PANDA - Detector and Current Developments

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Uppsala University

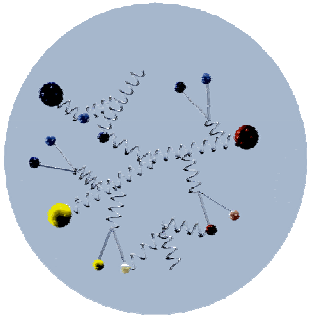
SFAIR, 12th Sept. 2005

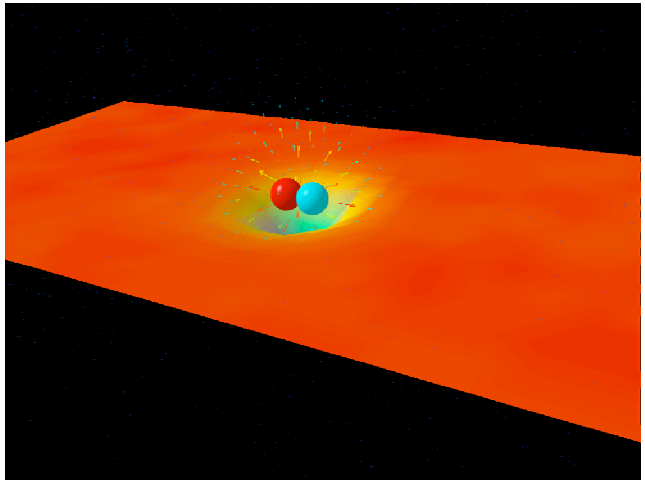
A Brief History

- 1930's: atoms (ατομον) in fact divisible
  => nucleons (p + n) and electrons
- 1950's - 60's: nucleons not elementary
  => "hadron zoo"
- 1960 ff: quark model + QCD
  - Gell-Man: Nobel Price 1969
  - Friedman, Kendall, Taylor: Nobel Price 1990
  - Gross, David, Wilczek: Nobel Price 2004
- 2007 ff: Higgs et al.

Open Problems

- generation of hadron masses
- strong interaction at large distances
- spin puzzle
- multi-quark systems

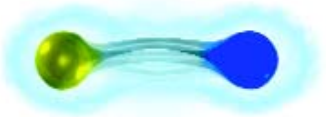




(flux tube animation by D. Leinweber et al.)

Non-Pertubative QCD at PANDA

- charmonium spectroscopy
- gluonic excitations (hybrids, glueballs)
- open and hidden charm in nuclei
- γ-ray spectroscopy of hypernuclei
- J/ψ-N scattering
- inverted DVCS
- ...

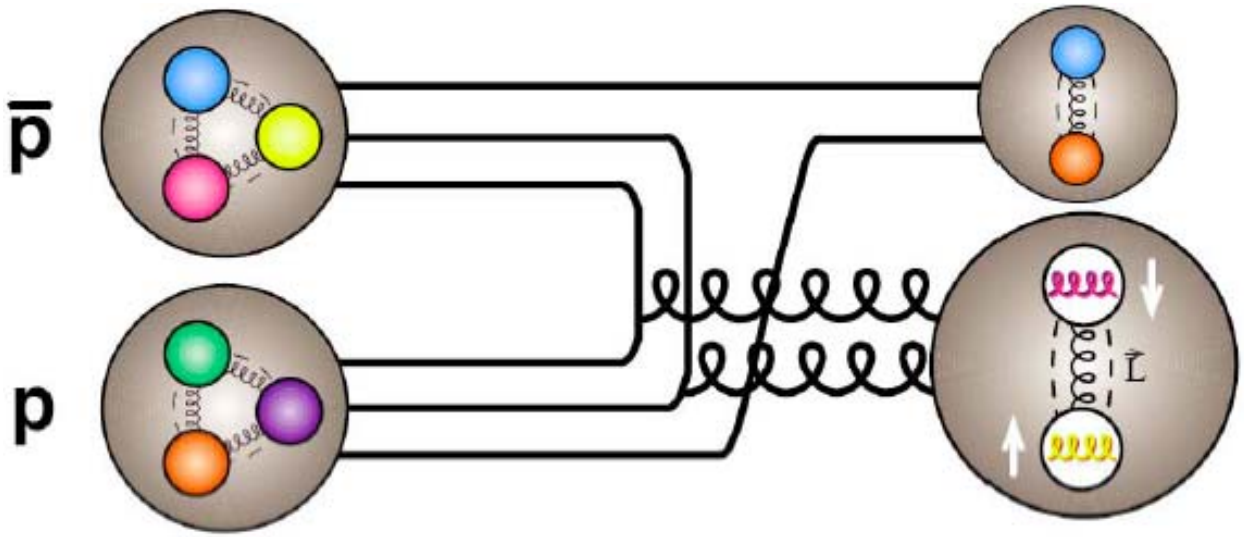


panda

What is Experimentally Needed?

- **gluon-rich environment**

  ⇒ **proton-antiproton anihilations**



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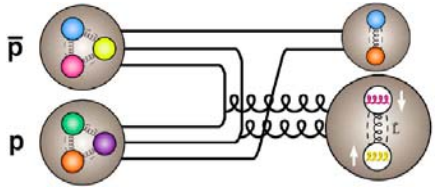
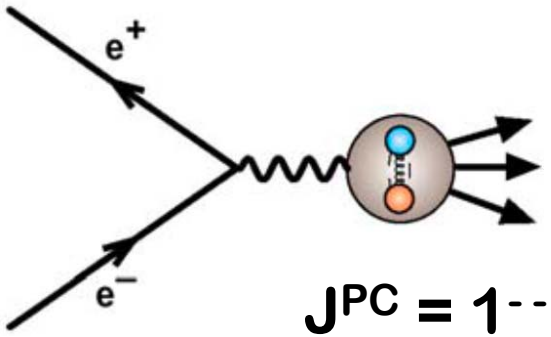
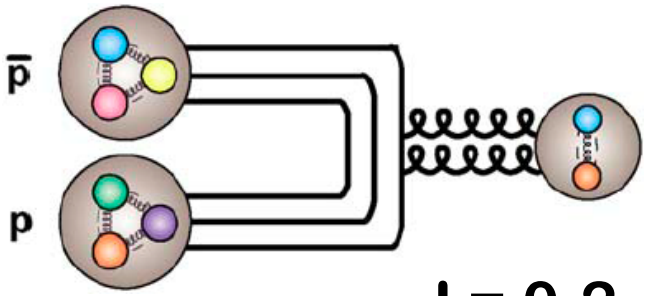


- **all quantum numbers**

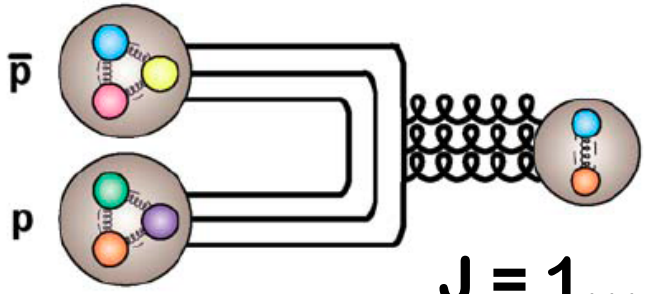
  ⇒ production exp. i.e. large acc. detector, fixed target



$J^{PC} = 1^{--}$

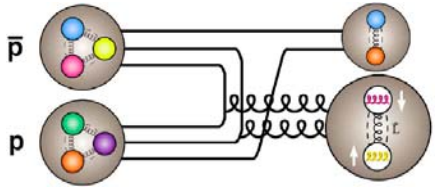


J = 0,2,.. C = +



J = 1,.. C = -

What is Experimentally Needed?



- **gluon-rich environment**
  ⇒ proton-antiproton anihilations
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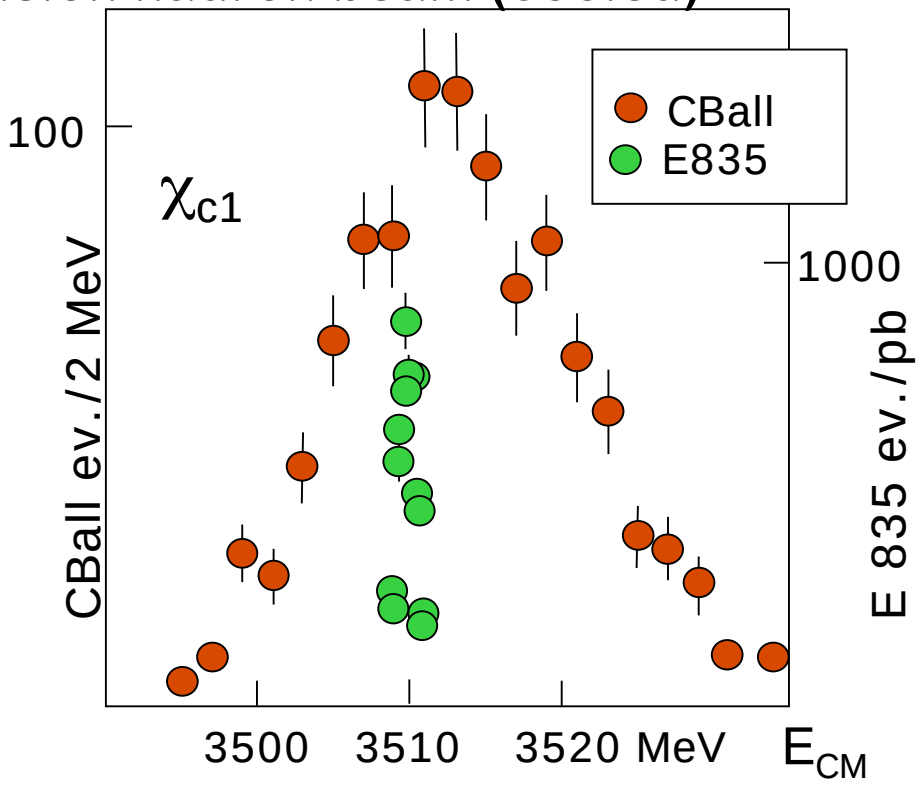
- **precise resonance scan**
  ⇒ high precision hadron beam (cooled)



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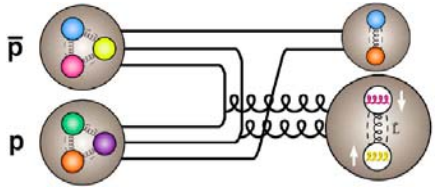

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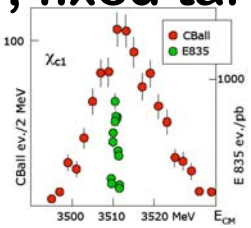
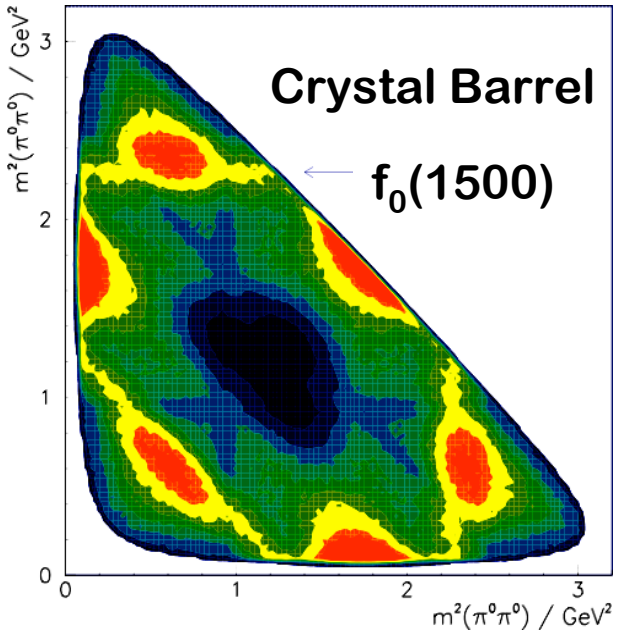
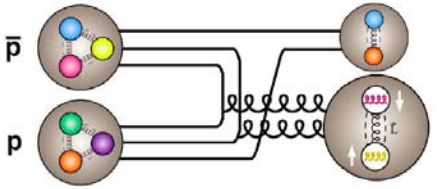
- **high statistics samples**
  - ⇒ high luminosity and prod. cross section

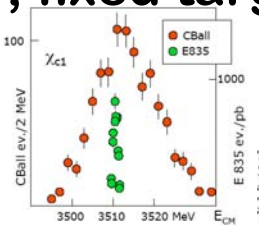


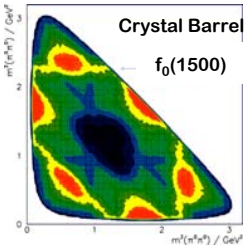


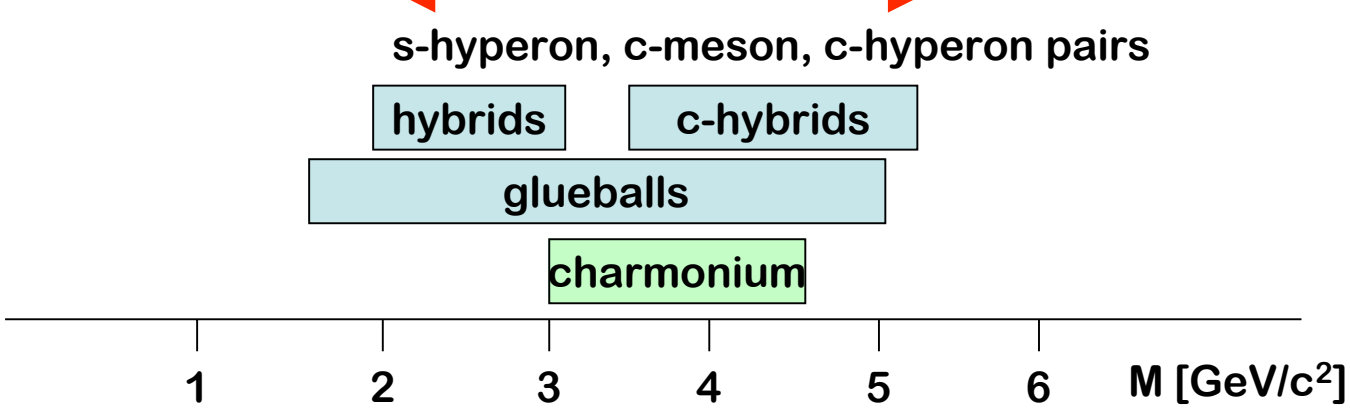
What is Experimentally Needed?

