Status of energy deposition studies in IR3

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Outline

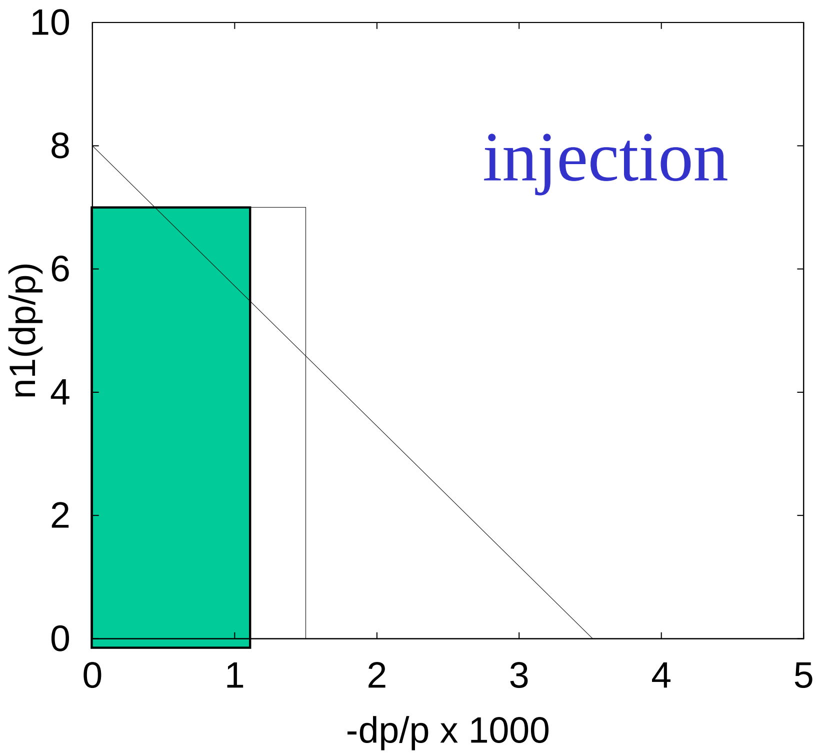
- Optics + dp-cut
- Layout of IR3
- Graphite , strength and weakness
- Tertiary absorbers
- 7 TeV : Allowed lifetimes
- Ramping : Allowed uncaptured fraction
- E-deposition and doses, preliminary

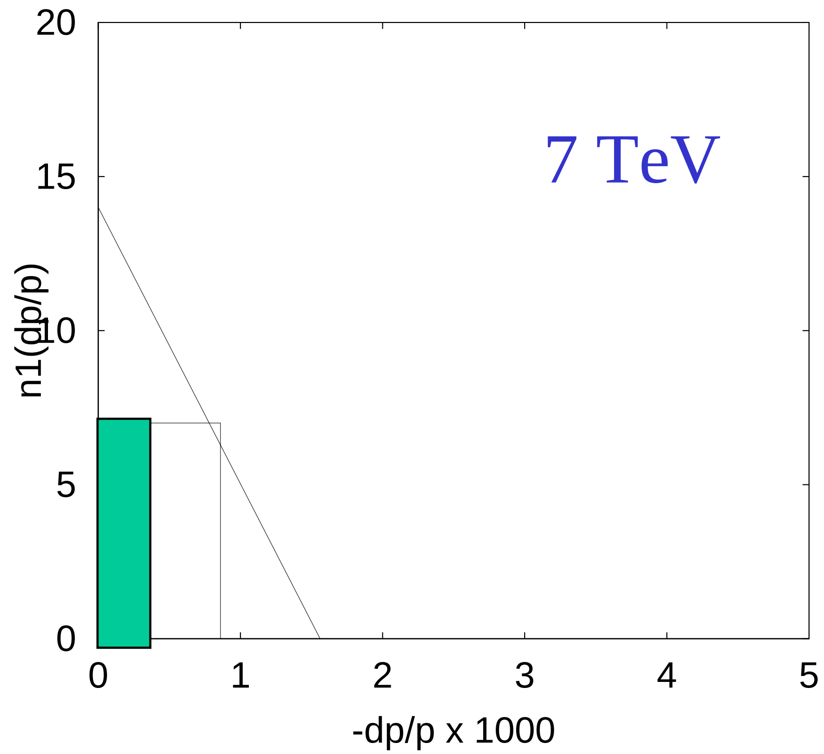
δp collimation

α_{PRIM}	ϕ	μ_x	μ_y	α_{Jaw} Norm.
0	0	μ_0	-	0
0	π	$\pi-\mu_0$	-	0
0	$\pi/2$	π	$3\pi/2$	μ_0
0	$-\pi/2$	π	$3\pi/2$	$-\mu_0$

