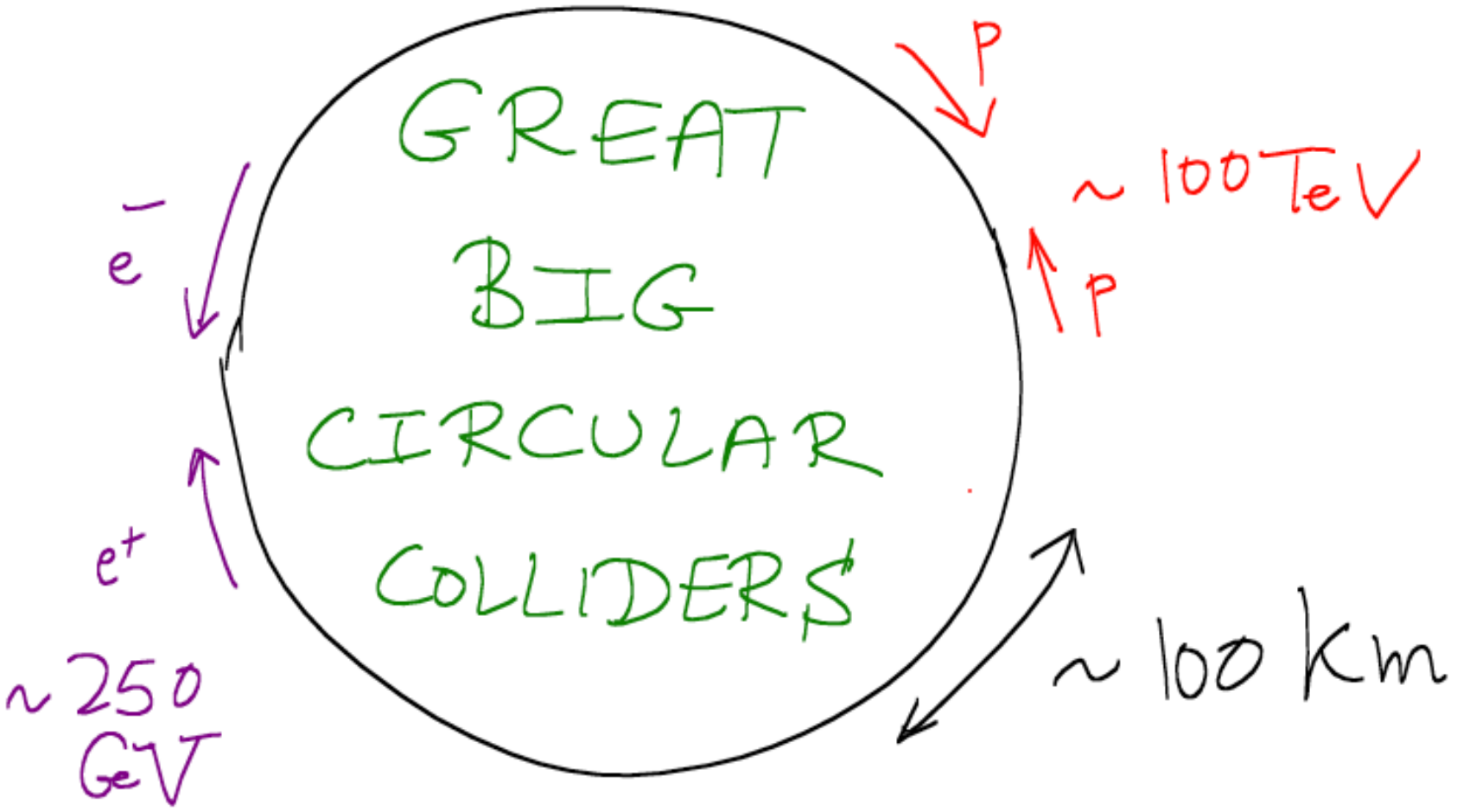
A brief introduction to CEPC

Manqi

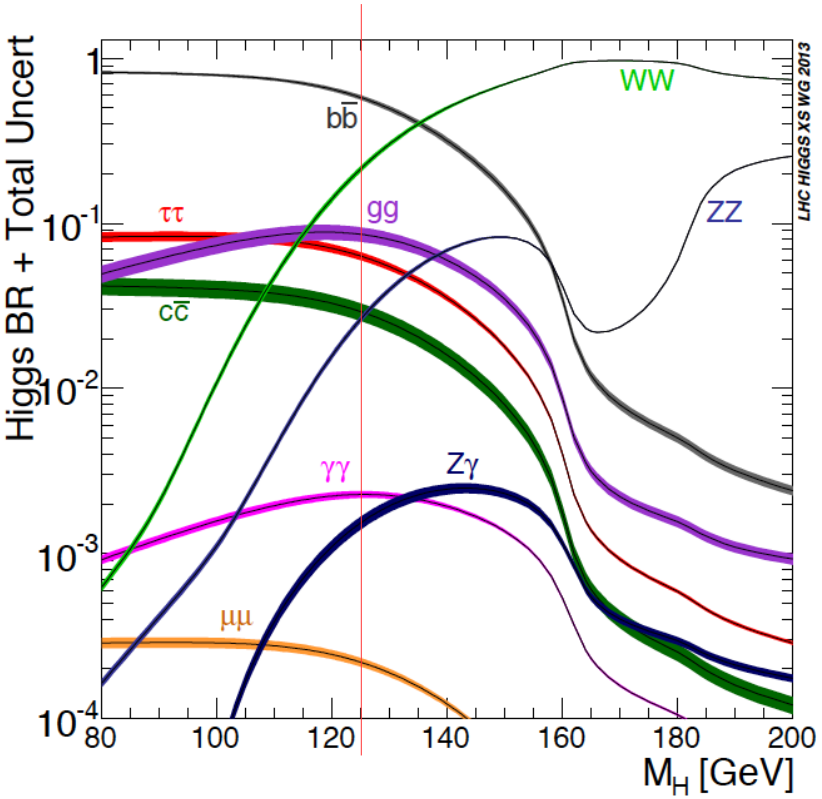

Higgs, the gate



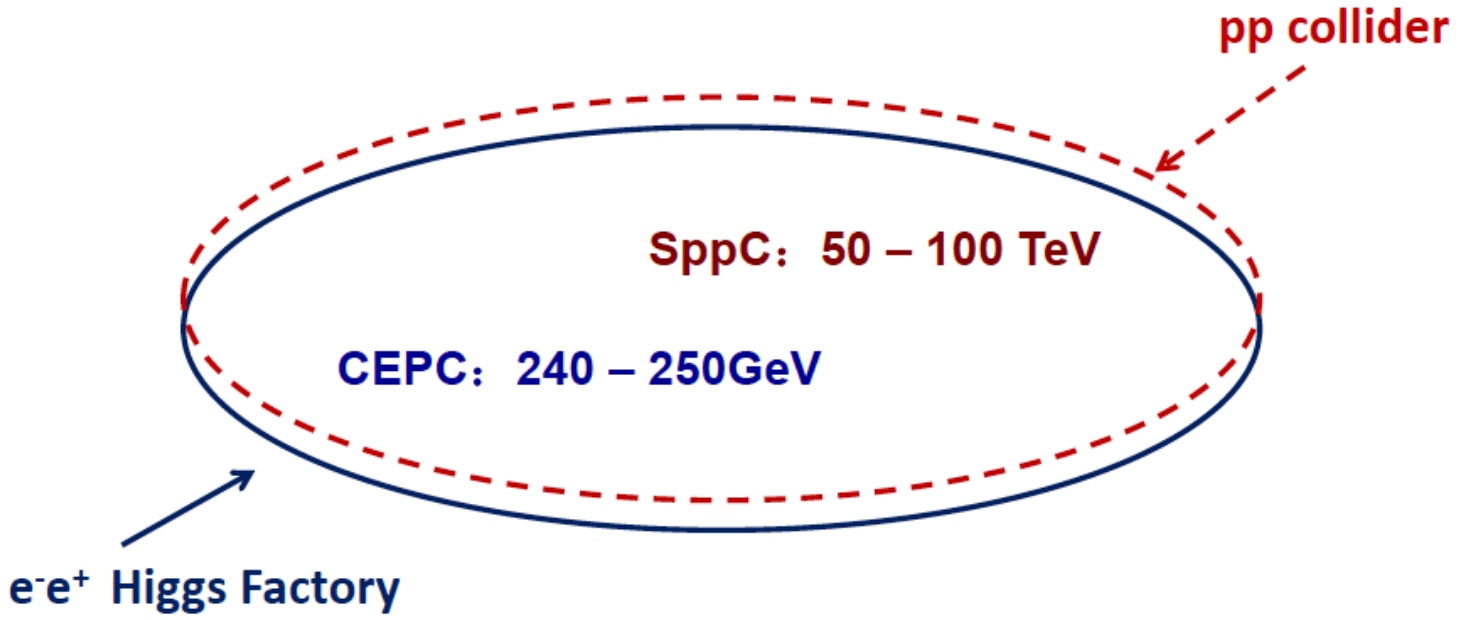
Precise measurement & Direct probe

...Physics program...

- 250 GeV electron positron collision
  - Higgs physics
    - Mass, spin, σ(ZH),
    - σ(ZH)/σ(νν̄H)*Br(H→X)
    - Access to the absolute value of Higgs width, Br(H→inv/exotic) and couplings between Higgs & its decay final states
