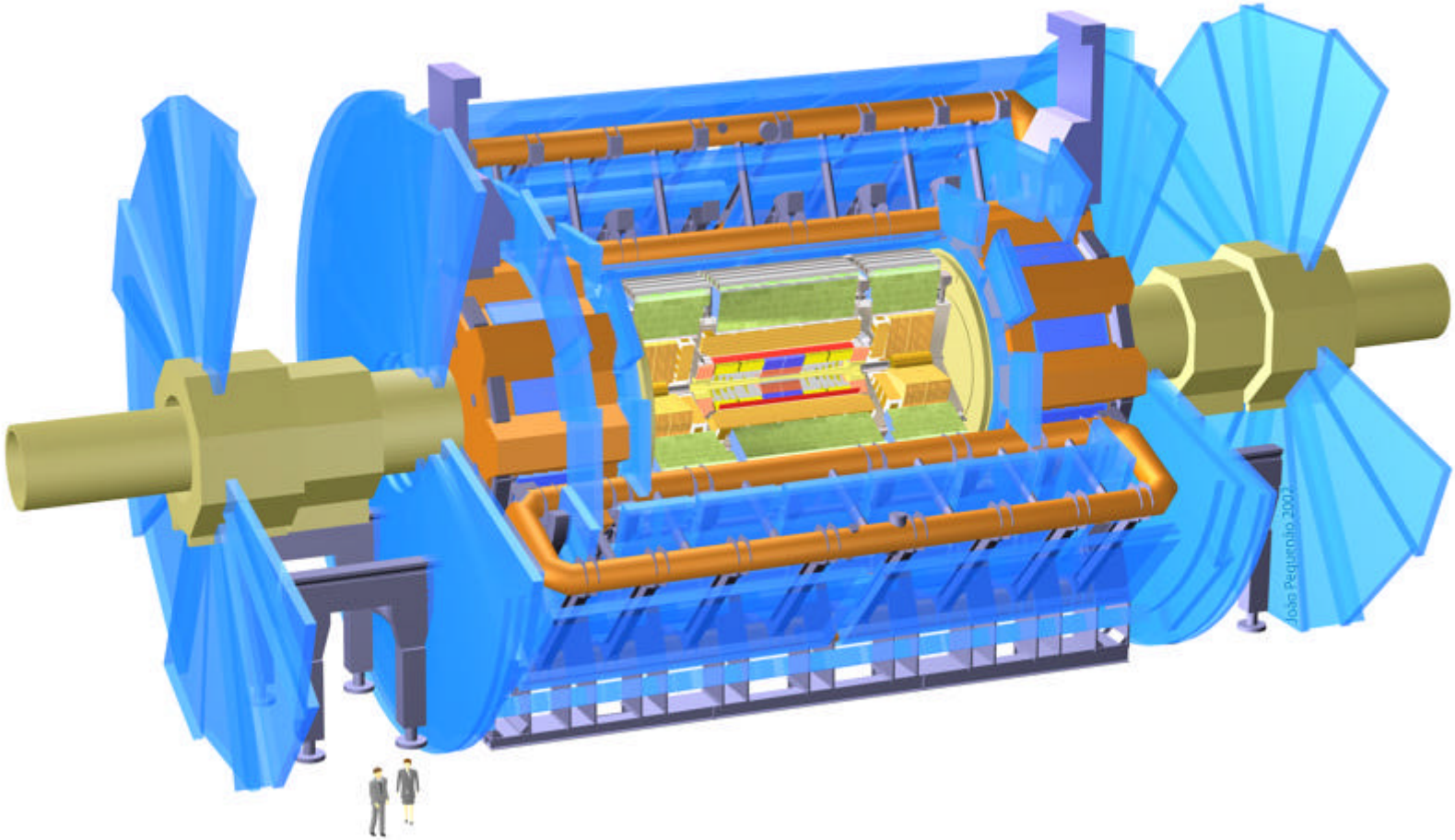
CERN-RRB-2002-144

ATLAS Completion Plan

Updates on the general situation

Initial detector planning for ATLAS



Cost to Completion

As discussed at the previous RRB meetings, three types of costs were identified and scrutinized by the LHCC CORE and the RRB SG that are not in the baseline construction budget

