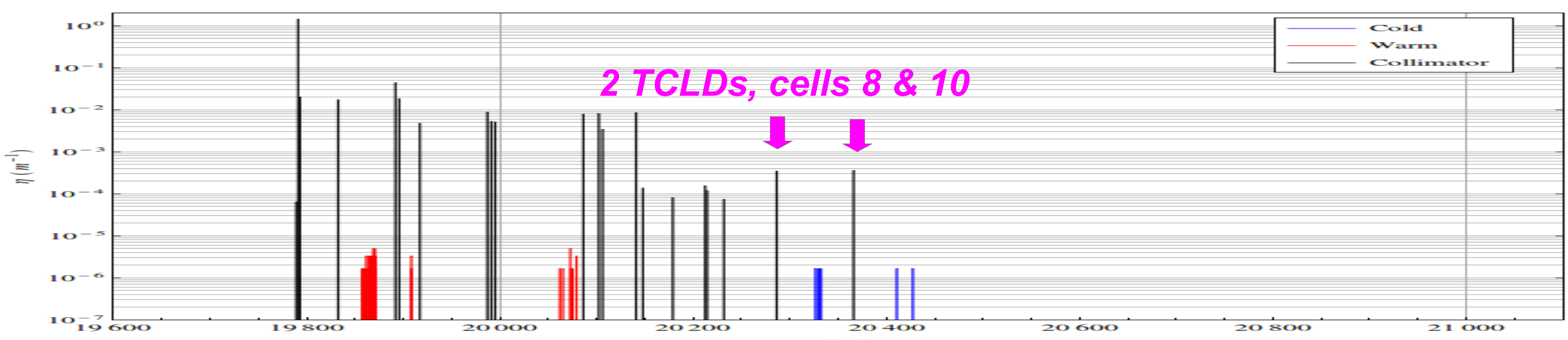
Global loss maps – nominal settings, B1H, 80 cm TCLD



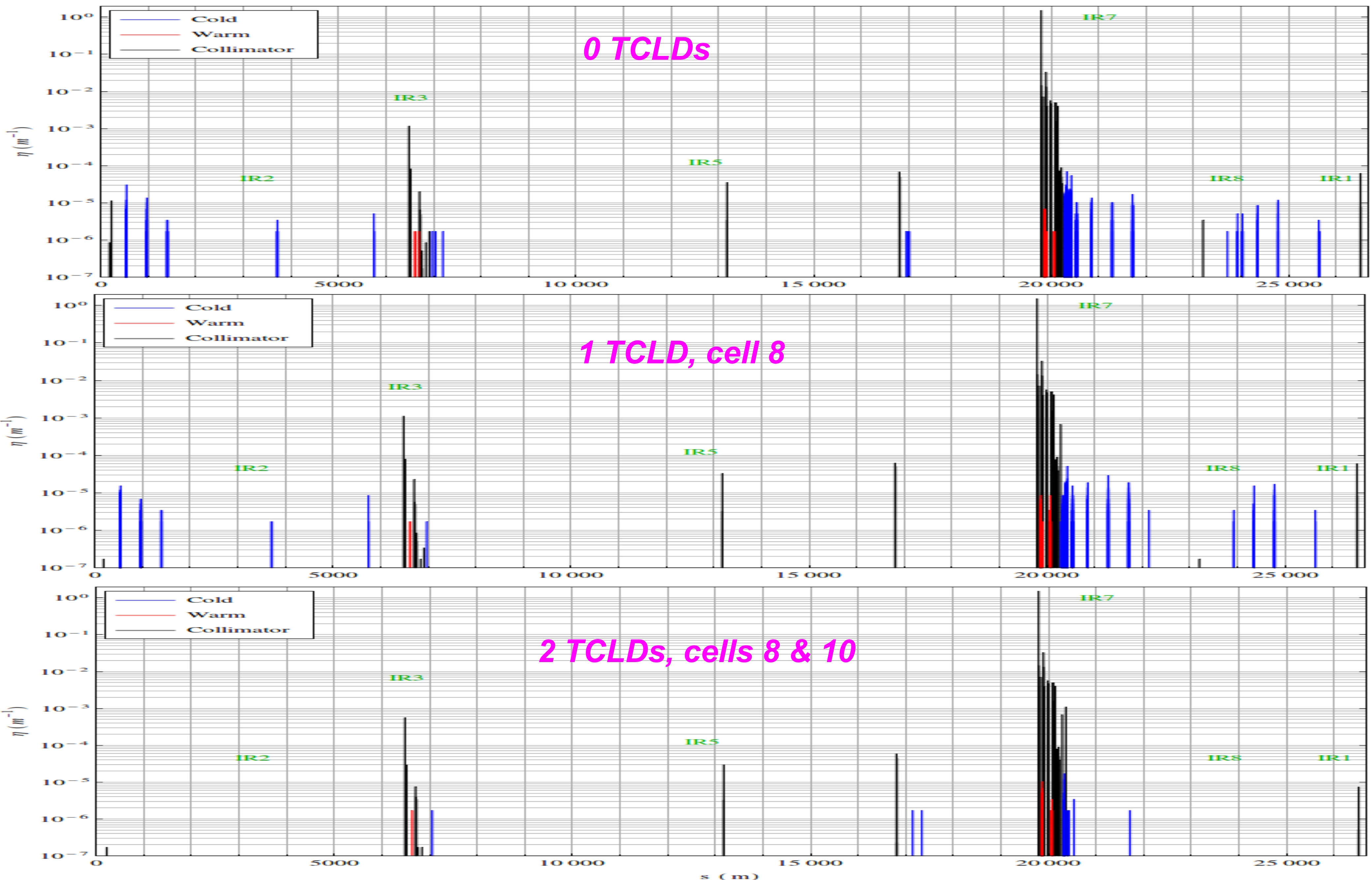
IR7 Loss maps – nominal settings, B1H, 80 cm TCLD



