



OVERVIEW OF HEP IN SERBIA & COOPERATION WITH CERN

**Overview of R&D programs, cooperation, education,
challenges and future plans.**

RECFA visit to the Republic of Serbia, November 2024

**Information compiled by P. Adzic, L. Zivkovic, and P. Milenovic,
as representatives of the R. Serbia at CERN Council, RECFA, and ECFA.**



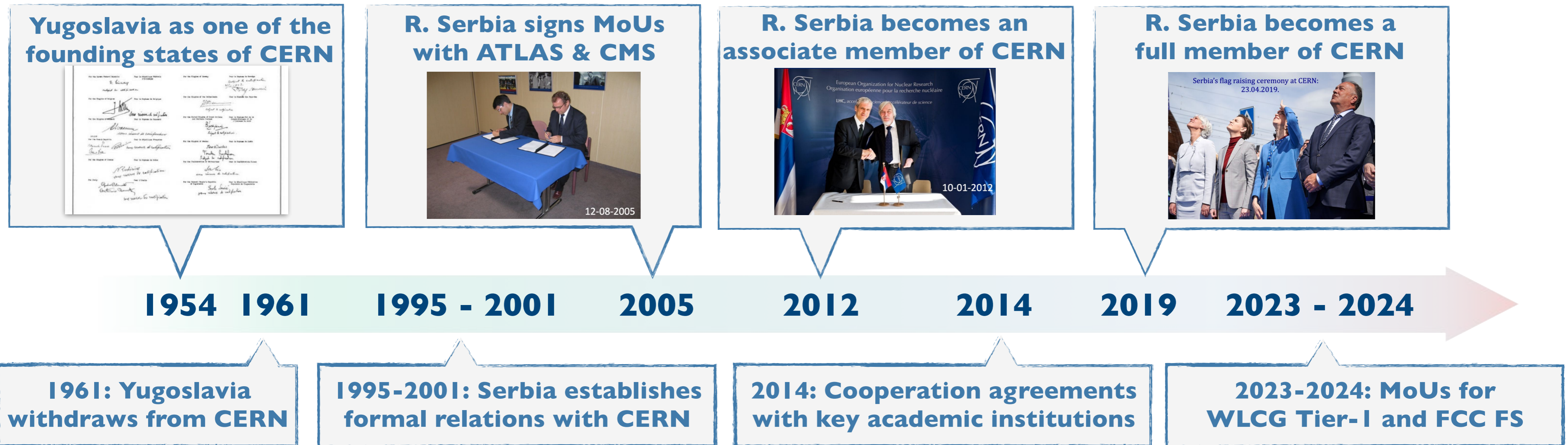
Brief history

Particle, nuclear and astro-particle physics in Serbia in early years:

- Foundation of research institutes (1948, 1961) and university programs fostering relevant expertise laid groundwork for research in nuclear and particle physics in Serbia.
- Research gradually expanded into high-energy physics., thanks to early involvement in international projects and collaborations, including CERN and other European institutions.

Brief history of CERN-Serbia relations:

- Cooperation since 1954, significantly expanded & intensified in the last two decades.



Particle physics & universities landscape in Serbia

Particle physics & universities landscape in Serbia today

University of Novi Sad

- Faculty of Sciences



Novi Sad

University of Belgrade

- Institute of physics in Belgrade
- Faculty of Physics in Belgrade
- "Vinca" Institute of nuclear sciences



Belgrade

University of Kragujevac

- Faculty of Sciences



Kragujevac

University of Nis

- Faculty of Sciences



Nis

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Theory of particles & fields

- theories of gravity, non-commutative space-time
- quantum gravity with multi-messenger approach

High energy particle physics

- pp collisions @ LHC: ATLAS, CMS
- HI collisions: ALICE, CMS, CERES
- Detector R&D for HL-LHC
- Others: SHINE, SHIP

Nuclear & astro-particle physics

- Experiments @ ISOLDE facilities
- Ultra-relativistic/nuclear theory
- Others: DUNE, BAIKAL

Future HEP projects

- R&D and physics @ FCC & CepC
- Other projects: ILC, MICE

Particle physics (theory, LHC)

