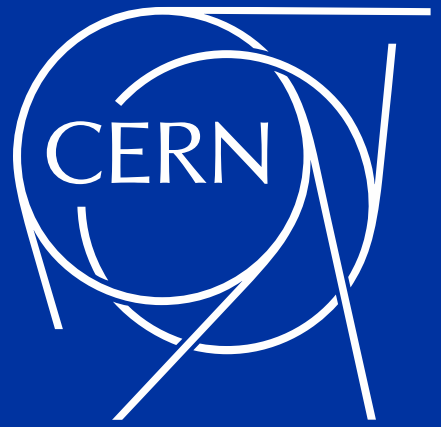


Status of the Experiments

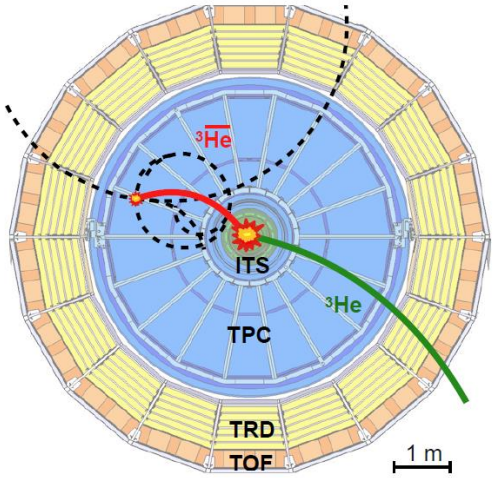
Plenary RRB 54th Meeting

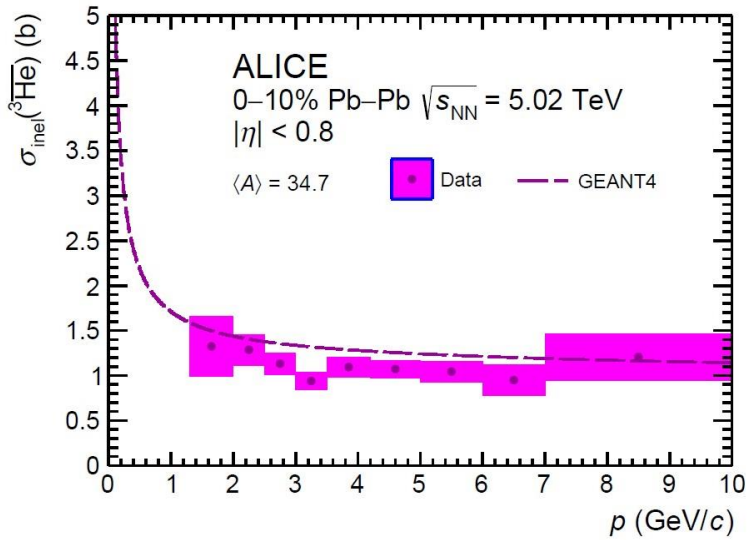
Joachim Mnich

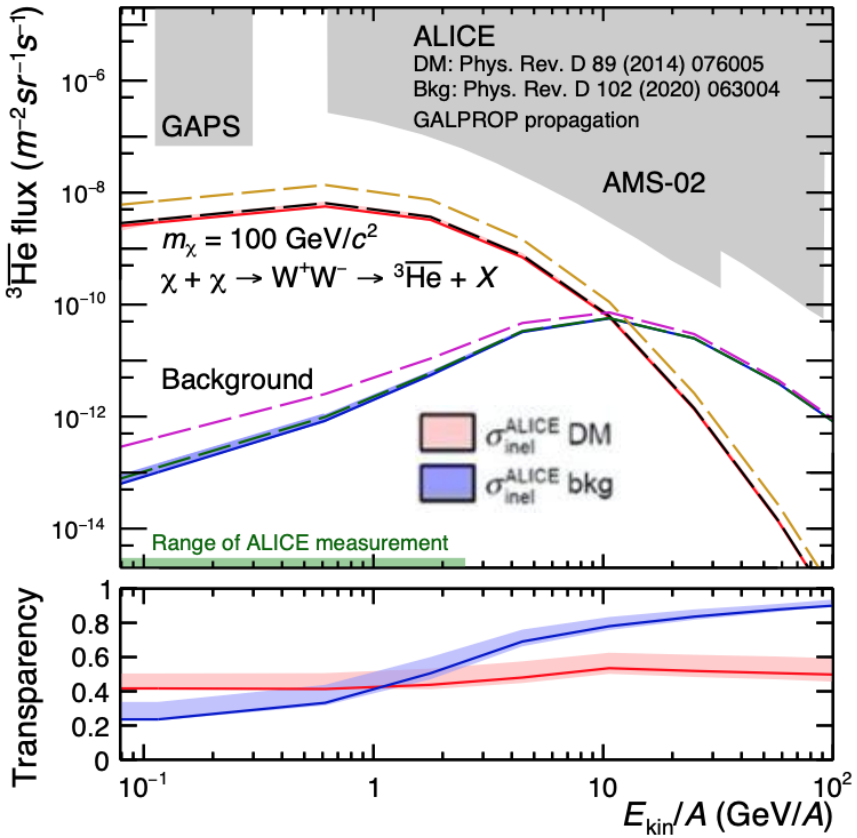
April 25th, 2022

Anti-^{3}He Absorption in ALICE and in the Galaxy

ALICE, arXiv:2202.01549







ALICE measured the anti-^{3}He absorption cross section in the detector material, for the first time at low momentum

Search for anti-nuclei in space such as anti-^{3}He is a very promising channel for the discovery of Dark Matter

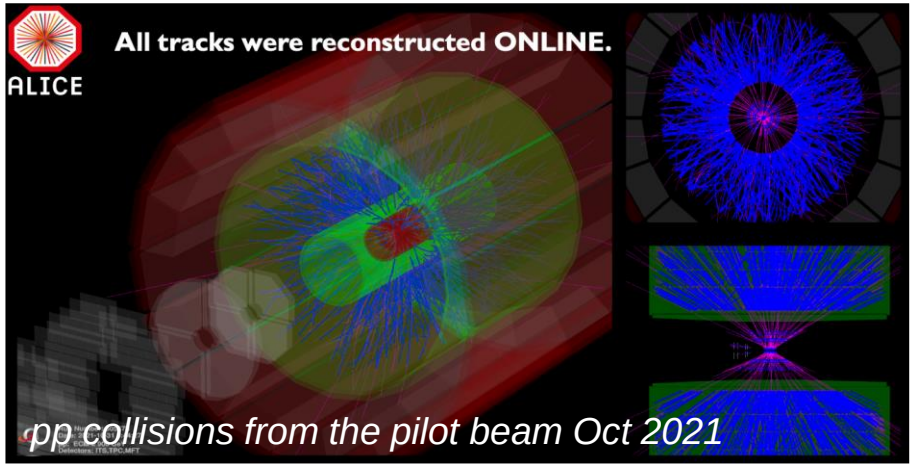
- essentially free from the background from ordinary collisions between cosmic rays and interstellar medium
- ALICE result provides estimate of absorption probability of anti-nuclei from dark mattter decays and from cosmic-ray background in the Galaxy

ALICE: LS2 Activities

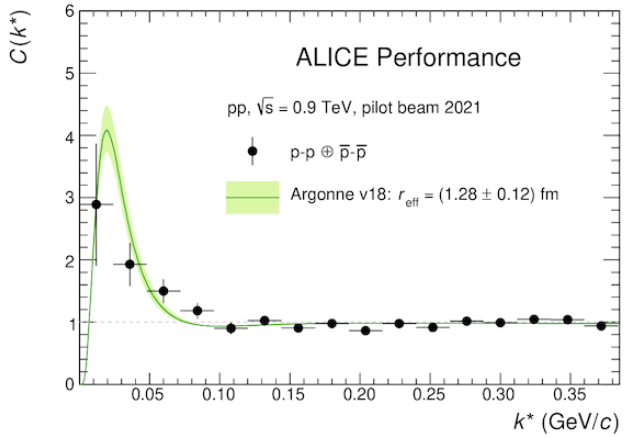
- **Installation of new and upgraded detectors and maintenance activities completed**
- **L3 doors closed** (Feb 14), **shielding installed** the following week
- ALICE closed on March 2 and **magnets restarted** on March 7
- **Underground access** ended on **March 24**

ALICE: Readiness at P2

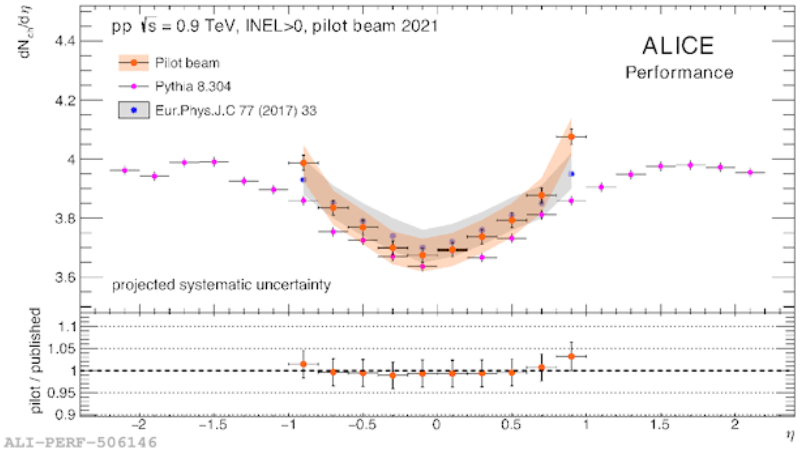
Installation of new and upgraded detectors completed!



