Consuntivi Gruppo IIII

Paolo Pedroni

Con l'indispensabile collaborazione di
G. Bonomi, A. Menegolli, L. Venturelli, N.Zurlo

CSN3 –Status 2016

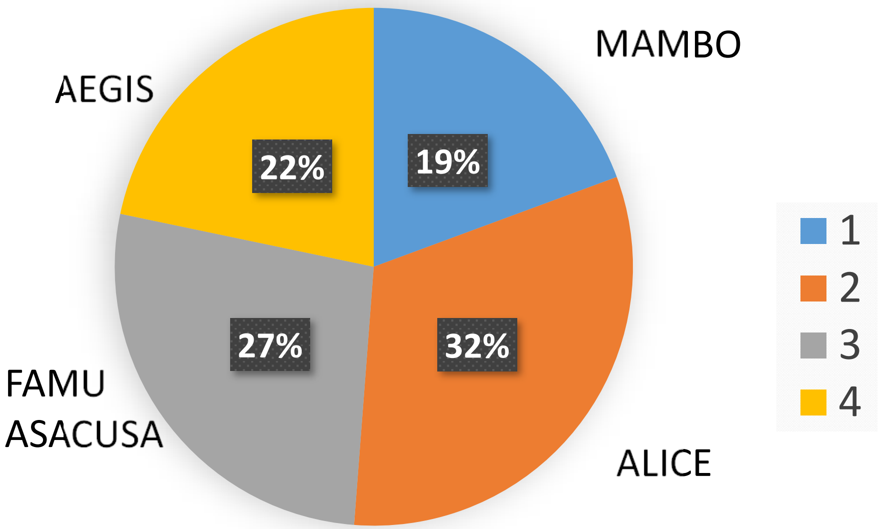
Linea 1: **Quark and hadron dynamics** **(6 sigle)**

Linea 2: **Phase transitions of nuclear and hadronic matter** **(2 sigle)**

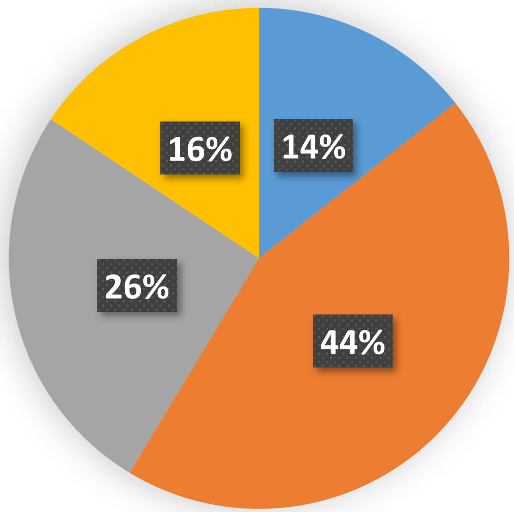
Linea 3: **Nuclear structure and reaction dynamics** **(7 sigle)**

Linea 4: **Nuclear astrophysics and interdisciplinary researches** **(6 sigle)**

Ripartizione FTE (483 FTE) (Circa 730 ricercatori)



Ripartizione Budget (circa 9.3 MEuro)



CSN3 19 kE/FTE

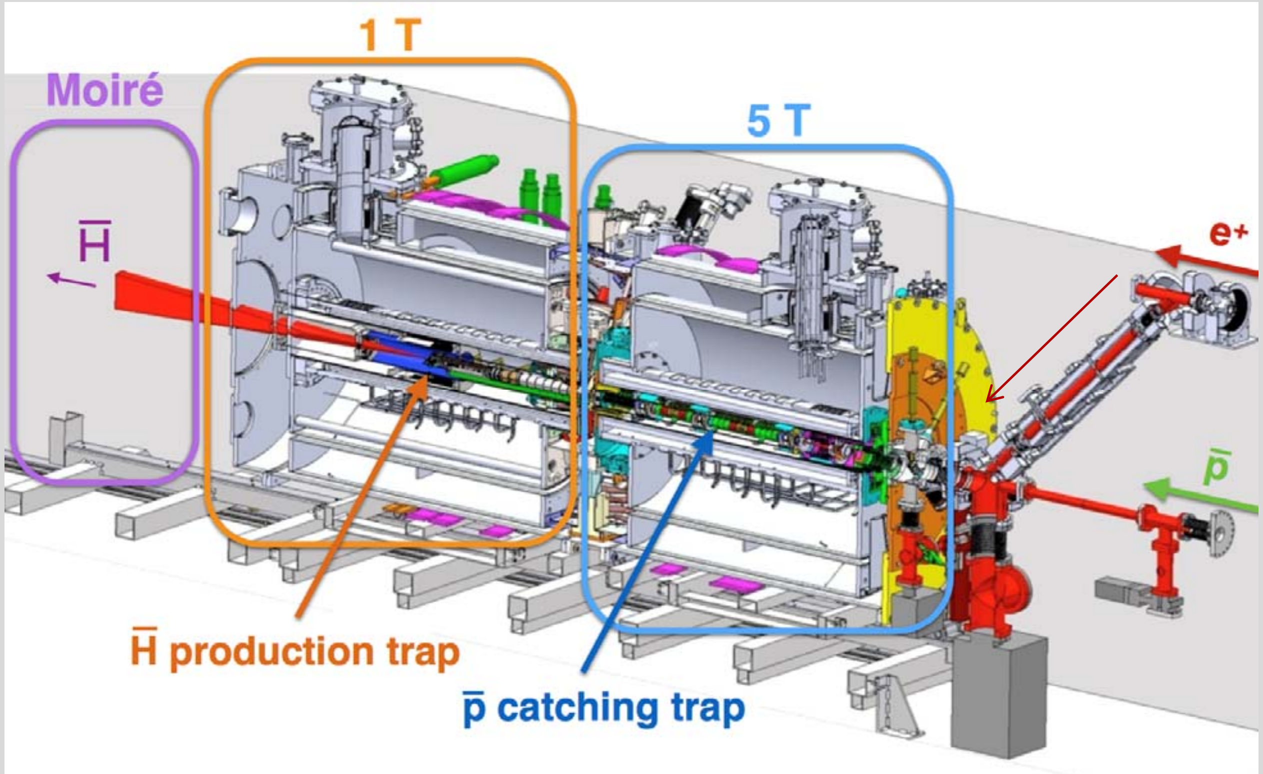
(CSN1 25 kE/FTE)

CSN3-Pavia 2016

SIGLA	FTE	Assegnazioni totali (kE)	Missioni (kE)	Altro (kE)
AEGIS	2.9	21.0	16.0	5.0
ALICE	3.8	20.0	17.5	2.5
ASACUSA	6.7	53.5	38.0	15.5
FAMU	2.0	14.0	11.0	3.0
MAMBO	1.9	31.5	18.0	13.5
TOTALI	**17.3**	**140**	**100.5**	**39.5**

Circa 8 kE/FTE (50% della media globale di CSN3)

CONSUNTIVO AEGIS-PAVIA 2016/2017



- AEgIS in sintesi
- Risultati 2016 (postroni, antiprotoni)
- Sviluppi delle attività del gruppo di Pavia/Brescia
- Obiettivi per il 2017

AEḡIS collaboration

ÖAW Austrian Academy of Sciences / SMI Stefan Meyer Institute	CERN	Czech Technical University	ETH Zurich
University of Genova	University of Milano	University of Padova	University of Pavia
Institute of Nuclear Research of the Russian Academy of Science	Max-Planck Institute Heidelberg	Politecnico di Milano	University College London
University of Bergen	University of Bern	University of Brescia	Heidelberg University
University of Lyon 1	University of Oslo	University of Paris Sud	University of Trento
INFN sections of: Genova, Milano, Padova, Pavia, Trento			

DATA TAKING IS IN PROGRESS at the CERN AD

AD Schedule 2016 (Version 3.0 July 12th, 2016)

	Wk	Mon			Tue			Wed			Thu			Fri			Sat			Sun			
Apr 4 - Apr 10	14	AD setting up																					
Apr 11 - Apr 17	15																						
Apr 18 - Apr 24	16	07-15	15-23	23-07																			
Apr 25 - May 1	17	MD	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	~~AD2~~
May 2 - May 8	18	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	~~AD2~~
May 9 - May 15	19	AD3	AD6	AD5	AD3	AD6	AD5	AD3	AD6	AD5	AD3	AD6	AD5	AD3	AD6	AD5	AD3	AD6	AD5	AD3	AD6	AD5	~~AD2~~
May 16 - May 22	20	MD	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	~~AD2~~
May 23 - May 29	21	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	~~AD2~~
May 30 - Jun 5	22	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	~~AD3~~
Jun 6 - Jun 12	23	MD	AD2	AD5	TS	AD2	AD5	AD8	AD2	AD5	AD8	AD2	AD5	AD8	AD2	AD5	AD8	AD2	AD5	AD8	AD2	AD5	~~AD3~~ ~~AD6~~
Jun 13 - Jun 19	24	AD3	AD8	AD2	AD3	AD8	AD2	AD3	AD8	AD2	AD3	AD8	AD2	AD3	AD8	AD2	AD3	AD8	AD2	AD3	AD8	AD2	~~AD5~~ ~~AD6~~
Jun 20 - Jun 26	25	AD6	AD3	AD8	AD6	AD3	AD8	AD6	AD3	AD8	AD6	AD3	AD8	AD6	AD3	AD8	AD6	AD3	AD8	AD6	AD3	AD8	~~AD2~~ ~~AD5~~
Jun 27 - Jul 3	26	MD	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	~~AD2~~
Jul 4 - Jul 10	27	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	~~AD3~~
Jul 11 - Jul 17	28	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	~~AD6~~
Jul 18 - Jul 24	29	MD	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	~~AD5~~
Jul 25 - Jul 31	30	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	~~AD2~~
Aug 1 - Aug 7	31	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	~~AD3~~
Aug 8 - Aug 14	32	MD	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	~~AD6~~
Aug 15 - Aug 21	33	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	~~AD5~~
Aug 22 - Aug 28	34	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	~~AD2~~
Aug 29 - Sep 4	35	MD	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	~~AD3~~
Sep 5 - Sep 11	36	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	~~AD6~~
Sep 12 - Sep 18	37	AD6	AD3	AD2	TS							AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	~~AD5~~
Sep 19 - Sep 25	38	MD	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	~~AD2~~
Sep 26 - Oct 2	39	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	~~AD3~~
Oct 3 - Oct 9	40	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	~~AD6~~
Oct 10 - Oct 16	41	MD	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	~~AD5~~
Oct 17 - Oct 23	42	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	~~AD2~~
Oct 24 -Oct 30	43	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	~~AD3~~
Oct 31 - Nov 6	44	MD	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	~~AD6~~
Nov 7 - Nov 13	45	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	~~AD5~~
Nov 14 - Nov 20	46	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	AD5	AD6	AD3	~~AD2~~
Nov 21 - Nov 27	47	MD	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	AD2	AD5	AD6	~~AD3~~
Nov 28 - Dec 4	48	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	AD3	AD2	AD5	~~AD6~~
Dec 5 - Dec 11	49	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	AD6	AD3	AD2	~~AD5~~
		AD physics stop December 12th 6AM.																					

