HEP in Finland – midterm report

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Outline:

- **Basic facts about Finland**
- **Education – students**
- **HEP in Finland:**
  - **research projects**
  - **human resources**
  - **organization & funding**
- **Grid & LHC computing**
- **Conclusions**

Basic facts about Finland

- population: 5.3 million
- GDP / capita: 32 700 USD (OECD: 31 500 USD)
- distance from CERN: ~ 2 500 km

Primary education (PISA 2006 assessment):

- best OECD <u>mean</u> score for science & maths

University (or other tertiary) education (age group: 25-64):
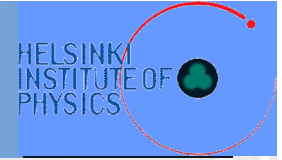
- 5th in % of population with degree: 34.6 %

Science & Technology indicators:

- 2nd in % R&D expenditure of GDP: 3.45 %

but gov. funded part significantly lower: 0.89 %

- 1st in # of research FTE / 1k employ. FTE: 16.6

but again gov. & higher education part significantly lower

source: OECD.StatExtracts (stats.oecd.org)

Education – students
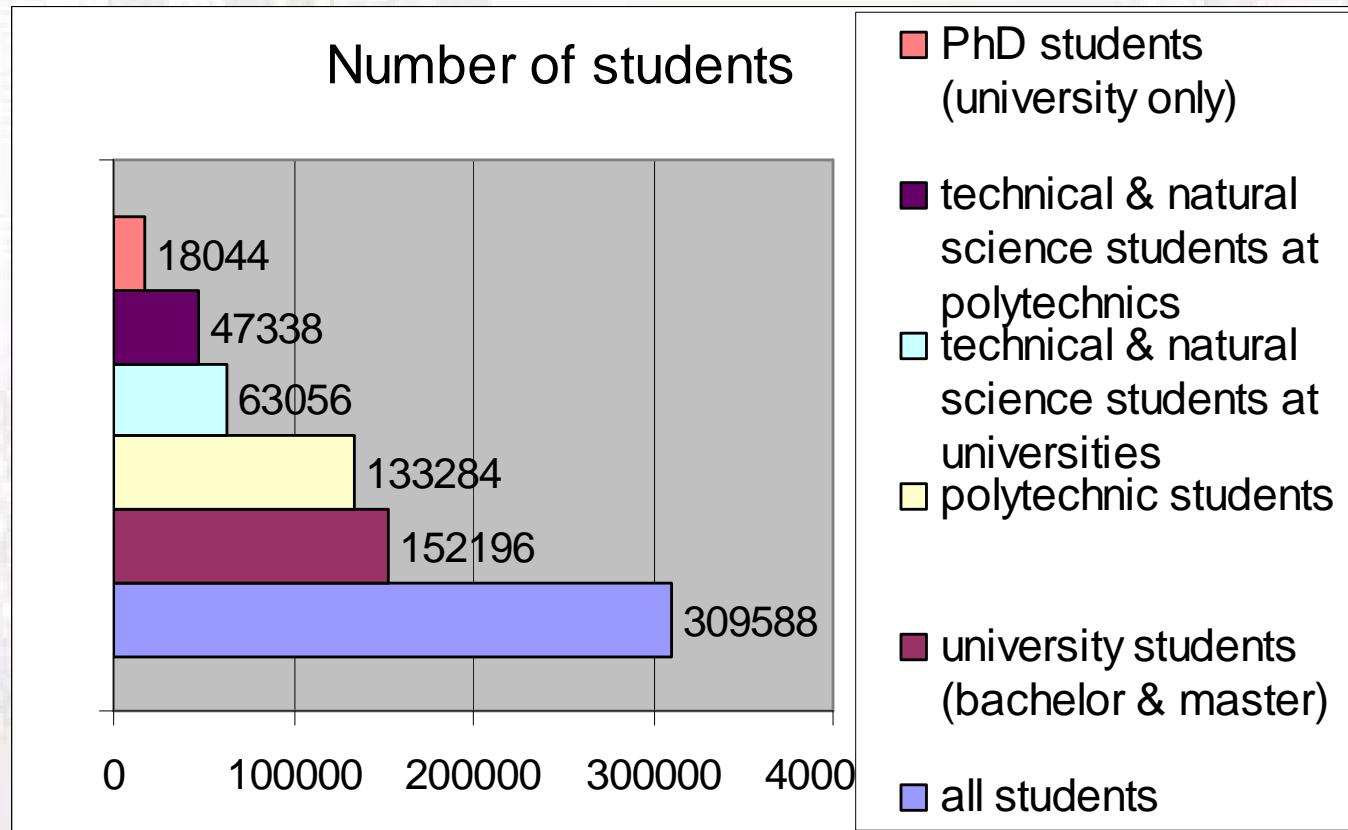
<u>20 Universities</u> (degrees:bachelor, master, licenciate, doctorate)

<u>29 Polytechnics</u> (degrees:bachelor, master)

Number of students

- 🟥 PhD students (university only)
- 🟪 technical & natural science students at polytechnics
- 🟦 technical & natural science students at universities
- 🟨 polytechnic students
- 🟥 university students (bachelor & master)
- 🟦 all students

Bar chart values:
- 18044
- 47338
- 63056
- 133284
- 152196
- 309588

x-axis: 0, 100000, 200000, 300000, 4000...

source: Statistics Finland (www.stat.fi):
university and polytechnic education 2007

Physics, natural science & technical students

Number of students

- physics students at universities *****
- natural science students at universities
- technical students at universities
- technical students at polytechnics
- natural science & technical students

