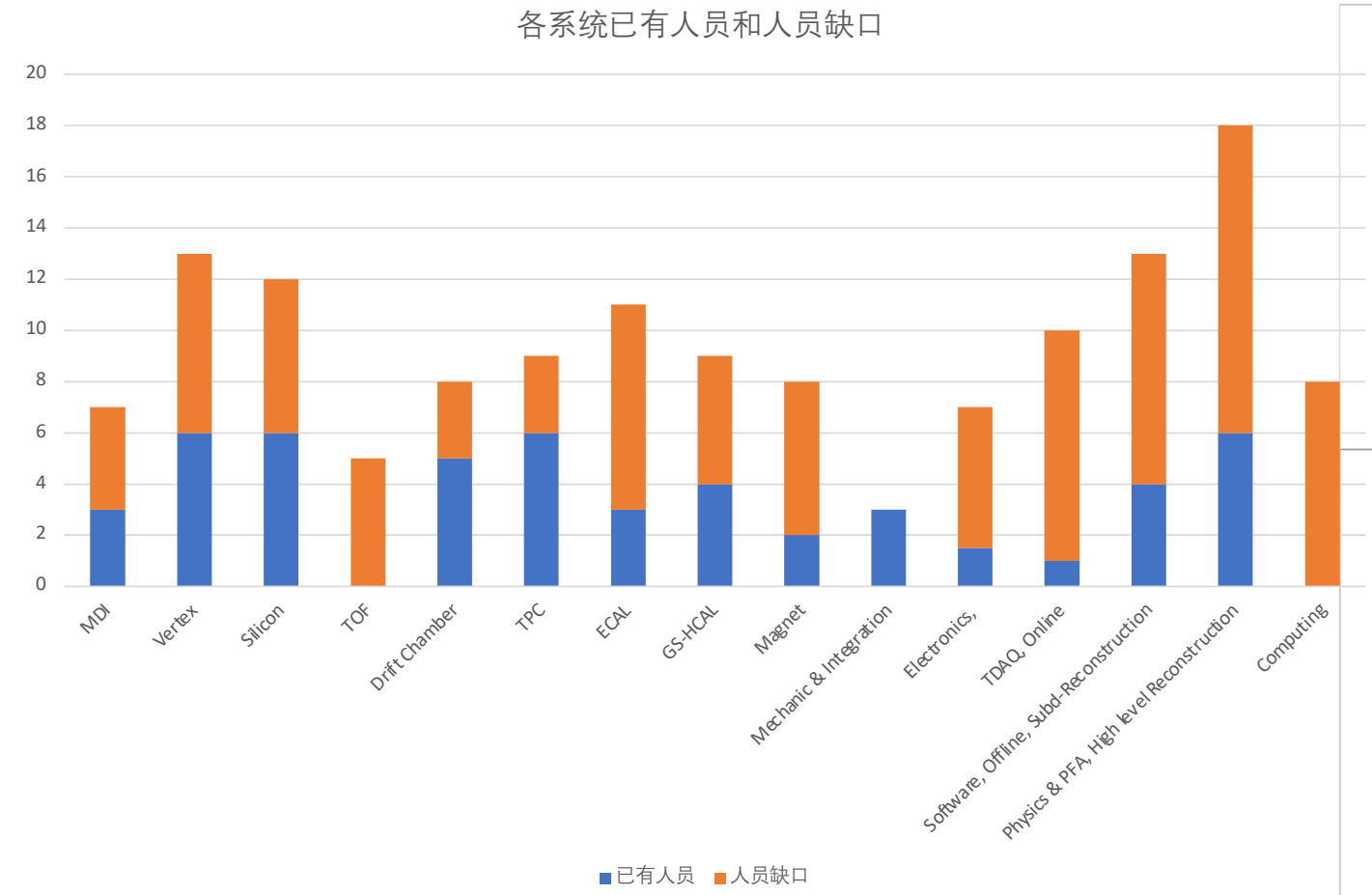
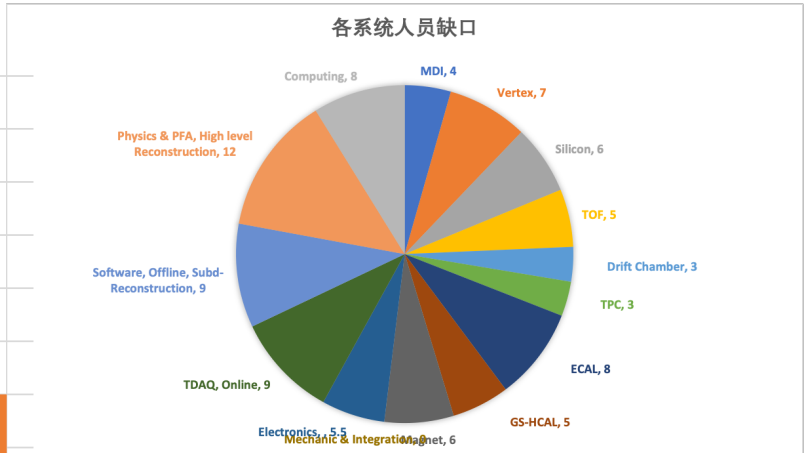
Junior Manpower Investigation Towards Ref. Det. TDR

