



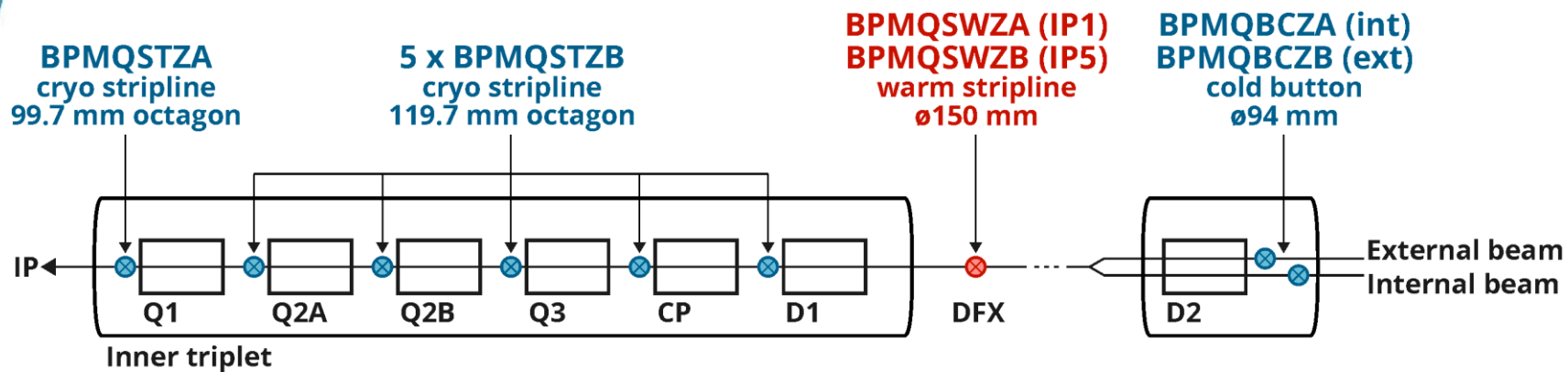
# HL-LHC cryogenic BPMs Status and delivery plans

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***WP13 meeting - 08/03/2019***

# HL-LHC BPMs



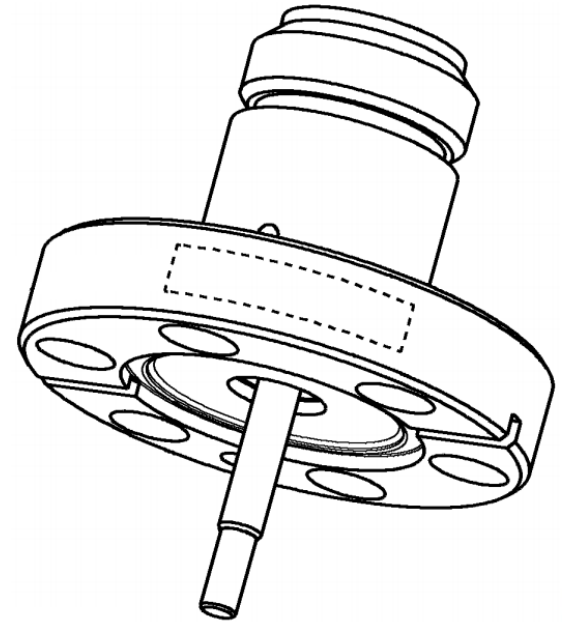
	BPMQSTZA	BPMQSTZB	BPMQSWZA/B	BPMQBWZA/B	TOTAL
Series	4	20	4	8	36
Spares	2	2	2	2	8
Prototypes	2	2	2	2	8

# Design status overview

Step	Cryo striplines	Cryo button	Warm stripline
Layout definition	Done (90%)		
Engineering spec	To be done (20%)		
Electromagnetic design	Done, optimizing cost	Started (25%)	Started (50%)
Mechanical design	Done, optimizing cost	Started (25%)	Started (50%)
Coating specification	flash gold + 100 $\mu\text{m}$ Cu + flash aC		To be defined
Thermal simulations	Done	To be done	N/A
Fluka (debris) simulations	Done	N/A	N/A
Impedance simulations	Done, final validation needed		
BPM integration	Ongoing (75%)	Ongoing (25%)	Ongoing (75%)
Cable integration	To be done (10%)		
Alignment specification	Formal documents to be produced and approved by WGA		
Installation sequence	Memorandum in preparation		N/A
Review	Done	Would it be useful?	