Chart values: 2982, 26401, 36655, 40567, 110394
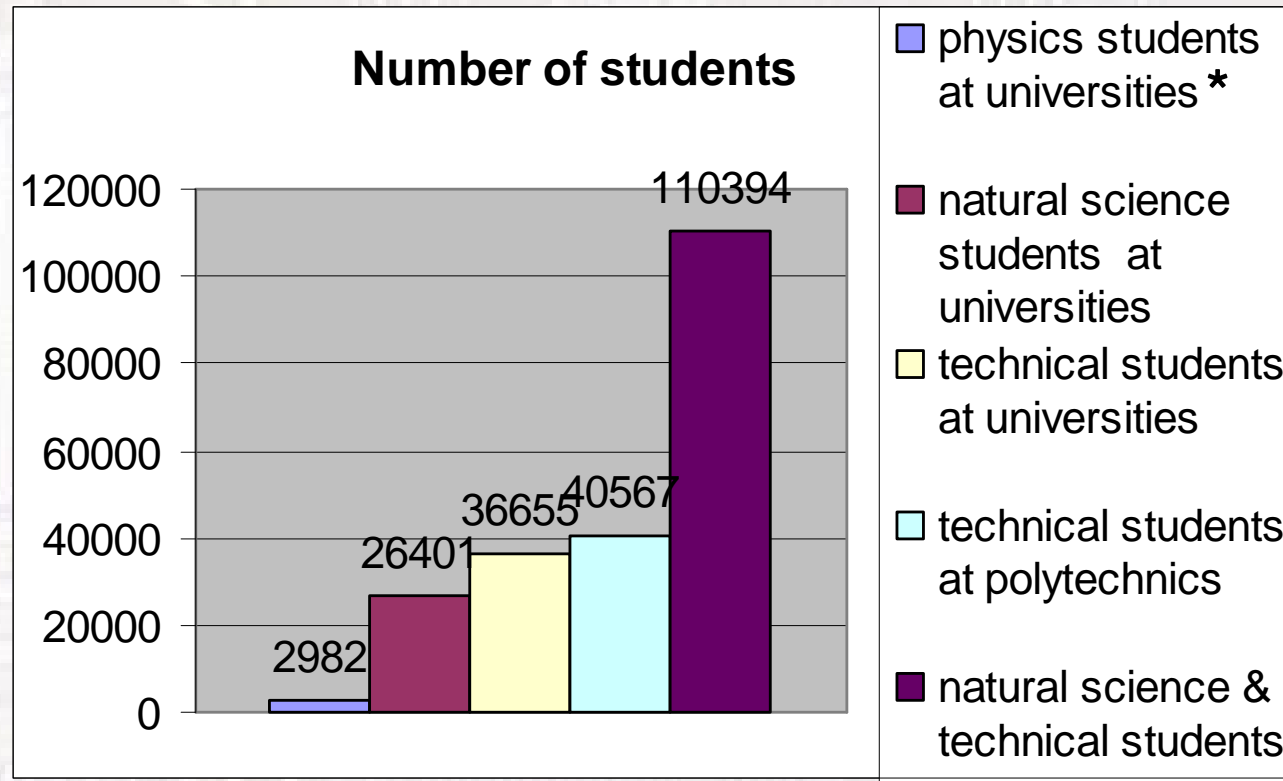
# of physics students / capita > European average ($\times$ 2–3.5)

source: Statistics Finland: university & polytechnic education 2007
*estimate based on numbers given by the Physics departments themselves with meteorology & astronomy students subtracted
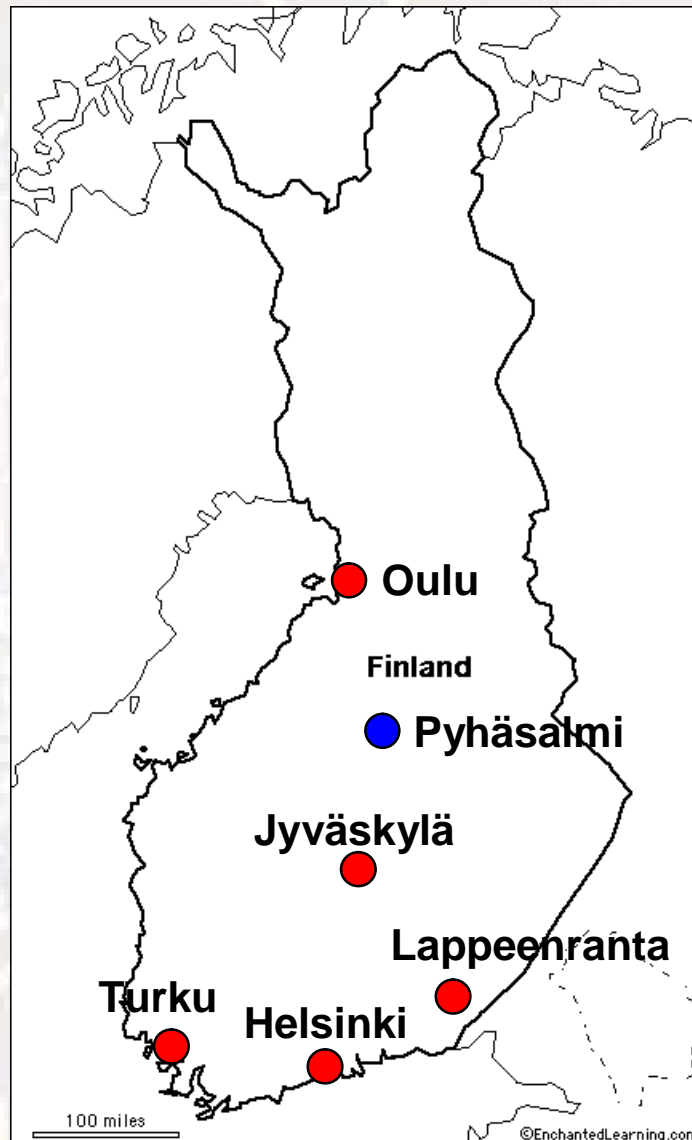
Oulu

Finland

Pyhäsalmi

Jyväskylä

Lappeenranta

Turku   **Helsinki**

100 miles   ©EnchantedLearning.com

Universities with HEP:

University of Helsinki – theory & experiment

University of Jyväskylä – theory & experiment

University of Oulu – theory & CUPP, Pyhäsalmi – experiment

Lappeenranta University of Technology – experiment

University of Turku – theory

• 5 more universities with physics but no HEP (Helsinki University of Technology has students in HEP)

• ~ 30 % of physics students attend University of Helsinki

- At LEP effort focused on **DELPHI** with large hardware contributions to HCAL and Microvertex / Silicon Tracker

- Finnish CERN activities coordinated by **HIP**

- At LHC Finland participates in **CMS, ALICE** and **TOTEM** with important construction tasks: trackers (both gas and silicon based) and trigger systems.

- Physics activity in **CDF** – to bridge gap between LEP and LHC + prepare for hadron collider environment

- Underground experimental activity in **Pyhäsalmi** mine

- Strong nuclear (& other accelerator based) physics activity: **Jyväskylä accelerator lab**, **ISOLDE** & **FAIR**.

