LARP ENERGY DEPOSITION CALCULATION ACTIVITIES AND PLANS

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INTRODUCTION

The LHC interaction region (IR) was designed to achieve a nominal luminosity of 10^{34} cm^{-2}s^{-1} with the lifetime of low-β quadrupoles limited by radiation loads to 6-7 years. After that, it is planned to replace the low-β insertions with a higher performance design based on advanced superconducting magnets to upgrade a luminosity up to 10^{35} cm^{-2}s^{-1} (SLHC). Preliminary studies show that, with magnet technology that is expected to be developed by early in the next decade, a factor of 2 to 5 reduction in β^* could be achieved with new insertions.

Three major factors drive the designs of new IRs: minimizing β^*, minimizing the effects of long-range parasitic beam-beam interactions, and the large radiation loads due to pp-collisions (9 kW/beam at 10^{35} cm^{-2}s^{-1}) directed towards the IRs. The first two point towards maximizing the magnet apertures and minimizing their distances to the IP.

I will describe LARP energy deposition calculation activities and plans to further attack the third issue.

SOURCE TERMS

1. **pp collisions:** radiation $\sim \sigma_p \times \mathcal{L}$, $\mathcal{L}=10^{34}$ to 10^{35} cm^{-2}s^{-1}.
2. **Operational beam loss:** tails from collimators and beam-gas scattering, radiation $\sim$ beam power $\times$ loss rate.
3. **Accidental beam loss:** abort kicker prefire / unsynchronized beam abort, radiation $\sim$ beam power $\times$ loss rate.
   Up to 10% loss in IR if not intercepted in the abort section.

INTENSITY AND LUMINOSITY ARITHMETIC

Machine	E (TeV)	I, 10^{14}	Q (GJ)	$\sqrt{S}$	$\mathcal{L}$, 10^{34}	σ_p(mb)	10^{16} (int/10yr)
Tevatron	0.98	0.1	0.0016	1.96	0.01	60	
LHC	7	3.1	0.35	14	1	80	4
LHC-2	7	4.8	0.54	14	4.7	80	19
SLHC	7	9.6	1.08	14	10	80	40

LHC rule:

