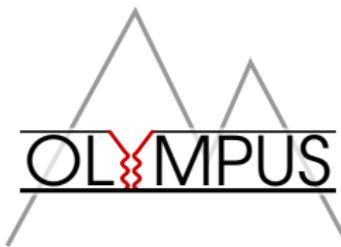


# The OLYMPUS experiment

Jan C. Bernauer



Radiative Corrections in Annihilation and Scattering  
Experiments  
Orsay 10/7/2013

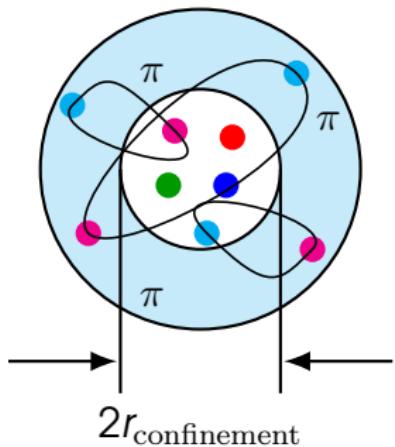


# Overview

- What
- Why
- Who
- Where
- How
- When

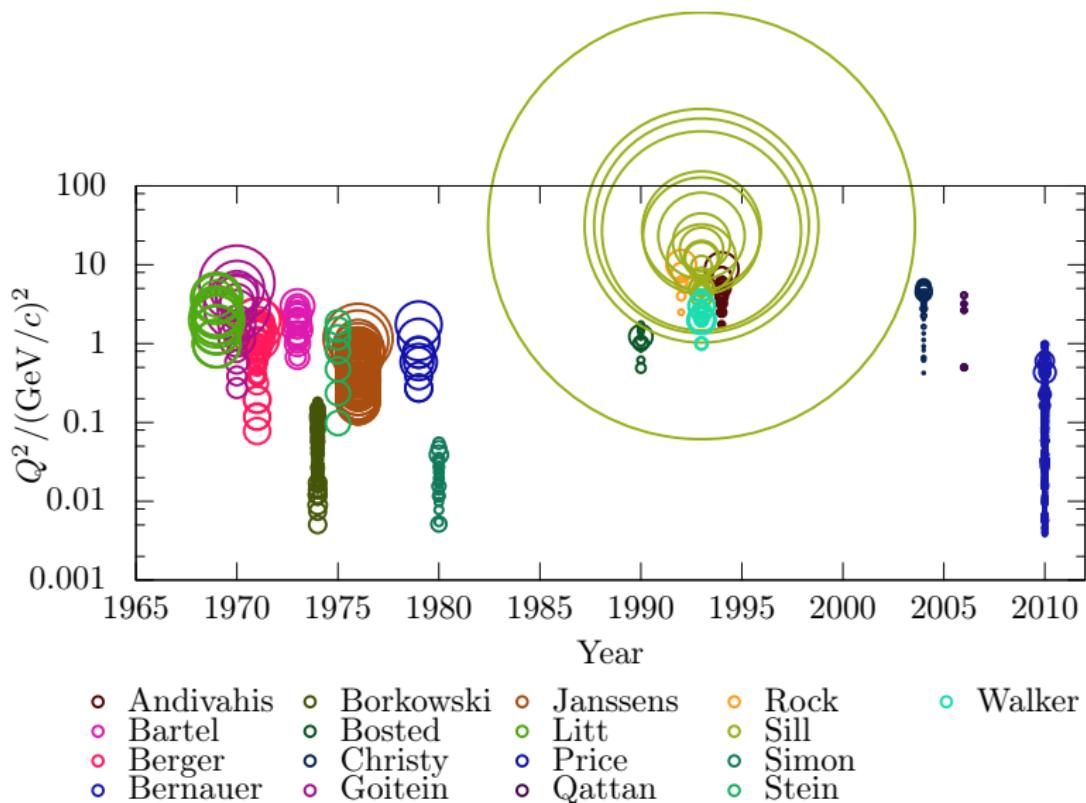
*I keep six honest serving-men (They taught me all I knew);  
Their names are What and Why and  
When And How and Where and Who.*  
Rudyard Kipling

# What is a proton?

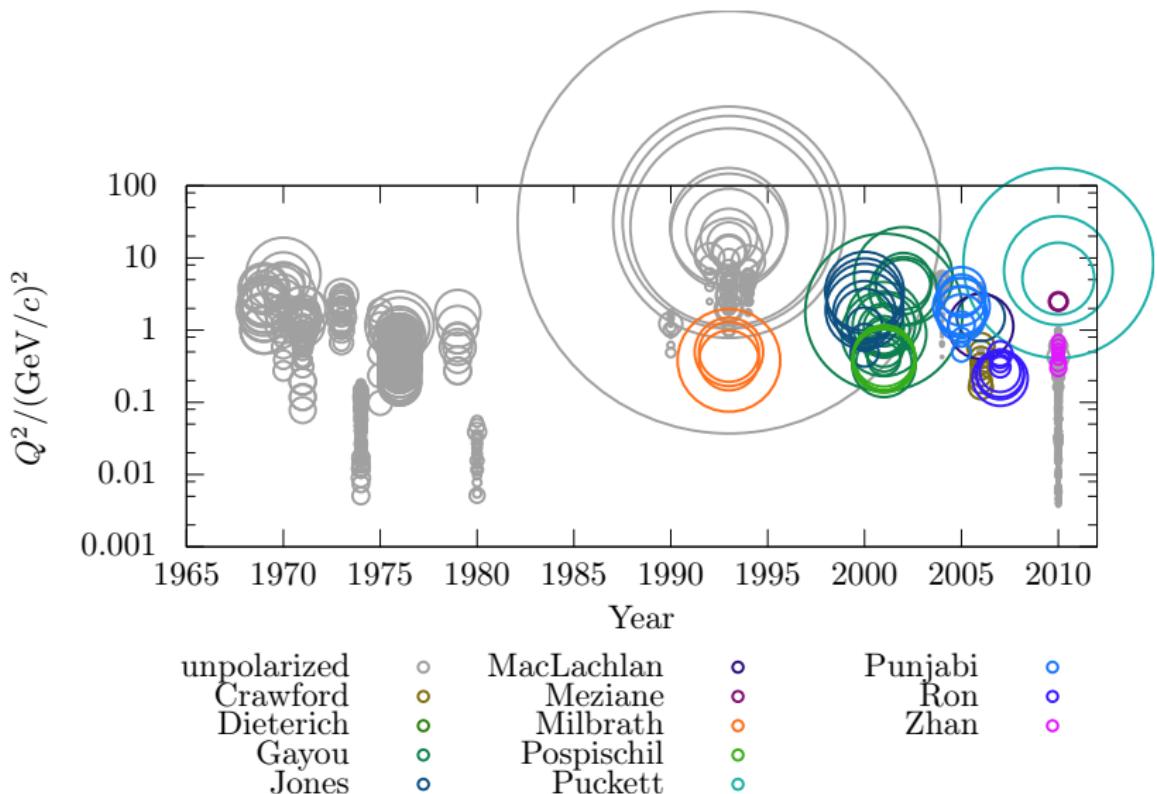


- How does it work?
- Distribution of charge and magnetization?
- Measure form factors!

