Present status of TCDQ concept

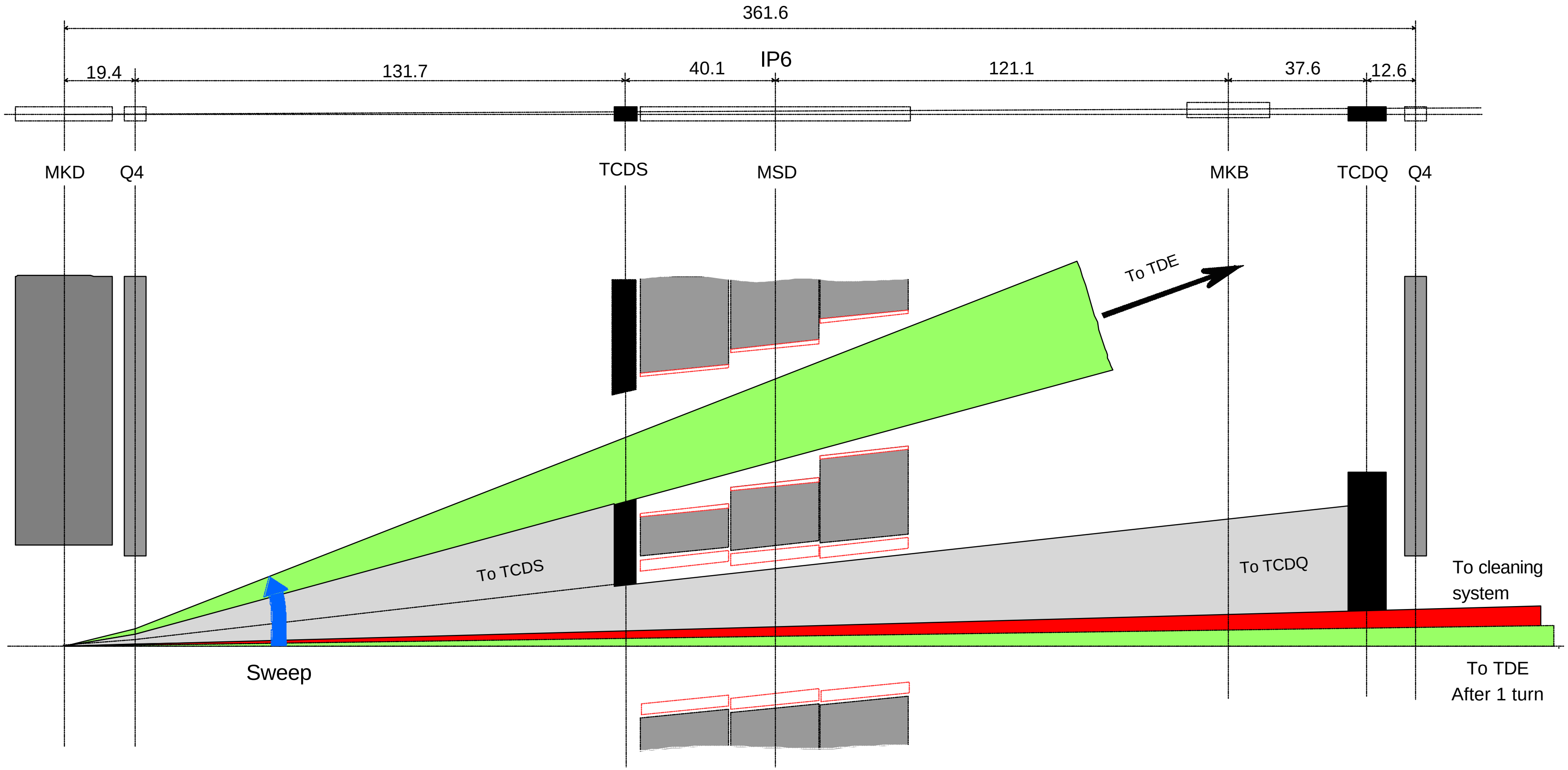
Results of :

- Long-running MARS simulations by Fermilab collaborators Nikolai Mokhov & Igor Rakhno
- Many discussions at CERN (Rüdiger, Ralph, Wim, Verena, Marcel, Jan, Jorg, Markus,…)

