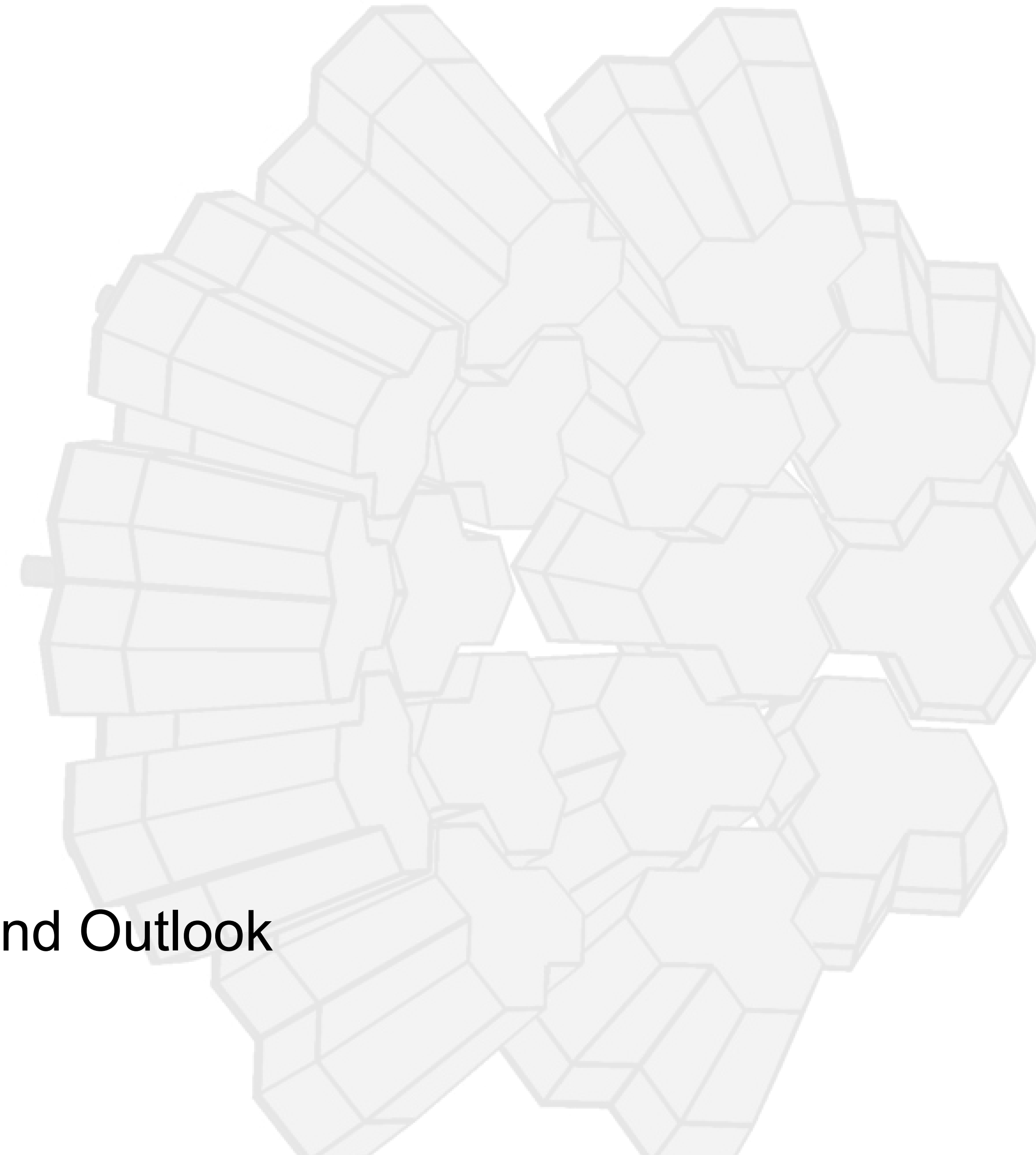
Report I on the in-beam test of the HPGe single crystal detector at COSY

Marcell Steinen

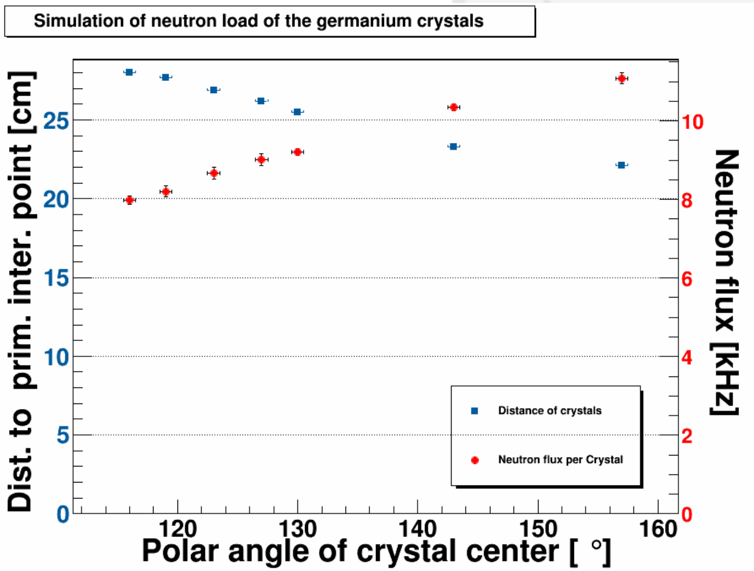
Outline

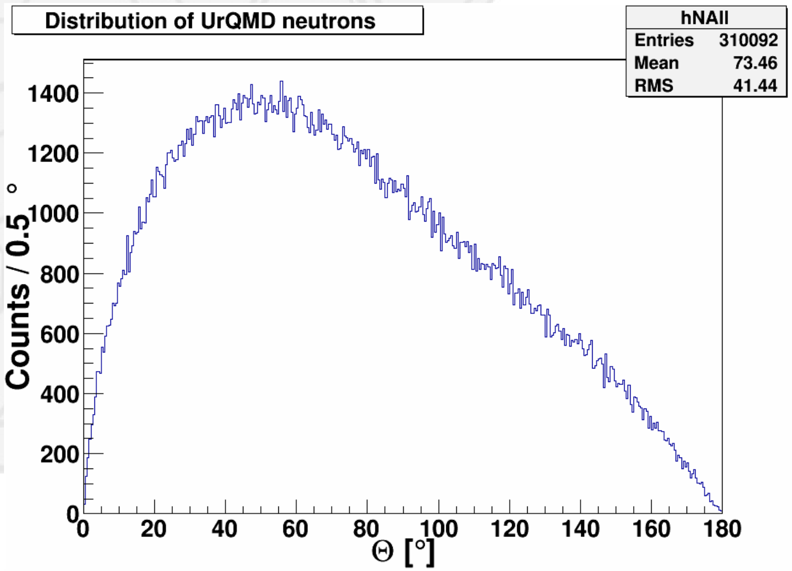


- Motivation
- Setup
- Data taken
- Problems
- Simulation
- Summary and Outlook

Motivation

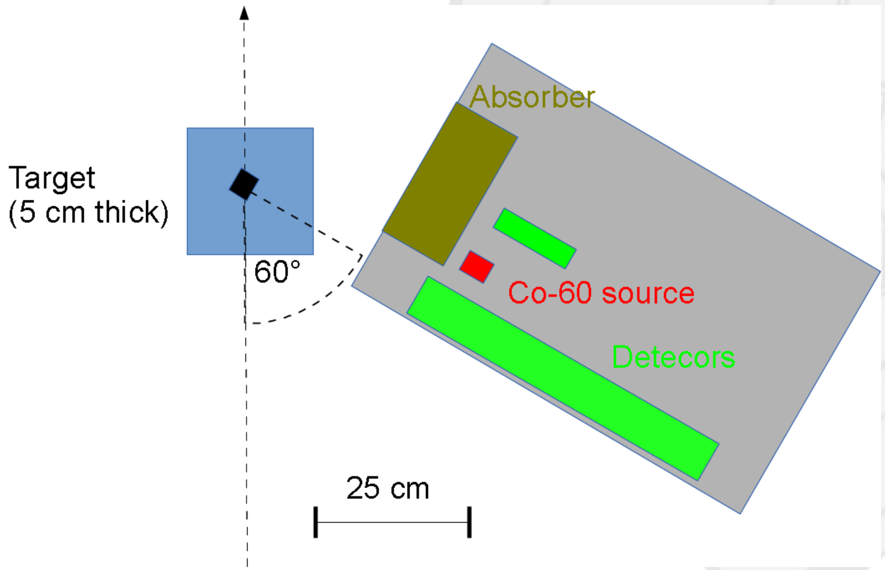
- Why the beam time in Jülich@COSY?
  - Influence of particle background on the detector must be tested
    - ➔Radiation damage of crystals?
    - ➔Direct effect on the energy resolution due to pile-up?
  - Spectrum of 3 GeV/c protons is similar to anti-protons in backward angles

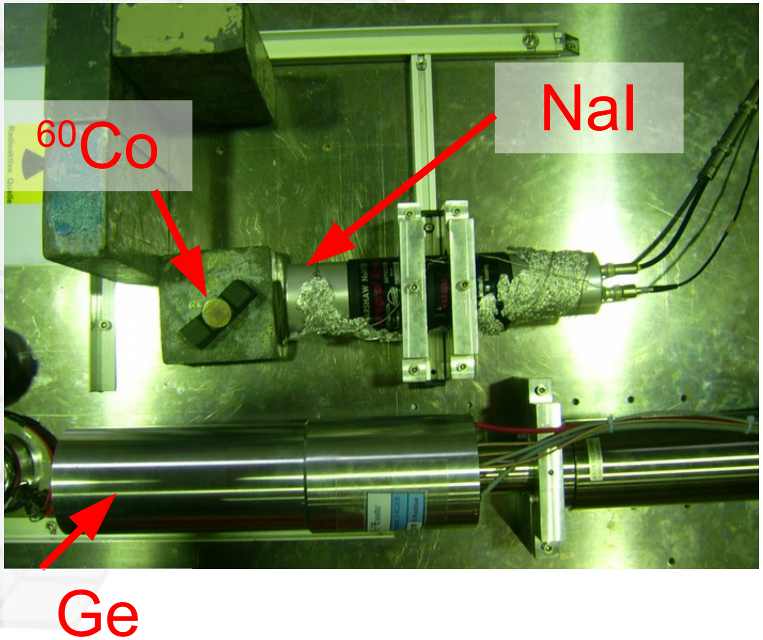




Planned Setup

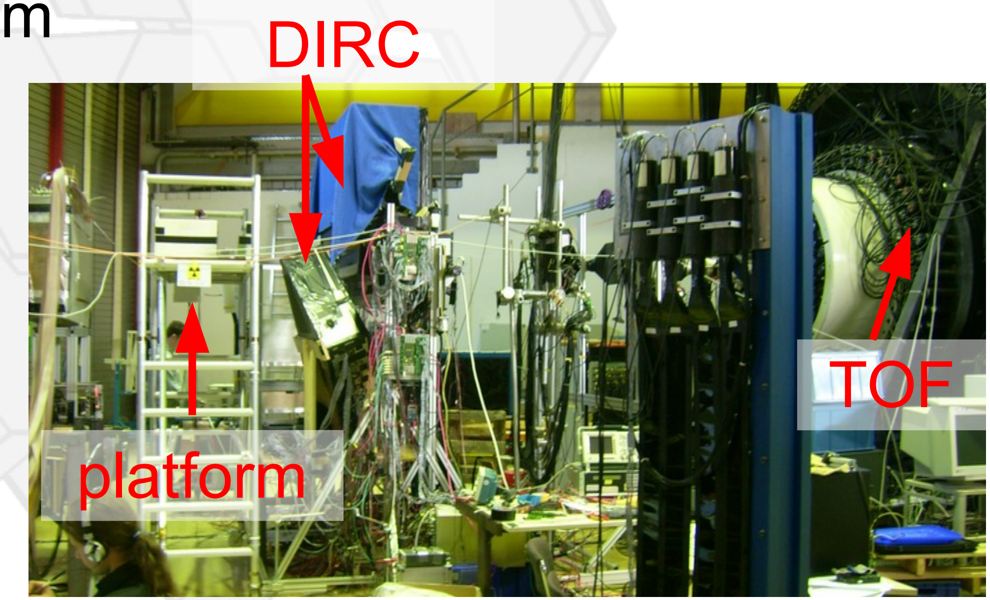
- Measure the resolution of a ^{60}Co source
- Detector at θ =120°, distance to target 30 cm
- 5 cm thick carbon target (~10 % interaction rate)
- NaI scintillator as coincidence trigger



