Evolution of LARP

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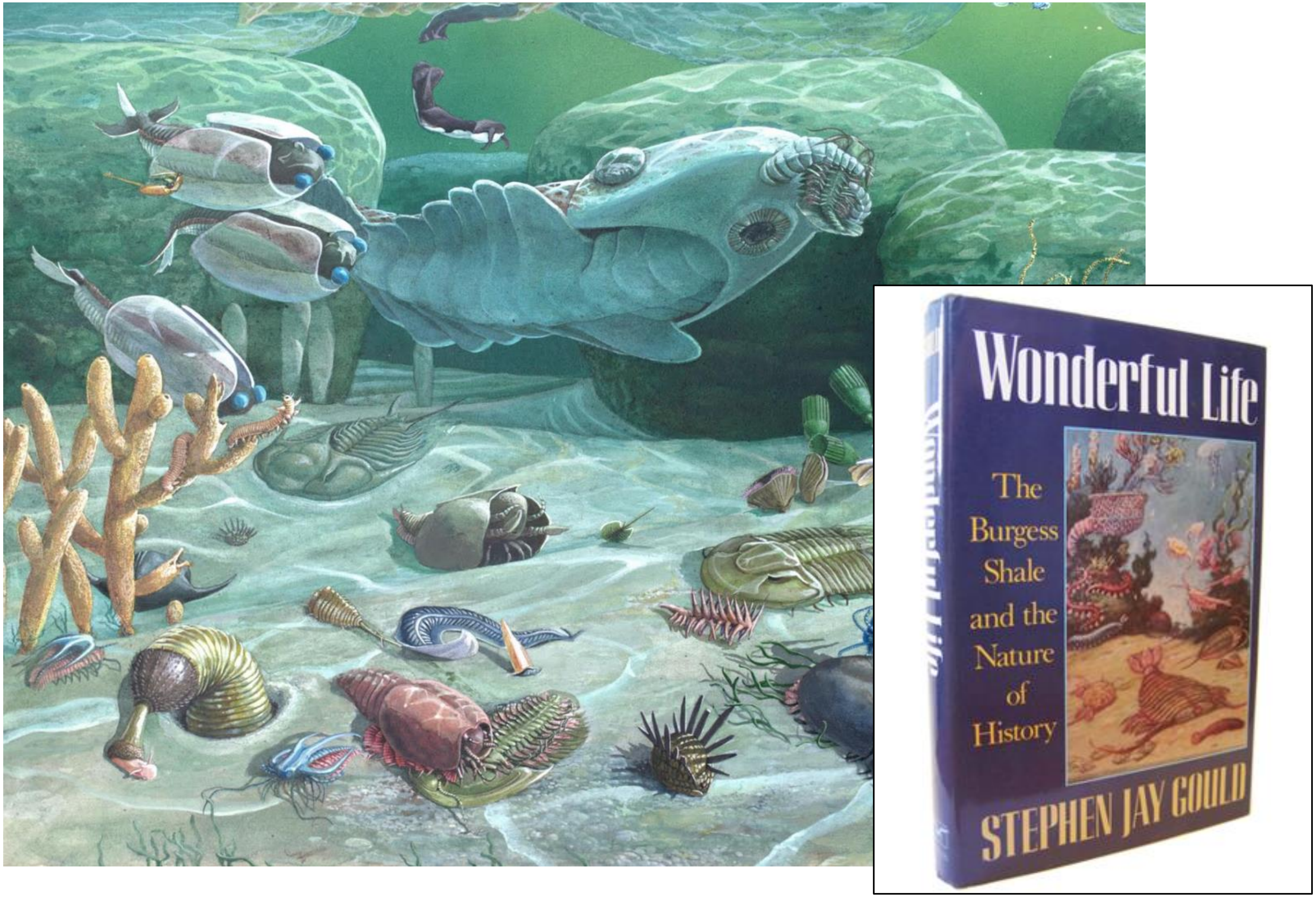
LARP Director

KEK, HiLumi/LARP 4th Meeting – Nov. 17th-21st, 2014

A Cambrian Ocean …



HEP Strategy

<u>European Strategy for Particle Physics - Update 2013</u>

*Europe's top priority should be the **exploitation of the full potential of the LHC**, including the high-luminosity upgrade of the machine and detectors with a view to collecting <u>ten times more data</u> than in the initial design, by around 2030…*

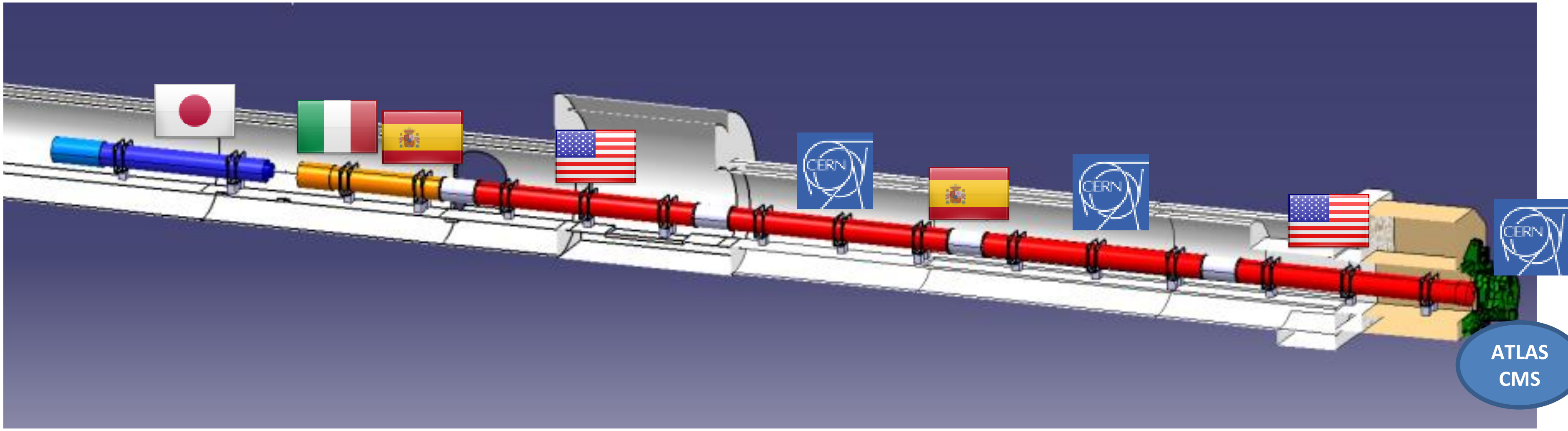
<u>US Prioritization for Particle Physics (P5) - May 2014</u>

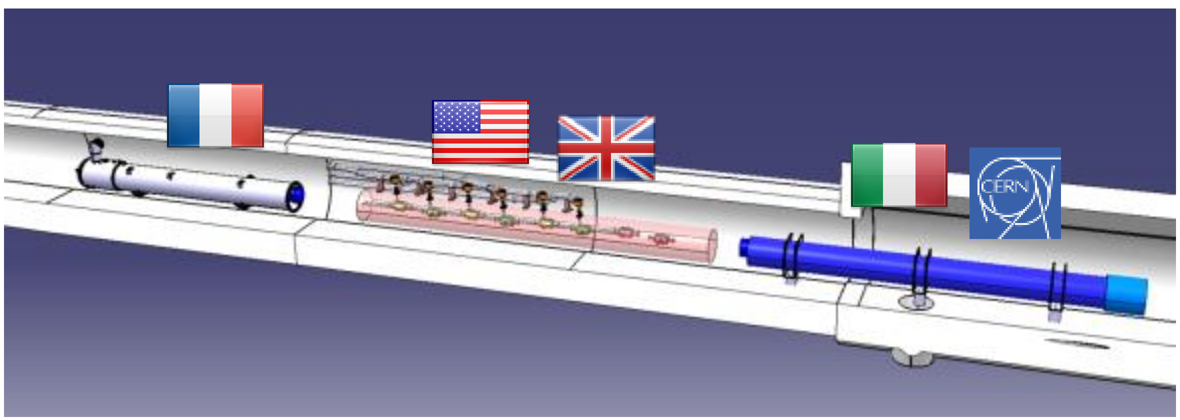
Complete the LHC phase-1 upgrades and continue the strong collaboration in the LHC with the phase-2 (HL-LHC) upgrades of the accelerator and both general-purpose experiments (ATLAS and CMS). The LHC upgrades constitute our highest-priority near-term large project (Recommendation to HEPAP).

HL-LHC from a study to a PROJECT

300 fb^{-1} → 3000/4000 fb^{-1}

New IRs





CC : R&D, Design and in-kind **USA**

CC : R&D and Design **UK**

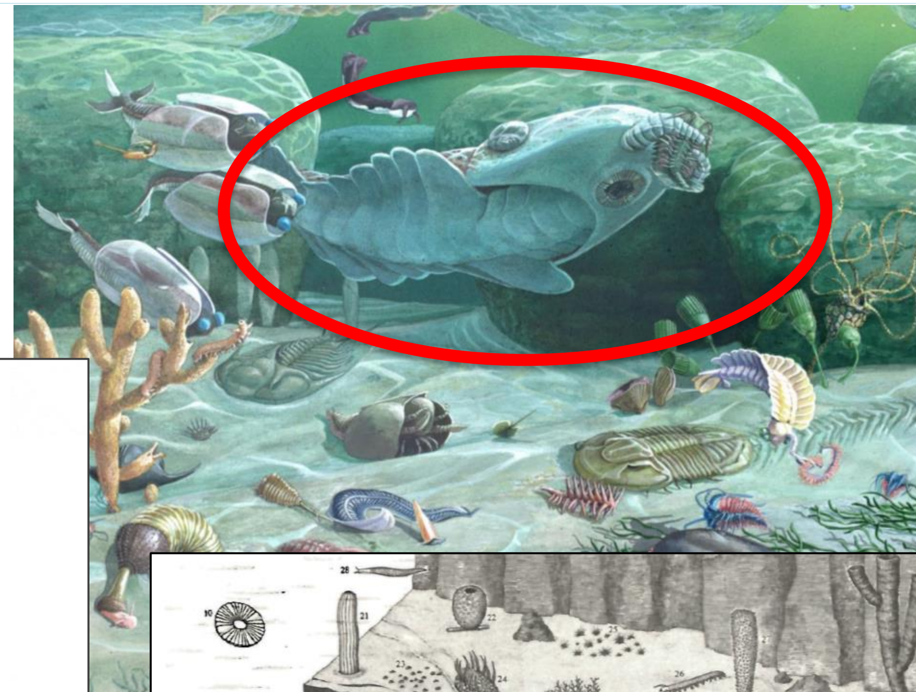
Q1-Q3 : R&D, Design, Prototypes and in-kind **USA**
D1 : R&D, Design, Prototypes and in-kind **JP**
MCBX : Design and Prototype **ES**
HO Correctors: Design and Prototypes **IT**
Q4 : Design and Prototype **FR**

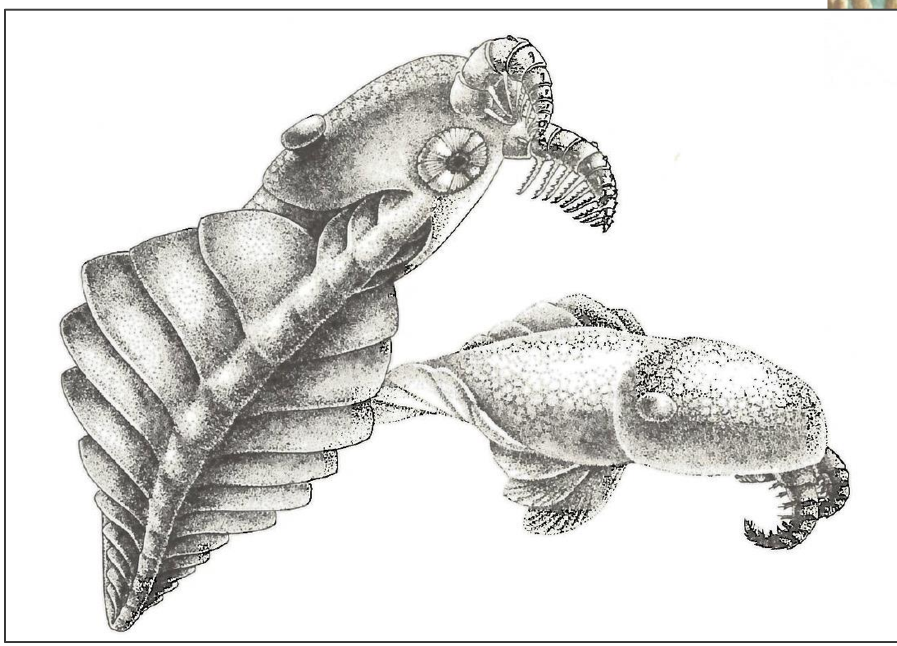
Where does US LARP come in ?