- A single primary collimator
- 4 secondary collimators - beyond gain in A_{sec} halo marginal
- Real case very close to above optimum
- Normalised dispersion at PRIM $D/\mathrm{sqrt}(\beta) = 0.2\ m^{1/2}$ to protect the arcs

δp and β-amplitude cut





Mom. aperture δp = 4/ 1000 including secondary halo

Kicker errors → Graphite Jaws

- 'Collimators shall not be made of grass' (Graphite ~ grass)
  - Hadronic mean free path :

    Cu : 15 cm C : 43 cm
  - e+e- pair mean free path

    Cu : 1.9 cm C : 28 cm
- Mechanically : L_{Cu} = 50 cm → L_C = 1m acceptable
  - Hadronic absorption suffers little (see relative efficiencies, Ralph)
  - EM energy nearly not absorbed ('selfish graphite')

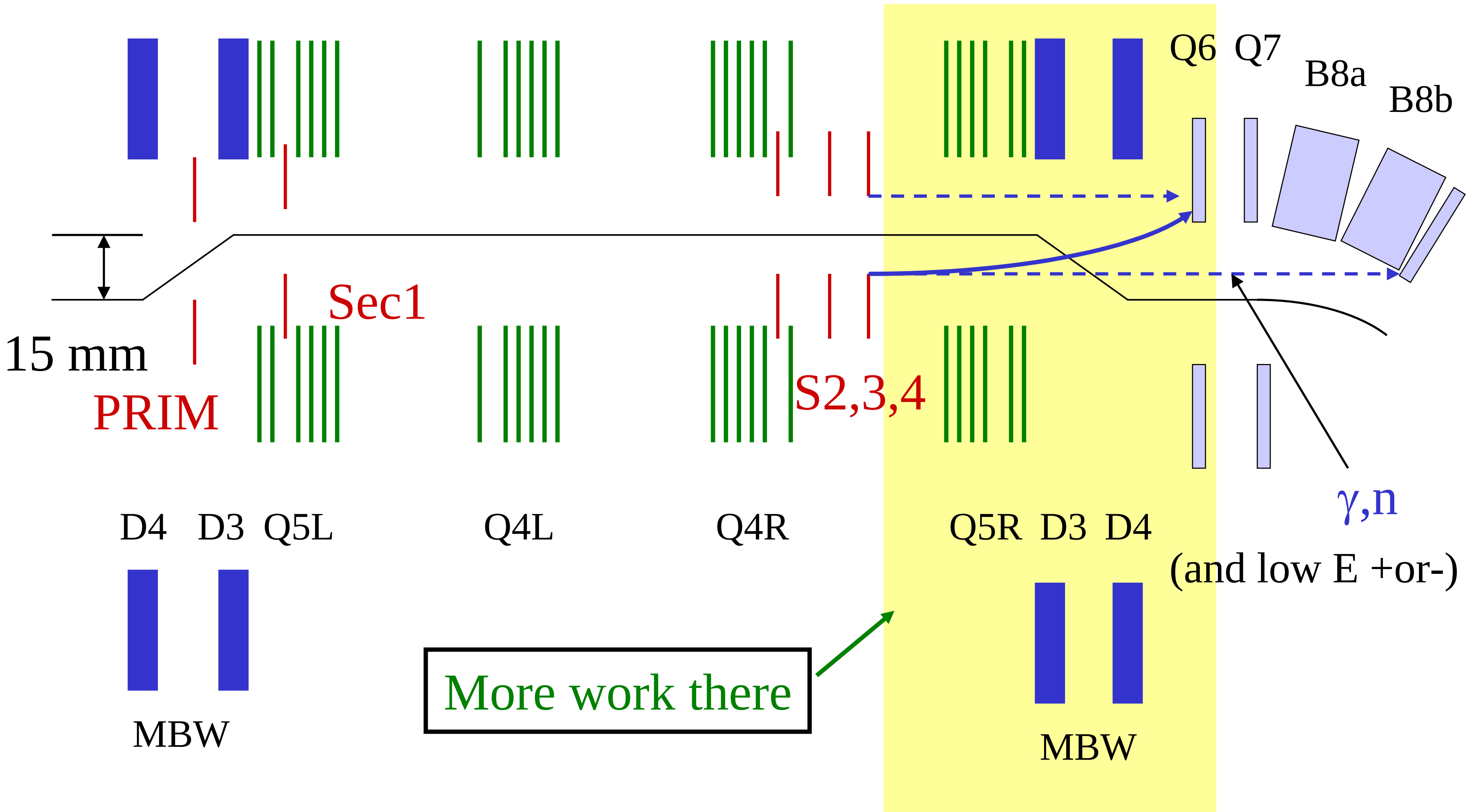
  → C survives to kickers, but more power to close-by elements

