Applied Physics and Computer Science Summer School '21

pp Collision at LHCb

Saliha Bashir

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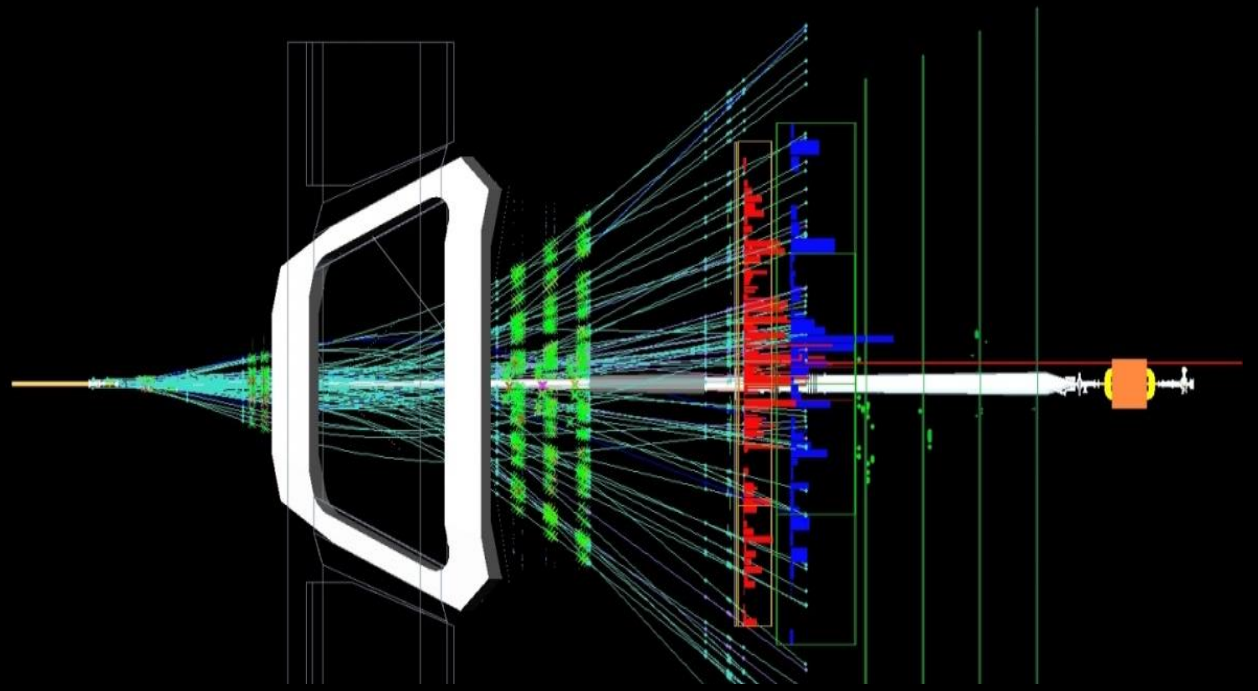
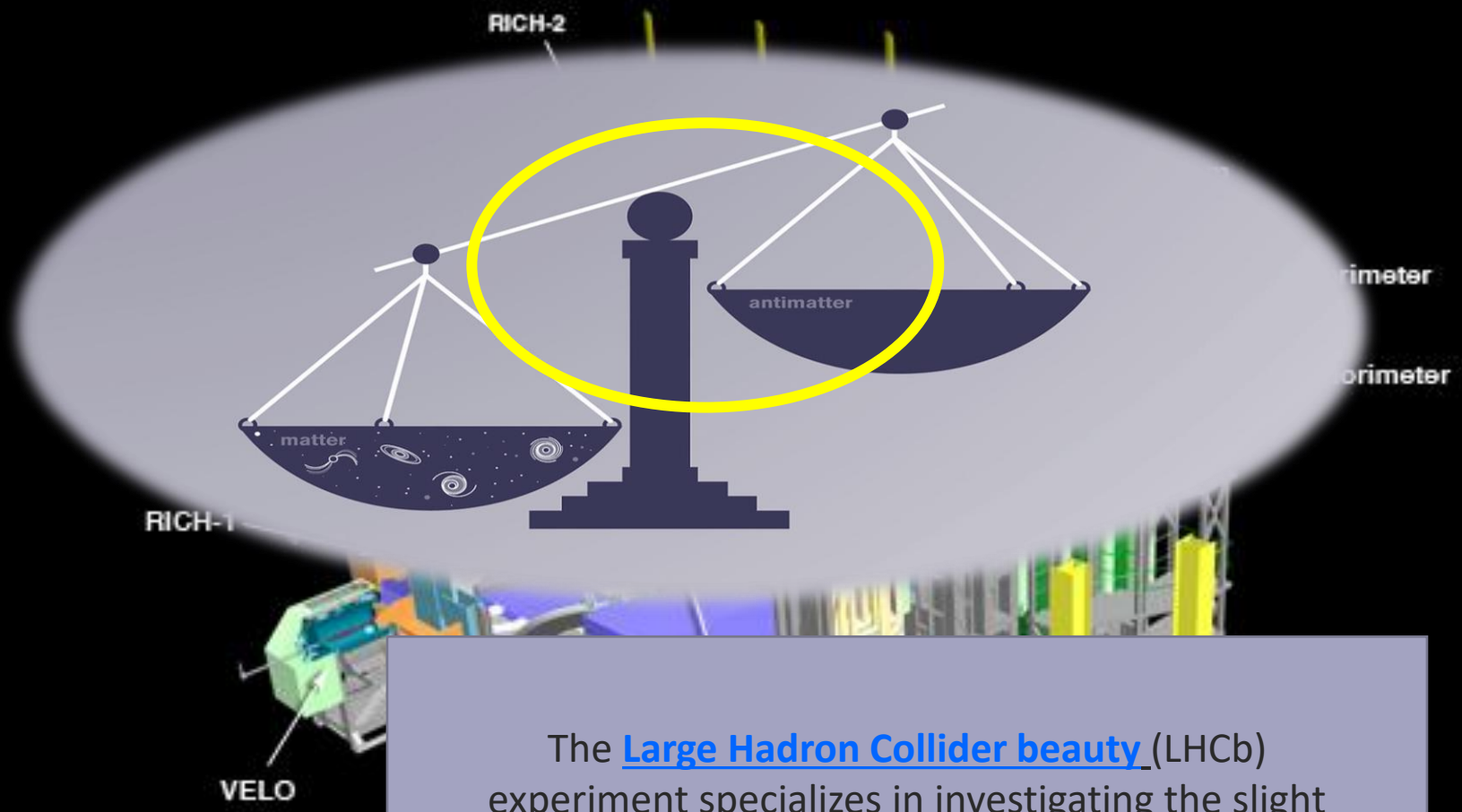
Outline

