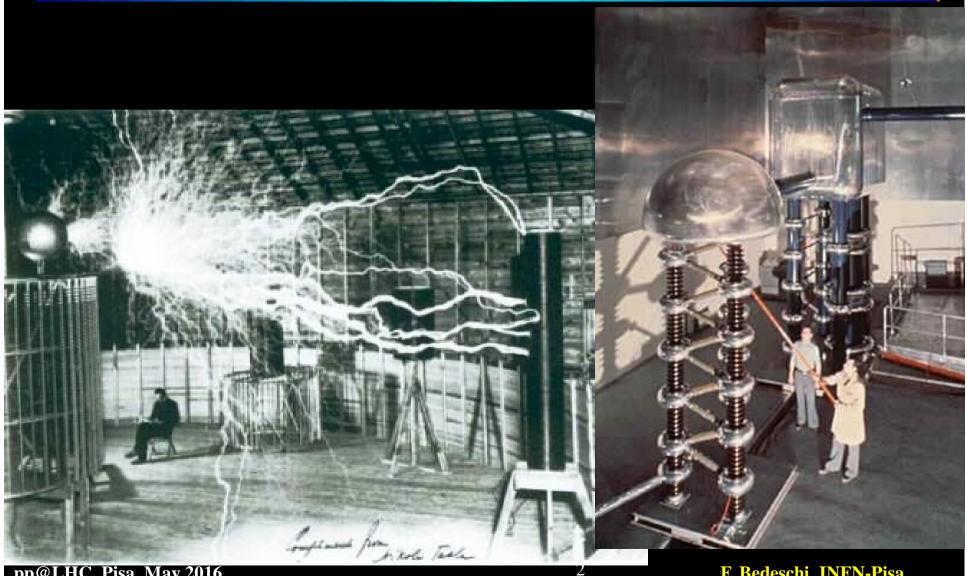
# <complex-block><text>

What are we talking about?
Where are we now?
Do we know where we are going?
Do we need new accelerators?
What could we build? Now, later, far future?
What can we do now?



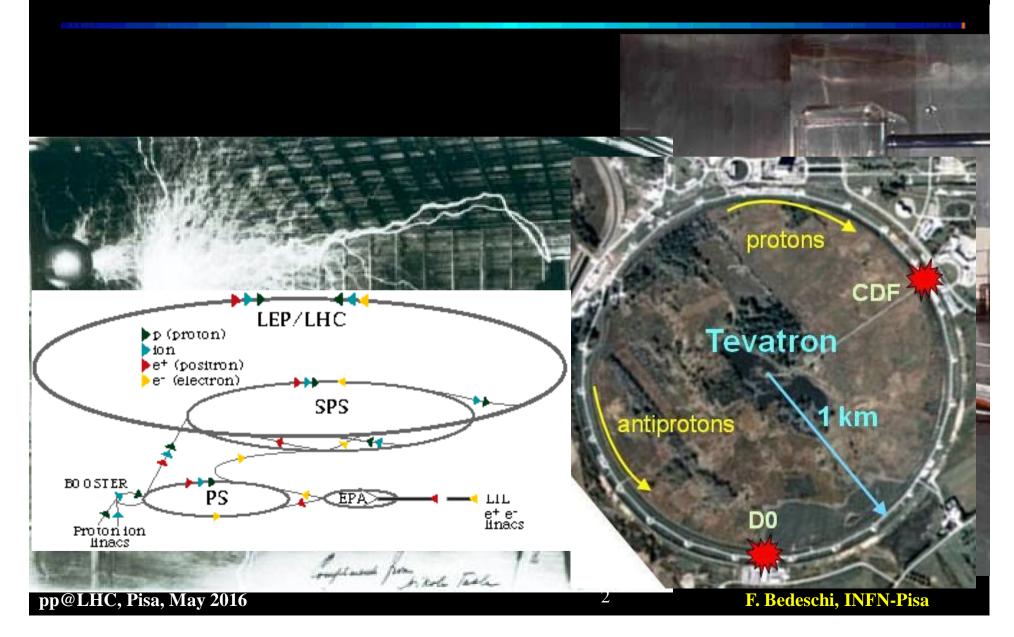




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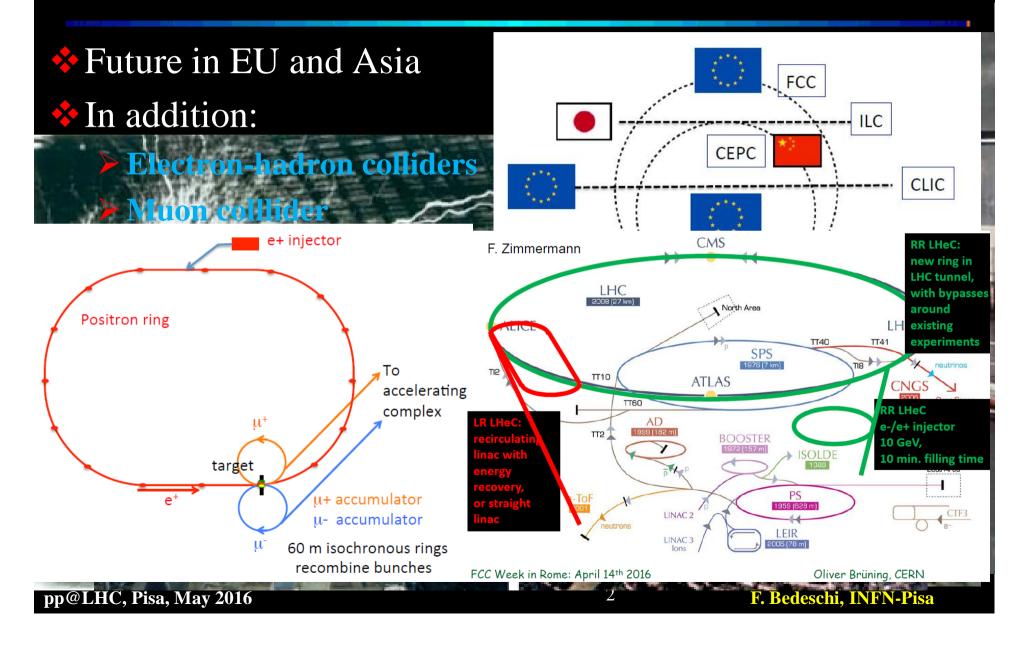


#### Future in EU and Asia FCC ILC CEPC CLIC KEKB M. Taukuba LHC HL-LHC KEKF **HE-LHC** B0 ( $\mathbf{Pr}$ pp@LHC, Pisa, May 2016 F. Bedeschi, INFN-Pisa



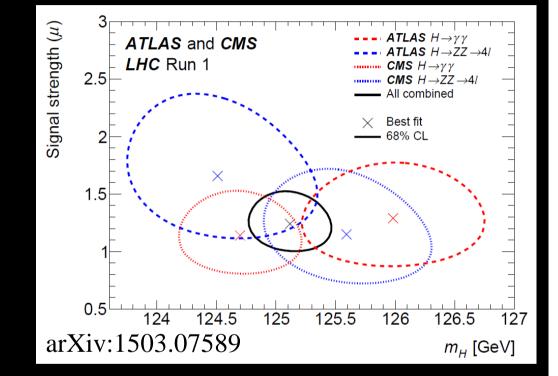
#### Future in EU and Asia FCC In addition: ILC CEPC Electron-hadron colliders CLIC CMS R LHeC: F. Zimmermann new ring in LHC tunnel, KEKB LHC 2008 [27 km] with bypasses M. Trukuba nest for CPV North Area around LH existing experiments TT40 TT41 KEKI SPS 1976 (7 km) TIS neutrinos π10 ATLAS CNGS TT60 **RR LHeC** AD 1999 (182 m) e-/e+ injector TT2 I BOOSTER 10 GeV, ISOLDE 10 min. filling time BO ( PS LINAC 2 CTF3 $\mathbf{Pr}$ LEIR LINAC 3 2005 (78 m Oliver Brüning, CERN FCC Week in Rome: April 14th 2016 F. Bedeschi, INFN-Pisa pp@LHC, Pisa, May 2016



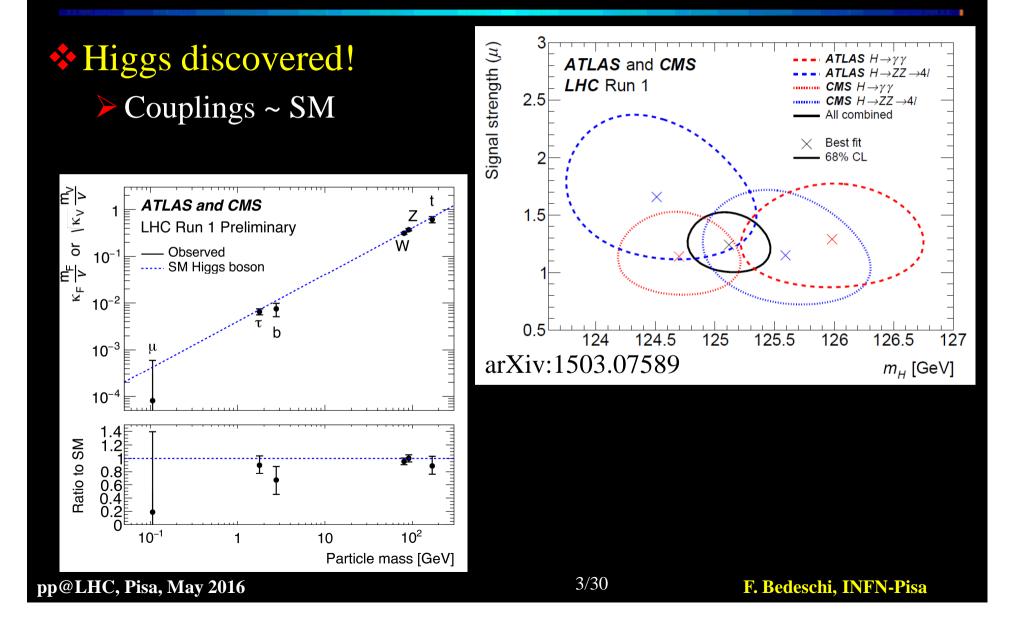




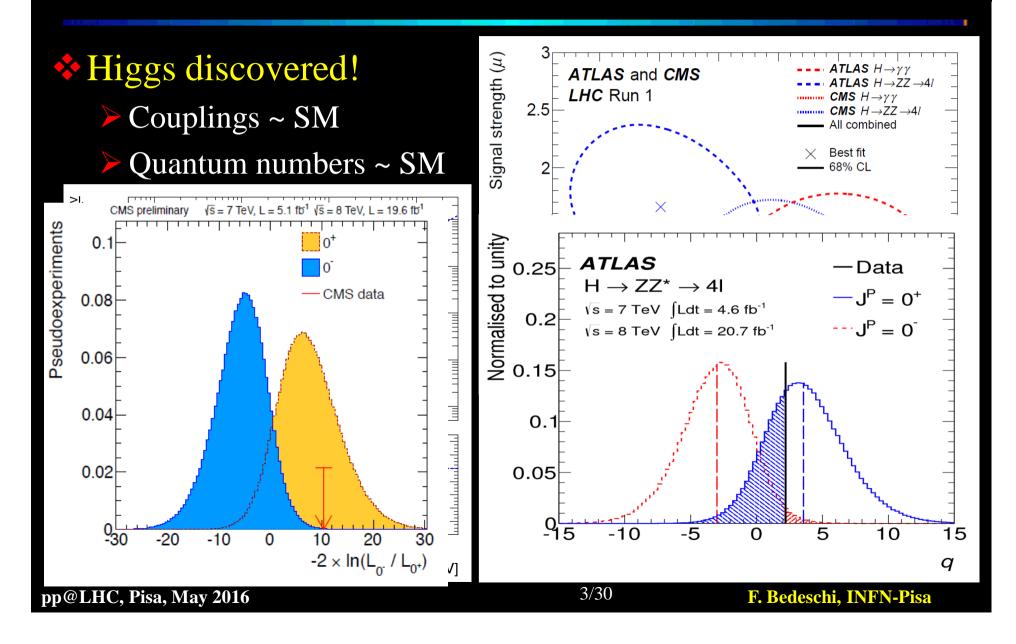
#### Higgs discovered!





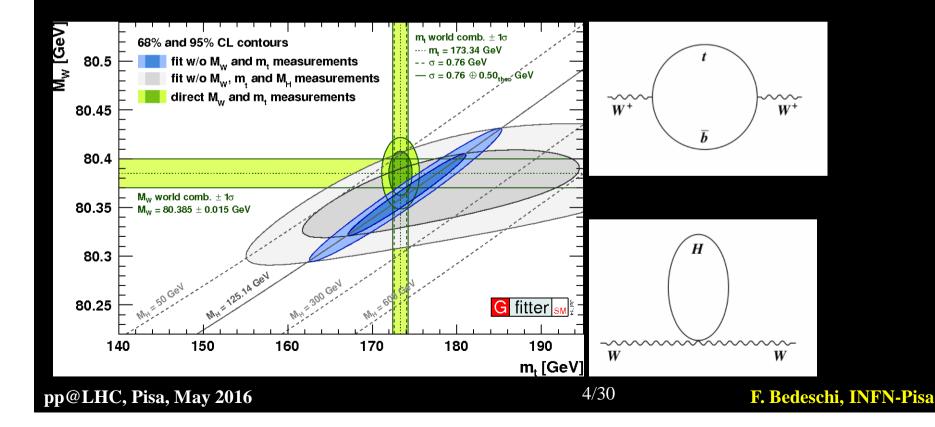






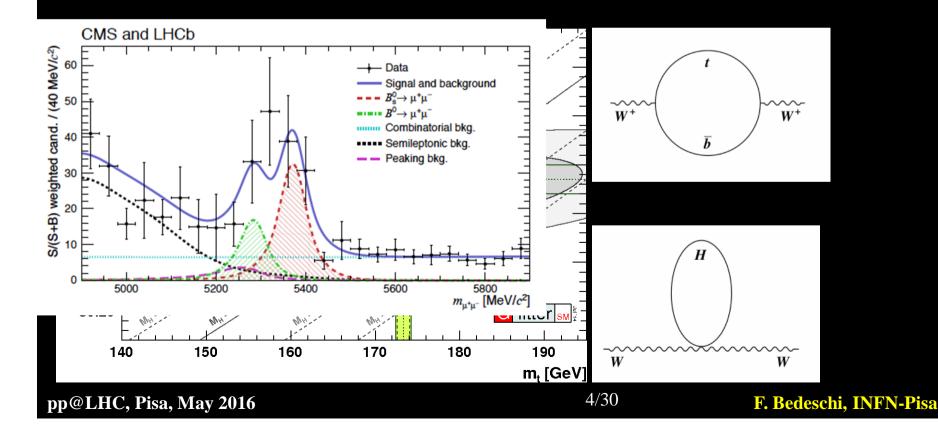


## Also indirect measur. sensitive to radiative corrections Mtop, Mw, M<sub>H</sub>





# ◆ Also indirect measur. sensitive to radiative corrections > Mtop, Mw, M<sub>H</sub> > Br (B→µµ)

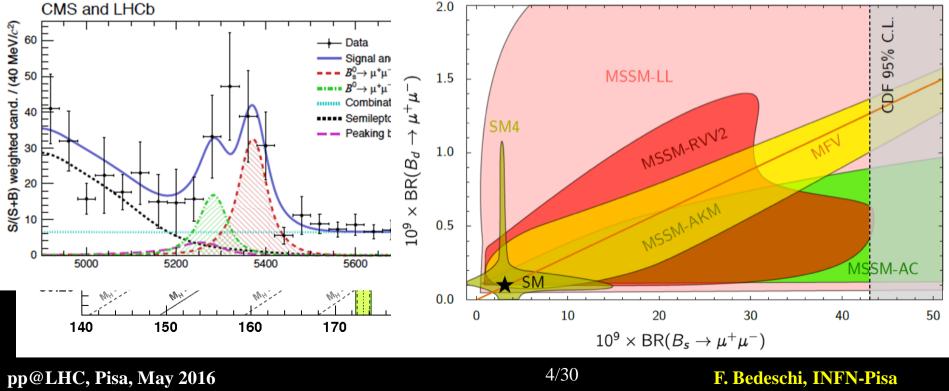




#### Also indirect measur. sensitive to radiative corrections

- Mtop, Mw, M<sub>H</sub>
- Br ( $B \rightarrow \mu \mu$ )



