NCLinac Kick-Off Meeting

Presentation task 2

G. Riddone

Contributions from sub-task leaders:

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R. Ruber/ V. Ziemann

2009.03.27

Content

- Task 2 goal and test module
- Recall of the sub-tasks
- Summary of spending profile and Gantt chart
- Conclusions

Task 2
Normal Conducting High Gradient Cavities

- Building on the success of CTF3 and complementing it, the goal of this task is to optimize CTF3 and its use towards
  - cost- and performance optimized accelerating structures and their integration in CLIC modules. Together with all subsystems (vacuum, cooling, alignment,..). This also requires
  - better modeling of breakdown and
  - better suppression of HOM's,
  - experimental verification
- Partners: CIEMAT, University of Manchester (CI), HIP/University Helsinki, Uppsala University, CERN (coordination)
- Estimated total: 2.45 M€, 22 FTE

- This task is complementary to the "module implementation" which is financed 100% by CERN (and other collaborators) and not part of this proposal
- Also note that the CLIC main beam accelerator structures are not explicitly part of this program.

Task 2
Normal Conducting High Gradient Cavities

- **Sub-task 1:** Design, manufacture, and validate experimentally a **Power Extraction and Transfer Structure (PETS)** prototype to improve CTF3 ➔ **F. Toral/D. Carrillo - CIEMAT**
- **Sub-task 2:** Explore influence of **alignment errors on wake fields**, elaborate and demonstrate **appropriate High Order Mode (HOM) damping** in the presence of alignment errors. ➔**R. Jones/A. D'Elia - Un. of Manchester**
- **Sub-task 3:** **Breakdown simulation**: Develop and use atomistic simulations of atom migration enhanced by the electric field or by bombarding particles, understand what kind of roughening mechanisms lead to the onset of RF breakdown in high gradient accelerating structures. ➔ **K. Österberg - HIP(#1)**
- **Sub-task 4:** **Design and build equipment to diagnose the electrons, ions and light emanating from the breakdown event** both in the CTF3 Two-Beam Test-Stand at CERN and inside a scanning electron microscope in UU to analyze the surface science relevant to RF-breakdown ➔ **R. Ruber/V. Ziemann - UPPSALA**
- **Sub-task 5:** **Precise assembly**: Develop a strategy of assembly for the CLIC accelerating and power extraction structures satisfying the few to 10 micrometer precision requirement of positioning both radial and longitudinal taking into account dynamical effects present during accelerator operation. ➔ **K. Österberg - HIP(#2)**

Task 2- Budget

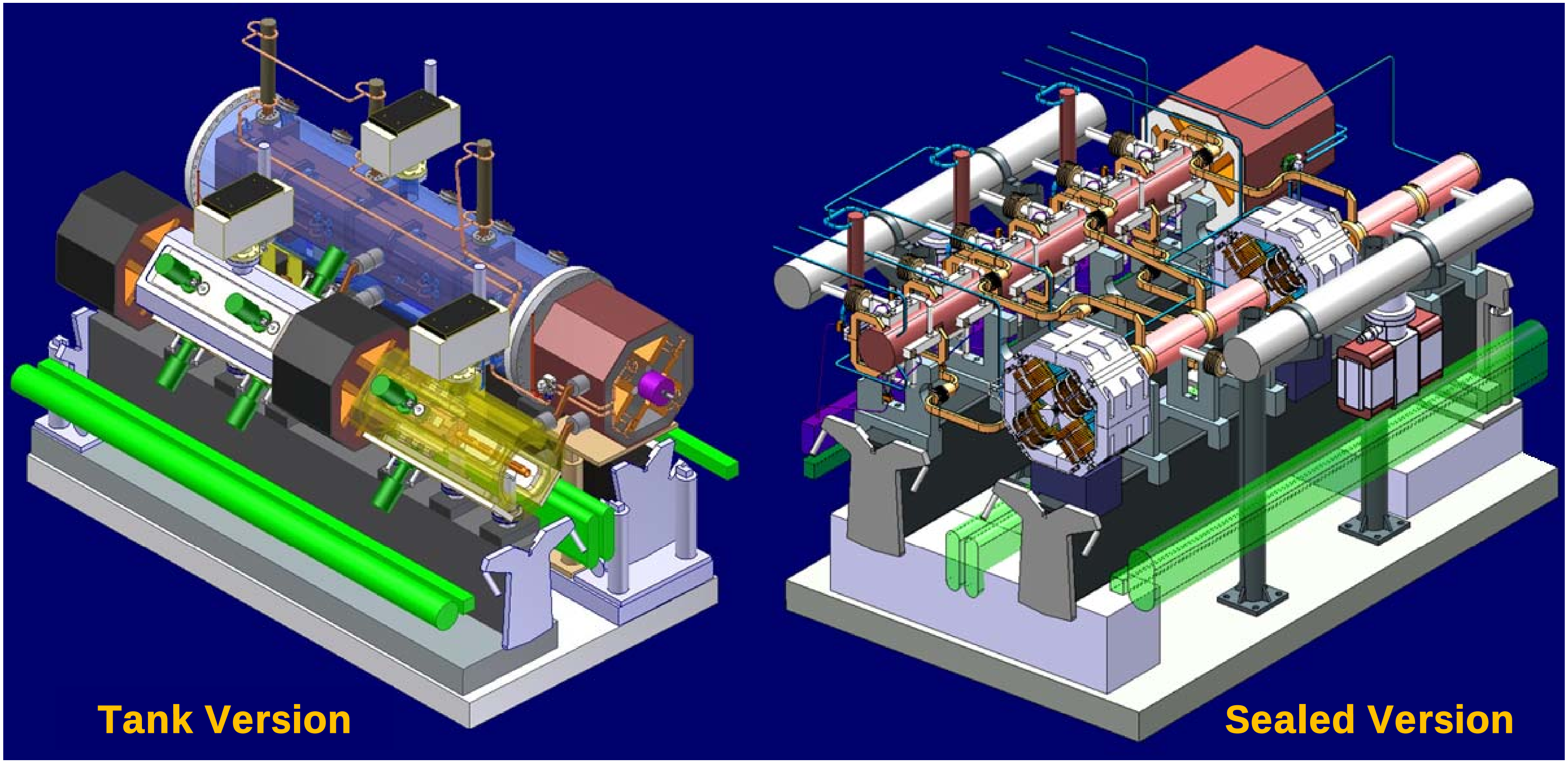
Beneficiary short name (all costs in €)	Person-Months	Total direct costs	Total indirect costs	Total costs (direct +indirect)	EC requested funding[1]
CIEMAT (sub-task 1)	32	257,000	122,080	379,080	114,000
UMAN (sub-task 2)	52	321,600	192,960	514,560	149,000
UH (sub-tasks 3 and 5)	112	515,200	309,120	824,320	249,000
UU (sub-task 4)	68	459,560	275,736	735,296	220,300
Totals:	**264**	1,553,360	**899,896**	**2,453,256**	**732,300**

