

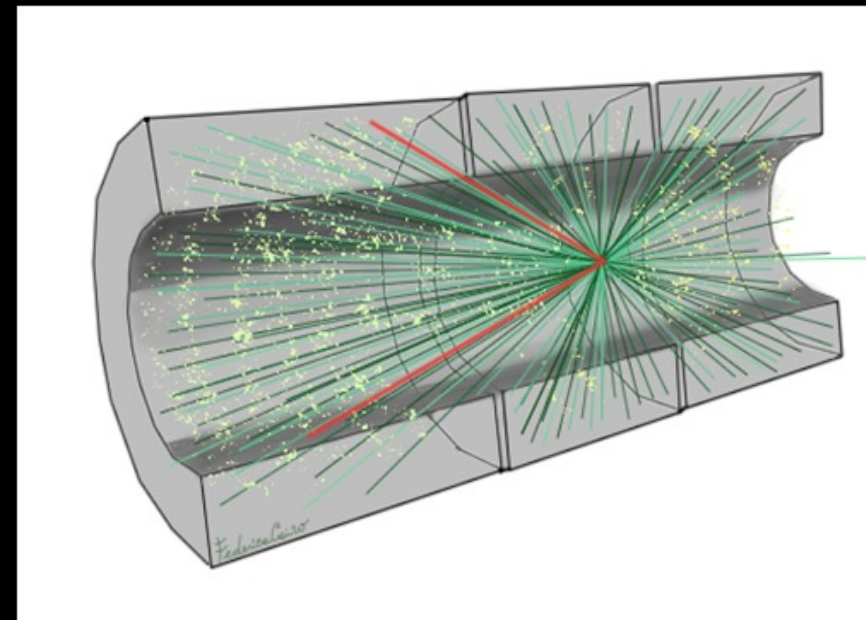
TRACKING DOWN THE HIGGS BOSON PROPERTIES IN ATLAS

Valentina Maria Martina Cairo

*A Nino,
Franca,
Federica
perché sono
e saranno sempre
loro
la mia vera
Vittoria.*

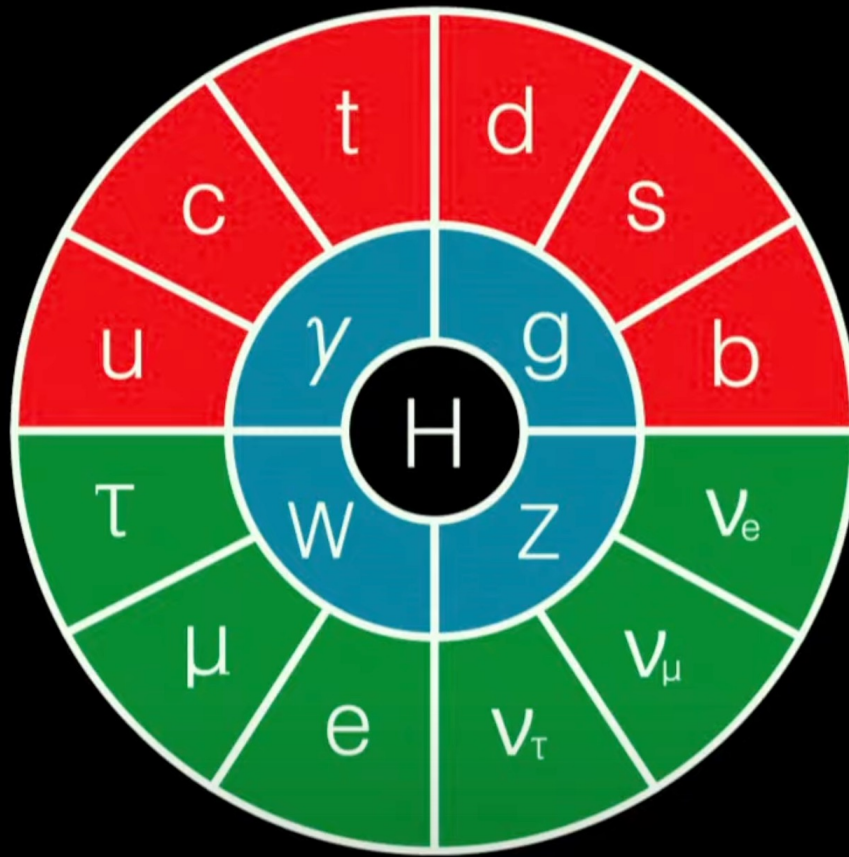
*(un po') A Ferri,
per tutte le volte
che diciamo la stessa
identica cosa.*

Illustrations:
Federica Cairo

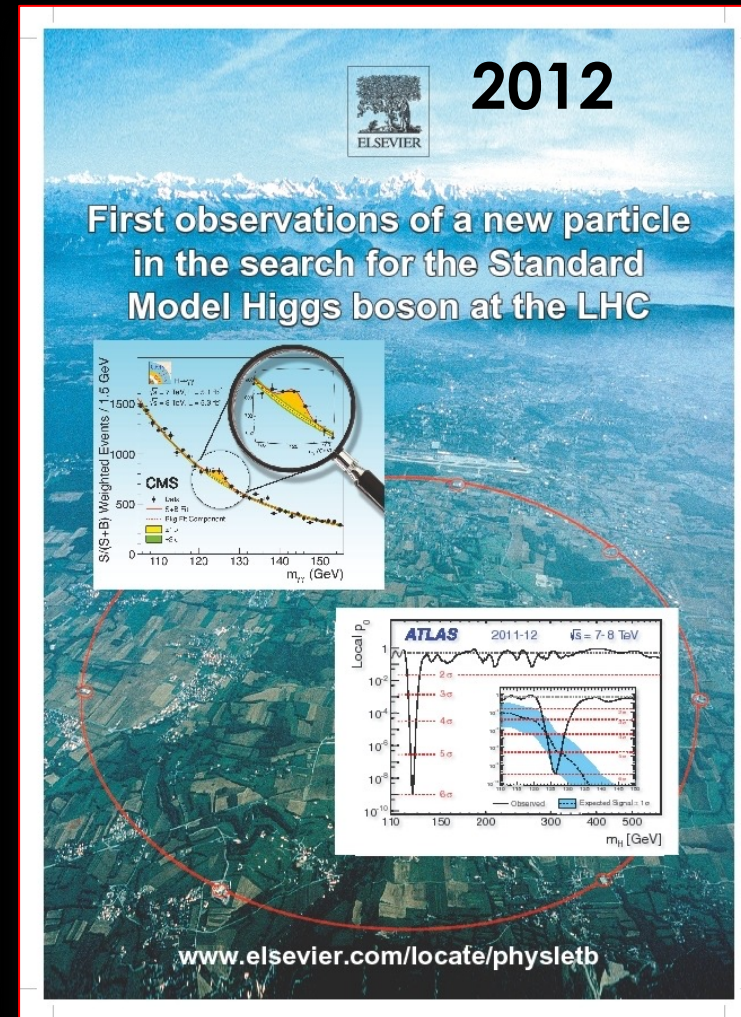


This is a journey that I have not done alone.