Asynchronous dump failure

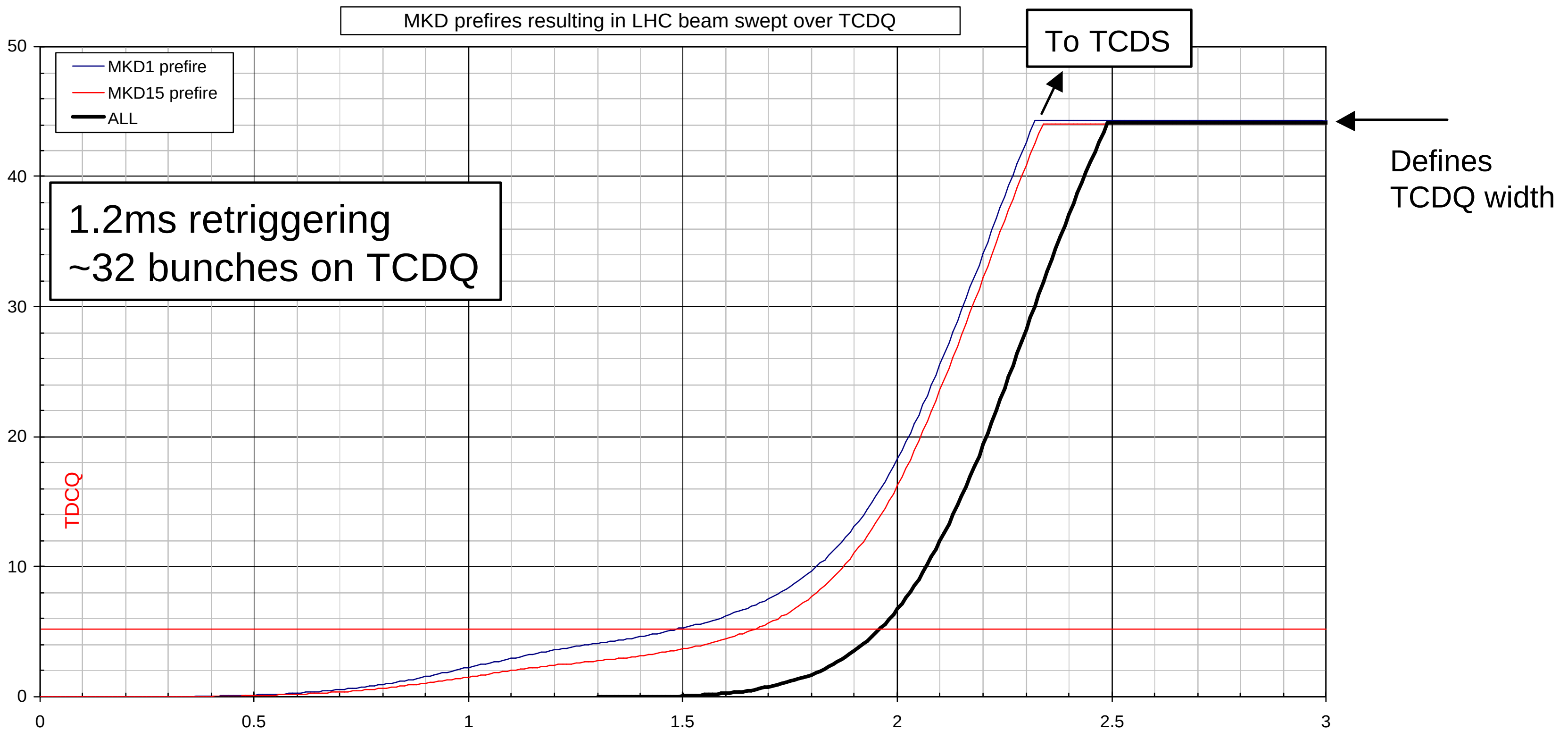
TCDS prevents damage to MSD + chambers (WW)

TCDQ protects Q4+, arc, low β insertions (collimators?)