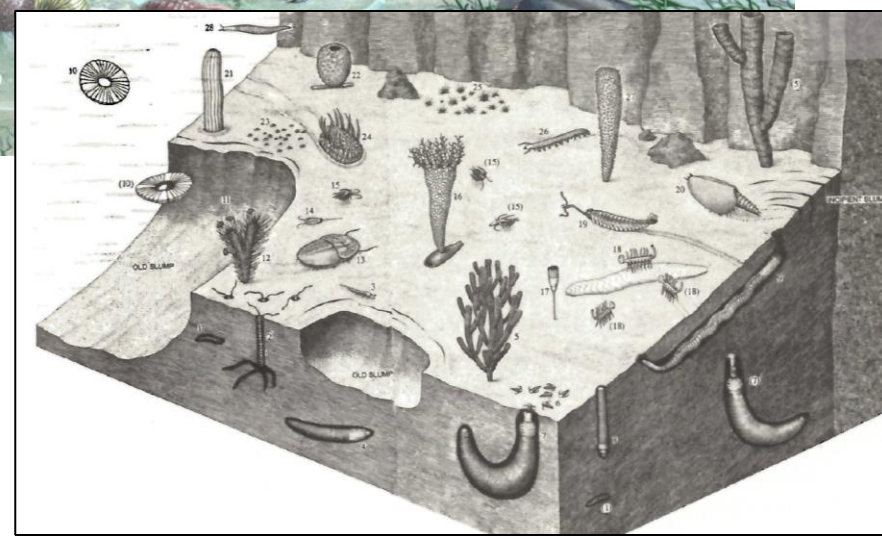
1. More Luminosity: increase squeeze at interaction region
   – Increase magnet aperture, therefore increase field.
   – Use Nb_3Sn Technology as ***Baseline***

2. More beam: larger beam-beam interactions in region where they are brought close together.
   – Solution 1: keep beam as separated as possible increasing crossing angle from 300 μrad to 600 μrad. Use Crab Cavities as ***Baseline***
   – Solution 2 (Plan B): If solution 1 does not work, reduce crossing to 300 mrad and mitigate beam-beam interaction with Long Range Beam Beam Wire or hollow e-lens (*R&D effort*).
   – Control possible transverse instabilities or e-cloud effects with Wide Band Feedback System (*R&D effort*).

Anomalocaris







- First rule: survive !
  - that is: know the law of the land and live by it !

DOE Critical Decision

- A DOE construction project is governed by DOE Order 413.3B
  - https://www.directives.doe.gov/directives-documents/0413.3-BOrder-b
  - Applies to capital assets projects having a Total Project Cost greater than or equal to $50M
- DOE projects typically progress through five Critical Decision (CD) gateways, which serve as major milestones
  - Each CD marks an authorization to increase the commitment of resources by DOE and requires successful completion of the preceding phase or CD
- We call the construction project **US-HiLumi**, to distinguish it from the LARP "R&D" Program
- **US-HiLumi**: What, How and How Much

The *"What"*: Key Performance Parameters (KPP)

1. **Magnets**: A total of ten (10) LHC Inner Triplets Q1 and Q3 cold masses (LMQXFA and LMQXFB). Two spares are included in this count. Each cold mass contains two 150mm Nb3Sn magnet structures (MQXFA) installed in a helium pressure vessel ready for insertion into the cryostat. The cryostat for these cold masses (QQXFA for Q1 and QQXFB for Q3) is outside the scope of the US-HiLumi project and will be provided by CERN to complete the Q1 assembly (LQXFA) and the Q3 assembly (LQXFB) for LHC tunnel installation.

   a. Preliminary threshold KPPs: the threshold KPP is to provide an operating magnetic field gradient of 140 T/m in the transverse plane at an operational temperature of 1.9K.

   b. Preliminary objective KPPs: to achieve the minimum operating gradient of 140 T/m with (no, few, less than?) quenches after a thermal cycle, and to achieve a maximum operating gradient in the range of TBD-TBD T/m.

1. **Crab Cavities**: A total of forty (40) dressed crab cavities (CERN naming convention?). The cryomodule for these cavities is outside the US-HiLumi project and will be provided by CERN. There will be 2/4(?) cavities per cryomodule, for a total of 8/16(?) cryomodules in two LHC interaction regions. A total of 32 dressed cavities are needed for these cryomodules, and the rest are spares. The number of spares is tentatively set at eight, assuming that there will be two dressed cavity types and one spare cryomodule is needed for each cavity type.

   a. Preliminary Threshold KPPs:

   b. Preliminary Objective KPPs:

Note: preliminary status of CC "baselining"
Beyond SPS test makes for difficult estimates

KPP (2)

1. **Wideband Feedback System:** the hardware, firmware, and diagnostics for an instability control processing system. CERN scope includes Beam Position Monitors (BPMs), kickers, cabling, etc.

    a. Preliminary Threshold KPPs: to provide the analog electronics, digital electronics and control algorithm to measure and control vertical intra-bunch motion in the SPS at 4 Gigasamples/second (20x SPS 200 MHz RF) with 8 bit resolution for a full LHC fill (5 stacks of 72 bunches/stack) from injection energy (26 GeV) to extraction energy (450 GeV). The digital processing system will synchronize with the injection and extraction acceleration cycles and compute slice by slice correction signals and apply them to a CERN-fabricated kicker correction system.

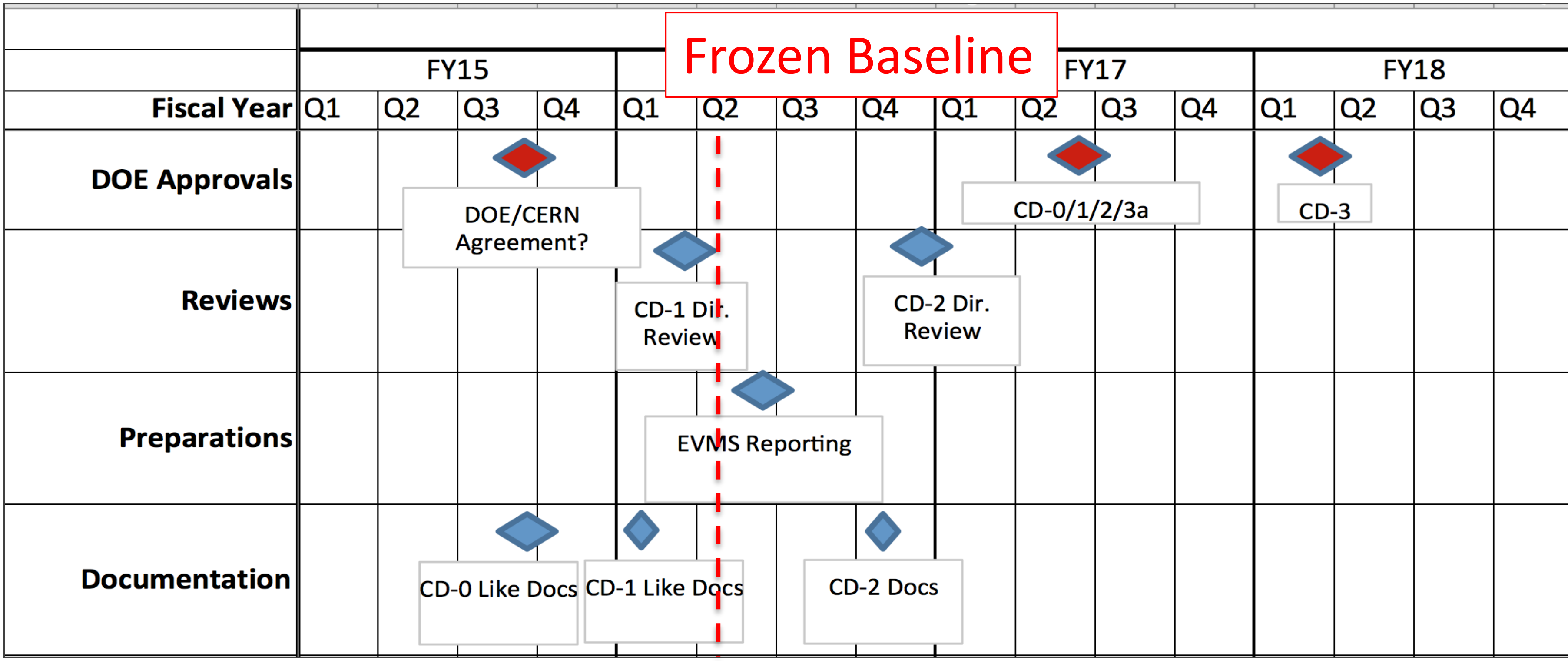
    b. Preliminary Objective KPPs: to expand the base architecture and signal processing to flexibly allow multiple beam pickups and kickers at 4-8 Gigasamples/sec each. Expand processing capability to allow more computationally sophisticated algorithms and beam diagnostics. Incorporate a flexible architecture for use at LHC or other facilities.

2. **Electron Lens System**

    a. Preliminary Threshold KPPs: 2 electron guns delivered to CERN providing 4 A of electron beam current at 10 kV.

    b. Preliminary Objective KPP: deliver to CERN 2 electron guns (5 A at 10 kV), 2 superconducting solenoids (3m long, 80 mm aperture, 6 T maximum field, 100 mm field straightness), and 2 backscattered electron detectors.

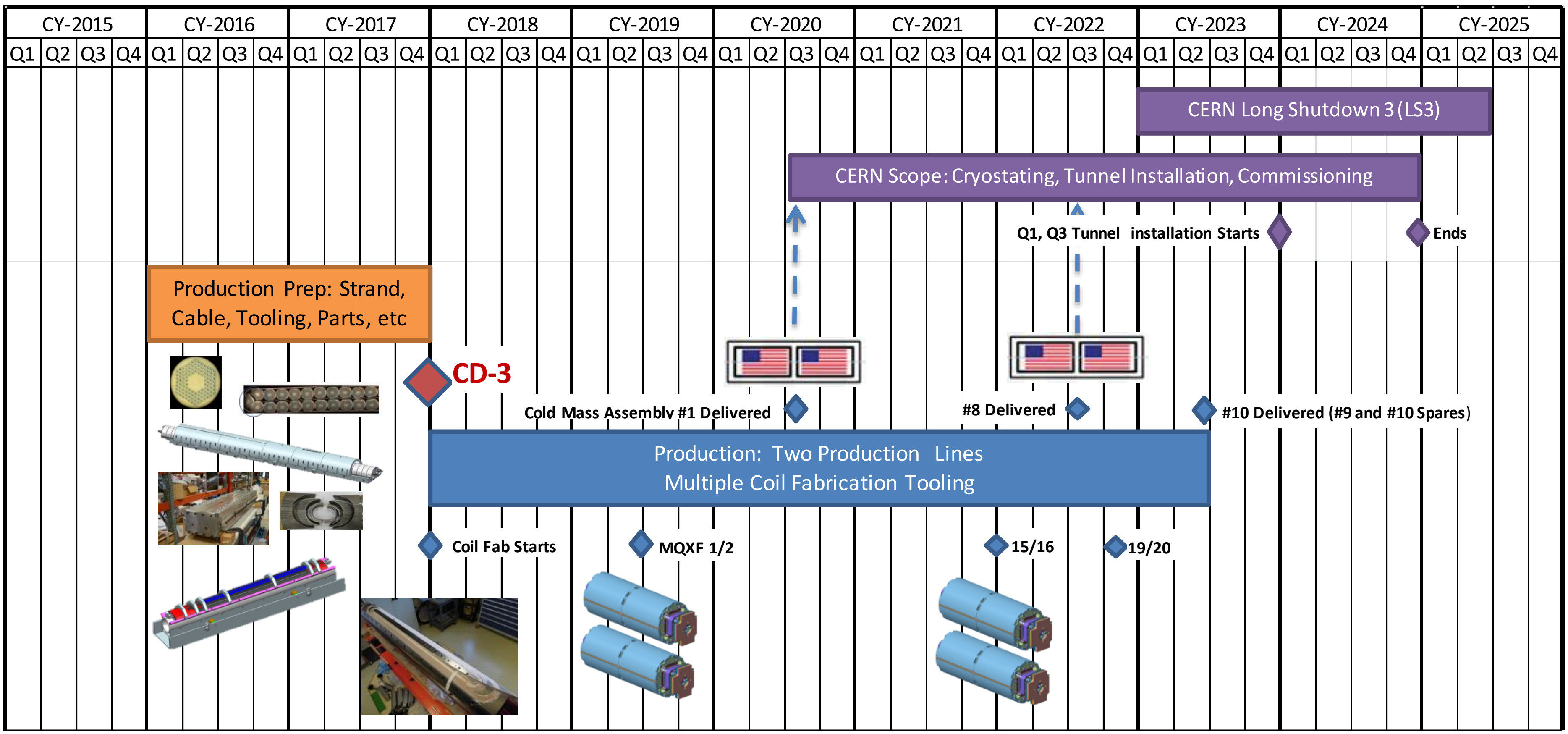
The "*How*": Schedule View



- "CERN" HL-LHC PDR Milestones
  - 2015 Release of Technical Design Report
  - 2017 Testing of Prototypes
  - 2017-2021 Construction
  - 2021-2022 Inner Triplet String Test (not covered by US-HiLumi, LARP2 ?)