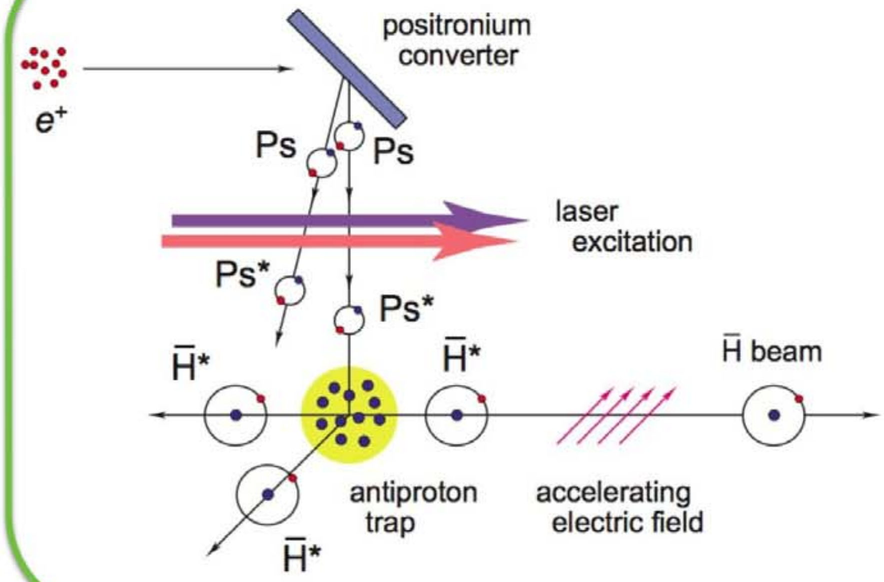
Injector MD (8:00-18:00) every Wednesday

AD2 (ATRAP) AD3 (ASACUSA) AD4 (ACE) AD5 (ALPHA) AD6 (AEGIS) AD8 (BASE)

Based on injector schedule V1.6

Antihydrogen production strategy

- Rydberg $\bar{H}^*$ atoms produced via **charge exchange**



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

- $\sigma \propto n_{Ps}^4 \longrightarrow n_{Ps}$ ~ 20 - 30
- $n_{\bar{H}}$ determined by n_{Ps}

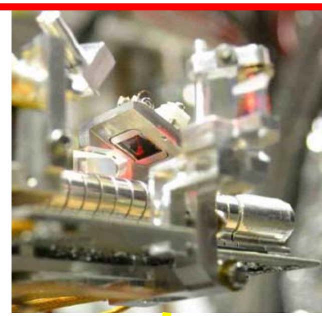
- Temperature of $\bar{H}$ given by the temperature of $\bar{p}$

- Rydberg $\bar{H}$: strong dipole moment → **Stark acceleration**

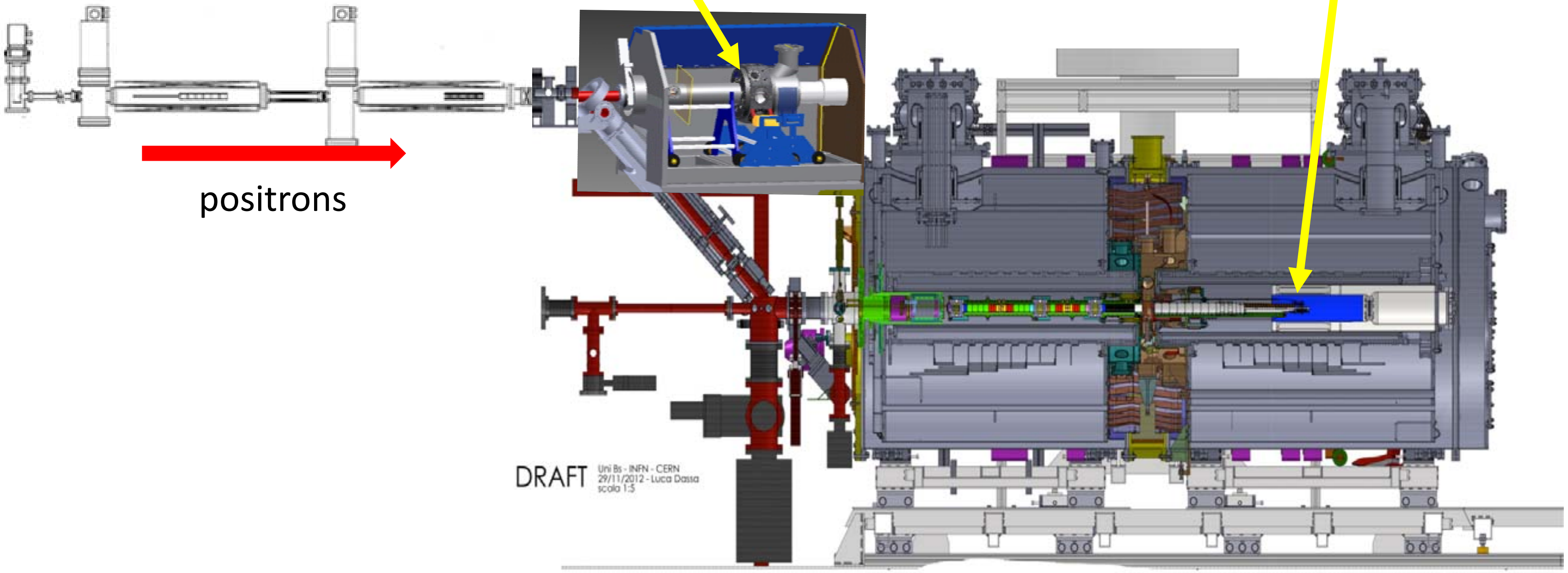
NEW IN 2016

with positrons

1 T activities (November-December)
-positron implantation onto the target
-diagnostic for SSPALS measurements



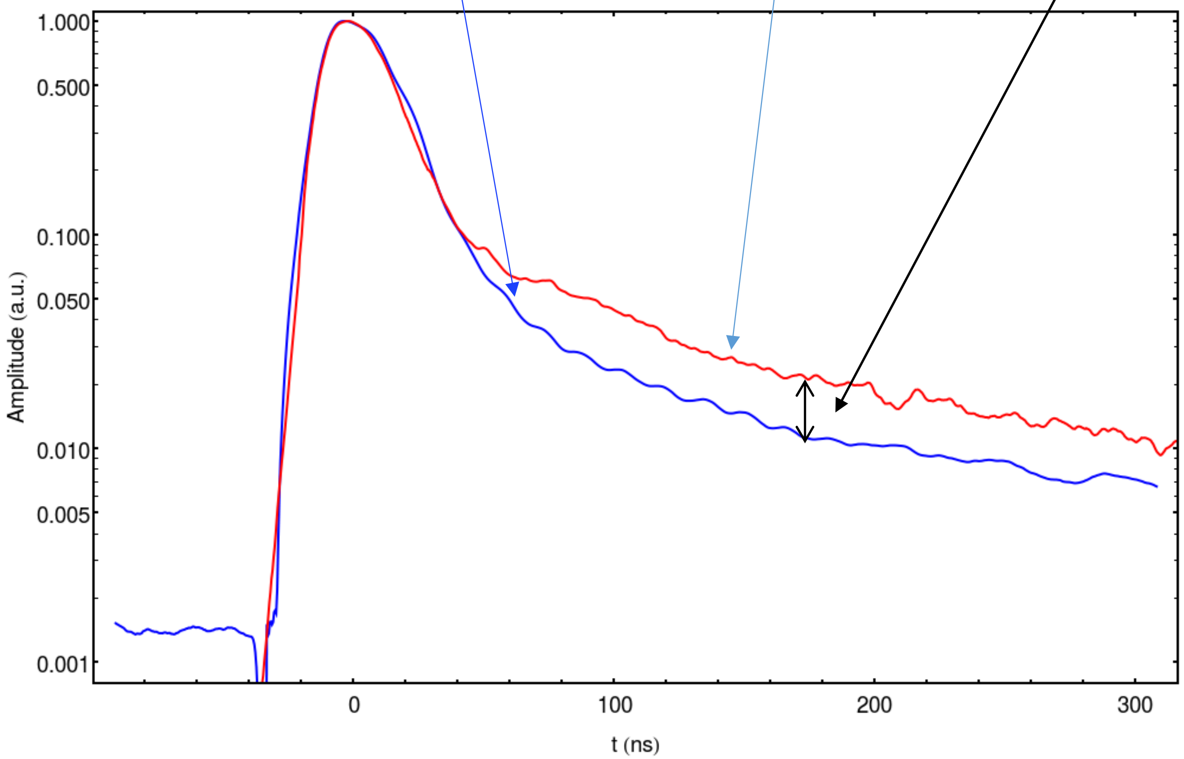
"Bread box" activities (April-June):
-n=2 metastable production
-transmission targets



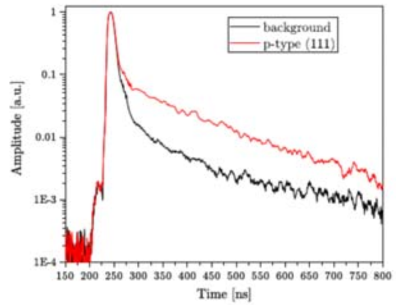
Prompt peak convoluted with the single photon response

The difference is a signature of the positronium formation in the 1 T region

measured SSPALS



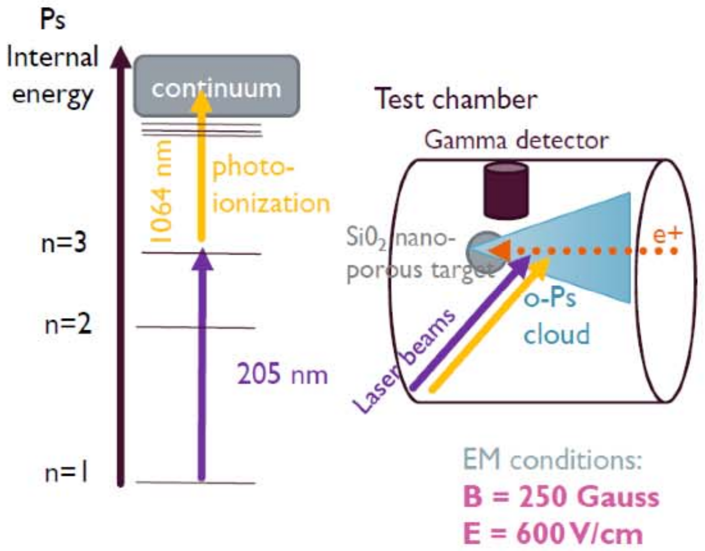
Same effect measure in the “Bread box”

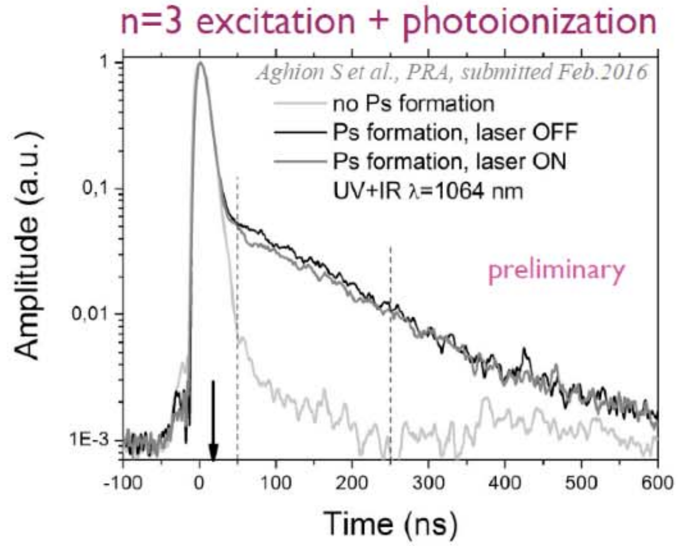


SSPALS = Single-shot positron annihilation lifetime spectroscopy

That is being efficiently combined with the Positronium excitation to n=3 (and to Rydberg states) achieved in 2015 in the so-called “bread box”