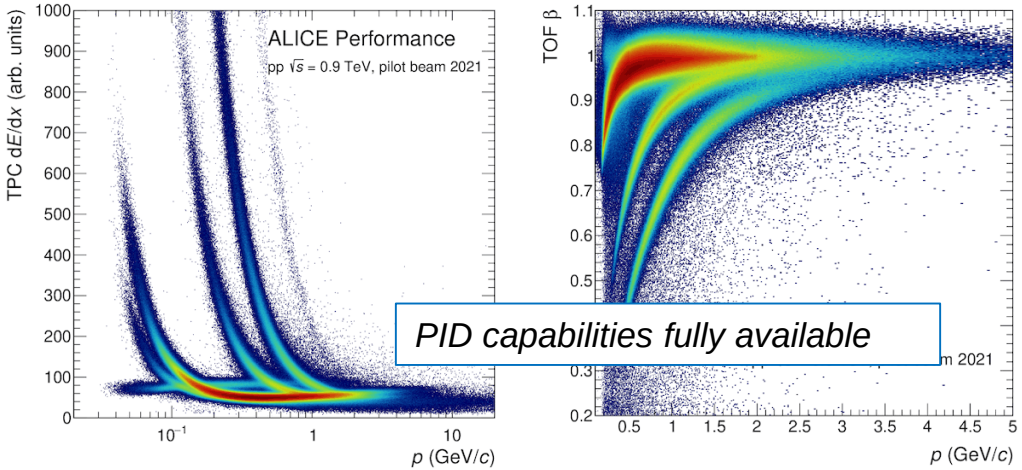
pp collisions from the pilot beam Oct 2021



First look at the p-p momentum correlation function

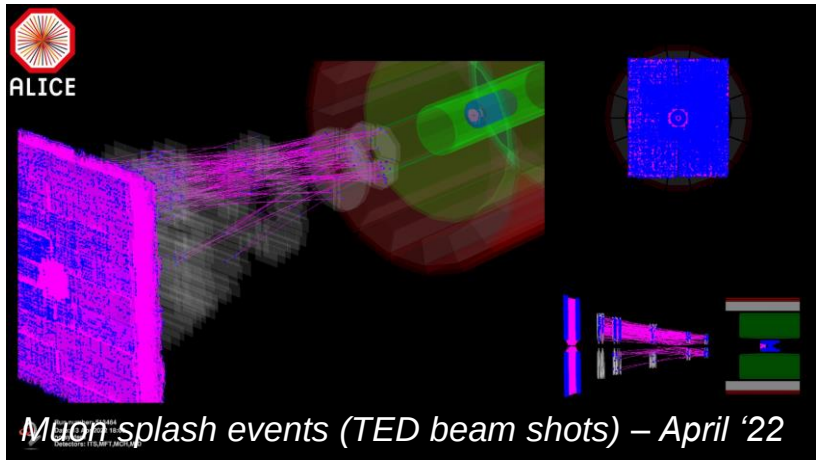


Measured $dN_{ch}/d\eta$ compatible with previous results



PID capabilities fully available

Preliminary analysis of the pilot beam data of Oct 2021



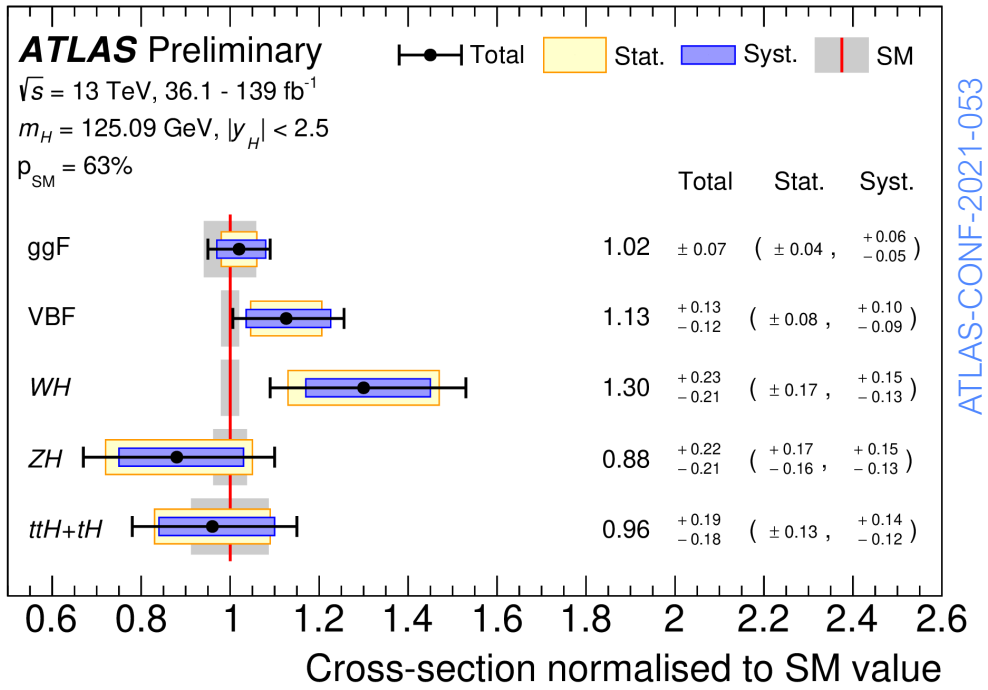
Muon splash events (TED beam shots) – April '22

ATLAS: Higgs Boson Couplings

Based on complete Run 2 data set

Global fit: signal strength μ = 1.06 ± 0.06

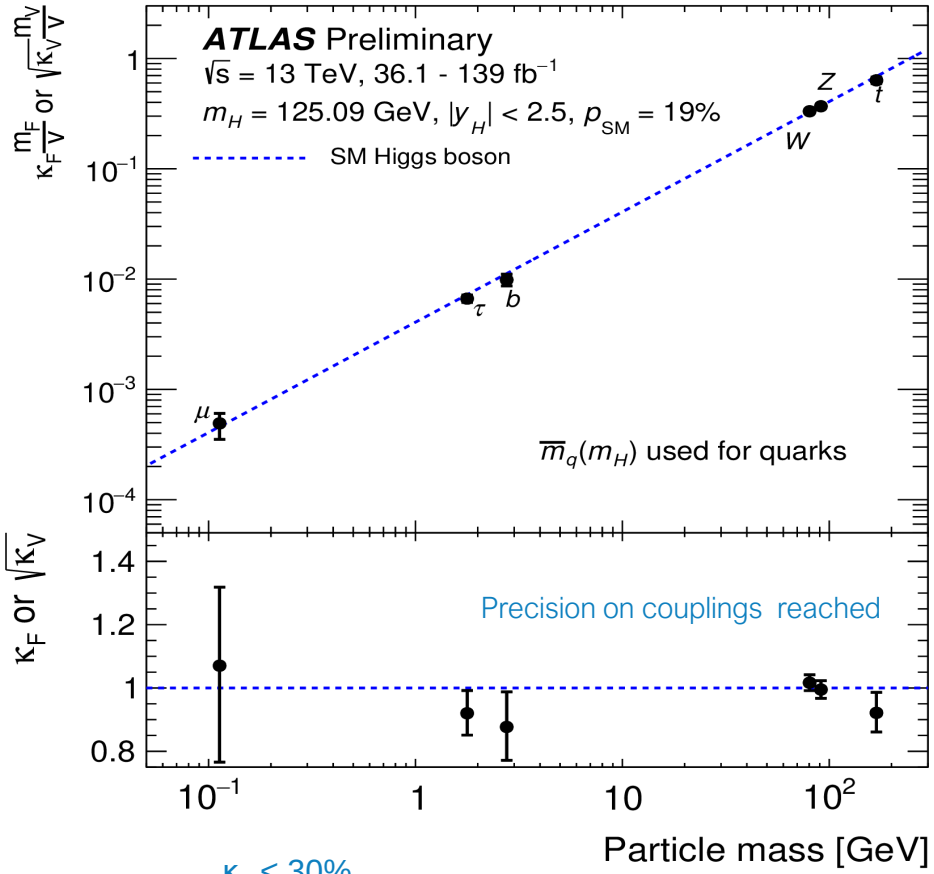
Cross sections of main Higgs production modes