- Strong theory, phenomenology and cosmology activity

- Active Finnish student exchange program

CMS contribution
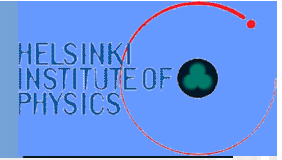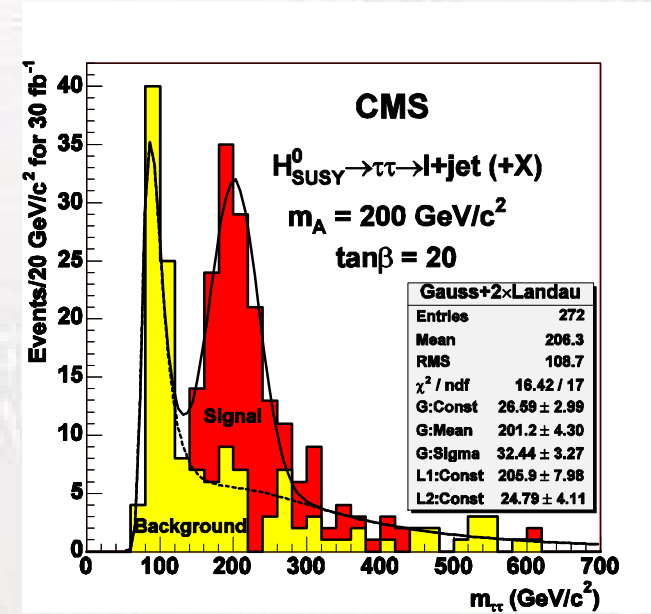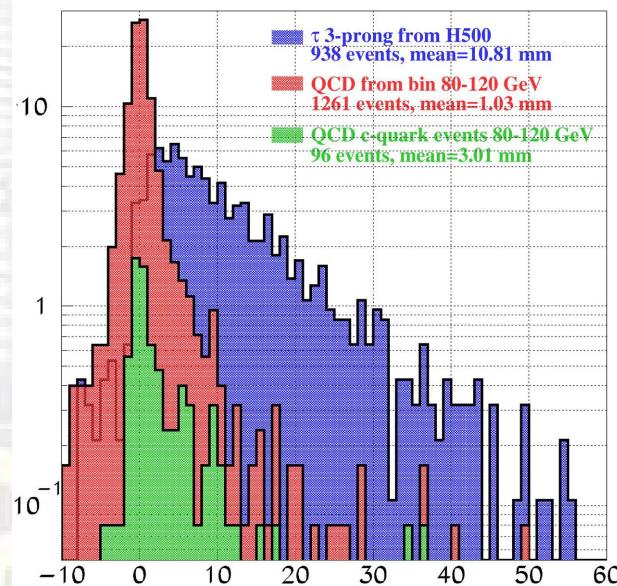

Participation in CMS from its conception in 1990

- longstanding participation in physics simulation, study of discovery potential (MSSM Higgses) + preparation for event reconstruction and physics analysis
- participation in creation of the core software for CMS
- software alignment of the pixel detector using tracks

H → ττ:
3D flight
path &
Higgs
mass

Outline

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CMS contribution

- design & construction of Tracker Outer Barrel mechanical support + comissioning of CMS Tracker
- design & manufacture of RPC muon trigger link boards + comissioning of RPC trigger
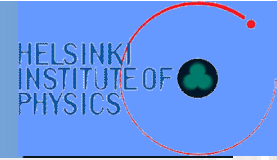- R&D for radiation hard silicon detectors for Tracker upgrade for SLHC

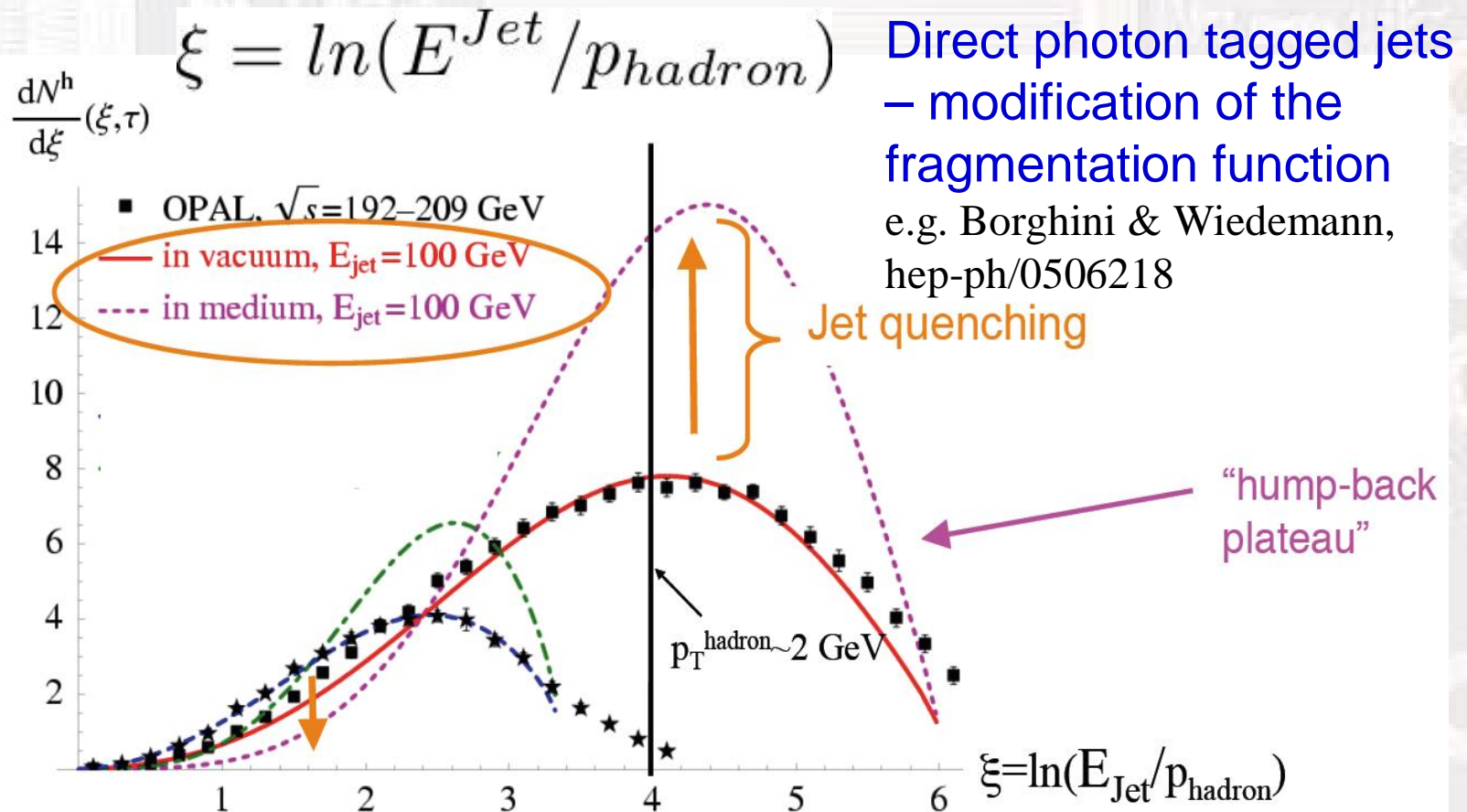Tracker Outer Barrel wheel, RPC muon trigger link boards
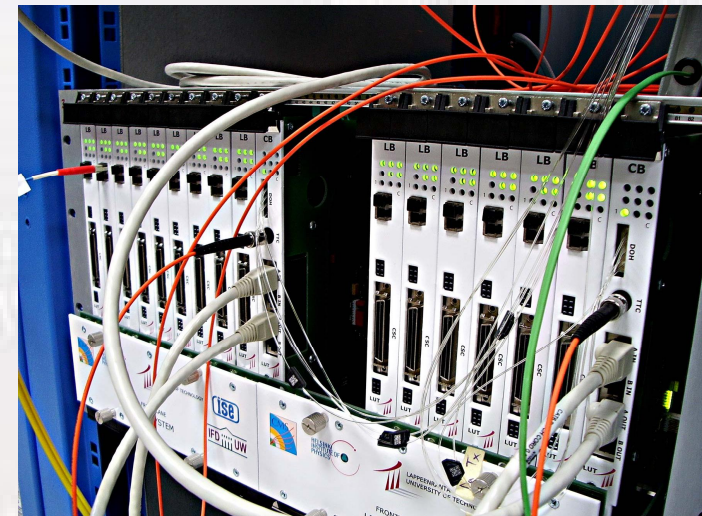
ALICE physics