- **gluon-rich environment**
  - ⇒ proton-antiproton anihilations
- **all quantum numbers**
  - ⇒ production exp. i.e. large acc. detector, fixed target
- **precise resonance scan**
  - ⇒ high precision hadron beam (cooled)
- **high statistics samples**
  - ⇒ high luminosity and prod. cross section
- **physics topics**
  - ⇒ energy range $p_{\bar{p}}$ = 1.5 - 15 GeV/c



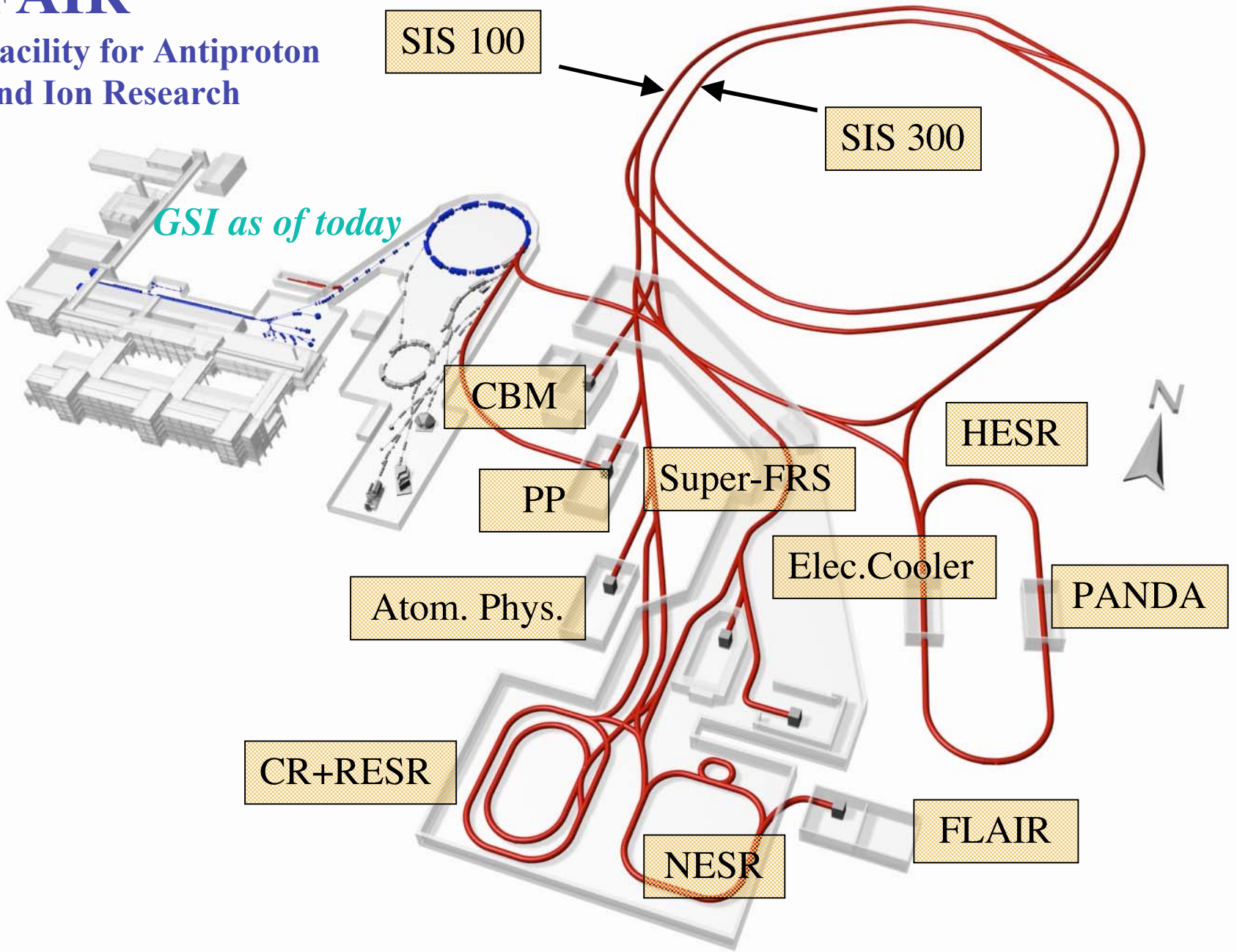


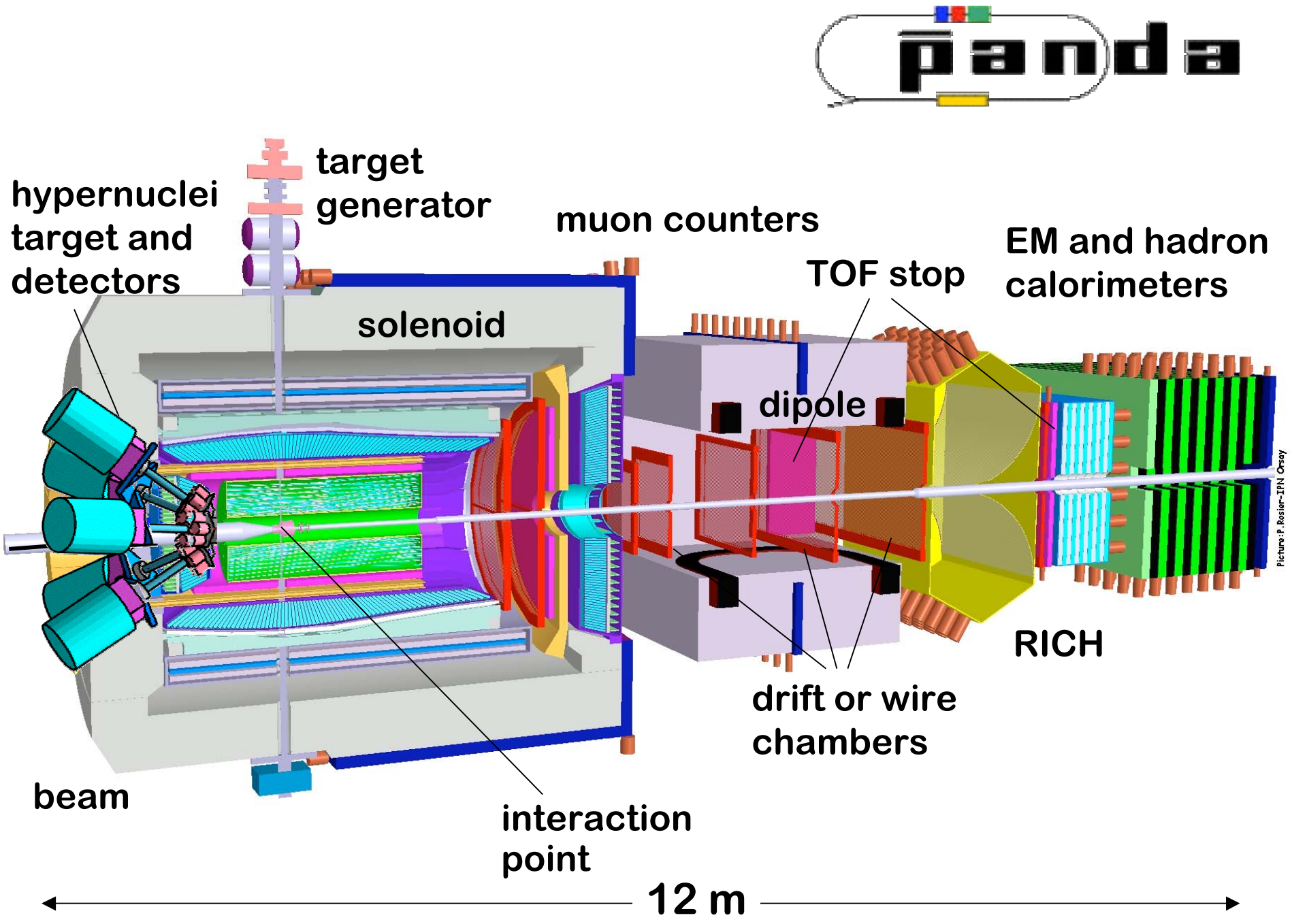


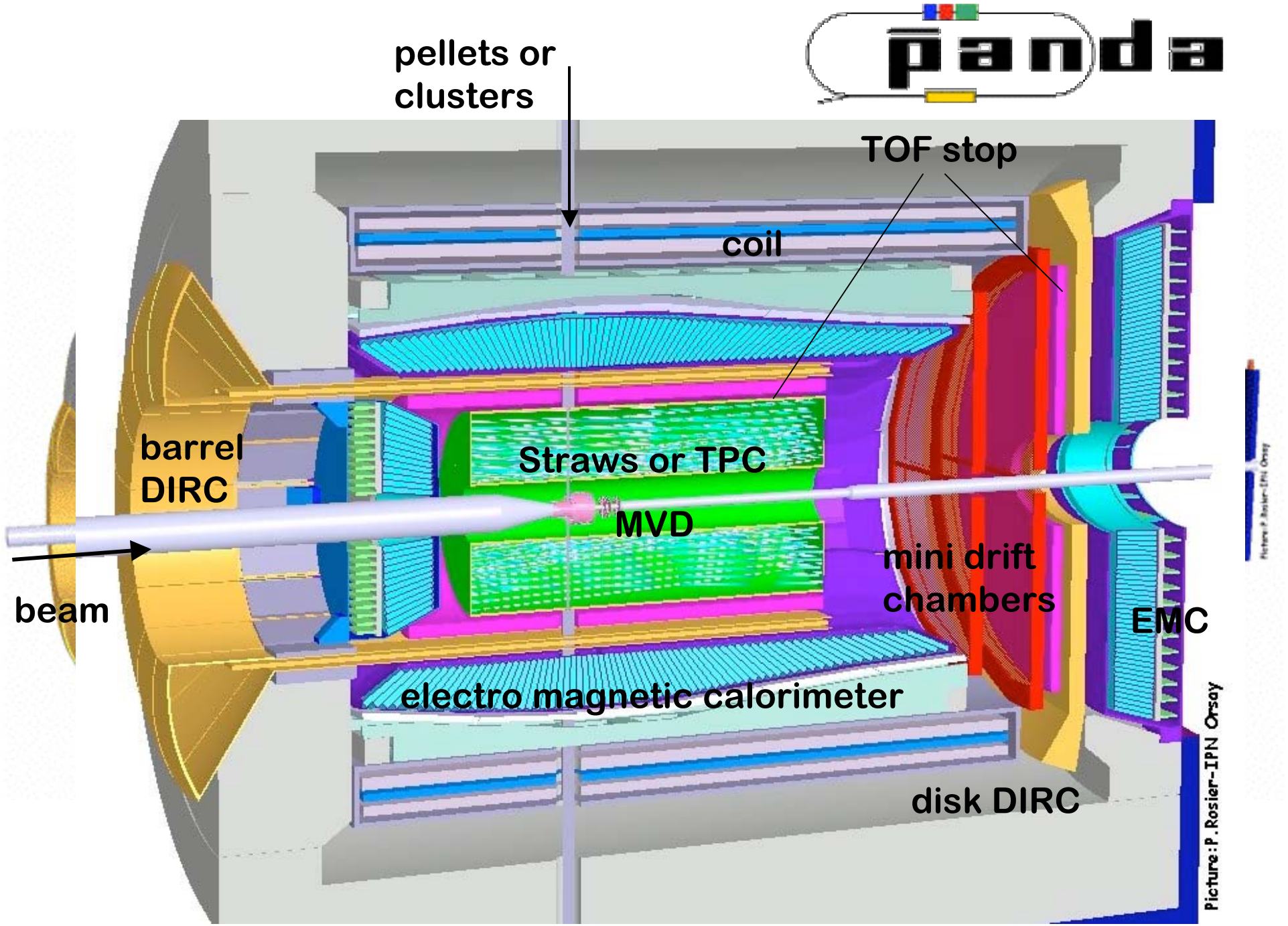


FAIR

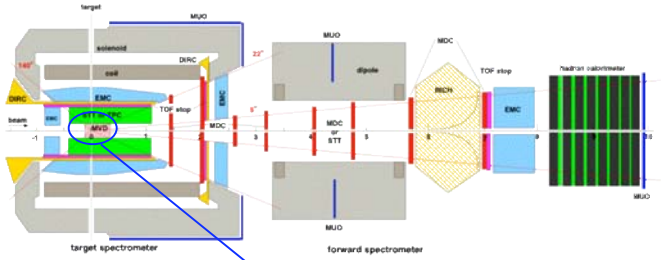
Facility for Antiproton and Ion Research