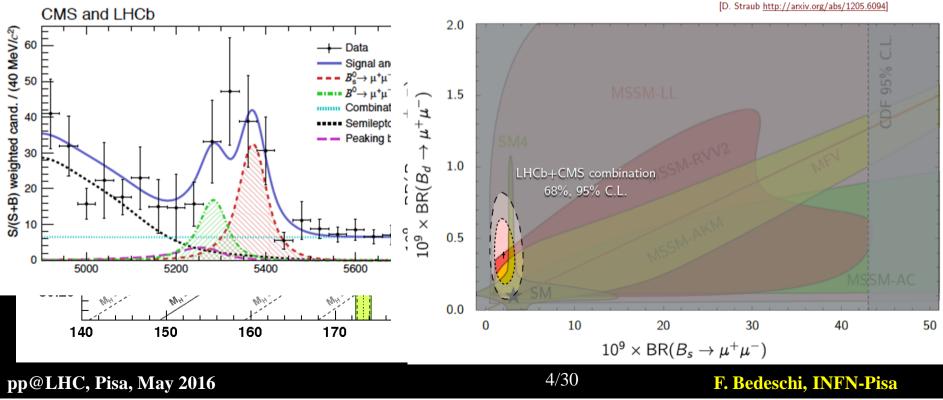




#### Also indirect measur. sensitive to radiative corrections

- Mtop, Mw, M<sub>H</sub>
- Br ( $B \rightarrow \mu \mu$ )

Stronger constraints on new physics



#### However ... New physics? ... Not yet C

ATLAS SUSY Searches\* - 95% CL Lower Limits **ATLAS** Preliminary Status: March 2016  $\sqrt{s} = 7.8.13$  TeV  $e, \mu, \tau, \gamma$  Jets  $E_{T}^{\text{miss}} \int \mathcal{L} dt [\text{fb}^{-1}]$ Model  $\sqrt{s} = 7, 8 \text{ TeV}$   $\sqrt{s} = 13 \text{ TeV}$ Reference Mass limit MSUGRA/CMSSM 0-3 e, µ /1-2 τ 2-10 jets/3 b Yes 20.3 1.85 TeV m(q)=m(g) 1507 05525 0 2-6 jets Yes 3.2  $m(\tilde{\chi}_1^0)=0$  GeV,  $m(1^{st} \text{ gen. } \tilde{q})=m(2^{nd} \text{ gen. } \tilde{q})$ ATLAS-CONF-2015-062  $\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}$ mono-iet 1-3 jets Yes 3.2 610 GeV  $m(\tilde{a})-m(\tilde{\chi}_{1}^{0}) < 5 \text{ GeV}$ To appear  $\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_{1}^{0}$  (compressed) 2 e, μ (off-Z) 2 iets Yes 20.3 1503.03290  $\tilde{q}\tilde{q}, \tilde{q} \rightarrow q(\ell \ell / \ell \nu / \nu \nu) \tilde{\chi}_1^0$ 820 Ge  $m(\tilde{\chi}_{1}^{0})=0$  GeV 2-6 iets Yes 3.2 1.52 TeV ATLAS-CONE-2015-062 0  $m(\tilde{\chi}_1^0) = 0 \text{ GeV}$  $\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\bar{q}\tilde{\chi}$  $\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq\tilde{\chi}_{1}^{\pm} \rightarrow qqW^{\pm}\tilde{\chi}_{1}^{0}$ 1 e.u 2-6 jets Yes 3.3 16 TeV  $m(\tilde{\chi}_{1}^{0}) < 350 \text{ GeV}, m(\tilde{\chi}^{\pm}) = 0.5(m(\tilde{\chi}_{1}^{0}) + m(\tilde{g}))$ ATLAS-CONE-2015-076  $\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$  $2e,\mu$ 0-3 jets 20 1.38 TeV  $m(\tilde{\chi}_{1}^{0})=0 \text{ GeV}$ 1501 03555 - $\tilde{g}\tilde{g}, \tilde{g} \rightarrow qqWZ\tilde{\chi}_{1}^{0}$ 7-10 jets Yes 3.2 0 1.4 TeV  $m(\tilde{\chi}_{1}^{0}) = 100 \text{ GeV}$ 1602.06194 GMSB (*l* NLSP) 1-2 τ + 0-1 *l* 0-2 jets Yes 20.3 1.63 TeV  $\tan\beta > 20$ 1407.0603 GGM (bino NLSP) . cτ(NLSP)<0.1 mm 20.3 1.34 TeV 1507.05493  $2 \gamma$ Yes GGM (higgsino-bino NLSP)  $m(\tilde{\chi}_{1}^{0})$ <950 GeV,  $c\tau$ (NLSP)<0.1 mm,  $\mu$ <0 γ 1 bYes 20.3 1.37 TeV 1507 05493 GGM (higgsino-bino NLSP) 2 iets Yes 20.3 1.3 TeV  $m(\tilde{\chi}_{1}^{0})$ <850 GeV,  $c\tau$ (NLSP)<0.1 mm,  $\mu$ >0 1507.05493 GGM (higgsino NLSP) 2 e, µ (Z) 2 jets Yes 20.3 900 GeV m(NLSP)>430 GeV 1503.03290  $m(\tilde{G}) > 1.8 \times 10^{-4} \text{ eV}, m(\tilde{q}) = m(\tilde{q}) = 1.5 \text{ TeV}$ Gravitino LSP 0 mono-jet Yes 20.3 865 GeV 1502.01518 0 3bYes 3.3 1.78 TeV m(X<sub>1</sub><sup>0</sup>)<800 GeV ATLAS-CONF-2015-067  $\tilde{g}\tilde{g}, \tilde{g} \rightarrow b\bar{b}\tilde{\chi}$  $\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\bar{t}\tilde{\chi}_{1}^{0}$ 0-1 e, µ 3 b Yes 3.3 1.76 TeV To appear  $m(\tilde{\chi}_{1}^{0})=0$  GeV 1.37 TeV 1407.0600 0-1 e. µ 3bYes 20.1  $m(\tilde{\chi}_1^0) < 300 \, \text{GeV}$ ĝĝ, ĝ→btX̃  $\tilde{b}_1 \tilde{b}_1, \tilde{b}_1 \rightarrow b \tilde{\chi}_1^0$ 0 Yes 3.2 840 GeV  $m(\tilde{\chi}_{1}^{0}) < 100 \text{ GeV}$ ATLAS-CONF-2015-066 2h2 e, µ (SS) 325-540 GeV  $m(\tilde{\chi}_{1}^{0}) = 50 \text{ GeV}, m(\tilde{\chi}_{1}^{\pm}) = m(\tilde{\chi}_{1}^{0}) + 100 \text{ GeV}$  $\tilde{b}_1 \tilde{b}_1, \tilde{b}_1 \rightarrow t \tilde{\chi}_1^{\dagger}$ 0-3 b Yes 3.2 1602 09058  $1-2 e, \mu$ 1-2 b Yes 4.7/20.3 200-500 GeV  $m(\tilde{\chi}_{\perp}^{\pm}) = 2m(\tilde{\chi}_{\perp}^{0}), m(\tilde{\chi}_{\perp}^{0}) = 55 \text{ GeV}$ 1209 2102 1407 0583  $\tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow b \tilde{\chi}_1^{\pm}$ ĩ:11<mark>7</mark>  $\tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow W b \tilde{\chi}_1^0$  or  $t \tilde{\chi}_1^0$ 0-2 e, µ 0-2 jets/1-2 b Yes 90-198 GeV 205-715 GeV 745-785 GeV 1506 08616, ATLAS-CONF-2016-007 20.3  $m(\tilde{\chi}_{1}^{0})=1 \text{ GeV}$  $\tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow c \tilde{\chi}_1^0$  $\tilde{t}_1 \tilde{t}_1 (natural GMSB)$ 0 mono-jet/c-tag Yes 20.3 90-245 GeV  $m(\tilde{t}_1) - m(\tilde{\chi}_1^0) < 85 \text{ GeV}$ 1407.0608  $2e.\mu(Z)$ 150-600 GeV 1403.5222 Yes 20.3 1h $m(\tilde{\chi}_1^0) > 150 \text{ GeV}$  $\tilde{t}_2\tilde{t}_2,\,\tilde{t}_2{\rightarrow}\tilde{t}_1+Z$ 3e.u(Z)1 bYes 20.3 290-610 GeV m(X10)<200 GeV 1403 5222  $\tilde{\iota}_2 \tilde{\iota}_2, \tilde{\iota}_2 \rightarrow \tilde{\iota}_1 + h$ 1 e, µ 6 jets + 2 b Yes 20.3 320-620 GeV  $m(\tilde{\chi}_1^0)=0$  GeV 1506.08616 2 e, µ  $\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell} \rightarrow \ell \tilde{\chi}_1^0$ 0 Yes 20.3 90-335 GeV  $m(\tilde{\chi}_1^0)=0 \text{ GeV}$ 1403 5294  $\tilde{\chi}_1^+ \tilde{\chi}_1^-, \tilde{\chi}_1^+ \rightarrow \tilde{\ell} \nu(\ell \tilde{\nu})$  $2 e, \mu$ 0 Yes 20.3 140-475 GeV  $m(\tilde{\chi}_{1}^{0})=0$  GeV,  $m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_{1}^{\pm})+m(\tilde{\chi}_{1}^{0}))$ 1403.5294  $\tilde{\chi}_{1}^{\dagger}\tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{\dagger} \rightarrow \tilde{\tau}\nu(\tau\tilde{\nu})$ 2τ Yes 20.3 355 GeV  $m(\tilde{\chi}_{1}^{0})=0$  GeV,  $m(\tilde{\tau}, \tilde{\nu})=0.5(m(\tilde{\chi}_{1}^{\pm})+m(\tilde{\chi}_{1}^{0}))$ 1407.0350  $\tilde{\chi}_{1}^{\pm}\tilde{\chi}_{2}^{0} \rightarrow \tilde{\ell}_{L} \nu \tilde{\ell}_{L} \ell(\tilde{\nu}\nu), \ell \tilde{\nu} \tilde{\ell}_{L} \ell(\tilde{\nu}\nu)$ 3 e, µ 0 20.3 1402.7029 Yes 715 GeV  $m(\tilde{\chi}_{1}^{\pm})=m(\tilde{\chi}_{2}^{0}), m(\tilde{\chi}_{1}^{0})=0, m(\tilde{\ell}, \tilde{\gamma})=0.5(m(\tilde{\chi}_{1}^{\pm})+m(\tilde{\chi}_{1}^{0}))$  $\begin{array}{c} \chi_{1}^{+}\chi_{2}^{0} \rightarrow W\chi_{1}^{0}Z\chi_{1}^{0} \\ \tilde{\chi}_{1}^{+}\chi_{2}^{0} \rightarrow W\chi_{1}^{0}h\chi_{1}^{0}, h \rightarrow b\bar{b}/WW/\tau\tau/\gamma\gamma \\ \tilde{\chi}_{2}^{0}\chi_{3}^{0}, \tilde{\chi}_{2,3}^{0} \rightarrow \tilde{\ell}_{R}\ell \end{array}$ 2-3 e.u 1403.5294, 1402.7029 0-2 jets Yes 425 GeV  $m(\tilde{\chi}_{\pm}^{\pm})=m(\tilde{\chi}_{\pm}^{0})$   $m(\tilde{\chi}_{\pm}^{0})=0$  sleptons decoupled 20.3  $e, \mu, \gamma$ 0-2 b Yes 20.3 270 GeV  $m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0$ , sleptons decoupled 1501.07110 4 e, µ Yes 20.3 635 GeV  $m(\tilde{\chi}_{2}^{0})=m(\tilde{\chi}_{3}^{0}), m(\tilde{\chi}_{1}^{0})=0, m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_{2}^{0})+m(\tilde{\chi}_{1}^{0}))$ 1405 5086 0 GGM (wino NLSP) weak prod. Yes 20.3 1507.05493  $1e.\mu + \gamma$ 115-370 GeV  $c\tau < 1 \text{ mm}$ Direct  $\tilde{\chi}_1^+ \tilde{\chi}_1^-$  prod., long-lived  $\tilde{\chi}_1^+$ Disapp. trk 1 jet Yes 20.3 270 GeV  $m(\tilde{\chi}_{1}^{\pm})-m(\tilde{\chi}_{1}^{0})\sim$ 160 MeV,  $\tau(\tilde{\chi}_{1}^{\pm})=0.2$  ns 1310.3675 Direct  $\tilde{\chi}_1^+ \tilde{\chi}_1^-$  prod., long-lived  $\tilde{\chi}_1^\pm$ dE/dx trk Yes 18.4 495 GeV  $m(\tilde{\chi}_{\perp}^{\pm})-m(\tilde{\chi}_{\perp}^{0})\sim 160$  MeV,  $\tau(\tilde{\chi}_{\perp}^{\pm})<15$  ns 1506.05332 Stable, stopped g R-hadron 0 1-5 jets Yes 27.9 850 GeV 1310.6584  $m(\tilde{\chi}_1^0)=100 \text{ GeV}, 10 \ \mu s < \tau(\tilde{g}) < 1000 \text{ s}$ Metastable g R-hadron dE/dx trk 1 54 TeV 32  $m(\tilde{\chi}_{1}^{0})=100 \text{ GeV}, \tau>10 \text{ ns}$ To appear 537 GeV GMSB, stable  $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{e}, \tilde{\mu}) + \tau(e, \mu)$  1-2  $\mu$ 19.1 10<tan8<50 1411 6795 2γ Yes 20.3  $1 < \tau(\tilde{\chi}_1^0) < 3$  ns, SPS8 model 1409 5542 GMSB,  $\tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}$ , long-lived  $\tilde{\chi}_1^0$ 440 GeV displ. ee/eµ/µµ 20.3 1.0 TeV  $7 < c\tau(\tilde{\chi}_1^0) < 740 \text{ mm}, m(\tilde{g}) = 1.3 \text{ TeV}$ 1504.05162  $\tilde{g}\tilde{g}, \tilde{\chi}_1^0 \rightarrow eev/euv/uuv$ displ. vtx + jets 20.3 1.0 TeV 1504.05162 GGM  $\tilde{g}\tilde{g}, \tilde{\chi}_1^0 \rightarrow Z\tilde{G}$ 6 <cτ(X10) < 480 mm, m(g)=1.1 TeV LFV  $pp \rightarrow \tilde{v}_{\tau} + X, \tilde{v}_{\tau} \rightarrow e\mu/e\tau/\mu\tau$ εμ,ετ,μτ 1.7 TeV  $\lambda'_{111}=0.11, \lambda_{132/133/233}=0.07$ 1503.04430 20.3 Bilinear BPV CMSSM 2 e. µ (SS) 0-3 bYes 1.45 TeV  $m(\tilde{q})=m(\tilde{g}), c\tau_{LSP} < 1 \text{ mm}$ 20.3 1404.2500  $\tilde{\chi}_{1}^{+}\tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{+} \rightarrow W \tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0} \rightarrow e e \tilde{v}_{u}, e \mu \tilde{v}_{e}$  $4 e, \mu$ Yes 20.3 760 GeV  $m(\tilde{\chi}_{1}^{0}) > 0.2 \times m(\tilde{\chi}_{1}^{\pm}), \lambda_{121} \neq 0$ 1405 5086  $\tilde{\chi}_{1}^{+}\tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{+} \rightarrow W \tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0} \rightarrow \tau \tau \tilde{\nu}_{e}, e \tau \tilde{\nu}_{\tau}$  $3 e, \mu + \tau$ Yes 20.3 450 GeV  $m(\tilde{\chi}_{1}^{0}) > 0.2 \times m(\tilde{\chi}_{1}^{\pm}), \lambda_{133} \neq 0$ 1405 5086  $\tilde{g}\tilde{g}, \tilde{g} \rightarrow qqq$ 6-7 jets BR(t)=BR(b)=BR(c)=0%1502.05686 0 20.3 917 GeV 6-7 jets  $\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq\tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0} \rightarrow qqq$  $\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{t}_{1}t, \tilde{t}_{1} \rightarrow bs$ 0 20.3 980 GeV  $m(\tilde{\chi}_1^0)=600 \text{ GeV}$ 1502.05686 2 e, µ (SS) 0-3 b Yes 1404.2500 20.3 880 GeV  $\tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow bs$ 2 iets + 2 b 320 GeV 1601.07453 0 20.3  $\tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow b\ell$ 2 e, µ 2b20.3 0.4-1.0 TeV  $BR(\tilde{t}_1 \rightarrow be/\mu) > 20\%$ ATLAS-CONF-2015-015 **Dther** Scalar charm,  $\tilde{c} \rightarrow c \tilde{\chi}_1^0$ 0 2 c Yes 20.3 510 GeV m(X10)<200 GeV 1501.01325 \*Only a selection of the available mass limits on new  $10^{-1}$ 1 Mass scale [TeV] states or phenomena is shown

