

# Pixel Vertex Detector Prototype MOST 2018-2023 (MOST2)

## Introduction

项目负责人: João Guimarães da Costa

Project Overview Meeting

28 November 2019



中国科学院高能物理研究所

*Institute of High Energy Physics  
Chinese Academy of Sciences*



# Major Project Milestones:

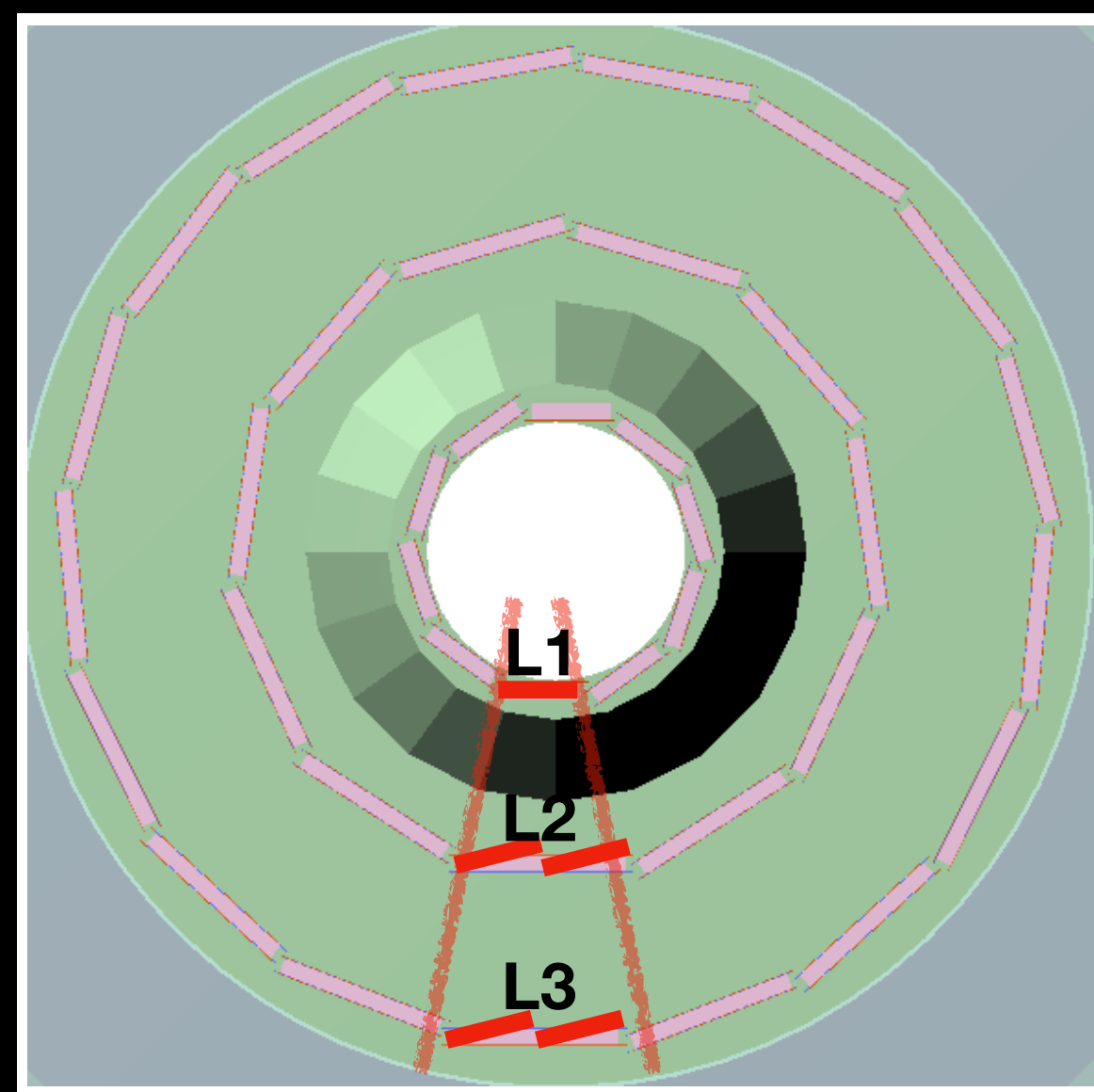
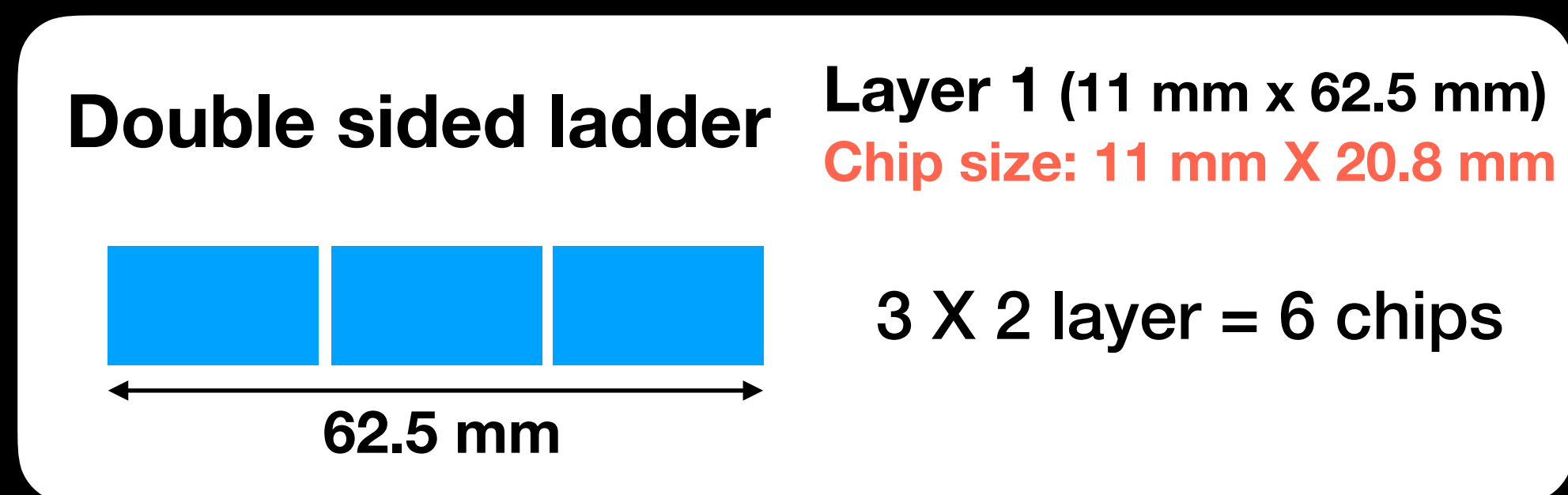
- Official starting date: May 1, 2018
- Official kick-off meeting: November 28, 2018
- Pixel Vertex Meeting, Hong Kong, Jan 16, 2019
- Pixel Vertex Meeting, Oxford, April 17, 2019
- First Annual Meeting: April 29, 2019
- Pixel Project Overview Meeting, today, Nov 28, 2019
  - Prepare for midterm review
  - Need to submit annual report in two weeks (Dec 11)
    - First year (2018/2019) annual technical progress report of the project is overdue. Needs to be submitted NOW.
- Midterm review: April 2020
- Final report: April 2023

