# ZARA BAGDASARIAN

Master's Student
Iv. Javakhishvili Tbilisi State University,


# CURRENT STUDIES OF SPIN FILTERING AT COSY, JUELICH

JÜLICH
FORSCHUNGSZENTRUM

Qobuleti,Georgia
29/10/2011

P A X
Polarized Antiproton eXperiments

# ZARA BAGDASARIAN

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## Short CV

### *EDUCATION:*

- Master's Student in Atomic, Nuclear, Particle Physics
- Deutsches Electronen Synchrotron (DESY) Summer Student Program 2009
- Hadron Physics Summer School 2010 in Bad Honnef
- ISTC-CERN-JINR Summer School on High Energy Physics and Accelerator Physics 2011
- Summer student at Juelich Research Center in 2010 and 2011

### *SCHOLARSHIPS:*

- Presidential scholarship
- WORLD FEDERATION OF SCIENTISTS' scholarship
- Estate Khmaladze (Victoria University of Wellington) Scholarship

# OUTLINE

- Introduction to Juelich Research Center
- General idea of Spin Filtering
- Current Results and Further plans

# JUELICH RESEARCH CENTER

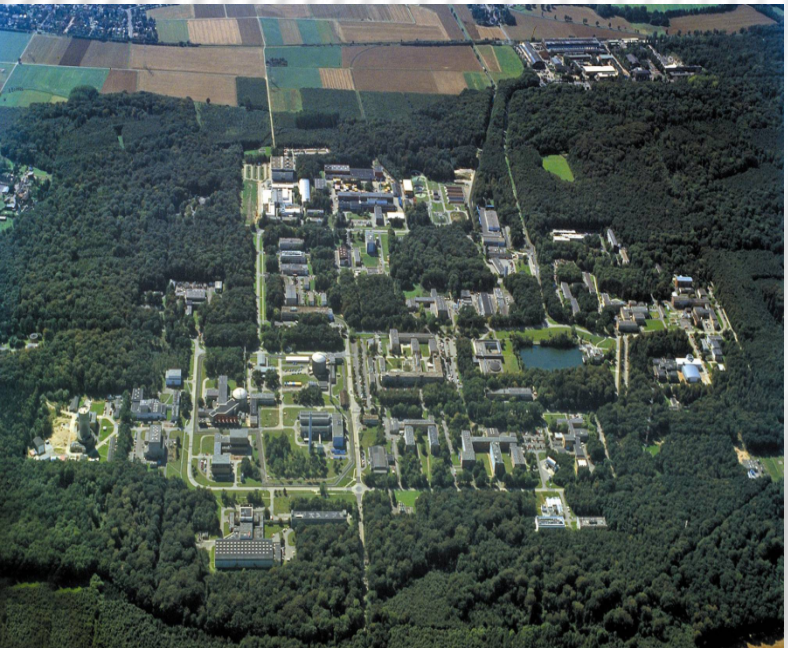
- 4,600 employes
- Scientists: 1.500

  + 900 guest scientists from more than 70 countries
- 8.500 patents, 192 licenses

  (100 new patents per year)

  1800 publications

  500 million budget



# INSTITUTES:

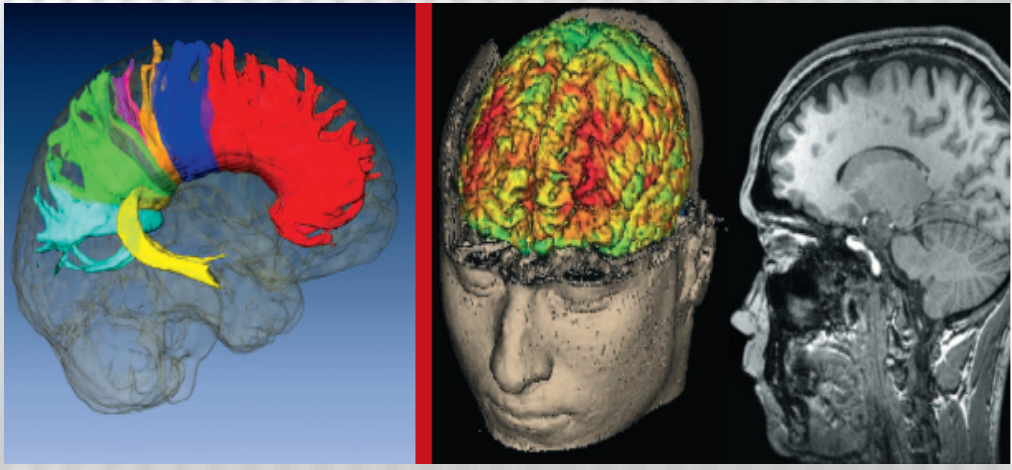
Advanced Simulation (IAS)
Biotechnology (IBT)
Bio- and Nanosystems (IBN)
Chemistry and Dynamics of the Geosphere (ICG)
Energy and Climate Research (IEK)
Solid State Research (IFF)
Nuclear Physics Institute (IKP)
Neurosciences and Medicine (INM)
Structural Biology and Biophysics (ISB)


**Fastest in Europe: 1petaflop (trilion operations per second)**

**Atmosphere simulation**

Nobel Prize in Physics 2007

**Brain Simulation**



# GEORGIANS AT JUELICH (OVER 30)

**Hadron Physics Experiment:** Dr. A. Kacharava, Prof. M.Nioradze, Dr. B.Chiladze, Dr. G. Macharashvili, Dr. N.Lomidze, Dr. M.Tabidze , Dr. I. Keshelashvili, Dr. David Chiladze, Dr. Archil Garishvili, D. Lamanidze, Z. Bagdasarian, M. Jabua

**Theory:** Prof. G.Devidze, Prof. A.Liparteliani, Prof. A.Rusetsky, Prof. A.Kvinikhidze, Dr. Z.Merebishvili

**Official Georgian Representatives :**

Acad. Prof, Albert Tavkhelidze, Prof. A.Motsonelidze, Prof A. Prangishvili, Prof. G. Khubua, A. Kvitashvili

**Engeeniring:**

Prof. A. Sharmazanashvili , N.Sharmazanashvili, D. Tushishvili, B. Kekelia, S.Samkharadze

