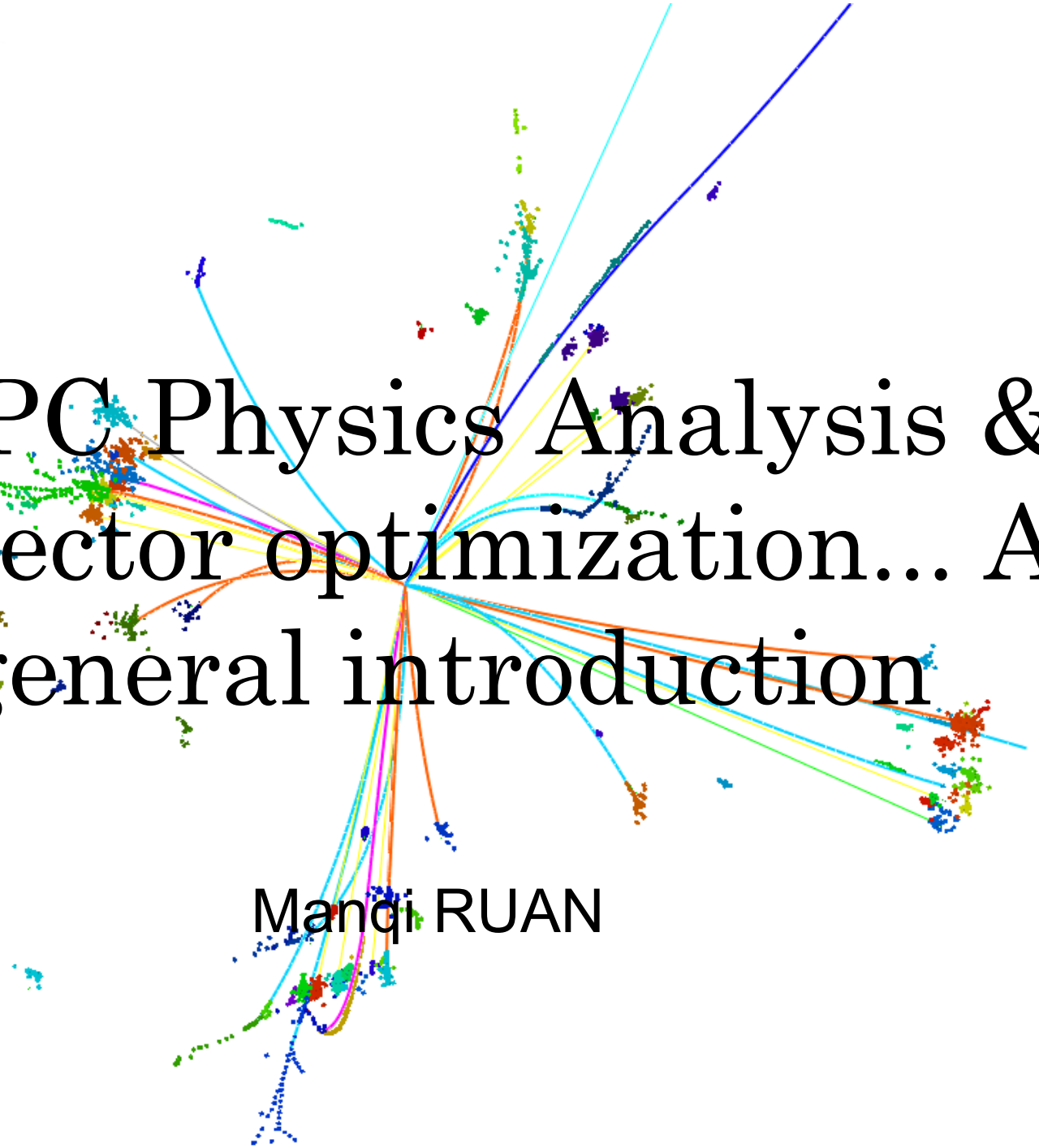
CEPC Physics Analysis & Detector optimization… A general introduction

