CMS触发升级进展报告

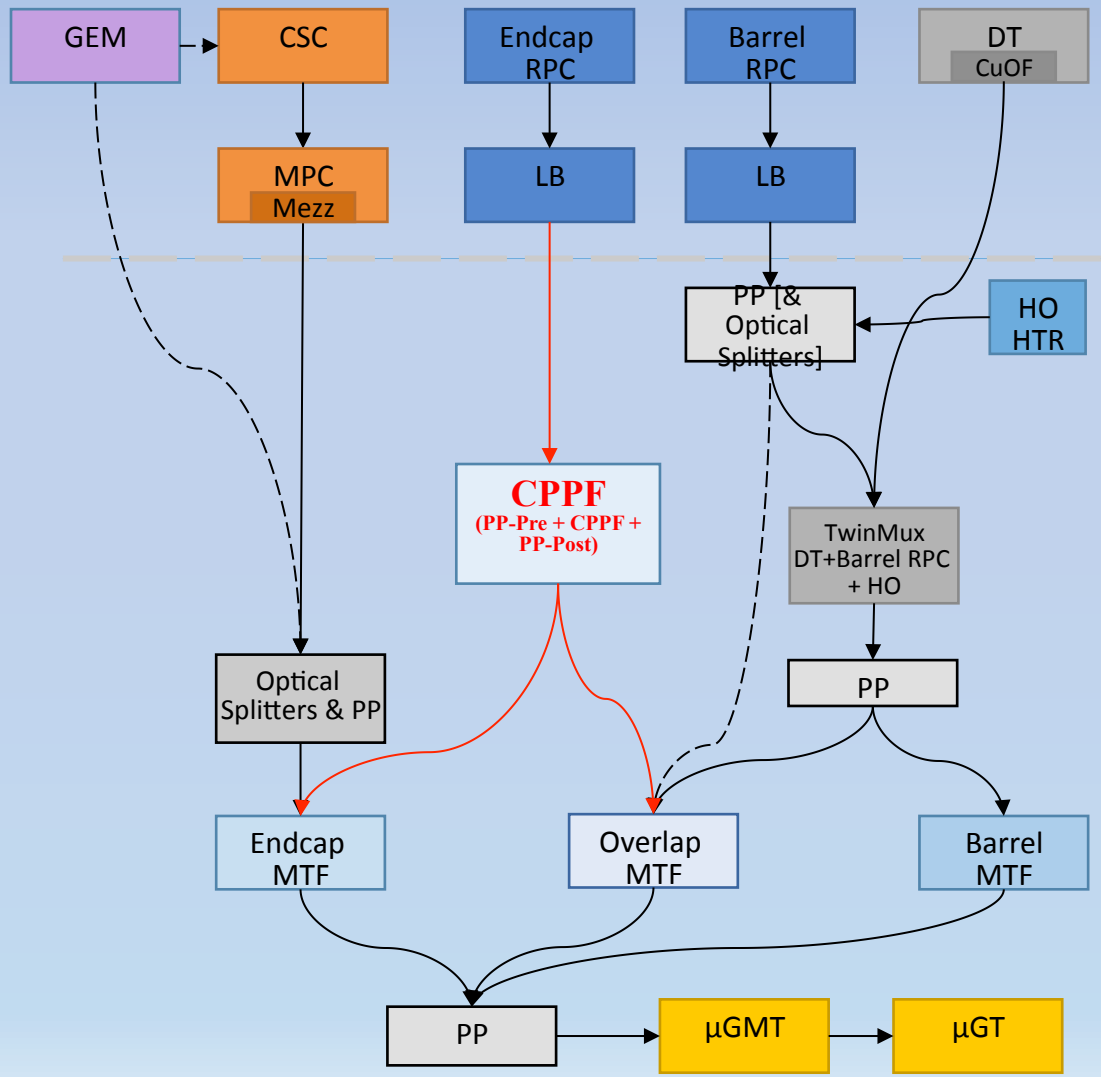
刘振安
中国科学院高能物理研究所触发实验室
LHC实验物理分析及探测器升级研讨会，威海，山东
2018年6月28-29日