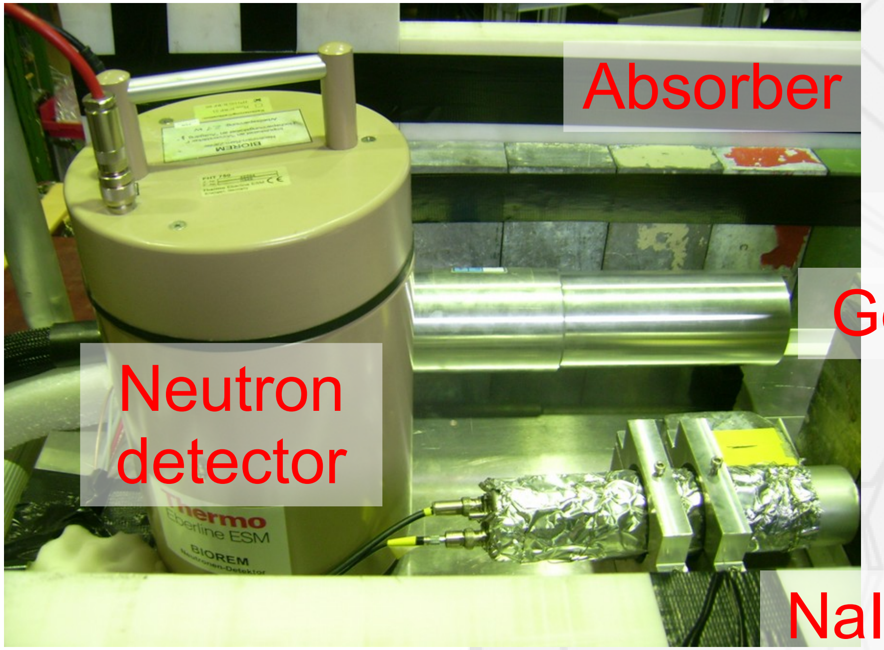


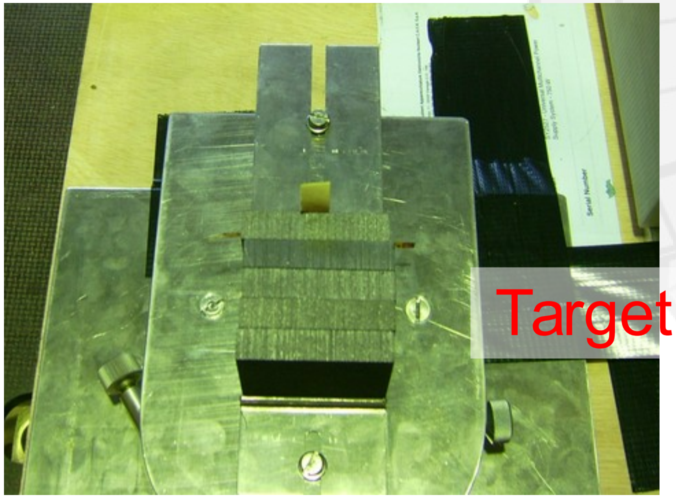
Real Setup

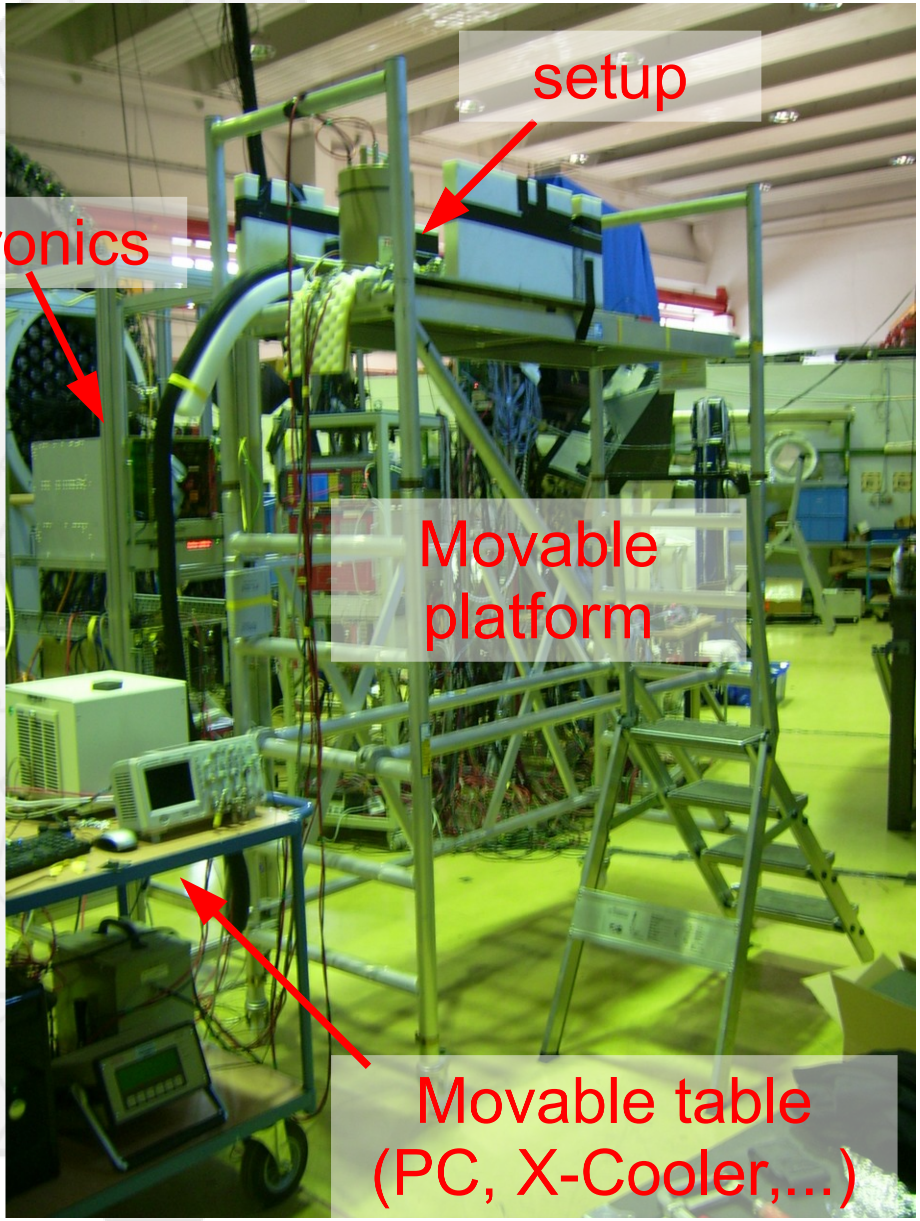
- Space in experimental area (TOF area) was very limited!
- Height of beam line: 220 cm → setup must be placed on platform
- No high θ angle possible → 90°
- A lot of material in front of the target
- Detector – target distance: 30 cm
- new cryostat (T ~ -178 °C)
- 5 cm lead absorber
- 5 cm boron doped PE
- Neutron detector



Real Setup (2)

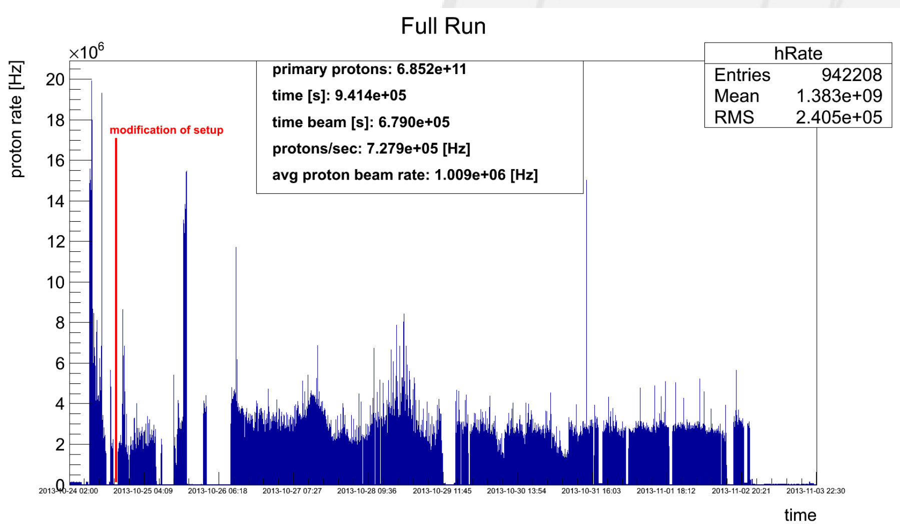

Absorber
Neutron detector
Ge
NaI
electronics

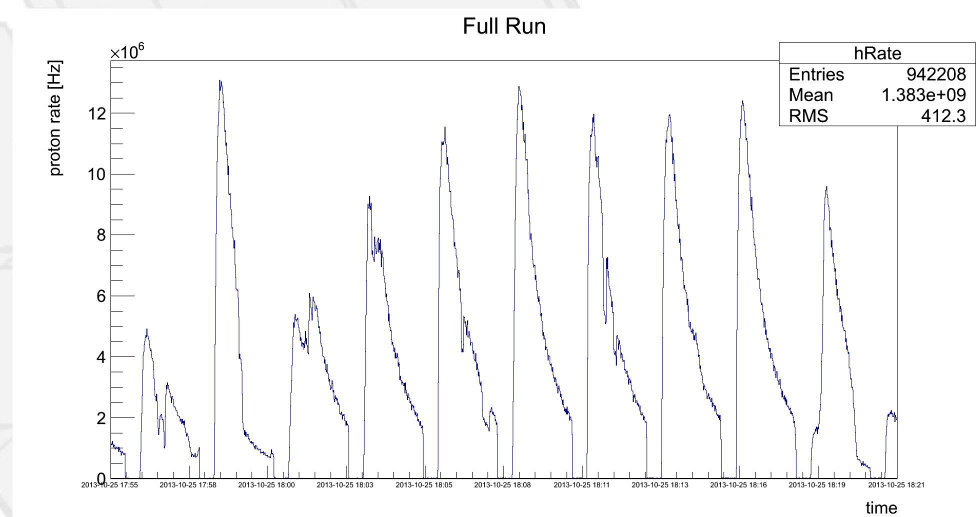

Target


setup
Movable platform
Movable table (PC, X-Cooler,...)

