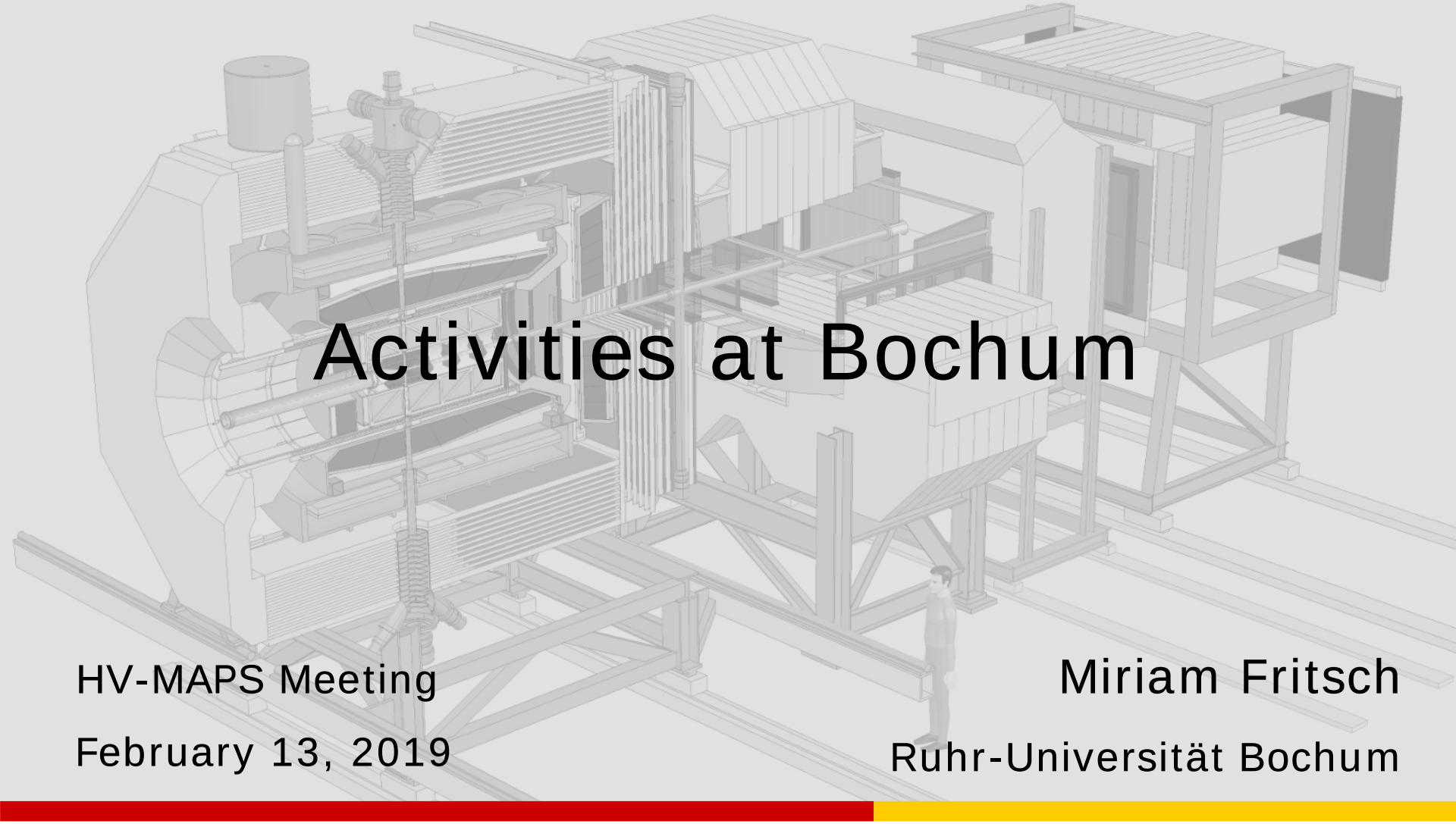


Activities at Bochum

HV-MAPS Meeting

February 13, 2019

Miriam Fritsch

Ruhr-Universität Bochum

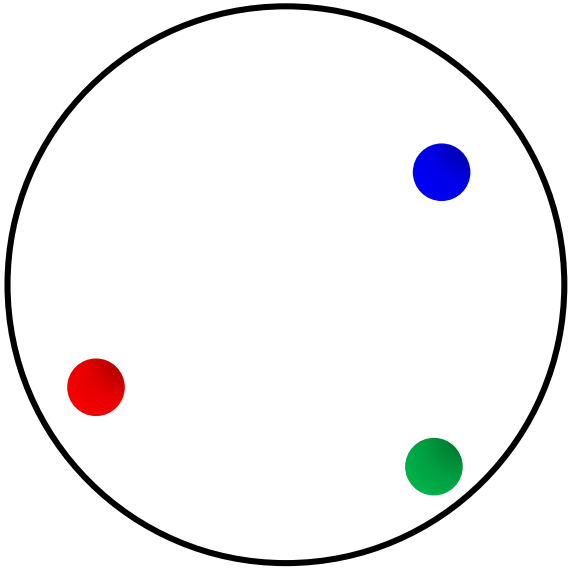
Millenium Question

How is the proton mass created ?

Proton consists of 3 quarks

But:

→ Only 2% of the proton mass from the quarks



Millenium Question

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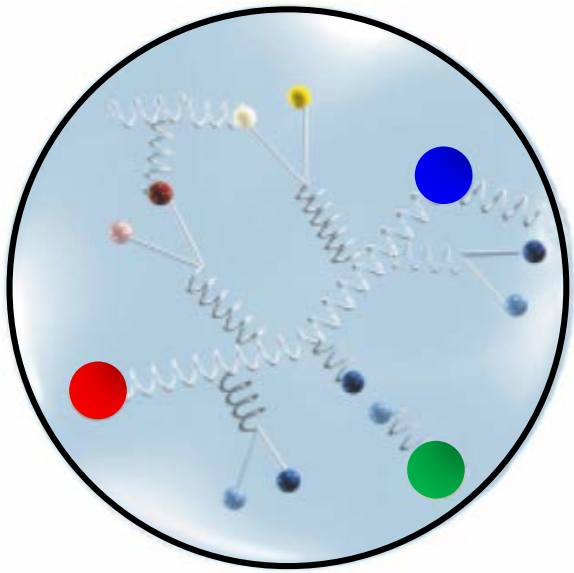


But:

→ Only 2% of the proton mass from the quarks

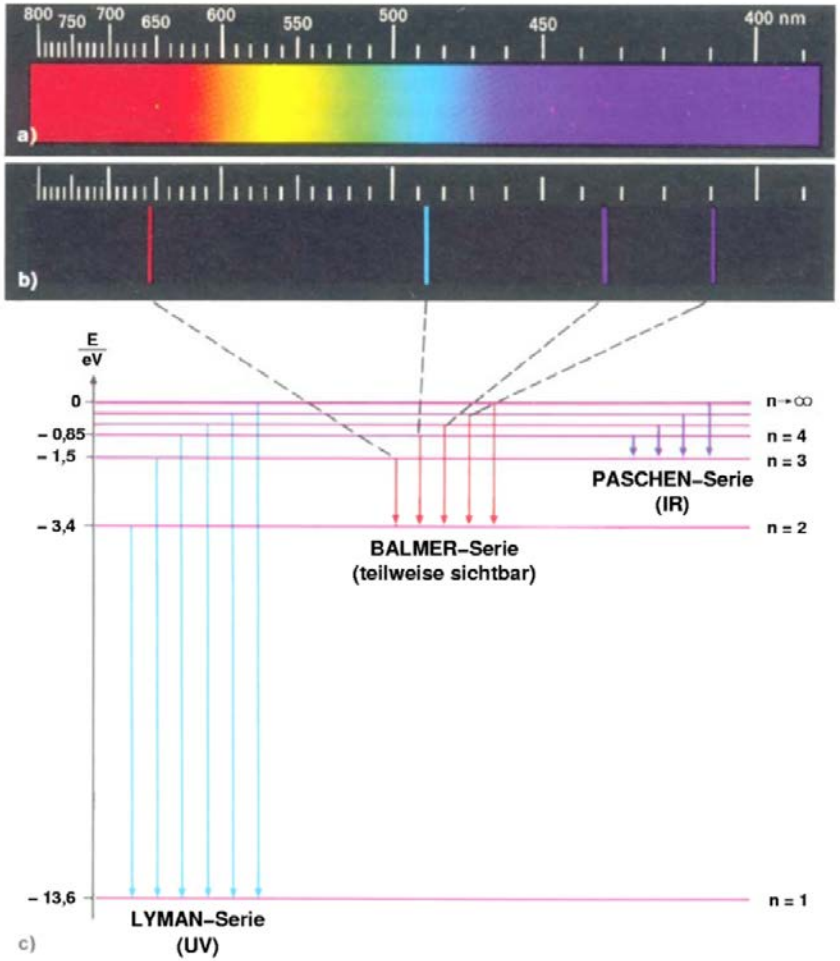
→ 98% from complex binding not understood sufficiently

Binding force between the quarks ?

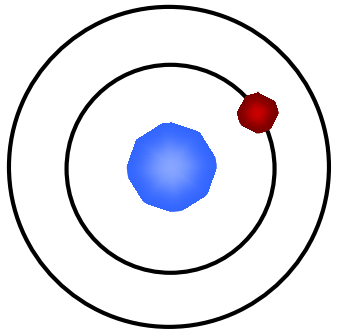
Internal structure ?