内容

- Phase I 升级CPPF系统现状简介
  - CMS触发负责人来信
- Phase II 升级进展介绍
- 总结

近一年CPPF系统的进展

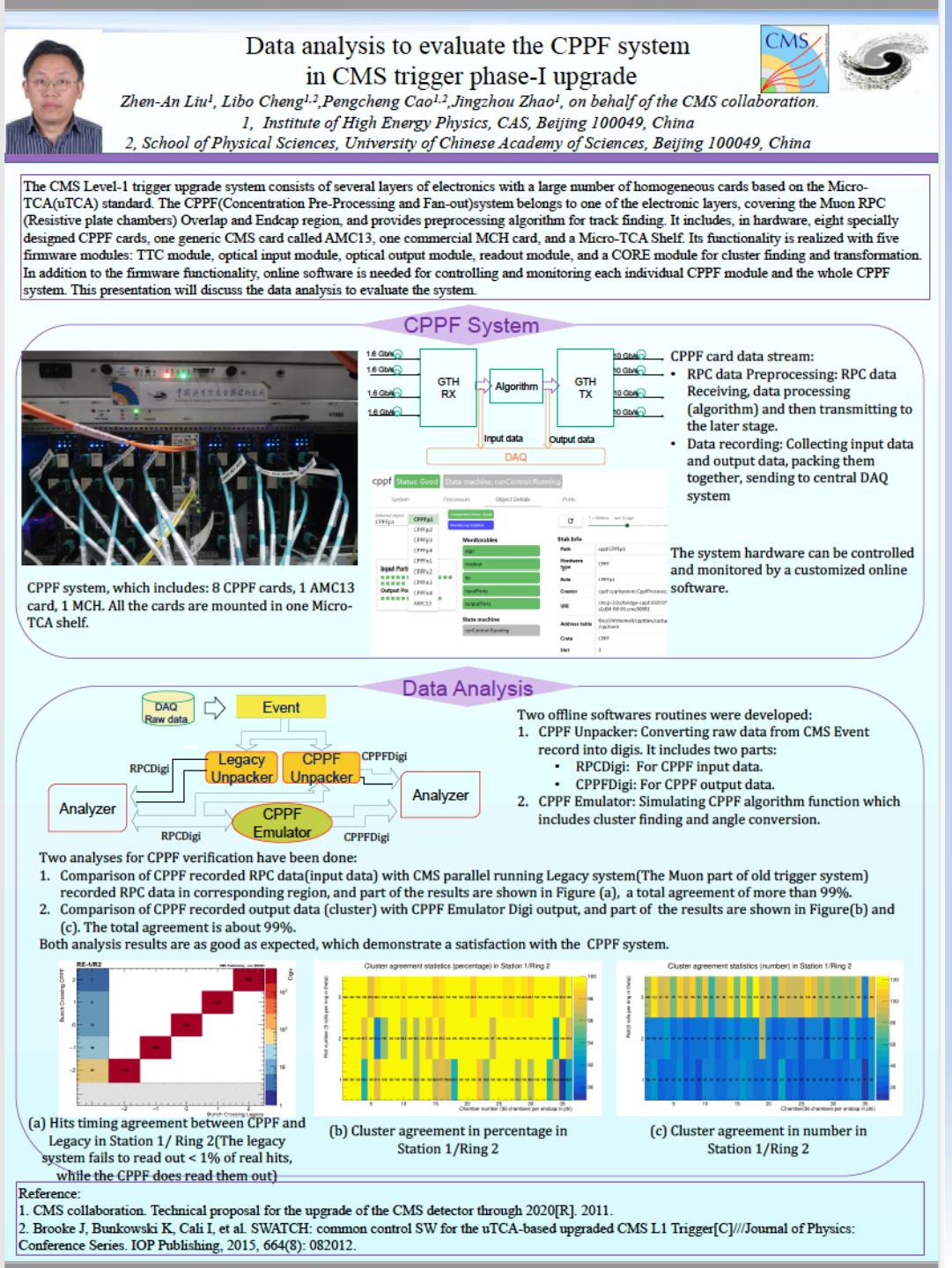
- CPPF是CMS触发系统的一个独立子系统，由中国组研建
- 2018年5月宇宙学调试成功
- 6月开始 LHC 质子质子对撞取数，一直稳定运行
- 程立波同学到今年3月一直在CERN进行数据分析软件CPPF Emulator软件和的开发、
- 程立波 和CMS的DQM数据组一起参加数据分析



CPPF 数据分析结果显示满足CMS要求

- 数据分析结果非常好
- 经过了合作组的严格审查
- 经过合作组推荐，代表CMS合作组在6月10-16日的Real Time Conference RT2018上进行了报告
- 下午赵京周做详细报告

- CPPF进入了正常运行阶段
  - 在访问CERN期间和新建沟通中合作组提出了新的要求



Data analysis to evaluate the CPPF system in CMS trigger phase-I upgrade

Zhen-An Liu[1], Libo Cheng[1,2], Pengcheng Cao[1,2], Jingzhou Zhao[1], on behalf of the CMS collaboration.
1, Institute of High Energy Physics, CAS, Beijing 100049, China
2, School of Physical Sciences, University of Chinese Academy of Sciences, Beijing 100049, China

The CMS Level-1 trigger upgrade system consists of several layers of electronics with a large number of homogeneous cards based on the Micro-TCA(uTCA) standard. The CPPF(Concentration Pre-Processing and Fan-out)system belongs to one of the electronic layers, covering the Muon RPC (Resistive plate chambers) Overlap and Endcap region, and provides preprocessing algorithm for track finding. It includes, in hardware, eight specially designed CPPF cards, one generic CMS card called AMC13, one commercial MCH card, and a Micro-TCA Shelf. Its functionality is realized with five firmware modules: TTC module, optical input module, optical output module, readout module, and a CORE module for cluster finding and transformation. In addition to the firmware functionality, online software is needed for controlling and monitoring each individual CPPF module and the whole CPPF system. This presentation will discuss the data analysis to evaluate the system.

CPPF System

CPPF system, which includes: 8 CPPF cards, 1 AMC13 card, 1 MCH. All the cards are mounted in one Micro-TCA shelf.

CPPF card data stream:
- RPC data Preprocessing: RPC data Receiving, data processing (algorithm) and then transmitting to the later stage.
- Data recording: Collecting input data and output data, packing them together, sending to central DAQ system

The system hardware can be controlled and monitored by a customized online software.

Data Analysis

Two offline softwares routines were developed:
1. CPPF Unpacker: Converting raw data from CMS Event record into digis. It includes two parts:
   - RPCDigi: For CPPF input data.
   - CPPFDigi: For CPPF output data.
2. CPPF Emulator: Simulating CPPF algorithm function which includes cluster finding and angle conversion.

Two analyses for CPPF verification have been done:
1. Comparison of CPPF recorded RPC data(input data) with CMS parallel running Legacy system(The Muon part of old trigger system) recorded RPC data in corresponding region, and part of the results are shown in Figure (a), a total agreement of more than 99%.
2. Comparison of CPPF recorded output data (cluster) with CPPF Emulator Digi output, and part of the results are shown in Figure(b) and (c). The total agreement is about 99%.

Both analysis results are as good as expected, which demonstrate a satisfaction with the CPPF system.