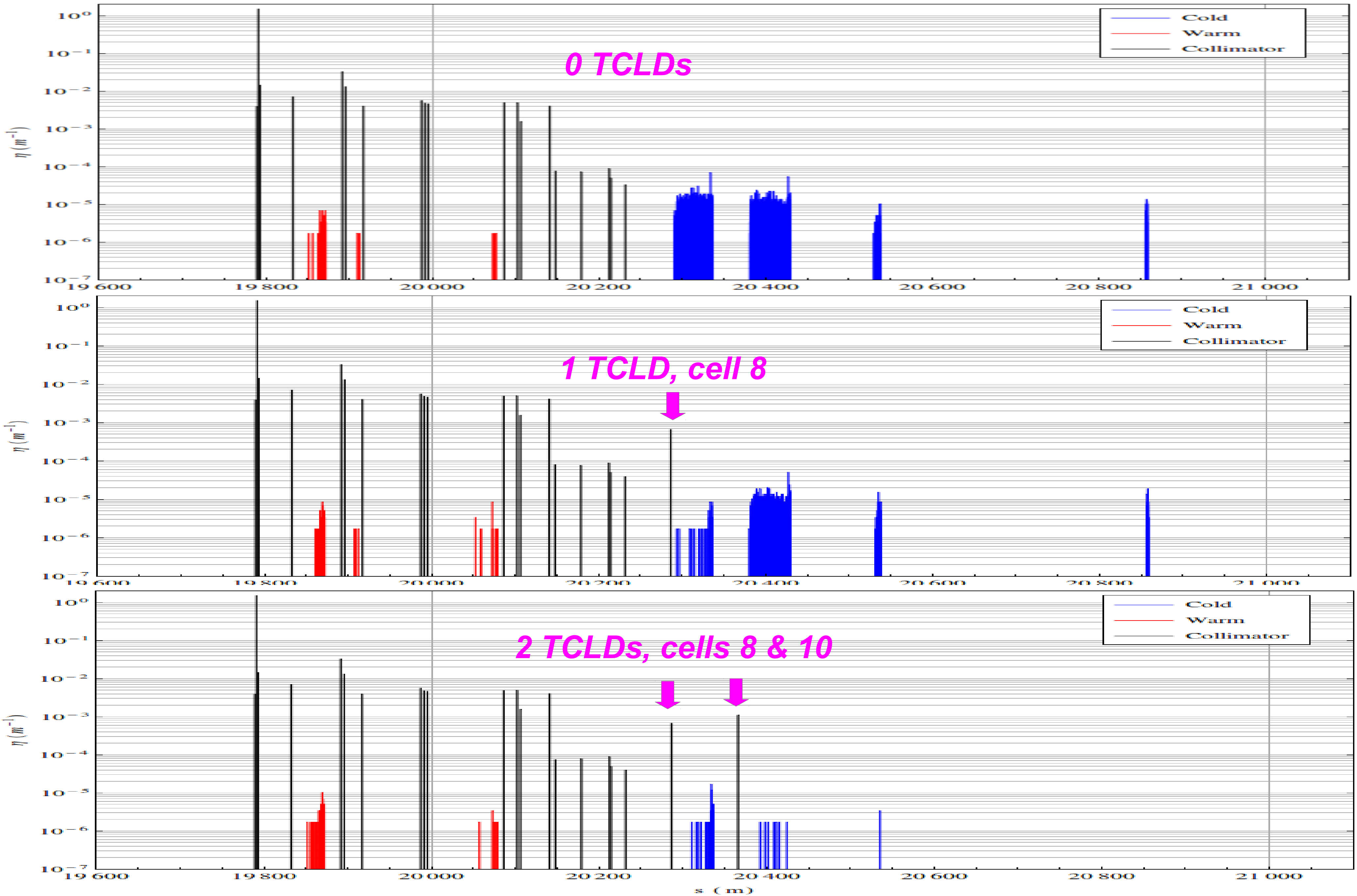




Global loss maps – relaxed settings, B1H, 80 cm TCLD

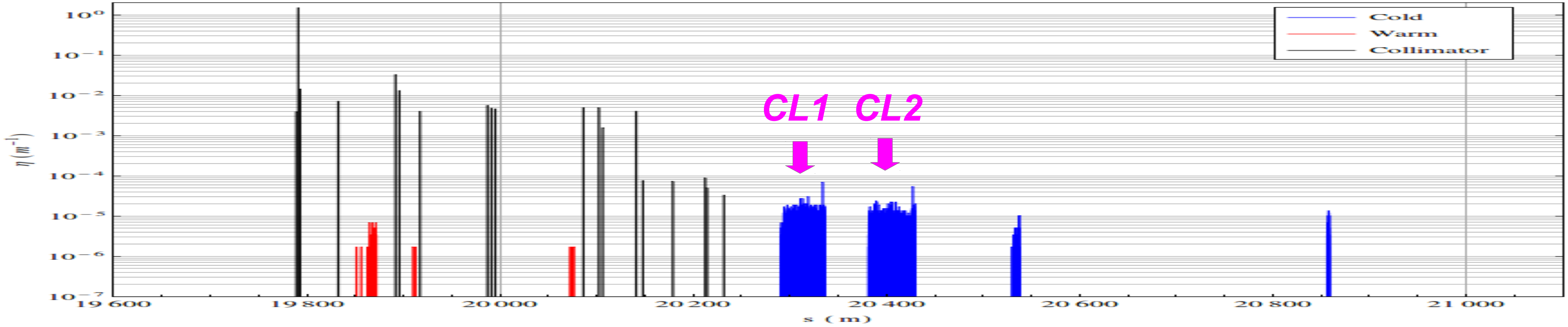


IR7 loss maps – relaxed settings, B1H, 80 cm TCLD



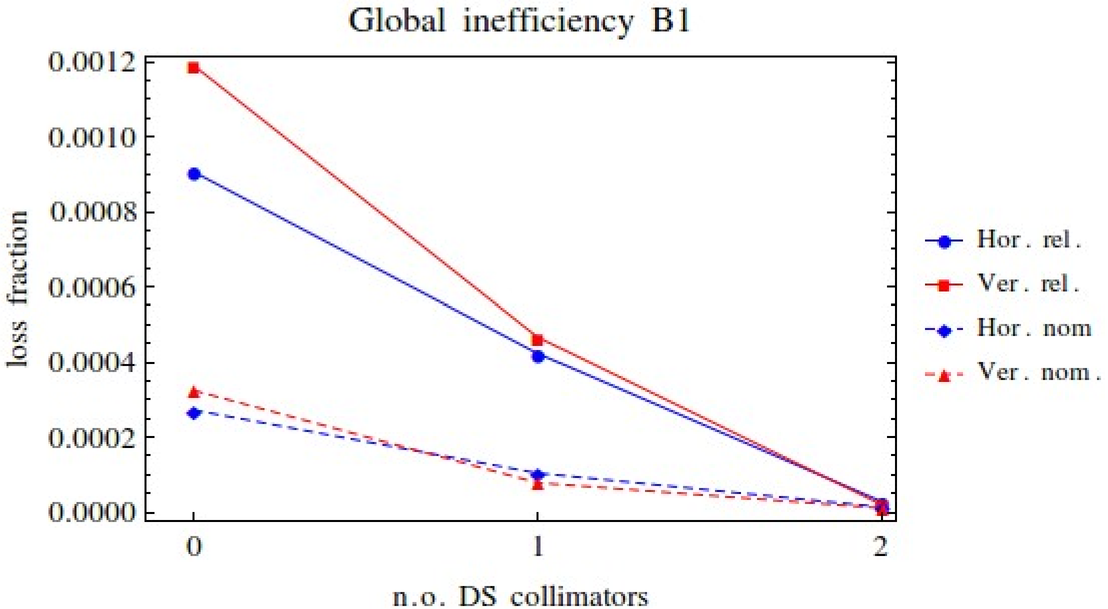
Losses as function of DS collimators

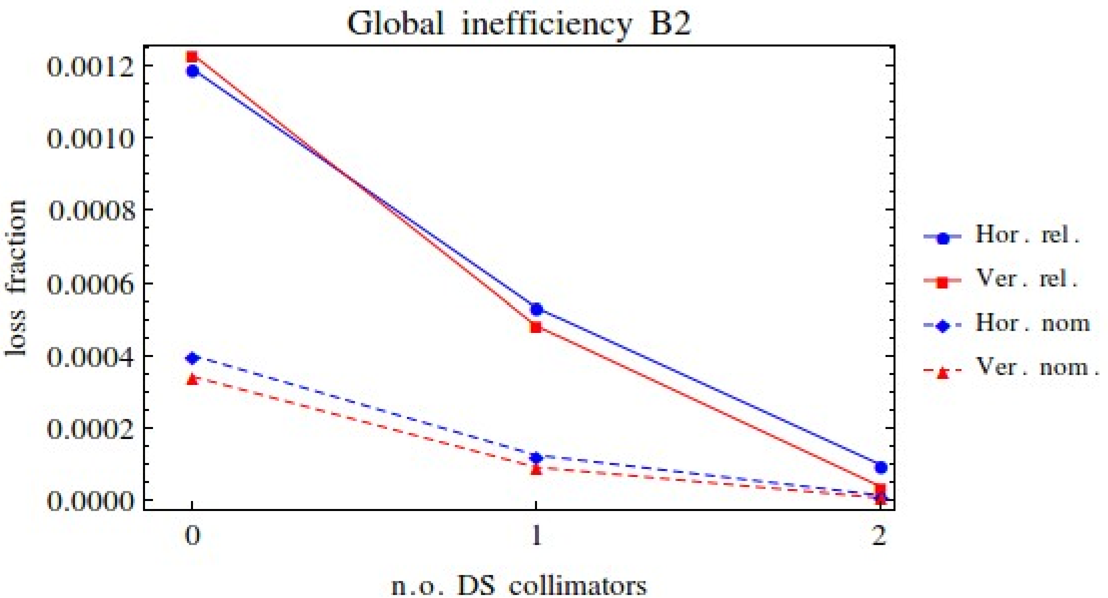
- Loss maps show:
  - TCLD in cell 8 decrease significantly the losses in cells 8-9.
  - TCLD in cell 10 decreases losses in cells 10-11 and in the rest of the ring
  - Both TCLDs are more efficient at 10 sigma than at 13 sigma
- To more easily compare different optics, and to quantify the gain of the DS collimators, compare the following quantities:
  - Global cold cleaning inefficiency (fraction of losses in cold regions)
  - Global warm cleaning inefficiency (fraction of losses in cold regions)
  - Highest local cold cleaning inefficiency
  - Fraction of losses in the two “clusters” in the IR7 DS (CL1(8-9) and CL2(10-11))