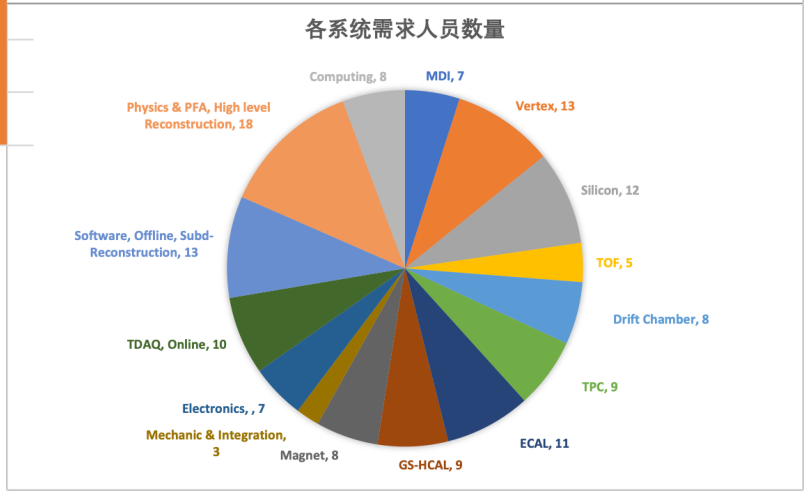
Postdoc/Student Manpower Requirements & Training towards Reference Detector TDR study

	Contacts	Available/Needed (PostDoc, Student)	Comments
MDI	Haoyu Shi	(0, 3)/(4, 3)	
Vertex	Zhijun Liang	(2, 4)/(5, 8)	(3,6) in 2024, (5, 8) for longer term
Silicon	Xin Shi, Yiming Li	(1, 5)/(5, 7)	
TOF	Zhijun Liang, Yong Liu	(0, 0)/(2, 3)	
Gaseous Tracker	Mingyi Dong, Huirong Qi, Linghui Wu, Guang Zhao, Gang Li		
Drift Chamber	Guang Zhao	(0, 5)/(2, 6)	
TPC	Huirong Qi	(0, 6)/(2, 7)	
Calorimeter	Yong Liu, Sen Qian		
ECAL	Yong Liu	(1, 2)/(3, 8)	
GS-HCAL	Sen Qian	(1, 3)/(1, 8)	Manpower partly available at GS collaboration
Magnet	Feipeng Ning	(0, 2)/(2, 6)	In badly need of Ph.D Students; (1,3) in 2024, (2,6) in 2025
Mechanic & Integration	Quan Ji	(0, 3)/(? ?)	Be addressed by collaboration – need funding support
Electronics,	Wei Wei	(0, 1.5)/(2, 5) or (10, 30)	Relies more on Staffs. 方案设计 > Chip Design Need dedicated Workshops & discussion with Sub-Det.
TDAQ, Online	Fei Li	(0, 1)/(3, 7)	
Software, Offline, Subd-Reconstruction	Weidong Li, Shensen Sun, Gang Li, Ziyan Deng	(1, 3)/(4, 9)	
Physics & PFA, High level Reconstruction	Manqi	(2, 4)/(8, 10)	(4,7) in 2024, (8, 10) in 2025
Computing	Xiaowei Jiang, Xiaomei Zhang	(0, 0)/(4, 4)	
Total		**(8, 44) /(46, 88)**	

Total Statistics







Observation

- In total: need ~ 40 PostDocs + ~ 45 Students in 2 years.