- LHC & LHCb
- Proton Structure
- Probing Techniques
- LHCb Uniqueness
- QCD
- Hard Scattering Cross-Section
- pp Cross-Section
- Real and Simulated Data Flow

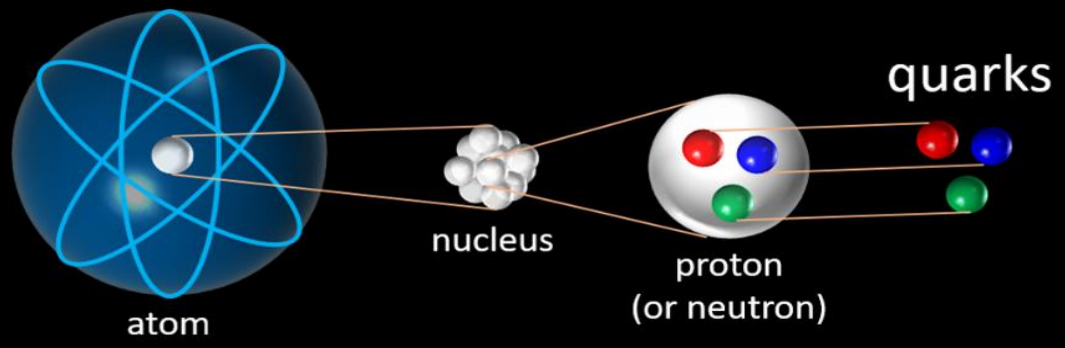


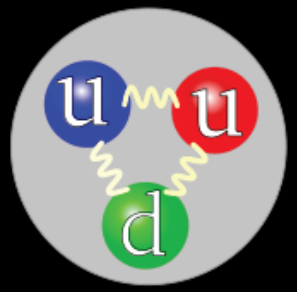
LHC & LHCb

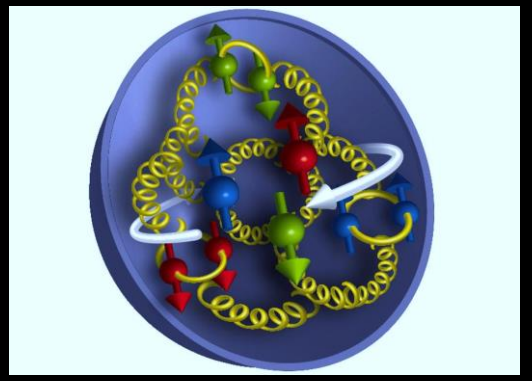
- VELO
- RICH-1
- Magnet
- Tracking System
- RICH-2
- Calorimeters
- Muon System

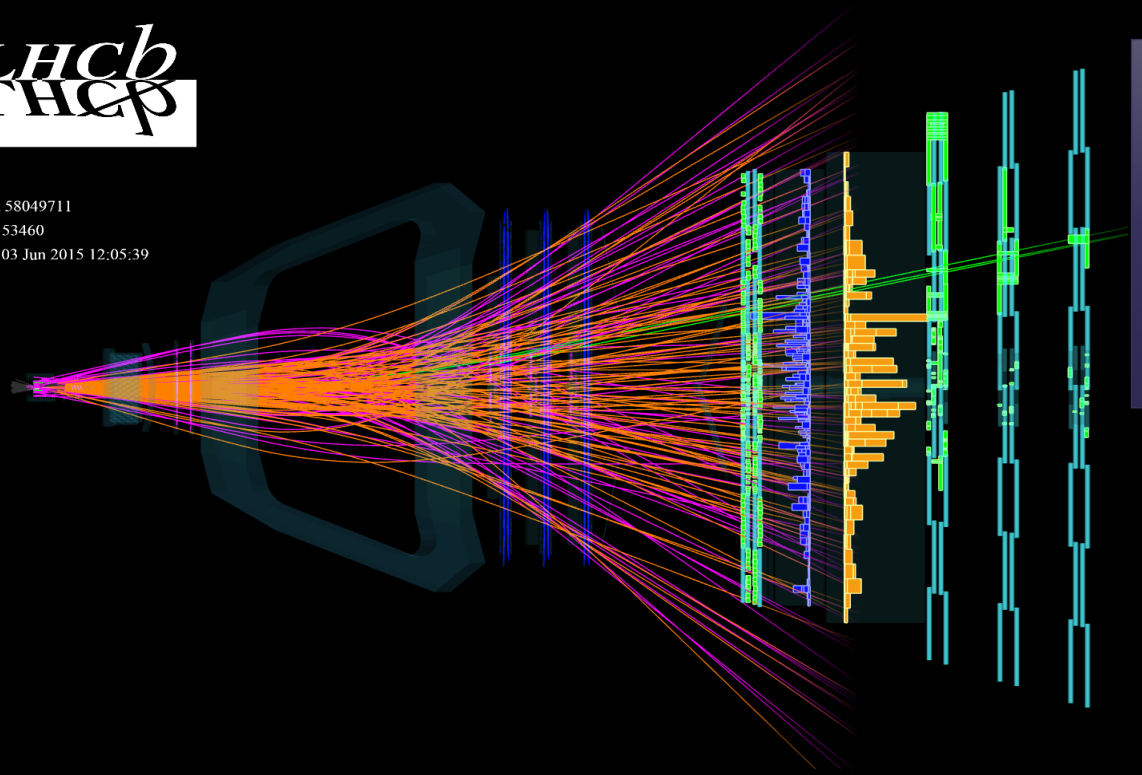


The [Large Hadron Collider beauty](#) (LHCb) experiment specializes in investigating the slight differences between matter and antimatter by studying a type of particle called the "beauty quark", or "b quark".



