Crossing (phase) boundaries with Gennady Zinovjev

- some historical comments
- Gena the experimentalist
- the QCD phase boundary
- Gena the theorist
- synchrotron radiation of quarks
- off to new frontiers – real and virtual photons, ALICE 3
-

pbm

symposium in honor of Gennady Zinovjev
zoom
Monday, April, 26, 2021

Gena the theorist, the early years 1968 – 2000
3 selected papers

1. Dispersion sum rules in quantum field theory
V.A. Miransky, G.M. Zinovjev
Lett. Nuovo Cim. 1S2 (1971) 612-616, Lett. Nuovo Cim. 1 (1971) 612-616

2. Dynamical averages in the dual-resonance model
Mark I. Gorenstein, V.A. Miransky, V.P. Shelest, B.V. Struminsky, G.M. Zinovjev
Lett. Nuovo Cim. 6S2 (1973) 325-328, Lett. Nuovo Cim. 6 (1973) 325-328

3. Photoproduction constraints on J / psi nucleon interactions
K. Redlich, H. Satz, G.M. Zinovjev
Eur. Phys. J. C 17 (2000) 461-465

Gena, the experimentalist, ALICE and Si detectors

ALICE SSD - very early phase: Kharkov 1998

photo provided by Luciano Musa

Al-kapton microcables

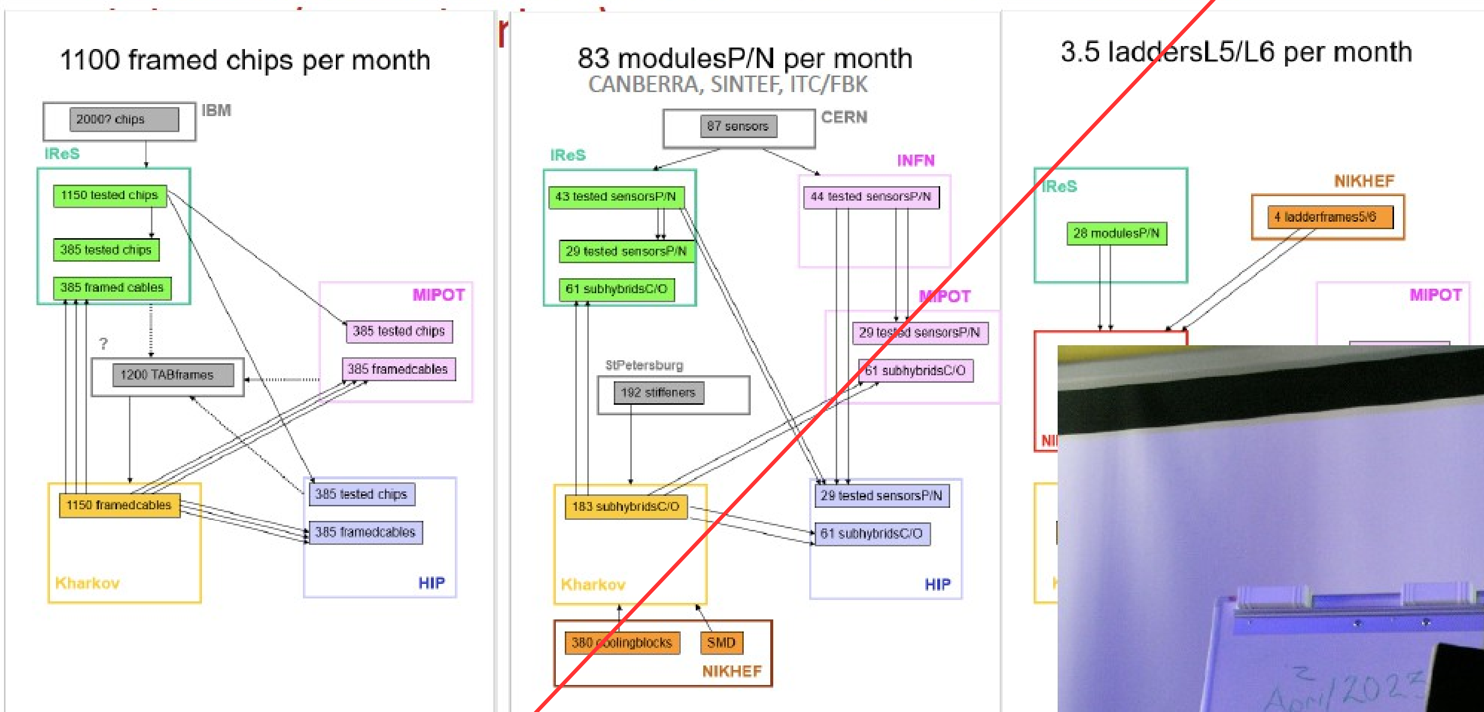
Of all potential jobs, Gena the experimentalist picked the construction and distribution of cables for the ALICE Si-strip detector SSD
this led to an important contribution to ALICE from Ukraine

around that time, I first met Gena personally in the ALICE Collaboration Board... where he made an imposing figure
when he got up to speak, people listened

in SSD production, Gena had to solve many crises
in the end all solved successfully

