Съвременно състояние на физиката на елементарните частици в катедра „Атомна физика“

Борислав Павлов
(кат. АФ, ФзФ, СУ “Св. Климент Охридски”)

Групата по неутрино

- проф. дфзн Румен Ценов
- доц. д-р Димитър Колев
- доц. д-р Мариян Богомилов
- гл. ас. д-р Галина Ванкова-Кирилова
- д-р Георги Петков
- д-р Симона Илиева
- Васил Вергилов
- Докторанти: Ивайло Дионисов, Георги Василев, Георги Златинов, Борис Хайдуков, Диляна Сувариева

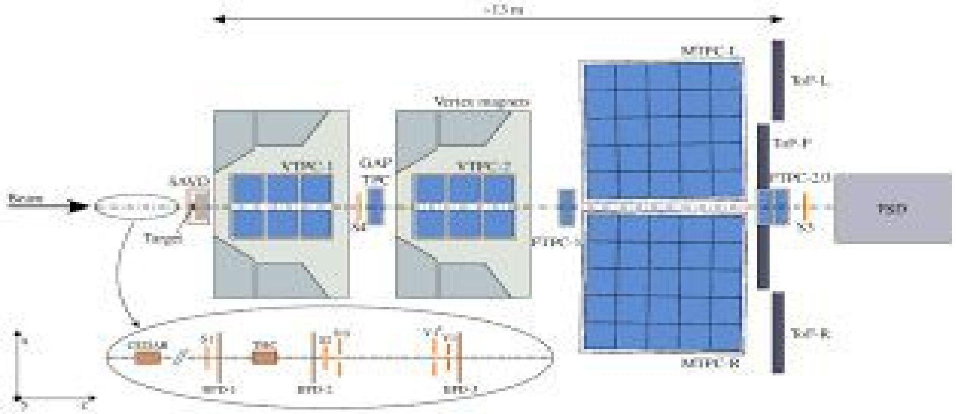
Експерименти

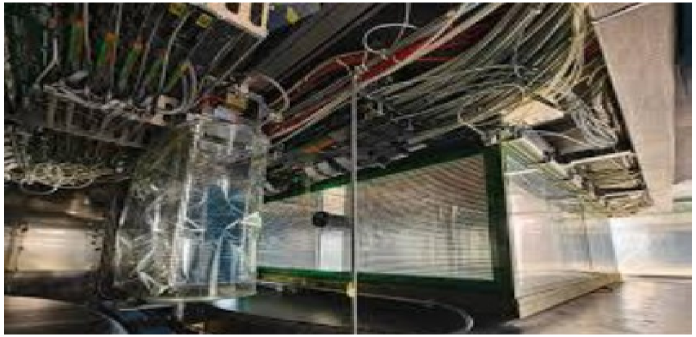
Опит и участие в предишни експерименти и проекти: CHORUS, HARP, OPERA, EUROν/IDS-NF, MICE

Текущи експерименти и проекти: NA61/SHINE, SND@LHC, SHiP, ESSνSB

NA61/SHINE

North Area 61 / SPS Heavy Ion and Neutrino Experiment





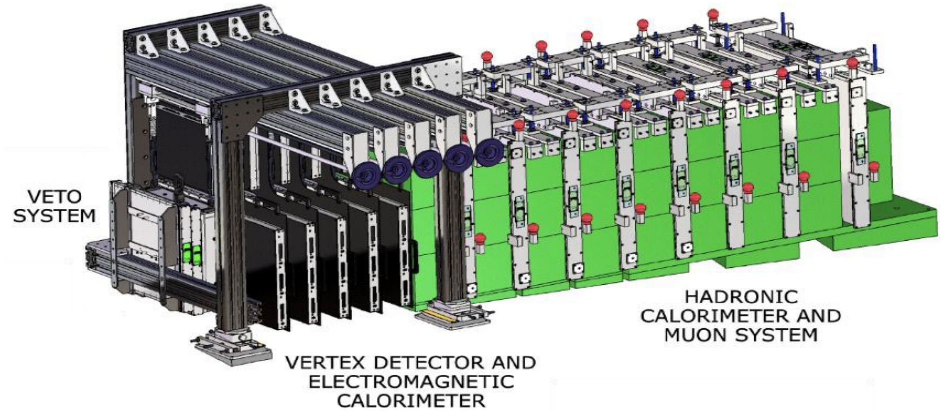
Разположен в ЦЕРН на ускорителя SPS.

Изучава:

- Адронни добиви за нуждите на неутринни експерименти.
- Силни взаимодействия с фокус върху кварк-глуонната плазма.
- Адронни взаимодействия за космични лъчи.

SND@LHC

Scattering Neutrino Detector @ Large Hadron Collider



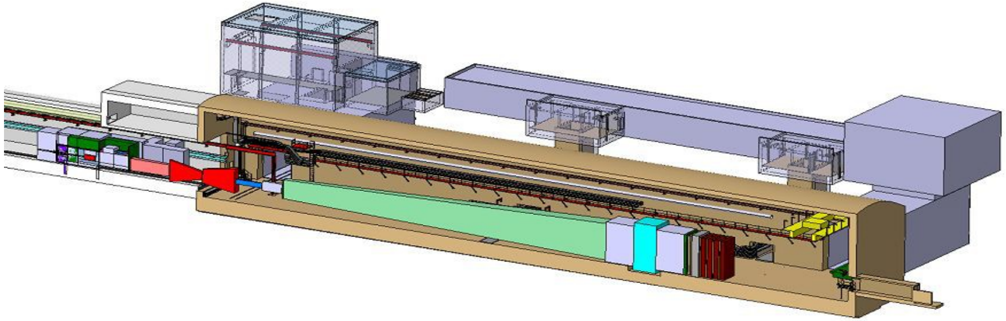
Разположен в ЦЕРН на ускорителя LHC.

Изучава:

- Неутрина, произведени от протон-протонни сблъсъци с псевдо-бързина $7.2 < \eta < 8.4$.
- Търсене на тъмна материя.

SHiP

Search for Hidden Particles

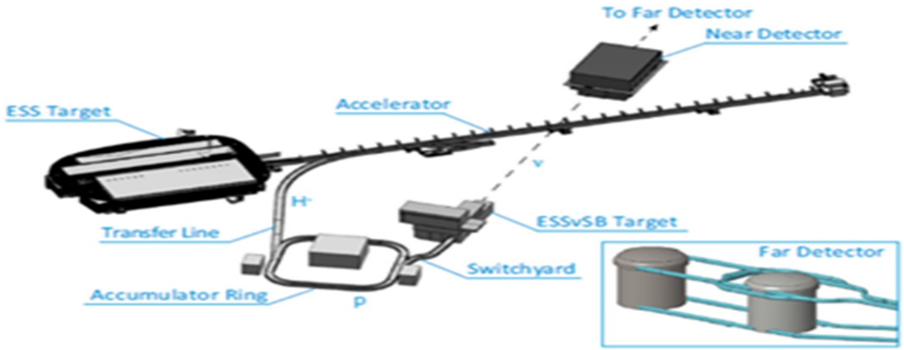


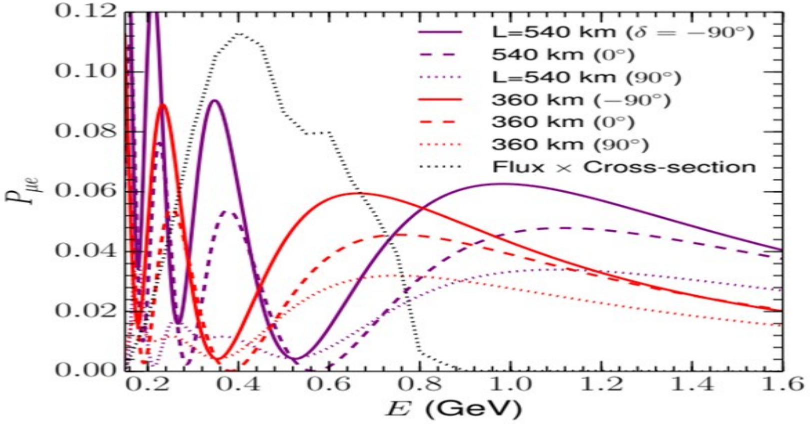
- Одобрен през март 2024.
- Ще бъде разположен в ЦЕРН на ускорителя SPS.

Ще изучава „скрити“ частици, предсказани от голям брой модели за “Скрития” сектор, като ще се опита да обясни тъмната материя, неутринните осцилации и барион-антибарионната асиметрия във вселената.

ESS⊙SB+

European Spallation Source Neutrino Superbeam Plus





Ускорител и близък детектор, разположени в ESS (European Spallation Source) край Лунд, Швеция; Далечен детектор на 360 км от близкия в мината Zinkgruvan, Швеция.

Дългосрочен проект, изследващ:

- нарушението на CP-симетрията в лептонния сектор, за да се разбере асиметрията материя-антиматерия във Вселената
- Неутрина с различен произход

Повече за неутриното

На лов за неутрино *Симона Илиева*

зала "София", Гранд хотел "София", София, България 14:30 - 14:50

Обсъждане на нов възможен експеримент за регистриране на резонансно мьосбауерово електронно неут…
Венцислав Русанов

Статут и перспективи пред експеримента SND@LHC *Ивайло Дионисов*

зала "София", Гранд хотел "София", София, България 11:35 - 11:50

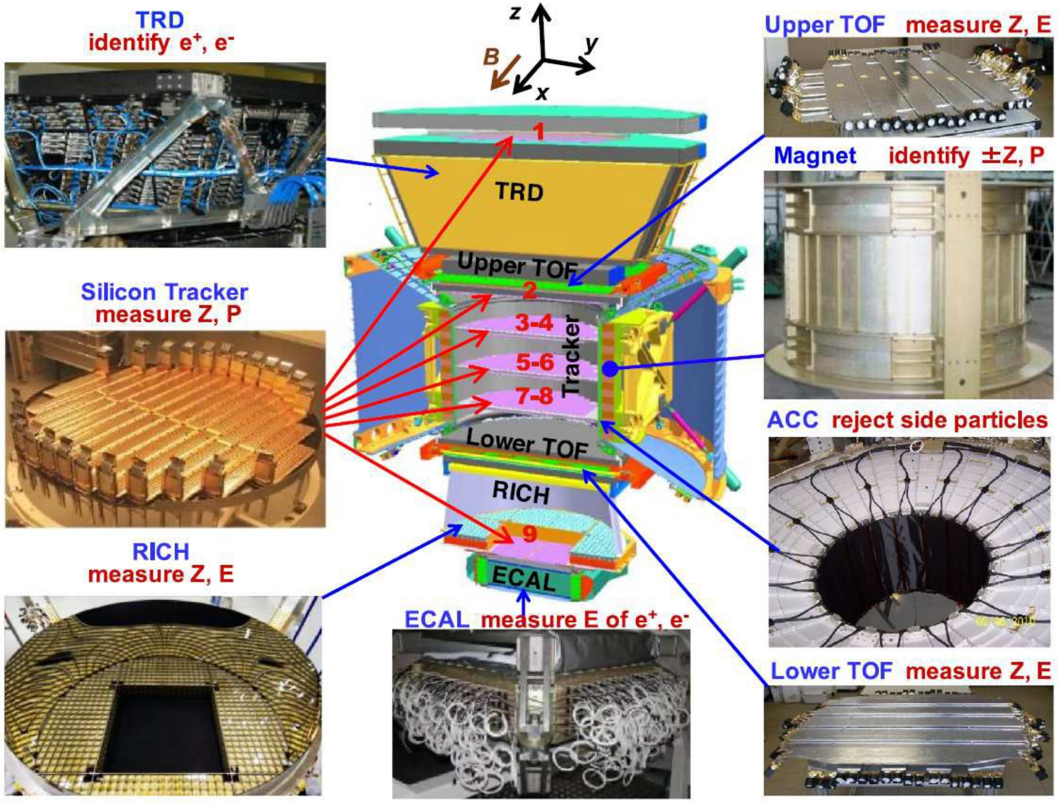
Зараждане на експерименталната физика на елементарните частици в катедра "Атомна физика"
Румен Ценов

Alpha Magnetic Spectrometer (AMS)

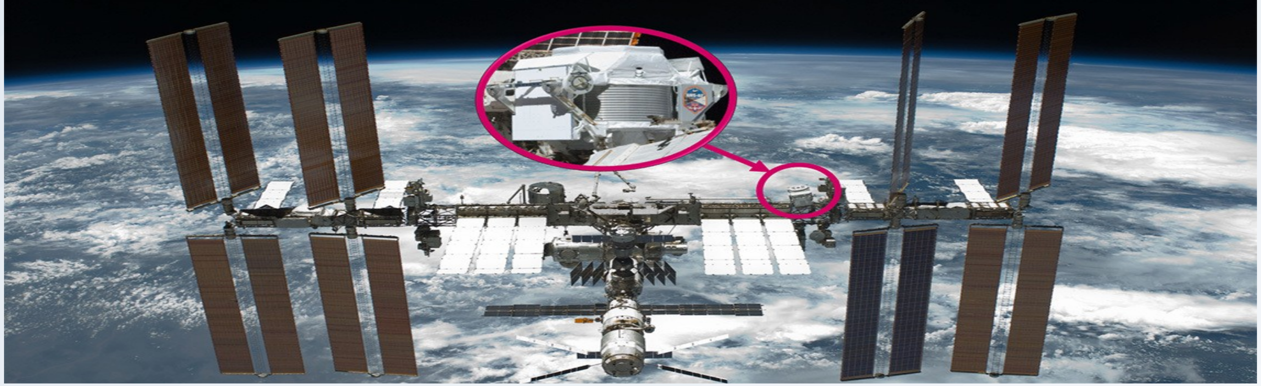
- The alpha magnetic spectrometer (AMS) is a high-energy particle detector to explore:
  - antimatter
  - dark matter
  - the origin of cosmic rays in space

- The AMS-02 spectrometer consists of:
  - Transition Radiation Detector (TRD)
  - Time Of Flight (TOF) with 4 planes of scintillating paddles
  - 9 planes of Silicon Tracker, surrounded by an array of Anti-Coincidence Counter (ACC)
  - Permanent Magnet
  - Ring Image Cherenkov detector (RICH)
  - Electromagnetic Calorimeter (ECAL).

- The AMS collaboration is a joint effort of NASA, CERN, MIT and 41 other institutions.



AMS



The Bulgarian group works on:

- Analysis of AMS data taken for the period 20211 - 2026. The main goal - study of the light antimatter production mechanisms in the Milky Way with the AMS detector;

Analysis of the detector efficiency for:

- positron/proton separation at energies around 1 TeV with TRD and ECAL detectors of AMS.

detection of antideuterons in TOF detector at energies below 2 GeV.

- looking for the optimum discrimination method of background particles detected in the RICH detector.
- Activities are currently ongoing.
- One published paper:

G. Vasilev, G. Vankova-Kirilova, G. Bozhkova, "Optimization of singly-charged particles identification with the AMS02 RICH detector by a machine learning method", Astroparticle Physics, Vol. 171, 2025, https://doi.org/10.1016/j.astropartphys.2025.103134

Повече за AMS

Изследване на лека антиматерия с детектора AMS-02 *Георги Василев*

зала "София", Гранд хотел "София", София, България 12:20 - 12:35

JINR NICA

доц. дфзн Михаил В. Чижов - сътрудничество

Участие в международни колаборации: CHORUS, DELPHI, HARP, OPERA, HERA, CDF, ATLAS.
Сътрудничество с университети: Geneva, Zurich (Швейцария); Paraiba (Бразилия); Brussels (Белгия); Fresno, Irvine (САЩ); Новосибирск (Русия); Lyon (Франция).
Работа в международни научни центрове: ОИЯИ, ICTP, CERN, SISSA, Nordita, PSI, DESY, FNAL.

Участие в ATLAS от ОИЯИ (следващи слайди).

Excited particles (compositeness)

$$L_{\psi^*} = \frac{g^*}{\Lambda}\,\bar{\psi}^*\sigma^{\mu\nu}\psi \cdot (\partial_\mu Z_\nu - \partial_\nu Z_\mu)$$

Searches for excited fermions ψ^* have been performed at LEP, HERA and the Tevatron, and also by the CMS and ATLAS experiments at the LHC.

ψ^* *why not* Z^*?

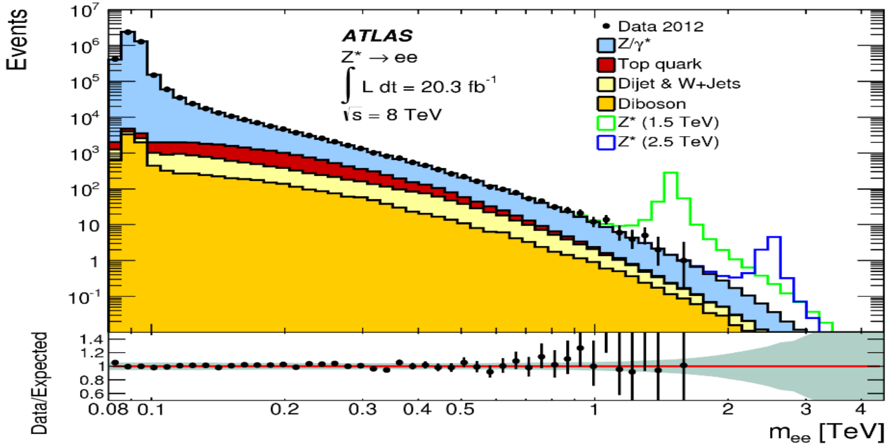
$$L_{Z^*} = \frac{g^*}{\Lambda}\,\bar{\psi}\,\sigma^{\mu\nu}\psi \cdot (\partial_\mu Z^*_\nu - \partial_\nu Z^*_\mu)$$

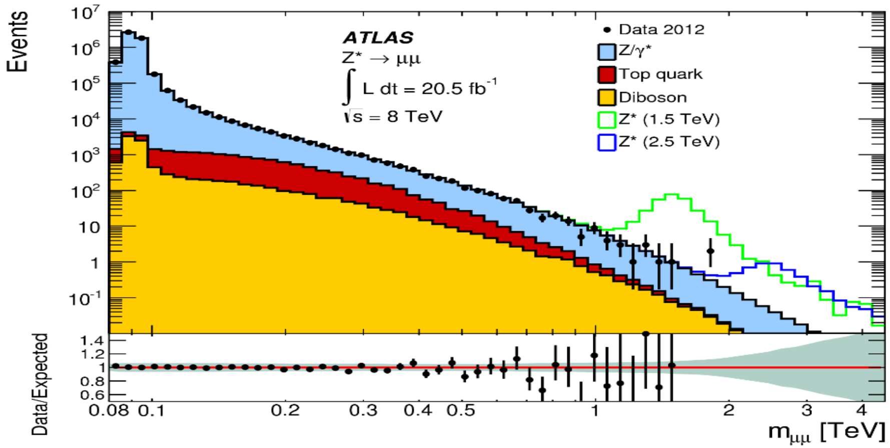
M. C., V. A. Bednyakov, and J. A. Budagov, Proposal for chiral bosons search at LHC via their unique new signature, *Phys. Atom. Nucl.* **71** (2008) 2096; arXiv:0801.4235

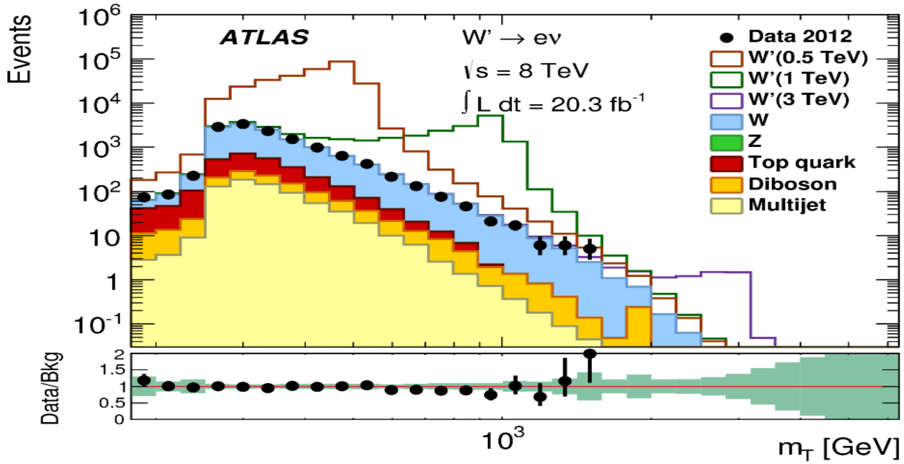
Z^* *has different interactions in comparison with* Z'!