  - Z pole physics: EW, Flavor
  - New Physics
- High Energy Proton collision
  - Higgs physics:
    - Rare production/decay
    - Direct access to g(HHH) & g(Htt)
  - EW phenomena @ high energy
  - **New Physics**



- **A CEPC (phase I) + SppC (phase II) was proposed in IHEP, Sept. 2012**



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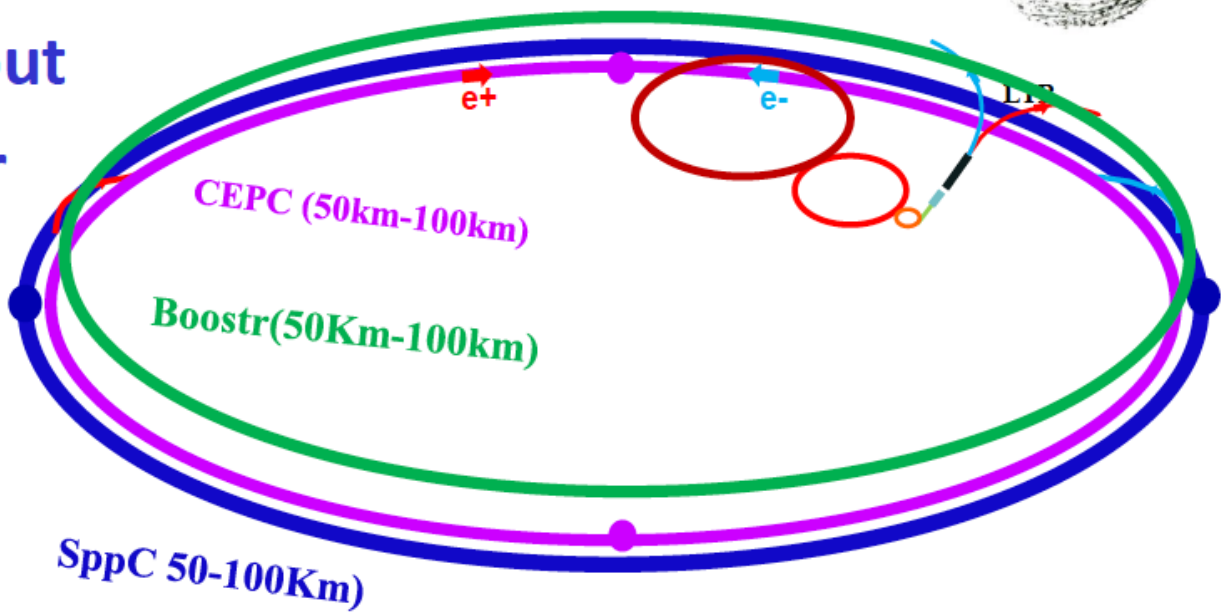
From Prof Q.Qin