more details in talks by
M. D. Ciric, J. Jovicevic,
V. Milosevic & V. Rekovic

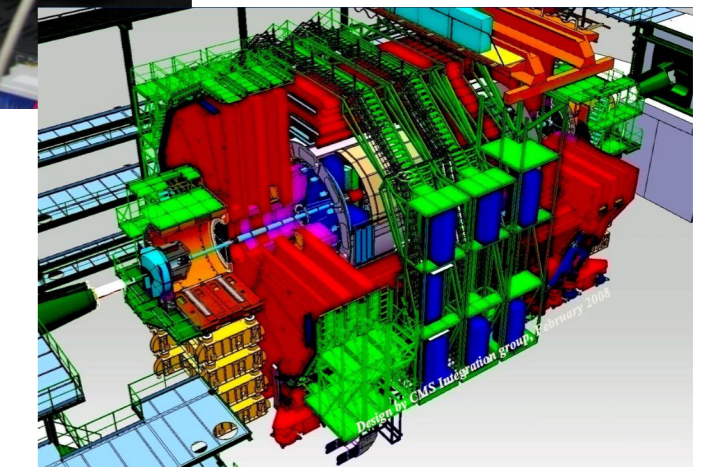
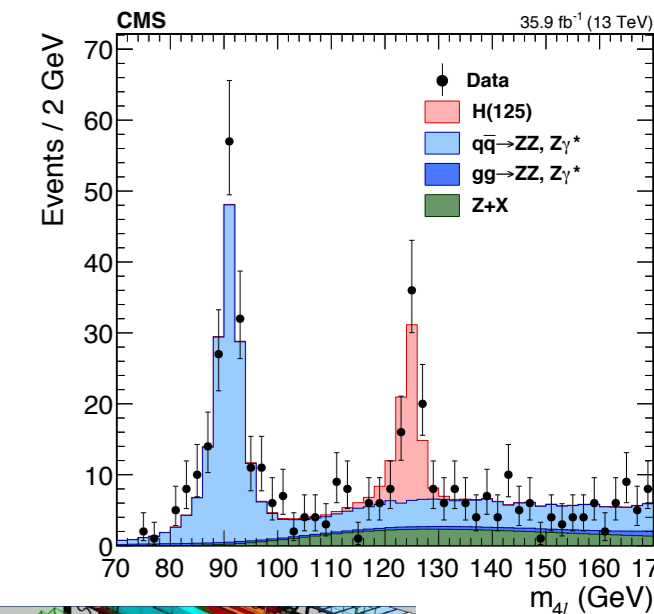
Theory of particles & fields:

- **Participating universities:**
Belgrade: 18 researchers, 11 PhD/master students.
Nis: 4 researchers, also external members.
- **Research areas:** Alternative gravity theories, non-commutative field theories, black holes, extra dimensions.



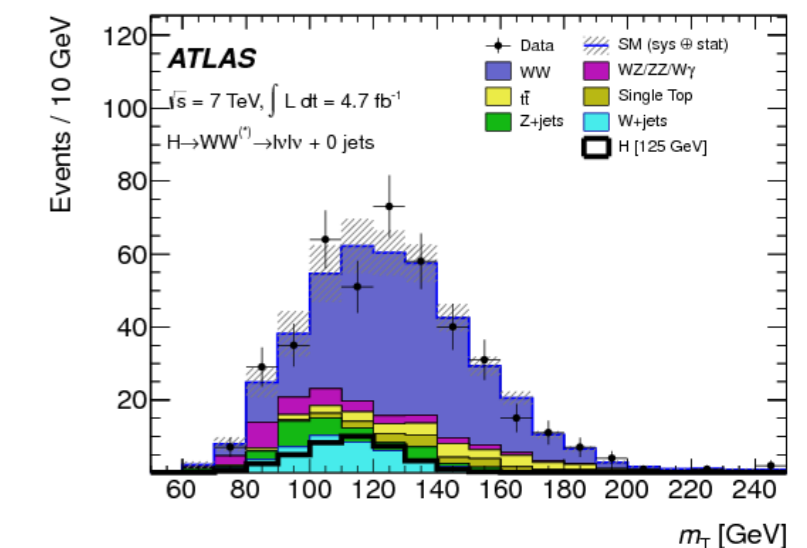
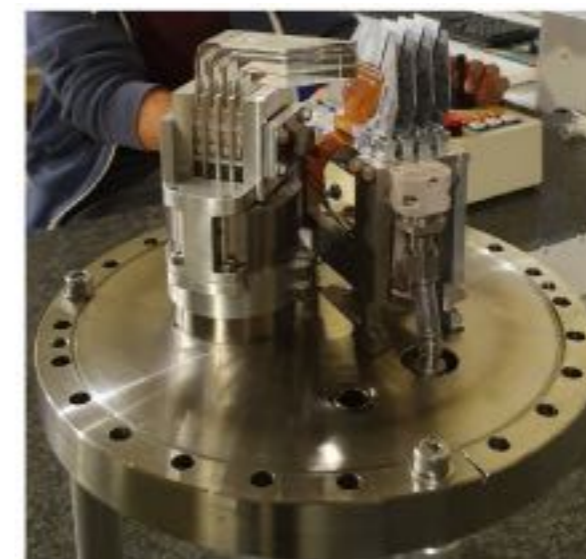
CMS Experiment:

- **Home institutes:** Faculty of Physics (FFUB), "Vinca" INN (VINS).
FFUB: 15 researchers/engineers, 5 PhD/master students.
VINS: 8 researchers/engineers, 2 master students.
- **Physics program:** FFUB+VINS: SM, Higgs boson, and BSM physics.
VINS: Heavy Ion collisions physics.
- **Detector:** FFUB: Development, maintenance, operation of control systems.
Mechanical 3D design for CMS detectors & services.



ATLAS Experiment:

- **Home institutes:** Institute of Physics Belgrade (IPB).
IPB: 8 researchers/engineers, 4 PhD/master students.
- **Physics program:** SM, top quark, Higgs boson, and BSM physics.
- **Detector:** Mechanical design/production for AFP/ALFA.