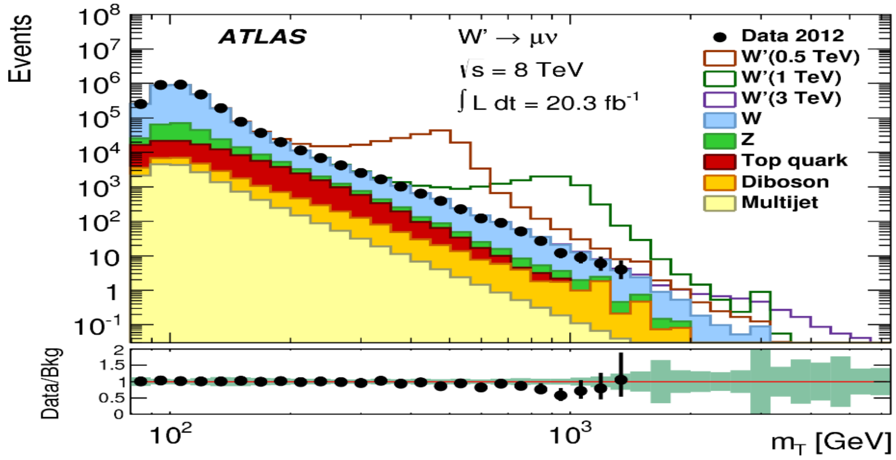
$$L_{Z'} = \bar{\psi}\,\gamma^\mu (g_V + g_A\gamma^5)\psi \cdot Z'_\mu$$

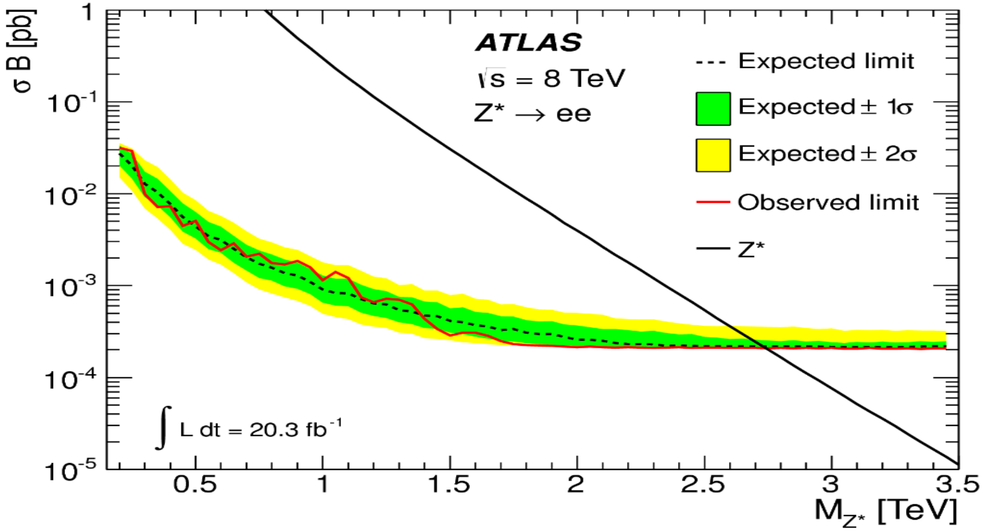
However, the search of new vector bosons in Drell-Yan channels at LHC has not given positive results

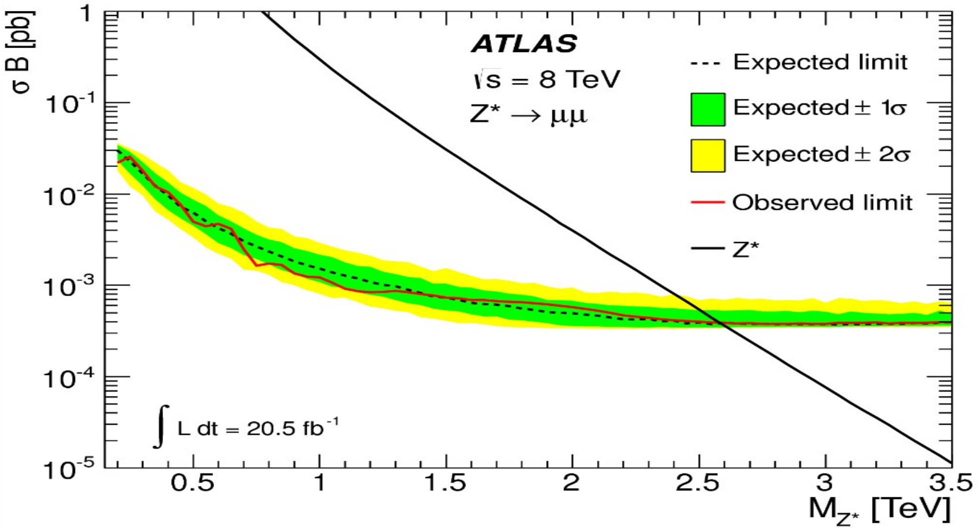


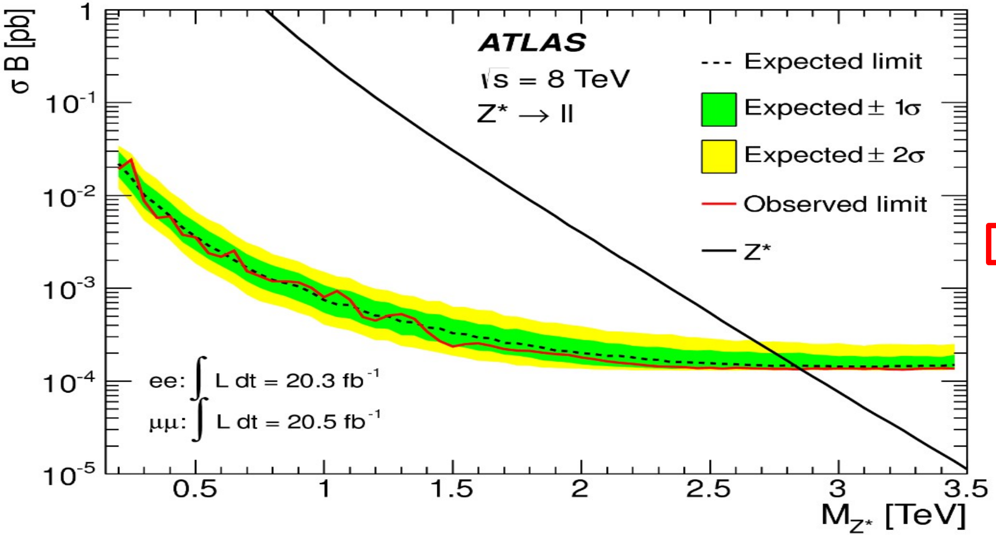






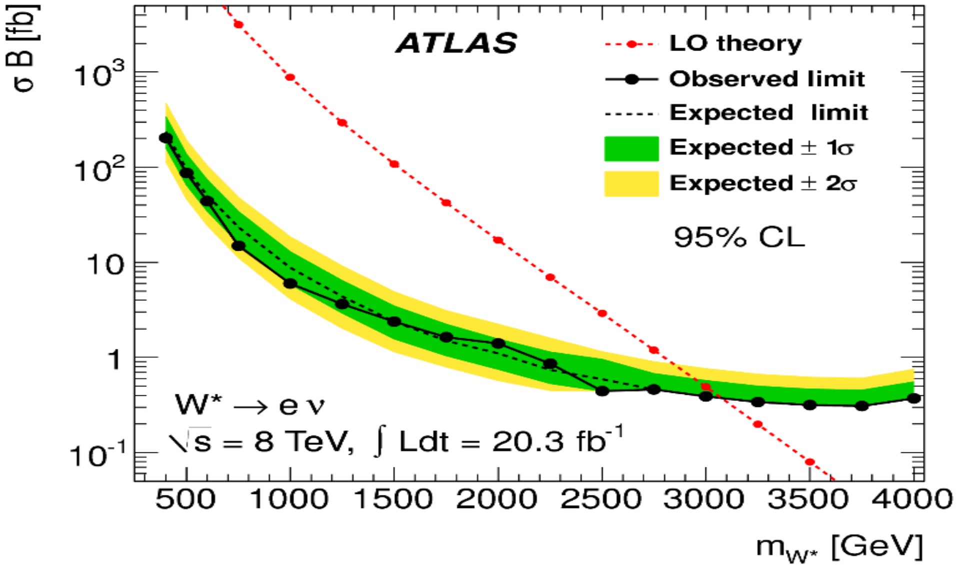


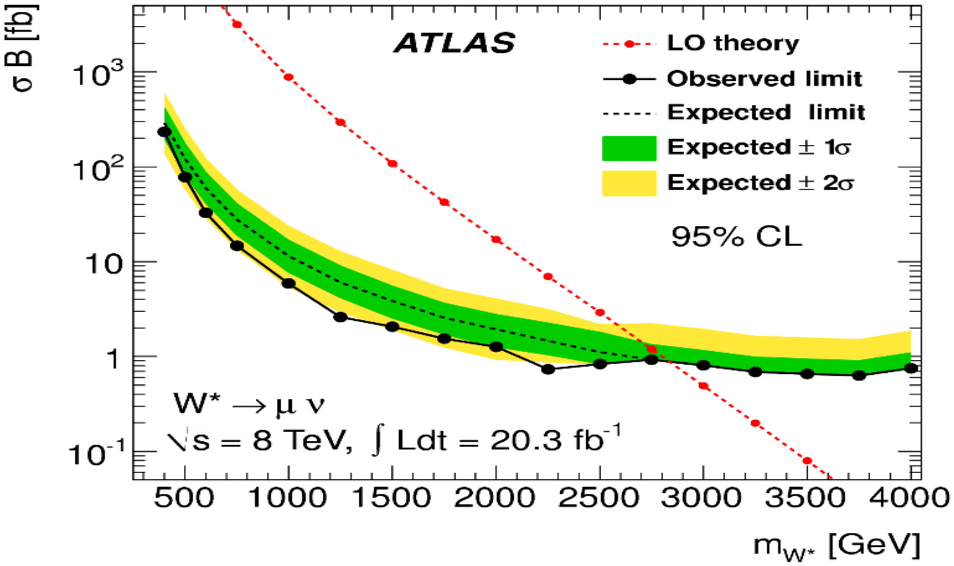


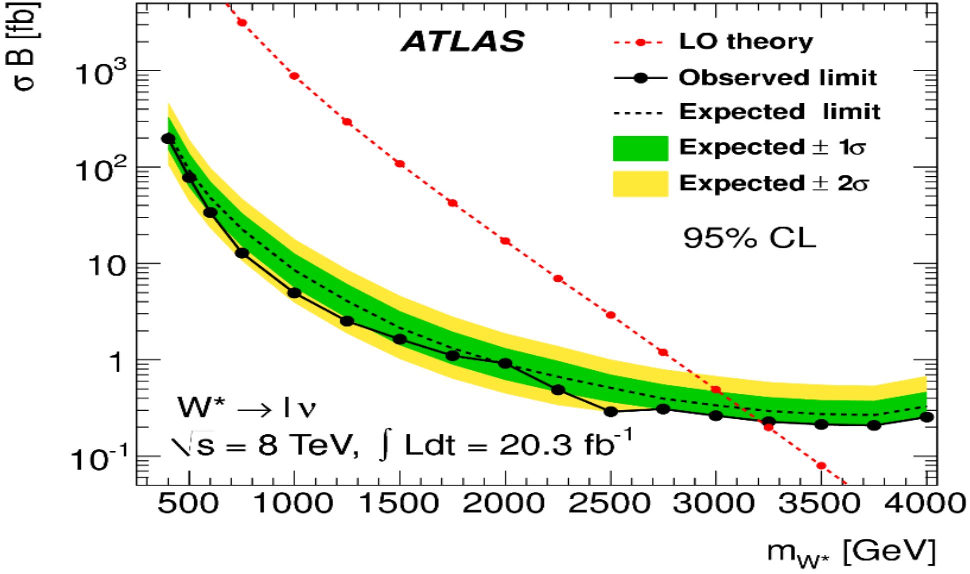


Model	Width [%]	Observed limit [TeV]	Expected limit [TeV]
Z'_{SSM}	3.0	2.90	2.87
Z'_{χ}	1.2	2.62	2.60
Z'_{ψ}	0.5	2.51	2.46
Z^*	3.4	2.85	2.82

The ATLAS Collaboration "Search for high-mass dilepton resonances in *pp* collisions at √s=8 TeV with the ATLAS detector", Physical Review D **90** (2014) 052005



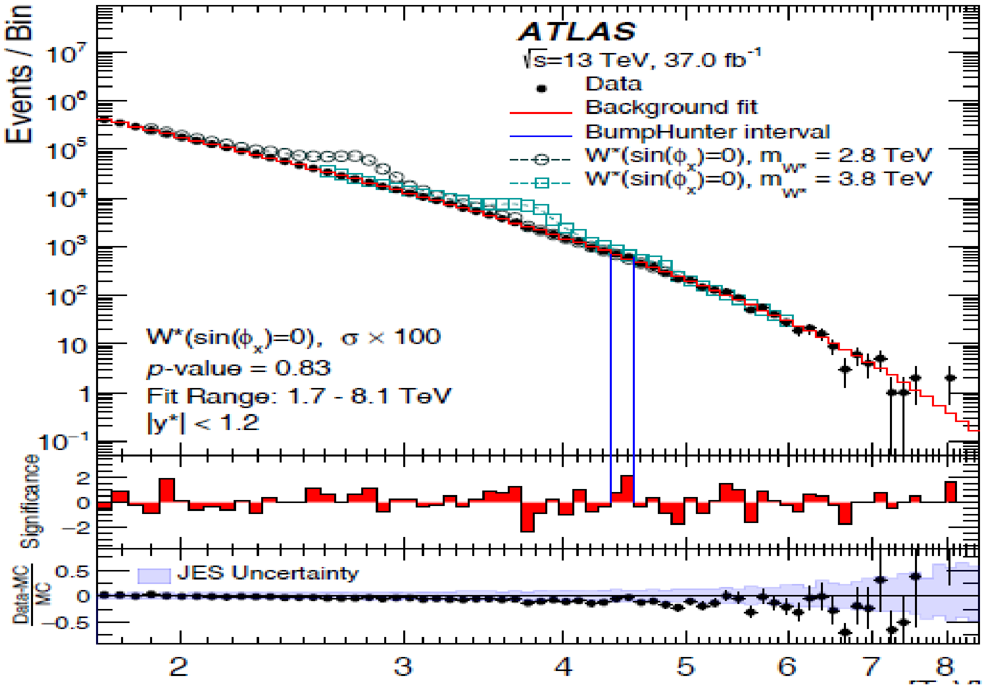


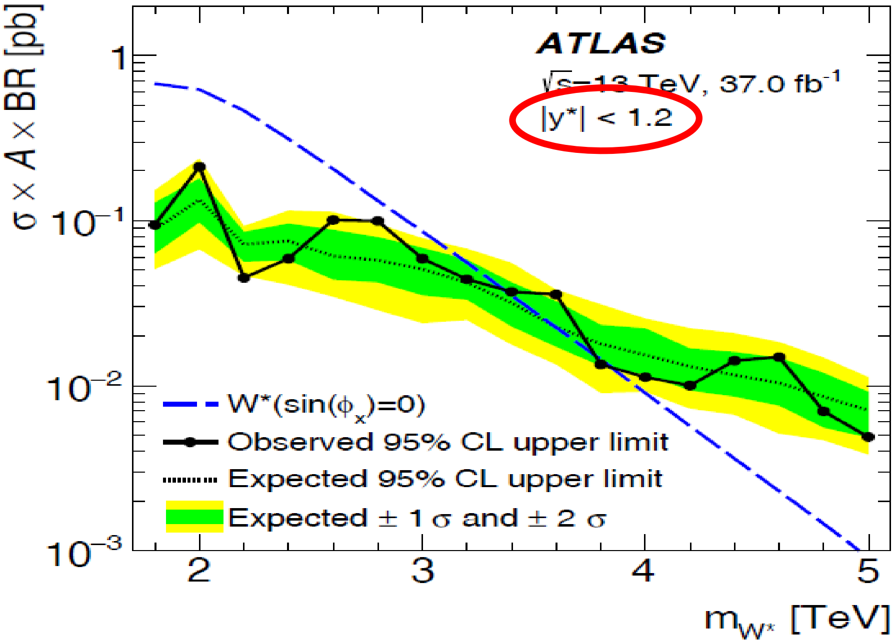


	$m_{W'}$ [TeV]		m_{W^*} [TeV]	
Decay	Exp.	Obs.	Exp.	Obs.
$e\nu$	3.13	3.13	3.08	3.08
$\mu\nu$	2.97	2.97	2.83	2.83
Both	3.17	3.24	3.12	3.21

The ATLAS Collaboration "Search new particles in events with one lepton and missing transverse momentum in *pp* collisions at √s=8 TeV with the ATLAS detector", JHEP **09** (2014) 037

Search for W* bosons in dijet processes also sets strong constraint on W* mass





Model	95% CL exclusion limit	
	Observed	Expected
Quantum black hole	8.9 TeV	8.9 TeV
W'	3.6 TeV	3.7 TeV
W^*	3.4 TeV 3.77 TeV – 3.85 TeV	3.6 TeV
Excited quark	6.0 TeV	5.8 TeV

The ATLAS Collaboration "Search for new phenomena in dijet events using 37 fb^{-1} of *pp* collision data collected √s=13 TeV with the ATLAS detector", Physical Review D **96** (2017) 052004

Example with extra dimensions

Let us consider a doublet of the gauge fields in N-dimension Minkowski space. Then its the fifth and the subsequent components can play a role of the Higgs fields (so-called Gauge-Higgs unification)

$$\begin{pmatrix} W_M^{*+} \\ Z_M^{*} \end{pmatrix} = \begin{pmatrix} W_\mu^{*+}, H^+, \ \dots \\ Z_\mu^{*}\ , H^0, \ \dots \end{pmatrix}$$

N.S. Manton, Nucl. Phys. B **158** (1979) 141;
D.B. Fairlie, J. Phys. G **5** (1979) L55; Phys. Lett. B **82** (1979) 97.