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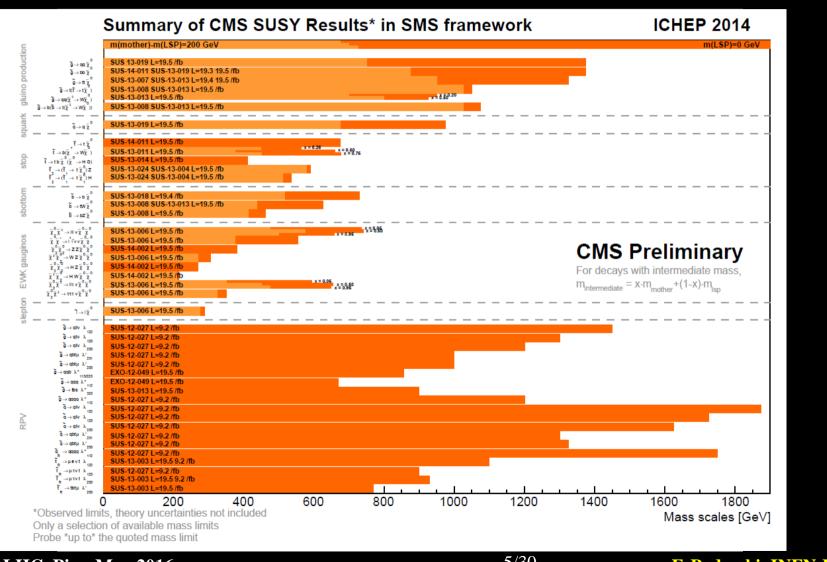
### However ... New physics? ... Not yet C

atus: March 2016			<b>–</b> mis	• Co	. 1-	5	= (3.2 - 20.3) fb <sup>-1</sup>	$\sqrt{s} = 8, 13 \text{ TeV}$
Model	<i>ℓ</i> , γ	Jets†	E <sup>miss</sup> T	<sup>s</sup> ∫£ dt[fb		Limit		Reference
ADD $G_{KK} + g/q$	-	≥ 1 j	Yes	3.2	Mp	6.86 TeV	n = 2	Preliminary
ADD non-resonant $\ell\ell$	2 e, µ		_	20.3	Ms	4.7 TeV	n = 3 HLZ	1407.2410
ADD QBH $\rightarrow \ell q$	1 e, µ	1 j	-	20.3	M <sub>th</sub>	5.2 TeV	<i>n</i> = 6	1311.2006
ADD QBH	-	2 j	-	3.6	M <sub>th</sub>	8.3 TeV		1512.01530
ADD BH high $\sum p_T$	$\geq$ 1 e, $\mu$		-	3.2	M <sub>th</sub>	8.2 TeV		ATLAS-CONF-2016-006
ADD BH multijet	-	≥3 j	-	3.6	M <sub>th</sub>	9.55 Te		1512.02586
RS1 $G_{KK} \rightarrow \ell \ell$	2 e, µ	-	-	20.3	G <sub>KK</sub> mass	2.68 TeV	$k/\overline{M}_{Pl} = 0.1$	1405.4123
RS1 $G_{KK} \rightarrow \gamma\gamma$	$2\gamma$	_	_	20.3	G <sub>KK</sub> mass	2.66 TeV	$k/\overline{M}_{Pl} = 0.1$	1504.05511
Bulk RS $G_{KK} \rightarrow WW \rightarrow qq\ell v$	1 e, µ	1 J	Yes		G <sub>KK</sub> mass	1.06 TeV	$k/\overline{M}_{PI} = 1.0$	ATLAS-CONF-2015-075
Bulk RS $G_{KK} \rightarrow HH \rightarrow bbbb$	1.0.11	4b	-	3.2	G <sub>KK</sub> mass	475-785 GeV	$k/\overline{M}_{PI} = 1.0$	ATLAS-CONF-2016-017
Bulk RS $g_{KK} \rightarrow tt$ 2UED / RPP		$\geq 1 \text{ b}, \geq 1 \text{ J/2}$ $\geq 2 \text{ b}, \geq 4 \text{ j}$			g <sub>KK</sub> mass	2.2 TeV	BR = 0.925 Tier (1,1), BR( $A^{(1,1)} \rightarrow tt$ ) = 1	1505.07018 ATLAS.CONE-2016-013
	1 e, µ	220, 27,	j Yes		KK mass	1.46 TeV	Her (1,1), $BH(A^{(1,1)} \rightarrow tt) = 1$	ATLAS-CONF-2016-013
$SSM Z' \to \ell\ell$	2 e, µ	-	-	3.2	Z' mass	3.4 TeV		ATLAS-CONF-2015-070
SSM $Z' \rightarrow \tau \tau$	2τ	-	-	19.5	Z' mass	2.02 TeV		1502.07177
Leptophobic $Z' \rightarrow bb$	-	2 b	-	3.2	Z' mass	1.5 TeV		Preliminary
SSM $W' \rightarrow \ell \nu$ HVT $W' \rightarrow WZ \rightarrow qq\nu\nu$ model A	1 <i>e</i> ,μ Α 0 <i>e</i> ,μ	- 1 J	Yes		W' mass W' mass	4.07 TeV	$g_V = 1$	ATLAS-CONF-2015-063 ATLAS-CONF-2015-068
HVT $W' \rightarrow WZ \rightarrow qqvv$ model A HVT $W' \rightarrow WZ \rightarrow qqqq$ model A		1 J 2 J	tes	3.2 3.2	W' mass W' mass	1.6 TeV 1.38-1.6 TeV	$g_V = 1$ $g_V = 1$	ATLAS-CONF-2015-068 ATLAS-CONF-2015-073
HVT $W' \rightarrow WZ \rightarrow qqqq$ model B		2 J 1-2 b, 1-0 j	i Yes		W' mass	1.38-1.6 TeV	$g_V = 1$ $g_V = 3$	ATLAS-CONF-2015-073 ATLAS-CONF-2015-074
HVT $Z' \rightarrow ZH \rightarrow yybb \mod B$	Β Τ θ, μ 0 e, μ	1-2 b, 1-0 j			Z' mass	1.76 TeV	$g_V = 3$ $g_V = 3$	ATLAS-CONF-2015-074 ATLAS-CONF-2015-074
LRSM $W'_{c} \rightarrow tb$	1 e, μ	2 b, 0-1 j			W' mass	1.92 TeV	sv - c	1410.4103
LRSM $W'_R \rightarrow tb$ LRSM $W'_R \rightarrow tb$	0 e, μ	≥ 1 b, 1 J		20.3	W' mass	1.76 TeV		1408.0886
CI qqqq	-	2 j		3.6			<b>17.5 TeV</b> $\eta_{LL} = -1$	1512.01530
Ci qqqq Ci qqll	2 e.μ	-	_	3.6	A		<b>17.5 IEV</b> $\eta_{LL} = -1$ <b>23.1 TeV</b> $\eta_{LL} = -1$	1512.01530 ATLAS-CONF-2015-070
			j Yes		Λ	4.3 TeV	$ C_{LL}  = 1$	1504.04605
Axial-vector mediator (Dirac DM)					m <sub>A</sub>	1.0 TeV	$g_{g}=0.25, g_{\chi}=1.0, m(\chi) < 140 \text{ GeV}$	Preliminary
	0 e, μ 0 e, μ, 1 γ	≥1j γ 1j	Yes Yes		m <sub>A</sub> m <sub>A</sub>	1.0 TeV 650 GeV	$g_q=0.25, g_{\chi}=1.0, m(\chi) < 140 \text{ GeV}$ $g_q=0.25, g_{\chi}=1.0, m(\chi) < 10 \text{ GeV}$	Preliminary
$ZZ_{\chi\chi}$ EFT (Dirac DM)	0 e, μ, 1 γ 0 e, μ	γ 1j 1J,≤1j			M.	550 GeV	$g_q=0.25, g_{\chi}=1.0, m(\chi) < 10 \text{ GeV}$ $m(\chi) < 150 \text{ GeV}$	ATLAS-CONF-2015-080
,			100		-			
Scalar LQ 1 <sup>st</sup> gen	2 e	≥ 2 j	-	3.2	LQ mass	1.07 TeV	eta=1 eta=1	Preliminary
Scalar LQ 2 <sup>nd</sup> gen Scalar LQ 3 <sup>rd</sup> gen	2μ 1e,μ	≥2j ≥1b,≥3j	i Yes	3.2 20.3	LQ mass	1.03 TeV 640 GeV	$\beta = 1$ $\beta = 0$	Preliminary 1508.04735
			•					
$VLQ TT \rightarrow Ht + X$	1 e, µ	$\geq 2 b, \geq 3 j$			T mass	855 GeV	T in (T,B) doublet	1505.04306
$VLQ \ YY \to Wb + X$	1 e, µ	$\geq 1 \text{ b}, \geq 3 \text{ j}$			Y mass	770 GeV	Y in (B,Y) doublet	1505.04306
$VLQ BB \rightarrow Hb + X$		$\geq 2 \text{ b}, \geq 3 \text{ j}$			B mass	735 GeV	isospin singlet	1505.04306
VLQ $BB \rightarrow Zb + X$	2/≥3 e, µ			20.3	B mass	755 GeV	B in (B,Y) doublet	1409.5500
$VLQ QQ \rightarrow WqWq$ $T_{5/3} \rightarrow Wt$	1 e,μ 1 e,μ	≥4j ≥1b,≥5j	Yes j Yes		Q mass T <sub>5/3</sub> mass	690 GeV 840 GeV		1509.04261 1503.05425
			J tes					
Excited quark $q^* \rightarrow q\gamma$	1γ	1 j	-	3.2	q* mass	4.4 TeV	only $u^*$ and $d^*$ , $\Lambda = m(q^*)$	1512.05910
Excited quark $q^* \rightarrow qg$	-	2j	-	3.6	q* mass	5.2 TeV	only $u^*$ and $d^*$ , $\Lambda = m(q^*)$	1512.01530
Excited quark $b^* \rightarrow bg$	1 01 2 0 /	1b,1j "1b,20i	-	3.2	b* mass	2.1 TeV	1-1-1-1	Preliminary
- 14-d k L* . 14/e	1 or 2 e, μ	μ 1 b, 2-0 j	Yes		b' mass	1.5 TeV	$f_g = f_L = f_R = 1$	1510.02664
Excited quark $b^* \rightarrow Wt$ Excited lepton $\ell^*$	3 e,μ 3 e,μ,τ	_	_	20.3 20.3	l* mass v* mass	3.0 TeV 1.6 TeV	$\Lambda = 3.0 \text{ TeV}$ $\Lambda = 1.6 \text{ TeV}$	1411.2921 1411.2921
Excited lepton ℓ*					-		V = 1.0 lev	
Excited lepton $\ell^*$ Excited lepton $\nu^*$		γ –	Yes		a <sub>T</sub> mass	960 GeV		1407.8150
Excited lepton $\ell^*$ Excited lepton $\nu^*$ LSTC $a_T \rightarrow W\gamma$	1 e, μ, 1 γ	· • •	-	20.3	N <sup>0</sup> mass H <sup>±±</sup> mass	2.0 TeV	$m(W_R) = 2.4$ TeV, no mixing	1506.06020
Excited lepton $\ell^*$ Excited lepton $\nu^*$ LSTC $a_T \rightarrow W\gamma$ LRSM Majorana $\nu$	1 e, μ, 1 γ 2 e, μ	2 j			Hit make	551 GeV	DY production, BR( $H_L^{\pm\pm} \rightarrow \ell \ell$ )=1 DY production, BR( $H^{\pm\pm} \rightarrow \ell \tau$ )=1	1412.0237
Excited lepton $\ell^*$ Excited lepton $\nu^*$ LSTC $a_T \rightarrow W\gamma$ LRSM Majorana $\nu$ Higgs triplet $H^{\pm\pm} \rightarrow \ell \ell$	1 e, μ, 1 γ 2 e, μ 2 e, μ (SS)	2j 6) –	-	20.3			DY production, BR $(H_I^{\pm\pm} \rightarrow \ell \tau)=1$	1411.2921
Excited lepton $\ell^*$ Excited lepton $\nu^*$ LSTC $a_T \rightarrow W\gamma$ LRSM Majorana $\nu$ Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$	1 e, μ, 1 γ 2 e, μ 2 e, μ (SS) 3 e, μ, τ	2j 6) –	- - Voc	20.3	H <sup>±±</sup> mass	400 GeV		
Excited lepton $\ell^*$ Excited lepton $\nu^*$ LSTC $a_T \rightarrow W\gamma$ LRSM Majorana $\nu$ Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$ Monotop (non-res prod)	1 e, μ, 1 γ 2 e, μ 2 e, μ (SS)	2j 6) –	Yes	20.3 20.3		657 GeV	$a_{\rm non-res} = 0.2$	1410.5404
Excited lepton $\ell^*$ Excited lepton $\nu^*$ LSTC $a_T \rightarrow W\gamma$ LRSM Majorana $\nu$ Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$ Monotop (non-res prod) Multi-charged particles	1 e, μ, 1 γ 2 e, μ 2 e, μ (SS) 3 e, μ, τ	2j 6) –		20.3 20.3 20.3	H <sup>±±</sup> mass	657 GeV 785 GeV	$a_{non-res} = 0.2$ DY production, $ q  = 5e$	1504.04188
Excited lepton $\ell^*$ Excited lepton $\nu^*$ LSTC $a_T \rightarrow W\gamma$ LRSM Majorana $\nu$ Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$ Monotop (non-res prod) Multi-charged particles Magnetic monopoles	1 e, μ, 1 γ 2 e, μ 2 e, μ (SS) 3 e, μ, τ	2j 6) –	Yes – –	20.3 20.3	H <sup>±±</sup> mass	657 GeV	$a_{\rm non-res} = 0.2$	1504.04188

