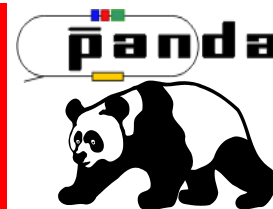


Panda Pavia 2008/09



Ricercatori:		%2009
Bendiscoli	PO	60
Rotondi	PO	60
Radici	1RIC	20
Boca	RU	30
Braghieri	RIC	50
Fontana	RIC	40
Montagna	RU	70
Salvini	RIC	20
Genova	ass.ric.	20
Lavezzi		0
Costanza	DOTT	100
Panzarasa docente		(50)
Tot 2009		4.7 FTE (5.2)

Assegnazioni 2008:

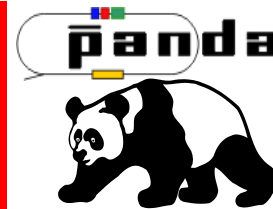
Miss.interne 6 k€ Miss.estere 17.5 k€
Consumo 3 k€ Inventariabile 3 k€



Situazione e aggiornamenti su:

- FAIR
- PANDA Collaborazione
- PANDA Italia
- PANDA Pavia:
 - **SW**
 - simulazioni STT
 - track fitting STT/MVD
 - pattern recognition STT
 - **HW**
 - test STT
 - studi HPGe in campo magn.

Tracking TDR - 2009→10



Tracciatore: opzione STT

- Primi studi e prototipo:
Frascati (+Pavia)
- Nuova geometria
(e realizzazione?):
Julich
- Supporto meccanico:
Frascati
- Simulazioni e test dE/dx :
Pavia
- Ancora competizione
con TPC...
- Technical Design Report
per tutto il sistema di
tracciamento

PANDA Tracking Group Tracking Technical Design Report Table of Contents

Chapter 1: Overview of the project and the requirements

Chapter 2: The Micro Vertex Detector

Chapter 3: The Straw Tube Tracker

3.1 General overview (Editor(s): P. Gianotti)

3.2 Straw tube design

3.2.1 Straw materials (Editor(s): P. Wintz)

3.2.2 Pressurized straws (Editor(s): P. Wintz)

3.2.3 Gas mixture (Editor(s): P. Wintz)

3.3 The layout of the whole detector (Editor(s): P. Gianotti)

3.4 Mechanics and detector installation (Editor(s): P. Gianotti)

3.5 Gas system (Editor(s): P. Wintz)

3.6 Readout electronics (Editor(s): P. Salabura)

3.7 Calibration and Monitoring (Editor(s): A. Rotondi/P.
Wintz)

3.8 Simulations (Editor(s): A. Rotondi)

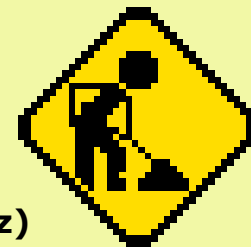
3.9 Prototype tests (Editor(s): P. Wintz)

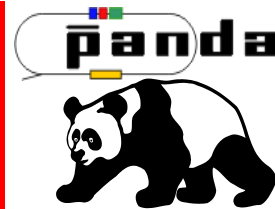
3.10 Organization (Editor(s): P. Gianotti/J. Ritman)

Chapter 4: The Time Projection Chamber

Chapter 5: The CT-Forward GEM Detectors

Chapter 6: The Forward Tracker





Software: contributo Pavia

STT: codice di simulazione e ricostruzione

- Simulazione singolo straw tube
(Rotondi)
- Pattern Recognition
(Boca)
- GEANE track follower e Kalman filter
(Rotondi, Fontana, Genova, Lavezzi, Costanza)

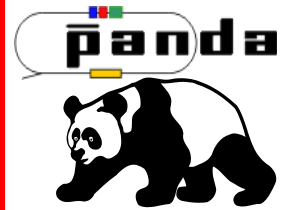
STT locale completato (2008) e superato in quanto inserito nel codice globale

STT+MVD: codice globale (GENFIT), test su STT

A Kalman filter has been developed in collaboration with the GSI and Munich groups: **genfit**, GENeric FITter, GEANE based.

- Studi di efficienza, risoluzione, valutazione parametri
(Costanza, Lavezzi)

STT+MVD: Kalman filter



PANDA Report PV/01-09

Study of the Kalman filter performances with STT+MVD

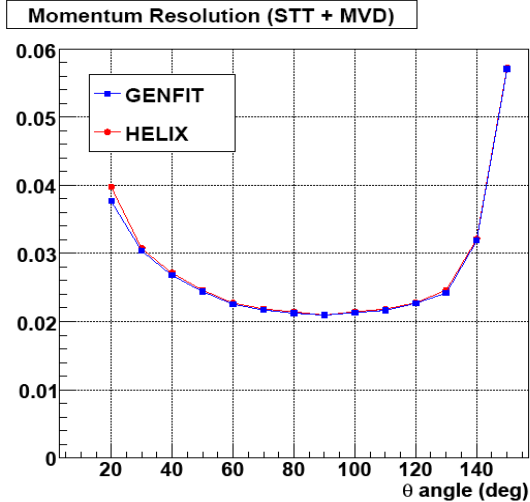
S. Costanza and L. Lavezzi

A brief description of the code and the mathematics used in order to perform the fit procedure is described. A list of the results obtained so far from the application of this fitting procedure to the Straw Tube Tracker (STT) + Micro Vertex Detector (MVD) simulated points follows.

Contents

- 1 The Helix Fit
- 2 The Kalman Filter
- 3 The simulation environment
- 4 Results
 - 4.1 Kalman procedure testing
 - 4.2 Systematic tests on momentum resolution
 - 4.2.1 Dependence on the straw tubes length
 - 4.2.2 Dependence on the skew angle
 - 4.2.3 Dependence on the drift tube resolution curves

STT+MVD: Kalman filter

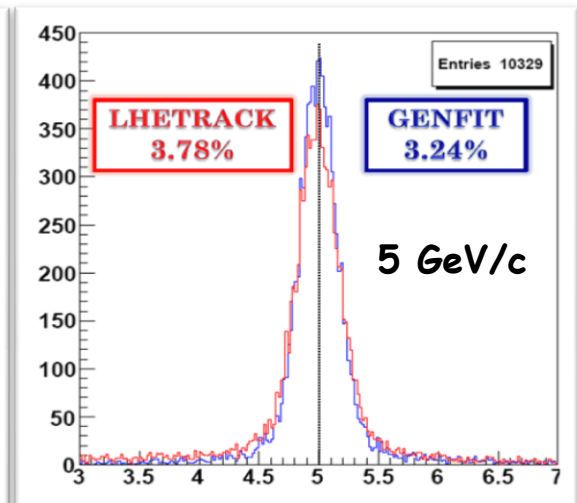
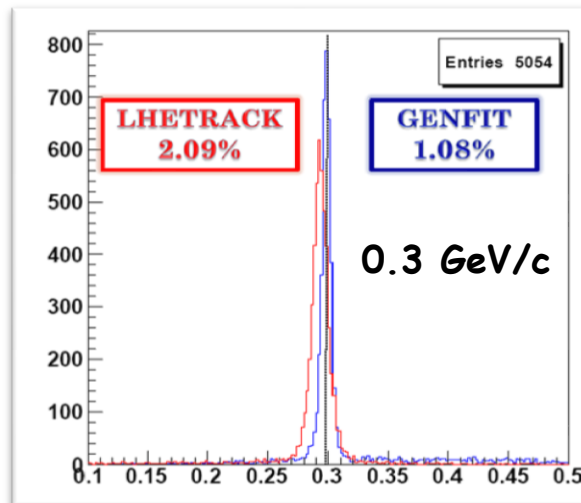
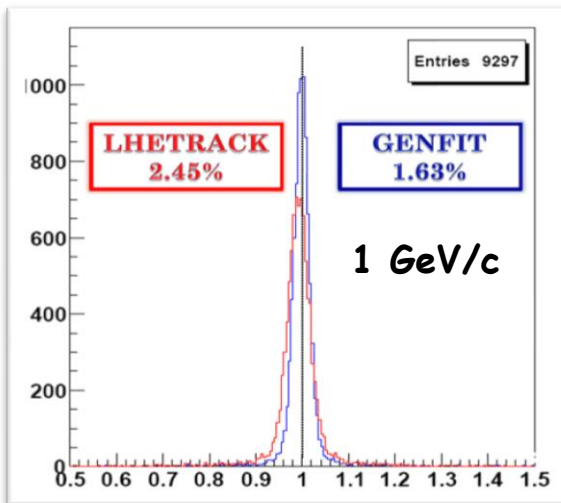


Tests performed in december 2008 showed no improvement with respect to by Kalman filter application to STT + MVD with respect to helix fit

By changing:

