Overview of Detector R&D Projects

Response to International Detector R&D Committee

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Chinese Academy of Sciences

CEPC Day
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IDRC Request:

Goal: Clarify the R&D activities on-going within the CEPC Detector Project

1. The project leadership and IDRC should assemble a coherent list of R&D activities, such that the presence of gaps and overlaps can be determined and addressed

2. Each current R&D project should provide, key information to the IDRC:
   - The objectives of the project
   - The anticipated schedule on which the objectives will be met
   - The funding available to the project, and the leadership arrangements within it
   - The extent to which the project is a CEPC-specific development

We added:

- Manpower resources available for the project, including type (student, faculty, engineer, etc) and FTE

Detector R&D Tasks Arrangement

1 - Vertex
2 - Tracker
2.1 - TPC
2.2 - Silicon Tracker
2.3 - Drift Chamber
3 - Calorimeter
3.1 - ECAL Calorimeter
3.2 - HCAL Calorimeter
3.3 - DR Calorimeter
4 - Muon Detector
5 - Solenoid
6 - MDI
7 - TDAQ
8 - Software and Computing

Detector R&D sub-projects identified and numbered accordingly

R&D tasks created under these tasks

Sub-group conveners and other detector R&D proponents were asked to compile documents with required information

Word document template:

CEPC Detector R&D Project
1.1 Vertex Prototype

Document Responsible:	Joao Guimaraes da Costa
Last saved by on	12/13/19 5:19:00 AM
Revision number:	1

Change history

Revision	When	What changed and why
1	12/12/2019	First draft
		< Add further lines to table as required >

Readme first

i. Please do not delete or modify this section or its structure.

ii. Only change text enclosed by (and including) angled brackets "< … >".

iii. Don't change field directly, instead modify the document options, under File→ Properties (or similar)

- Enter name of person that wrote the document in Document:Summary: Author
- The project ID number, should follow the rules provided to you earlier. The number should be changed in Document:Custom: PBS.
- The project name should be changed in Document:Summary: Subject.

iv. In Section *Project Objectives* provide a brief description of the project goals, i.e. why and what is being produced, for PBS item **1.1 Vertex Prototype**. If this project includes identifiable sub-projects you can indicate them in the the *Sub-projects Description* Section, otherwise submit a separate document for each of them. The sub-project IDs are free for you to define.

v. Finally, remember to update the *Change History*.

Word document template:

1.1 Vertex Prototype: Project Objectives

<Include a short description of the goals of the project>

1.1 Vertex Prototype: Sub-projects Description

Project ID	Title	Description
1.1.1	Pixel sensor R&D	
1.1.1.1	CMOS pixel sensor R&D	
1.1.1.1.1	Full size CMOS sensor	Full size CMOS pixel sensor with full functionality to be used in a pixel vertex detector
1.1.1.1.2	MOST1 CMOS sensor	MOST 1 CMOS R&D
1.1.1.2	SOI pixel sensor R&D	
1.1.2	Low-mass ladder	Ladder with low mass to satisfy CEPC requirements
1.1.3	Mechanical structure	Low-mass mechanical structure for pixel detector
		< Add further lines to table as required >

1.1 Vertex Prototype: CEPC Relationship

<Indicate to what extent this project is a CEPC-specific development.>

1.1 Vertex Prototype: Project Schedule

<Enter a rough schedule for the project, indicating the ultimate schedule goal for when the objectives will be met, and some intermediate steps if found important.>

1.1 Vertex Prototype: Funding Availability

<Short statement about the funding sources and amount of funding available. If no funding yet, please indicate that. Indicate if funding is enough or more funds are desirable.>

1.1 Vertex Prototype: Leadership Arrangement

<Indicate who is leading the project and the leadership arrangement within the project. Should identify names and institutions.>

1.1 Vertex Prototype: Manpower Resources

< Briefly summarize the manpower resources available for the project, including type (student, faculty, engineer, etc) and FTEs for each type. >

Type	Average FTE Expected
Faculty	
Postdoc	
Students	
Engineers	

Preliminary Documents:

17 documents

CEPC Detector R&D Project
2.1 TPC Module and Prototype

Document Responsible:	Qihurong
Last saved by on	12/18/19 6:40:00 AM
Revision number:	1

CEPC Detector R&D Project
2.2 Silicon Tracker Prototype

Document Responsible:	Harald Fox, Meng Wang
Last saved by on	12/29/19 10:42:00 AM
Revision number:	1

CEPC Detector R&D Project
3.1.1 Crystal Calorimeter

Document Responsible:	Yong Liu
Last saved by Yong Liu on	12/30/19 5:56:00 AM
Revision number:	1

CEPC Detector R&D Project
3.3 Dual-readout Calorimeter

Document Responsible:	Roberto Ferrari
Last saved by Roberto Ferrari on	17/12/19 08:00:00 PM
Revision number:	1

CEPC Detector R&D Project
4.1 Scintillator-based Muon Detector Prototype

Document Responsible:	Xiaolong Wang, Liang Li
Last saved by on	12/18/19 3:15:00 AM
Revision number:	1

