

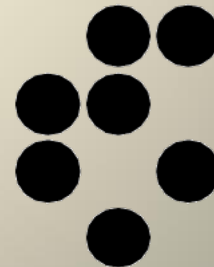
HEP in Slovenia

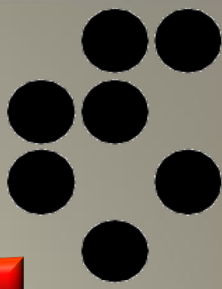
Marko Mikuž

University of Ljubljana & Jožef Stefan Institute

RECFA Country Visit

April 5, 2019





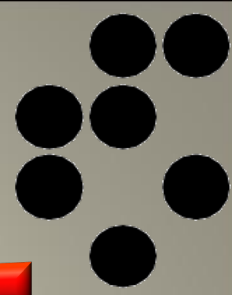
Outline

- Slovenia in a nutshell
- History of HEP in Slovenia
- HEP in Slovenia today - introduction
- Prospects

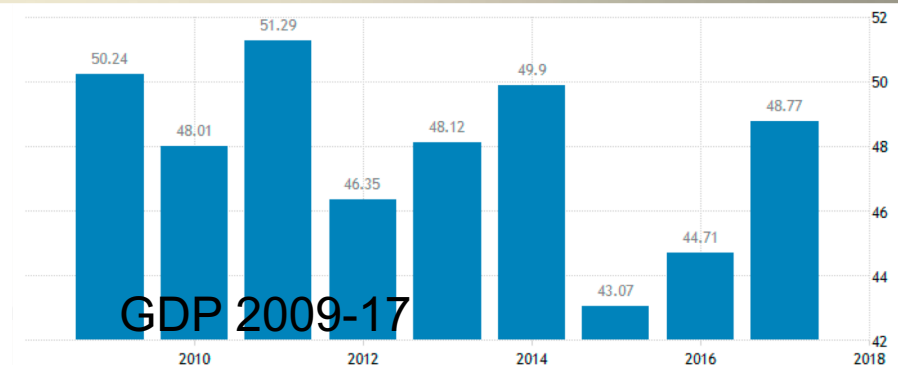
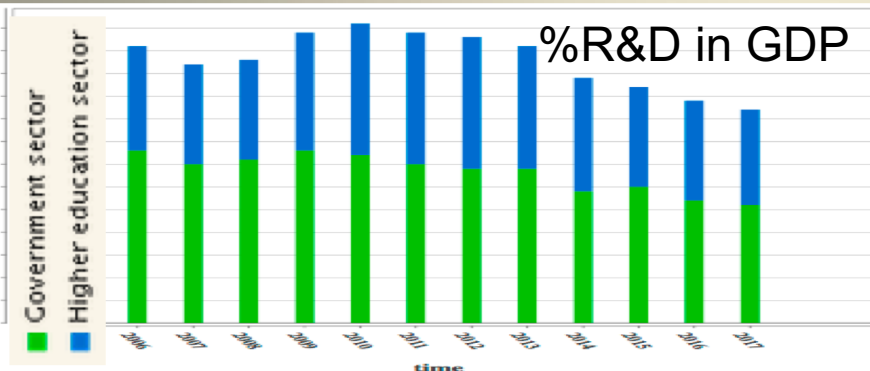
... focused mainly on HEP experiment; theory, astroparticle and nuclear in separate talks



Slovenia in a Nutshell

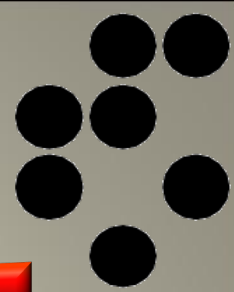


- Small middle-European country
 - Population: 2 million
 - GDP: 55 GUSD (2018 est.), 26.6 kUSD/cap.
 - ~2 orders of magnitude smaller than Germany
 - ~1 order of magnitude smaller than Poland
 - < 0.5% GDP public spending on Science
 - You should be able to apply appropriate scaling...

