High Intensity Electron Positron Accelerator (HIEPA)

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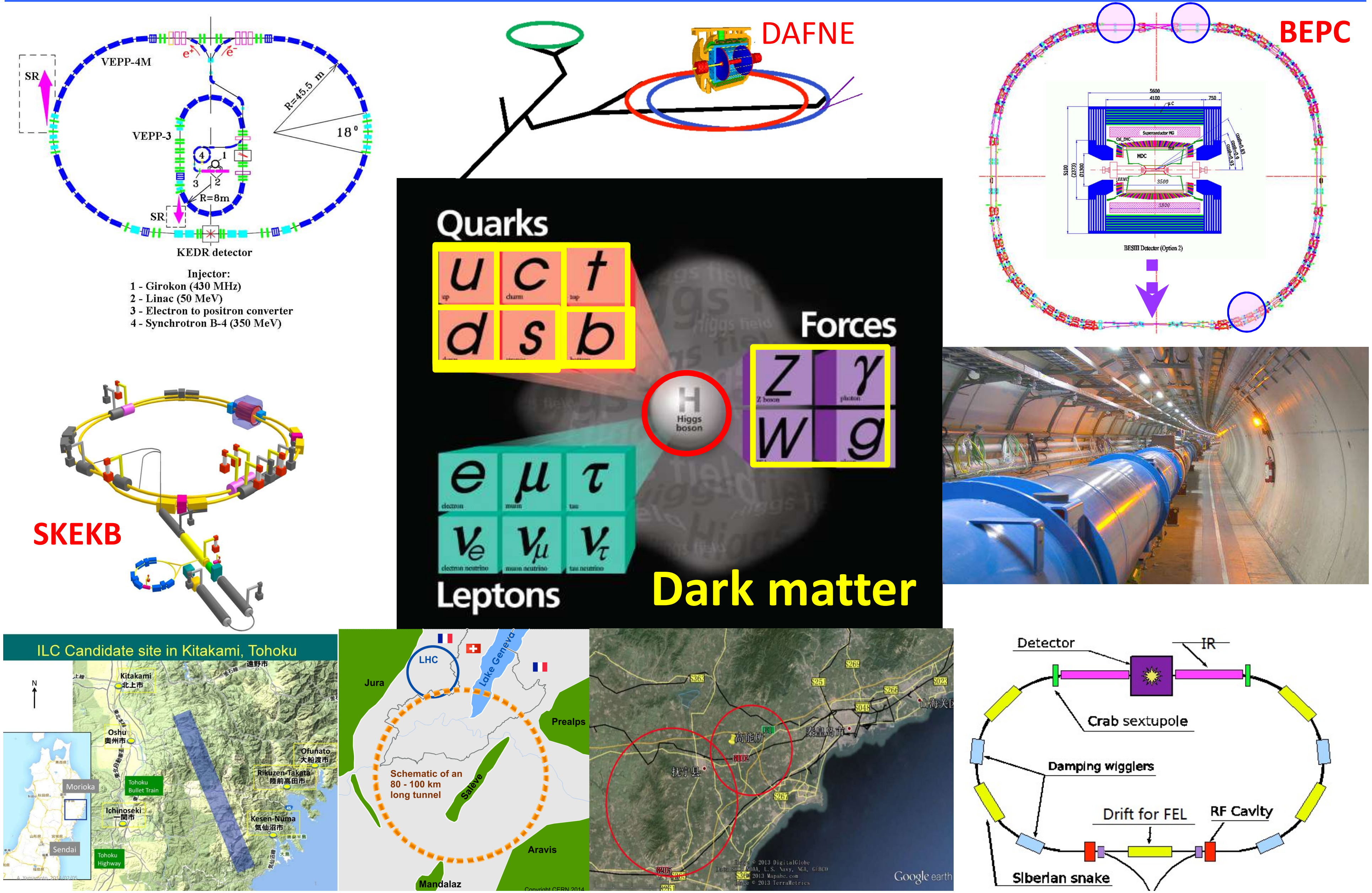
Outline

- Introduction - Why
- HIEPA - What
- Proposal - How

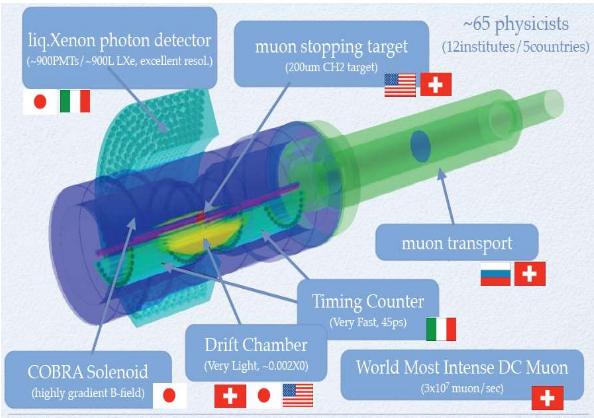
The Standard Model and Accelerators for Particle Physics



High Energy Physics in Post Higgs Era

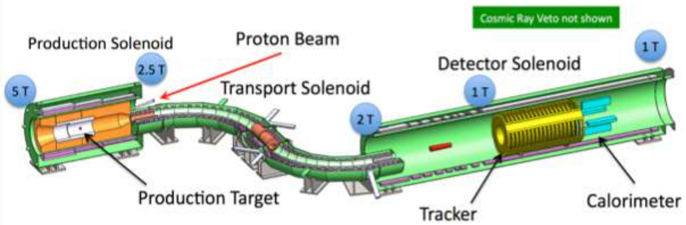
- **Origin of the electroweak spontaneous symmetry breaking**
  - **Higgs property (m_H, Γ, J^{PC}, couplings, σ, Br of all possible modes)**
  - **Higgs as a tool for discovery (structure, additional Higgs bosons..)**

- **New physics beyond the SM**
  - **New energy territory**
  - **Precision measurements of SM rare processes**



$\mu \to e\gamma$

4.2×10^{-13} 90% C.L.



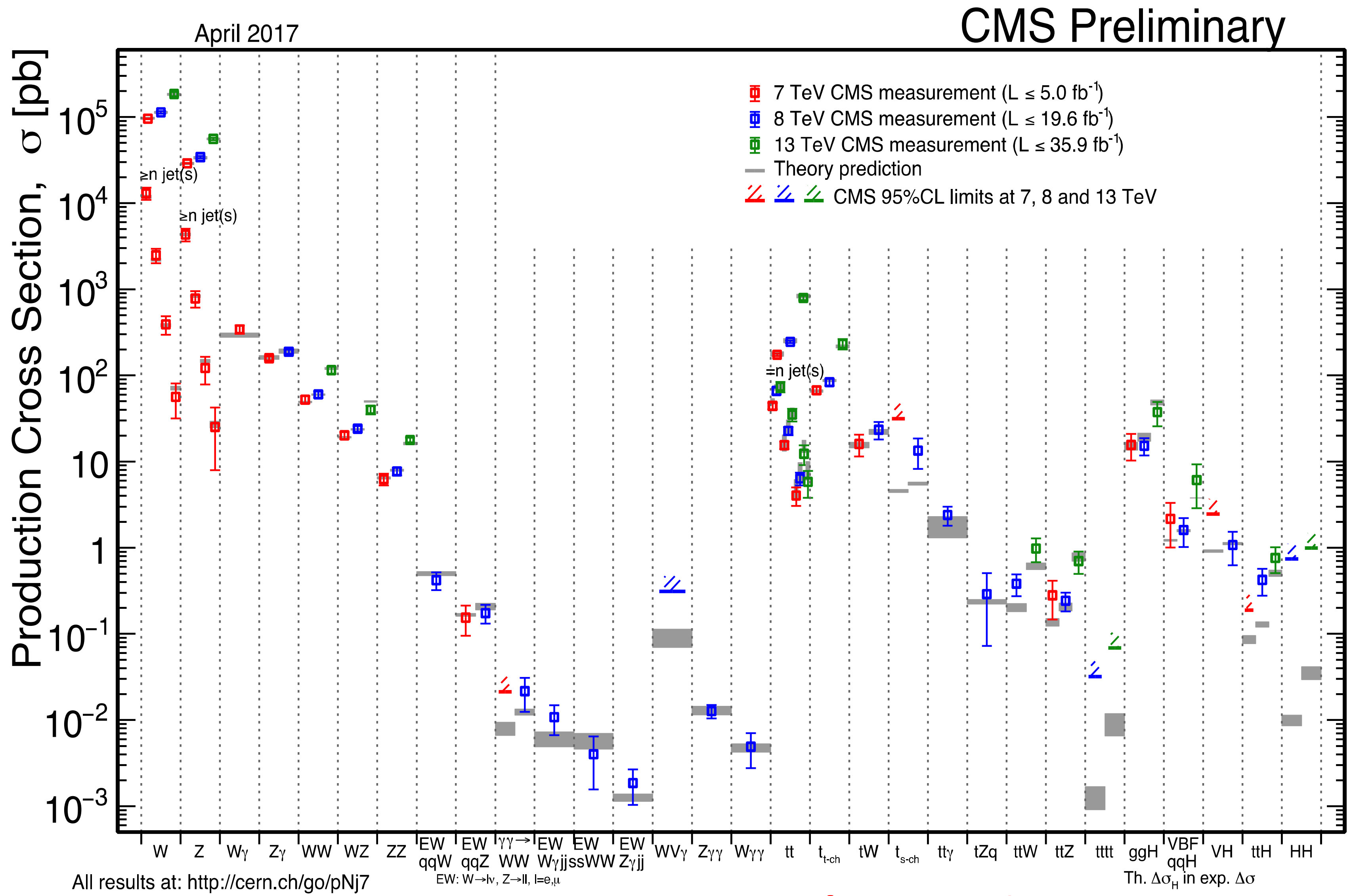
Mu2e

$$B(\mu^- + Al \to e^- + Al) = 5 \times 10^{-17} \quad \text{(S.E.)}$$
$$B(\mu^- + Al \to e^- + Al) < 10^{-16} \quad \text{(90\%C.L.)}$$

g–2

0.14 ppm

Standard Model



Consistent with SM !

ATLAS SUSY Searches* - 95% CL Lower Limits

May 2017

ATLAS Preliminary

$\sqrt{s}$ = 7, 8, 13 TeV

$\sqrt{s}$ = 7, 8 TeV | $\sqrt{s}$ = 13 TeV

	Model	e,μ,τ,γ	Jets	E_T^{miss}	$\int\mathcal{L}\,dt[fb^{-1}]$	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 e,μ/1-2 τ	2-10 jets/3 b	Yes	20.3	$\tilde q,\tilde g$ 1.85 TeV	$m(\tilde q)=m(\tilde g)$	1507.05525
	$\tilde q\tilde q$, $\tilde q\to q\tilde\chi^0_1$	0	2-6 jets	Yes	36.1	$\tilde q$ 1.57 TeV	$m(\tilde\chi^0_1)$<200 GeV, m(1st gen. $\tilde q$)=m(2nd gen. $\tilde q$)	ATLAS-CONF-2017-022
	$\tilde q\tilde q$, $\tilde q\to q\tilde\chi^0_1$ (compressed)	mono-jet	1-3 jets	Yes	3.2	$\tilde q$ 608 GeV	$m(\tilde q)-m(\tilde\chi^0_1)$<5 GeV	1604.07773
	$\tilde g\tilde g$, $\tilde g\to q\bar q\tilde\chi^0_1$	0	2-6 jets	Yes	36.1	$\tilde g$ 2.02 TeV	$m(\tilde\chi^0_1)$<200 GeV	ATLAS-CONF-2017-022
	$\tilde g\tilde g$, $\tilde g\to qq\tilde\chi^\pm_1\to qqW^\pm\tilde\chi^0_1$	0	2-6 jets	Yes	36.1	$\tilde g$ 2.01 TeV	$m(\tilde\chi^0_1)$<200 GeV, $m(\tilde\chi^\pm)=0.5(m(\tilde\chi^0_1)+m(\tilde g))$	ATLAS-CONF-2017-022
	$\tilde g\tilde g$, $\tilde g\to qq(\ell\ell/\nu\nu)\tilde\chi^0_1$	3 e,μ	4 jets	-	36.1	$\tilde g$ 1.825 TeV	$m(\tilde\chi^0_1)$<400 GeV	ATLAS-CONF-2017-030
	$\tilde g\tilde g$, $\tilde g\to qqWZ\tilde\chi^0_1$	0	7-11 jets	Yes	36.1	$\tilde g$ 1.8 TeV	$m(\tilde\chi^0_1)$ <400 GeV	ATLAS-CONF-2017-033
	GMSB ($\tilde\ell$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	3.2	$\tilde g$ 2.0 TeV		1607.05979
	GGM (bino NLSP)	2 γ	-	Yes	3.2	$\tilde g$ 1.65 TeV	$c\tau$(NLSP)<0.1 mm	1606.09150
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	$\tilde g$ 1.37 TeV	$m(\tilde\chi^0_1)$<950 GeV, $c\tau$(NLSP)<0.1 mm, $\mu<0$	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	13.3	$\tilde g$ 1.8 TeV	$m(\tilde\chi^0_1)$>680 GeV, $c\tau$(NLSP)<0.1 mm, $\mu>0$	ATLAS-CONF-2016-066
	GGM (higgsino NLSP)	2 e,μ (Z)	2 jets	Yes	20.3	$\tilde g$ 900 GeV	m(NLSP)>430 GeV	1503.03290
	Gravitino LSP	0	mono-jet	Yes	20.3	$F^{1/2}$ scale 865 GeV	$m(\tilde G)>1.8\times10^{-4}$ eV, $m(\tilde g)=m(\tilde q)$=1.5 TeV	1502.01518
3rd gen. $\tilde g$ med.	$\tilde g\tilde g$, $\tilde g\to b\bar b\tilde\chi^0_1$	0	3 b	Yes	36.1	$\tilde g$ 1.92 TeV	$m(\tilde\chi^0_1)$<600 GeV	ATLAS-CONF-2017-021
	$\tilde g\tilde g$, $\tilde g\to t\bar t\tilde\chi^0_1$	0-1 e,μ	3 b	Yes	36.1	$\tilde g$ 1.97 TeV	$m(\tilde\chi^0_1)$<200 GeV	ATLAS-CONF-2017-021
	$\tilde g\tilde g$, $\tilde g\to b\bar t\tilde\chi^+_1$	0-1 e,μ	3 b	Yes	20.1	$\tilde g$ 1.37 TeV	$m(\tilde\chi^0_1)$<300 GeV	1407.0600
3rd gen. squarks direct production	$\tilde b_1\tilde b_1$, $\tilde b_1\to b\tilde\chi^0_1$	0	2 b	Yes	36.1	$\tilde b_1$ 950 GeV	$m(\tilde\chi^0_1)$<420 GeV	ATLAS-CONF-2017-038
	$\tilde b_1\tilde b_1$, $\tilde b_1\to t\tilde\chi^\pm_1$	2 e,μ (SS)	1 b	Yes	36.1	$\tilde b_1$ 275-700 GeV	$m(\tilde\chi^0_1)$<200 GeV, $m(\tilde\chi^\pm_1)=m(\tilde\chi^0_1)$+100 GeV	ATLAS-CONF-2017-030
	$\tilde t_1\tilde t_1$, $\tilde t_1\to b\tilde\chi^\pm_1$	0-2 e,μ	1-2 b	Yes	4.7/13.3	$\tilde t_1$ 117-170 GeV; 200-720 GeV	$m(\tilde\chi^\pm_1)=2m(\tilde\chi^0_1)$, $m(\tilde\chi^0_1)$=55 GeV	1209.2102, ATLAS-CONF-2016-077
	$\tilde t_1\tilde t_1$, $\tilde t_1\to Wb\tilde\chi^0_1$ or $t\tilde\chi^0_1$	0-2 e,μ	0-2 jets/1-2 b	Yes	20.3/36.1	$\tilde t_1$ 90-198 GeV; 205-950 GeV	$m(\tilde\chi^0_1)$=1 GeV	1506.08616, ATLAS-CONF-2017-020
	$\tilde t_1\tilde t_1$, $\tilde t_1\to c\tilde\chi^0_1$	0	mono-jet	Yes	3.2	$\tilde t_1$ 90-323 GeV	$m(\tilde t_1)-m(\tilde\chi^0_1)$=5 GeV	1604.07773
	$\tilde t_1\tilde t_1$ (natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	$\tilde t_1$ 150-600 GeV	$m(\tilde\chi^0_1)$>150 GeV	1403.5222
	$\tilde t_2\tilde t_2$, $\tilde t_2\to\tilde t_1+Z$	3 e,μ (Z)	1 b	Yes	36.1	$\tilde t_2$ 290-790 GeV	$m(\tilde\chi^0_1)$=0 GeV	ATLAS-CONF-2017-019
	$\tilde t_2\tilde t_2$, $\tilde t_2\to\tilde t_1+h$	1-2 e,μ	4 b	Yes	36.1	$\tilde t_2$ 320-880 GeV	$m(\tilde\chi^0_1)$=0 GeV	ATLAS-CONF-2017-019
EW direct	$\tilde\ell_{L,R}\tilde\ell_{L,R}$, $\tilde\ell\to\ell\tilde\chi^0_1$	2 e,μ	0	Yes	36.1	$\tilde\ell$ 90-440 GeV	$m(\tilde\chi^0_1)$=0	ATLAS-CONF-2017-039
	$\tilde\chi^+_1\tilde\chi^-_1$, $\tilde\chi^+_1\to\tilde\ell\nu(\ell\tilde\nu)$	2 e,μ	0	Yes	36.1	$\tilde\chi^\pm_1$ 710 GeV	$m(\tilde\chi^0_1)$=0, $m(\tilde\ell,\tilde\nu)=0.5(m(\tilde\chi^\pm_1)+m(\tilde\chi^0_1))$	ATLAS-CONF-2017-039
	$\tilde\chi^\pm_1\tilde\chi^\mp_1/\tilde\chi^0_2$, $\tilde\chi^+_1\to\tilde\tau\nu(\tau\tilde\nu)$, $\tilde\chi^0_2\to\tilde\tau\tau(\nu\tilde\nu)$	2 τ	-	Yes	36.1	$\tilde\chi^\pm_1$ 760 GeV	$m(\tilde\chi^0_1)$=0, $m(\tilde\tau,\tilde\nu)=0.5(m(\tilde\chi^\pm_1)+m(\tilde\chi^0_1))$	ATLAS-CONF-2017-035
	$\tilde\chi^\pm_1\tilde\chi^0_2\to\tilde\ell_L\nu\tilde\ell_L\ell(\tilde\nu\nu)$, $\ell\tilde\nu\tilde\ell_L\ell(\tilde\nu\nu)$	3 e,μ	0	Yes	36.1	$\tilde\chi^\pm_1,\tilde\chi^0_2$ 1.16 TeV	$m(\tilde\chi^\pm_1)=m(\tilde\chi^0_2)$, $m(\tilde\chi^0_1)$=0, $m(\tilde\ell,\tilde\nu)=0.5(m(\tilde\chi^\pm_1)+m(\tilde\chi^0_1))$	ATLAS-CONF-2017-039
	$\tilde\chi^\pm_1\tilde\chi^0_2\to W\tilde\chi^0_1Z\tilde\chi^0_1$	2-3 e,μ	0-2 jets	Yes	36.1	$\tilde\chi^\pm_1,\tilde\chi^0_2$ 580 GeV	$m(\tilde\chi^\pm_1)=m(\tilde\chi^0_2)$, $m(\tilde\chi^0_1)$=0, $\tilde\ell$ decoupled	ATLAS-CONF-2017-039
	$\tilde\chi^\pm_1\tilde\chi^0_2\to W\tilde\chi^0_1h\tilde\chi^0_1$, $h\to b\bar b/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	$\tilde\chi^\pm_1,\tilde\chi^0_2$ 270 GeV	$m(\tilde\chi^\pm_1)=m(\tilde\chi^0_2)$, $m(\tilde\chi^0_1)$=0, $\tilde\ell$ decoupled	1501.07110
	$\tilde\chi^0_2\tilde\chi^0_3$, $\tilde\chi^0_{2,3}\to\tilde\ell_R\ell$	4 e,μ	0	Yes	20.3	$\tilde\chi^0_{2,3}$ 635 GeV	$m(\tilde\chi^0_2)=m(\tilde\chi^0_3)$, $m(\tilde\chi^0_1)$=0, $m(\tilde\ell,\tilde\nu)=0.5(m(\tilde\chi^0_2)+m(\tilde\chi^0_1))$	1405.5086
	GGM (wino NLSP) weak prod., $\tilde\chi^0_1\to\gamma\tilde G$	1 $e,\mu+\gamma$	-	Yes	20.3	$\tilde W$ 115-370 GeV	$c\tau$<1 mm	1507.05493
	GGM (bino NLSP) weak prod., $\tilde\chi^0_1\to\gamma\tilde G$	2 γ	-	Yes	20.3	$\tilde W$ 590 GeV	$c\tau$<1 mm	1507.05493
Long-lived particles	Direct $\tilde\chi^+_1\tilde\chi^-_1$ prod., long-lived $\tilde\chi^\pm_1$	Disapp. trk	1 jet	Yes	36.1	$\tilde\chi^\pm_1$ 430 GeV	$m(\tilde\chi^\pm_1)-m(\tilde\chi^0_1)$~160 MeV, $\tau(\tilde\chi^\pm_1)$=0.2 ns	ATLAS-CONF-2017-017
	Direct $\tilde\chi^+_1\tilde\chi^-_1$ prod., long-lived $\tilde\chi^\pm_1$	dE/dx trk	-	Yes	18.4	$\tilde\chi^\pm_1$ 495 GeV	$m(\tilde\chi^\pm_1)-m(\tilde\chi^0_1)$~160 MeV, $\tau(\tilde\chi^\pm_1)$<15 ns	1506.05332
	Stable, stopped $\tilde g$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde g$ 850 GeV	$m(\tilde\chi^0_1)$=100 GeV, 10 μs<$\tau(\tilde g)$<1000 s	1310.6584
	Stable $\tilde g$ R-hadron	trk	-	-	3.2	$\tilde g$ 1.58 TeV		1606.05129
	Metastable $\tilde g$ R-hadron	dE/dx trk	-	-	3.2	$\tilde g$ 1.57 TeV	$m(\tilde\chi^0_1)$=100 GeV, τ>10 ns	1604.04520
	GMSB, stable $\tilde\tau$, $\tilde\chi^0_1\to\tilde\tau(\tilde e,\tilde\mu)+\tau(e,\mu)$	1-2 μ	-	-	19.1	$\tilde\chi^0_1$ 537 GeV	10<tanβ<50	1411.6795
	GMSB, $\tilde\chi^0_1\to\gamma\tilde G$, long-lived $\tilde\chi^0_1$	2 γ	-	Yes	20.3	$\tilde\chi^0_1$ 440 GeV	1<$\tau(\tilde\chi^0_1)$<3 ns, SPS8 model	1409.5542
	$\tilde g\tilde g$, $\tilde\chi^0_1\to ee\nu/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	$\tilde\chi^0_1$ 1.0 TeV	7 <$c\tau(\tilde\chi^0_1)$< 740 mm, $m(\tilde g)$=1.3 TeV	1504.05162
	GGM $\tilde g\tilde g$, $\tilde\chi^0_1\to Z\tilde G$	displ. vtx + jets	-	-	20.3	$\tilde\chi^0_1$ 1.0 TeV	6 <$c\tau(\tilde\chi^0_1)$< 480 mm, $m(\tilde g)$=1.1 TeV	1504.05162
RPV	LFV $pp\to\tilde\nu_\tau+X$, $\tilde\nu_\tau\to e\mu/e\tau/\mu\tau$	$e\mu,e\tau,\mu\tau$	-	-	3.2	$\tilde\nu_\tau$ 1.9 TeV	λ'_{311}=0.11, $\lambda_{132/133/233}$=0.07	1607.08079
	Bilinear RPV CMSSM	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde q,\tilde g$ 1.45 TeV	$m(\tilde q)=m(\tilde g)$, $c\tau_{LSP}$<1 mm	1404.2500
	$\tilde\chi^+_1\tilde\chi^-_1$, $\tilde\chi^+_1\to W\tilde\chi^0_1$, $\tilde\chi^0_1\to ee\nu, e\mu\nu, \mu\mu\nu$	4 e,μ	-	Yes	13.3	$\tilde\chi^\pm_1$ 1.14 TeV	$m(\tilde\chi^0_1)$>400GeV, $\lambda_{12k}\neq0$ ($k=1,2$)	ATLAS-CONF-2016-075
	$\tilde\chi^+_1\tilde\chi^-_1$, $\tilde\chi^+_1\to W\tilde\chi^0_1$, $\tilde\chi^0_1\to\tau\tau\nu_e, e\tau\nu_\tau$	3 $e,\mu+\tau$	-	Yes	20.3	$\tilde\chi^\pm_1$ 450 GeV	$m(\tilde\chi^0_1)>0.2\times m(\tilde\chi^\pm_1)$, $\lambda_{133}\neq0$	1405.5086
	$\tilde g\tilde g$, $\tilde g\to qqq$	0	4-5 large-R jets	-	14.8	$\tilde g$ 1.08 TeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2016-057
	$\tilde g\tilde g$, $\tilde g\to qq\tilde\chi^0_1$, $\tilde\chi^0_1\to qqq$	0	4-5 large-R jets	-	14.8	$\tilde g$ 1.55 TeV	$m(\tilde\chi^0_1)$=800 GeV	ATLAS-CONF-2016-057
	$\tilde g\tilde g$, $\tilde g\to t\bar t\tilde\chi^0_1$, $\tilde\chi^0_1\to qqq$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde g$ 2.1 TeV	$m(\tilde\chi^0_1)$= 1 TeV, $\lambda_{112}\neq0$	ATLAS-CONF-2017-013
	$\tilde g\tilde g$, $\tilde g\to\tilde t_1t$, $\tilde t_1\to bs$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde g$ 1.65 TeV	$m(\tilde t_1)$= 1 TeV, $\lambda_{323}\neq0$	ATLAS-CONF-2017-013
	$\tilde t_1\tilde t_1$, $\tilde t_1\to bs$	0	2 jets + 2 b	-	15.4	$\tilde t_1$ 410 GeV; 450-510 GeV		ATLAS-CONF-2016-022, ATLAS-CONF-2016-084
	$\tilde t_1\tilde t_1$, $\tilde t_1\to b\ell$	2 e,μ	2 b	-	36.1	$\tilde t_1$ 0.4-1.45 TeV	BR($\tilde t_1\to be/\mu$)>20%	ATLAS-CONF-2017-036
Other	Scalar charm, $\tilde c\to c\tilde\chi^0_1$	0	2 c	Yes	20.3	$\tilde c$ 510 GeV	$m(\tilde\chi^0_1)$<200 GeV	1501.01325

10^{-1} — 1 — Mass scale [TeV]

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

No indication of SUSY yet, but set lower limits!

ATLAS Exotics Searches* - 95% CL Exclusion

Status: August 2016

ATLAS Preliminary

$\int \mathcal{L}\, dt = (3.2 - 20.3)\ \text{fb}^{-1}$ $\sqrt{s} = 8, 13$ TeV

No indication of SUSY yet, but set lower limits!