Beam parameters

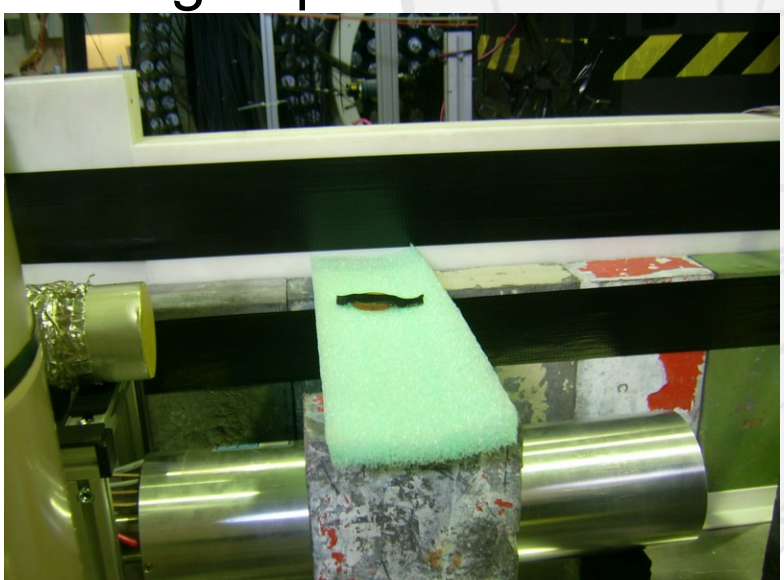
- 6.8*10^{11} 3 GeV/c protons
- Beam is focused on TOF target
- beam diameter @ carbon target ~2 cm





Modification of detector position

- Too many primary protons on first detector position
- no additional absorber possible (space limitation)
- Distance of target to detector changed to 90 cm
- Scintillator added to coincidence for on beam triggering
- Changed position of NaI and source

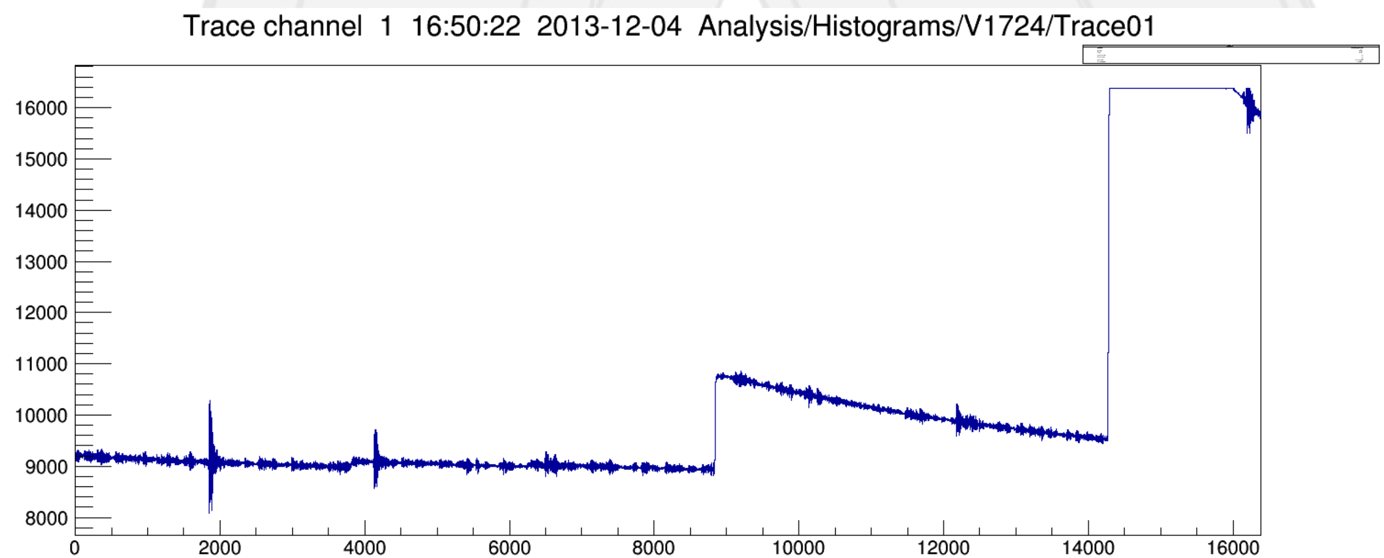


Data taken

- $4.3*10^{10}$ protons on position 1
- $6.4*10^{11}$ protons on position 2
- 100 MSamples/s 14 bit FADC, 500 mV dyn. range
- analog timing (triggering) circuit
- Length of trace varied between 5 µs and 160 µs
- 540 GB of Data taken:
  - ➔58 GB without beam
  - ➔7 GB in position 1
  - ➔190GB in position 2
  - ➔276 GB in position 2 with on beam triggering
- in total ~ 20 million traces

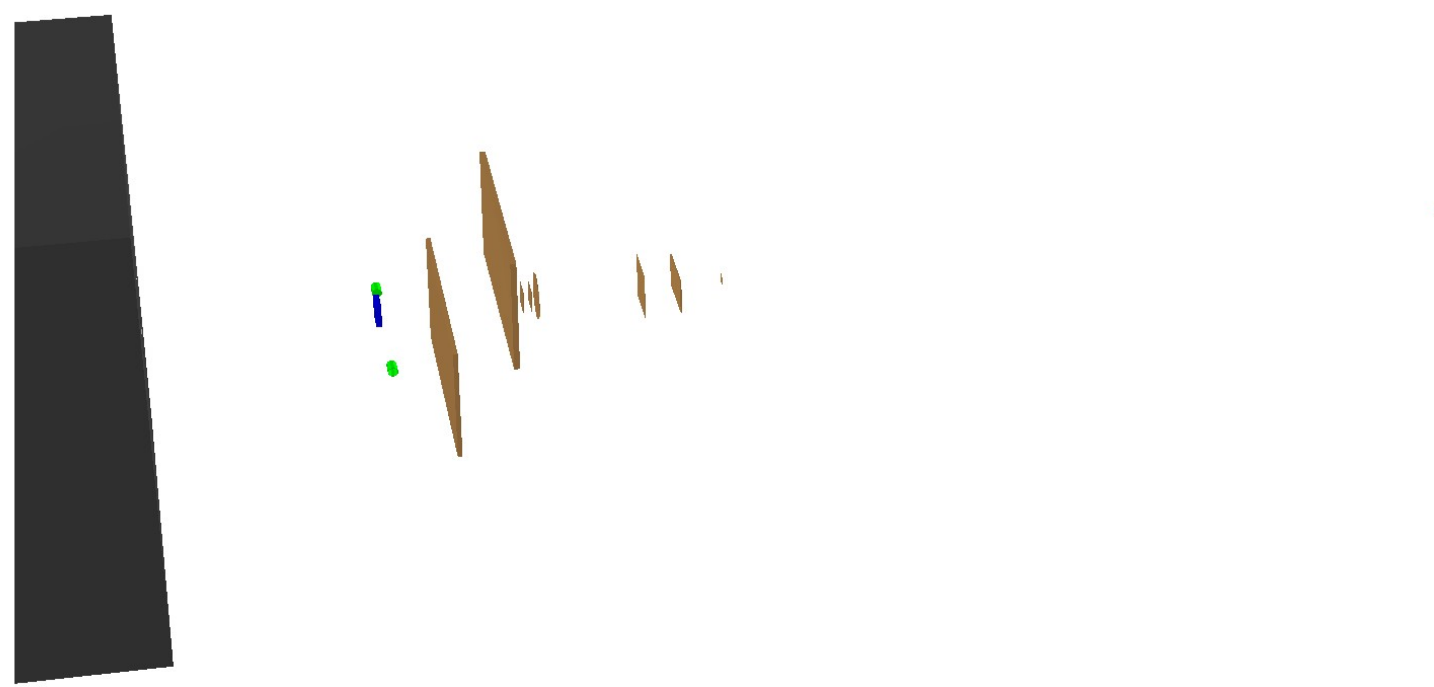
Signal shape

- Noise
  - better grounding needed
- High energy particles
  - Need of active resetting preamplifier

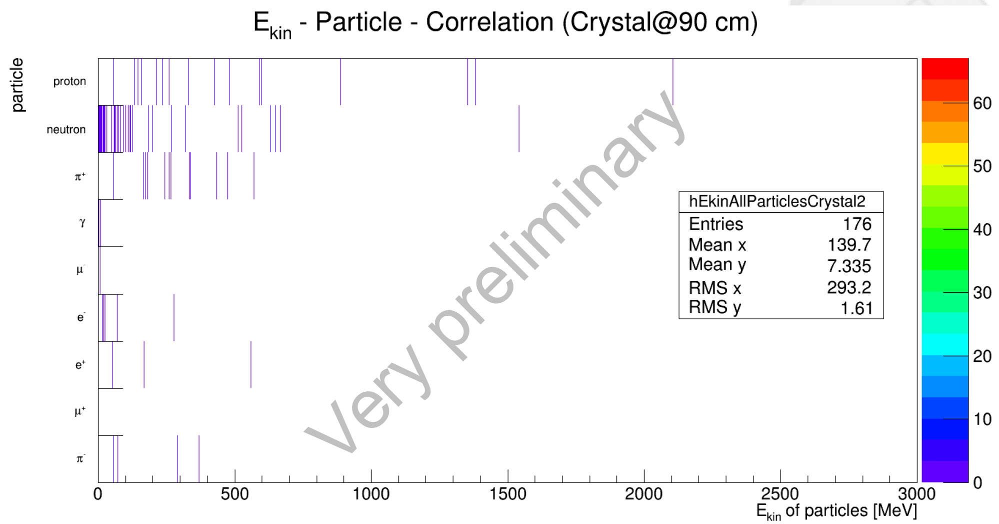


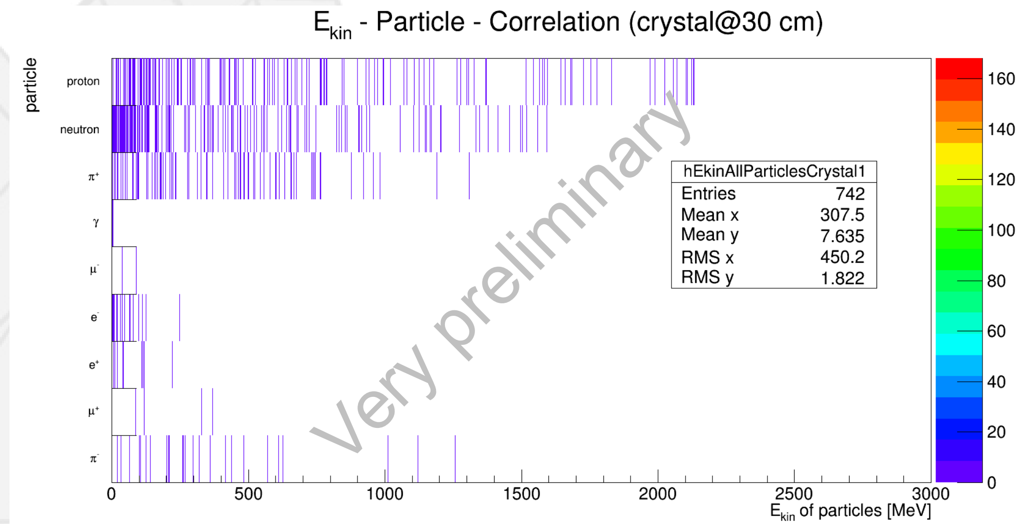
Simulation of beam time

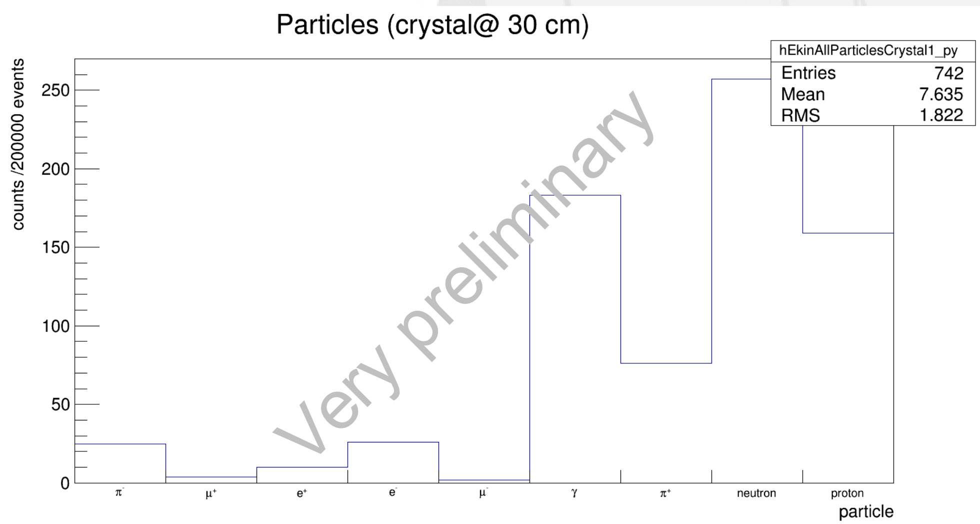
- material in front of target ignored in previous simulation
- included in new geometry (preliminary, no absorbers yet)
- simulation with $2*10^5$ 3 GeV/c protons (memory leak prevents atm more!)