ATLAS-CONF-2021-053

Coupling measurements ($B_i = B_u = 0$)

$\kappa_\gamma = 1.04 \pm 0.06$, $\kappa_g = 0.92\ ^{+0.07}_{-0.06}$, $\kappa_{Z\gamma} = 1.37\ ^{+0.31}_{-0.37}$



ATLAS-CONF-2021-053

Yet unattained precision on Higgs boson couplings

$\kappa_\mu < 30\%$

$\kappa_\tau = 7\%$ $\kappa_b = 11\%$ $\kappa_t = 6\%$ $\kappa_{W,Z} = 6\%$

ATLAS — Phase-I upgrades completed

Both Muon New Small Wheels installed and under commissioning

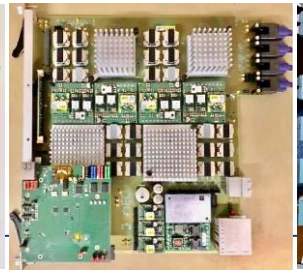
Completion of NSW-A on 28 May 2021

Completion of NSW-C on 13 September 2021

Digital LAr trigger and new Trigger & DAQ boards installed and under commissioning

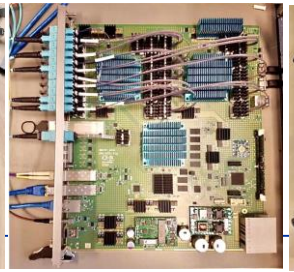
FELIX IO card

eFEX

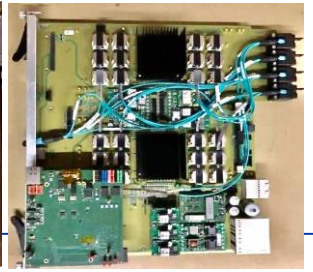


jFEX

gFEX



MUCTPI



L1Topo

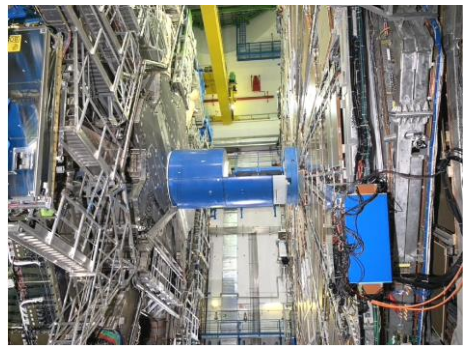
ATLAS: LS2 Work Beginning of 2022

Phase-I upgrades successfully completed

Endgame and cavern closure

- 8 Jan: **start of detector closing**
- 21 Jan both **Endcap Toroids on beam line**
- End of Jan: begin of new CO_2 building construction at P1
- 1 Feb: **endcaps in run position**, begin of **Central Solenoid test**
- 10 – 17 Feb: successful **beampipe bake-out**
- Feb 23: M11 and **cavern cleaning** (40 volunteers will help, thanks!)
- 10 Mar: begin of **final closing** and installation of forward shielding
- **24 March: final patrol and cavern closed**
- Since 21 March **two weeks M12**, including long cosmic run for barrel alignment of the muons
- 20 April: **Toroid and solenoid ramp**, both magnets are kept ON

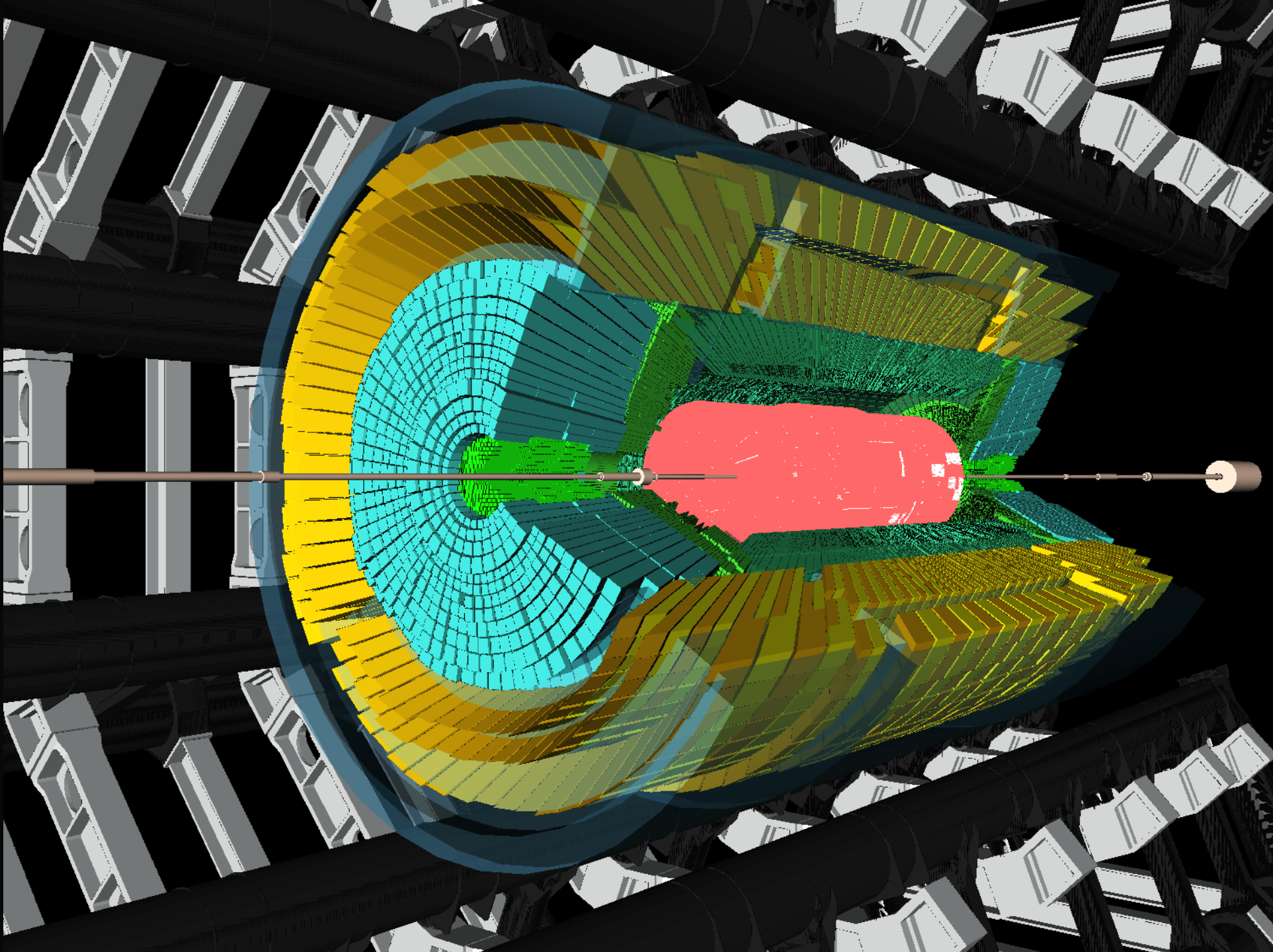
Side A with JFC1/2 shielding before closing



Side B ECT-C in run position

Construction of new CO_2 building at P1 (for Phase-II)

Members of beampipe bake-out team, Feb 2022



ATLAS EXPERIMENT

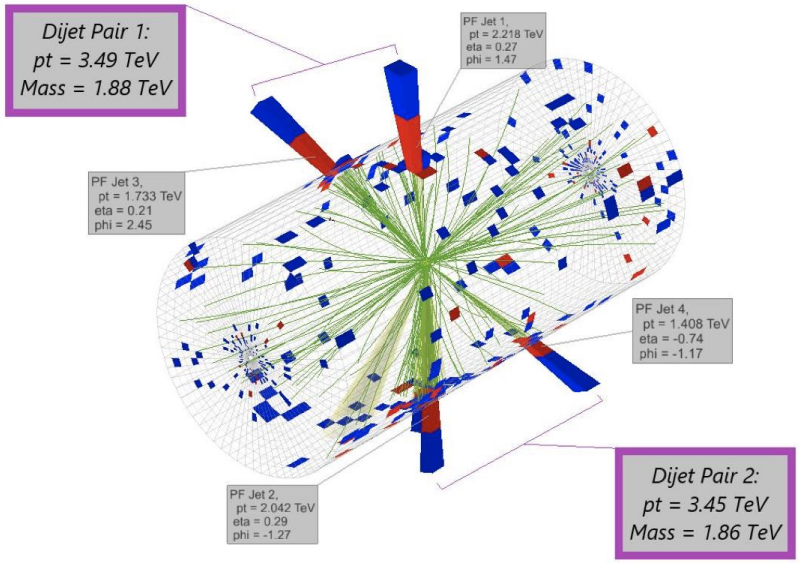
A beam splash event
recorded on 22 Apr 2022