	Model	ℓ, γ	Jets†	E_T^{miss}	$\int \mathcal{L}\, dt[\text{fb}^{-1}]$	Limit		Reference
Extra dimensions	ADD $G_{KK} + g/q$	–	≥ 1 j	Yes	3.2	M_D 6.58 TeV	$n = 2$	1604.07773
	ADD non-resonant $\ell\ell$	2 e, μ	–	–	20.3	M_S 4.7 TeV	$n = 3$ HLZ	1407.2410
	ADD QBH $\to \ell q$	1 e, μ	1 j	–	20.3	M_{th} 5.2 TeV	$n = 6$	1311.2006
	ADD QBH	–	2 j	–	15.7	M_{th} 8.7 TeV	$n = 6$	ATLAS-CONF-2016-069
	ADD BH high $\sum p_T$	≥ 1 e, μ	≥ 2 j	–	3.2	M_{th} 8.2 TeV	$n = 6$, $M_D = 3$ TeV, rot BH	1606.02265
	ADD BH multijet	–	≥ 3 j	–	3.6	M_{th} 9.55 TeV	$n = 6$, $M_D = 3$ TeV, rot BH	1512.02586
	RS1 $G_{KK} \to \ell\ell$	2 e, μ	–	–	20.3	G_{KK} mass 2.68 TeV	$k/\overline{M}_{Pl} = 0.1$	1405.4123
	RS1 $G_{KK} \to \gamma\gamma$	2 γ	–	–	3.2	G_{KK} mass 3.2 TeV	$k/\overline{M}_{Pl} = 0.1$	1606.03833
	Bulk RS $G_{KK} \to WW \to qq\ell\nu$	1 e, μ	1 J	Yes	13.2	G_{KK} mass 1.24 TeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2016-062
	Bulk RS $G_{KK} \to HH \to bbbb$	–	4 b	–	13.3	G_{KK} mass 360-860 GeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2016-049
	Bulk RS $g_{KK} \to tt$	1 e, μ	≥ 1 b, ≥ 1J/2j	Yes	20.3	g_{KK} mass 2.2 TeV	BR = 0.925	1505.07018
	2UED / RPP	[illegible]	[illegible]	Yes	[illegible]	KK mass 1.46 TeV	Tier (1,1), [illegible] tt [illegible]	ATLAS-CONF-2016-013
Gauge bosons	SSM $Z' \to \ell\ell$	[illegible]	[illegible]	[illegible]	[illegible]	Z' mass 4.05 TeV		ATLAS-CONF-2016-045
	SSM $Z' \to \tau\tau$	2 τ	–	–	19.5	Z' mass 2.02 TeV		1502.07177
	Leptophobic $Z' \to bb$	–	2 b	–	3.2	Z' mass 1.5 TeV		1603.08791
	SSM $W' \to \ell\nu$	1 e, μ	–	Yes	13.3	W' mass 4.74 TeV		ATLAS-CONF-2016-061
	HVT $W' \to WZ \to qq\nu\nu$ model A	0 e, μ	1 J	Yes	13.2	W' mass 2.4 TeV	$g_V = 1$	ATLAS-CONF-2016-082
	HVT $W' \to WZ \to qqqq$ model B	–	2 J	–	15.5	W' mass 3.0 TeV	$g_V = 3$	ATLAS-CONF-2016-055
	HVT $V' \to WH/ZH$ model B	multi-channel			3.2	V' mass 2.31 TeV	$g_V = 3$	1607.05621
	LRSM $W'_R \to tb$	1 e, μ	2 b, 0-1 j	Yes	20.3	W' mass 1.92 TeV		1410.4103
	LRSM $W'_R \to tb$	0 e, μ	≥ 1 b, 1 J	–	20.3	W' mass 1.76 TeV		1408.0886
CI	CI $qqqq$	–	2 j	–	15.7	Λ 19.9 TeV	$\eta_{LL} = -1$	ATLAS-CONF-2016-069
	CI $\ell\ell qq$	2 e, μ	–	–	3.2	Λ 25.2 TeV	$\eta_{LL} = -1$	1607.03669
	CI $uutt$	2(SS)/≥3 e, μ	≥1 b, ≥1 j	Yes	20.3	Λ 4.9 TeV	$\lvert C_{RR}\rvert = 1$	1504.04605
DM	Axial-vector mediator (Dirac DM)	0 e, μ	≥ 1 j	Yes	3.2	m_A 1.0 TeV	g_q=0.25, g_χ=1.0, $m(\chi) < 250$ GeV	1604.07773
	Axial-vector mediator (Dirac DM)	0 e, μ, 1 γ	1 j	Yes	3.2	m_A 710 GeV	g_q=0.25, g_χ=1.0, $m(\chi) < 150$ GeV	1604.01306
	$ZZ\chi\chi$ EFT (Dirac DM)	0 e, μ	1 J, ≤ 1 j	Yes	3.2	M_* 550 GeV	$m(\chi) < 150$ GeV	ATLAS-CONF-2015-080
LQ	Scalar LQ 1st gen	2 e	≥ 2 j	–	3.2	LQ mass 1.1 TeV	$\beta = 1$	1605.06035
	Scalar LQ 2nd gen	2 μ	≥ 2 j	–	3.2	LQ mass 1.05 TeV	$\beta = 1$	1605.06035
	Scalar LQ 3rd gen	1 e, μ	≥1 b, ≥3 j	Yes	20.3	LQ mass 640 GeV	$\beta = 0$	1508.04735
Heavy quarks	VLQ $TT \to Ht + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	T mass 855 GeV	T in (T,B) doublet	1505.04306
	VLQ $YY \to Wb + X$	1 e, μ	≥ 1 b, ≥ 3 j	Yes	20.3	Y mass 770 GeV	Y in (B,Y) doublet	1505.04306
	VLQ $BB \to Hb + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	B mass 735 GeV	isospin singlet	1505.04306
	VLQ $BB \to Zb + X$	2/≥3 e, μ	≥2/≥1 b	–	20.3	B mass 755 GeV	B in (B,Y) doublet	1409.5500
	VLQ $QQ \to WqWq$	1 e, μ	≥ 4 j	Yes	20.3	Q mass 690 GeV		1509.04261
	VLQ $T_{5/3}T_{5/3} \to WtWt$	2(SS)/≥3 e, μ	≥1 b, ≥1 j	Yes	3.2	$T_{5/3}$ mass 990 GeV		ATLAS-CONF-2016-032
Excited fermions	Excited quark $q^* \to q\gamma$	1 γ	1 j	–	3.2	q^* mass 4.4 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1512.05910
	Excited quark $q^* \to qg$	–	2 j	–	15.7	q^* mass 5.6 TeV	only u^* and d^*, $\Lambda = m(q^*)$	ATLAS-CONF-2016-069
	Excited quark $b^* \to bg$	–	1 b, 1 j	–	8.8	b^* mass 2.3 TeV		ATLAS-CONF-2016-060
	Excited quark $b^* \to Wt$	1 or 2 e, μ	1 b, 2-0 j	Yes	20.3	b^* mass 1.5 TeV	$f_g = f_L = f_R = 1$	1510.02664
	Excited lepton ℓ^*	3 e, μ	–	–	20.3	ℓ^* mass 3.0 TeV	$\Lambda = 3.0$ TeV	1411.2921
	Excited lepton ν^*	3 e, μ, τ	–	–	20.3	ν^* mass 1.6 TeV	$\Lambda = 1.6$ TeV	1411.2921
Other	LSTC $a_T \to W\gamma$	1 e, μ, 1 γ	–	Yes	20.3	a_T mass 960 GeV		1407.8150
	LRSM Majorana ν	2 e, μ	2 j	–	20.3	N^0 mass 2.0 TeV	$m(W_R) = 2.4$ TeV, no mixing	1506.06020
	Higgs triplet $H^{\pm\pm} \to ee$	2 e (SS)	–	–	13.9	$H^{\pm\pm}$ mass 570 GeV	DY production, BR($H_L^{\pm\pm} \to ee$)=1	ATLAS-CONF-2016-051
	Higgs triplet $H^{\pm\pm} \to \ell\tau$	3 e, μ, τ	–	–	20.3	$H^{\pm\pm}$ mass 400 GeV	DY production, BR($H_L^{\pm\pm} \to \ell\tau$)=1	1411.2921
	Monotop (non-res prod)	1 e, μ	1 b	Yes	20.3	spin-1 invisible particle mass 657 GeV	$a_{non-res} = 0.2$	1410.5404
	Multi-charged particles	–	–	–	20.3	multi-charged particle mass 785 GeV	DY production, $\lvert q\rvert = 5e$	1504.04188
	Magnetic monopoles	–	–	–	7.0	monopole mass 1.34 TeV	DY production, $\lvert g\rvert = 1g_D$, spin 1/2	1509.08059

$\sqrt{s}$ = 8 TeV $\sqrt{s}$ = 13 TeV

10^{-1} **1 TeV** **10 TeV** Mass scale [TeV]

*Only a selection of the available mass limits on new states or phenomena is shown. Lower bounds are [illegible] en explic[illegible]

†Small-radius (large-radius) jets are denoted by the letter j (J).

Beijing Electron Positron Collider

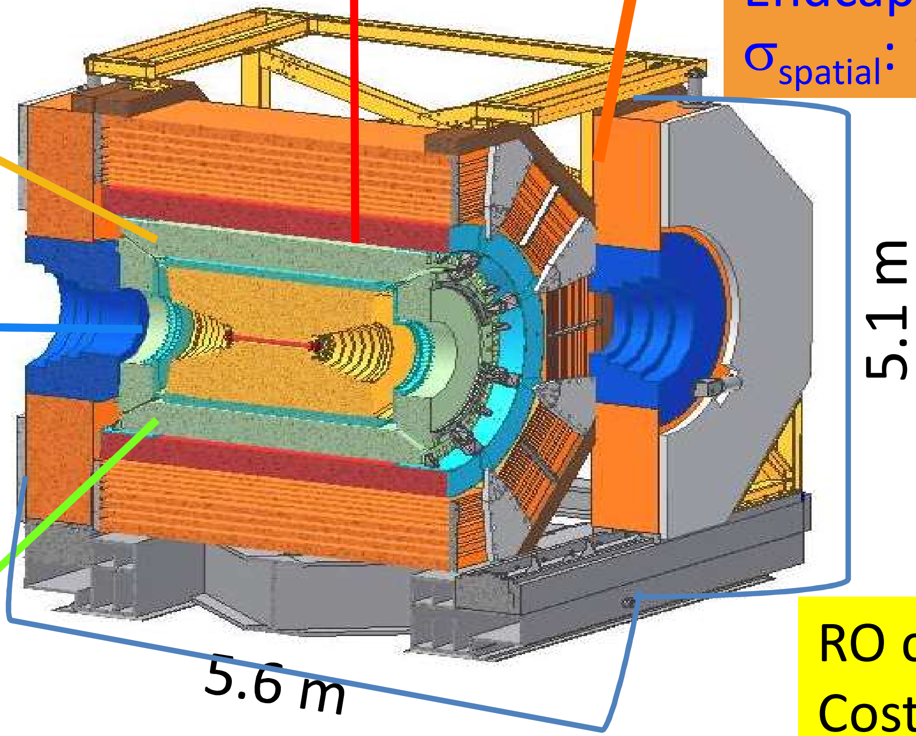
BESIII Detector and Collaboration

Drift chamber (MDC)
Small cell, 43 layer
Gas He/C_3H_8=40/60
σ_{xy}=130 μm, dE/dx~6%
σ_p/p = 0.6% at 1 GeV

1 T Super conducting magnet

Muon counter
Resistive plate chamber
Barrel: 9 layers
Endcaps: 8 layers
$\sigma_{spatial}$: 1.48 cm

Time-of-flight (TOF)
Plastic scintillator
σ_T(barrel): 80 ps
σ_T(endcap): 90 ps



ECAL calorimeter
CsI(Tl): L=28 cm ($15X_0$)
Energy range: 0.02-2GeV

At 1 GeV	σ_E (%)	σ_l(mm)
Barrel:	2.5	6.1
Endcap:	5	9

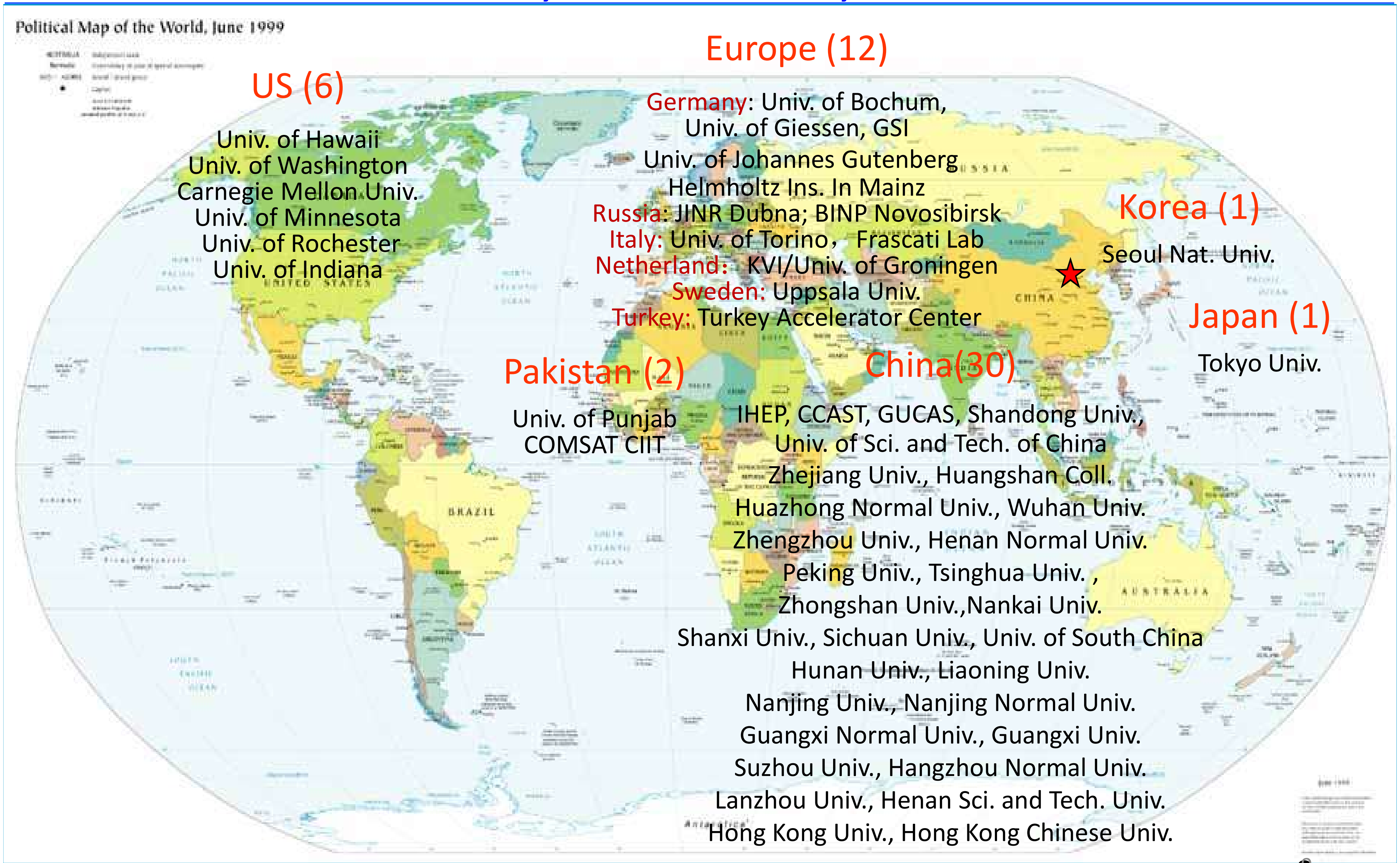
RO channels: 10^4
Cost: 200 M RMB

Data acquisition
Event rate: 4 kHz
Data size: 50 MB/s

Grid computing
CPU: 3200 core
Storage: 2.2 pB

BESIII Experiment

11 countries, 52 institutions, 351 authros



US (6)

Univ. of Hawaii
Univ. of Washington
Carnegie Mellon Univ.
Univ. of Minnesota
Univ. of Rochester
Univ. of Indiana

Europe (12)

Germany: Univ. of Bochum, Univ. of Giessen, GSI
Univ. of Johannes Gutenberg
Helmholtz Ins. In Mainz
Russia: JINR Dubna; BINP Novosibirsk
Italy: Univ. of Torino，Frascati Lab
Netherland: KVI/Univ. of Groningen
Sweden: Uppsala Univ.
Turkey: Turkey Accelerator Center

Korea (1)

Seoul Nat. Univ.

Japan (1)

Tokyo Univ.

Pakistan (2)

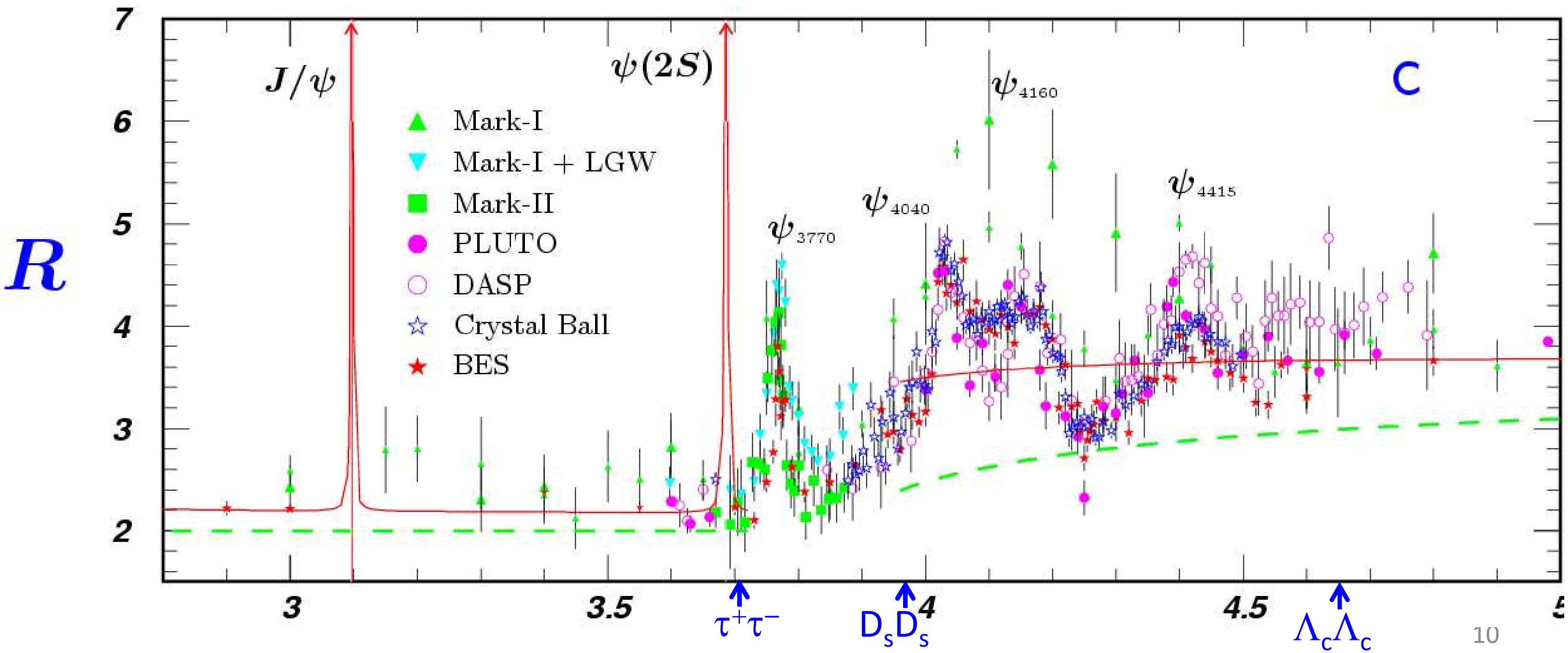
Univ. of Punjab
COMSAT CIIT

China(30)

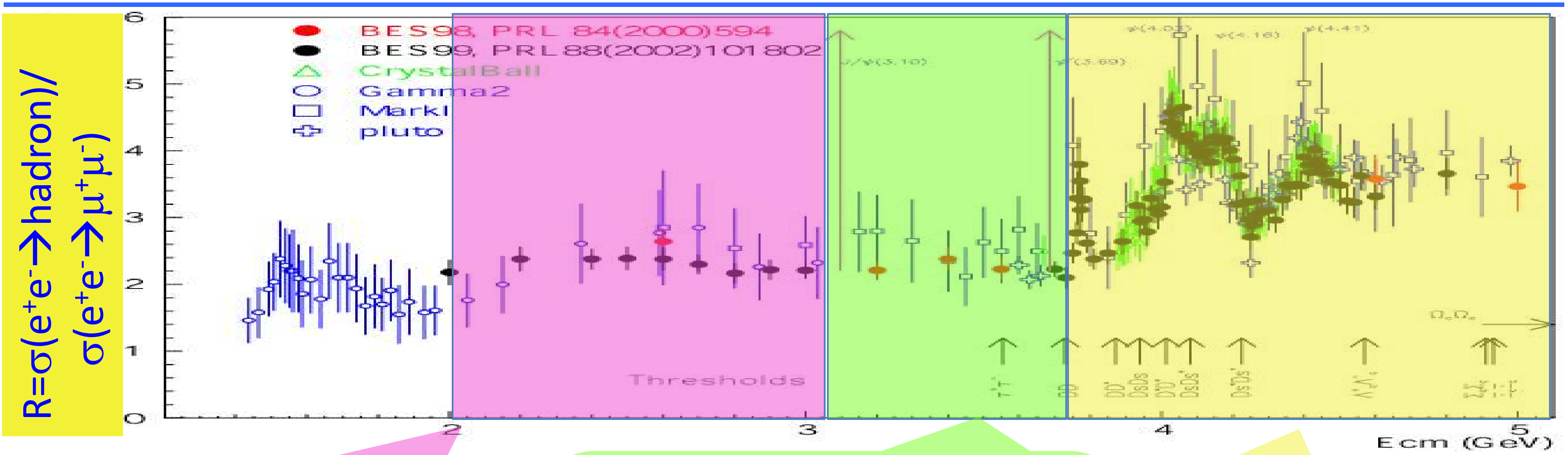
IHEP, CCAST, GUCAS, Shandong Univ.,
Univ. of Sci. and Tech. of China
Zhejiang Univ., Huangshan Coll.
Huazhong Normal Univ., Wuhan Univ.
Zhengzhou Univ., Henan Normal Univ.
Peking Univ., Tsinghua Univ. ,
Zhongshan Univ.,Nankai Univ.
Shanxi Univ., Sichuan Univ., Univ. of South China
Hunan Univ., Liaoning Univ.
Nanjing Univ., Nanjing Normal Univ.
Guangxi Normal Univ., Guangxi Univ.
Suzhou Univ., Hangzhou Normal Univ.
Lanzhou Univ., Henan Sci. and Tech. Univ.
Hong Kong Univ., Hong Kong Chinese Univ.

Features of the τ-c Energy Region

- Rich of resonances, charmonium and charmed mesons.
- Threshold characteristics (pairs of τ, D, D_s, charmed baryons…).
- Transition between smooth and resonances, perturbative and non-perturbative QCD.
- Mass location of the exotic hadrons, gluonic matter and hybrid.



