62TeV cm P-P Hadron Collider with Superbunch Beams

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1. A brief History of VLHC

For Post LHC	100 TeV cm Hadron Collider
Low Field Plan	2 Tesla Piptron, by Bill Foster
High field Plan	10 Tesla

2. Two Stage

3 TeV x 3 TeV	Low field design
12 TeV x 12 TeV	with Two stage, Low and High field

3. 62 TeV cm P-P collider

Idea of SuperBunch by Takayama's group

Two stage collider,

7 TeV x 7 TeV Low Field with 15 times more Luminosity

Eventually 31 TeV x 31 TeV High Field with SuperBunch

4. 175 TeV cm P-P collider

20 TeV x 20 TeV Low Field & 87.5 TeV x 87.5 TeV Proposal

5. 14 TeV cm P-P collider

More Realistic Plan at this Stage and at this Time

62-TeV Center of Mass Hadron Collider with Superbunch Beams

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Abstract:

The scheme of a 62-TeV center of mass p-p collider with superbunch beams at Fermilab is proposed as a practical and realistically achievable future project. It will be built in two stages, using the same tunnel, first with a 2 Tesla low field magnet collider ring and later with a 10 Tesla high field magnet collider ring. Both low and high field magnets have twin bore aperture and will be installed in the tunnel with the circumference of 87.25 km. In each bore a proton beam is accelerated, using induction cavities to increase luminosity. In the first stage we install a 7 TeV accelerator ring with operating field of 2 Tesla, based on the superferric transmission-line design. This ring will be operated as a 14-TeV center of mass collider. This will have the same energy as the LHC, but it will have 15 times higher luminosity, namely 1.5 x 10^{35}/cm^2/sec. The estimated synchrotron radiation is negligible with this machine. The existing Fermilab accelerator system, including the 150 GeV main injector, will be used as the injector system. Its rough cost estimation and schedule for this first stage are presented. In the second stage proton beams are accelerated, also using induction cavities up to 31 TeV with the10 Tesla dipole magnets. The counter circulating beams will collide with the 62-TeV center of mass energy. With the superbunch beams we can expect the luminosity can be increased about 15 times more than the conventional method with RF cavities. It will be 10^{35}/cm^2/sec. In the second stage, the synchrotron radiation power will be about 12 W/m, and we need an elaborated beam screen.

In appendix another hadron collider up to 90 to 100 TeV center energy is attached.

