CMS Physics results

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on the behalf of CMS Switzerland

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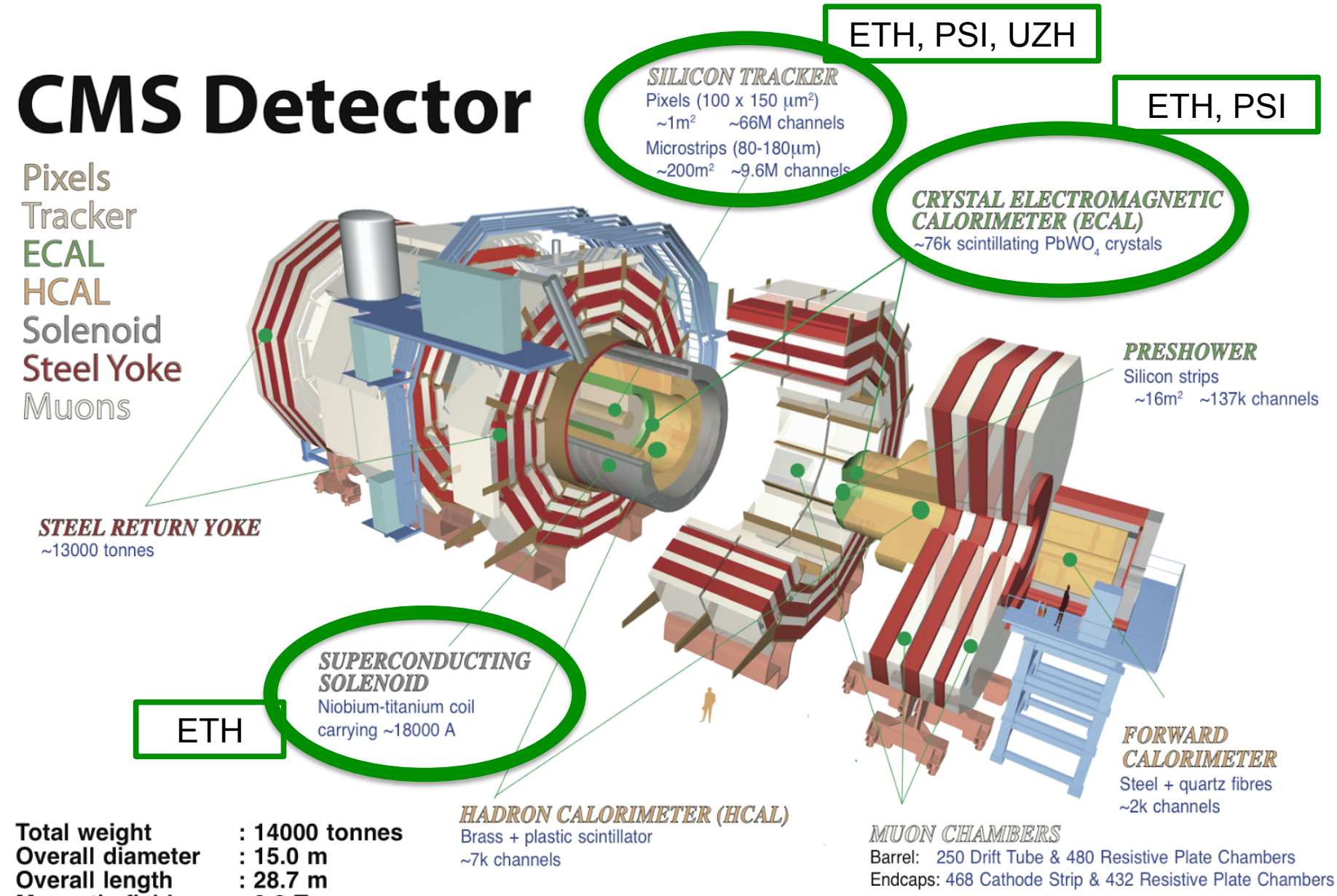
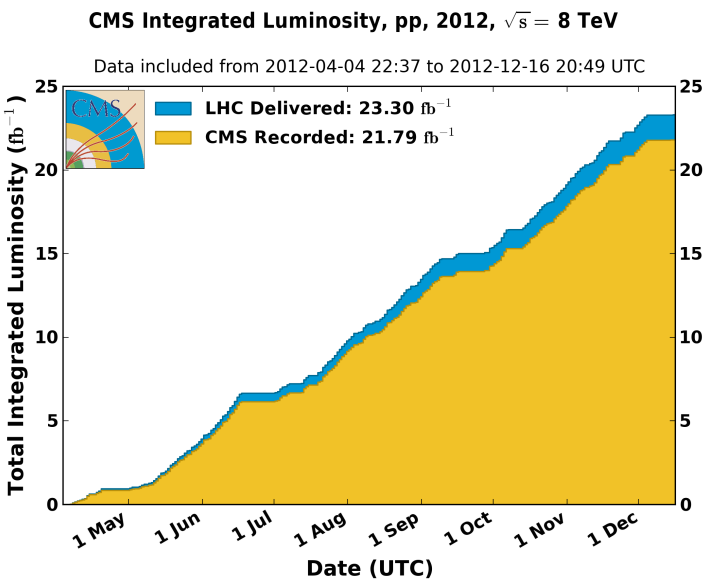
CMS Experiment



CMS Experiment - Swiss contributions



CMS worked very well in data taking.

- Swiss involvement in operation:
  - Detector on call: Pixel and ECAL
  - Detector experts (ECAL, DAQ, DQM, DCS, Pixel DAQ)
  - Offline detector performance group
  - Managing and coordination

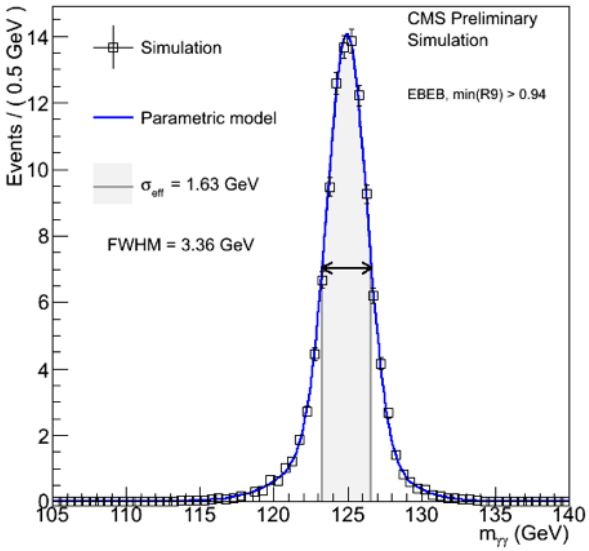
Swiss leading roles:

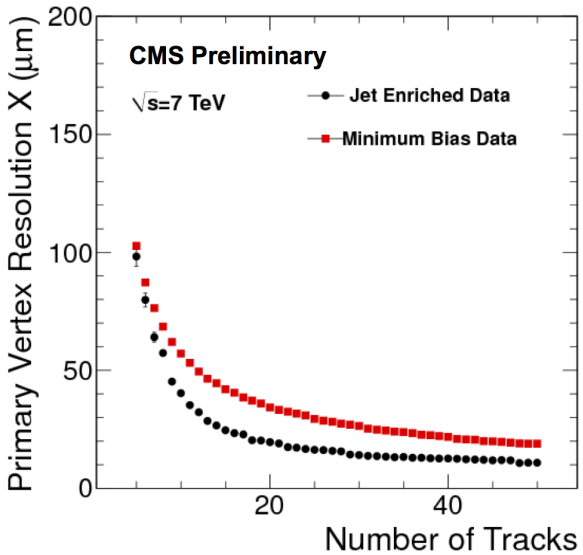
- PSI+ETHZ ECAL
  - APDs
  - PbWO4 crystal technology
  - Radiation hardness and detector properties
  - ECAL DAQ & DCS System
  - ECAL Integration Center at Prevessin
- ETHZ Integration
  - Magnet
  - Engineering Center Prevessin
- PSI+ETHZ+UZH BPIX:
  - Complete BPIX detector conceived, designed and built at PSI
  - Complete mechanical support and supply tube built by UZH
  - Development of the Pixel chip (15 years of R&D) at PSI
  - Current BPIX is a CH-only project!

