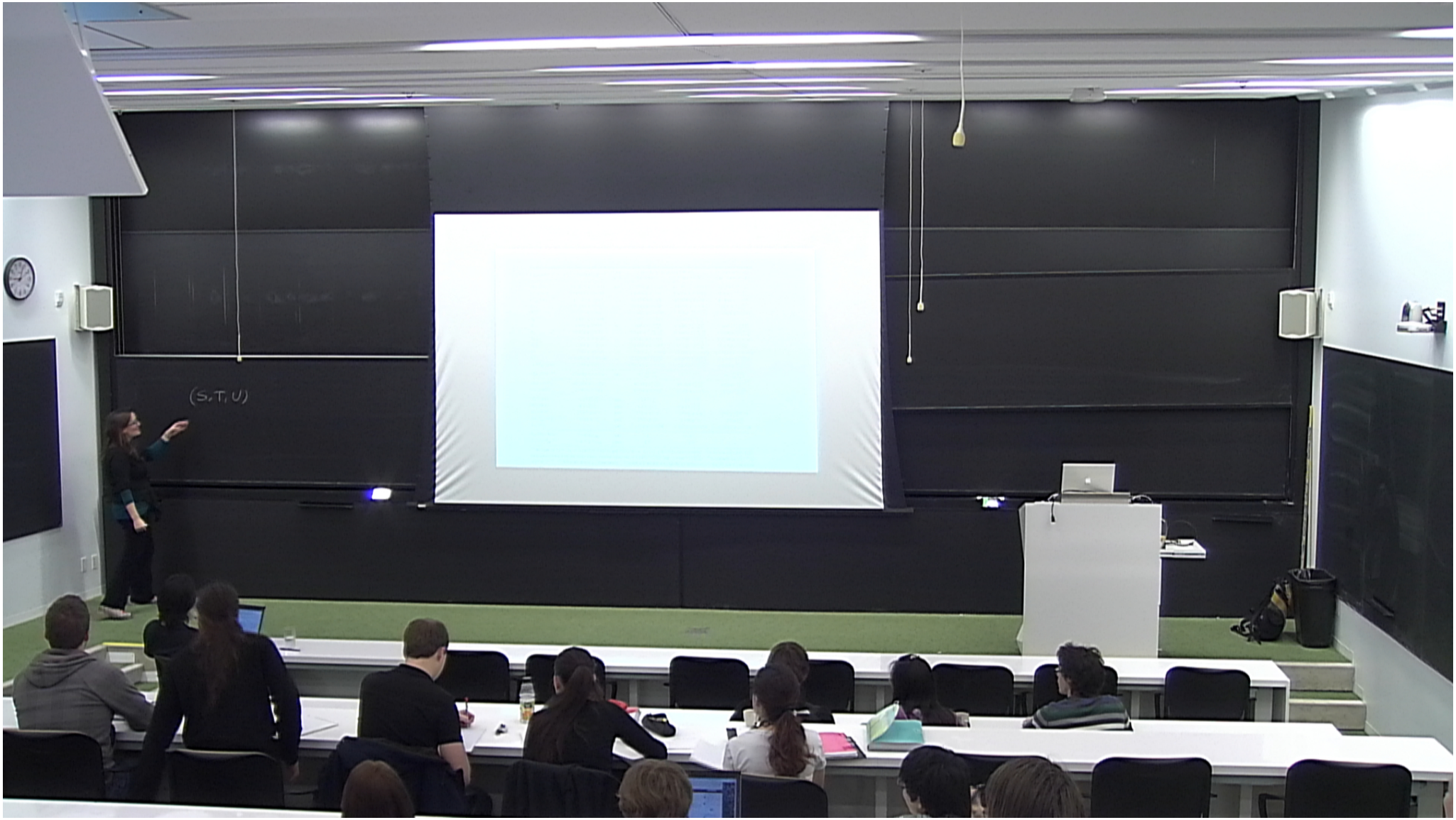
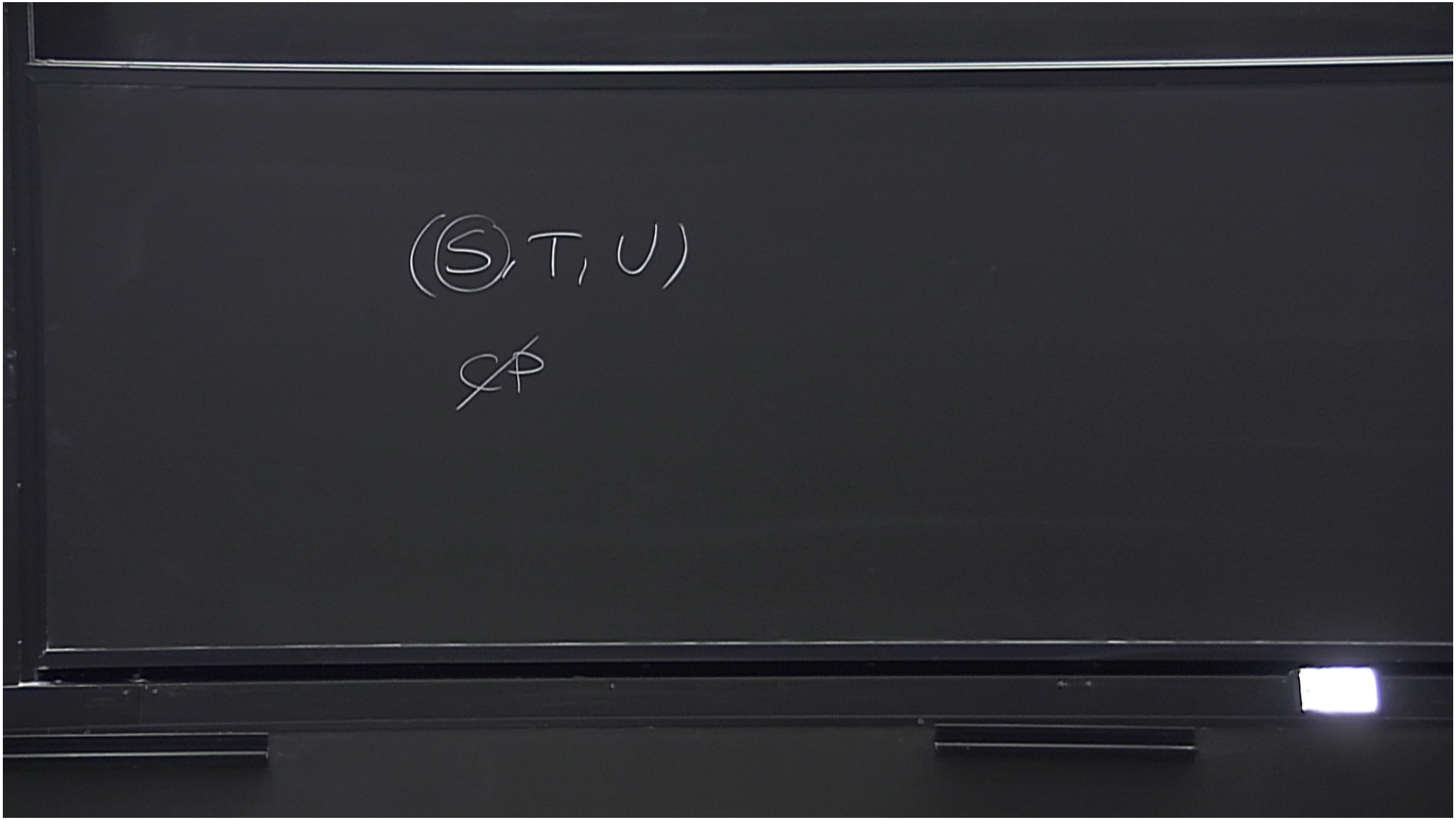
Title: Beyond the Standard Model (Review) - Lecture 14