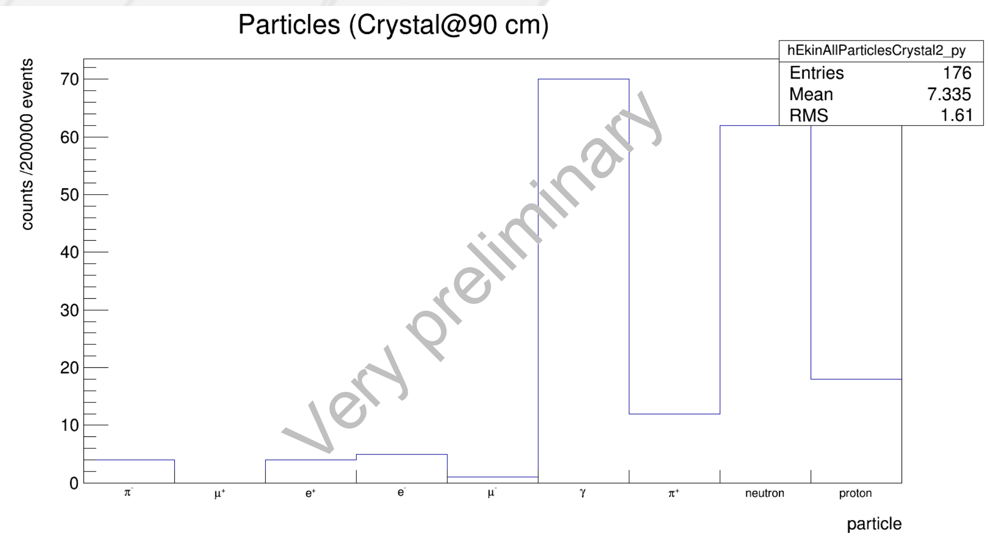
Simulation of beam time (2)







12.85 kHz neutron rate in position 1



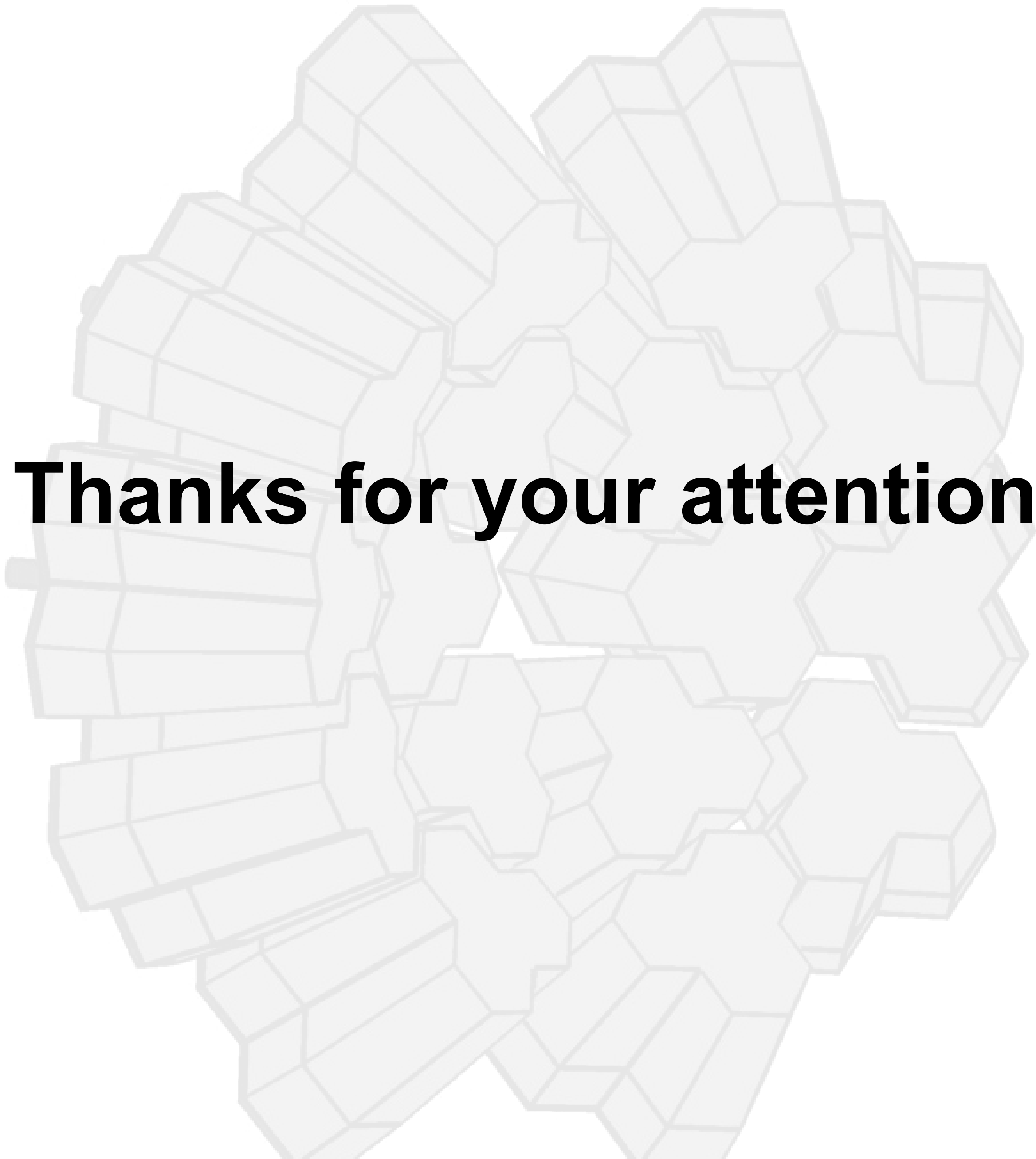
3.1 kHz neutron rate in position 2

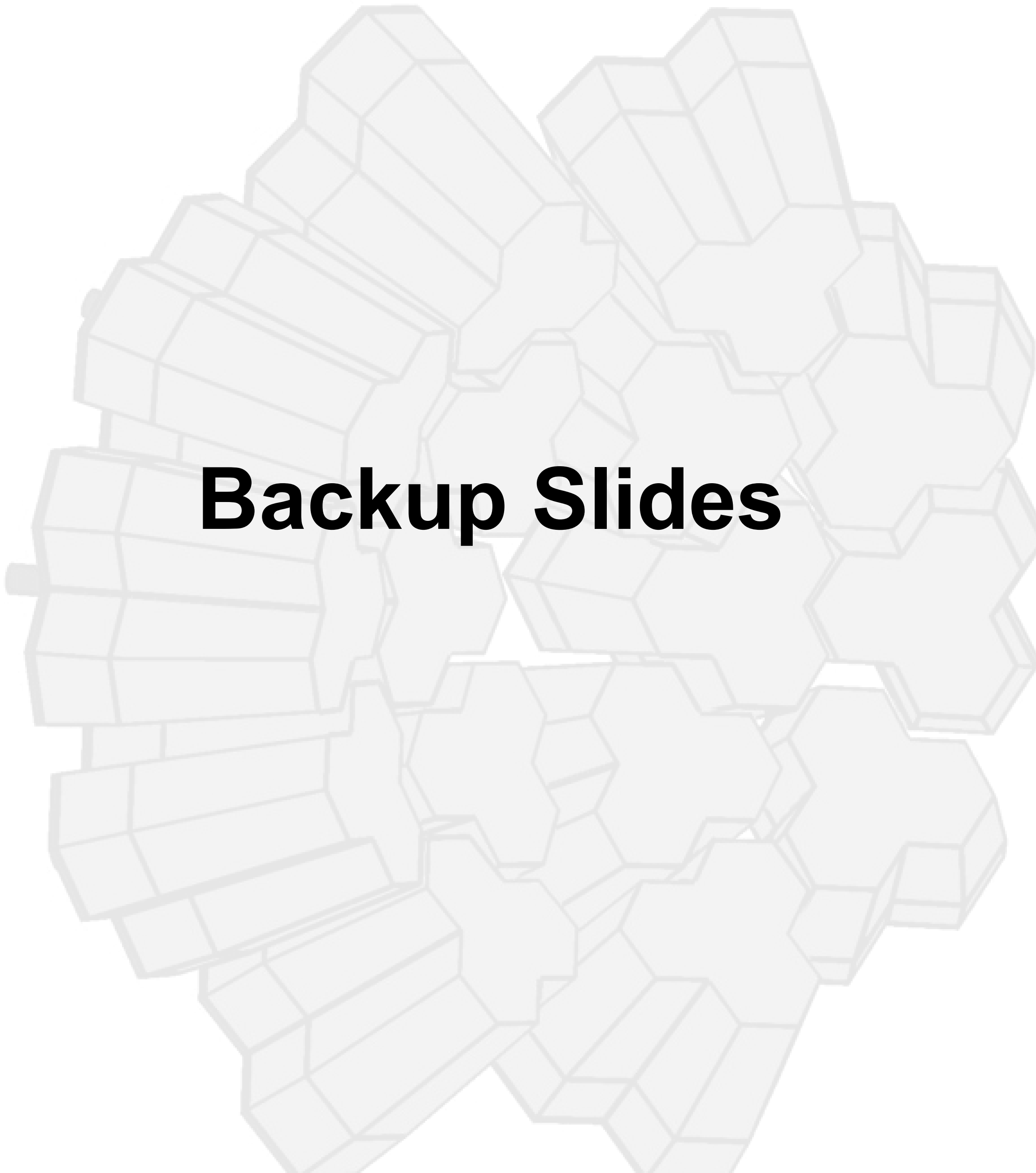
accumulated: ~2 **10^8 neutrons on the crystal (~6.6***10^6 n/cm^2)
==> no effect on resolution expected

Summary and Outlook

- new cryostat works nicely
- Improvements of setup necessary:
  - Elimination of ground loops
  - No material in front of detector / more absorber
- Analysis of data (see Kai's talk)
- No change of resolution due to neutron damage expected
  - Much higher neutron load needed in next beam time
- Simulation needs improvements (time)