The lightness of the Higgs doublets is guaranteed by the gauge symmetry. This symmetry is spontaneously broken by compactification. In this way the mass of the Higgs doublet is controlled by the compactification scale, as opposed to the high-dimensional cutoff of the theory.

M.V. Chizhov and V.A. Bednyakov, Phys. Atom. Nucl. **79** (2016) 721.

$$L^* = \frac{g^*}{M_{W^*}}(\partial_\mu W_\nu^{*-}\ \bar{b}_L \sigma^{\mu\nu} t_R + \partial_\mu W_\nu^{*+}\ \bar{t}_R \sigma^{\mu\nu} b_L)$$

$$+ \frac{g^*}{\sqrt{2}M_{Z^*}}(\partial_\mu \mathrm{Re}\, Z_\nu^*\ \bar{t}\, \sigma^{\mu\nu} t + i\partial_\mu \mathrm{Im}\, Z_\nu^*\ \bar{t}\, \sigma^{\mu\nu}\gamma^5 t)$$

CP even CP odd

Implemented in MadGraph.

Prediction:

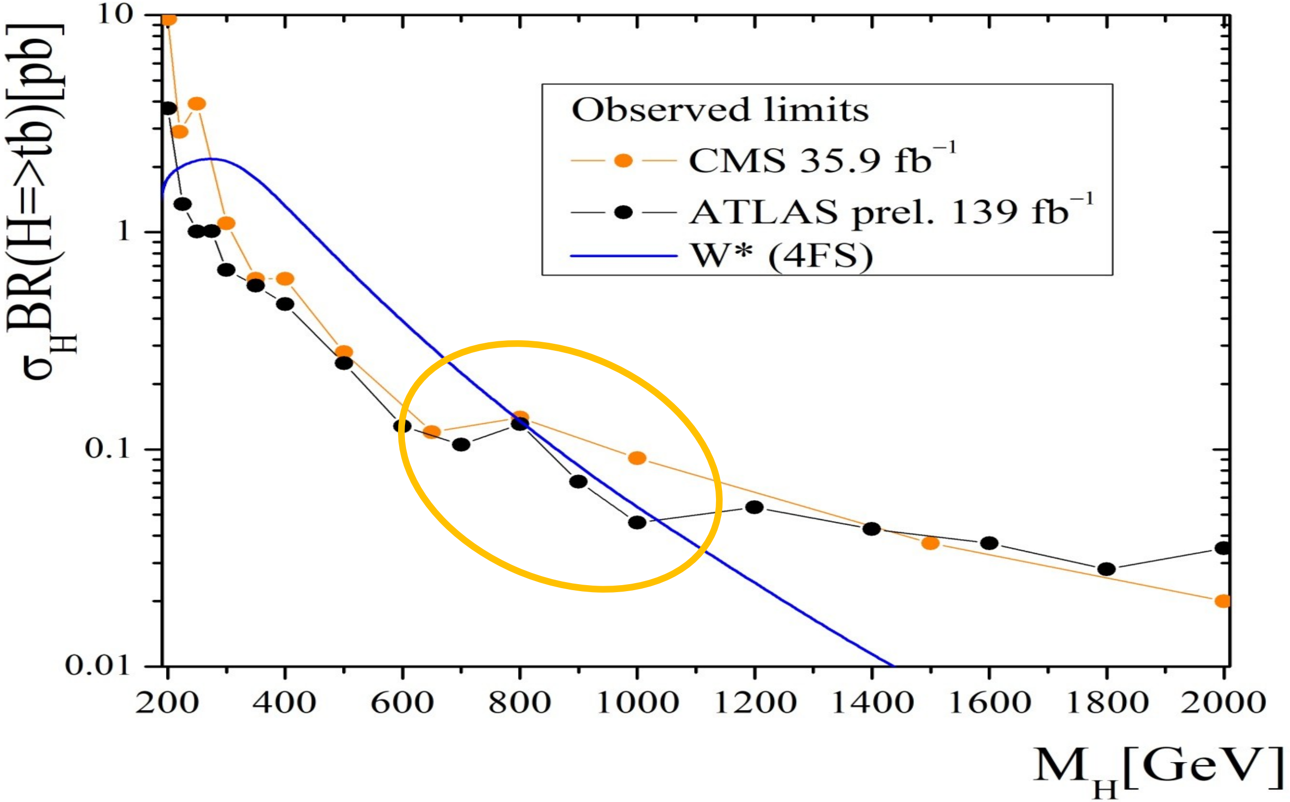
$M_{W^*} \sim M_{Z^*} =$

692^{+144}_{-120} GeV

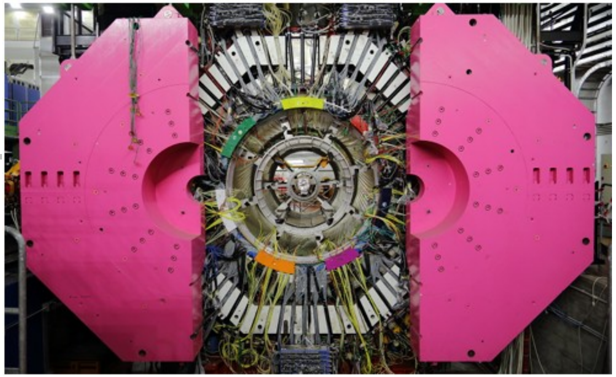
Present sensitivity (139 fb^{-1})

ATLAS: JHEP 06 (2021) 145; CMS: JHEP 01 (2020) 096

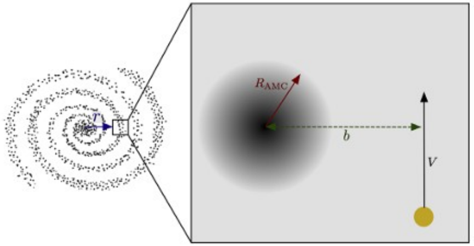
Search for a charged Higgs boson decaying into a top and a bottom quarks at √s=13 TeV in the ATLAS and CMS detectors



гл. ас. д-р Момчил Найденов

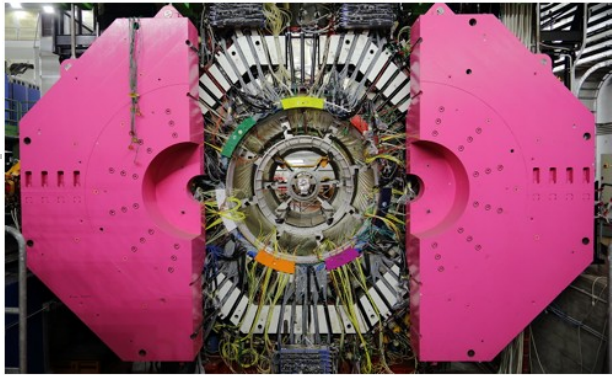


- От 2024 съм в теоретичния състав на експеримента FLASH (Finuda magnet for Light Axion Search with Haloscope), базиран във Фраскати, Италия. Експериментът цели детектирането на аксиони, аксионоподобни частици и гравитационни вълни;
- Разширен модел на квантова електродинамика с огледална група U’(1), предсказваща съществуването на тъмни фермиони с милизаряд. Такива частици могат да бъдат използвани за космологична проба за гравитационни ефекти теорията на полето (в колаборация с колеги от Салерно, Италия);

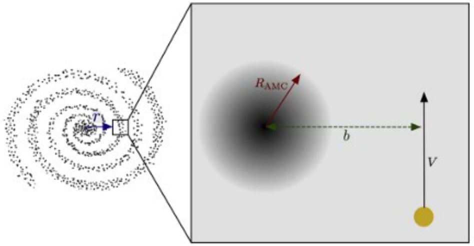


NA62 P326

гл. ас. д-р Момчил Найденов



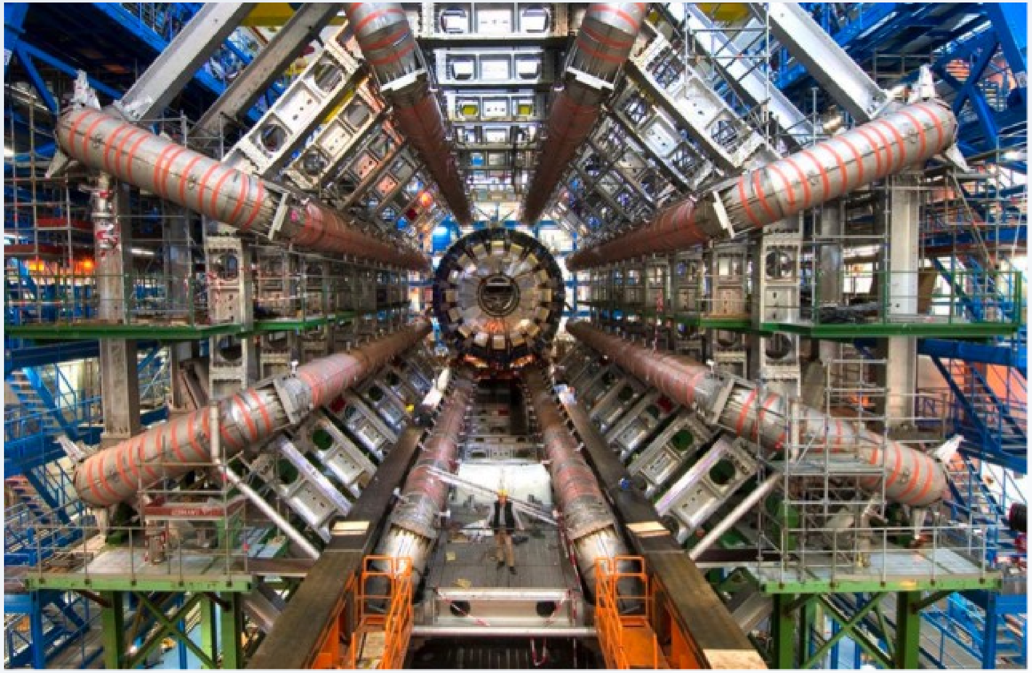
- Детектирането на хипотетични компактни обекти, аксионни клъстери, или потоци от тях, породени в следствие от гравитационно взаимодействие (в колаборация с колеги от Салерно, Италия);
- Влияние на аксиони и аксионоподобни частици във физиката на неутронни звезди (в колаборация с колеги от Roma Tor Vergata, Италия);
- Възможности за детектиране на аксионоподобни частици в експеримента NA62 (в колаборация с колеги от Фраскати).



Повече за ATLAS

Система за разпределени изчисления на експеримента ATLAS *Иван Глушков*

зала "София", Гранд хотел "София", София, България 17:00 - 17:20



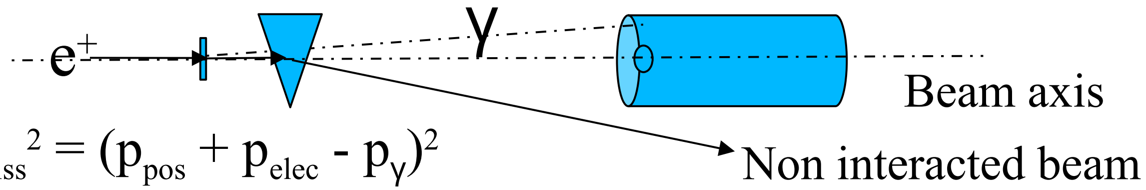
PADME team

- The team:
  - Assoc. prof. Venelin Kozhuharov (Group leader, PADME spokesperson)
  - Assist. Prof. Radoslav Simeonov
  - Kalina Dimitrova, PhD Student
  - Simeon Ivanov, PhD Student
  - Svetoslav Ivanov, PhD Student
  - Katerina Kostova, PhD student
  - Ruslan Nastaev, technician

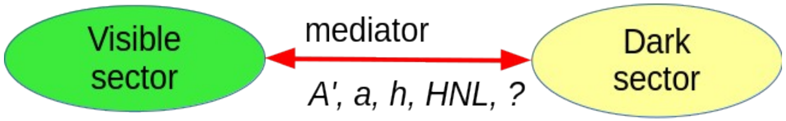
  Theoretical support from head assist. prof. Momchil Naydenov

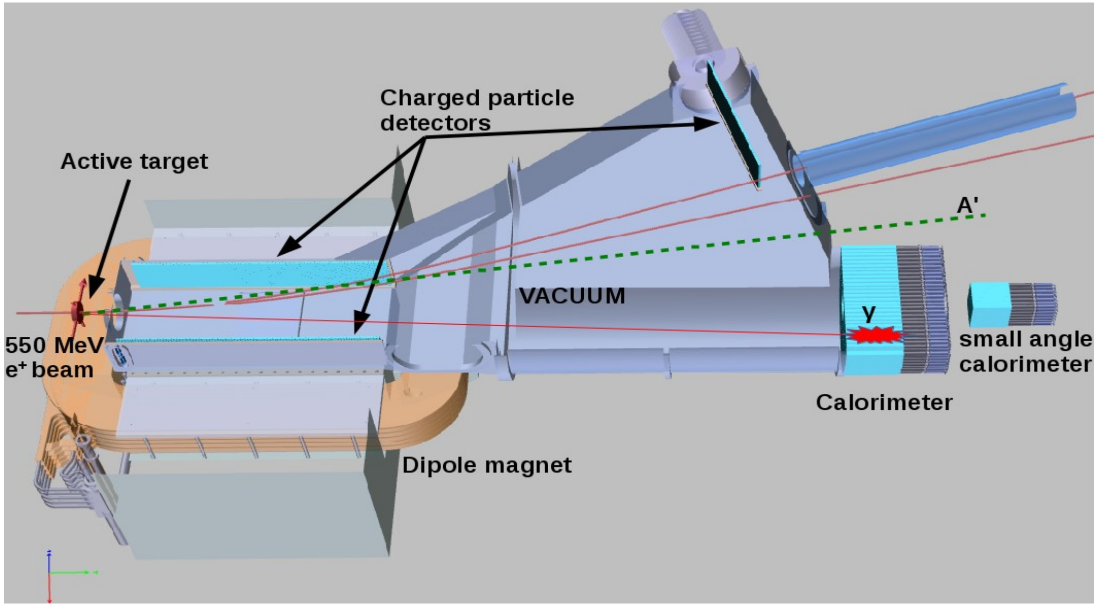
The PADME Experiment @ LNF, INFN

Positron Annihilation into Dark Matter Experiment



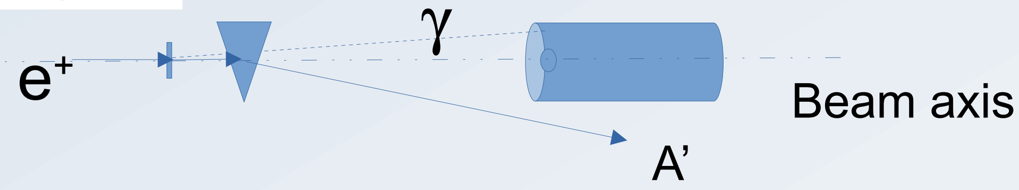
$$M_{miss}^2 = (p_{pos} + p_{elec} - p_\gamma)^2$$





- Small scale fixed target experiment
  - e^+ @ Frascati Beam Test Facility
  - Accelerated e+ interacting in a thin diamond active target
  - Final states: e+, e-, photons
  - Charged particles detectors
  - Calorimeter
  - Beam monitoring system

PADME Run II Dark Photon search

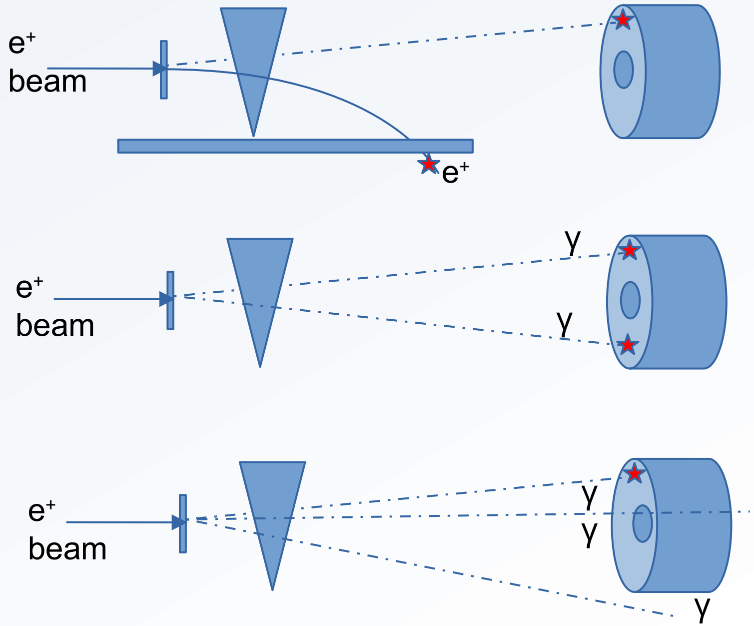


Associated production: $e^+ e^- \rightarrow A' \gamma$
Search for single photon events and calculate the missing mass

$$M_{miss}^2 = (p_{pos} + p_{elec} - p_\gamma)^2$$

Background composition:

