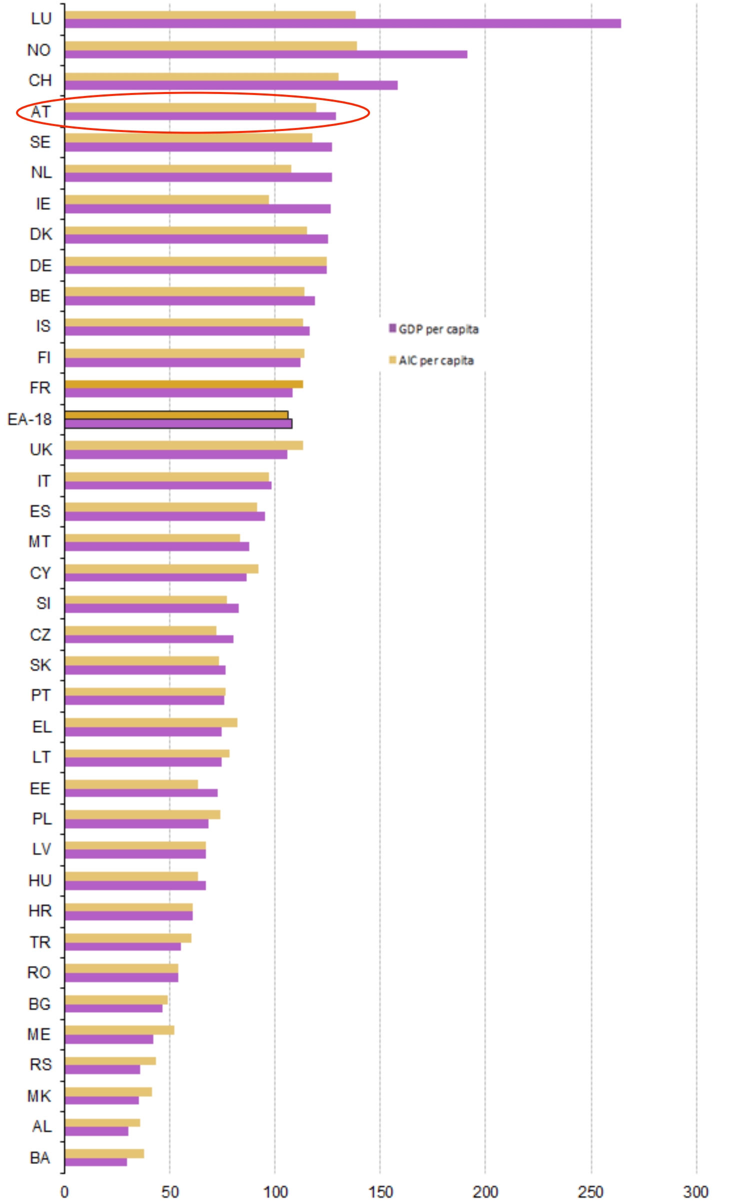
ECFA Midterm Report for AUSTRIA

Presented by
Claudia-Elisabeth Wulz
Institute for High Energy Physics, Vienna

Plenary ECFA Meeting, CERN, 20 Nov. 2014

BASIC INFORMATION ABOUT AUSTRIA

Population: 8.5 million
GDP per capita (2013): 45474 US$
(OECD average 36847 US$)
Total expenditure for R&D in % of GDP:
2.81% - 9.1 billion €
(2.42% last ECFA report,
EU average 2.02%)



RESEARCH PROJECTS

Accelerator-based physics

CERN LHC:	ATLAS, CMS, CLOUD, ALICE (soon)
CERN AD:	ASACUSA, AEgIS
CERN PS:	CLOUD, nTOF
KEKB, SuperKEKB:	BELLE, BELLE-II
J-PARC:	E15, E17
GSI FAIR:	PANDA
LNF DAFNE-2:	SIDDHARTA-2

Non-accelerator-based physics

LNGS:	VIP, CRESST
ILL Grenoble:	NoMoS, PERKEO III, aSPECT, qBOUNCE
Atominstitut Vienna:	Experiments in neutron and quantum physics
FRM-II Munich:	PERC

Astroparticle physics

FERMI, HESS, CTA

R&D for detectors and accelerators

Phase I and Phase II LHC upgrades, AIDA (EU), ILC, FCC, medAUSTRON

Particle physics theory and phenomenology

SUSY, QCD, QFT, chiral perturbation theory, neutrino physics, quantum mechanics, gravitational physics

RESEARCH GROUPS

- Institute of High Energy Physics Vienna (HEPHY Vienna)
  - experimental physics, theory/phenomenology
- Stefan Meyer Institute for Subatomic Physics Vienna (SMI)
  - experimental physics
- University of Vienna
  - theory/phenomenology
- Vienna University of Technology
  - theory/phenomenology
- Institute of Atomic and Subatomic Physics, Vienna
  - experimental physics, theory/phenomenology
- University of Graz
  - theory/phenomenology
- Institute for Astro- and Particle Physics of the University of Innsbruck
  - experimental physics, theory/phenomenology
- Fachhochschule Wiener Neustadt
  - experimental physics

NEW POSITIONS SINCE LAST REPORT

- New professor in theoretical particle physics at University of Graz (since 2014)
  - Axel Maas

- New director of HEPHY (since 2013) and professor in experimental particle physics at TU Vienna (since 2014)
  - Jochen Schieck

- New professor in theoretical particle and astroparticle physics at University of Vienna (since 2010)
  - André Hoang

- New professor in experimental physics at TU Vienna (since 2009)
  - Hartmut Abele

HEPHY

CMS, including upgrades

Data analysis, trigger, silicon tracker, electronics, algorithms and software, collaborations with industry

BELLE / BELLE-II

Data analysis, silicon vertex detector, electronics, algorithms and software

CRESST

New research direction in non-accelerator physics

http://www.hephy.at

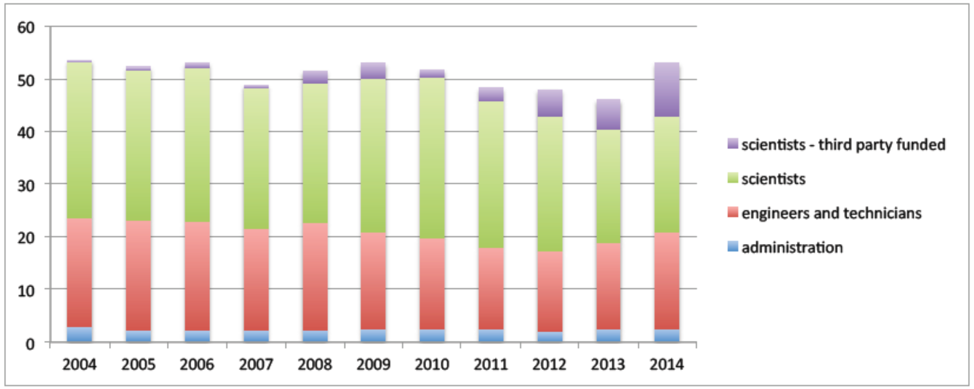
Future projects

ILC/ILD, FCC,

EURECA, SuperCDMS

Theory

SUSY, QCD, Dark Matter



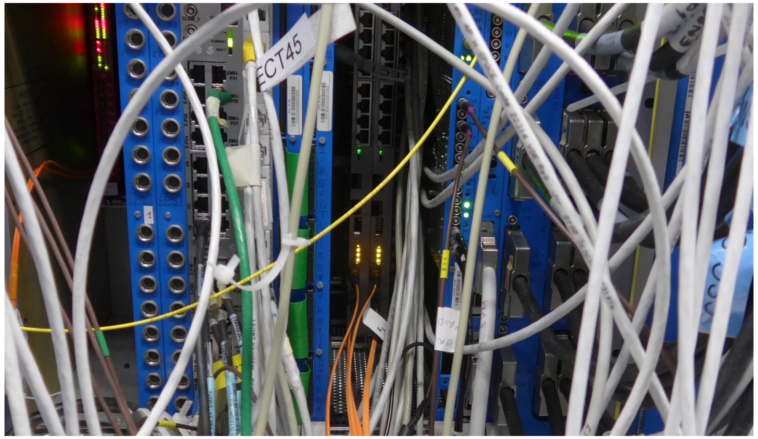
CMS Level-1 Trigger

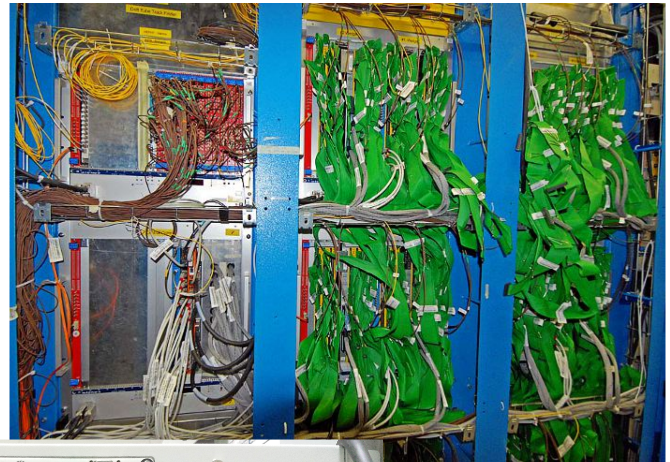
Responsibility for Global Trigger, Global Muon Trigger and Regional Barrel Muon Trigger