Global inefficiency

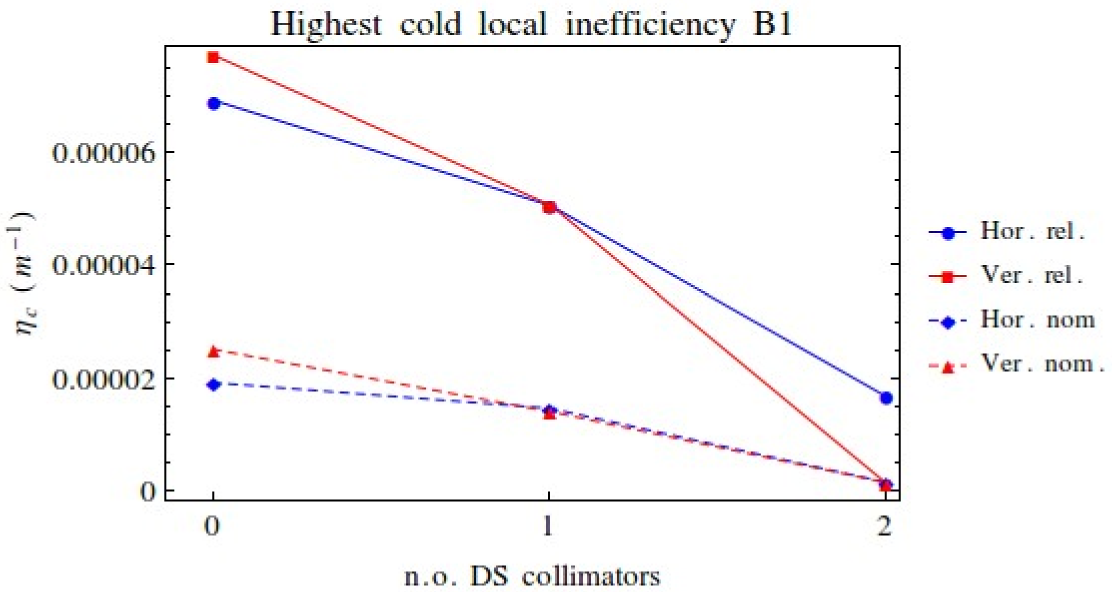
- Clear reduction in global inefficiency – less losses in the whole ring! With 2 TCLDs:
  - Factor ~10 for relaxed settings
  - Factor ~20 for nominal settings