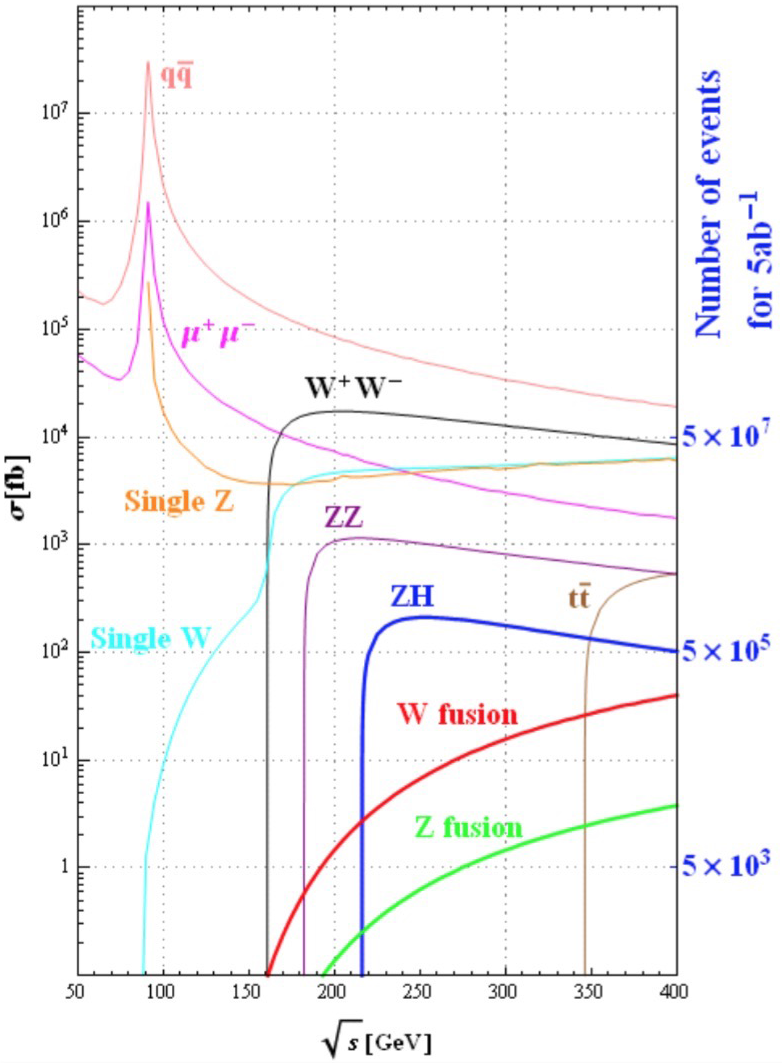


Manqi RUAN

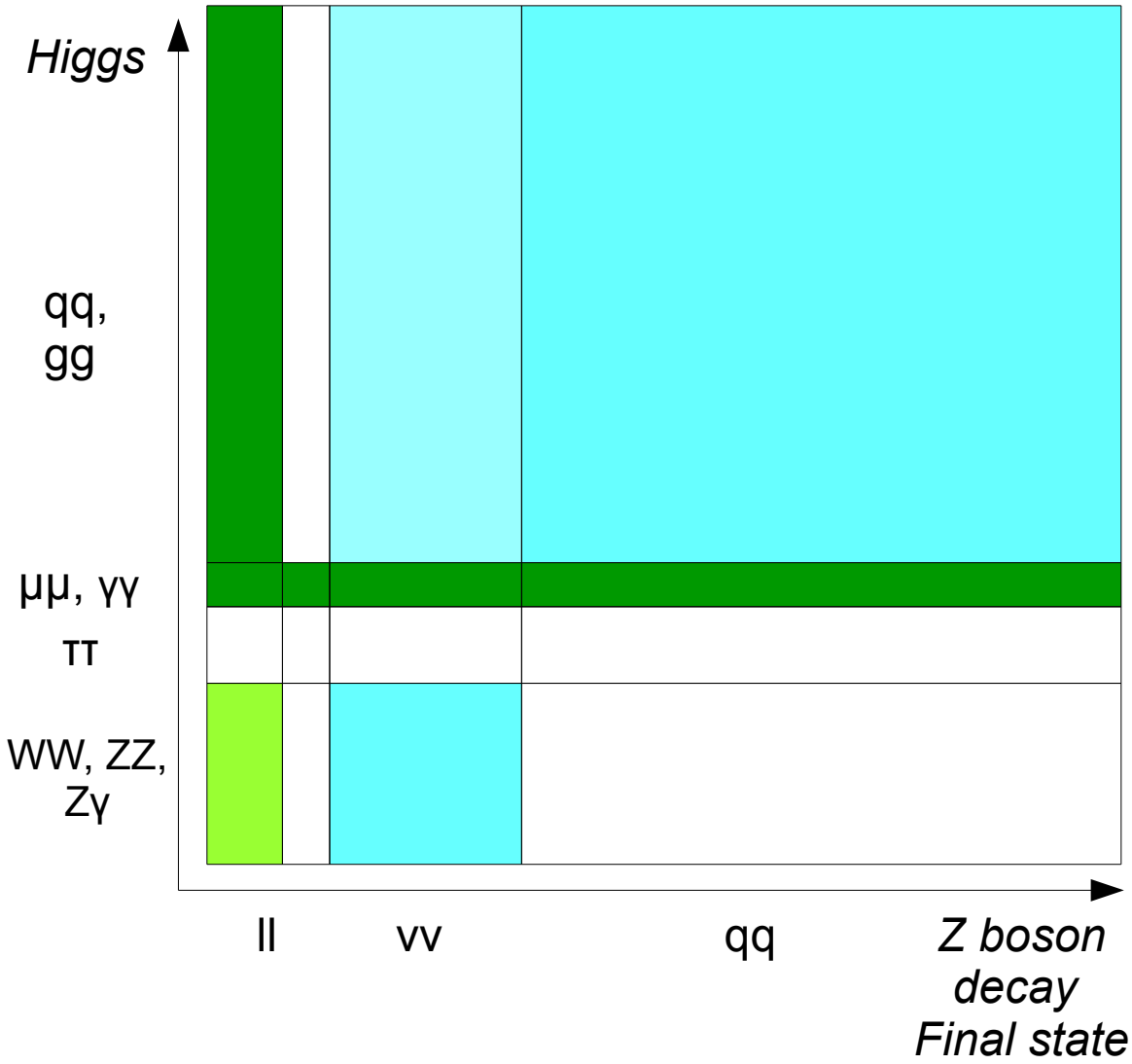
At CEPC

- Higgs Run: 10 years, 1 M Higgs boson at 1 B physics events
- Z Pole Runs: 10 Billion Z boson in 1 year

- Perfect understanding of the nature of Higgs boson, precise EW measurements, probe for NP...