- Electronic: need to specify scenario:
  - 1: 7 staff + 7 Junior (PostDoc/Student)
  - 2: 16 staff + 40 Junior

- Requirements might be slightly reduced:
  - Exist minor synergies between different task
  - Collaboration: international & Universities

- Need top-down design of the Ref Det. TDR content – define critical tasks for each sub-system, and arrange manpower accordingly.

- Similar requirements on training, shall be organized collectively & twice a year:
  - software, simulation, sensor testing, test beam preparation, etc

Key Objectives

- For each sub-detector: need to address the integration
  - Power – cooling
  - DAQ - on line: rates: Signal, Intrinsic Noise, Radiation induced(MIP/Dose)
  - Material budget, especially for Tracker & VTX
  - Mechanics

- Quantify intrinsic sub-D performance and optimize the configuration (with cost estimation)

- Overall design, especially Calorimetry: BMR (Total PFA) ~ 3% & jet origin id performance (need excellent Pid & VTX)
  - Feasibility study of Glass ECAL

- Electronic & TDAQ: conceptual design towards **Triggerless Equivalent**

- Magnet: HT-Coil, saving ~ o(MW) power consumption ~ o(一亿) CNY Electricity Bill (In badly need of Manpower)

- *Synergies & Spinoff?*

Electronics for Ref-TDR R&D

- Scenario-1：General overall electronics scheme + sub-det electronics to the spec + limited key R&D in 2024 (7 staff + 7 stud)
  - Global electronics scheme with reasonable feasibility (1.5 Staff)
  - General system interface: powering, clocking, data link with reasonable feasibility (1 Staff +1 stud)
  - Sub-det electronics with specification and general readout scheme:
    - Staff 4.5 : Vertex 1 + Tracker 2.5 (silicon 1 + DC 1 + TPC 0.5@thu) +Cal 1
      - Mainly on scheme design and feasibility consideration
      - Other sub-dets elec (Muon+Lumi) are supposed to be fully covered by other univertisities.
    - Postdoc + stud 4: system evaluation for the main detectors (2) + ASIC test & performance evaluation (2)
  - Key R&D (2 stud):
    - Wireless communication & clocking (1)
    - Advanced algorithm on data compression & on-detector L1 trigger (1)
- Scenario-2: General overall electronics scheme + sub-det electronics to the detailed design + general R&D in 3~5 years (16 staff + 40 stud)
  - Global electronics scheme with preliminary proved feasibility (3 Staff + 2 stud)
  - General system interface: powering, clocking, data link with proved feasibility & evaluation (3 Staff +2 stud)
  - Sub-det electronics with detailed electronics design :
    - Staff 10 : Vertex 2 + Tracker 6 (silicon 2.5 + DC 2 + TPC 1.5@thu) +Cal 2
      - Other sub-dets elec (Muon+Lumi) are supposed to be fully covered by other univertisities.
      - Including ASIC R&D + backend readout electronics R&D
    - Postdoc + stud 8: system evaluation for the main dets (2) + ASIC design, test & performance evaluation (3) + backend electronics design (3)
  - Main R&D (12 postdoc + stud):
    - Wireless communication & clocking (2)
    - Advanced algorithm on data compression & on-detector L1 trigger (4)
    - Radiation effect test & study(2)
    - Advanced powering & cooling (2)
    - Generic backend electronics hardware development (2)
- Current available: 5.5 staff + 1.5 stud + 0 postdoc