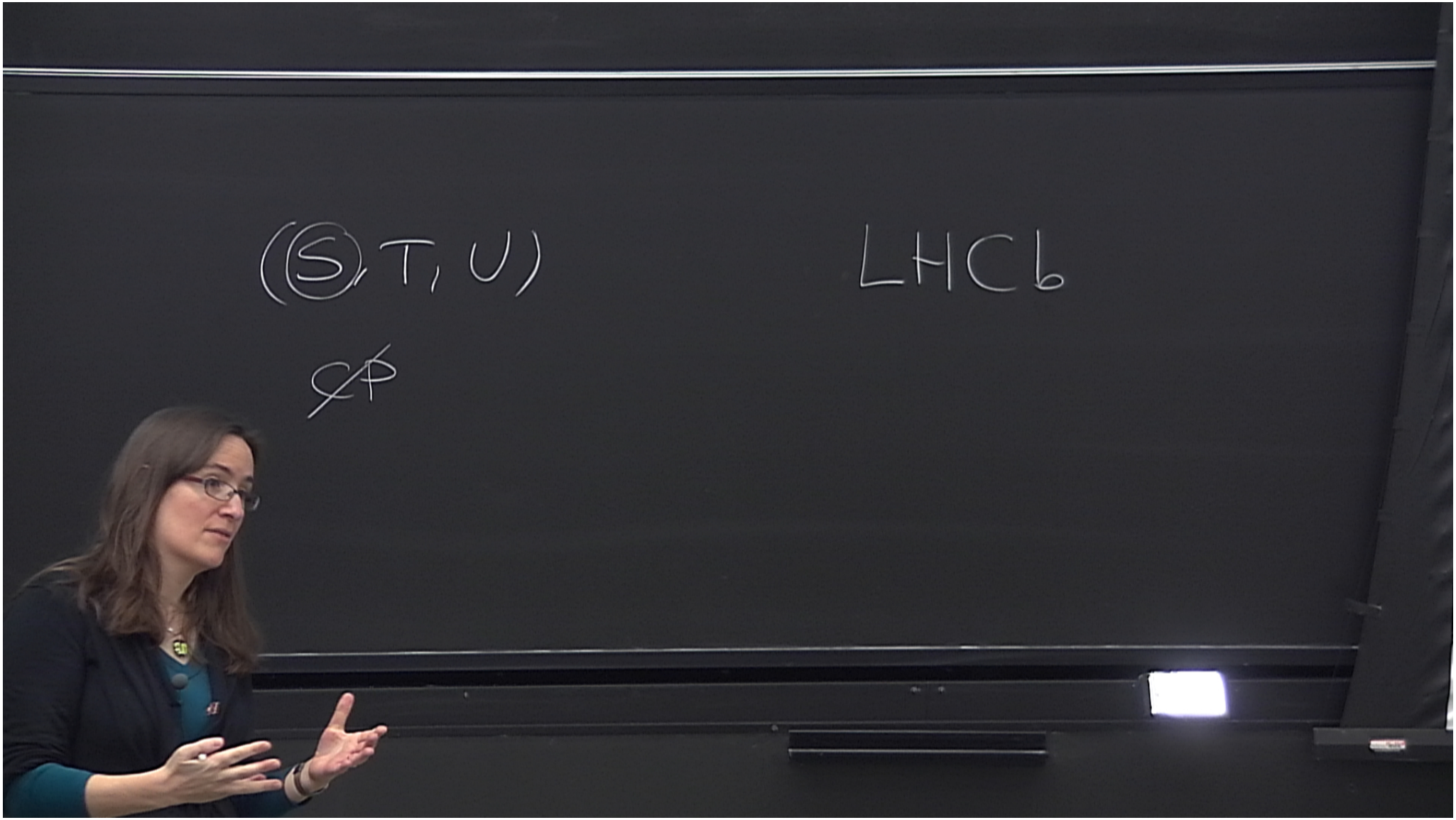
Date: Mar 02, 2012 09:00 AM

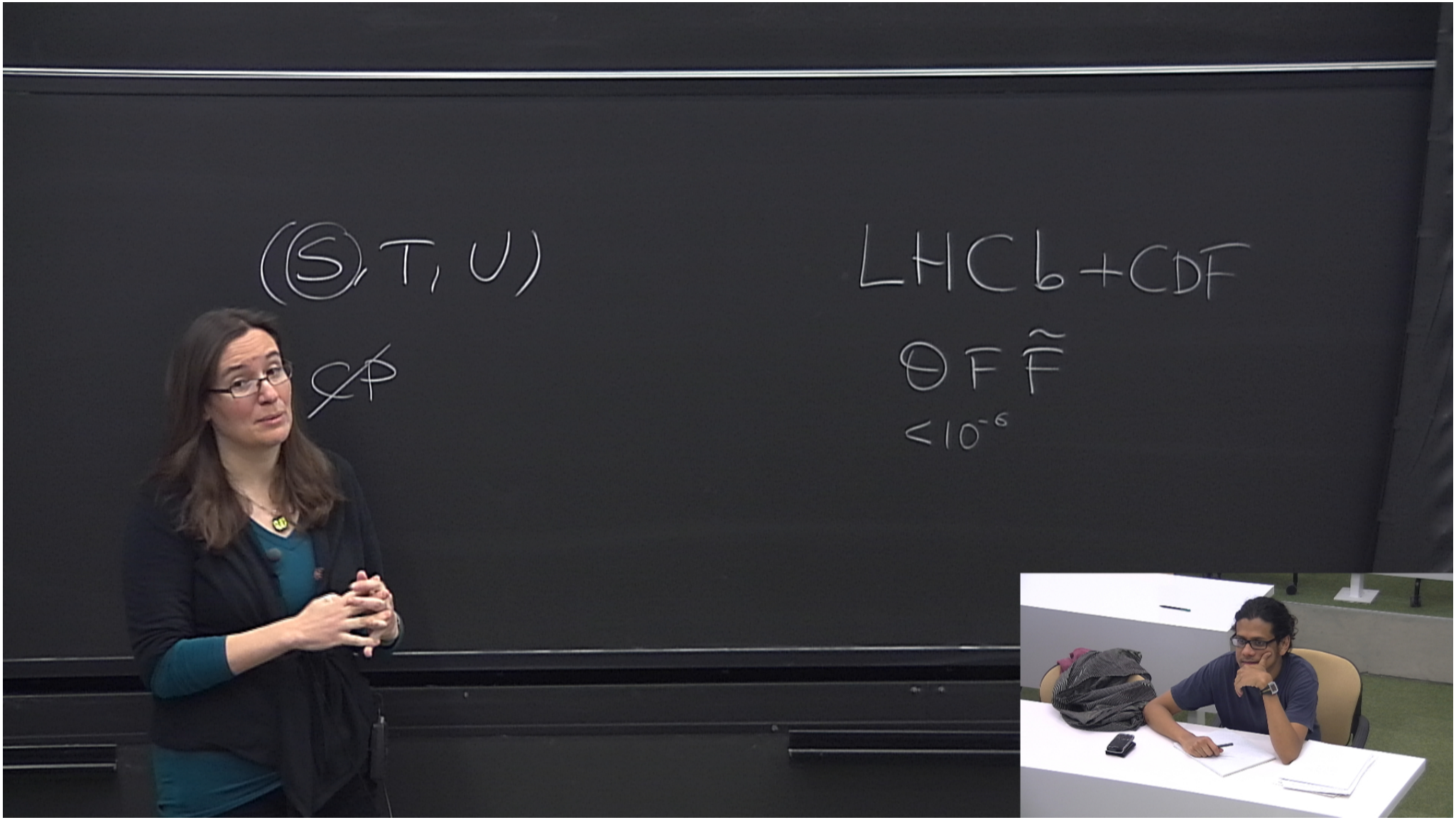
URL: http://www.pirsa.org/12030066

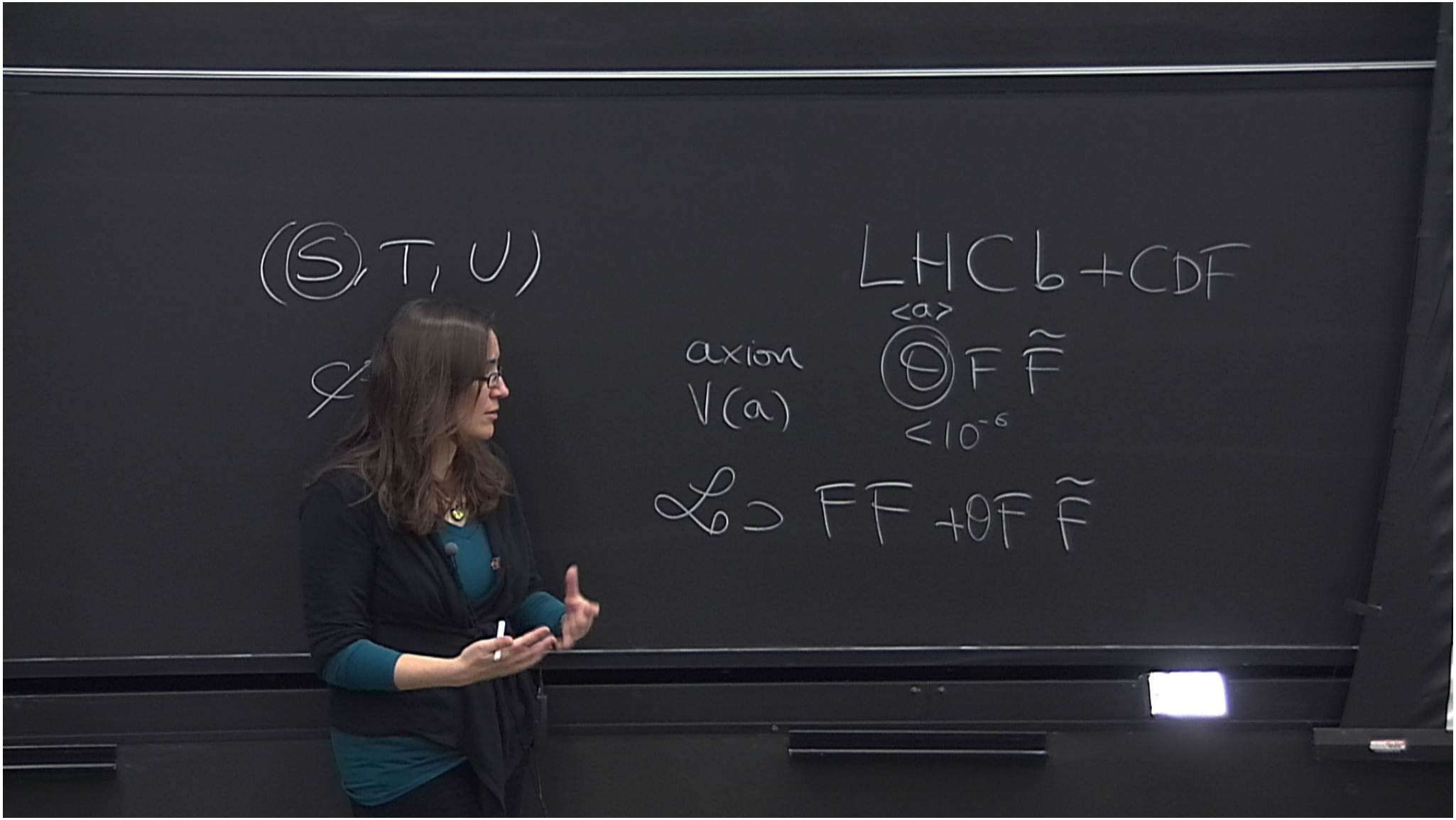
Abstract:

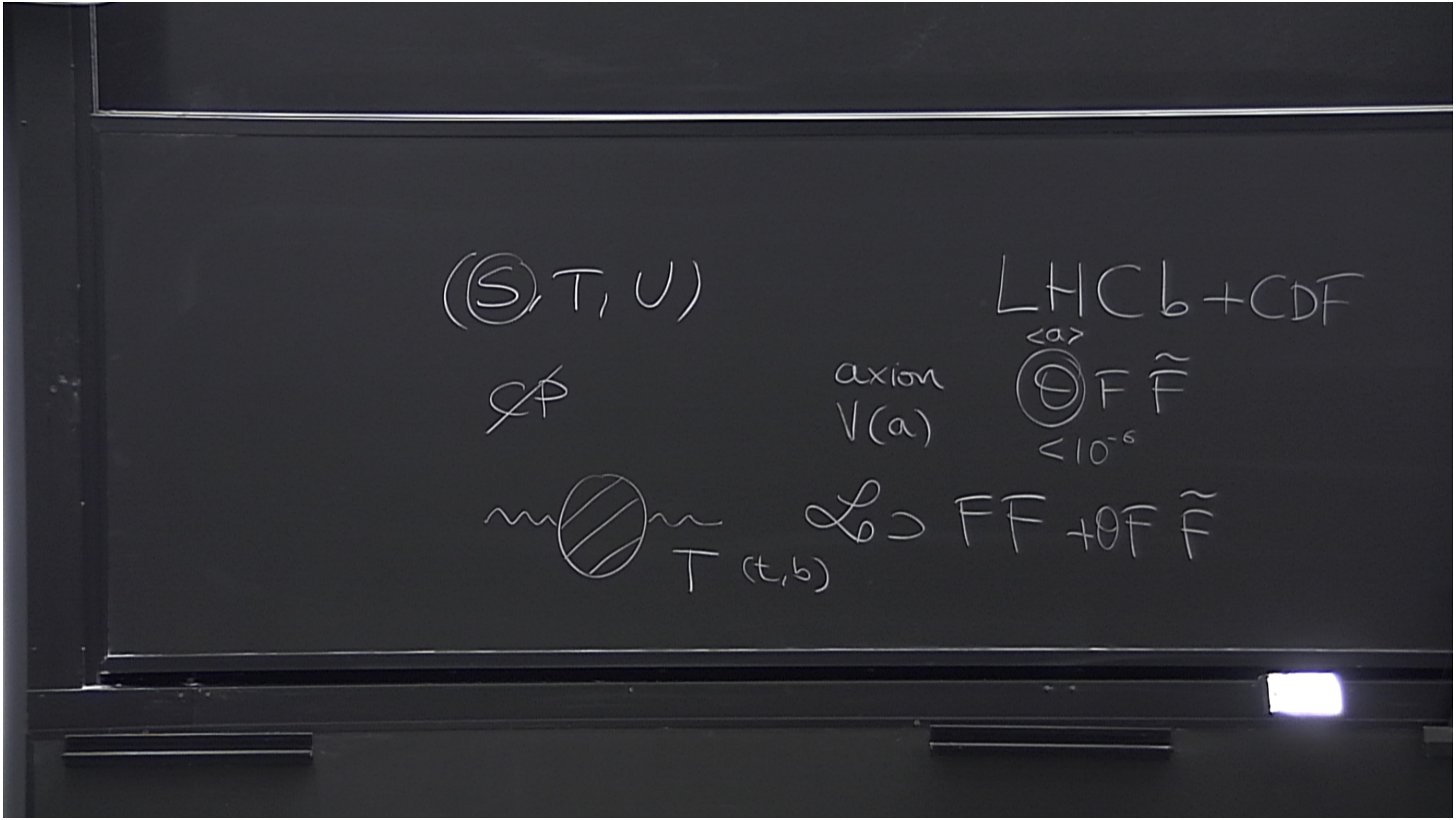

(S, T, U)


(S, T, U)
CP


(S, T, U)
LHCb

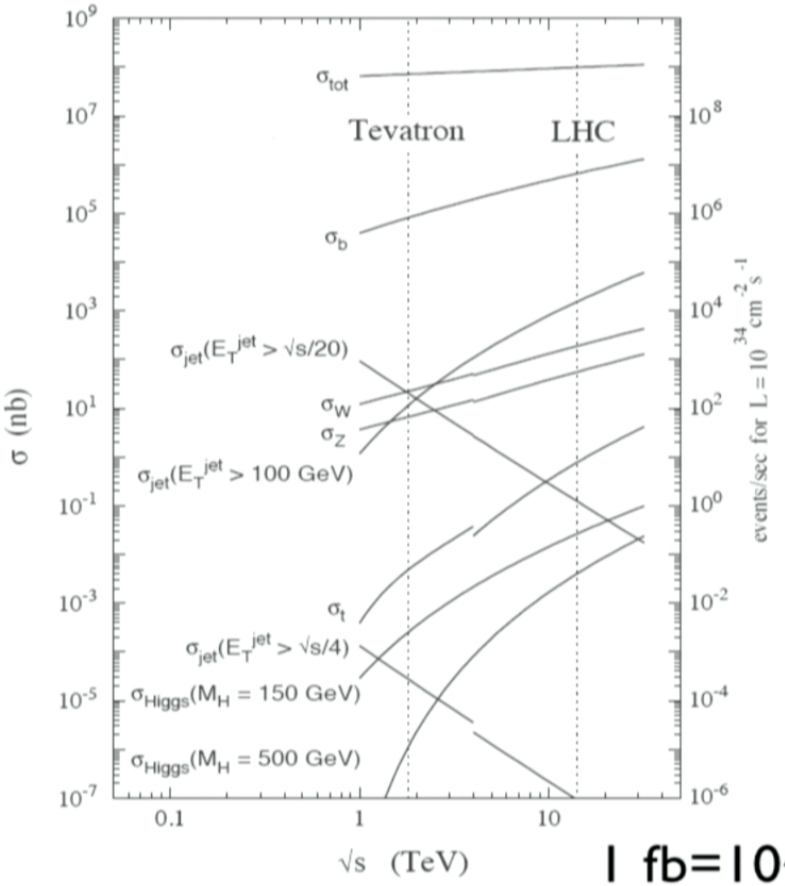

(S, T, U)
LHCb + CDF
$\not{CP}$
Θ F $\tilde{F}$
$< 10^{-6}$


(S, T, U)
LHCb + CDF
axion
V(a)
<a>
θ F F̃
< 10⁻⁶
ℒ ⊃ FF + θF F̃


(S, T, U)
LHCb + CDF
axion
V(a)
<a>
θ F F̃
< 10⁻⁶
T (t, b)
ℒ ⊃ FF + θF F̃

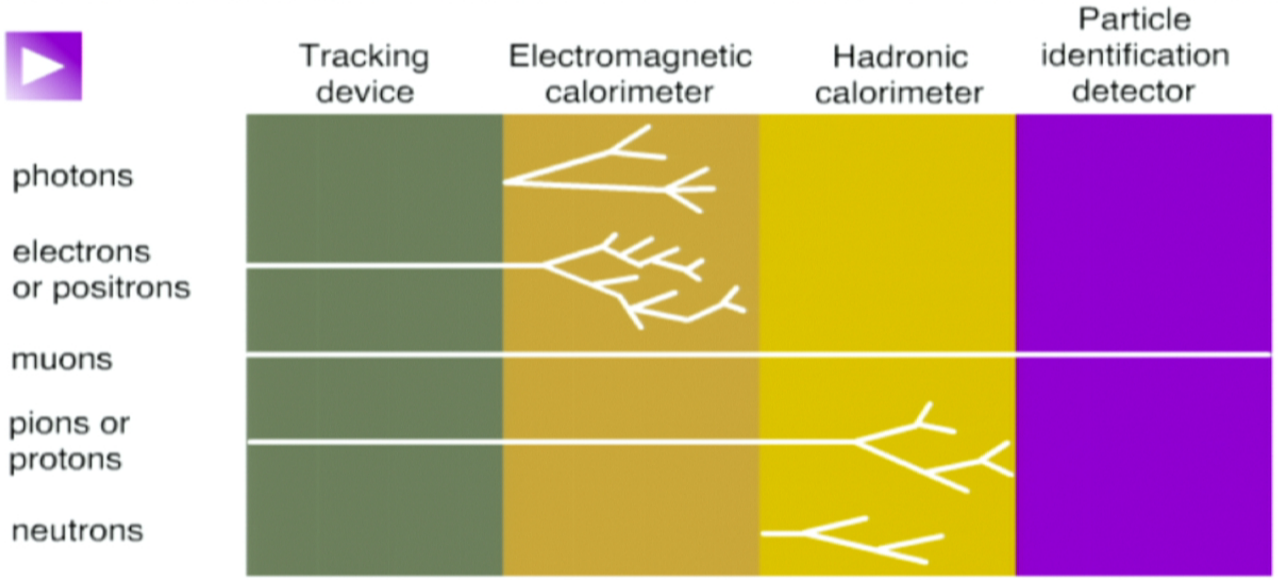
Parameter	Input value	Free in fit	Results from global EW fits: *Standard fit*	*Complete fit*	*Complete fit w/o exp. input in line*
M_Z [GeV]	91.1875 ± 0.0021	yes	91.1874 ± 0.0021	91.1877 ± 0.0021	$91.1983^{+0.0133}_{-0.0155}$
Γ_Z [GeV]	2.4952 ± 0.0023	–	2.4959 ± 0.0015	2.4955 ± 0.0014	$2.4951^{+0.0017}_{-0.0016}$
$\sigma^0_{\rm had}$ [nb]	41.540 ± 0.037	–	41.478 ± 0.014	41.478 ± 0.014	41.469 ± 0.015
R^0_ℓ	20.767 ± 0.025	–	20.743 ± 0.018	20.741 ± 0.018	$20.718^{+0.027}_{-0.026}$
$A^{0,\ell}_{\rm FB}$	0.0171 ± 0.0010	–	0.01641 ± 0.0002	$0.01620^{+0.0002}_{-0.0001}$	0.01606 ± 0.0001
A_ℓ (*)	0.1499 ± 0.0018	–	0.1479 ± 0.0010	$0.1472^{+0.0009}_{-0.0006}$	–
A_c	0.670 ± 0.027	–	$0.6683^{+0.00044}_{-0.00043}$	$0.6680^{+0.00040}_{-0.00028}$	$0.6679^{+0.00042}_{-0.00025}$
A_b	0.923 ± 0.020	–	$0.93470^{+0.00009}_{-0.00008}$	$0.93463^{+0.00008}_{-0.00005}$	$0.93463^{+0.00007}_{-0.00005}$
$A^{0,c}_{\rm FB}$	0.0707 ± 0.0035	–	0.0741 ± 0.0005	$0.0737^{+0.0005}_{-0.0004}$	0.0738 ± 0.0004
$A^{0,b}_{\rm FB}$	0.0992 ± 0.0016	–	0.1037 ± 0.0007	$0.1035^{+0.0003}_{-0.0004}$	$0.1038^{+0.0003}_{-0.0005}$
R^0_c	0.1721 ± 0.0030	–	0.17226 ± 0.00006	0.17226 ± 0.00006	0.17226 ± 0.00006
R^0_b	0.21629 ± 0.00066	–	$0.21578^{+0.00005}_{-0.00008}$	$0.21577^{+0.00005}_{-0.00008}$	$0.21577^{+0.00005}_{-0.00007}$
$\sin^2\theta^\ell_{\rm eff}(Q_{\rm FB})$	0.2324 ± 0.0012	–	0.23141 ± 0.00012	$0.23150^{+0.00008}_{-0.00011}$	$0.23152^{+0.00006}_{-0.00013}$
M_H [GeV] (○)	Likelihood ratios	yes	$95^{+30[+74]}_{-24[-43]}$	$125^{+8[+21]}_{-10[-11]}$	$95^{+30[+74]}_{-24[-43]}$
M_W [GeV]	80.399 ± 0.023	–	$80.382^{+0.014}_{-0.015}$	$80.368^{+0.007}_{-0.010}$	$80.360^{+0.012}_{-0.011}$
Γ_W [GeV]	2.085 ± 0.042	–	2.093 ± 0.001	2.092 ± 0.001	$2.091^{+0.002}_{-0.001}$
$\overline{m}_c$ [GeV]	$1.27^{+0.07}_{-0.11}$	yes	$1.27^{+0.07}_{-0.11}$	$1.27^{+0.07}_{-0.11}$	–
$\overline{m}_b$ [GeV]	$4.20^{+0.17}_{-0.07}$	yes	$4.20^{+0.16}_{-0.07}$	$4.20^{+0.16}_{-0.07}$	–
m_t [GeV]	173.2 ± 0.9	yes	173.3 ± 0.9	173.5 ± 0.9	$177.2^{+2.9}_{-3.1}$ (▽)
$\Delta\alpha^{(5)}_{\rm had}(M_Z^2)$ (†△)	2749 ± 10	yes	2750 ± 10	2748 ± 10	2716^{+60}_{-45}
$\alpha_s(M_Z^2)$	–	yes	0.1192 ± 0.0028	0.1193 ± 0.0028	0.1193 ± 0.0028
$\delta_{\rm th} M_W$ [MeV]	$[-4,4]_{\rm theo}$	yes	4	4	–
$\delta_{\rm th}\sin^2\theta^\ell_{\rm eff}$ (†)	$[-4.7,4.7]_{\rm theo}$	yes	4.7	4.7	–

