

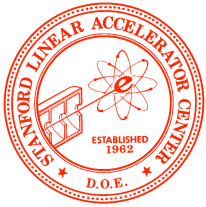
Tracking Studies of LHC Collimation System at SLAC

Yunhai Cai

Stanford Linear Accelerator Center

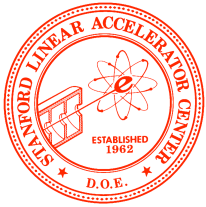
October 20, 2004

*US HLC Accelerator Research Program meeting,
Napa Valley, California, October 19-21, 2004*



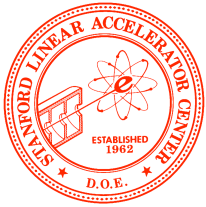
Motivations for Phase II Collimation System

- Impedance of the phase I collimators (C) is over the budget for the nominal design current. This means that we most likely to select metal as collimator material for the phase II collimators.
- But, due to the high energy and high intensity of the LHC beam to metallic collimator is easily melted in an accidental beam loss. Hence, we consider to use consumable collimators based on the design for linear collider for the phase II system.
- Efficiency of the secondary collimators has to be improved to the level of 1×10^{-4} . That means that the number of escaped protons from the secondary collimators relative to the number of impacted protons on the primary collimators is below **0.01%**.
- Needs to reduce the background in the particle detectors to a tolerable level. Collimators are an important part of the machine protection system



Purposes of Multi-Turn Tracking Study of Collimation System

- Optimize the collimator system: functionality, location, material, geometry, and operating procedure.
- Provide the loss map to study the energy deposition. Support the engineering design of the collimator, over heating? What kind of cooling system?
- Understand and predict the beam halo, beam loss and the background in the detector



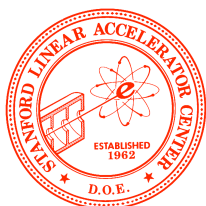
Planned Collimators for LHC

- IR7 betatron cleaning (warm section) :
 - 4 primary collimators (3+1)
 - 3 scraper (3)
 - 32 secondary collimators (11+11+10)
- IR3 energy cleaning (warm section):
 - 1 primary collimator (1)
 - 1 scraper (1)
 - 8 secondary collimators (4+4)

SLAC

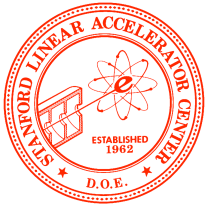


It is not clear to me if this system could satisfy all design requirements.



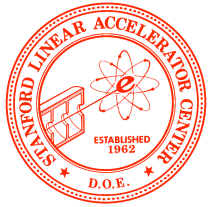
Phase II Collimators in IR7 (betatron collimators: 11)

Name	A [degree]	S[m]
TCSM.A6L7.B1	142.5	45.495
TCSM.B5L7.B1	141.6	104.722
TCSM.A5L7.B1	42.7	108.722
TCSM.D4L7.B1	90.0	130.052
TCSM.B4L7.B1	0.0	199.978
TCSM.A4L7.B1	135.7	203.978
TCSM.A4R7.B1	45.2	207.978
TCSM.B5R7.B1	139.6	299.234
TCSM.D5R7.B1	53.3	315.234
TCSM.E5R7.B1	128.5	319.234
TCSM.6R7.B1	0.5	353.839



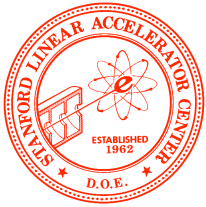
Simulation of Collimation System Using Sixtrack+K2(CERN)

- Nonlinear but ideal lattices: injection and collision
- Thin-lens approximation is used in Sixtrack to speed up the simulation
- A run of 200 turns with 64×1000 protons takes eight hours on a Linux PC
- Primary collimators at 6σ and secondary ones at 7σ (It is in the linear region and matrix approximation is quite adequate)
- Initial beam distribution: center: 6.003σ and spread 0.0015σ . (h,v,r)