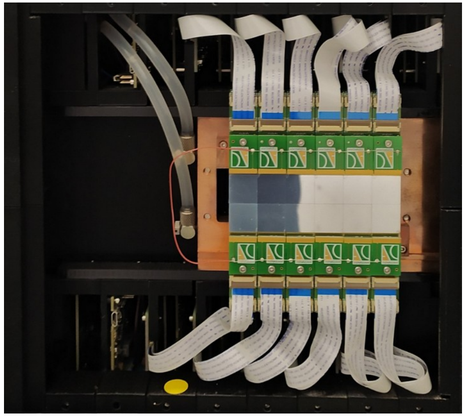
- **Bremsstrahlung in the field of the target nuclei**
  - Photons mostly @ low energy, background dominates the high missing masses
  - An additional lower energy positron that could be detected due to stronger deflection
- **2 photon annihilation**
  - Peaks at $M_{miss} = 0$
  - Quasi symmetric in gamma angles for $E_\gamma > 50$ MeV
- **3 photon annihilation**
  - Symmetry is lost – decrease in the vetoing capabilities
- **Radiative Bhabha scattering**



BG Contribution to PADME

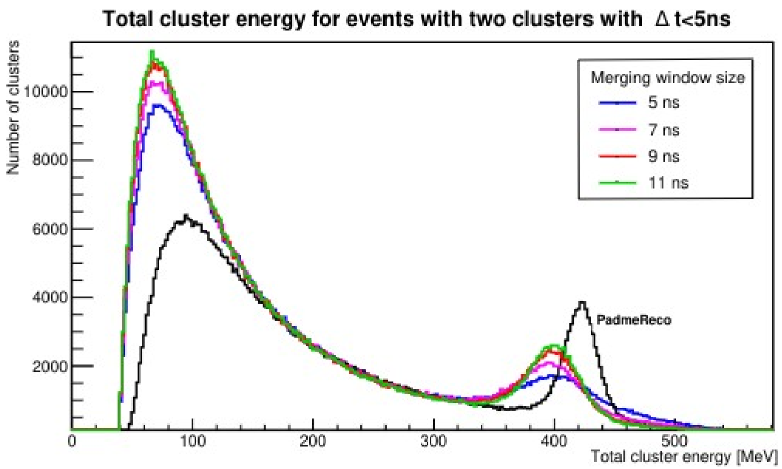
- Design, production and installation of the Charged Particle Detector system
  - Prototypes tested (1 PhD thesis defended in 2021)
  - BG team is overall responsible for the PADME veto detectors

- **Custom PADME Detector Control System entirely developed by BG team from scratch** (1 paper in advanced stage)



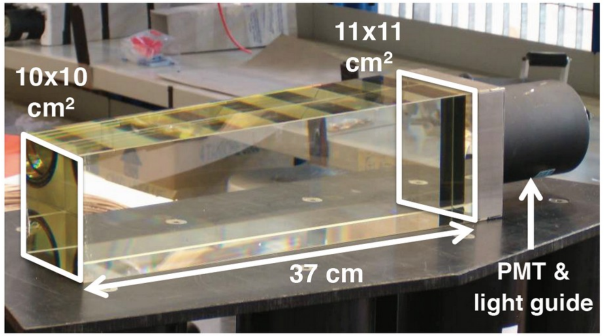
- Operation and data acquisition of the Timepix3 beam monitoring system
  - Custom DAQ developed
  - Fast feedback on data quality and beam parameters development
  - 4 papers published

BG Contribution to PADME



- Single photon analysis; development and implementation of ML methods for data reconstruction
  - developed a new **ML-based method for signal reconstruction** in individual crystals and implemented it for real data
  - **cluster reconstruction with ML methods** currently under development
  - ongoing **analysis of 2020 data** for single photon events
  - 1 master thesis defended in 2023, 3 papers already published; 2 more in development

- Lead glass positron flux measurement data analysis
  - analysis of 2022 data
  - obtaining results to help the experiment calibration in future runs
  - 1 master thesis defended in 2025



ALICE team

- assoc. prof. Venelin Kozhuharov
- Assoc. prof. Martin Makariev
- head assist. prof. Dimitar Lubomirov Mihaylov
- Assist. prof. Rado Simeonov

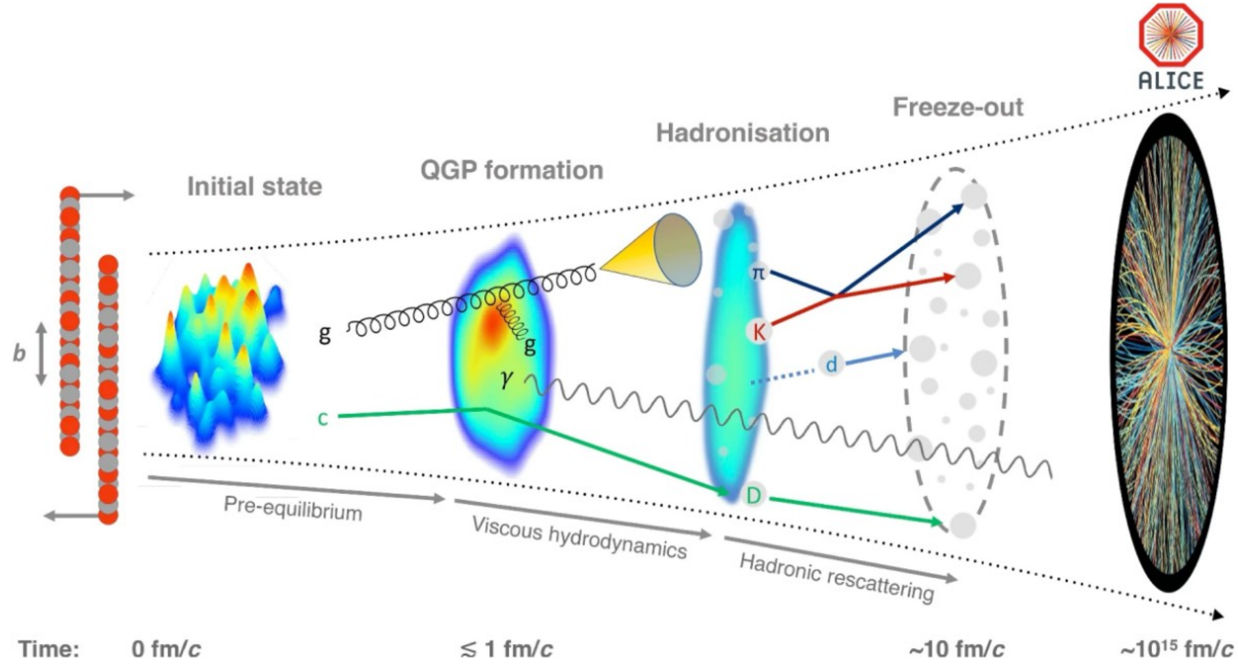
- Anton Alkin
- Valentin Buchakchiev
- Kalina Dimitrova
- Martina Docheva
- Mira Ivaylova Gencheva
- Daniel Ivanov
- Svetoslav Ivanov
- Katerina Kostova
- Ruslan Nastaev

Quark gluon plasma

Мотивацията за ALICE

ALICE изследва QGP и етапите на сблъсъци между тежки йони (HI) чрез наблюдаеми величини във финалното състояние

- Адронизация, адронна химия и свойства на средата
- Взаимодействия на средата с “твърди” проби
- Спектрални форми на адроните и колективни ефекти



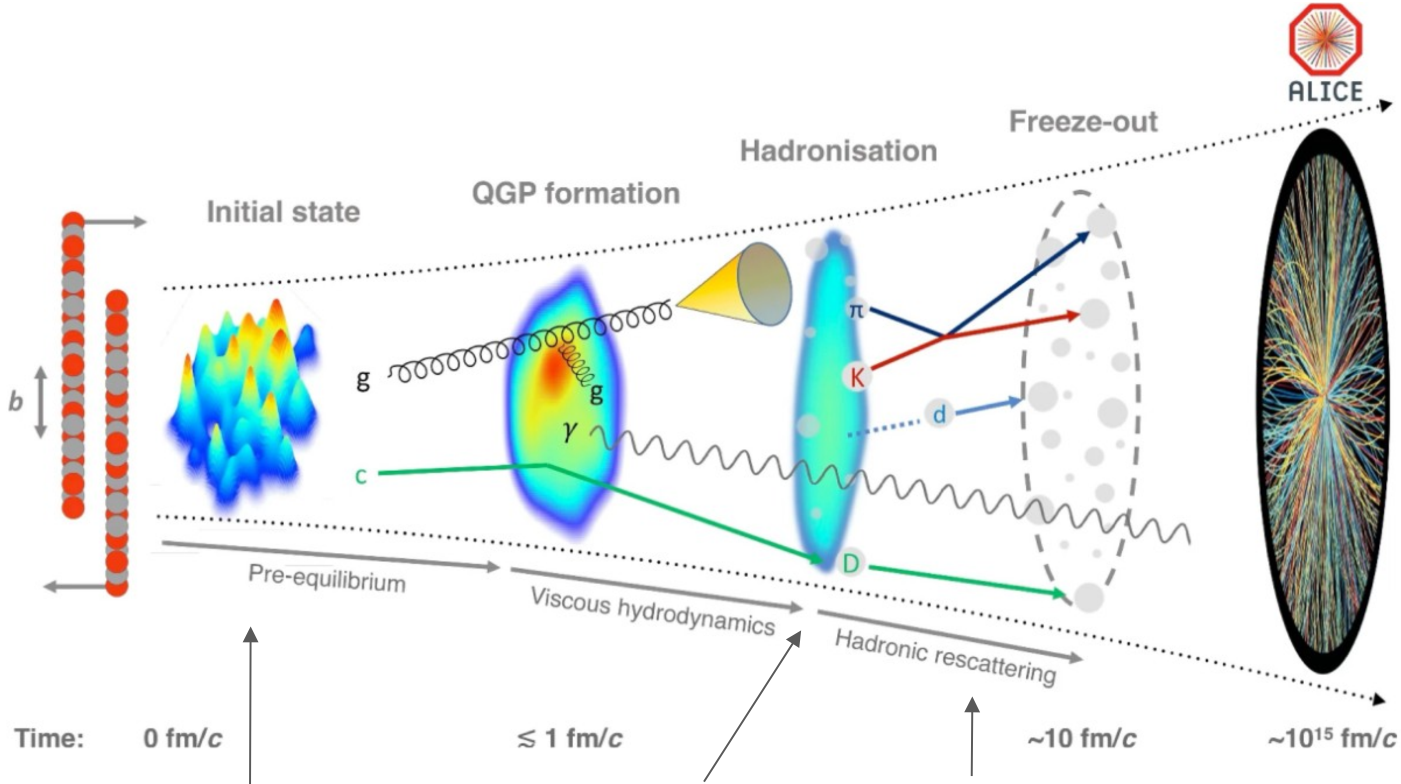
Plot from the SQM 2026 conference - Chiara Pinto

Интересните въпроси:

- Начални условия и геометрия
- QGP: транспортни свойства
- QGP: температура
- Кога настъпва адронизация?
- Остатъчно силно взаимодействие
- Как се образуват леките ядра?

Обобщение

Приноса на катедра Атомна Физика към ALICE



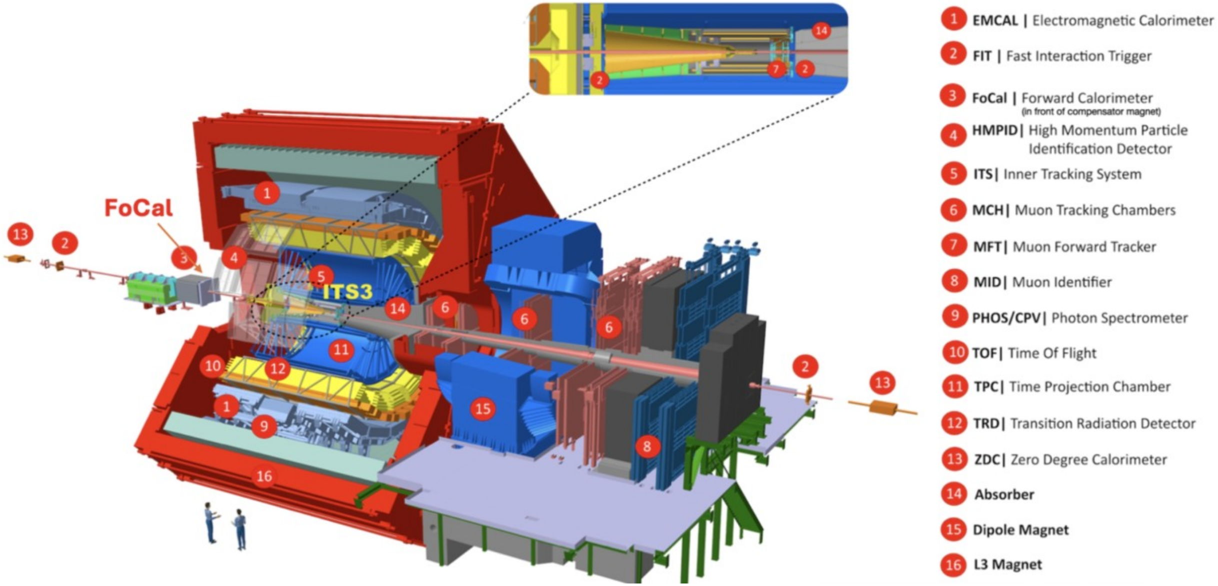
FoCal

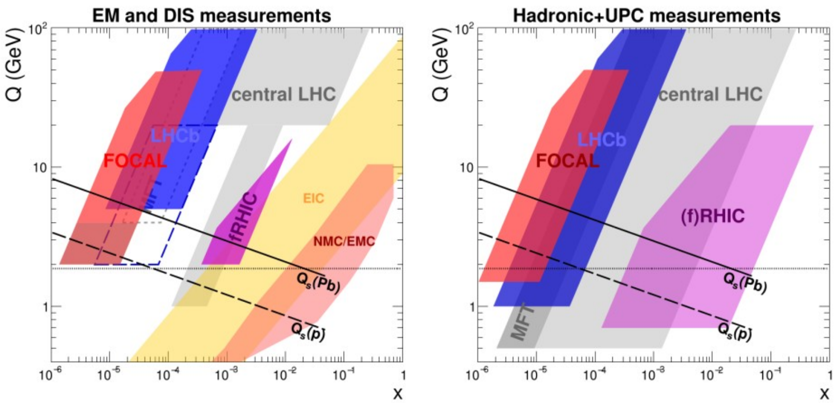
Коалесценция

Фемтоскопия

FoCal

Калориметър за RUN4 (след 2029 г.)





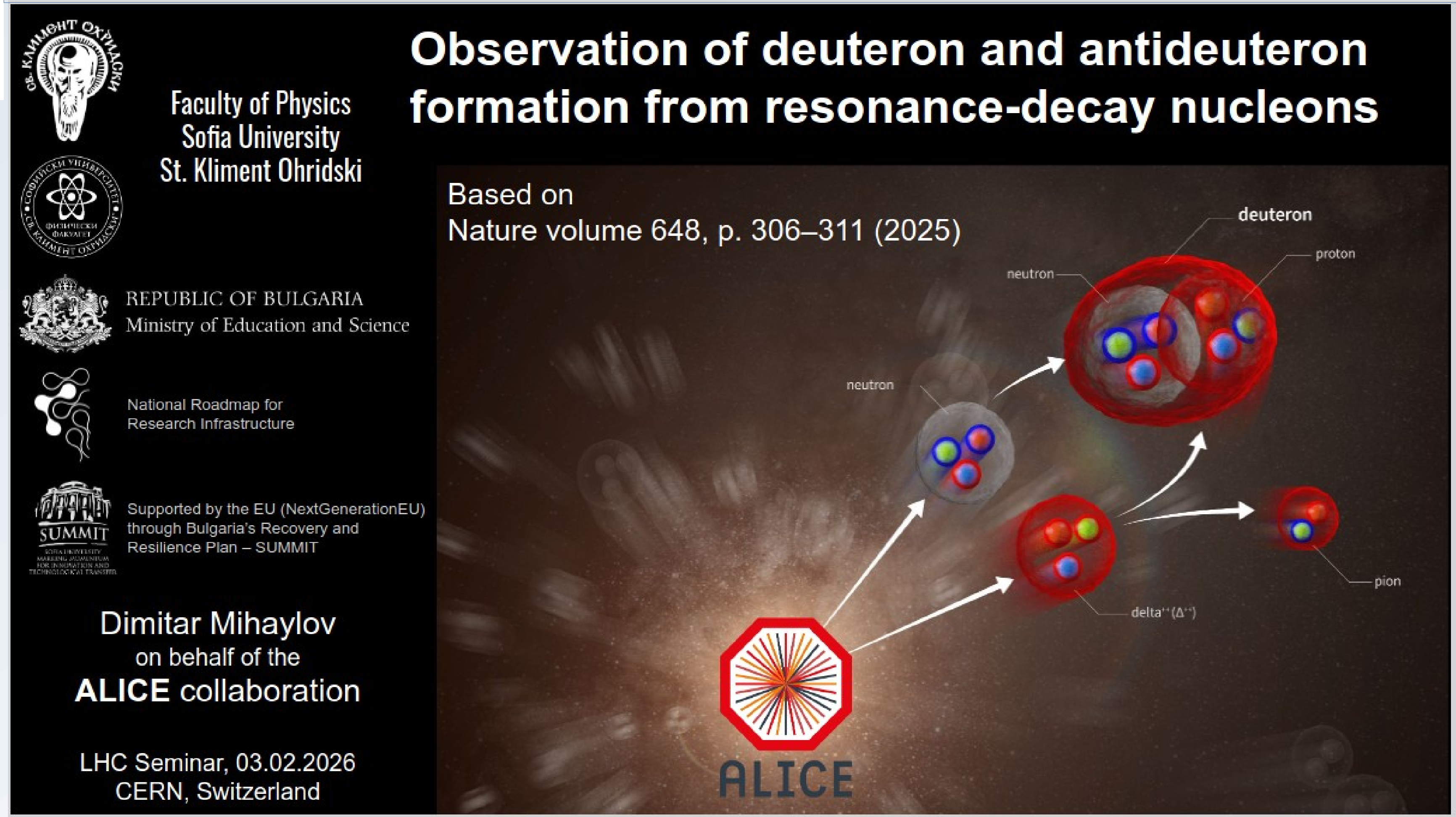
Цел: изследване на глуонното насищане

- FoCal-E: финосегментиран електромагнитен калориметър
- FoCal-H: адронен калориметър (метален сцинтилатор) позволяващ изолирането на фотони и засичане на джетове