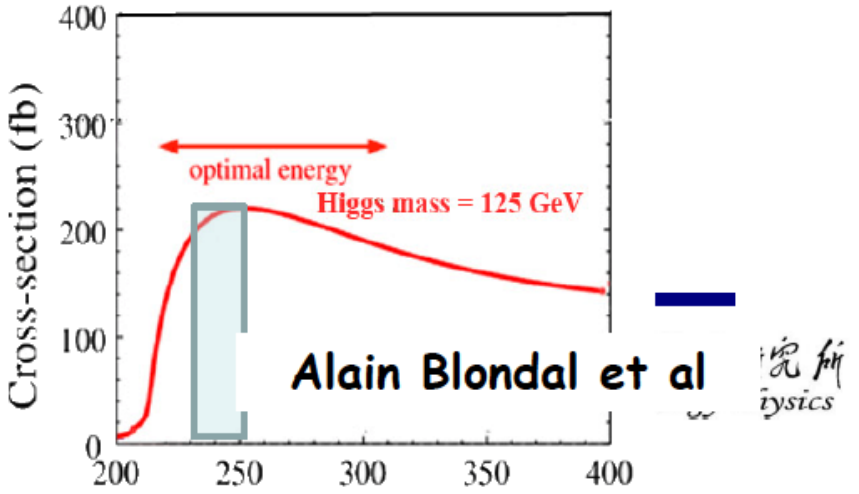
3-ring in one tunnel

- Schematic layout
- Linac + booster as injectors

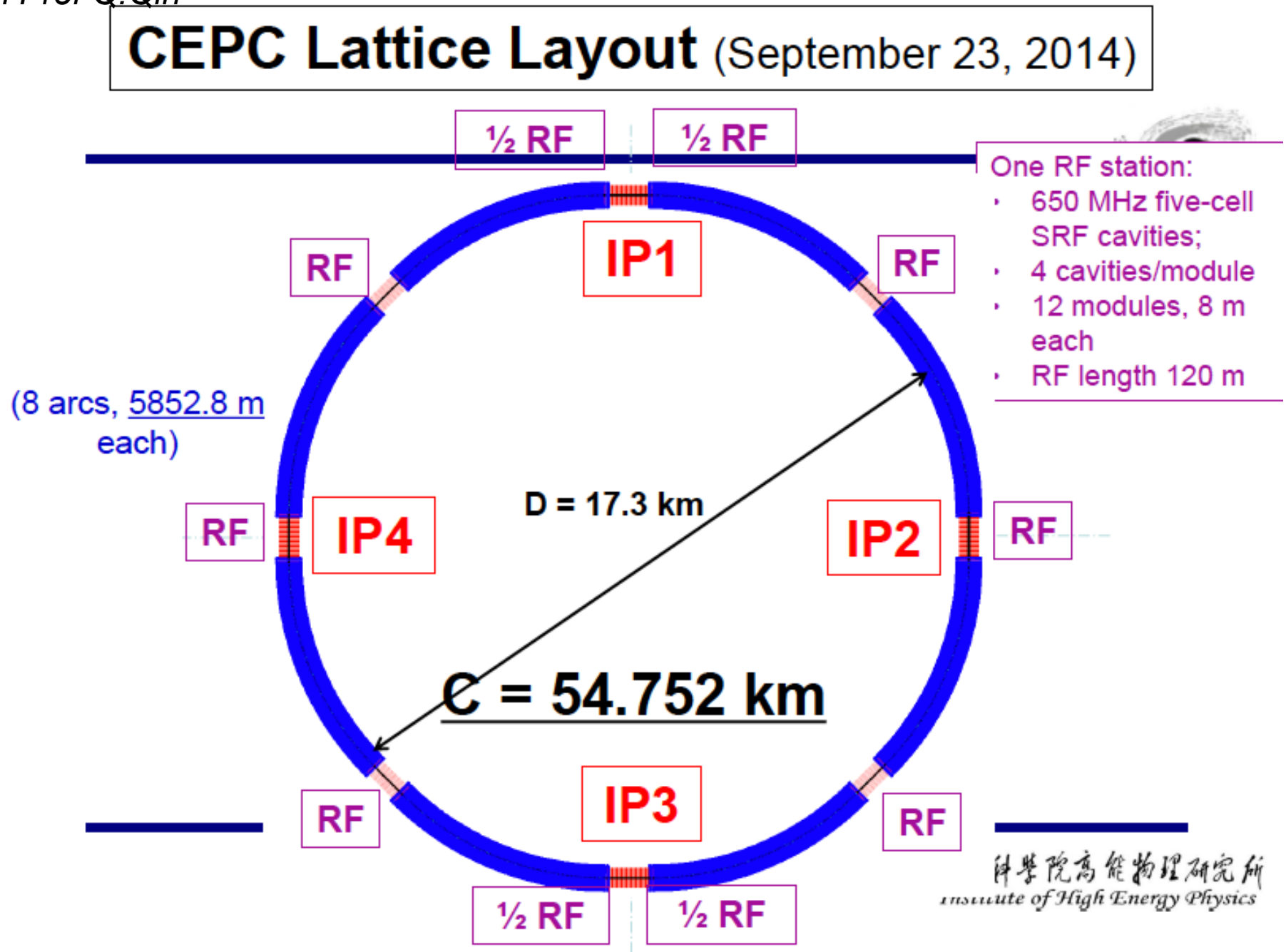


CEPC:

- E_b=120GeV
  - Limited by beamstrahlung & SR (~125GeV)
- Cross-section = 200 fb