$\mathcal{L}_{10yr}$ = (0.1+1/3+2/3+7) $\times \mathcal{L}$ at 180 days/yr

10yrs = 5×10^7 s $\rightarrow$ 500 fb^{-1}

8×10^8 int/s at 80 mb and $10^{34} \rightarrow 4\times10^{16}$ int/10yr

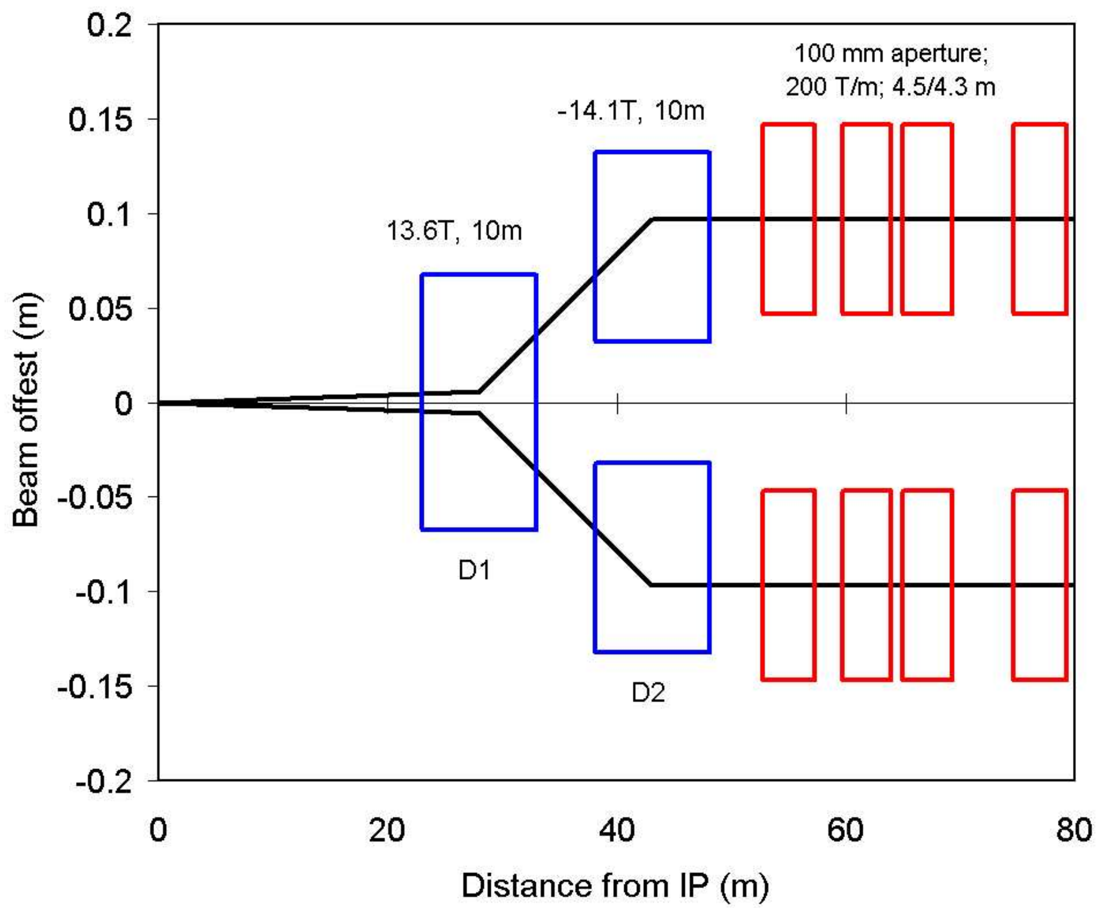
ENERGY DEPOSITION ISSUES

1. Quench stability: peak power density in SC coils and heat transfer.
2. Dynamic heat loads: Power dissipation and cryogenic implications.
3. Components lifetime: peak radiation dose in components and limits for various materials.
4. Residual dose rates: hands-on maintenance.
5. Operational and accidental beam loss.
6. Main collimation system, abort system collimators and IR collimators/absorbers.
7. Beam instrumentation: TAS, TAN, TOTEM Roman Pots, ZDC, BLM.

