Budget & Schedule management for HL-LHC

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INFN- CNPM – 23rd March 2022

Outline

What is HiLumi

How is HiLumi managed

Cost management

Schedule management

Conclusion

Filigrane

In a monster lab

- How we manage a 1 billion, 12 years project?
- Line management and Project management: conflict or collaboration?
- Project management processes: a hassle or an opportunity?
- Can we say something new in PM?

What is HiLumi

LHC TODAY

Peak luminosity L_{peak} = **2×10^{34} cm^{-2}s^{-1}**

Integrated luminosity in 10 years **300-350 fb^{-1}**

HL-LHC

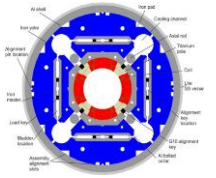
LHC TOMORROW

Ultimate peak luminosity **7.5×10^{34} cm^{-2}s^{-1}**

Integrated luminosity in 12 years **L_{int} = 4000 fb^{-1}**

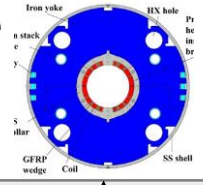
Inner triplet Nb_3Sn focusing **Q**uadrupoles

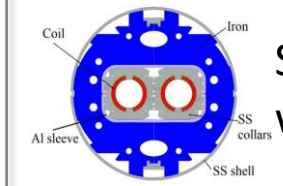
Q1/Q3, Q2



Recombination dipole

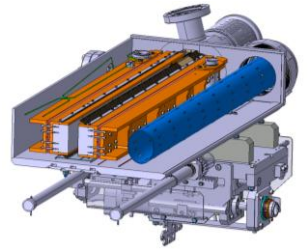
D1

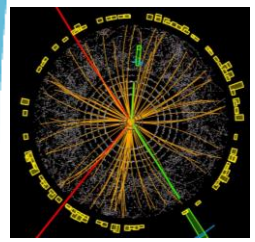


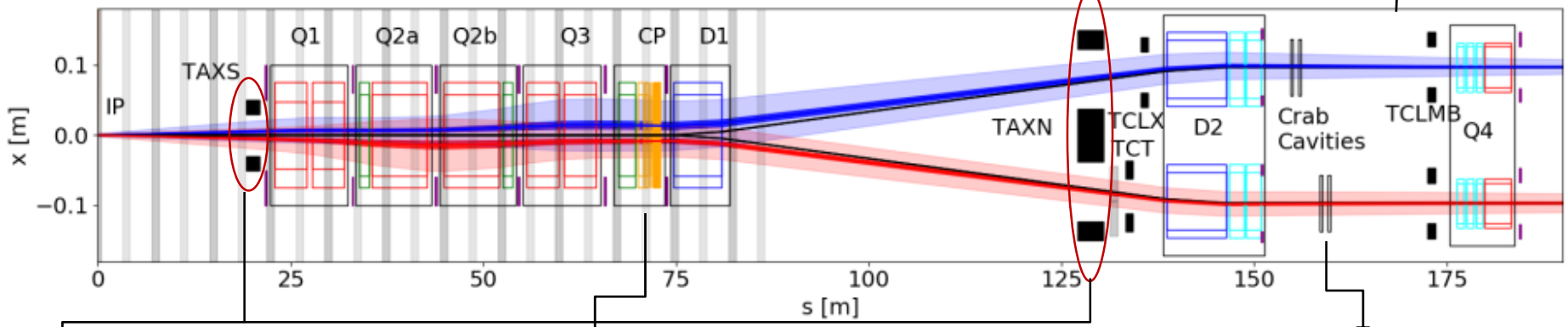


Separation dipole with correctors

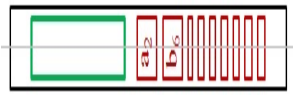
Collimators



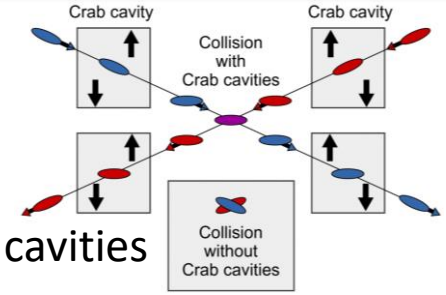




TAXN, TAXS target absorbers



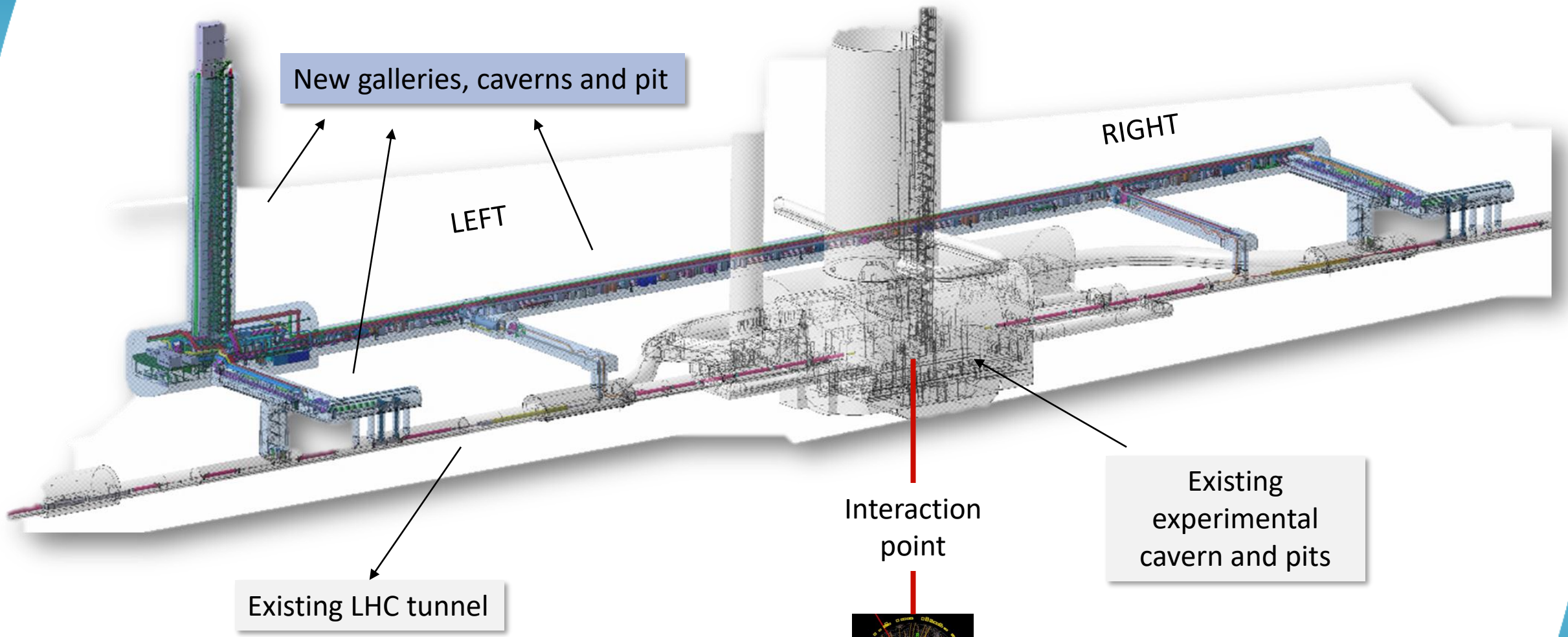
Corrector package (orbit and multipole)

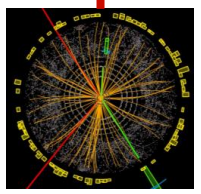


crab cavities

Interaction region HL layout

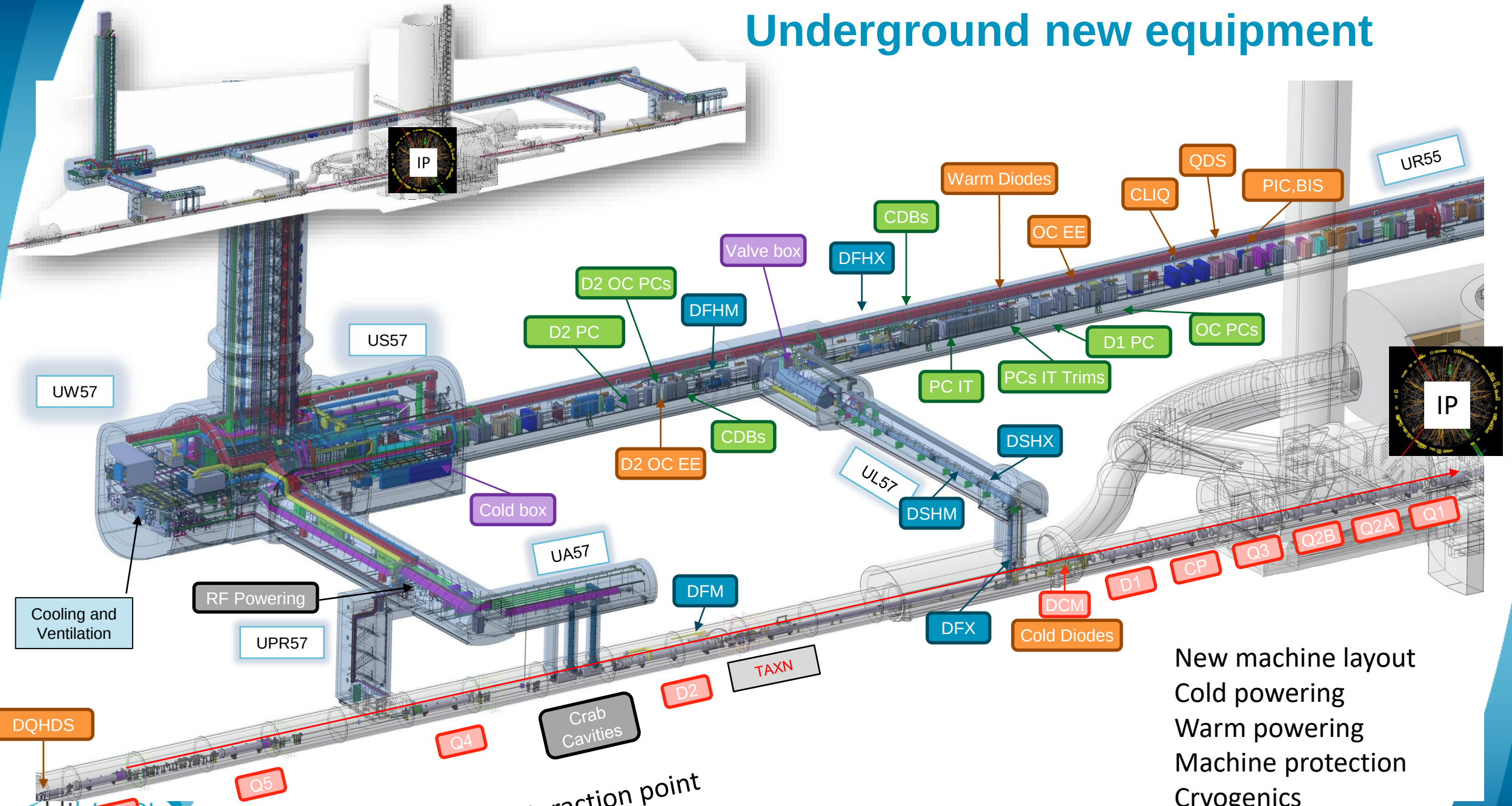
Underground civil engineering





What

Underground new equipment



New machine layout
Cold powering
Warm powering
Machine protection
Cryogenics
Infrastructures

6

Cutting-edge technology

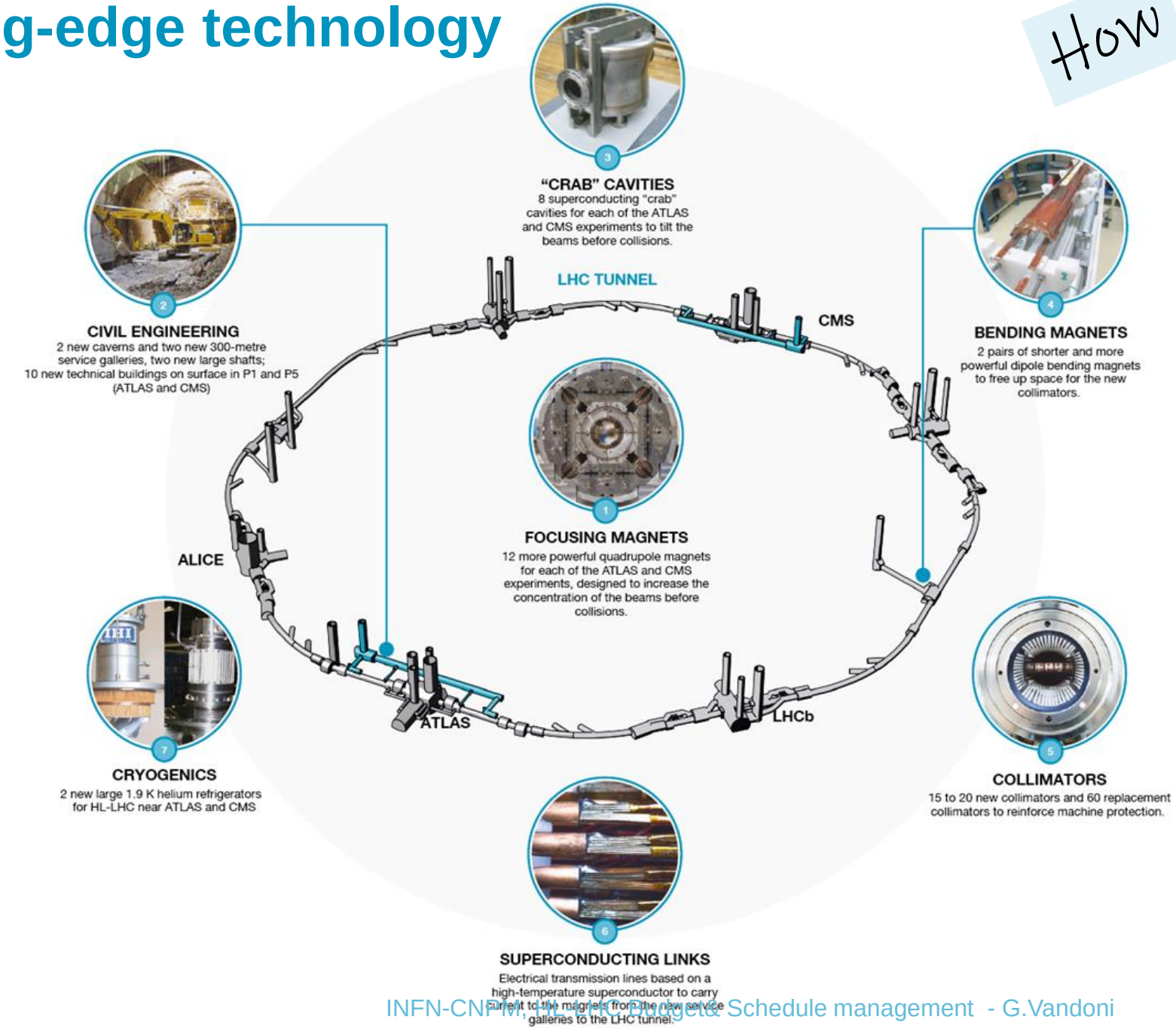
How

New triplets Nb_3Sn required due to:
-Radiation damage
-Need for more aperture

Superconducting Crab Cavities
Fully Remote Alignment System in MS

For collimation, change the dispersion suppression in the continuous cryostat in IR7: 11Tesla Nb_3Sn dipole

Superconducting link in MgB_2 and HTS

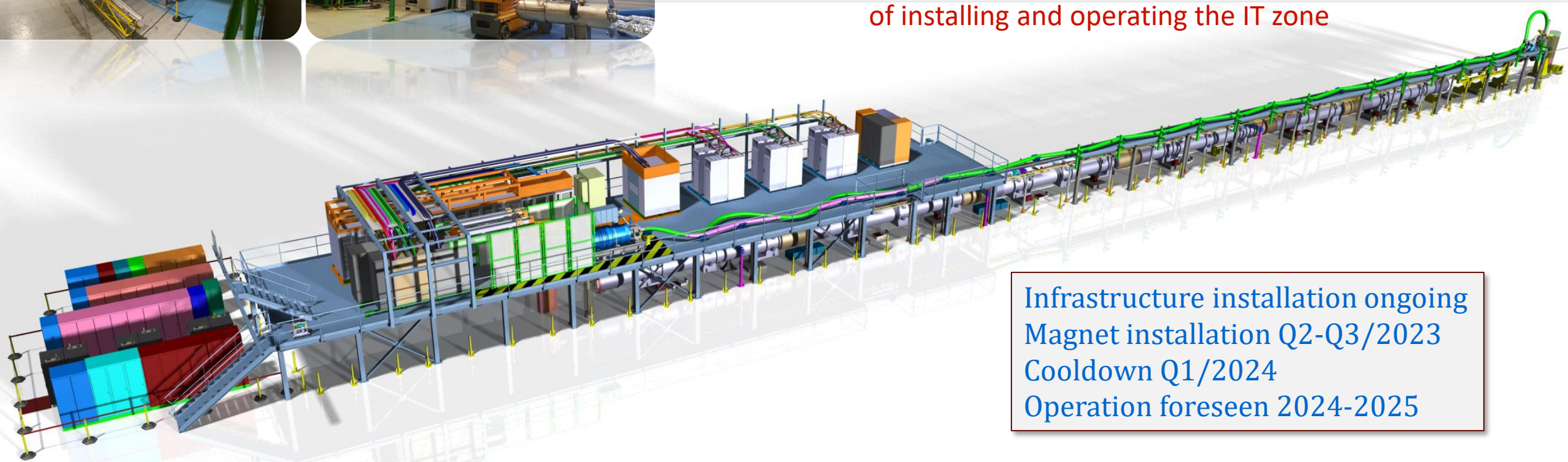


- More than 1.2 km of LHC
- Challenging new technologies
- Civil engineering & technical infrastructure

The Inner Triplet String

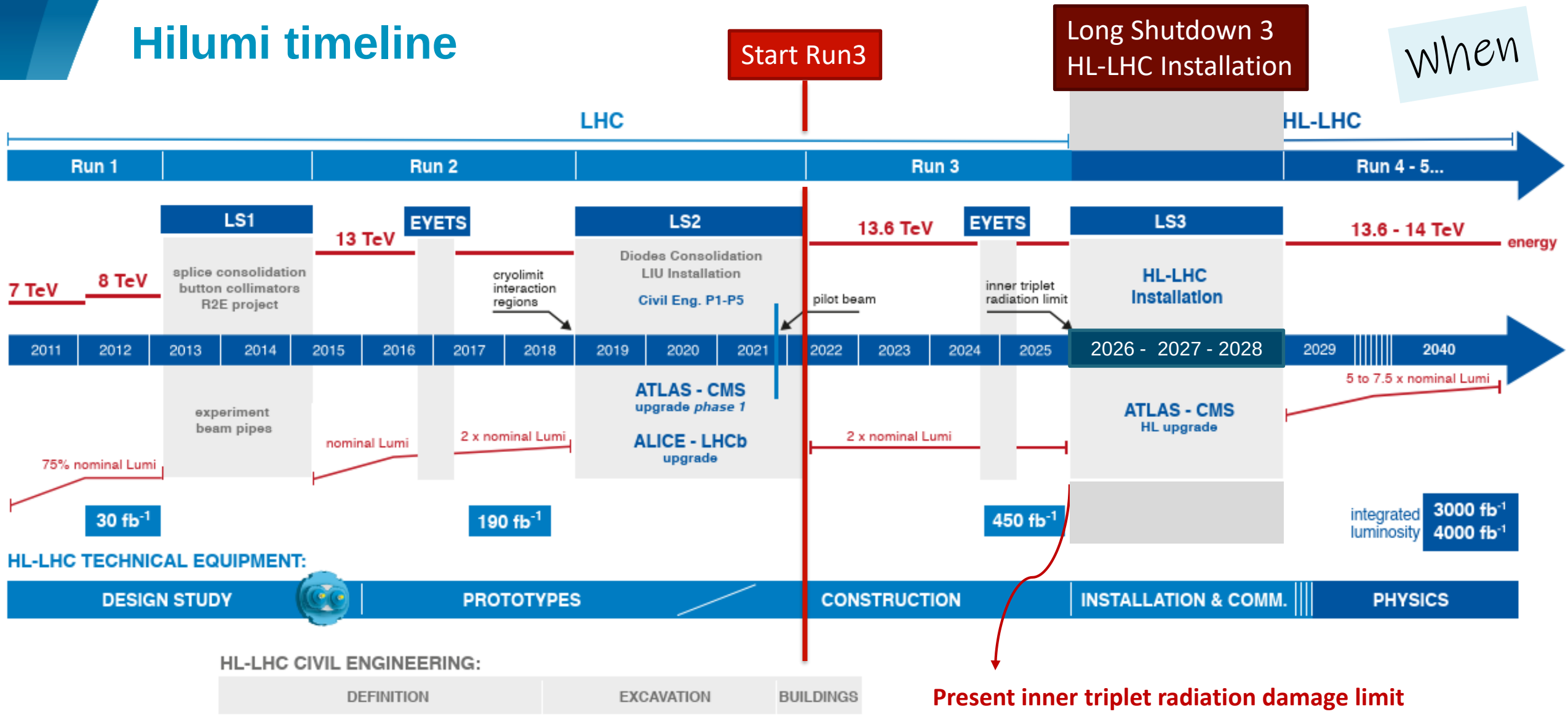
Scope of the WP16 IT STRING is to represent all operation modes to **STUDY and VALIDATE the COLLECTIVE BEHAVIOUR** of the different systems of the HL-LHC's IT zone (magnets, magnet protection, cryogenics for the magnets and the superconducting link, magnet powering, vacuum, alignment, interconnections between magnets, and the superconducting link itself).

The IT **STRING** will deliver **the first complete experience** of installing and operating the IT zone



Infrastructure installation ongoing
Magnet installation Q2-Q3/2023
Cooldown Q1/2024
Operation foreseen 2024-2025

Hilumi timeline



The Long Shutdown 3 was already shifted twice, each time by 1 year. Now reached hard limit

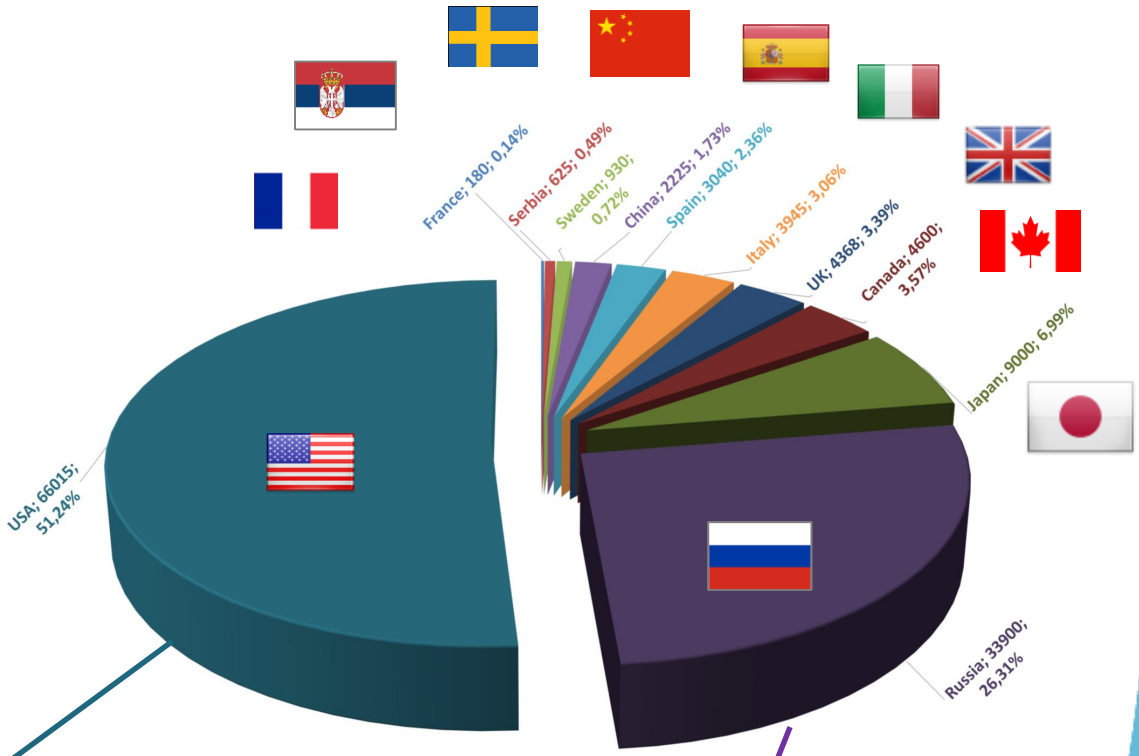
Global Budget Figures

The last Cost & Schedule Review endorsed an increase of 14.2 MCHF

HL-LHC Budget at Completion [M CHF]	**1087.9**
CERN funded	953.0
External collaborations “in-kind”	134.9

+14.2

In-kind per country, kCHF, %



Nb_3Sn Quadrupoles
RFD crab cavities

Solid state RF Power amplifiers
RF power transmission
BPMs
Dilution kickers & new dumps
Collimators
…

Evolution of Budget At Completion, from 2016 to today

CSR2016

Cost increase in CE balanced by descoping:

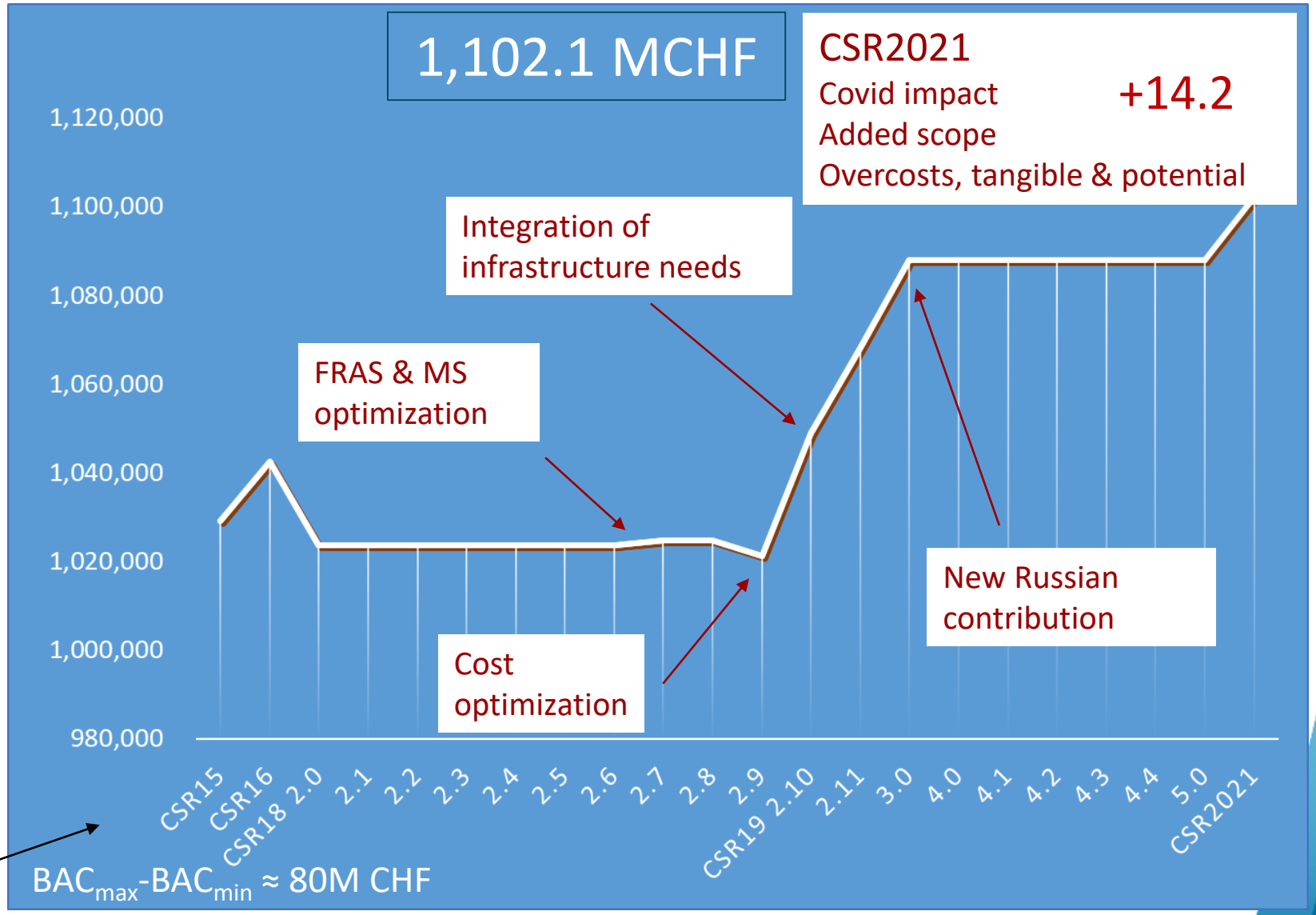
Q4, crabs, SC link length, TColl, 11T…

CSR2018

No further descoping possible

CSR2019

Implementation of additional budget + cost optimization + new Russian contribution: Hollow e-lens, Crystal Collimation, additional dilution kickers, new beam dumps…

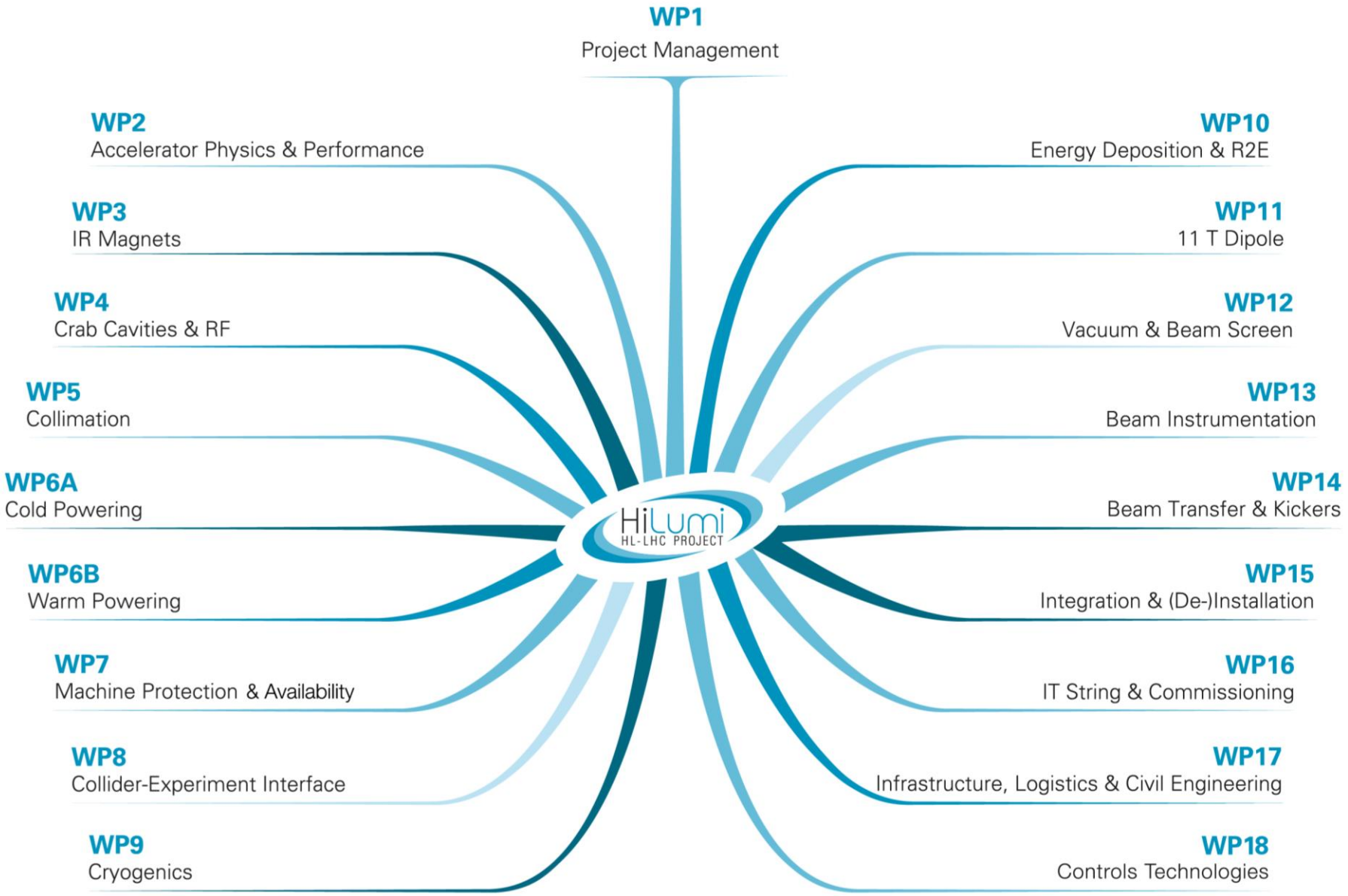


HiLumi WorkBreakdownStructure

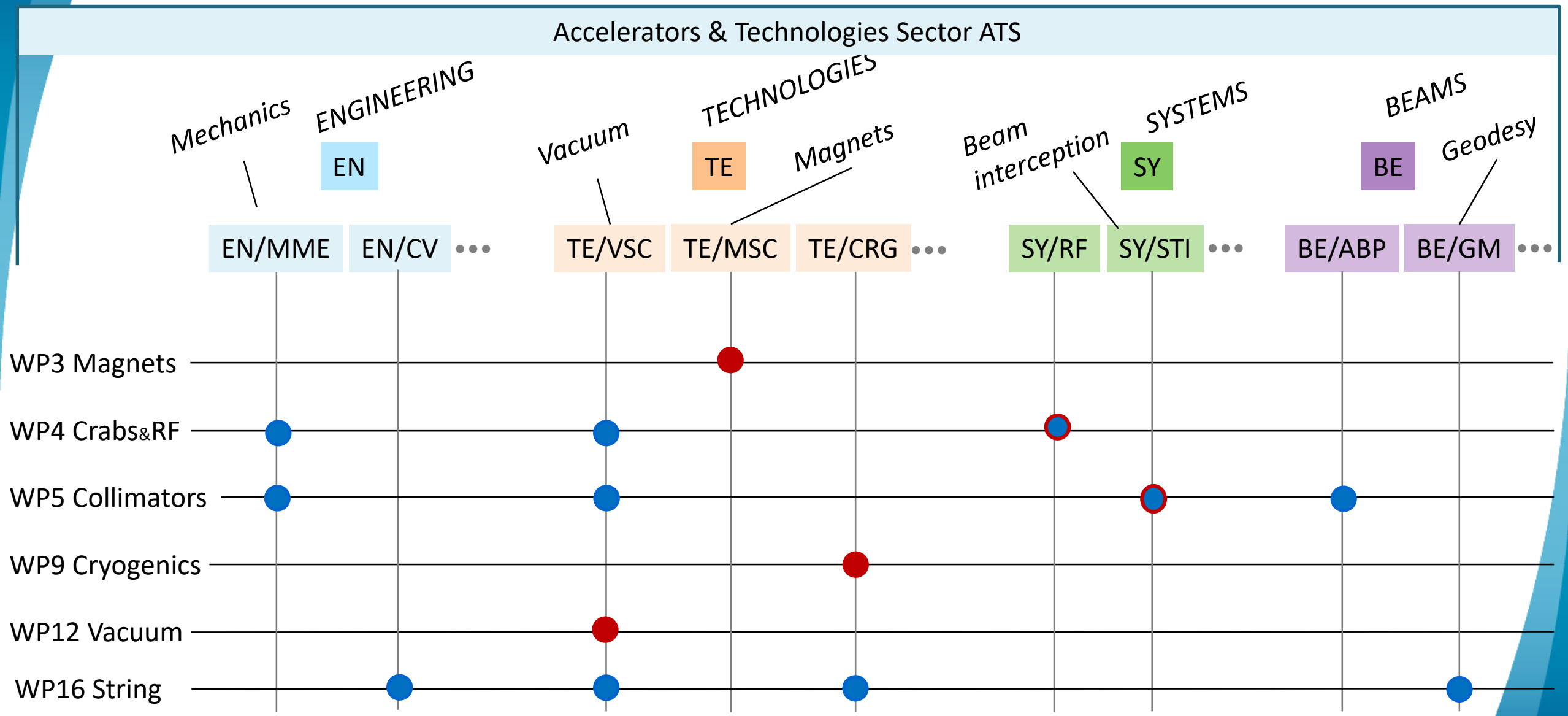
19 work-packages or subprojects

Strong **delegation of PM** to WPs

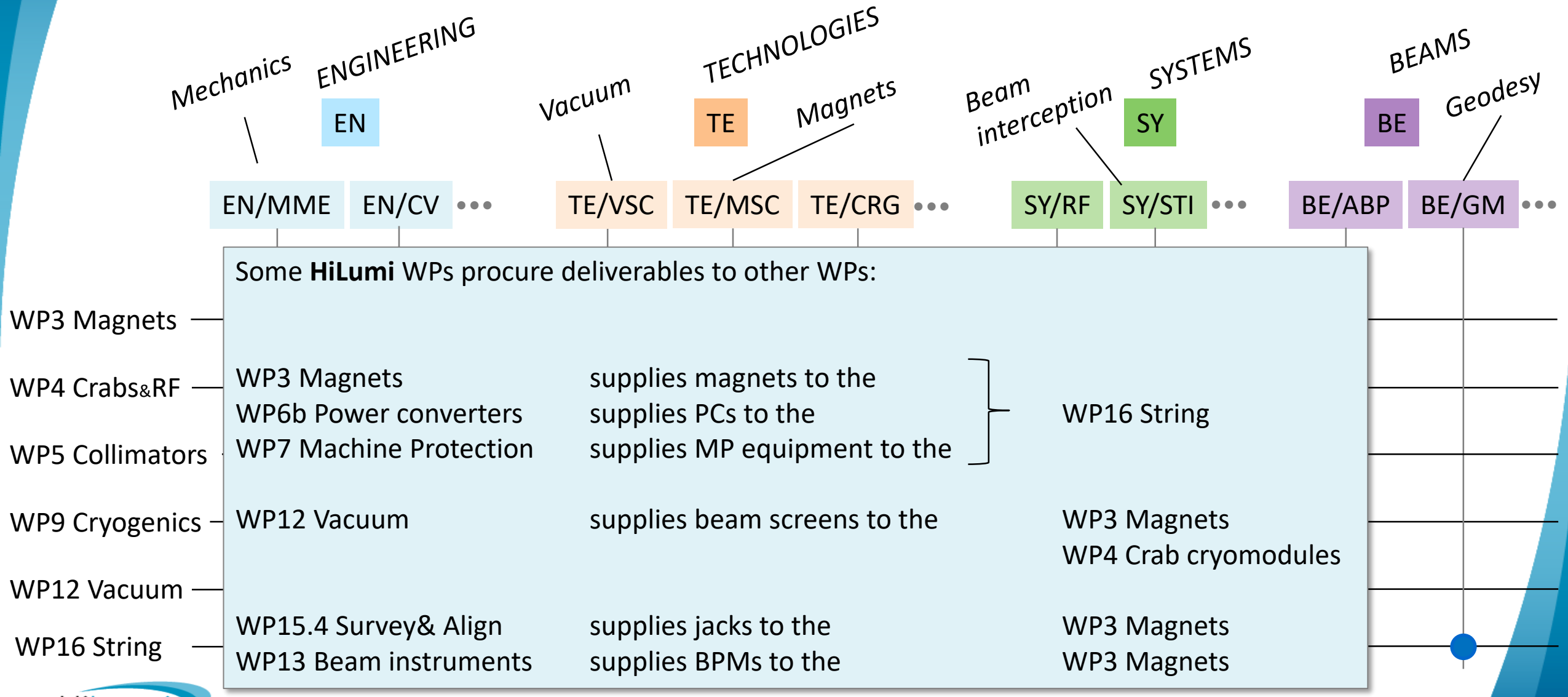
In principle, **NO MATCH** with CERN line organic structure