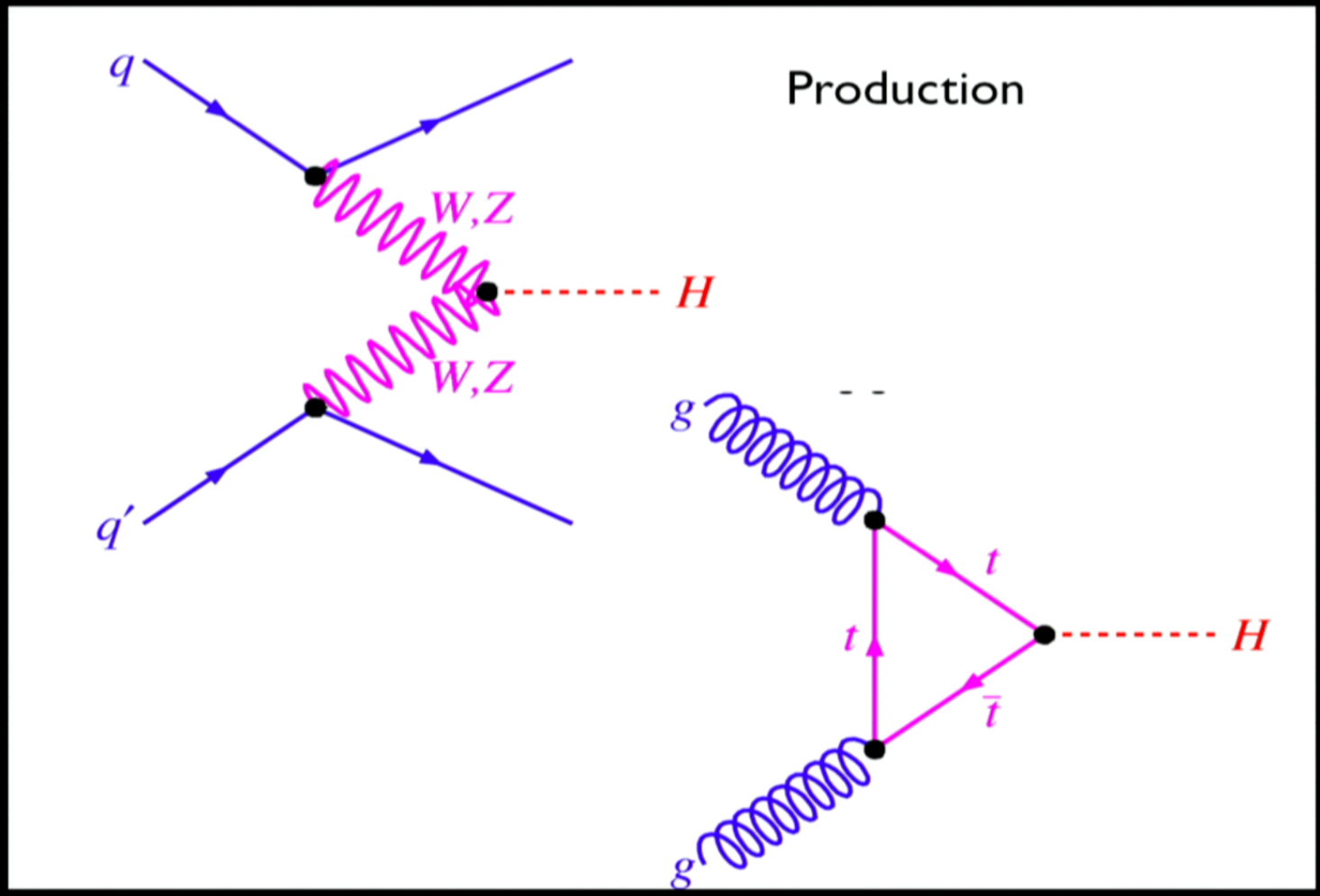
(*)Average of LEP ($A_\ell = 0.1465 \pm 0.0033$) and SLD ($A_\ell = 0.1513 \pm 0.0021$) measurements. The fit w/o the LEP (SLD) measurement but with the direct Higgs searches gives $A_\ell = 0.1471^{+0.0010}_{-0.0005}$ ($A_\ell = 0.1467^{+0.0007}_{-0.0004}$). (○)In brackets the 2σ. (†)In units of 10^{-5}. (△)Rescaled due to α_s dependency. (▽)Ignoring a second less significant minimum, *cf.* fig. ?? and the result of

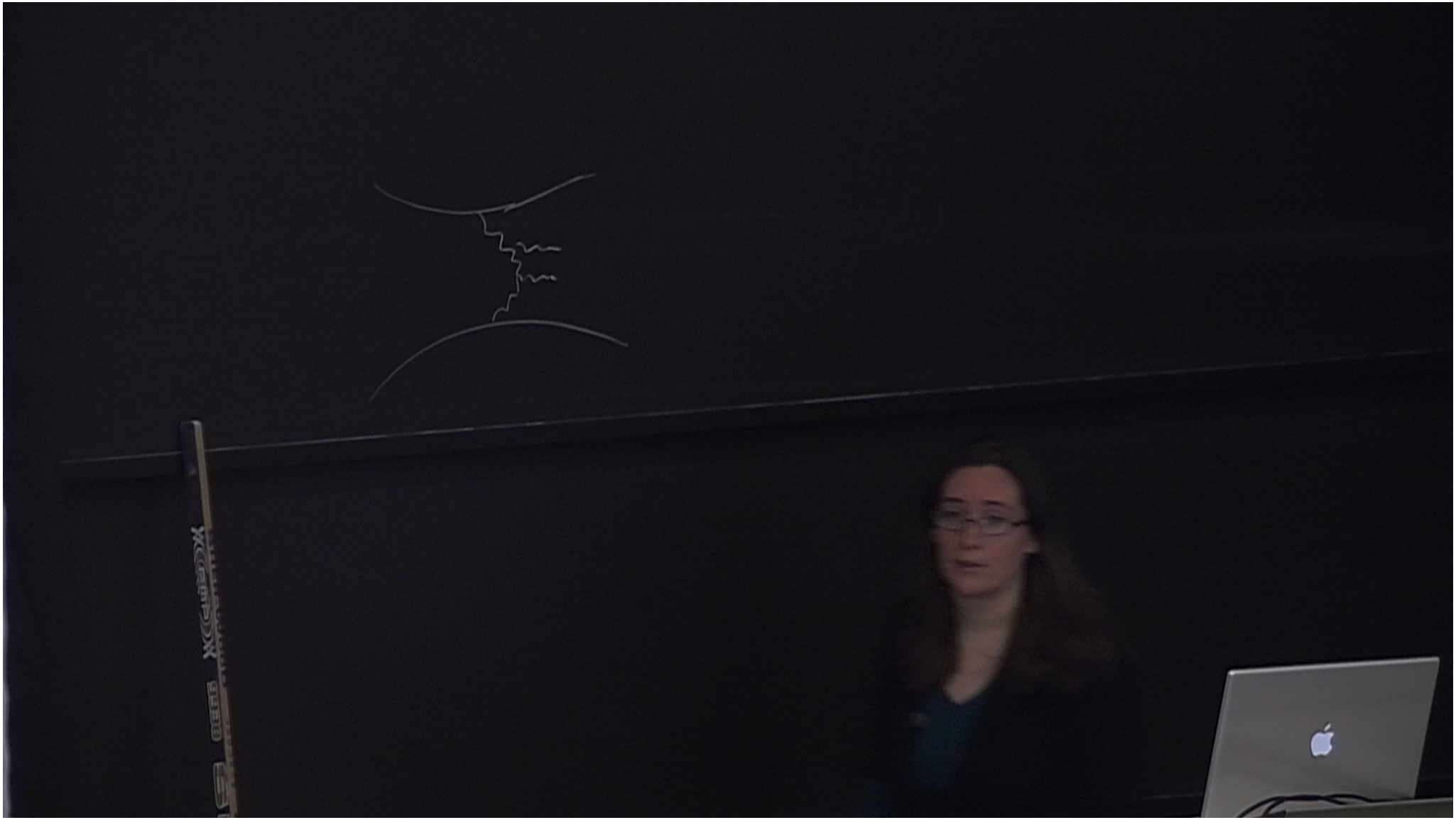

σ (nb)
events/sec for L = 10^34 cm^-2 s^-1
√s (TeV)
Tevatron
LHC
σ_tot
σ_b
σ_jet(E_T^jet > √s/20)
σ_W
σ_Z
σ_jet(E_T^jet > 100 GeV)
σ_t
σ_jet(E_T^jet > √s/4)
σ_Higgs(M_H = 150 GeV)
σ_Higgs(M_H = 500 GeV)