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

#### pp@LHC, Pisa, May 2016

#### However ... New physics? ... Not yet (



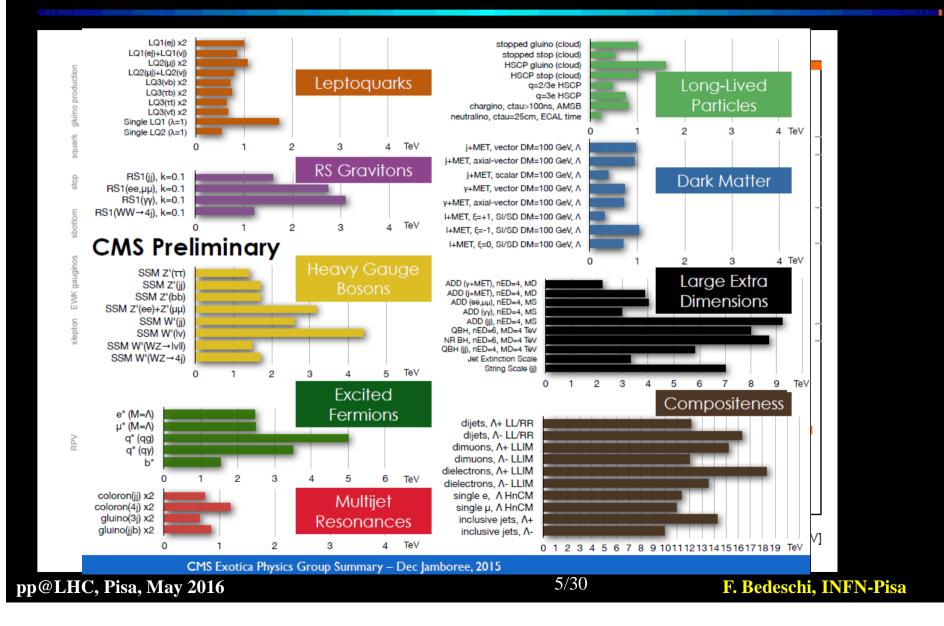
pp@LHC, Pisa, May 2016

5/30

F. Bedeschi, INFN-Pisa

Istituto Nazionale di Fisica Nucleare

#### However ... New physics? ... Not yet C



Istituto Nazionale di Fisica Nucleare

#### However .....



Many of our past expectations have been shattered Naturalness as guiding principle

G. Giudice, FCC meeting, Rome 2016

Technicolor  $\rightarrow$  no fundamental Higgs

Supersymmetry  $\rightarrow m_h \leq 120 \text{ GeV},$  $\widetilde{m}_t \leq 300 \text{ GeV}, \widetilde{m}_g \leq 1 \text{ TeV}$ 

Extra dimensions  $\rightarrow$  hell breaks loose at TeV

Composite Higgs  $\rightarrow \Delta BR_h \sim O(1)$ 

Change of paradigm?

pp@LHC, Pisa, May 2016

F. Bedeschi, INFN-Pisa



#### Di-photons?

#### The epiphany of a new era...

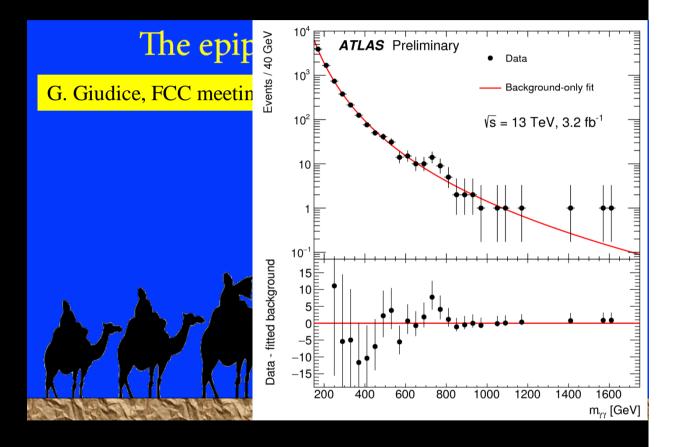
G. Giudice, FCC meeting, Rome 2016





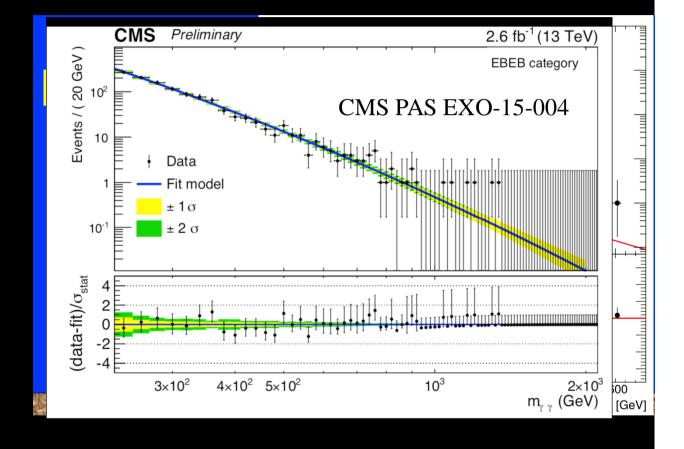
Di-photons?

Atlas: 3.6/1.8 σ



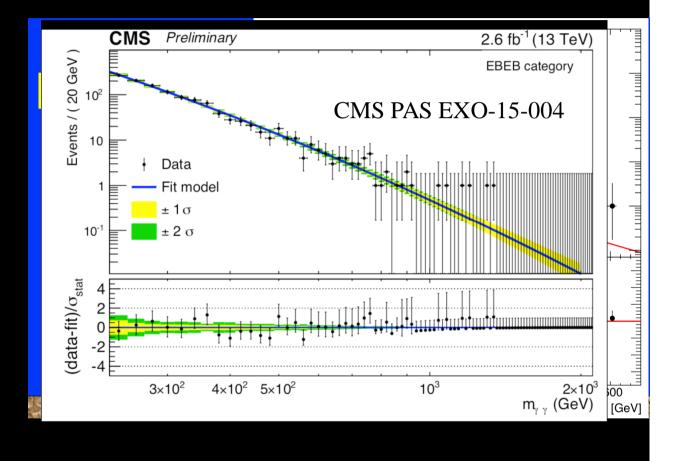


Di-photons?
 Atlas: 3.6/1.8 σ
 CMS: 2.9/>1 σ





◆ Di-photons?
 > Atlas: 3.6/1.8 σ
 > CMS: 2.9/>1 σ
 ◆ Flavor:
 > LHCb ~3.5 σ :
 ■ Bd→K\*<sup>0</sup>μμ
 ■ Bs→φμμ



7



Di-photons? 0.5  $R(D^*)$  $\Delta \chi^2 = 1.0$ ----- BaBar, PRL109,101802(2012) Atlas: 3.6/1.8 σ 0.45 Belle, arXiv:1507.03233 LHCb, arXiv:1506.08614 CMS: 2.9/>1 σ Average 0.4 **Flavor:** 0.35 **LHCb** ~3.5 σ : 0.3 ■ Bd $\rightarrow$ K\*<sup>0</sup>µµ HFAG **B**s→φμμ 0.25 Inst. EPOB115 SM prediction  $P(\chi^2) = 55\%$ R(D)0.20.2 0.3 0.4 0.5 0.6 (2012) **α** ~3.9 σ R(D) $R(D^{(*)}) = BR(\bar{B} \rightarrow D^{(*)}\tau\bar{\nu}) / BR(\bar{B} \rightarrow D^{(*)}l\bar{\nu})$ 

7

#### **Directions**?



"Confusion is the best moment in science"

- "...privilege of being in a state of confusion"
  - ► G. Giudice: FCC week, Rome, April 2016

the discussion of the future in HEP must start from the understanding that there is no experiment/facility, proposed or conceivable, in the lab or in space, accelerator or non-accelerator driven, which can guarantee discoveries beyond the SM, and answers to the big questions of the field:

M. Mangano: 98° ECFA meeting, Nov. 2015

pp@LHC, Pisa, May 2016

#### **Directions**?



#### Proposed criteria to evaluate future facilities (MLM):

- Guaranteed deliverables
- Exploration potential
  - Target broad well justified BSM scenarios

Potential to provide conclusive answers to relevant broad questions

#### Additional practical criteria apply

- > When will the technology needed to build it be available?
- Are the expected construction and operation costs acceptable?

#### **Guaranteed deliverables**



Detailed study of Higgs boson
 Higgs is VERY special
 Beyond HL-LHC precision

Extreme precision physics
 EWK sector
 Heavy Flavor sector



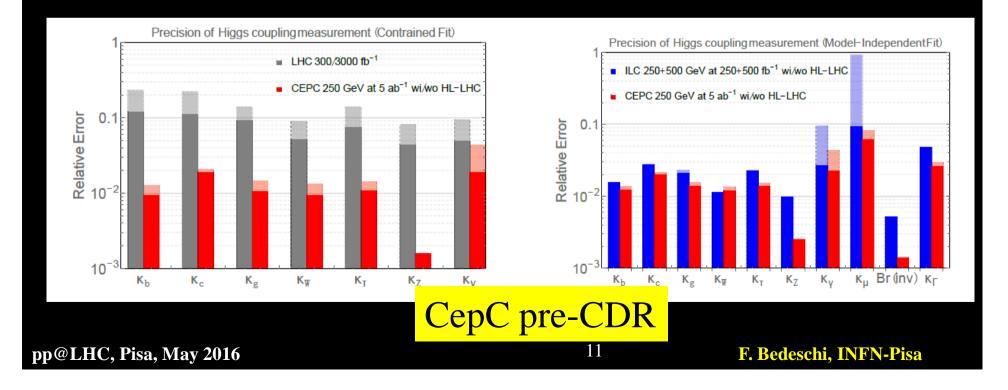
• Deviation from SM:  $\delta \sim v^2/M^2$  v = 246 GeV

- M scale of new physics
- $\blacktriangleright$  M ~ 1 10 TeV  $\rightarrow$   $\delta$  ~ 6 0.6%



• Deviation from SM:  $\delta \sim v^2/M^2$  v = 246 GeV

- ► M scale of new physics
- $\blacktriangleright$  M ~ 1 10 TeV  $\rightarrow$   $\delta$  ~ 6 0.6%
- $\blacktriangleright$  Need < ~ % sensitivity  $\rightarrow$  beyond HL-LHC

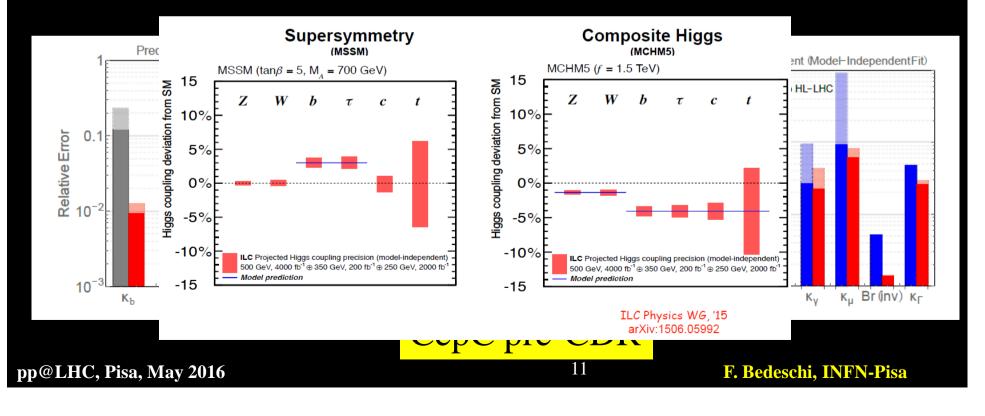




• Deviation from SM:  $\delta \sim v^2/M^2$  v = 246 GeV

- ► M scale of new physics
- $\blacktriangleright$  M ~ 1 10 TeV  $\rightarrow$   $\delta$  ~ 6 0.6%

 $\blacktriangleright$  Need < ~ % sensitivity  $\rightarrow$  beyond HL-LHC





#### M. Klute LCWS 2015

Uncertainties	HL-LHC*	μ-	CLIC	ILC**	CEPC	FCC-ee
m <sub>H</sub> [MeV]	40	0.06	40	30	5.5	8
Г <sub>Н</sub> [MeV]	-	0.17	0.16	0.16	0.12	0.04
<b>g</b> нzz [%]	2.0	-	1.0	0.6	0.25	0.15
<b>д</b> нww [%]	2.0	2.2	1.0	0.8	1.2	0.2
<b>д</b> ньь [%]	4.0	2.3	1.0	1.5	1.3	0.4
g <sub>Ηττ</sub> [%]	2.0	5	2.0	1.9	1.4	0.5
<b>д</b> нүү [%]	2.0	10	6.0	7.8	4.7	1.5
<b>g</b> <sub>Нсс</sub> [%]	-	-	2.0	2.7	1.7	0.7
<b>д<sub>Ндд</sub> [%]</b>	3.0	-	2.0	2.3	1.5	0.8
<b>g</b> нtt [%]	4.0	-	4.5	18	-	-
<b>д<sub>Нµµ</sub> [%]</b>	4.0	2.1	8.0	20	8.6	6.2
<b>д</b> ннн [%]	30	-	24	-	-	-