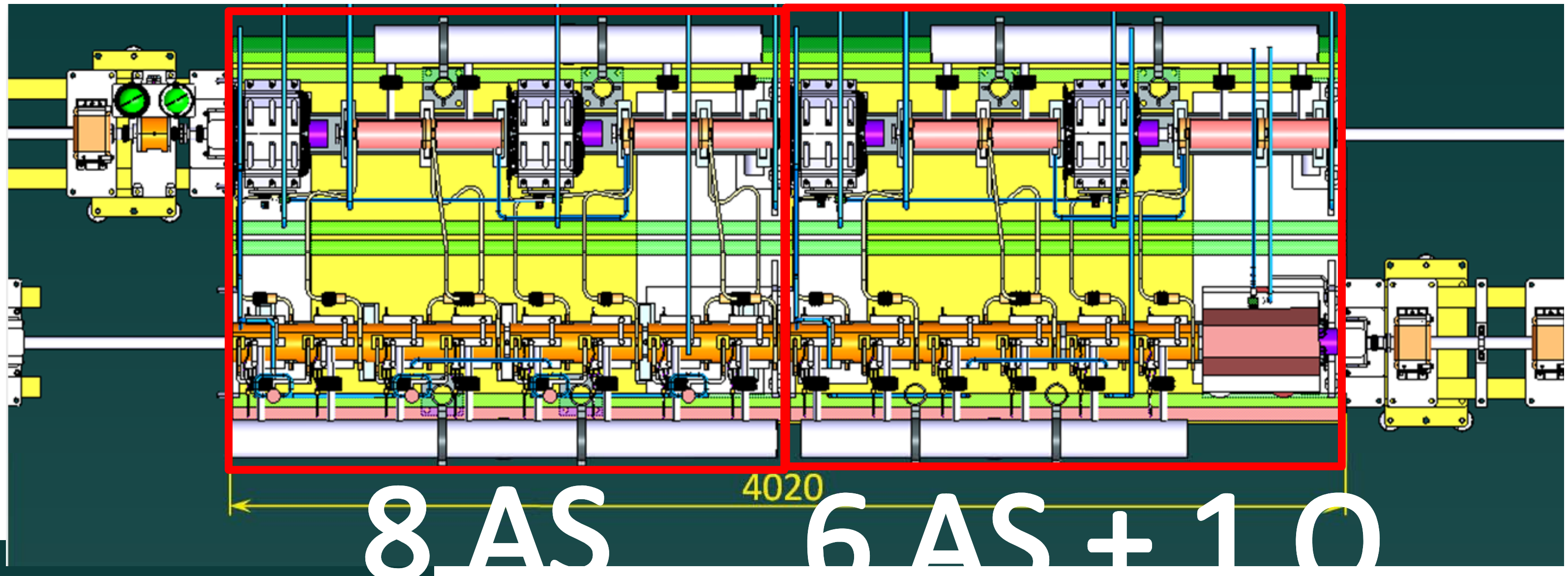
[1] In principle 30% of total costs

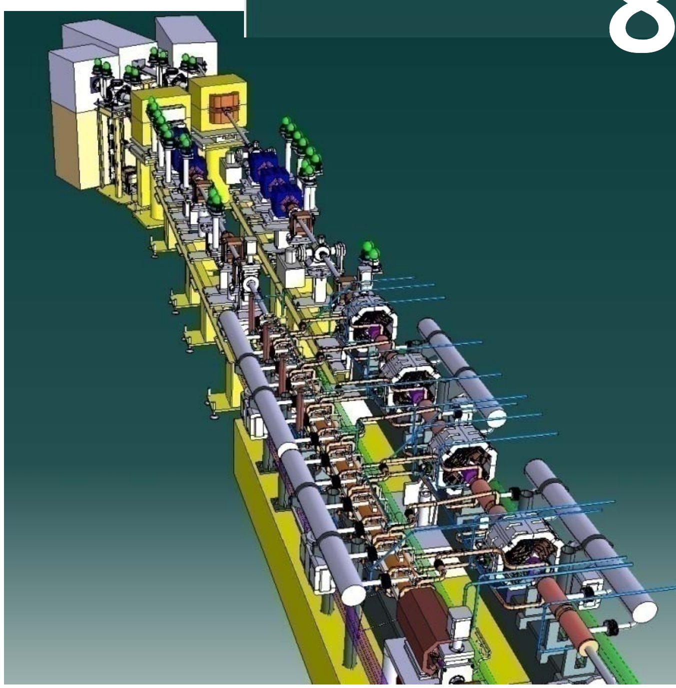
CLIC module – integration

MB: AS (quadrants) in vac. tank
DB: PETS in vac. tank
Quads: simplified 3D model

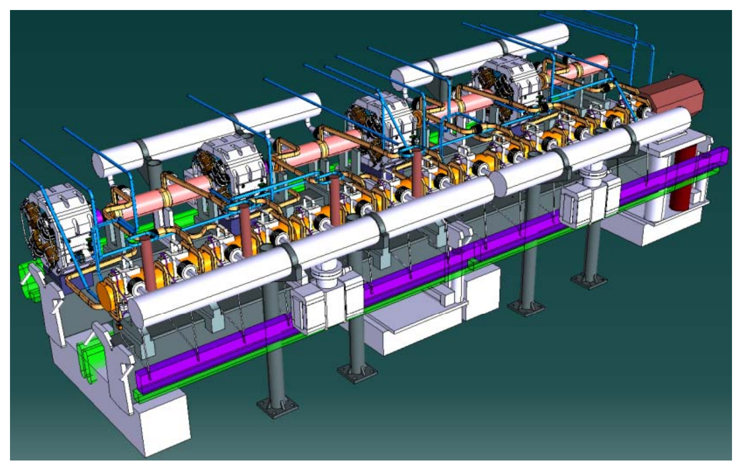
MB: AS (disks) sealed
DB: PETS with “mini-tank”
DB Quads: updated 3D model





