INFN Istituto Nazionale di Fisica Nucleare

UNIVERSITÀ DEGLI STUDI DI FERRARA
- EX LABORE FRUCTUS -

JÜLICH FORSCHUNGSZENTRUM

Experimental study of proton deuteron breakup reaction at 50 MeV

6th Georgian-German School and Workshop in Basic Science

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Outline

- Physics case
- pd breakup @COSY
- Data analysis: pd breakup identification criteria
- Application (preliminary)
- Conclusions

Physics case

- *3NF* : where to look for experimental evidence?

  → Nucleon-Deuteron elastic scattering

  cross sections + polarization observables

  → Nucleon-Deuteron Breakup reaction

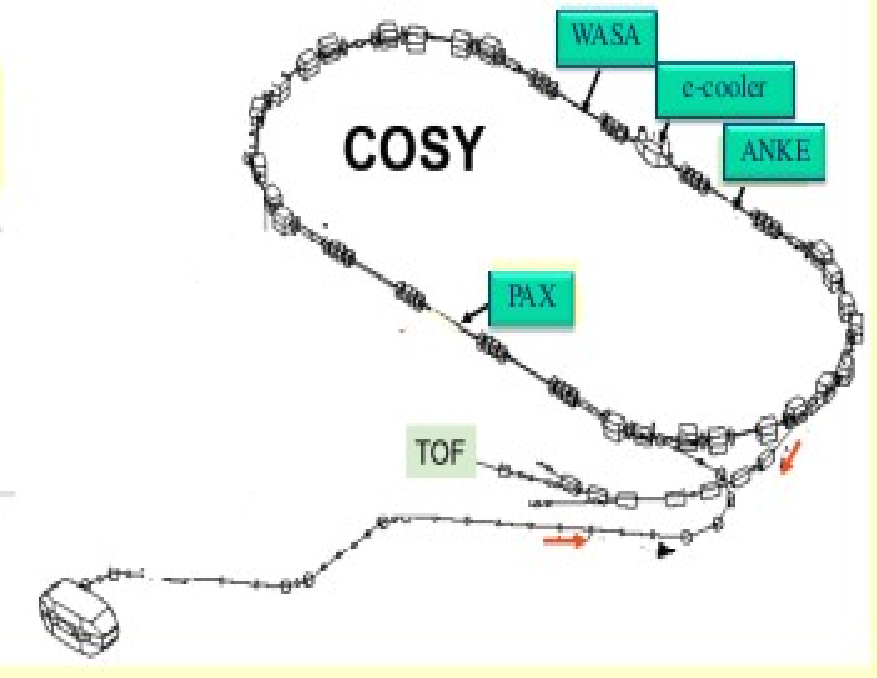
  - richer kinematics, broader phase-phase
  - cross sections + more polarization observables

- *Experimental investigation:*

  Privileged kinematic region 30-50 MeV

  Polarized data → constraints for chiral-EFT to provide evidence of 3NF (or lack)

Deuteron Breakup @COSY



COSY circumference 184 m

(Un)polarized Proton and Deuteron beam

Maximum p_{max} = 3.7 GeV/c

Deuteron Breakup & PAX

PAX
Polarized Antiprotons eXperiments

↓

$\vec{p}\vec{p}$ Physics case: Proton structure

↓

$\vec{p}$ stored beam?

↓

Preparatory phase:
test on polarized beams
i.e. $\vec{p}\vec{d}$ scattering @COSY

↓

pd breakup
Physics case: Nuclear Forces

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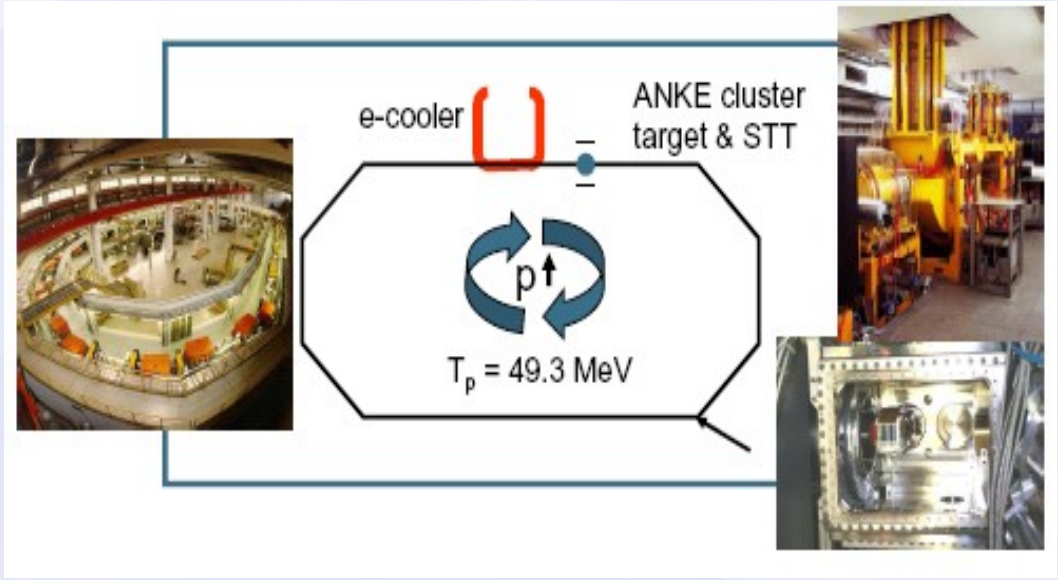

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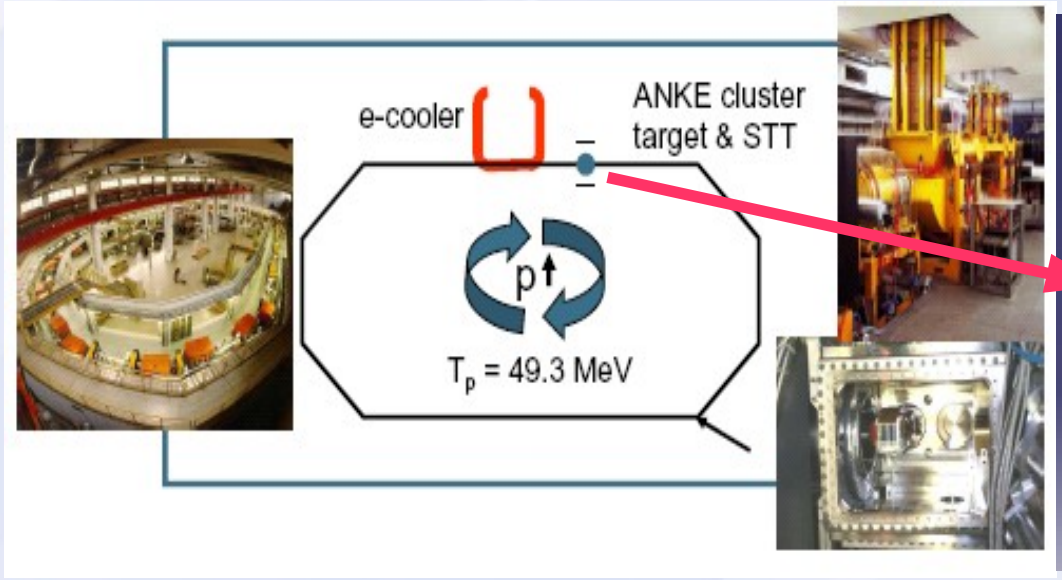

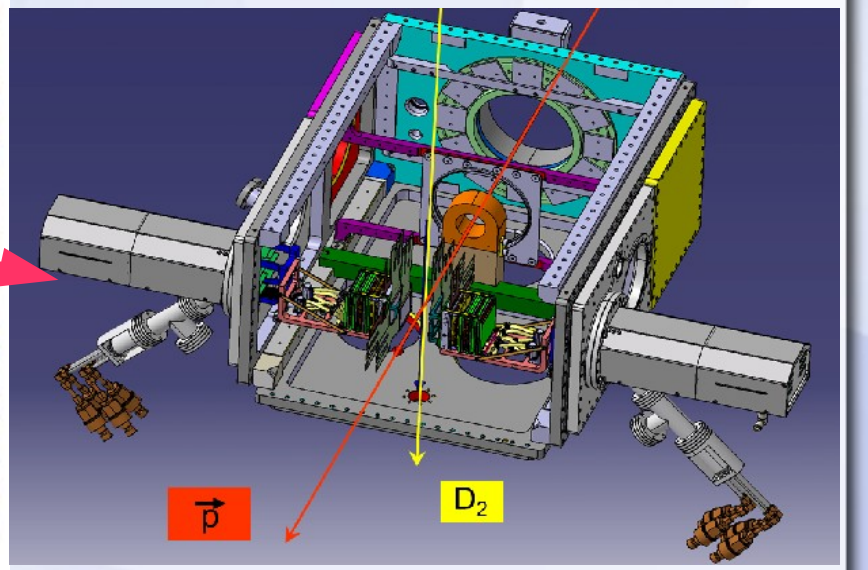

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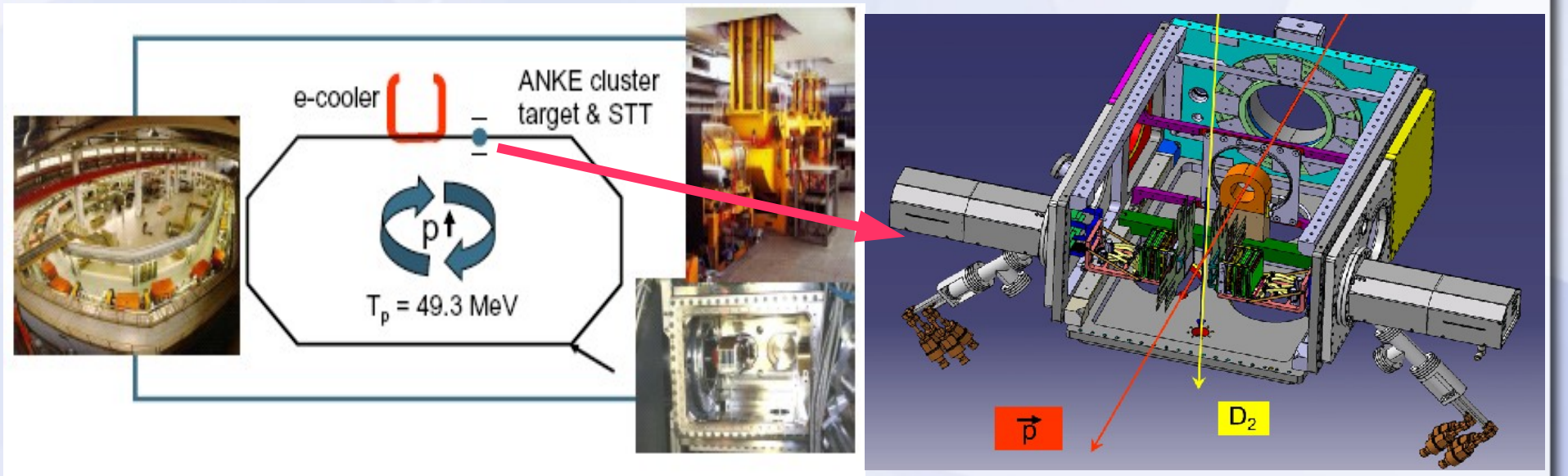
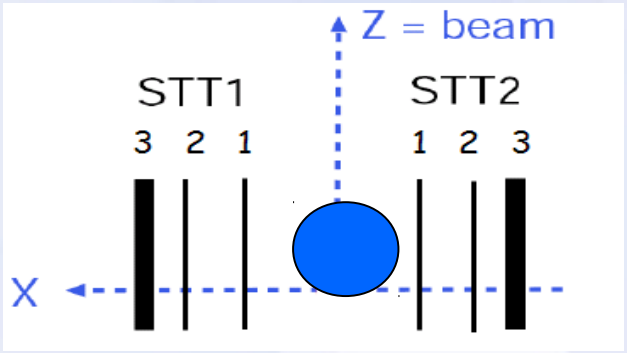