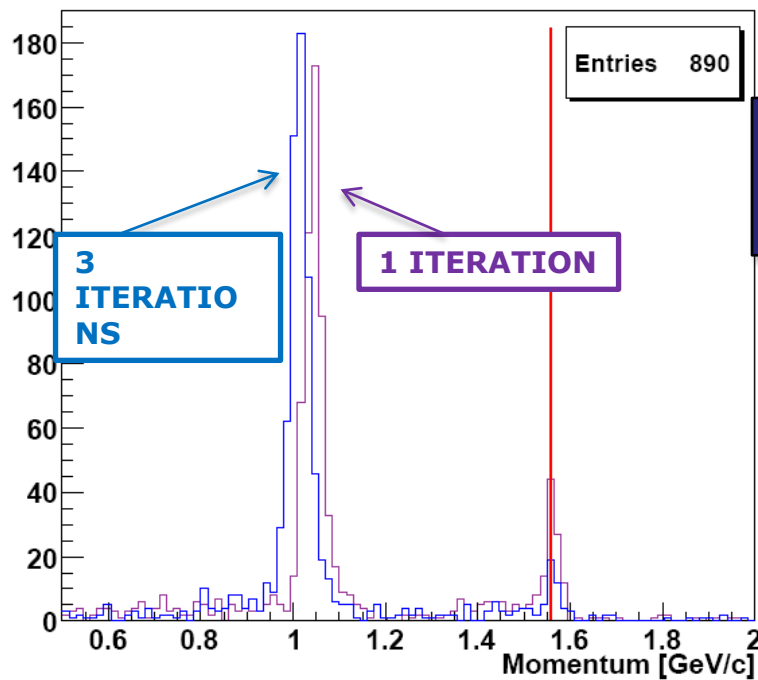
- starting pos/mom errors;
- MVD and STT measured point coord. covariances
- Kalman filter planes orientation

we get these results:

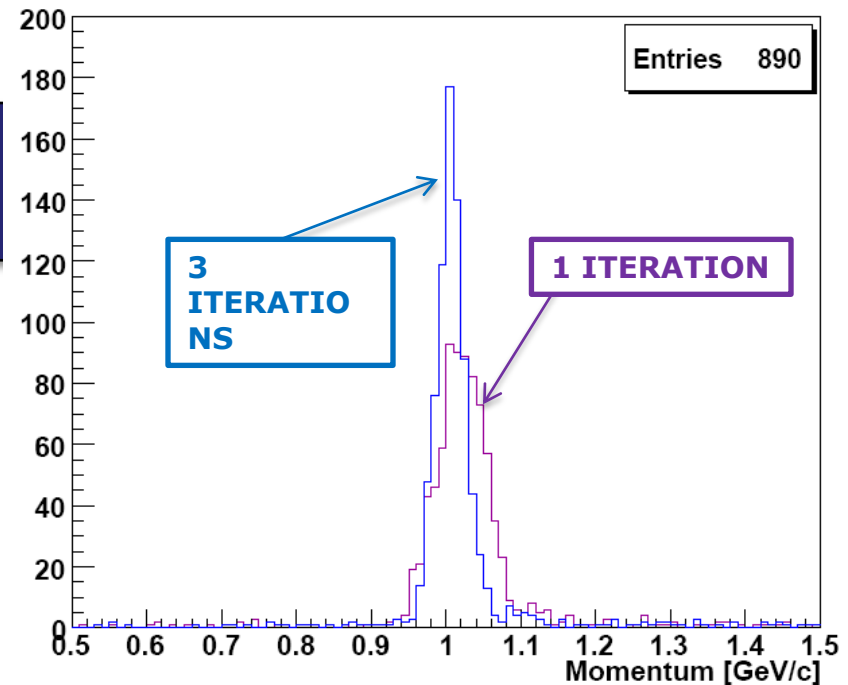


STT+MVD: Kalman filter

Even starting from a REALLY WRONG starting momentum, the Kalman procedure (after 1 and more after 3 iterations) finds the right one!

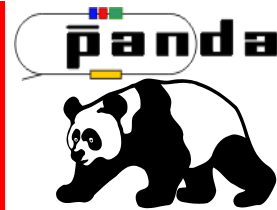


Kalman input 1:
 $(-0.9, -0.9, -0.9) \text{ GeV/c}$



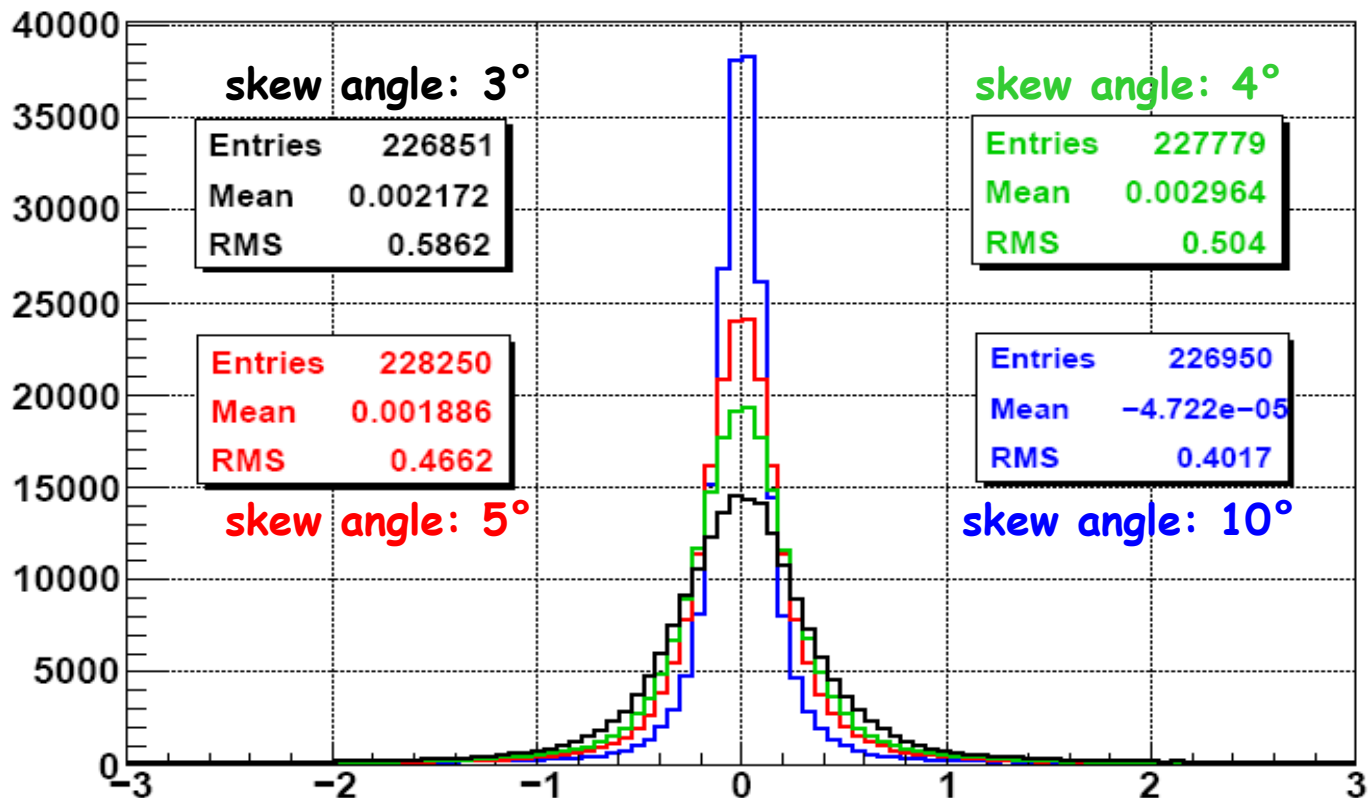
Kalman input 2:
 $MCmom + (0.4, 0.4, 0.4) \text{ GeV/c}$

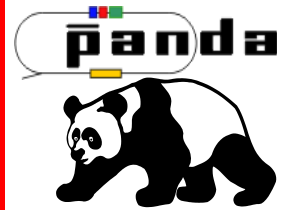
STT test: skew angle



10000 μ^- , π^- @ 1 GeV/c,
generati uniformemente in ϕ ($\phi = [0^\circ, 360^\circ]$) e $\cos\theta$ ($\theta = [20^\circ, 140^\circ]$)
Geometry layout: skew angle = 3° , 4° , 5° , 10°

Residui della
coordinata z





STT test: lunghezza dei tubi

10000 μ^- @ 1 GeV/c

$$\theta = \{20^\circ, 25^\circ, 30^\circ, 35^\circ, 40^\circ\} \pm 2.5^\circ$$
$$= \{50^\circ, 80^\circ, 110^\circ, 140^\circ\} \pm 5^\circ$$

Risoluzione in momento ($\sigma(p)/p$)

