LHC Phenomenology

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For Precision High Energy Physics (PHEP) 2018: School for future colliders

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LHC Instagram

Some Numbers

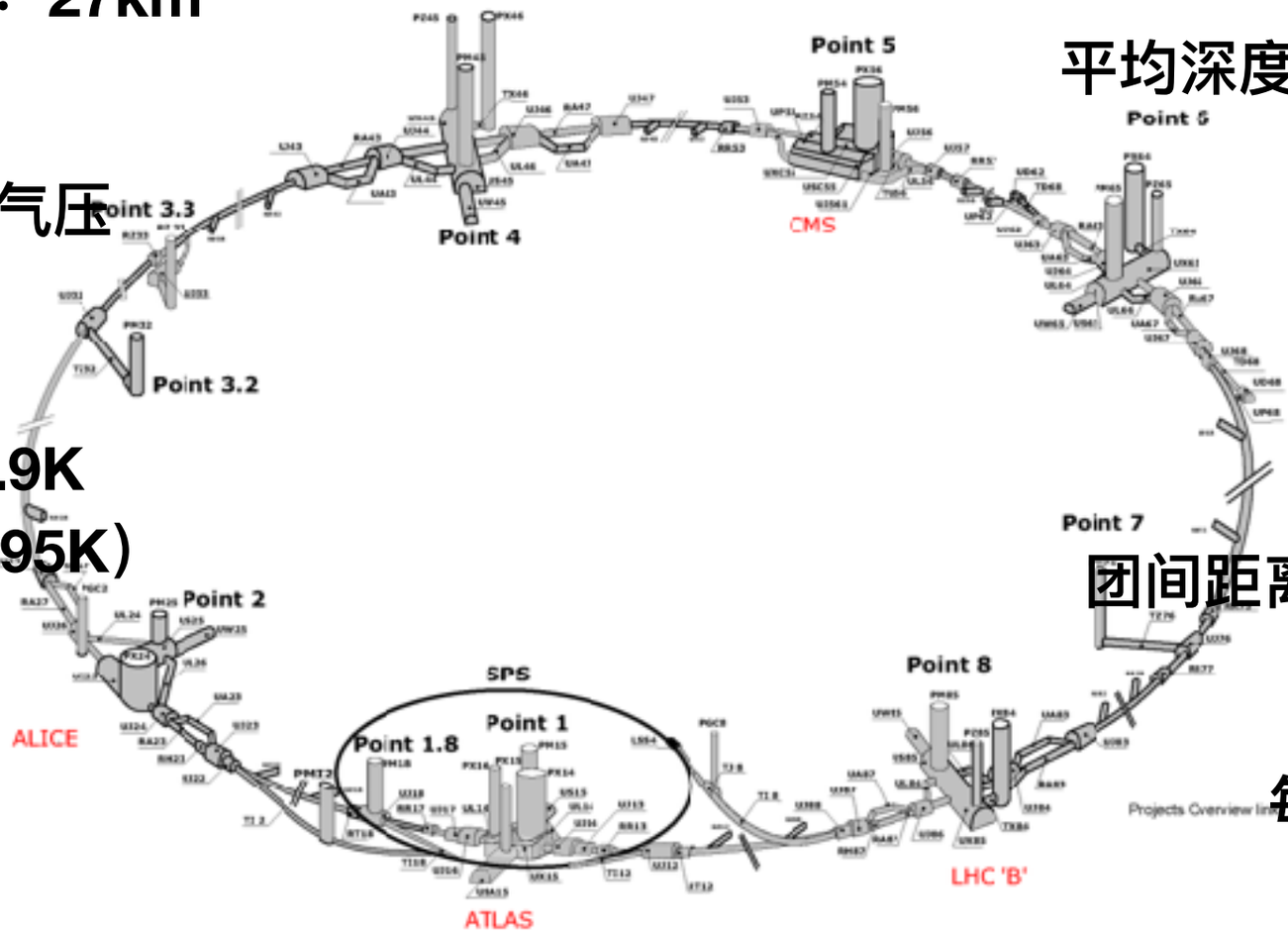
对撞能量：14TeV=2.2×10^{-6}J, v=0.999999991c

造价: 4332 兆瑞士法郎　　月球潮汐力影响：1毫米

周长：27km

平均深度：地下100米

高真空：10^{-13}标准大气压



超低温：超导磁铁1.9K
（CMB 2.71K, CNB 1.95K）

每束团数：2808

团间距离：7.5米（25纳秒）

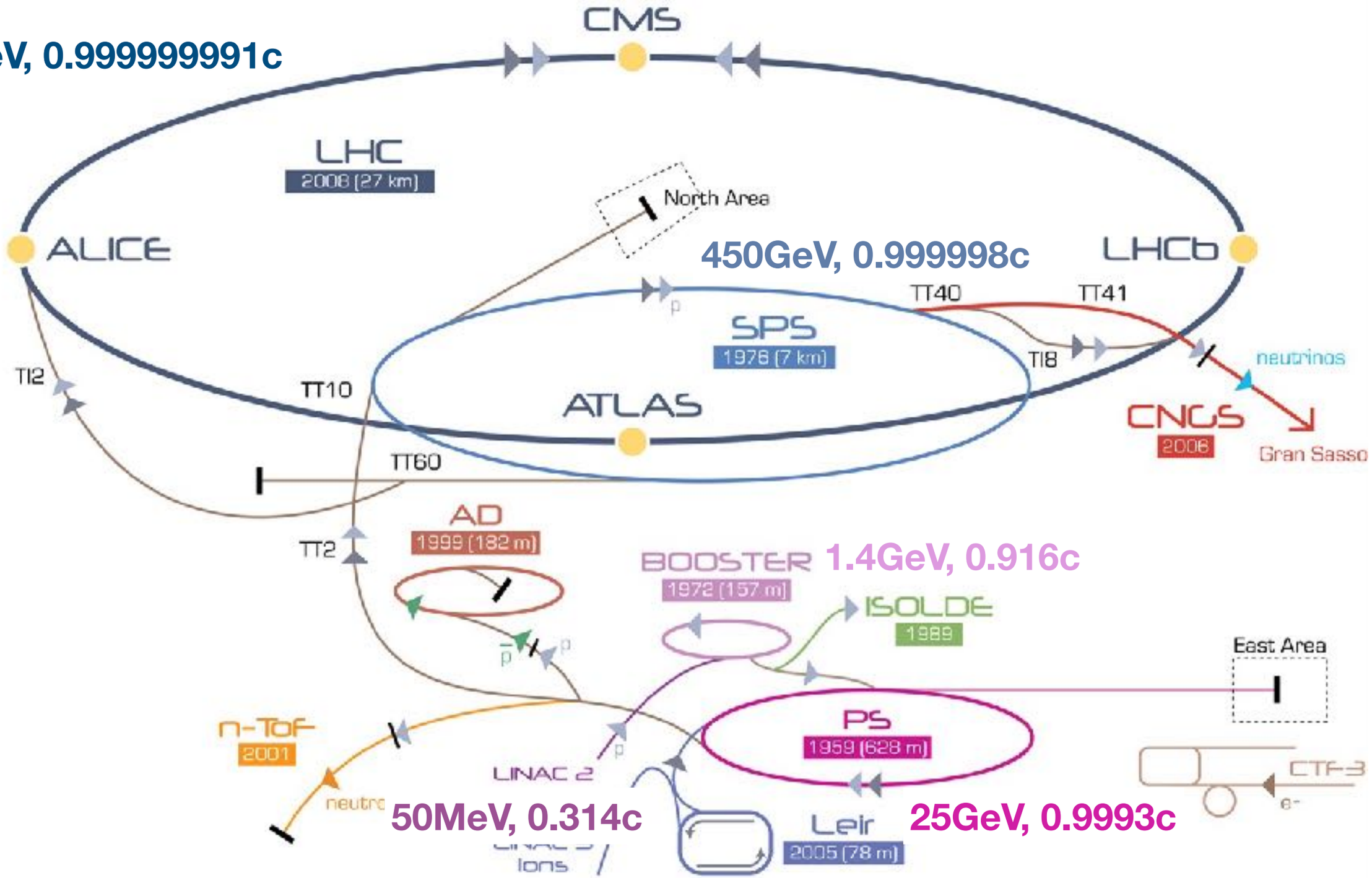
9593块各型磁铁

每团质子数：1.2×10^{11}

偶极磁铁1232块：15米长，35吨，超导线圈
（1.9K，电流强度11850安培），8.33特斯拉

每秒10亿次粒子对撞

7TeV, 0.999999991c



p (proton) ion neutrons p̄ (antiproton) proton/antiproton conversion neutrinos electron