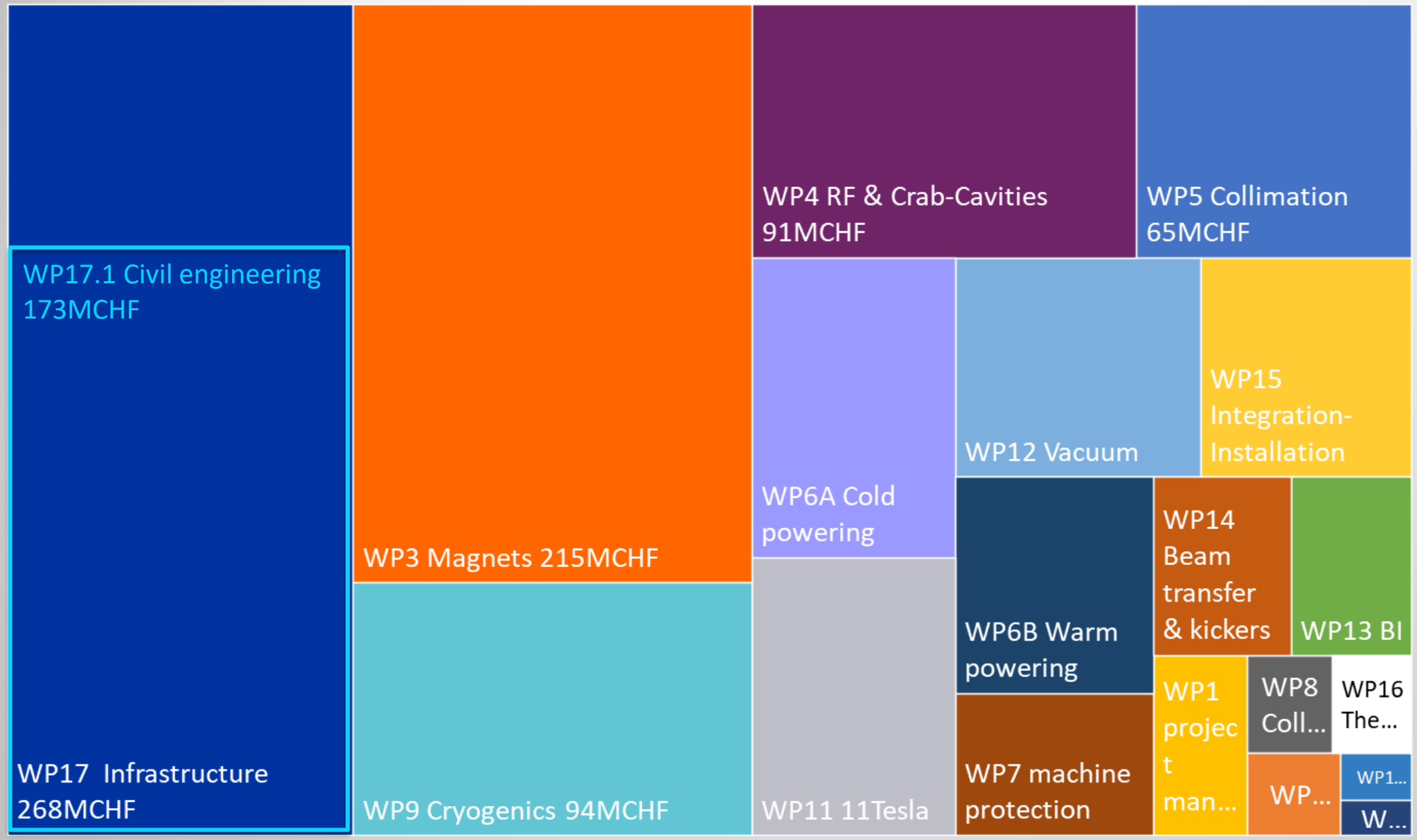


Work-packages and organic structure - examples



INPUT and OUTPUT deliverables amongst WPs

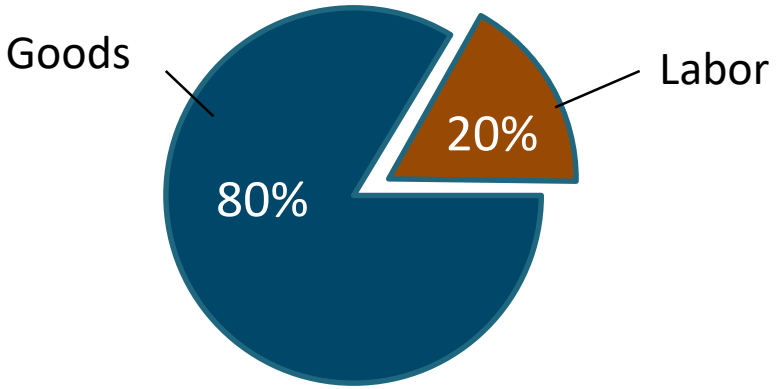




Work-packages cost breakdown

Included/ Excluded

Goods	**Included**
Labor: industrial service, students, consultants, associated	**Included**
CERN Staff	**Excluded**
Contingency for risk	**Excluded**



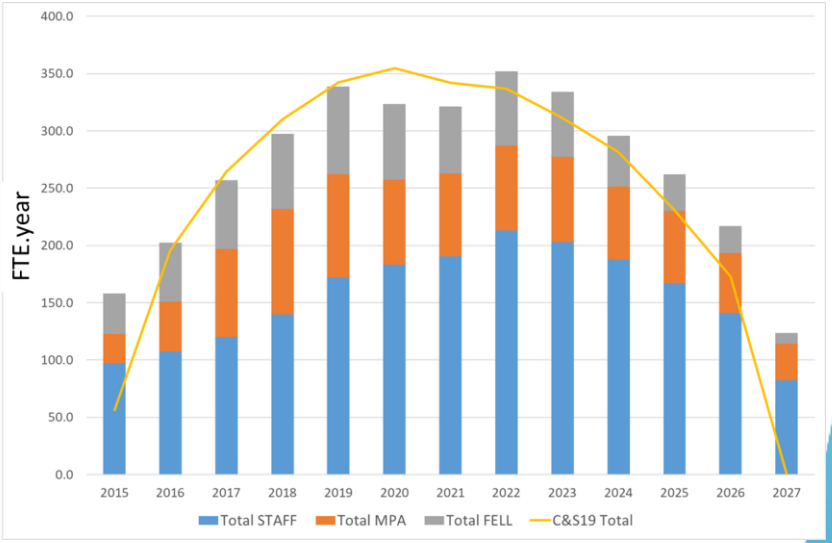
Departments control CERN staff figures
The project controls budget associated with Labor

Tension between manpower needs of departments and budget requests to project

Line vs Project management

PERSONPOWER

	[FTE · year]
CERN Staff	2,073
Labour	1,407



CERN Staff
Fellows
Associated personnel

Contingency for risk: excluded

HL Project owns the internally constructed contingency
Management **delegates strong control** to the project

PMI-type project

Risk catalogue

Initial studies Prior projects Vendors' quotes

Known risk budget

Estimate uncertainty

Base cost estimate

Initially **zero**, the reserve "lives" by descoping initially included options and recuperating savings

Total Estimated Project Cost at completion

HiLumi HL-LHC PROJECT

Missing scope
Risk mitigation
Overcost

Buffering reserve

Descoping Saving

Intrinsic estimate contingency*

Base cost estimate

Progressive rigidity, as scope gets more and more refined

*Uncertainties inherent to estimating process

Adverse event = risk becoming reality
Their impact cannot be absorbed by the budget →resort to managerial reserve

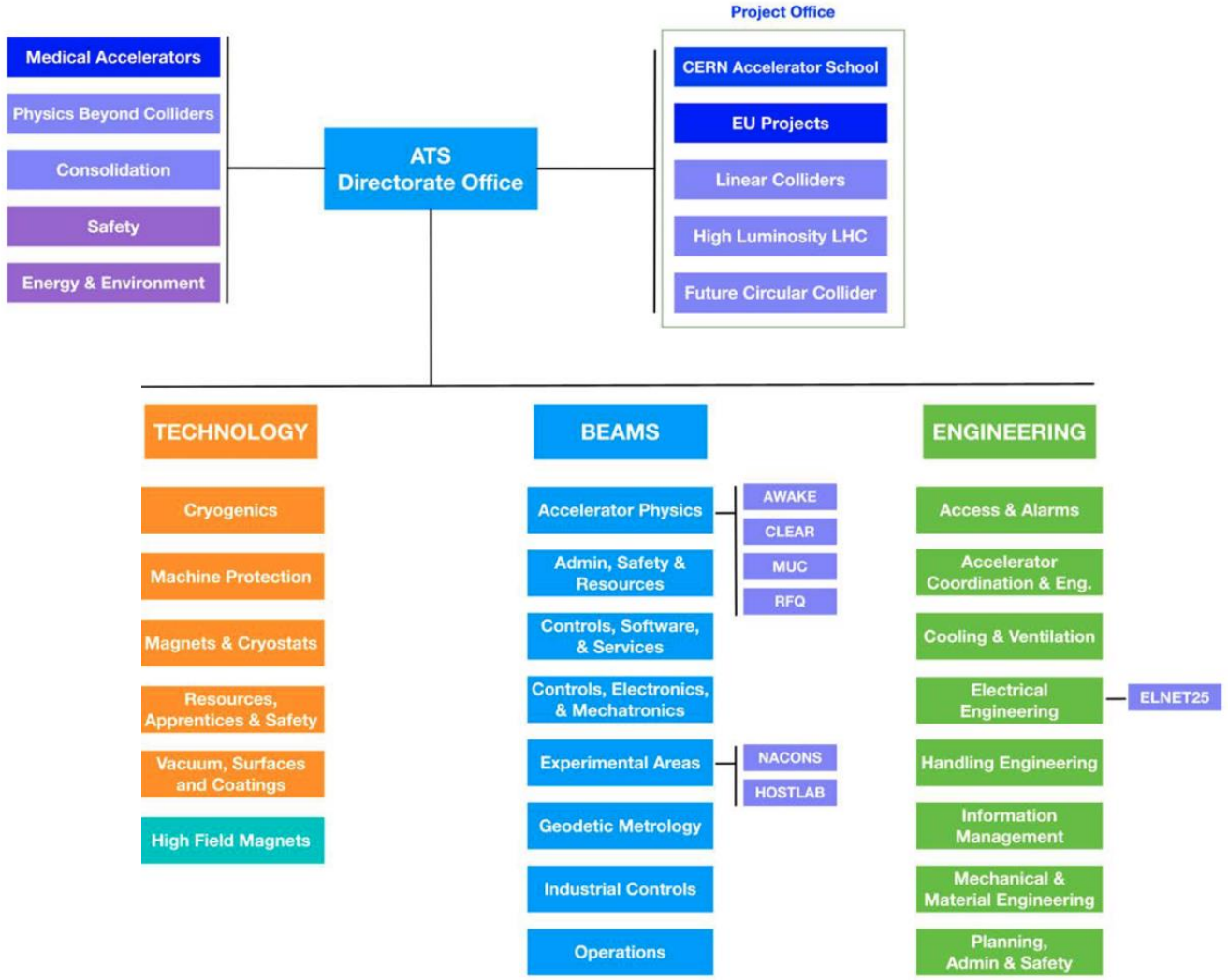
How is all this managed

2021 Restructuration

Accelerators & Technology Sector

<2021

ATS



Line vs Project management

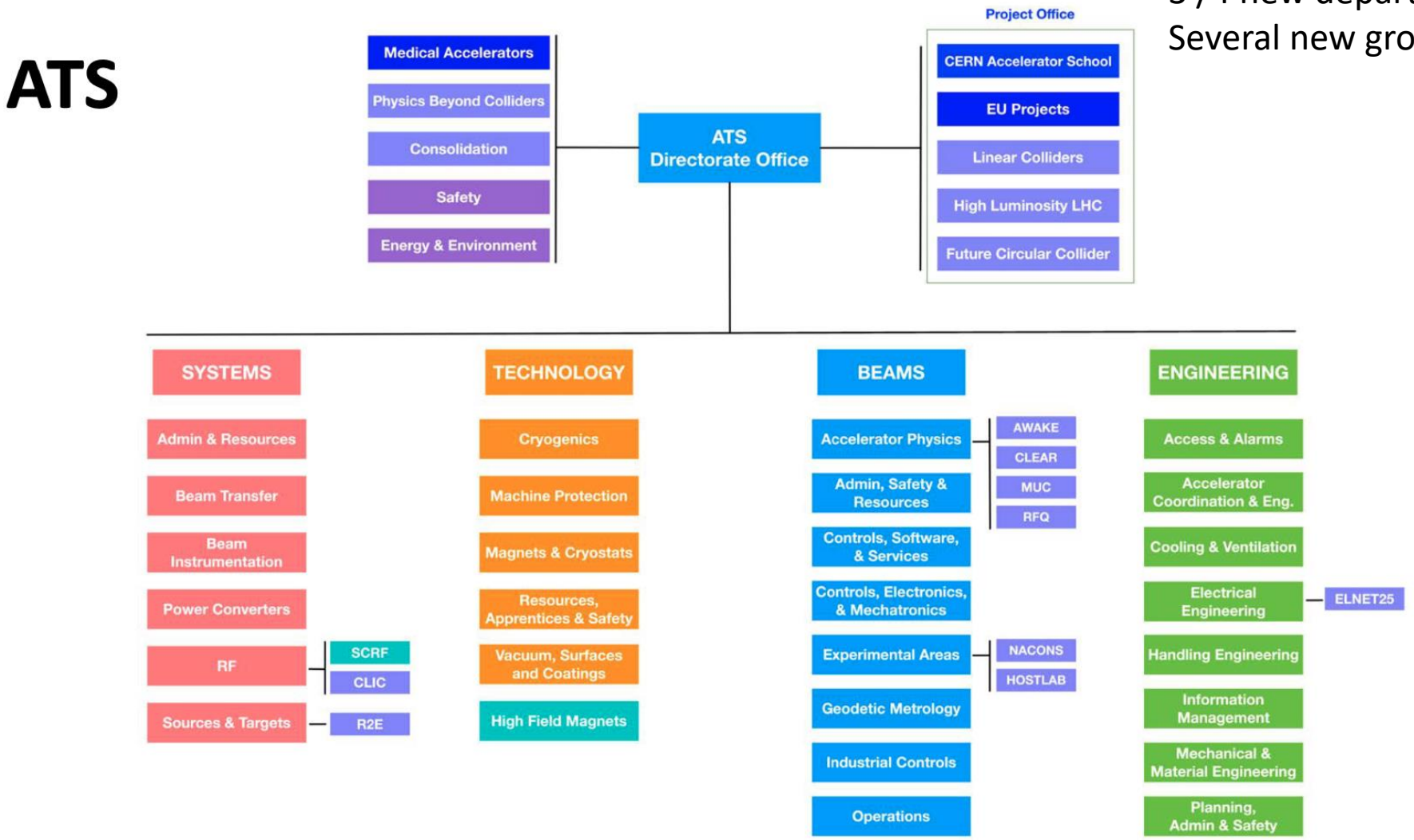
2021 Restructuration

Accelerators & Technology Sector

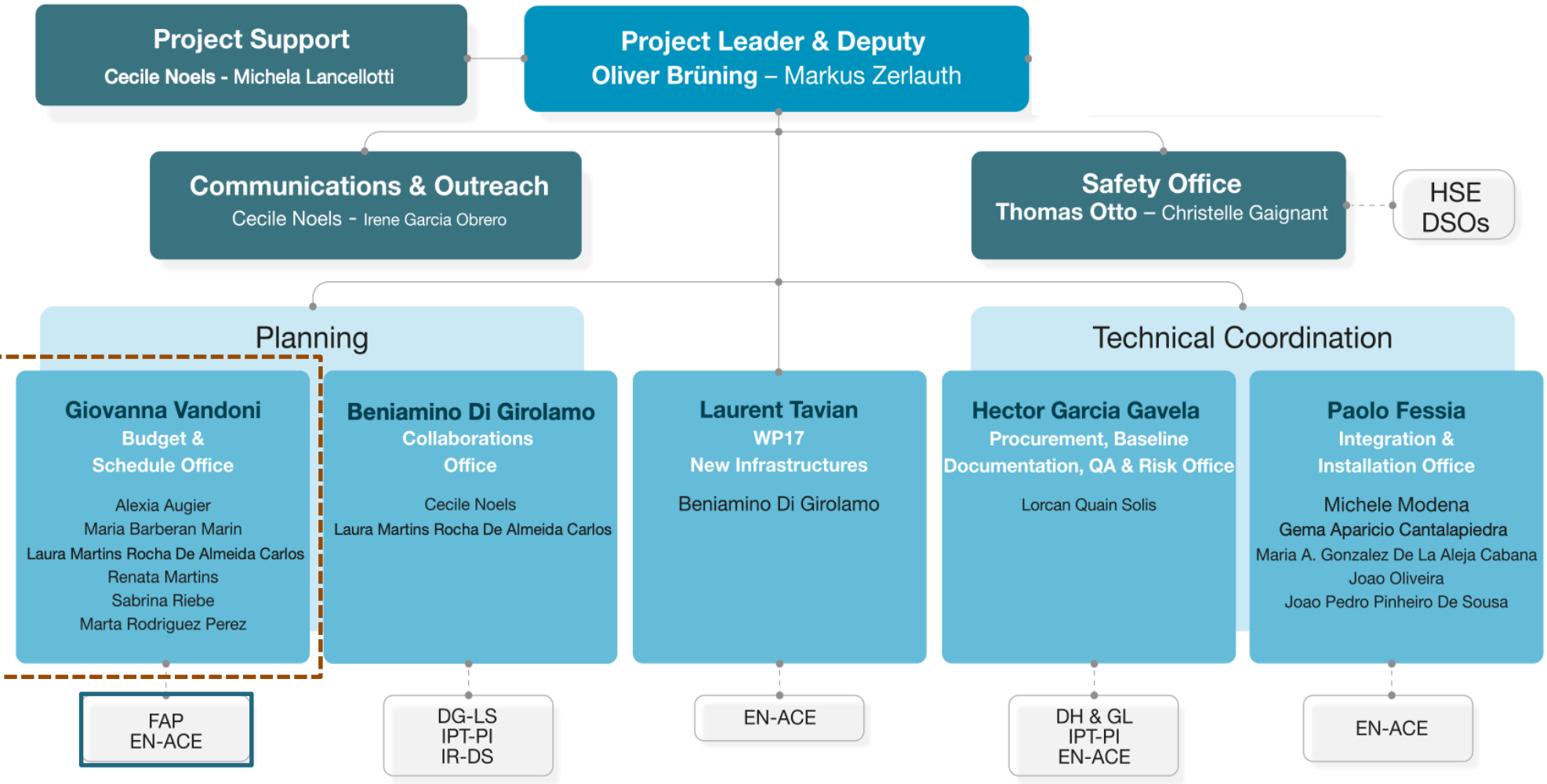
New management
Creation of new department
3 /4 new department leaders
Several new groups

HL Project management

New Project leader
New Project Office structure
Several newcomers in PO



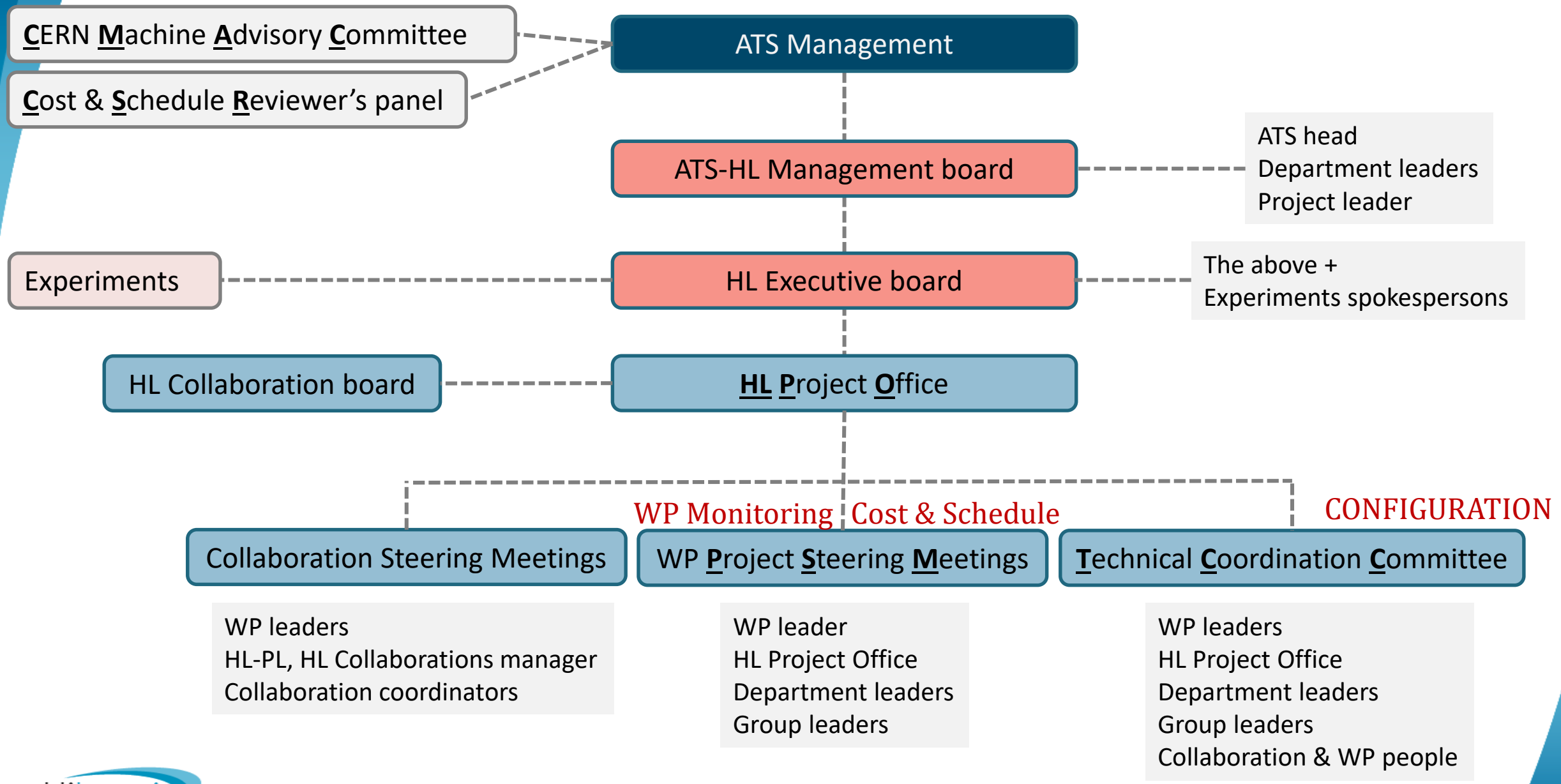
HL-LHC Project Office



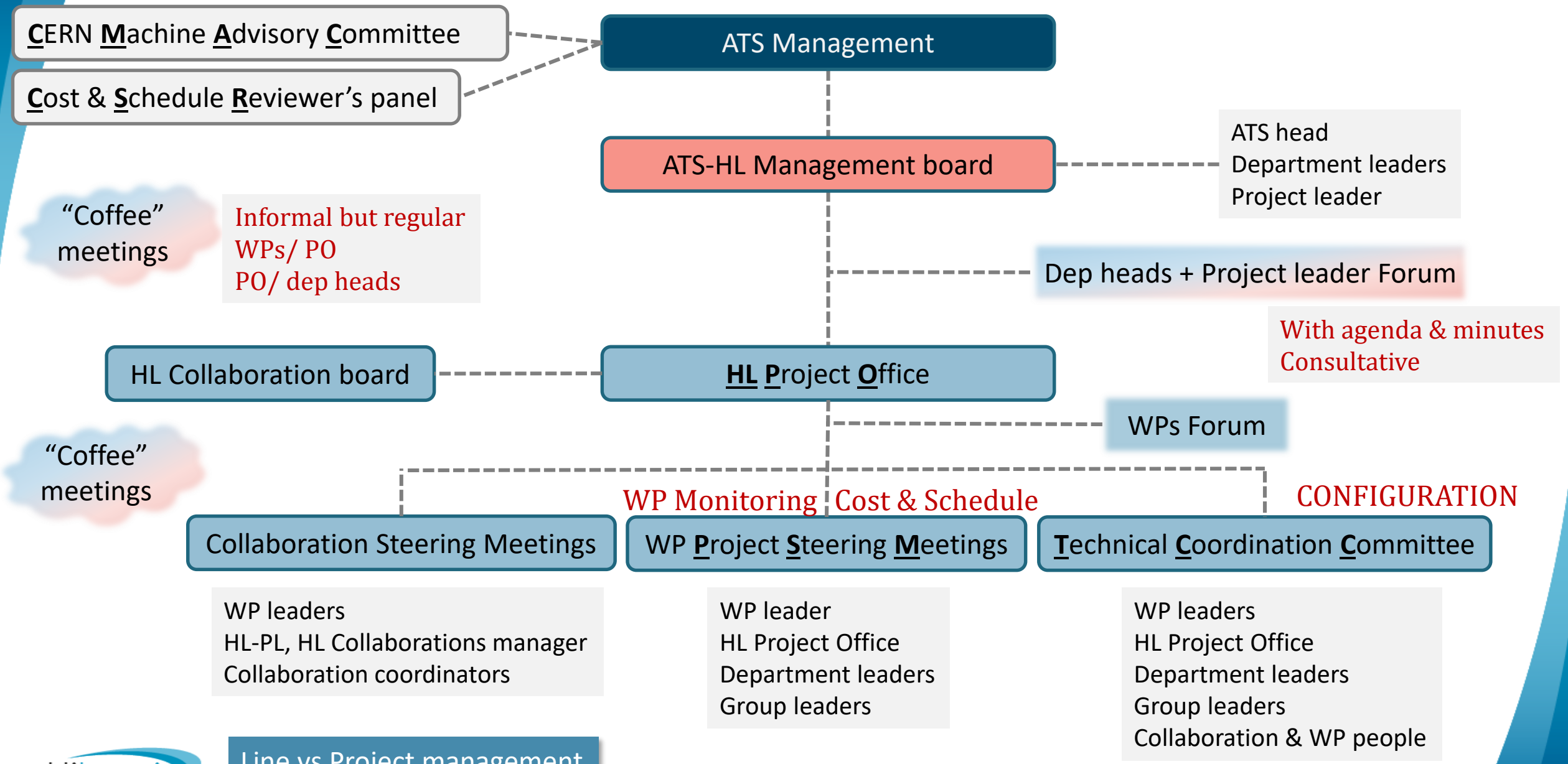
5 FTE
2 full time staff
Temporary labor
Support from
- Coord. team
- Finance

External support

Committees & Forums



Committees & Forums



Cost management

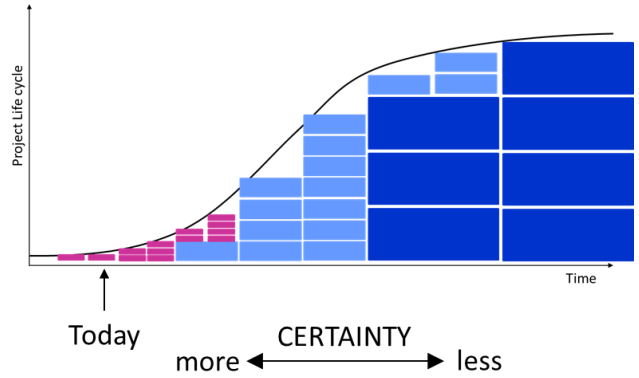
Budget planning

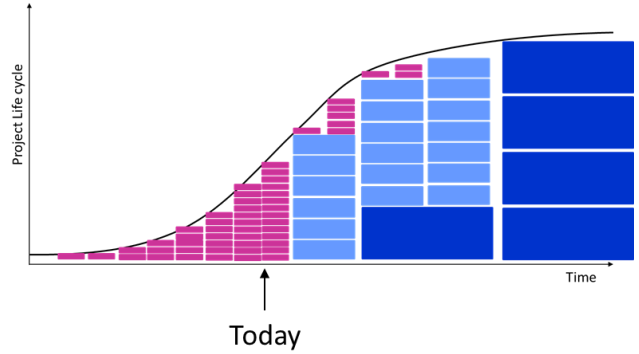
Basis of estimate
Market trends
Previous experience

Scheduling of activities

This is where our action is situated today

EVM construction of Planned Value
Rolling wave planning
Daily management of
- Rolling to Normal workunit
- Monitoring
- Control
- Budget change processes





Which were the basis of estimate?

Budget management tools:
A hassle or an opportunity?

How to draw a “lessons learned” register?