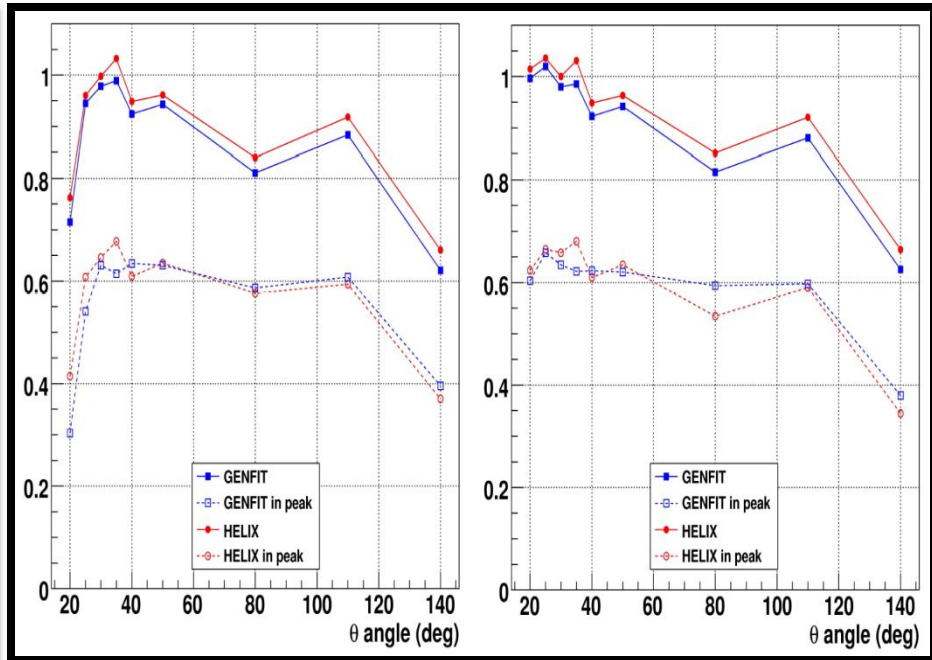
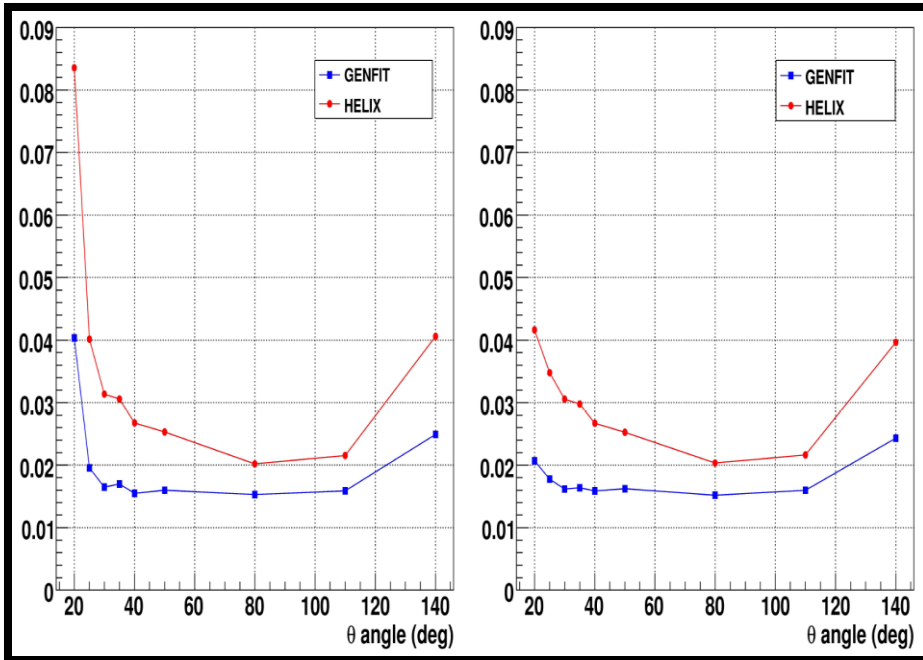
Efficienza

120 cm

150 cm

120 cm

150 cm

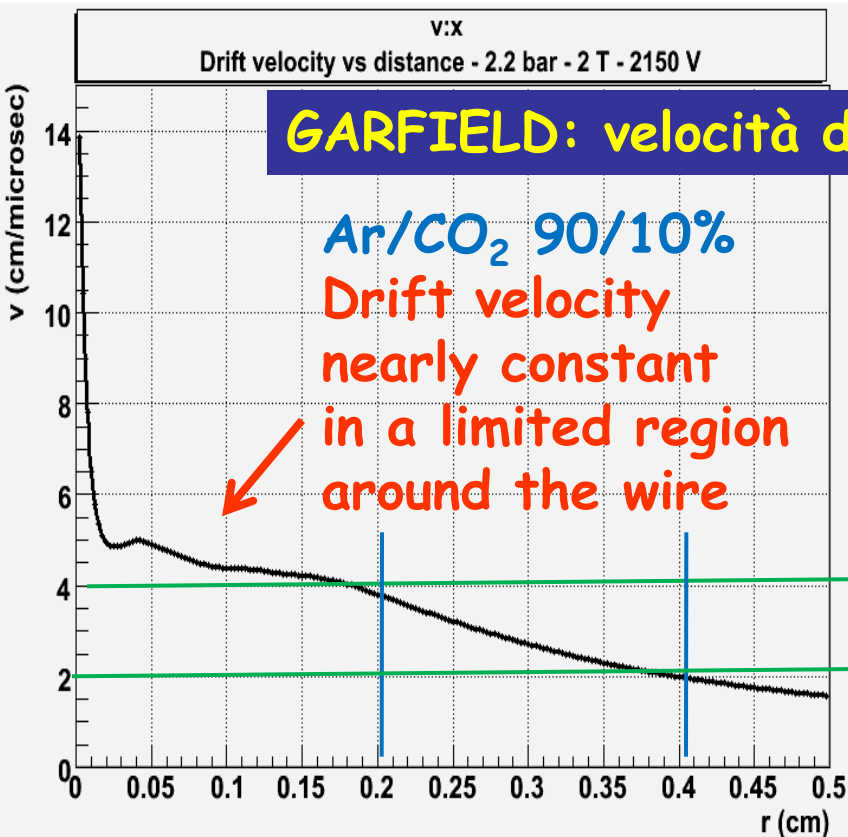


STT test: miscela di gas

GARFIELD: velocità di drift vs distanza dall'anodo

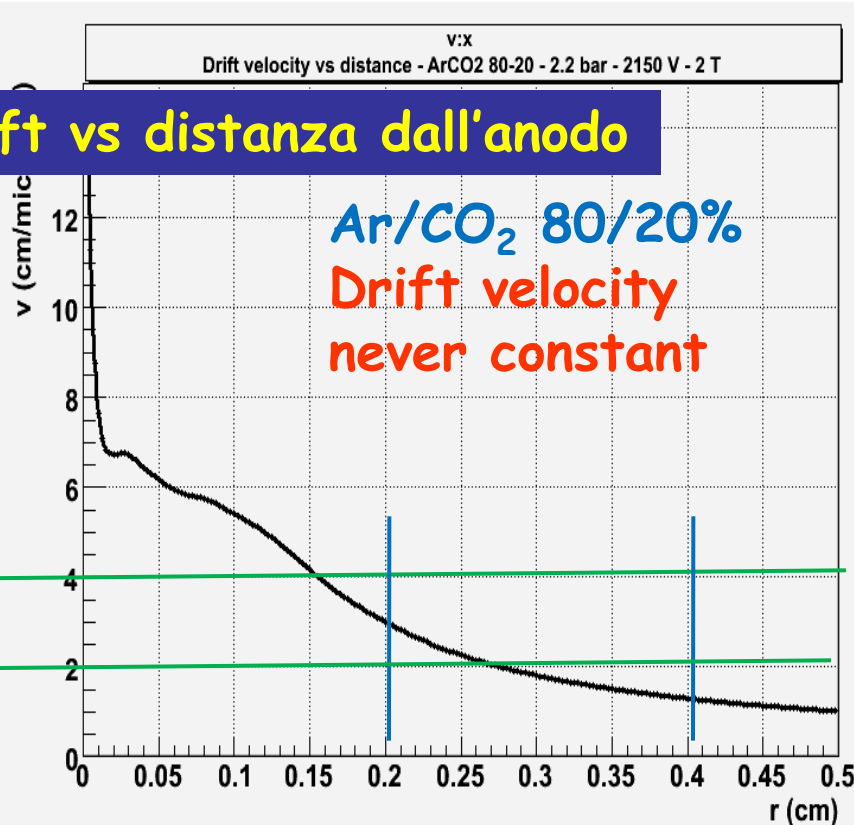
Ar/CO₂ 90/10%

Drift velocity
nearly constant
in a limited region
around the wire



Ar/CO₂ 80/20%

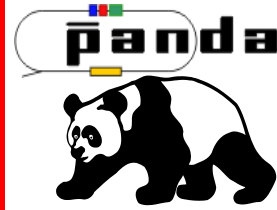
Drift velocity
never constant



Both cases:

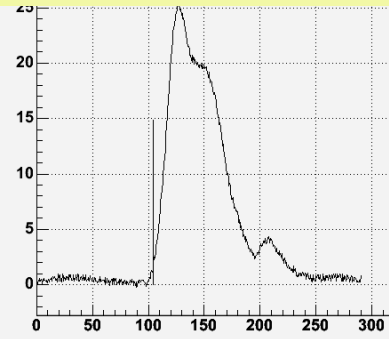
$p = 2.2 \text{ bar}$ $\Delta V = 2150 \text{ V}$ $B = 2 \text{ T}$
 tube diameter = 1 cm anode diameter = 20 μm