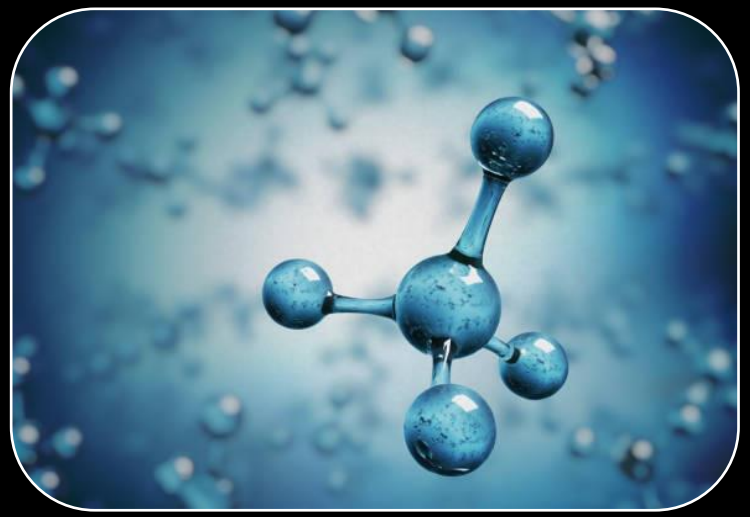






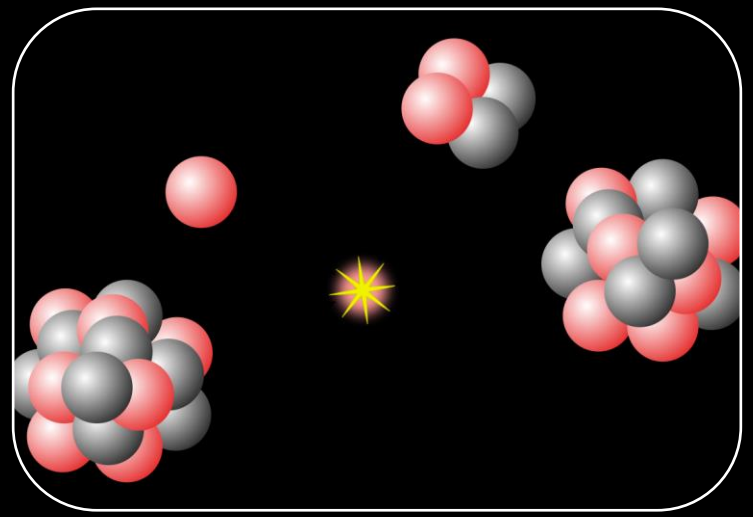
- Particles -> Grouped in bunches
- LHC collides two proton beams
- Collision happens every 25ns
- In each collision ~25 pairs of protons/collision (1 per million is interesting)
- Rest is uninteresting