**Mathematics/Computing:** Prof. R. Botchorishvili, Prof. A. Gamkrelidze, Dr. Z. Modebadze

**Material Sciences:** Prof. E. Kutelia, Prof. I. Kakubava, Dr. O.Tsurtsamia

Georgian TV

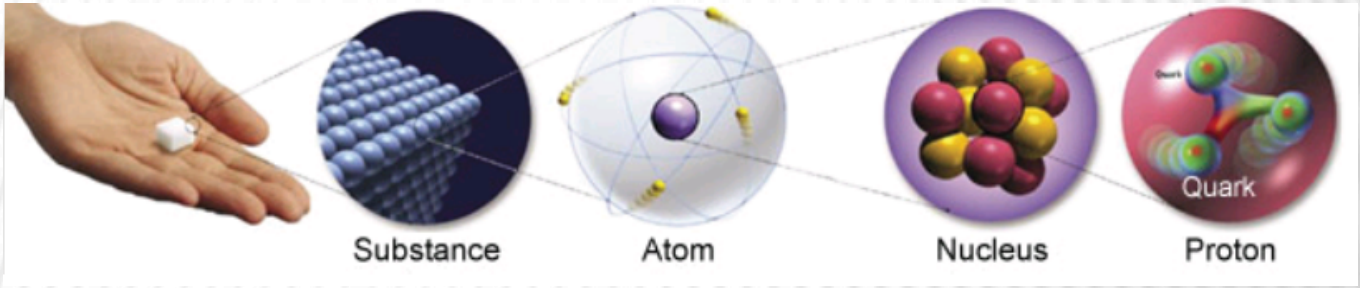
# COMMON SCHOOL/WORKSHOP CGSWHP


2004 **2006** (2008 canceled) 2010

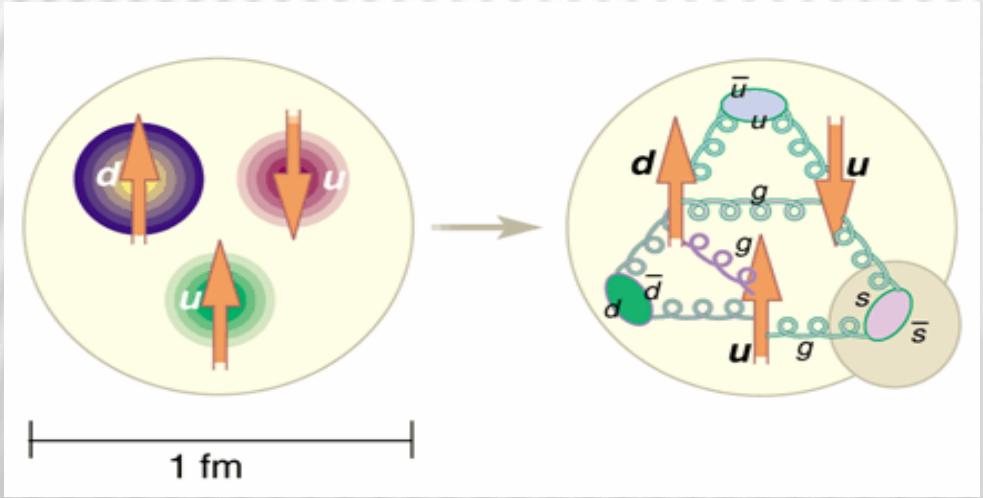
**2012**

# HADRON PHYSICS

- Understanding of all matter comprised of quarks and gluons




QCD has not yet provided complete explanation on structure of hadrons




Proton spin

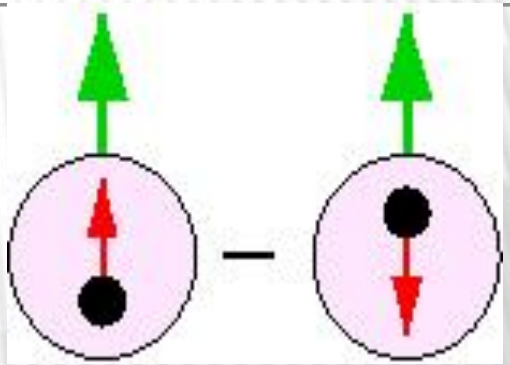
~14%÷23%


"Spin Crisis"

# MOTIVATION

- Number of New Fundamental Observables

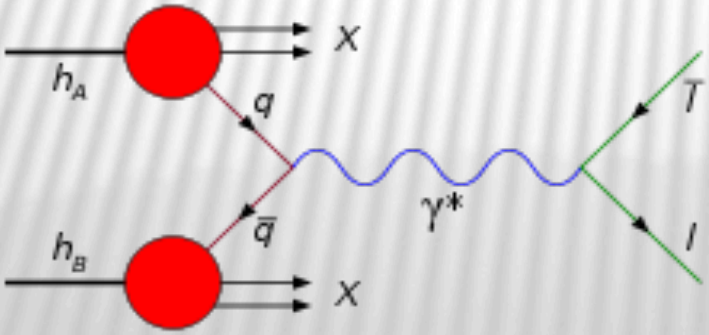
(which can't be studied without transverse polarization of protons and antiprotons)



- Transversity distribution

(missing piece of QCD description of the nucleon partonic structure)

*If the hadron is polarized upwards, it's the difference between the probability of finding a quark polarized upwards minus the probability of finding a quark polarized downwards.*



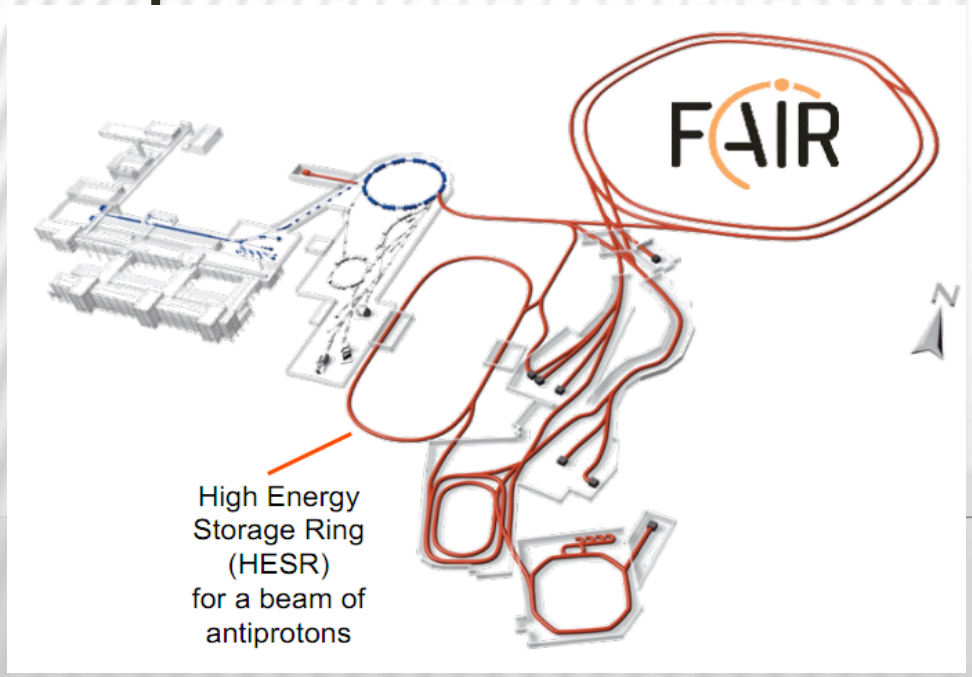

Drell-Yann Process

# POLARISED ANTIPROTON EXPERIMENTS

Polarized Antiproton eXperiments

2010-2012: Spin Filtering Studies for protons at COSY

- 2012-2015: Spin-Filtering Studies fo antiprotons at CERN AD




- After 2015: PAX at FAIR:

Collide polarized protons and polarized antiprotons

# CAN WE POLARIZE ANTIPROTONS?

- From polarized ion sources (No)
- **From polarized hyperons (low intesnities)**
- By stochastic method (No)

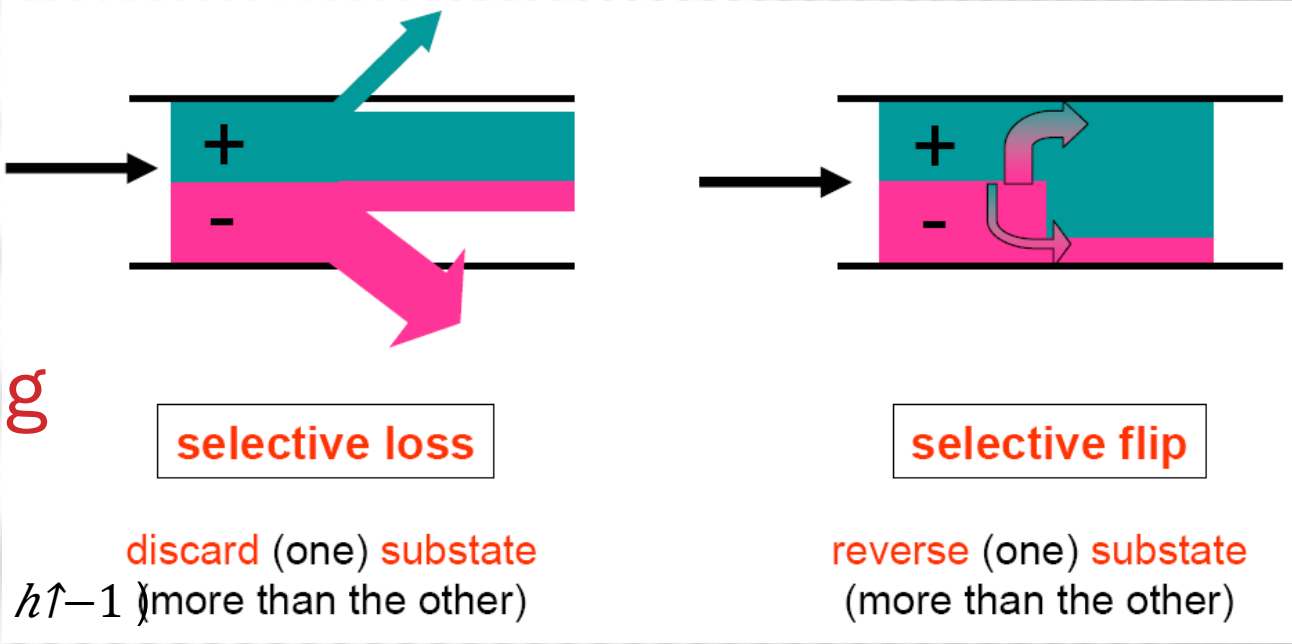
## By Spin Flip

(showed small cross sections $4 \cdot 10\uparrow 6$ b and $7 \cdot 10\uparrow 6$ b)

## By Spin Filtering

demonstrated by FILTEX

$\Delta P/\Delta t = \pm(1.24 \pm 0.06) 10\uparrow -2\ h\uparrow -1$ )




*Interesting experiments on the spin dependence should be possible, even if the achievable polarization of the stored antiproton beam is a few percent.*