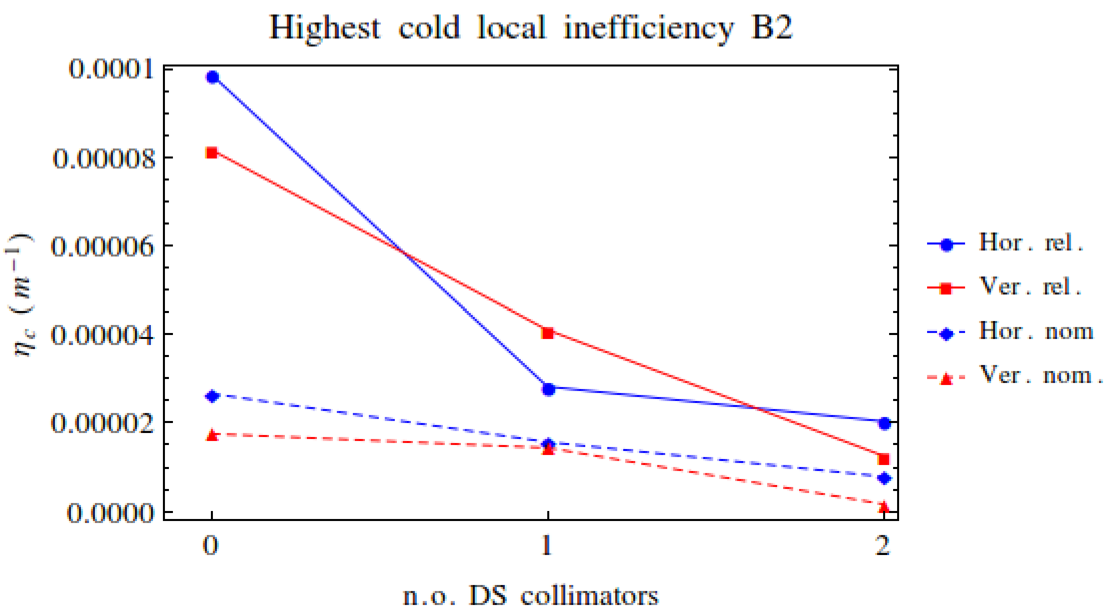




Highest cold local inefficiency

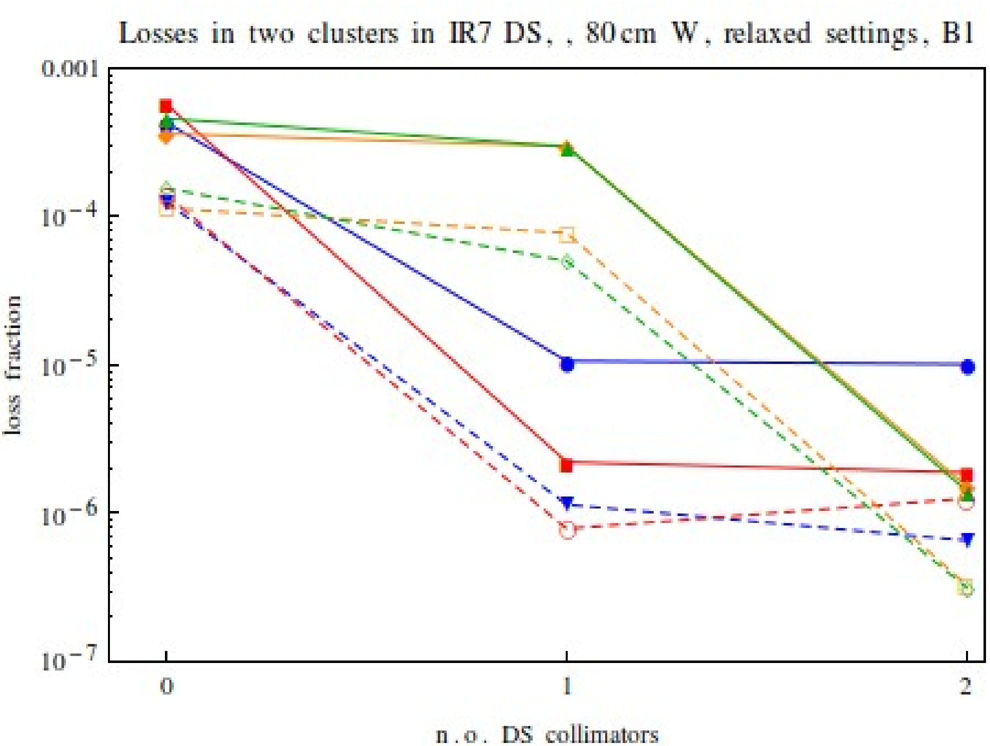
- With 2 TCLDs, the reduction is
  - Factor ~5 with relaxed settings
  - Factor ~10 with nominal settings
- Statistical error is ~20%

