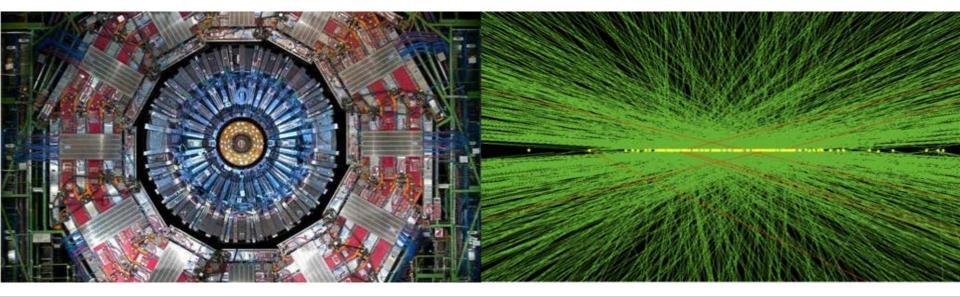


# **B08: MTD Cost and Schedule Overview** 402.8

Frank Chlebana, MTD Deputy L2 Manager Fermilab HL-LHC CMS CD-1 Review 23 October 2019





Frank Chlebana, Senior Scientist at Fermilab

- Serving as deputy L2 in US-MTD
- Experience in construction, commissioning, operations, and project planning while on CMS, CDF, and ZEUS

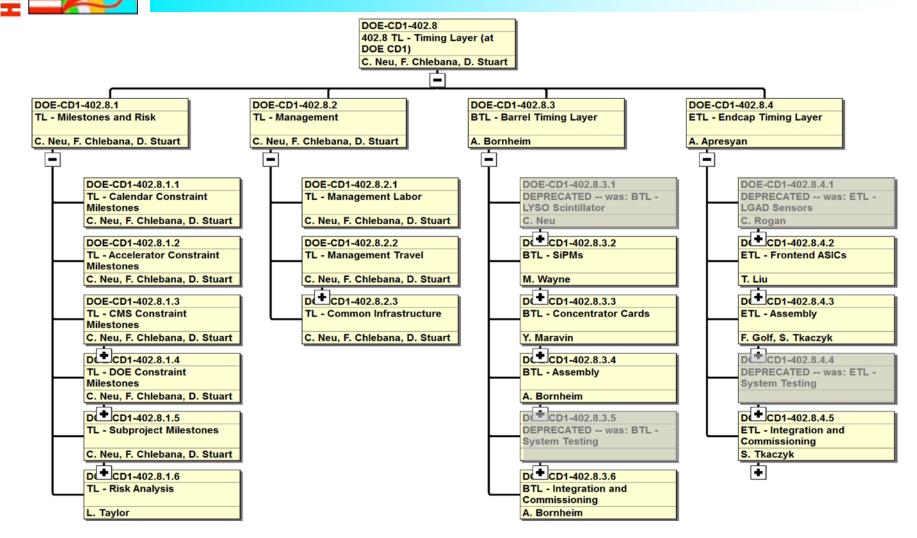
Deputy head of the Fermilab CMS Department Former deputy L2 for the HCAL phase 1 upgrades Former HGCal DPG co-convener Former HCAL DPG co-convener Former head of the DAQ group at CDF



## Schedule Development

- Costs
- Critical path
- Milestones
- Float
- Risks

## MTD Work Breakdown Structure



Deprecated WBS areas were included before scope optimization Removed LYSO and LGAD WBS elements  $\rightarrow$  moved LYSO contribution to "Common Infrastructure"

System testing focuses on US deliverables  $\rightarrow$  moved related activities to the associated assembly WBS

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MTD schedule has about ~1500 activities (including milestones)

A comprehensive set of tiered milestones allows us to monitor technical progress BTL ~60 milestones ETL ~90 milestones

Activity durations are **less than 3 months** to allow monitoring progress Some exceptions (Supervision activates treated as LOE activates, extended burn-in activities...)

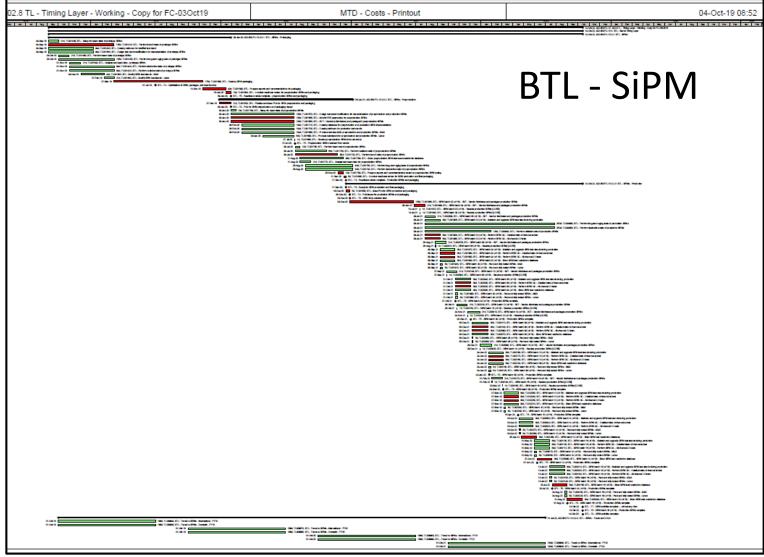
BTL and ETL production model updated to reflect the **design presented in the TDR** and taking **input from recent reviews**: CD-1 IPR (2018), Technical review (Nov 2018), OPSS cost and schedule review (Jan 2019), Director's Review (Mar 2019)

We are **directly involved** with developing the iMTD schedule and **fully synchronized** with iMTD planning *Adi Bornheim (BTL L3 manager) is the international BTL coordinator* 