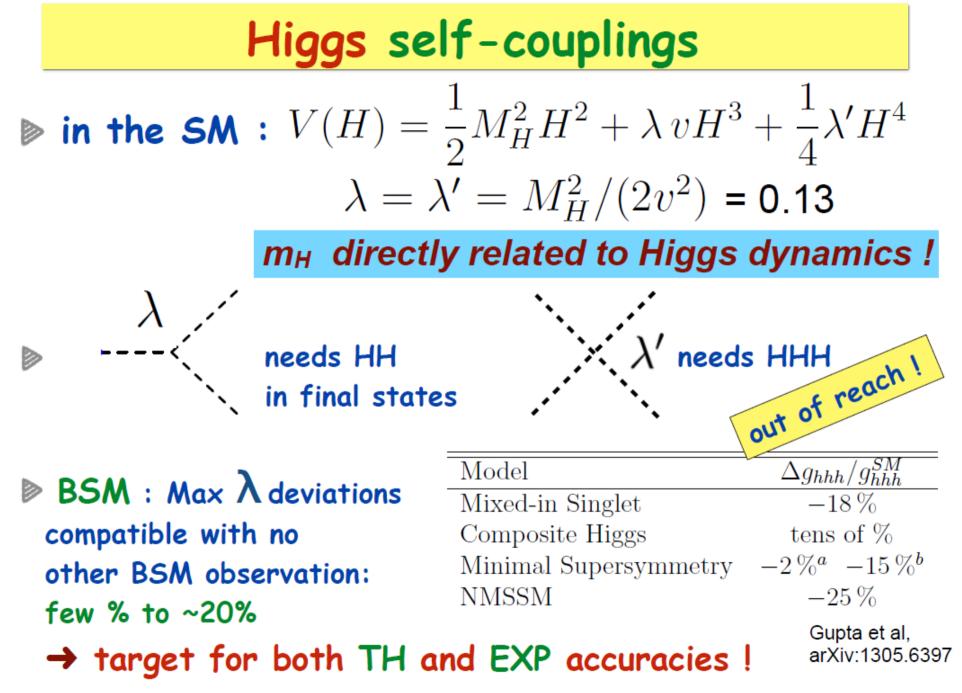
\* Estimate for two HL-LHC experiments

\*\* ILC lumi upgrade improves precision by factor 2

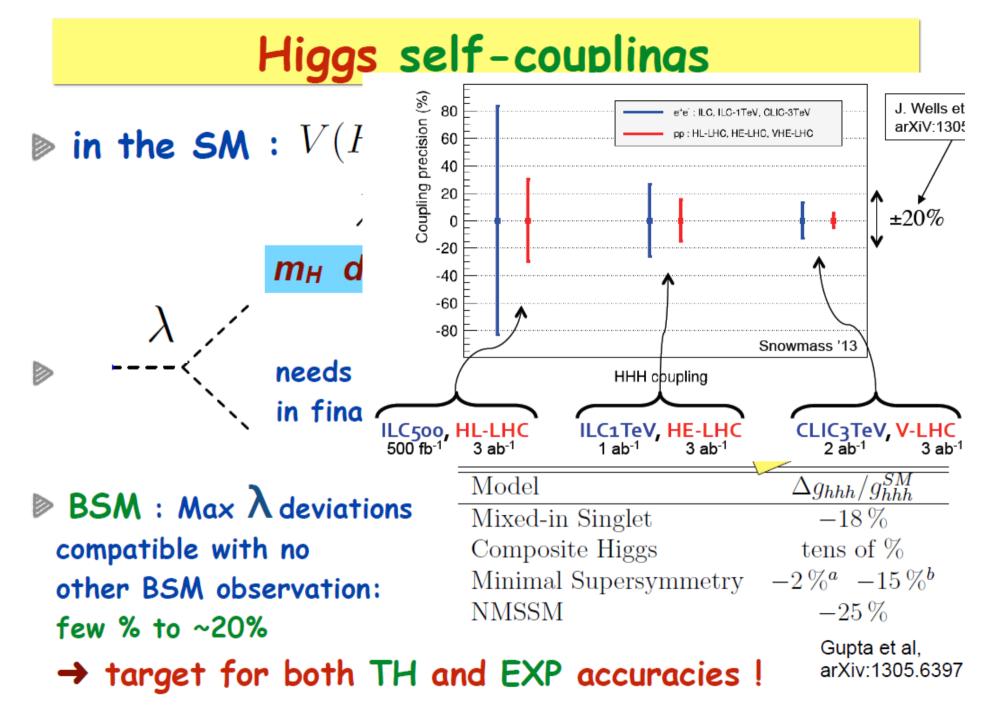
For ~10y operation. Lots of "!,\*,?" **Every number comes with her own story.** 

pp@LHC, Pisa, May 2016

F. Bedeschi, INFN-Pisa



LNF, 2 April 2015



Barbara Mele

LNF, 2 April 2015

#### Precision in EFT



Constrain Wilson coefficients/mass scale due to new physics with precise EWK/flavor measurements

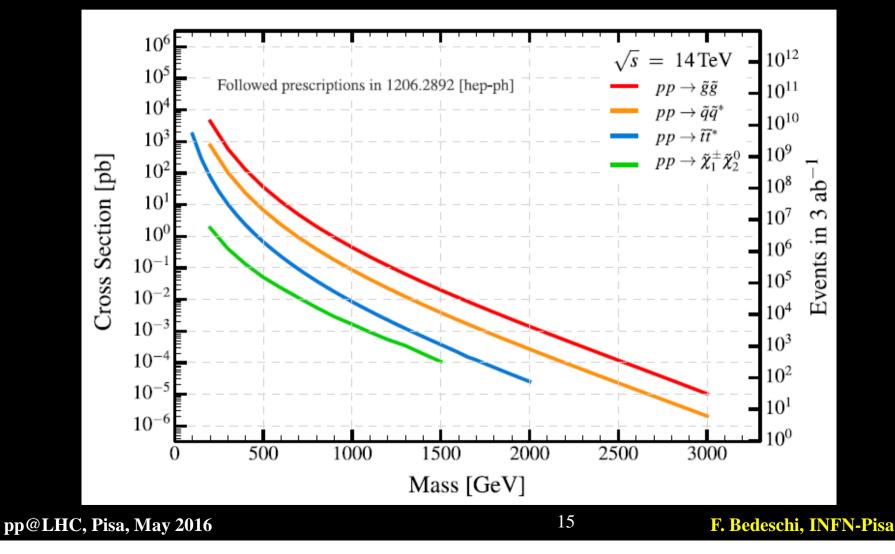
$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \sum_{i} \frac{c_{i}}{\Lambda^{2}} \mathcal{O}_{i}$$

$$\int_{0}^{0} \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}}$$

#### **Exploration potential**



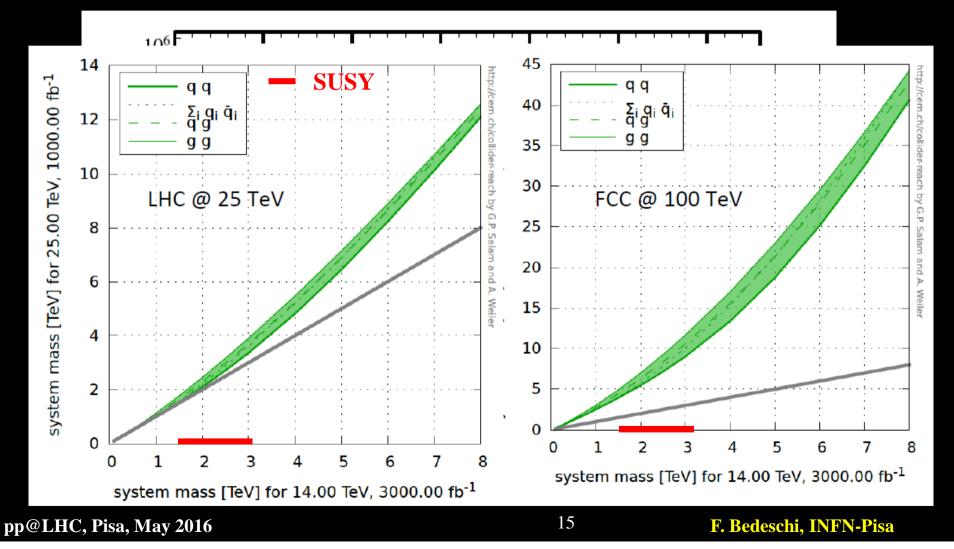
#### Search reach scaled from HL-LHC (2-3 TeV for SUSY)



#### **Exploration potential**



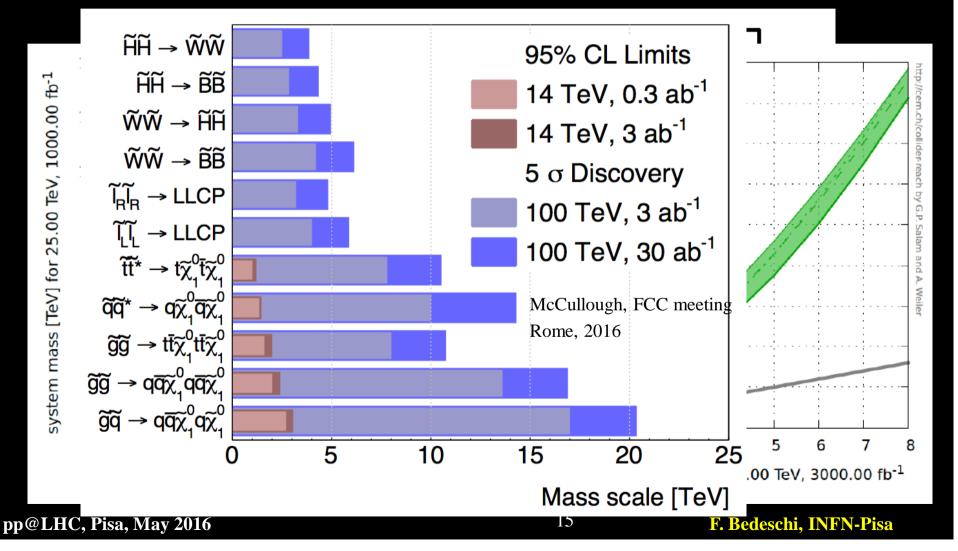
#### Search reach scaled from HL-LHC (2-3 TeV for SUSY)



# **Exploration potential**



### Search reach scaled from HL-LHC (2-3 TeV for SUSY)

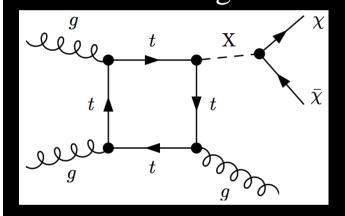


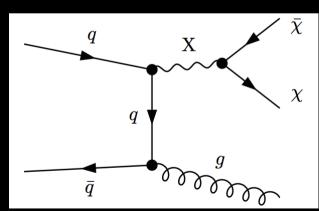
### Conclusive answers?

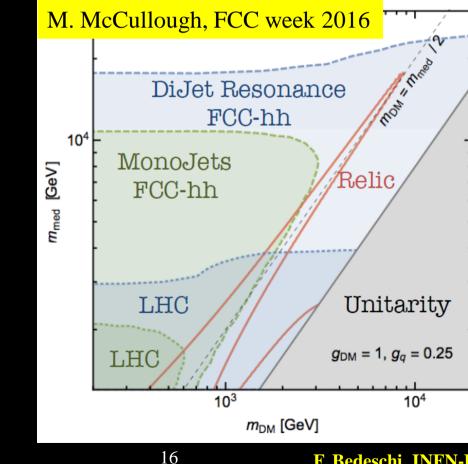


### Dark matter (simplified models)

▶ 100 TeV pp could cover all parameter space allowed by cosmological bounds







pp@LHC, Pisa, May 2016

# The need



Summary (assuming we build everything):

- Detailed Higgs studies and precision physics are guaranteed deliverables
  - Guidelines for new theories
- Exploration potential could be expanded from 2-3 TeV up to 10-20 TeV
- Dark matter could be very seriously constrained
- If (few) new physics hints are confirmed HL-LHC most likely not sufficient to fully explore the resulting new physics scenarios

# **Build what?**



Could build now ... almost ➢ ILC/CepC/FCC-ee LHeC Need more R&D HE-LHC, FCC-hh/SppC **CLIC** Not yet demonstrated PWFA = «Plasma WakeField Acceleration» Muon collider Potential extensions ILC/CLIC  $\rightarrow$  PWFA CepC/FCC-ee/LHeC  $\rightarrow$  Muon collider

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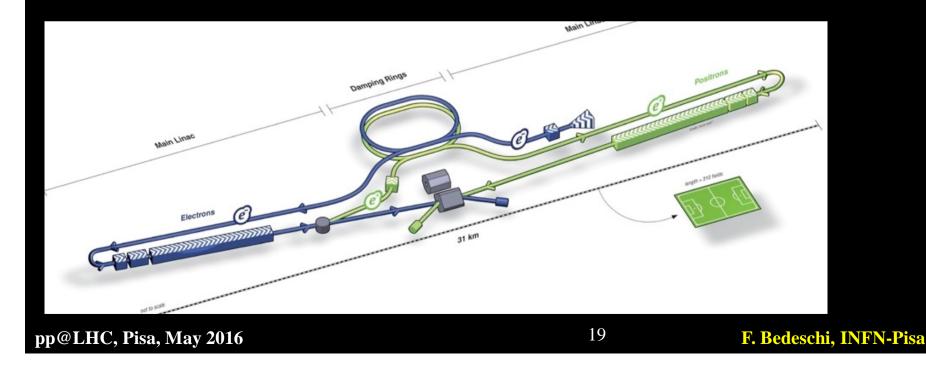
### ILC: linear e+e- collider

pp@LHC, Pisa, May 2016



### ILC: linear e+e- collider

- SC Linac 500 GeV ( $\rightarrow$ 1 TeV)
- Detailed TDR/Engineering



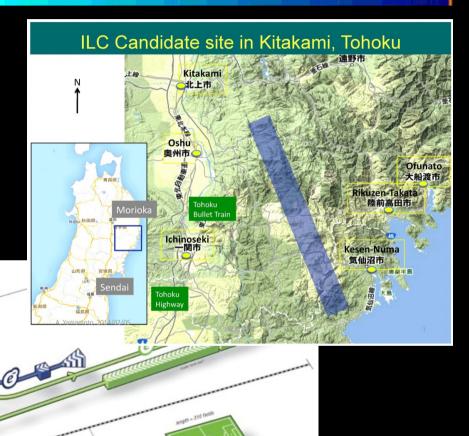
31 km



# ◆ ILC: linear e+e- collider > SC Linac 500 GeV (→1 TeV)

- Detailed TDR/Engineering
- Site chosen/Review by MEXT

Damping Rings



Main Linac

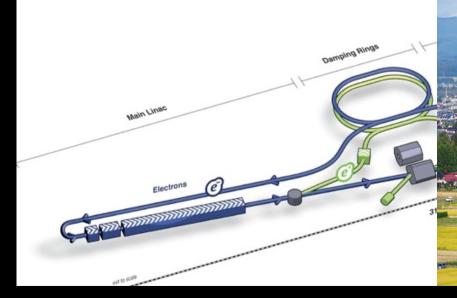
and a second second



### ILC: linear e+e- collider

- SC Linac 500 GeV ( $\rightarrow$ 1 TeV)
- Detailed TDR/Engineering
- Site chosen/Review by MEXT
  - Govnmt negotiation 2-3 yr





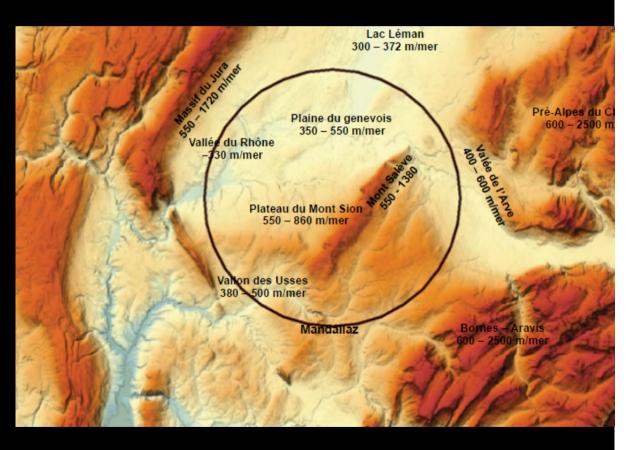


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### FCC-ee: circular e+e- collider

≻ ~100 km tunnel
> → 350 GeV
> CDR by 2018
> Beam 2035?