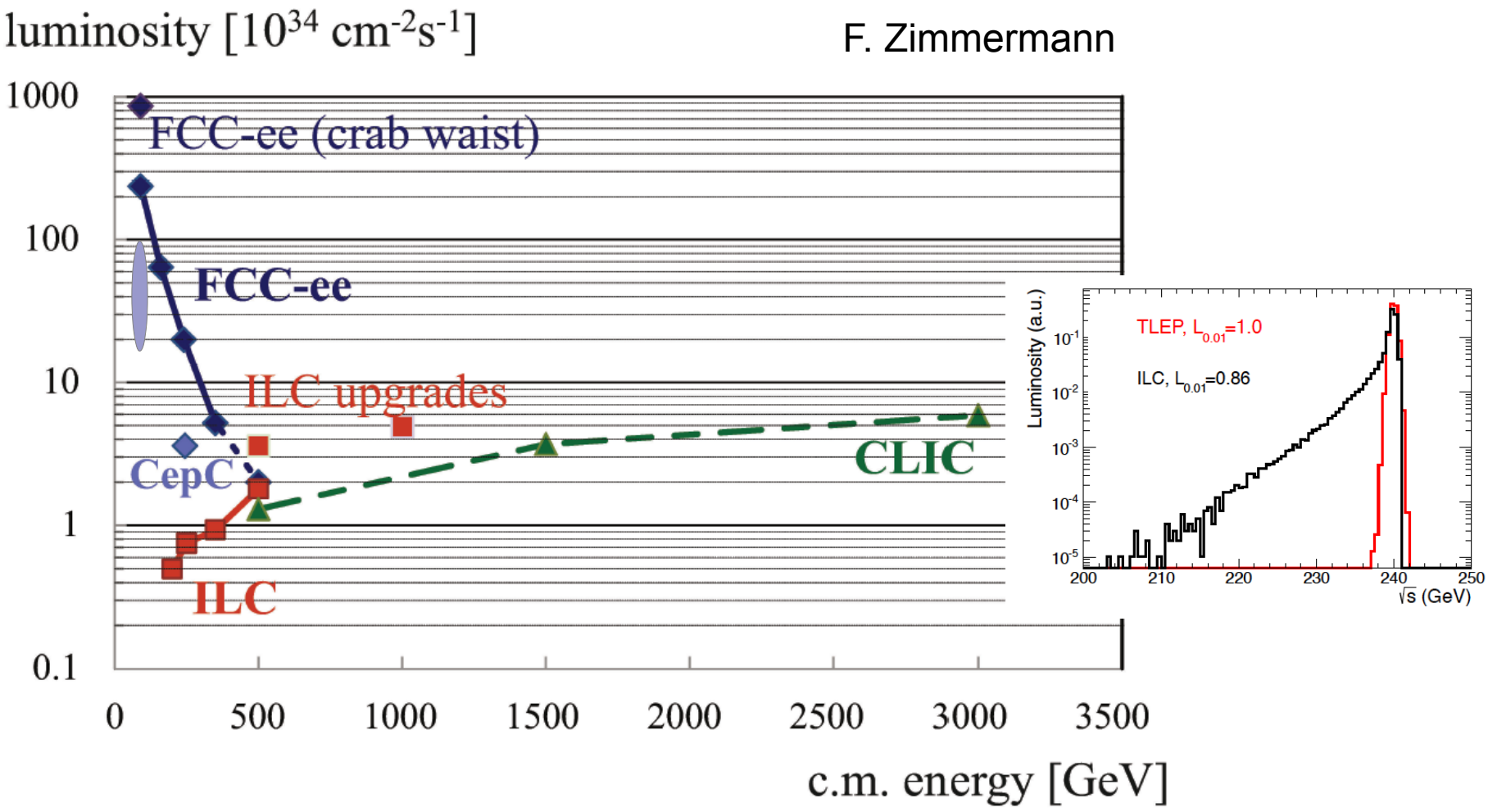
From Prof Q.Qin



From Prof Q.Qin

- **Possible site: Qinhuangdao, Hebei province**

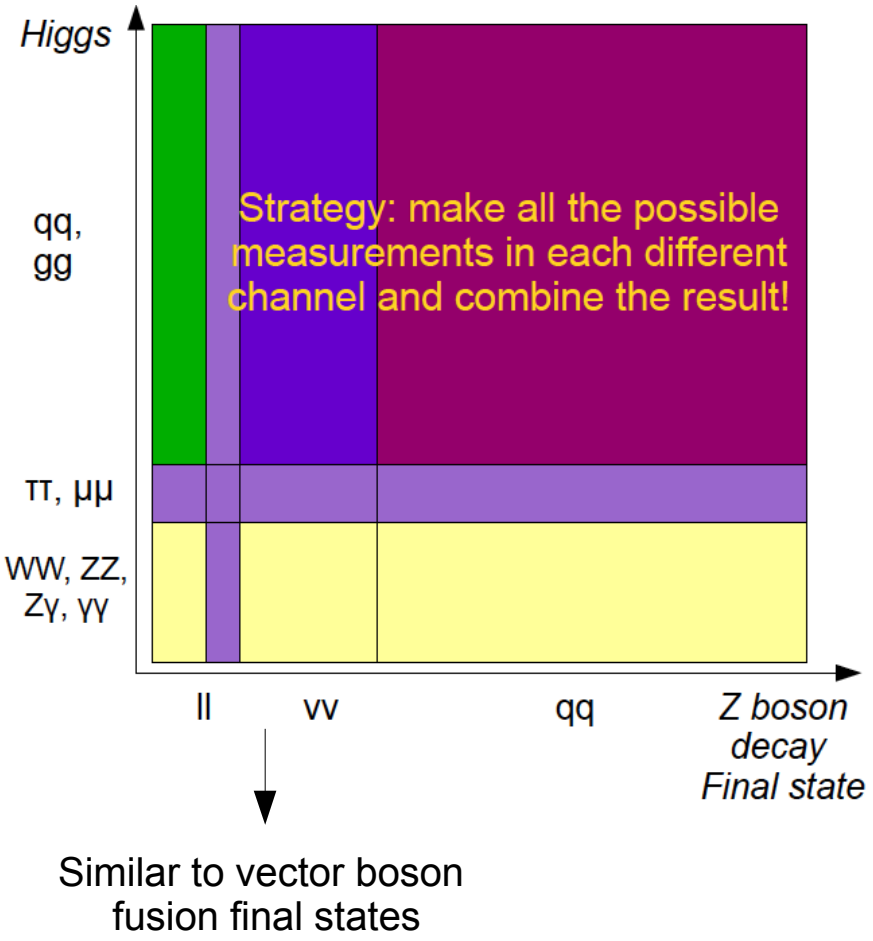
e^+e^- luminosity vs energy



	FCCee 240 (10 ab^{-1})	FCCee 350 (2.6 ab^{-1})	CEPC 250 (5 ab^{-1})
Higgs from HZ	500 k/IP * 4 IP	85 k/IP * 4 IP	500 k/IP * 2 IP
Higgs from fusion	12.5 k/IP * 4 IP	17.5 k/IP * 4 IP	18.7 k/IP * 2 IP

FCCee: 5 year of operation at each point, 1 year ~ 10^7 sec;
*CEPC: 10 year of operation, 1 year ~ 1.25*10^7 sec*

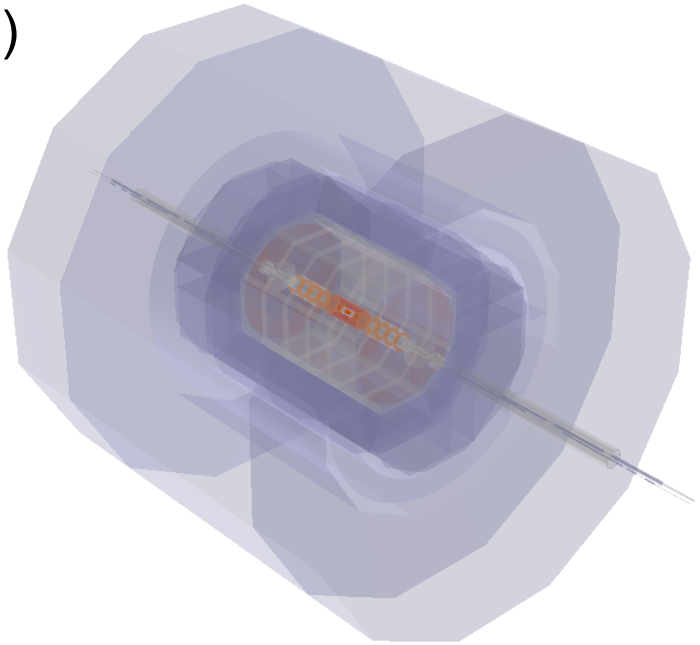
Detector consideration



- Perfect efficiency/acceptance
- Perfect tagging
  - Lepton (to low energy)
  - Photon (from Jets, VTX, brems)
  - Tau
  - Jets: with different flavor
- Precise measurement
  - Track, Photon & Neutral hadron - Jets energy resolution
- Extremely low systematic: for Z pole runs
  - Homogenous, small constant term