Operation of legacy VME system until 2015-2016

Complete rebuild in µTCA technology, operational by 2016

- improved functionality and selectivity





bmwfw
Bundesministerium für Wissenschaft, Forschung und Wirtschaft

Special funding 1 M€ till 2017

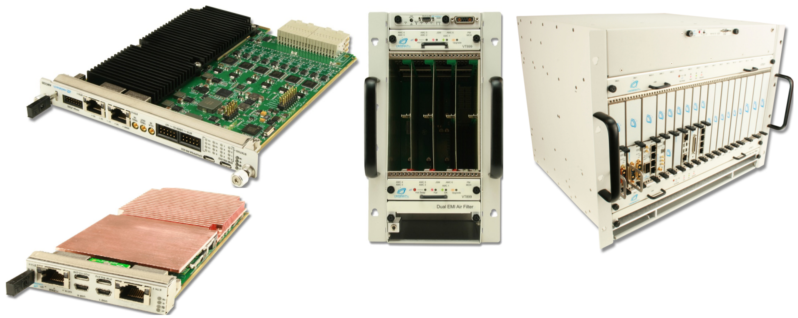
HEPHY Institute of High Energy Physics

CMS Silicon Strip and Pixel Tracker

ÖAW Austrian Academy of Sciences

Responsibilities for phase I upgrade

- New firmware for pixel detector readout system



Responsibilities for phase II upgrade

- Silicon sensor design
- Sensor procurement for prototypes
- Quality assurance strategies for mass production

Collaboration with Austrian industry

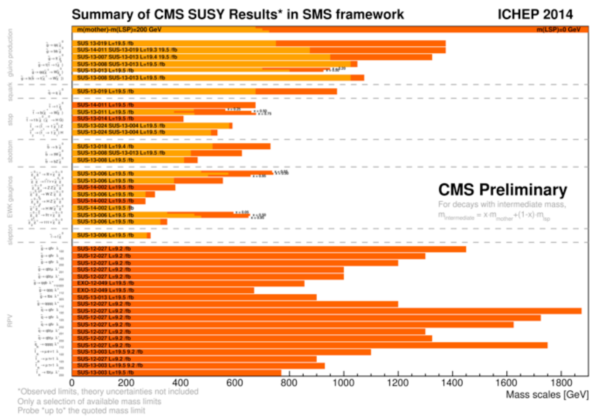
- Establishment of new vendor of high-quality and high-volume silicon sensors (currently only Hamamatsu)
- Apart from CMS, interest by ATLAS, LHCb, CMS HGC (780 m^2), UCSC (proton CT)

Search for SUSY in the single lepton channel

- Gluino search
- Nearly degenerate stop-LSP search

Interpretations of searches in SUSY and alternative models

- HEPHY was one of the pioneers implementing the use of "simplified models"
- Responsible for SUSY summary plots



QCD studies in quarkonium production

- Polarization and production cross sections

Higgs physics in the ττ channel

- New activity

BELLE

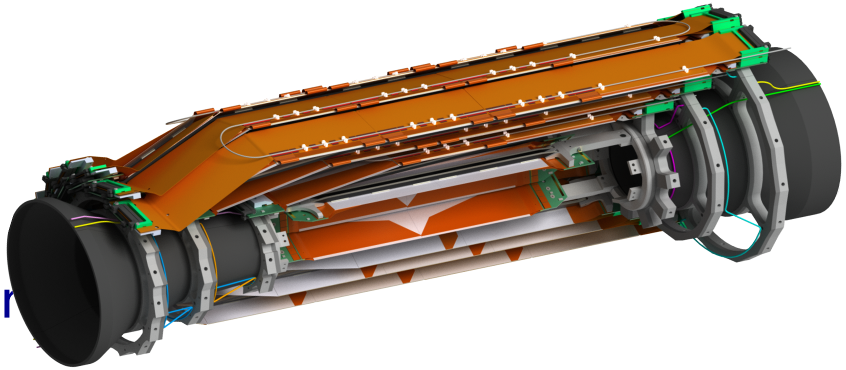
- Belle is a heavy flavor experiment (B- and D-mesons, τ-leptons), which operated from 1999 to 2010 (about 770 million $\Upsilon(4S) \rightarrow BB$ events on tape) and confirmed the Cabibbo-Kobayashi-Maskawa mechanism of the Standard Model (Nobel Prize 2008)
- HEPHY has been a member since 2001, built the silicon readout electronics and actively participated in physics analysis (semileptonic B decays, B_s decays, charm physics – in total 7 collaboration papers with a Vienna first author)
- Recent contributions to Belle physics
  - $|V_{cb}|$ from $B \rightarrow D^*l\nu$ (PRD 82, 112007 (2010), Victor-Hess prize 2010, ÖAW best paper award 2011) and from $B \rightarrow Dl\nu$ (ICHEP 2014 preliminary)
  - $B_s \rightarrow J/\psi\ K\ K$ (PRD 88, 114006 (2013))
  - 2 completed PhD since Nov. 2008, one PhD ongoing

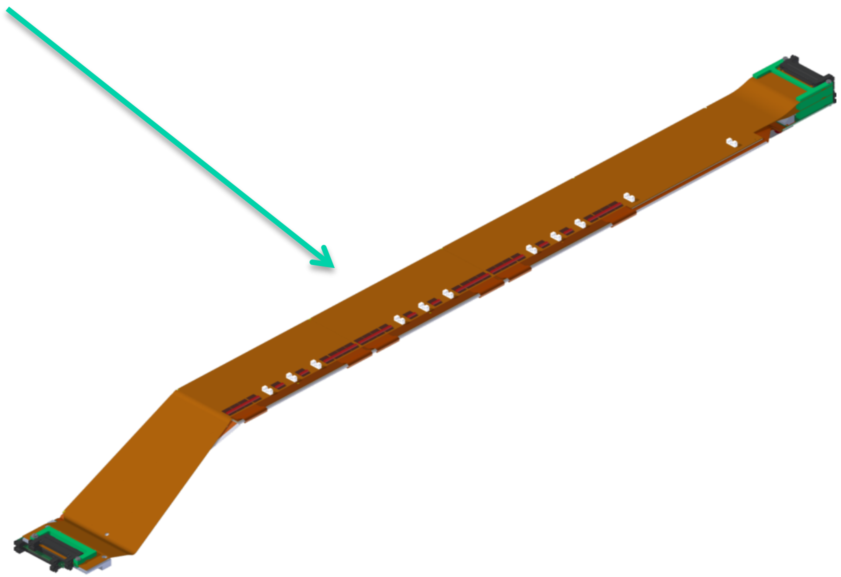
BELLE-II

- The Belle II upgrade aims at accumulating 50-times the Belle dataset and will start taking data in 2017

- HEPHY is leading the design and construction of the Silicon Vertex Detector (SVD)
  - in charge of the entire readout electronics and the construction of the layer 5 ladders
  - SVD construction proceeds on schedule for a delivery in 2016

- Further contributions to the detector software and Belle II physics planning





MoU between KEK and Austria

ÖAW Austrian Academy of Sciences

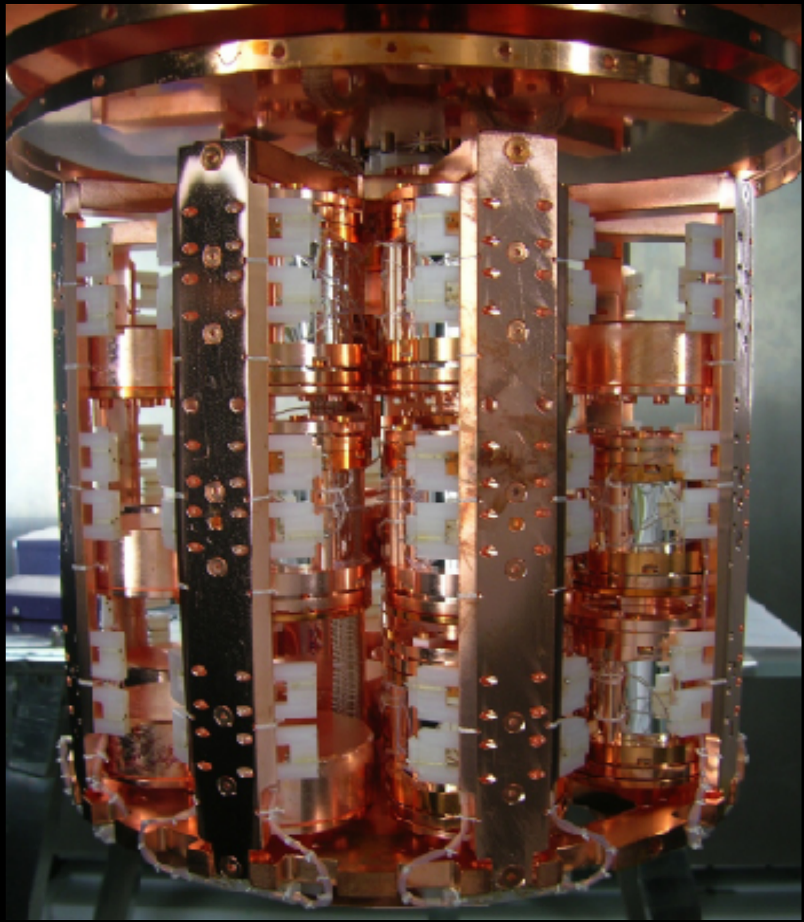
bmwfw Bundesministerium für Wissenschaft, Forschung und Wirtschaft

- Signed on 4 November 2014

Special funding 0.2 M€ 2014

Direct Dark Matter Detection

- New experimental group on direct Dark Matter detection
- joined TU Vienna / HEPHY cooperation
- currently 3 FTE (extension to 6 FTE planned)
- member of the CRESST and EURECA collaborations
  - simulation and data analysis
  - hardware contribution for upgrade under discussion



Theory at HEPHY Vienna

Supersymmetry

- SUSY Higgs decays
- SUSY phenomenology at LHC and ILC
- Radiative corrections to processes with SUSY particles
- CP violation in SUSY
- R-parity violation
- Spin correlations (in chargino/neutralino production and decay)
- Lepton flavour violation (LFV)