Higgs analysis: Status at PreCDR

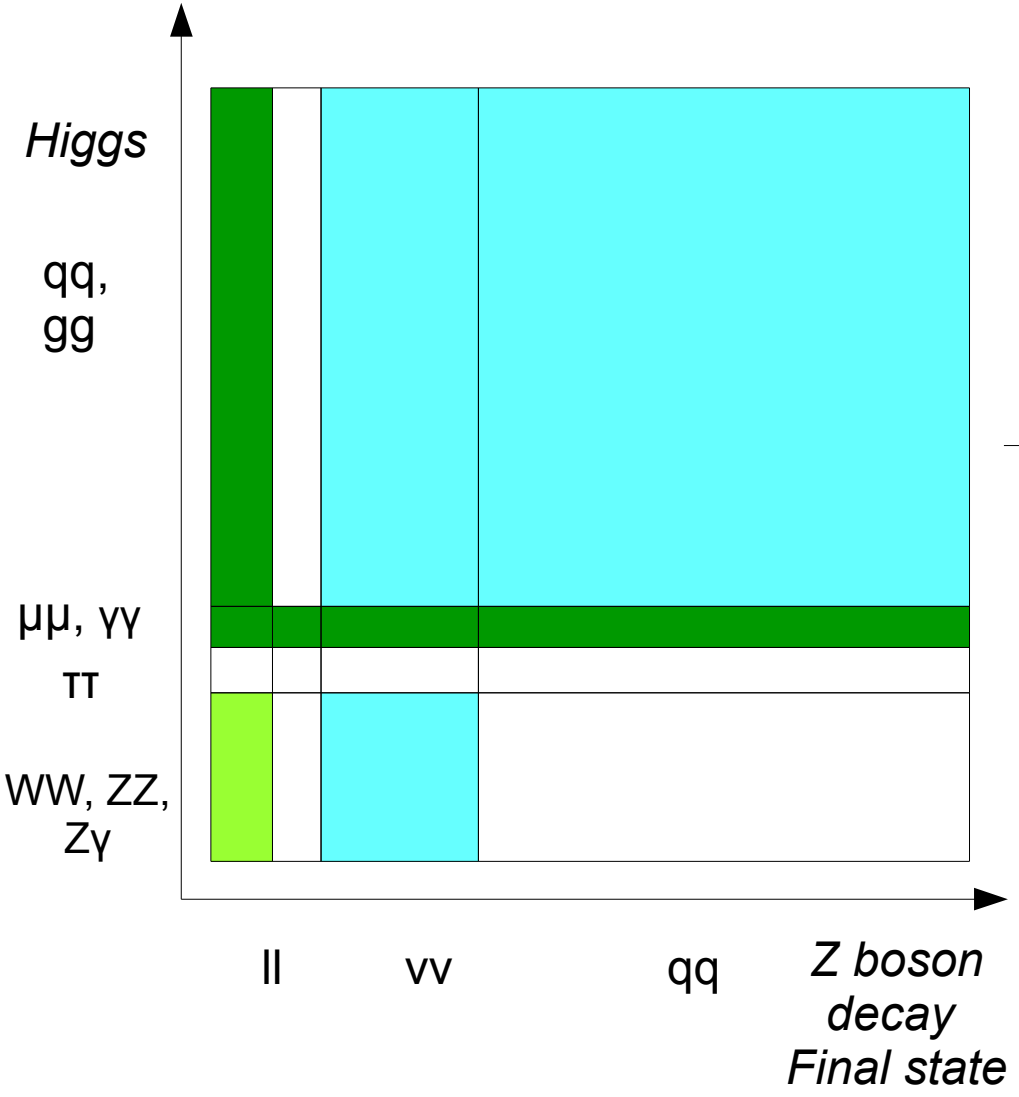


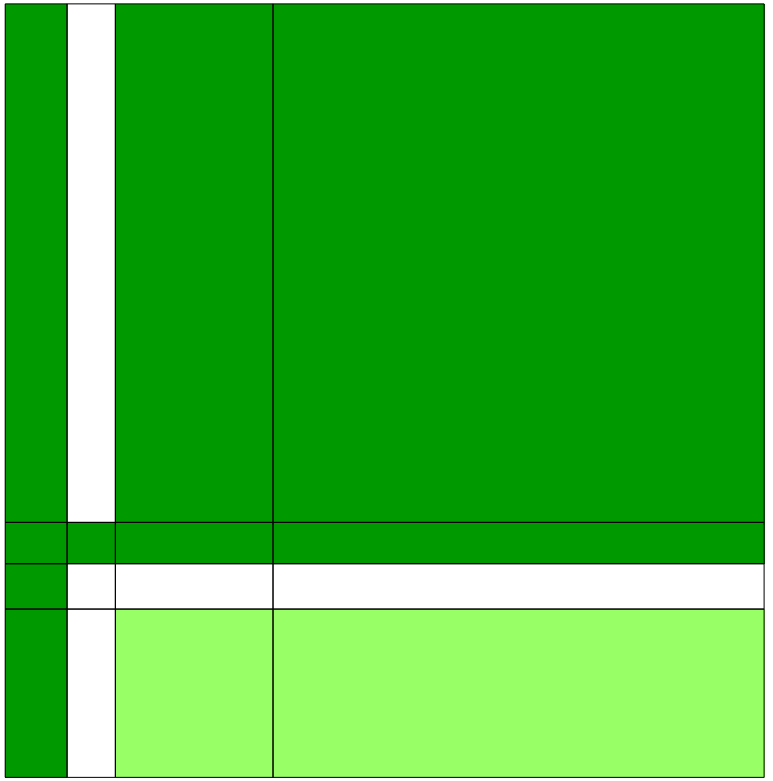
Full Simulation

Fast Simulation

Extrapolation

And now...





Significant progress had been made on
Br(H->bb, cc, gg)
Br(H->WW, ZZ)
Br(H->exotic)
Br(H->di tau, di muon)
Measurements!

σ(ZH)*Br(H->bb, cc, gg)

- Strategy: Event selection + Template fit on the b-likeness Vs c-likeness plane
- 4 independent channels: Signal & Key background are processed with Full Simulation

	Analyzer	bb	cc	gg	
mumuH	Zhenxing, etc	0.96%	13.5%	11.6%	
		0.96%	11.0%	8.73%	
eeH					
tautauH					
vvH	Lianghao, Yulei, Dikai	0.38%	3.5%	2.4%	Notes submitted
qqH	Baiyu, Boyang, etc	0.27%	4.4%	3.0%	Notes submitted
Comb. opti		0.21%	2.5%	1.7%	
Result at PreCDR		0.28%	2.2%	1.6%	

σ(ZH)*Br(H->bb, cc, gg)

- Key points
  - MumuH: different template fit technologies need to be compared and understood
  - qqH:
    - Complex analysis:
      - Jet clustering algorithm,
      - Hard gluon emission,
      - Matching
      - Systematic control
  - EeH & tautauH: to be covered
  - All channels: distinguish between H->gg events and H->WW/ZZ->4 jets events is still challenging!