(a) Hits timing agreement between CPPF and Legacy in Station 1/ Ring 2(The legacy system fails to read out < 1% of real hits, while the CPPF does read them out)

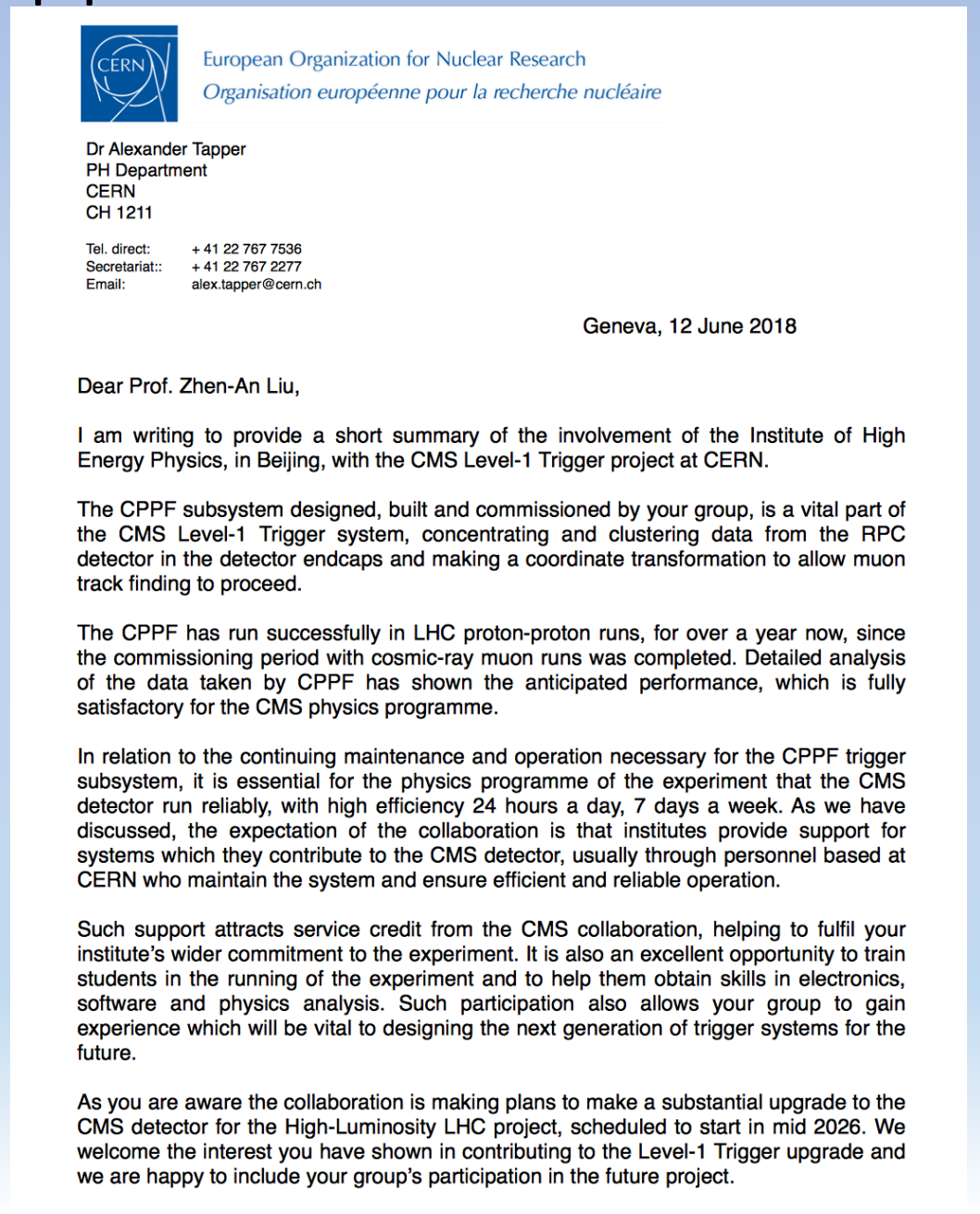
(b) Cluster agreement in percentage in Station 1/Ring 2

(c) Cluster agreement in number in Station 1/Ring 2

Reference:
1. CMS collaboration. Technical proposal for the upgrade of the CMS detector through 2020[R]. 2011.
2. Brooke J, Bunkowski K, Cali I, et al. SWATCH: common control SW for the uTCA-based upgraded CMS L1 Trigger[C]///Journal of Physics: Conference Series. IOP Publishing, 2015, 664(8): 082012.

CMS触发系统升级负责人Alex Tapper6月12日来信

- 来信已向赵院士和基金委领导汇报
- 来信主要内容
  1. 贵组设计、建造、并运行调试的CPPF子系统是CMS一级触发系统的要害部分，负责把端盖RPC探测器的粗团进行找寻、并进行数据精选浓缩、坐标变换等处理，以便后续进行径迹寻找
  2. CPPF系统宇宙学调试运行结束后在LHC质子质子对撞取数运行已成功运行一年多，经对CPPF存储的数据进行的仔细分析结果显示，完全满足CMS物理实验任务的要求



European Organization for Nuclear Research
Organisation européenne pour la recherche nucléaire

Dr Alexander Tapper
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CH 1211

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Email: alex.tapper@cern.ch

Geneva, 12 June 2018

Dear Prof. Zhen-An Liu,

I am writing to provide a short summary of the involvement of the Institute of High Energy Physics, in Beijing, with the CMS Level-1 Trigger project at CERN.

The CPPF subsystem designed, built and commissioned by your group, is a vital part of the CMS Level-1 Trigger system, concentrating and clustering data from the RPC detector in the detector endcaps and making a coordinate transformation to allow muon track finding to proceed.

The CPPF has run successfully in LHC proton-proton runs, for over a year now, since the commissioning period with cosmic-ray muon runs was completed. Detailed analysis of the data taken by CPPF has shown the anticipated performance, which is fully satisfactory for the CMS physics programme.

In relation to the continuing maintenance and operation necessary for the CPPF trigger subsystem, it is essential for the physics programme of the experiment that the CMS detector run reliably, with high efficiency 24 hours a day, 7 days a week. As we have discussed, the expectation of the collaboration is that institutes provide support for systems which they contribute to the CMS detector, usually through personnel based at CERN who maintain the system and ensure efficient and reliable operation.