Construction Completion costs:

These are given in detail in Annex 1 of CERN-RRB-2002-114 and arise from

- **Technical developments since 1995**
- **Cost increases in industry, including contract changes and exchange rates**
- **Complexity of detector and infrastructure**

Commissioning and Integration (C&I):

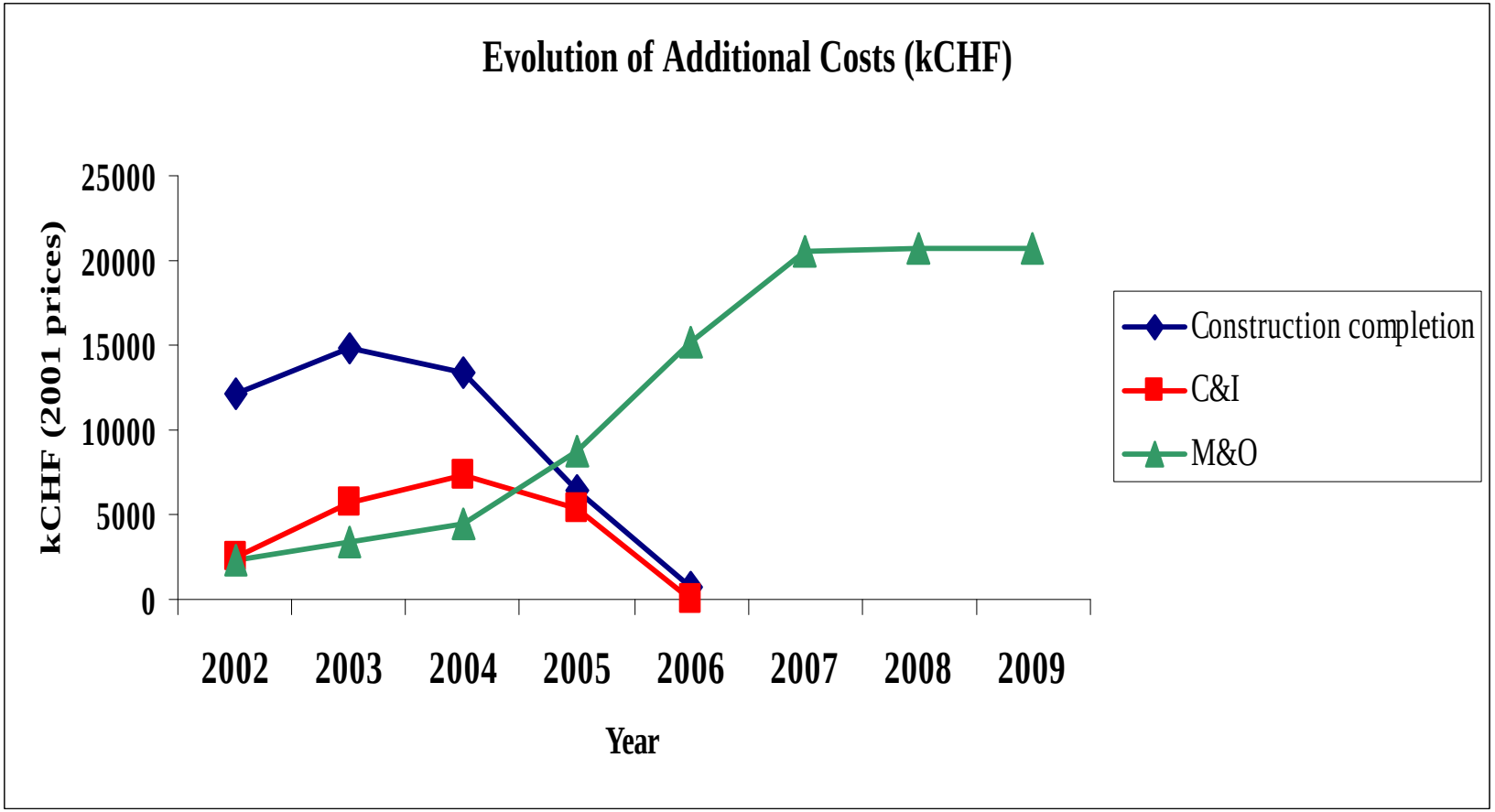
ATLAS has many decentralized detector integration and pre-assembly activities outside the ATLAS pit (this helped also to minimize the surface hall costs)

