

α_s (2019) introduction

α_s (2019) workshop

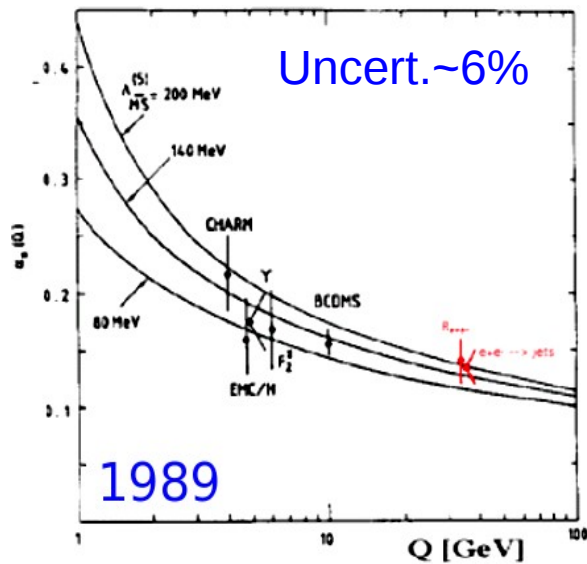
ECT* (Trento), 11th -15th Feb. 2019

David d'Enterria (CERN)

Stefan Kluth (MPP, MPI)

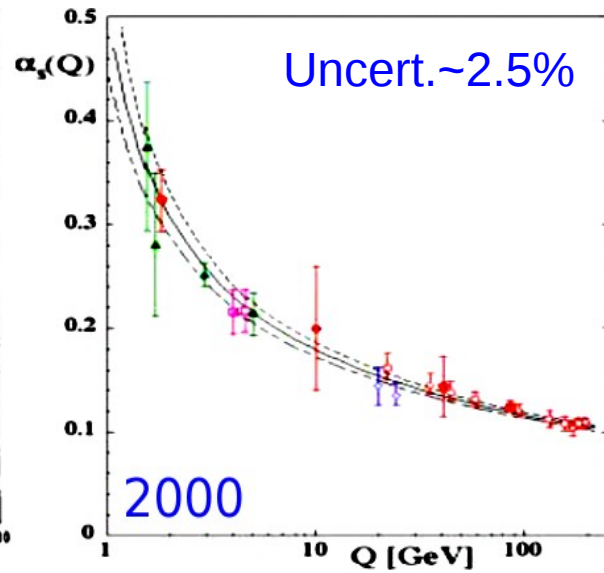
QCD coupling α_s

- ➔ Determines **strength of the strong interaction** between quarks & gluons.
- ➔ **Single free parameter in QCD** in the $m_q \rightarrow 0$ limit.
- ➔ Determined at a ref. scale ($Q=m_Z$), decreases as $\alpha_s \sim \ln(Q^2/\Lambda^2)^{-1}$, $\Lambda \sim 0.2$ GeV



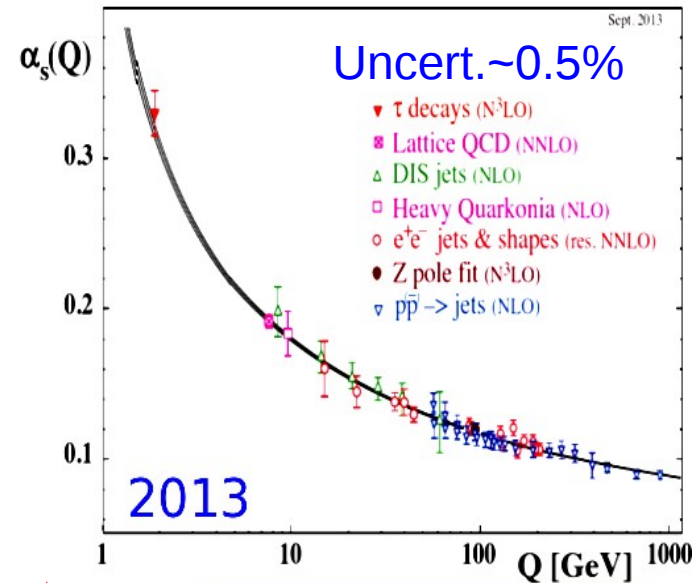
$$\alpha_s(M_Z) = 0.110^{+0.006}_{-0.008} \text{ (NLO)}$$

