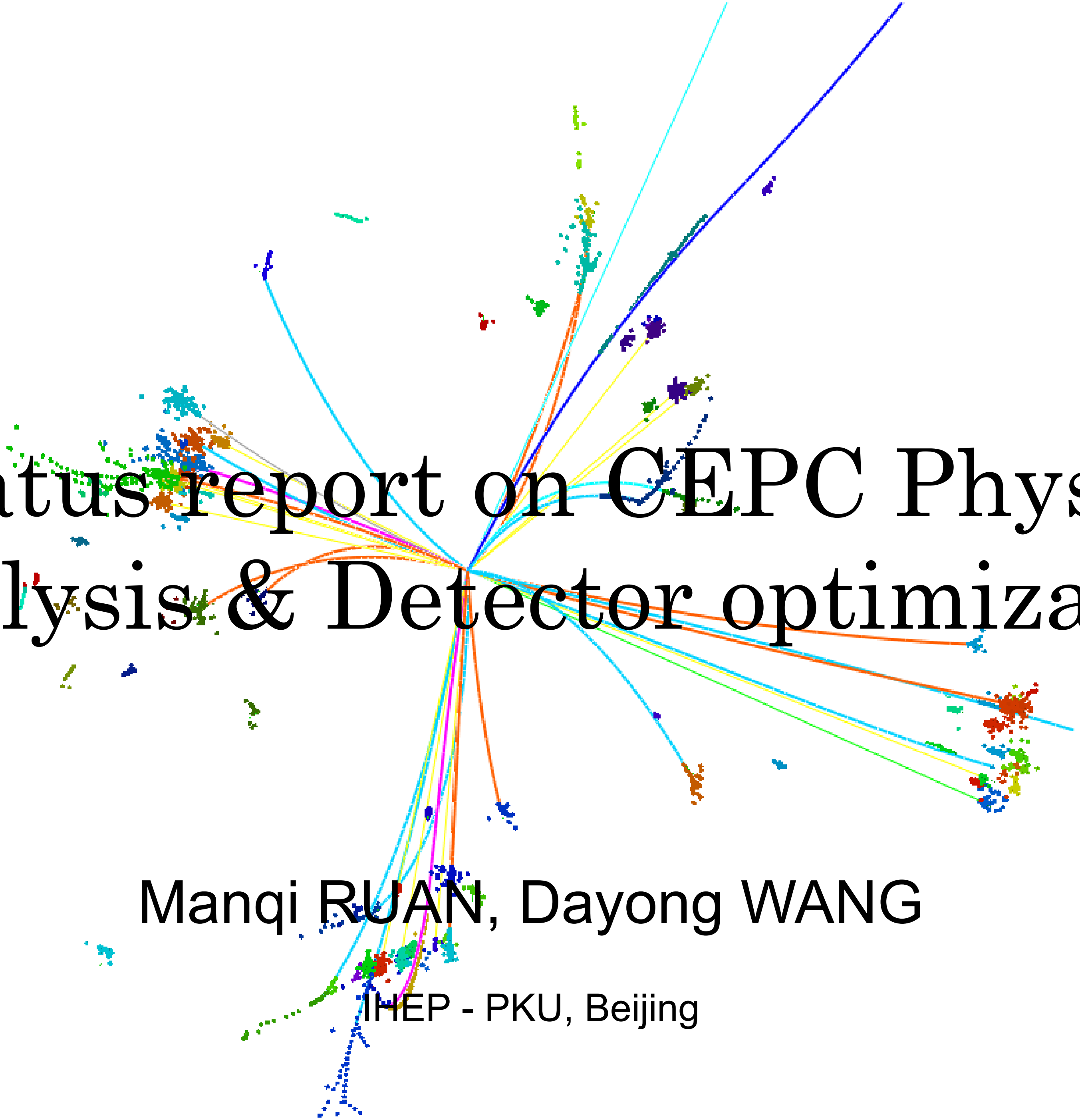
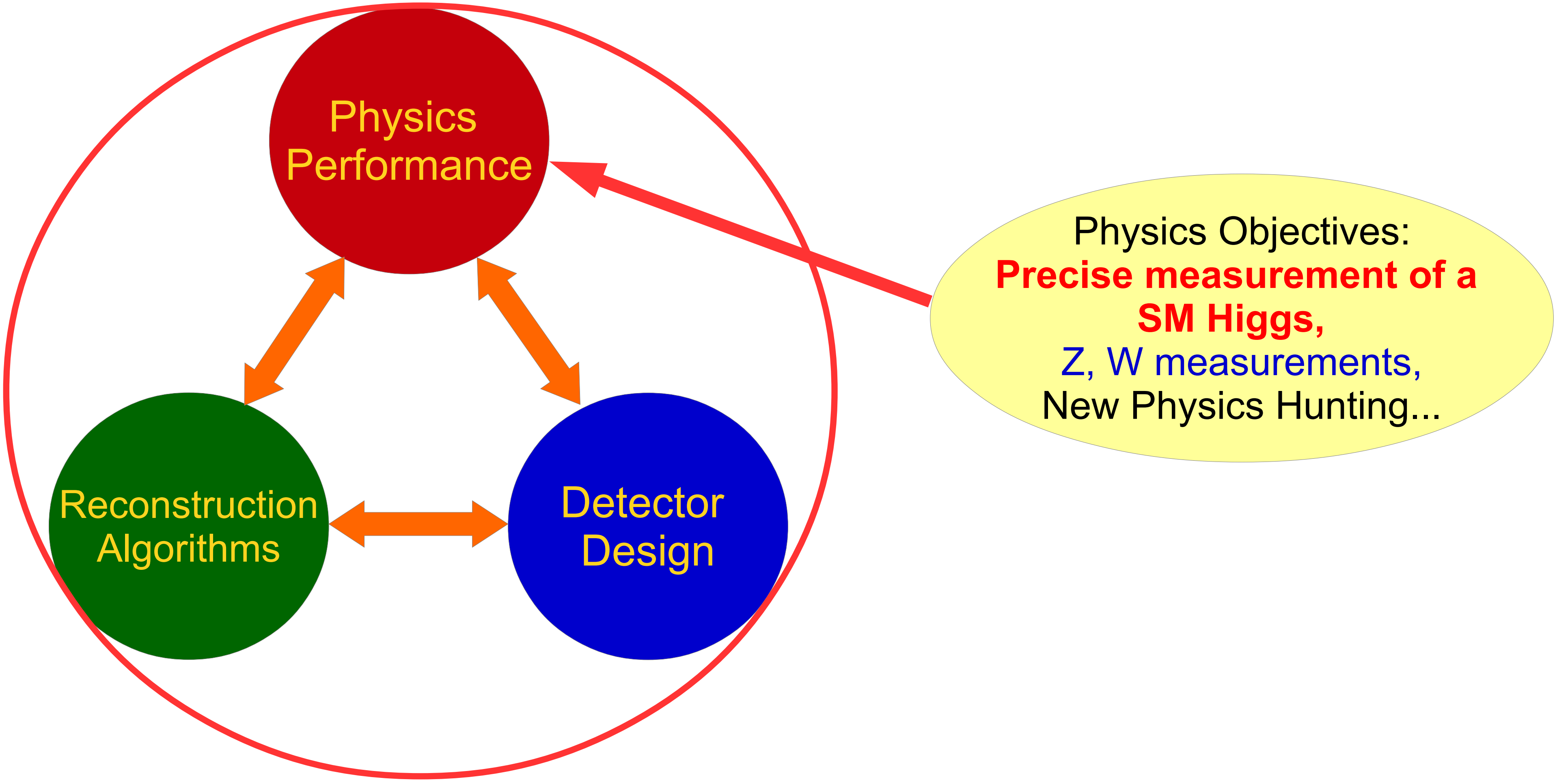
Status report on CEPC Physics Analysis & Detector optimization



Manqi RUAN, Dayong WANG

IHEP - PKU, Beijing

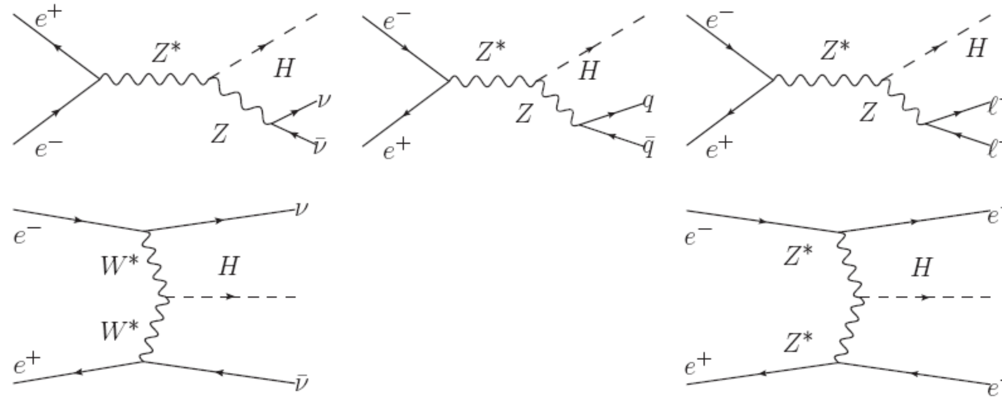
Perspective of CEPC Physics Measurement



8 + 2 → 8 + 5 + 1 SM Higgs observables

- From 100k – 1M Higgs: Direct observables
  - Mass, spin, σ(ZH)
  - Branching ratios (b, c, tau, g, W)
  - Branching ratios (gamma, mu)

    \+
  - Branching ratios (Z - gamma)
  - Invisible Branching ratio
  - σ(vvH)*Br(H→bb)



(a) (b) (c)

- Calculate: width – coupling

Mode	$b\bar{b}$	$c\bar{c}$	gg	WW^*	$\mu^+\mu^-$	$\tau^+\tau^-$	ZZ^*	$\gamma\gamma$	$Z\gamma$
BR (%)	57.8	2.7	8.6	21.6	0.02	6.4	2.7	0.23	0.16

g(Hbb), g(Hcc), g(Htt), g(HWW)/Γ_H, g(Hμμ), g(Hττ), g(HZZ)/Γ_H, g(HWW)/g(Htt)

SM Higgs measurement Status

	ILC @ 250 fb^{-1} (-0.8, 0.3)	CEPC @ 500 fb^{-1} (0, 0)	Status
mH (MI)	29 MeV	25 MeV	FS Validated
σ(ZH)	2.6%	2.2%	
Δ(σ*Br)/(σ*Br)			
ZH, H→bb	1.2%	1.0%	FS Estimated
H→cc	8.3%	6.6%	
H→gg	7.0%	5.6%	
H→WW*	6.4%	**4.0%**	PKU, SJTU L. Yuan
H→ττ	4.2%	3.7%	USTC
H→ZZ*	19%	16%	SDU
H→γγ	29-38%	25%	IHEP, WhU
H→μμ	-	?	L. Yuan
H→Inv.	0.95%	0.8%	
ννH, H→bb	10.5%	**12%**	PKU

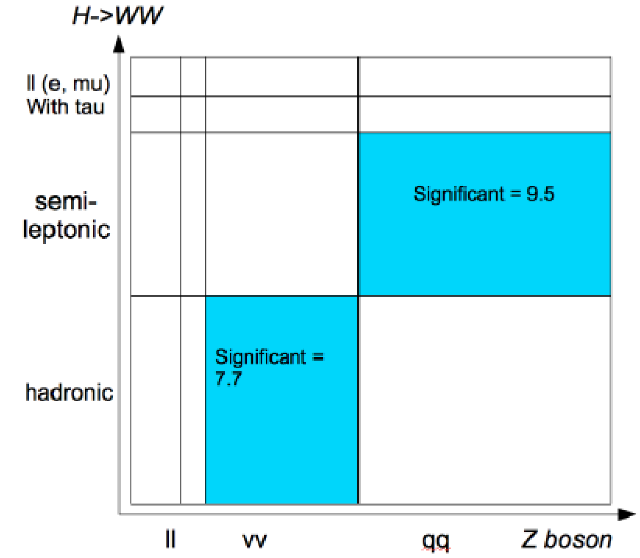
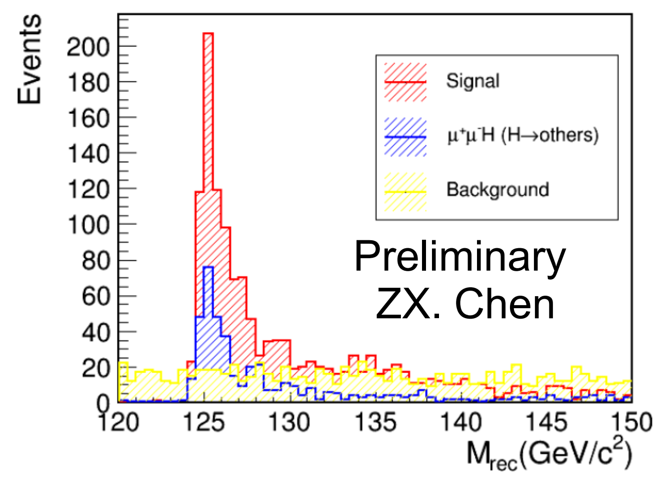


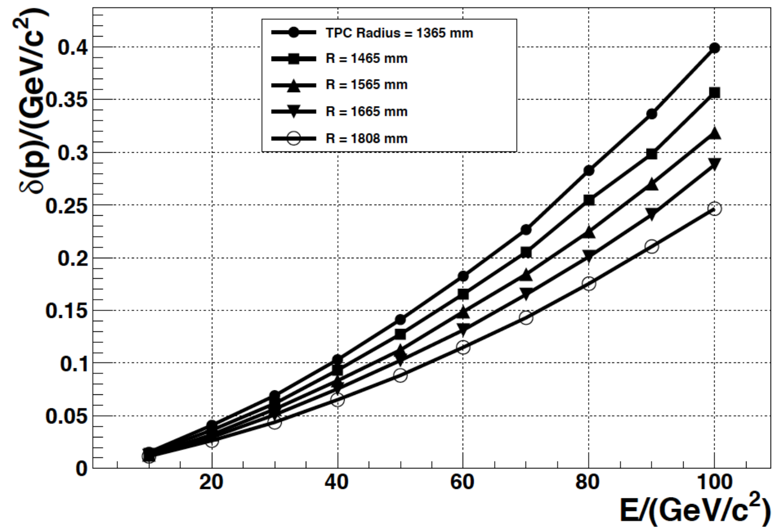
Figure 8. Result of ILC Analysis on $Br(H \to WW^*)$