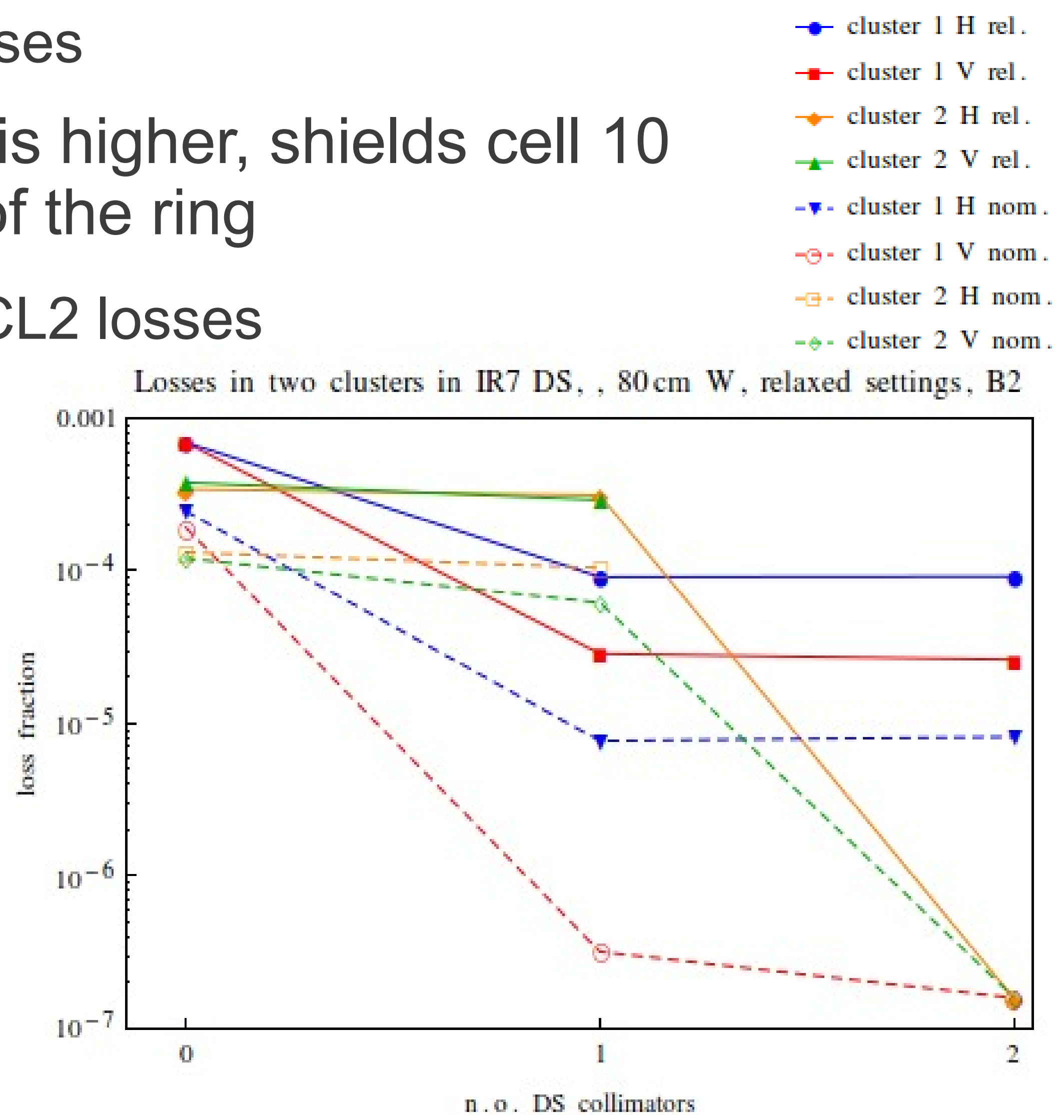




Local losses in the two "clusters" in the IR7 DS

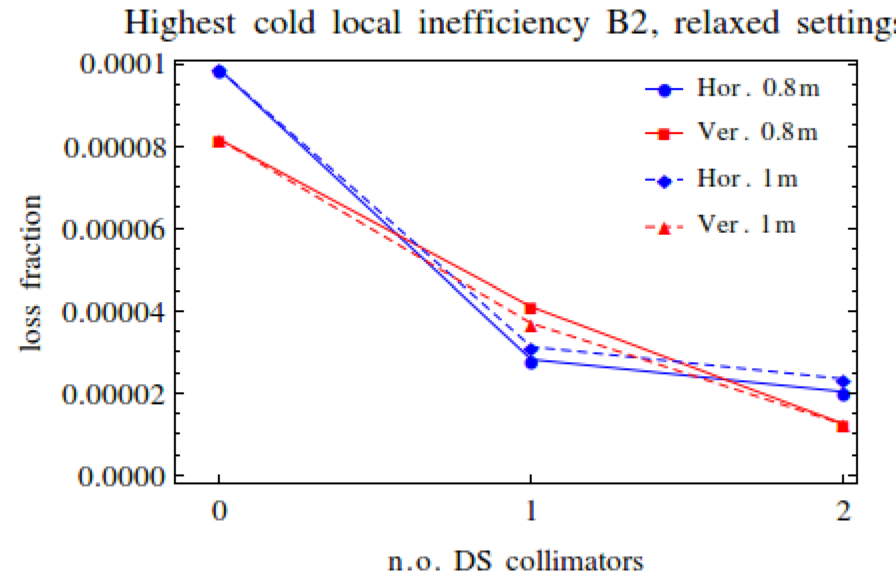
- The TCLD in cell 8 acts on the first cluster. Not high enough momentum cut to shield cell 10
  - Up to 300 reduction of CL1 losses
- The TCLD in cell 10, where Dx is higher, shields cell 10 but also large parts of the rest of the ring
  - Up to factor 500 reduction of CL2 losses