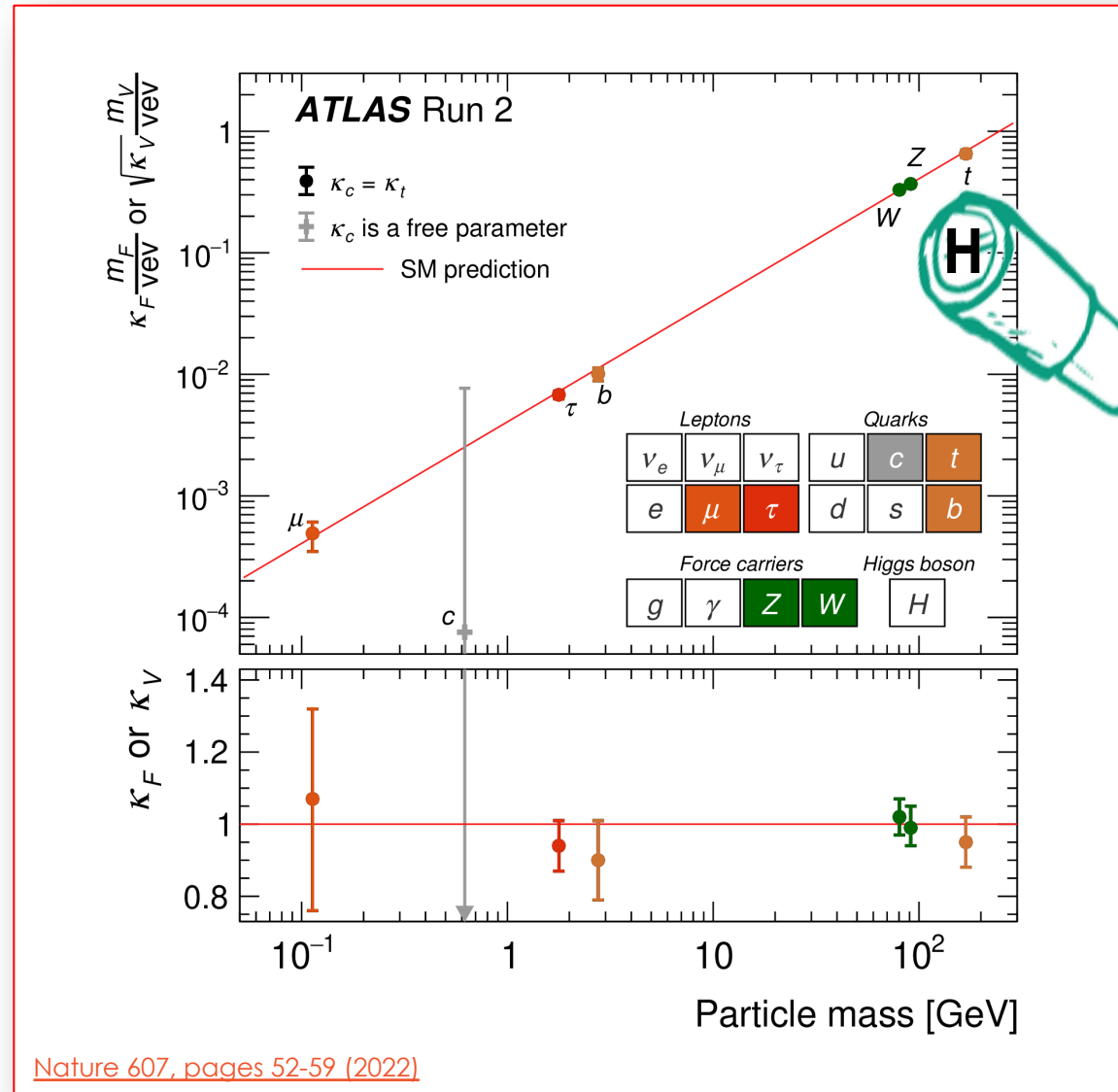
**I have had the pleasure of collaborating with
brilliant and creative colleagues within the ATLAS
collaboration,
without whom the achievements I will describe
today would have not been possible.**



From the movie *Particle Fever*



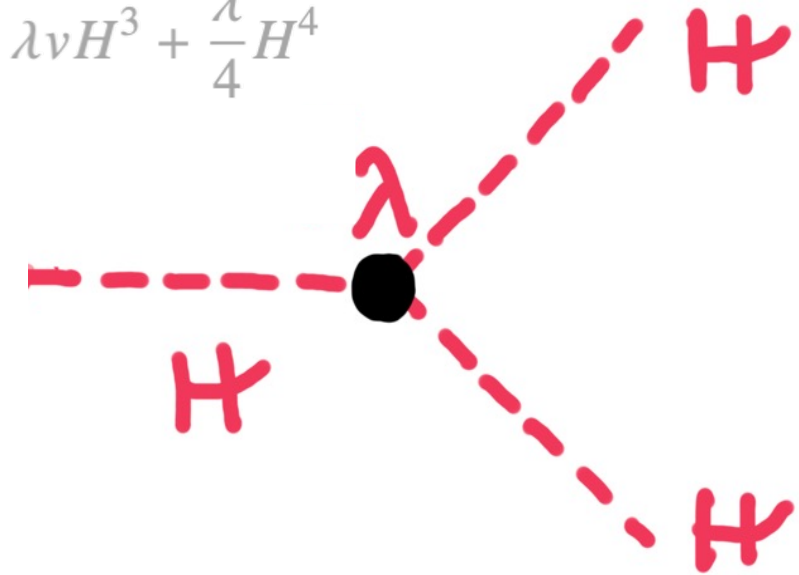
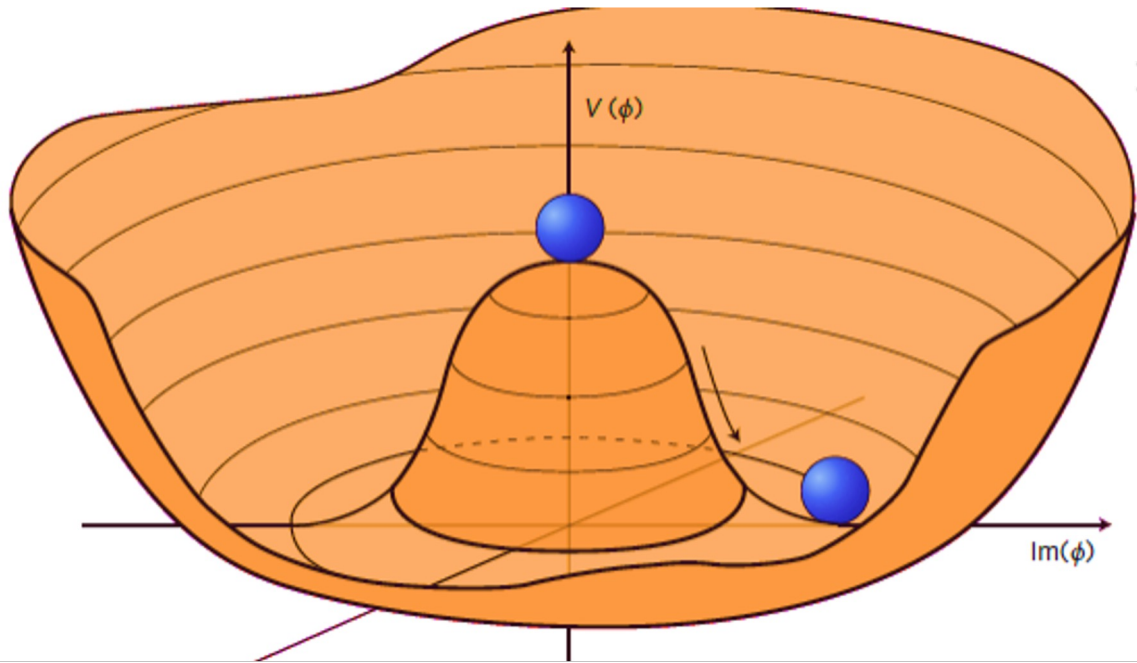
THE POST-HIGGS BOSON ERA



THE HIGGS SELF-COUPLING

$$V(\phi^\dagger \phi) = \mu^2 \phi^\dagger \phi + \lambda (\phi^\dagger \phi)^2$$