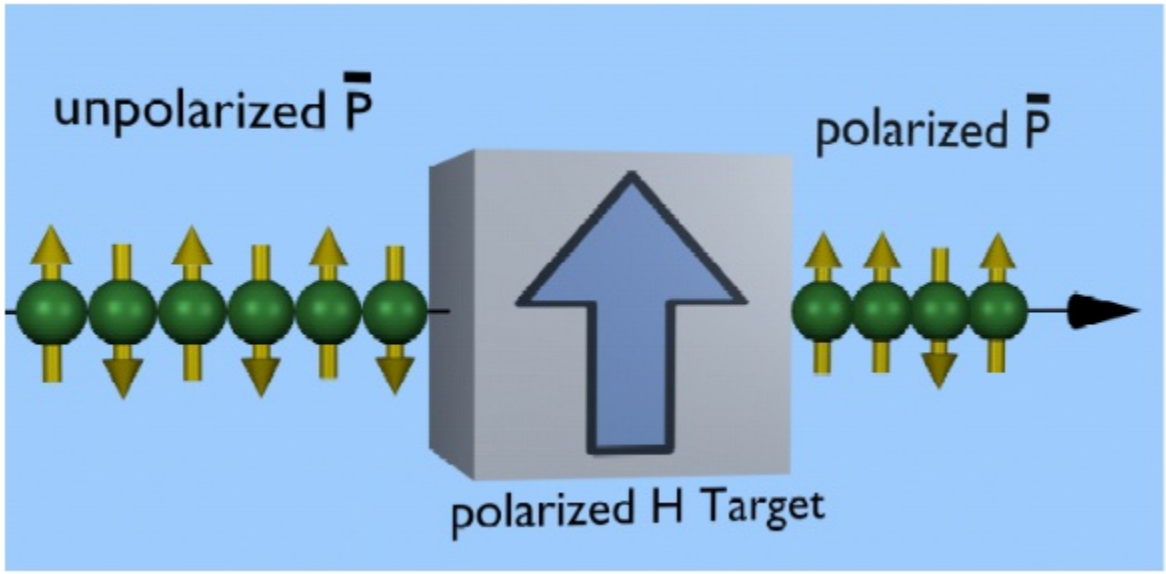
# HOW DO WE SPIN FILTER?

Unpolarized beam starts circulating in the ring

- **Hits polarized target**

$P(t) = \frac{N\downarrow\uparrow - N\downarrow\downarrow}{N\downarrow\uparrow + N\downarrow\downarrow}$

- $\sigma(\uparrow\uparrow) \neq \sigma(\uparrow\downarrow)$
- **One spin direction depleted more than the other**




- **A fraction of beam is lost**

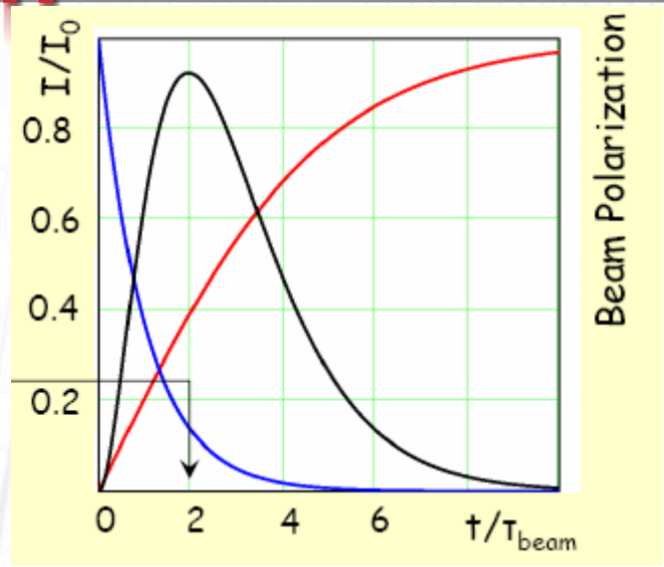
- **BUT: the left beam is polarized**

$$\sigma_{tot} = \sigma_0 + \sigma_{\perp}\cdot\vec{P}\cdot\vec{Q} + \sigma_{||}\cdot(\vec{P}\cdot\vec{k})(\vec{Q}\cdot\vec{k})$$

P beam polarization
Q target polarization
k || beam direction

- **In other words: more protons with spin in direction parrallel to the one of the target**

# FIGURE OF MERIT




$$t \sim FOM = P^2 I$$

Optimum time for Polarization Build-up, given by maximum of FOM(t)

$$t_{filter} = 2\tau_{beam}$$

$$I(t) = I_{\uparrow\uparrow}(t) + I_{\uparrow\downarrow}(t) = I_0 e^{-t/\tau_b} \cosh(t/\tau_p)$$

$$P(t) = I_{\uparrow\uparrow}(t) - I_{\uparrow\downarrow}(t) / I_{\uparrow\uparrow}(t)$$

## AS SMALL AS POSSIBLE FILTER TIMES:

- **The maximum target density $d_t$**
- **Maximum spin-dependent cross section $\sigma_p$ (corresponding energy of the beam)**
- *minimize the Coulomb beam losses*

## HIGHEST POSSIBLE BEAM POLARIZATION:

- *Elimination of the effects of depolariziation*
- *Increase of the beam lifetime*

*(Minimal for spin-filtering at COSY is 5000 s)*
*In 09.2011 average 8000*

# COSY (COOLER SYNCHROTRON)

- *Unpolarised and transversely polarized proton and deuteron beams*

- *Momentum range: 300MeV/c - 3.7 GeV/c*

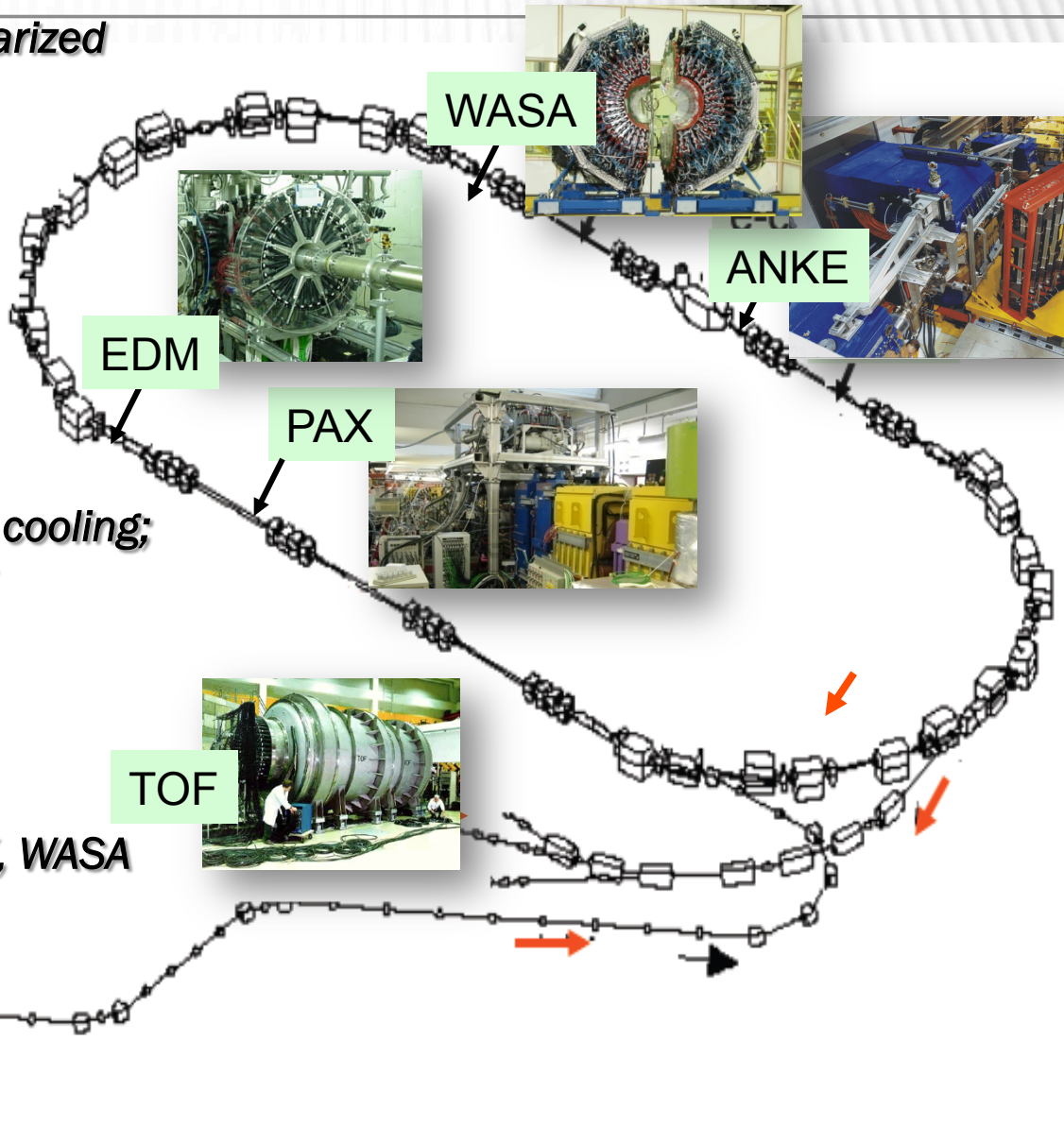
- *183 m circumference, including two 40m straight sections*