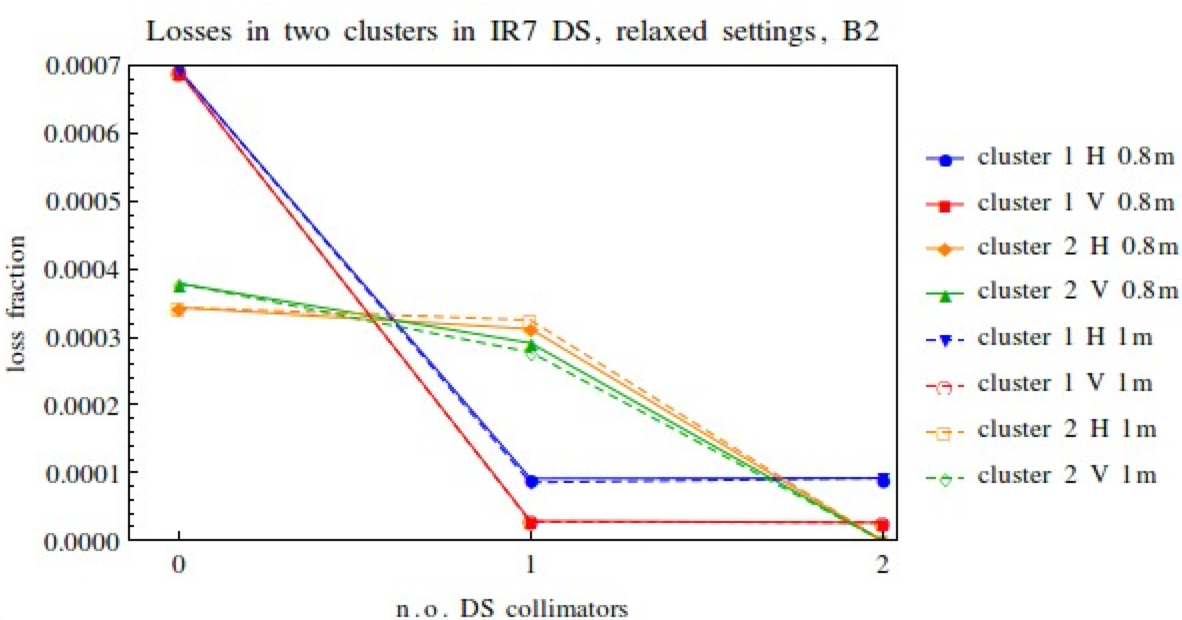


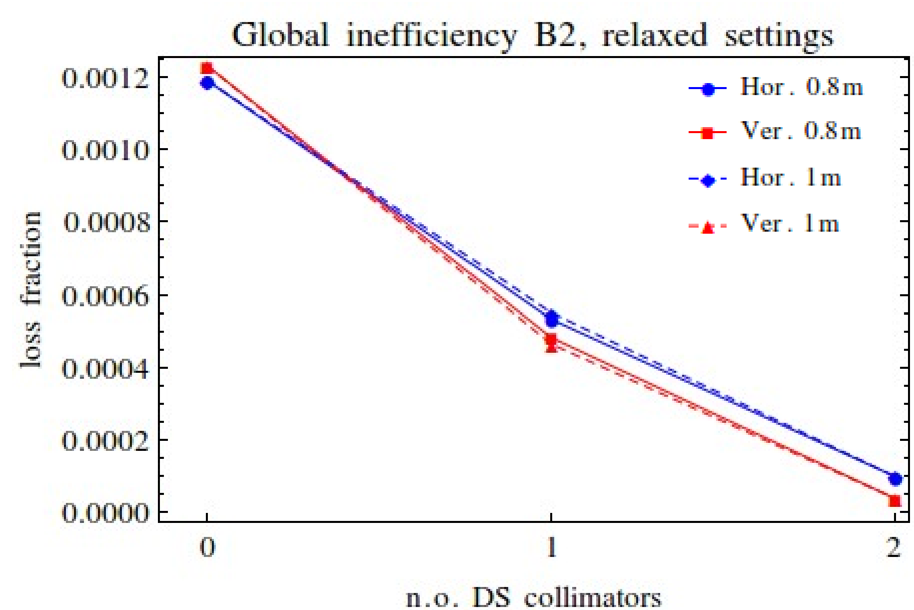


80cm vs 1m TCLD length

- No significant difference observed in the the reduction of losses between 80cm and 1m TCLD length







Conclusions

- DS collimators seem to be a very promising way of decreasing proton losses to cold magnets in the LHC.
- Present design proposal: assembly with warm DS collimator between 2 short 11T dipoles can replace existing long dipole
- MAD lattice with DS collimators in IR7 created, both for nominal optics and for ATS. Used for SixTrack input
- SixTrack simulations of cleaning in nominal optics show a very significant loss reduction in cold magnets from DS collimators
  - Gain factor 10-20 in global inefficiency, and even more in local losses in the IR7 DS
  - Results consistent with results from ATS simulations (A. Marsili) and previous studies with different layout (T. Weiler)
- Installing 2 DS collimators seems as a better option: shields the whole IR7 DS and reduced losses also in other parts of the ring.
- Decreasing the length of the TCLD from 1m to 80cm has no visible impact on the losses
- Detailed energy deposition studies needed to quantify gain in dose and quench margin – SixTrack output forwarded to FLUKA team (see A. Lechner in next talk)