From ILD to CEPC detector

- New designs/considerations
  - Changed granularity (no power pulsing)
  - Changed L*
  - Changed VTX inner radius
  - Changed TPC outer Radius
  - Changed Detector Half Z
  - Changed Yoke/Muon thickness
  - Changed Sub detector design
  - …



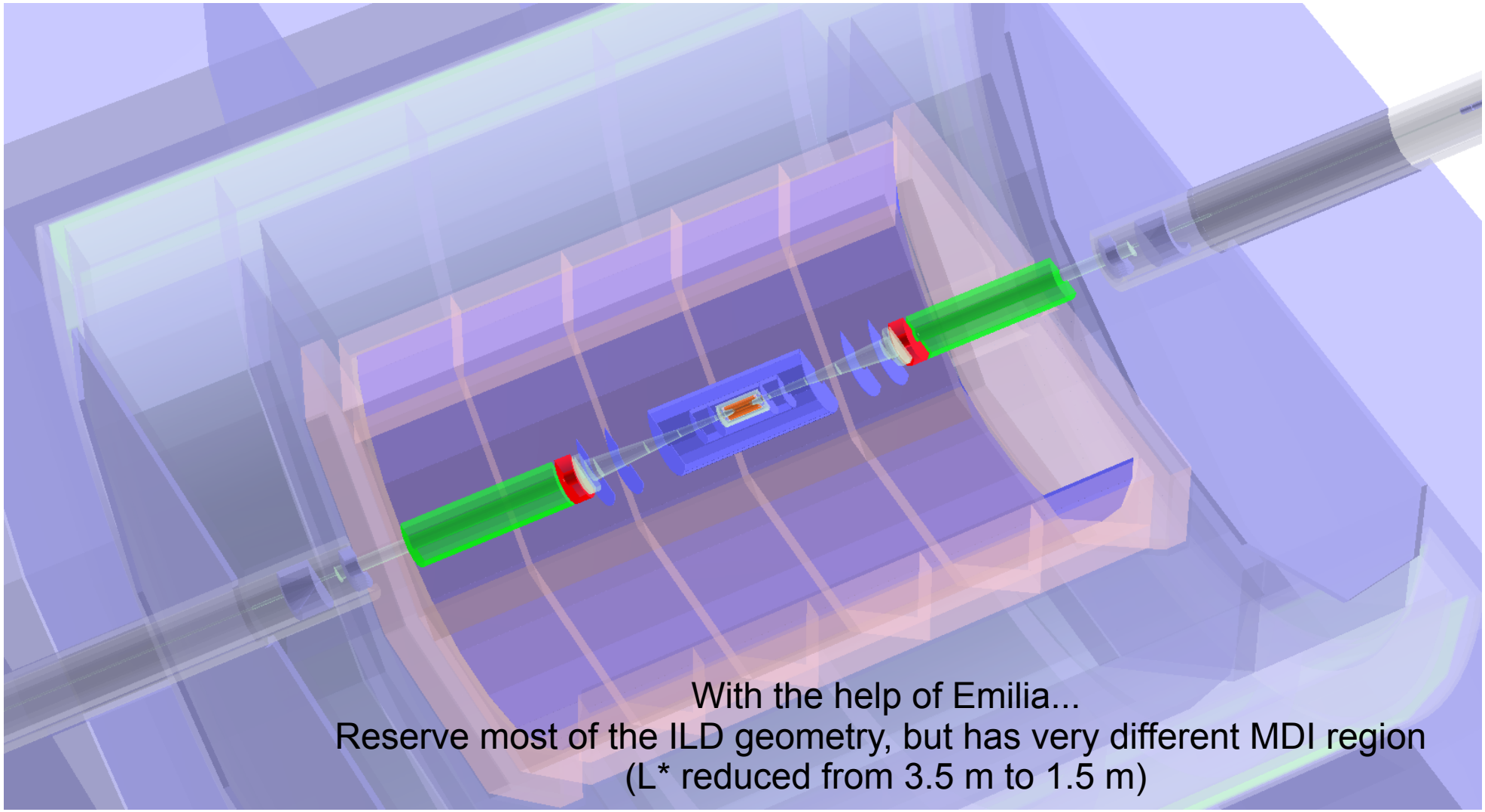
- All Changes need to be implemented into simulation, iterate with physics analysis (Fast – Full Simulation) and cost estimation

Collision Environment

- Higgs Runs (240 -250 GeV)
  - Lower beam background (BS effect ~ o(0.01 – 0.001) of ILC)
  - Bunch collision rate: 300k Hz, bunch separation 3 μs (1 km)
  - Head on collision
- Z pole runs
  - 10 ns (0.3 m) separation at FCCee Z pole (Crab.Waist scenario)
  - Z pole events: o($10^{4\text{-}5}$) Hz Z->hadronic events

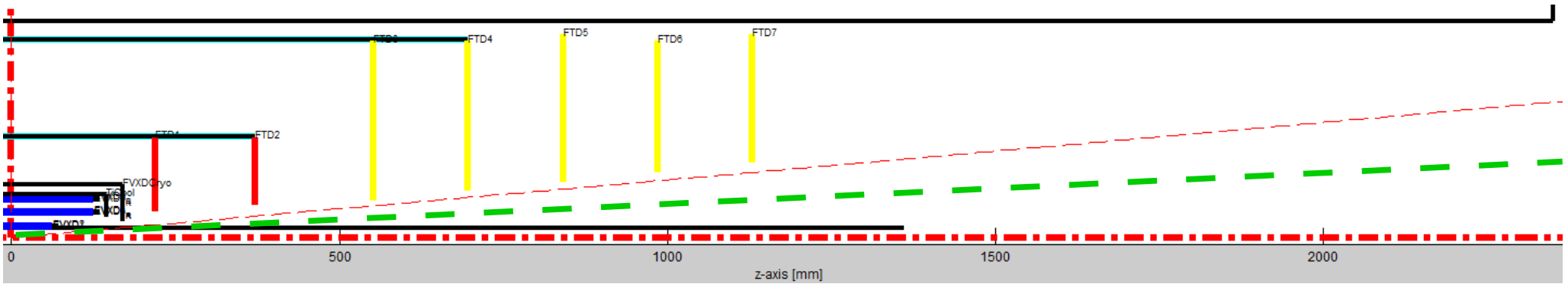
- Electronics work in continuous readout mode
  - Different Front End Chips, DAQ design;
  - Cooling
- Different Final Focusing Machine Detector interface design...