Spectroscopy

Example: Atomic Hydrogen



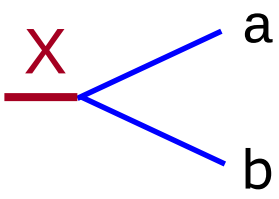
$$\tilde{\nu} = R\left(\frac{1}{m^2} - \frac{1}{n^2}\right)$$



→ Translation into an atomic model

→ Binding among proton and electron

Observables of Hadron Spectroscopy

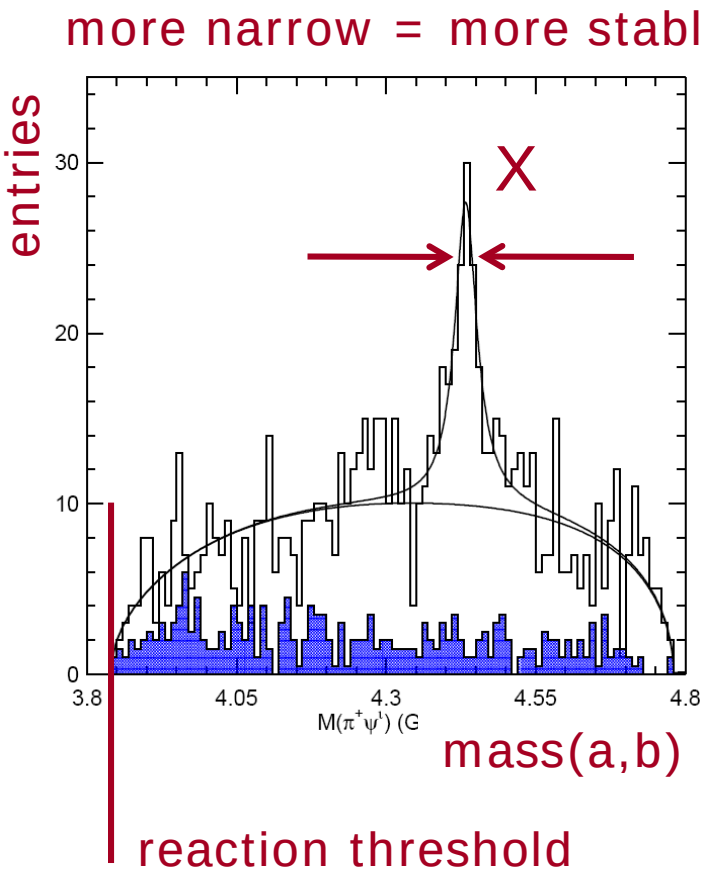


mass

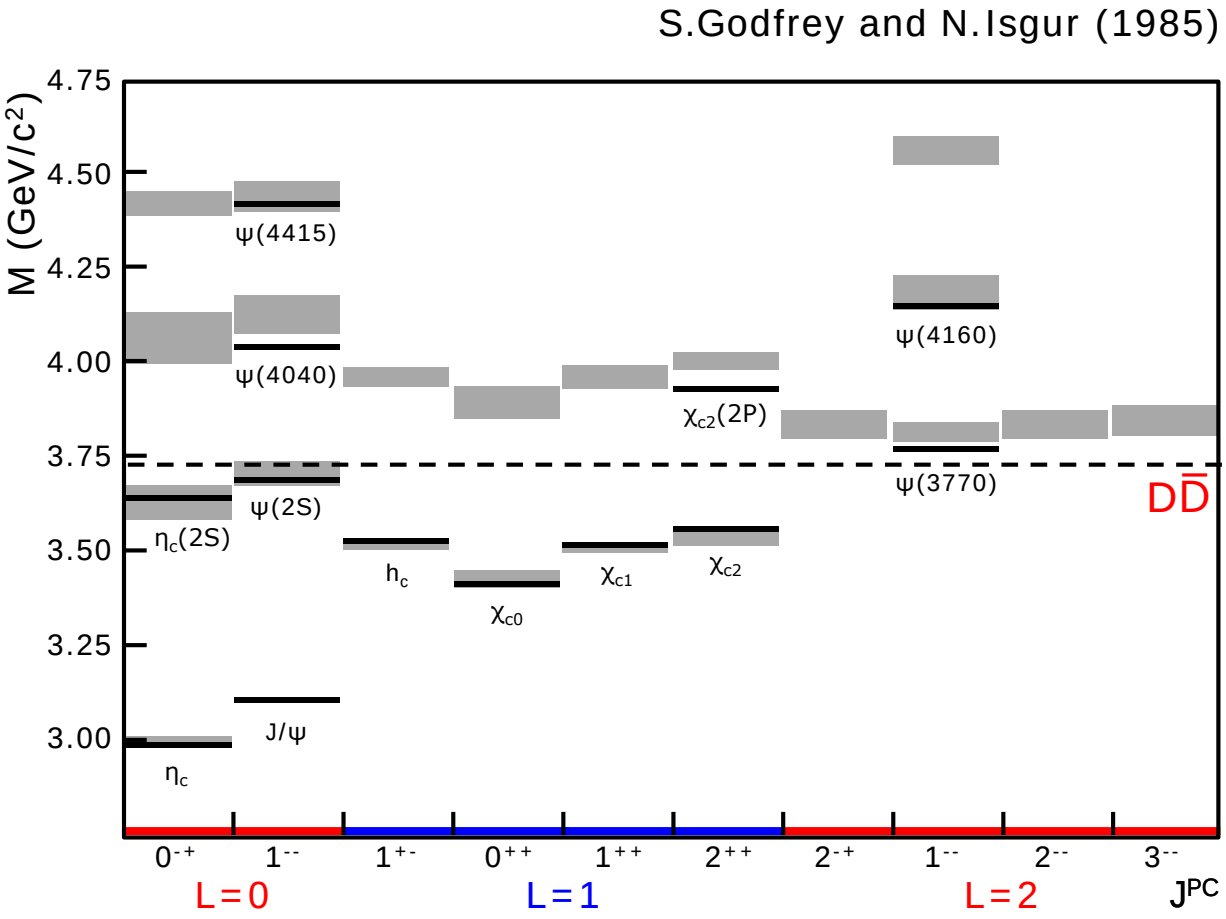
width (~ 1/lifetime)

quantum numbers

decay properties

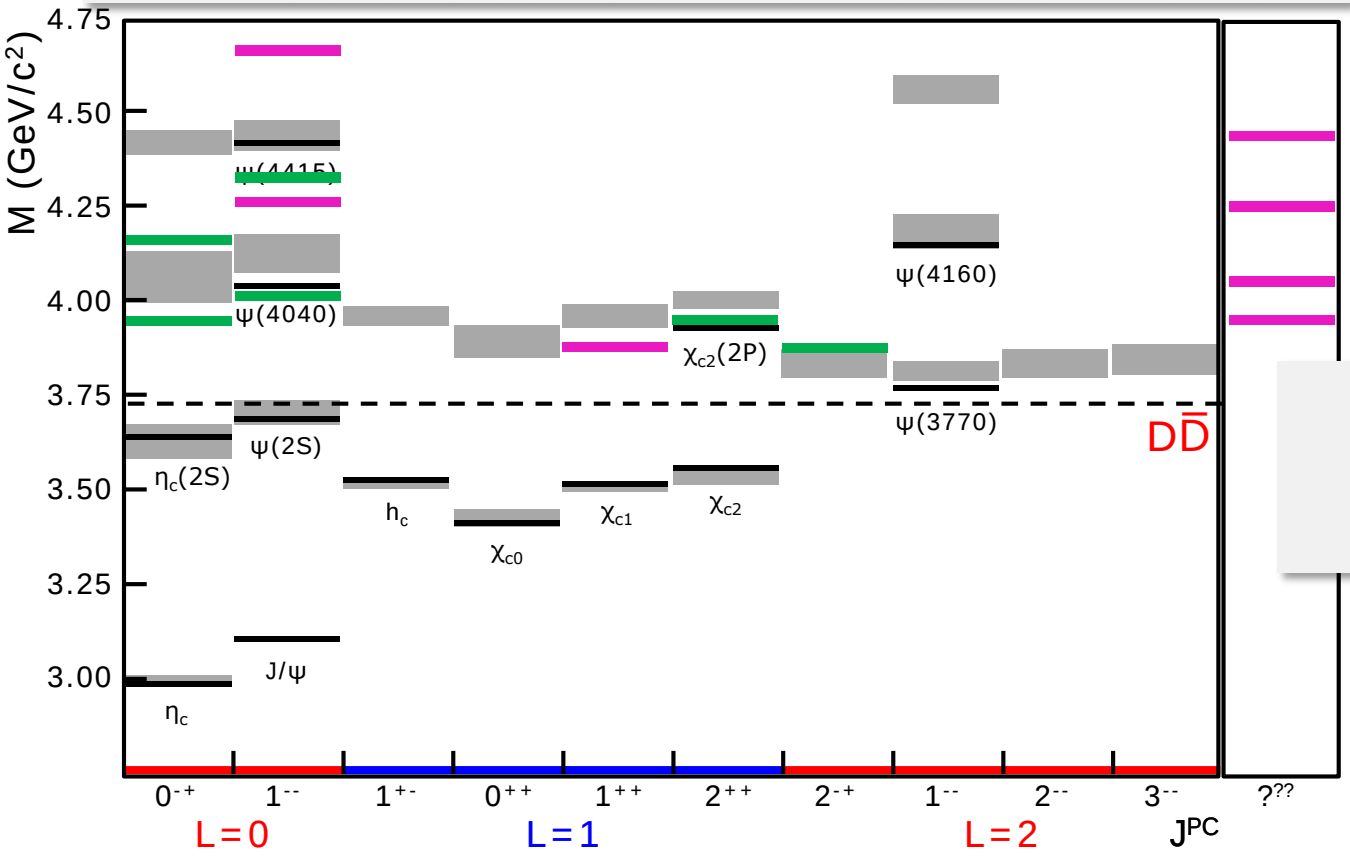


Charmonium Spectrum ($c\bar{c}$-Mesons)

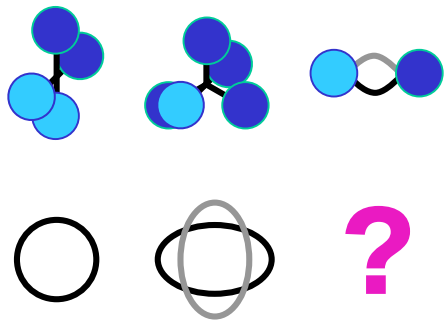


Charmonium Spectrum ($c\bar{c}$-Mesons)

Charmonium and Exotic States with $c\bar{c}$ content



→ X,Y,Z states



Research Topics

BESIII Data Analysis

ComPWA (Common Partial Wave Analysis Framework)

PANDA Luminosity Detector

Generic HV-MAPS Development

Research Topics

BESIII Data Analysis

ComPWA (Common Partial Wave Analysis Framework)