- *For 300-600MeV range: electron cooling; for higher energy: stochastic cooling*
- *Ring Acceptance:*

27.0 ± 3.4 7.7 ± 1.2π mm mrad
17.4 ± 2.2 3.4 ± 0.6 π mm mrad

- *Internal experiments: ANKE, PAX, WASA COSY-11, EDDA;*

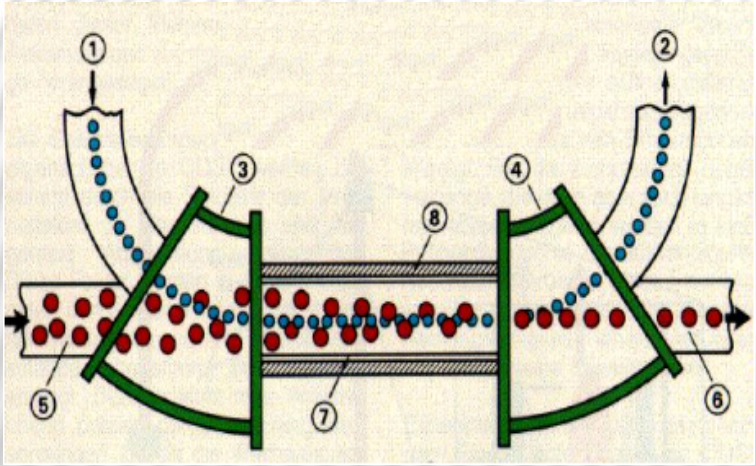
- *External: TOF, JESSICA and etc.*



# WHY COSY IS SO COOL?

## ELECTRON COOLING

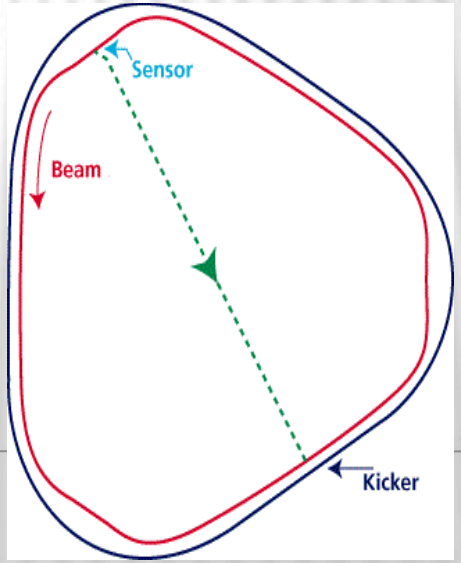
- High quality electron beam injected into the straight section
- Electrons velocities spread: 1/100 000 of the average velocity
- Average V(el)=V(pr)
- Electron Beam Current >>Proton BC




☹: Difficult to accelerate an intense beam of electrons by more than ~100 KV

## STOCHASTIC COOLING

- Sensor: the average position of circulating particles with respect to a central orbit
- Signal proportional to the displacement sent to another point
- Corrective pulse forces the particle to approach the central orbit




- Obvious for one particle
- Shown that works for many particles as well

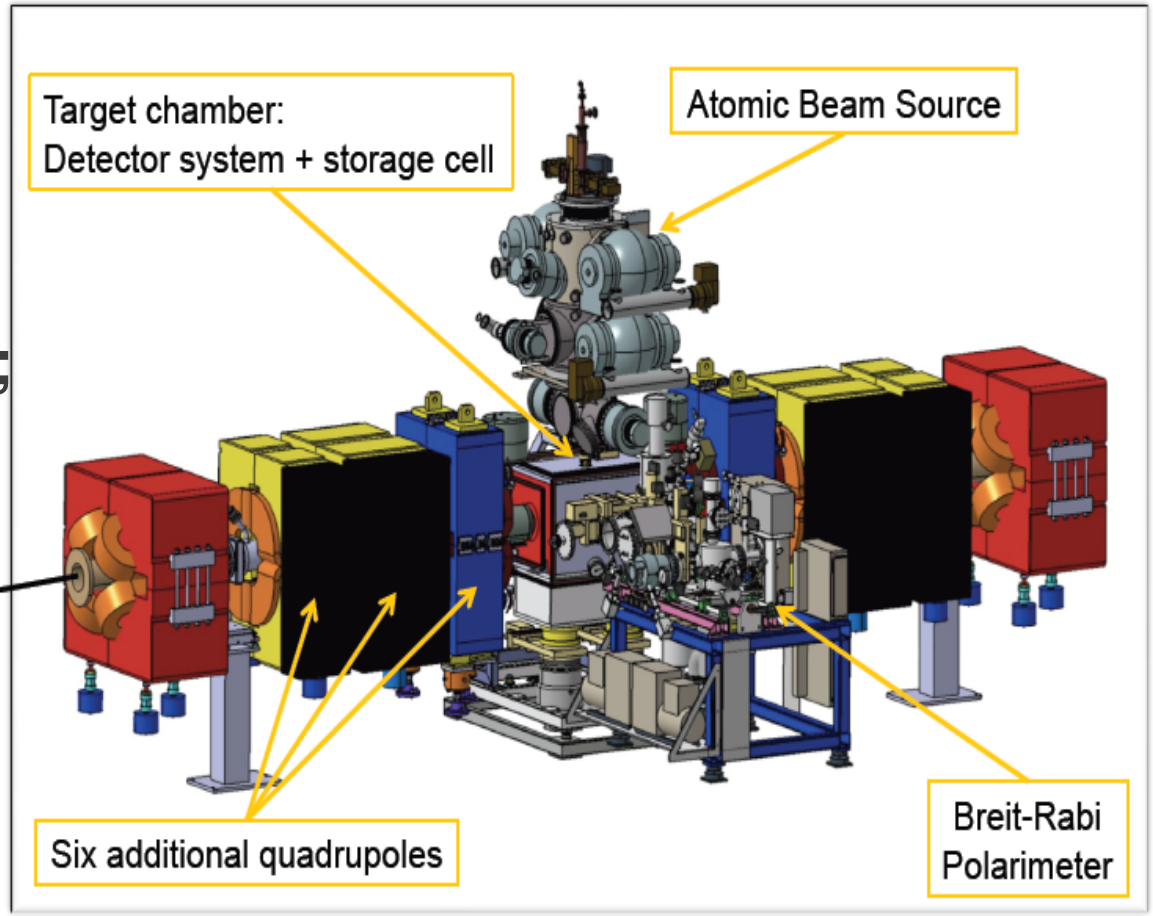
# PAX HARDWARE

**Atomic Beam Source (ABS):**
**polarized atoms (H, D);**

**Storage cell to increase target density;**

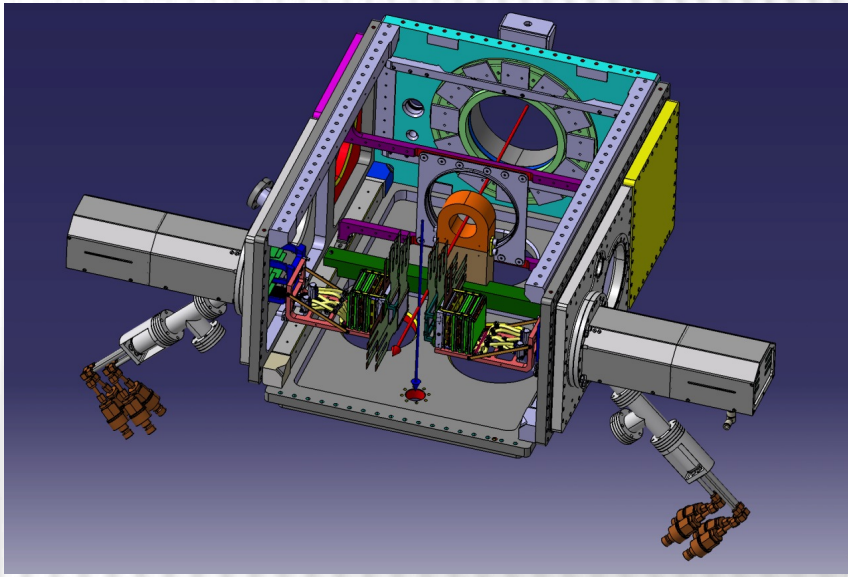
**Breit-Rabi Polarimeter:**
**Monitoring of target polarization;**

