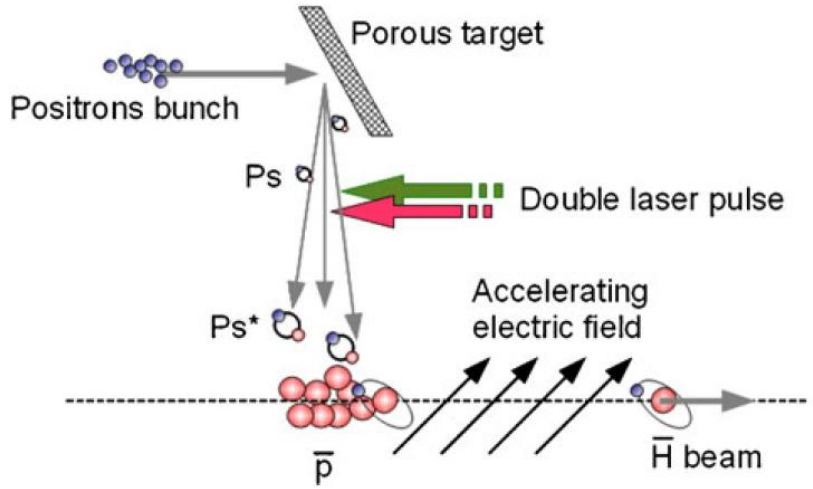
Aegis-PV

Consuntivo attivita' 2011/2012

Andrea Fontana
INFN Sezione di Pavia – CdS 20.06.2012

AEgIS summary



1) Catch pbar from AD , cool, store
Pbar ultracooling (100 mK cioe' 10^{-5} eV)

2) Accumulate e+
Launch e+ toward a e+Ps converter (nanoPorous target)
Produce Ps

3) Excite Ps to Rydberg states (laser pulses)

4) Produce Rydberg Hbar

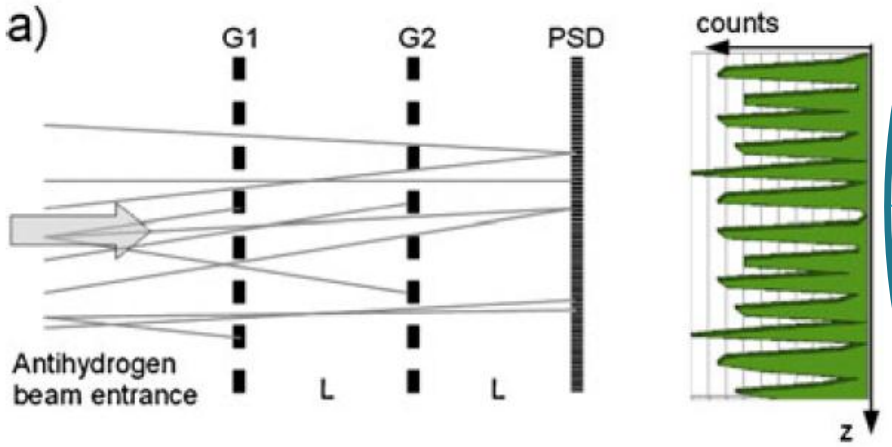
$$\bar{p} + Ps^{*} \rightarrow \bar{H}^{*} + e^{-}$$

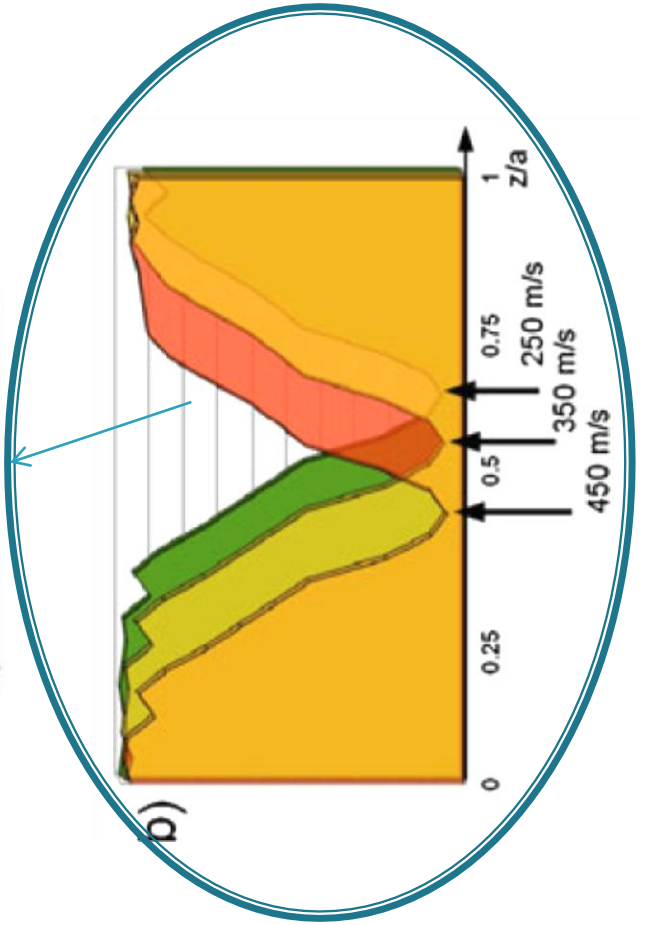
5) Form the beam
(electric field gradient)

6) Measure gravity

AEgIS summary

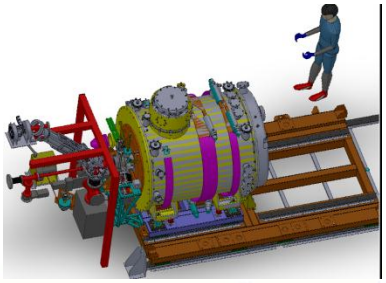
The gravity measurement:

