Report from the VLHC Workshop on Accelerator Technology

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Charge to the Accelerator Technologies Working Group

Guided by the Snowmass '96 parameter sets explore and develop innovative concepts that will result in significant cost reductions. Coordinate parameter sets, infrastructure requirements for the various options, and designs with the other working groups. Foster dialog and partnerships with industry. Develop bases including costs for comparing different designs.

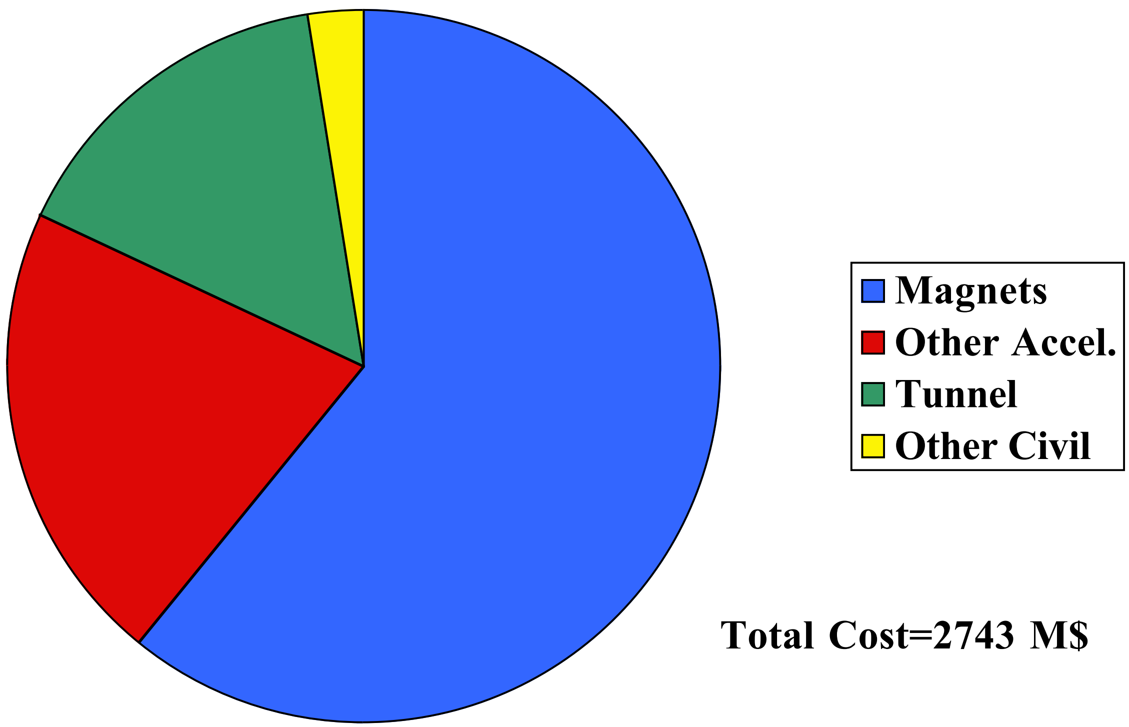
Accelerator Technology Working Group Goals

- **Consider all accelerator components except magnets and all technical infrastructure required for a VLHC**
- **Determine cost drivers and dependence on magnet choice**
- **Develop cost saving strategies**