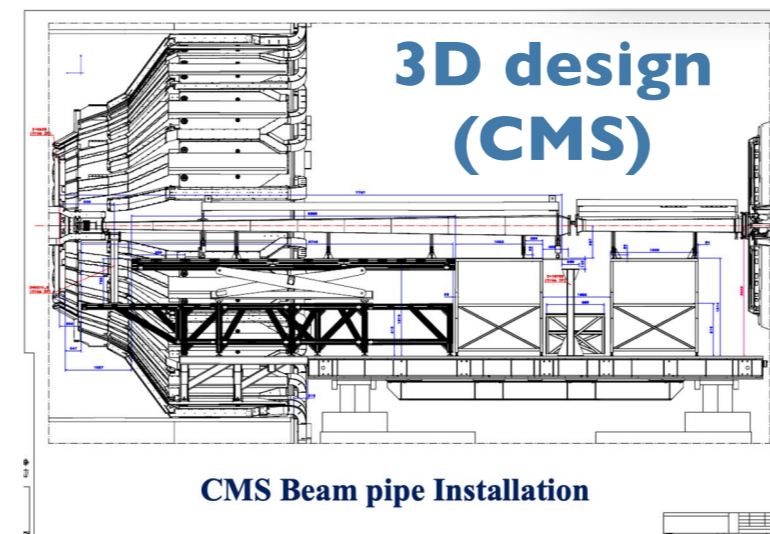
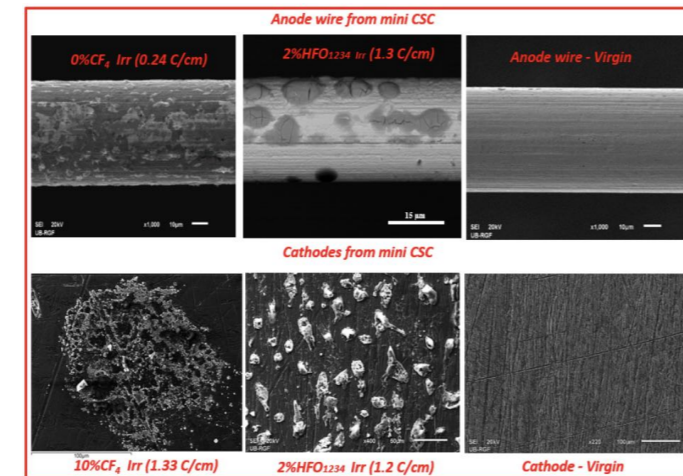
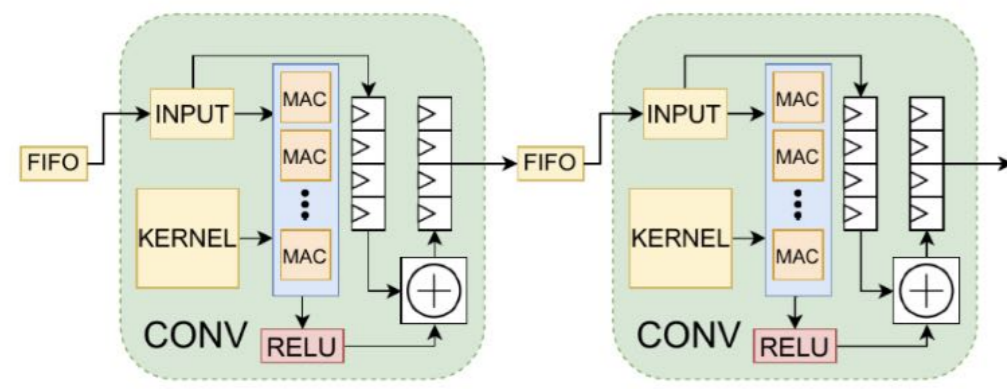
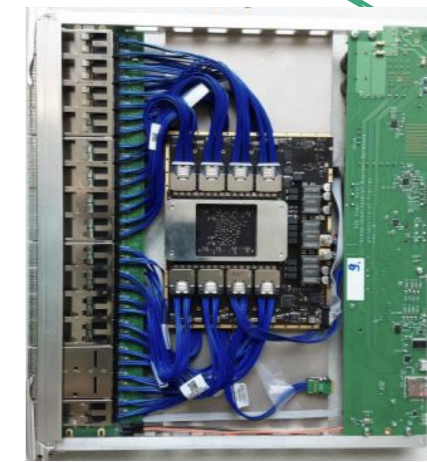


Future projects (HL-LHC & beyond)

more details in talks by
J. Jovicevic, V. Milosevic,
V. Rekovic & I. J. Bozovic

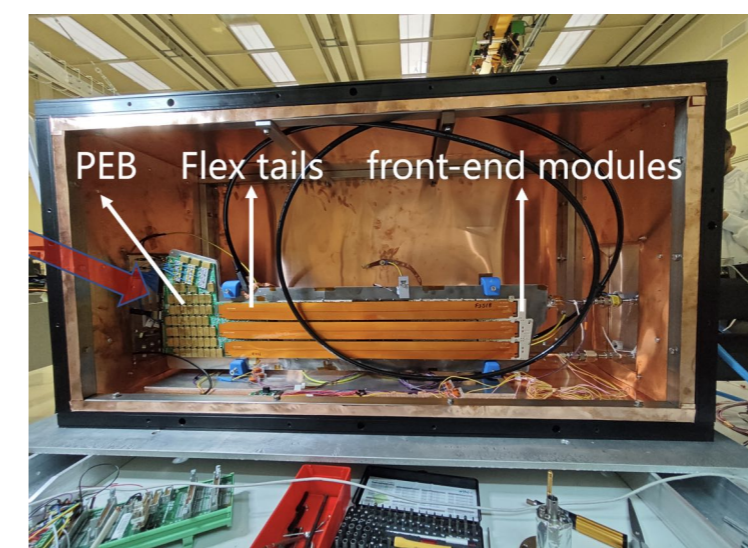
HL-LHC - Detector R&D - CMS:

- Detector control and safety systems: for testing, integration, production.
- ECAL readout electronics: screening, testing, calibration, integration.
- Muon chambers: physiochemical measurements, modelling, simulations, eco-gas searches.
- LI Trigger: prototyping & developments.



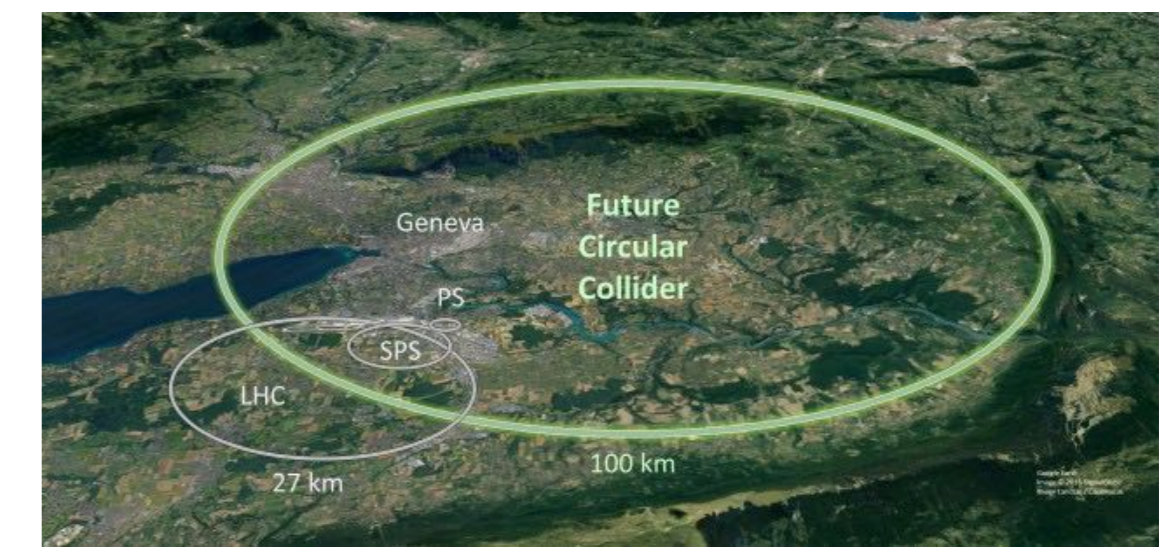
HL-LHC - Detector R&D - ATLAS:

- HLT Trigger: prototyping & developments.
- HGTD: Control system, demonstrator testing/LVPS.
- ZDC: design & production of portable shielding.



Future HEP projects:

- Participating teams: VINCA, IPB, FFUB
- Projects: CLIC (2012-), MICE (2015-2017), CepC (2016-), FCC (2023-)
- R&D program for future colliders: Higgs boson physics studies, simulations, integrated luminosity measurements.

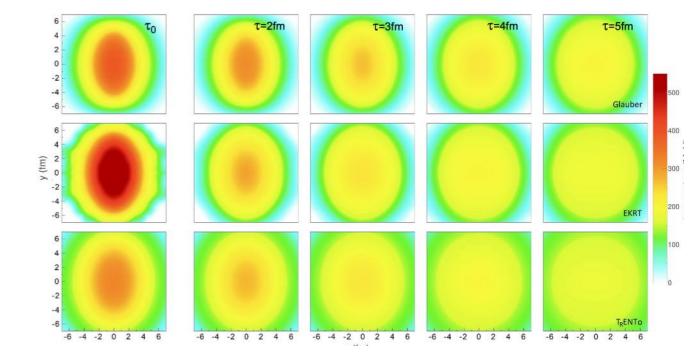
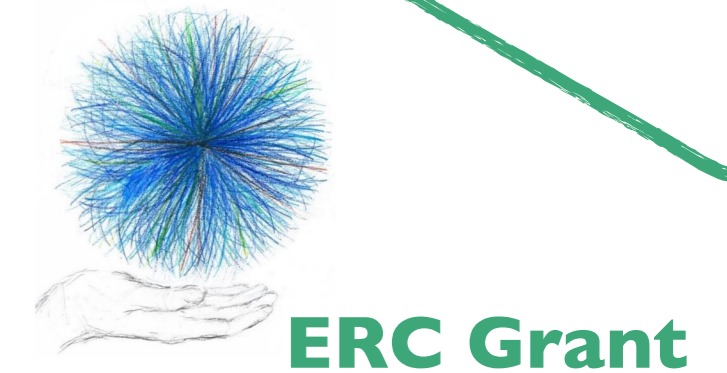


Nuclear, neutrino, astro-particle physics

more details in talk by
M. Djordjevic, J. Nikolov,
N. Todorovic

Nuclear physics (theory & experiments):

- **Participating institutions:** University of Novi Sad, Institute of Physics Belgrade, Vinca Institute of Nuclear Sciences (9 researchers, 3 PhD students)
- **Physics program (theory, ISOLDE, nucl. structure):**
 - ultra-relativistic and nuclear theory (ERC grant)
 - photo-nuclear & neutron induced reactions, nuclear structure



Neutrino physics experiments:

- **Participating institutions:** University of Novi Sad and Institute of Physics Belgrade (5 researchers, 1 PhD student)
- **Physics program (DUNE / ProtoDUNE):** Testing and calibration of the ProtoDUNE detector and preparation for the main DUNE experiment.



