VINS in CMS

Visit to IHEP

Vladimir Rekovic, Vinca Institute of Nuclear Sciences

IHEP, Beijing, 25.09.2024.

VINS History in CERN

National Institute of the Republic of Serbia

- Founded in 1948 by Prof. Pavle Savic, one of 12 **CERN** founding fathers (1953)

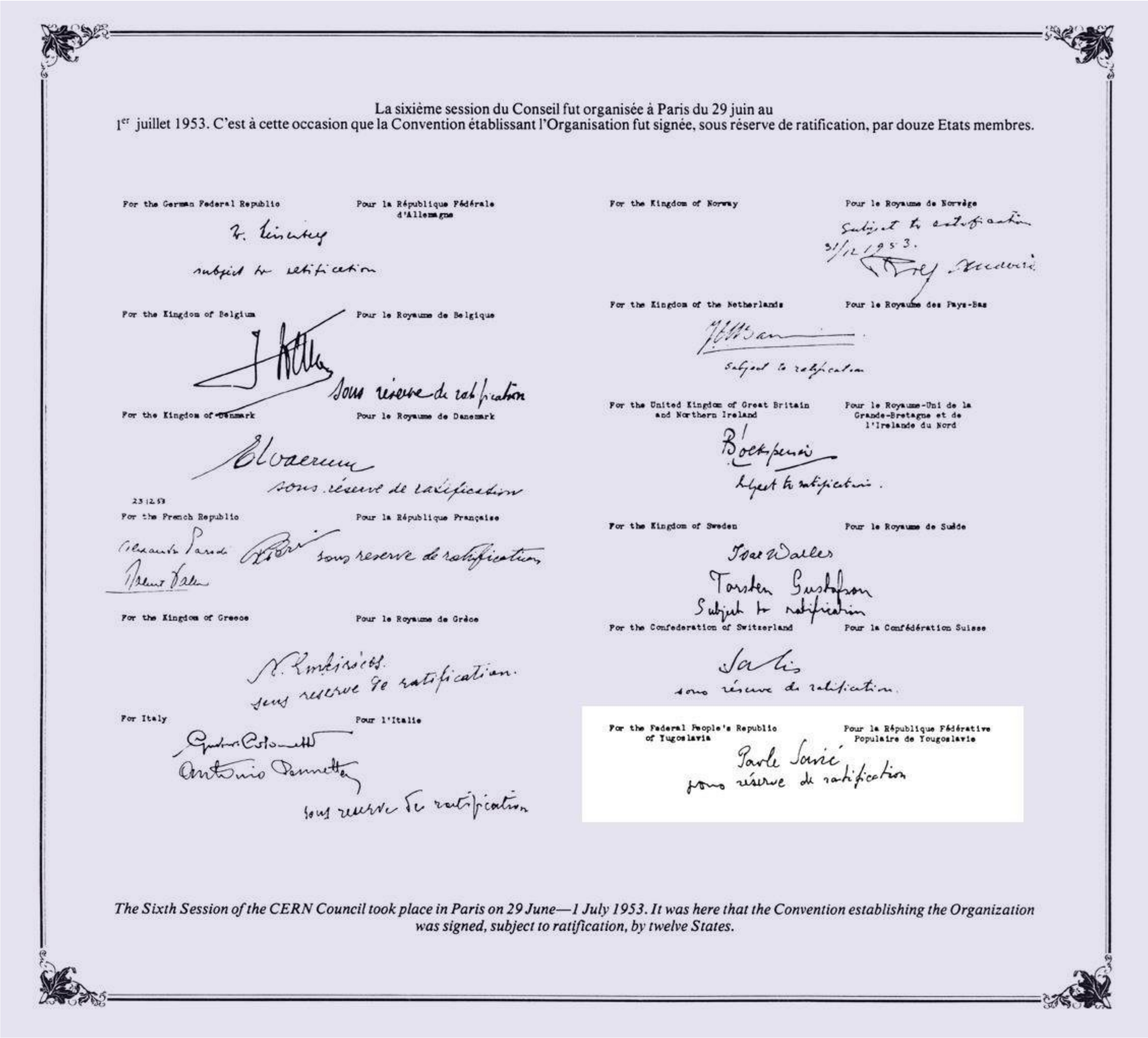
- Yugoslavia (Serbia) in CERN

  - 1953 - 1961 Full Member

  - 1961 - 2012 Observer

  - 2012 - 2019 Associate Member

  - from 2019 Full Member



La sixième session du Conseil fut organisée à Paris du 29 juin au 1er juillet 1953. C'est à cette occasion que la Convention établissant l'Organisation fut signée, sous réserve de ratification, par douze Etats membres.

For the German Federal Republic — Pour la République Fédérale d'Allemagne

For the Kingdom of Norway — Pour le Royaume de Norvège

For the Kingdom of Belgium — Pour le Royaume de Belgique

For the Kingdom of the Netherlands — Pour le Royaume des Pays-Bas

For the Kingdom of Denmark — Pour le Royaume de Danemark

For the United Kingdom of Great Britain and Northern Ireland — Pour le Royaume-Uni de la Grande-Bretagne et de l'Irelande du Nord

For the French Republic — Pour la République Française

For the Kingdom of Sweden — Pour le Royaume de Suède

For the Kingdom of Greece — Pour le Royaume de Grèce

For the Confederation of Switzerland — Pour la Confédération Suisse

For Italy — Pour l'Italie

For the Federal People's Republic of Yugoslavia — Pour la République Fédérative Populaire de Yougoslavie

The Sixth Session of the CERN Council took place in Paris on 29 June—1 July 1953. It was here that the Convention establishing the Organization was signed, subject to ratification, by twelve States.

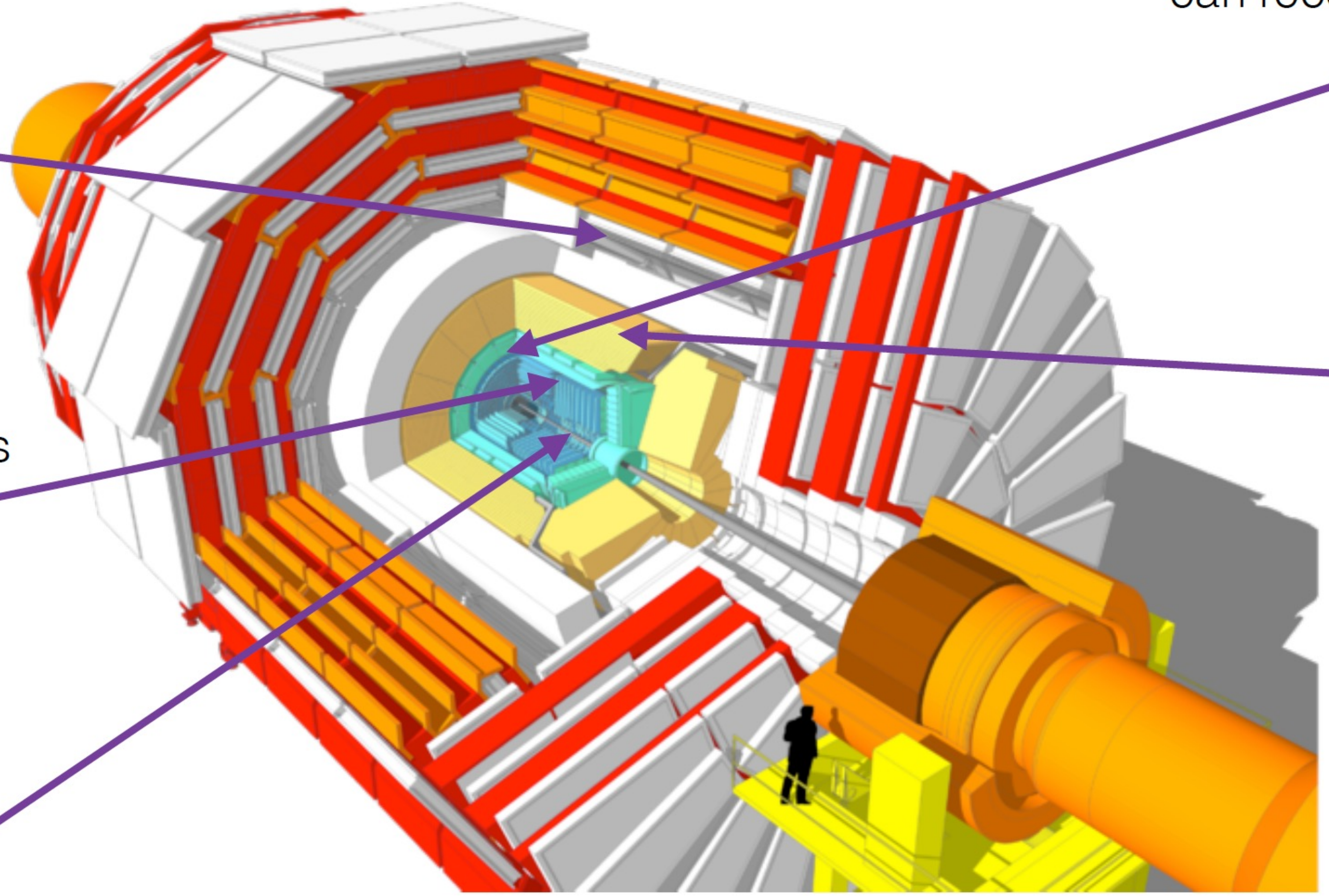
History - Vinca in CMS since 2001

- VINCA group is in CMS since 2001, originally participating in ECAL Project
- FA signed 2 MoU’s with Ministry of Republic of Serbia for CMS
  - 2001 “Construction”, 2007 “Maintenance and Operations”
- Now there are 2 Ungroups in CMS, with researchers in **two institutions,** committed to sign **two PhaseII MoUs.**
  - **VINCA Institute of Nuclear Sciences, (VINS)** -> **Phase II** Upgrade Level-1 Trigger
  - Faculty of Physics, University of Belgrade (FP) -> Phase II Upgrade ECAL Barrel
- Two groups have de-facto developed **different** research interests and goals over a course of last several years.
- In this presentation will cover activities of Vinca Group

Phase-2 upgrade for the CMS detector

Improved muon coverage and trigger
increased RPC coverage (1.5 < |η| < 2.4)
new electronics
CMS-TDR-016

New endcap calorimeters
high granularity
can reconstruct showers in 3D
CMS-TDR-019



New precision timing detector
Timing resolution of 30-40 ps for MIPs
full coverage of |η| < 3.0
CMS-TDR-020

Updates to calorimeter and trigger
higher granularity
electronics for trigger
CMS-TDR-015

L1: CMS-TDR-021
DAQ/HLT: CMS-TDR-022

New inner tracker
all silicon tracker
4 layers of pixels
5 layers of strips
coverage to |η| < 4
CMS-TDR-014

Beam Radiation Instrumentation and Luminosity Detectors
CMS-TDR-023

Upgrade to trigger and DAQ
L1 rate increased to 750 kHz
High Level trigger rate to 7.5 kHz
Track information at L1

VINS – Full Membership Group in CMS

Personnel - 6 physicists, 1 engineers

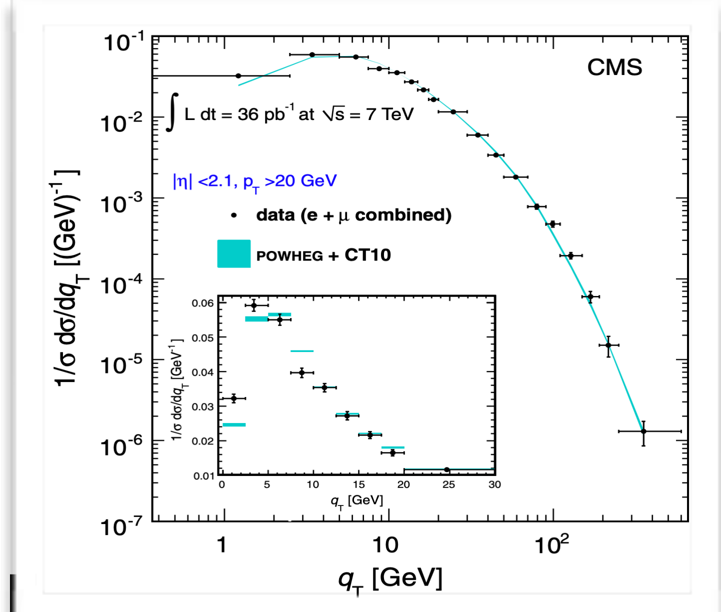
- VINS researchers in CMS consist of 4 physicists, 1 doctoral student, 1 electrical engineer.
  - Ms. Luka Terzic, (EE),
  - Ms. Ana Jelisijevic. (EE, external)
  - Dr. Laslo Nadderd (physicist)
  - Dr. Milos Djordjevic (physicist)
  - Dr. Milan Stojanovic (physicist, currently @Perdue)
  - Dr. Damir Devetak (physicist)
  - Dr. Jovan Milosevic (physicist) - Deputy TL
  - Dr. Vladimir Rekovic (physicist) - Team Leader

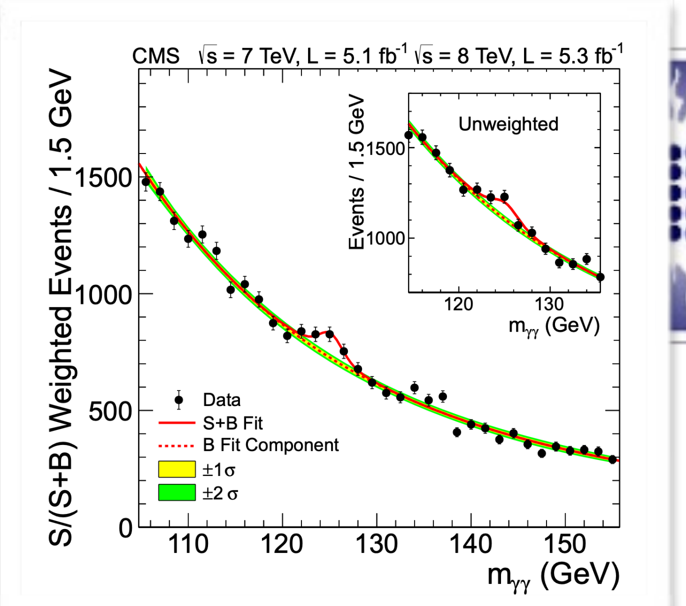
- Good connections with the Universities in Serbia, good to attract new students and grow with the support from the Ministry
- Expertise in HEP Physics with International collaborations at CERN. Good visibility in Serbia.
- Working connections with the School of Electrical Engineering University of Belgrade, working on Phase-II Upgrade.

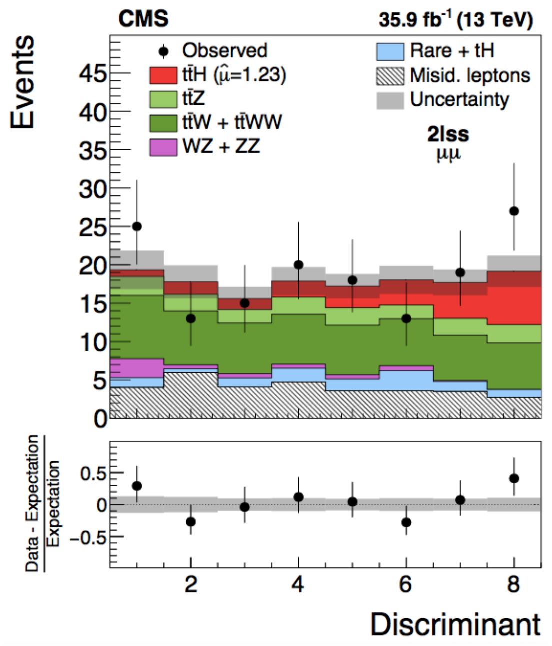
CMS Physics with VINS

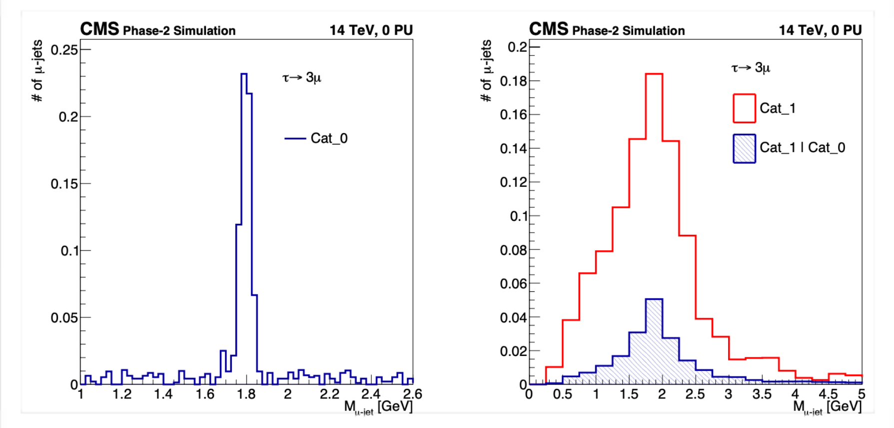
Physics Expertise

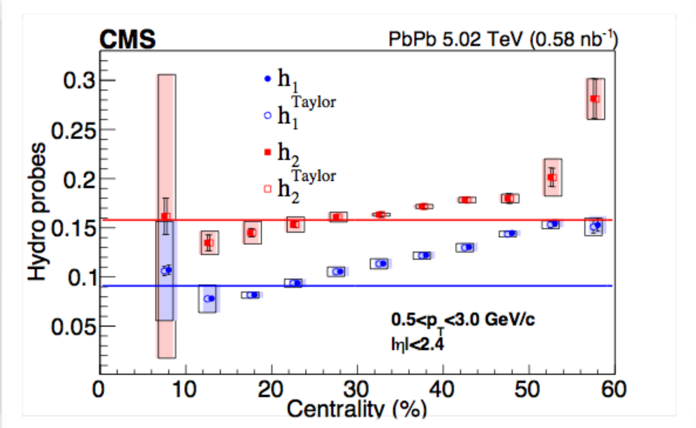
- Most of physicists active members of CMS over 10 years





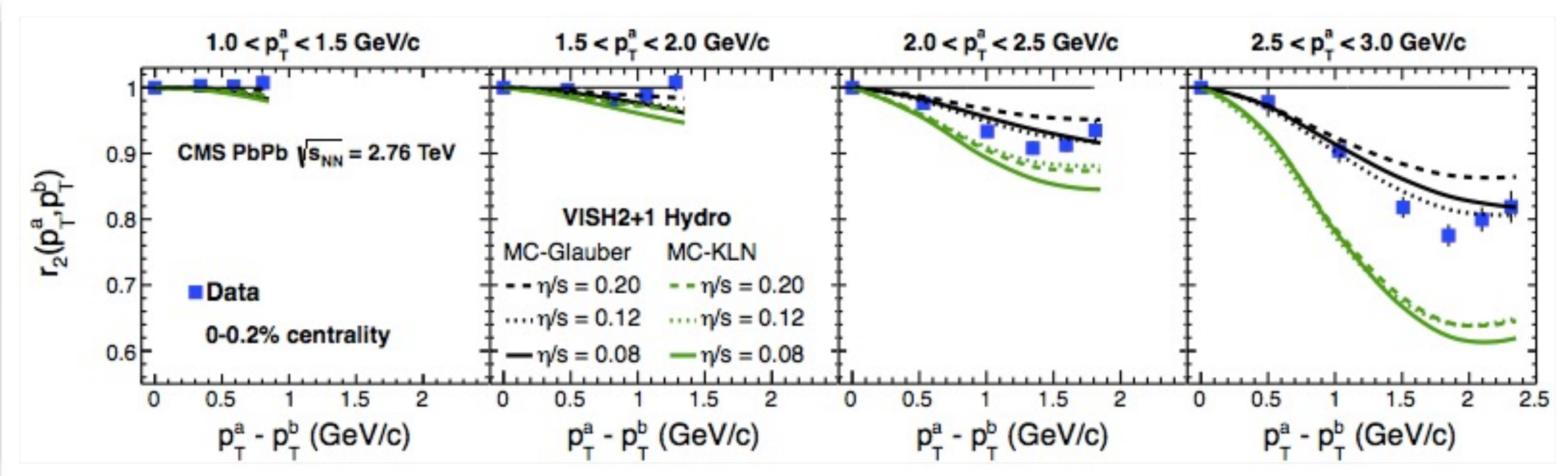


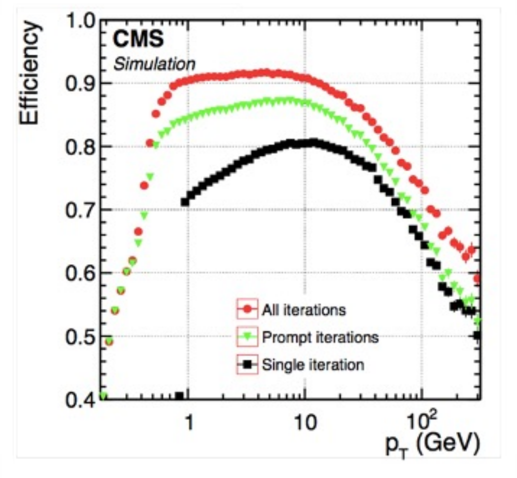


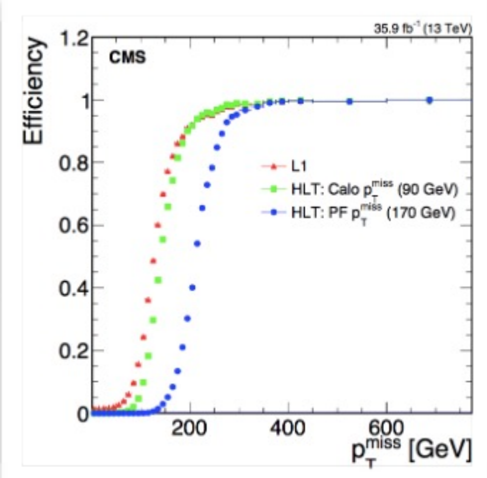


- **Research activities - selection of contributions**

  - **Higgs** (Discovery γγ, VBF, Low Mass, ttH)
  - **EWK, BPH**
  - **Heavy Ion (**Collectivity, Jets, IS fluctuations)
  - **Particle Flow**
  - **Level-1 Trigger** and **HLT**