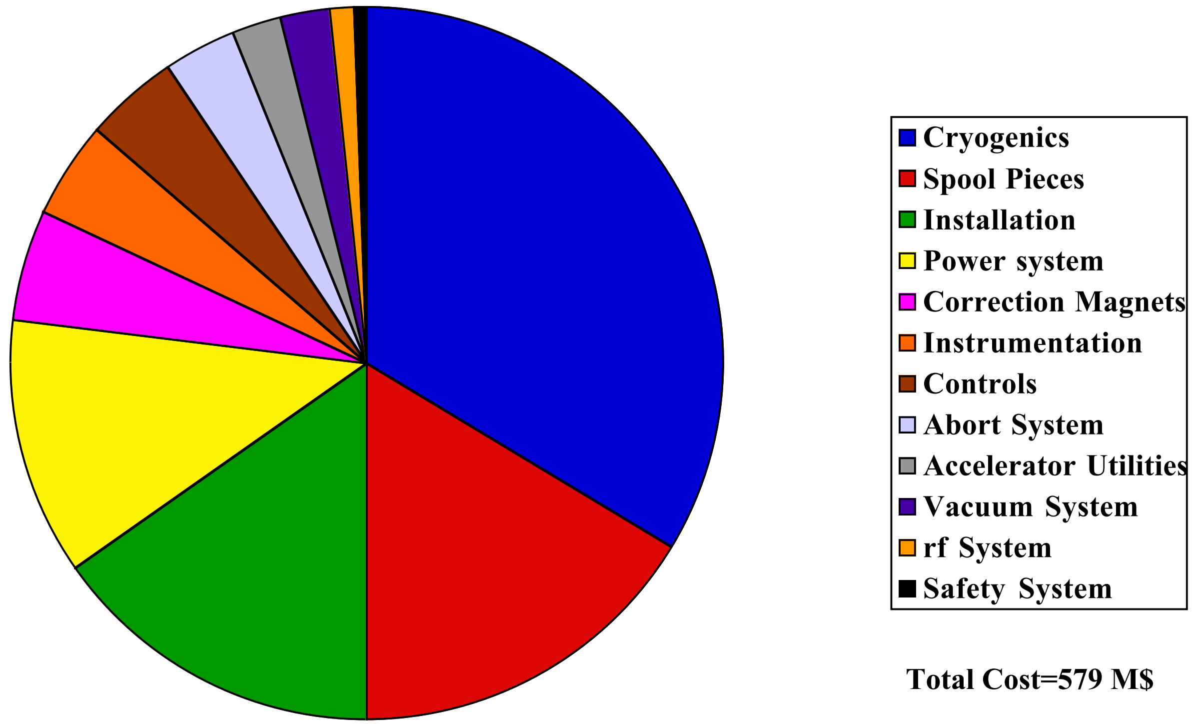
Major Result of the Workshop

- There is only one issue—It's the cost, dummy!
- Has a cost estimate been made?
  - Less than SSC
  - Greater than the SNS
- Yes, there are some technical issues...

SSC Collider Costs



SSC Collider Costs
Accelerator Components



Total Cost=579 M$

Subjects Covered

- **Instrumentation & Alignment**
- **Cryogenics & Beam Screens**
- **Rf & feedback**

Subjects *not* Covered

- **Everything else**

Cryogenics

- **Any magnet scenario can be accommodated.**
- **Beam screens are doable.**
- **Cryogenic systems need to be designed in conjunction with magnets.**
- **Simplicity is not just a virtue—scaling LHC is not an option.**

R&D on Cryogenics

- Flow instabilities
- Beam screens
- Cycle and efficiencies for sensible heat vs latent heat systems

Instrumentation

- Standard techniques are adequate
- Reliability should be achieved through redundancy
- Commercial electronics should be used
- 0.5 T-m correctors required

R&D on Instrumentation

- Radiation map of VLHC tunnel
- Measurement of long-term ground motion
- Study orbit correction requirements
- Robotics
- Radiation damage to electronics
- Position sensors & movers

Rf & Feedback

- 50 to 200 MV of superconducting rf in the range 372 MHz (h=7) to 1221 MHz (h=23) seems straightforward.
- Low frequency noise (ground motion & PS ripple is a serious concern).
- Feedback systems (gain=1) reduce emittance growth caused by noise.

Rf considerations

- Bunch length
- Acceleration time
- Longitudinal emittance
  - Intrabeam scattering
  - Quantum lifetime
  - Damping time
- Synchrotron Frequency & Spread

Rf & Feedback (cont’d)

- Feedback systems (gain=1) reduce emittance growth caused by noise.
- Feedback systems can provide a solution to instabilities
- Other techniques (rf quadrupole) can also be effective to stabilize beam motion.

Rf & Instability R&D

- TCMI studies
- Measure magnetic field fluctuations to $\Delta B/B=10^{-9}$
- Investigate damper gain limitations

Noise & Beam Heating

- **Magnetic Field Fluctuations**
- **Ground motion**
- **Feedback can reduce the effects**

Run II Parameters

RUN	Ib (1993-95) (6x6)	Run II (36x36)	Run II (140x121)	
Protons/bunch	$2.3x10^{11}$	$2.7x10^{11}$	$2.7x10^{11}$	
Antiprotons/bunch*	$5.5x10^{10}$	$3.0x10^{10}$	$3.0x10^{10}$	
Total Antiprotons	$3.3x10^{11}$	$1.1x10^{12}$	$3.6x10^{12}$	
Pbar Production Rate	$6.0x10^{10}$	$2.0x10^{11}$	$2.0x10^{11}$	hr^{-1}
Proton emittance	23π	20π	20π	mm-mrad
Antiproton emittance	13π	15π	15π	mm-mrad
β*	35	35	35	cm
Energy	900	1000	1000	GeV
Antiproton Bunches	6	36	121	
Bunch length (rms)	0.60	0.37	0.37	m
Crossing Angle	0	0	136	μrad
Typical Luminosity	$0.16x10^{31}$	$0.86x10^{32}$	$1.61x10^{32}$	$cm^{-2}sec^{-1}$
Integrated Luminosity†	3.2	17.3	32.5	pb^{-1}/week
Bunch Spacing	~3500	396	132	nsec
Interactions/crossing	2.5	2.3	1.3	

*The antiproton intensities given are merely examples. Higher antiproton intensities yield proportionally higher luminosities. The initial Run II upgrades are expected to have the ultimate potential to achieve luminosities of $2x10^{32}$ with 36 antiproton bunch operation.

†The typical luminosity at the beginning of a store has traditionally translated to integrated luminosity with a 33% duty factor. Operation with antiproton recycling may be somewhat different.

Electron Cooling

- Possible to reduce emittance at—say—8 GeV
- Tends to reduce aperture requirements
- Increases intrabeam scattering rate

Accelerator Physics Concerns

- Magnet aperture
- Correction system (Steering, tune, chromaticity)
- Lattice (cell length, tune)
- Rf parameters (bunch length, longitudinal emittance)

The wrong questions
(Wrong-think)

- How much aperture is needed?
- How many correctors are needed?
- Is synchrotron radiation damping useful?
- What is the optimal cell length?

The right questions
(Right-think!)

- How little aperture is needed?
- How few correctors is needed?
- Is synchrotron radiation cost effective?
- How long can I make the cells?

Conclusion

- **The VLHC is a machine that we know how to build, but we may not be able to afford.**
- **Differences in performance of high field versus low field machines seem to be insignificant compared to the issues of cost.**