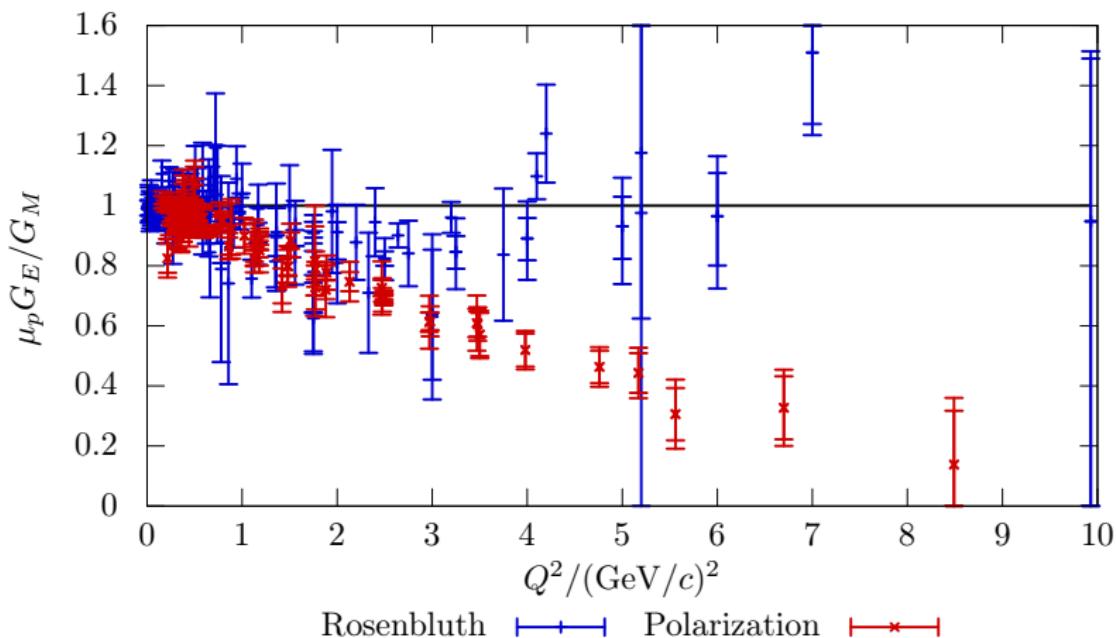
# Unpolarized: Rosenbluth



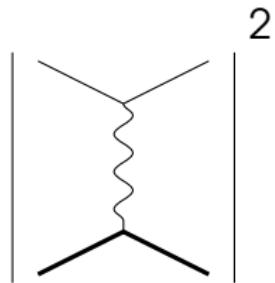
# Polarized: Ratio



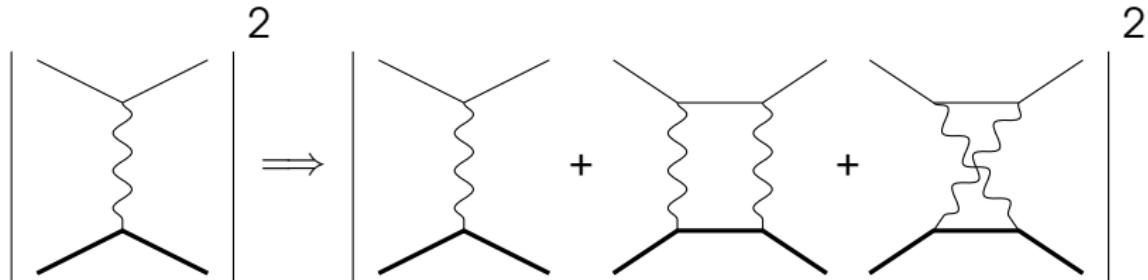
# Ratio: Difference!



# Most likely solution: Two Photon Exchange



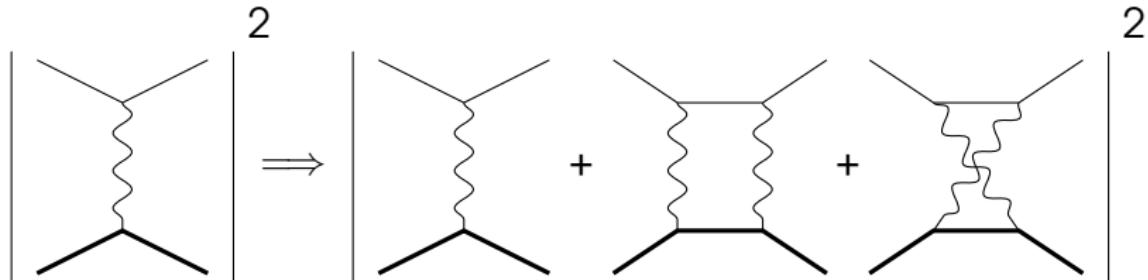
# Most likely solution: Two Photon Exchange



## Two-Photon-Exchange

- Not in standard radiative corrections
- Off-shell proton!
- How to handle high momenta in loop?

# Most likely solution: Two Photon Exchange



## Two-Photon-Exchange

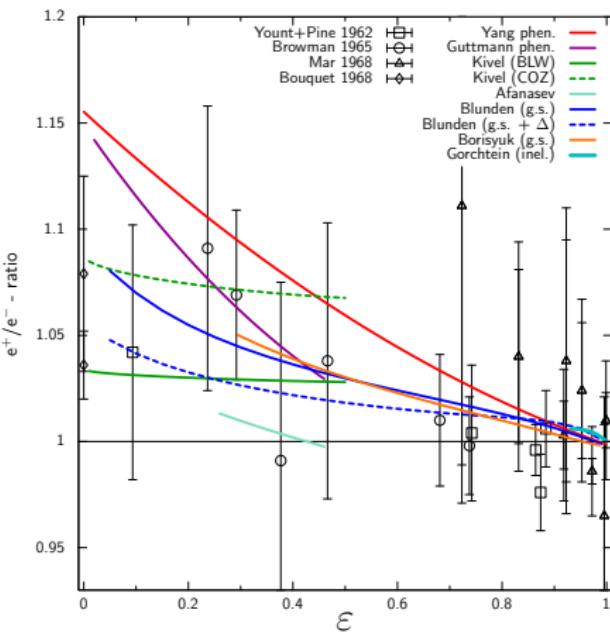
- Not in standard radiative corrections
- Off-shell proton!
- How to handle high momenta in loop?

## Measurement

- Rosenbluth/polarized reconciled?
- How to treat the hadron line?

# Measure TPE

- Interference term changes sign with lepton sign!
- Measured in the 1960s
- Not much data
- A lot of predictions!