→ Minimum lifetime allowed in *(see below)*

- Front of Q6 : 150 h (specification : 1 h)
- MB8b : 36 h

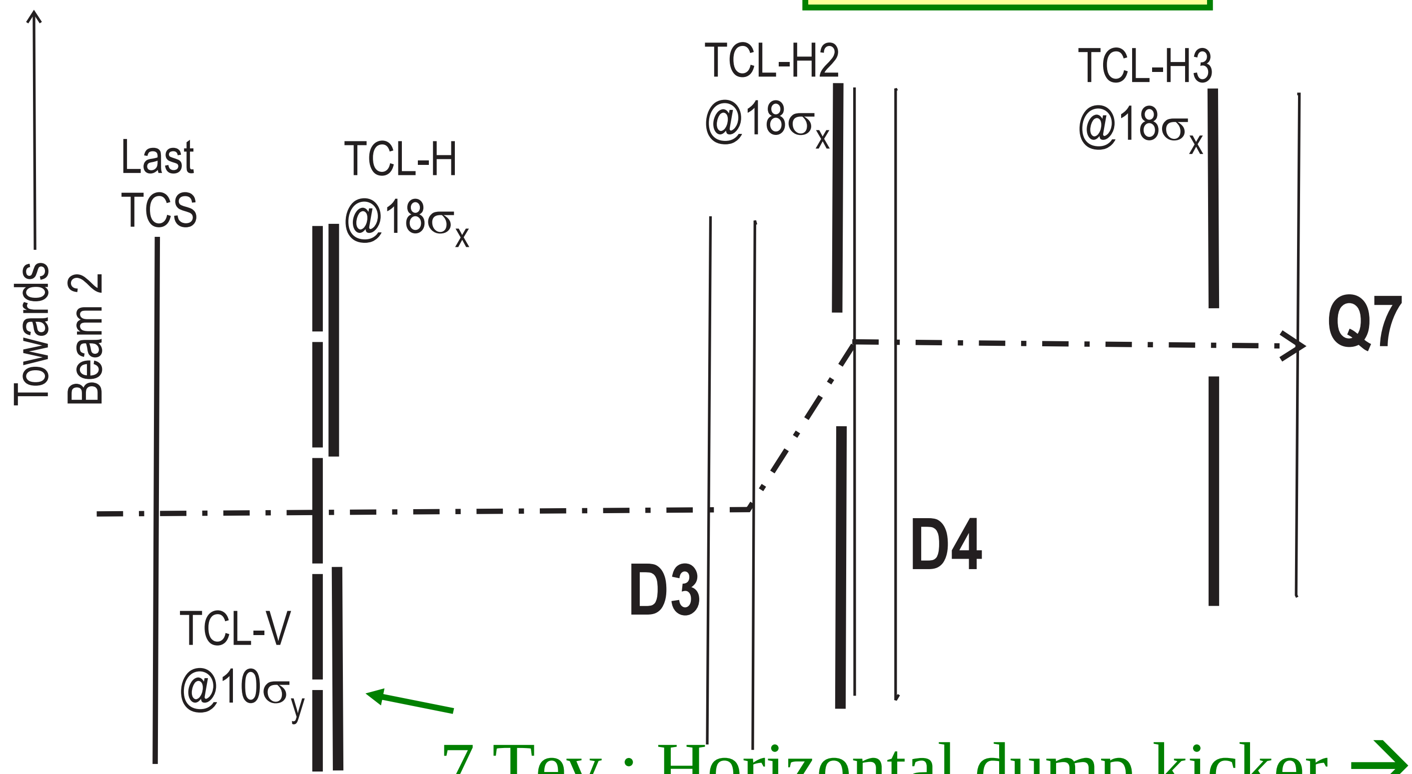
→ Additional absorbers needed

Layout of IR3 - baseline



Additional absorbers