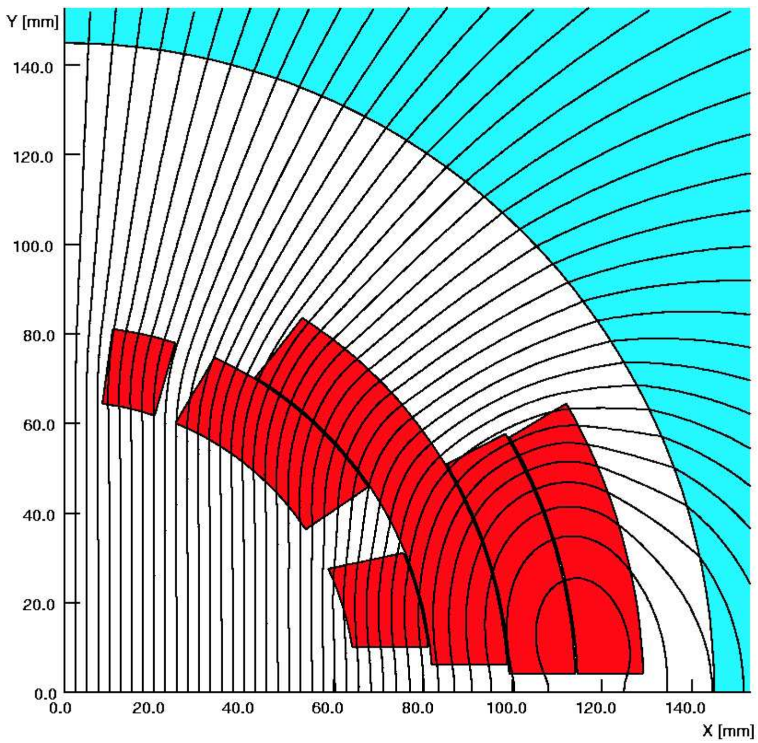
LARP ENERGY DEPOSITION ACTIVITIES

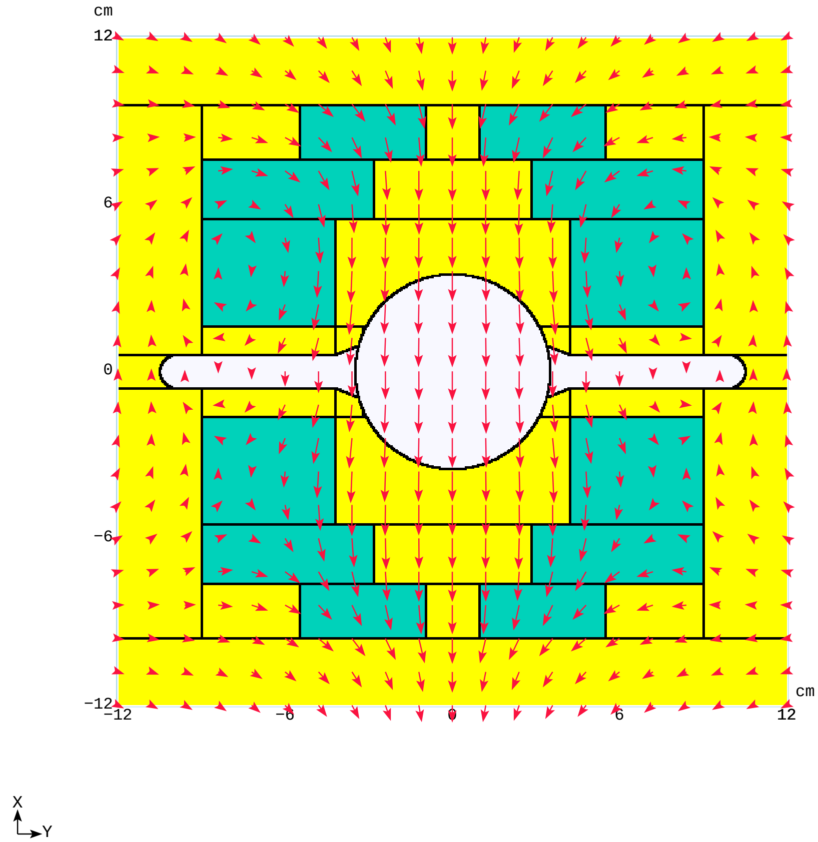
1. Development of adequate reliable tools.
2. Monte Carlo modeling (all of the above issues!) for LHC and SLHC IRs.
3. Protection system design under realistic engineering constraints.
4. Uncertainty analysis and reduction.
5. Baseline IR and dipole-first designs.
6. Materials analysis and possible tests (Pbar!).
7. Near-beam experiments and their interference with the IR systems.