CEPC Detector R&D Project
4.2 muRWell detectors

Document Responsible:	Paolo Giacomelli
Last saved by Joao Guimaraes da Costa on	12/30/19 12:23:00 AM
Revision number:	1

CEPC Detector R&D Project
5.1 LTS solenoid magnet

Document Responsible:	Zhu Zian
Last saved by on	12/18/19 1:40:00 AM
Revision number:	1

CEPC Detector R&D Project
5.2 HTS solenoid magnet

Document Responsible:	Zhu Zian
Last saved by on	12/18/19 1:41:00 AM
Revision number:	1

CEPC Detector R&D Project
6.2 Interaction Region Mechanics

Document Responsible:	Microsoft Office User
Last saved by on	12/18/19 11:08:00 AM
Revision number:	1

A couple of examples: HTS Solenoid

5.2 HTS solenoid magnet: Project Objectives

A large HTS solenoid concept is proposed by IHEP team for the CEPC detector, with the calorimeter located outside of the solenoid, which requires a very thin solenoid.

The HTS solenoid is supposed to use YBCO stacked-tape cable as the conductor. The radiation length of single YBCO tape coated with 10 um copper is about 0.004 X0, we can get a thinner solenoid by using HTS compare to LTS. Therefore, the YBCO stacked-tape cable and the cryogenics are brought into R&D. Up to 20% additional reduction in the overall thickness may be achieved with more R&D and engineering.

The objectives of the detector magnet R&D projects are relative to the four different tasks listed as follows.

5.2 HTS solenoid magnet: Sub-projects Description

Sub-project ID	Title	Description
5.2.1	Development of HTS conductor	Develop aluminum stabilized ReBCO stacked tape cable, the tapes are embedded in a pure aluminum, cable length > 200 m, current > 6 kA at 20 K. We also consider other HTS cables if they are suitable for large detector magnet.
5.2.2	Development of 20 K cooling for HTS coil	Explore the cooling mechanism and heat conductivity structure at 20 K, study the stability and quench behavior at this temperature.
5.2.3	Development of low material cryostat	Study the cryostat structure with less mass material to make particles more easily penetrate to reach the calorimeter.
5.2.4	Construction of 1:20 superconducting coil prototype	Develop the prototype of large HTS magnet, study the winding process, cable joint, quench protection and so on, with an inner diameter 2m, 4.2K liquid helium cooling, stack cable 4mm width 20 layers.
		< Add further lines to table as required >

5.2 HTS solenoid magnet: CEPC Relationship

All four activities are strictly (almost exclusively) related to the design of the solenoid magnet of the CEPC detector.

5.2 HTS solenoid magnet: Project Schedule

Project 5.2.1 and 5.2.4 got funding from the Chinese Academy of Sciences Foundation for original innovation project from 0 to 1, research focus on the key technology of high temperature superconducting magnet for large detector in the future. It was expected to complete the project by the end of 2024.

Project 5.2.2 and 5.2.3 have to get new funding support, activity is expected to start in 2023, we expect to master all aspects of the technology of large-scale HTS detector magnet and complete the project by the end of 2026.

5.2 HTS solenoid magnet: Funding Availability

We have obtained 3M CNY from the Chinese Academy of Sciences Foundation for original innovation project from 0 to 1, for the key technology of high temperature superconducting magnet for large detector in the future, mainly focus on the research described in the first and second step of project 5.2.1 and 5.2.2.

We are missing the funds needed for the low material cryostat study described in the third and fourth step of project 5.2.3 and 5.2.4.

5.2 HTS solenoid magnet: Leadership Arrangement

Leading institute for the HTS solenoid magnet project will be Institute of High Energy Physics, CAS (coordinated by Ning Feipeng).

Significant support will be given by the industrial companies, Toly Electric Works Co. LTD at Wuxi (coordinated by Liao He'an) and Shanghai Superconductor Technology Co. Ltd at Shanghai (coordinated by Zhu Jiamin) for what concerns high temperature superconducting cable development. Cooperation partners for simulations and finite element analysis of the cable and coil are under investigation.

5.2 HTS solenoid magnet: Manpower Resources

Type	Average FTE Expected
5 Faculty	2
1 Postdoc	0.5
4 Students	2
1 Engineer	0.5

A couple of examples: Dual Readout Calorimeter

3.3 Dual-readout Calorimeter: Project Objectives

The 20-year-long experimental research program on dual-readout calorimetry of the DREAM/RD52 collaboration has yielded a technology that is mature for application at CEPC. The results show that the parallel, independent, readout of scintillation and Čerenkov light, makes it possible to cancel the effects of the fluctuations of the electromagnetic fraction in hadronic showers, heavily affecting the energy resolution of the present calorimetry technologies. In conjunction with high-resolution em and hadronic energy measurements, excellent standalone particle-ID capability was demonstrated as well.

Those results strongly support the conviction that a matrix of alternating scintillating and clear fibres, inserted in copper or lead strips and readout by Silicon PhotoMultipliers (SiPMs), will be able to provide performance more than adequate for the physics program at the CEPC collider. A pointing geometry may allow for unprecedented transverse sampling granularity. Photon pairs could be identified and reconstructed down to a separation of less than 1 cm. Moreover, timing measurements should provide the capability to reconstruct the longitudinal shower development position. A 100 ps time resolution should result in a position resolution of about 5 cm.