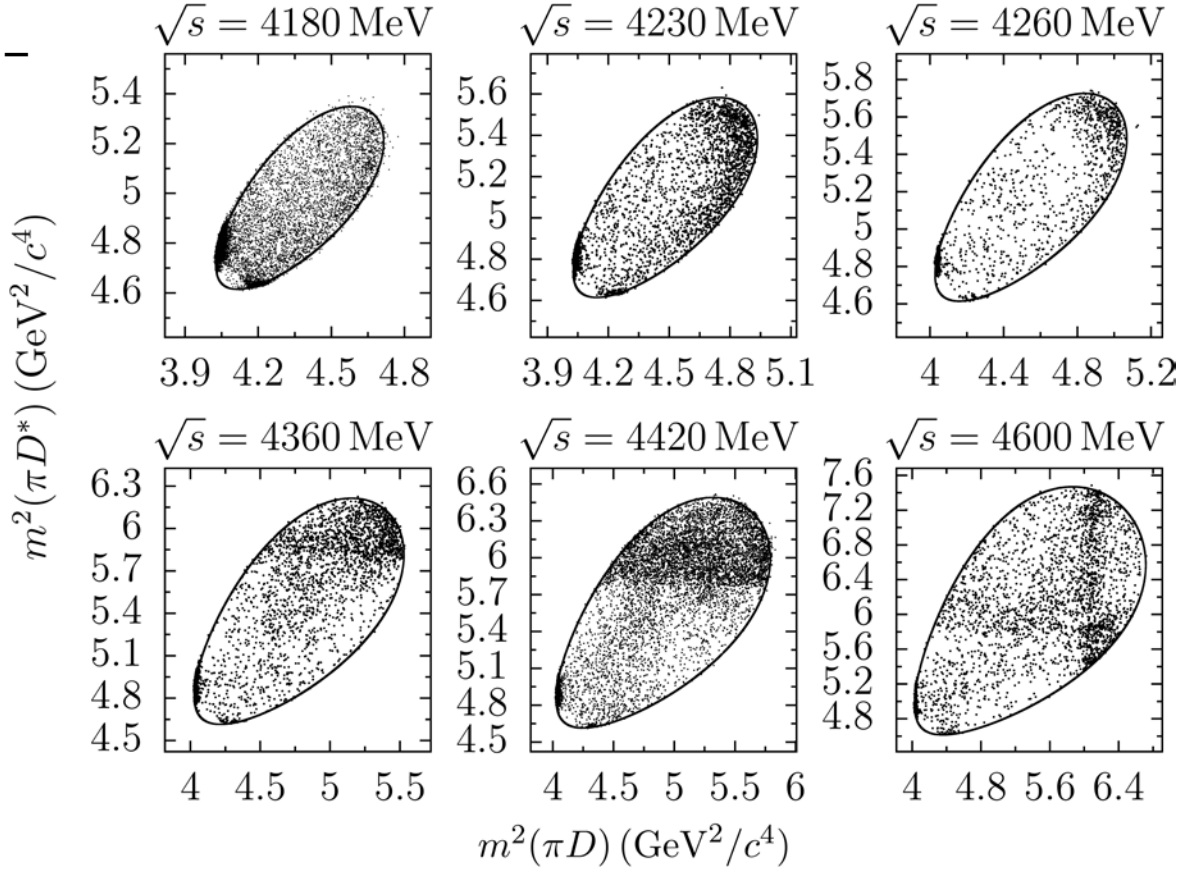
PANDA Luminosity Detector

Generic HV-MAPS Development

Data Analysis at BESIII (Beijing, China)

Discovery Channel of the $Z_c(3885)^+$ at E_{CM} = 4260 GeV

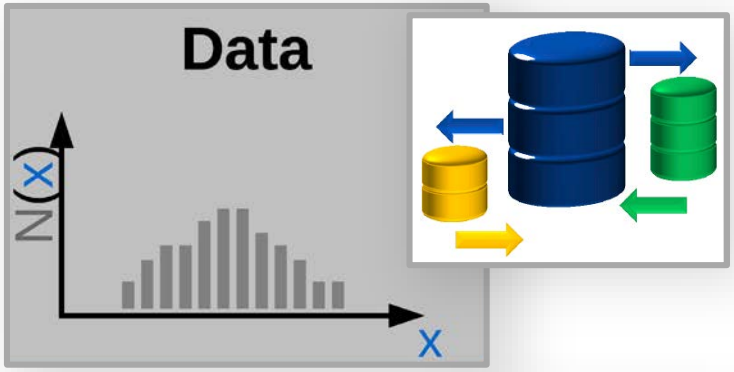
$e^+e^- \rightarrow (D\bar{D}^*)^+\pi^-$

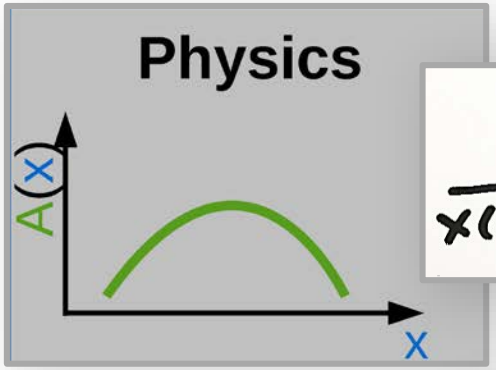


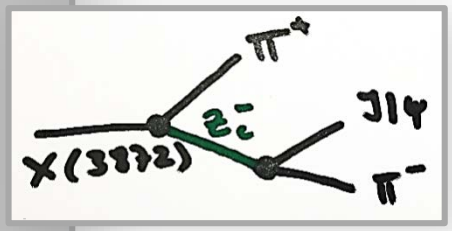
ComPWA

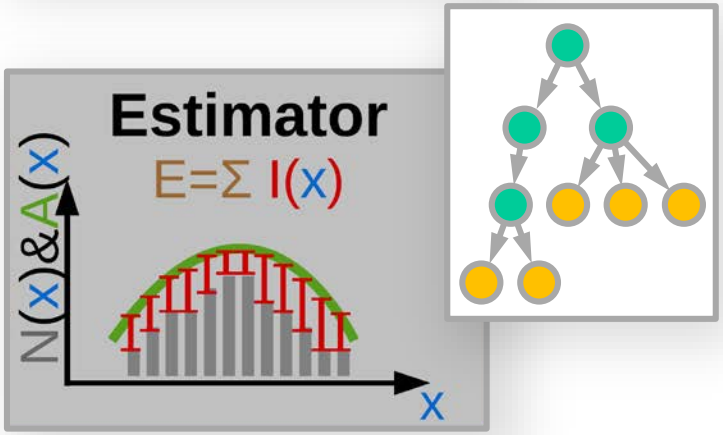
Common Partial Wave Analysis Framework for BESIII, PANDA …

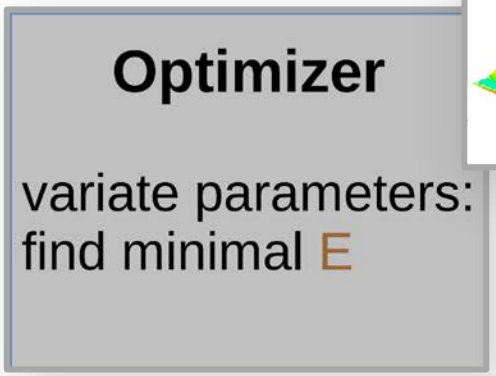
Modular Software Tool

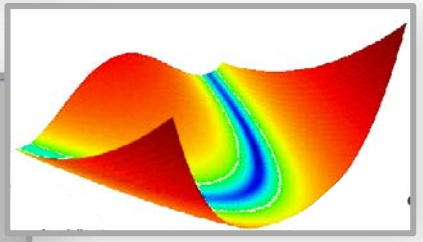












Research Topics

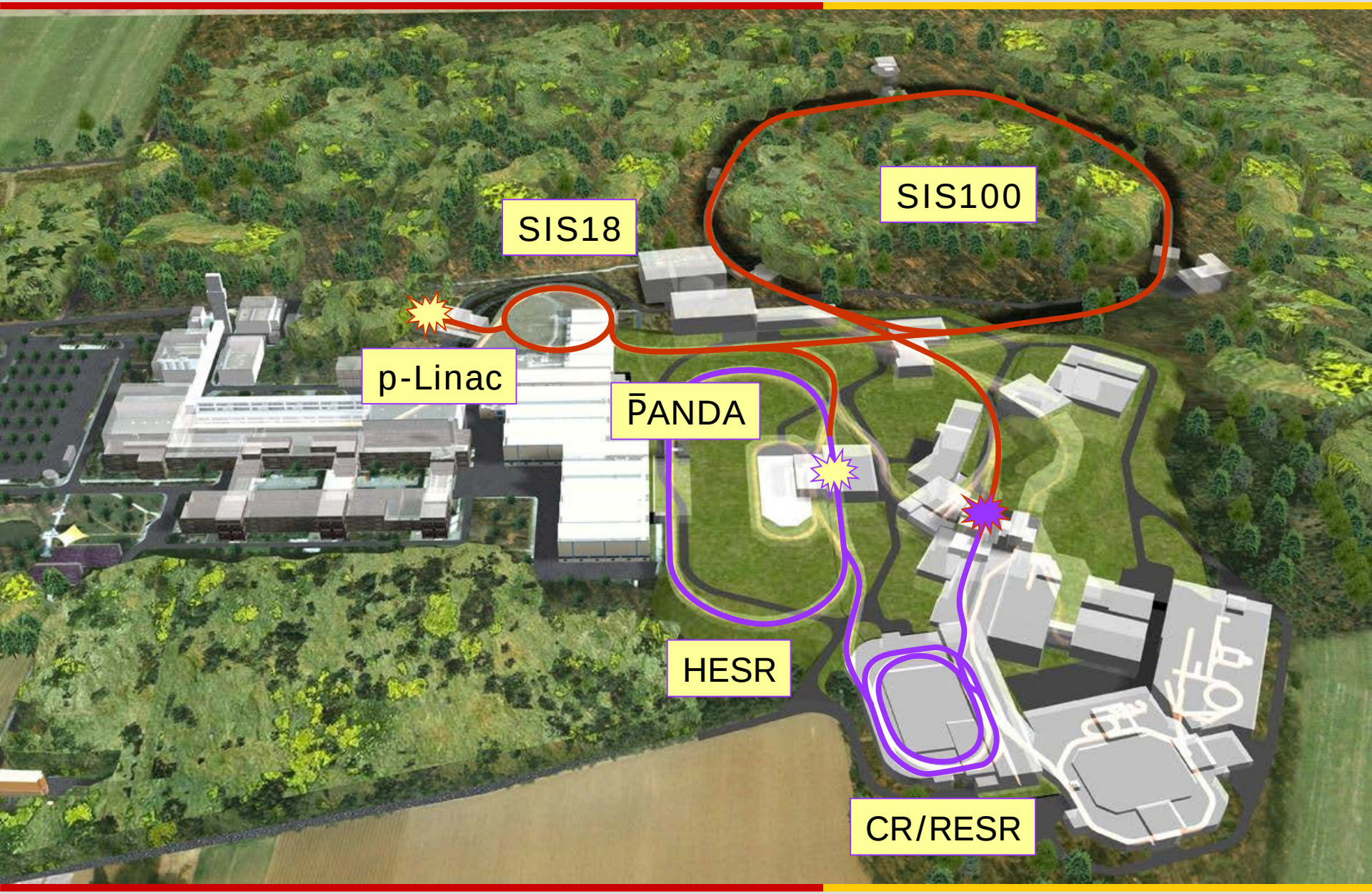
BESIII Data Analysis

ComPWA (Common Partial Wave Analysis Framework)