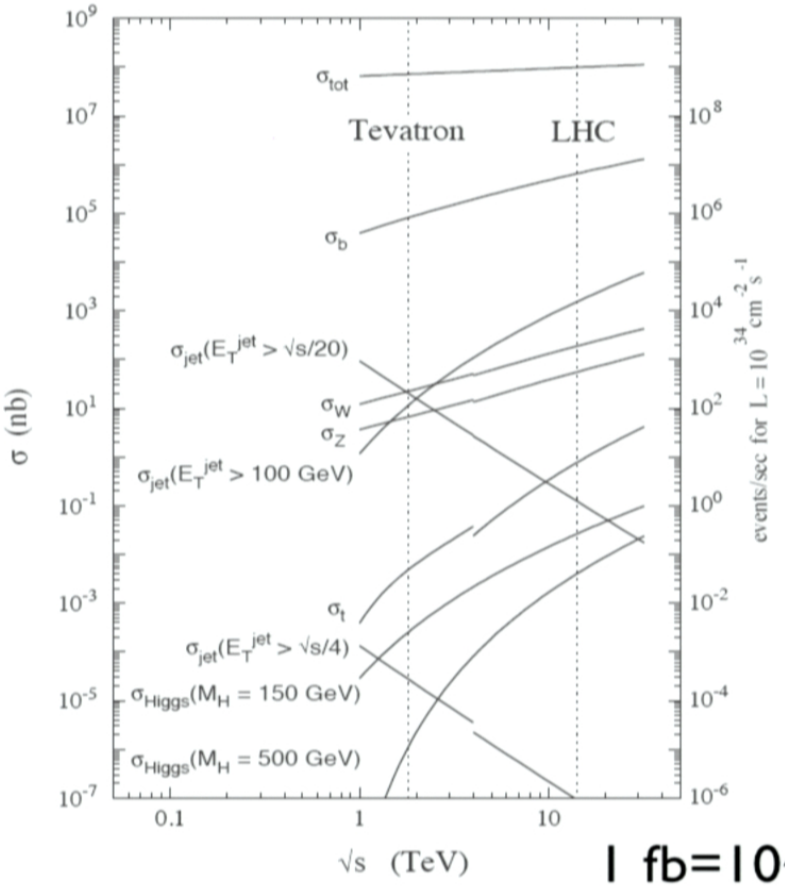
1 fb=10^{-39} cm2

using various techniques

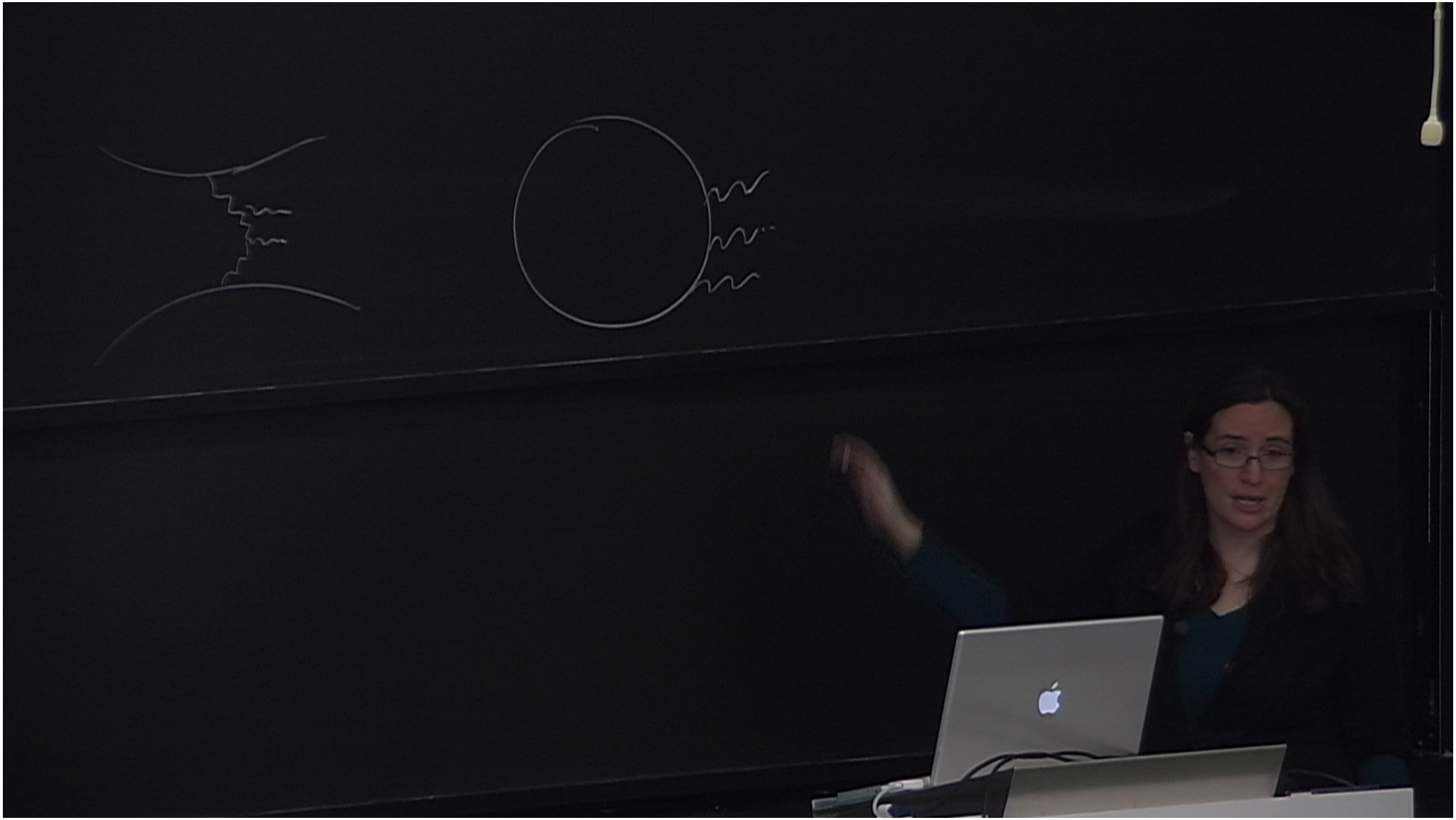


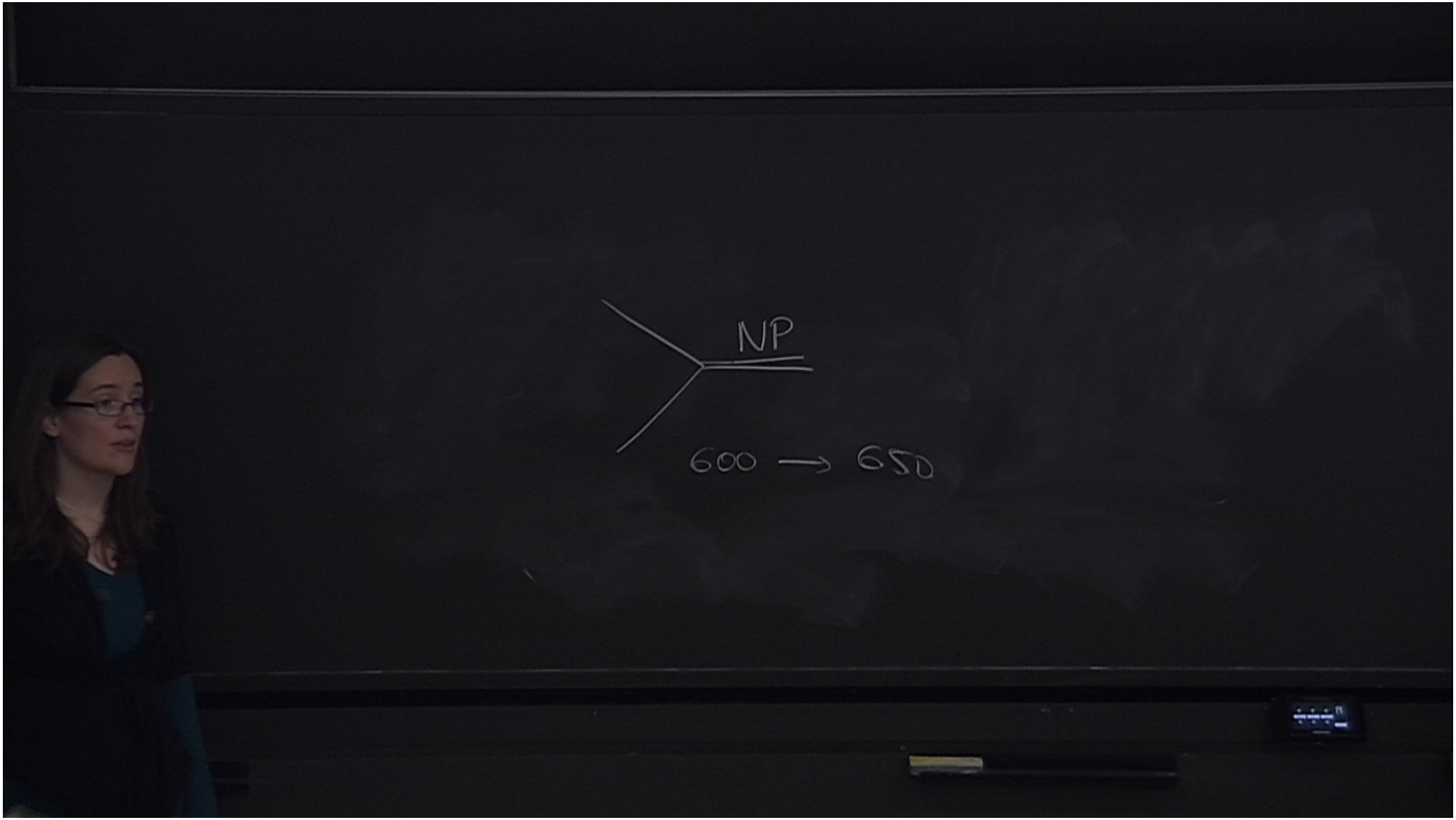

Production
q
W,Z
H
W,Z
q′
g
t
t
H
t̄
g

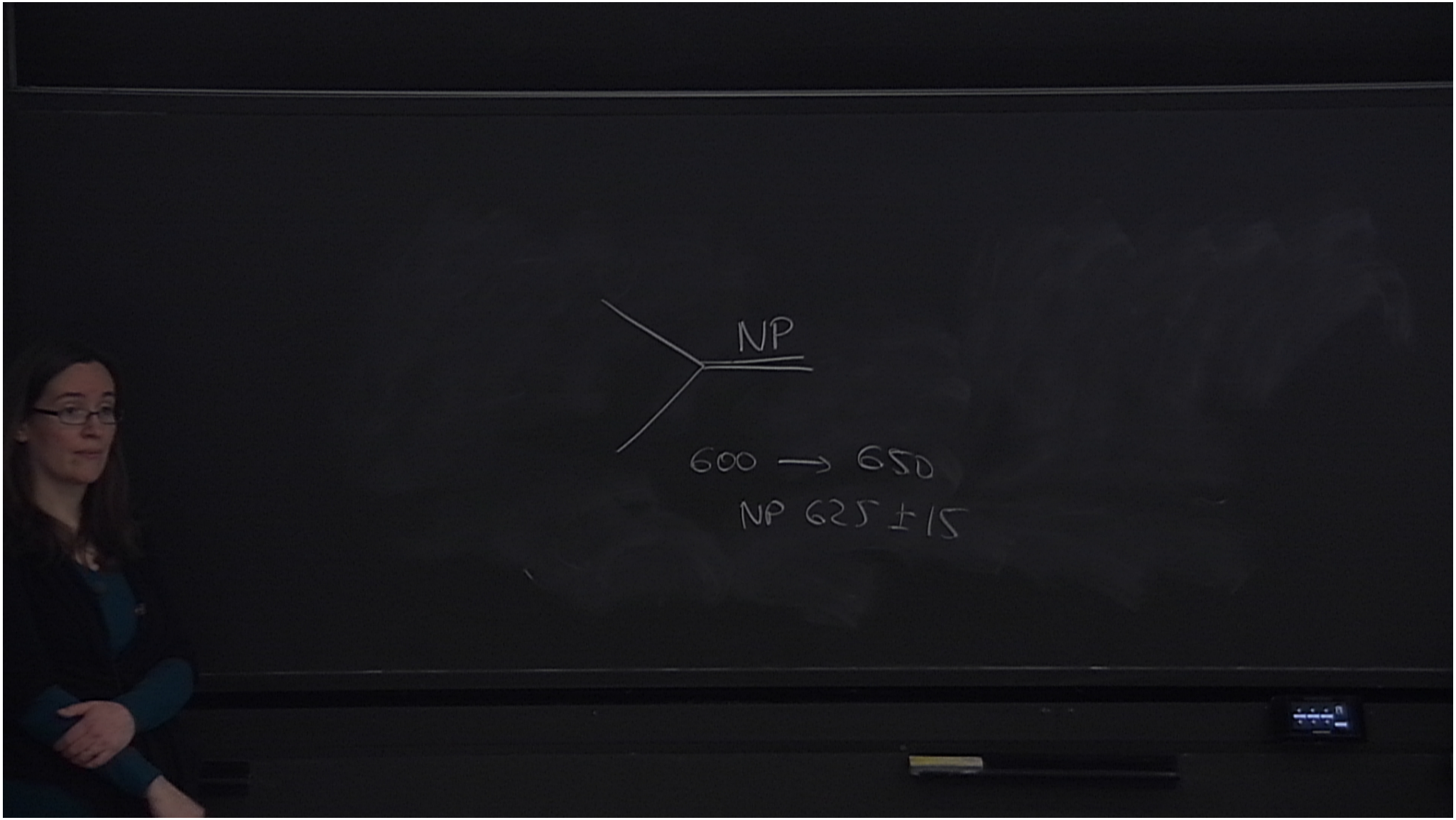


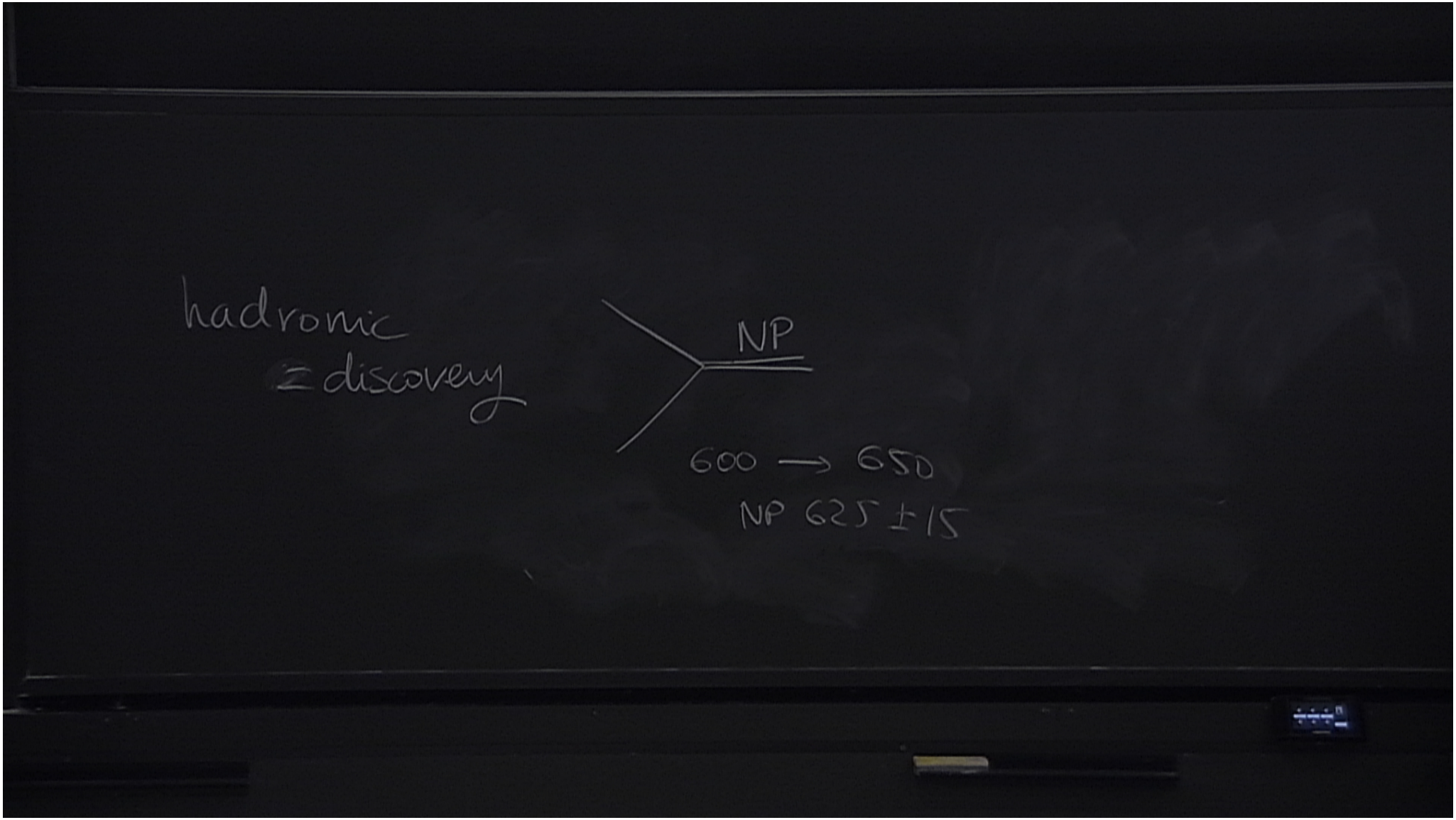

Tevatron
LHC
σ_{tot}
σ_b
$\sigma_{jet}(E_T^{jet} > \sqrt{s}/20)$
σ_W
σ_Z
$\sigma_{jet}(E_T^{jet} > 100\ GeV)$
σ_t
$\sigma_{jet}(E_T^{jet} > \sqrt{s}/4)$
$\sigma_{Higgs}(M_H = 150\ GeV)$
$\sigma_{Higgs}(M_H = 500\ GeV)$
σ (nb)
events/sec for $L = 10^{34}\ cm^{-2}\ s^{-1}$
√s (TeV)
0.1
1
10