# Goals for today:

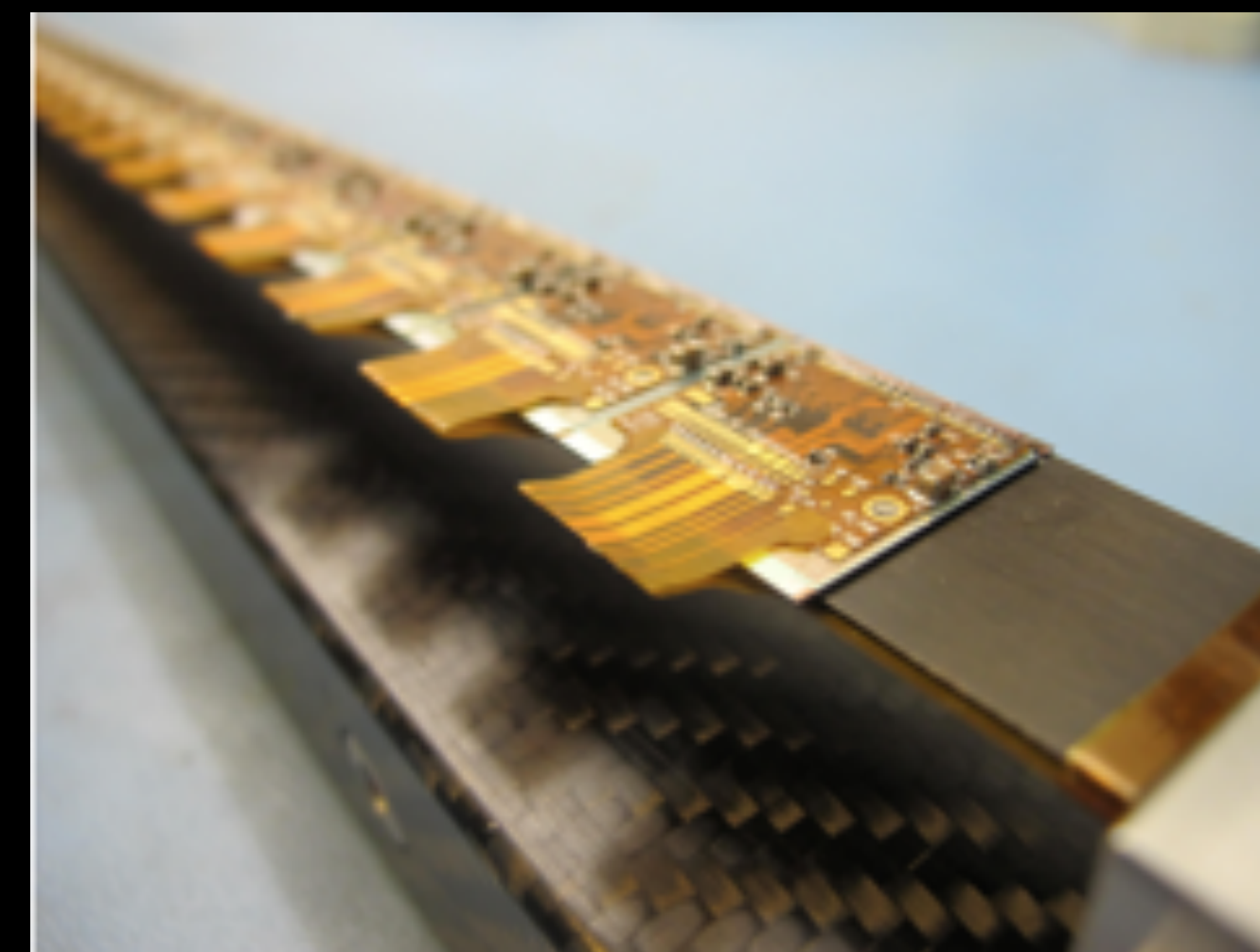
- Learn about the progress from different areas
- Identify areas that need accelerated progress
- Identify lack of required resources
- Discuss common issues — interface between the different tasks
  - Any failing piece can affect the success of all project
- Evaluate budget situation
- Plan for publications
- Explore possible interesting extensions
- Consider international collaborations

# Task 2: Research Goal

- **Produce a world class vertex detector prototype**
  - Spatial resolution 3~5  $\mu\text{m}$  (pixel detector)
  - Radiation hard ( $>1$  MRad)
- **Preliminary design of prototype**
  - Three layer, module  $\sim 1\text{ cm} \times 6\text{--}12\text{ cm}^2$



Typical module



Resolution

ATLAS/CMS upgrade  
(15  $\mu\text{m}$ )

Alice upgrade  
(8~10  $\mu\text{m}$ )

This project (3~5  $\mu\text{m}$ )