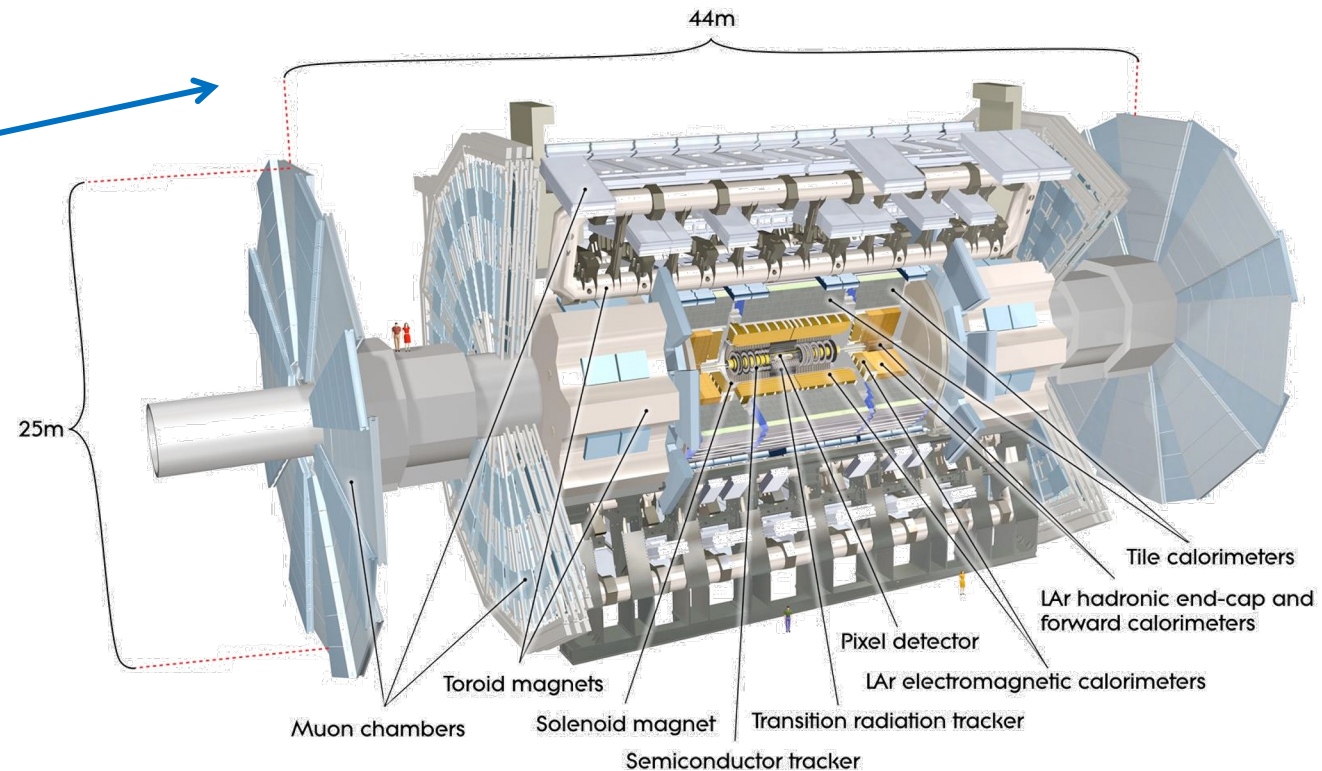
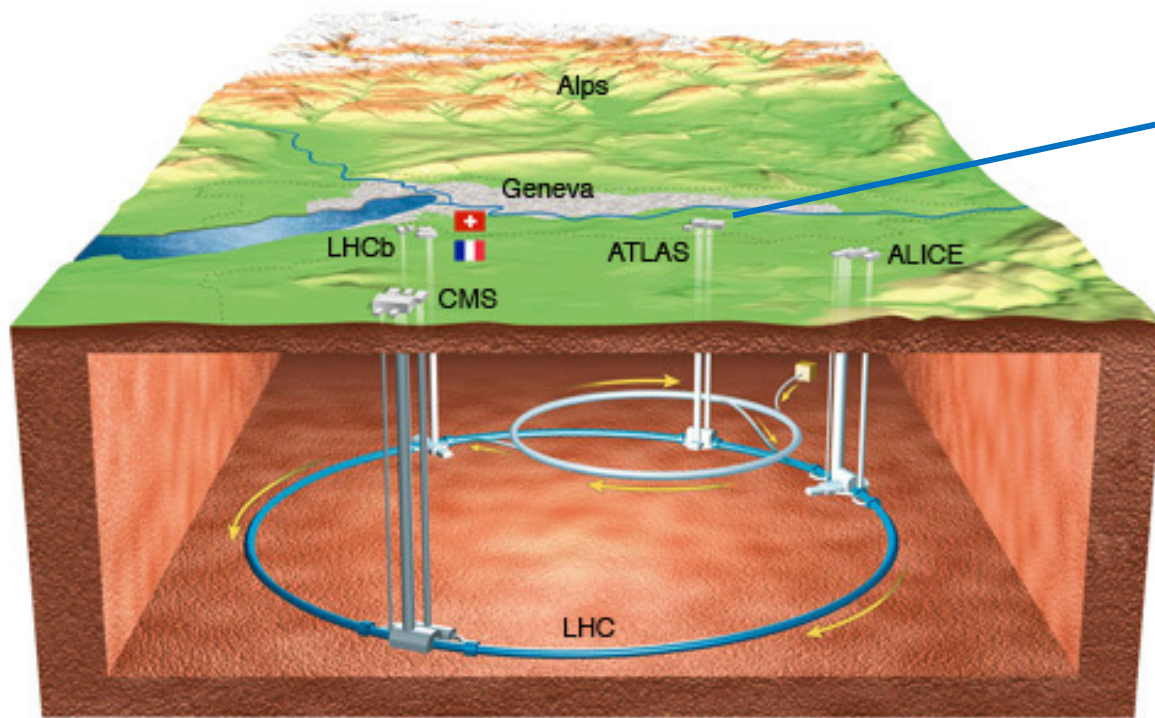
$$\supset \lambda v^2 H^2 + \lambda v H^3 + \frac{\lambda}{4} H^4$$



The Higgs self-coupling λ determines the **shape** of the energy potential of the Higgs field

HIGGS PAIRS AT THE LHC WITH THE ATLAS EXPERIMENT

Need **high energy** to produce a **Higgs boson pair** & **high luminosity** to produce many

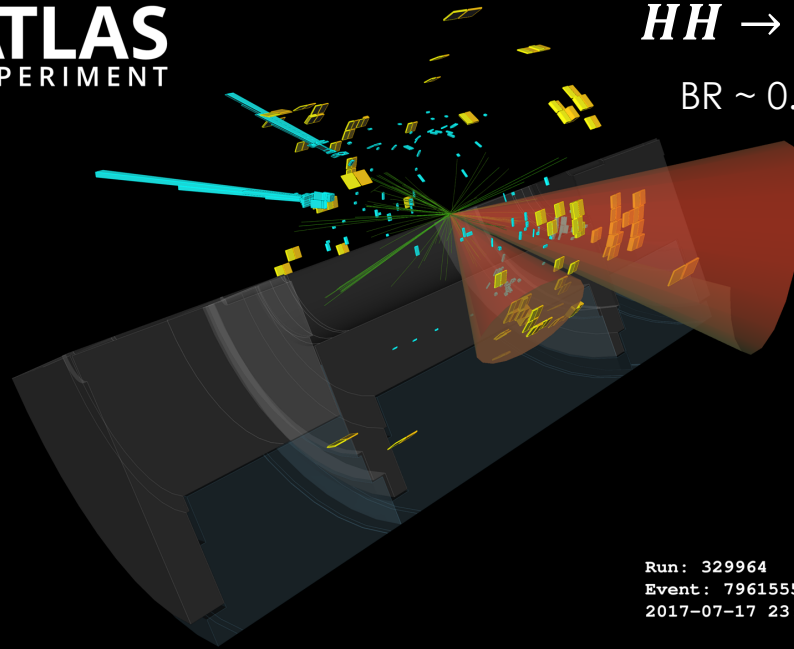


~ **1 in 1 billion** proton-proton collisions @LHC produces a **Higgs boson**
~ **1 in 1 trillion** proton-proton collisions @LHC produces a **Higgs boson pair**