TCDQ loading

- Bunch disposition evaluated assuming 1.2, 3.0 and 4.0 μs MKD retriggering delays (all now pessimistic)…



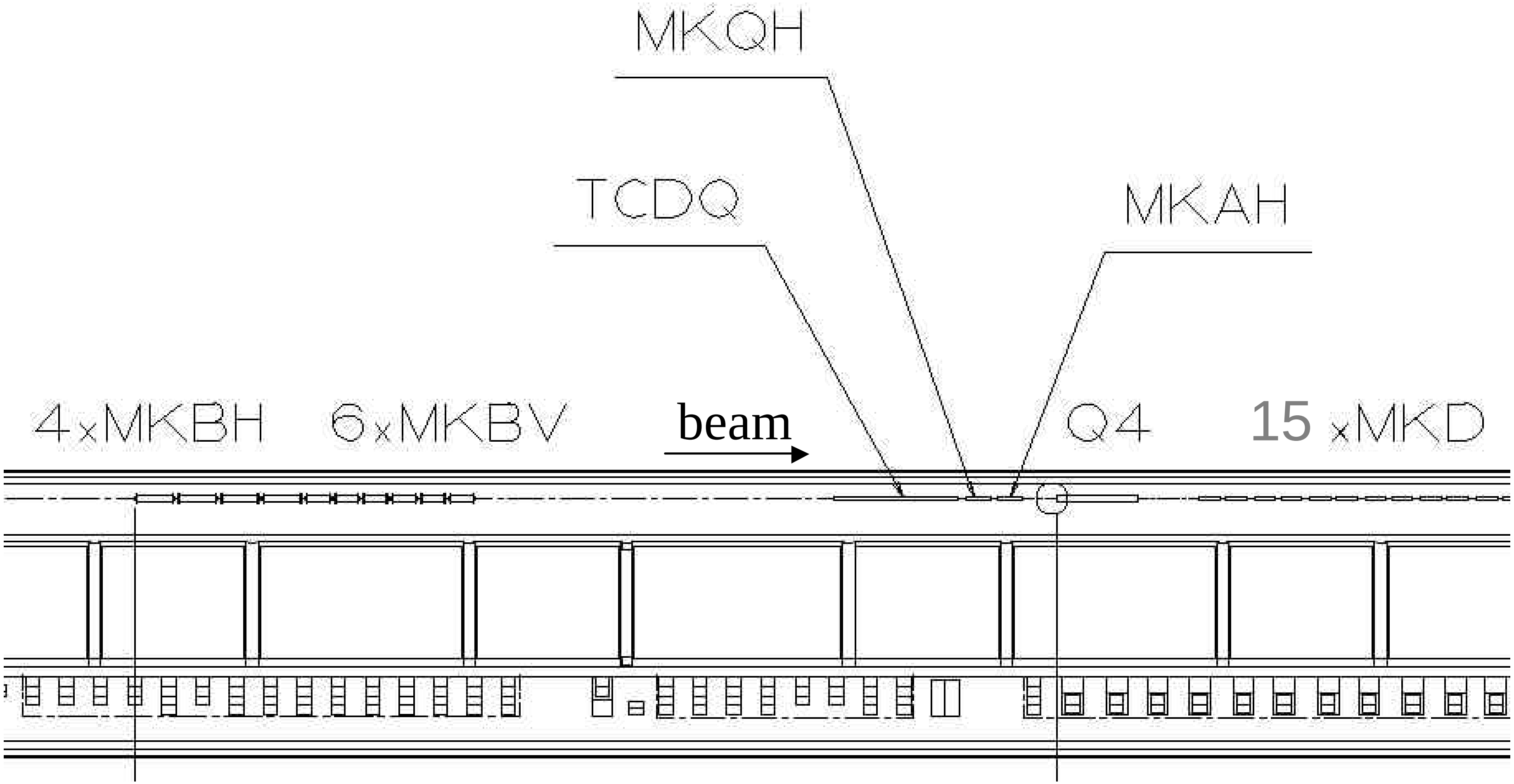
TCDQ - boundary conditions

- Should be at **10 ± 0.5** s at injection and in collision (at 7TeV unsqueezed to be defined…) ⇒ **movable jaw**
- Must dilute asynchronously dumped beam sufficiently to prevent downstream damage (Q4, arc, low-β) ⇒ **long object**
- Must dilute normal residual abort gap population sufficiently to avoid Q4 quench ⇒ **long object**
- Must survive worst-case beam impact ⇒ **low Z**
- Integration, vacuum compatibility & impedance constraints ⇒ **usual stuff**
- RP issues for handling etc. *depending on activation*.