Conceptual CEPC Detector: modified from ILD



With the help of Emilia...
Reserve most of the ILD geometry, but has very different MDI region
(L* reduced from 3.5 m to 1.5 m)

Beam induced background



Absolute geometry acceptance - beam pipe cone angle

Beam induced background: Beamstrahlung photons

Input Machine Parameters

- Input CEPC machine parameters into GUINEA-PIG; ILC250 listed for comparison

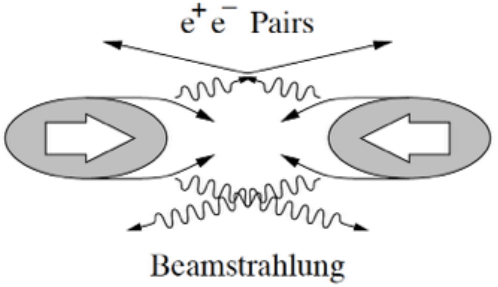
Machine Parameters	CEPC	ILC250
E_{cm} [GeV]	240	250
Particles per bunch	3.7×10^{11}	2.0×10^{10}
Beam size σ_x/σ_y [nm]	73700/160	729/7.7
Beam size σ_z [μm]	2260	300
Emittance $\varepsilon_x/\varepsilon_y$ [mm · mrad]	1595/4.8	10/0.035

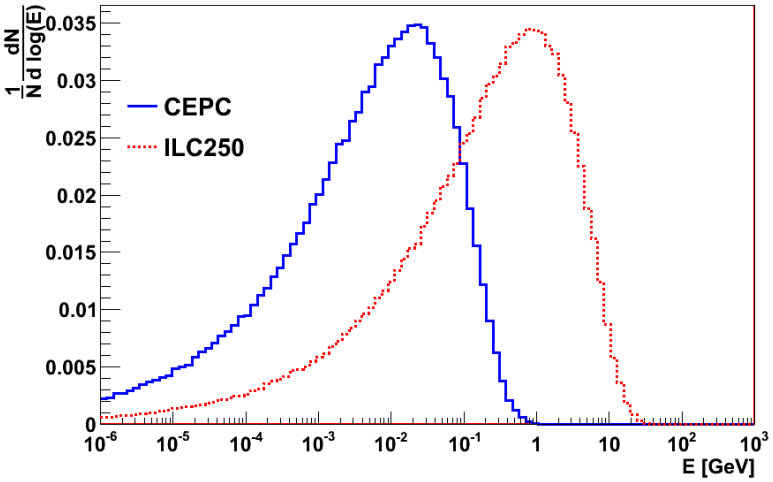
$$\delta \propto \frac{\gamma}{E\sigma_z}\left(\frac{N}{\sigma_x+\sigma_y}\right)^2$$

$$\Upsilon \propto \frac{N\gamma}{\sigma_z(\sigma_x+\sigma_y)}$$

→ Promising smaller average relative energy loss and less beamstrahlung for CEPC

2014-10-11 ICFA HF2014, H. Zhu (IHEP) 6



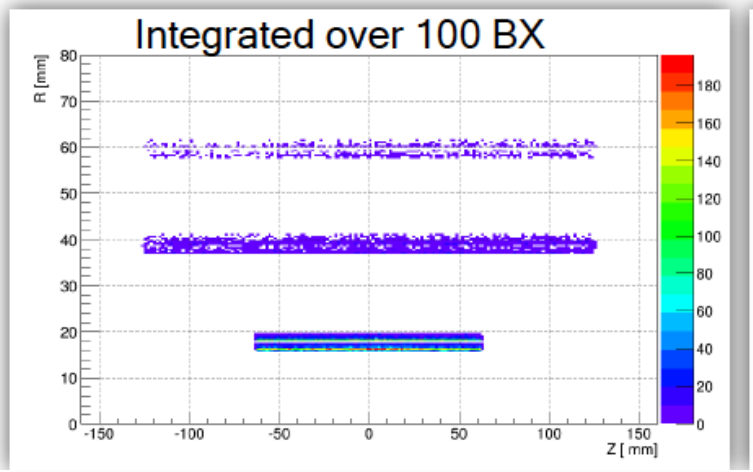


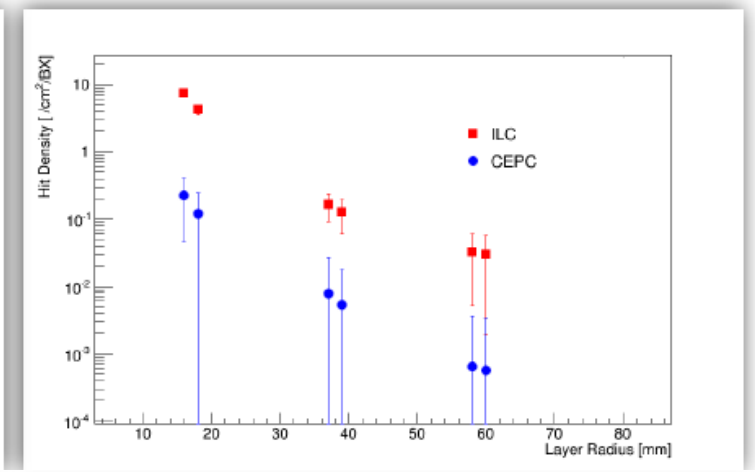
- The Vertex Detector placed closest to the interaction point, hence most vulnerable to radiation background
  - Radiation damage, detector occupancy, double-hit probability …