1. Introduction

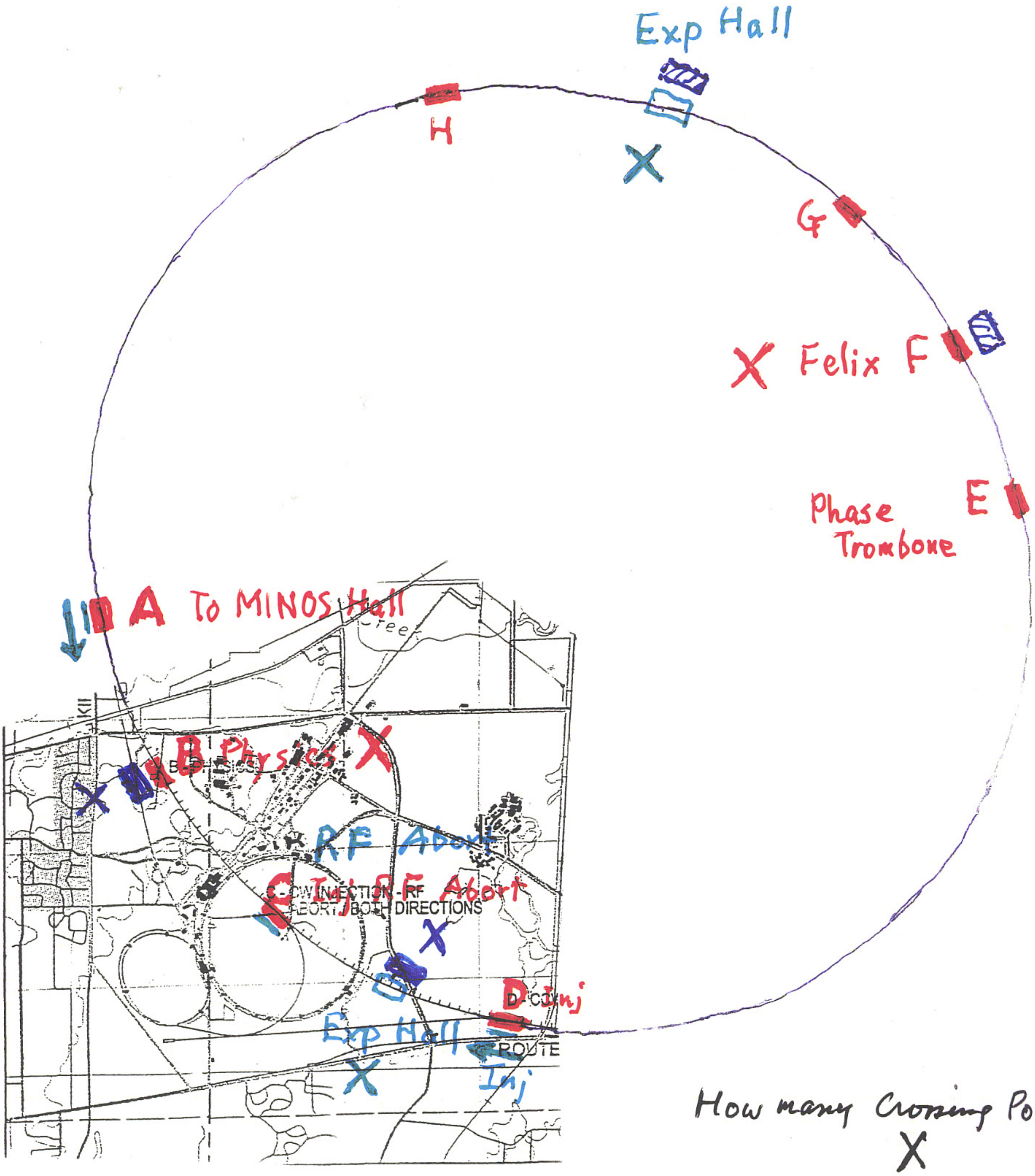
As a future project in high energy physics, the VLHC has been proposed for the future hadron collider in USA. The LHC, 14-TeV center of mass hadron collider is being constructed now at CERN, and probably will be in operation in 2006 [1]. We should consider building a hadron collider, which eventually surpass the energy of the LHC, but it should be realistically conceived as a realizable machine, budgetwise, spacewise, and timewise. The scale of the collider should be in the range, which can be manufactured by the industry in a reasonable time, and with an affordable cost. The machine should be