David Stuart (MTD Deputy L2 manager) is the international ETL coordinator

10/23/19





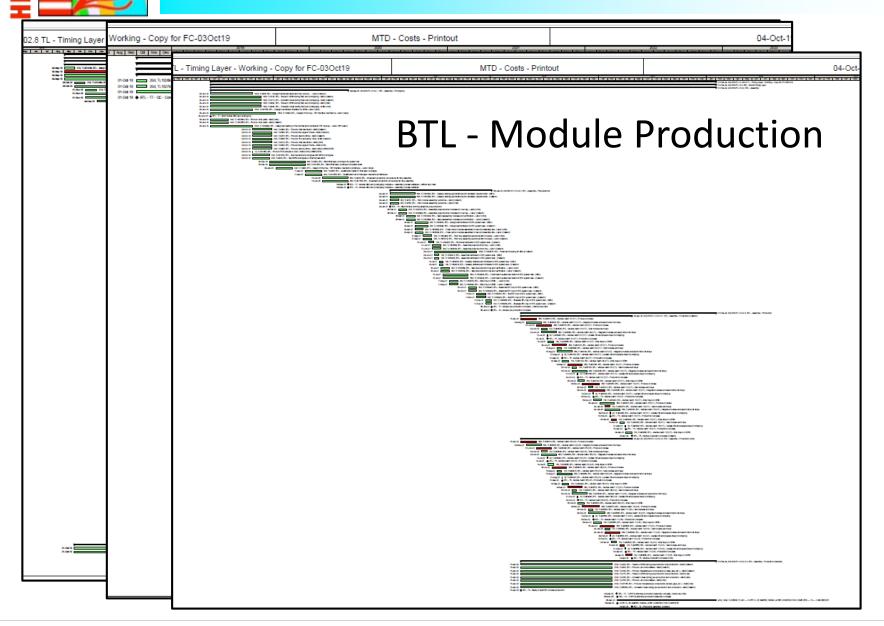


### BTL – Concentrator Card

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HL-LHC CMS CD-1 Review

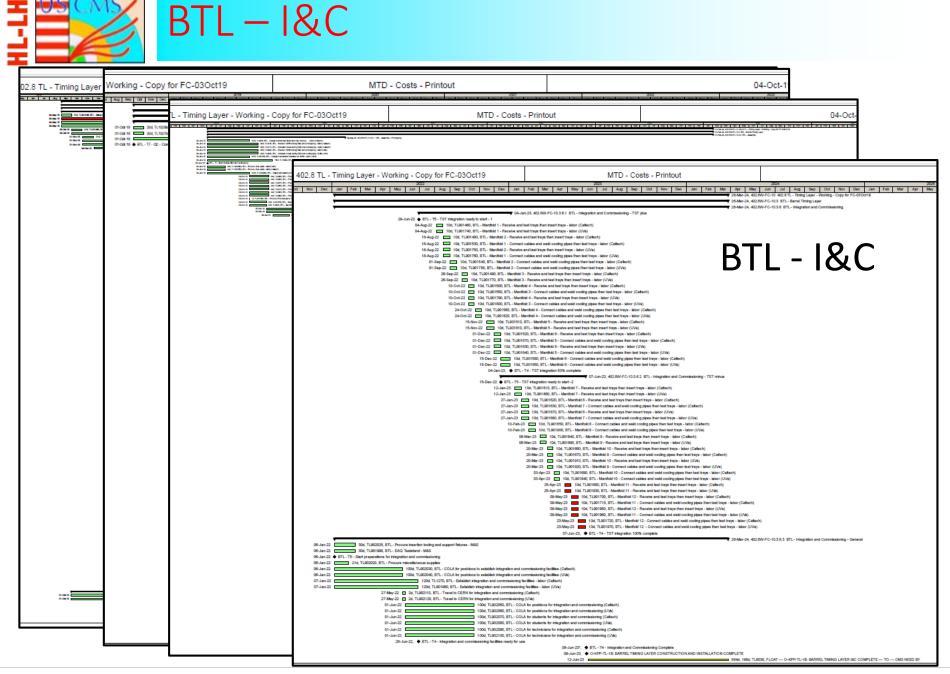
## **BTL – Module Production**



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MTD - Cost and Schedule Overview