Earned Value Management for HL-LHC

Budget planning, monitoring & control

Budget Planning Monitoring

Activity Planning Tool - EVM

Interfaced with

In-house developed Business computing application

Purchasing documents

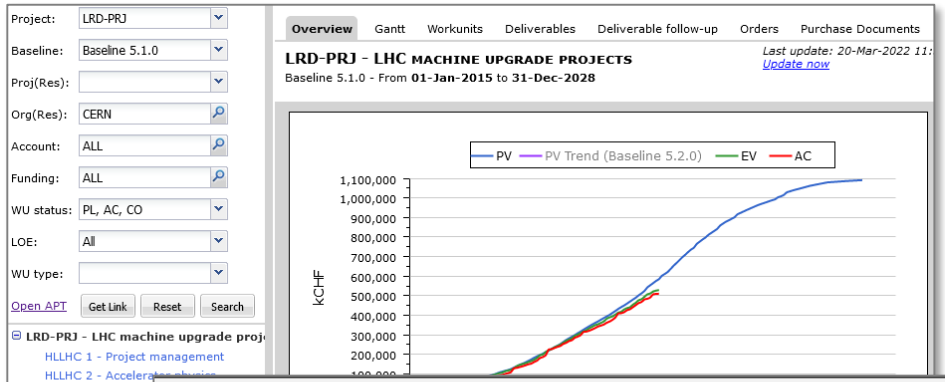
Electronic Document Handling

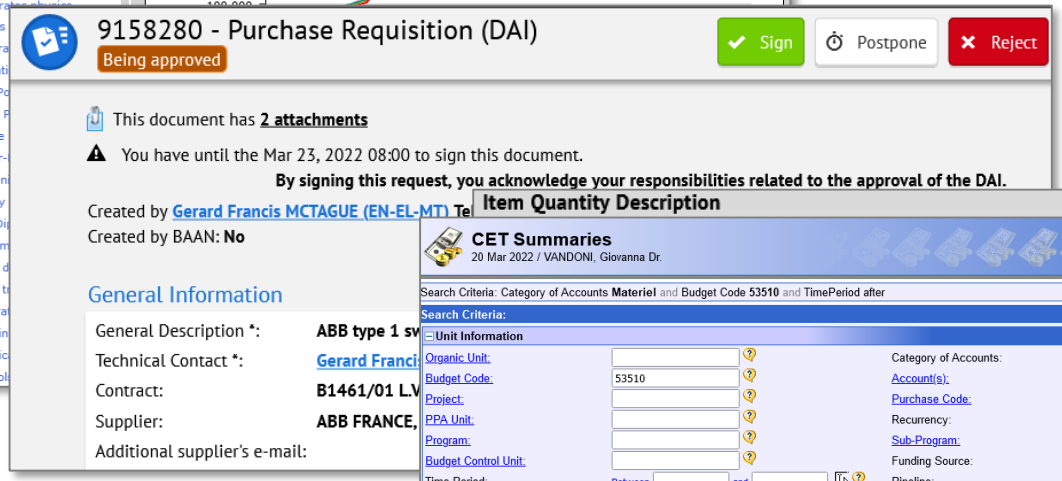
Accounting

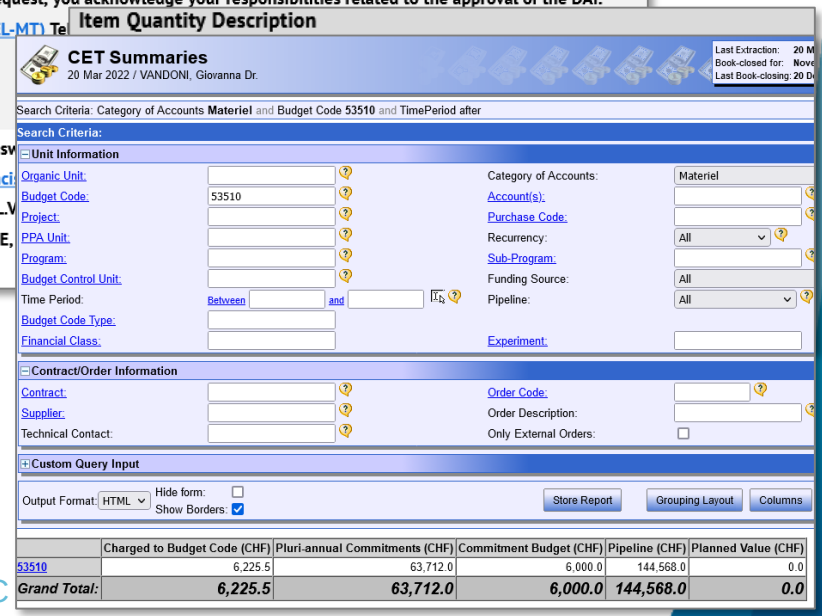
CERN Expenditure Tracking

EVM is also used for **Financial Planning**

Cash Flow planning







(PV) planned value

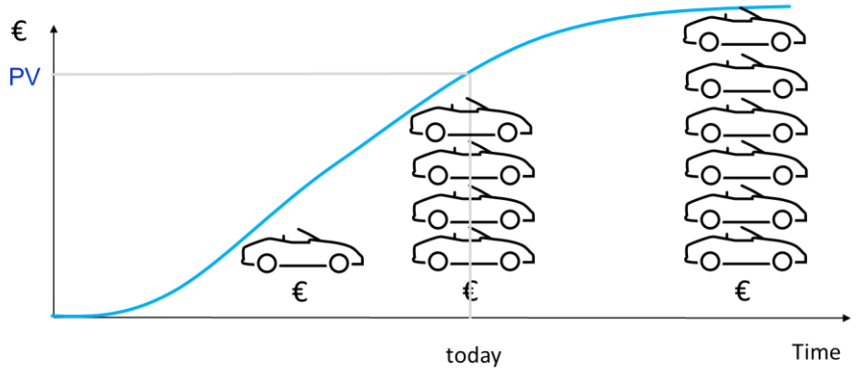
Approved budget for work scheduled to be completed at a specif date

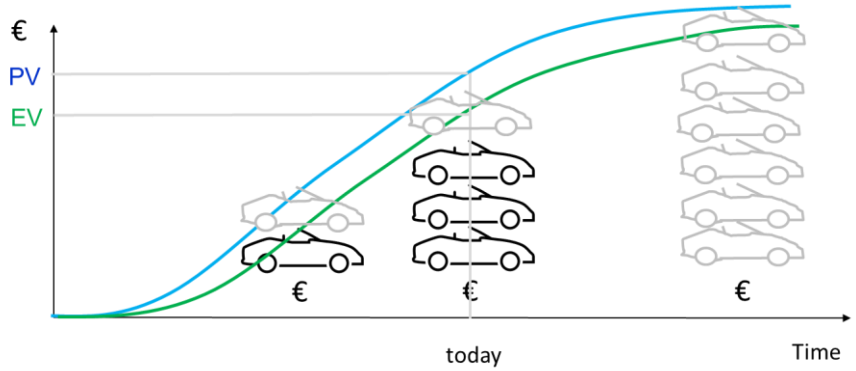
(EV) Earned value

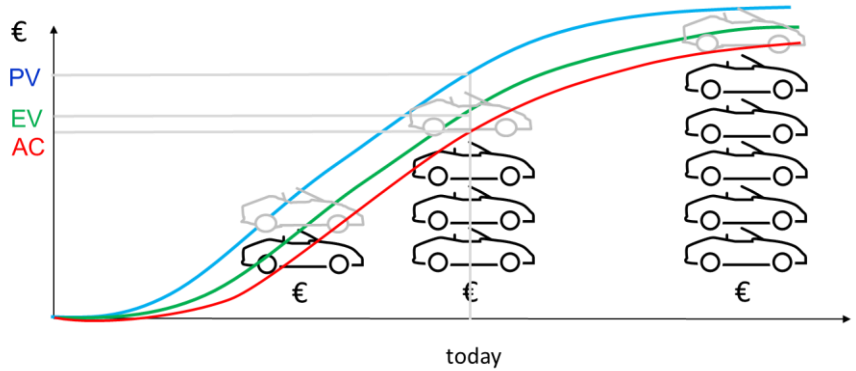
Based on the technical progress report made on the deliverables *("deliverable oriented")*

(AC) Actual Cost

Computed from the financial system (CERN CET) every day based on Charged on Budget Codes







Planned Value

Work planned to be completed to date (in units of cost estimated to complete it)

Earned Value

Work actually completed to date (in units of cost estimated to complete it)

Actual Cost

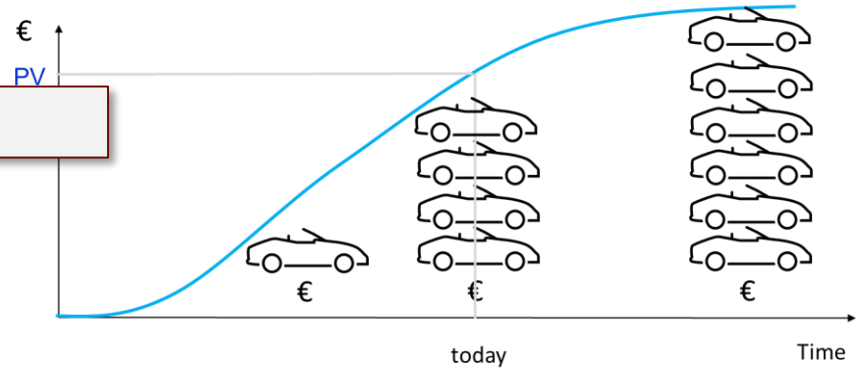
Real **cost** of work performed as of today

EVM @ CERN

(PV) planned value

Budget & work Planning methodology

scheduled to be completed at a specif date

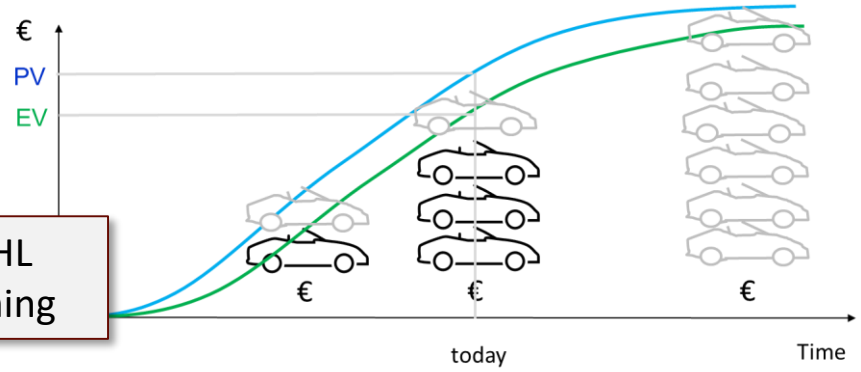


Planned Value

Work planned to be completed to date (in units of cost estimated to complete it)

Task responsibles report progress on activities

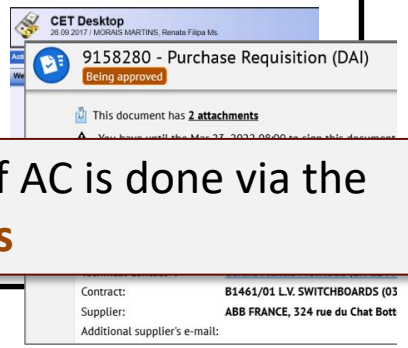
To ensure correct progress reporting by HL engineers, Budget Office gives EVM Training



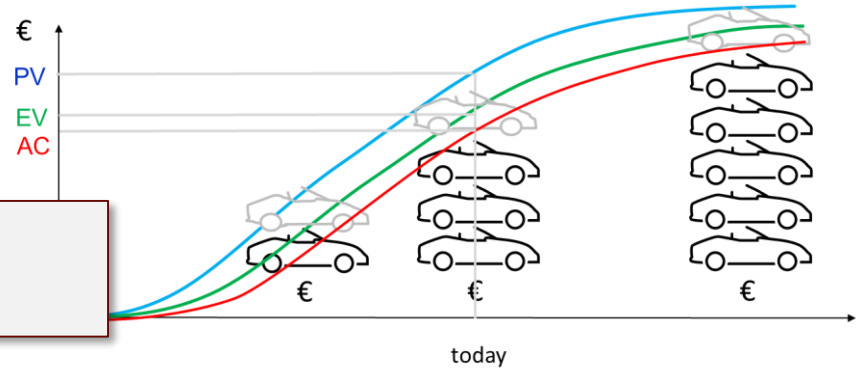
Earned Value

Work actually completed to date (in units of cost <u>estimated</u> to complete it)

Accounting System



Calculation of AC is done via the **Budget Codes**

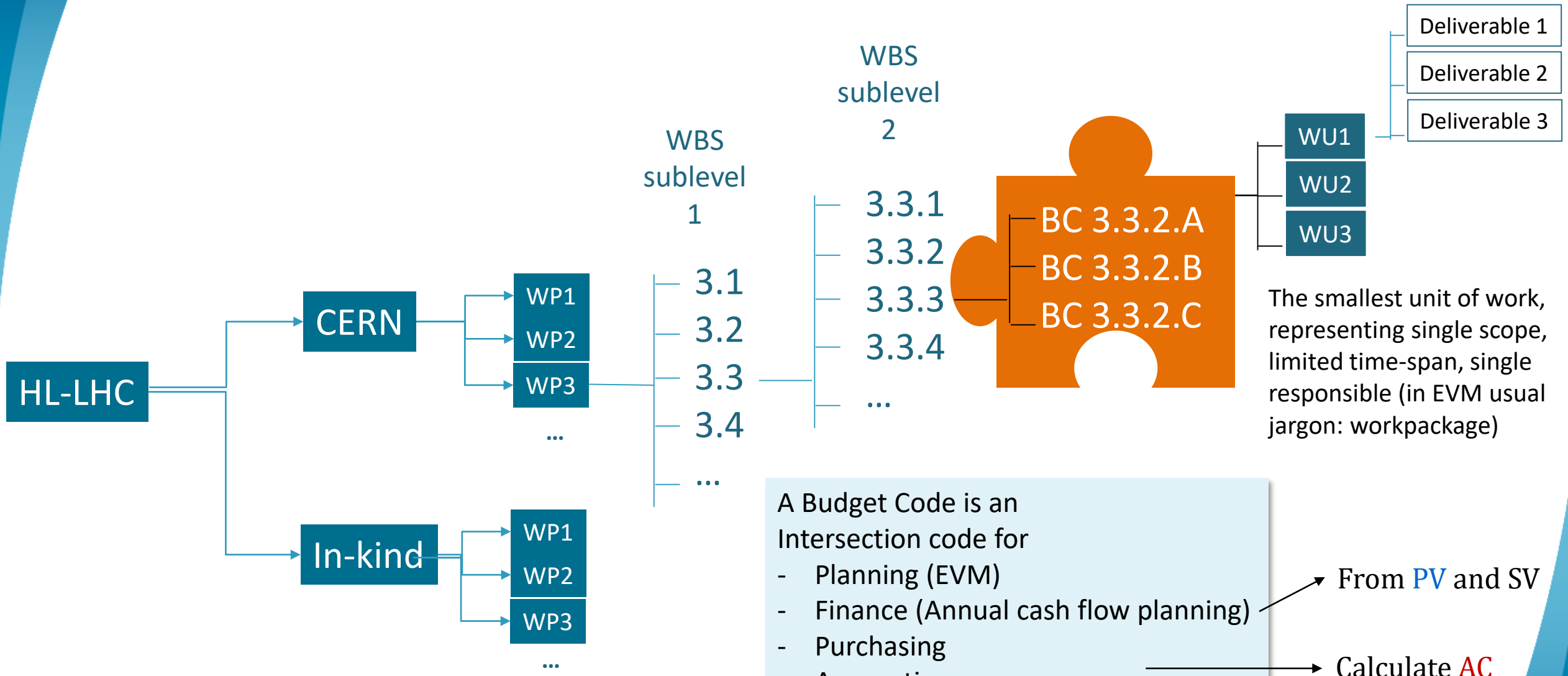


Actual Cost

Real **cost** of work performed as of today

EVM @ CERN

Work Breakdown Structure & Budget Codes



The smallest unit of work, representing single scope, limited time-span, single responsible (in EVM usual jargon: workpackage)

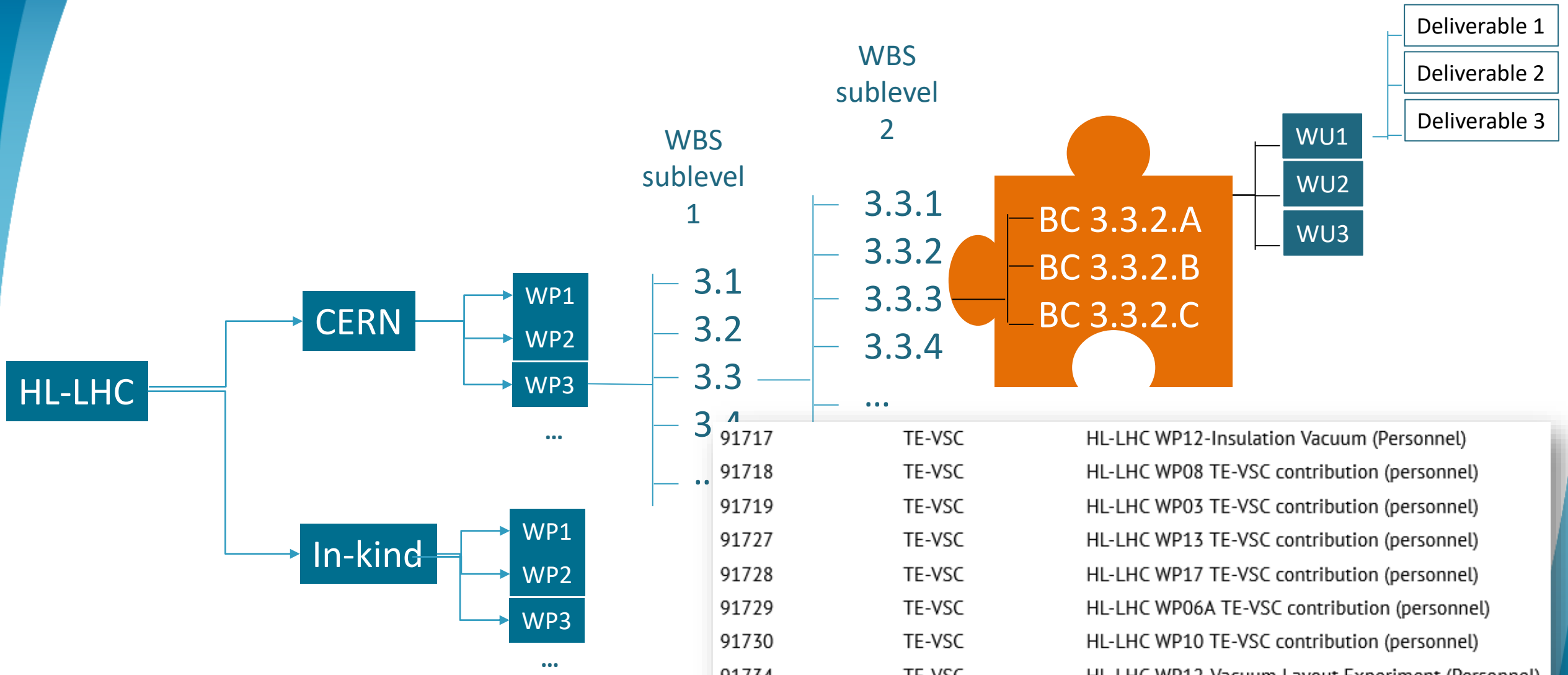
A Budget Code is an Intersection code for

- Planning (EVM)
- Finance (Annual cash flow planning)
- Purchasing
- Accounting

→ From PV and SV

→ Calculate AC

Work Breakdown Structure & Budget Codes



91717	TE-VSC	HL-LHC WP12-Insulation Vacuum (Personnel)
91718	TE-VSC	HL-LHC WP08 TE-VSC contribution (personnel)
91719	TE-VSC	HL-LHC WP03 TE-VSC contribution (personnel)
91727	TE-VSC	HL-LHC WP13 TE-VSC contribution (personnel)
91728	TE-VSC	HL-LHC WP17 TE-VSC contribution (personnel)
91729	TE-VSC	HL-LHC WP06A TE-VSC contribution (personnel)
91730	TE-VSC	HL-LHC WP10 TE-VSC contribution (personnel)
91734	TE-VSC	HL-LHC WP12-Vacuum Layout Experiment (Personnel)
91735	TE-VSC	HL-LHC WP12 - in situ aC coating (Personnel)

Procurement, approvals and EVM

PURCHASE

Requests between 10 and 50 kCHF

3 Offers

Requests between 50 and 750 kCHF

Departmental **R**equest (Dep Head approval)
Market Survey
Invitation to Tender

Requests above 750 kCHF

As above
+
Finance Committee approval

Project leader
Budget Officer

A
P
P
R
O
V
A
L

Check PV is existing in EVM

Written confirmation by BSO that HL has the budget to cover contract

EVM

Budget management tool

Opening of 1 workunit
Or
Attachment of several orders to 1 workunit

DR covered by one workunit

DR declared at the highest value of the uncertainty in estimate

…or inferior to estimate + provision workunit

DR covered by one workunit

DR declared at the highest value of the uncertainty in estimate

…or inferior to estimate + provision workunit

(Cost) change process

See Committees & forums:

TCC: Technical Coordination Committee
PSM: Project steering Meeting

In this process it is possible for the Project to approve a change which increases its budget-at-completion, before approval by CERN's management

YES

TCC: Configuration
Scope issues
Technical issues
→ cost/schedule changes

WPx PSM: Cost & Schedule
WP Monitoring
Scope/ interface issues
Cost changes
Schedule changes

APPROVAL
- Engineering (scope) Change Request
- Decision Management Reports
- Schedule Change Request
- **Budget Change Request**

APPROVED

REBASELINING
Baseline XX cost
Baseline XX Schedule

IMPLEMENTED

ENDORSEMENT
Cost
&
Schedule
Review

ENDORSED

CERN
Medium
Term
Plan

CERN-wide ARBITRATION

NO

Configuration change
Descoping

Importance of well-justified strategies for a successful negotiation/ arbitration

Novel ideas & open issues

1. **Categorize** cost changes for better control

Clearly tag each overcost to detect scope drift, in documents to-approve

What are we spending for ?

Detect added scope from external decisions, control scope drift

2. Include **UNCERTAIN** cost changes in PLANNING

Over-costs appear today
Savings appear later

Is cost-overrun threatening ?
Are overcosts/ savings balanced?

Today, we still have margin, but later…?

3. Integrate unsuccess in EVM

The 11 Tesla example

How to plan a recovery plan, upon a crash?

>2000 workunits!!
…1000 completed

4. Assess remaining budget

At 50% of plan, flexibility is still sufficient
…but close to project's end?

How to phase, close activities?

EVM blocks Budget for planning in past savings

What the PL wants to know

What are we spending for?

CATEGORY
Added scope
Missing scope
Mitigation of risk:
- Performance
- Cost
- Schedule

Overcost
Saving
Descoping

Categorization of cost changes

7.1	DQ- Energy Extraction System	scope +	46	Second CLIQ spare for the IT String	Potential	Missing scope
7.1	DQ- Energy Extraction System	cost +	20	EE system for String, 5% overcost	Potential	Overcost
7.1	DQ- Energy Extraction System	cost +	170	CLIQ Units for String	Potential	Mitigation of risk: cost
7.1	DQ- Energy Extraction System	scope -	-200	Fast BIS interlock electronics- All new fast failure cases in HL-LHC will have dedicated interlocks. Failure severity has been limited to allow for standard beam dump delays of 5-10 turns from the start of the failure.	Potential	Descoping
7.1	DQ- Energy Extraction System	cost -	-159.5	Capacitors for CLIQ Units- Contract was awarded to less than the DR (evolution remains under scrutiny) https://apt.cern.ch/apt/gui/workunit/edit/216212	Tangible	Saving

Missing scope
Orphan equipment at interfaces
Minor scope not initially seen

Risk mitigation
Buy in anticipation of market trends
Fragment contracts to avoid supply rupture
In-source parts of late in-kind contributions

Added scope
Scope drift

What the PL wants to know

Is cost overrun threatening?

Inclusion of potential cost changes

UNCERTAINTY	
Tangible	-5% / +20
Potential	-15% / +50%

7.1	DQ- Energy Extraction System	scope +	46	Second CLIQ spare for the IT String	Potential	Missing scope
7.1	DQ- Energy Extraction System	cost +	20	EE system for String, 5% overcost	Potential	Overcost
7.1	DQ- Energy Extraction System	cost +	170	CLIQ Units for String	Potential	Mitigation of risk: cost
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TANGIBLE

Estimations mature (in-house), jobs/ contracts signed
Production well advanced, but not concluded

POTENTIAL

Tendering ongoing, offers received, contracts not awarded
Contract awarded to lesser value than estimate
Internal Job estimate in early preparation
Market trends, identified threats/ opportunities

What the PL wants to know

Is cost overrun threatening?

Budget management tools

Integrate **IMMINENT** uncertain cost changes in the process:

Announce **LYKELY** cost changes with **ASSESSED, approved** ones

TCC: Configuration
Scope issues
Technical issues
→ cost/schedule changes

WPx PSM: Cost & Schedule
WP Monitoring
Scope/ interface issues
Cost changes
Schedule changes

APPROVAL
Engineering (scope) Change Request
Decision Management Reports
Schedule Change Request
Budget Change Request

APPROVED

REBASELINING
Baseline XX cost
Baseline XX Schedule

IMPLEMENTED

ENDORSEMENT
Cost
&
Schedule
Review

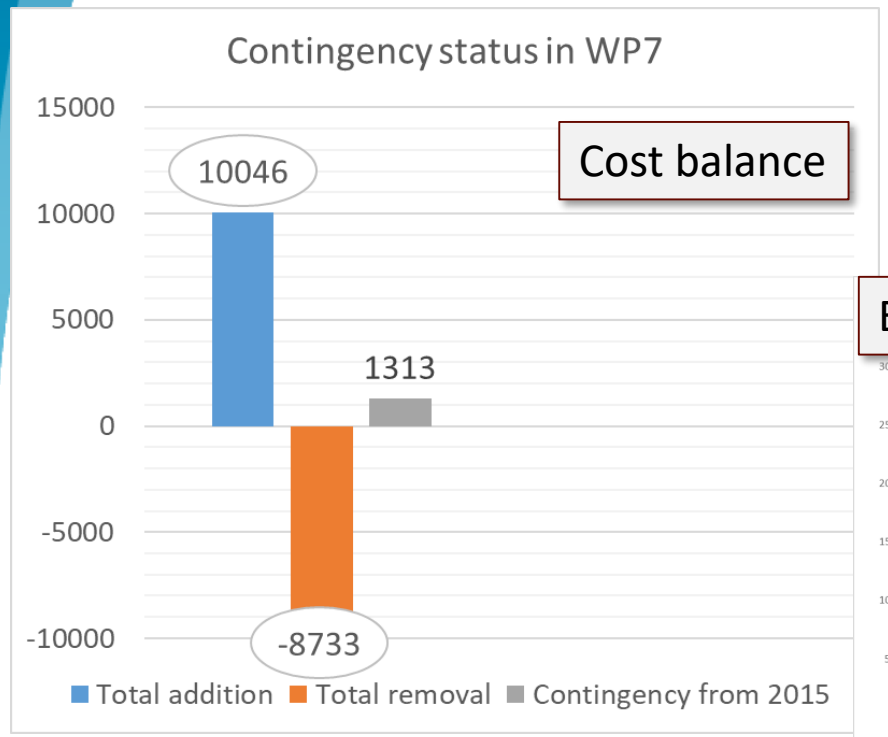
ENDORSED

Request of 14.2 MCHF, including potential cost changes

ENDORSED

Dynamical Cost Balance table

A side-gain of integration of **LYKELY, imminent** cost changes



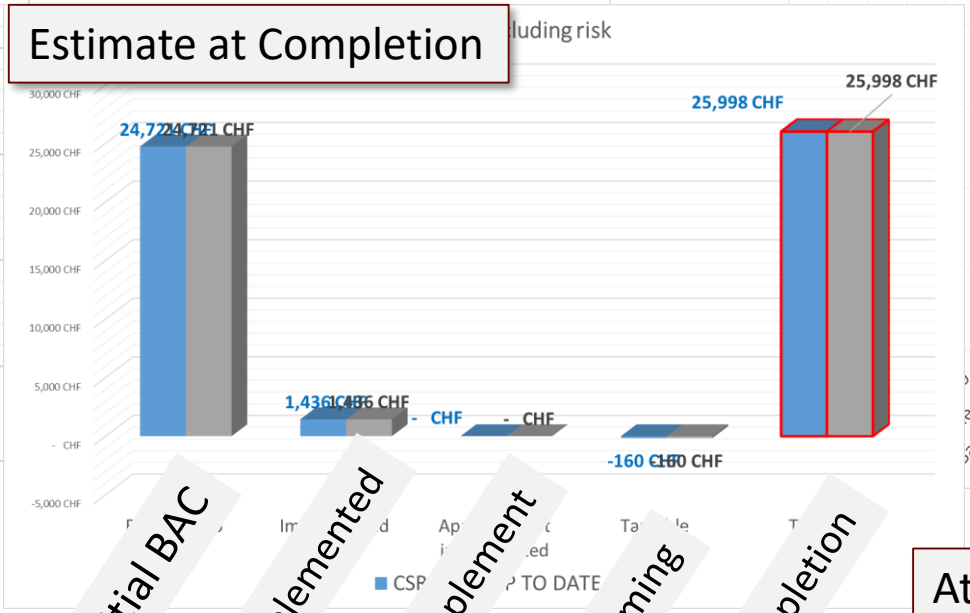
Cost balance

Building contingency

or

Incurring overcost

Estimate at Completion



Initial BAC

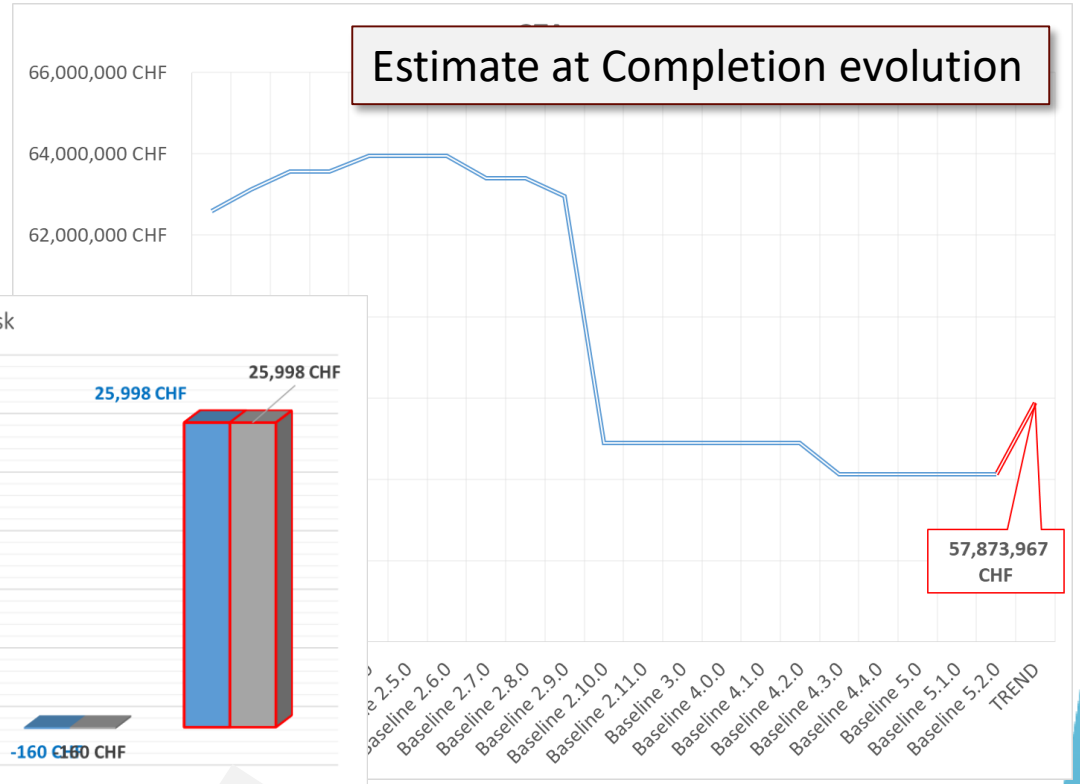
Approved/ implemented

Approved/ to implement

Upcoming

Estimate at Completion

Estimate at Completion evolution



At time t, we can tell the PL whether the project is incurring **overcost**, or constructing **contingency**

What the PL wants to know

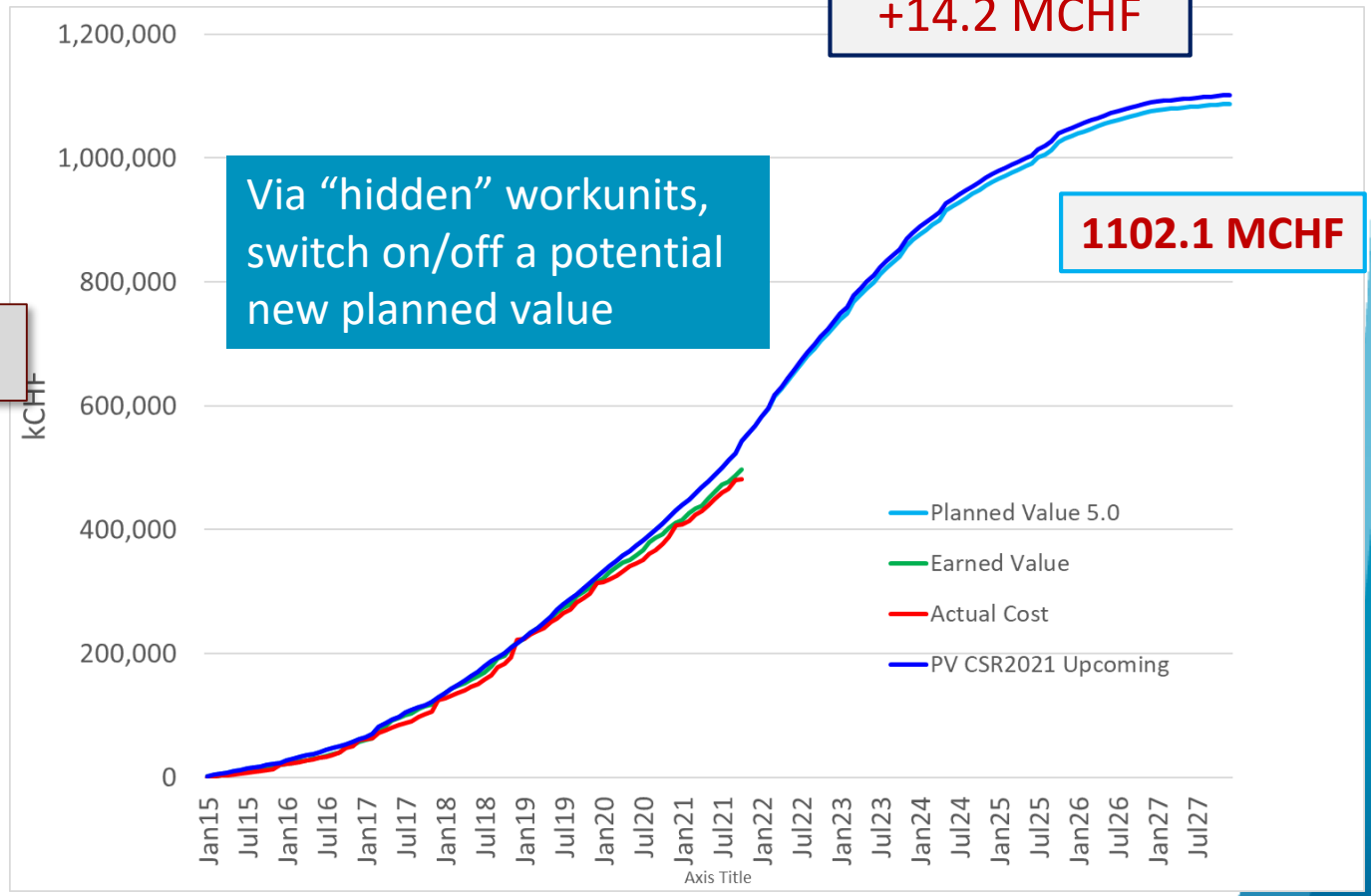
Is cost overrun threatening?

Budget management tools

Integration of tangible / potential upcoming cost changes

Include POTENTIAL Planned Value in EVM

+14.2 MCHF

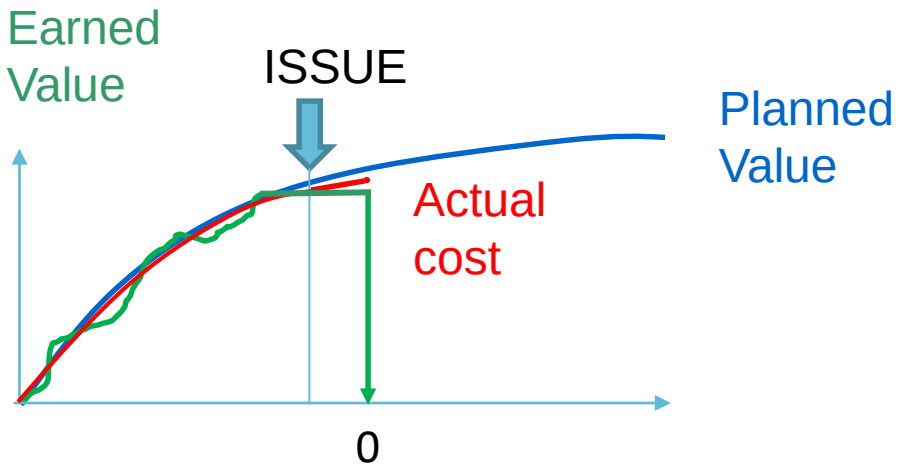


Via “hidden” workunits, switch on/off a potential new planned value

1102.1 MCHF

How to recover from failure

Budget management tools
Both a technical and a psychological opportunity



Seen in terms of Earned Value, the plan should be zeroed.