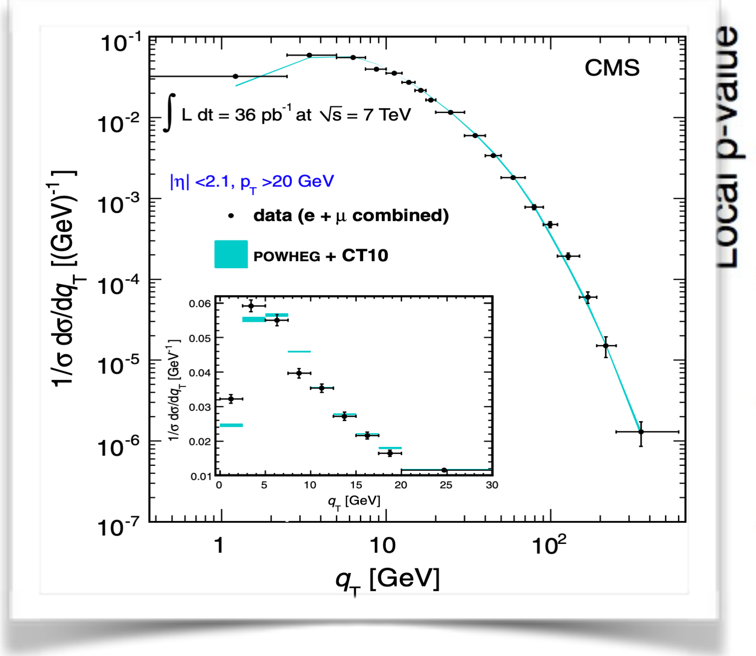


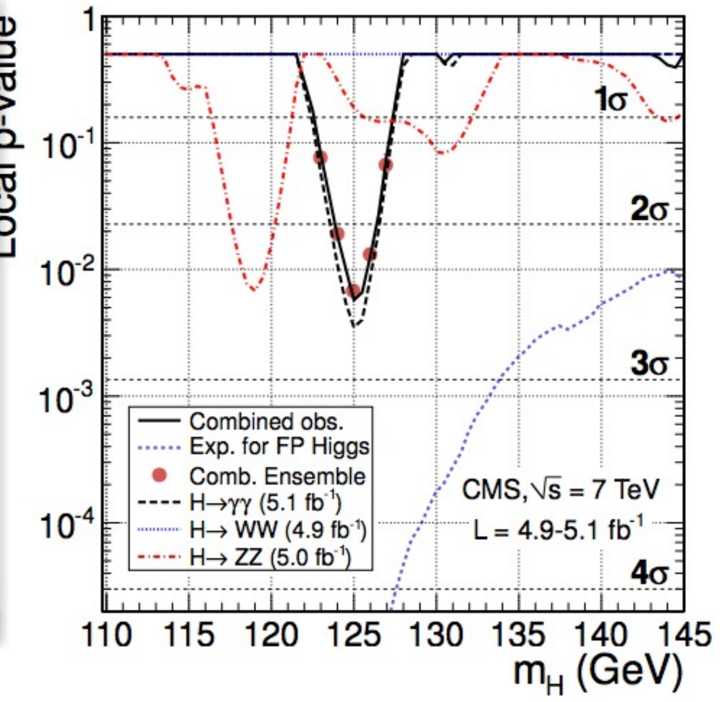


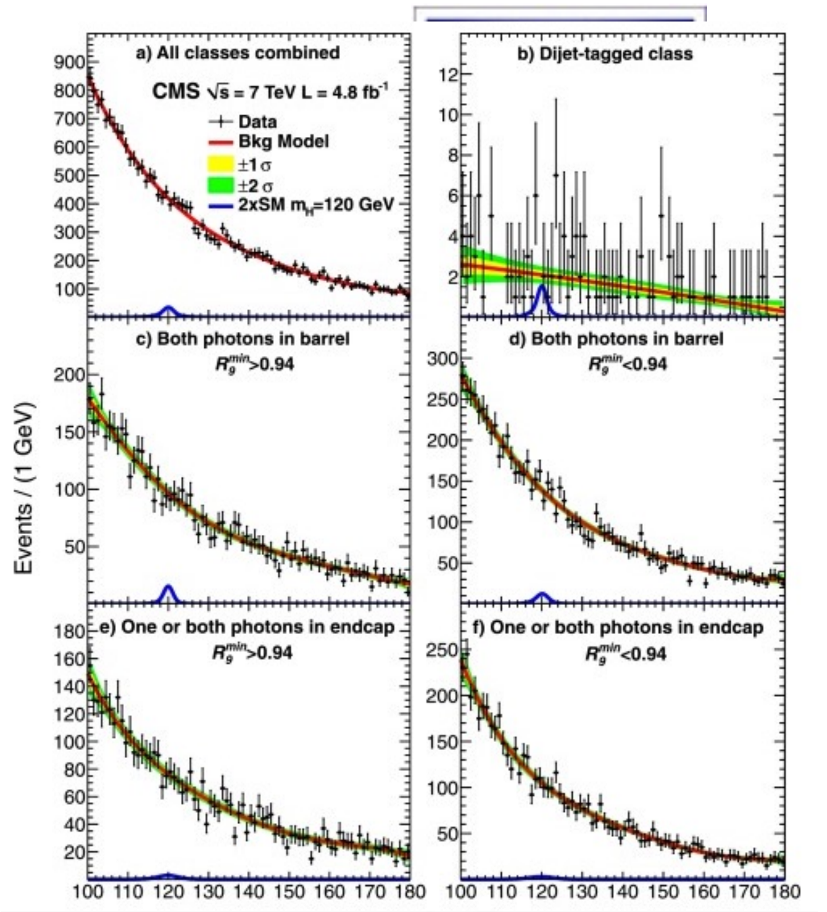


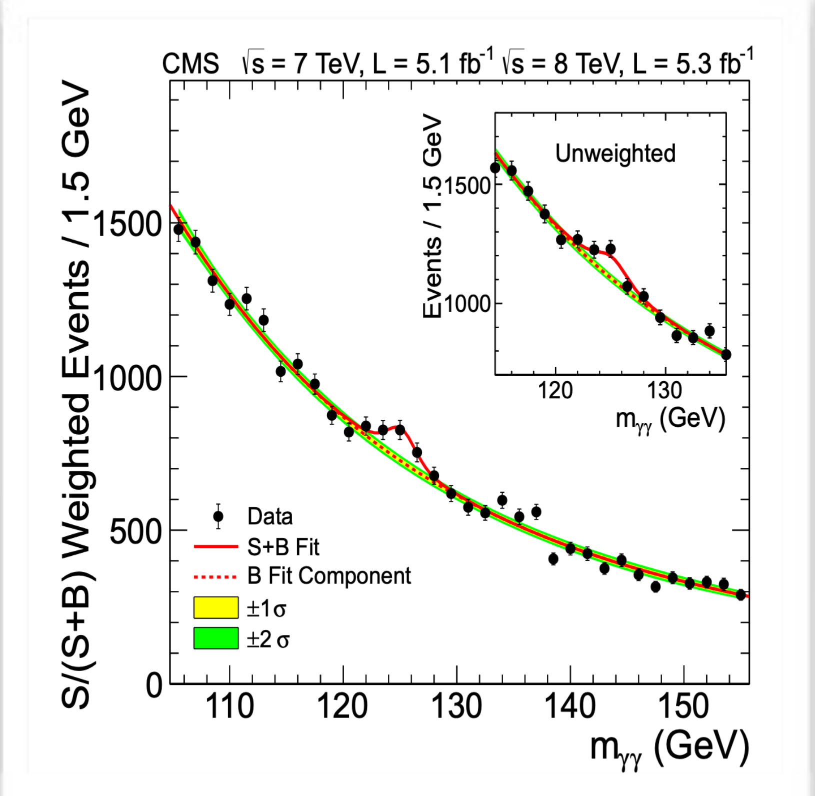
Selected publications in pp collisions

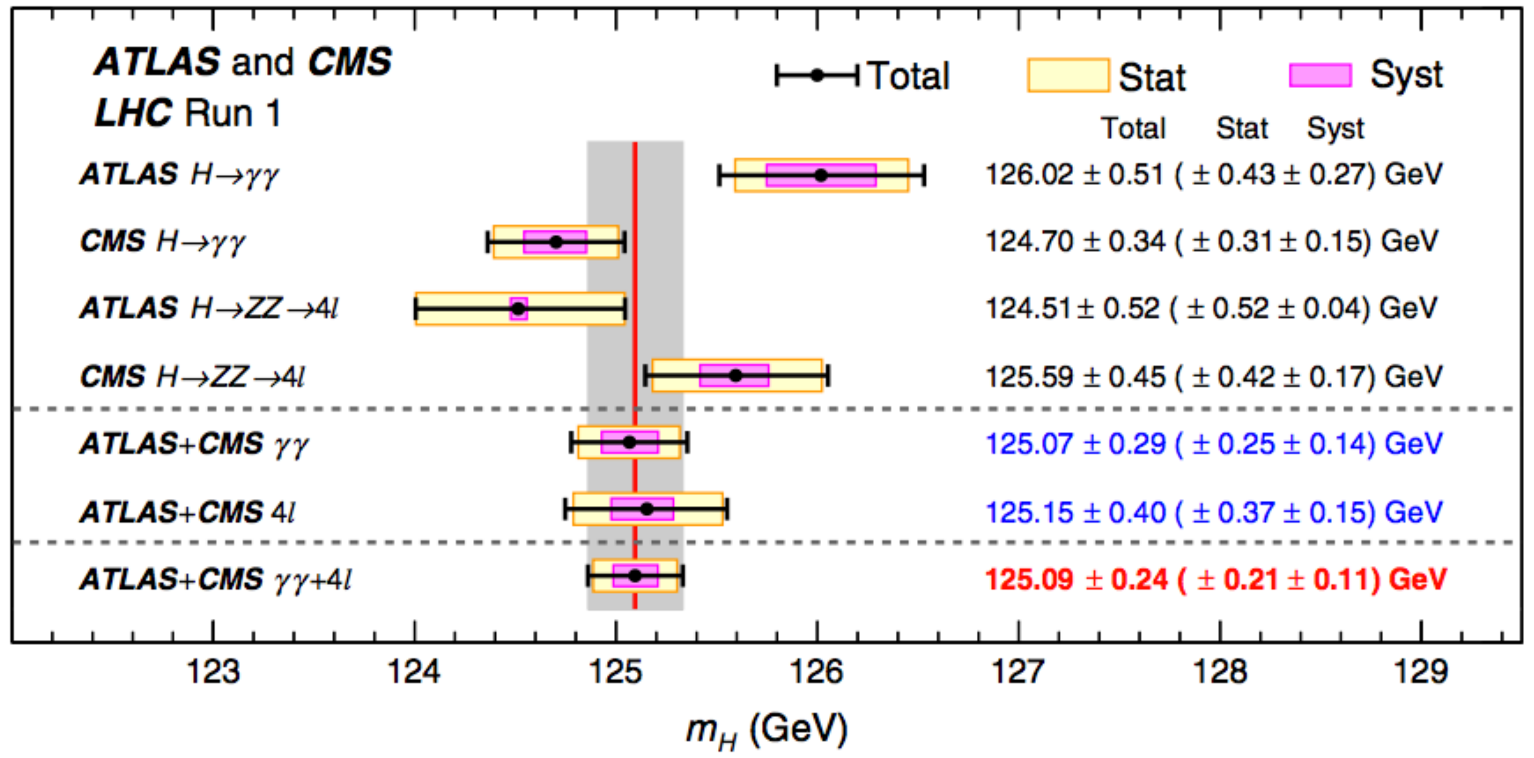
- Phys. Rev. D 85 (2012) 032002 (Diff Zee cross section)
- JHEP 09 (2012) 111 (Fermiophobic Higgs)
- Phys. Lett. B (2012) 710:3 (Search for Higg γγ 7 TeV)
- Phys. Lett. B 726 (2013) 587 (Higgs to Zgamma@7 TeV)
- Phys. Lett. B (2012) 716:30 (Observation of a new boson)
- Eur. Phys. J. C 74(2014) 3076 (Observation of Higgs γγ & prop)
- Phys. Rev. Lett. **114**, 191803 (Combined Meas. Higgs)
- JHEP 08 (2018) 066 (tt + Higgs in the multilepton state)
- Phys. Rev. Lett. 120, 231801 (2018) (tt+Higgs combined)
- JHEP 06 (2018) 102 (BSM single t + Higgs FCNC@13 TeV)
- JINST 14 (2019)P07004   (MET performance @ 13 TeV)
- JINST 15 (2020) P09018   (Pileup mitigation @ 13 TeV)
- JINST 12 (2017) P10003 (Particle Flow and GED at CMS)