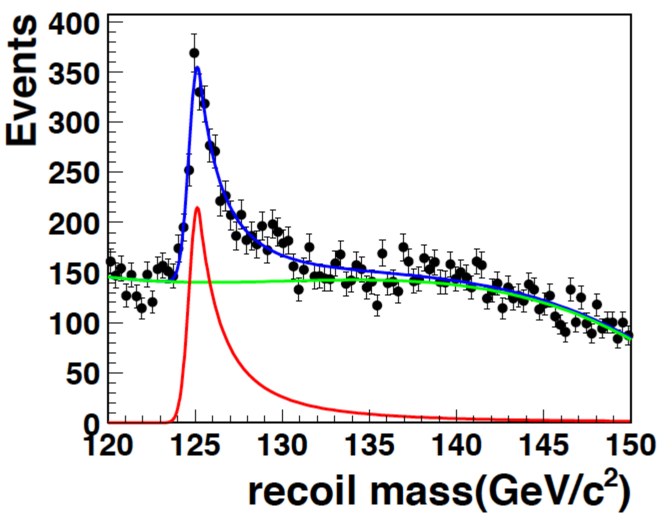


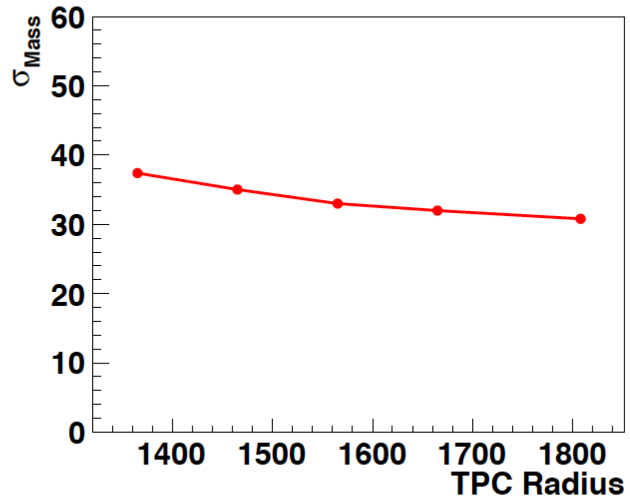
More details: CEPC Note, "Roadmap and Perspective of Higgs Measurement at CEPC"

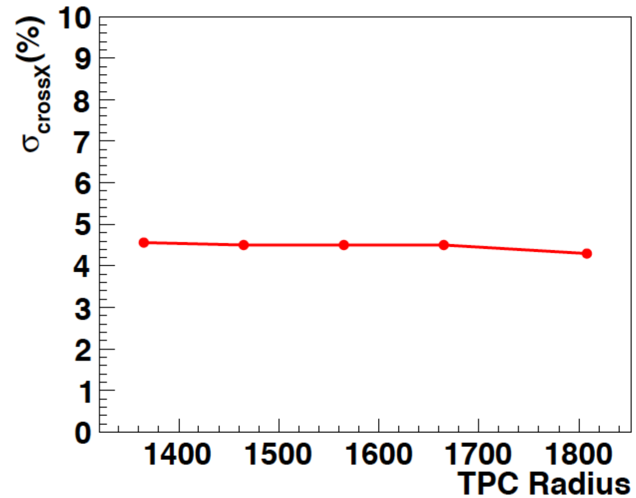
Yang ying: mass & Xsec measurement

- A combined study on physics analysis & Detector optimization
  - Reproduce ILC result
  - Flexible FS tools developed, applied to different geometry, can also be applied to different beam condition, and other measurements (i.e, Br(H→μμ))
  - To be published

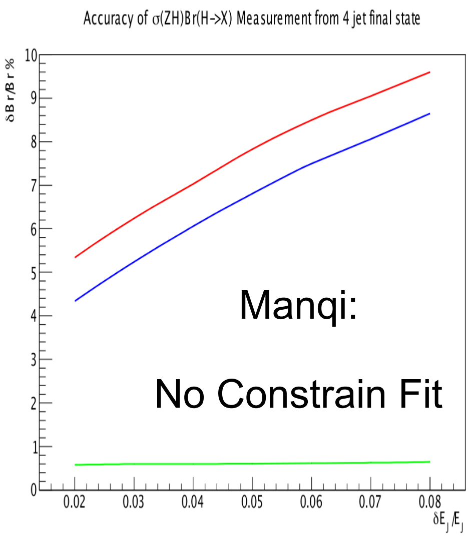


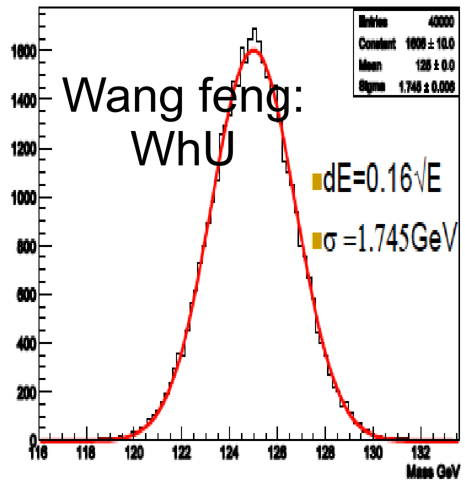


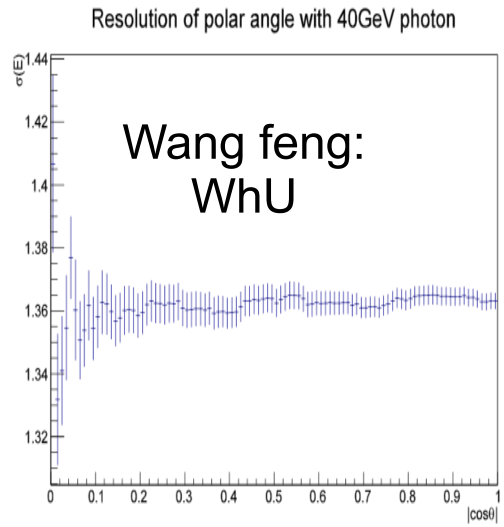


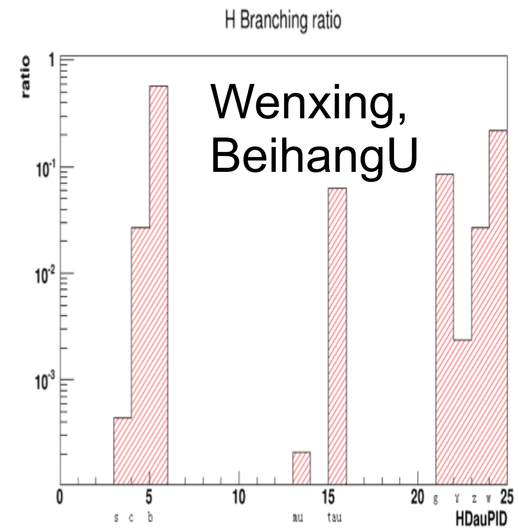


Ongoing Analysis and perspectives









Du chun(IHEP): generator development/comparison

- Cover most of the SM Higgs measurements at CEPC & a clear version of the landscape
  - ILC Studies provides a reliable starting point, however, limit by its own resource, there are loopholes in these studies
  - Cross checked with existing studies and filling these loop holes.
  - Limited by manpower & time, our analysis are mainly at FS level. Long termly, we should be able to performance every analysis at Full simulation level, with arbitrary detector geometry and beam condition.

Z & W measurements

- Numbers:
  - e+e-: 17 M Visible Z boson at LEP & 500k at SLC;
  - Many measurements are updated from Tevatron/LHC
  - $10^{10} – 10^{11}$ Z can be easily produced at CEPC: accuracy will be dominated by systematics – where a nature limit on the needed statistic arise
- Observables:
  - All LEP measurements (mass, width, Weinberg angle, A_{fb}, A_l, R_b, R_l...)
  - Neutrino generation: though Zγ events
  - Rare decays of Z and its daughters
  - α_S: though Ratio of 3-jet events to 2-jet events
  - W measurements (mass, width & g(ZWW))
- Zhijun Liang (ATLAS SM measurements convener) is investigating into the systematics and perspective at CEPC, including a comparison to existing results (PDG) and LHC expectation.

Zhijun: Perspective of Z pole measurements

Summary

Observable	LEP precision	CEPC precision
$A_{FB\ (b)}$	1.7%	0.15%
R^b	~0.3%	0.08%
N_ν (direct measurement)	1.7%	0.18%
R^{mu}	0.2%	0.05%
R^{tau}	0.2%	0.05%

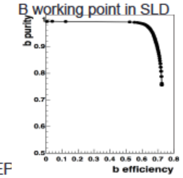
Assume Lumi(CEPC) >100 lumi(LEP)

Branching ratio (R^b)

$$\frac{\Gamma(Z \to b\bar{b})}{\Gamma(Z \to had)}$$

- LEP measurement 0.21594 ±0.00066
  - Stat error : 0.44%
  - Syst error : 0.35%
    - Charm mistag (0.2%)
    - Light jet mistag rate (0.2%)
    - Gluon radiation (g->bb , g->cc) (0.15%)

B working point in SLD



- CEPC
  - Expect 10~20% higher B tagging efficiency than LEF
    - In 95% B jet purity working
    - Reduce charm mistag and light jet mistag and hemi corrections systematics
  - Stat error (0.04%)
  - Syst error (0.07%)
    - Charm mistag (0.05%)
    - Light jet mistag (0.05%)
    - Gluon radiation (g->bb , g->cc) (0.1%)

Number of neutrino generation (N_ν)

- LEP measurement :
  - Indirect measurement (Z line shape method): 2.984+-0.008
    - Measured in Z peak region
    - No much room to improve
  - Direct measurement (neutrino counting method): 2.92+-0.05
    - Measured in 180~209 GeV runs
    - Using single photon + missing energy events
    - Stat error (1.7%)
    - Systematics (1.4%)
      - Photon Trigger efficiency (0.5%)
      - Photon Identification efficiency (0.5%)
      - Calorimeter energy scale (0.5%)

$$e^+e^- \to \nu\bar{\nu}\gamma.$$

- CEPC
  - focus on direct measurement
    - Need to consider Photon trigger in early stage
    - Trigger performance is key for this measurement
  - Measured in ZH runs (cms= 216GeV)
    - Stat error (0.1%)
    - Syst error (0.15%)
      - expected better granularity in calorimeter can help photon identification
      - Photon Trigger efficiency (0.1%)
      - Photon Identification efficiency (0.1%)
      - Calorimeter energy scale (<0.05%)

Backward-forward asymmetry measured from b jet

$$A_{FB}^{b\bar{b}}(0)$$

- LEP measurement : 0.1000+-0.0017 (Z peak)
  - Stat error: ~1.2% (4 experiments)
  - Systematics: ~1.4% (combination of three methods)
    - Method 1: Soft lepton from b/c decay (~2%)
      - Branching rate of b/c decay into lepton (1.5%)
      - B-tag and jet charge (1.1%)
      - Lepton pT and lepton Identification (0.9%)
    - Method 2: jet charge method using Inclusive b jet (~1.2%)
      - B-tag efficiency (0.4%)
      - charge correlations due to B tag/ jet charge (0.1%)
      - Sample statistics in light/heavy flavor jet sample (0.74%)
    - Method 3: D meson method (>8%, less important method)
- CEPC
  - Should focus on inclusive b jet measurement
    - Expected Stat error (0.1%) (>100 times of LEP stat)
    - Expected Systematics (0.12%) :
      - B-tag efficiency (0.1%)
      - charge correlations due to B tag/ jet charge (0.05%)

Branching ratio (R^{mu})

- LEP result: 0.2% total error
  - Stat : 0.15%
  - Syst : 0.1%
    - Radiative events (Z->μμγ) - > (0.05%)
    - Photon energy scale (0.05%)
    - Momentum scale - > 0.009%
    - Momentum resolution -> (0.005%)
- CEPC : 0.05% total error expected
  - Better EM calorimeter is the key
  - Stat: 0.01%
  - Syst: 0.05%
    - Radiative events (Z->μμγ) - > (0.05%)
    - Photon energy scale (0.01%)
    - Momentum scale - > 0.003%
    - Momentum resolution -> (0.003%)

Branching ratio (R^{tau})

- LEP result: ~0.2% total error
  - Stat : 0.15%
  - Syst : 0.17%
    - Tau selection efficiency : 0.08%
    - Consistency of analysis cuts in different dataset: 0.11%
    - Background (Bhabha events ...): 0.08%
      - BG Modelling is not good
- CEPC result:
  - Stat (0.01%)
  - Syst (0.04%)
    - Expect better BG MC modelling , no consistency issue
    - Tau selection efficiency : 0.03%
    - Background (Bhabha events ...): 0.03%

CEPC: comparison of performances

- With ILC
  - \+ Possible synergy:
- With Photon Collider(s):
  - A natural plug-in for liner collider, physics potential is limited comparing to e+e- machine
- With LHC
  - Tech. Notes at LHC...
  - In the future: develop CEPC statistic tool from existing LHC tools (MingShui Chen)

JP. Tian synergy with ILC500

coupling $\Delta g/g$	benchmark		full program	
	500 fb^{-1}	+ILC500	10 ab^{-1}	+ILC500
HZZ	1.15%	1.04%	0.26%	0.26%
HWW	5.02%	1.16%	1.12%	0.41%
Hbb	5.12%	1.53%	1.14%	0.57%
Hcc	6.09%	2.62%	1.36%	0.92%
Hgg	5.84%	2.19%	1.30%	0.82%
$H\tau\tau$	5.45%	2.17%	1.22%	0.71%
$H\gamma\gamma$	13.5%	7.71%	3.02%	2.74%
$H\mu\mu$	-		-	
Γ_0	11.0%	4.87%	2.46%	1.46%