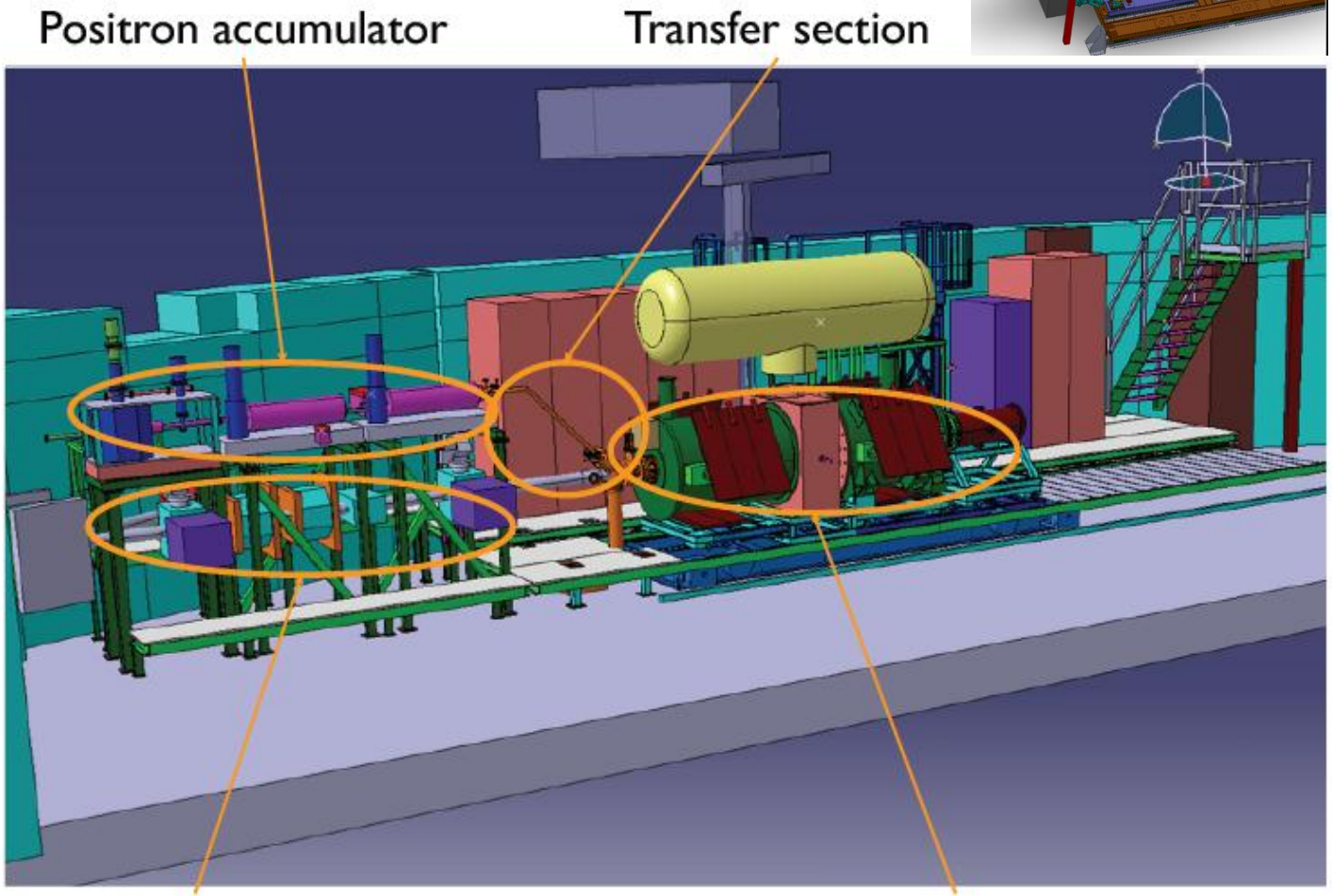




- 2 gratings
- Position sensitive detector
- Measure the vertical shift of the annihilation pattern vs velocity

L'apparato AEgIS





Run 2012: programma

•Beam time con antiprotoni : fine aprile- 30 giugno >8 ore/giorno
ottimizzazione cattura antiprotoni
ottimizzazione cooling
accumulazione

In modo parassita: test rivelatori posizione con pbar estratti dalla trappola (Si strips e emulsioni (OPERA))

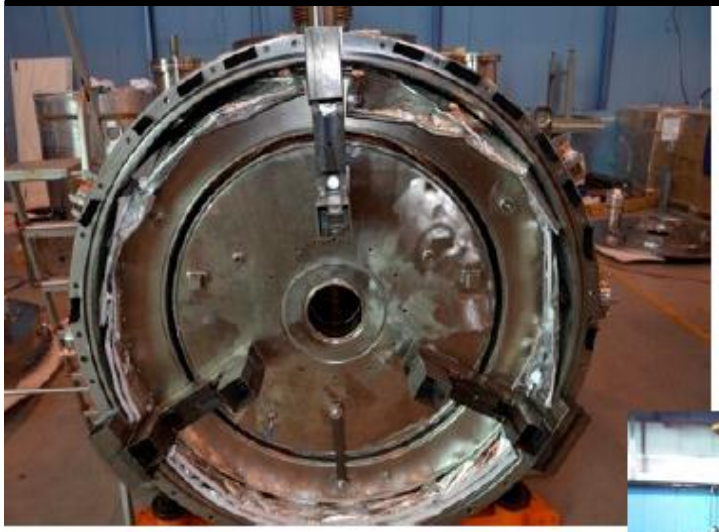
• In parallelo : run con e+

• Manipolazione simultanea e+- antiprotoni

• Luglio- agosto: completamento installazione zona 1 Tesla

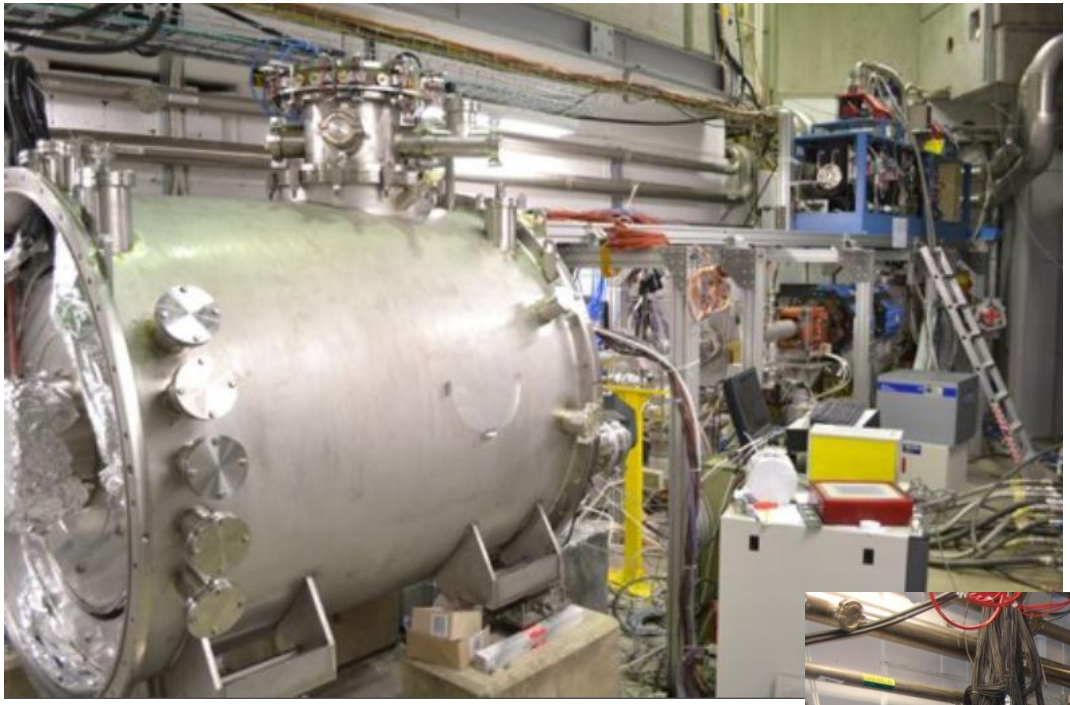
• Settembre-ottobre-novembre: beam time 8 ore/ giorno con antiprotoni

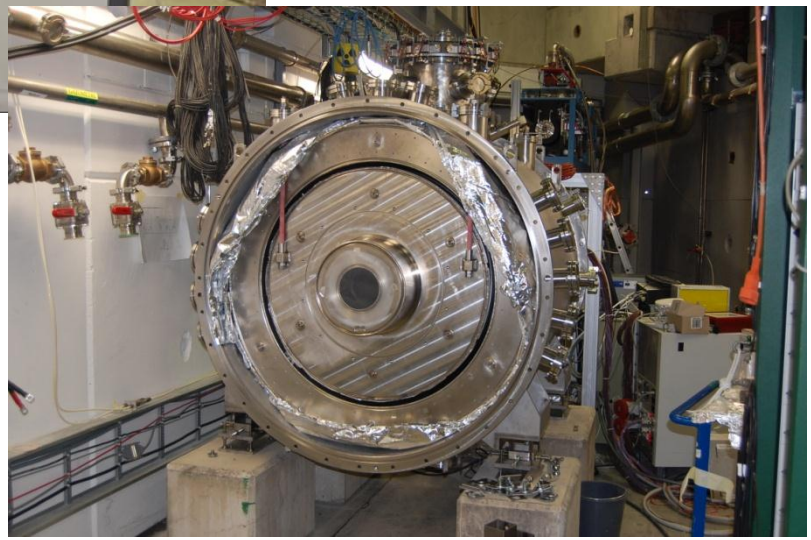
5 Tesla superconducting magnet assembly (full design and construction by AEgIS)