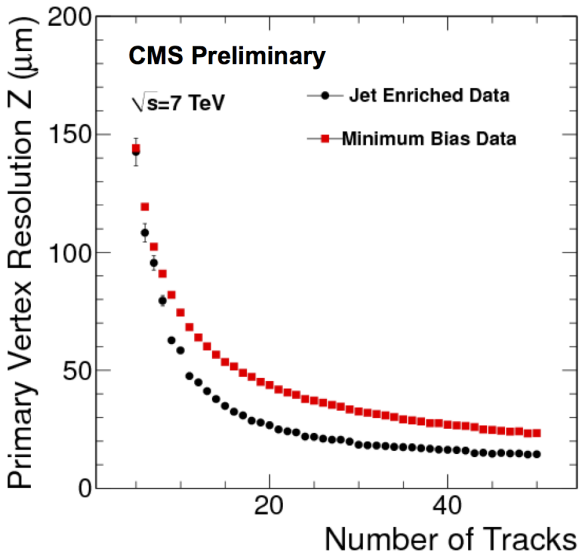
CMS Experiment - Event reconstruction

Excellent work done for:

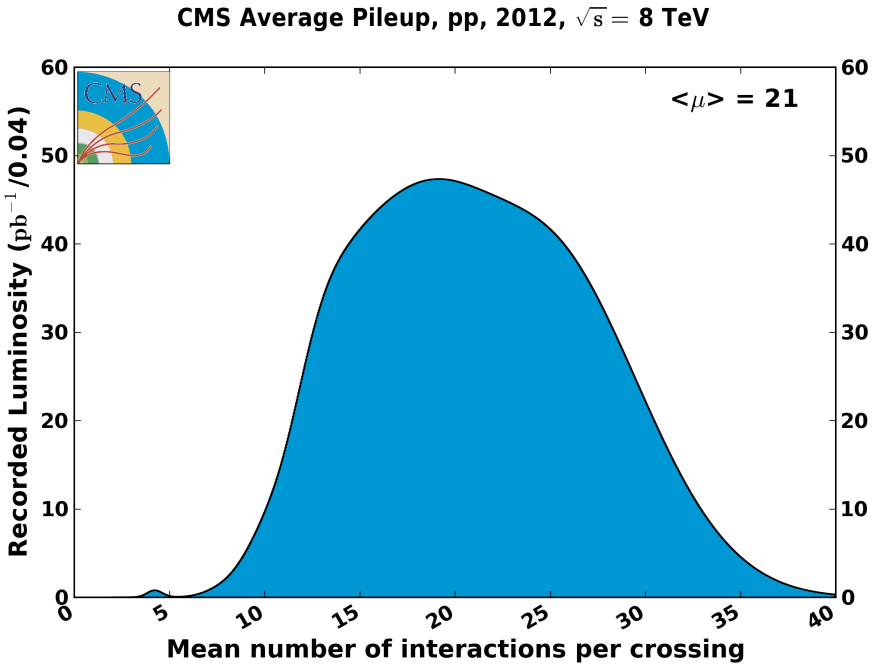
- detector operation
- calibration, alignment and validation (ECAL: ETHZ, pixel and tracker: PSI and UZH)
- reconstruction (ETH: particle flow, clustering and correction; ETH and UZH: b-tagging; UZH: tracking and calibration; PSI: vertexing)



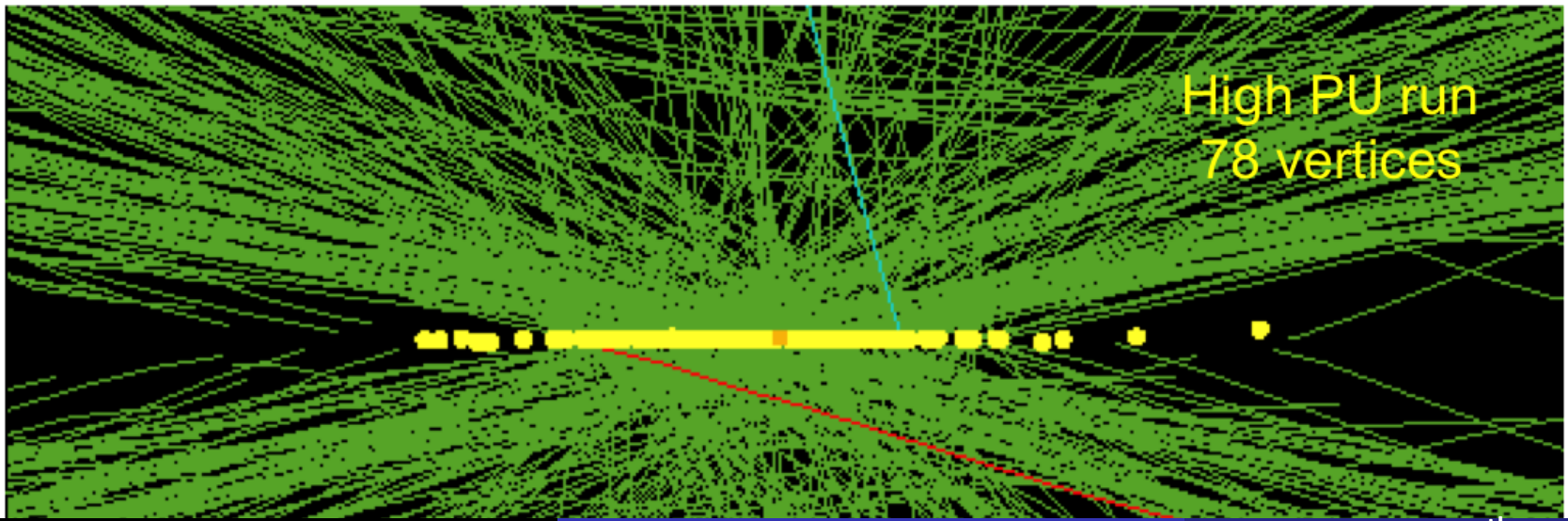




CMS Experiment - Pile up



High performance of the event reconstruction despite the high pile up 21 interactions/crossing in 2012, (10 in 2011).

