SMARTHEP

REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

SMARTHEP Yearly Meeting

ESR1: Machine learning and Real-Time Analysis for Higgs boson measurements and fleet safety

Lund, 27 November 2023

Patin Inkaew

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

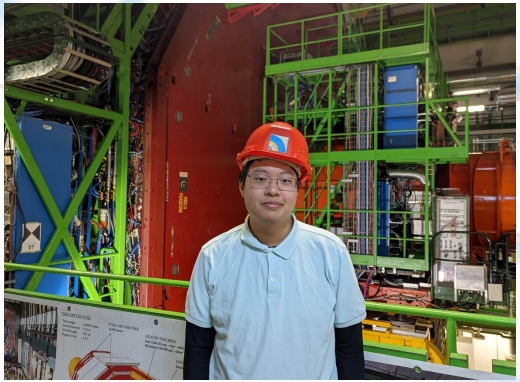
SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

About me

HELSINKI INSTITUTE OF PHYSICS

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Name: Patin Inkaew (PI ~ 3.14)
Nickname: Earth
Birthday: 22 July 1998 (22/7 ~ 3.14)
Hometown: Bangkok, Thailand
Institution:
University of Helsinki (UH), Helsinki Institute of Physics (HIP)
Contract start: 01/10/2022



Education
Stanford University, CA, USA (Thai Government Scholarship)

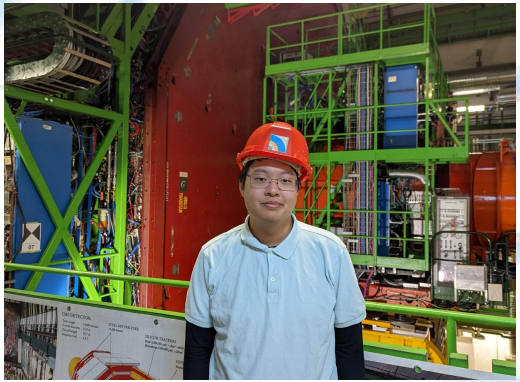
- **Coterminal program** (Joint BS+MS) in 4 years
- **BS:** Physics, Minor: Mathematics, East Asian Studies (Japan subplan)
- **MS:** Computer science (AI track)
- **Research:** Many things: laser, detector design, ML, CV, CG, ComBio
  but not much experience with particle physics analysis

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

Stanford University

About me

Name: Patin Inkaew (PI ~ 3.14)
Nickname: Earth
Birthday: 22 July 1998 (22/7 ~ 3.14)
Hometown: Bangkok, Thailand
Institution:
University of Helsinki (UH), Helsinki Institute of Physics (HIP)
Contract start: 01/10/2022



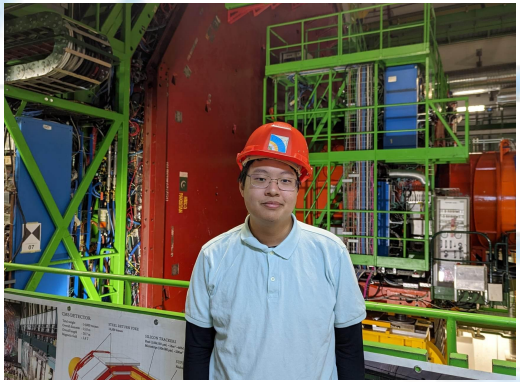
Education
Stanford University, CA, USA (Thai Government Scholarship)

- **Coterminal program** (Joint BS+MS) in 4 years
- **BS:** Physics, Minor: Mathematics, East Asian Studies (Japan subplan)
- **MS:** Computer science (AI track)
- **Research:** Many things: laser, detector design, ML, CV, CG, ComBio
  but not much experience with particle physics analysis

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

About me

Name: Patin Inkaew (PI ~ 3.14)
Nickname: Earth
Birthday: 22 July 1998 (22/7 ~ 3.14)
Hometown: Bangkok, Thailand
Institution:
University of Helsinki (UH), Helsinki Institute of Physics (HIP)
Contract start: 01/10/2022



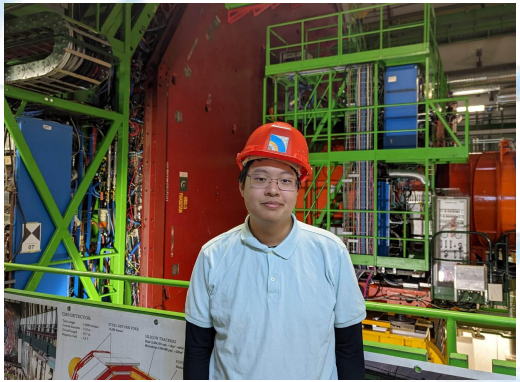
Education
Stanford University, CA, USA (Thai Government Scholarship)

- **Coterminal program** (Joint BS+MS) in 4 years
- **BS:** Physics, Minor: Mathematics, East Asian Studies (Japan subplan)
- **MS:** Computer science (AI track)
- **Research:** Many things: laser, detector design, ML, CV, CG, ComBio ~~but not much~~ experience with particle physics analysis

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

About me

Name: Patin Inkaew (PI ~ 3.14)
Nickname: Earth
Birthday: 22 July 1998 (22/7 ~ 3.14)
Hometown: Bangkok, Thailand
Institution:
University of Helsinki (UH), Helsinki Institute of Physics (HIP)
Contract start: 01/10/2022



Education
Stanford University, CA, USA (Thai Government Scholarship)

- **Coterminal program** (Joint BS+MS) in 4 years
- **BS:** Physics, Minor: Mathematics, East Asian Studies (Japan subplan)
- **MS:** Computer science (AI track)
- **Research:** Many things: laser, detector design, ML, CV, CG, ComBio

a bit more experience with particle physics analysis

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

ESR1: Machine learning and Real-Time Analysis for Higgs boson measurements and fleet safety

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

ESR1: Machine learning and Real-Time Analysis for Higgs boson measurements and fleet safety

PhD:
University of Helsinki (UH) & Helsinki Institute of Physics (HIP), Finland

Supervisors:
Mikko Voutilainen,
Henning Kirschenmann

Secondment:
CERN, Switzerland

Collaborator:
Maurizio Pierini

Secondment:
Verizon Connect, Italy

Collaborators:
Leonardo Taccari,
Francesco Sambo

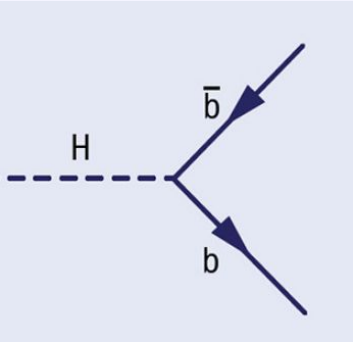
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

ESR1: Machine learning and Real-Time Analysis for Higgs boson measurements and fleet safety

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

Why Higgs?



- Higgs boson was one of the initial goal of LHC
- Higgs boson was discovered in 2012!

- Higgs boson gives mass to other particles
- **But where does Higgs' mass come from?**
- If Higgs gives its own mass, self-interaction (di-Higgs) can be observed
- Unfortunately, di-Higgs events are extremely rare → goal for HL-LHC
- Improve Higgs boson measurement
  - H → γγ / H → ZZ* → 4l are rare, but have low background
  - H → bb has higher branching ratio, but suffers larger background
  - Real-time analysis can improve data acquisition rate in trigger system
  - Validated with frequent and well-studied Z → bb

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

ESR1: Machine learning and Real-Time Analysis for Higgs boson measurements and fleet safety

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Data Scouting Jet for Run 3 at CMS

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

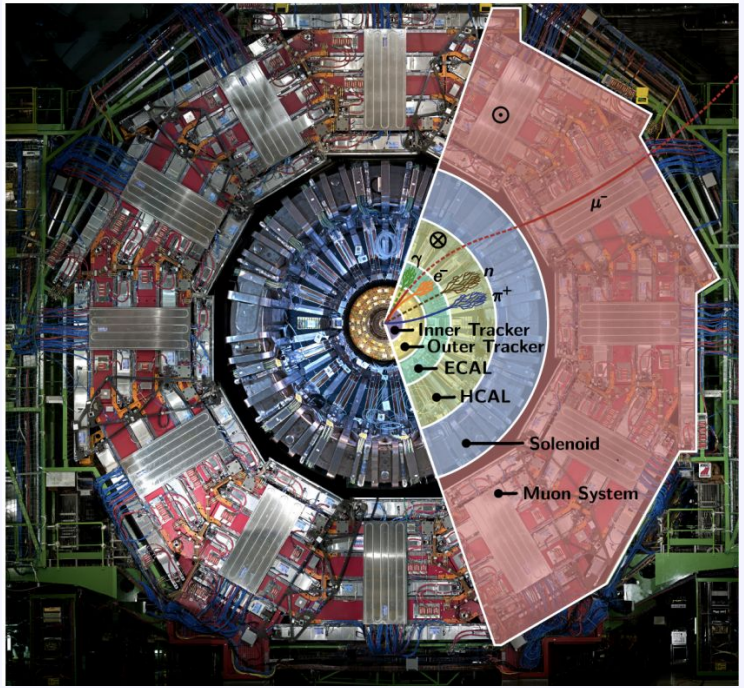
SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Data Scouting Jet for Run 3 at CMS

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

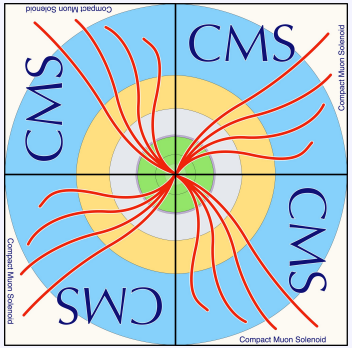
The Compact Muon Solenoid Experiment (CMS)



CMS is a general-purpose detector,

one of the four large experiments at LHC.

Focus: rare event search, precise measurement



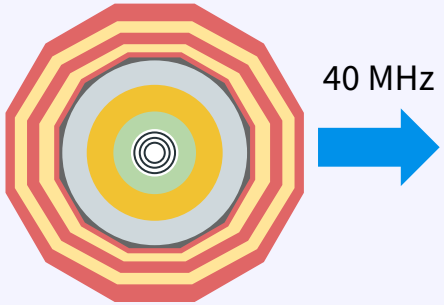
publish.etp.kit.edu/record/21378/files/0_EKP-2016-00014.pdf

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

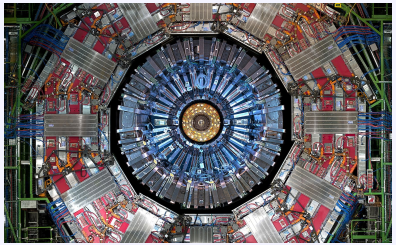
SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

CMS Trigger System

LHC collides pp every ~25 ns = 40 MHz



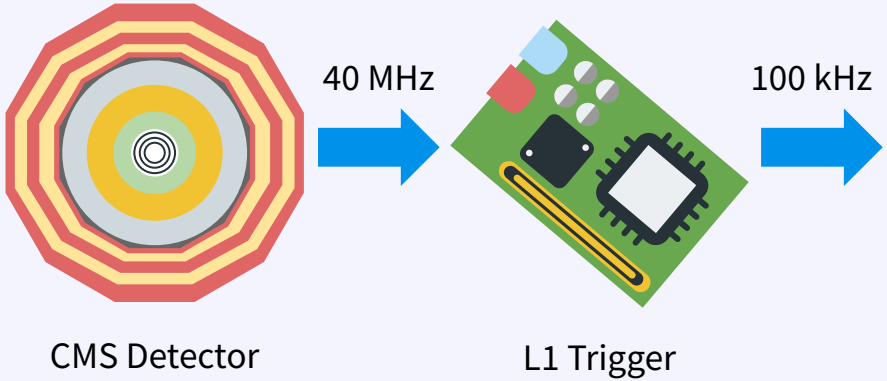
CMS Detector

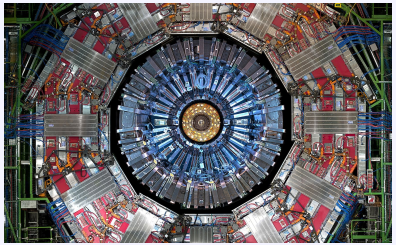


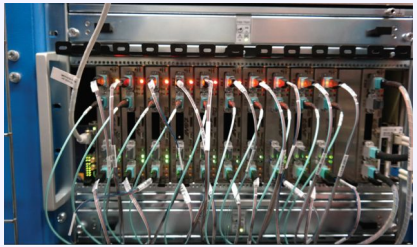
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