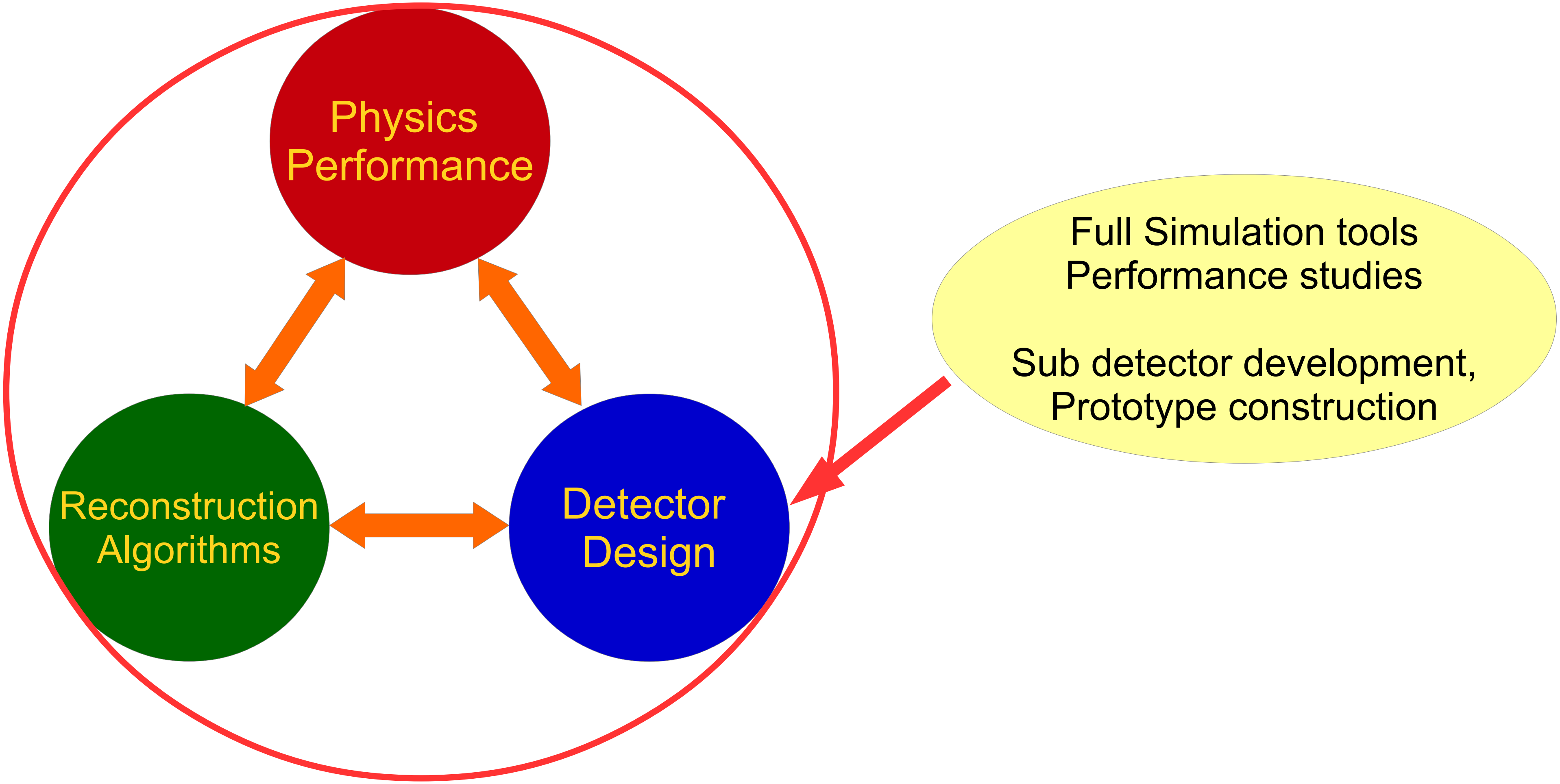
ILC500 baseline: 500 fb-1 @ 500 GeV, P(e-,e+)=(-0.8,+0.3)

will hit systematics @ full program, $g_{H\gamma\gamma}$ can be further improved by including HL-LHC

Physics performance of different Higgs factories: e^+e^- Vs. Photon collider

Manqi RUAN[a] Ning CHEN[b] Hongjian HE[b]
[a] *IHEP, Beijing, China*
[b] *TUHEP, Tsinghua University, Beijing, China*

Detector Design



From ILD to CEPC detector

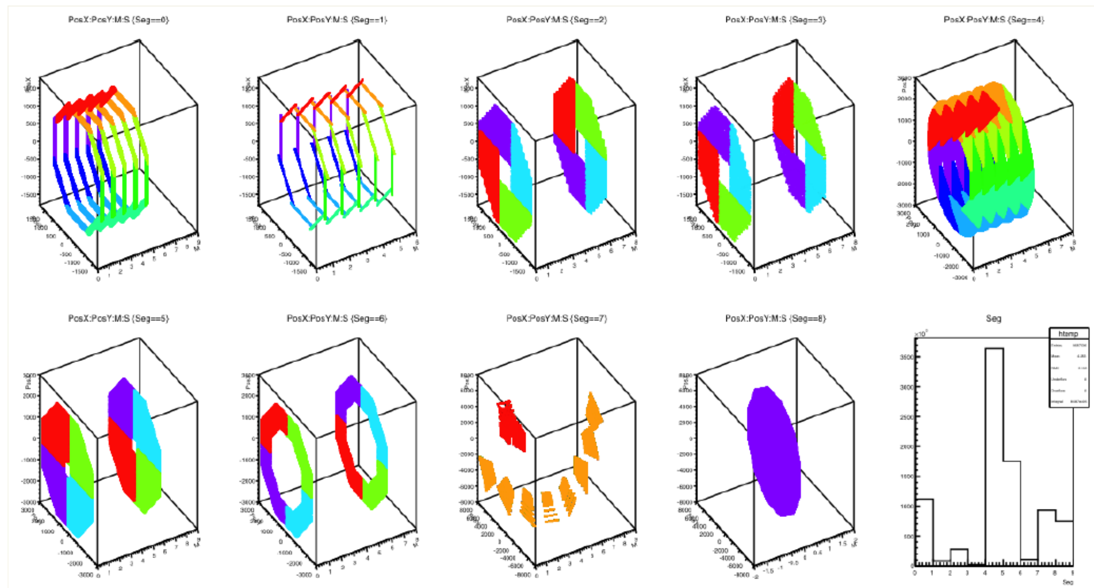
- Many new designs
  - Changed granularity (no power pulsing)
  - Changed L*
  - Changed VTX inner radius
  - Changed TPC outer Radius
  - Changed Detector Half Z
  - Changed Yoke/Muon thickness
  - Changed Sub detector design
  - …

Scale the detector size
&
Integrate our own design

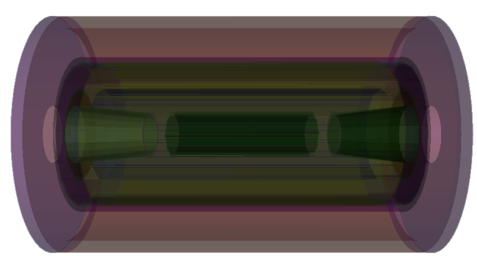
- All Changes need to be implemented into simulation, iterate with physics analysis (Fast – Full Simulation) and cost estimation

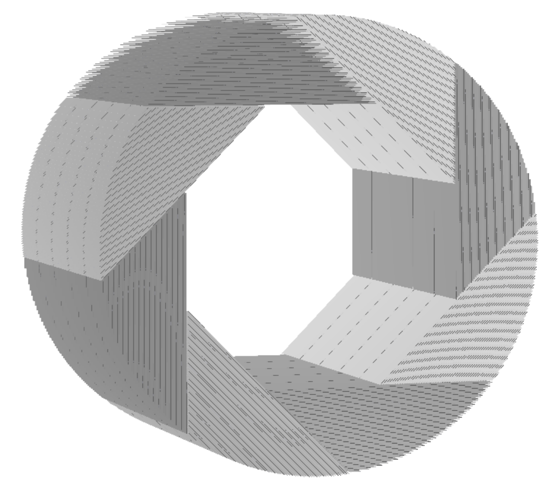
Detector simulation studies

- Center simulation support: Nankai U
  - Validation of New geometry: ILD V2 (TPC radius/length reduced by 25%, less longitudinal segments in Calo)
  - Cooperating with Ecole polytechnique (France)

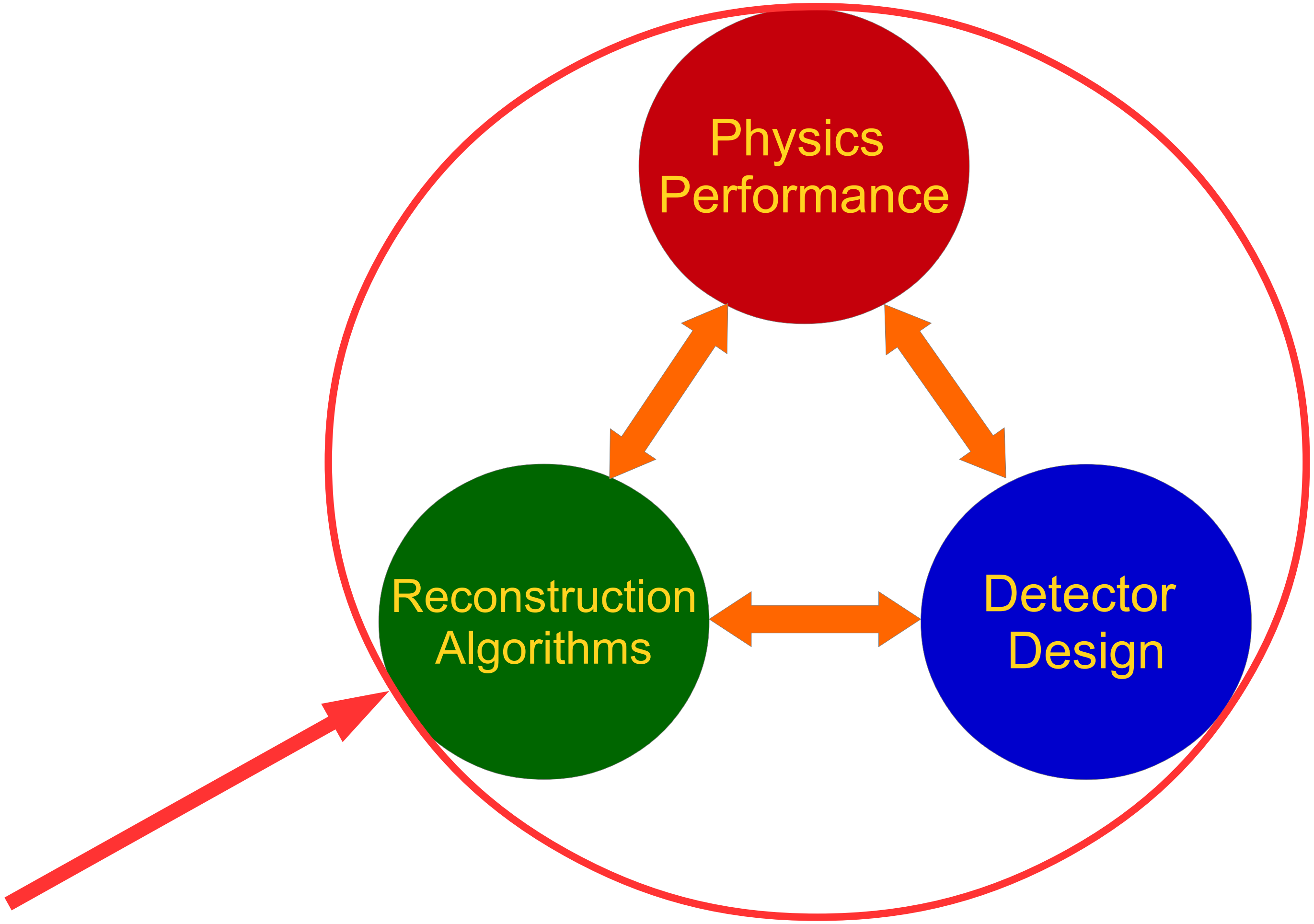


- Sub detector simulation
  - TPC: UCAS (binglong Wang)
  - VTX: SDU (Qingyuan Liu)
  - Calo: SJTU
- Sub detector performance studies
  - Charged particle: IHEP (finished)
  - Neutron hadron: SJTU
  - Photons: WhU & IHEP (Feng Wang)



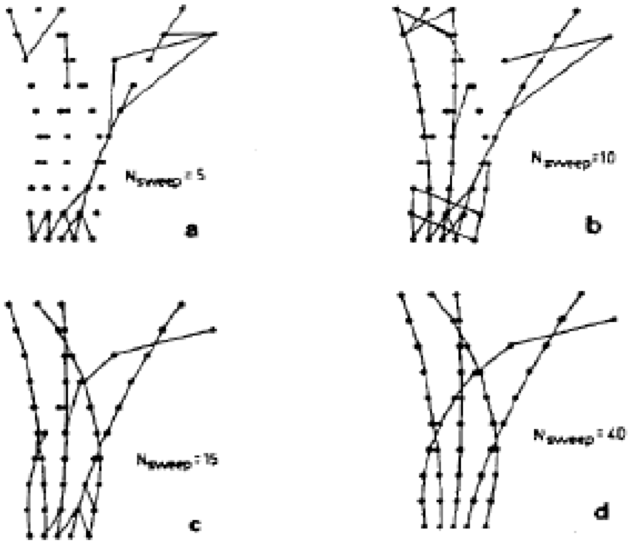


Reconstruction chain developments



Reconstruction Algorithms: Status

- Solid starting point: ILD reconstruction chain
  - Tsinghua: Track reconstruction for LCTPC
  - IHEP: PFA & Calorimeter reco-algorithm development
- A long wish list:
  - Calorimeter Cluster Pattern Identification
  - Particle identification, especially lepton ID
  - Cluster energy estimation
  - Track-Clustering match, track hierarchic
  - Tau tagging algorithm, Jet clustering
  - …



Tracking algorithm: B. Li

- Advanced Analysis Algorithms: progressing well
  - Shower Fractal Dimensional Analysis, published at PRL (112.012001)
  - ...

Arbor
Tree Topology

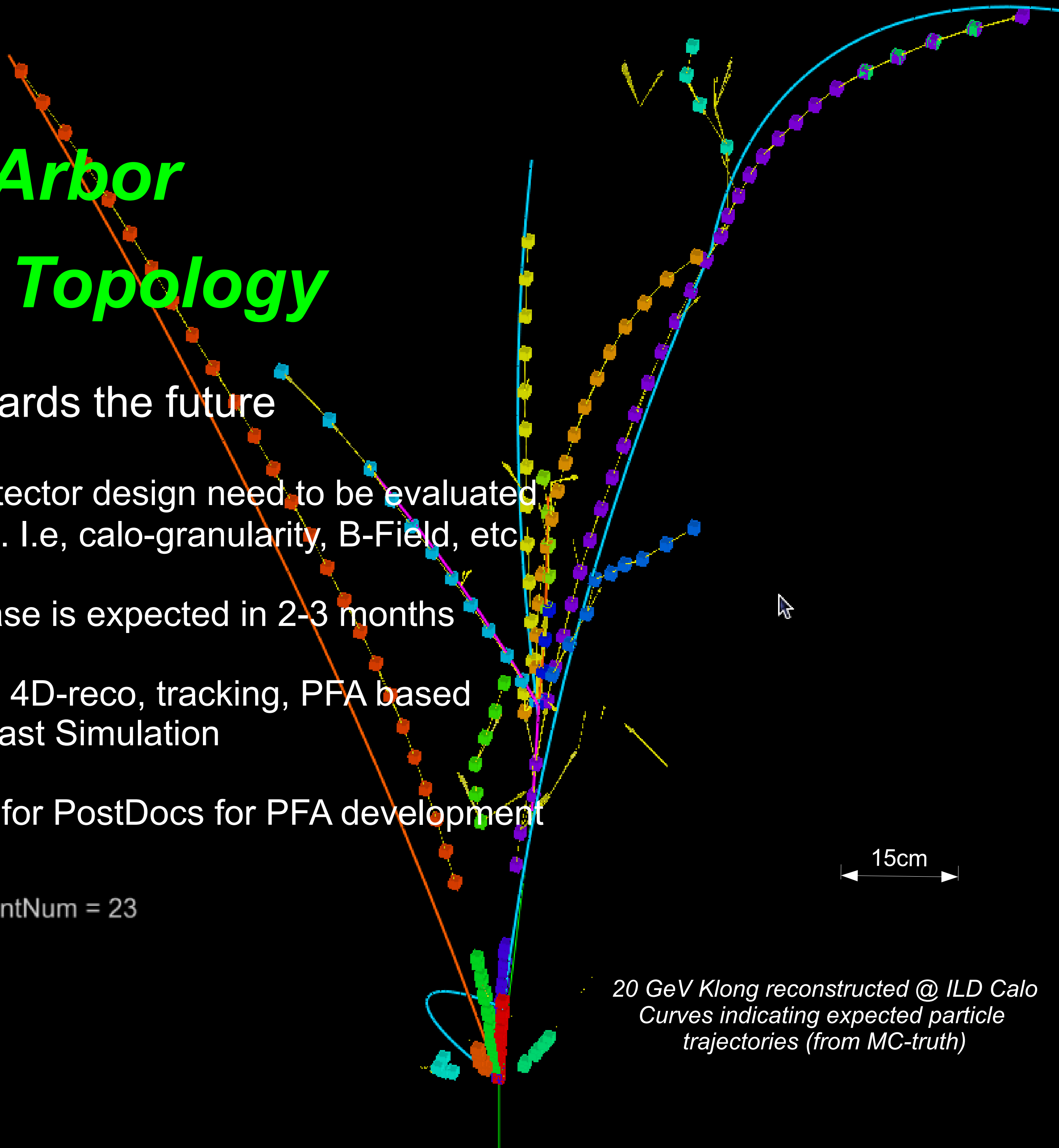
Towards the future

URGENT task: detector design need to be evaluated by PFA performance. I.e, calo-granularity, B-Field, etc