- При следващия ъпгрейд на ALICE, ще се добави калориметър
- Ще се покрие псевдобързината 3.4 < η < 5.8
- Ще се намира на 7 м. от точката на сблъсък

For details see the presentation by head assist. prof. Dimitar Mihaylov

For details see the presentation by head assist. prof. Dimitar Mihaylov



Reported by Dimitar Mihaylov (SU) at CERN LPCC seminar

Повече за PADME и ALICE

Търсене на нови леки частици с PADME *Калина Димитрова*
зала "София", Гранд хотел "София", София, България 15:10 - 15:30

Изследване параметрите на снопа в Run III и Run IV на експеримента PADME *Катерина Костова*
зала "София", Гранд хотел "София", София, България 11:50 - 12:05

Изследване на ефектите на радиация върху параметрите на избрани силициеви фотоумножители
Валентин Бучакчиев

Compton-TDCR система за изследване на светлинния отклик на органични сцинтилатори *Владислав Тодоров*
зала "София", Гранд хотел "София", София, България 11:20 - 11:35

Изследване на силно взаимодействащи системи с ALICE *Димитър Михайлов*
зала "София", Гранд хотел "София", София, България 16:00 - 16:20

96% water

CMS

проф. дфзн Л. Литов
доц д-р Б. Павлов
доц. д-р П. Петков
д-р А. Димитров
докторант М. Пехливанова

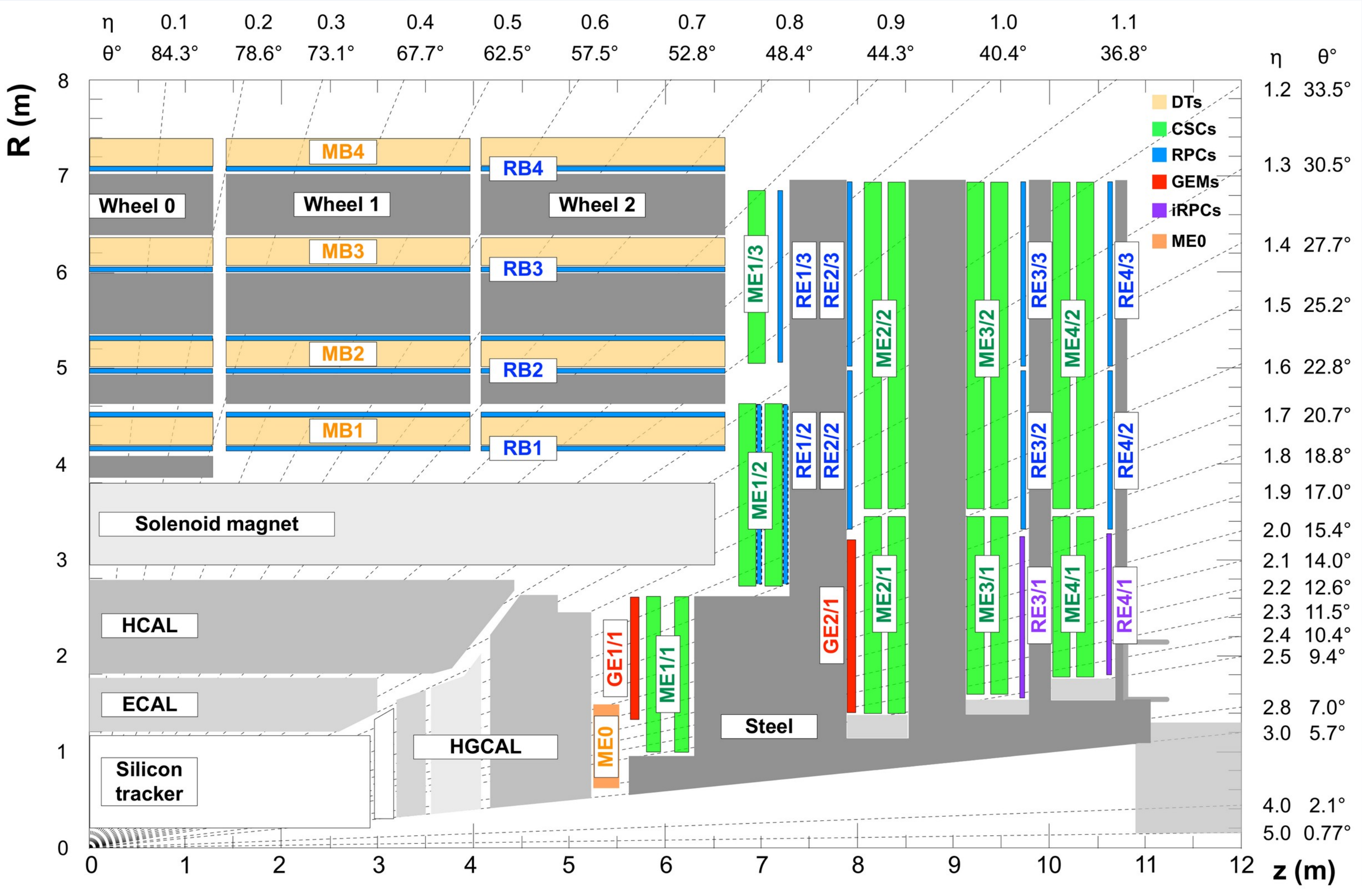
д-р Е. Шумка
физик Т. Иванов
физик А. Петров

А. Киркова

студенти:

Г. Бистрев
В. Асова
Н. Костадинов

CMS



η
θ°
0.1
84.3°
0.2
78.6°
0.3
73.1°
0.4
67.7°
0.5
62.5°
0.6
57.5°
0.7
52.8°
0.8
48.4°
0.9
44.3°
1.0
40.4°
1.1
36.8°
1.2 33.5°
1.3 30.5°
1.4 27.7°
1.5 25.2°
1.6 22.8°
1.7 20.7°
1.8 18.8°
1.9 17.0°
2.0 15.4°
2.1 14.0°
2.2 12.6°
2.3 11.5°
2.4 10.4°
2.5 9.4°
2.8 7.0°
3.0 5.7°
4.0 2.1°
5.0 0.77°
R (m)
z (m)
DTs
CSCs
RPCs
GEMs
iRPCs
ME0
Wheel 0
Wheel 1
Wheel 2
MB4
MB3
MB2
MB1
RB4
RB3
RB2
RB1
ME1/3
ME1/2
ME1/1
RE1/3
RE2/3
RE1/2
RE2/2
ME2/2
ME2/1
ME3/2
ME3/1
RE3/3
RE3/2
RE3/1
ME4/2
ME4/1
RE4/3
RE4/2
RE4/1
GE1/1
GE2/1
ME0
Steel
Solenoid magnet
HCAL
ECAL
HGCAL
Silicon tracker

Institutes

SOFIA UNIVERSITY

ST. KLIMENT OHRIDSKI

EST. 1888

INRNE

Institue for Nuclear Research and Nuclear Energy (Bulgarian Academy of Science)

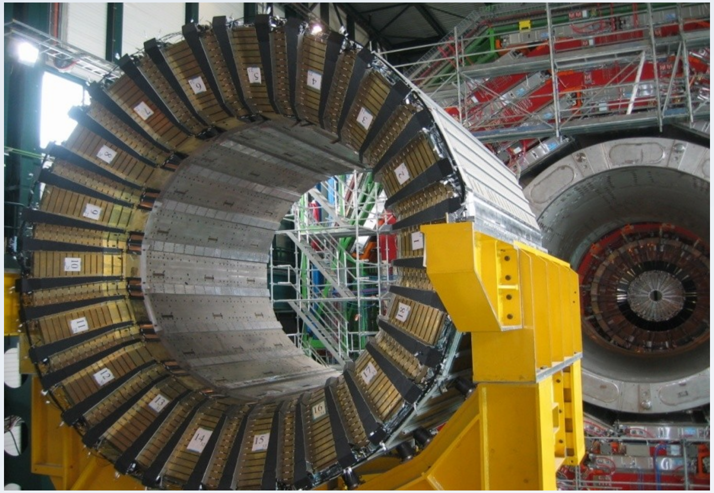
SU

Sofia University

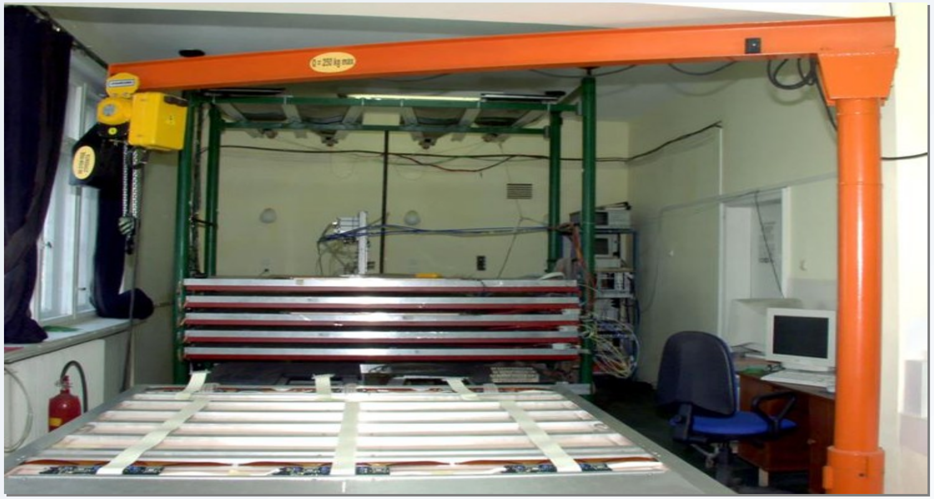
ISER

Institute of System Engeneering and Robotics (Bulgarian Academy of Science)

HCAL



RPC



2 CMS achievements awards

BRIL

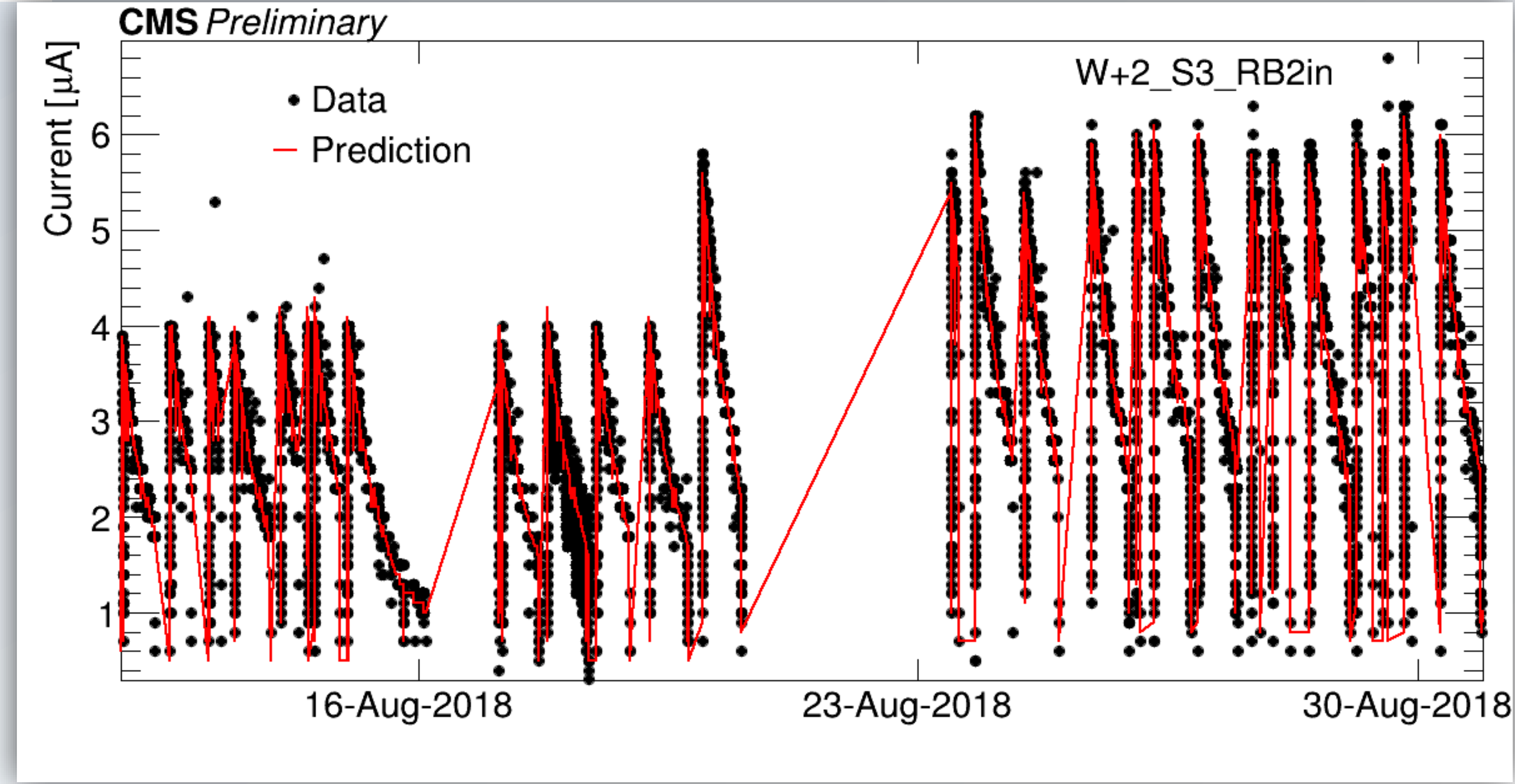
- **Peter Tsrunchev (U. Sofia) -** *the development of almost real-time analysis of the CMS emittance scans allowing for prompt monitoring of the stability of the online luminosity calibration and rapid identification of problems.*

Offline S&C

- **Todor Ivanov (U. Sofia) -** *for running and improving the CMS Distributed Analysis infrastructure.*

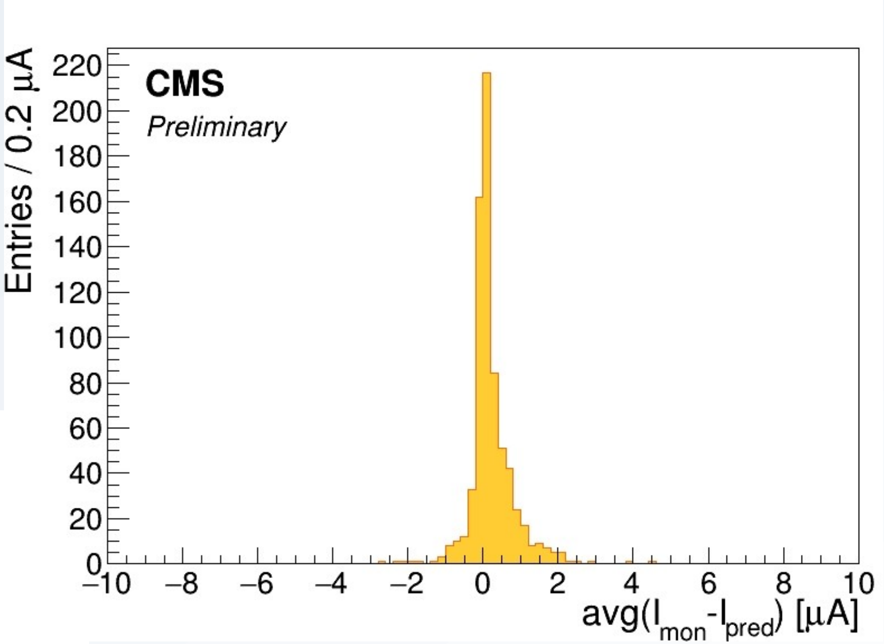
2017
CMS awards

ML for RPC

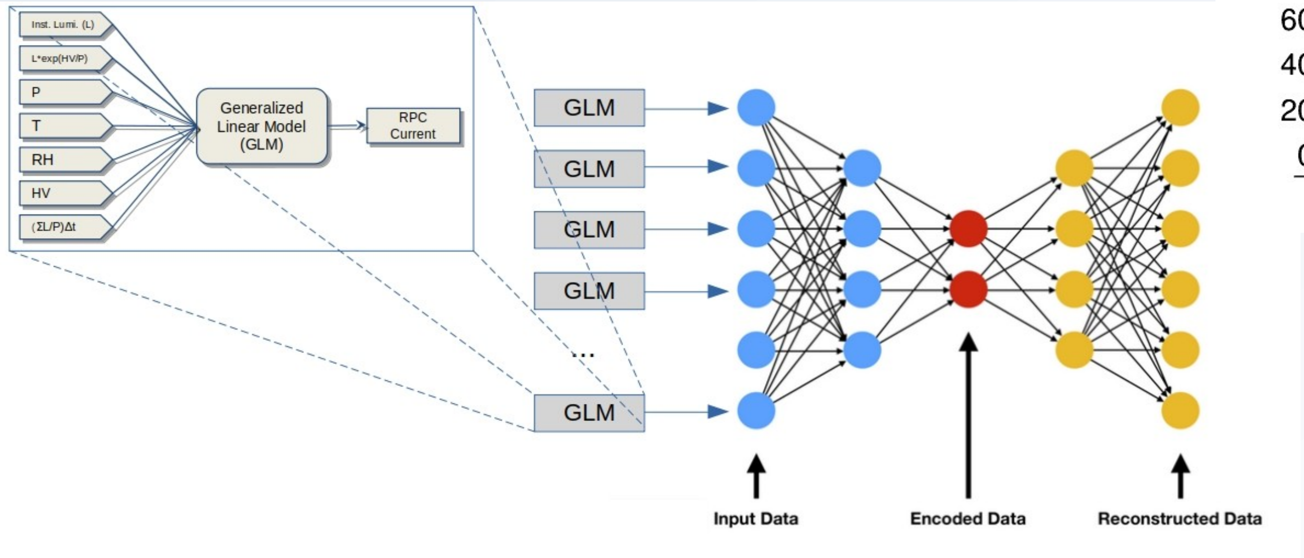


CMS Preliminary
W+2_S3_RB2in
Data
Prediction
Current [μA]
1
2
3
4
5
6
16-Aug-2018
23-Aug-2018
30-Aug-2018