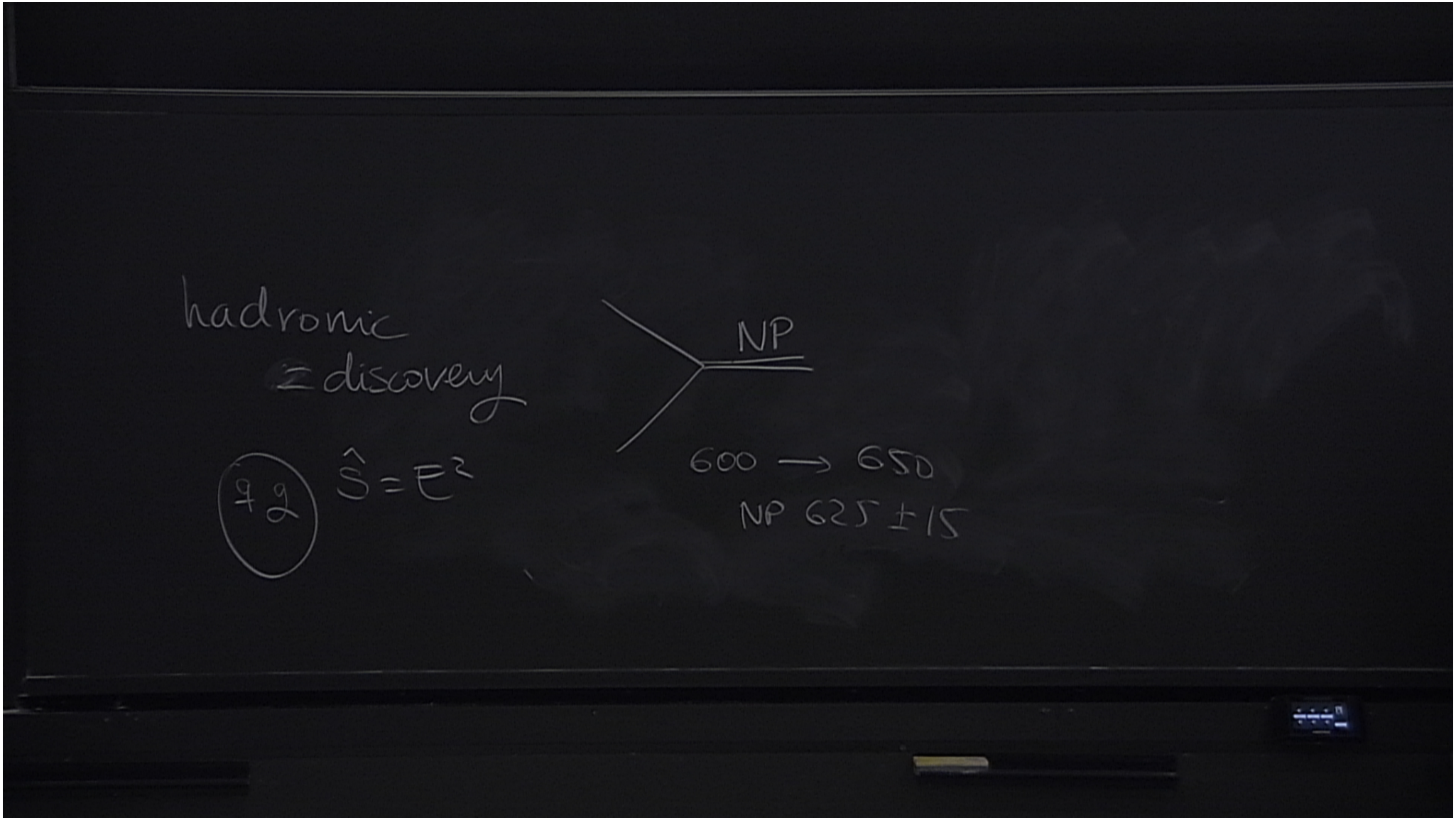
1 fb=10^

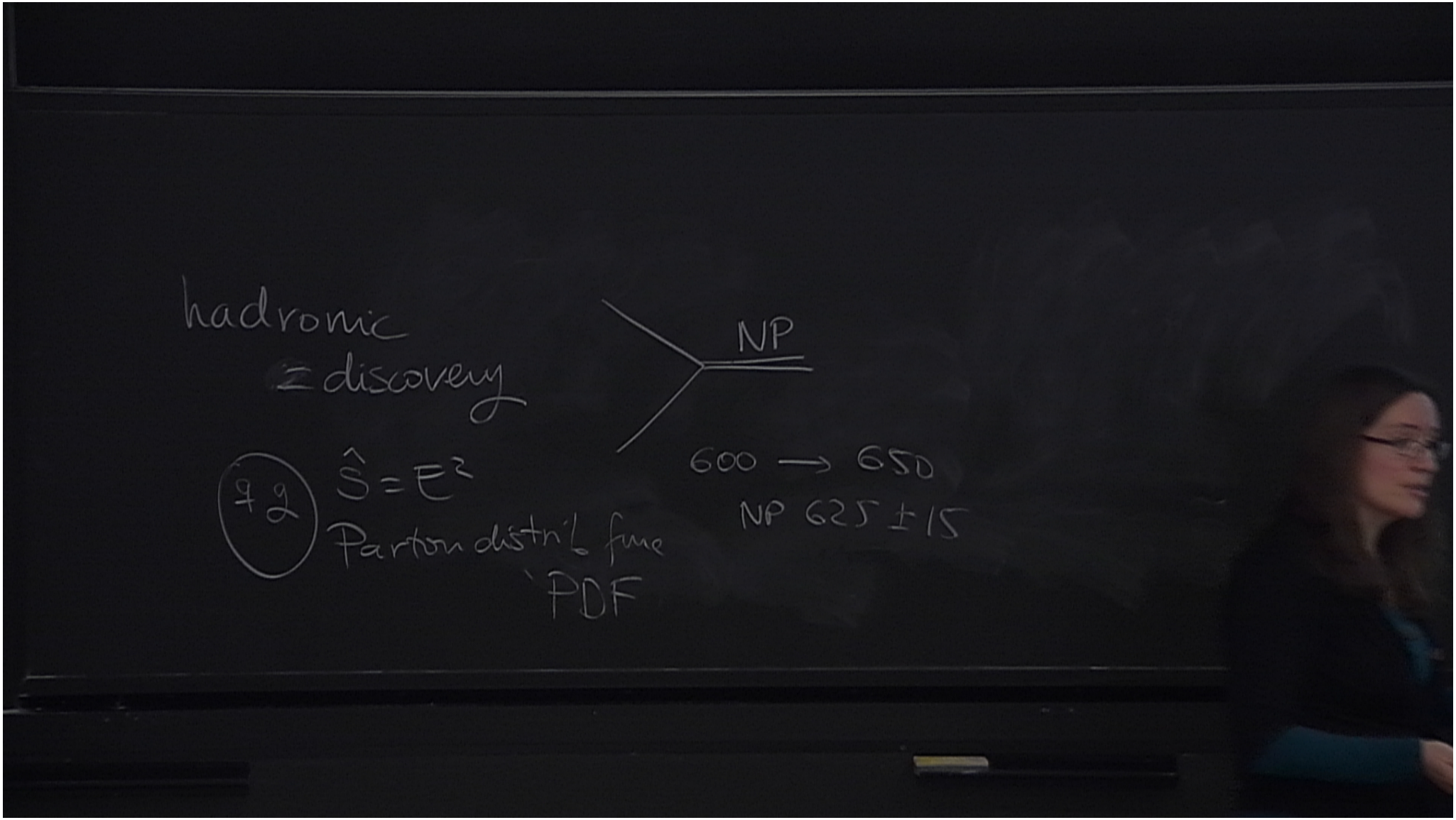



NP
600 → 650


NP
600 → 650
NP 625 ± 15


hadronic
≥ discovery
NP
600 → 650
NP 625 ± 15

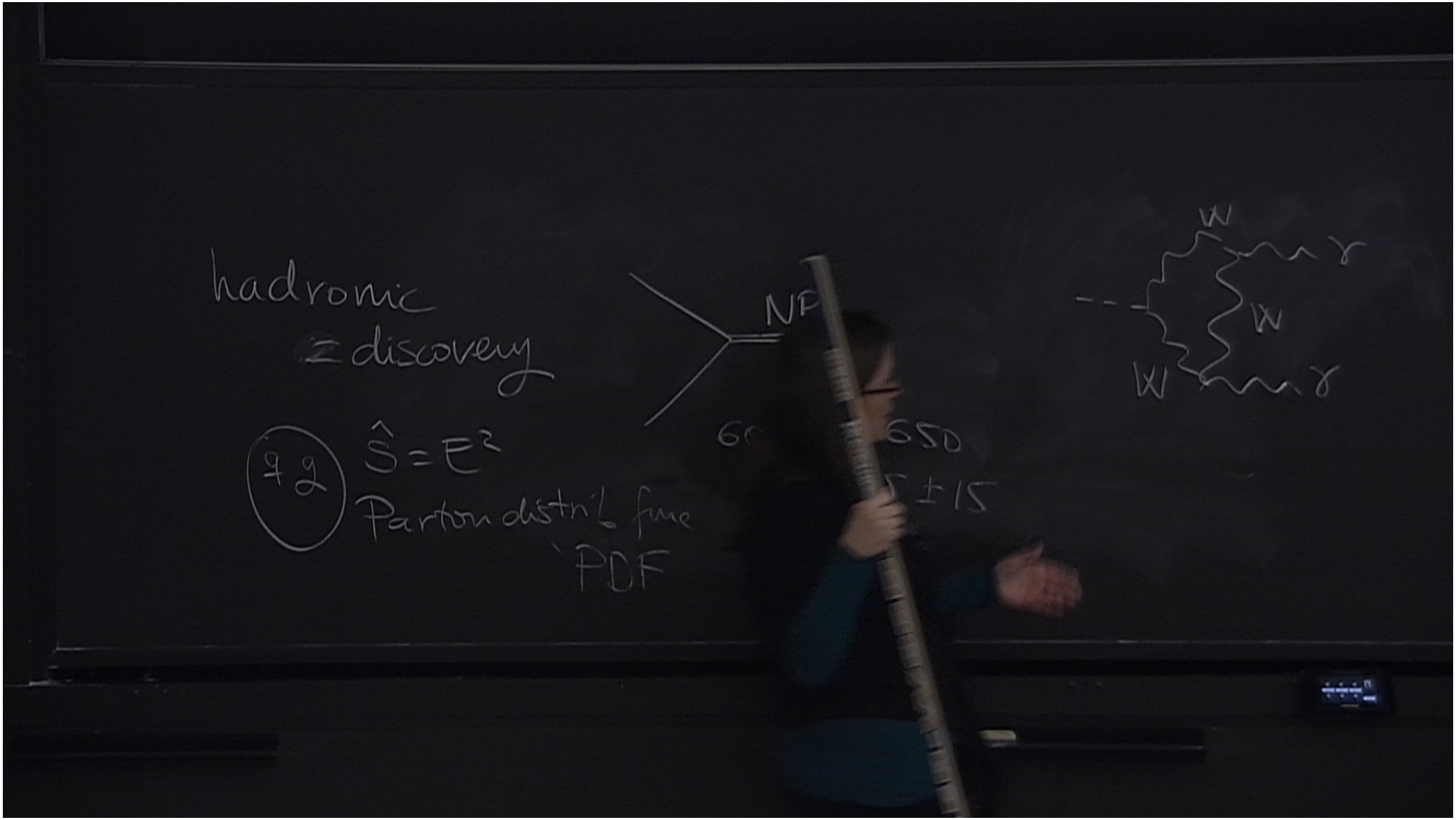

hadronic
discovery
NP
$\hat{s} = E^2$
600 → 650
NP 625 ± 15

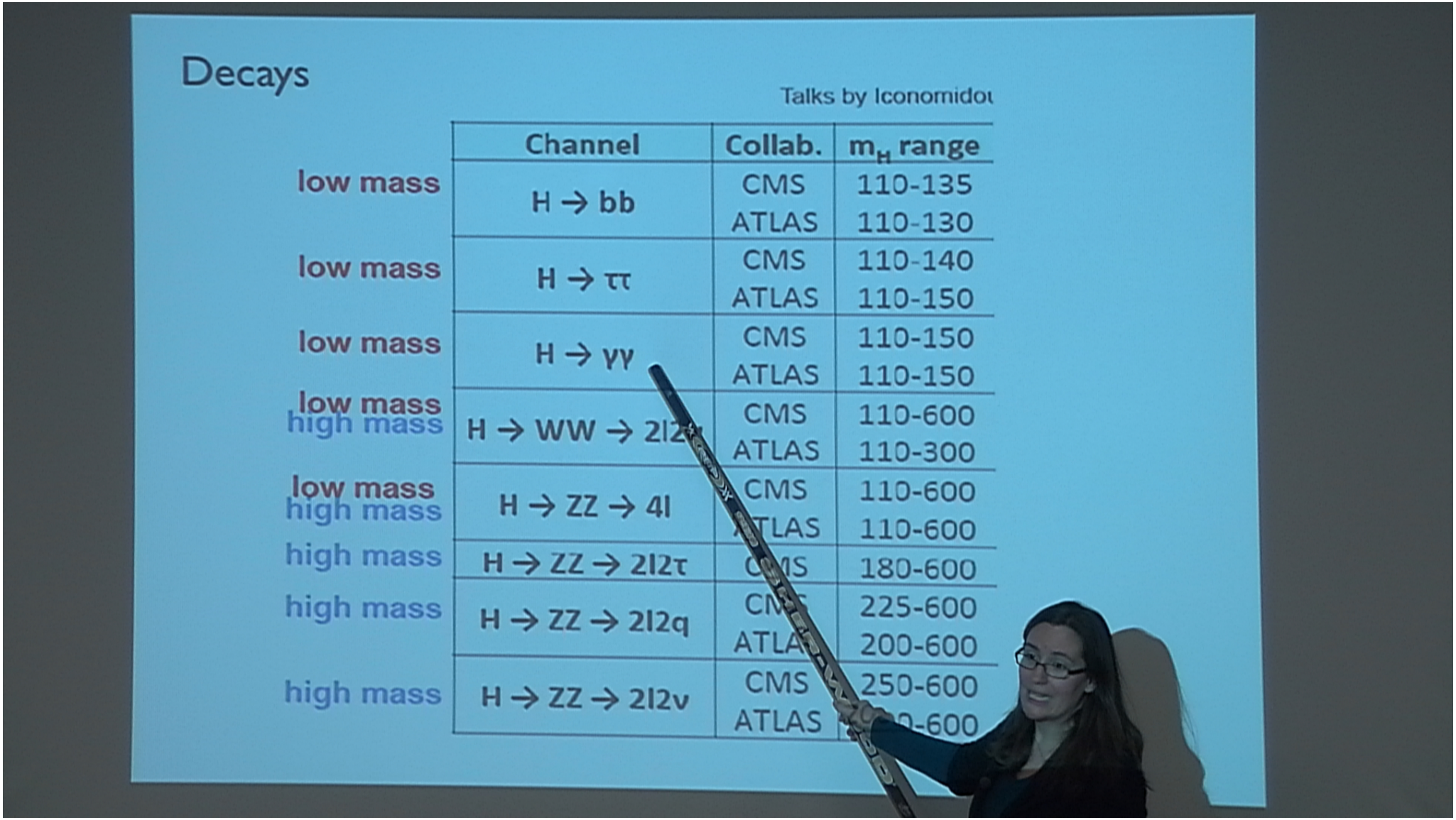

hadronic
discovery
NP
600 → 650
NP 625 ± 15
$\hat{s} = E^2$
Parton distn'l fns
PDF