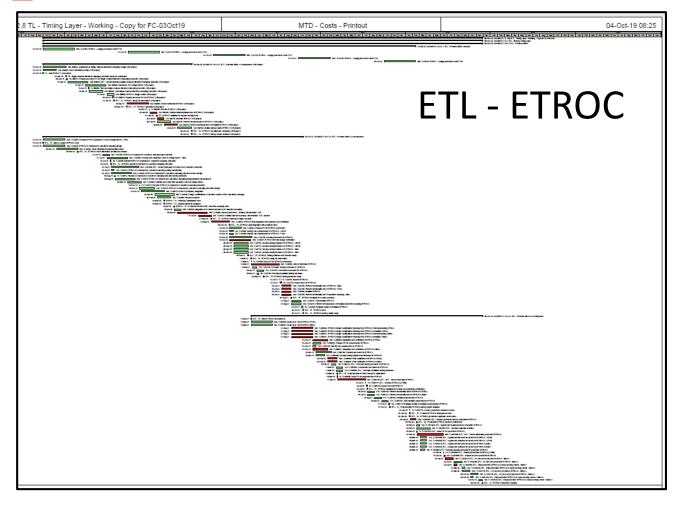
10/23/19

F. Chlebana

HL-LHC CMS CD-1 Review

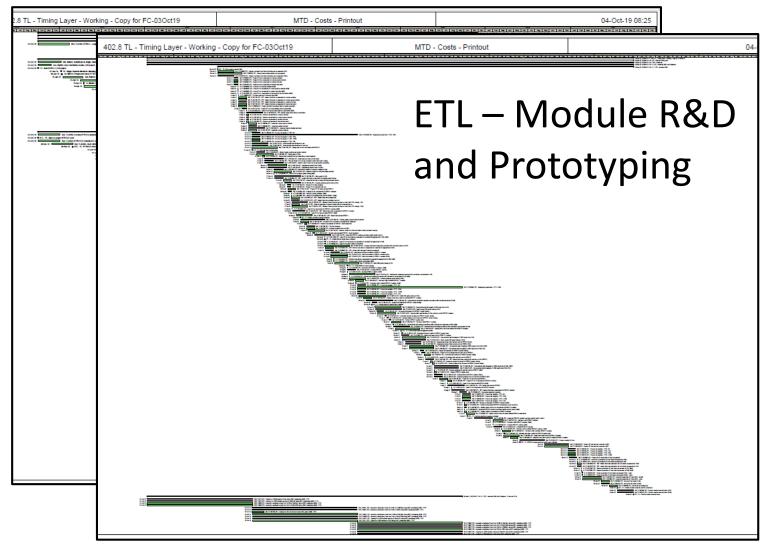
MTD - Cost and Schedule Overview



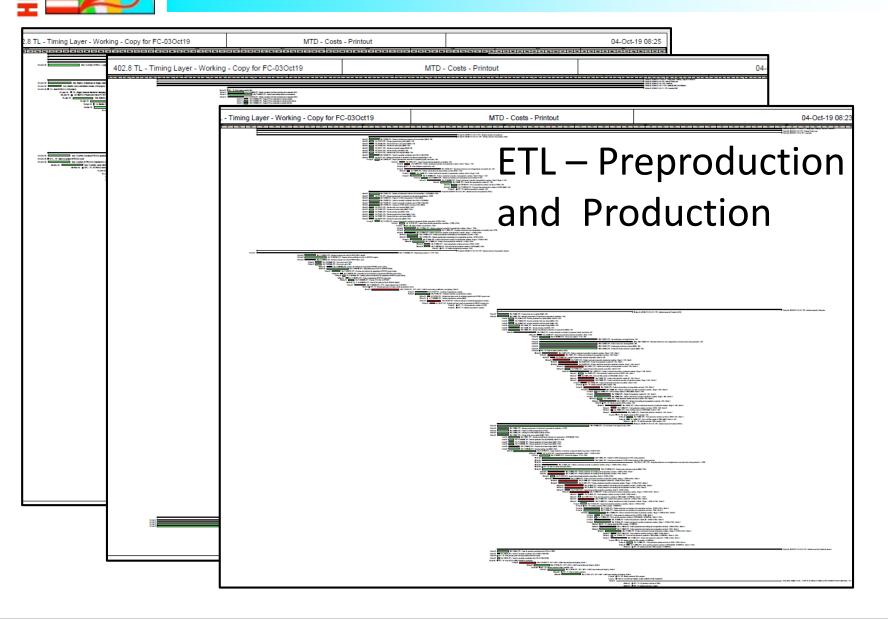




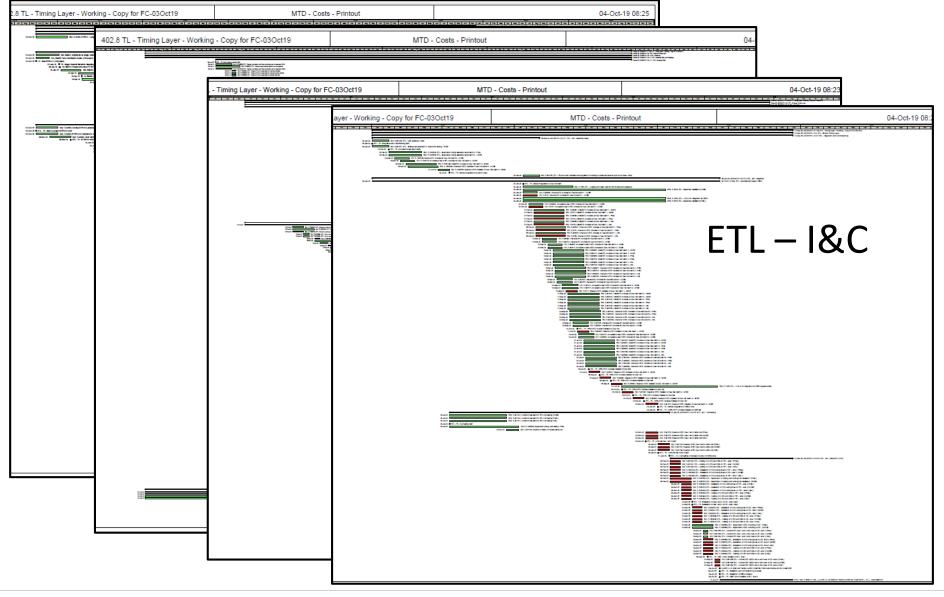
## **ETL - Module R&D and Prototyping**



## **ETL – Preproduction and Production**









## Basis of Estimate (BoE)

CMS-doc-13508

CMS-doc-13590

CMS-doc-13591

CMS-doc-13592

CMS-doc-13593

Basis of Estimates and supporting documentation are available in DocDB

Documentation includes a detailed description of scope, vendor quotes, and a summary of how the costs and labor effort was determined

L3 Parent:WBS : 402.8.2 TL - Management (1)

402.8.2 TL - Management

L3 Parent:WBS : 402.8.3 BTL - Barrel Timing Layer (4)

402.8.3.2 BTL - SiPMs 402.8.3.3 BTL - Concentrator Cards

402.8.3.4 BTL - Assembly

402.8.3.6 BTL - Integration and Commissioning

L3 Parent:WBS : 402.8.4 ETL - Endcap Timing Layer (3)

402.8.4.2 ETL - Frontend ASICs	CMS-doc-13595
402.8.4.3 ETL - Assembly	CMS-doc-13597
402.8.4.5 ETL - Integration and Commissioning	CMS-doc-13598

#### Example of documentation for the BTL Concentrator Cards saved in DocDB

#### Files in Document:

<ul> <li><u>M&amp;S and Labor estimates excel spreadsheet</u> (BTL Concentrator-Cardcost-estimate-V9.1.xlsx, 503.0 kB)</li> <li><u>Main BoE file</u> (BoE402-8-3-3BTLConcentrator-Cards- 11.pdf, 650.9 kB)</li> </ul>
Other Files:
<ul> <li><u>Activity list</u> (CC_ActivityList_v0 (3).docx, 20.3 kB)</li> </ul>
<ul> <li>BOE Source file (BoE402-8-3-3BTLConcentrator-</li> </ul>
Cards-11.docx, 1.6 MB)
<ul> <li><u>BOM</u> (Bill of Materials-CC_V1Quote Updated 6-14-2019 for</li> </ul>
Yurii.xls, 42.5 kB)
<ul> <li><u>GBT-SCA receipt (quote)</u> (GBT-SCAReceipt.pdf, 6.7 kB)</li> </ul>
M&S Test Stand components quote
(MS-13_TestStand_components.pdf, 2.9 MB)
<u>PCB production quote</u> (Quote_278697.pdf, 200.9 kB)
• <u>PCB quote</u> (103369-A.pdf, 71.7 kB)
<u>Samtec board quote</u> (Samtec Quote 201906-11157.pdf, 49.0
kB)
<u>Spreadsheet to calculate costs for production</u> (MandS.xlsx,
17.0 kB) - Test Stand BOM (MS 42, TestStand, BOM adf, 46 5 kB)
Test Stand BOM (MS-12_TestStand_BOM.pdf, 46.5 kB)     Test Stand standing upte (MS 10, TestStand, Standing 1, 216.1
<u>Test Stand stencil quote</u> (MS-10_TestStand_Stencil.pdf, 216.1
<ul> <li>kB)</li> <li><u>Trenz Electronics board quote</u> (Trenz Electronics 88-3981</li> </ul>
• <u>Thenz Electronics Doard Quote</u> (Thenz Electronics 86-3961 Order Confirmation.pdf, 91.8 kB)
<u>Vivado license quote</u> (EF-VIVADO-DESIGN-FL Xilinx Inc
Development Boards,pdf, 240.6 kB)
XILINX KCU105 board quote (EK-U1-KCU105-G Xilinx Inc
Development Boards, Kits,pdf, 851.3 kB)

• <u>lpGBT receipt (quote)</u> (lpGBTReceipt.pdf, 6.7 kB)



All estimates for the major cost drivers are based on recent vendor quotes

LYSO: Received quotes from multiple vendors (Nov 10, 2018) Non-binding RFQ issued in June 2019, average price was 6% lower Our contribution to the LYSO purchase is a fixed dollar amount

SiPM: Hamamatsu-SiPM (Apr 1, 2019) Concentrator Cards: Bill of material parts list (June 6, 2019), PCB production (Sep 12, 2019) BTL Assembly: Pick and place gantry and stencil printer (Aug 15, 2018)

ASIC: MPW, Fabrication, Estimates for Multi-project Wafer submission and maskset are based on contractual agreement between CERN and foundry (Sep 20, 2018) ETL Assembly: Service contract, misc parts, AIN quote (Jan 2019)