Physics at τ-c Energy Region



- Hadron form factors
- Y(2175) resonance
- Mutltiquark states with s quark, Zs
- MLLA/LPHD and QCD sum rule predictions

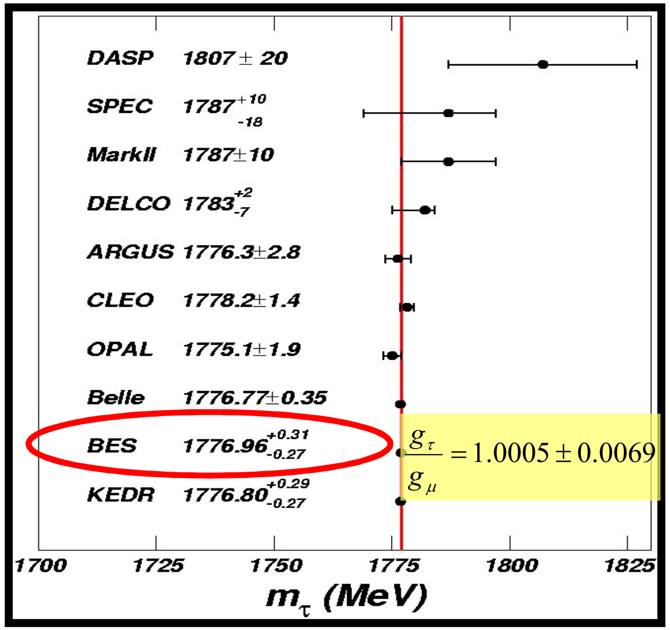
- Light hadron spectroscopy
- Gluonic and exotic states
- Process of LFV and CPV
- Rare and forbidden decays
- Physics with τ lepton

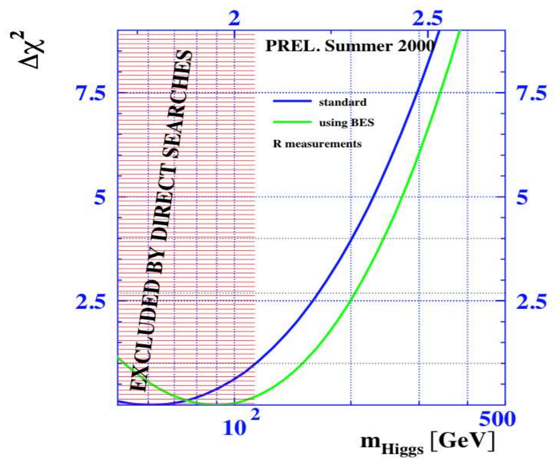
- XYZ particles
- Physics with D mesons
- f_D and f_{Ds}
- D_0-$\overline{D}_0$ mixing
- Charmed baryons

R scan

- **Precision $\Delta\alpha_{QED}$, a_μ, charm quark mass extraction.**
- **Hadron form factor(nucleon, Λ, π).**

Selected Highlights from BES



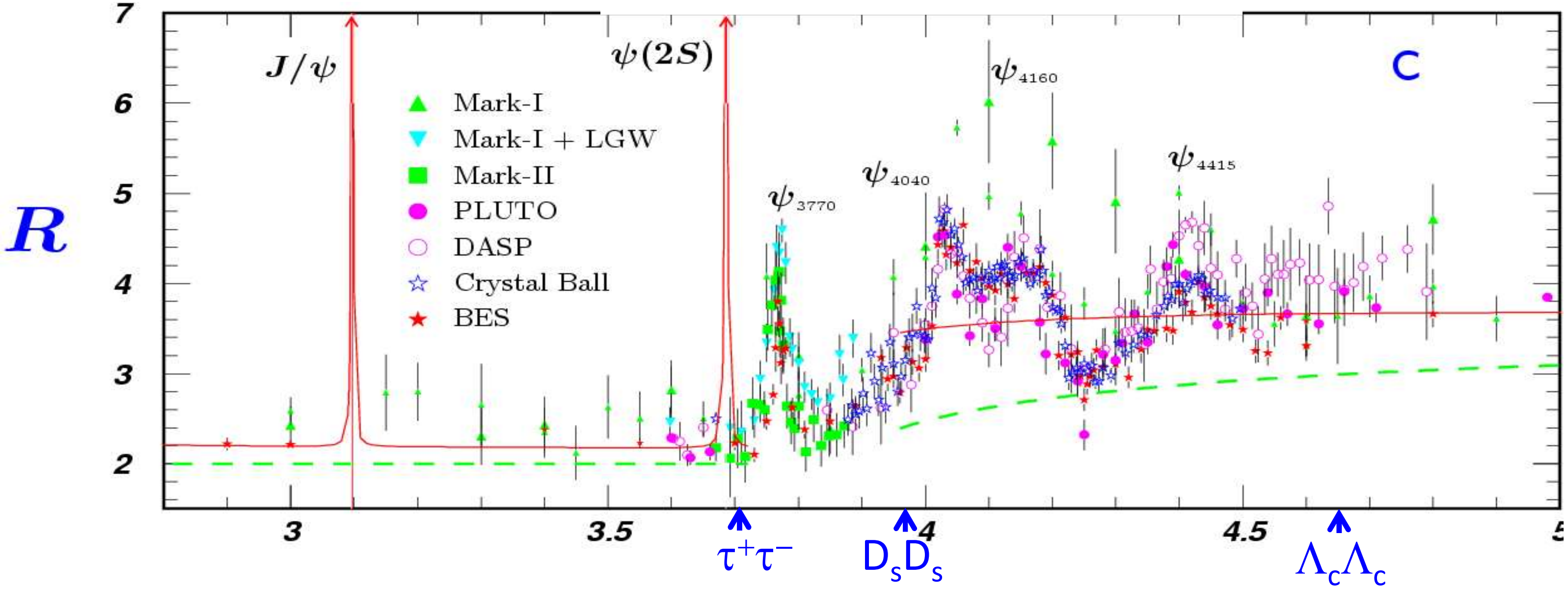


minimum moves to 90 GeV, upper limit moves to 210 GeV

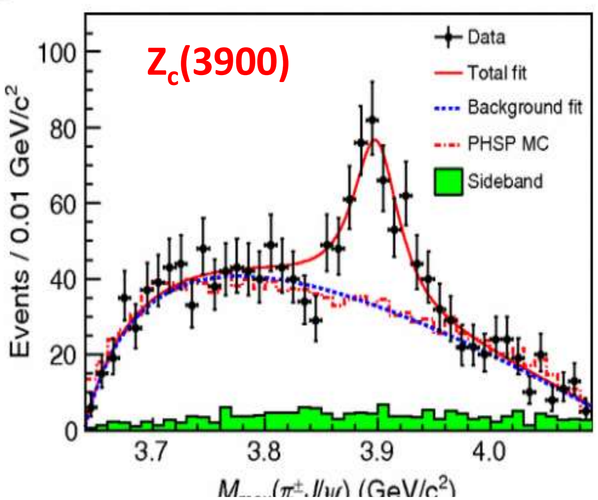
↑ very preliminary ↑

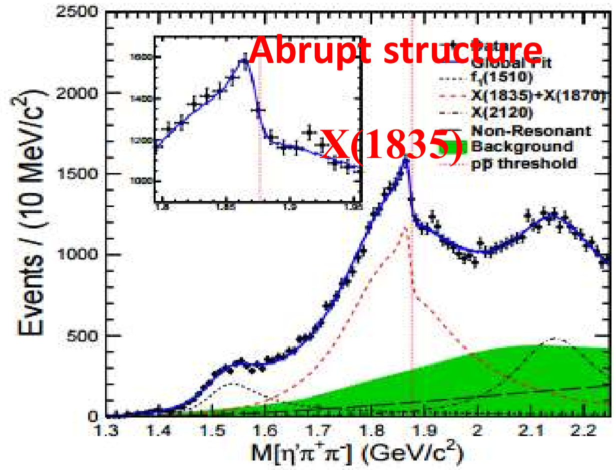
"without this result, we could have excluded the SM Higgs"

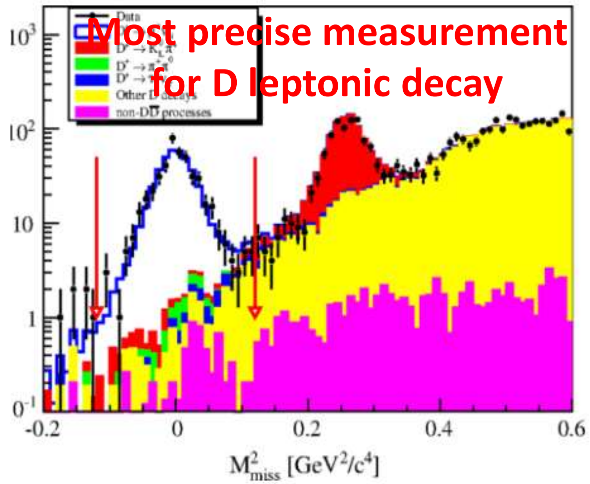
Bolek Pietrzyk at ICHEP 2000

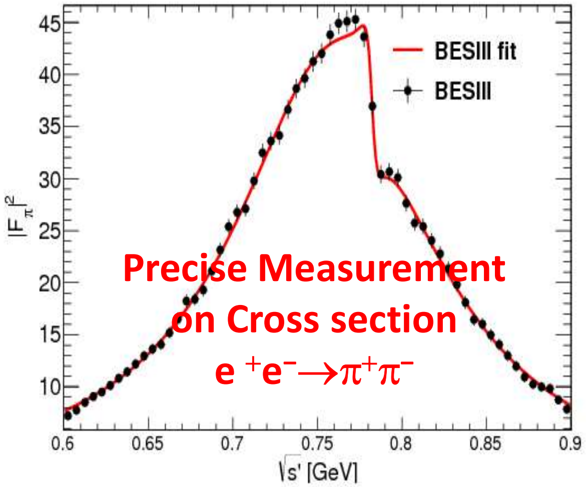


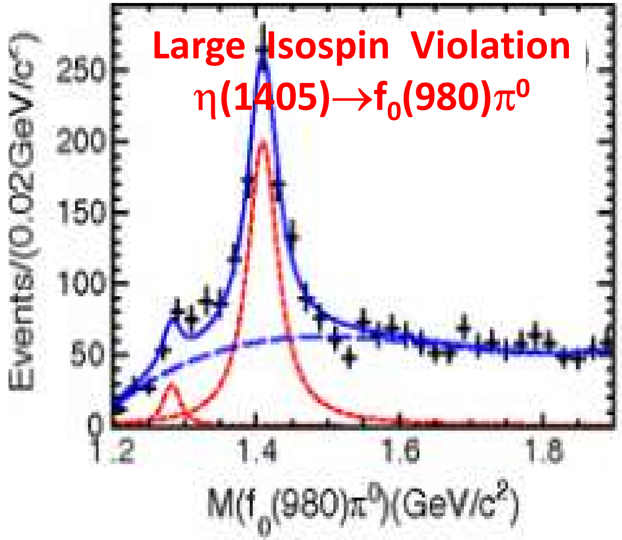
Selected Highlights

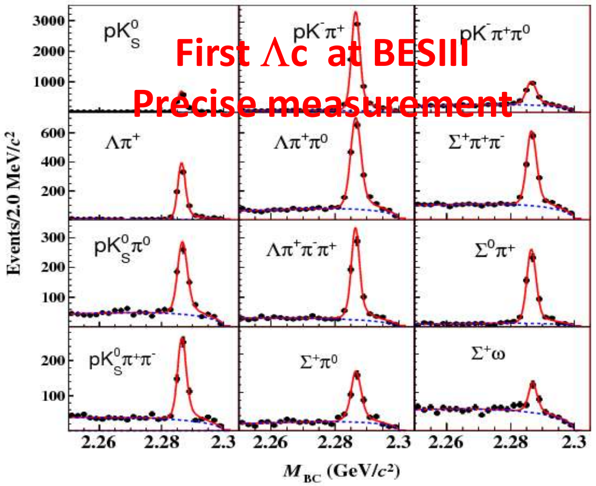












A Super Tau-charm Factory to Succeed BEPC

BEPCII/BESIII will end its mission around 2024

High Intensity Electron Positron Accelerator (HIEPA)

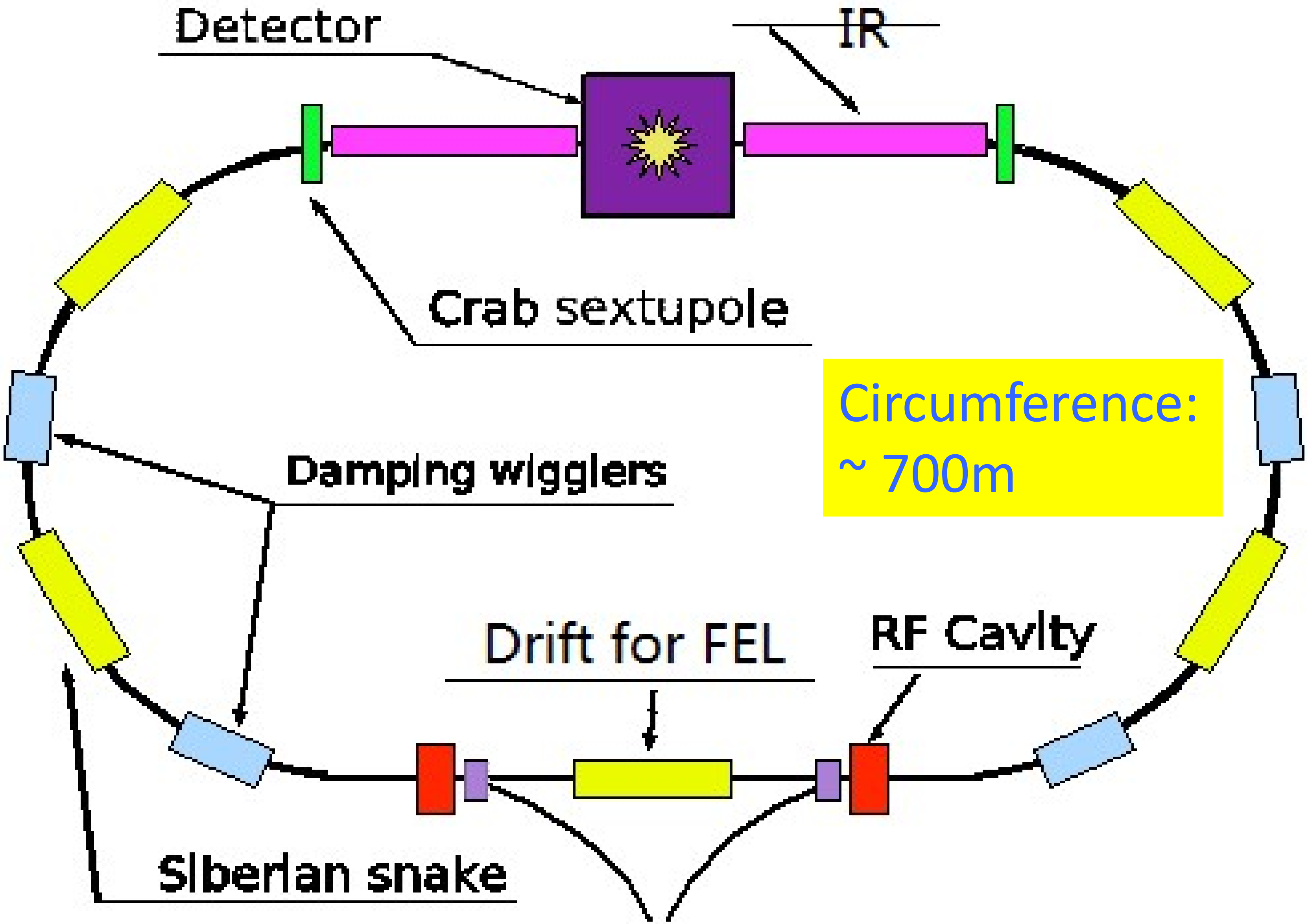
What is HIEPA?

- Electron Positron Collider for physics
  - E_{cm} = 2–7GeV
  - Luminosity > 0.5-1×10^{35} $cm^{-2}s^{-1}$ at 4 GeV
  - Polarization available on one beam (phase II)
    - Polarized electron beam source
    - Siberian Snake curing depolarization

- Being a SRF (synchrotron radiation facility).

- Reserving the potential for future FEL (free electron laser) study with the long LINAC.

What Is HIEPA ?



Data Samples / Year

Luminosity | **Seconds/days** | **Running time/year** | **Efficiency**

$$10^{35}\text{cm}^{-2}\text{s}^{-1} \times 86400\text{s} \times 180\text{days} \times 90\% = 1.4\text{ab}^{-1}$$

	CLEO-C		BES-III/ year $10^{33}\text{cm}^{-2}\text{s}^{-1}$ (10fb^{-1})	HIEPA/year $10^{35}\text{cm}^{-2}\text{s}^{-1}$ (1ab^{-1})
J/ψ	–	–	10×10^9	10×10^{11}
$\psi(2S)$	54 pb^{-1}	27×10^6	3×10^9	3×10^{11}
$\psi(3770)$	818 pb^{-1}	5×10^6 D-pair	4×10^7	4×10^9
4.17 GeV	586 pb^{-1}	7×10^5 D_s-pair	1×10^6	1×10^8
$\tau^+\tau^-$ (4.25)		4×10^6	3×10^7	3×10^9

Highlighted Physics Program

- **Search for new forms of hadron and study their properties.**
- **The nucleon/hadron electromagnetic form factors (NEFFs) and QCD study in none perturbative region.**
- **Search for new physics beyond the SM.**
- **……**

Key science question: is there any new forms of hadron exist ?

- **Exotic hadrons are not predicted by the simple quark model.**
- **Many candidates, such as X(3872), Y(4260) and Zc(3900), have been discovered, but some are not firmly established and their property are poorly known.**
- **To reach conclusive evidence, an e^+e^- collider in the τ-c sector, which is able to provide much higher statistical data and cover wide energy range is essential.**

  - **Search for lower mass glueballs, 1^{-+} hybrid;**
  - **Explore the nature of XYZ particles;**
  - **Search for Zcs states**

Key science question: why do quarks forms colourless hadrons with only two stable configurations, proton and neutron?

- **NEFFs are among the most basic observables of the nucleon, and intimately related to its internal structure.**
- **Nucleons are the building blocks of almost all-ordinary matter in the universe. The challenge of understanding the nucleon's structure and dynamics has occupied a central place in particle physics.**
- **The fundamental understanding of the hadron form factor in terms of QCD is one of the outstanding problems in particle physics.**

Key science question:
are there any new physics beyond the SM?

- **We believe physics beyond the SM exist:**

  - Gravity is not take into account

  - No candidates for dark matter

  - No explanation to asymmetry of matter and anti matter

  - .....

- **Search for new physics in precision frontier is complementary to that at high energy frontier.**

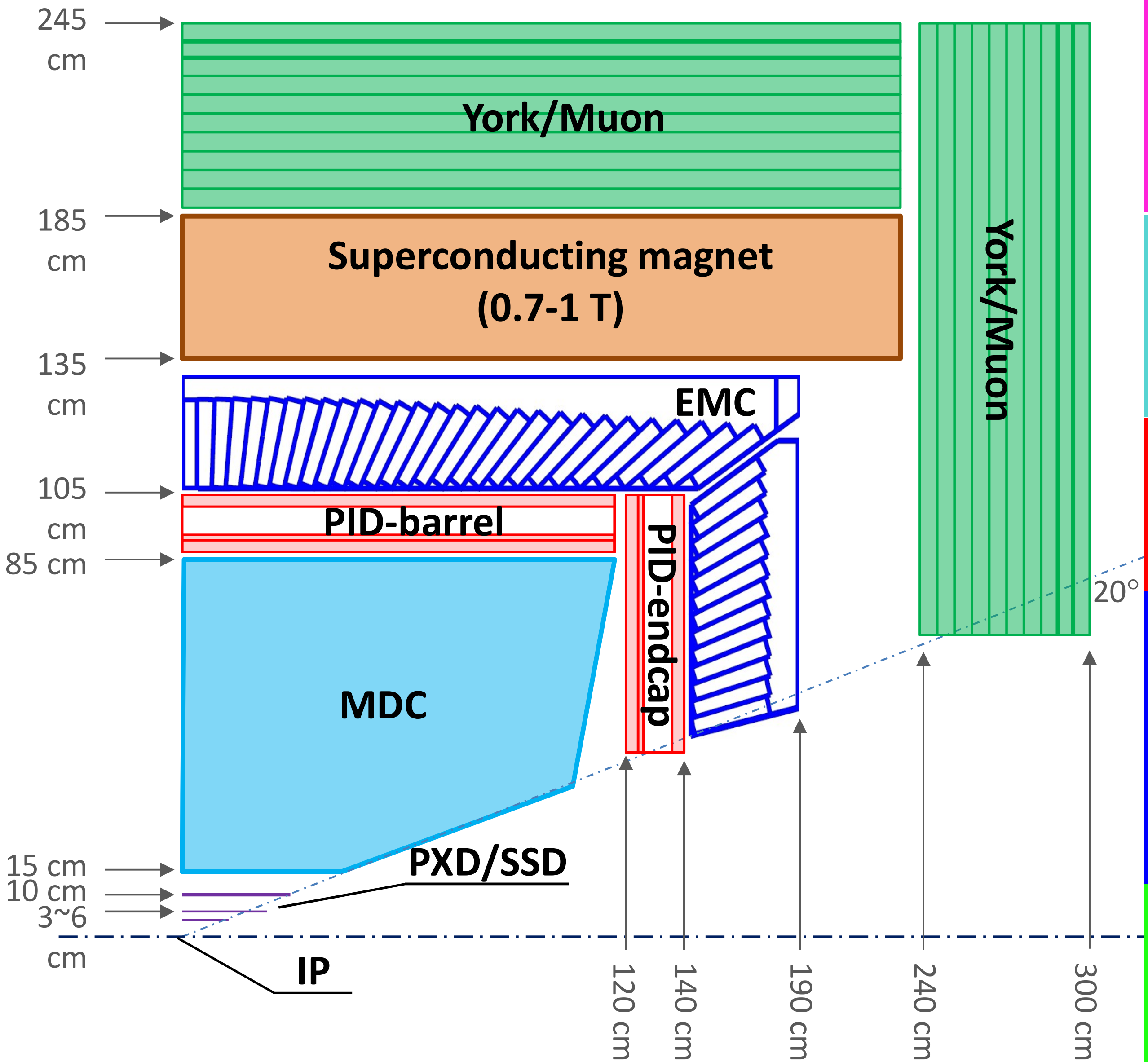
  - **CP Violation in τ decay**

    - $\tau^- \to K_S \pi^- \nu$

    -T-odd rotationally invariant produ $P_2^{\tau} \cdot (\vec{P}_{\pi^+} \times \vec{P}_{\pi^0})$ e.g. of $\tau^- \to \pi^- \pi^0 \nu_\tau / k^- \pi^0 \nu_\tau$

  - **cLFV:** $\tau \to \mu\gamma$

Detector



PXD

- Material budget ~0.15%X_0 / layer
- σ_{xy}=50 μm

MDC

- σ_{xy}=130 μm
- dE/dx<7%, σ_p/p =0.5% at 1 GeV

PID

- π/K (and K/p) 3-4σ separation up to 2GeV/c

EMC

Energy range: 0.02-2GeV

At 1 GeV	σ_E (%)
Barrel(Cs(I)):	2
Endcap (Cs):	4

MUD

- μ/π suppression power >10

Activities

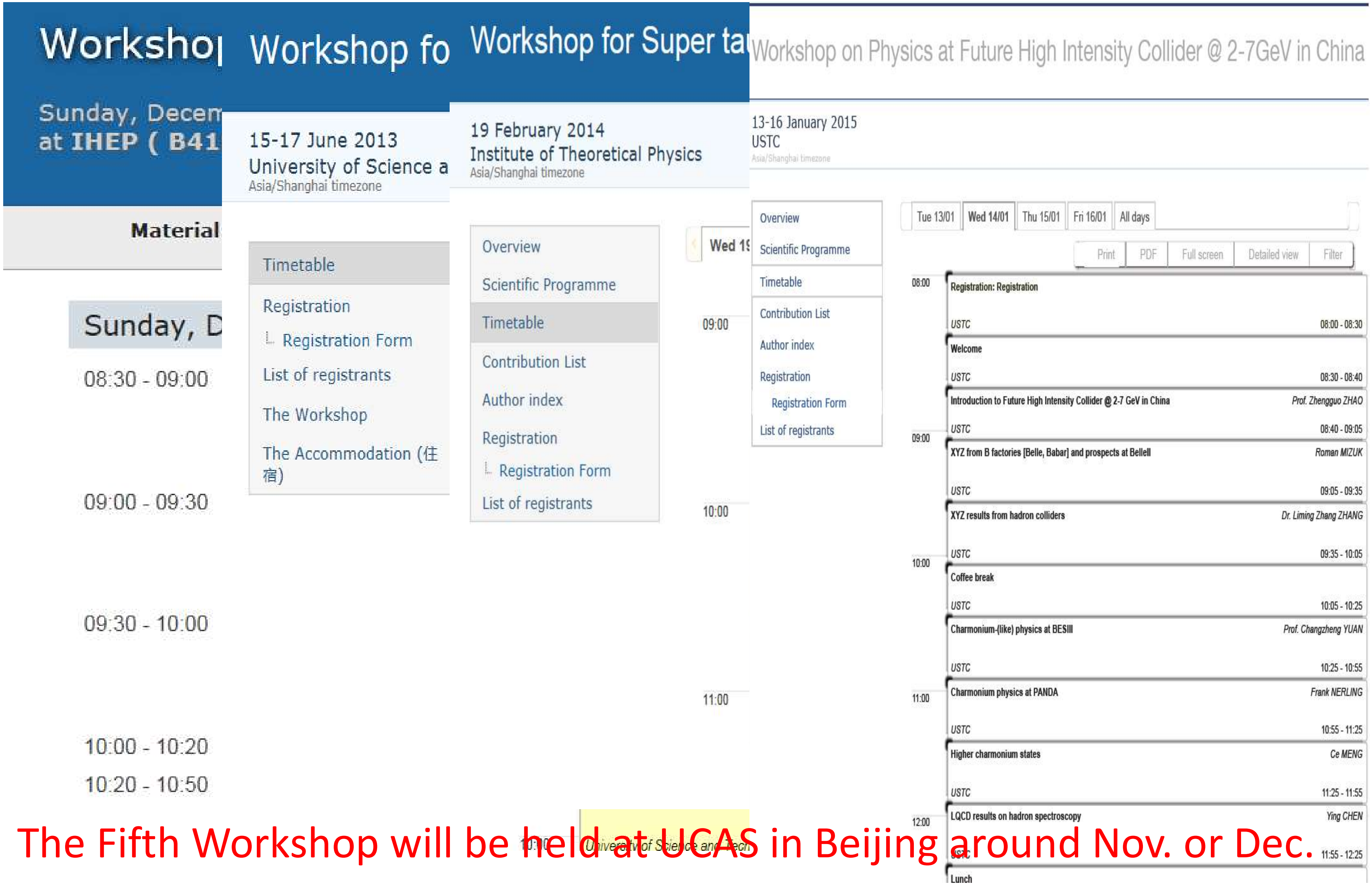
http://wcm.ustc.edu.cn/pub/CICPI2011/futureplans/

High Luminosity Tau Charm Physics

Indico for High Luminorcity Tau Charm Physics R&D

Coordinator Meeting	2 events
Mini Workshop	1 event
Monthly Meeting	3 events
Physics Weekly Meeting	3 events
Workshop	3 events

Workshops for HIEPA



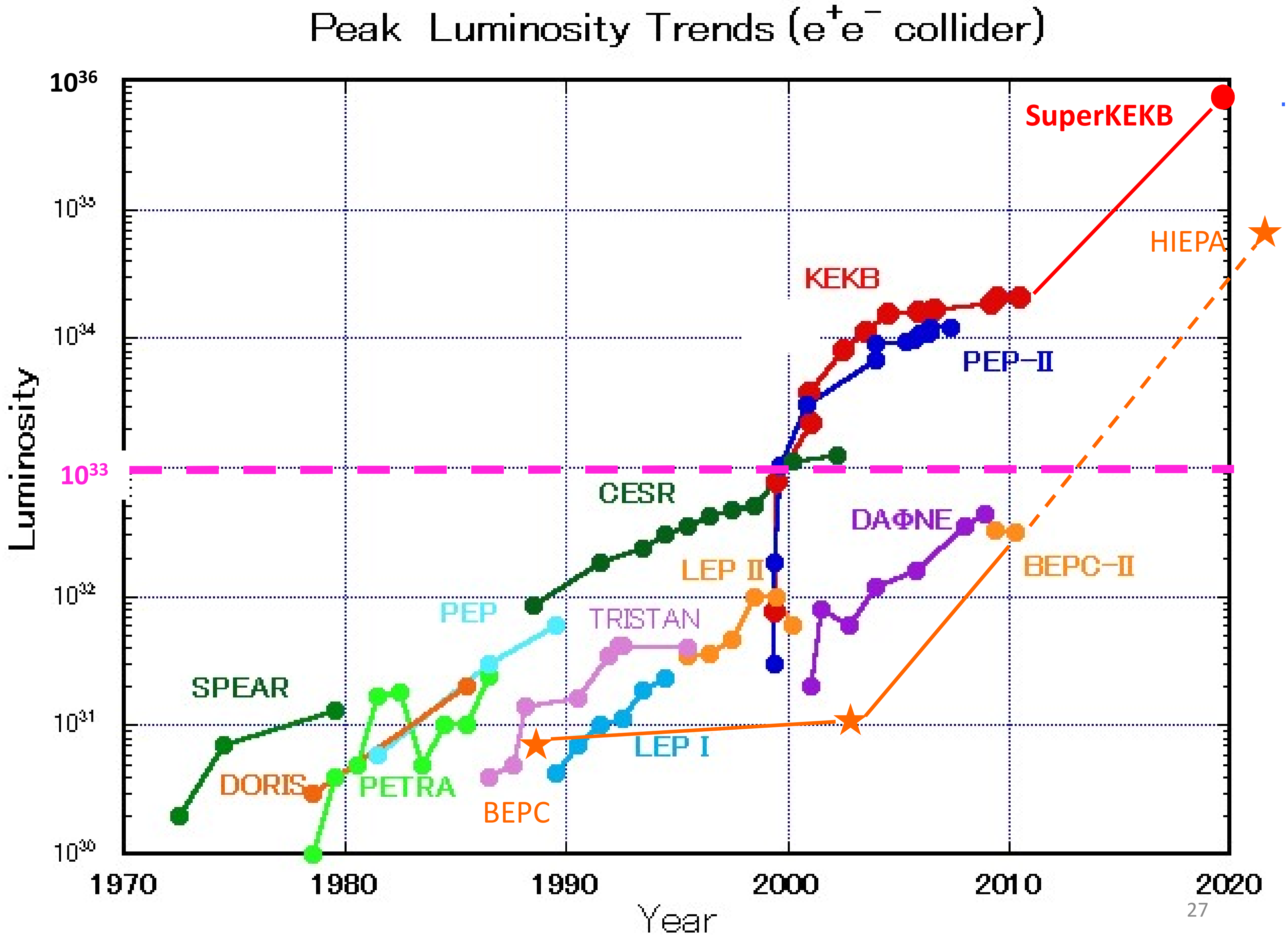
The Fifth Workshop will be held at UCAS in Beijing around Nov. or Dec.