Hit density

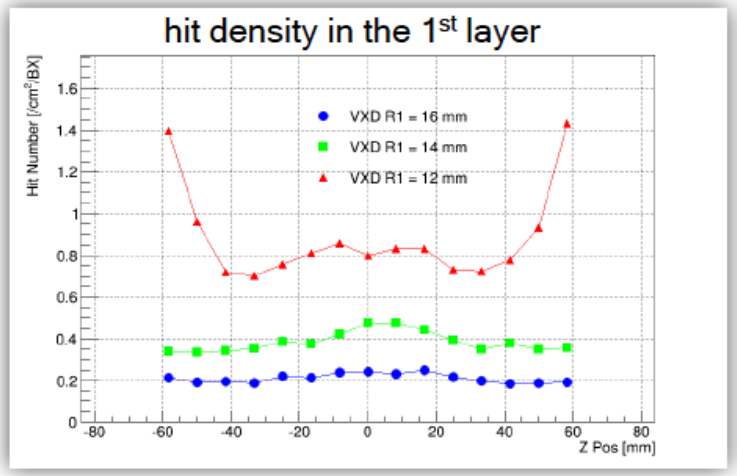
Hit Density on the 1st layer:

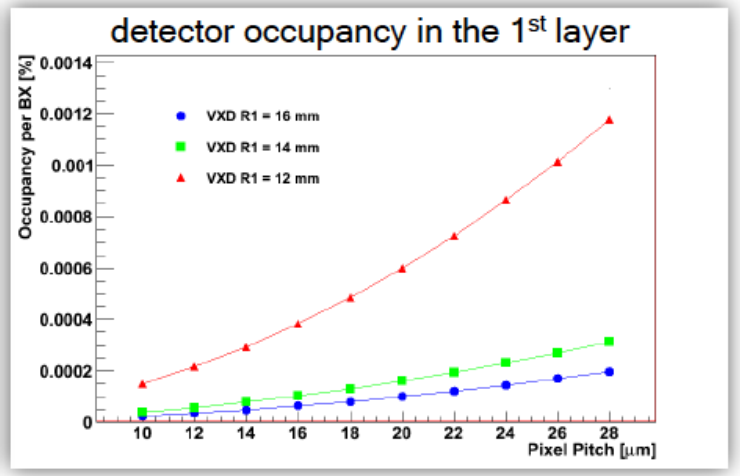
~0.2/cm²/BX (CEPC) and 8/cm²/BX (ILC250)





Short? Closer?...





... some fast questions on detector...

- Tracking:
  - Is TPC feasible?
  - Material budget/performance?
- Calorimeter:
  - Cooling, #channels & DAQ?
  - How well we can control the constant term: how well we need it?
  - Faster enough for K-pi separation?
- VTX:
  - What would be the optimized design?
  - How to achieve even better c-tagging performance?

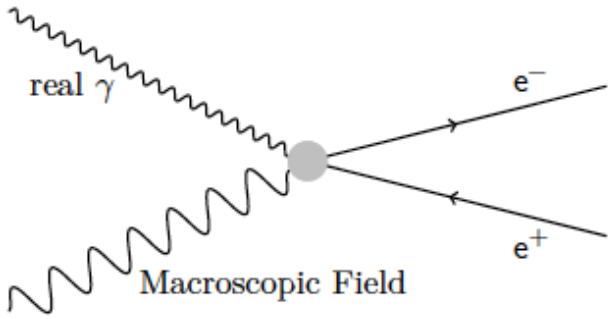
Summary

- CEPC: toward precise SM - Higgs measurements & New physics
  - As a circular collider, CEPC will host more than 1 detector
- ILD detector provides excellent starting point for CEPC: need to be adjusted & optimized
  - Collision environments
  - Physics requirements
- Key requirements for Calorimeter:
  - Adequate DAQ & Cooling system
  - Control of systematics, noise & homogeneity...
  - ...
- Lots of open questions...

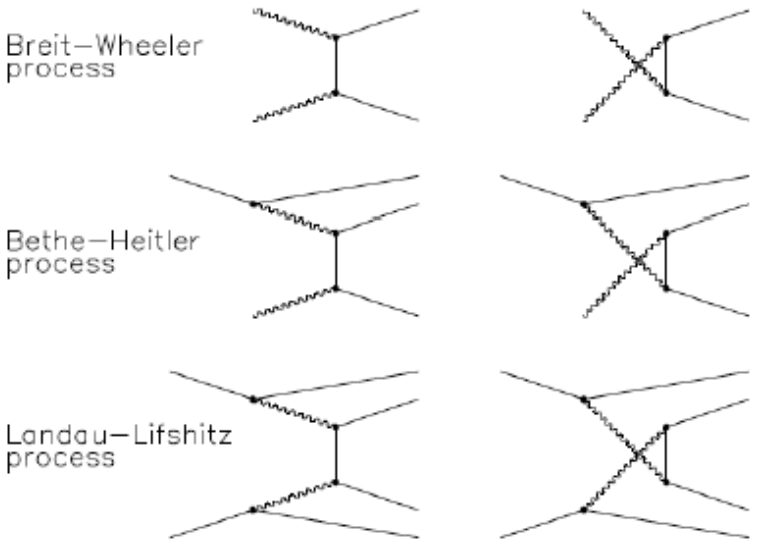
backup

Beam induced background: pair production (γγ→ee)

- Coherent and incoherent electron-positron pair production; the most important background for detectors
  - **Coherent**: real photons (e.g. beamstrahlung) interaction with the coherent field of the out-coming bunch → in small angle
  - **Incoherent**: real/virtual photon interactions, including the Breit-Wheeler, Bether-Heitler and Landau-Lifschitz processes.