Simulazione singolo straw tube: curva di risoluzione spaziale

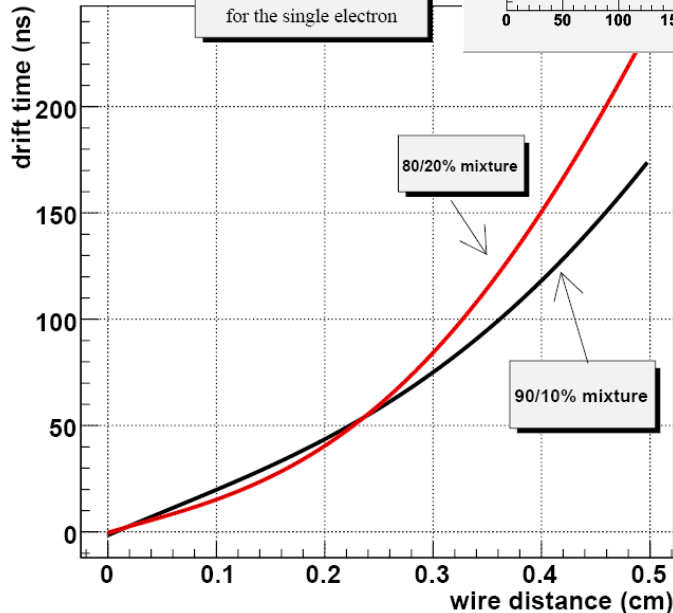


Drift faster in
Ar/CO₂ 90/10%
mixture

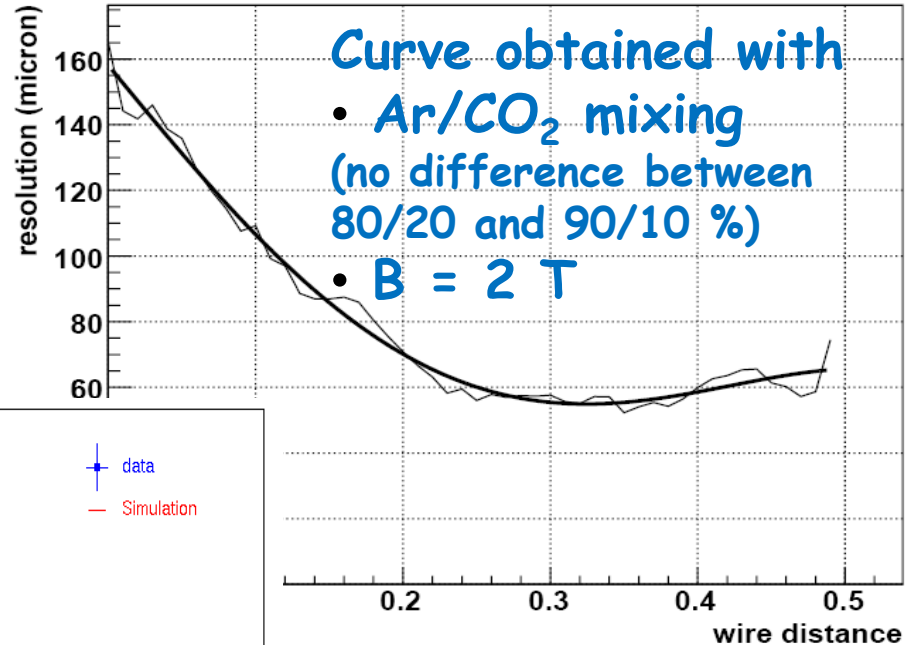
Signal in time (ns)



x-t curves from GARFIELD
for the single electron

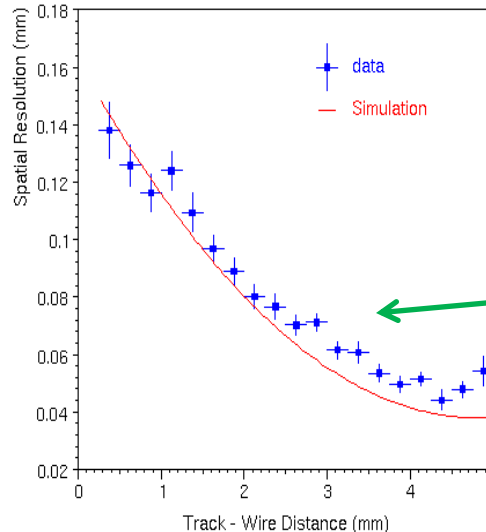


Graph
resolution, 80/20 or 90/10

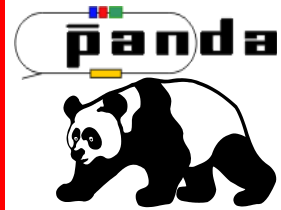


Curve obtained with

- Ar/CO₂ mixing
(no difference between
80/20 and 90/10 %)
- B = 2 T

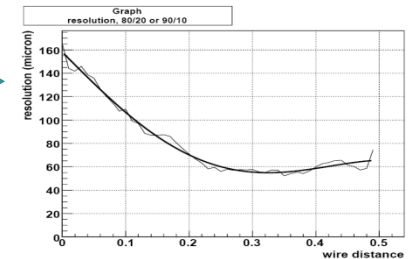


Experimental data
(Juelich group, with B=0)
well reproduced

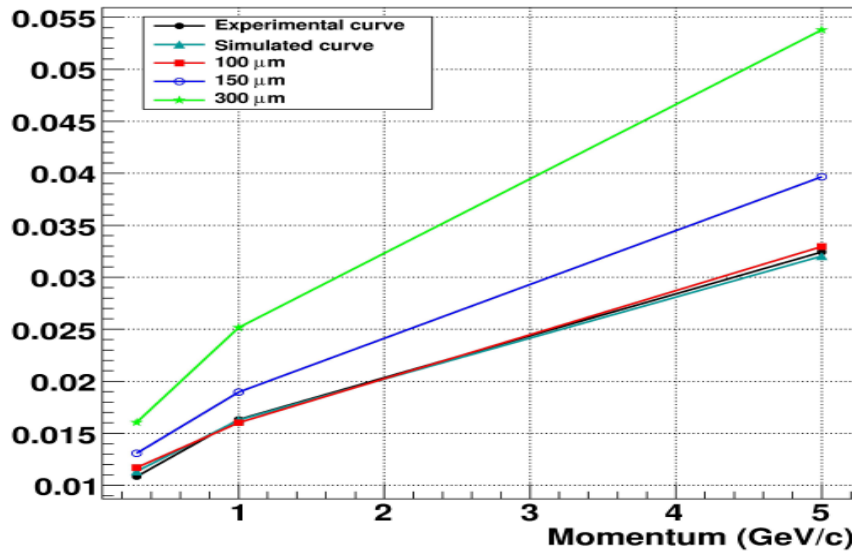


STT+MVD test: dipendenza dalla curva di risoluzione spaziale

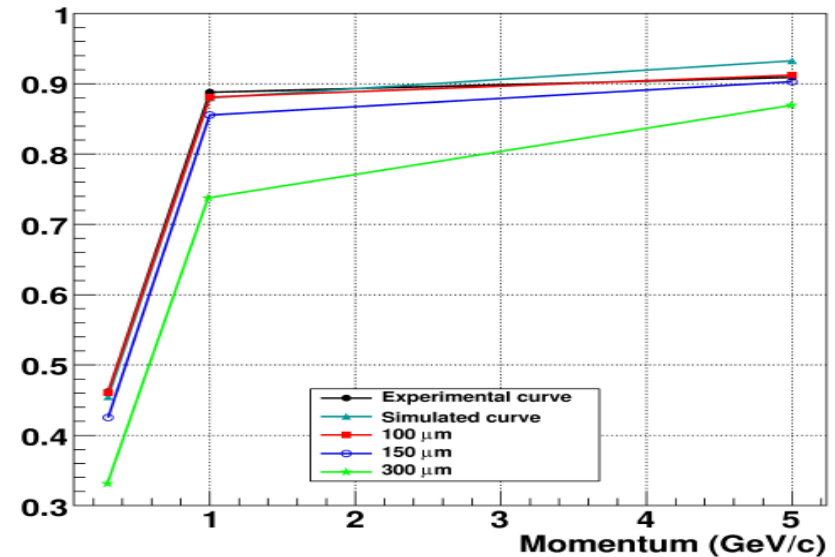
- Curva sperimentale di Juelich, senza campo magnetico
- Curva simulata con GARFIELD, con campo magnetico
- Curva a risoluzione costante a 100 μm
- Curva a risoluzione costante a 150 μm
- Curva a risoluzione costante a 300 μm