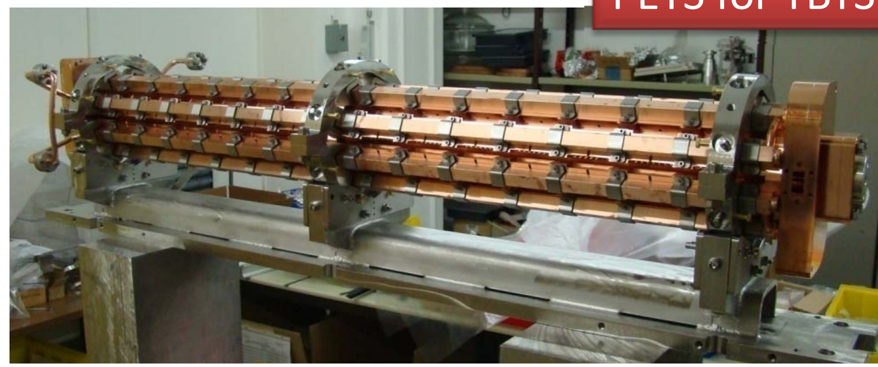


STANDARD & TYPE 1 CLIC MODULES IN CLEX
(2010 mm + 2010 mm = 4020 mm)



Sub-task 1 - CIEMAT

PETS for TBTS

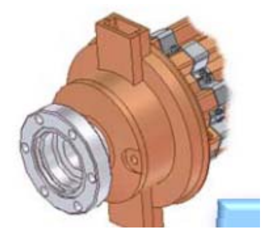


Design, manufacture a Power Extraction and Transfers Structure (PETS) for the test module in CLEX

- Fabrication of 2 PETS (tbc)