### FCC-ee: circular e+e- collider

►~100 km tunnel  $\rightarrow$  350 GeV CDR by 2018 Beam 2035? CepC: circular e+e- collider ► 54 km tunnel 240 GeV Pre-CDR finished CDR by 2016/17 Beam 2028-30?



Figure 3.3: Illustration of the CEPC-SPPC ring sited in Qinghuangdao. The small circle is 50 km, and the big one 100 km. Which one will be chosen depends on the funding scenario.

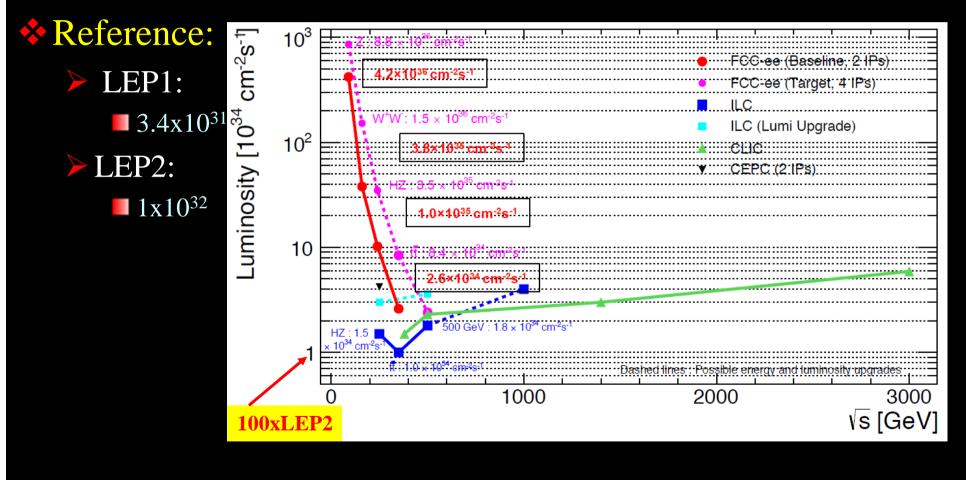
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# e+e- luminosity comparison



### Planning for extreme luminosities!



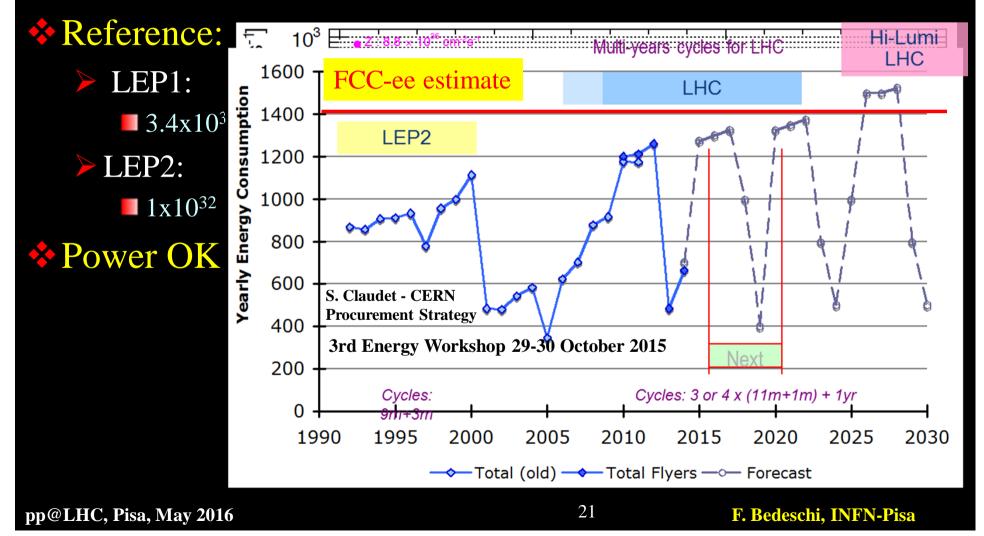
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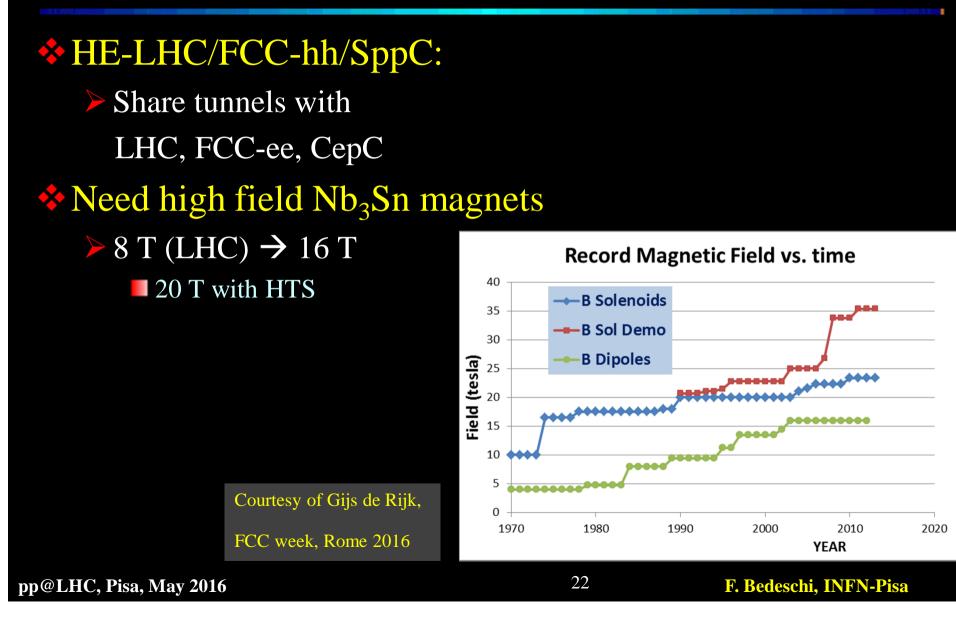
# e+e- luminosity comparison



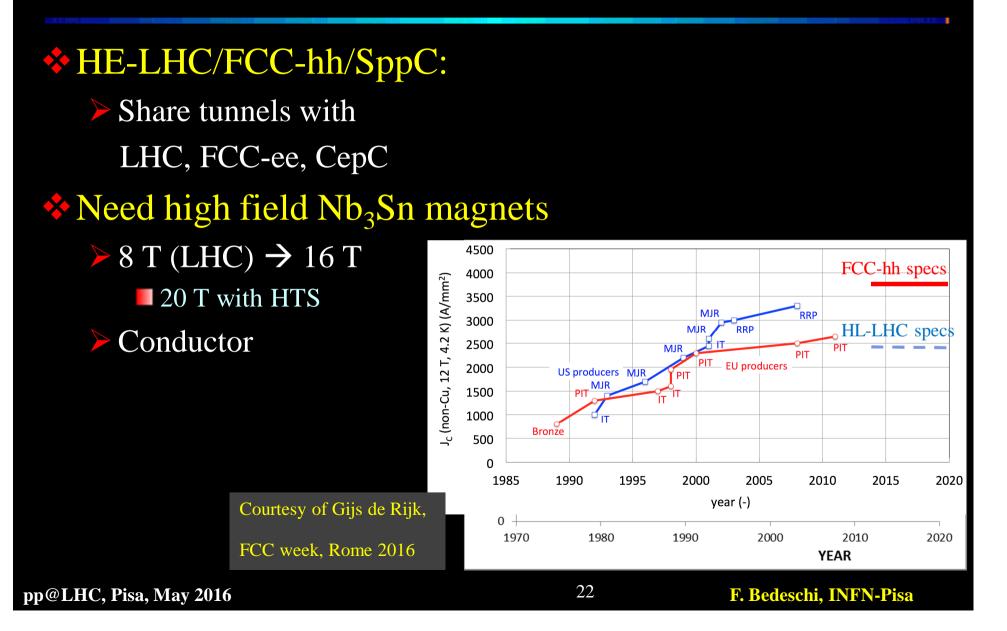
### Planning for extreme luminosities!



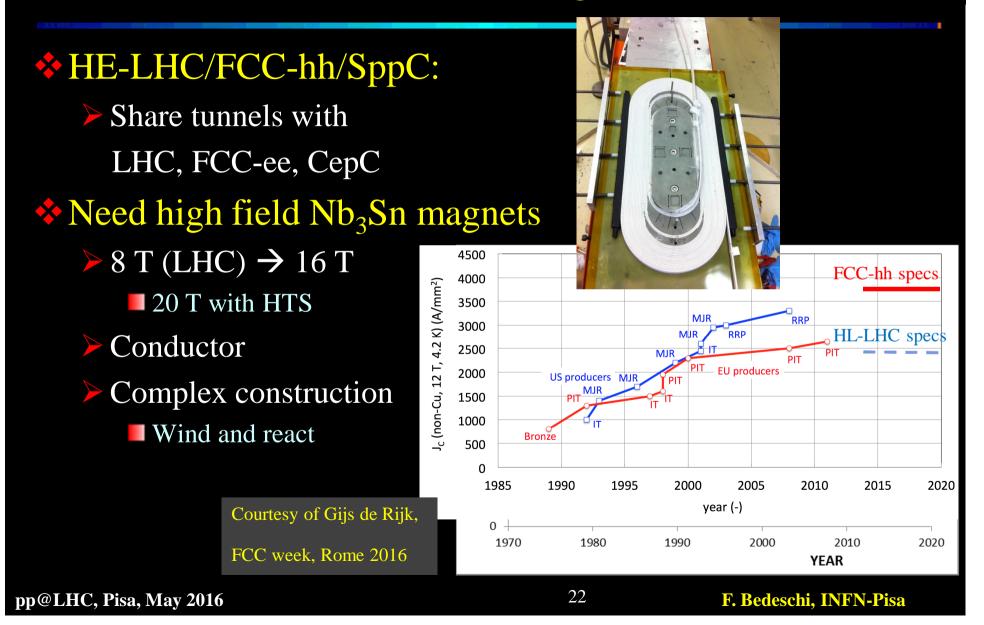




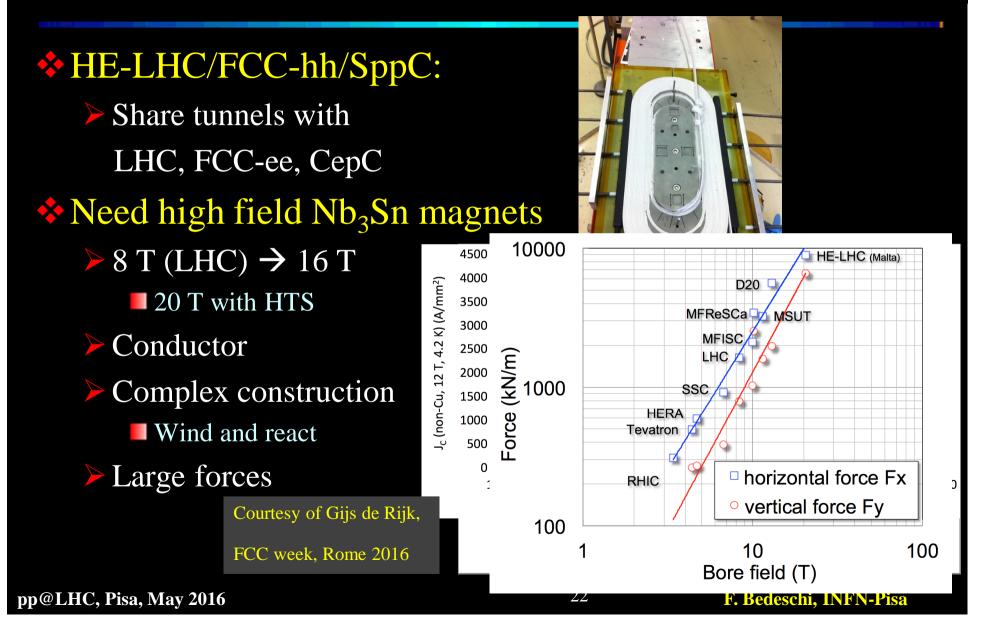












### Magnet R&D



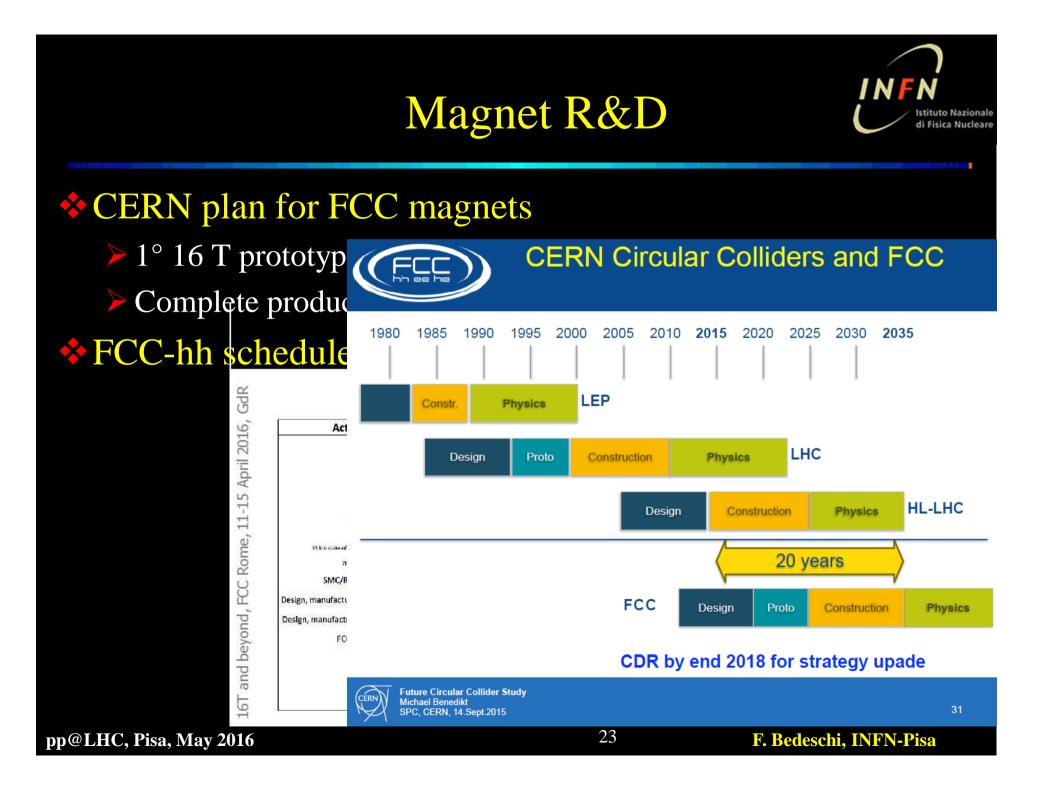
#### CERN plan for FCC magnets > 1° 16 T prototype by mid 2020's Complete production 2030 GdR 10 un April 2016, 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 Activity End Begin FCC EuroCirCol 01.05.2015 30.04.2019 Fund Colleancears 01.05.2015 EuraCirCol 30.04 2015 ERMC Function analysis 01.05.2015 30.04 2017 beyond, FCC Rome, 11-15 EuroCirCol design 01.05.2017 21.12 2018 FCC Conductor R&D 01.05.2015 30.04 202 ويترجعوا والمراجعين والمراجع المتراجعين والمراجعين والمراجع . RMM P&D wire orders 01.05.2015 30.04 2021 35 km state-of-the-art wire for demonstrators 01.12.2015 30.05 2017 30.05 2019 70 km high Ic wire for 16 Timodel 01.06.2017 ٠ SMC/RMC technology R&D 01.05.2015 30.05.2021 Demo Design, manufacture and test of ERMC 01.05.2015 30.05.2017 Design, manufacture and test of RMM 31.12.2015 31.12.2017 FCC 16 T Demonstrator 30.05.2016 31.12.2018 FCC 16 T Model 31.12.2018 30.05.2021 and