Accessible channels @ T_p = 49.3 MeV:

pd → pd (elastic channel)



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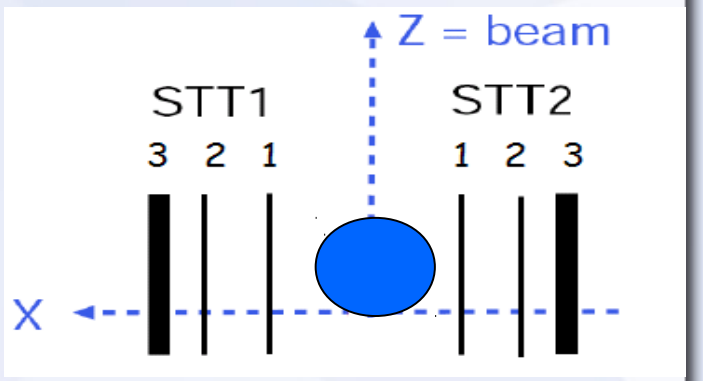

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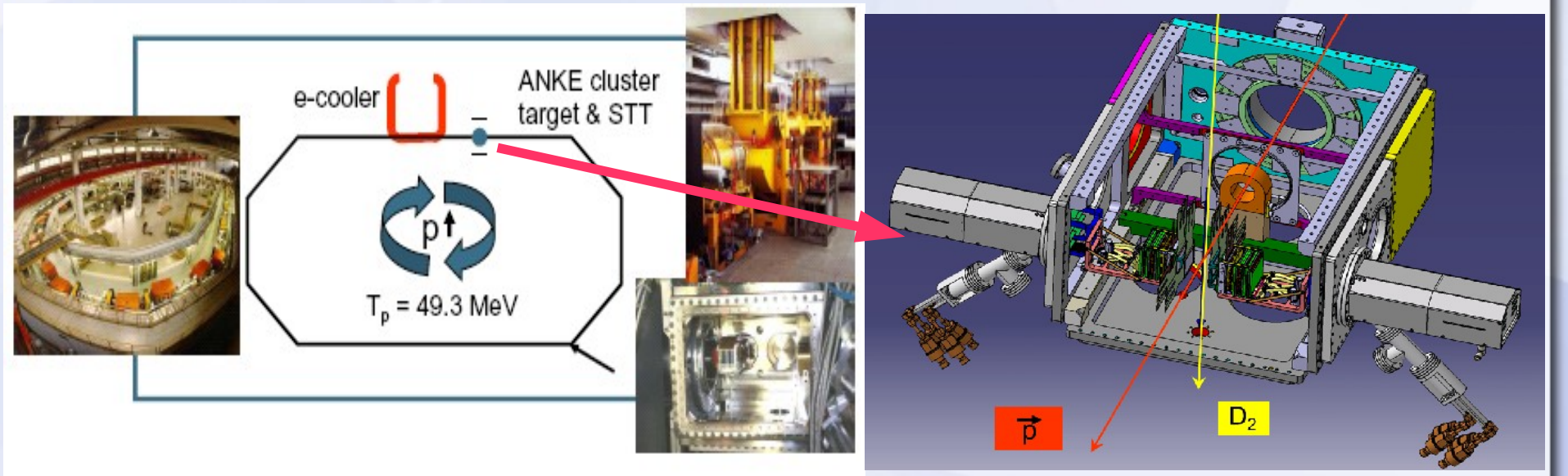

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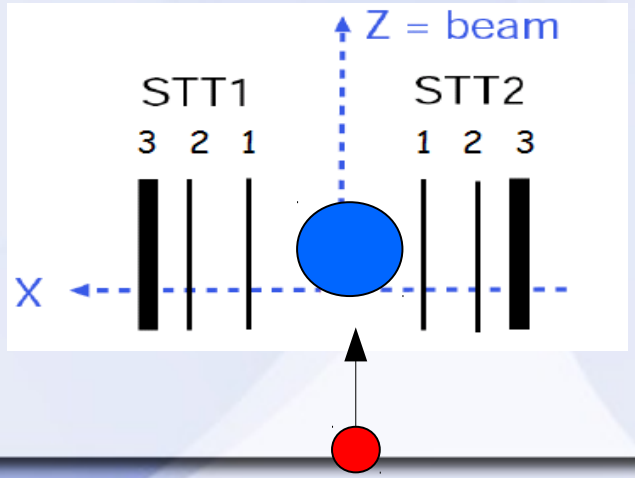

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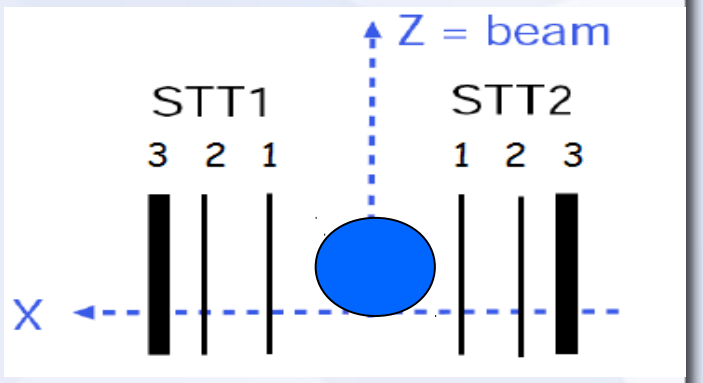

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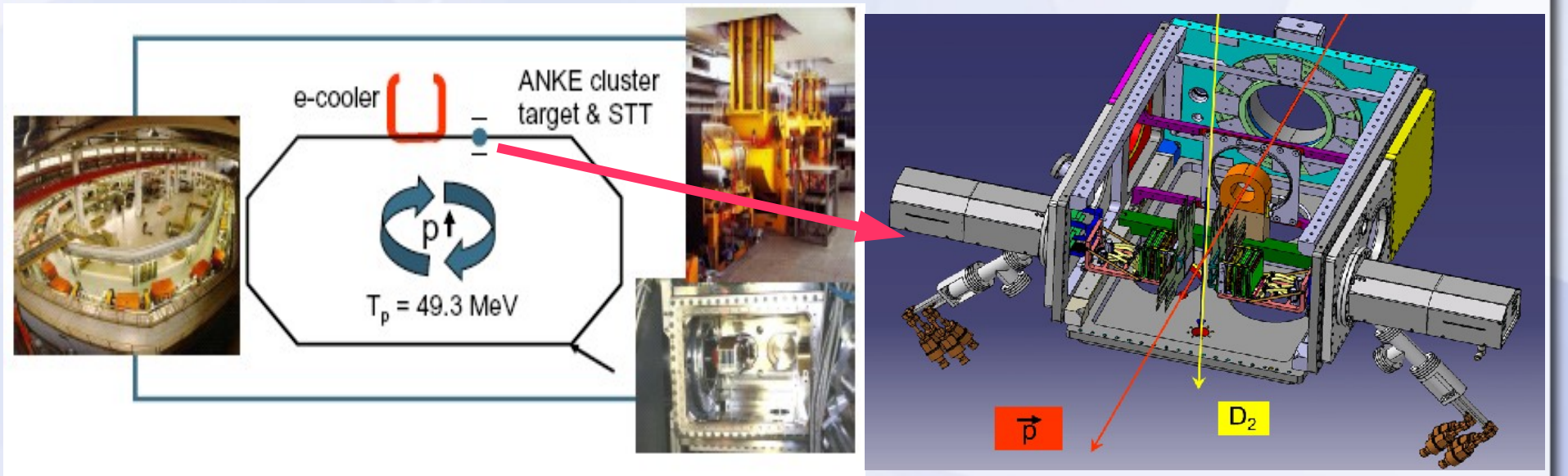

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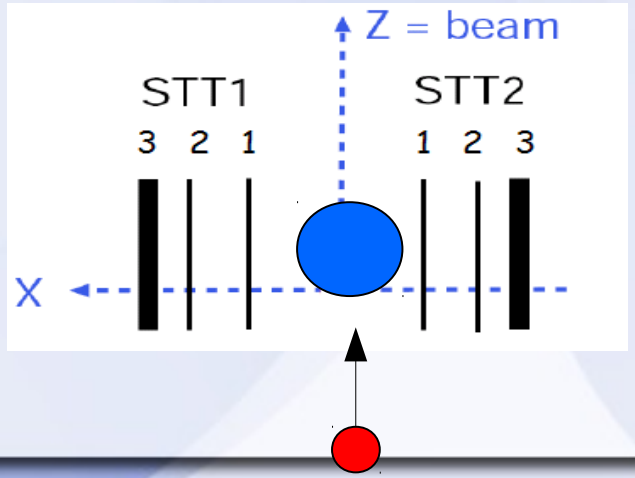

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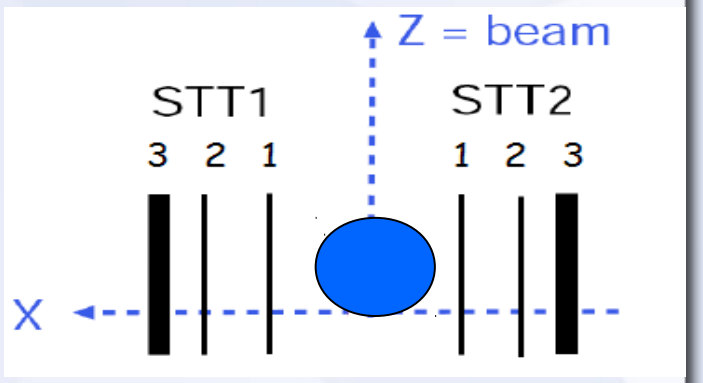