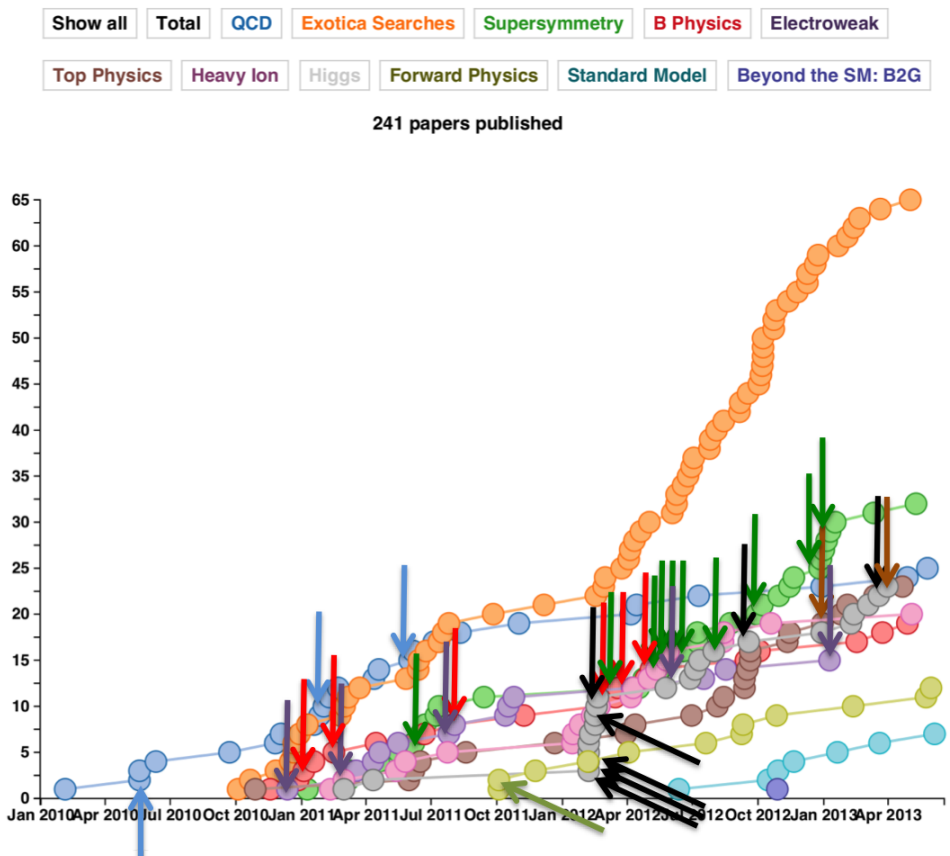


CMS Publications

Very good job done by Swiss people confirmed by publications:
47/ 274 papers published by CMS have Swiss involvement!

- ETHZ: 31 papers (26 physics + 5 performance)
- PSI: 7 (5+2)
- UZH: 14 (11+3)

$\sim$ 17% of papers!



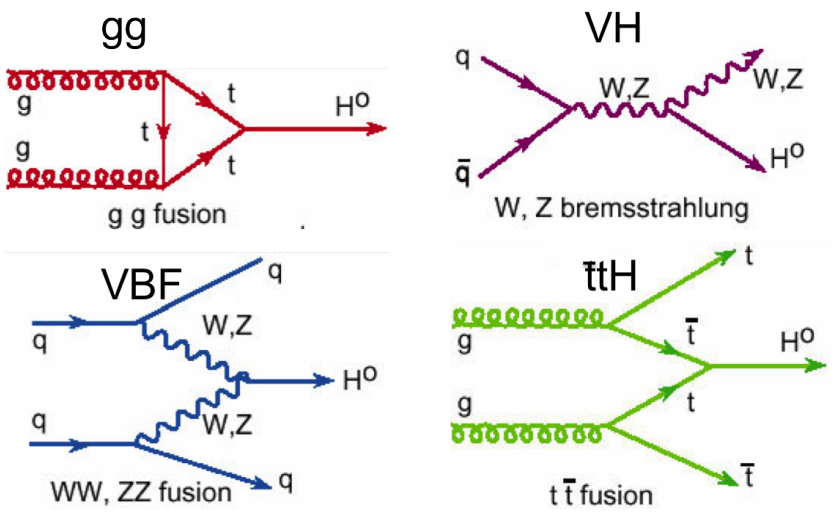
Swiss group members:

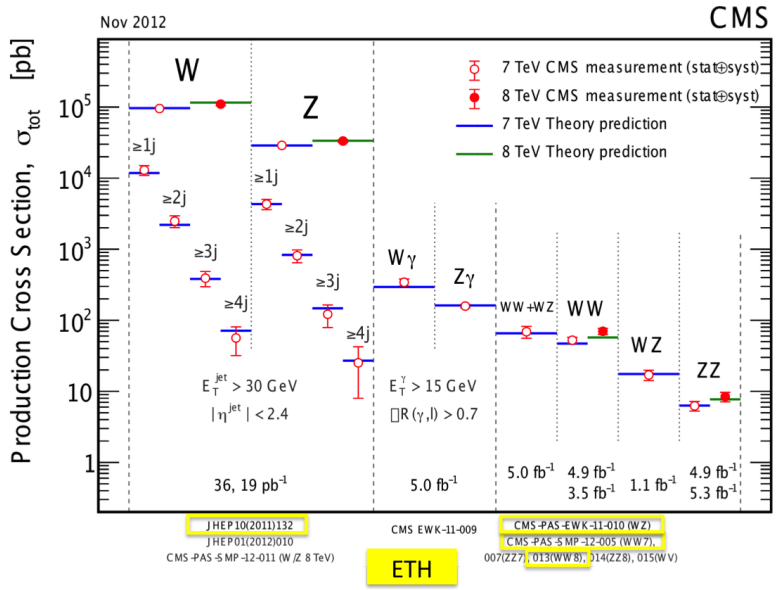
- ETHZ: 44
- PSI: 12
- UZH: 18

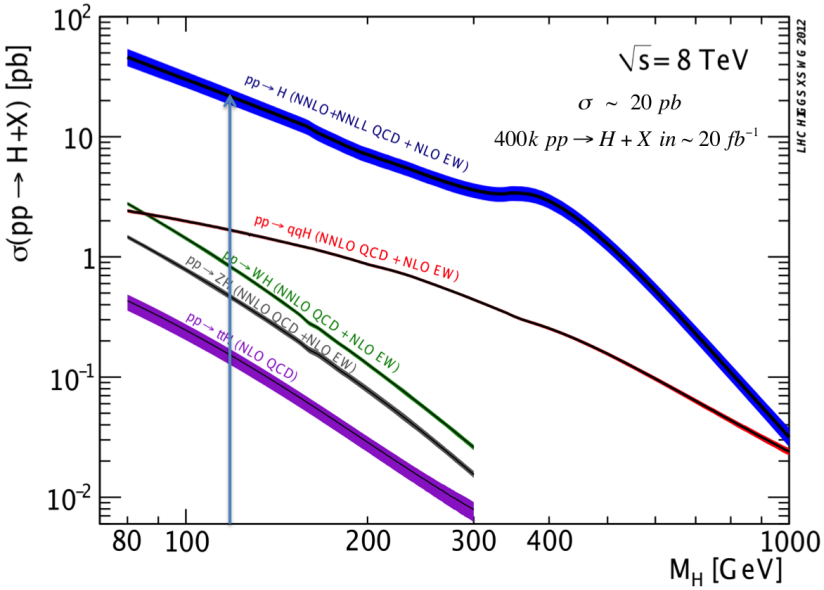
$\sim$ 3% of CMS autors

Higgs Searches

- Particle physics is very well described by SM.
- SM needs a Higgs field to give mass to the vector bosons
  $\rightarrow$ Higgs boson (0^+)
  - 4 production processes:
    - gg, VBF, VH, $t\bar{t}H$