n1 = 12.5, n2 = 14, L_{TCP} = 0.6 m ← Better than 0.2m



7 Tev : Horizontal dump kicker → 10σ OK

Absorbers : 1m long Cu Coll ← standard

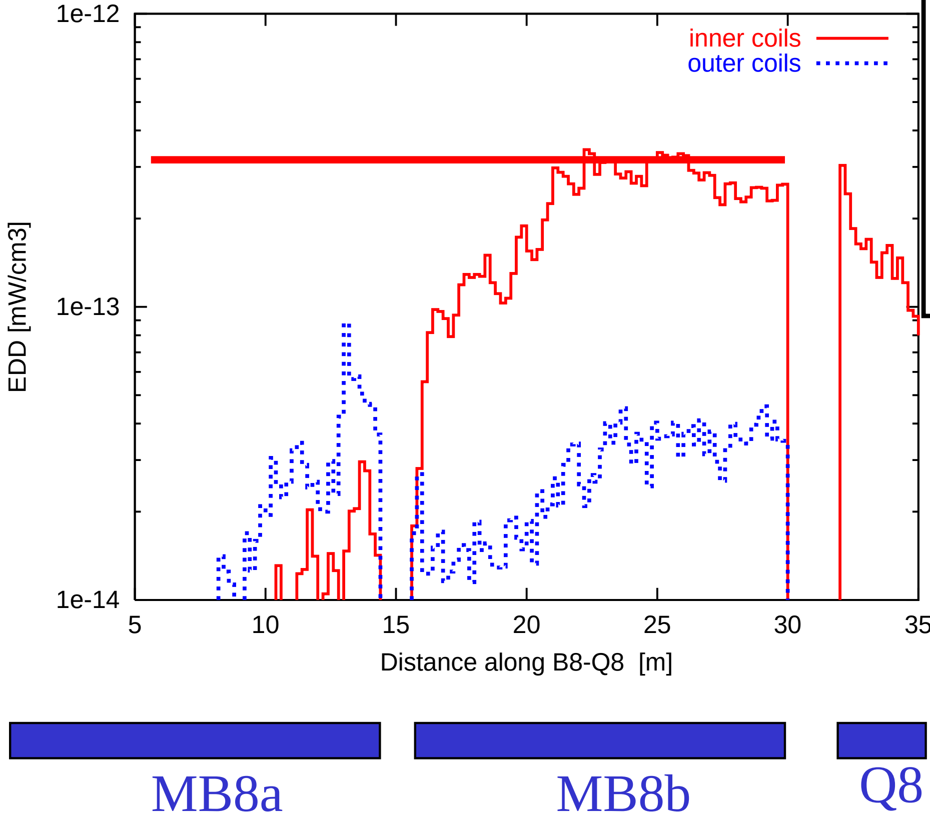
(remote enough to out of the way of kicked beams)