Seen in terms of "what remains to be done", the plan is yet unknown, but definitely not zero

- Assets
- Knowledge

11 Tesla project

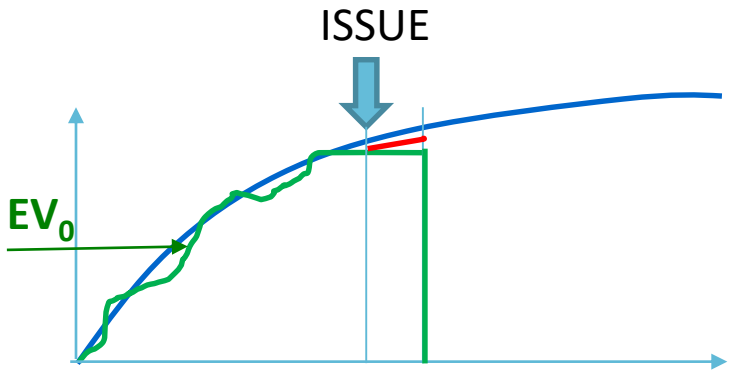
After reaching 85% of the Planned Value, assembled magnets failed cold test

A request to study a recovery plan was done:

How much money is left? : BAC-AC
How much Earned Value is recuperable?

EVM limit:

If failure occurs at the end, Earned Value becomes meaningless



Original plan

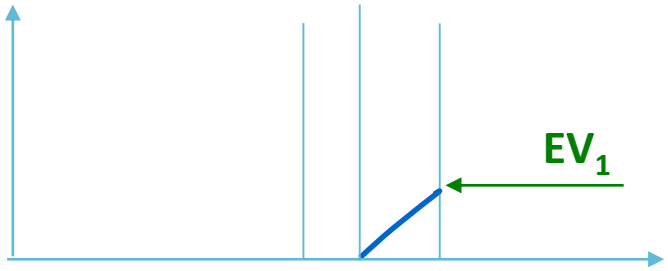
EV: zero
Remaining to completion: undefined

Block all Budget codes
Keep what needed to honor commitments
Put back all the rest to reserve

Analysis plan

Linearized expenditure over an imparted time:

R&D profile



Analysis plan

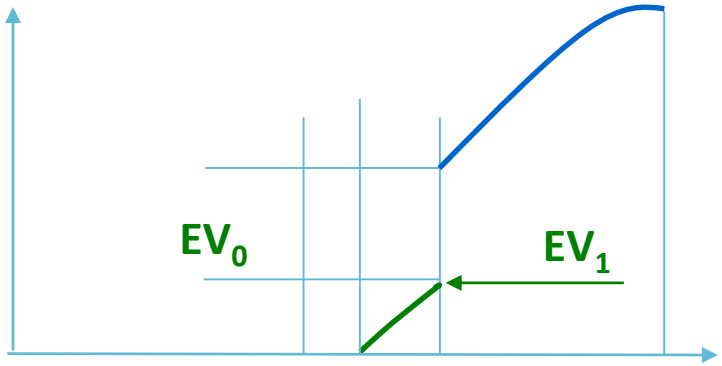
EV_1 = Earned Knowledge
Profile: Level-of-effort

Establish limit budget for analysis: study of root causes
Create new BC and charge to cover this phase

Discovery of failure cause:
assessment of what can be recuperated EV_0

Recovery plan

EV_0
+ new PV starting from
$EV_0 + EV_1$



New Plan

New Planned Value according to earned knowledge

Estimate budget for new plan:
Create new PV, starting from the equivalent EV_0 of initial plan

As for Cost, also for Schedule I didn't witness Schedule planning.
Basis of estimates?
→ Lessons learned register?
…No contingency…?

Schedule management

How can a project <u>without resources control</u> manage schedule?

"Schedule compression is used when you want to shorten the duration of your project without changing project scope"

Crashing	Add resources to your project so you can finish faster. Crashing almost always involves a financial cost.
Fast Tracking	Perform tasks in parallel so you can finish faster. Overlapping tasks in this way often increases risk.

Schedule: bottom-up

Each WP manages its Coordination schedule

Support from Planning support team **EN-ACE**

The HL-BSO manages:

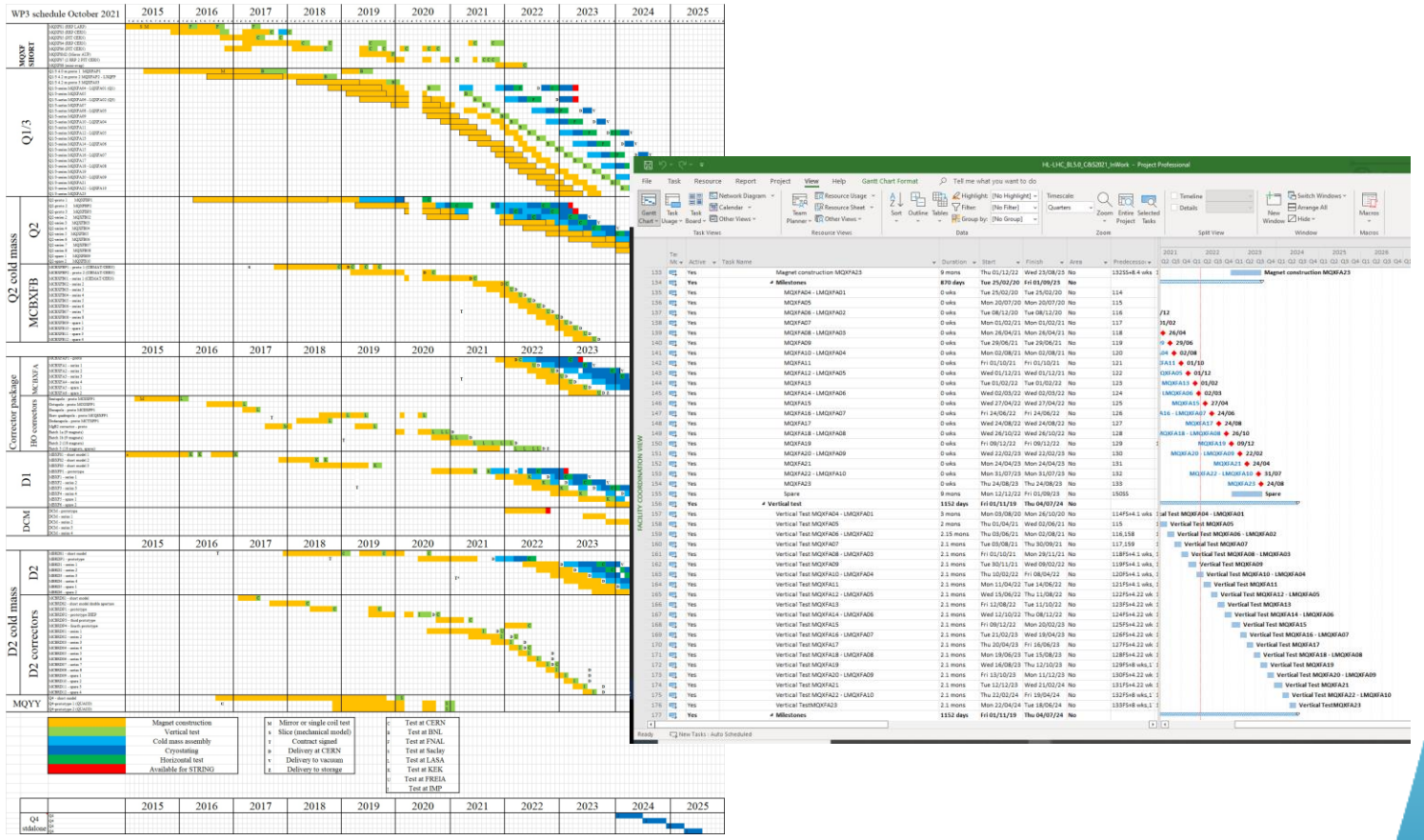
Schedule baseline
Isochrone line
Schedule change

next slides

EN-ACE

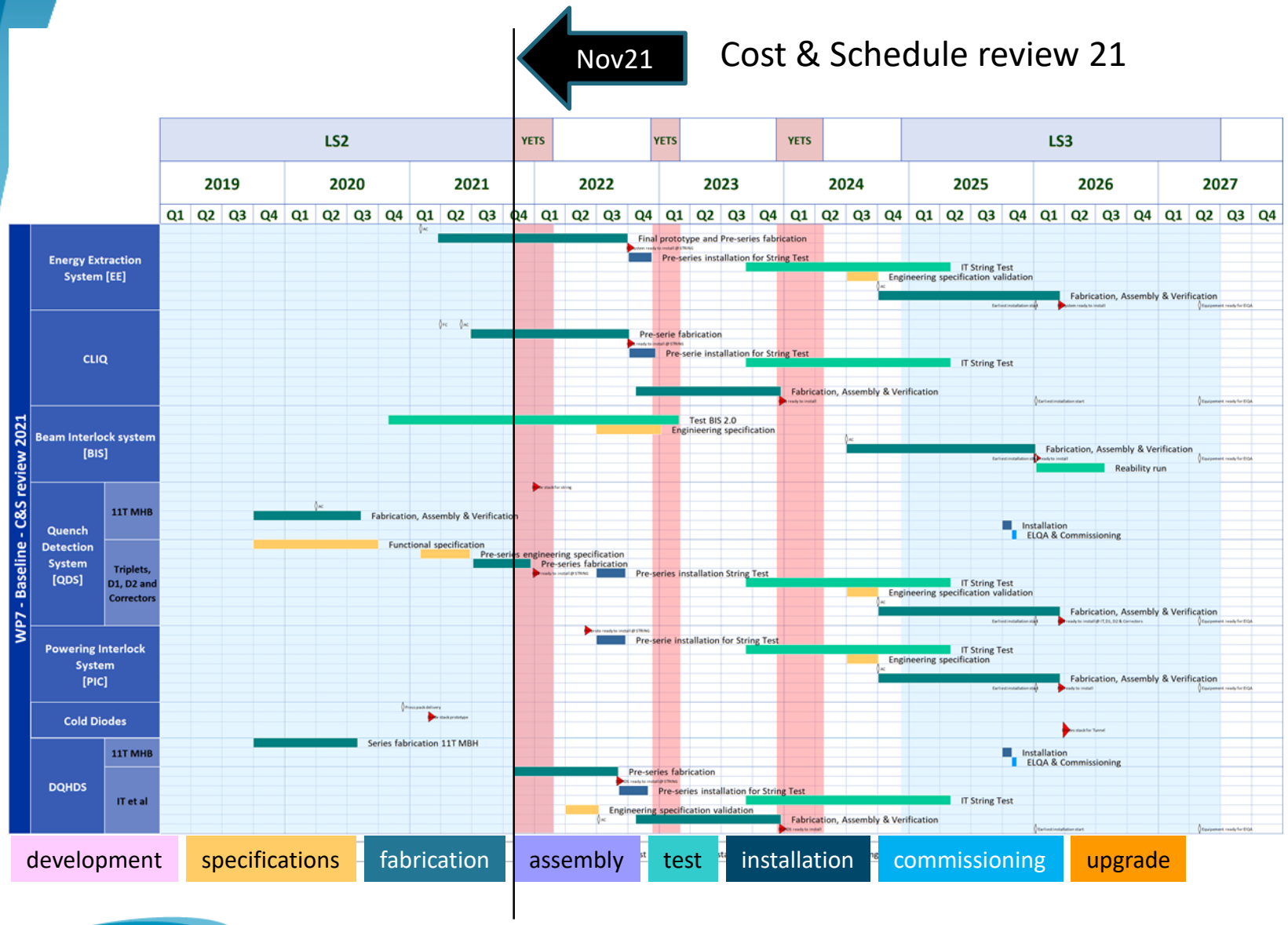
Interlinked deliverables
Project master schedule

Critical/ sub-critical path
Schedule margins via installation plan



EN-ACE manages configuration & layout, integration, organization of technical stops, scheduling, worksites, operational safety

Schedule baseline and changes



Active baseline
Master schedule of
WP7 Machine Protection

Activities per WBS level, milestones
main deliverables

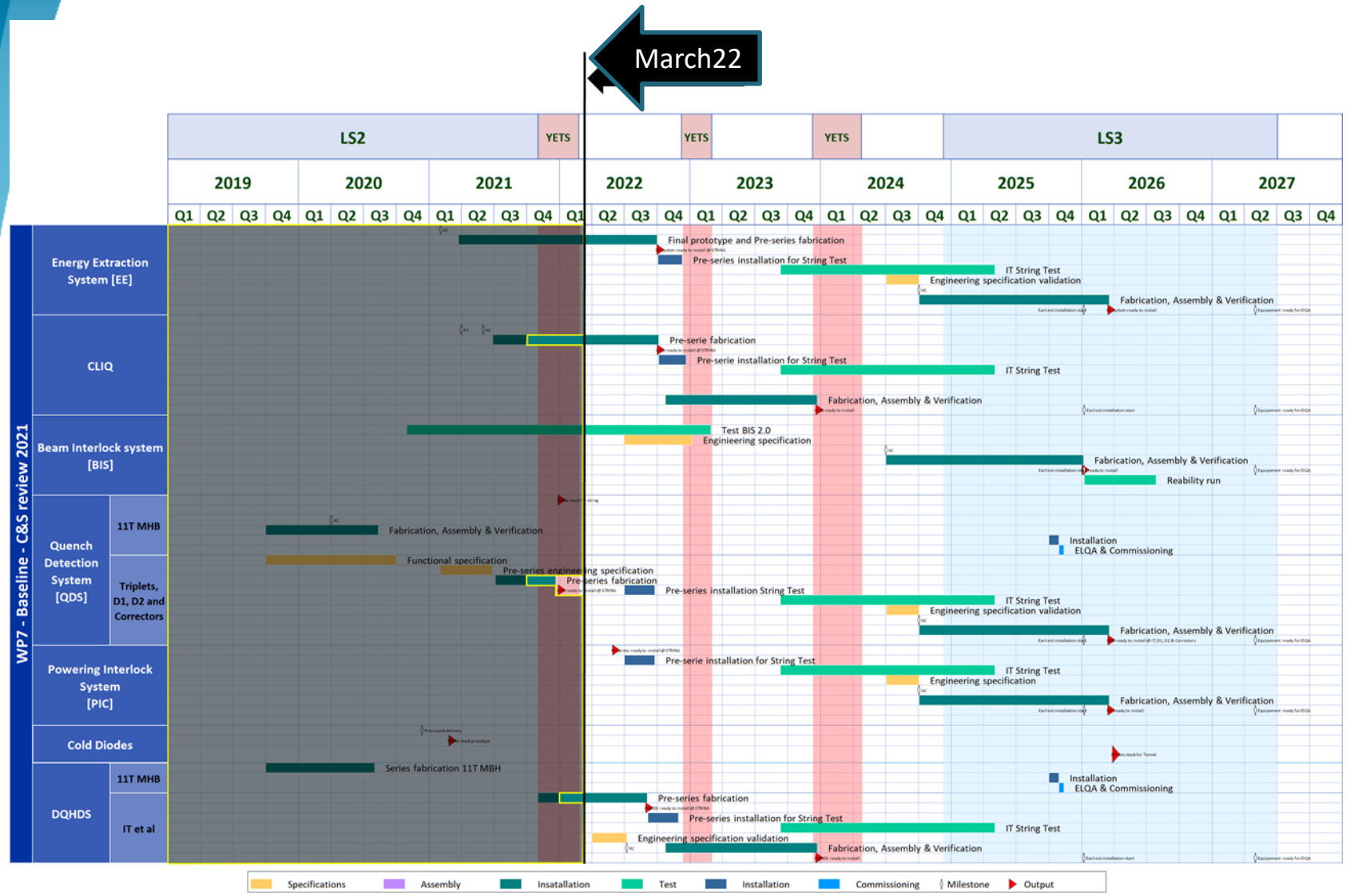
Proto
Preseries
First/ last

A Master schedule baseline is presented and endorsed at each Cost & Schedule review

Major global events might require intermediate Schedule re-baselining:

- Long shutdown shift
- Covid

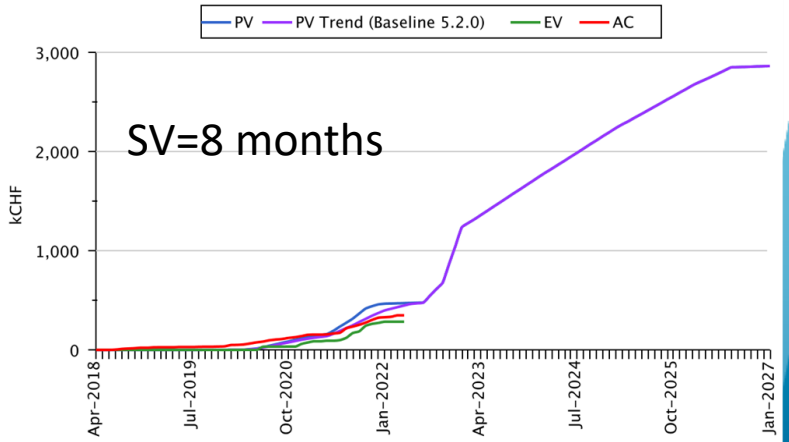
The isochrone line (or broken line)



Presented at each PSM

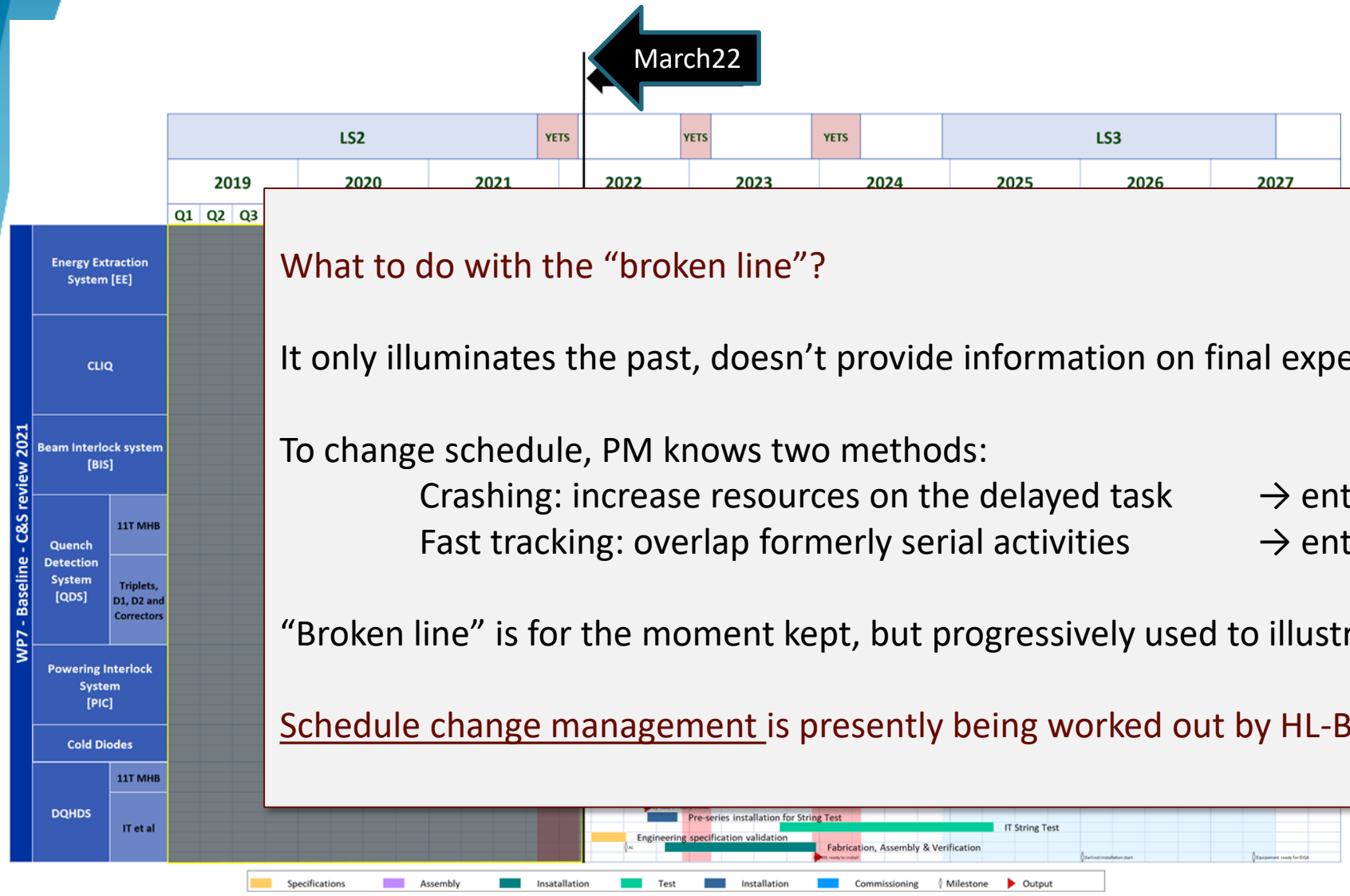
Pre-series (proto) of CLIQ to be installed on the IT String has taken **8 months delay** on the CSR21 baseline

Quench detection system for the IT String (proto) has taken **4 months delay**



What to do with the broken line?

The isochrone line (or broken line)



Presented at each PSM

What to do with the “broken line”?

It only illuminates the past, doesn’t provide information on final expected delays.

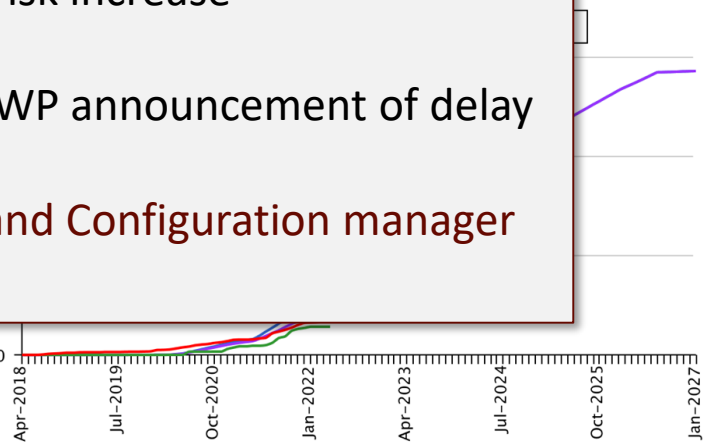
To change schedule, PM knows two methods:

Crashing: increase resources on the delayed task → entails cost increase

Fast tracking: overlap formerly serial activities → entails risk increase

“Broken line” is for the moment kept, but progressively used to illustrate WP announcement of delay

Schedule change management is presently being worked out by HL-BSO and Configuration manager



Schedule change process

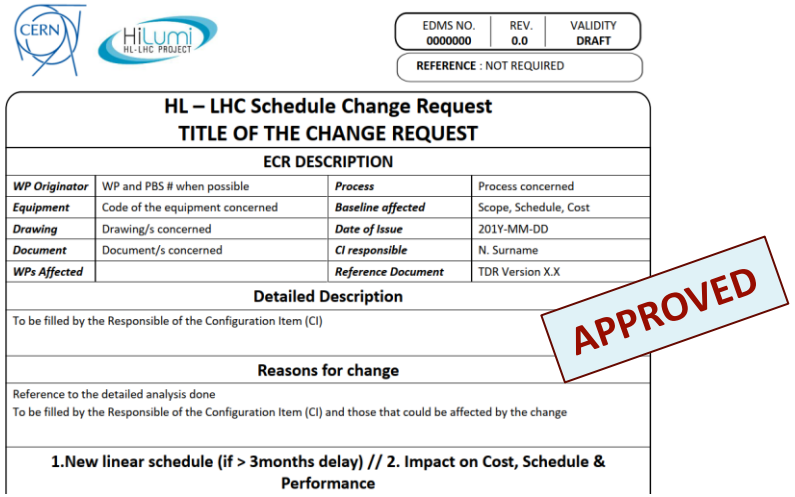
WPx PSM: Cost & Schedule
WP Monitoring
Scope/ interface issues
Cost changes
Schedule changes

If shift < 6months

ALERT generated
Tag deliverable, delay
Follow-up at next PSM

If shift > 6months

APPROVAL triggered
Schedule Change Request


EDMS NO. 0000000 | REV. 0.0 | VALIDITY DRAFT
REFERENCE : NOT REQUIRED

HL – LHC Schedule Change Request
TITLE OF THE CHANGE REQUEST

ECR DESCRIPTION

WP Originator	WP and PBS # when possible	*Process*	Process concerned
Equipment	Code of the equipment concerned	*Baseline affected*	Scope, Schedule, Cost
Drawing	Drawing/s concerned	*Date of Issue*	201Y-MM-DD
Document	Document/s concerned	*CI responsible*	N. Surname
WPs Affected		*Reference Document*	TDR Version X.X

Detailed Description

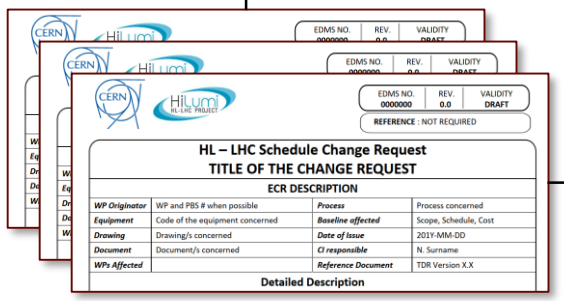
To be filled by the Responsible of the Configuration Item (CI)

Reasons for change

Reference to the detailed analysis done
To be filled by the Responsible of the Configuration Item (CI) and those that could be affected by the change

1.New linear schedule (if > 3months delay) // 2. Impact on Cost, Schedule & Performance

APPROVED



REBASELINING
Baseline XX Schedule

At CSR only

ENDORSEMENT
Cost
&
Schedule
Review

ENDORSED

Schedule change process

WPx PSM: Cost & Schedule
WP Monitoring
Scope/ interface issues
Cost changes
Schedule changes

Approval or Acknowledgement?

ALERT
Tag deliverable delay
Follow-up at next PSM

Approval by
- **WP leader**
- **Project Leader**

Decision of the WPL/s during TCC :

☐ Rejected.
☐ Accepted

Date of Decision:

Decision of the Project Leader during TCC:

☐ Rejected.
☐ Accepted
☐ Accepted with remarks.

of Approval:

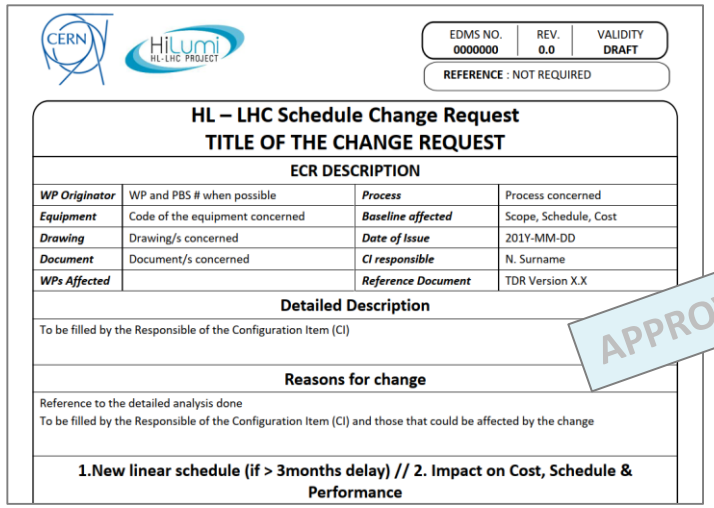
APPROVAL
Schedule Change Request

REBASELINING
Baseline XX Schedule

At CSR only

ENDORSEMENT
Cost
&
Schedule
Review

ENDORSED



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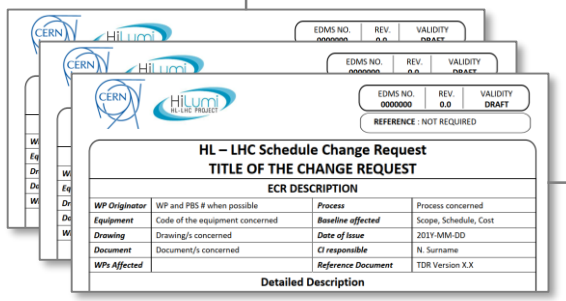
APPROVED



Schedule change process

WPx PSM: Cost & Schedule
WP Monitoring
Scope/ interface issues
Cost changes
Schedule changes

ALERT
Tag deliverable delay
Follow-up at next P

Approval by
- **WP leader**
- **Project Leader**
- **Department head**

NEW !!

Acknowledgement for action

Decision of the WPL/s during TCC :
☐ Rejected.
☐ Accepted

Date of Decision:

Decision of the Project Leader during TCC:
☐ Rejected.
☐ Accepted
☐ Accepted with remarks.

Date of Approval:

ENDORSEMENT
Cost

ENDORSED

Only organic management can take action to reduce schedule delay, not the Project Leader

Document raises awareness of the delay → triggers schedule reduction action

WP Originator	WP a		
Equipment	Code of the equipment concerned	***Baseline affected***	Scope, Schedule, Cost
Drawing	Drawing/s concerned	***Date of Issue***	201Y-MM-DD
Document	Document/s concerned	***CI responsible***	N. Surname
WPs Affected		***Reference Document***	TDR Version X.X

Detailed Description

To be filled by the Responsible of the Configuration Item (CI)

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Reference to the detailed analysis done
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Fast Tracking	Perform tasks in parallel so you can finish faster. Overlapping tasks in this way often increases risk.

Line vs Project management

Interlinking deliverables from WP to WP

Magnets for LS3

INPUTS

- WP13, cold BPM
- WP12, shielded beam screens
- (WP3 Jacks from Serbia)
- WP15.4 internal monitoring instrumentation

Crab cryomodules for LS3

INPUTS

- WP3 Jacks from Serbia
- WP15.4 internal monitoring instrumentation

The String chain

INPUTS

- WP3
- WP6A
- WP6B
- WP7
- Jacks

- ✓ Identification of chains
- ✓ Construction of deliverables list, with promised dates
- ✓ Identification & follow-up of these at PSM

→*see next slide*

	WP#	Deliverables			Dependencies		Delivery dates													
		Planning reference	#	Description	Input(s) # (filled with macro!)	Output(s) #	Approved changes					Proposed change(s)								
							PSM WP13 (10.06.20	PSM WP6A (15.06.20	PSM WP8 (17.06.20	PSM WP7 (24.06.20	PSM WP12 (24.06.20	Update from WP leaders (13.08.20								
															Update "Inputs" column	Highlight new dates	Crosscheck with Master Schedule	Approve proposed change(s)		
74	WP6B		D6B.DCCT.S1	Full set of DCCTs (incl. racks) 1x		String	08/08/2022	08/08/2022	08/08/2022	08/08/2022	08/08/2022	24/02/2023								
75	WP6B		D6B.14kA._PC.S1	Full 14kA PC (incl. racks) 1x		String	22/08/2022	22/08/2022	22/08/2022	22/08/2022	22/08/2022	24/02/2023								
76	WP6B		D6B.2kA_PC.S1	Full 2kA PC (incl. racks) 8x		String	22/08/2022	22/08/2022	22/08/2022	22/08/2022	22/08/2022	24/02/2023								
77	WP6B		D6B.0,2kA_PC.S1	Full 0,2kA PC (incl. rack) 1x		String	22/08/2022	22/08/2022	22/08/2022	22/08/2022	22/08/2022	24/02/2023								
78	WP6B		D6B.0,12kA_PC.S1	Full 0,12kA PC (incl. racks) 8x		String	22/08/2022	22/08/2022	22/08/2022	22/08/2022	22/08/2022	24/02/2023								
79	WP6B		D6B.FGC3.S1	Gateway-FGC3/FGC2 (incl. racks)		String	22/08/2022	22/08/2022	22/08/2022	22/08/2022	22/08/2022	24/02/2023								
80	WP6B		D6B.Electronics	Electronics		String	14/11/2022	14/11/2022	14/11/2022	14/11/2022	14/11/2022									
81	WP7		D7.QDS.PS	uQDS pre-serie		String	02/01/2023	02/01/2023	02/01/2023	31/12/2021	31/12/2021	30/09/2021								
82	WP7		D7.DAQ.PS	DAQ pre-series		String						30/09/2021								
83	WP7		D7.PDSU.PS	PDSU pre-series		String						30/09/2021								
84	WP7		D7.QDS.S	uQDS serie		LS3	14/03/2025	14/03/2025	14/03/2025	14/03/2025	14/03/2025	31/12/2025								
85	WP7		D7.DAQ.S	DAQ series		LS3						31/12/2025								
86	WP7		D7.PDSU.S	PDSU series		LS3						31/12/2025								
87	WP7		D7.EE.PS	Energy Extraction system pre-serie		String	02/01/2023	02/01/2023	02/01/2023	30/09/2022	30/09/2022									
88	WP7		D7.EE.S	Energy Extraction system serie		LS3	21/02/2025	21/02/2025	21/02/2025	21/02/2025	21/02/2025	31/12/2025								
89	WP7		D7.HDS.PS	Quench Heaters Power system Pre-serie		String	02/01/2023	02/01/2023	02/01/2023	26/01/2022	26/01/2022	30/09/2022								
90	WP7		D7.HDS.S	Quench Heaters Power system serie		LS3	11/12/2023	11/12/2023	11/12/2023	11/12/2023	11/12/2023	31/12/2025								
91	WP7		D7.CLIQ.PS	CLIQ pre-serie		String	02/01/2023	02/01/2023	02/01/2023	30/09/2022	30/09/2022									
92	WP7		D7.CLIQ.S	CLIQ serie		LS3	11/12/2023	11/12/2023	11/12/2023	11/12/2023	11/12/2023	29/02/2024								
93	WP7		D7.PIC.P	PIC prototype		String	02/01/2023	02/01/2023	02/01/2023	01/06/2022	01/06/2022	30/09/2022								
94	WP7		D7.PIC.S	PIC serie		LS3	06/06/2025	06/06/2025	06/06/2025	06/06/2025	06/06/2025	31/12/2025								
95	WP7		D7.BIS.S	BIS serie		LS3	19/12/2025	19/12/2025	19/12/2025	19/12/2025	19/12/2025	31/12/2025								
96	WP7		D7.WDR.P	Warm diode rack - String		String						30/09/2022								
97	WP7		D7.WDR.S	Warm diode rack		LS3						TBD								
98	WP7		D7.IFS.P	IFS boxes - prototypes		String						Following WP3 req.								
99	WP7		D7.IFS.S	IFS boxes		LS3						TBD								
100	WP7		D7.EIQA	EIQA racks		LS3						TBD								
101	WP7		D7.CD.P	Cold diode stacks - prototype		D3.DCM.P	31/12/2021	31/12/2021	31/12/2021	31/12/2021	31/12/2021									
102	WP7		D7.CD.S	Cold diode stacks		LS3						Following WP3 req								
103	WP12		D12.S-BS.type1.1	Shielded beamscreen - type 1		D3.Q1.S3					30/06/2024	01/06/2024								
104	WP12		D12.S-BS.type1.2	Shielded beamscreen - type 1		D3.Q1.S5						01/06/2024								
105	WP12		D12.S-BS.type1.3	Shielded beamscreen - type 1		D3.Q1.S7						01/07/2024								
106	WP12		D12.S-BS.type1.4	Shielded beamscreen - type 1		D3.Q1.S9					31/07/2024	01/07/2024								
107	WP12		D12.S-BS.type2.1	Shielded beamscreen - type 2		D3.Q3.S4					31/07/2022	01/06/2022								
108	WP12		D12.S-BS.type2.2	Shielded beamscreen - type 2		D3.Q3.S6						01.07.0222								
109	WP12		D12.S-BS.type2.3	Shielded beamscreen - type 2		D3.Q3.S8						01/03/2023								
110	WP12		D12.S-BS.type2.4	Shielded beamscreen - type 2		D3.Q3.S10					31/10/2024	01/03/2023								