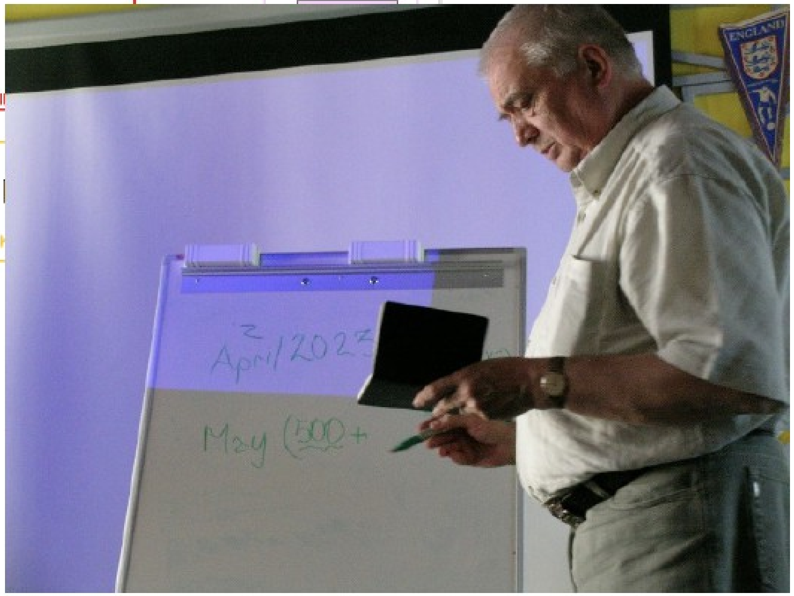
SSDD production

challenges: logistics, quality (a.o. SINTEF sensors),



just one of many emails:

…In other words, the stock of chipcables and subhybrids is now 0 and module production will stop everywhere within about 10 days because of lack of components…



slide provided by Luciano Musa

Gena and the ALICE Collaboration Board

from 2011 to 2013 Gena was (together with John Harris) deputy chair of the ALICE Collaboration Board

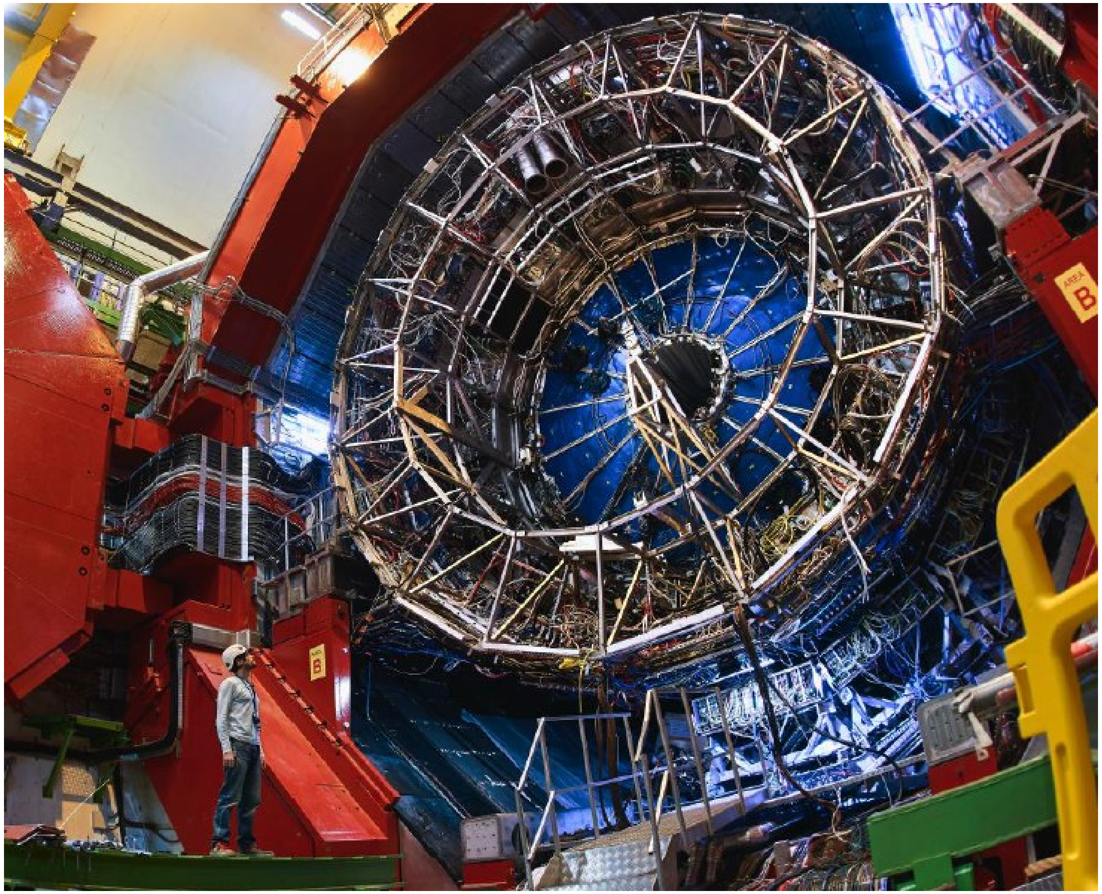
during this time he also served as member of the ALICE Management Board

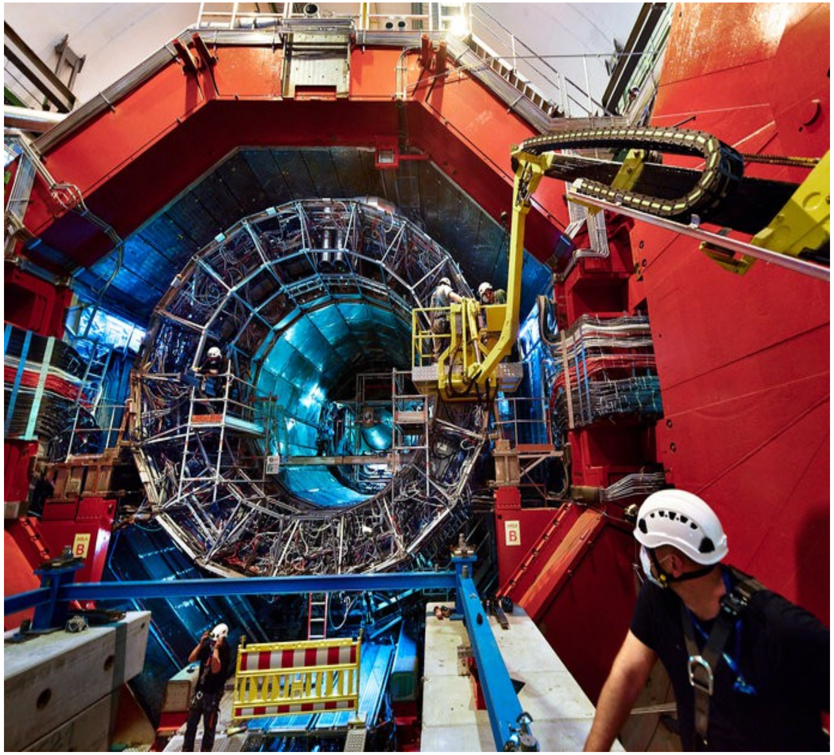
focus on ALICE members from eastern countries