$$HH \rightarrow b\bar{b}\gamma\gamma$$

BR ~ 0.26%

21.08.23

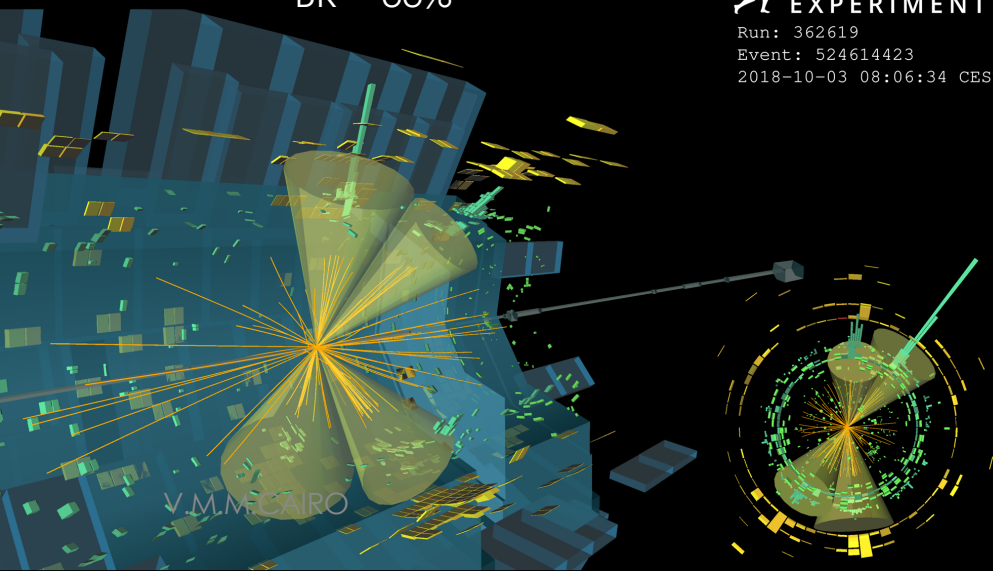


Run: 329964
Event: 796155578
2017-07-17 23:58:15 CEST

$$HH \rightarrow b\bar{b}b\bar{b}$$

BR ~ 33%

Run: 362619
Event: 524614423
2018-10-03 08:06:34 CEST

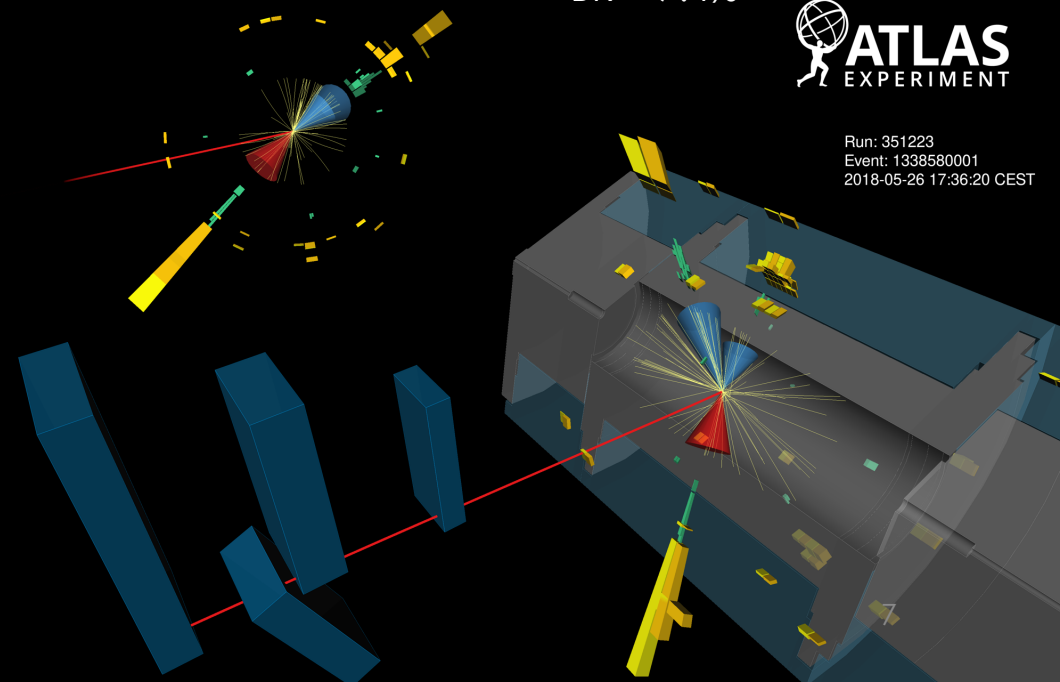


V.M. CAIRO

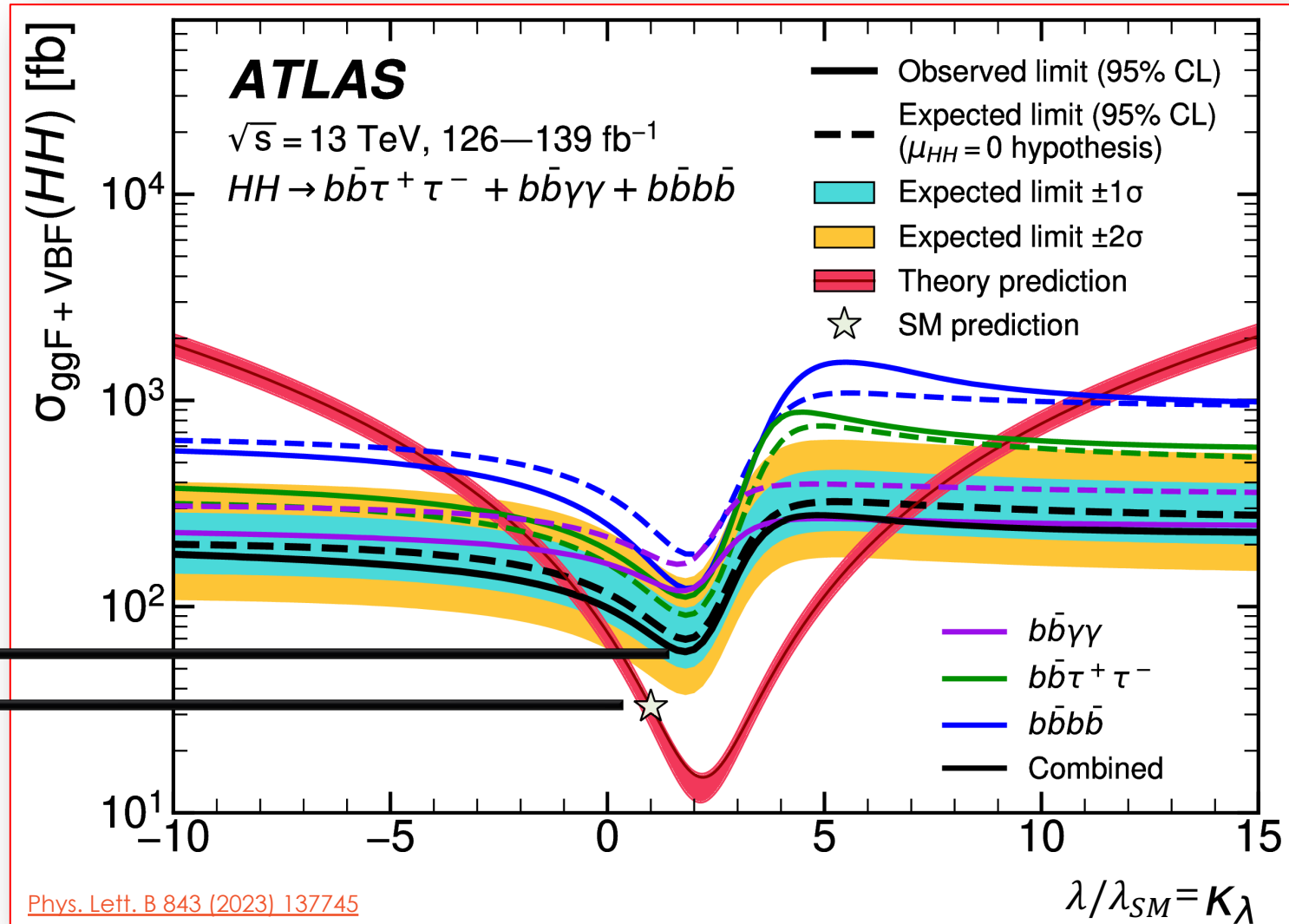
$$HH \rightarrow b\bar{b}\tau\tau$$