QCD

- Study and description of bound states - primarily but not exclusively of quarks - by relativistic equations of motion

Theory at HEPHY Vienna

New Frontiers Group on Dark Matter

- New 5-year grant for cutting-edge research led by outstanding junior scientists from abroad or from Austria

- 2.3 M€ for group led by Josef Pradler for 5 years from June 2014

- includes personnel costs for principal investigator, 2 postdocs, 2 PhD or master students, computing, travel and relocation, ability to host speakers and collaborators, organization of topical workshops

- Objectives: consider theoretical scenarios motivated by the DM problem and confront them with data from underground rare event searches and colliders, check for cosmological implications and associated observational signatures, and work out scenarios for high-energy and high-luminosity colliders

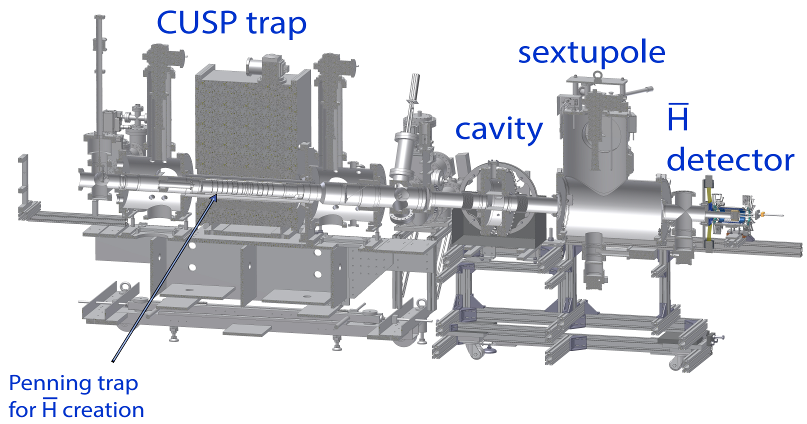
Personnel (FTE)

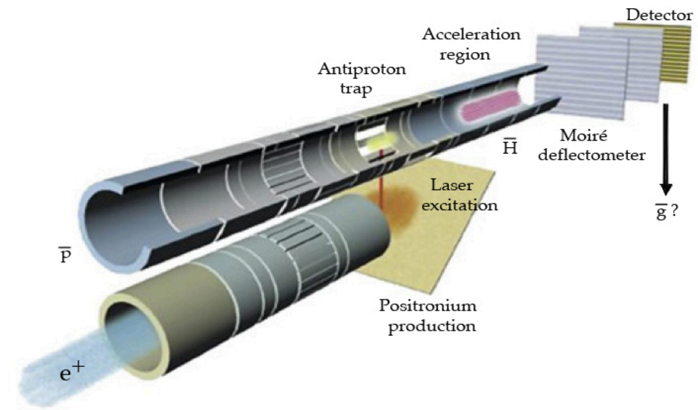
ASACUSA@CERN: 5
AEgIS@CERN: 2.5
ALICE@CERN: 2.5
E15@J-PARC : 1
SIDDHARTA-2@LNF: 3
PANDA@FAIR: 2
BELLE@SuperKEKB: 1.5
VIP@LNGS: 2
NoMoS@ILL: 2.5

Austrian Academy of Sciences

Antimatter research at CERN-AD

- Ground-state hyperfine structure of antihydrogen: ASACUSA
  - Precise test of CPT symmetry
  - Rabi-type atomic beam experiment
- Antimatter gravity: AEgIS
  - First ever direct measurement of the free fall of antimatter in the Earth's gravitational field





ERC Advanced Grant
E. Widmann (2.6 M€ 5 years)

European Research Council
Established by the European Commission

Der Wissenschaftsfonds.

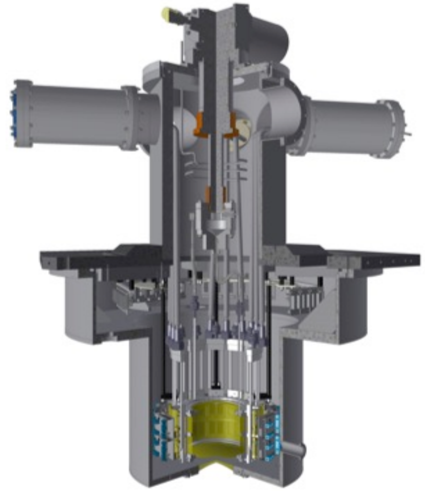
Bundesministerium für Wissenschaft, Forschung und Wirtschaft

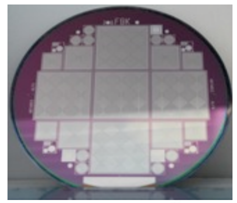
Stefan Meyer Institute Vienna

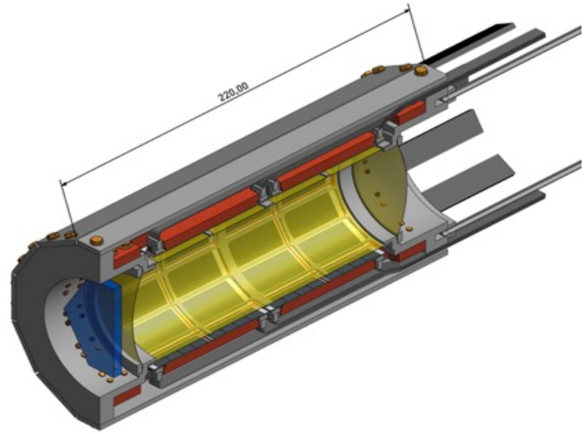
Austrian Academy of Sciences

Accelerator based Hadron Physics

- LNF-INFN DAFNE: SIDDHARTA2, AMADEUS
  - Kaonic atoms (kaonic deuterium), strong interaction in kaonic atoms, studies on resonance and bound states with strangeness (KLOE-data, AMADEUS)
- J-PARC: E15, E17
  - Search for strange di-baryons (E15), precision studies of kaonic atoms with cryogenic detectors (E17)

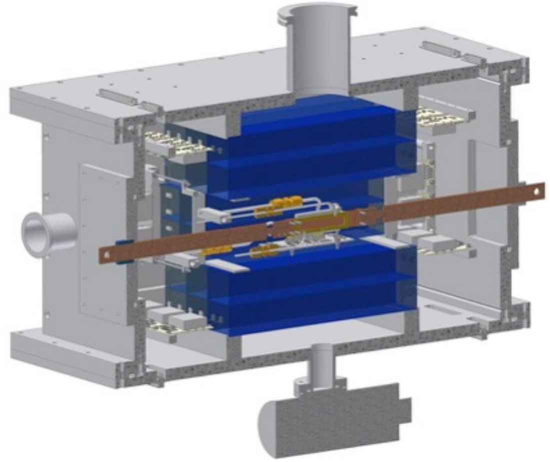


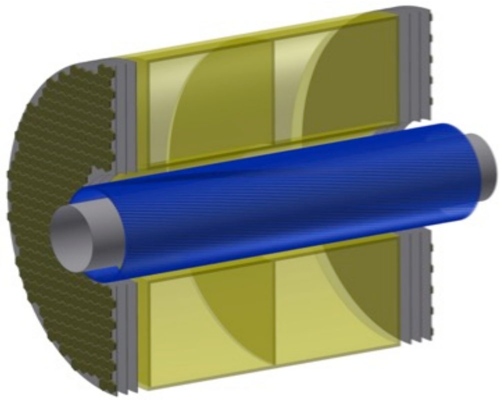




Non-accelerator-based research

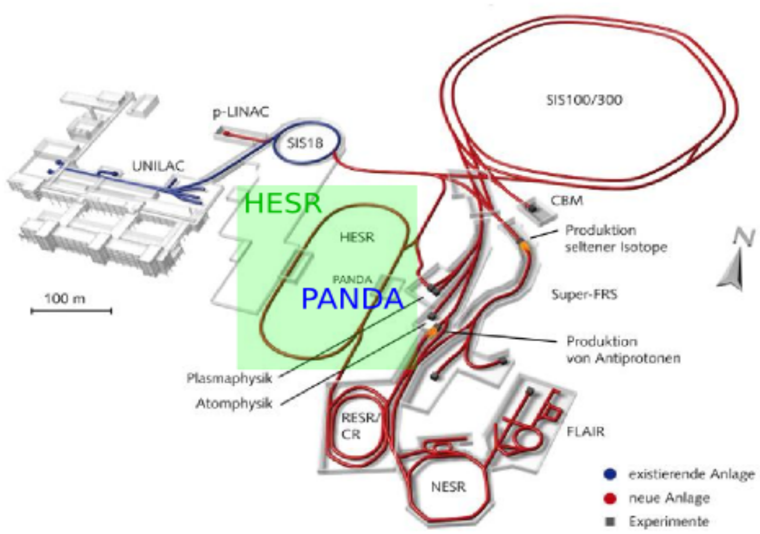
- Experiment VIP2
  - Experiment on the validity of the Pauli Exclusive Principle (PEP) for electrons at LNGS (Gran Sasso)
- Detector R&D
  - GEM based detectors: AMADEUS
  - SiPM based detectors: Hbar, PANDA-TOF, VIP2
  - SDDs for X-ray spectroscopy of kaonic atoms (SIDDHARTA2)