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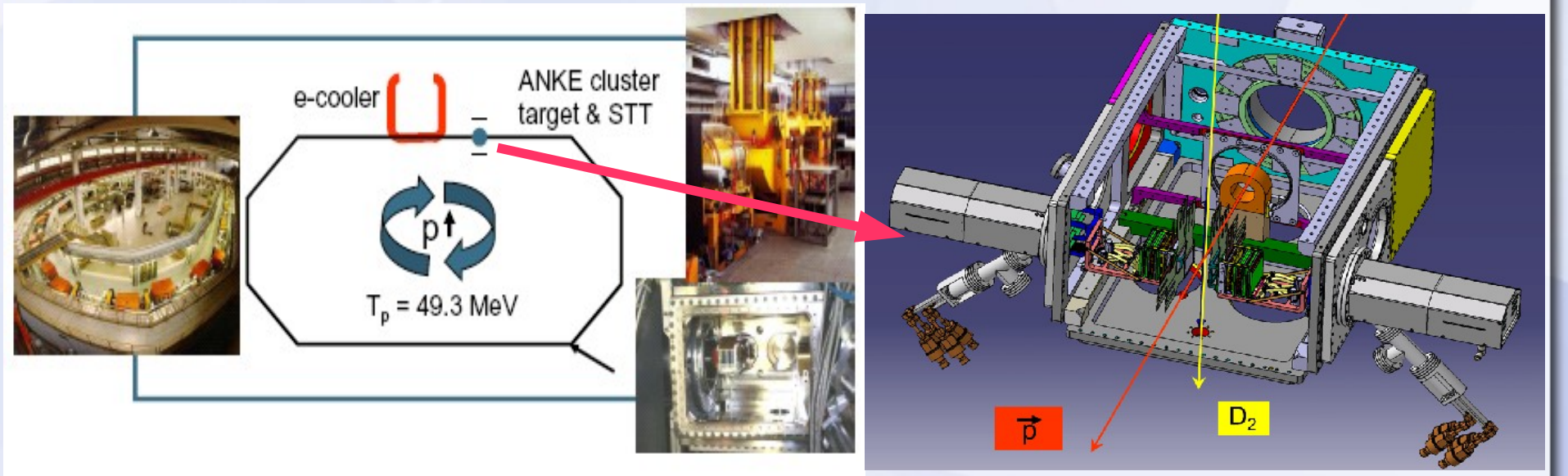

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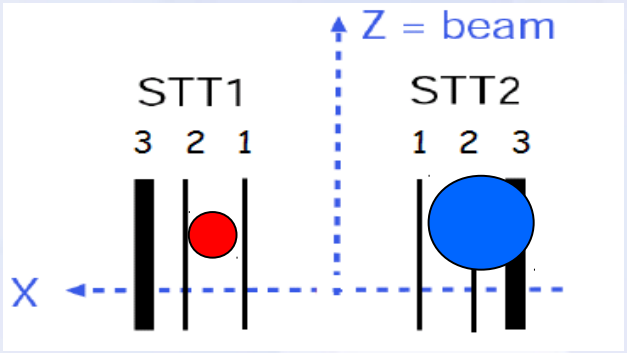

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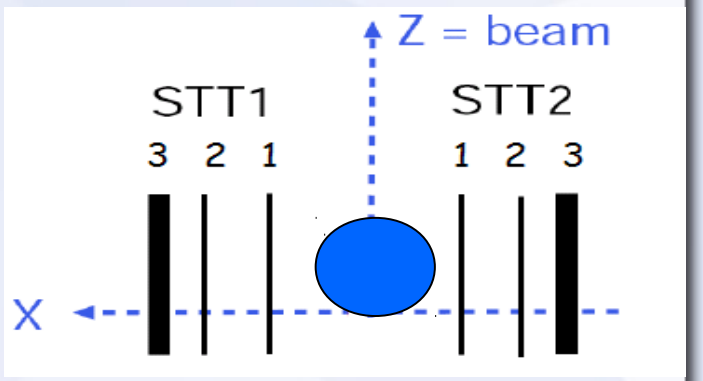

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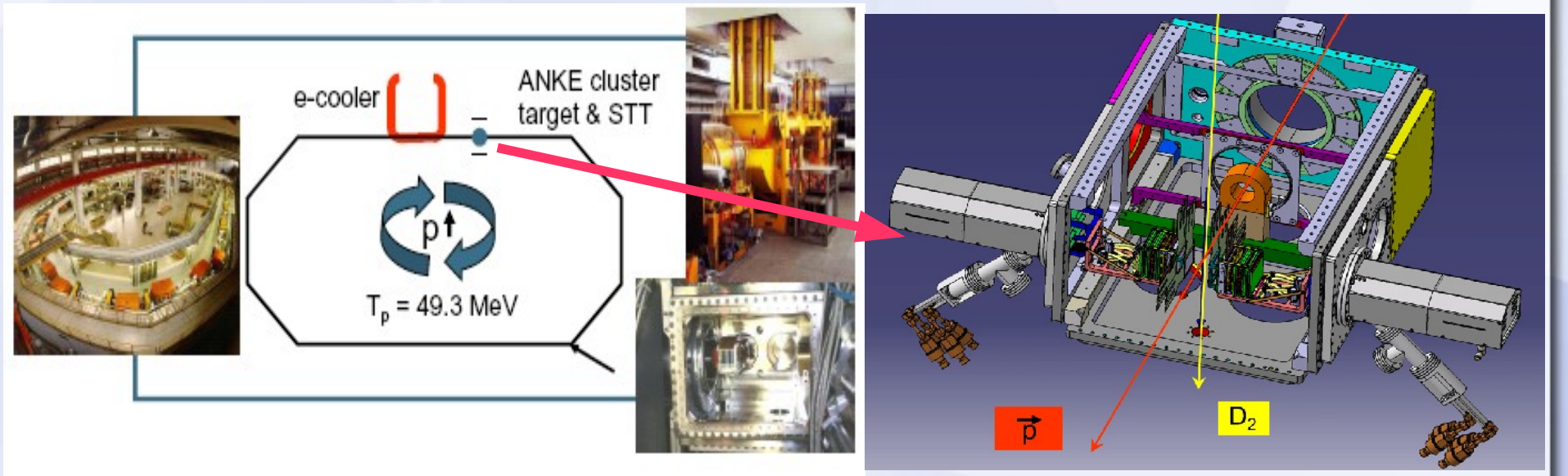

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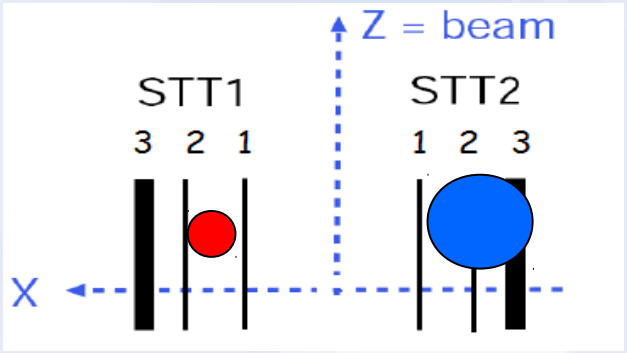

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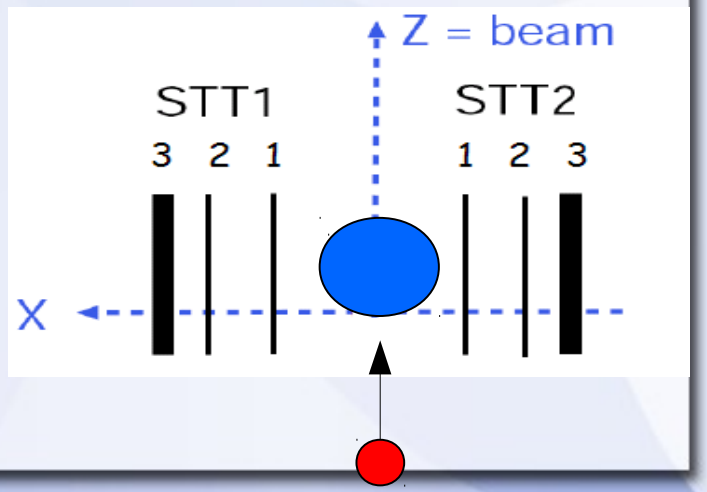

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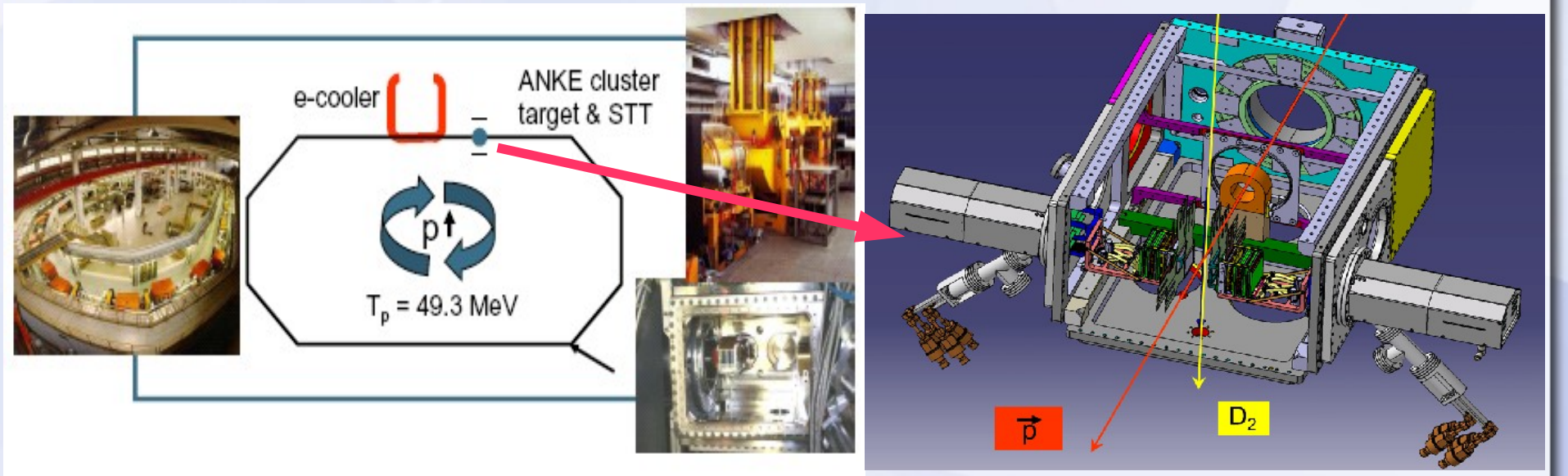

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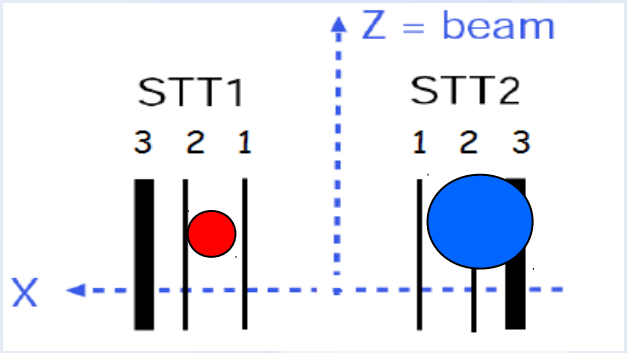