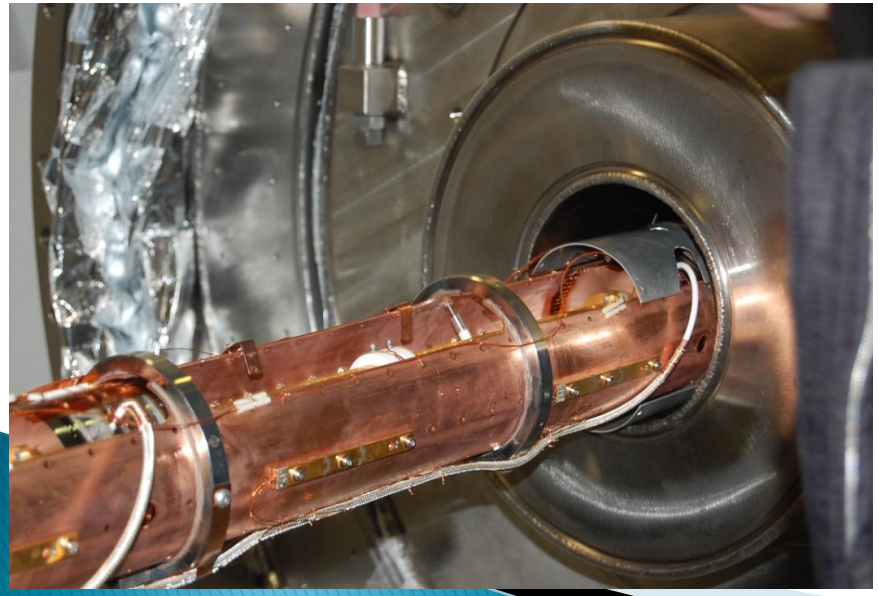
Installation in the zone

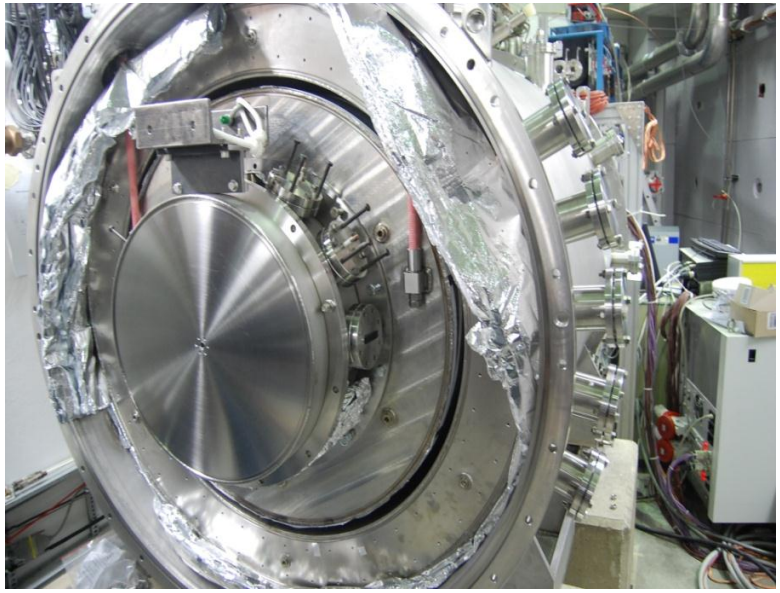
5 Tesla magnet in the experimental zone





Mounting the trap in the 5 tesla region





Rivelatori gia' montati

- Scintillatori esterni attorno al magnete 5 Tesla (pbar) letti da HPD e PMTs
- Faraday Cup (misura numero totale e−, e+ in trap)
- MCP + Phosphor+ CCD : numero tot e distribuzione radiale integrata su z (e+, e−, pbar)
- CsI su accumulatore di positroni

Faraday Cup e MCP+Phosphor : montati nel bore del magnete in ambiente criogenico sul cammino del fascio
Devono essere rimossi per catturare pbar, e+, e−
Movimentazione meccanica esterna

Impegno del gruppo di Pavia/Brescia

1. **Rivelatori esterni**: fornitura detectors (PMT e HPD)
   (Andrea, Alberto, Cristina, Pablo + servizio elettronico/officina)

2. **Simulazioni MC**
   a. Linea di fascio e degraders (Germano)
   b. Rivelatori esterni (Pablo)
   c. Rivelatore centrale antiidrogeno (Andrea, Martin, Pablo, Mario)
   d. Rivelatore downstream per misura g (Germano, Cristina, Alice)

3. **Integrazione DAQ** e software online/offline (A.,C.,P.,G.,Martin+Francesco)

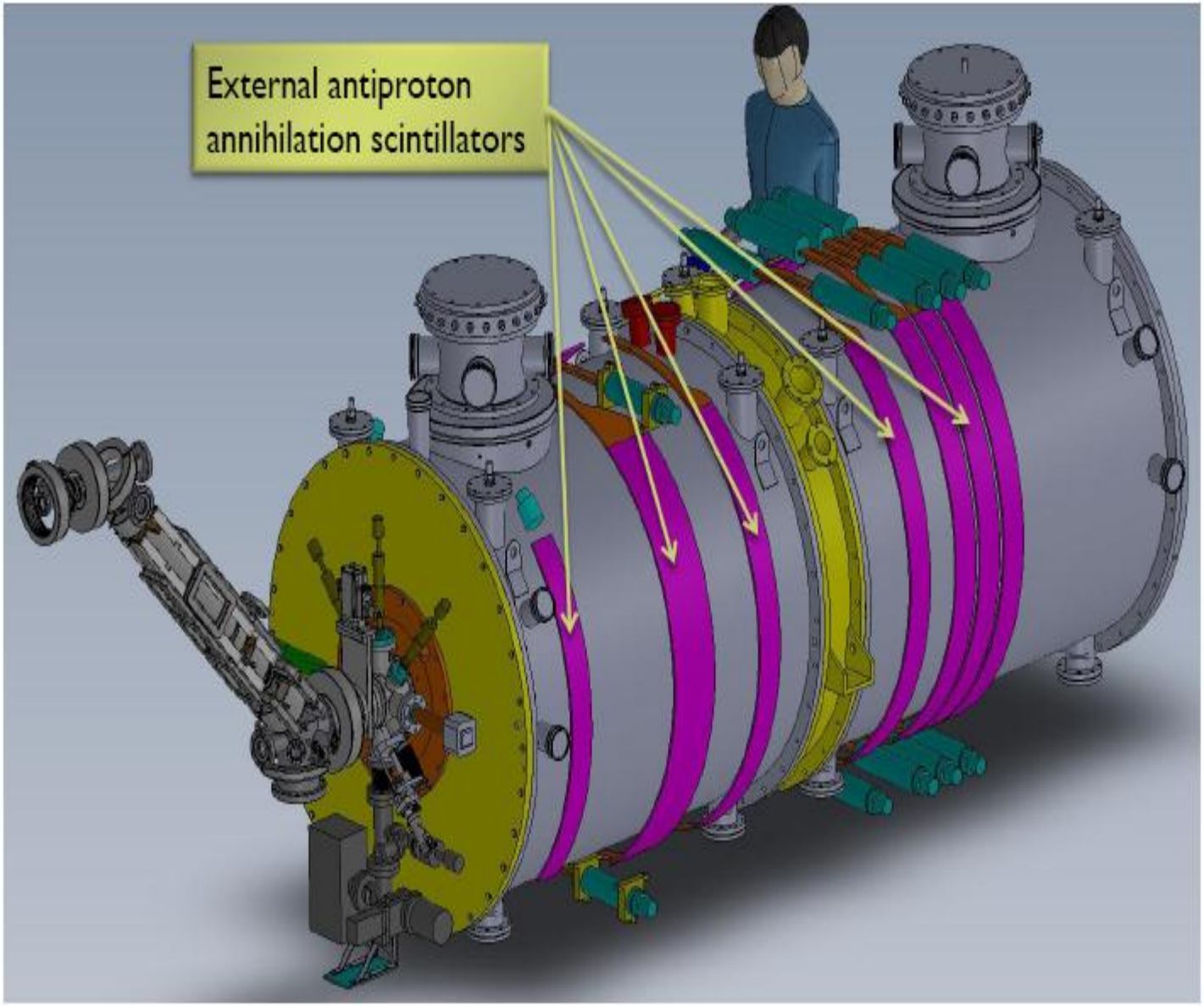
4. Progettazione e **disegno meccanica** (Bs) (Luca+officina)