Present status

- All nuclear simulations carried out by Mokhov/Rakhno - present iteration uses 9.5m total length
  - 8m C (1.8g/cc)
  - 1.5m Al
- Concept validated from dilution aspect and TCDQ survival for 1.2μs retriggering time (see [4]).
- Assume one single-sided jaw (movement ex-vacuum). If another jaw required for machine protection reasons, will be separate 2-sided short collimator-like object.
- Mechanically, TCDQ probably 3 separate modules on mobile girder
- Location ~fixed
- Heat loads and temp. rises calculated
- Instantaneous doses calculated
- Downstream masks to reduce IP6 quenches investigated…

Location (RA67 side of IP6)



Heat load and temperature rise

Heat load (kJ) in IP6 components

Module	Relative position* (m)	Delay time τ (μs) 1.2	3.0	4.0
TCDS	-42.1	1120	1160	1150
MSD1	-36.6	1340	1380	1380
MSD6	-12.05	20	20	20
MSD11	12.5	8	8	6
MSD15	32.14	3	3	3
TCDQ1	155.3	1640	2530	3470
TCDQ2	159.3	528	1020	1630
TCDQ3	160.8	60	149	299
Q4	170.1	22	86	235
Q5	206.5	4.6	23	68
MBA1	270.1	3.0	16	45
MBB1	285.8	0.64	3.6	10
Q8	302.1	0.11	0.27	0.9
MBA2	309.2	0.30	0.61	2.5
MBB2	324.8	0.17	0.55	1.7

*) Between upstream end and IP6 marker.