US-HiLumi Magnets Timeline

- Plan requires CD-3 approval by January 2018
- Plan requires two years of production preparation funding
  - Tooling, materials, parts, and personnel must be in place to start coil series production in two lines by CD-3



The *“How Much”*: Project WBS and Cost Estimate

Responsible	WBS Level						Activity	
	L1	L2	L3	L4	L5	L6	ID	WBS or Activity Name
	1							US HL-LHC
		1.01						Project Office
Ambrosio		1.02						Cold Masses for Q1 and Q3
Ambrosio			**1.02.01**					**MQXF Management**
				1.02.01.01				Design & documentation
Ghosh			**1.02.02**					**Conductor**
				1.02.02.01				Strand Procurement
				1.02.02.02				Cable Fabrication and shipping
				1.02.02.03				Cable insulation and shipping
Yu			**1.02.03**					**Coil parts & materials**
				1.02.03.01				Coil parts
					1.02.03.01,01/02/03			
				1.02.03.02				Traces
				1.02.03.03				Other materials
Nobrega			**1.02.04**					**Q1 Coils**
				1.02.04.01				Q1 Winding and Curing Tooling
				1.02.04.02				Q1 Reaction and Impregnation Tooling
				1.02.04.03				Q1 Handling, Storage & Shipping tooling
				1.02.04.04				Coil #Q1.1
					1.02.04.04.01			Coil #1 Winding and Curing
					1.02.04.04.02			Coil #1 Reaction
					1.02.04.04.03			Coil #1 Impregnation
					1.02.04.04.04			Coil #1 Instrumentation and Inspection
					1.02.04.04.05			Coil #1 Storage and Shipping
				Repeat 45 Times				
Schmalzle			**1.02.05**					**Q3 Coils**
				1.02.05.01				Q3 Winding and Curing Tooling
				1.02.05.02				Q3 Reaction and Impregnation Tooling
				1.02.05.03				Q3 Handling, Storage & Shipping tooling
				1.02.05.04				Coil #Q3.1
					1.02.05.04.01			Coil #1 Winding and Curing
					1.02.05.04.02			Coil #1 Reaction
					1.02.05.04.03			Coil #1 Impregnation
					1.02.05.04.04			Coil #1 Instrumentation and Inspection
					1.02.05.04.05			Coil #1 Storage and Shipping
				Repeat 45 Times				
Felice			**1.02.06**					**Structures pre-assembly & Qualification**
				1.02.06.01				Structure Assembly Tooling
				1.02.06.02				Structure Handling, Storage & Shipping Tooling
				1.02.06.03				Structure parts procurement
				1.02.06.04				Instrument practice coils
				1.02.06.05				Yoke/Shell Subassembly #1
					1.02.06.05.01			Yoke/Shell Subassembly #1 Construction
					1.02.06.05.02			Yoke/Shell Subassembly #1 Storage
				Repeat 20 times				
				1.02.06.06				Structure #1 Assembly & Qualification
					1.02.06.06.01			Practice Coils/Pads Subassembly #1
					1.02.06.06.02			Assembly of Coils/Pads #1 in Yoke/Shell #1
					1.02.06.06.03			Loading & Qualification
					1.02.06.06.04			Remove practice coils
					1.02.06.06.05			Structure #1 Shipment
				Repeat 20 times				

- Preliminary WBS
  - Created for Magnets, Crab Cavities, Electron Lenses, and Wideband Feedback System
  - Responsibilities assigned down to Level 3 (L3s)
  - Decomposition into WBS activities in progress
  - Basis of Estimates (BOEs) at the Activity Level (Working Package Level) in most cases
    - BOE Template was created and distributed to estimators
- Target is to have an updated cost estimate completed before the end of the year
  - Previous rough estimate end of CY2012
- Possible input/supporting documentation to CERN Cost & Schedule Review in February 2015
- Input to DOE/CERN agreement and needed budget funding profile

BOE Template

- Excel Workbook with automated features

US HL-LHC Activity Basis of Estimate (BOE) - DRAFT v2, 9/17/14		
SUMMARY		
WBS:		From the WBS Structure
WBS Name:		From the WBS Structure
Activity ID:		From the WBS Structure
Activity ID Name:		From the WBS Structure
Activity ID Description		
Estimator:		Name of the person providing the estimate
Contributors:		Names of the person(s) contributing to the esti
Date:		Estimate Date
Organization:		Organization where the activity will take place (pick from the drop-down list)
Base Labor (h):	0	Filled in automatically from the Labor Table Sh
Labor Estimate Type:	0	Filled in automatically from the Labor Table Sh
Base M&S ($):	0	Filled in automatically from the M&S Table She
M&S Estimate Type:	0	Filled in automatically from the M&S Table She
Most Likey Duration (Working Days):		Estimate most likely activity duration. Assume
Optimistic Duration Working Days):		Estimate optimistic duration (when everything
essimistic Duratiion (Working Days):		Estimate pessimistic duration (when there are
ASSUMPTIONS		
Common Assumptions		**These assumptions are common to all BOEs**
BOEs are for US-HL-LHC Project Activities only		
CD-0 is assumed to take place in FY17 (together with CD-1 and CD-2), CD-3 in FY18, and CD-4 in FY24		
M&S Costs are in 2014 (2015>?) dollars and do not include indirects and escalation		
Duration estimates are in calendar days. Minimum duration is 1 working day		
1 Calendar Year = 250 Working Days		
Labor estimates are in working hours		
A common set of resource roles are used for labor estimates, independent of the organization performing t		
1 FTE = 1768 hours for an average year		
Activity ID Assumptions		**These assumptions are specific to this Activity BOE**
List assumptions for inputs/outputs, quantities,		
List assumptions for available tooling, other equipment or infrastructure necessary to conduct the work or t		
List assumptions for necessary materials and/or labor provided by others and not costed as part of this acti		
Refer to other sheets or documents for more detail if necessary		

Resource Role	Hours	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
	0									
Total:	0	0	0	0	0	0	0	0	0	0
Estimate Type:										

M&S Item	Base Cost	FY15	FY16	FY17	FY18	FY19
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
	0					
Total:	0	0	0	0	0	0
Estimate Type:						

Standard Contingency Tables

Code	Type of Estimate	Contingency %	Description
LABOR Guidelines			
L1	Actual	0%	Actual costs incurred on activities completed to date.
L2	Level of Effort Tasks	0%-20%	Support type activities that must be done to support other work activities or the entire project effort, where estimated effort is based on the duration of the activities it is supporting.
L3	Advanced	10%-25%	Based on experience with documented identical or nearly identical work. Development of activities, resource requirements, and schedule constraints are highly mature. Technical requirements are very straightforward to achieve.
L4	Preliminary	25%-40%	Based on direct experience with similar work. Development of activities, resource requirements, and schedule constraints are defined at a preliminary (beyond conceptual) design level. Technical requirements are achievable and with some precedent.
L5	Conceptual	40%-60%	Based on expert judgment using some experience as a reference. Development of activities, resource requirements, and schedule constraints are defined at a conceptual level. Technical requirements are moderately challenging.
L6	Pre-conceptual	60%-80%	Based only on expert judgment without similar experience. Development of activities, resource requirements, and schedule constraints are defined at a pre-conceptual level. Technical requirements are moderately challenging.
L7	Rough Estimate	80%-100%	Based only on expert judgment without similar experience. Development of activities, resource requirements, and schedule constraints is largely incomplete. Technical requirements are challenging.
L8	Beyond state of the art	>100%	No experience available for reference. Activities, resource requirements, and schedule constraints are completely undeveloped. Technical requirements are beyond the state of the art.

Code	Type of Estimate	Contingency %	Description
M&S Guidelines			
M1	Existing Purchase Order	0%	Items that have been completed or obligated. (Note: Contact Change Orders are considered a Risk and should not be included as estimate uncertainty contingency)
M2	Procurements for LOE / Oversight work	0%-20%	M&S items such as travel, software purchases and upgrades, computers, etc. estimated to support LOE efforts and other work activities.
M3	Advanced	10%-20%	Items for which there is a catalog price or recent vendor quote based on a completed or nearly completed design or an existing design with little or no modifications and for which the costs are documented.
M4	Preliminary	20%-40%	Items that can be readily estimated from a reasonably detailed but not completed design; items adapted from existing designs but with moderate modifications, which have documented costs from past projects. A recent vendor survey (e.g., budgetary quote, vendor RFI response) based on a preliminary design belongs here.
M5	Conceptual	40%-60%	Items with a documented conceptual level of design; items adapted from existing designs but with extensive modifications, which have documented costs from past projects
M6	Pre-Conceptual - Common work	60%-80%	Items that do not have a documented conceptual design, but do have documented costs from past projects. Use of this estimate type indicates little confidence in the estimate. Its use should be minimized when completing the final estimate.
M7	Pre-Conceptual - Uncommon work	80%-100%	Items that do not have a documented conceptual design, and have no documented costs from past projects. Its use should be minimized when completing the final estimate.
M8	Beyond state of the art	>100%	Items that do not have a documented conceptual design, and have no documented costs from past projects. Technical requirements are beyond the state of the art.

Example of assumptions: Magnet Production Throughput

- Plan requires 2 MQXF magnets every ~ 5 months
  - Need two production lines for:
    - Coils
    - Coil Pack Insert
    - Yoke/Shell Assembly
    - Quadrupole Assembly
  - One set of tooling will be available from LARP, but need more. For example:
    - Coil throughput requires multiple tooling in each coil production line:
      - 1 Additional Mandrel Assembly per line
      - 3 Additional Reaction and Impregnation Tooling per line

Cost Slide with all caveats

US-HiLumi WBS Structure - FY15-01 Draft 11-14-14

2.8%

Total Project (without risk contingency)

esponsible	L1	L2	L3	L4	L5	L6	ID	WBS or Activity Name	BOE	Total Qty	Base FTEs	Base Labor Cost	Base M&S Cost	Base Total Cost	Uncertainty Contingency Cost	Contingency %	Escalation Cost	Total Cost
	1							US-HiLumi Project			352.72	$89,473,265	$69,391,315	$158,864,580	$65,559,625	41%	$1,222,782	$225,646,987
		1.01						Project Office			37.05	[redacted]						
mbrosio		1.02						Cold Masses for Q1 and Q3 (LMQXFA and LMQXFB)			243.68	[redacted]						
mbrosio			1.02.01					LMQXFA/B Management				[redacted]						
hosh			1.02.02					MQXFA Conductor			29.52	[redacted]						
u			1.02.03					Coil parts & materials			12.41	[redacted]						
lobrega (Yu)			1.02.04					Q1 Coils			37.05	[redacted]						
chmalzle			1.02.05					Q3 Coils			36.87	[redacted]						
elice			1.02.06					Structures Assembly & Qualification			11.38	[redacted]						
ossert			1.02.07					MQXFA Q1 Magnet Assemblies at FNAL (Option)										
nerella			1.02.08					MQXFA Q3 Magnet Assemblies at BNL (Option)										
nerella			1.02.09					Q1 & Q3 Magnet Vertical Test (Option)			17.30	[redacted]						
BD			1.02.10					Cold Mass Assemblies Q1 and Q3			4.45	[redacted]						
hlachidze			1.02.11					Cold Mass Horizontal Test			25.46	[redacted]						
atti		1.03						Crab Cavities			37.64	[redacted]						
			1.03.01					Design				[redacted]						
							1.03.01	Design Planning Package	Y	1	3.70	[redacted]						
			1.03.02					Tooling and Infrastructure				[redacted]						
							1.03.02	Tooling and Infrastructure Planning Package	Y	1	1.70	[redacted]						
			1.03.03					Cavities Fabrication				[redacted]						
							1.03.03	Initial Fabrication Planning Package	Y	6	5.77	[redacted]						
							1.03.04	Fabrication Planning Package	Y	36	26.47	[redacted]						
larkiewicz		1.04						Wide Band Feedback System			12.50	[redacted]						
			1.04.01					Full Function Processing System				[redacted]						
			1.04.02					Full Function High Power RF				[redacted]						
			1.04.03					Management of CERN-supplied components				[redacted]						
tancari		1.05						Electron lenses			21.85	[redacted]						
			1.05.20					Components for electron lens #1				[redacted]						
				1.05.20.10				Electron gun			1.59	[redacted]						
				1.05.20.20				Superconducting solenoid			14.73	[redacted]						
				1.05.20.30				Backscattered electron detector			2.53	[redacted]						

- Extremely preliminary output as of Nov 15th, 2014
- L2/L3 inputs taken without critical examination. Not all inputs of same maturity level
- Individual labs rate for SWF, 1FTE=1,768h
- Escalation included at 2.8%/y
- Cost Profile to be matched to DOE Funding profile (still unknown)