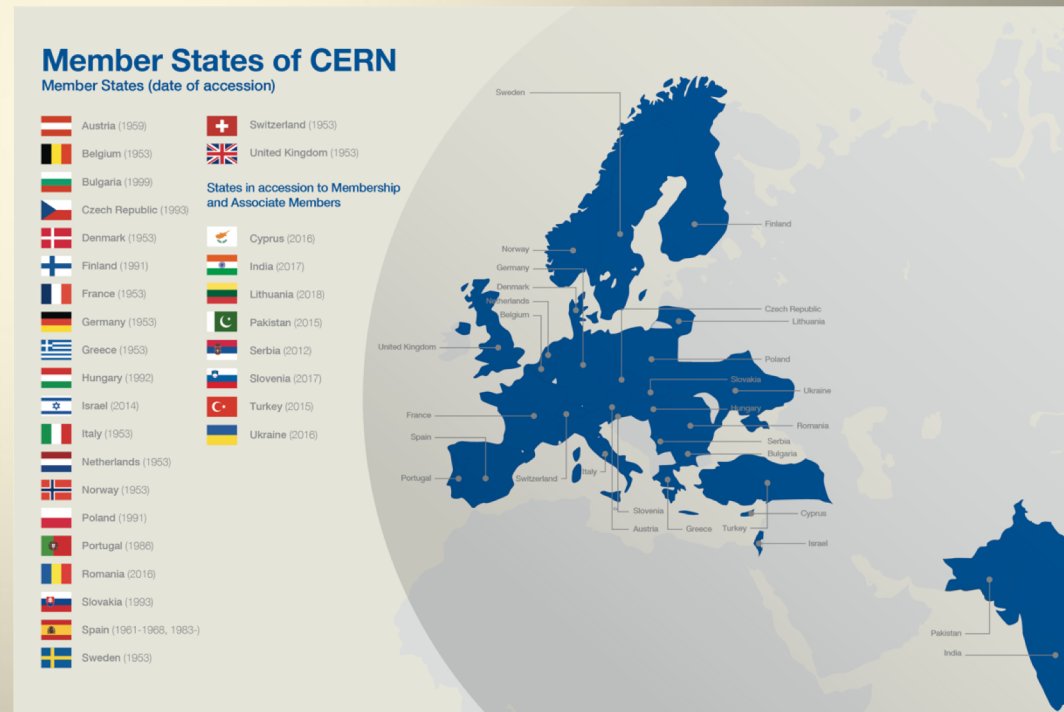




Slovenia at CERN



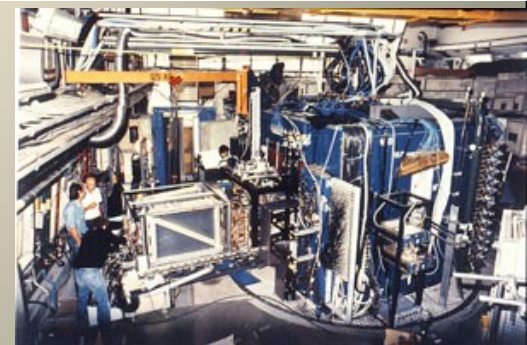
- Long struggle leading to Slovenia's adherence as *Associate Member State of CERN in the pre-stage to Membership* was successfully concluded on *July 4th 2017* (5y after Higgs discovery, 241y after US independence declaration)
 - First *LoI* in 1992
 - Two CERN fact-finding missions
 - Stalled
 - Second *LoI* in 2009
 - Council task force visit 2010
 - Negotiations started
 - Stalled
 - Process resumed 2015
- Part of ECFA since July 2018



History of HEP - OMICRON

1975-1991

- Prof. G. Kernel invited by Oxford colleagues to join the OMICRON collaboration at CERN SC
- Up to 1982 the OMICRON collaboration conducts a series of experiments on pion scattering
- Prof. Kernel is joined by several PhD students and the Slovenian group becomes a full member of the OMICRON collaboration
- For the last experiment, threshold pion production (CERN SC-94), the Slovenian group assumes a leading role with Prof. Kernel the spokesperson of the experiment



CROSS SECTION MEASUREMENT OF THE $\pi^-p \rightarrow \pi^- \pi^+ n$ REACTION NEAR THRESHOLD