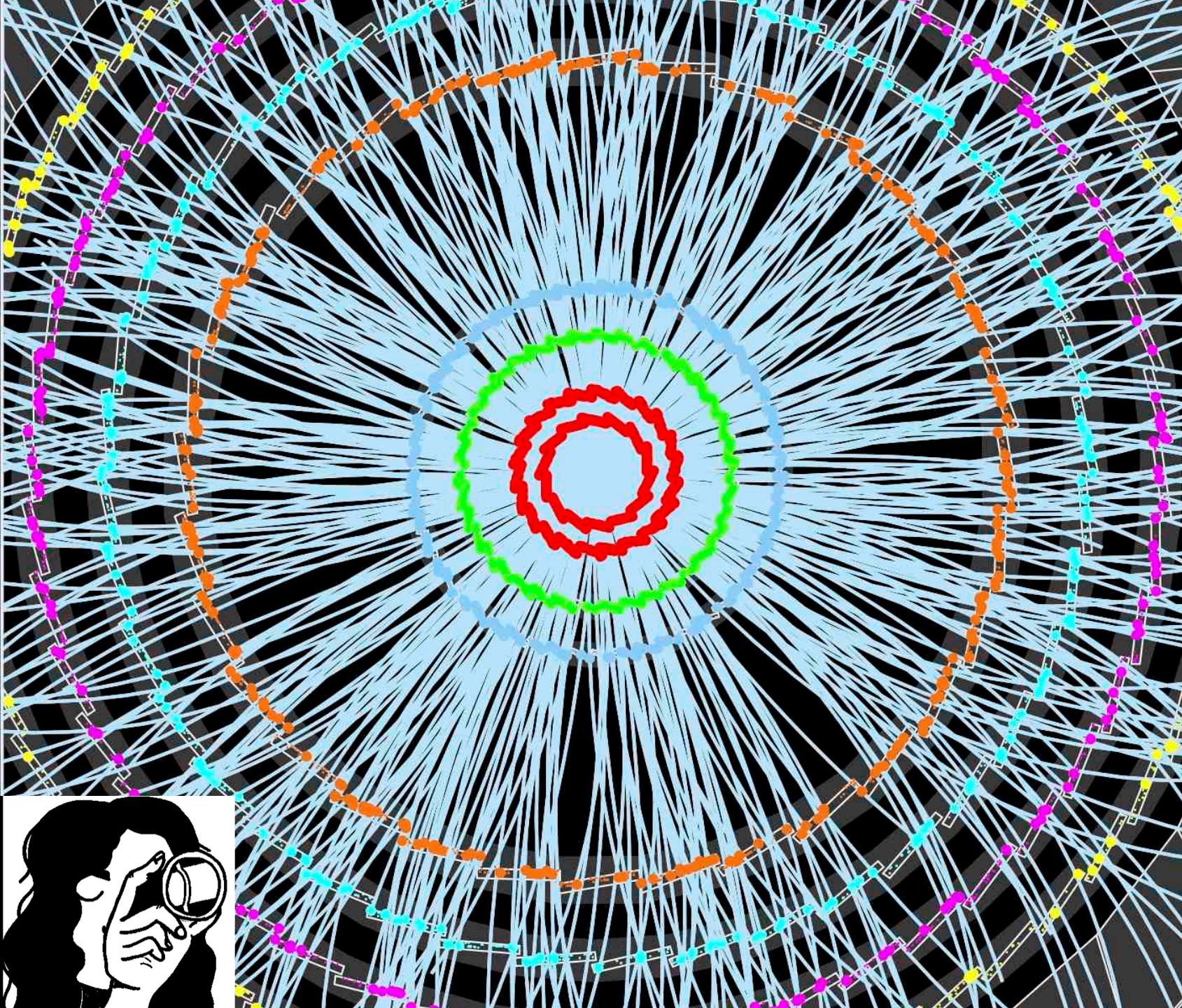
BR ~ 7.4%

Run: 351223
Event: 1338580001
2018-05-26 17:36:20 CEST



HIGGS PAIRS

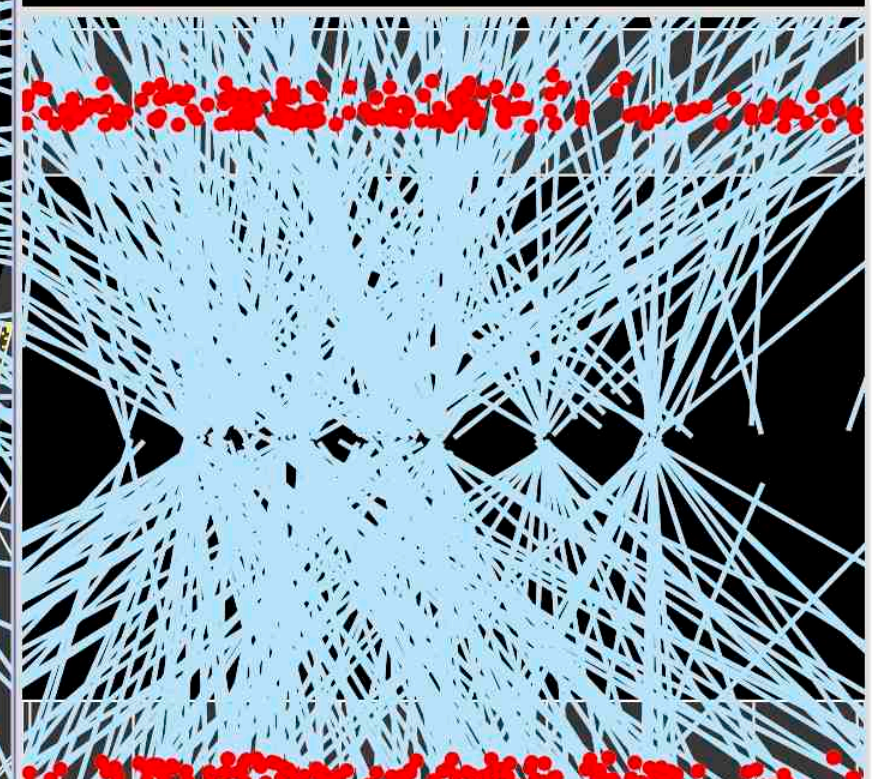




Run Number: 266904, Event Number: 25884805

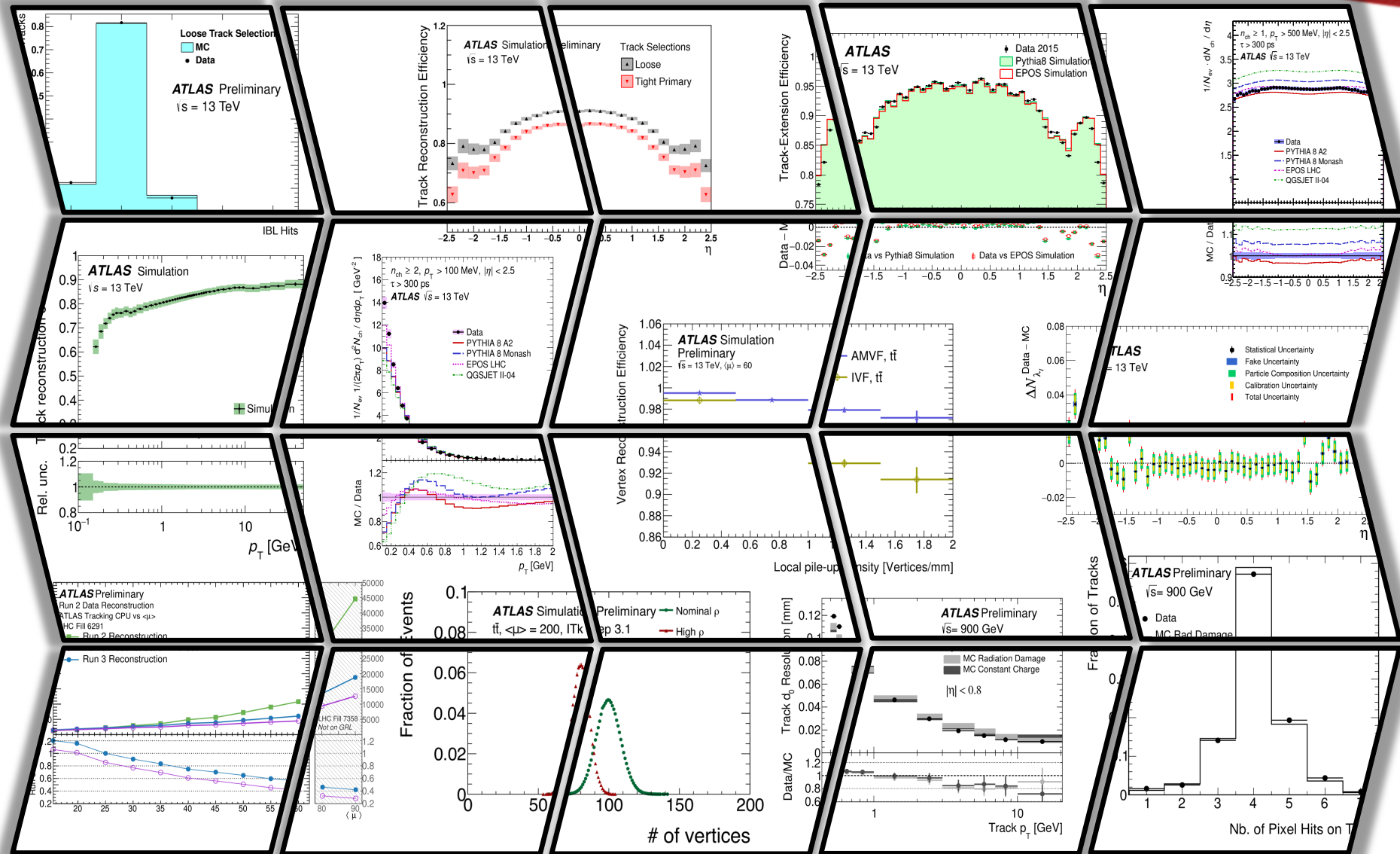
Date: 2015-06-03 13:41:54 CEST

O(15) charged-particles per p-p interaction
X # simultaneous p-p interaction



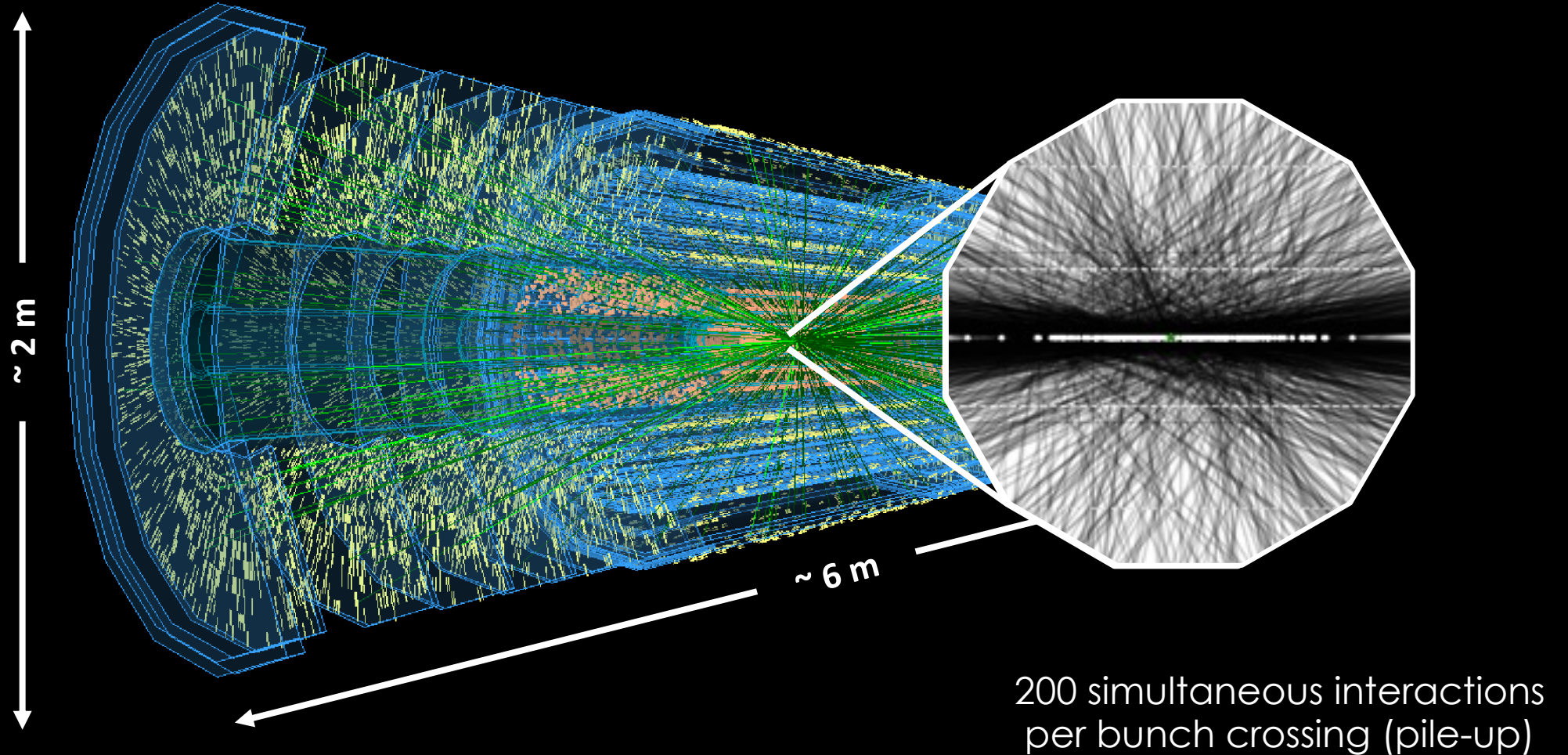