The objectives of the R&D projects are relative to the four different tasks listed as follows.

3.3 Dual-readout Calorimeter: Sub-projects Description

Project ID	Title	Description
3.3.1	Mechanics	In order to arrive to an executive design and engineering drawings of a realistic detector, the following issues need to be clarified: a) dimensions and construction method of the building elements of the absorber structure; b) the procedure for the assembly of single towers; c) the definition of a sensible breakdown of a full coverage 4π geometry. All depends on the choice of the absorber material, one among brass and iron being, at present, the baseline. The gluing of capillary tubes seems to be a viable solution for the construction of O(10×10 cm^2) modules and an R&D programme in this direction is ongoing, with fundings from INFN, University of Sussex and RBI. A 1 m long single (brass) module will be built, in the next months, to be tested at DESY. A beam period was allocated at the end of 2020 but, following the COVID-19 crisis, the schedule needs to be revised as soon as possible. In parallel, a 3-year R&D project will be submitted during next year for the construction of a "hadronic-size" prototype as well as for addressing the issues related to the construction of projective modules (including engineering drawings of a possible 4π detector). In February 2020, the National Research Foundation of Korea (NRF) granted a 5-year funding of about 2M USD for building a full-scale "hadronic-size" projective prototype..
3.3.2	Fibres and optical elements	The fibre selection needs to target the proper tuning of light collection yield and attenuation-length properties. Since scintillating and Čerenkov light production processes have yields that differ by orders of magnitude, the transmission chain critically needs to tackle possible optical cross-talk of scintillation in Čerenkov signals. A suitable choice of core material, numerical aperture (i.e. cladding structure) and light filtering, properly matched with the sensor PDE, should allow to obtain a yield of ~100-400 p.e./GeV, with manageable attenuation-length effects. Qualification of fibres, optical coupling and light sensors will be part of the R&D plans.
3.3.3	Light sensors and readout electronics	A SiPM-based readout provide several advantages: no fibres sticking out (i.e. no tail oversampling), operation in magnetic field, larger light yield with respect to standard PMTs, very high readout granularity. On the other hand, being digital detectors, SiPMs may show saturation, non-linearity, after pulsing, cross-talk. The R&D program will address these points with a market survey of sensors and front-end ASICs. The large dynamic range (a single fibre collects O(10%) of the em shower signals) requires high-density sensors (small cell size). This is a requirement also in the case that we need to guarantee a linear response. Indeed, to reduce the huge number of readout elements, the analog grouping of sensor outputs will be exploited, making impossible to apply non-linearity corrections. A readout chain based on modular (innovative) elements will be tested with specific efforts for the assessment and optimisation of the timing performance. The possibility of using a sampling ASIC is also being considered. In this context, the collaboration with CAEN and, as far as possible, with other producers, will be carried on. Hamamatsu SiPMs, with 15 μm cell pitch, and the CAEN DT5550W readout system, based on the Citiroc1A ASIC, are the baseline choices for the 2020 prototype.
3.3.4	Simulations and detector performance	A complex (Geant4) simulation programme is being pursued in order to assess both the standalone and the combined performance of dual-readout calorimeter implementations. Square (testbeam) modules, according to real and possible prototypes, have been and will be simulated for comparison with data. At the same time, simulations of a 4π detector will be carried on in order to estimate at best the possible performance in a real experiment concerning: 1. Energy resolution for electrons, gammas, single hadrons and hadronic jets both standalone and with a preshower detector; 2. Angular and position resolution, in particular for the identification and separation of the two photon showers from π^0 decays; 3. Reconstruction of the longitudinal shower development position through timing measurements; 4. Particle identification of single e, π, μ, γ, both isolated and within jets; 5. Identification and reconstruction of final states from hadronic τ-decays; 6. Identification and reconstruction of final states from $Z/W/H \to jj$, $H \to ZZ^*/WW^* \to 4j$, $H \to \gamma\gamma$, $Z/H \to \tau\tau$ decays.
3.3.5	Data selection and processing with deep-learning algorithms	Development of deep-learning algorithms (over convolutional neural networks) exploiting timing information, for online and offline data selection and processing. The performance assessment will concern the same final states as in task 3.3.4.

3.3 Dual-readout Calorimeter: CEPC Relationship

This R&D on dual-readout calorimetry is an integral part of the program for the calorimeter system of the IDEA detector concept. IDEA is included in the CDRs of both high-energy circular e^+e^- colliders presently under discussion: CEPC in China and FCC-ee at CERN. The R&D is the same for both colliders.

3.3 Dual-readout Calorimeter: Project Schedule

In the initial planning, all the tasks were meant to be completed by 2024. The prototype under preparation was planned to be tested at DESY by the end of 2020. At the time of writing, due to the present COVID-19 emergency, no solid statement on the date can be done. The test beam period is expected to be postponed (probably to 2021). Further planning, including the schedule for the hadronic-size prototype, will need to be reassessed as soon as possible. At present, the delay is meant to be of the order of months. Of the other hand, the schedule will depend on the amount of funding and resources that will be secured.