Astro-particle physics experiments:

- **BAIKAL-GVD:** Identification of sources of high-energy neutrinos (7 researchers).
- **DARWIN:** Search and direct detection of dark matter (5 researchers).

Scientific computing

more details in talk
by A. Balaz & V. Rekovic

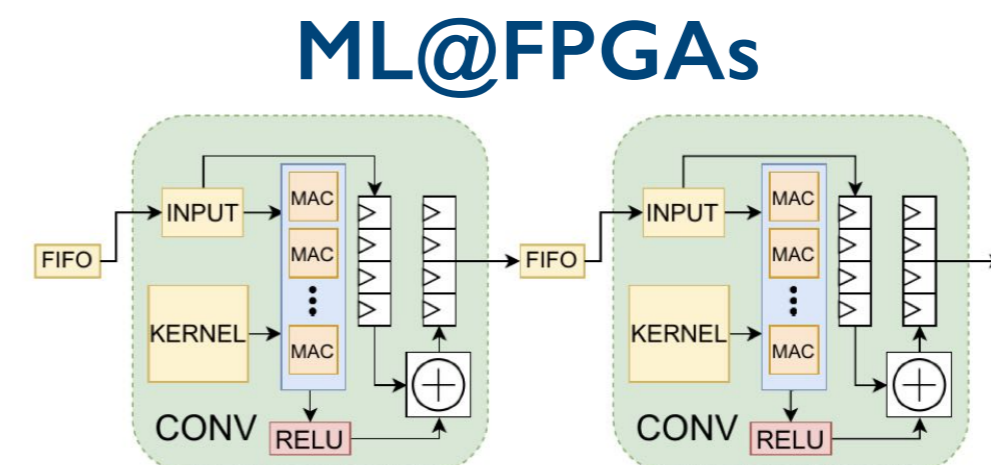
Scientific computing infrastructure & WLCG project:

- **Computing infrastructure:**
 - **PARADOXs @ Institute of Physics:** 1.7k cores, 106 GPUs, infiniband 100Gb/s 32 researchers, scientific computing, members of EuroHPC.
 - **State Data Center @ Kragujevac:** state-of-the-art DC (TIER-4 rated) member of the Nordic Data Grid Facility, resources available for researchers.
- **WLCG:** Tier-3 (2006 - 2014), establishing Tier-I (MoU signed in Dec 2023).



Advanced computing technologies (IPB, FFUB):

- **AI/ML & specialised accelerators:**
 - **Development of tools:** ML@FPGAs, "ML on-demand" service, training/architecture optimisation.
 - **Specialised accelerators:** exploring application in HEP.
- **Exploration of quantum technologies:**
 - Application of quantum technologies/algorithms in HEP (cooperation with Vienna, MIT, CERN).



Science education & outreach

more details in talk by
G. Djordjevic

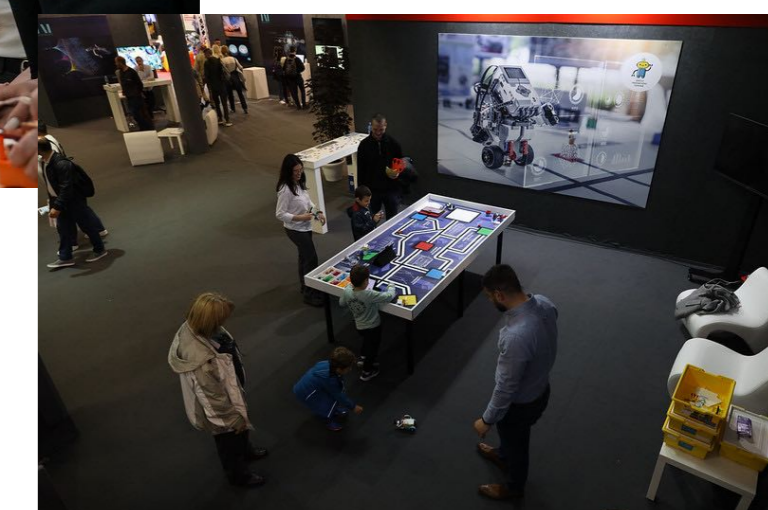
Science education:

- **High-school teacher programs @ CERN:** High-school teachers program every 3-4 years (financed by MoSTDI).
- **High-school student programs with CERN:** IPPOG IMC high-school students program yearly (since 2009). Pilot internship program for high-school students (in 2022).
- **Academic studies:** Low and decreasing number of students enrolling for academic studies (experimental/theoretical/applied physicists, physics teachers).