OMICRON Collaboration

G. KERNEL, D. KORBAR, P. KRIZAN, M. MIKUŽ, F. SEVER, A. STANOVNIK, M. STARIČ, D. ZAVRTANIK

J. Stefan Institute and Department of Physics, E. Kardelj University, JU-61111 Ljubljana, Yugoslavia

C.W.E. VAN EIJK, R.W. HOLLANDER, W. LOURENS¹

Delft University of Technology, Delft, The Netherlands

E.G. MICHAELIS²

CERN, CH-1211 Geneva 23, Switzerland

N.W. TANNER

Nuclear Physics Laboratory, Oxford University, Oxford OX1 3RH, UK

S.A. CLARK

Rutherford and Appleton Laboratory, Chilton, Didcot OX11 0QX, UK

J. JOVANOVIĆ

Department of Physics, University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2

J.D. DAVIES, J. LOWE and S.M. PLAYFER³

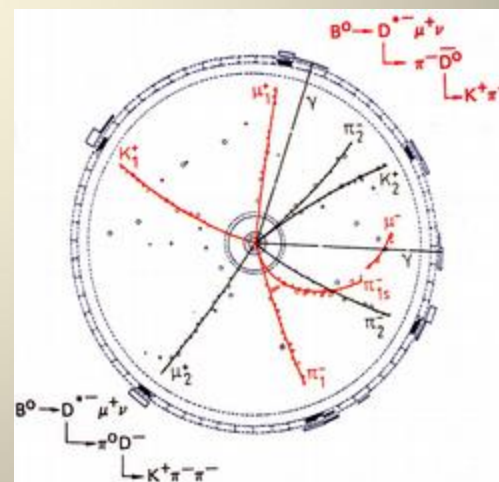
Department of Physics, University of Birmingham, Birmingham B15 2TT, UK

Received 24 October 1988

Result of cross section measurements for the reaction $\pi^-p \rightarrow \pi^- \pi^+ n$ are presented. They cover a range of incident pion momenta between 295 and 450 MeV/c. It is the first time that the cross section has been measured so close to threshold. The experiment was performed with Omicron, a large-solid-angle spectrometer, which enables a measurement of the full set of kinematic variables. In the region of overlap there is a good agreement with other experiments. The extracted value for the chiral-symmetry-breaking parameter ξ is seen to be largely extrapolation dependent but the measured value of -0.5 ± 0.8 leaves Weinberg's prediction of $\xi=0$ the only remaining choice.

History of HEP - ARGUS

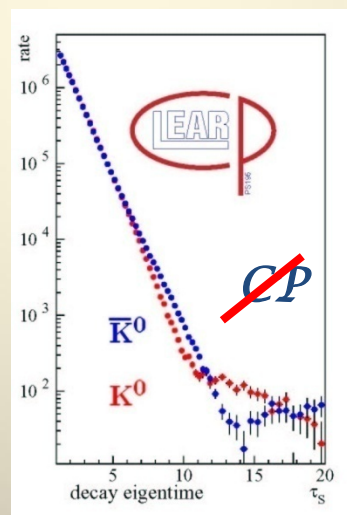
- 1983-2000
 - Following the end of OMICRON measurements in 1982, Prof. Kernel joined the ARGUS experiment at DESY
 - First limited to Prof. Kernel and one PhD student the group gradually grew to 6 researchers
 - Major involvement in physics analysis, specializing in two-photon physics
 - In excess of 130 papers, 3700 citations, one of the most productive experiments in late eighties
 - Discovery of B-mixing the physics highlight (459 citations)



History of HEP - CPLEAR

- 1988-2003

- 1985 – Slovenian physicists participate in a proposal to measure time reversal violation at LEAR (PSCC P-88)
- 1986 – the proposal is postponed, the collaboration is proposed to merge with the approved CPLEAR experiment (CERN PS-195)
- 1988 – Slovenian group joins CPLEAR in the final stage of detector preparation
- 1989 – 1996 successful measurements of CP , T and CPT violation in the neutral kaon system, featuring the first direct observation of time reversal non-invariance



17 December 1998

Physics Letters B 444 (1998) 43–51

PHYSICS LETTERS B

First direct observation of time-reversal non-invariance in the neutral-kaon system