Such support attracts service credit from the CMS collaboration, helping to fulfil your institute's wider commitment to the experiment. It is also an excellent opportunity to train students in the running of the experiment and to help them obtain skills in electronics, software and physics analysis. Such participation also allows your group to gain experience which will be vital to designing the next generation of trigger systems for the future.

As you are aware the collaboration is making plans to make a substantial upgrade to the CMS detector for the High-Luminosity LHC project, scheduled to start in mid 2026. We welcome the interest you have shown in contributing to the Level-1 Trigger upgrade and we are happy to include your group's participation in the future project.

CMS触发系统升级负责人Alex Tapper6月12日来信

- 信中第三部分对运行ONCALL值班提出了要求
  - 为了CMS物理目标实现，CMS探测器需要每周7天每天24小时不间断的可靠运行，因此CPPF子系统也要保证连续的维护与运行。如我们讨论的，合作组期望各个研究所能够通过常驻CERN的人员提供系统维护保证有效而科考队实验运行。 这些技术支持能够在CMS合作组内积累信誉，完成研究所在国际合作中的承诺的任务。这也是在研究生培养中学生在电子学、软件和物理分析中积累经验的极好机会。

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CMS触发系统升级负责人Alex Tapper6月12日来信

- 信中第四部分欢迎高能所在Phase II升级中继续发挥作用
  - 如你所知为配合2026年高亮度LHC计划，CMS合作组正在对CMS再次进行实质升级，我们欢迎你们对Level-1一级触发系统继续升级所表现的继续做贡献的兴趣，我们非常高兴你们继续参加参加触发系统的未来计划

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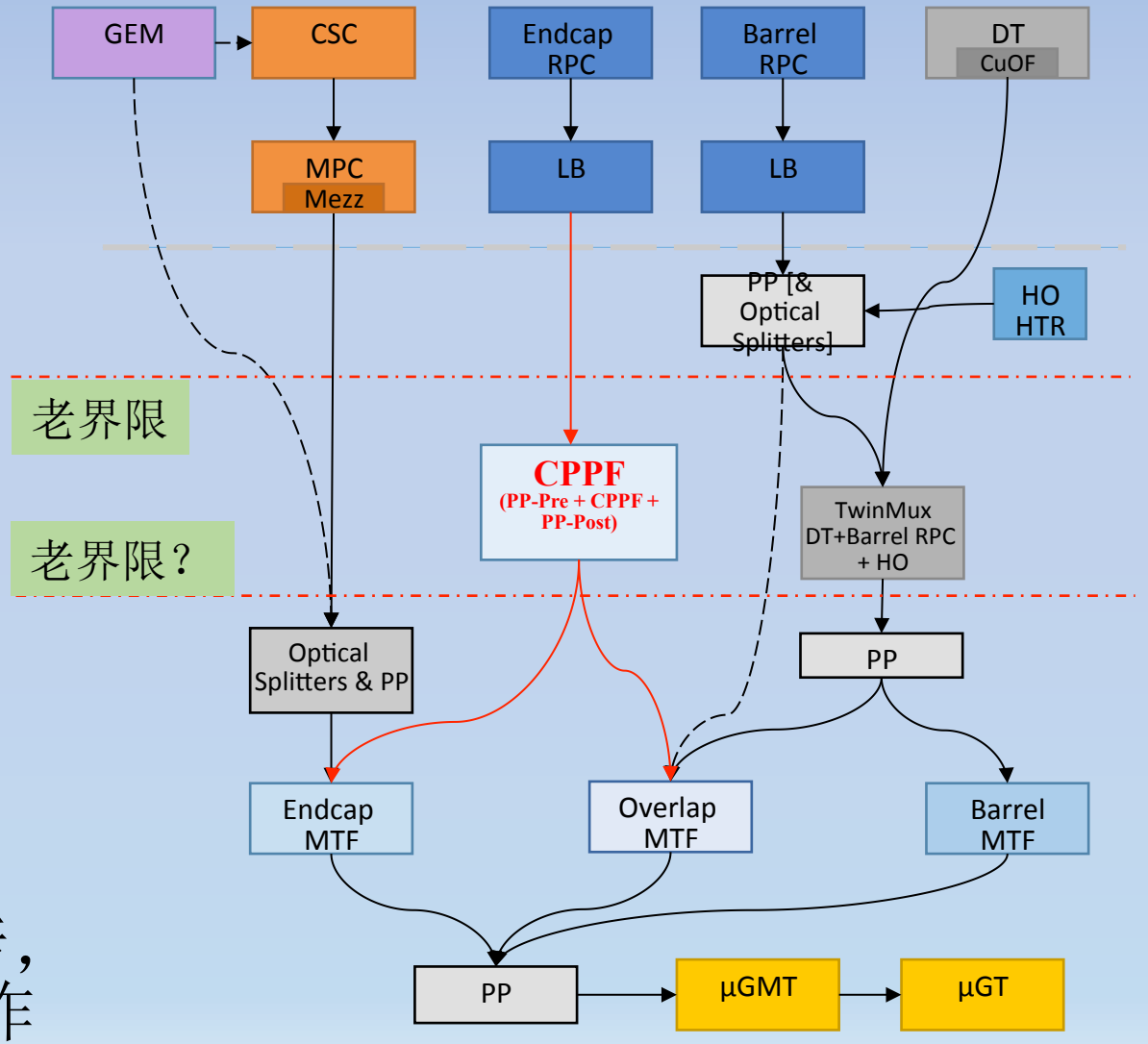
Phase II升级工作介绍