3 Experimental Probes of Elementary Particle Interactions:



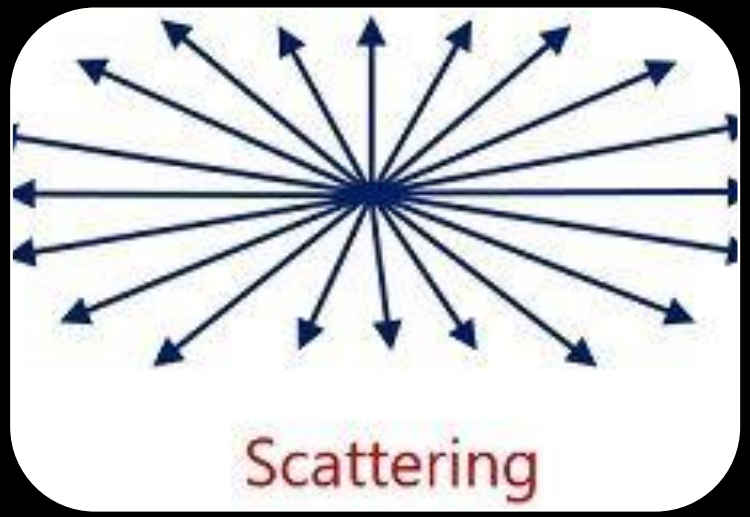
Bound States

- Schrodinger Formulation



Decays

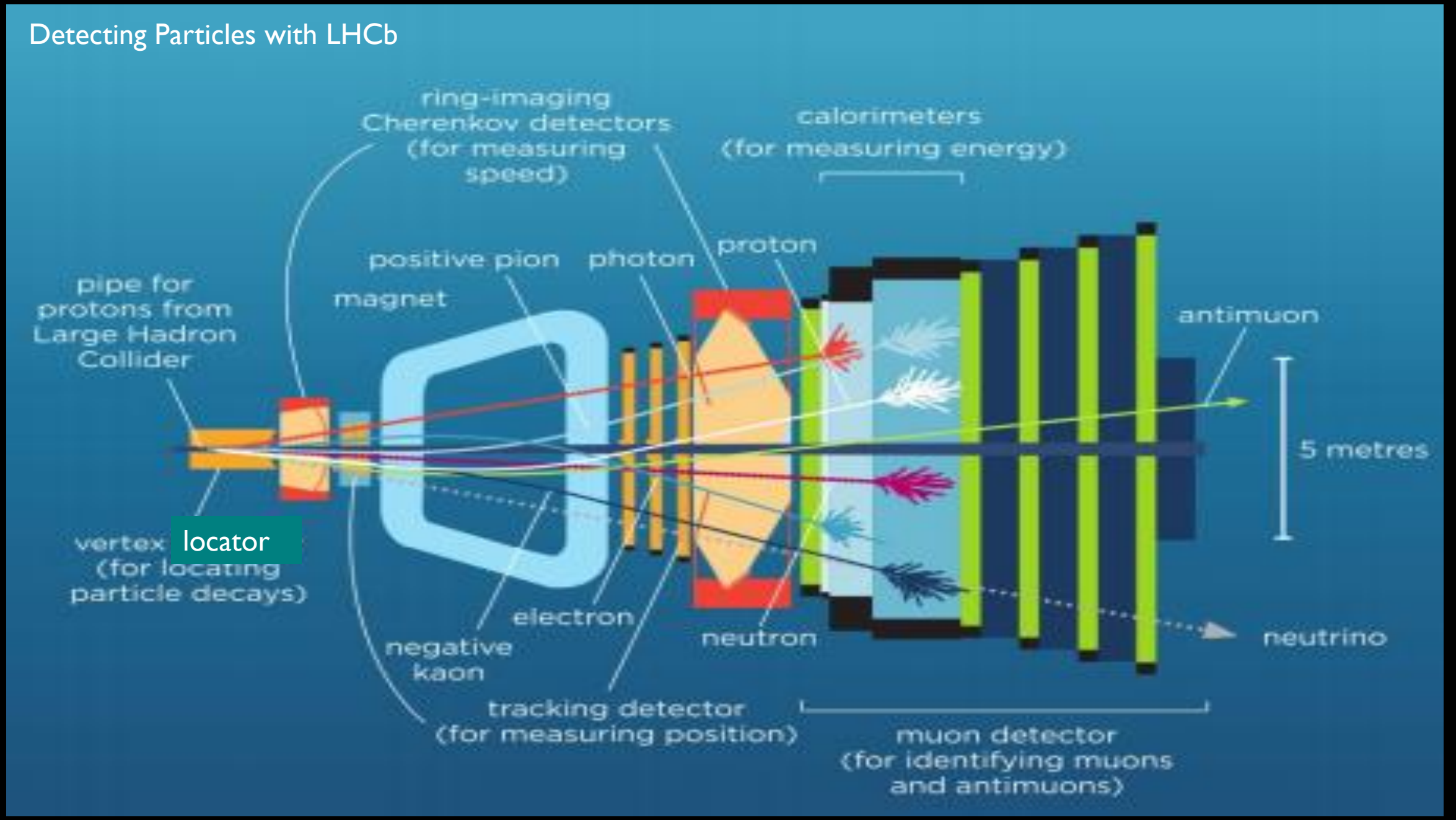
- Life-Time



Scattering

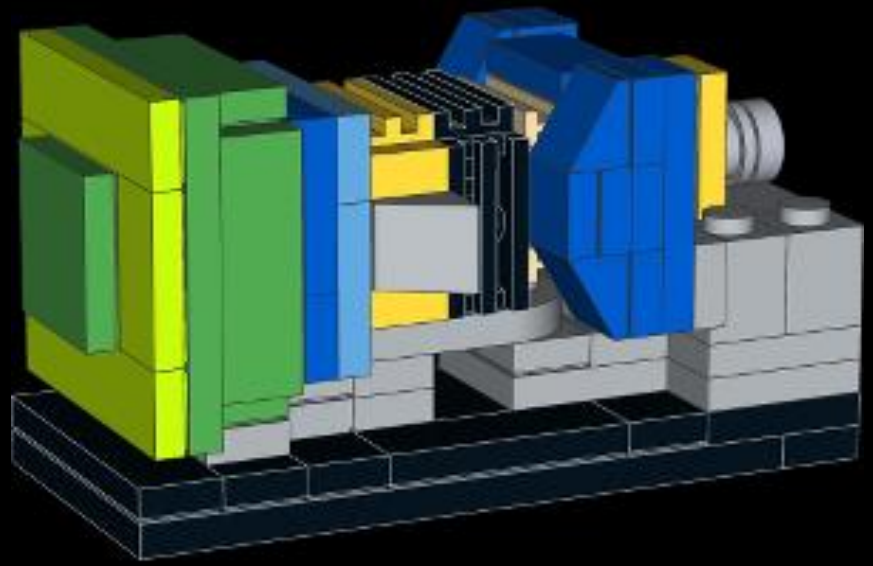
- Cross-Section

Detecting Particles with LHCb



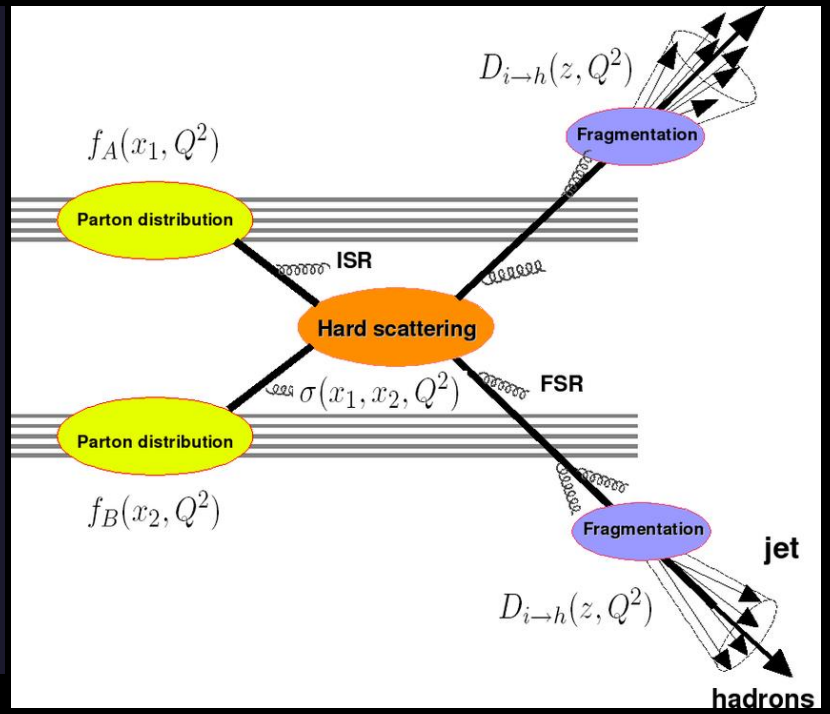
LHCb Uniqueness

- Tracking, RICH,CALO MUON cover full detector acceptance ($2.0<\eta<5.0$)
- Kinematic coverage → study low-p_T processes at large η
- Covers only 4% of solid angle but captures ~25% of heavy quark pairs produced at LHC
- Excellent tracking performance
- High Quality particle Identification
- Selective and flexible Trigger



Quantum Chromodynamics (QCD)

- QCD is a good theory for strong interactions (quarks & gluons)
- Help us to better understand Standard Model
- When probed at short wavelengths QCD explains free partons
- But QCD is partially solved.



QCD

Perturbative (Hard)

- High energy
- Short distance
- α_s is small
- Asymptotic freedom
- Multiparton Scattering
- Fragmentation

Non -Perturbative (Soft)

- Low energy
- Long distance
- α_s is large
- Confinement
- Parton showers and Hadronizations

Hard Scattering Cross-Sections

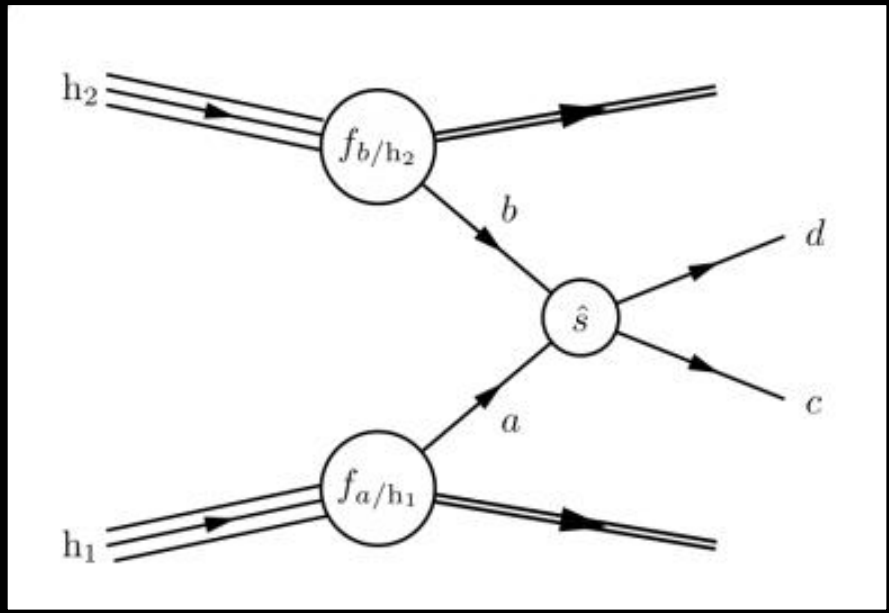
$$d\sigma^{h_1 h_2 \to cd} = \int_0^1 dx_1 \int_0^1 dx_2 \sum_{a,b} f_{a/h}(Q^2) f_{b/h}(Q^2) d\sigma^{ab \to cd}(Q^2)$$