CPLEAR Collaboration

A. Angelopoulos ^a, A. Apostolakis ^a, E. Aslanides ^b, G. Backenstoss ^b, P. Bargassa ^m, O. Behnke ^a, A. Benelli ^b, V. Bertin ^b, F. Blanc sm, P. Bloch ^d, P. Carlsson ^e, M. Carroll ^f, E. Cawley ^g, S. Charalambous ^h, M.B. Chertok ⁱ, M. Danielsson ^e, M. DeJardin ^a, J. Derre ^a, A. Ealet ^b, C. Eleftheriadis ^b, L. Faravel ^h, W. Fetscher ^g, M. Fidecaro ^d, A. Filipčić ^j, D. Francis ⁱ, J. Fry ⁱ, E. Gabathuler ⁱ, R. Gamet ⁱ, H.-J. Gerber ^a, A. Go ^a, A. Haselden ⁱ, P.J. Hayman ⁱ, F. Henry-Couannier ^k, R.W. Hollander ^l, K. Jon-And ^o, P.-R. Kettle ^m, P. Kolkas ^a, R. Krenger ^k, R. Le Gac ^k, F. Leimgruber ^b, I. Mandić ^j, N. Manthos ^b, G. Marel ^a, M. Mikuž ^j, J. Miller ^o, F. Montanet ^b, A. Müller ^a, T. Nakada ^m, B. Pagels ^q, I. Papadopoulos ^r, P. Pavlopoulos ^b, A. Policarpo ^o, G. Polivka ^b, R. Rickenbach ^b, B.L. Roberts ^o, T. Ruf ^q, C. Santoni ^b, M. Schäfer ^q, L.A. Schaller ^q, T. Schietinger ^b, A. Schopper ^d, L. Tauscher ^q, C. Thibault ⁱ, F. Touchard ^b, C. Touramanis ⁱ, C.W.E. Van Eijk ^l, S. Vlachos ^b, P. Weber ^a, O. Wigger ^m, M. Wolter ^q, D. Zavrtnik ^j, D. Zimmerman ^c

^a University of Athens, Greece

^b University of Basel, Switzerland

^c Boston University, USA

^d CERN, Geneva, Switzerland

^e LIP and University of Coimbra, Portugal

^f Delft University of Technology, Netherlands

^g University of Fribourg, Switzerland

^h University of Ioannina, Greece

ⁱ University of Liverpool, UK

^j J. Stefan Inst. and Phys. Dep., University of Ljubljana, Slovenia

^k CPPM, IN2P3-CNRS at Université d'Aix-Marseille II, France

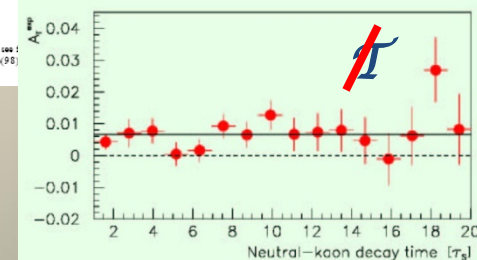
^l CERN, IN2P3-CNRS, Orsay, France

^m Paul Scherrer Institut (PSI), Switzerland

ⁿ CEA, DSM / DAPNIA, CE-Saclay, France

^o Royal Institute of Technology, Stockholm, Sweden

0370-2693/98/\$ - see front matter
PII: S0370-2693(98)00100-0





History of HEP - DELPHI

• 1992-2013

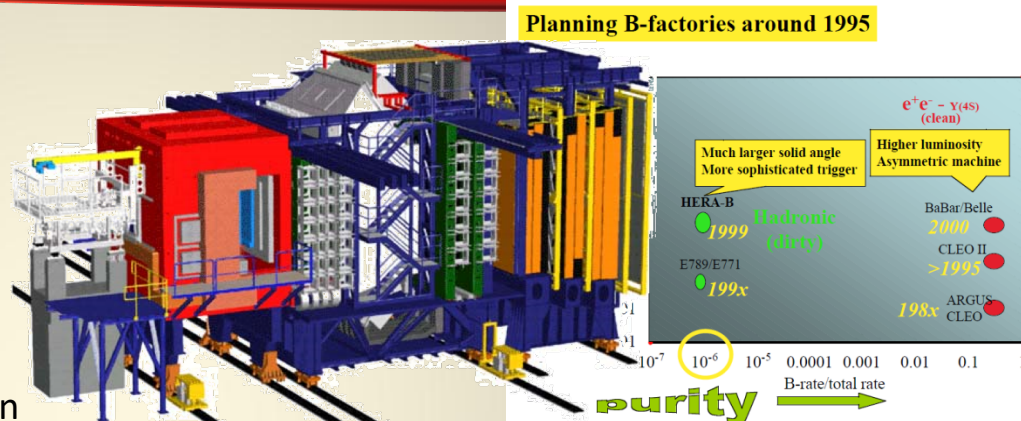
- 1992 – prof. D. Zavrtanik is invited to join the DELPHI collaboration
- Up to 2000 we participated in measurements with one of the most successful experiments in HEP history
- Numerous precision verifications of the Standard model published in more than 270 SCI papers with 5700 citations
- Slovenian physicists participated in data analysis, forward RICH commissioning and extension of the silicon tracker in the forward direction (VFT) for LEP-200