CMS Trigger System

L1 (Hardware based on FPGA) reduces rate to ~ 100 kHz



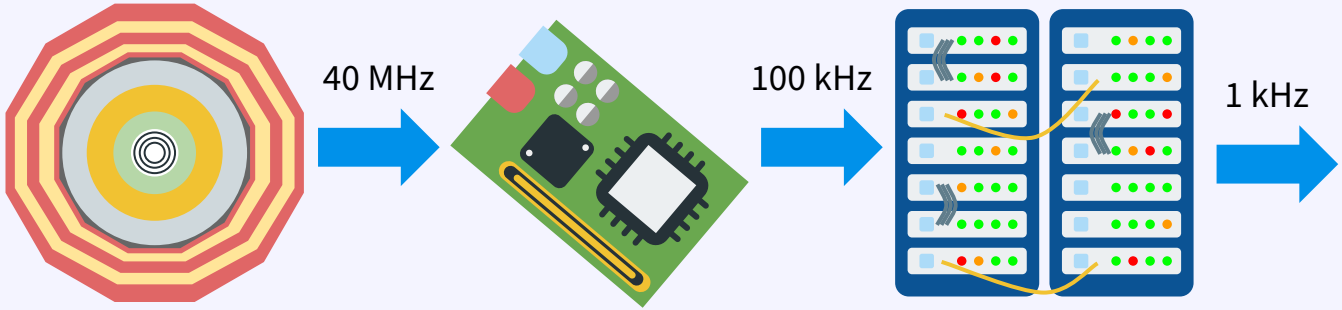


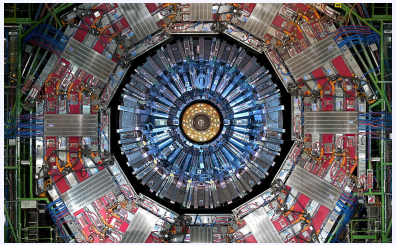


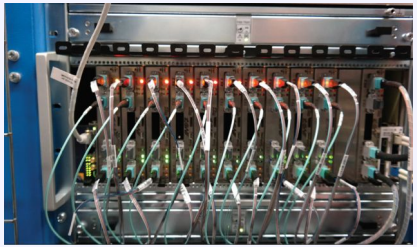
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

CMS Trigger System

HLT (Computer farm) reduces rate to ~ 1 kHz





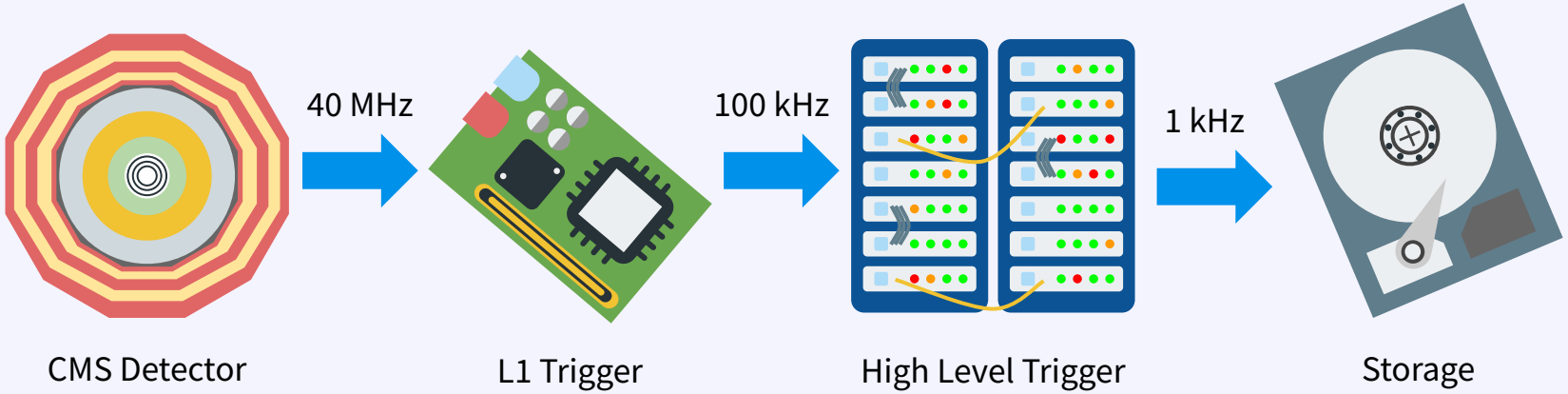


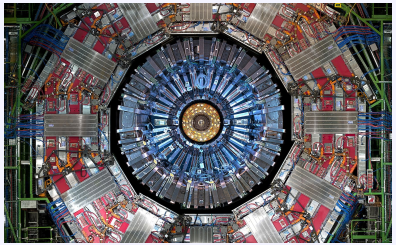
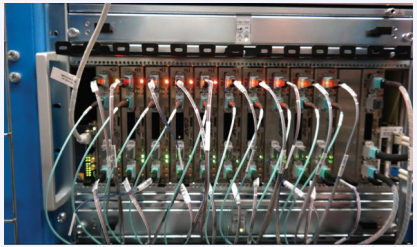
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

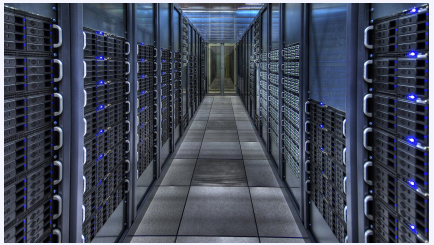
SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

CMS Trigger System

Data is transferred and stored at Tier 0





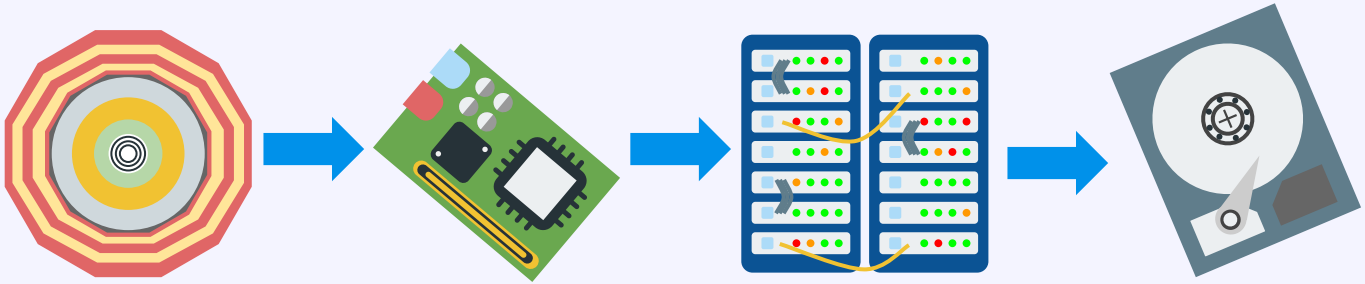
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Data Scouting Jet for Run 3 at CMS

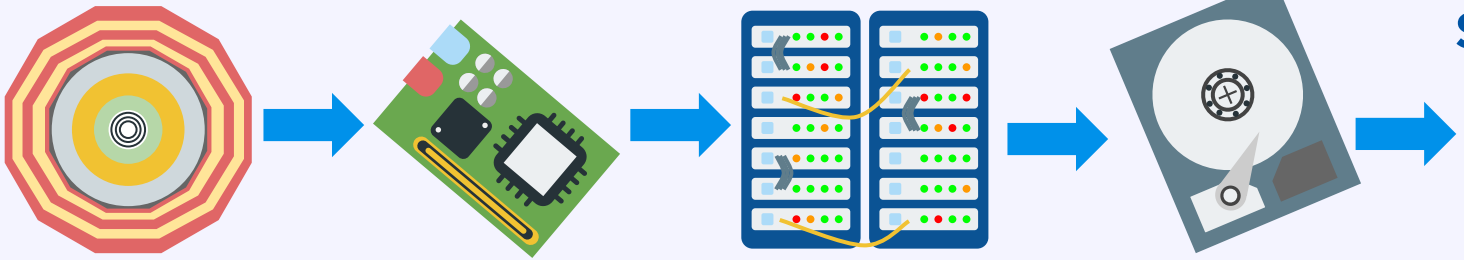
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



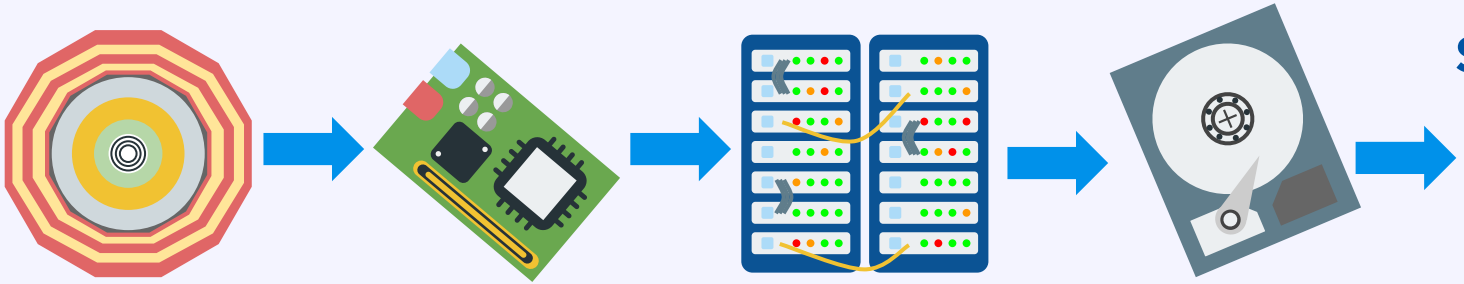
CMS → L1 Trigger → HLT → Storage

Standard Stream

- ~ 1 kHz
- ~ 1.5 MB/event
- full event
- reconstructed at Tier0 within 48 hours

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



CMS | L1 Trigger | HLT | Storage

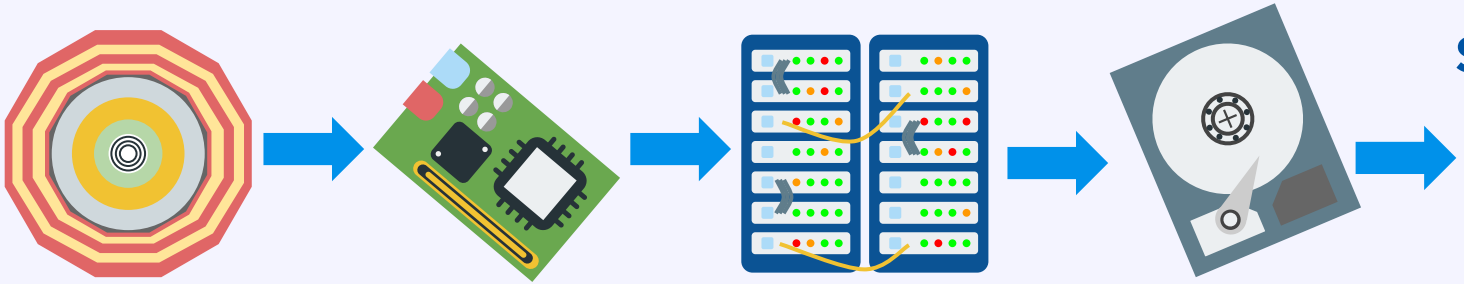
Standard Stream

- ~ 1 kHz
- ~ 1.5 MB/event
- full event
- reconstructed at Tier0 within 48 hours

The real bottleneck is data recording rate (MB/sec), not event rate (event/sec)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