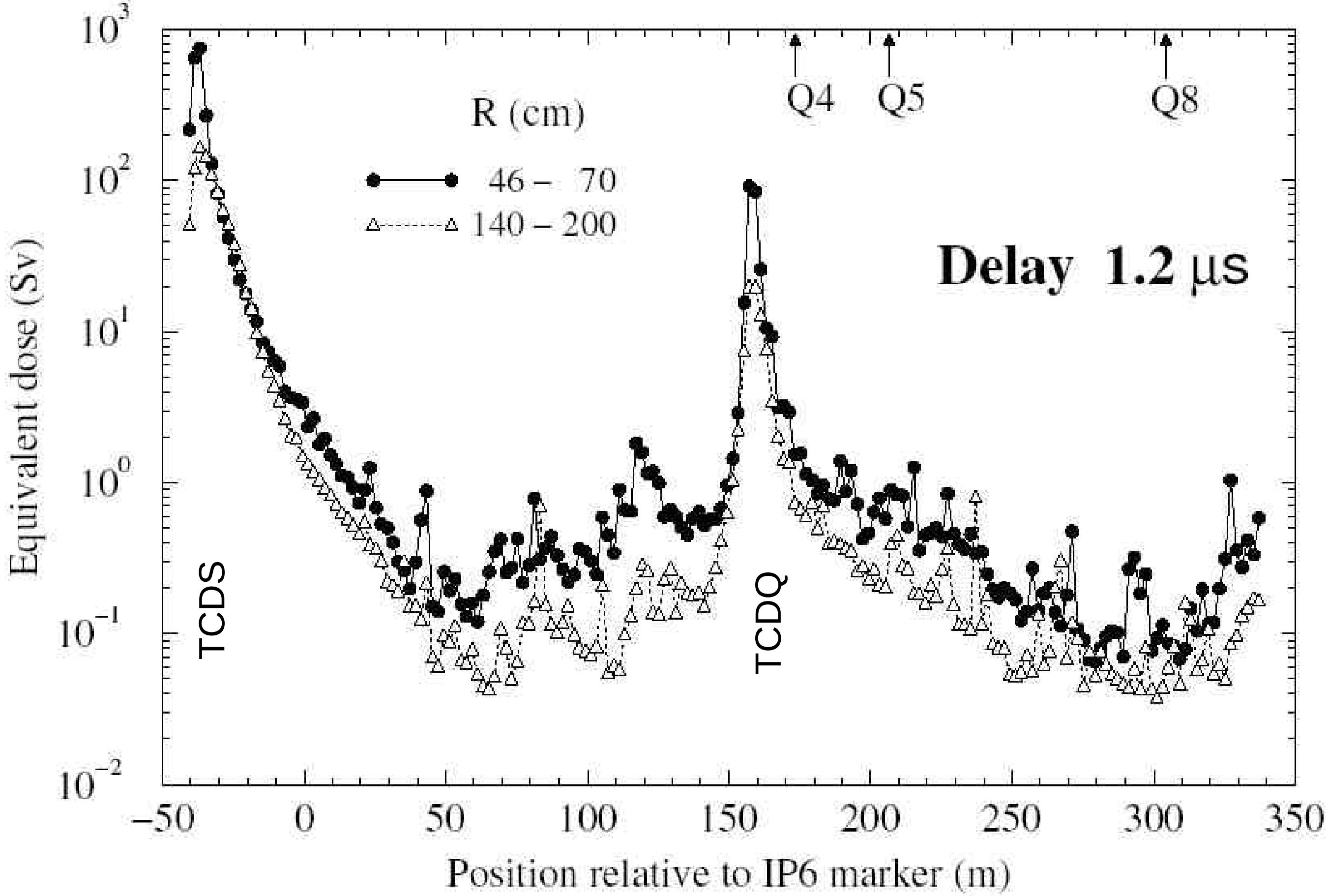
LHC ultimate intensity assumed

Temperature rise (K) in IP6 components

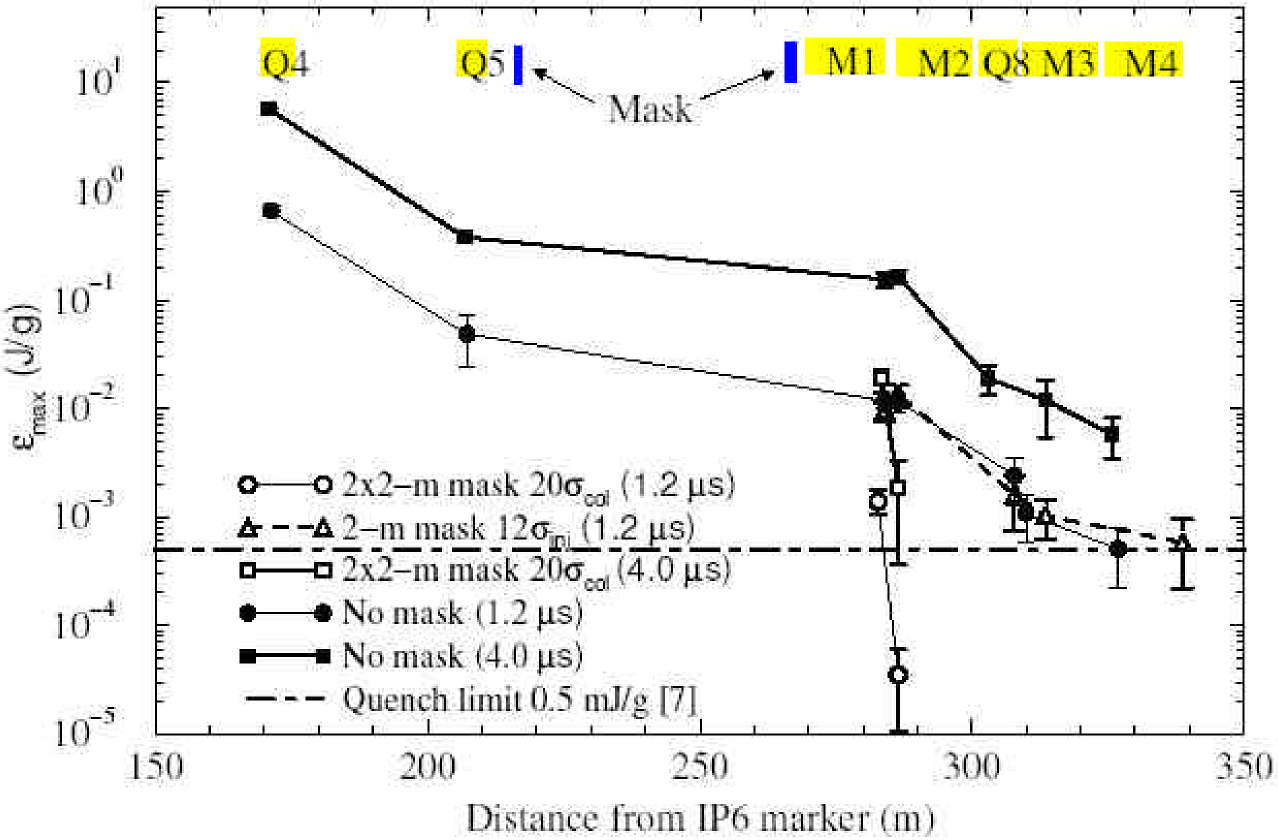
Module	Delay time τ (μs) 1.2	3.0	4.0
TCDS	1018	993	1015
MSD1	785 !	653	715
TCDQ1 (4 m)	651	1167	1697
TCDQ2 (4 m)	227	355	499
TCDQ3 (1.5 m)	9	23	55