- direct photon and jet correlations
- partonic kT, nuclear modification of fragmentation function

$$\xi = ln\left(E^{Jet}/p_{hadron}\right)$$

Direct photon tagged jets – modification of the fragmentation function
e.g. Borghini & Wiedemann, hep-ph/0506218
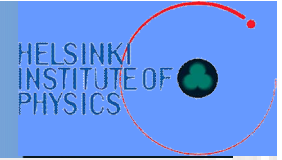
ALICE contribution
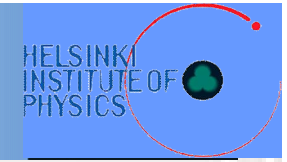
- assembly of the SSD silicon detectors (~35 %)
- design, construction and commissioning of T0 detector (online & offline luminosity)
- VIRTeX trigger board construction and development for EMCal (L0 threshold trigger)

VIRTeX trigger board layout ,
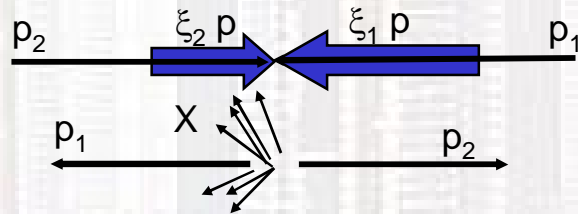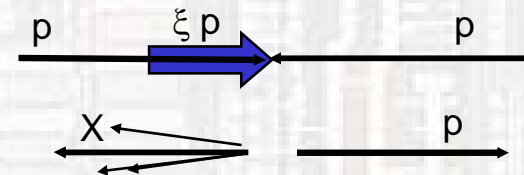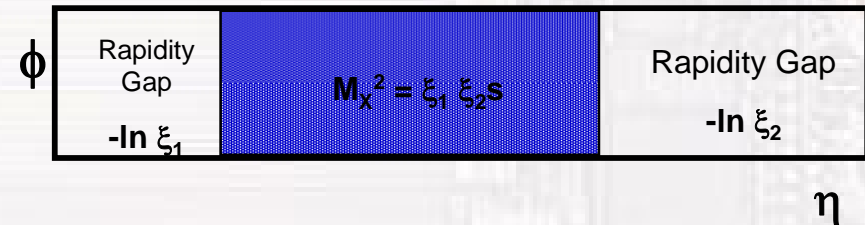T0 detector before installion
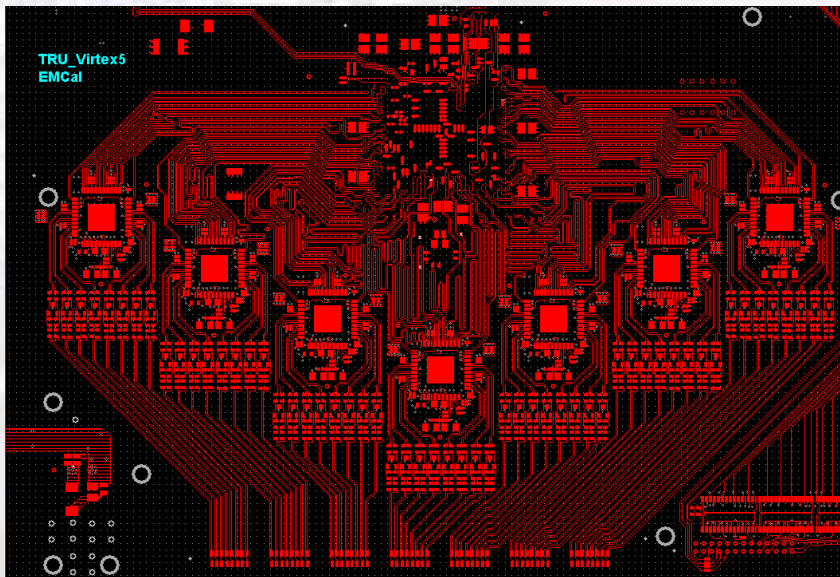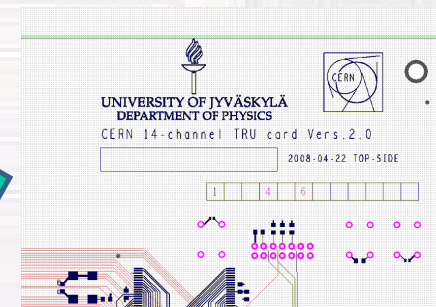
logo

TOTEM physics

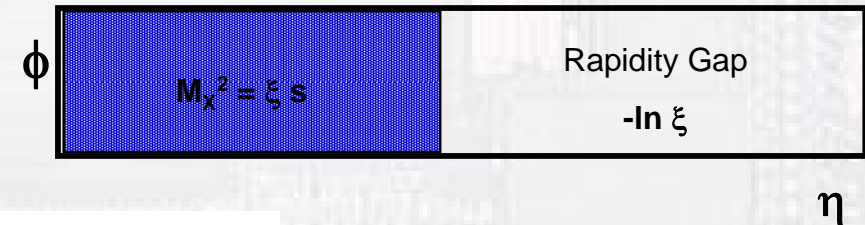Proton structure: total σ, elastic, diffractive & low x physics