CMS: Search for Paired Di-jet Resonances

CMS-PAS-EXO-21-010

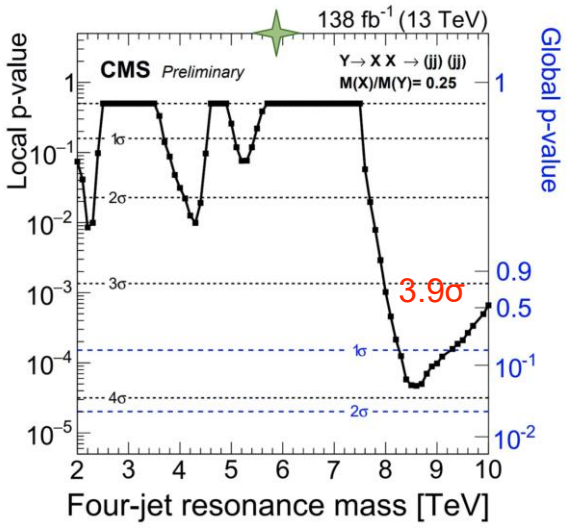
Search for resonant and non-resonant production of pairs of di-jet resonances

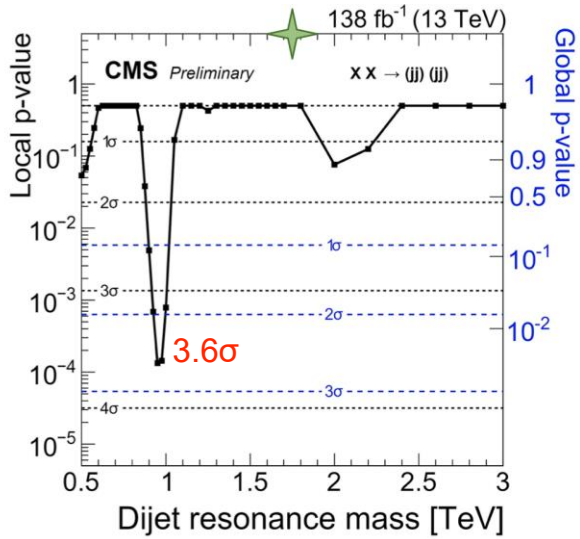
- full Run-2 dataset
- data driven background estimate

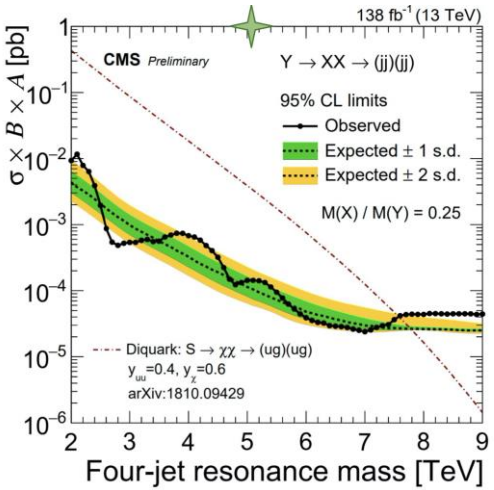


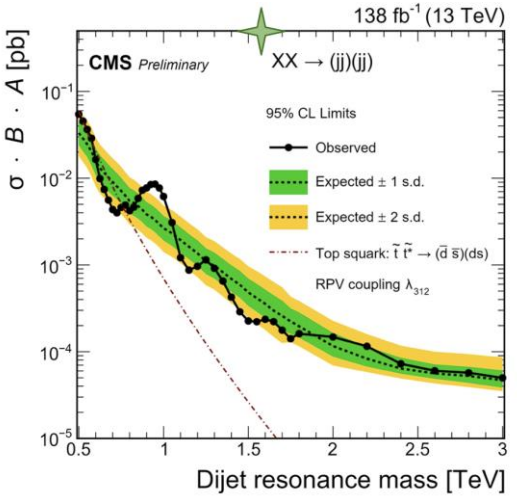
Limits with benchmark models:

- non-resonant: RPV stops
- resonant: diquarks









CMS: Readiness at Point 5

Pixels

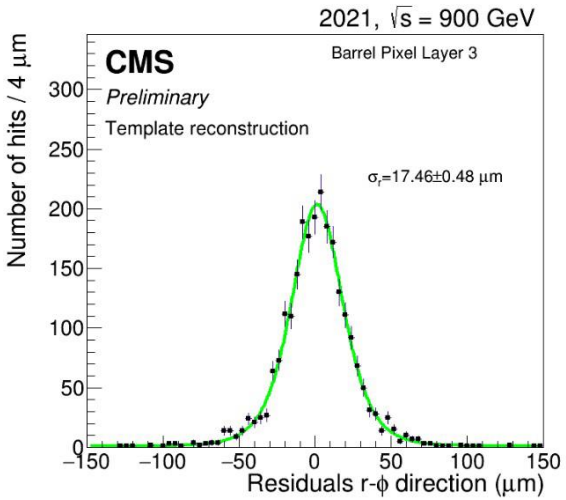
Successful time and spatial alignment using the 900 GeV data, resolution nearly optimal