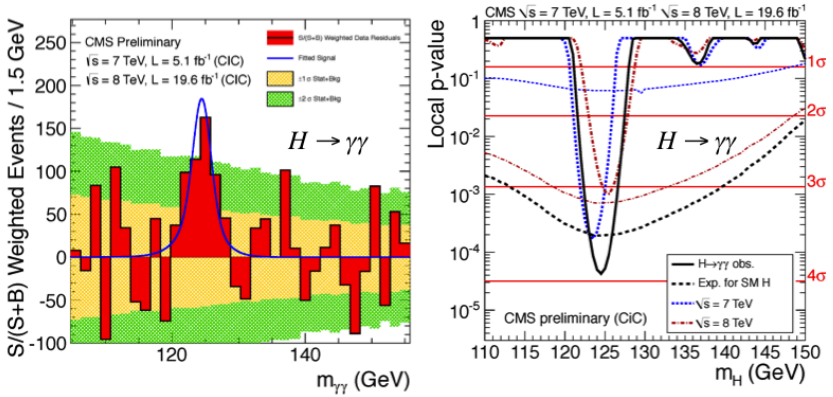


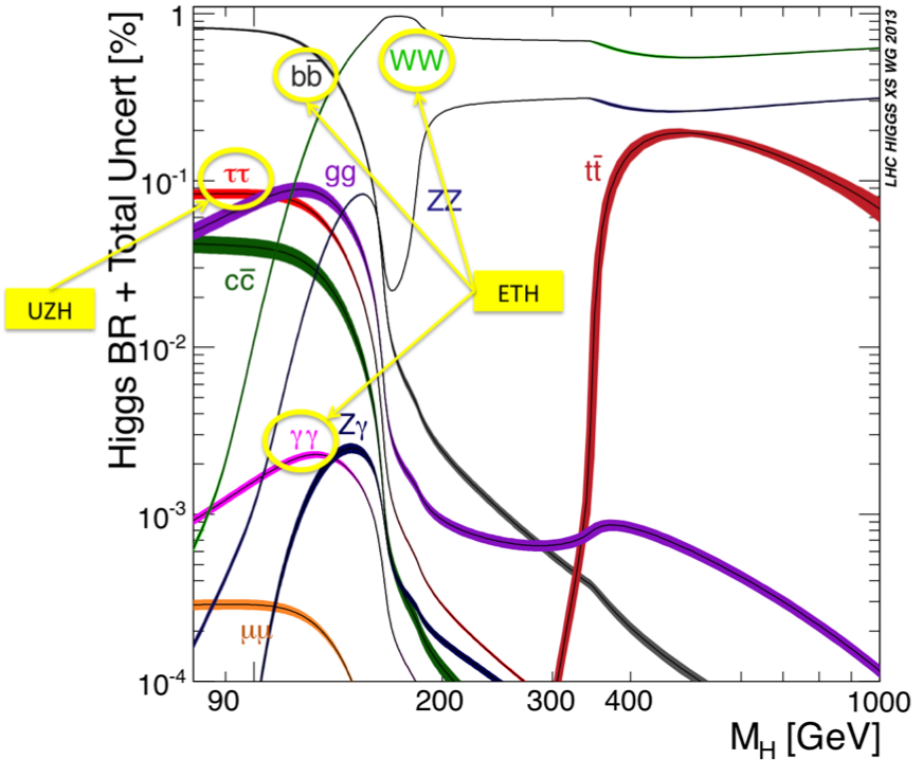




Higgs Mass

- 4/7/2012: evidence of a new boson
- 5 decay modes exploited by CMS:
  - $\gamma\gamma$, $b\bar{b}$, $\tau\tau$, WW*, ZZ*
- $\gamma\gamma$, ZZ*: very good mass resolution
  - calorimeter calibration
  - tracker alignment
- latest mass measurement: $125.7 \pm 0.3(stat) \pm 0.3(syst)$ GeV.
- Is it the SM Higgs Boson?
  - spin - parity
  - coupling to vector bosons and fermions
  - additional bosons
  - is it elementary or composite?
  - self coupling





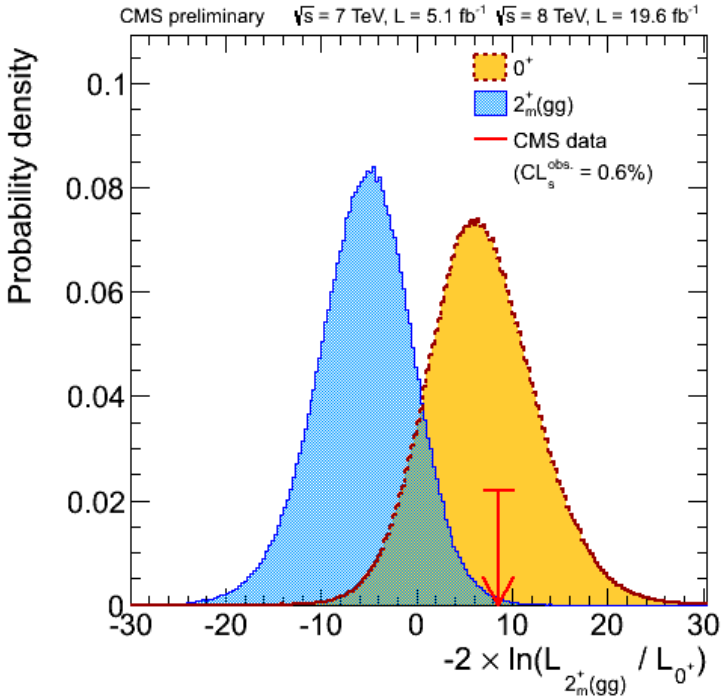
Higgs Spin-Parity

SM Higgs Boson is pure scalar ($J^P = 0^+$).

- spin 0^- and 1^+ with $H \to ZZ$
- spin $2+$ hypotheses with $H \to ZZ$, $H \to WW$

From the post-fit distribution of the test statistics

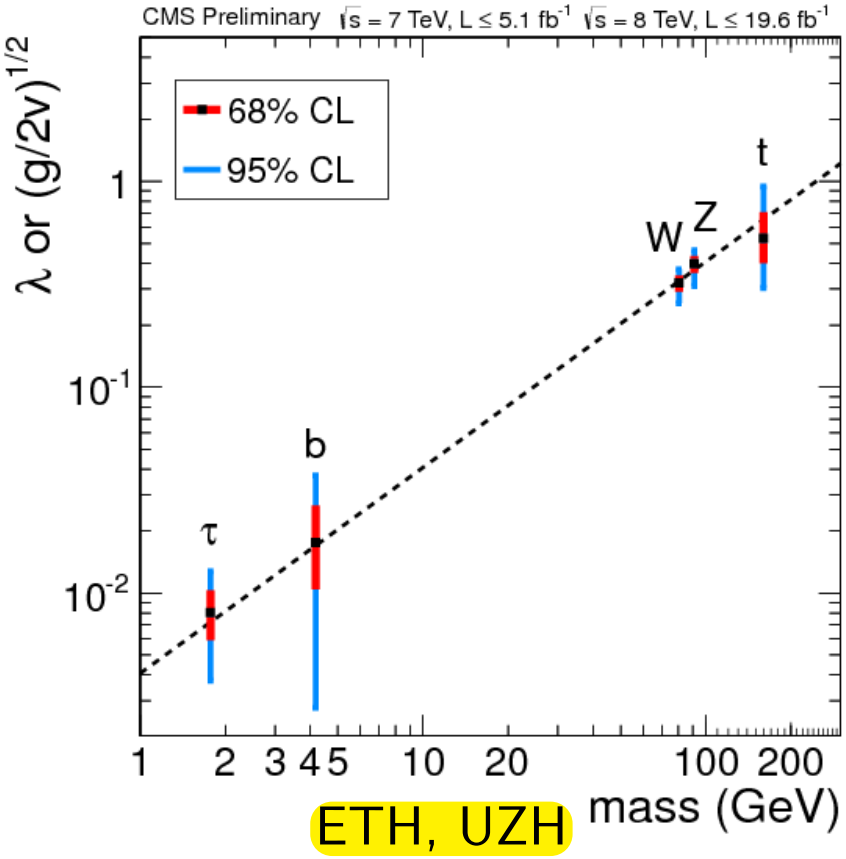
- 2^+: obs value at 2.84σ from the expected median
- 0^+: obs value at 0.34σ from the expected median