Cost Slide with all caveats (2)

esponsible	L1	L2	L3	L4	L5	L6	ID	WBS or Activity Name	BOE	Total Q	Base FTEs	Base Labor Cost	Base M&S Cost	Base Total Cost	Uncertainty Contingency Cost	Contingency %	Escalation Cost	Total Cost
US-HiLumi WBS Structure - FY15-01 Draft 11-14-14										Total Project (without risk contingency)								2.8%
	1							US-HiLumi Project			352.72	$89,473,265	$69,391,315	$158,864,580	$65,559,625	41%	$1,222,782	25,646,987
		1.01						Project Office			37.05	[redacted]						
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nerella			1.02.09					Q1 & Q3 Magnet Vertical Test (Option)			17.30	[redacted]						
BD			1.02.10					Cold Mass Assemblies Q1 and Q3			4.45	[redacted]						
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			1.03.02					Tooling and Infrastructure				[redacted]						
							1.03.02	Tooling and Infrastructure Planning Package	Y	1	1.70	[redacted]						
			1.03.03					Cavities Fabrication				[redacted]						
							1.03.03	Initial Fabrication Planning Package	Y	6	5.77	[redacted]						
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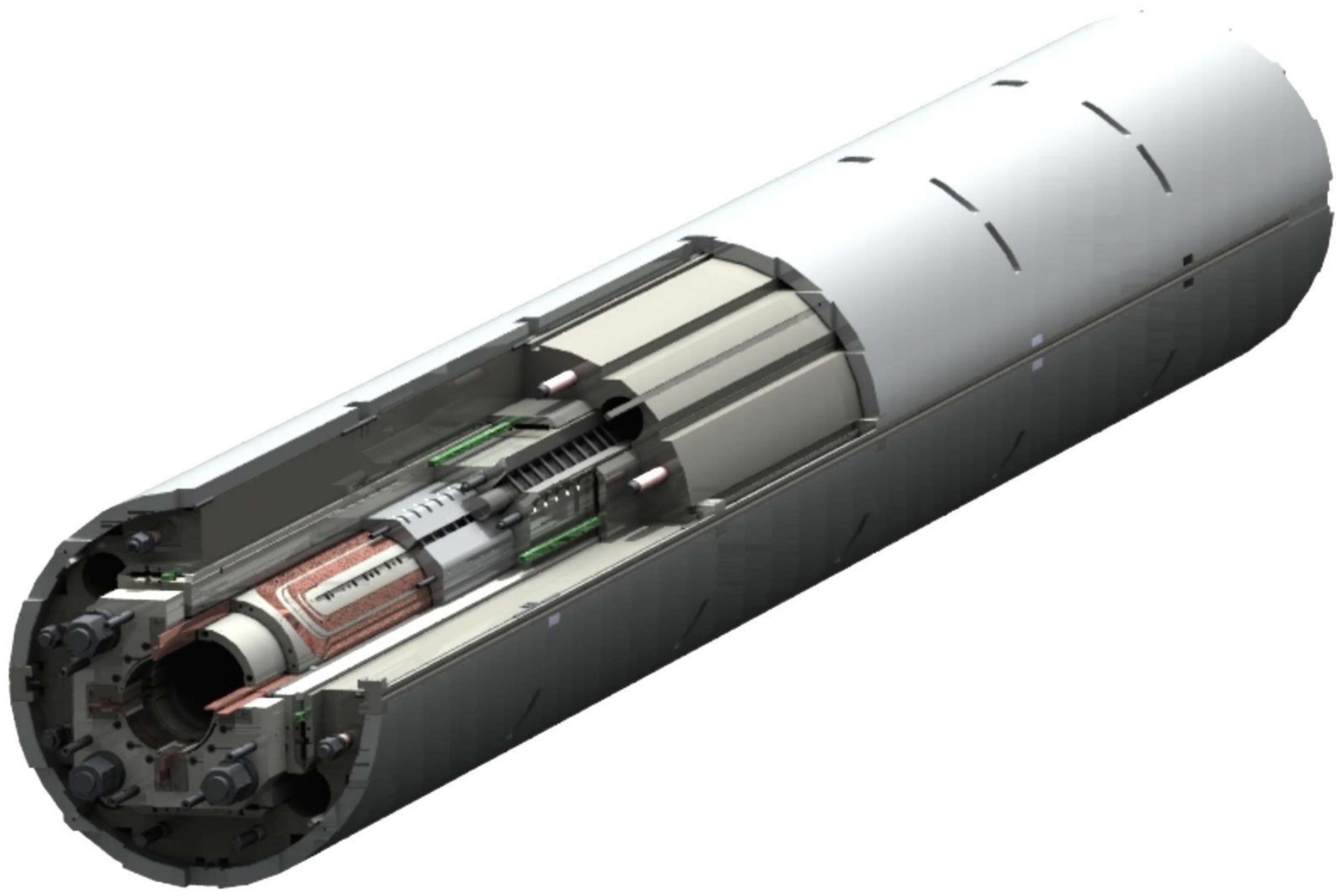
			1.04.02					Full Function High Power RF				[redacted]						
			1.04.03					Management of CERN-supplied components				[redacted]						
tancari		1.05						Electron lenses			21.85	[redacted]						
			1.05.20					Components for electron lens #1				[redacted]						
				1.05.20.10				Electron gun			1.59	[redacted]						
				1.05.20.20				Superconducting solenoid			14.73	[redacted]						
				1.05.20.30				Backscattered electron detector			2.53	[redacted]						

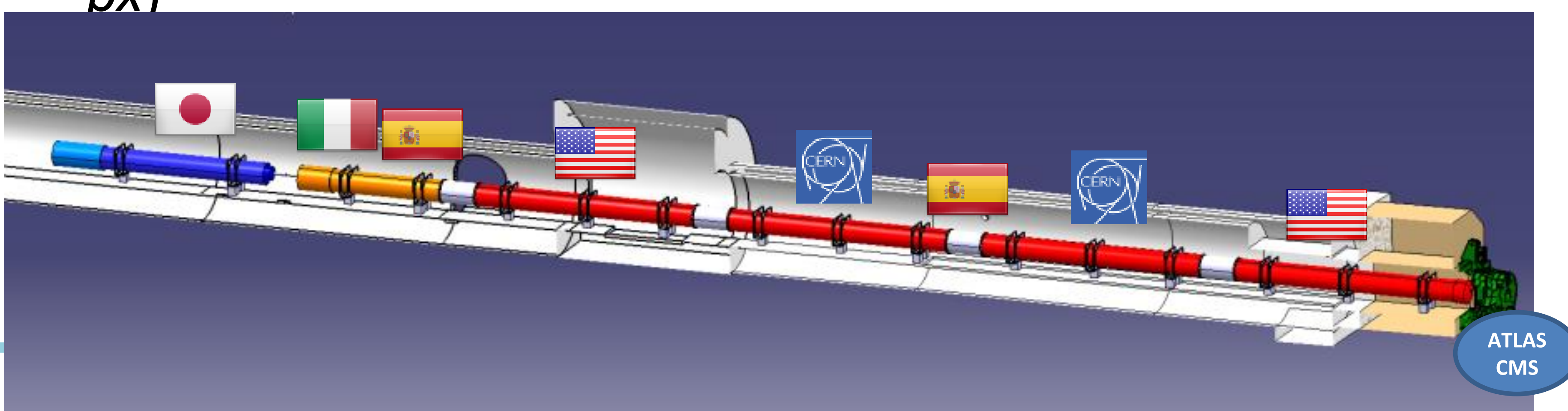
- Close to expected ~200 M$ US contribution to LHC, but cuts to this list might be necessary (assuming Cost Estimate is robust)
- Approximately 300 FTEs effort in US
- SWF-to-M&S close to 1-to-1
- “Escalation” is a bitch

Pikaia



MQXF Main Parameters

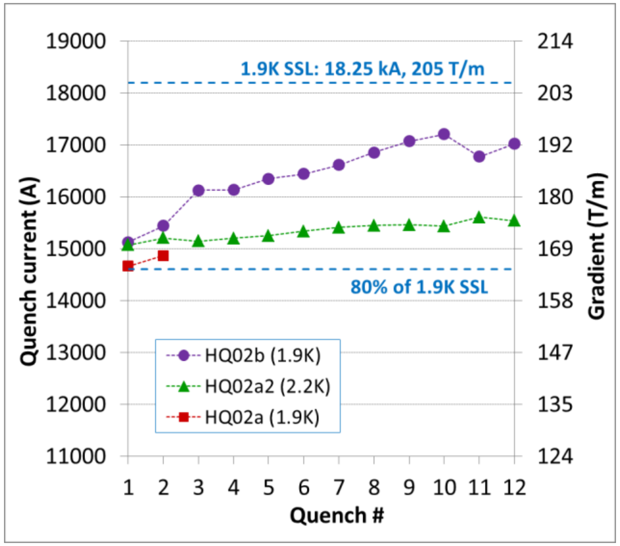
- 140 T/m in 150 mm coil aperture
- Q1/Q3 length: 8 m
- Q2 length: 6.8 m
- Max outer diameter: 630 mm
- 1.9 K operating temperature
- Radiation strength: > 33 MGy
- Field quality: < 1 unit (*https://espace.cern.ch/HiLumi/WP3/SitePages/Home.aspx*)



HQ as Risk Reduction

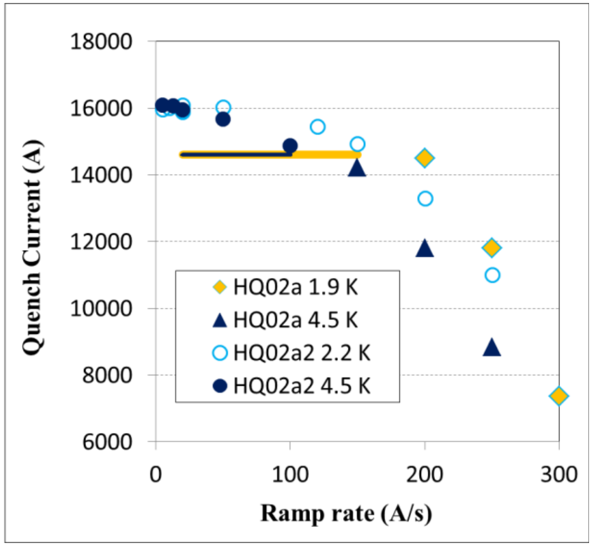
<u>**Quench performance**</u>

- HQ02a: operational gradient (80% SSL) with no training
- HQ02b: fast training to 95% level with 200 MPa pre-load



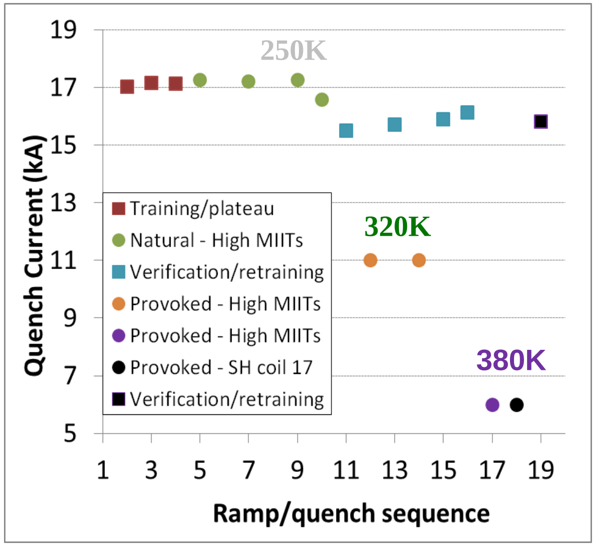
<u>**Accelerator Quality**</u>

- Order of magnitude reduction of dynamic effects (ramp rate, field quality) with cable core



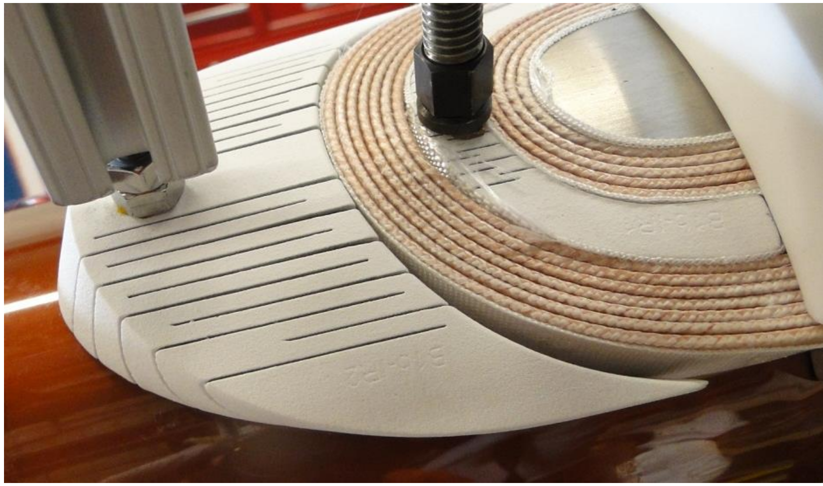
<u>**Quench protection**</u>

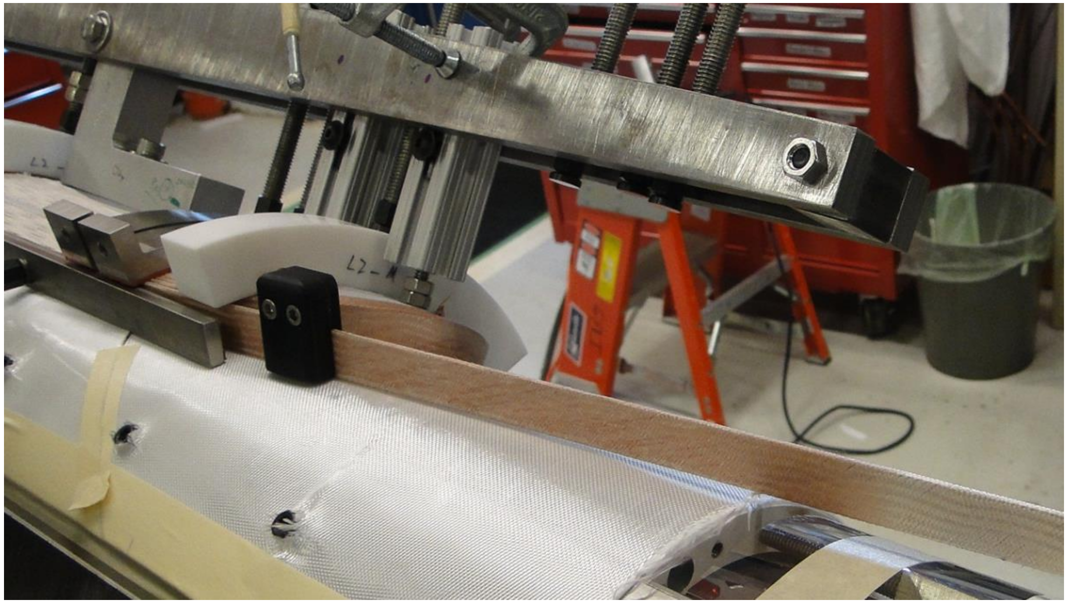
- 380K quench temperature without degradation
- Successful first test of the CLIQ system in Nb_3Sn