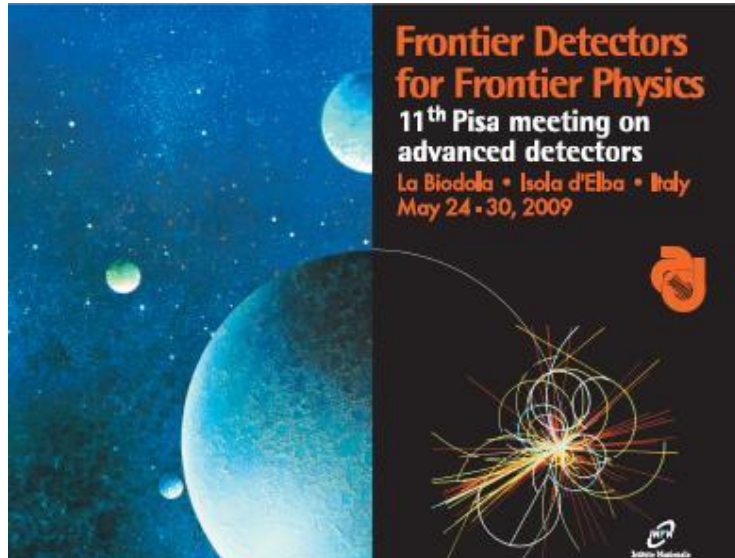
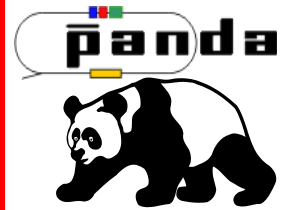
Risoluzione in momento



Efficienza



STT in sintesi



Frontier Detectors for Frontier Physics
11th Pisa meeting on advanced detectors
 La Biodola • Isola d'Elba • Italy
 May 24 - 30, 2009

S. Costanza,
The Straw Tube Tracker
of the PANDA experiment,
 Poster a
11° Pisa Meeting on advanced detectors
Elba-LaBiodola, maggio 2009

The Straw Tube Tracker of the PANDA experiment

L. Basso¹, A. Baghetti¹, G. Boca¹, S. Costanza¹, P. Gronzoni¹, P. Giannotti¹, L. Lavezzi¹, V. Luchetti¹, P. Montagna¹, D. Orsini¹, D. Pieraggi¹, J. Rinnert¹, M. Rossi¹, A. Rotondi¹, A. Russer¹, P. Wüster²
¹ INFN Laboratori Nazionali di Frascati, Via E. Fermi 40 - 00044 Frascati, (Italy)
² Dept. Nucl. Theor. Phys., Pavia University, Via Bassi 6 - 27100 Pavia (Italy)
³ INFN Pavia, Via Bassi, 6 - 27100 Pavia (Italy)
⁴ BIP Forschungszentrum Jülich, D-51742 Jülich (Germany)

THE PANDA EXPERIMENT
 PANDA is one of the major projects of the FAIR facility at Darmstadt, which is an extension of the existing Heavy Ion Research Lab (GSI), expected to start its operation in 2018.
 The universal PANDA detector will be built in order to study fundamental questions of hadron and nuclear physics in interactions of antiprotons with fixed target protons and nuclei, using the High Energy Storage Ring.

THE STRAW TUBE TRACKER OF PANDA
 The Straw Tube Tracker (STT) is one of the possible options for tracking the charged particles inside the target spectrometer. Its goal is to provide precise measurements of the track coordinates and to reach a momentum resolution on the percent level.

STT DESIGN
 The proposed arrangement will have:
 - 4 double layers parallel to the detector axis,
 - 4 skewed double-layers with an angle of $\pm 3^\circ$ with respect to the beam axis,
 - further 4 straight double-layers,
 - incomplete double-layers in the outer region, for a total number of 420 straw tubes.

STT MECHANICS
 In order to support the straw tube double-layers, an support structure has been designed. In order to reduce the weight of the support structure, the tubes are close-packed and the wires are stretched by 50 g @ 4g - 1 bar at this gas overpressure the double-layers become self-supporting.

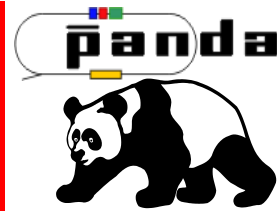
SINGLE STRAW SIMULATION
 A detailed simulation of the charge generation and collection in a single straw tube includes ionization statistics, electron diffusion, gas gain and noise and discriminator threshold.
 - The position and number of electron clusters is sampled from the exponential distribution.
 - The number of electrons belonging to a cluster is taken from both experimental and theoretical papers.
 - Their position is dispersed according to the GARFIELD diffusion curves.
 - The arrival time of each electron on the wire is derived from a Poisa distribution having as mean value the gain given by GARFIELD.

SIMULATIONS
 All the simulations have been performed inside the PandaROOT framework, by running the complete chain simulation: digitization-reconstruction and by using the packages devoted to the global tracking.
Simulation
 The simulations are run using more than one subdetector with the addition of the passive elements.
Digitization
 - Ideal: geometrical distance of closest approach to the wire - Geant energy loss
 - Real full: full simulation (ionization clusters, diffusion process, drift time, gain, signal formation)
 - Real fast: sampling from simulated or experimental resolution to track-sect distance
Reconstruction
 The fitting algorithm has been developed using the helix model and serves as a prefit of the track. It's performed in two planes separately:
 -y plane, perpendicular to the magnetic field direction, with a circle fit;
 -x-track length plane, with a straight line fit.

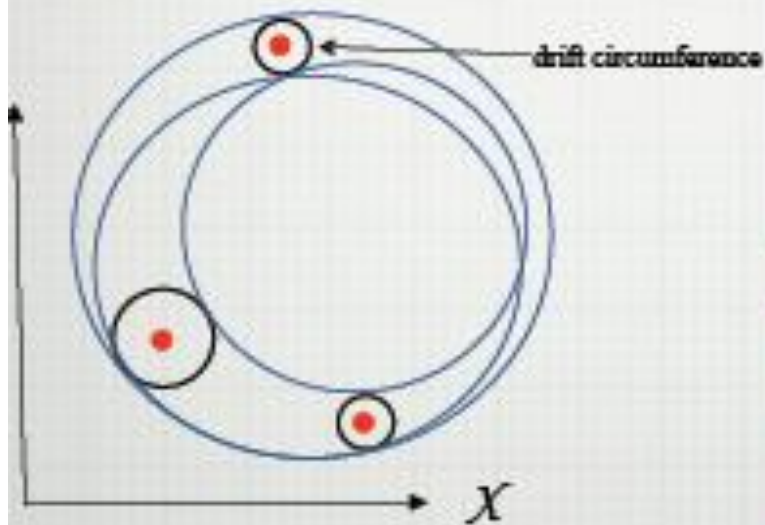
AGING TESTS
 The straw setup consisted of a double-layer of 32 tubes, installed behind the COSY-TOF apparatus and exposed to the residual proton beam with a momentum of 3 GeV/c. Each tube was made of 30 µm thick mylar film tubes with 30 mm diameter and had a length of 505 cm. The gas supply was divided into 4 individual circuits with one circuit for every 8 straws, in order to test different gas mixtures (Ar based, with different fractions of CO₂). The gas pressure was 150 mbar for all mixtures.

EXPERIMENTAL RESULTS
 Signal of 3 wires in proton beam, signal rates of a few µA sec⁻¹
 Single straw signals (cosmic) and corresponding discriminator output
 The total charge is obtained by summing the signal over the number of e⁻. When considering the arrival time of each electron and assigning a gaussian-shaped electrical response to each charge multiplication, the shape of the electrical signal can be reproduced too. The time is given by the threshold on the impulse.
 The cumulative of the simulated time histogram gives the response curve $r(t)$ of the tube.
 This allows to obtain the resolution curve.
 Experimental: without magnetic field
 Simulated: with magnetic field
 Kalman fit
 The Kalman filter is applied to improve the momentum resolution. The procedure can be iterated several times until it converges.
 Experimental resolution curve without magnetic field
 Momentum distributions for 10000 fit reconstructed with MVD & STT
 Simulated resolution curve with magnetic field

STT - Pattern Recognition



Pattern Recognition for STT Based on Hough transformation of Helix trajectory G.Boca, giugno 2009



Parametrization of the Helix trajectory

$$x - x_0 = R \cos(Kz + \varphi_0)$$

$$y - y_0 = R \sin(Kz + \varphi_0)$$

$$\varphi = Kz + \varphi_0$$

5 parameters :