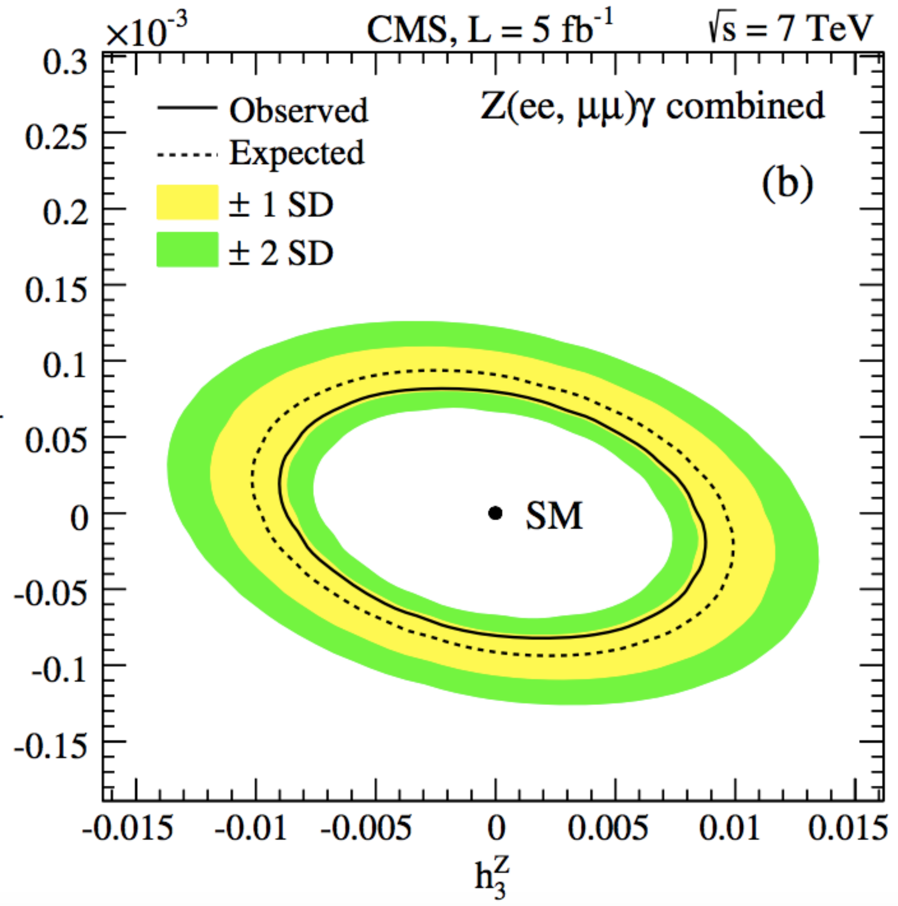


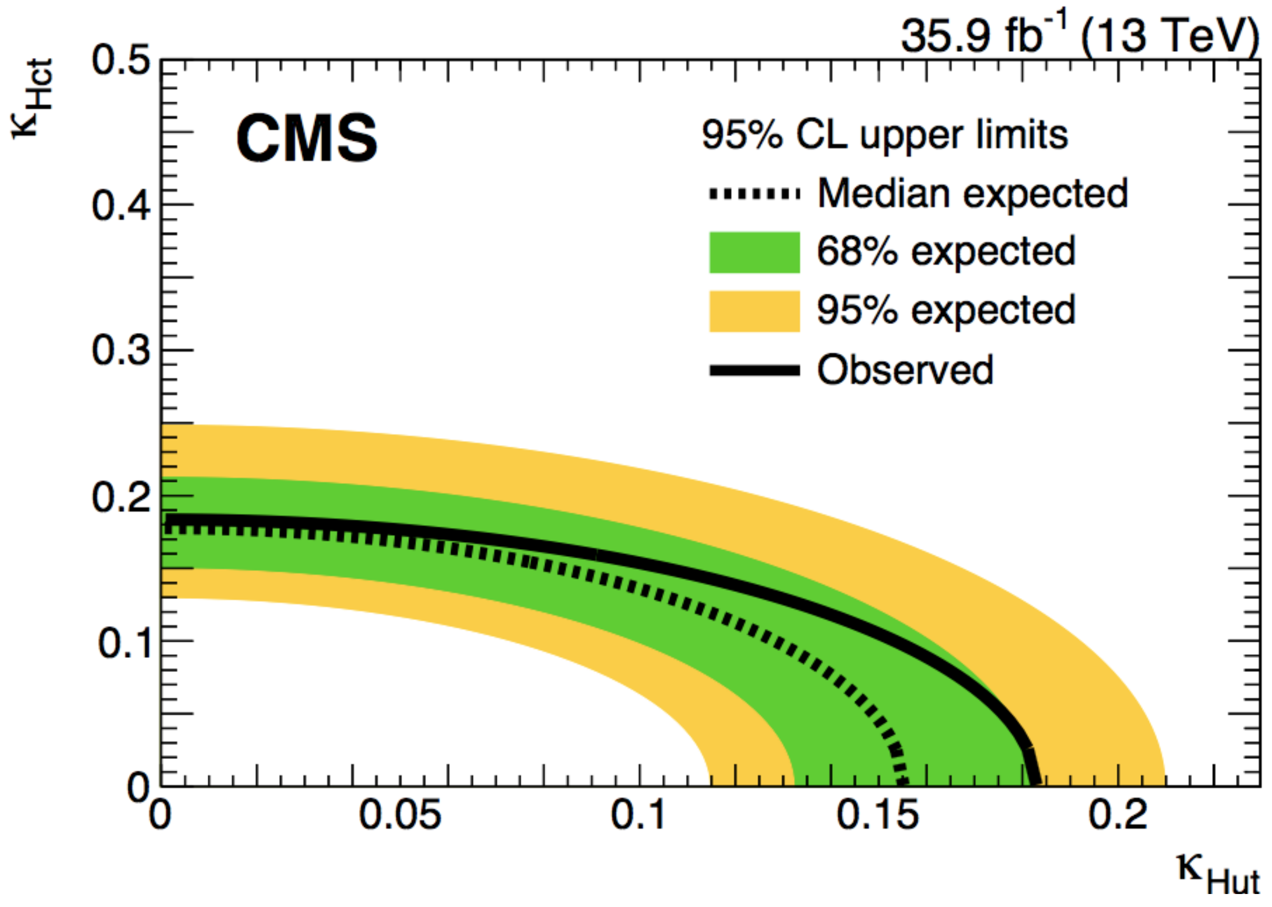


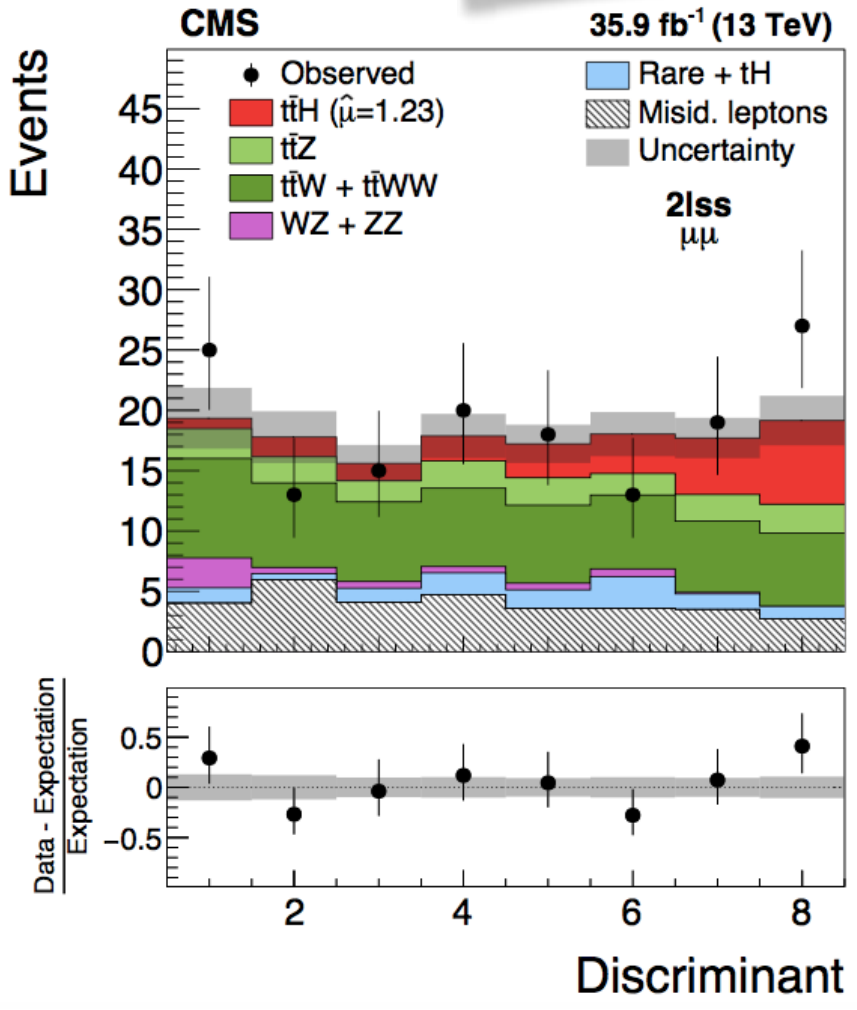


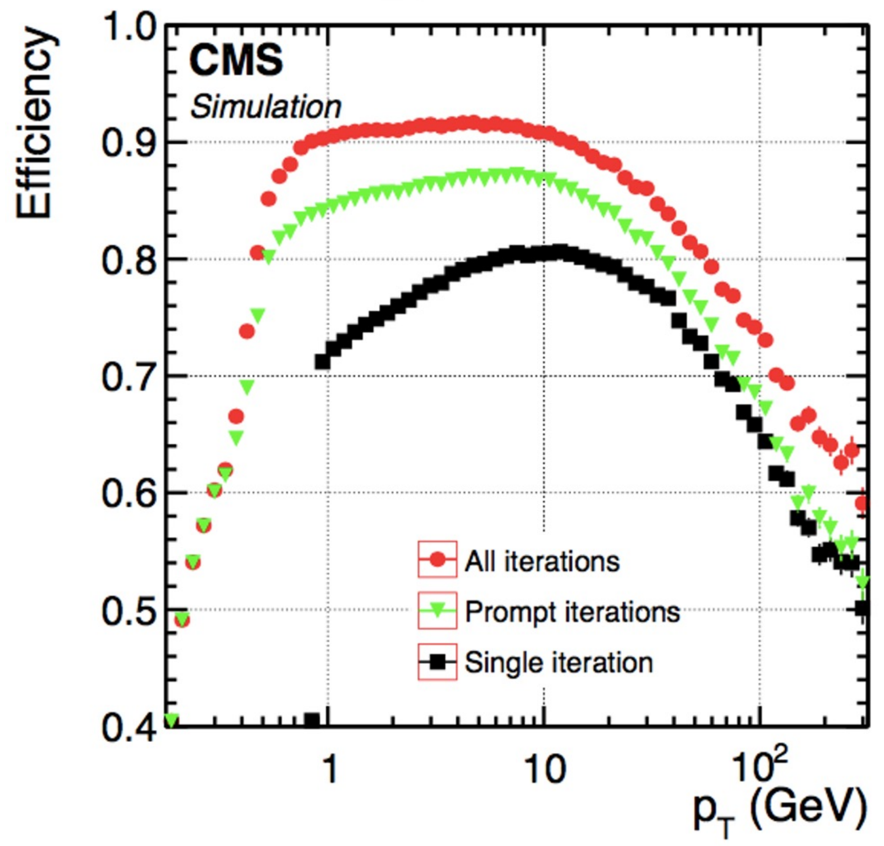


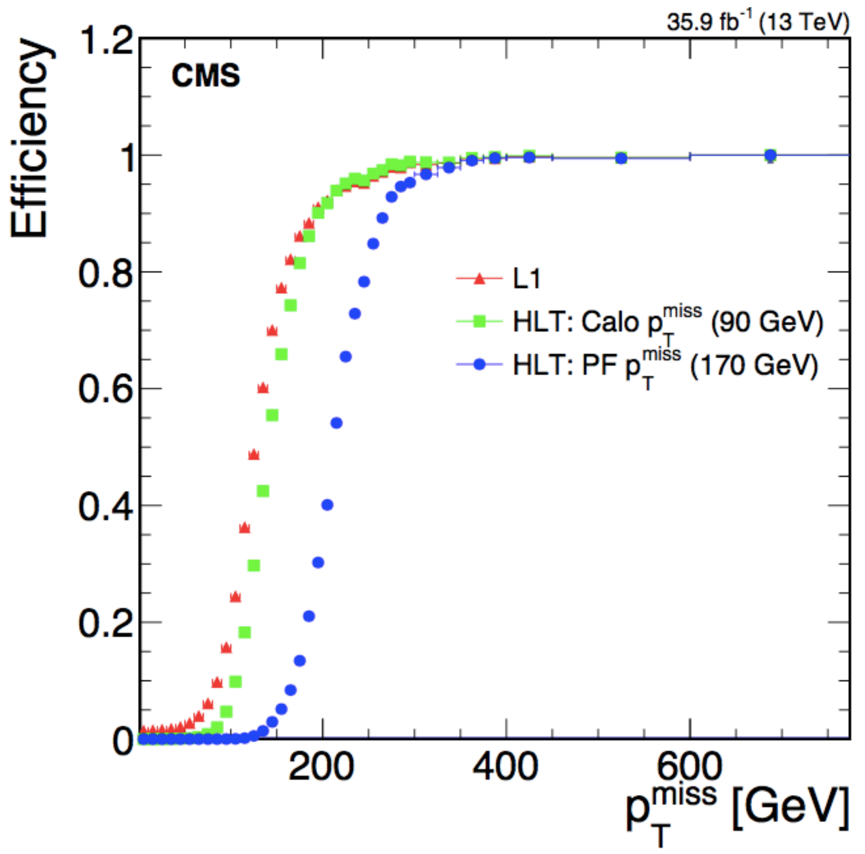






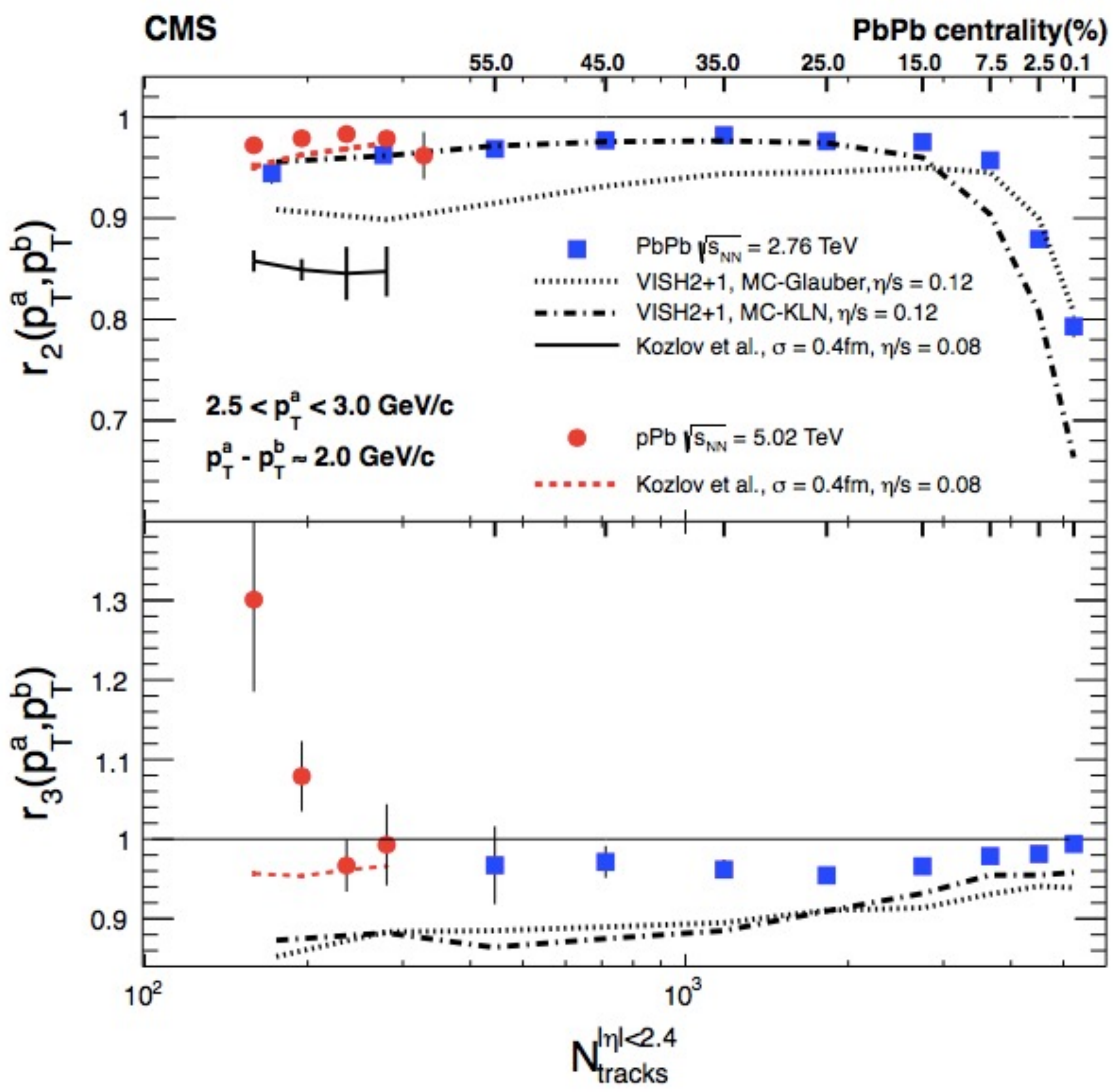




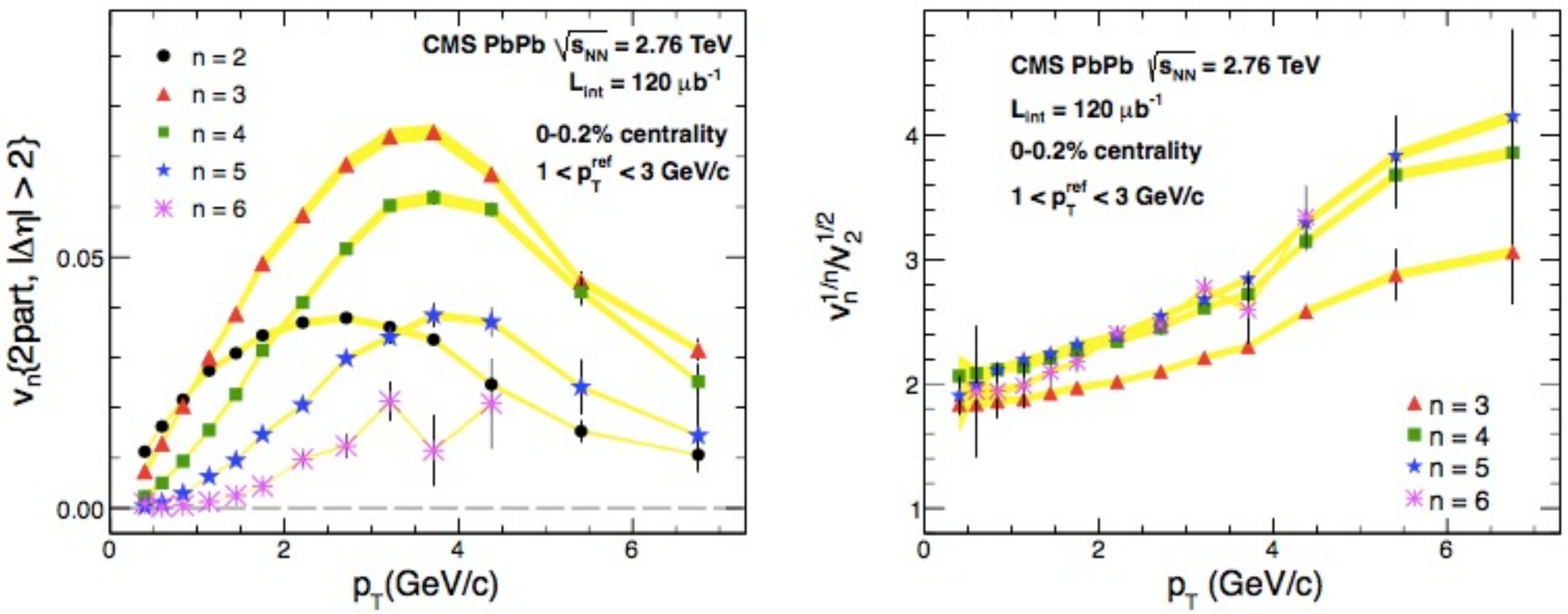


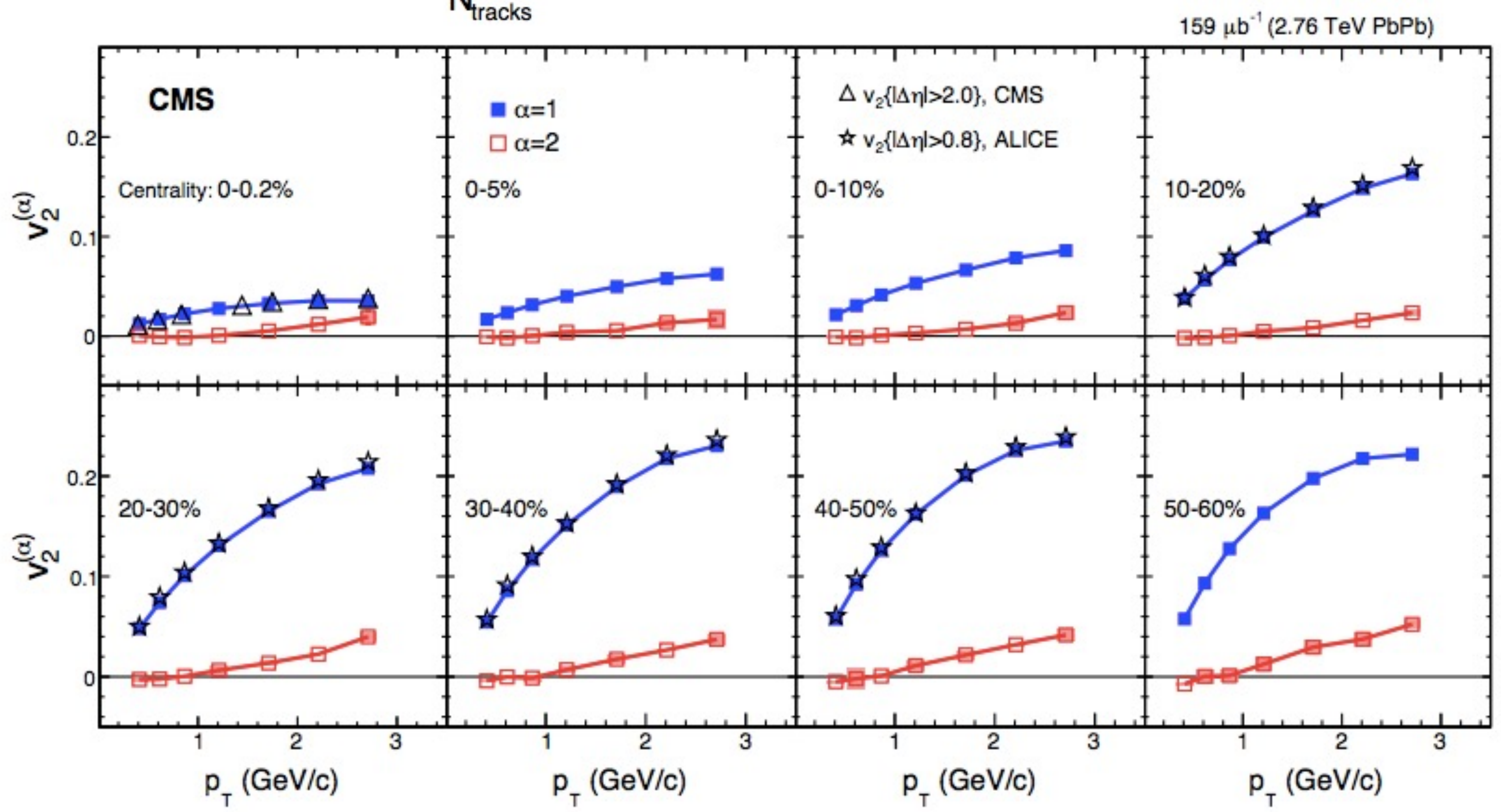
CMS Heavy Ion at INS Vinca

Anisotropic flow
Phys.Rev.**C**92(2015)034911

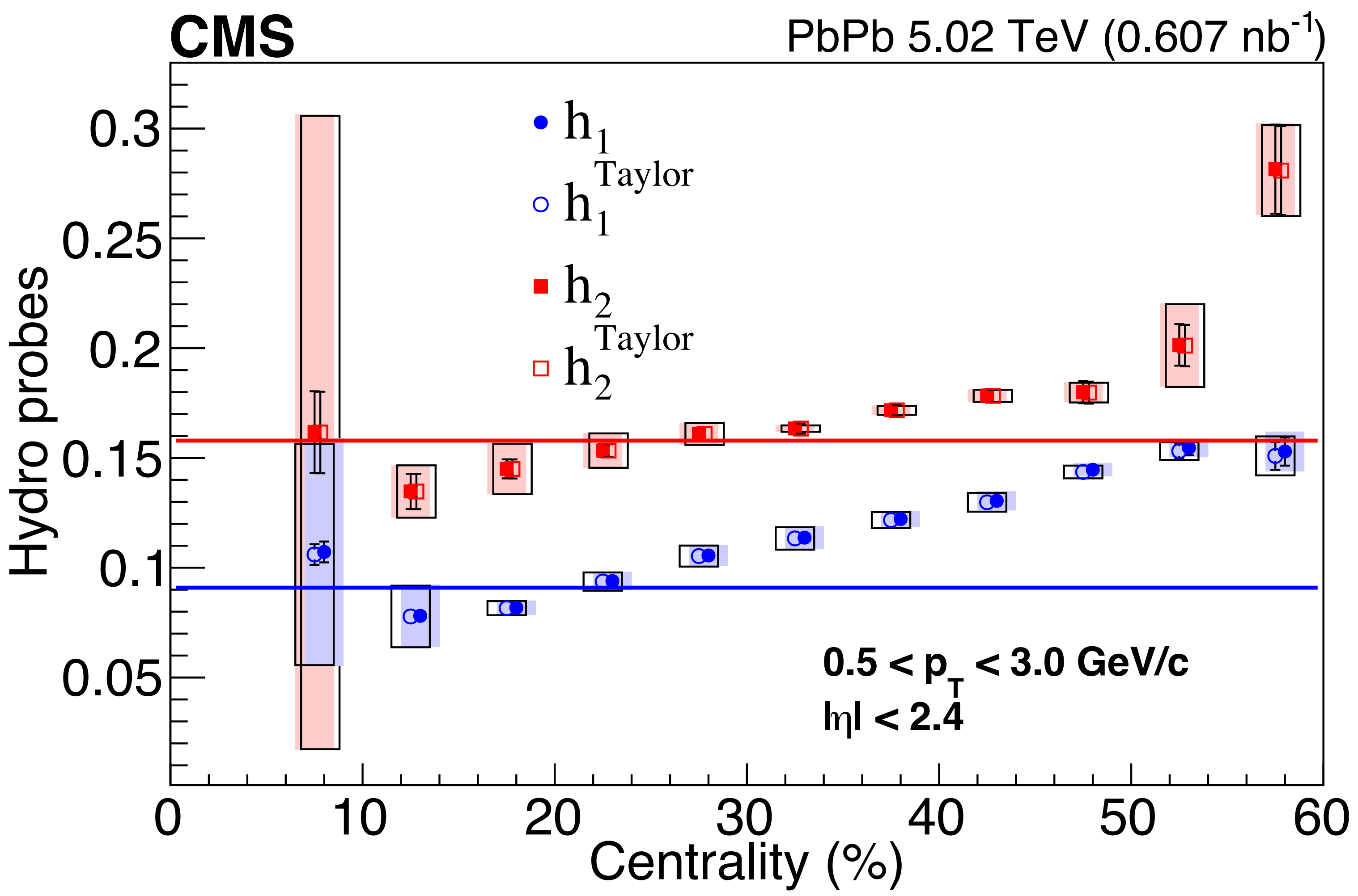


Jet quenching
JHEP 1402 (2014) 088





Two particle azimuthal correlations
Phys. Rev. **C** 96 (2017) 064902



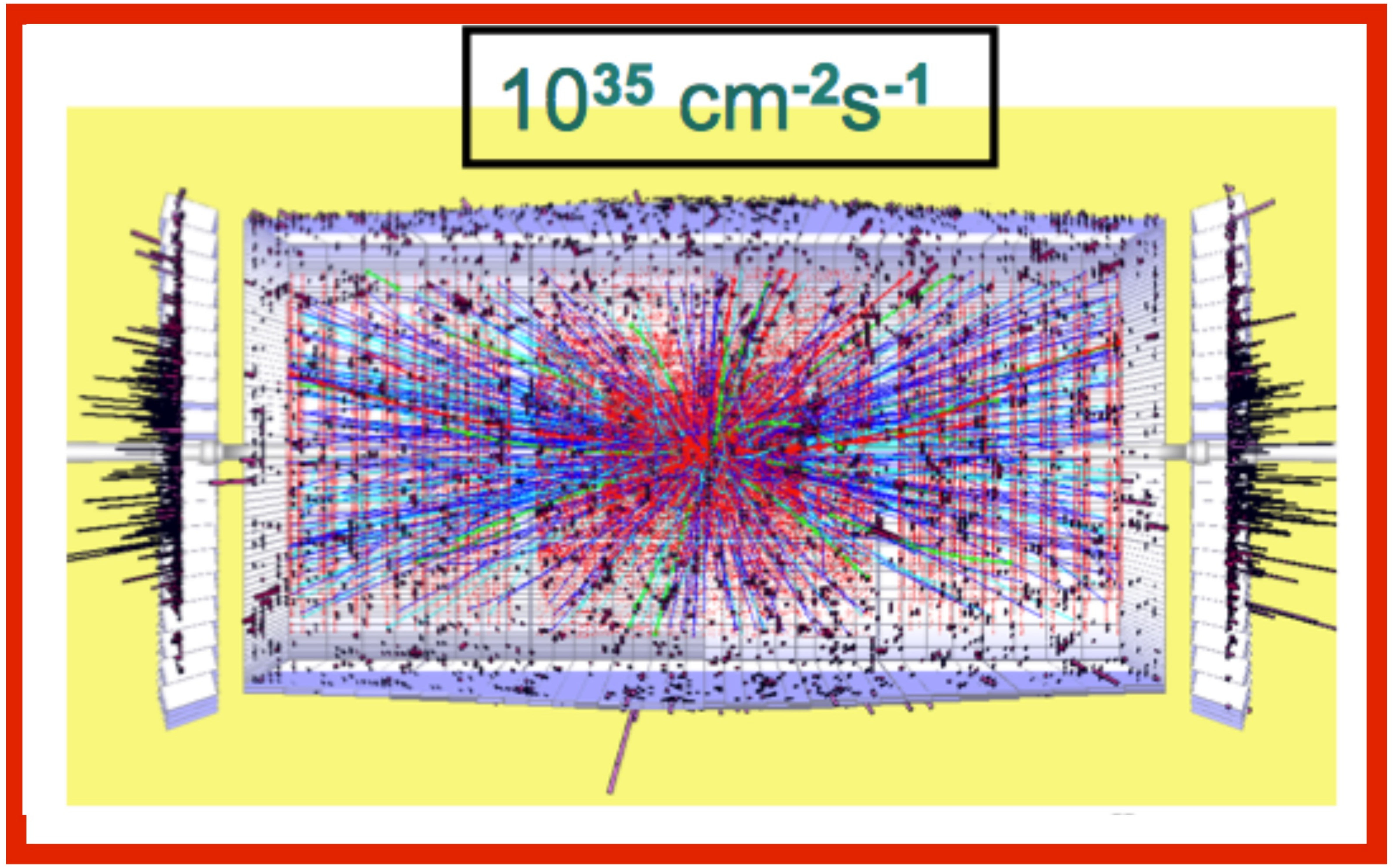
Collectivity in small systems
Submitted to JHEP

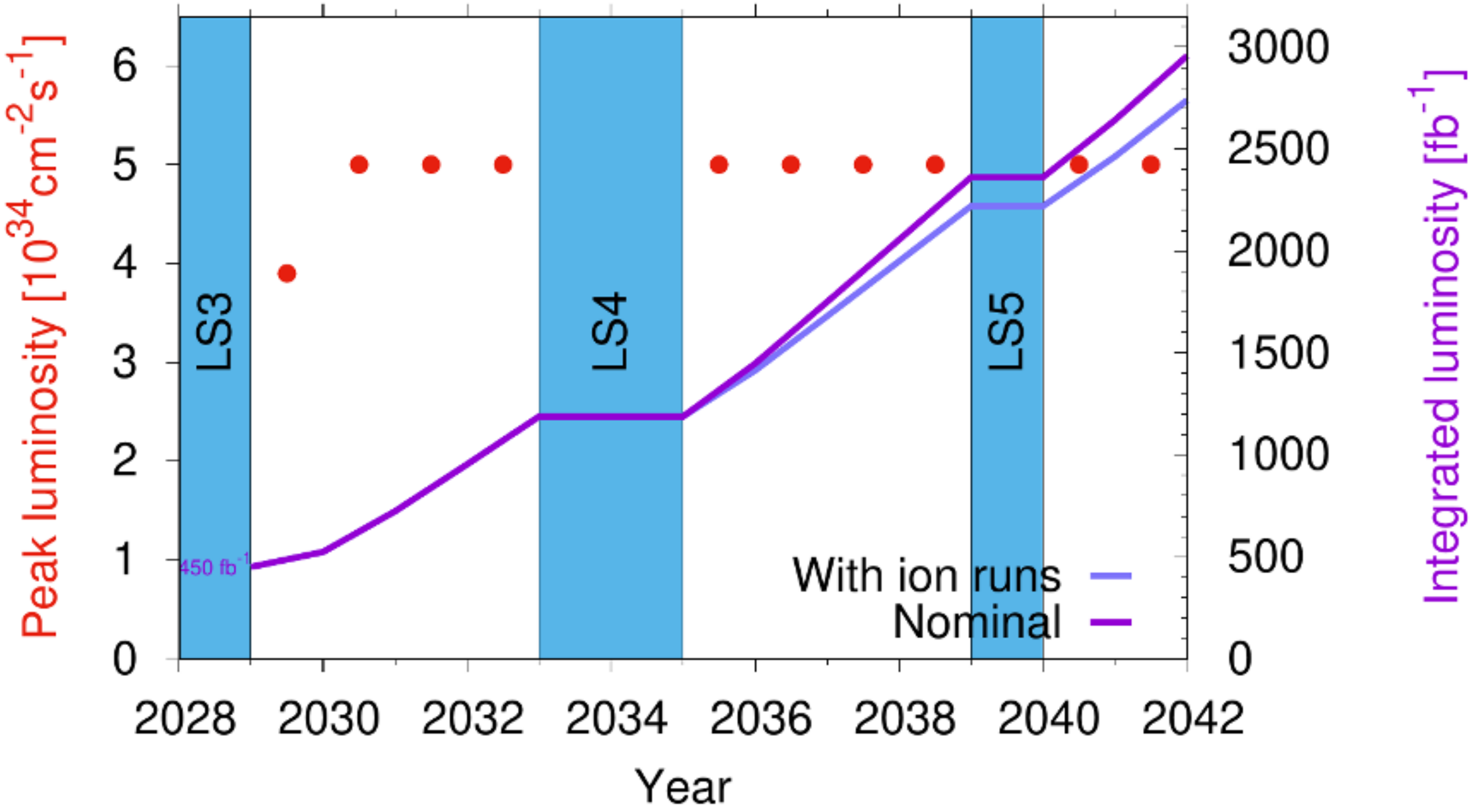
And many more results…

HL-LHC

The Phase II (HL-LHC) project established in 2010, is already more than half-way through:

- Inst. Luminosity up to 7.5e34 (updated projection for Integrated 4000 fb-1)
- Energy: 14 TeV or more (discussion ongoing on availability of the machine)
- Filling schemes considered: similar to previous experience (8b4e, 48b etc.)

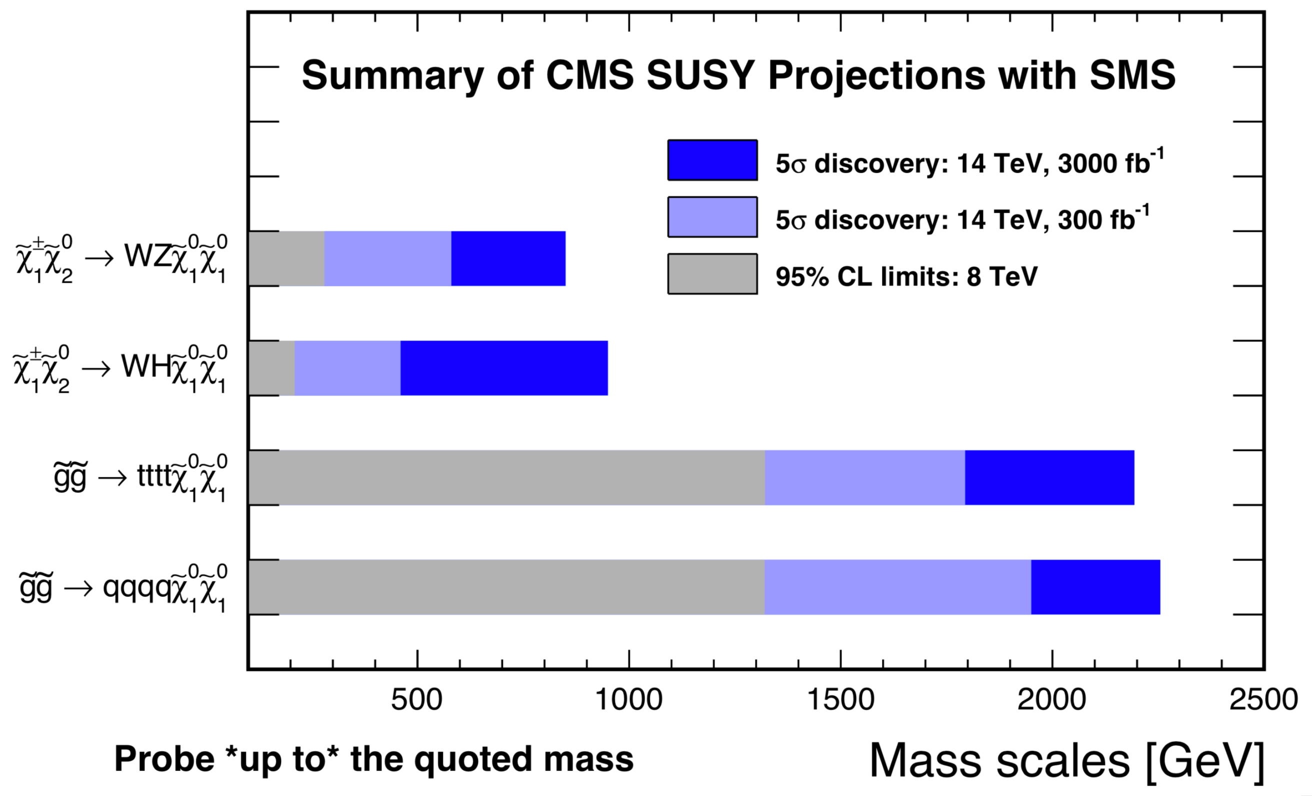




p-p collisions in HL-LHC

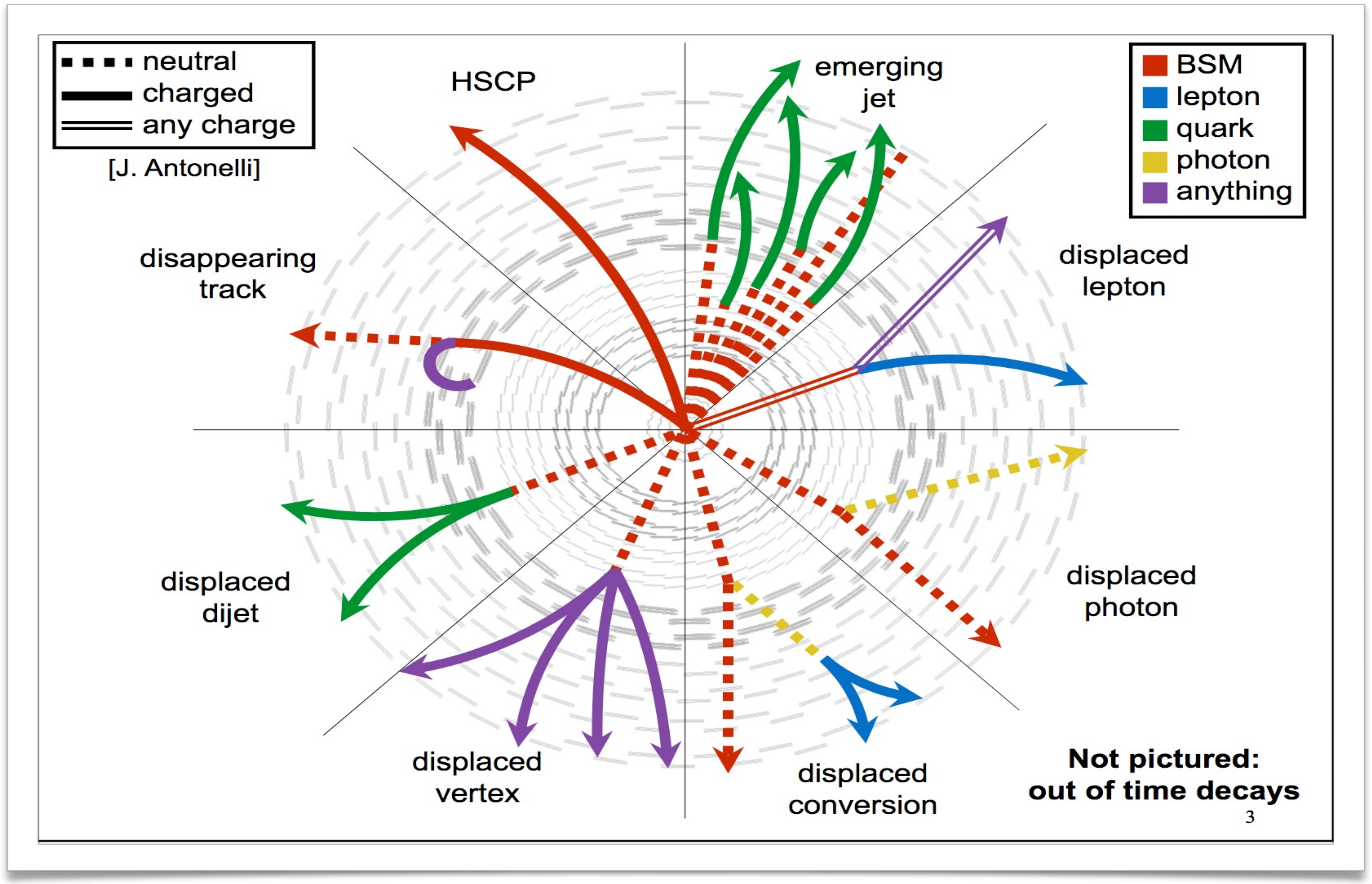
- Interaction region with Gaussian spread 45 mm along beam axis
- Average number of collisions : <μ> 200
  - Average interaction density: 1.8 collisions/mm

Reasons for HL-LHC



Significantly extend the physics program with HL-LHC 10x data of LHC

- SM Precision measurement: Higgs, PDFs, QCD,
- New Physics: DM, SUSY, BSM, extra dim.