10/20/99

6 TeV CM P-P

30 TeV CM P-P (Horizontal Twin)

30 TeV CM P-P (Vertical Twin)

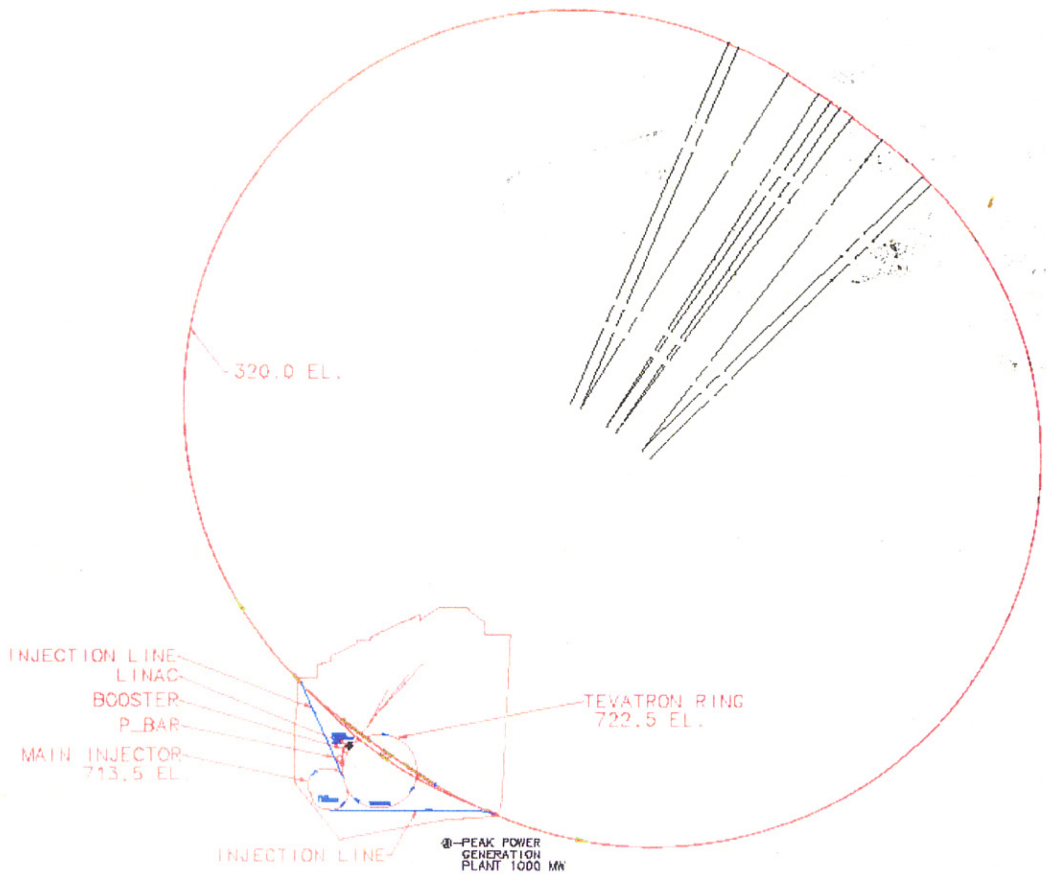


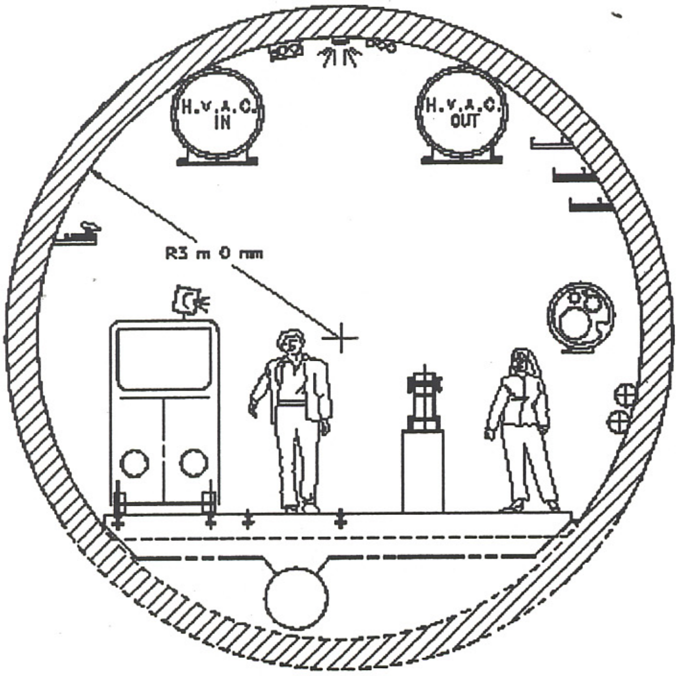
How many Crossing Points? X

Bypass ?