H -> WW* && H->ZZ*

- Various Final States! Any combination of leptons, missing E/P, jets...
- Processed with Full Simulation:
  - Final states with at most 2 jets
  - Lepton id, Isolate lepton finding and total momentum/energy resolution: key ingredient for these analysis
- WW*
  - Dedicated Isolation lepton finding algorithm has been developed, compared & tuned
- ZZ*
  - Tau related bakground could be largely suppressed once tau finder is more mature

H -> WW*

Table 2.8 Expected precision of the $\sigma(ee \to ZH) \times \mathrm{BR}(H \to WW^*)$ measurement, assuming an integrated luminosity of 5 ab^{-1}.

Channel	Precision	Comment
$Z \to \mu\mu, H \to WW^* \to \ell\nu qq, \ell\ell\nu\nu$	4.9%	CEPC Full Simulation
$Z \to ee, H \to WW^* \to \ell\nu qq,\ \ell\ell\nu\nu$	7.0%	Estimated
$Z \to \nu\nu, H \to WW^* \to qqqq$	2.3%	Extrapolated from ILC result
$Z \to qq, H \to WW^* \to \ell\nu qq$	2.2%	Extrapolated from ILC result
Combined	1.5%	

Table from PreCDR

4.9% accuracy, should be updated to 4.2% at the CEPC note, which is composed Of 14.2% from llvv channel and 4.4% of lvqq channel.