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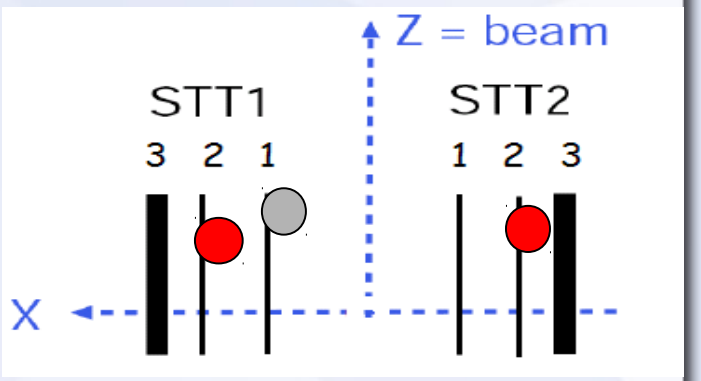

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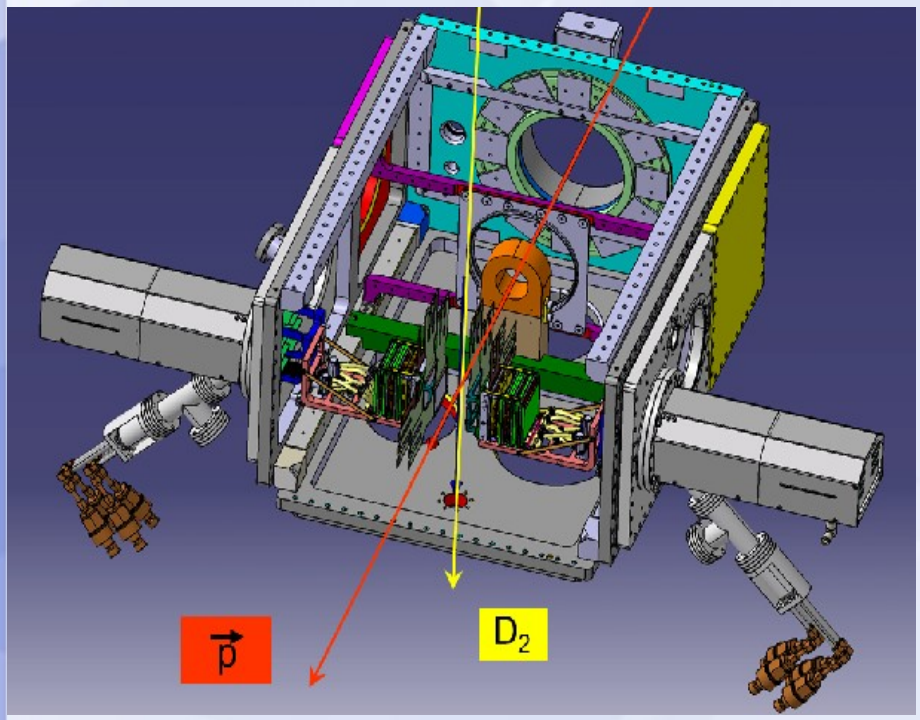

- *Proton Beam*
  - T_p=49 MeV
  - polarization state: Up, Down
- *Silicon Tracking Telescope*
  - Double-sided silicon sensors
  - Left-Right geometry
  - 3 layers per telescope:
  - 69 µm +300 µm + 5000 µm
- *Deuterium Cluster Target*
  - 10^{14} atoms/cm^2

Data analysis

- Goal: identification of pd breakup events with STTs
- Experimental data and Monte Carlo comparative analysis
- Procedure: (i) separation of protons from elastic and protons from breakup

  (ii) stopped protons selection

  (iii) tag the reaction with the Missing Mass

pd-breakup identification 1/3

- pd elastic and pd breakup separation (MonteCarlo → data)
  Deposited energy versus polar angle + co-planarity cut

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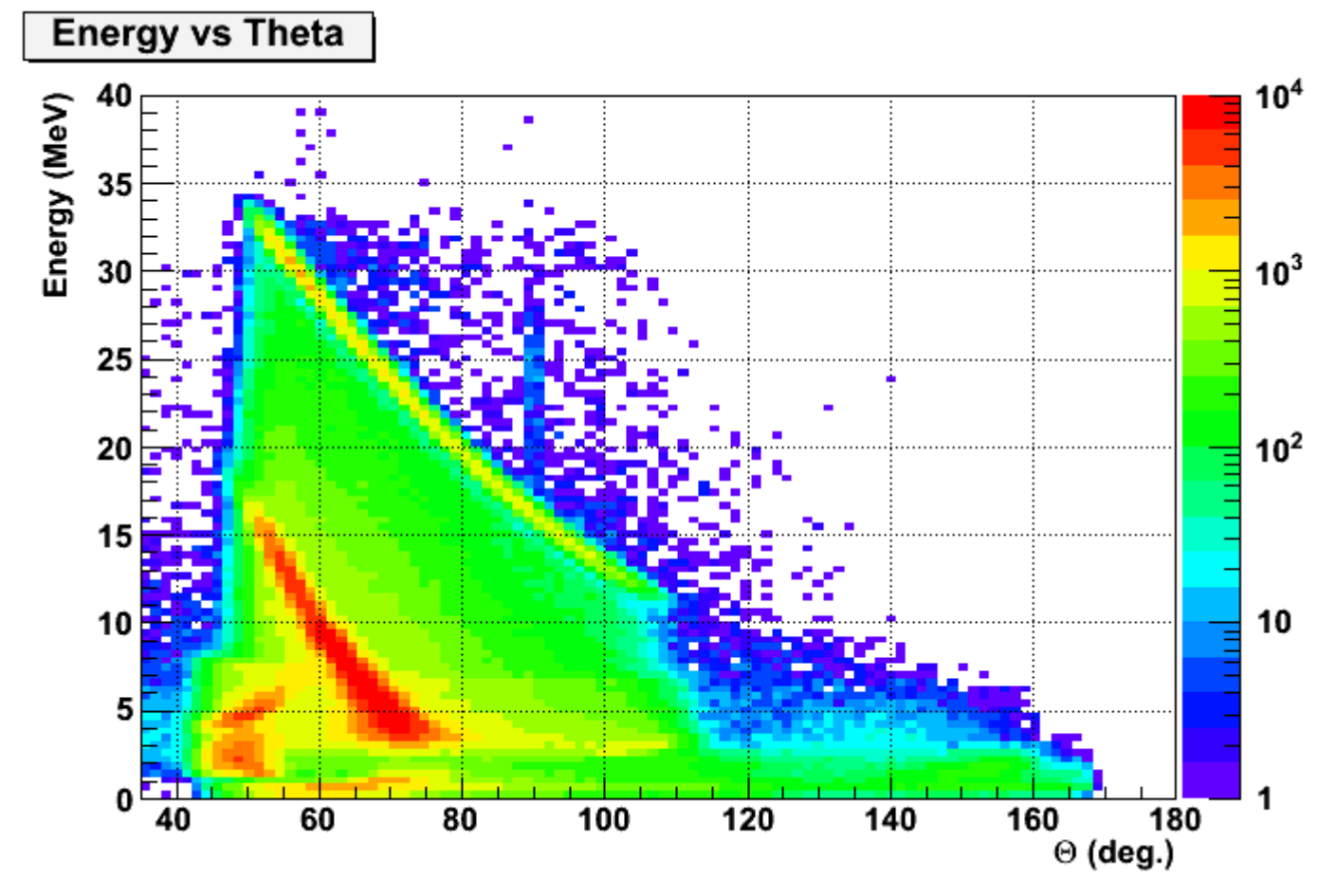

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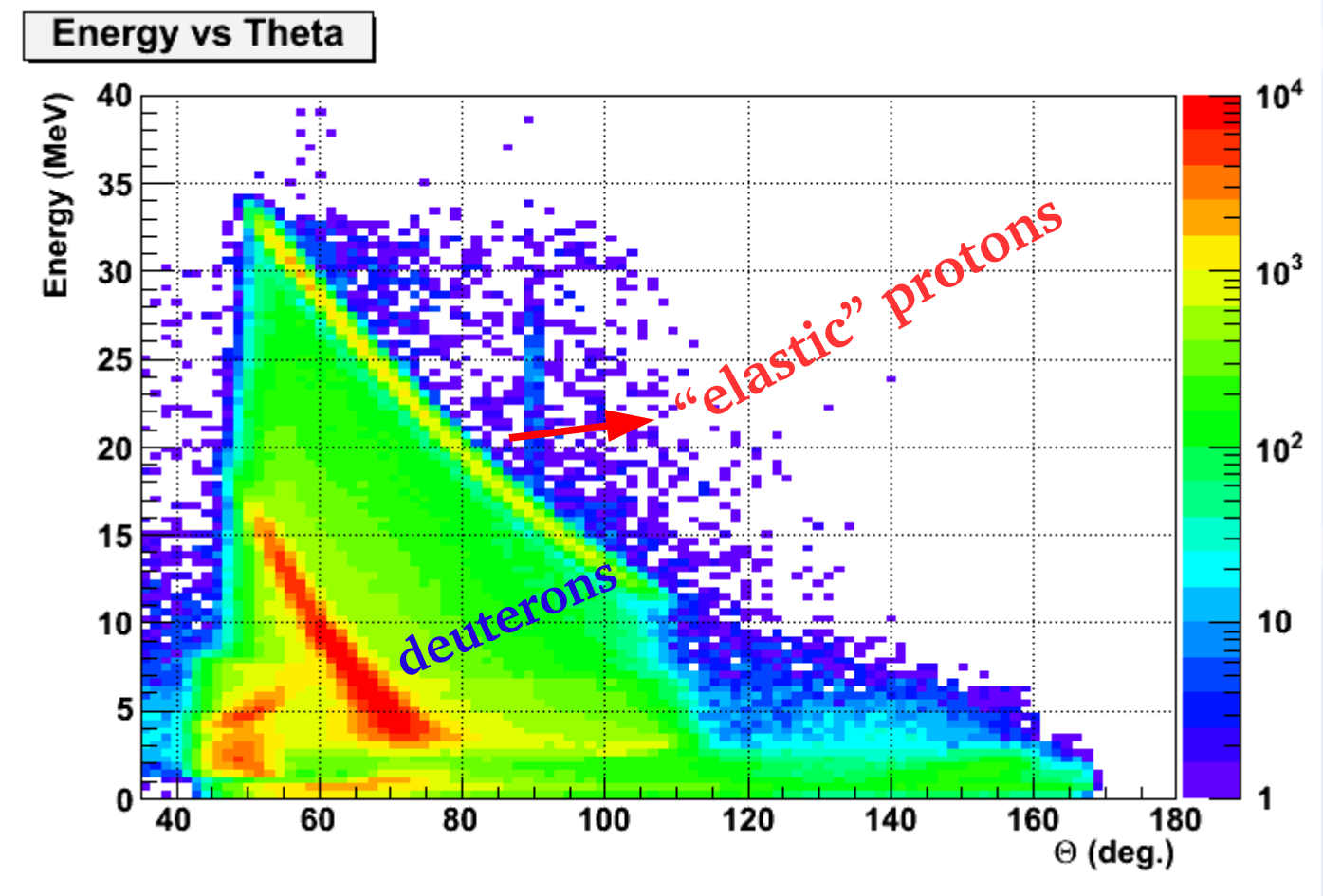