MDI

- Topic/Objective & Manpower Requirements（3 ~ 4 postdoc，4 ~ 5 students in total）:
  - Objectives:
    - Clarify the Boundary configuration of Beam induced background
    - Collaborate with det, especially tracker & vtx, for their geometry configuration
    - Provide dedicated Beam Background simulation to quantify its impact on phy. Measurements.
    - Address machine protection & Luminometer
  - Beam Induced Backgrounds and Optimization of the IR Layout (2 postdoc, 3 students)
    - Full Simulation of the Impacts of BIB in IR, to estimate the impacts. To give the results in numbers, also the radiation map in the interaction region
    - Benchmark using existing machines like BEPCII or SuperKEKB
    - Optimization of the design of IR and other components like collimators
  - Fast luminosity measurement systems and detectors, deliver the specific deign for all 3 detecting schemes including diamond/SiC/LGAD. (2 postdocs, 2 students + university)
    - Design the fast luminosity measurement system, including the number/position of detectors and the requirements of the detectors.
    - Design the Diamond/SiC/LGAD detectors and readout/electronic systems based on different scenarios.
    - If possible, prototype and beam testing on the detectors/system.
  - LumiCal of the CEPC(Postdocs/students mainly from universities like NJU and JLU)
    - Design and simulate the lumical detector itself, and working together with mechanical/shielding people to make it work.
  - 0.5 FTE*2 beam monitor relevant design.
- Status + Plan of recruitment and training
  - Basic knowledge of MC/Simulation Tool/ Linux; Could be trained together with Software Group
  - Knowledge on Detector Simulation/Study/Testing; Could be trained together with Detector people

Vertex

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Objectives:
    - Quantify Geo. Configuration, especially the radiation tolerance, noise rate
    - Optimize its geometry w.r.t. Jet origin id
    - Integration: quantify power, cooling, mechanics, signal & noise rates
  - Reference TDR level study
    - Beam induced background level ,radiation level
      - Relevant radiation test (1 Student)
      - Background Influence on Tracking Performance, Occupancy and Pattern recognition (1 PostDoc, 1 Student)
    - Geometry Change (smaller beampipe) -> Phy + Geometry optimization : (1 PostDoc , 2 Student)
      - Endcap (tracking disk) need or not?
    - Long Ladder prototyping: (1 PostDoc , 1 Student)
    - High Data Rate in Z pole study – Bandwidth -> DAQ (1 PostDoc , 1 Student)
  - Longer term future
    - New Chip design, tesing and performance verification, Flexible PCB design and testing (1 PostDoc , 1 Student)
    - New round Prototype assembly and testing (1 PostDoc , 1 Student)
- Manpower
  - Requirement: 5 PostDocs , 8 Students
  - Address half of the needed manpower by 2024 (3 PostDoc , 6 Student): the rest by 2025.
  - Current available: 2 PostDocs , 4 Students .
- Needed Profile: physics , hardware experiences, software/reconstruction
- Planned training: Automatic assembly, Tracking reconstruction, sensor testing

Silicon tracker

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Objectives:
    - Quantify the physics impact on tracking (momentum, impact para, directions); PFA; Jet origin id; Optimize the intrinsic performance characteristics.
    - Integration: material, power & cooling, mechanics, signal & noise rates
  - CMOS design, verification and test: 2 + 4
  - DAQ and prototyping: 1 + 1
  - Layout optimization and performance: 0 + 1
  - Silicon Strip Outer Tracker: 2 + 1 已有 1.5 FTE （还需考虑train curve, 可认为实际有1 FTE）
    - Physics + Silicon Stirp Module + Sensor: 1 FTE
    - Electronics + ASICs: 1 FTE
    - Mechanical + Integration : 1 FTE

- Manpower
  - Requirement: 5 + 7
  - Current: 1 + 5

- Needed Profile: electronics, detector test, data analysis, detector design.

Drift Chamber

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Objectives:
    - Clarify the geometry design,
    - Quantify Performance (differential Pid & dP/P, etc),
    - Quantify Endcap material, total power & cooling scheme, mechanics
  - Detector overall design (mechanical structure, material, power consumption, beam background): 0 +1
  - Detector performance optimization (simulation): 1+1
  - Tracking simulation: 0+1
  - Reconstruction algorithm with ML: 0+1
  - Prototype experiment at IHEP: 1+1
  - Readout electronics design and test: 0+1
  - Test beam analysis: 0+1
  - Delphes physics study: 0+1
- Manpower
  - Requirement: 2 + 8.
  - Current available: 0 + 5.