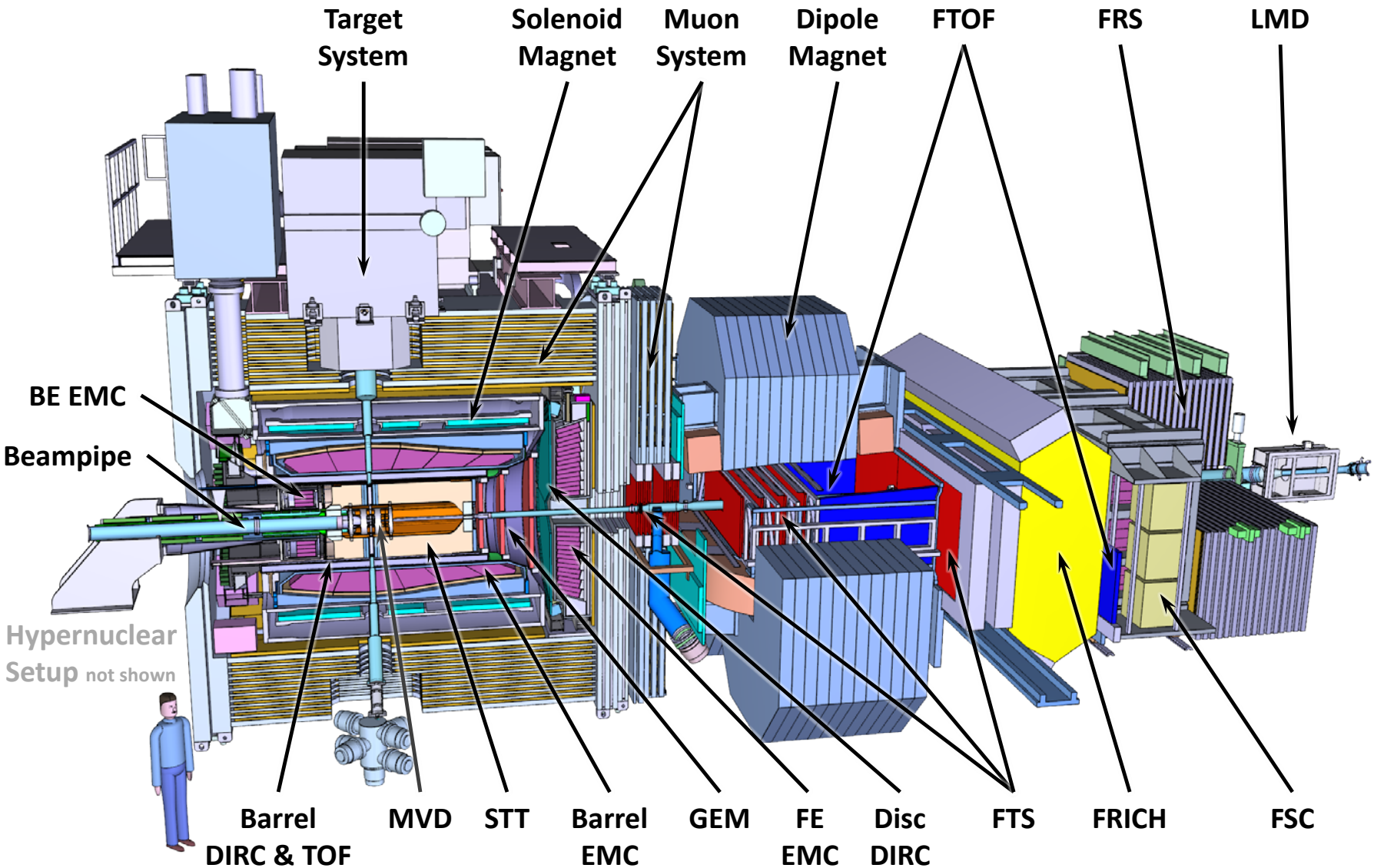
PANDA Luminosity Detector

Generic HV-MAPS Development

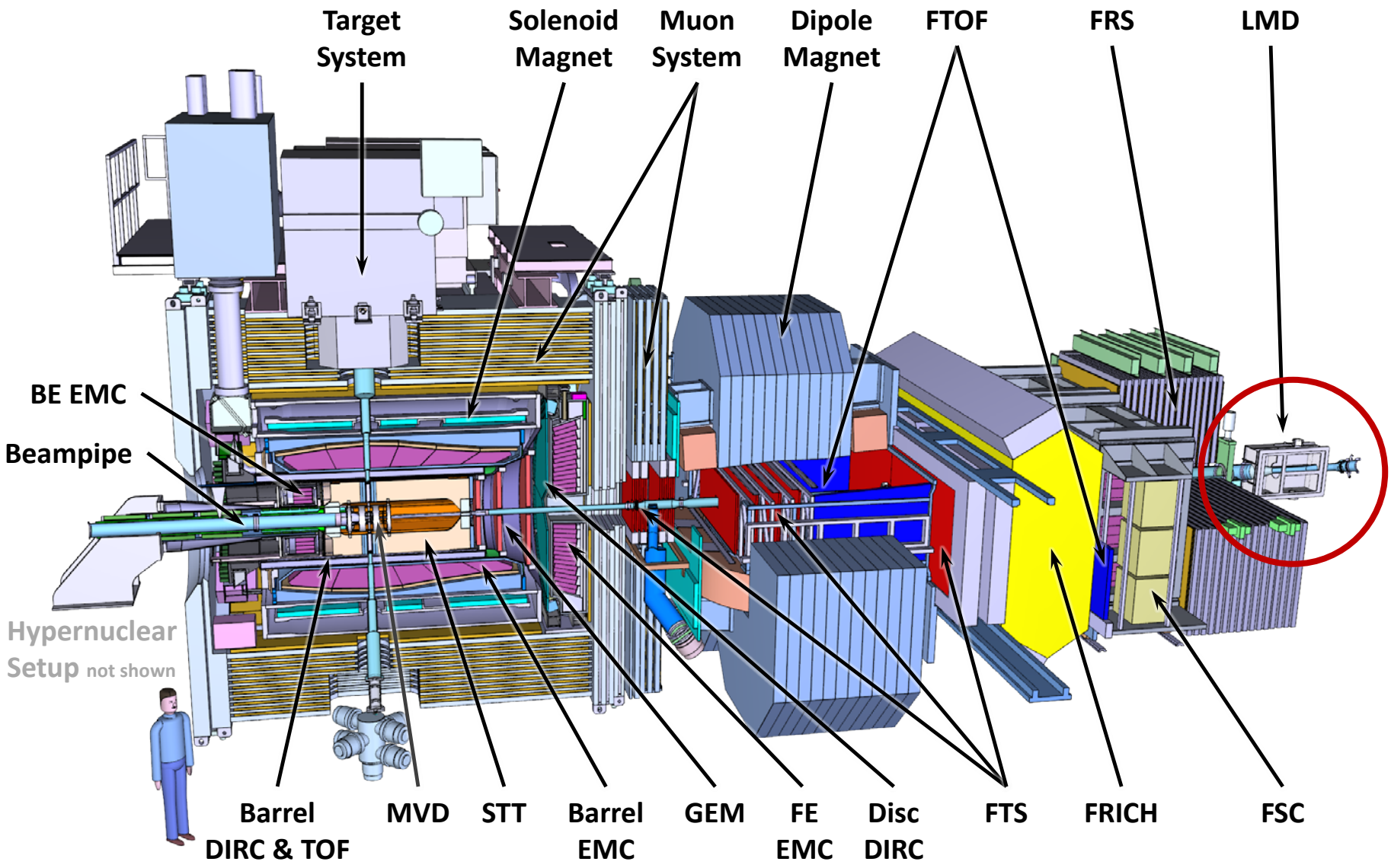
Antiproton Facility PANDA @ FAIR



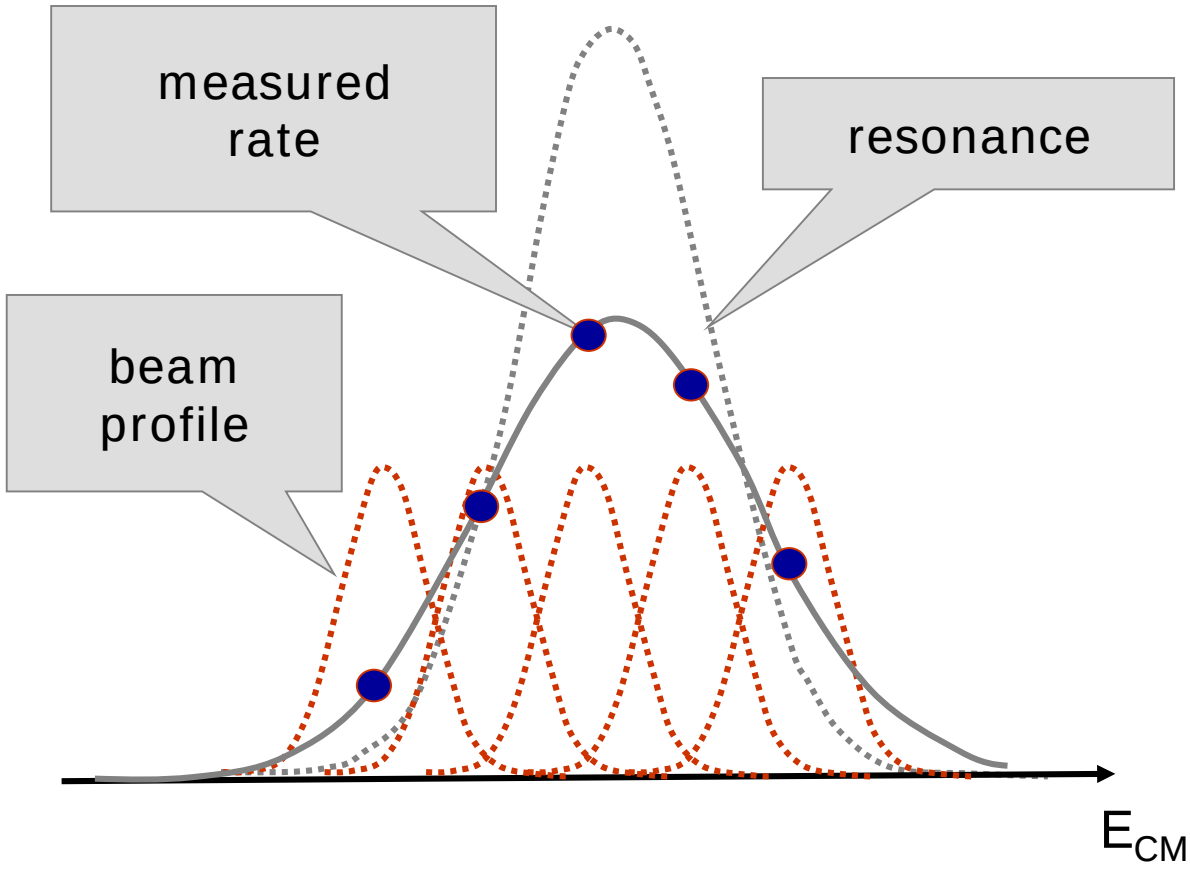
PANDA Detector



PANDA Detector



Energy Scans – Luminosity Determination



→ Relative time-integrated luminosity L, with $N = \sigma L$