G. Altarelli, Ann. Rev. Nucl. Part. Sci. 39, 1989



$$\alpha_s(M_Z) = 0.1184 \pm 0.0031 \text{ (NNLO)}$$

S. B. , J. Phys. G 26, 2000

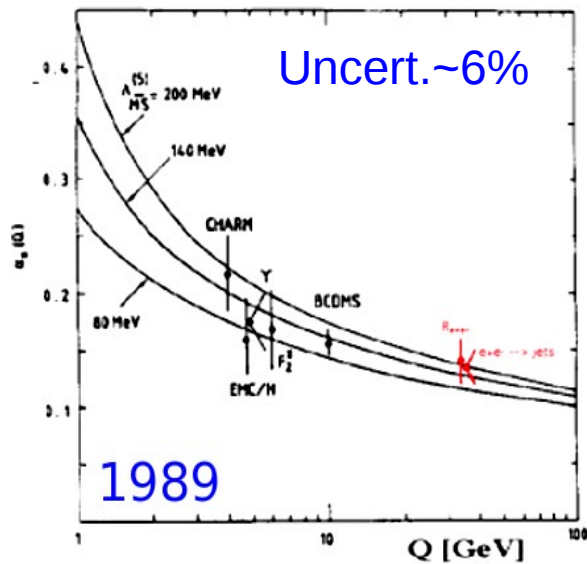


$$\alpha_s(M_Z) = 0.1185 \pm 0.0006 \text{ (NNLO)}$$

Sept. 2013

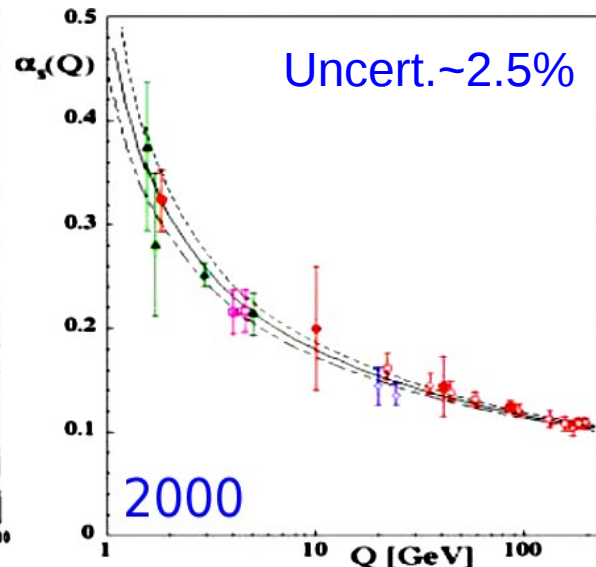
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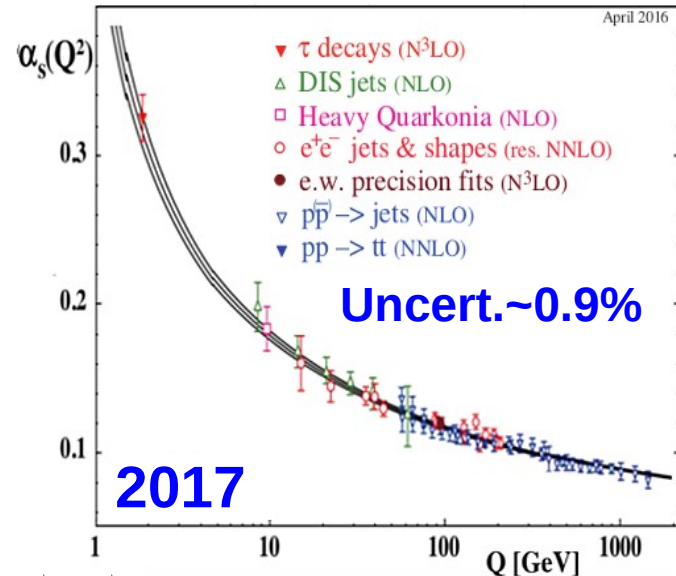
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$$\alpha_s(M_Z) = 0.1181 \pm 0.0011 \text{ (NNLO)}$$