CMS | L1 Trigger | HLT | Storage

Standard Stream

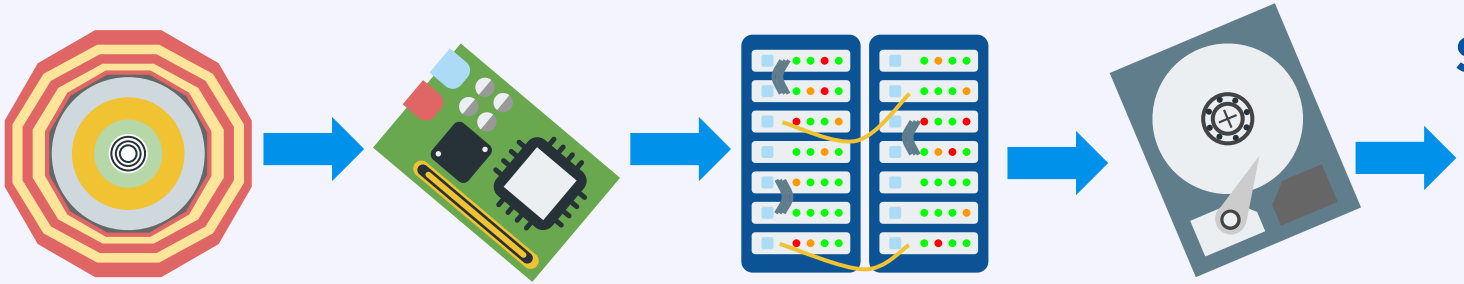
- ~ 1 kHz
- ~ 1.5 MB/event
- full event
- reconstructed at Tier0 within 48 hours

The real bottleneck is data recording rate (MB/sec), not event rate (event/sec)

Data writing rate (MB/s) = event size (MB) x rate (Hz)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



CMS | L1 Trigger | HLT | Storage

Standard Stream

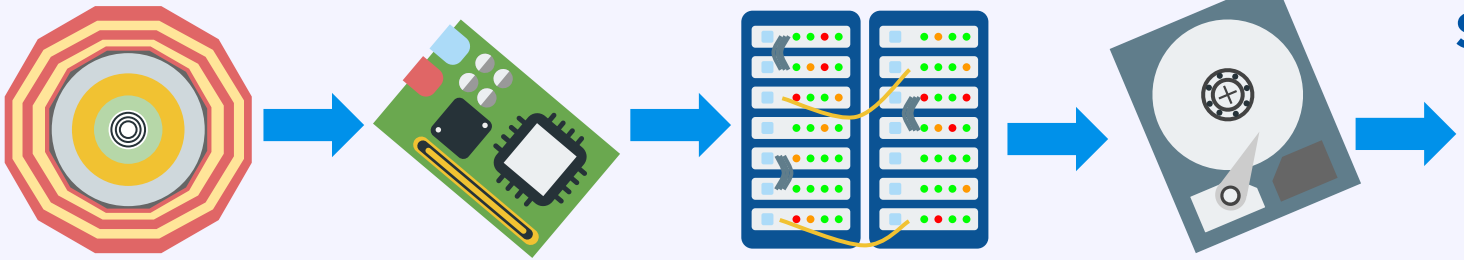
- ~ 1 kHz
- ~ 1.5 MB/event
- full event
- reconstructed at Tier0 within 48 hours

The real bottleneck is data recording rate (MB/sec), not event rate (event/sec)

Data writing rate (MB/s) = event size (MB) x rate (Hz)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



CMS | L1 Trigger | HLT | Storage

Standard Stream

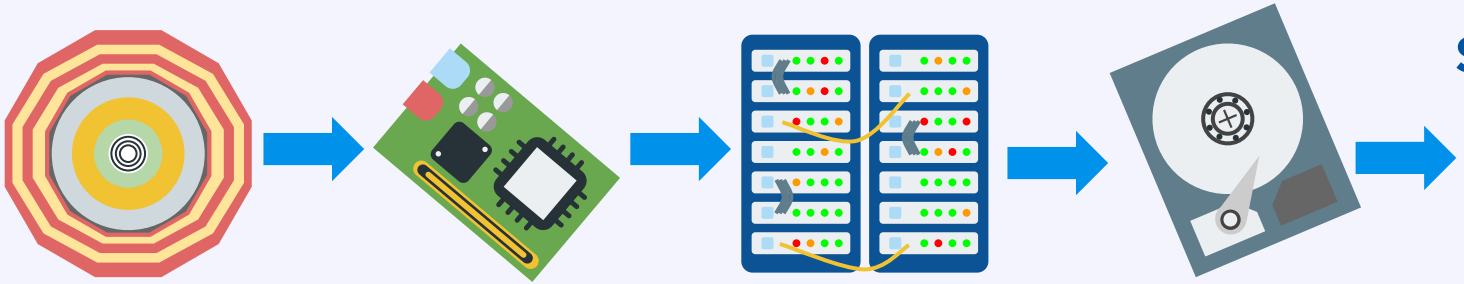
- ~ 1 kHz
- ~ 1.5 MB/event
- full event
- reconstructed at Tier0 within 48 hours

The real bottleneck is data recording rate (MB/sec), not event rate (event/sec)

Data writing rate (MB/s) = event size (MB) x rate (Hz)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



CMS | L1 Trigger | HLT | Storage

Standard Stream

- ~ 1 kHz
- ~ 1.5 MB/event
- full event
- reconstructed at Tier0 within 48 hours

The real bottleneck is data recording rate (MB/sec), not event rate (event/sec)

Data writing rate (MB/s) = event size (MB) x rate (Hz)

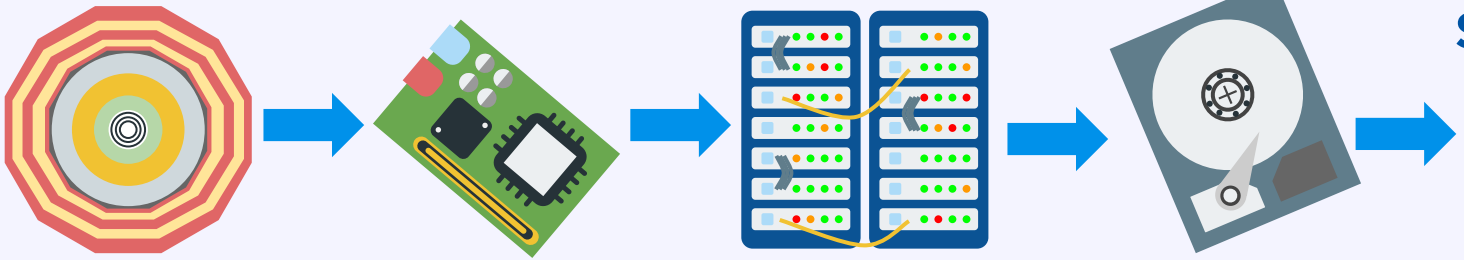
only keep smaller high-level description, and discard raw detector signals

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Scouting Stream

- reduced data format
- event size reduced by 100x
- event rate increased by 30x
- based on reconstruction at HLT (no offline reconstruction)



CMS L1 Trigger HLT Storage

Standard Stream

- ~ 1 kHz
- ~ 1.5 MB/event
- full event
- reconstructed at Tier0 within 48 hours

The real bottleneck is data recording rate (MB/sec), not event rate (event/sec)

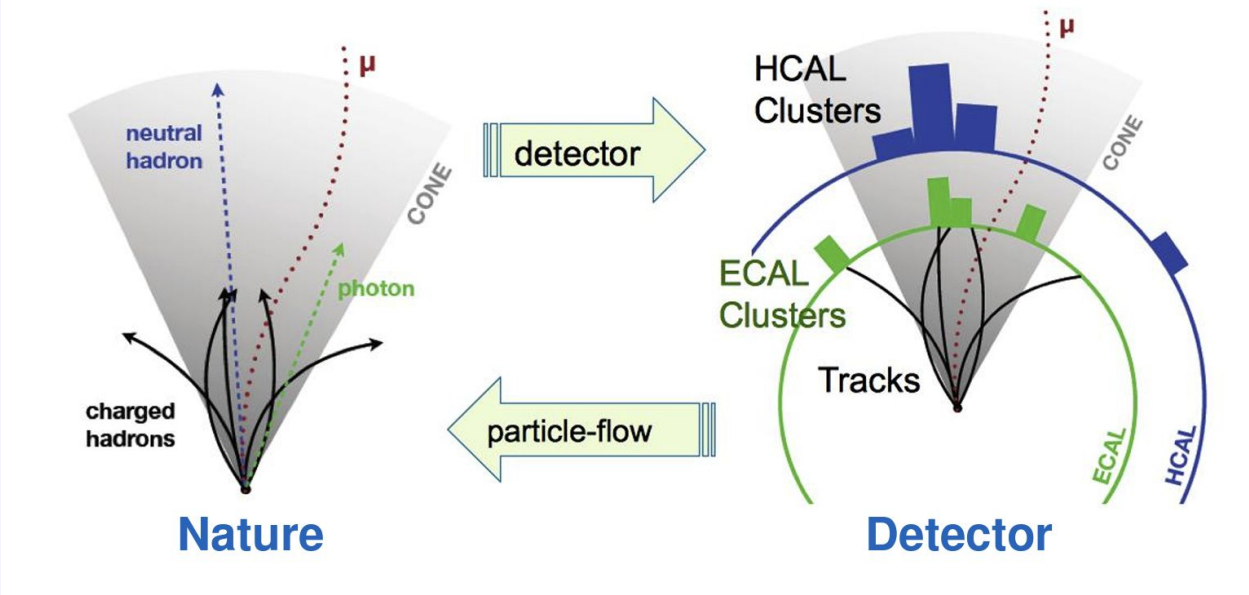
Data writing rate (MB/s) = event size (MB) x rate (Hz)

only keep smaller high-level description, and discard raw detector signals

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Interlude: Particle Flow (PF)

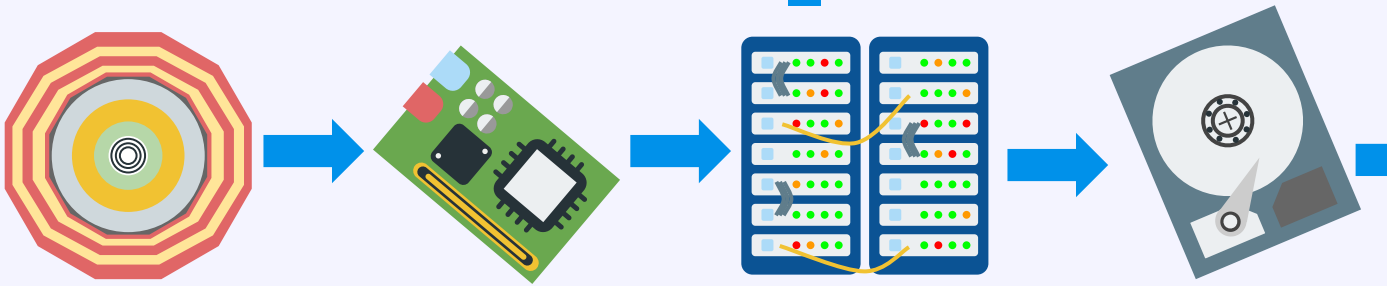


PF combines all sub-detector primitives (tracks, clusters) to produce physical objects: electron, photon, muon, neutral and charged hadrons.