Science communication and outreach activities:

- **Science communication:** Part of the EPPCN (via IPB).
- **Public events:** Public lectures, forums, panels, CERN events.
- **Outreach:** Center for the promotion of science (CPN) organises numerous expositions & science shows at science festivals, researcher's nights, and science & technology fairs each year (financed by MoSTDI).



Funding mechanisms for HEP projects

more details in talks by
MoSTDI & SF

MoSTDI funding and Science Fund projects:

- **MoSTDI (and MoF):**
Regularly: CERN, MoUs (ATLAS, CMS, Upgrades, FCC, WLCG), researchers (salaries, modest travel/material costs).
- **National Science Fund (SF):**
Occasionally: Individual projects (1x FC, 2x TH, 1xD).

major
funding



Ministry of Science, Technological
Development and Innovation
of the Republic of Serbia



Science Fund
of the Republic of Serbia

International projects & cooperations:

- **EU projects/funding:**
Occasionally: 1x ERC project, 1x MCS project, 7x COST actions.
- **International cooperation agreements:**
INFN (LHC, FCC, ET), IHEP (CepC), Beijing (CMS), ETHZ (CMS).
- **Joint PhD programs:**
Occasionally: Joint funding with partnering institutions (Italy, France, Netherlands).

important
for R&D



European Research Council
Established by the European Commission



CERN funding & training programs:

- **Technical & PhD students:** 2x technical students per year; so far only 2x CERN PhD students.
- **Fellowships:** 2x engineering fellow per year, 0.5x research fellow per year.
- **Associateships (project, corresponding, scientific):**
Occasionally: in average 1 project or corresponding associate per year.

important
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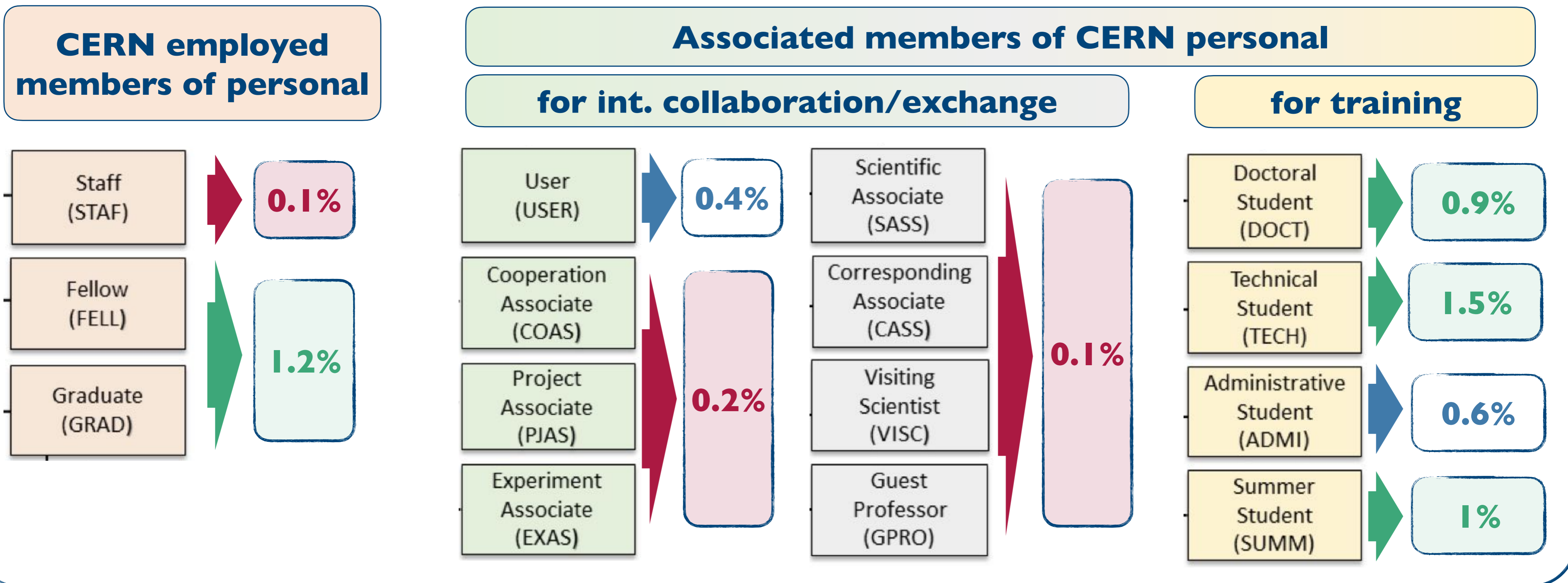
Dominant source of funding
for R&D and work at CERN

CERN personnel from R. Serbia

Associated/employed members of CERN personnel from R. Serbia:

- **Stability & balancing** (w.r.t. the contribution of R. Serbia to the CERN budget 0.29%):
Stable over the last 5 years. Positively balanced in several areas (annual report 2023).
- **Several areas would benefit from improvement:**
Poorly balanced in CERN long-term contracts and associateships for collaboration & staff exchange.