Strip Tracker

Finalised timing, alignment and calibration with cosmic ray and 900 GeV data

Muon System

Commissioning in cosmic rays, overall excellent performance

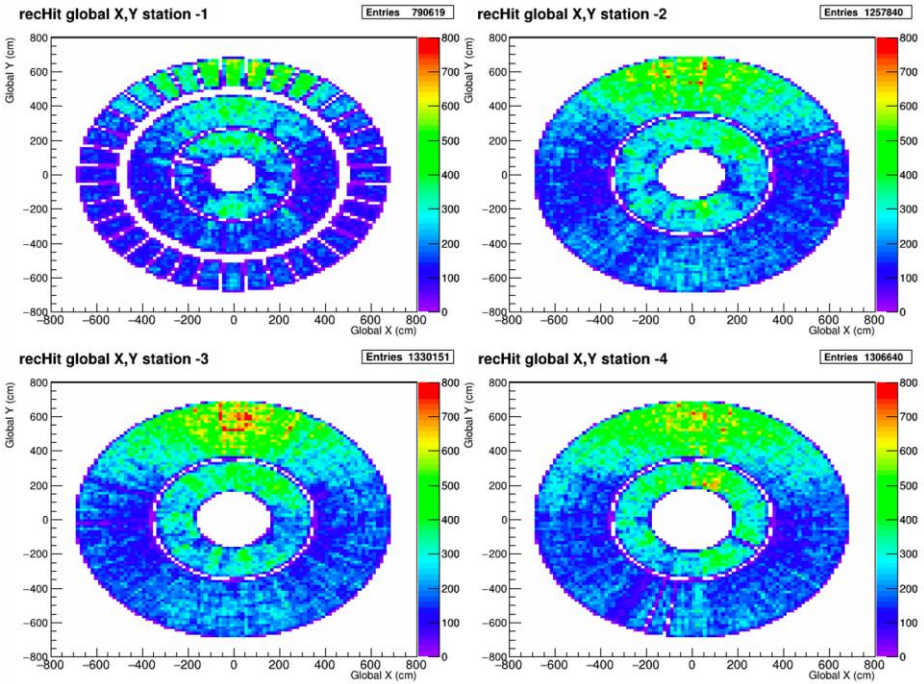


ECAL

commissioning with cosmic rays

HCAL

All, including HF, participating in global runs



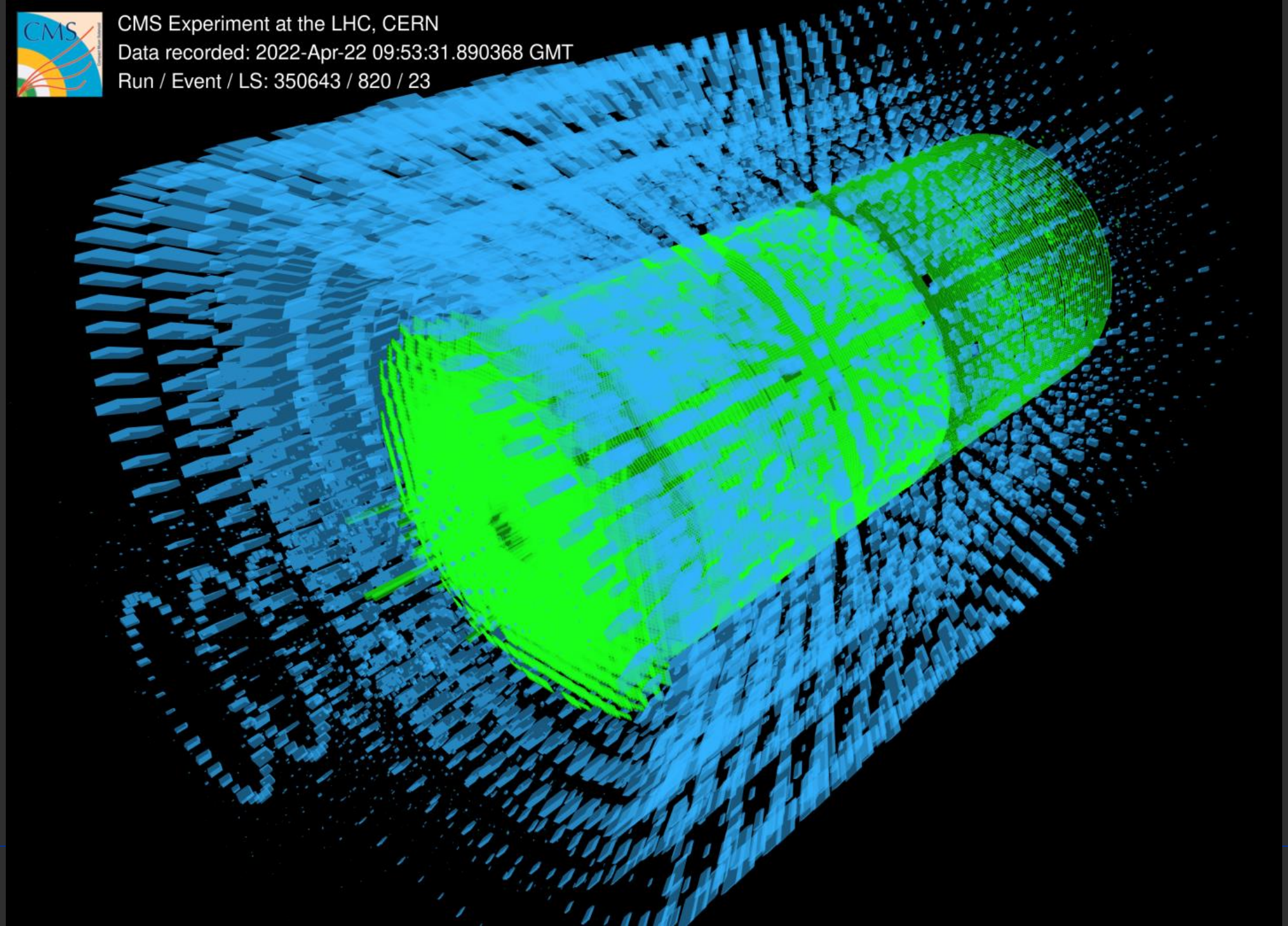
CSC occupancy @ 2022 MWGR #1

BRIL

Phase-2 demonstrators installed: BCML (diamond, sapphire) and BLM (ionisation chambers)

PPS

New 3D-pixel detectors in horizontal RP installed


CMS Experiment at the LHC, CERN
Data recorded: 2022-Apr-22 09:53:31.890368 GMT
Run / Event / LS: 350643 / 820 / 23

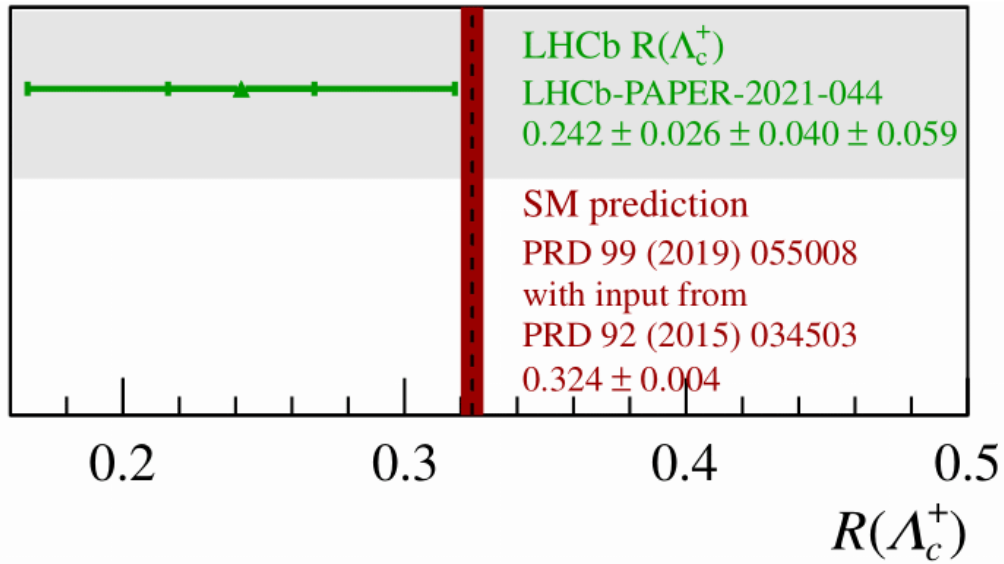
LHCb: Semi-leptonic Lepton Flavour Test

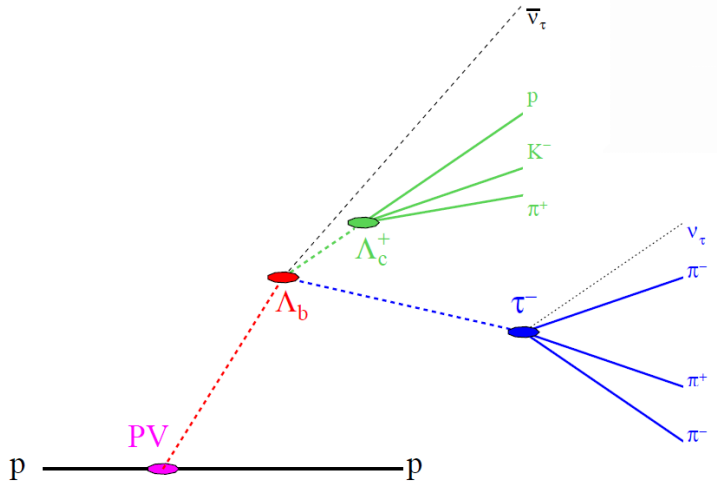
LHCb-PAPER-2021-044

The other lepton flavour anomalies (outside b→sll)

- $R(\Lambda_c^+)$ decays of baryon to tau lepton compared with muon

First observation of this channel and first test of ratios with semi-leptonic baryon decays





LHCb Upgrade I

Largest CERN particle physics detector project since LHC completion

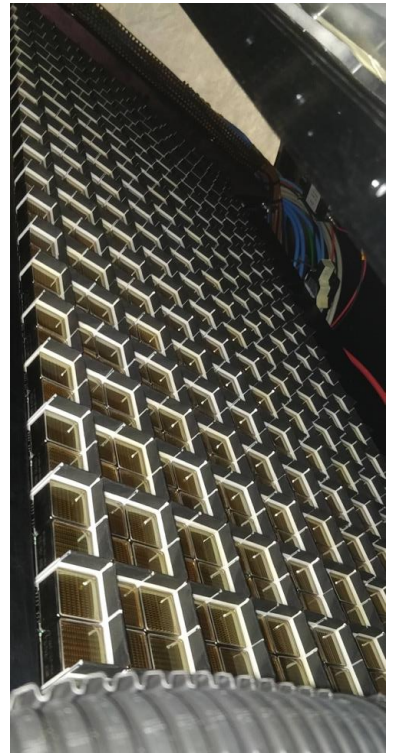
- despite pandemic, is being completed on-budget and *near* schedule

Completed installation in first months of 2022:

- RICH1, Scintillating Fibre main tracker, first-half of VELO, luminometer

Minor issues with cooling circuit led to a delay in VELO second-half

- construction of second half of VELO has now been completed
- will be transported to CERN this week
- installation foreseen in next weeks, with minimal effect on LHC schedule
- upstream tracker not essential for initial operation and will be installed at a later stage



2nd half of of VELO ready to be shipped to CERN

Risks Associated with the War Against Ukraine

Russian (and Ukraine) institutes are strong and important partners in the CERN programme