Output from **WP6B** to **String**

Output from **WP7** to

- **String**
- WP3 DCM
- **LS3**

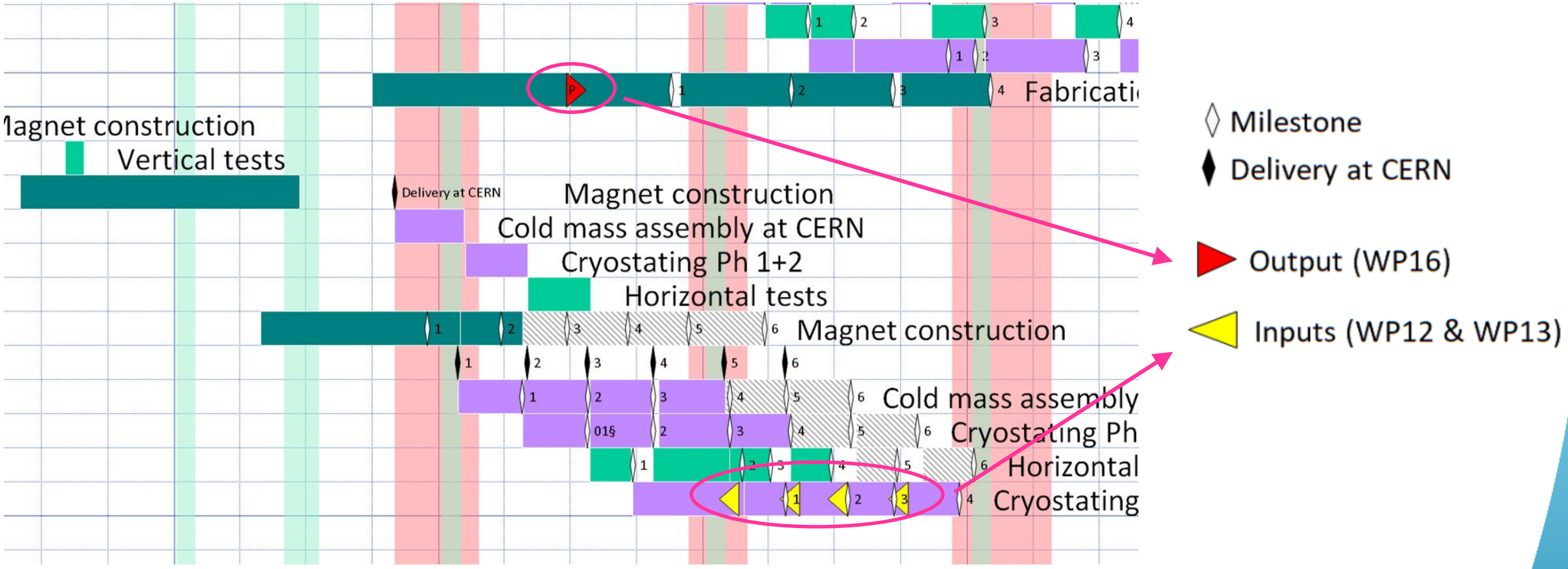
Output from **WP12** to **WP3**
Shielded beam screen

Documentation and change management process differentiates threshold times and approval procedure/ list

Examples of interlinking deliverables

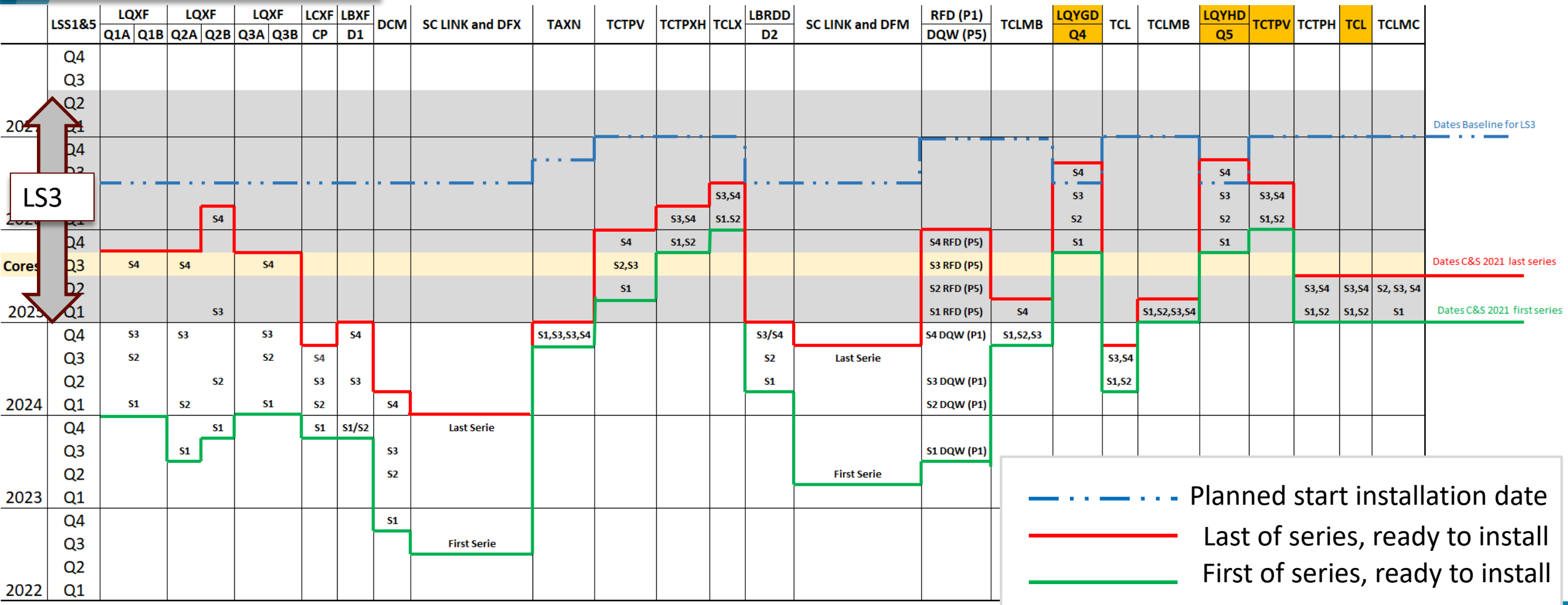
Deliverables are identified: D12.S-BS.type2.4 Shielded beamscreen - type 2→ D3.Q3.S1

Graphical visualization of Inputs/ Outputs



Installation date and availability date – margins

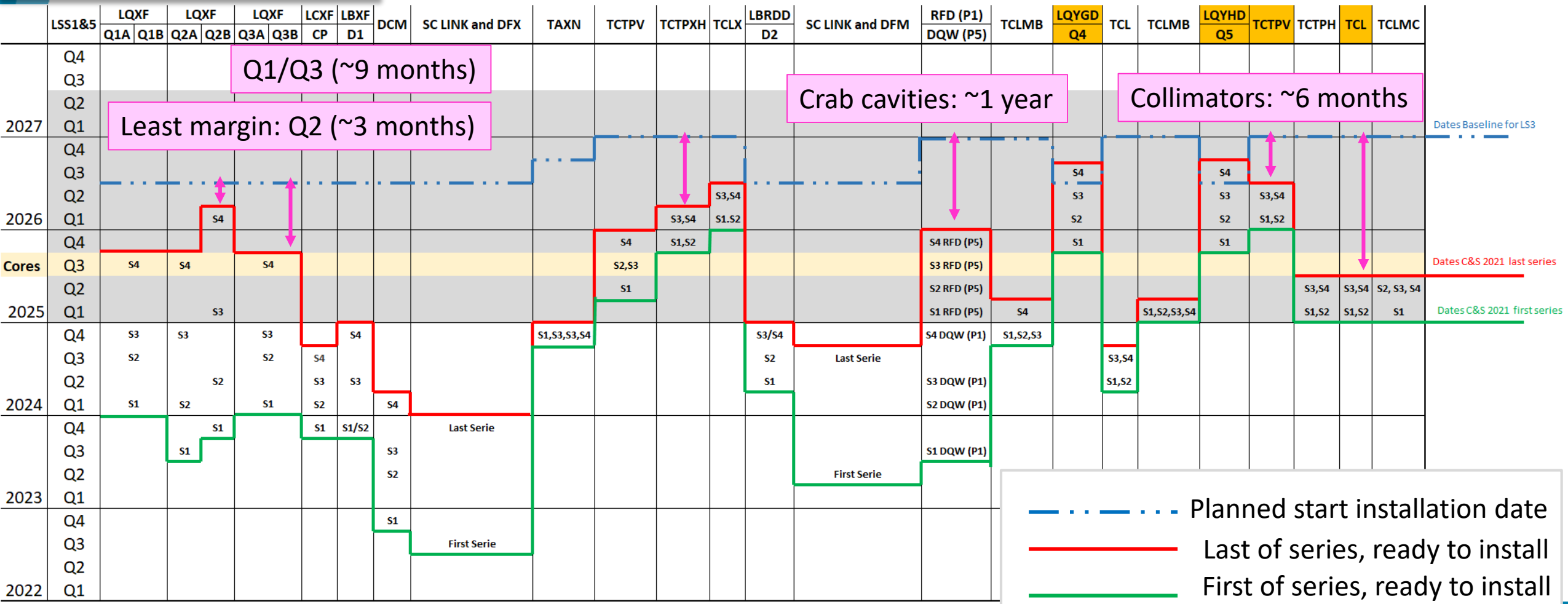
LHC tunnel areas



Comparison btw deliverables **needed** and deliverables **available**

Installation date and availability date – margins

LHC tunnel areas

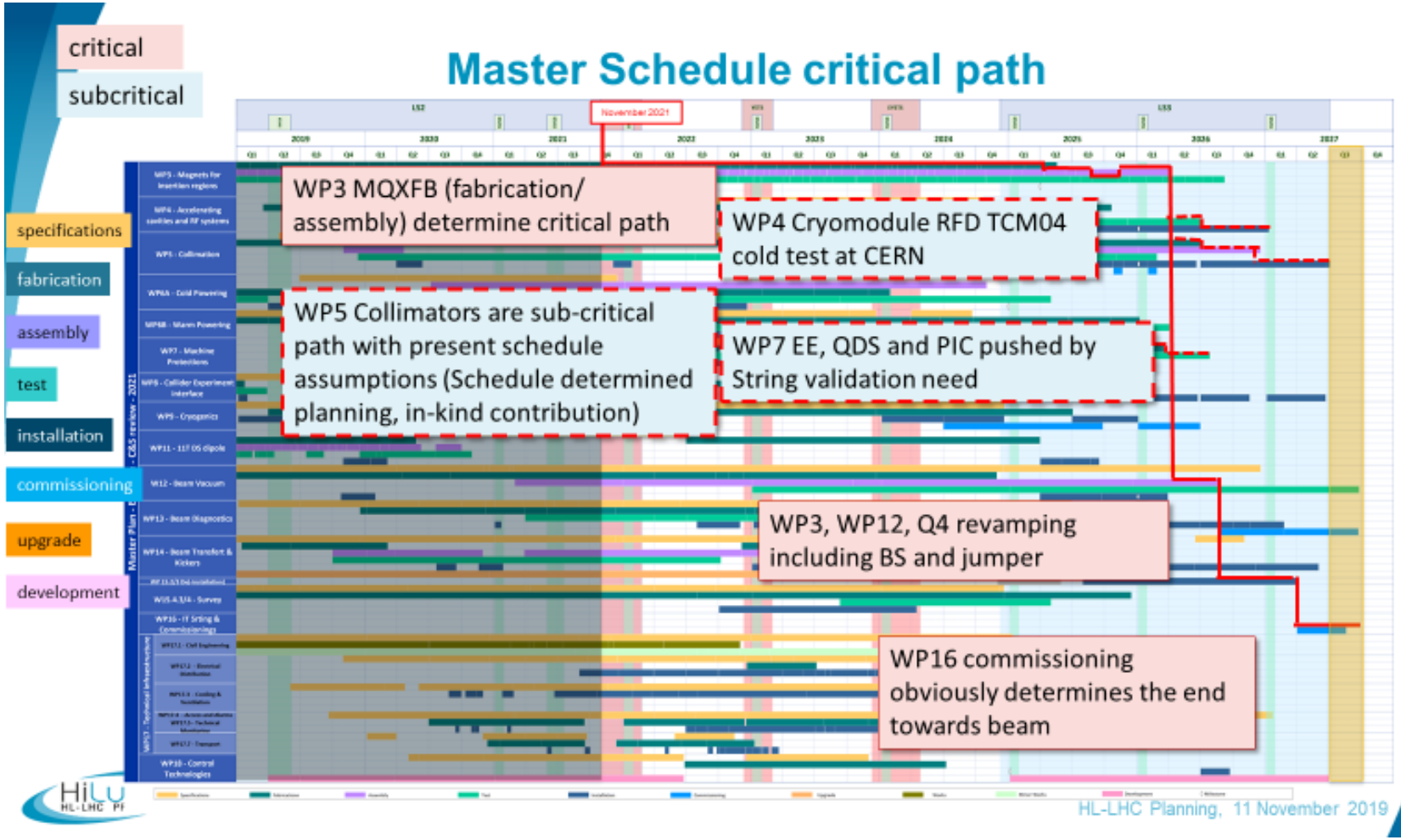


Critical path

Identification of critical/ subcritical path across the project

Specific managerial processes and time thresholds, to follow

- The corresponding WPs
  - Their (sub)critical path
  - Their main activities
  - Their delays
- The interlinking deliverables on these



Any further smart idea?

Managing it with agility

Small team managing a **large project** might be managed in **AGILE**

AGILE

ACTIVITY type

- Mostly operational

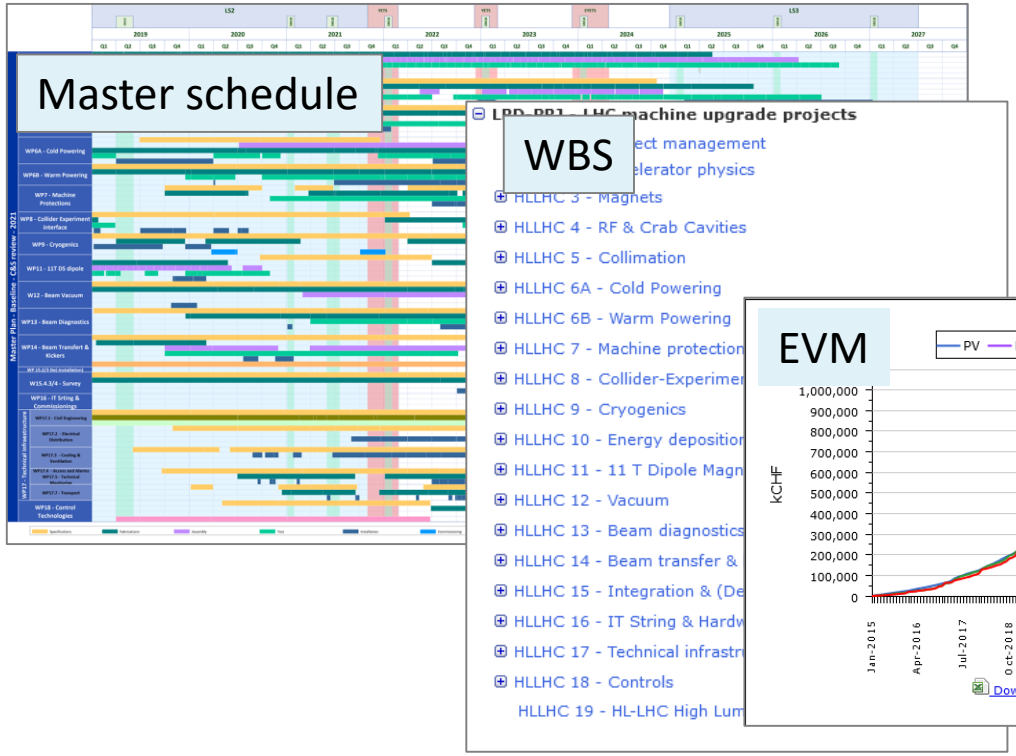
PROJECT types

- Re-baselining
- Study new processes
- Study new analysis techniques
- Restructuring WBS
- Organization of Cost & Schedule reviews

SCALE
100 kCHF
6 months
5 FTE/ year

Sprints
Retrospectives
Manage the backlog action list via JIRA kanbans

Waterfall PM



SCALE
1 billion
12 years
350 FTE/ year

Conclusion ?

Filigrane

How we manage a 1 billion, 12 years project?

Line management and Project management: conflict or collaboration?

Project management processes: a hassle or an opportunity?

Can we say something new in PM?

Very personal answers

Lean yet ambitious

Lucidity on roles and prerogatives is path for efficient, collaborative strategy

(Cost/ Schedule) management tools are an opportunity, via focus on essential objectives, creativity

Question to you

Acknowledgements

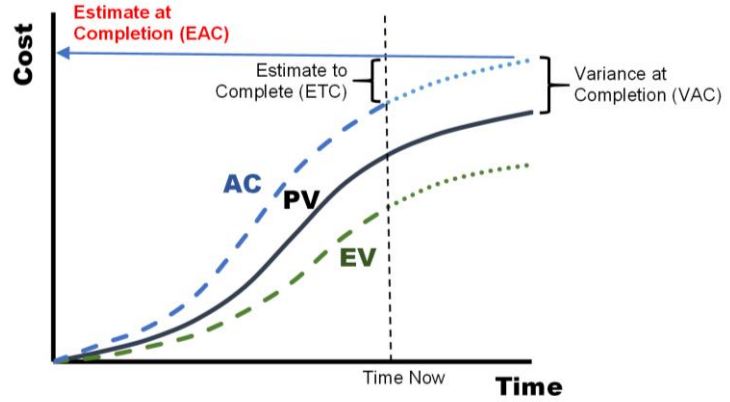
O.Bruning, M.Zerlauth, L.Tavian, B.di Girolamo, H. Garcia Gavela, P.Fessia, M.Modena, C.Noels
A.Augier, L.Carlos, R.Martins, S.Riebe, M.Rodriguez Perez, M.Barberan Marin,
S.Perrault, E.Vergara, M.Bernardin, H. De Maynard,
S.Knoops, V.Perez Reale, L.Salvi, K.Sigerud, R.Billen, I.Laugier
E.Delachenal, S.Prodon
…all WP leaders

Spare slides

Glossary

HL	High Luminosity LHC, aka HiLumi	Upgrade for more luminosity of the existing LHC
WP	Work-package	Sub-project of HiLumi, of circumscribed scope, WBS level zero
ATS	Accelerators and Technology sector	Grouping of 4 departments mostly active in accelerators
HL-PO	Project office of HiLumi	
HL-BSO	Budget & Scheduling office of HiLumi	
CSR	Cost & Schedule Review	18 month, then since 2021 annual, international MAC review of HL
PSM	Project Steering Meeting	Regular scrutiny of single WP (trimestral circa)
PMM	Project Management Meeting	Hebdomadary meeting of the Project Office
TCC	Technical Coordination Committee	Bi-hebdomadary technical meeting of HL
IR	Interaction region	The machine region on both sides of the ATLAS & CMS experiments
IT	Inner Triplets	The ensemble of the quadrupole magnets of the Interaction region
MTP	Medium Term Plan	CERN wide annually revised financial (scopes & cash flow) plan over 5 years

Novel ideas and open issues



What the PL want to know:
How much will finally HL cost?

Estimate at Completion:

Future performance based on

budgeted cost

$$EAC = AC + (BAC - EV)$$

past schedule performance

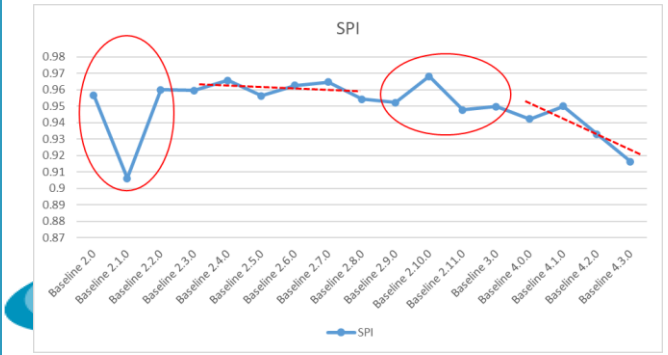
$$EAC = AC + \frac{(BAC - EV)}{SPI}$$

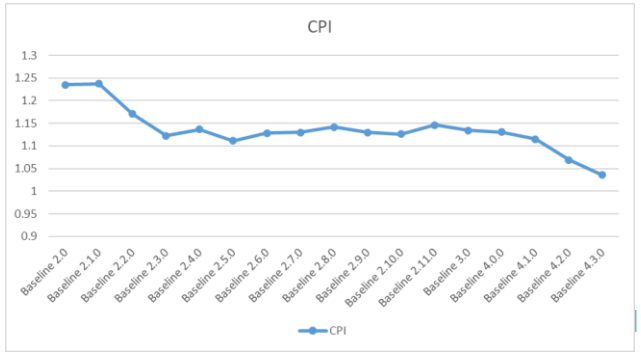
past cost performance

$$EAC = AC + \frac{(BAC - EV)}{CPI}$$

	CPI	SPI	PV	EV	AC	BAC	BAC in kCHF	EAC-CPI	EAC-SPI		Delta CPI	Delta SPI
WP1	1.06	0.98	4,249,795	4,169,188	3,925,835	15,178,920	15,179	14,312	15,160		867	-19
WP2	0.99	1.00	4,950,847	4,950,847	4,992,230	7,128,682	7,129	7,192	7,170		-63	41
WP3	1.00	0.97	147,390,032	143,441,586	143,938,564	216,846,595	216,847	217,344	219,614		-497	2767
WP4	1.04	0.84	35,843,206	29,960,902	28,870,485	91,437,994	91,438	87,983	102,057		3455	10620
WP5	1.05	0.95	25,782,902	24,428,447	23,324,164	64,874,717	64,875	61,844	65,899		3030	1024
WP6A	1.01	0.91	26,586,303	24,167,823	24,020,724	56,123,998	56,124	55,661	59,137		463	3013
WP6B	1.05	0.87	8,599,332	7,503,671	7,132,873	37,025,148	37,025	35,249	41,066		1777	4040
WP7	0.99	0.96	8,724,440	8,394,131	8,438,015	26,157,340	26,157	26,381	26,941		-223	784
WP8	1.05	1.00	1,613,807	1,613,806	1,535,759	7,686,460	7,686	7,319	7,608		367	-78
WP9	0.99	0.98	9,083,376	8,894,724	8,943,653	94,053,423	94,053	94,963	95,840		-909	1787
WP10	0.97	1.00	1,383,078	1,383,078	1,425,795	2,296,905	2,297	2,368	2,340		-71	43
WP11	0.99	1.00	48,878,501	48,800,785	49,162,200	52,481,575	52,482	52,880	52,843		-399	361
WP12	0.95	0.94	18,906,629	17,842,546	18,687,746	51,334,091	51,334	53,942	54,317		-2608	2983
WP13	0.97	0.95	9,381,689	8,887,783	9,155,778	19,974,455	19,974	20,585	20,826		-611	852
WP14	0.97	0.93	10,896,832	10,179,107	10,446,165	22,198,849	22,199	22,838	23,371		-639	1172
WP15	0.95	0.95	5,532,848	5,264,464	5,531,014	43,480,680	43,481	45,759	45,759		-2278	2278
WP16	1.08	0.93	2,051,373	1,909,469	1,773,910	7,116,008	7,116	6,595	7,372		521	256
WP17	1.11	0.92	157,074,142	144,063,371	129,287,507	269,324,796	269,325	242,136	265,441		27189	-3884
WP18	1.13	0.99	903,021	896,385	792,336	3,180,000	3,180	2,813	3,099		367	-81

MIN	MAX
-12,359	70,058





The Project Steering Meetings

EDMS NO. xxxxxxxxx | REV. | VALIDITY

REFERENCE :

HL-LHC PROJECT STEERING MEETING REPO

BUDGET AND SCHEDULE REPORTING – DOCUMEN

WP7 – MACHINE PROTECTION

Abstract

This document summarizes the PSM situation of WP7 for the PSM that is held on the 17th

Disclaimer: The document is prepared by the HL-LHC budget office and planning team. Th
EVM curves shall be complemented by WP Leader's view on EVM performance indices.

Table 13 – Upcoming cost changes

WBS (HL/HL-C)	Description	Rationale	Estimated amount (kCHF) +	Estimated amount (kCHF) -	Uncertainty (Tangible/Potential)
7.1	EE system for String, 5% overcost	3. /4.	20		Potential
7.1	CLIQ Units for String		170		Potential
7.1	Capacitors for CLIQ Units- Contract was awarded to less than the DR (evolution remains under scrutiny) https://apt.cern.ch/apt/gui/workunit/edit/216212			-159,5	Tangible
Total			190	-159,5	

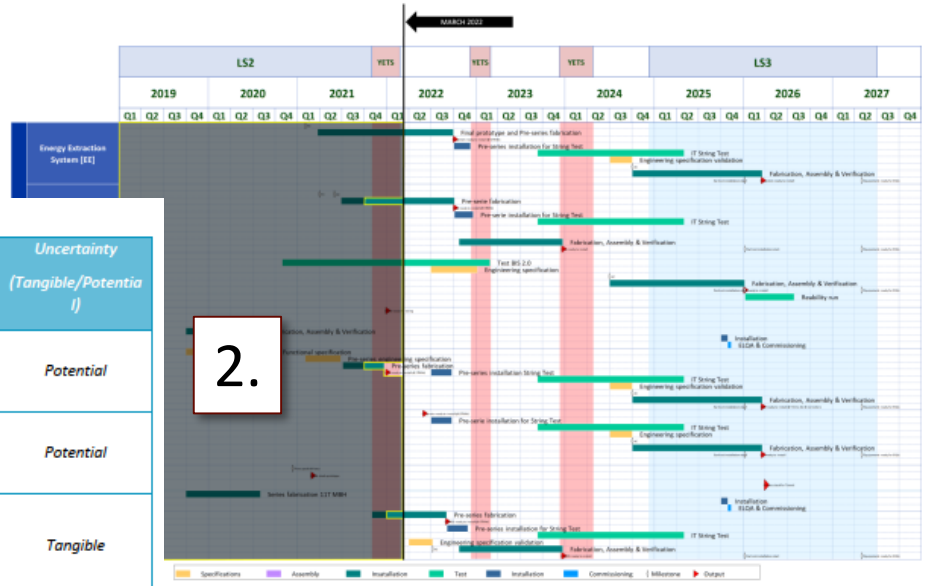


Figure 11 – Progress line with respect the last update planning presented on C&S review Nov 2021

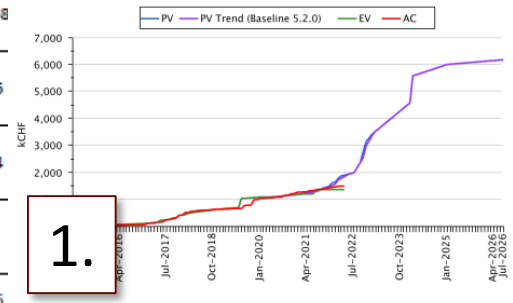
Table 2 – EVM indicators for each WBS level

WBS	WBS description	kCHF PV	kCHF EV	kCHF AC	kCHF BAC	kCHF PV Trend	kCHF CV current	kCHF CV CSR21	months SV(t) current	months SV(t) CSR21
	M4P									
7.1	DQ – Energy Extraction System	1.866	1.358							-2.26
7.2	CIB – Beam Interlock System	308	306							-0.58
7.4	DQ – Quench Detection System	470	284							-4.58
7.6	CIP – Power Interlock System	0	0							0
7.7	DQDX – Cold Diodes	379	346							-4.71
7.8	QH Power supplies	404	402							-0.39
7.9	Transport and Installation	104	104							0

1.

2.2 Detailed View

2.2.1 WBS 7.1 – [DQ – Energy Extraction System]



1.

Figure 2 – WBS 7.1 EVM Detailed View

Table 4 – EVM indicators for WBS 7.1

Metrics on the 16-Mar-2022

PV (kCHF)	EV (kCHF)	AC (kCHF)	BAC (kCHF)	PV Trend (Baseline 5.2.0) (kCHF)	SV (kCHF)	SPI (%)	CV (kCHF)	CPI (%)	SV(t) (months)
1,879	1,477	1,496	6,169	1,563	-402	79	-19	99	-4.61

Extended EVM and Schedule Report

1. EVM Analysis and trends
2. Schedule reference and deviations
3. Scope changes proposals
4. Cost changes proposals
5. Schedule changes proposals

WP#	Deliverables #	Deliverables Description	Dependencies Output(s) #	Delivery dates Proposed change(s)	Delivery dates Baseline C&S Nov21
WP7	D7.QDS.S	uQDS serie	LS3		18/03/2026
WP7	D7.DAQ.PS	DAQ pre-series	String		
WP7	D7.DAQ.S	DAQ series	LS3		
WP7	D7.PDSU.PS	PDSU pre-series	String		
WP7	D7.PDSU.S	PDSU series	LS3		
WP7	D7.EE.PS	Energy Extraction system pre-serie	String		03/10/2022
WP7	D7.EE.S	Energy Extraction system serie	LS3		18/03/2026
WP7	D7.HDS.PS	Quench Heaters Power system Pre-serie	String		02/09/2022
WP7	D7.HDS.S	Quench Heaters Power system serie	LS3		22/12/2023
WP7	D7.CLIQ.PS	CLIQ pr	String		04/10/2022
WP7	D7.CLIQ.S	CLIQ	LS3		22/12/2023
WP7	D7.PIC.P	PIC pro	String		01/06/2022
WP7	D7.PIC.S	PIC s	LS3		18/03/2026
WP7	D7.BIS.S	BIS s	LS3		05/01/2026
WP7	D7.WDR.P	Warm diode	String		
WP7	D7.WDR.S	Warm diode rack	LS3		
WP7	D7.IFS.P	IFS boxes - prototypes	String		
WP7	D7.IFS.S	IFS boxes	LS3		
WP7	D7.EIQA	EIQA racks	LS3		
WP7	D7.CD.P	Cold diode stacks - prototype	D3.DCM.P		28/02/2021
WP7	D7.CD.PS	Cold diode stack - string	String		31/12/2021
WP7	D7.CD.S	Cold diode stacks - serie	LS3		31/03/2026

5.

Figure 12 – WP7 Deliverable table

The PSM

Actions follow-up

RISK Management
Main risks from Risk exercise
Main (3 new) risks seen by WP leader

COST Management
EVM data commented
Changes in SCOPE: for approval
Changes in COST: for approval

Schedule management
Master plan
Master plan deviations: the isochrone line
Deliverable's delays

Heads-up
Upcoming Engineering Change Requests
Upcoming Decision Management reports
Upcoming cost/ scope changes
Milestones: achieved
Milestones: upcoming
Upcoming tenders
Non-conformities

Extra WP management

Collaborations status & issues
Interface issues
Infrastructure issues
Resources issues

Safety

Budget & Schedule Office organization and tasks

1 linkperson Budget per WP
1 linkperson Schedule per WP

5FTE – 19 Work-packages

Everyday's management: reprofiling, cost assessment & estimate, phasing

PSM preparation
- WP regular report & CSR report
- PSM minutes

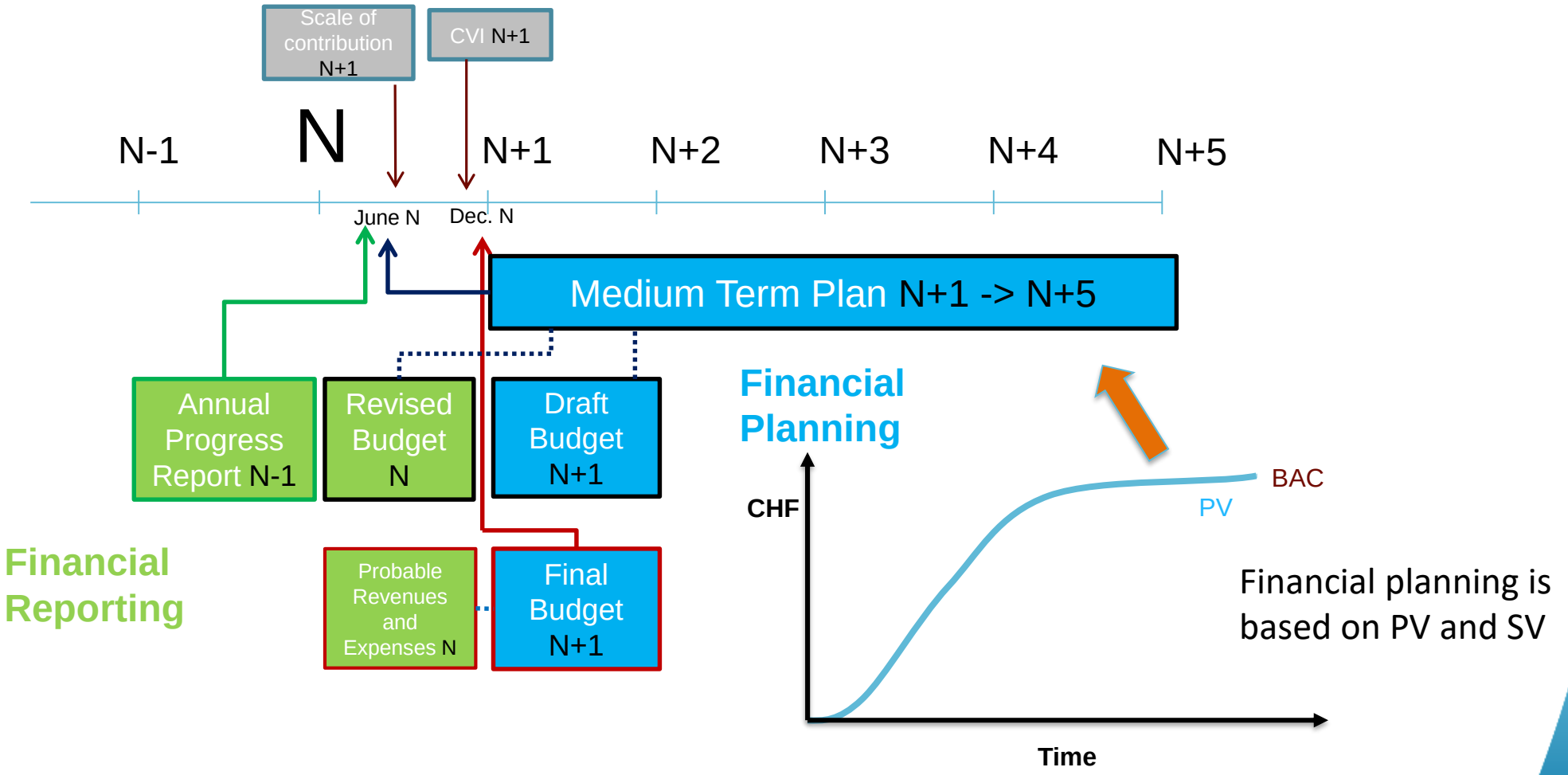
Budget & Schedule monitoring
- EVM analysis & variances, change implementation
- Master schedules & deviations, change implementation

Approval and EVM assignment of all procurement documents > 10k CHF

The measure of our monitoring possibility

EVM in the HL-LHC Project : How is it connected to CERN Managerial and Financial processes?