- Needed Profile: simulation/reconstruction, hardware experiences, data analyses.
- Planned training: core software, simulation-reconstruction, cepc-sw, cepc phy. analyses

Tracker – TPC detector

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Objectives:
    - Quantify the ion distortion, develop. Correction methodologies
    - Develop dN/dx tech. using Pixelated readout
    - Optimize the tracker config. w.r.t. tracking & Pid
    - Deliver design that addresses integration issues (power, cooling, material, mechanics)
  - Pixel readout TPC prototype studies: 1 + 3
    - To study the electrons and ions in the prototype in 2024,
    - To develop the prototype and beam test at DESY (~ 2024 - 2026),
  - PID Simulation + reconstruction: 1 + 2
    - PID simulation/reconstruction
    - Performance & analyses using the optimization of the detector design
  - Electronic and commission testing: 0 + 2

- Manpower for TDR (Available)
  - Current available: 0 + 6. (Qi Huirong, Chang Xue, She Xin, Liwen Yu and Dengzhi, Liu Yue)
  - International collaboration: LCTPC collaboration, Peter Kluit, Jochen Kaminski, and DESY T20 beam station.

Time of flight

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Objectives:
    - Identify different Schemes of Pid: Calo based or dedicated ToF
    - Address integration issue (power, cooling, material, mechanics, data-noise-rate, DAQ)
    - Explore synergies with other sub-d, via dedicated reco. algo. development
  - Reference TDR level study
    - TOF detector design: Phy + Geometry optimization (1 Student)
    - Detector Module prototyping: (1 PostDoc , 1 Student)
    - Electronics (1 PostDoc, 1 Student)

- Manpower
  - Requirement: 2 PostDoc , 3 Student
  - Current manpower : no dedicated manpower

- Needed Profile: physics , hardware experiences, software/reconstruction
- Planned training: sensor testing , Electronics

ECAL

- Objective: Novel PFA oriented ECAL(HCAL) Design: BMR ~ 3%, EM resolution ~ 3%/sqrt(E), PFA compatible
- Feasibility study of Glass ECAL
- To validate/optimize design specs and understand limitations: 2 students, 1 postdoc (connection to hardware)
  - Lab/beam tests to fully characterize performance of calorimetry units and modules
  - Key parameters: dynamic range (SiPM, front-end electronics), noise level, energy linearity/resolution, timing resolution
  - Calibration schemes (SiPMs, crystal/glass): non-uniformity, radiation damage
  - Designs for calorimetry endcap regions
- To develop/update tools for performance studies: 2 students, 1 postdoc (connection to software/PFA)
  - Detector geometry description and updates, digitisation and validation
  - Reconstruction and PFA clustering studies
- Studies related to front-/back-end electronics: 2 students, 0.5 postdoc (connection to electronics/DAQ)
  - To refine and validate specs for the SiPM-readout ASIC
  - Trigger-less readout and data throughput
  - Power supplies and cabling
- System integration (mechanics): 2 students, 0.5 postdoc (connection to meachanics)
  - Support structure (tolerances, deformation/vibration) and cooling system
  - Module assembly and system integration scheme
- Person power needs in total: 3 postdocs, ~8 students

GS-HCAL

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Objectives:
    - To deliver and optimize a design that reaches BMR of 3%
    - To matured the GS technology: mass production of GS, control the quality (homogeneity), develop the coupling & SiPM scheme
  - The Simulation of the GS-HCAL: 1 Post Doctor + 1 Doctor
  - The Mechanical of the GS-HCAL: 1 Master
    - to produce the large size, high density and high light yield glass;
  - The Glass Scintillator: 2 Doctor + GS group (9)
    - to produce the large size, high density and high light yield glass;
  - The SiPM: 1 Doctor + 1 Master
    - to study the SiPM performance; the cost of the SiPM;
    - to study the coupling designs with the glass cell and the photon CE;
  - The Electronics: 1 Master
  - The Calibration algorithm: 1 Master
- Manpower
  - Requirement: 1 Post Doctor + 4 Doctor + 3 Matesr.
  - Current available: 1 Post Doctor + 2 Doctor + 1 Matesr (in Lab); 1 Post Doctor + 4 Doctor + 3 Matesr (in GS group);
- Needed Profile: software/reconstruction, data analyses, preferably with sub-d hardware experiences.
- Planned training: core software, simulation-reconstruction, cepc-sw, cepc phy. analyses