History of HEP – HERA-B

- 1994-2009

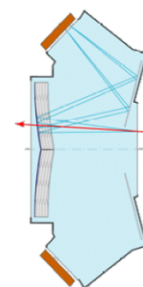
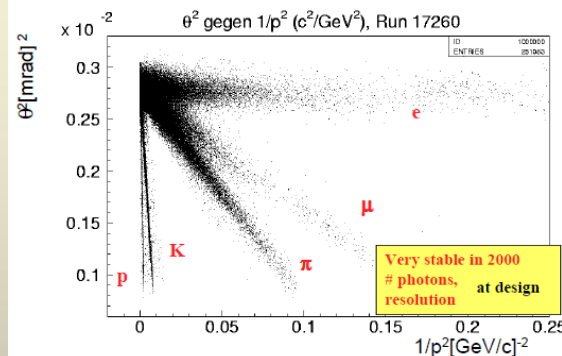
- 1994 – After participation in the design of the HELENA asymmetric B-factory Prof. P. Križan joins the HERA-B proposal, set to discover CP violation in the B meson system
- Slovenian group plays a leading role in constructing the RICH detector; Prof. Križan is RICH project leader
- Enormous detector challenges due to huge particle rates resembling LHC conditions
- Plagued by significant delays and out-of-spec performance of many sub-detectors, HERA-B misses its primary physics goal
- The RICH detector is one of the systems built on time and within specifications
- Despite moderate physics turnout, HERA-B established the Slovenian group as capable of building large particle physics detectors



ACHIEVEMENTS

Particle Separation

Cherenkov Relation for $\theta_{\beta=1} \ll 1$: $\theta^2 \approx \theta_{\beta=1}^2 + \frac{m^2}{p^2}$

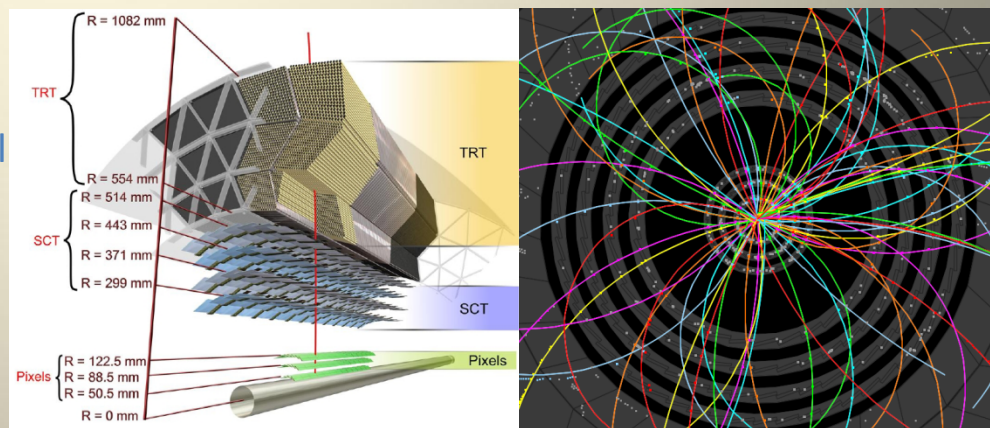
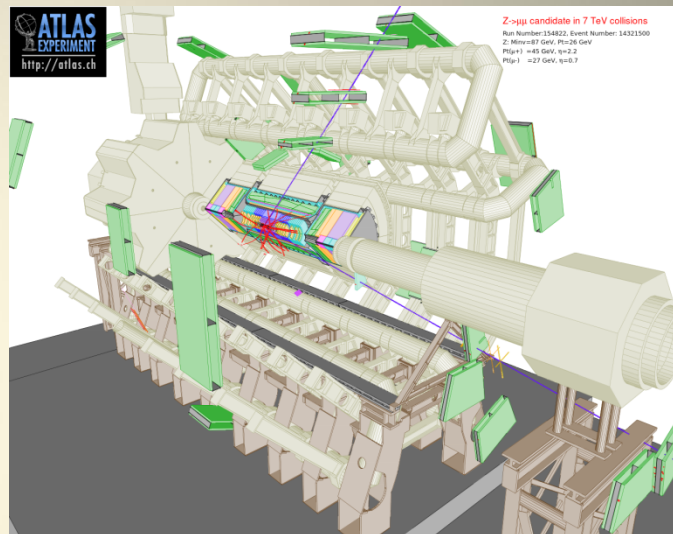
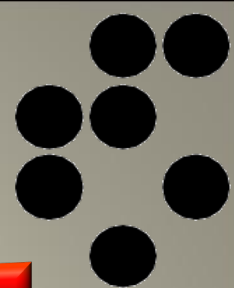