3.3 Dual-readout Calorimeter: Funding Availability

The first stage of the project (the 2020 prototype) has received funding from INFN CSN1 (~40 k€), from RBI (about 15 k€) and from the University of Sussex (about 5 k€). Small amount of funding from University grants has also been made available.

A request of about 100 k€ has been also presented for the AIDA++ proposal, mainly thought to be used for hiring young manpower.

About the building of a hadronic-size prototype, a request will be submitted for EU grants and to European funding agencies in 2020 (INFN, RBI, Royal Society).

In South Korea, a R&D fund of about 2M USD has been granted, from March 2020 over 5 years, by the Korea National Research Foundation (NRF) for building a full-hadronic-scale projective prototype, addressing the main engineering, operating and readout issues. Additional soft funding is also available for simulation study to support postdoc positions and graduate students in each institute.

3.3 Dual-readout Calorimeter: Leadership Arrangement

Project leader: Roberto Ferrari INFN Pavia

Technical coordinator: Romualdo Santoro Università dell'Insubria Como and INFN Milan

Group leaders/contacts:

Hwidong Yoo	South Korea Consortium (Kyungpook National University, Korea Universit University of Seoul, Yonsei University, includes also Iowa State University)
Romualdo Santoro	Università dell'Insubria Como and INFN Milano
Gabriella Gaudio	INFN Pavia
Franco Bedeschi	INFN Pisa
Stefano Giagu	Università di Roma "La Sapienza" and INFN Roma 1
Paolo Giacomelli	INFN Bologna
Iacopo Vivarelli	University of Sussex
Valery Chmill	RBI Zagreb

3.3 Dual-readout Calorimeter: Manpower Resources

Type	Average FTE Expected
Faculty	4.2
Postdoc	2.2[1]
Students	6.8[1]
Engineers	1.3[2]

1. The number for students and postdoc includes positions that will be funded within the R& project (i.e. for which at present funds are not guaranteed).

2. The number of engineers includes technical manpower from institute workshops that are n engineers but are nevertheless actively participating to the design efforts.

Detector R&D Major R&D Breakdown

17 documents

1. Vertex
   - 1.1. Pixel Vertex Prototype
   - 1.2. ARCADIA/LFoundry CMOS
2. Tracker
   - 2.1. TPC
   - 2.2. Silicon Tracker
   - 2.3. Drift Chamber
3. Calorimeter
   - 3.1.ECAL Calorimeter
     - 3.1.1. Crystal Calorimeter
     - 3.1.2. Scintillator-Tungsten
   - 3.2. HCAL PFA Calorimeter
     - 3.2.1. DHCAL
     - 3.2.2. Sci AHCAL
   - 3.3. DR Calorimeter
4. Muon Detectors
   - 4.1. Muon Scintillator Detector
   - 4.2. Muon and pre-shower MuRWell Detectors
5. Solenoid
   - 5.1. LTS Solenoid
   - 5.2. HTS Solenoid
6. MDI
   - 6.1. LumiCal Prototype
   - 6.2. Mechanics
7. TDAQ
8. Software and Computing

- 1.1-RD-Vertex-Prototype
- 1.2-RD-Vertex-ARCADIA.docx
- 2.1-RD-Tracker-TPC-v3.docx
- 2.2-RD-Tracker-SiliconTracker-Prototype_v3.docx
- 2.3-RD-Tracker-DriftChamber-v2.docx
- 3.1.1-RD-ECAL-Crystal-Calorimeter-v2.docx
- 3.1.2-RD-ECAL-Sci-W-v1.docx
- 3.2.1-RD-HCAL-PFA-DHCAL-v2.docx
- 3.2.2-RD-HCAL-PFA-Sci-AHCAL.docx
- 3.3-RD-Dual-Readout-Calorimeter-v2.docx
- 4.1_RD_Muon_Scintillator-v1.docx
- 4.2-RD-muRwell-detectors-v2.docx
- 5.1-RD-LTS-solenoid-magnet.docx
- 5.2-RD-HTS-solenoid-magnet.docx
- 6.1-RD-MDI-LumiCal-prototype-v2.docx
- 6.2-RD-MDI-Mechanics_v2.docx
- 8-Software_v1.3.docx