Ps excitation to n=3





S(%)=(Area laser OFF−Area laser ON) / ser OFF

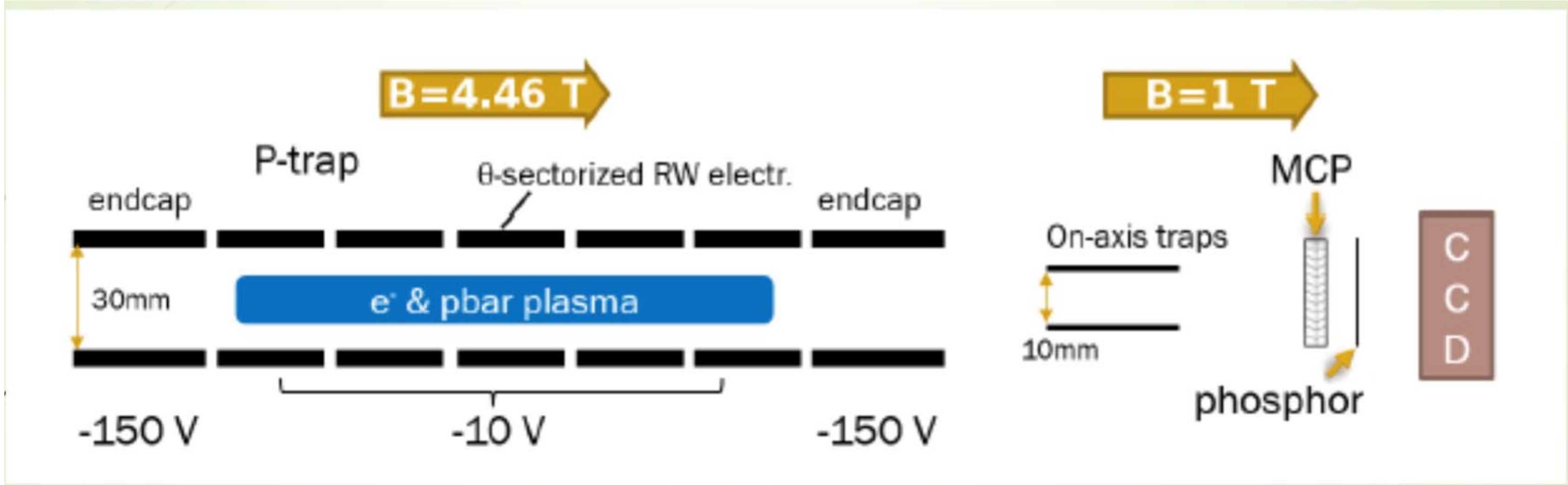
PHYSICAL REVIEW A **94**, 012507 (2016)

Laser excitation of the $n = 3$ level of positronium for antihydrogen production

S. Aghion,[1,2] C. Amsler,[3] A. Ariga,[3] T. Ariga,[3] G. Bonomi,[4,5] P. Bräunig,[6] J. Bremer,[7] R. S. Brusa,[8,9] L. Cabaret,[10] M. Caccia,[2,11] R. Caravita,[12,13] F. Castelli,[2,14] G. Cerchiari,[15] K. Chlouba,[16] S. Cialdi,[2,14] D. Comparat,[10] G. Consolati,[1,2] A. Demetrio,[6] L. Di Noto,[12,13] M. Doser,[7] A. Dudarev,[7] A. Ereditato,[3] C. Evans,[1,2] R. Ferragut,[1,2] J. Fesel,[7] A. Fontana,[5] O. K. Forslund,[7] S. Gerber,[7] M. Giammarchi,[2,3] A. Gligorova,[17] S. Gninenko,[18] F. Guatieri,[8,9] S. Haider,[7] H. Holmestad,[19] T. Huse,[19] I. L. Jernelv,[7] E. Jordan,[15] A. Kellerbauer,[15] M. Kimura,[3] T. Koettig,[7] D. Krasnicky,[12,13] V. Lagomarsino,[12,13] P. Lansonneur,[23] P. Lebrun,[23] S. Lehner,[20] J. Liberadzka,[7] C. Malbrunot,[7,20] S. Mariazzi,[20,*] L. Marx,[7] V. Matveev,[18,21] Z. Mazzotta,[2,14] G. Nebbia,[22] P. Nedelec,[23] M. Oberthaler,[6] N. Pacifico,[17] D. Pagano,[4,5] L. Penasa,[8,9] V. Petracek,[16] C. Pistillo,[3] F. Prelz,[2] M. Prevedelli,[24] L. Ravelli,[8,9] L. Resch,[7] B. Rienäcker,[7] O. M. Røhne,[19] A. Rotondi,[5,25] M. Sacerdoti,[2,14] H. Sandaker,[19] R. Santoro,[2,11] P. Scampoli,[3,26] L. Smestad,[7,27] F. Sorrentino,[12,13] M. Spacek,[16] J. Storey,[3] I. M. Strojek,[16] G. Testera,[13] I. Tietje,[7] S. Vamosi,[20] E. Widmann,[20] P. Yzombard,[10] J. Zmeskal,[20] and N. Zurlo[5,28]
(AEgIS Collaboration)

NEW IN 2016
with antiprotons

We succeeded in moving antiprotons into the 1 tesla region, where they will be combined with positronium atoms in order to form antihydrogen



This has required additional improvement, because the 1 tesla trap has small diameter compared to the 5 tesla trap (so antiprotons must be compressed via rotating wall techniques)

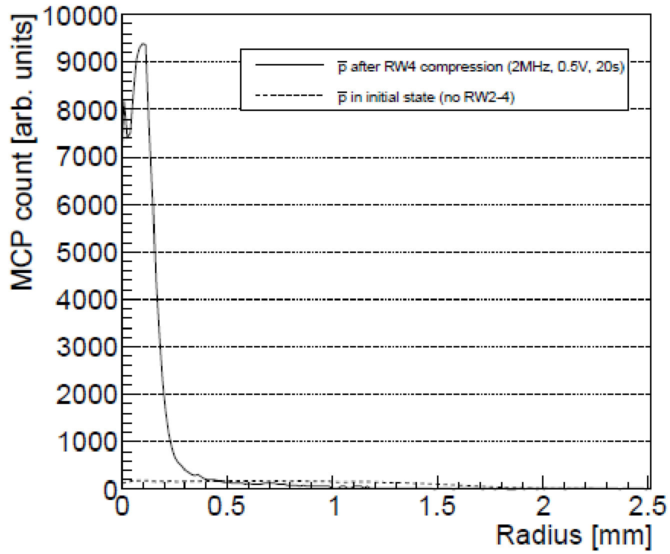
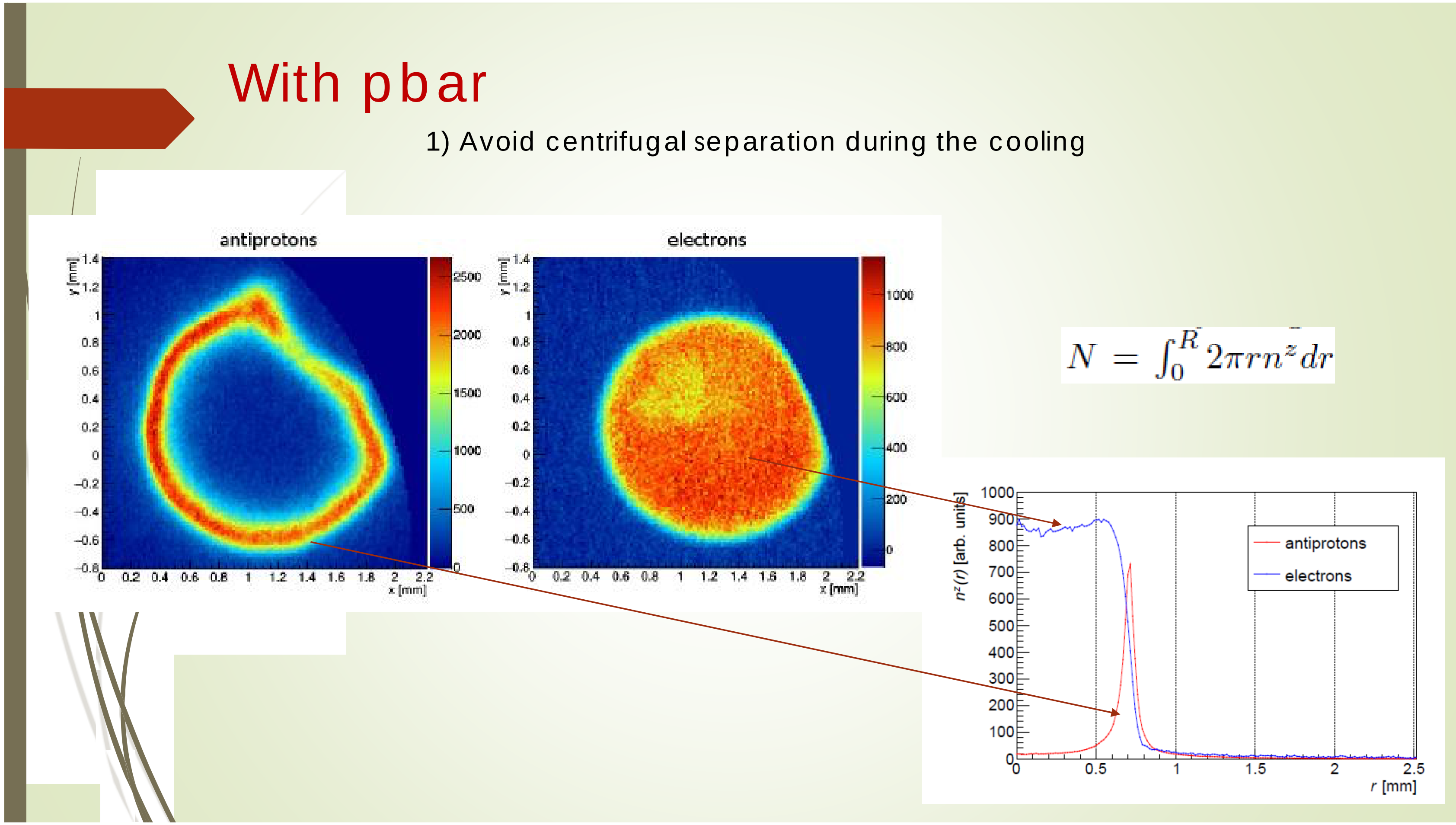


Fig. 11. Antiproton radial profile before (dotted line) and after (full line) multi-step RW compression with $f_{RW_4} = 2\,\mathrm{MHz}$ and $A_{RW_4} = 0.5\,\mathrm{V}$. The inset shows the same figure with zoom to see the original $\bar{p}$ distribution before compression. During this procedure two e^- reduction steps were applied and in total three $\bar{p}$ RW compression steps were used. $\bar{p}$ HWHM was 1.7 mm before and 0.17 mm after the compression.