A workable release is expected in 2-3 months

Lots of new ideas: 4D-reco, tracking, PFA based Fast Simulation

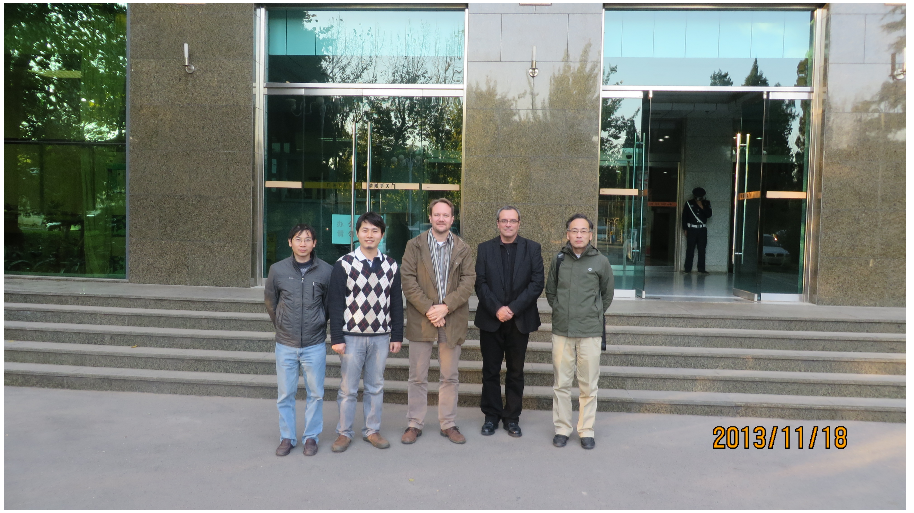
I'm (always...) looking for PostDocs for PFA development



20 GeV Klong reconstructed @ ILD Calo
Curves indicating expected particle trajectories (from MC-truth)

International cooperations

- With France (FCPPL +)
  - Ecole polytechnique:
    - Joint Ph.D program
    - Short term visiting
    - Calorimeter R & D
    - Full Simulation support
  - CEA: TPC
    - Physics analysis and TPC design



- With Japan (KEK)
  - Sample sharing: Generator & Simulated with ILD
  - Documents
  - Short term visit, communications
- With CERN: discussing/communication with TLEP
- … with Argonne, IPNL, Strasbourg...

Summary: Perspective for pre-CDR

- SM Measurements:
  - Higgs (understood): consistent with ILC results, ~1/2 of the measurements will be updated with our loophole filling efforts
    - mH, sigma(ZH), sigma(vvH), Br($H \to \mu\mu$), Br($H \to \gamma\gamma$), Br($H \to WW^*$), Br($H \to ZZ$)
  - Z & W (initialized): Investigate the systematic error, estimate the performance at a point with a reasonable statistic
- To be determined:
  - With theory group: BSM benchmark observables and theory landscape
  - With accelerator: Machine environment, luminosity, MDI
- G4 Detector Simulation:
  - Mature simulation tool + good support
  - We are studying detector design – performance
  - Sub-detector design: to be developed & integrated

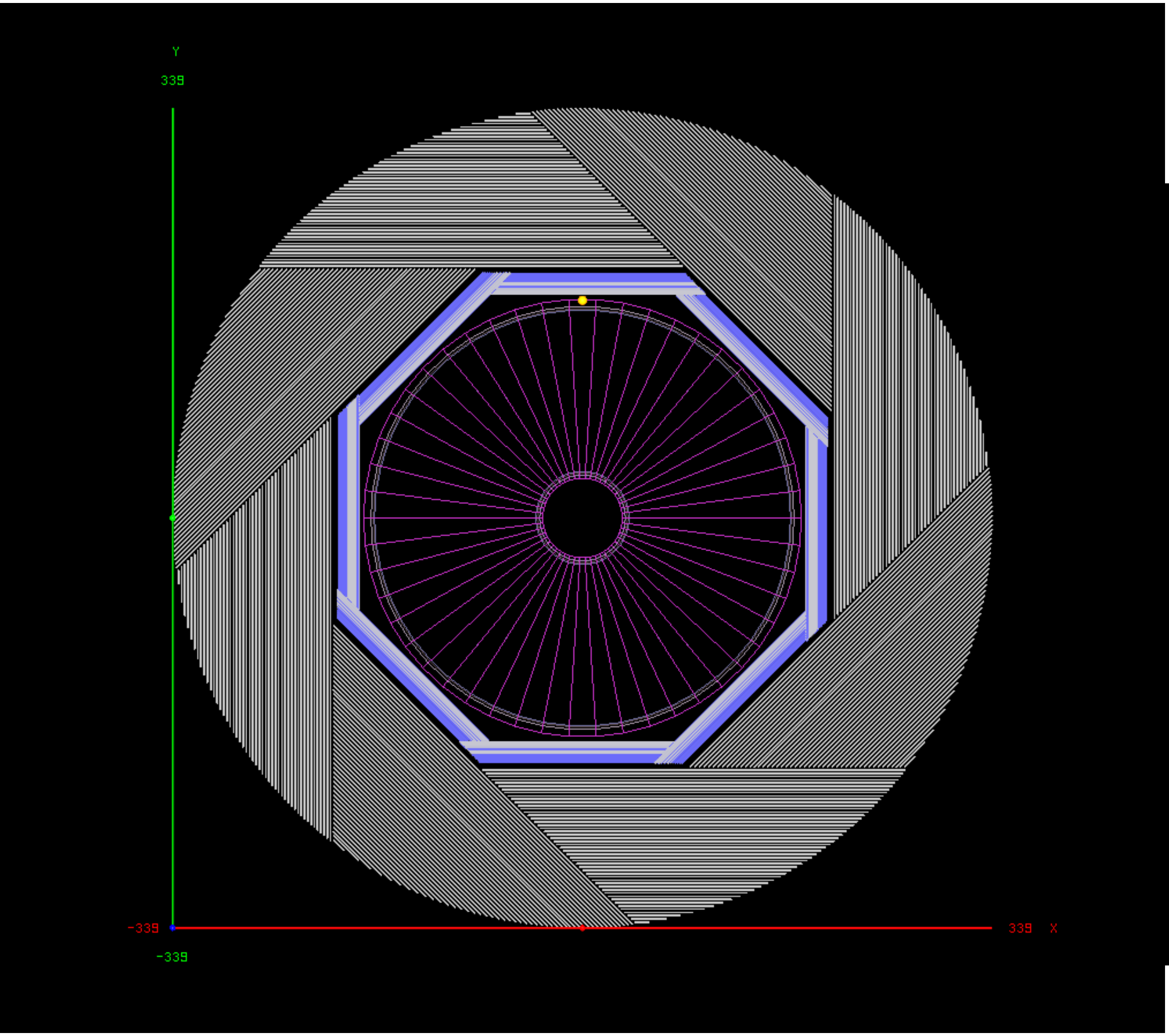
Summary: working plan

- Tool preparation & Team building
  - Limited by man power, our study depends on ILC samples and fast simulation tool
  - Long termly (TDR level):
    - Full simulation (with **our** geometry) +
    - Full Reconstruction (with **our** PFA tools) +
    - All benchmark observables (SM + BSM, **our** generator)
  - Need series of tool development & lots of man power
    - *Generator:*
      - *Not urgent, but important for long term studies (esp. toward pp phase, communication started)*
    - *Geant 4 Full Simulation:*
      - *Mature framework + support from NankaiU & Ecole polytechnique*
    - *Fast Simulation: Toward a generic, PFA based fast simulation tool*
    - ***Reconstruction**: Urgent, well progressing*

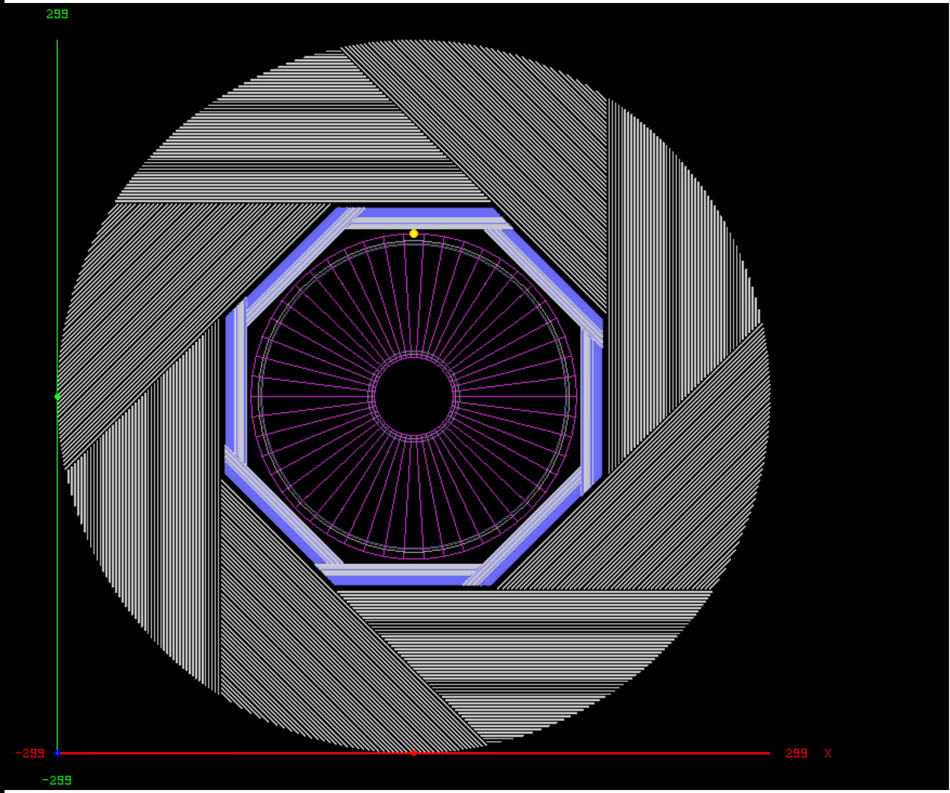
Thank you!

Back up

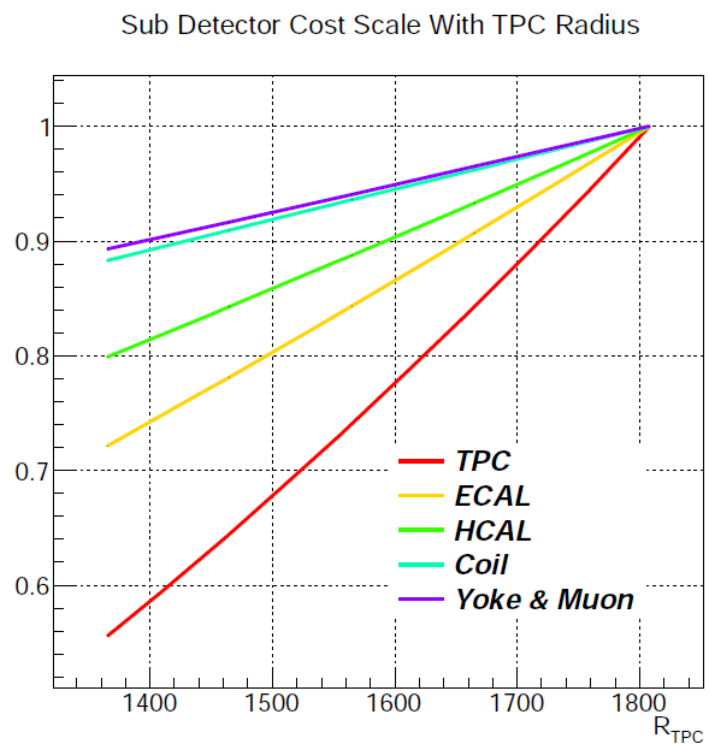
Design new geometry

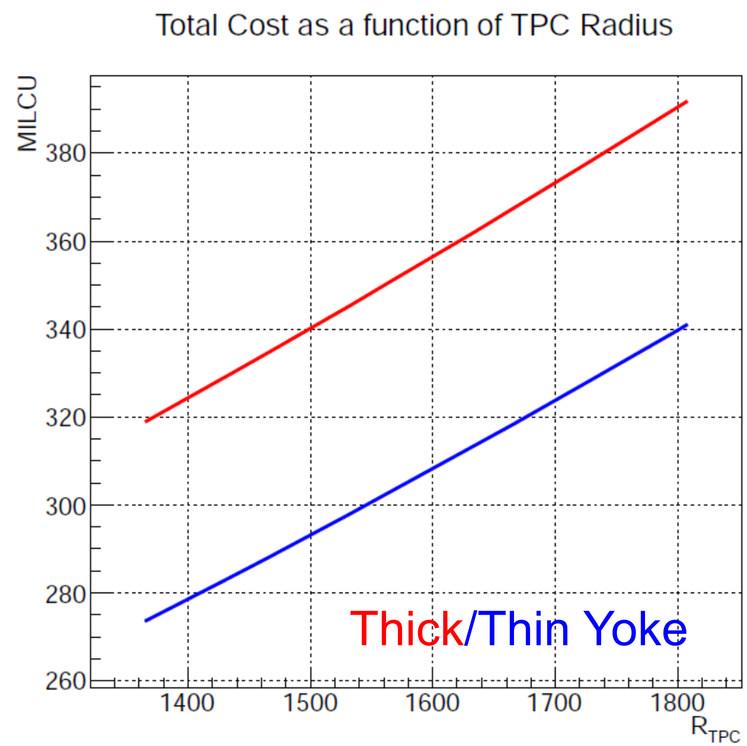


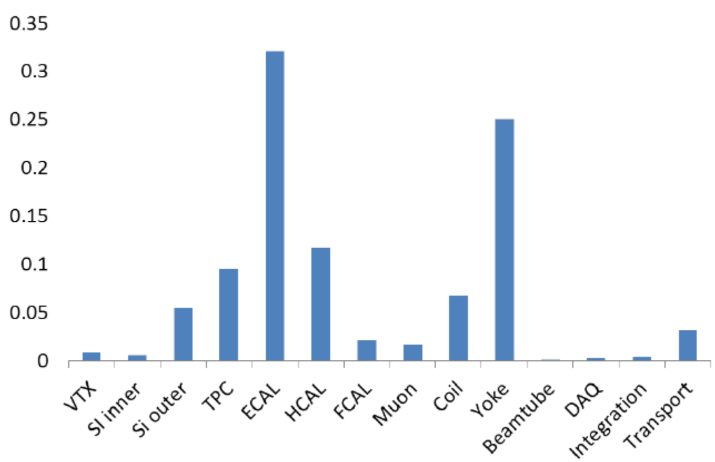
Reduce TPC Radius by 25%
Why not?