Projects overview

Total subtasks: 95

17 documents, total: 80 pages

PBS	Task Name	Page	Subtasks	Context	Team	Document Responsible
	CEPC Detector R&D Project					
1	**Vertex**					
1.1	**Vertex Prototype**	5	9	CEPC	China+ international collaborators	Zhijun, Ouyang
1.2	**ARCADIA CMOS MAPS**	6	6	Generic	INFN, Italy	Manuel Rolo
2	**Tracker**					
2.1	**TPC Module and Prototype**	6	12	CEPC	IHEP, Tsinghua	Huirong
2.2	**Silicon Tracker Prototype**	6	8	Generic	China, UK, Italy	Harald Fox, Meng Wang
2.3	**Drift Chamber Activities**	4	3	FCC-ee/CEPC	INFN, Novosibirsk	Franco Grancagnolo
3	**Calorimetry**					
3.1	**ECAL Calorimeter**					
3.1.1	Crystal Calorimeter	5	6	CEPC	IHEP, Princeton + others	Yong Liu
3.1.2	PFA Sci-ECAL Prototype	3	3	CEPC	USTC, IHEP	Jianbei Liu
3.2	**HCAL Calorimeter**					
3.2.1	PFA Digital Hadronic Calorimeter	4	5	CEPC	SJTU, IPNL, Weizmann, IIT, USTC	Haijun Yang, Imad Laktineh, Shikma Bressler
3.2.2	PFA Sci-AHCAL Prototype	4	4	CEPC	USTC, IHEP, SJTU	Jianbei Liu
3.3	**Dual-readout Calorimeter**	5	5	FCC-ee/CEPC	INFN, Sussex, Zagreb, South Korea	Roberto Ferrari
4	**Muon Detector**					
4.1	Scintillator-based Muon Detector	4	5	CEPC	Fudan, SJTU	Xiaolong Wang, Liang Li
4.2	Muon and pre-shower µRWELL-	5	4	FCC-ee/CEPC	INFN, LNF	Paolo Giacomelli
5	**Solenoid**					
5.1	LTS solenoid magnet	4	4	CEPC	IHEP+Industry	Zhu Zian
5.2	HTS solenoid magnet	4	4	CEPC	IHEP+Industry	Zhu Zian
6	**MDI**					
6.1	LumiCal Prototype	4	2	ILC/CEPC	AC, IHEP	Suen Hou
6.2	Interaction Region Mechanics	3	4	CEPC	IHEP	Hongbo Zhu
8	**Software and Computing**	7	11	CEPC	IHEP, SDU	Li Weidong, Ruan Manqi, Sun Shengseng, Li Gang

Projects overview: Funding

17 documents, total: 80 pages

PBS	Task Name	Page	Subtasks	Context	Team	Funding
	CEPC Detector R&D Project					
1	**Vertex**					
1.1	**Vertex Prototype**	5	9	CEPC	China+ international collaborators	MOST1/MOST2
1.2	**ARCADIA CMOS MAPS**	6	6	Generic	INFN, Italy	INFN: 1.35 MEur
2	**Tracker**					
2.1	**TPC Module and Prototype**	6	12	CEPC	IHEP, Tsinghua	MOST, NSF
2.2	**Silicon Tracker Prototype**	6	8	Generic	China, UK, Italy	None dedicated
2.3	**Drift Chamber Activities**	4	3	FCC-ee/CEPC	INFN, Novosibirsk	INFN: 370 kEur
3	**Calorimetry**					
3.1	**ECAL Calorimeter**					
3.1.1	Crystal Calorimeter	5	6	CEPC	IHEP, Princeton + others	CAS: 4 MRMB
3.1.2	PFA Sci-ECAL Prototype	3	3	CEPC	USTC, IHEP	MOST, NSF: 3 MRMB
3.2	**HCAL Calorimeter**					
3.2.1	PFA Digital Hadronic Calorimeter	4	5	CEPC	SJTU, IPNL, Weizmann, IIT, USTC	MOST, NSF: 5.6M, Cremlin+
3.2.2	PFA Sci-AHCAL Prototype	4	4	CEPC	USTC, IHEP, SJTU	MOST: 10 MRMB
3.3	**Dual-readout Calorimeter**	5	5	FCC-ee/CEPC	INFN, Sussex, Zagreb, South Korea	INFN, RBI: 60kEur, KNRF: 2 MUSD
4	**Muon Detector**					
4.1	Scintillator-based Muon Detector	4	5	CEPC	Fudan, SJTU	Fudan
4.2	Muon and pre-shower µRWELL-	5	4	FCC-ee/CEPC	INFN, LNF	INFN: 150 kEur
5	**Solenoid**					
5.1	LTS solenoid magnet	4	4	CEPC	IHEP+Industry	CAS, IHEP: 4.5 MRMB
5.2	HTS solenoid magnet	4	4	CEPC	IHEP+Industry	CAS: 3 MRMB
6	**MDI**					
6.1	LumiCal Prototype	4	2	ILC/CEPC	AC, IHEP	AC: Small
6.2	Interaction Region Mechanics	3	4	CEPC	IHEP	IHEP
8	**Software and Computing**	7	11	CEPC	IHEP, SDU	None