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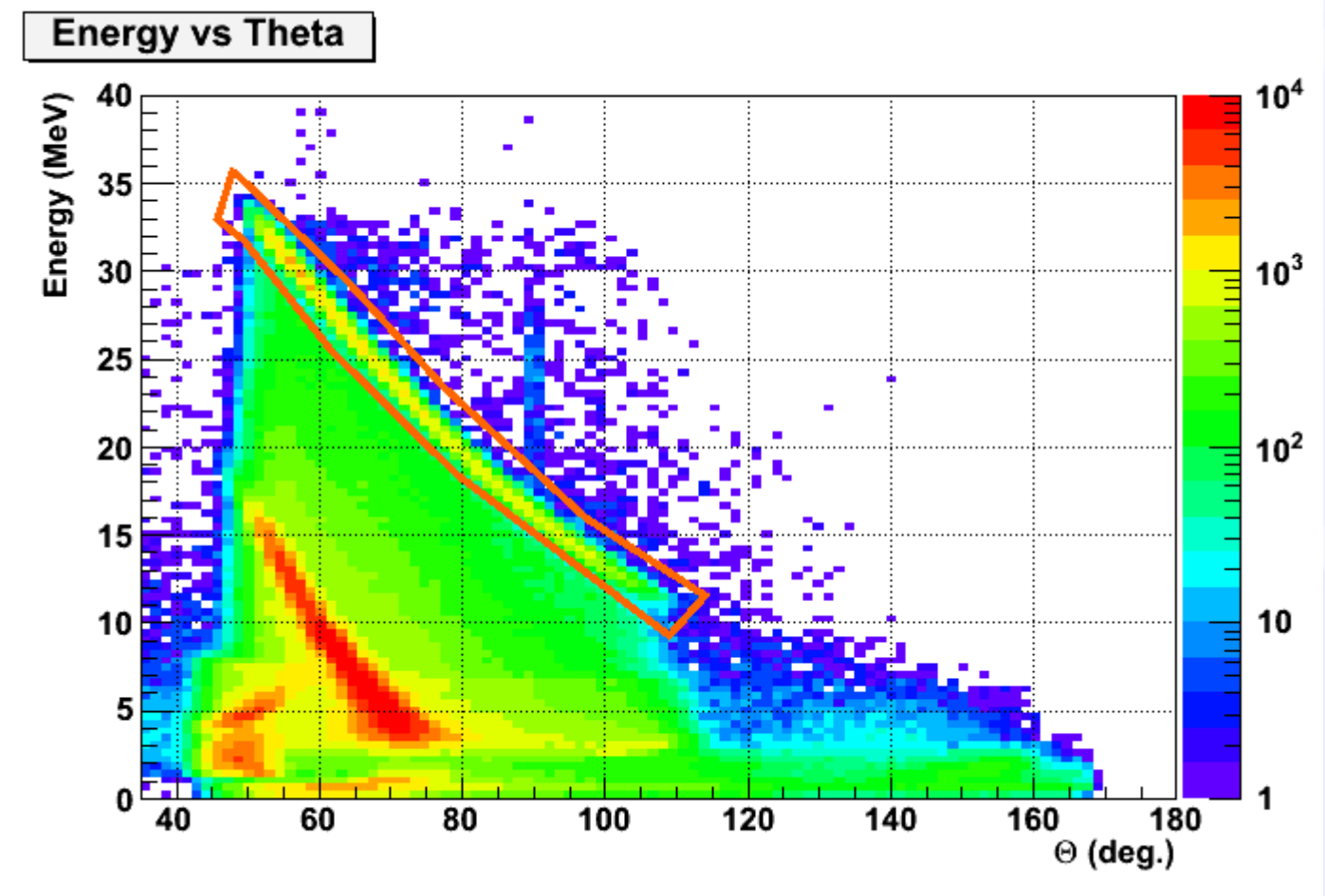

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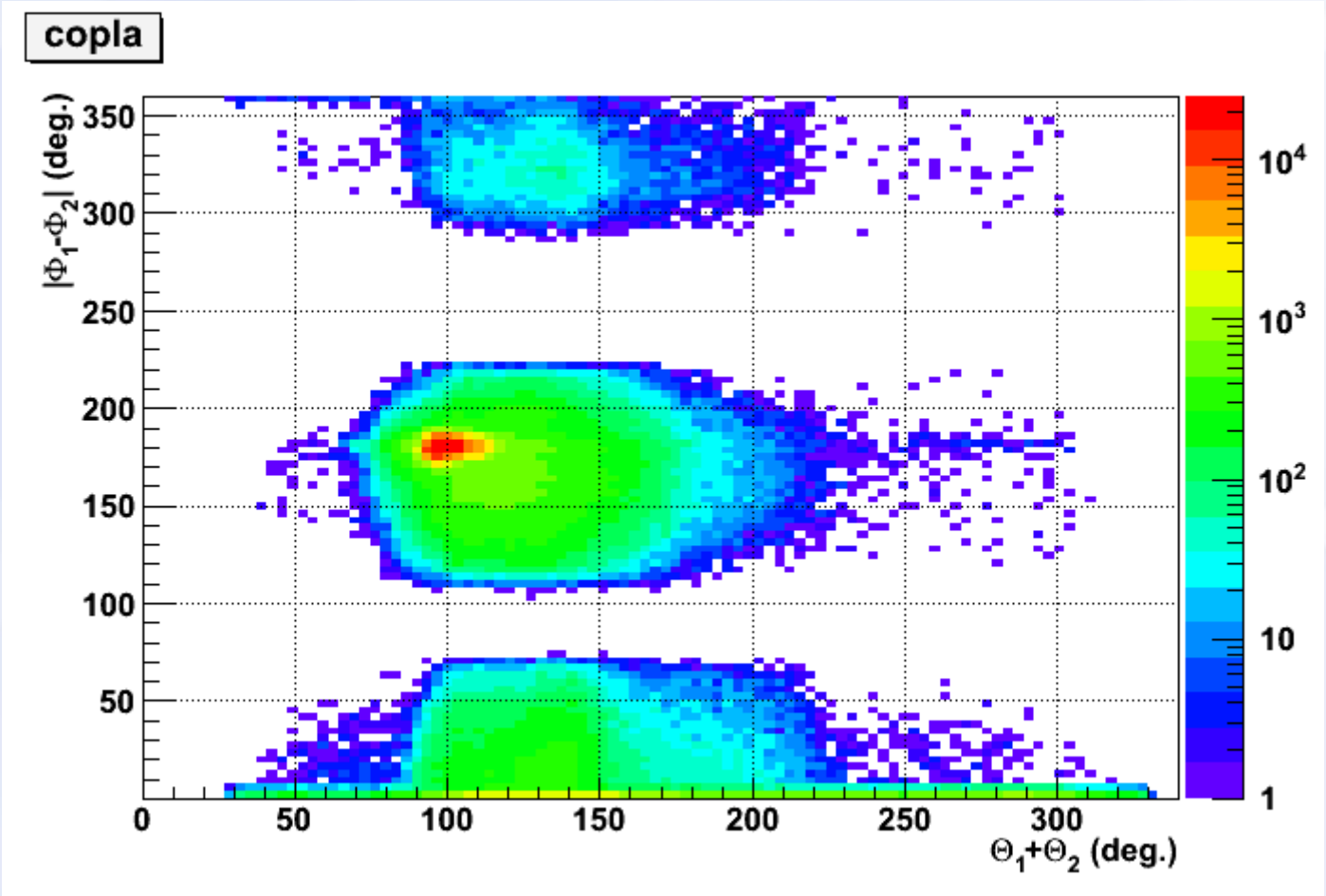