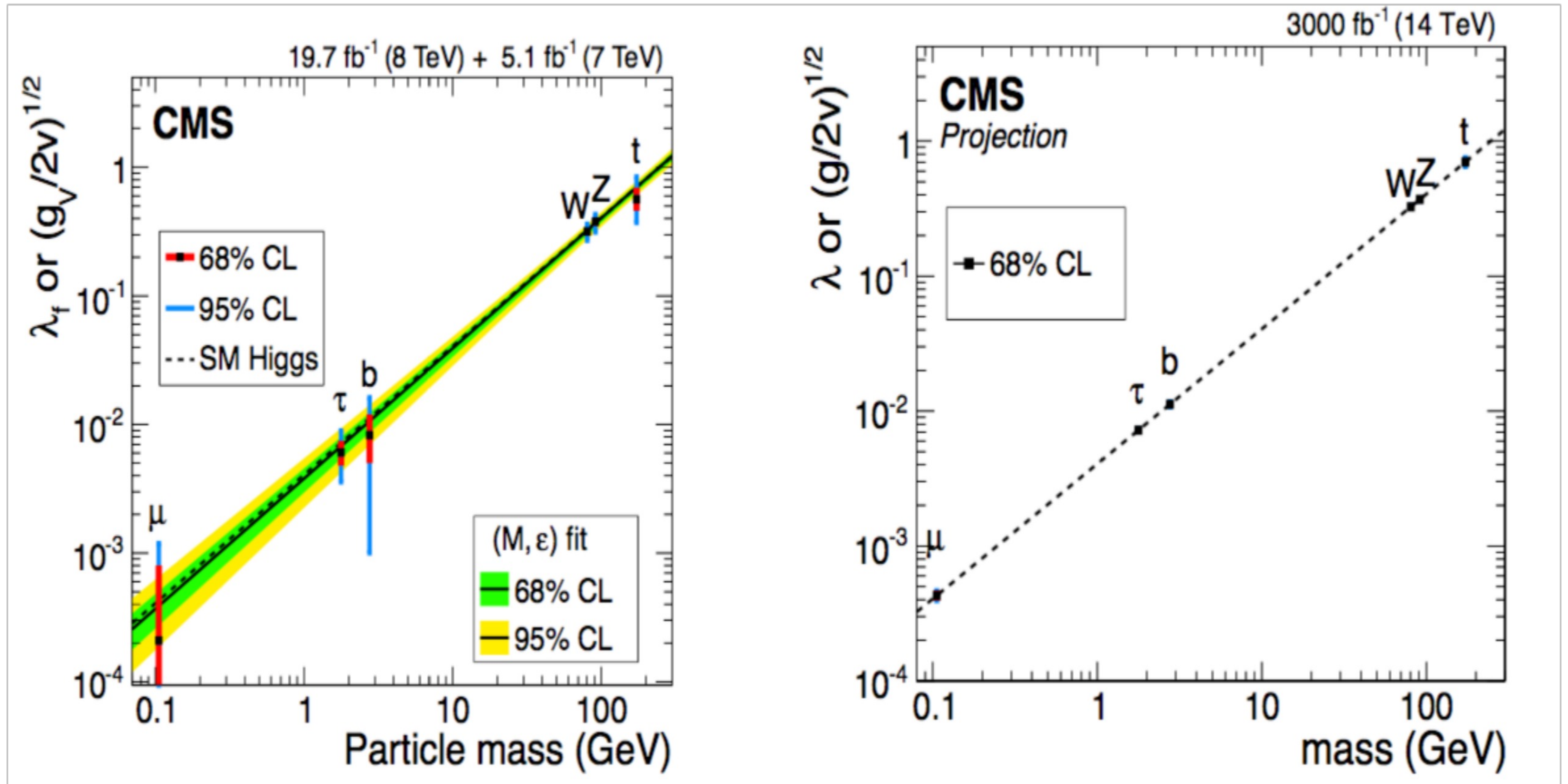


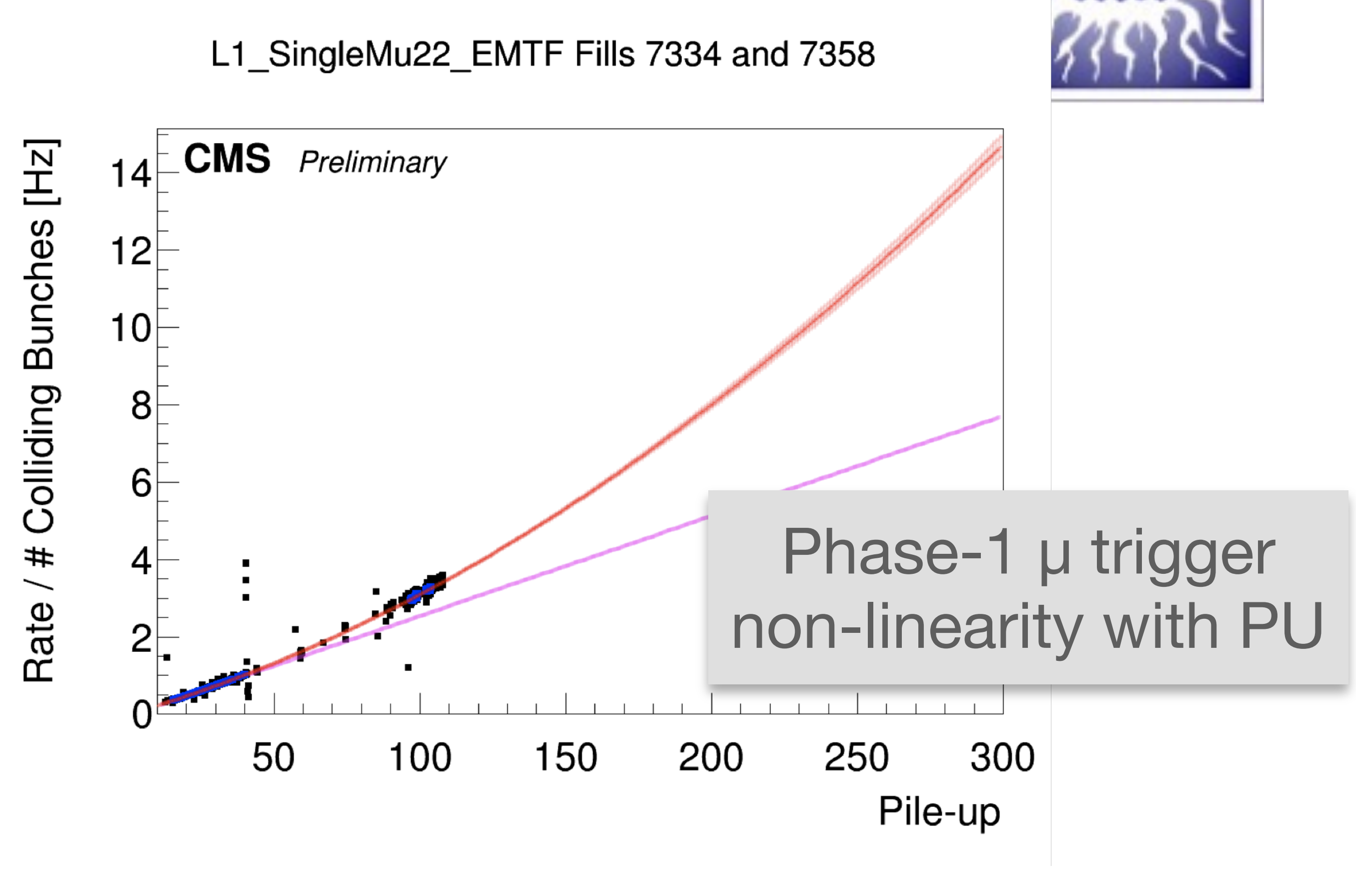
Figure 1.10: Observed and projected precision on Higgs boson couplings as a function of boson or fermion masses.

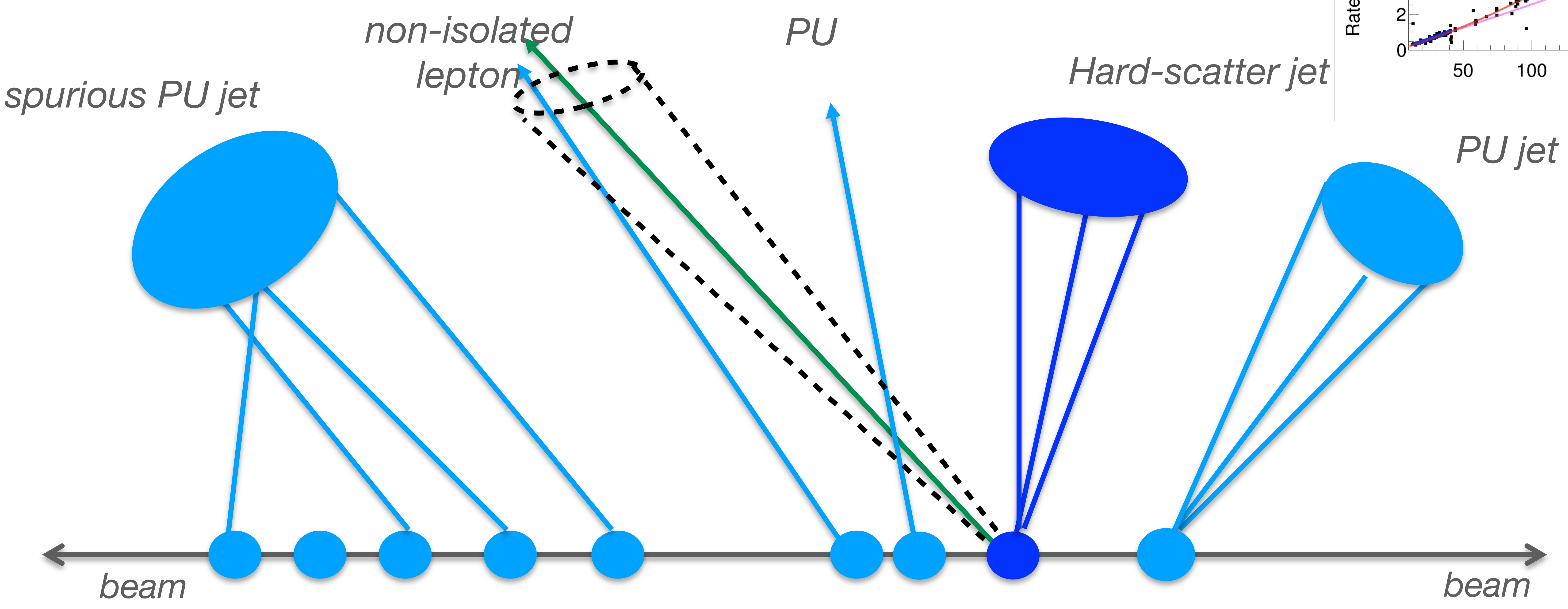
Major challenge for tracking detectors in HL-LHC CMS

- Efficiently reconstruct charged particles from primary interactions
  - Correctly assign them to production vertices -> Need upgraded detectors for Phase-2.

Main challenge in HI-LHC: effects of PU

- **Pile up (PU) – many inelastic proton-proton collisions in (small) interaction region of crossing beams**





- **Approach to solving problem: Use of tracking to identify a primary vertex and associate reconstructed objects.**
- **Objective**: exclude from relevant quantities charged particles not associated with hard interaction.
  —> build time-of-flight detector to assign time tag to particle signatures
  —> use tracking in the trigger and higher detector granularity

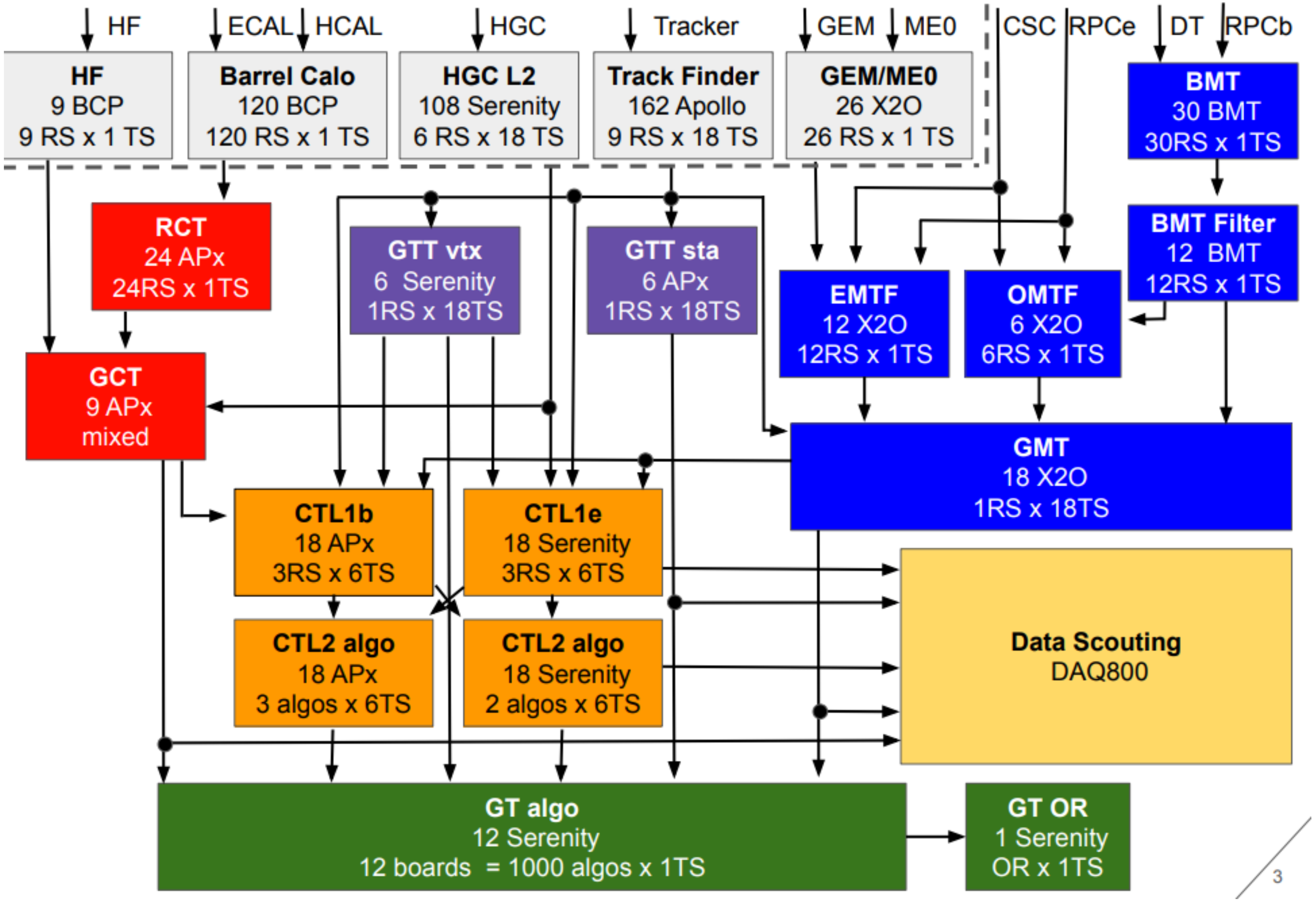
High Luminosity LHC

Increase in data rate and volume

- **CMS detector needed upgrade (Phase-2). Level-1 Trigger as well.**
  - **Higher resolution in upgraded detectors (at L1) HGCal, ECAL, more muon chamber, introduced L1 Tracker**
  - **Larger event size, but increased available latency with new electronics**

CMS detector	LHC Run-2	HL-LHC Phase-2	
Peak ⟨PU⟩	60	140	200
L1 accept rate (maximum)	100 kHz	500 kHz	750 kHz
Event Size	2.0 MB [a]	5.7 MB [b]	7.4 MB
Event Network throughput	1.6 Tb/s	23 Tb/s	44 Tb/s
Event Network buffer (60 seconds)	12 TB	171 TB	333 TB
HLT accept rate	1 kHz	5 kHz	7.5 kHz
HLT computing power [c]	0.5 MHS06	4.5 MHS06	9.2 MHS06
Storage throughput	2.5 GB/s	31 GB/s	61 GB/s
Storage capacity needed (1 day)	0.2 PB	2.7 PB	5.3 PB

Use of 4 flavors of Boards in Phase-II Trigger



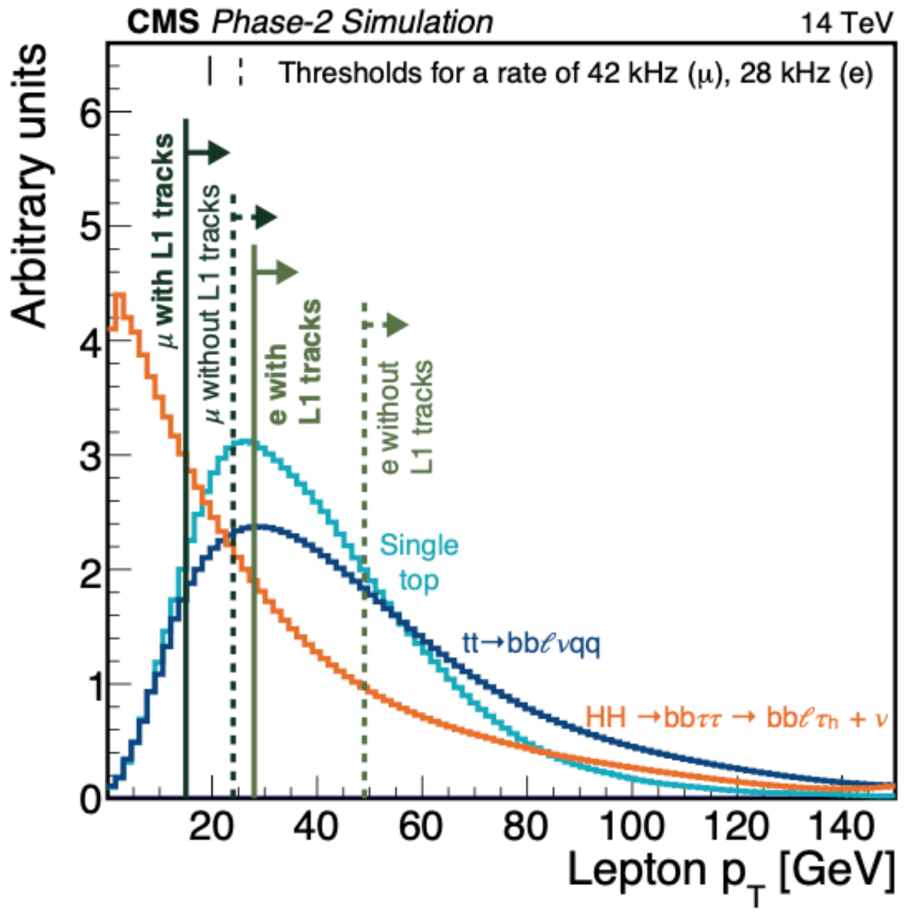
CMS Phase-II at VINS

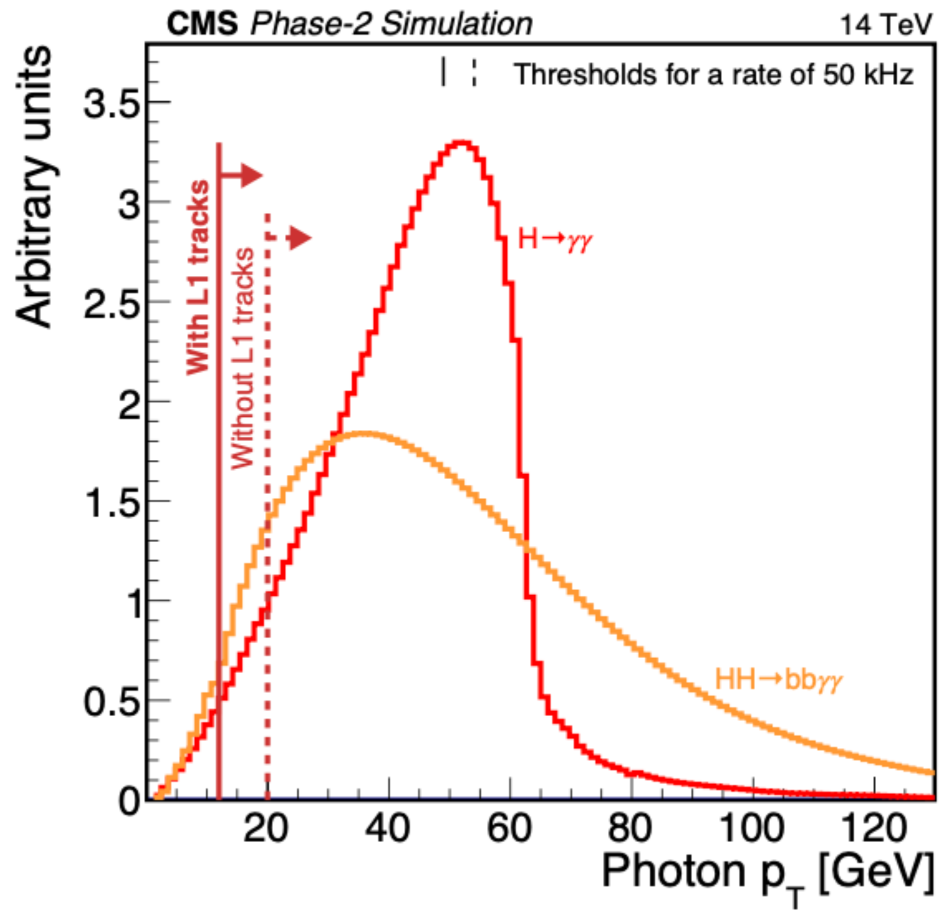
Level-1 Trigger Upgrade

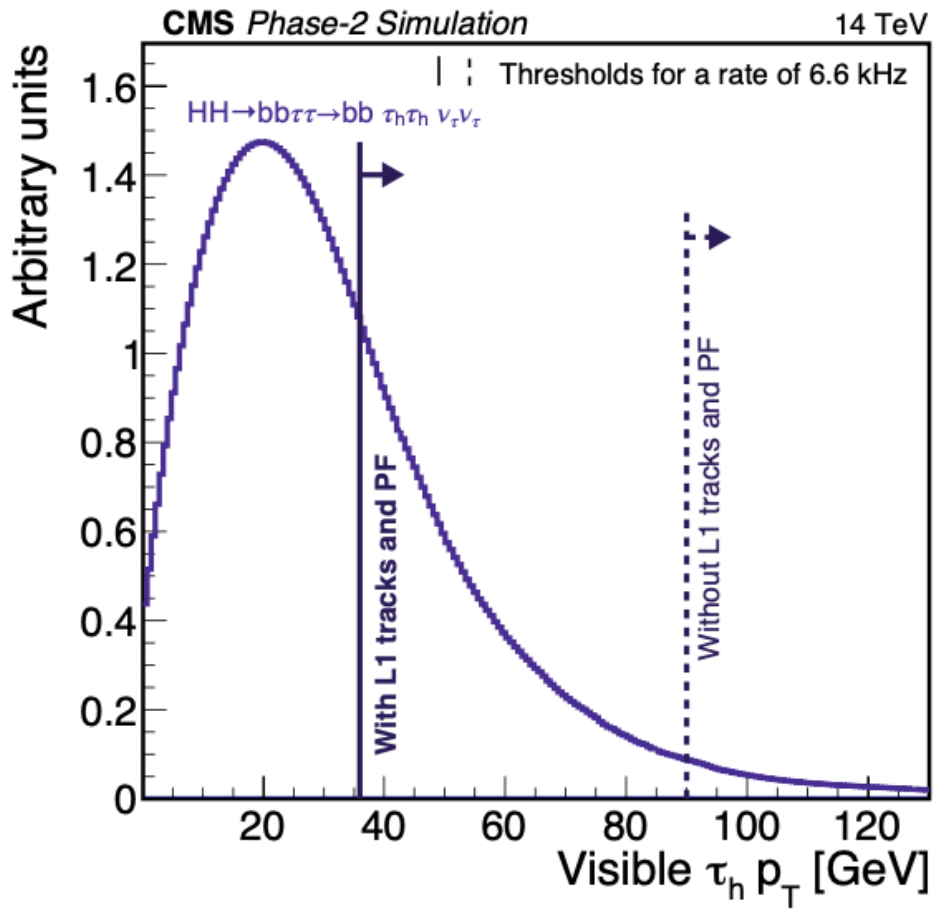
- **Physics Menu ,**
  - **Run 2 physics, with total Rate 350 Hz**
- **Retained object thresholds of Run1/2, made possible with use of Level-1 Tracker tracks in GMT, GCT, GTT, Correlator**

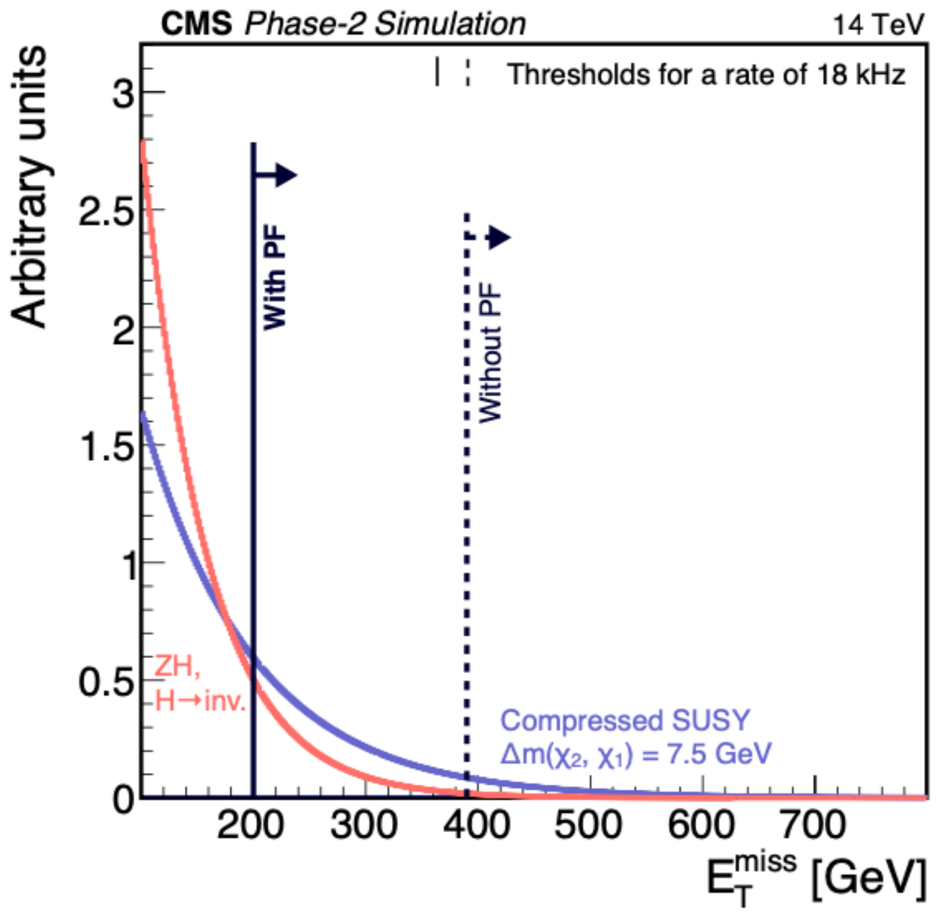
L1 Trigger seeds	Offline Threshold(s) at 90% or 95% (50%) [GeV]	Rate $\langle PU \rangle = 200$ [kHz]	Additional Requirement(s) [cm, GeV]	Objects plateau efficiency [%]
Single/Double/Triple Lepton (electron, muon) seeds				
Single TkMuon	22	12	$\lvert\eta\rvert < 2.4$	95
Double TkMuon	15,7	1	$\lvert\eta\rvert < 2.4, \Delta z < 1$	95
Triple TkMuon	5,3,3	16	$\lvert\eta\rvert < 2.4, \Delta z < 1$	95
Single TkElectron	36	24	$\lvert\eta\rvert < 2.4$	93
Single TkIsoElectron	28	28	$\lvert\eta\rvert < 2.4$	93
TkIsoElectron-StaEG	22, 12	36	$\lvert\eta\rvert < 2.4$	93, 99
Double TkElectron	25, 12	4	$\lvert\eta\rvert < 2.4$	93
Single StaEG	51	25	$\lvert\eta\rvert < 2.4$	99
Double StaEG	37,24	5	$\lvert\eta\rvert < 2.4$	99
Photon seeds				
Single TkIsoPhoton	36	43	$\lvert\eta\rvert < 2.4$	97
Double TkIsoPhoton	22, 12	50	$\lvert\eta\rvert < 2.4$	97
Taus seeds				
Single CaloTau	150(119)	21	$\lvert\eta\rvert < 2.1$	99
Double CaloTau	90,90(69,69)	25	$\lvert\eta\rvert < 2.1, \Delta R > 0.5$	99
Double PuppiTau	52,52(36,36)	7	$\lvert\eta\rvert < 2.1, \Delta R > 0.5$	90
Hadronic seeds (jets,H_T)				
Single PuppiJet	180	70	$\lvert\eta\rvert < 2.4$	100
Double PuppiJet	112,112	71	$\lvert\eta\rvert < 2.4, \Delta\eta < 1.6$	100
PuppiH_T	450(377)	11	jets: $\lvert\eta\rvert < 2.4, p_T > 30$	100
QuadPuppiJets-PuppiH_T	70,55,40,40,400(328)	9	jets: $\lvert\eta\rvert < 2.4, p_T > 30$	100,100
E_T^{miss} seeds				
PuppiE_T^{miss}	200(128)	18		100
Cross Lepton seeds				
TkMuon-TkIsoElectron	7,20	1	$\lvert\eta\rvert < 2.4, \Delta z < 1$	95, 93
TkMuon-TkElectron	7,23	3	$\lvert\eta\rvert < 2.4, \Delta z < 1$	95, 93
TkElectron-TkMuon	10,20	1	$\lvert\eta\rvert < 2.4, \Delta z < 1$	93, 95
TkMuon-DoubleTkElectron	6,17,17	0.1	$\lvert\eta\rvert < 2.4, \Delta z < 1$	95, 93
DoubleTkMuon-TkElectron	5,5,9	4	$\lvert\eta\rvert < 2.4, \Delta z < 1$	95, 93
PuppiTau-TkMuon	36(27),18	2	$\lvert\eta\rvert < 2.1, \Delta z < 1$	90, 95
TkIsoElectron-PuppiTau	22,39(29)	13	$\lvert\eta\rvert < 2.1, \Delta z < 1$ $\Delta R > 0.3$	93, 90