FCC 16 T Prototypes 30.06.2020 31.12.2025

FCC Production 01.07.2024 01.01.2030

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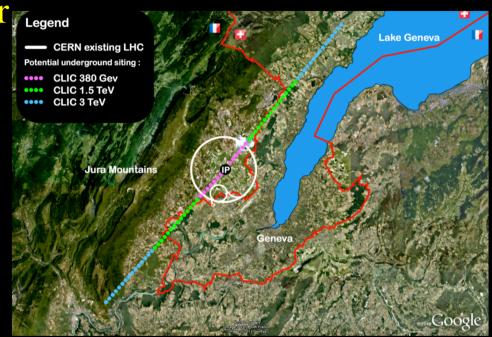
16T





### CLIC: Linear e+e- collider

- > 380 GeV → 3 TeV
- Room temp. Linac100 MV/m @ 12 GHz



TA

DR

BC

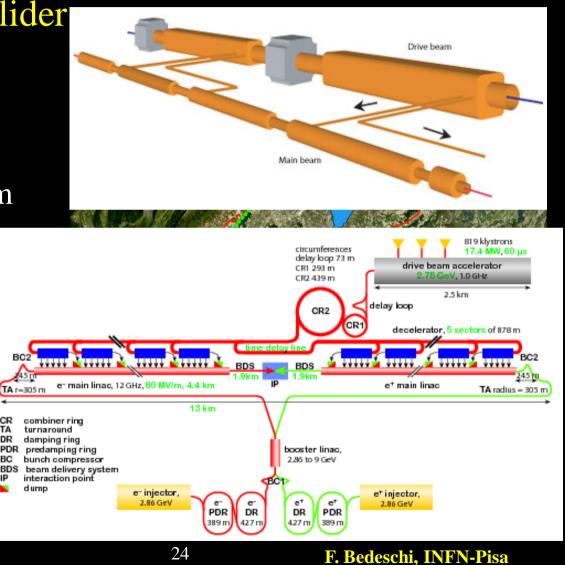
BDS iP

PDR



# CLIC: Linear e+e- collider $380 \text{ GeV} \rightarrow 3 \text{ TeV}$

- Room temp. Linac 100 MV/m @ 12 GHz
- Klystrons $\rightarrow$ Drive beam



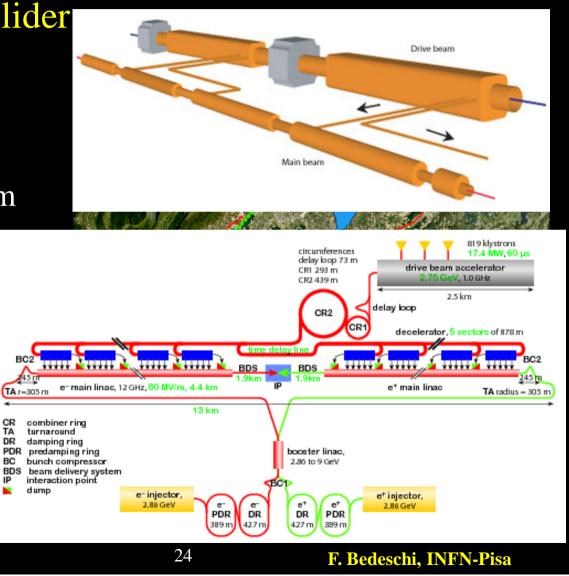


### CLIC: Linear e+e- collider

- ≻ 380 GeV → 3 TeV
- Room temp. Linac100 MV/m @ 12 GHz
- $\succ$  Klystrons $\rightarrow$ Drive beam

### Challenges:

- RF breakdown
- RF power transfer
- ▶ 600 MW @ 3 TeV
- Final focus
- Beamstrahlung
- Alignment pp@LHC, Pisa, May 2016

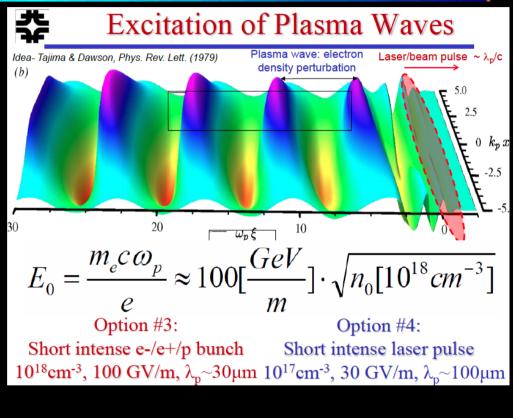


### LWFA/PWFA



### Plasma acceleration R&D:

Many GeV/m !
Laser driven (LWFA)
Particle driven (PWFA)
Significant progress:

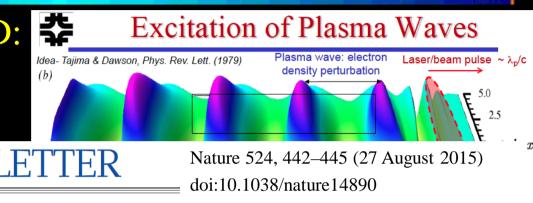


### LWFA/PWFA



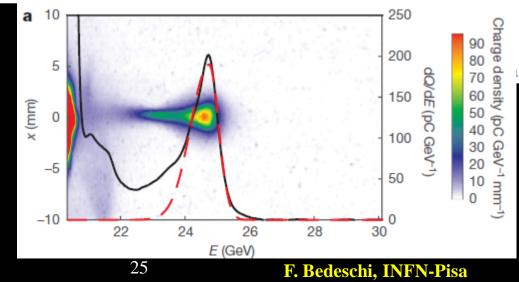
### Plasma acceleration R&D:

- Many GeV/m !
- Laser driven (LWFA)
- Particle driven (PWFA)
- Significant progress:
  - Positron



#### Multi-gigaelectronvolt acceleration of positrons in a self-loaded plasma wakefield

S. Corde<sup>1,2</sup>, E. Adli<sup>1,3</sup>, J. M. Allen<sup>1</sup>, W. An<sup>4,5</sup>, C. I. Clarke<sup>1</sup>, C. E. Clayton<sup>4</sup>, J. P. Delahaye<sup>1</sup>, J. Frederico<sup>1</sup>, S. Gessner<sup>1</sup>, S. Z. Green<sup>1</sup>, M. J. Hogan<sup>1</sup>, C. Joshi<sup>4</sup>, N. Lipkowitz<sup>1</sup>, M. Litos<sup>1</sup>, W. Lu<sup>6</sup>, K. A. Marsh<sup>4</sup>, W. B. Mori<sup>4,5</sup>, M. Schmeltz<sup>1</sup>, N. Vafaei-Najafabadi<sup>4</sup>, D. Walz<sup>1</sup>, V. Yakimenko<sup>1</sup> & G. Yocky<sup>1</sup>



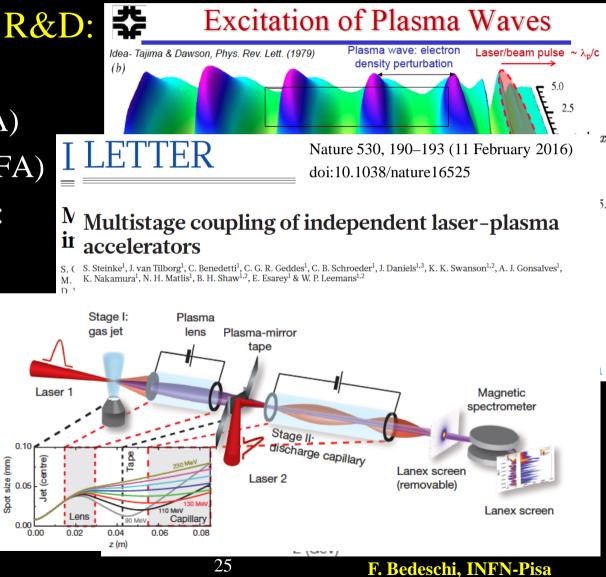
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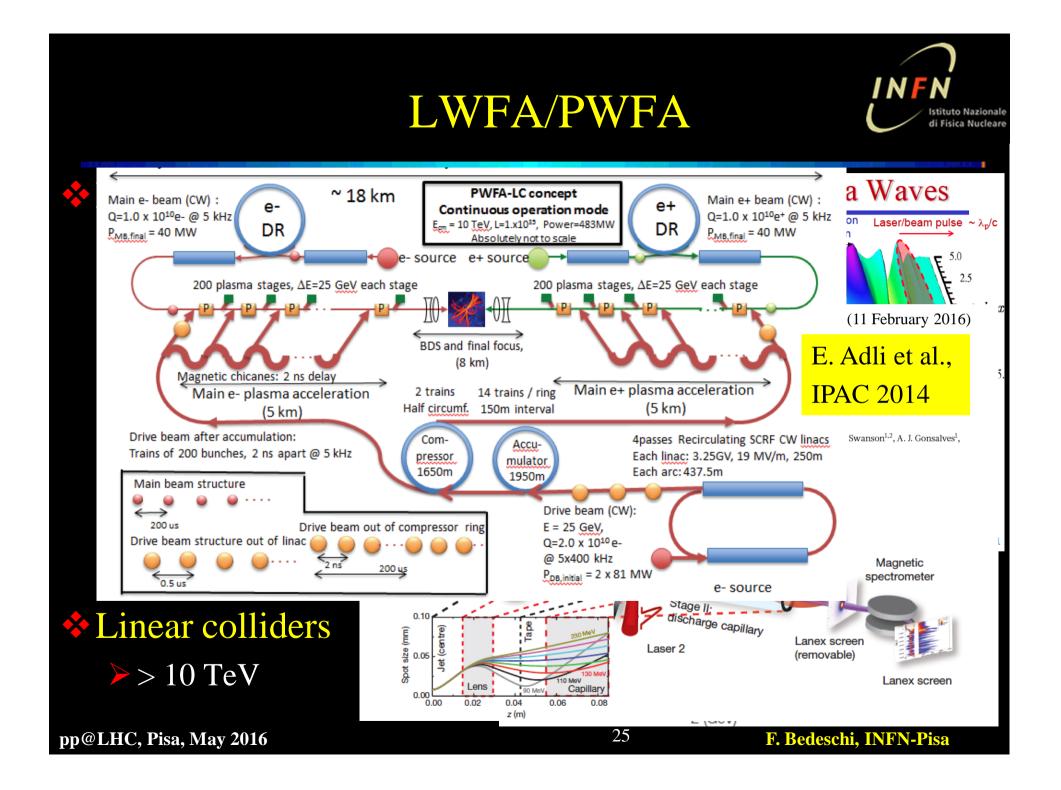
### LWFA/PWFA



### Plasma acceleration R&D:

- Many GeV/m !
- Laser driven (LWFA)
- Particle driven (PWFA)
- Significant progress:
  - Positron
  - Multistage







Circular µ+µ- collider
> 125 GeV→10 TeV
> No beamstrahlung
> Low power
★ Two approaches:

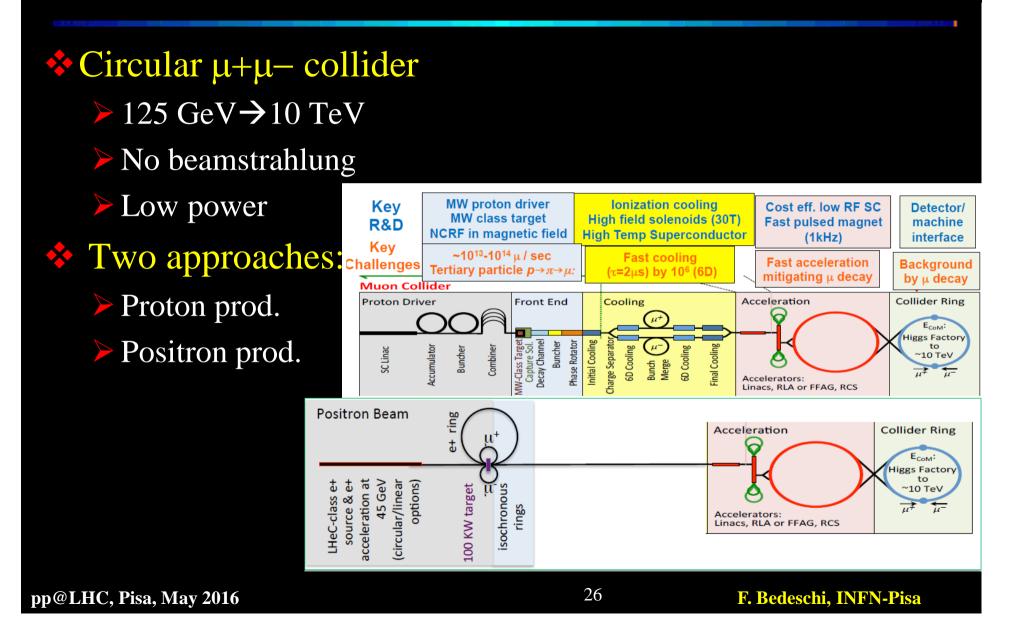


### **\*** Circular $\mu + \mu -$ collider

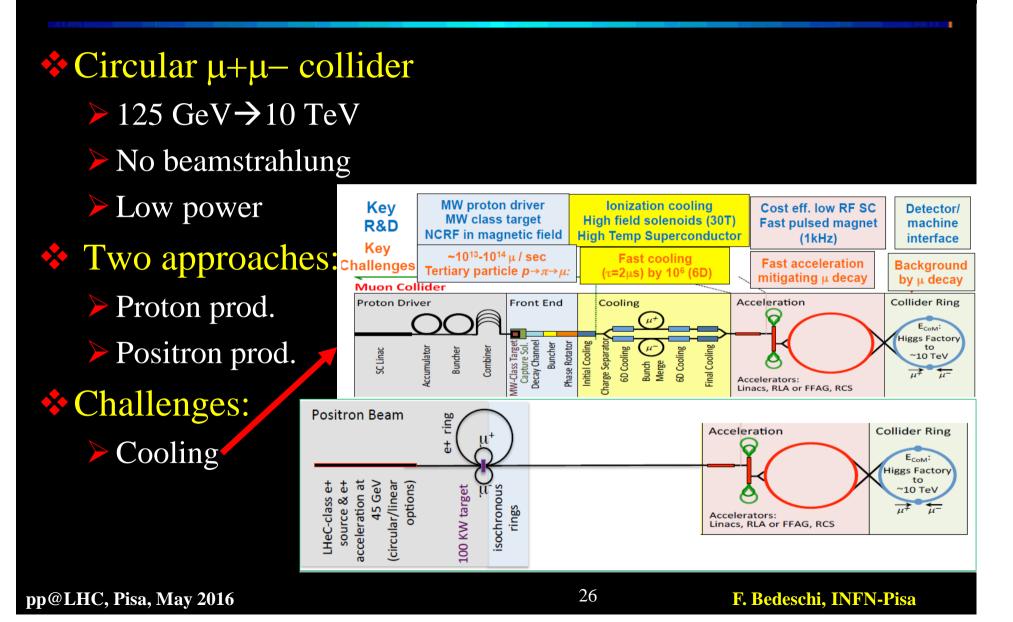
- ▶ 125 GeV→10 TeV
- No beamstrahlung
- ► Low power
- Two approaches:
  - Proton prod.