Radius decreases by a factor 10

Density 2 10**7 cm**3
The highest reported at AD

And simultaneously antiprotons are cooled with electrons, but avoiding in the meanwhile the centrifugal separation:



NEW IN 2016
Secondary beamline

Tests of emulsions to be used for antihydrogen fringes detection.
These tests are performed with low energy antiprotons

Jinst

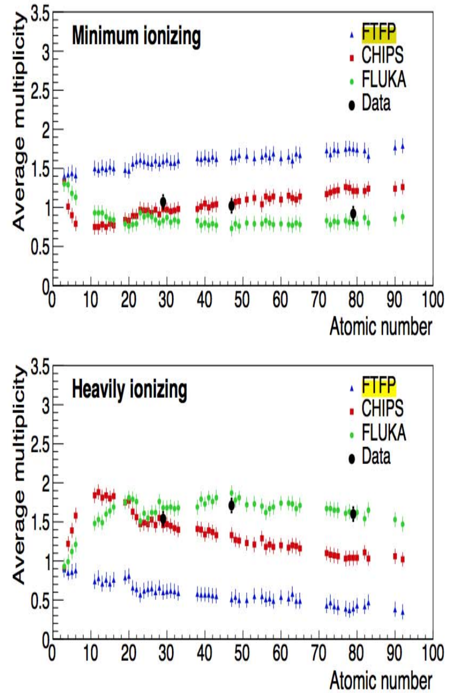
PUBLISHED BY IOP PUBLISHING FOR SISSA MEDIALAB

RECEIVED: *January 23, 2017*
REVISED: *March 13, 2017*
ACCEPTED: *March 30, 2017*
PUBLISHED: *April 19, 2017*

Measurement of antiproton annihilation on Cu, Ag and Au with emulsion films

The AEgIS collaboration

S. Aghion,[a,b] C. Amsler,[c,d] A. Ariga,[c] T. Ariga,[c,1,2] G. Bonomi,[e,f] P. Bräunig,[g] R.S. Brusa,[h,i] L. Cabaret,[j] M. Caccia,[b,k] R. Caravita,[l,m] F. Castelli,[b,n] G. Cerchiari,[o] D. Comparat,[j] G. Consolati,[a,b] A. Demetrio,[g] L. Di Noto,[l,m] M. Doser,[p] A. Ereditato,[c] C. Evans,[a,b] R. Ferragut,[a,b] J. Fesel,[p] A. Fontana,[f] S. Gerber,[p] M. Giammarchi,[i] A. Gligorova,[q] F. Guatieri,[h,i] S. Haider,[p] A. Hinterberger,[p] H. Holmestad,[r] T. Huse,[r] J. Kawada,[c] A. Kellerbauer,[o] M. Kimura,[c] D. Krasnický,[l,m] V. Lagomarsino,[l,m] P. Lansonneur,[s] P. Lebrun,[s] C. Malbrunot,[d,p] S. Mariazzi,[d] V. Matveev,[t,u] Z. Mazzotta,[b,n] S.R. Müller,[g] G. Nebbia,[v] P. Nedelec,[s] M. Oberthaler,[g] N. Pacifico,[q] D. Pagano,[e,f] L. Penasa,[h,i] V. Petracek,[w] C. Pistillo,[c] F. Prelz,[b] M. Prevedelli,[x] L. Ravelli,[h,i] B. Rienaecker,[p] O.M. Røhne,[r] A. Rotondi,[f,y] M. Sacerdoti,[b,n] H. Sandaker,[r] R. Santoro,[b,k] P. Scampoli,[c,z] M. Simon,[d] L. Smestad,[p,aa] F. Sorrentino,[l,m] G. Testera,[m] I.C. Tietje,[p] S. Vamosi,[d] M. Vladymyrov,[c] E. Widmann,[d] P. Yzombard,[j] C. Zimmer,[o,p,ab] J. Zmeskal[d] and N. Zurlo[f,ac]



. Particle multiplicity from antiproton annihilations as a function of atomic number for MIPs (top) (bottom).

INFN BRESCIA/PAVIA GROUP ACTIVITY

We are responsible for the DAQ, for the online & offline software and for the external scintillator system

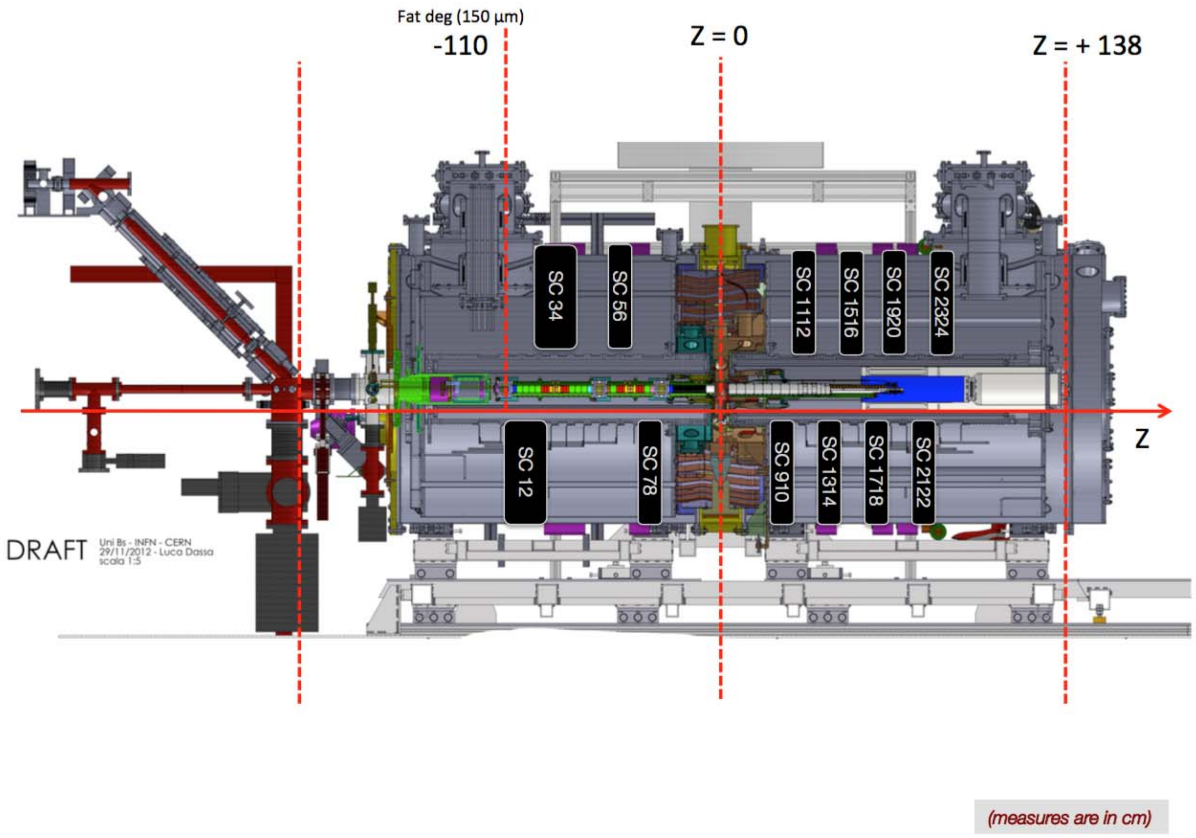
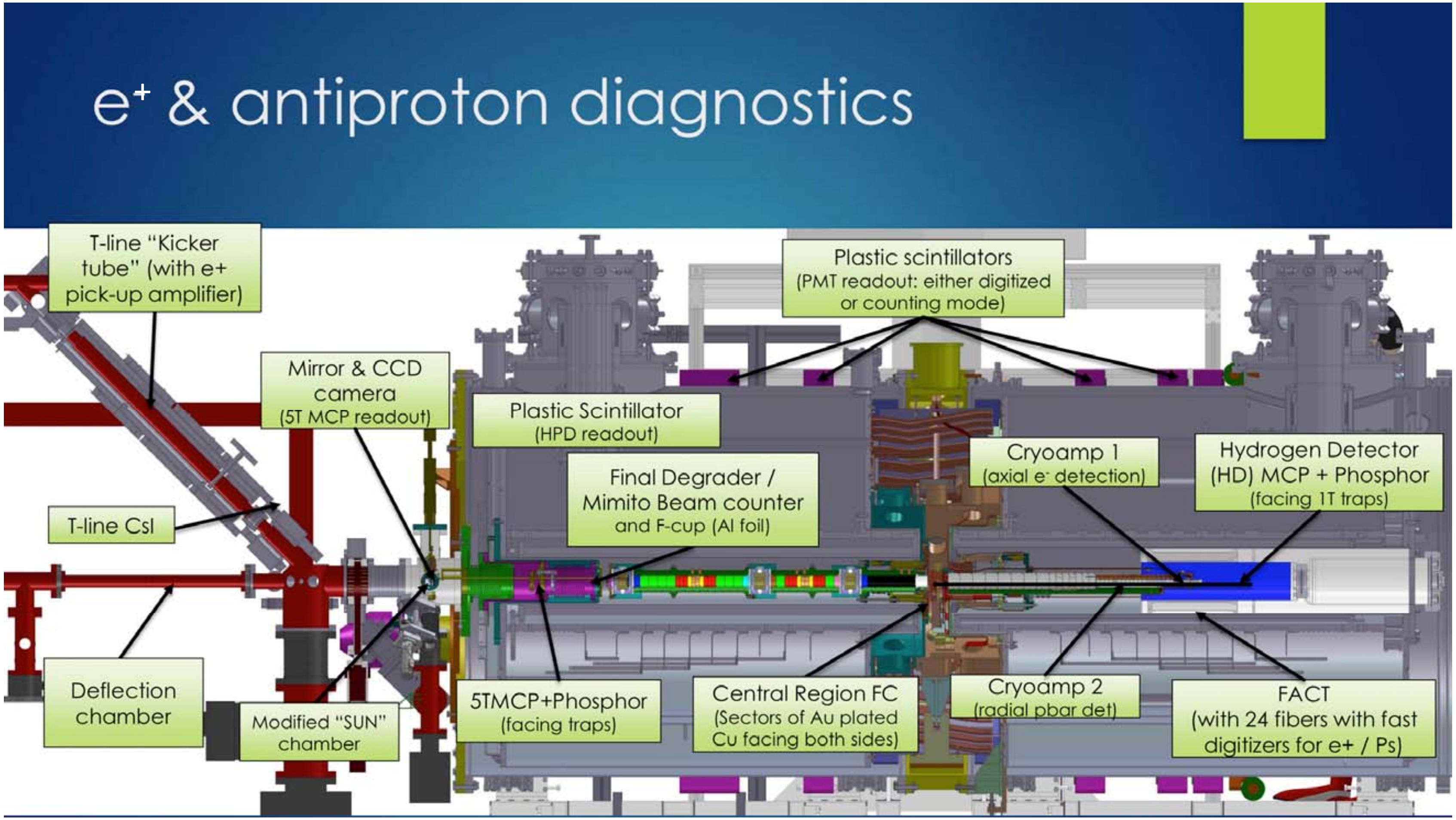


FIGURE 1. The AE$\bar{g}$IS external scintillators are placed around the 5 tesla and 1 tesla magnets.