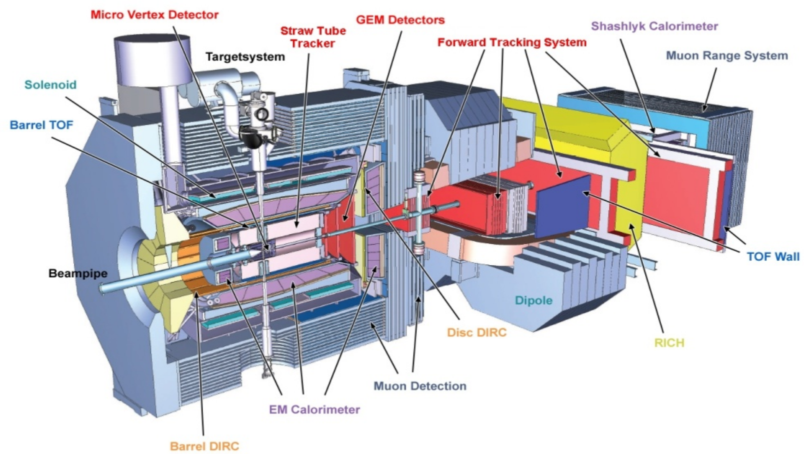




FAIR

- PANDA physics program
  - p^{bar} + p and p^{bar} + A
  - Physics topics
    - Hadron physics
    - Hadrons in matter
    - Nucleon structure
    - Hypernuclei
  - Physics Performance Report
    - arXiv:0903.3805 [hep-ex]





Stefan Meyer Institute Vienna

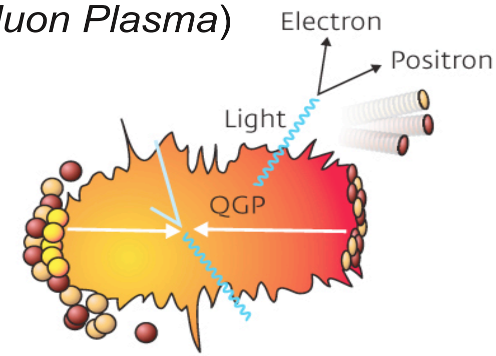
New Frontier Group: Michael Weber, starting summer 2015

A Large Ion Collider Experiment

ALICE

STUDYING THE QUARK GLUON PLASMA VIA LOW–MASS DIELECTRONS

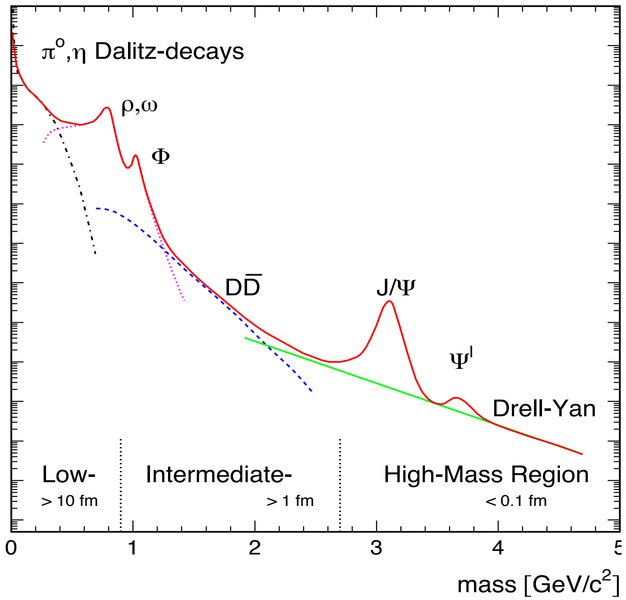
Heavy-ion collisions:
Study QCD matter under extreme conditions
(*Quark Gluon Plasma*)



Virtual photons→Electrons/Positrons:

- No strong interaction
- Probe of (in-)medium properties

Invariant mass of e^+e^- pairs



- **At LHC**: Pb-Pb, $\sqrt{s_{NN}}$= 5.1 TeV
- **ALICE**: low momentum e^+/e^- identification
- **ÖAW**: New Frontier Group at SMI (Vienna)

Explore the Quark Gluon Plasma:

- **Mass modifications of hadrons**
- **Temperature**
- **Time evolution**

Stefan Meyer Institute Vienna

Austrian Academy of Sciences

New Frontier Group: Gertrud Konrad, starting spring 2015

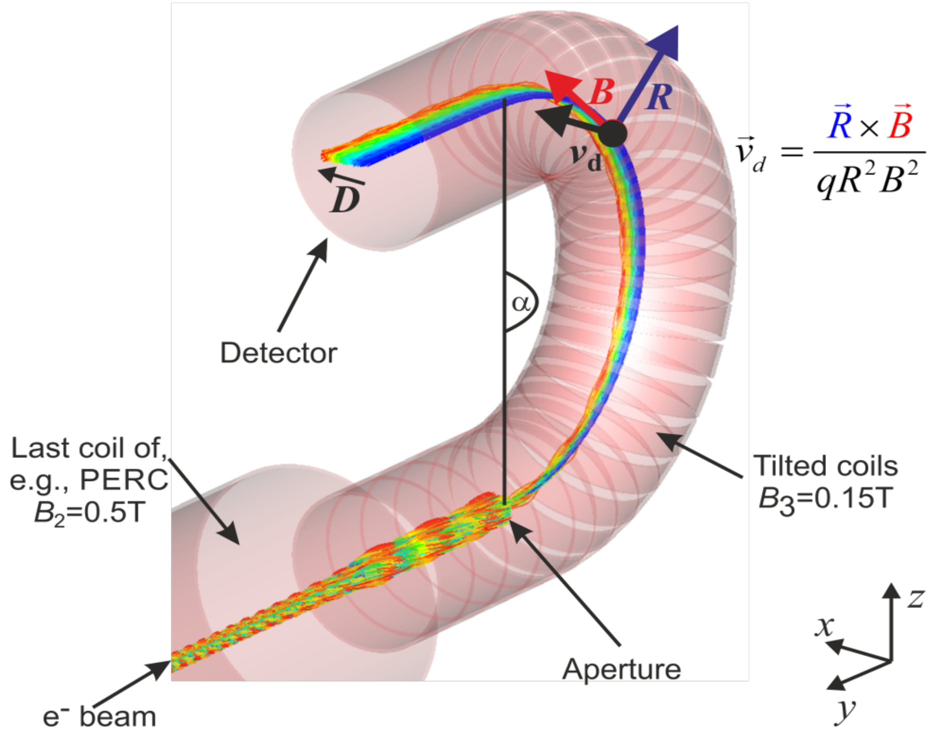
NoMoS

Beyond the Standard Model Physics in Neutron Decay

Neutron Decay Products Momentum Spectrometer

- Physics Programme:
  - Study structure of weak interaction
  - Test CKM unitarity
  - Search for BSM physics, e.g., scalar and tensor interations
  - Test Lorentz invariance
  - Theoretical analysis of ‘standard‘ correlation coefficients to order 10^{-5}
- Goal:

  Electron and proton spectroscopy on sub-10^{-4}- respectively 10^{-3}-level



universität wien

Research Areas of Particle Physics Group

http://particle.univie.ac.at/

A. Hoang (P)
H. Neufeld (assP)
W. Grimus (assP)
H. Hüffel (assP)

V. Mateu (postdoc, UniAss)
M. Procura (postdoc, UniAss)
B. Hiesmayr (postdoc, FWF)
S.M. Gianpaolo (postdoc, FWF)
P. Ludl (postdoc, FWF)
G. Kelnhofer (postdoc)

5 PhD students
2 Master students

A. Bartl (emeritus)
E. Ecker (retired)

Collider and Jet Physics
Effective Field Theories
Parton distribution functions
Precision and perturbative QCD
Low energy hadron dynamics (chiral perturbation theory)
SUSY phenomenology (LHC and ILC)
Neutrino physics
Quantum entanglement

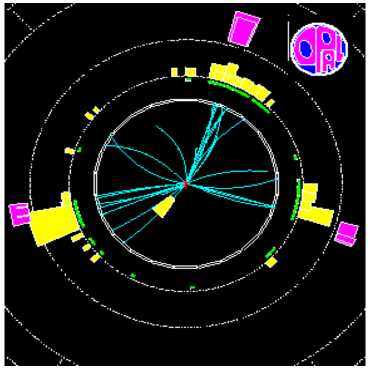
Participation in FWF graduate school "Particles and Interactions"

QCD Factorization in Soft-Collinear-Effective Theory

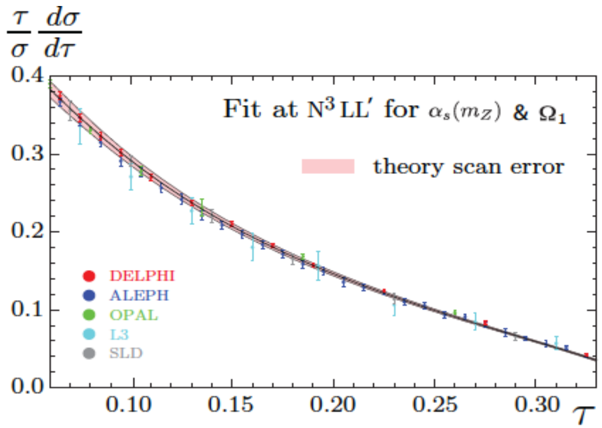
Hoang, Mateu, Stewart (MIT) 2011-2014

$$\left(\frac{d\sigma}{d\tau}\right)^{\rm sing}_{\rm part} \sim \sigma_0\, H(Q,\mu_Q) U_H(Q,\mu_Q,\mu_s) \int d\ell d\ell'\, U_J(Q\tau-\ell-\ell',\mu_Q,\mu_s)\, J_T(Q\ell',\mu_j)\, S_T(\ell-\Delta,\mu_s)$$

Predictions of event-shape distributions at NNNLL order.