Thanks for your attention

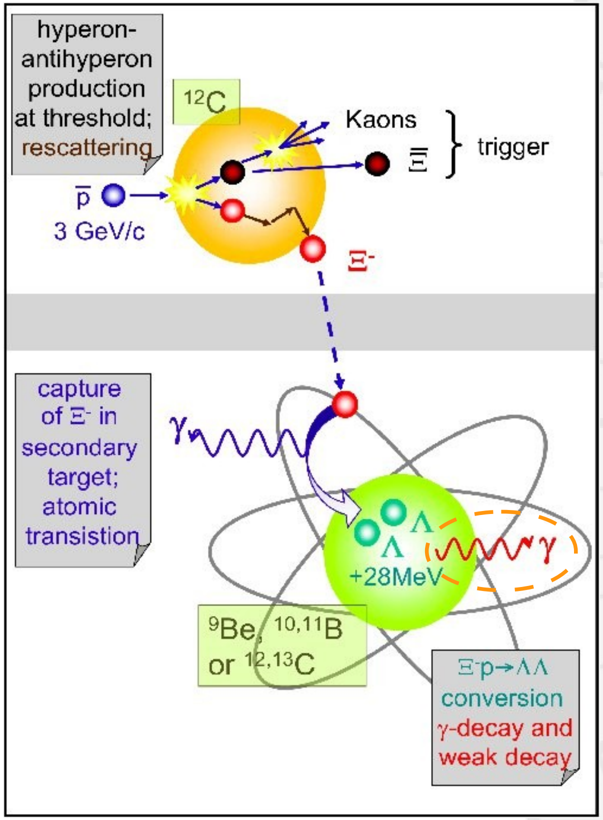


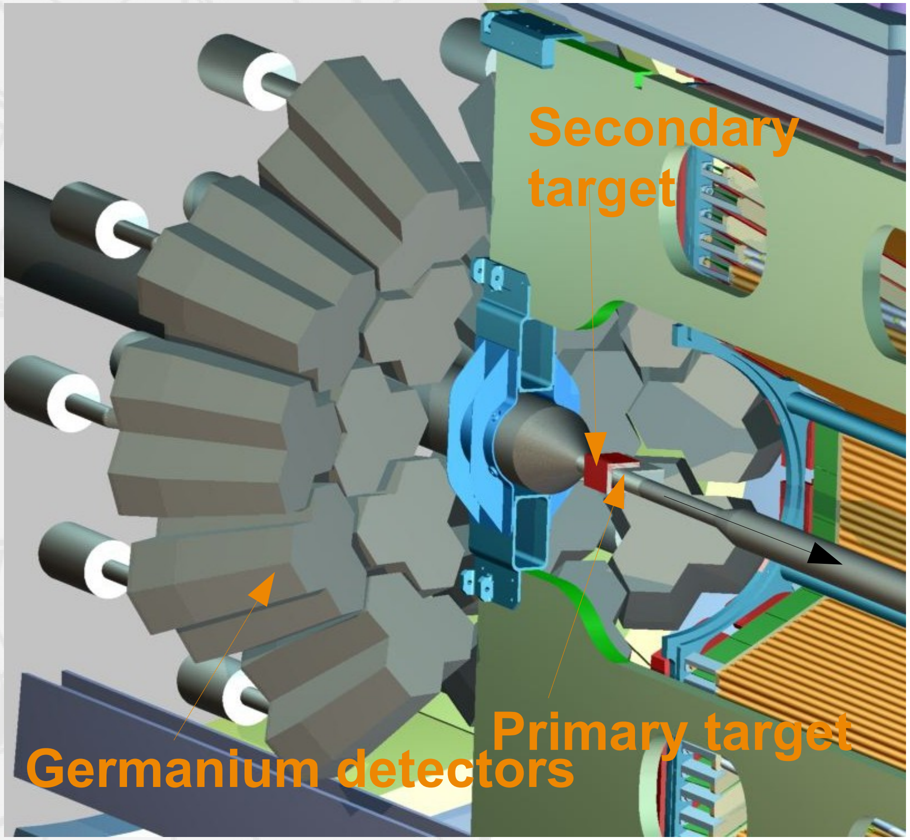


Backup Slides

Motivation

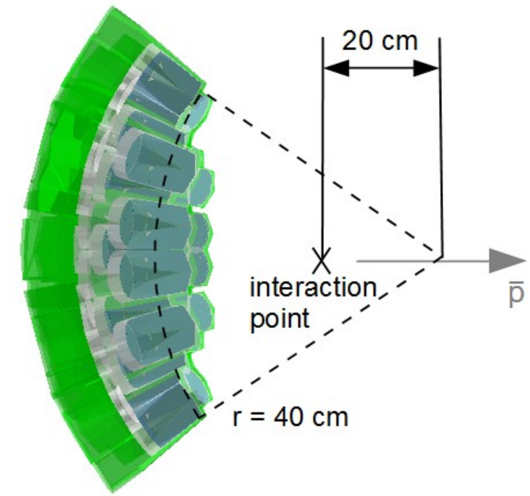
Why do we need this detector?

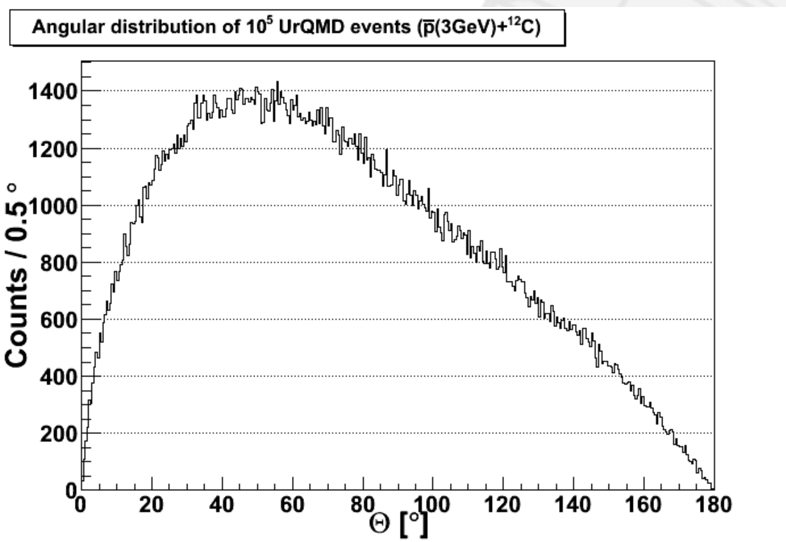




Measure energy levels of double Λ hypernuclei

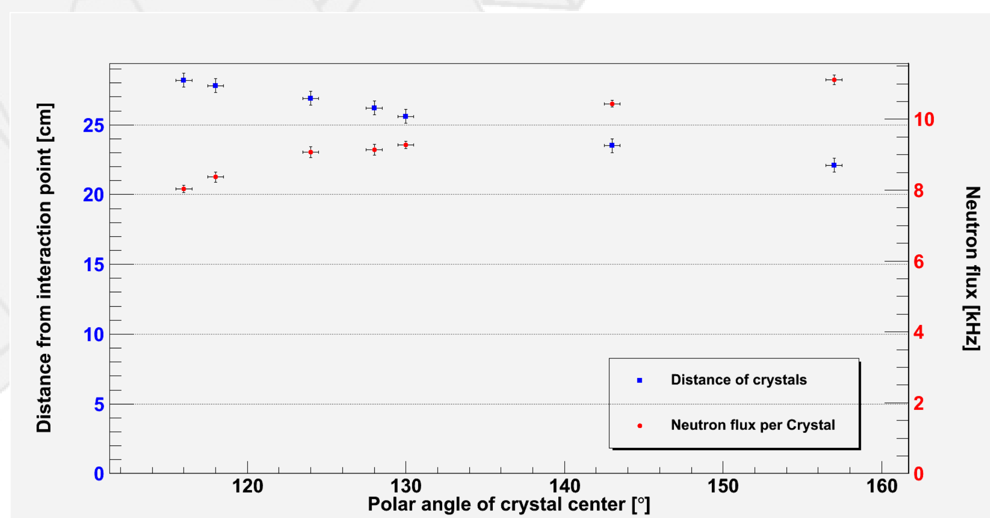
Neutron background inside PANDA





- Geometry with r = 40 cm and shifted center by 20 cm
  → Detector distance to interaction point depends on Θ

- 10^5 events (100 ms PANDA)
- strong Θ dependance

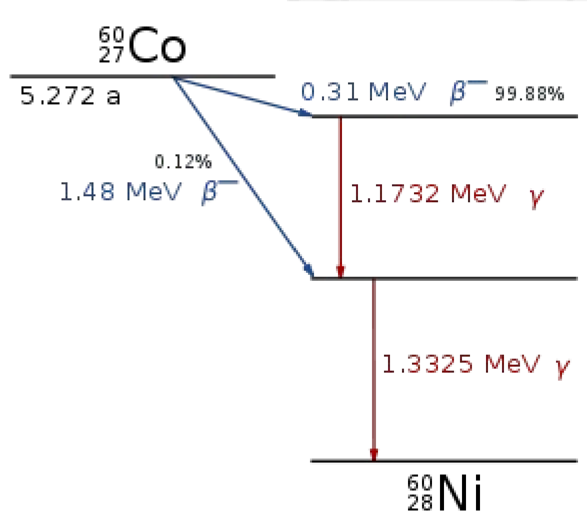


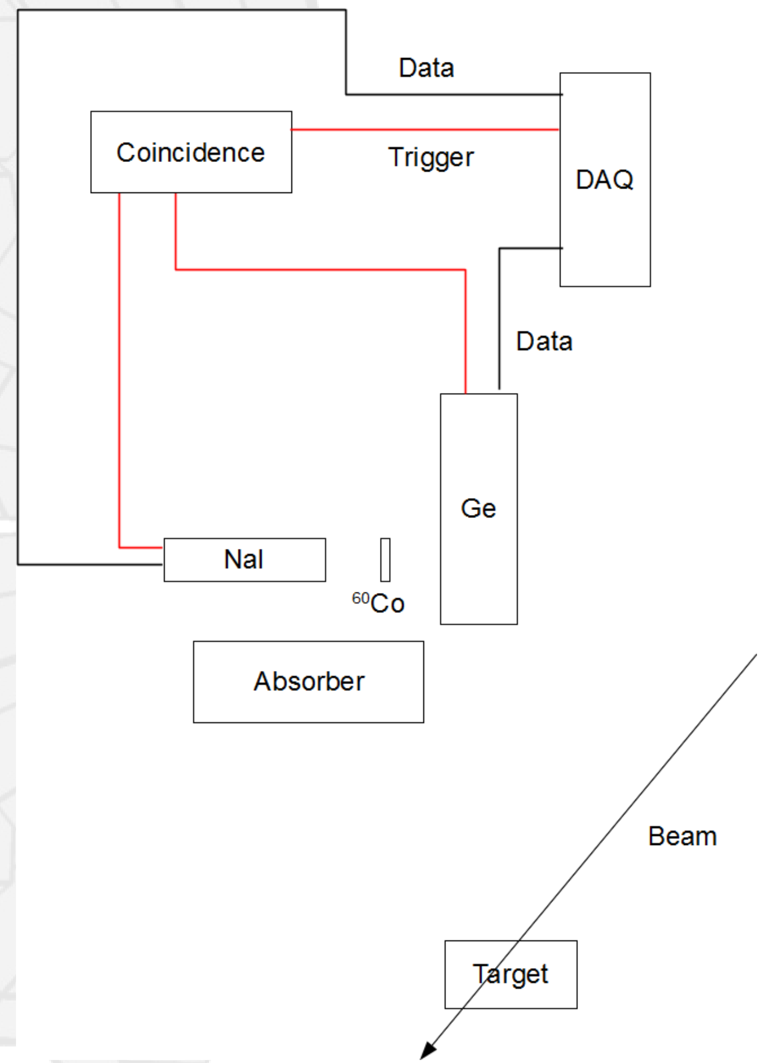
- Both dependency nearly cancel out
  ≈11 kHz neutron flux maximal

Planned tests at COSY

1. Data taking with background

^{60}Co source





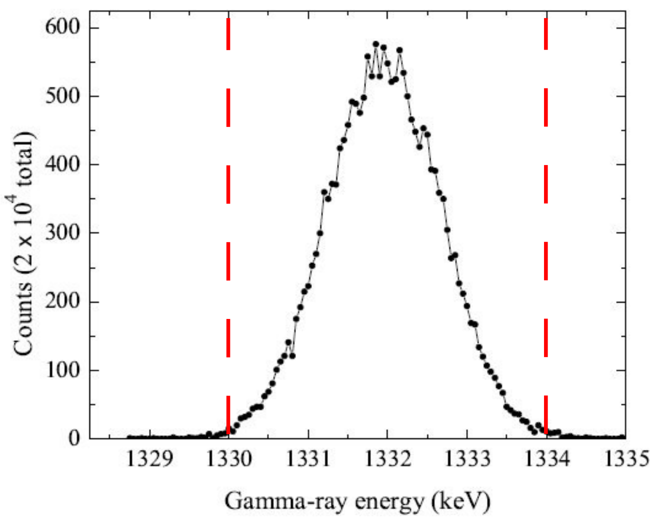
- Coincidence with NaI scintillator

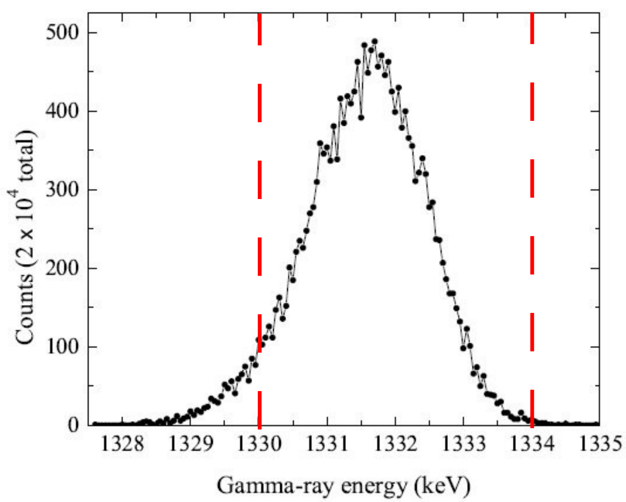
- Rate?
- Absorber?