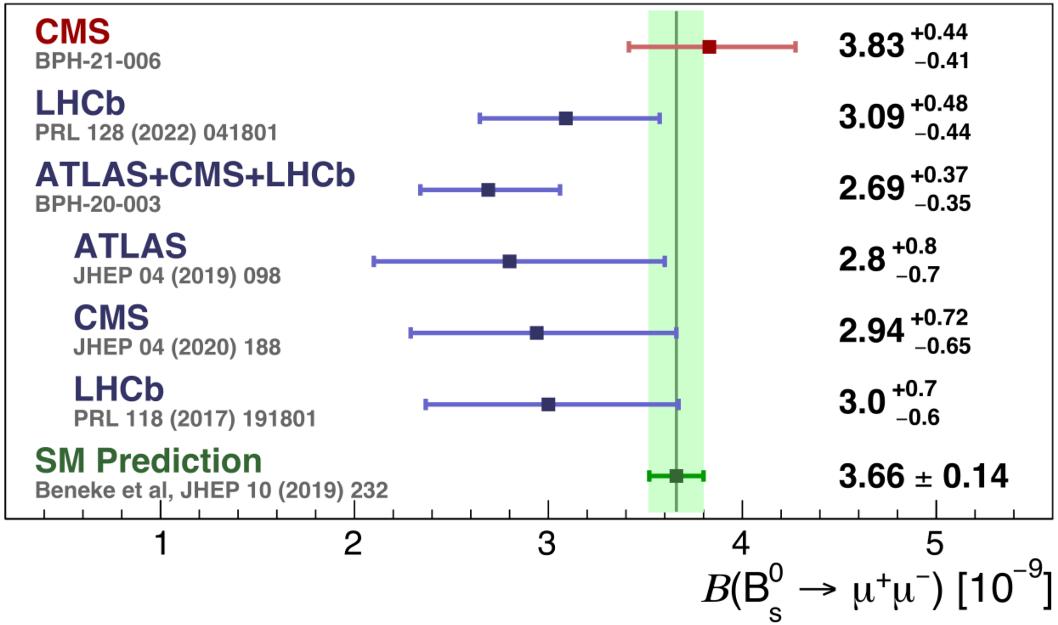
ML for RPC

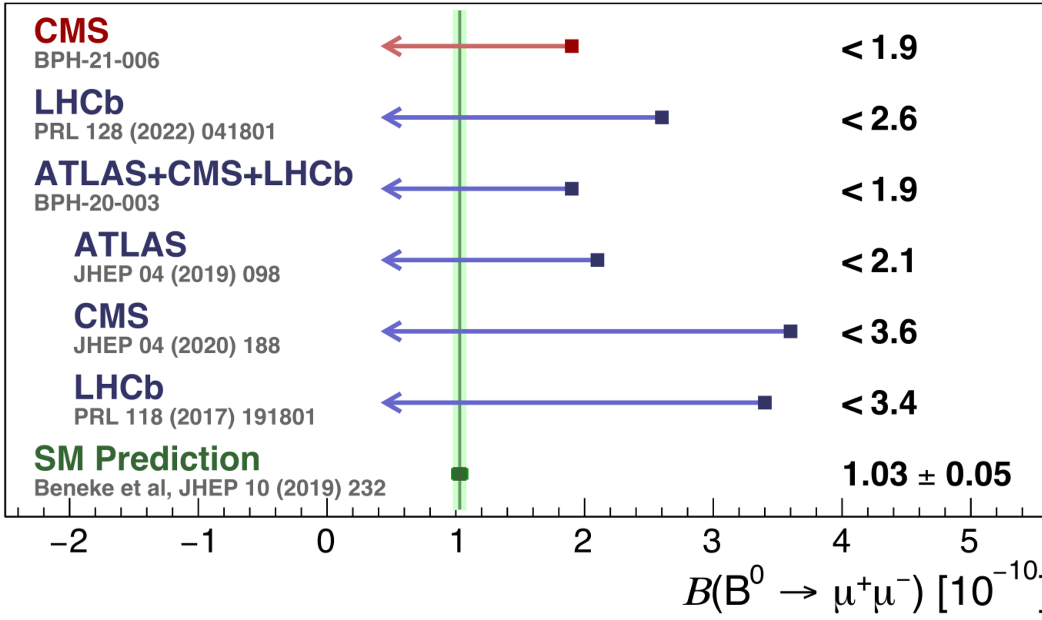


Mean = 0.21 μA; σ = 0.59 μA



$B^0_s \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$

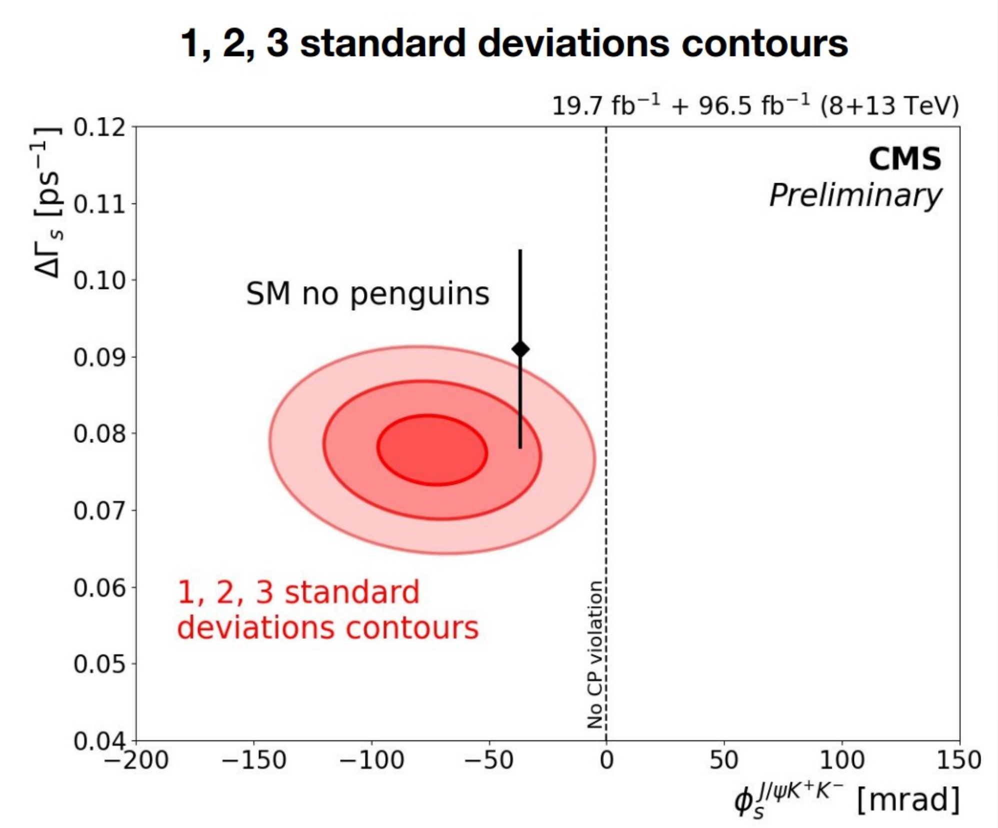


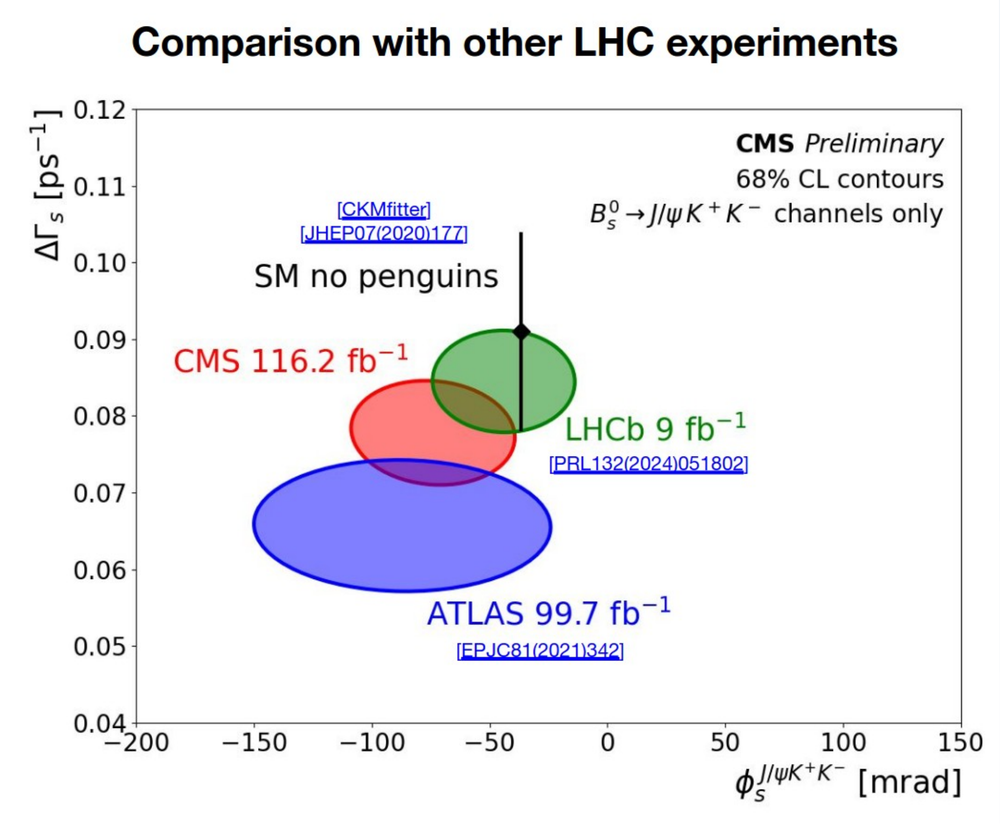


- a PhD thesis – Todor Ivanov (under preparation)

Reported by Dmytro Kovalskyi (MIT) at CERN LPCC seminar

CP violation in $B^0_s \to J/\Psi\ \varphi$

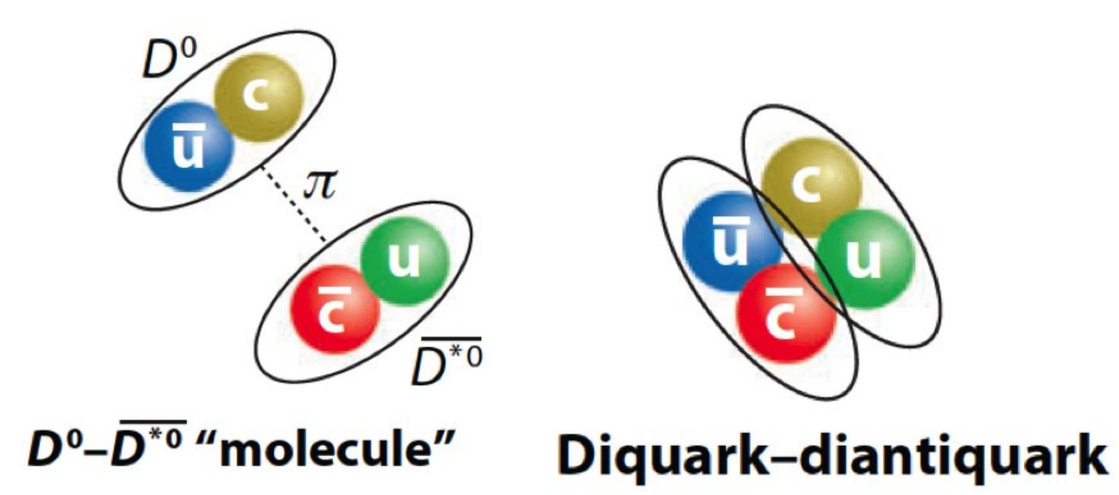




- a PhD thesis - Elton Shumkato (defended in 2025)

Reported by Alberto Bragangnolo (INFN) at CERN LPCC seminar

Ongoing research

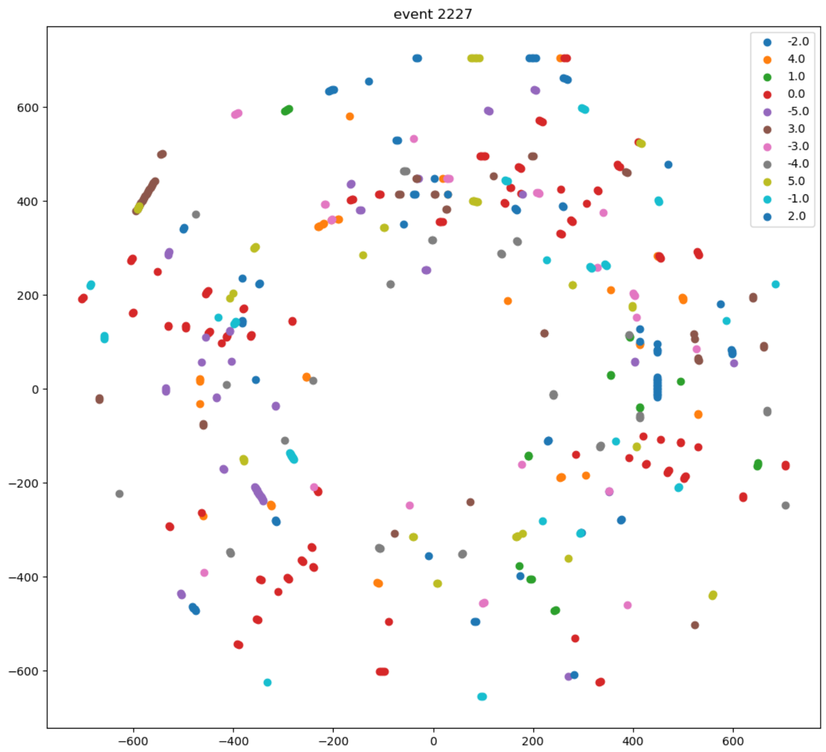


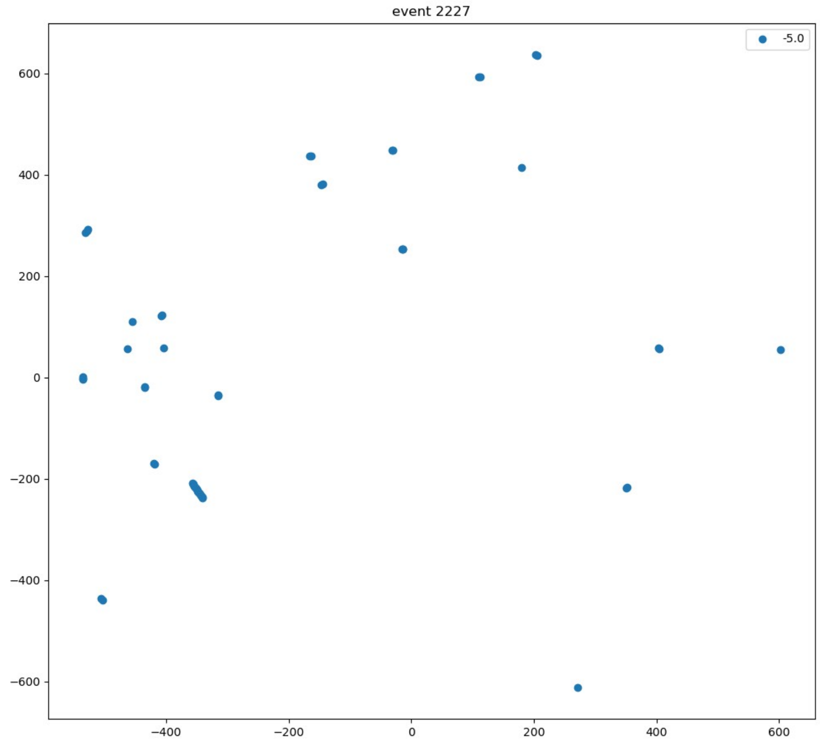
$$X^{\pm} \rightarrow J/\Psi\ \pi^{\pm}\ \pi^{0}$$

X(3872) exotic resonance

Trigger studies – RPC for Run4

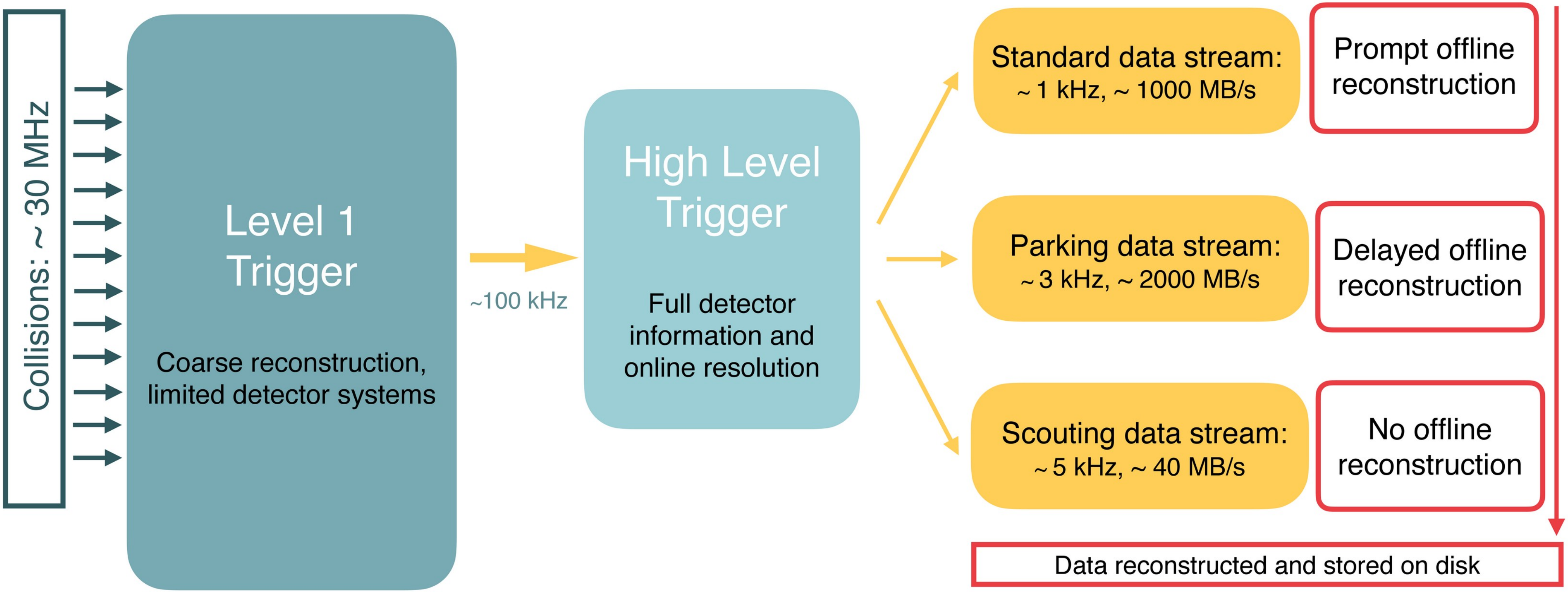
RPC trigger for Run4





A typical Run 2 data flow during 2018

Data flow for a typical 2018 data-taking scenario



Повече за CMS

Развитие на физиката на елементарните частици и нейните приложения в Катедра „Атомна физика“
Леандър Литов

От прототип до експлоатация: нашият принос към RPC системата на експеримента CMS *Антон Димитров*
зала "София", Гранд хотел "София", София, България 16:20 - 16:40

Търсене на дългоживущи заредени частици в CMS *Елтон Шумка*
зала "София", Гранд хотел "София", София, България 16:40 - 17:00

breakthroughprize.org/Laureates/1

FUNDAMENTAL PHYSICS
BREAKTHROUGH
PRIZE

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COMMITTEE PRIZES LAUREATES RULES

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LAUREATES

Breakthrough Prize | Special Breakthrough Prize | New Horizons Prize | Physics Frontiers Prize

2025 | 2024 | 2023 | 2022 | 2021 | 2020 | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012

The 2025 Breakthrough Prize in Fundamental Physics is awarded co-authors of publications based on CERN's Large Hadron Collider Run-2 data released between 2015 and July 15, 2024, at the experimental collaborations ATLAS, CMS, ALICE and LHCb. (ATLAS – 5,345 researchers; CMS – 4,550; ALICE – 1,869; LHCb – 1,744).