- ➔ **Least precisely known** of all interaction **couplings** !

$$\delta\alpha \sim 10^{-10} \ll \delta G_F \ll 10^{-7} \ll \delta G \sim 10^{-5} \ll \delta\alpha_s \sim 10^{-3}$$

Key role of the QCD coupling α_s

Impacts all QCD x-sections & decays (H), precision top & parametric EWPO:

Process	σ (pb)	$\delta\alpha_s$ (%)	PDF + α_s (%)	Scale (%)
ggH	49.87	± 3.7	-6.2 +7.4	-2.61 + 0.32
ttH	0.611	± 3.0	± 8.9	-9.3 + 5.9

Channel	M_H [GeV]	$\delta\alpha_s$ (%)	Δm_b	Δm_c
H $\rightarrow c\bar{c}$	126	± 7.1	$\pm 0.1\%$	$\pm 2.3\%$
H $\rightarrow gg$	126	± 4.1	$\pm 0.1\%$	$\pm 0\%$

Msbar mass error budget (from threshold scan)

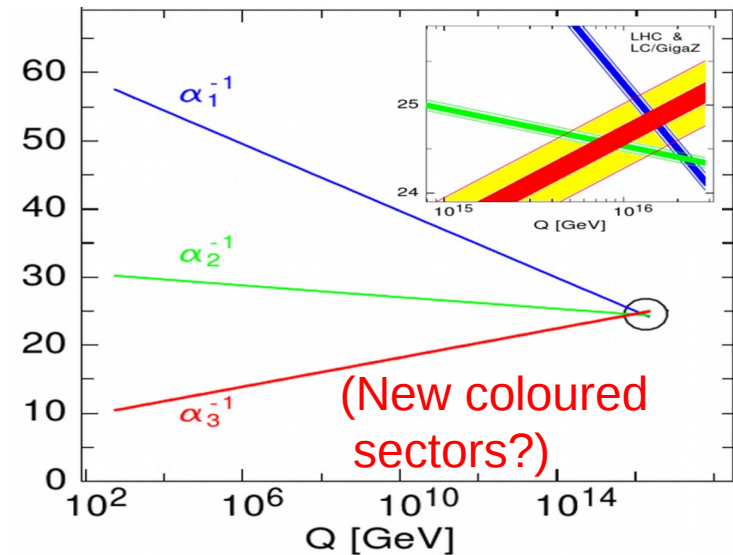
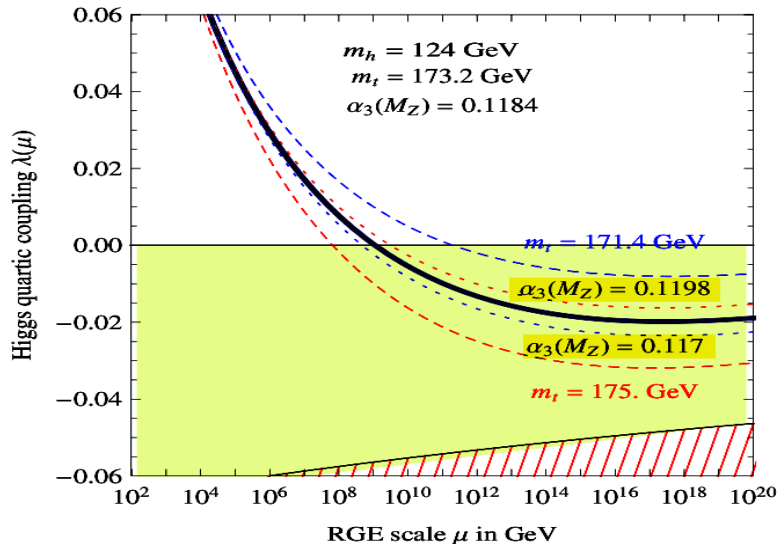
$(\delta M_t^{\text{SD-low}})^{\text{exp}}$	$(\delta M_t^{\text{SD-low}})^{\text{theo}}$	$(\delta \bar{m}_t(\bar{m}_t))^{\text{conversion}}$	$(\delta \bar{m}_t(\bar{m}_t))^{\alpha_s}$
40 MeV	50 MeV	7 – 23 MeV	70 MeV