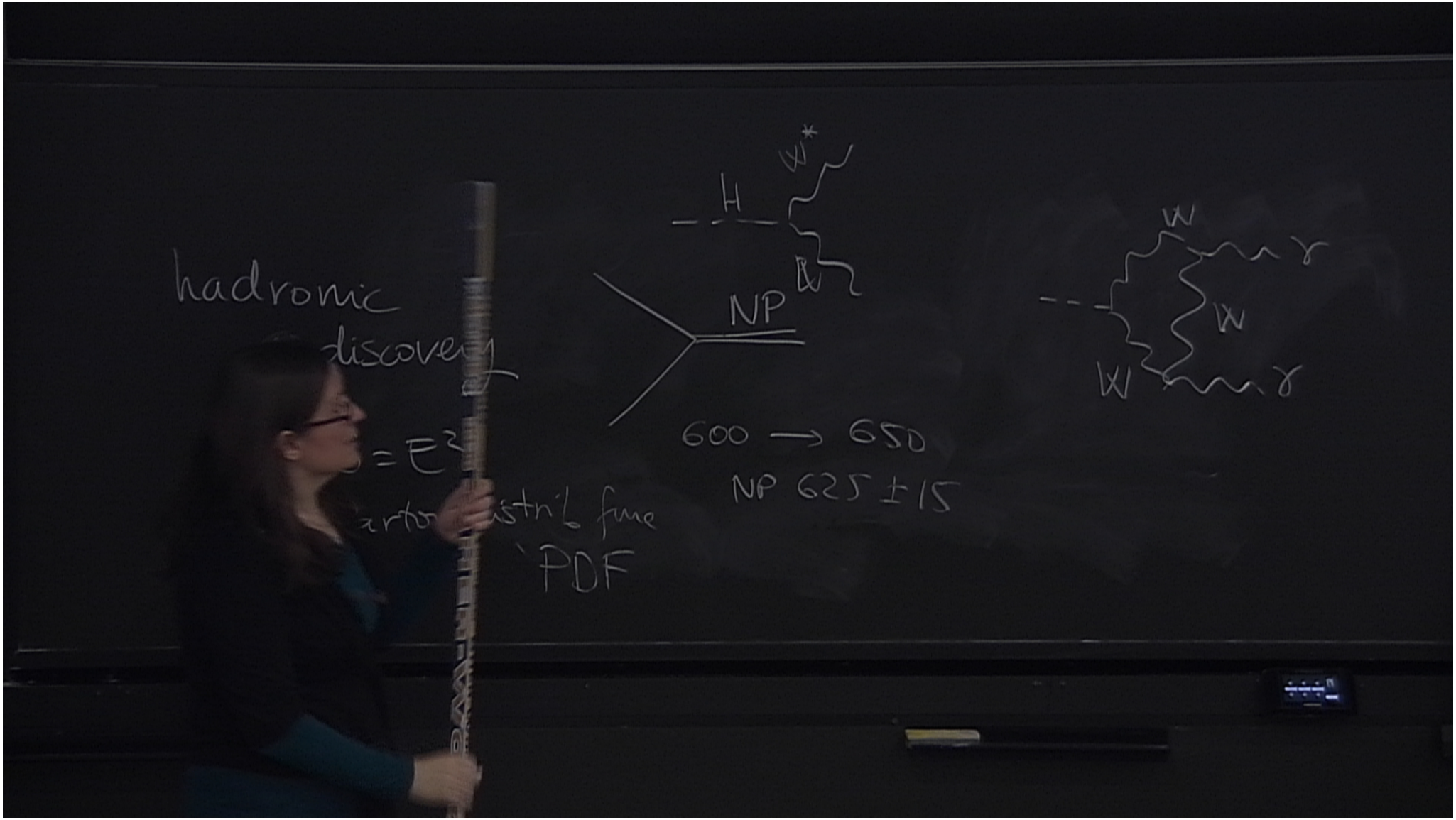
Decays

Talks by Iconomidou

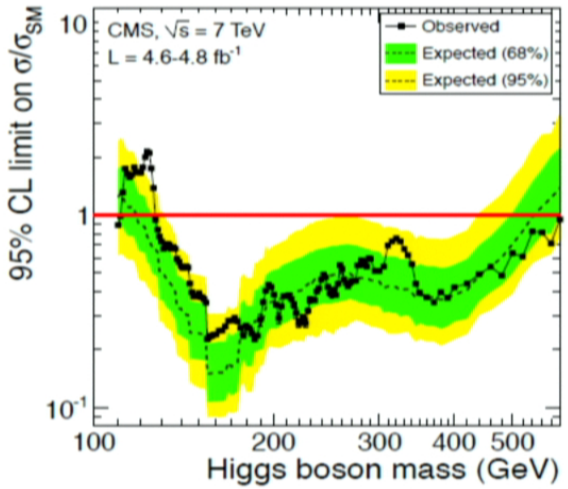
	Channel	Collab.	m_H range
low mass	$H \to bb$	CMS	110-135
		ATLAS	110-130
low mass	$H \to \tau\tau$	CMS	110-140
		ATLAS	110-150
low mass	$H \to \gamma\gamma$	CMS	110-150
		ATLAS	110-150
low mass high mass	$H \to WW \to 2l2\nu$	CMS	110-600
		ATLAS	110-300
low mass high mass	$H \to ZZ \to 4l$	CMS	110-600
		ATLAS	110-600
high mass	$H \to ZZ \to 2l2\tau$	CMS	180-600
high mass	$H \to ZZ \to 2l2q$	CMS	225-600
		ATLAS	200-600
high mass	$H \to ZZ \to 2l2\nu$	CMS	250-600
		ATLAS	200-600

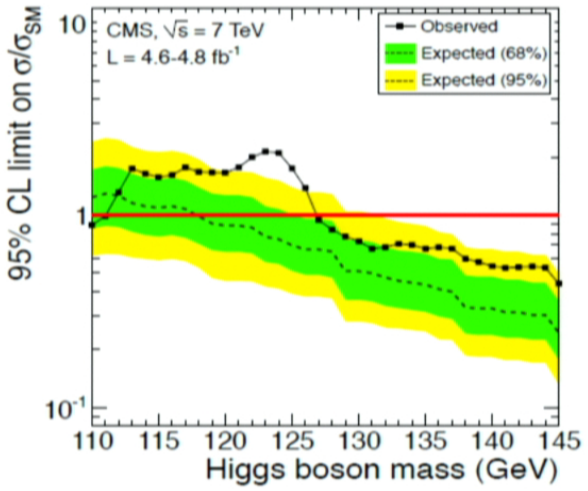

hadronic
discovery
NP
W
γ
W
W
γ
$\hat{s} = E^2$
Parton distrib. func
PDF
650
±15

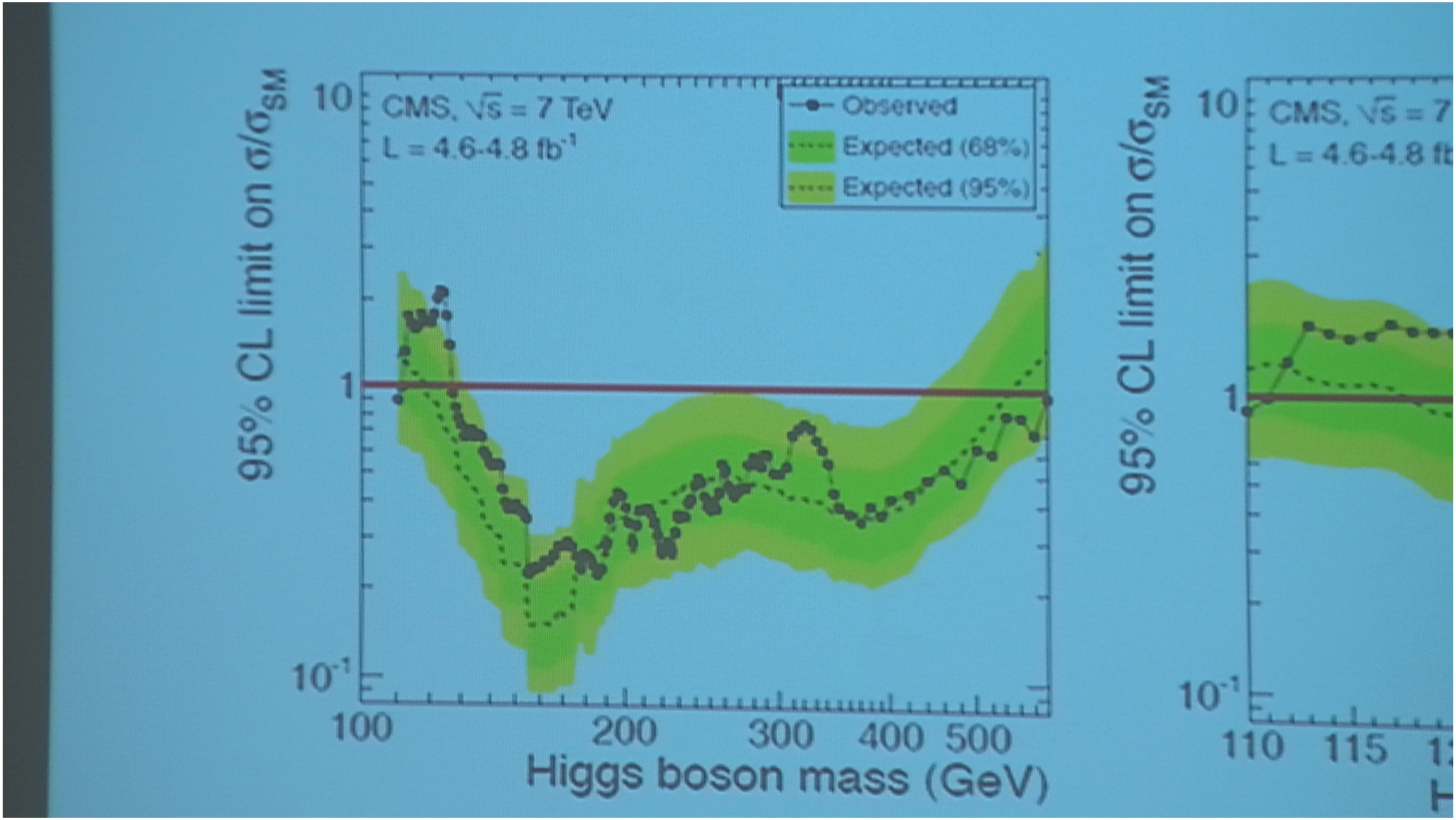

Decays
Talks by Iconomidou
Channel
Collab.
m_H range
low mass
H → bb
CMS 110-135
ATLAS 110-130
low mass
H → ττ
CMS 110-140
ATLAS 110-150
low mass
H → γγ
CMS 110-150
ATLAS 110-150
low mass
high mass
H → WW → 2l2
CMS 110-600
ATLAS 110-300
low mass
high mass
H → ZZ → 4l
CMS 110-600
ATLAS 110-600
high mass
H → ZZ → 2l2τ
CMS 180-600
high mass
H → ZZ → 2l2q
CMS 225-600
ATLAS 200-600
high mass
H → ZZ → 2l2ν
CMS 250-600
ATLAS -600