SLHC: DIPOLE-FIRST IR LAYOUT



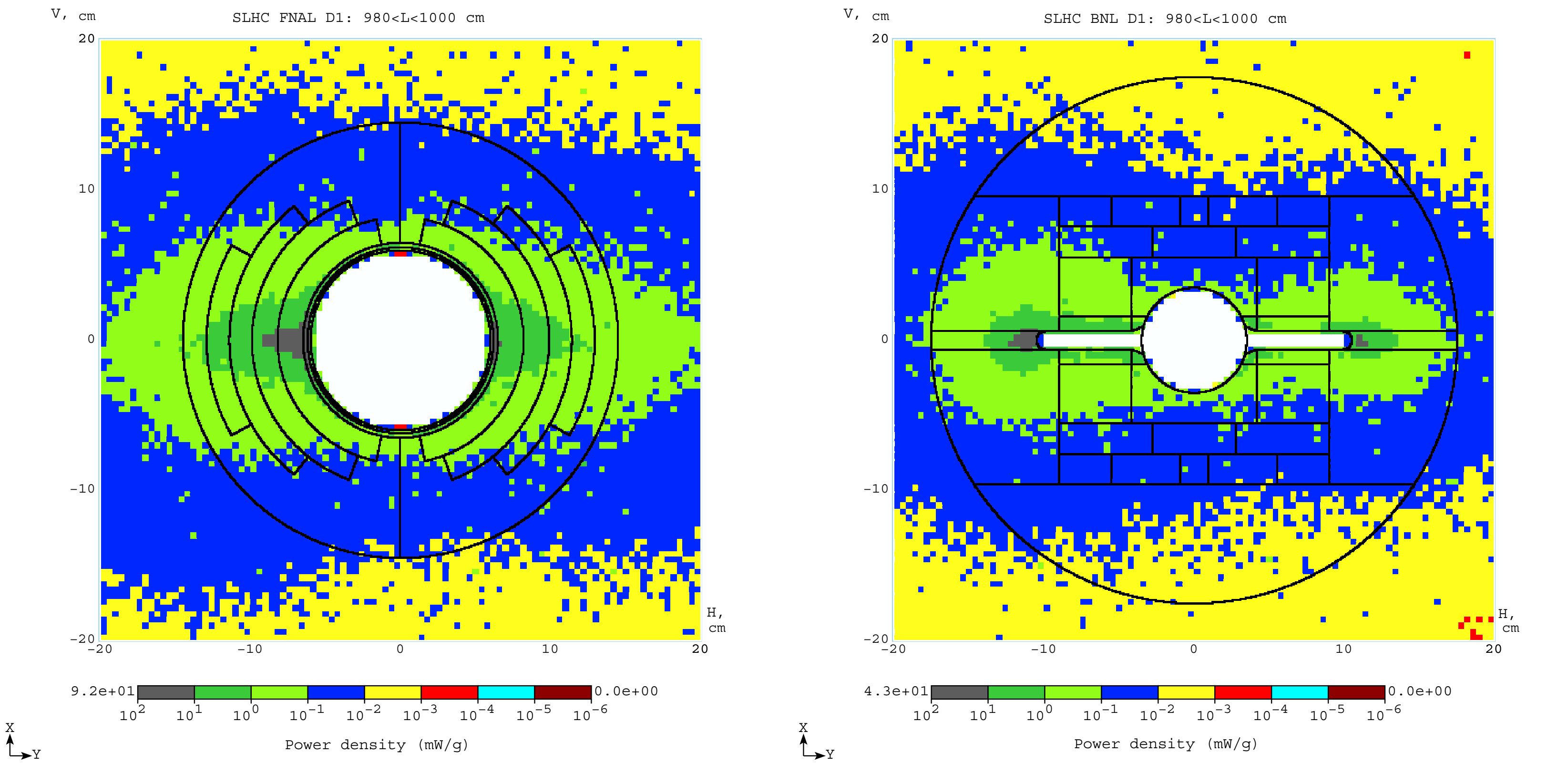
DIPOLE-FIRST MAGNET DESIGNS





Peak power density is a factor of 100 higher in SLHC dipole ($\mathcal{L}$ = 10^{35}) than in LHC IR quads ($\mathcal{L}$ = 10^{34}).

SLHC: DIPOLE-FIRST ENERGY DEPOSITION



Peak power density is 49 mW/g in copper spacer and 13 mW/g in SC coil (left) and only 1.1 mW/g in the SC coils of block-type dipole (right). Total power dissipated in the dipole is 3.5 kW in either design.

LARP ENERGY DEPOSITION: FY04

1. MARS14 code developments: drastically improved hadron-nucleus x-sections, forward low-p_t physics (inelastic, diffractive, elastic, correlated Coulomb scattering and energy loss), heavy-ion modules, advanced MAD-MARS Beam Line Builder (MMBLB), parallelized version prototype.
2. Realistic modeling of the dipole-first IRs with Cosθ and block coils for pp-collisions at SLHC.
3. A little further look at TOTEM and Zero-Degree Calorimeter and D2 separation dipole.
4. Design of a materials irradiation facility downstream of the Fermilab Pbar target (PIF).

LARP ENERGY DEPOSITION: FY05

1. MARS14 $\longrightarrow$ MARS15: finalizing FY04 developments, new hadron-nucleus event generator (including 14-TeV pp), complete heavy-ion and parallelized version, new electromagnetic shower module.
2. MAD-STRUCT-MARS developments.
3. Developments towards response matrices and operational modeling.
4. Operational and accidental beam loss in the LHC and SLHC IRs analysis.
5. Further modeling of the dipole-first IRs with Cosθ and block coils for pp-collisions and beam loss.
6. Materials tests at PIF with MSU (if approved).

LARP ENERGY DEPOSITION: FY06

1. Further code developments including response matrices and operational modeling.
2. Operational and accidental beam loss in the SLHC IRs: modeling and protection.
3. Energy deposition in the dipole-first IRs with Cosθ and block coils for *pp*-collisions and beam loss, sensitivity and uncertainty analyses and protection system conceptual design under realistic engineering constraints.
4. Calculation studies on near-beam experiments and their interference with the IR systems: TOTEM and Zero-degree calorimeters.
5. Materials tests at PIF with MSU (if approved).