L1 Trigger seeds	Offline Threshold(s) at 90% or 95% (50%) [GeV]	Rate $\langle PU \rangle = 200$ [kHz]	Additional Requirement(s) [cm, GeV]	Objects plateau efficiency [%]
Cross Hadronic-Lepton seeds				
TkMuon-PuppiH_T	6,320(250)	4	$\lvert\eta\rvert < 2.4, \Delta z < 1$	95,100
TkMuon-DoublePuppiJet	12,40,40	10	$\lvert\eta\rvert < 2.4, \Delta R_{j\mu} < 0.4,$ $\Delta\eta_{jj} < 1.6, \Delta z < 1$	95,100
TkMuon-PuppiJet-PuppiE_T^{miss}	3,100,120(55)	14	$\lvert\eta\rvert < 1.5, \lvert\eta\rvert < 2.4,$ $\Delta z < 1$	95,100, 100
DoubleTkMuon-PuppiJet-PuppiE_T^{miss}	3,3,60,130(64)	4	$\lvert\eta\rvert < 2.4, \Delta z < 1$	95,100, 100
DoubleTkMuon-PuppiH_T	3,3,300(231)	2	$\lvert\eta\rvert < 2.4, \Delta z < 1$	95,100
DoubleTkElectron-PuppiH_T	10,10,400(328)	0.9	$\lvert\eta\rvert < 2.4, \Delta z < 1$	93,100
TkIsoElectron-PuppiH_T	26,190(124)	9	$\lvert\eta\rvert < 2.4, \Delta z < 1$	93,100
TkElectron-PuppiJet	28,40	34	$\lvert\eta\rvert < 2.1, \lvert\eta\rvert < 2.4,$ $\Delta R > 0.3, \Delta z < 1$	93,100
PuppiTau-PuppiE_T^{miss}	55(38),190(118)	4	$\lvert\eta\rvert < 2.1$	90,100
VBF seeds				
Double PuppiJets	160,35	40	$\lvert\eta\rvert < 5, m_{jj} > 620$	100
B-physics seeds				
Double TkMuon	2,2	12	$\lvert\eta\rvert < 1.5, \Delta R < 1.4,$ $q1 * q2 < 0, \Delta z < 1$	95
Double TkMuon	4,4	21	$\lvert\eta\rvert < 2.4, \Delta R < 1.2$ $q1 * q2 < 0, \Delta z < 1$	95
Double TkMuon	4.5,4	10	$\lvert\eta\rvert < 2.0, 7 < m_{\mu\mu} < 18,$ $q1 * q2 < 0, \Delta z < 1$	95
Triple TkMuon	5,3,2	7	$0 < m_{\mu5\mu3,q1*q2<0} < 9$ $\lvert\eta\rvert < 2.4, \Delta z < 1$	95
Triple TkMuon	5,3,2.5	6	$5 < m_{\mu5\mu2.5,q1*q2<0} < 17$ $\lvert\eta\rvert < 2.4, \Delta z < 1$	95
Rate for above Trigger seeds				346
Total Level-1 Menu Rate (+30%)				**450**



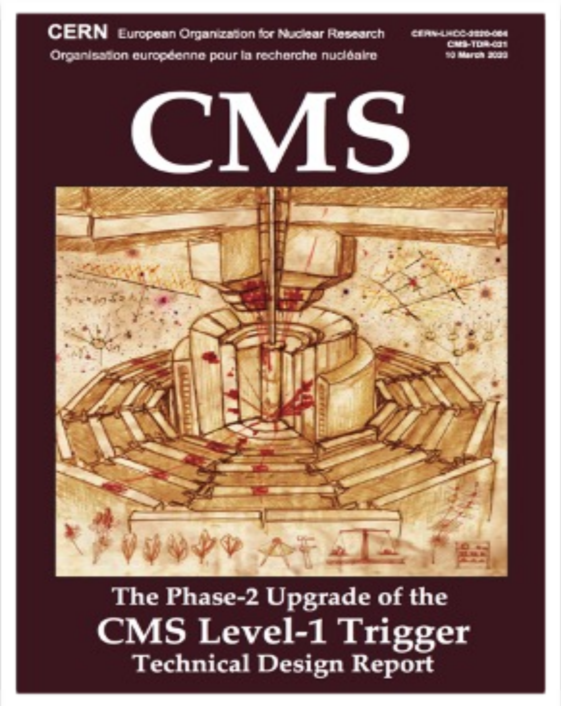




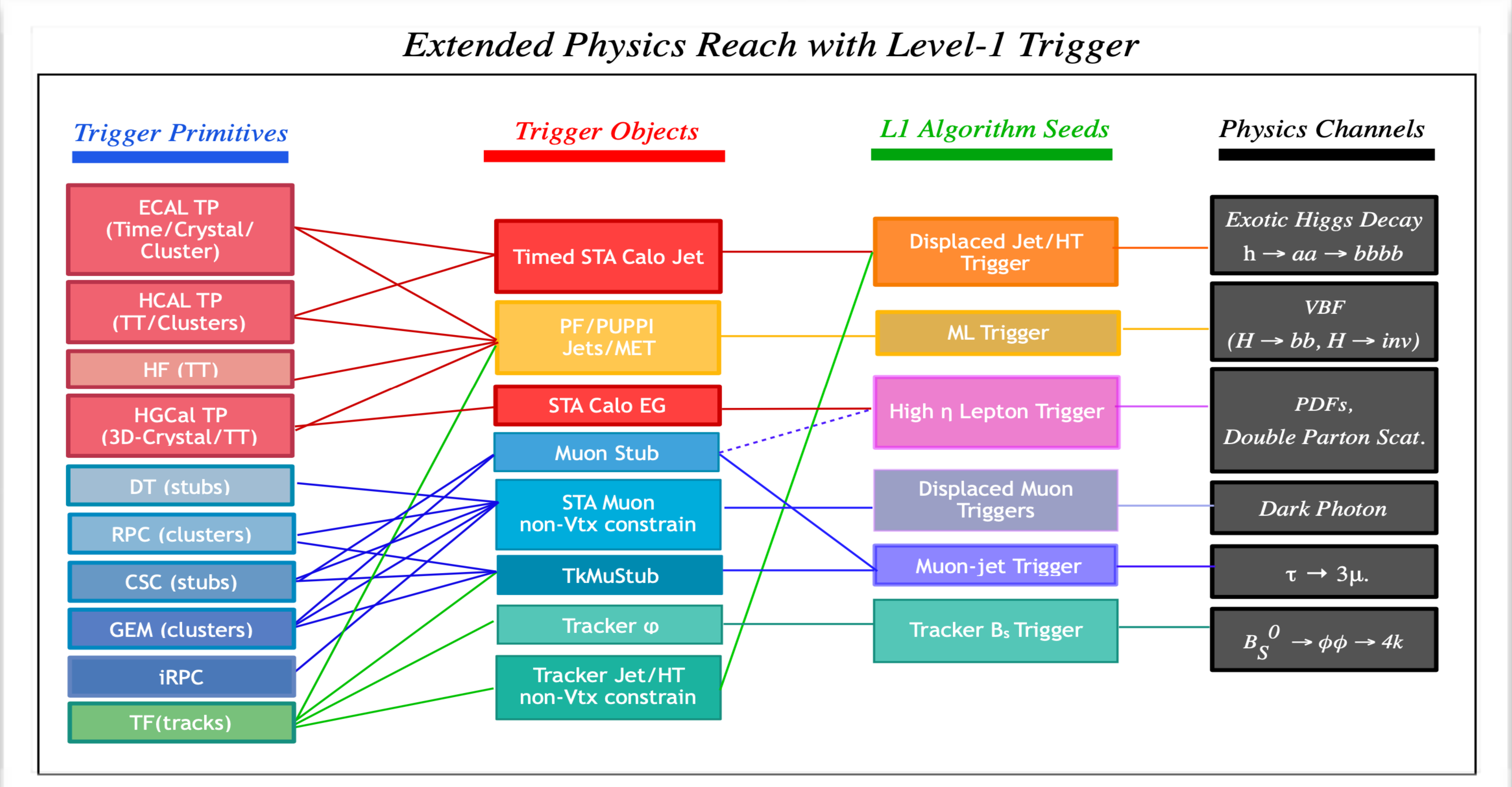


CMS Phase-II at VINS

Level-1 Trigger Upgrade



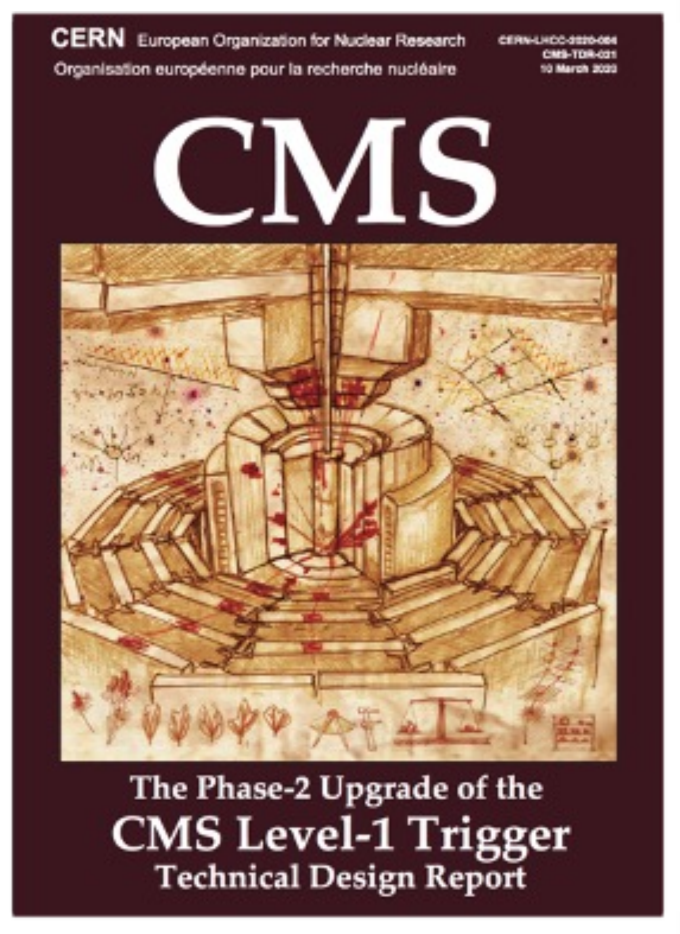
- “Phase II Upgrade of Level-1 Trigger TDR” authors
  - New Physics,

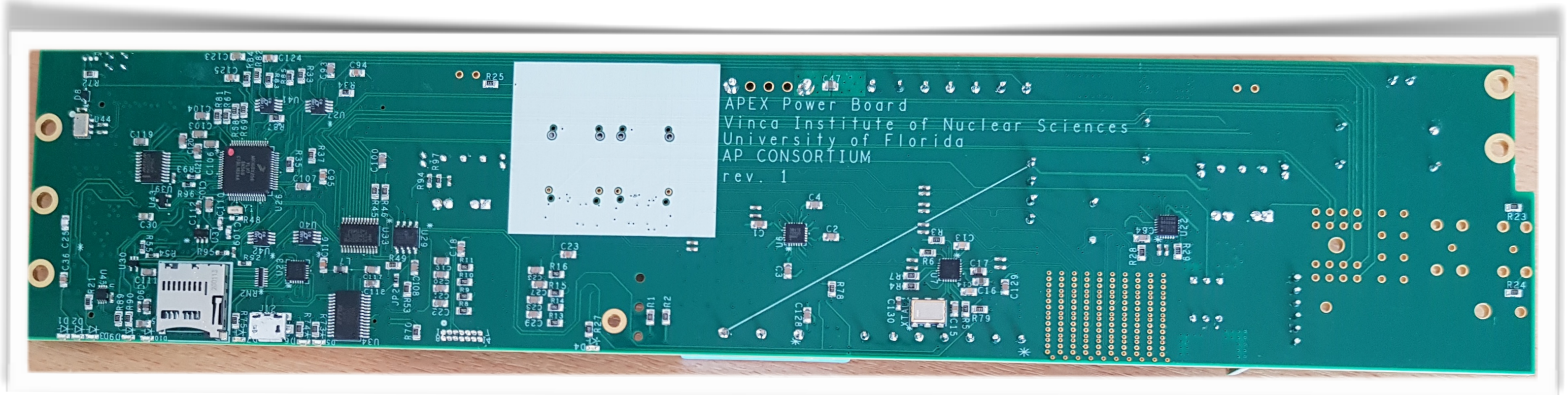


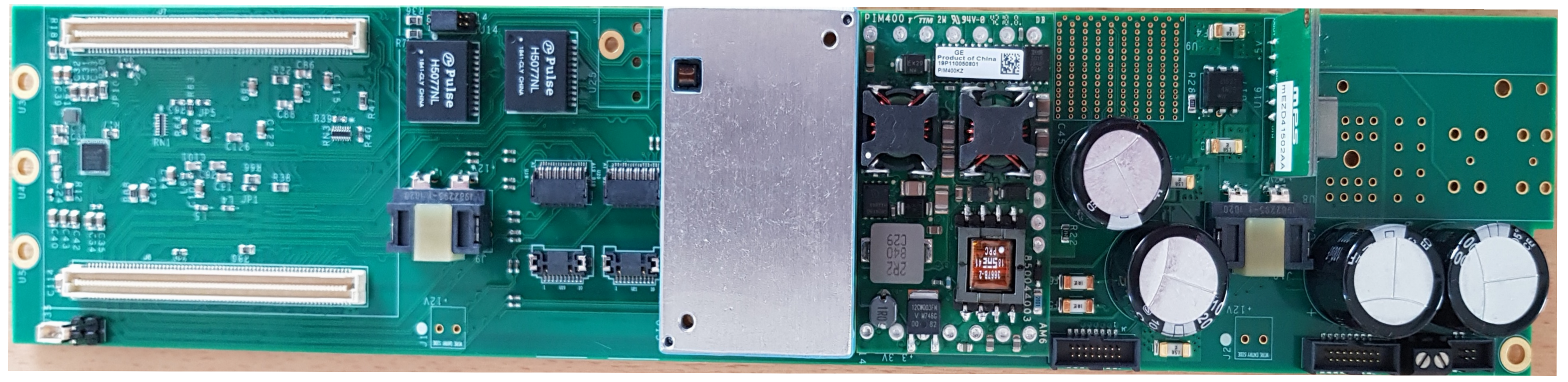
CMS Phase-II at VINS

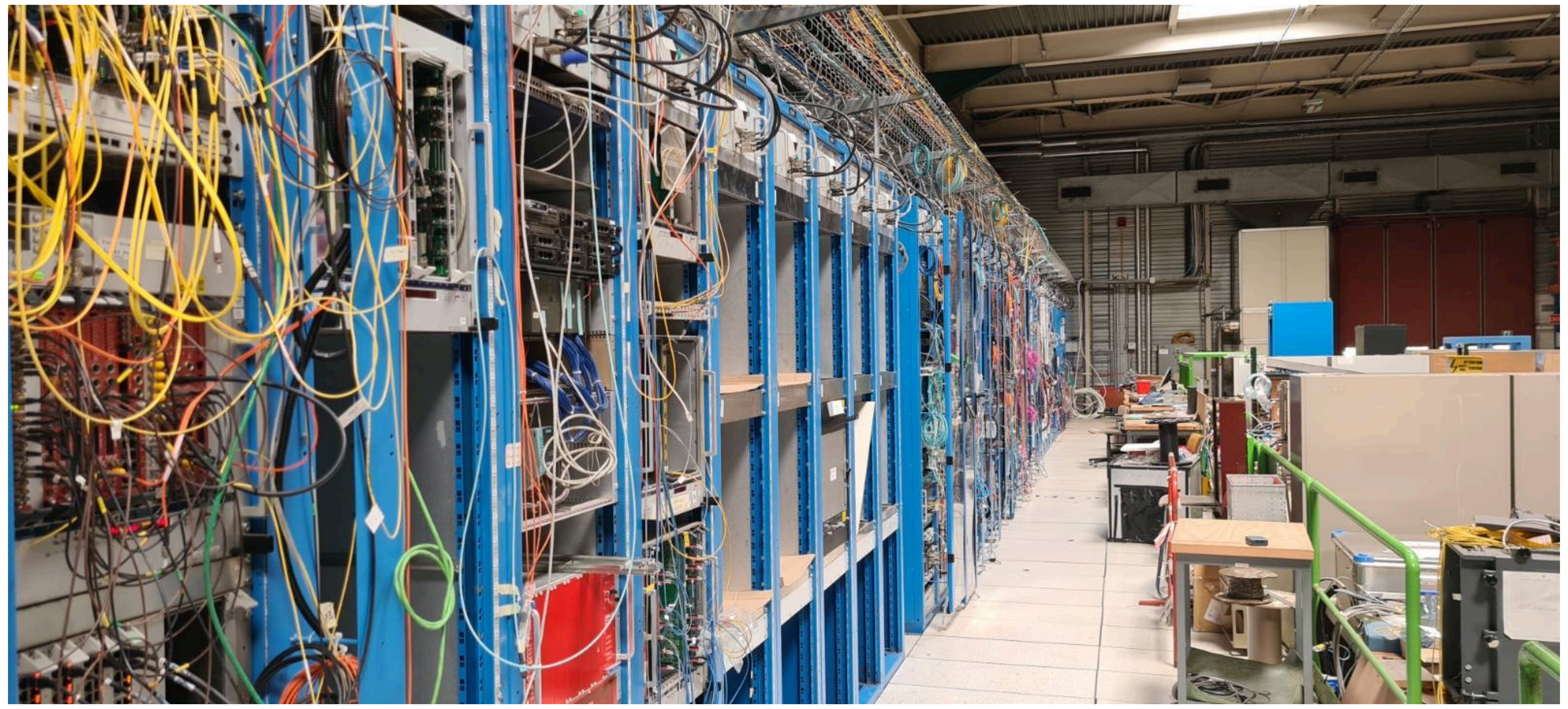
Level-1 Trigger Upgrade

- **Level-1 Trigger detector development:**
  - “Phase II Upgrade of Level-1 Trigger TDR” authors
    - Muon trigger, Menu, New Physics, b-2-b variations
    - Tau->3μ
- Pledge for **R&D** of **Muon Trigger** hardware (EndCap and Global Muon)
  - Prototyped **X2O Trigger boards** Power Module
    - Designed and assembled in Serbia
    - Part of slice test at b-904
  - Design X2O Dual Trigger board FPGA
  - X2O Consortium: Florida, UCLA, **Vinca**

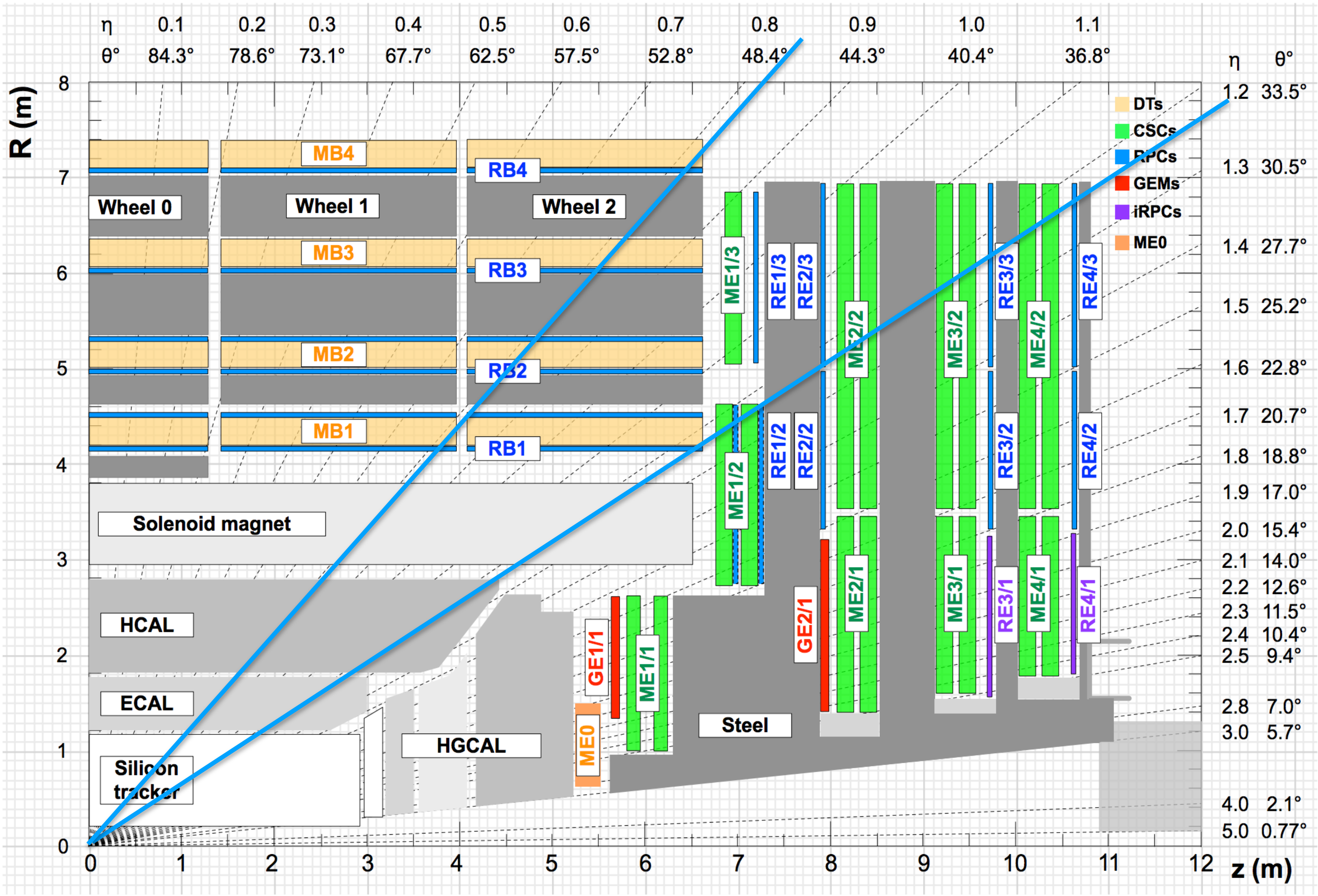






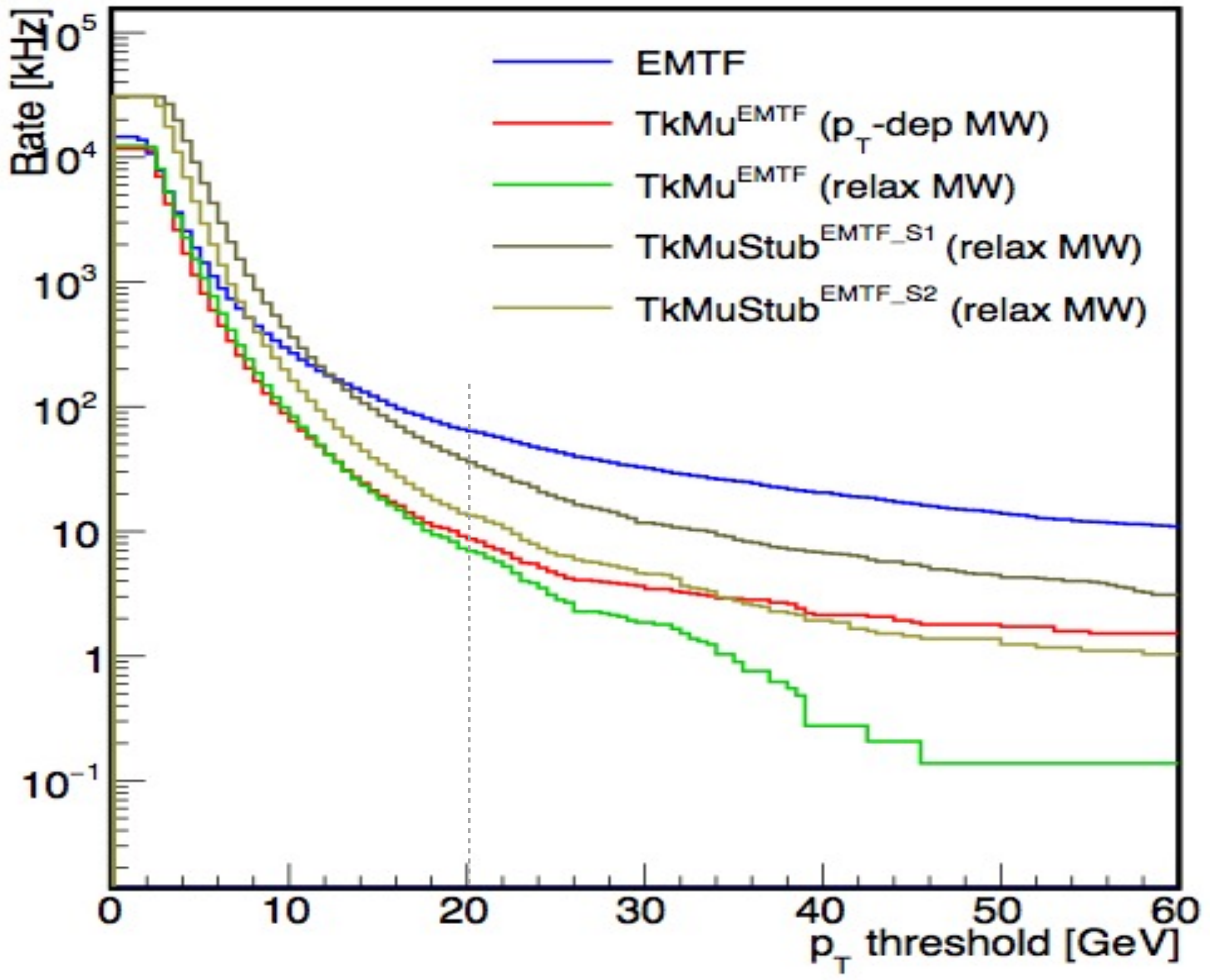


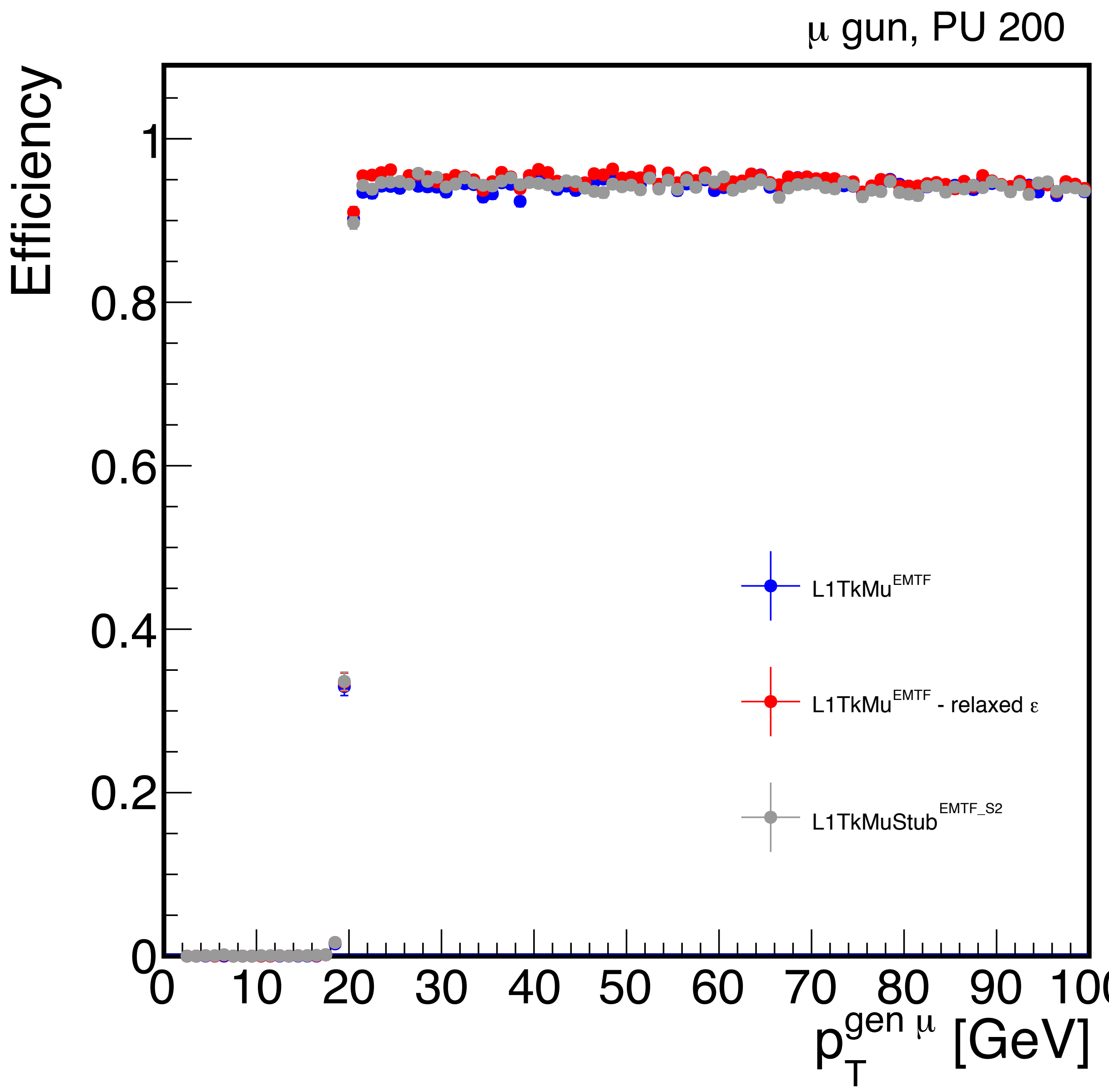
Phase-II Muon Level-1 Trigger in the EndCap