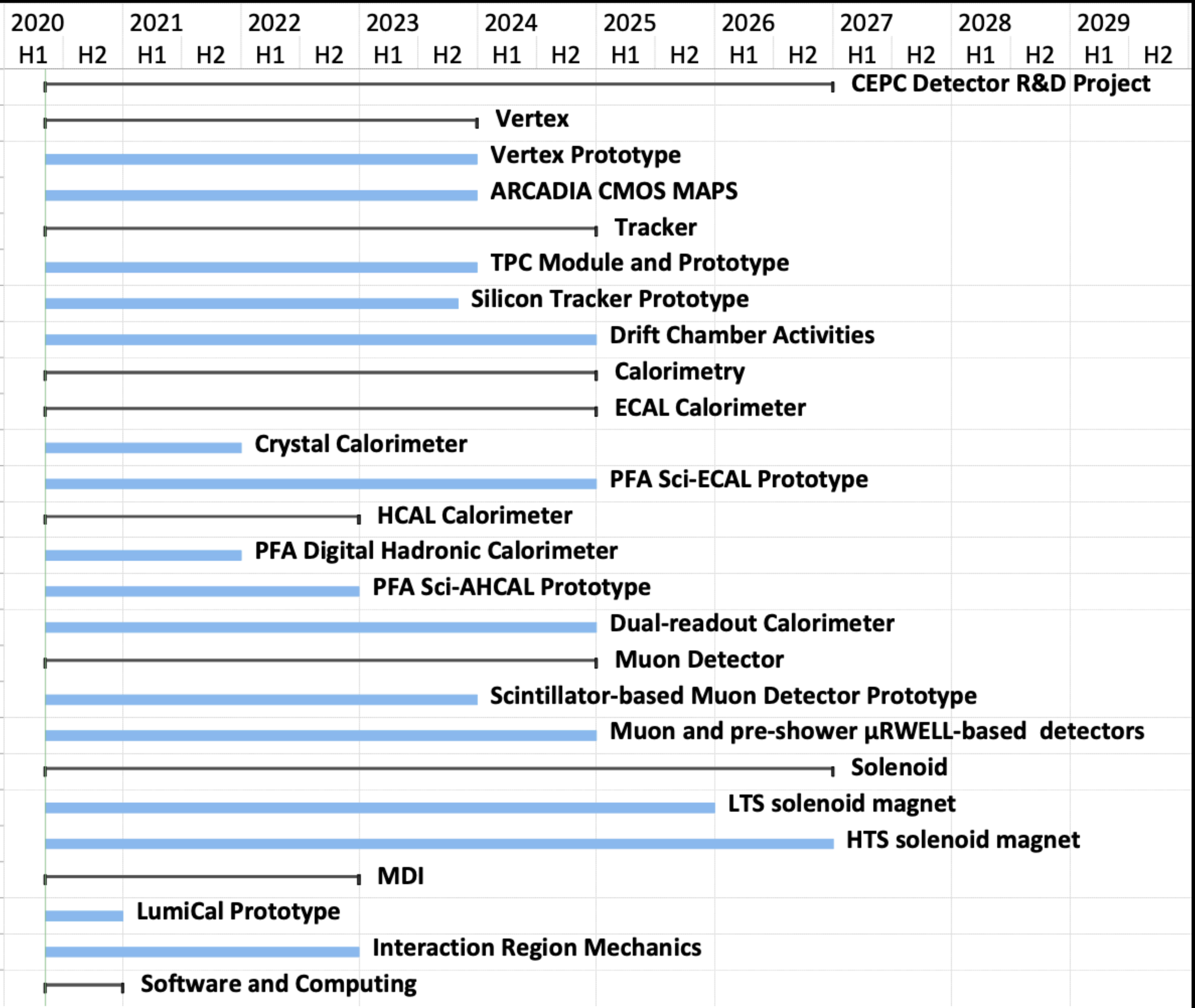
Projects overview: FTE

Total: 54 | 12 | 52 | 11

PBS	Task Name	Team	Faculty	Postdoc	Students	Engineers
	CEPC Detector R&D Project					
1	**Vertex**					
1.1	**Vertex Prototype**	China+ international collaborators	21		17.2	3.5
1.2	**ARCADIA CMOS MAPS**	INFN, Italy				
2	**Tracker**					
2.1	**TPC Module and Prototype**	IHEP, Tsinghua	3		4	1
2.2	**Silicon Tracker Prototype**	China, UK, Italy				
2.3	**Drift Chamber Activities**	INFN, Novosibirsk	2.5	2.4	1.8	0.8
3	**Calorimetry**					
3.1	**ECAL Calorimeter**					
3.1.1	Crystal Calorimeter	IHEP, Princeton + others	1.3		1	
3.1.2	PFA Sci-ECAL Prototype	USTC, IHEP	1.9		2.5	
3.2	**HCAL Calorimeter**					
3.2.1	PFA Digital Hadronic Calorimeter	SJTU, IPNL, Weizmann, IIT, USTC	2	1.5	2.5	0.5
3.2.2	PFA Sci-AHCAL Prototype	USTC, IHEP, SJTU	2.3	0.8	4	
3.3	**Dual-readout Calorimeter**	INFN, Sussex, Zagreb, South Korea	4.2	2.2	6.8	1.3
4	**Muon Detector**					
4.1	Scintillator-based Muon Detector	Fudan, SJTU	1		2.1	0.2
4.2	Muon and pre-shower µRWELL-	INFN, LNF	2	1.5	1	0.3
5	**Solenoid**					
5.1	LTS solenoid magnet	IHEP+Industry	2.5	0.5	2	0.5
5.2	HTS solenoid magnet	IHEP+Industry	2	0.5	2	0.5
6	**MDI**					
6.1	LumiCal Prototype	AC, IHEP	1	1	2	1
6.2	Interaction Region Mechanics	IHEP	0.5			1.5
8	**Software and Computing**	IHEP, SDU	7	2	3	0