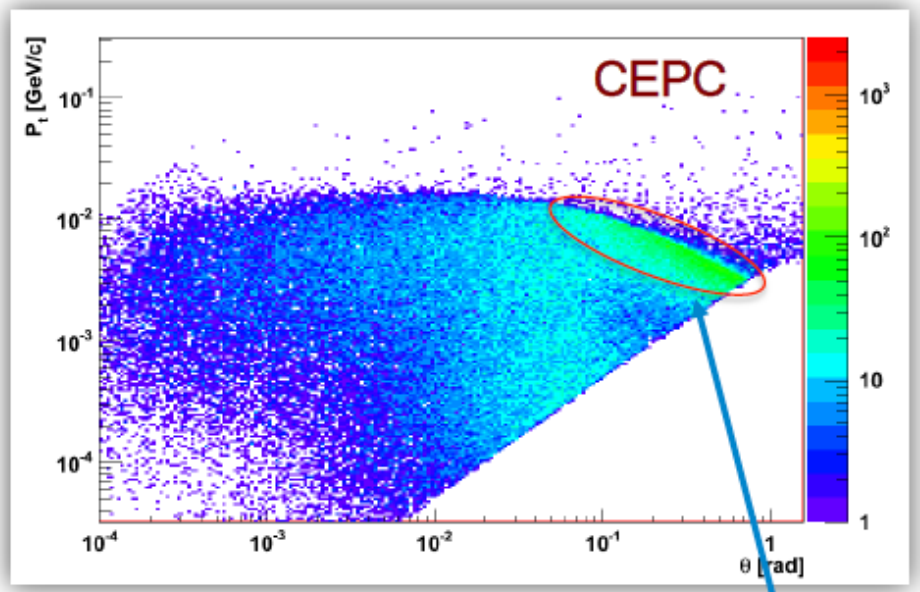
Coherent pair production

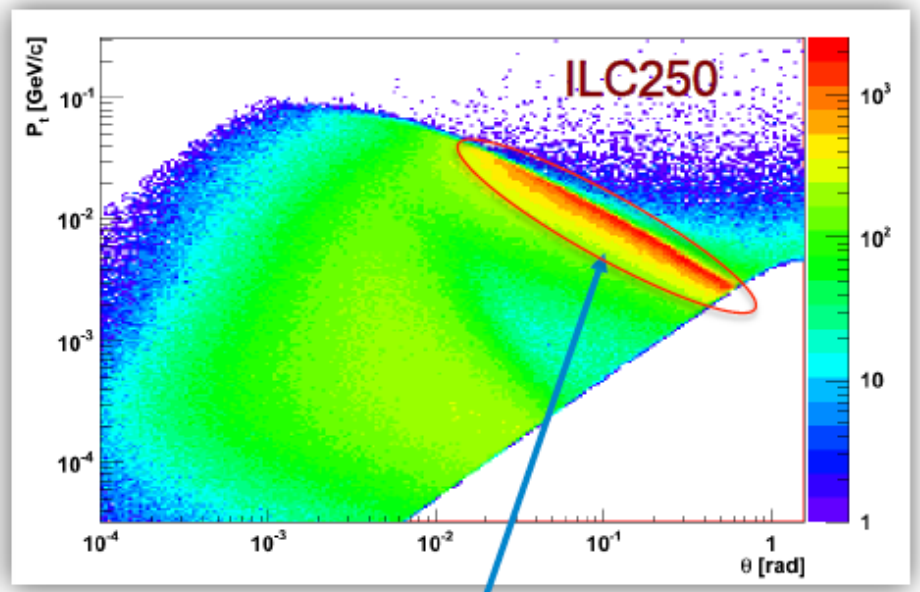


Incoherent pair production

Beam induced background: pair production (γγ→ee)

- Transverse momentum of pairs vs. polar angle (integrated over 50 BX for better visualization)
- Significantly less background from pair production for CEPC, in particular in the detector coverage area





Vertex detector must be kept away from those particles.

Team Building & trainings



Training

Go t

August 2014

11 Aug - 15 Aug Detector Simulation and Geometry editing

October 2013

19 Oct - 20 Oct CEPC Training: Physics Analysis, Detector Optimization and Software tools

International Summer school on TeV Experimental Physics (iSTEP)

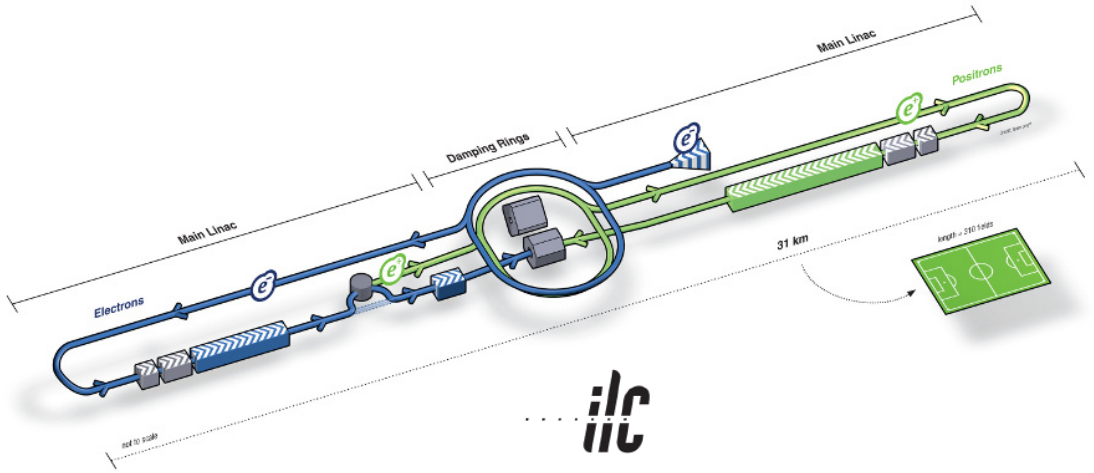
20-29 August 2014
IHEP
Asia/Shanghai timezone

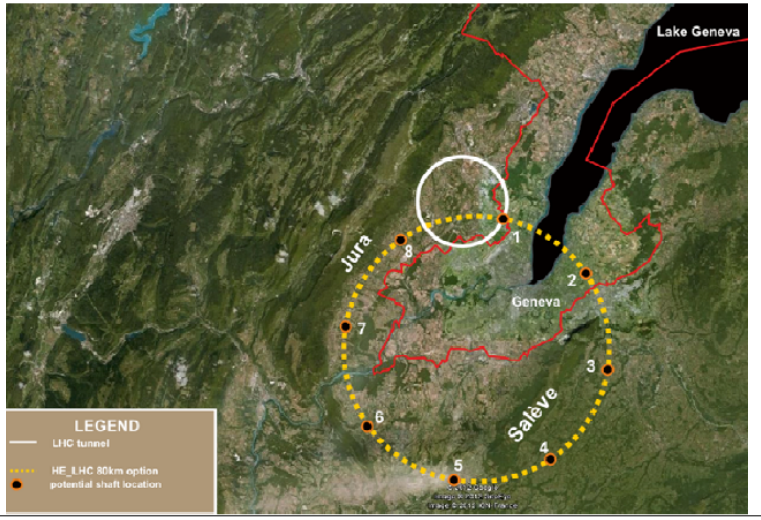
Overview

Continuous efforts + dedicated training

We have a group of Analyzers...

Higgs factory: Linear or Circular





	Linear: ILC, CLIC	Circular: CEPC, TLEP
Pro	Center of mass energy can be upgraded to 1-3 TeV Longitudinal polarized beam Power pulsed detector	Cost-efficient, mature technology Multiple interaction point High luminosity & beam quality
Con	Expensive Single interaction point, might need push-pull	Center of mass energy limited in e^+e^- phase (but can be upgraded to ~ 100 TeV in pp phase) No beam polarization at high energy No power pulse

Muon & photon colliders are also possible Higgs factories, but...