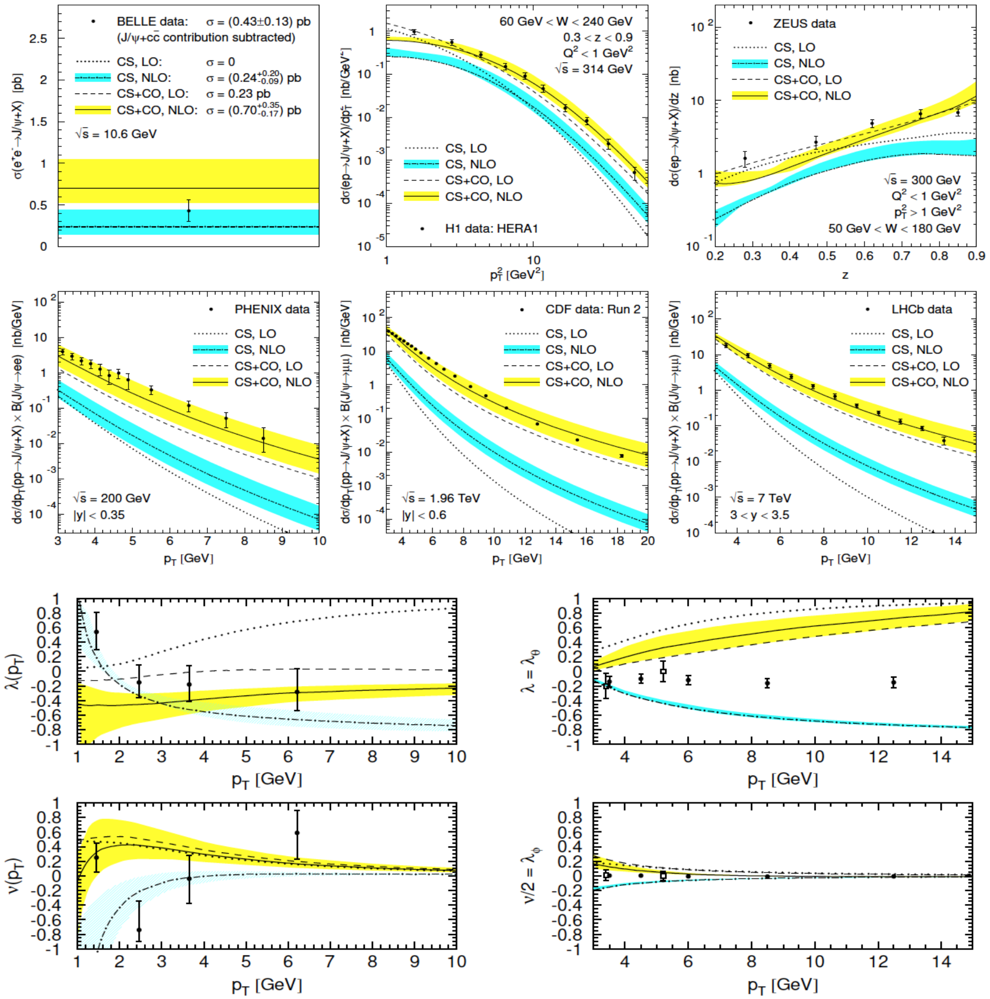
$$T = \max_{\hat{\mathbf{t}}} \frac{\sum_i |\hat{\mathbf{t}}\cdot\vec{p}_i|}{\sum_i |\vec{p}_i|}$$



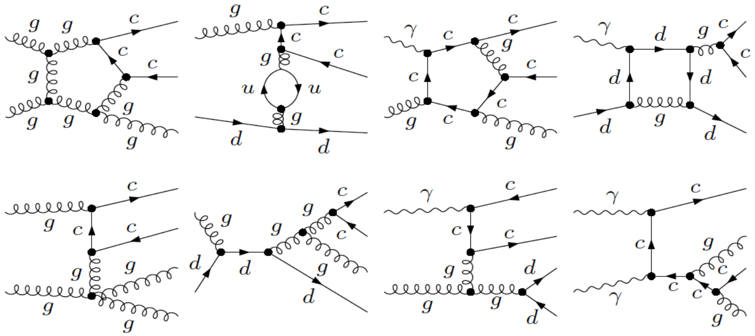
$$\alpha_s(M_z) = 0.1135 \pm (0.0002)_{\rm exp} \pm (0.0005)_{\Omega_1} \pm (0.0009)_{\rm pert}$$

Charmonium Production at NLO

Butenschön, Kniehl 2010-12



Global fits of charmonium production data at using NLO calculations: Tests of NRQCD for production and polarization.



Atomic Institute Vienna

http://www.ati.ac.at/

Neutron Beta Decay at European Research Reactors

- TRIGA Vienna: MONOPOL (Pulsed Spatial Magnetic Spin Resonator)
  - advanced flexible neutron beam tailoring
- ILL Grenoble: PERKEO III Collaboration, *a*SPECT Collaboration
  - tests of the Standard Model (SM), searches for right-handed currents as well as scalar and tensor interactions
- FRM-II Munich: PERC Collaboration (Proton and Electron Radiation Channel)
  - new facility for dedicated user experiments
  - tests of fundamental symmetries, searches for beyond SM physics
  - Austria contributes to design as well as construction of user experiments

Gravity Resonance Spectroscopy

- ILL Grenoble: *q*BOUNCE Collaboration
  - Gravity Resonance Spectroscopy constrains Dark Matter / Dark Energy
  - Free Fall and Einstein Equivalent Tests

Quantum Metrology

- Variation of fundamental constants in high-precision laser spectroscopy
  - Matter-wave interferometry
  - Fundamental questions in low-energy, tabletop experiments

Vienna University of Technology

Institute for Theoretical Physics

1 full and 4 associate/assistant professors, 1 scientist, 10 postdocs, 11 PhD students

http://www.itp.tuwien.ac.at

RESEARCH TOPICS

String theory, QFT, theory of the quark-gluon plasma, gravity

RECENT RESEARCH HIGHLIGHTS

- new constructions of string compactifications in extra dimensions
- 3+1-dimensional simulations of quark-gluon plasma instabilities
- holographic calculations of hadron spectra and glueball decay rates
- AdS/CFT calculations for heavy-ion thermalization
- generalizations of holography to different dimensions
- construction of first interacting massless higher spin theory in flat space

University of Graz

Institute for Physics, Theory Department:
Theoretical Particle Physics (60% of department)
http://physik.uni-graz.at/itp

5 professors, 6 postdocs, 11 PhD students
Graduate school, funded by FWF

Wide range of methods:

- Lattice gauge theory
- Functional continuum methods
- Perturbation theory
- Few-body approaches
- Effective field theories

University of Graz

Widespread research topics:

- QCD (FAIR, RHIC, LHC, BELLE/Bes3/Jlab)
  - Hadrons and hadronic interactions
  - QCD phase diagram
  - Generalized distribution and fragmentation functions

- High-energy physics (LHC, HL-LHC, ILC, Dark Matter Searches)
  - Higgs physics and electroweak background
  - Beyond the Standard Model: Technicolor, 2 HDM, GUTs

- Formal aspects
  - Quantization of (gauge) theories
  - Development of lattice algorithms

University of Innsbruck

Institute for Astro- and Particle Physics founded in 2004

http://astro.uibk.ac.at/

Particle Physics fields of work:

- ATLAS (3 staff, 3 PhD): B-Physics (rare decays, software development)
- CLOUD

Astrophysics fields of work:

- HESS (ground-based gamma-ray astrophysics)
- FERMI (spaced-based gamma-ray astrophysics)
- CTA (development of astroparticle detectors)
- modeling of propagation of cosmic rays

REGULAR CONFERENCES

Vienna Conference on Instrumentation

Organised every 3rd year by HEPHY Vienna with the Vienna University of Technology

VIENNA CENTRAL EUROPEAN SEMINAR ON PARTICLE PHYSICS AND QUANTUM FIELD THEORY

Organised annually by University of Vienna

Schladming Winter School

Organised annually by University of Graz

EXA - Exotic Atoms and Related Topics

Organised 3-annually by SMI since 2002

EPS-HEP 2015


EUROPEAN PHYSICAL SOCIETY
HEP2015
Home
Programme
Venue
Social Events
Registration
Contributions
Travel
EUROPEAN PHYSICAL SOCIETY
CONFERENCE ON HIGH ENERGY PHYSICS 2015
22 - 29 JULY 2015
VIENNA, AUSTRIA

LECTURES AND SCHOOLS

Schrödinger Guest Professorships

Annual lectures by distinguished particle physicists at University of Vienna

Graduate School "Hadrons in Vacuum, Nuclei and Stars"

University of Graz; cooperation with Jena and new Vienna graduate school

http://physik.uni-graz.at/~dk-user/

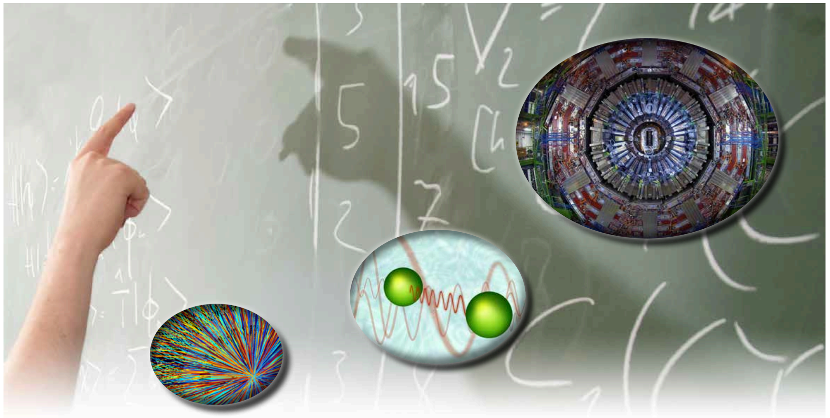
Speaker/deputy: Ch.Gattringer, R. Alkofer

NEW: Graduate School "Particles and Interactions"

Vienna cluster: University, TU, Institute of Atomic and Subatomic Physics, HEPHY, SMI, cooperation with International Max-Planck Research School on Elementary Particle Physics and Graz graduate school

http://dkpi.at

Speaker/deputy: A. Rebhan, A. Hoang



$\int dk\, \Pi$ VIENNA DOCTORAL PROGRAM Particles & Interactions

The Vienna Doctoral Program for Particles and Interactions (DK-PI) welcomes applications for

PhD fellowships in experimental and theoretical particle physics.