- Develop full size CMOS sensor for use in real size prototype

# Task 2: Technical route and schedule

Use CMOS image sensor technology

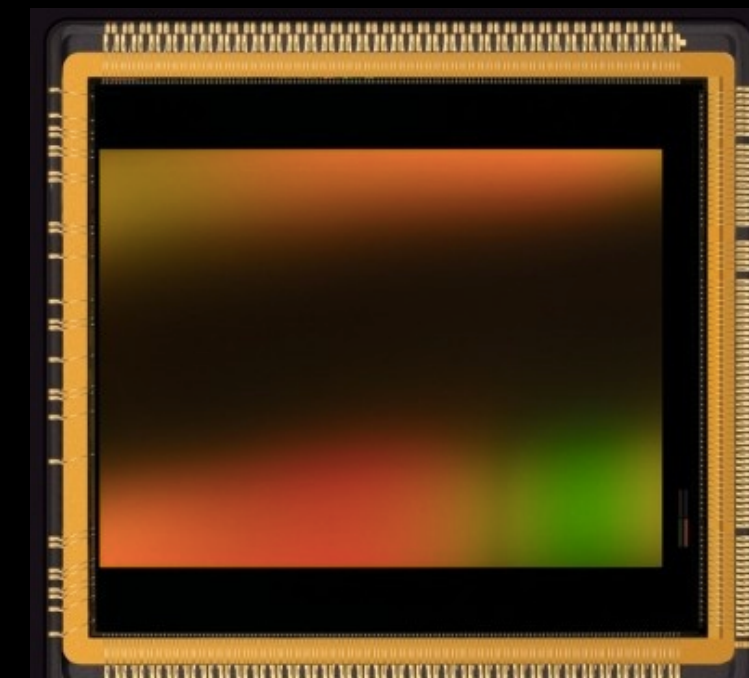
Optimize pixel circuitry, reduce size

Special design and latest technology

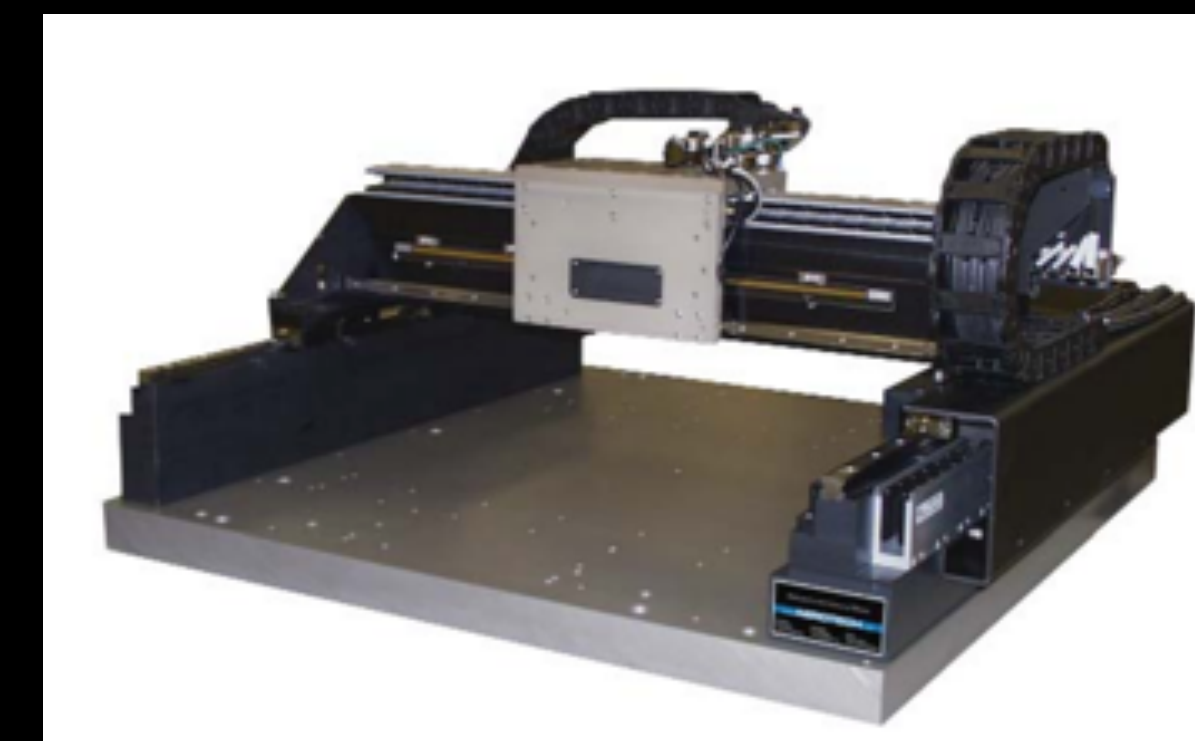
High resolution

Radiation hard

CMOS imaging sensor



Gantry



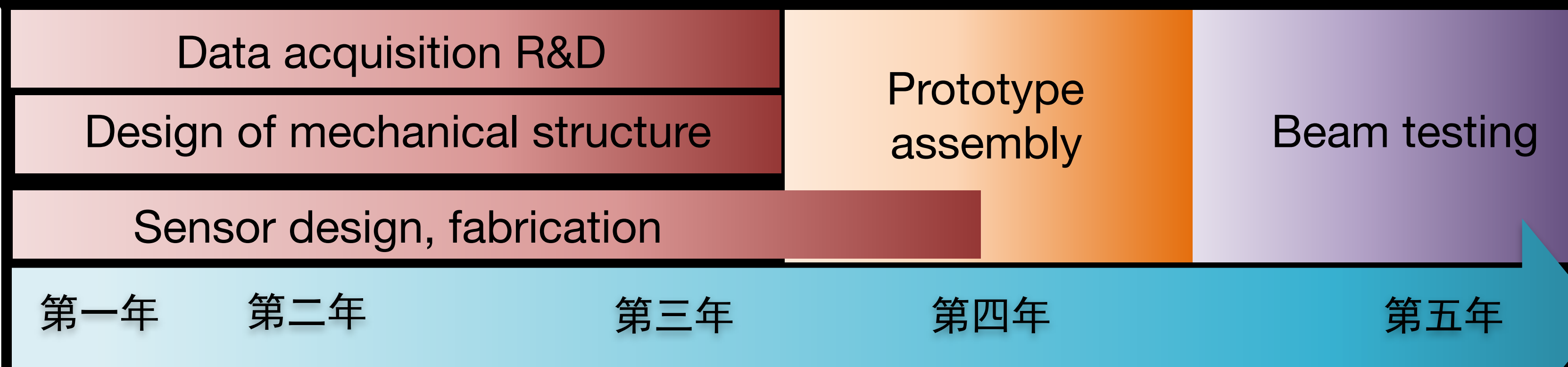
Use carbon fiber, polyamide, graphene, and other light materials for mechanical structure