**Silicon Tracking Telescope:**
**Particle tracks and energy**



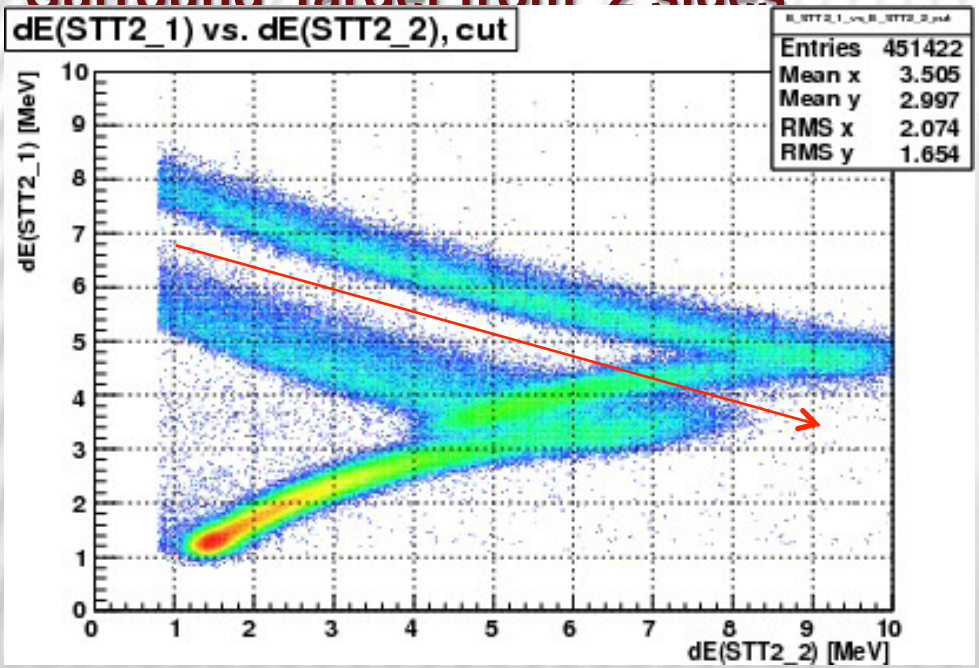
# ANKE SECTION

- Unpolarized deuteron cluster target
- Silicon Tracking Telescope



**3 layers of double – sided silicon-strip detectors**

**Surround target from 2 sides**




**Particle tracking -> Vertex**

**Stopping particle -> Total energy**

**Distinguishing protons and deuterons**

# POLARIZATION MEASUREMENT

$$d\sigma/d(\theta,\varphi) = d\sigma\downarrow 0 /d(\theta)\,[1+PA\downarrow y\,(\theta)\cos\varphi]$$

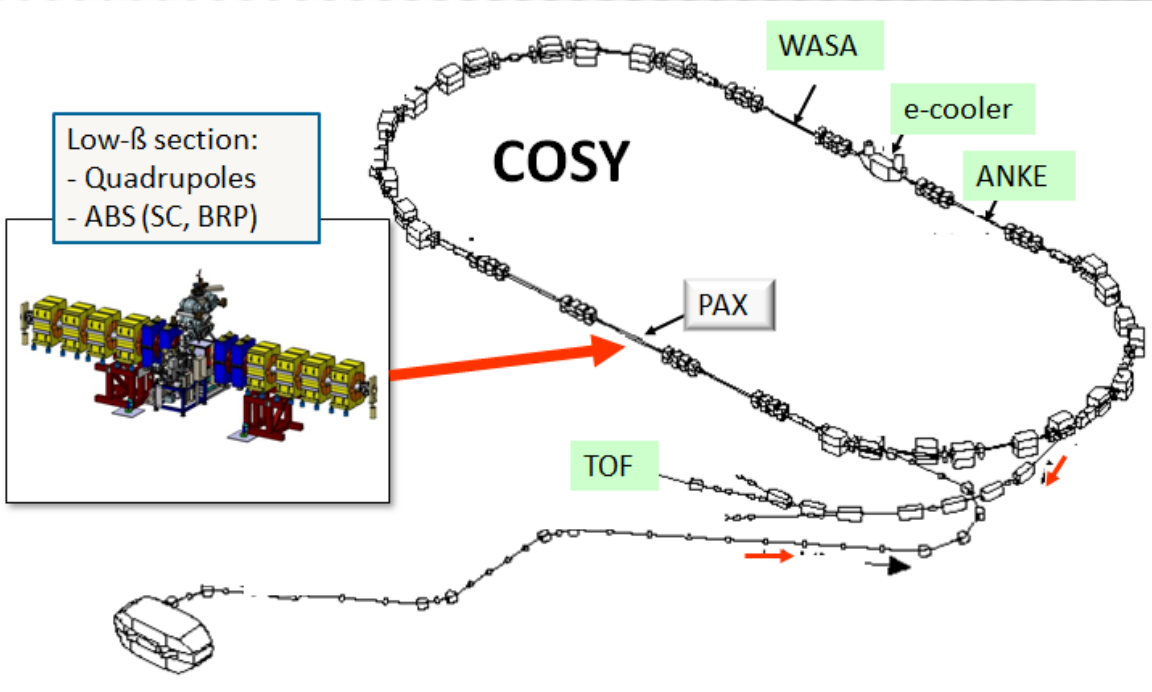
- For pd-pd $A\downarrow y$ Analyzing Power is well known

After 4.5 hours of polarization PAX polarized target is turned off and ANKE unpolarized deuteron target turns on

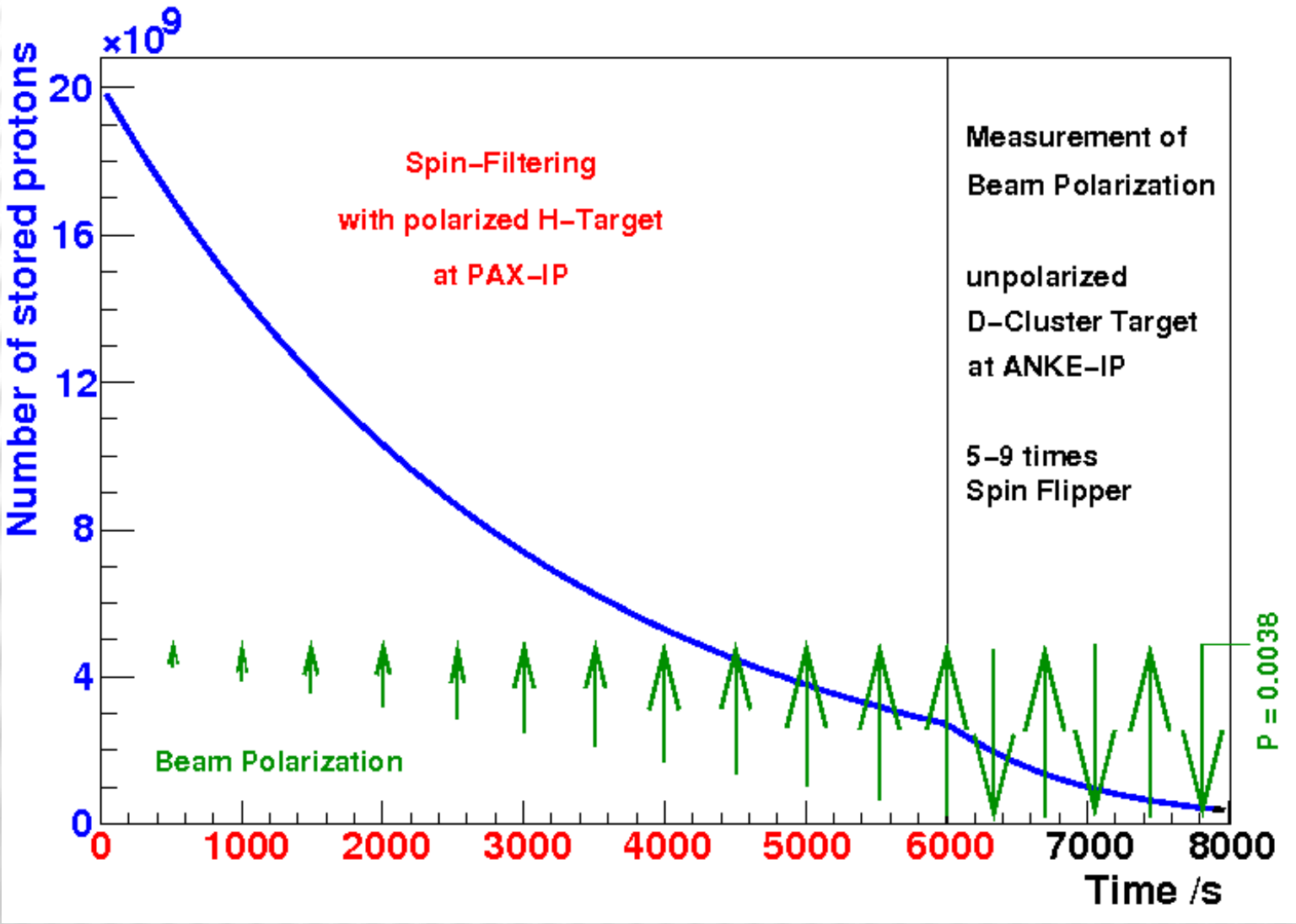
- $\varepsilon=\delta-1/\delta+1=PA\downarrow y\,(\theta)$