The DK-PI is a graduate program that is targeted to outstanding and excellent students and offers

- research opportunities in the physics of elementary particles and hadronic matter, including theories beyond the standard model, and gravity
- three year contract with social and health benefits
- introductory and specialized as well as soft skill courses at TU Wien, University of Vienna, and Austrian Academy of Sciences
- support for travel to scientific workshops, schools, and international conferences
- research stays at various partner institutions around the globe

Please visit www.dkpi.at for details on research opportunities and the application procedure.

www.dkpi.at

The next call for applications for PhD fellowships is open.

Three selection rounds per year.
We specifically invite applications by women.

VIENNA PARTICLE PHYSICS

universität wien · TU WIEN · ÖAW · FWF Der Wissenschaftsfonds.

COMPUTING

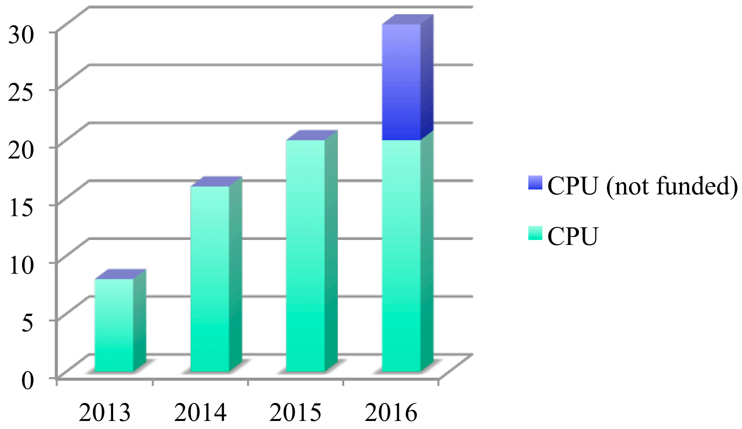
- 2002: Tier-2 pilot project in Innsbruck

- 2008: WLCG-MoU signed for federated Tier-2 project Vienna-Innsbruck for ATLAS-CMS (in the framework of the Austrian GRID-project).
  Now also for Belle.

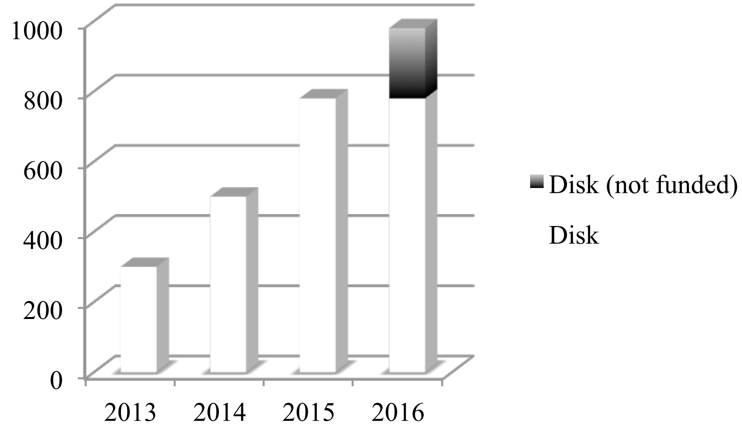
- From 2018: local infrastructure too limited

- Initiative for cloud computing started with partners

CPU in kHS06



Disk in TB



PHYSICS EDUCATION

http://statcube.at/

The obtained physics degrees are for the academic year 2013/2013.
“Physics” does not include astronomy or meteorology.

2013/2014 Physics	TOTAL	FEMALE	MALE	% FEMALE	% MALE
Obtained Diploma/Bsc/MSc	**512**	87	425	17	83
Obtained Teaching Diplomas	**25**	9	16	36	64

Figures subdivided in experimental and theoretical physics are not officially available.

OUTREACH ACTIVITIES

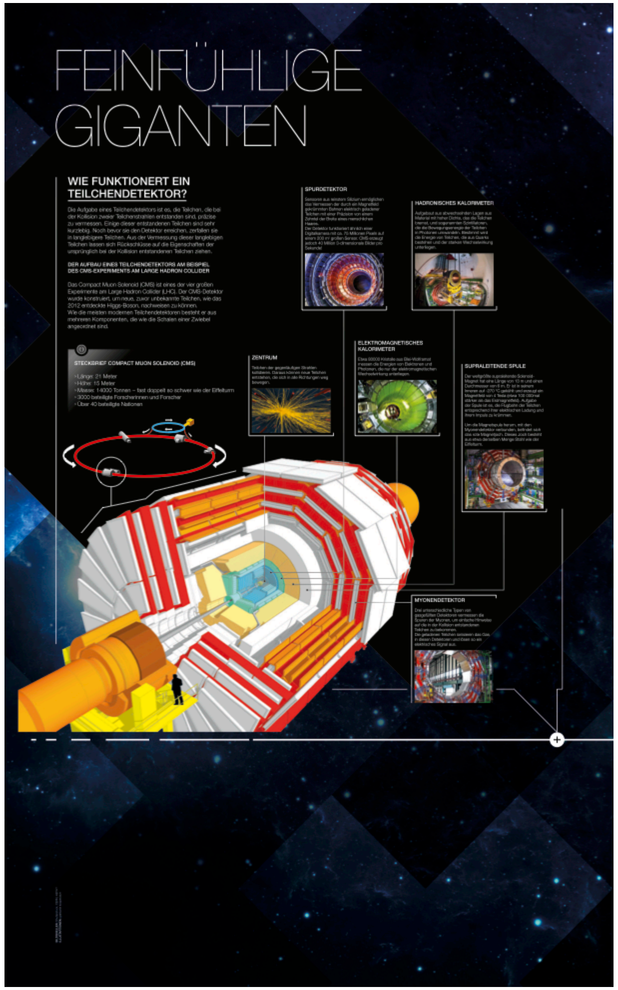
General Public
- Large exhibitions with partners
- Events (movie screenings, celebrations, etc. …)
- University meets Public
- Researchers' night
- Public talks
- Open Day/Guided Tours @HEPHY
- Guided Tours @CERN

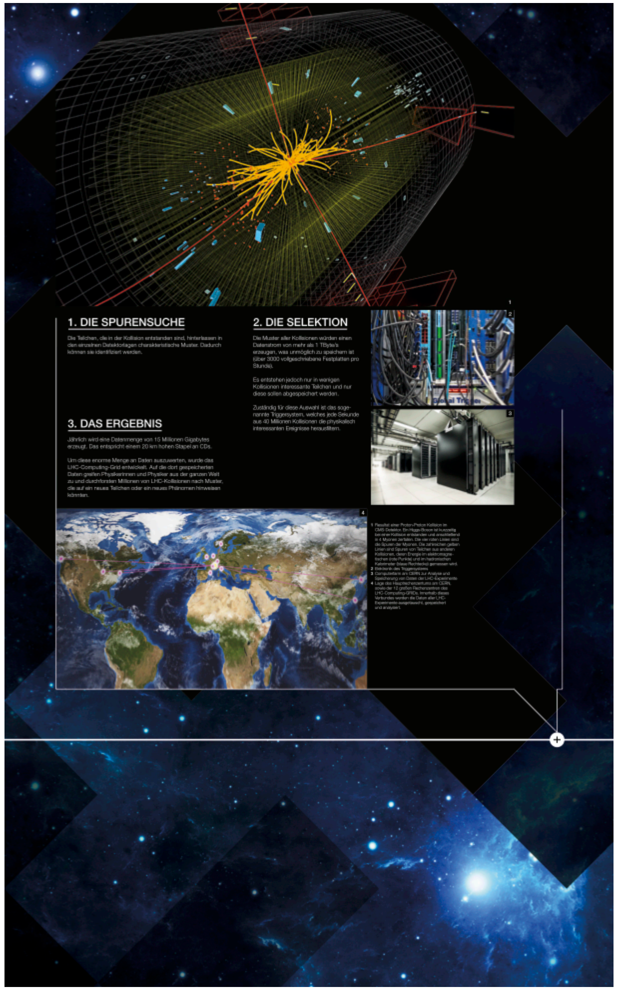
Schools
- International Masterclasses
- Traveling exhibition
- Physik-zum-Anfassen
- Science&Art@School

Teachers
- „Masterclass" teachers seminar
- Teaching materials

Kids
- Children's universities
- Grenzgenial (Science Center Network)
- Perchtoldsdorfer Forschertage
- Academy for gifted children

OUTREACH ACTIVITIES





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BACKUP

TEACHING OVERVIEW

Universities with teaching and research activities: 22
Universities offering physics education: 7
Universities offering HEP education (Vienna, Innsbruck, Graz): 4
Estimated length of PhD in particle physics: 3 years recommended

Following the 1999 Bologna recommendations, studies have gradually been reorganized since 2003/2004. Bachelor and Master degrees were introduced. Normal duration of studies: Bachelor 6 semesters, Master additional 4 semesters.

"Fachhochschulen" (universities of applied sciences) also exist.
These are not taken into account in the above list. They offer Bachelor (6 sem.), Diploma (+2 sem.) and Master (+2 sem.) degrees.