thank you, Gena, for 3 years of important service

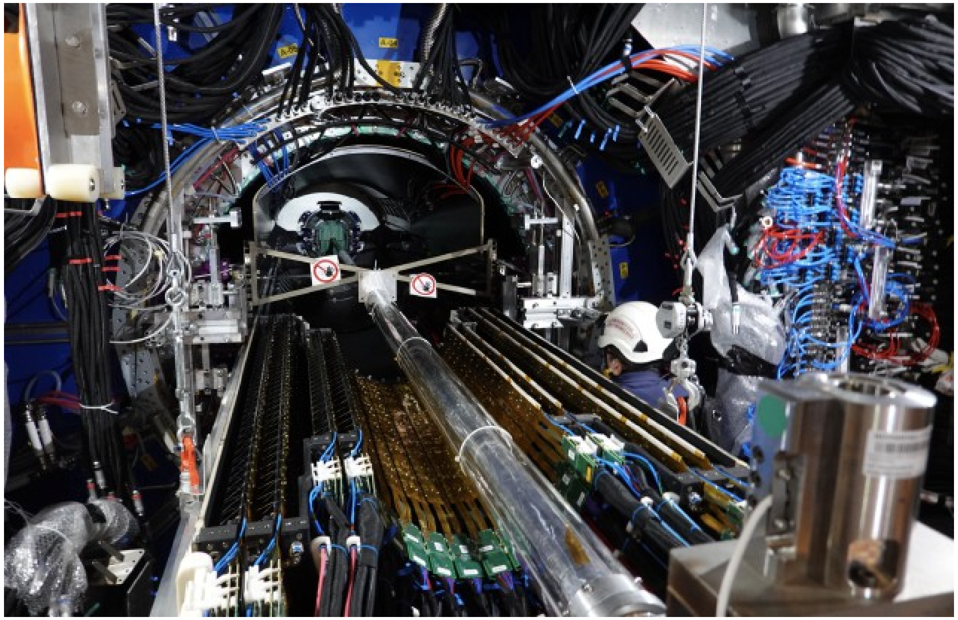
short interlude, jump to 2021

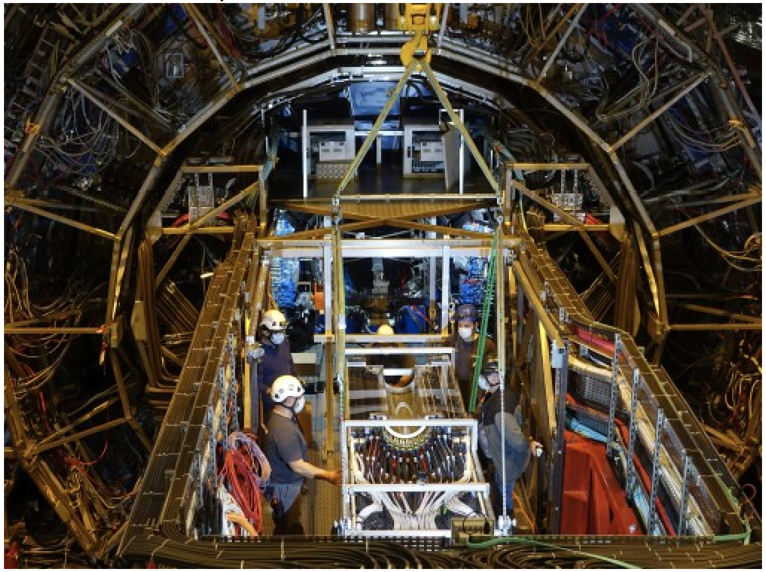
Gena continues close collaboration with ALICE and ITS, and Collaboration Board