- Close to 7% of the members of the LHC collaborations are from institutes in Russia (incl. JINR)
- They are essential for the operation of the experiments Most critical examples:
  - ALICE: Fast Interaction Trigger, Photon Spectrometer, …
  - ATLAS: Inner Detector, Tile Calo., TDAQ, Technical Coordination, …
  - CMS: HCAL, CSC, BRIL, Technical Coordination,…
  - LHCb: Muon systems, ECAL, HCAL, ..
- More than 100 scientists, engineers and technicians are crucial for the operation of the four detectors

Members from Russian institutes in the LHC collaborations

	Total	Russia (incl. JINR)		JINR	
ALICE	1942	167	8.5%	34	1.7%
ATLAS	5917	364	6.2%	147	2.5%
CMS	5365	306	5.4%	88	1.6%
LHCb	1500	148	9.9%	0	0%
Sum	**14724**	**985**	**6.7%**	**269**	**1.8%**

Collaborators essential for the operation of the LHC experiments

	Russia (incl. JINR)	JINR
ALICE	20	5
ATLAS	44	15
CMS	34	10
LHCb	15	0
Sum	**113**	**30**

Recall the **HUGE** contributions Russian, JINR (also Belarus, Ukrainian) technicians, engineers and physicists made to the construction and operation of the detectors

More Information on Russian Engagement in LHC Experiments

M&O A and B contributions (w/o electricity)

[kCHF]	2022 total	Russia (incl. JINR)		JINR	
ALICE	6401	562	8,8%	107	1.7%
ATLAS	19240	720	3.7%	266	1.4%
CMS	19455	1231	6.3%	376	1.9%
LHCb	4220	438	10.4%	0	0.0%
Sum	**49316**	**2951**	**6.0%**	**749**	**1.5%**

Note that for CMS all JINR numbers include the institutes from JINR member states which are part of the RDMS collaboration

Core contributions to current detectors, incl. Phase I

[MCHF]	2022 total	Russia (incl. JINR)		JINR	
ALICE	216	21.7	10%	3.1	1.4%
ATLAS	569	29.7	5.2%	8.7	1.5%
CMS	588	26.0	4.4%	7.9	1.3%
LHCb	128	10.3	8.0%	0	0,0%
Sum	**1501**	**87.7**	**5.8%**	**19.7**	**1.3%**

Students from Russian institutes in the LHC experiments

	Russia (incl. JINR)		JINR	
	PhD	Master/ Bachelor/ Engineering	PhD	Master/ Bachelor/ Engineering
ALICE	32	14	5	0
ATLAS	41	39	14	14
CMS	32	14	5	0
LHCb	33	8	0	0
Sum	**138**	**75**	**24**	**14**

WLCG: Readiness for Run 3

In 2021 we tested extensively the WLCG services in preparation for Run 3

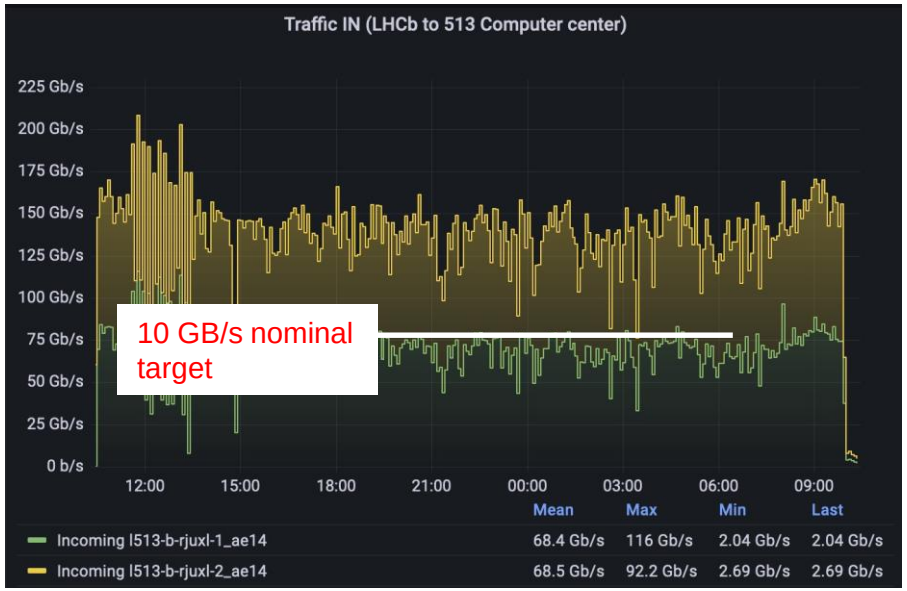
- network & archive storage tests
- no standing concerns while final tests are ongoing

The combined tests of the experiments have shown that we have enough infrastructure in place for the start of Run-3

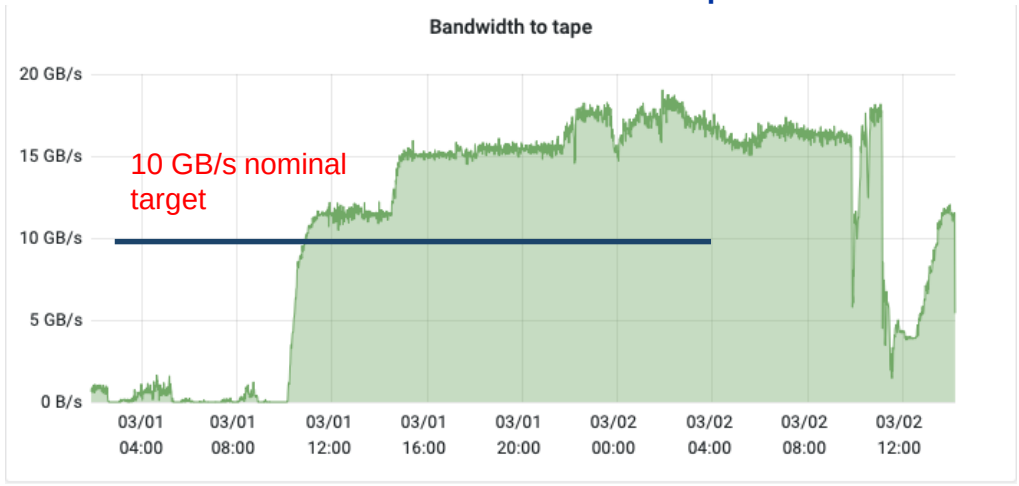
- additional hardware has been deployed after the challenges and some is still being deployed

A final commissioning campaign is happening in March 2022, with excellent results so far

March 2022: LHCb P8 to T0 disk



March 2022: LHCb T0 disk to tape



Impact of War Against Ukraine on WLCG

Russia participates in the Worldwide LHC Computing Grid (WLCG) and has two Tier-1 centres at the Kurchatov Institute in Moscow (RRC-KI) and at JINR in Dubna:

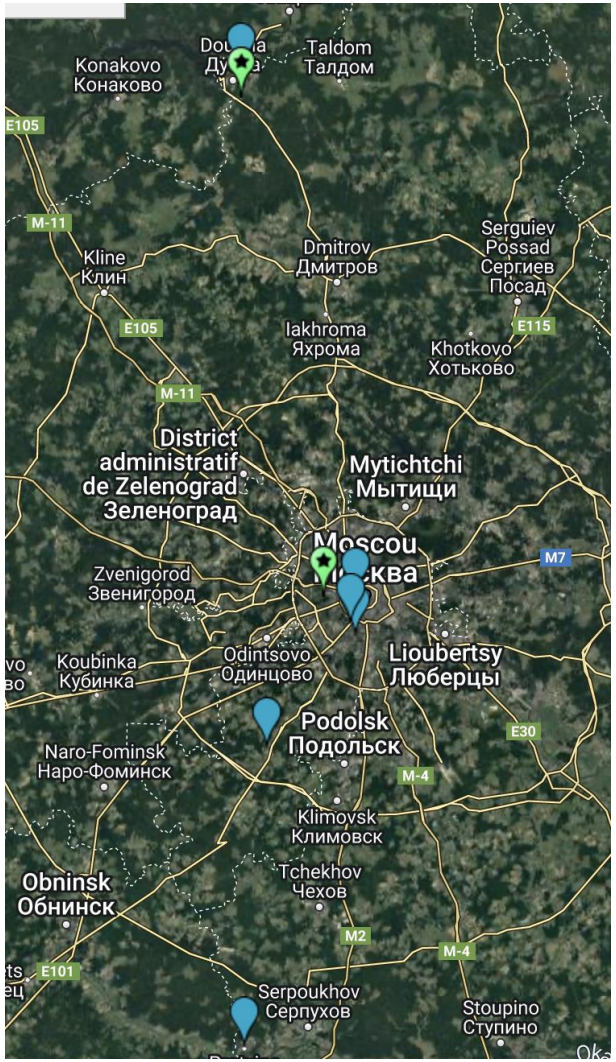
- RRC-KI: Tier-1 for ALICE, ATLAS and LHCb
- JINR: Tier-1 for CMS