Maintenance and Operation (M&O):

Their nature is specified in the M&O MoU (approved at the April 2002 RRB), and the Collaboration thanks all the Funding Agencies which have already signed the M&O MoU

The first two, construction completion and C&I, add up to the *Cost to Completion* which are considered further in this presentation

The time profile for these costs is shown in the figure below



The revised and scrutinized Cost to Completion (all in MCHF), in addition to deliverables, are within the frame presented at the last RRB (total unchanged)

Construction Completion			**47.3**
Common items (category A)		**35.6**	
Magnet System	**19.6**		
LAr Cryostats and Cryogenics	**2.3**		
Infrastructure and supports	**11.4**		
Missing Common Fund	**2.3**		
Detector specific (category B)		**11.7**	
Inner Detector	**4.0**		
LAr Calorimetry	**3.6**		
Tile Calorimeter	**1.8**		
Muon Spectrometer	**2.3**		
C&I Total			**20.9**
Common items (category A)		**10.1**	
Magnet System	**4.7**		
Infrastructure and overall integration	**4.8**		
TDAQ and Controls	**0.6**		
Detector specific (category B)		**10.8**	
Inner Detector	**3.8**		
LAr Calorimeter	**2.5**		
Tile Calorimeter	**2.3**		
Muon Spectrometer	**2.3**		
Total Costs to Completion			**68.2**

Additional cost exposure

As already announced to the April RRB, and also explained in RRB-2002-114, it is very likely that the completion of the Barrel Toroid (BT) engineering contract with CEA will need up to 1.5 MCHF more than budgeted in the cost to completion

Many constructive negotiations with CEA have taken place to reduce this over cost, and CEA is offering to cover 20% of this over cost as part of increasing their contribution to the cost to completion funding, and other reductions are sought actively (covering one key engineer at CERN as associate for two years)

It is expected that the negotiations will be concluded soon with an agreement for the execution of the final phases C and D of this contract, which will include all the CEA engineering and supervision work on the BT as well as the construction and installation of the cryoring, which is on the critical path for the project

At this stage these over costs will have to be covered within the 68.2 MCHF and the available resources

Construction Completion and C&I Funding

Many fruitful and constructive interactions took place with the funding partners of the Collaboration, either directly with the Funding Agencies or via the ATLAS network of National Contact Physicists relating to their Funding Agency

Following the conclusion of the RRB meeting in April 2002, the availability of Cost to Completion funding was established for two different categories

It is understood that the actual planning can only be based at this stage on the first category in the following funding table, namely the resources for which the Funding Agencies are able to take a commitment at this RRB under the same premises as in the initial Construction MoU (ATLAS RRB-D 98-44 rev.)

This first category of Cost to Completion funding includes the obligation of the minimum cash contribution arising from the extension of the collaboration member fee over the three years 2004 to 2006, as a continuation of the principle established in the Construction MoU (Article 6.3)

The second category lists the resources for which there is a good prospective through ongoing funding requests that they might become available, either still before the LHC start-up or shortly after

However, no commitment can be made at this stage for resources from this second category, and therefore the initial detector configuration cannot call upon them

The following Funding Table, which is a slight revision and replaces the one distributed as Annex 2 of CERN-RRB-2002-114, adds up to 46.5 MCHF for the first category and 13.5 MCHF for the second one (tabled as Annex 2 CERN-RRB-2002-114 rev.)