count-rate-asymmetry

- $P=\varepsilon/A\downarrow y\,(\theta)\langle\cos\varphi\rangle$



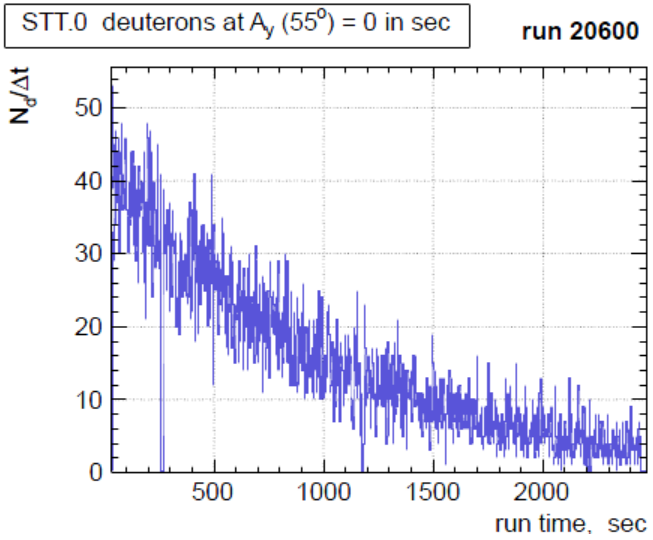
# SPIN FILTERING CYCLE

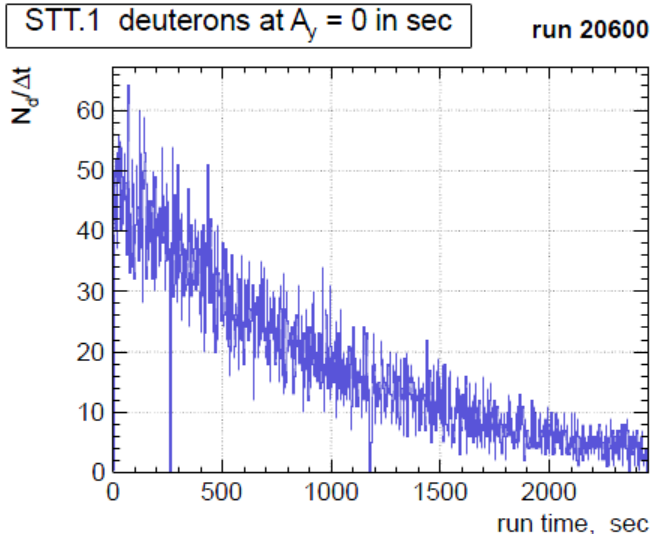


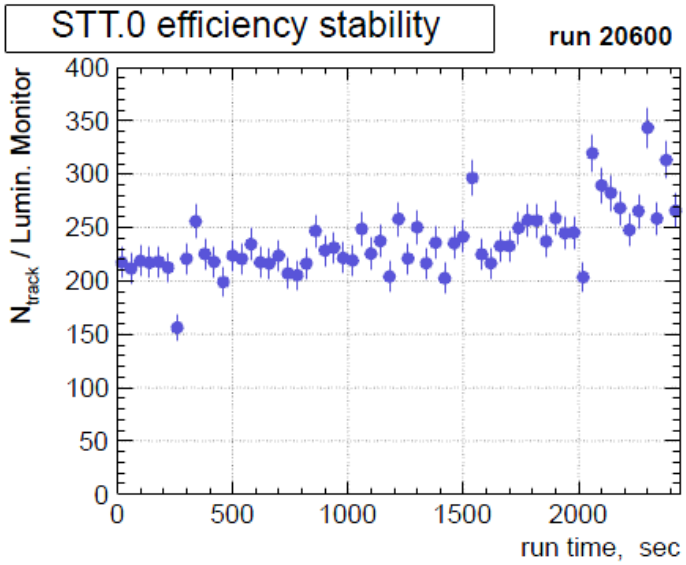
# FULL DATA ANALYSIS

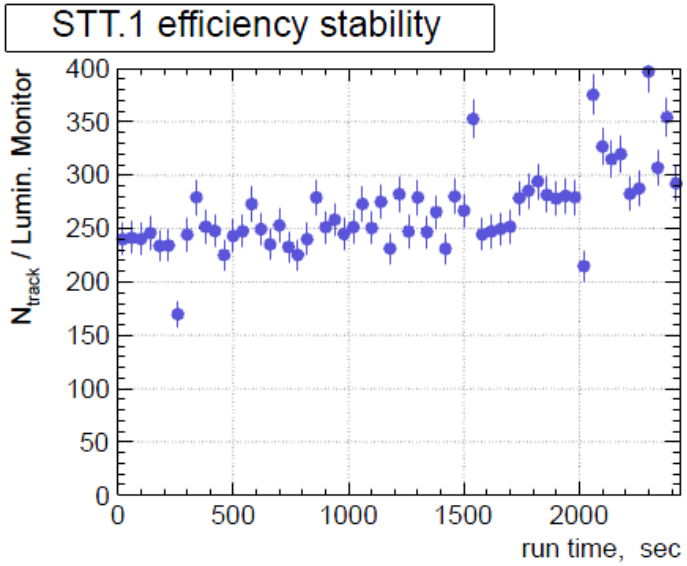
- *the detector stability should be checked*
- *the reaction independent track reconstruction should be performed, various cuts should be applied to identify protons and deuterons and reactions they came from*
- *and finally the polarization (count-rate asymmetry is determined, additionally error estimation should be done.*