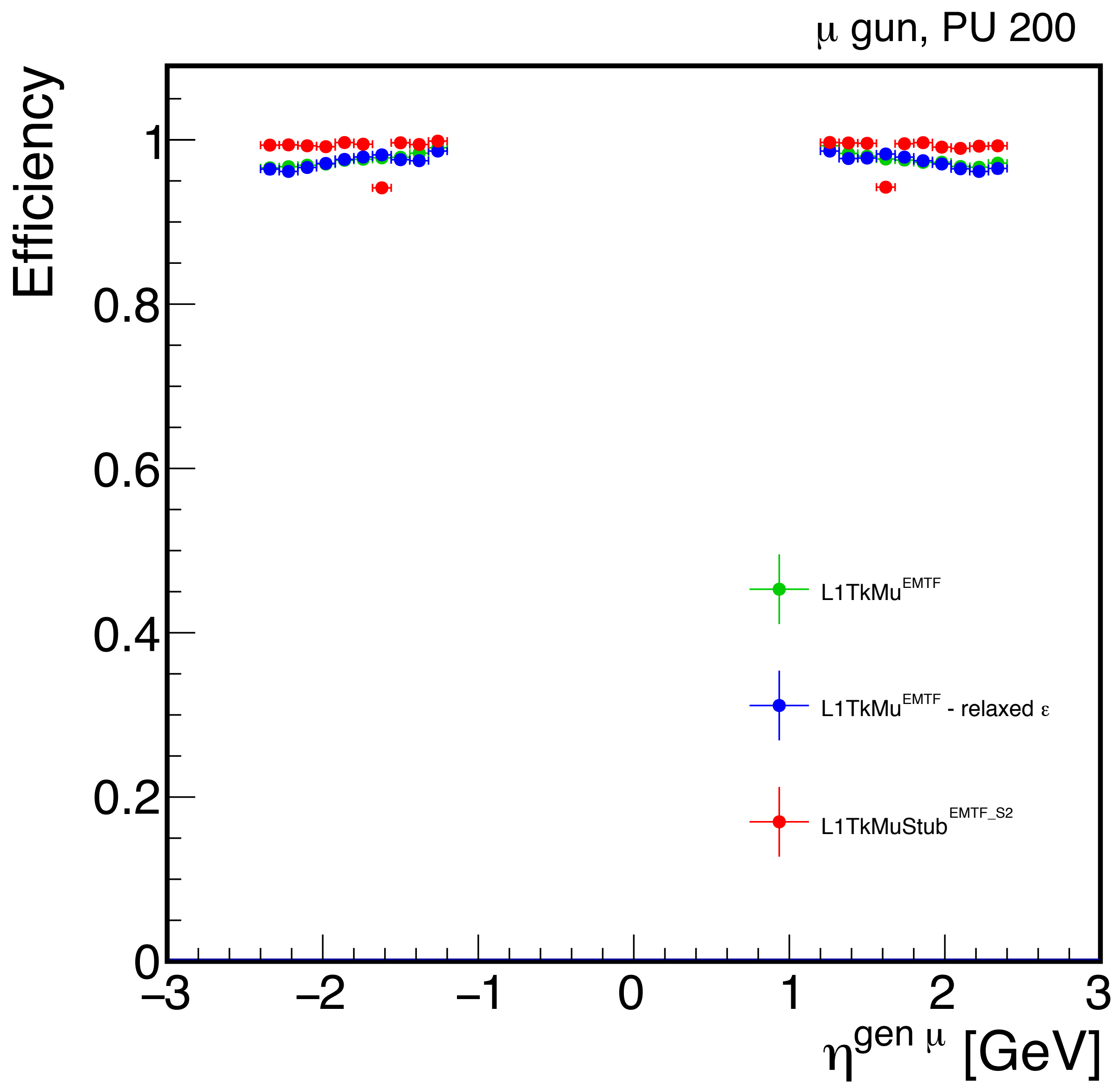


VINS Developed Tracker Track + μ Stub trigger

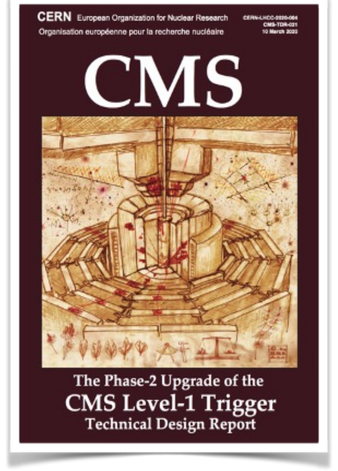
- 10 x reduced rate of standalone EndCap μ trigger





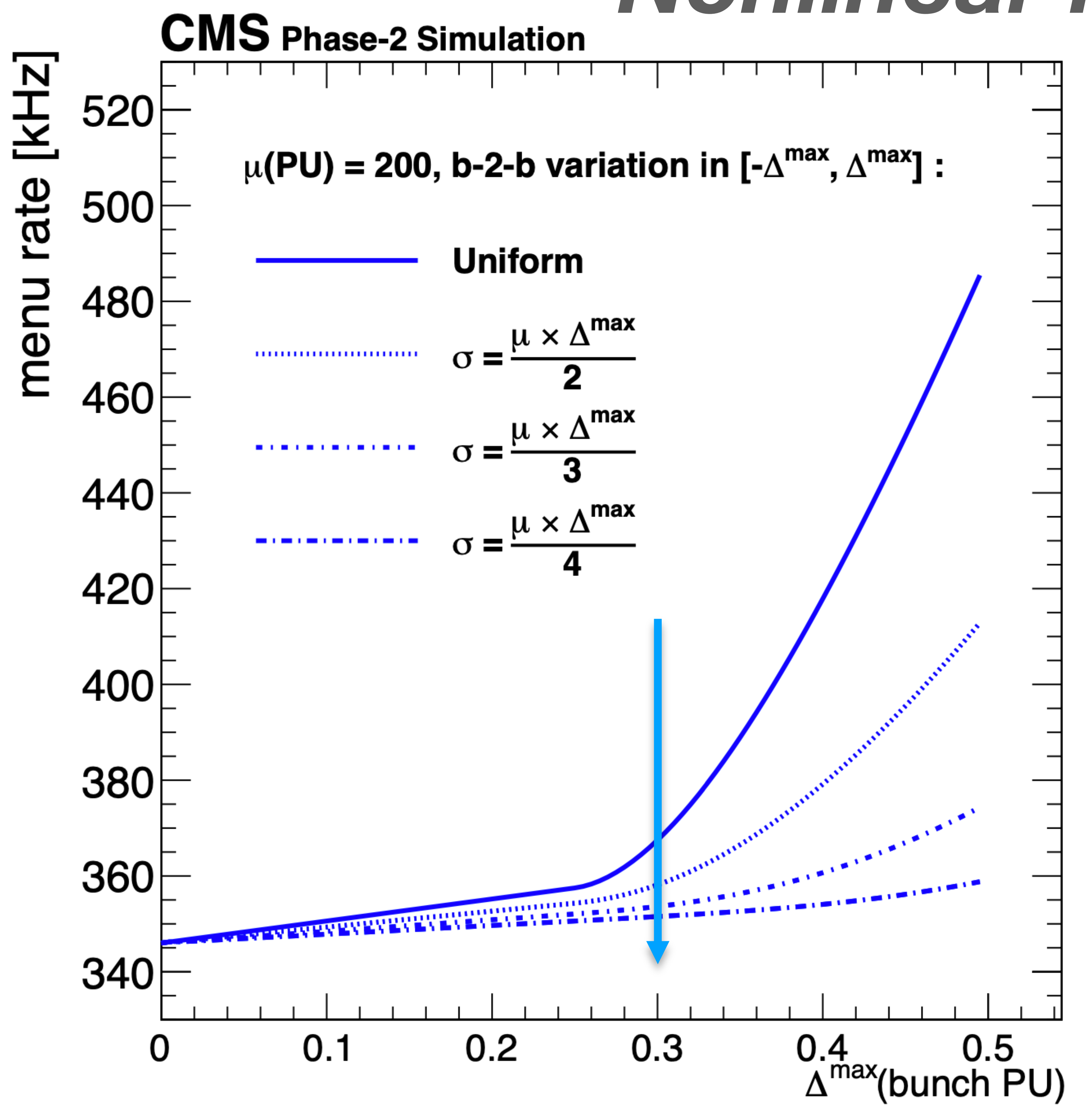


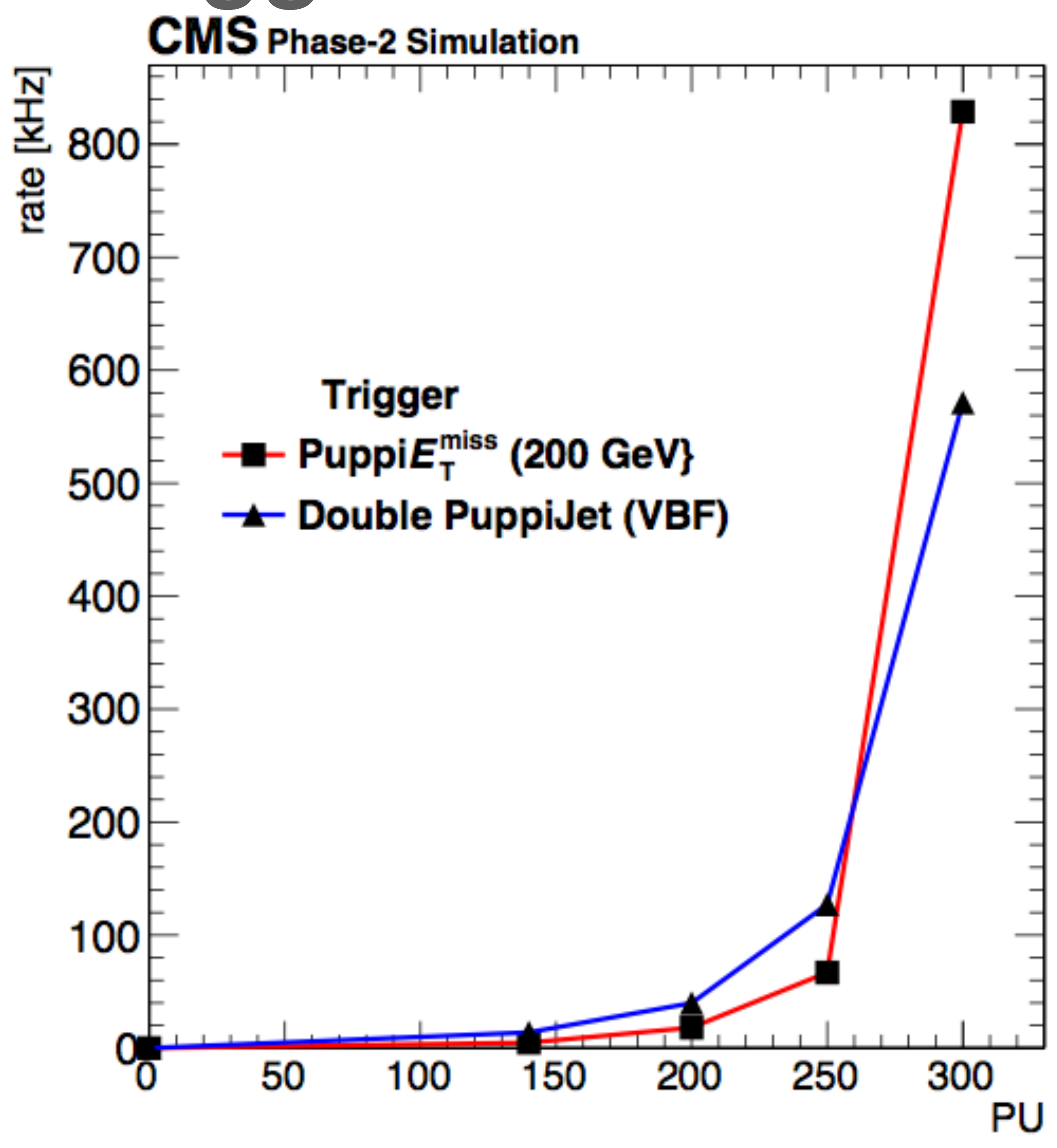
Rate stability with PU bunch to bunch variations



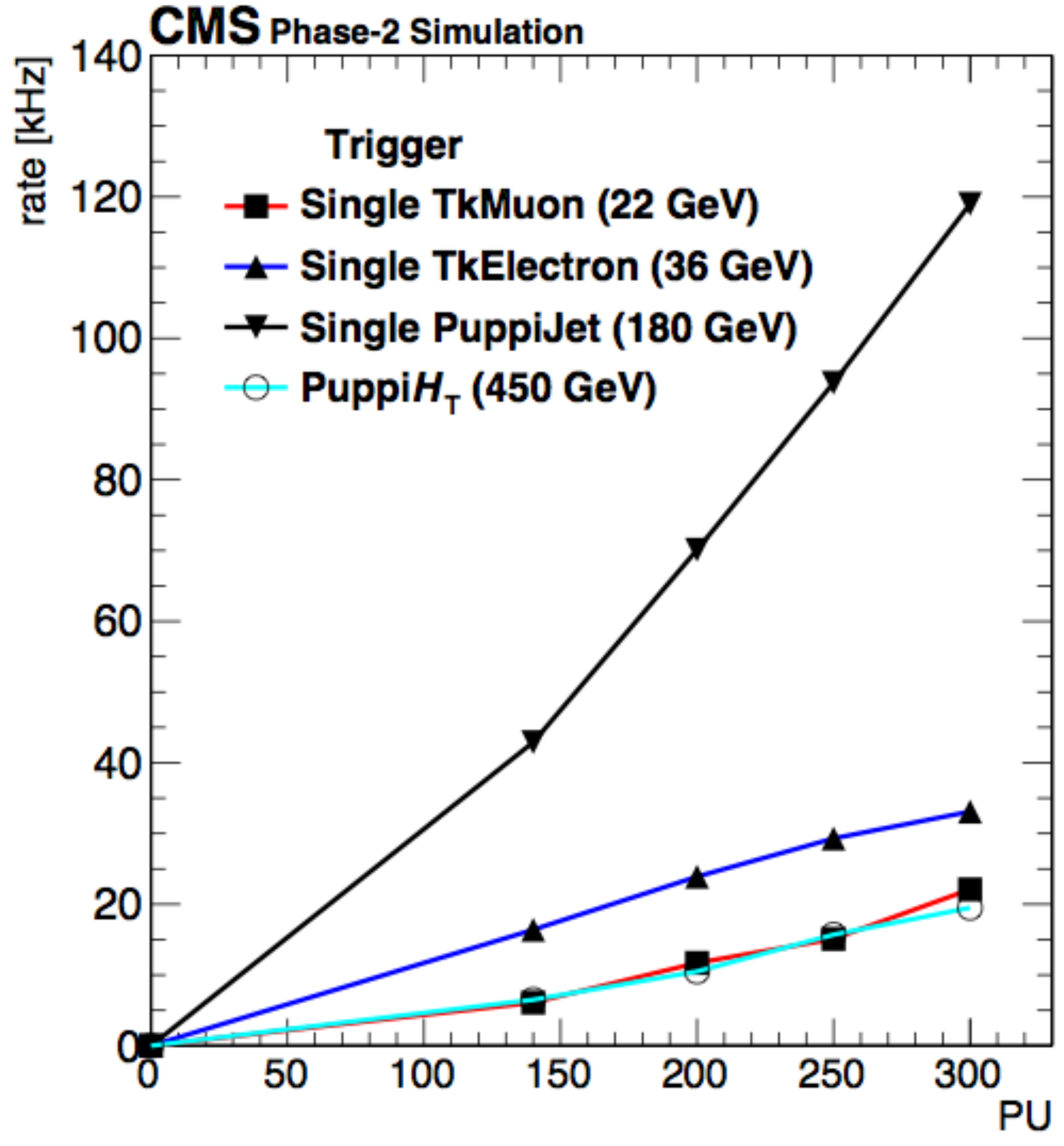
- L1 trigger rate of 347 kHz at <PU> = 200 is stable with PU bunch-to-bunch variation of about 25% and increases by ~10 kHz
  - even for the case of the most drastic (uniform) bunch-to-bunch PU variation

Nonlinear rate triggers





Linear rate triggers



Alternative MET triggers for extreme PU

MET triggers are extremely important

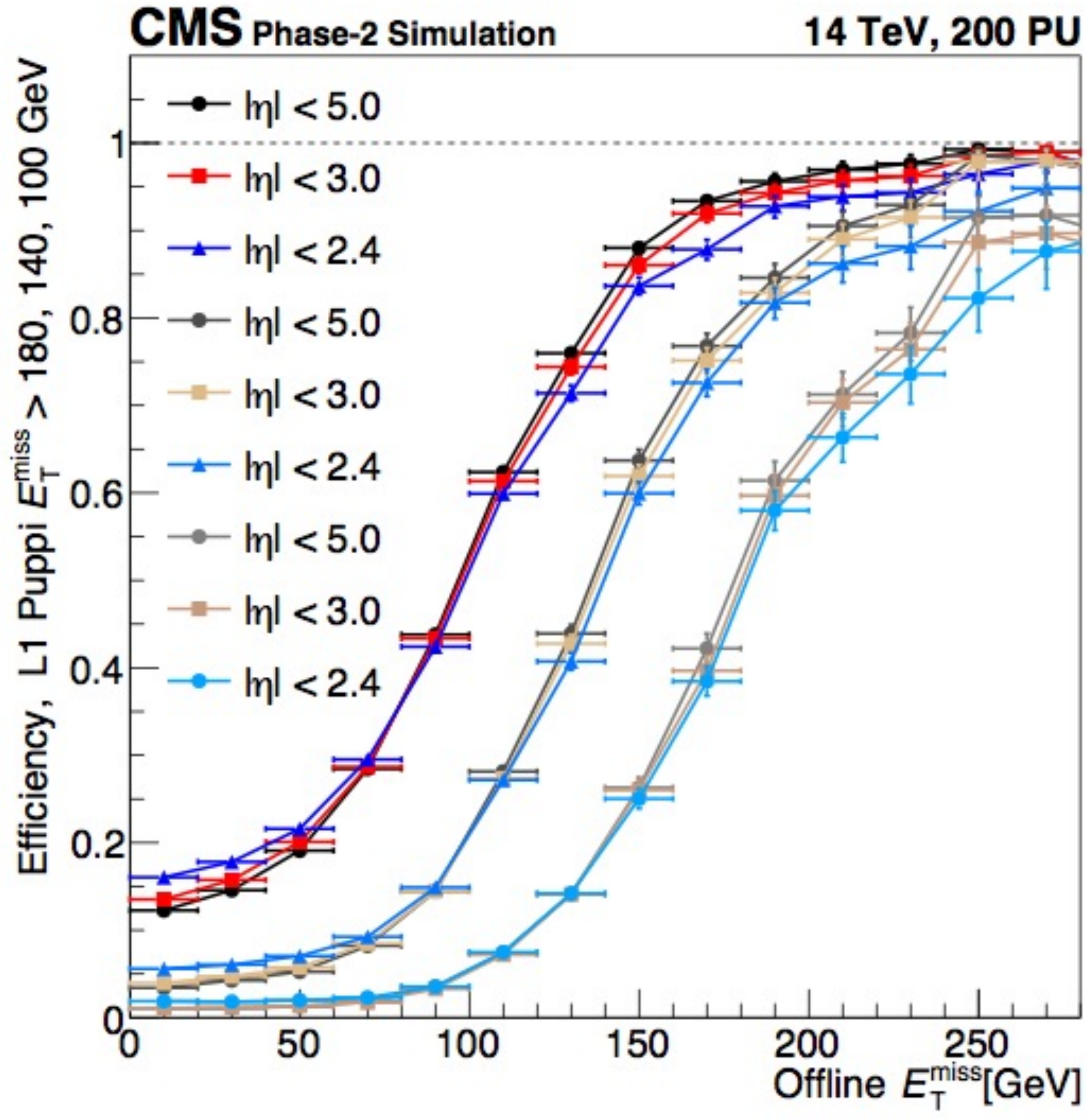
- Some BSM physics only accessible via these triggers
  - Problem at high rate: standard PuppiMET trigger rate explodes, 67 kHz @ PU 250, 830 kHz @ PU 300

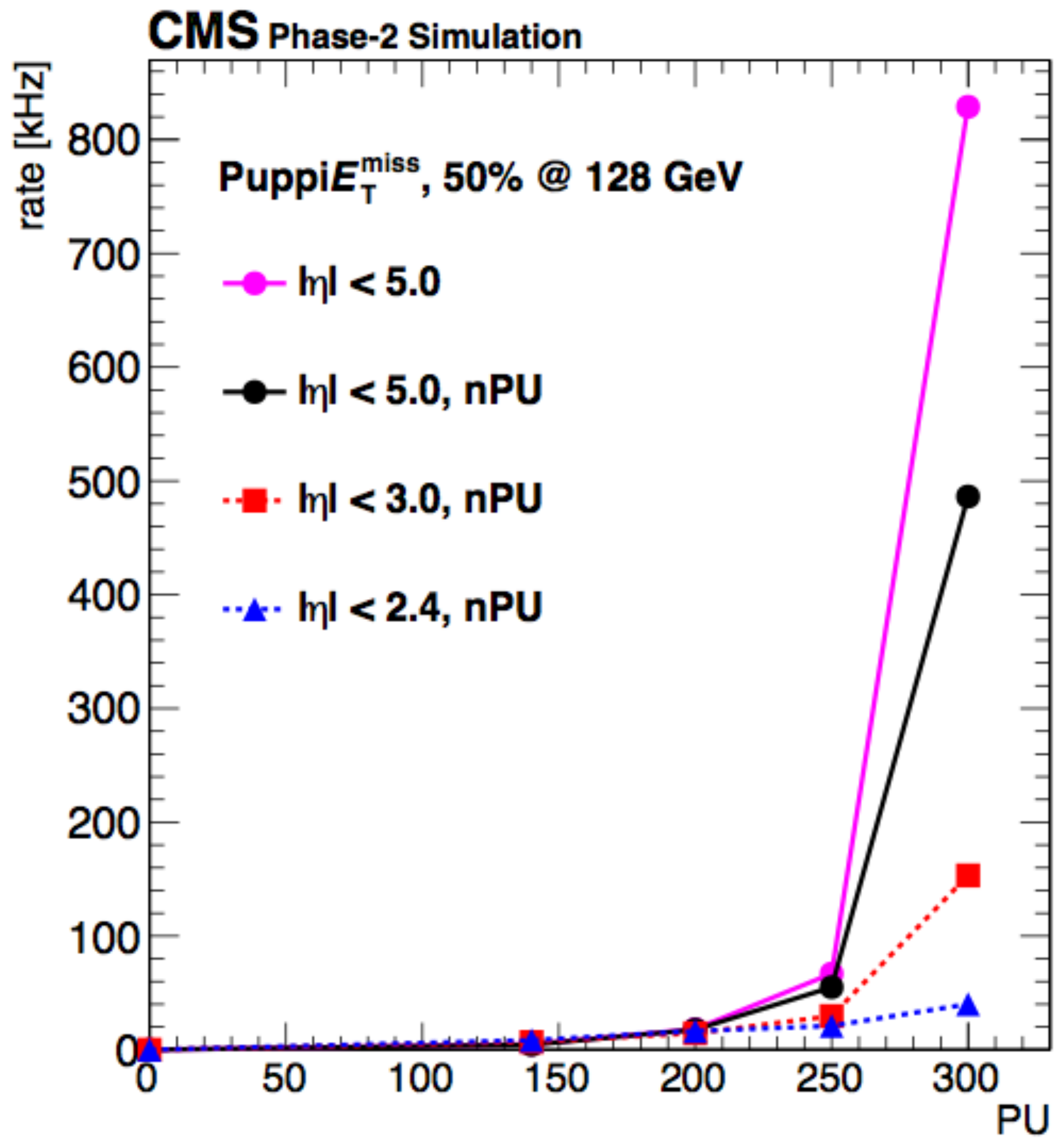
VINS Invented an improved PUPPI MET reconstruction algorithm which controls the rate at extrem PU (250, 300) while preserving efficiency

- Use event PU estimate as input to Puppi reconstruction, can be done from # vertices (GTT)

$$
\begin{aligned}
w_i &= \frac{1}{1+e^{-x_{\text{tot}}}} \\
x_{\text{tot}} &= x_\alpha + x_{p_\text{T}} - x_{\text{PU}} \\
x_\alpha &= \min(\max(c_\alpha \cdot (\alpha - \alpha^0), -x_\alpha^{\max}), +x_\alpha^{\max}) \\
x_{p_\text{T}} &= c_{p_\text{T}} \cdot (p_\text{T} - p_\text{T}^0) \\
x_{\text{PU}} &= \log(N_{\text{PU}}/200) + c_0.
\end{aligned}
$$