The ATLAS Collaboration is very grateful to all those Funding Agencies which are able to commit already at this stage such a significant amount of fresh resources, and which make it with this generous support possible that ATLAS can plan for a viable initial detector

The Cost to Completion funding situation is expected to evolve with time

In many cases Funding Agencies have expressed and confirmed their best efforts to secure additional resources reaching the proposed share, but were not able to achieve this within the time scale of this RRB meeting

The ATLAS Collaboration has good hopes that some of the category 2 requests will evolve already in the months before the next RRB

The process of firming up further commitments will certainly extend over the coming years

This would then allow the ATLAS Collaboration to gradually improve the expected performance of its initial detector, thereby becoming capable of exploiting more fully the LHC physics opportunities

With respect to Annex 2 of CERN-RRB-2002-114 the following changes have been included in the revised cost to completion funding table:

BMBF will not be able to commit in a first step the full share in category 1, and needs to retain 900 kCHF of the 4517 kCHF in category 2 as contingency until all required German resources including deliverables are available

Russia will be able to commit to 500 kCHF C&I manpower following the JWG discussion, with another 500 kCHF in category 2

An agreement with Belgrade/ Serbia has almost been reached (300 kCHF category 2), pending on CB decision

The Taipei category 2 funding was planned computing funding, eventually usable for HLT/DAQ, but it is premature to have this listed now

Revised Annex 2 for CERN-RRB-2002-114

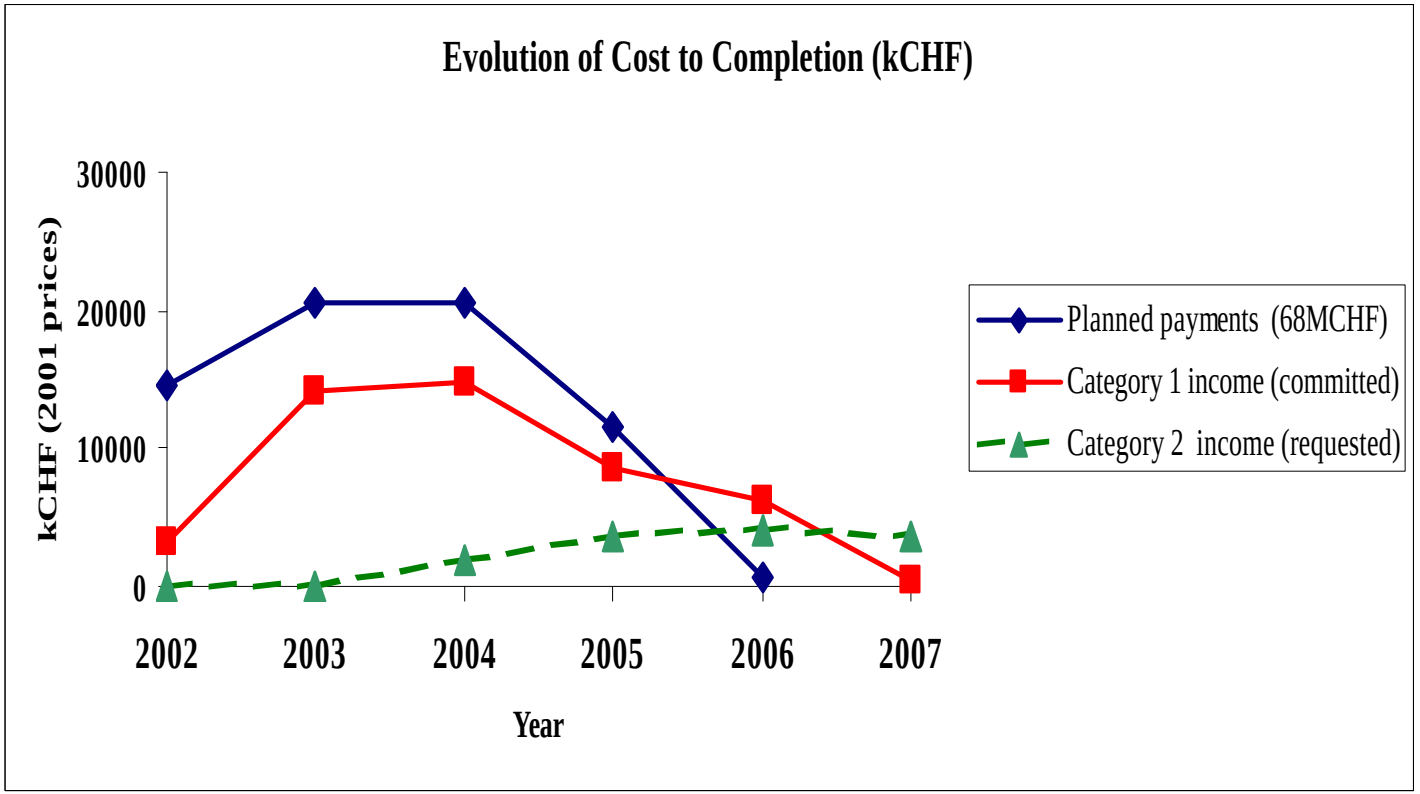
(all in kCHF)