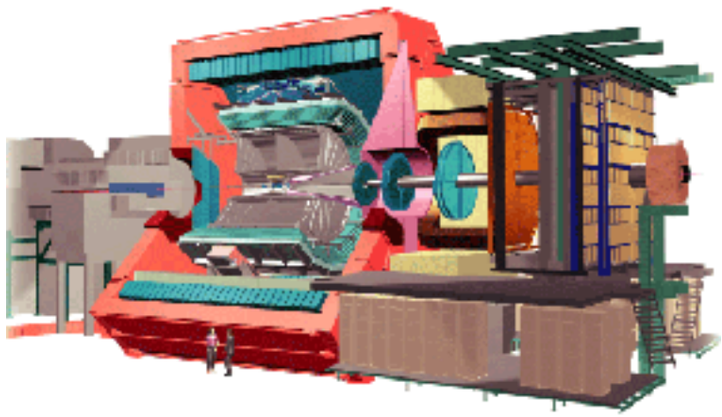
LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron

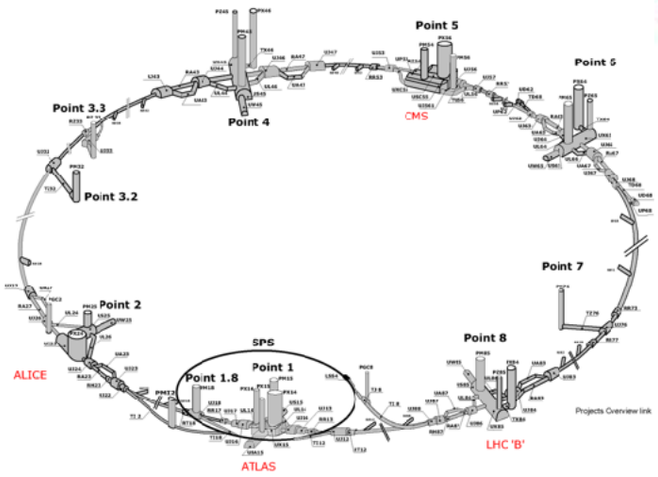
AD Antiproton Decelerator CTF-3 Clic Test Facility CNGS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice

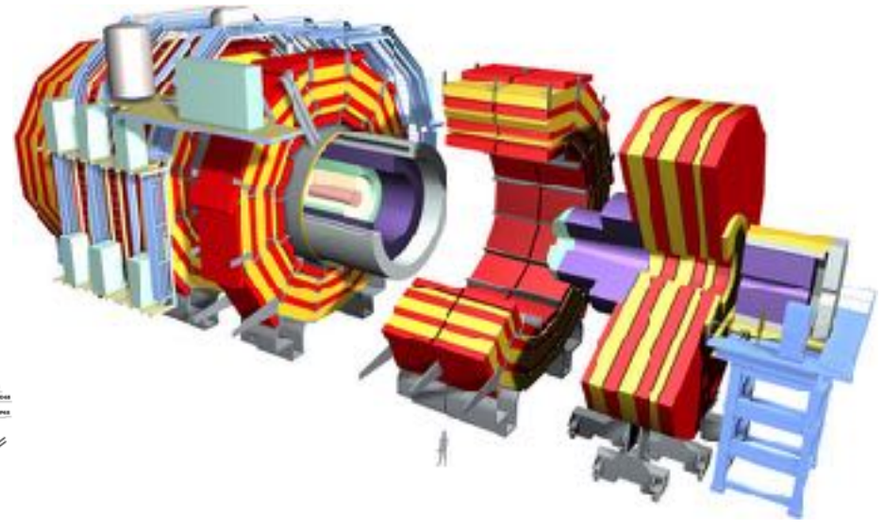
LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight