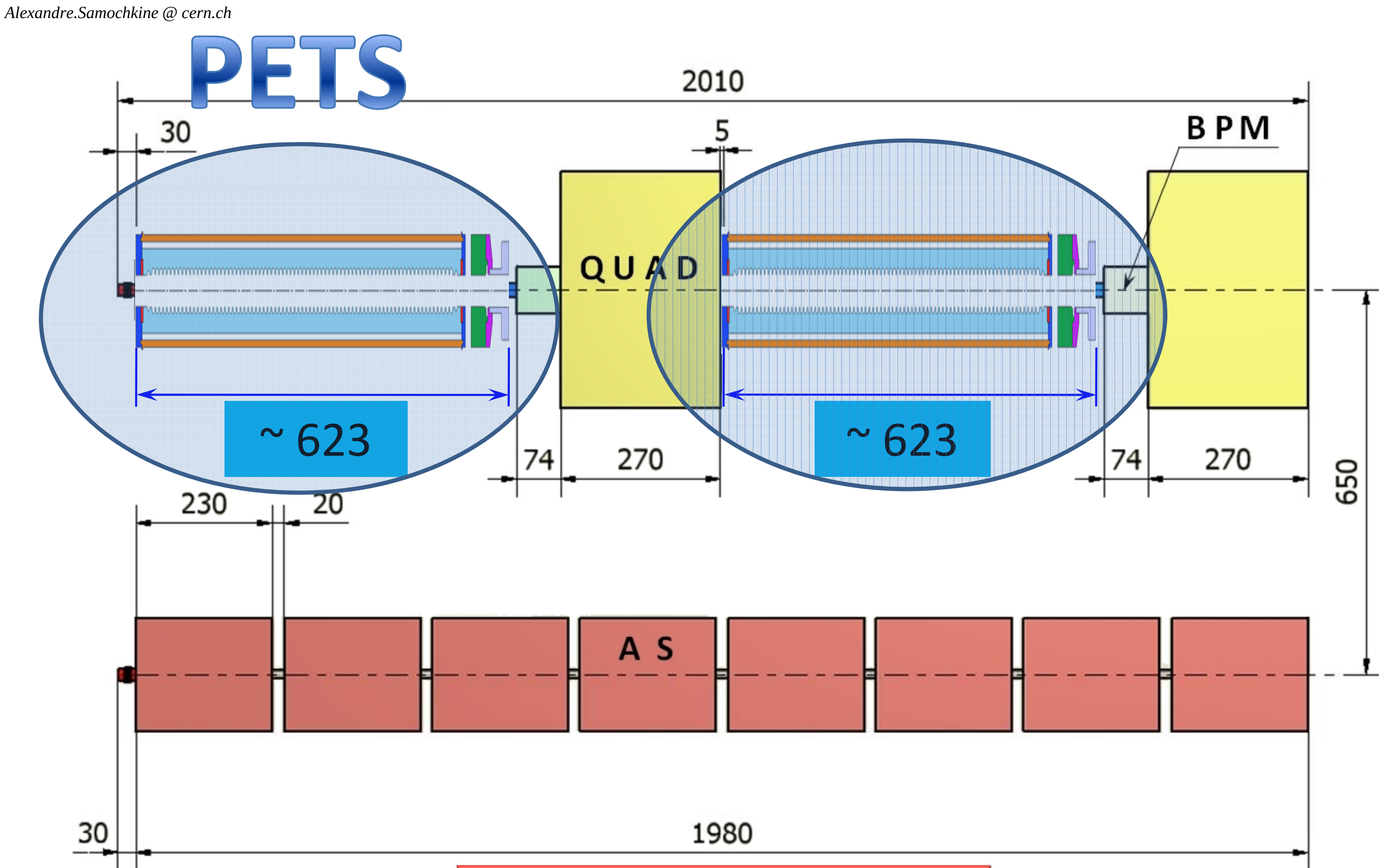
List of deliverables and preliminary schedule

- Coupler design & PETS engineering and detailed design: M10
- First prototype PETS parts fabrication and assembly: M22
- First prototype PETS tests: M25
- Design review: M27
- Second prototype PETS production: M36
- Complete TEST module tests: M46



	Year #1	Year #2	Year #3	Year #4	Total
Sub-task 1					
Person.months	8	8	8	8	32
Total cost [kEUR]	30	130	119	100	379