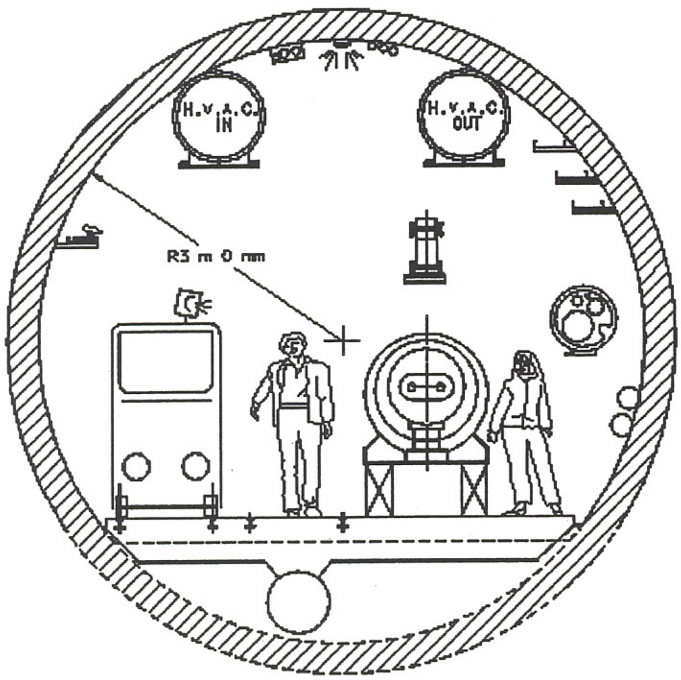
14 TeV Hadron Collider

- 87km Circumference
- 2T Pipetron
- Superbunch Collider
- Injection at 150GeV



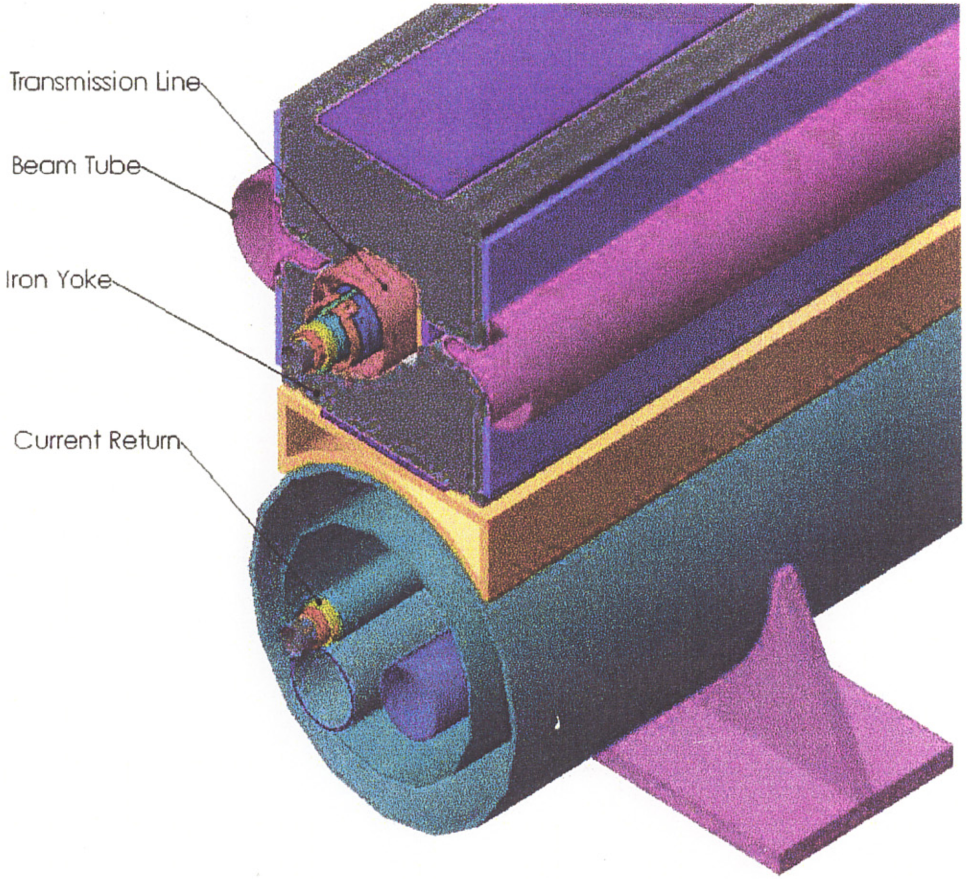


The tunnel cross section is shown with the low field magnet ring of the first stage. The magnet is installed at the optimum height for maintenance. The diameter of the tunnel is set at 6 meters.
The fast transit system is installed for the accelerator maintenance and for personnel transportation. The center lines of the detectors are made to coincide with the center line of the low field magnet ring.



The cross section of the tunnel is shown with both the low and high field magnets installed.
The low field magnet is lifted up to make room for the installation of much heavier high field magnets. The detectors are kept at the same height for the 62 TeV runs. Enough space for the maintenance of the high field magnets is reserved on both sides.