Projects overview: Schedule

PBS	Task Name	Finish
	CEPC Detector R&D Project	**26/12/31**
1	**Vertex**	**23/12/29**
1.1	Vertex Prototype	23/12/29
1.2	ARCADIA CMOS MAPS	23/12/29
2	**Tracker**	**24/12/31**
2.1	TPC Module and Prototype	23/12/29
2.2	Silicon Tracker Prototype	23/10/31
2.3	Drift Chamber Activities	24/12/31
3	**Calorimetry**	**24/12/31**
3.1	**ECAL Calorimeter**	**24/12/31**
3.1.1	Crystal Calorimeter	21/12/31
3.1.2	PFA Sci-ECAL Prototype	24/12/31
3.2	**HCAL Calorimeter**	**22/12/30**
3.2.1	PFA Digital Hadronic Calorimeter	21/12/31
3.2.2	PFA Sci-AHCAL Prototype	22/12/30
3.3	**Dual-readout Calorimeter**	**24/12/31**
4	**Muon Detector**	**24/12/31**
4.1	Scintillator-based Muon Detector Prototype	23/12/29
4.2	Muon and pre-shower μRWELL-based detectors	24/12/31
5	**Solenoid**	**26/12/31**
5.1	LTS solenoid magnet	25/12/31
5.2	HTS solenoid magnet	26/12/31
6	**MDI**	**22/12/30**
6.1	LumiCal Prototype	20/12/31
6.2	Interaction Region Mechanics	22/12/30
8	**Software and Computing**	**20/12/31**



Plan and Final Remarks:

1. Vertex
   - 1.1. Pixel Vertex Prototype
   - 1.2. ARCADIA/LFoundry CMOS
2. Tracker
   - 2.1. TPC
   - 2.2. Silicon Tracker
   - 2.3. Drift Chamber
3. Calorimeter
   - 3.1.ECAL Calorimeter
     - 3.1.1. Crystal Calorimeter
     - 3.1.2. Scintillator-Tungsten
   - 3.2. HCAL PFA Calorimeter
     - 3.2.1. DHCAL
     - 3.2.2. Sci AHCAL
   - 3.3. DR Calorimeter
4. Muon Detectors
   - 4.1. Muon Scintillator Detector
   - 4.2. Muon and pre-shower MuRWell Detectors
5. Solenoid
   - 5.1. LTS Solenoid
   - 5.2. HTS Solenoid
6. MDI
   - 6.1. LumiCal Prototype
   - 6.2. Mechanics
7. TDAQ
8. Software and Computing

1) Collected preliminary version of documents describing R&D projects related to CEPC
   - In general documents are in good shape, requiring only minor modifications to be released
   - Describing up to 95 different tasks
   - Some funding available, but to realize the tasks described more funding will be required
   - Labour resources involved > 120 FTE!

2) Compile into one single document and provide to detector R&D committee soon
   - Summary document will be circulated among everyone for final comments
   - Documents are available at: https://indico.ihep.ac.cn/event/11799/

3) Discuss with committee next steps, including proposal submission procedure

Extra Slides

CEPC International Detector R&D Committee (IDRC)

Committee: 16 members

In Beijing

Dave Newbold, UK, RAL (chair) ★
Jim Brau, USA, Oregon
Brian Foster, UK, Oxford
Liang Han, China, USTC
Andreas Schopper, CERN, CERN
Steinar Stapnes, CERN, CERN
Hitoshi Yamamoto, Japan, Tohoku

By Vidyo

Valter Bonvicini, Italy, Trieste
Ariella Cattai, CERN, CERN
Cristinel Diaconu, France, Marseille
Abe Seiden, USA, UCSC
Laurent Serin, France, LAL
Roberto Tenchini, Italy, INFN
Ivan Villa Alvarez, Spain, Santader

Excused from first meeting

Harvey Newman, USA, Caltech
Marcel Stanitzki, Germany, DESY

CEPC International Detector R&D Committee (IDRC)

Committee proposed by CEPC IAC

Detector R&D Committee that reviews and endorses the **Detector R&D proposals** from the **international community**, such that the international participants could apply for funds from their funding agencies and make effective and sustained contributions.

CEPC International Detector R&D Committee (IDRC)

First meeting happened on Tuesday, Nov 19

https://indico.ihep.ac.cn/event/10941/

Organizational Meeting:

Key tasks of this inaugural meeting were:

- To establish the working mode of the panel
- To review the current catalogue of R&D activities
- To provide initial feedback to the project leadership on the shape and scale of the R&D programme, and on short-term priorities
- To identify further information the committee will need in the future.