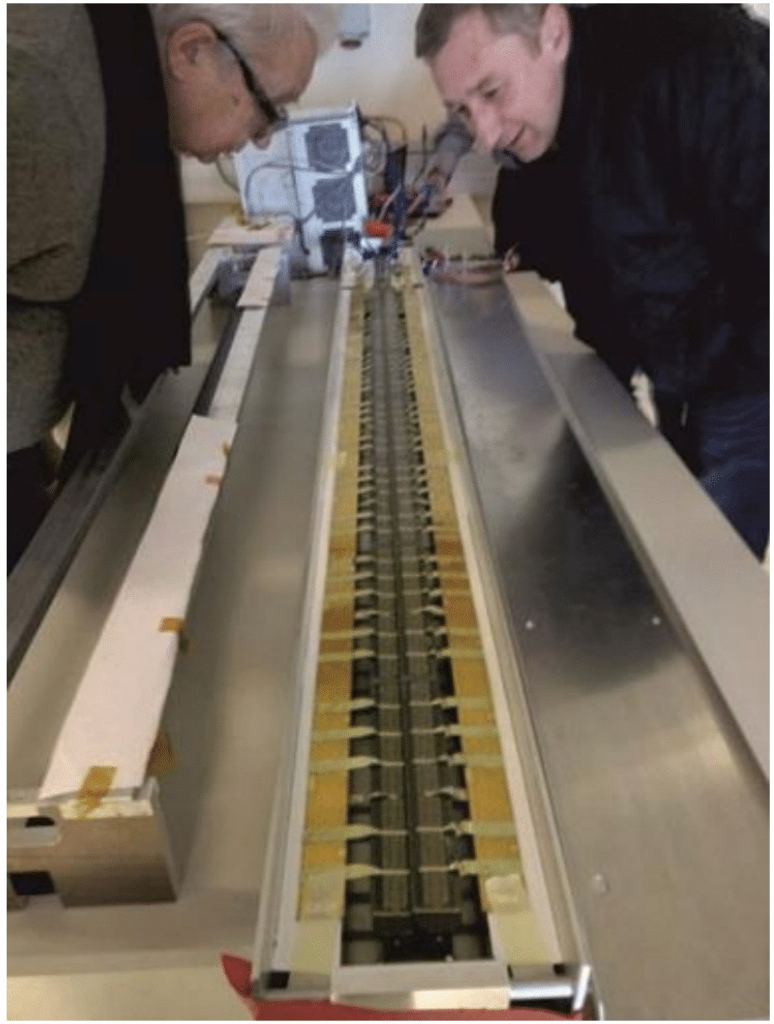


ITS and TPC removed
installation of upgraded detectors
TPC and (new) ITS2
March 25, 2021





ITS 2 – Outer Barrel



ITS 2 stave

Gena and part of the team

Gena the theorist and the QCD phase boundary – 2000 - now

Resolution of hyper-triton chemical freeze-out puzzle in high energy nuclear collisions

O. V. Vitiuk[1,2], K. A. Bugaev[1,3], E. S. Zherebtsova[4,5], D. B. Blaschke[4,6,7], L. V. Bravina[2], E. E. Zabrodin[2,8], G. M. Zinovjev[3]

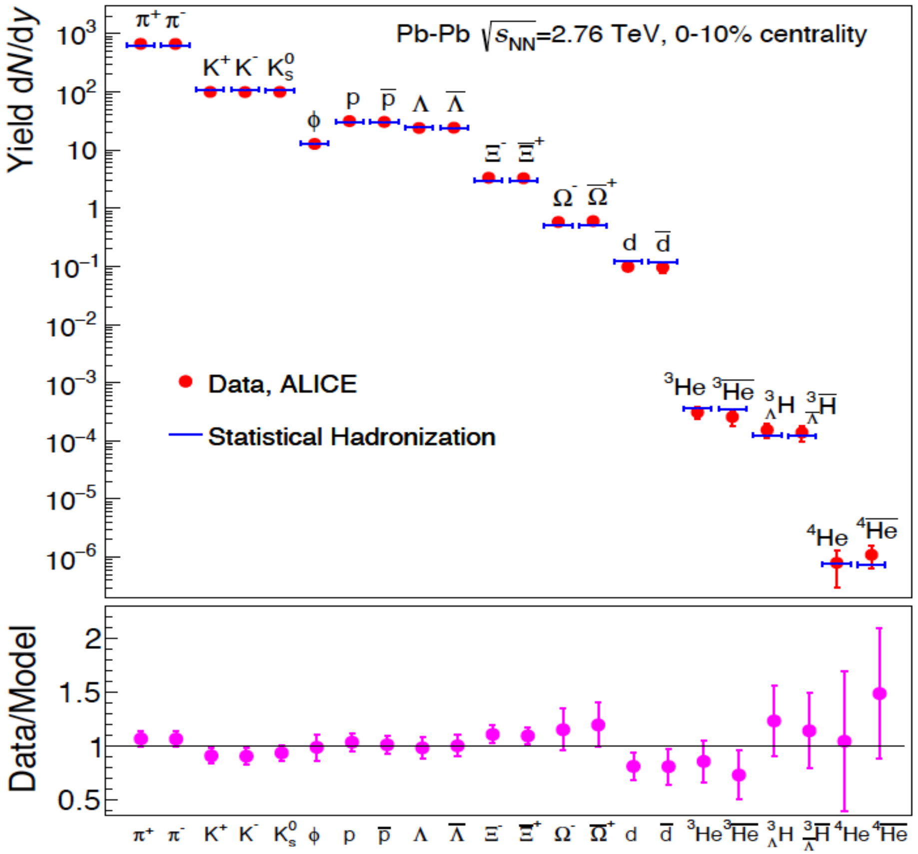
Eur.Phys.J.A 57 (2021) 2, 74

with the hyper-triton paper Gena and the Kiev crew put themself (characteristically) into a hotly debated area of discussion of how light nuclei, molecules (possibly X(3872) and other loosely bound objects are produced in the hot fireball of relativistic nuclear collisions

…to explain what is behind this I have to digress a bit

statistical hadronization of (u,d,s) hadrons

A. Andronic, P. Braun-Munzinger, K. Redlich, J. Stachel, Nature 561 (2018) 321



Best fit:

$T_{CF} = 156.6 \pm 1.7$ MeV

$\mu_B = 0.7 \pm 3.8$ MeV

$V_{\Delta y=1} = 4175 \pm 380$ fm^3

$\chi^2/N_{df} = 16.7/19$

S-matrix treatment of interactions (non-strange sect.)