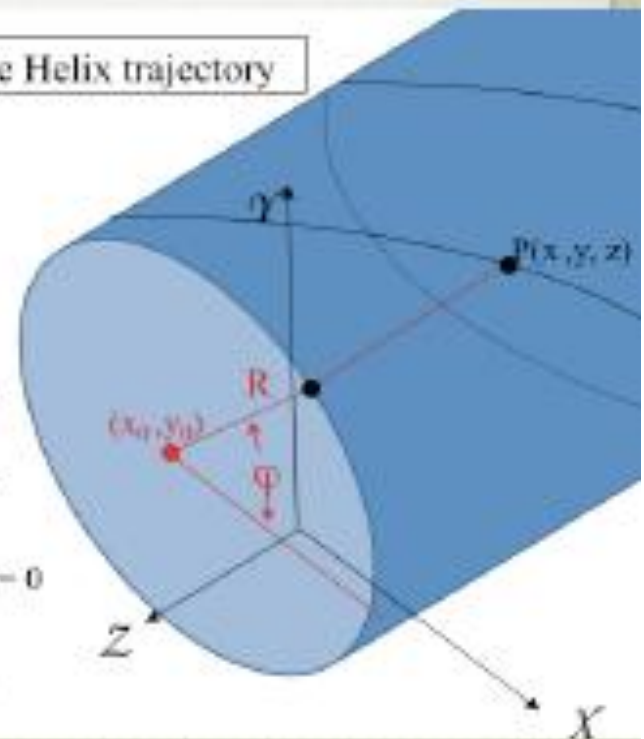
x_0 = abscissa of center of cylinder

y_0 = ordinate of center of cylinder

φ_0 = azimuthal angle at $z = 0$

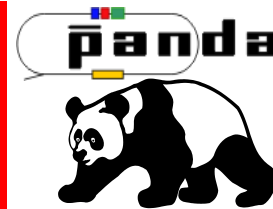
R = radius of cylinder

K = rate of increase of φ



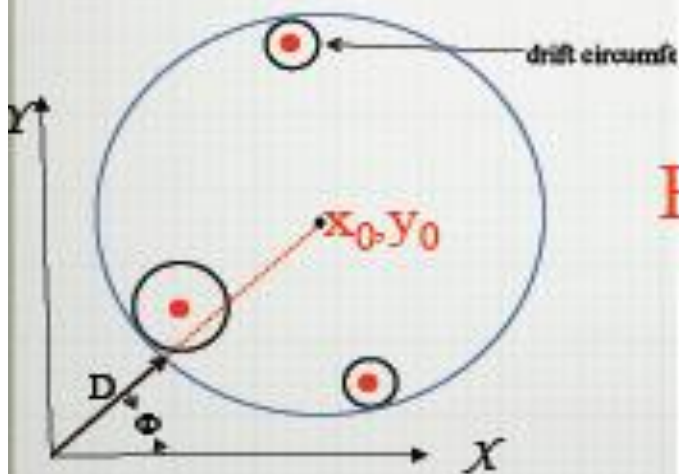
Gianluigi Boca

STT - Pattern Recognition

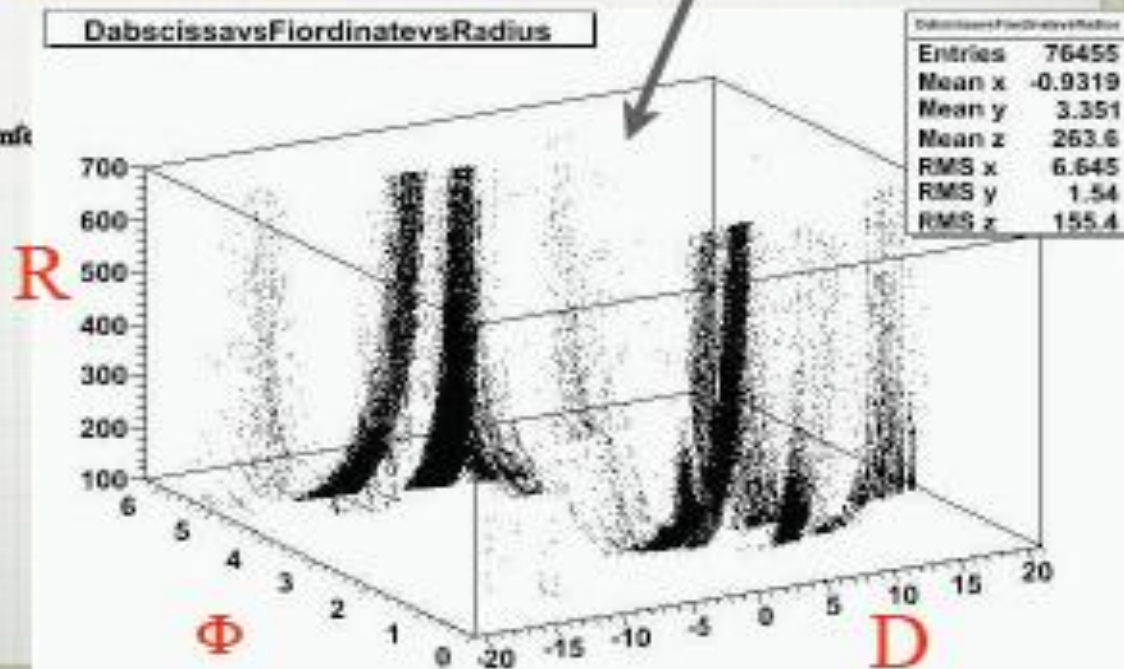


- Good news: speed of code OK (0.1-0.2 secs/event)
- Bad news: efficiency moderate (44-90%); problems to overcome for hit finding for skew straws

peak finding !!!



Gianluigi Boca



STT R&D: Test su prototipo

Risposta STT in regime proporzionale
Test con cosmici

Coincidenza tra due slabs di scintillatori
plastici (45 x 7 x 0.5 cm) a distanza 10 cm

Rate basso: 1000 cosmici/ora
2% su singolo straw tube

Prototipo STT (by LNF):

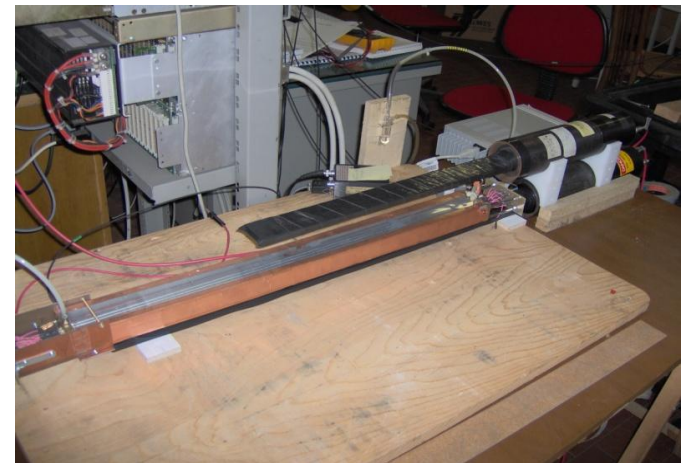
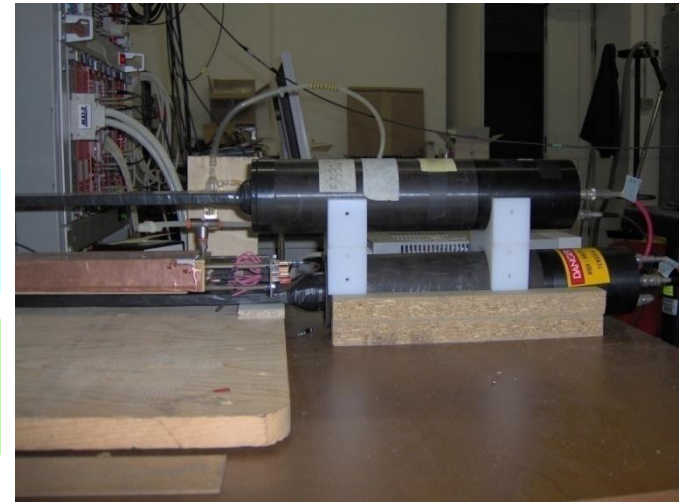
12 tubi da 70 cm, \varnothing 6 mm
di kapton XC e alluminio (tot. 100 μ m)
(prod. LAMINA, metodo LHCB)

3 strati incollati

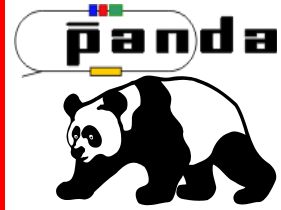
Anodo: tungsteno-rhenio dorato, \varnothing 20 μ m)

Gas: 93% Ar, 7% CO₂

d.d.p. 1300 Volt



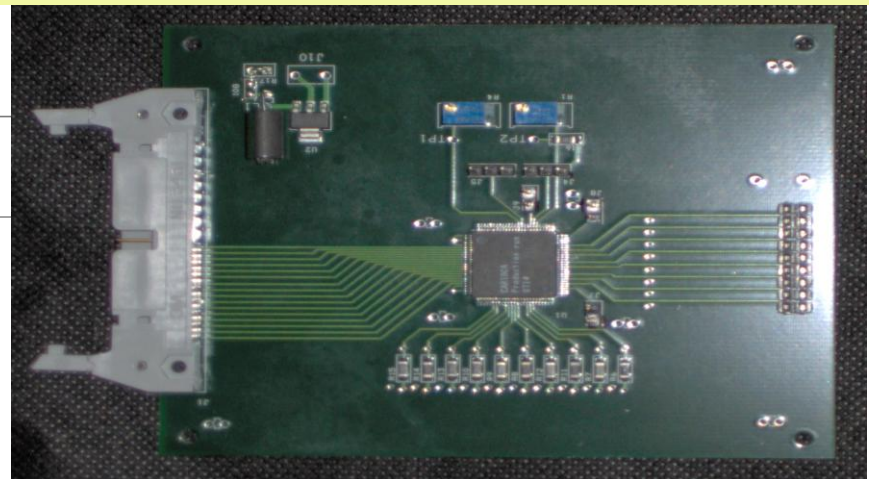
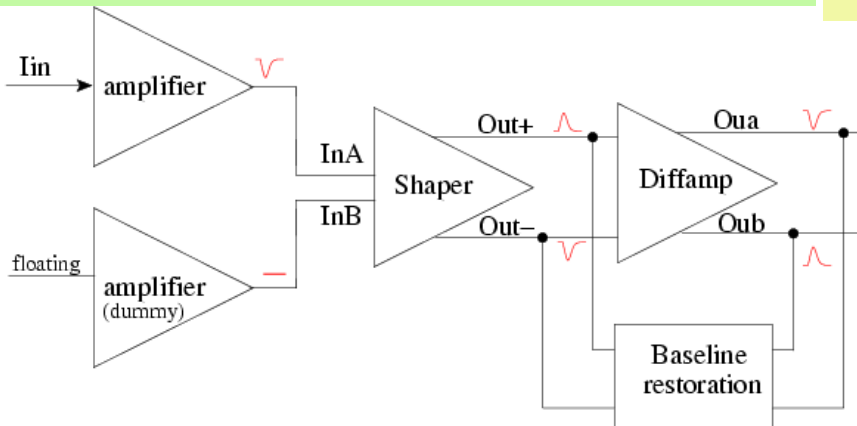
STT R&D: Sviluppo elettronica