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Scouting Stream
= only PF particles reconstructed at HLT



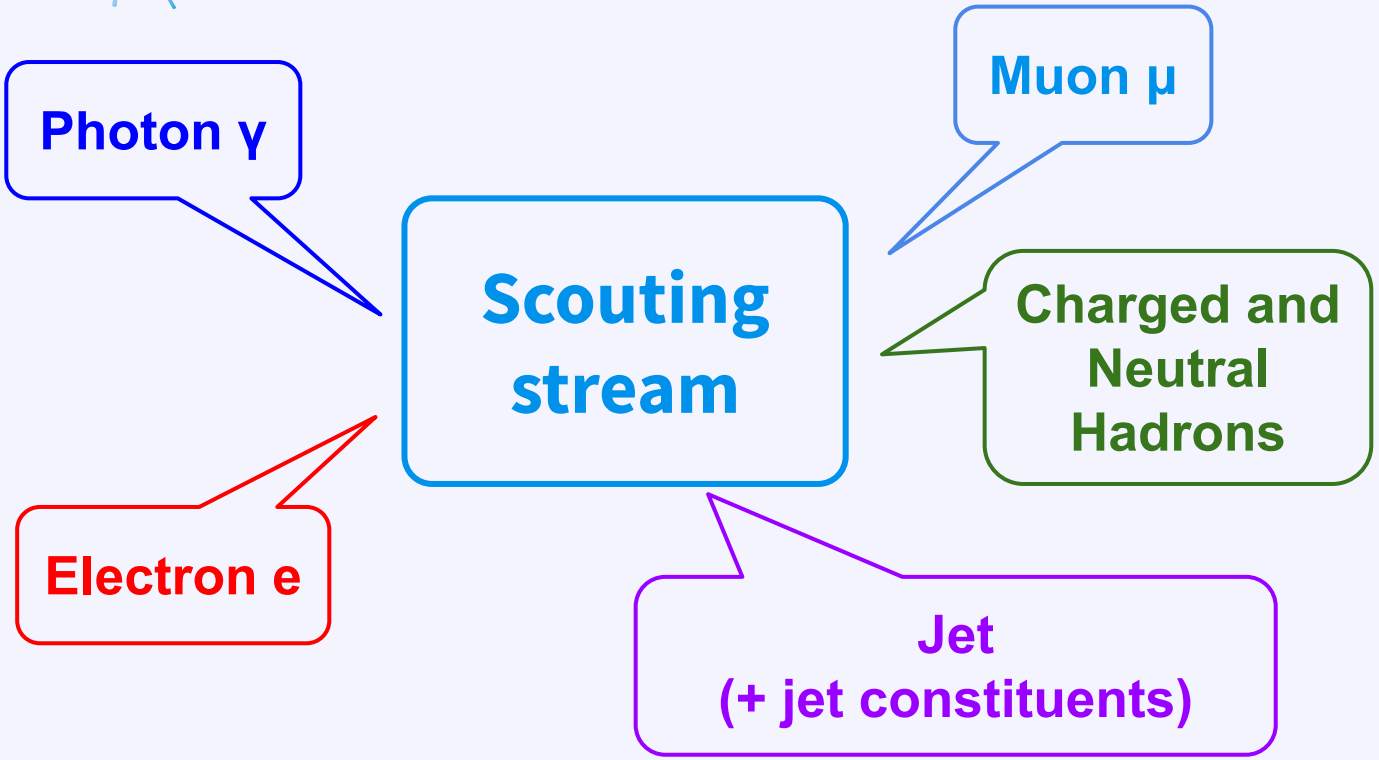
CMS | L1 Trigger | HLT | Storage

Standard Stream
= all raw detector readout

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

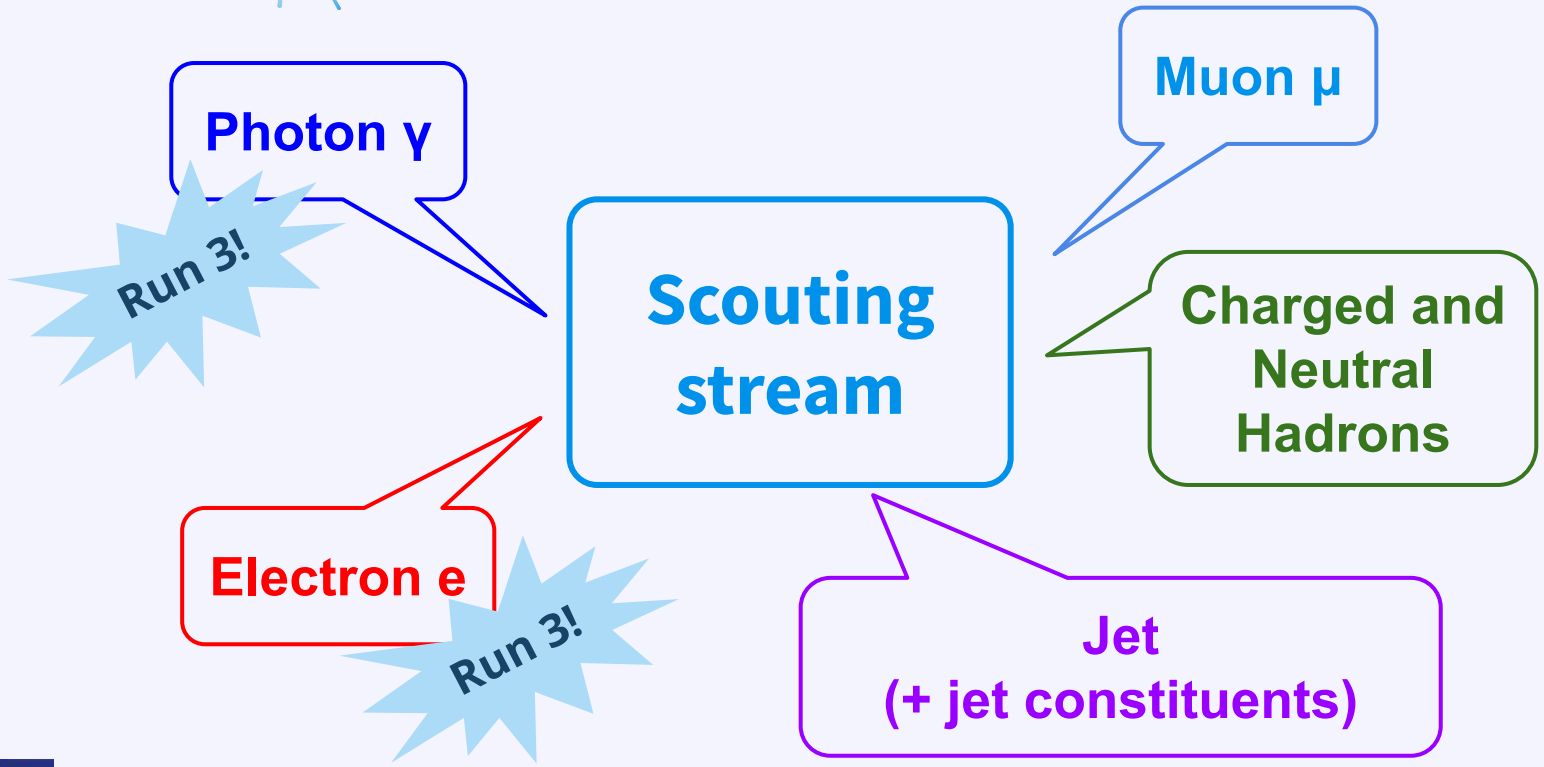
What's in scouting stream



SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

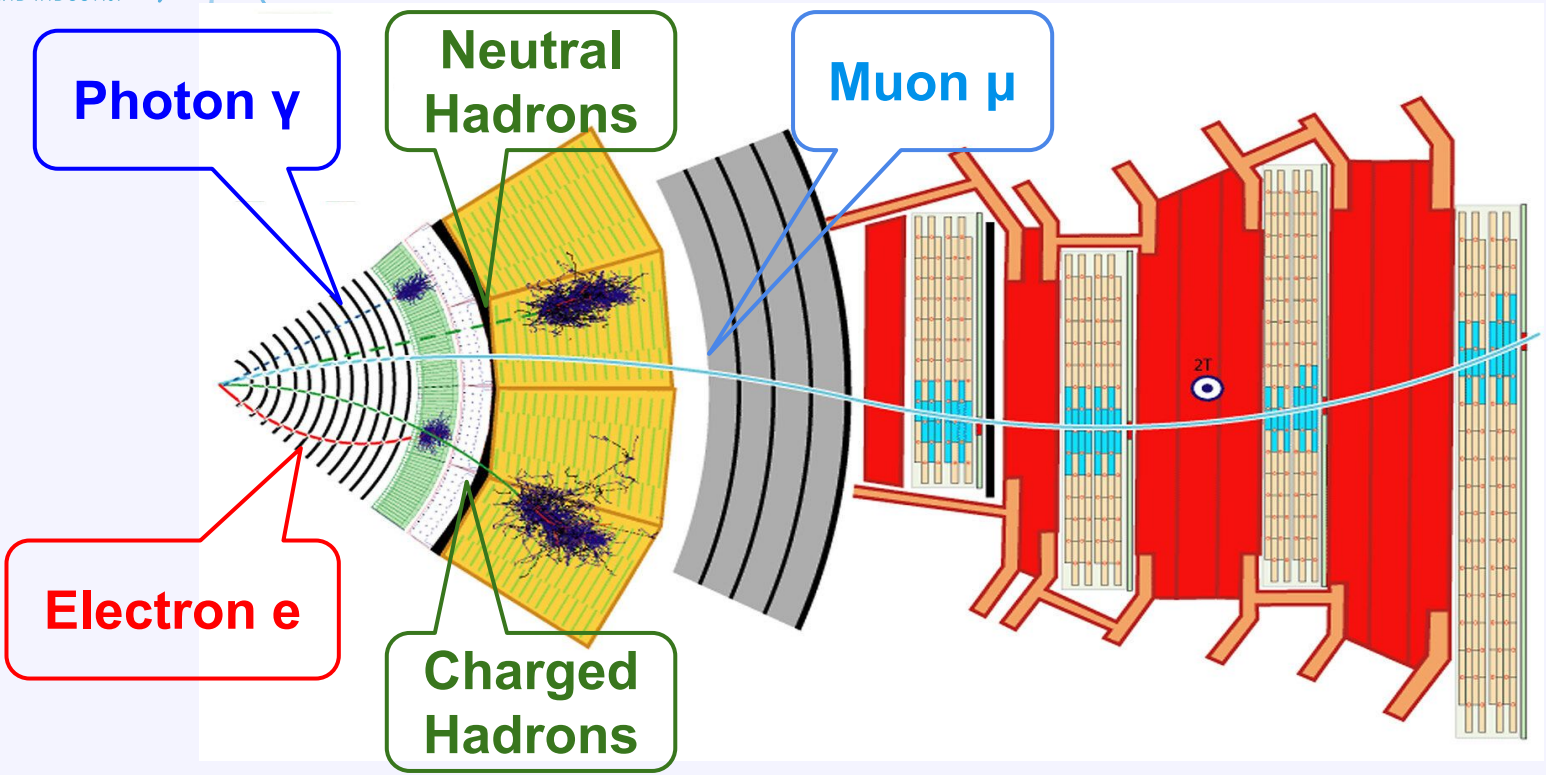
SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