In total, the two centres contribute about 10% of the total Tier-1 resources not equally shared between experiments, e.g. JINR provides ≈ 30% of CPU for CMS

In addition, there are eight Tier-2 centres in the Moscow and St Petersburg region, supporting all four LHC experiments:

- RRC-KI, JINR which serve also as Tier-2 centres,
- FIAN (the Lebedev institute), ITEP (Institute of Theoretical and Experimental Physics), the Troitsk institute for Nuclear Research and IHEP Protvino
- Saint Petersburg State University (SPbSU) and the Petersburg Nuclear Physics Institute

Ukraine supports two Tier-2 centres in Kiev and Kharkiv



Impact of War Against Ukraine on WLCG

Associated risks:

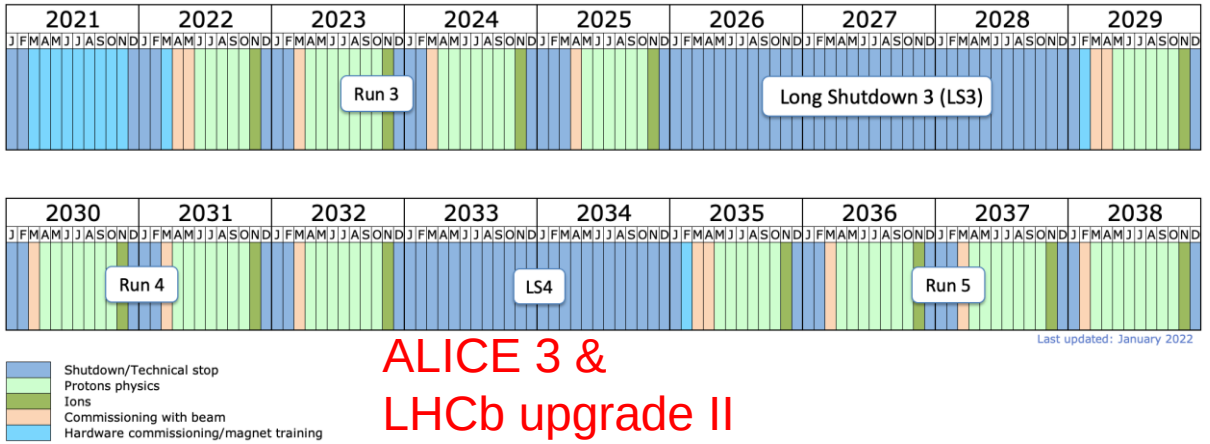
- loss of about 10% Tier-1 resources (less critical for Tier-2)
- even more serious: Russian experts contribute to the development and operations of WLCG software and services, in the experiments (about 30 people) and at the WLCG sites
- connectivity: on pressure from several EU countries GEANT has discontinued the connection to Russia dedicated to LHC (LHCONE); currently connection through public internet

The most valuable unique data sets in Russian Tier-centres were replicated also at other sites by the experiments

An extra-ordinary WLCG Overview Board was held on March 28th

Phase II: LHC Schedule

Phase II upgrade
ATLAS & CMS



ALICE 3 &
LHCb upgrade II

Recall schedule discussion of December 2021:

- following recommendations of LHCC and
  HL-LHC Cost & Schedule Review CERN management
  proposed to extend Run 3 by 1 year and LS3 by ½ year
- feedback from funding agencies (RRB) was supportive

  Thank you very much for your many useful comments
  and your support!

- CERN management decided in January 2022 to adapt
  the schedule as proposed
  underlining that any further shift of LS3 is technically excluded!

CERN measures to help experiments to consolidate the Phase II schedule:

- CERN EP, ATLAS and CMS established a priority list and roadmap for electronics
- CERN will try to continue the CHIPS initiative and support it with experienced workforce
- discussion with Fraunhofer IPA in Germany started
  this institute is specialized on (industrial) process optimization
  plan for workshops with experiments once re-baselining is completed (hopefully Q2 2022)

In addition, both experiments are working hard to consolidate the schedule

Risks Associated with the War Against Ukraine

Phase II: very significant contributions from Russian institutes are part of the Phase II projects

- approx. 20 MCHF core contributions
- key in-kind contributions depend on their workforce and expertise

Some examples:

Phase II core contributions from institutes in Russia

[MCHF]	Total	Russia (incl. JINR)		JINR	
ATLAS	248.8	8.3	3.3%	3.1	1.2%
ATLAS common fund	24.4	1.2	5.0%	0.4	1.6%
CMS	283.5	9.2	3.2%	2.4	0,8%
CMS common fund	25.0	1.5	6.1%	0.4	1.7%
Sum	**581.7**	**20.2**	**3.5%**	**6.2**	**1.1%**

ATLAS: needed in 2022

- ITK: delivery of manifolds, start of flip-chip qualification and pre-production of pixel end-cap modules
- RPC: shipping to CERN of prototype transport frames and the pre-production of installation equipment, temporary export of RPC readout panels for assembly at JINR

CMS: by far largest project with Russia is the HGCAL with 8.2 MCHF core contributions expected

- already blocked collaboration between Russia and Ukraine: moulded scintillators (Russia), machined scintillator (Ukraine), copper-tungsten base-plates for silicon modules (Russia), copper cooling plate prototypes (Belarus)
  These components are all needed for pre-series activities this year

→ Significant budget and schedule risk

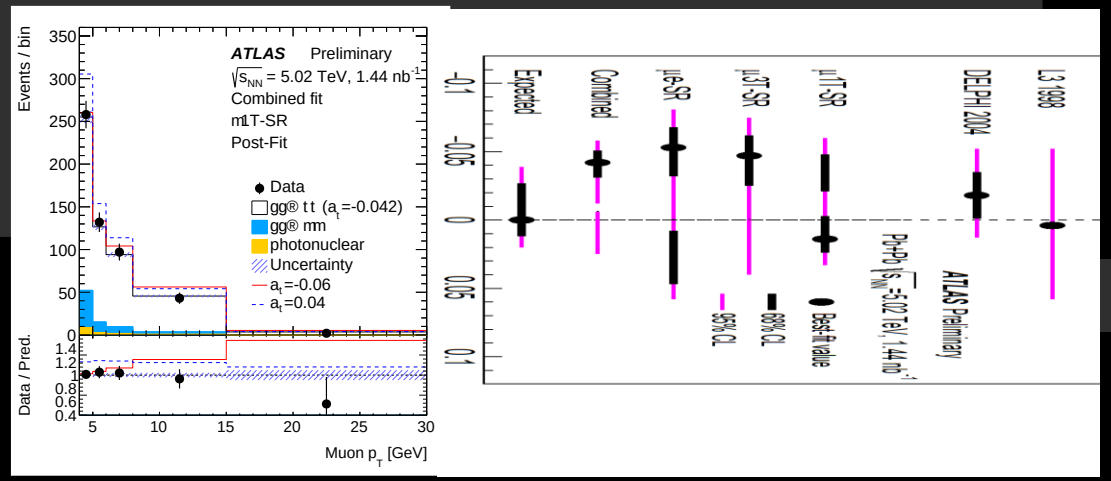
Summary

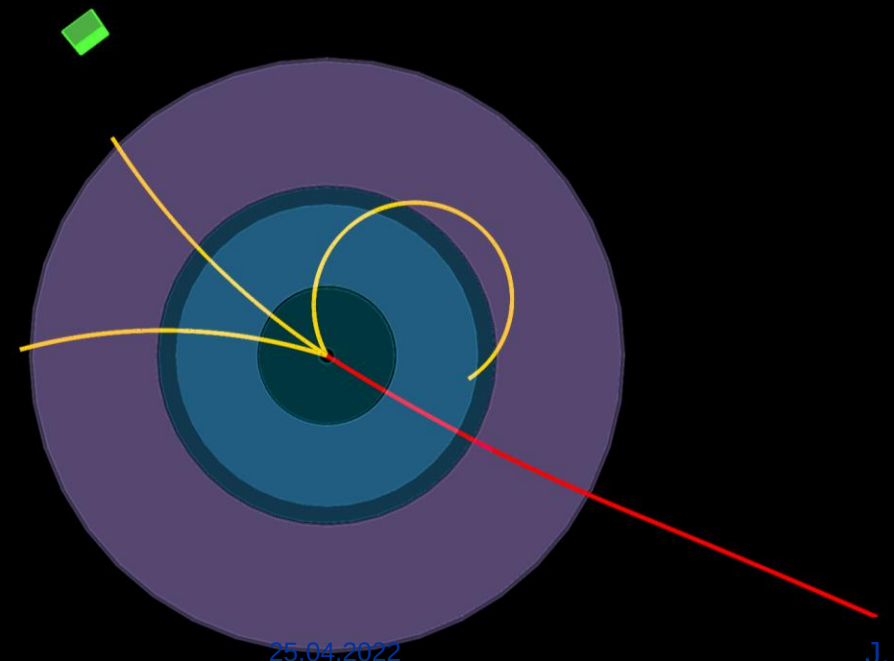
- LHC experiments continue to produce excellent physics results from Run 2 data
  - 10th anniversary of Higgs discovery 4th of July, 2022
- Experiments are ready for Run 3
  - cavern closed since March 24th
  - computing ready for Run 3
- Russian war against Ukraine constitutes a significant risk
  - to the LHC and non-LHC experiments at CERN and
  - to our Ukrainian and Russian colleagues who contributed and are still contributing to the scientific programme of CERN