The $3 million prize is allocated to ATLAS ($1 million), CMS ($1 million), ALICE ($500,000) and LHCb ($500,000). In consultation with the leaders of the experiments, the Breakthrough Prize Foundation donated 100 percent of the prize funds to the CERN & Society Foundation. The prize money will be used by the collaborations to offer grants for doctoral students from member institutes to spend research time at CERN, giving the students experience working at the forefront of science and new expertise to bring back to their home countries and regions. The name of each winner can be found on the experiment pages below.


ALICE Collaboration


ATLAS Collaboration


CMS Collaboration


LHCb Collaboration


BREAKTHROUGH PRIZE
Stephane
Willocq
ATLAS
Marco van Leeuwen
ALICE
Yuri Milner
Jeff Bezos
Patricia L. McBride
CMS
Vincenzo Vagnoni
LHCb

Atomic Physics Department University of Sofia

Обучение

Задължителни бакалавърски курсове:

- “Физика на елементарните частици” – пълен (30+15+30)
- “Физика на елементарните частици” – кратък (15+15+15)

Бакалавърска програма на английски език:

- Nunclear and Particle Physics (NPP) → Qunatum, Nuclear and Particle Physics (QNPP)

Магистърски програми на български и английски език:

- Физика на ядрото и елементарните частици (3 сем. и 5 сем.)

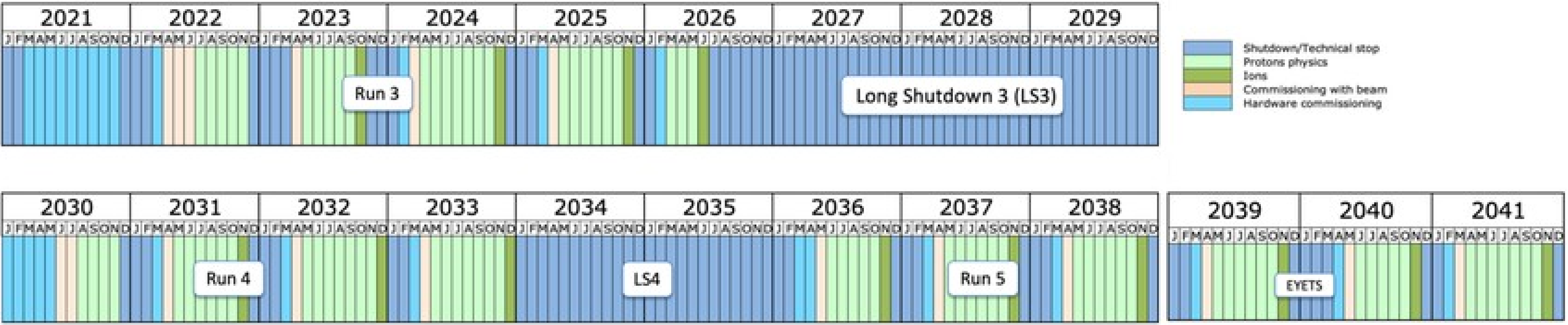
Учебна лаборатория по ФЕЧ

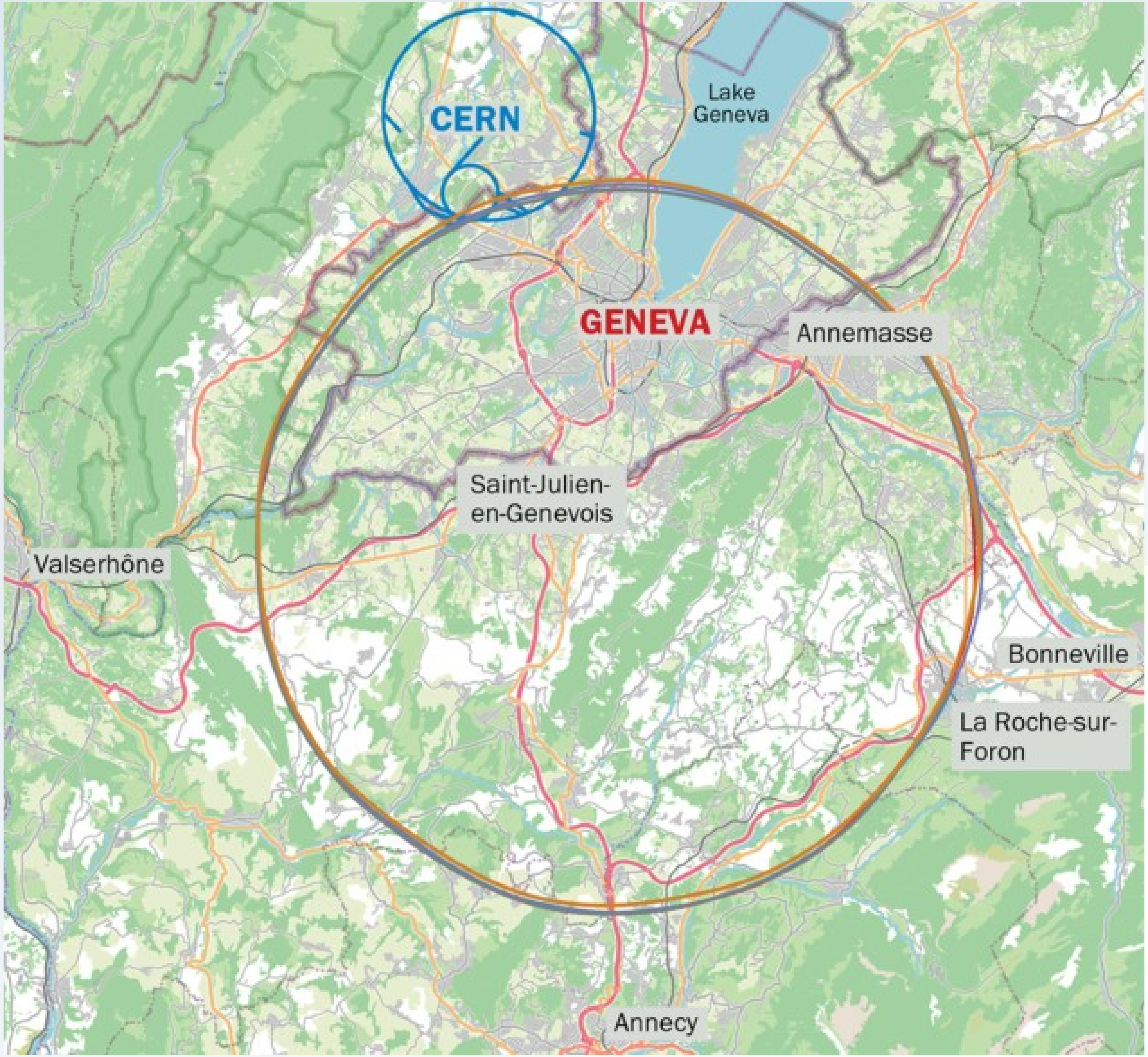
Докторанти 2017-2026

1. Милена Христова Дюлендарова - защитила през 2025 г.
2. Момчил Николаев Найденов - защитил през 2020 г.
3. Симона Илиева Илиева - защитила през 2021 г.
4. Антон Руменов Петров - отчислен през 2021
5. Тодор Трендафилов Иванов - отчислен през 2022
6. Елтон Шумка - защитил през 2025 г.
7. Радослав Росенов Симеонов - защитил през 2025
8. Светослав Пламенов Иванов - защитил през 2026
9. Симеон Венциславов Иванов - защитил през 2026
10. Валентин Димитров Бучакчиев - обучава се
11. Калина Красимирова Димитрова - обучава се
12. Георги Данев Василев - обучава се
13. Ивайло Георгиев Дионисов - обучава се
14. Георги Радославово Златинов - обучава се
15. Катерина Петрова Костова - обучава се
16. Михаела Пенчева Пехливанова - обучава се
17. Борис Огнянов Хайдуков - обучава се
18. Диляна Асенова Сувариева - обучава се

The Future

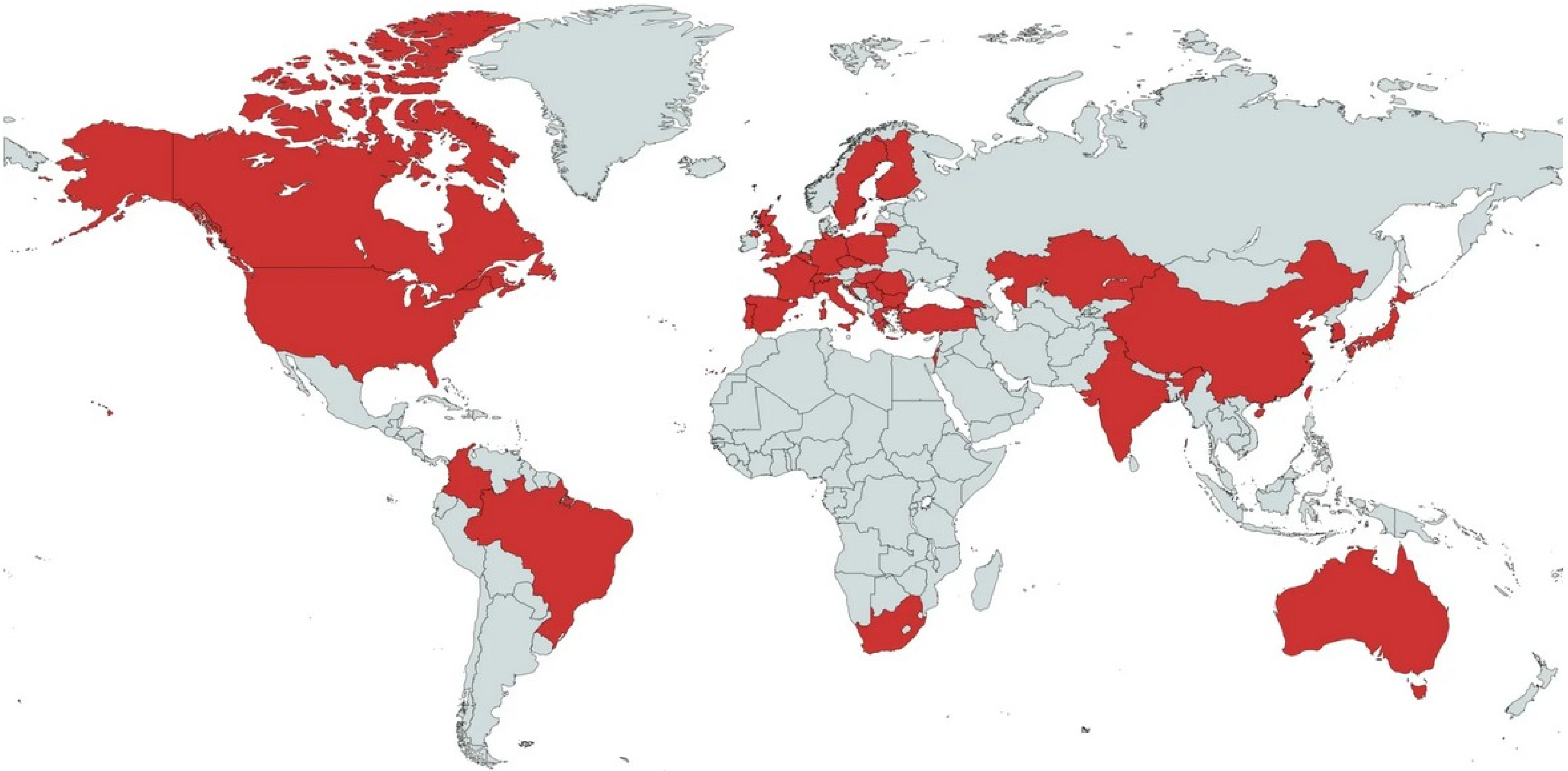
LHC
HL-LHC


2021
2022
2023
2024
2025
2026
2027
2028
2029
Run 3
Long Shutdown 3 (LS3)
Shutdown/Technical stop
Protons physics
Ions
Commissioning with beam
Hardware commissioning
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
Run 4
LS4
Run 5
EYETS


CERN
Lake
Geneva
GENEVA
Annemasse
Saint-Julien-
en-Genevois
Valserhône
Bonneville
La Roche-sur-
Foron
Annecy

DRD1 R&D Collaboration

Development of Gaseous Detectors Technologies



AF@DRD1

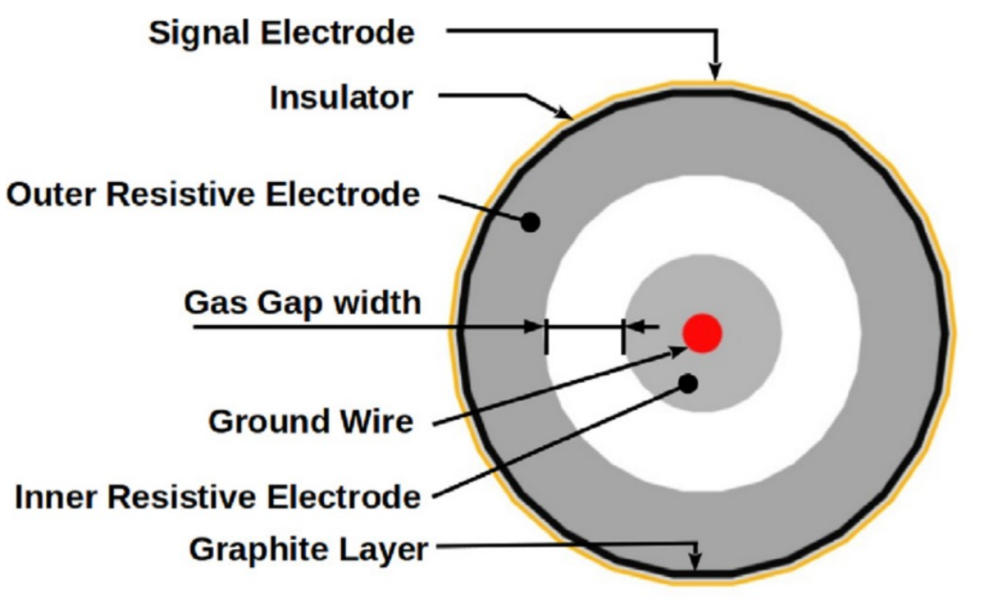


Fig. 1. Simple RCC design cross section.

GARFILED++:

- HPC
- New gases

Close collaboration with:

- CERN
- University of Cambridge

Проект SUMMIT: Моделиране на комплексни системи *Пейчо Петков*

зала "София", Гранд хотел "София", София, България 11:00 - 11:20

Thank you !!!

Conclusions

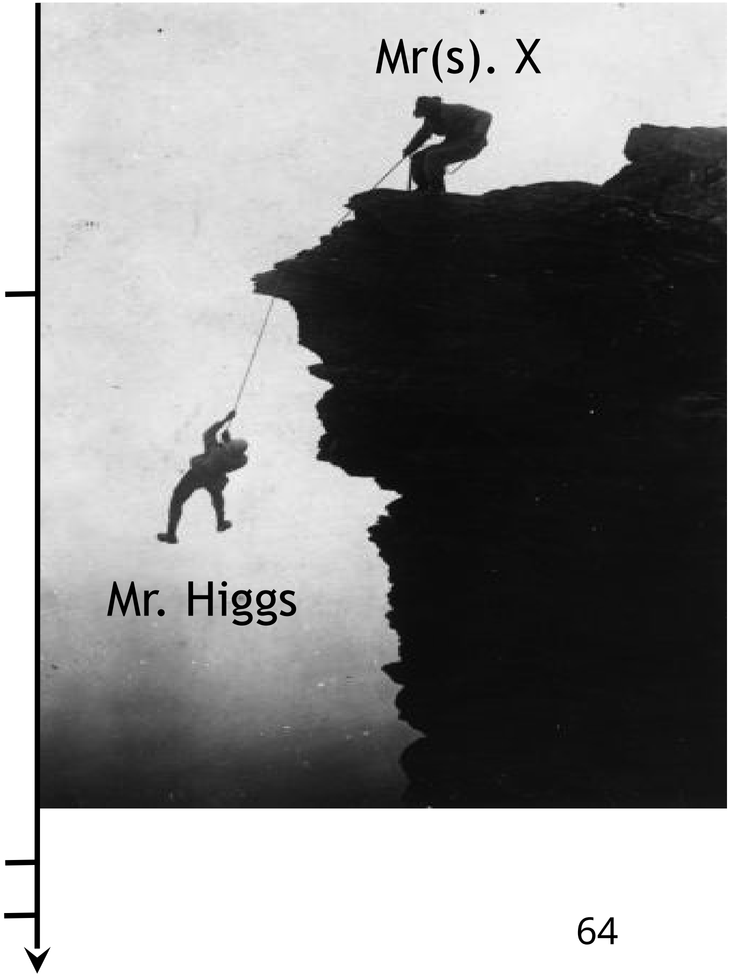
Backup slides

Naturalness of the Higgs mass

Courtesy of C. Grojean & A. Weiler, and A. Hoecker

EW scale^{-1}

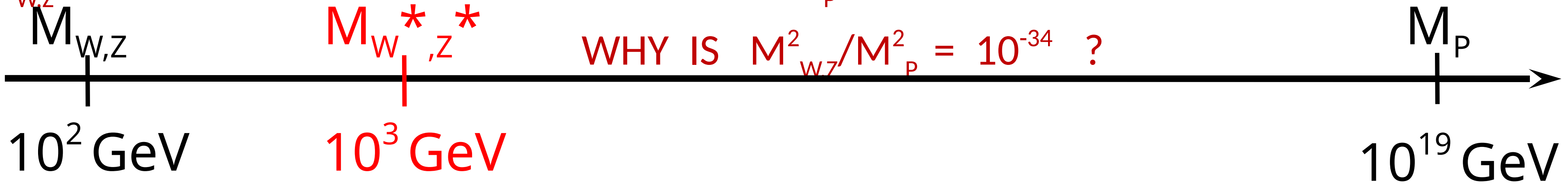
GUT scale^{-1}



Motivation for SM extension

The main theoretical motivation for beyond the Standard Model physics around TeV energies (LHC) is provided by the Hierarchy Problem, an inexplicable the UltraViolet stability of the weak interaction scale

(M_{WZ} = 10^2 GeV) versus the Planck mass (M_P = 10^{19} GeV),



Introduction of new spin-1 bosons with the internal quantum numbers identical to the Standard Model Higgs doublet can help to solve the Hierarchy Problem.

$$\begin{pmatrix} H^+ \\ H^0 \end{pmatrix} \longleftrightarrow \begin{pmatrix} W_\mu^{*+} \\ Z_\mu^{*} \end{pmatrix}$$

M.V. Chizhov and G. Dvali “Origin and Phenomenology of Weak-Doublet Spin-1 Bosons”, Phys. Lett. B **703** (2011) 593, arXiv:0908.0924

New vector bosons and their interactions

There are two states for charged boson $W_\mu^{*\pm}$

and two neutral bosons: CP-even $\mathrm{Re}\,Z_\mu^*$ and CP-odd $\mathrm{Im}\,Z_\mu^*$

$$L_{Z^*} = \frac{g^*}{\Lambda}\bar{\Psi}\sigma^{\mu\nu}\psi \cdot (\partial_\mu Z_\nu^* - \partial_\nu Z_\mu^*)$$

Initial hypothesis: coupling constant g^* is equal to SU(2) gauge coupling constant g which is universal for leptons and quarks and does not depend on generation $\psi = e, \mu, \tau, u, d, s, c, b, t$

The scale of the new physics Λ is accepted equal to the mass of new bosons which should be around or less 1 TeV.