"proton puzzle" solved

PLB 792 (2019) 304

data: ALICE coll.,
Nucl. Phys. A971 (2018) 1

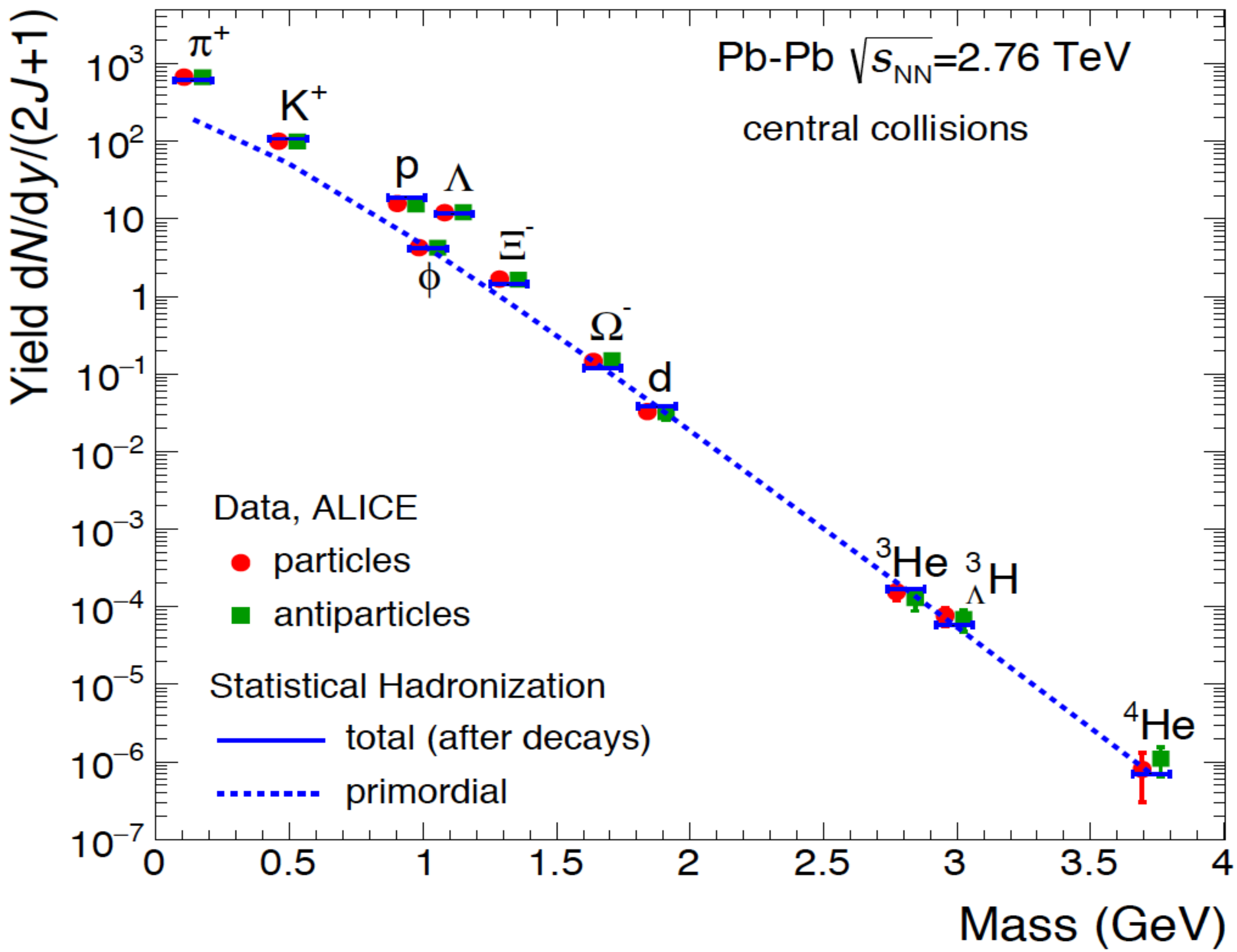
agreement over 9 orders of magnitude with QCD statistical operator prediction
(- strong decays need to be added)

- matter and antimatter formed in equal portions
- even large very fragile (hyper) nuclei follow the systematics

similar results at lower energy, each new energy yields a pair of (T, μ_B) values

connection to QCD (QGP) phase diagram?

at LHC energy, production of (u,d,s) hadrons is governed
by mass and quantum numbers only
quark content does not matter



universal hadronization

1 parameter (T)