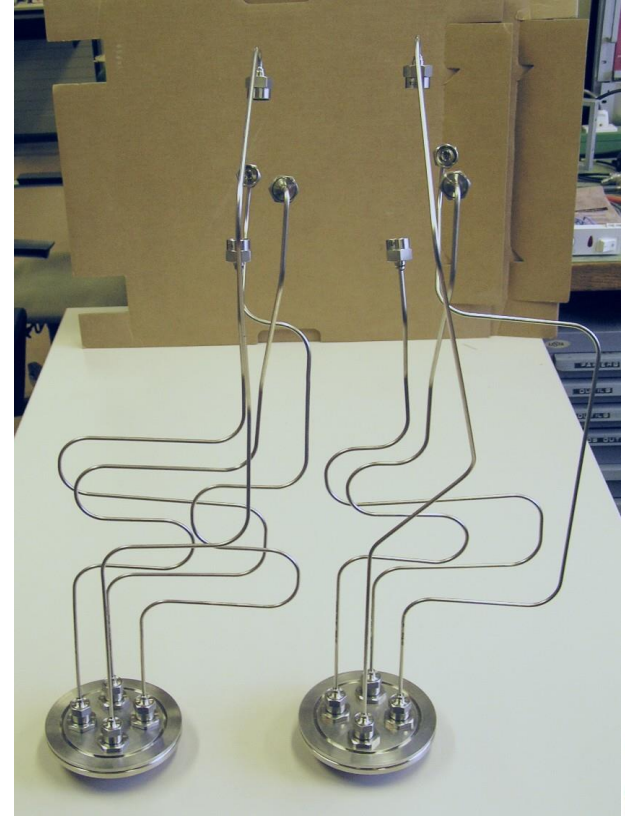
# Tendering overview (1)

- BPM feedthroughs
  - Highly special component: RF, vacuum, cryo
  - 370 units needed (prototypes, series, spares)
  - Price enquiry concluded 20 February 2019
  - 3 bids received (from 9 invited suppliers)
  - Significant differences among the offers
  - Next steps being discussed with procurement
- Cryostat flanged feedthroughs
  - ~ 60 units needed (prototypes, series, spares)
  - Tendering currently on hold
  - Strategy do be defined based on BPM experience



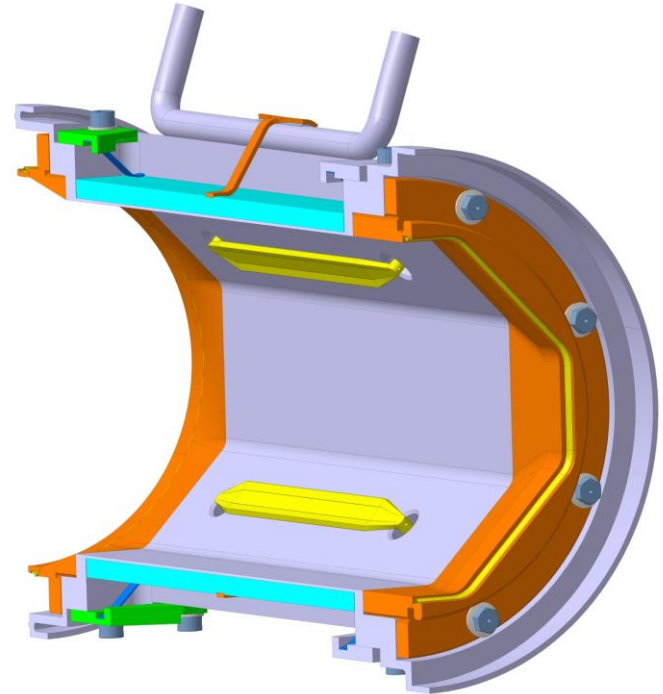
# Tendering overview (2)