TRACKS AND VERTICES

The
building
blocks
of the
LHC
events



HL-LHC: USING GIGANTIC CAMERAS FOR RARE & COMPLEX EVENTS!

ATLAS Inner
Tracker
(ITk) in
preparation
for
HL-LHC
(2029)

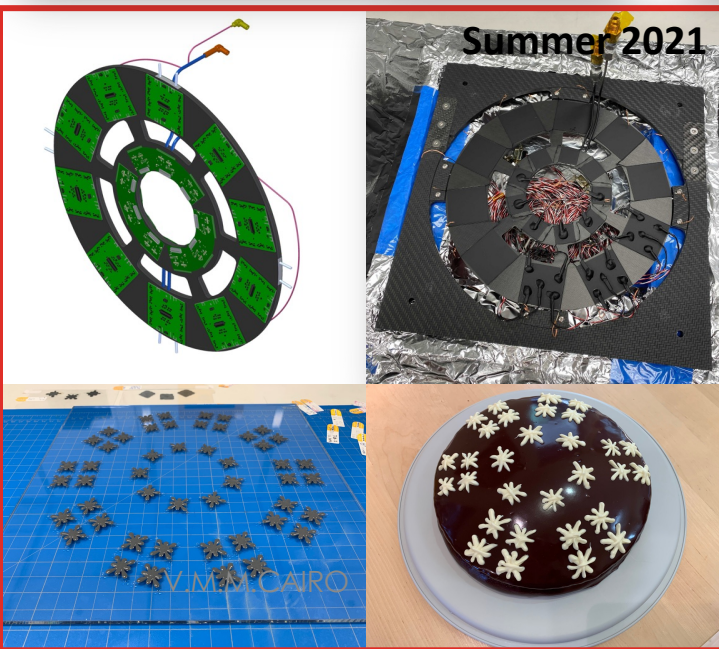
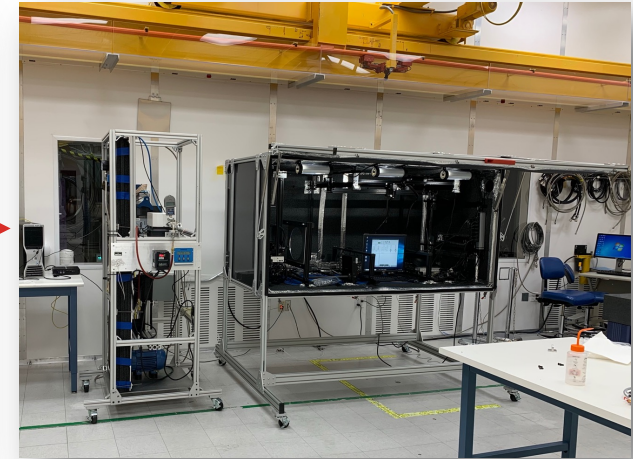


BUILDING THE ATLAS ITK

Fall 2019

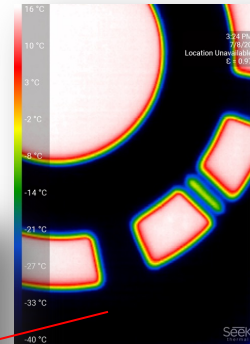
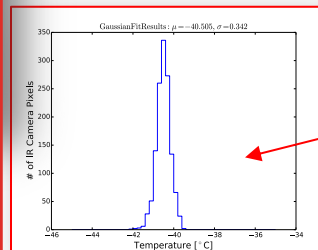