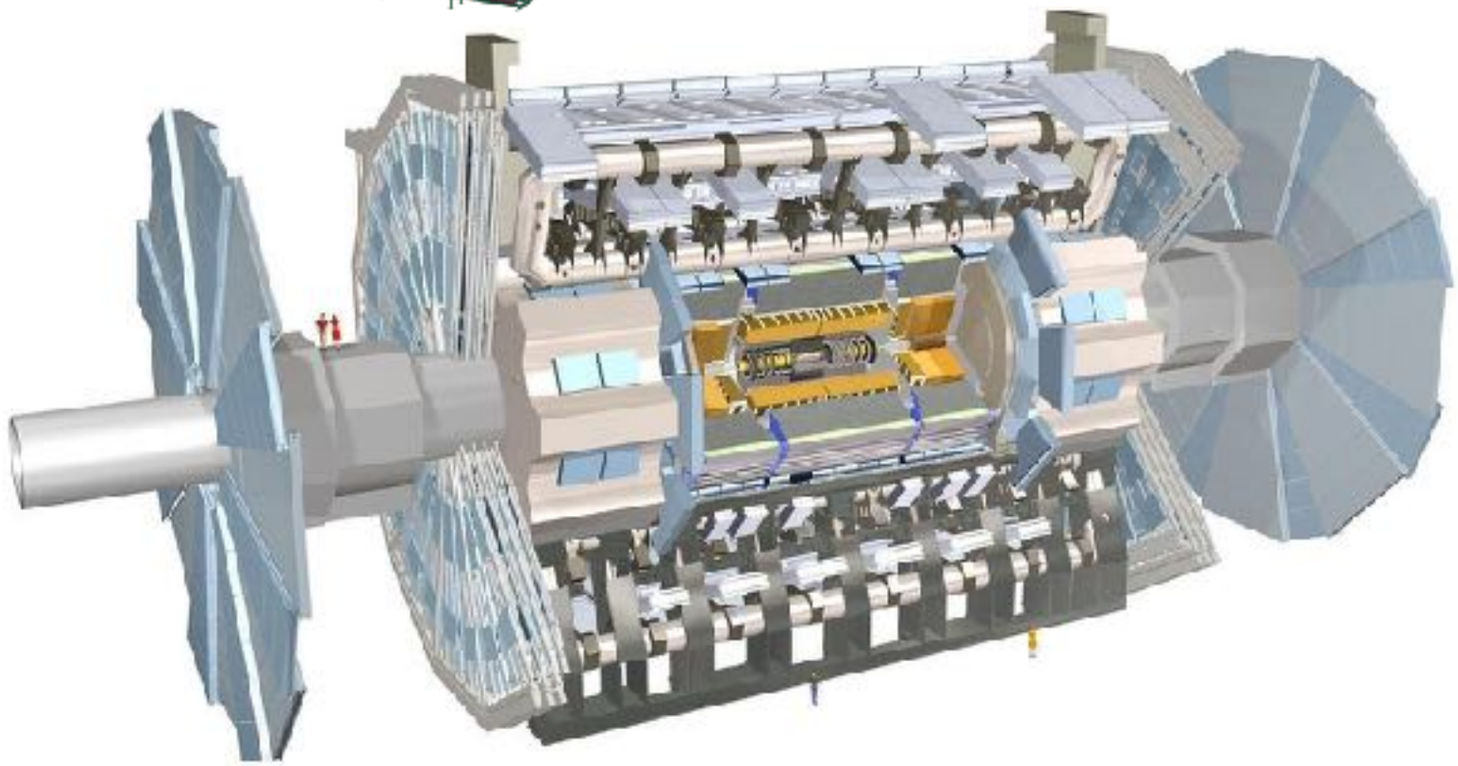
The Detectors

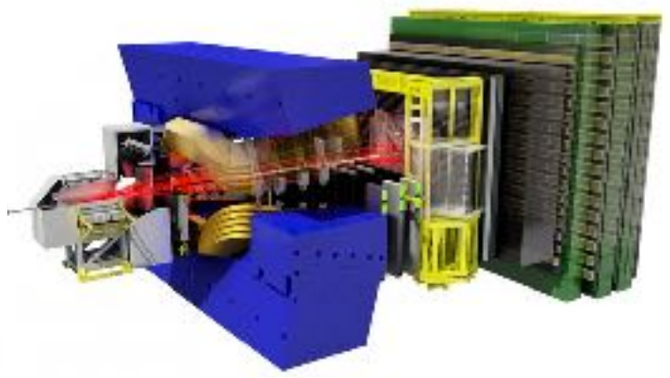
记录数据量~50PB=5千万GB每年！











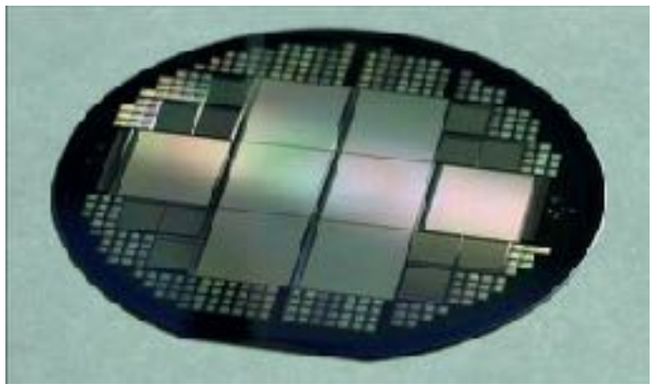
ATLAS produces about 1 GB/s

CMS produces about 1 GB/s

LHCb produces about 0.6 GB/s

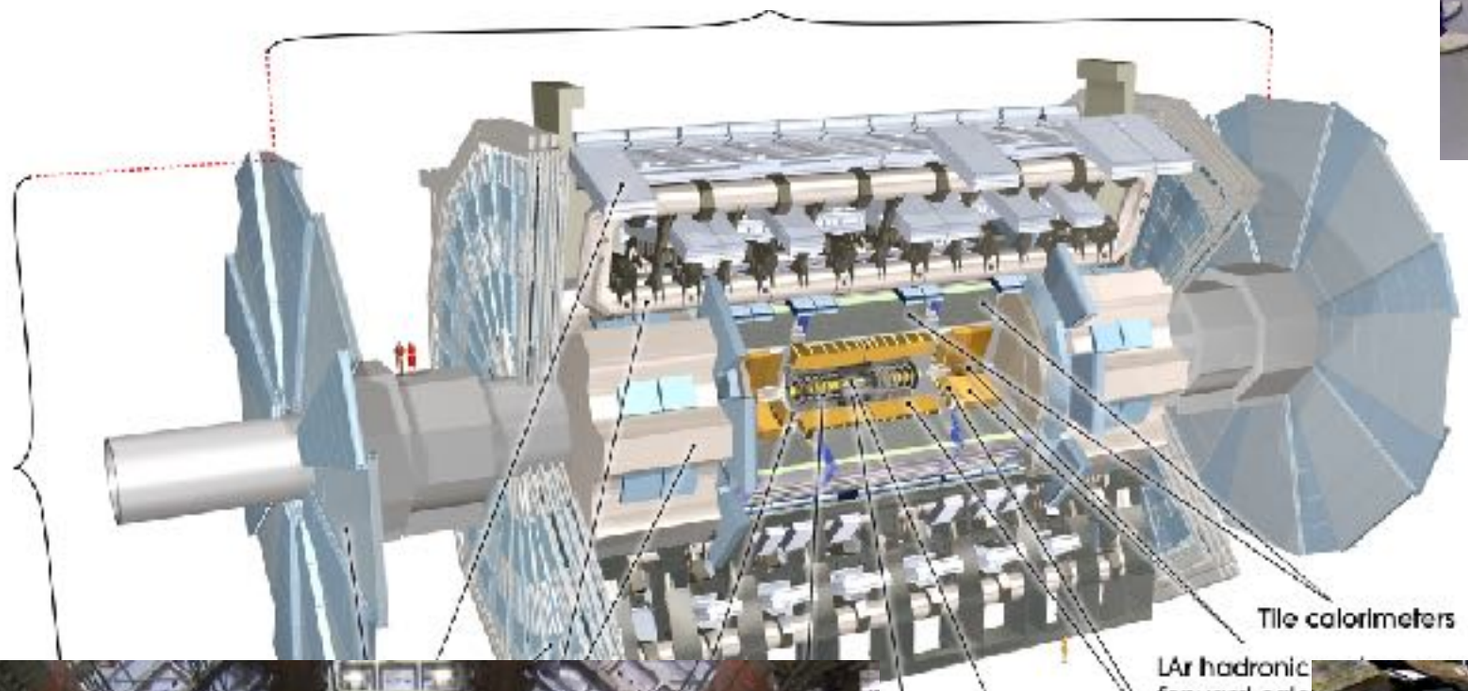
ALICE produces several GB/s during heavy-ion running