What's in scouting stream



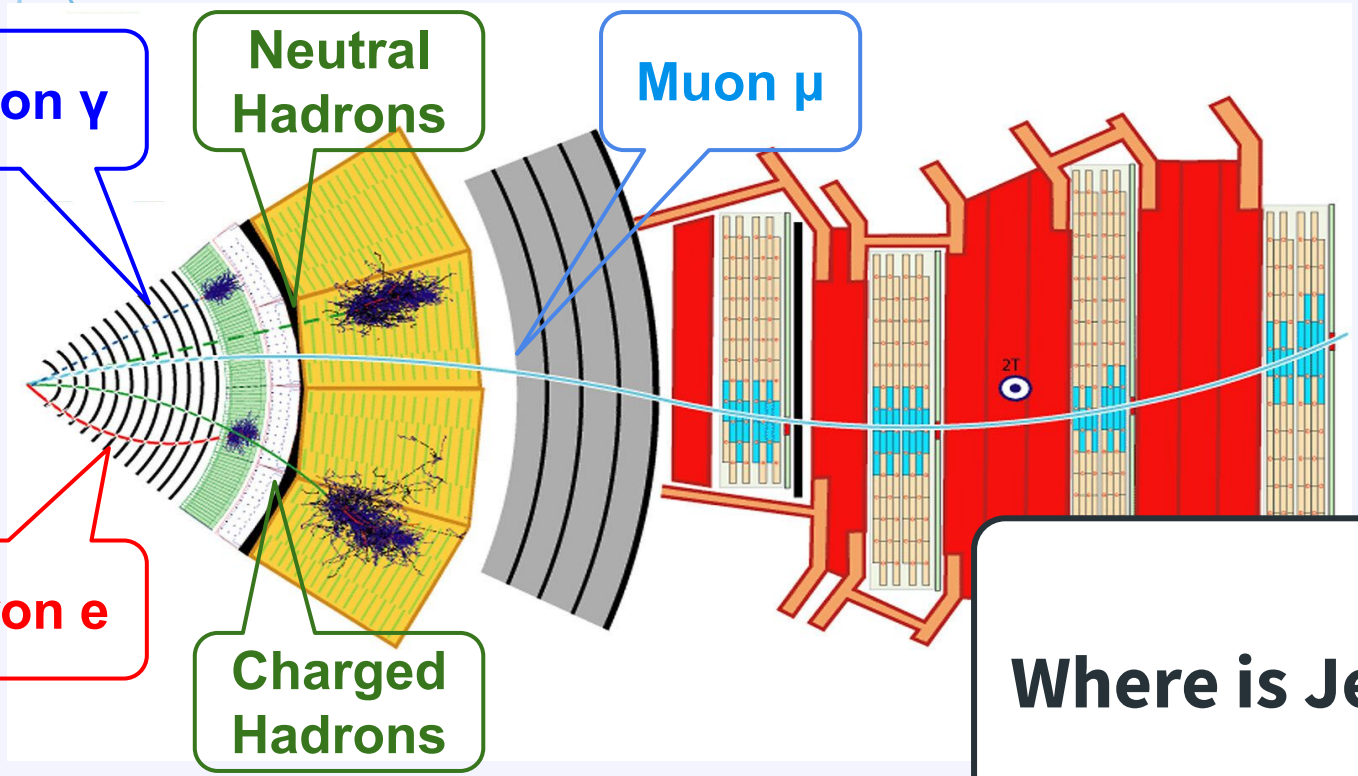
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

What's in scouting stream



SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

What's in scouting stream



Where is Jet?

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

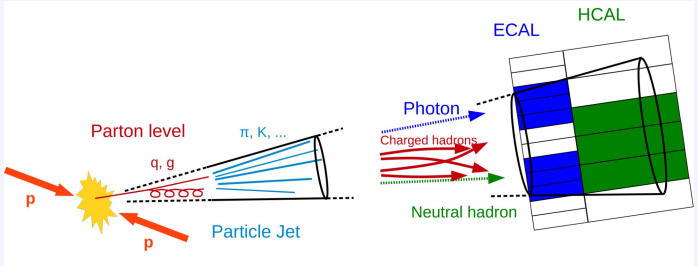
SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Data Scouting **Jet** for Run 3 at CMS

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

What is “Jet”?

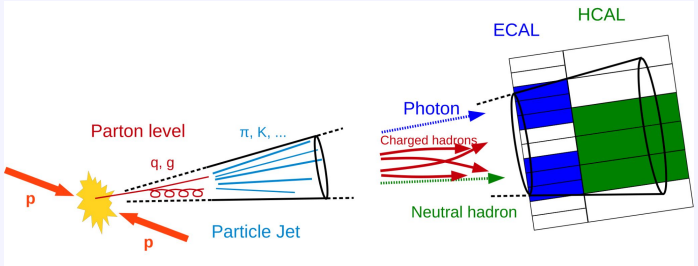
- Jets are the signatures of quarks and gluons (?)
  - color confinement
  - hadronization: quarks and gluons quickly become a cone of particles **“Jet”**



SMARTHEP is funded by the European Union’s Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

What is “Jet”?

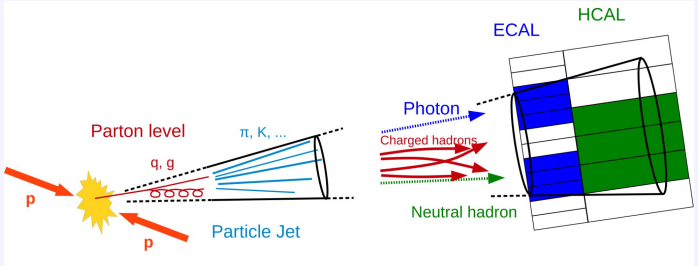
- Jets are the signatures of quarks and gluons (?)
  - color confinement
  - hadronization: quarks and gluons quickly become a cone of particles **“Jet”**
  - **Jet clustering:** group particles to a jet



SMARTHEP is funded by the European Union’s Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

What is “Jet”?

- Jets are the signatures of quarks and gluons (?)
  - color confinement
  - hadronization: quarks and gluons quickly become a cone of particles **“Jet”**
  - **Jet clustering:** group particles to a jet
  - In a more generalized picture, almost everything becomes a jet: gluons, quarks, top quarks, W/Z boson, Higgs boson

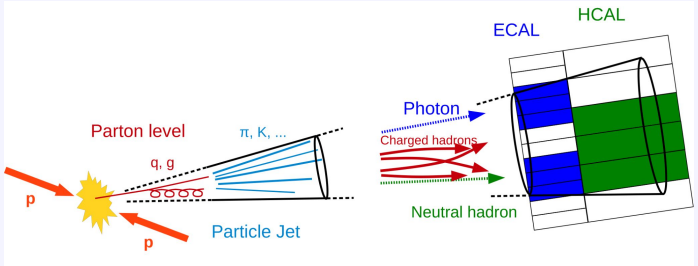


SMARTHEP is funded by the European Union’s Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

What is “Jet”?

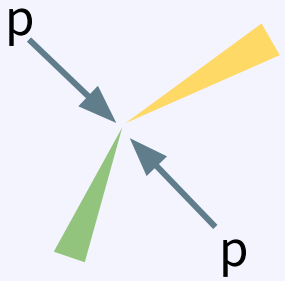
- Jets are the signatures of quarks and gluons (?)
  - color confinement
  - hadronization: quarks and gluons quickly become a cone of particles **“Jet”**
  - **Jet clustering:** group particles to a jet
  - In a more generalized picture, almost everything becomes a jet: gluons, quarks, top quarks, W/Z boson, Higgs boson

Lots of interesting stuff!



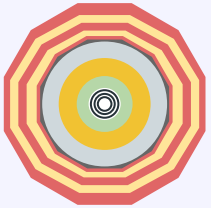
SMARTHEP is funded by the European Union’s Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



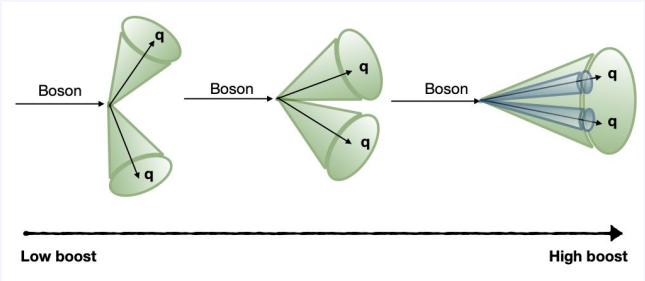
Detector Response

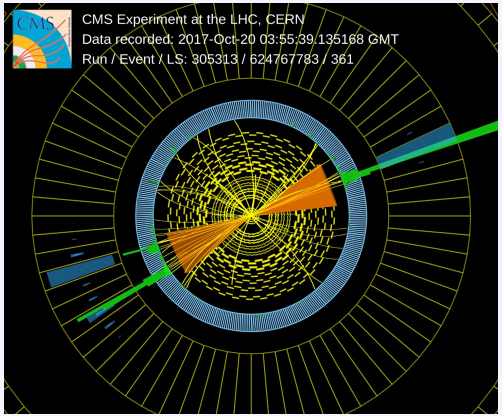
Jet Energy Correction (JEC)



1. Jet Energy Correction (JEC) for scouting jets

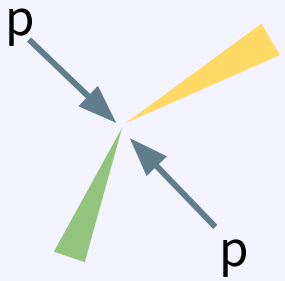
2. Boosted H → bb analysis using scouting data





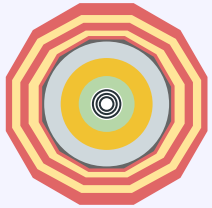
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



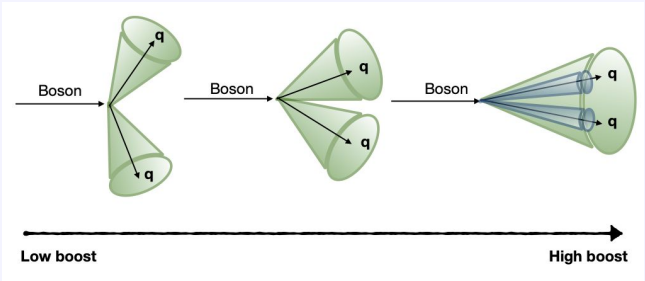
Detector Response

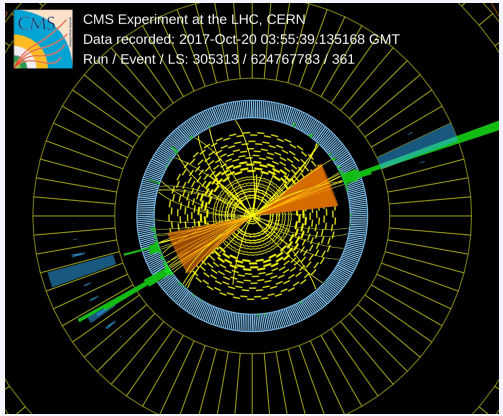
Jet Energy Correction (JEC)



1. Jet Energy Correction (JEC) for scouting jets

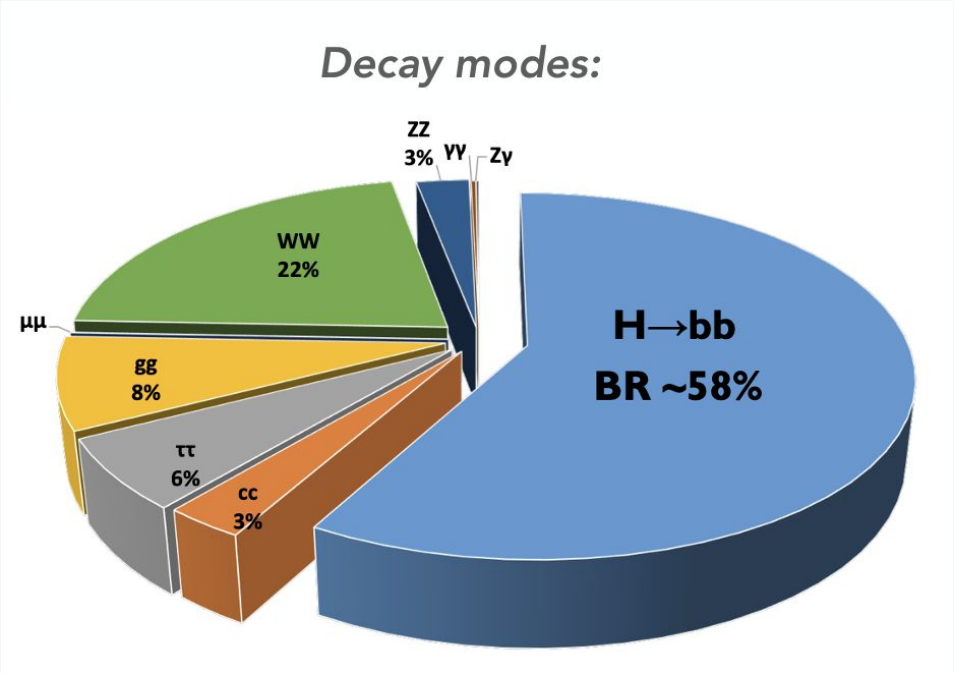
2. Boosted H → bb analysis using scouting data