Therefore, first searches have been conducted in Drell-Yan and dijets channels.

Нов проект в ATLAS: Ассоциативное рождение W^*/Z^* бозонов с тяжелыми кварками

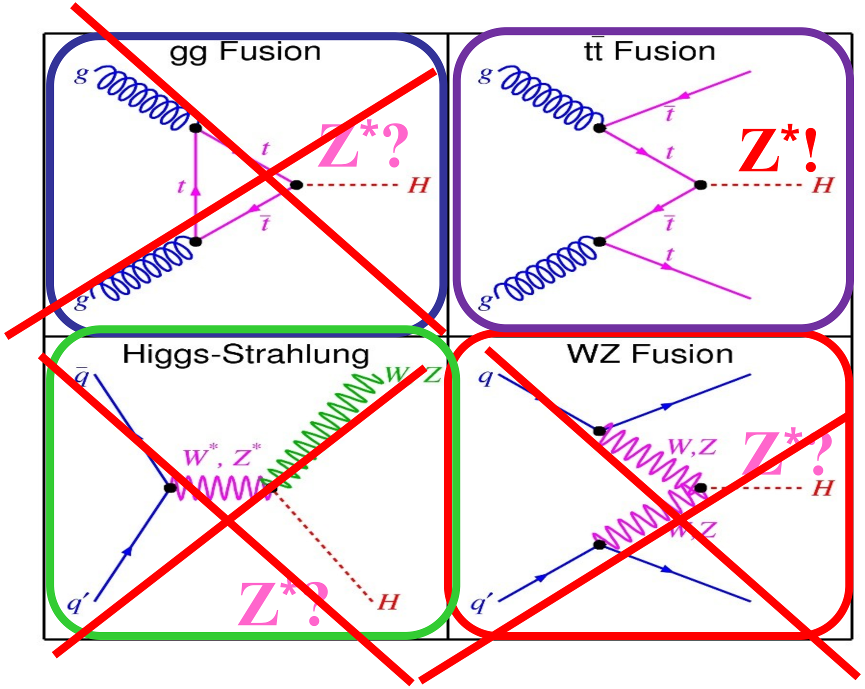
At first glance, these results exclude the possibility of existence of new vector bosons with masses M ~ 1 TeV or less. However, their production and decays were searched only in Drell-Yan (LPX subgroup) and dijets (JDM) processes. In other words, the quark-lepton and family universality was always assumed.

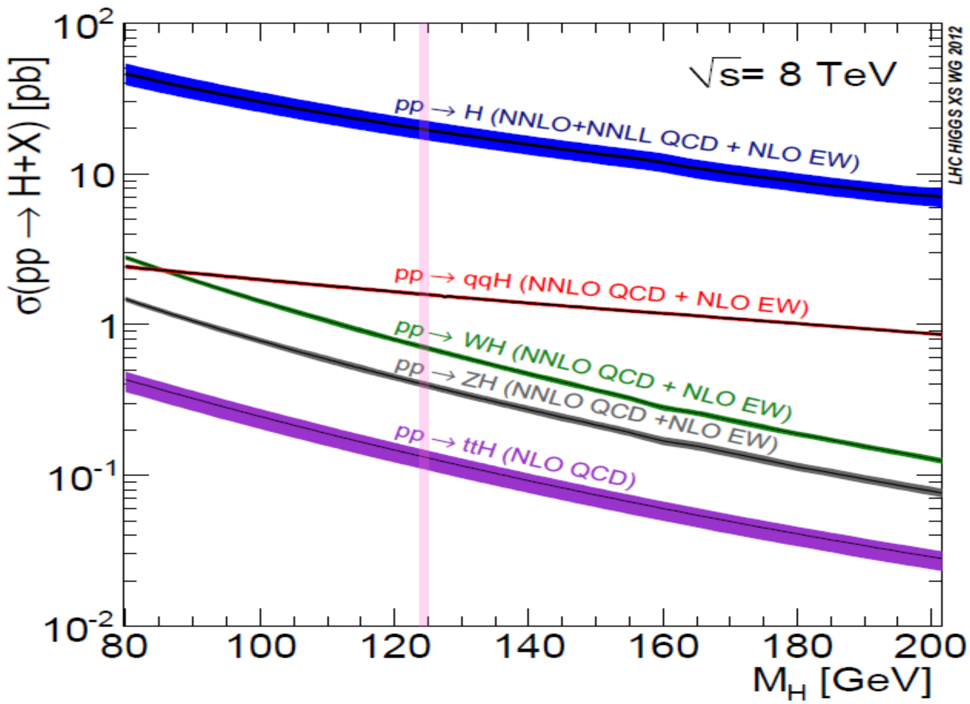
This assumption is natural for the vector fields like Z'/W' from the adjoint representations of the gauge group in order to avoid tree-level flavor-changing neutral currents, whereas the scalar Higgs doublet from the fundamental representation interacts mainly with the fermions from the third family, which is the source of the flavor violation in Nature. Since the vector doublets come along with the scalar doublets, it is more natural to suggest a similar pattern of couplings for the vector doublets too.

$$\begin{pmatrix} H^+ \\ H^0 \end{pmatrix} \longleftrightarrow \begin{pmatrix} W_\mu^{*+} \\ Z_\mu^* \end{pmatrix}$$

Higgs vs. new vector bosons production at LHC

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CrossSections





σ[pb]

19.27

1.578

0.7046

0.4153

0.1293

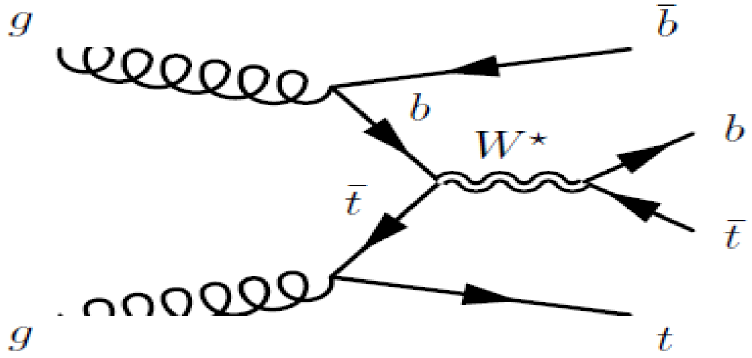
125 GeV

Signature of charged W* bosons (4FS)

The charged W* boson is interacting only with top and bottom quarks. Therefore, it is produced in top-bottom quarks annihilation and also it decays to them.

This process is analogous to previous neutral Z* boson production:

$$gg \to t\bar{b}W^{*} \to t\bar{t}b\bar{b}$$



The final state coincides with the associated production of the Higgs boson with a top quark pair and the following Higgs decay into bottom quarks, although with absolutely different kinematics.

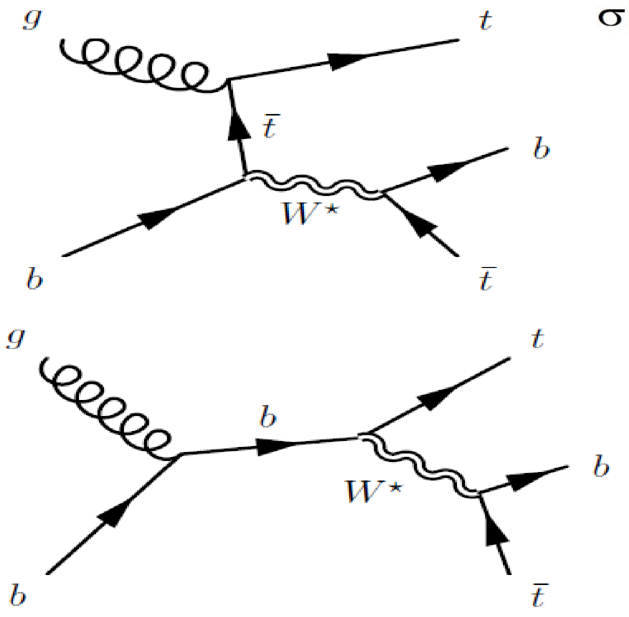
Decay of BSM charged Higgs into top and bottom quarks has nearly the

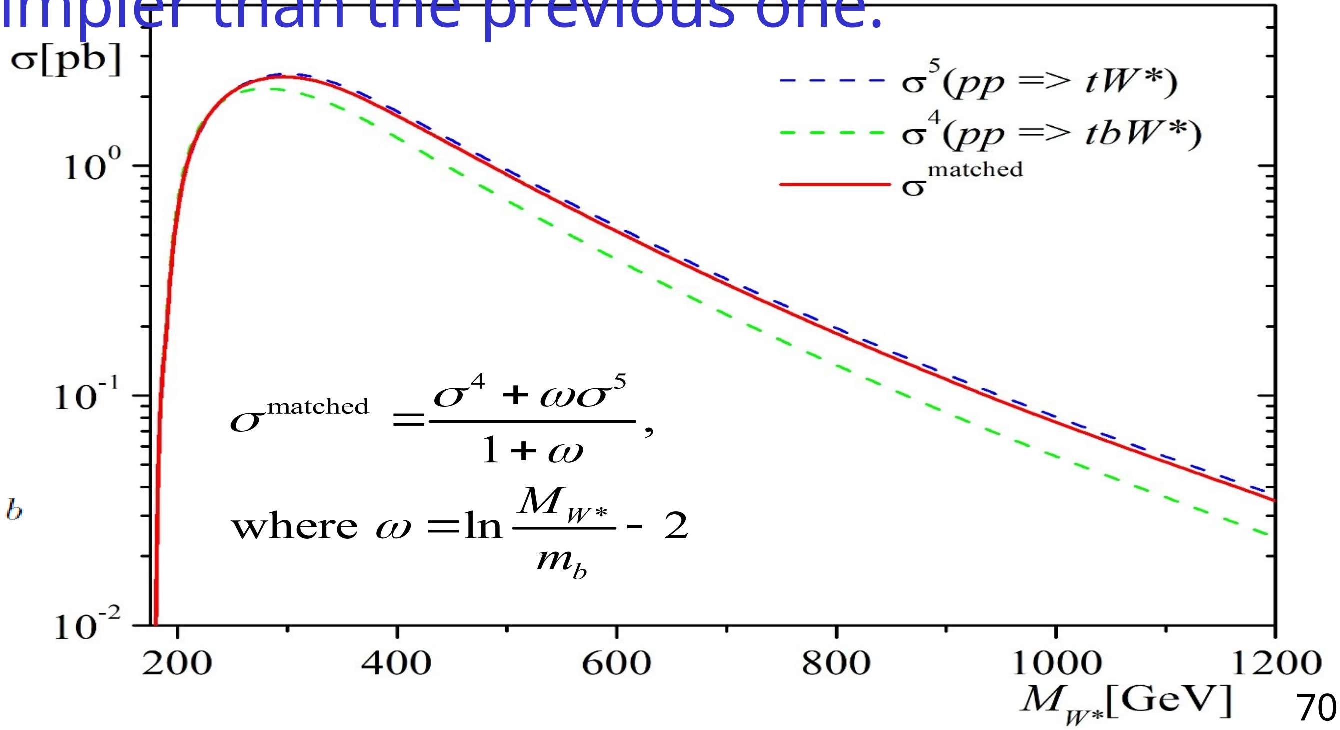
Signature of charged W* bosons (5FS)

The second signature of the charged W* boson production, when the bottom quark comes from the proton contamination (5FS),

$$gb \to tW^* \to t\,b\,\bar{t}$$

is much simpler than the previous one.





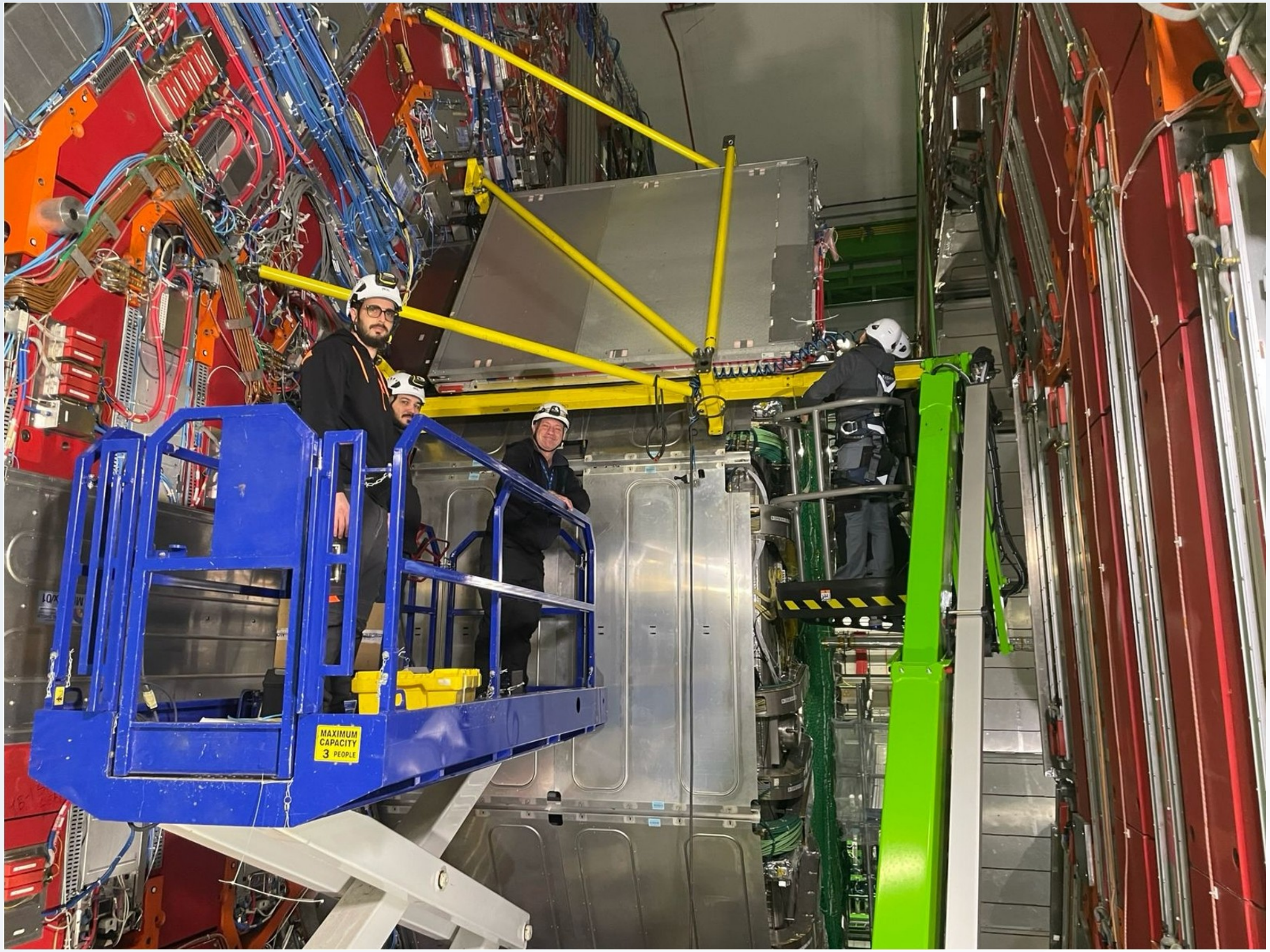
$$\sigma^{matched} = \frac{\sigma^4 + \omega\sigma^5}{1+\omega},$$

$$\text{where } \omega = \ln\frac{M_{W^*}}{m_b} - 2$$

Positions

- Collaboration Board Deputy Chair – 1
- Muon Institution Board Deputy Chair – 1 (2 mandates)
- RPC Institution Board Chair – 2 (2 persons served and one of them served 2 mandates)
- Member of the CMS Conference Committee – 1 (10 years)
- Muon Conference and Publication Board Chair – 1 (7 years)
- Muon Internal Scrutiny group chair -1 (2 mandates)
- Member of Muon Conference and Publication Board - 4
- Muon TCO – 1
- Muon DPGO – 1 (2 mandates)
- RPC Conference Committee – 2 (4 mandates in total)
- RPC DPG – 3 (3 persons served and one of them served 2 mandates)
- RPC TC -1 (10 years)
- RPC RC -1 (10 years)
- RPC Trigger -1

RPC YETS 2024/2025



Barrel Leak repair campaign

YETS 2024/2025

All RE3/1 and RE4/1 are installed