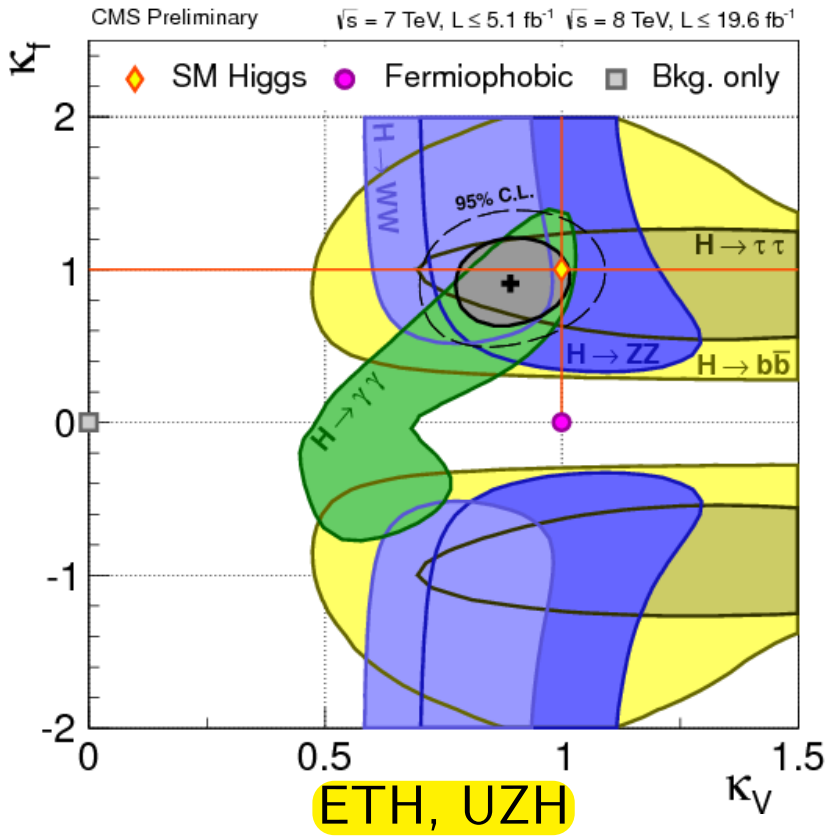
$H \to ZZ$, $H \to WW$ combination ETH

Higgs Couplings

- SM Higgs couplings proportional to particle masses.



- Couplings to fermions and vector bosons: compatible with SM expectations

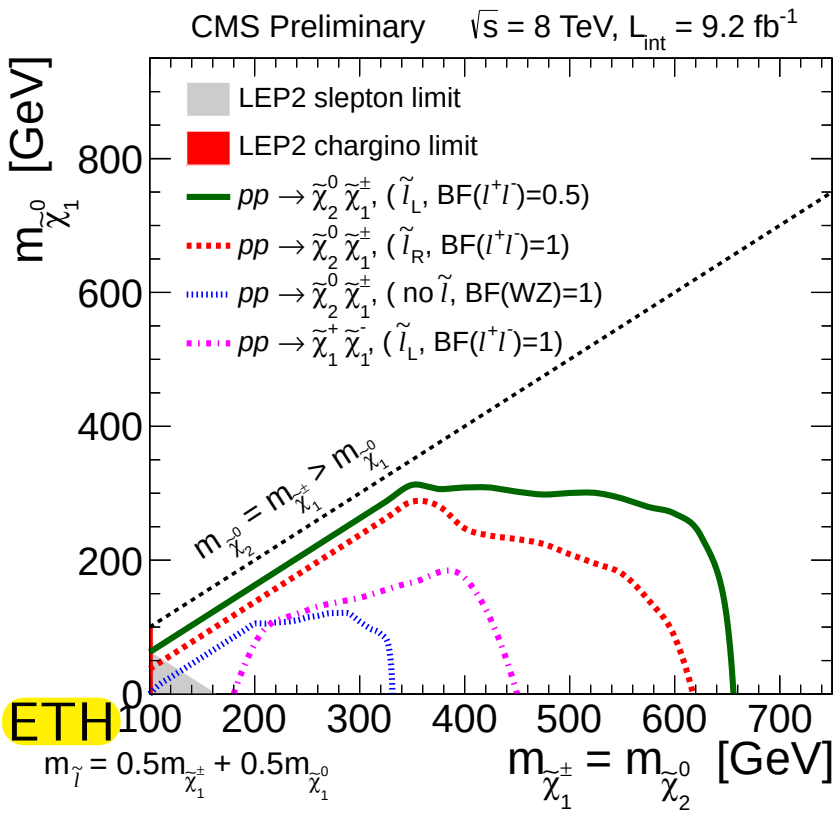


SUSY

- SM works well but has problems:
  - Hierarchy
  - matter - antimatter asymmetry
  - dark matter
- SM = is it a low energy approximation of a wider theory?
- SUSY is a candidate for SM extension
- SUSY introduces a super-partner for each SM element
- CMS recently focused on third generation partners ($\tilde{t}$), $\tilde{\chi}_i^0$, $\tilde{\chi}_i^+$

SUSY

Search for electroweak production of charginos and neutralinos.
Focus on the electroweak sector of the SUSY.



Final states:

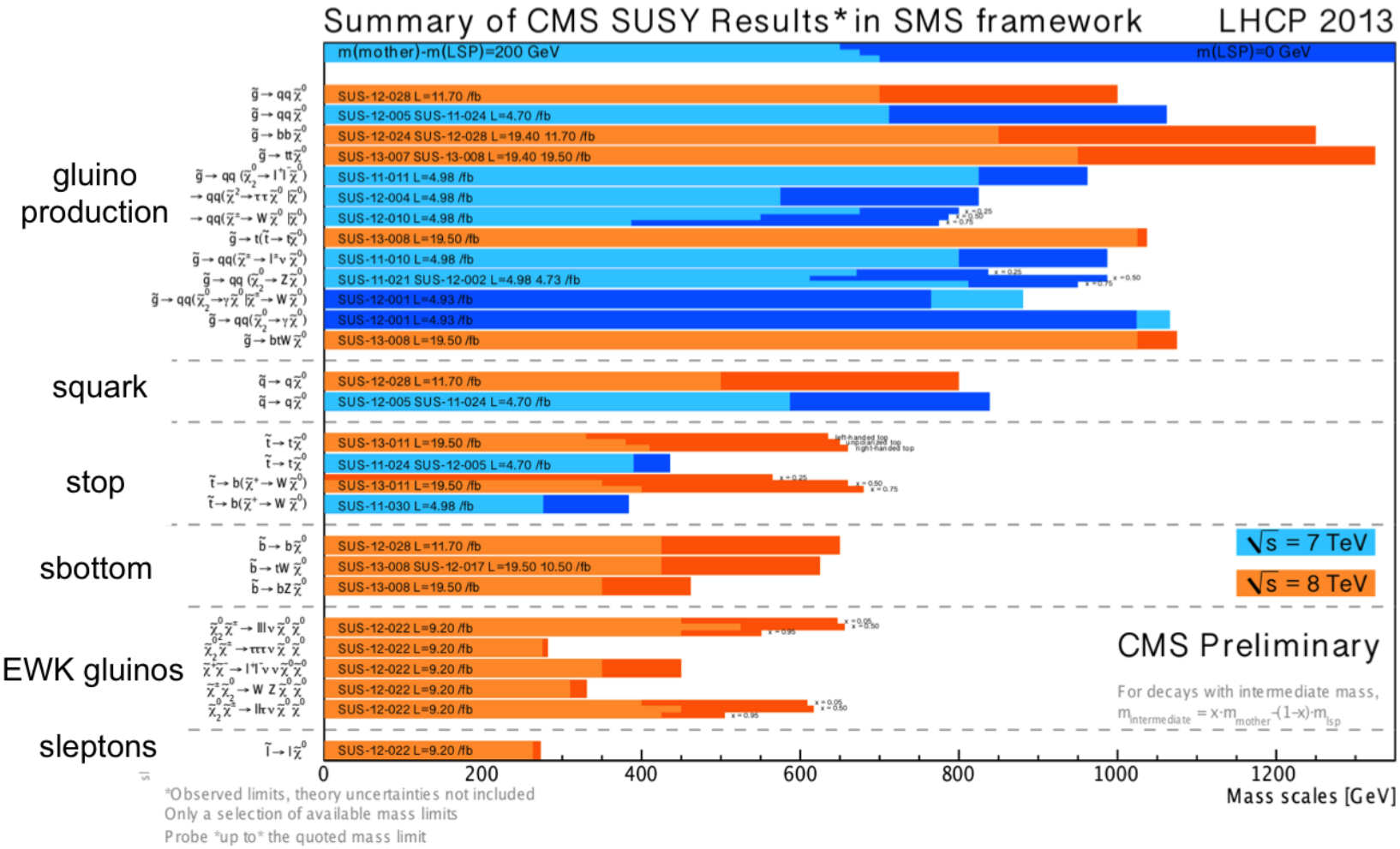
- three leptons,
- four leptons,
- two same-sign leptons,
- two opposite-sign-same-flavor leptons plus two jets,
- two opposite-sign leptons inconsistent with Z boson decay

Chargino/neutralino decay products:

- left-, right-handed sleptons
- vector bosons.