RESOURCES

Total investments per year into particle physics equipment, both to CERN and other labs:
HEPHY: 220 kEUR, SMI: 100 kEUR
Total investment in CMS 1996-2011 (Ministry): 3356 kEUR
Total investment by Atomic Institute in nTOF at CERN: 190 kEUR up to 2005, resources for new phase to be defined

Yearly maintenance and operation costs per year to CERN and other labs, including funds for travel and subsistence:
HEPHY: 120 kEUR (M&O), 180 kEUR (travel), 150 kEUR (subsistence)
SMI: 300 kEUR

Principal funding organisations for Austria:

- Ministry of Science and Research (funds the Universities, the Academy of Sciences and provides additional funds on a case-to-case basis)
- FWF - Science Fund, for basic research (but not big CERN experiments)
- FFG - Research promotion agency (applied industrial research)
- EU

Chiral Perturbation Theory

Effective theory for low energy dynamics of the lightest mesons (Goldstone bosons of chiral symmetry breaking).

$$\begin{aligned}\mathcal{L}_4 \;=\;& L_1\langle D_\mu U^\dagger D^\mu U\rangle^2 + L_2\langle D_\mu U^\dagger D_\nu U\rangle\langle D^\mu U^\dagger D^\nu U\rangle \\ &+L_3\langle D_\mu U^\dagger D^\mu U D_\nu U^\dagger D^\nu U\rangle + L_4\langle D_\mu U^\dagger D^\mu U\rangle\langle \chi^\dagger U + \chi U^\dagger\rangle \\ &+L_5\langle D_\mu U^\dagger D^\mu U(\chi^\dagger U + \chi U^\dagger)\rangle + L_6\langle \chi^\dagger U + \chi U^\dagger\rangle^2 \\ &+L_7\langle \chi^\dagger U - \chi U^\dagger\rangle^2 + L_8\langle \chi^\dagger U \chi^\dagger U + \chi U^\dagger \chi U^\dagger\rangle \\ &-iL_9\langle F_R^{\mu\nu} D_\mu U D_\nu U^\dagger + F_L^{\mu\nu} D_\mu U^\dagger D_\nu U\rangle + L_{10}\langle U^\dagger F_R^{\mu\nu} U F_{L\mu\nu}\rangle \\ &+L_{11}(\langle F_R^{\mu\nu} F_{R\mu\nu}\rangle + \langle F_L^{\mu\nu} F_{L\mu\nu}\rangle) + L_{12}\langle \chi^\dagger \chi\rangle\end{aligned}$$

Chiral extrapolation to physical meson masses for lattice results for low-energy constants.

Ecker, Masjuan, Neufeld

Electromagnetic effects and V_{us} determination from K_{l3} decays.

Cirigliano, Giannotti, Neufeld

$$K^0(p_K) \to \pi^-(p_\pi)\ell^+(p_\ell)\nu_\ell(p_\nu), \quad K^+(p_K) \to \pi^0(p_\pi)\ell^+(p_\ell)\nu_\ell(p_\nu)$$

$$\Gamma(K_{\ell 3[\gamma]}) = \frac{G_F^2 |V_{us}|^2 M_K^5 C_K^2}{128\pi^3} S_{EW} |f_+^{K^0\pi^-}(0)|^2 I_{K\ell}^{(0)}(\lambda_i)\left(1 + \delta_{EM}^{K\ell} + \delta_{SU(2)}^{K\pi}\right)$$

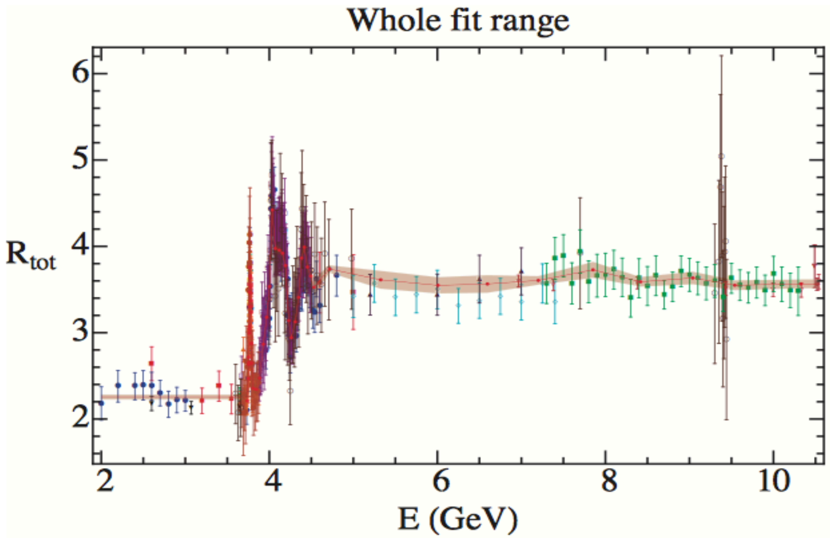
$$|V_{us}| f_+^{K^0\pi^+}(0) = 0.21661(47)$$

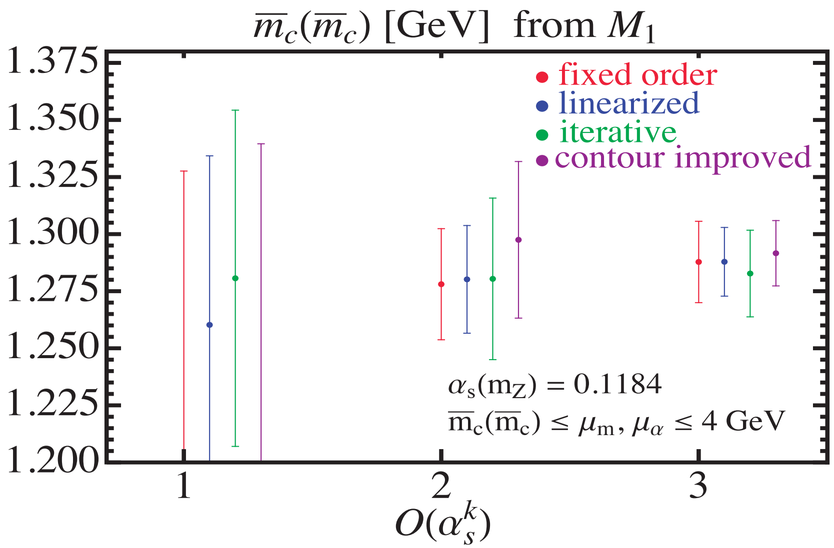
$$\longrightarrow \quad |V_{us}| = 0.2246(12)$$

QCD Sum Rules for Quark Masses

Dehnadi, Hoang, Mateu 2013/14

Use perturbative QCD, causality and quark-hadron duality to determine bottom and charm quark masses at highest precision.





$$\overline{m}_c(\overline{m}_c) = 1.282 \pm 0.024\,\text{GeV}$$

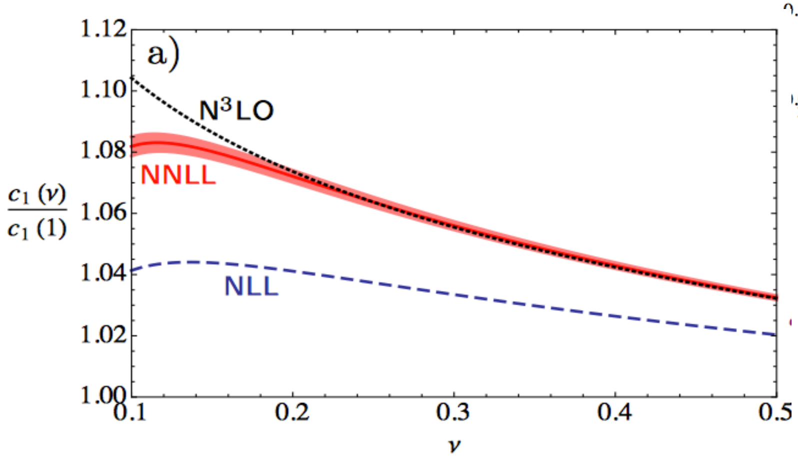
Top Threshold at a Future LC

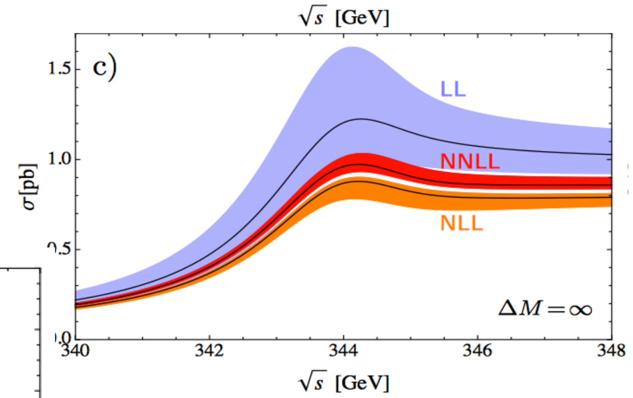
Hoang, Stahlhofen 2013

class	example diagram	Vertices: potential	Vertices: quark-gluon	Vertices: 3 gluon	Vertices: kin. ins.	contrib.
1		$1\times V_c$ $1\times \mathbf{A}\cdot\mathbf{k}$	$1\times \mathrm{A}$ $2\times A^0$	-	-	I
2		$2\times \mathbf{A}\cdot\mathbf{k}$	$2\times A^0$	-	-	
3		$2\times V_c$	$2\times \mathrm{A}$ $2\times A^0$	-	-	0
4		$2\times V_c$	$4\times A^0$	-	$2\times\nabla\cdot\mathbf{p}$	0
5		$2\times V_c$	$4\times A^0$	-	$1\times\nabla^2$	II
6		$2\times\nabla\cdot\mathbf{k}$	$4\times A^0$	-	-	III
7		$1\times V_c$ $1\times\nabla\cdot\mathbf{k}$	$4\times A^0$	-	$1\times\nabla\cdot\mathbf{p}$	IV
8		$1\times\nabla^2$	$4\times A^0$	-	-	V
9		$2\times V_c$	$2\times \mathrm{A}$ $1\times A^0$	A^2A^0	-	i
10		$2\times V_c$	$1\times \mathrm{A}$ $2\times A^0$	$\mathrm{A}(A^0)^2$	$1\times\nabla\cdot\mathbf{p}$	ii
11		$1\times V_c$ $1\times\nabla\cdot\mathbf{k}$	$1\times \mathrm{A}$ $2\times A^0$	$\mathrm{A}(A^0)^2$	-	iii
12		$1\times V_c$ $1\times \mathbf{A}\cdot\mathbf{k}$	$1\times \mathrm{A}$ $1\times A^0$	A^2A^0	-	iv
13		$2\times \mathbf{A}\cdot\mathbf{k}$	$1\times A^0$	A^2A^0	-	
14		$1\times V_c$ $1\times \mathbf{A}\cdot\mathbf{k}$	$2\times A^0$	$\mathrm{A}(A^0)^2$	$1\times\nabla\cdot\mathbf{p}$	v
15		$1\times\nabla\cdot\mathbf{k}$ $1\times \mathbf{A}\cdot\mathbf{k}$	$2\times A^0$	$\mathrm{A}(A^0)^2$	-	vi