Low mass

Robot automatic mechanical assembly

High accuracy

项目启动



项目结题

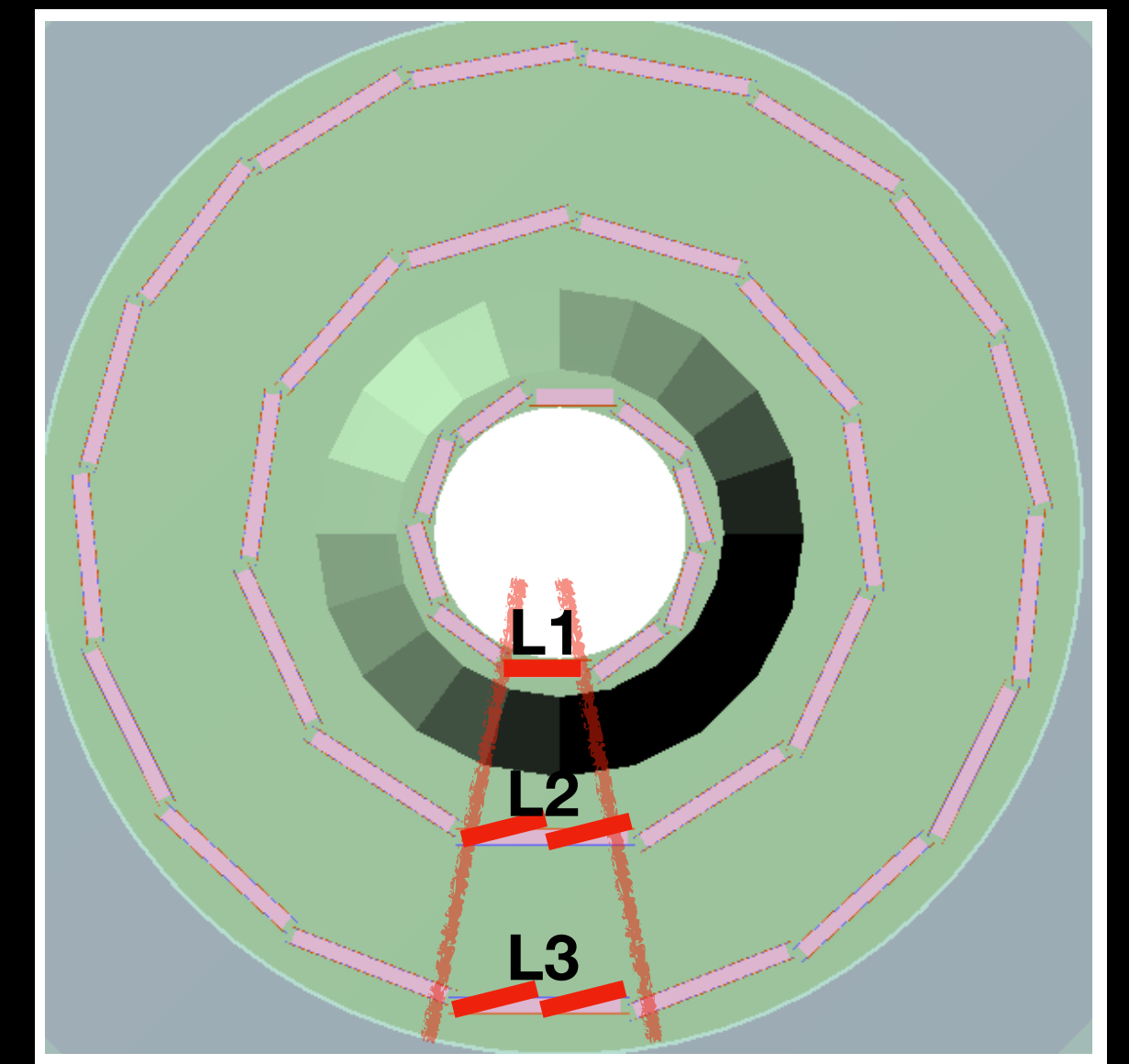
# Baseline MOST2 Project and Extensions

- **Baseline**

- Large CMOS chip
- Three layers “loosely defined”
- Tested on test beam

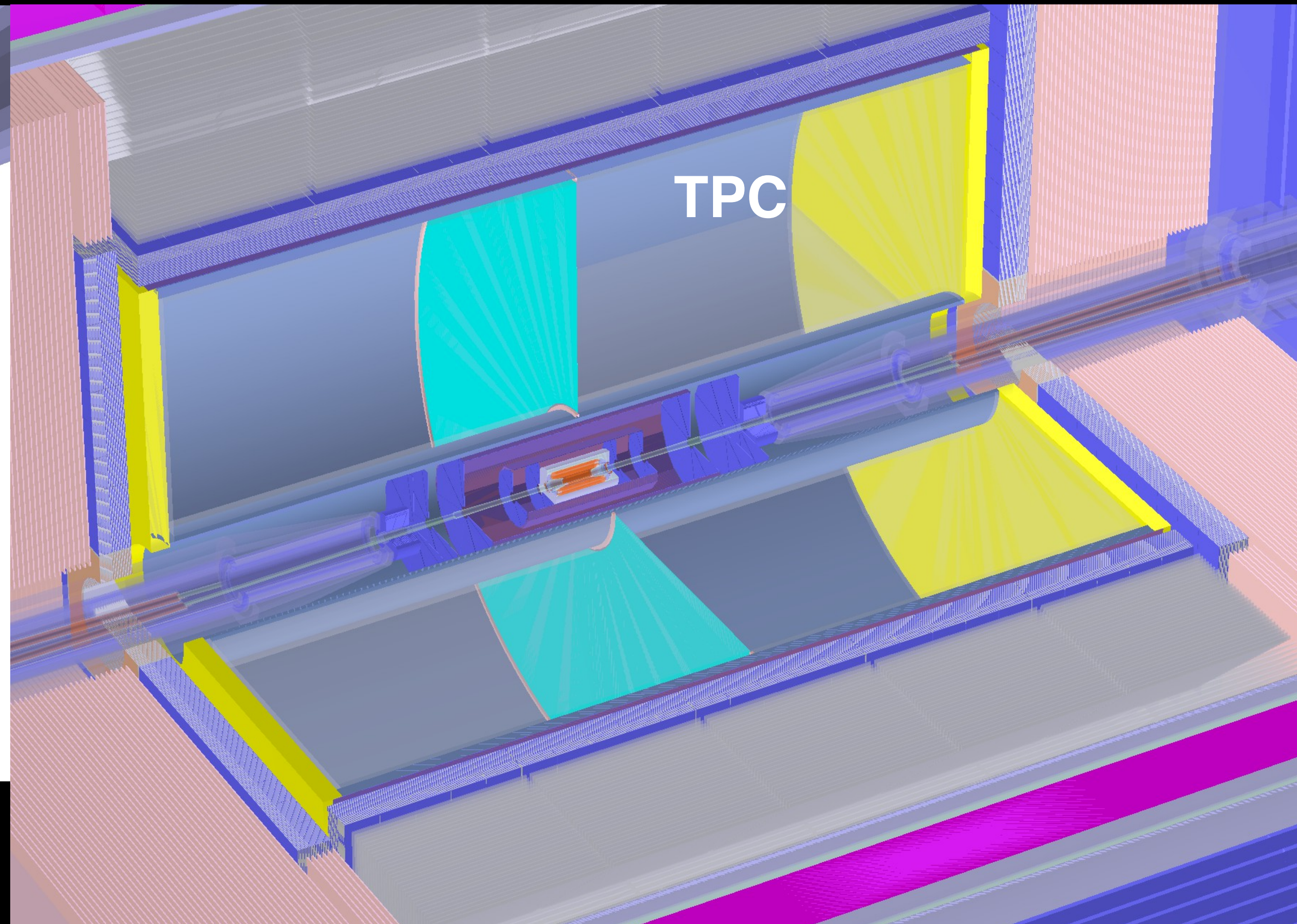
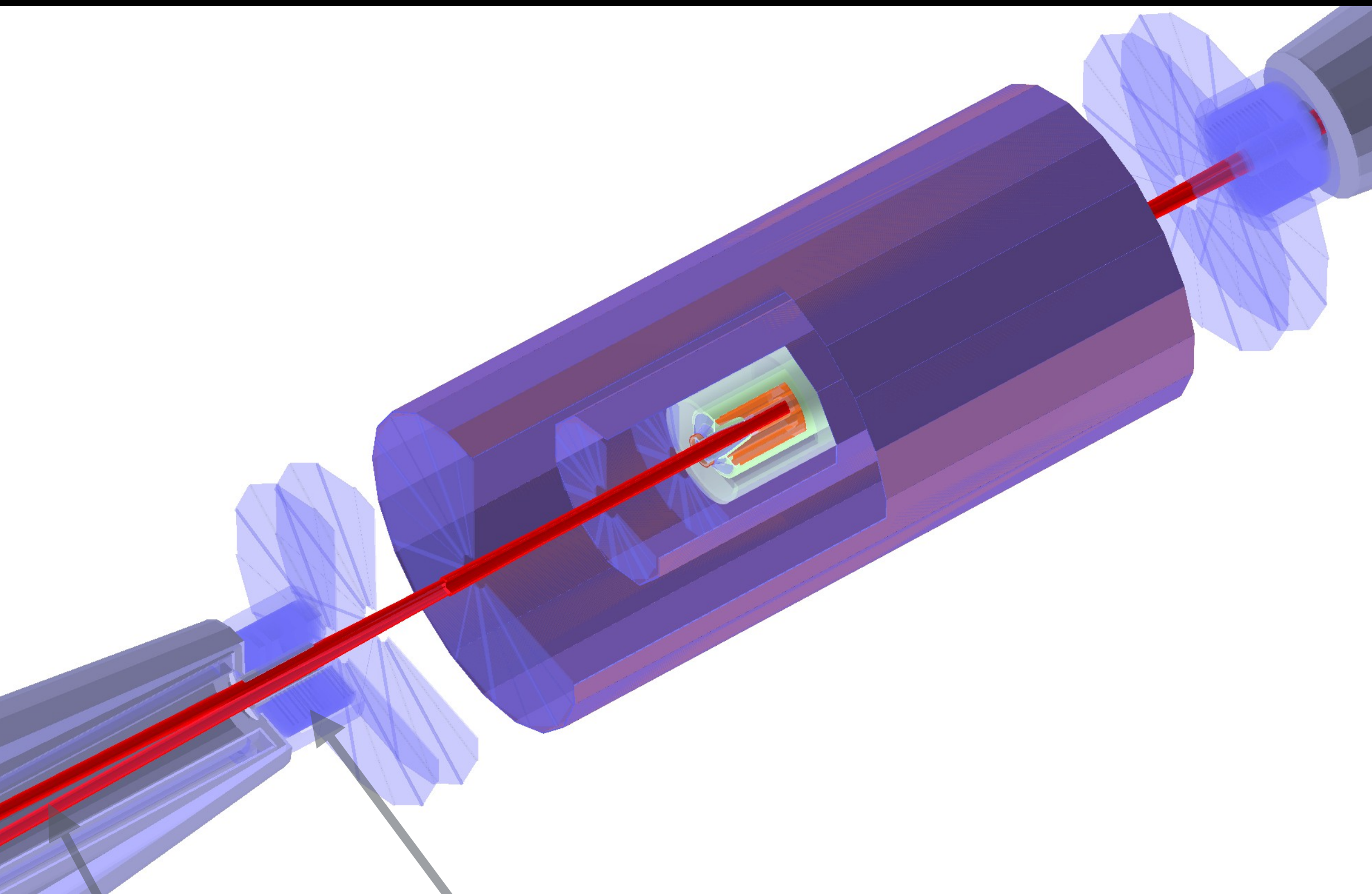
- **Extensions**