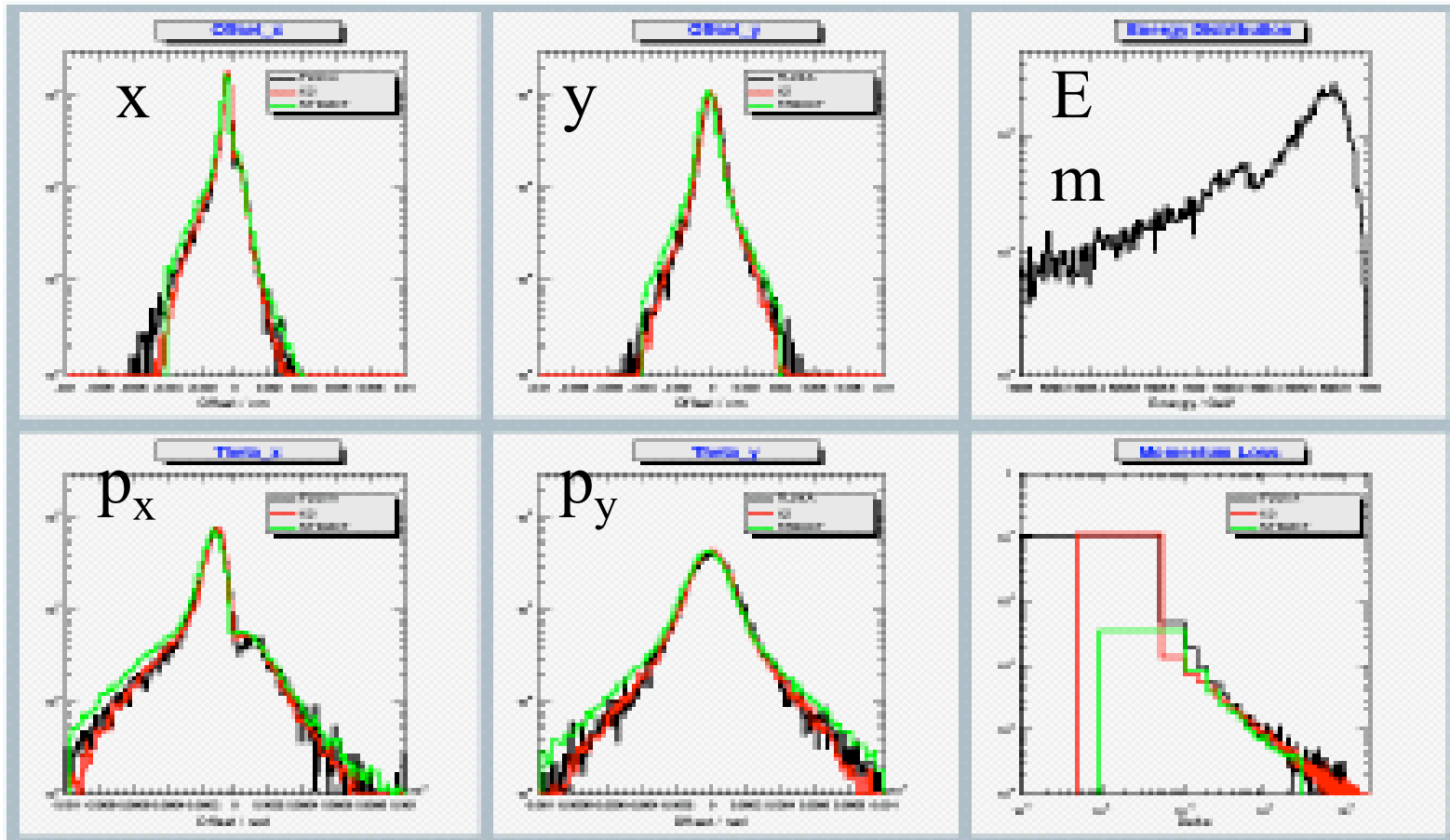


Proton Scattering inside Collimators (K2)

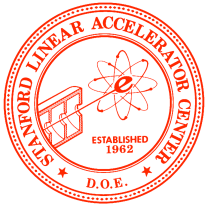
- Electromagnetic: ionization and Coulomb scattering
- Bremsstrahlung and lepton pair production
- Nuclear: elastic and inelastic scattering
- Including edge effects
- Benchmarked against (FLUKA and Struct)
- Save coordinates of inelastic scattered protons as absorbed and used as FLUKA simulation of energy deposition