Institutions Shown Interest

- University of Science and Technology of China
- Institute of High Energy Physics, CAS
- Institute of Theoretical Physics, CAS
- Tsinghua University
- University of Chinese Academy of Sciences
- Shangdong University
- Shanghai Jiaotong University
- Peking University
- Zhejiang University
- Nanjing University
- Nankai University
- Wuhan University
- Central China Normal University Lanzhou University
- Nanhua University
- Beijing University of Aeronautics and Astronautics
- Institute for Basic Science, Daejeon, Korea
- Dubna, Russia
- Budker Institute and Novosibirsk University, Russia
- T. Shevchenko National University of Kyiv, Kyiv, Ukraine
- University Ljubljana and Jozef Stefan Institute Ljubljana, Slovenia
- Jozef Stefan Institute Ljubljana, Slovenia
- Stanford University, USA
- Wayne State University, USA
- Carnegie Mellon University, USA
- GSI Darmstadt and Goethe University Frankfurt, Germany
- Goethe University Frankfurt, Germany
- GSI Darmstadt, Germany
- Johannes Gutenberg University Mainz, Germany
- Helmholtz Institute Mainz, Germany
- LAL (IN2P3/CNRS and Paris-Sud University), Orsay, France
- Sezione di Ferrara, Italy
- L'Istituto di Fisica Nucleare di Torino, Italy
- L'Istituto di Fisica Nucleare di Firenze, Italy
- Scuola Normale Superiore, Pisa, Italy
- University of Silesia, Katowice, Poland
- Laboratori Nazionali di Frascati, Italy
- INFN, Padova, Italy
- University of Pavia, Pavia, Italy
- University of Parma, Italy

Pre-CDR

Contents


Peak Luminosity Trends (e+e− collider)
10^36
10^35
10^34
10^33
10^32
10^31
10^30
Luminosity
1970
1980
1990
2000
2010
2020
Year
SuperKEKB
HIEPA
KEKB
PEP-II
CESR
DAΦNE
BEPC-II
LEP II
PEP
TRISTAN
SPEAR
DORIS
PETRA
BEPC
LEP I

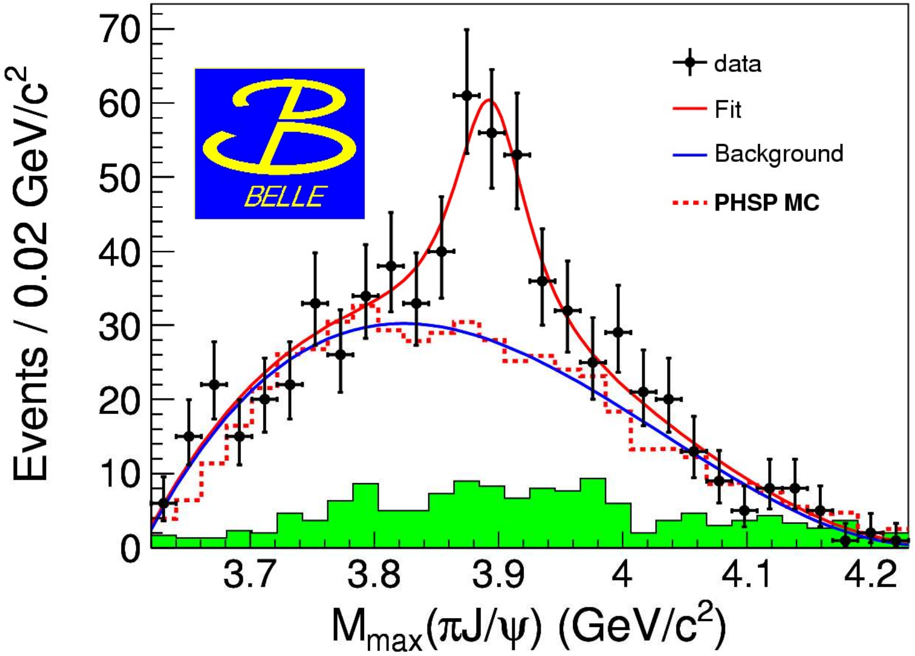
Summary

- **STCF could be one of the crucial precision frontier - rich of physics program, unique for physics with c quark and τ leptons, important playground for study of QCD, exotic hadrons and search for new physics.**
- **HIEPA has a ring of ~700 m in circumference and can provides:**
  - e^+e^- collision with E_{cm}=2-6 GeV, L=5x10^{34}
  - SRF for beam of 1-3.5 GeV
  - Potential for future FEL with long LINAC line
- **A draft of pre-CDR exist, effort to move to CDR, TDR.**
- **International collaboration is badly need for promoting the project.**

Extra Slides

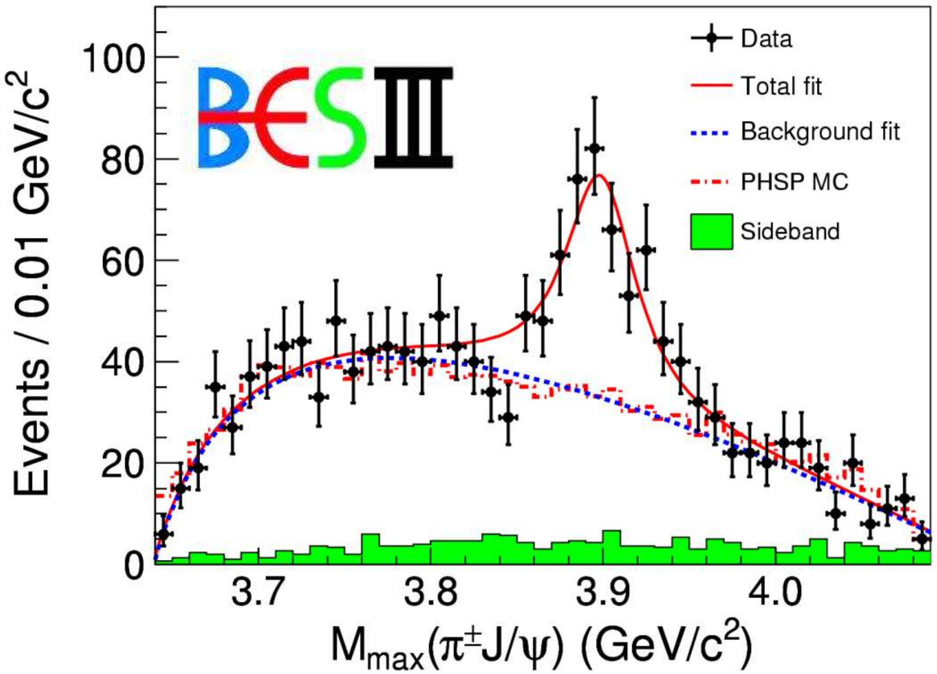
$Z_c(3900)$ Observed at BESIIII and Belle

Belle with ISR: PRL110, 252002
967 fb^{-1} in 10 years running time



- M = 3894.5±6.6±4.5 MeV
- Γ = 63±24±26 MeV
- 159 ± 49 events
- >5.2σ

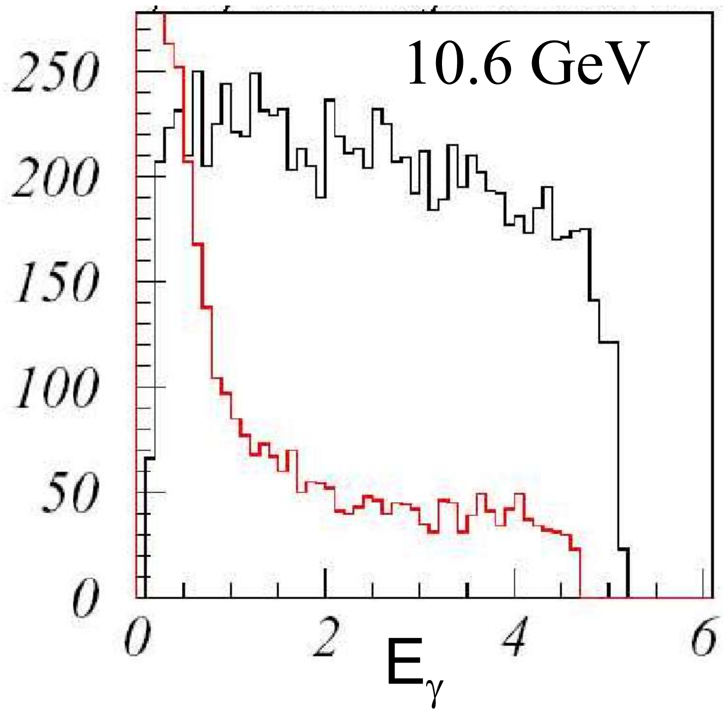
BESIII at 4.260 GeV: PRL110, 252001
0.525 fb^{-1} in one month running time

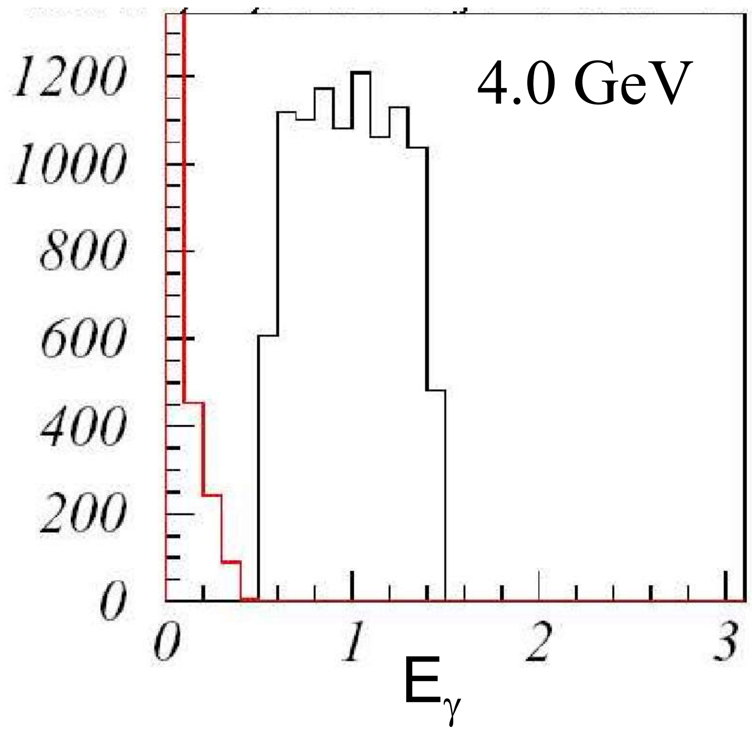


- M = 3899.0±3.6±4.9 MeV
- Γ = 46±10±20 MeV
- 307 ± 48 events
- >8σ

$\tau \to \mu\gamma$

- The process $e^+e^- \to \tau^+\tau^-\gamma$, dominant background source at Υ(4S), does not contribute below $2E \approx 4m_\tau/\sqrt{3} \approx 4.1$ GeV.
- The favorable kinematical condition and the use of polarization can allow an UL(STCF in 1-2 years) ≤ UL(SuperBelle@Y in 12-15 yrs).





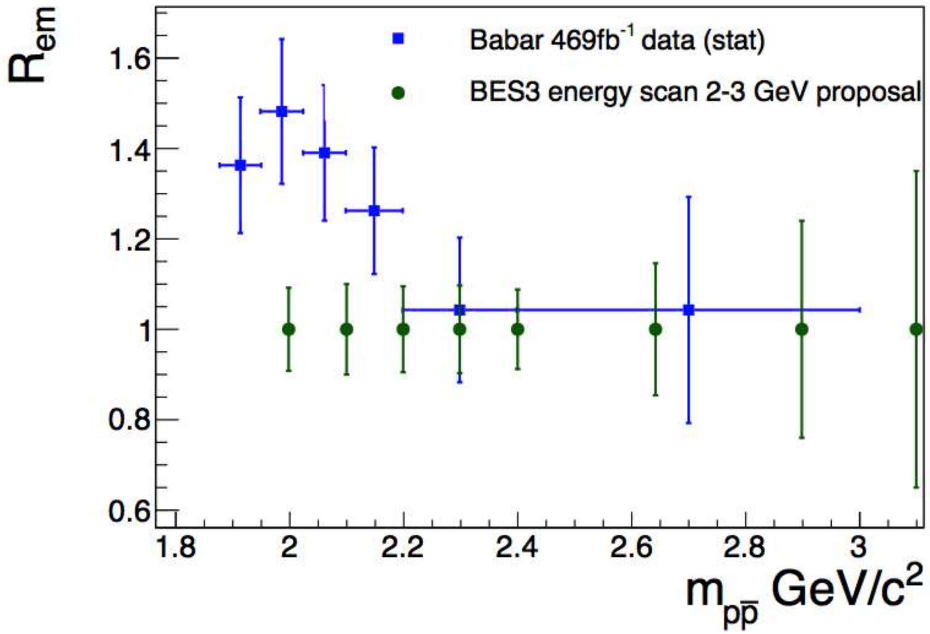
Questions to be addressed

- **What are the key science questions that needs a STCF to answer?**
- **Do we need a STCF at the SBF era?**
- **What are the key technologies and challenges to HIEPA?**
- **What kind of detector we should build to fit the physics reaches, and what are the challenges?**

Measurement of Proton FFs with BESIII

Babar: 469 fb^{-1} 10-24% precision

BESIII: 0.4 fb^{-1} ~10% precision (expected)



$\delta|R_{EM}|/|R_{EM}|$ ~ 9% - 35%

$\delta|G_M|/|G_M|$ ~ 3% - 9%

$\delta|G_E|/|G_E|$ ~ 9% - 35%

first time extraction without any assumption.

Big Questions to the Standard Model

Cosmology:

- **Unable to explain matter anti-matter asymmetry;**
- **Not account for the accelerating expansion of the universe (dark energy), no prediction power for dark matter candidates.**

Force and unification:

- **Does not incorporate the full theory of gravity;**
- **No answer to the origin of electroweak symmetry breaking;**
- **No solution to hierarchy problem.**

Particle properties:

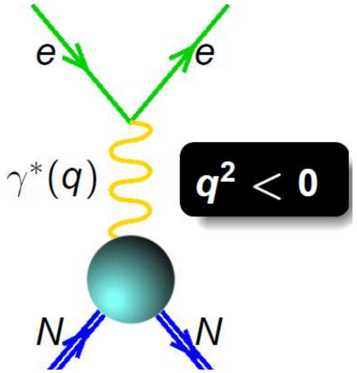
- **Does not incorporate neutrino oscillation and their masses;**
- **Does not explain electric charge quantization.**

Expect new physics beyond SM

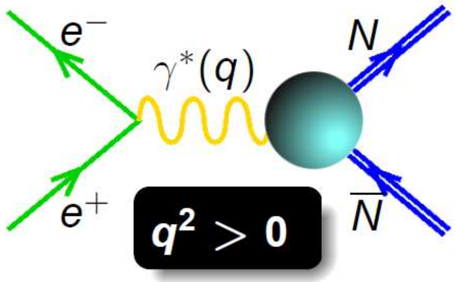
Nucleon Electromagnetic Form Factors(NEFFs)

$eN \rightarrow eN$

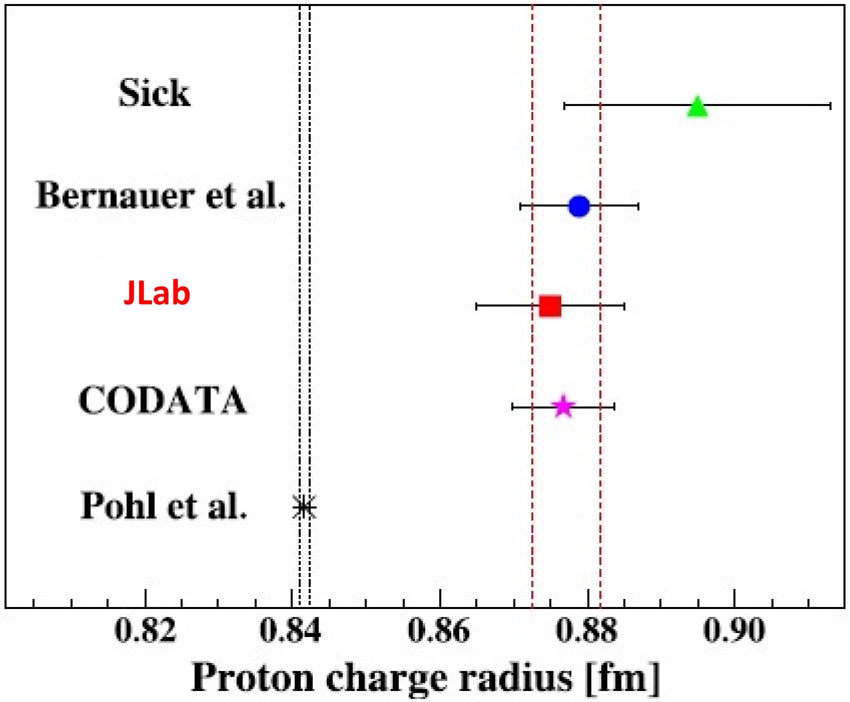
Space-like:
FF real

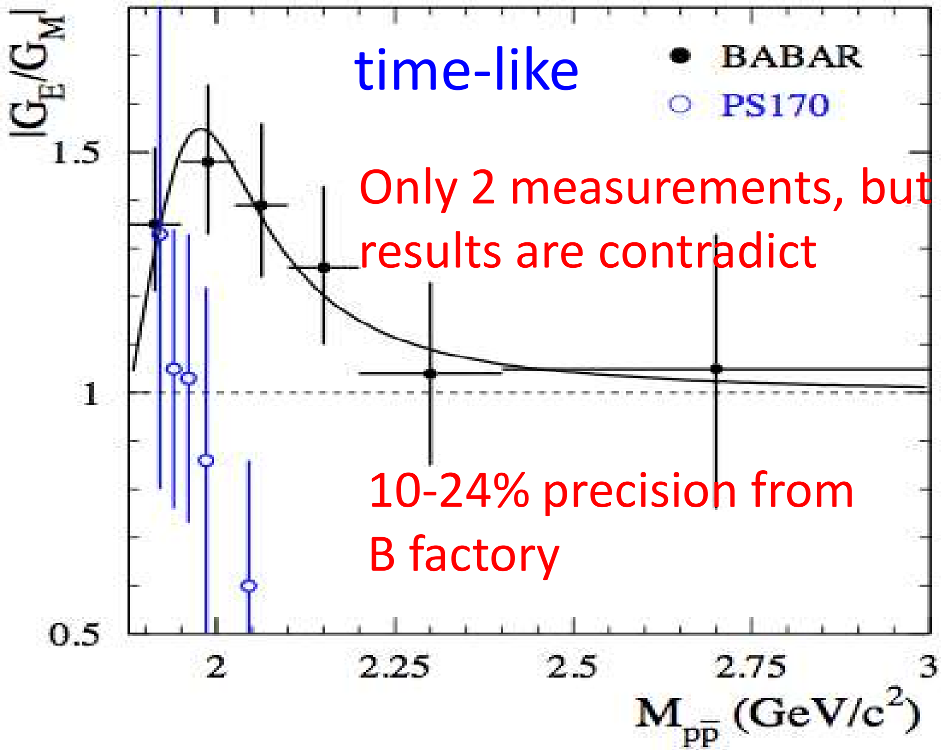


$e^+e^- \leftrightarrow N\overline{N}$, $\Lambda\overline{\Lambda}$



Time-like:
FF complex





CP Violation in τ Decay

- CP violation is observed in B, D and K systems to date
- No CPV has been observed in the lepton sector
- The discovery of CPV in the tau sector would be a clean signature of NP
- One of the most promising CPV channels is $\tau^- \to K_S \pi^- \nu$
  - SM CP asymmetry from K_S-K_L mixing is expected to be :

    [Bigi & Sanda, PLB 625, 2005, Grossman &Nir JHEP 1204 (2012) 002]

$$|K_S\rangle = p|K^0\rangle + q|\overline{K}^0\rangle$$
$$|K_L\rangle = p|K^0\rangle - q|\overline{K}^0\rangle$$

$$\frac{\Gamma(K_L \to \pi^- l^+ \nu) - \Gamma(K_L \to \pi^+ l^- \overline{\nu})}{\Gamma(K_L \to \pi^- l^+ \nu) + \Gamma(K_L \to \pi^+ l^- \overline{\nu})} = |p|^2 - |q|^2 \simeq (3.27 \pm 0.12) \times 10^{-3}$$

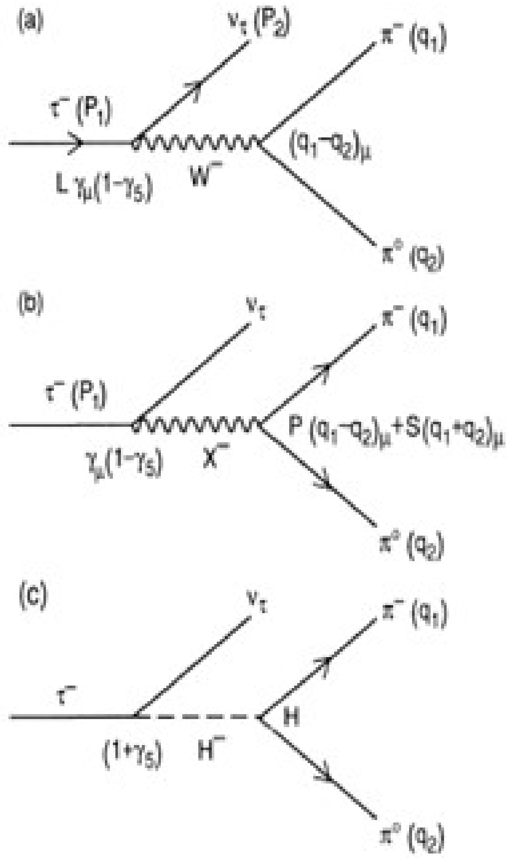
  - BaBar measurement [PRD 85, 031102]

$$A_\tau \equiv \frac{\Gamma(\tau^+ \to \pi^+ K_S \bar{\nu}_\tau) - \Gamma(\tau^- \to \pi^- K_S \nu_\tau)}{\Gamma(\tau^+ \to \pi^+ K_S \bar{\nu}_\tau) + \Gamma(\tau^- \to \pi^- K_S \nu_\tau)} = (-4.5 \pm 2.4 \pm 1.1) \times 10^{-3}.$$

  - Belle measurement [PRL 107, 131801]

$$|\mathrm{Im}(\eta_S)| < 0.026 \text{ or better.}$$

$A_{cp} = (1.8 \pm 2.1 \pm 1.4) \times 10^{-3}$ @ W ~ [0.89-1.11] GeV



Charge Higgs, new Scalar, W_L-W_R Mixings, LeptonQuarks

τ CPV in Angle Distribution

Need new measurement on the angular CPV asymmetry

Use T-odd rotationally invariant products : e.g.