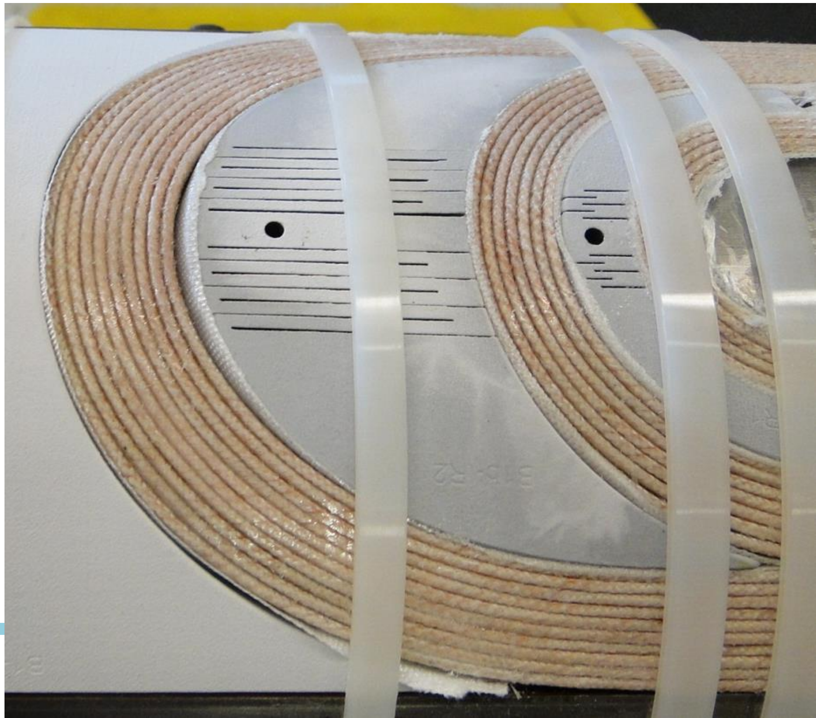


Feedback from MQXF Winding

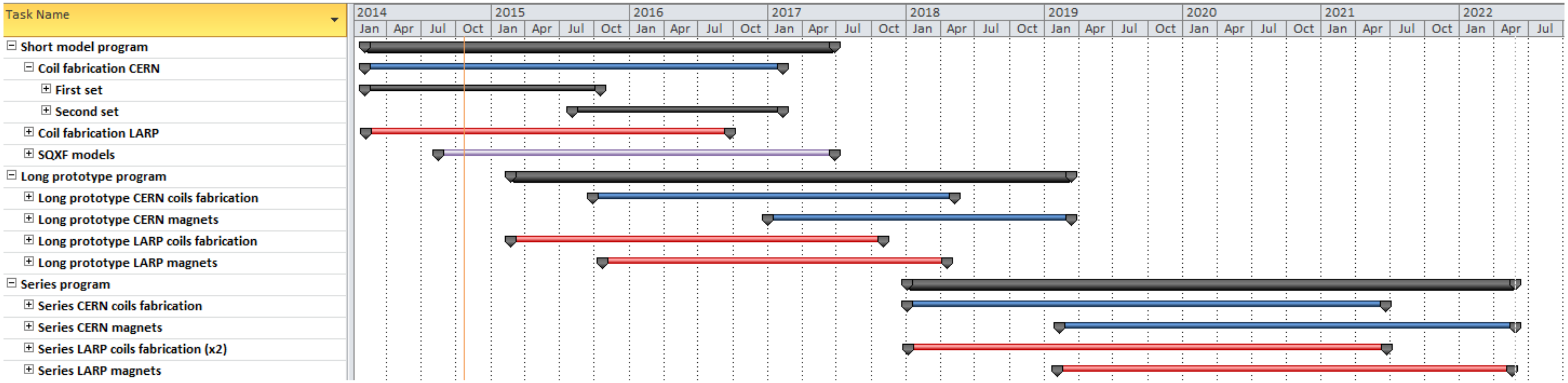
- No popped strands during winding
- Flexible features of end parts are working well







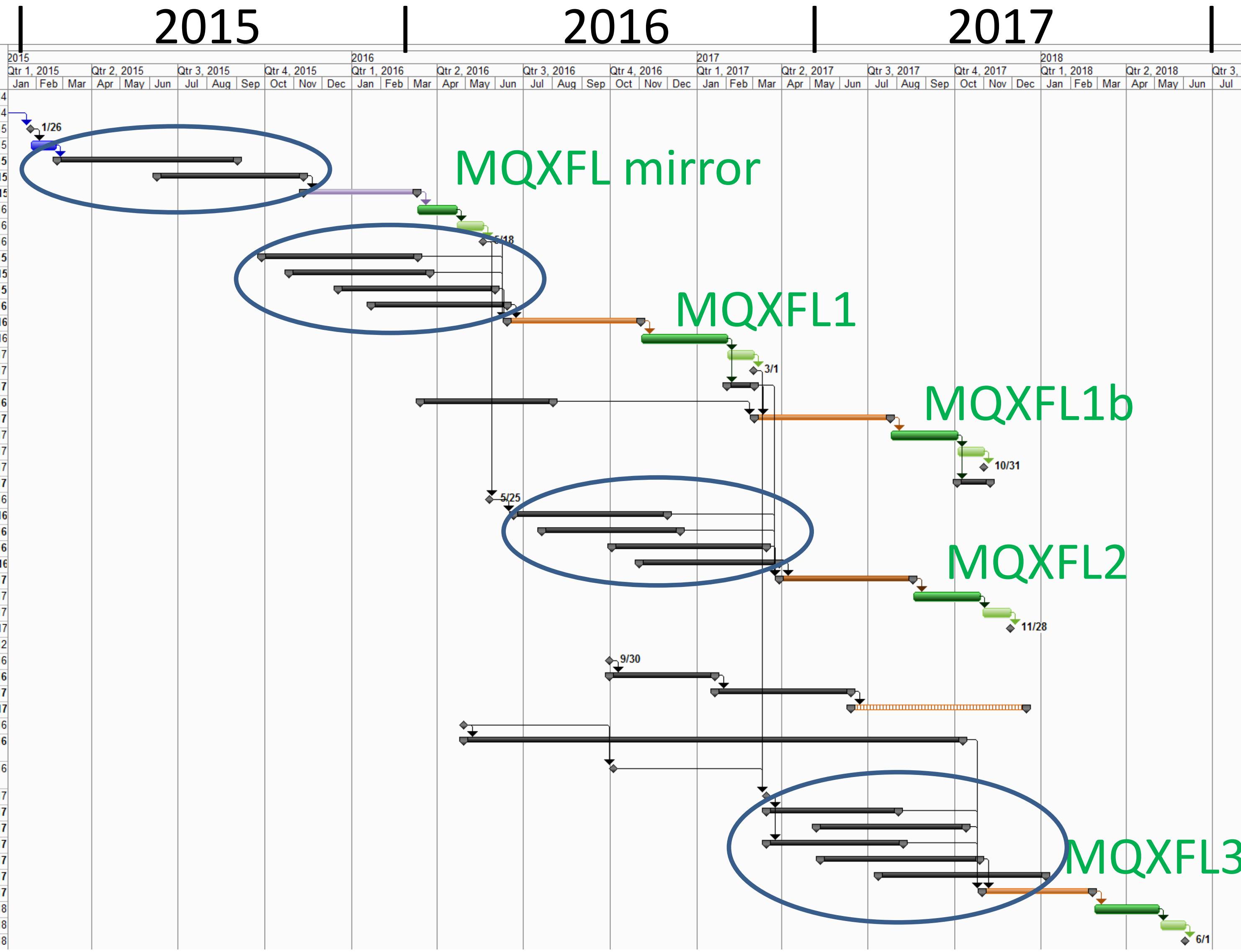
MQXF schedule



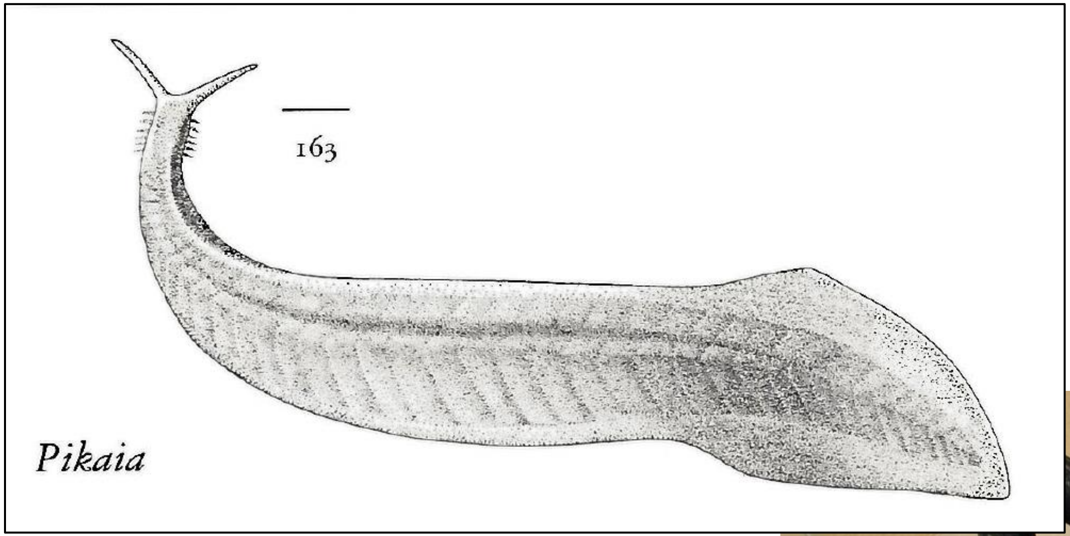
- Short model program: *5 CERN-LARP models*, **2014-2016**
  - Coil fabrication starts in 02-03/2014
  - First magnet test (SQXF1) in 07/2015 (3 LARP coils, 1 CERN coil)
- Long model program: *2 (CERN) + 3 (LARP) models*, **2015-2018**
  - Coil fabrication starts in 2015: 02 (LARP), 10 (CERN)
  - First magnet test in 08/2016 (LARP) and 07/2017 (CERN)
- Series production: *10 (CERN) + 10 (LARP) cold masses*,**2018-2021**
  - Coil fabrication starts in 01/2018
  - First magnet test in 10/2019

MQXFL plan @ LARP

ID	Task Name	Duration	Start
342	Selva Winder phase 0 completed	0 days	Wed 10/1/14
343	Selva winder tests	20 days	Wed 10/1/14
344	Selva winder commisioned	0 days	Mon 1/26/15
345	winding tests	20 days	Mon 1/26/15
346	**Lcoil #1 Practice Coil**	**135 days**	**Mon 2/23/15**
352	**Lcoil #2 (for mirror)**	**109 days**	**Tue 6/9/15**
357	**LQXFM assembly**	**80 days**	**Wed 11/11/15**
361	Mirror test	6 wks	Thu 3/10/16
362	LQXFM Test Analysis	4 wks	Thu 4/21/16
363	LQXFM Test Review	0 days	Wed 5/18/16
364	**Lcoil #3**	**113 days**	**Mon 9/28/15**
371	**Lcoil #4**	**101 days**	**Tue 10/27/15**
377	**Lcoil #5**	**113 days**	**Fri 12/18/15**
384	**Lcoil #6**	**101 days**	**Fri 1/22/16**
390	**LQXF1 assembly**	**100 days**	**Tue 6/14/16**
395	Test	60 days	Thu 11/3/16
396	LQXF1 Test Analysis	4 wks	Thu 2/2/17
397	LQXF1 Test Review	0 days	Wed 3/1/17
398	**LQXF1 disassembly**	**21 days**	**Thu 2/2/17**
401	**Lcoil #7**	**99 days**	**Mon 3/14/16**
407	**LQXF1b**	**100 days**	**Fri 3/3/17**
412	Test	50 days	Tue 7/25/17
413	Test analysis	4 wks	Wed 10/4/17
414	Review	0 days	Tue 10/31/17
415	**LQXF1b disassembly**	**25 days**	**Wed 10/4/17**
418	LQS02 Coils readiness review	0 days	Wed 5/25/16
419	**Lcoil #8**	**113 days**	**Tue 6/21/16**
426	**Lcoil #9**	**101 days**	**Thu 7/21/16**
432	**Lcoil #10**	**113 days**	**Mon 10/3/16**
439	**Lcoil #11**	**101 days**	**Tue 11/1/16**
445	**LQXF2 assembly**	**100 days**	**Wed 3/29/17**
450	Test	50 days	Fri 8/18/17
451	LQXF2 Test Analysis	4 wks	Mon 10/30/17
452	LQXF2 Test Review	0 days	Tue 11/28/17
453	<New Task>	1 day?	Mon 10/1/12
454	Complete Wind&Cure equip. at BNL	0 days	Fri 9/30/16
455	**W&C PCs at BNL (Short&Long)**	**75 days**	**Fri 9/30/16**
459	**Lcoil #B1 (full coil at BNL)**	**101 days**	**Fri 1/20/17**
465	**LQXF Mirror#2 (optional)**	**130 days**	**Tue 6/13/17**
471	MQXF TDR completed	0 days	Fri 4/29/16
472	**LQXF3 Magnet structure (design for MQXF)**	**366 days**	**Fri 4/29/16**
479	Completed coil modifications based on MQXF TDR	0 days	Tue 10/4/16
480	LQXF3 Readiness Review	0 days	Wed 3/15/17
481	**Lcoil #B2**	**98 days**	**Thu 3/16/17**
486	**Lcoil #B3**	**111 days**	**Mon 5/8/17**
491	**Lcoil #F1**	**101 days**	**Thu 3/16/17**
497	**Lcoil #F2**	**118 days**	**Fri 5/12/17**
503	**Lcoil #F3**	**123 days**	**Wed 7/12/17**
508	**LQXF3 assembly**	**80 days**	**Mon 10/30/17**
513	Test	50 days	Mon 2/26/18
514	LQXF3 Test Analysis	4 wks	Mon 5/7/18
515	LQXF3 Test Review	0 days	Fri 6/1/18