- **Highly desirable:** Full size mechanical prototype
  - Think about new pixel detector layout, cable routing, cooling, readout electronics integration, detector installation and mounting
- **Highly desirable:** Extended specifications for chip (closer to final requirements)
- Explore different sensor technologies/vendors (HV-CMOS/HR-CMOS)
- Investigate active/advance cooling methods
- Extend prototype to include forward pixel disks



**Requires new people**

# CEPC CDR baseline conceptual detector



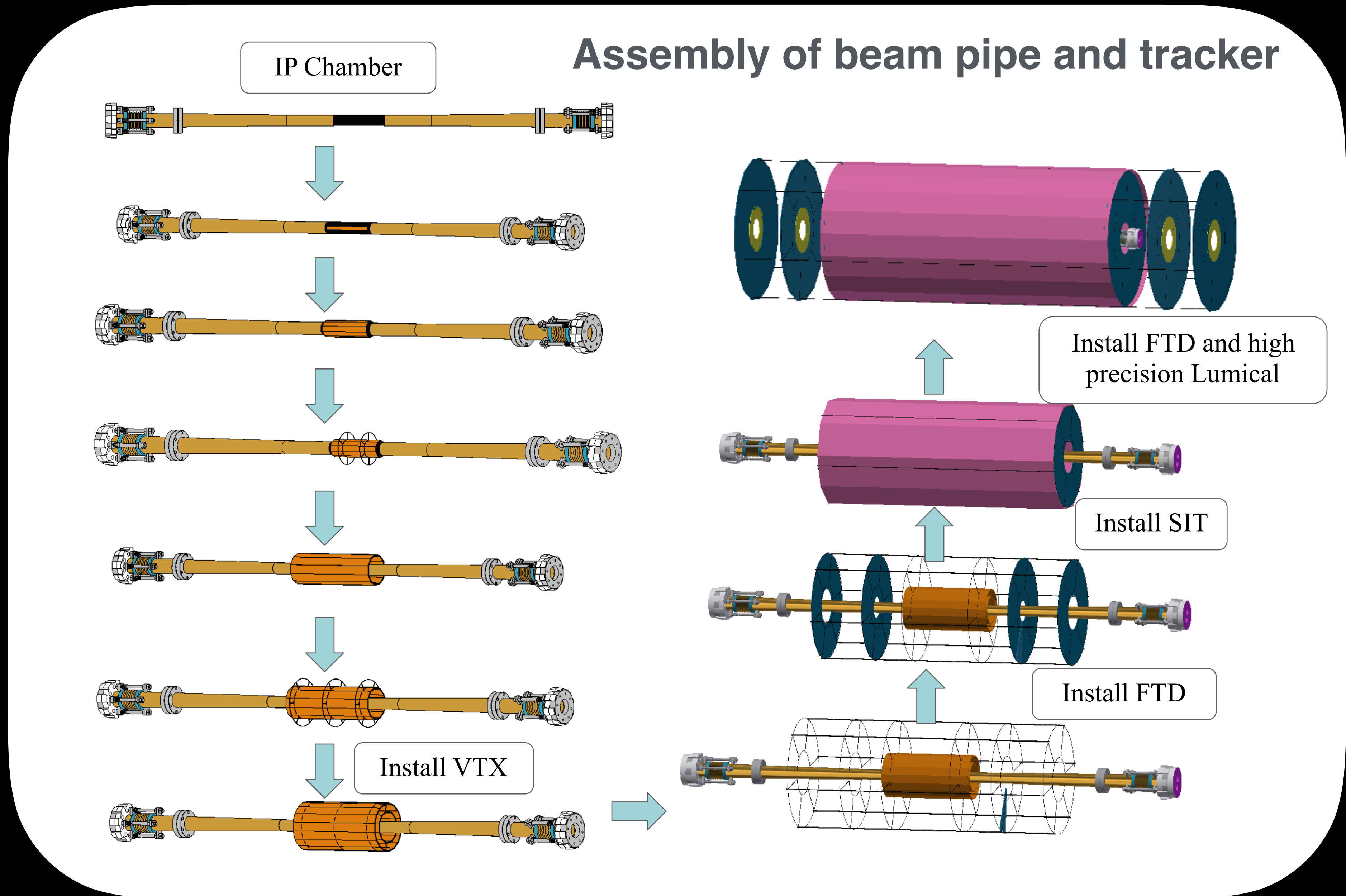
**MDI**      **Lumical**  
**Beam pipes**       $L^* = 2.2 \text{ m}$   
                         **Cross angle = 33 mrad**

# MDI Assembly and Installation

Engineering studies started

Different scenarios under study

Needs close collaboration between detector designers and MDI engineers





# International Collaboration

- **Barcelona**
  - Participating in the design of the CMOS sensor/chip
  - Help with submission to TowerJazz
- Jinyu visited **Oxford** and **Liverpool**
  - Learnt about several issues regarding pixel detector mechanical design
  - **Liverpool**
    - Interested in contributing to services and mechanical design
  - **Oxford**
    - Still interested in mechanical design
    - Kewei to visit them soon to learn about operating Gantry
    - Can make sensor studies at DIAMOND (photon source) facility
- **UMass**
  - Interested in investigation of cooling needs, R&D on cooling aspects
- **Italians** from ARCADIA/AIDA++
  - Readout electronics and DAQ
  - Discussion of possible collaboration with LFoundry

# 第一年 (2018.5–2019.4)

## Main Milestones

- Task 2:
  - Preliminary designs of mechanics, readout electronics and ASIC
  - First ASIC MPW submitted

Outcome: Annual Report

# 第二年 (2019.5–2020.4)

- Task 2:
  - Engineering designs of mechanics structure
  - Second ASIC MPW submitted