- CPPF的成功以及我们在ATCA/xTCA领域的领先位置我们在CMS合作组受到欢迎

- CMS 触发数据获取升级相关技术
  - Micro-TCA -> ATCA
  - 数据互联带宽 10Gbps ->23 – 26 Gbps
- CPPF 的工作与Muon探测器直接相关
- Muon探测器升级有两部分
  - 电子学与触发 / DAQ信号链接 1.6Gbps -> 10Gbps
  - iRPC （RE3.1 + RE4.1）（高能所）
  - 通用后端电子学（？）
- 在明确不能参加 Tracker和HGCAL的工作后，Muon探测器和触发系统邀请参加相关工作
  - 后端电子学 / 触发

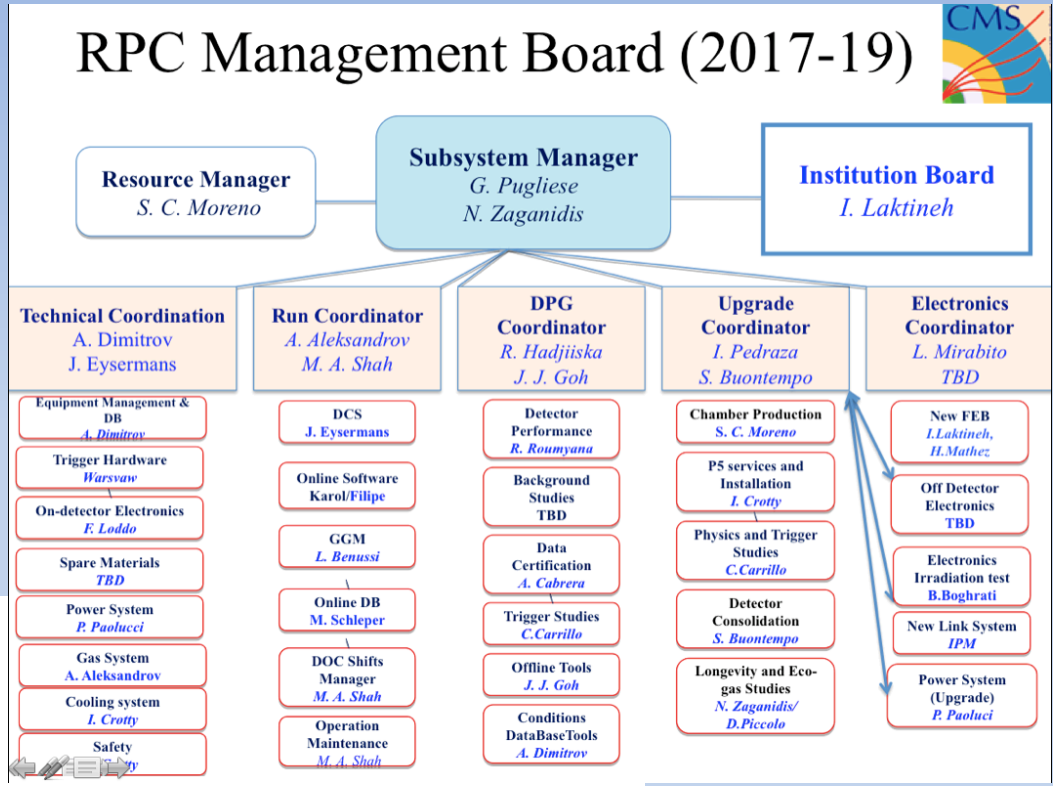


密集讨论

- RPC 组的正式联系
  - Imad -> Gabriella
  - 2017年11月24日RPC组报告
  - 跟 Salvator/Laurent密切联系
    - 了解情况

Report on IHEP Team Background and CPPF system in CMS Phase I upgrade

Zhen-An Liu, IHEP/CAS, China
CMS Phase II RPC Workshop
CERN, Switzerland
Nov.23-24 2017