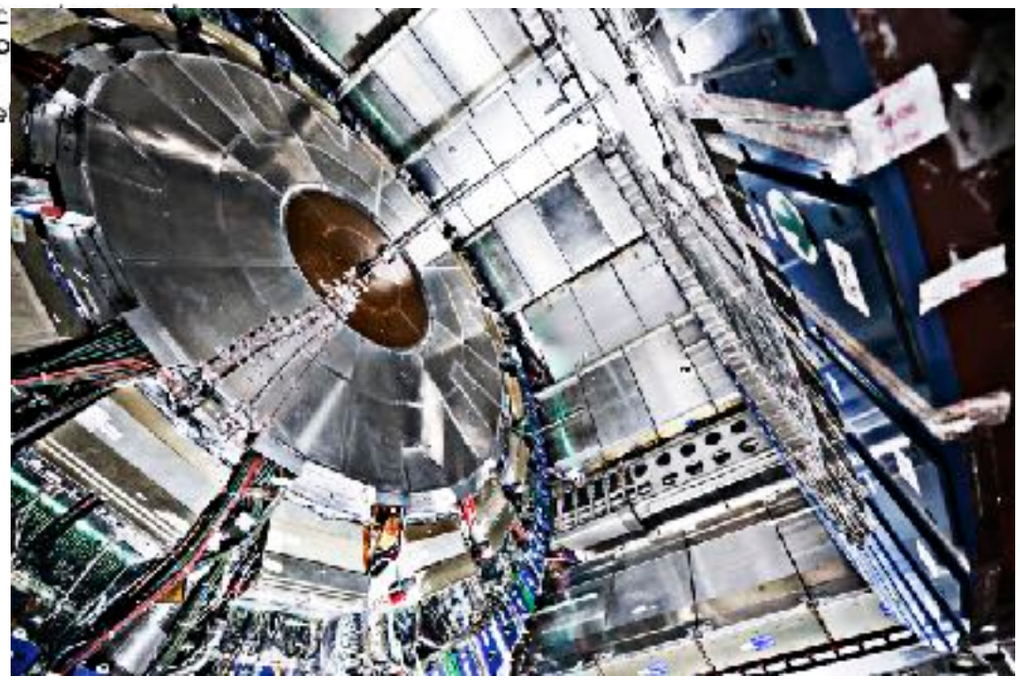
An Example: ATLAS

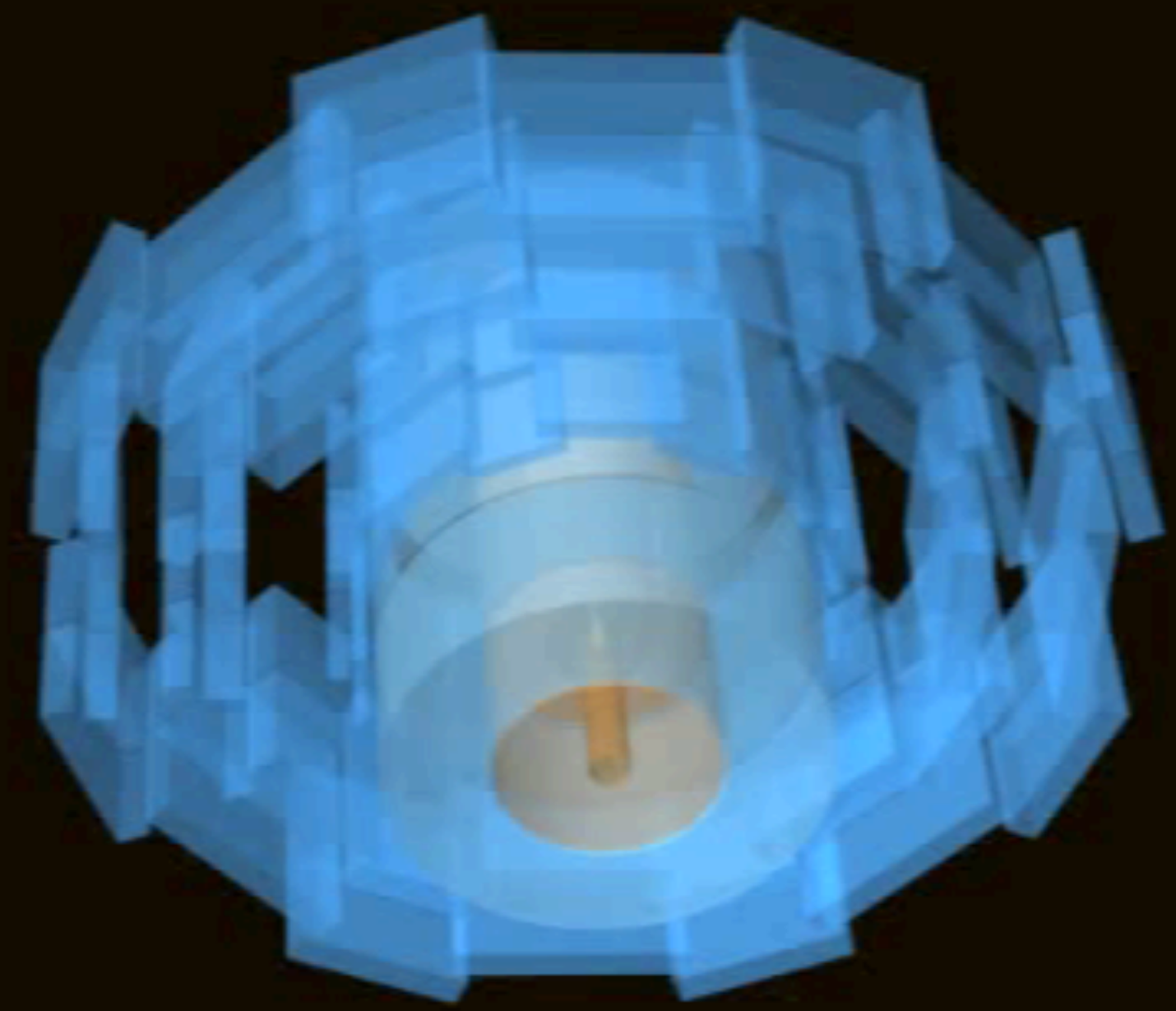


46米长

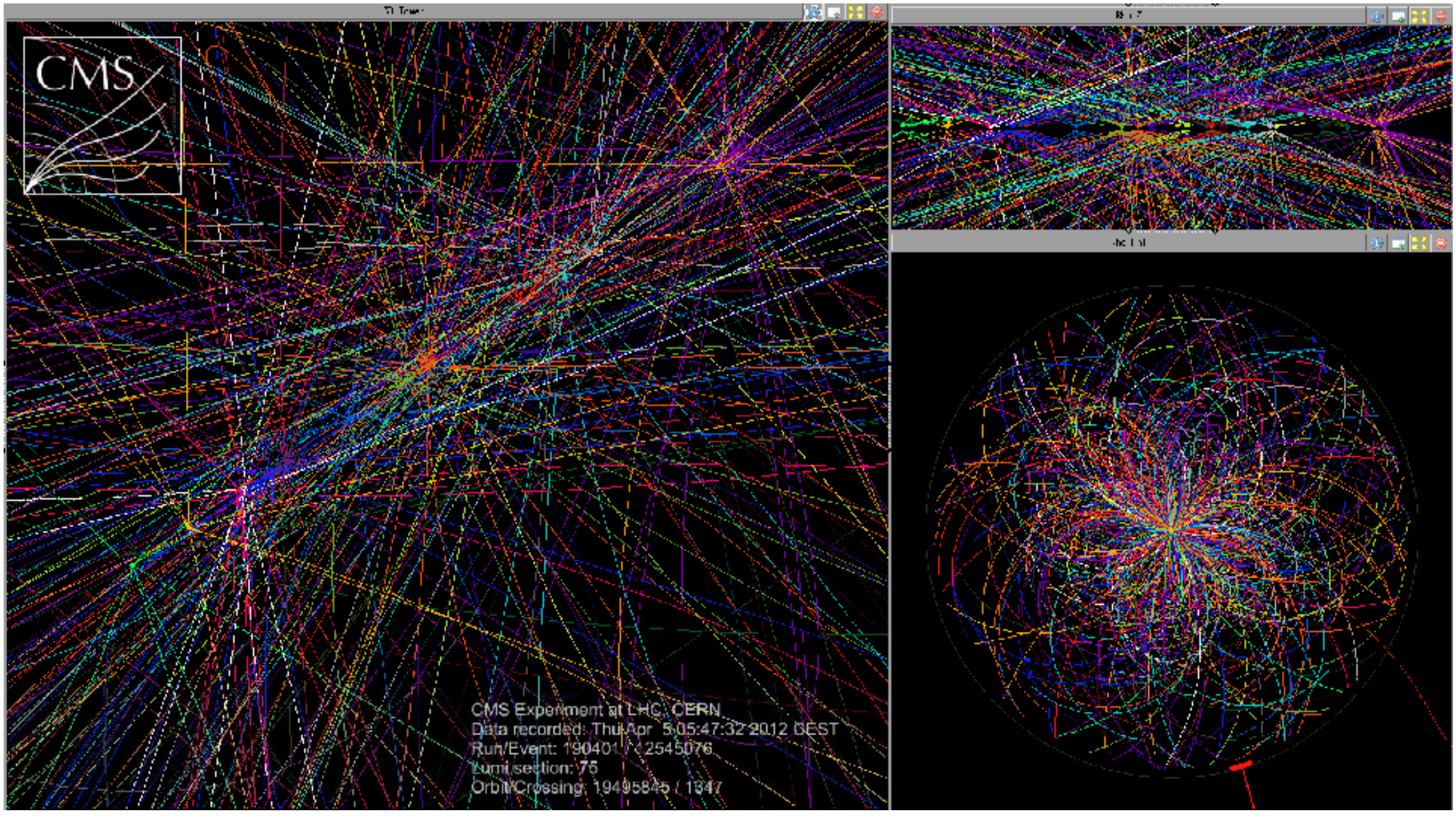
直径
26米





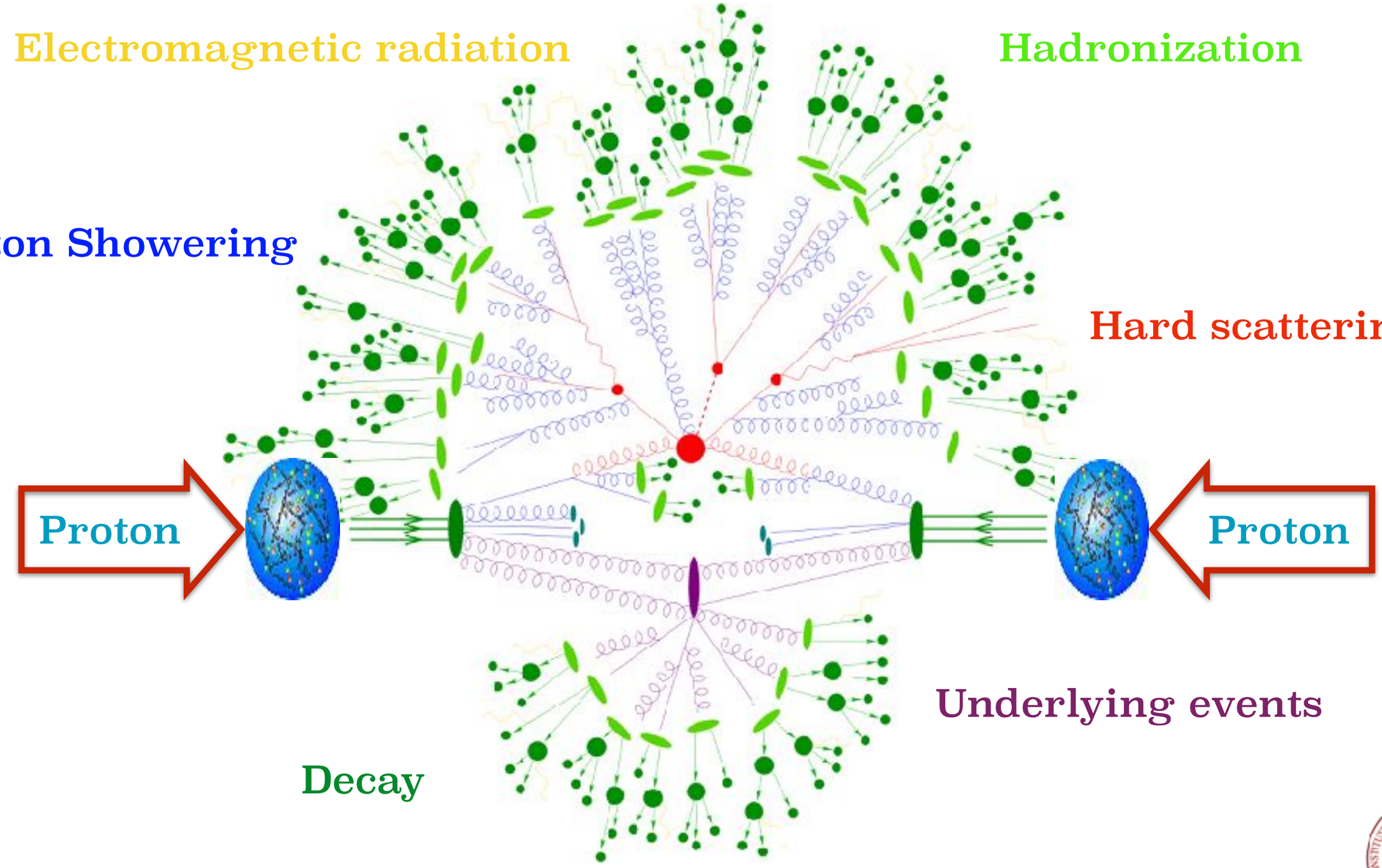


Reconstruction of the particles



pp Collision

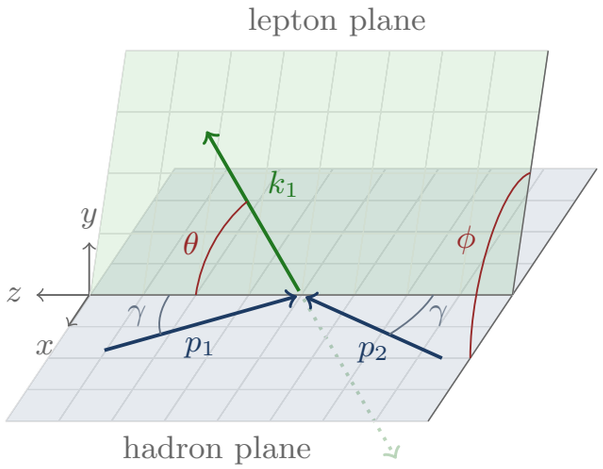
- The proton-proton collision.

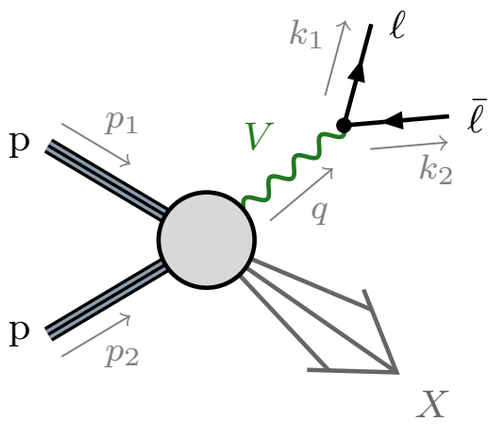


Why precisely calculation?

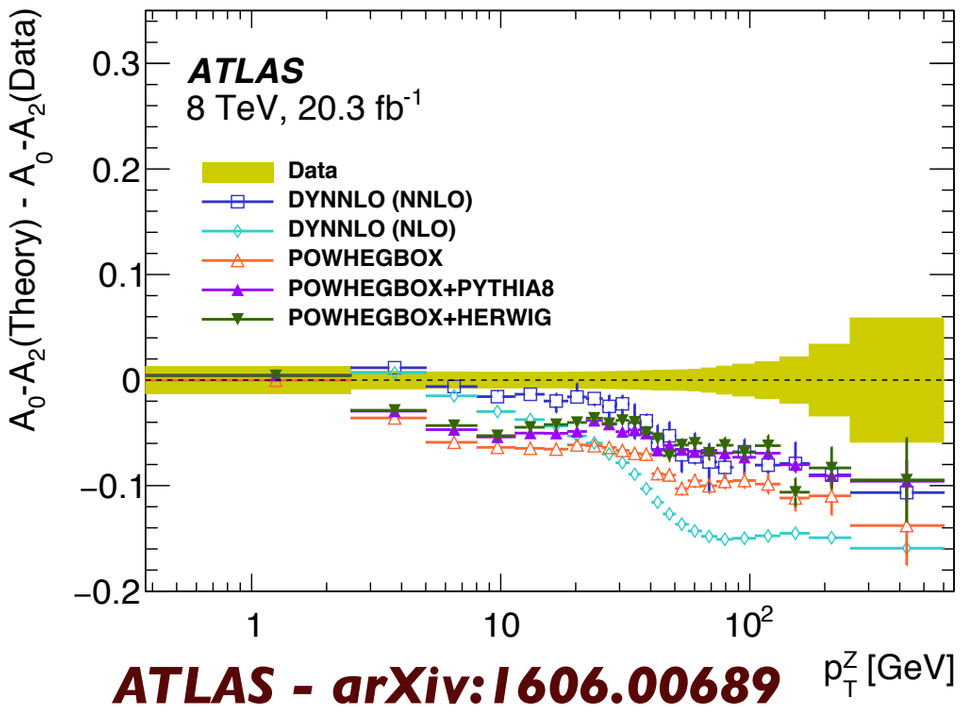
Angular Coefficients in Z-boson production

Rhorry Gauld





$$\frac{d\sigma}{d^4q\ \cos\theta\ d\phi} = \frac{3}{16\pi}\ \frac{d\sigma^{\text{unpol.}}}{d^4q}\Big\{(1+\cos^2\theta) + \frac{1}{2}\ A_0\ (1-3\cos^2\theta)$$