Outcome: Mid-term Report

# What we really promised by 第二年 (2019.5-2020.4) ?

细化硅径迹探测器整体支撑结构设计，绘制该结构的工程图，开始加工模块的结构；对第一次MPW的传感器芯片做测试以验证其功能，其中包括初步小剂量的辐照测试；完成传感器芯片的像素阵列与外围读出电路等功能模块之间的集成，并进行第二次多项目晶圆(MPW)流片加工；开始设计探测器单元模块的读出电子学与数据获取系统

Refine the overall support structure design of the silicon track detector, draw the engineering drawing of the structure, and start to process the structure of the module;

Test the sensor chip of the first MPW to verify its function, including the preliminary low dose irradiation test; complete the integration between the pixel array of the sensor chip and the peripheral readout circuit and other functional modules, and carry out the second multi project wafer (MPW) wafer processing;

Start to design readout electronics and data acquisition system of detector unit module

# Assessment index: 第二年 (2019.5-2020.4)

完成硅径迹探测器模块结构的初步设计报告;

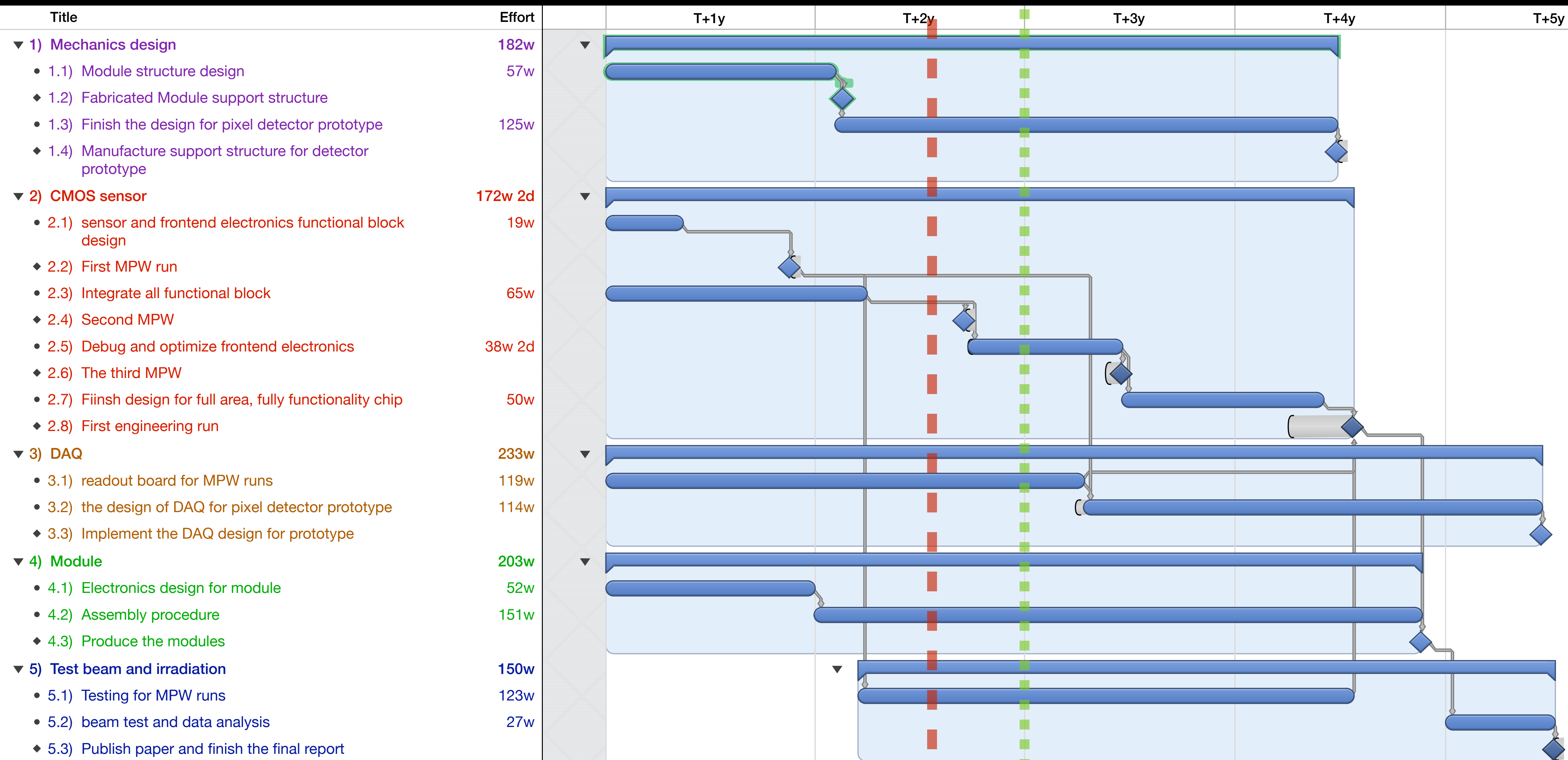
完成硅径迹探测器中传感器芯片各个主要功能模块(传感器像素单元与芯片外围读出模块等)的初步设计,并完成第一次传感器流片的设计报告

Complete the **preliminary design report** of the module structure of the silicon track detector;

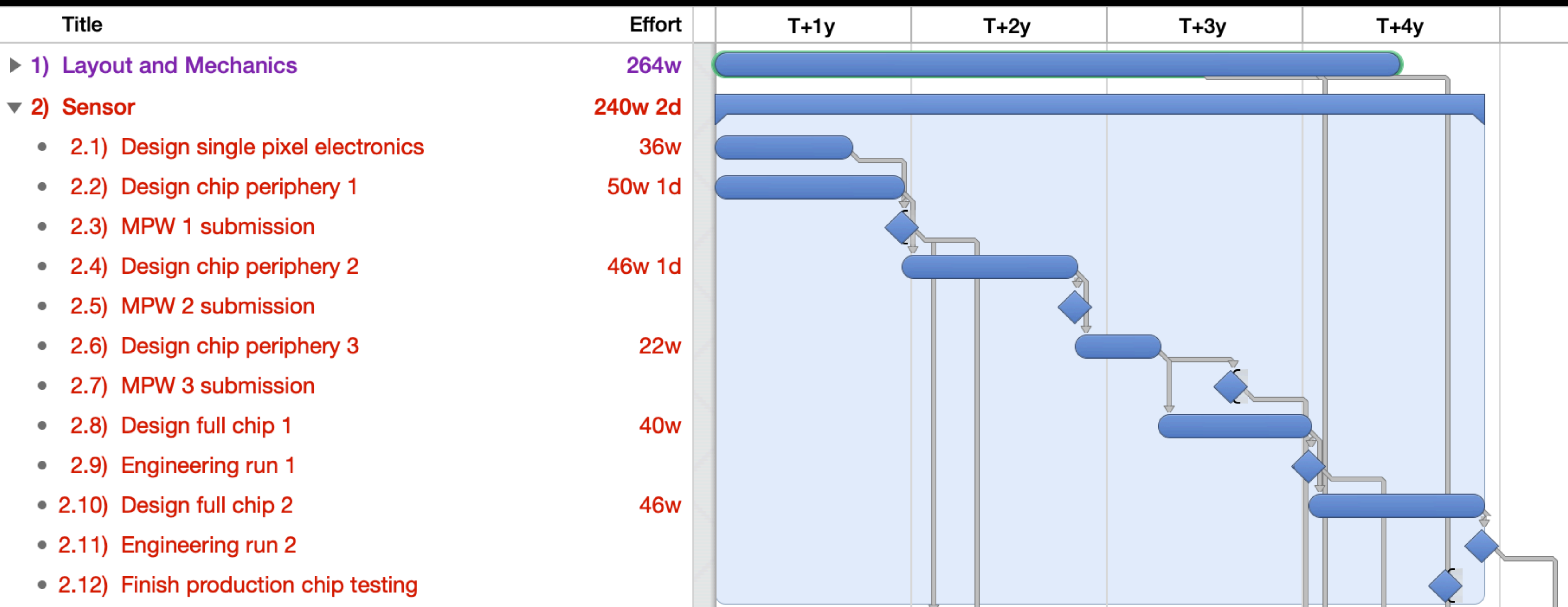
Complete the **preliminary design** of the main functional modules of the sensor chip in the silicon track detector (sensor pixel unit and peripheral readout module of the chip, etc.), and complete the **design report** of the first sensor chip

