Remarks on cost of high energy collider detectors

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Disclaimer

LHC detectors

SSC detectors

DØ upgrade and BTeV

Conclusions

Disclaimer

Estimates for ATLAS and CMS are taken from published TDR's

SSC detectors $'s are taken from "my memory"

DØ and 3TeV $'s are from appropriate cost estimates

CMS detector cost estimate

Table 19.6
CMS detector cost estimate (MCHF).

Sub-system	Cost estimate
Magnet	117.0
Tracking	87.0
ECAL	79.2
HCAL	36.1
VF	4.4
Muons	59.9
Trigger/DAQ	46.8
Software	3.6
Infrastructure	25.0
Total	459.0

Tracking → 204M or 44%

Calorimetry → 120M or 26%

Muons → 13%

Electronics → 10%

Miscell. → 28.6 or 6%

Cost estimate does not include manpower (except industry)

Clearly compact/high resolution calorimetry increased cost of tracker (magnet) considerably.

ATLAS cost estimate

Table 10.1: Cost estimates (in MCHF)

Detector subsystem	Material cost Mechanics	Material cost Electronics	Total Subsystem cost
Inner detector			77.6
Pixel detectors	6.2	6.6	
Strip detectors	21.4	9.4	
GaAs	1.6	3.2	
TRT	11.5	3.6	
MSGC	6.9	6.2	
Support, alignment, etc.	1.0		
Superconducting solenoid	8.6		8.6
Liquid argon calorimeter			117.7
Barrel e.m. calorimeter	30.4	20.6	
End-cap calorimeters	30.8	15.5	
Cryogenics and common items	18.3	2.1	
Tile calorimeter	9.4	5.4	14.8
Air-core toroid			105.1
Barrel toroid	68.7		
End-cap toroids	32.5		
Common cryogenics	3.9		
Muon detectors			41.5
MDT	13.4	9.1	
CSC	0.4	1.2	
RPC	3.6	2.2	
TGC	5.8	2.8	
Supports, alignment, etc.	3.0		
Trigger electronics		26.1	26.1
Data acquisition		25.1	25.1
Detector control system		3.1	3.1
Infrastructure	24.9		24.9
Offline links	5.0		5.0
Total detector cost	307.3	142.2	449.5

→ 19% Tracking

→ 30% Calorimetry

→ 33% Muon

→ 11% Trigger/DAQ

→ 7% Misc.

→ 32%

Labor for design, testing, installation is not included, but estimated at 2500 man·year:

2500 × \$100k ≈ \$250 M → "Real" cost ≈ \$0.7B

2500 man·year / 10 years = 250 people of "permanent" staff

ATLAS and CMS comparison

- 1. Total cost is the same within 2%...
- 2. Labor is ~ 55% of "materials" costs.
- 3. Electronics is substantial part of total cost : ~ 32%
- 4. By sub-system in %:

	CMS	ATLAS	"Average"
Tracker	44	19	32
Calorimetry	26	30	28
Muon	13	33	23
Trigger / DAQ	10	11	10
Miscel.	6	7	6

! "Exotic" options (calorimeter inside solenoid, air core muon toroids) add to the price

SSC detectors

- Detectors designed for $\sqrt{s} \times 3$ of LHC, but 10 times lower luminosity
- Cost estimate done in "US accounting" and about
  $ 0.5B / detector

DØ upgrade and BTeV

- DØ upgrade in 1997-2001 for $L \approx 2 \cdot 10^{32} cm^{-2} s^{-1}$, $\tau = 132 ns$
  - Si
  - Fiber Tracker
  - Forward Muon System
  - Electronics, Trigger, DAQ

Total cost is ~$40M

- BTeV experiment cost estimate as of spring 2001

  ~ $120 M

  Includes design / construction from scratch + labor

  ! Specialized detector

Conclusions

1. To some extent cost is driving what physics we can do, so cost reduction is important:
   1°. Inovations in detectors concentrated on cost reduction.
   2°. "Compromises" in detector design.
   3°. Use of "proved" technology.
   4°. Optimization of "accelerator + detector" cost.
   5°. Appropriate selection of collaborators responsibilities.
   6°. Planning of design / construction / assembly.

2. "Qualified" Labor is considerable part of detector cost:
   1°. Collaborators.
   2°. Reduction of design / construction / installation time.

3. VLHC phase I detector cost based on existing technology could be built for ~ $0.7B extrapolating SSC/LHC detectors costs.