# DETECTOR EFFICIENCY



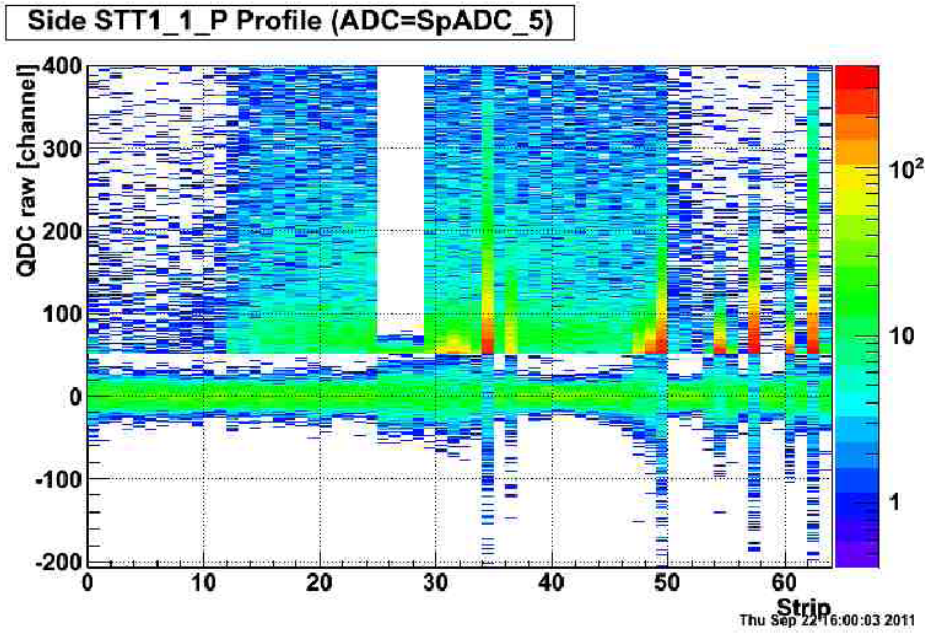

Number of detected deuterons around the $A_y = 0$ point

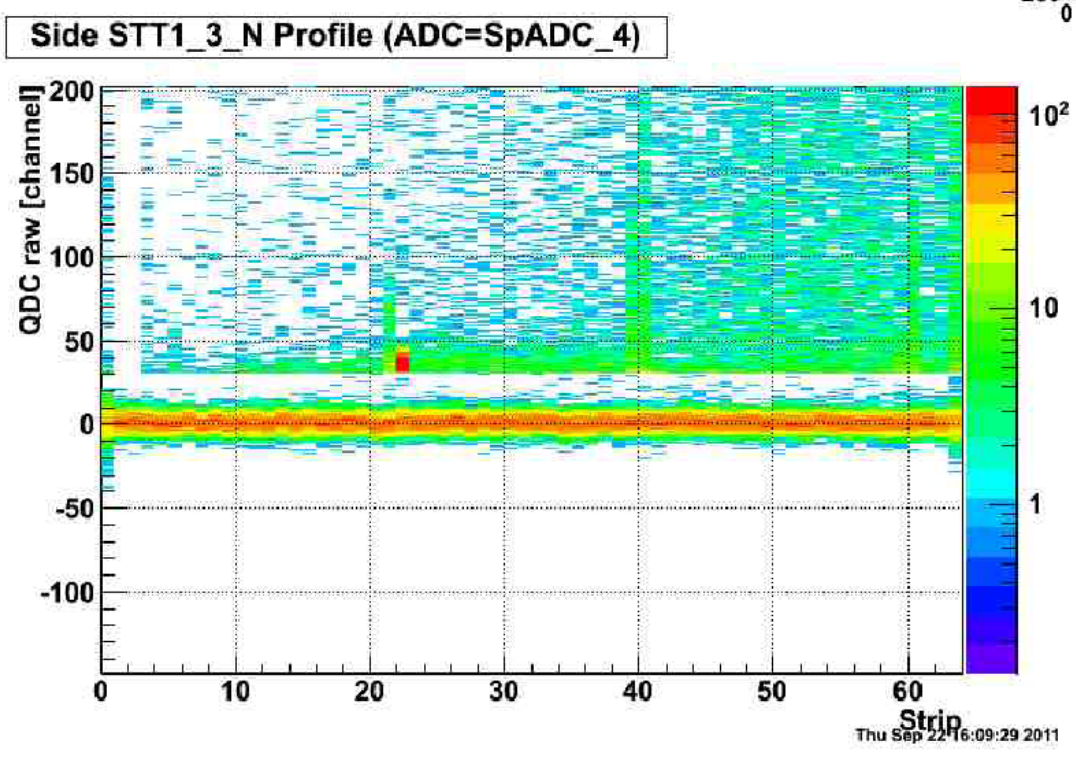
The left and right telescope efficiencies:

Number of recorded tracks normalized to the beam intensity

# PEDESTAL STABILITY

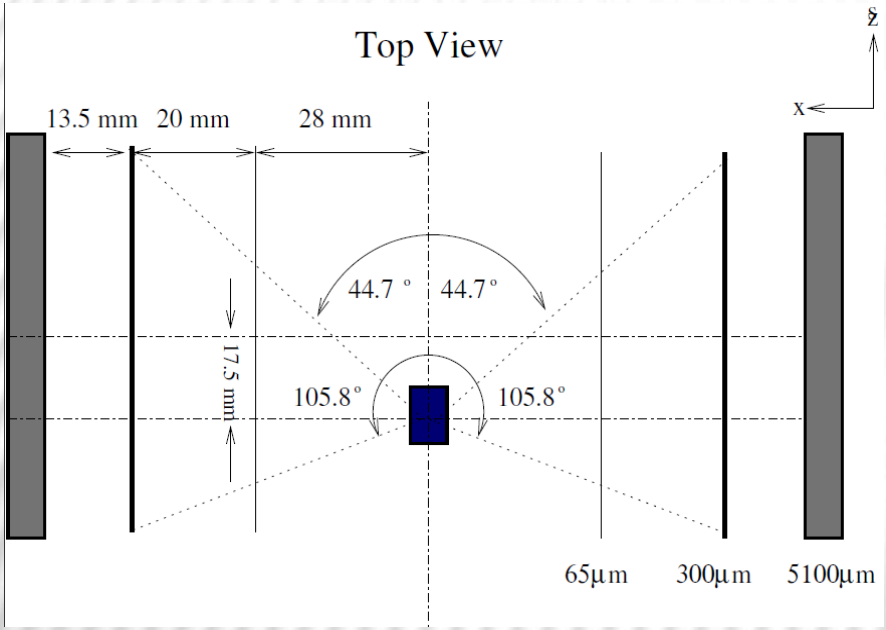
- On each stripe small signal (pedestal) is given to test detector stability

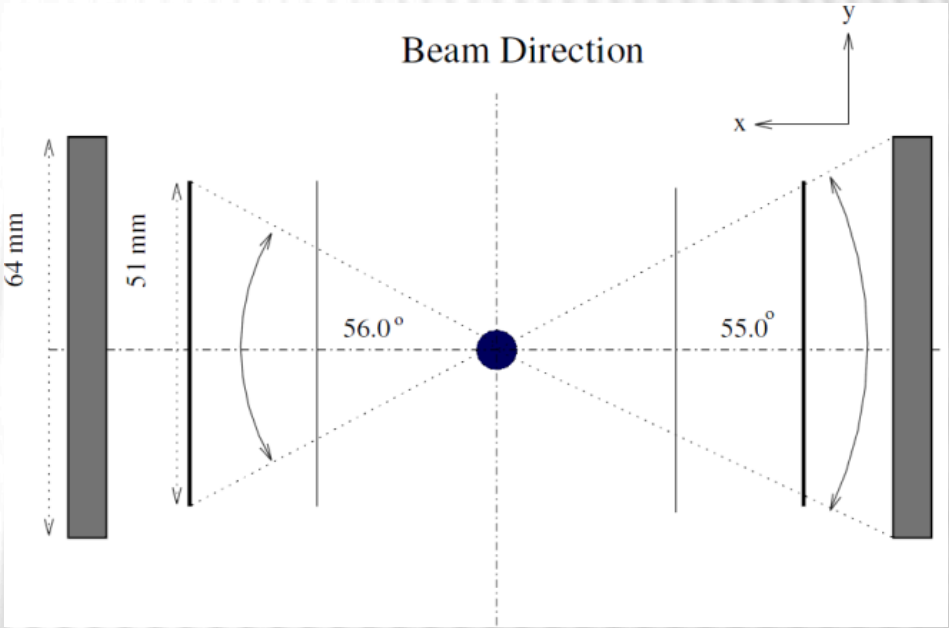


# GEANT4 SIMULATION

## Tracking of particles through a current experimental setup geometry

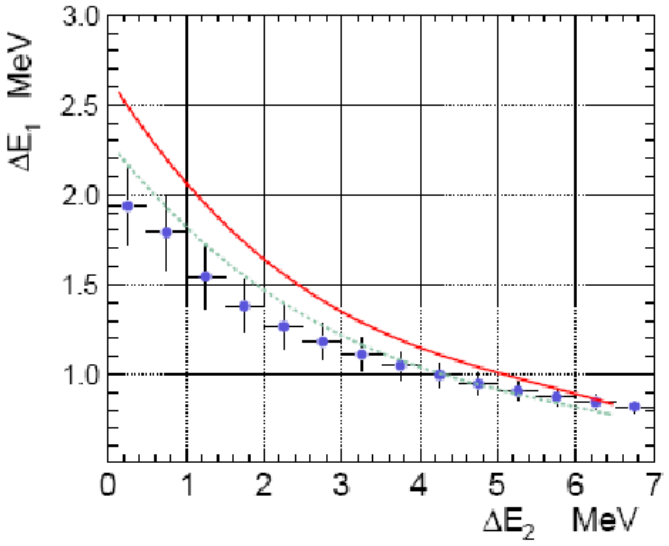


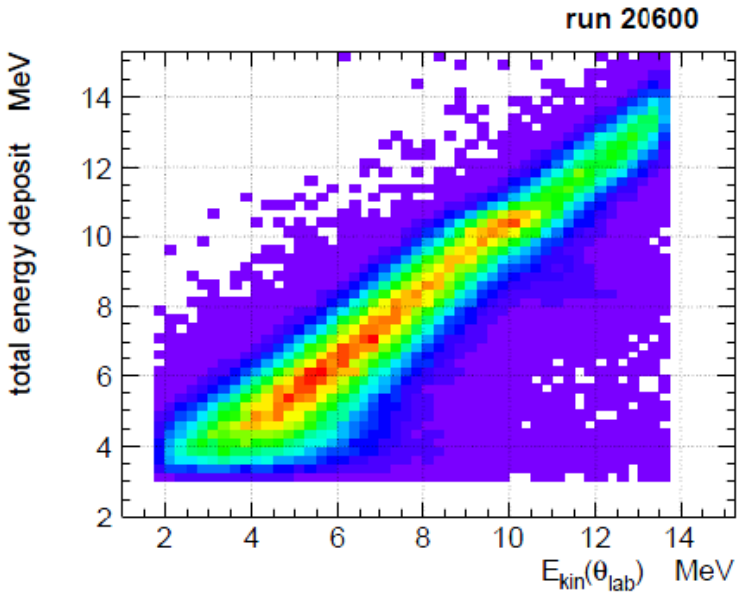

- **Hits:coordinates, energy deposits in layers**
- Tracks:θ,φ
- Particle type, kinetic energy, stopped or not
- Not isotropically (crossections from experiment at 46.3 MeV were used to fit)