Sub-task 1 - CIEMAT

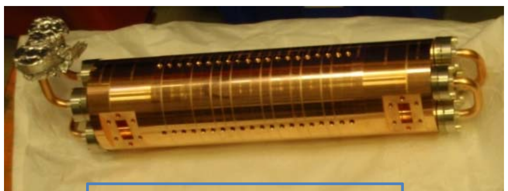


CLIC standard module in CLEX

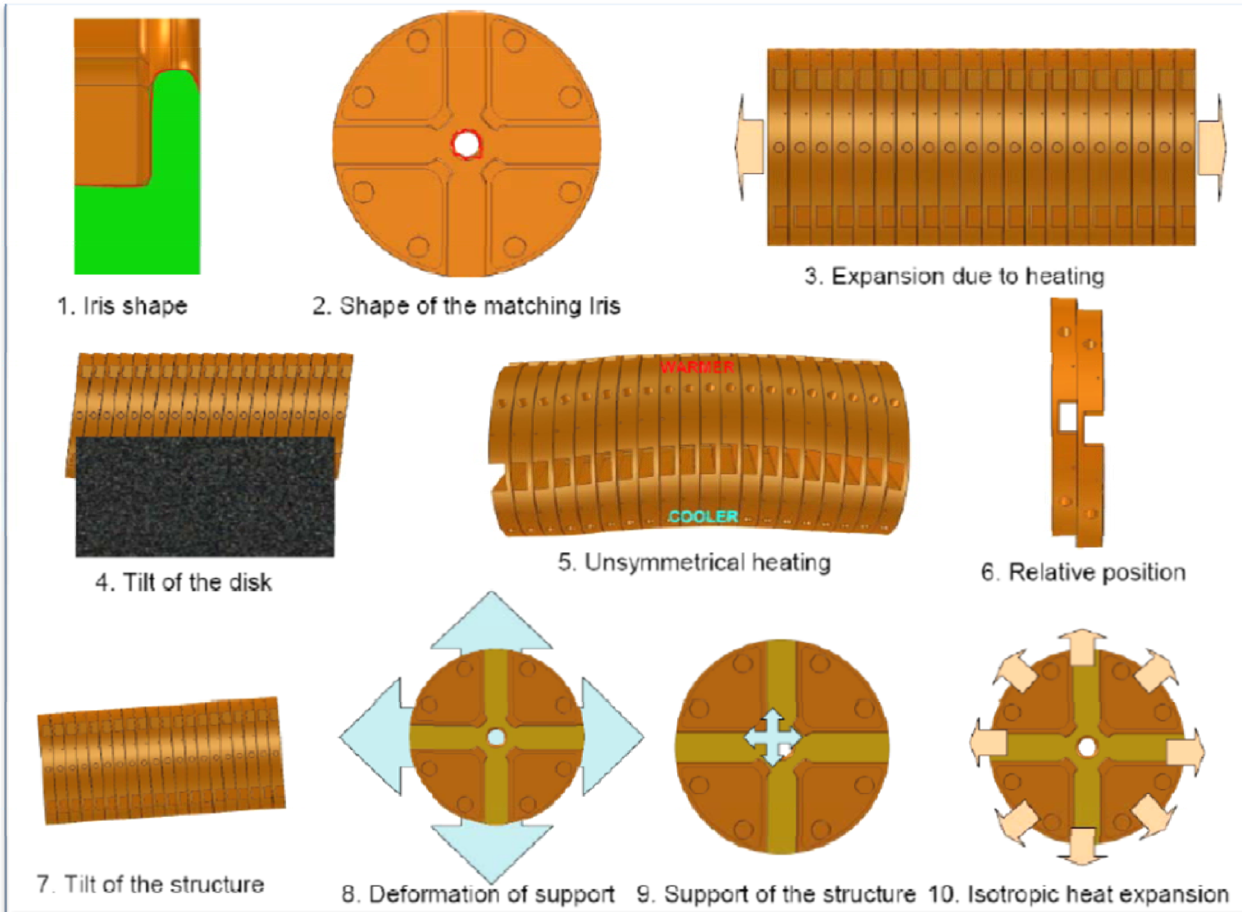
Sub-task 2 – Un. of Manchester

Explore influence of alignment errors on wake fields, elaborate and demonstrate appropriate High Order Mode (HOM) damping in the presence of alignment errors.

Types of errors



Acc. structure



Sub-task 2 – Un. of Manchester

Goals and Milestones

Goal 1. Develop a circuit model and a generalized scattering matrix technique to obtain accurate calculations on the global electromagnetic field from small segments thereof. This is a *study of mode excitation.*

Milestones

1.1 Sep 09: Write report on circuit model and globalised scattering matrix technique. This will include an analysis of the partitioning of dipole modes in CLIC structures

1.2 Apr 10: Produce a report for the design of damping and detuning a CLIC module

Sub-task 2 – Un. of Manchester

Goal 2. Make an accurate simulation of the wake-fields and HOMS. This is expected to be broadly verified with initial experiments on CTF3 and more precisely verified with an experiment at the SLAC FACET facility and stretched wire measurements.

Milestones

2.1 Apr 10: Experiments on the measurement of HOMs on CTF3. This will enable the predicted features of HOM damping to be verified although only the broad characteristics of the modes are expected to be measurable.

2.2 Aug 10: Perform additional measurements on the wake-field at the SLAC FACET facility. This will facilitate a detailed comparison between the predicted decrement in the wake envelope and experimentally determined values. ASSET typically is accurate to better than 0.01 V/pC/mm/m.

2.3 Sept 10: Write up a report on the experimental measurement of modes.

2.4 April 11: Conduct wire measurement on CLIC cavities to verify the distribution of frequencies and kick factors

Sub-task 2 – Un. of Machester

Goal 3. Undertake beam dynamics simulations with Placet. These simulations will take into account both the long-range and short-range wake-fields. Simulations will be performed both with the baseline design and with relaxed fabrication tolerances. In addition to the standard wake-field the influence of x-y coupling of wake-fields from possible cavity distorsions will also be investigated.