- leading proton measurement – performance studies vs different LHC optics
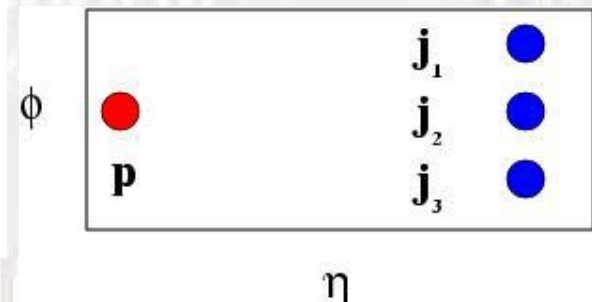
- physics potential central (CD) & single (SD) diffraction

SD proton dissociation into 3 jets

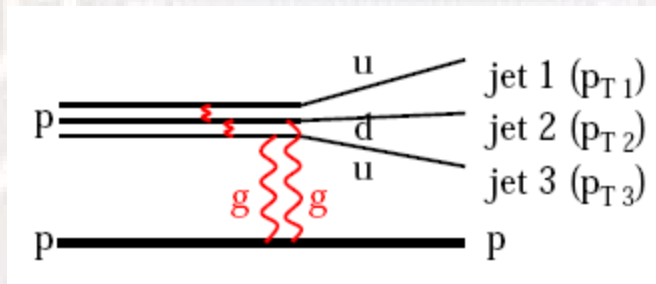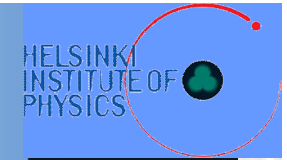L. Frankfurt & M. Strikman, hep-ph/0210087

TOTEM contribution
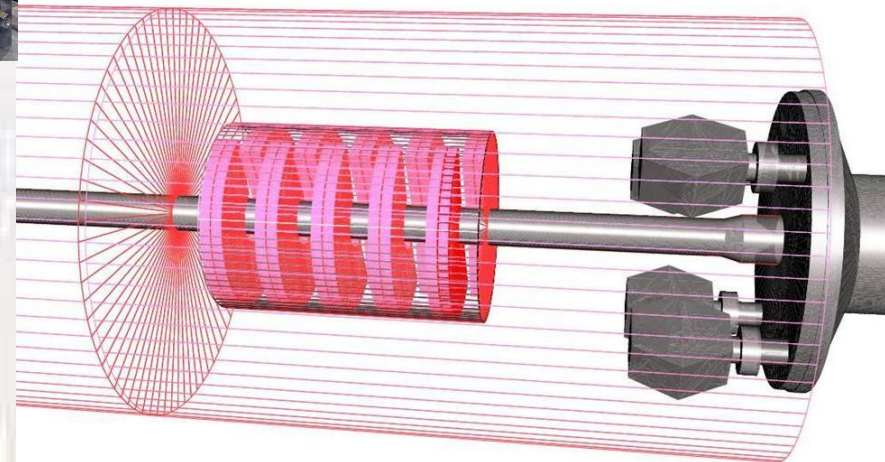
- T2 telescope: tripple-GEM detector construction, T2 mechanics, simulation, installation & commissioning
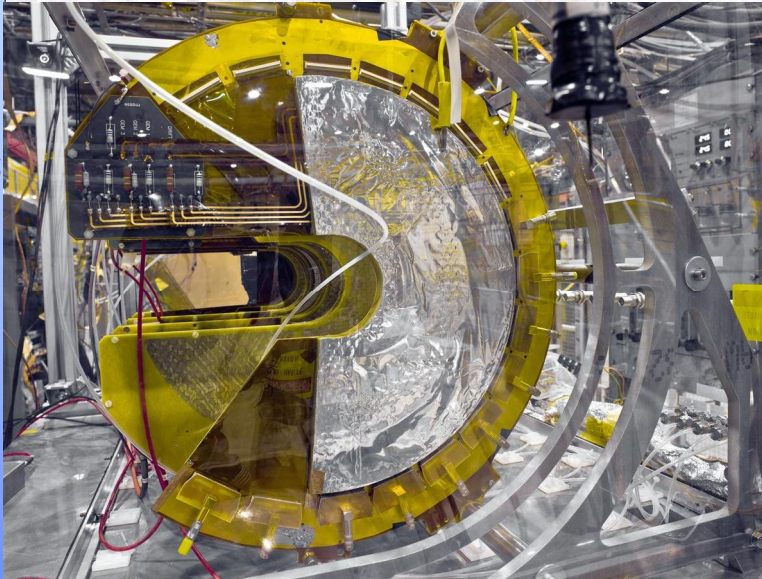
shielded GEM detector telescope in test beam & T2 geometry in simulation

CDF activity
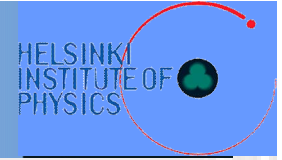
- physics: top mass measurement in all-hadronic and dileptonic channel, low mass Higgs search
- b-jet energy scale calibration using neural networks
- offline calibration of the SVXII silicon detector

CDF Run II Preliminary (1.9 fb^{-1})

Measured values
-Ln(L/L$_{max}$) = 0.5 (1 σ)
-Ln(L/L$_{max}$) = 2.0 (2 σ)
-Ln(L/L$_{max}$) = 4.5 (3 σ)

JES (σ_{JES})

M_t (GeV/c^2)
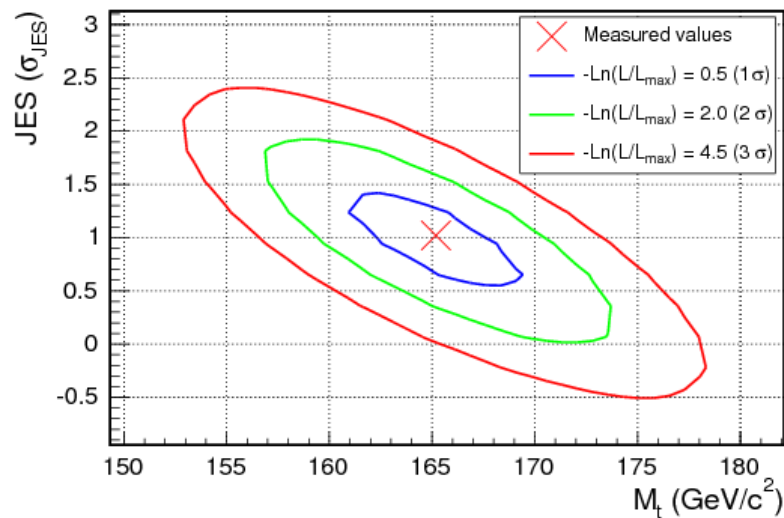
all-hadronic top mass & jet energy scale determination (ideogram technique)

CDF Run II Preliminary (1.2 fb^{-1})

$\sigma_{t\bar{t}}$ (pb)

theoretical $\sigma_{t\bar{t}}$
measured $\sigma_{t\bar{t}}$
measured M_t, no $\sigma_{t\bar{t}}$ dep.
measured M_t, $\sigma_{t\bar{t}}$ dep.