Cost estimation: extrapolate from ILD







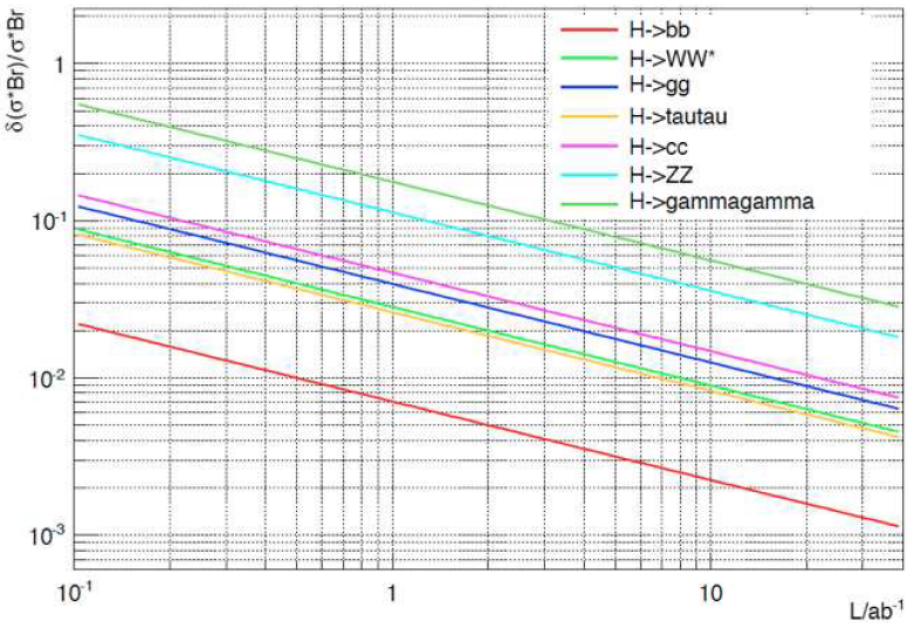
ILD Cost ~ 400 MILCU
CEPC detector ~ 270 MILCU
~ 1.6 Billion CNY
~ 3 B CNY for 2 detectors;

Without manpower

Expected performance: extrapolate from ILC

Scale the signal and all the background accordingly

	ILC, $250 fb^{-1}$, $P = (-0.8, 0.3)$	CEPC, $500 fb^{-1}$, $P = (0, 0)$
m_H/MeV	29 MeV	25 MeV
$\sigma(ZH)$	2.6%	2.3%
$\sigma(ZH) \times Br(H \to b\bar{b})$	1.2%	1.0%
$\sigma(ZH) \times Br(H \to WW^*)$	6.4%	4.0%
$\sigma(ZH) \times Br(H \to gg)$	7.0%	5.6%
$\sigma(ZH) \times Br(H \to \tau^+\tau^-)$	4.2%	3.7%
$\sigma(ZH) \times Br(H \to c\bar{c})$	8.3%	6.6%
$\sigma(ZH) \times Br(H \to ZZ^*)$	19%	16%
$\sigma(ZH) \times Br(H \to \gamma\gamma)$	29-38%	25%
$\sigma(ZH) \times Br(H \to \mu\mu)$	-	to be investigate
$\sigma(ZH) \times Br(H \to Invisible)$	0.95%	0.8%
$\sigma(\nu\nu H) \times Br(H \to b\bar{b})$	10.5%	12%



- A reliable starting point. However
  - CEPC machine environment/detector design are different from ILC
  - Limited by resource, many ILC studies have loopholes, some are also extrapolated (CEPC Note: Roadmap and perspective of Higgs Measurement at CEPC)
  - Our priority: loophole tagging/filling, team building & tool development (with capability and flexibility to carry on all these studies at full simulation level in middle – long term)

Why an e$^+$e$^-$ Higgs factory

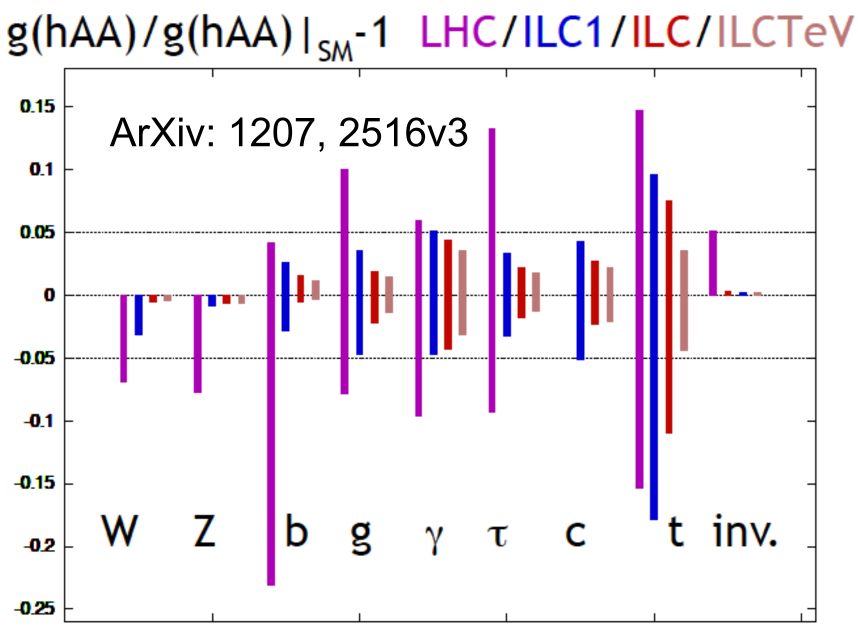
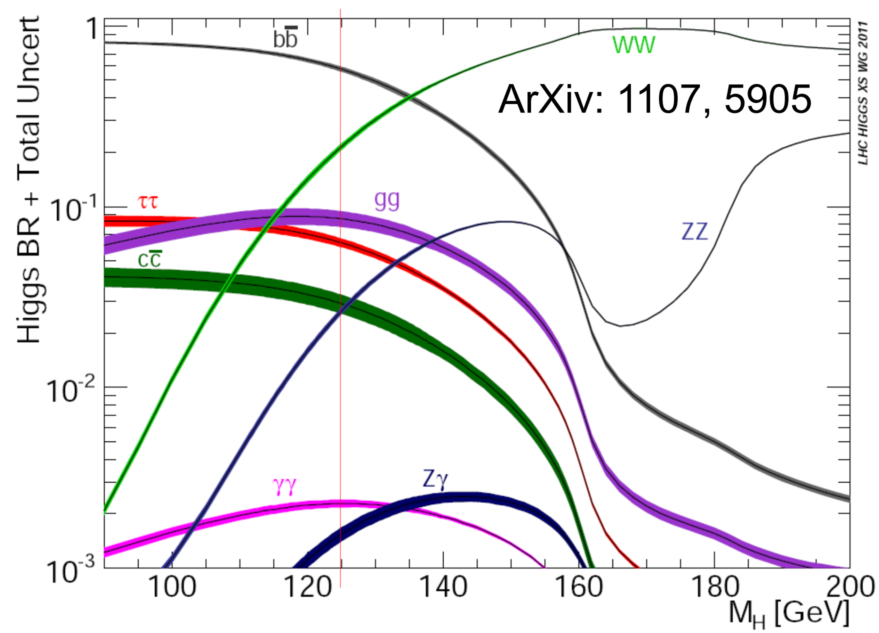


Figure 2: Comparison of the capabilities of LHC and ILC for model-independent measurements of Higgs boson couplings. The plot shows (from left to right in each set of error bars) 1 σ confidence intervals for LHC at 14 TeV with 300 fb^{-1}, for ILC at 250 GeV and 250 fb^{-1} ('ILC1'), for the full ILC program up to 500 GeV with 500 fb^{-1} ('ILC'), and for a program with 1000 fb^{-1} for an upgraded ILC at 1 TeV ('ILCTeV'). More details of the presentation are given in the caption of Fig. 1. The marked horizontal band represents a 5% deviation from the Standard Model prediction for the coupling.

SM Higgs Branching ratio



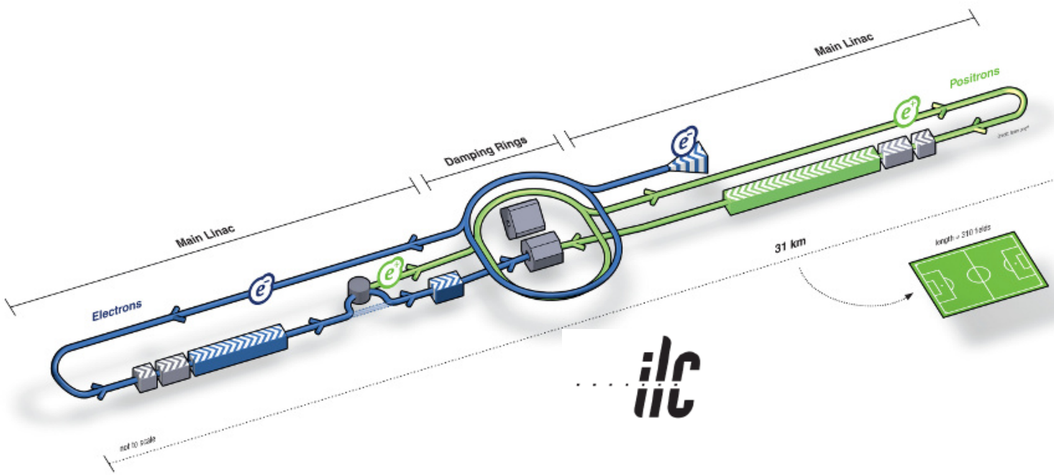
Bb: 58%; WW, 21%; gg, 9%; ττ, 6%; cc, 3%; ZZ + others, 3%

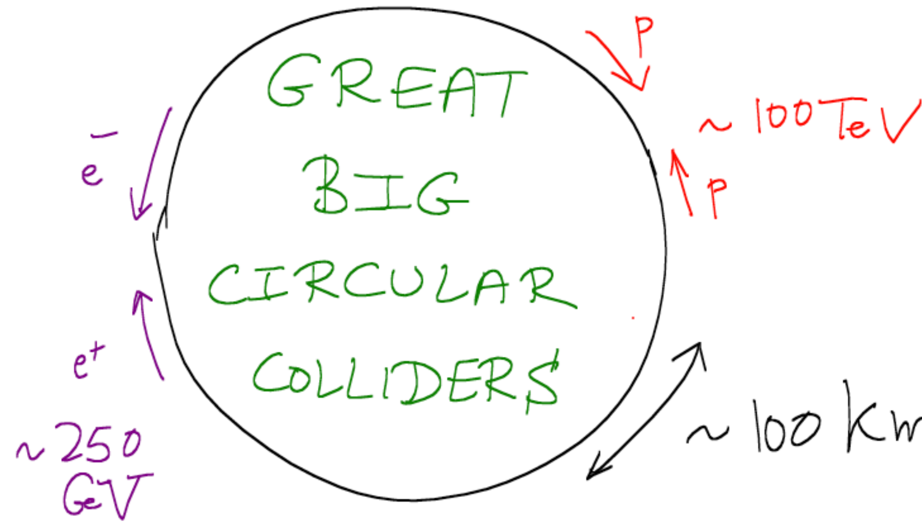
Precisely verify the standard model – searching for possible new physics
Higgs couplings must be measured to at least 10% to reveal TeV scale new physics

$$\frac{g_{HXX}}{g_{HXX}^{SM}} \approx 1 + \delta \times \left(\frac{1\,\mathrm{TeV}}{\Lambda_{\mathrm{NP}}}\right)^2$$

LHC: high productivity, no tagging signal, huge backgrounds & systematics.
Ultimate precision in Higgs coupling limited
e$^+$e$^-$ machine: low background – triggerless mode, precisely known/adjustable initial state, allowance of model independent measurement...
a precise Higgs factory must be a lepton machine (ILC/CLIC, TLEP/FCC, **CEPC**...)

Higgs factory: Linear or Circular

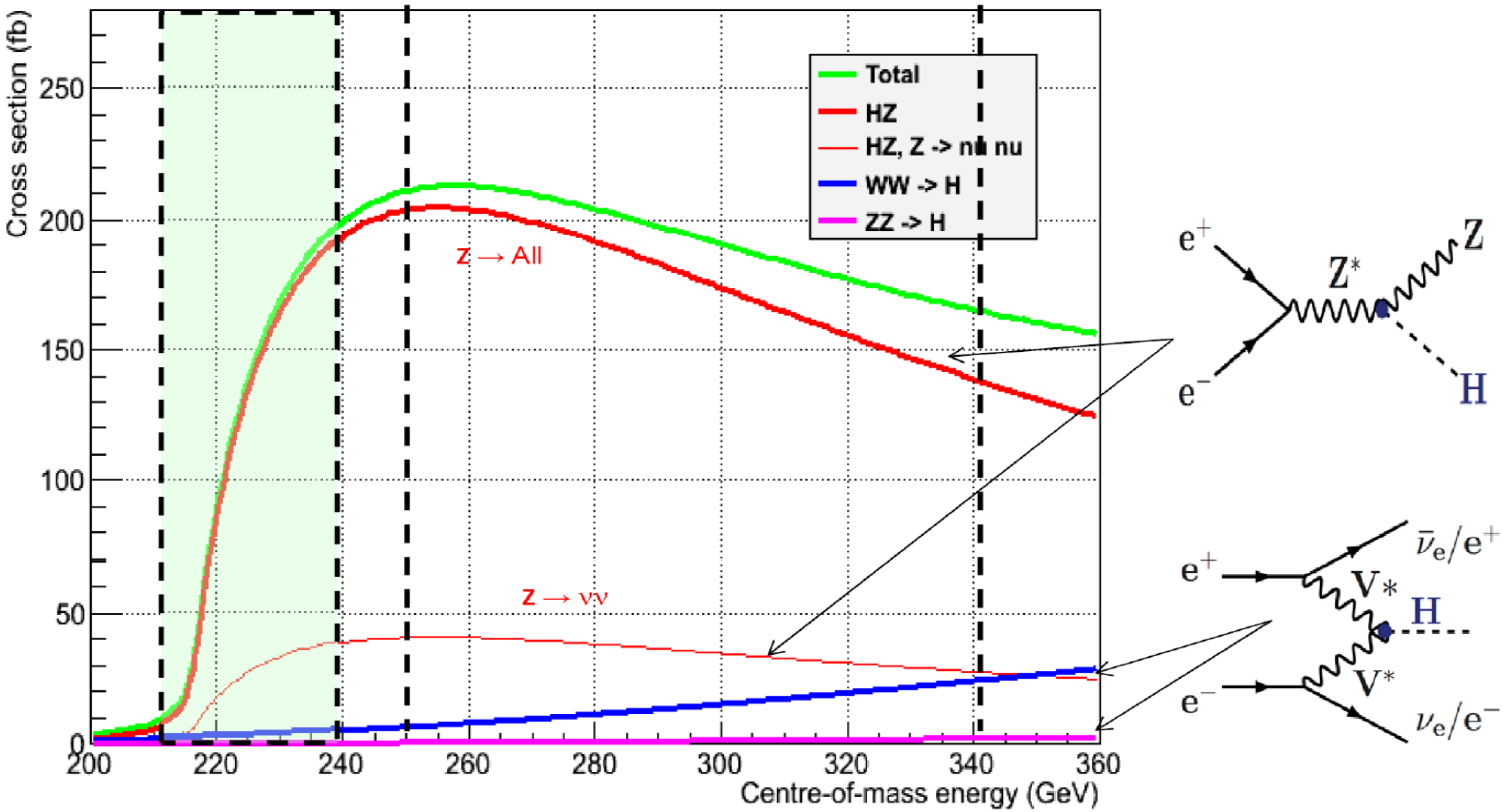




	Linear: ILC, CLIC	Circular: CEPC, TLEP, FCC
Pro	C.o.M energy can be upgraded to 1-3 TeV Longitudinal polarized beam Power pulsed detector	Cost-efficient, mature technology Multiple interaction point High luminosity & beam quality
Con	Expensive (~ 8 – 10 B euros) Single interaction point, might need push-pull	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...