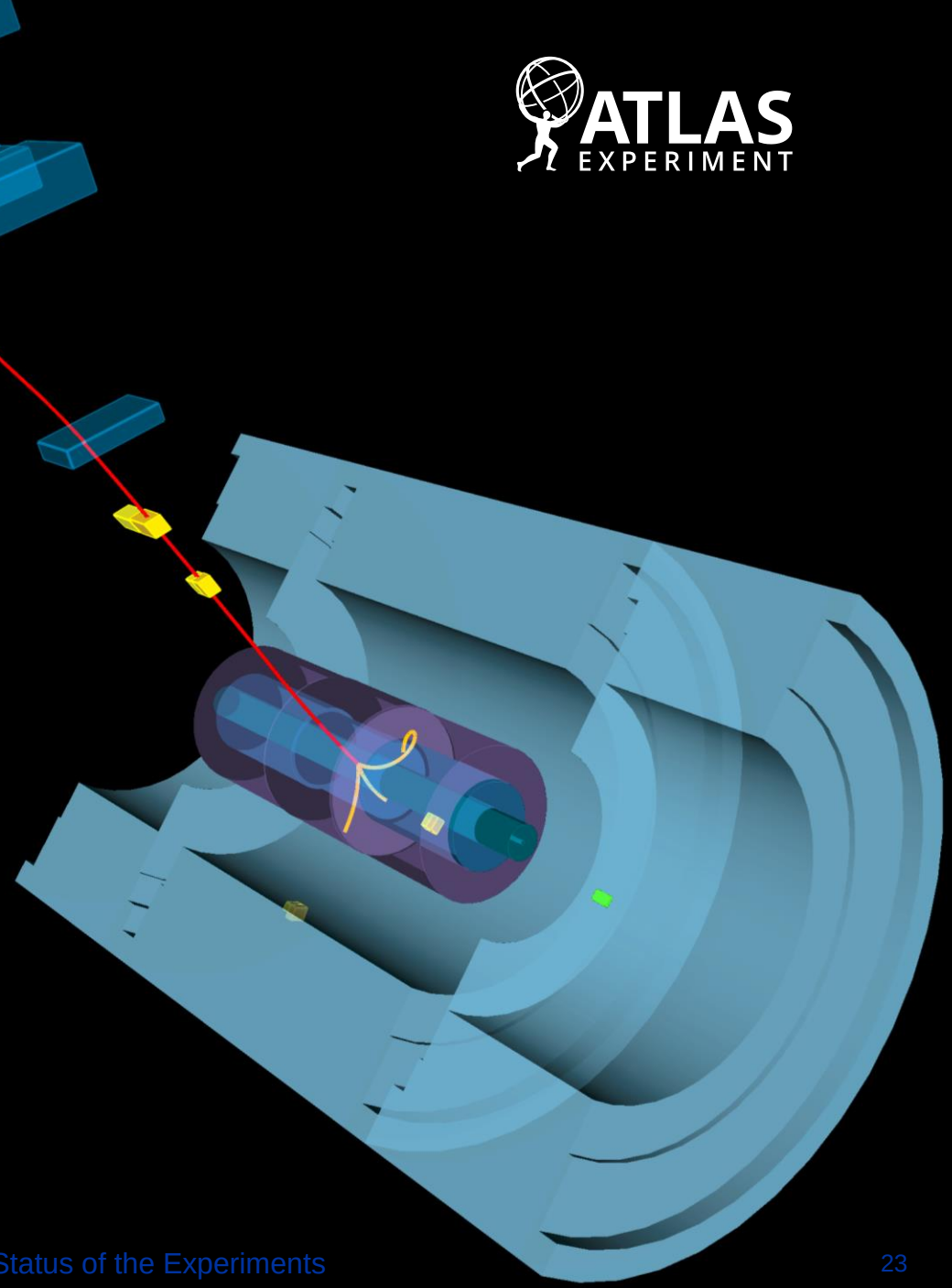
  if the International Collaboration Agreements (ICAs) and MoUs are suspended
  - Russian contributions will have to be covered by the other FAs pro-rata
- LHC and HL-LHC are the highest priority projects for CERN and particle physics
  - we are working very hard to keep the projects on schedule and on budget
  - we are grateful to the continuous support of the Funding Agencies

Backup

Observation of $\gamma\gamma \to \tau\tau$ in Pb-Pb collisions and constraint on tau anomalous magnetic moment







Observation of $\gamma\gamma \to \tau\tau$ in Pb-Pb collisions and constraint on a_τ [Physics Briefing, Interview]

ATLAS is closed and ready for Run 3

Side A on 3 Feb 2022

ATLAS EXPERIMENT

More Information on Russian Engagement in CERN Experiments

Detector components relying most critically on Russian experts and workforce:

- ALICE:
  - Fast Interaction Trigger (FIT): Russian groups have major responsibilities in the FIT detector, the main level-0 trigger detector; large part of the detector was developed and built by them
  - Photon Spectrometer (PHOS) is entirely under the responsibility of the Russian groups and JINR, who are the only ones in ALICE to have the technical expertise for its maintenance and operation.
  - Important contributions to inner Tracking System (ITS), the Muons Forward Tracker (MFT) and the Muon Spectrometer detector (Muon), but less critical

- ATLAS:
  - Inner Detector
  - Tile Calorimeter (incl. project leadership)
  - TDAQ
  - Technical Coordination
  - JINR colleagues contribute to the commissioning of the Muon New Small Wheel, and more generally to the Muon Spectrometer, and to the Liquid-Argon Calorimeter

More Information on Russian Engagement in CERN Experiments

Detector components relying most critically on Russian experts and workforce:

- CMS:
  - Fast Interaction Trigger (FIT): Russian groups have major responsibilities in the FIT detector, the main level-0 trigger detector; large part of the detector was developed and built by them
  - Hadron Calorimeter (HCAL), incl. JINR
  - Cathode Strip Chambers (CSC)
  - BRIL
  - Technical Coordination, in particular JINR

- LHCb:
  - Russian experts are crucial for the operation of the Muon Systems and Calorimeters (ECAL and HCAL). In these systems Russian institutes have leadership roles and both rely heavily on the Russian teams for maintenance and calibration during Run 3, including some elements where all knowledge currently resides in the Russian teams. Replacement muon chambers are currently under construction in Russia.
  - Scintillating Fibre Tracker (SciFi): fibre mat production in Russia (approx. 9% of the total system)
  - Data Monitoring and processing
  - Technical Coordination

Ukraine in LHC Experiments

ATLAS: no Ukrainian institute

ALICE: 2 institutes

- Bogolyubov Institute for Theoretical Physics (Kiev)
- Scientific Research Technological Institute of Instrument Engineering (Kharkiv)

Important contribution to LS3 upgrade: the group of Kharkiv has developed the technology for the fabrication of aluminum-based electrical substrates for the FoCal detector

CMS: Ukraine contributes to RDMS collaboration (Russia and Dubna member states)

- National Scientific Center, Kharkov Institute of Physics and Technology
- Institute for Scintillation Materials of National Academy of Science of Ukraine (Kharkov)
- Kharkov State University

Important contributions to Phase II: HGCAL

LHCb: four institutes from the Ukraine

- Institute for Nuclear Research (KINR, Kyiv)
- National Science Center Kharkiv Institute of Physics and Technology
- Taras Shevchenko National University of Kyiv
- Institute for Scintillation Materials (Kharkiv) (the latter 2 groups joined recently)

Contribution to the calorimeter pre-shower detector of the Run 1 and 2 detector, and the radiation monitoring system
For LHCb Upgrade I they have designed and produced a new radiation monitoring
Leading role in the design, testing, installation and commissioning of the Plume luminometer system