Full Simulation analysis, performed by Libo, is applied on Z->dimuon, H->WW*->llvv channel
Clean signal, tiny fraction: 0.1% of all H->WW* events.

Category	Total	Signal	Background
$l_1 = e, l_2 = \mu$	105±10.2	105±10.2	0.0±0.0
$l = \mu$	58±7.6	52±7.2	6±2.4
$l = e$	40±6.3	36±6	4±2
WW^* full leptonic decay	203±14.2	193±13.9	10±3.2

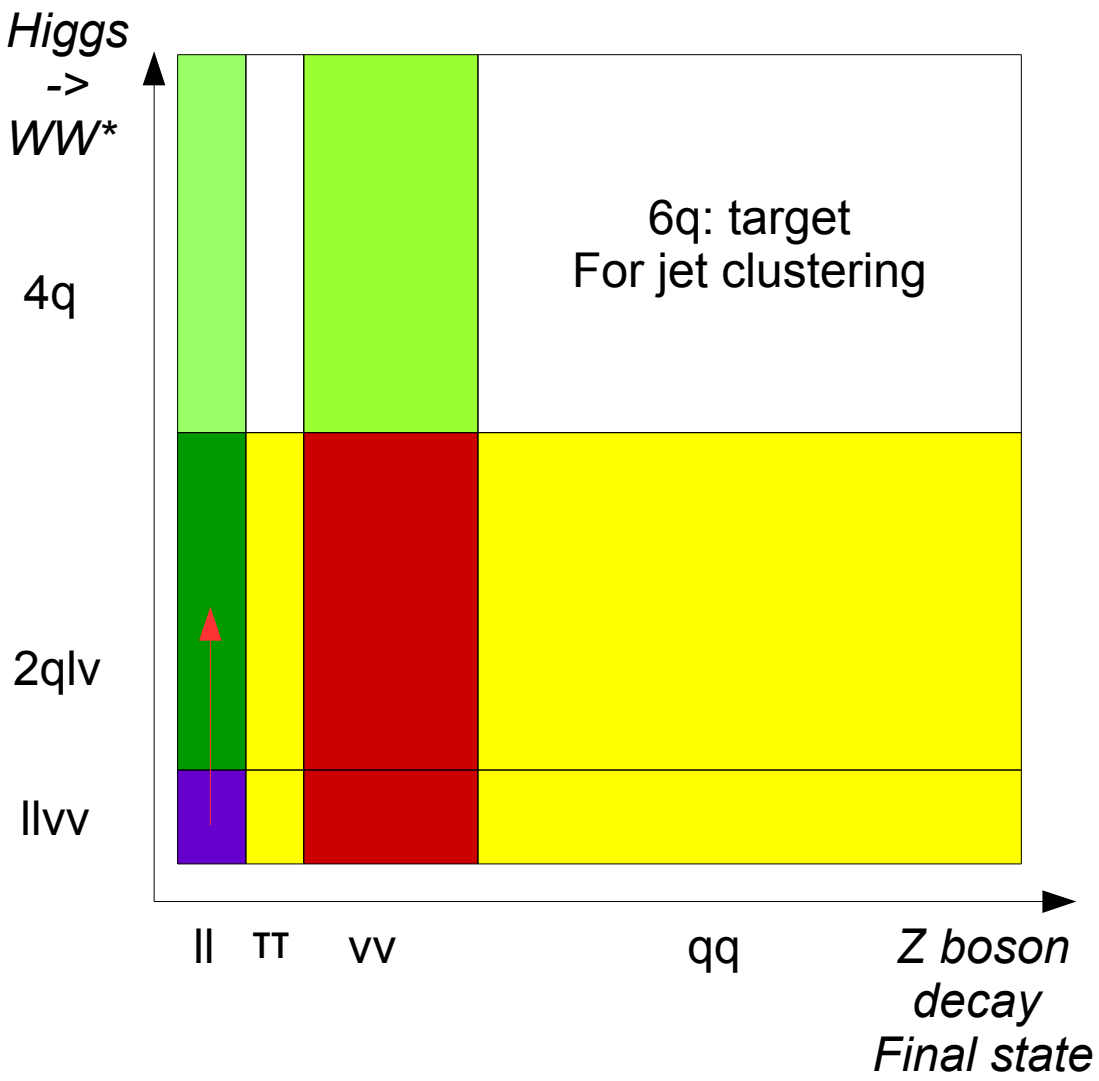
9.8%
14.6%
17.6%

In total:
7.4%

Table 4: Statistic error of different flavor final state and $H \to WW^* \to llv\bar{\nu}(l = e, \mu)$

Improved by a factor of **2** comparing to PreCDR

H -> WW*



Suggested Priority:

Repeat zhenxin's analysis

1: Z(vv) + H(llvv, 2qlv) (iso lepton)
(王峰 + 立波)
Di lepton: dR & mass, flavor classification,
Bkg: WW, ZZ, isrZ

2: vv + 4q; ll + 4q
JER (peak at 125 GeV);
mixed with Higgs backgrounds
Z->vv/ll & H->2q, H->ZZ* -> 4q
B-tagging can be used to veto 40% of ZZ;
(+ 彧骞)
Bkg: Higgs noise

3: qq + 2qlv/llvv, Jet Clustering +
Iso lepton

H->ZZ*

Yuqian's
Full simulation

	Z->ll	taus	vv	qq
ZZ*->4q	888	444	2.64k	9.24k
2v + 2q	508	254	1.51k	5.29k
2l + 2q	170	85	508	1778
4v	73	36	216	756
2l + 2v	49	24	145	508
4l	8	4	24	86
X + tau	120	60	356	1246

Yang Xuan's
Fast simulation

Priority 1: isolated leptons.

H->ZZ*

Resolution ~ 40-50%

ZZ*	ll	taus	vv	qq
4q	888	444	2.64k	9.24k
2v+2q	508	254	1.51k	5.29k
2l+2q	170	85	508	1778
4v	73	36	216	756
2l+2v	49	24	145	508
4l	8	4	24	86
X+tau	120	60	356	1246

S/B = 65/31 S/B = 94/21

ZZ*\IniZ	$\mu^+\mu^-$	e^+e^-
vvqq	126	126
qqvv	126	126

ZZ*\IniZ	qq
$\mu\mu\nu\nu$	126
$\nu\nu\mu\mu$	126
eevv	126
vvee	126

	vv
$\mu\mu$qq	126
qq$\mu\mu$	126
eeqq	126
qqee	126

Result on cut base

Needs more optimise for better result

Difficult for now

S/B = 97/18

S/B = 82/30

S/B = 54/67

Result from ini-Z to di-muon/electron: 15% comb 11.4% = 9.0%
Result from ini-Z to invisible: 11% comb 13% comb 20% = 7.7%;
including W fusion contribution, should increase the statistic by 18%; thus 7%
(comparing to 6.9% accuracy we achieved with Fast simulation at Pre-CDR)
In total: 5.5%

Reference Num at PreCDR: 4.3%
Next step: Including other channels with leptonic final states

H->di photon

- Feng & JianHuan
- Converted Photon recovery algorithm: proved to be efficient & save back ~ 10-15% of statistic: need further polishment
- Dedicated Photon Energy Estimator & Photon ID has been developed and adjusted to CEPC_v1 geometry

H->di muon

- Cui Zhenwei, (Wang Binlong)
- Test bed for event selection tuning
  - Cut based;
  - MVA-BDT based;
- Carefully designed BDT seems could largely improve the analysis result. Checking details

H->di tau

- Yu Dan
- Test bed for PFA
- Goal: identify not only Tau candidate but also flag the tau decay mode.
- Key to every tau-related physics channels
  - H->di tau measurement was carried on at Higgs signal only (distingulish H->di tau from H->others)
  - A simultaneous fit on log(D0) Histogram leads to a measurement of Br(H->WW) and Br(H->tautau) simultaneously

H->Exotic, leptonic

- Wang Lei
- Full Simulation analysis of H->e+e- pair
  - Uplimt set to be 0.016%, one order of magnitude better than LHC
  - Will extend this study to cover H->emu, etau, etc.

H->Exotic, hadronic

- Jiawei, Kevin, Zhenxing
- Good understanding of the Simu-Reconstruction correspondence and Promising results has been achieved with full simulation.

EW measurement

- Afb(B), Afb(tau)...
- Certainly lots more topics need to be covered in the future!

Interpretation & New observables

- ShaoFeng's talk

Combination & Analysis technologies

- Yaquan's talk

Reconstruction

- Tracking
- Arbor
- PID
- Jet Clustering
- Flavor Tagging

Talks of Binsong & Bo

New Geometry

- CEPC_o2 under its way: Li Qiuyang
- New Simulation toolkit: DD4HEP, Prof Fu Chengdong

Irradiation Study

- Toward more realistic detector: Prof Xu Yin

Software & Computing

- Supplies & Logistic: Xiaomei's talk

Goal & Future

- Summarize current studies, get all the tools prepared
- Geometries are changing & Let's iterate!
- Goal:
  - Optimized detector geometry,
  - Reconstruction-analysis tool,
  - Profoundly understood performance & physics

Enjoy!