## Timing Layer Costs (Project Cost Book)

CMS-doc-13777

WBS	Direct M&S (\$)	Labor (Hours)	FTE	Direct + Indirect + Esc. (\$)	Estimate Uncertainty (\$)	Total Cost (\$)
DOE-CD1-402.8 402.8 TL - Timing Layer (at DOE CD1)	6,845,630	156109	88.30	12,718,472	3,230,993	15,949,466
DOE-CD1-402.8.2 TL - Management	1,051,980	26520	15.00	1,245,677	221,782	1,467,459
DOE-CD1-402.8.2.1 TL - Management Labor	0	26520	15.00	0	0	0
DOE-CD1-402.8.2.2 TL - Management Travel	233,000	0	0.00	349,612	27,526	377,138
DOE-CD1-402.8.2.3 TL - Common Infrastructure	818,980	0	0.00	896,064	194,256	1,090,321
DOE-CD1-402.8.3 BTL - Barrel Timing Layer	2,832,903	47774	27.02	5,141,304	1,263,514	6,404,817
DOE-CD1-402.8.3.2 BTL - SIPMs	1,785,400	5384	3.05	2,474,076	392,929	2,867,005
DOE-CD1-402.8.3.3 BTL - Concentrator Cards	559,143	4506	2.55	936,334	194,269	1,130,603
DOE-CD1-402.8.3.4 BTL - Assembly	290,360	27236	15.40	1,293,636	553,215	1,846,851
DOE-CD1-402.8.3.6 BTL - Integration and Commissioning	198,000	10648	6.02	437,258	123,101	560,359
DOE-CD1-402.8.4 ETL - Endcap Timing Layer	2,960,747	81815	46.28	6,331,492	1,745,697	8,077,190
DOE-CD1-402.8.4.2 ETL - Frontend ASICs	2,110,992	24495	13.85	4,186,640	839,972	5,026,613
DOE-CD1-402.8.4.3 ETL - Assembly	641,455	38348	21.69	1,754,080	787,463	2,541,542
DOE-CD1-402.8.4.5 ETL - Integration and Commissioning	208,300	18972	10.73	390,773	118,262	509,035

The MTD costs derived from the P6 schedule include institutional specific labor rates, overheads, escalation, and estimate uncertainty

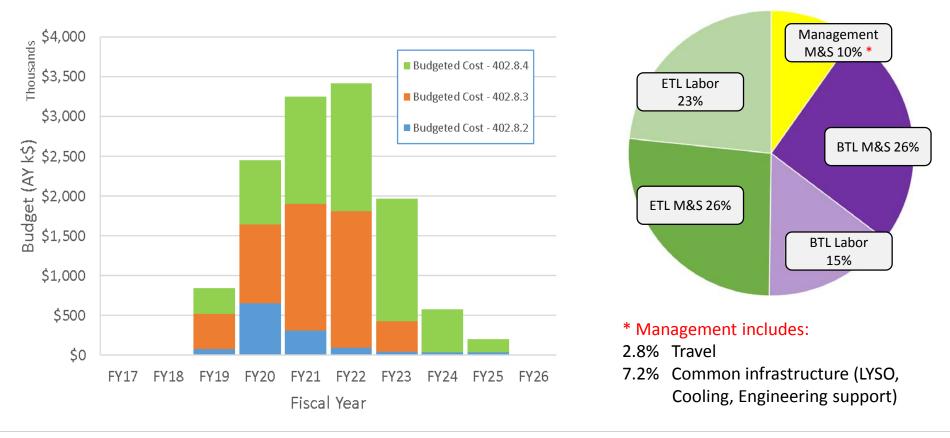
The MTD total project cost is: 15.95M\$ = 12.72 (BAC) + 3.23 (EU)



## Costs at Level 3

#### CMS-doc-13215

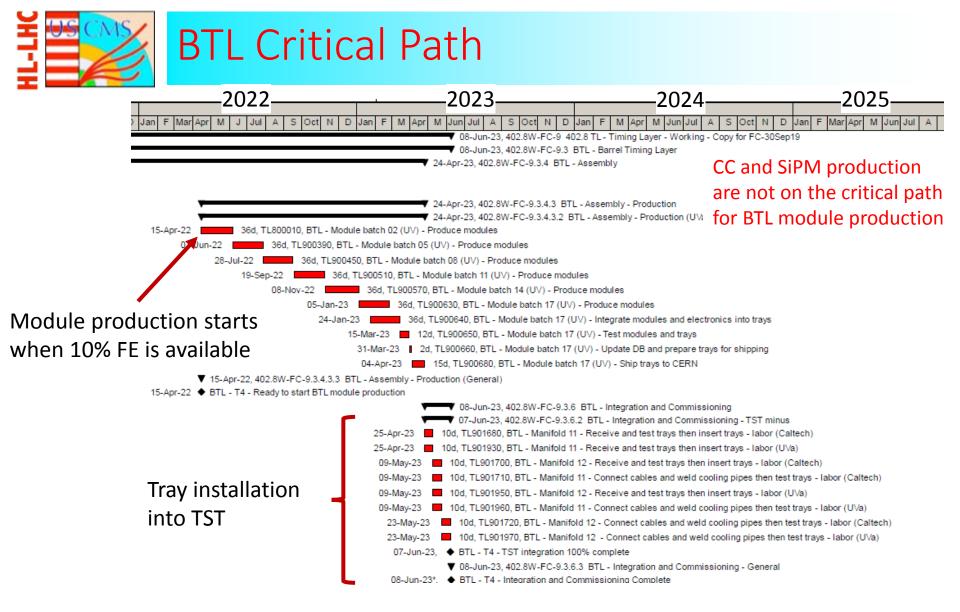
WBS	Direct M&S (\$)	Labor (Hours)	FTE	Direct + Indirect + Esc. (\$)	Estimate Uncertainty (\$)	Total Cost (\$)
DOE-CD1-402.8 402.8 TL - Timing Layer (at DOE CD1)	6,845,630	156109	88.30	12,718,472	3,230,993	15,949,466
DOE-CD1-402.8.2 TL - Management	1,051,980	26520	15.00	1,245,677	221,782	1,467,459
DOE-CD1-402.8.3 BTL - Barrel Timing Layer	2,832,903	47774	27.02	5,141,304	1,263,514	6,404,817
DOE-CD1-402.8.4 ETL - Endcap Timing Layer	2,960,747	81815	46.28	6,331,492	1,745,697	8,077,190





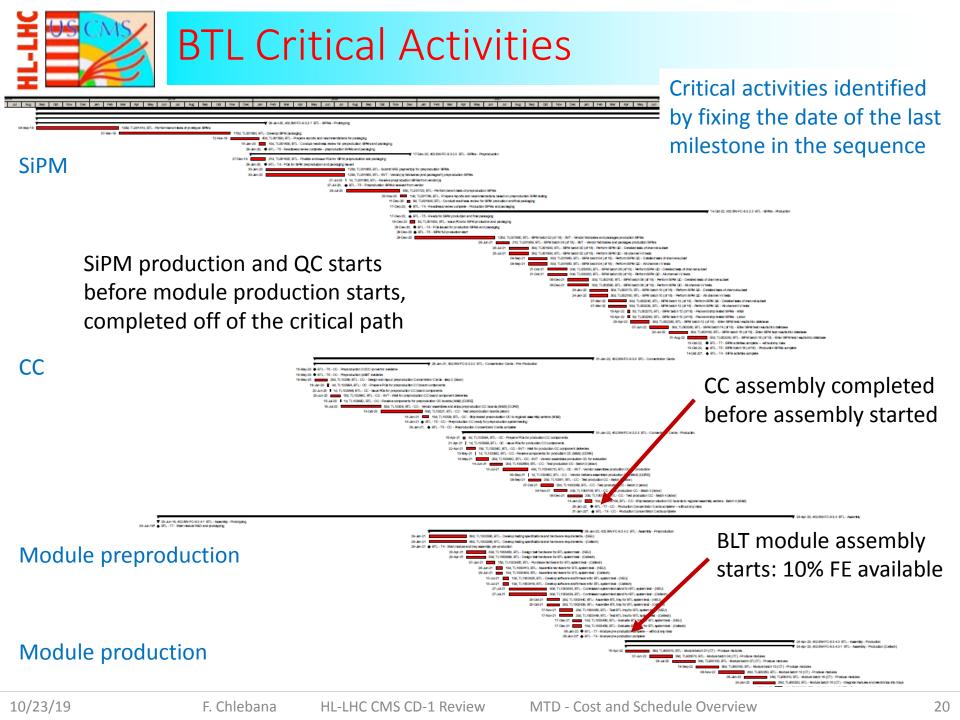
## **BTL Critical Path and Schedule Contingency**