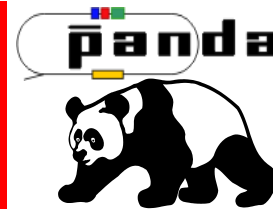
- Utilizzo di chips CMOS multicanale:
Charge Preampl+filter+shaper
- Prime esperienze con "antiquato" chip GASSIPLEX 16
- Progettazione e realizzazione di una scheda basata su chip **CARIOCA10** (**++ Supporto & ++ Performances**):
scheda di test **ServEI PV**

Attività di laboratorio: test di misura dell'ampiezza della carica rilasciata negli straw tubes, per l'identificazione di particelle cariche mediante dE/dx .

E' stata messa a punto e testata una scheda di Front End (FE) basata sul chip Gassiplex a tecnologia CMOS. Le prime misure hanno dato esito positivo, tuttavia si è ritenuto di cambiare tipo di chip in quanto il gassiplex non verrà supportato e prodotto a lungo ed inoltre è richiesta una seconda scheda FE per la misura del Drift Time (TDC). Dunque si è deciso di utilizzare un chip differente denominato CARIOCA che permette di misurare sia il drift time (mediante un TDC) sia l'ampiezza di carica mediante la tecnica del Time-Over-Threshold (TOT).



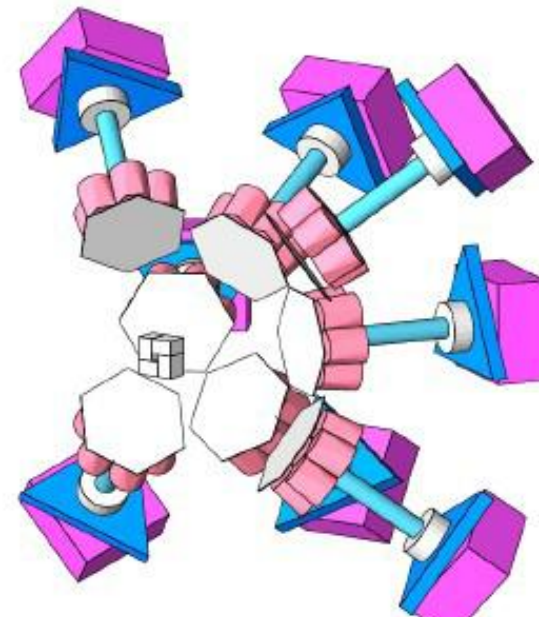
HPGe: obiettivo



Studio delle performances di un cristallo di Germanio ad alta purezza (HPGe) in campi magnetici elevati

Obiettivo: caratterizzazione di un cristallo di Germanio HPGe in campo magnetico di elevata intensità (fino a 2.5 T) con campo diretto lungo l'asse del cristallo.

Studio preliminare alla costruzione del rivelatore per spettroscopia gamma di ipernuclei di Panda.



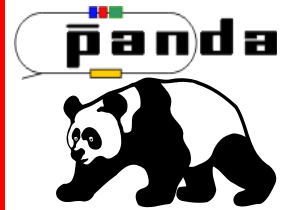
PRIN 2005: Pavia, Torino, Bologna, Catania

Misure effettuate ai LNS, nov.2007

Risultati presentati da A.Fontana a ANIMMA 2009, Marsiglia, mag.09

Advancements in Nuclear Instrumentation, Measurement Methods and their Applications

HPGe: experimental setup



Experimental setup @ INFN LNS Laboratory

Germanium detector: GX10P4-S-PLUS coaxial crystal manufactured by ORTEC.
High-purity, **n-type**, non-segmented, germanium cylindrical crystal (external diameter: 42 mm, length: 57 mm).
Nominal **energy resolution:** 1.8 keV at 1332.50 keV (for the γ -ray of the ^{60}Co)
Nominal **efficiency:** > 10% is guaranteed.
Cooling of the crystal: ORTEC electric cooler CFG-X-Cool-II-230, placed outside the magnet.

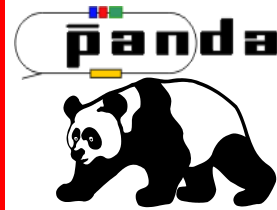


Magnetic field: superconducting SOLE magnet located at the Laboratori Nazionali del Sud (LNS) of the National Institute of Nuclear Physics (INFN).
Maximum value of the magnetic field: 2.5 T
Uniformity: within 0.95% up to 15 cm from the coil axis.

Total free volume allows to place the HPGe detector with its symmetry axis along the field direction and to tilt the crystal up to a **maximum angle of 40°** with respect to the magnet axis.

HPGe detectors in high magnetic fields – Conference ANIMMA 2009 – presented by Andrea Fontana, INFN Pavia

HPGe: effetti del campo magnetico sugli spettri gamma



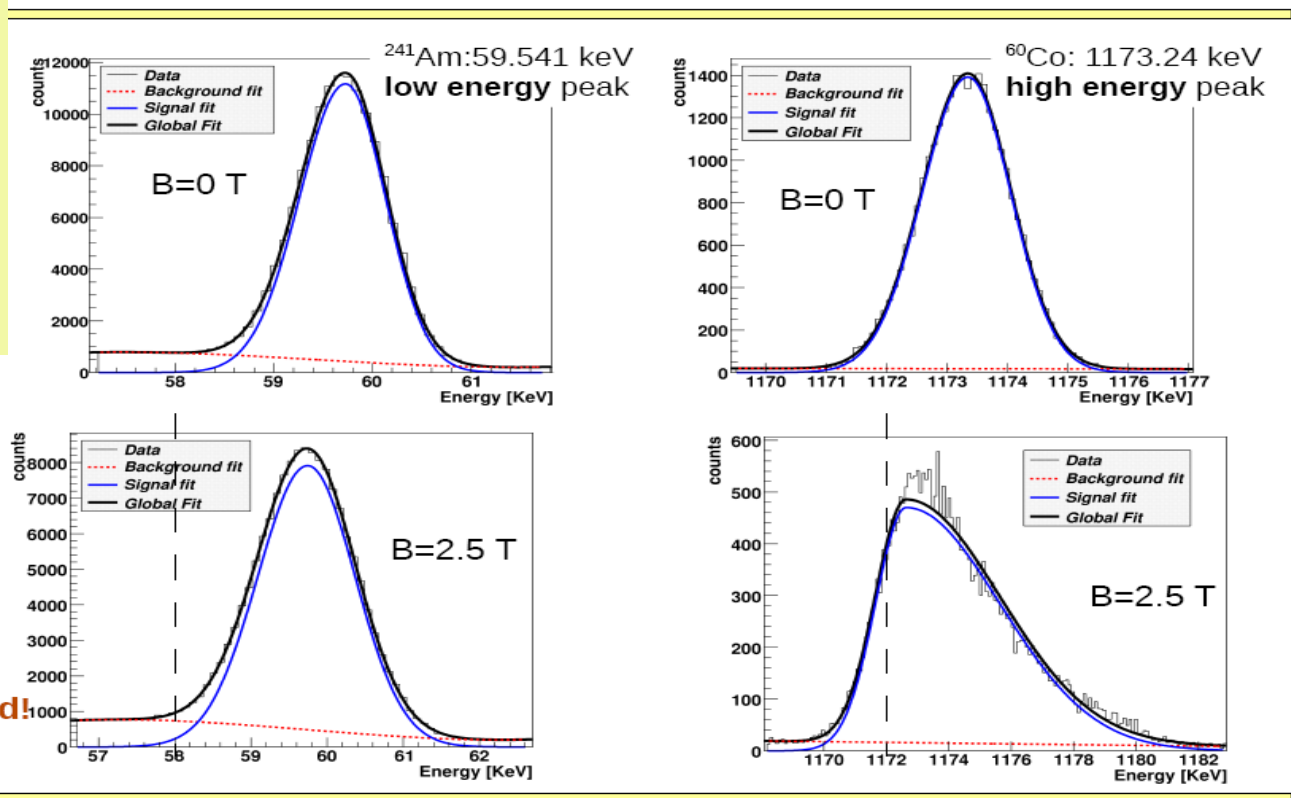
Observed effects of magnetic field on γ spectra

Tre effetti attesi su picchi dello spettro:

- spostamento a sinistra del centroide
- aumento della FWHM
- perdita di efficienza

The effect varies as a **function of the γ energy and of the B field intensity.**

Note background!