- Cryostat cables
  - Very limited number of reliable suppliers
  - ~ 300 SiO<sub>2</sub> RF cables needed (proto, series, spares)
  - Tendering strategy discussed with HL PO
    - Technical specification by June 2019
    - Market Survey by December 2019
- Button electrodes
  - 40-50 needed (prototypes, series, spares)
  - Electromagnetic design ongoing
  - Button BPM workshop in May 2019 at Diamond (UK)
    - Feedback from other facilities
    - Feedback from suppliers
  - Tendering end of 2019 or in 2020



# Tendering overview (3)

- Raw material for BPM bodies
  - 44 blocks of 316LN needed (series, spares)
  - 76 blocks of copper needed (series, spares)
  - Final design needed for exact dimensions
  - To be purchased in next months
- Machined tungsten absorbers
  - 88 units needed
  - Tendering via VSC beam screen contract
  - Pre-series (10 units) delivery February 2020
  - Series delivery September 2020
- Cooling tubes
  - 112 tubes + connections needed (series, spares)
  - To be specified and purchased soon



# Infrastructure overview

- HL-LHC BPM equipment codes done
  - Coherent codes defined with HL PO
  - 32 new codes available
- EN/EL pre-DIC requests done
  - 360 signal cables (1/2 inch)
  - 240 optical fibres
  - 40 TN connection
  - WorldFIP under discussion with CO
- Rack requests and integration
  - 26 racks requested: 16 already exist, 6 already integrated, 4 under study
  - Radmons requested at all rack locations

<b>B</b>	B - BI equipment
<b>P</b>	P - Position measurements
<b>M</b>	M - Monitor
<b>Q</b>	Q - HL-LHC equipment
<b>B/C/S</b> <b>F/G/H</b>	B - button
	C - combined
	S - stripline
	F - subcomponent
	G - tooling
<b>T/W/C</b>	H - support
	C - cold
	T - inner triplet
<b>(Z)</b>	W - warm
	Z - top assembly of one or two BPMs (optional)
<b>A</b>	Subtype - A - Z

# Budget overview

- Detailed budget break-down available
- Total production and installation cost 1.38 MCHF
- 485 - 655 kCHF Russian in-kind possible