\Rightarrow improvement in α_s crucial $\delta\alpha_s(M_Z) = 0.001$

Quantity	FCC-ee	future param.unc.	Main source
Γ_Z [MeV]	0.1	0.1	$\delta\alpha_s$
R_b [10^{-5}]	6	< 1	$\delta\alpha_s$
R_ℓ [10^{-3}]	1	1.3	$\delta\alpha_s$

Sven Heinemeyer – 1st FCC physics workshop, CERN, 17.01.2017

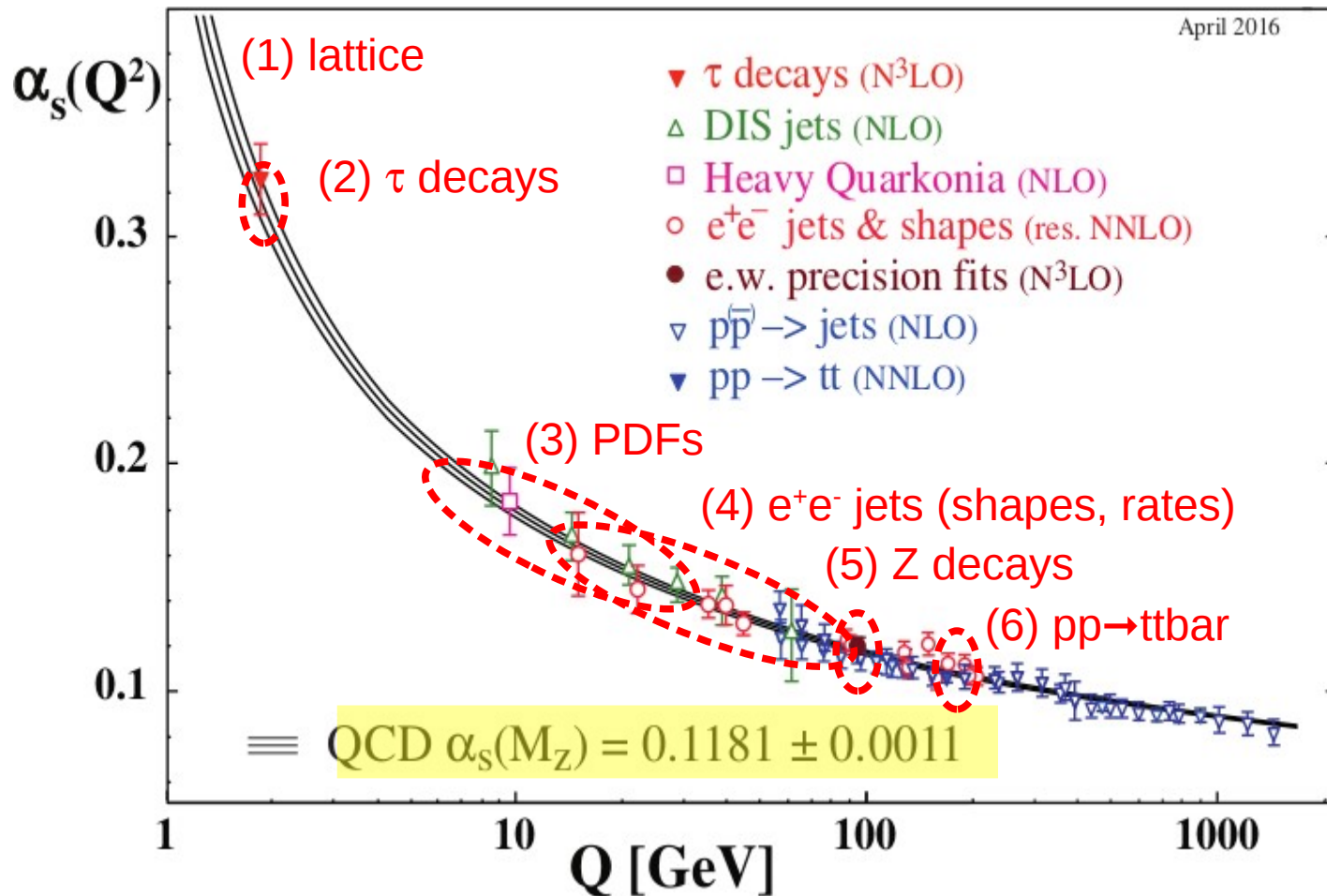
Impacts physics approaching Planck scale: EW vacuum stability, GUT