# Three modern experiments

## Novosibirsk/VEPP-3

- Analysis in progress
- 1.6/1 GeV beam
- No magnetic field

## CLAS/Jlab

- Analysis in progress
- $e^-$  to  $\gamma$  to  $e^{+/-}$ -beam

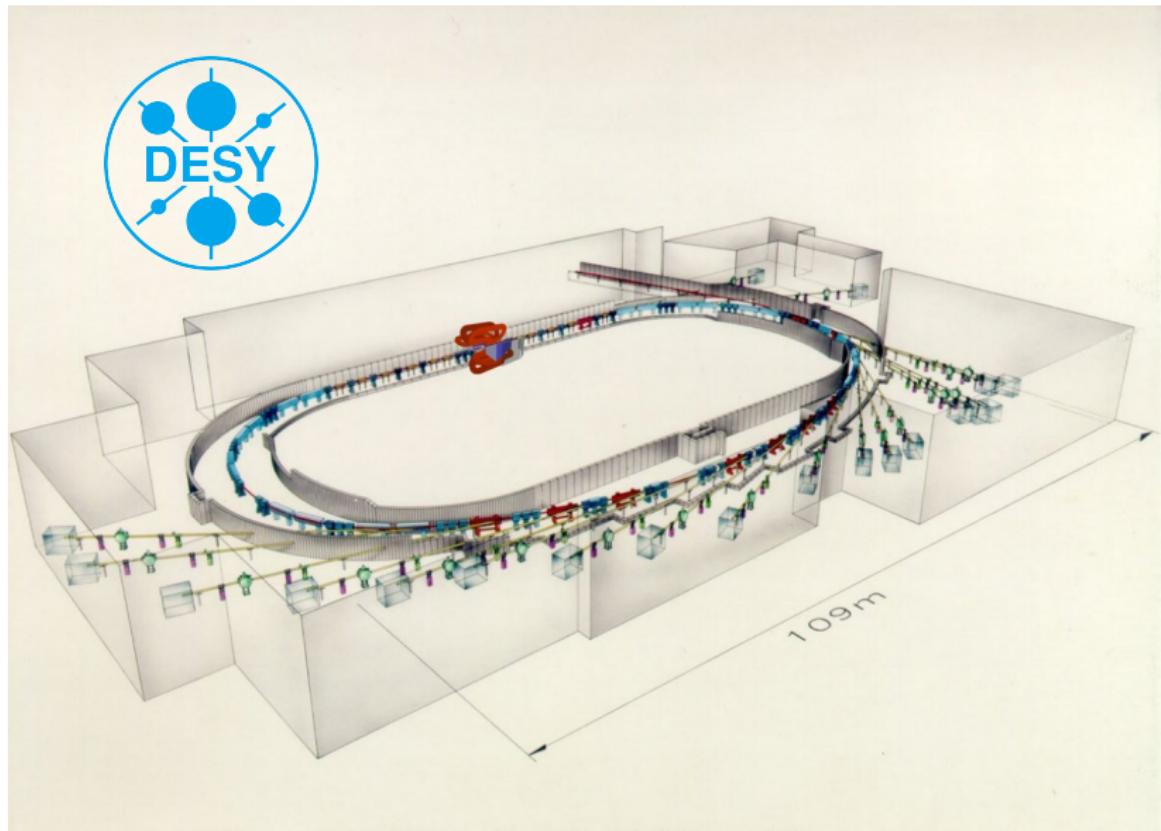


- Doris/DESY
- 2 GeV beam
- data taking finished 01/2013

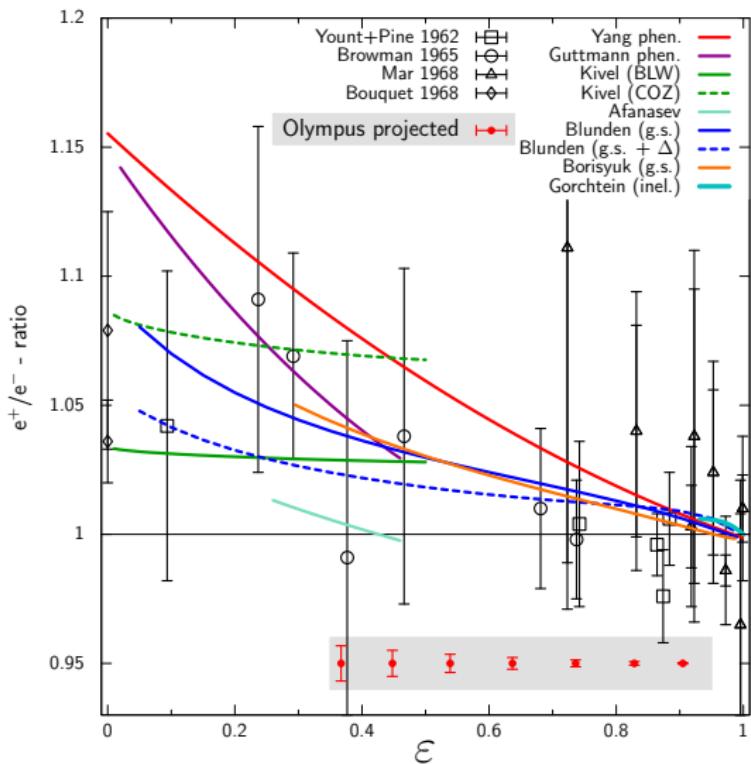
# The OLYMPUS collaboration

- Arizona State University, USA
- DESY, Hamburg, Germany
- Hampton University, USA
- INFN, Bari, Italy
- INFN, Ferrara, Italy
- INFN, Rome, Italy
- MIT Laboratory for Nuclear Science, Cambridge, USA
- Petersburg Nuclear Physics Institute, St. Petersburg, Russia
- University of Bonn, Bonn, Germany
- University of Glasgow, United Kingdom
- University of Mainz, Mainz, Germany
- University of New Hampshire, USA
- Yerevan Physics Institute, Armenia

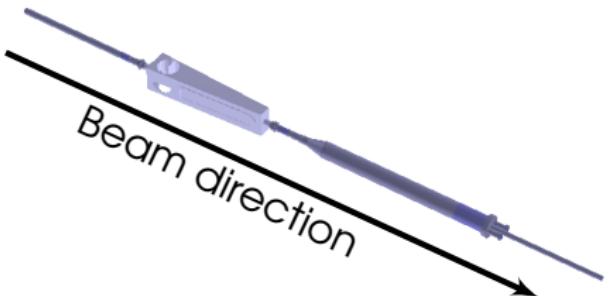
# At DESY: DORIS



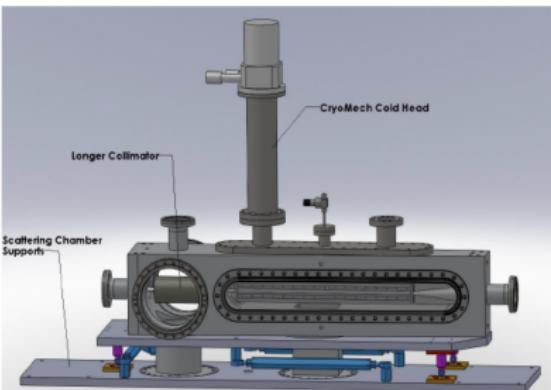
# Projected performance



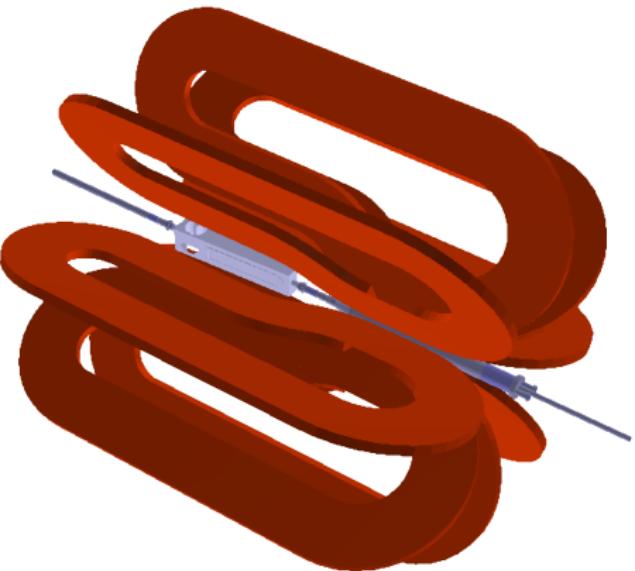
# Target / Vacuum



- Open cell design
- Cryogenic
- Target density:  $3 \cdot 10^{15} \text{ 1/cm}^2$
- Multi-stage pump system