Milestones

3.1 April 11: Initial result on baseline beam dynamics simulations

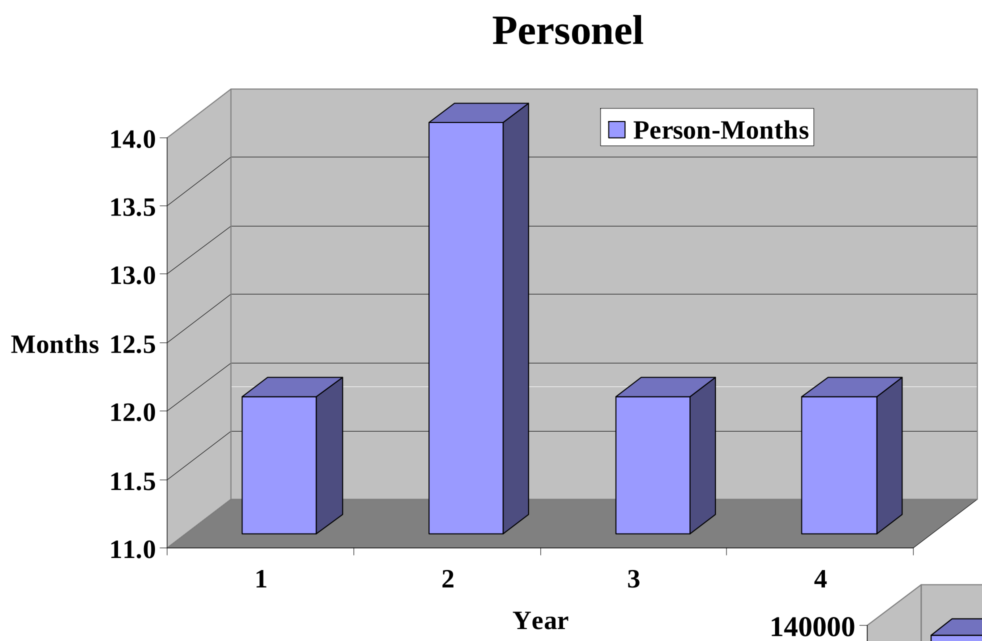
3.2 June 11: Results on beam dynamics simulations with relaxed tolerances and initial simulations on transverse mode coupling

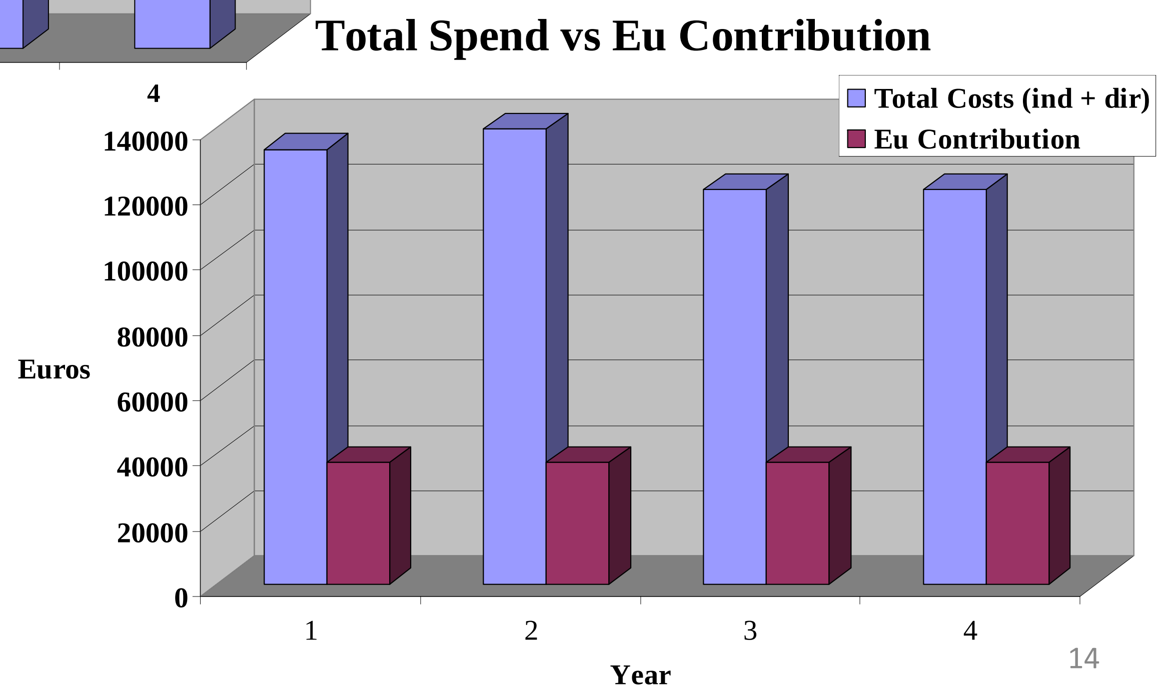
3.3 August 11: Report on beam dynamics simulations including long and short range wakefields.