World α_s determination (PDG 2017)

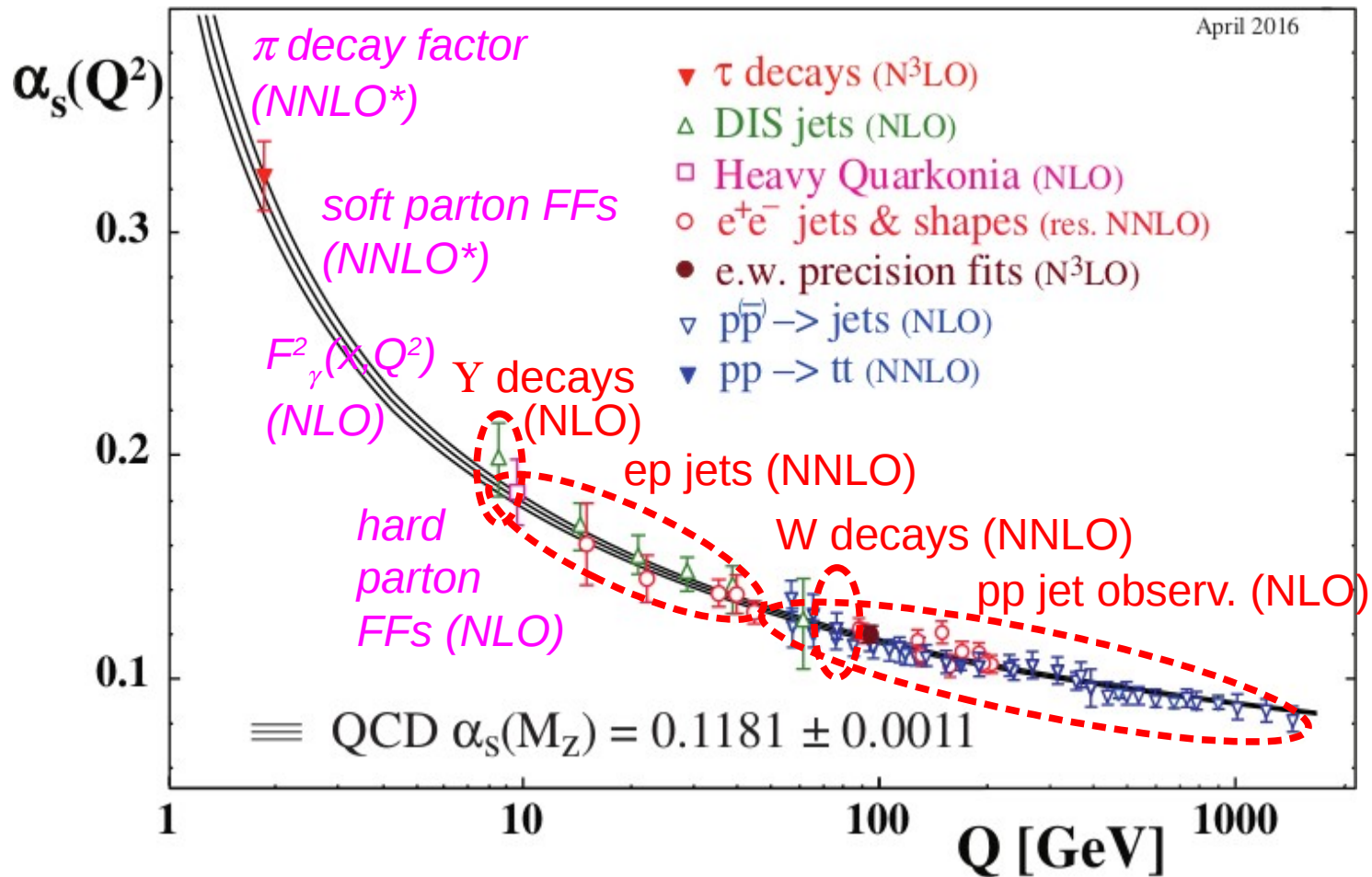
- Determined today by comparing 6 experimental observables to pQCD NNLO, N³LO predictions, plus global average at the Z pole scale:

[Bethke/Dissertori/Salam]

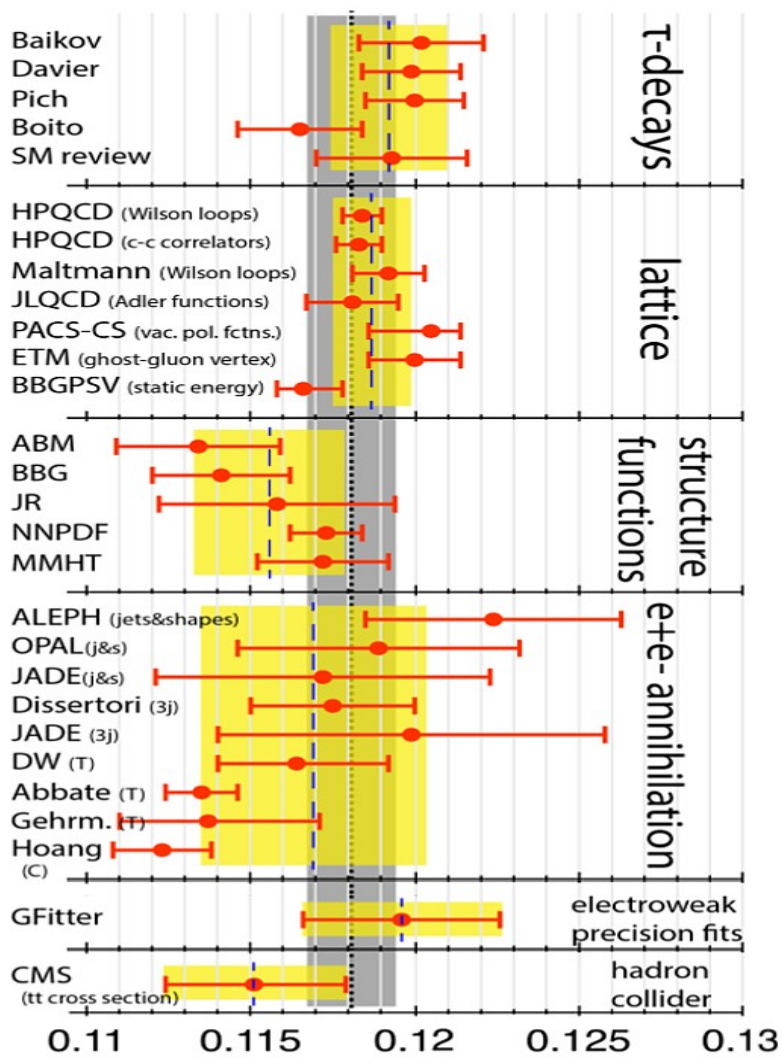


Other α_s extractions (not yet in world average)