**Interim technical progress report of the project**

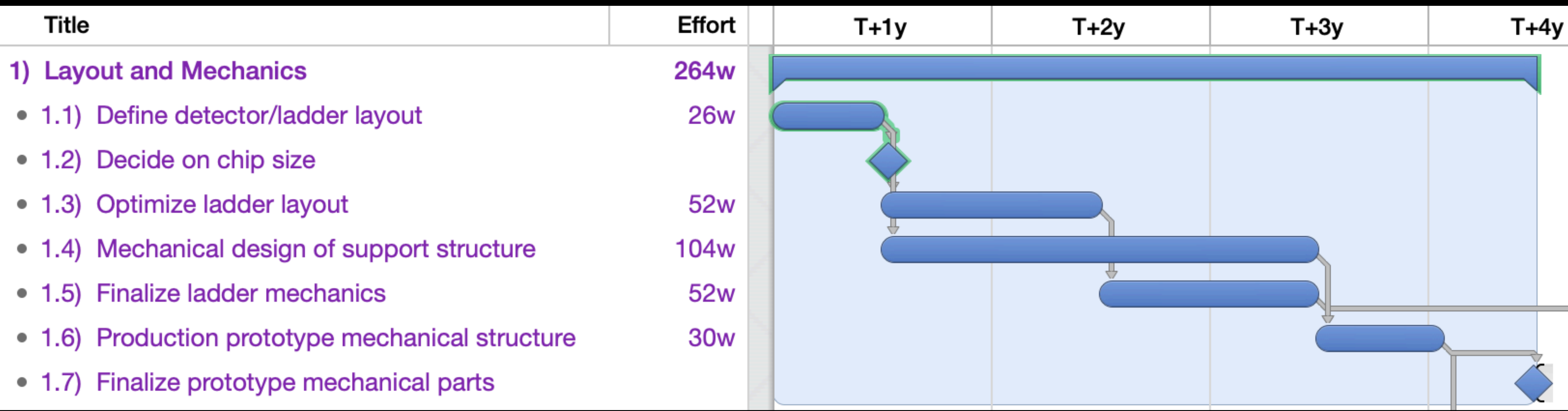
# MOST2 Project Schedule



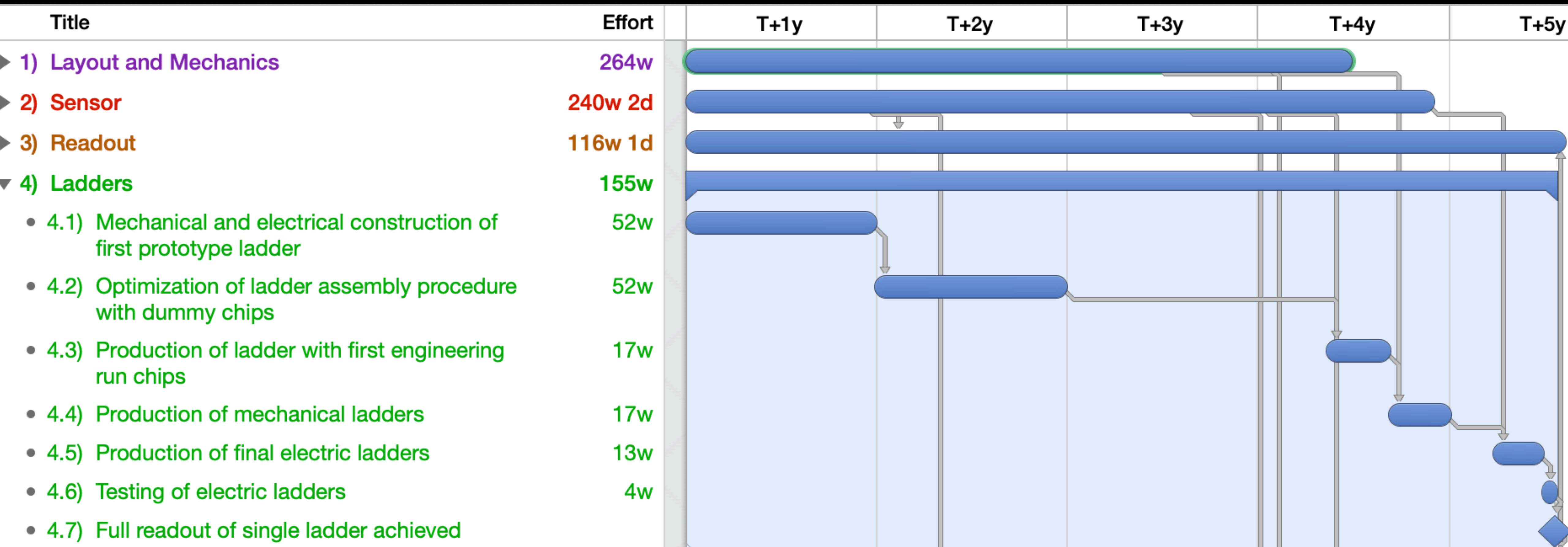
# Schedule: Sensor



# Schedule: Layout and Mechanics

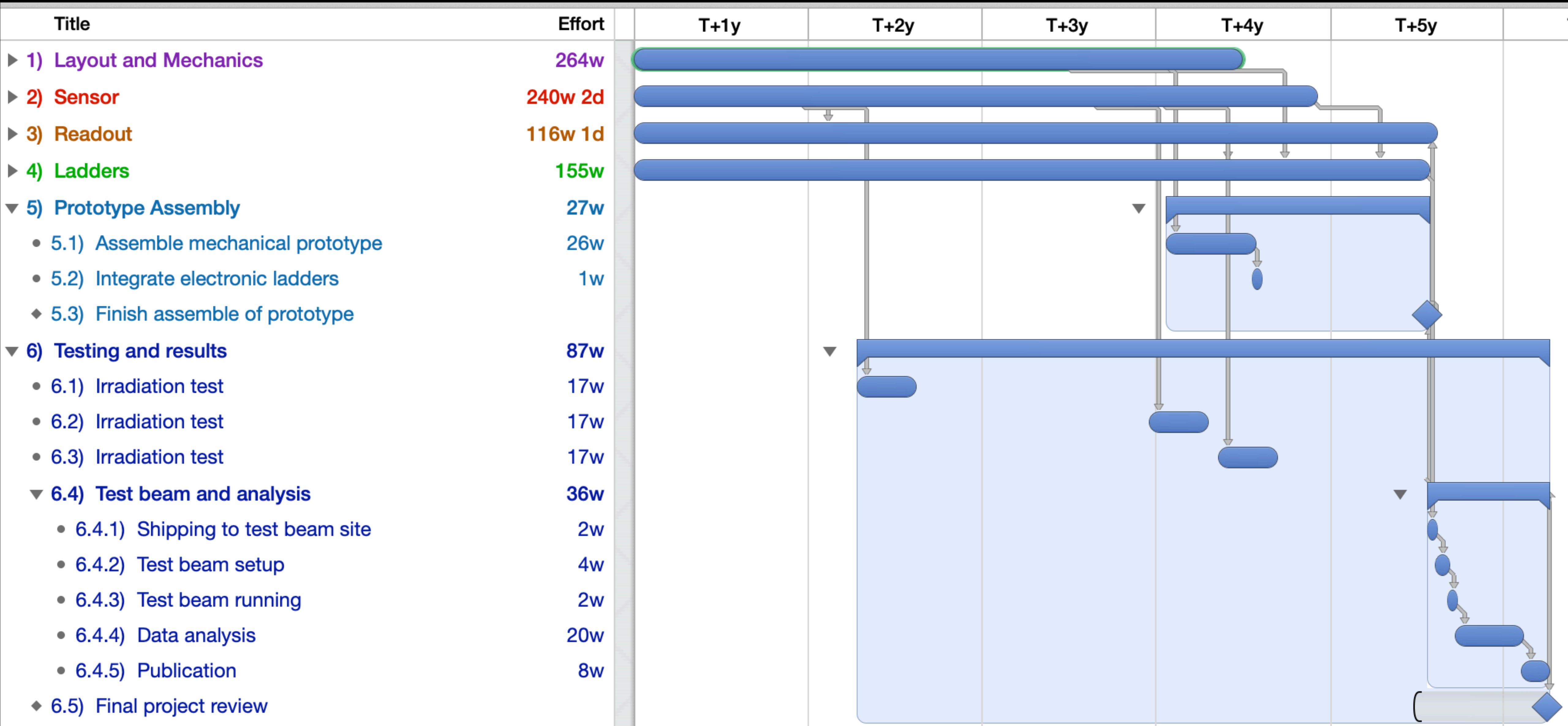


# Schedule: Ladders





# Schedule: Prototype Construction and Testing



# Achievement Presentation and Assessment Methods



## Assessment method and means of evaluation:

- Peer expert review
- **Beam test** and offline analysis; report to be included in final report (2)

- Peer expert review
- Provide sensor **design** and **test** report for expert evaluation

研制出硅径迹探测器原型机 <b>Silicon Detector</b>	<input type="checkbox"/> 新理论 <input type="checkbox"/> 新原理 <input type="checkbox"/> 新产品 <input type="checkbox"/> 新技术 <input type="checkbox"/> 新方法 <input type="checkbox"/> 关键部件 <input type="checkbox"/> 数据库 <input type="checkbox"/> 软件 <input type="checkbox"/> 应用解决方案 <input checked="" type="checkbox"/> 实验装置/系统 <input type="checkbox"/> 工程工艺 <input type="checkbox"/> 标准 <input type="checkbox"/> 专利 <input checked="" type="checkbox"/> 论文 <input type="checkbox"/> 其他	课题 2: 硅径迹探测器关键技术验证	硅径迹探测器原型机的空间分辨率	无	研制出小型传感器芯片, 像素单元尺寸小于或等于 25 微米 × 25 微米。	3-5 微米	同行专家评审。(通过束流实验, 离线分析数据获得空间分辨率。该测试结果写入原型机设计与测试报告, 以供同行专家评审)
			所设计的抗辐照硅传感器能承受的总剂量	无	完成传感器的初步设计, 通过仿真初步验证其抗辐照性能	1 MRad	同行专家评审(提供传感器的设计与测试报告供专家评审)

(2) Final report: "CEPC Detectors Test Report"

09:00 - 09:30	Introduction 30' Speaker: Joao Guimaraes Costa	▼
09:30 - 09:50	Project budget situation and issues 20' Speaker: ZHANG Zhaoru	▼
10:00 - 10:45	Status and plan of the TaichuPix1 chip design and testing for high-rate CEPC Vertex Detector in MOST2 45' Speaker: Mr. Wei WEI (高能所) Material: <a href="#">Slides</a> 	▼
10:45 - 11:05	Break	
11:05 - 11:20	Status of CEPC MOST-2 R&D in NJU 15' Speaker: Prof. MING QI (nanjing university)	▼
11:20 - 12:00	Planning for Irradiation and Test Beams 40' Speakers: Prof. Zhijun Liang (IHEP), Prof. MING QI (nanjing university)	▼
12:00 - 13:00	Lunch Box	
14:00 - 14:20	Vertex CDR Optimization and Updates 20' Speaker: 志岗 吴 (高能所) Material: <a href="#">Slides</a> 	▼