Fraction of CERN personnel from R. Serbia for period 2019 - 2023



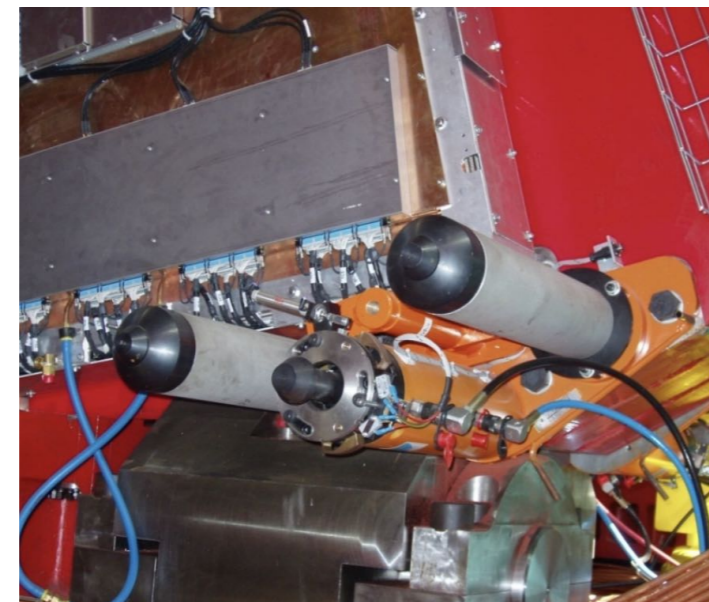
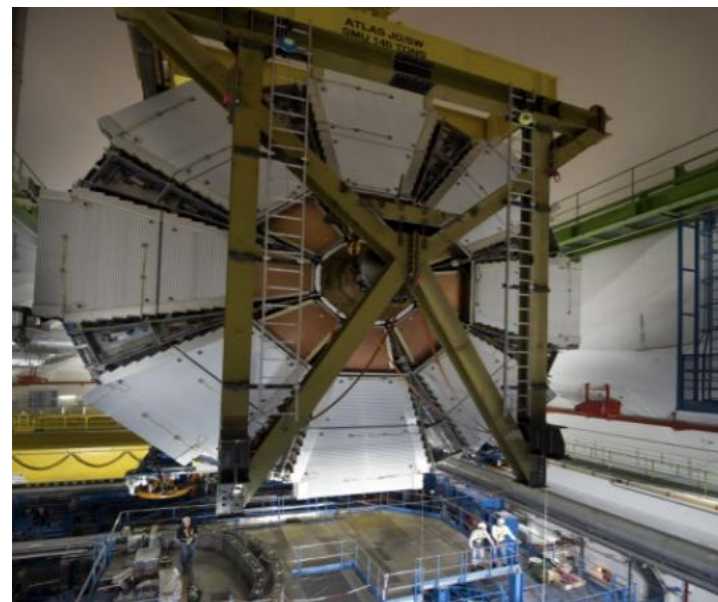
Cooperation with industry

more details in talks by Serbian CERN ILOs

Serbian industry - cooperation with CERN:

- **Serbian ILOs @ CERN:**
Dj.Vukovic (Institute of Physics in Belgrade), A. Raicevic (Chamber of Commerce and Industry of Serbia).
- **Engagements of industry:**
 - **Modest industrial return - Serbia is categorised as "poorly balanced" CERN member state.**
 - **Fluctuations over the years due to limited number of suppliers and service providers.**

Industrial supplies for LHC (ATLAS, CMS) and HL-LHC

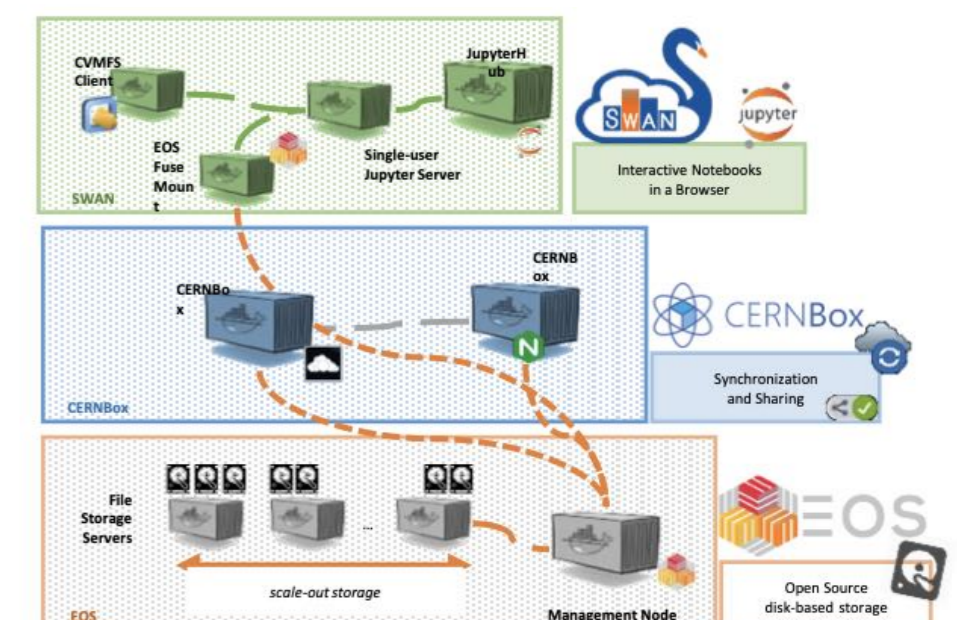


Industrial return (supplies, 2019-2023)



Development & applications of new technologies with CERN:

- **Serbian KT contacts @ CERN:**
Dj.Vukovic (Institute of Physics in Belgrade), V.Artiko (University of Belgrade).
- **Engagements in development of new technologies:**
Modest engagement, predominantly by the IT industry (software, hardware).
Successful example: Comrade & CERN OpenLab development of EOS.