Conquest of Earth

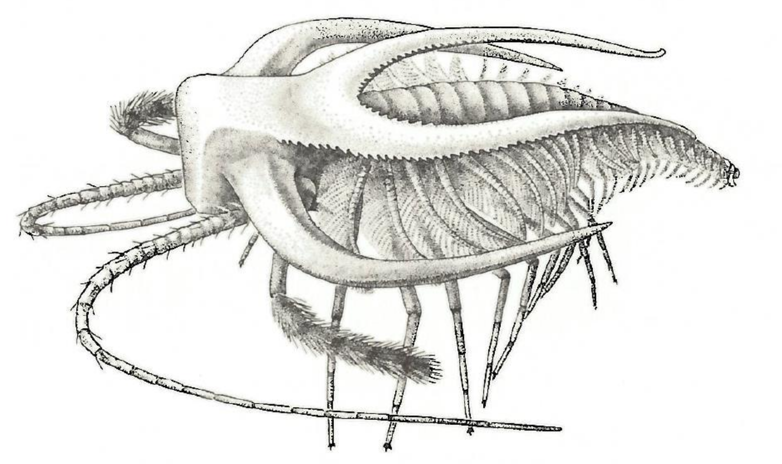


Conquest of HEP by Nb_3Sn

"This significant milestone (i.e. MQXF for HL-LHC) will open up the route to much higher energy accelerators than the LHC using for the first time superconductors beyond Nb-Ti in its main magnets."

- Evolution through series of critical design reviews for MQXF design
  - November '14: Conductor and Cable
  - December '14: Magnet Design
  - 2015-16: Final Tech. Des. Rev & Production Review
- Int. Conductor and Cable Review (CERN Nov 5-6, '14)
  - Reduce keystone angle of PIT cable and support PIT R&D
  - Consider same change for RRP cable
  - Optimize margin & Confirm strand/Cable specs by model program
- Plan to address Cable and Design review recommendations by beginning of 2015.
  - US Baseline timing is unlikely to allow further changes in the future

Marella

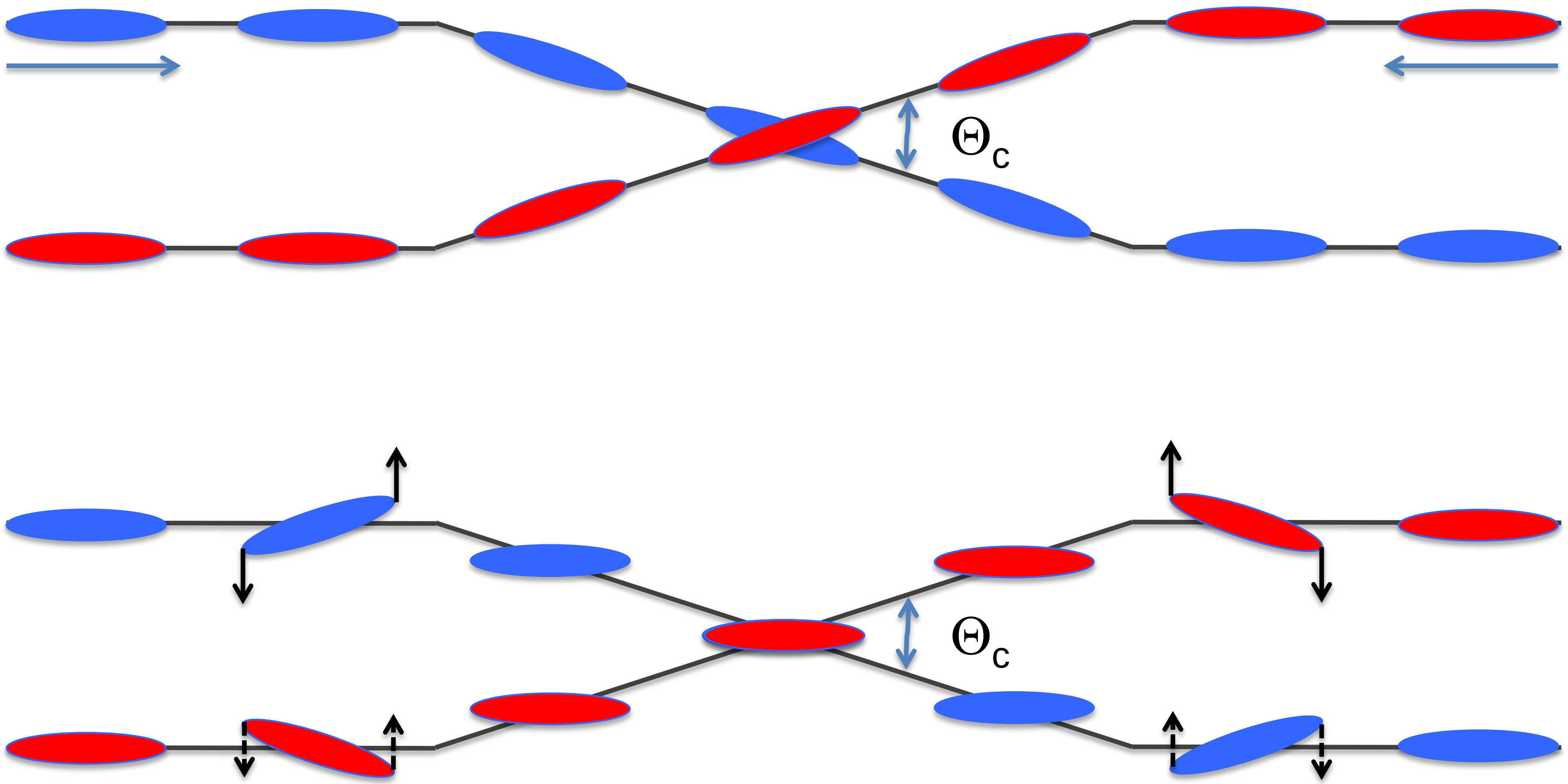


Side view of *Marrella*. Drawn by Marianne Collins.

- "Lace Crab", belonging to the arguably most successful phylum on Earth (Arthropods)

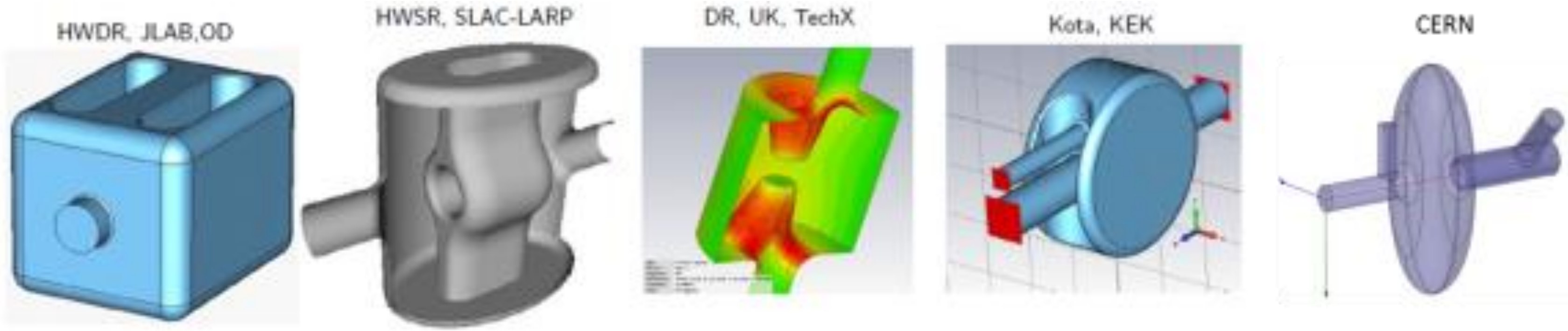
Crab Cavities

- Larger Crossing angle (~300 μrad in HL-LHC vs. ~150 μrad in LHC) calls for a correction of individual bunches orientation



(Another) Inverted Evolution Tree

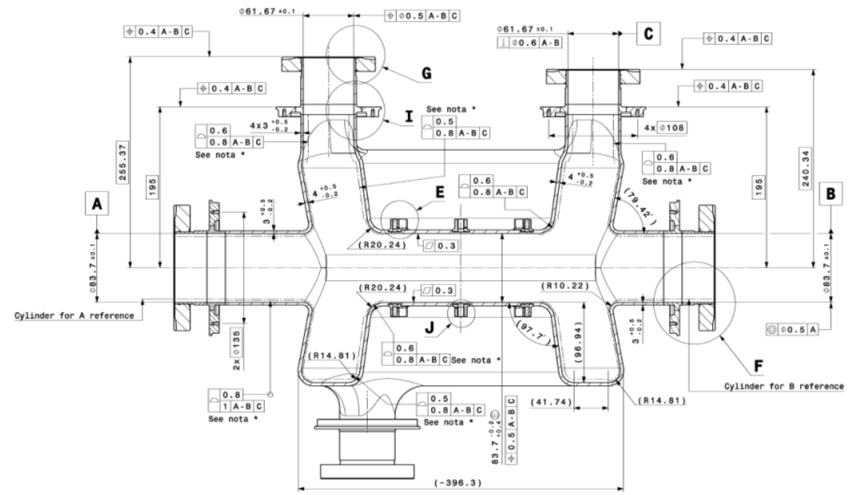
- Lot of Different ideas

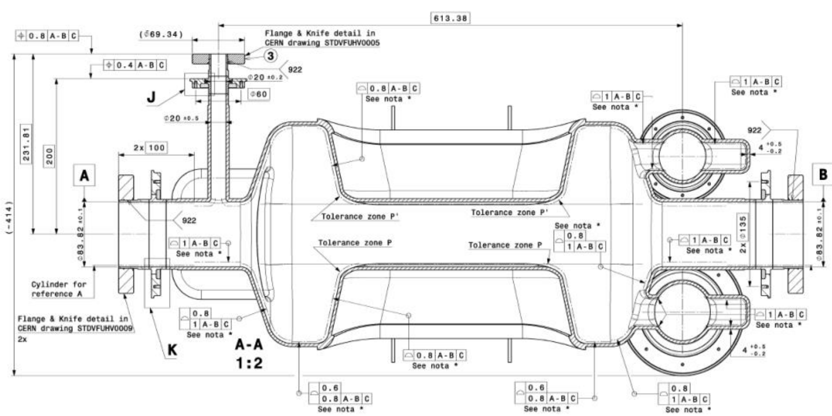


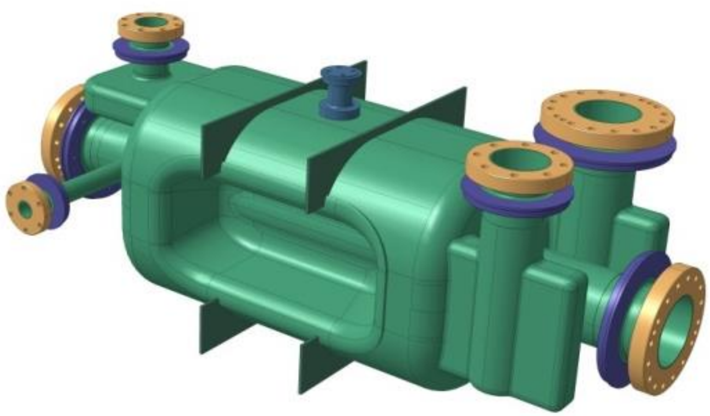
Compact cavities aiming at small footprint & 400 MHz, ~5 MV/cavity

Int. Review on May 2014:
Concentrate on two designs (RFD & DQW)