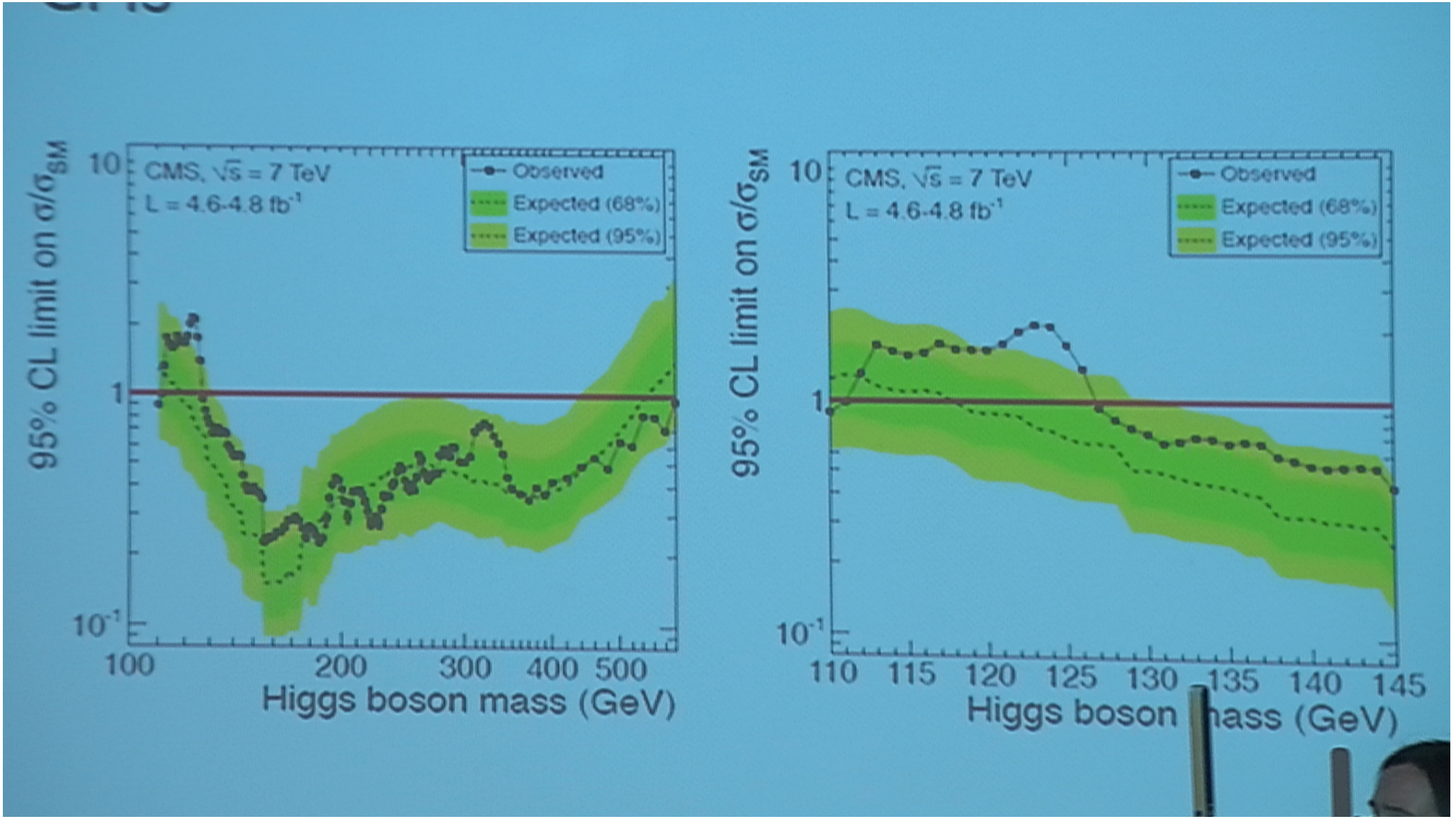

hadronic
discovery
H
W*
NP
W
W
W
γ
γ
600 → 650
NP 625 ± 15
PDF

Feb 7th, 2012
CMS

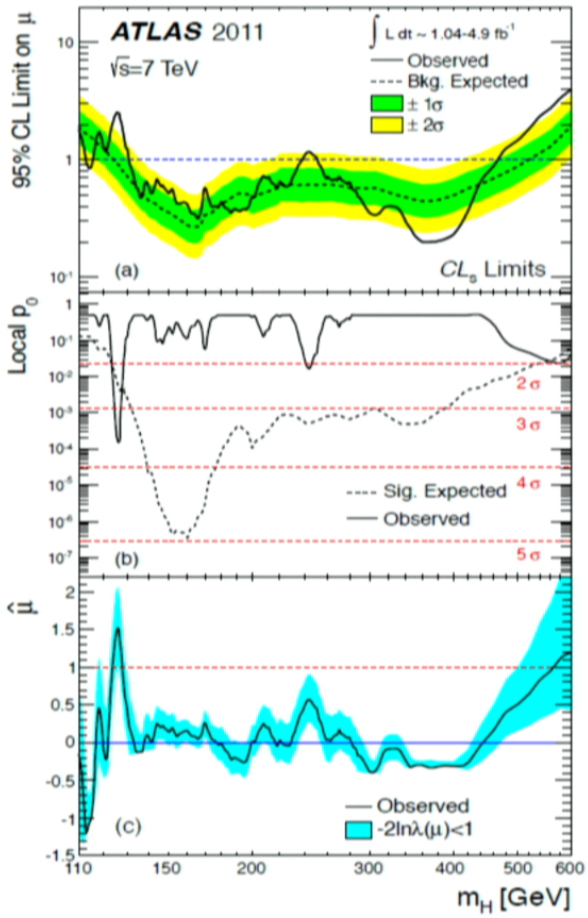


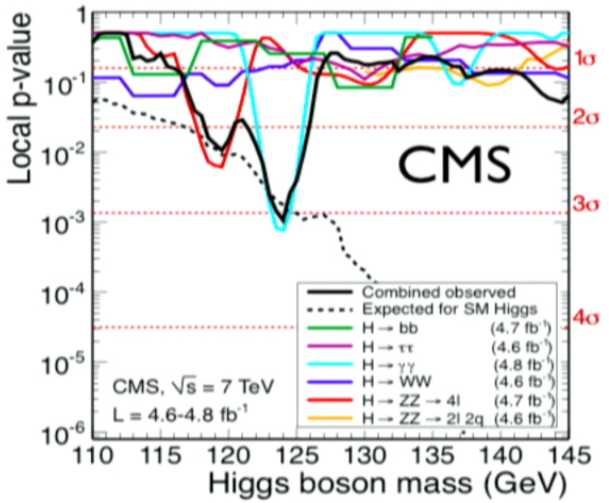



95% CL limit on σ/σSM
CMS, √s = 7 TeV
L = 4.6-4.8 fb-1
Observed
Expected (68%)
Expected (95%)
10
1
10-1
100
200
300
400
500
Higgs boson mass (GeV)
95% CL limit on σ/σSM
CMS, √s = 7
L = 4.6-4.8 fb
10
1
10-1
110
115


95% CL limit on σ/σSM
10
1
10-1
CMS, √s = 7 TeV
L = 4.6-4.8 fb-1
Observed
Expected (68%)
Expected (95%)
100
200
300
400
500
Higgs boson mass (GeV)
95% CL limit on σ/σSM
10
1
10-1
CMS, √s = 7 TeV
L = 4.6-4.8 fb-1
Observed
Expected (68%)
Expected (95%)
110
115
120
125
130
135
140
145
Higgs boson mass (GeV)

Feb 7th, 2012
ATLAS




Local p-value
CMS
1σ
2σ
3σ
4σ
Combined observed
Expected for SM Higgs
H → bb (4.7 fb⁻¹)
H → ττ (4.6 fb⁻¹)
H → γγ (4.8 fb⁻¹)
H → WW (4.6 fb⁻¹)
H → ZZ → 4l (4.7 fb⁻¹)
H → ZZ → 2l 2q (4.6 fb⁻¹)
CMS, √s = 7 TeV
L = 4.6-4.8 fb⁻¹
Higgs boson mass (GeV)

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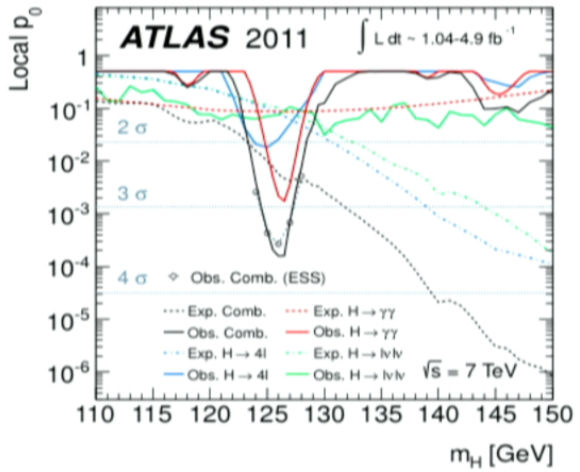
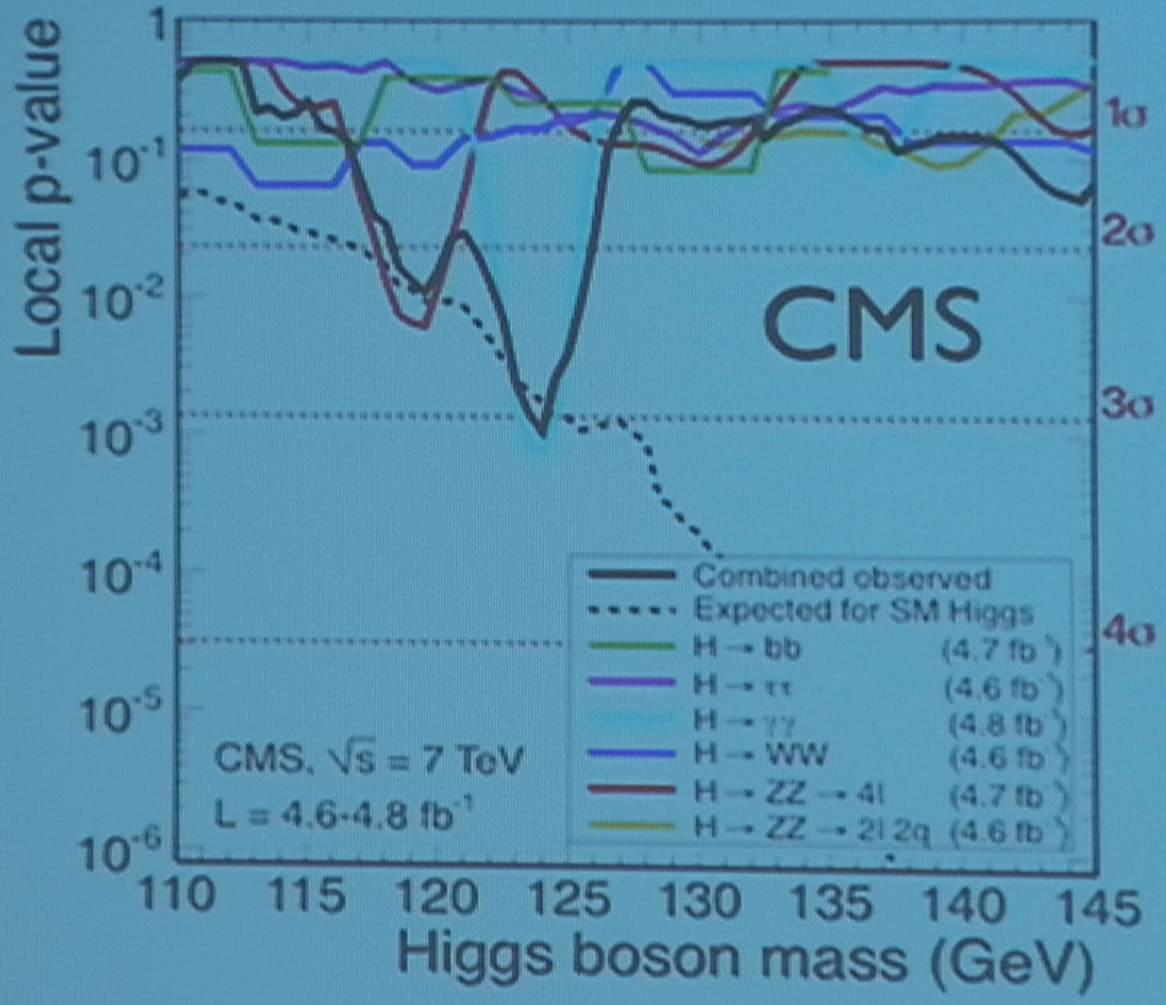
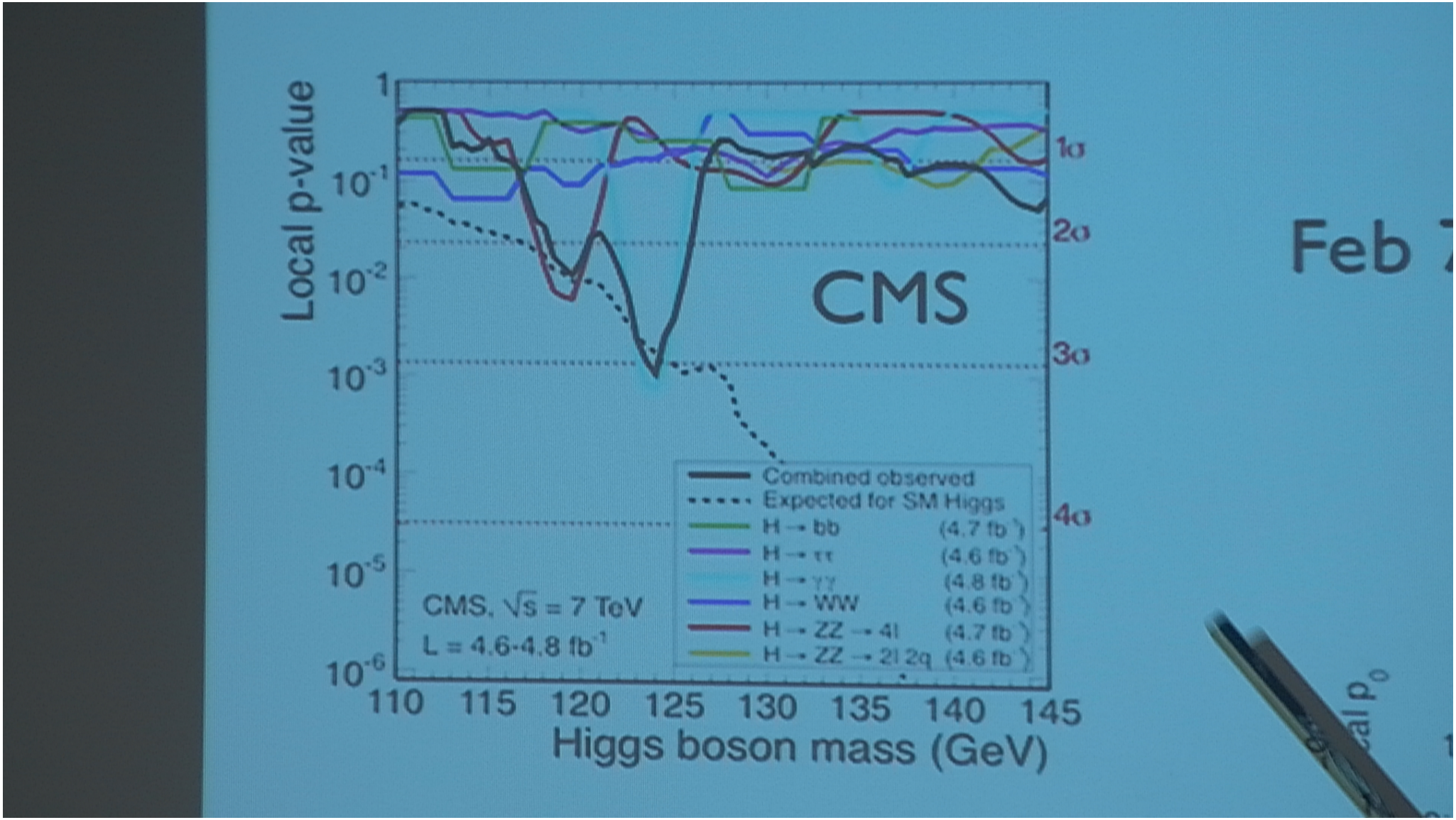
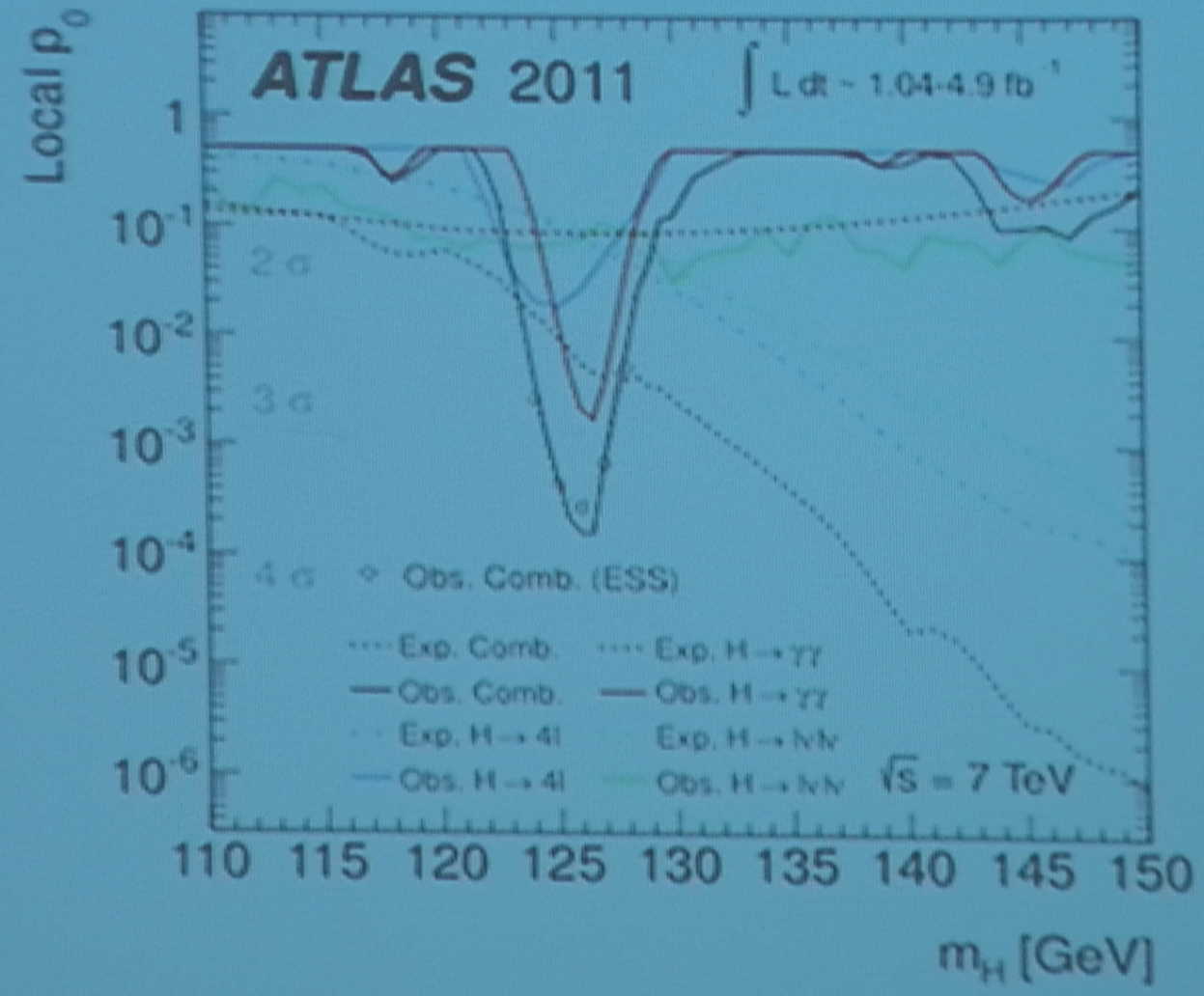