SUSY

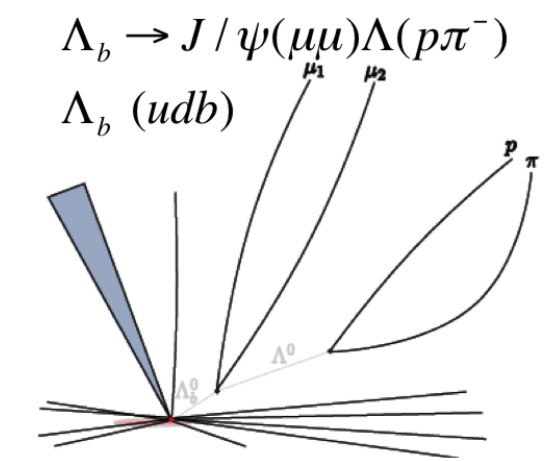
Recent investigations don't show any signal of SUSY

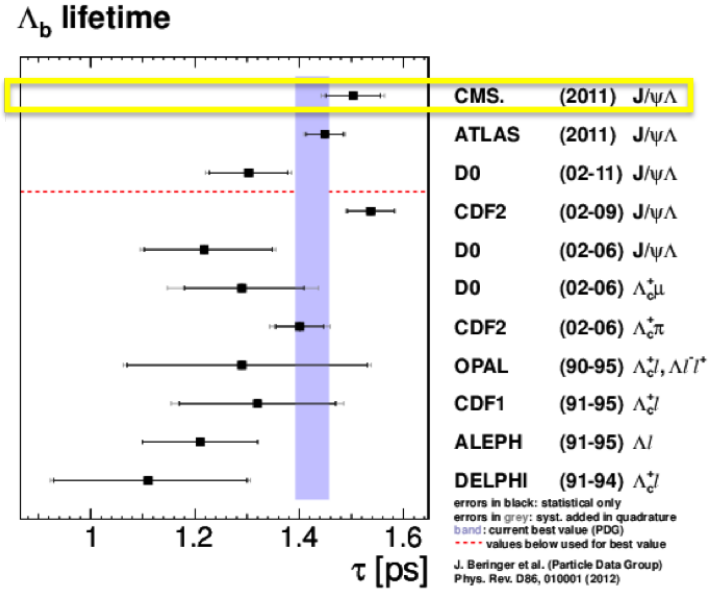


15 analyses in progress in 2013

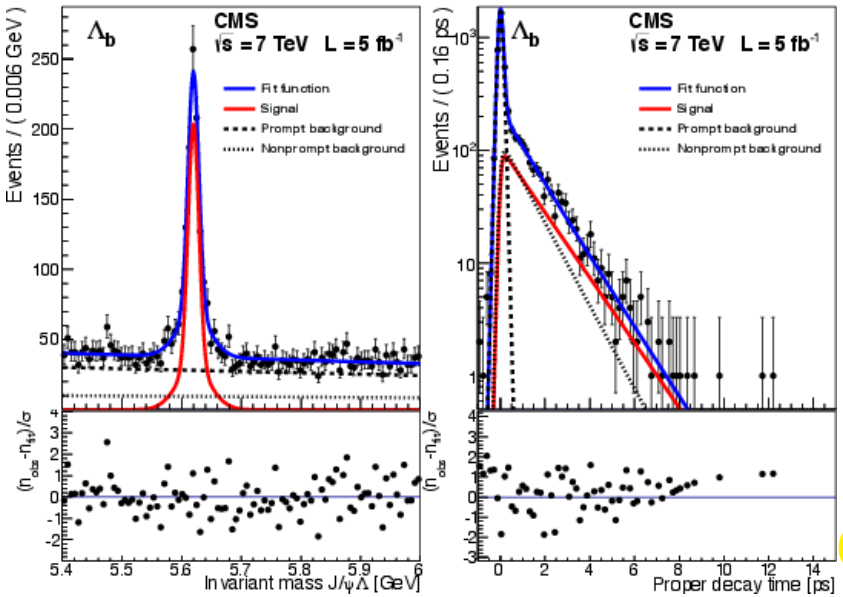
Flavour physics: Λ_b^0 lifetime

HQET predicts $\tau(B_c) \ll \tau(\Lambda_b^0) < \tau(B_s) \approx \tau(B^0) < \tau(B^+)$





- recent prediction[1-3]: $\tau(\Lambda_b)/\tau(B^0) = 0.86$ - 0.95
- latest average (PDG): $\tau(\Lambda_b^0)/\tau(B^0) = 1.012 \pm 0.031$



PSI

$\tau_{\Lambda_b} = 1.503 \pm 0.052(stat) \pm 0.031(syst)$ ps

Other "Swiss" results since last CHIPP meeting

- *Measurement of B hadron angular correlations in association to a Z boson*, CMS-PAS-EWK-11-015, UZH and ETH
- *Event shapes and azimuthal correlations in Z + jets events in pp collisions at* $\sqrt{s}$*=7 TeV*, submitted to Phys. Lett. B, arXiv:1301.1646, ETH
- *Interpretation of searches for supersymmetry with simplified models*, submitted to PRD arXiv:1301.2175, ETH
- *Measurement of associated production of vector bosons and* $t\bar{t}$ *at* $\sqrt{s} = 7$ *TeV*, accepted by Phys.Rev.Lett., arXiv:1303.3239, ETH
- *Search for new physics in events with same-sign dileptons and b-tagged jets in pp collisions at* $\sqrt{s}$*=8 TeV*, JHEP03(2013)037, ETH
- *Measurement of the* $t\bar{t}$ *production cross section in pp collisions at* $\sqrt{s} = 7$ *TeV with lepton + jets final states*, Phys. Lett. B 720 (2013) 83-104, ETH