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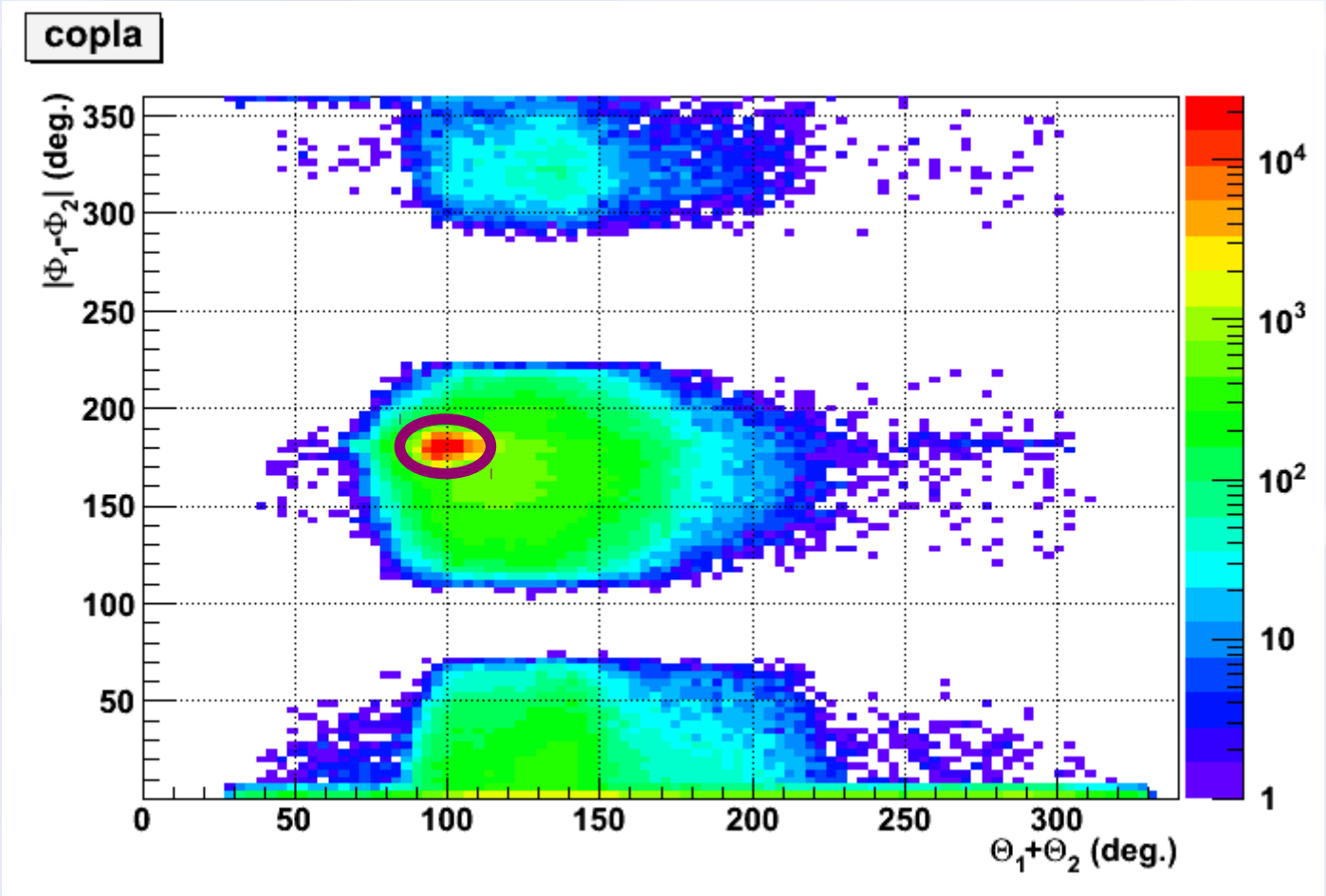
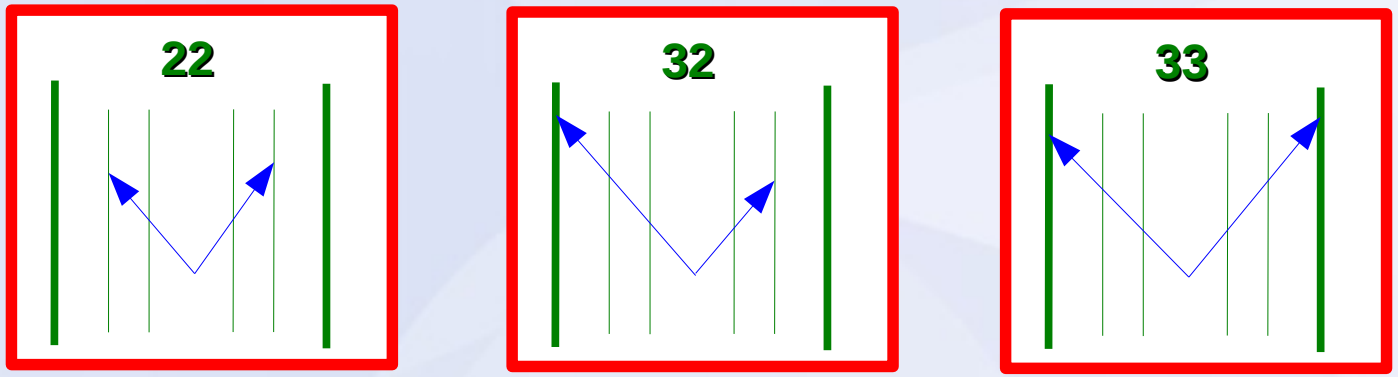
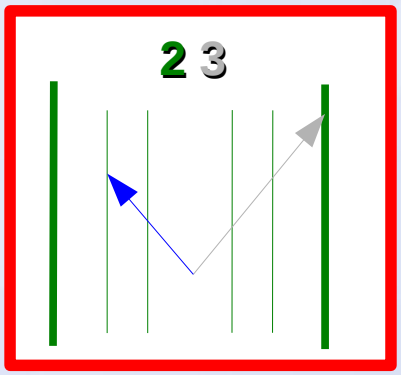


pd-breakup identification 2/3

- Selection of stopped protons

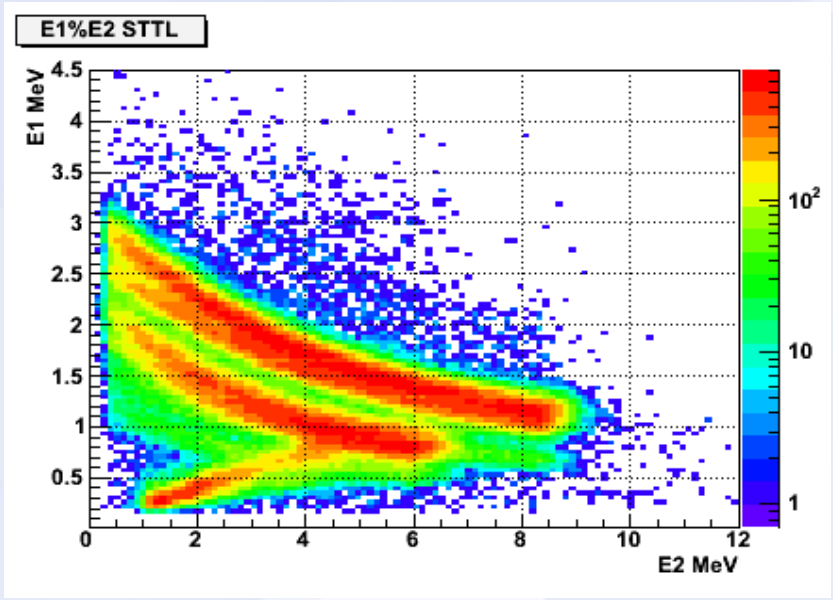


pd-breakup identification 2/3



Protons stopped on 2nd layer

ΔE/E plot + projection on 3rd layer



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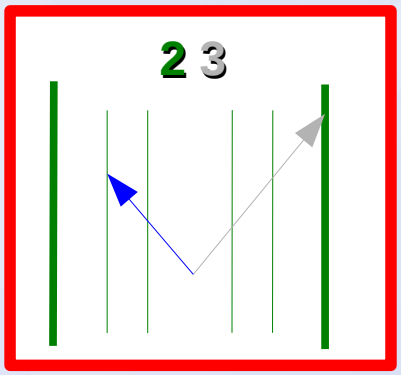

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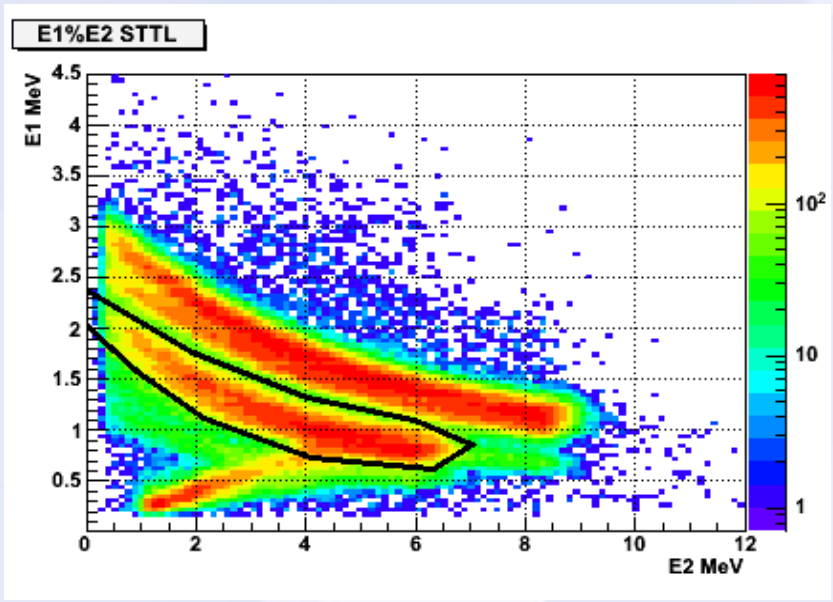

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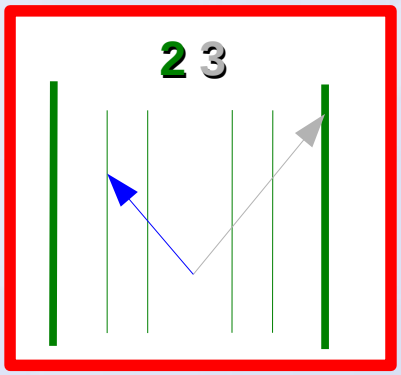

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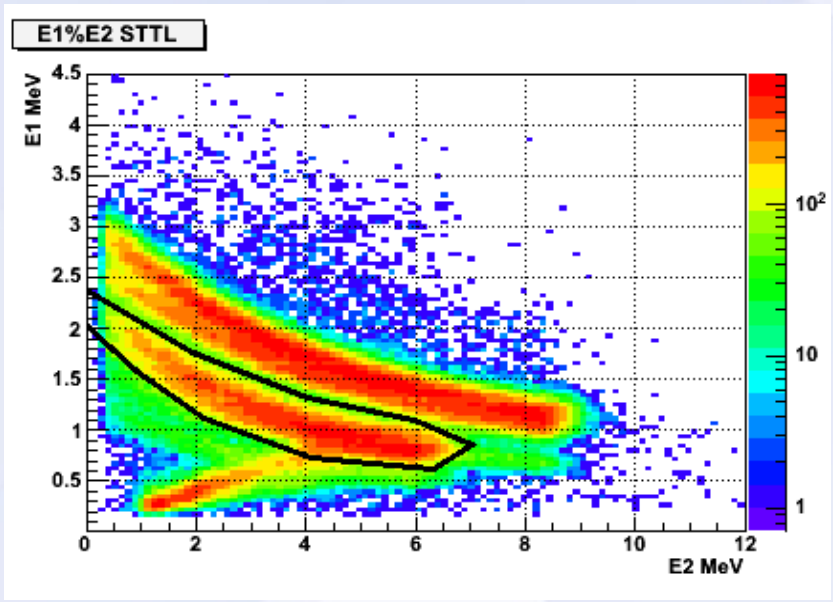

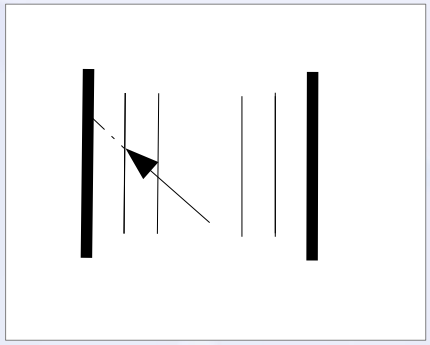

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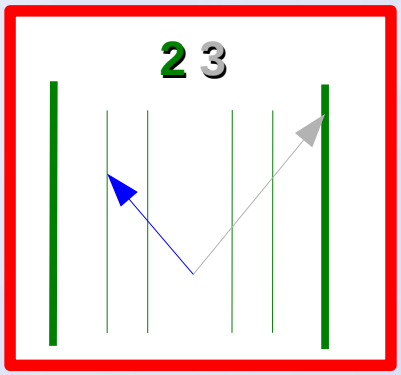