M_t (GeV/c^2)
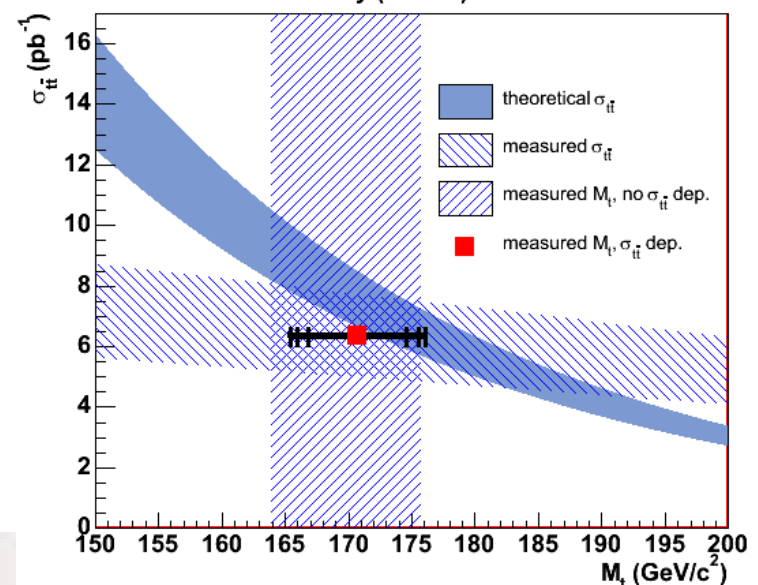
dileptonic top mass with $\sigma_{t\bar{t}}$ constraint (kinematic method)

Outline

Basic facts

Education

HEP Finland

LHC computing

Conclusions

- Pyhäsalmi mine in Pyhäjärvi
- active at least until 2016
- free cavities in old mine
- depth 1444 m (4000 m.w.e.)
- lab run by University of Oulu (EU funded)
- main activity: Experiment with MultiMuon Array (EMMA)
- measures cosmic ray muons shallow underground to confirm CERN anomalies on multiple muon bundles
- possible future site for a very large underground facility; strengths: exceptionally good rock, northern location, deepest European metal mine.
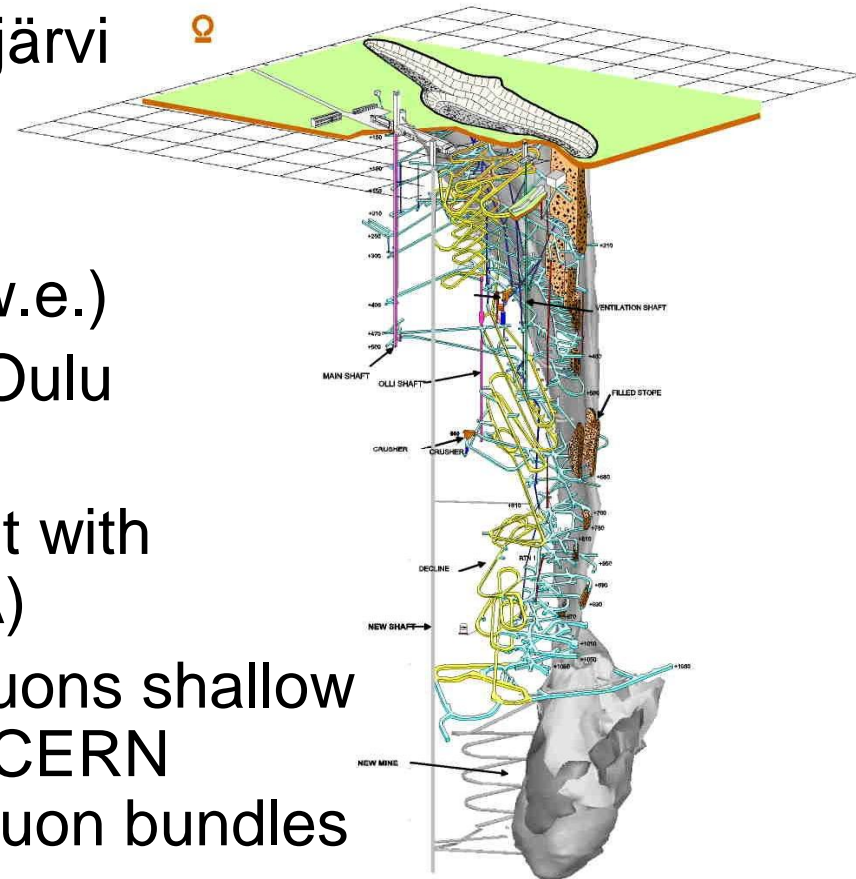
Detector and accelerator R&D

detector R&D (LHC upgrade):

- rad hard silicon detectors:
  - cryogenic CID (RD39)
  - Czochralski (RD50)
  - (semi-)3D (EUDET)
- large area & rad hard MPGD (RD51 proposal)
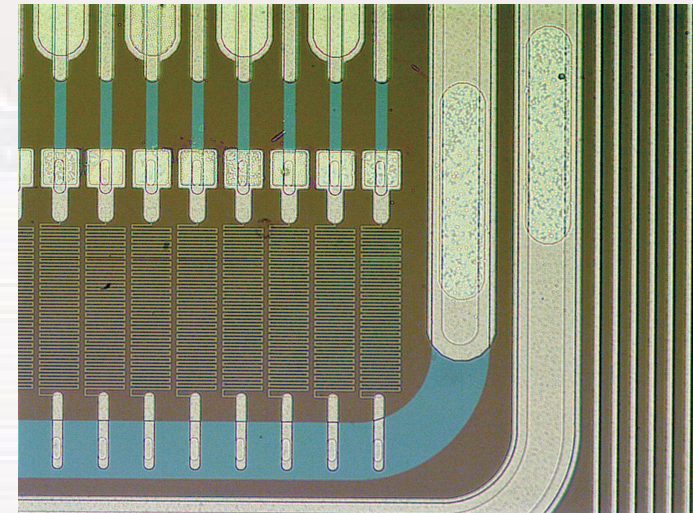
Czochralski detector

CLIC module

accelerator R&D (CLIC):