IDRC Recommendations:

3. As a step in the transition from R&D to detector choices and TDRs, the project should aim to complete an update to the CDR within 12-18 months. This should take into account machine parameter changes, any new or modified physics requirements, and the availability of new sub-detector systems. This process should happen in parallel with sub-system R&D, and form the focal point for global detector optimisation studies

4. A conservative full-detector concept, potentially deliverable on an aggressive time scale, should be specified by the CEPC Management and adopted as the baseline for the CDR update. This should then act as a comparator for alternative concepts, that can fit within a less aggressive schedule, with a different balance of risk, cost and performance

IDRC Recommendations:

5. A set of short-term requirements on simulation and reconstruction tools should be established, serving the needs of detector optimization studies, and informing the plans for software and data management development in the pre-TDR period

6. Find ways to increase the rate of progress should be found for certain R&D areas, such that they do not hold up the overall detector design process. These include:
   - The precision timing detector
   - The trigger and readout strategy
   - The machine-detector interface and LumiCal

7. Sufficient time should be allocated during CEPC workshops for IDRC discussions, not conflicting with other events requiring the attendance of project leadership or IDRC members

Findings

- Requirements on sub-detectors should not be viewed in isolation, but increasingly in the context of studies of global detector performance, since there are strong interactions between sub-detector design choices. One example is the interplay between calorimetry, precision timing, and tracking in achieving the overall particle ID performance goals.

- In light of the above, the requirements on, and potential of, the proposed precision timing detector should be determined as a matter of urgency.

- A clear chain of argument, starting with physics requirements and culminating in detailed sub-detector specifications, should be maintained during the optimisation of the detector concepts. This will allow the impact of design changes to be assessed in terms of their effect on overall physics performance.

- The requirements on the muon sub-detector should be clarified, specifying the minimum performance needed for the core physics programme, as well as desirable additional features to allow a wider range of physics. The justification for a stand-alone muon spectrometer should be carefully examined.

Findings

- Regardless of choices regarding a precision timing detector, a common timestamping strategy should be defined, capable of dealing with 25ns running at the Z pole.

- There is no clear overarching trigger and readout strategy for the CEPC detectors. Decisions on architecture may have strong effects on the design of sub-detector electronics, and one or more clear options for triggering need to be rapidly established. The feasibility of operation in ‘triggerless mode’ should also be evaluated.

- There are a number of overlapping proposals for calorimetry, with a wide range of cost and performance. A clear set of requirements and a path to a baseline design choice need to be established.

- Global detector studies will require, at a minimum, a coherent and flexible fast simulation tool, capable of supporting parallel studies of several evolving integrated detector concepts. This should continue to be a priority in experiment software development, though it is also important to begin the process of designing the experiment data model and base software framework. It is likely that software tools are on the critical path for detector design.

Findings

- The CEPC software suite builds upon common tools used for studies of several different machines. The strategy to continue co-development of common tools with other experiments is correct, and divergence between projects should be avoided in view of the limited available effort.

- The machine-detector interface and LumiCAL are complex and challenging aspects of the overall detector design. Close cooperation between accelerator and detector teams must be reinforced and maintained.

- In general, the process of transition from generic R&D to concrete optimised CEPC detector designs is not yet fully mapped out. Adherence to an aggressive overall project plan will require this process to be understood in the coming year, and for a clear strategy for optimisation and technology selection criteria to be defined well in advance of the collaboration-building stage.

- A wide-ranging R&D programme should be maintained for the time being, though with the recognition that not all concepts under development will be mature on the time scale dictated by the overall CEPC schedule.

Highlights for discussion at IDRC Meeting

Machine Detector Interface *5'*
Speaker: Dr. Hongbo ZHU (IHEP)
Material: **Slides**

Luminometer *5'*
Speaker: Suen Hou (高能所)
Material: **Slides**

Silicon vertex detector *5'*
Speakers: Prof. Qun OUYANG (IHEP), Prof. Zhijun Liang (IHEP)
Material: **Slides**

Silicon tracker *5'*
Speakers: Prof. Meng Wang (Shandong University), Dr. Hongbo ZHU (IHEP)
Material: **Slides**

Time Projection Chamber *5'*
Speaker: Dr. Huirong Qi (Institute of High Energy Physics, CAS)
Material: **Slides**

Drift Chamber *5'*
Speakers: Franco Grancagnolo, Franco Bedeschi (INFN-Pisa)
Material: **Slides**

Electromagnetic Calorimetry *5'*
Speakers: Dr. Yong Liu (Institute of High Energy Physics), Dr. Jianbei Liu (University of Science and Technology of China)
Material: **Slides**

Hadronic Calorimetry *5'*
Speakers: Haijun Yang (Shanghai Jiao Tong University), Dr. Jianbei Liu (University of Science and Technology of China)
Material: **Slides**

Dual Readout Calorimeter *5'*
Speakers: Dr. gabriella gaudio (INFN-PV), Franco Bedeschi (INFN-Pisa), Prof. Sehwook Lee (Kyungpook National University)
Material: **Slides**

Solenoid Magnet *5'*
Speaker: Dr. Feipeng NING (IHEP)
Material: **Slides**

Muon detector *5'*
Speaker: Paolo Giacomelli (INFN-Bo)
Material: **Slides**

Software *5'*
Speaker: Dr. Weidong Li (高能所)
Material: **Slides**

Trigger and DAQ *5'*
Speakers: Mr. Jingzhou ZHAO Jingzhou (高能所), Prof. Zhen An LIU Zhenan (IHEP)
Material: **Slides**

https://indico.ihep.ac.cn/event/10941/