at LHC energy, matter and anti-matter is produced with equal yields

The Hypertriton

mass = 2990 MeV, binding energy = 2.3 MeV

Lambda sep. energy = 0.13 MeV

molecular structure: (p+n) + Lambda

2-body threshold: (p+p+n) + pi- = ^{3}He + pi-

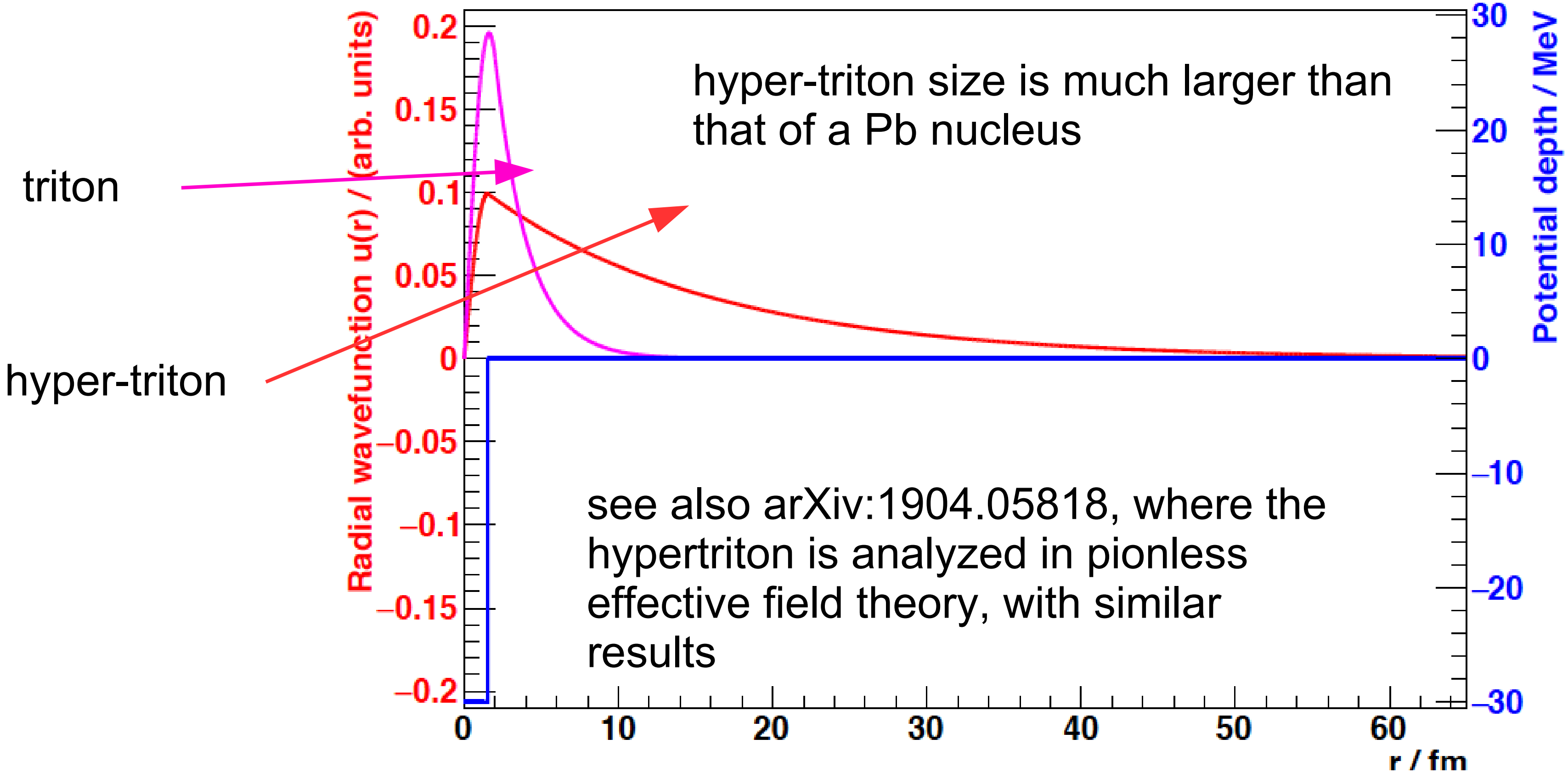
rms radius = $(4\ \mathrm{B.E.}\ M_{red})^{-1/2}$ = 10.3 fm =
rms separation between d and Lambda

in that sense: hypertriton = (p n Lambda) =
(d Lambda) is the ultimate halo state

yet production yield is fixed at 156 MeV temperature
(about 1000 x Lambda separation energy.)

wave function of the hyper-triton – schematic picture

pbm, Benjamin Doenigus
Nucl.Phys.A 987 (2019) 144-201



Wavefunction (red) of the hypertriton assuming a s-wave interaction for the bound state of a Λ and a deuteron. The root mean square value of the radius of this function is $\sqrt{\langle r^2 \rangle} = 10.6$ fm. In blue the corresponding square well potential is shown. In addition, the magenta curve shows a "triton" like object using a similar calculation as the hypertriton, namely a deuteron and an added nucleon, resulting in a much narrower object as the hypertriton.

from Gena's paper:

Abstract. The recently developed hadron resonance gas model with multicomponent hard-core repulsion is used to address and resolve the long standing problem to describe the light nuclear cluster multiplicities including the hyper-triton measured by the STAR Collaboration, known as the hyper-triton chemical freeze-out puzzle. An unprecedentedly accurate description is obtained for the hadronic and other light nuclear cluster data measured by STAR at the collision energy $\sqrt{s_{NN}} = 200$ GeV and by ALICE at $\sqrt{s_{NN}} = 2.76$ TeV. This success is achieved by applying the new strategy of analyzing the light nuclear cluster data and by using the value for the hard-core radius of the (anti-)Λ hyperons found in earlier work. One of the most striking results of the present work is that for the most probable scenario of chemical freeze-out for the STAR energy the obtained parameters allow to simultaneously reproduce the values of the experimental ratios S_3 and $\overline{S}_3$ which were not included in the fit.

my assessment: an important contribution. But not the final solution. Hard core radii should not matter for very dilute objects such as hyper-triton. But Gena's excellent physics instincts have led him again to the forefront of physics research.

Gena the politician

signing the MoU for Associate Membership of Ukraine at CERN
Rolf-Dieter Heuer (CERN DG), Ukrainian Minister for Science V.P Seminozhenko,
in the picture behind the Minister: V. Borshov (ALICE-Kharkiv), G. Zinovjev, ALICE, B. Grinev (Deputy Minister), M. Maymeskul (ambassador for Ukraine in Switzerland).
Date: Oct. 2013

Gena, the theorist and the future

Probing confinement by direct photons and dileptons

V.V. Goloviznin[1], A.V. Nikolskii[2], A.M. Snigirev[3,2], and G.M. Zinovjev[1]

The intensive synchrotron radiation resulting from quarks interacting with the collective confining color field in relativistic heavy ion collisions is discussed. The spectrum of photons with large transverse momentum is calculated and compared with the experimental data to demonstrate the feasibility of this type of radiation. A study of the earlier predicted azimuthal anisotropy in the angular distribution of dileptons with respect to the three-momentum of the pair is performed as well. This boundary-induced mechanism of lepton pair production is shown to possess the features that are distinctly different from the standard mechanisms and can potentially provide an efficient probe of quark-gluon plasma formation.

...picking up the subject of an earlier paper by Botz, Haberl and Nachtmann

SOFT PHOTONS IN HADRON-HADRON COLLISIONS: SYNCHROTRON RADIATION FROM THE QCD VACUUM?