→ Momentum resolution of the beam

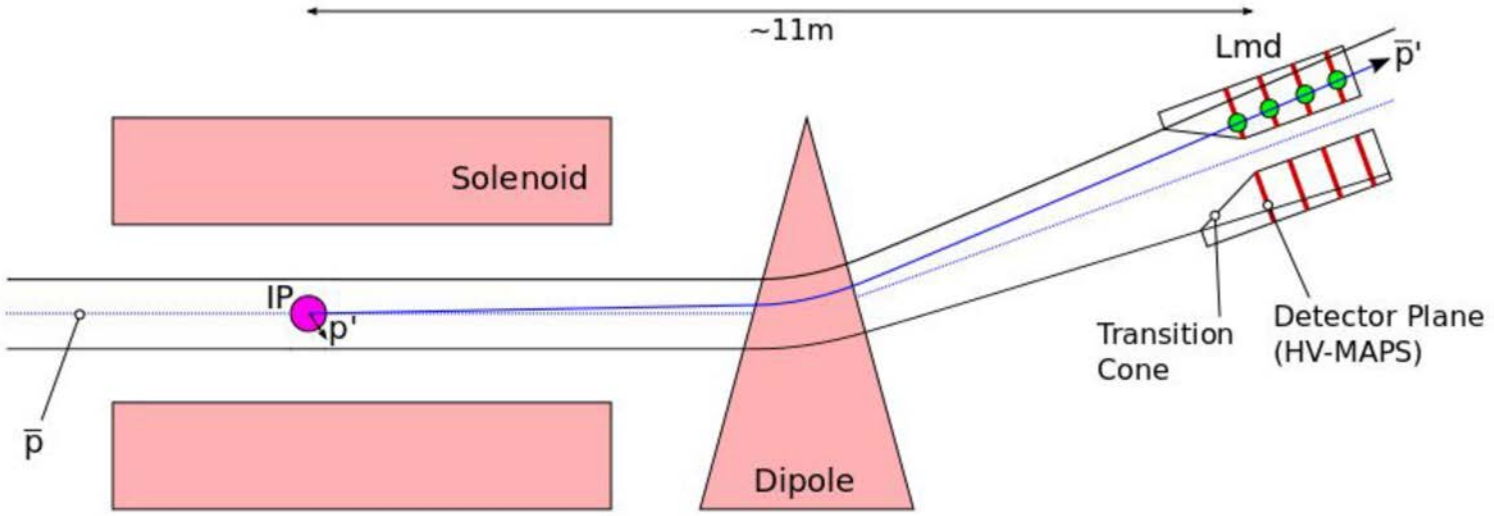
Luminosity Determination Method

Measurement of elastically scattered antiproton at very small scattering angles **with high precision**

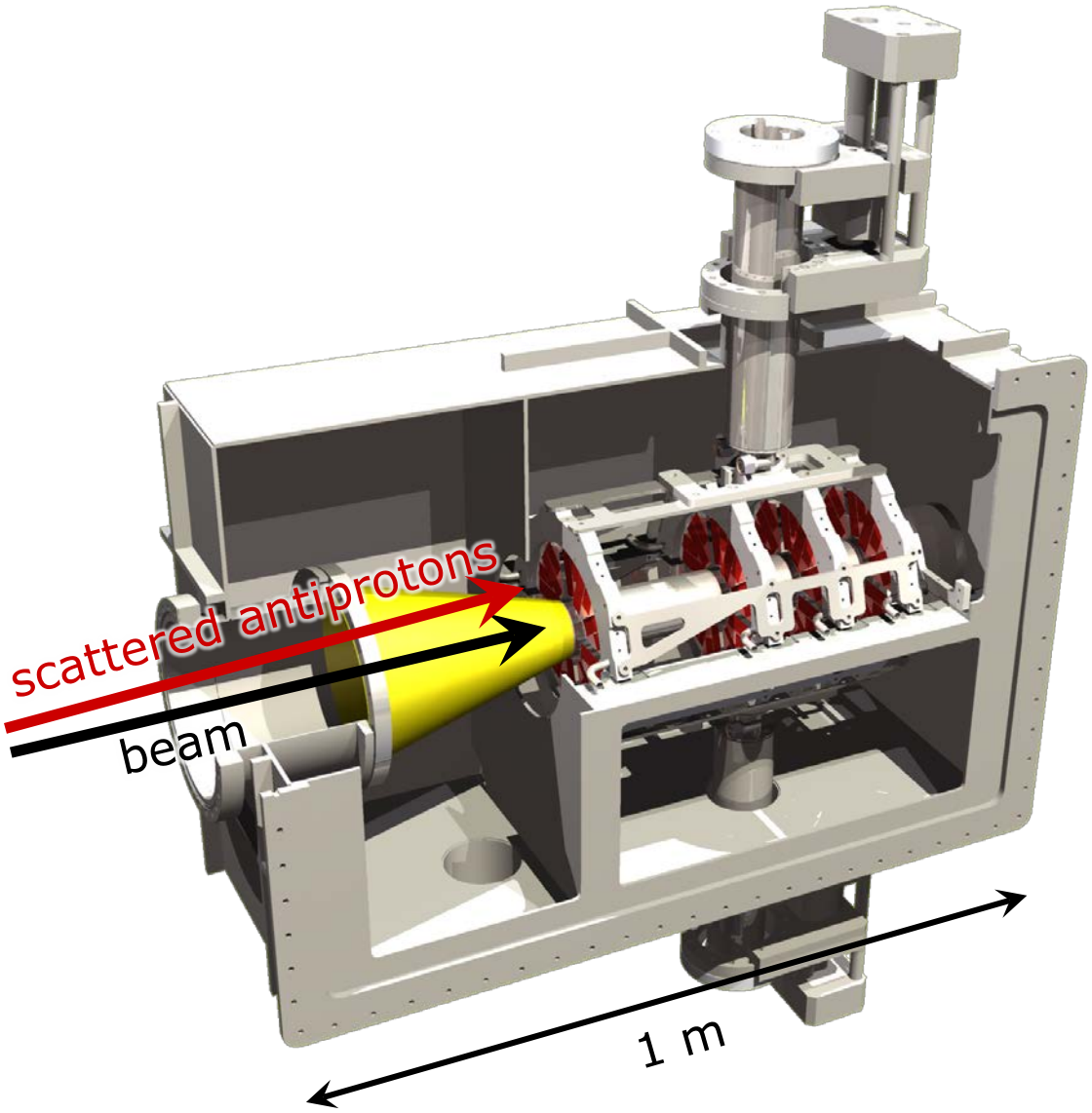
Reconstruction of tracks via 4 detector planes, 11 m behind IP