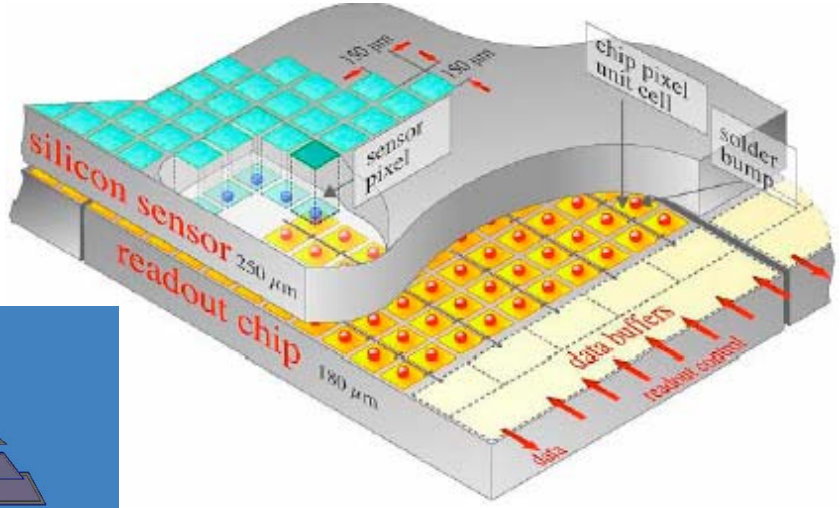

panda
hypernuclei target and detectors
target generator
muon counters
TOF stop
EM and hadron calorimeters
solenoid
dipole
RICH
drift or wire chambers
beam
interaction point
12 m
Picture: P. Rosier - IPN Orsay

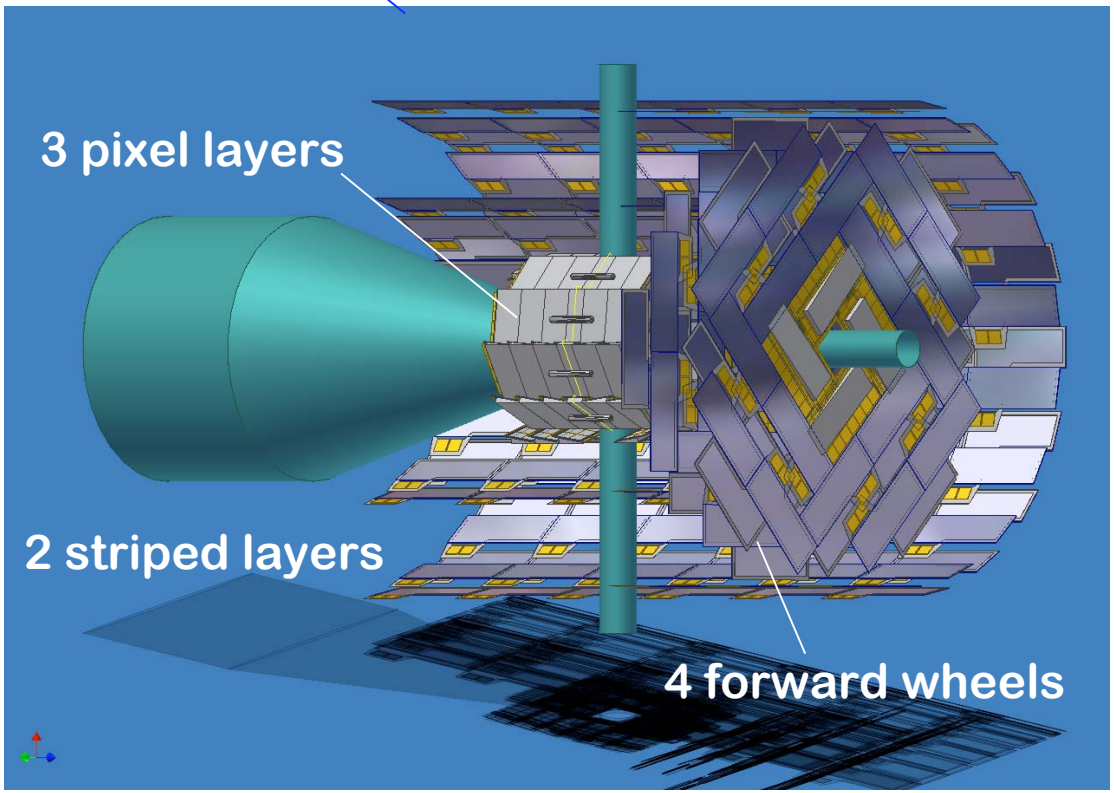

pellets or clusters
TOF stop
coil
barrel DIRC
Straws or TPC
MVD
mini drift chambers
EMC
beam
electro magnetic calorimeter
disk DIRC
Picture: P. Rosier-IPN Orsay

Micro-Vertex Detector (MVD)

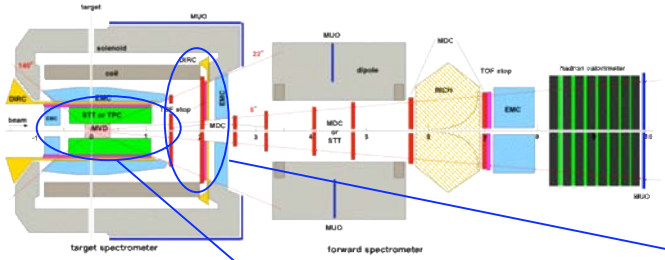


hybrid pixel design

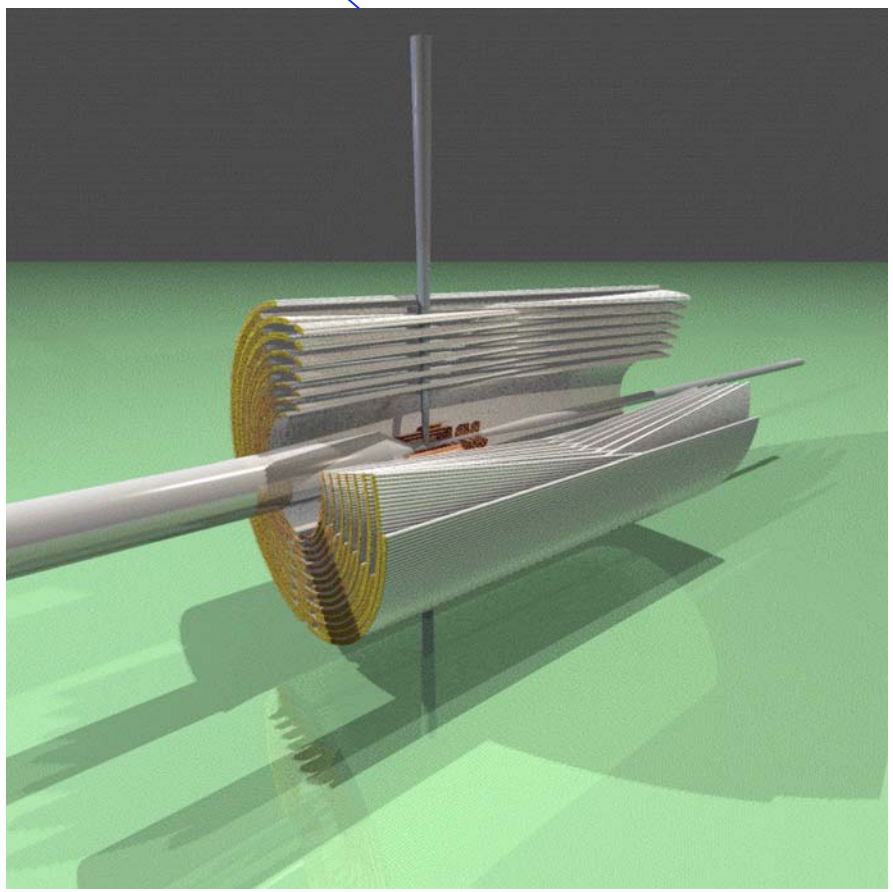


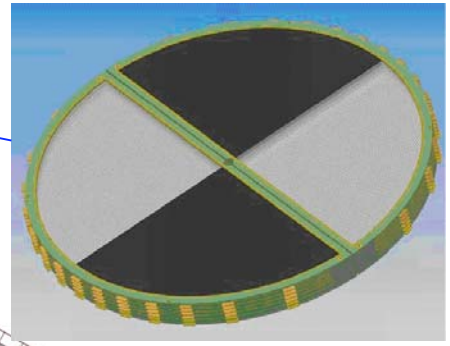


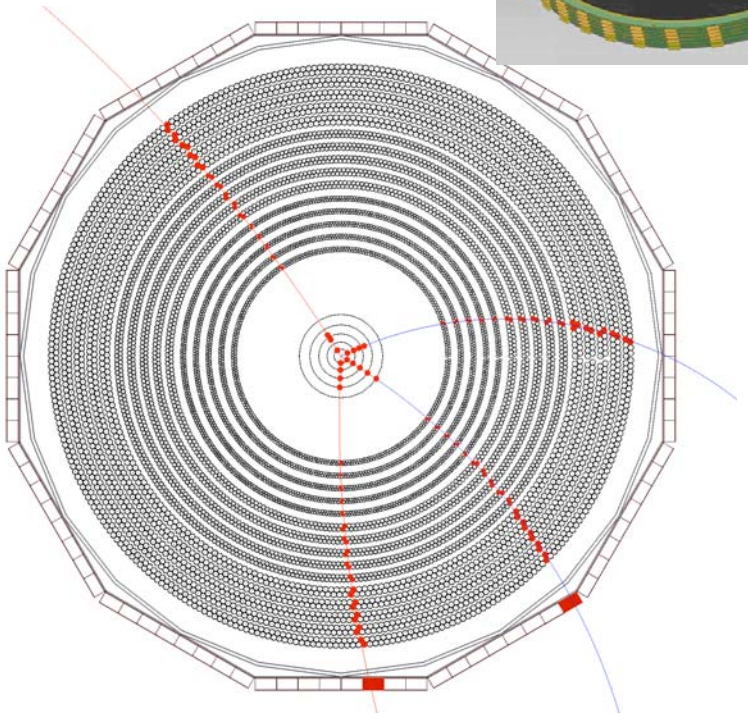
Central Tracker (STT or TPC, MDC)



- straw tubes: 11 skewed double-layers
- option (TPC with GEM readout)
- mini drift chambers