Higgs productivity at e^+e^- machine



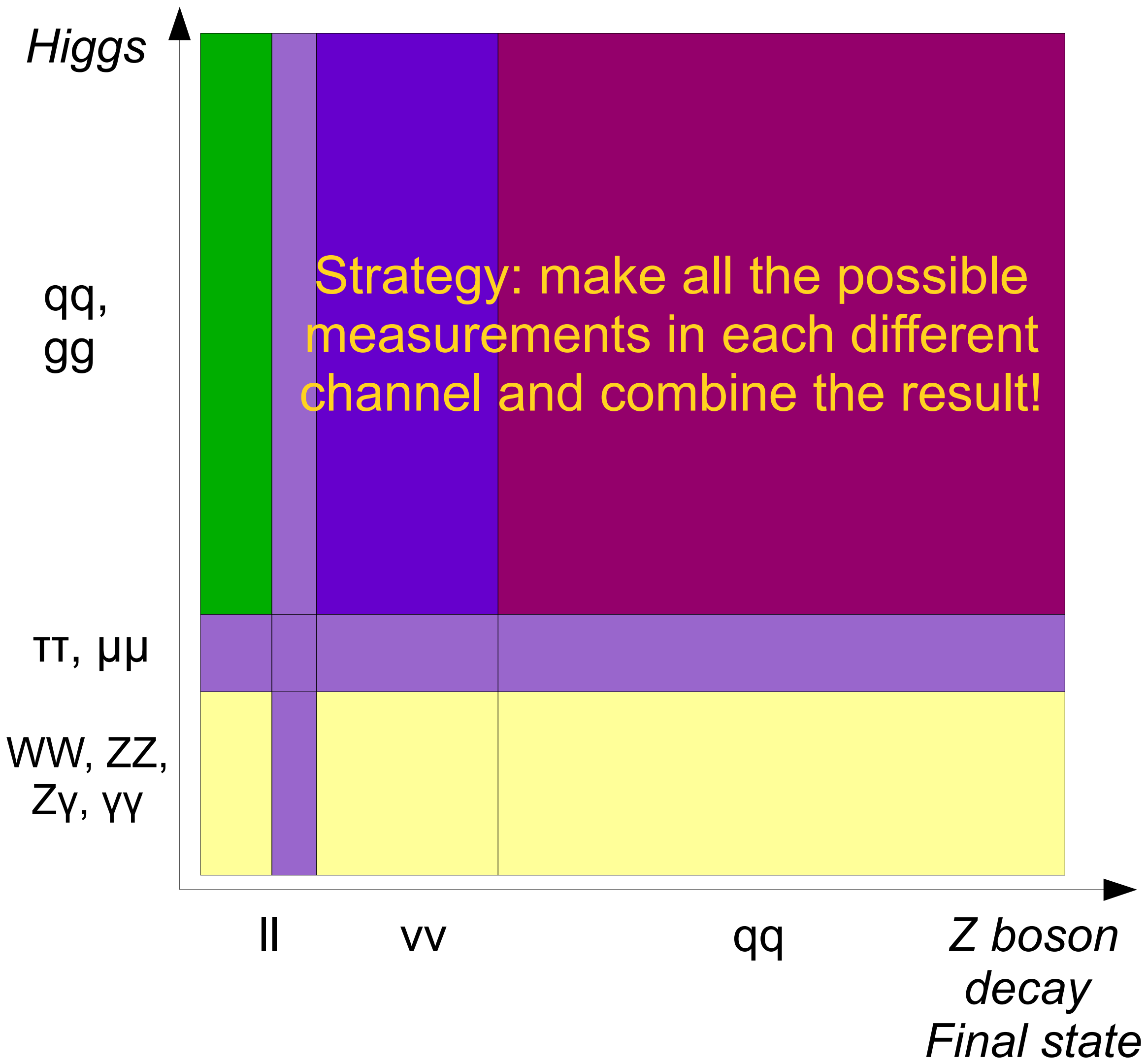
σ(HZ, 240 GeV) ~ 200fb with non-polarized beam

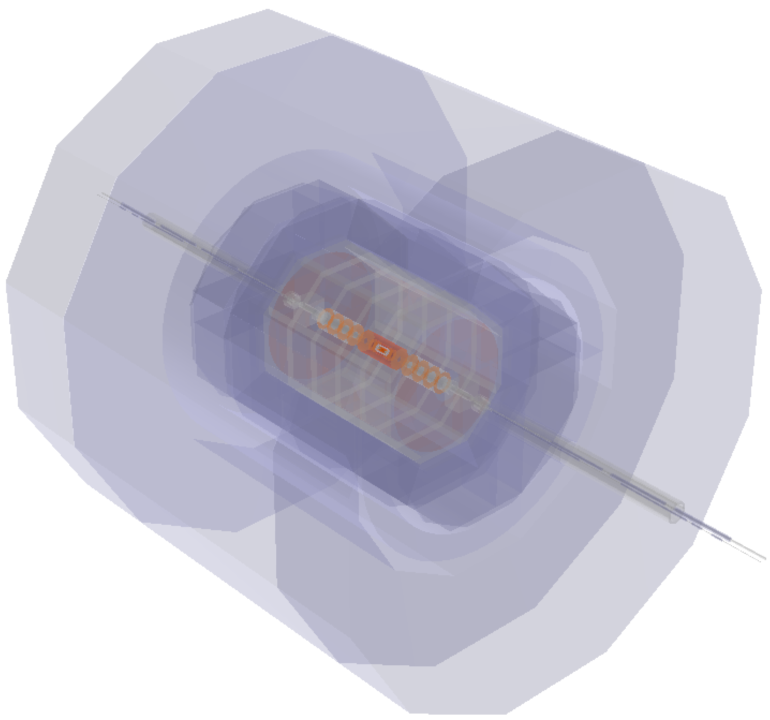
L $\sim 10^{34}$ $cm^{-2}s^{-1} \sim 100fb^{-1}/y$ ： Nominal luminosity $500fb^{-1}$ ~ 10^5 Higgs/IP

Benchmark: 100 k Higgs, but can be (largely) increased

Beam polarization can enhance the Higgs productivity by ~ 50% at ILC, and reduce the SM Background at the same time. However, it's not crucial for Higgs measurement

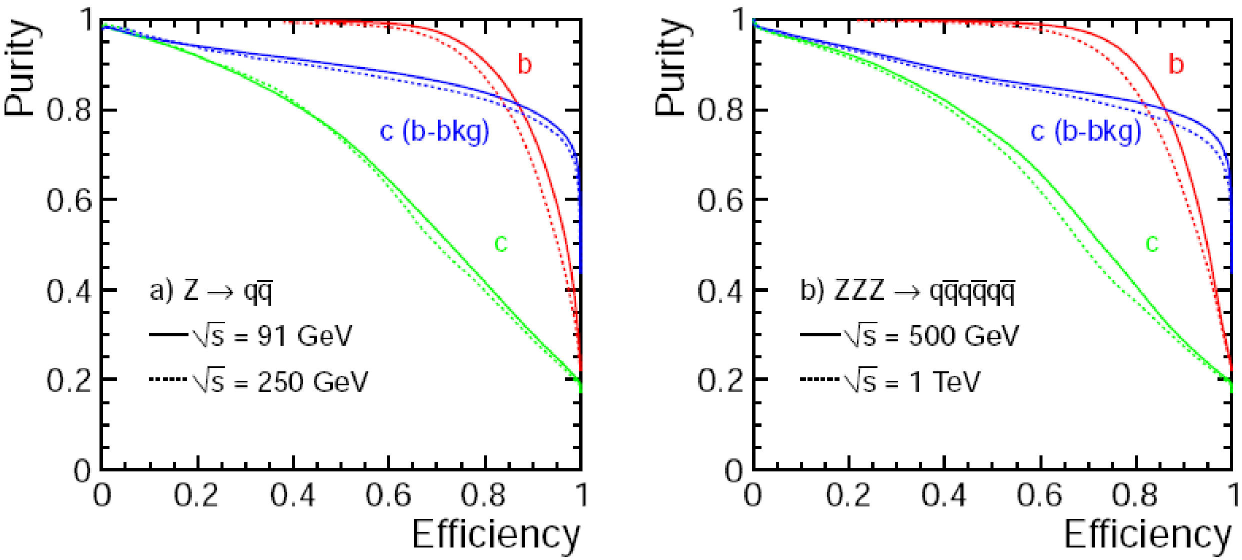
ZH event: requirement on detector

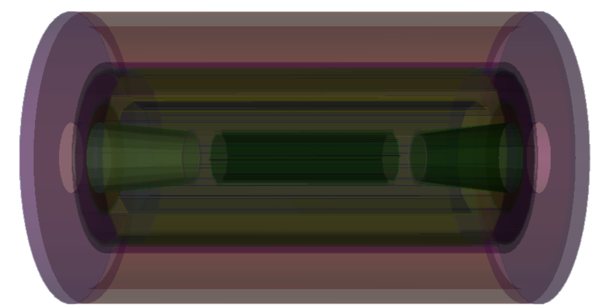




Sub detector & performance: VTX

b Vs udsc; c Vs b; c Vs udsb





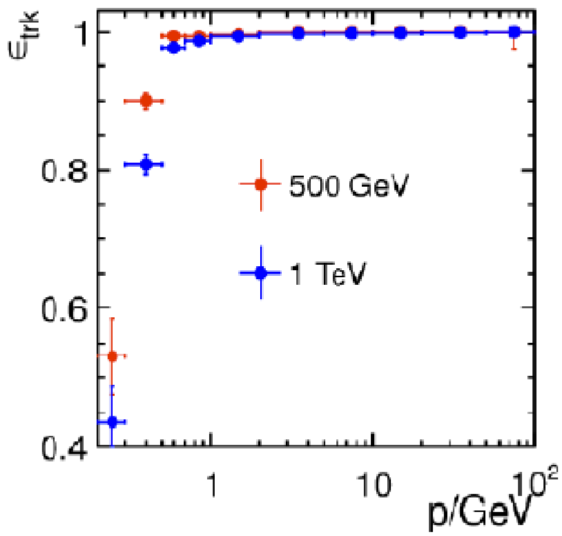
VTX detector: spatial resolution ~ 5 μm, located with inner radius of 15 mm

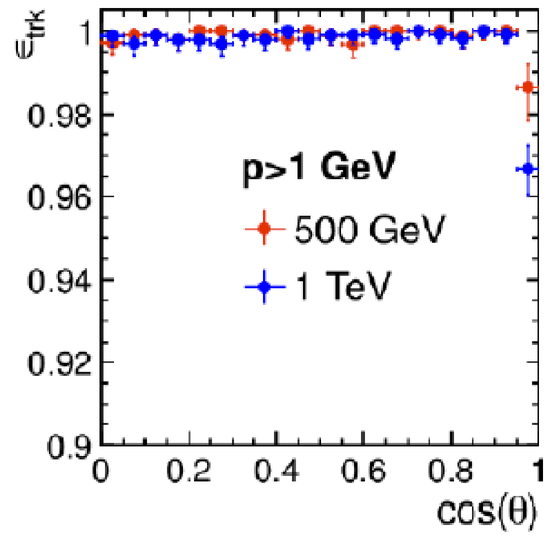
Flavor tagging performance:

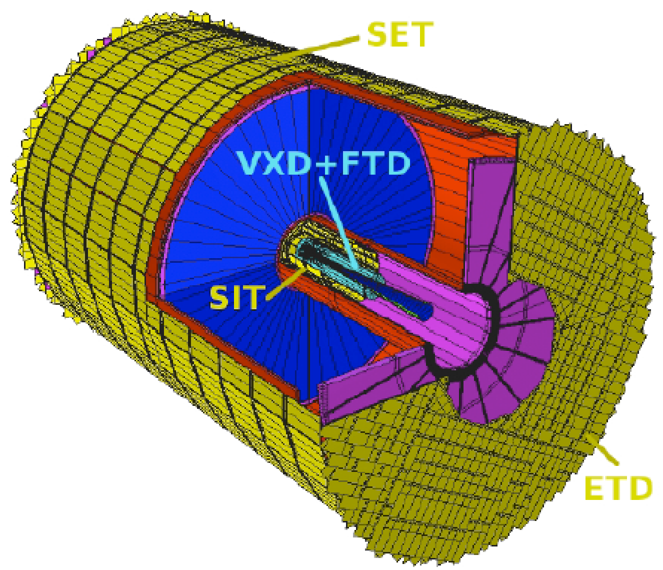
- Eff = 80%, purity > 90% for b-tagging
- Capability for c tagging

Algorithm: LCFIPlus, Tokyo University (Tomohiko Tanabe. etc)

Tracker





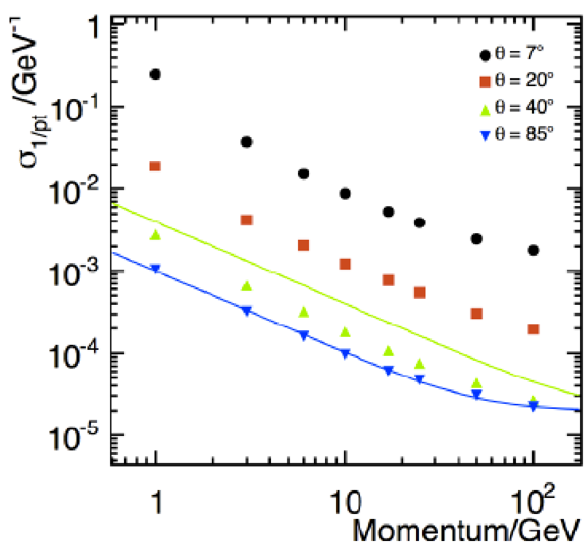


Tracking:

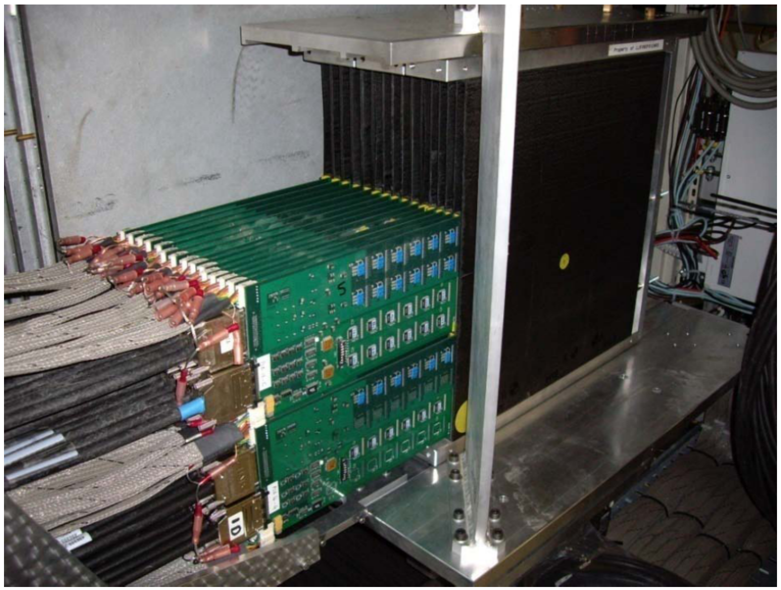
Barrel: TPC + Inner Silicon (VTX, SIT)
Forward: Front Tracking Disks;
Optional: External Silicon Tracker

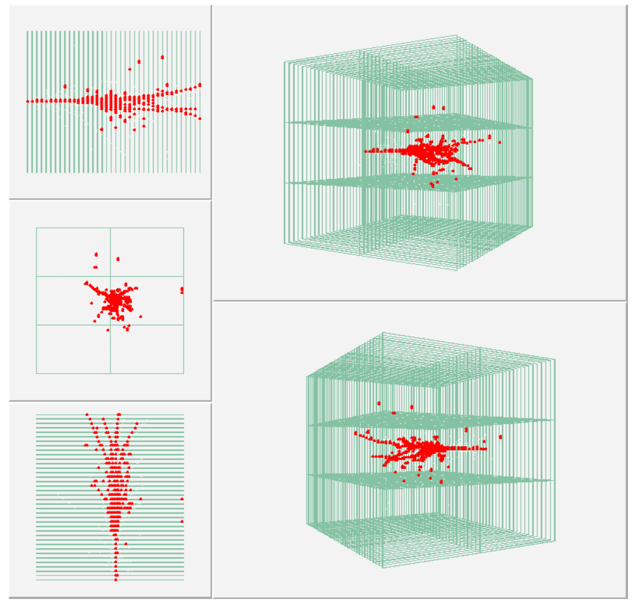
Performance: $\delta(1/P_T) \sim 2\text{-}5 * 10^{-5}(1/\text{GeV})$

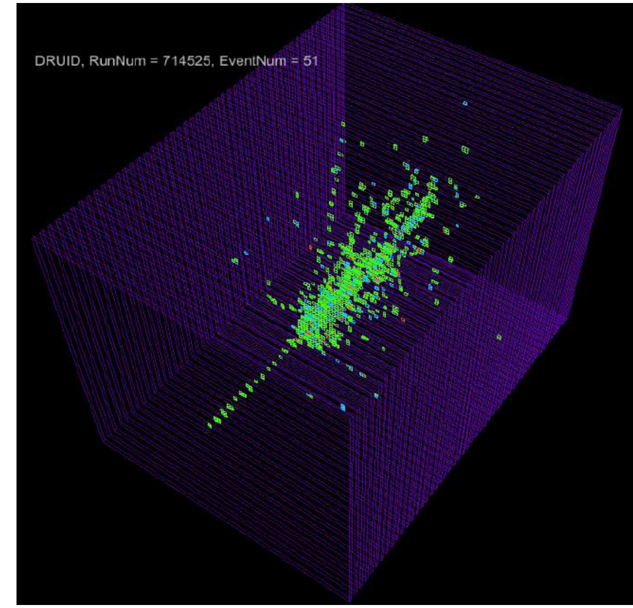
Algorithm: Clupatra, DESY (F. Gaede);
KalTest, KEK (K. Fujii), Tsinghua (B. Li)



Imagine Calorimeter

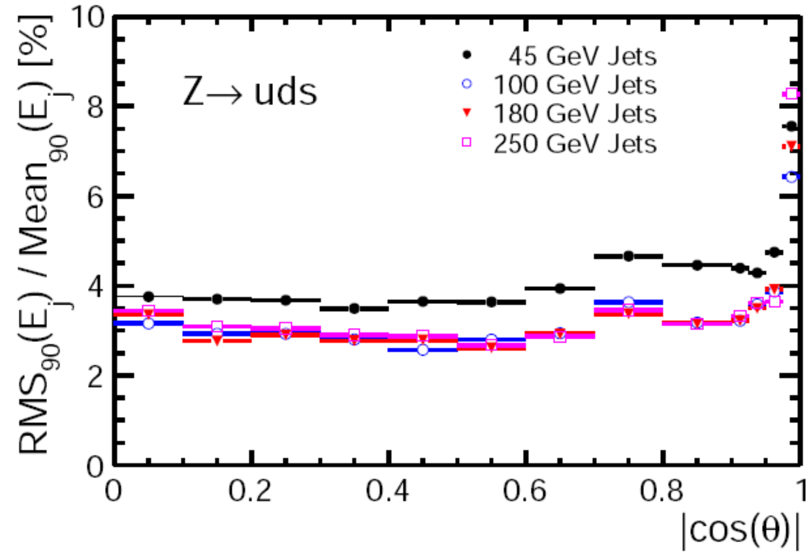






Ultra high granularity ~ 1 channel cm^{-3}.
3d, 4d or 5d image...

PFA： δEJ/E = 3 - 4%
Algorithms:
PandoraPFA, Cambridge (M. Thomson);
Arbor, LLR & IHEP(Manqi, Henri)



Higgs Measurement at ILD

ILC Higgs Measurement:

Well understood,

But for sure potential

to improve

	$\Delta(\sigma \cdot BR)/(\sigma \cdot BR)$				
$\sqrt{s}$ and $\mathcal{L}$	$250\,\text{fb}^{-1}$ at 250 GeV		$500\,\text{fb}^{-1}$ at 500 GeV		$1\,\text{ab}^{-1}$ at 1 TeV
(P_{e^-}, P_{e^+})	(-0.8,+0.3)		(-0.8,+0.3)		(-0.8,+0.2)
mode	ZH	$\nu\bar{\nu}H$	ZH	$\nu\bar{\nu}H$	$\nu\bar{\nu}H$
$H \to b\bar{b}$	1.2%	10.5%	1.8%	0.66%	0.32%
$H \to c\bar{c}$	8.3%	-	13%	6.2%	3.1%
$H \to gg$	7.0%	-	11%	4.1%	2.3%
$H \to WW^*$	6.4%	-	9.2%	2.4%	1.6%
$H \to \tau^+\tau^-$	4.2%	-	5.4%	9.0%	3.1%
$H \to ZZ^*$	19%	-	25%	8.2%	4.1%
$H \to \gamma\gamma$	29-38%	-	29-38%	20-26%	7-10%
$H \to \mu^+\mu^-$	-	-	-	-	31%
$H \to \text{Inv.}(95\% C.L.)$	$< 0.95\%$		-		-
$t\bar{t}H, H \to b\bar{b}$	-		28%		6.0%

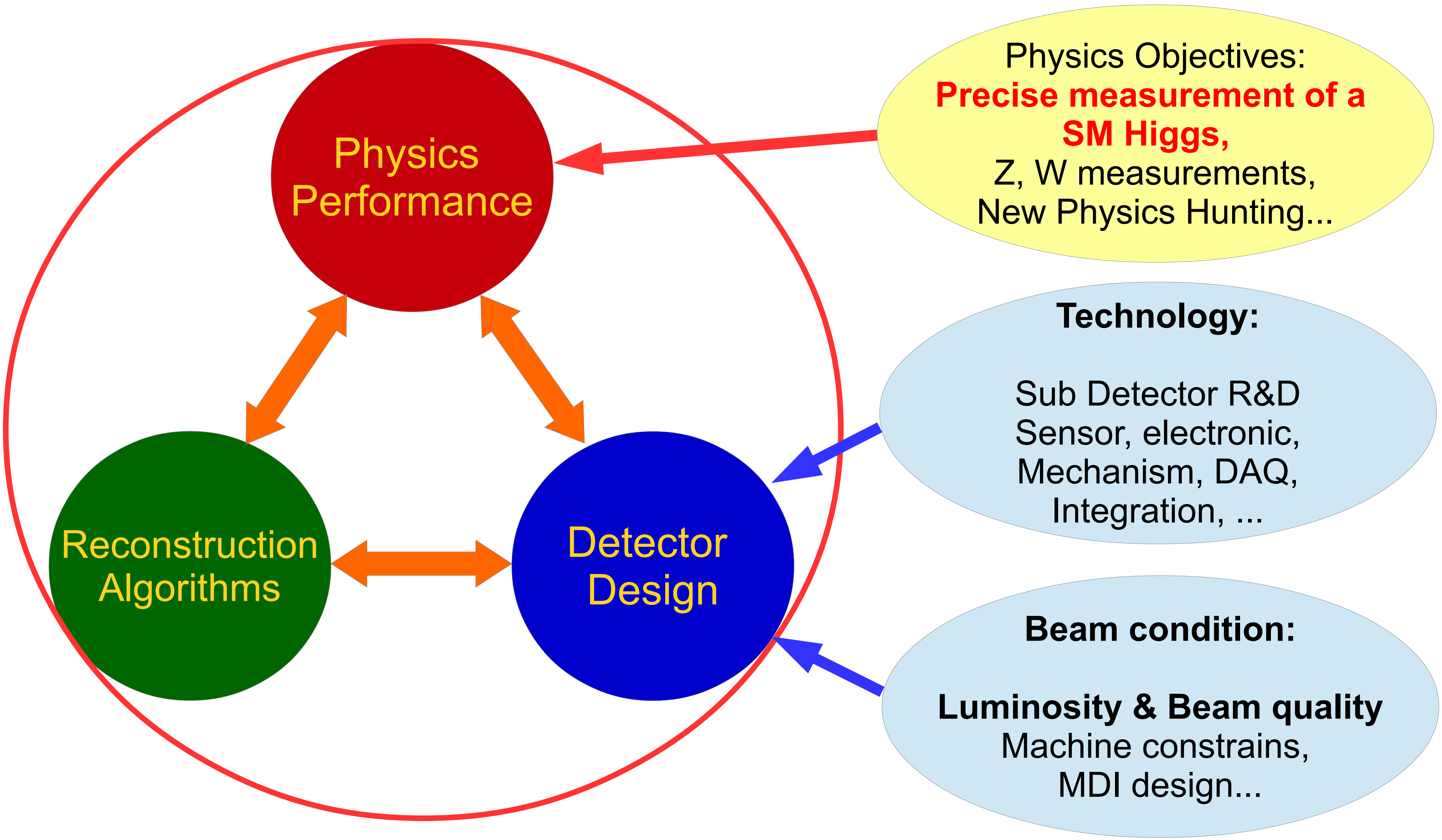
TABLE I: Expected accuracies for cross section times branching ratio measurements for the 125 GeV H boson by the canonical scenario.

couplings	250 GeV	250 GeV + 500 GeV	250 GeV + 500 GeV + 1 TeV
g_{HZZ}	1.3%	1.3%	1.3%
g_{HWW}	4.8%	1.4%	1.4%
g_{Hbb}	5.3%	1.8%	1.5%
g_{Hcc}	6.8%	2.9%	2.0%
g_{Hgg}	6.4%	2.4%	1.8%
$g_{H\tau\tau}$	5.7%	2.4%	1.9%
$g_{H\gamma\gamma}$	18%	8.4%	4.1%
$g_{H\mu\mu}$	-	-	16%
g_{Htt}	-	14%	3.2%
Γ_0	11%	5.9%	5.6%

TABLE II: Expected accuracies of Higgs couplings and total Higgs width by the canonical scenario.

J. Tian & K. Fujii
LC-REP-2013-021

Detector optimization: Basic ingredients



Kick-off @ Sep 2013

Training @ Oct 2013

Regular meetings, communications

Physics and Detector Meetings

November 2013

- 29 Nov CEPC Calorimeter Group Meeting 3rd New!
- 20 Nov CEPC Physics & Detector 5th New!
- 18 Nov - 19 Nov Franco-Chine Detector Discussing
- 15 Nov CEPC Tracking Group Meeting 2nd
- 07 Nov Simulation - Physics Analysis Meeting 1st
- 07 Nov CEPC Physics & Detector 4th
- 04 Nov CEPC Vertex Working Group Meeting 1st
- 01 Nov CEPC Tracking Group Meeting 1st
- 01 Nov CEPC Calorimeter Group Meeting 2nd

October 2013

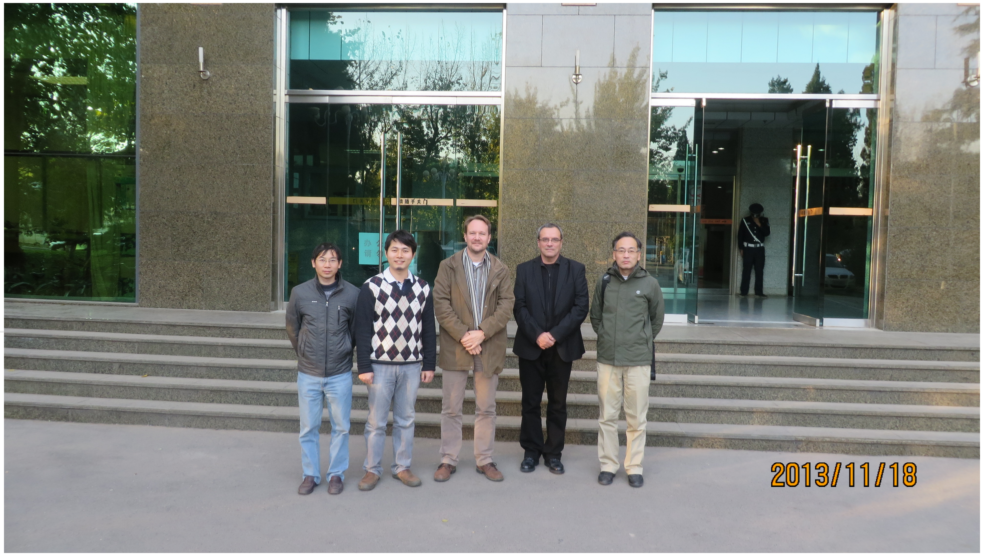
- 23 Oct CEPC Physic & Detector 3rd
- 18 Oct CEPC Calorimeter Group Meeting 1st
- 09 Oct CEPC Physics & Detector 2nd

CEPC

CEPC + SppC events

Managers: WEN, S.; Zhu, H.; Yang, H.; Hu, T.; Ruan, M.; QI, H.