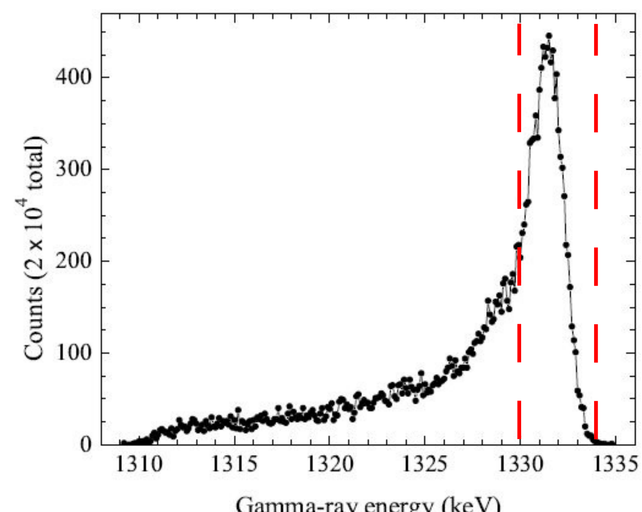
Planned tests at COSY

2. “Simulate“ irradiation of a PANDA measurement cycle

Crystal resolution will degrade due to radiation damage







Van Siclen, C.D.; et.al , Nuclear Science, IEEE Transactions on , vol.59, no.5, pp.2487-2493, Oct. 2012

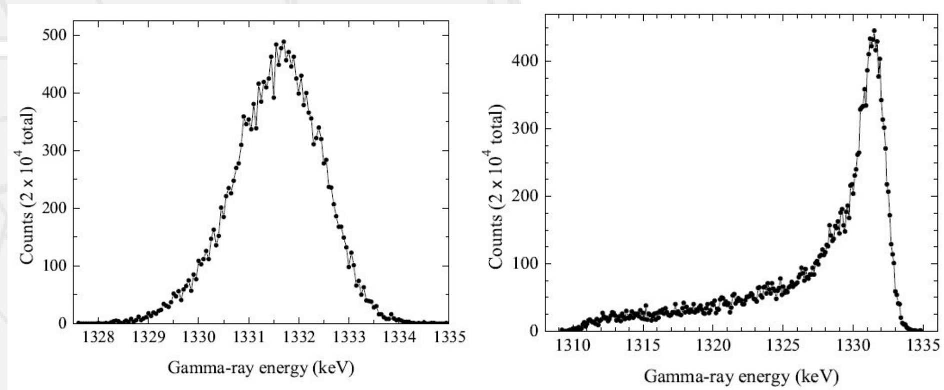
10^8 n/cm^2 10^9 n/cm^2 10^{10} n/cm^2

Planned tests at COSY

PANDA beam time	100 days
inter. rate	$2*10^6$ /s
duty cycle	50 %
number of interactions	$8.64*10^{12}$

COSY	
proton rate	10^9 /s
duty cycle	50 %
target efficiency (C target)	10 %
necessary beam time	2 days

PANDA beam time	100 days
n flux (simulation)	11 kHz /crystal
n per beam time	$9.5*10^{10}$
crystal front surface	30.11 cm^2
n per cm^2	$3.16*10^9$



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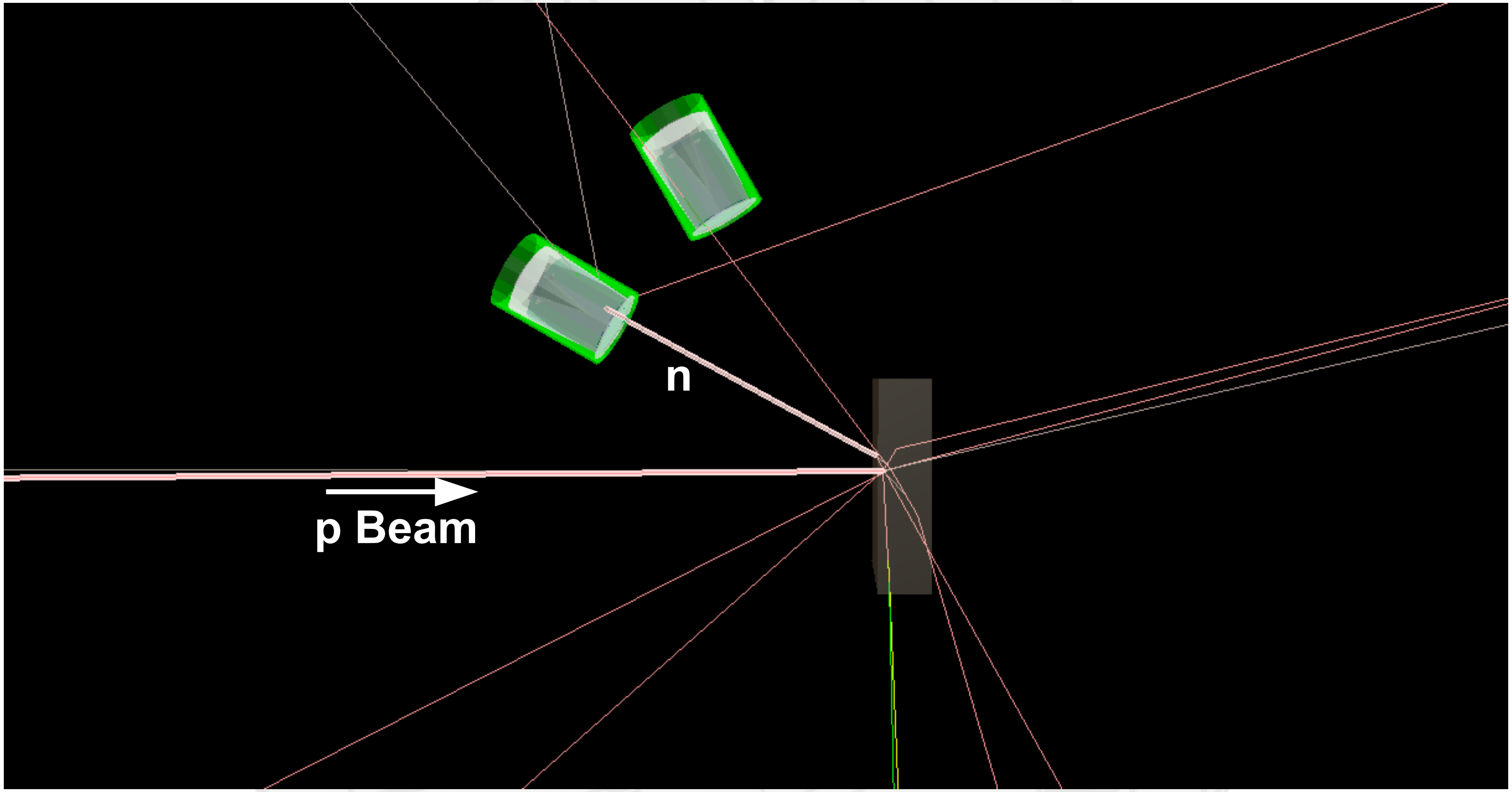
10^9 n/cm^2 10^{10} n/cm^2

- Annealing
- Lend crystals from EUROBALL

Planned tests at COSY

Simulation of radiation test



- C target (5 cm thick)
- single crystal detector (r = 30 cm, Θ = { 120°, 150°})
- no numbers yet

Modification of the readout electronics

FlashADC (VX1724, 14 bit, Upp = 2.25 V):

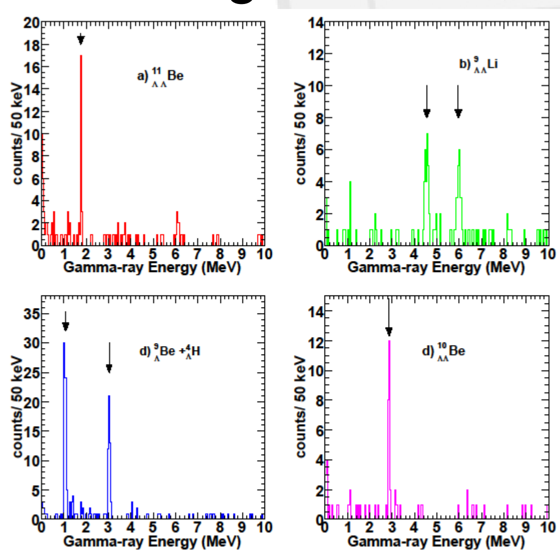
Pulse height of typical 1.332 MeV trace: 80 mV (≈570 bin)

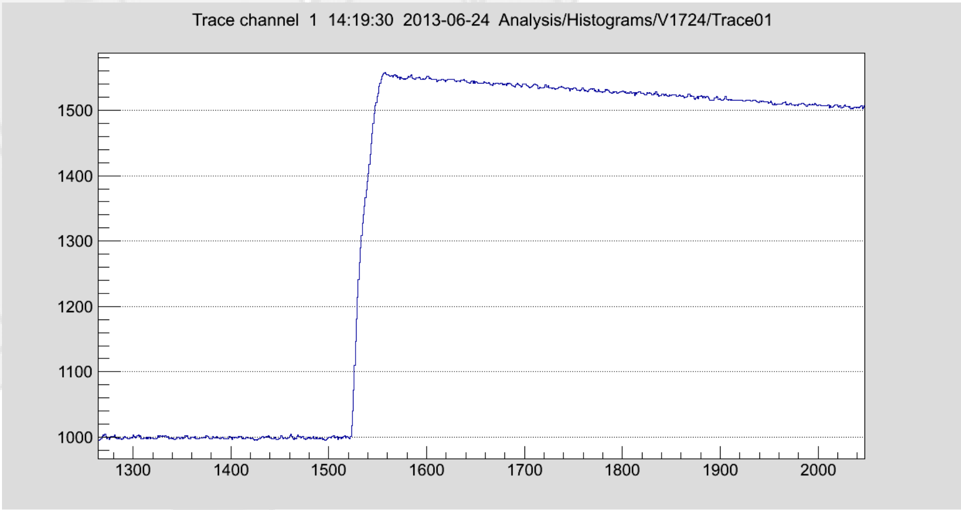
→ max E_γ ≈ 36 MeV   resolution: 2.3 keV/bin

Modification of Upp to 0.5 V:

→ max E_γ ≈ 8 MeV   resolution: 0.5 keV/bin

Enough for now, more bins needed for final experiment

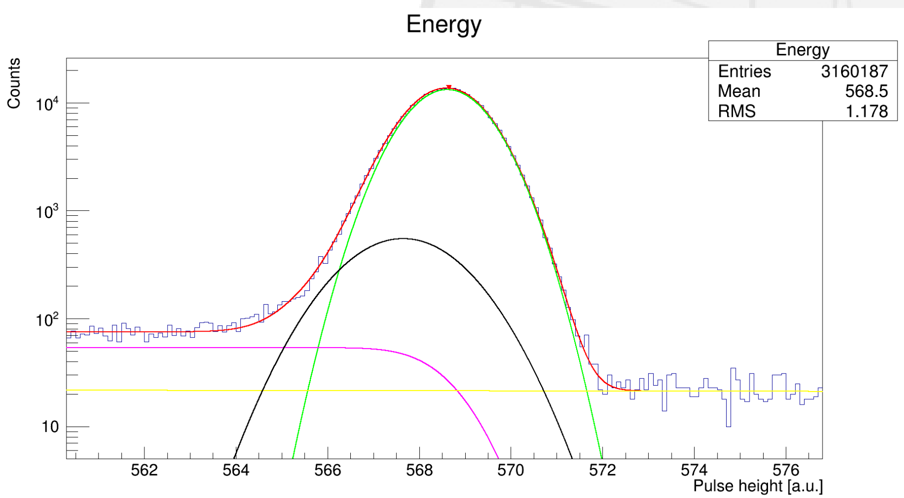


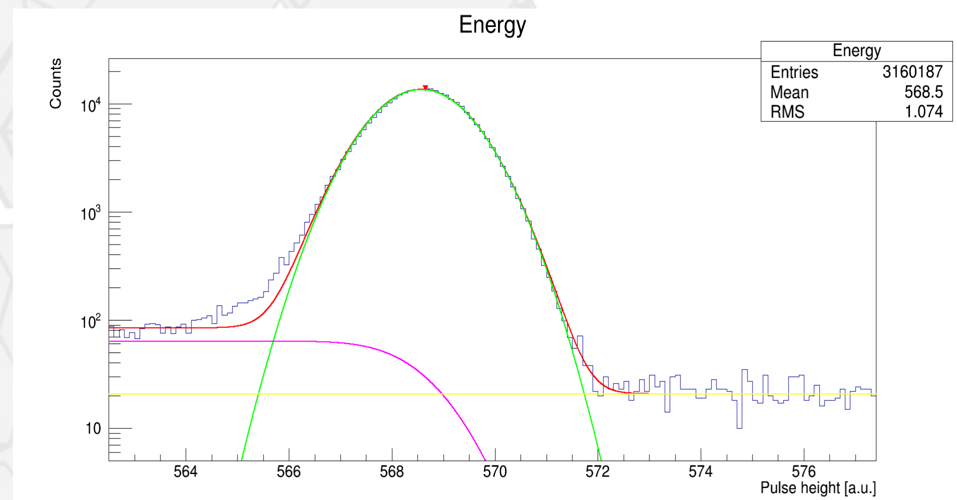


Fitting program

Simple gaussian fitting (+background) not enough

- Components of fit:
  1. Gaussian — main peak
  2. Smoothed step function — compton background
  3. pol1 — background
  4. 2nd gaussian — low energy tail





$X^2_{red} = 1.25$

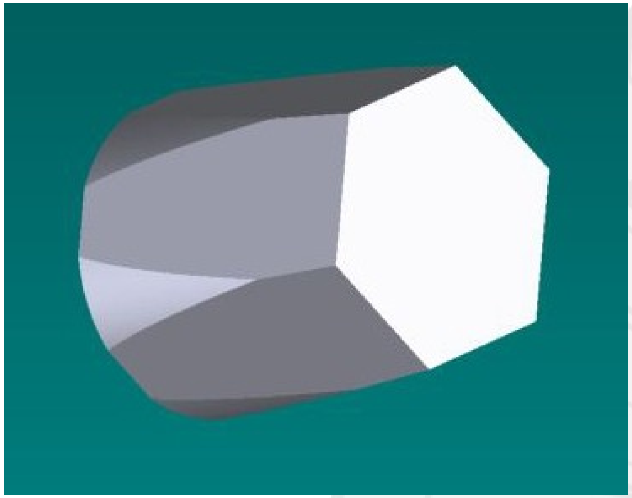
$x_{0\_1stGaus} = 568.613 \pm 0.004$

$X^2_{red} = 5.14$

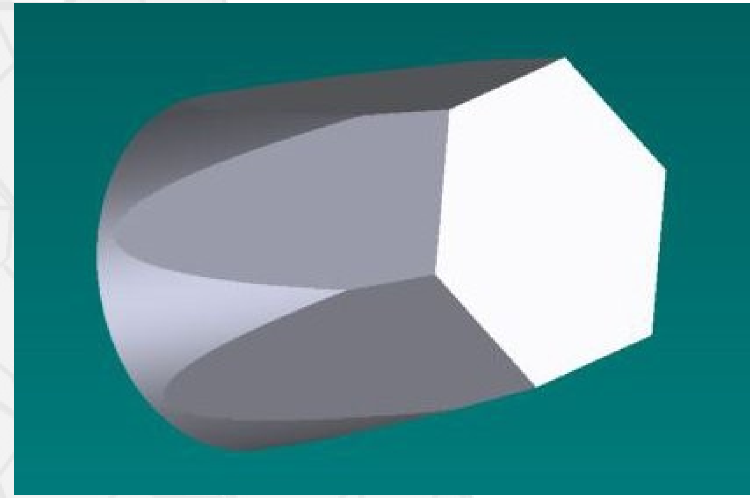
$x_{0\_1stGaus} = 568.574 \pm 0.002$

- 9 parameters!, hard to find good starting values
- Fit may be improved by replacing the second gaussian with a skewed gaussian (10 parameters!)

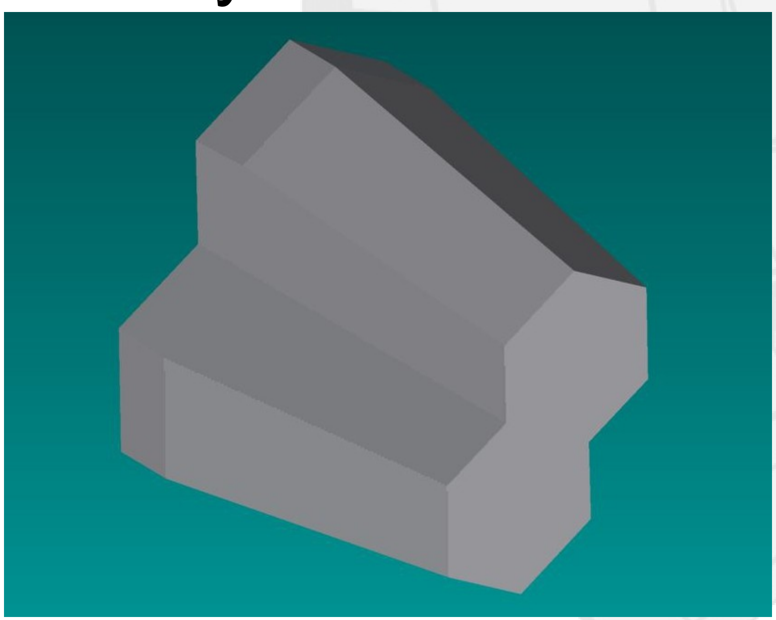
Implementation in PANDAROOT



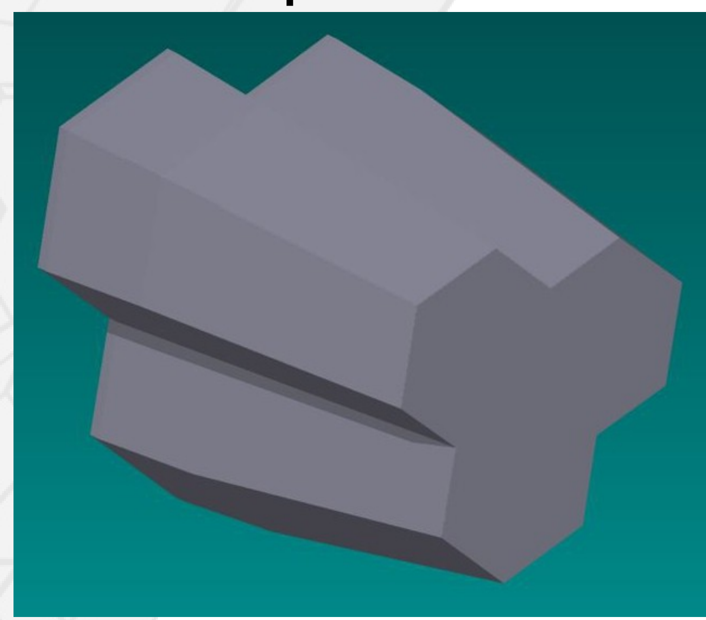
Ge crystal



Al encapsulation



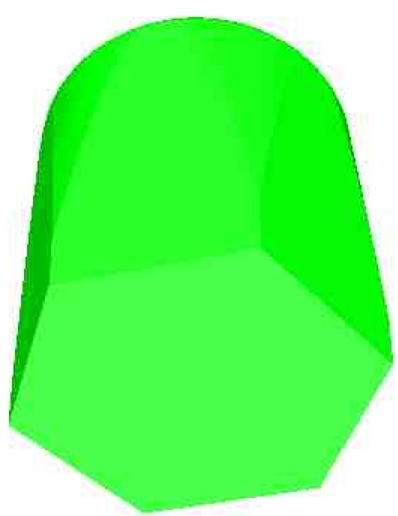
Double detector

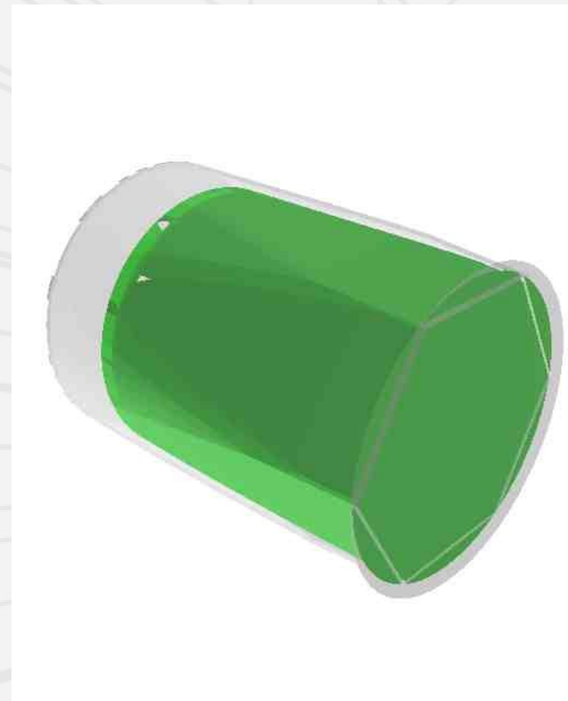


Triple detector

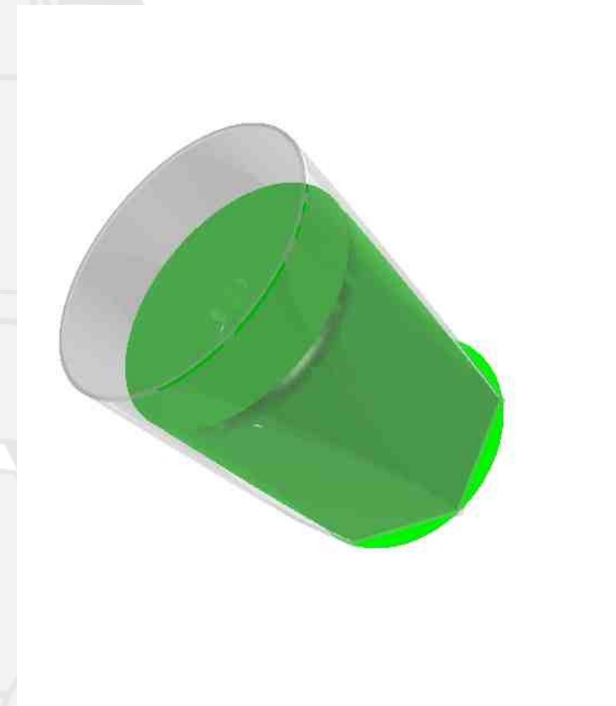
Implementation in PANDAROOT

PndGeoHypGeCrystal





ogl viewer strikes back ...