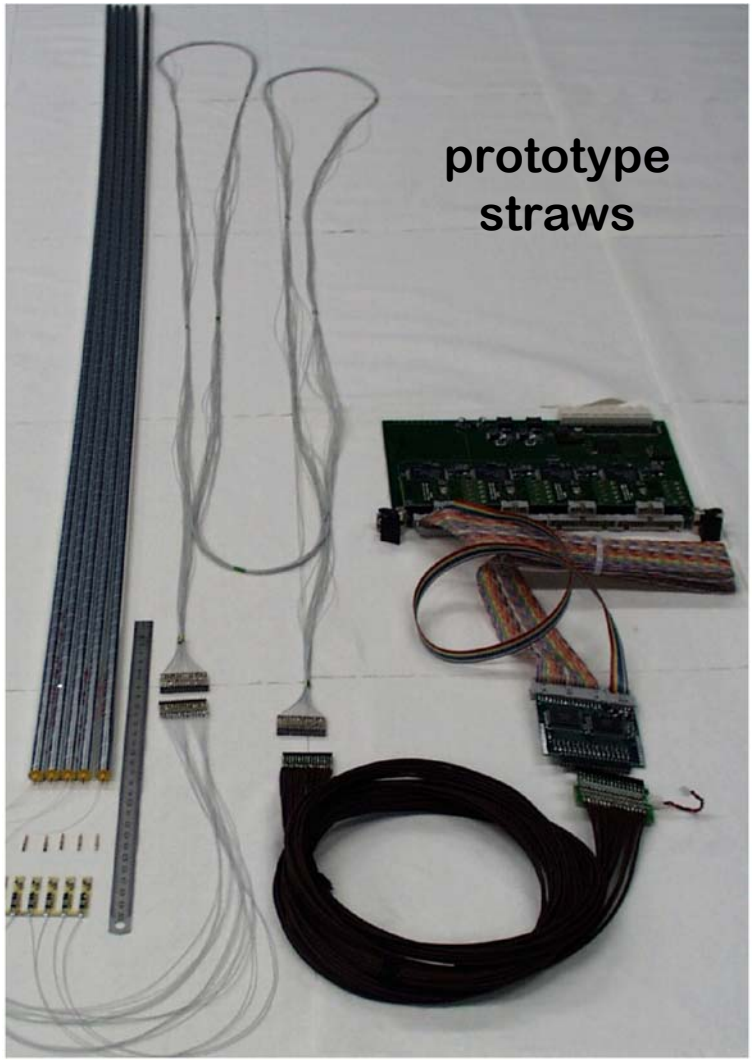






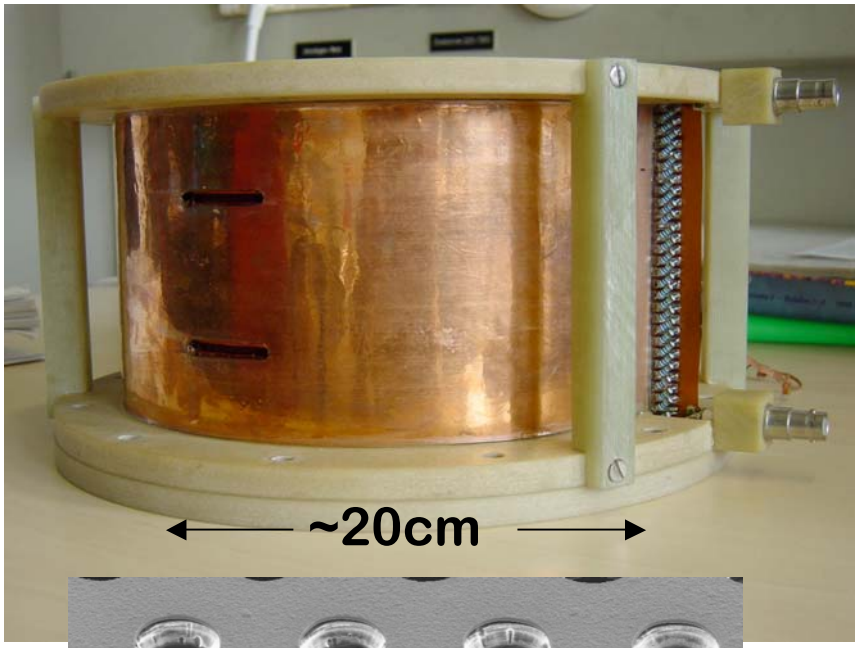
Tracker R&D

Straw Tubes

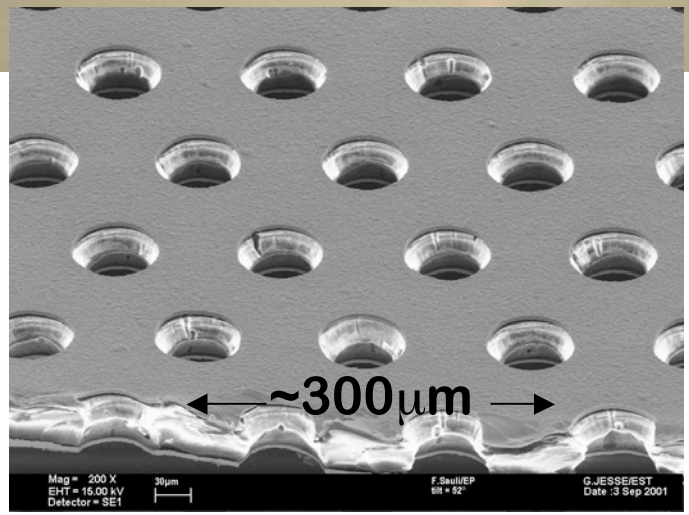


Time Projection Chamber

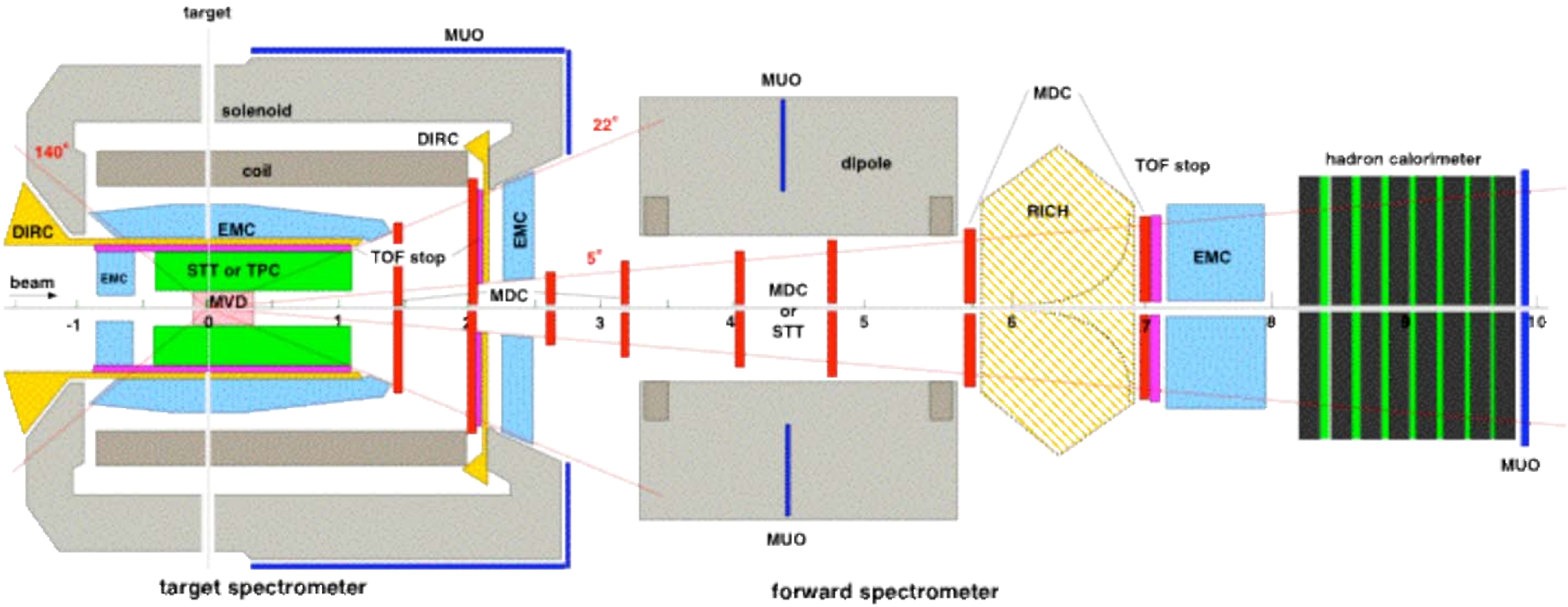
TPC proto-type



GEM readout



Charged Particle Identification

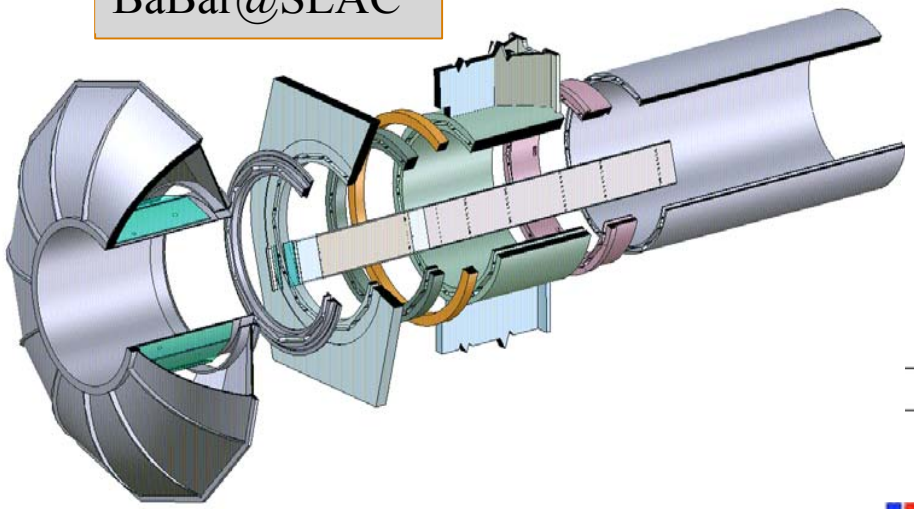


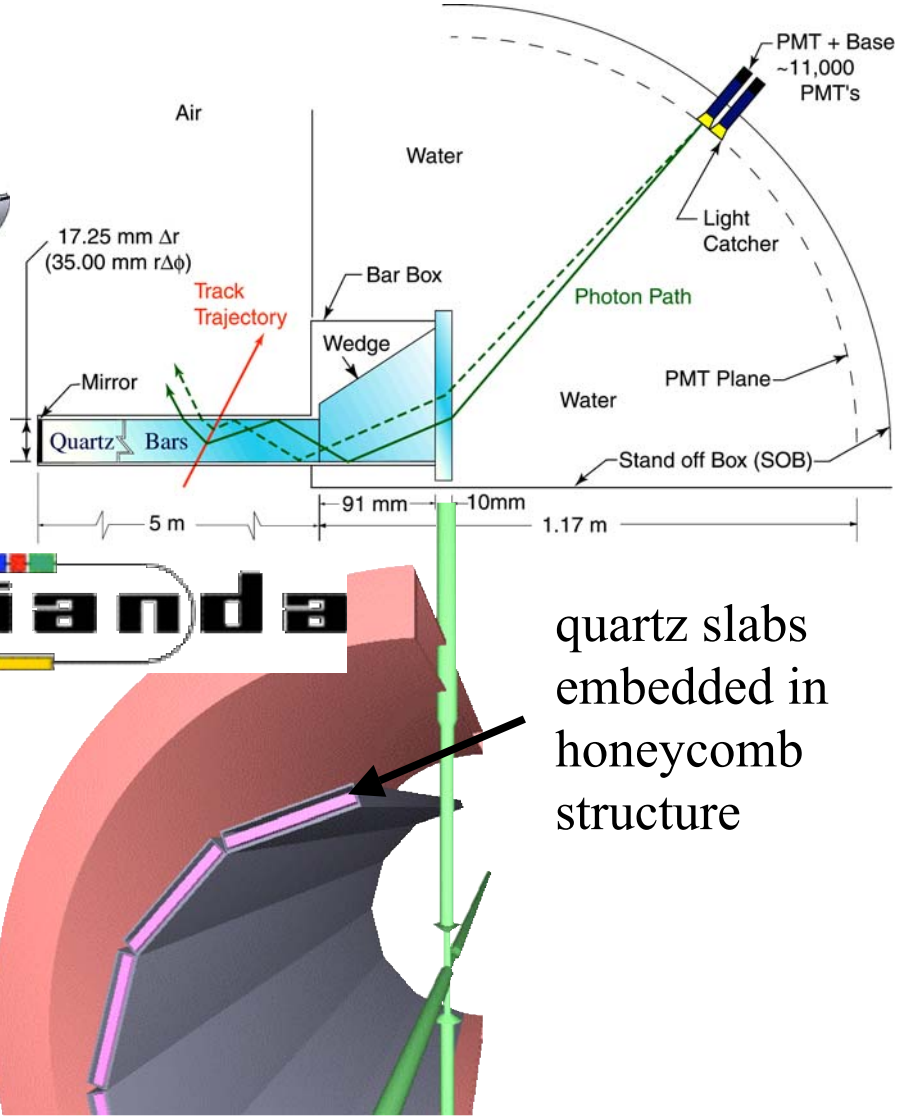
12 m

Charged Particle Identification

Detection of Internally Reflected Cherenkov Light (DIRC)