Simulation Method

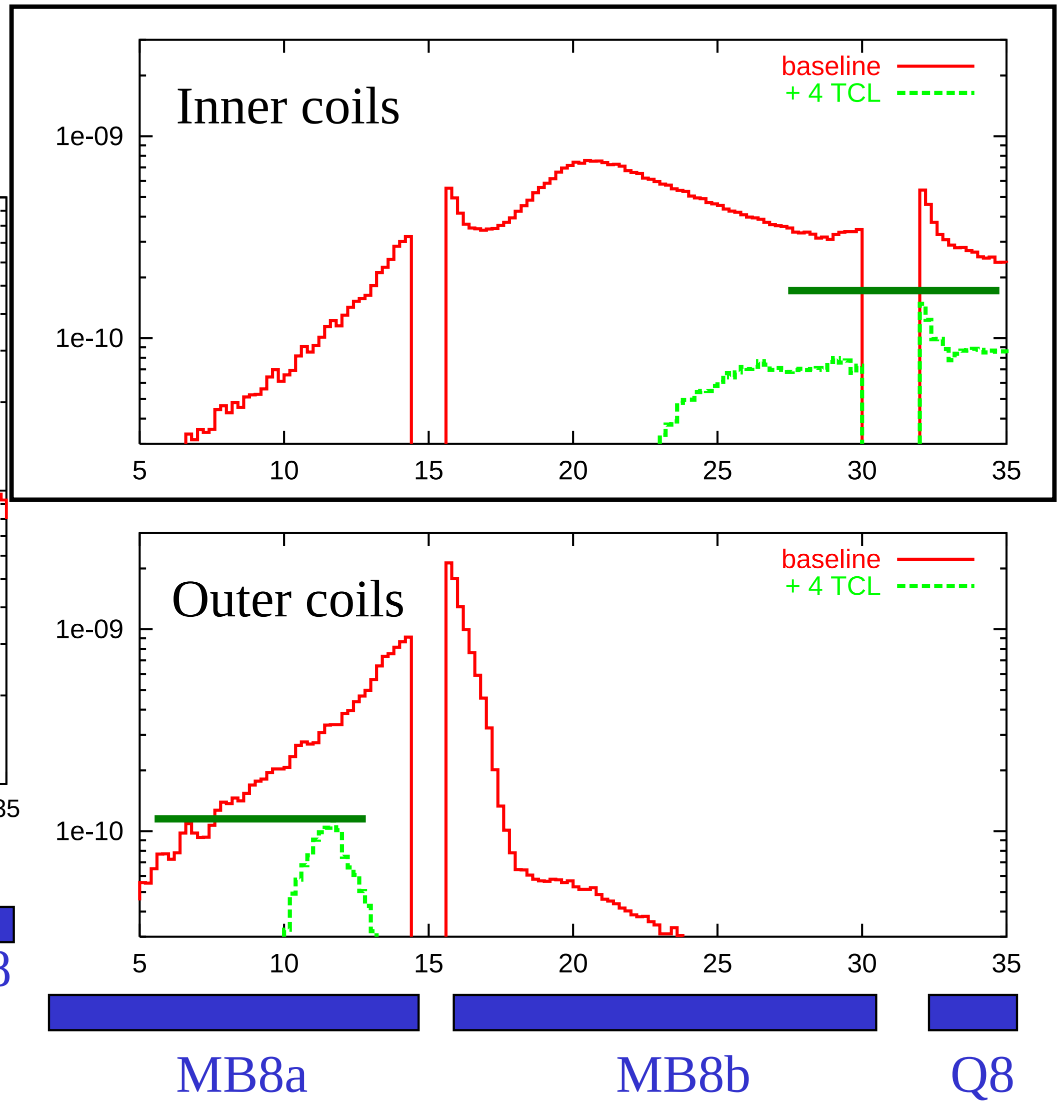
- STRUCT :
  - Multi-turn tracking to get primary and secondary impact maps of nearly on-momentum protons
  - Longitudinal density of off-momentum protons at and beyond the dog-leg section
- MARS -- Full cascade development
  - Detailed power densities (pipe, coils,…)
  - Contribution to forward maps (>= dog-leg)
- Flexible, Understandable and CPU reasonable

Peak Energy Deposition in coils [mJ/cm3/proton]