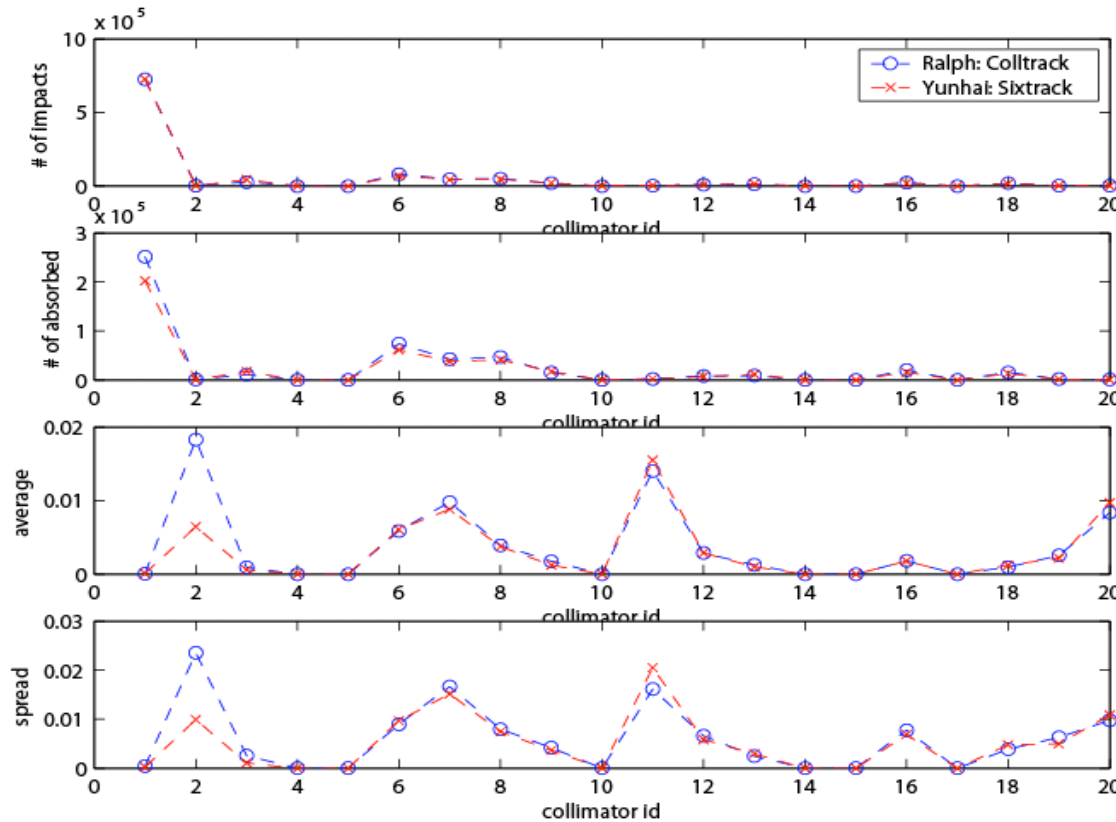
Code Comparison: K2/STRUCT/FLUKA by M. Brugger



Collision energy: 7Tev, 0.5m long CU, 40 (μm , μrad)