$f_{a/h_i}(x_i)$: Parton Distribution Function (PDF)
(Probability of finding a parton of type a with momentum fraction x_i in hadron h_i)

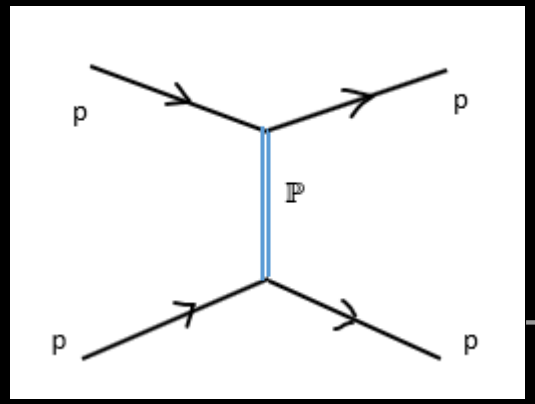
- ❑ Not calculable in perturbation theory
- ❑ Needs data to be determined

$\sigma^{ab \to cd}$: parton level hard scattering cross-section

- ❑ Calculable in perturbative QCD



pp Cross-section



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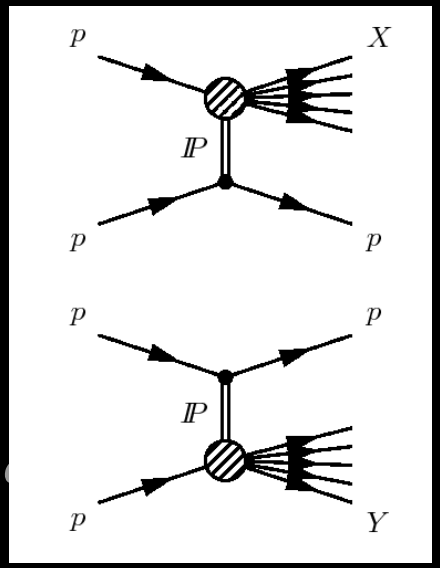
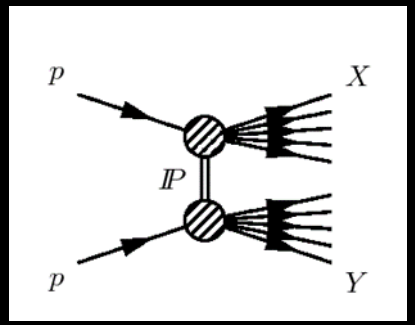
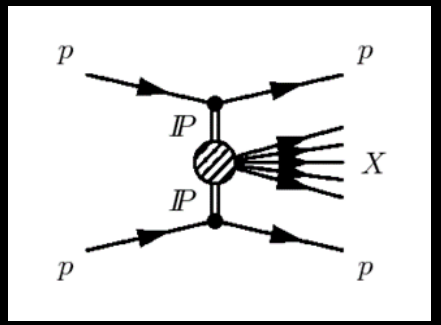
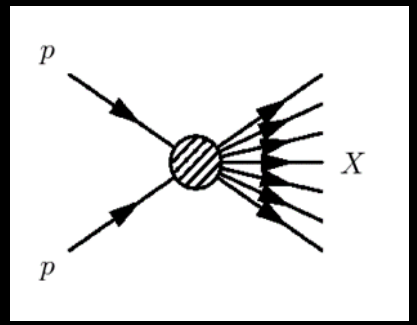
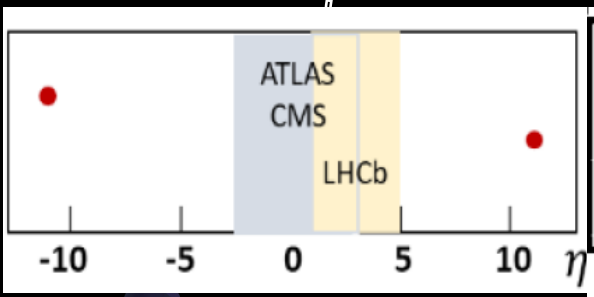
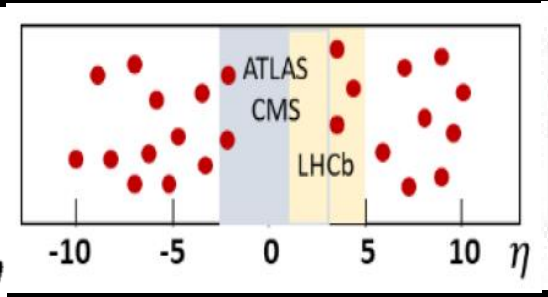