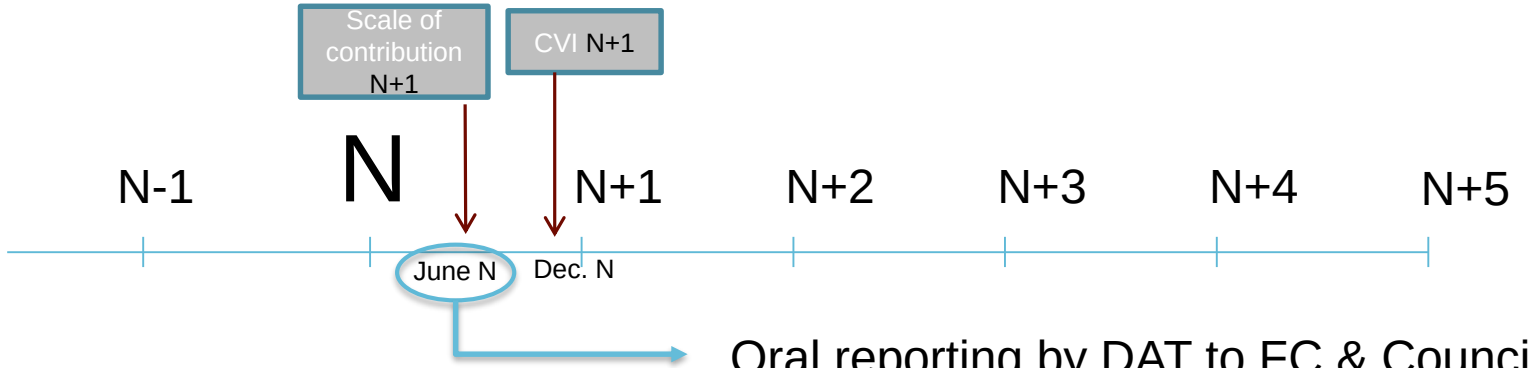
CERN Committees - Financial Planning & Project Reporting cycle



Courtesy: K. Pokorska

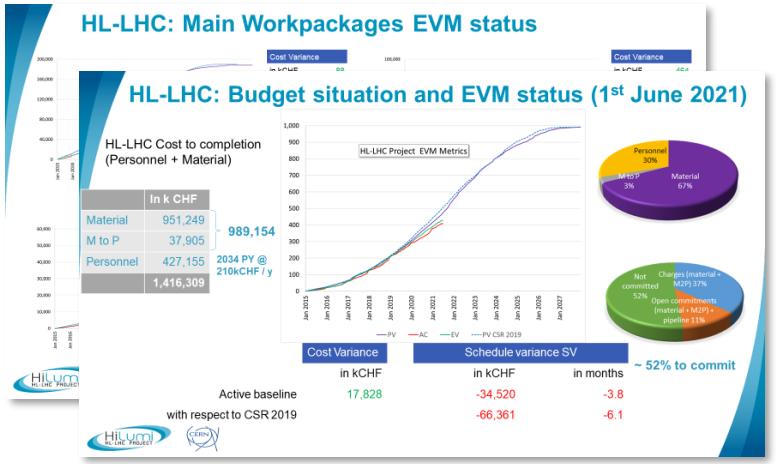
EVM in the HL-LHC Project : How is it connected to CERN Managerial and Financial processes?

CERN Committees - Financial Planning & Project Reporting cycle



Oral reporting by DAT to FC & Council

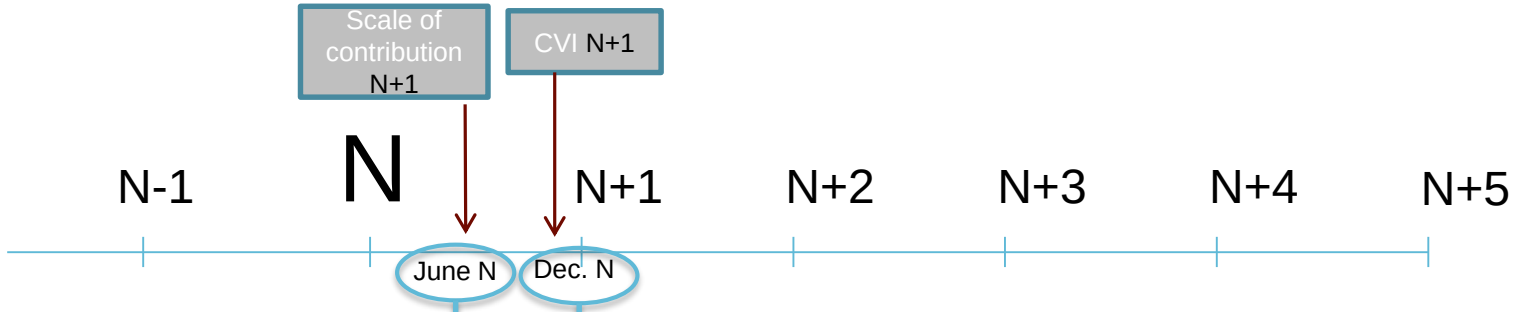
Project Reporting



Courtesy: K. Pokorska

EVM in the HL-LHC Project : How is it connected to CERN Managerial and Financial processes?

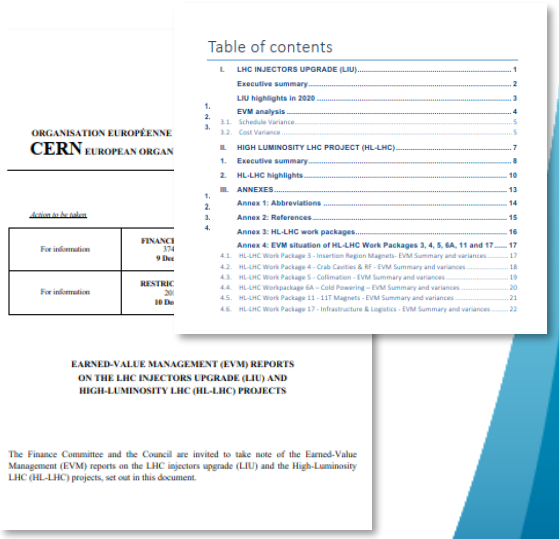
CERN Committees - Financial Planning & Project Reporting cycle



Oral reporting by DAT to FC & Council

Oral & Written reporting by DAT to FC & Council

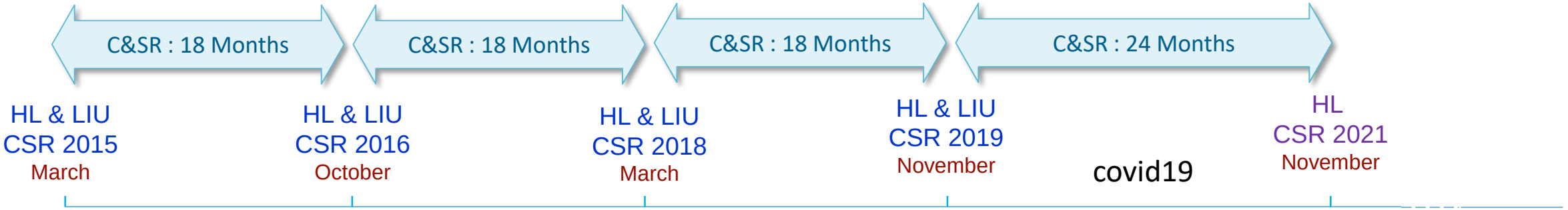
Project Reporting

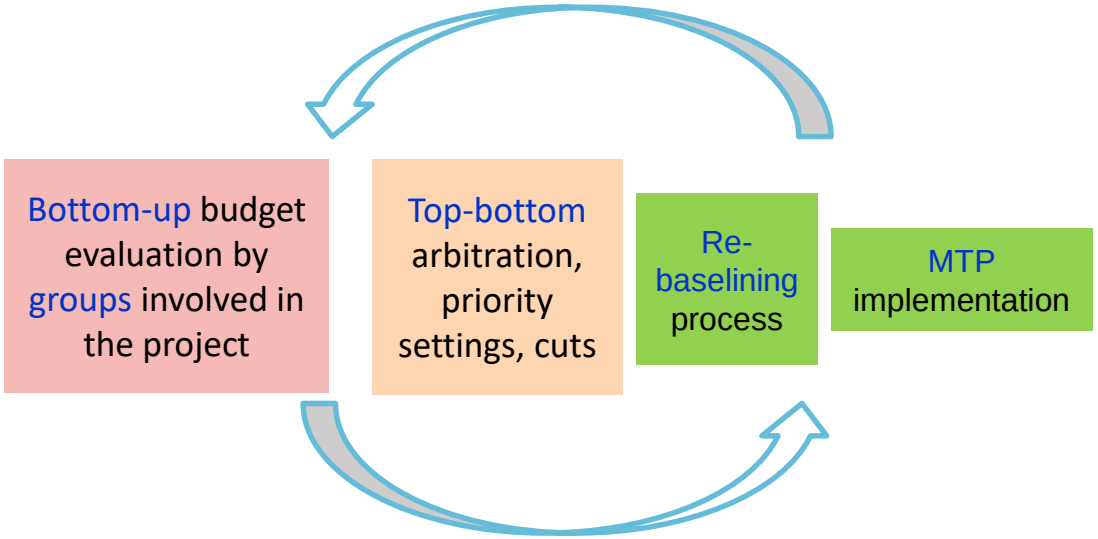


Courtesy: K. Pokorska

EVM in the HL-LHC Project : How is it connected to CERN Managerial and Financial processes?

HL-LHC Budgeting and Baseline Management Cycle





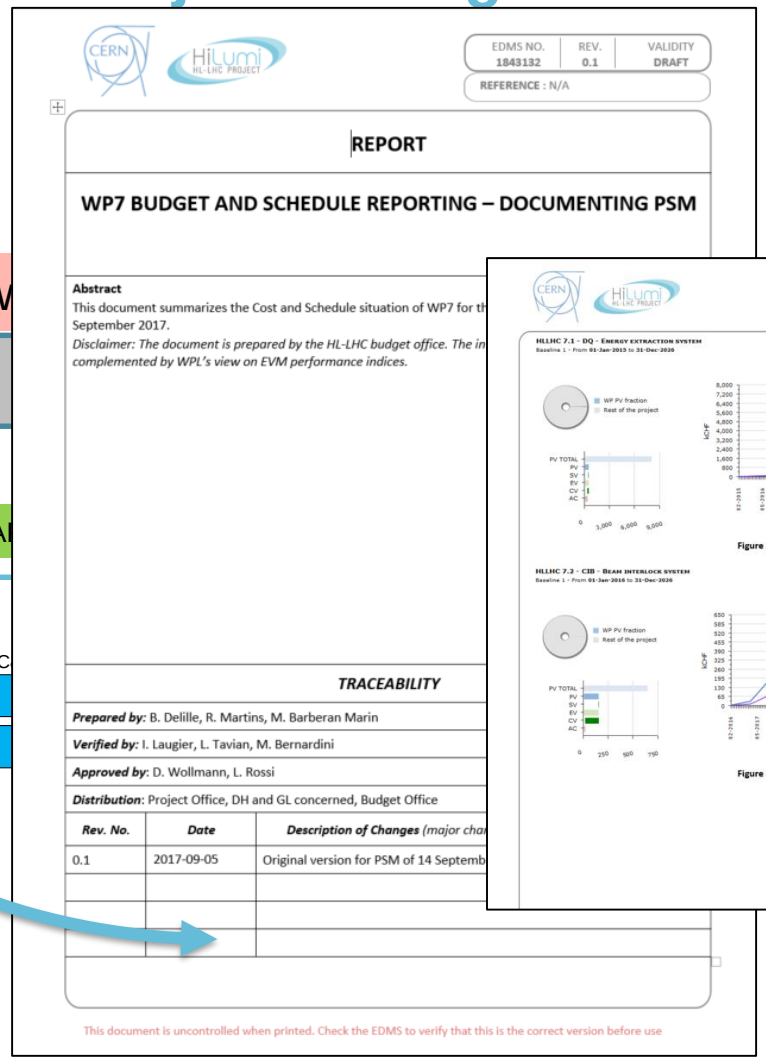
EVM in the HL-LHC Project : How is it connected to CERN Managerial and Financial processes?

HL-LHC Project Management & Project Steering Meetings

C&S Review

CERN Financial cycle

HL-LHC PSM



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REFERENCE : N/A

REPORT

WP7 BUDGET AND SCHEDULE REPORTING – DOCUMENTING PSM

Abstract

This document summarizes the Cost and Schedule situation of WP7 for th
September 2017.
*Disclaimer: The document is prepared by the HL-LHC budget office. The in
complemented by WPL's view on EVM performance indices.*

TRACEABILITY

Prepared by: B. Delille, R. Martins, M. Barberan Marin

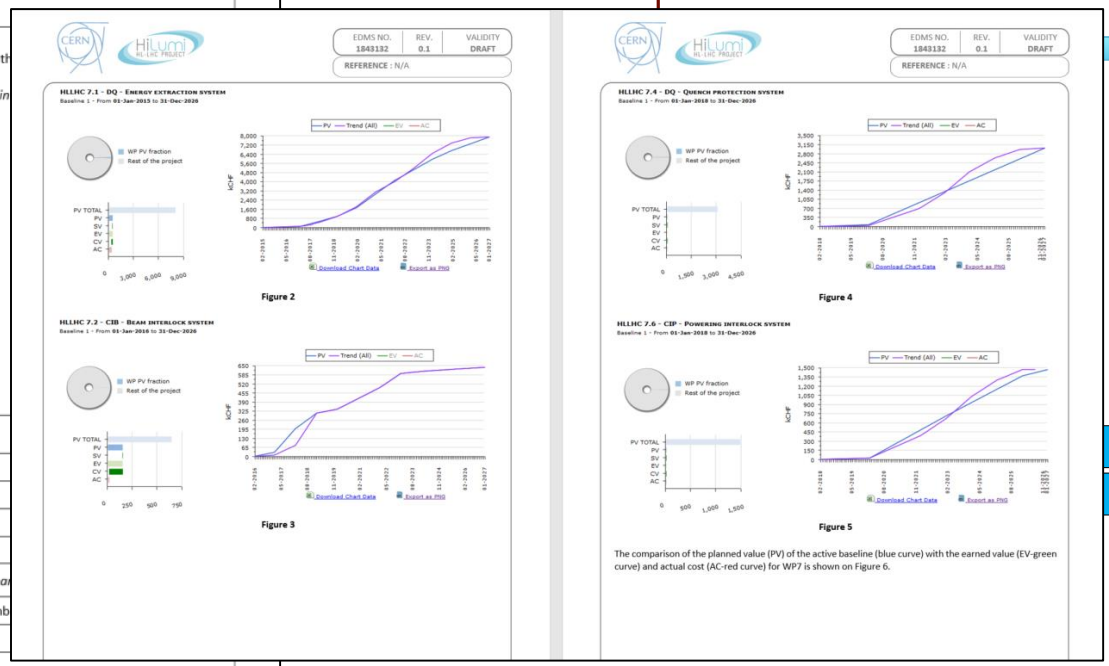
Verified by: I. Laugier, L. Tavian, M. Bernardini

Approved by: D. Wollmann, L. Rossi

Distribution: Project Office, DH and GL concerned, Budget Office

Rev. No.	*Date*	*Description of Changes (major cha*
0.1	2017-09-05	Original version for PSM of 14 Septemb

This document is uncontrolled when printed. Check the EDMS to verify that this is the correct version before use



HLLHC 7.1 - DQ - Energy extraction system

Figure 2

HLLHC 7.4 - DQ - Quench protection system

Figure 4

HLLHC 7.2 - CIB - Beam interlock system

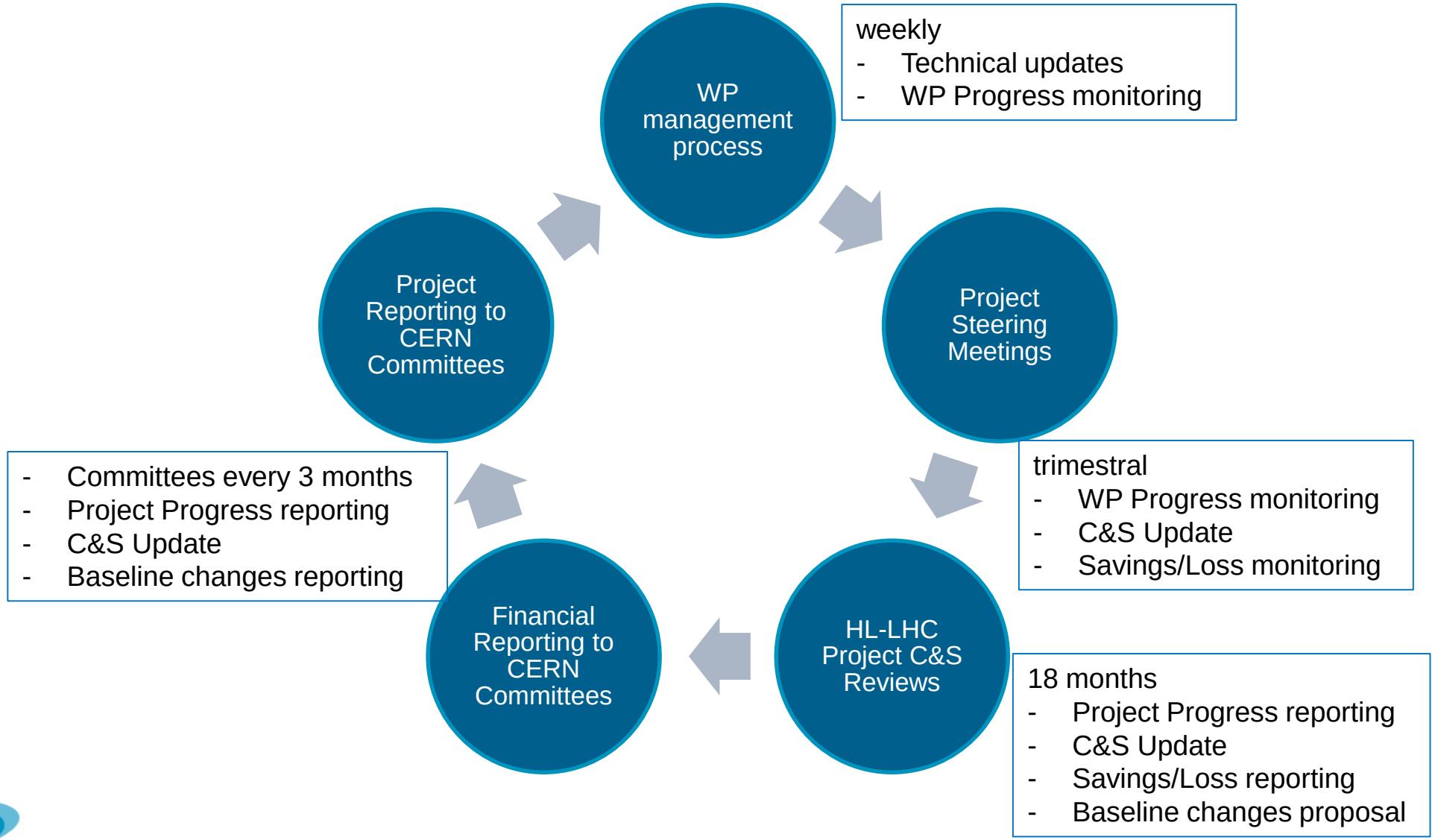
Figure 3

HLLHC 7.6 - CIP - Powering interlock system

Figure 5

The comparison of the planned value (PV) of the active baseline (blue curve) with the earned value (EV-green curve) and actual cost (AC-red curve) for WP7 is shown on Figure 6.

EVM in the context of the HL-LHC project
Providing input to



RISK: over cost estimate in MCHF and %

In MCHF	To be spent (M)	To be spent (M)
Budget to be spent (M)	435,162 MCHF	%
Mean	30,216 MCHF	6.94%
Lowest	25,644 MCHF	5.89%
Highest	34,598 MCHF	7.95%

Risk evaluation today shows a risk exposure of ~30MCHF

Over costs materialize **now**

Savings materialize **later***

*Savings can only be assessed at the closure of contracts – while contract is open, claims exposure is always present.

From the application of MonteCarlo analysis to risk exercise → H.Garcia Gavela@CSR21

Risk considerations

- **Risks figures** show the project is **under control,** but **vulnerable** to existing **global situation** (market, change of laws, etc)
- **Market** (**COVID** impact and **collateral effects**) increases **uncertainty; might have serious impact** in our **upcoming tenders**
- 60% of budget engaged and most of big procurements launched, HL-LHC Risk is less **linked** to the **maturity level/pricing/procurement** and more to **production nonconformities**, **Contract/Collaboration management** and **non-detected design problems**
- **Risk** from the **Collaborations not quantified**. N**o "direct cost"** effect (**full in-kind contributions**) but potentially **strong indirect impact** (retake activities, procurement of components, rework if nonconformities, delay on other activities)
- **Risk Response** from the Project to **mitigate cost**, **schedule** and/or **technical** risks following carefl monitoring by WPs and HLPO

Global funding breakdown

989.1 MCHF

- HLLHC 1 - Project management
- HLLHC 2 - Accelerator physics
- ⊞ HLLHC 3 - Magnets
- ⊞ HLLHC 4 - RF & Crab Cavities
- ⊞ HLLHC 5 - Collimation
- ⊞ HLLHC 6A - Cold Powering
- ⊞ HLLHC 6B - Warm Powering
- ⊞ HLLHC 7 - Machine protection
- ⊞ HLLHC 8 - Collider-Experiments Interface
- ⊞ HLLHC 9 - Cryogenics
- ⊞ HLLHC 10 - Energy deposition
- ⊞ HLLHC 11 - 11 T Dipole Magnets
- ⊞ HLLHC 12 - Vacuum
- ⊞ HLLHC 13 - Beam diagnostics & instrumentation
- ⊞ HLLHC 14 - Beam transfer & kickers
- ⊞ HLLHC 15 - Integration & (De-)installation
- ⊞ HLLHC 16 - IT String & Hardware commissioning
- ⊞ HLLHC 17 - Technical infrastructure
- ⊞ HLLHC 18 - Controls

HL

98.8 MCHF

- ⊞ HLLHC 3 - Magnets
- ⊞ HLLHC 4 - RF & Crab Cavities
- ⊞ HLLHC 5 - Collimation
- ⊞ HLLHC 6A - Cold Powering
- ⊞ HLLHC 6B - Warm Powering
- ⊞ HLLHC 7 - Machine protection
- ⊞ HLLHC 8 - Collider-Experiments Interface
- ⊞ HLLHC 9 - Cryogenics
- ⊞ HLLHC 10 - Energy deposition
- ⊞ HLLHC 11 - 11 T Dipole Magnets
- ⊞ HLLHC 12 - Vacuum
- ⊞ HLLHC 13 - Beam diagnostics & instrumentation
- ⊞ HLLHC 14 - Beam transfer & kickers

- ⊞ HLLHC 18 - Controls

HL-Cons

Including price escalation

Global funding breakdown

HL

989.1 MCHF

CERN-fund	In-kind*
HLLHC 1 - Project management	
HLLHC 2 - Accelerator physics	
HLLHC 3 - Magnets	HLLHC 3 - Magnets
HLLHC 4 - RF & Crab Cavities	HLLHC 4 - RF & Crab Cavities
HLLHC 5 - Collimation	HLLHC 5 - Collimation
HLLHC 6A - Cold Powering	HLLHC 6A - Cold Powering
HLLHC 6B - Warm Powering	
HLLHC 7 - Machine protection	HLLHC 7 - Machine protection
HLLHC 8 - Collider-Experiments Interface	HLLHC 8 - Collider-Experiments Interface
HLLHC 9 - Cryogenics	HLLHC 9 - Cryogenics
HLLHC 10 - Energy deposition	
HLLHC 11 - 11 T Dipole Magnets	
HLLHC 12 - Vacuum	
HLLHC 13 - Beam diagnostics & instrumentation	HLLHC 13 - Beam diagnostics & instrumentation
HLLHC 14 - Beam transfer & kickers	HLLHC 14 - Beam transfer & kickers
HLLHC 15 - Integration & (De-)installation	
HLLHC 16 - IT String & Hardware commissioning	
HLLHC 17 - Technical infrastructure	
HLLHC 18 - Controls	
868.2 MCHF	120.9 MCHF

HL-Cons

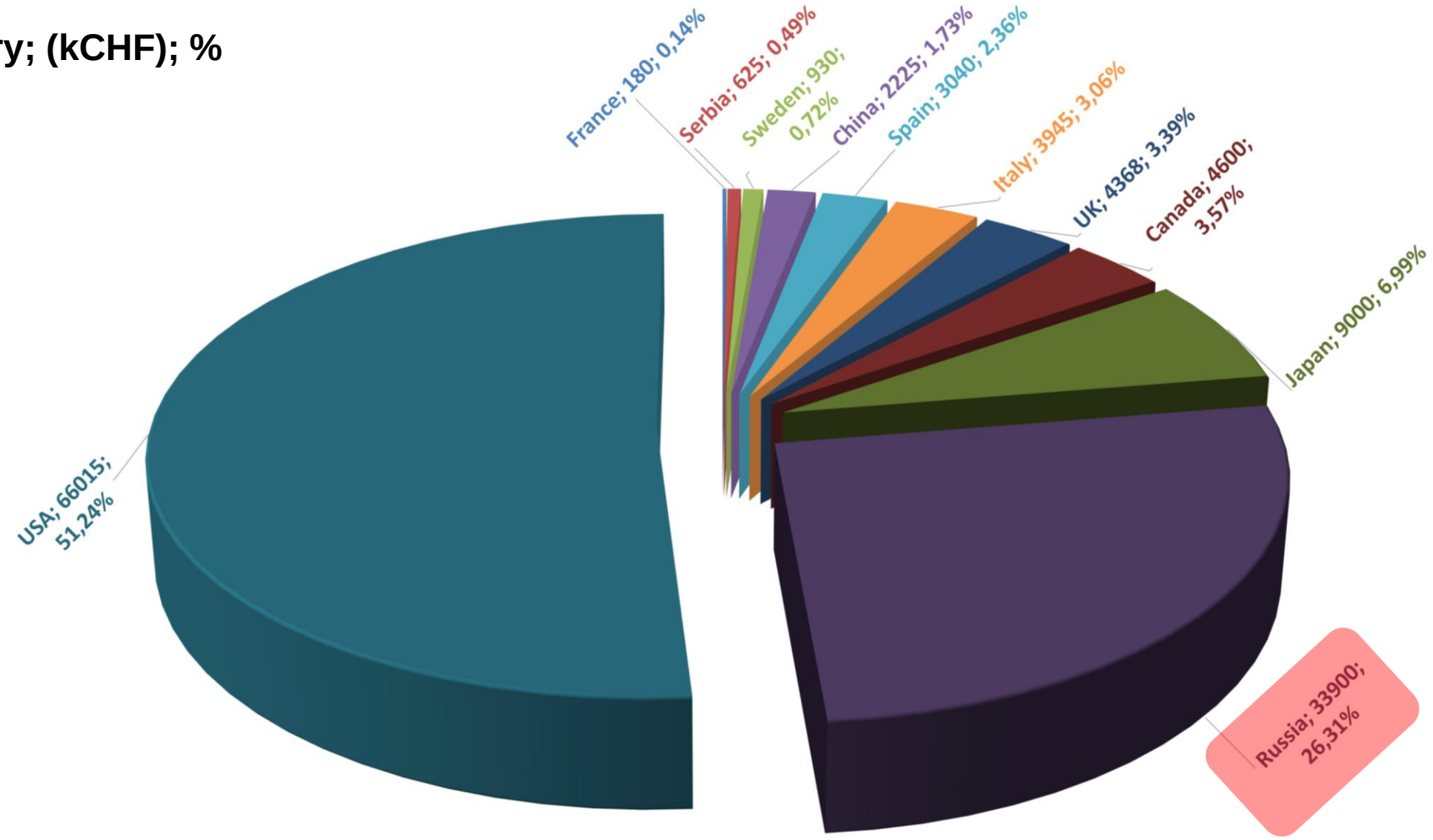
98.8 MCHF

CERN-fund	In-kind*
HLLHC 3 - Magnets	HLLHC 3 - Magnets
HLLHC 4 - RF & Crab Cavities	HLLHC 4 - RF & Crab Cavities
HLLHC 5 - Collimation	HLLHC 5 - Collimation
HLLHC 6A - Cold Powering	HLLHC 6A - Cold Powering
HLLHC 6B - Warm Powering	
HLLHC 7 - Machine protection	HLLHC 7 - Machine protection
HLLHC 8 - Collider-Experiments Interface	HLLHC 8 - Collider-Experiments Interface
HLLHC 9 - Cryogenics	HLLHC 9 - Cryogenics
HLLHC 10 - Energy deposition	
HLLHC 11 - 11 T Dipole Magnets	
HLLHC 12 - Vacuum	
HLLHC 13 - Beam diagnostics & instrumentation	HLLHC 13 - Beam diagnostics & instrumentation
HLLHC 14 - Beam transfer & kickers	HLLHC 14 - Beam transfer & kickers
84.8 MCHF	14.0 MCHF

* From CERN core-value

Graphical summary of the in-kind contributions

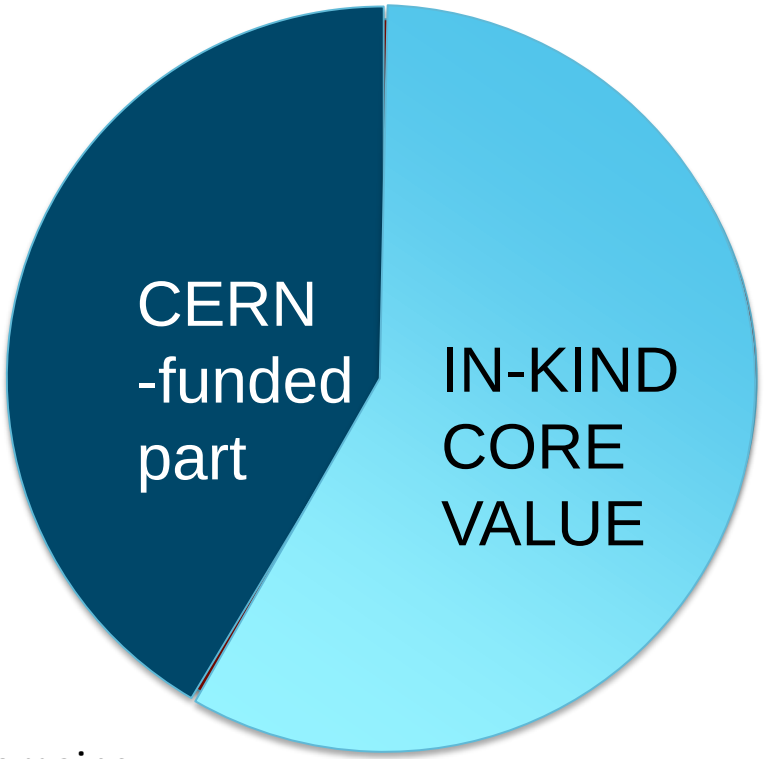
Country; (kCHF); %



Core value and In-Kind value

This defines in-kind value

CORE VALUE
=
Equivalent cost for CERN to execute the full extent of the scope



In-kind core value is what remains from the core value estimate, when we subtract what CERN funds

*Proportion for illustration purpose only

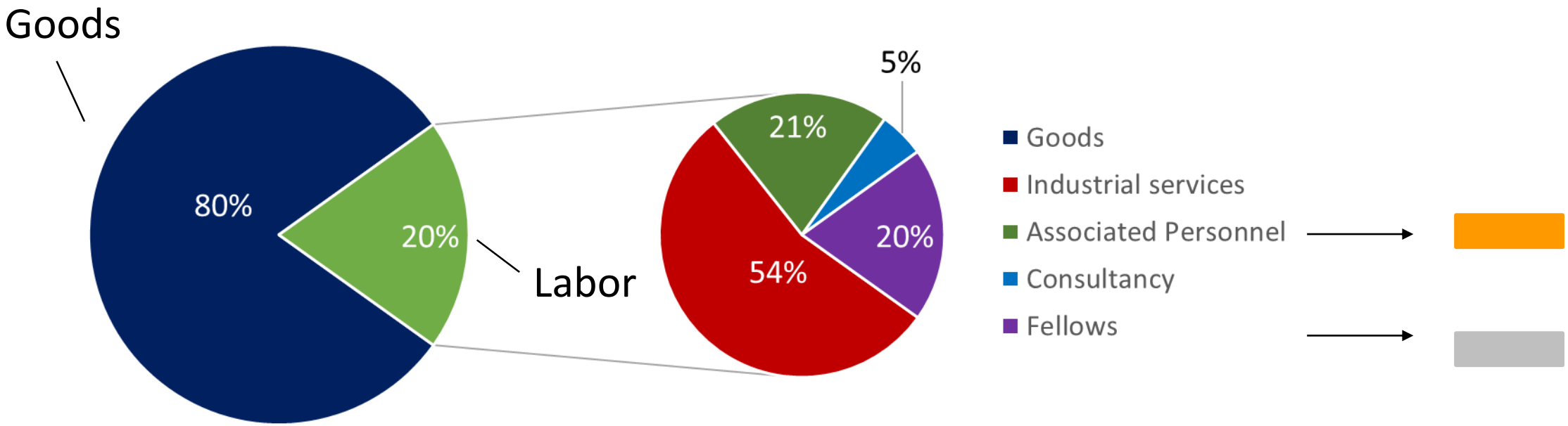
In-kind Collaborations

TOTAL in-kind ~ 129 MCHF (CORE COST)

See talk by Beniamino di Girolamo for more details

	COUNTRY	Institute	Brief description of the collaboration
Signed	France	CEA	Thermal Design of Superconducting High Field Magnets at CERN
	UK	Manchester	Beam instrumentation
	UK	Manchester	Cold powering: DFBX for String
	UK	ASTeC+Dundee	Laser treatment prototype (LESS)
	Italy	INFN	High-order corrector magnets + prototypes
	Spain	CIEMAT	Nested orbit correctors + prototypes
	China	IHEP	D2 Correctors
	Sweden	Uppsala Univ.	Cold testing of corrector magnets and crab cavities
	Japan	KEK	D1 magnet model and cold mass
	Italy	INFN	D2 model + prototype+ Magnet
	USA	Several	Crab Cavities
	USA	Several	Triplet magnets
	Canada	TRIUMF	RFD Crab-cavities cryomodules
not yet signed	Sweden	Uppsala Univ.	DFHM and DFHX 8+2 units
	UK	SOTO	DFM and DFX 8+2 units
	UK	ASTeC+Lancaster	DQW Crab-cavities cryomodules
	UK	LIV+RHUL	Beam instrumentation EO-BPM
	UK	Liverpool	Beam Instr. For Hollow e-lens
	UK	Dundee	Laser treatment final (LESS)
	Serbia	Ministry	Magnets and CC jacks
signed not yet funded	Russia	BINP	TAXS and TAXN
	Russia	BINP	Current leads matching section and inner triplets
	Russia	BINP	Low impedance collimators (12 units) + IR collimators (28 units)
	Russia	BINP	Solid State RF powering (replacing IOT)
	Russia	BINP	BPM Mechnics (20+28 units)
	Russia	Protvino	Ionisation chambers for SPS and LHC systems for HL-LHC beams (1000 units)
	Russia	MEPhI	HF-HOM and HOM Couplers and Filed Antennas
	Russia	BINP	LHC Kickers and Dump
	Russia	BINP	Hollow e-lens
	Russia	PNPI/Protvino	Crystal collimation for ions