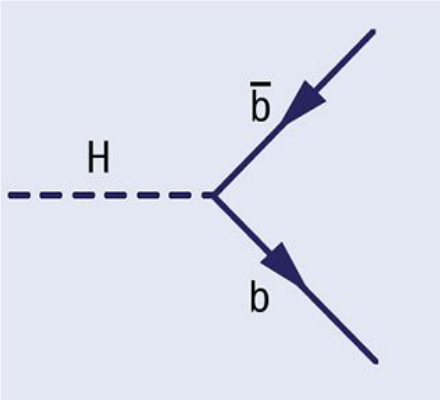




SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

Boosted objects analysis exploiting jet substructure



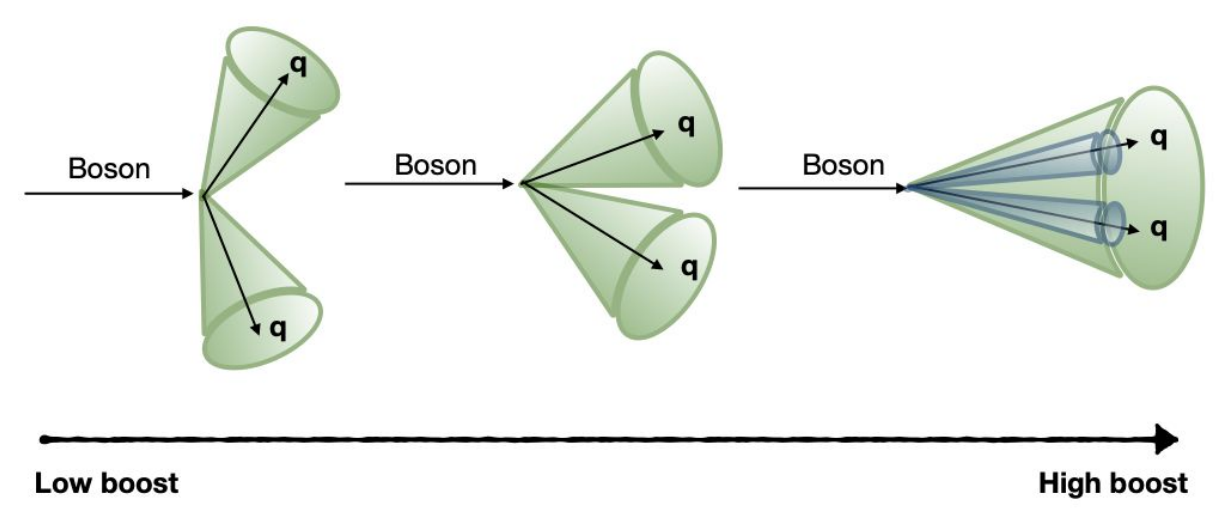


- H → bb is the most probable decay mode
- However, suffer from enormous background (QCD)

ATL-PHYS-SLIDE-2022-013

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

Boosted objects analysis exploiting jet substructure



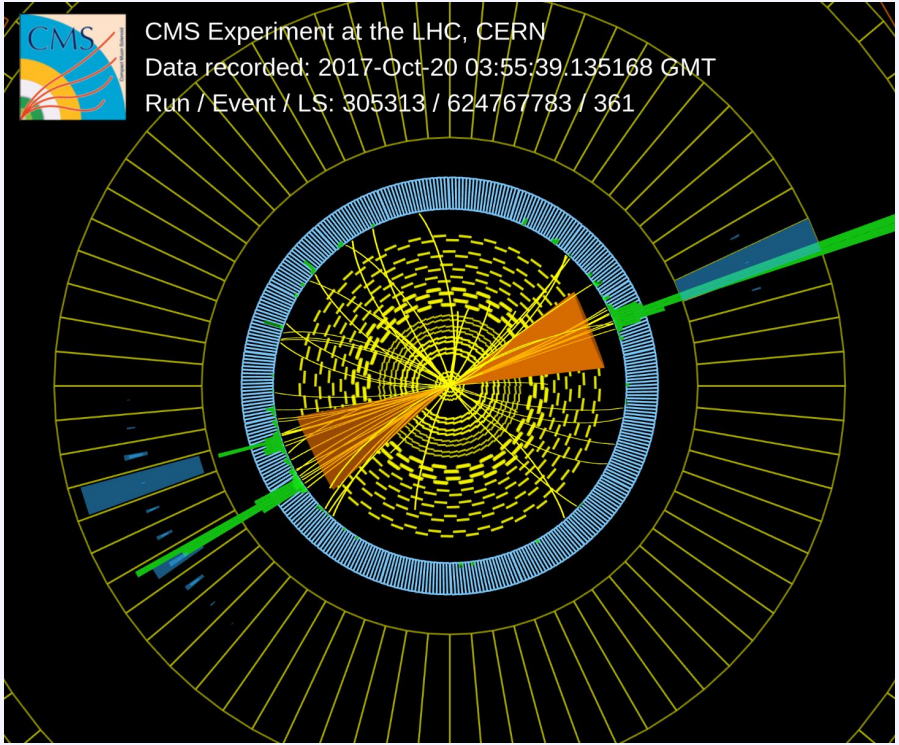
With high boost, two jets originating from single boson merge into single large jet.

Probing jet substructure can improve signal sensitivity from QCD background.

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

CMS-PHO-EVENTS-2022-018

Boosted objects analysis exploiting jet substructure

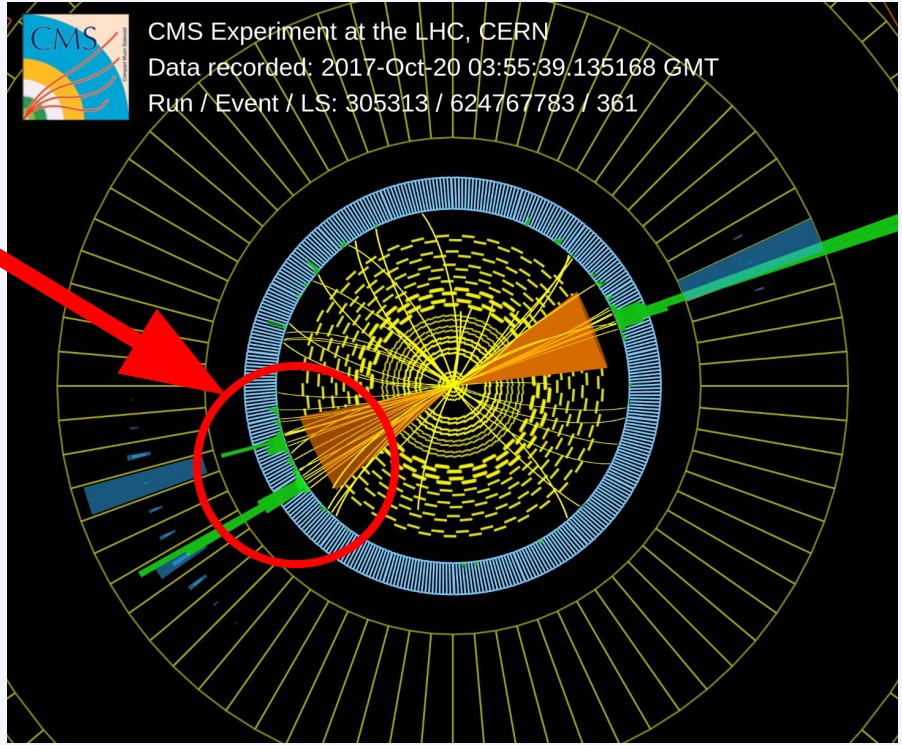


CMS-PAS-HIG-19-003

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

Boosted objects analysis exploiting jet substructure

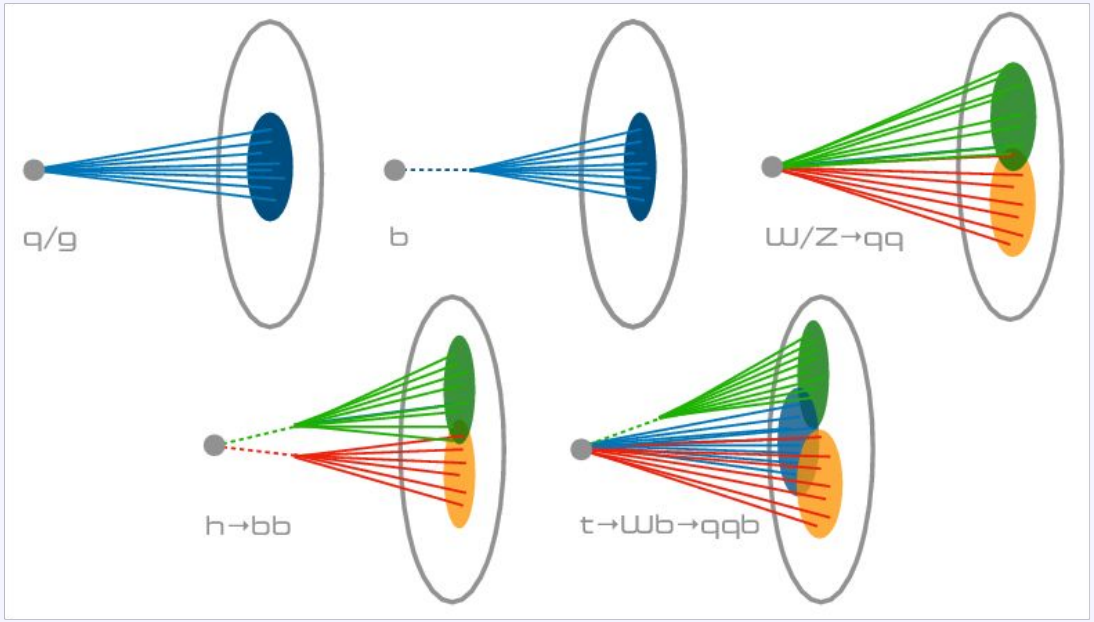
2 subjets



CMS-PAS-HIG-19-003

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

Boosted objects analysis exploiting jet substructure



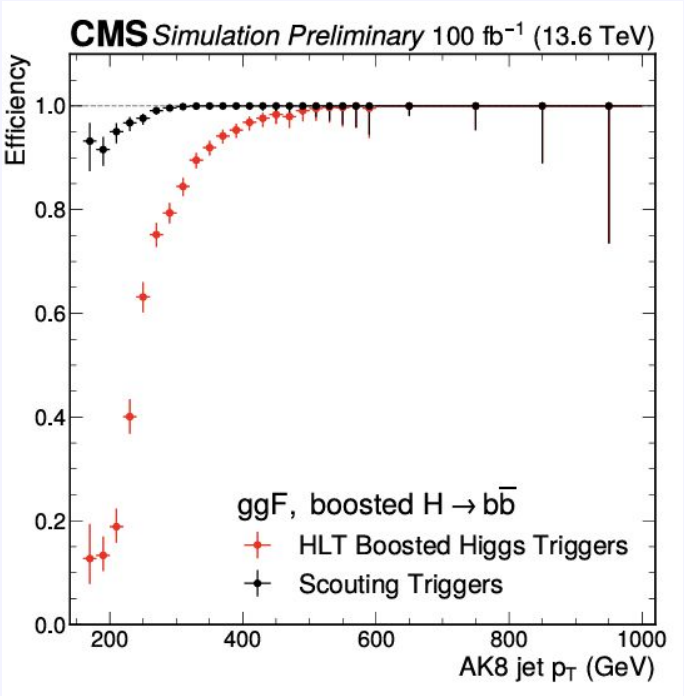
arxiv.org/abs/1909.12285

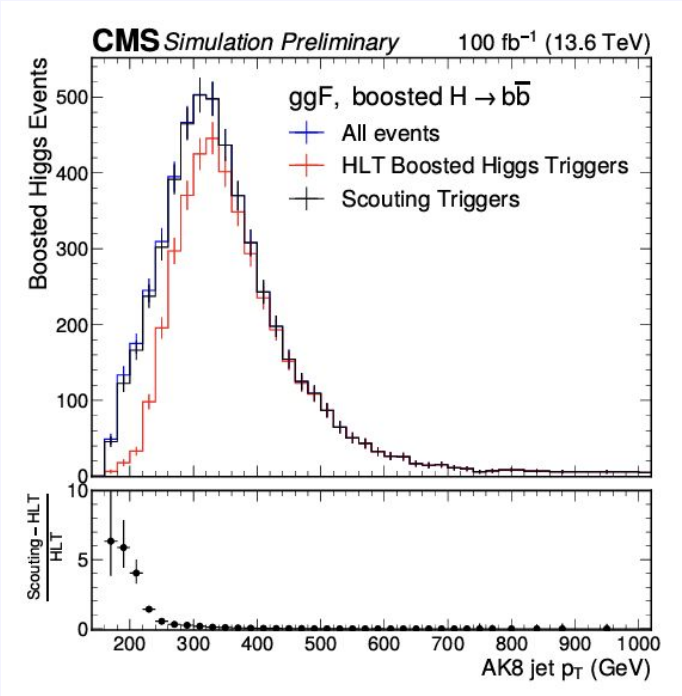
Jet structure indicates type of original particles