Non Higgs Topic

- EM measurements:
  - TGC (韩爽)
  - Wmass + Width
  - Neutrino generation
  - A_{FB}
- New Physics (李强)
- Systematic controls （朱凯，白羽，李刚）
- Reconstruction oriented
- Detector optimization
  - Calorimeter (赵航，陈石)

CEPC Higgs Analysis: Status at Aug 2015

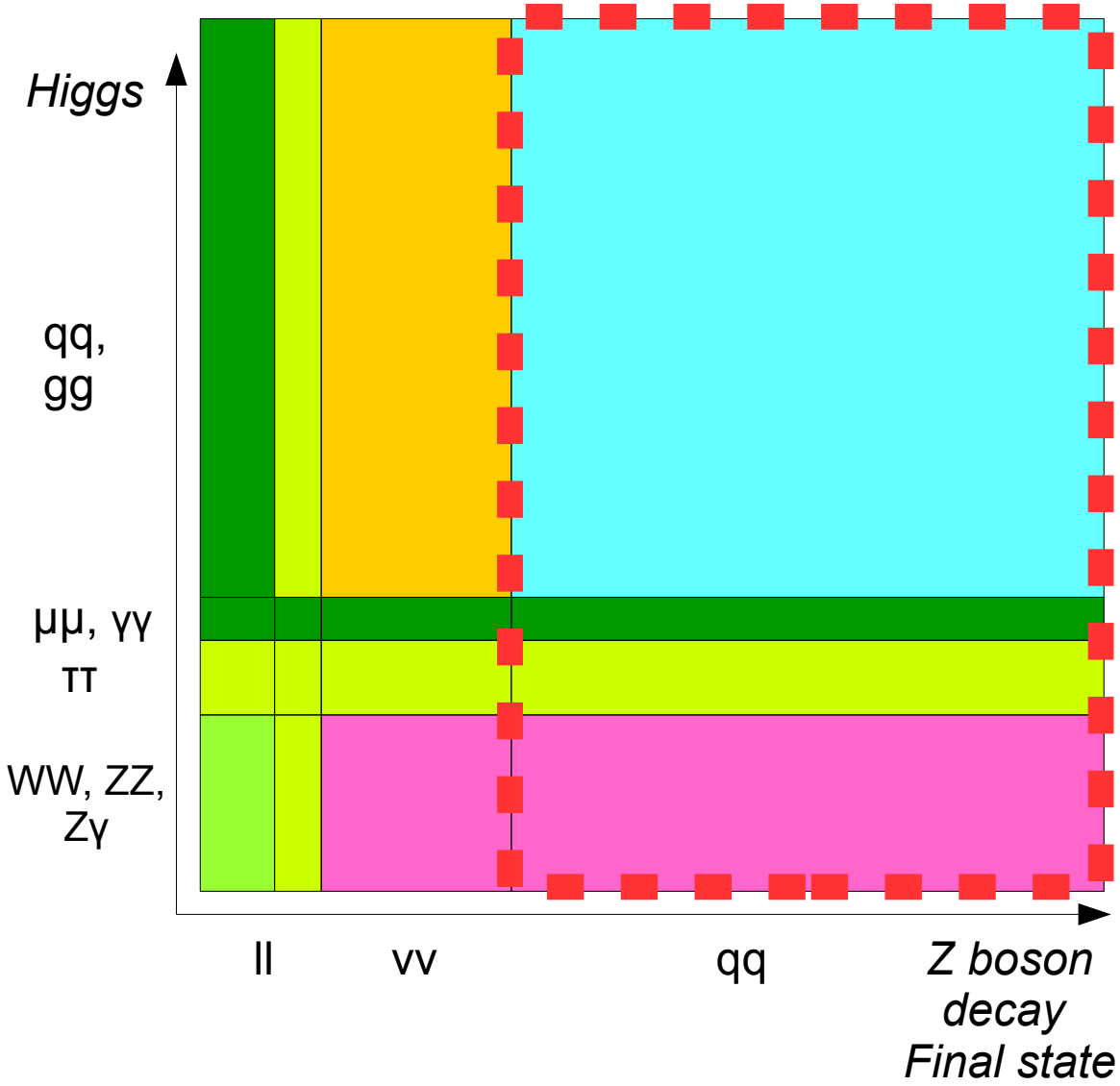
	di-muon	di-electron	di-neutrino	di-jets	di-taus
σ(ZH)			-		
M_H					
σ(ZH)*Br(H→bb)					
σ(ZH)*Br(H→cc)					
σ(ZH)*Br(H→gg)					
σ(ZH)*Br(H→WW)					
σ(ZH)*Br(H→ZZ)					
σ(ZH)*Br(H→ττ)					
σ(ZH)*Br(H→γγ)					
σ(ZH)*Br(H→μμ)					
σ(vvH)*Br(H→bb)	-	-		-	
Br(H→invisible)			-		
Br(H→exotic)					