Bare cavities with interfaces

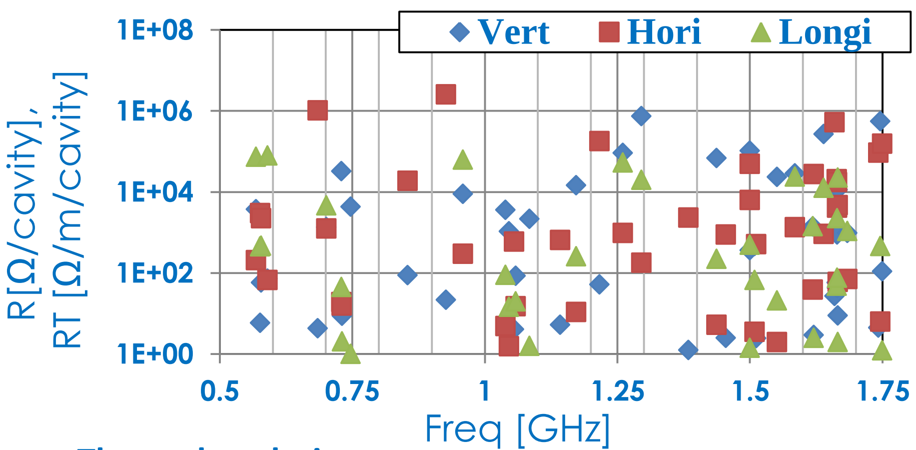






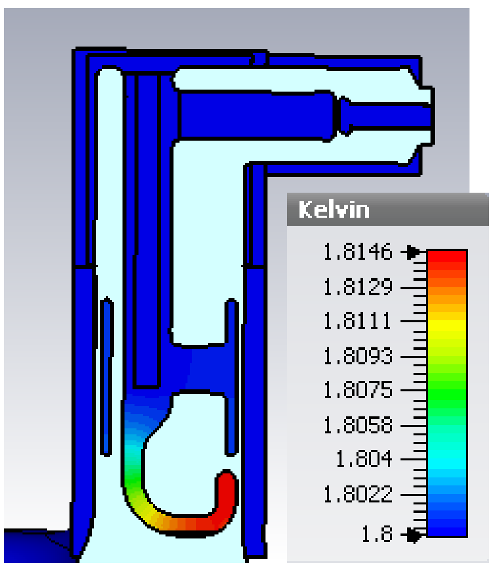
DQW HOM Filter

HOM Impedance

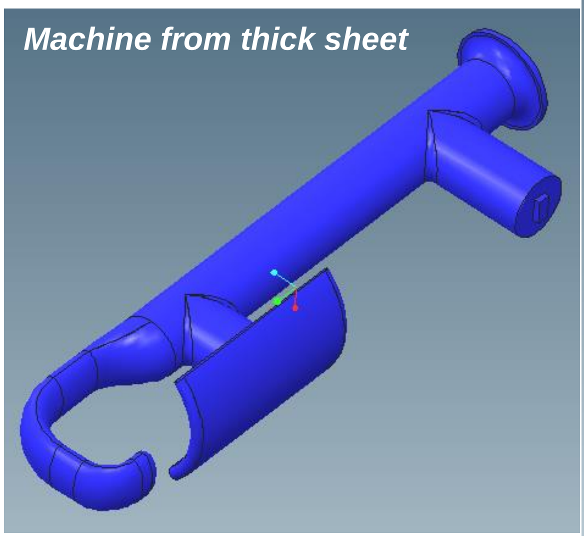


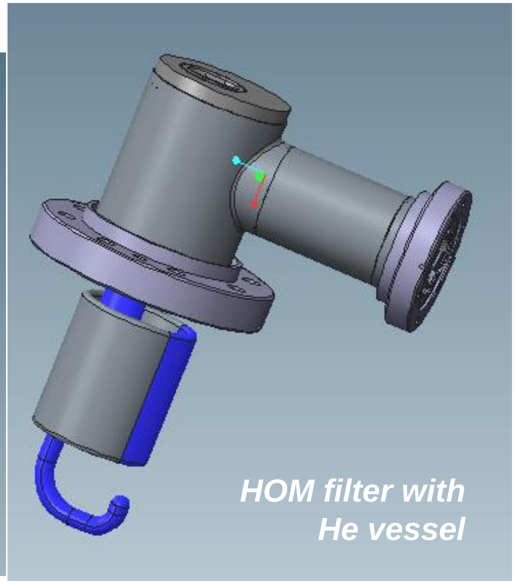
- **Impedances are calculated considering the assembling errors. Tables are generated and sent to CERN for verification.**
- **HOM power is about 69 Watts per cavity.** Power of transverse modes estimated based on 5mm offsets.
- **In the worst case the power increased to 86 Watts if HOM frequencies shift in ±2.5 MHz range.**
- **HOM induced heat on the Cu gaskets and Cu pins are in mW range.**
- **Thermal analysis is on-going**
- **Machining study is on-going**

Thermal analysis



Machining study





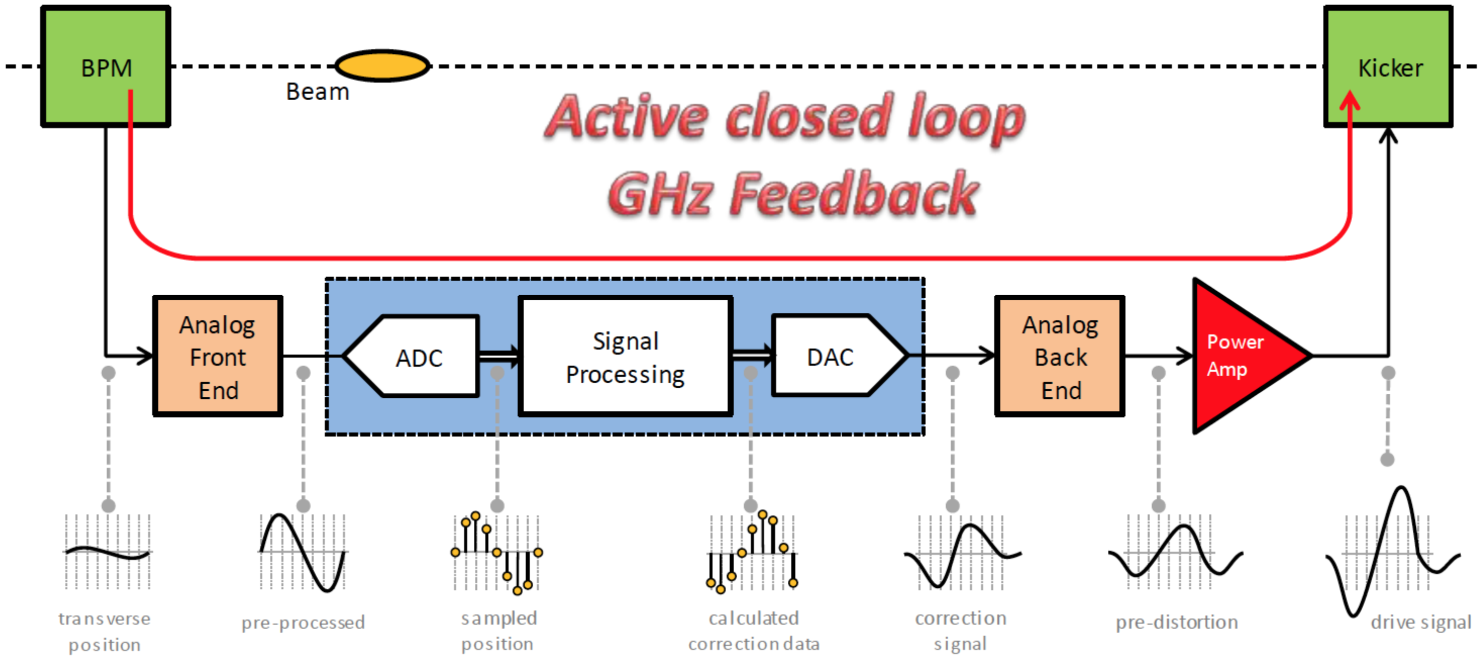
Goals for CC-LARP

- Complete SPS Cavities
  - Challenges: M&S funding for HOM and tuning mechanics in FY15.
- Complete set of International Reviews a-la-MQXF
  - HOM design review in early '15 (?)

- Planning beyond SPS Test
  - Do we need an LHC Prototype ? *YES*
  - What will LARP or US-HiLumi provide to LHC Prototype ?

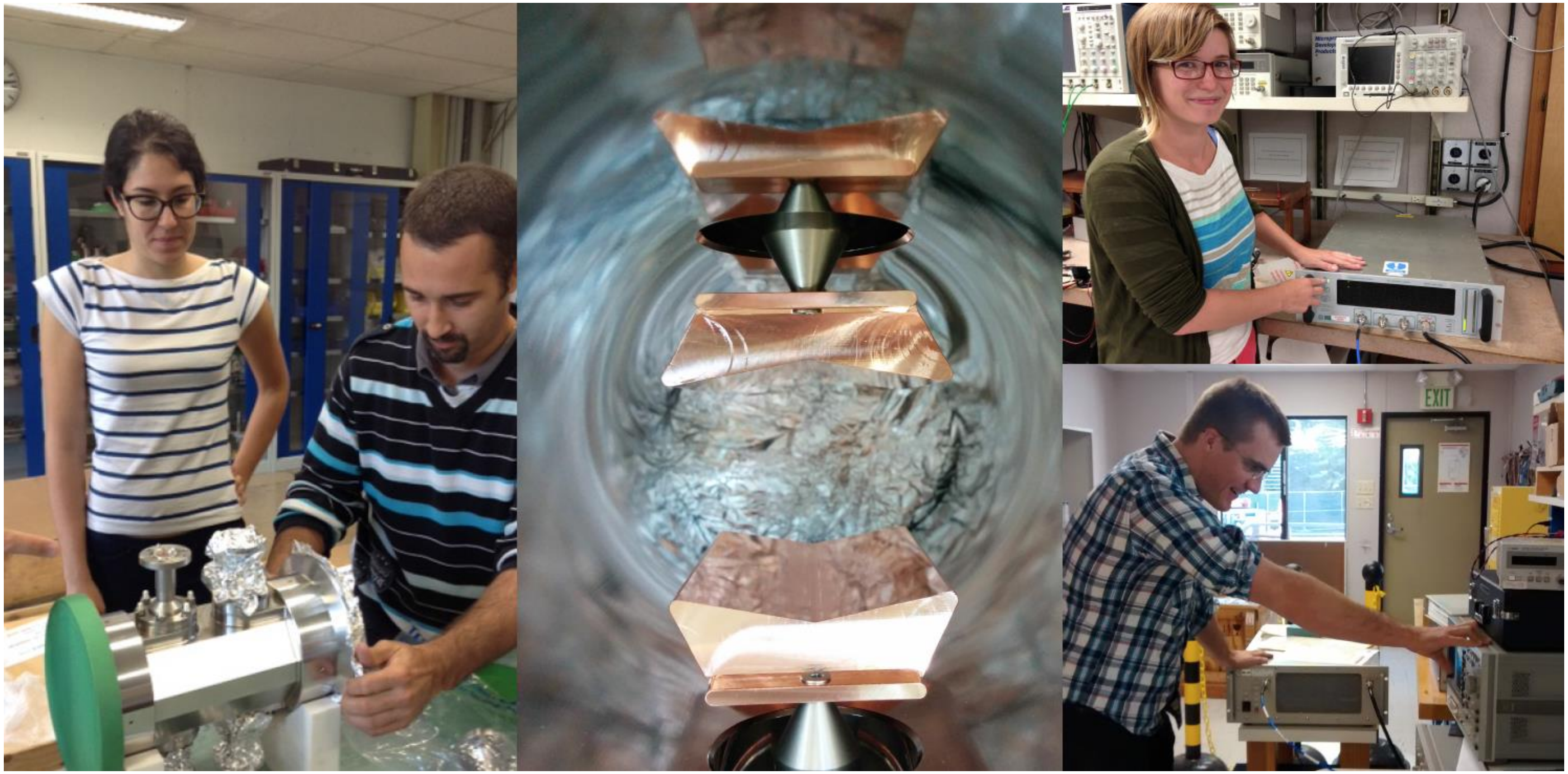
    ? *3-V and 3-H Cavities ?*
    - Aggressive timing (start by 2016) a challenging resources allocation problem within LARP for LHC Prototypes
  - <u>Defensible baseline by late'15 is a must to allow inclusion of CC in US-HiLumi deliverables in a FY18-FY23 Project</u>
    - Plans for "Parametric" baseline in January '15

WBFS for Stability Control



- Control of Ecloud and Impedance-driven transverse instabilities in the SPS as HL-LHC Injector - Demo system achieved closed loop control November 2012 before LS1
- GHz Bandwidth Digital Signal Processing via reconfigurable architecture
- Optimal Control Formalism - allows formal methods to quantify stability and dynamics, margins
- Research Phase uses numerical simulations (HeadTail), Reduced Models, technology development, 1 bunch Demonstrator, SPS Machine Measurements

Stripline kicker & Power Amp.