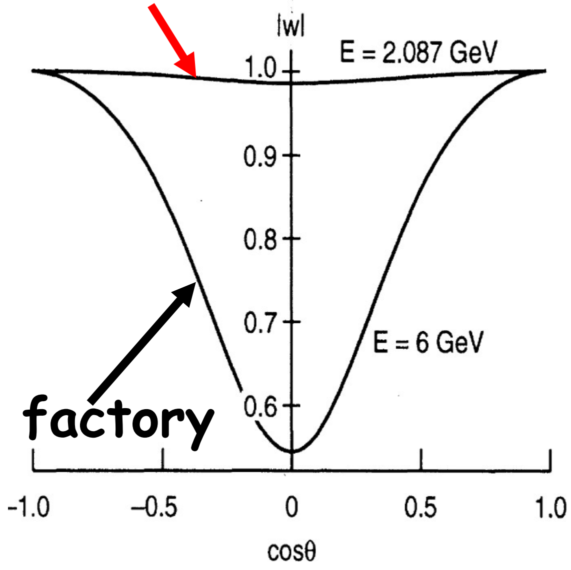
$$P_2^{\tau} \cdot (\vec{P}_{\pi^+} \times \vec{P}_{\pi^0})$$

in τ^+ and τ^- decays to >=2 hadrons such as :

$\tau^- \to \pi^-\pi^0\nu_\tau$ /$k^-\pi^0\nu_\tau$, $\tau^- \to \pi^-\pi^+\pi^-\nu_\tau$ /$K^-\pi^+\pi^-\nu_\tau$,

Need polarized beam

tau-charm



B factory

"Figure Of Merits" -- Y. S. TSAI

$$\text{merit} = \text{luminosity} \times \bar{w}_Z \times \text{ total cross section}$$
$$\propto \text{luminosity} \times (w_1 + w_2)$$
$$\times \sqrt{1 - a^2} a^2 (1 + 2a) ,$$

BESIII @ 4.25 ($10^{33}cm^{-2}s^{-1}$)   FOM=1

HIEPA @ 4.25 ($10^{35}cm^{-2}s^{-1}$)   FOM=100

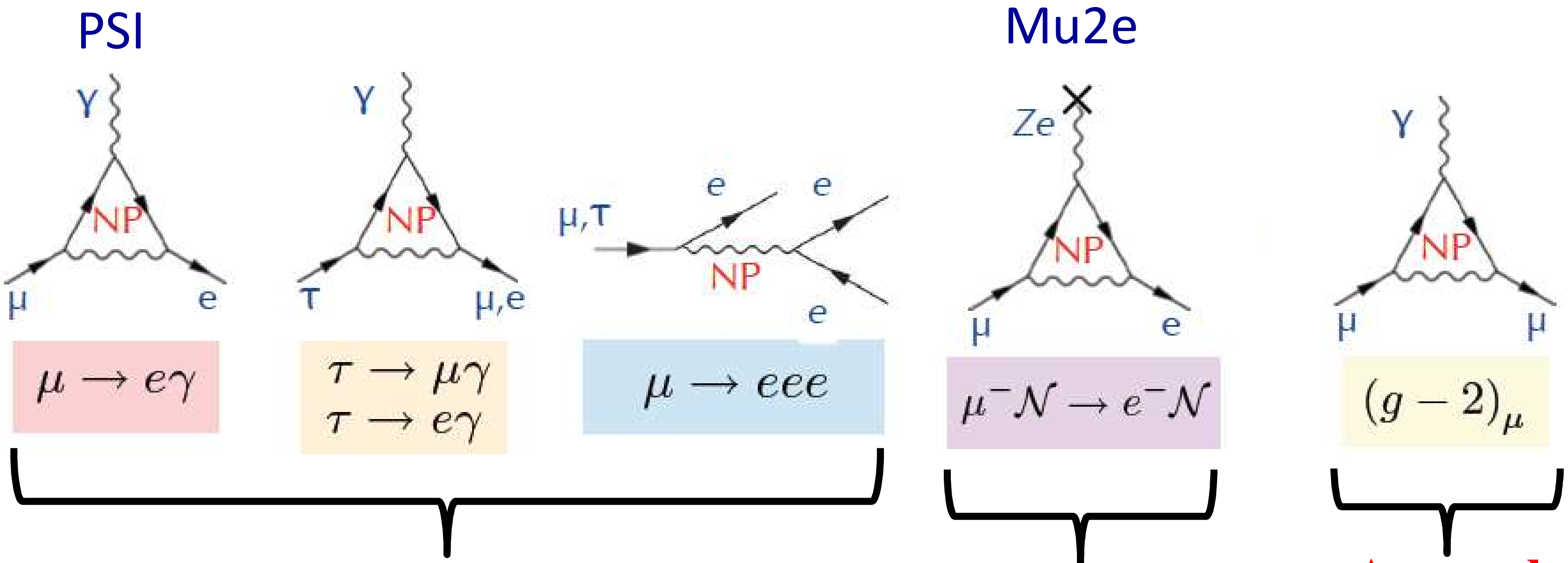
Super B @ ($10^{36}cm^{-2}s^{-1}$)   FOM=65

Y. S. Tsai, PRD 51.3172

Lepton Flavour Violating (LFV)

CLFV processes sensitive to New Physics (NP)

through lepton-lepton coupling $y_{ij}\bar{\ell}_i F^{\mu\nu}\ell_j\sigma_{\mu\nu}$



μ, τ anomalous decays

μ → e conversion

Anomalous magnetic moment

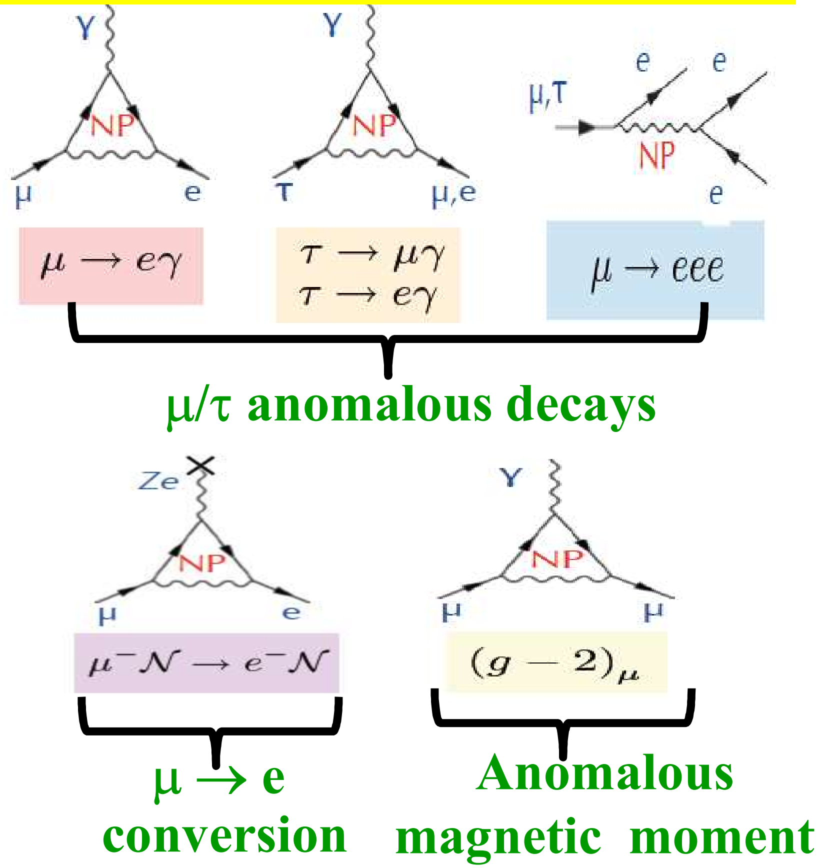
Charged Lepton Flavor Violation (cLFV)

In SM, cLFV is negligibly even taking into account neutrino mass

	AC	RVV2	AKM	δLL	FBMSSM	LHT	RS
$D^0-\bar{D}^0$	★★★	★	★	★	★	★★★	?
ϵ_K	★	★★★	★★★	★	★	★★	★★★
$S_{\psi\phi}$	★★★	★★★	★★★	★	★	★★★	★★★
$S_{\phi K_S}$	★★★	★★	★	★★★	★★★	★	?
$A_{CP}(B \to X_s\gamma)$	★	★	★	★★★	★★★	★	?
$A_{7,8}(B \to K^*\mu^+\mu^-)$	★	★	★	★★★	★★★	★★	?
$A_9(B \to K^*\mu^+\mu^-)$	★	★	★	★	★	★	?
$B \to K^{(*)}\nu\bar{\nu}$	★	★	★	★	★	★	★
$B_s \to \mu^+\mu^-$	★★★	★★★	★★★	★★★	★★★	★	★
$K^+ \to \pi^+\nu\bar{\nu}$	★	★	★	★	★	★★★	★★★
$K_L \to \pi^0\nu\bar{\nu}$	★	★	★	★	★	★★★	★★★
$\mu \to e\gamma$	★★★	★★★	★★★	★★★	★★★	★★★	★★★
$\tau \to \mu\gamma$	★★★	★★★	★	★★★	★★★	★★★	★★★
$\mu + N \to e + N$	★★★	★★★	★★★	★★★	★★★	★★★	★★★
d_n	★★★	★★★	★★★	★★	★★★	★	★★★
d_e	★★★	★★★	★★	★	★★★	★	★★★
$(g-2)_\mu$	★★★	★★★	★★	★★★	★★★	★	?

Table 8: "DNA" of flavour physics effects for the most interesting observables in a selection of SUSY and non-SUSY models ★★★ signals large effects, ★★ visible but small effects and ★ implies that

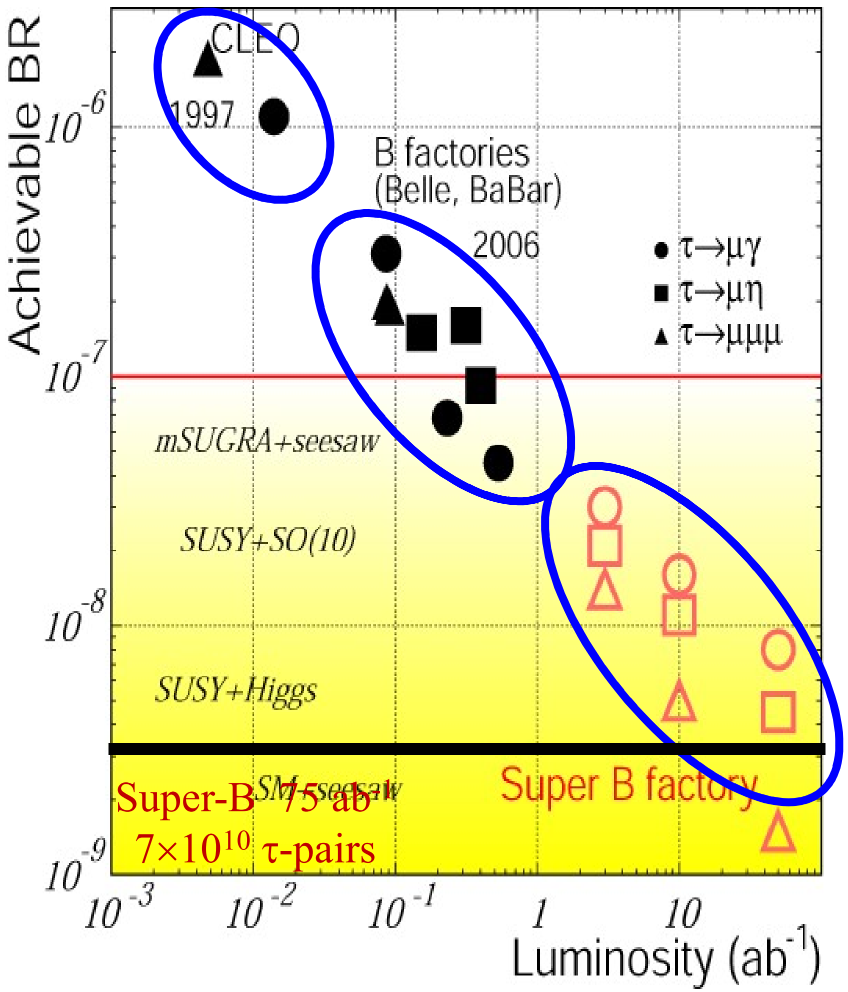
W. Altmannshofer et al. arXiv: 0909.1333



In tau-charm factory, $\tau \to \mu\gamma$ decay is a golden mode to search for NP

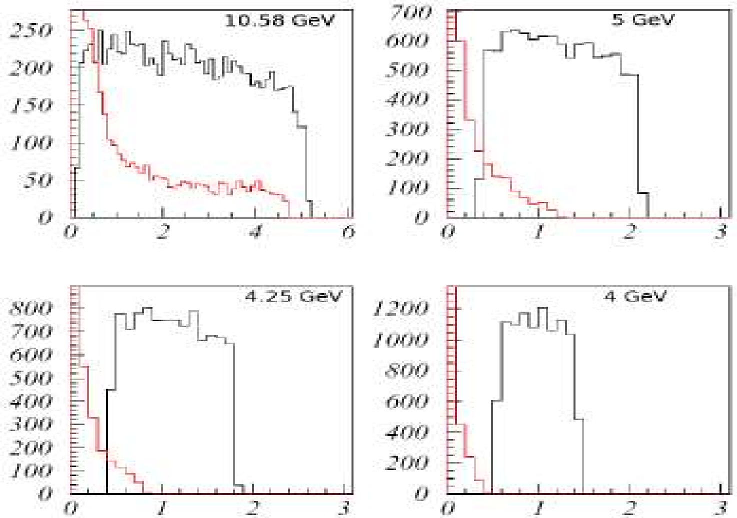
cLFV Decay $\tau \to \mu\gamma$ @ B Factory

From A. Bondar, Charm2010



- **Current limit : ~ 4×10^{-8} (5×10^{8} τ-pairs)**
  - BABAR : 516fb^{-1} [PRL, 104, 021802]
  - BELLE : 545fb^{-1}
- **At (4S) :**
  - ISR background $e+e- \to \tau^+\tau^-\gamma$
  - Upper Limit $\propto 1/\sqrt{L}$
  - Expected limit : 3×10^{-9}@75ab^{-1} (7×10^{10} τ-pairs)

Background $e^+e^- \to \tau^+\tau^-\gamma$



Does not contribute below
$\sqrt{s} \approx 4m_\tau/\sqrt{3} \approx 4.1$ GeV.

Expected $\tau \to \mu\gamma$ Br upper limit

E(GeV)	σ(nb)	L(ab^{-1})	$N_{\tau\tau}(10^{10})$
3.686	5.0	1.5	0.75
3.77	2.9	3.5	1.03
4.17	3.6	2.0	0.71
Total		7.0	2.49

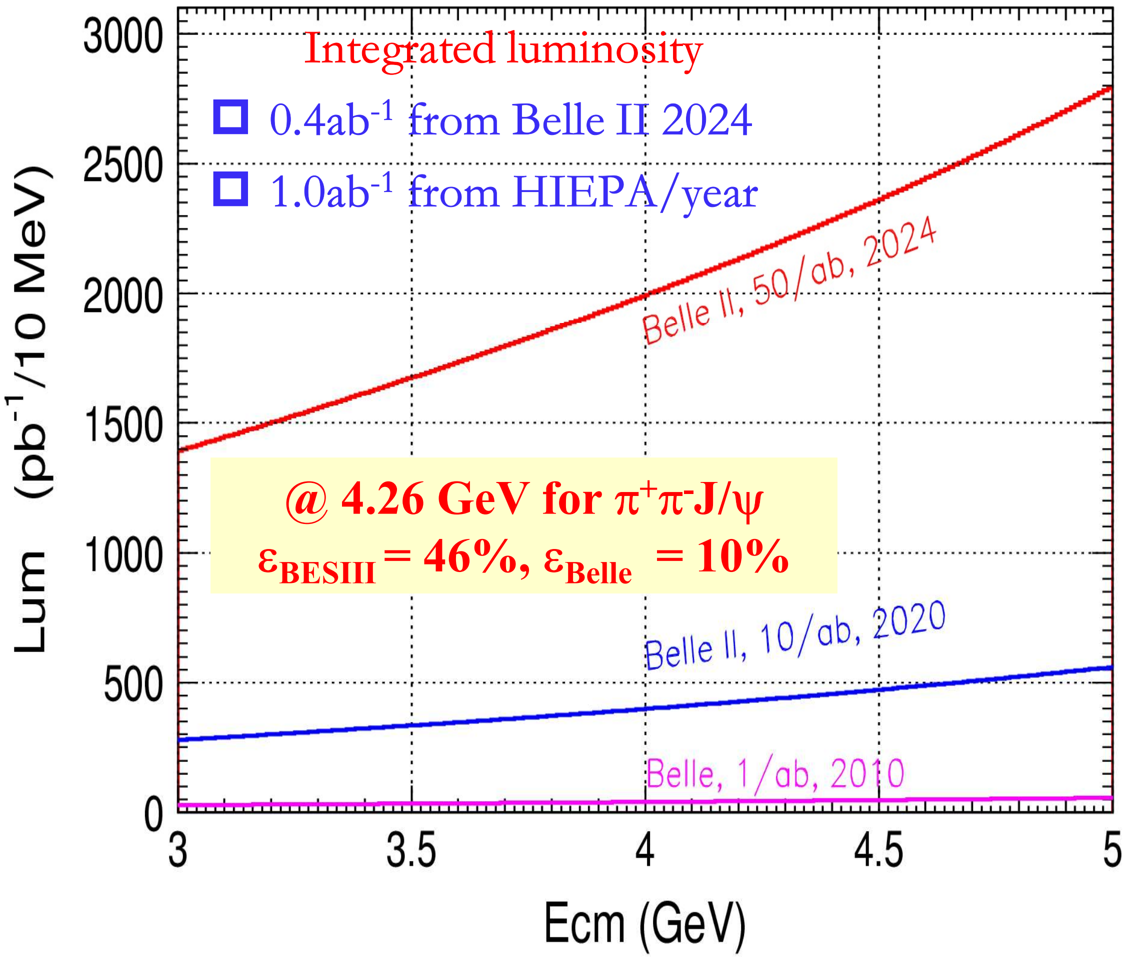
Dominant background

- τ decays, direct ($\tau^+ \to \pi^+\pi^0\nu_\tau$) and combinatorial
- QED processes: $e^+e^- \to \mu^+\mu^-\gamma\gamma$, $e^+e^- \to e^+e^-\mu^+\mu^-\gamma$
- Continuum hadron production $e^+e^- \to qq$
- ψ(2S) and D-meson decays

	σ_E/E=1.5%	σ_E/E=2.5%
Signal (Br=10^{-9})	17	15
Muon background	7	11
Pion background	83	271
Expected 90% CL upper limit for Br	1.1×10^{-9}	3.0×10^{-9}
Expected 90% CL upper limit for Br with pion suppression by a factor of 30	3.3×10^{-10}	5.1×10^{-10}

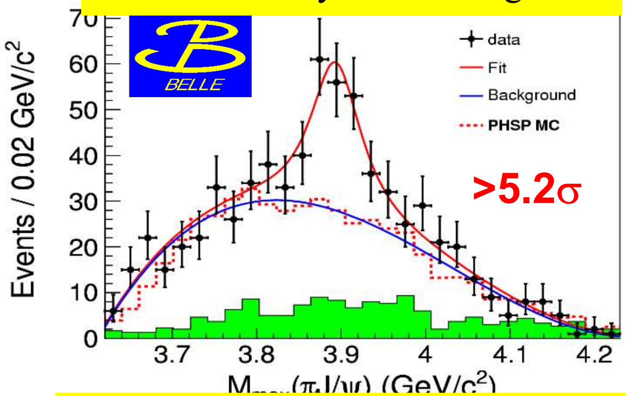
Supper-B Expected limit : $3\text{x}10^{-9}$@75ab^{-1} (7×10^{10} τ-pairs)

Competition from Belle II?

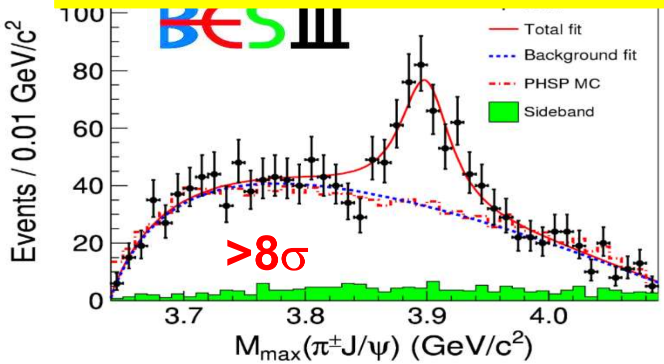


@ 4.26 GeV for $\pi^+\pi^-J/\psi$
ε_{BESIII} = 46%, ε_{Belle} = 10%

Belle with ISR: PRL110, 252002
967 fb^{-1} in 10 years running time



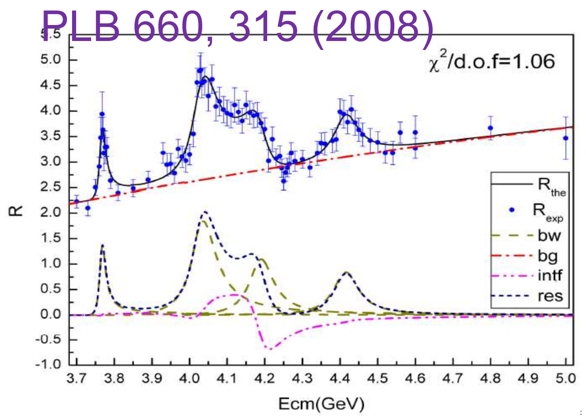
BESIII at 4.260 GeV: PRL110, 252001
0.525 fb^{-1} in one month running time



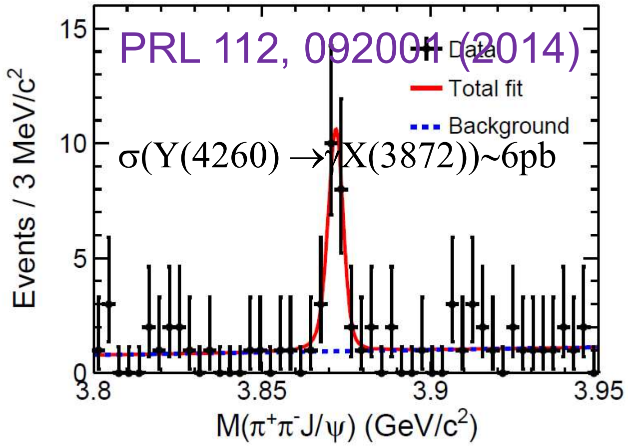
Have incomparable superiority to explore Charmonium(like) states

Production Mechanism @ τ-c Factory

- ψ/Y/Hybrid(ccg) (1^{--}) produced directly in the e^+e^- collision
  - To determine the resonance parameters for the excited ψ or Y state
  - Precisely measure the x-sec of inclusive/exclusive final states at different Ecms



- Charge parity c=+1 states produced via radiative transition from vector ψ/Y
  - The decay rate $\psi(nS/nD) \to \gamma X(3872)$, X(3940)···
  - $\chi_{cJ}(2P)$、$\chi_{cJ}(3P)$、$\eta_c(3S)$、$\eta_c(4S)$、···
    $B(\psi(3S) \to \gamma \chi'_{cJ}) = (7, 3, 1) \times 10^{-4}$ for J=2,1,0



- Search for new states from hadronic transition
  - To search for Zc, Zcs, hc(2P) ···.

Complementary to B factory

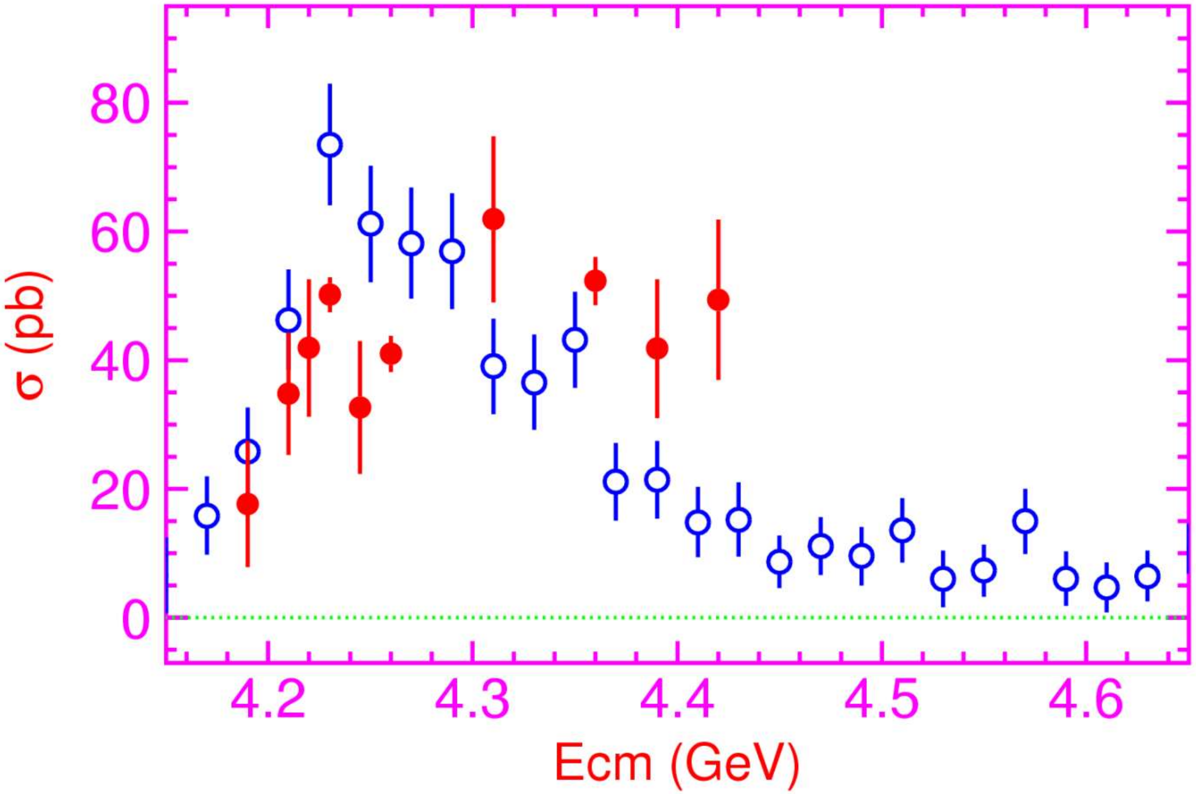
Search for 1^{--} hybrid

- $B(H_{ccg} \to \gamma\eta_c) \sim 2x(B(H_{ccg} \to \gamma\chi_{c0}) \sim 4x10^{-4}$

  [in H, $\bar{c}c$ in spin-singlet! LQCD by Dudek'09]
- $\sigma(e^+e^- \to H_{ccg}) \sim$ O(10-100) pb [???]
- Scan $e+e^- \to \gamma\eta_c$ and $\gamma\chi_{c0}$ for exotic structures

  $\varepsilon B \sim 10\%$ for $\gamma\eta_c$ and $\gamma\chi_{c0} \to \gamma$+hadrons
- $L_{peak}=10^{35}/cm^2/s$, 1 year running = $10^6 pb^{-1}$=1 ab^{-1}
- At 100 energy points above $\bar{D}D$ threshold
  - $N^{obs}(\gamma\eta_c)$=O(4~40)/point/year at peak
  - $N^{obs}(\gamma\chi_{c0})$=O(2~20)/point/year at peak

Exclusive Line Shape Measurement

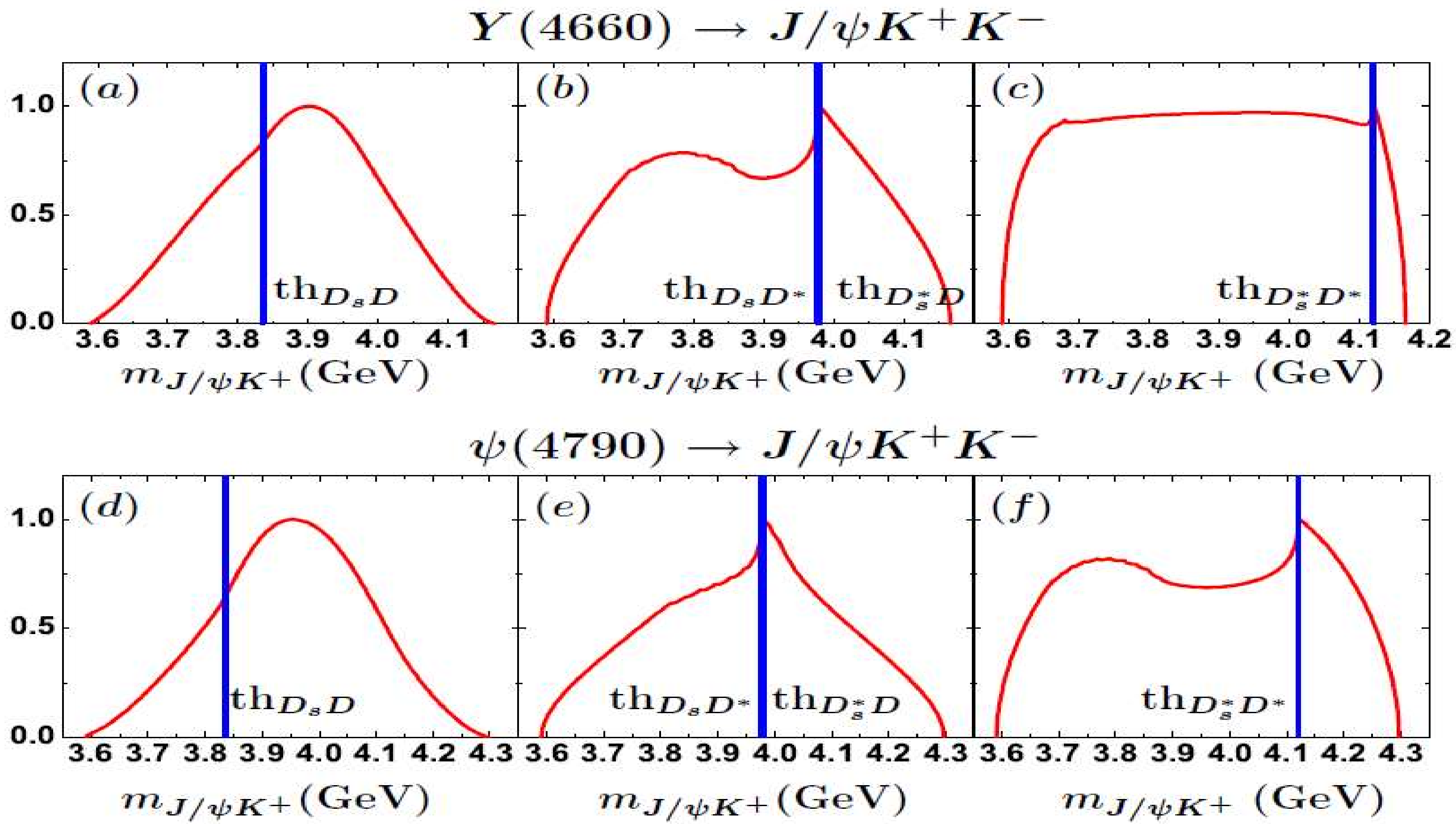


- $L_{peak}=10^{35}/cm^2/s$, 1 year running = $10^6 pb^{-1}$ = 1 ab^{-1}
- At 100 energy points above $\bar{D}D$ threshold
- Precisely measure the x-sec for exclusive final states