Item	Unit price [chf]	Quantity required					Paid by	Cost borne by			Comment
		BPMQSTZA Cold strip	BPMQSTZB Cold strip	BPMQSVZ Warm strip	BPMQBCZ Cold button	All BPMs		CERN [chf]	BIMP [chf]	TBD [chf]	
SERIES	0	4	20	4	8	36	CERN	0	0	0	
SPARES	0	2	2	2	2	8	CERN	0	0	0	
<b>BODY PRODUCTION</b>											
316 LN SS forged	1500	6	22	6	10	44	TBD	0	0	68000	Purchased through CERN, TBD who pays
Body machining cold strips	8000	6	22	0	0	28	BIMP	0	224000	0	Estimate based on MWE prototype
Body machining warm strips	8000	0	0	0	6	6	BIMP	0	48000	0	Estimate
Body machining cold buttons	4000	0	0	0	10	10	BIMP	0	40000	0	Estimate
Production DA	200	6	22	6	10	44	BIMP	0	8800	0	200 chf per BPM?
RF contacts raw material	1500	12	44	0	20	76	TBD	0	7600	0	2 per cold BPM
RF contacts manufacturing	1000	12	44	0	20	76	BIMP	0	114000	0	2 per cold BPM
Cooling tubes, brazing, laser welding	200	24	88	0	0	112	TBD	0	22400	0	4 per cold stripline
Copper plating	800	6	22	6	10	44	BIMP	0	35200	0	Each BPM?
RFRI check of copper plating	5000	2	0	0	0	2	CERN	10000	0	0	Two checks are enough?
Carbon coating	10000	1	4	1	2	8	CERN	80000	0	0	Price per run, 5-8 BPMs per run?
Carbon coating tooling design	50	40	40	40	40	160	CERN	8000	0	0	Price per hour of design office
Carbon coating tooling manufacturing	9000	1	0	0	0	1	CERN	9000	0	0	One-off cost
Machined tungsten inserts	500	0	88	0	0	88	CERN	44000	0	0	Only needed for BPMQSTZB
Leak check gaskets	8	48	176	48	40	312	TBD	0	2496	0	8 per stripline, 4 per button
Leak check gaskets	8	48	176	48	40	312	TBD	0	2496	0	8 per stripline, 4 per button
Leak check	2000	12	44	12	20	88	BIMP	0	17600	0	2 per BPM, before and after copper coating
Visits to supplier	2000	2	2	0	1	6	CERN	12000	0	0	6 visits foreseen
CERN verification tests	30000	0	0	0	0	1	CERN	30000	0	0	One-off cost, dimensions, leaks, plating etc.
Warm BPM support platforms	2000	0	0	5	0	5	BIMP	0	10000	0	Support platforms for warm BPMs, 1 per series BPM + 1 spare
							<b>Subtotal</b>	<b>193000</b>	<b>485600</b>	<b>100992</b>	<b>77952</b>
<b>ELECTRODES AND FEEDTHROUGHS</b>											
Electrodes A	500	24	88	0	0	112	TBD	0	0	56000	4 per cold striplines
Electrodes B	500	0	0	24	0	24	TBD	0	0	12000	4 per warm striplines
Buttons	500	0	0	0	40	40	CERN	20000	0	0	4 per button
Feedthroughs	500	148	176	48	0	370	CERN	185000	0	0	8 per stripline + 38 spares / prototypes for tests
Silver coated screws	5	288	1056	288	240	1872	CERN	9360	0	0	48 per stripline, 24 per button
Copper gasket	8	48	176	48	40	312	CERN	2496	0	0	8 per stripline, 4 per button
Crystal feedthrough	800	12	40	0	8	60	CERN	36000	0	0	4 connectors, 2 per series stripline, 1 per series button + 4 spares
							<b>Subtotal</b>	<b>252856</b>	<b>0</b>	<b>68000</b>	<b>320856</b>
<b>BODY AND ELECTRODE ASSEMBLY</b>											
Manpower	50	24	88	24	40	176	CERN	8800	0	0	4 hours per BPM
Electric tests	50	24	88	24	40	176	CERN	8800	0	0	4 hours per BPM
Copper gaskets	8	48	176	48	40	312	CERN	2496	0	0	Counted twice?
Leak test	200	6	22	6	10	44	CERN	8800	0	0	After full assembly
							<b>Subtotal</b>	<b>28896</b>	<b>0</b>	<b>0</b>	<b>28896</b>
<b>CABLING</b>											
Routing design	50	40	40	0	40	120	CERN	6000	0	0	40 hours per cold BPM
Cables	500	48	160	48	48	304	CERN	152000	0	0	8 per stripline, 4 per button, with spares
							<b>Subtotal</b>	<b>158000</b>	<b>0</b>	<b>0</b>	<b>158000</b>
<b>CRYO MAGNET ASSEMBLY</b>											
Manufacturing study	50	100	100	0	100	300	CERN	15000	0	0	100 h of MWE per cold BPM
Installation and alignment tooling design	50	40	40	0	40	120	CERN	6000	0	0	40 h of MWE per cold BPM
Installation and alignment tooling manufacturing	5000	1	0	0	0	1	CERN	5000	0	0	One-off cost
Supply of dummy BPM for integration tests	3000	0	1	0	0	1	CERN	3000	0	0	What is this cost?
Development of welding parameters	10000	1	0	0	0	1	CERN	10000	0	0	One-off cost requested by WP12
Carbon coating tests	10000	1	0	0	0	1	CERN	10000	0	0	VSC cost of a single run
Installation of BPM alignment tool	50	6	22	0	10	38	CERN	1900	0	0	1 hour per cold BPM
Spot welding body to vacuum chamber	50	12	44	0	20	76	CERN	3800	0	0	2 hours per cold BPM, paid by WP13, done by WP12
Final total weld	50	24	88	0	40	152	CERN	7600	0	0	4 hours per cold BPM, paid by WP13, done by WP12
Intermediate leak check (body)	0	12	44	0	20	76	CERN	0	0	0	2 hours per cold BPM, paid by WP12
Installation and welding of cooling tubes	25	24	88	0	0	112	CERN	2800	0	0	4 hours per cold stripline, paid in 50% by WP12
Supply of cooling tubes connections	100	24	88	0	0	112	CERN	11200	0	0	4 per cold stripline
Intermediate leak check (cooling tubes)	25	24	88	0	0	112	CERN	2800	0	0	4 hours per cold stripline, paid in 50% by WP12
Cable installation and electrical tests	50	24	88	0	40	152	CERN	7600	0	0	4 hours per cold BPM
Intermediate leak check (cable flange)	0	6	22	0	10	38	CERN	0	0	0	1 hour per cold BPM, paid by WP12
Alignment and position verification	0	24	176	0	40	240	CERN	0	0	0	4 hours per BPM, paid by WP15
Documentation	700	12	44	12	20	88	CERN	6160	0	0	2 hours per BPM, 70 chf/h
							<b>Subtotal</b>	<b>92860</b>	<b>0</b>	<b>0</b>	<b>92860</b>
<b>TOTAL PRODUCTION COST</b>											
							<b>Subtotal</b>	<b>725612</b>	<b>485600</b>	<b>168992</b>	<b>1380204</b>