2019 2020 202	120222023	2024 2025	2026	2027			
2017 2018 2019 2020 202 01 02 03 04 01 02 03 04 01 02 03 04 01 02 03 04 01 02 03					2028	2029 2030	
27-Nov-2019* 2 DOE - CD-1 Alternative			11/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1	4 101 102 103 104 10		02 03 04 01 02 0	3   44   41   42   43   44   41   42   43   44   41   42   43   4
16-Dec-2019*, 🟅 CMS - BTL - FE board a							
14-Feb-2020*, 📩 CMS - BTL - LYSO cn							
15-Apr-2020*, 🛔 CMS - BTL - Comp							
15-May-2020*, 🛔 CMS - BTL - BTL.	EDR - BTL Engineering design rev	ew held					Critical path activity
15-May-2020* 🚼 DOE - CD-3A Lo	ong lead procurements - Receive E	SAAB approval					
18-May-2020*, 👗 CMS - BTL - IpGB	T and DCDC - Preproduction versi	on available					Schedule contingency
15-Jun-2020* 👗 CM <mark>S</mark> - BTL - LYS	O pre-production complete					•	External milestone
30-Nov-2020* 📩 DOE - CD	-2/3 Performance Baseline - Re	eive ESAAB approval					
15-Apr-2021*, 👗 CMS	S - BTL - IpGBT and DCDC - Produced	ction version available					(e.g. CMS need by date)
Apr 2022: Ready to start PTI 15-Apr-	2022*CMS - BTL - B.FE.6 - FI						
Apr 2022: Ready to start BTL		BTL module production					
module production		(CT) - Produce modules					
		04 (CT) - Produce modules					
		h 07 (CT) - Produce modules					
		atch 10 (CT) - Produce module batch 13 (CT) - Produce mod					
		e batch 13 (CT) - Integrate mo		etropice into trave			
		e batch 13 (CT) - Test module		cuonics into trays			
		e batch 13 (CT) - Update DB	-	trave for shinning			
		odule batch 13 (CT) - Product					
		ule batch 13 (CT) - Ship trays t					
Timing Layer Threshold KPP:		T-KPP (9 batches) production		mblete - before any	risks		
		T-KPP (9 batches) production		· · · · · · · · · · · · · · · · · · ·			
Mar 2023: BTL construction complete —		1B: BARREL TIMING LAYER		1			
(11.0 months float before CMS need by d	ate)	FLOAT T-KPP-TL-1B: B		NG LAYER CONST	FRUCTION COMP	PLETE TO CMS	S NEED BY
(		TL-1B: BARREL TIMING LAY	ER CONSTR	RUCTION AND INS	TALLATION CON	<b>IPLETE</b>	
	·	FLOAT O-KPP-TL-1B	BARREL TI	MING LAYER I&C	COMPLETE TO	O CMS NEED BY	
	01-Feb-2024*	CMS - BTL - B.A.6 - Tray p	oduction 100	0% complete (inclue	ding iMTD schedu	le contingency as lag	<b>J</b> )
	26-Mar-2024	🗱 CMS - BTL - B.A.8.1 - TS	T- end of acc	cess for BTL (CMS	need by date)		
	17-Apr-20	24 THRESHOLD KPP. (T-K	P.PTL): TIMI				
		4 <b>-</b>					ONSTRUCTION COMPLETE TO CD-4
Timing Lower Objective KDD	: :	09-Jun-2025 😁 OBJE	TIVE KPP (				ALLATION COMPLETE
Timing Layer Objective KPP:		A					BJECTIVE KPP COMPLETE TO CD-4
Jun 2023: BTL construction and installation	on complete	Long Shutdowr	30.	-Sep-2027*** DOI	E - CD-4 Projec	t Completion - Recei	ve approval
Jun 2023. BTE COnstruction and Installation	in complete	Long Chataowi				· · · · · ·	
		N	V				

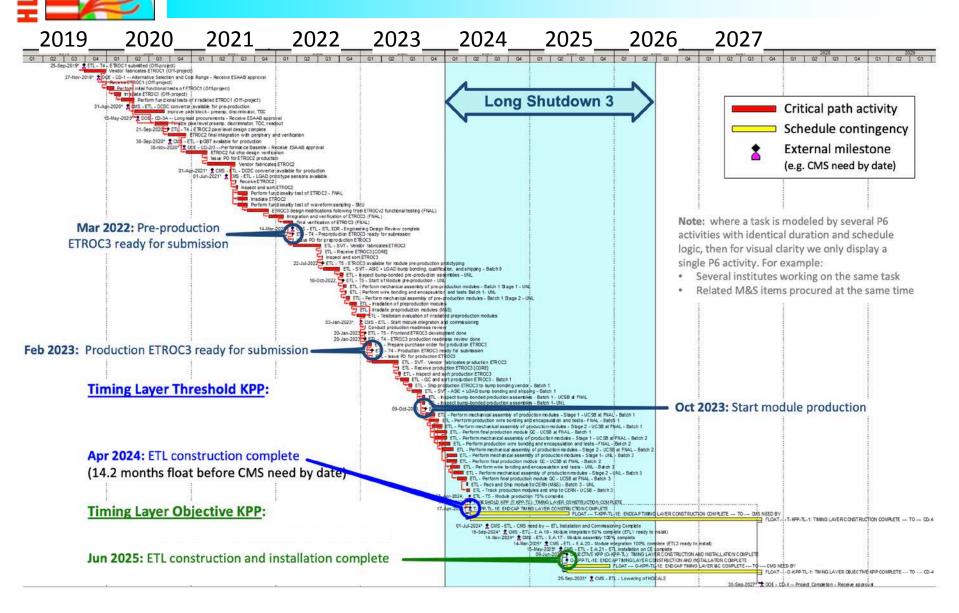


T-KPP (9/12 batches) production assembly complete (75%), 6-Mar-23 T4 Production assembly complete (100%), 24-Apr-23