Explore the Nature of Z_c

- $\sigma(e+e^- \to \pi\pi(\pi)+\text{charmonium}) \sim O(10)$ pb
- Look for states in π+charmonium
  - $\varepsilon B \sim 2.7\%$ for $\pi\pi h_c \to \pi\pi\gamma\eta_c$
  - $\varepsilon B \sim 5.0\%$ for $\pi\pi J/\psi$
  - $\varepsilon B \sim 2.0\%$ for $\pi\pi\chi_c \to \pi\pi\gamma J/\psi$
  - $\varepsilon B \sim 1.0\%$ for $\pi\pi\psi' \to \pi\pi\pi\pi J/\psi$
- $L_{peak}=10^{35}/cm^2/s$, 1 year running = 10^6 pb^{-1}=1 ab^{-1}
- $N^{obs}=O(10^5)$/year; sufficient for PWA or Argand plot analysis

Search for Zcs



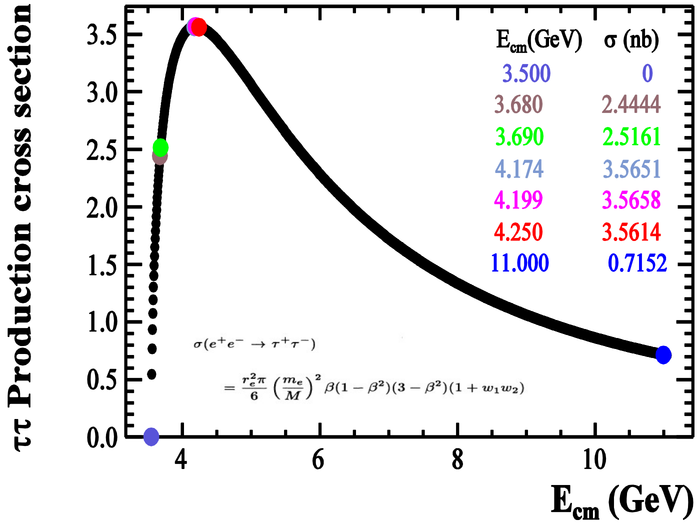
search for Excited Z_c and Z_{cs} particle@ Ecms>4.5 GeV

Search for $\eta_{c2}(1^1D_2)$

- $B(h_c(2P) \to \gamma\eta_{c2}) \sim 3\times10^{-4}$ [E1 trans., Barnes′ 05]
- $B(\eta_{c2} \to \gamma h_c) \sim (44\text{–}54)\%$ [E1 trans., Fan′ 09]
- $B(h_c \to \gamma\eta_c) \sim 54\%$ [E1 trans., BESIII′10]
- $\sigma(e^+e^- \to \pi^+\pi^- h_c(2P)) \sim 20$ pb @ Ecm = ?? GeV
- $\epsilon B(\eta_c \to \text{hadrons}) \sim 1.5\%$ at BESIII
- $N^{obs} = 2\times10^{-5}\times L$ (L is int. lumi. in pb^{-1})
- $L_{peak} = 10^{35} cm^{-1}s^{-1}$, 1 year running = $10^6 pb^{-1} = 1 ab^{-1}$
  - N^{obs}=20 events /year,
- Background is expected to be low for narrow h_c and η_c

τ Lepton Physics

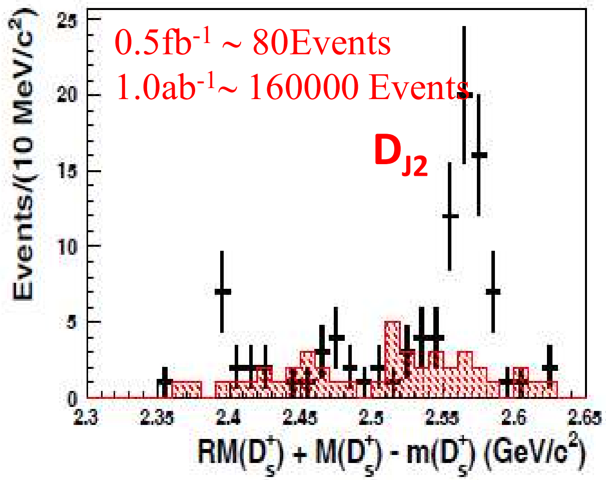
- X sec grows from 0.1nb near threshold to 3.5nb at 4.25GeV
  - 10^8 tau pairs per year at threshold (x-sec = 0.1nb)
  - 3.5×10^9 tau pairs/year at 4.25GeV (x-sec = 3.5nb)
  - 10^{10} tau pairs per year for Belle II (x-sec = 1nb)

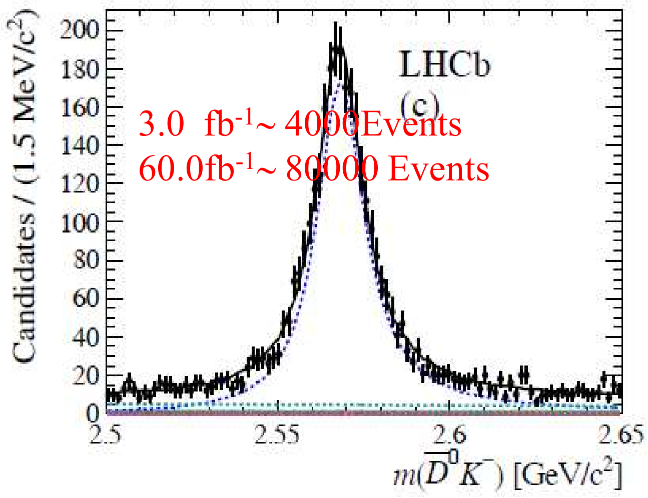


- Physics Highlighted Physics program
  - Precision measurements of α_s, m_s, V_{us}
  - Lepton universality : m_τ, $\tau\to\pi^+\nu_\tau$ and $\tau\to K^+\nu_\tau$
  - Lorentz structure of the amplitude for $\tau\to\ell\nu_\ell\nu_\tau$
  - Search for LFV processes : $\tau\to\ell\gamma$, $\ell\ell\ell$, ℓh
  - Search for CPV
  - V-A Structure of the weak current in leptonic decays
  - Rare hadronic decays
- Competition to Belle II
  - Threshold effect is important for controlling and understanding background
  - Longitudinal polarization of the initial beams will significantly increase sensitivity in searches for CPV in lepton decays.

Charm Physics

- 4×10^9 pairs of $D^{\pm,0}$ and 10^7~$10^8 D_s$ pairs per year
  - 10^{10} charm from Belle II/year
- Competition to Belle II
  - The multiplicity of final state is lower by a factor of 2
  - Threshold effect, clean, double tagging
  - QM coherent state, $J^{PC}=1^{--}$ for DD, $J^{PC}=0^{++}$ for γDD
- Highlighted Physics programs
  - Precise measurement of leptonic, semi-leptonic decay (f_D, f_{Ds}, CKM matrix…)
  - D^0-D^0 bar mixing, CPV
  - Rear Decay (FCNC, LFV, LNV….)
  - Excite Charm meson D_J, D_{sJ} (mass, width, J^{PC}, decay modes)
  - Charmed Baryons (J^{PC}, Decay modes, Br)
- Some sensitivities @ 1 ab^{-1} data at threshold
  - Direct CPV in D→hh sensitivity : 10^{-3}~10^{-4}
  - Probe y : $\Delta(y_{CP})$~0.1%
  - $RM=(x^2+y^2)/2$~10^{-5} in Kπ and Keν channels
  - $\Delta(\cos\delta_{K\pi})$~0.007; $\Delta(\delta_{K\pi})$ ~ 1°



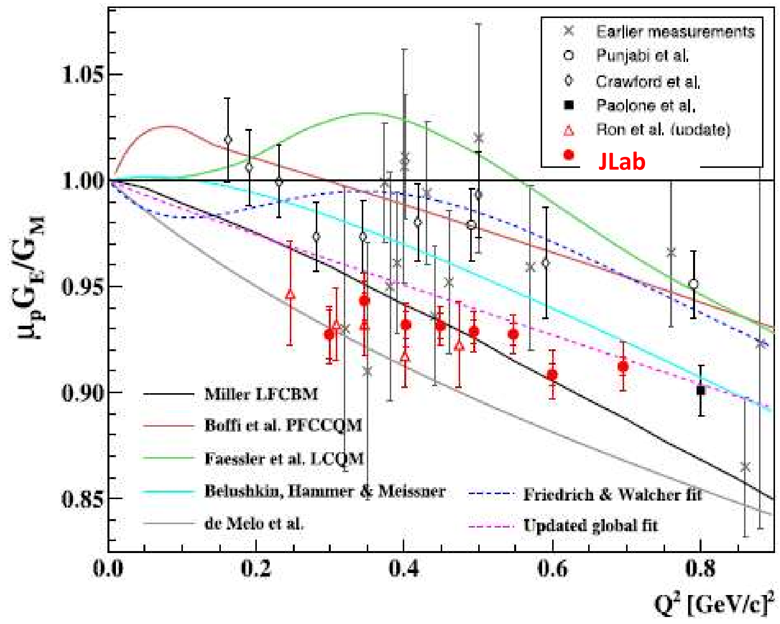


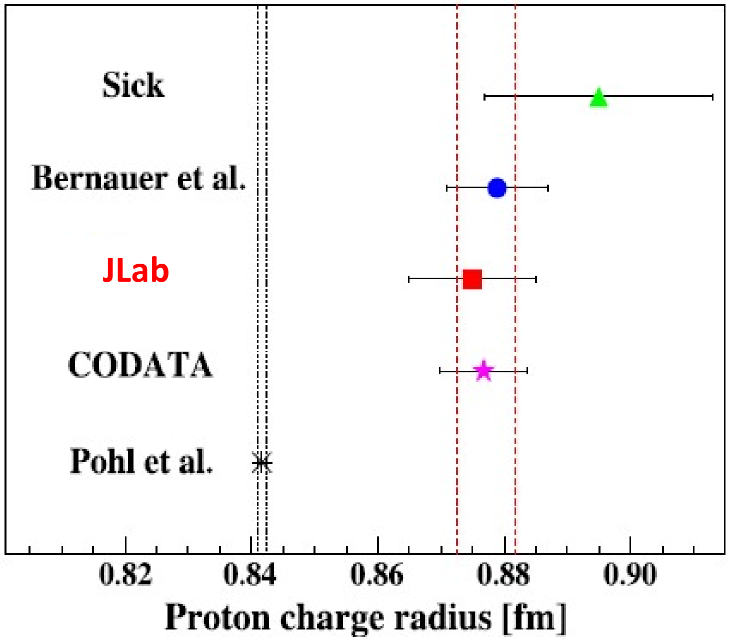
R and QCD Physics

- Detailed study of exclusive processes $e^+ e^- \to (2\text{-}10)h$, $h=\pi, K, \eta, p\cdots$,
  Scan between 2-7GeV and ISR $\sqrt{s}<2$GeV
  - Meson Spectroscopy
  - Intermediate dynamics
  - Search for exotic states (tetraquarks, hybrids, glueballs)
  - Form factors
- High precision determination of $R=\sigma(e^+ e^- \to hadrons)/\sigma(e^+ e^- \to \mu^+\mu^-)$ at low energies and fundamental quantities
  - $(g_\mu-2)/2$, 92% from < 2GeV, 7% from 2-5GeV
  - $\alpha(M_z)$, 19.0% from < 2GeV, 18.1% from 2-5GeV
  - QCD parameters (charm quark masses)
- Inclusive cross section $e^+ e^- \to h + X$
  - QCD parameters (α_s, quark and gluon condensates)
  - Fragmentation functions
  - Spin alignment of vector
  - MLLA/LPHP prediction

Proton FF : Space-Like

- Many measurements of the proton form factors in the space-like region.
- At Jlab, the proton factor ratio was measured precisely with an uncertainty of ~1%, based on which the proton electronic and magnetic radii could be extracted.



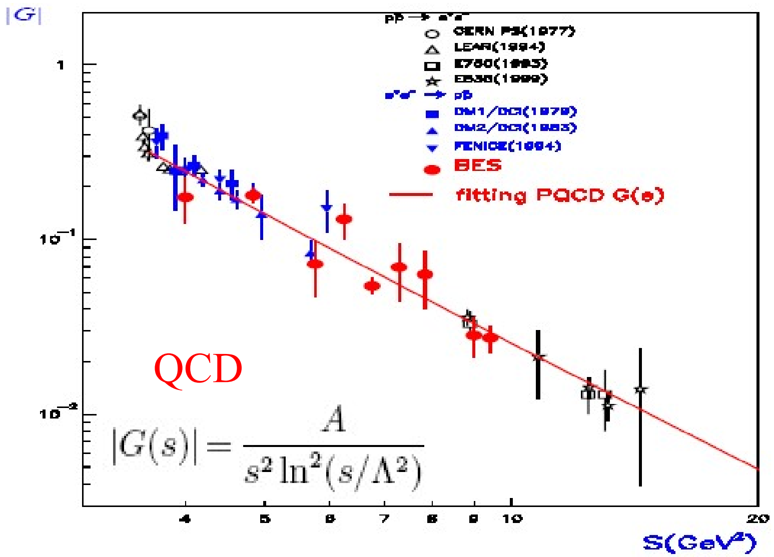


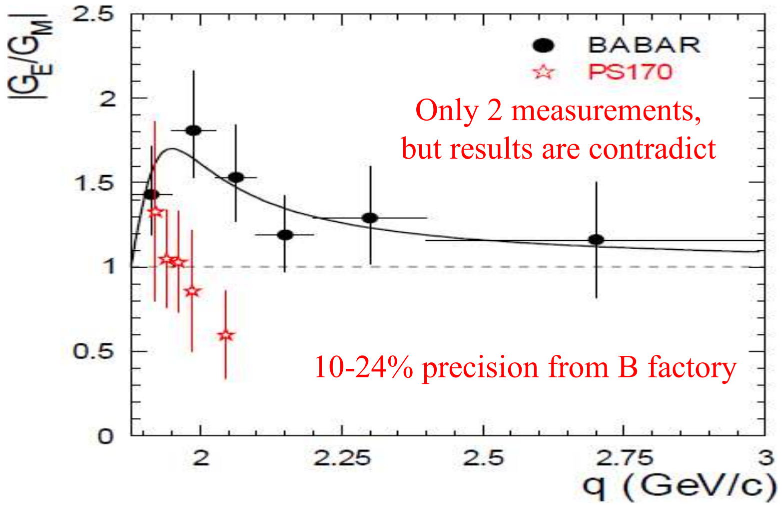
Proton FF : Time-Like

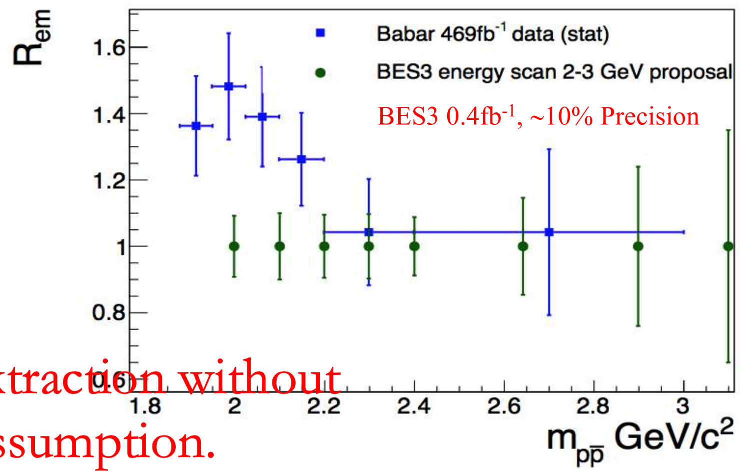
$$\sigma_{e^+e^-\to N\bar{N}} = \frac{4\pi\alpha^2\beta}{3s}\,C_N(s)\left[\left|G_M^N(q^2)\right|^2 + \frac{2M_N^2}{s}\left|G_E^N(q^2)\right|^2\right]$$

$$|G_M(q^2)| = [1 + (q^2 - 4M_p^2)/q_2^2]^{-2}$$
$$|G_E(q^2)| = |G_M(q^2)|[1 + (q^2 - 4M_p^2)/q_1^2]^{-1}$$

Assume $G_M = G_E$ $\quad \sigma_0 = \frac{4\pi\alpha^2\beta}{3s}(1+\frac{2M^2}{s})|G(s)|^2$







$\delta|R_{EM}|/|R_{EM}|$ ~ 9% - 35%

$\delta|G_M|/|G_M|$ ~ 3% - 9%

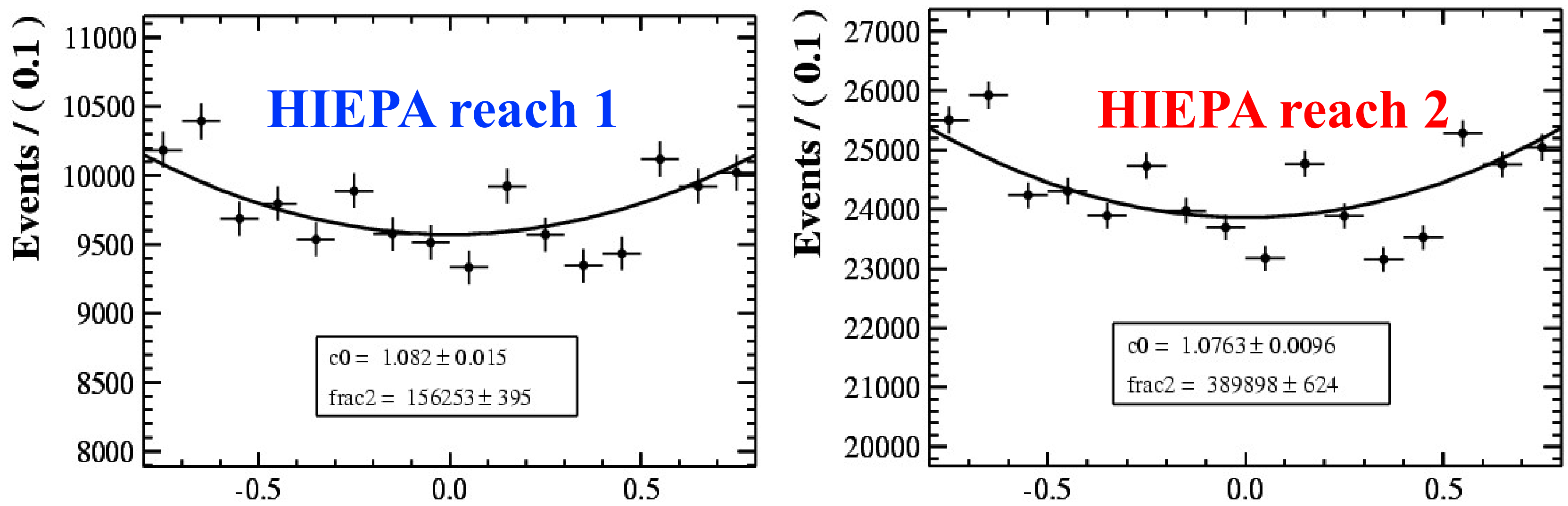
$\delta|G_E|/|G_E|$ ~ 9% - 35%

first time extraction without any assumption.

Proton FF @ HIEPA

√s=2.23 GeV

Nsig	$\delta R_{EM}/R_{EM}$	$\delta\sigma/\sigma$	Luminosity (pb^{-1})	comment	
614±24	24%	3.9%	2.631	BESIII test run	
3881±62	9.5%	1.6%	16.630	BESIII expected	
156253±395	1.5%	0.25%	669.533	HIEPAF reach 1	1 day
389898±624	0.96%	0.16%	1670.69	HIEPA reach 2	2 days



Using two days data, proton FF can reach 1% precisions at super τ-charm factory !

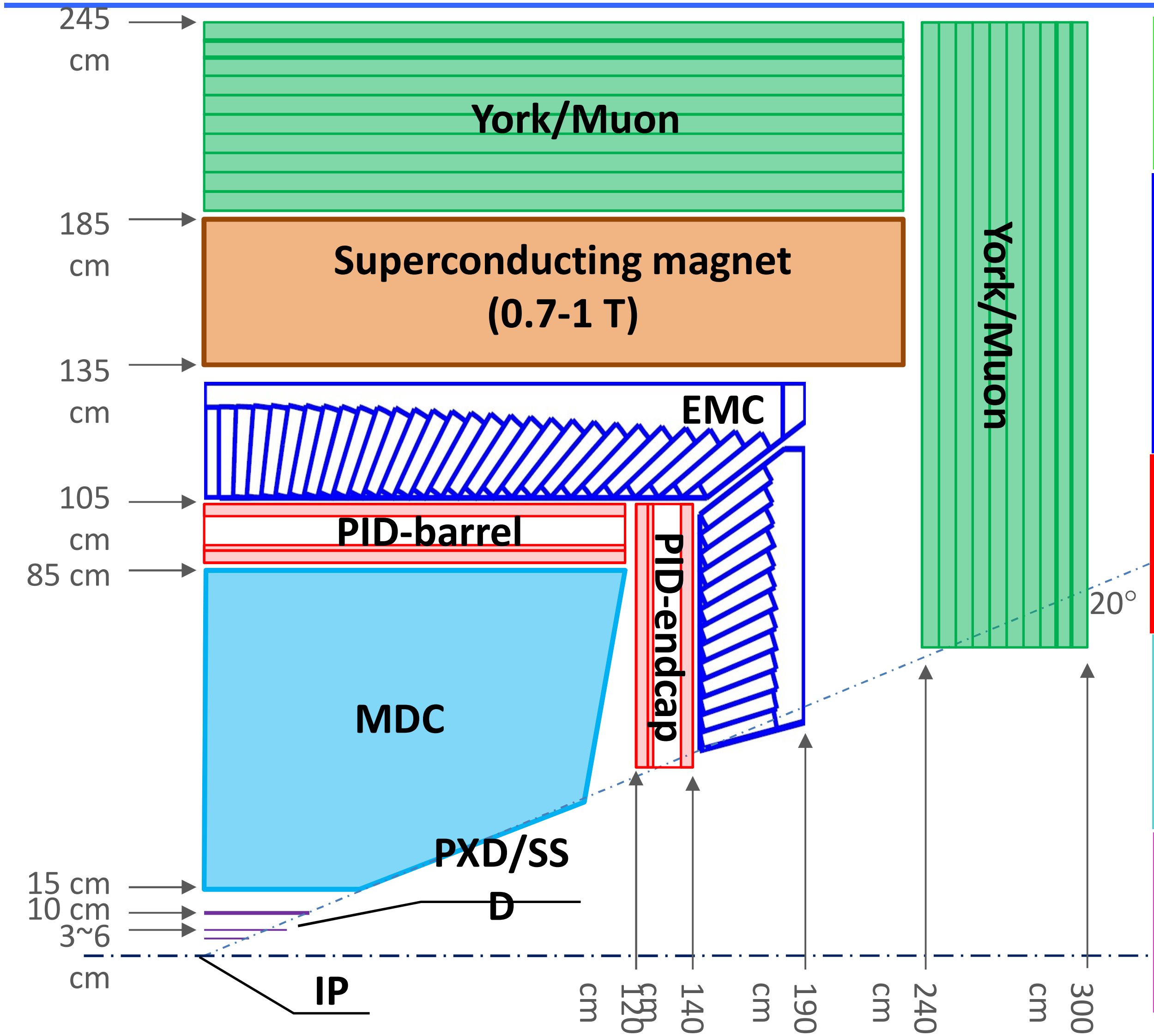
General Consideration of Detector

- Efficient event triggering, exclusive state reconstruction and tagging
  - high efficiency and resolutions for charged and neutral particles
  - Low noise and High rate
- Much larger radiation does hardening, especially at IP and forward regions
  - The detector and electronics should withstand the expected does
- The Systematic error will be dominant in many physics studies
  - Detector acceptance : geometrical acceptance or detector response
  - Mis-Measurement : mis-tracking, fake photon, particle mis-id, noise
  - Luminosity measurement
- Reasonable cost

General Consideration

- Vertex performance and low-momenta tracking eff.
- Tracking : multiple scattering effect is important
  - P T resolution : 0.5~0.7%@ 1 GeV/c, and dE/dx resolution: 6%
  - low material budge.
- PID : π/K and K/p separation up to 2GeV/c
  - modest material budget ($<0.5X_0$)
  - Cherenkov detector is necessary
- EMC : fast response to match the high luminosity
  - stochastic term<2%/√E and constant term < 0.75%,
  - angular resolution?
- MUC : large-area fast sensors (RPC/MPRC etc)
  - μ/π suppression power>10/30, down to p=0.5GeV/c
- Large solid angle detector ~Nearly 4π

Detector



MUD

- μ/π suppression power >10/30

EMC

- Energy range: 0.02-2.5 GeV
- At 1 GeV σ_E (%)
  - Barrel(Cs(I)): 2
  - Endcap (Cs): 4

PID

- π/K (and K/p) 3-4σ separation up to 2GeV/c

MDC (Low mass)

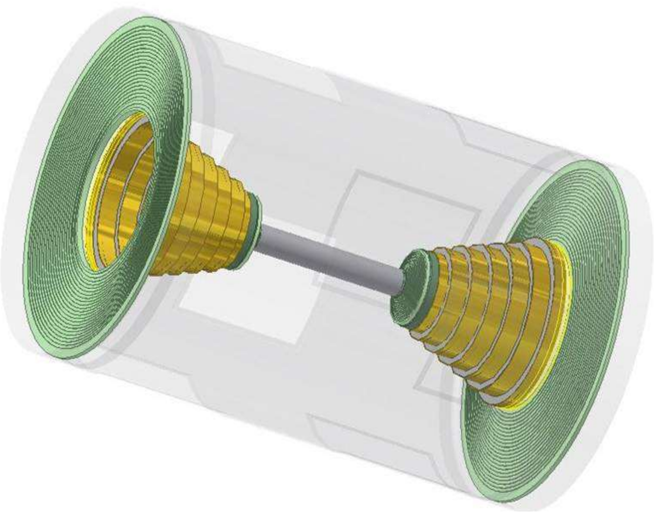
- σ_{xy}=130 mm
- dE/dx<7%, σ_p/p =0.5% at 1 GeV