- There exist **at least 8 other classes of observables**, computed at lower accuracy (**NLO, NNLO***), used to extract the QCD coupling:



PDG 2017 α_s world average (NNLO)



class averages:

$$\alpha_s(M_Z) = 0.1192 \pm 0.0018 \quad (\pm 1.5\%)$$

$$\alpha_s(M_Z) = 0.1184 \pm 0.0012 \quad (\pm 1.0\%)$$

$$\alpha_s(M_Z) = 0.1156 \pm 0.0021 \quad (\pm 1.8\%)$$

$$\alpha_s(M_Z) = 0.1169 \pm 0.0034 \quad (\pm 2.9\%)$$

$$\alpha_s(M_Z) = 0.1196 \pm 0.0030 \quad (\pm 2.5\%)$$

$$\alpha_s(M_Z) = 0.1151 \pm 0.0028 \quad (\pm 2.5\%)$$

unweighted χ^2 average:

$$\alpha_s(M_Z) = 0.1181 \pm 0.0011 \quad (\pm 0.9\%)$$

Structure of the workshop

- Discuss latest developments & prospects in $\alpha_s(m_Z)$ determinations via:
 - (i) Lattice QCD: **Mo. afternoon, Tues. morning**
 - (ii) Hadronic tau decays: **Thurs. morning**
 - (iii) DIS & global PDF analyses: **Tues. afternoon**
 - (iv) Hadronic final states in e^+e^- : **Wed. morning**
 - (v) Hadronic final states at the LHC: **Wed. afternoon, Thurs. morning**
- Discuss $\alpha_s(m_Z)$ averaging: **Friday morning**
- Prepare online proceedings contributions: **Thurs. afternoon**
- **Each talk has an indicative 30' allocated time**, but our goal is to have as lively and direct discussions as possible: **questions during presentations are encouraged** (in the philosophy of a truly working-discussion meeting).
- We have ample time at the end of each day, so **no strong time constraints will be actually imposed** on each talk: EXCEPT that we need to respect scheduled times for **lunch (12:30 – 14:00) & coffee breaks (10:30-11:00 and ~15:00-15:30)**

“Logistics” organization

- 1) Remind to **sign every morning the 3 reception-desks lists:** presence book, dinners, lunches.

LUNCHES:

Monday--Friday: At the ECT* canteen.

DINNERS:

Sunday 02/10/2019 (for participants arriving Sunday to Trento): **PIZZA DINNER** from 19.00 to 23:00 at **Ristorante Pizzeria Bouganville** <http://www.bouganvilletrento.com/>

Monday 02/11/2019 at 20:00: **WELCOME DINNER** *Scigno del Duomo* <http://www.scignodelduomo.com/?lang=en>

Tuesday 02/12/2019 at 20:00: **Ristorante Antico Pozzo** <https://www.antico-pozzo.it/>

Wednesday 02/13/2019 at 18:00 (1 hour after the end of last talk): **Trattoria Baracca** <http://www.trattoriabaracca.it/>

Thursday 02/14/2019 at 18:00: **SOCIAL DINNER** at the ECT* canteen.

Friday 02/15/2019 (for participants who stay in Trento on Friday): **PIZZA DINNER** from 19.00 PM to 23:00 PM at **Ristorante Pizzeria Bouganville** <http://www.bouganvilletrento.com/>

- 2) Pick up your certificate of attendance.

- 3) Fill out the survey for evaluation of catering service.

Backup slides