People in Pavia/Brescia

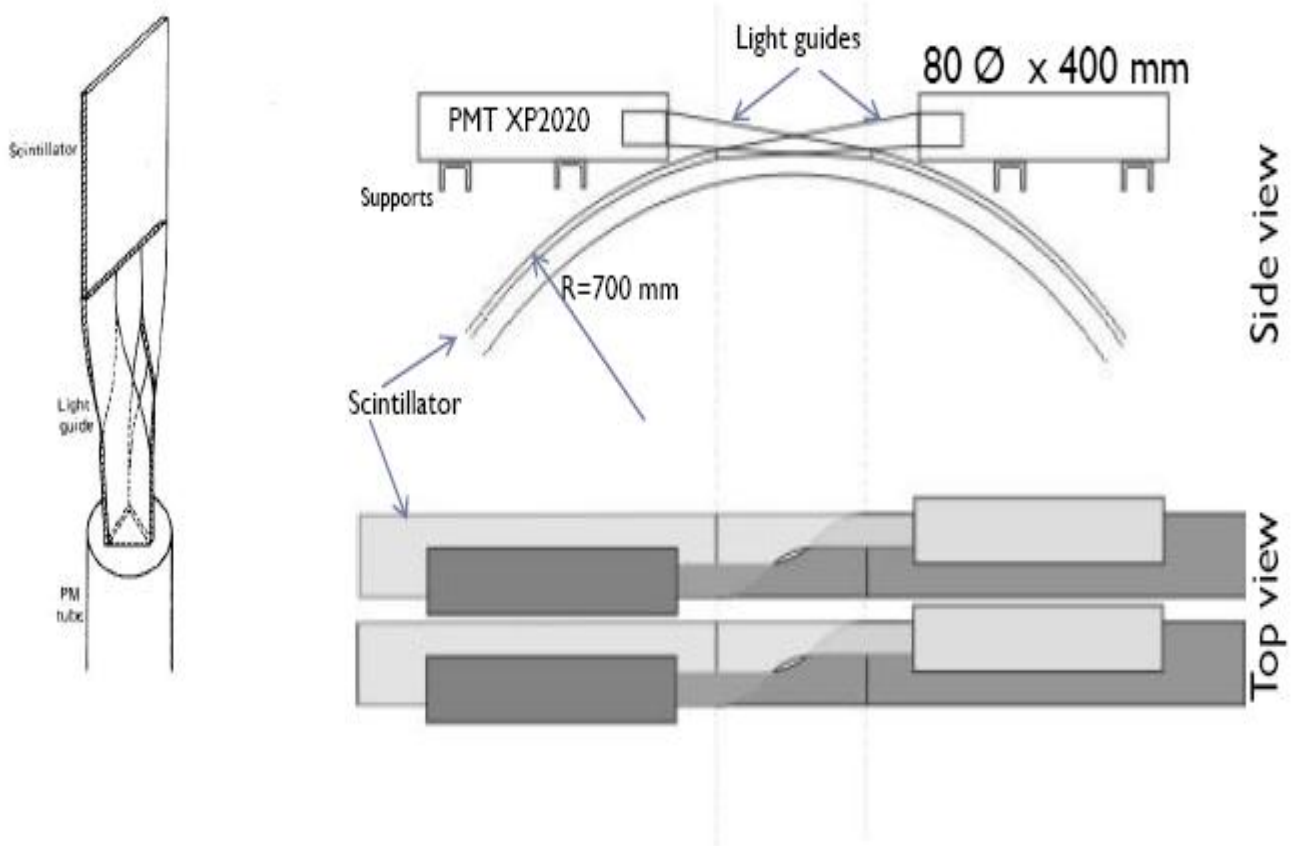
G. Bonomi	RU
L. Dassa	AS/BS
A. Donzella	TL
A. Fontana	RI(RL)
(P. Genova	*AS/PV)*
C. Riccardi	RU
A. Rotondi	PO
M. Subieta	AS/BS
A. Zenoni	PO

+ 2 laureandi (magistrale)

Antiproton annihilation detectors



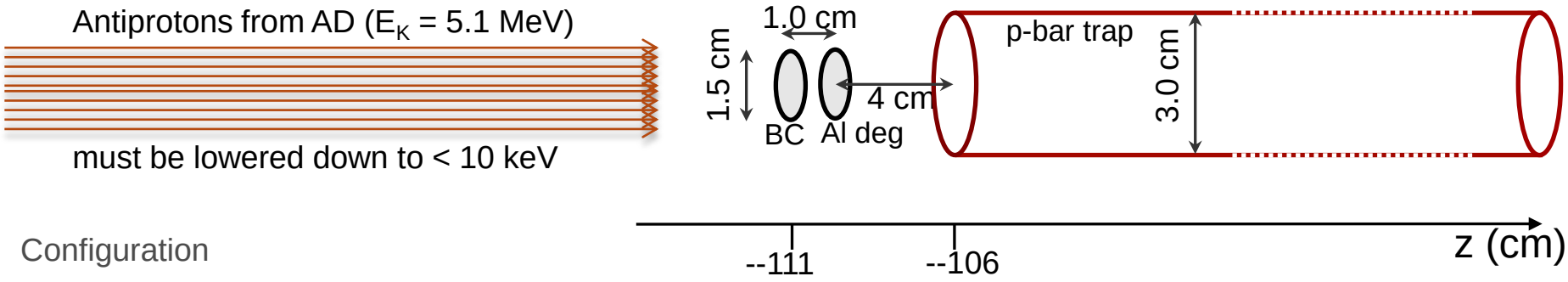
External hodoscope setup



Elettronica partitori: servizio elettronico (Marco, Massimo)
Meccanica PMT e telaio: officina (Angelo, Claudio, Filippo)

Apparatus simulations: degrader system

(not in scale)