Magnet

- Objective:
  - Development of HT Coil, etc. (if the HT Coil uses half of the cooling power compared to LT… it saves ~ MW of power, equivalent to 24k * 365 * 10 ~ 0.8亿电费)
- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Magnetic design studies: 1 + 1
    - Design of the magnet in 2024,
    - Design optimization and improvement (~ 2024 - 2026),
  - Superconducting cable design and development: 0 + 2
    - Short Sample development/test
    - Full-size cable design and development/test
  - Design, machining and experiment of prototype coil: 0 + 2
  - Quench analysis and detection studies: 1+1
- Manpower
  - Requirement: 2 + 6: Address half of the needed manpower by 2024 (1 + 3): another half by 2025.
  - Current available: 0 + 2.
- Needed Profile: Finite element simulation, mechanical design, electro-magnetic experiences, electromagnetism, electrodynamics.
- Planned training: Ansys, Comsol, Matlab, Opera
- 需求：招生名额有限，帮忙招一两个博士

TDAQ

- Objectives: Deliver Conceptual design of **triggerless equivalents**. Collaborate with
  - Physics study: to quantify the requirements on Signal efficiency (signal purity > 90%)
  - Detector study: design & optimize the data stream

- Topics & Objectives + Manpower Requirements(PostDoc + students)
  - Background and trigger study(1+2)
  - Timing, Fast control, slow control and DAQ readout system structure design and prototype boards design(1+2)
  - DAQ software, online processing and software trigger(1+3)
- Needed profile: software/data analyses, electronic hardware design

Software, Offline & SubDet-Recon

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Objectives:
    - Develop & maintain the full simulation – reconstruction software chain for Ref. Det.
    - Co-develop low level reconstruction & digitization with Sub-D groups.
  - Participate in R&D of Key4hep: 1+1
  - Developments of full simulation, fast simulation and parametric simulation software: 1+2
  - Accurate pattern recognition algorithm for tracker: 1+2
  - PFA algorithm for long crystal bar ECAL: 1+2
  - PID software with combination of several sub-detectors: 0+2

- Manpower
  - Requirement: 4 + 9
  - Current available: 1 + 3.
  - Staff available: not enough

- Needed Profile: software/reconstruction, data analyses, preferably with sub-d hardware experiences.
- Planned training: core software, simulation-reconstruction, cepc-sw, cepc phy. analyses

Physics & PFA-Reco, etc

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Physics White Paper studies: 2 + 4
    - To deliver the EW/NP White paper in 2024,
    - To conduct QCD and Phase-II Flavor Physics Studies (~ 2024 - 2026),
  - Central Simulation + Core Performance/Physics Benchmarks: 2 + 2
    - Sample simulation/reconstruction
    - Core Performance & analyses iterate with Detector design
  - Detector global design & optimization: 2 + 2
  - PFA upgrade with AI: 2 + 2 (Reach BMR ~ 3%)
  - Jet origin id iterate with Detector optimization: 2 + 2

- Manpower
  - Requirement: 8 + 10: Address half of the needed manpower by 2024 (4 + 7): another half by 2025.
  - Current available: 2 + 4.