Funding Agency	Cost to Completion proposed sharing			Member fee 2004-6	New funding (category 1) including member fee	New funding requests as prospects (category 2) without commitment from FA
	Total	Constr.	C&I		Total	Total
Armenia	46	28	18	38	38	
Australia	355	242	113	75	75	280
Austria	67	52	15	38	67	
Azerbaijan	22	17	5	38	38	
Belarus	44	35	10	75	75	
Brazil	43	27	16	38	38	
Canada	2123	1528	595	263	263	1860
China NSFC+MSTC	144	99	45	38	144	
Czech Republic	305	187	118	113	305	
Denmark	420	291	129	38	38	382
France IN2P3	5954	4176	1778	225	3500	2454
France CEA *)	1960	1379	581	38	1000	
Georgia	22	17	5	38	38	
Germany BMBF	4517	3250	1267	338	3617	900
Germany MPI	1096	761	335	38	1096	
Greece	258	172	86	113	113	145
Israel	734	497	237	113	734	
Italy	6618	4651	1967	450	4000	
Japan	4362	3029	1333	563	563	3799
Morocco	38	27	11	38	38	
Netherlands	1920	1368	552	75	1920	
Norway	577	391	186	75	577	
Poland	130	88	42	75	75	55
Portugal	444	265	179	38	338	106
Romania	140	85	55	38	140	
Russia	3075	2028	1047	263	763	500
JINR	989	626	363	38	418	
Slovak Republic	69	49	20	38	38	31
Slovenia	222	152	70	38	222	
Spain	1710	1109	601	113	1710	
Sweden	1691	1122	569	150	150	
Switzerland	2360	1701	659	75	1400	960
Taipei	447	319	128	38	447	
Turkey	45	35	10	75	75	
United Kingdom	4355	3064	1291	450	2575	1780
US DOE + NSF	12263	8437	3826	1238	6200	
CERN	8611	5968	2643	38	13700	
Serbia						300
Total	68176	47272	20905	5563	46528	13552

*) The commitment shown does not include a 1 MCHF additional engineering contribution provided on the initial BT contract (see MoU Annex 8.A)

The profile of the total Cost to Completion, and the expected funding income are shown in the plot

A cash flow problem is anticipated for the years 2004 – 2006, and ATLAS is negotiating solutions with CERN and other FAs for this problem



Initial Staged Detector

A concept for the initial staged detector, driven by availability of resources, was worked out quite a while ago and was presented to the LHCC Comprehensive Review, and in preliminary form to the October 2001 and April 2002 RRBs

The main staged components are:

One Pixel layer in the ID
Outermost TRT endcap wheels (C-type)
Part of the LAr ROD system
Tile gap scintillators
EES and EEL MDTs
Half of the layers of the CSCs
Part of the Common Project processors
Part of the high luminosity shielding

As already discussed at the last RRB, some of these staged components will 'liberate' 8 MCHF of resources which will be redirected towards covering over-costs on the common items of the construction completion costs (4 MCHF from staged CP processors, 3 MCHF from staged pixel layer, and 1 MCHF from staged high-luminosity shielding)