RPC off-detector electronics discussion

Vidyo conference with RPC team
16:00 BJT Dec. 20 2017

密切讨论

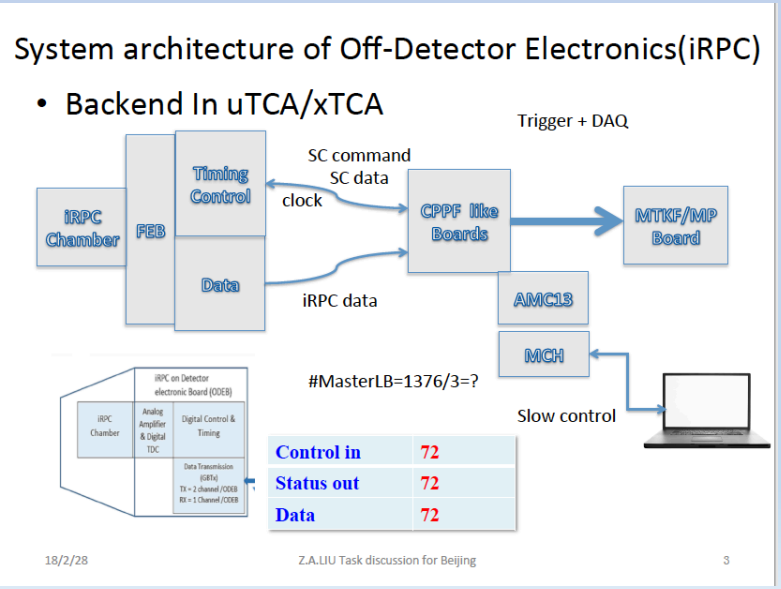
Idea on iRPC BackEnd Electronics

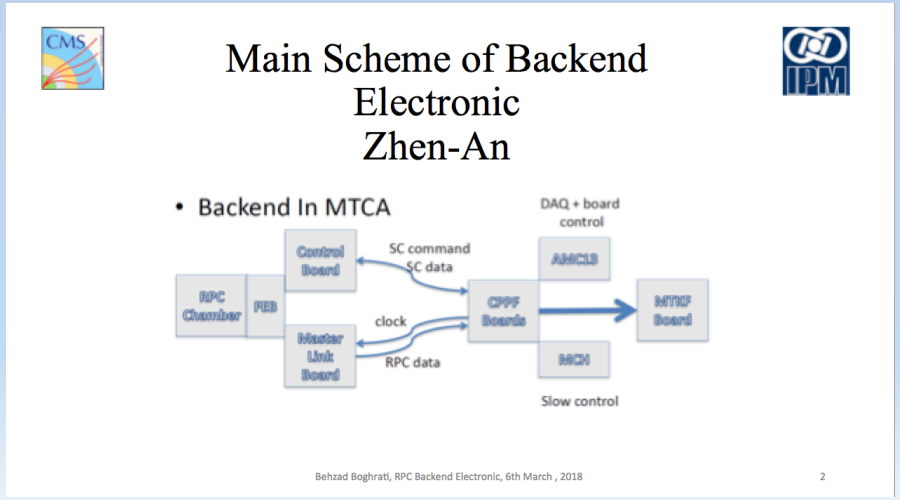
Zhen-An LIU
IHEP Beijing/TriggerLab
RPC Electronics Discussion
CERN, Apr. 27 2018

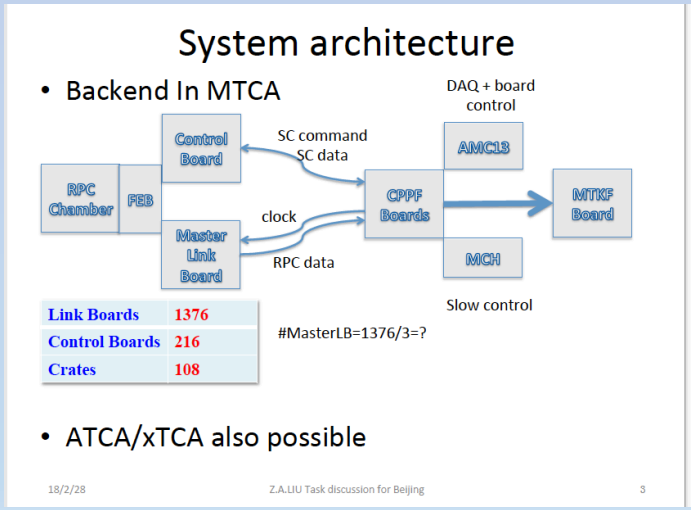
- 2018年2月／3月访问CERN期间提出想法与建议（最右上、下）
- 3月6日高能所建议被采纳（见中下Behzad报告）
- 建议在4月27日正式提出（左上及左下）

Thoughts from IHEP on Phase II Level 1 Trigger upgrade task

Zhen-An LIU
CMS RPC Upgrade: back-end electronics discussion
CERN, Building 904
Mar.1st 2018







现状

- 5月14日RPC workshop期间做了进展报告（右上）
  - 测试系统在北京以及建立（右下）
- 6月19号和20号两次做报告
  - iRPC(RE3.1+RE4.1)
  - 通用后端设计（ATCA样机）
- 合作组对北京的进展印象深刻

Off-electronics for 3.1 and 4.1 chambers: status and plan

Zhen-An LIU
TriggerLab, IHEP Beijing
First 2018 RPC Workshop
May 14 2018, Vidyo

Backend Electronics

Zhen-An LIU
On behalf of Trigger Lab,
Institute of High Energy Physics, Chinese Academy of Sciences
And CMS collaboration
Jun. 20 2018

中国科学院高能物理研究所
Institute of High Energy Physics Chinese Academy of Sciences

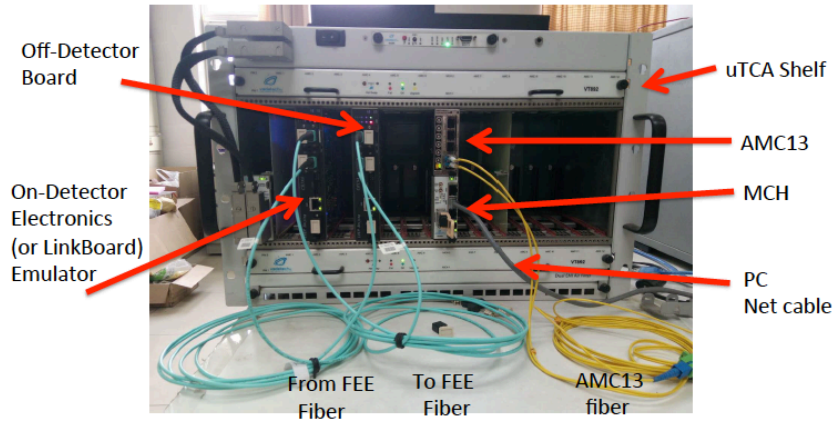
Status on RE3.1+RE4.1 Backend Electronics

Zhen-An Liu, Jingzhou Zhao, Pengcheng Cao

IHEP@Beijing
Jun. 19 2018

Status

1. Conceptional Design discussed
2. Test bench has setup.



18/5/14 RPC Workshop 6

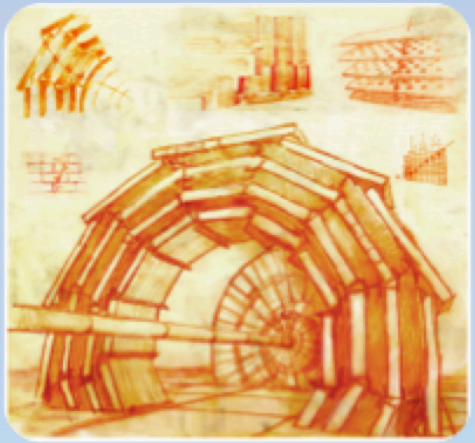
现状

- 由Behzad和我在CMSWEEK会议上提出了 Phase II 新的设计方案报告

- 总体进展很好

New RPC Link System and Back-end electronics for RE3/1 and RE4/1

(2018.06.26)