HL-LHC CMS CD-1 Review



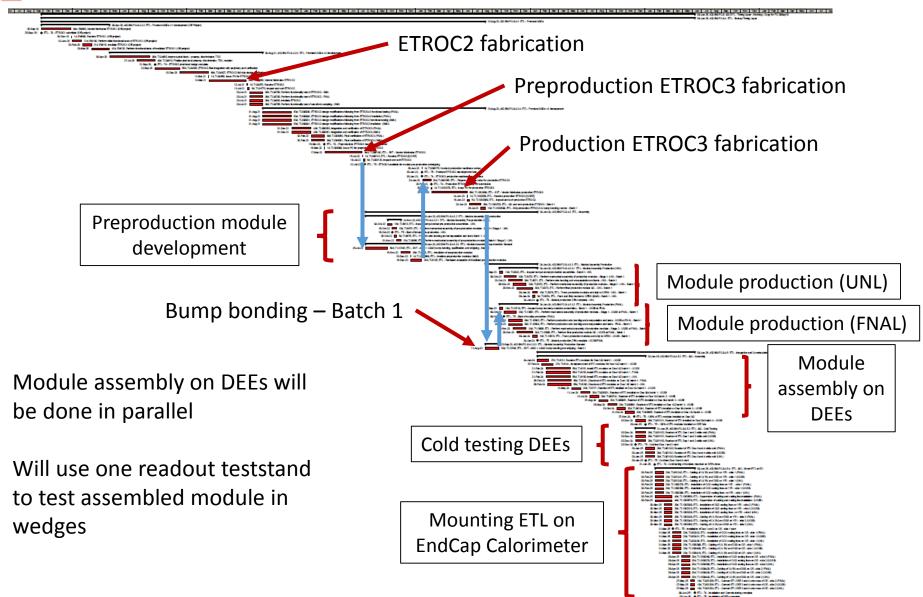
## ETL Critical Path and Schedule Contingency



10/23/19

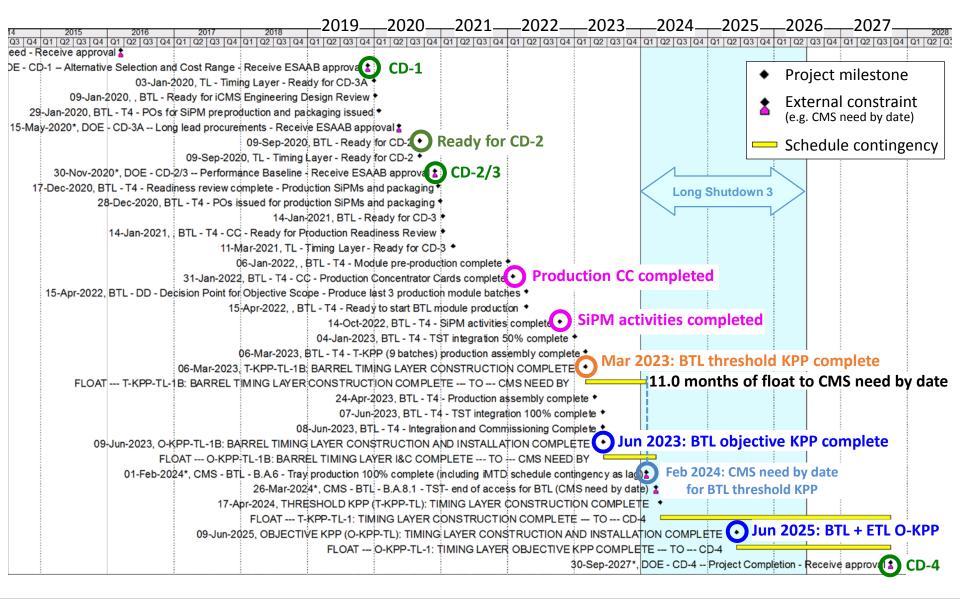
HL-LHC CMS CD-1 Review





### **BTL Key Milestones and Schedule Contingency**

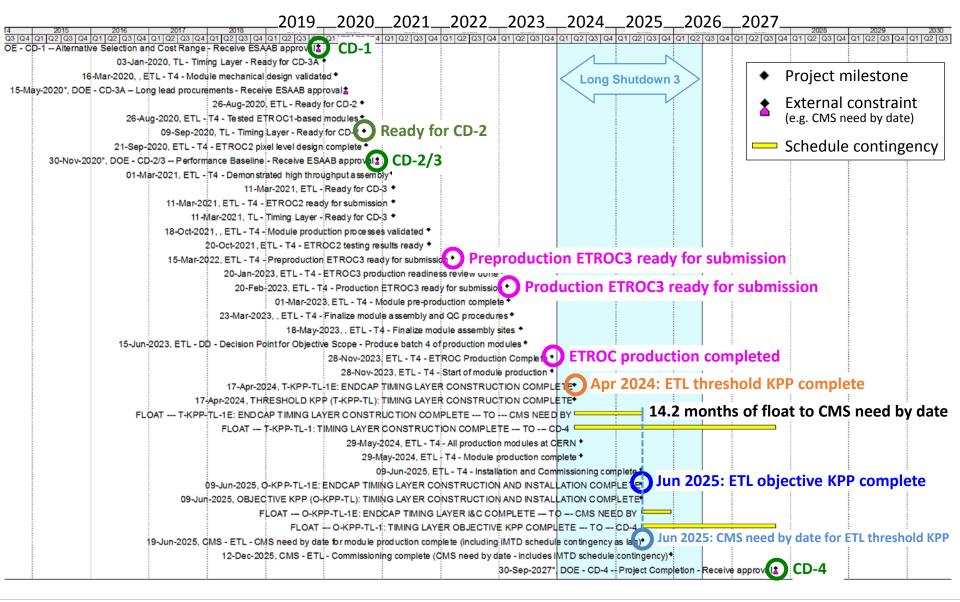




### ETL Key Milestones and Schedule Contingency



10/23/19





# Main M&S Cost Drivers (>500k\$)

Material	Obligation Date	Direct Cost (k\$)	Direct+Esc (k\$)	<b>Relevant Review</b>
LYSO production	June 2020	500	523	CD-3a (May 2020)
SiPM production	Dec 2020	1600	1765	CD-2/3 (Nov 2020)
ETROC preproduction	Mar 2022	728	816	CD-2/3 (Nov 2020)
ETROC production	Feb 2023	887	1014	CD-2/3 (Nov 2020)

#### Main cost drivers represent ~54% of the MTD M&S cost

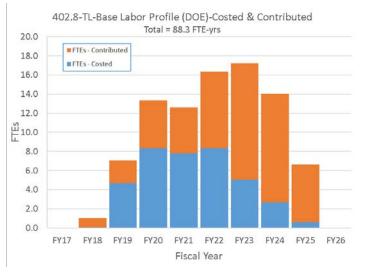
ETROC pricing is well-defined via the IMEC/CERN agreement.

The LYSO pricing is based on multiple vendor quotes and we contribute a fixed cost. LYSO is a commonly available commodity in the medical industry. We are not doing anything exotic in terms of its specification or preparation --hence our needs are similar to existing designs with little or no modifications.

SiPM pricing is based on a recent vendor quote from HPK. These SiPMs that were the subject of the vendor quote reflect a nearly-completed design and are similar to the design used for the HCAL upgrade, for which costs are well documented.