External scintillators are extremely important since they are used as reference for others detectors



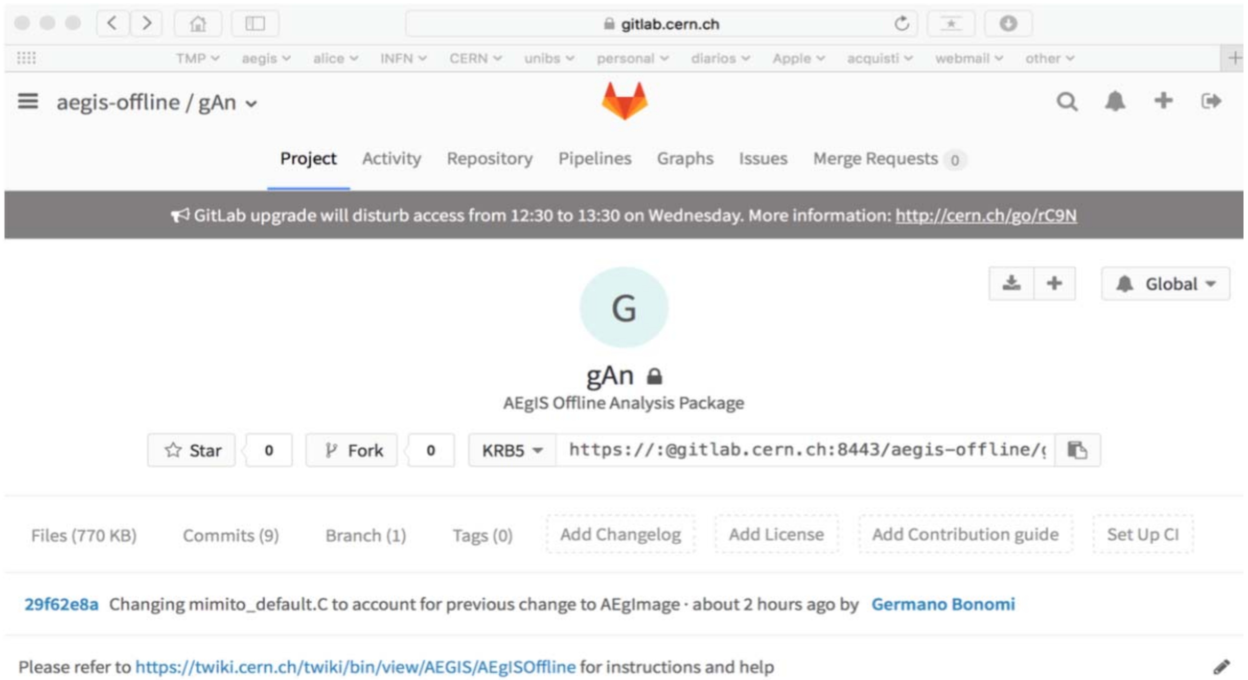
Brescia members are also involved in the FACT development

NEW IN 2016

A new comprehensive offline tool called gAn has been developed and is being completed including all the gathered information

AEgIS Analysis Framework

It is managed via the CERN GitLab



Also an interactive version via web has been developed

Annihilation vertex reconstruction algorithm with FACT (Fast Annihilation Cryogenic Tracking) detector

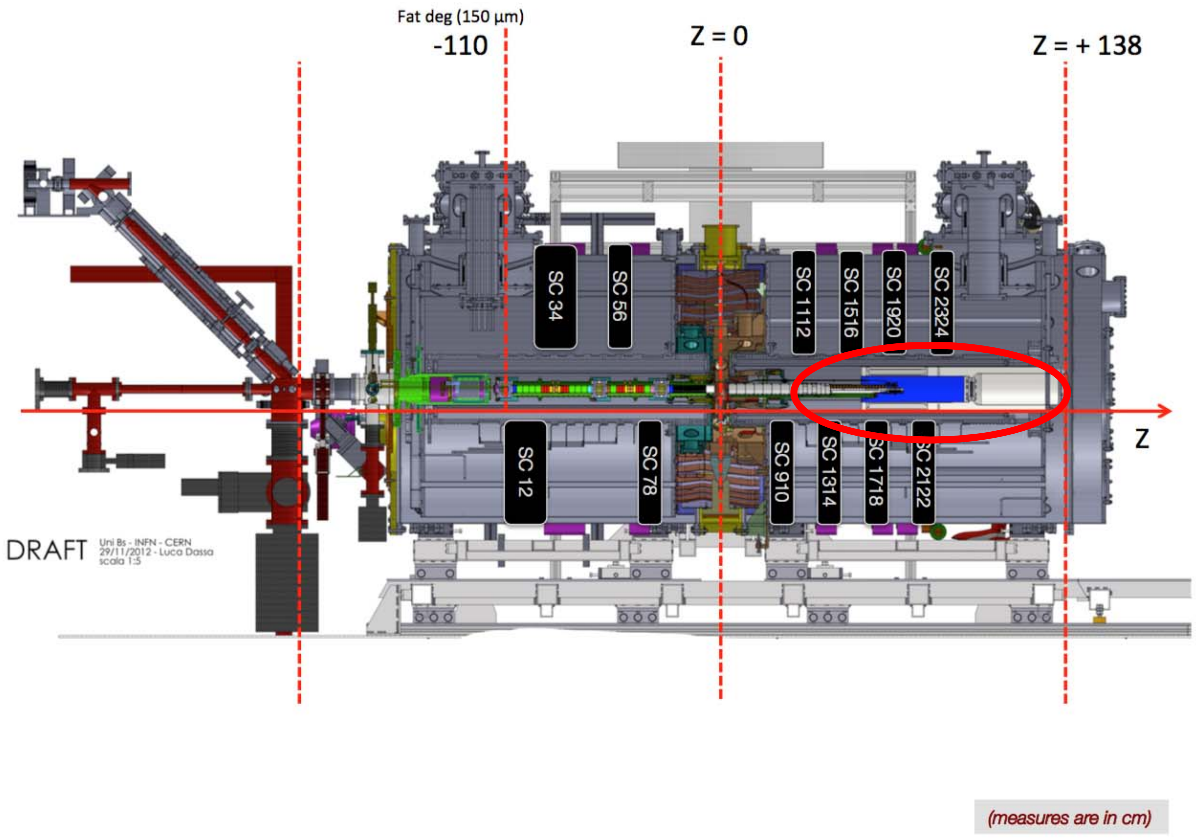
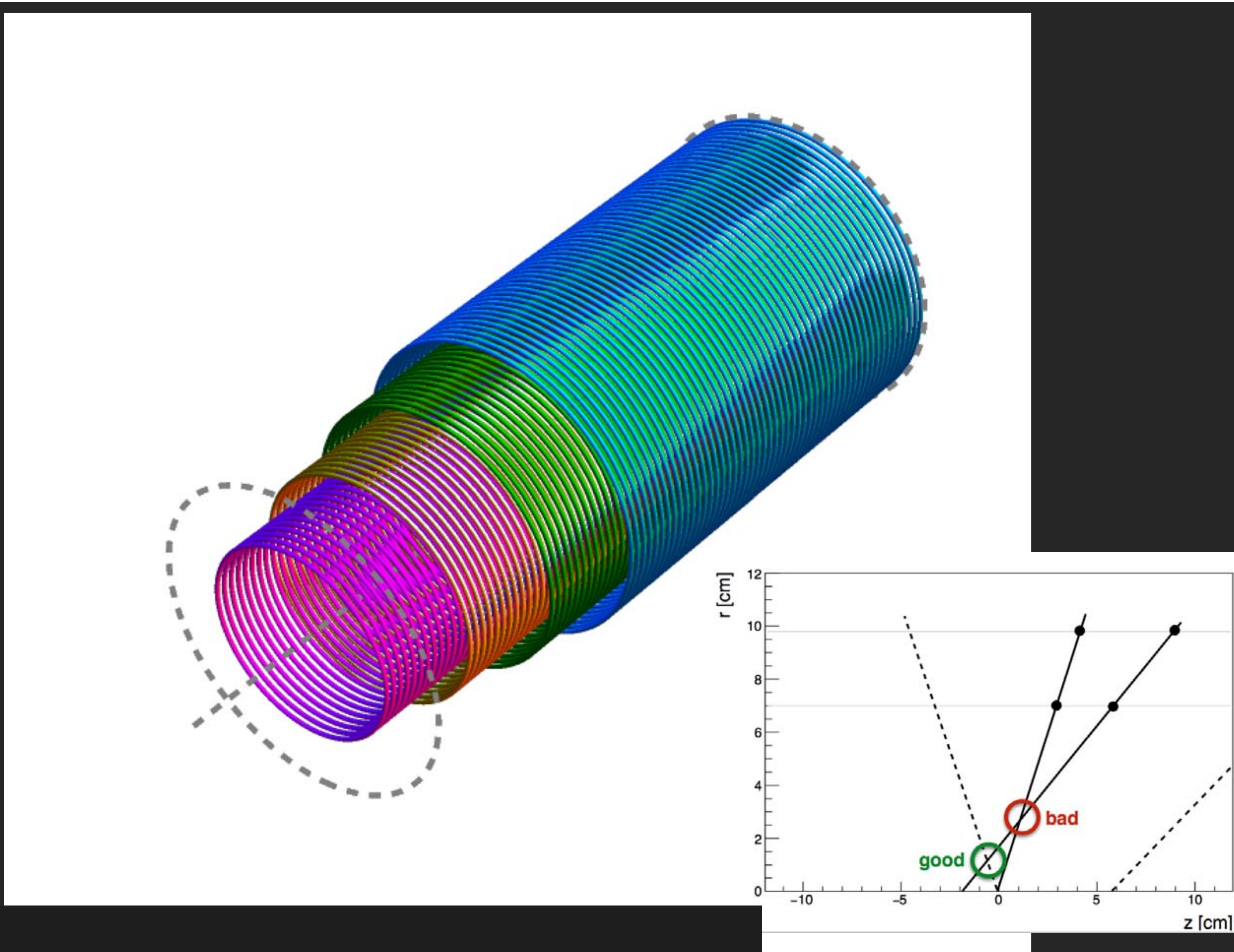
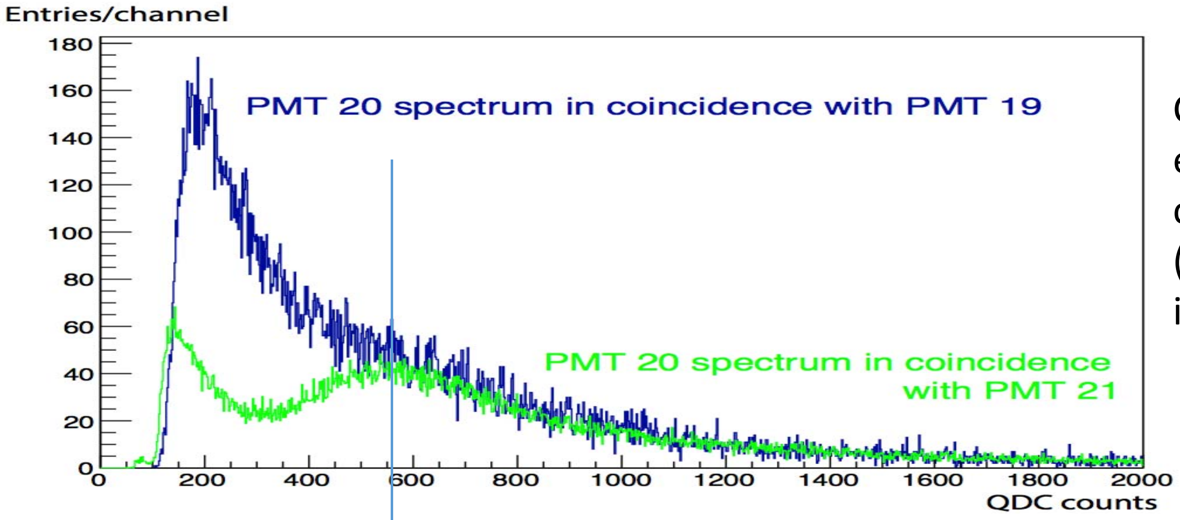


FIGURE 1. The AE$\bar{g}$IS external scintillators are placed around the 5 tesla and 1 tesla magnets.