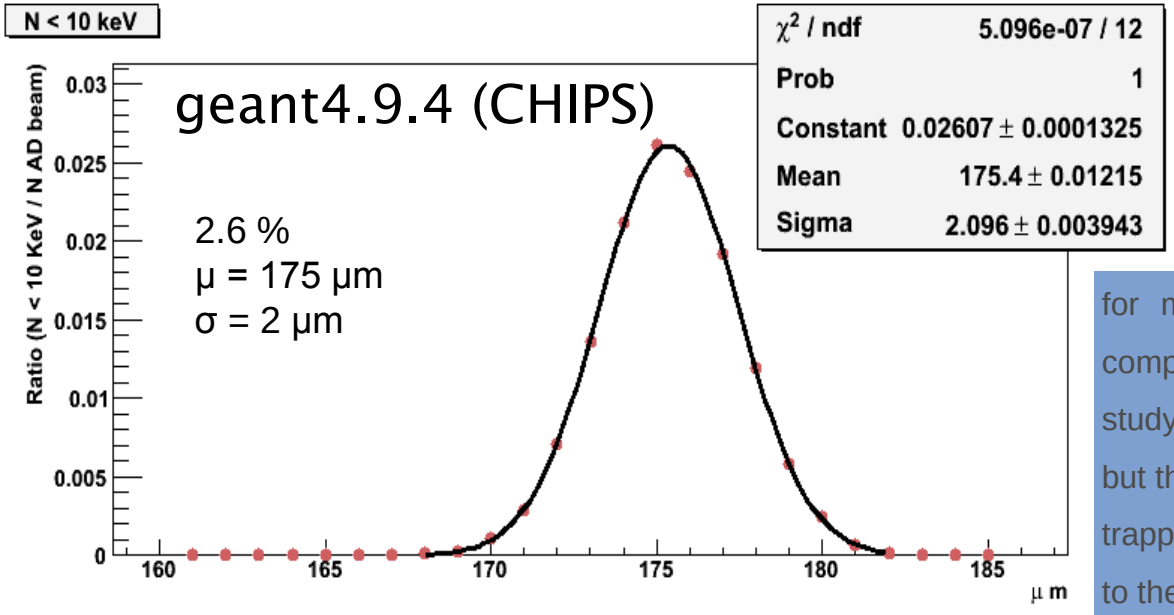


Configuration

55 μm Silicon Beam Counter + additional Al degraders in front of the trap

Goal of the simulation: optimizing the thickness

⇒ maximizing the number of pbar with E_K < 10 keV



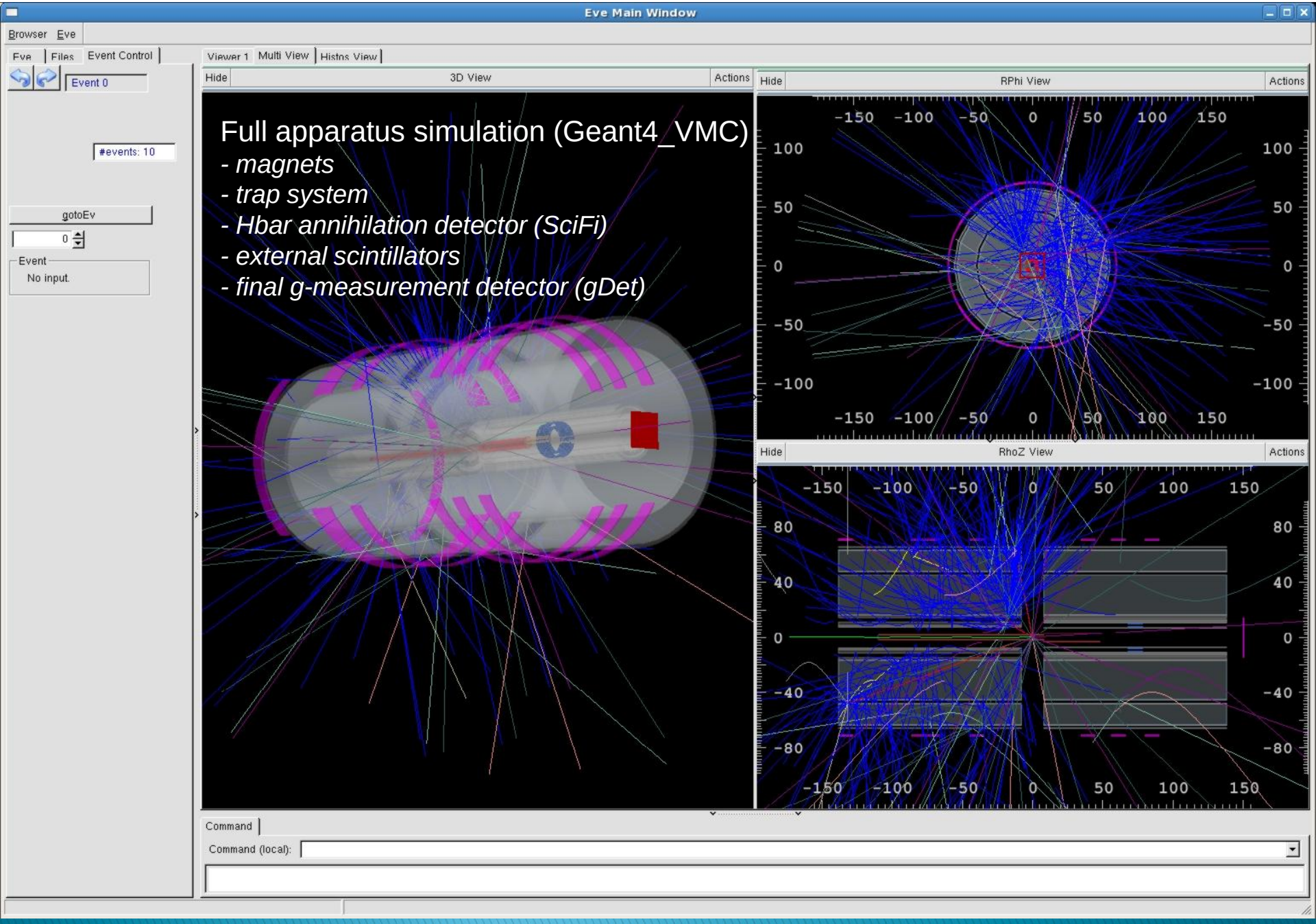
Running conditions

- 55 μm Silicon Beam Counter
- 156 μm Al degrader in front of the trap
- 20 μm Al additional 1m upstream

TOTAL THICKNESS: 176 μm

for mechanical reasons we could not perform a complete “trapping efficiency vs degrader thickness” study (only few microns from the running conditions), but the simulations proved to be reliable since we are trapping a high number of antiprotons (we are close to the maximum)

Apparatus simulations: full geometry

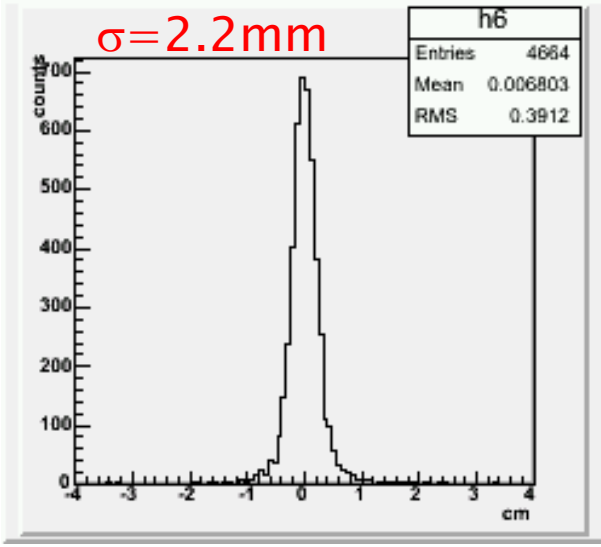


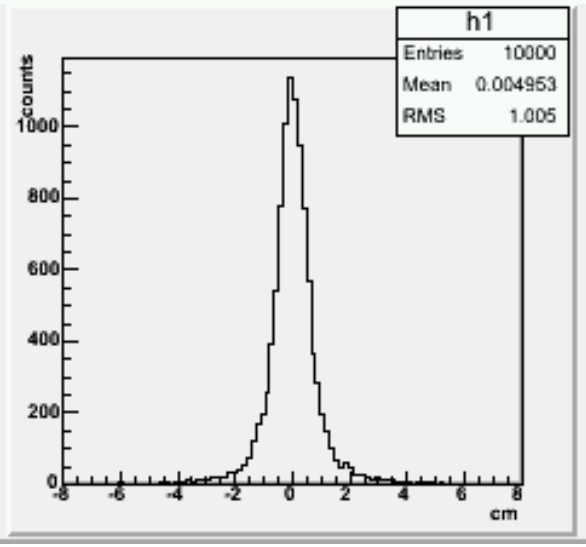
Z Gen. – Z Rec. Z Gen. Z Rec.

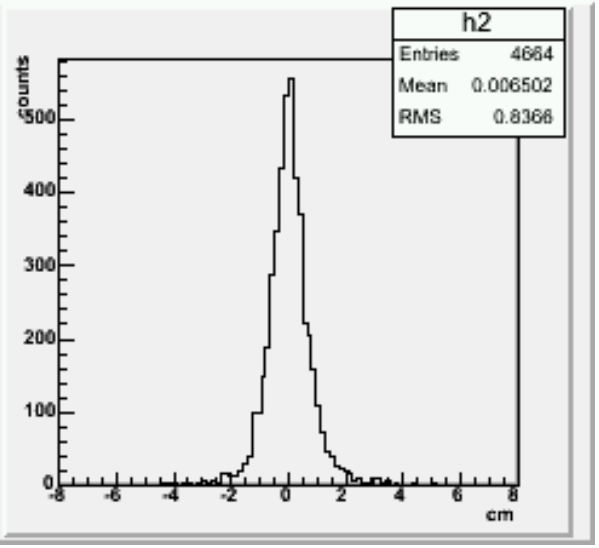
∅=1mm – all materials – no dilution refrigerator