# Simplified budget breakdown

<b>Mechanics</b>	<b>571 kCHF</b>
Raw materials	96 kCHF
Machining	433 kCHF
Outsourcing overhead	42 kCHF

<b>Coating and vacuum</b>	<b>184 kCHF</b>
Amorphous carbon	107 kCHF
Copper plating	45 kCHF
Leak checks	32 kCHF

<b>Tungsten</b>	<b>44 kCHF</b>
Machined absorbers	44 kCHF

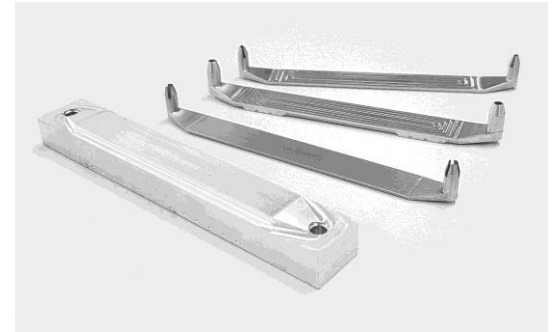
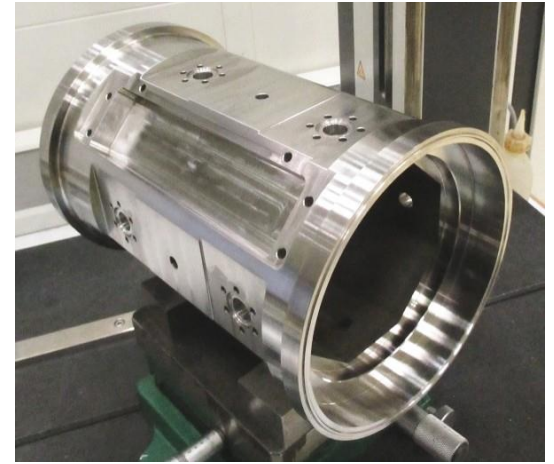
<b>RF components</b>	<b>478 kCHF</b>
Electrodes + buttons	88 kCHF
All feedthroughs	232 kCHF
Cryogenic RF cables	158 kCHF