• atomistic simulation of RF breakdown

• CLIC module technical specification, cooling, assembly & fabrication

RF Distribution

Accelerating Structure
+100 MV/m, 64 MW, 229 mm

Main Beam
1.1 A

Drive Beam
100 A

PETS
-6.5 MV/m
136 MW
210 mm
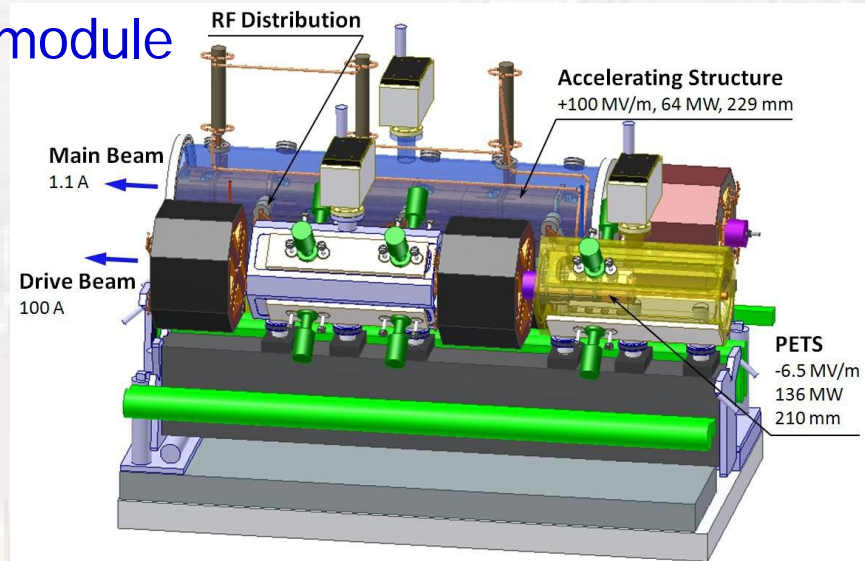
Theory and phenomenology

- Supersymmetry, Higgs and extradimensional phenomenology
- Heavy ion collision phenomenology
- Theoretical hadron physics
- QCD and numerical QFT
- Non-commutative QFT
- Neutrino physics
- Cosmology
- String theory

Human resources
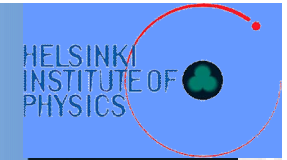
HEP survey November 2007 (people)

	permanent staff	postdocs + technical	PhD students
■ theory	7	12	22
■ experiment	5	23	22
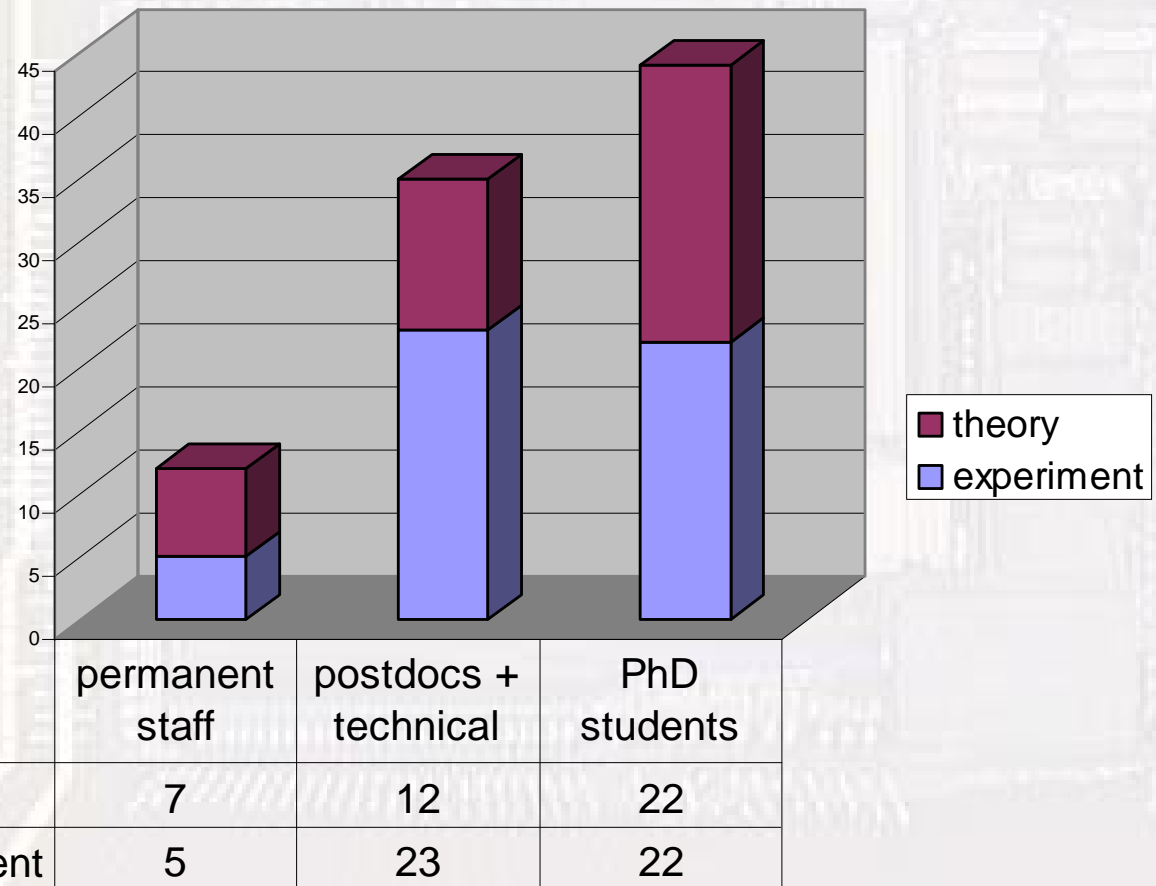
HEP & NP PhD students in common graduate school (GRASPANP)

Human resources
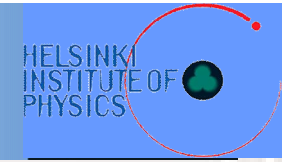
HEP survey November 2007 (FTE)

Bar chart legend:
- total
- theory & phenomenology
- accelerator R&D
- detector R&D
- heavy ion
- astroparticle physics
- non-accelerator physics
- accelerator physics