$$+ A_1\ \sin(2\theta)\cos\phi + \frac{1}{2}\ A_2\ \sin^2\theta\ \cos(2\phi)$$
$$+ A_3\ \sin\theta\ \cos\phi + A_4\ \cos\theta + A_5\ \sin^2\theta\ \sin(2\phi)$$
$$+ A_6\ \sin(2\theta)\ \sin\phi + A_7\ \sin\theta\ \sin\phi\Big\}$$



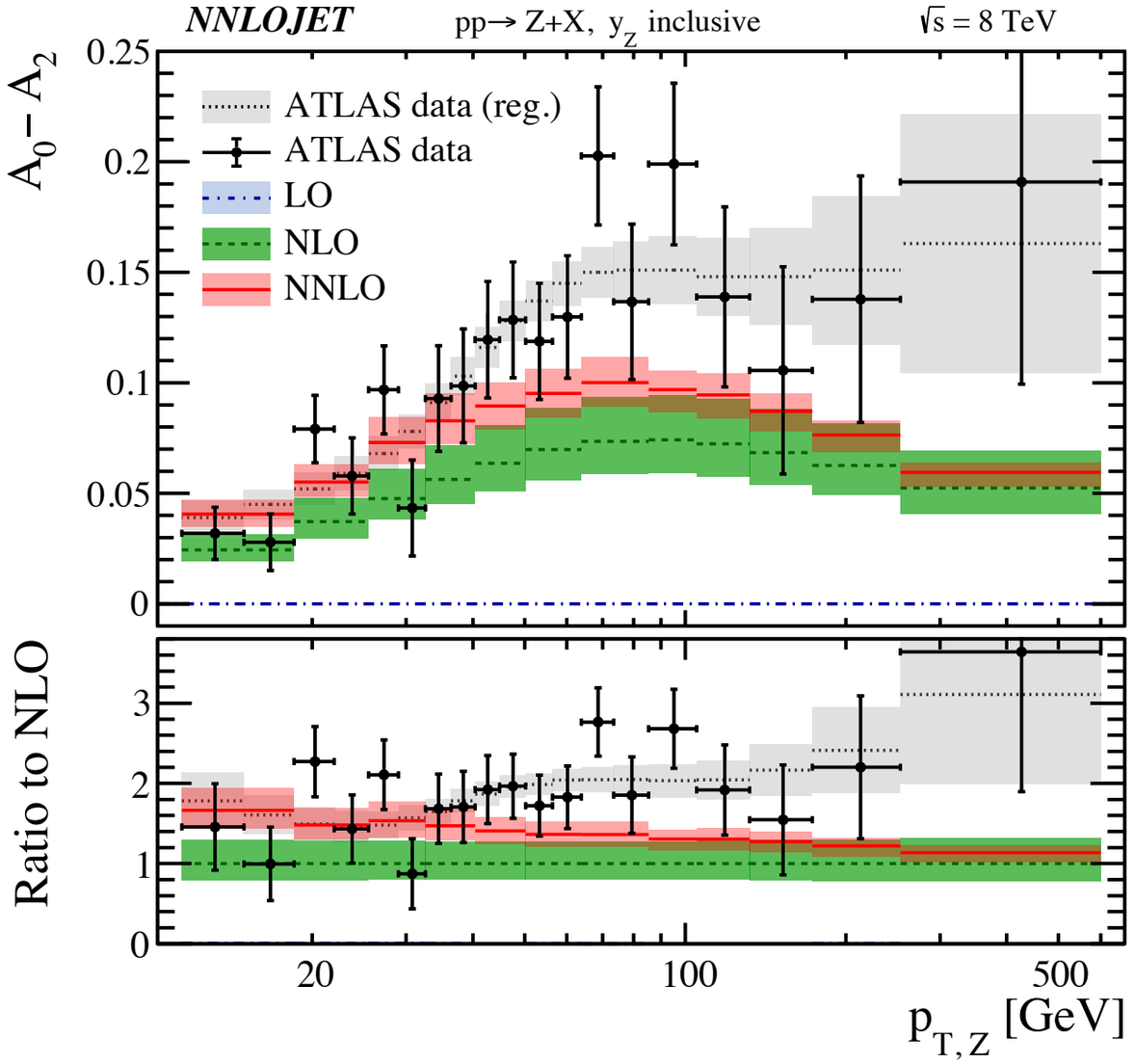
ATLAS - arXiv:1606.00689

Tension observed for $\mathbf{A_0 - A_2}$

X. Chen, J. Cruz-Martinez, RG, A. Gehrmann-De Ridder, T. Gehrmann, E.W.N. Glover, A. Huss, I. Majer, J. Niehues, J. Pires, D. Walker + J. Currie, T. Morgan
[CERN, IPPP Durham, Zurich (ETH, UZH), Lisbon (CFTP)]