- Needed Profile: software/reconstruction, data analyses, preferably with sub-d hardware experiences.
- Planned training: core software, simulation-reconstruction, cepc-sw, cepc phy. analyses

Computing

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - Computing platform design and study:2+2
    - Objective: Conceptual design for the future computing platform
    - High performance network and global network model
    - EB-scale storage technology
    - Million-core HPC/HTC computing and computing federation
    - Operation quality system, including site/service monitoring
  - Distributed computing design and study: 2+2
    - Objective:
      - Provide extra computing resource to support Ref. Det. TDR study
      - Explore novel Distributed computing methodologies for future.
    - Computing model design based on CEPC offline activities requirements
    - Workload management: Dirac study, heterogeneous resource integration, application design based on Dirac
    - Data management: Rucio data management
    - authorization and authentication infrastructure (AAI) : Token, IAM-based (AAI)
- Manpower
  - Requirement: 4+4
  - Current available: 0
- Needed Profile: software, preferably with grid computing/storage/network experiences, distributed computing preferably with WLCG experiences
- Planned training: : software programming, computing platform technologies, distributed computing, cepc

Backup

[Vetex] Backup : key issue to address in TDR

Plan toward TDR

- Major change from CDR to TDR
  - Beam pipe diameter: 28mm (CDR) → 20mm (TDR) (reduce 30%)
  - Instant Luminosity per IP:
    - Z pole: 32×10^{34} $cm^{-2}s^{-1}$ (CDR) → 192×10^{34} $cm^{-2}s^{-1}$ (TDR, 50MW) (6 times increase)
    - ZH: 5.6×10^{34} $cm^{-2}s^{-1}$ (CDR) → 8.3×10^{34} $cm^{-2}s^{-1}$ (TDR) (~1.5 times increase)

- Action item
  - Optimize the geometry
    - Whether we can reduce the radius of the first vertex layer , put it close to beam pipe
      - First vertex layer: Radius=12mm (TDR candidate) or Radius =16mm (CDR design) ?
  - Estimate the hit rate from background
  - Fluence and total ionization dose estimation

[Vetex] On Radiation hardness

Initial input on TID	First layer radius=16mm (CDR vertex design)	First layer radius=12mm (TDR design candidate)
ZH (240GeV)	~1 Mrad/year	3-5 Mrad/year
Z pole (91GeV)	~60 Mrad/year	200-300 Mrad/year

neutron fluence n_{eq} $10^{12} \cdot cm\text{-}2 \cdot yr$	First layer radius=16mm (CDR vertex design)	First layer radius=12mm (TDR design candidate)
ZH (240GeV)	3	9-15
Z pole (91GeV)	120	360-600

- Requirement on TID
  - 5 Mrad/y (Taichu) →200~300Mrad/y
  - Generally very difficult for MAPS (at the ATLAS level), even by 65nm
- Requirement on NIEL
  - CDR requirement: ~2*$\mathbf{10^{13}} neq \cdot cm\text{-}2 \cdot yr$
  - TDR requirement: 1-6 *$\mathbf{10^{14}} neq \cdot cm\text{-}2 \cdot yr$ (depending on radius)
- Taichu's results of 30Mrad & 10^{14}neq is only a preliminary results, needs more test especially on high dose region

[Vetex] Specification calculation- from hit density

		Hit density (Hits/cm²/BX)	Bunch spacing (ns)	Hit rate (M Hits/cm²)	Hit Pix rate (M Px/cm²)	Hit rate/chip (MHz)	Data rate@triggerless (Gbps)	Pixel/bunch	FIFO Depth @3us rg latency	Data rate@trigger (Mbps)
CDR	Higgs	2.4	680	3.53	10.59	34.62	1.1	23.5	103.9	105.28
	W	2.3	210	10.95	32.86	107.44	3.4	22.6	322.3	101.248
	Z	0.25	25	10	30	98.1	3.1	2.4	294.3	53.76
TDR	Higgs	6~10	591	10.15~16.92	30.46~50.76	99.59~166.0	3.2~5.3	58.9~98.1	298.8~498	
	W	6~10	257	23.35~38.91	70.04~116.73	229.0~381.7	7.3~12.2	58.9~98.1	687~1145.1	
	Z	1.8~3	23	78.26~130.43	234.78~391.30	767.7~1279.6	23.6~40.9	17.6~29.4	2.3k~3.8k	473~790 (trigger rate?)