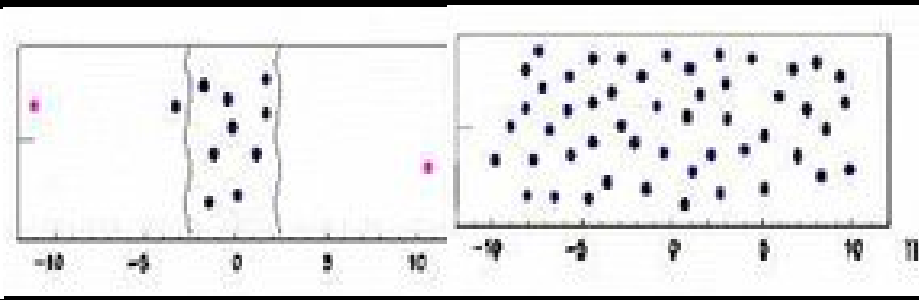






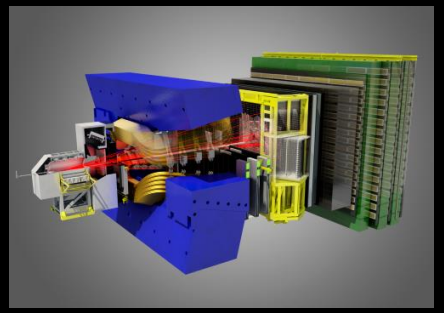




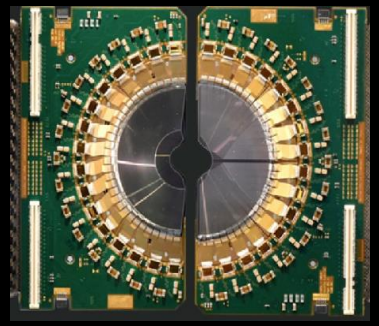


THE FLOW CHART

pp collision



Interaction with detector

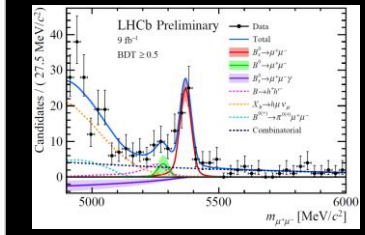


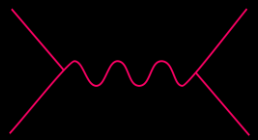
Readout of detector electronics

Event selection

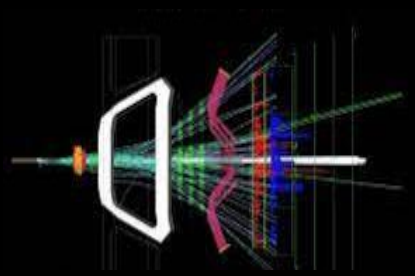
Data reconstruction

Physics analysis

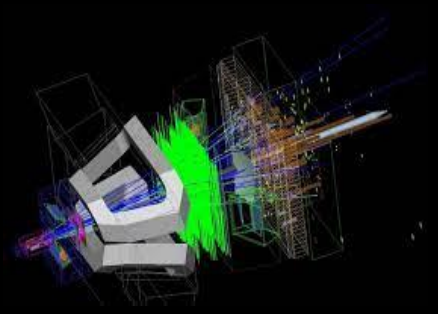




Physics modelling



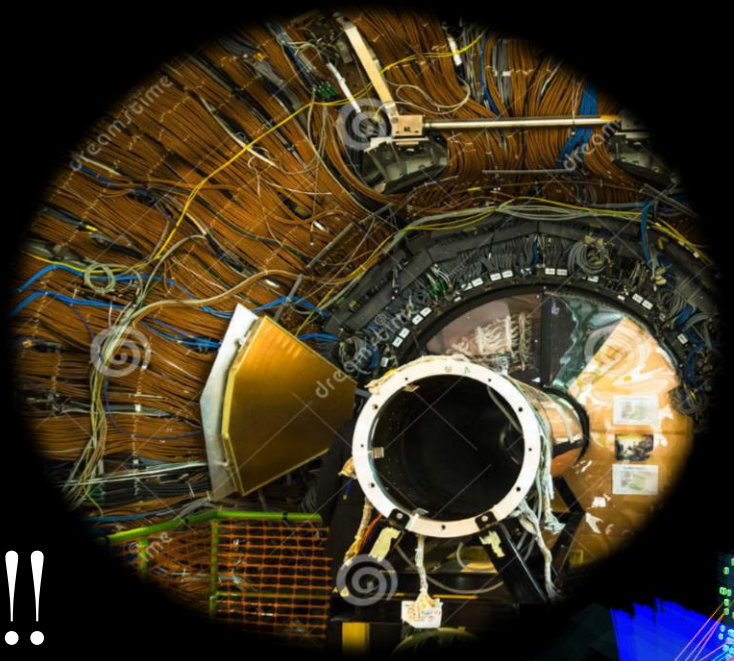
Event generation

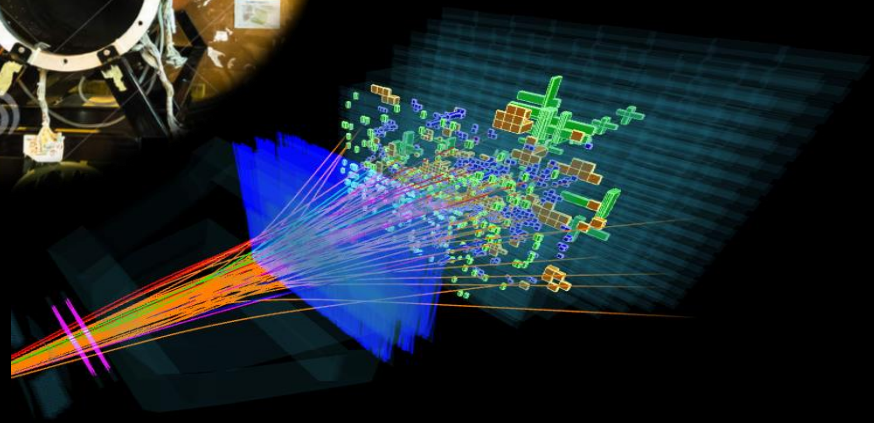


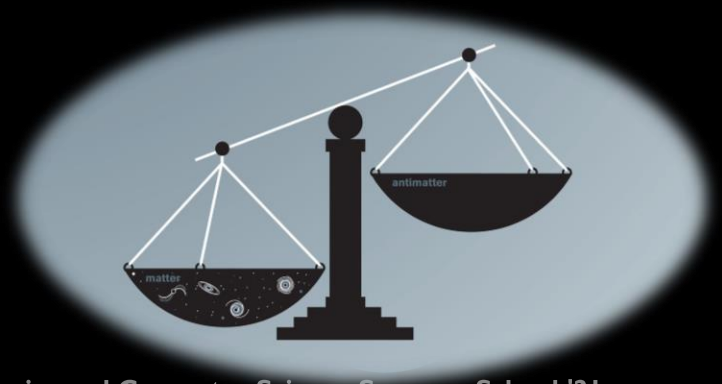
Detector simulation

Simulation of detector electronics

Thank You..!!