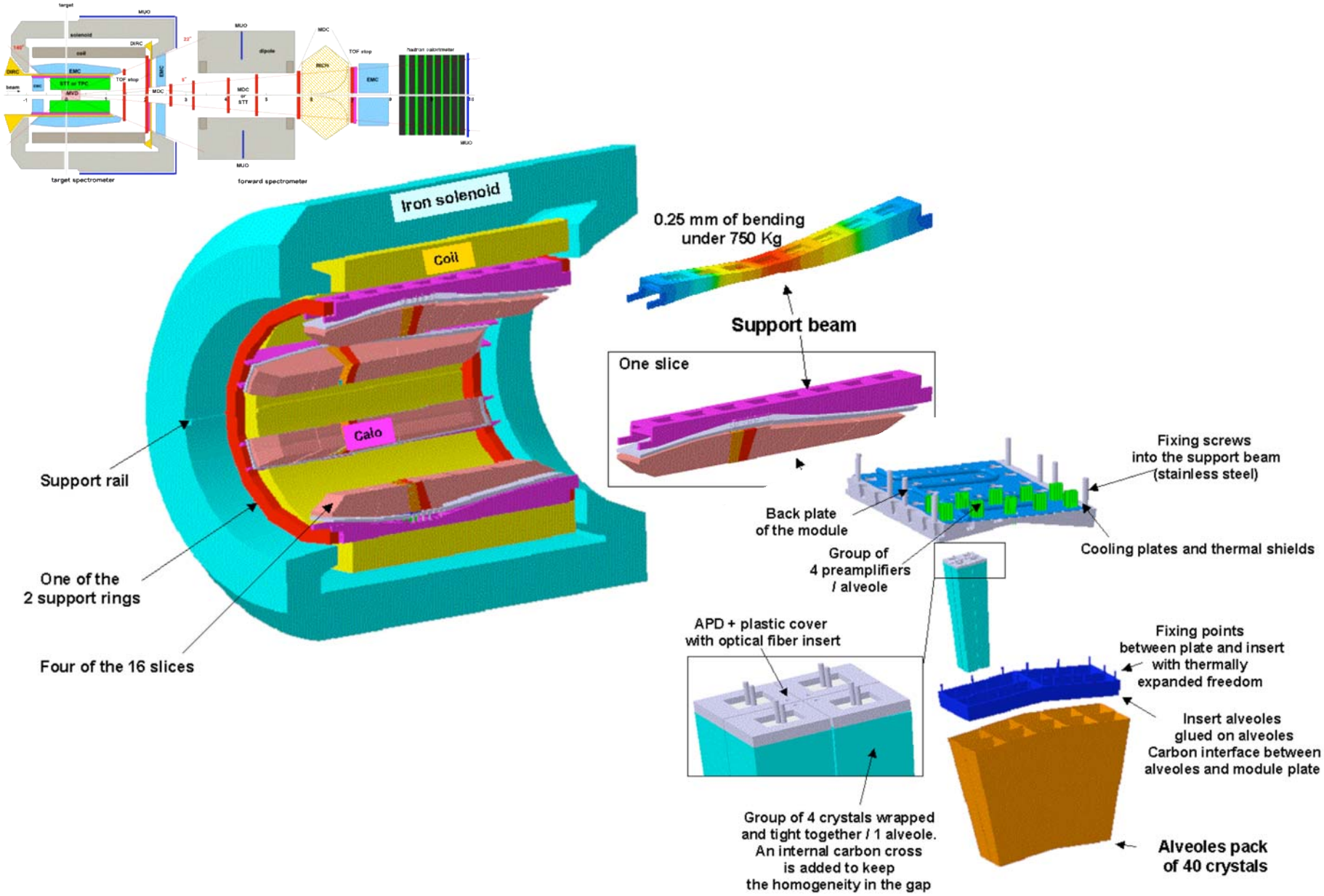
BaBar@SLAC



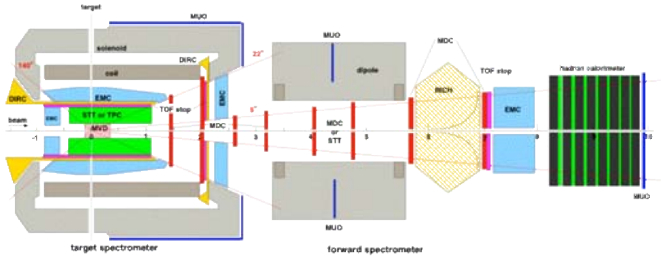


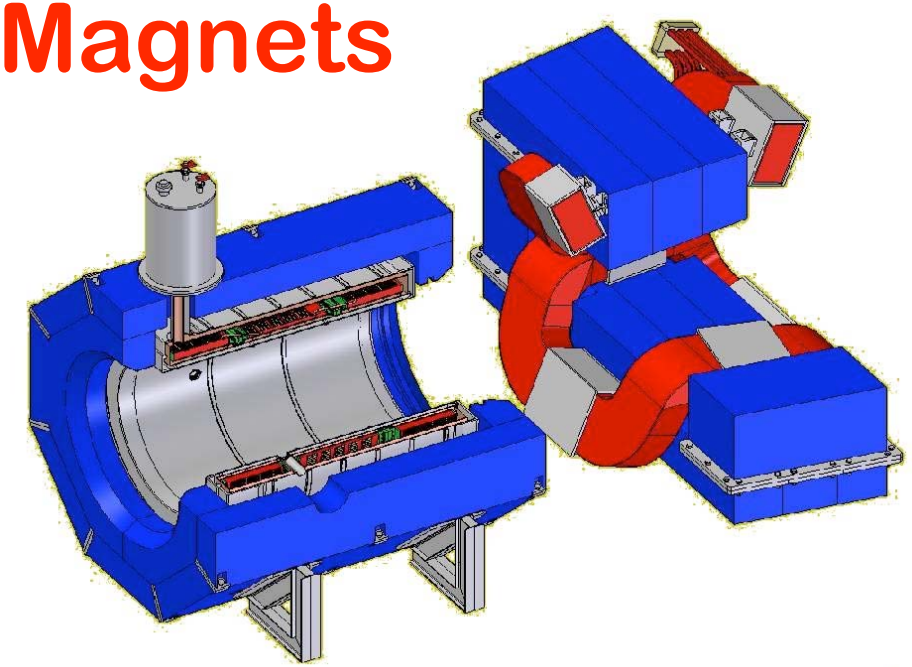
quartz slabs embedded in honeycomb structure

Electromagnetic Calorimeter (EMC)

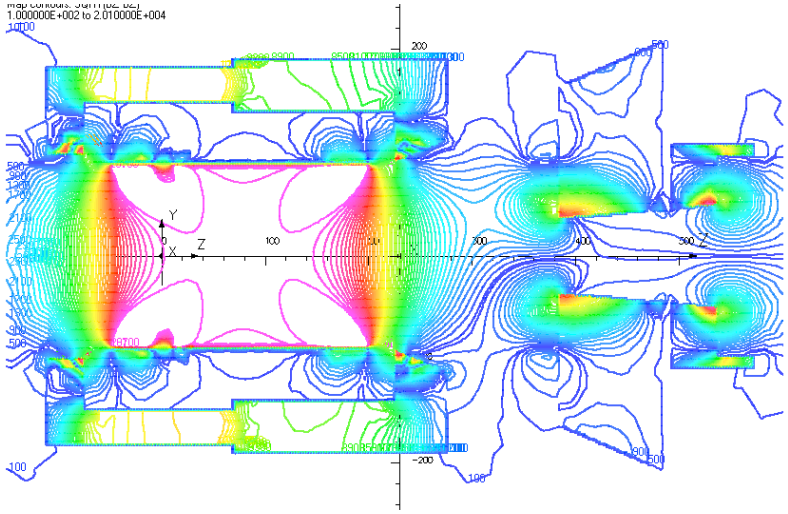


Solenoid & Dipole Magnets





unclamped



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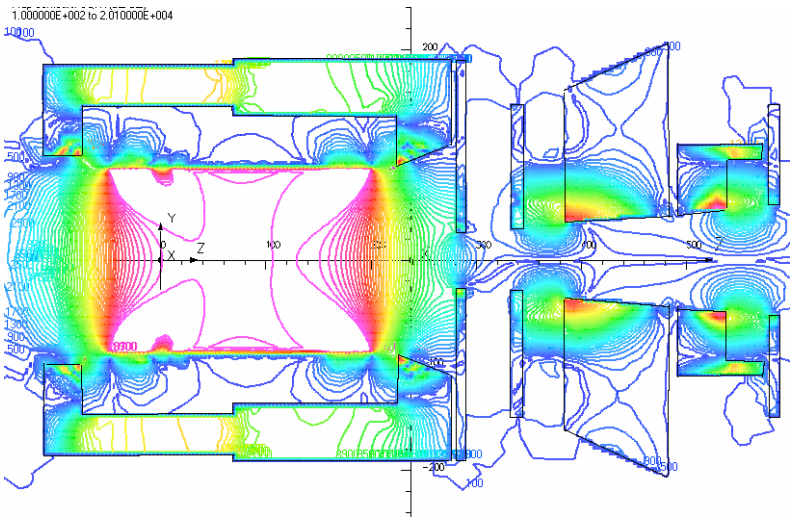


Activities in Sweden

- simulation of meson hybrid and glueball production
  - ISV, Uppsala
- e-cooler for the HESR
  - TSL, Uppsala -> Dag Reistad
- hypernuclear target and Ge detectors
  - Fysikum Stockholm Univ.; KTH Stockholm
- pellet target development, design and construction
  - TSL and ISV, Uppsala -> Örjan Nordhage
- electromagnetic calorimeter (EMC)
  - ISV, Uppsala
  - Fysikum Stockholm Univ.

Simulation of Benchmark Channels

e.g. charmonium hybrid

$$p\bar{p} \rightarrow \Psi_g \, \eta \qquad J^{PC} = 1^{-+}$$

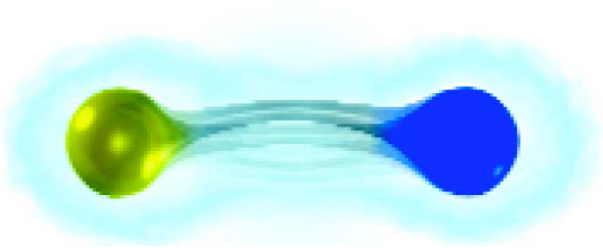
$$\hookrightarrow \gamma\gamma$$

$$\hookrightarrow \chi_c \left(\pi^0\pi^0\right)_s$$

$$\hookrightarrow \gamma\gamma\gamma\gamma$$

$$\hookrightarrow J/\psi \, \gamma$$

$$\hookrightarrow l^+ l^-$$



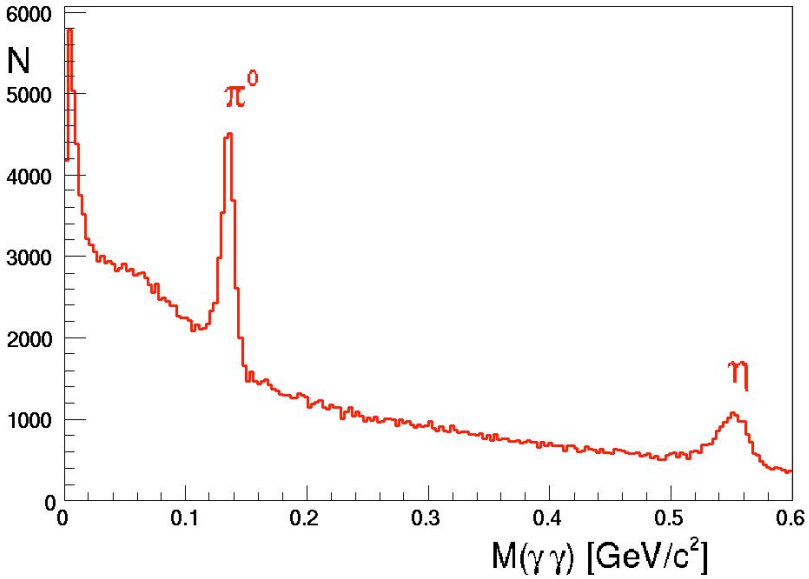
$$\Rightarrow p\bar{p} \rightarrow l^+ l^- \, 7\gamma$$