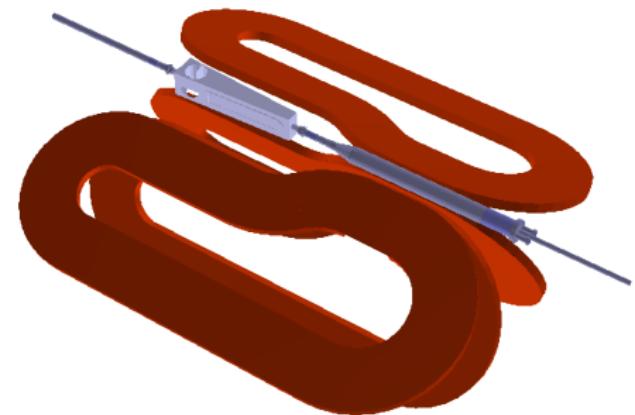


# Toroid



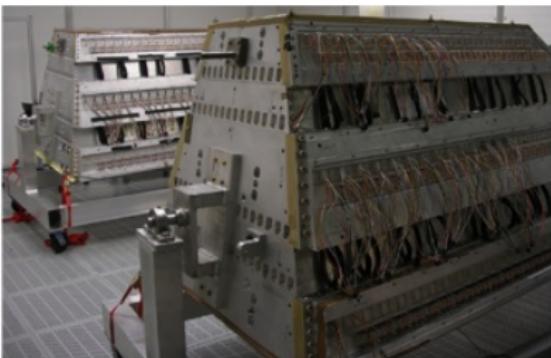
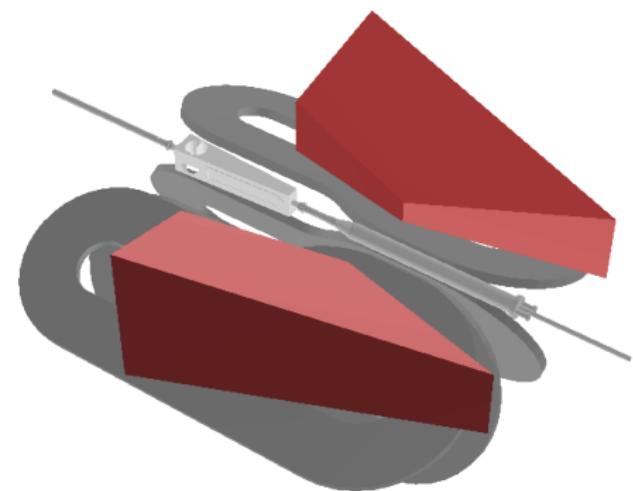
- From BLAST
- $\pm 5000 \text{ A} = 75\% \text{ of max.}$
- $\Rightarrow$  Peak field: 2.8 kG
- 8 coils

# Toroid



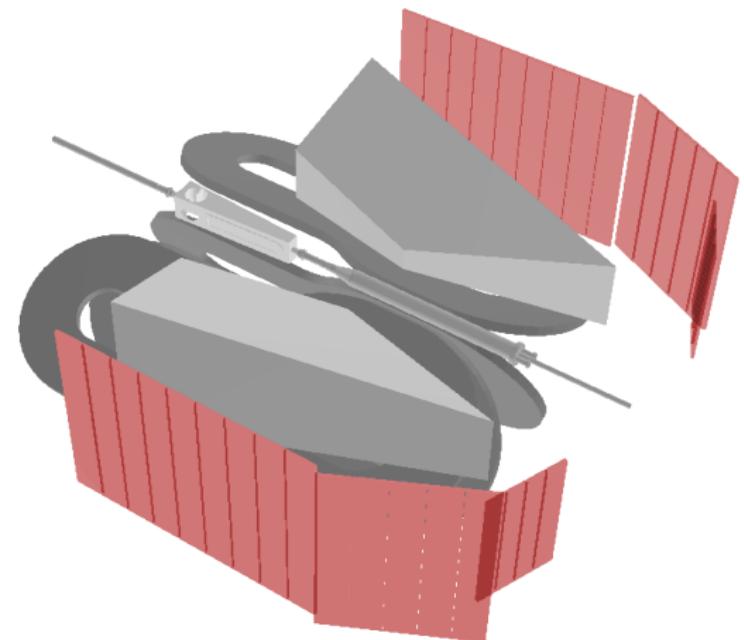
- From BLAST
- $\pm 5000 \text{ A} = 75\% \text{ of max.}$
- $\Rightarrow$  Peak field: 2.8 kG
- 8 coils
- 4 shown

# Wire chamber



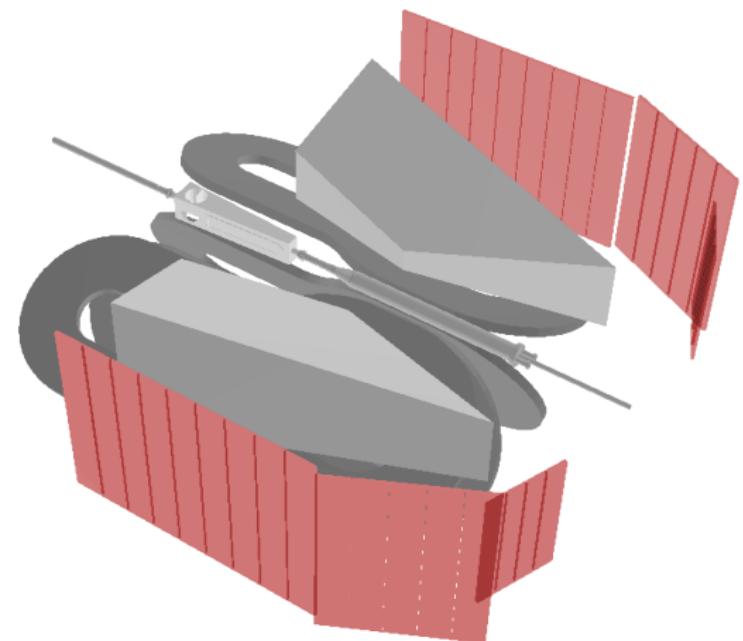
- From BLAST
- HDC design, 3 signal wires
- completely rewired
- 3 chambers, 2 planes per sector
- $10^\circ$  stereo angle

# Time Of Flight



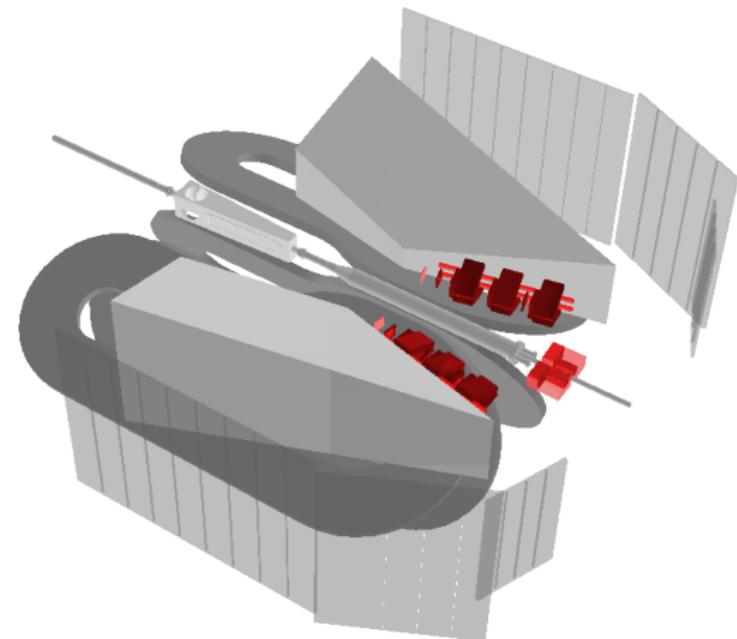
- From BLAST
- Rewrapped, tested
- Trigger
  - Top/bottom coinc.
  - kinematically constrained