- CERN, LNF-INFN, LBL and SLAC Collaboration. Design Report SLAC-R-1037
- Stripline fabricated by E. Montesinos et al , Installed with 3 kicker support system.
- New wideband power amps evaluated. Selection of 1 GHz amps for Dec. 2014
- Slotline Kicker design in optimization (S. Verdu) - fab in 2015

MD Studies in FY15 & FY16

- The Demo system is being upgraded for MD studies, and technology development through the end of 2016
  - Explore scrubbing fill control - MD November 2014, closed-loop December 2014
  - Explore Q20 control methods (New filters? Multiple pickups?) - optimize system performance
  - Validate multi-bunch control Spring FY2015
  - Diagnostic and beam instrumentation techniques to optimize feedback parameters and understand system effectiveness
  - Evaluate Stripline and Slotline wideband kickers and RF Amplifiers with beam
  - We benefit from synergistic combination of simulation models, machine measurements, and technology development
- Technology Development and system estimation for 4 -8 GS/sec Full-function system
  - lab evaluation and firmware development
  - estimation of possible bandwidths, multiple pickup/kicker architectures, technology options
- WBFS has been estimated and budgeted within the LARP system for future production decision

Hollow e-beam Collimation

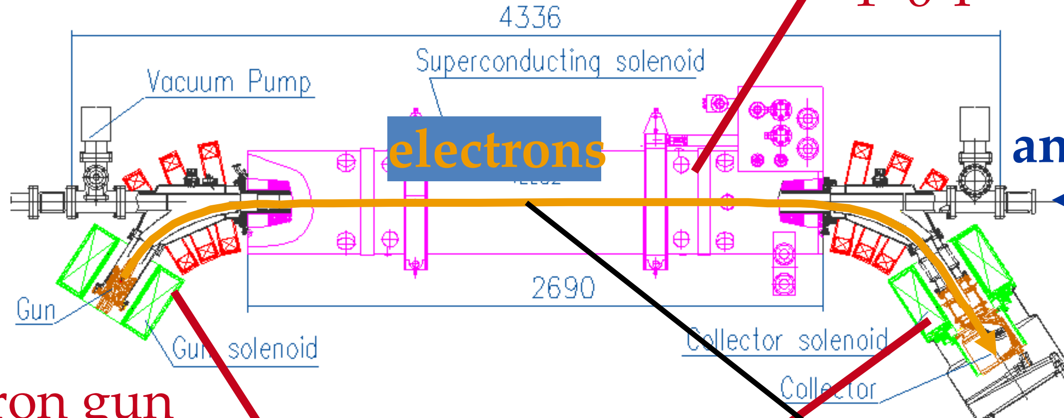
Electron Beam stability provided by strong axial magnetic fields

6 m total length

superconducting solenoid
1–6 T

protons

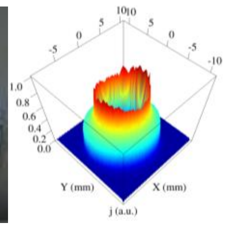
antiprotons

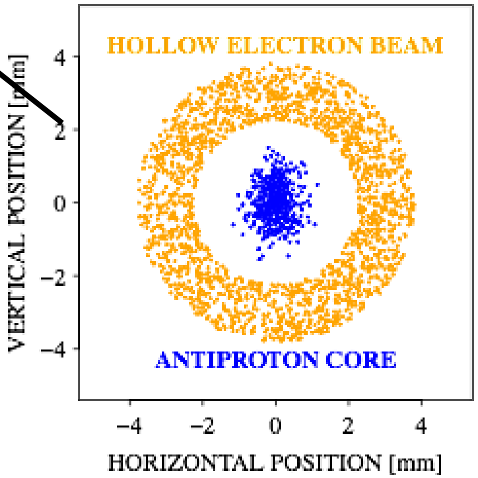


collector

5-kV, 1-A electron gun
thermionic cathode
200-ns rise time

conventional solenoids
0.1–0.4 T





Stancari et al.: CERN-ACC-2014-0248, arXiv:1405.2033

LARP Goals (FY15-FY17)

- Overall goal: minimize the risk of Project in FY18-FY23
  - Build 5 QXF Magnets
    - 2 1-m long SQXF
    - 3 4-m long LQXF (including 2 Mechanical Structures)
    - Develop/Commission 2 production lines (FNAL/BNL)
  - Deliver Four Dressed Crab Cavities for SPS Test
    - 2 QWR
    - 2 RFD
  - Support Toohig Fellowship
  - Support R&D on Acc. Science (if possible)
    - Deliver Fully Functional WBFS for SPS Test
    - Support studies on e-hollow lenses

LARP funding *Evolution:* FY14 to FY15

- Good News (~Aug '14):
  - Guidance for LARP-FY15 increased to 14M$ from 12.6M$ in FY14
  - Good hope for additional funding at ~1M$
- Recent News (~Nov '14):
  - FY15 started in Continuing Resolution until Dec 11th 2014
  - Fears of year-long CR (no new FY15 Budget approval, support based on ~previous year level)
    - Rely on DOE internal allocation to maintain LARP at healthy level.
- Some tough decisions in FY15:
  - Allocate funding in FY15 to much needed M&S procurements
    - Nb_3Sn for MQXFL1, mechanical structure for MQXFL1
  - Decreased support for SWF, maintain FY15 personnel at FY14 levels by *total* use of Carry-over funds. FY16 will be critical year !

FY14-FY15 Budget Comparisons

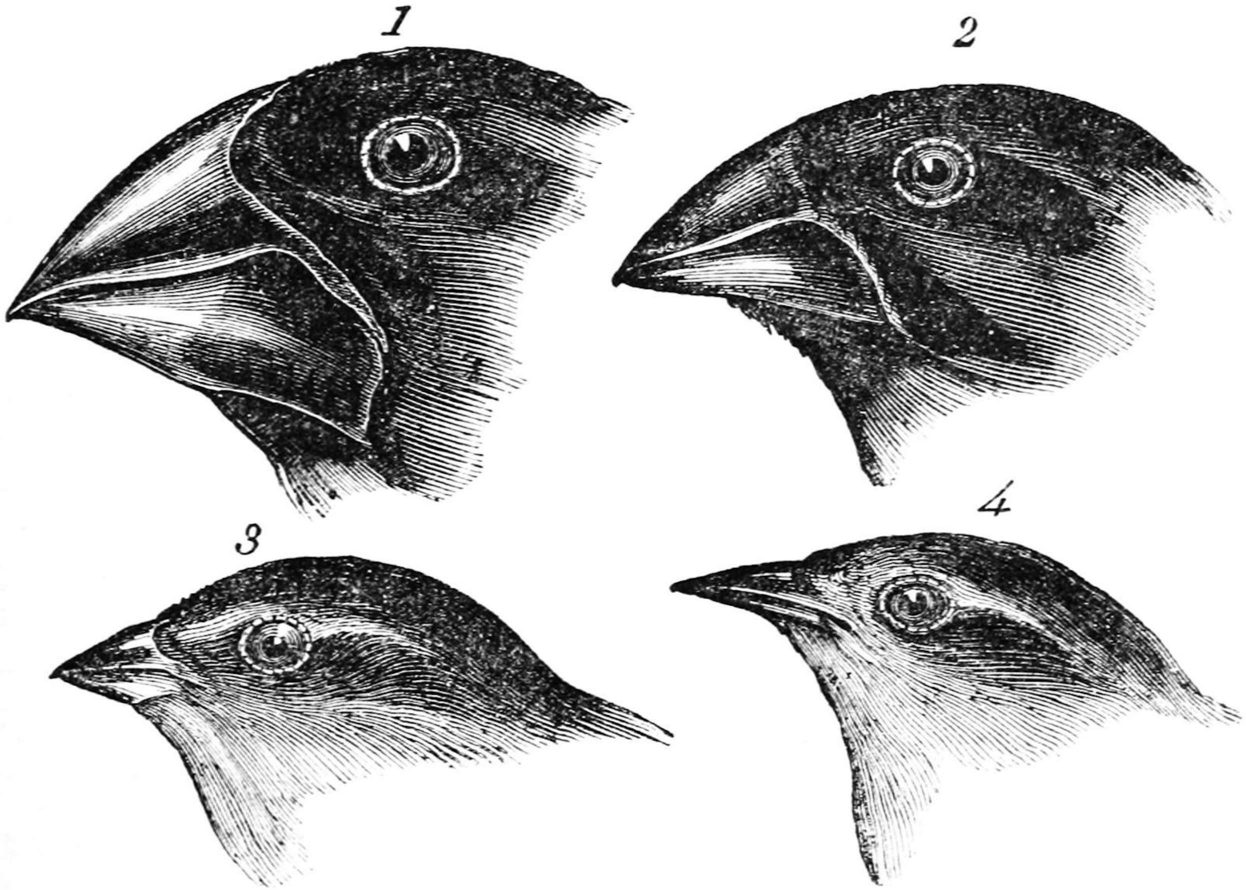
	FY14	FY15
Contingency		590
Acc. Phys	587	300
Magnets	7662	10045
Manag.	1835	1375
CC System	1390	1090
WBFS	1128	600
	12602	*14000*

	FY14	FY15
Contingency		590
SWF Budget	10729	9703
M&S Budget	1873	3707
	12602	*14000*

Toohig Fellowship *Evolution*

- Commitment to maintain program in LARP and US-HiLumi to facilitate the involvement of PostDocs in the US to work at the leading Energy Frontier Machine for the next ~2 decades
- New Toohig Fellow:
  - Trey Holick (U. Texas A&M)
- Given present uncertainty on existence of a "LARP 2" (i.e. an R&D program in parallel to **US-HiLumi** Project to support R&D efforts and a generic fellowship) it is necessary to "evolve" the Toohig fellowship toward direct support of **US-HiLumi** deliverables:
  - I. Pong: QA/QC on SC Strand/Cables
  - T. Holick: QA/QC on Coils/Magnet Construction
  - S. Verdu: CC Construction and Testing

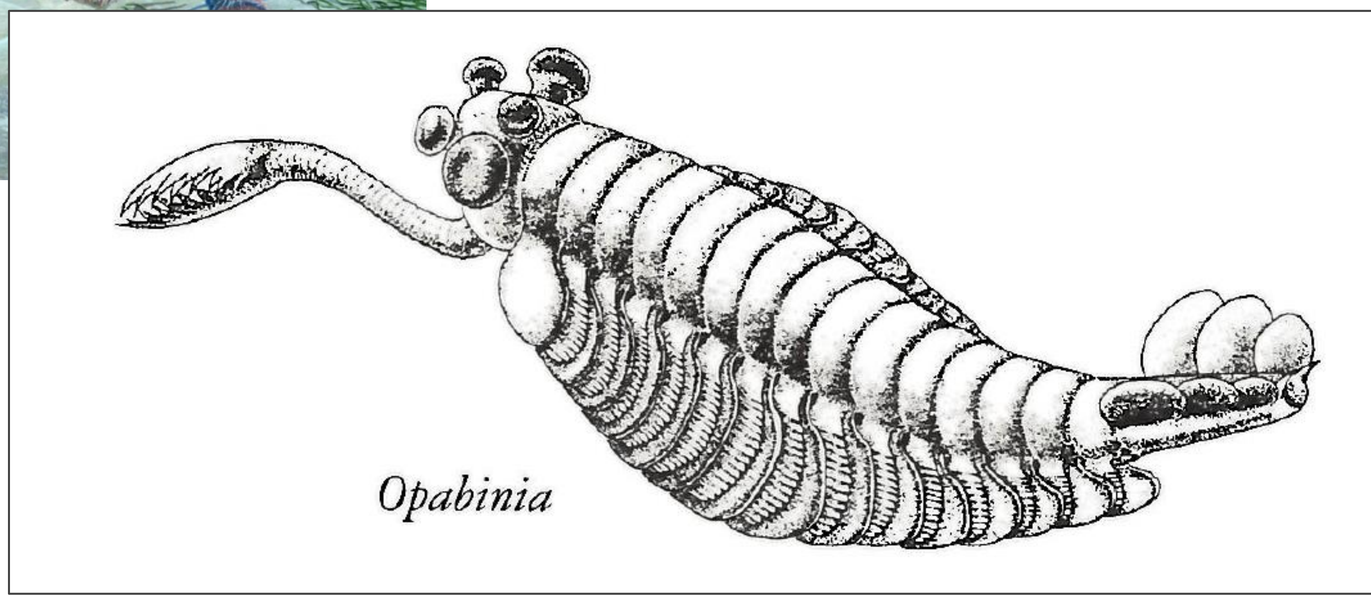
Picture I tried to provide….



1. Geospiza magnirostris.
3. Geospiza parvula.

2. Geospiza fortis.
4. Certhidea olivasea.

…and what I probably achieved



Joint Spring LARP/HiLumi CM

- Also LARP-CM24
- Where
  - Fermilab, IL – USA
- When
  - May 11th-13th, 2015
  - Monday-Wednesday after IPAC15 in Richmond, VA -USA
- What
  - 2 ½ - 3 days format to avoid excessive compression
  - No satellite meeting foreseen at this time. If necessary, will be run on May 14th/15th.

Summary

- Constant progress toward Projectization of US-HiLumi
- Challenge in prioritizing activities clearly related to US-HiLumi deliverables without over-damaging "R&D" activities
- QXF Strand/Cable Review has provided a very strong renormalization point for quadrupole design
  - Margin Issue & Lessons from decade-long LARP experience
  - Decision following QXF Design Review in Dec '14
- Support of CC in **US-HiLumi** might be challenging and a strong proposal for the US contribution can only benefit from proper planning post-SPS test.
- Funding is never enough, but nevertheless is not zero !