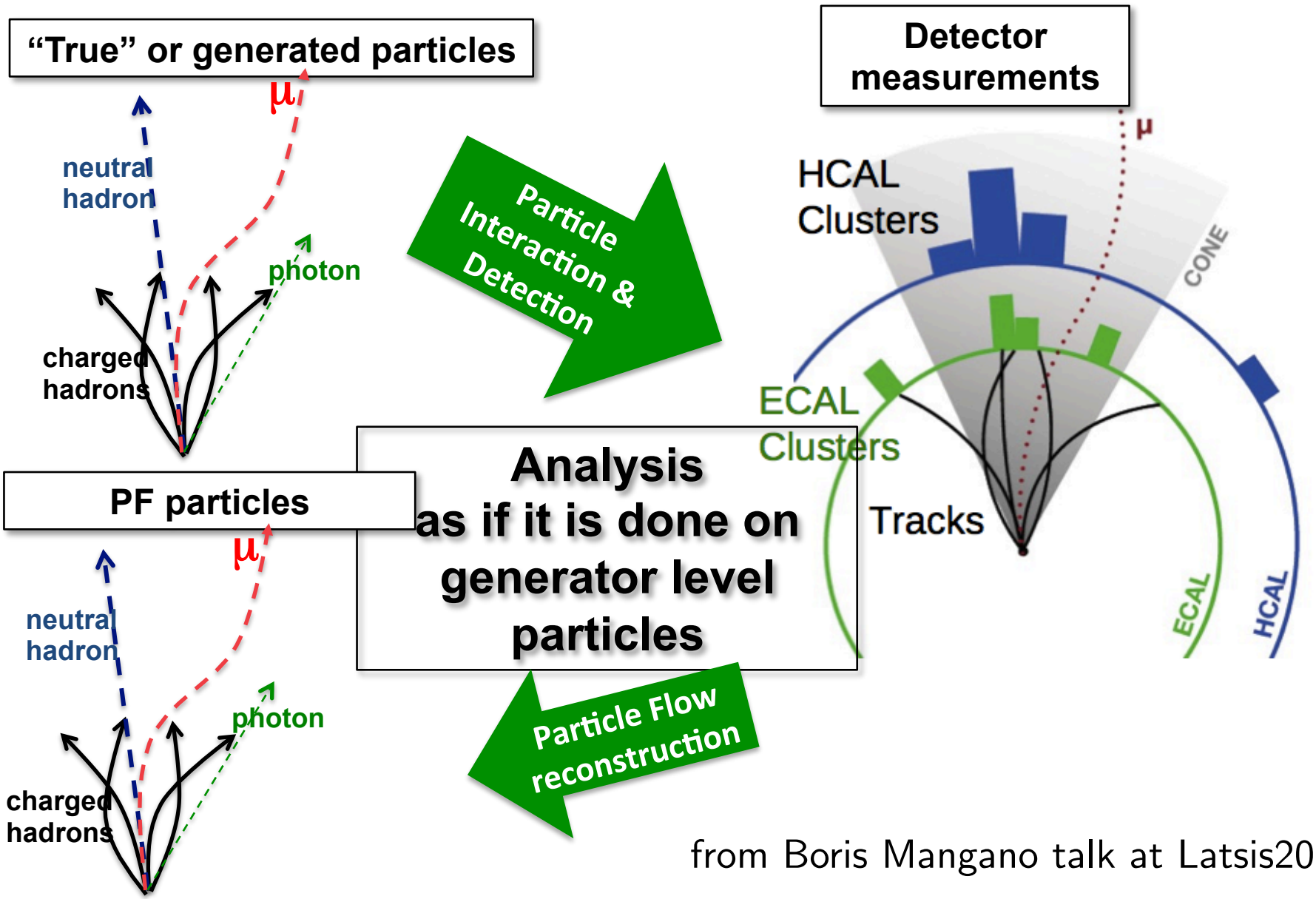
Summary and outcomes

- CMS experiment works very well, Swiss institutes play a crucial role
- Swiss contributions to Higgs, Susy and SM physics
  - Higgs: Spin - parity and couplings compatible with SM Higgs
  - Susy: no evidence, still searching
  - SM and flavour physics: Λ_b lifetime, $t\bar{t}V$, $V + jets$ and $V + b\bar{b}$ angular correlations
- We keep on working on both physics...
  - Analyzing current data and preparing analyses for 13 TeV data
    - Higgs: is it SM? is it alone?
    - Susy: direct new physics searches
    - SM and flavour physics: understanding QCD and indirect searches for new physics ($B_s \rightarrow \mu\mu$)
- ... and detector
  - Swiss institutes have a crucial role in the LS1 maintenance work and upgrade

1. C. Tarantino, Eur. Phys. J. C33, s895s899 (2004), arXiv:hep-ph/0310241;
2. F. Gabbiani, A. I. Onishchenko, and A. A. Petrov, Phys. Rev. D68, 114006 (2003), arXiv:hep-ph/0303235.
3. F. Gabbiani, A. I. Onishchenko, and A. A. Petrov, Phys. Rev. D70, 094031 (2004), arXiv:hep-ph/0407004.