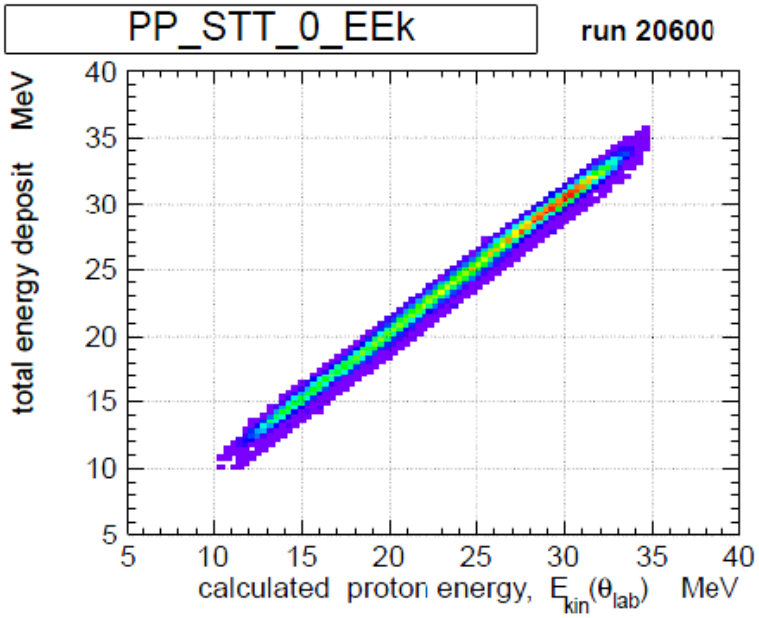
# STT CALIBRATION QUALITY

Energy deposits in first and second layer (red line- simulation by GEANT4 , blue crosses- experimental data)



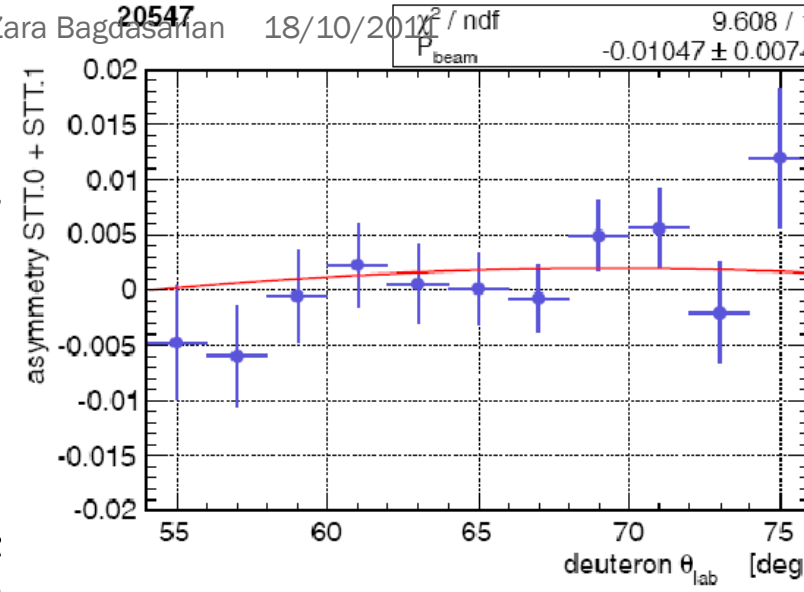

Total energy deposit and reconstructed kinetic energy correlation for stopped deuterons and stopped in the 3rd layer protons

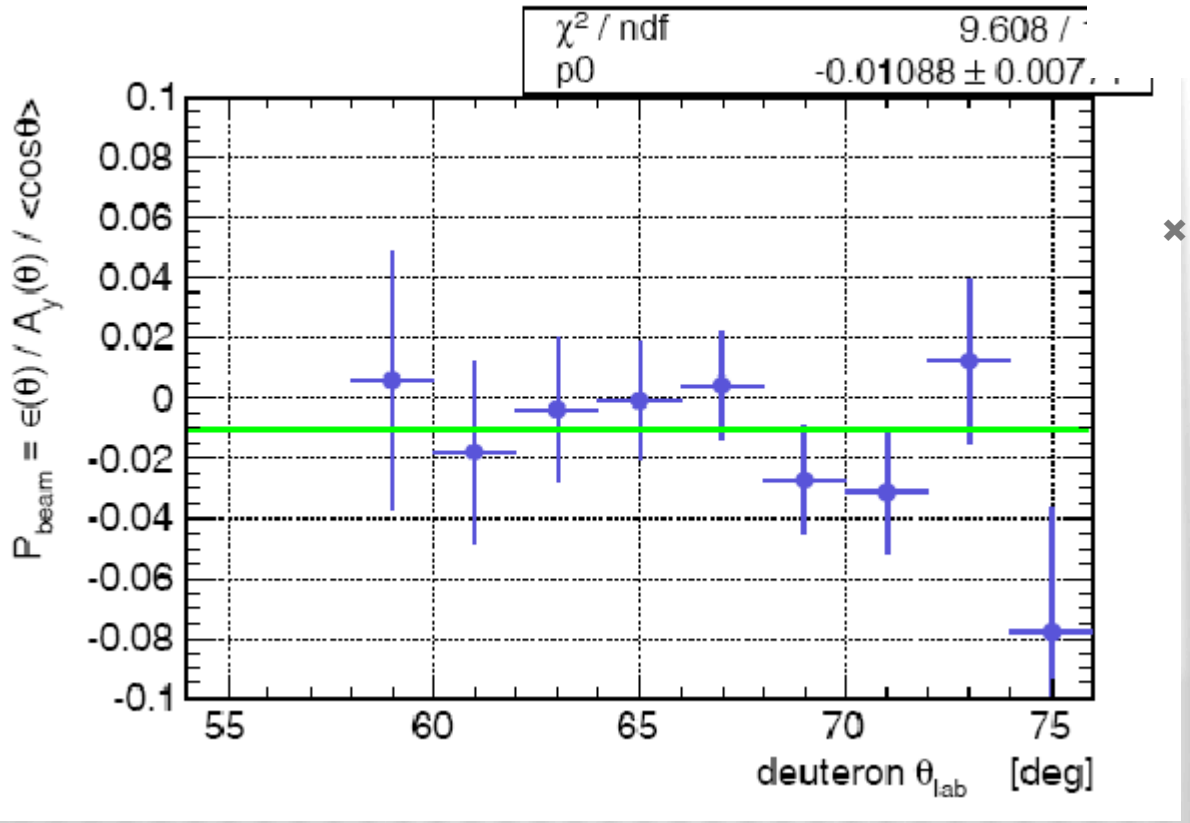


# PRELIMINARY RESULTS

$\delta = L/R = 1 + PA\downarrow y\,(\theta)/1 - PA\downarrow y\,(\theta)$




- $P = \varepsilon / A\downarrow y\,(\theta)\langle\cos\varphi\rangle$

# WORK IN PROGRESS

- Calibrate analysis using data with unpolarized beam. (precise measurement of zero)
- Run analysis using data with high polarized beam
- Check and handle dead time
- Optimize energy calibration
- Identification of protons from pd-elastic to increase statistics (background from break-up reactions)

# CONCLUSIONS

- Spin Filtering Experiment successful performance at COSY
- Necessary subsystems work as expected or even better
- Sufficient data for statistical significant result
- Collected data to gain experience in high precision experiments
- Preliminary result (holding field up) is close to expected 0.006+-0.00015
- If PAX goes to CERN with AD ring acceptance 220 π mm mrad antiproton polarization of several percent is expected

# THANKS FOR YOUR ATTENTION


- Acknowledgements to Dr. Andro Kacharava and all georgian team at IKP Juelich Forshungzentrum

- Looking forward to the following successful collaboration (Georgian-German Workshop in Basic Science 2012)
- Thanks to the Organizing Committee of the conference for the opportunity to give a talk