Ke R8	D		1W pr MW cl RF in ı	lass magi	targo netic	lonization cooling High field solenoids (30T High Temp Superconducto								Cost eff. low RF SC Fast pulsed magnet (1kHz)	Detector/ machine interface			
Challe	-	rentary particle							Fast coo (τ=2μs) by 1				(CO) <sup>6</sup> (6D)		<u> </u>	Fast acceleration mitigating $\mu$ decay		ckground γ μ decay
Proto	on Driv		Buncher	Combiner	Capture Sol.		Buncher p	Initial Cooling	Charge Separator S	6D Cooling			6D Cooling	Final Cooling	Ac	celeration	Hig	$E_{COM}:$ $E_{COM}:$ $E_{COM}:$ $TO TeV$ $u^{2}$ $u^{2}$

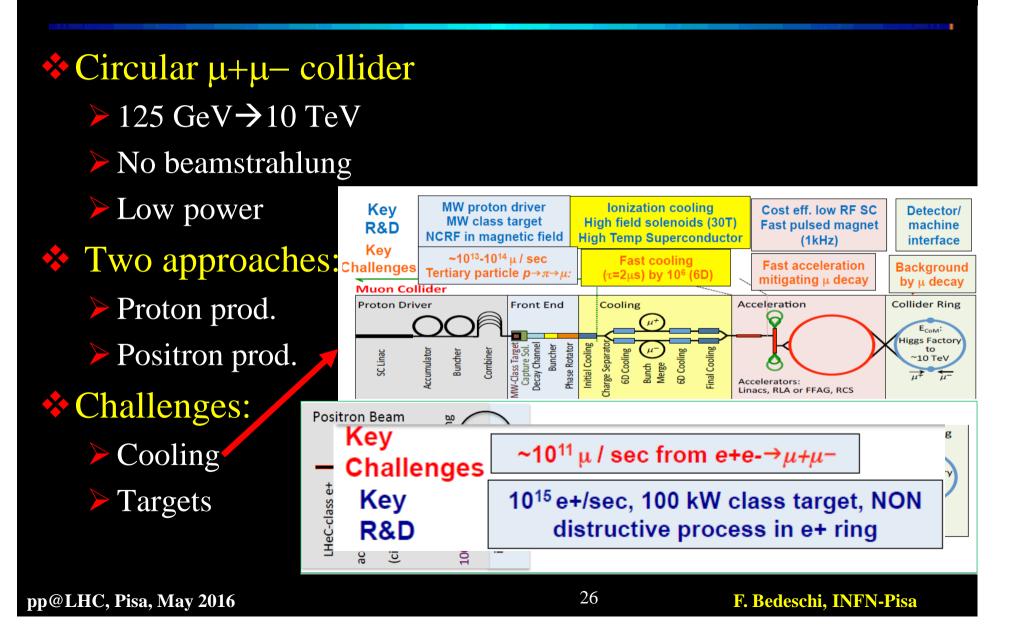




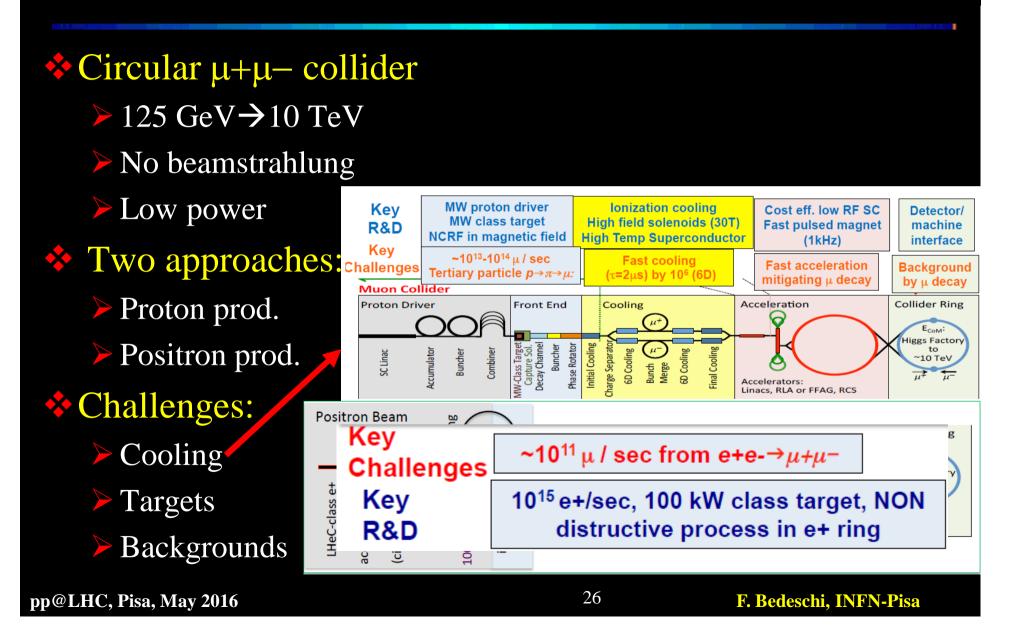






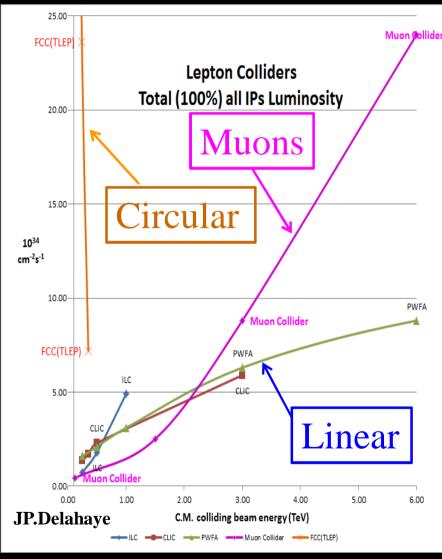






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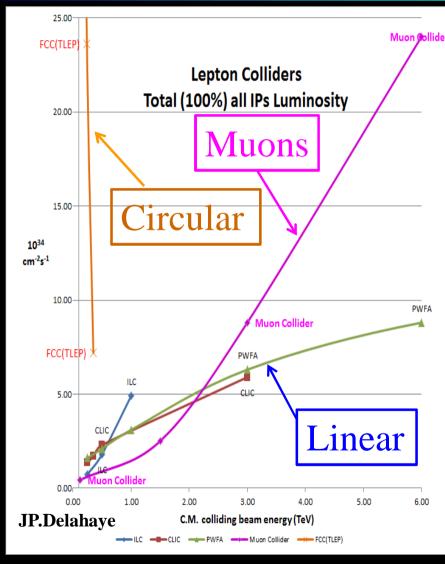
# Scaling lepton machines to high energy (

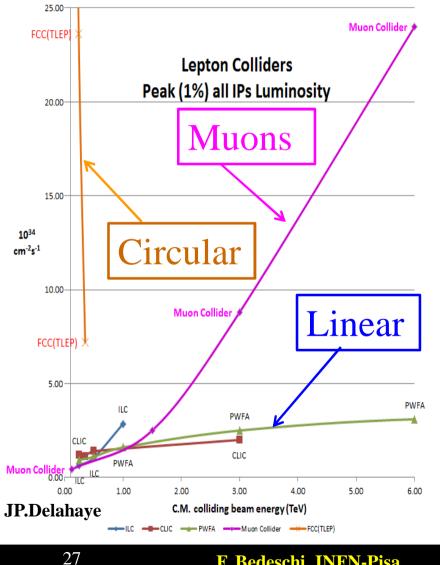


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# Scaling lepton machines to high energy (

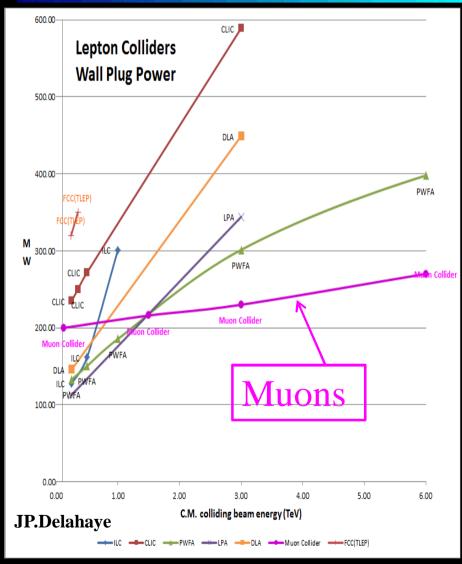




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# Scaling lepton machines to high energy



### Muon colliders:

Most convenient option above 1.5 TeV

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Istituto Nazionale di Fisica Nucleare

# **Options** Fisica Nucleare How long can you stretch HL-LHC? > Then FCC-ee or hh? Magnets/money Time gap? Extreme flavor as filler? Backup ■ HE and/or LHeC? $\blacksquare$ HE $\rightarrow$ Several year gap in running experiments What could start construction in early '20s? $\rightarrow$ ILC/CepC $\rightarrow$ Could be operational by early '30s

Could complement each other Lumi: CepC/Energy: ILC

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# **Decision times**



### **ILC:**

- ► Japan MEXT review completed (2015)
- Governament negotiations for 2-3 years

**FCC:** 

CDR by 2018 – to be discussed at the next European strategy update (2019-2020)

CepC:

Pre-CDR done (2015)

Machine CDR by end of 2016

- Detector CDR by end of 2017
- Substantial R&D funds requested ... ?

# Conclusions (1)



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- Clear physics goals
- Well established technology
- Costs are high, but manageable (comparable to LHC)
- Which one? We'll know in the next few years

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### An e+e- collider is the most likely next step

- Clear physics goals
- Well established technology
- Costs are high, but manageable (comparable to LHC)
- Which one? We'll know in the next few years
- Given enough time many other options become feasible
  > 100 TeV pp, 10 TeV ee or μμ colliders

# Conclusions (2)



Invest in R&D for new accelerator related technologies

So many exciting developments!

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 Continue to think about these issues to give our contributions to the upcoming European strategy

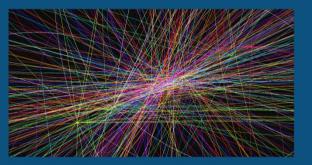
# Conclusions (2)



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A useful starting point from the Italian HEP community ISTITUTO NAZIONALE DI FISICA NUCLEARE Laboratori Nazionali di Frascati
FRASCATI PHYSICS SERIES

INFN Commissione Scientifica Nazionale 1 (CSN1)



What Next: White Paper of CSN1 Proposal for a long term strategy for accelerator based experiments

Frascati Phys. Ser. 60 (2015) pp. 1-291 ISBN 978-88-864-0999-5

> Editors F. Bedeschi, R. Tenchini, J. Walsh

# Conclusions (3)



Several detector R&D activities started recently on FCC/CepC (ILC may re-start)

Very large synergy (also with HL-LHC and other present or past Italian activities)

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Italian community?

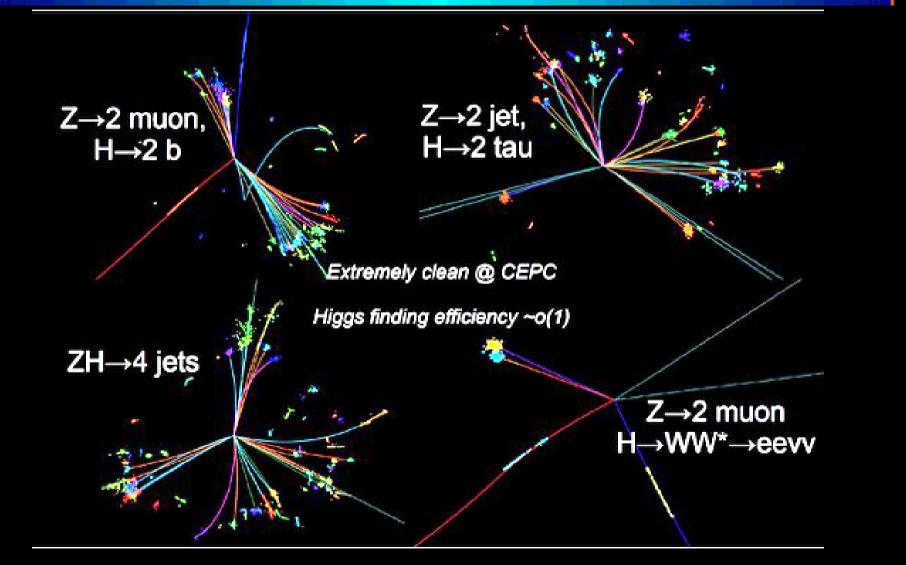




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## ZH in e+e- simulations

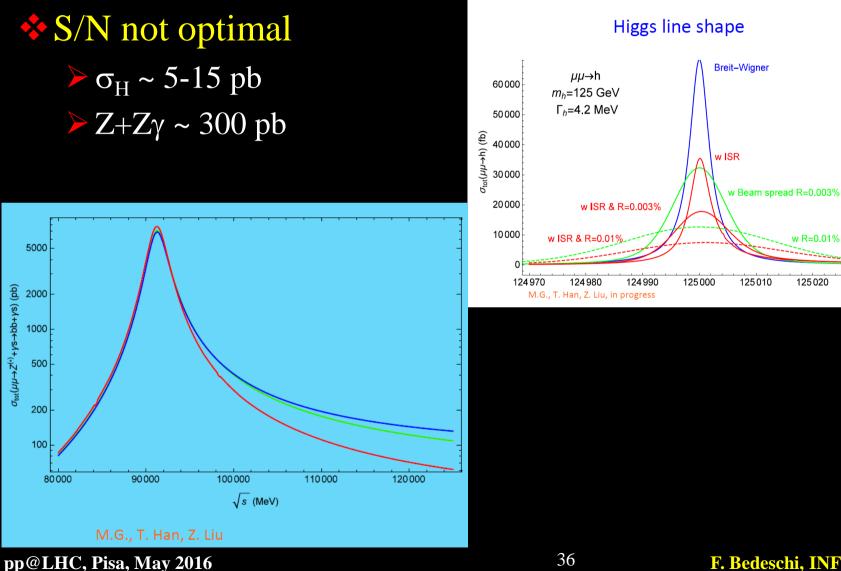




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## Muon collider on Higgs energy



w R=0.01%

125020

12503