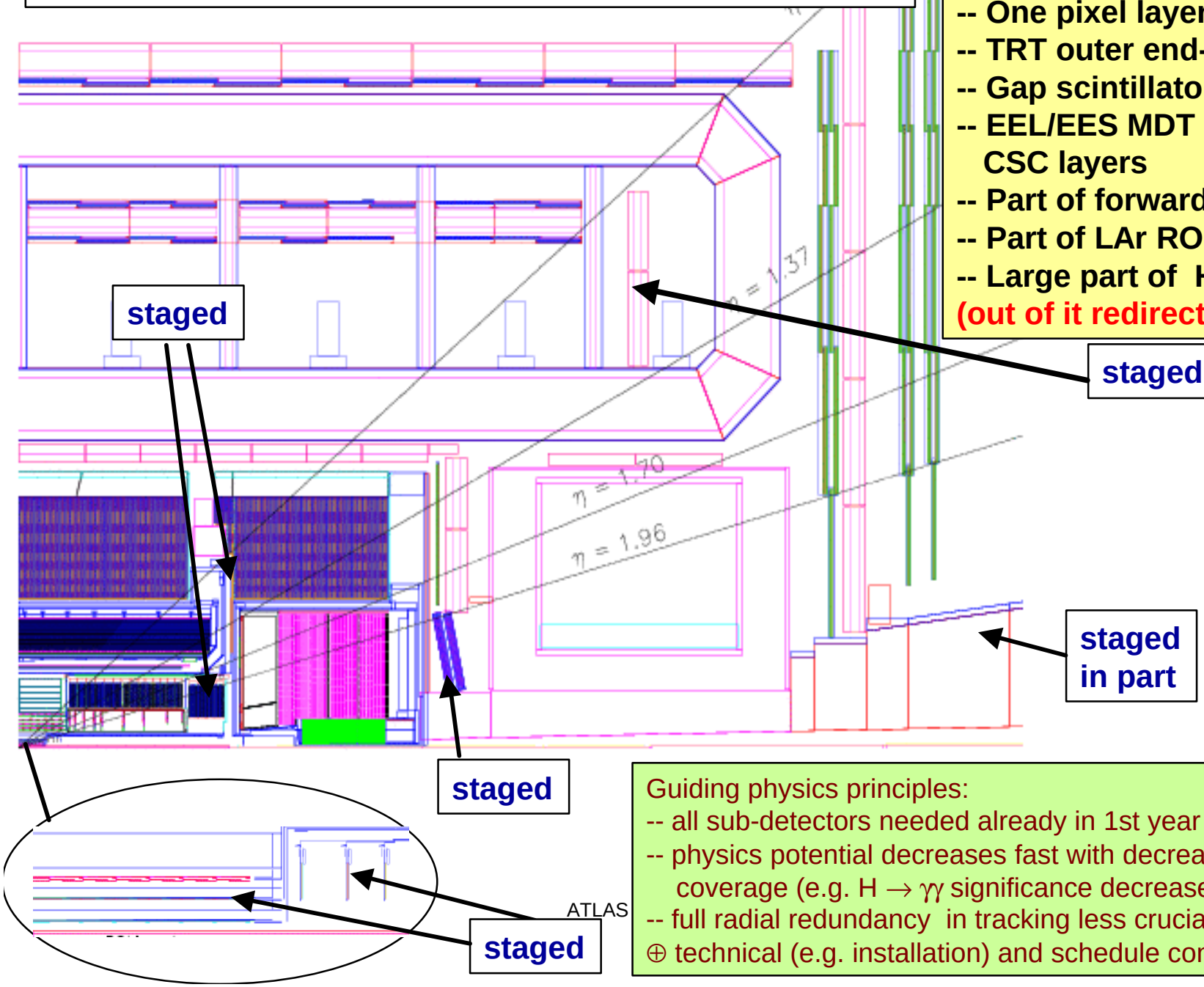
The corresponding funding of the other staged components will not be available in time for the initial detector, and can therefore not be redirected

Staged components for the initial physics run

Staged components:

- -- One pixel layer
- -- TRT outer end-caps
- -- Gap scintillator
- -- EEL/EES MDT and half CSC layers
- -- Part of forward shielding
- -- Part of LAr ROD
- -- Large part of HLT/DAQ

(out of it redirect 21.5 MCHF)