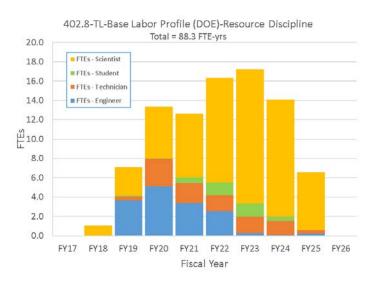
## **Timing Layer Labor**

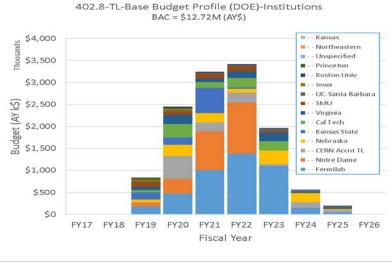


The areas with technical deliverables, SiPM, CC, ASIC, are done with mostly costed labor The main labor cost is associated with the ASIC development

Contributed labor is used during the R&D phase of module assembly, system testing, I&C

Assembly production is done with a combination of costed and contributed labor





F. Chlebana

HL-LHC CMS CD-1 Review



CMS Driver	Labor	Labor BAC	M&S BAC	Total BAC
	(FTE-yrs)	(M\$)	(M\$)	(M\$)
TL - ETL ASIC Development	12.5	1.8	1.3	3.2
TL - BTL Production SiPMS [CORE]	0.0	0.0	1.8	1.8
TL - ETL module assembly	15.4	1.0	0.7	1.8
TL - BTL module assembly	15.1	0.9	0.5	1.5
TL - ETL Production ASICs [CORE]	0.0	0.0	1.0	1.0
TL - Timing Layer installation and commissioning	6.5	0.3	0.6	0.9
TL - BTL SiPM labor	3.0	402.8-TL-Base I	Budget Profile (DOE) BAC = \$12.72 M (AY\$)	-Resource Type
TL - BTL LYSO crystals M&S [CORE]	00 1	\$4,000	BAC - \$12.72 IVI (AI\$)	Budgeted Cost - Material
TL - BTL electronics - concentrator board [CORE]	0.0	\$3,000		Budgeted Cost - Labor
TL - BTL electronics - concentrator board	2.5 (SX LAR)	\$2,500		
TL - Travel	Budget 0.0	\$2,500 \$2,000 \$1,500		
TL - BTL iCMS common core infrastructure [CORE]	0.0	\$1,000		
TL - ETL iCMS common core infrastructure [CORE]	0.0	\$500		
* BAC = Budget at Completion (=direct + indirect + escalation)		FY17 FY18 F	Y19 FY20 FY21 FY2 Fiscal Yea	2 FY23 FY24 FY25 FY26 r



Risks modelling is included in the P6 schedule and a risk analysis has been done to determine the cost and schedule impact

A detailed description of the methodology used for the risk analysis can be found in CMS-doc-13481

BWBS / Ops Lab Activity : 402.8 TL - Timing Layer (general risks) (2)	General Risks (2)			
Bisk Rank : 2 (Medium) (1)				
RT-402-8-91-D TL - Shortfall in Timing Layer scientific labor	30 % 0 0 611 k\$	0 months	61	0.0
■ Risk Rank : 1 (Low) (1) RT-402-8-90-D TL - Key Timing Layer personnel need to be replaced	25 % 45 135 261 k\$	0 0 3 months	37	0.3



RI-ID	Title	Probability	Cost Impact	Schedule Impact	P * Impact (k\$)	P * Impact (months)
WBS / Ops Lal	b Activity : 402.8 TL - Timing Layer (general risks) (2)					
■ WBS / Ops Lal	b Activity : 402.8.3 BTL - Barrel Timing Layer (14)	<b>BTL Risk</b>	(14)			
D Diek Deek - 0						
Risk Rank : 3		50.0/		1 0 0	50	17
RT-402-8-30-D	BTL - Concentrator Card requires significant design changes		40 135 175 k\$	1 3 6 months	58	1.7
RT-402-8-07-D	BTL - Concentrator Card delay in external component deliveries	50 %	50 k\$	3 6 9 months	25	3.0
Brisk Rank : 2	(Medium) (4)					
RT-402-8-05-D	BTL - Change in interfaces of tray assembly components	20 %	150 250 350 k\$	3 months	50	0.6
RT-402-8-46-D	BTL - Problems with sensor gluing facility	50 %	90 k\$	1 2 3 months	45	1.0
RT-402-8-33-D	BTL - Difficulties procuring LYSO from international suppliers	10 %	100 250 400 k\$	3 6 9 months	25	0.6
RT-402-8-14-D	BTL - Problems with SiPM vendor	20 %	32 96 128 k\$	2 6 8 months	17	1.1
🖃 Risk Rank : 1	(Low) (B)					
RT-402-8-15-D	BTL - Batch shipment of SiPMs lost in transport	5 %	224 k\$	1 months	11	0.1
RT-402-8-35-D	BTL - Delays or damage of tray in transport to CERN	5 %	220 k\$	1 months	11	0.1
RT-402-8-04-D	BTL - LYSO matrices not meeting specifications	10 %	100 k\$	1 2 3 months	10	0.2
RT-402-8-36-D	BTL - Interface to iCMS changes	20 %	30 k\$	1 2 3 months	6	0.4
RT-402-8-34-D	BTL - Delay in delivery of components from iCMS	20 %	10 20 30 k\$	1 2 3 months	4	0.4
RT-402-8-18-D	BTL - Concentrator card production & testing facility problem	20 %	10 k\$	0.5 1 2 months	2	0.2
RT-402-8-08-D	BTL - Delay in cooling plate delivery	10 %	10 20 30 k\$	1 2 3 months	2	0.2
RT-402-8-42-D	BTL - Problems with module assembly site	10 %	10 20 30 k\$	1 2 3 months	2	0.2
WBS / Ops Lal	b Activity : 402.8.4 ETL - Endcap Timing Layer (10)					



RI-ID	Title	Probability	Cost Impact	Schedule Impact	P * Impact (k\$)	P * Impact (months)
WBS / Ops Lai	Activity : 402.8 TL - Timing Layer (general risks) (2)					
⊞ WBS / Ops Lal	Activity : 402.8.3 BTL - Barrel Timing Layer (14)					
■ WBS / Ops Lat	Activity : 402.8.4 ETL - Endcap Timing Layer (10)	TL Risks	(10)			
Risk Rank : 3	(High) (1)					
RT-402-8-01-D	ETL - Additional FE ASIC prototype cycle is required	40 %	500 600 700 k\$	4 5 6 months	240	2.0
🗉 Risk Rank : 2	(Medium) (5)					
RT-402-8-03-D	ETL - FE ASIC does not meet specs - needs another pre-prod run	10 %	874 930 986 k\$	6 7.5 9 months	93	0.8
RT-402-8-55-D	ETL - Schedule delay in submitting ETROC2	30 %	55 110 165 k\$	2 4 6 months	33	1.2
RT-402-8-02-D	ETL - ETL module facility unavailable	50 %	20 k\$	2 months	10	1.0
RT-402-8-10-D	ETL - Sensor quality problem during production	15 %	28 52 109 k\$	2 3 6 months	9	0.6
RO-402-8-01-D	ETL - Use AltiROC	10 %	-720 k\$	-8 months	-72	-0.8
Risk Rank : 1	(Low) (4)					
RT-402-8-54-D	ETL - Schedule delay in submitting ETROC3	20 %	27.5 55 82.5 k\$	1 2 3 months	11	0.4
RT-402-8-53-D	ETL - Integration facility at CERN runs out of components	25 %	21 k\$	3 months	5	0.8
RT-402-8-31-D	ETL - Storage-related degradation of LGADs	10 %	18 k\$	3 months	2	0.3
RT-402-8-51-D	ETL - Problem with vendor provision of module components	5 %	0 15 30 k\$	1 2 3 months	1	0.1