Benchmark to Ralph's Simulation of Phase I Collimation System



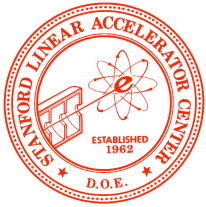
impacts

absorbed

<impact parameter>

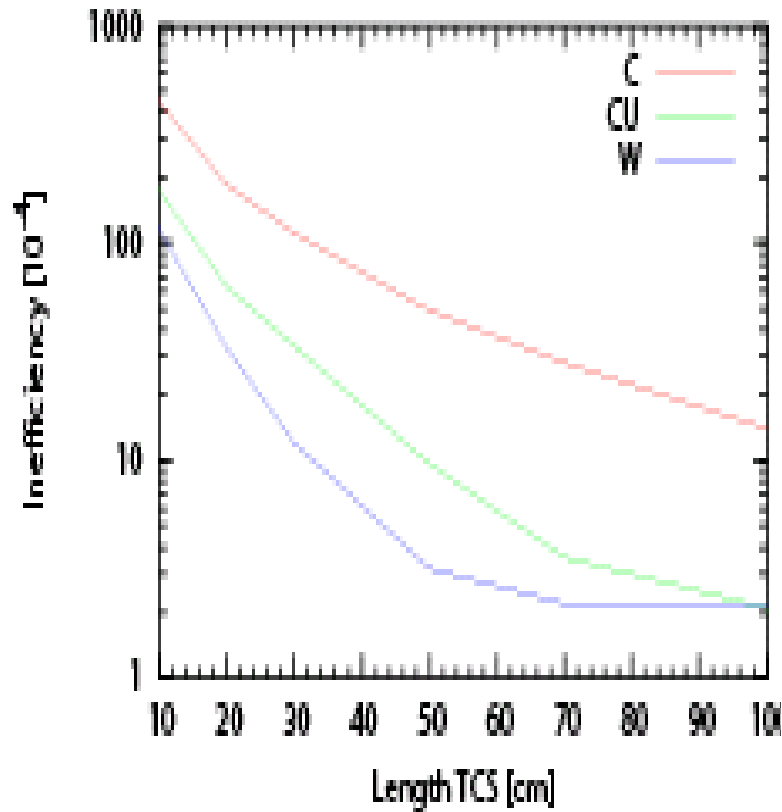
spread of impact parameter

Injection energy: 450 Gev

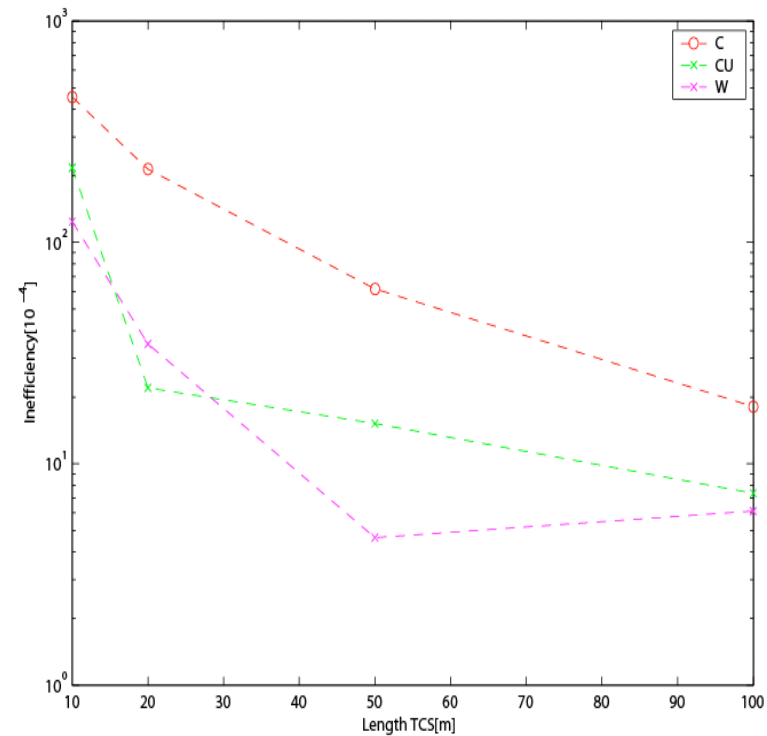


Efficiency vs. Length

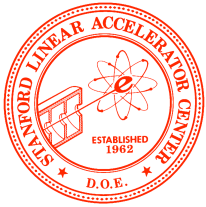
Ralph's phase II



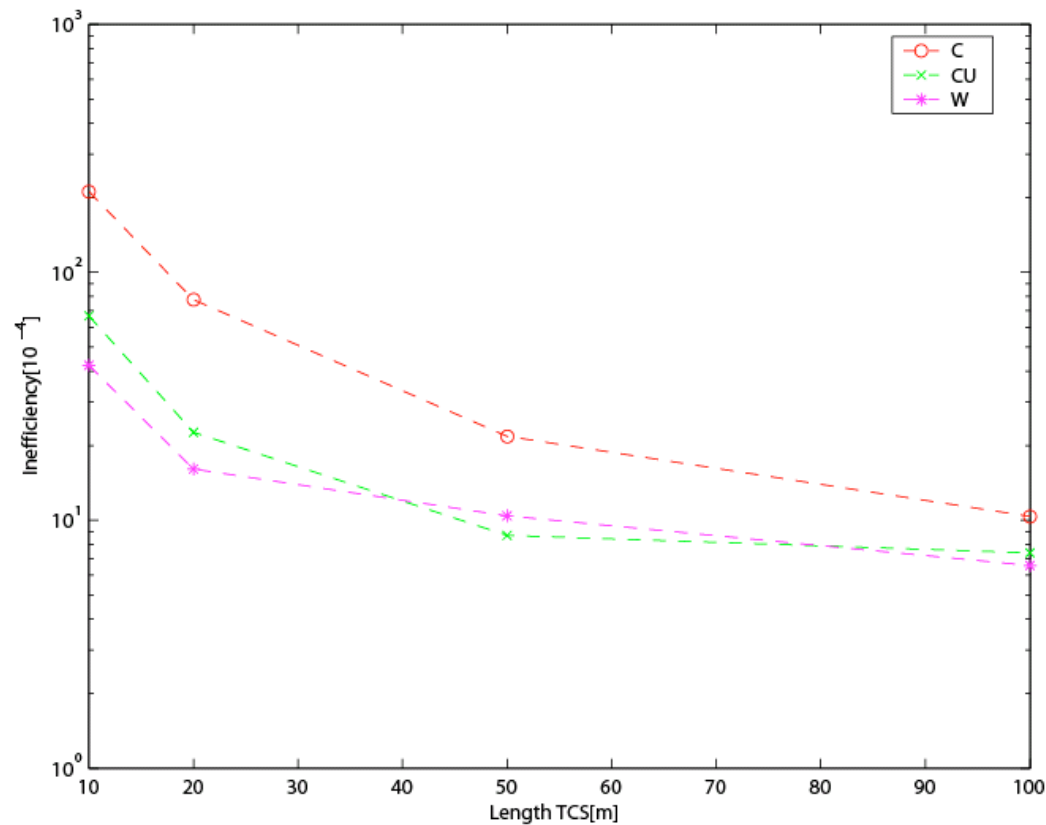
Yunhai's phase I



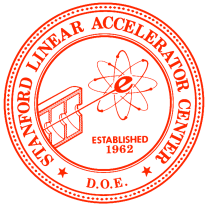
Injection energy: 450 GeV?



Efficiency vs. Length at Collision Energy (7 Tev)

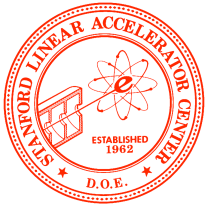


only phase I collimators are used in simulation



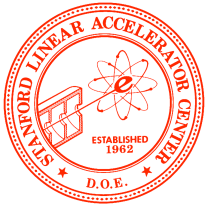
Design Issues and Boundary Conditions

- Can we change the primary collimators?
- Can we use more collimators? Phase 4
- Can we replace the phase I collimators?
- What material? Length?
- Setting of the collimators? Gaps and orientation?
- Where the escaped protons go? Triplets?
- Change location or optics?



Issues to be Discussed

- Apertures of entire machine
- Who should implement it?
- Local beam loss and protection near the superconducting magnets
- Near detector cleaning and background?
- Should we benchmark the code?
- Direct simulation of halo generation?
- Plan to measure the background during the commissioning?



Conclusion

- The sixtrack+K2 has been ported to SLAC successfully and we are ready to use it to do the design work
- Near-term goal is to finalize the phase II design before **April 2005**. To achieve that, we should define a few **milestones** along the way and clarify the **requirements**.
- Many thanks to our CERN colleagues!!!