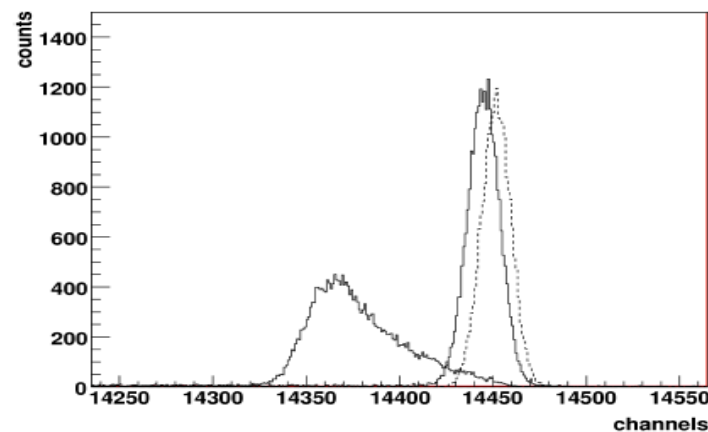
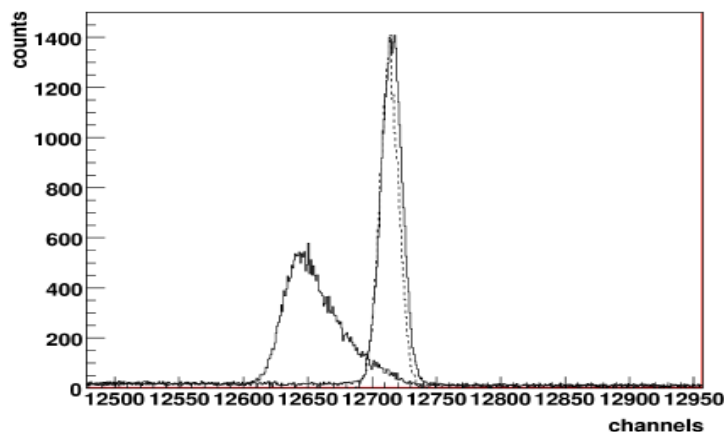
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HPGe: metodo di correzione

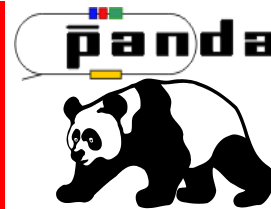
Spectra recovery procedure

By using the interpolating functions for σ_1 , σ_2 and for the centroid shift and the experimental values for the efficiency loss, it is possible to **correct the peak shape** measured in magnetic field by extrapolating the parameters to the zero field value.

- 1) the peak **centroid shift** is calculated and added to the measured centroid position;
- 2) the **ratios** $R_1 = \sigma_1(B=0)/\sigma_1(B \neq 0)$ and $R_2 = \sigma_2(B=0)/\sigma_2(B \neq 0)$ are calculated;
- 3) the experimental σ_1 and σ_2 obtained with $B \neq 0$ are multiplied by R_1 and R_2 to obtain the **corrected σ 's**;
- 4) the efficiency loss is evaluated from the data and is used to **rescale** the number of entries of the measured spectrum.



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HPGe: risultati e conclusioni

Results and conclusions

- We have studied the performances of a **HPGe detector**, with commercial assembly, placed in the **highest magnetic field** ever tried for this type of detectors (**2.5 T**).
- The results show that the detector **works well** globally with **performances slowly worsening** with increasing energy of the γ -rays and field intensity.
- The peaks have been fitted with a **bi-gaussian function** whose parameters have been deduced as a **function of the energy and the field intensity**.
- We obtained an **almost full recovery of the detector resolution** and efficiency and we **demonstrated the possibility of using the HPGe's in very high magnetic fields**.

Our paper has been published (online) last week on **Nuclear Instruments and Methods A** with doi:10.1016/j.nima.2009.04.035 and is available at:

<http://dx.doi.org/10.1016/j.nima.2009.04.035>

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Study of the performance of HPGe detectors operating in very high magnetic fields

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Contributo teorico

M.Radici

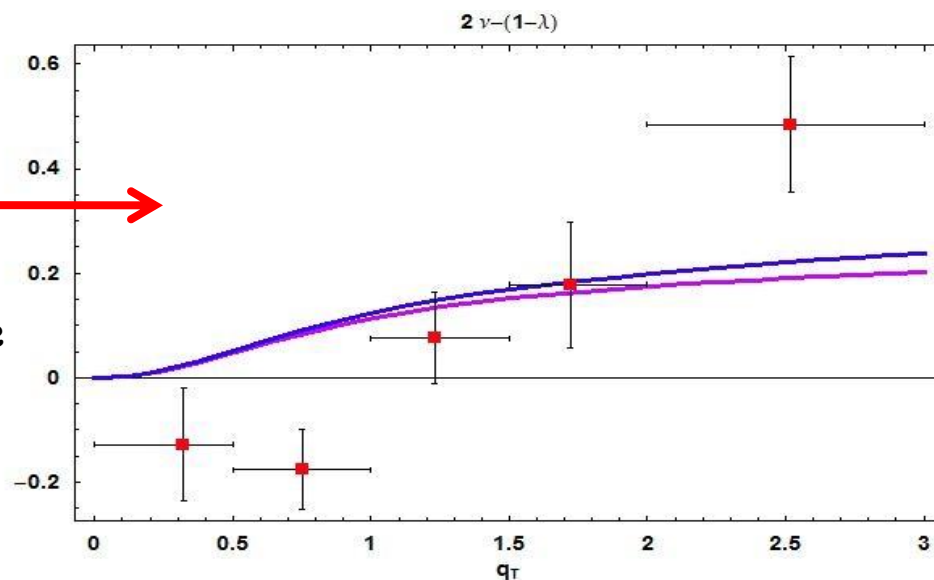
Studio della struttura partonica di spin del nucleone attraverso simmetrie azimutali che coinvolgono distribuzioni partoniche "esotiche"
 → come costruire lo spin $\frac{1}{2}$ dallo spin totale dei partoni costituenti
 Studi di fattibilità con nuovo modello MC

Processo

Drell-Yan non polarizzato

Dati NA10, $\pi^- p \rightarrow \mu^+ \mu^- X$
 con fasci di pioni di 190 GeV

L'asimmetria azimutale dei dati potrebbe essere dovuta al moto trasverso dei partoni negli adroni, cioè al loro moto orbitale (che in QCD perturbativa si trascura sistematicamente).

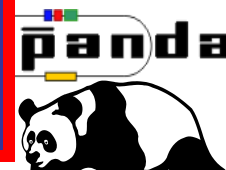


In PANDA reazione analoga: $p\bar{p} p \rightarrow \mu^+ \mu^- X$

(annichilazione dominante in entrambi i casi $u\bar{u}$ - $d\bar{d}$)

Miglior copertura angolare: grande riduzione delle barre di errore

Panda PV 2010: impegni e richieste



Situazione simile al 2009:

Ricercatori: %2010 %09

Bendiscioli	PO sr	100	60
Rotondi	PO	60	60
Radici	1RIC	20	20
Boca	RU	50	30
Braghieri	RIC	50	50
Fontana	RIC	30	40
Montagna	RU	70	70
Salvini	RIC	20	20
Genova	ass.ric.	20	20
Lavezzi		0	0
Costanza	DOTT	100	100
Cattaneo C.	docente	(20)	(0)
Panzarasa	docente	(50)	(50)

Tot 2010 5.2 FTE (5.9)
(2009 4.7 FTE)

+ 100% ass.ric.biennale
Hadron FP7 - nov.09?

PREVENTIVO DI SPESA 2010

Missioni interne: 9 K€

- 2 meeting Collab.italiana x 4 ric. x 2gg (2 k€)
- 4 meeting resp.locali e coordinatori (Montagna, Braghieri x 2gg Roma, 4 k€)
- contatti LNF per sviluppo STT (2 ric. x 5gg, 1.5 k€)
- contatti gruppi italiani SW (2 ric. x 5gg, 1.5 k€)

Missioni estere: 37 K€

- 4 meeting Collab. x 3 ric. x 5gg (18 k€)
- Mobilità rappr.Speakers Board e coord. SW-Tracking (Rotondi, 4x3gg, 5k€)
- 2 SW workshop x 2 ric. x 5gg (6 k€)
- Contatti con Julich per sviluppo STT (2x3gg, 3 k€)
- 2 meeting tracking x 2 ric. x 3gg (5 k€)

Consumo: 5 K€

- gas: argon, etano, freon, mix Ar-CO2 (3 k€)
- realizzazione stampati test carioaca10 2° versione per time-over-threshold (1 k€)
- varie, piccola meccanica, comp.elettronica (1 k€)

Materiale inventariabile: 10 K€

- 4 HD 750 GB per upgrade server (1 k€)
- discriminatore VME constant fraction (3 k€)
- PC per catena test DAQ (2 k€)
- modulo sampling ADC Wiener test DAQ (4 k€)

TOTALE 2010 61 k€

2009
Rich. Ass

12 6

39 17.5

6 3

9 3

TOT '09

65 29.5