# Time Of Flight



- From BLAST
- Rewrapped, tested
- Trigger
  - Top/bottom coinc.
  - kinematically constrained
  - + 2nd level WC

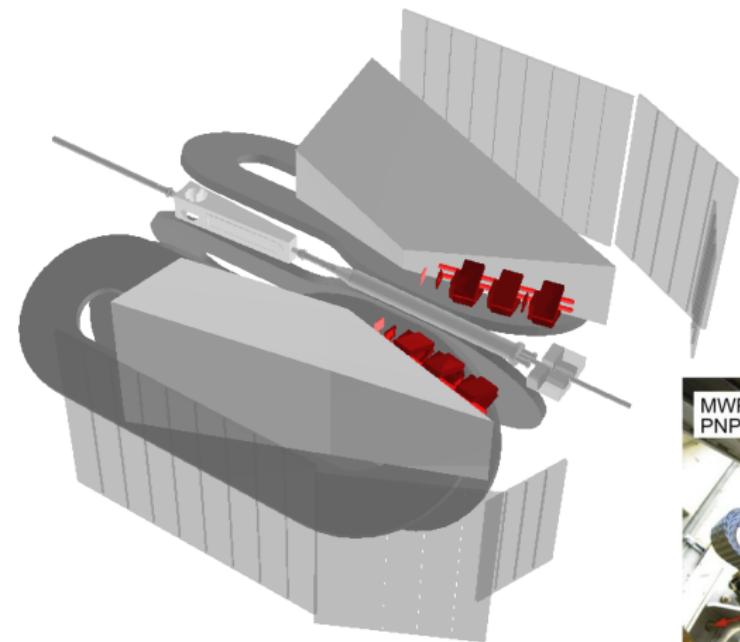
# Luminosity



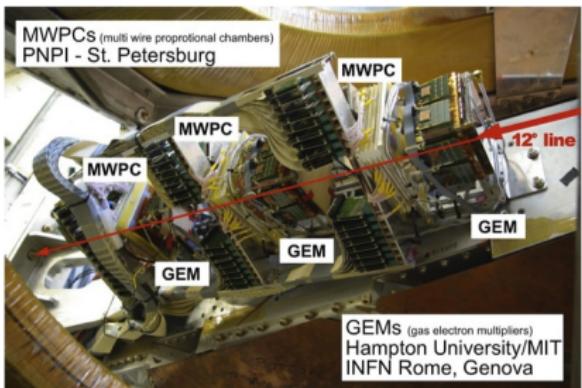
Tight control crucial!  
Redundant systems:

- $12^\circ$ -detector
- Symmetric  
Møller/Bhabha

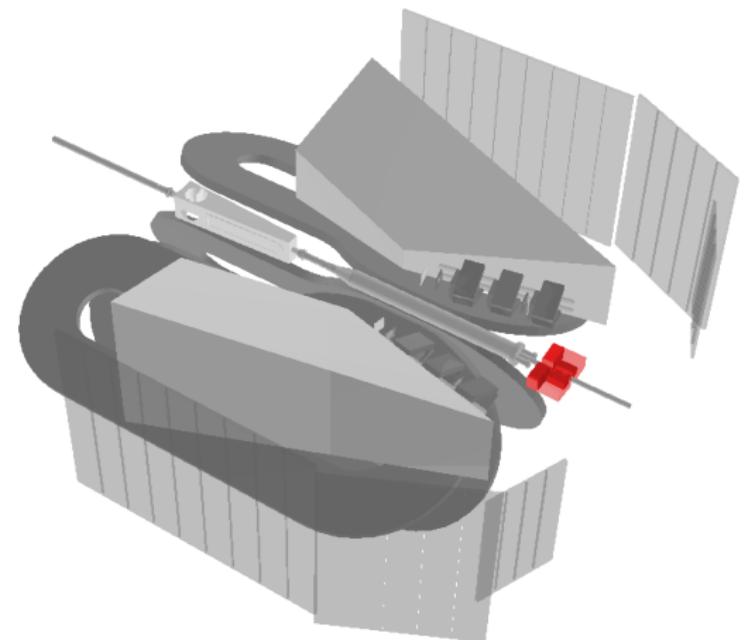
# 12°-detector



- 3 GEM (Hampton) + 3 MWPC (PNPI) each
- highly redundant
- SiPM trigger scintillators



# Symmetric Møller/Bhabha



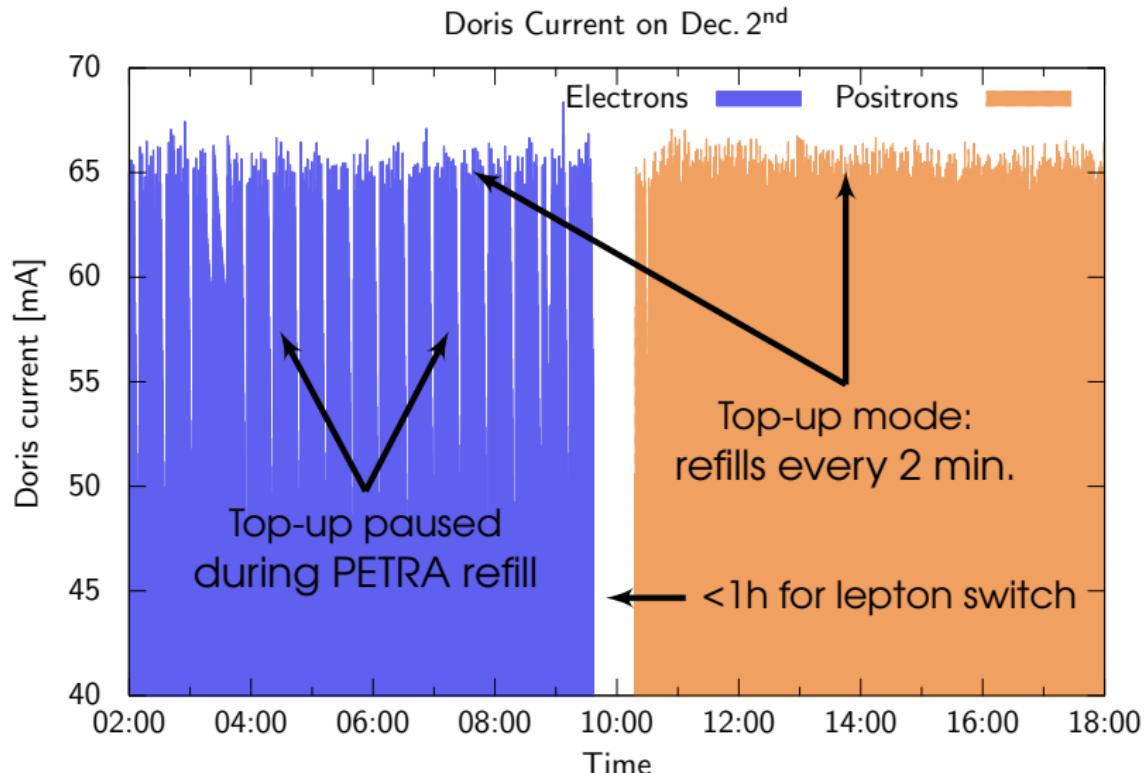
- 2×9 crystals (Mainz)
- $1.3^\circ$  symmetric angle
- high rate, no deadtime