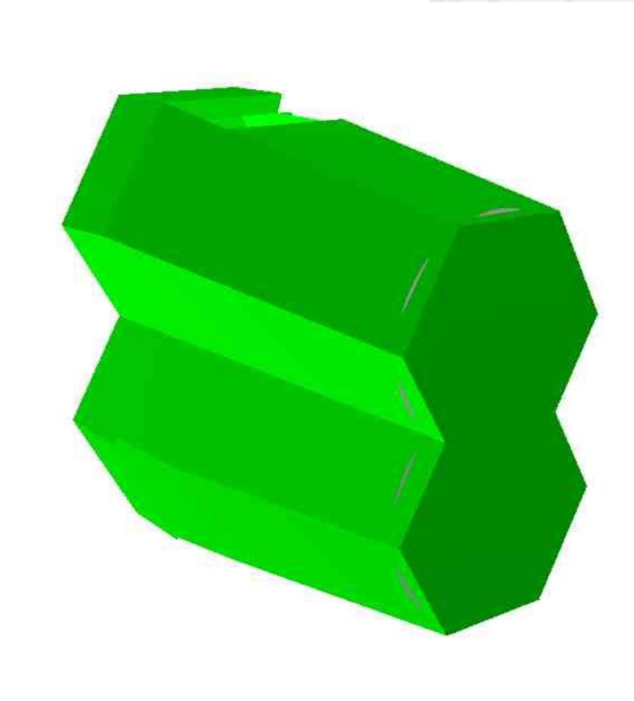


ogl viewer strikes back ...

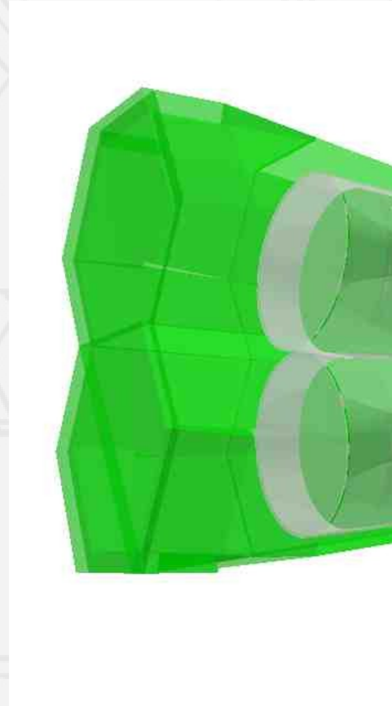
EUROBALL HPGe crystal in aluminum capsule
TGeoPgon is subtracted of a TGeoTube to create the tapered shape

Implementation in PANDAROOT

PndGeoHypGeDoubleCluster



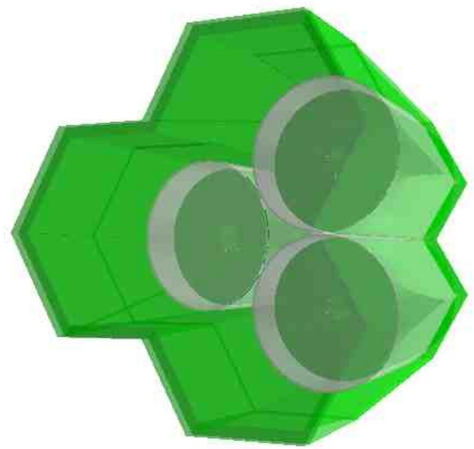
ogl viewer strikes back ...



2 encapsulated crystals
cryostat (38 TGeoArb8 in a TGeoCompositeShape)

Implementation in PANDAROOT

PndGeoHypGeTripleCluster



ogl viewer strikes back ...

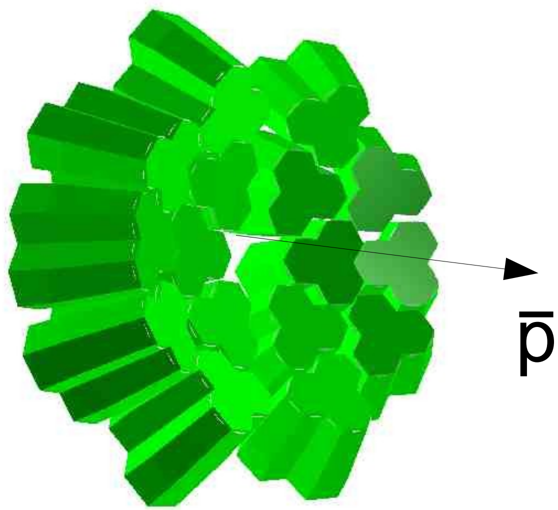
3 encapsulated crystals

cryostat (46 TGeoArb8 in a TGeoCompositeShape)

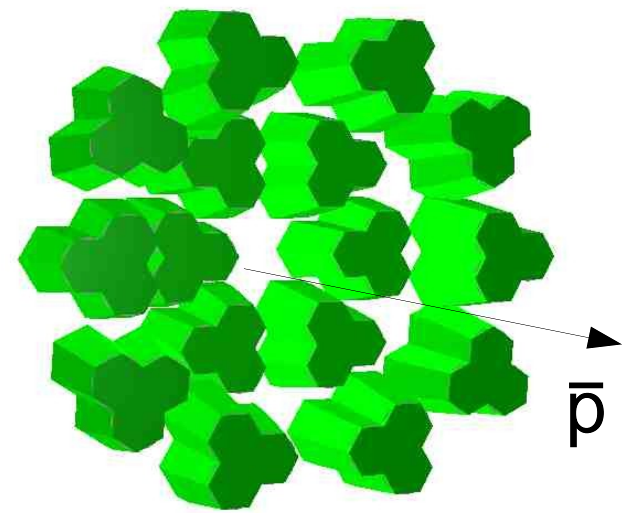
Implementation in PANDAROOT

Example:

Macros in $VMCWORKDIR/macro/hypGe/Marcell/Geometry
root files in $VMCWORKDIR/geometry



hypGeGeoBuilderTripleBall40Offset20Geometry.C
hypGeGeoTripleCluster_Ball40_Offset20.root



hypGeGeoBuilderTripleStraightGeometry.C
hypGeGeoTripleCluster_Straight.root

Simulation with different geometries

	1 MeV		2 MeV	
	Peak	P/C	Peak	P/C
Ball30	486841	158	331664	133
Straight	415794	148	277837	123
Ball40_10	537037	153	367159	131
Ball40_20	704206	161	478355	137

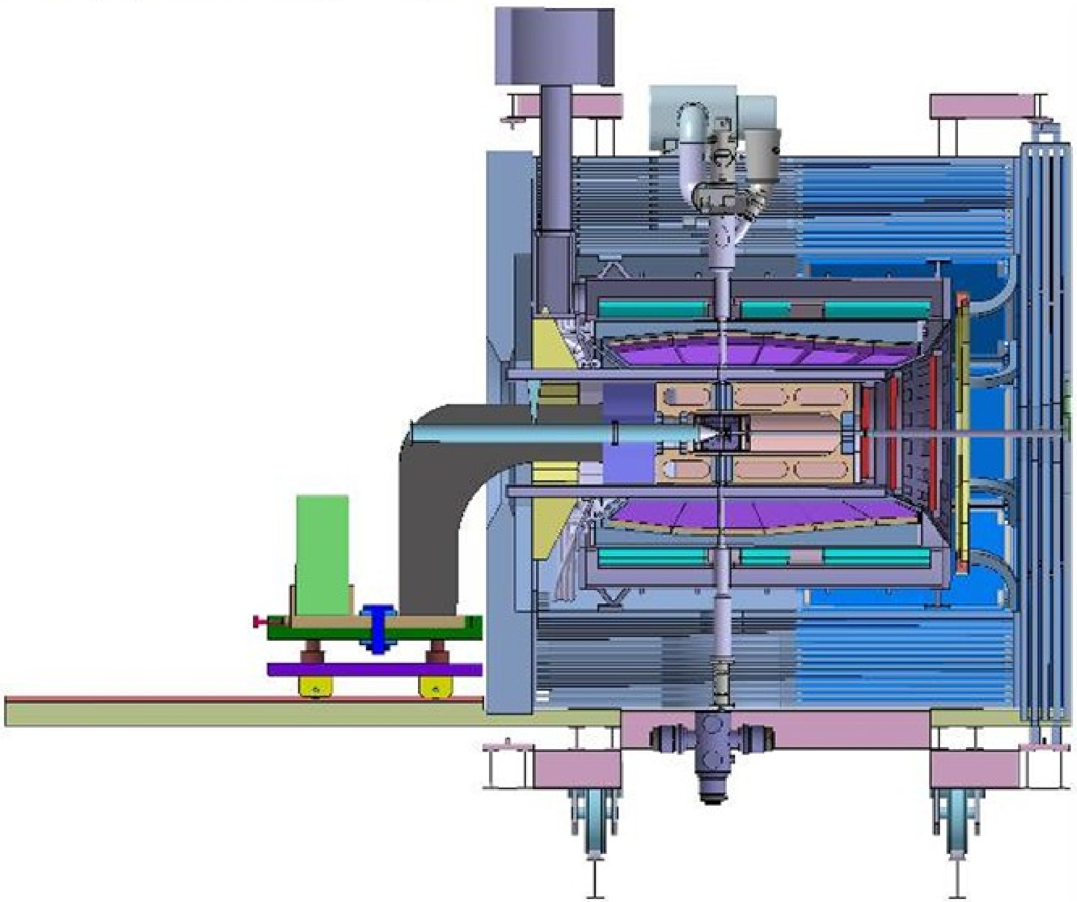
Ball30: sphere, 30 cm radius
Straight: Detectors not rotated,
1st layer 30 cm to source, 2nd layer Offset 15 cm
Ball40_10: sphere, 40 cm radius, 10 cm z-Offset
Ball40_10: sphere, 40 cm radius, 20 cm z-Offset

Radiation damage/background not considered!!!

Ideas to hold the germaniums

Backward Endcap EMC

Supporting System

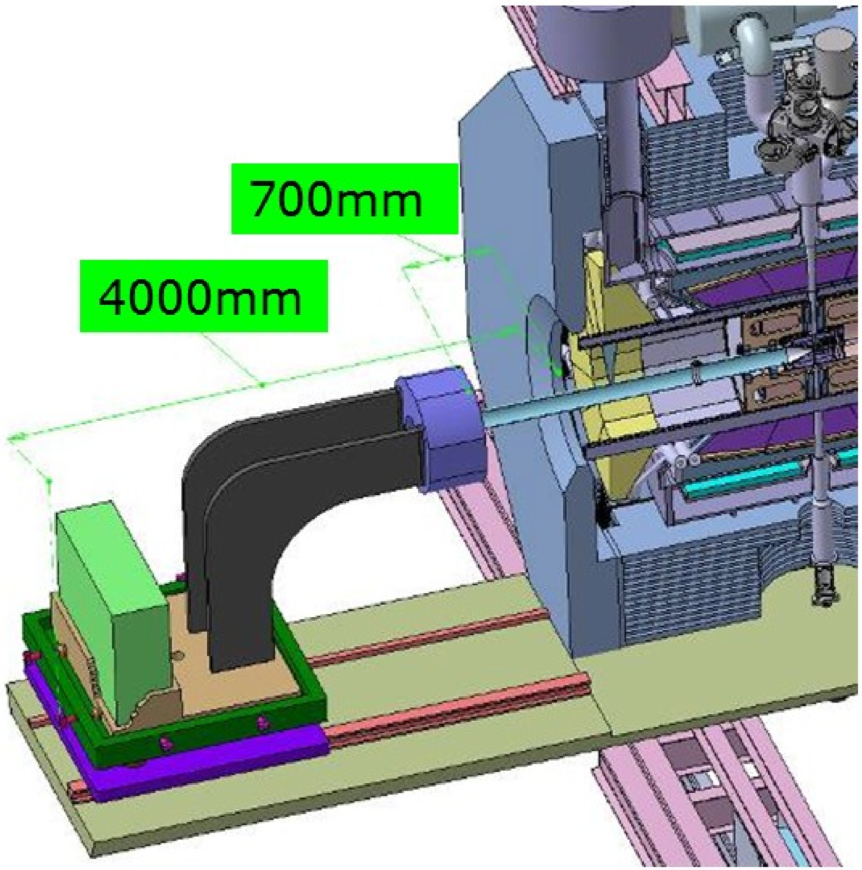


Cut View

Ideas to hold the germaniums

Backward Endcap EMC

Supporting System



Distances to the **Magnet**

08/12/2009 David Rodríguez Piñeiro - GSI Darmstadt - PANDA Collaboration Meeting 20