Common framework for NNLO corrections

Assessing Lam-Tung violation

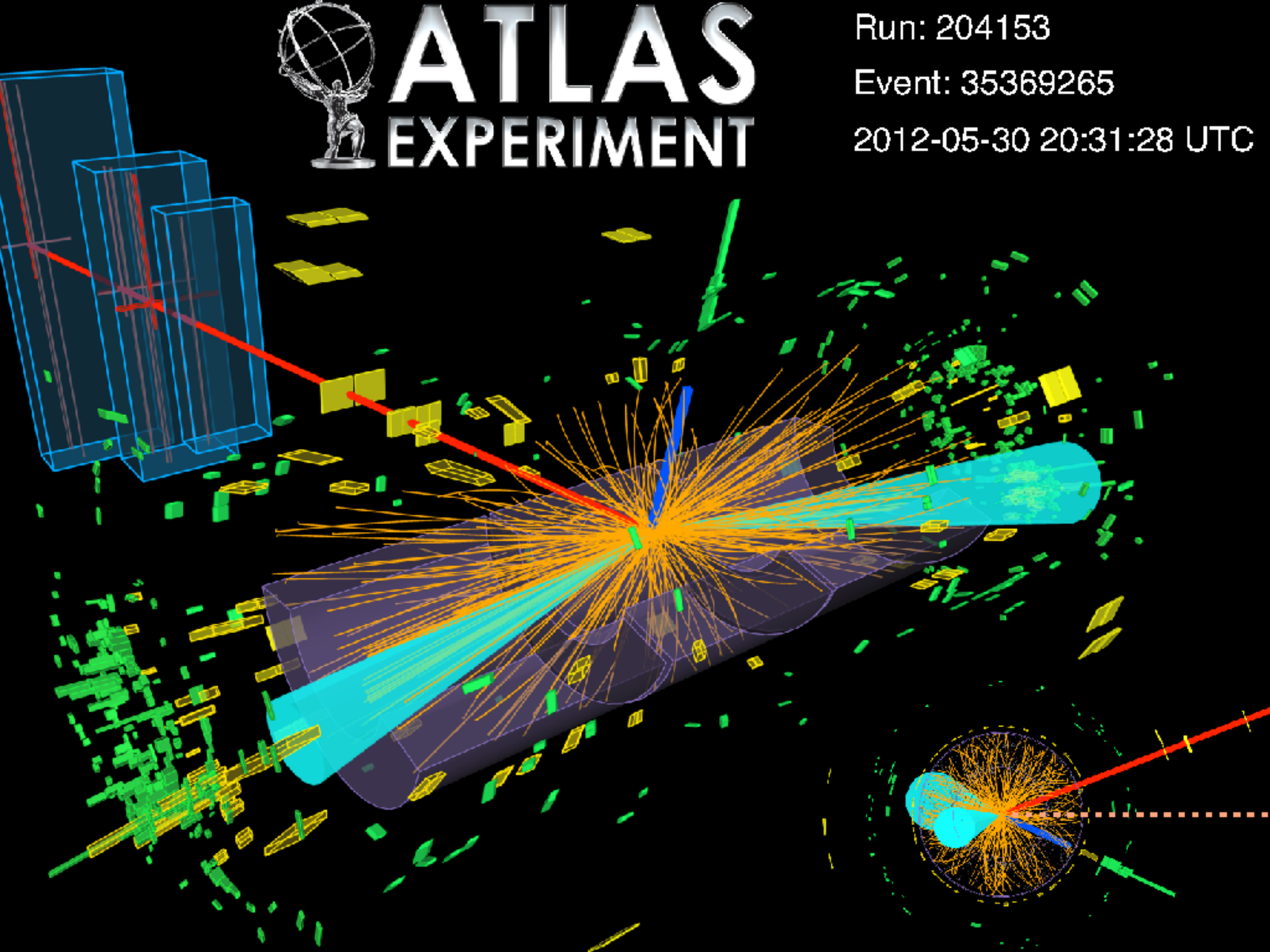


ATLAS EXPERIMENT

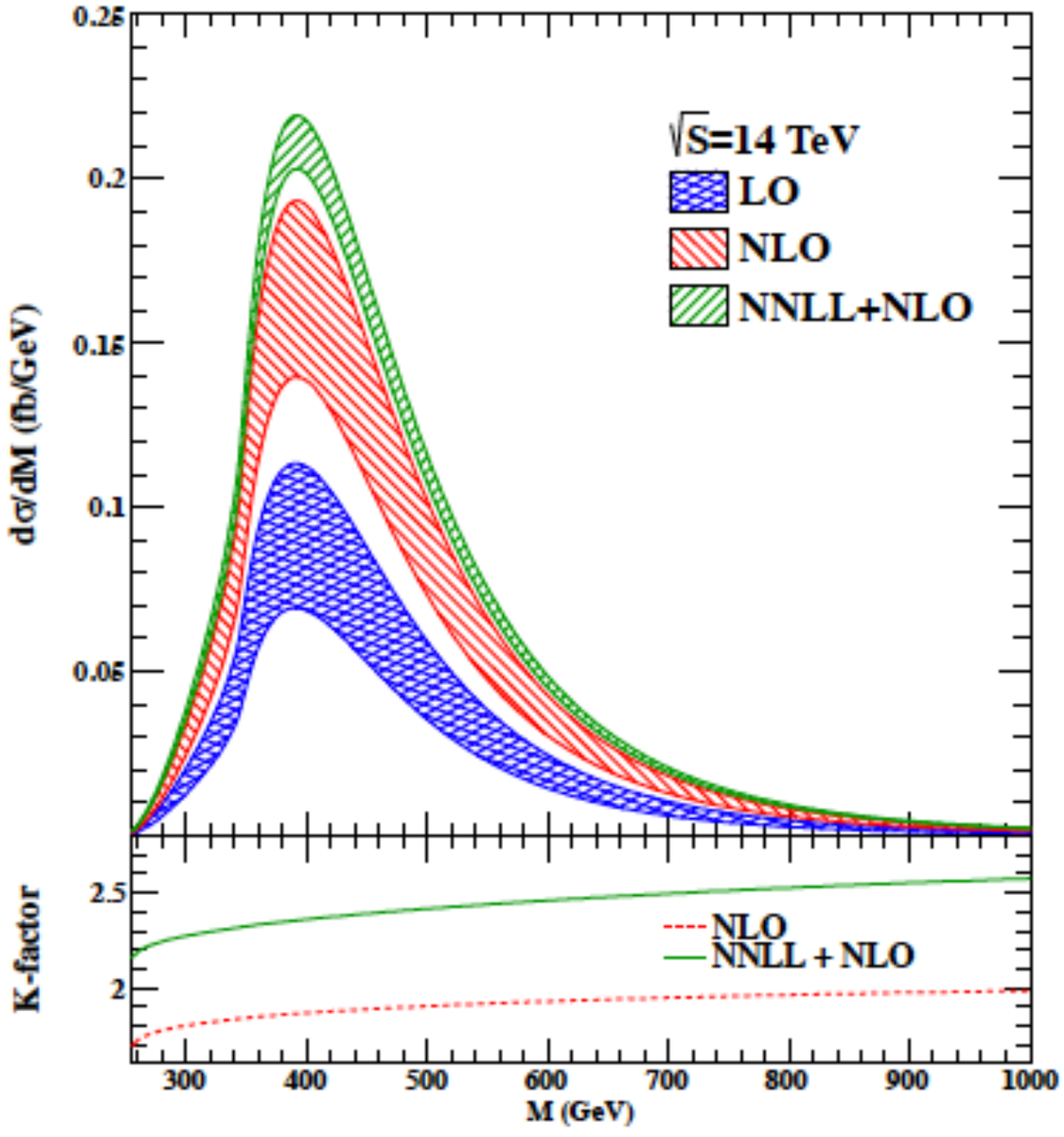
Run: 204153

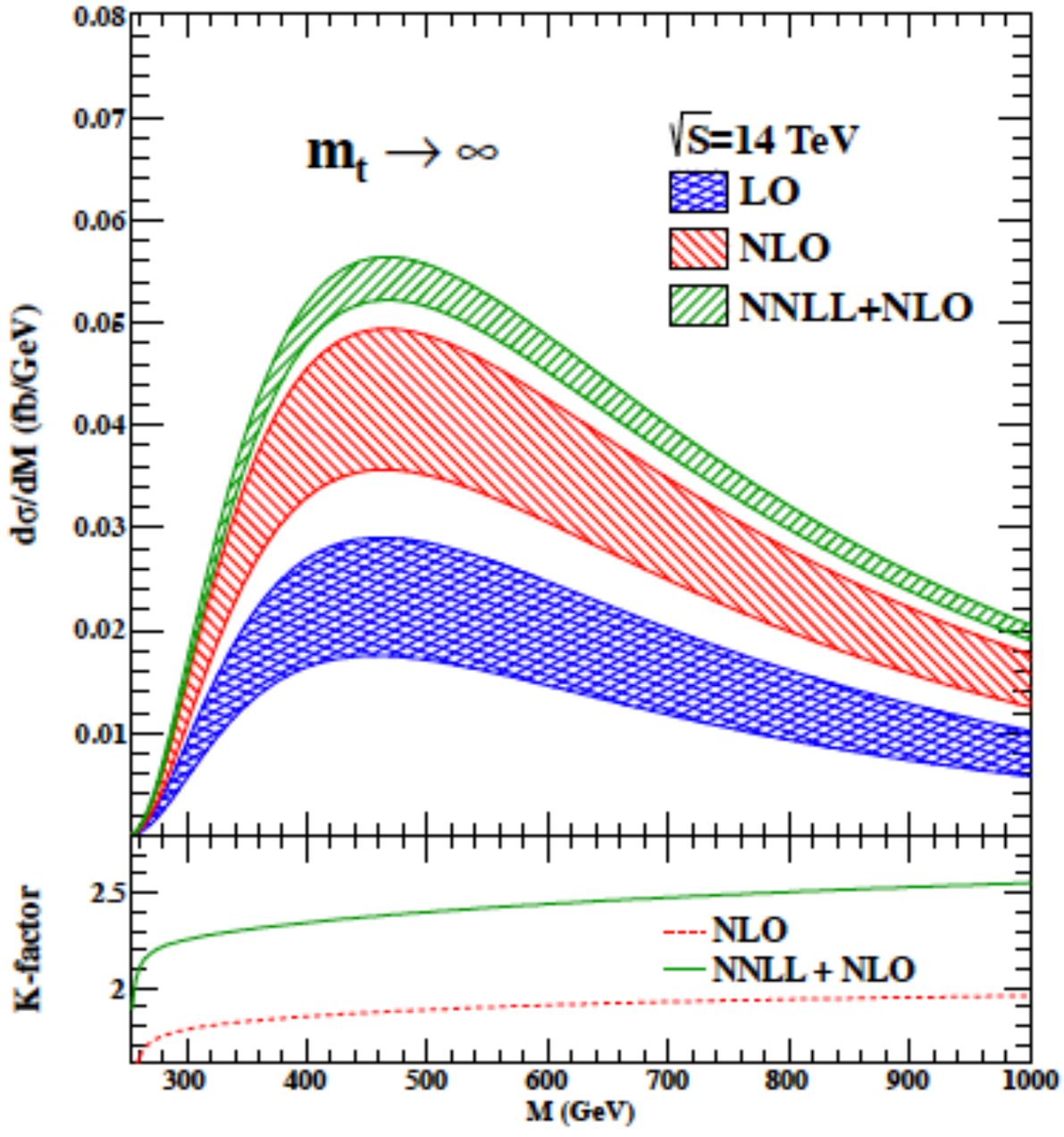
Event: 35369265

2012-05-30 20:31:28 UTC

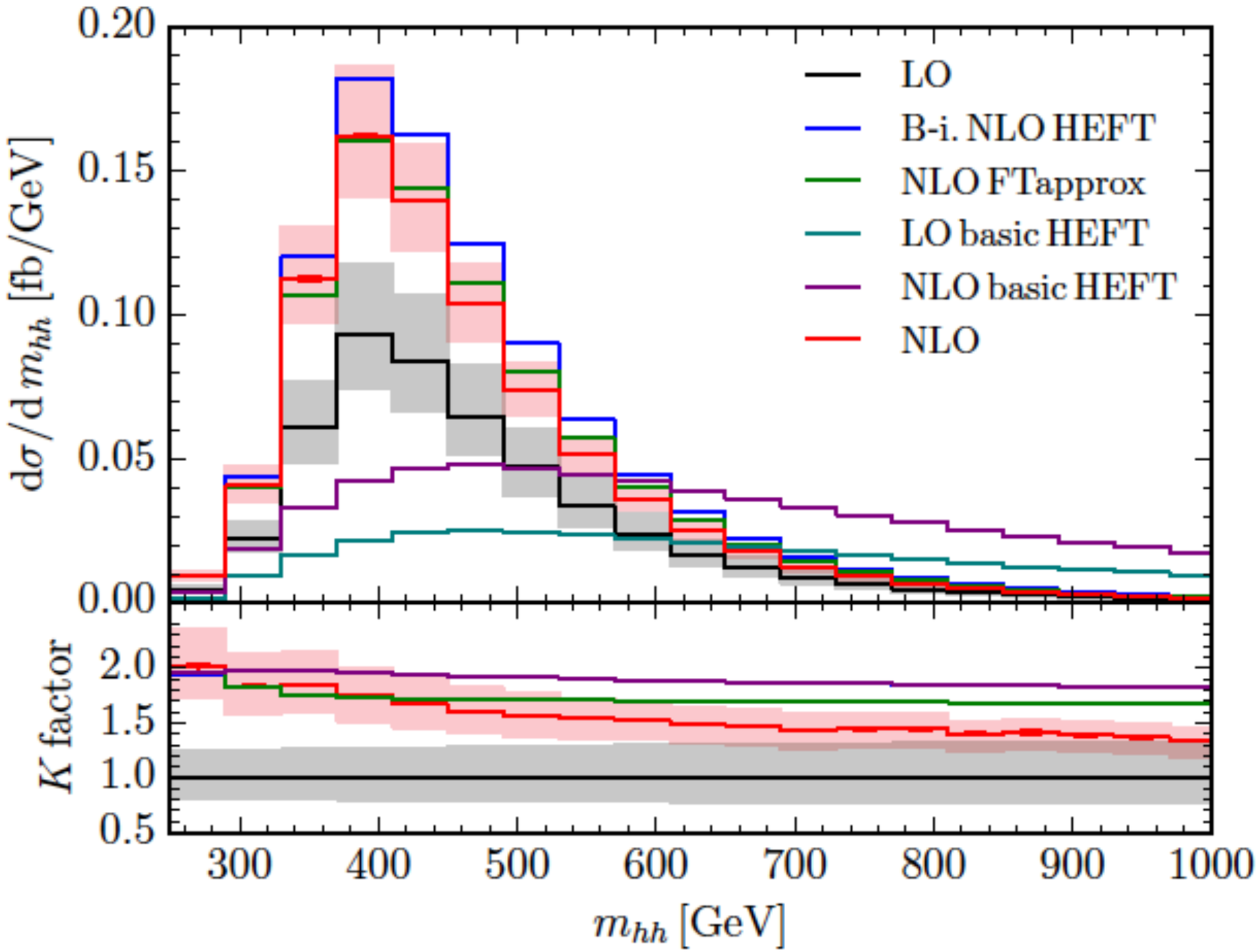


Higgs Pair

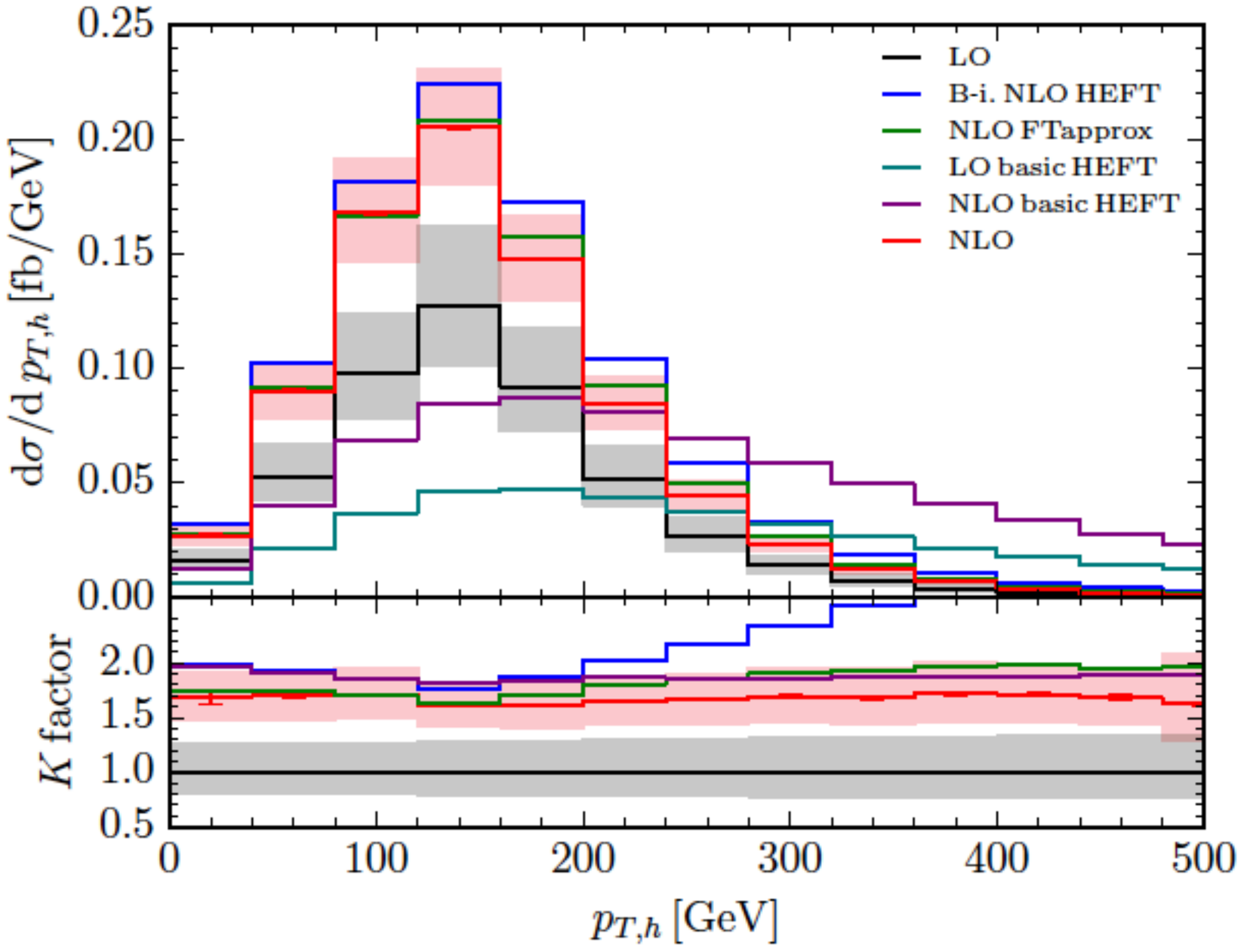

√S=14 TeV
LO
NLO
NNLL+NLO
dσ/dM (fb/GeV)