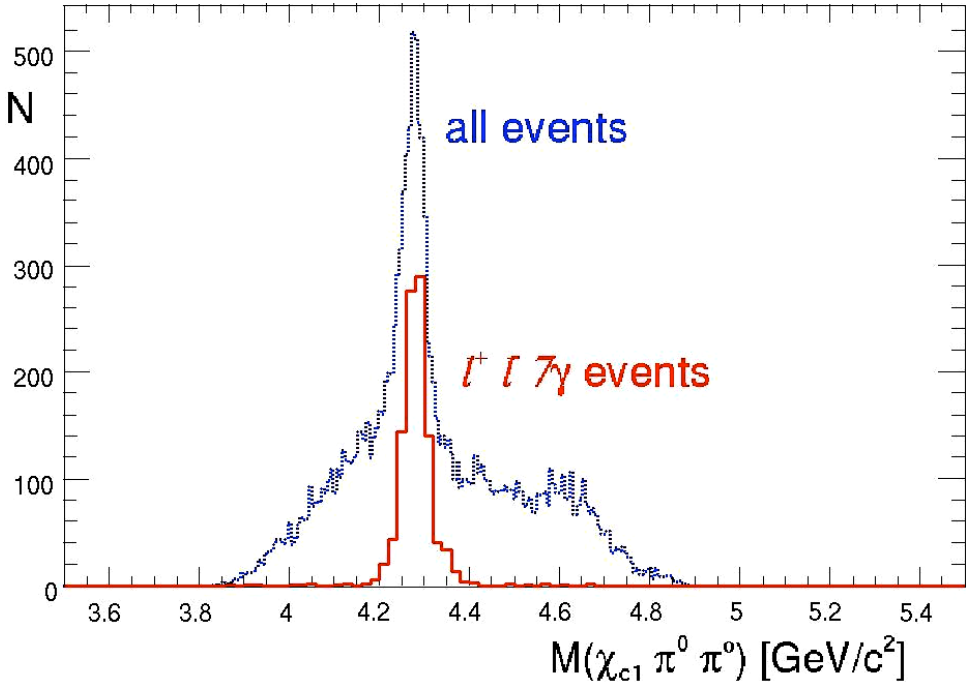
$\Rightarrow$ implications on the EMC

$\Rightarrow$ reconstruction difficult

Simulation of Benchmark Channels

e.g. charmonium hybrid

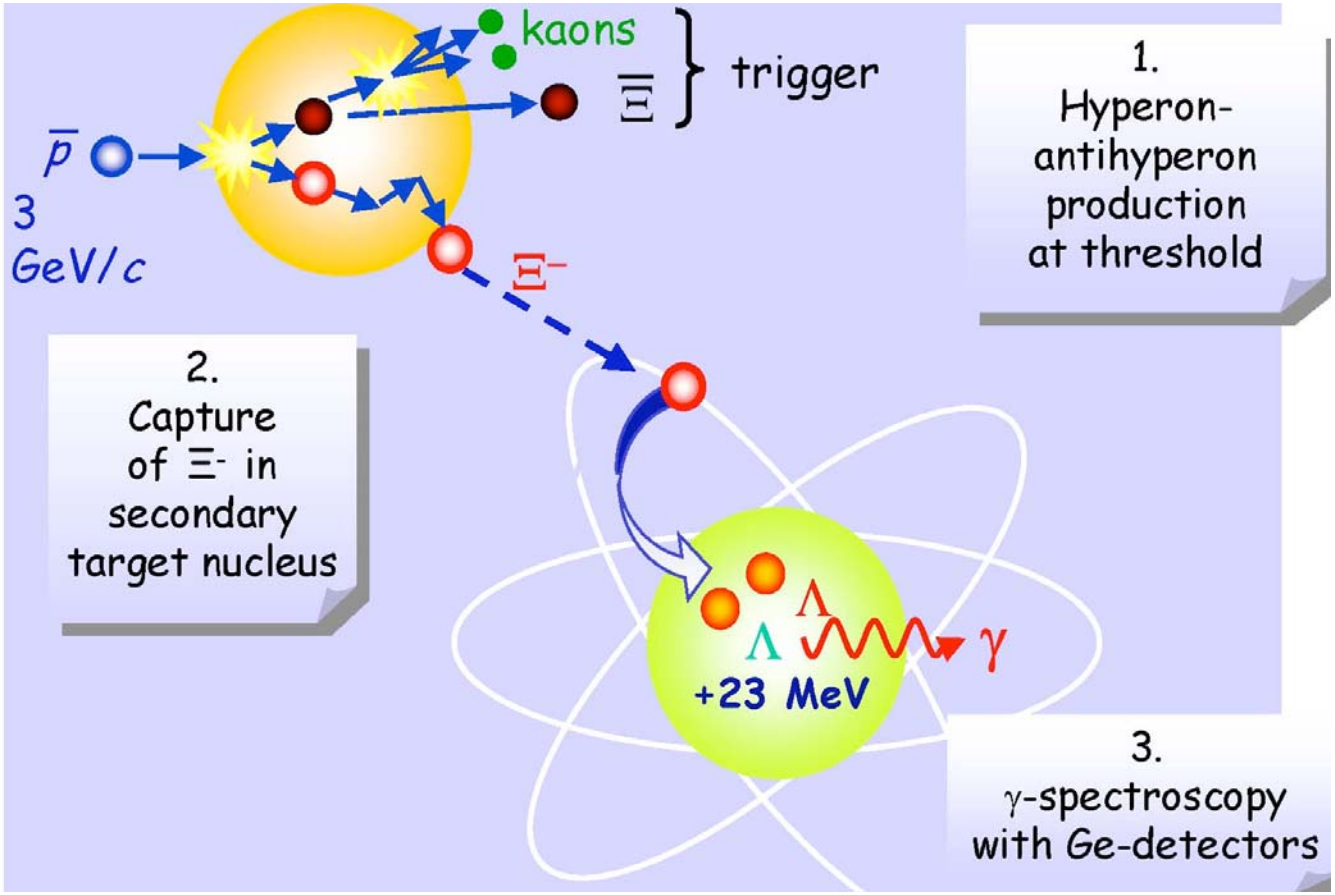




- **Reconstruction of Ψ_g**
  - 12% efficiency feasible
  - split off reconstruction?

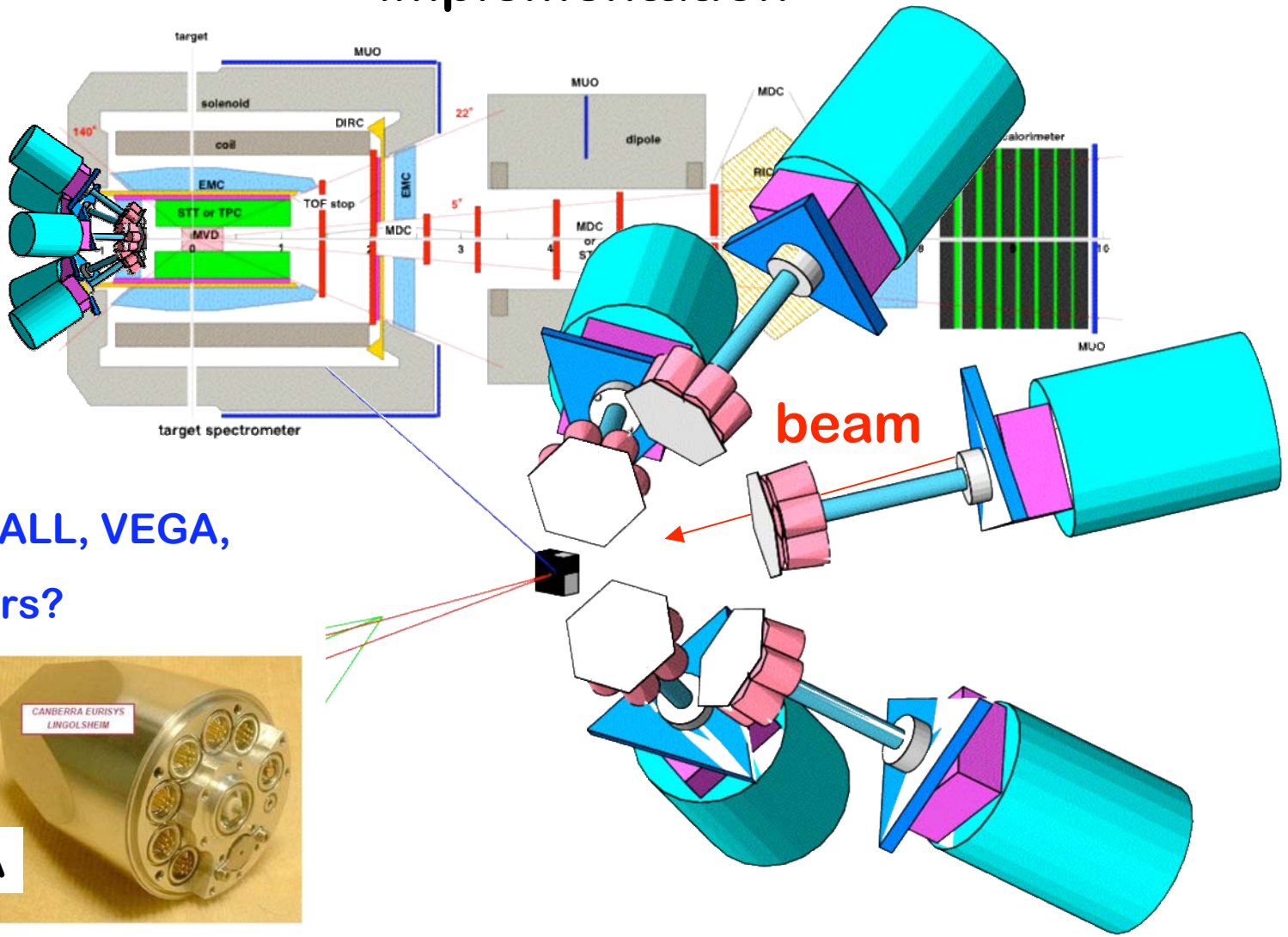
Spectroscopy of Hypernuclei

detection principle



Spectroscopy of Hypernuclei

implementation



EUROBALL, VEGA,

detectors?

AGATA

Spectroscopy of Hypernuclei

use at CELSIUS

detector telescope

in UHV, windowless
in a high magnetic field
germanium detectors operate
at -195° C

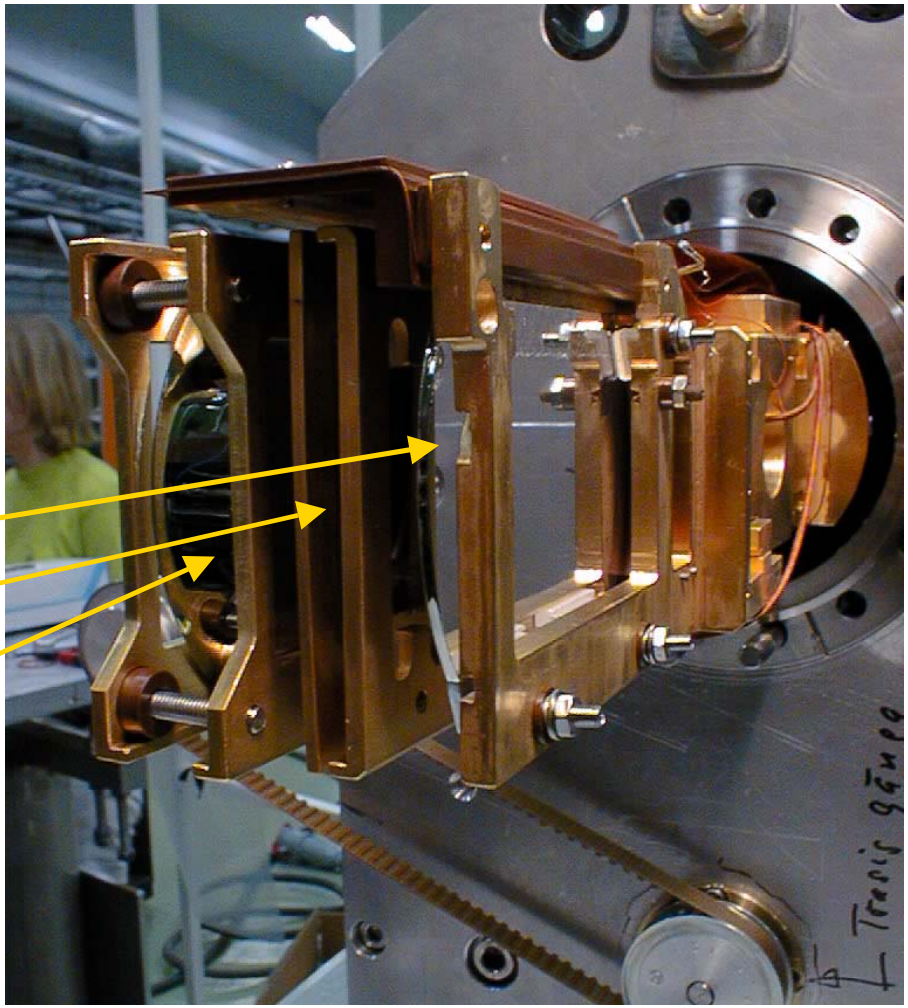
typical set of detectors:

1) thin (2 mm) germanium, position sensitive

2) thin (1 mm) silicon

3) thick (12 mm) germanium

particle identification
energy determination

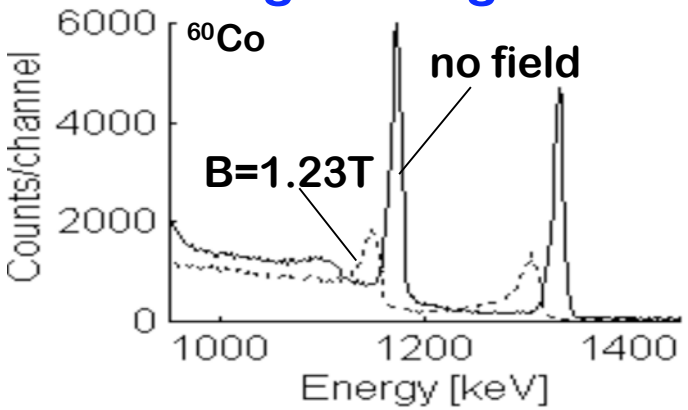


Karl Lindberg, Per-Erik Tegnér

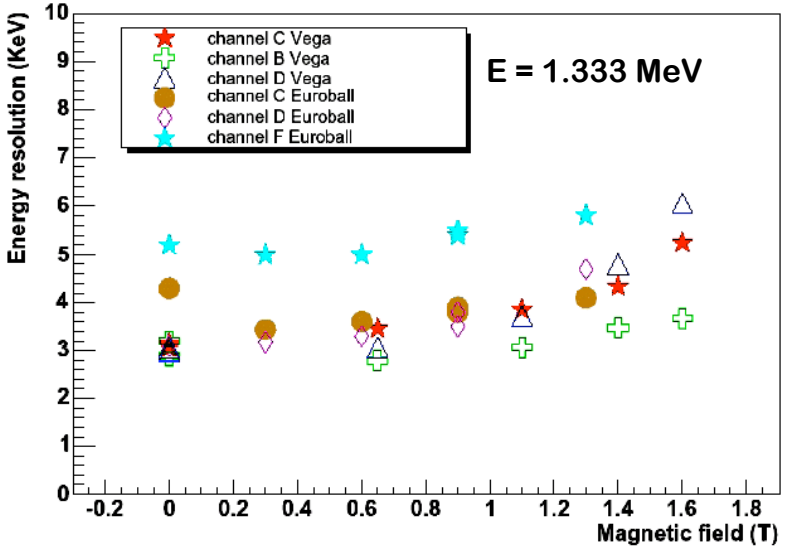
Spectroscopy of Hypernuclei

experiments in a magnetic field

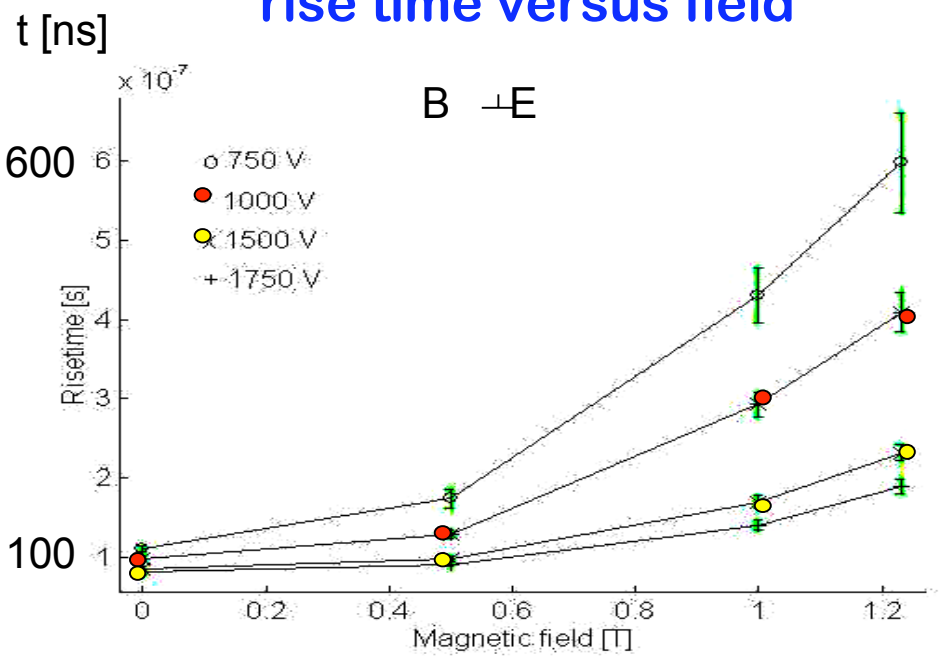
signal height



resolution versus field



rise time versus field



Electro-Magnetic Calorimeter

scintillator material

- **scintillator material**
  - **PWO II, III**

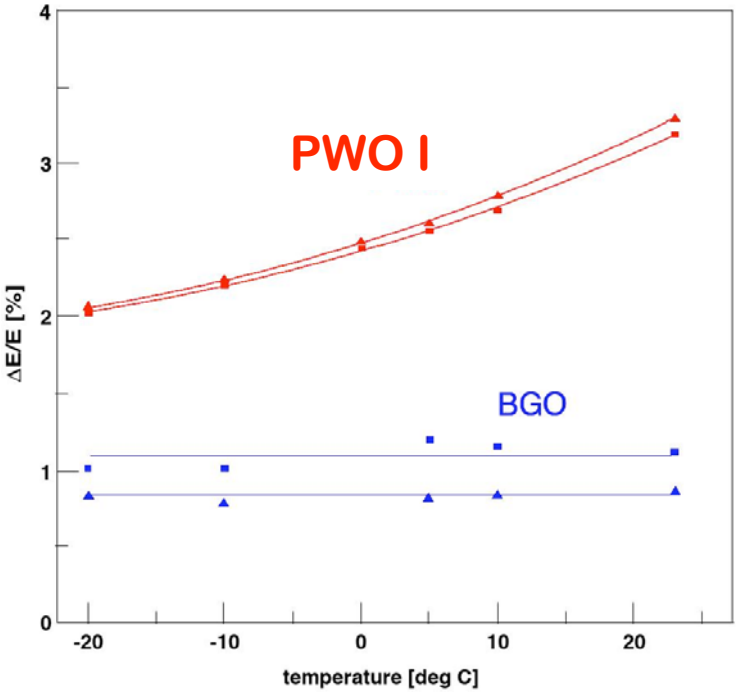
    SICCAS, Bogoroditsk
  - **BGO**

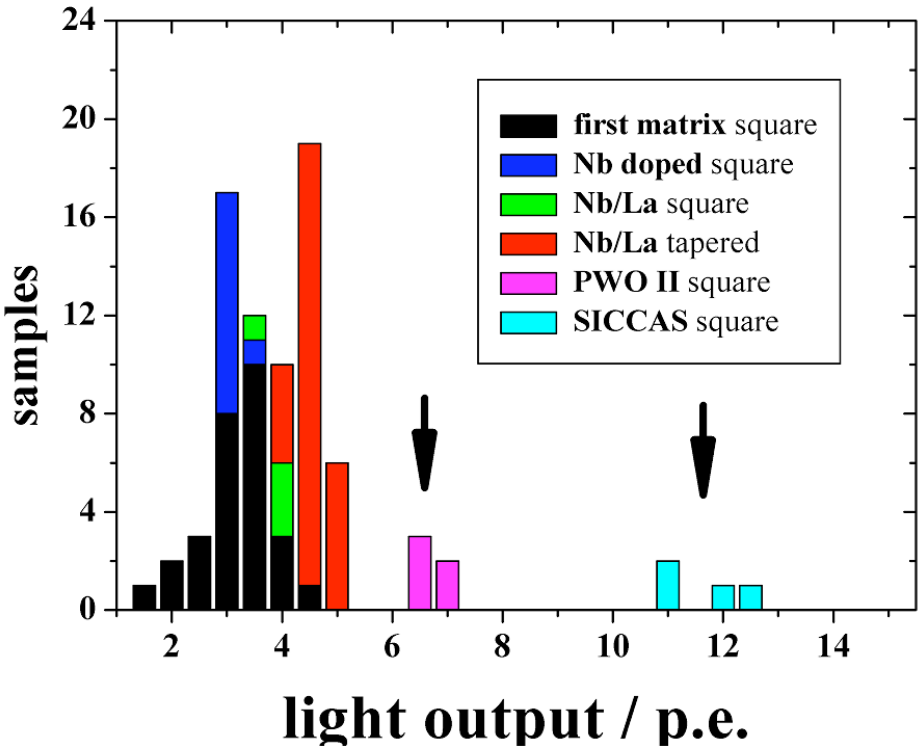
    SICCAS, (Saint Gobain)

Electro-Magnetic Calorimeter

scintillator material

- **scintillator material**
  - PWO II, III, BGO

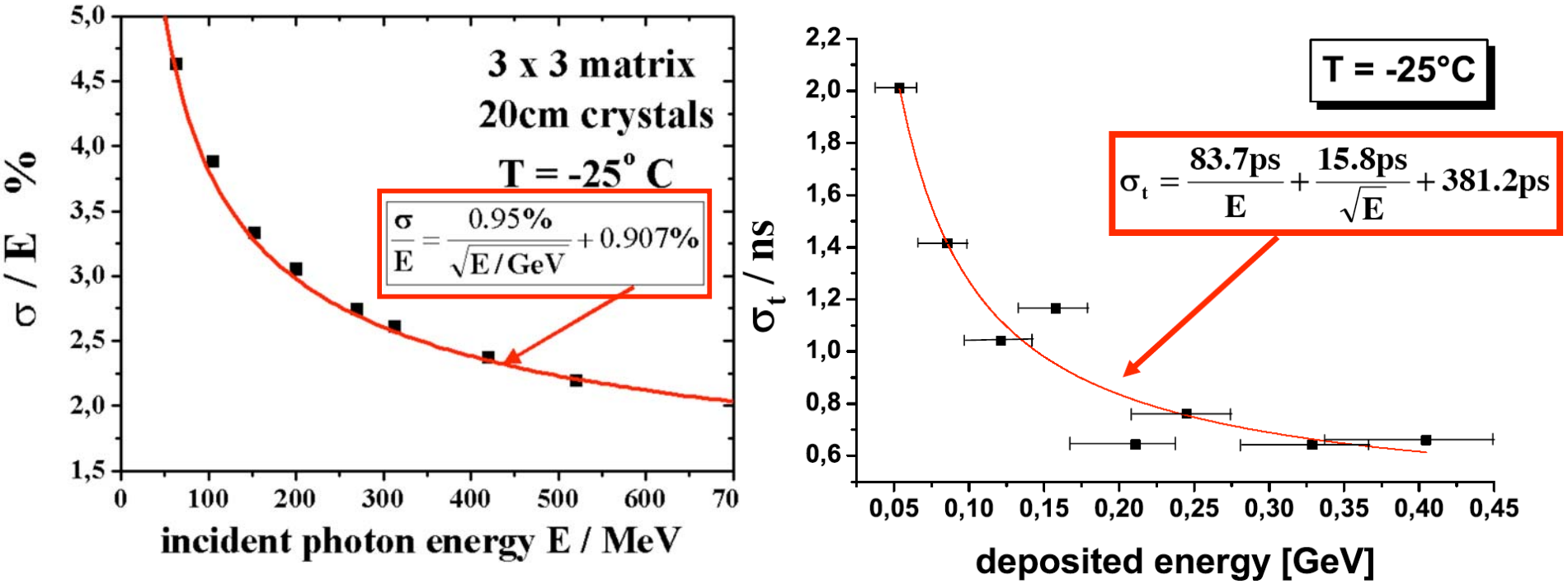




Electro-Magnetic Calorimeter

scintillator material

3x3 array PWO III at -25°C and PMT read-out:



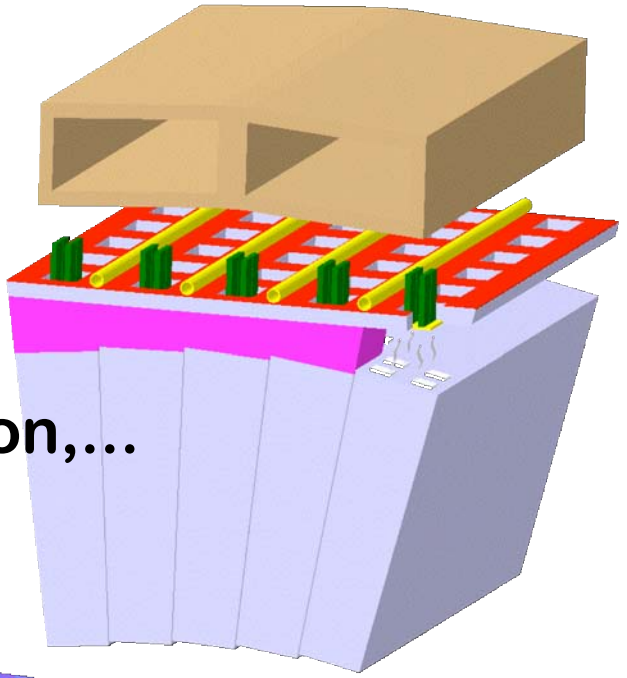
PANDA CDR: $\Delta E/E = 0.3\% + 1.54\% / \sqrt{E[GeV]}$

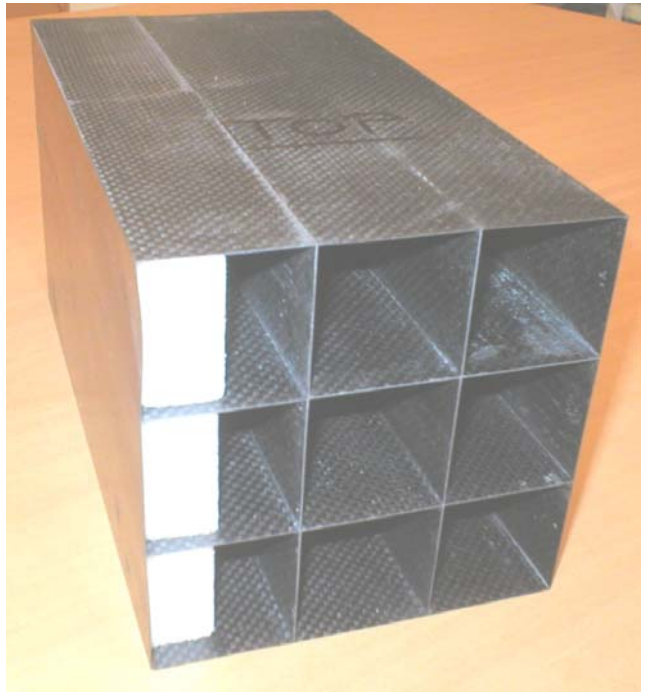
$\Rightarrow$ Homogeneity and quality of crystals?