- Restricted in η to control rate in extreme PU

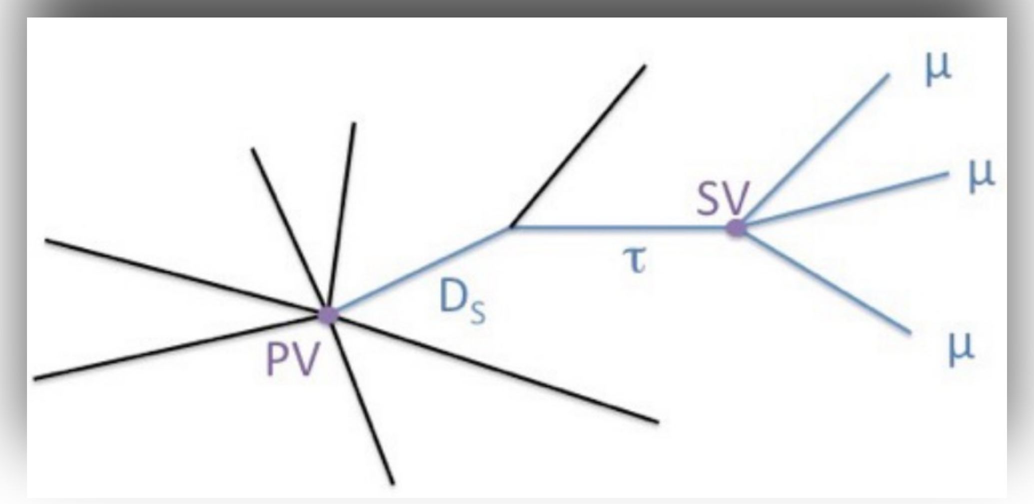


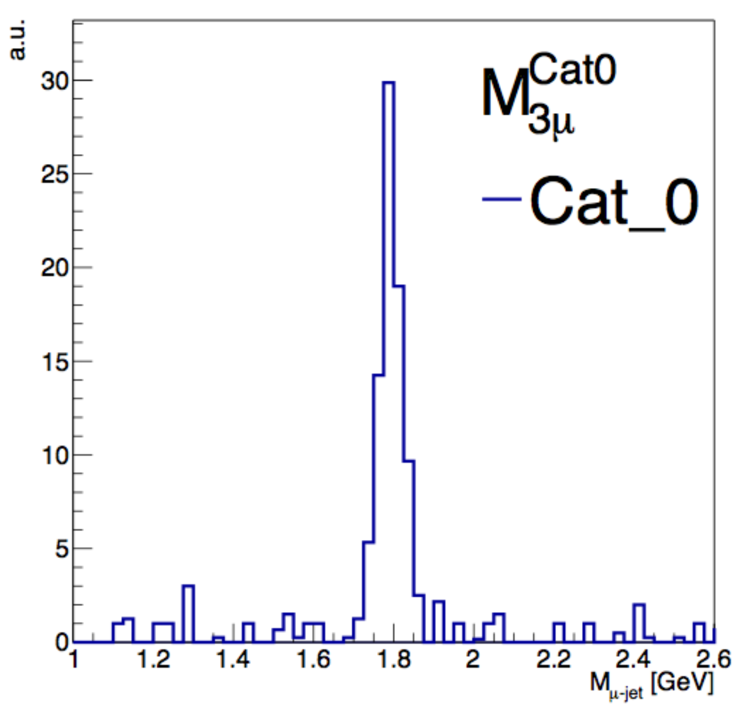


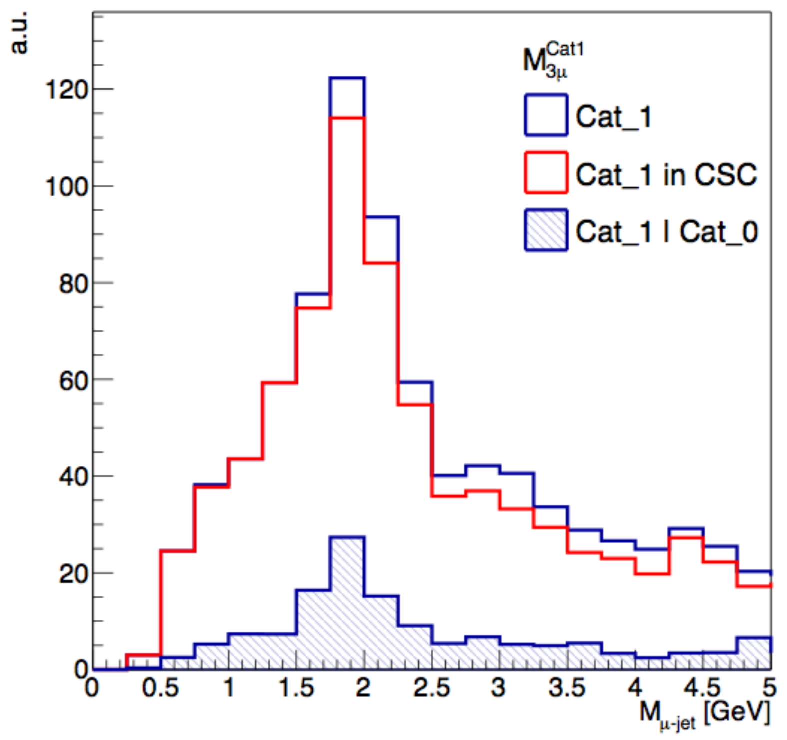
Phase-2 Trigger - Novel types of triggers in FPGAs

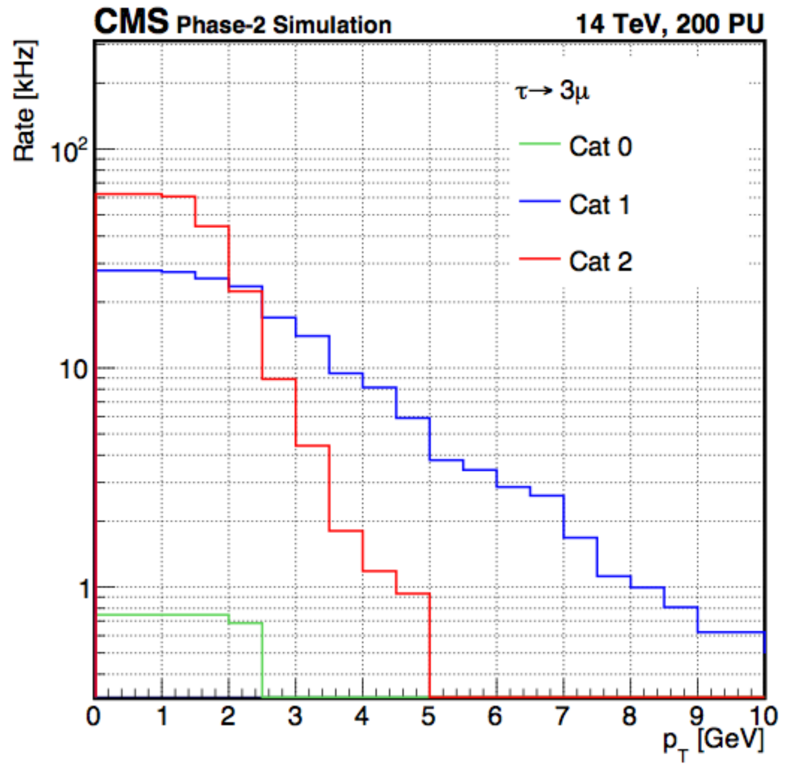
- Presence of Tracker Trigger Tracks allows for a more precise reconstruction
  - low mass resonances decaying to charged particles with an acceptable Level-1 trigger rate

LFV: Tau-> 3μ with L1 Muon Jets in GMT, predominantly in the EndCap









LFV: Tau-> 3μ with L1 Muon Jets (3 tracks, 2 tracks +1 stub, 2 stubs +1 track)

- L1 Muon Jets (2 stubs +1 track)
  - Very challenging due to large background
    - Develop new algorithms
    - Need to deploy machine learning

Algorithm to run on X2O board produced in Belgrade

ATCA Board with VU13P

Slide on Phase-II Level-1 Trigger Cards

4 flavors – all with same functionality, hosting VU13P FPGAs

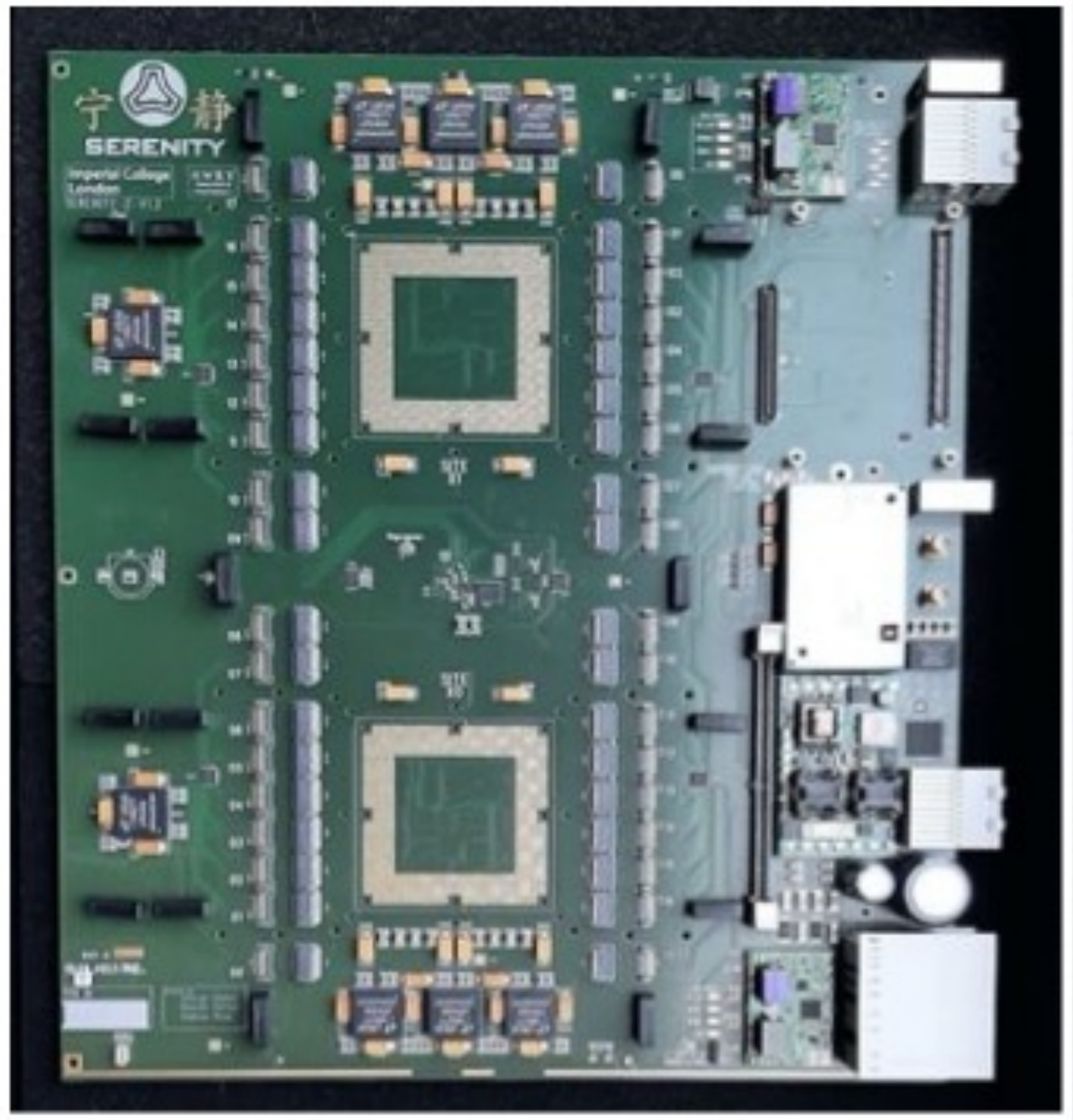
APx

U Winsconsin,
U. Virginia
U. Illinois
Notre Dame
etc

BMT

Ioannina

Serenity

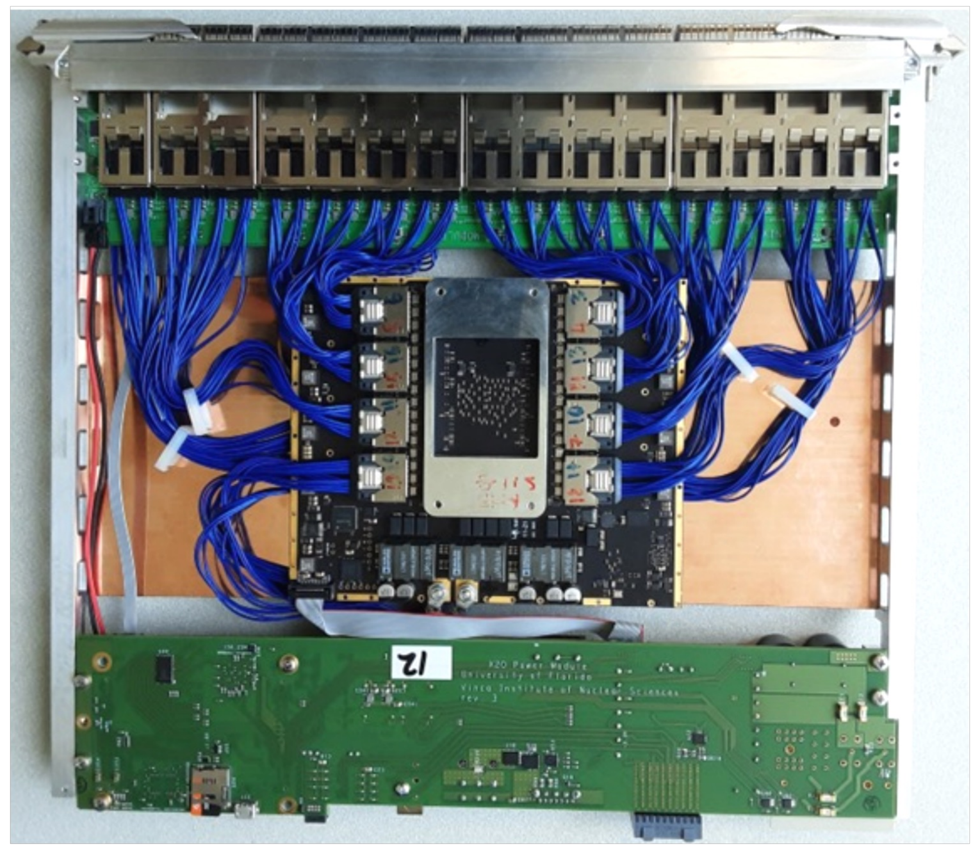


Imperial,
IHEP,
etc

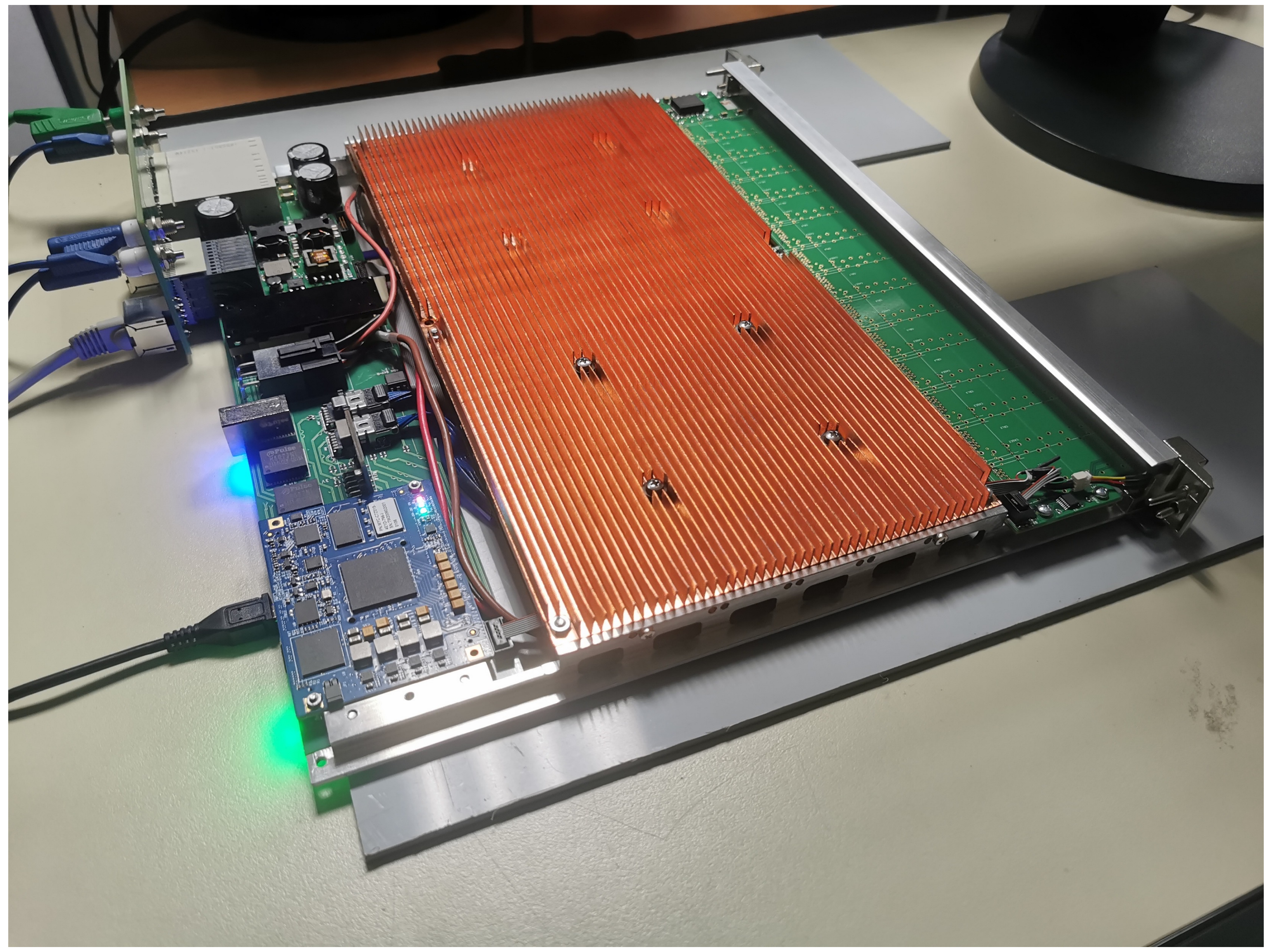
X2O

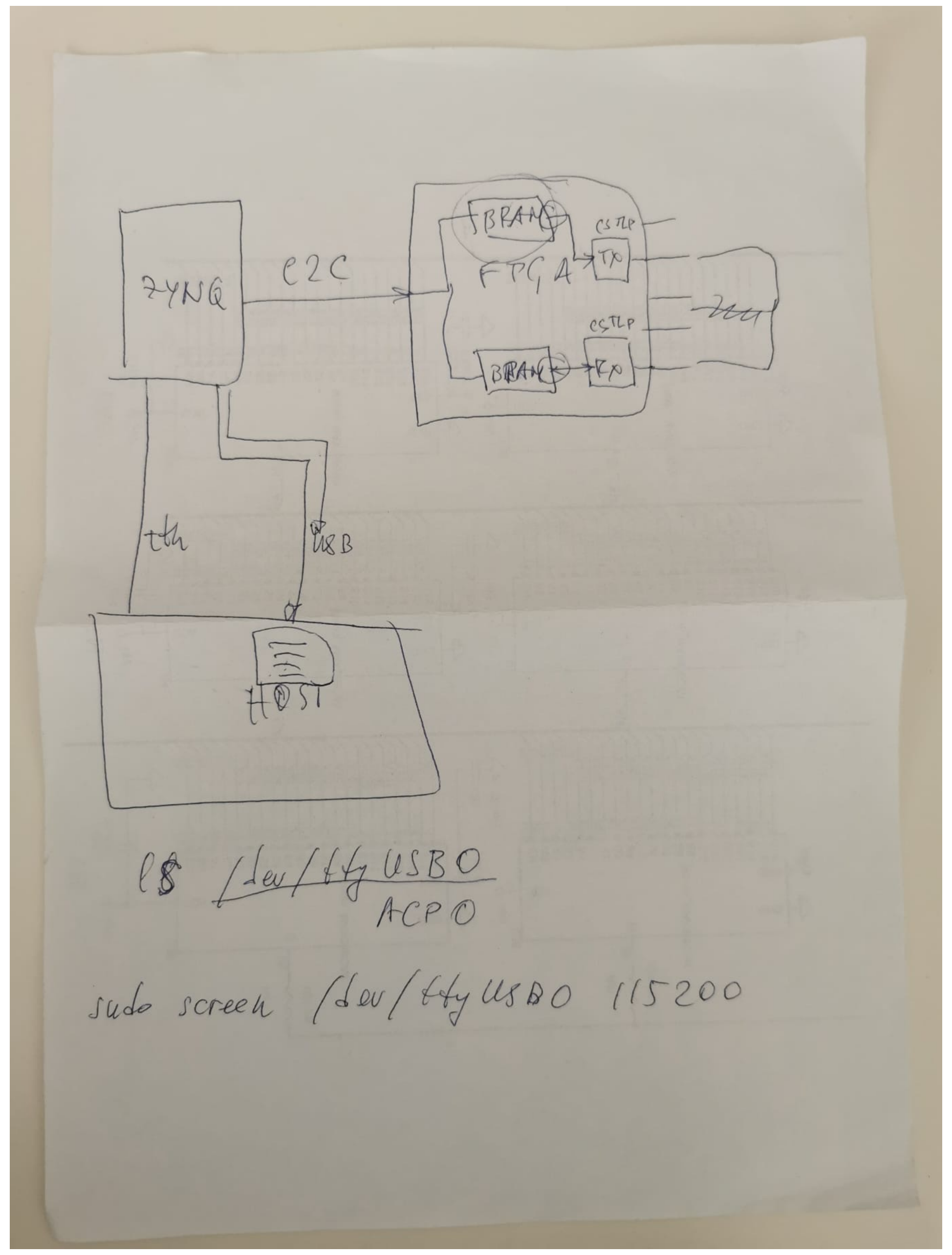
Vinca
U Florida
UCLA

Vinca test-stand at CERN with X2O



- Power Module produced in Belgrade“*Vinca Institute of Nuclea Sciences”*
- Testing CERN L1T Standard Protocol
- Developing firmware and emulation for reconstruction



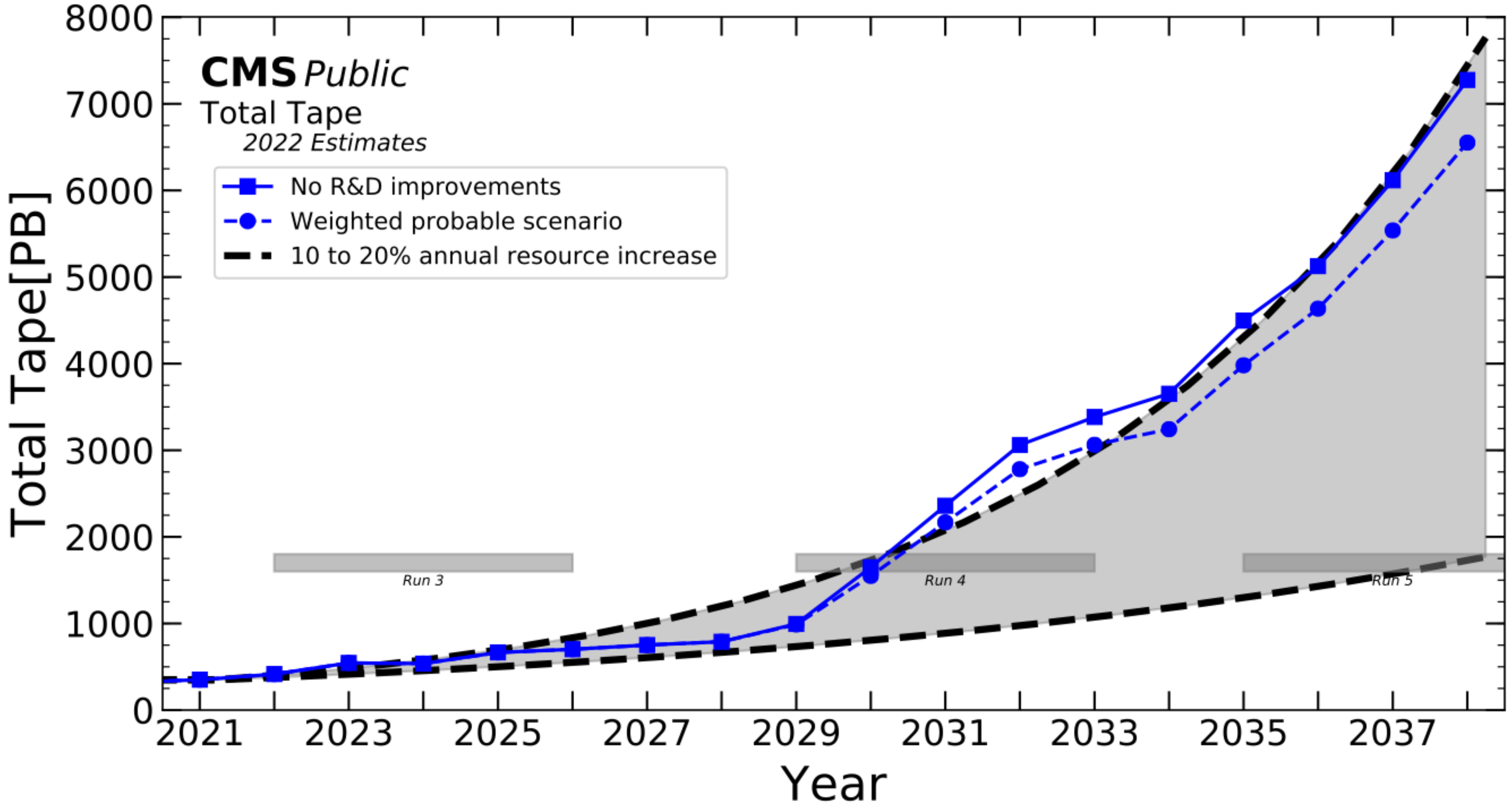


Lots of experience in CMS Core software and Trigger and Data Acquisition System

- In **Vinca** group over 15 years in R&D of CMS core software
- Heavy involvement in development of the CMS Computing model
    - HLT Legacy and Phase-1 and Phase-2 Upgrade
        - Design of OpenHLT framework, data streams (HLTMON), Smart prescales, HLT Seeding
    - Level-1 Trigger (Phase-1, Phase-2)
        - DataFormats , EventContent, Emulation workflows, MC, data reprocessing, code optimization and profiling

Need for R&D in (HL-) LHC computing

- Simple doubling of T1 resources would not suffice
- SSC-T1 would like to contribute in scientific R&D to provide improvements. Potential areas
  - Computing
    - CMSSW
    - ROOT
    - Alternative processors
  - Disc-Storage
    - CEPH for HEP storage
- VERY IMPORTANT aspect of the design is to create a platform so that scientist and students can contribute