Challenges & concerns for HEP in Serbia

Funding of R&D programs and engagement in HEP

- **Limited mechanisms for long-term funding of R&D programs**
Inhibits consistent institutional involvements and prevents any major capacity/expertise building.
- **Limited support for international representation or for joining future projects**
Need of additional funding for delegates to international committees (CERN Council, ECFA, NuPECC, ApPEC), as well as additional funding for new/future projects & collaborations (DUNE, DRDs, IPPOG).

Education, training, employment:

- **Limited investment in education of teachers & training of young researchers/engineers**
Inhibits development of interest in STEM, and establishing the expertise in key research/engineering domains.
- **Non-flexible legal procedures for recruiting technical staff & engineers**
Inhibits institutional involvements in engineering projects and R&D activities.
- **Non-flexible legal procedures for hiring international researchers**
Prevents possibility for enlarging the expertise and human resources with international candidates.

Return of investments at CERN:

- **Insufficient industrial return on investments and usage of KT potential at CERN**
Need to establish mechanisms/procedures/practices to improve the overall return.

Other concerns:

- **Disfavouring legal frameworks (in terms of salaries and taxes on international sources)**
Disfavour researchers from abroad due to high taxes on grants & pensions/salaries from CERN & other IOs.

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Ideas towards the future

Build research & engineering capacities by establishing:

- Yearly programs for education of high-school teachers/students in the R. Serbia & at CERN.
- Yearly programs for training of young researchers/engineers co-funded with CERN.

Enable research & engineering activities by establishing:

- **Mechanisms for funding the long-term R&D programs in HEP.**
- Financial & procedural support for recruiting and engagement of engineers in engineering activities.

Optimise cooperation with CERN by establishing:

- Suitable mechanisms to improve industrial & innovation activities of Serbian companies at CERN, and to improve recruitment of personnel from the R. Serbia by CERN.



President of the Republic of Serbia at the occasion of the celebration of CERN's 70th anniversary indicated that: **R. Serbia should improve the support and engagement of the Serbian researcher/engineers at CERN, as well as improve industrial cooperation with CERN, and exploit the full potential offered by the membership at CERN.**



Additional material

Contacts @ CERN

CERN:

CERN Council: Dr. Peter Adzic, H.E. Mr. Milan Milanovic

CERN Finance Board: Miroslav Zotovic

LHC RRB: Dr. Peter Adzic

Advisory Committee of CERN Users: Dr. Dragoslav Lazic

ECFA representatives:

Restricted ECFA: Dr Lidija Zivkovic

Plenary ECFA: Dr Predrag Milenovic

ECFA ECR: Veljko Maksimovic, Jovan Mitic, Ema Maricic

CERN Industry & KT Liaisons:

Industry liaison officers: Dr Djordje Vukovic, Ms. Ana Raicevic

KT liaison officers: Dr Djordje Vukovic, Dr Vera Artiko

CERN Education & Outreach programs:

European Particle Physics Communication Network: Mr. Slobodan Bubnjevic

Teachers and students program: Dr Predrag Milenovic, Dr Dusko Latas

R. Serbia personnel at CERN - from annual report 2023

CERN Summer students with nationality of R. Serbia (2019-2023)

Nationality	Year					Total
	2019	2020	2021	2022	2023	
RS	2	4	2	3	4	15
Total	344	354	292	332	348	1,670

CERN Technical students with nationality of R. Serbia (2019-2023)

Nationality	Year					Total
	2019	2020	2021	2022	2023	
RS	3		3	5	2	13
Total	154	183	185	140	185	847

CERN Fellows with nationality of R. Serbia (2019-2023)

Nationality	Year					Total
	2019	2020	2021	2022	2023	
RS	5	2	3	5	7	22
Total	262	311	367	404	509	1,853

CERN personnel with nationality of R. Serbia (by type, 2023)

Nationality	Graduates and Fellows		MPA (excl. Users and MPA training)		MPA training		Users		Grand Total	
	HC	%	HC	%	HC	%	HC	%	HC	%
RS	10	1.0	2	0.2	8	1.5	48	0.4	68	0.5
Total	1,002	100.0	990	100.0	523	100.0	12,370	100.0	14,885	100.0
%	6.7		6.7		3.5		83.1		100.0	

CERN Users with nationality of R. Serbia (2014-2023)

Nationality	Year									
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
RS	41	42	43	51	50	49	46	46	42	48
Total	10,885	11,454	11,806	12,231	12,569	12,427	11,399	11,175	11,860	12,370

CERN Stuff with nationality of R. Serbia (2019-2023)

Nationality	Year					Total
	2019	2020	2021	2022	2023	
RS		1				1
Total	114	138	149	143	172	716