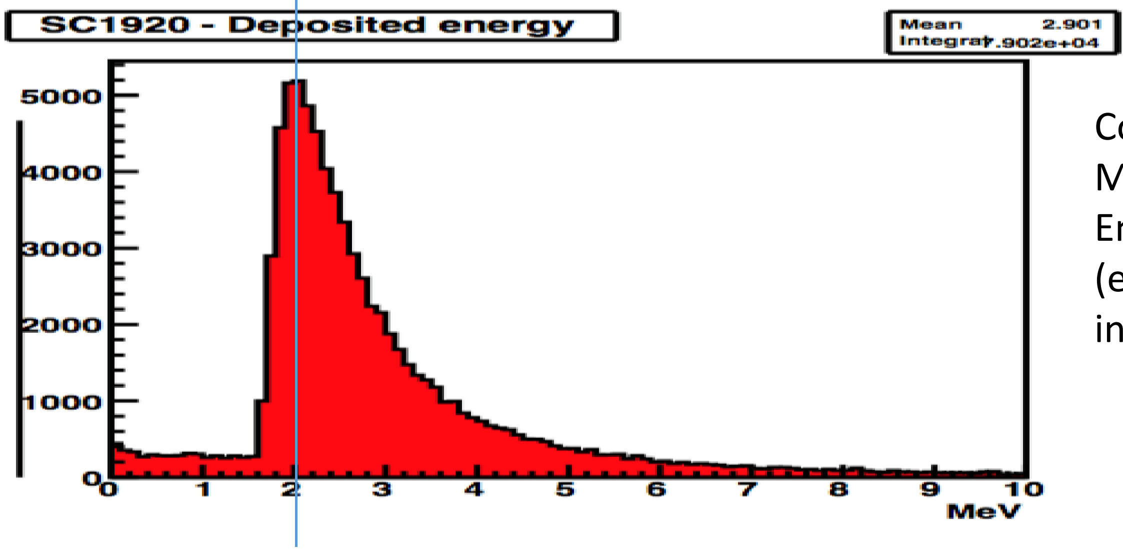


r [cm]
z [cm]
12
10
8
6
4
2
0
−10
−5
0
5
10
good
bad

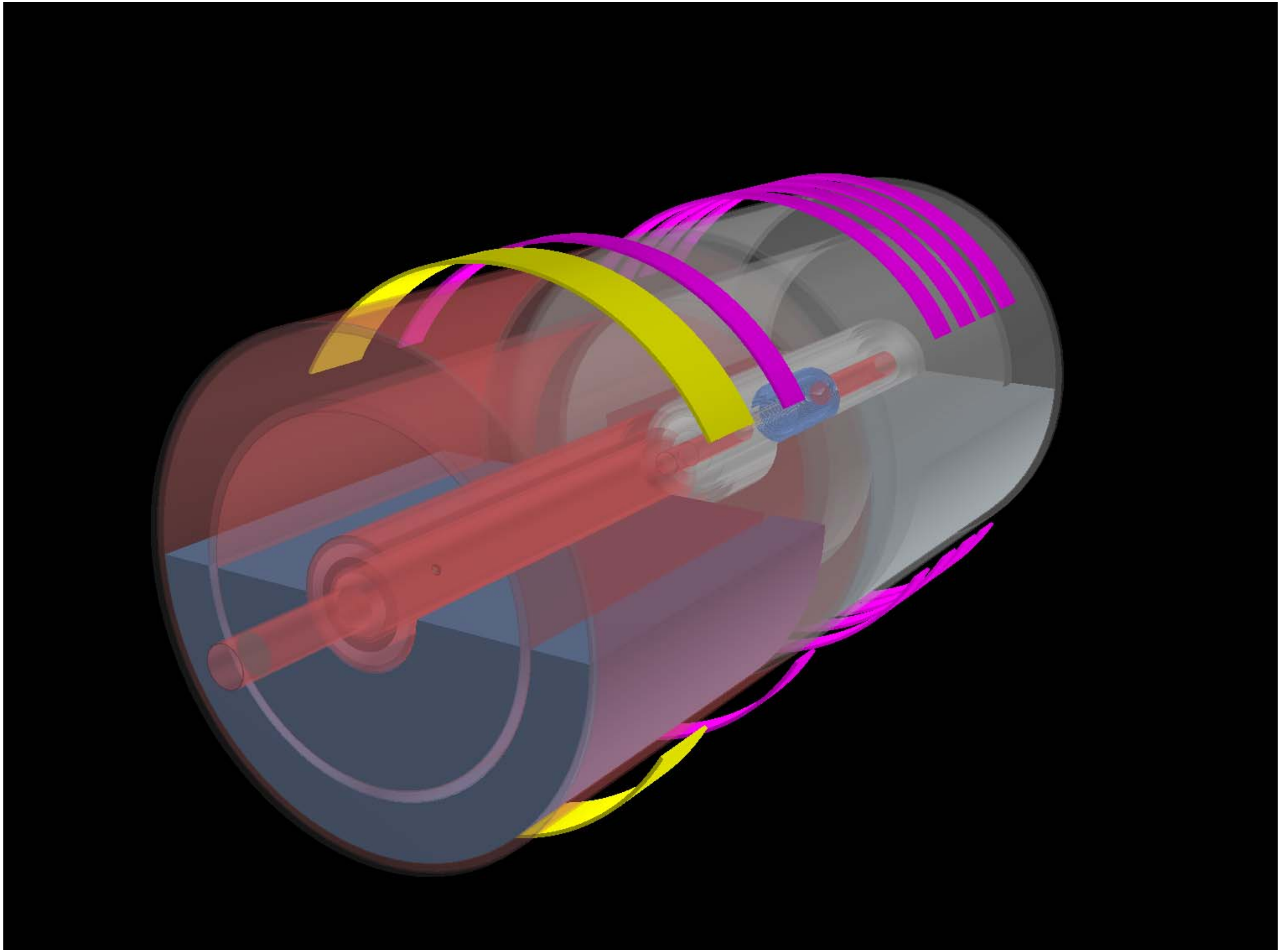
New, more accurate calibration of the external scintillators performed with cosmic rays



Cosmic ray experimental charge spectrum (charge collected by a QDC in a 70 ns long window)



Cosmic ray Monte Carlo Energy spectrum (energy deposited in the scintillator)



PMT	HV (volt)	QDC channel	cosmic peak position (QDC counts)			calibration constant (pC/MeV)
			uncorrected value	offset subtracted	corrected for QDC channel disuniformity	
1	2300	1	403 ± 3	333 ± 3	320 ± 3	15.9 ± 0.1
2	2300	1	313 ± 3	243 ± 3	233 ± 3	11.6 ± 0.1
3	2300	2	392 ± 3	344 ± 3	358 ± 3	17.8 ± 0.1
4	2300	2	268 ± 2	220 ± 2	229 ± 2	11.4 ± 0.1
5	2500	1	641 ± 20	556 ± 20	535 ± 20	26.5 ± 1.0
6	2350	1	660 ± 10	575 ± 10	553 ± 10	27.4 ± 0.5
7	2450	2	937 ± 13	913 ± 13	950 ± 13	47.0 ± 0.6
8	2250	2	388 ± 5	328 ± 5	341 ± 5	16.9 ± 0.3
9	2250	1	661 ± 2	576 ± 2	554 ± 2	27.5 ± 0.1
10	2220	2	436 ± 6	376 ± 6	391 ± 6	19.3 ± 0.3
11	2150	2	976 ± 4	916 ± 4	952 ± 4	47.1 ± 0.2
12	2250	1	562 ± 60	477 ± 60	459 ± 58	22.7 ± 2.9
13	1900	2	605 ± 4	545 ± 4	567 ± 4	28.1 ± 0.2
14	1800	2	1043 ± 20	1083 ± 20	1146 ± 21	57.7 ± 1.1
15	2030	1	1130 ± 50	1045 ± 50	1005 ± 48	49.7 ± 2.4
16	1950	1	819 ± 4	734 ± 4	706 ± 4	35.0 ± 0.2
17	2300	1	1300 ± 18	1215 ± 18	1168 ± 18	57.8 ± 0.9
18	2000	2	991 ± 9	931 ± 9	968 ± 9	47.9 ± 0.5
19	1925	1	464 ± 3	370 ± 3	364 ± 3	18.0 ± 0.2
20	1910	2	558 ± 3	498 ± 3	518 ± 3	25.6 ± 0.2
21	2000	1	1790 ± 20	1705 ± 20	1640 ± 19	81.2 ± 0.9
22	1820	2	540 ± 8	480 ± 8	499 ± 8	24.7 ± 0.4
23	1970	1	967 ± 14	882 ± 14	848 ± 14	42.0 ± 0.7
24	1900	2	1685 ± 40	1625 ± 40	1690 ± 40	83.6 ± 2.0

TABLE 4. Calibration constants for all the PMTs. For PMTs 1-4, these values are taken from 2016 data. For PMTs 5-24, the spectra were recorded in Feb 2017 (after some adjustment in the HV's). In both cases, the main apparatus magnetic field was off.

Obiettivi per il 2017

1) Laser excitation of positronium in the 1 T region

2) Optimization of antiprotons transfer in the 1 T region

3) Cooling of antiprotons and measurement of their temperature in the 1 T region

4) Hbar production

Consuntivo fondi CSN: III **Anno: 2016** **Sigla: AEGIS**

FTE: 2,6+0,5

Persone (Ricercatori + Tecnologi): 5+1

Missioni				
	Assegnato	**Speso**	**%**	**Note**
Meetings	2	2	100,00	
Turni o costruzione	14	14	100,00	
Conferenze	0	0	100,00	
Totale	16	16		

Capitolo	**Assegnato**	**Speso**			**Note**
		Come richiesto	**Altro**	**Variazioni Bilancio**	
Consumi	1	0,5	0	0	
Altri Consumi	0	0	0	0	
Costruzione Apparati	0	0	0	0	
Inventario	0	0	0	0	
Licenze	0	0	0	0	
Trasporti	0	0	0	0	
Servizi	4	4	0	0	
Totale	5	4,5	0	0	

Tutte le cifre in kEuro

CONSUNTIVO SCIENTIFICO ALICE 2016

ALICE

Attività scientifiche 2016

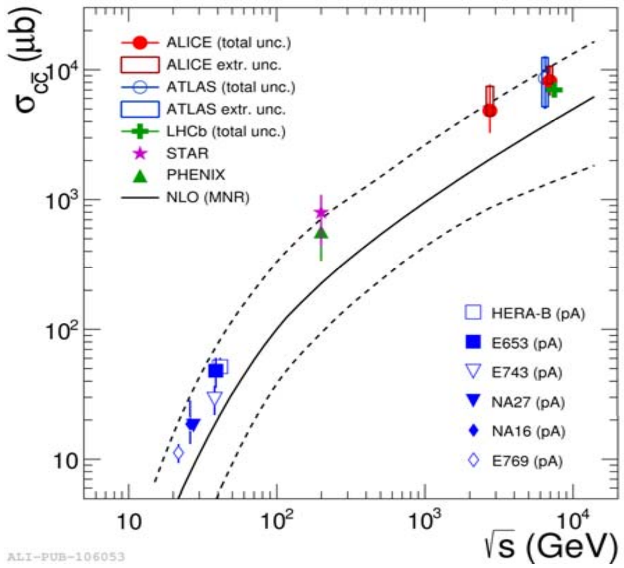
- Analisi dei canali di decadimento dei mesoni D
- Quality Assurance per il rivelatore di vertice (Inner Tracking System – ITS)
- ALICE Masterclass
- Sviluppo del codice di simulazione per il nuovo rivelatore di vertice (ITSU)

- *Premio come prima migliore comunicazione della Sezione diFisica Nucleare e Subnucleare, con la presentazione dal titolo"Ricostruzione di mesoni D in collisioni pp a 8 TeV con l'esperimentoALICE a LHC"' (Susanna Costanza)*
- *Da dicembre 2016 abbiamo iniziato a firmare gli articoli scientifici*
- *Dal 2017 abbiamo iniziato a partecipare ai turni di presa dati (~2 settimane/firma)*

D-meson hadronic decays

Why do we study D mesons?