3.3 Sept 11: Report on beam dynamics simulations including transverse mode coupling

Major goal: Design and measure wakefield suppression in module

Sub-task 2 – Un. of Manchester





Sub-task 3: Helsinki Un. of Physics

Breakdown simulations

2009

- Simulate effects of sparking on surface morphology √
- Generalize implementation of hybrid electrodynamics – molecular dynamics (ED-MD) code to deal with arbitrary surface geometry
- Simulate the direct field emission of atoms from flat surfaces √
- Use (quasi)static simulations of tips on surfaces to test different hypothesis for rf breakdown onset: tip energetics vs. isolated adatoms – single crystalline surfaces
- Implement Ohmic heating of tips into hybrid ED-MD code
- Dynamically simulate the emission of atom clusters from tips

2010 -2011

- Use static and quasistatic simulations of tips on surfaces to test different hypothesis for onset of rf breakdown: energetics of tip vs. isolated adatoms: tips associated with dislocations/grain boundaries
- Dynamically simulate the onset of electrical (dc and rf) breakdown: atom and cluster emission from most probable onset configurations determined in 2009-2010, including Ohmic heating effects
- Carry out DFT calculations of surfaces under high electric fields to refine the implementation of electric fields in the hybrid ED-MD model *(requires additional funding)*
- Consideration of long-time scale effects
  - Evaluate possibilities for analytical vs. different kinds of Kinetic Monte Carlo (KMC) modelling *(requires additional funding)*
  - Initiate modelling of long-time scale effects with model of choice

√ possible subjects of internal EuCARD notes

Sub-task 5: Helsinki Un. of Physics

Precise assembly

2009

- Precise assembly in beginning focus on accelerating structures (ACS) from disks
- Assembly and brazing test with symmetrical disk structure (CLIC-G) √
- FEM-modelling of residual stresses in manufacturing to get information about the mechanical behaviour of manufactured disks and ACS assembly √
- Developing and studying assembly methods for accelerating structures of disks
- Assembly test of high precision alignment method (ACS quadrants, useful for PETS) √

2010-2011

- Study of using machine vision in component alignment in assembly to achieve micrometer level accuracy
- Design and assembling a full structure in collaboration with CERN
- Studying manufacturability of high precision parts
- Studying and designing precision assembly for accelerating structure and PETS
- FEM-modelling mechanical behaviour of the accelerator components taking into account mechanical loads
- Studying the implications of large scale manufacturing and assembly, such as automation of assembly *(requires additional funding)*

√ possible subjects of internal EuCARD notes

University of Helsinki – personnel

- PhD K. Österberg (~ 15 %) – scientific contact, high precision assembly sub-task leader
- Prof. K. Nordlund (~ 10 %) – 2. scientific contact, breakdown simulation sub-task co-leader (sub-task 3)
- PhD F. Djurabekova (~ 70 %) – breakdown simulation sub-task co-leader, onset mechanism simulation (sub-task 3)
- MSc A. Pohjonen (2009: ~ 75 %, 2010–: 100 %) – breakdown simulation (sub-task 3)
- MSc J. Huopana (~ 50 %) – different aspects high precision assembly (sub-task 5)

	Year #1	Year #2	Year #3	Year #4	Total
Sub-tasks 3 and 5					
Person.months	26.5	28.5	28.5	28.5	112
Total cost [kEUR]	187	205	212	220	824

Total: 112 personmonths, budget: 824,3 k€, EU funding: 249 k€

Sub-task 4 – Uppsala University

Design and build equipment to diagnose the electrons, ions and light emanating from the breakdown event both in the CTF3 Two-Beam Test-Stand at CERN and inside a scanning electron microscope in UU to analyze the surface science relevant to RF-breakdown

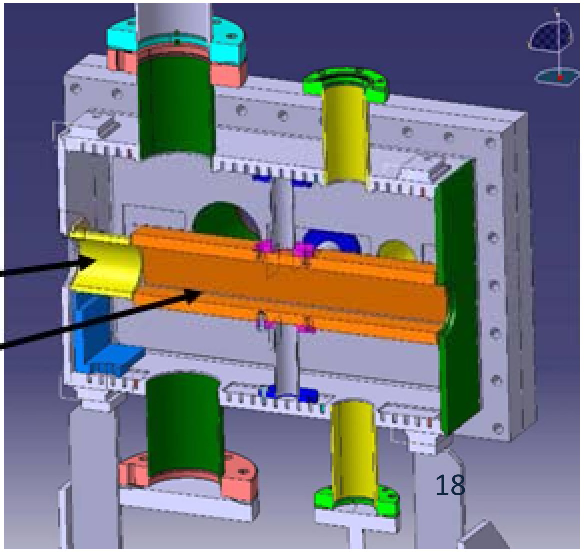
List of deliverables and preliminary schedule:

- Diagnostics for dark current and ion measurements - 12/2009
- Identify need for improved diagnostics - 2009-2010
- Install and commission improved diagnostics - 2011
- Surface analysis of breakdown sites with SEM, AFM, EDX 2009-2012
- DC-breakdown analyzer (flash box) with nano-stage under SEM - 2010

DIAGNOSTICS FLASHBOX

pick-up coil

4 electrodes
(electron - ion separation)



