

US LHC Accelerator Research Program
Task Sheet

Task Name: LHC Head-on beam-beam compensation study

Date: May 31, 2006

Responsible Person: V.Shiltsev (FNAL)

Budget for FY07: FNAL 120k\$, BNL \$50k, SLAC 50k\$

Statement of work:

Introduction:

Luminosity of the LHC scales quadratically with maximum achievable beam-beam tuneshift parameter dQ , therefore, any advance in dQ is of interest for the luminosity upgrade. Currently, the nominal parameter for the design luminosity of $1e34 \text{ cm}^{-2} \text{ s}^{-1}$ is $dQ=0.01$. The first several years of the machine operation will show what is maximum allowed dQ actually is. Use of electron lenses for the either footprint compression or driving term minimization can allow significant 50-100% increase of the dQ .

Electron lenses were proposed for beam-beam compensation in late 90's, and since then, two of them were built and installed in the Tevatron. Many physics and technical issues were resolved during the Collider Run II operation of the TEL, and emittance growth suppression and a very good lifetime in excess of 100 hours have been demonstrated good beam lifetime with tuneshift $dQ \sim 0.005$ in the regime of long-range beam-beam compensation (same tuneshift for all the particles).

Task Description:

In this task, we plan to perform a study of beam dynamics in a proton-proton collider with a one or two IPS and two TELs for head-on compensation – one for each beam, placed at an equal beta-function location. The study will be combine theoretical investigations and parallel processor numerical tracking with the goal to explore parameter space and effectiveness of head-on BBC in LHC, Tevatron and RHIC.

This study will address following issues:

- Will Gaussian or truncated Gaussian e-current density distribution work (improve lifetime and reduce diffusion rates)?
 - Straightforward tracking with a weak-strong code
 - Is partial compensation helpful?
- Is there a better (than Gaussian) distribution?

- from first principles, theory, analytical consideration
- Effects of $\beta_{TEL}/\beta^*/\sigma_z$; or dP/P , crossing angle
- check in numerical tracking
- Importance of e-p interaction in bending sections
 - Which of three configurations - Π , S or straight - is better?
 - Is the choice tune dependent?
- Lifetime deterioration due to e-p misalignment:
 - e-beam straightness tolerances
 - relative e-p displacement, angle
- Effect of low-frequency variations dJ , dX on beam lifetime
- Ion cleaning efficiency tolerances
- Cross-interaction with wires in LHC – if there is any
- e-beam effect on coherent stability or strong-strong beam-beam effects

Deliverable(s):

A report on the study and recommendation on head-on compensation for the LHC.

Milestones:

New LARP L3 Task “Head-on BBC” is formed	Sep’06
Preliminary studies reported at HHH Workshop (Valencia)	Oct’06
Mini-workshop on results of studies (FNAL)	Mar’07
Final report delivered	June’07
Review and recommendation on further steps	Summer’07

BNL Personnel:

W. Fischer and a postdoc (? – TBC)

LBL Personnel:

J.Qiang (? – TBC)

SLAC Personnel:

A.Kabel (? – TBC)

FNAL Personnel:

V.Shiltsev, T.Sen, Y.Alexahin, V.Kamerdzhev, V.Ranjbar, a Guest Scientists (?)

ORNL Personnel:

V.Danilov

Follow on funding request:

We anticipate to complete this study in FY07. Depending upon the results of this work we will submit additional requests for funding to perform beam studies either at Fermilab or at RHIC or for funding of construction of a LHC-compatible