Local p0
ATLAS 2011
∫ L dt ~ 1.04-4.9 fb⁻¹
2 σ
3 σ
4 σ
Obs. Comb. (ESS)
Exp. Comb.
Obs. Comb.
Exp. H → 4l
Obs. H → 4l
Exp. H → γγ
Obs. H → γγ
Exp. H → lνlν
Obs. H → lνlν
√s = 7 TeV
mH [GeV]



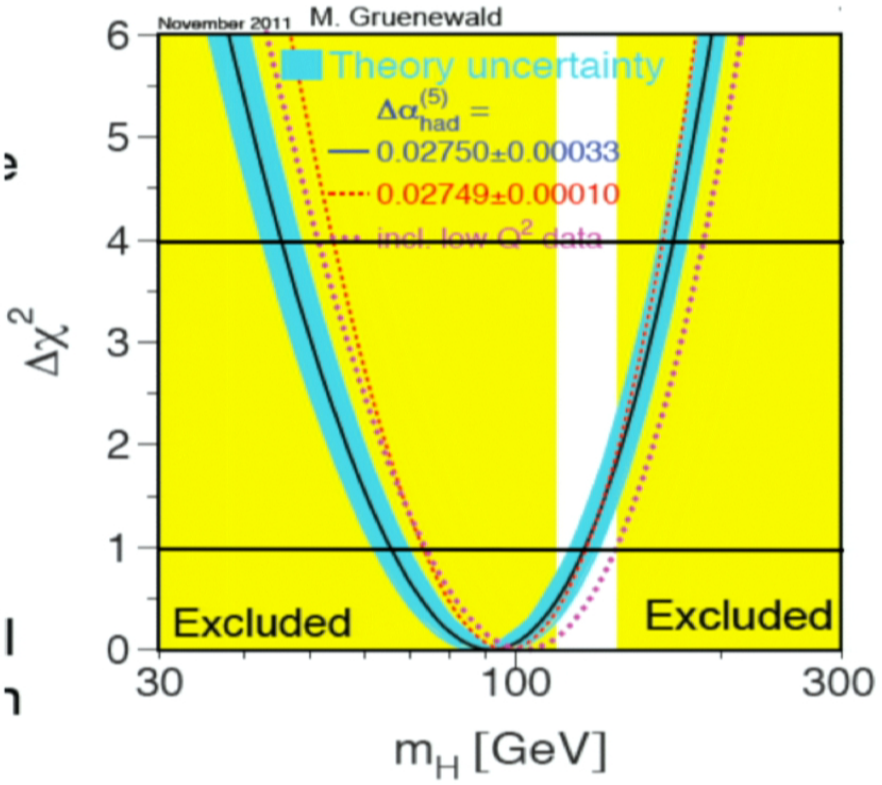
Feb 7

Local p_0


Local p-value
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
1σ
2σ
3σ
4σ
CMS
CMS, $\sqrt{s}$ = 7 TeV
L = 4.6-4.8 fb^{-1}
Combined observed
Expected for SM Higgs
H → bb (4.7 fb^{-1})
H → ττ (4.6 fb^{-1})
H → γγ (4.8 fb^{-1})
H → WW (4.6 fb^{-1})
H → ZZ → 4l (4.7 fb^{-1})
H → ZZ → 2l 2q (4.6 fb^{-1})
110 115 120 125 130 135 140 145
Higgs boson mass (GeV)
Feb 7

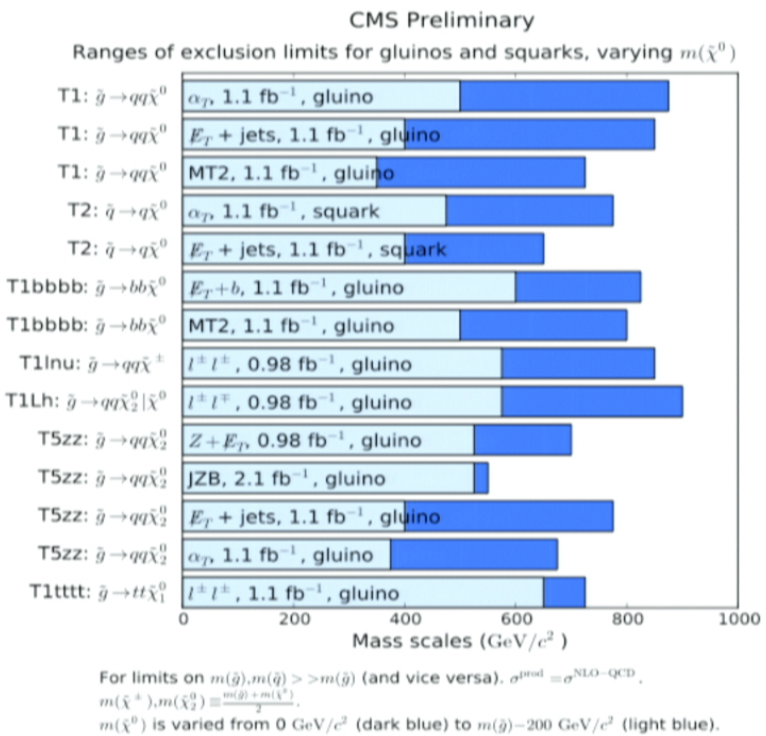

ATLAS 2011
∫ L dt ~ 1.04-4.9 fb⁻¹
Local p0
1
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
2σ
3σ
4σ
Obs. Comb. (ESS)
Exp. Comb.
Obs. Comb.
Exp. H→γγ
Obs. H→γγ
Exp. H→4l
Obs. H→4l
Exp. H→lνlν
Obs. H→lνlν
√s = 7 TeV
110 115 120 125 130 135 140 145 150
mH [GeV]

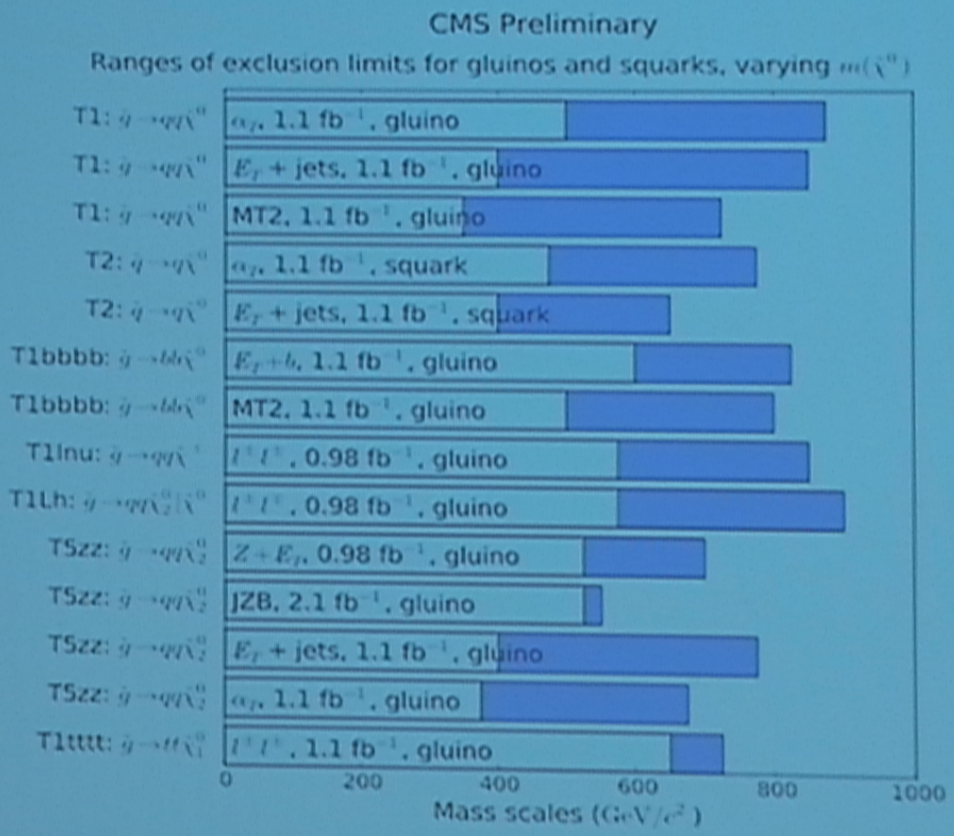
85 -28+39 GeV, that is to say, there is a 68% chance that it lies in the interval [57-124] GeV



2 sigma

1 sigma


CMS Preliminary
Ranges of exclusion limits for gluinos and squarks, varying $m(\tilde{\chi}^0)$
T1: $\tilde{g} \to qq\tilde{\chi}^0$
T1: $\tilde{g} \to qq\tilde{\chi}^0$
T1: $\tilde{g} \to qq\tilde{\chi}^0$
T2: $\tilde{q} \to q\tilde{\chi}^0$
T2: $\tilde{q} \to q\tilde{\chi}^0$
T1bbbb: $\tilde{g} \to bb\tilde{\chi}^0$
T1bbbb: $\tilde{g} \to bb\tilde{\chi}^0$
T1lnu: $\tilde{g} \to qq\tilde{\chi}^\pm$
T1Lh: $\tilde{g} \to qq\tilde{\chi}_2^0|\tilde{\chi}^0$
T5zz: $\tilde{g} \to qq\tilde{\chi}_2^0$
T5zz: $\tilde{g} \to qq\tilde{\chi}_2^0$
T5zz: $\tilde{g} \to qq\tilde{\chi}_2^0$
T5zz: $\tilde{g} \to qq\tilde{\chi}_2^0$
T1tttt: $\tilde{g} \to tt\tilde{\chi}_1^0$
α_T, 1.1 fb^{-1}, gluino
$\not{E}_T$ + jets, 1.1 fb^{-1}, gluino
MT2, 1.1 fb^{-1}, gluino
α_T, 1.1 fb^{-1}, squark
$\not{E}_T$ + jets, 1.1 fb^{-1}, squark
$\not{E}_T + b$, 1.1 fb^{-1}, gluino
MT2, 1.1 fb^{-1}, gluino
$l^\pm l^\pm$, 0.98 fb^{-1}, gluino
$l^\pm l^\mp$, 0.98 fb^{-1}, gluino
$Z + \not{E}_T$, 0.98 fb^{-1}, gluino
JZB, 2.1 fb^{-1}, gluino
$\not{E}_T$ + jets, 1.1 fb^{-1}, gluino
α_T, 1.1 fb^{-1}, gluino
$l^\pm l^\pm$, 1.1 fb^{-1}, gluino
0
200
400
600
800
1000
Mass scales (GeV/c^2)
For limits on $m(\tilde{g}),m(\tilde{q}) >> m(\tilde{g})$ (and vice versa). $\sigma^{\text{prod}} = \sigma^{\text{NLO-QCD}}$.
$m(\tilde{\chi}^\pm),m(\tilde{\chi}_2^0) \equiv \frac{m(\tilde{g})+m(\tilde{\chi}^0)}{2}$.
$m(\tilde{\chi}^0)$ is varied from 0 GeV/c^2 (dark blue) to $m(\tilde{g})-200$ GeV/c^2 (light blue).


CMS Preliminary
Ranges of exclusion limits for gluinos and squarks, varying $m(\tilde{\chi}^0)$
T1: $\tilde{g}\to qq\tilde{\chi}^0$
α_T, 1.1 fb^{-1}, gluino
T1: $\tilde{g}\to qq\tilde{\chi}^0$
$\not{E}_T$ + jets, 1.1 fb^{-1}, gluino
T1: $\tilde{g}\to qq\tilde{\chi}^0$
MT2, 1.1 fb^{-1}, gluino
T2: $\tilde{q}\to q\tilde{\chi}^0$
α_T, 1.1 fb^{-1}, squark
T2: $\tilde{q}\to q\tilde{\chi}^0$
$\not{E}_T$ + jets, 1.1 fb^{-1}, squark
T1bbbb: $\tilde{g}\to bb\tilde{\chi}^0$
$\not{E}_T$+b, 1.1 fb^{-1}, gluino
T1bbbb: $\tilde{g}\to bb\tilde{\chi}^0$
MT2, 1.1 fb^{-1}, gluino
T1lnu: $\tilde{g}\to qq\tilde{\chi}^\pm$
$l^\pm l^\pm$, 0.98 fb^{-1}, gluino
T1Lh: $\tilde{g}\to qq\tilde{\chi}_2^0[\tilde{\chi}^0$
$l^\pm l^\pm$, 0.98 fb^{-1}, gluino
T5zz: $\tilde{g}\to qq\tilde{\chi}_2^0$
Z+$\not{E}_T$, 0.98 fb^{-1}, gluino
T5zz: $\tilde{g}\to qq\tilde{\chi}_2^0$
JZB, 2.1 fb^{-1}, gluino
T5zz: $\tilde{g}\to qq\tilde{\chi}_2^0$
$\not{E}_T$ + jets, 1.1 fb^{-1}, gluino
T5zz: $\tilde{g}\to qq\tilde{\chi}_2^0$
α_T, 1.1 fb^{-1}, gluino
T1tttt: $\tilde{g}\to tt\tilde{\chi}_1^0$
$l^\pm l^\pm$, 1.1 fb^{-1}, gluino
0
200
400
600
800
1000
Mass scales (GeV/c^2)
For limits on $m(\tilde{g}),m(\tilde{q})>>m(\tilde{g})$ (and vice versa), $\sigma^{prod}=\sigma^{NLO+NLL}$,
$m(\tilde{\chi}^\pm),m(\tilde{\chi}_2^0)=\frac{m(\tilde{g})+m(\tilde{\chi}^0)}{2}$,
$m(\tilde{\chi}^0)$ is varied from 0 GeV/c^2 (dark blue) to $m(\tilde{g})-200$ GeV/c^2 (light blue).