PXD

- Material budget ~0.15%X_0/layer
- σ_{xy}=50 mm

Tracking Detector

- Must balance momentum resolution and curling of low momentum tracks :
  - Low B field (~1T), need re-optimized
- Multiple coulomb scattering is critical :
  - low mass helium-based gas, wires
  - Small cells are needed for speed – more wires in tension with low mass
  - Carbon fiber support structure to minimize effect on PID, EMC etc



$$\sigma_x \sim 130\ \mu m$$

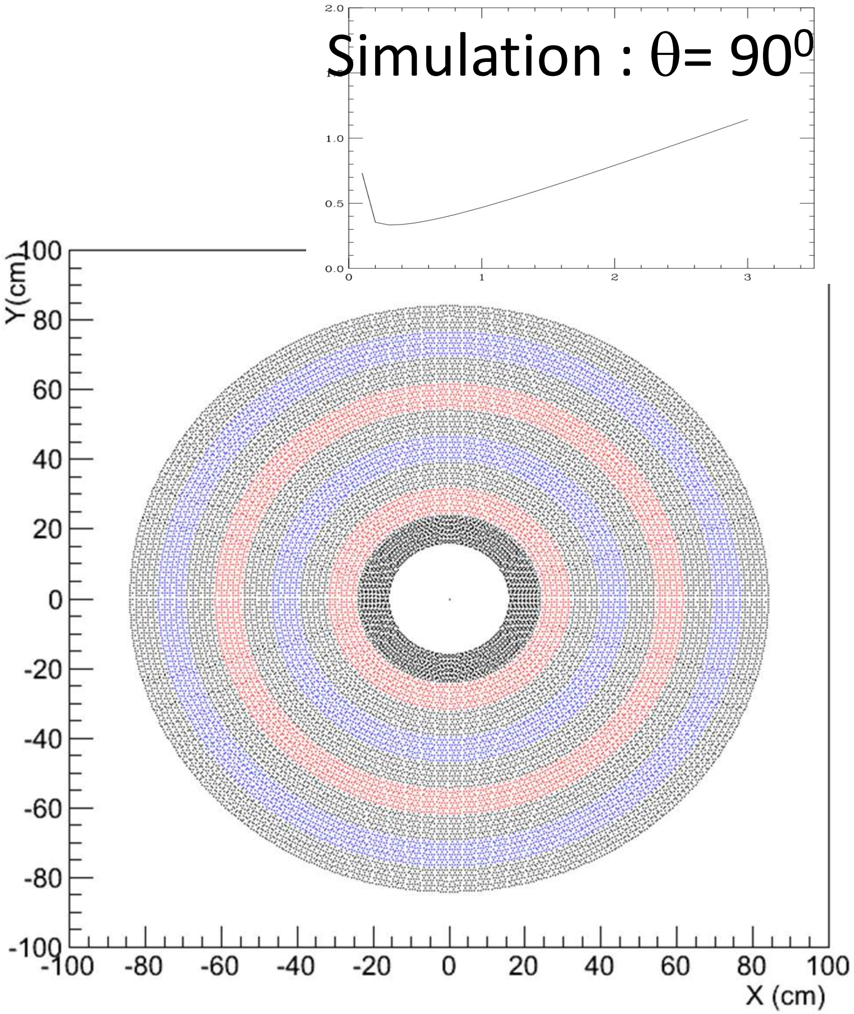
$$\frac{\sigma_P}{P} \sim 0.5\%\ @1\mathrm{GeV/C}$$

$$\frac{\sigma_{\frac{dE}{dx}}}{\frac{dE}{dx}} \sim 6\%$$

BESIII Drift Chamber

Starting point

Tracking Detector



- R in = 15 cm
- Rout = 85 cm
- L = 2.4 m
- B = 1 T
- He/C2H6 (60/40)
- # of layers = 48
- Cell size =1.0cm(inner),1.5cm(outer)
- Sense wire: 20 um W
- Field wire: 110 um Al
- 0.5%X0 carbon fiber inner wall
- Expected spatial resolution: 130 um
- Expected dE/dx resolution: 7%
- Layer configuration: 8A-5S-5A-5S-5A-5S-5A-5S-5A

Low mass

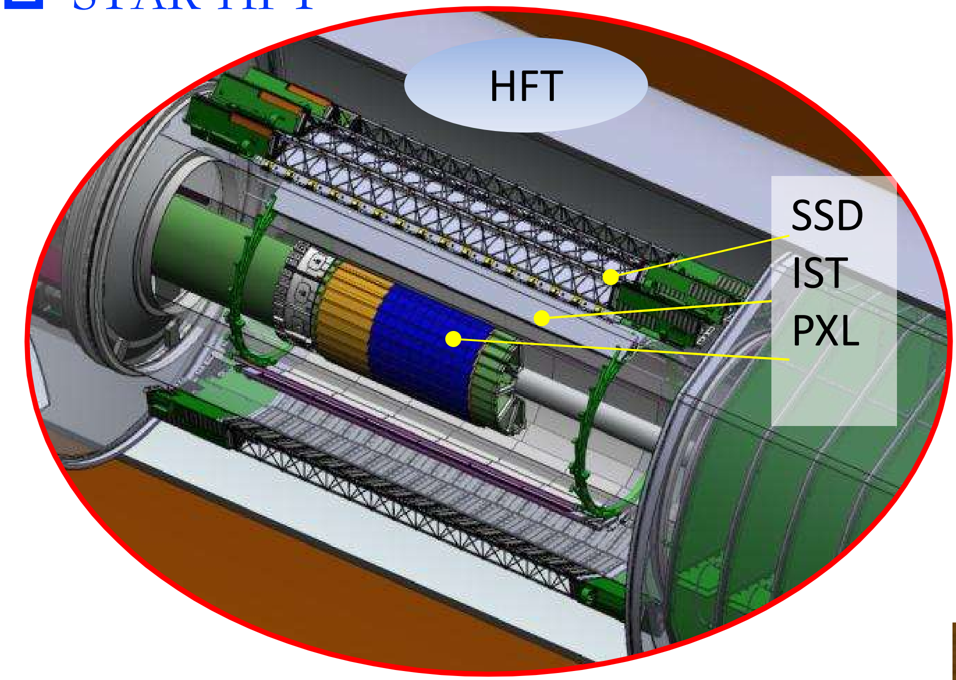
Vertex Detector

- Provide precise hit close to collision vertex.
  - Secondary vertices reconstruction.
  - Help on tracking, improve momentum resolution.
  - Help on vertex finding, improve the position resolution (impact parameter d_0).

- Challenge and risk
  - Develop pixel technology in China.
  - Material control (low mass must be required).
  - Man power and cost.
  - …

Vertex Options

- STAR-HFT

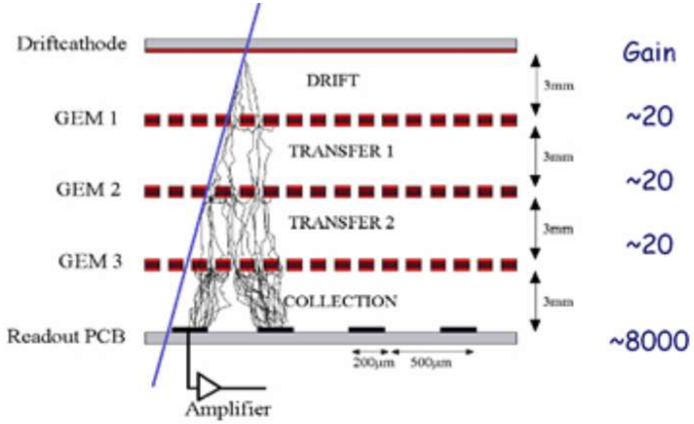


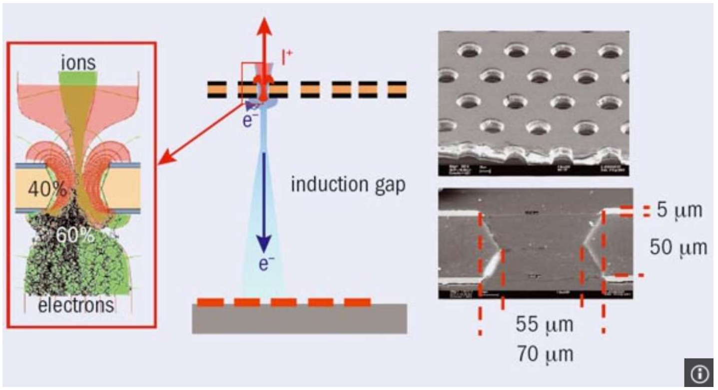
- PIXEL
  - double layers, 20.7x20.7 um pixel pitch, 2 cm x 20 cm each ladder, 10 ladders, delivering ultimate pointing resolution.
  - new active pixel technology

- Belle II PXD
  - In the active pixel matrix region: thickness ~ 75 mm.

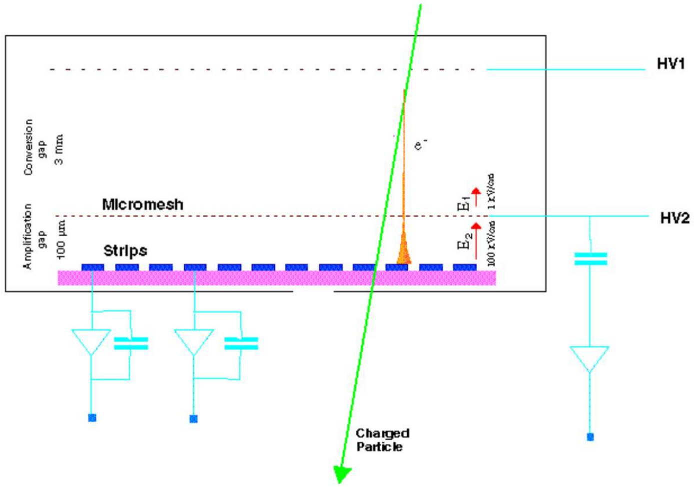
Others option

- GEM





- MicroMegas



- 在HIEPA上应用的技术难点
  - 圆柱型
  - 像素读出

Performances

Option I : MDC + STAR HFT

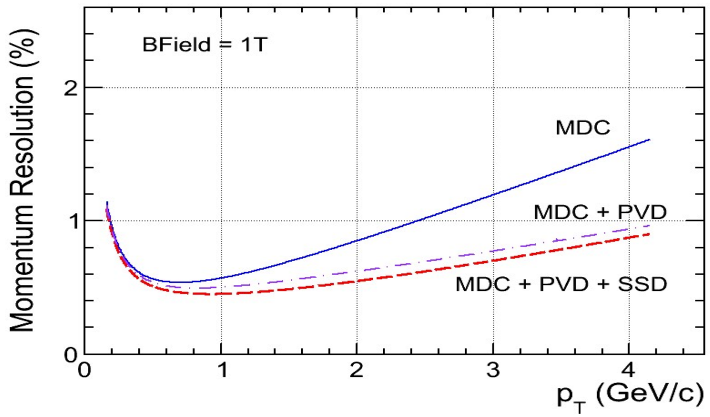
Detector	radius (cm)	material ($\%X_0$)	resolution (mm)
MDC Outer 9-48	23.5-82	0.0045 /layer	130
MDC Inner 1-8	15-22	0.0051 /layer	130
SSD	10	1.5	250
PXD 2 layers	3/6	0.37 /layer	30
Beam pipe	2	0.15	–

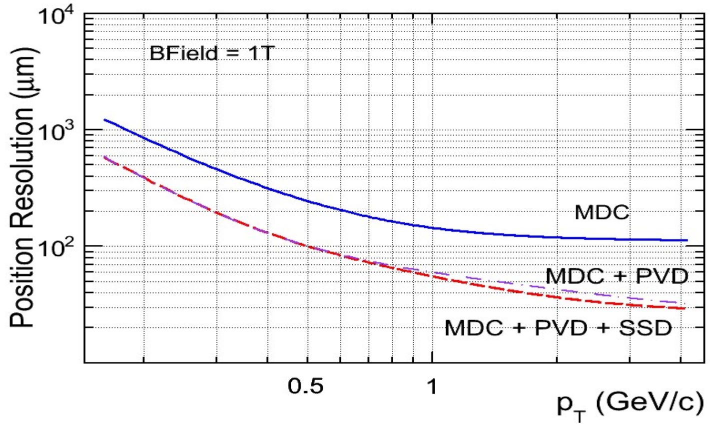
Option II: MDC + Belle-II PXD

Detector	radius (cm)	material ($\%X_0$)	resolution (μm)
MDC Outer 9-48	23.5-82	0.0045 /layer	130
MDC Inner 1-8	15-22	0.0051 /layer	130
PXD 3rd layer	10	0.15	50
PXD 2 layers	3/6	0.15 /layer	50
Beam pipe	2	0.15	–

Similar in terms of performance

Geometry not optimized





Improvement at low pT is small, significant at High pT and the position resolution

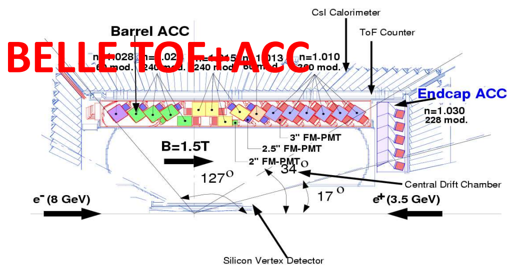
PID Detector

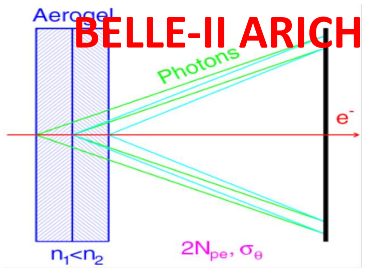
Key Features

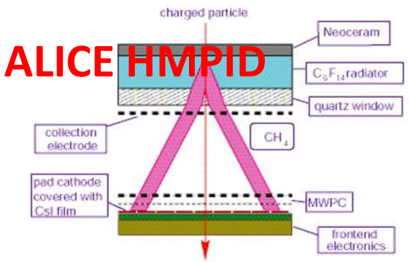
- Enable π/K (and K/p) 3-4σ separation up to 2GeV/c (30ps for TOF, impossible)
- For high luminosity run – fast detector
- Radiation hard, especially in the endcap
- Compact – reduce costs of outer detectors
- Modest material budget - $<0.5X_0$

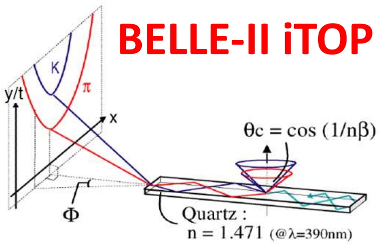
Low Momentum

- Specific energy loss (dE/dx) in MDC
- Better dE/dx resolution for longer track
- BESIII MDC (~6%, track length ~0.7m)
  – clean π/K/p ID for p<0.8/1.1 GeV/c









High Momentum

- Cherenkov detector is necessary
- Two catalogs
  – Threshold Cherenkov – simple to build
  – Imaging Cherenkov: RICH (large momentum range)/ DIRC / TOP (most compact)

PID Detector

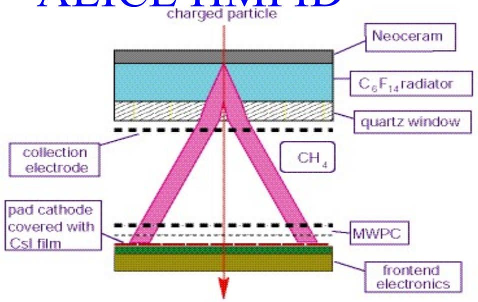
Baseline Design

- PID by RICH at 0.8<p<2GeV/c, no TOF
- Proximity RICH, similar to ALICE HMPID design, but with PHENIX HBD (CsI coated GEM) readout
- n~1.3 (liquid C_6F_{14}), UV detection
- Already proven
- Immune to B field → same structure at both the endcap and the barrel

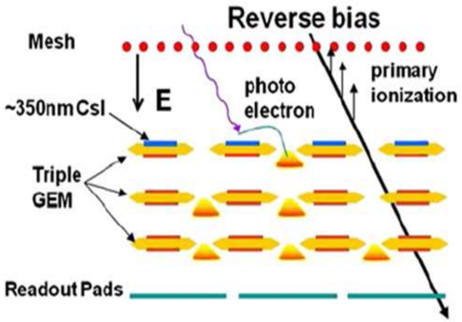
Alternative Design

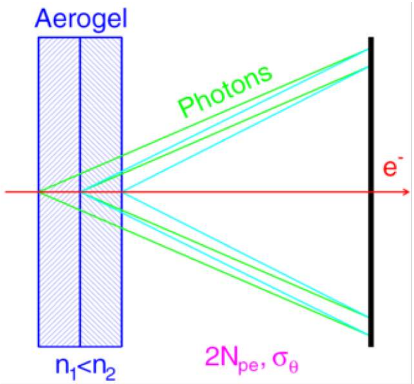
- No TOF, PID by RICH only
- Similar to BELLE-II ARICH design, Aerogel + Position Sensitive Photon Detector
- n~1.13 (Below threshold for proton at p<2GeV/c)
- Already proven at the BELLE-II endcap, how about the barrel part?
- Need R&D

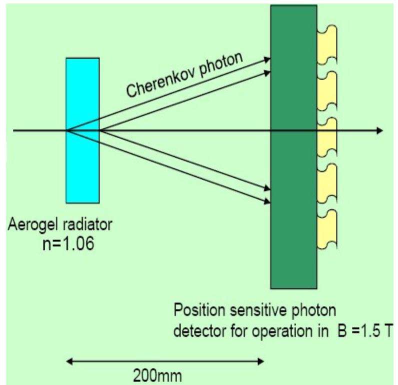
ALICE HMPID



PHENIX HBD







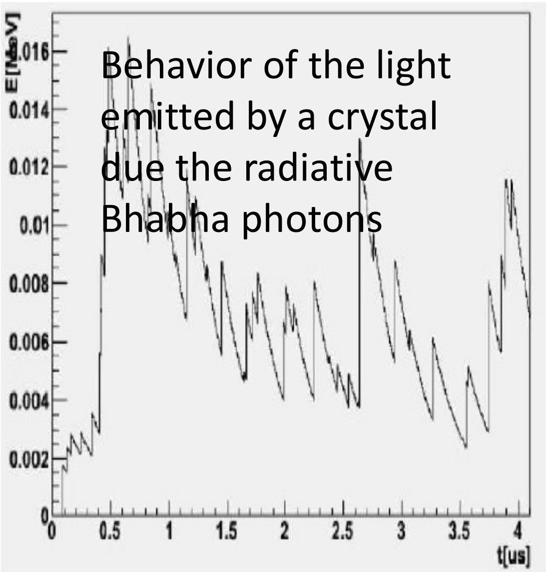
Electromagnetic Calorimeter

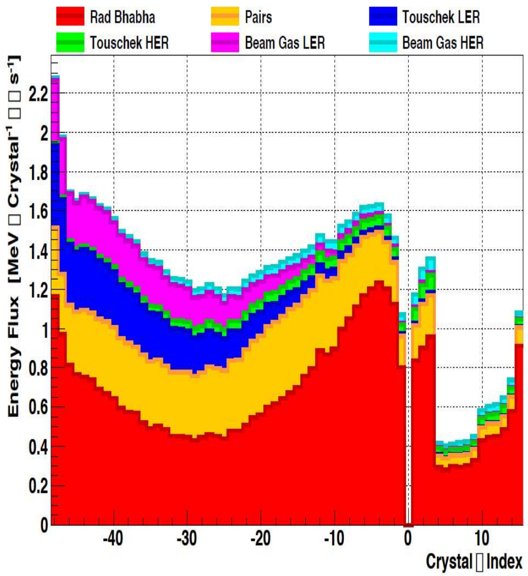
EMC Requirements

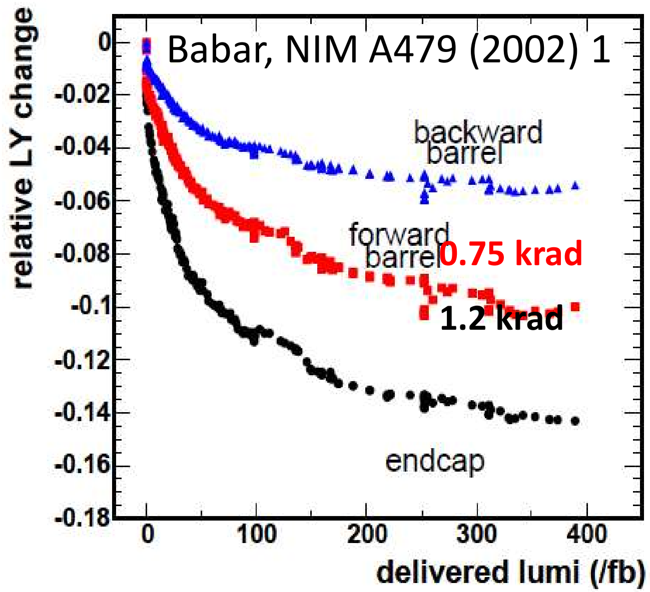
- Good energy resolution
- Good position/angular resolution
- Good timing resolution if possible

Challenging

- Radiation damage
  - Decrease light yield
  - A function of run time
- High photon background rate
  - Produce pile-up
  - Degrade energy and angular resolution







Crystal Comparison

Crystal	CsI(Tl)	CsI	BSO	$PbWO_4$	LYSO(Ce)
Density (g/cm^3)	4.51	4.51	6.8	8.3	7.40
Melting Point (°C)	621	621	1030	1123	2050
Radiation Length (cm)	1.86	1.86	1.15	0.89	1.14
Molière Radius (cm)	3.57	3.57	2.2	2.0	2.07
Interaction Len. (cm)	39.3	39.3	23.1	20.7	20.9
Hygroscopicity	Slight	Slight	No	No	No
Peak Luminescence (nm)	550	310	480	425/420	420
Decay Time [b] (ns)	1220	30 6	100 26,2.4	30 10	40
Light Yield [b,c] (%)	165	3.6 1.1	3.4 0.5/0.25	0.30 0.077	85
LY in 100 ns	13	4.6	2.9	0.37 *(2-3x↑)*	78
LY in 30 ns	4	3.3	1.5	0.26 (2-3x↑)	45
d(LY)/dT [b] (%/ °C)	0.4	-1.4	-2.0	-2.5	-0.2
Radiation hardness (rad)	10^3	10^{4-5}	10^{6-7}	10^{6-7}	10^8
Dose rate dependent	no	no	yes	yes	
Experiment	CLEO, *BABAR*, Belle, BES III	KTeV,E787 Belle2 1st SuperB 2nd	Belle2 3rd	CMS, ALICE PANDA Belle2 2nd	SuperB 1st (Hybrid)

Barrel EMC

- CsI calorimeters (BABAR, BES-III, CLEO-c) are a reasonable first-order, match to a 10^{35} collider in the 4 GeV region
- Similar to that of SuperB
  - Adjusts electronics time constants, the barrel calorimeter is adequate
  - Such as pure CsI, which were considered for the endcap at SuperB , could be re-evaluated. Need for a fast, efficient readout device that works in a magnetic field.

Parameter	BESIII	CLEO-c	BaBar	Belle
$\Delta\Omega/4\pi$ (%)	93	93	90	91
Active media	CsI(Tl)	CsI(Tl)	CsI(Tl)	CsI(Tl)
Depth (X_0)	15	16	16–17.5	16.2
σ_E at 1 GeV (MeV)	$\sim$25	$\sim$20	$\sim$28	$\sim$17
σ_E at 100 MeV (MeV)	3.3	4	4.5	4
Position resolution at 1 GeV/c (mm)	6	4	4	6

EndCap : LYSO

SuperB Forward EMC options

A detector faster, with finer granularity and higher radiation hardness

Option	Number of new crystals	New crystal volume (cm^3)	Crystal cost/cm^3 (k€)	Crystal cost (M€)	Photo-detectors (M€)	Calibration system (M€)	Total structure (M€)	Total Cost (M€)
Baseline - Hybrid								
3 CsI(Tl) + 6 LYSO	2160	245	19.23	4.76	0.38	-	0.19	5.33
LYSO new structure	4500	402	19.23	7.72	0.44	-	1.75	9.91
LYSO old structure	3600	402	19.23	7.72	0.44	-	0.19	8.35
Reduced Hybrid								
4 CsI(Tl) + 5 LYSO	1760	198	19.23	3.81	0.31	-	0.19	4.31
5 CsI(Tl) + 4 LYSO	1360	154	19.23	2.93	0.24	-	0.19	3.38
Alternative crystals								
Pure CsI	900	692	3.92	2.71	0.43	-	0.19	3.33
BGO	4500	392	6.92	2.72	0.44	0.92-2.31	1.75	5.82-7.21
$PbWO_4$	4500	306	2.96	1.18	0.44	0.92-2.31	1.75	4.28-5.67

Best performance: Full LYSO (too expensive, crystal cost 3x pure CsI/BGO, 7x PWO)

EndCap : PWO

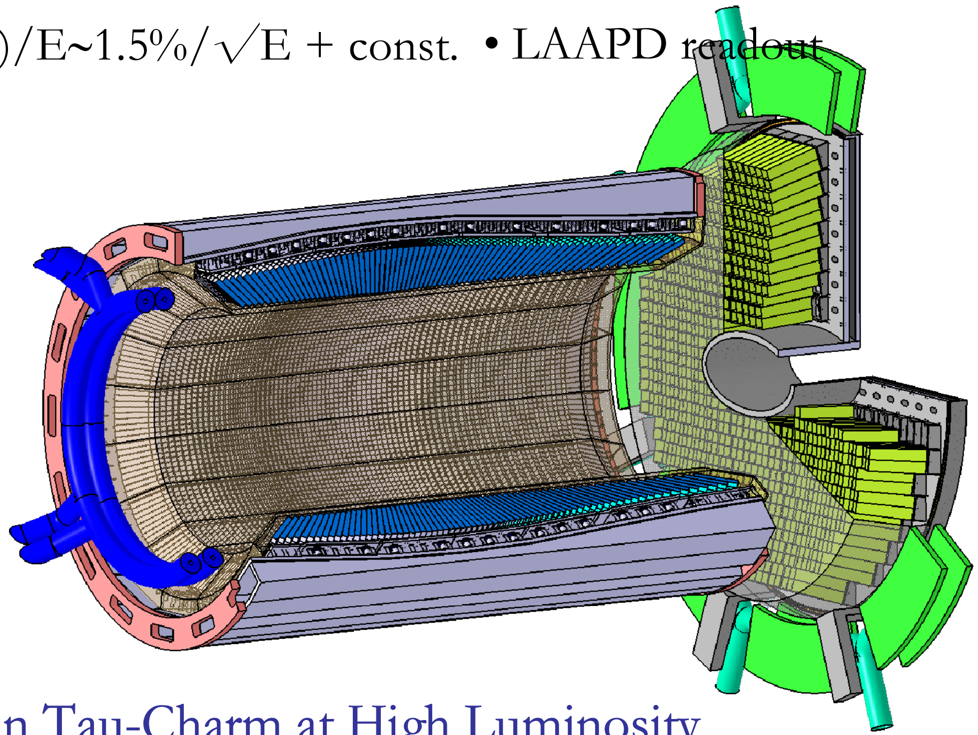
- PWO is dense and fast
- Increase light yield:
  - improved PWO II
  - operation at -25° C
- Challenges:
  - temperature stable to 0.1°C
  - control radiation damage
  - low noise electronics
- Delivery of crystals started

Barrel Calorimeter

- 11000 PWO Crystals
- LAAPD readout, 2 x 1cm^2
- $\sigma(E)/E \sim 1.5\%/\sqrt{E}$ + const.