O(10^4) Feynman diagrams for NNLL order anomalous dimension of quark production current.

$$\sigma_{\mathrm{tot}} \propto \mathrm{Im}\left[\mathrm{C}(\nu)^2\, \mathrm{G}(0,0,\sqrt{\mathrm{s}}+i\Gamma_t)\right]$$





Stabilization of NNLL prediction.

Neutrino Physics

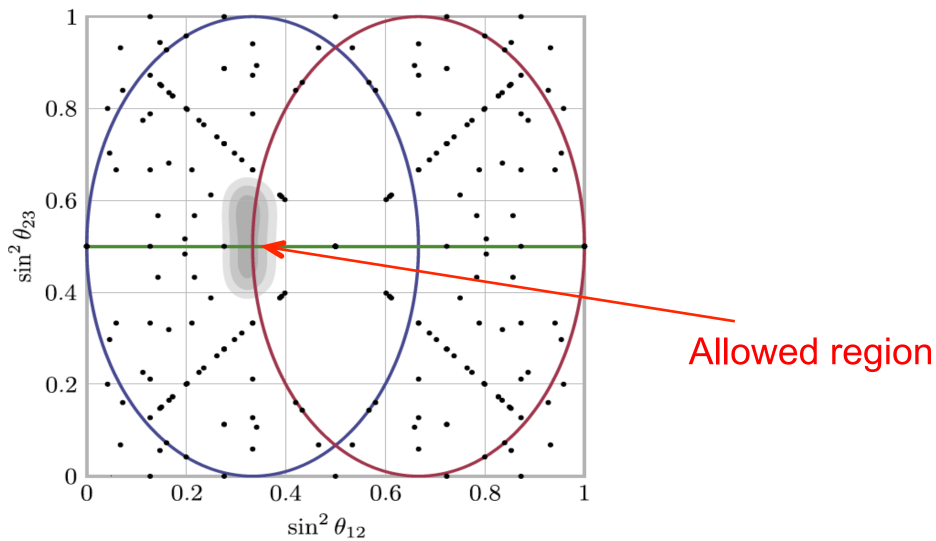
Grimus, Fonseca 2014

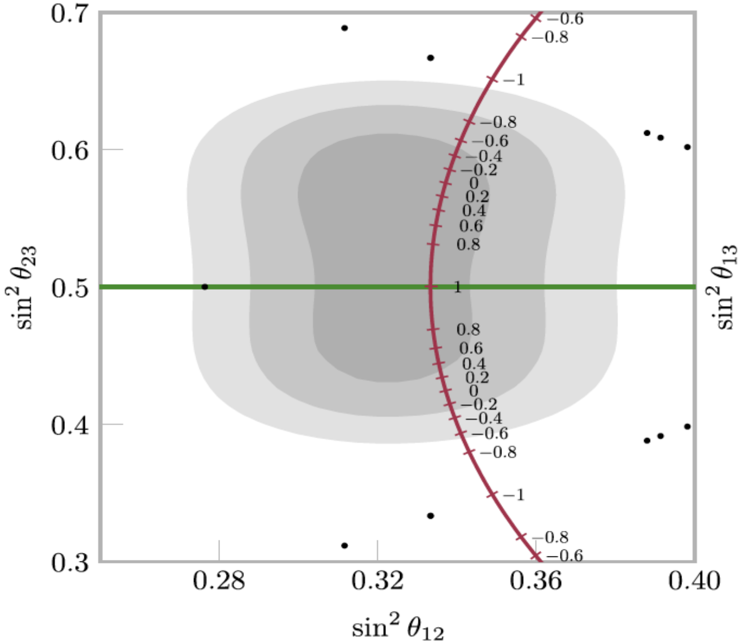
Complete classification of lepton mixing matrices from residual symmetries in lepton mass matrices

17 sporadic cases (all ruled out experimentally)
One infinite class

$$|U|^2 = \frac{1}{3}\begin{pmatrix} 1+\mathrm{Re}\,\sigma & 1 & 1-\mathrm{Re}\,\sigma \\ 1+\mathrm{Re}\,(\omega\sigma) & 1 & 1-\mathrm{Re}\,(\omega\sigma) \\ 1+\mathrm{Re}\,(\omega^2\sigma) & 1 & 1-\mathrm{Re}\,(\omega^2\sigma) \end{pmatrix} \quad \text{with} \quad \omega = e^{2\pi i/3}$$

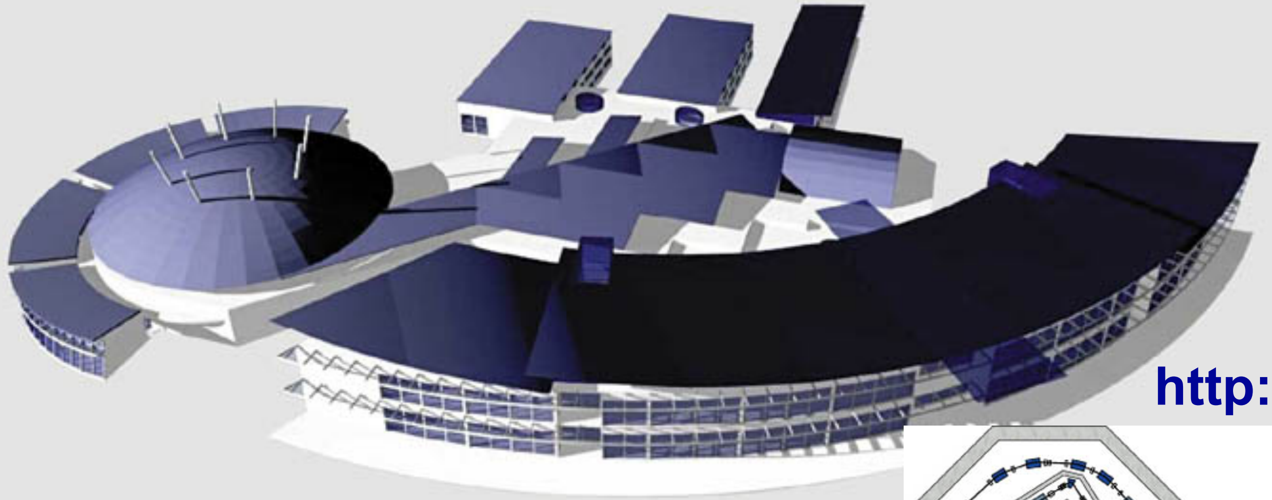
Free parameter: rational number p/n, $\sigma \equiv \exp(2\pi i p/n)$



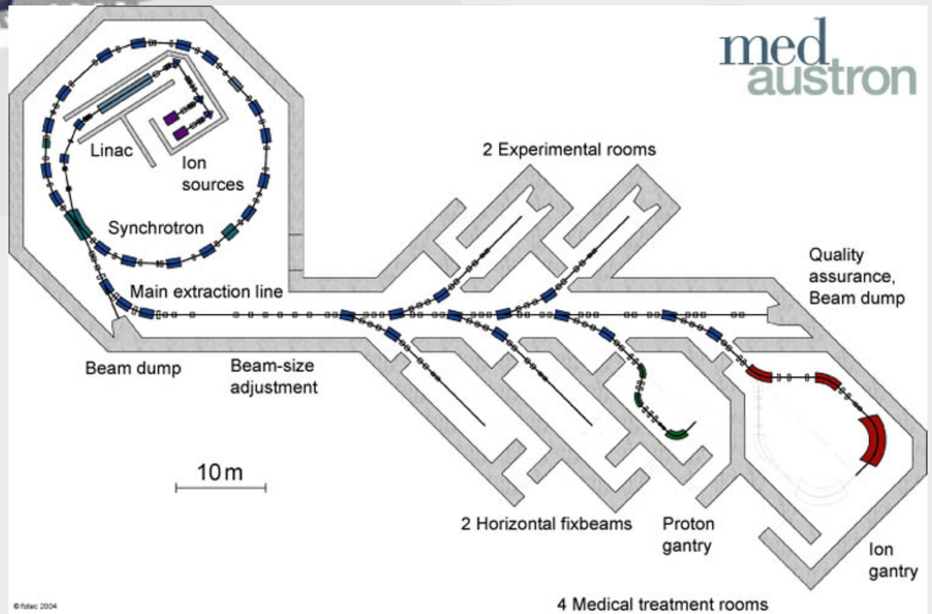


MedAUSTRON

Proton and ion therapy and non-clinical research



http://www.medaustron.at



Partnership agreement with CERN

First experimental operation is planned for 2015.