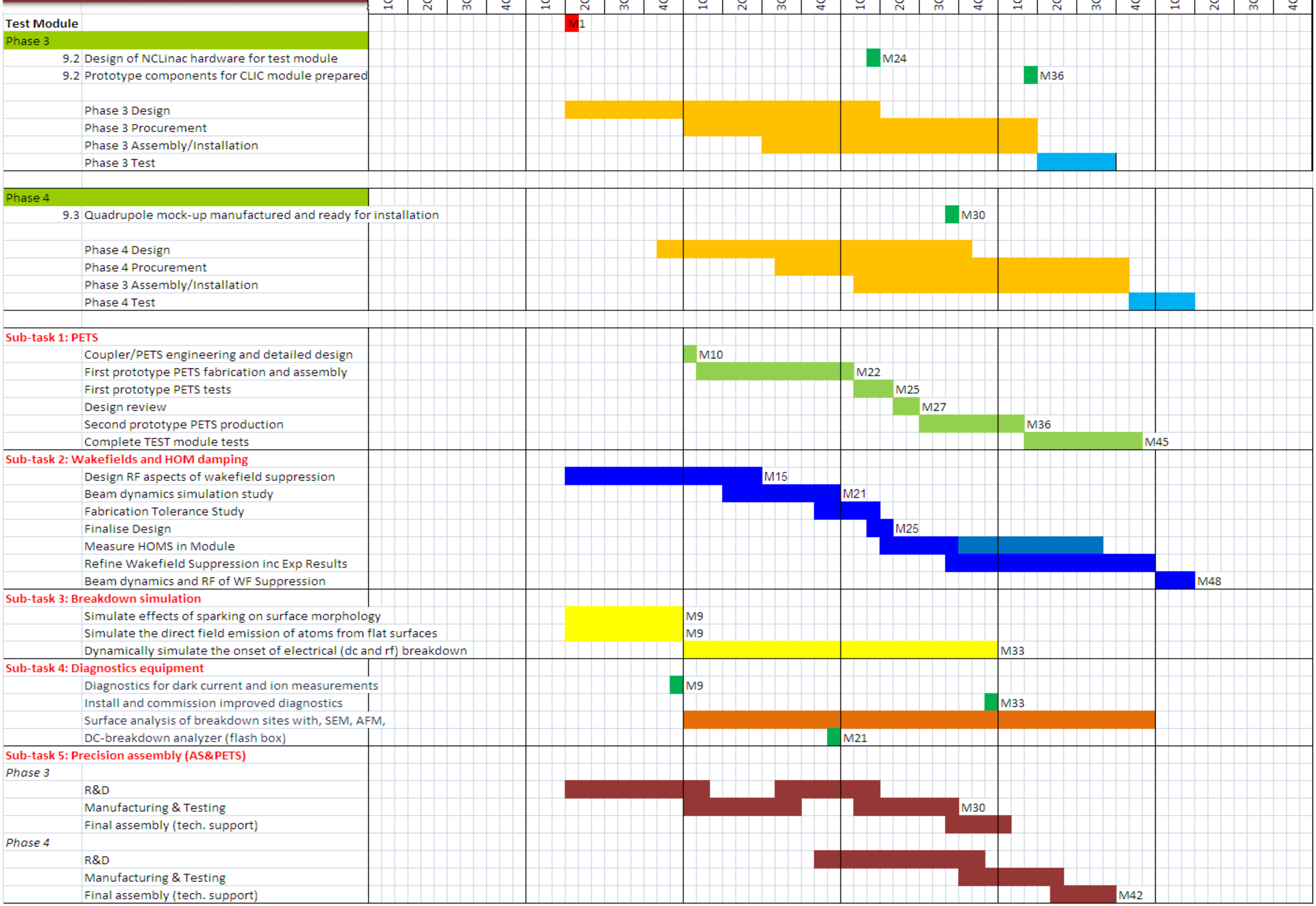
Sub-task 4 – Uppsala University

	Source	percentage	2009	2010	2011	2012	2013	SUM/UU	SUM/FP7	
			9 month	12 month	12 month	12 month	3 month			
Volker Ziemann	UU	0.20	16.2	21.6	21.6	21.6	5.4	86.4		
Roger Ruber	UU	0.80	54	72				126		
Andrea Palaia	UU	0.80	36	40	40	40	10	166		378.4
Hardware	UU		60	50	29.7			139.7		
PostDoc	FP7	1.00	40	80	40				160	
Hardware	FP7		30	30.3					60.3	
Sum/UU			166.2	183.6	91.3	61.6	15.4	518.1		
Sum/FP7			70	110.3	40	0	0		220.3	
per year			236.2	293.9	131.3	61.6	15.4			
Grand Total										
									738.4	
Volker Ziemann	108kE/year		9.6							
Roger Ruber	90kE/year		16.8							
Andrea Palaia	60kE/year		38.4							
PostDoc	80kE/year		24							
				88.8						

Summary – spending profile (proposal)

	Year #1	Year #2	Year #3	Year #4	Total
Sub-task 1					
Person.months	8	8	8	8	32
Total cost [kEUR]	30	130	119	100	379
Sub-task 2					
Person.months	133	139	121	121	514
Total cost [kEUR]	12	14	12	12	50
Sub-tasks 3 and 5					
Person.months	26.5	28.5	28.5	28.5	112
Total cost [kEUR]	187	205	212	220	824
Sub-task 4					
Person.months	22	22	12	12	68
Total cost [kEUR]	304.6	250.6	121.6	61.6	738.4
Total cost (direct + indirect)					

Summary – Gantt chart (proposal)



Conclusions

- Tasks: overall goals defined but details still under definition
- Milestones and spending profile to be confirmed
- Integration in test modules needs careful coordination