G. W. Botz, P. Haberl, and O. Nachtmann

Z.Phys.C 67 (1995) 143-158

Abstract:
We discuss the production of soft photons in high energy hadron-hadron collisions. We present a model where quarks and antiquarks in the hadrons emit "synchrotron light" when being deflected by the chromomagnetic fields of the QCD vacuum, which we assume to have a nonperturbative structure. This gives a source of prompt soft photons with frequencies $\omega \lesssim$ 300 MeV in the c.m. system of the collision in addition to hadronic bremsstrahlung. In comparing the frequency spectrum and rate of "synchrotron" photons to experimental results we find some supporting evidence for their existence. We make an exclusive–inclusive connection argument to deduce from the "synchrotron" effect a behaviour of the neutron electric formfactor $G_E^n(Q^2)$ proportional to $(Q^2)^{1/6}$ for $Q^2 \lesssim 20\ \mathrm{fm}^{-2}$. We find this to be consistent with available data. In our view, soft photon production in high energy hadron-hadron and lepton-hadron collisions as well as the behaviour of electromagnetic hadron formfactors for low Q^2 are thus sensitive probes of the nonperturbative structure of the QCD vacuum.

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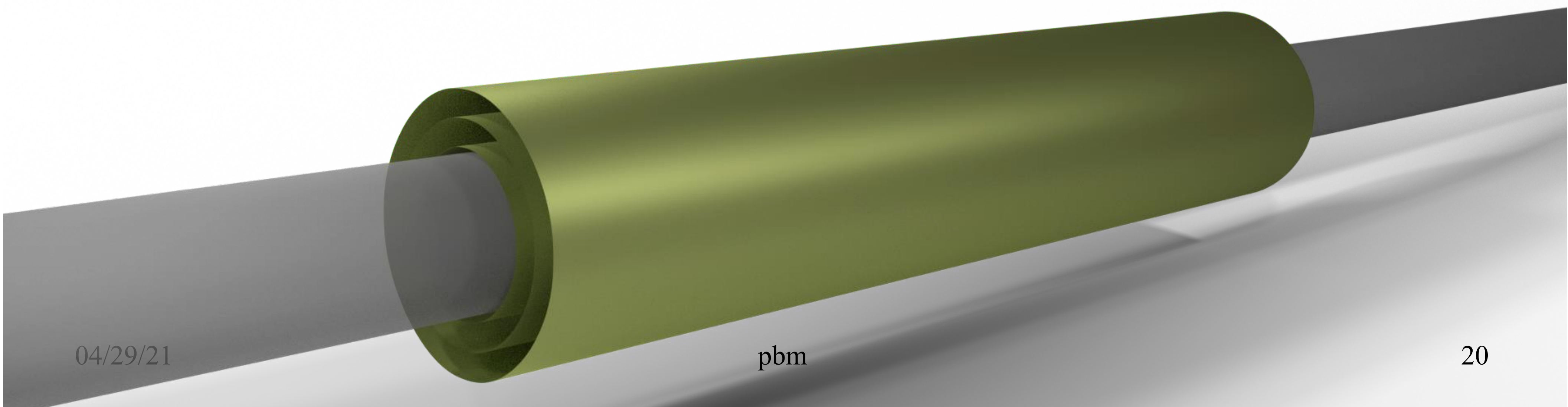
ALICE 3: a (nearly) massless detector for ALICE after LHC Run4 (2030+)

principle: surround the beam pipe by very thin (< 40 μm) Si pixel-chips bent into cylindrical shape

1st application: the ITS3 detector with 3 cylindrical layers, to be inserted into the current ALICE experiment after LHC Run3 (2026), see sketch below

baseline: monolithic active pixel (MAPS) sensors fabricated in the commercially available CMOS process

sensor and detector development currently underway in the framework of ITS3



A new HI dedicated experiment at the LHC beyond LS4

- Idea for new dedicated heavy-ion experiment at the LHC developed within ALICE in the course of 2018/19
- Discussed at the Heavy-Ion Town meeting (CERN, Oct 2018)
- Expression of Interest submitted (Dec 2018) as input to the European Particle Physics Strategy Update (EPPSU) - arXiv:1902.01211
- Presented at the EPPSU Symposium (Granada workshop, May 2019)
  - Presentation Johanna Stachel
  - Summary Strong Interactions
  - Briefing Book 1910.11775 [hep-ex]
- Presented at several conferences
  - XXV Conference EPIPHANY Conference on Advance in Heavy Ion Physics, January 2019
    Luciano Musa
  - Strangeness in Quark Matter, June 2019
    Johanna Stachel, Luciano Musa
  - 3rd EMMI workshop on Exotica at the LHC, Wroclaw, Nov. 2019
    pbm

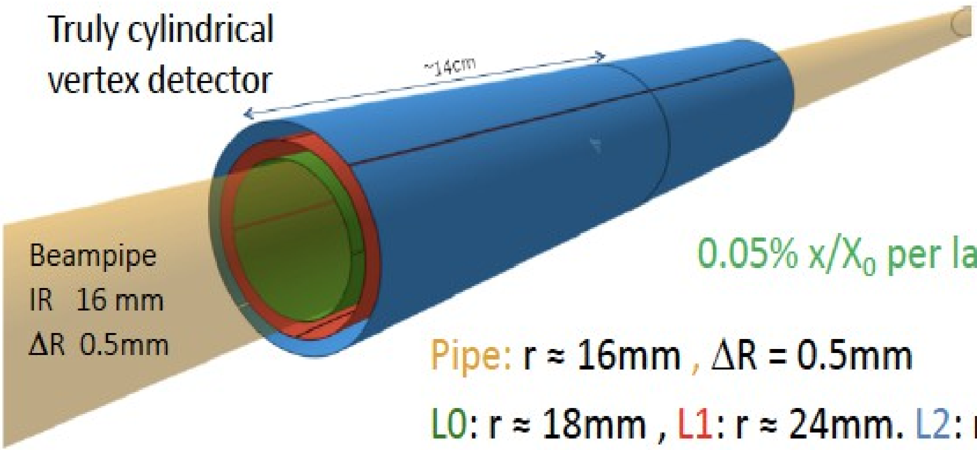
L. Musa (CERN) – Arbeitstreffen Kernphysik, Schleching 2020 32