<b>Installation</b>	<b>103 kCHF</b>
Assembly + installation	103 kCHF

**1.38 MCH total, 31.4 kCHF per BPM**

# Prototyping overview (1)

- Mechanics
  - Pre-prototype of a BPMQSTZB done with MME
  - Metrology done at CERN
  - Cost and manufacturing challenges reviewed
  - Optimisation under study
- BPM feedthrough test campaign
  - Prototypes requested for Q3 2019
  - Test campaign planned
    - RF, cryogenics, vacuum, mechanics
  - Specialised tooling already designed



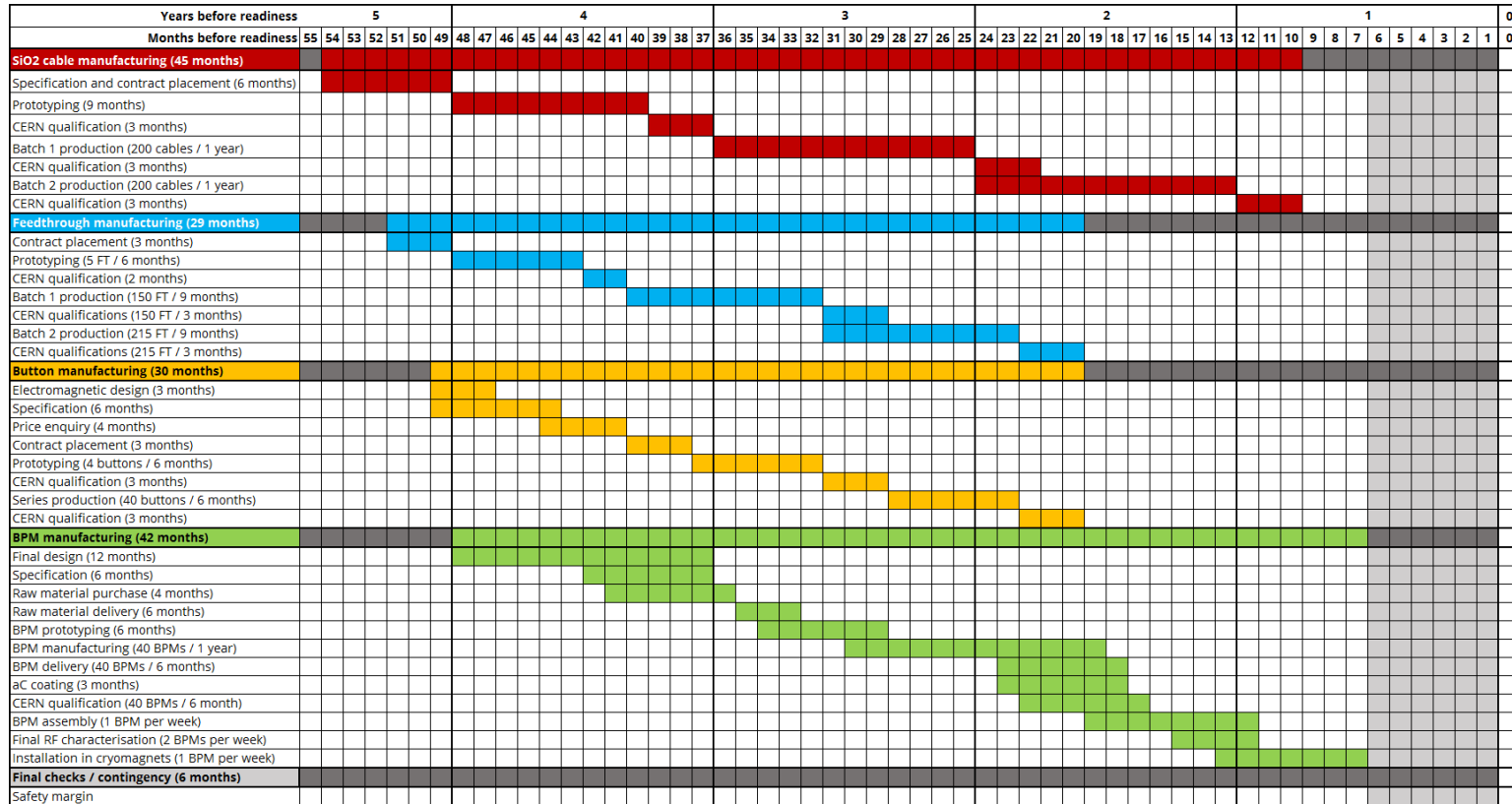
# Prototyping overview (2)