K-factor
NLO
NNLL + NLO
M (GeV)


m_t → ∞
√S=14 TeV
LO
NLO
NNLL+NLO
dσ/dM (fb/GeV)
K-factor
NLO
NNLL + NLO
M (GeV)

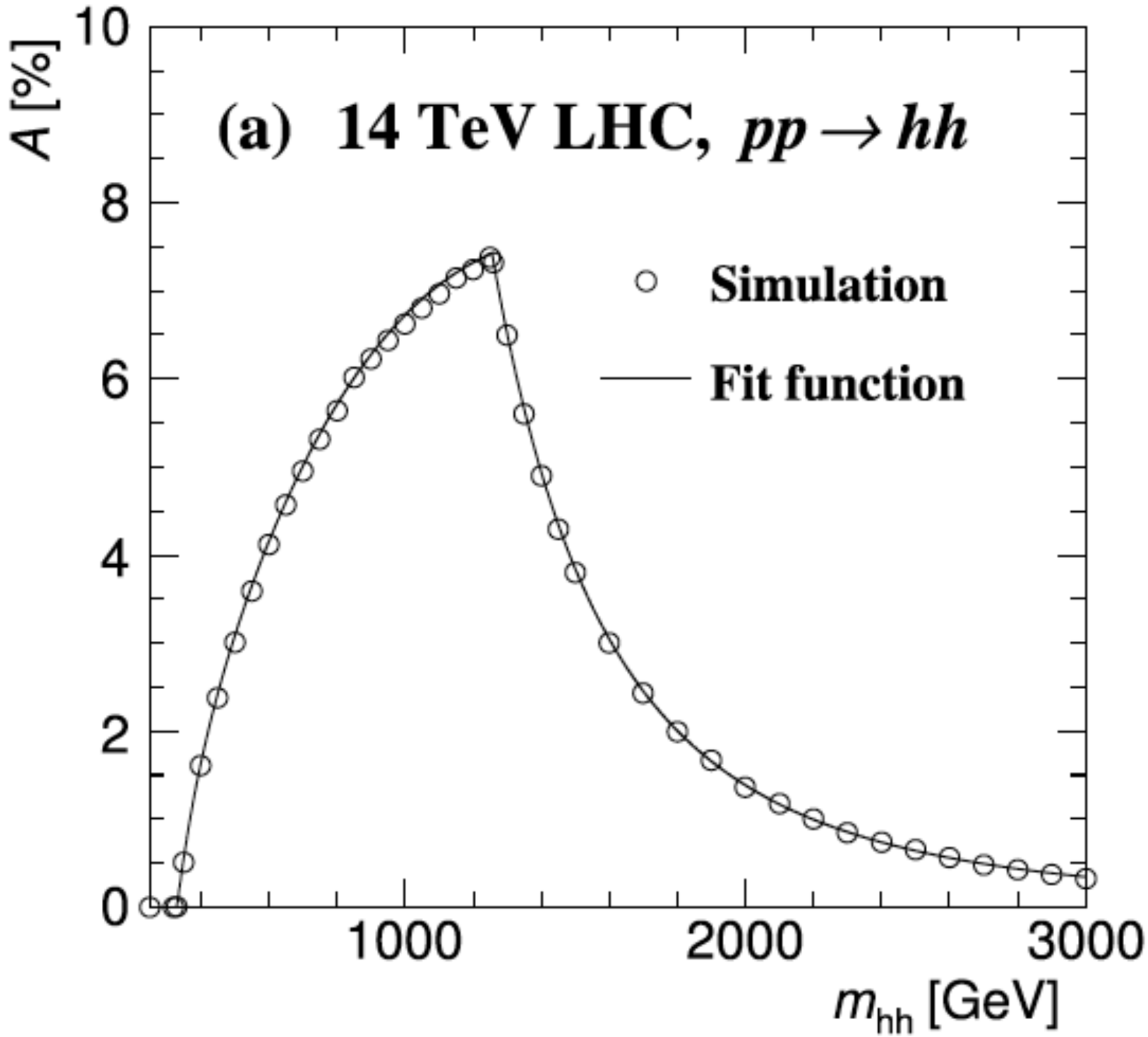
Higgs Pair


0.20
0.15
0.10
0.05
0.00
$\mathrm{d}\sigma/\mathrm{d}\,m_{hh}$ [fb/GeV]
LO
B-i. NLO HEFT
NLO FTapprox
LO basic HEFT
NLO basic HEFT
NLO
K factor
2.0
1.5
1.0
0.5
300
400
500
600
700
800
900
1000
m_{hh} [GeV]

Higgs Pair


LO
B-i. NLO HEFT
NLO FTapprox
LO basic HEFT
NLO basic HEFT
NLO
$d\sigma/d\,p_{T,h}$ [fb/GeV]
0.25
0.20
0.15
0.10
0.05
0.00
K factor
2.0
1.5
1.0
0.5
0
100
200
300
400
500
$p_{T,h}$ [GeV]

Higgs Pair


(a) 14 TeV LHC, $pp \to hh$
Simulation
Fit function
A [%]
10
8
6
4
2
0
1000
2000
3000
m_{hh} [GeV]

- SM is good.
- More and more precise calculations are needed.
- More data — ICHEP2018.

Thank you!