Behzad Boghrati , Zhen-An Liu
on behalf of the IPM, IHEP & CMS Collaboration

RPC meeting during CMSWEEK

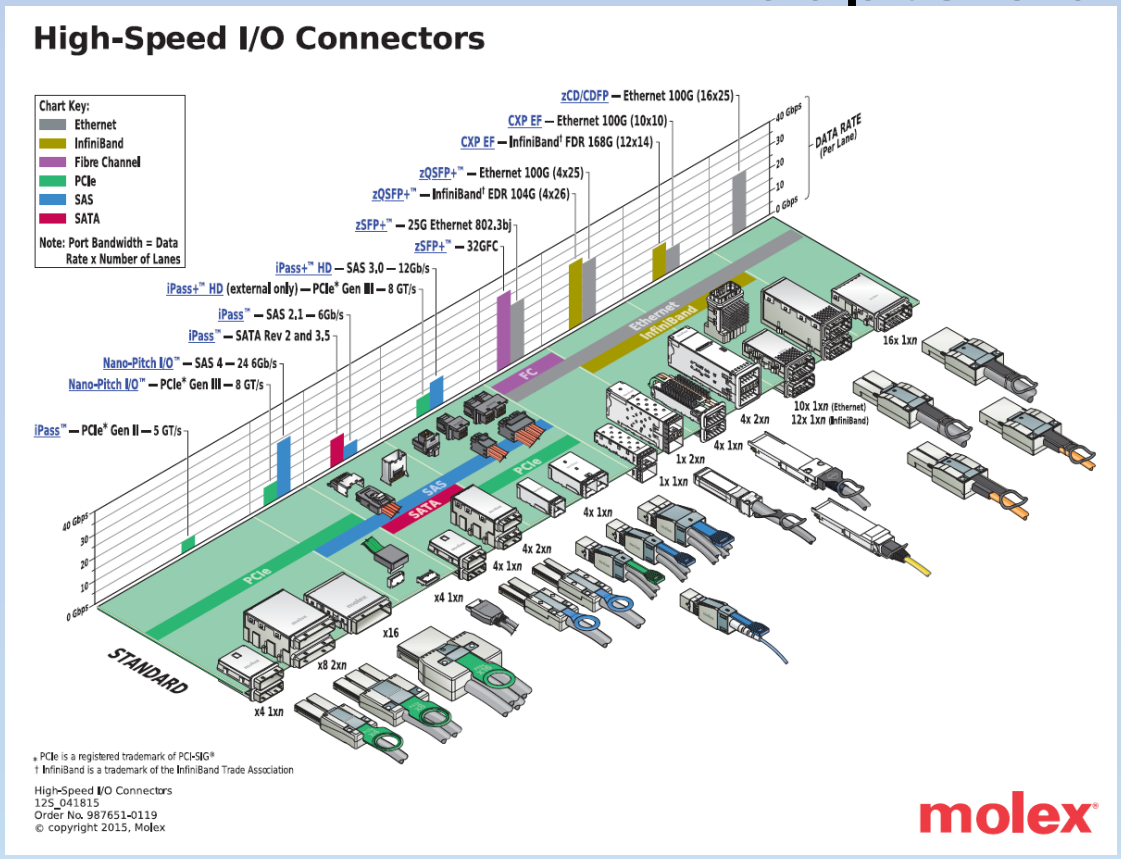
26th June 2018

Behzad Boghrati, New Link System, 26th June , 2018 1

总结

- CPPF系统设计建造成功，得到CMS合作组正式确认
- 高能所提出的Phase II iRPC 后端读出设计方案，得到确认，取得了明确进展
- 高能所提出的Muon整体后端ATCA读出方案得到RPC组认可，并由RPC组提议作为整个MUON的建议方案，等待后续深入讨论。高能所实验室ATCA设计载板原型通过了测试。
- 整体课题进展优秀

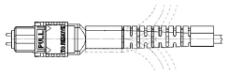
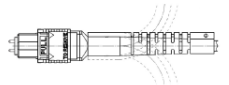
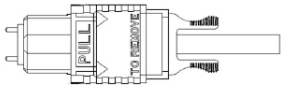
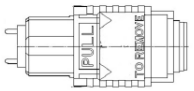
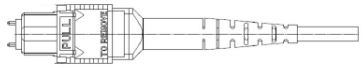
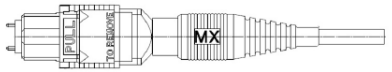
Molex® High-speed I/O Connector CXP Connector & MTP Adapters and Cable Assemblies