- **Cluster size: 3pixels/hit (@Twjz 180nm, EPI 18~25um)**
- **Area: 1.28cm*2.56cm=3.27cm² (@pixel size 25um*25um)**
- **Word length: 32bit/event (@Taichu's scale, 512*1024 array)**
- **Trigger rate：20kHz@CDR，120kHz@TDR estimated**
  - **Trigger latency: 3us(very likely not enough), Error window: 7 bins**
  - **FIFO depth: @3us * hit rate/chip**
  - **Data rate=pixel/bunch*trigger rate*32bit*error window**

[Vetex] Comment according to the data rate

- Highest hit rate/chip: 107MHz@W → 1279.6MHz@Z
- Max Data rate @ triggerless: 23.6~40.9Gbps@Z
  - We can thus make an assertion: it is not possible to run triggerless mode, even by using 65nm technology
  - Data rate of higgs & W: 3.2~12.2Gbps
    - Possible to run triggerless, but with high cost and challenge on ladder design → low feasibility
- Max data rate @trigger 1.58~2.64Gbps@Higgs
  - Feasible, but the data interface must run by 8b10b or other protocol
    - Remember current Taichu is not with a TRUE 8b10b protocol
  - What is the trigger rate of Z? still depends
- On chip FIFO
  - 2.3k~3.8k words * 32bit, 10 times of current Taichu
  - Must use high density RAM, registers based on DFF is not allowed (too large area =dead area)

Electronics

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - ASIC design for sub-detector systems (21=9+12)
    - Detector specific ASIC (Pre-Amp, shaper, etc) for each sub-detector system in 2024 - 2026 (Vertex, Strip, DC, TOF, ECAL+HCAL, MUON) (6+6)
    - ASIC test & performance evaluation (2024~2026)(3+6)
  - General purpose ASIC design and COTS evaluation for common services (26=13+13)
    - ASICs for amplitude measurements (SCA, ADC, etc) (2+2)
    - ASIC for time measurement (TDC, etc) (1+1)
    - Studies for SiPM readout chips (2+2)
    - Rad-tol data link ASIC, module and system development (3+3)
    - ASIC development or COTS evaluation for Rad-tol detector front-end electronics (FEE) (2+2)
    - Common design blocks (I2C master and client, etc) and Slow control and monitoring (voltage, temperature, etc) ASIC/COTS (2 + 2)
    - Radiation effect test & study (1+1)
  - FEE system developments (Vertex, Strip, DC, TOF, ECAL, HCAL, MUON, Trigger information, calibration, Powering, Slow control, etc) (20 = 10 + 10) :
  - Backend Electronics (BEE) development (22=11+11)
    - Wireless communication & clocking (1+1)
    - Advanced algorithm on data compression & on-detector L1 trigger (2+2)
    - Generic BEE hardware development: (3 + 3)
    - Firmware development (5 + 5)
- Manpower
  - Requirement: 8 + 10: half manpower are for design & rest are for test.
  - Current available: 0 + 1.5.
- Needed Profile: Design: experience on ASIC design, FPGA & Verilog; Test: Python/MATLAB, experience on chip test is preferable
- Planned training: FPGA test firmware coding, test equipments operation

Electronics for Ref-TDR R&D

- Topics & Objectives + Manpower Requirements (PostDoc + Students)
  - ASIC design for related detectors (8=4+4)
    - Chip design & simulation for the main detectors in 2024(Vertex, Strip, Cal, DC...) (4)
    - ASIC test & performance evaluation (2024~2026)(4)
  - General purpose ASIC design for common technology (4=3+1)
    - Rad-tol power management chip design & strategy study (1)
    - Rad-tol data link chip design (1)
    - Radiation effect test & study (1+1)
  - Backend Electronics development (6=3+3)
    - Wireless communication & clocking (1+1)
    - Advanced algorithm on data compression & on-detector L1 trigger (2+2)
- Manpower
  - Requirement: 8 + 10: half manpower are for design & rest are for test.
  - Current available: 0 + 1.5
- Needed Profile: Design: experience on ASIC design, FPGA & Verilog; Test: Python/MATLAB, experience on chip test is preferable
- Planned training: FPGA test firmware coding, test equipments operation