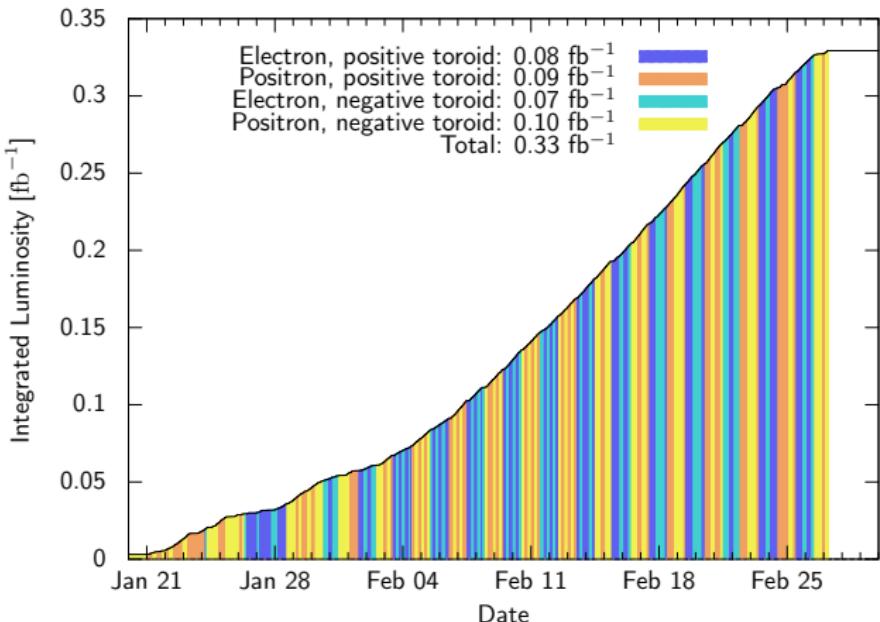
# Timeline

OLYMPUS full proposal	September 2008
Experiment funded by DOE	January 2010
BLAST moved to Germany	Spring 2010
Target test experiment	February 2011
Drift chambers installed	Spring 2011
Luminosity monitors installed	Summer 2011
Olympus roll-in	July 2011
First full Olympus test	August 2011
Sym. Møller/Bhabha installed	Fall 2011
First data run	January 2012
Second data run	October-December 2012
DORIS shut down	January 2013

# Run: Doris performance

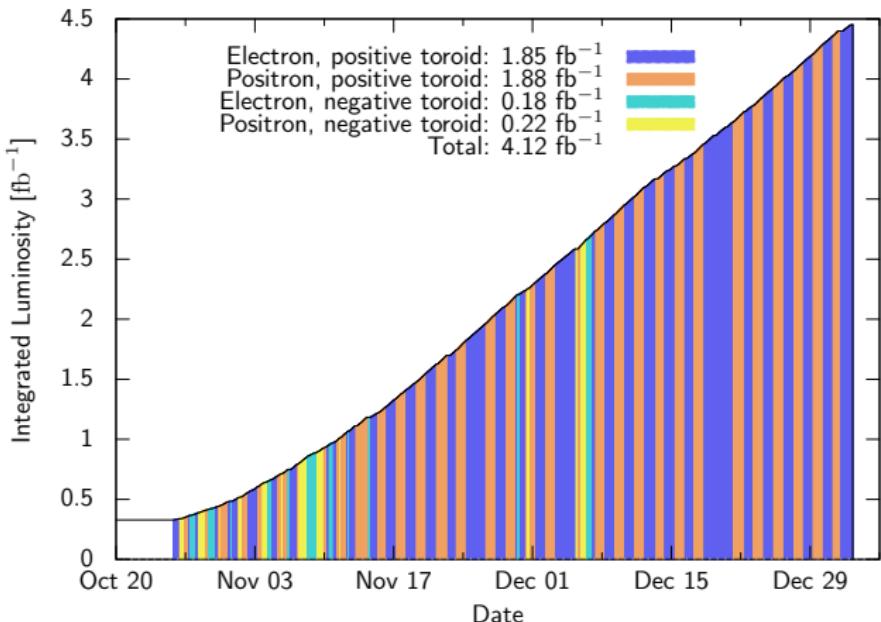


# Luminosity: first run



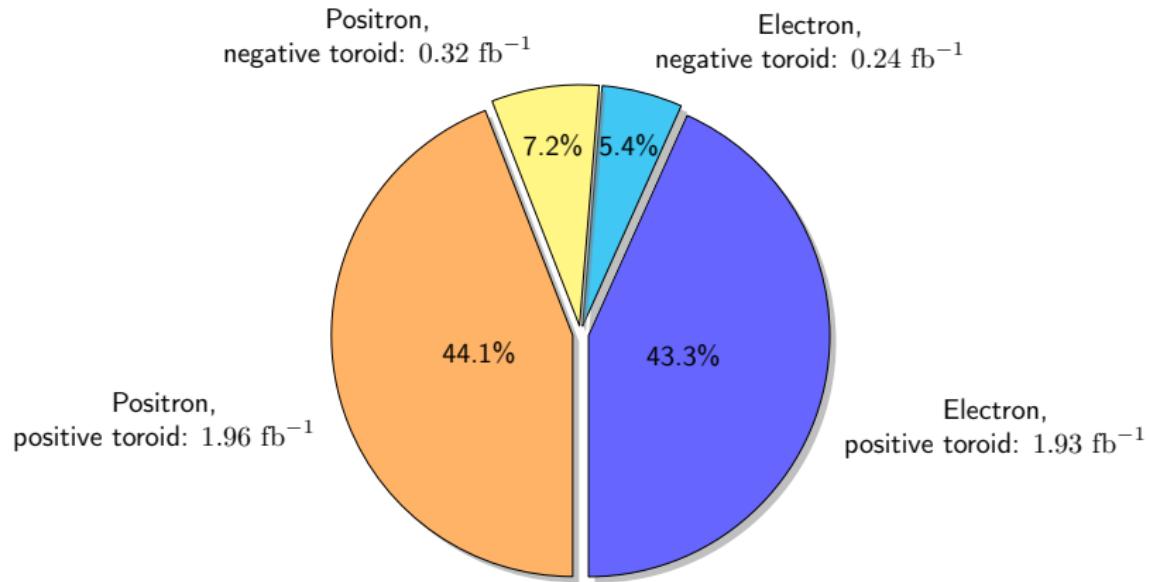
- All four settings
- Leak in target  $\Rightarrow$  only 1/8 of density.  
Could compensate to 1/4 with higher flow

# Luminosity: second run



- Exceeded goal for integrated luminosity:  $> 4 \text{ fb}^{-1}$
- Full flow + negative toroid  $\Rightarrow$  outbending electrons  
 $\Rightarrow$  only positive toroid

# Luminosity: Distribution on Settings



- Dead-time corrected!
- Good balance
- Systematic checks possible with negative field

# Analysis

CAVEAT: The analysis has just started. All plots are preliminary.

# Analysis software stack: Cooker

## Frontends

- Command line
- GUI
- ...