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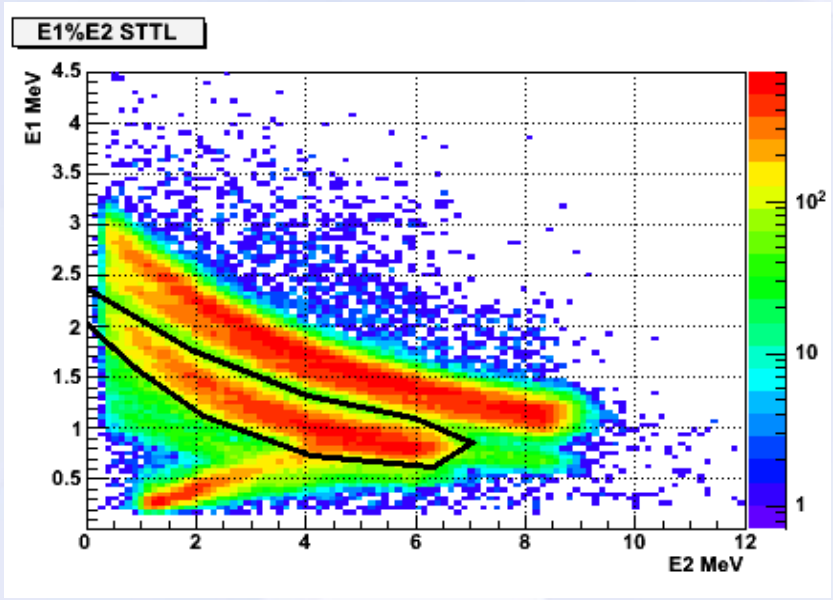

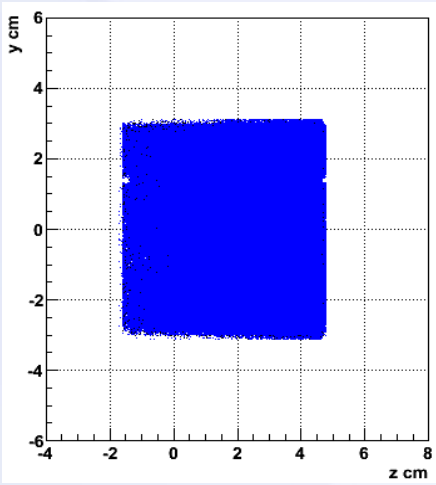

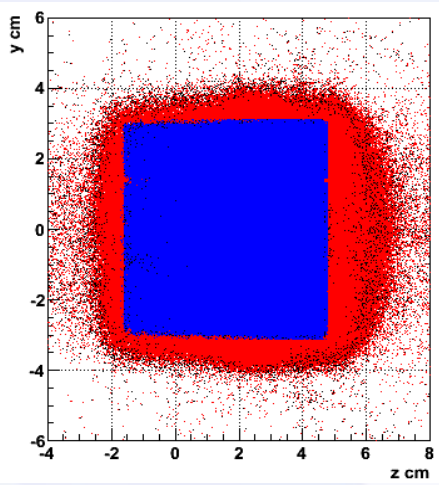

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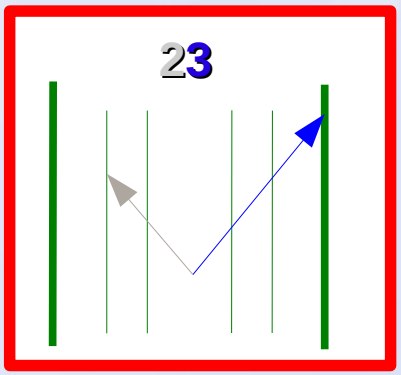

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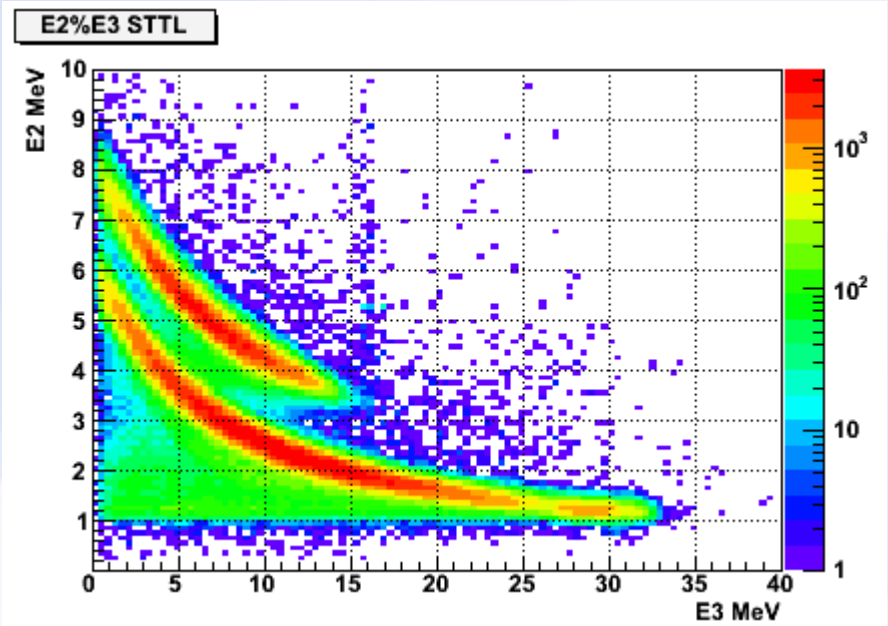

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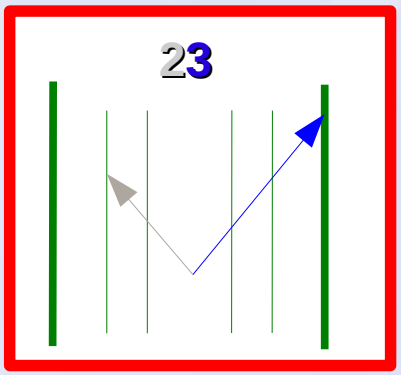

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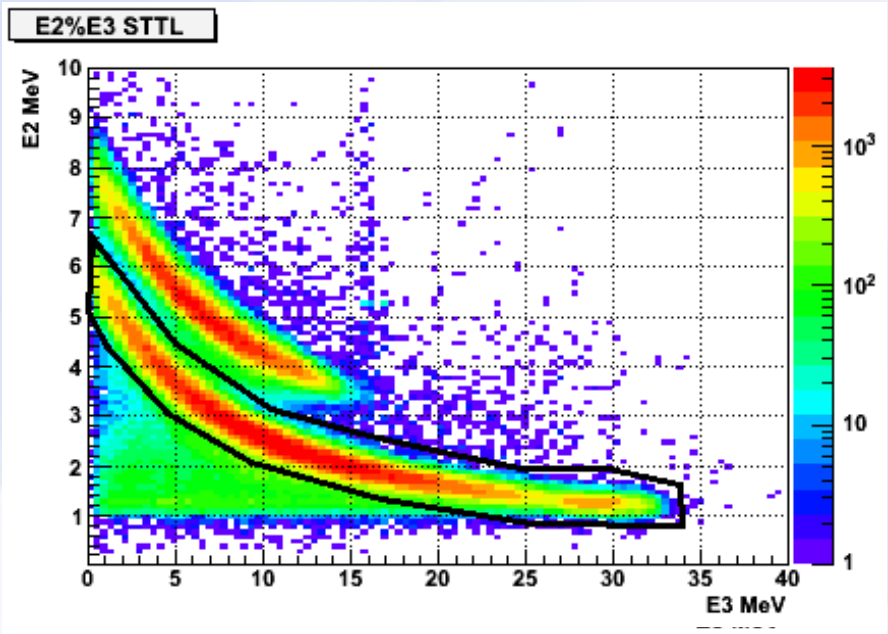
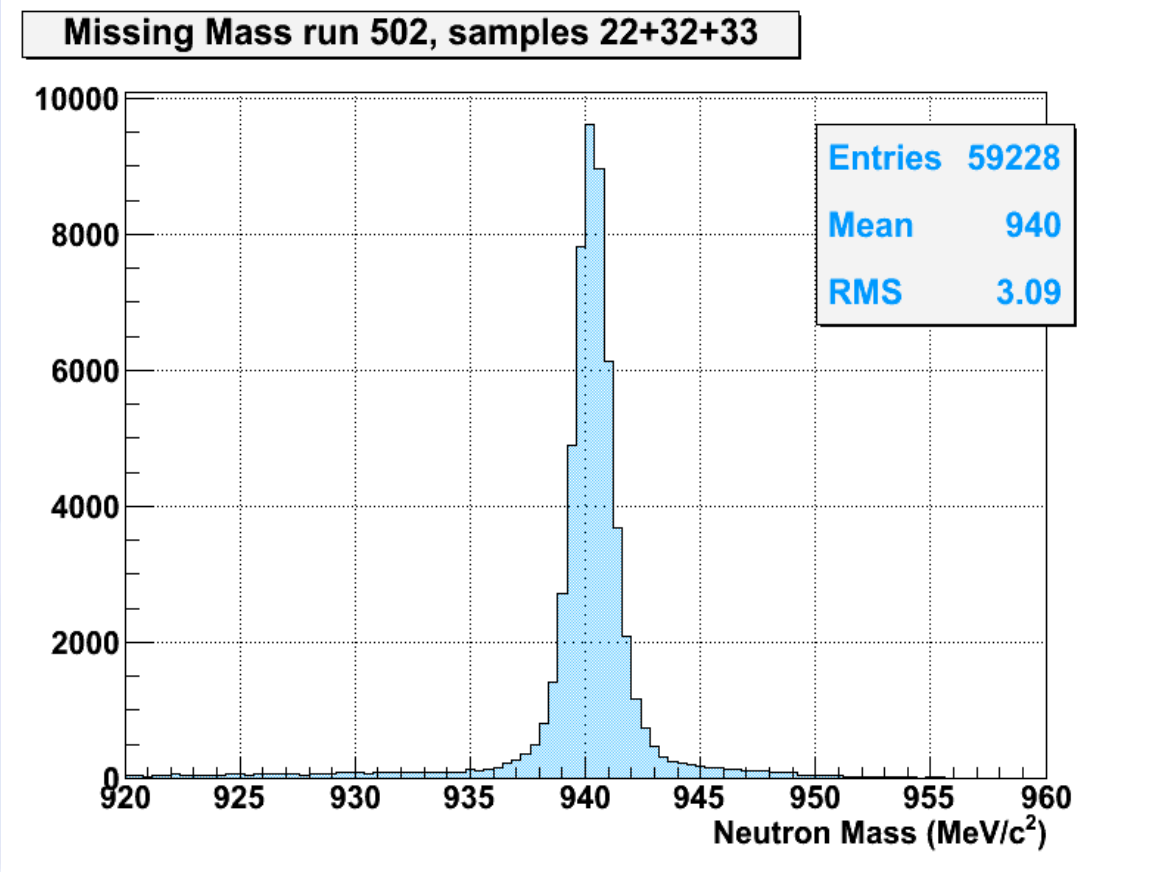