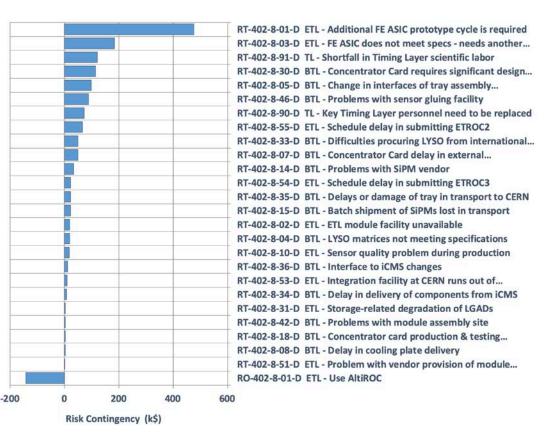
# MTD Risk Cost Impact

# Main risk changes in past 12 months are

- Detailed risk analysis of both BTL and ETL
- Careful alignment with iCMS (TDR) plans
- External risk reviews
- ASIC risks to cover realistic scenarios and submission delays



= Total contingency at 90% C.L. shared amongst risks pro-rata with (Probability \* Cost Impact)



#### **MTD risk contingency** ≈ **\$1.95M** (15.3% of MTD BAC)

MTD risk contingency includes cost weighted fraction of project wide common risks (exchange rate, escalation, funding delay, import/export issues, OH, ES&H incident)



## Project Cost Risks

# Main risk changes in past 12 months are

- Reviewed and updated full spectrum of risks
- New: detailed risk analyses of BTL & ETL
- Re-aligned with the evolving iCMS plans
- Held external risk reviews
- Escalation, overheads, and exchange rate risks decreased (we have advanced by one year)

#### Risk Contingency (k\$)

= Total contingency at 90% C.L. shared amongst risks pro-rata with (Probability \* Cost Impact)

	RU-402-1-01-D PM - Foreign exchange rates are uncertain (DO
	RU-402-1-02-D PM - Future escalation rates are uncertain (DOR
	RU-402-2-01-D OT - Uncertain performance of Hybrids vendor
	RT-402-8-01-D ETL - Additional FE ASIC prototype cycle is
	RT-402-1-05-D PM - Significant funding delay during project
	RT-402-2-11-D OT - MaPSA bump bonding cost increases
	RT-402-4-18-D CE - Additional concentrator ASIC engineering
Top 25	RT-402-2-10-D OT - Vendor cannot perform MaPSA
nroject	RT-402-4-22-D CE - Additional production acceleration required
project	RT-402-6-03-D TD - I/O performance does not meet
cost risks	RT-402-1-12-D PM - Major import or export issue (DOE)
	RT-402-2-91-D OT - Shortfall in Outer Tracker scientific labor
	RT-402-4-91-D CE - Shortfall in Calorimeter Endcap scientific
	RT-402-4-04-D CE - Concentrator does not meet specifications
	RT-402-8-03-D ETL - FE ASIC does not meet specs - needs
	RT-402-4-01-D CE - Additional FE ASIC engineering run required
	RT-402-2-09-D OT - MaPSA yield is lower than expected
	RT-402-2-90-D OT - Key Outer Tracker personnel need to be
	RT-402-4-90-D CE - Key Calorimeter Endcap personnel need to
	RT-402-6-06-D TD - Baseline FPGA does not satisfy
	RT-402-4-02-D CE - Infrastructure failure at module assembly
	RU-402-6-07-D_TD - DAO STMS I/O performance does not mee
	RT-402-8-91-D TL - Shortfall in Timing Laver scientific labor
	RT-402-8-30-D BTL - Concentrator Card requires significant
	RT-402-2-23-D OT - Vendor is unable to produce sensors to
	RT-402-8-05-D BTL - Change in interfaces of tray assembly
	RT-402-2-46-D OT - Problem with carbon foam vendor
	RT-402-2-01-D OT - Sensor quality problem during production
	RO-402-8-01-D ETL - Use AltiROC
	RO-402-2-03-D OT - Module assembly can be automated

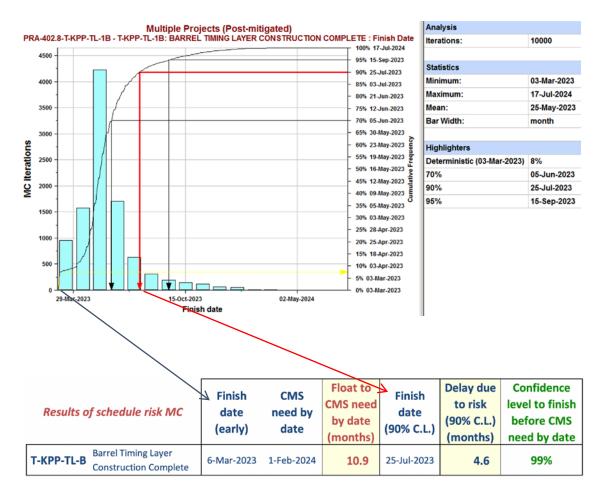
#### Risk Contingency (k\$)

#### **Project Risk-based contingency** ≈ **\$10.07M** (8.1% of BAC)



# **BTL Schedule Contingency**

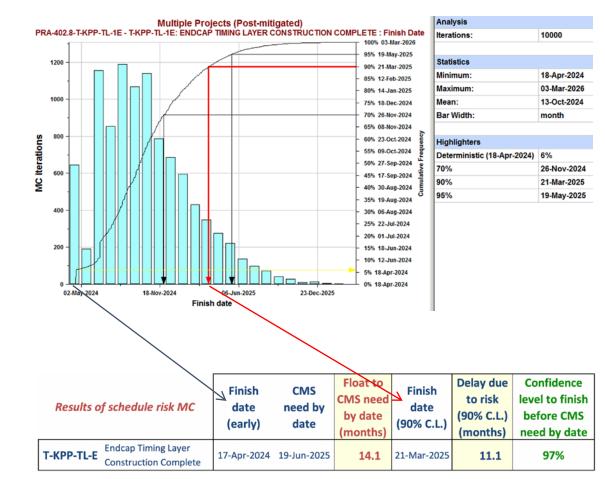
- Risk MC aggregates delays stochastically in the full P6 schedule
- Risks will delay finish by < 4.6 months at 90% confidence level
- Plan has 10.9 months of float before the CMS need by date
- T-KPP will finish before the need by date at 99% confidence level
- Will revisit schedule risk when new LHC schedule is known





# **ETL Schedule Contingency**

- Risk MC aggregates delays stochastically in the full P6 schedule
- Risks will delay finish by < 11.1 months at 90% confidence level
- Plan has 14.1 months of float before the CMS need by date
- T-KPP will finish before the need by date at 97% confidence level
- Will revisit schedule risk when new LHC schedule is known





The BTL and ETL design is mature and we have a well-developed schedule that reflects the design described in the MTD TDR and includes recommendations from the previous reviews

The detailed schedule in P6 has well motivated cost and labor estimates that are documented in the BOEs

Risks have been identified and reviewed and are linked in the schedule allowing us to model the cost and schedule impact

The MTD cost estimate and schedule is advanced, and we are well on the way to being prepared for CD-2