Hbar temp 15 K

σ=2.2mm

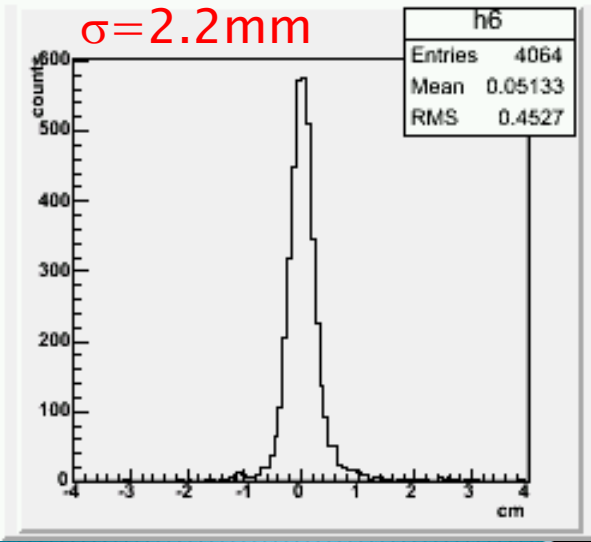


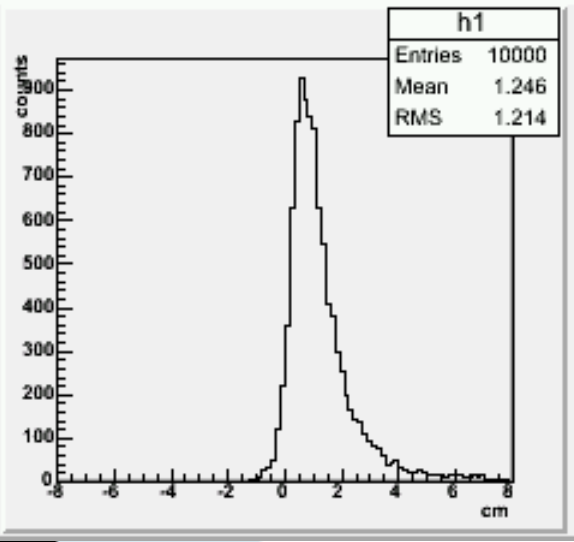


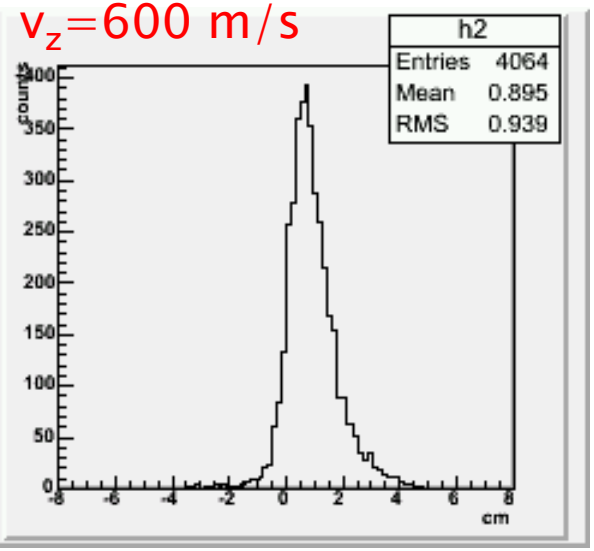


Hbar temp 15 K + v_z=600 m/s

σ=2.2mm

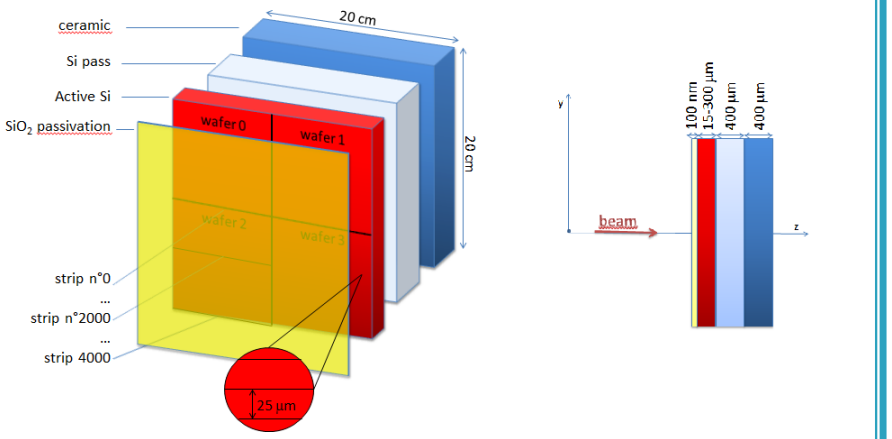






Reconstruction of antihydrogen annihilation point through a Silicon μ-strip detector

Simulated detector geometry (design of the detector will start soon)



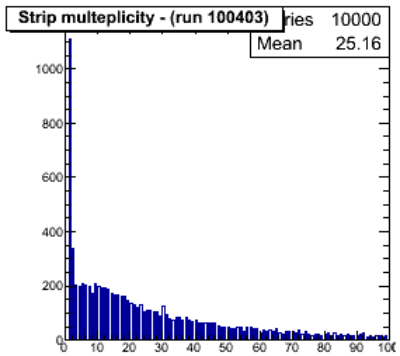
The annihilation of antihydrogen is simulated generating pbars uniformly over the detector 's surface. (v = 600 m/s)

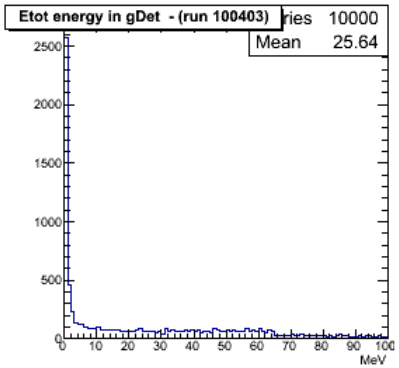
Looking for a reliable annihilation generator

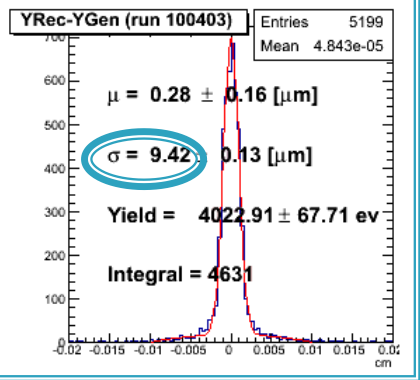
- There are no experimental data concerning the pbar–^{28}Si annihilation in the very low energy range.
- However, we expect production of πs and Ks plus nuclear fragmentation.
- The generators we used:
  - ATHENA pbar+^{28}Si → π^+ π^- π ^{26}Mg / π^+ π^- ^{12}C t α α α / π^+ π^- ^{27}Al
  - CHIPS (it does not produce nuclear fragments)
- A new "physics list" is now available and is going to be tested soon (FTFP_BERT_TRV).

Reconstruction results with the ATHENA generator

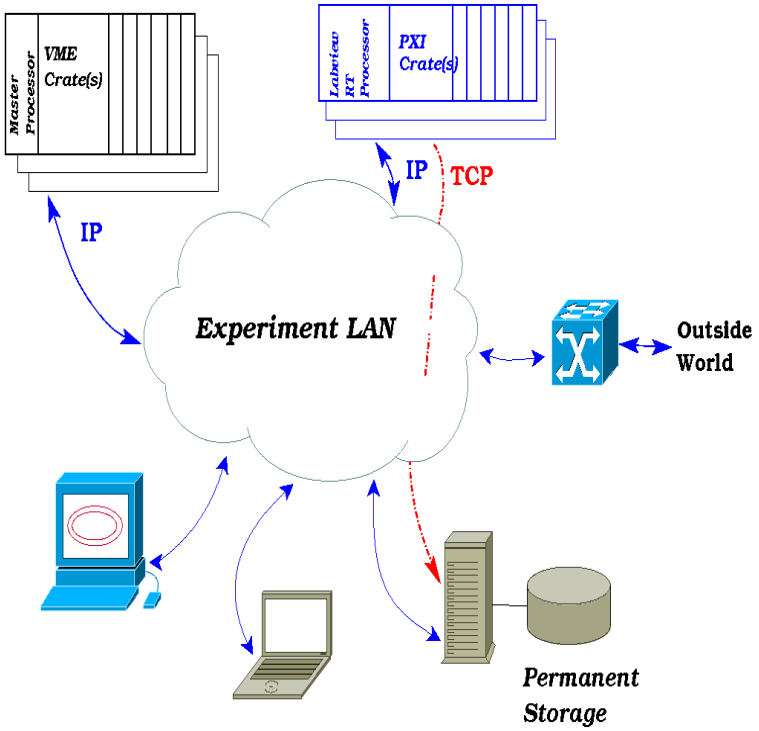
We tried many reconstruction algorithms; with the digital algorithm (annihilaton strip ≡ the strip with highest signal) we obtained: RESOLUTION = 9.4 μm (<10-15 required)







Integrazione DAQ



Collaborazione con
Gemma Testera (INFN-GE)
Francesco Prelz (INFN-MI)