Backtracking to interaction point through magnetic fields

Normalization to the elastic antiproton proton cross section



Luminosity Detector



Very precise measurement of particle tracks

No Multiple Scattering

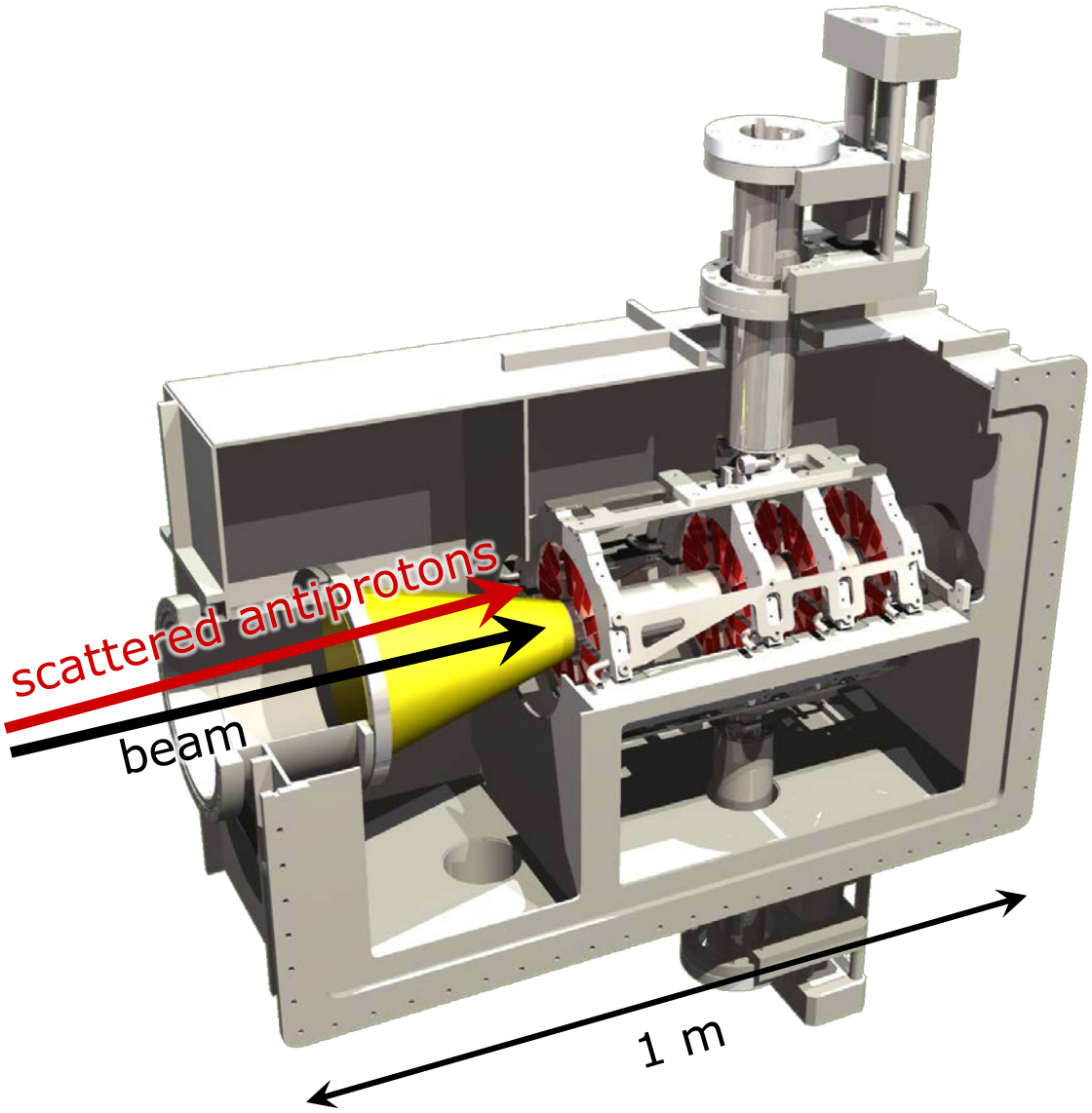
→ Vacuum

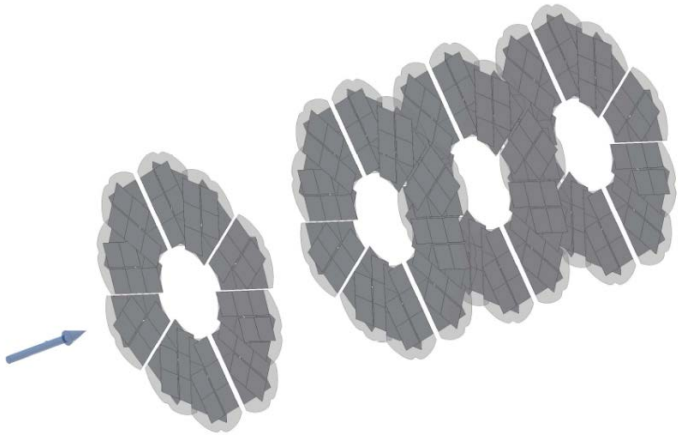
High spatial resolution

→ Silicon Pixel Sensors, HV-MAPS

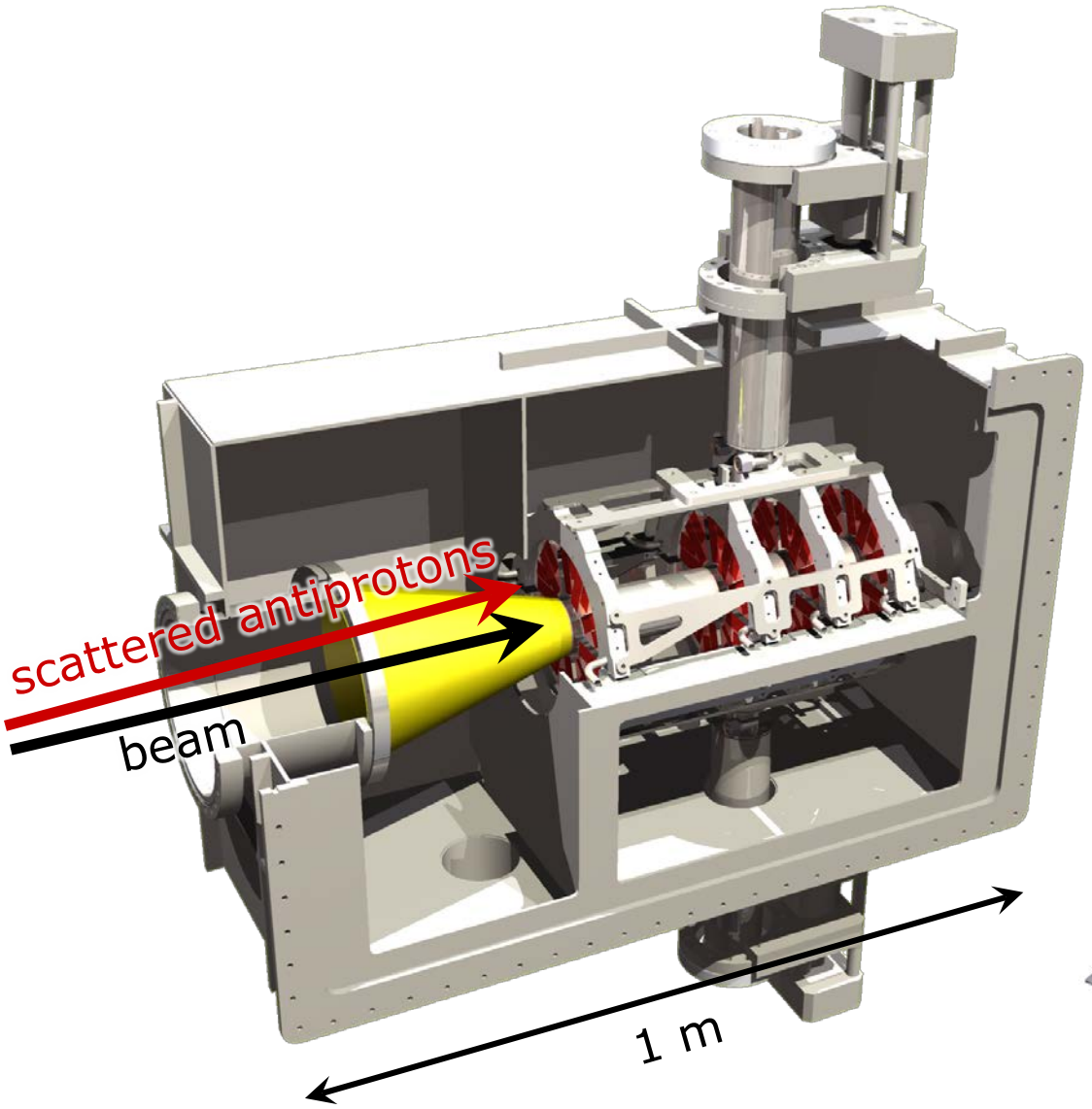
→ Cooling

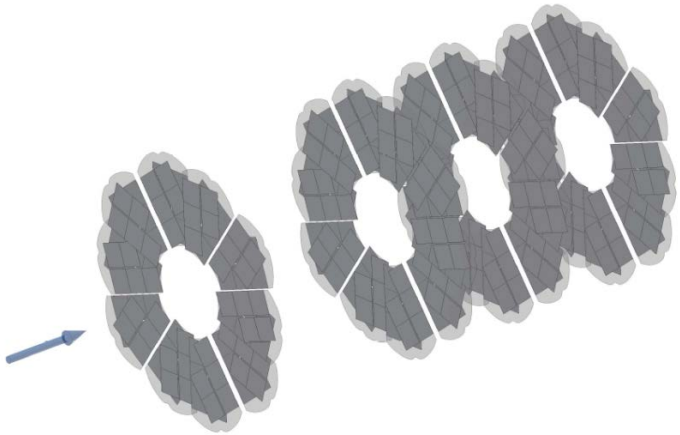
Luminosity Detector

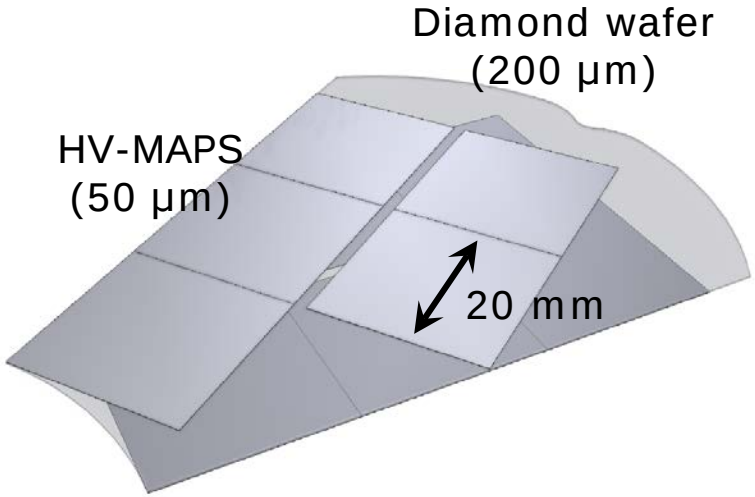




Luminosity Detector







Complete Setup (shared with HIM)

Mechanics and Cooling

Electronics

Characterization/Development of the Sensors

Data Acquisition System with Online Trigger/Monitoring based on FPGA and GPU

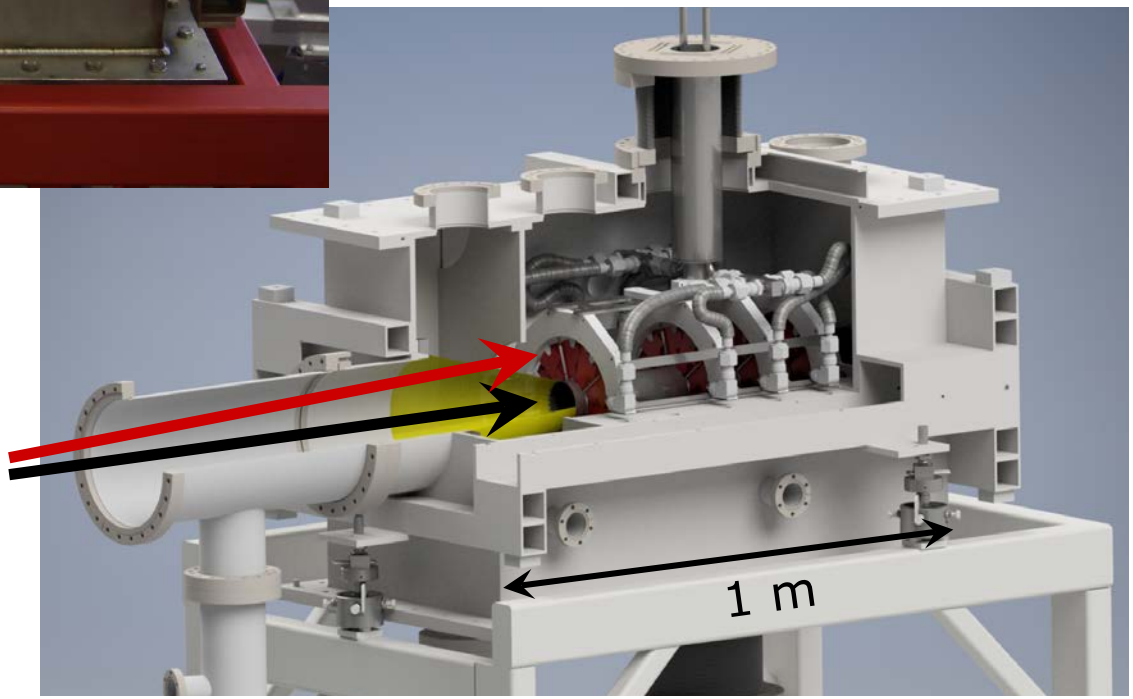
Software Development $\rightarrow$ Determination of the Luminosity