Early 2020



Summer 2021

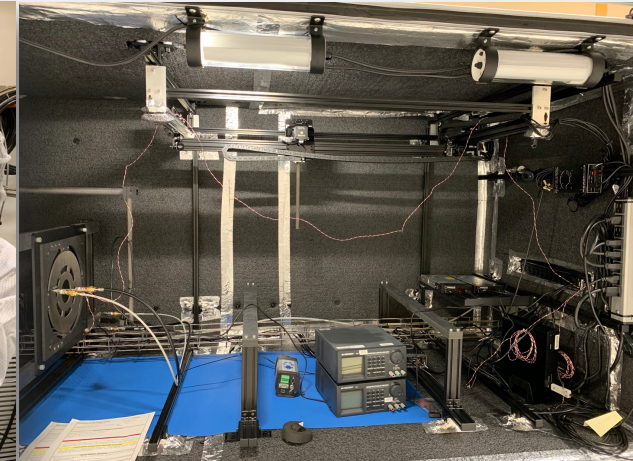
Bare
local support
meets
specifications



$$T = -40.5 \pm 0.3^{\circ}\text{C}$$

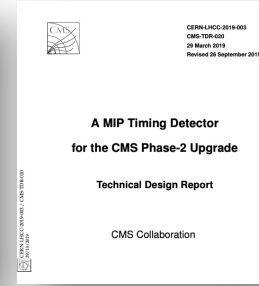
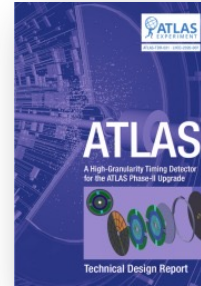


Early 2021



WHAT'S NEXT?

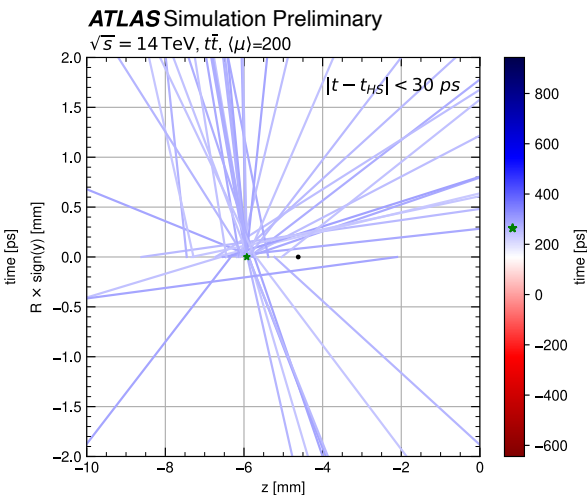
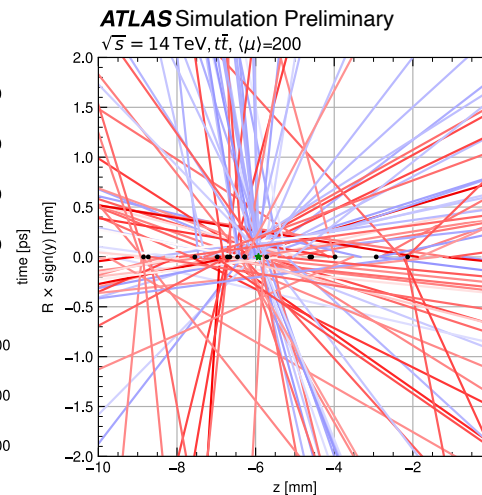
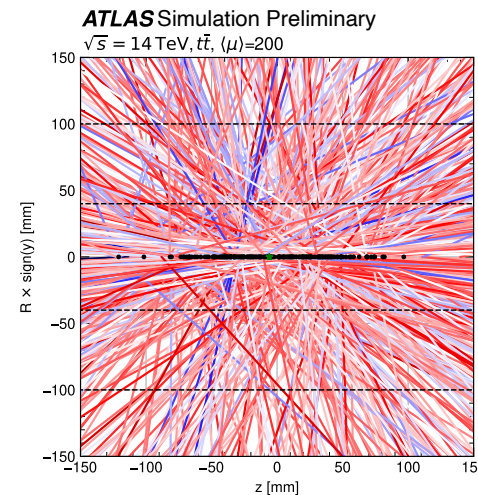
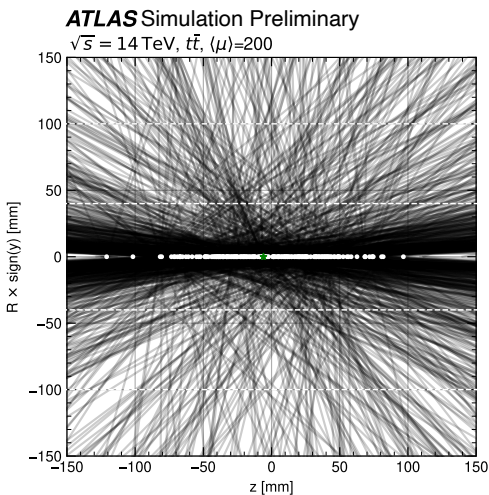
- Addition of timing layers to HEP detectors growing area of interest
- **Next step in advancing technologies are real 4-dimensional silicon trackers** (resolution of $\mathcal{O}(10\ \mu\text{m})$ & $\mathcal{O}(10\ \text{ps})$)
- **Excellent opportunity during HL-LHC and, in particular, for future energy frontier trackers**
 - First exploratory studies in ATLAS