- Cryogenic RF cables
  - KT collaboration with a possible member state supplier under preparation
  - Discouraging recent experience with (similar) collimator cables
  - Long and challenging test campaign ahead of us
  - Should we seriously consider in-house development?
- Button test campaign
  - Lots of experience with qualifying buttons
  - Exact test procedures to be defined in technical specification
- Interconnection mock-ups
  - Promised and discussed but details very hazy
  - Formal global plan needed?

# Planning overview

- Task in generally good shape and on track
- No BPMs in String Test
  - Redistribution of priorities
- Formal clarification of required-by date needed
  - Meeting with HL PO scheduled on 25 March 2019
- Russian in-kind contribution possible
  - Draft collaboration agreement ready
  - Impact on planning
- Fine tuning of formal agreements with other WPs
  - Distribution of responsibilities between WP3 / WP12 / WP13 / WP15

# Conservative planning – 54 months



# Planning details

## Feedthrough manufacturing (29 months)

Contract placement (3 months)
Prototyping (5 FT / 6 months)
CERN qualification (2 months)
Batch 1 production (150 FT / 9 months)
CERN qualifications (150 FT / 3 months)
Batch 2 production (215 FT / 9 months)
CERN qualifications (215 FT / 3 months)

## Button manufacturing (30 months)

Electromagnetic design (3 months)
Specification (6 months)
Price enquiry (4 months)
Contract placement (3 months)
Prototyping (4 buttons / 6 months)
CERN qualification (3 months)
Series production (40 buttons / 6 months)
CERN qualification (3 months)

## Final checks / contingency (6 months)

Safety margin (6 months)
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## SI02 cable manufacturing (45 months)

Specification and contract placement (6 months)
Prototyping (9 months)
CERN qualification (3 months)
Batch 1 production (200 cables / 1 year)
CERN qualification (3 months)
Batch 2 production (200 cables / 1 year)
CERN qualification (3 months)

## BPM manufacturing (42 months)

Final design (12 months)
Specification (6 months)
Raw material purchase (4 months)
Raw material delivery (6 months)
BPM prototyping (6 months)
BPM manufacturing (40 BPMs / 1 year)
BPM delivery (40 BPMs / 6 months)
aC coating (3 months)
CERN qualification (40 BPMs / 6 month)
BPM assembly (1 BPM per week)
Final RF characterisation (2 BPMs per week)
Installation in cryomagnets (1 BPM per week)

# Conclusions

- HL-LHC BPMs in generally good shape and on track
- Multiple activities ongoing simultaneously
- Russian in-kind contribution possible
- Most of tendering strategy discussed with purchasing and progressing according to the schedule
- All necessary infrastructure ready or requested
- Prototyping progressing as foreseen
- Long test campaigns foreseen
- Detailed budget breakdown and planning available
- Outstanding issues:
  - Required-by date for every BPM type – soon to be defined
  - Global interconnection mock-up planning



***Thank you for your attention***