## Plugins

- Independent
- One for each detector
- Can be chained

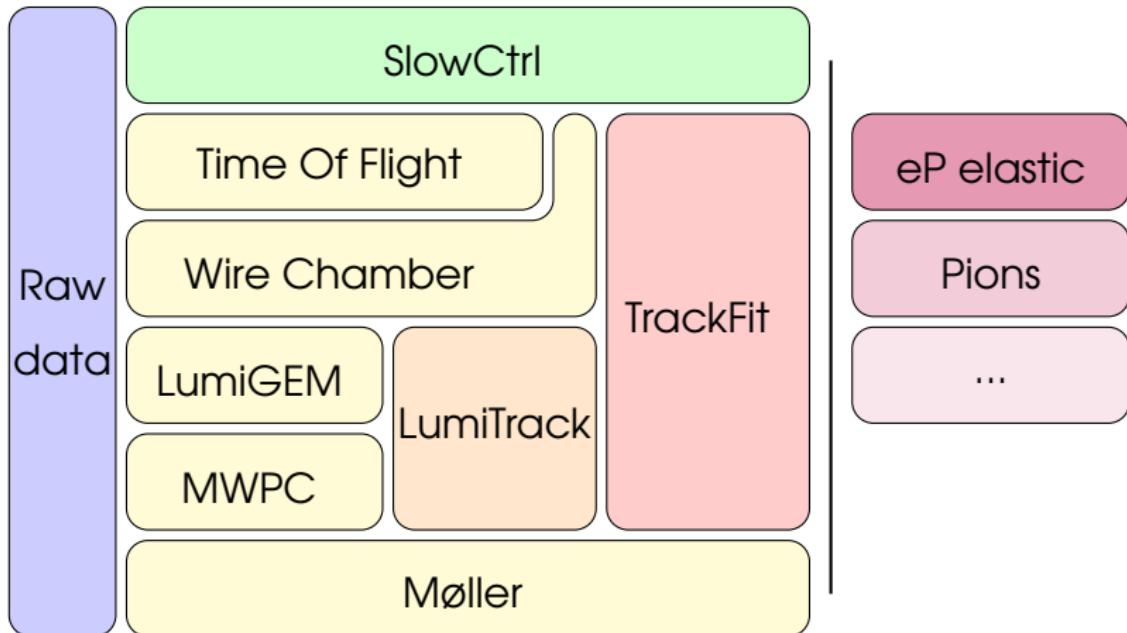
## Chef

## Plugin

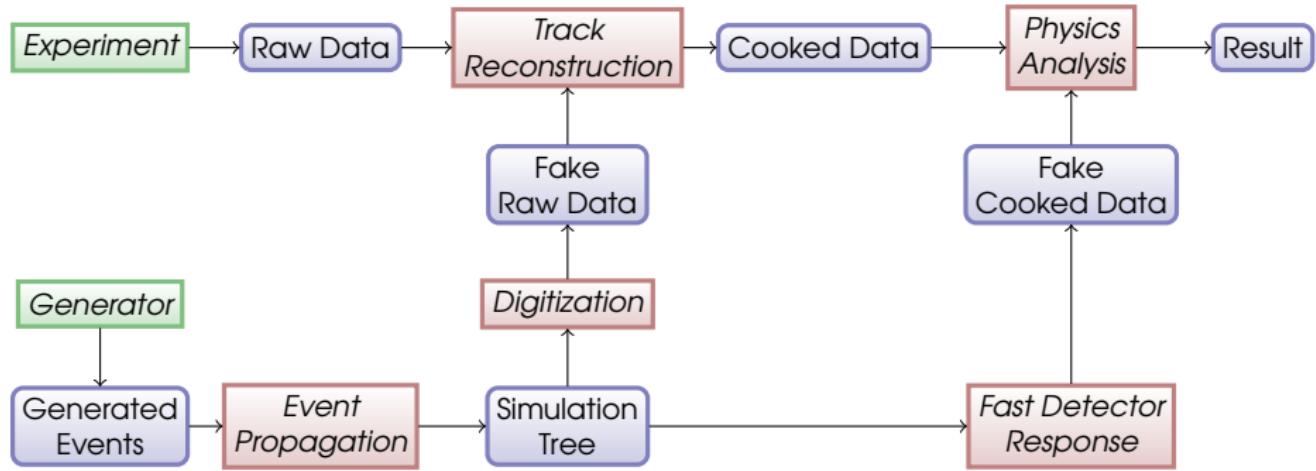
Xerces-C, XQilla

Root, CLHEP, Geant4

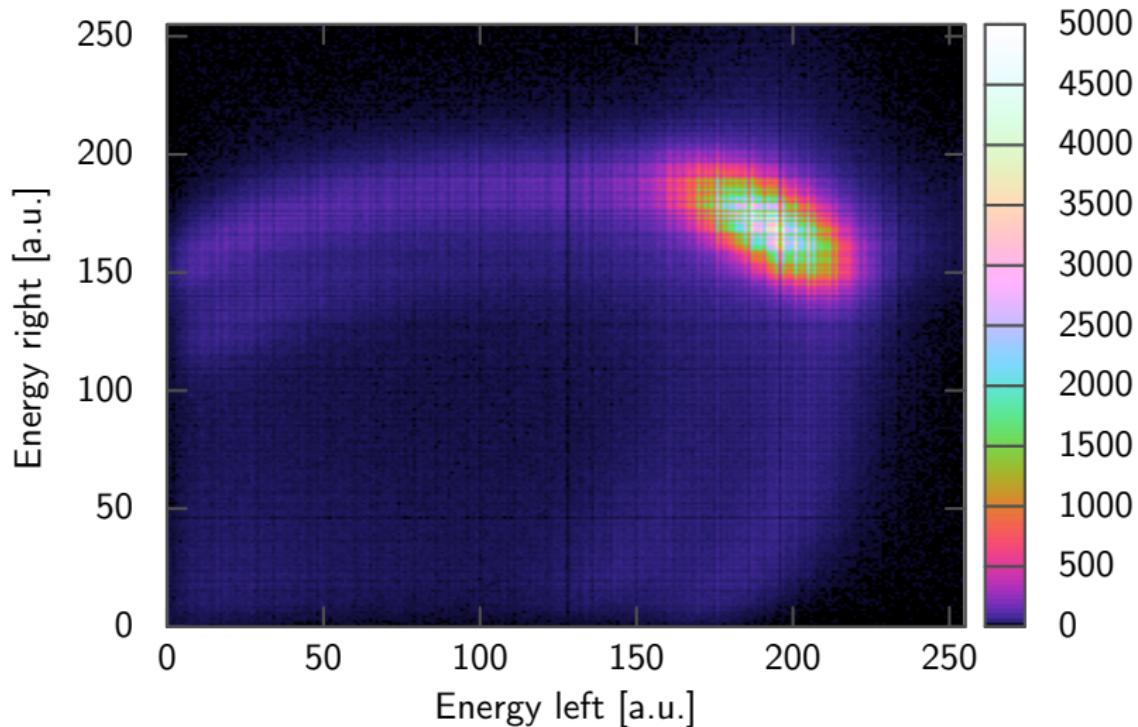
# Plugin System



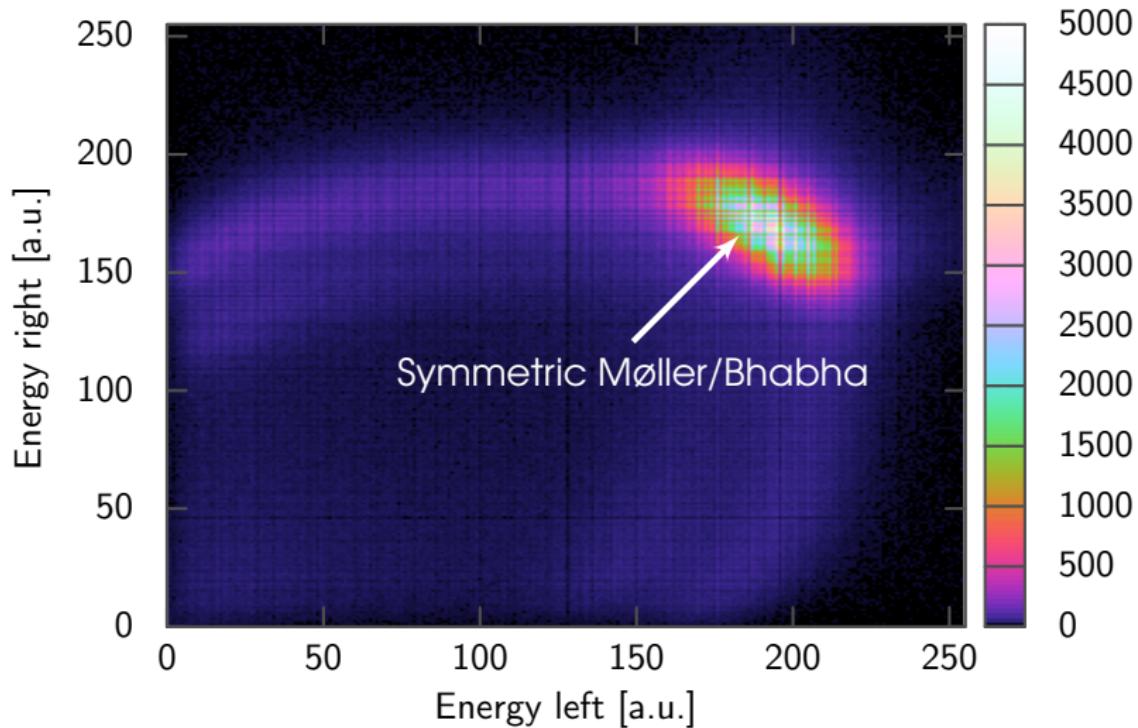
# Flow chart of software components



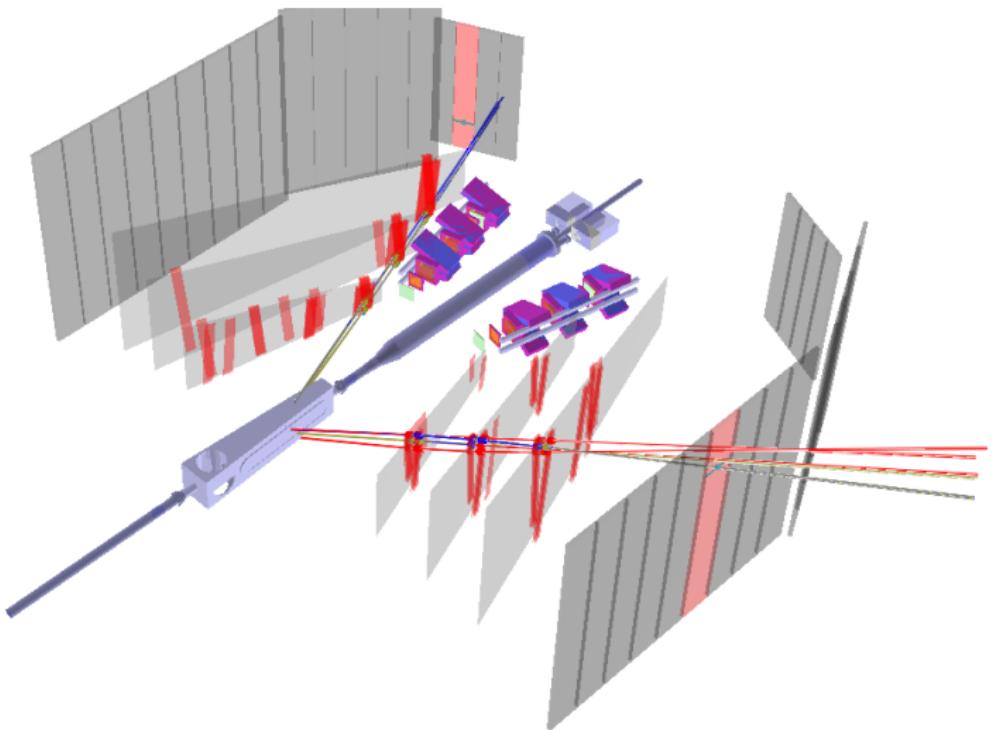