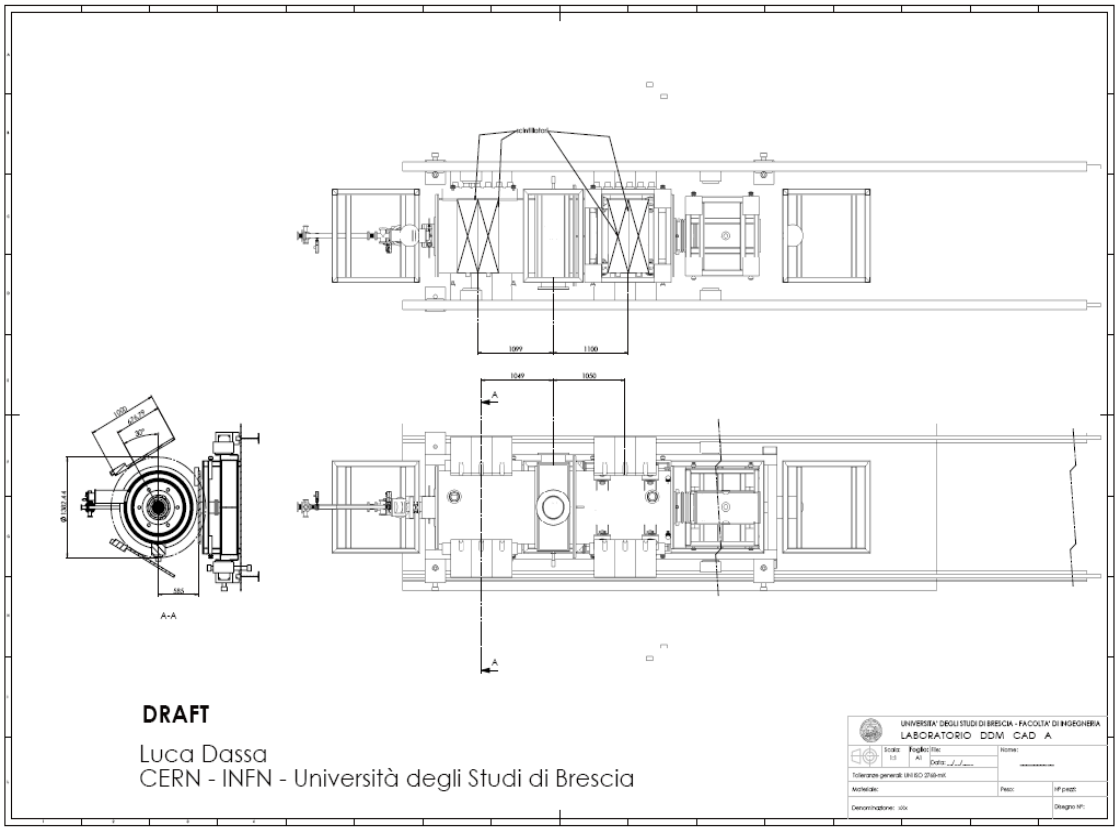
- Data format defined to be GXML: can be shared over an IP network and easily accessed and handled by both LabVIEW and ROOT.
- Installed and netbooted VP110 VME processor on loan from Cern Pool (we use this to acquire data from VME crate).
- New channels (detectors) to be acquired soon.

- *Run 2012: guasto a FPGA Caen V1495*
- *Debug e ottimizzazione del sistema in corso.*

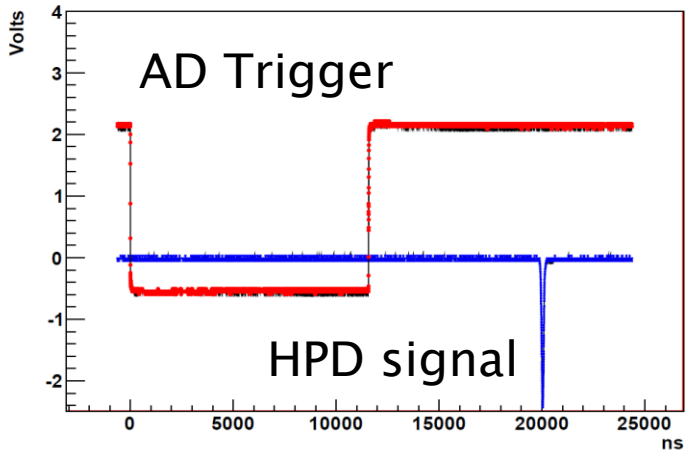
Progettazione meccanica (in coll. con CERN)

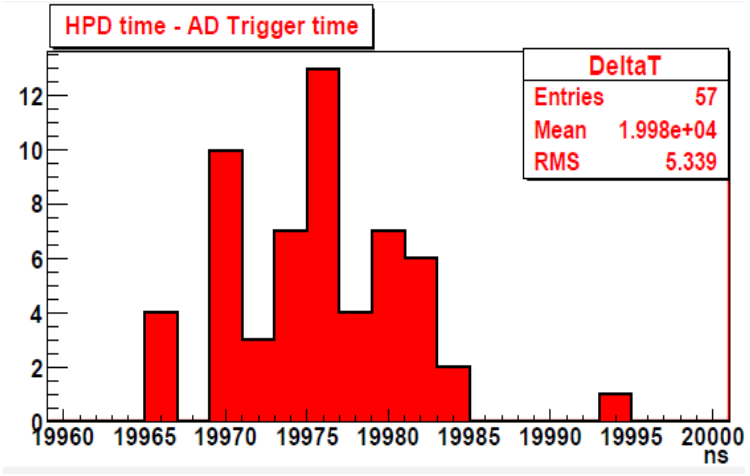
Luca Dassa, Dip. Ing. Meccanica, University of Brescia

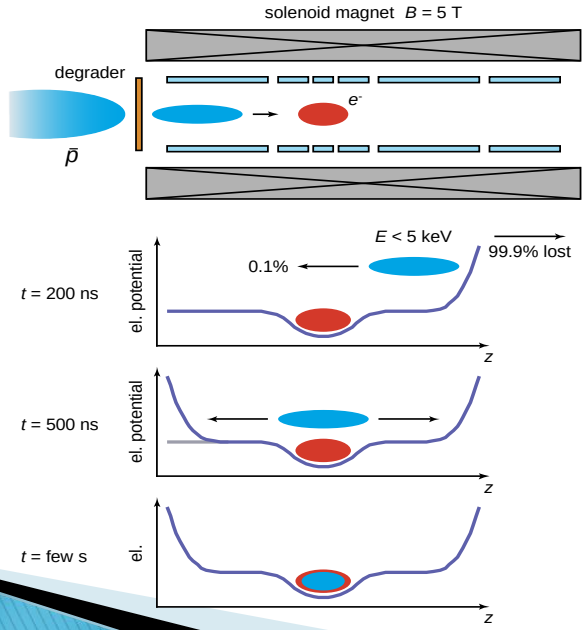
- Technical drawings of the whole apparatus
- Mechanical project
- Collaboration with CERN groups for cryogenics and magnets.



Timing setup and HPD tests with antiprotons 2 days run 2011







- Scintillator+ HPD to detect the pbar arrival time
- Study the delay between AD trigger and the HPD signal
- 5 ns rms: AD trigger is the good start signal to trigger the pbar catch procedure

Run 2012: primi risultati

- Beam time con antiprotoni : fine aprile– 30 giugno >8 ore/giorno
  ottimizzazione cattura antiprotoni
  ottimizzazione cooling
  accumulazione

Hot & cold dump

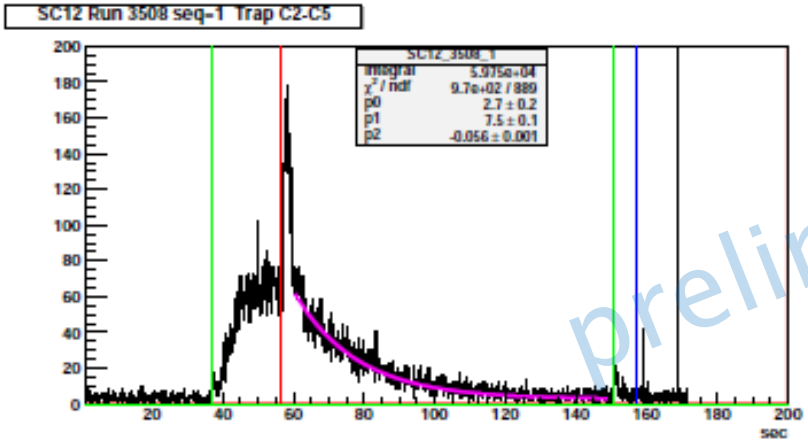


Figure 2: This figure refers to Run 3508. Electrons were trapped in the C2-C5 trap. The green line marks the AD trigger; the red one the time of the hot dump and the blue one the time of the cold dump. The counts as a function of time after the hot dump have been fit with and exponential plus a constant. Th fit result is the pink line. The time decay is $\tau = 1./p_2$ (sec) = 17.9 sec.