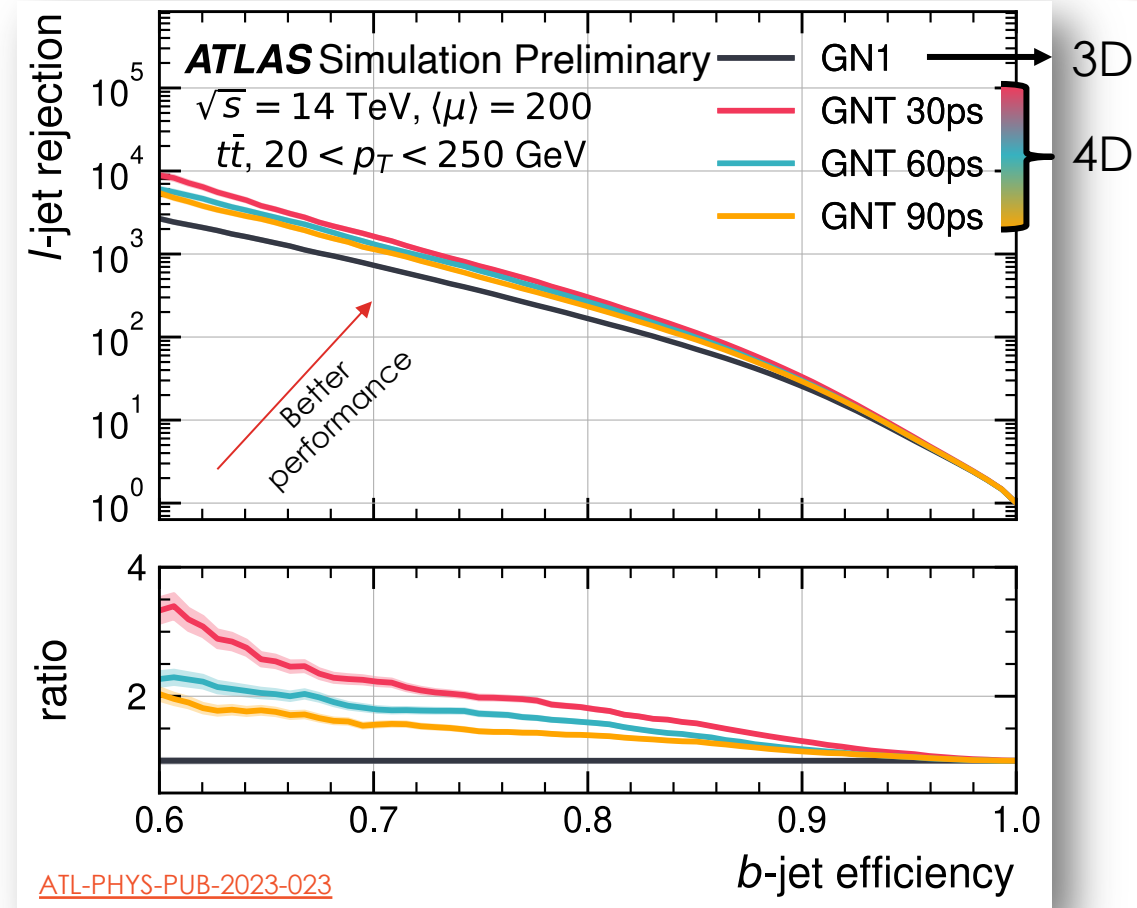
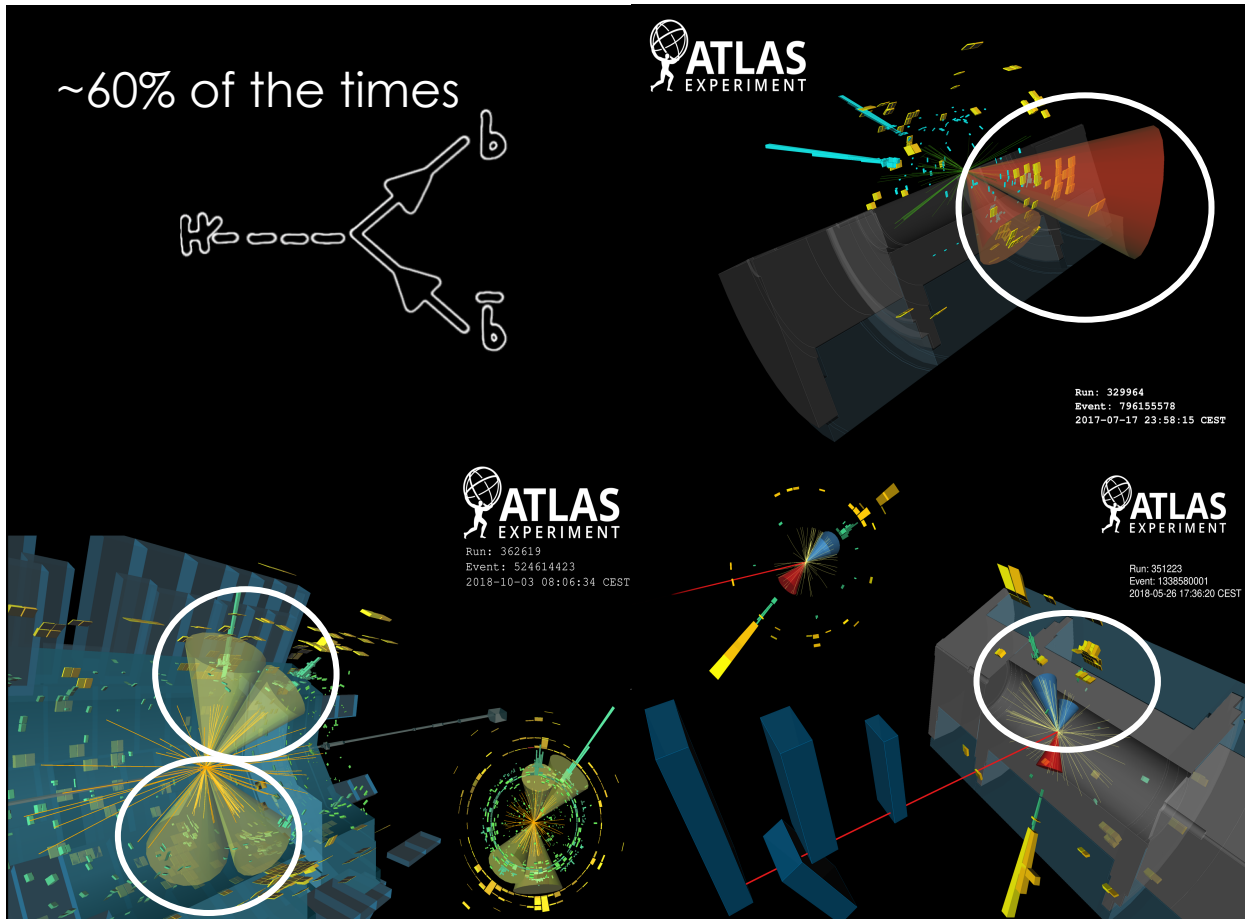
FLAVOUR PHYSICS | FEATURE

LHCb looks forward to the 2030s

1 March 2023



4-DIMENSIONAL TRACKING

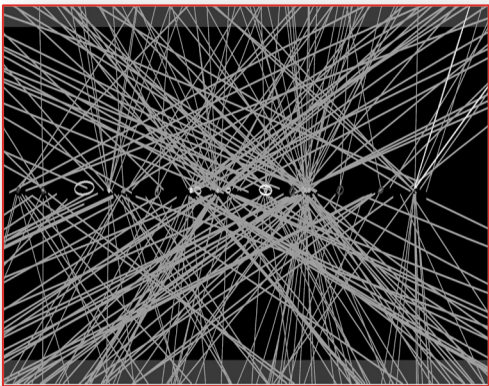


Interesting potential HH sensitivity increase!

CONCLUSIONS

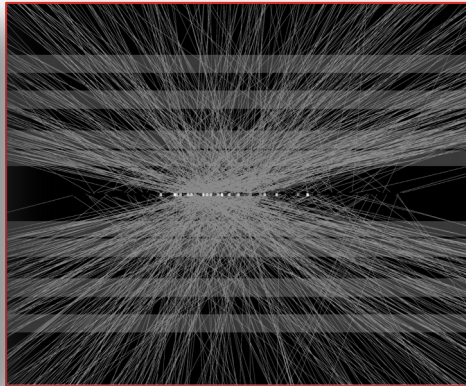
- **Exciting science ahead** to track down the Higgs boson properties and solve some of the yet-to-be answered questions in Particle Physics
- Interplay between **detector design, performance, measurements and searches** is of paramount importance for LHC physics

2009



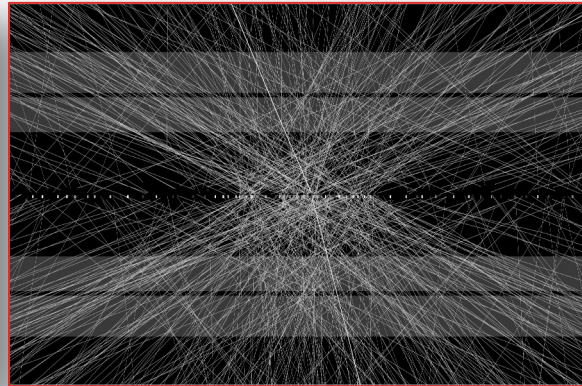
$\langle \text{pile-up} \rangle \sim 20$

2015



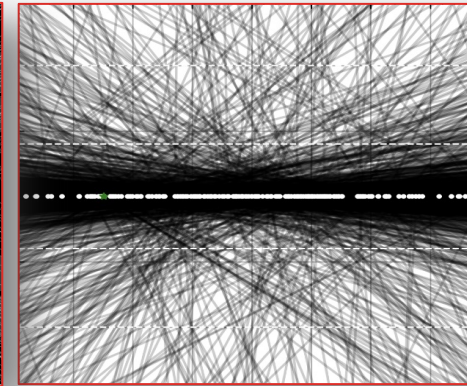
$\langle \text{pile-up} \rangle \sim 30$

2022



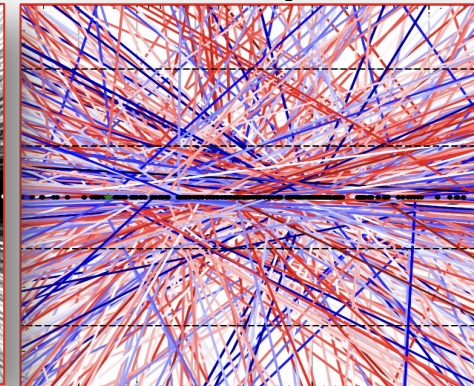
$\langle \text{pile-up} \rangle \sim 60$

2029



$\langle \text{pile-up} \rangle \sim 140$

...and beyond?



$\langle \text{pile-up} \rangle \sim 200$

A HEARTFELT THANKS TO...

...the EPS High Energy Particle Physics Division for this recognition
and to the very many special people, groups, and institutes who share this award with me.



*Istituto Istruzione
Superiore "E. Siciliano"*
Bisignano (CS)