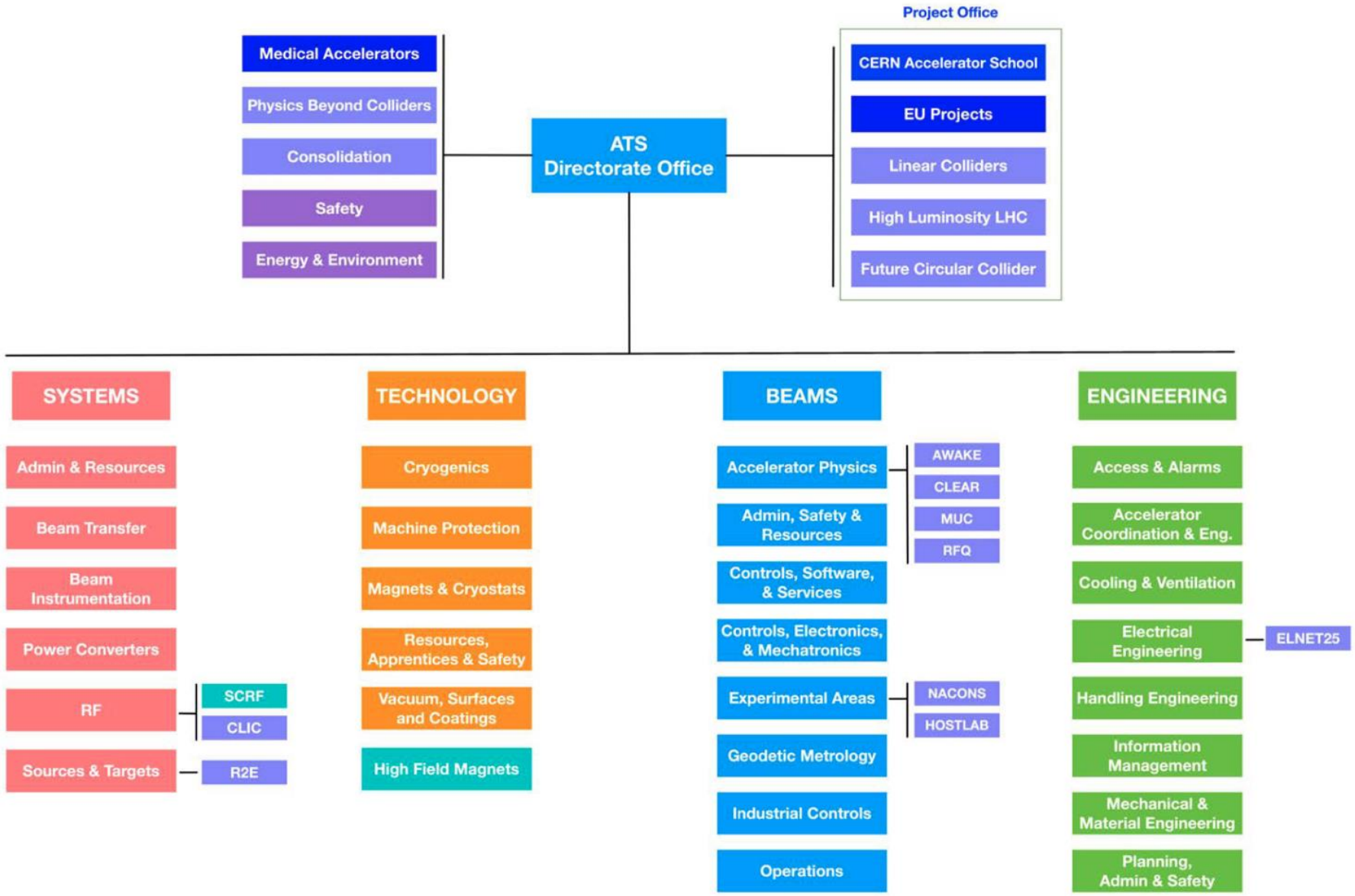
Budget breakdown by resource



Labor in CERN's budgeting jargon:

M4P: Money-for-Personnel
Includes
Industrial services and contracts
MPA Associated personnel
Fellows

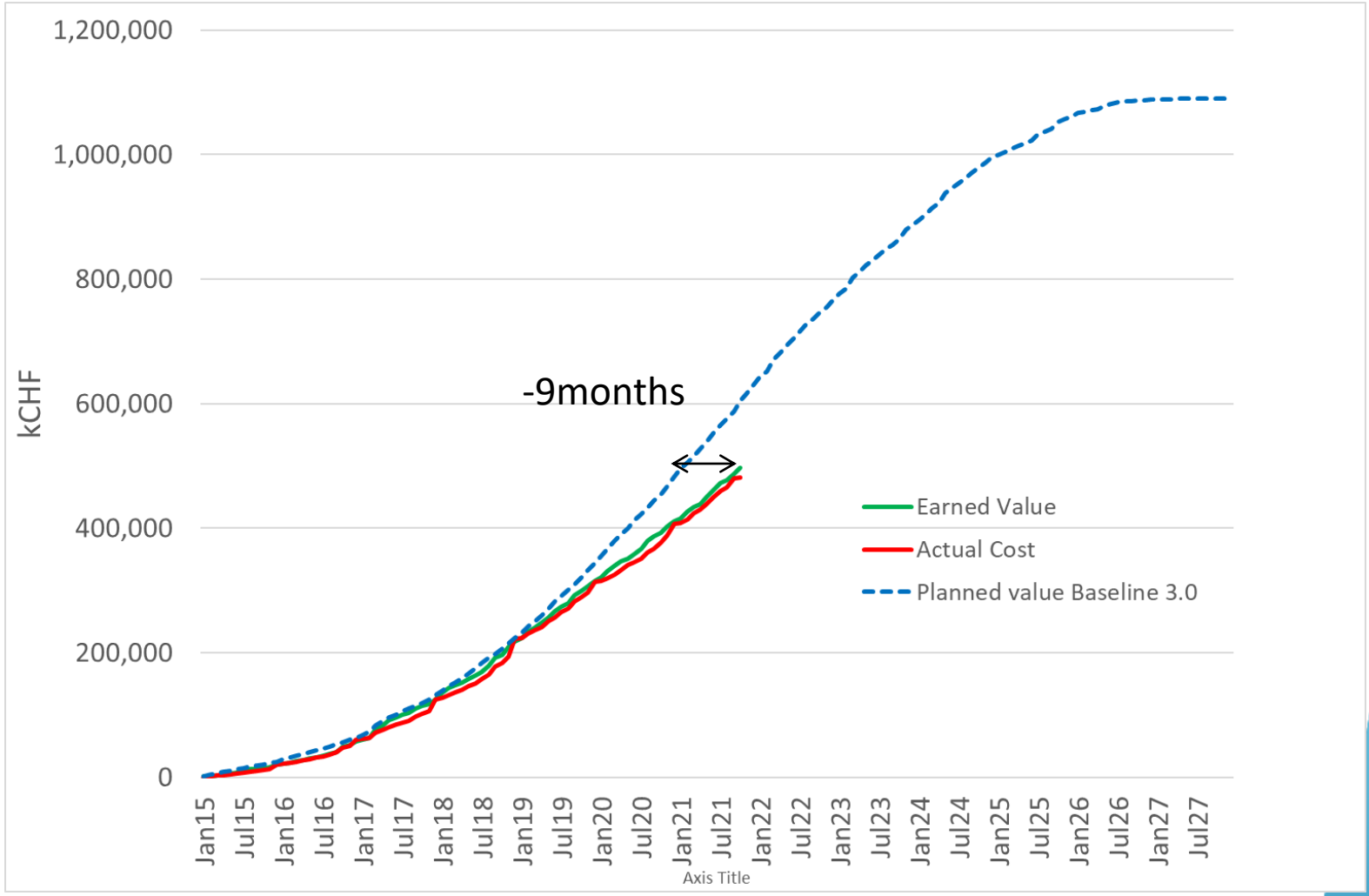
ATS


Medical Accelerators
Physics Beyond Colliders
Consolidation
Safety
Energy & Environment
ATS
Directorate Office
Project Office
CERN Accelerator School
EU Projects
Linear Colliders
High Luminosity LHC
Future Circular Collider
SYSTEMS
Admin & Resources
Beam Transfer
Beam Instrumentation
Power Converters
RF
SCRF
CLIC
Sources & Targets
R2E
TECHNOLOGY
Cryogenics
Machine Protection
Magnets & Cryostats
Resources, Apprentices & Safety
Vacuum, Surfaces and Coatings
High Field Magnets
BEAMS
Accelerator Physics
AWAKE
CLEAR
MUC
RFQ
Admin, Safety & Resources
Controls, Software, & Services
Controls, Electronics, & Mechatronics
Experimental Areas
NACONS
HOSTLAB
Geodetic Metrology
Industrial Controls
Operations
ENGINEERING
Access & Alarms
Accelerator Coordination & Eng.
Cooling & Ventilation
Electrical Engineering
ELNET25
Handling Engineering
Information Management
Mechanical & Material Engineering
Planning, Admin & Safety

11

EVM today, compared to BL 3.0

	[MCHF]
Budget at completion	1087.9
In-kind budget	128.8
Earned Value	496.9
Actual Cost	481.2
	[months]
Schedule variance @3.0	-8.8



Planned value:
The work to do, expressed in estimated budget to complete it

Earned value:
The work done, expressed in estimated budget to complete it

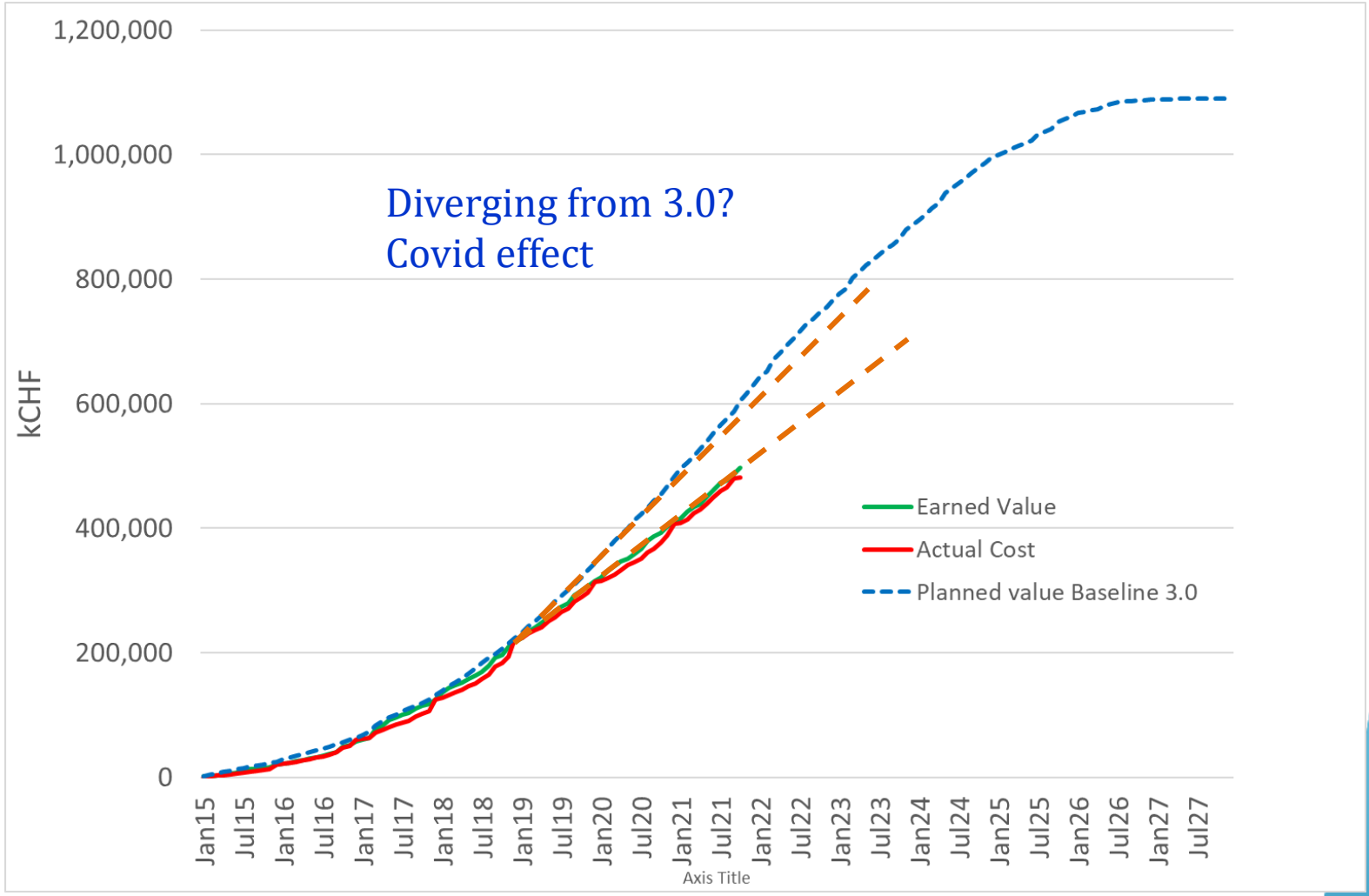
Actual Cost:
The real cost of the work done

Effect of covid on planned value

	[MCHF]
Budget at completion	1087.9
In-kind budget	128.8
Planned Value	527.8
Earned Value	496.9
Actual Cost	481.2
Uncommitted	524.7
Material Budget remaining to spend	432.9
Cost variance [kCHF]	15,700
	[months]
Schedule variance	-2.65

Let's take one step back

Comparison of EV and the PV of baseline 3.0



Effect of covid on planned value

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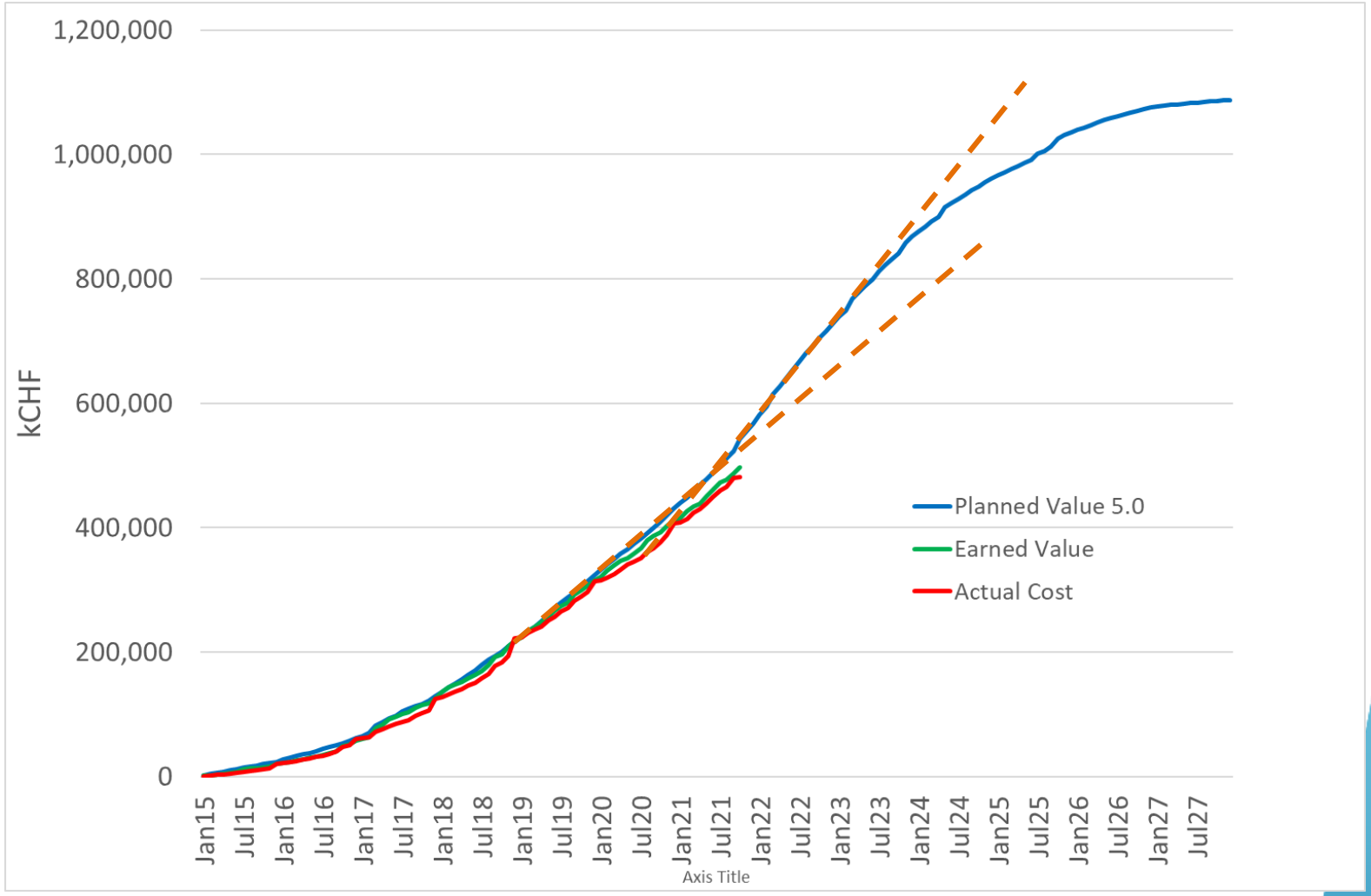
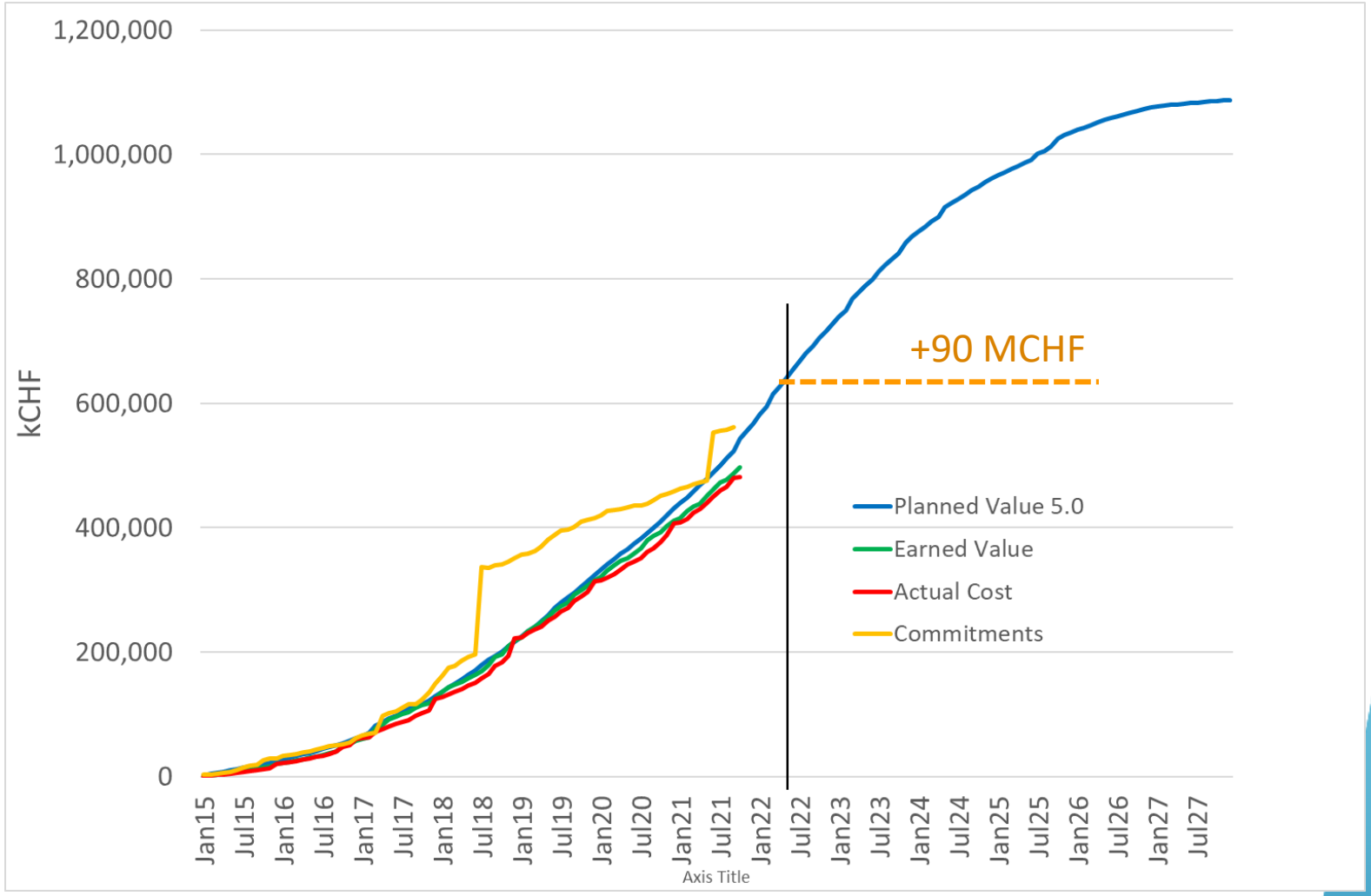


Committments

	[MCHF]
Budget at completion	1087.9
In-kind budget	128.8
Planned Value	527.8
Earned Value	496.9
Actual Cost	481.2
Uncommitted	524.7
Material Budget remaining to spend	432.9
Cost variance [kCHF]	15,700
	[months]
Schedule variance	-2.65



At next 3 FCs, **90 MCHF** more will be committed

→H.Garcia Gavela, Procurement

The main concepts of EVM

BAC Budget at Completion

What you plan to spend for 100% of the work to be completed

PV Planned Value

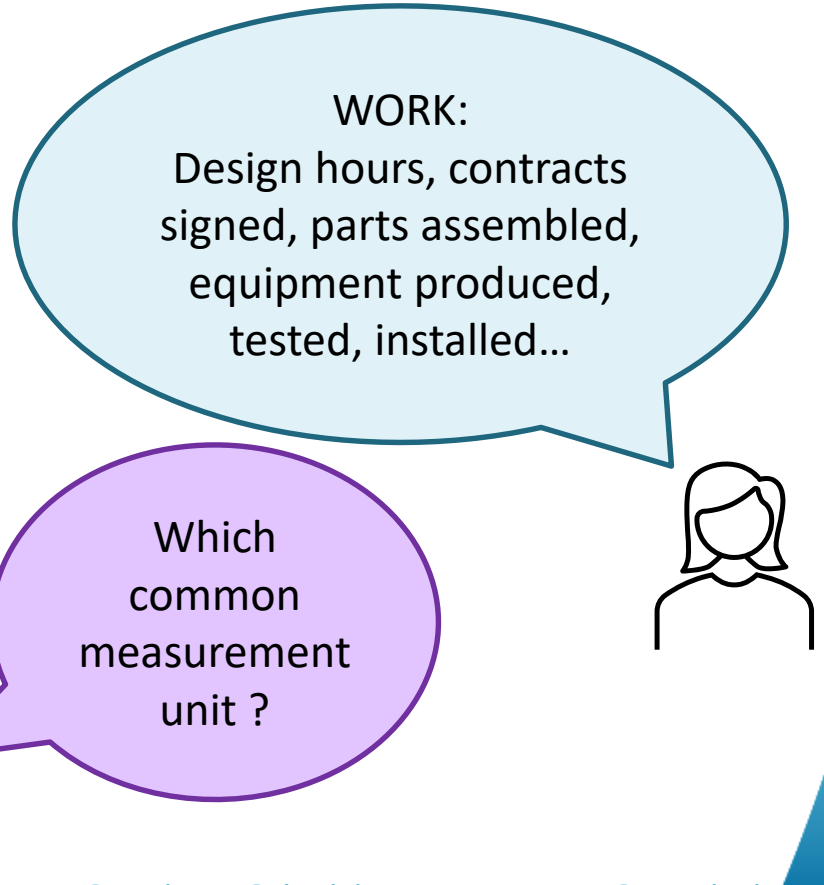
Work planned to be completed to date

EV Earned Value

Work actually completed to date

AC Actual Cost

Real **cost** of work performed as of today



The main concepts of EVM

BAC Budget at Completion

What you plan to spend for 100% of the work to be completed

PV Planned Value

Work planned to be completed to date **(in units of cost estimated to complete it)**

EV Earned Value

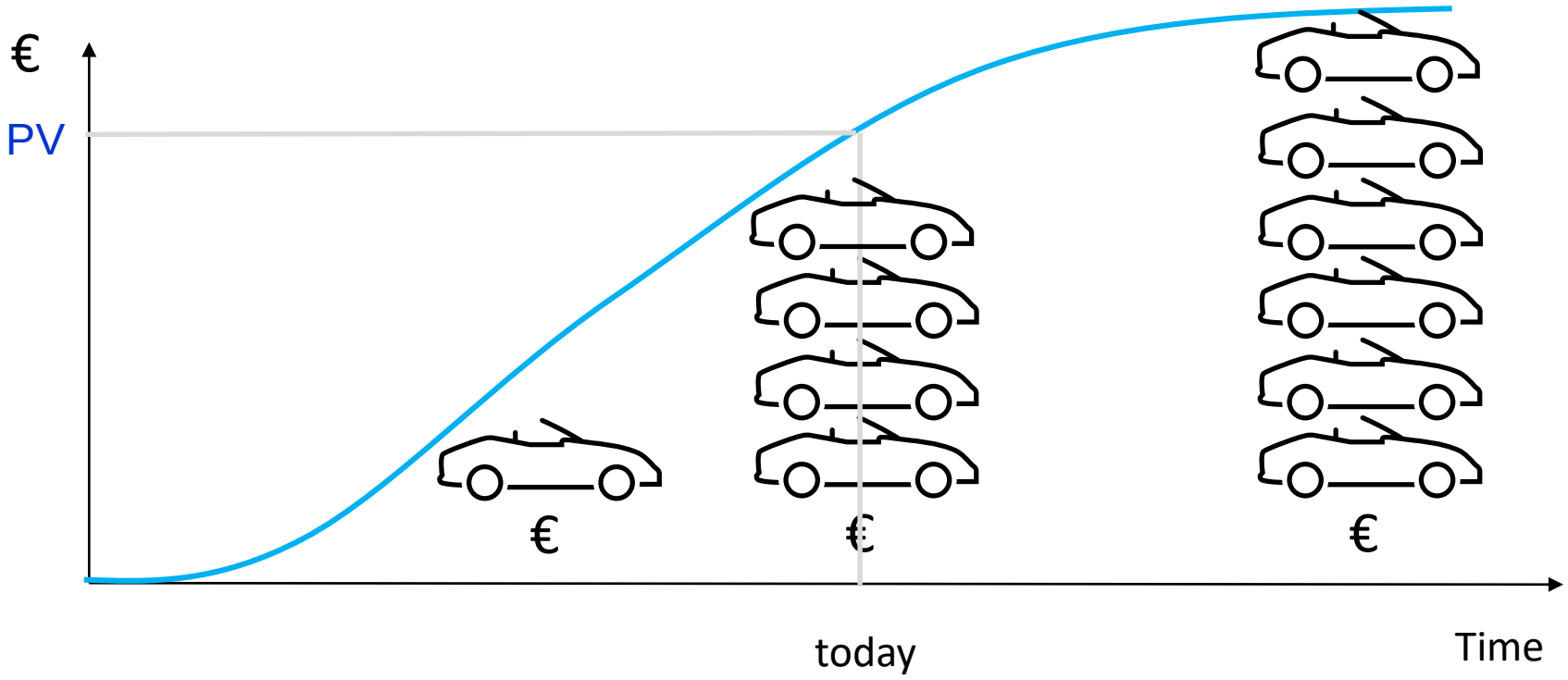
Work actually completed to date **(in units of cost estimated to complete it)**

AC Actual Cost

Real **cost** of work performed as of today

What is Planned Value

Planned value is the amount of work **which was originally planned to be completed** to date, expressed in the monetary terms of estimated cost required and approved to complete it

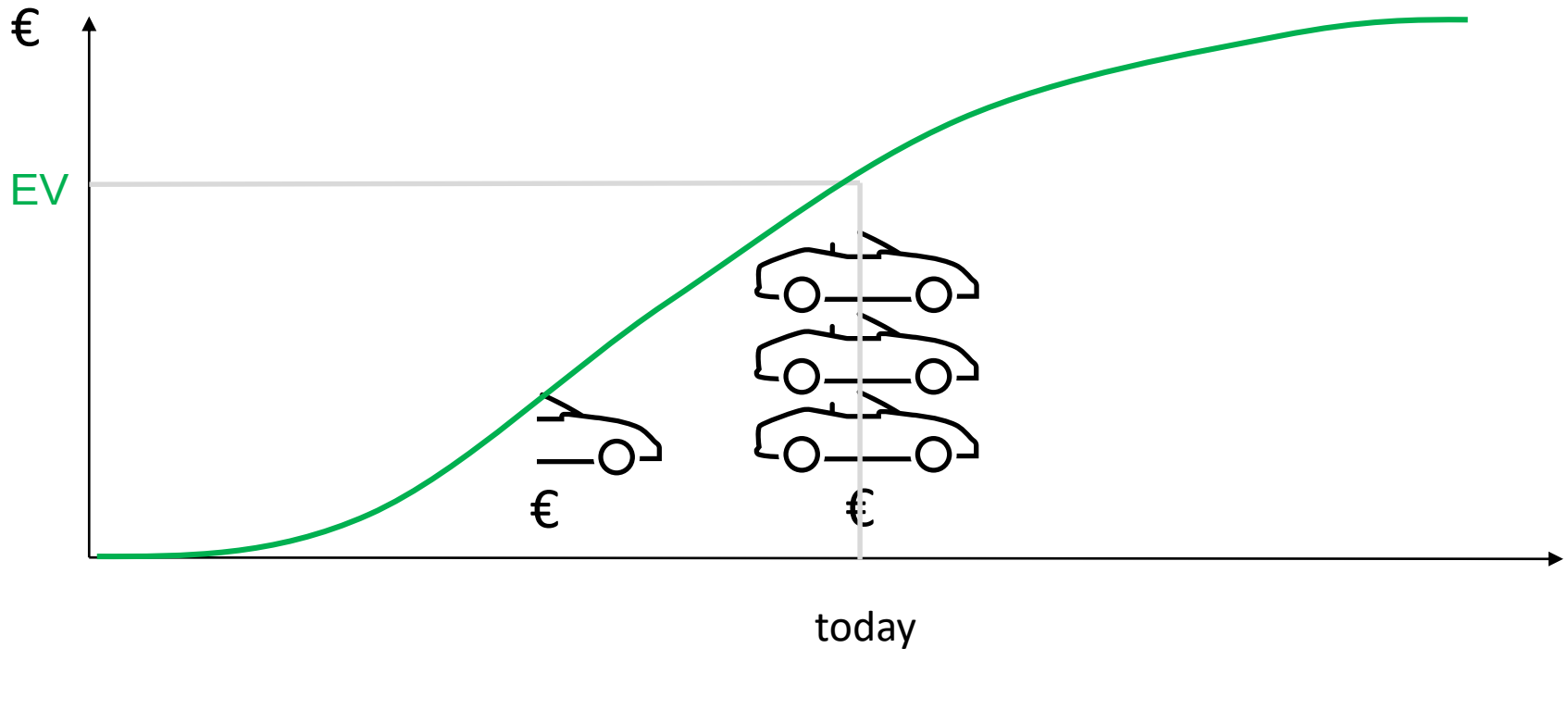


(PV) planned value

Approved budget for work scheduled to be completed at a specif date

What is Earned Value

Earned value is the amount of work **completed** to date, expressed in the monetary terms of estimated cost required to complete it



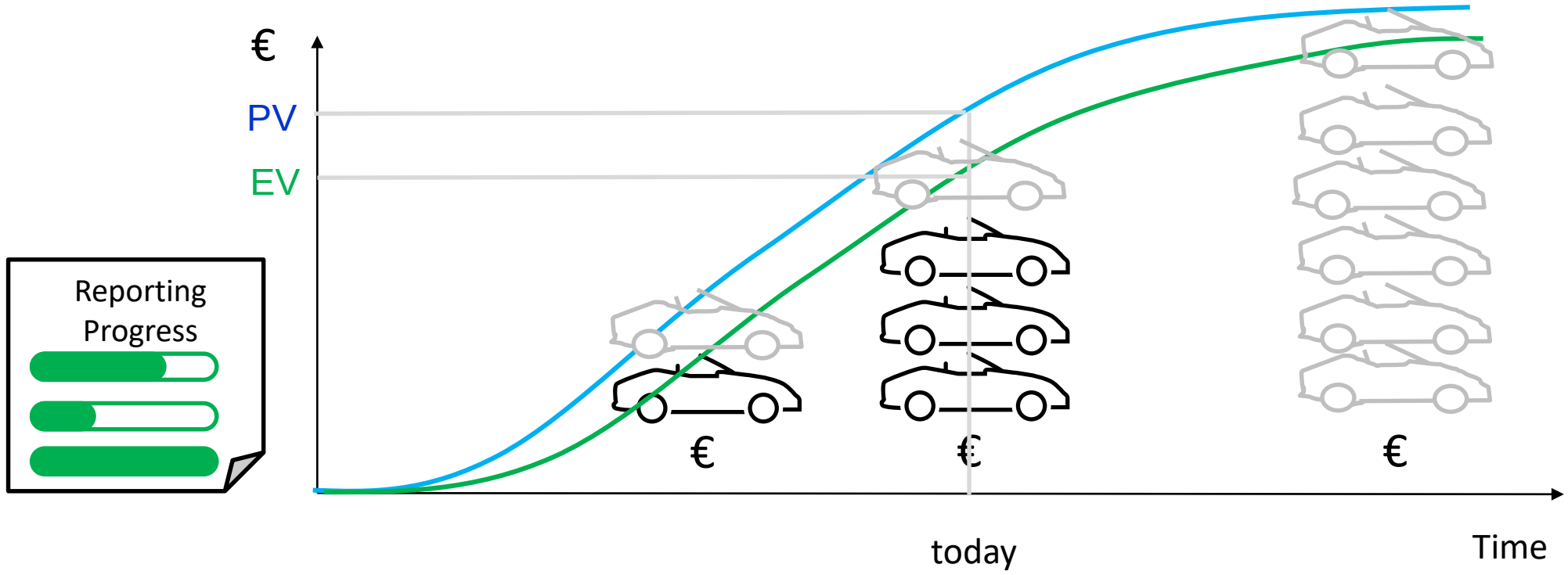
Earned
..means:

Received
Done
Made
Obtained
Collected
Brought in

NOT !
…ordered
…spent

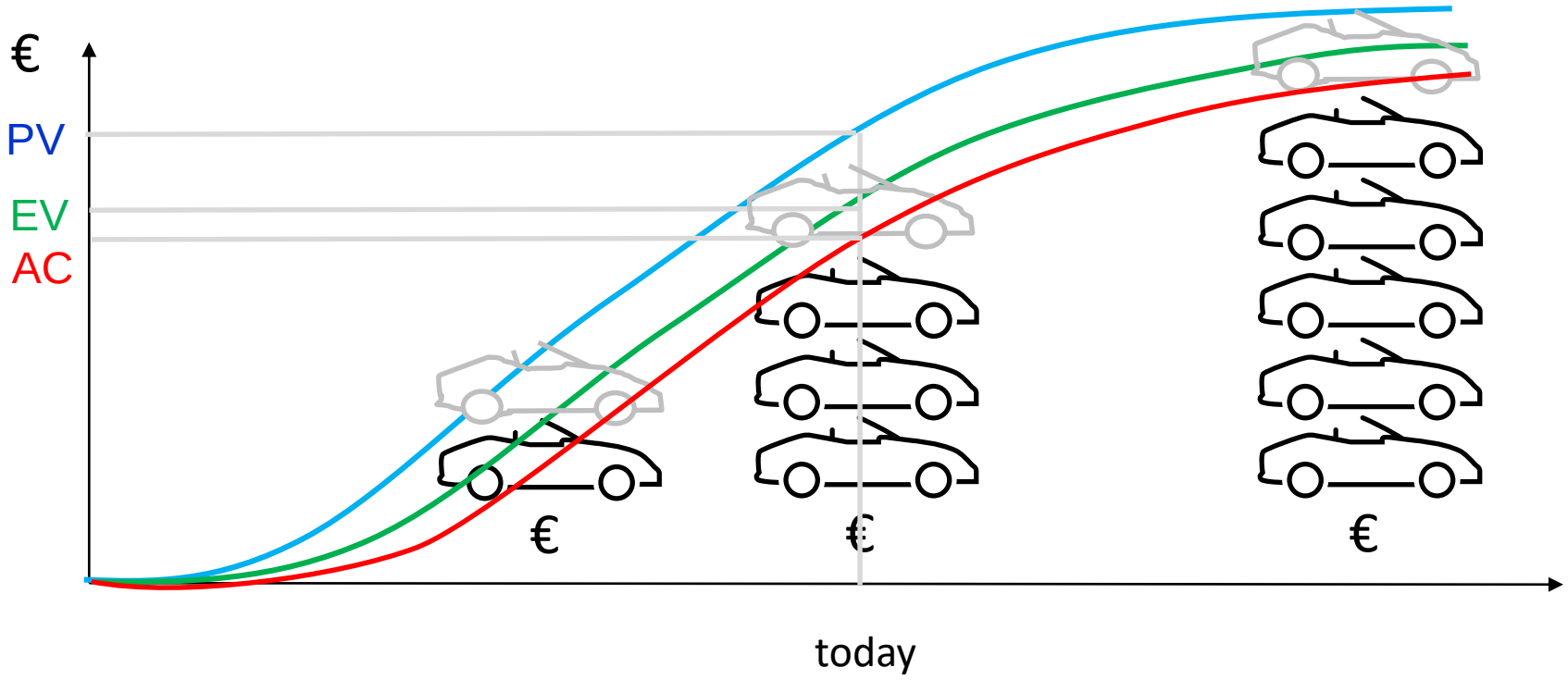
What is Earned Value

Earned value is the amount of work **completed** to date, expressed in the monetary terms of estimated cost required to complete it

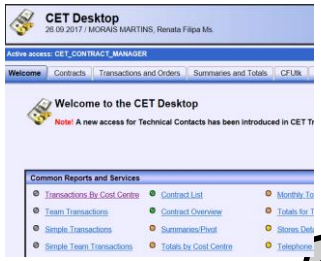


What is Actual Cost

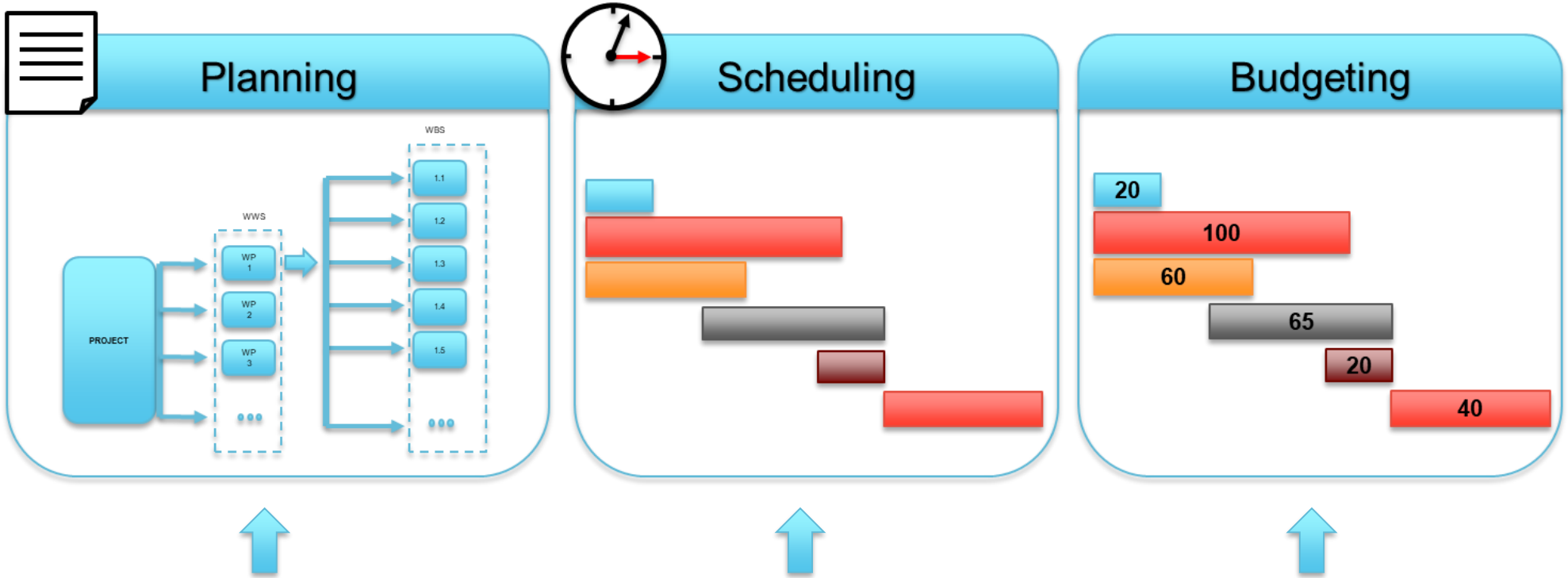
Actual Cost is **the real cost** of work **actually done** to date



Accounting System



Plan, Schedule and Budget work



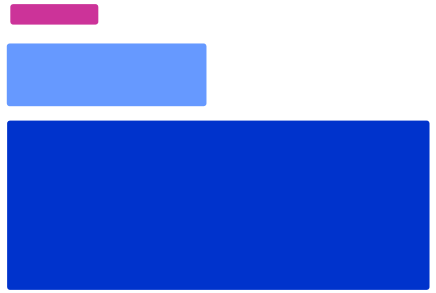
WBS

Gantt chart
Rolling wave planning

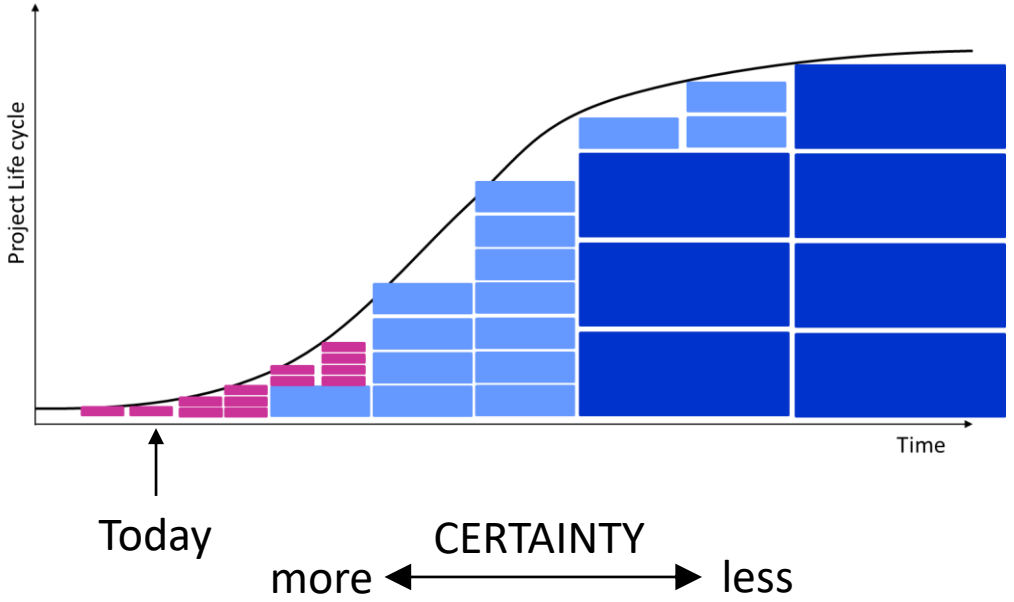
Estimates
DR's
Labour, hours…

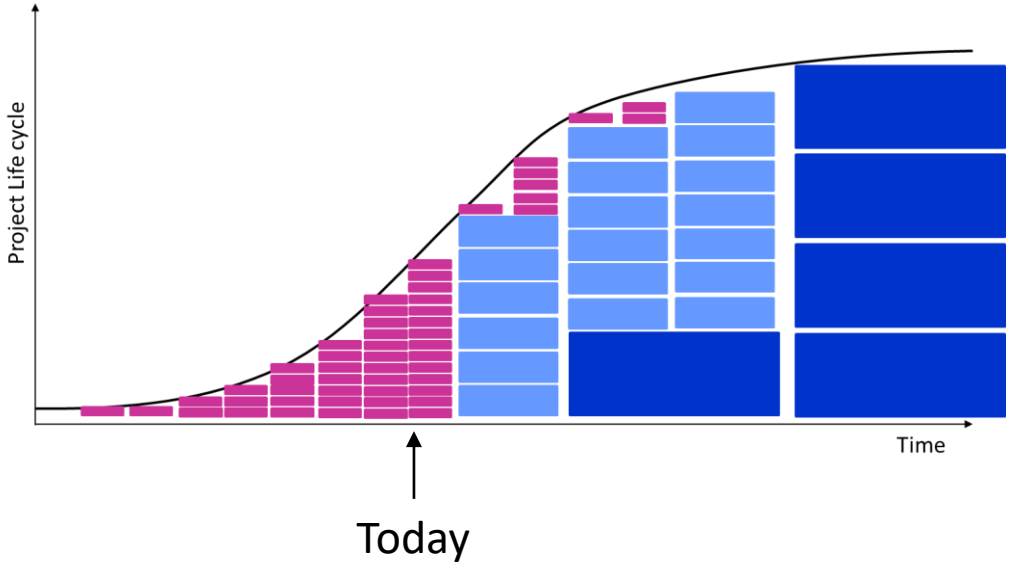
“Rolling” wave planning

workunit

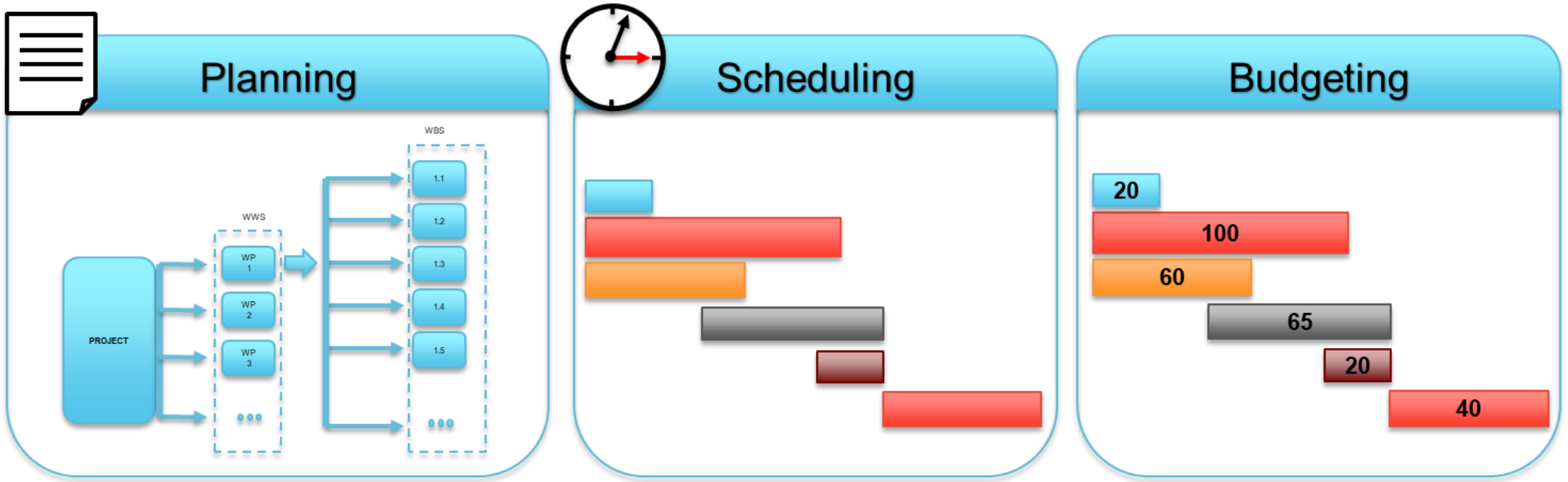


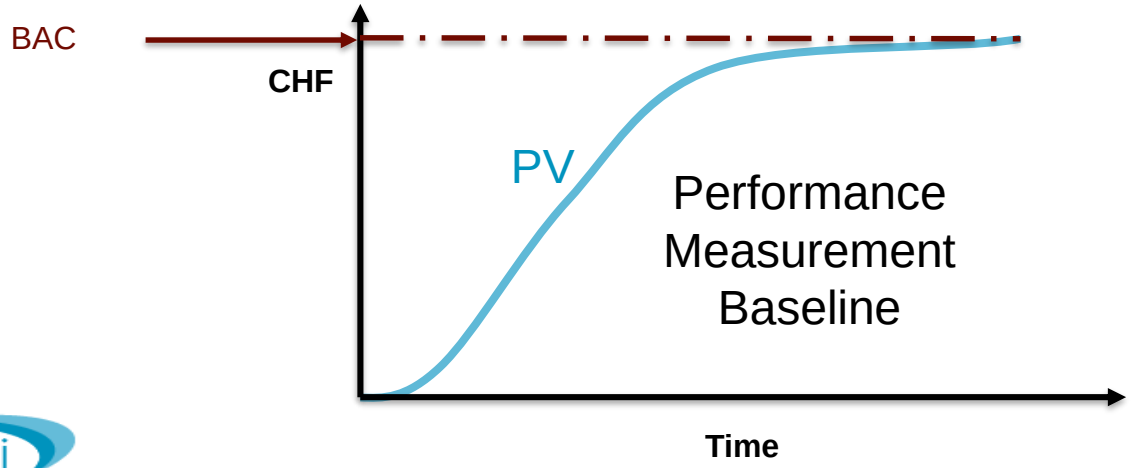
Increasing level of detail as time approaches to activity planned date





Plan, Schedule and Budget work





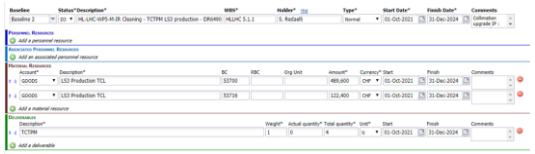
(PV) planned value

Work planned in unit of approved budget, to complete at a specif date

(BAC) Budget at completion

Total budget originally planned to spend on the project.

EVM Metrics - recap



- **PV Planned Value** : weighted linear distribution of the resources between the deliverables in a workunit
- **EV Earned Value** : based on the technical progress report made on the deliverables *("deliverable oriented")*
- **AC Actual Cost** : taken from the financial system at CERN (CET) every day, based on charged on Budget Codes

Cost and schedule variances are defined by PV, EV, AC:

Are we on schedule?	**Schedule variance**	**SV=EV-PV**
Are we spending what foreseen?	**Cost variance**	**CV=EV-AC**

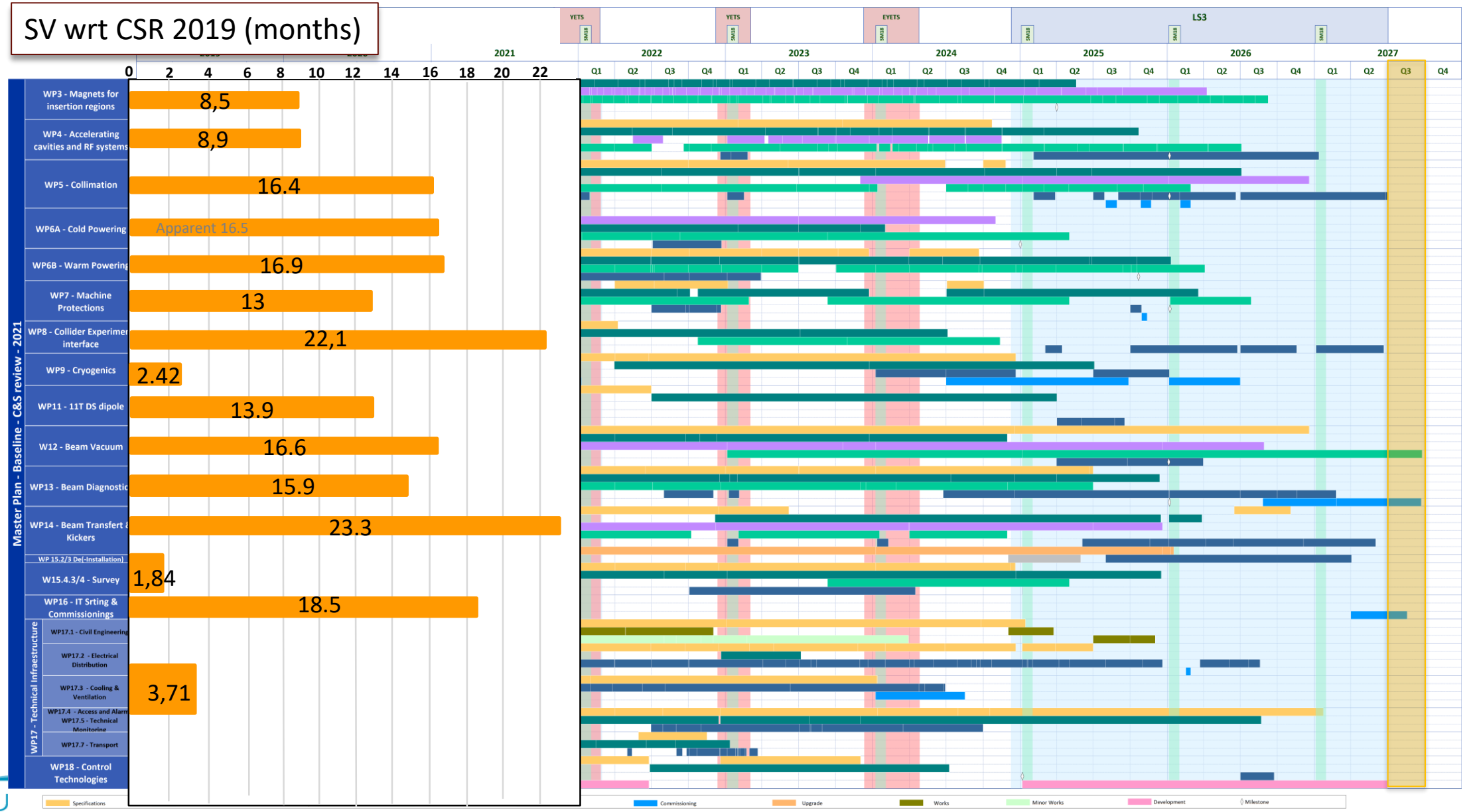
Main changes on deliverables for LS3 - CSR2019 to CSR2021

Only last of the series considered, precision 3 months

WP	Deliverable	CSR2019	CSR2021	Months
WP3	MQXFA	End Q1/2025	End Q3/2025	6
	MQXFB	End Q4/2024	End Q1/2026	18
	Corrector package	End Q4/2022	End Q3/2024	21
WP4	RFD	End Q3/2024	End Q4/2025	15
	DQW	End Q4/2024	End Q4/2025	12
	Power amplifiers	End Q3/2023	End Q2/2025	21
WP5	Collimators	End Q2/2024	End Q4/2025 to end Q2/2026	18-24
	Hollow e-lens	End Q1/2024	End Q3/2025	18
WP6A	DFHM+link	End Q1/2024	End Q3/2024	6
WP6B	2kA	End Q4/2023	End Q2/2025	18
	14kA	End Q2/2024	End Q2/2025	12
WP7	QDS, EE, PIC	End Q4/2024 end Q2/2025	End Q1/2026	9-12
WP9	Refrigeration	End Q4/2023	End Q1/2024	3
WP14	MKBH	End Q1/2024	End Q1/2026	24
	Dump	End Q1/2024	End Q2/2025	15

Master Schedule: schedule variance on EVM

SV wrt CSR 2019 (months)



UPCOMING cost/scope changes (~18 months)

Over costs	Amount	Comment
Pending missing scopes	3,500	
Tangible over-costs (c1)	9,400	Including **3 MCHF** covid claims, additional support SM18 Market price increase **not included** (covid impact) → H.Garcia Gavela@CSR21
Potential over-costs (c2)	23,000	Ir … e of Fellowships
	36,300	

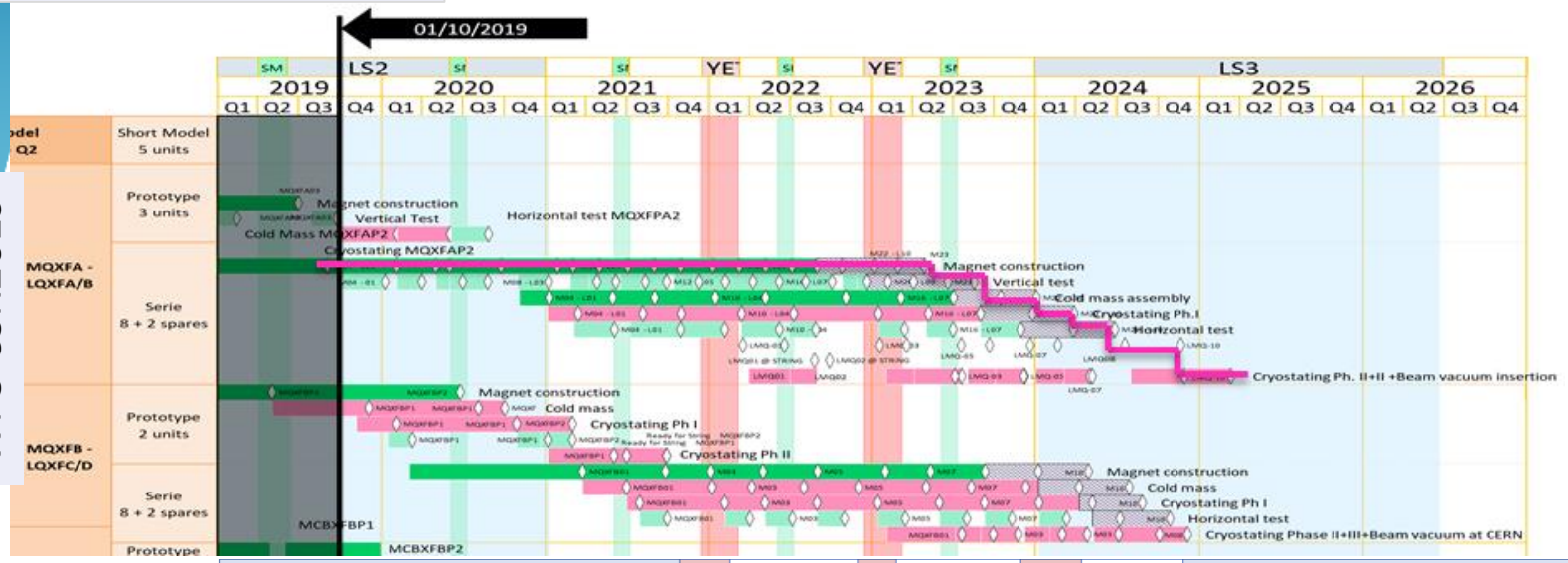
Savings		Amount	C
Tangible savings	(c1)	3,200	S … at closure
Potential savings	(c2)	24,600	Ir … eduction of claims
		27,800	

Descoping		Amount	Comment
Agreed	6,100	2,400	Several in WP6B, WP7, WP9, WP13 see Top descoping opportunities

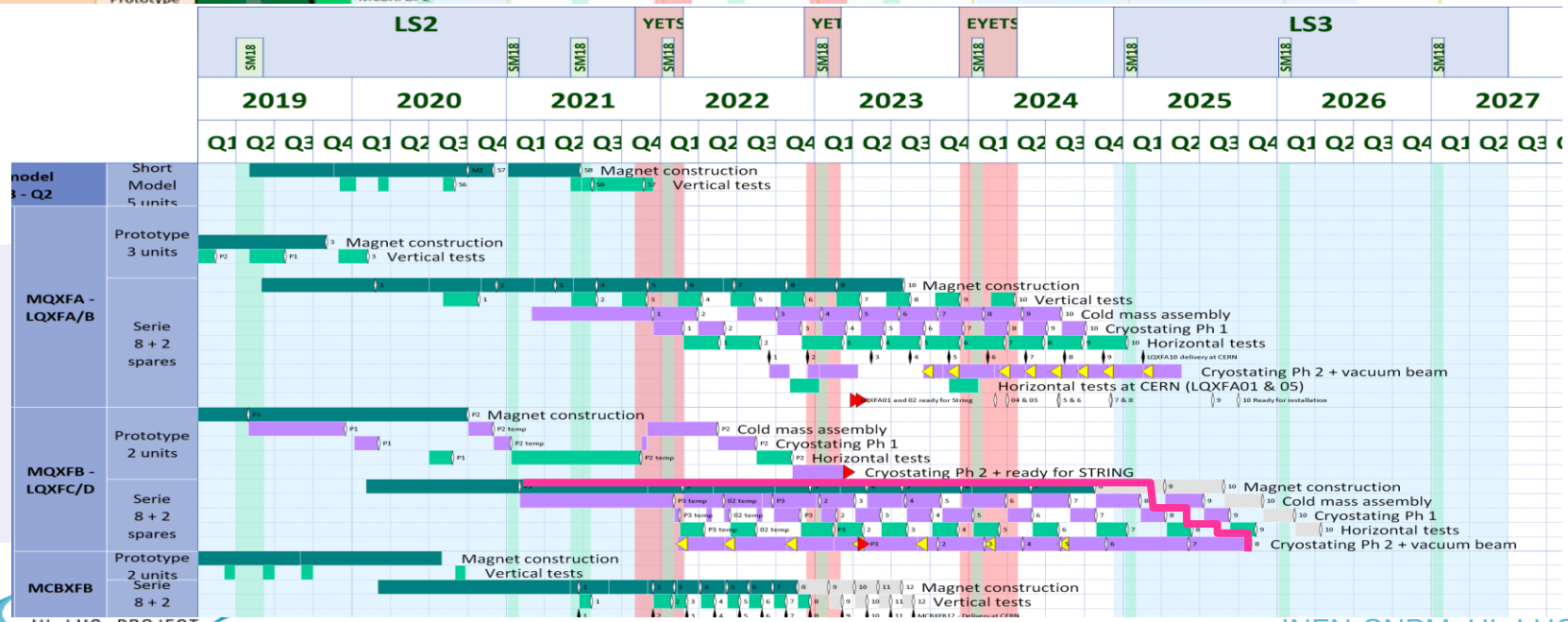
Confirmed	+ 8.1
Upcoming	+ 8.5
Descoping	- 2.4
=	14.2

AUP promised date versus success oriented date

WP3 CSR2019



WP3 CSR2021



R9 : In the CERN master schedule, make explicit float of in-kind contributions visible

In-kind contributions scheduling by AUP <u>now</u> discerns:

- Promised delivery dates (contractual)
- <u>Success oriented</u> delivery dates

Real critical path now visible

→ see G.Apollinari, AUP

Covid impact on cost

Covid **direct** impact (kCHF)	Civil engineering claims	Invoiced (initial claim 2,046 kCHF)	785
		Under negotiation (reduce 50%?) →L.Tavian	3,157
	11T fabrication contract claim		113
		TOTAL	~~4055~~ **2,400**

Covid **indirect** impact (kCHF)	WP3 additional D2 corrector protos		220
	WP4 insourcing of 2 series crab cavities		399
Mitigation of schedule risk	WP5 insourcing of crystal collimator goniometers		600
		TOTAL	**1,219**

Covid savings	WP1 Travel & events	Redirected to M4P, mitigate experience build-up in BSO	**80**

Covid related market risks: →H.Garcia Gavela, Risk/ Procurement

Covid impact on cost

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	11T fabrication contract claim		113
	Confirmed : 900	**Pending+confirmed :** TOTAL	~~4055~~ **2,400**

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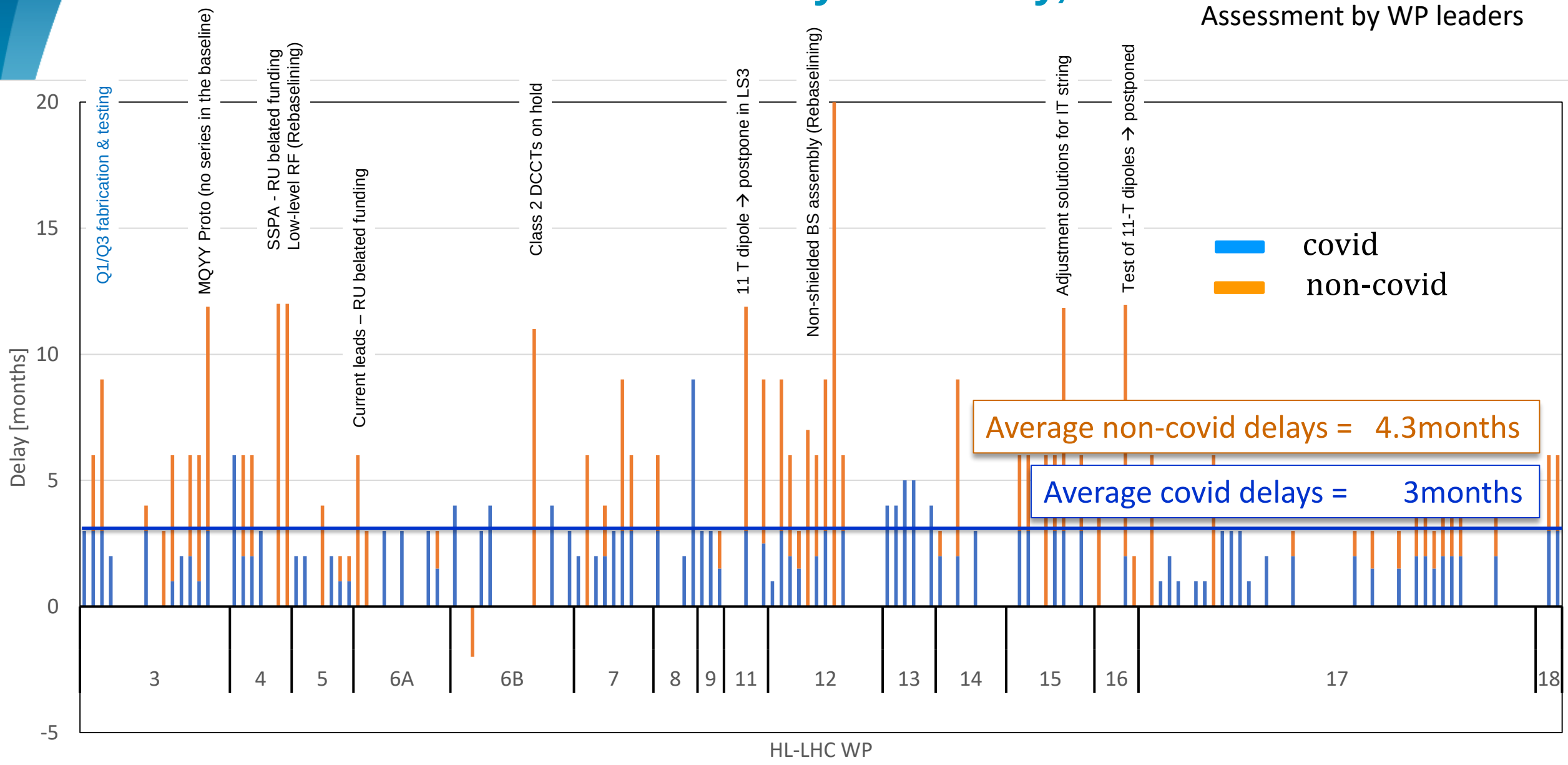
Covid related market risks: →H.Garcia Gavela, Risk/ Procurement

Covid & non-covid delay summary, Nov 2020



Covid delayed expenditure

	M CHF	
Covid delayed expenditure	-28	With PV~120 MCHF/year, a net 3months delay in expenditure
Civil engineering	-15	50% of the delayed expenditure
M4P	-6	Industrial services ramp-up is hampered, delayed recruitment of associated personnel
Other	-7	Distributed amongst WPs, with net influence of CERN expenditure for in-kind activities WP3 Orbit corrector package and D2 WP4 European crab-cavity cryomodule, AUP delays impacting our own expenditure (mainly for Canadian cryomodules) WP6A SC links for inner triplets

- 50% typical labor cost for prototypes: evidently linked to moment in HL project lifecycle
- Covid delayed relations to external partners

See cost presentation: we plan to recuperate those 3 months by extra PV in 3 years (2021 onwards), see commitment curve

Covid impact on industrial fabrication

Industrial suppliers in **production**

Limited impact: see WP5 collimators for LS2

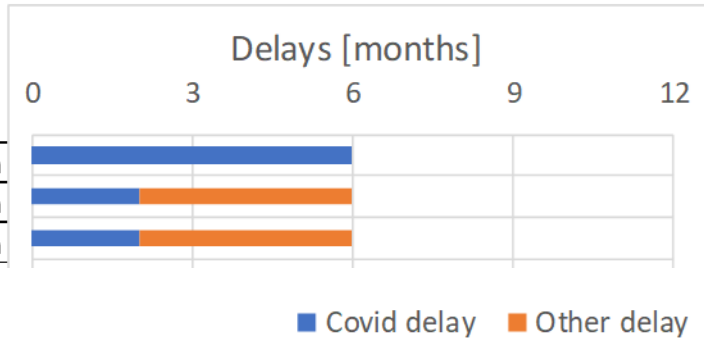
Industrial suppliers in **industrialization** (WP4)

Net stop

Then delays accumulate as persisting travel restrictions hamper knowledge transfer

WP4

Cryomodule for SPS test	Fabrication
DQW RF cavities	Fabrication
DQW cryomodules	Fabrication



In order to

Honor commitment to deliver to UK 2 pre-series DQW cavities

Accompany industrialization by CERN building experience

Schedule mitigation

- Insourcing of 2 crab-cavities
- Injection of temporary labor for documentation follow-up, to help industry to retrieve or assure pace (DQW, RFD)

Summary of delays seen in Nov2021

Today, our perception of covid delays is finer

Covid impact:

- on most workpackages, **~3months** net, from lockdown
- up to **6months** depending on lifecycle:

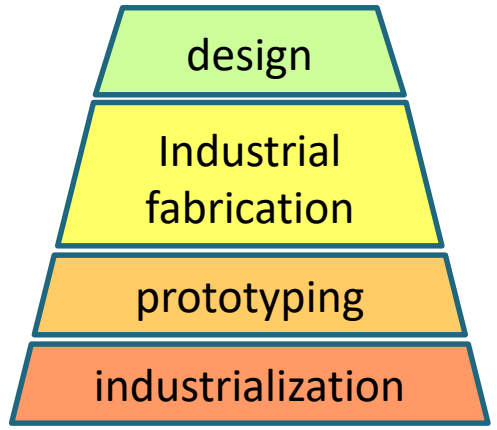
→see spare slide *Covid impact on industrial fabrication*
Including industrialization hampering, e.g. WP4

Performance limitation impact:

11Tesla, MQXFB

Belated Collaborations signatures

Sweden, UK2, **Russia**



Impact scale of covid on delays, depending on particular step in lifecycle

Generation of a new Master Schedule
For all WPs and the project