Forward Endcap

- 4000 PWO crystals
- High occupancy in center
- LAAPD readout



EndCap BSO

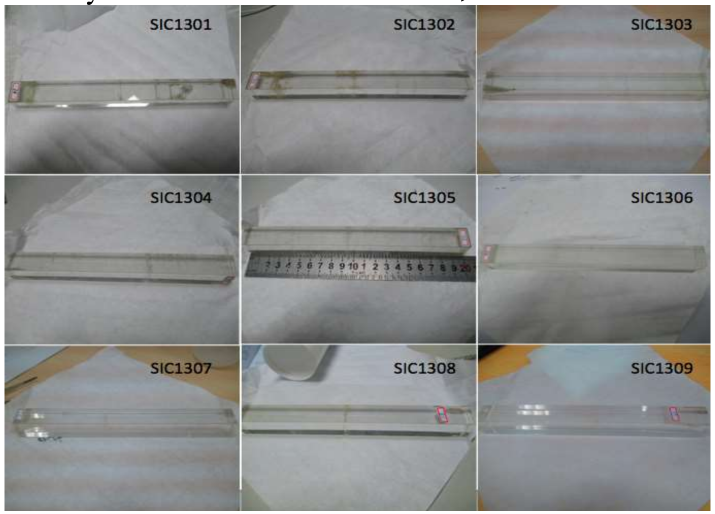
Pros:

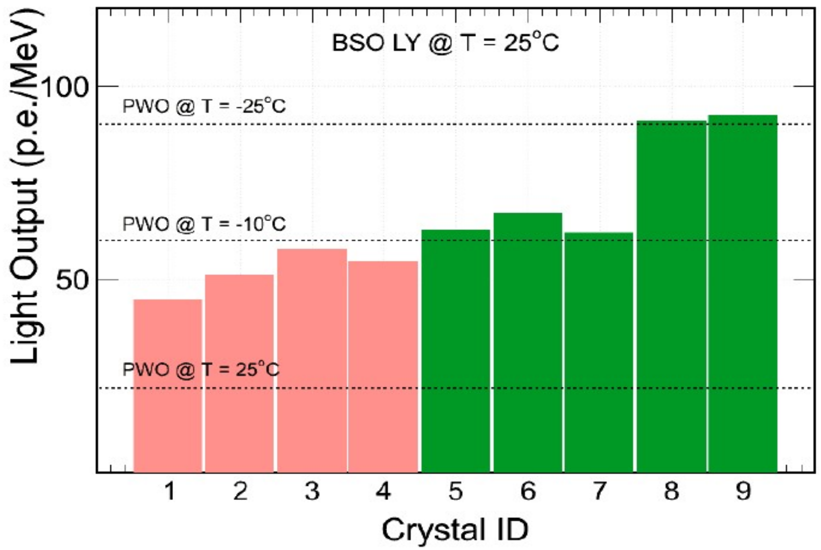
- Relative fast
- Radiation hard
- Emission spectrum compatible to different photosensors (PMT, Si)
- Small X0 (60% CsI) → more compact
- Small Moliere Radius (60% CsI) → finer segmentation
- Low raw material cost (~PWO and 50% BGO, mush less than LYSO)

Cons:

- LY smaller than CsI(Tl) and LYSO (however, ~ PWOII at -25 ^{0}C)
- Dose rate dependent LY, fast recovery time → LY Calibration system needed
- Not mature (large size available, mass production not proven)

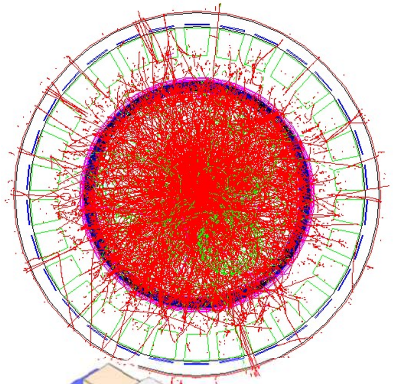
9 crystals from SICCAS, 2x2x20 cm^3

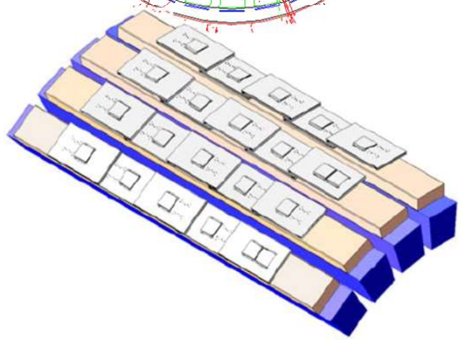




Muon Identification

- Expected μ/π suppression power >10 (30)
- Typically used large area RPCs, scintillator strips with wavelength shifting fiber and pixelated APD or SiPM readout.
- A new Muon ID method-Star MTD at STAR
  - ✓ based on the Long-strip MRPC technology
    - good timing performance
    - moderate spatial resolution
    - Cost-effective
  - ✓ using the iron bars as absorber
- Requirement on the MRPC
  - Time resolution: < 100 ps
  - Spatial resolution: ~ 1 cm
  - High efficiency

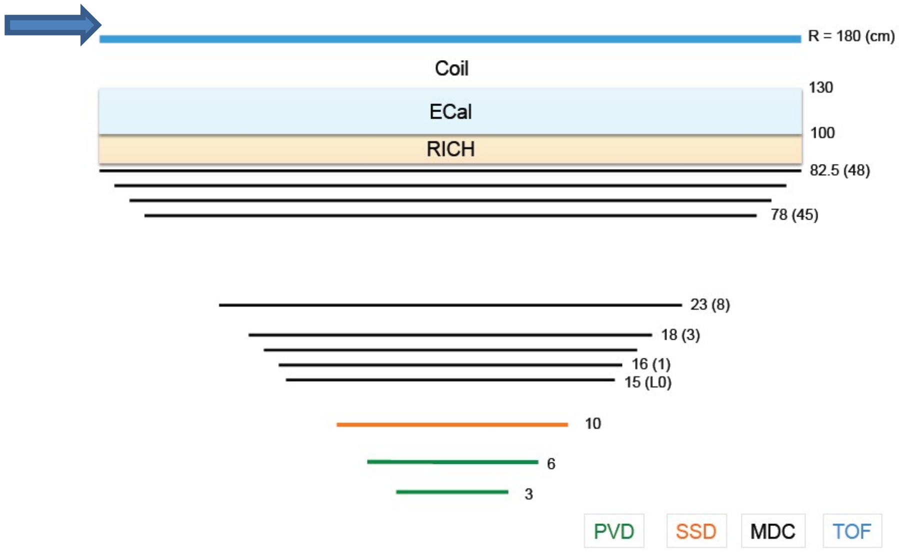


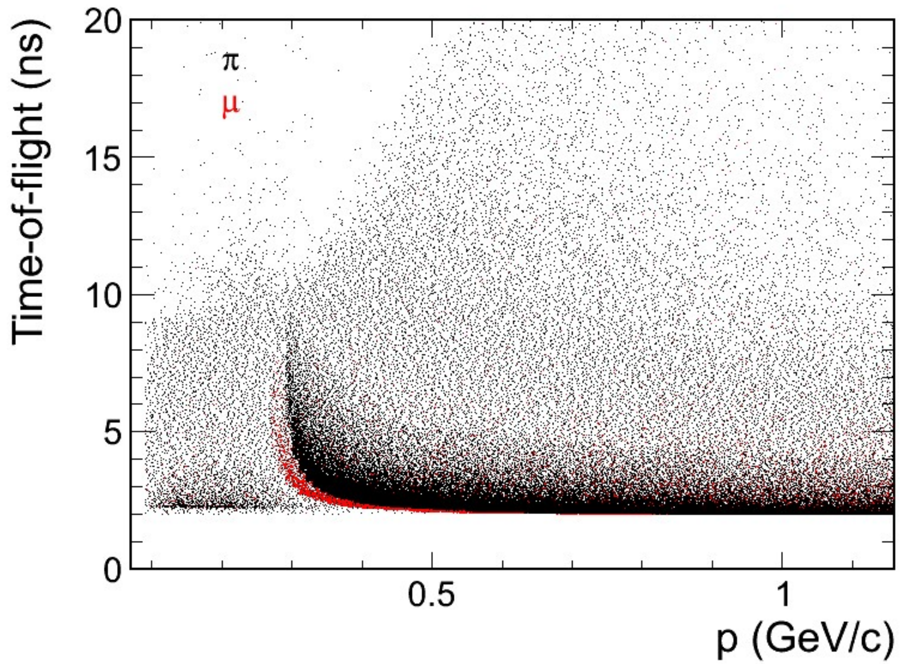


Performance :

- **Time resolution : 108ps**
- **Spatial resolution : 2.6cm(z), 1.9 cm(ϕ)**

Extending π/μ separation range





- The time-of-flight for punch through pion and muon coming out from ECal shows some difference at low momentum.

Activities

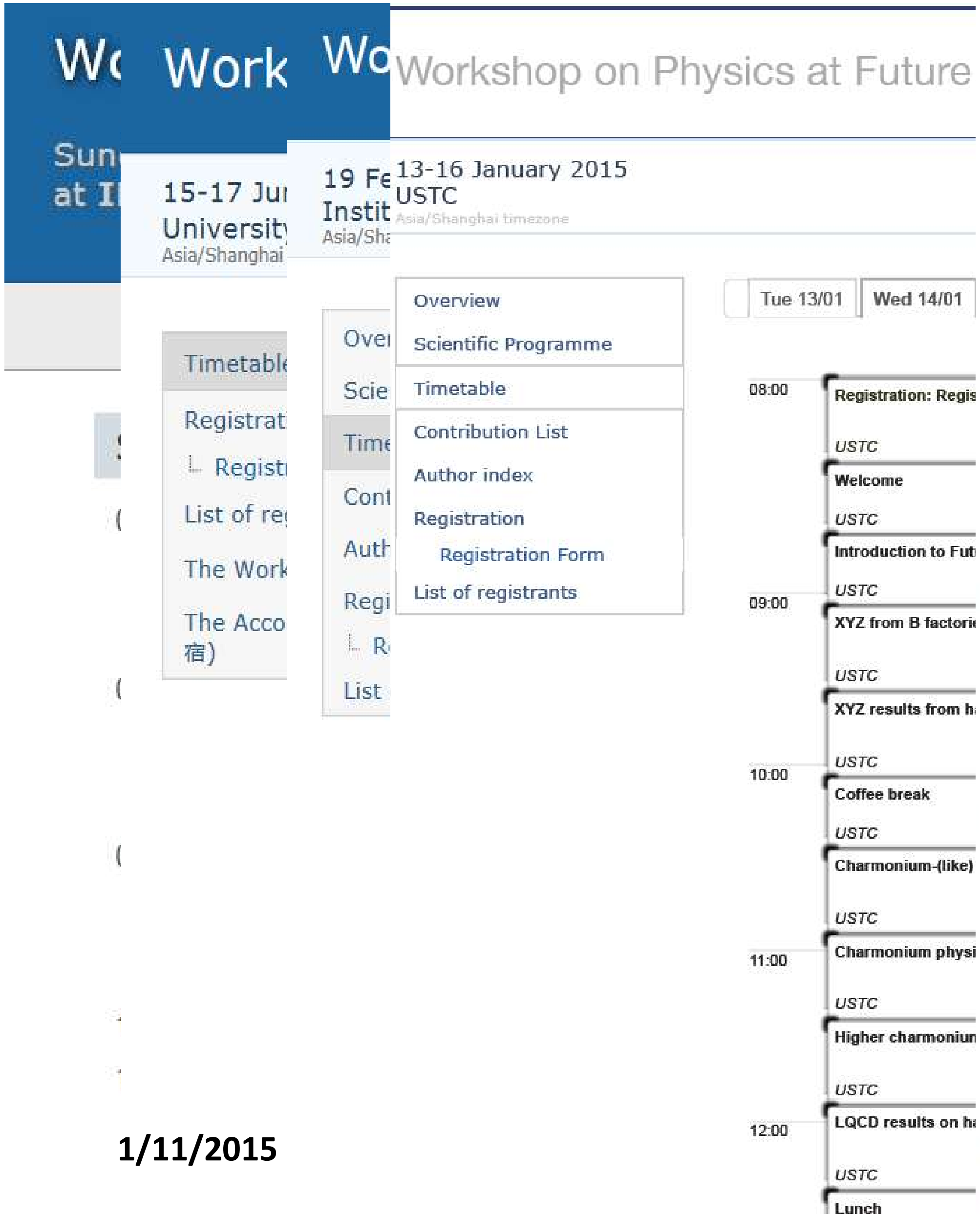
http://wcm.ustc.edu.cn/pub/CICPI2011/futureplans/

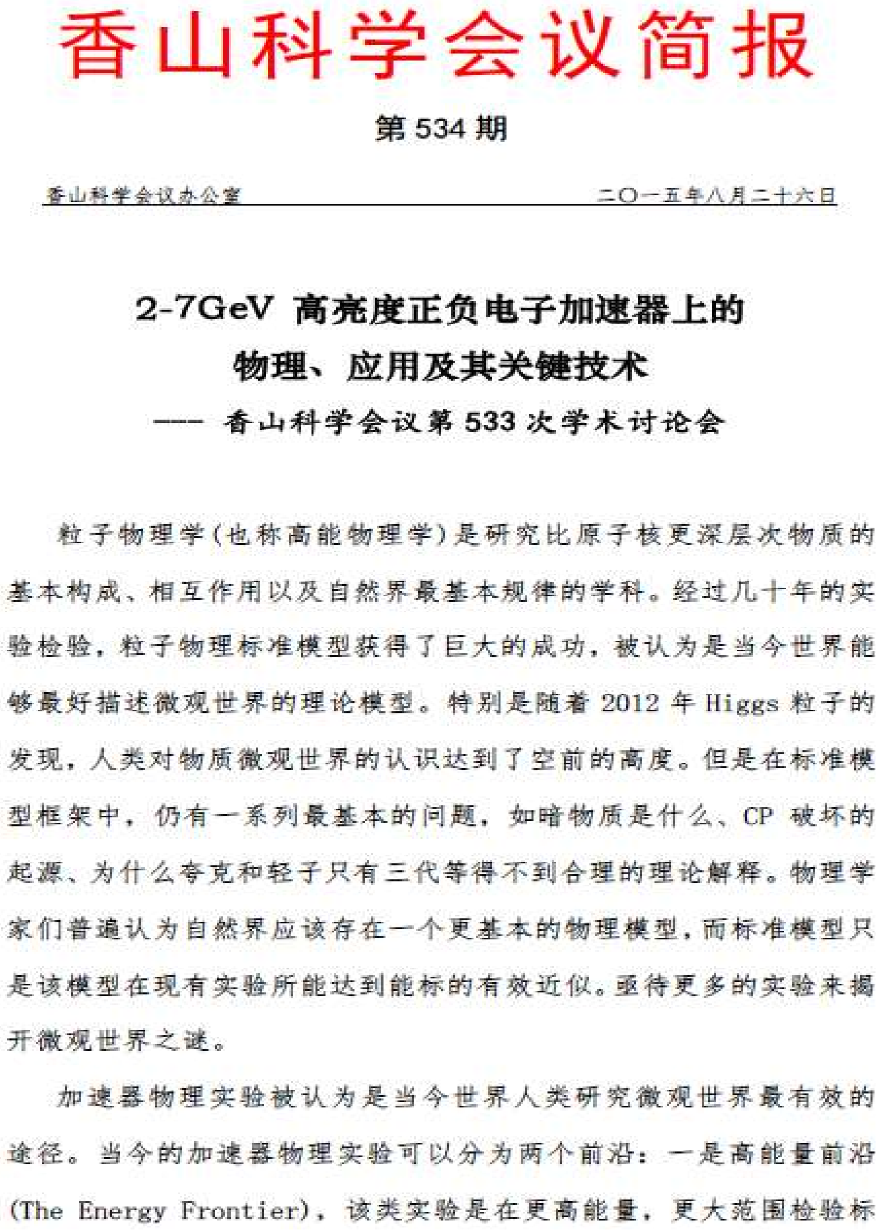
High Luminosity Tau Charm Physics

Indico for High Luminorcity Tau Charm Physics R&D

Coordinator Meeting	2 events
Mini Workshop	1 event
Monthly Meeting	3 events
Physics Weekly Meeting	3 events
Workshop	3 events

Workshops for HIEPA





香山科学会议简报

第 534 期

香山科学会议办公室　　二〇一五年八月二十六日

2-7GeV 高亮度正负电子加速器上的

物理、应用及其关键技术

---- 香山科学会议第 533 次学术讨论会

粒子物理学（也称高能物理学）是研究比原子核更深层次物质的基本构成、相互作用以及自然界最基本规律的学科。经过几十年的实验检验，粒子物理标准模型获得了巨大的成功，被认为是当今世界能够最好描述微观世界的理论模型。特别是随着 2012 年 Higgs 粒子的发现，人类对物质微观世界的认识达到了空前的高度。但是在标准模型框架中，仍有一系列最基本的问题，如暗物质是什么、CP 破坏的起源、为什么夸克和轻子只有三代等得不到合理的理论解释。物理学家们普遍认为自然界应该存在一个更基本的物理模型，而标准模型只是该模型在现有实验所能达到能标的有效近似。亟待更多的实验来揭开微观世界之谜。

加速器物理实验被认为是当今世界人类研究微观世界最有效的途径。当今的加速器物理实验可以分为两个前沿：一是高能量前沿(The Energy Frontier)，该类实验是在更高能量，更大范围检验标

2015 Internal Workshop

香山会议

Data Sample at Resonances for 1 ab^{-1}

	J/ψ	$\psi(2S)$	$\psi(3770)$	$\psi(4040)$	$\psi(4160)$	$\psi(4415)$
M, GeV	3.097	3.686	3.773	4.039	4.153	4.421
Γ, MeV	0.093	0.304	27	80	103	62
σ, nb	$\sim$3400	$\sim$640	$\sim$6	$\sim$10	$\sim$6	$\sim$4
L, fb^{-1}	300	150	350	10	20	25
N	10^{12}	10^{11}	2×10^9	10^8	10^8	10^8
BESIII	10^9	10^8	10^7	10^6	10^6	10^6

Requirement To The Detector

Efficient event triggering, exclusive state reconstruction and tagging – high efficiency and resolutions for charged and neutral particles

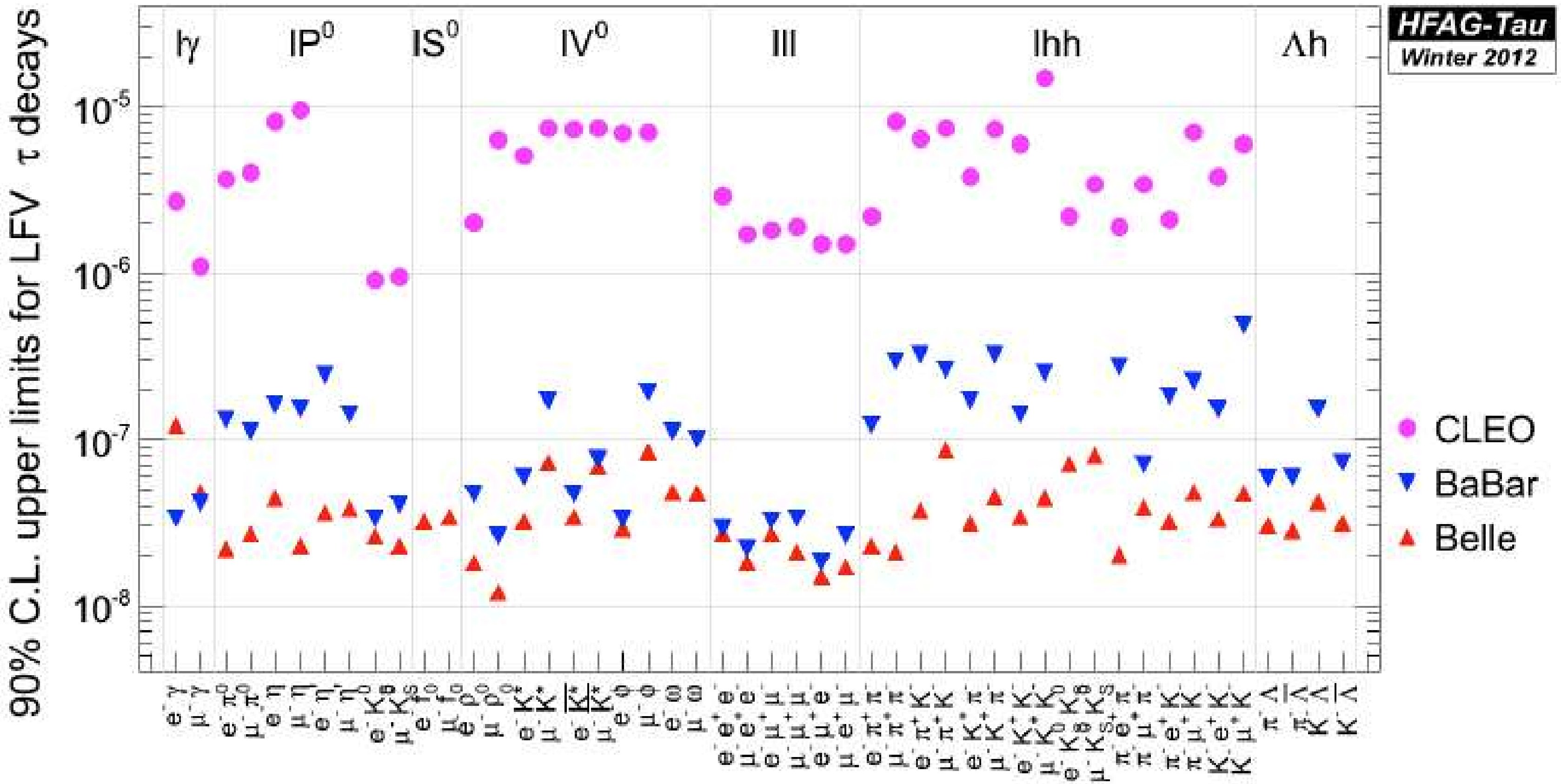
- **Best possible solid angle coverage**
- **High resolution for charged particles: [0.05, 1.6] GeV**
- **Good PID: [0.05, 2] GeV**
- **Good e, γ detection eff. and energy resolution: [0.02,2.5] GeV**
- **Good vertex detection: 50 μm**

Nucleon Form Factors

- **Fundamental properties of the nucleon**
  - Connected to charge, magnetization distribution
  - Crucial testing ground for models of the nucleon internal structure
  - Necessary input for experiments probing nuclear structure, or trying to understand modification of nucleon structure in nuclear medium
- **Driving renewed activity on theory side**
  - Models trying to explain all four electromagnetic form factors
  - Trying to explain data at both low and high Q^2
  - Progress in QCD based calculations

Model	$\tau \to \ell\gamma$	$\tau \to \ell\ell\ell$	Ref.
SM + lepton mixing	10^{-40}	10^{-14}	hep-ph/9810484
SM + left-h. heavy Dirac neutrino	$< 10^{-18}$	$< 10^{-18}$	SJNP25(1977)340
SM + right-h. heavy Majorana neutrino	$< 10^{-9}$	$< 10^{-10}$	PRD66(2002)034008
SM + left and right-h. neutral singlets	$< 10^{-8}$	$< 10^{-9}$	PRD66(2002)034008
mSUGRA + seesaw	$< 10^{-7}$	$< 10^{-9}$	hep-ph/0206110, hep-ph/9911459
SUSY $SU(5)$	$< 10^{-4}$		hep-ph/0303071
SUSY flipped $SU(5)$	$< 10^{-7}$		hep-ph/0304130
SUSY $SO(10)$	$< 10^{-8}$	$< 10^{-10}$	hep-ph/0209303, hep-ph/0304190
SUSY anomalous $U(1)$	$< 10^{-7}$		hep-ph/0308093
neutral SUSY Higgs	$< 10^{-10}$	$< 10^{-7}$	hep-ph/0304081
charged SUSY Higgs triplet		$< 10^{-7}$	hep-ph/0209170
MSSM+nonuniversal soft SUSY breaking	$< 10^{-10}$	$< 10^{-6}$	hep-ph/0305290
Non universal Z' (technicolor)	$< 10^{-9}$	$< 10^{-8}$	PLB547(2002)252
two Higgs doublet III	$< 10^{-15}$	$< 10^{-17}$	hep-ph/0208117
extra dimensions	$< 10^{-11}$		hep-ph/0210021

Upper limits on tau LFV branching fractions



Search for CPV, LFV Processes

One of physical effects BSM is the existence of the non-zero electric dipole moment (EDM) of quarks or leptons leading to CPV

- $J/\psi \rightarrow \gamma\phi\phi$ c quark EDM at 10^{-15} e-cm level
- $J/\psi \rightarrow \Lambda\bar{\Lambda}$ set limit ~10^{-19} e-cm for EDM of Λ
  (two order of magnitude more stringent)

Lepton flavor violation

- $J/\psi \rightarrow ll'$ ($l,l'=e, \mu, \tau$) $< 10^{-9}$

Physics with τ Leptons

- $e^+e^- \rightarrow \tau^+\tau^-$ near threshold -- low and controlled background
- Precision measurements of α_s, m_s, V_{us}
- Lepton universality: m_τ, $\tau \rightarrow \pi^+\nu_\tau$ and $\tau \rightarrow K^+\nu_\tau$
- Lorentz structure of the amplitude for $\tau \rightarrow l\nu_l\nu_\tau$
- Search for LFV processes: $\tau \rightarrow l\gamma$, lll', lh – sensitive to new physics (10^{-7}–10^{-8} from BF)
- Search for CPV: $A_{CP} = (\Gamma(\tau \rightarrow f+) - \Gamma(\tau \rightarrow f-)) / (\Gamma(\tau \rightarrow f+) + \Gamma(\tau \rightarrow f-))$
  Most promising processes $\tau \rightarrow K\pi^0\nu_\tau$, $\rho\pi\nu_\tau$, $\omega\pi\nu_\tau$, $a_1\pi\nu_\tau$
  Observation of CP asymmetry would be an explicit indication of physics BSM.
- Competition from SBF, but threshold effect is important for controlling and understanding background
- Longitudinal polarization of the initial beams will significantly increase sensitivity in searches for CPV in lepton decays.