EoI for new ultra-light Inner Barrel in LS3 (CDS, ALICE-PUBLIC-2018-013)

Recent silicon technologies (ultra-thin wafer-scale sensors) allow

- Eliminate active cooling ⇨ possible for power < 20mW/cm²
- Eliminate electrical substrate ⇨ Possible if sensor covers the full stave length
- Sensors arranged with a perfectly cylindrical shape ⇨ sensors thinned to ~30μm can be curved to a radius of 10-20mm

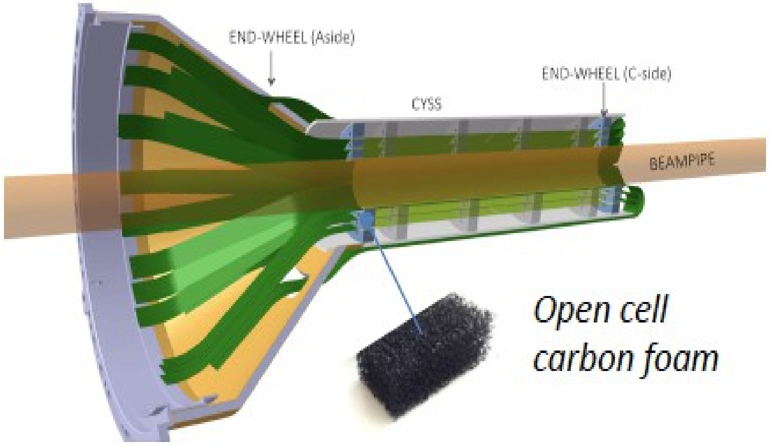
Truly cylindrical vertex detector



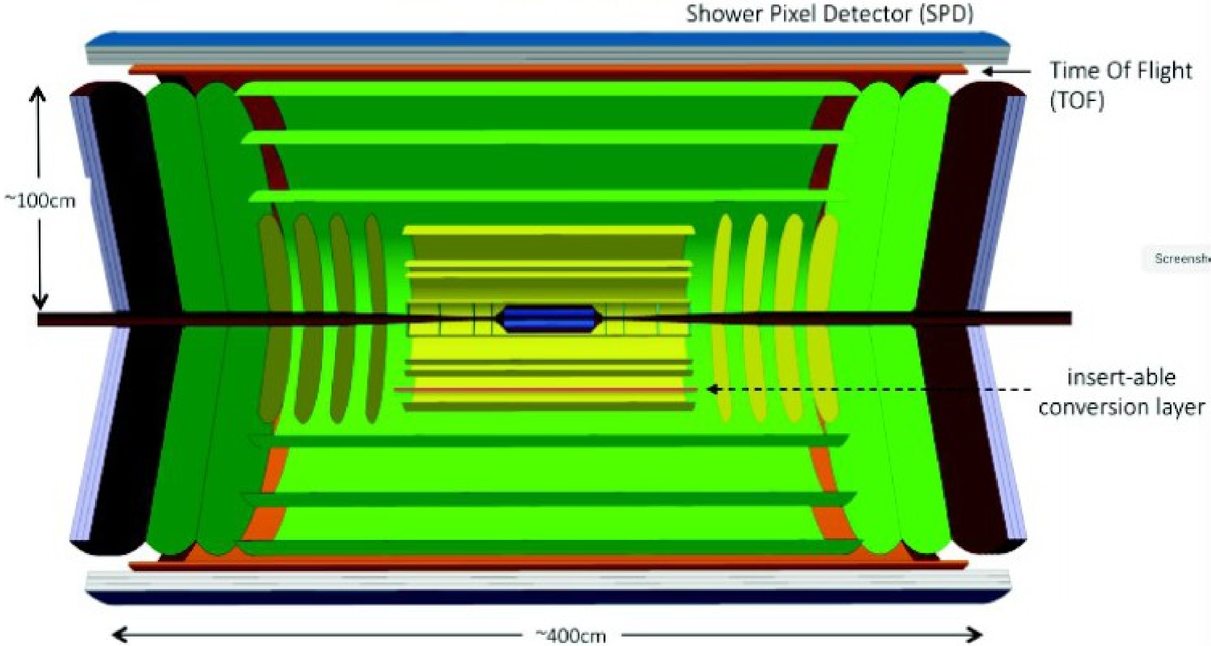
0.05% x/X_0 per layer

Pipe: r ≈ 16mm , ΔR = 0.5mm

L0: r ≈ 18mm , L1: r ≈ 24mm. L2: r ≈ 30 mm



Next generation of AA/pA/pp experiment for installation beyond Run4 @ HL-LHC



proposal to replace ALICE

Ultra-thin chip (<50 um): flexible with good stability

Detector concept is an all Silicon detector:

- Pixel detector with fast and light CMOS MAPS
- High-rate capabilities of MAPS will allow the experiment to run at significantly higher luminosities (a factor 20 to 50), e.g. with lighter ions

Physics potential:

- QGP properties via precision measurements in heavy flavor sector
- Access to new low-p_T phenomena (γ & hadrons)
- Low mass di-leptons

1902.01211

experimental coverage: $-4 < y < 4$ $0 < p_t < 30$ GeV
particle ID via time-of-flight in the low p_t region < 4 GeV

synchrotron radiation from quarks

Happy Birthday, Gena, and many more years of success stories

Gennady Zinovjev, a man of many talents