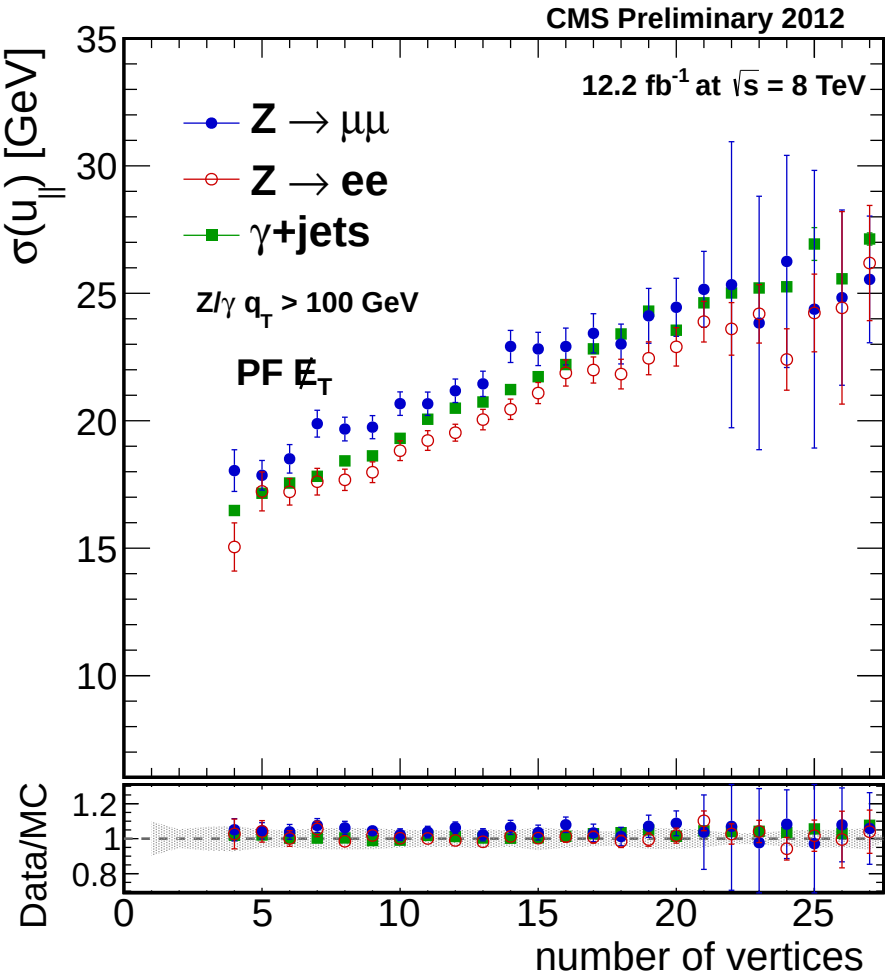
Backup slides

From particle to PF particles

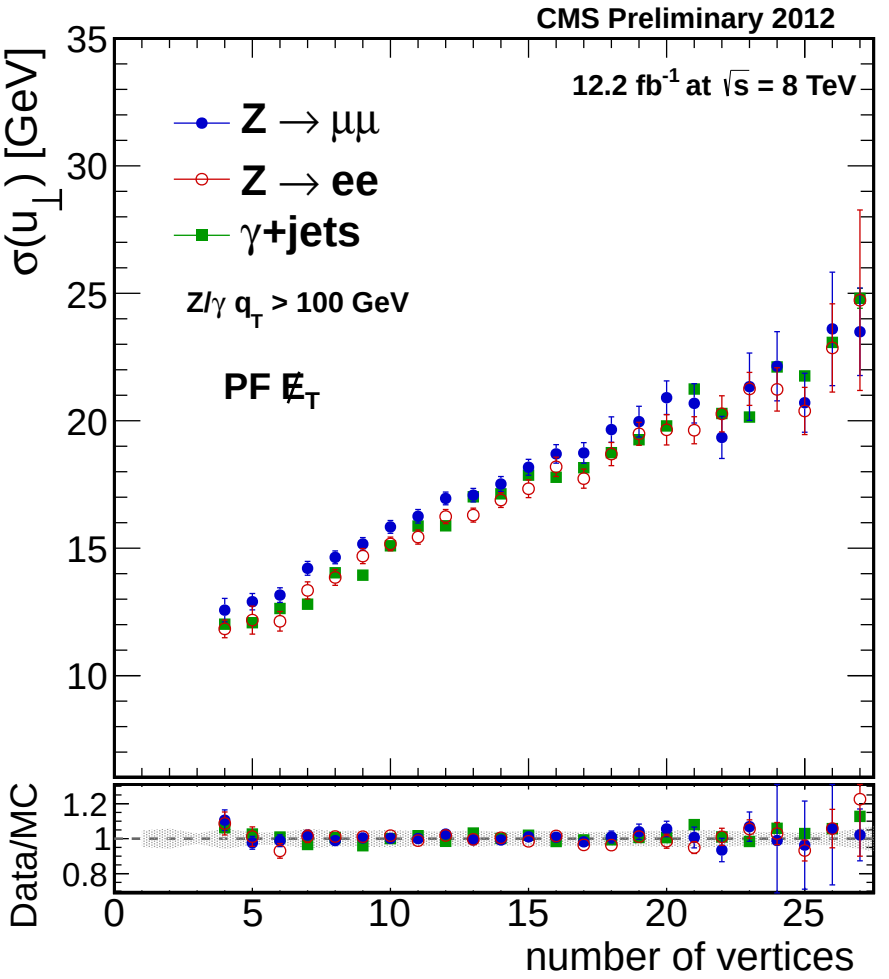


from Boris Mangano talk at Latsis2013

MET Resolution vs PU

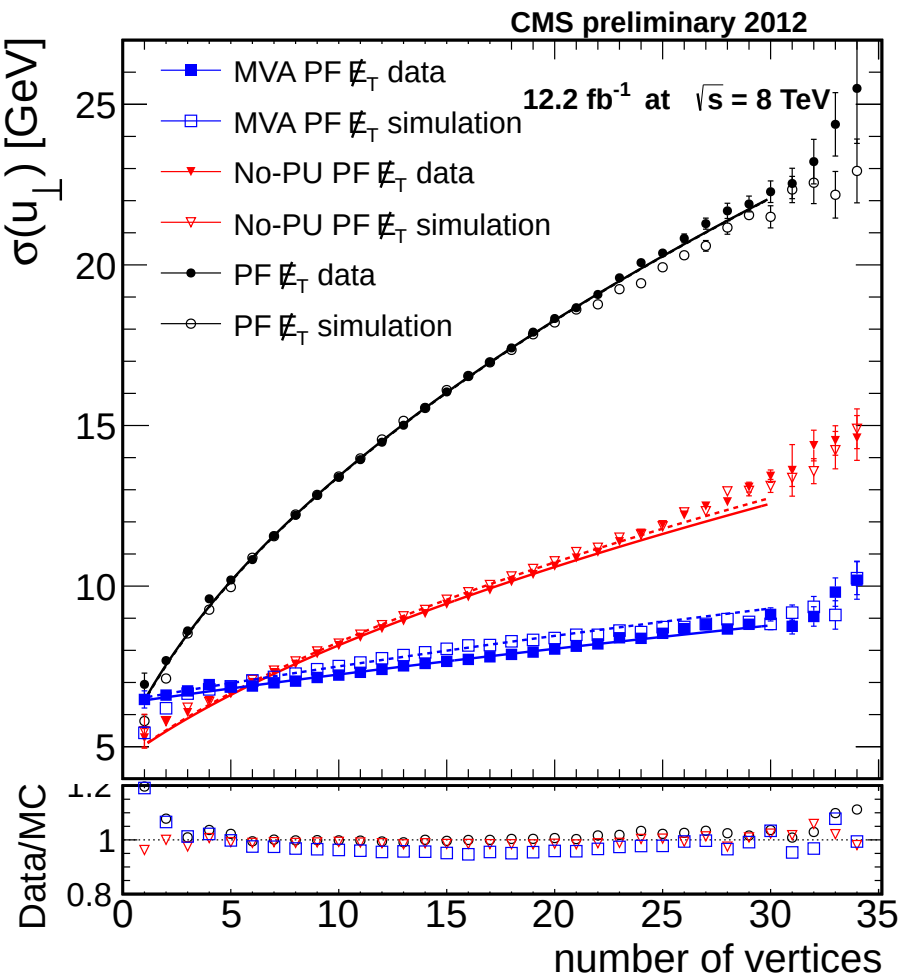


parallel direction

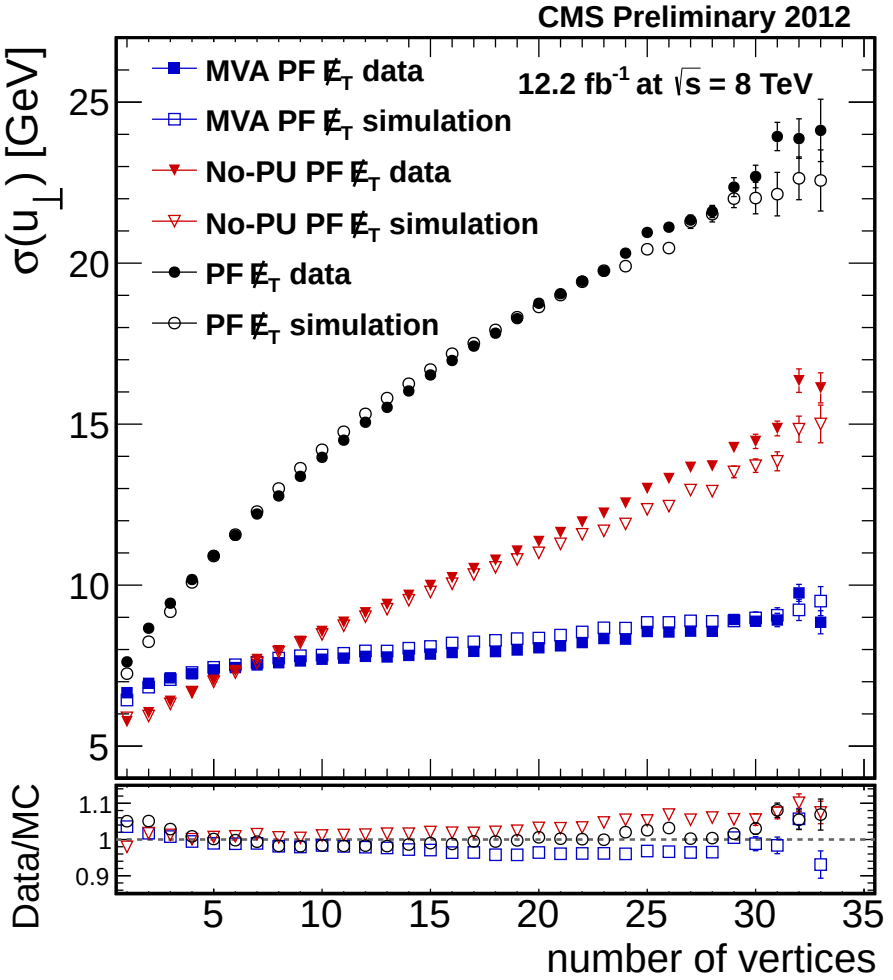


perpendicular direction

MET Resolution vs PU



$Z \rightarrow ee$



$Z \rightarrow \mu\mu$

SUSY Production