# Symmetric Møller - Coincidence



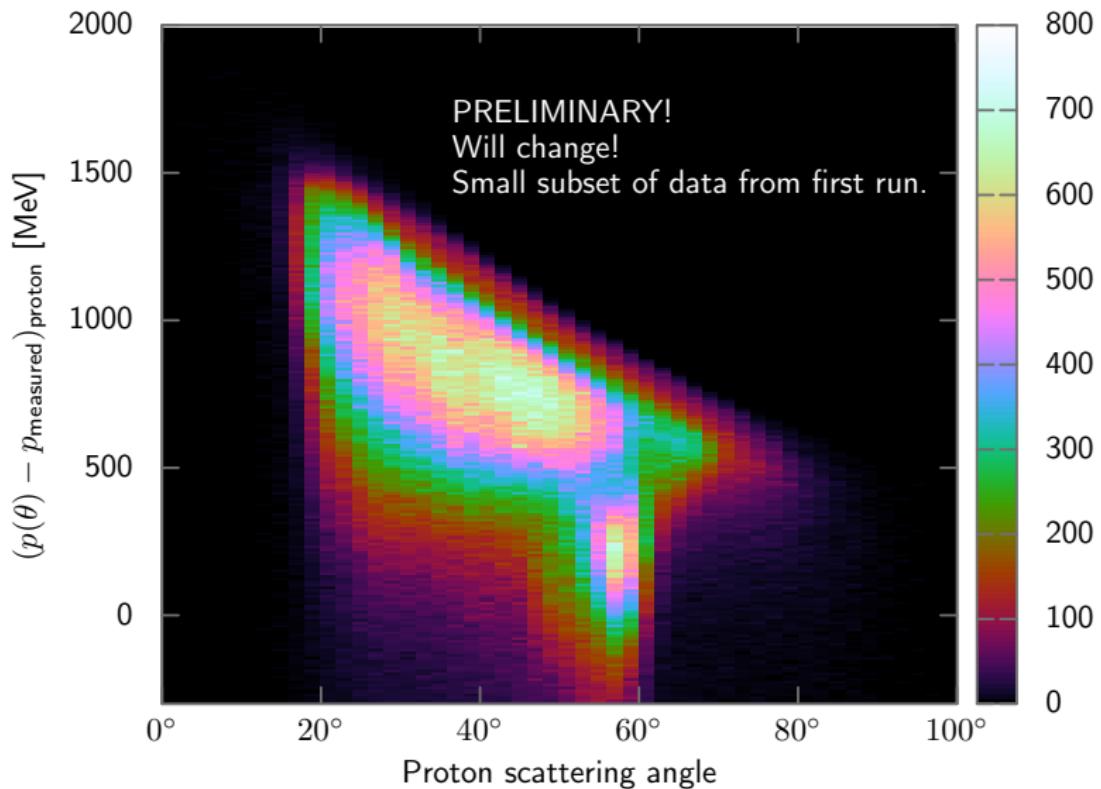
# Symmetric Møller - Coincidence



# Wire chamber / Event-Display



# Reconstructed proton momentum



## Status in a nutshell

- OLYMPUS will determine the TPE effect for  $Q^2 \sim 2 \text{ (GeV/c)}^2$  with high accuracy.
- Data-taking completed successfully
- Calibration / Magnetic field measurement done.
- Analysis progresses quickly
- Expect final result 2014