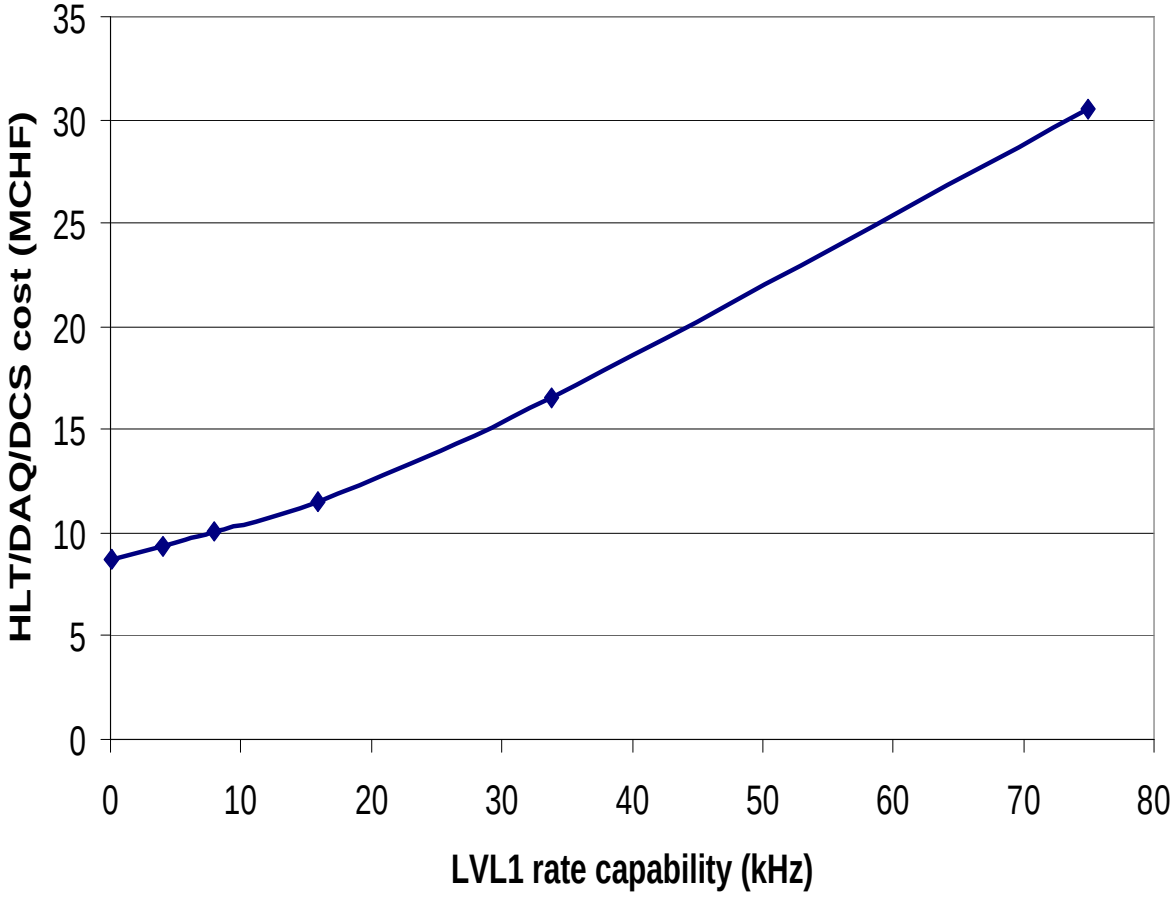


Guiding physics principles:

- -- all sub-detectors needed already in 1st year
- -- physics potential decreases fast with decreasing η coverage (e.g. $H \rightarrow \gamma\gamma$ significance decreases linearly)
- -- full radial redundancy in tracking less crucial at ~ 10^{33}

⊕ technical (e.g. installation) and schedule constraints

Components of the scalable HLT/DAQ system will have to be deferred at the level of 4 MCHF from the CP processors plus an additional 13.5 MCHF, reducing the input bandwidth for level-1 triggers from 75 kHz to the range 20-25 kHz



This means that initially the dedicated B-physics trigger has to be given up, and some cuts into the high-p_T discovery physics are inevitable