MTP*/MPO
Adapters and
Cable Assemblies

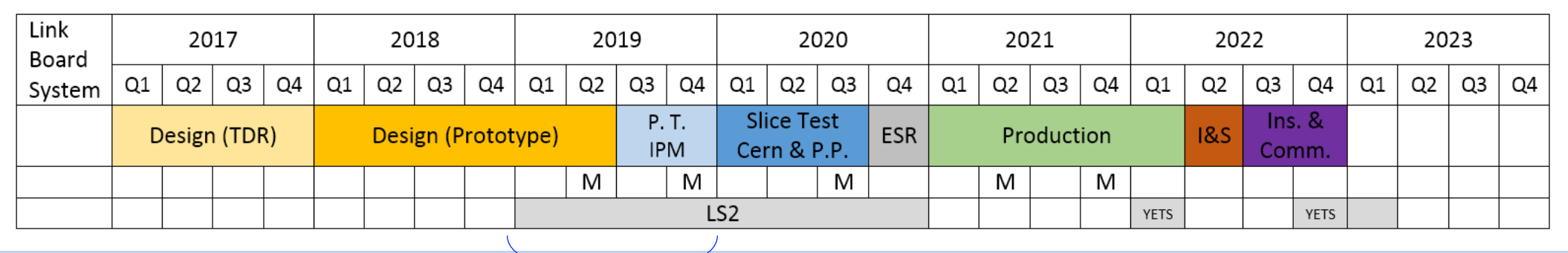
Ordering Information

MTP/MPO Cables & Adapters

Order Number	Description	ISO Drawing
106082-1000	MTP Connector Kit with FlexiBend™ Boot, 3mm Round Cable, Male and Female - 12-fiber cable	
106082-1100	MTP Connector Kit with FlexiBend™ Boot, 3.8mm Round Cable, Male and Female - 24-fiber cable	
106081-3250	Short MTP Connector Kit, Male and Female - bare ribbon cable	
106081-2030	MTP Connector with Short Push Spring, Male and Female - bare ribbon cable	
106081-3510	MTP Connector Kit, 3mm Round Cable, Male and Female - 12-fiber cable	
106081-3310	MTP Connector Kit, 3mm Round Cable with Enhanced Strain Relief, Male and Female - 12-fiber cable	

- http://www.molex.com/fiber/index.html

Prototype Tests and Validation Proposed on TDR



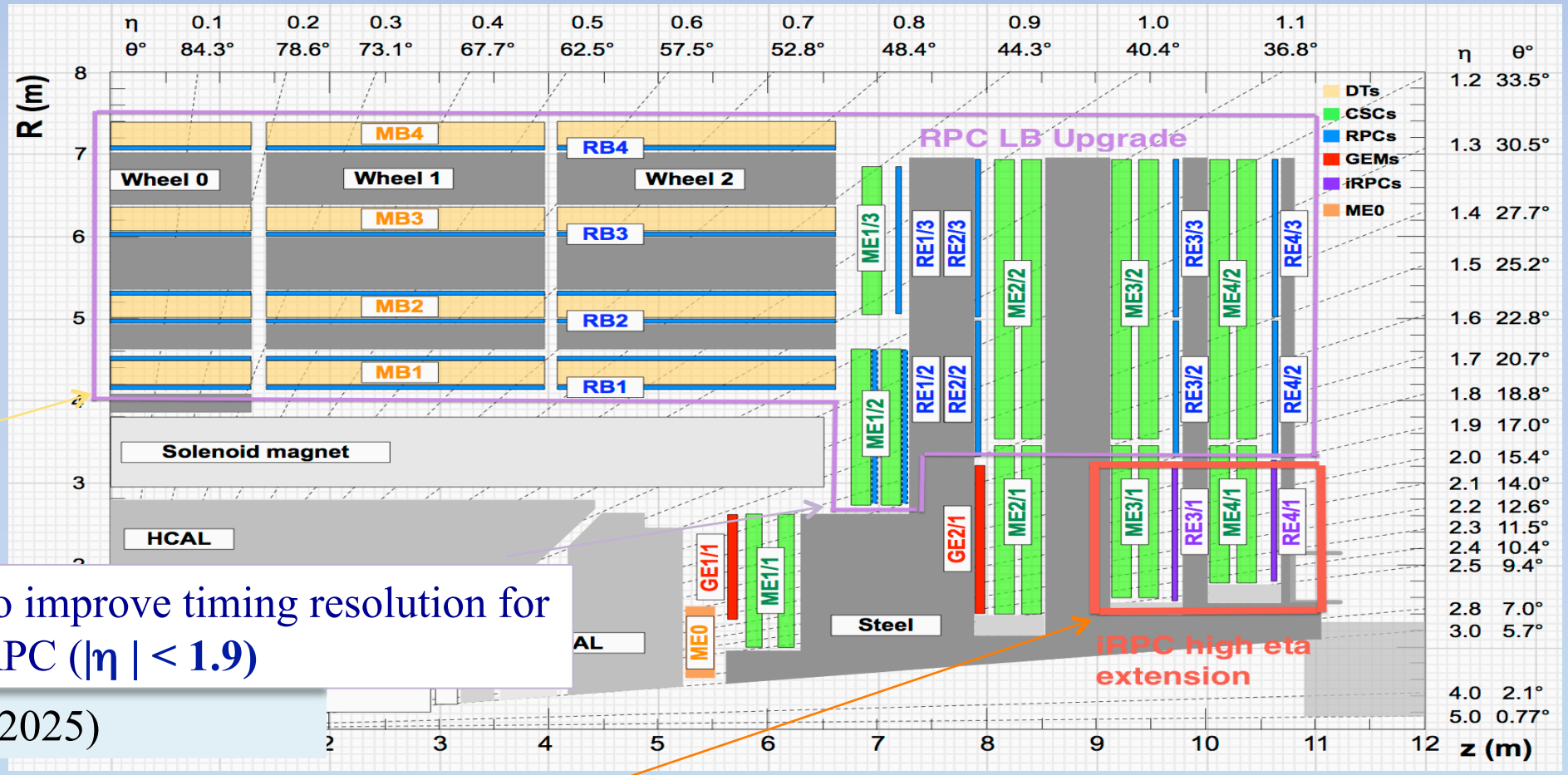
Link Board System	2017				2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	Design (TDR)				Design (Prototype)						P. T. IPM		Slice Test Cern & P.P.			ESR	Production				I&S		Ins. & Comm.					
										M		M			M			M		M								
									LS2												YETS			YETS				

TDR reported

Tests, Verification and Validation of Prototypes including Radiation Tests, EMC, Temperature & Burn-in tests , ….

- P. T. ： Prototype Test in IPM
- P. P. ： Pre-production
- ESR ： Electronic System Review
- I & S :Integration and Shipment
- Ins. & Comm. : Installation & Commissioning

The RPC Upgrade project



Upgrade of Link System to improve timing resolution for existing RPC (|η | < 1.9)

Installation in LS3 (2024-2025)

Extend the RPC coverage up to |η | = 2.4 to increase redundancy in high eta region in stations 3 and 4

Installation in YETS 2021-22 & YETS 2022-23