14:20 - 14:40	Vertex Prototype Layout and Optimization 20' Speaker: Hao Zeng (IHEP)	▼
14:40 - 15:00	Criteria for Physics Optimization 20' Speaker: Dr. Gang LI (EPD, IHEP, CAS)	▼
15:00 - 15:20	Break	
15:20 - 15:50	Prototype Mechanical Design and CEPC Vertex Mounting 30' Speaker: Jinyu (高能所)	▼
15:50 - 16:10	BES prototype and ladder design 20' Speaker: Dr. Mingyi Dong (IHEP)	▼
16:10 - 16:25	MOST2 Module Assembly Gantry 15' Speaker: 吴科伟	▼
16:25 - 16:40	Temperature and Cooling 15' Speaker: Jinyu (高能所)	▼
16:40 - 16:55	DAQ Plans 15' Speaker: Hongyu ZHANG (EPC, IHEP, CAS, China)	▼

# Extra Slides

# 第三年 (2020.5-2021.4)

## Main Milestones

- Task 1:
  - Small prototype of magnet fully tested
  - Design of magnet complete
  - Processing of the vacuum tube, the coating experiment device and the shielding bellows are completed
- Task 2:
  - Mechanical structure completed
  - Second ASIC MPW tested
  - ASIC design optimized and completed
- Task 3:
  - Batch production of readout electronics, development of data acquisition system
  - Development of beam test platform and cosmic ray test platform

## Outcome

- Annual report

# 第四年 (2021.5–2022.4)

## Main Milestones

- Task 1:
  - Completed the formal prototype of the dipole magnet and measurement system
  - Prototypes of vacuum tube and RF bellows completed
  - High pressure experiment was carried out on the electrostatic separator
- Task 2:
  - Silicon wafer processing of large area sensor submitted
  - Assembling and installing the prototype
- Task 3:
  - Integrated calorimeter prototype.
  - Carry out the cosmic ray test of the prototype

## Outcome

- Annual report

# 第五年 (2022.5-2023.4)

## Main Milestones

- Task 1:
  - Complete the performance test of dipole prototype
  - Complete tests of prototypes of vacuum tube, RF bellows and electrostatic separator
  - High pressure experiment was carried out on the electrostatic separator
- Task 2:
  - Test beam and data analysis
  - Finish assembling of prototype
- Task 3:
  - Test beam and data analysis
  - Finish assembling of prototype

## Outcome

- Final report, paper and experimental equipment