RICH detector

(Austin, Ljubljana, Houston, DESY, LIP Coimbra, Barcelona)



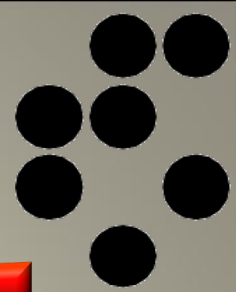
History of HEP – ATLAS



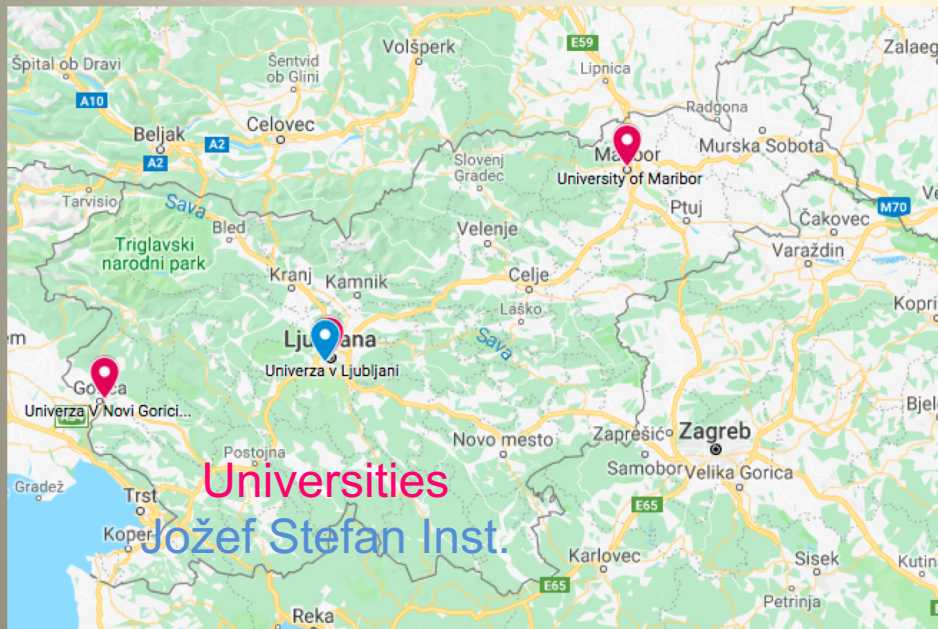
- 1996-
 - With CPLEAR completed looked for opportunities for the future
 - Discussions with CMS and ATLAS tracking
 - Opted for ATLAS
 - Slovenian group member of ATLAS collaboration since 1996 (148th institution admitted)
 - Main construction effort – building the SemiConductor Tracker - SCT, part of the particle tracking system - Inner Detector
 - CORE investment ~1.7 MCHF
 - After completing SCT taken on additional responsibilities
 - Beam Conditions Monitor
 - Beam Loss Monitor
 - Radiation Monitor
 - More in Borut's talk