December 2024 – Serbia & CERN sign MoU for Computing

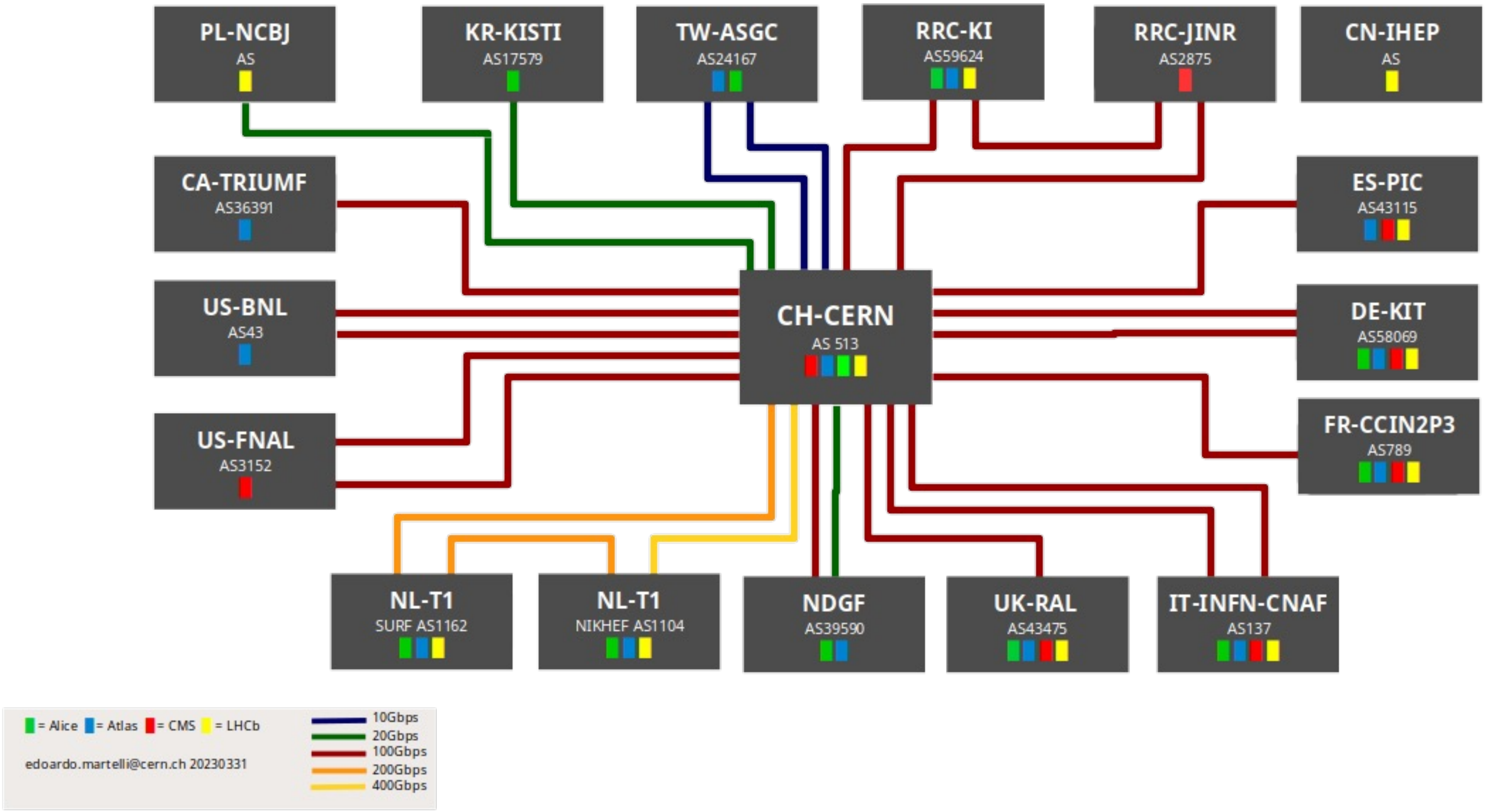
Serbia joins the Worldwide LHC Computing Grid

On 9 December, CERN and Serbia signed a Memorandum of Understanding (MoU) at the Serbian State Data Centre. The centre will become a Tier1 member of the Worldwide LHC Computing Grid (WLCG), the highest level of collaboration within the Grid

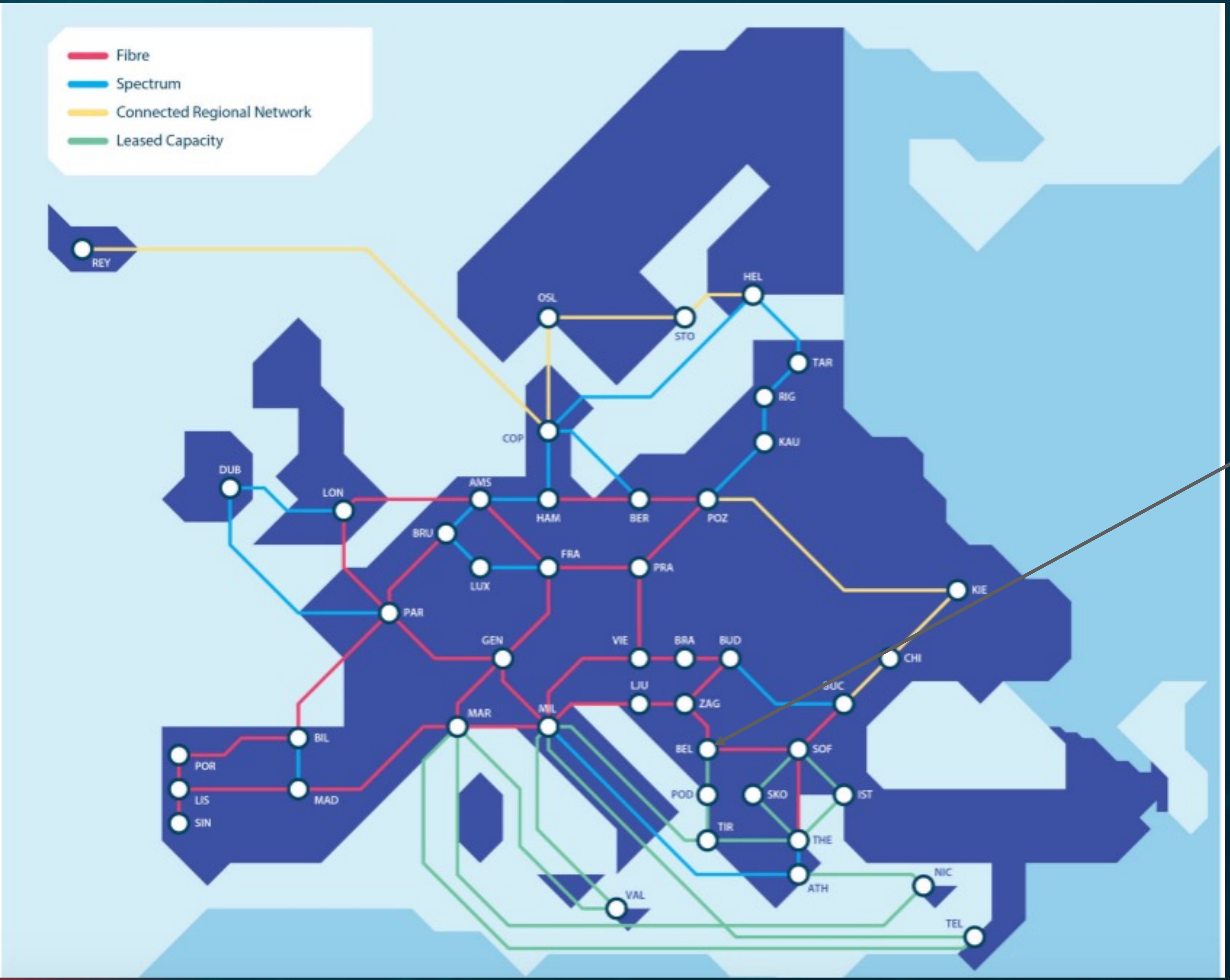
14 DECEMBER, 2023 | By Antonella Del Rosso

From left to right: Enrica Porcari, Head of CERN's IT department, Jelena Begović, Serbian Minister of Science, Technological Development and Innovation, and Mihailo Jovanović, Serbian Minister of Information and Telecommunications. (Image: Serbian Ministry of Information and Telecommunications)

LHC Optical Private Network - Topology



Serbia NETWORK connectivIty



Serbia well integrated in GEANT.

- collaboration of European National Research ar Education Networks (NRENs)
- Academic Network of Serbia (AMRES)

Connection to CERN good.

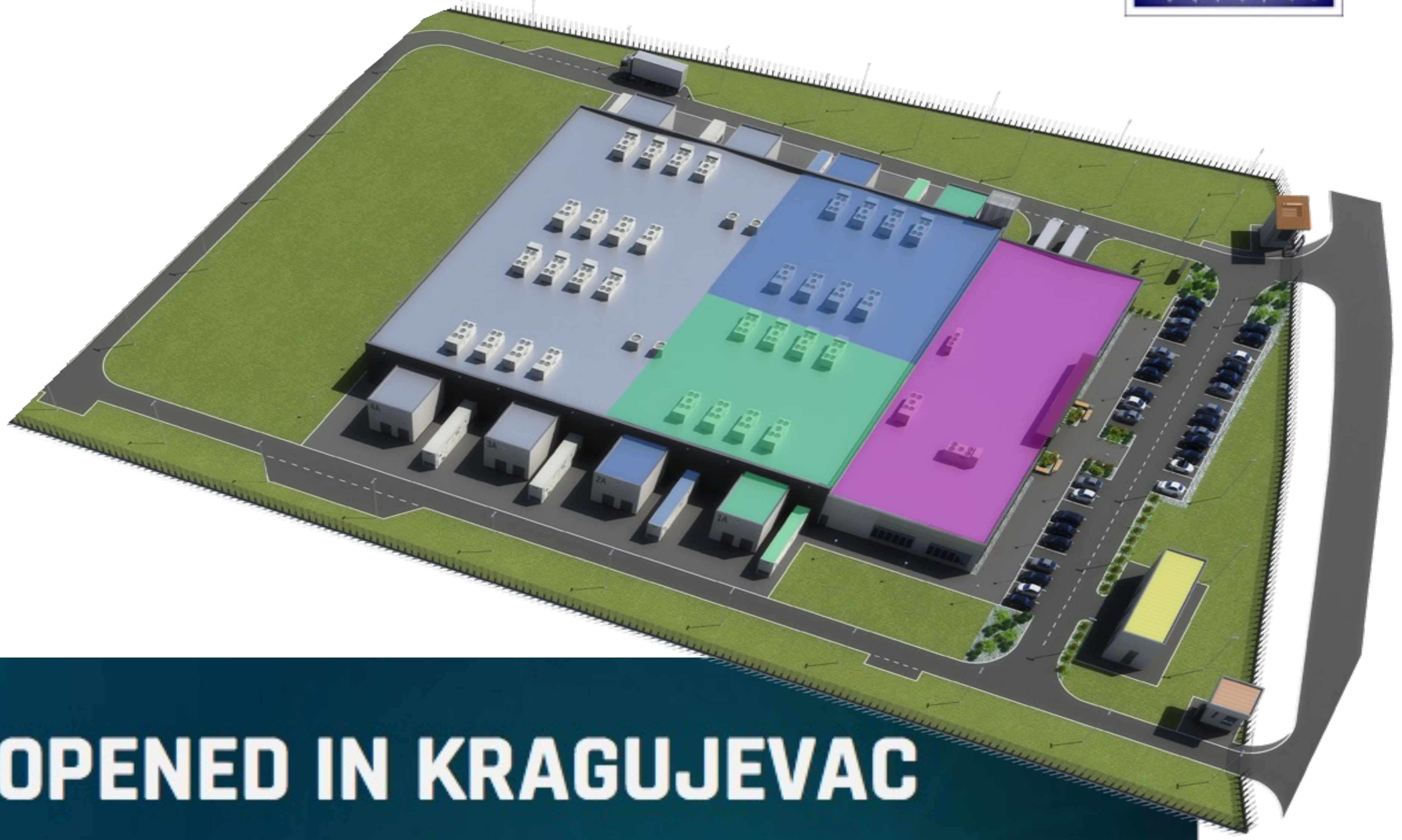
- Belgrade and DC connected to CERN via DarkFiber

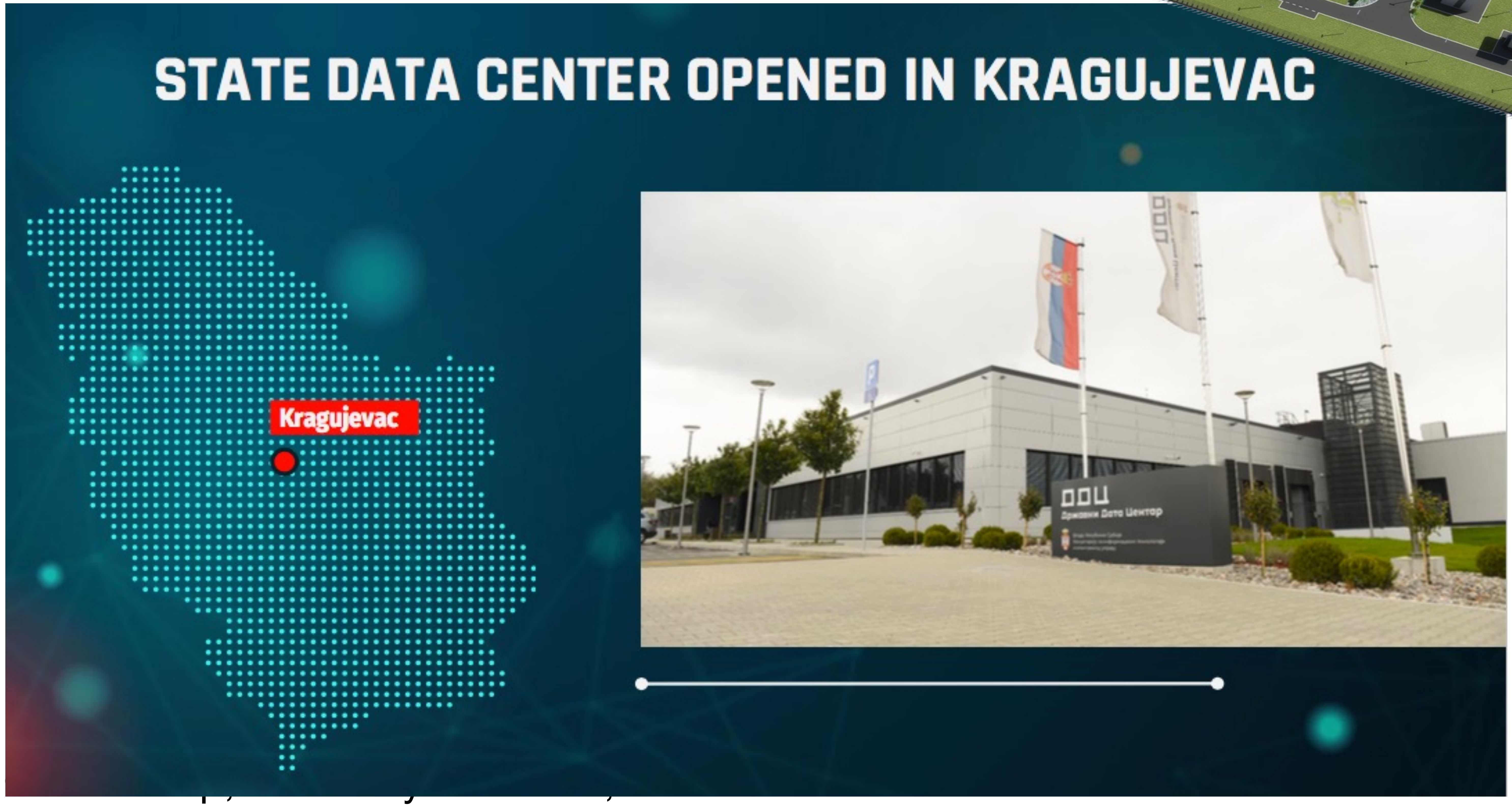
LHC-OPN (1 or few x 100 G GEANT via DarkFiber)

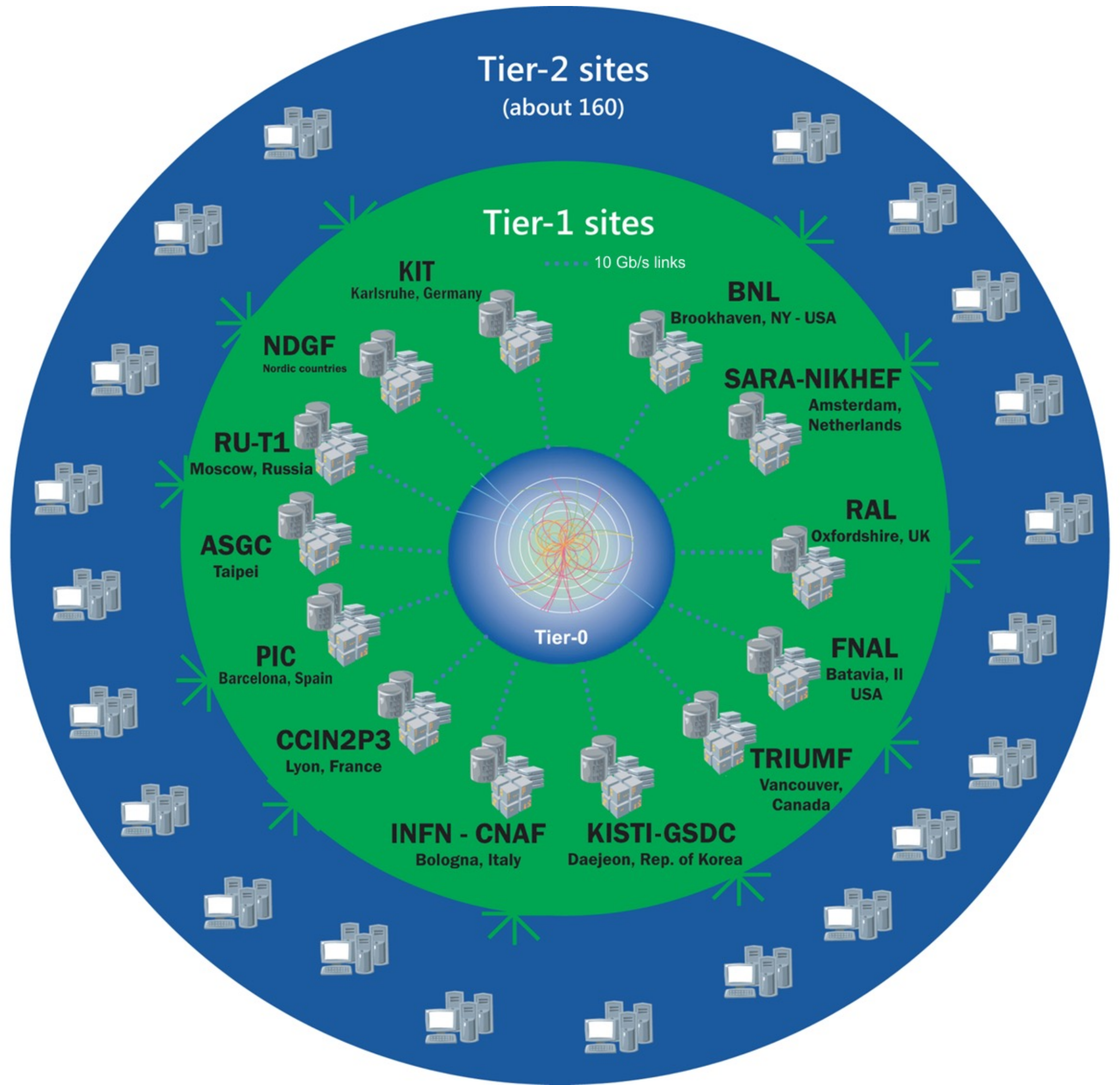
LHC-ONE (State TC, via DarkFiber Amsterdam,CERN)

State of the Art computing Data Center in Serbia

- CMS Tier-1 In Serbia
- Providing services satisfying conditions
  - Availability
  - Reliability
  - Maintainability
  - Connectivity







Vinca

Physics needs for Serbian Tier-1

Computing needs:
- 5 MB /s/ thread

Stage 1
- For 24 k threads,
  - 960 Mbps
  - X 2 core SW = 2 Tbps

Stage-2:
- 40 k threads
  - 1,900 Mbps
  - X 2 core SW – 4 Tbps

Disc Storage needs:
- 2-3 MB /s/TB (read/write limit)

Stage 1
- For storage of 20 PB,
  - 20 SU @ 1.2 PB
    - 20 x 100 G (100 G @ SU)
  - X 2 core SW = 40 x 100G

Stage-2:
- Disc storage of 40 PB
  - 40 x 100 G, X 2 SW = 80 x 100 G

Tape requirement :
- 10 Gbps / drive

Stage 1
- Tape library 30 PBs
  - 12 drives x 10 Gbps
  - x 2 core SW

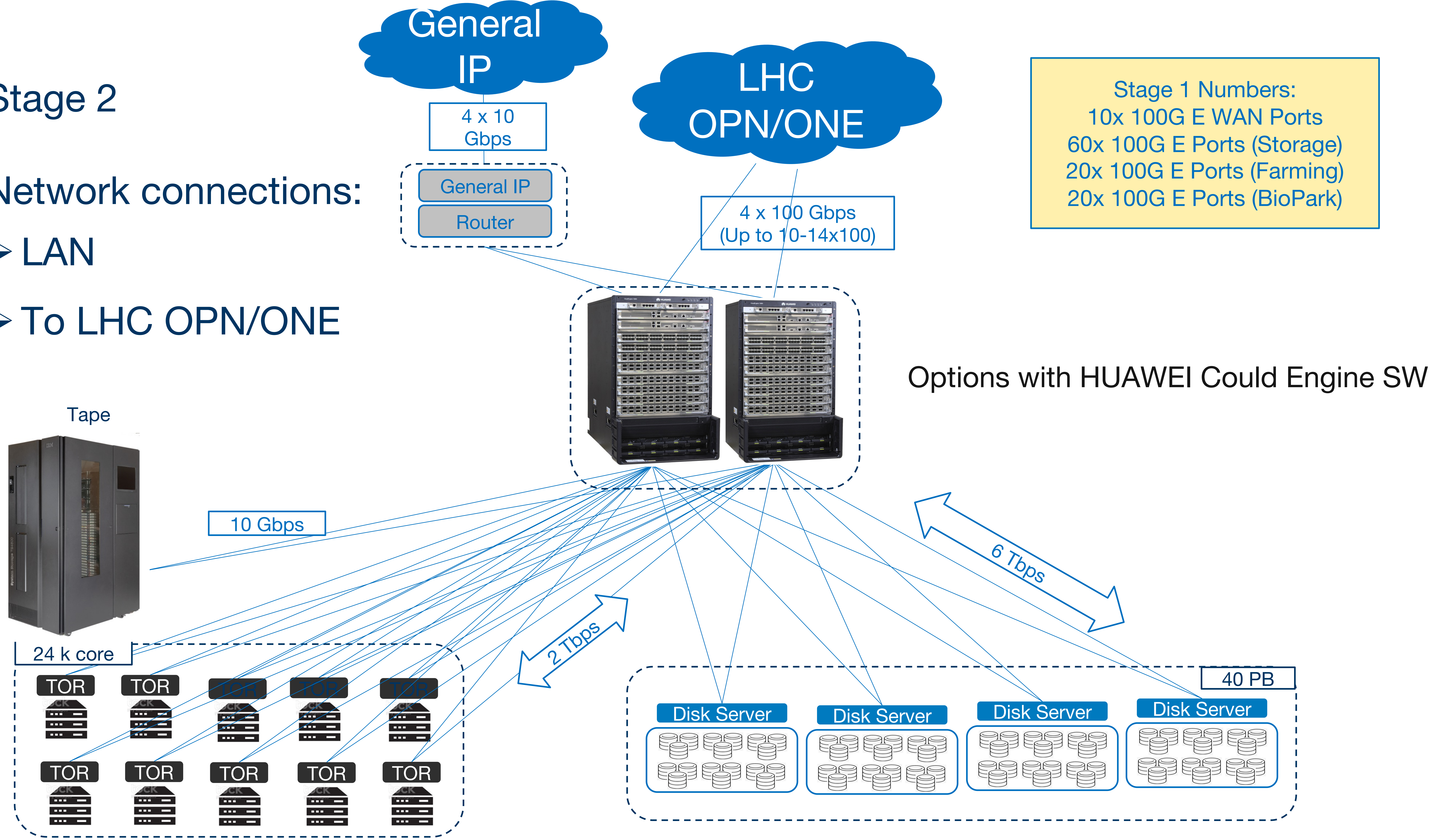
Stage-2:
- Tape library 80 PBs
  - 30 drives x 10 Gbps
  - x 2 core SW

Stage 2
Network connections:
➢ LAN
➢ To LHC OPN/ONE
➢ To future Science Bio
General IP
4 x 10 Gbps
General IP
Router
LHC OPN/ONE
4 x 100 Gbps
(Up to 10-14x100)
Stage 2 Numbers:
10x 100G E WAN Ports
80 x 100G E Ports (Storage)
40x 100G E Ports (Farming)
20x 100G E Ports (BioPark)
2 Tbps
BioPark Storage
Tape
2 x 28 x 10 Gbps
4 Tbps
8 Tbps
24 k core
TOR
TOR
TOR
TOR
TOR
TOR
TOR
TOR
TOR
TOR
40+ PB
Disk Server
Disk Server
Disk Server
Disk Server

Stage 2

Network connections:

- LAN
- To LHC OPN/ONE



SCIENTIFIC MISSION for DEVELOPMENT

- SSC-T1 will provide a platform to enable research in computing for high energy physics scientific fields:
  - Possible contributions perhaps essential to face the challenge of managing, processing and serving large amounts of HEP and future experiments at CERN.
  - Topics: network and data management, computer security, cold to warm storage, data caching, data compression, innovative algorithms for data processing (also on heterogeneous platforms), novel data center architectures, incorporation of HPC resources for high throughput processing, energy efficient computing, monitoring and big data analysis, AI driven decision making and failure pre-emption.

- Plugged into CMS international collaboration w/other Tier-1's, CERN opens opportunities
  - Train students, exposing them to operational tasks and big data management tools
  - Share best practices, potentially exchange staff
  - Participation in software/computing R&D: opportunity for Ph.D. topics
  - Privileged access to CMS data and software

- Potential cross-fertilization at the host lab/university, e.g. usage of HEP tools and infrastructure for other data intensive analysis/processing use cases, and other scientific fields.

- Impact can be reflected in several conference presentation and journals where we can publish results.

Conclusions

- Vinca CMS Group has total of 7 researchers (physics and engineers)

- Very active in physics analysis (Heavy Ion, Higgs, Lepton Flavor Violation)
- Since a few years the effort on detector development (Level-1 Trigger Upgrade)
- Very extensive experience and expertise in Offline computing including Core CMS SW
- Looking into intensifying the computing expertise
- Looking forward to strengthening the collaboration with colleagues from IHEP
    - Areas: Higgs, Level-1 Trigger Reconstruction Algorithms in FPGA and Computing

BACK-UP

VINS Responsibilities at CMS

- Aprovals/Preaprovals
  - EWK-10-010, HIG-12-002, HIG-13-001
  - HIN-12-011, HIN-14-012, HIN-15-010, HIN-18-001, HIN-21-003, HIN-21-010
  - PRF-14-001
- Contact persons or Pdf authors
  - HIG-12-002, HIG-12-009, HIG-12-013
  - HIN-12-001, HIN-14-012, HIN-15-010, HIN-18-001, HIN-21-003, HIN-21-010

- L2/L3 coordination
  - L2 @ TSG - Trigger Performance Group
  - L2 @ TSG - Steam Group
  - L2 @ Level-1 Trigger - Offline Software Group
  - L3 @ TSG - Offline Trigger Performance Group
  - L3 @ TSG - JetMET Trigger
  - L3 @ Level-1 Trigger - Phase2 Upgrade Menu Group

Members of CMS ARC (~30),

Chair for HIN (7)

Scientific evaluator(referee) for European & National grants

FARMING (CPU)

Serbia Tier-1
- 11.5 k cores (23 k threads, 170 kHS06)
- 5/6 racks with CPU with TOR switches
- 180 CPUs with 64 cores @ ~280 W

- Options 5 racks, per rack:
  - 36 U
  - 10 kW CPU
  - 5 kW cooling
- Options 6 racks, per rack:
  - 30 U
  - 8.4 kW CPU
  - 4.2 kW cooling

Management: In the Top of the Rack (TOR) architecture, each cabinet can be considered as an independent management entity. Servers and switches can be upgraded by cabinet while the traffic forwarding of other cabinets is not affected and impact on services is minimized.

Configuration options with HUAWEI TOR Switches

TOR SWITCH

- in a server cabinet (1/2U)
- Huawei CE5800, CE6800 series .

TOR SW Huawei CloudEngine 6863

- Uplink: 6 x 40/100 GE QSFP28
- Downlink: 48 x 10/25 GE SFP28