Injection , 4 TCL



7 TeV



Presentation of results

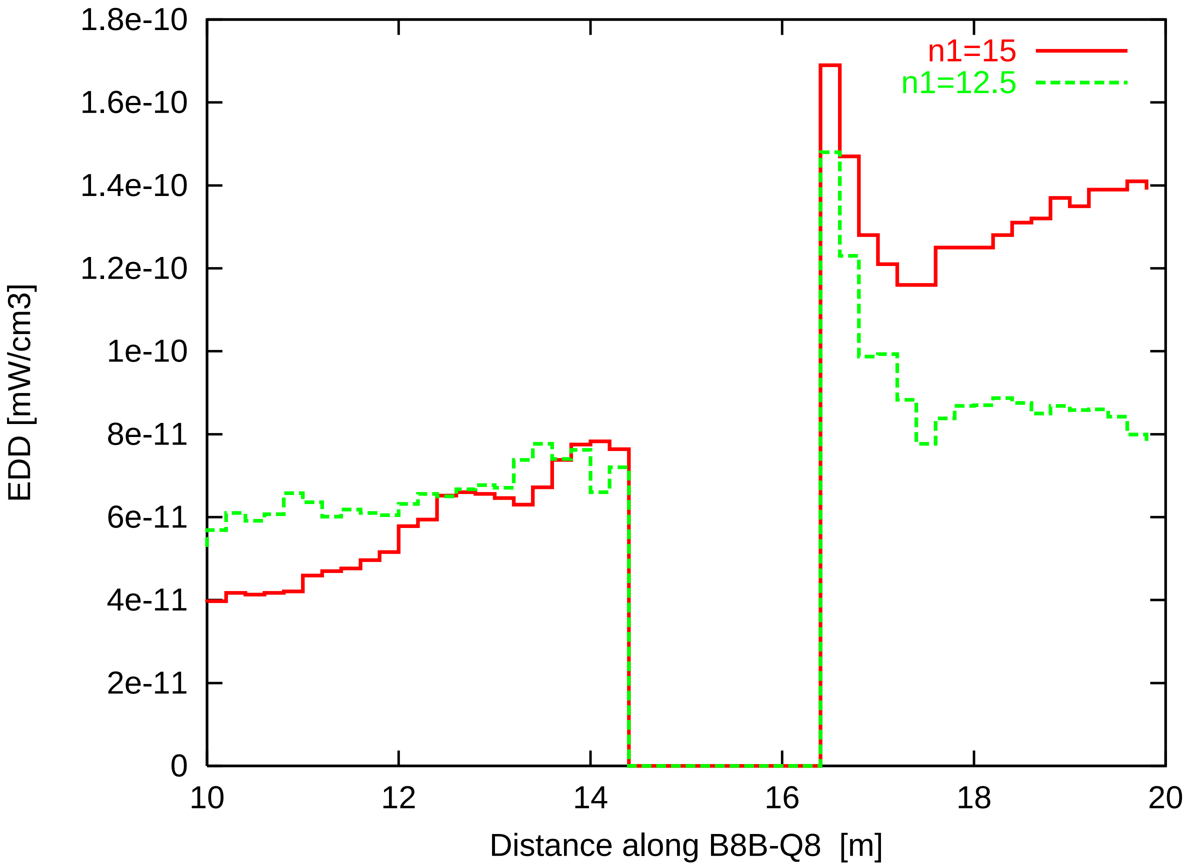
- For a given s.c. element, get the

  Energy deposition ε_p [J/cm^3/proton captured]
- Compare to quench power density ε_q [W/cm^3]
- Get $dN/dt_{max} = \varepsilon_q / \varepsilon_p$ allowed for this magnet
- Convert to $\tau_{long} = N_{coast}/(dN/dt_{max})$, $N_{coast} = 3 \times 10^{14}$ p
- Build an 'allowed lifetime map'

Local Quench limit and allowed lifetime at 7TeV

	Local Allowed Lifetime [hours]		
SC magnet	No TCL	3 TCL (no H3)	4 TCL
MCBCV	150	1.2	1.2
Q6	18	0.3	0.3
Q7	18	0.4	0.2
MB8a	15	3.0	1.8
MB8b	36	4.5	1.3
Q8	9	3.7	2.5

n_1 dependence



- Peak EDD : 10% increase with n1=12,5 → 15

Allowed transient losses at Injection (quench only)

- The transient heat reserve of the cable at injection from T_0= 1.9K to T_c= 9K is $\Delta Q = 0.35\ J/cm^3$
- The peak enegy deposition is $\varepsilon = 3\ 10^{-16}\ J/cm^3/proton$
- Use a margin factor of 2 for uncertainties
- The ramp must continue → another factor 1.5

→ $\Delta N_{off\text{-}bucket} = 0.33\ \Delta Q/\ \varepsilon = 3.8 \times 10^{14}$ p

→ $\Delta N_{off\text{-}bucket} > N_{nominal} = 3.3 \times 10^{14}$ p

-- Comfortable --

Side results

- Peak radiation deposition in warm magnet coils
- Peak power deposition in Vacuum chambers
- Overall power flow distribution
  (preliminary results)

Integrated radiation peaks in IR3 - magnets

- For 10^{16} protons captured per year (Mike Lamont)
- Peak always in coil – Rad. resistance specified 50 MGy
- Drops rapidly with radius