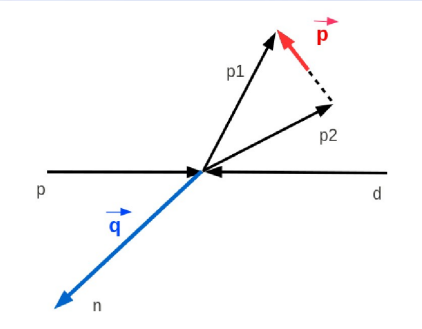
pd-breakup identification 3/3

Missing Mass calculation

$$n^{\mu} = p^{\mu}_{BEAM} + d^{\mu}_{TARGET} - p^{\mu}_{1} - p^{\mu}_{2}$$



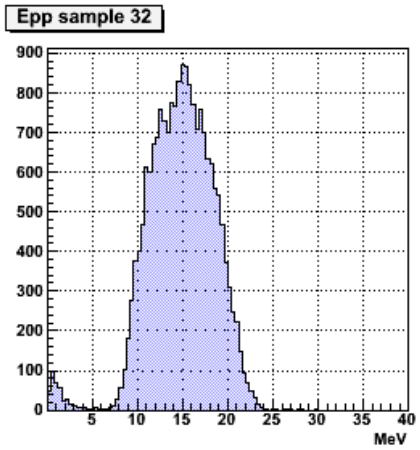
A look to neutrons phase space

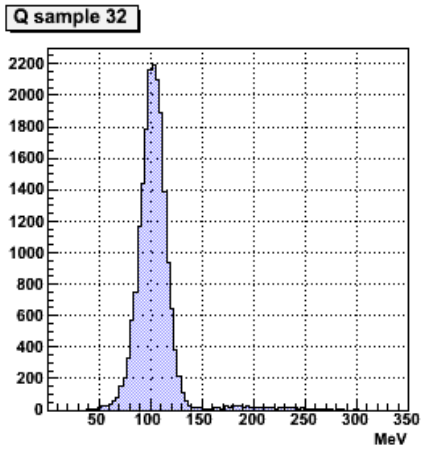


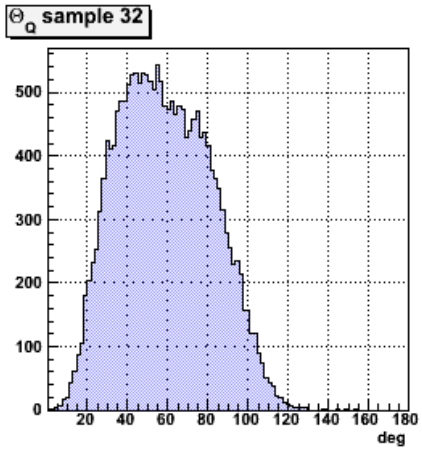
3 PARTICLES in final state Jacobi momenta

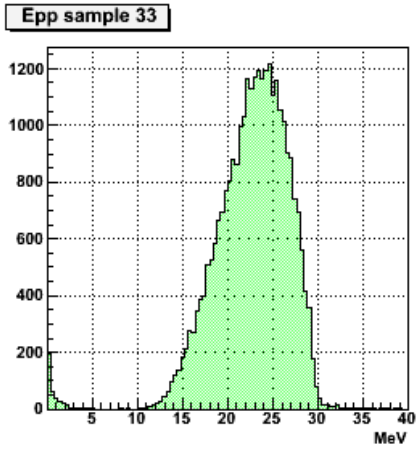
p = 1/2(p1-p2)

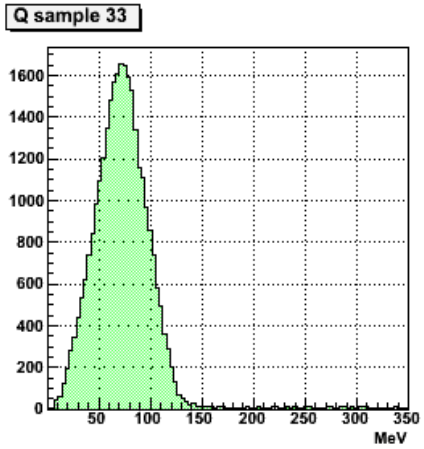
q = -(p1+p2)

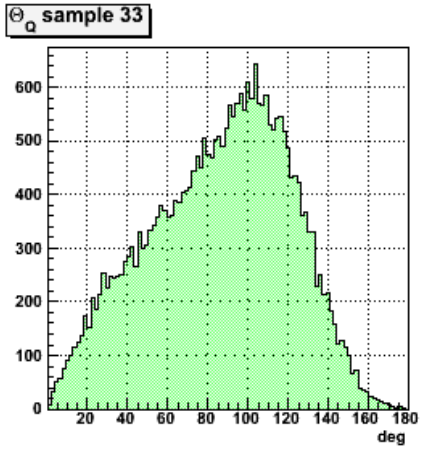










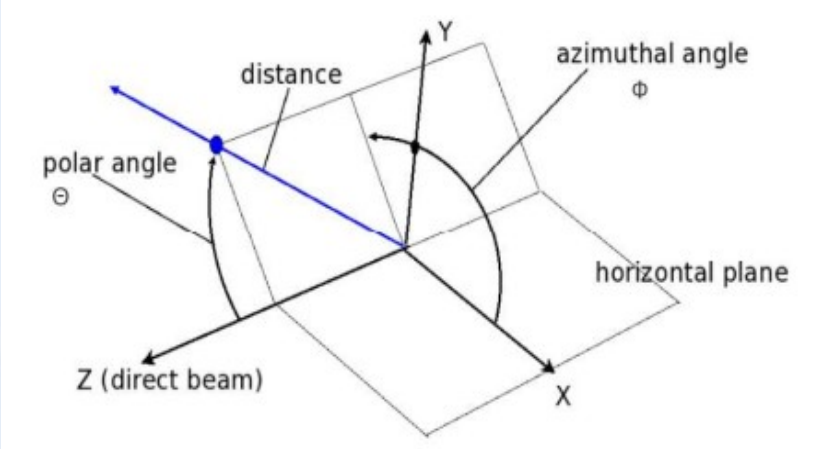


Application: asymmetry calculation

Spin dependent differential cross section for a spin ½ beam and an unpolarized target is given:

$$\frac{d\sigma}{d\Omega}(\Theta,\phi) = \frac{d\sigma_0}{d\Omega}(\Theta)\cdot[1 + P\cdot A_y\cdot cos(\phi)]$$

$$\varepsilon = P\cdot A_y\cdot cos(\phi)$$



$d\sigma_0/d\Omega$ unpolarized cross section

P beam polarization

A_y analysing power

A_y measurement for *pd* breakup

A_y *pd* → ppn with respect to the neutron:

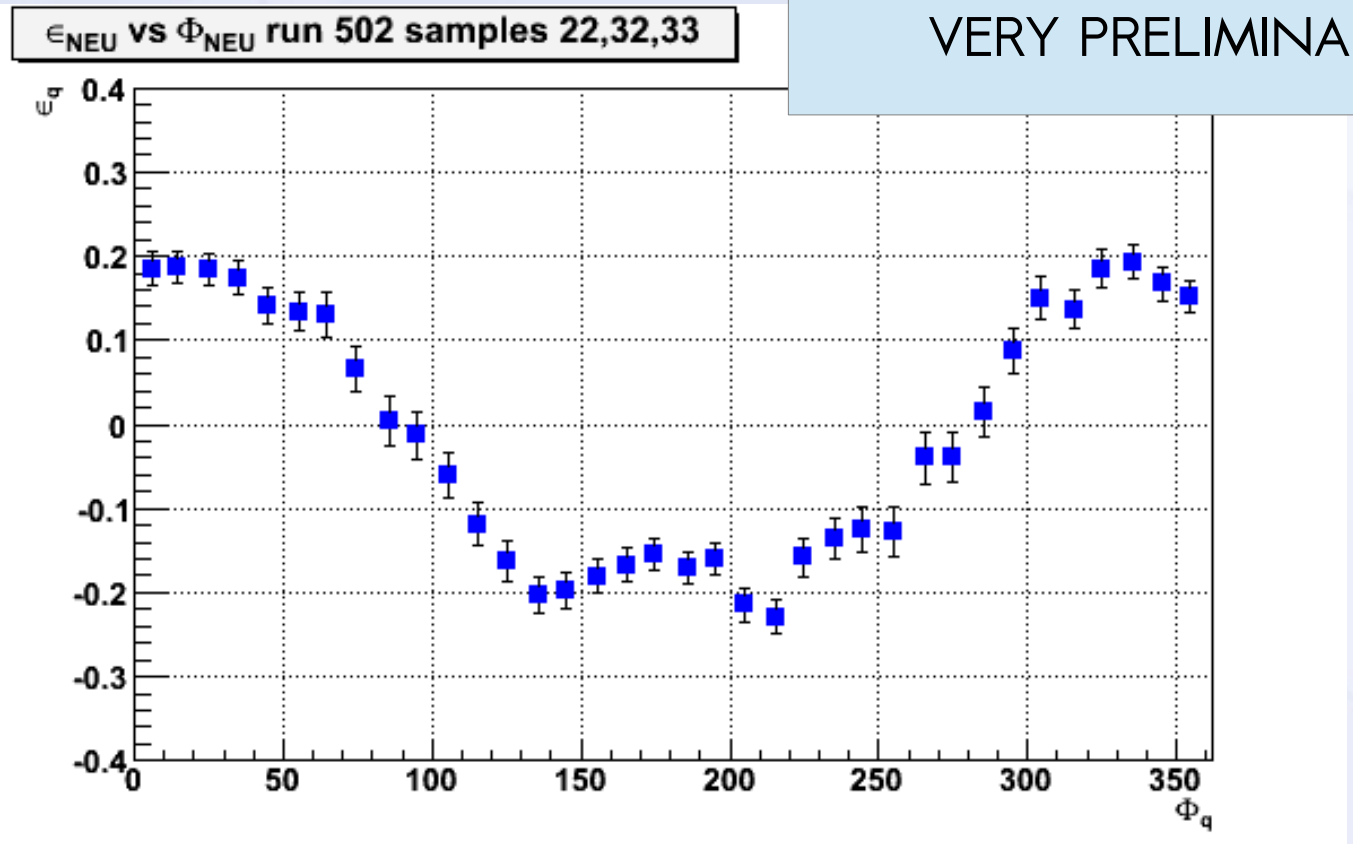
$$A_y = \frac{\varepsilon^n}{P_B \cdot \cos(\varphi)} \longrightarrow \varepsilon = \frac{n(\uparrow) - n(\downarrow)}{n(\uparrow) + n(\downarrow)}$$

$n(\uparrow)$ identified neutrons when Pol Up
$n(\downarrow)$identified neutrons when Pol Down

- Ay is usually represented with respect to one of the Jacobi momenta and integrated over the others

ε for pd breakup run test 502

VERY PRELIMINARY



Conclusions

- pd breakup identified in run 502 August11
- Beam polarization calculation with protons to be carried out
- Ay of pd → ppn with respect to the neutron, data to be added to the analyzed 504-509 runs.
- Comparison with theory
- Other observables

Acknowledgments

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