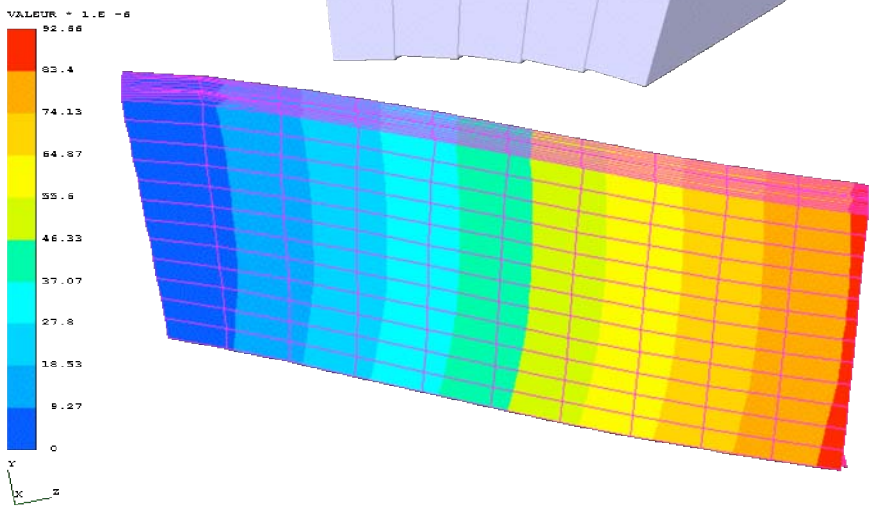
Electro-Magnetic Calorimeter

packaging and mounting

- **scintillator material**
  - PWO II, III (BGO)
- **packaging and mounting**
  - cooling, alveoles, deformation,…







Electro-Magnetic Calorimeter

light yield dependence on position

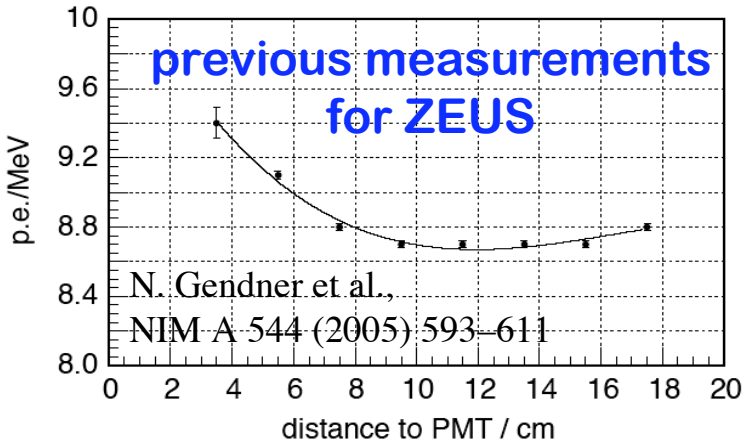
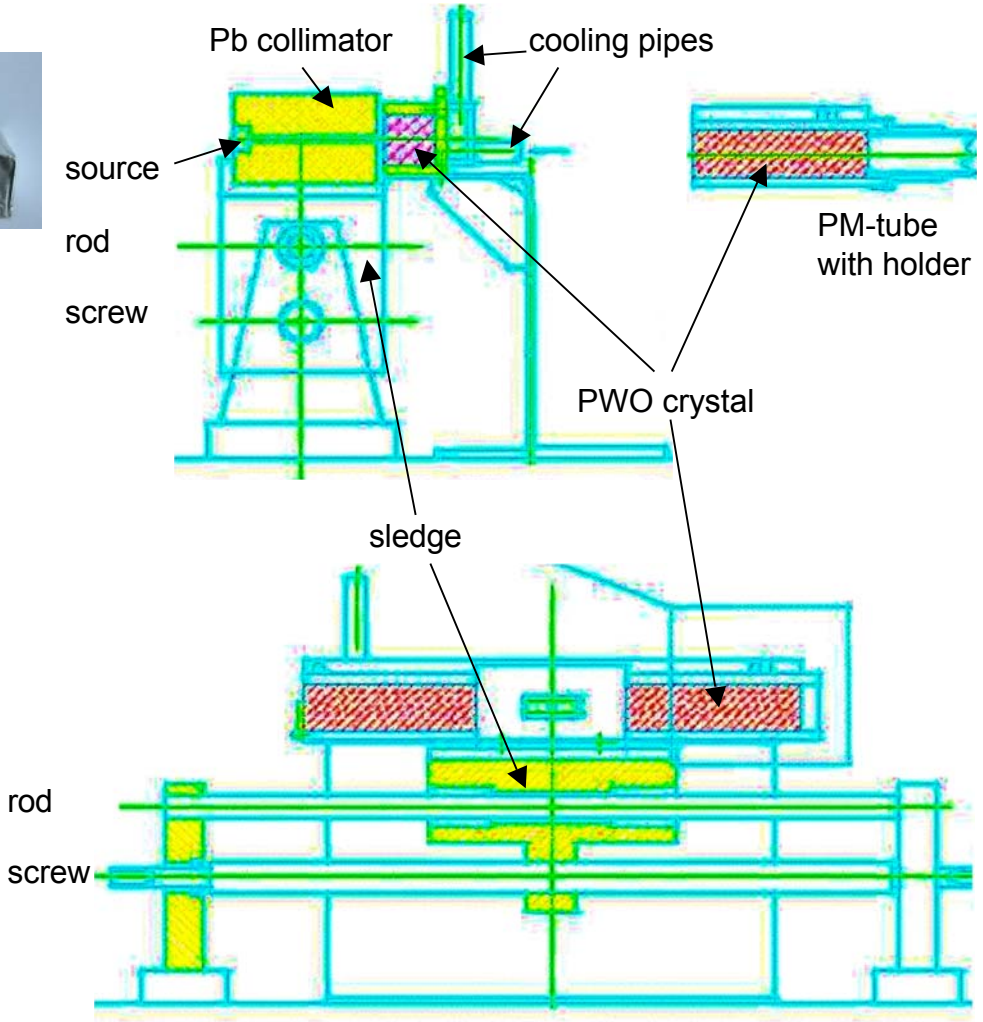


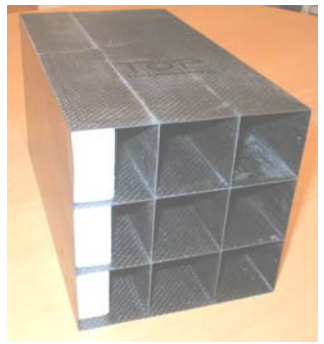
Fig. 3. The light yield of crystal 388 as a function of the distance from the exciting ^{60}Co source to the PMT.

set up build in Stockholm

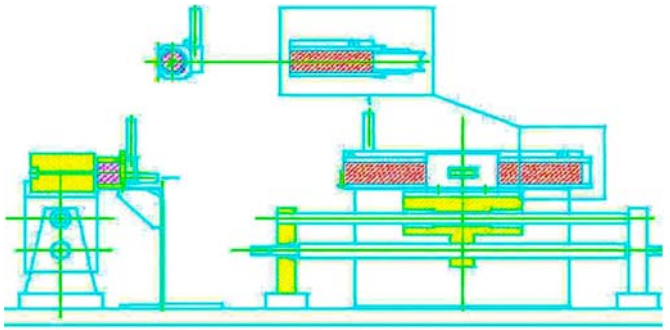


Electro-Magnetic Calorimeter

summary



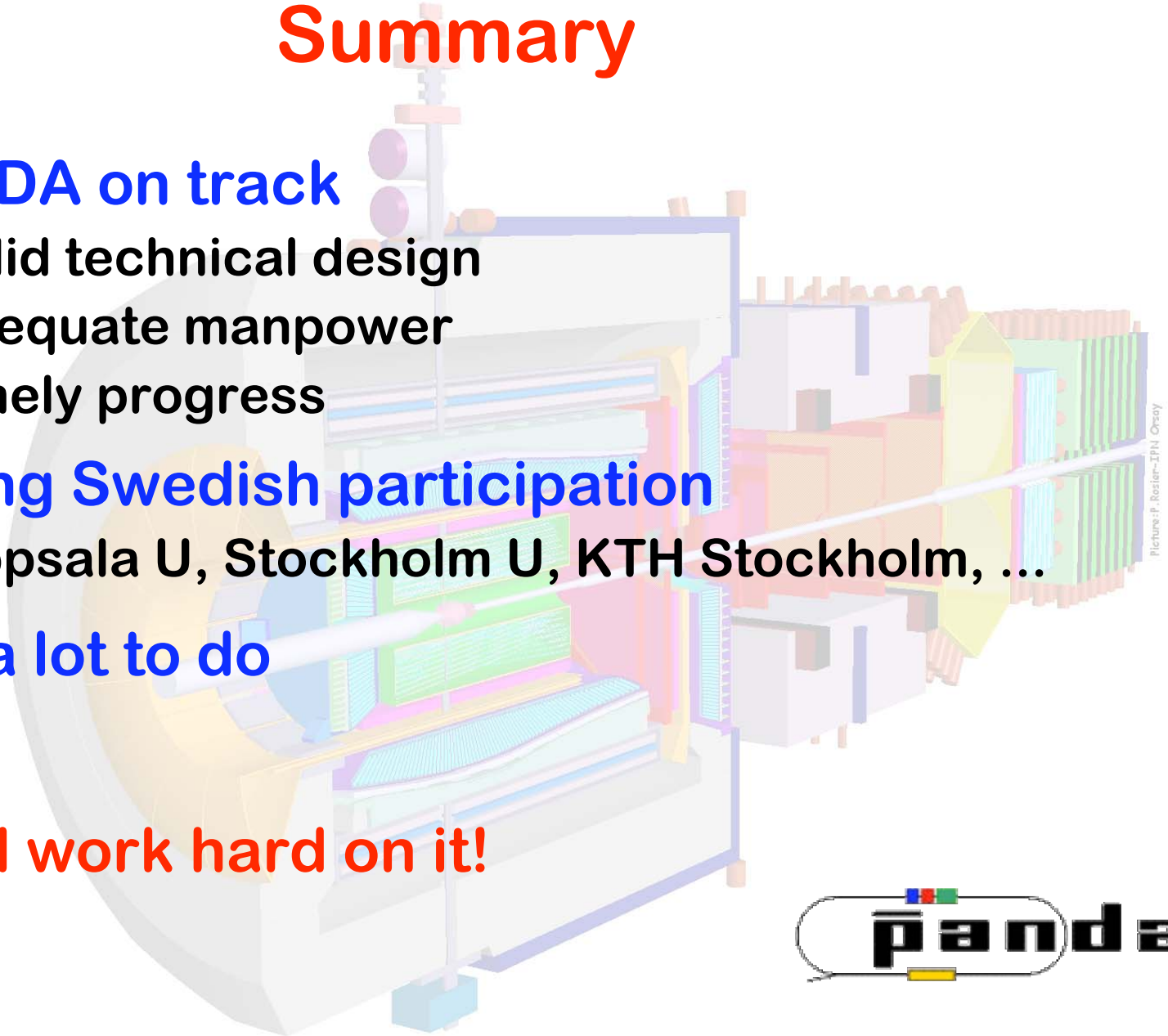
- scintillator material
  - PWO II, III (BGO)
- packaging and mounting
  - alveoles, cooling, deformation,…
- light yield vs position
  - crystal modification, quality control
- photo sensors
- radiation hardness
- …



Summary

- PANDA on track
  - solid technical design
  - adequate manpower
  - timely progress
- strong Swedish participation
  - Uppsala U, Stockholm U, KTH Stockholm, …
- still a lot to do

We will work hard on it!



PANDA Collaboration

- At present a group of **350 physicists** from 47 institutions of 15 countries

Austria – Belaruz – China – Finland – France – Germany – Italy – Poland – Romania – Russia – Spain – Sweden – Switzerland – U.K. – U.S.A.

Basel, Beijing, Bochum, Bonn, IFIN Bucharest, Catania, Cracow, Dresden, Edinburgh, Erlangen, Ferrara, Frankfurt, Genova, Giessen, Glasgow, GSI, Inst. of Physics Helsinki, FZ Jülich, JINR Dubna, Katowice, Lanzhou, LNF, Mainz, Milano, Minsk, TU München, Münster, Northwestern, BINP Novosibirsk, Pavia, Piemonte Orientale, IPN Orsay, IHEP Protvino, PNPI St. Petersburg, KTH Stockholm, Stockholm, Dep. A. Avogadro Torino, Dep. Fis. Sperimentale Torino, Torino Politecnico, Trieste, TSL Uppsala, Tübingen, Uppsala, Valencia, SINS Warsaw, TU Warsaw, AAS Wien

http://www.gsi.de/panda