Detector Control System

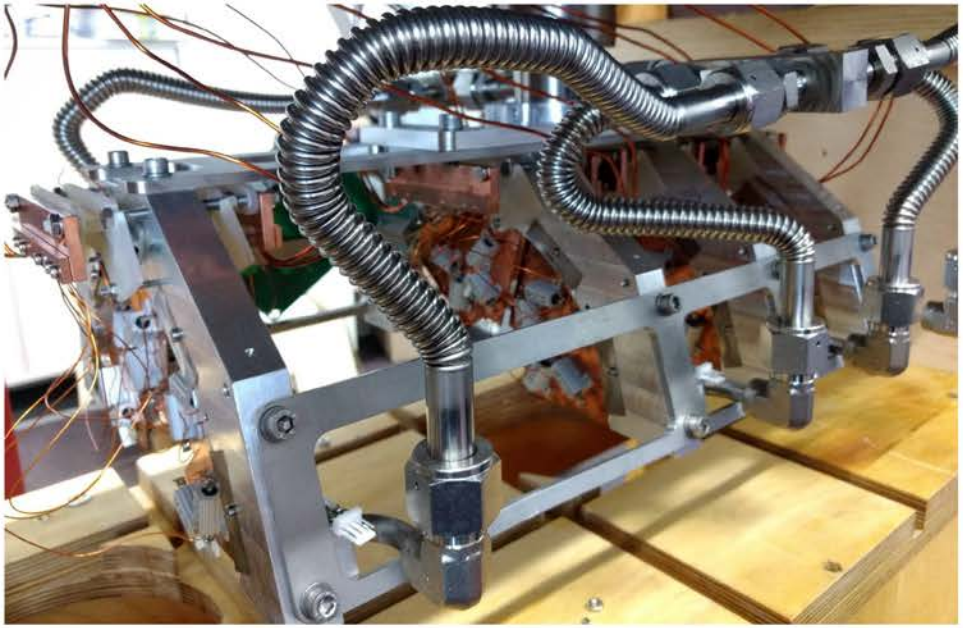
Measurement of the elastic cross section with high precision (< 1%) with KOALA@HESR

$\rightarrow$ KOALA@COSY

Prototype vacuum box



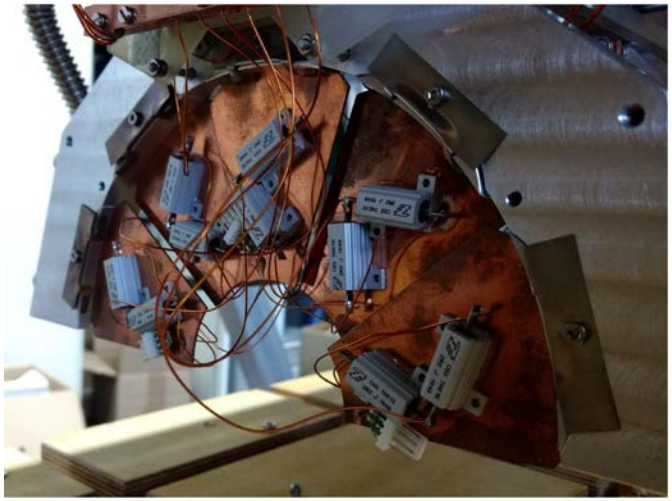
Cooling Test



Complete half detector equipped

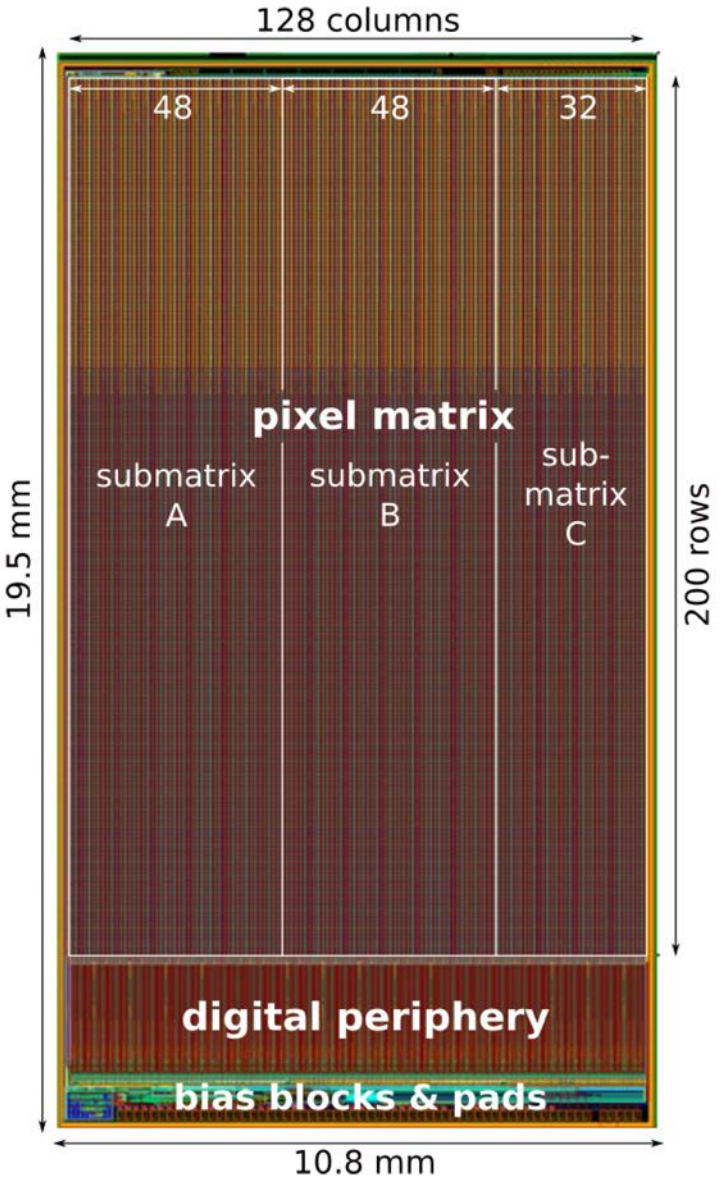
Cooling liquid: Ethanol at -20°C

Heat load: 25 W per module



Test is running

MuPix8 – First large-sized sensor



Active area 16.2 mm × 10.2 mm

Production on **substrates** with different resistivities

Separation of **pixel matrix**

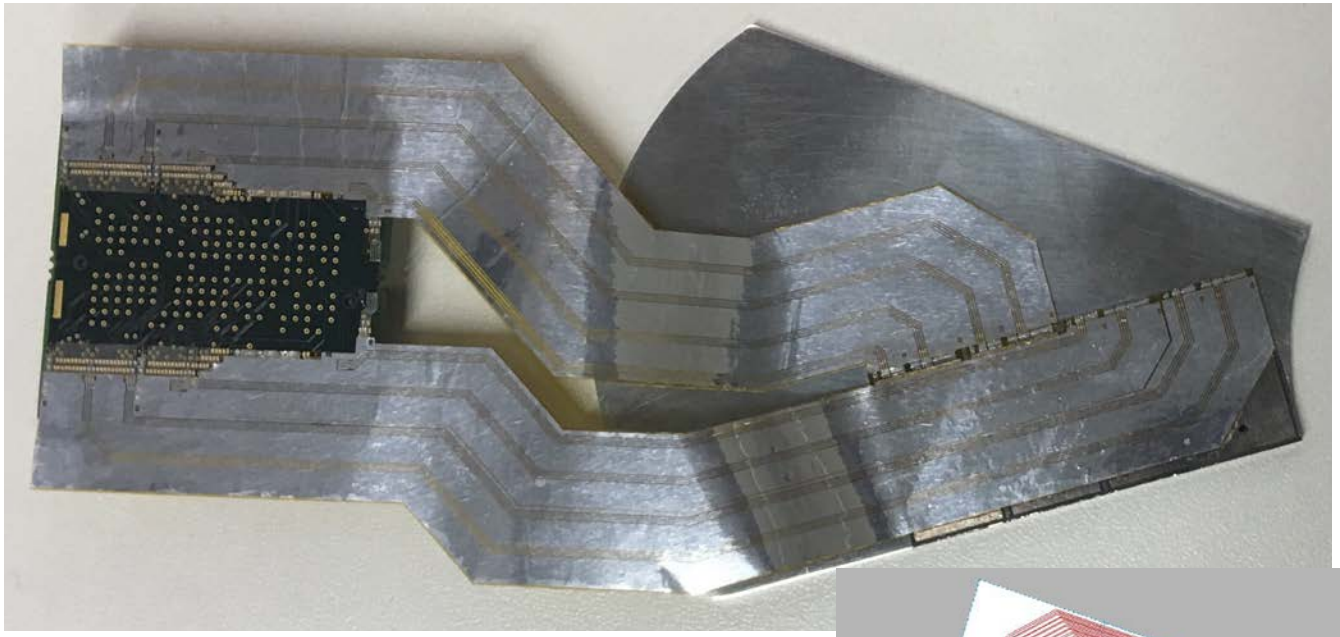
Voltage or current mode signal transmission