Instantaneous doses

- Calculated near vacuum tank and near wall



Limiting the quench region



Two additional masks limit the quench region to one dipole with other magnets downstream remaining superconducting. Unfortunately, the masks need to be closed to 20σ at 7TeV, i.e. they need to be movable… so forget it for the moment.

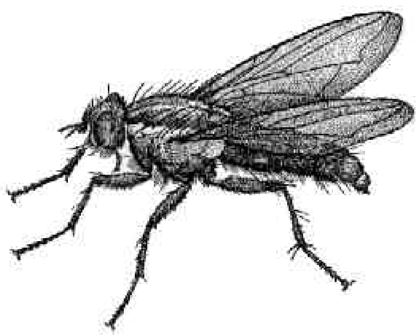
Remaining work

- Refine TCDQ sandwich (8m C clearly excessive since only 9K ΔT in Al part $\Rightarrow$ reduce length or/and increase effectiveness).
- Check absence of second jaw OK as regards energy deposited in Q4.
- Activation analysis.
- Check OK for ions.
- Can we optimise (presently rather crappy) MKQA kicker location?
- Validation of MARS model with FLUKA for TCDQ thermal load (ATB want this for several reasons).
- Engineering specification (à la TCDS).
- Thermomechanical stress analysis.
- Detailed mechanical design.
- Build and install.

so, all pretty straightforward, except…

….urghh : flies in the ointment…

- Need investigation of required orbit tolerances (assumed to be 0.5σ) at TCDQ for arc/triplet protection
  – decision on strategy on how to guarantee this (interlock, feedback, crossed fingers?)



If the TCDQ will act as a secondary collimator in phase 2 of the LHC collimation scheme, first estimates of few 10^{16} p+/y (?) mean substantial concerns about

– Q4 quenches due to 1..3 x 10^{9} p+/s load

– Activation at & around TCDQ

References

[1] P.Sala, "*Energy deposition from a swept 7TeV proton beam in graphite*", SL/BT/TA Memorandum, 2000.

[2] P.Sala, "*Effect of swept beam on the LHC vacuum chamber near MSD*", SL/BT/TA Internal Note 5-01, 2001.

[3] N.V.Mokhov *et al.* "*Protecting LHC components against radiation resulting from an unsynchronised beam abort*", Proc. PAC 2001.

[4] I.L.Rakhno *et al.* "*Further studies on protecting LHC components against radiation resulting from an unsynchronised beam abort*", Fermilab Project Note FN-0724, 2002.

[5] R.Assmann *et al.* "*The consequences of abnormal beam dump actions on the LHC collimation system*", LHC-Project-Note-293, 2002.

[6] W.Weterings *et al.* "*TCDS diluter to protect MSD septum magnets*", LHC-TCDS-ES-0001 rev 0.1, (393973), 2003.

[7] B.Goddard & M.Gyr, "*The Aperture and Layout of the LHC Extraction Septa and TCDS Diluter with an Enlarged MSDC Vacuum Chamber*", LHC-Project-Note, 2003 (in preparation).