→ **jet tagging,** e.g. with neural network (ParticleNet, ParT, etc.)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

Trigger efficiency studies of the CMS Run-3 Data Scouting





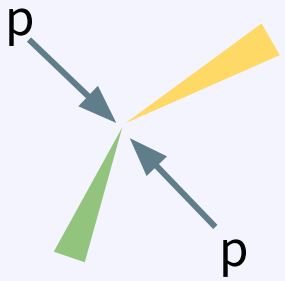
Overall number of events gain ~20%

See gains particularly in low pT region

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

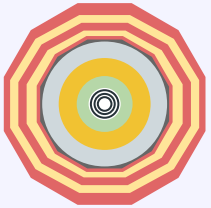
CMS-DP-2023-076

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY



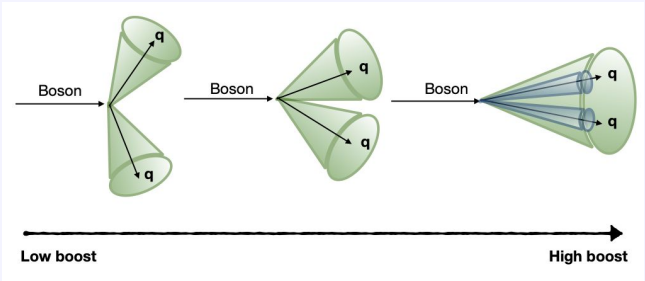
Detector Response

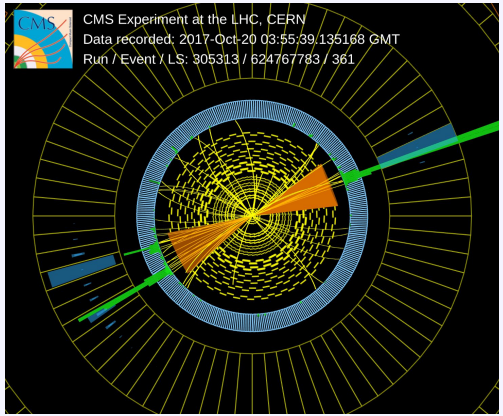
Jet Energy Correction (JEC)



1. Jet Energy Correction (JEC) for scouting jets

2. Boosted H → bb analysis using scouting data

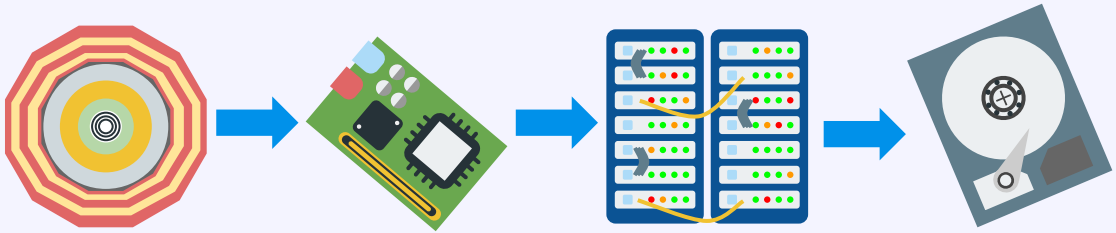




SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

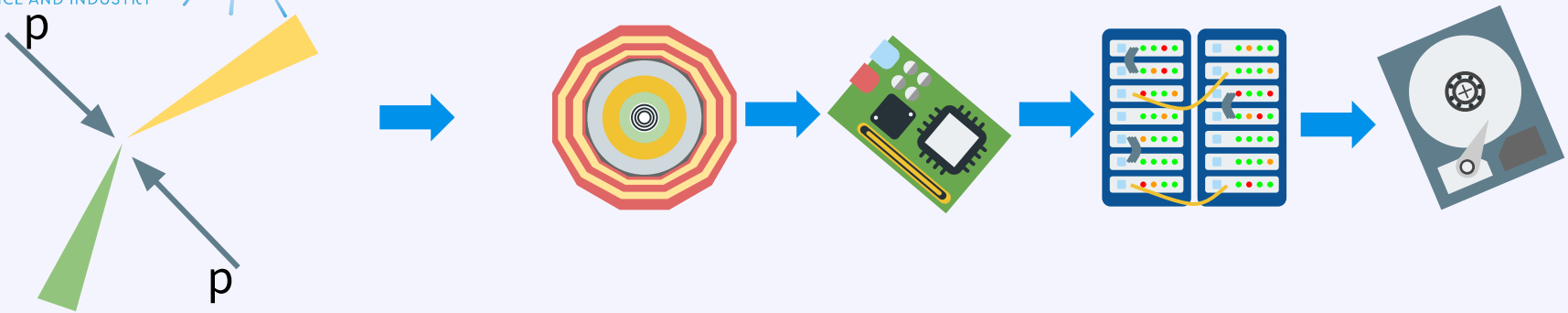
Jet Energy Correction (JEC)



SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

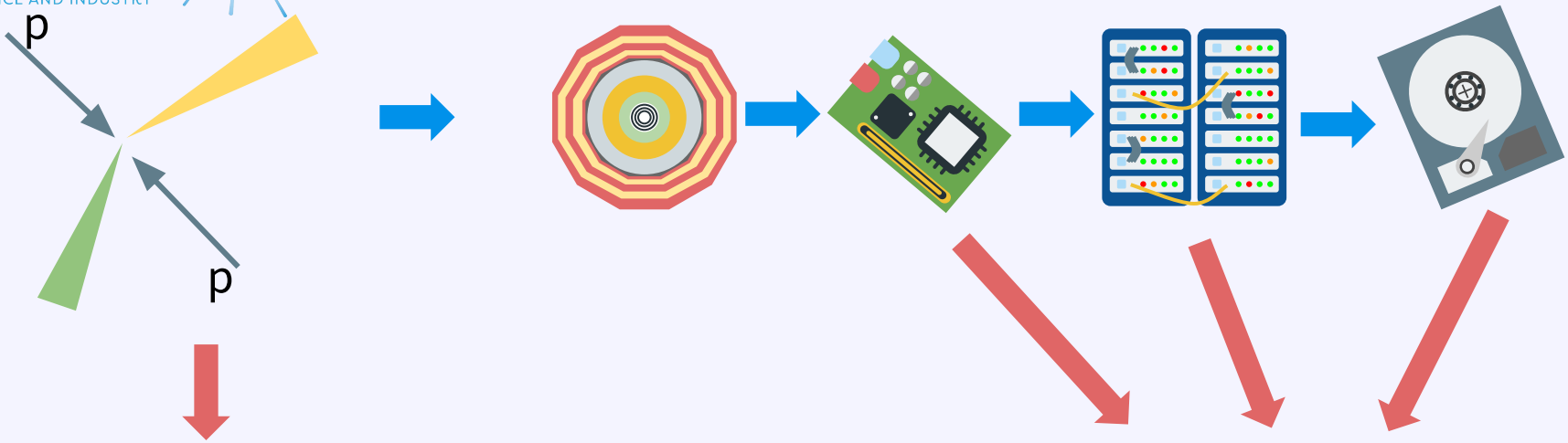
Jet Energy Correction (JEC)



SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Jet Energy Correction (JEC)



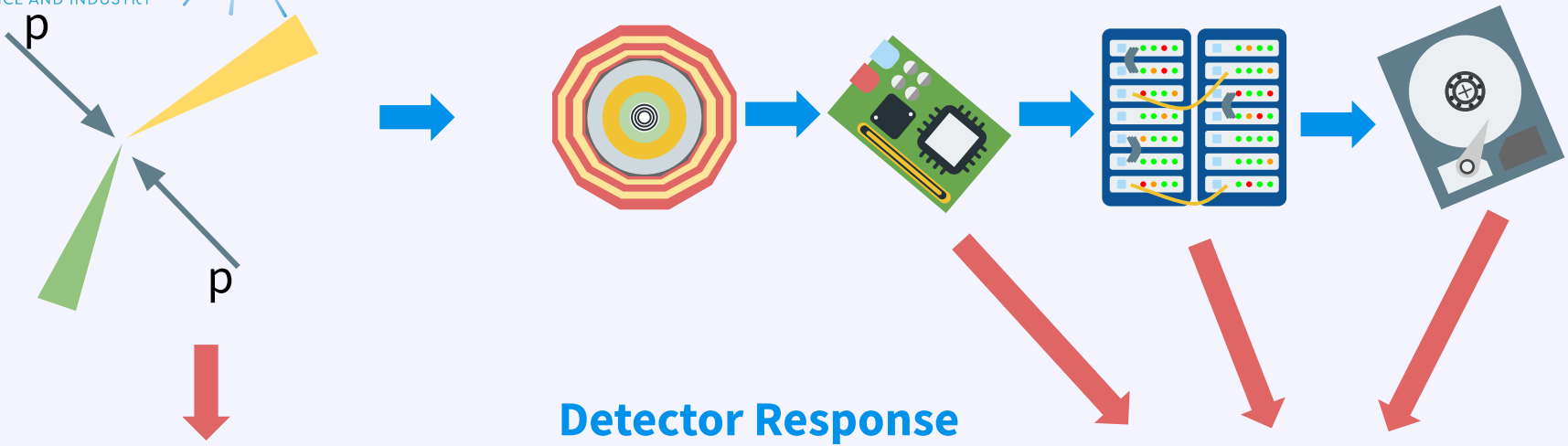
Particle-level / Truth / Generator Jets (Gen Jets)

Reconstructed Jets (Reco Jets)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Jet Energy Correction (JEC)