Values: 85,9 / 39,8 / 1 / 8,8 / 6,2 / 4 / 1 / 25,1

Helsinki Institute of Physics (HIP)
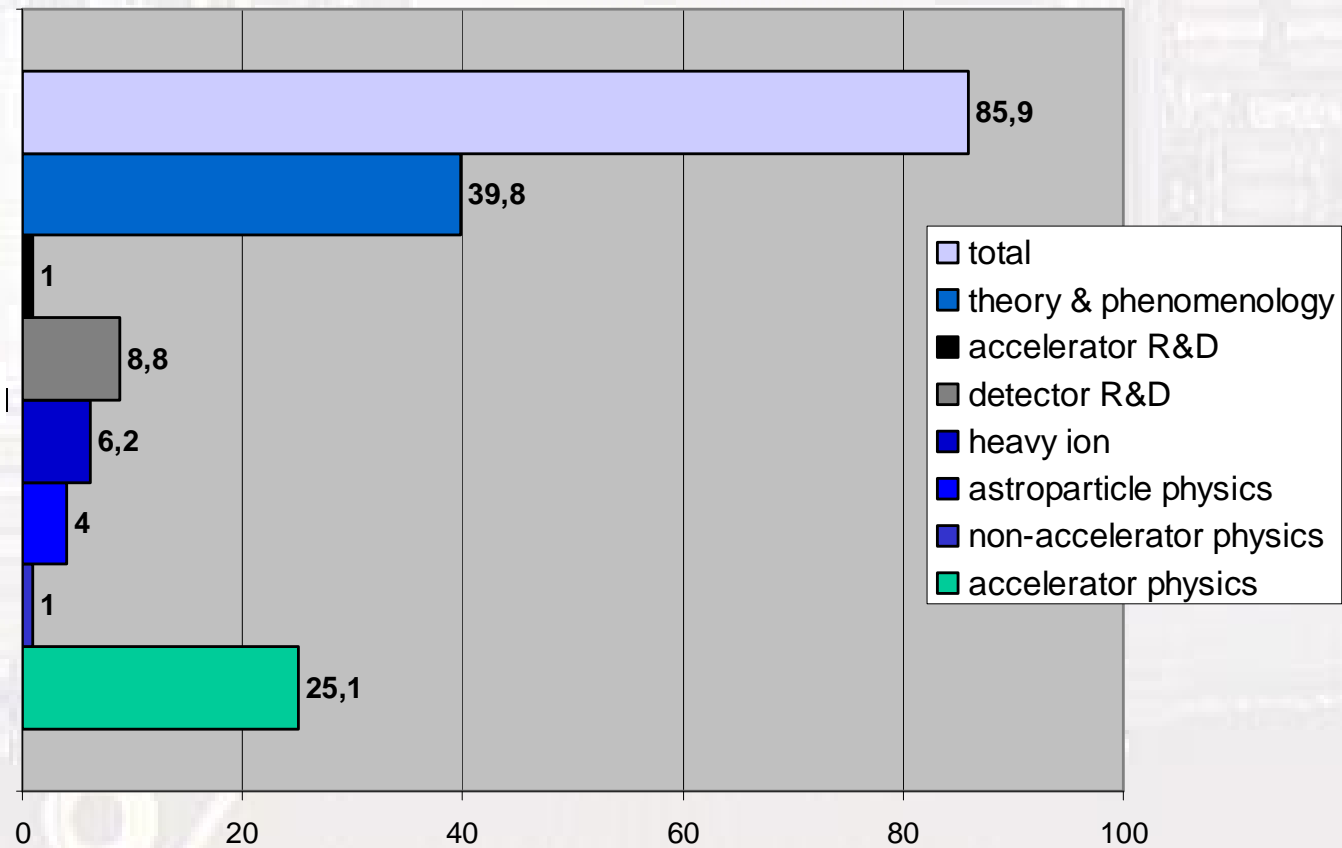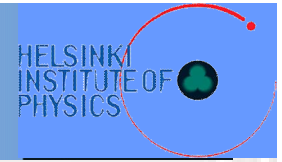
National mandate to coordinate all CERN activities

• operated by Universities of Helsinki and Jyväskylä, Helsinki and Lappeenranta Universities of Technology

• budget: 5.8 + 1.1 (external) MCHF (average 2003-6)

• 5 programs: CMS, Nuclear matter (ALICE, ISOLDE), High energy physics (TOTEM, CDF, CLIC), Theory & Technology

• Theory contain projects for LHC phenomenology and atomistic simulation of detector & accelerator material

• Technology supports technology transfer and GRID

• active outreach to high school students & teachers

• active summer student program (partly funded by MoE)

• coordinates also Finnish FAIR and Fermilab activities

(www.hip.fi)

Finland member of CERN since 1991

- CERN membership fee: 14.4 MCHF (1.41 %)

- Finnish CERN users (any %): 60-70

- Finnish CERN users (with $\geq$ 80 % presence): 27

- Finnish staff members (fellows & associates): 24 (8)

- Finpro promotes technological & commercial CERN–Finland co-operation; supplies return coefficient: **1.72**

HEP funding

- big portion of funding through HIP

- external funding from Academy of Finland, TEKES (technology & innovation), EU and private fundations

- professors & lecturers mainly funded by Universities, rest mainly by HIP or external funding.

- total funding for experimentation: 4.3 MCHF / year (average 2003-6)

LHC computing

LHC computing resources part of Nordic Data Grid Facility:
Tier1 service for ALICE & Tier2 service for CMS (+TOTEM)

Total available and planned CPU, disk and tape storage

	CPU (kSI2k)	Disk (TB)	Tape (TB)
2008	824	171	64
2009	946	302	127

Budget for new investments and maintenance:
800 kEUR / year for 2008–2010.
Technical & scientific computing personnel: ~ 2 FTE / year

HEP specific grid computing: HIP granted first funding only
in 2008; built & maintained together with CSC
(Finnish Center for Scientific Computing, www.csc.fi)

LHC computing

General grid computing: 13 clusters connected using ARC-middleware as M-grid for physics, chemistry... (> 3k CPU's)

ARC Grid Monitor

2008-06-30 CEST 10:48:27

Prosessit: ▬ Grid ▬ Paikallinen

Maa	Kohde	Prosesseja	Kuorma (prosesseja: Grid+paikall.)	Jonottamassa
	Akaatti (M-grid)	58	0+72	0+0
	Ametisti (M-grid)	260	0+90	0+5
	Hiekka	8	0+0	0+0
	Jaspis (M-grid, HIP)	16	0+0	0+0
	Kiniini (CSC)	16	0+0	0+0
╋ *Suomi*	**Kivi (M-grid)**	8	0+0 (queue inactive)	0+0
	Kvartsi (M-grid)	192	0+140	0+33
	Mill	60	0+26	0+3
	Murska	2176	0+0	0+0
	Opaali (M-grid)	88	0+28	0+0
	Sepeli (M-grid)	512	0+1	0+0
	Topaasi (M-grid)	52	0+1	0+0
TOTAL	*12 kohdetta*	*3446*	*0 + 358*	*0 + 41*

KAIKKI

Conclusions

- significant hardware contributions to LHC experiments: succesfully completed, now commissioning & installation
- active preparation for LHC data taking & LHC upgrades

new since last RECFA visit 2003:

- new chair (from 1 Sep 2008) in experimental elementary particle physics at University of Helsinki
  (shared with HIP, only 2nd dedicated in Finland)
- LHC computing funded for 2008−10

not much change:

- average PhD time still longish: 4.5 years
  (experimental longer than theory: 4.9 vs. 4.1 years)
- lack of sufficient number of long-term post-PhD position