	Dose [MGy/year]	
Location	Face	Inside
D3L	1.5	0.5
Q5L	4.5	1.5
Q4R	1.5	0.5

- → OK for at least 10 years
- Can be further reduced with few passive absorbers

Power deposition in Vacuum Chambers

- Checked for all MQW chambers
- (MBW : see IR7 team – similar results)
- Worst lifetime : $\tau_{beam} = 1$ h
- Power map nearly constant along one chamber

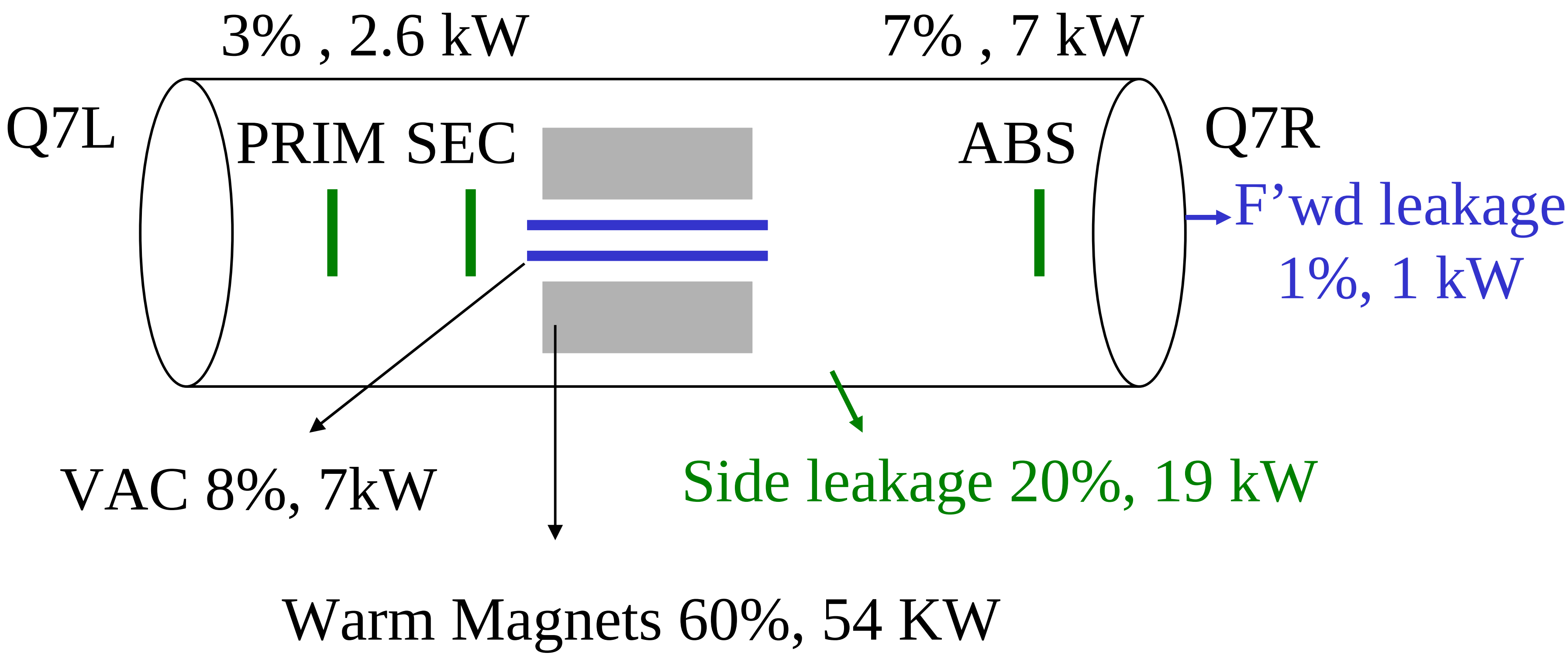
- Peak power integrated along the chamber

P_max = 2.7 kW

→ Cooling mandatory

see I. Baichev et al., AB-Note-2003-085(ABP)

Power flow, $\tau = 1h$, $P_{tot} = 90kW$



- Need passive aborbers to limit load on auxiliary systems

Conclusions for IR3

- Baseline ’Phase 1’ graphite-only not enough even with reduced current , etc
- 4 additional absorbers (1m Cu standard Coll.) allow for $\tau_{beam} = 2.5$ h

→Nearly ultimate system (IR3/momentum)

- Many side studies still needed (passive absorbers, local shielding …)