- General Meetings 2 events
- Physics and Detector Meetings 13 events
- Training 1 event



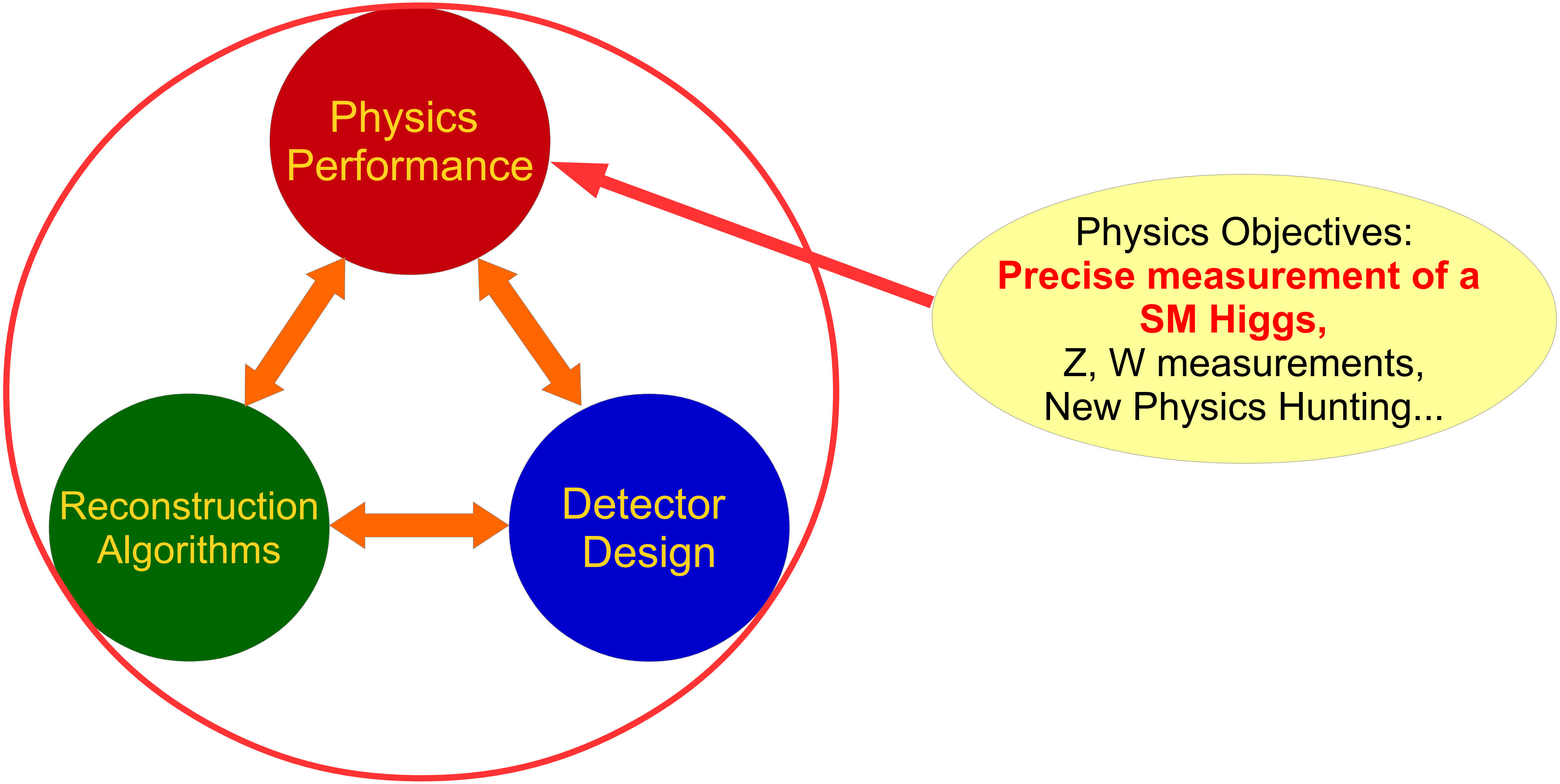
CEPC Detector: Institutes

Theory

VTX	TPC	Calo	Physics Requirement
ShanDong University (SDU) IHEP ...	Tsinghua University (THU), University of Chinese Academic of Science (UCAS), IHEP ...	University of Science and Technology of China (USTC), Shanghai Jiaotong University (SJTU), Wuhan University (WhU), Nanjing University IHEP ...	Nankai University, Peking University (PKU), Beihang University, Center China Normal University (CCNU), IHEP ...

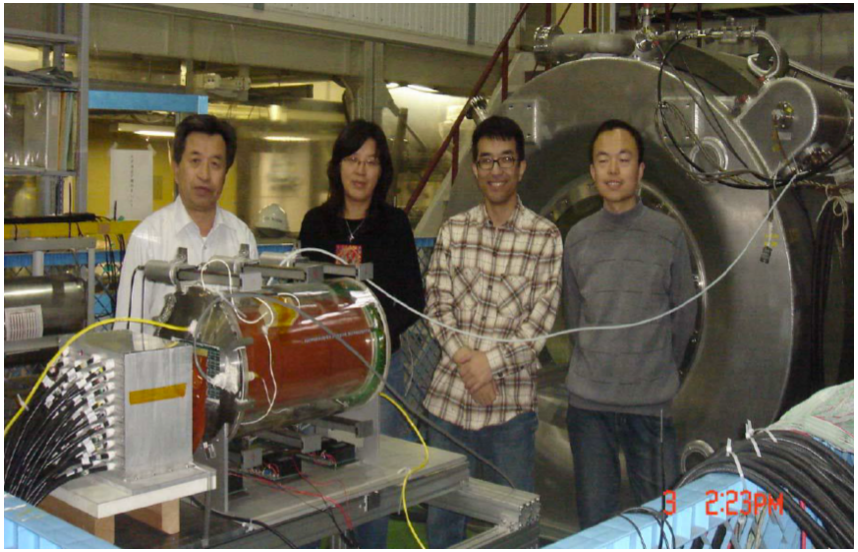
Machine

Perspective of CEPC Physics Measurement

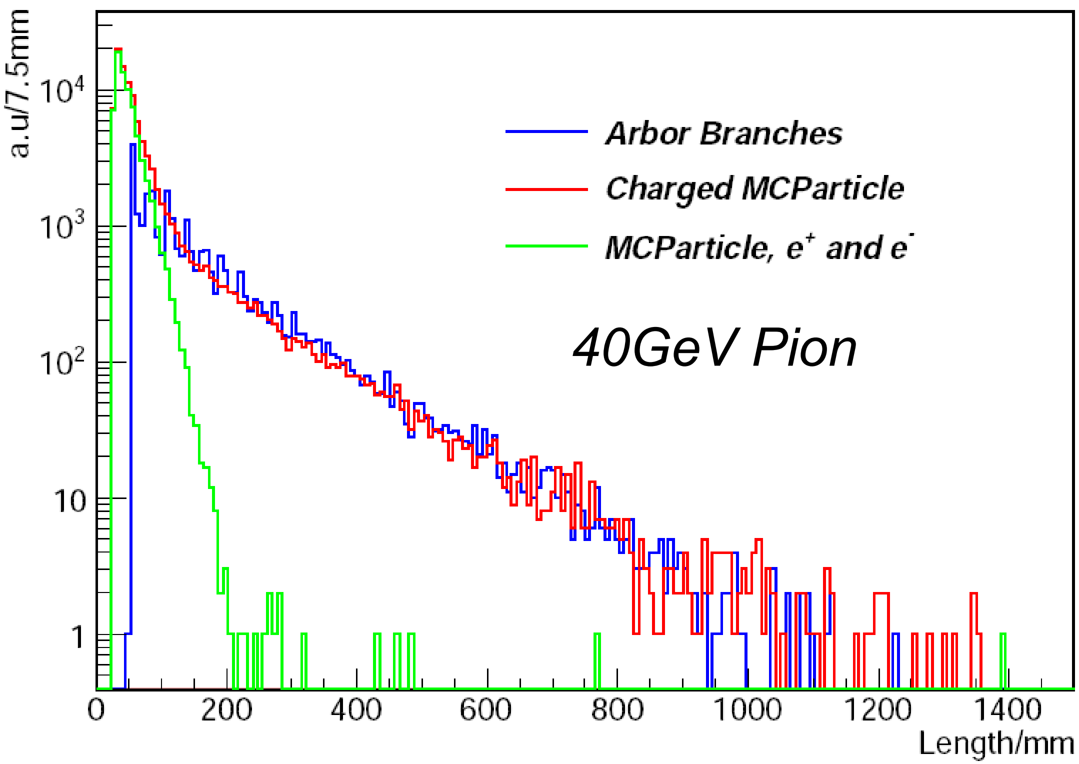


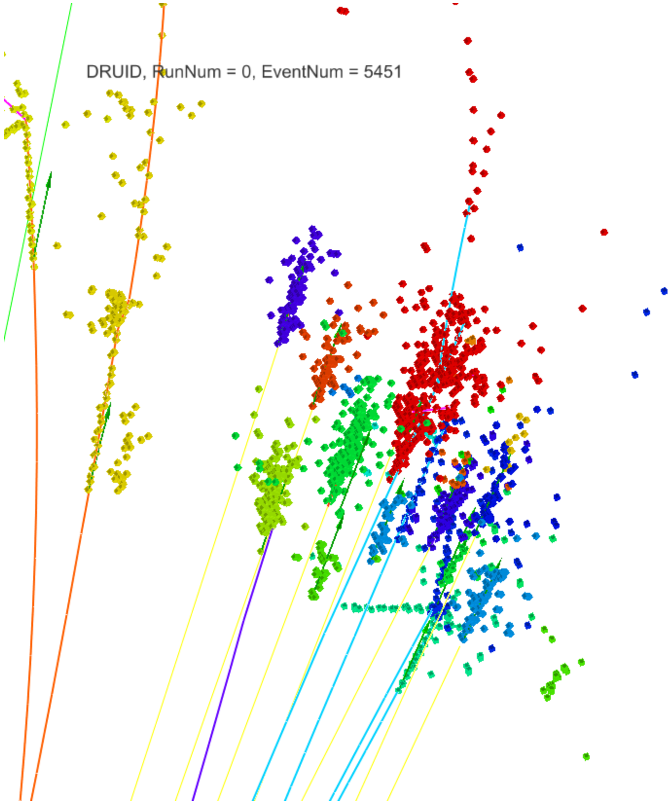
Detector R&D

- Status:
  - TPC: Tsinghua & IHEP have participated in LCTPC
  - VTX: Investigating into the technology Market, lots of related projects
  - Calorimeter: cooperation with CALICE collaboration
- *Long termly: prototype design, construction, test, integration...*



Arbor: Validation & Goal



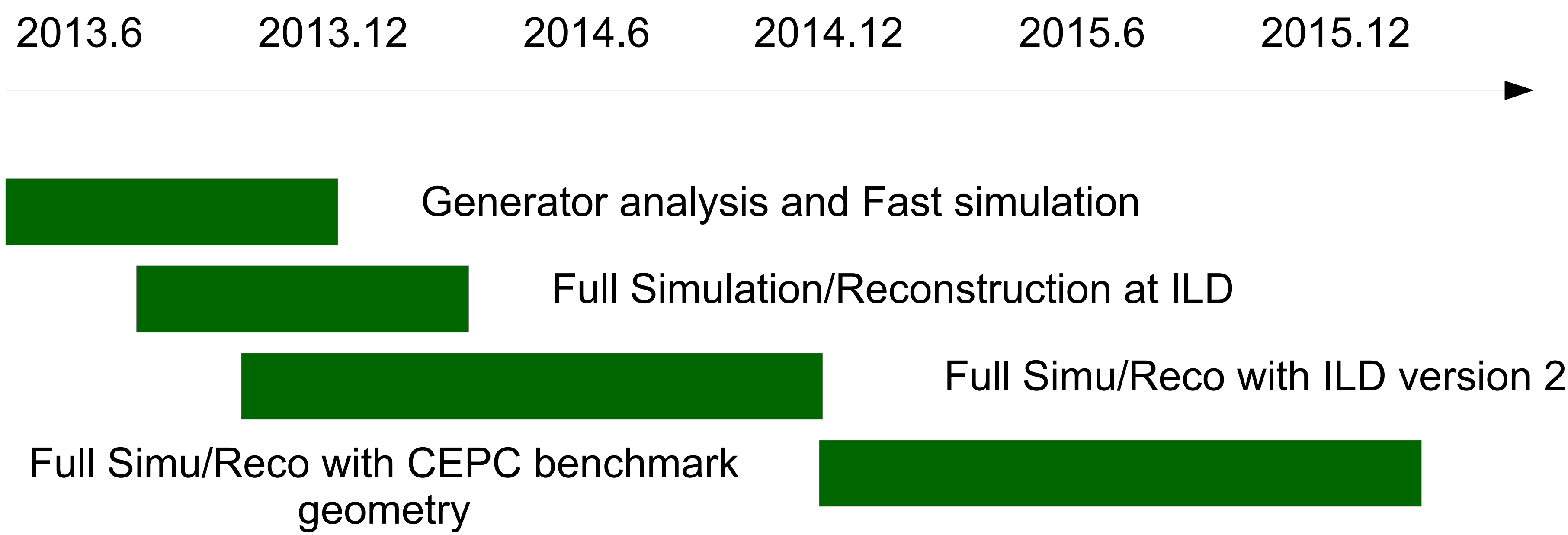


Arbor: successfully tag sub-shower structure
Ultimate goal: reconstruct every energetic final state particle

Samples: Particle gun event at ILD HCAL (readout granularity 1cm^2 & layer thickness 2.65cm)
Length: Charged MCParticle: spatial distance between generation/end points
Arbor branch: sum of distance between neighboring cells

Personal Perspective: A Tentative Time Line

4 Steps...



Summary

- Lots of activities toward Detector R&D & Physics analysis at CEPC
  - 120 ppl from 19 institutes at Kick off meeting
  - 80 ppl from 12 institutes participated the Training
  - Phone meeting: 10 ~ 30 participates
  - **Key point: get people trained**
- Parallel Studies on going
  - Generator: ILD official sample, Validation – fast simulation, nearly finished
  - Detector geometry: changing TPC radius, model validation & cost estimation
  - Full simulation: ILD Version 2 to be validated
  - Reconstruction - Analysis: developing & testing
- Communications: with machine, theory group and foreign experts
- Long to do list: especially at detector R&D side
  - Needs lots of manpower, computing resources and International Cooperation

* End of 20'th Century

[1895 — 2012]

* Dawn of a New Era in Fundamental Physics