Storage time

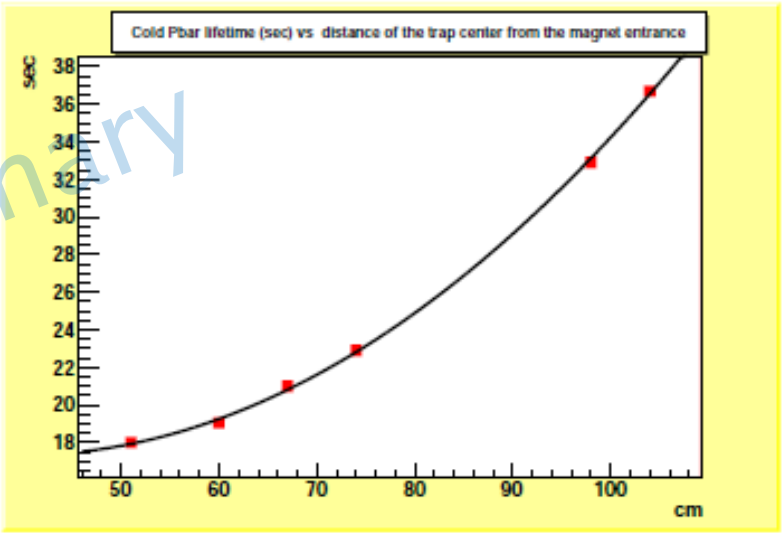
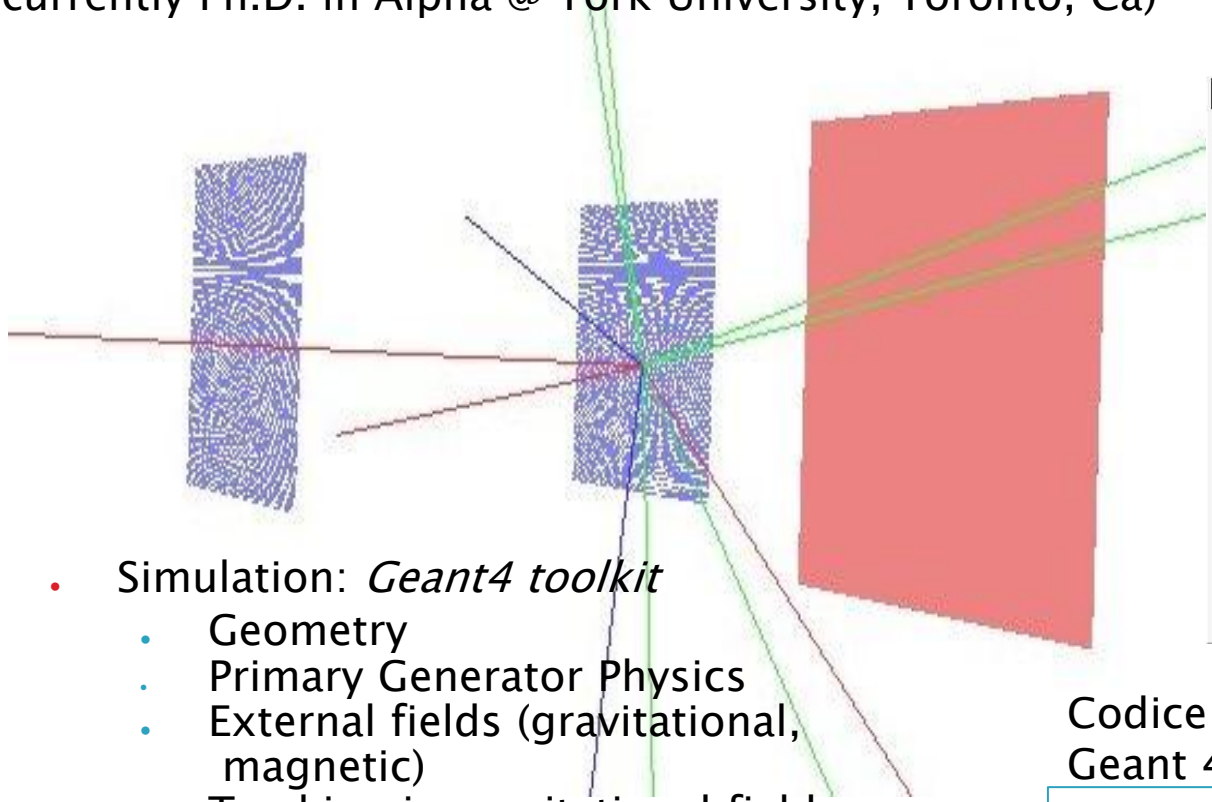
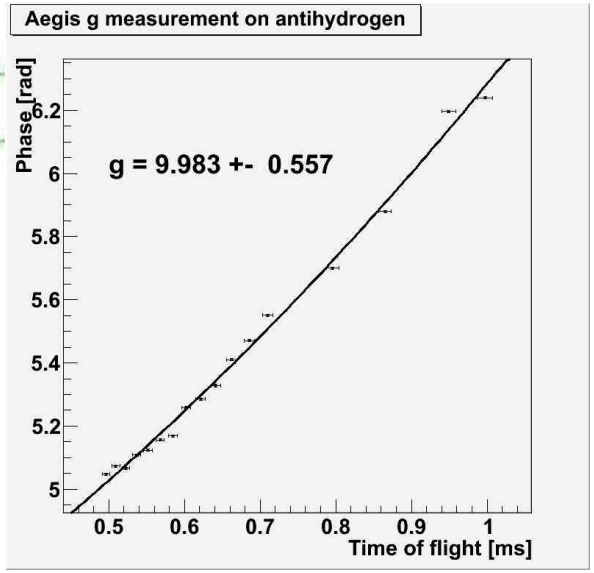


Figure 3: Storage time of cold antiprotons as a function of the position of the trap. The x axis is the distance between the center of the trap and the flange of the magnet.

Geant4 simulation of moiré deflectometer

Tesi specialistica Andrea Capra
(currently Ph.D. in Alpha @ York University, Toronto, Ca)





- Simulation: *Geant4 toolkit*
  - Geometry
  - Primary Generator Physics
  - External fields (gravitational, magnetic)
  - Tracking in gravitational field
- Data analysis: *ROOT framework*
  - Shadow image
  - Phase shift
  - Gravitational acceleration

Codice incluso since release Geant 4.9.5 (dec. 2011)

Classe G4UniformGravityField (source/geometry/magneticfield/src)

```
// History:
// - 14.06.11 P.Gumplinger, Created.
// ---------------------------------------------------------------
// Adopted from G4UniformElectricField.hh
//
// Thanks to Peter Fierlinger (PSI) and
// A. Capra and A. Fontana (INFN Pavia)
// ---------------------------------------------------------------
```

Collaborazione

- 48 persone + phd + students
- 21 INFN + dottorandi e studenti
- INFN: 43.7 % della collaborazione

Variazione rispetto ai preventivi INFN 2012 (FTE inclusi dottorandi)

- Genova 3.7 FTE + 0.8 FTE
- Milano 5 + 1 dott.
- Pavia-Brescia 5.6 + 1 FTE
- Trento 5.6 + 0.7 (Ing)
- Bologna (ex Firenze) 0.5 (DTZ)
- Totale 20.4 FTE (23.9) (28 (32) persone)

AEgIS INFN

Genova : x persone y FTE
Fisica e tecnologia particelle in trappola, elettronica &DAQ traps, e+ transfer line,Cryo amplifiers , Disegno globale AegIS

Milano:
accumulatore e+, misure su e+ table

Trento:
misura velocita, accumulatore e+, misure su e+ table

Pavia + Brescia :
simulazioni MC, meccanica e disegno globale, scintillatori esterni

Bologna (dot) 1 persona:

AEgIS collaboration

Annex 1 **Collaborating Institutions in the Collaboration and the names of their Contact Persons**

Country	Institute	Contact Person
	CERN	M. Doser
Czech Republik	Czech Tech. Univ. Prague	V. Petracek
France	Laboratoire Aimé-Cotton, Orsay	D. Comparat
France	UCBL Lyon	P. Nedelec
Germany	Kirchhoff Institute of Physics, Heidelberg	M. Oberthaler
Germany	MPI-K Heidelberg	A. Kellerbauer
Italy	Istituto Nazionale di Fisica Nucleare (INFN) Genova (G. Testera) ; Pavia-Brescia (A. Fontana) ; Milano (M. Giammarchi); Padova-Trento (R. Brusa); Bologna (M. Prevedelli)	G. Testera
Norway	Univ. Bergen, Univ. Oslo	H. Sandaker
Russia	INR Moscow	S. Gninenko
Switzerland	ETH, Zürich	F. Merkt
Switzerland	University Zürich	C. Amsler

Nuovo gruppo Vienna (E. Widmann)

Collaboration meeting: next week…