Basic Features of the Magnet

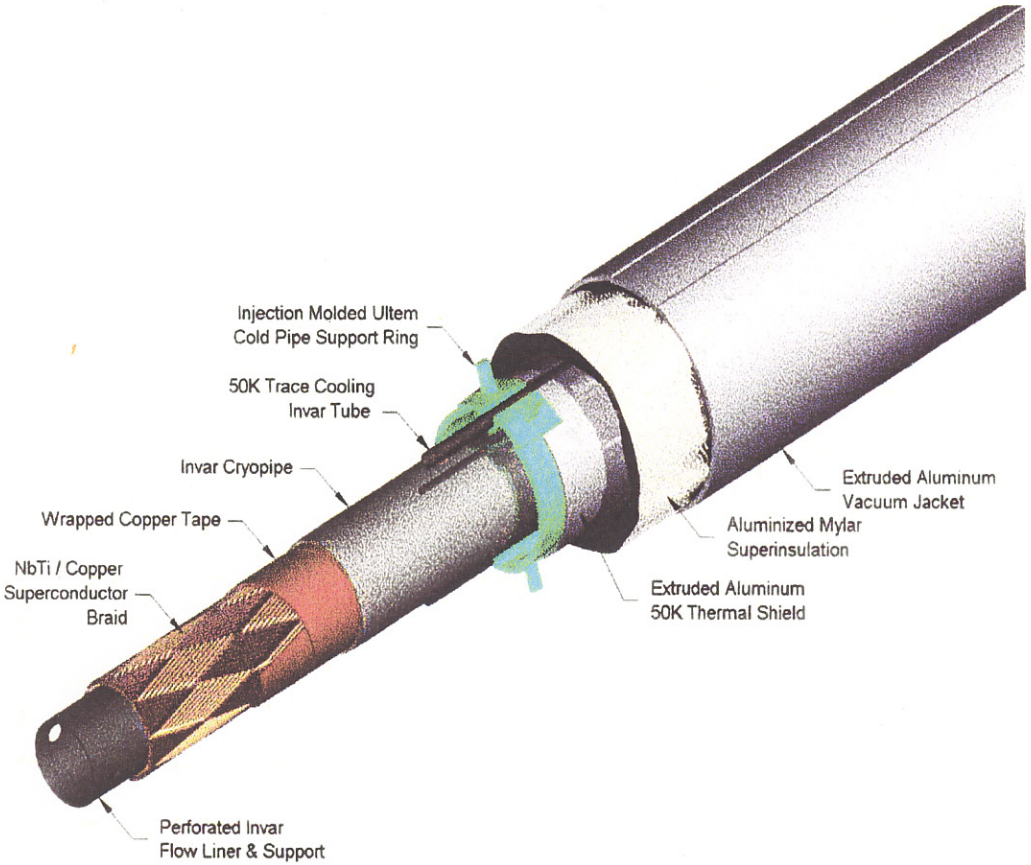


- Combined function gradient dipole

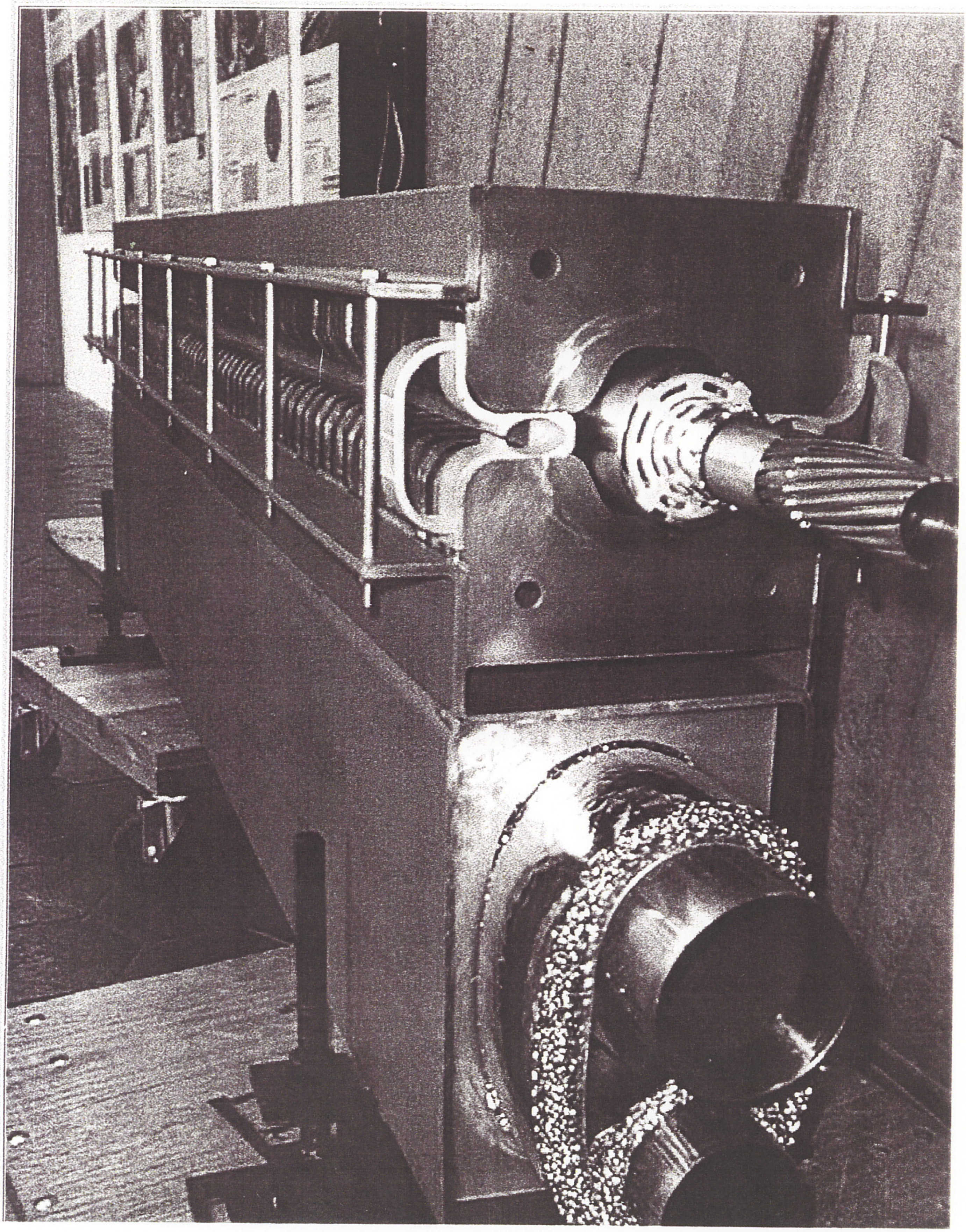
- 2-in-1 warm iron yoke
- 2 Tesla bend field
- 20 mm pole gap
- Alternating gradient 65m (half-dipole length)
- Single-turn 100 kA transmission line conductor
- Operating temperature up to 6.5 K
- Warm beam pipe vacuum system