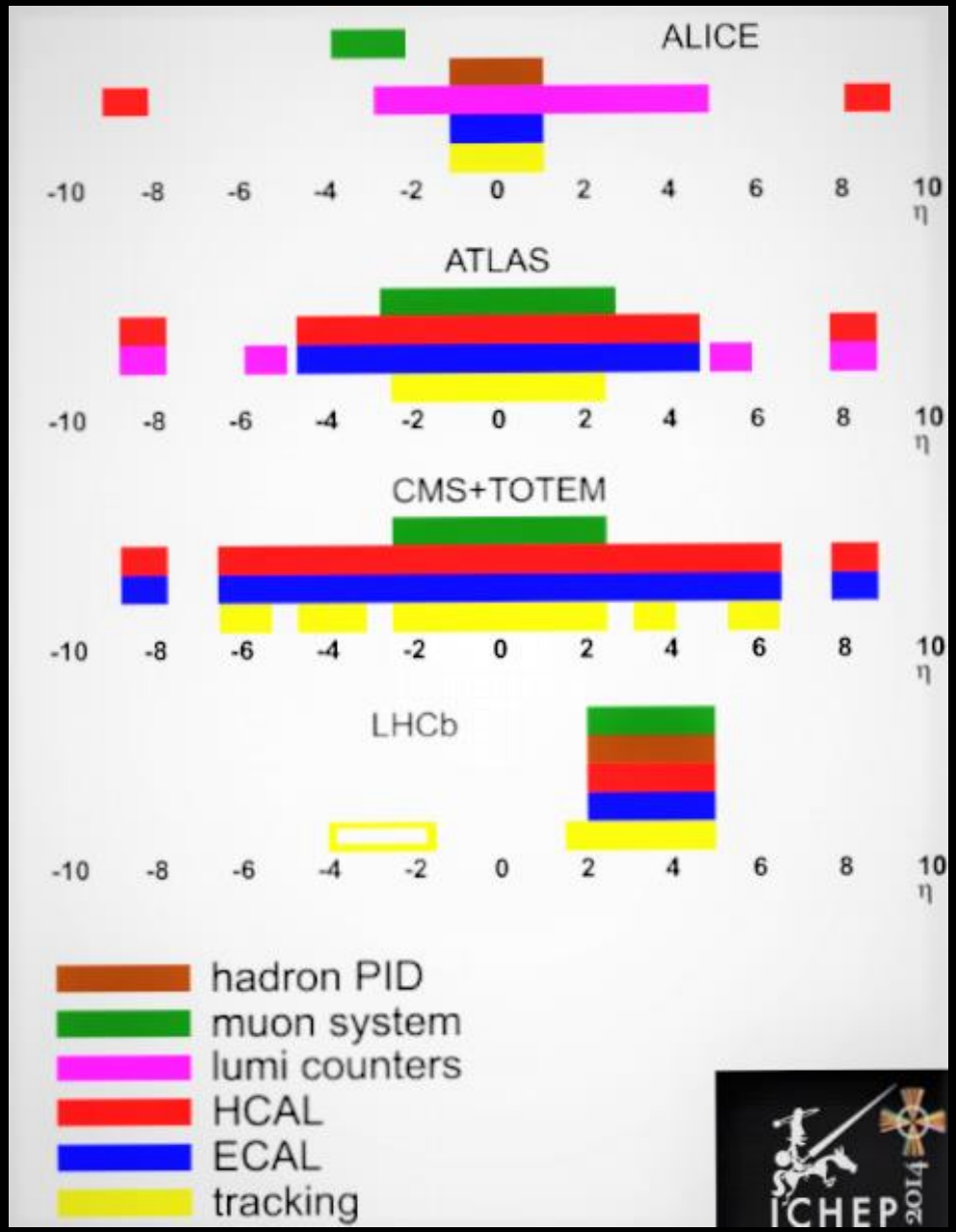




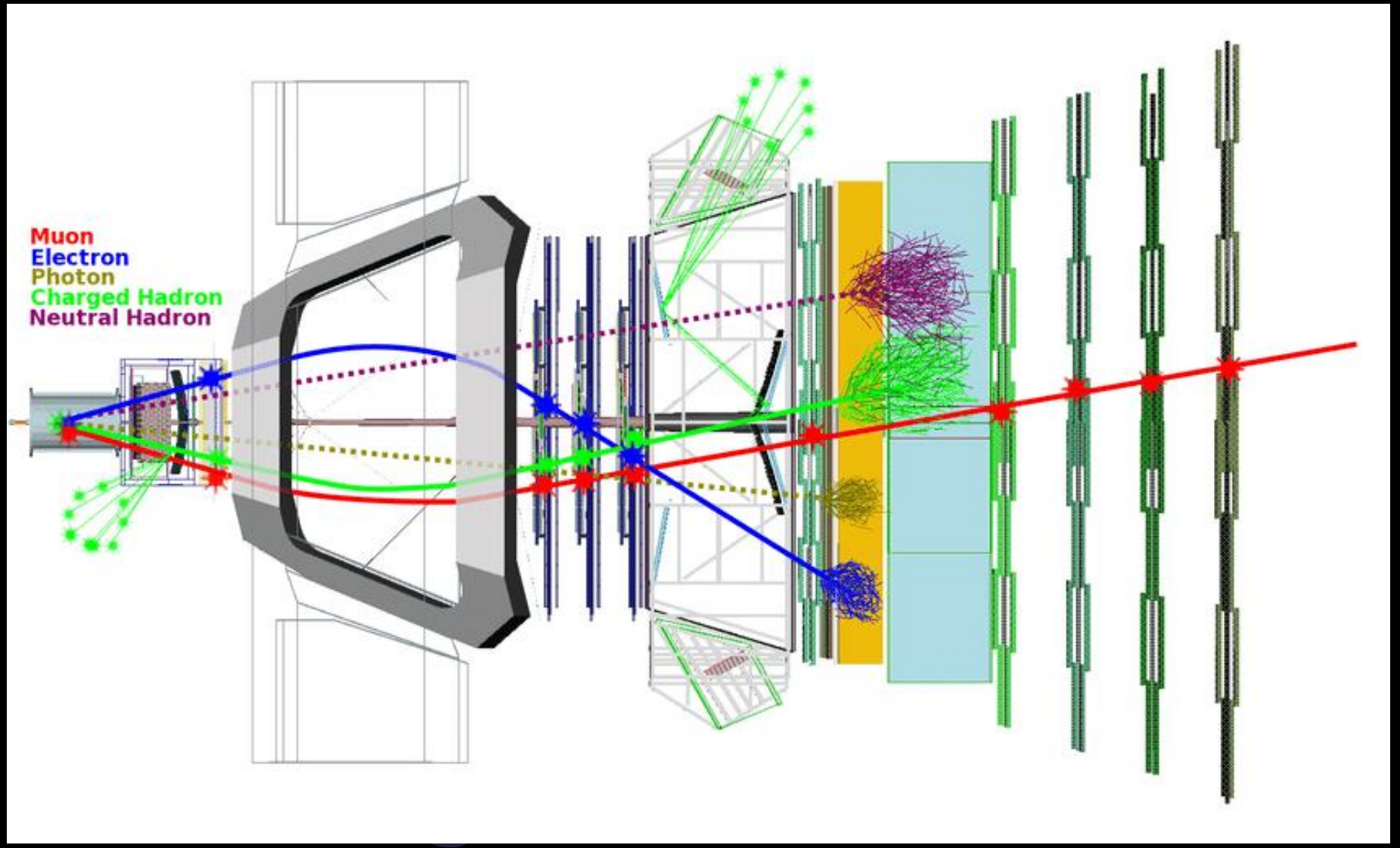
bashir@agh.edu.pl

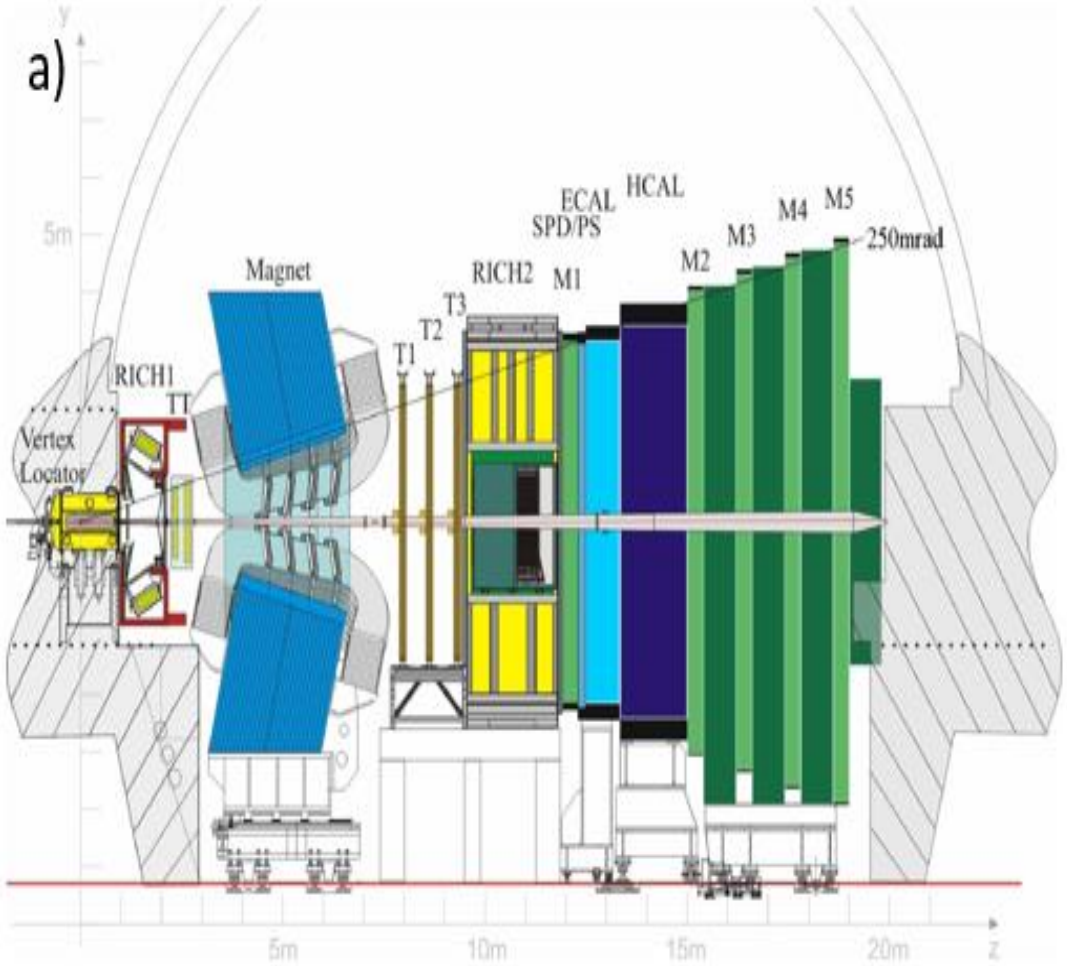
Back-up

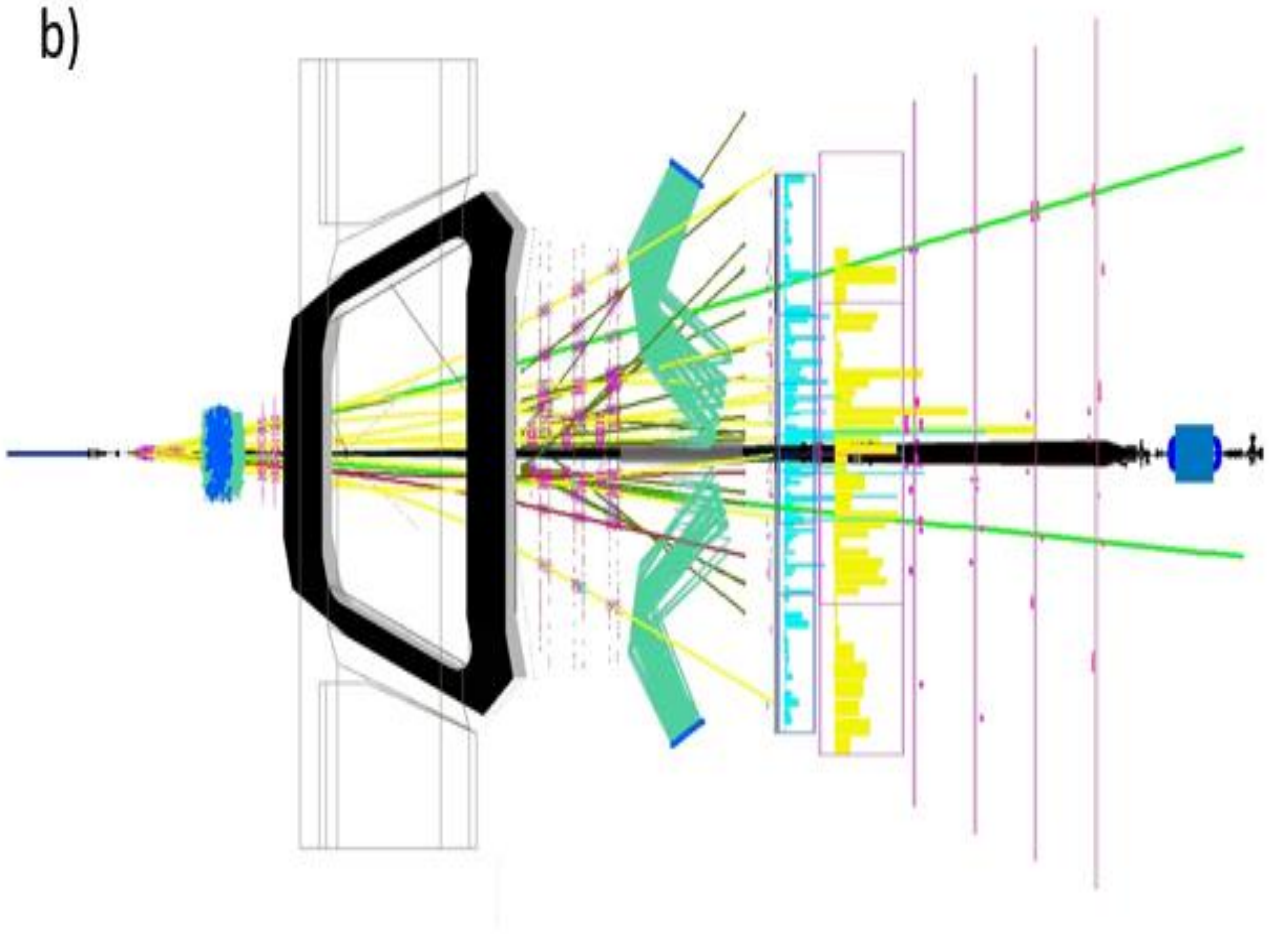
Eta Ranges for various Detectors and various purposes



Schematic View




a)
y
5m
Magnet
RICH1
TT
Vertex
Locator
T1
T2
T3
RICH2
M1
ECAL
SPD/PS
HCAL
M2
M3
M4
M5
250mrad
5m
10m
15m
20m
z


b)