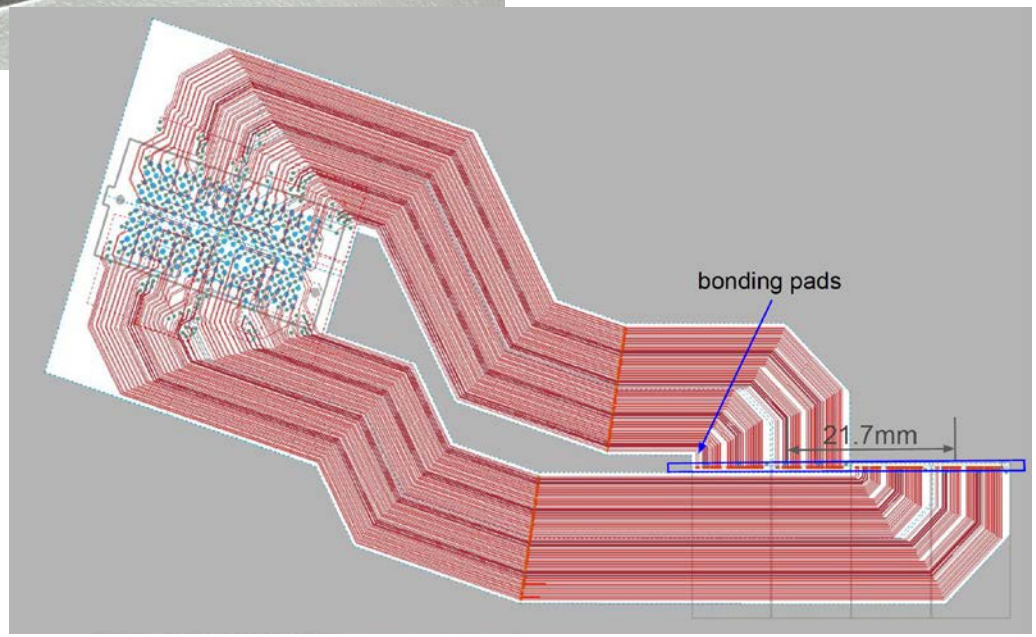
Amplifier output available

Expected radiation hardness

5 x 10^{15} n_{eq}/cm^2

Alu Flex Cables

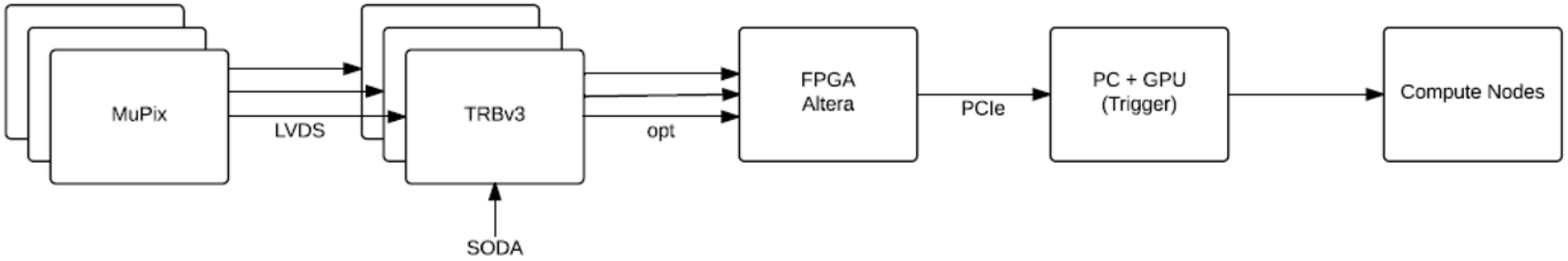




Testing setup on the way
up to 1.25 Gbit/s

DAQ – Trigger

Data Acquisition for Luminosity Determination

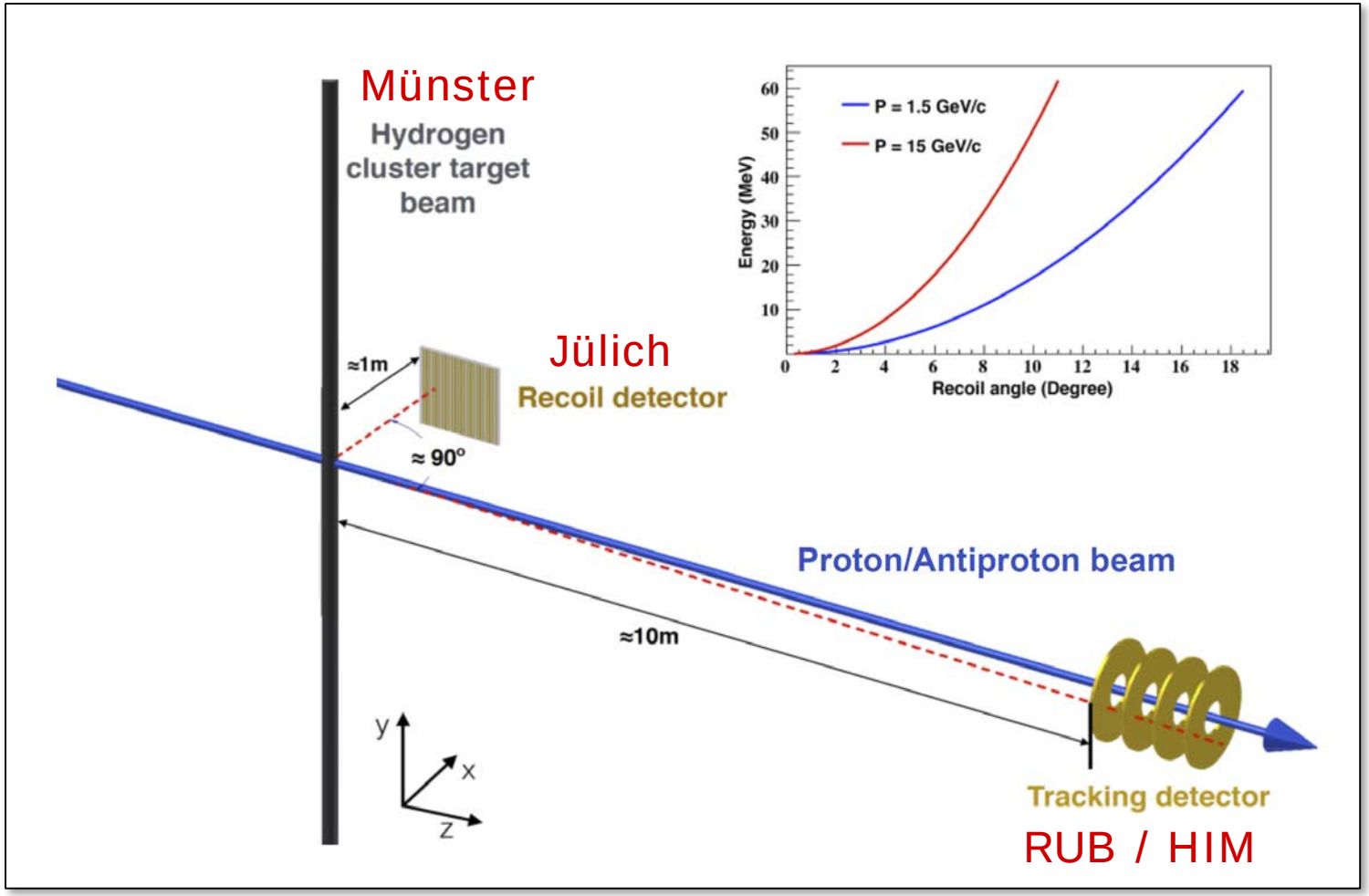


Data rate too large to store every single hit

- Online track reconstruction
- Only hits of tracks are stored
- Pre-scaling possible if necessary
- Offline only hits already assigned to tracks available

KOALA@COSY

planned for summer 2020



Huagen Xu

Measurement of dσ/dt of elastic **antiproton-proton** scattering with high precision by measuring **both tracks**

Research Topics

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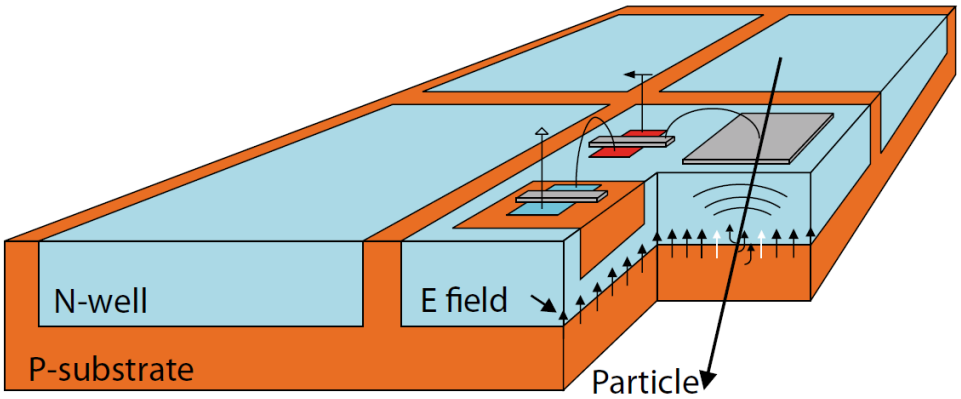
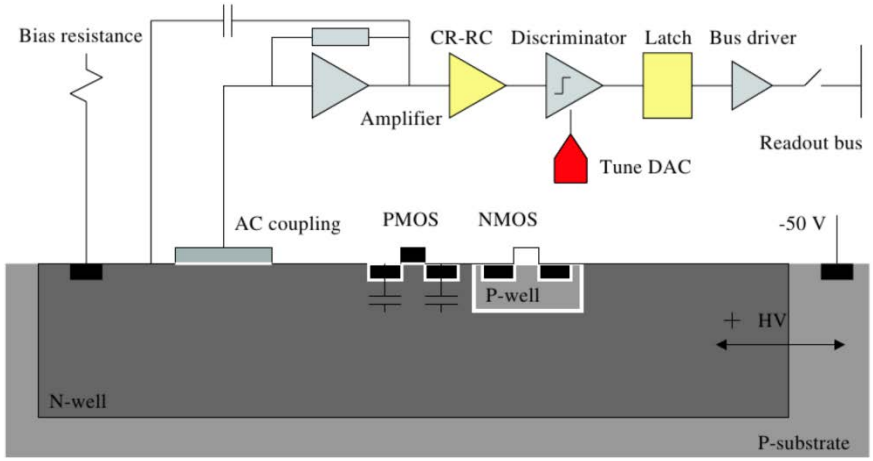
Generic HV-MAPS Development

High Voltage Monolithic Active Pixel Sensors

HV-MAPS





180 nm CMOS process

HV for fast charge collection

No FEE, digital part on chip

Readout for each pixel separately

Zero suppression

Readout frequency: 20 - 40 MHz

Self-triggering

Radiation hard

Signal length ~ 1 µs

Pixel size 80 µm × 80 µm

Sensor size 2 cm × 2 cm

Thickness 50 µm