SC Magnets
at Fermilab

Transmission Line Conductor R&D



- **All conductor lines use invar tubing for cryopipes to minimize shrinkage**
- **Conductor properties:**
  - **Drive bus**
    - *Braid of 288 SSC outer dipole strands*
    - *100 kA current @ 1 Tesla at 6.5K*
    - *LHe channel 25.3 mm dia.*
  - **Return bus**
    - *As above, except for the increase of the LHe channel dia. to 36.8 mm in order to minimize the pressure drop*
  - **Corrector space conductors**
    - *9 Rutherford cables (270 SSC inner dipole strands)*
    - *100 kA current @ 1.5 Tesla at 7 K allows to place drive and return buses at ~5cm of each other*



Parameter List of 14-TeV and 62-TeV Colliders

	Unit	14-TeV CM	62-TeV CM
Energy of Ring	TeV	7	31
Dipole Field	Tesla	2	10
Injection Energy	TeV	0.15	7
Injection Field	Tesla	0.0429	2.258
Luminosity	$/cm^2/s$	1.5×10^{35}	5×10^{34}
Crossing Angle	μ rad.	400	400
Ring Circumference	km	87.249	87.249
Arc Circumference	km	73.304	64.926
Dipole Filling Factor	%	90	80
Dpl Mag. Field Radius	km	11.667	10.333
No. of P / Bunch		1.3×10^{14}	7.8×10^{13}
No. Bunch / Beam		114	26
No. of P / Beam		1.5×10^{16}	2×10^{15}
Ave. Beam Current	A	8.16	1.1
Synchro. Rad. Loss/B	W/m	0.18	12
Unit Ind. Cell Lngth	m	0.2	0.1
Unit Ind. Cell Volt	kV	2.5	2.5
Rotation Period	μsec	290.83	290.83
Acceleration Energy	TeV	6.85	24
Acceleration Period	sec	1620	3620
Accele. Voltage /turn	kV/t	1090.6	1938.8
Syn.Rad. Loss /cycle/p	keV	1.9	940
Total V. for BB-IC	kV	93	93
Ttl No. of Ac IC/B	#	437	1152
Ttl Length of Ac IC/B	m	87.4	115
Coreloss of Unit Cell	kW	2.0 x2	0.45
Total Coreloss/beam	kW	1,748	518
SuperBunch Spacing	m	765	3356
SuperBunch Length	m	300	150
Time Period /SB	μsec	2.55	11.19
Rep. Rate of IC Pulser	kHz	392	89.4

Conclusion

- 14Tev collider with 1.5E35 luminosity
- Capability to be upgraded to 62tev
- We can start now

Once dust of Linear collider settle down