Level-1 trigger rate and threshold limitations

(Note that there are large uncertainties both in the cost model and the physics and background cross-sections)

Selections (examples …) Real thresholds set for 95% efficiency at these E_T	LVL1 rate (kHz) L= 1 x 10^{33} no deferrals	LVL1 rate (kHz) L= 2 x 10^{33} no deferrals	LVL1 rate (kHz) L= 2 x 10^{33} with deferrals example for illustration…
MU6,8,20	23	→ 19	→ 0.8
2MU6	---	0.2	0.2
EM20i,25,25	11	→ 12	12
2EM15i,15,15	2	4	4
J180,200,200	0.2	0.2	0.2
3J75,90,90	0.2	0.2	0.2
4J55,65,65	0.2	0.2	0.2
J50+xE50,60,60	0.4	0.4	0.4
TAU20,25,25 +xE30	2	2	2
MU10+EM15i	---	0.1	0.1
Others (pre-scaled, etc.)	5	5	5
Total	~ 44	~ 43	→ ~ 25

LVL1 designed for 75 kHz
® room for factor ~ 2 safety

Likely max. affordable rate,
no room for safety factor

Summary of physics impact of initial detector staging

Staged items	Main impact for first run on	Effect
One pixel layer	ttH ® ttbb	~8% significance loss
Gap scintillator	H ® 4e	~8% significance loss
MDT	A/H ® 2m	~5% significance loss for m ~ 300 GeV
HLT /DAQ	B-physics High-p_T physics	program jeopardized no safety margin (e.g. for EM triggers)

Requires 10-15% more integrated luminosity to compensate

Complete detector needed at high luminosity:

- -- robust pattern recognition (efficiency, fakes rate) in the presence of pile-up and radiation background
- -- muon measurement } at (very) high p_T
- -- powerful b-tag } at (very) high p_T
- -- robustness against detector aging and $L > 10^{34}$
- -- precise measurements (e.g. light Higgs) may require low trigger thresholds

Completion of the High-Luminosity Detector

The LHC is expected to reach its design (high-) luminosity already after only a few years of initial data taking

It can be anticipated that the machine will then operate for a decade at its maximum capability, and perhaps this will be followed at some future time by the only foreseeable LHC upgrade, namely with a luminosity even beyond its current design

Besides restoring the basic HLT/DAQ processing and background rejection power, running at the LHC design luminosity will require not only complete angular coverage but also complete tracking devices with all layers along the tracks as in the baseline ATLAS TDR design

The ATLAS Collaboration plans to restore the deferrals and staged items for which the funds have been redirected as soon as additional resources would become available

The HLT/DAQ system is designed such that its required performance can be restore gradually without major shut-down constraints

Very high priority will also be given to complete the high-luminosity shielding, if needed based on the first experience with beams, and to the completion of the Pixel sub-system

The corresponding funding deferred from these items is 21.5 MCHF

Restoring the other staged components of the full high-luminosity TDR ATLAS detector will require most likely resources beyond the the ones discussed so far

The initial bare CORE value for these items, without inclusion of any related manpower costs, is about 10 MCHF, as detailed in CERN-RRB-2002-114, even though these 1995 estimates may not be very representative for future upgrade costs

The intention is to define upgrade projects for them to enhance and restore the high-luminosity physics potential of ATLAS

Some of the future upgrades may also be guided by the experience with the first LHC data

For the upgrades one will make use as much as possible of existing tooling and infrastructure, where this is applicable

The installation of the staged detector components will require typically a standard yearly shutdown of the LHC (~5 months)

Conclusions

A completion plan for the initial ATLAS detector has been presented, based on the funding level that the funding partners are able to commit to at this stage

The plan is based on trying to maximize the highest-priority discovery physics potential for the initial LHC running with the currently expected resources, and the possibility to gradually complete and upgrade the detector afterwards towards the performance required for the high design luminosity running of LHC

The plan implies that the funding of several components from the baseline TDR detector is redirected initially in order to finish the construction and installation of the highest priority and most time-critical items

The RRB is kindly invited to approve this plan