HEP in Slovenia Today



- The Slovenian HEP community is composed of researchers from Jožef Stefan Institute and three Universities (Ljubljana, Maribor, Nova Gorica)
 - Experimental and Theoretical Particle Physics effort led by JSI
 - Astro-Particle by University of Nova Gorica (spawned off PP)
 - Nuclear Physics at JSI



- Experiment (PP&AP):
~40 researchers, including
~10 faculty and ~10 PhD
students
- Theory: ~10 researchers,
4 faculty, 4 students
- Faculty staff holds part-
time positions at JSI



HEP Today: Experiment

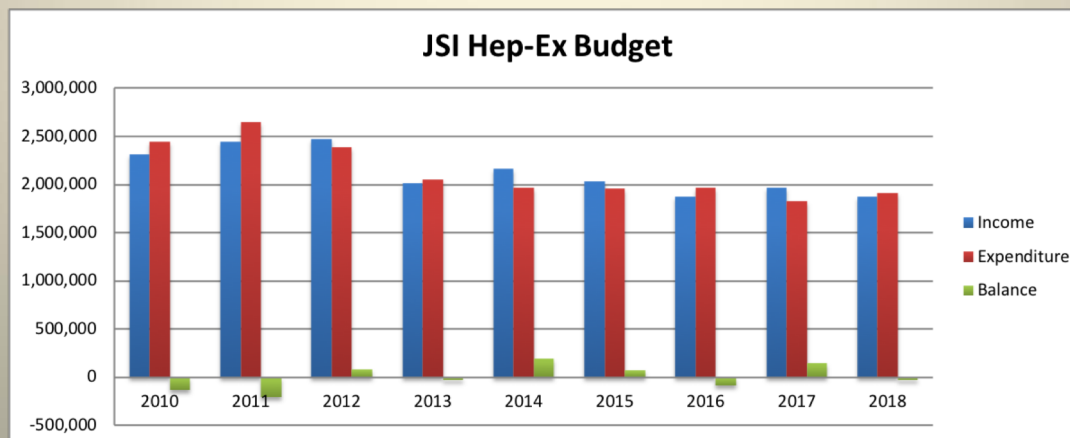


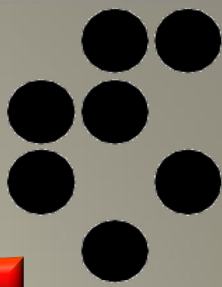
- Led by Experimental Particle Physics Department of JSI – Head count: ~30 researchers
- Currently active in two major HEP collaborations
 - ATLAS at the LHC in CERN (talk B.P. Kerševan)
 - Belle2 at Super-KEKB in KEK (talk P. Križan)
- Detector development (talk S. Korpar)
 - Also as part of two R&D collaborations at CERN
 - RD-42: diamond detectors
 - RD-50: radiation-hard silicon detectors
- Computing (talk A. Filipčič)



HEP Experiment - Funding

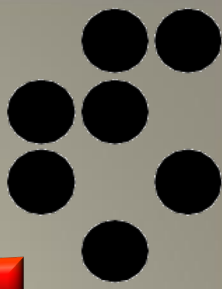
- Nearly all funding is competitive !
 - ~8 FTE Slovenian Research Agency long-term (6y, rolling) research grant
 - ~4 FTE short-term (3y) projects (SRA/EU) – fluctuating
 - Overhead money (partially institutional) – net loss
 - 8 full time positions at Universities – salary only
 - PhD students receive separate grants (SRA, Marie Curie in the past)
 - Travel, experiment M&O, upgrade serviced through an SRA infrastructure grant (~0.55 MEUR, had ups and downs – 0.3 MEUR 4-5y ago)
 - SRA calls for large/medium equipment (very fluctuating)





HEP-EX: Prospects

- Long term experimental HEP commitments
 - ATLAS Phase-II upgrade
 - ITk
 - HGTD
 - BCM'
 - ATLAS HL-LHC Operations and Physics
 - Belle2 Commissioning, Operations and Physics
 - R&D for future colliders (e.g. FCC-hh)



Conclusions

- Slovenian HEP perfectly integrated into the international HEP community, both at CERN and elsewhere
- Past achievements, present engagements and future directions guarantee stable and sustainable development at least in the decade to come