Signal with CEPC Full Simulation, Bkgrd with Fast Simulation

CEPC Fast Simulation

Extrapolated from ILC/FCC-ee results

Newly formed Working groups



振兴 + 树正 + 李直

白羽（庞通） + 周宁（博扬）
+ 杨柳

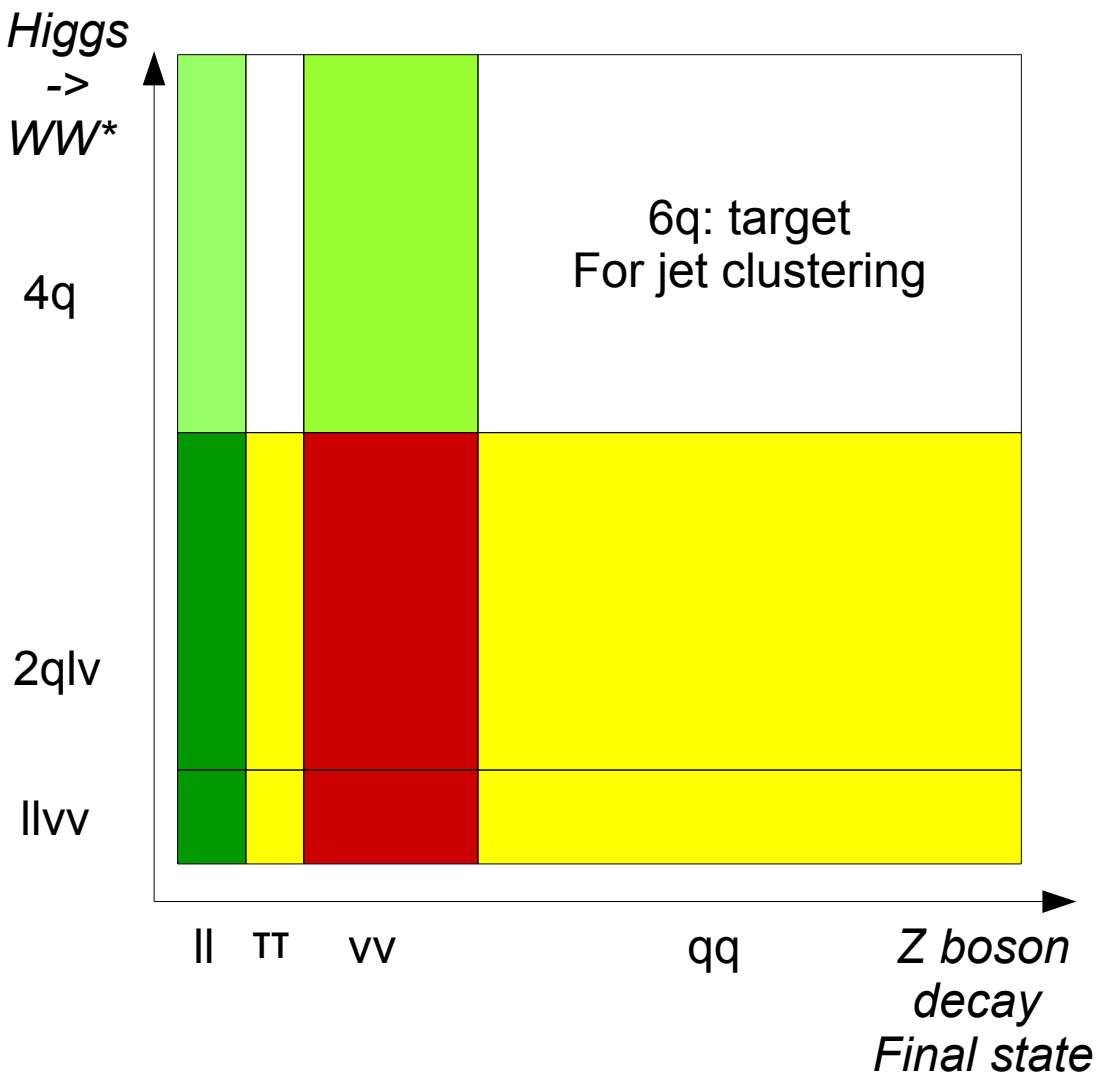
迪开 + 李直 + 梁浩 + 振兴

王峰 + 俊机 + 滨松 + 立波
+ 彧骞 + 陈石 + 于淼 + 杨柳

于丹 + **王磊** + 立波 + 赵航

王峰 + **莫欣**

H -> WW* && H->ZZ*



Suggested Priority:

Repeat zhenxin's analysis

1: Z(vv) + H(llvv, 2qlv) (iso lepton)
(王峰 + 立波)
Di lepton: dR & mass, flavor classification,
Bkg: WW, ZZ, isrZ

2: vv + 4q; ll + 4q
JER (peak at 125 GeV);
mixed with Higgs backgrounds
Z->vv/ll & H->2q, H->ZZ* -> 4q
B-tagging can be used to veto 40% of ZZ;
(+ 彧骞)
Bkg: Higgs noise

3: qq + 2qlv/llvv, Jet Clustering +
Iso lepton