- LHC as a heavy-flavour factory (charm and beauty):
  - large cross section for $c\bar{c}$ and $b\bar{b}$ production: $\sigma^{c\bar{c}}_{LHC} \approx 10\sigma^{c\bar{c}}_{RHIC}$
- Heavy quarks are produced in hard scattering processes in the initial stages of the collision → test of pQCD calculations
- Energy dependence of total charm production cross section in pp well reproduced by NLO pQCD-based calculation over more than 3 orders of magnitude → charm production in pp theoretically under control
- In pp collisions,
  - a reference for Pb-Pb collisions
  - Insight in the production mechanism
  - a test for perturbative QCD in a new energy regime

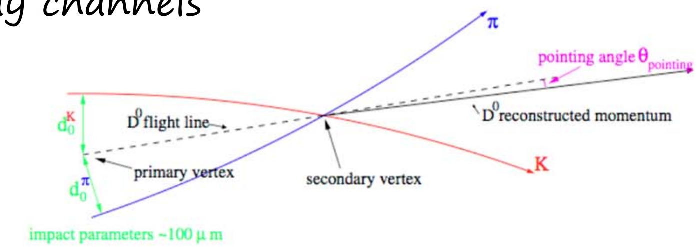


arXiv:1605.07569v1

D-meson hadronic decays

Channel studied: $D^0 \rightarrow K^- \pi^+$

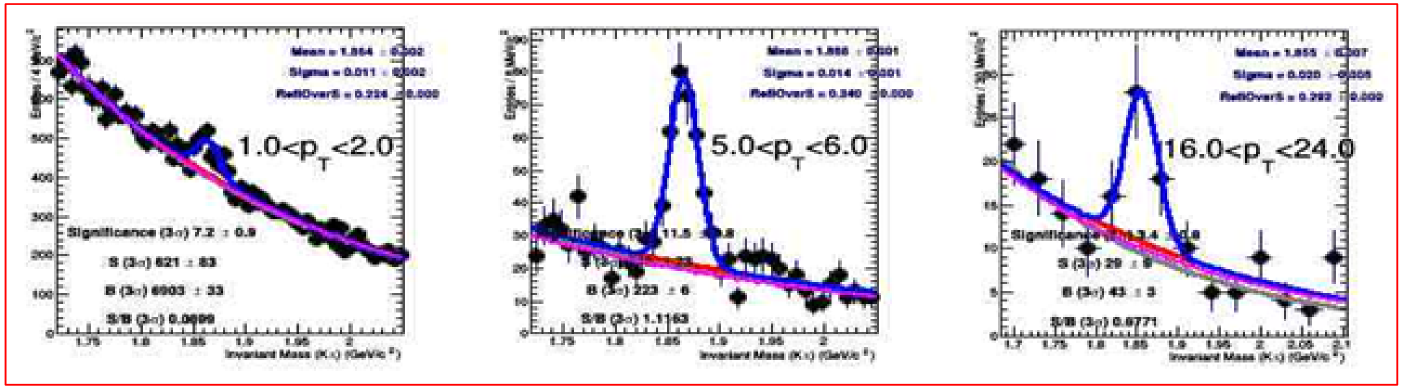
- Data sample analysed: pp collisions, $\sqrt{s} = 8$ TeV and 13 TeV
- D^0 mesons and their antiparticles reconstructed in the central rapidity region from their charged hadronic decay channels
- Displaced decay vertex is signature of heavy-flavour hadron decay → tracking and vertexing precision essential for heavy-flavour analysis



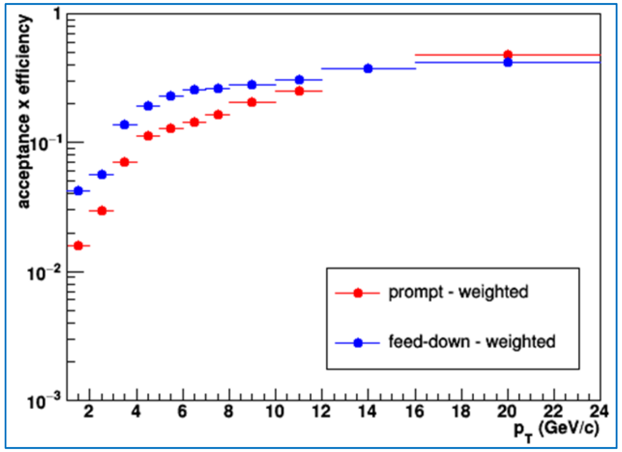
- Secondary vertices of D-mesons reconstructed using tracks with:
  - $\eta < |0.8|$
  - $p_T > 0.3$ GeV/c
  - at least 70 associated space points in TPC (out of a maximum of 159)
  - $\chi^2/ndf < 2$ in the TPC
  - at least one associated hit in either of the two innermost layers in ITS
- p_T dependent kinematic and topological cuts applied on the final decay products to enhance signal-to-background ratio and maximize significance.
- Additional background rejection in the low momentum region through particle identification (PID) in TPC and TOF

D-meson reconstruction

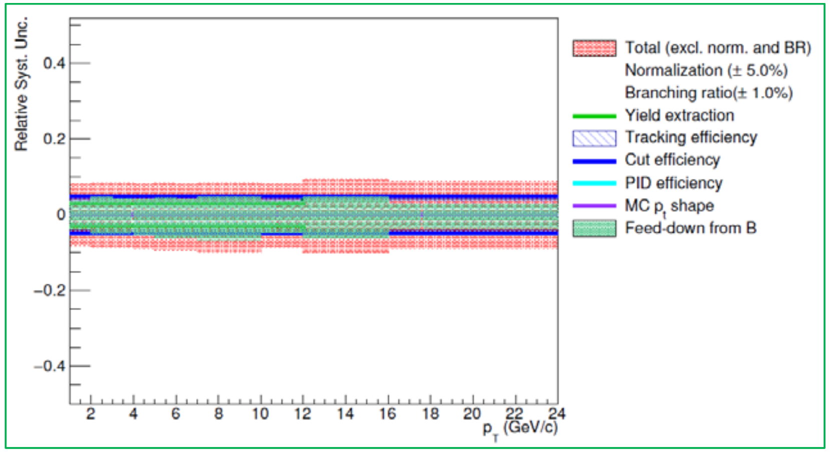
Invariant mass analysis



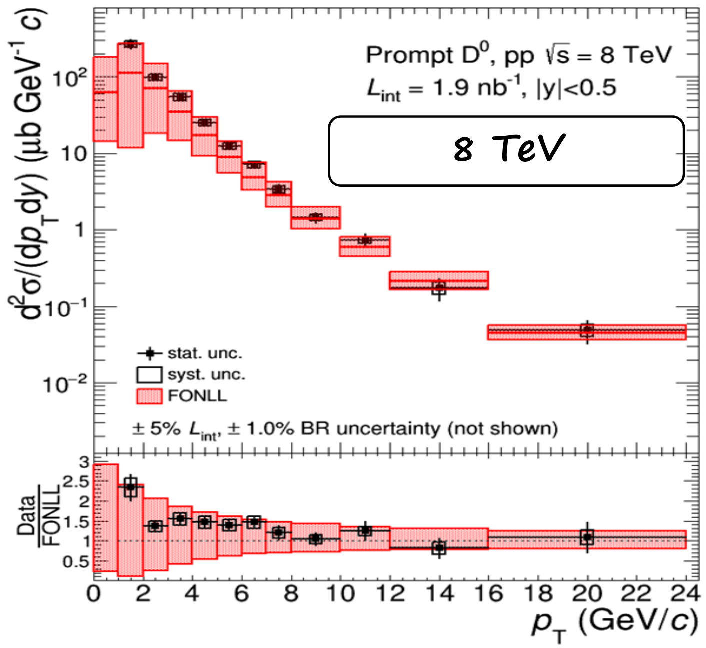
Efficiency studies

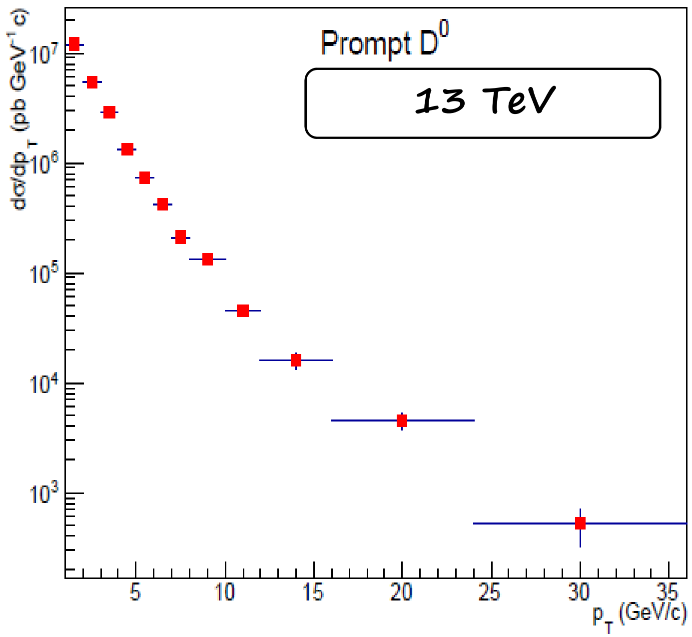


Systematics



Cross section





2 Analysis Notes in preparation

D-meson reconstruction in pp collisions at $\sqrt{s}$ = 8 TeV with the ALICE detector

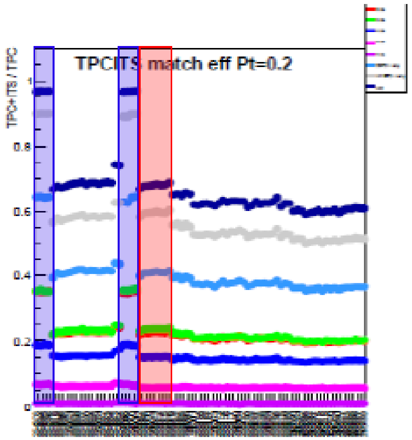
R. Bala, G. Bonomi, S. Costanza, A. Grelli, D. Leermakers, G. Luparello, A. Sharma, Z. C. del Valle

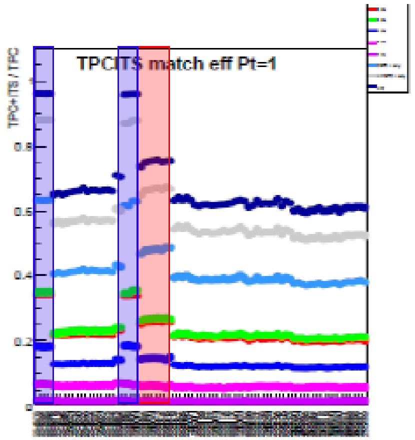
D-meson production in proton-proton collisions at $\sqrt{s} = 13$ TeV

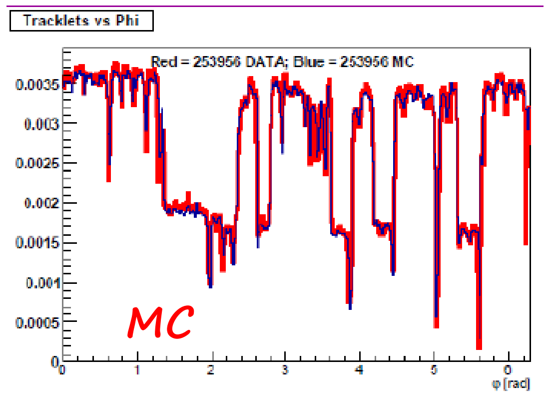
R. Bala[1], S. Costanza[2], J. Hamon[3], A. Veen[4]