Detector Response

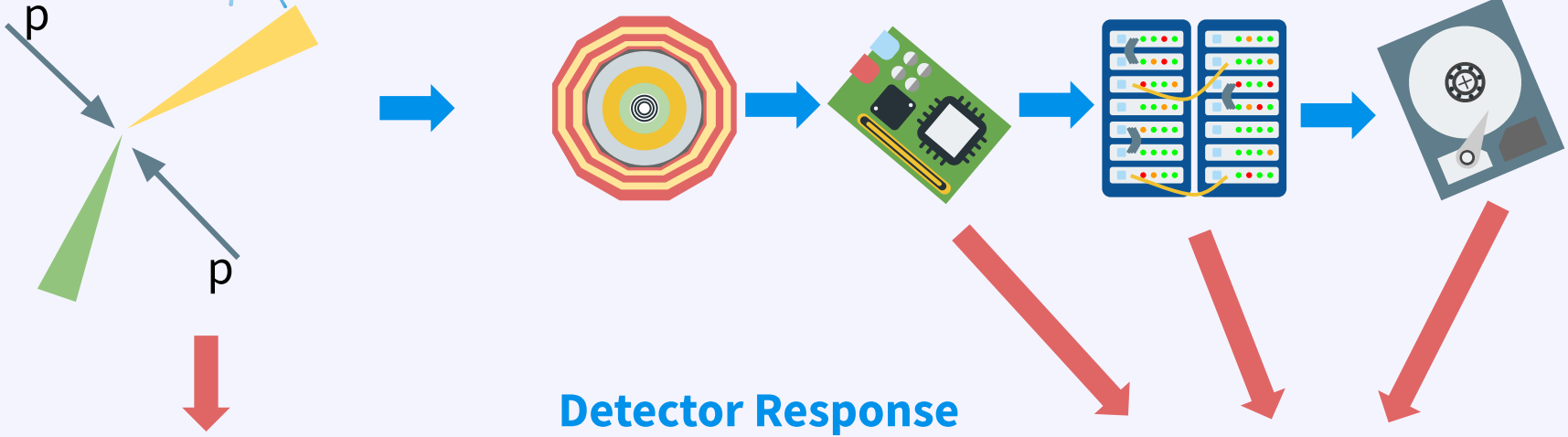
Particle-level / Truth / Generator Jets (Gen Jets)

Reconstructed Jets (Reco Jets)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Jet Energy Correction (JEC)



Particle-level / Truth / Generator Jets (Gen Jets)

Detector Response

Reconstructed Jets (Reco Jets)

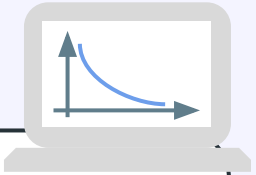
Jet Energy Correction (JEC) / Jet Calibration

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

JEC for Scouting (+Online) Jet

HLT/Scouting Jet

+ more statistics (exposed to full incoming data streaming before triggering)
- uses simpler reconstruction due to speed constraint



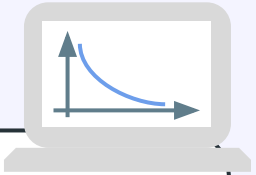
Offline jets

+ more sophisticated reconstruction
- contain less statistics (constructed from stored data after HLT)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

JEC for Scouting (+Online) Jet

transfer low systematic uncertainties from offline to online reconstruction



HLT/Scouting Jet

+ more statistics (exposed to full incoming data streaming before triggering)
- uses simpler reconstruction due to speed constraint

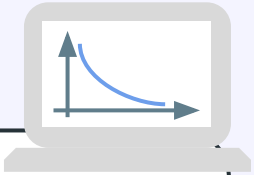
Offline jets

+ more sophisticated reconstruction
- contain less statistics (constructed from stored data after HLT)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

JEC for Scouting (+Online) Jet

transfer low systematic uncertainties from offline to online reconstruction



HLT/Scouting Jet

+ more statistics (exposed to full incoming data streaming before triggering)
- uses simpler reconstruction due to speed constraint

Offline jets

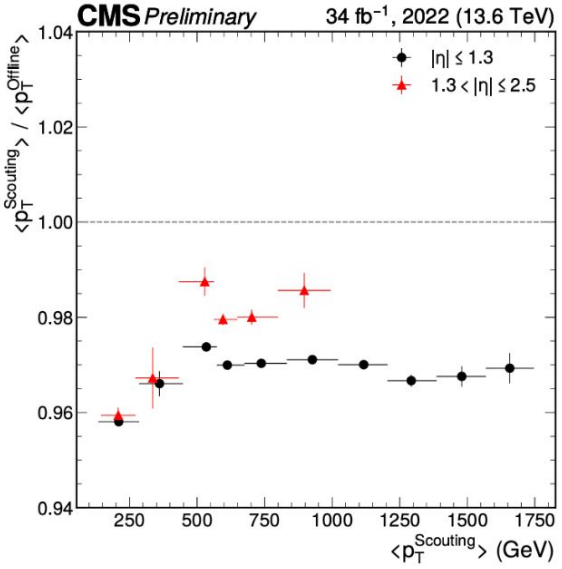
+ more sophisticated reconstruction
- contain less statistics (constructed from stored data after HLT)

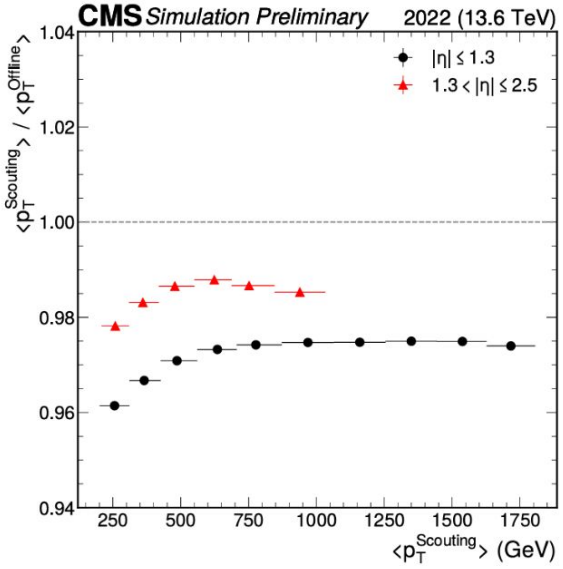
improve offline calibration with abundant HLT jet statistics

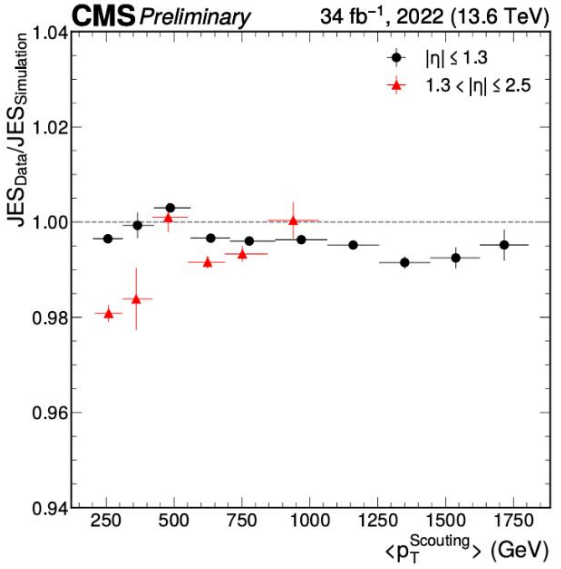
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

JEC for Scouting (+Online) Jet

Studies by Adelina Lintuluoto







SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

CMS-DP-2023-072

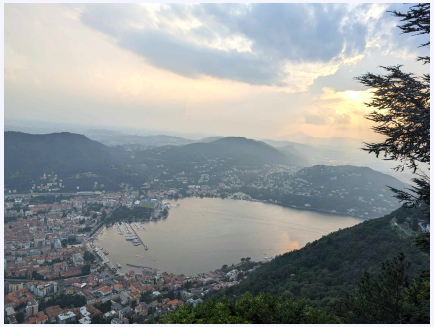
SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Other activities

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Participation



Past

- PAPU Fall Seminar (22 November 2022): **lightning talk!**
- CMS Week December 2022 (5 - 9 December 2022)
- Spåtind 2023: Nordic Conference on Particle Physics (3-8 January 2023): **talk!**
- JetMET Workshop (15 - 17 May 2023)
- Stay at CERN (1 June - 20 August 2023): **shifts + summer project supervision!**
- CMS Data Analysis School (5 - 10 June 2023)
- CMS Week June 2023 (12 - 16 June 2023)
- 13th Patatrack Hackathon (26 - 30 June 2023)
- Advanced Artificial Intelligence for Precision High Energy Physics (16 - 28 July 2023)
- CERN School of Computing (20 August - 2 September 2023): **lightning talk!**
- Researcher Night (29 September 2023): **outreach!**
- Particle Physics Day (12 October 2023)
- ML4Jets (4 - 6 November 2023)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Participation

Future

- ML@L1 Workshop (11 - 15 December 2023)
- Physics Day (4-6 March 2024): **organisation!**
- Midsummer school in QCD (24 June - 6 July 2024)
- Spåtind 2025: Nordic Conference on Particle Physics (Early 2025)

CMS Young Scientist Committee (CMS YSC)

- CMS Welcome message translation (→ Thai)
- LHC Mentorship program
- LHC Job Matching Event
- Regional Representative (new initiative!)

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086


Midsummer School in QCD 2024
24 June – 6 July 2024
Saariselkä, Finland
Register by
31 January 2024
Organizing Committee
Christophe Royon, Henning Kirschenmann, Kati Lassila-Perini
Kenneth Österberg, Mikko Voutilainen, Tuomas Lappi
HELSINKI INSTITUTE OF PHYSICS
HELSINGIN YLIOPISTO HELSINGFORS UNIVERSITET UNIVERSITY OF HELSINKI
JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ
KU THE UNIVERSITY OF KANSAS
indico.cern.ch/event/qcd2024

indico

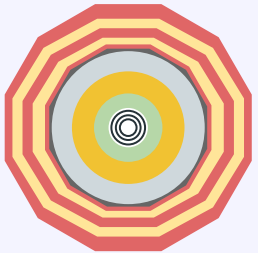
SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

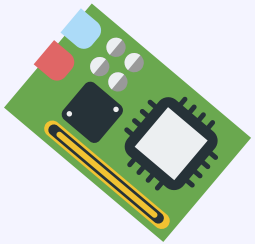
HL-LHC Upgrade: L1 Scouting

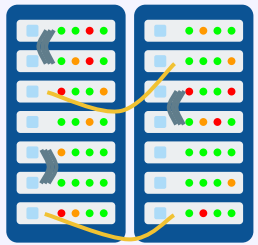
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

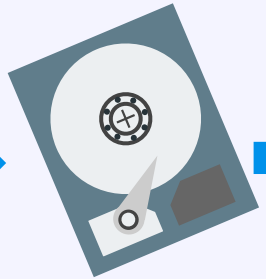
SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Scouting Stream
= only PF particles reconstructed at HLT









Standard Stream
= all raw detector readout

CMS

L1 Trigger

HLT

Storage

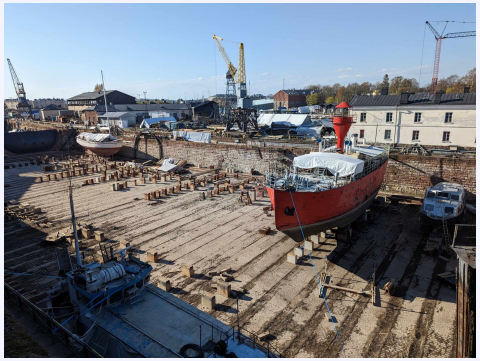
L1 Scouting (40 MHz)
= L1 Primitives

HiLumi HL-LHC PROJECT

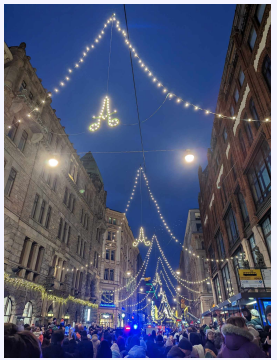
SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

Conclusion



- Introduction
  - CMS trigger system: L1 and HLT to reduce data taking rate
  - Data scouting: save only PF candidates at HLT
    → increase event rate
  - Jets are signature of quark + gluons
    + other interesting new physics (e.g. boosted objects)
- JEC for scouting jets
  - offline and online jets can support calibration of each other
- Boosted H → bb using scouting data
  - scouting data contains 20% more H → bb events overall, particular gain at low momentum region
  - studies on tagger performance on scouting jets
- Other activities
  - learning a lot, meeting a lot of new people, and a lot of memories



SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086