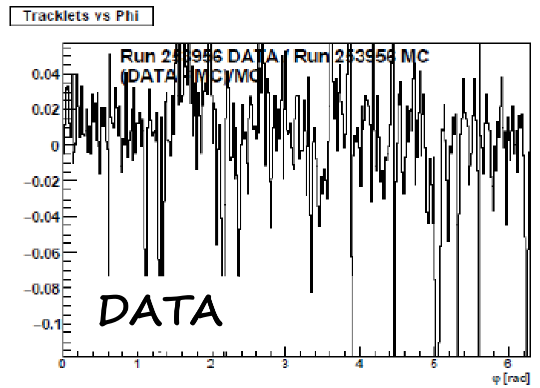
Quality Assurance for ITS detector

- Trending studies (periodic checks) to evaluate the performances of the ITS detector, in corrispondence of the calibration and reconstruction steps of the data collected at the LHC.
- Checks performed also on the Monte Carlo productions, anchored to specific data set.
- Direct comparison between experimental runs and Monte Carlo productions, run by run (for 10% production)



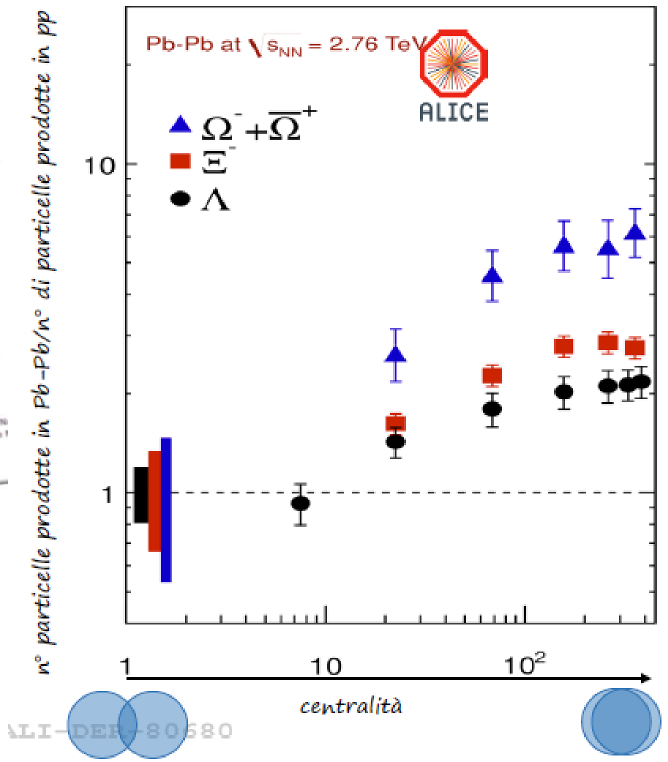






- Weekly meeting + reports on JIRA
- Daily meetings for pPb data taking and for new pp productions

ALICE Masterclass



- **ALPIDE** chip is a CMOS Monolithic Active Pixel Sensor developed for a major upgrade of the Inner Tracking System (ITS) of ALICE
- The ITS Upgrade pursues 3 major objectives:

- Improvement of the impact parameter resolution
  - Innermost layer from 39 mm down to 22 mm
  - Improved single point resolution due to a smaller pixel size

- Improvement of the tracking efficiency and transverse momentum resolution in the low p_T range
  - 7 detection layers in place of the current 6

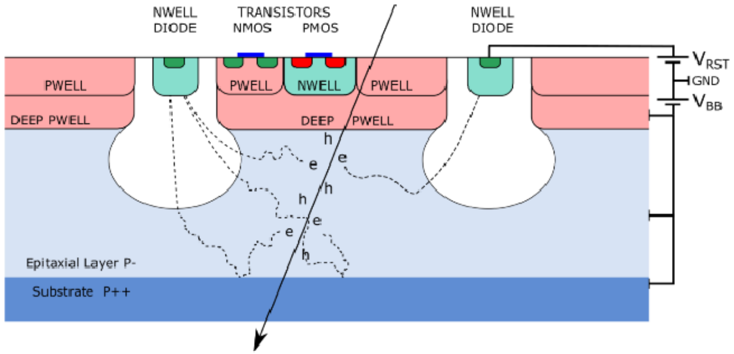
- Improvement of the readout rate capability with Pb-Pb data

Introduction

- The **ALPIDE** chip is implemented in a 180 nm CMOS Imaging Process

- chip size: 15 mm x 30 mm containing a matrix of 512 x 1024 pixels

- pixel size: 29.24 µm x 26.88 µm



- A charged particle crossing the sensor liberates free charge carriers in the material by ionization

- The electrons released in the epitaxial layer diffuse laterally while remain vertically confined by potential barriers

- The signal sensing elements are n-well diodes (~2 µm diameter)

- For the simulation of the ALPIDE chip a fully parametrized solution has been proposed (mainly because of its unknown analog response)

- In this context, the chip response can be regarded as the convolution of a contribution due to physics and one due to the detector

- Response, however, can be factorized:

$$F(\beta\gamma,\theta)\cdot D(\bar{x},I)$$

Physics contribution **Detector contribution**

- $F(\beta\gamma,\theta)$ is estimated from MC whereas $D(\bar{x},I)$ is estimated from data

Physics Contribution

- The contribution from physics takes into account the fact that the average cluster size (**ACS**) is proportional to the energy deposit E_{loss}

- From the Bethe-Block formula, ACS (<u>from the physics contribution only</u>) is parametrized as

$$A \cdot \frac{1+x^2}{x^2}\left[\frac{1}{2}\cdot\ln(B\cdot x^2) - \frac{x^2}{1+x^2} - C\cdot\ln(x)\right]\cdot\frac{1}{\cos\theta}$$

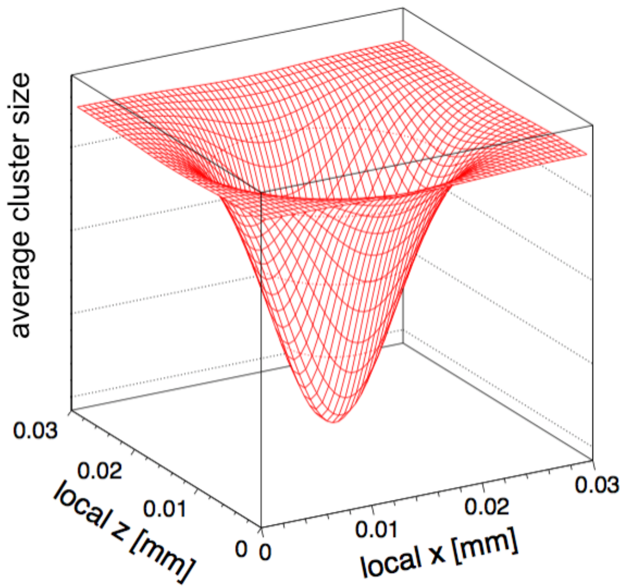
- What about $D(\bar{x}, \Gamma)$?

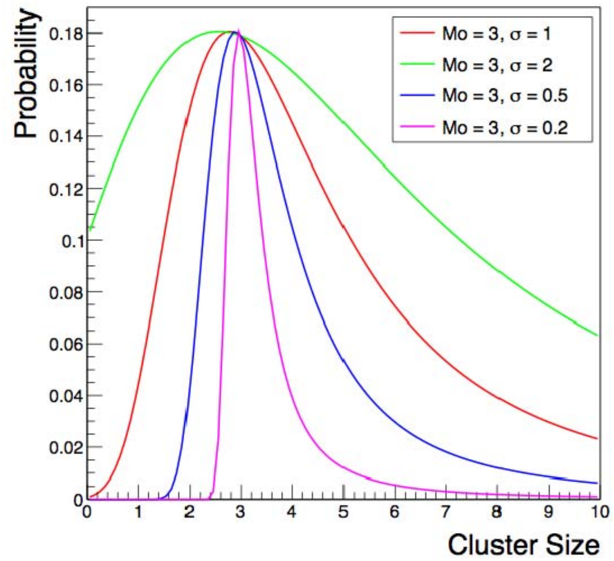
- From the analysis of the test beam data with the ALPIDE-3 chip, a strong dependence between ACS and crossing position is observed

- This effect has been parametrized with 2D gaussian in the simulation

- Because of this strong dependance a 2D gaussian model was implemented in the simulation to parametrize the average cluster size

- The actual cluster size was sampled from a Landau with Mo = ACS
  - The FWHM was tuned to match the CS distribution in data



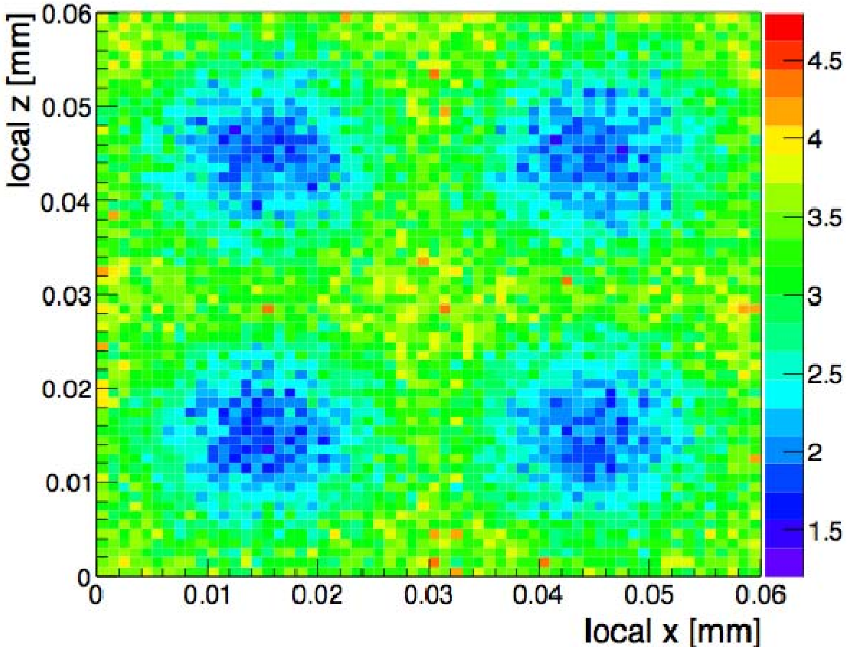


- The simulation, initially developed in AliRoot, was ported (and, since then, further developed) in O2

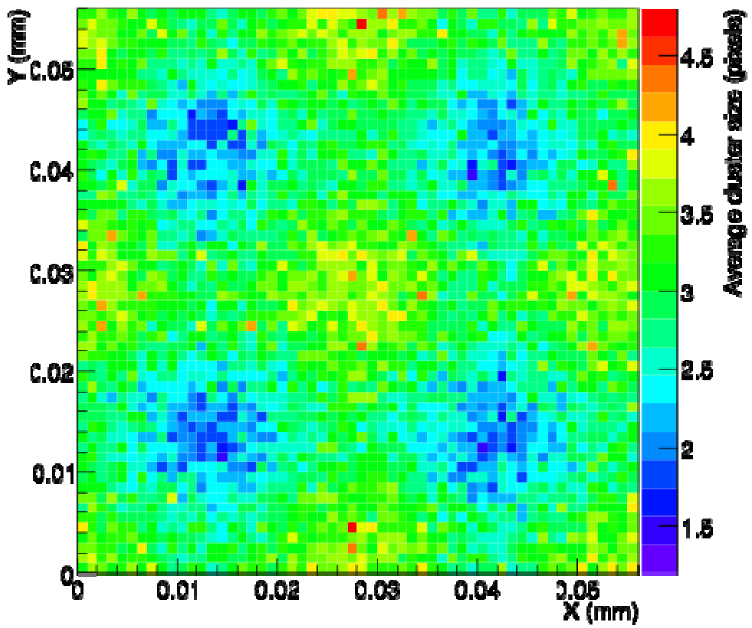
Cluster size vs track position

- This model can reproduce the data quite well

SIMULATION

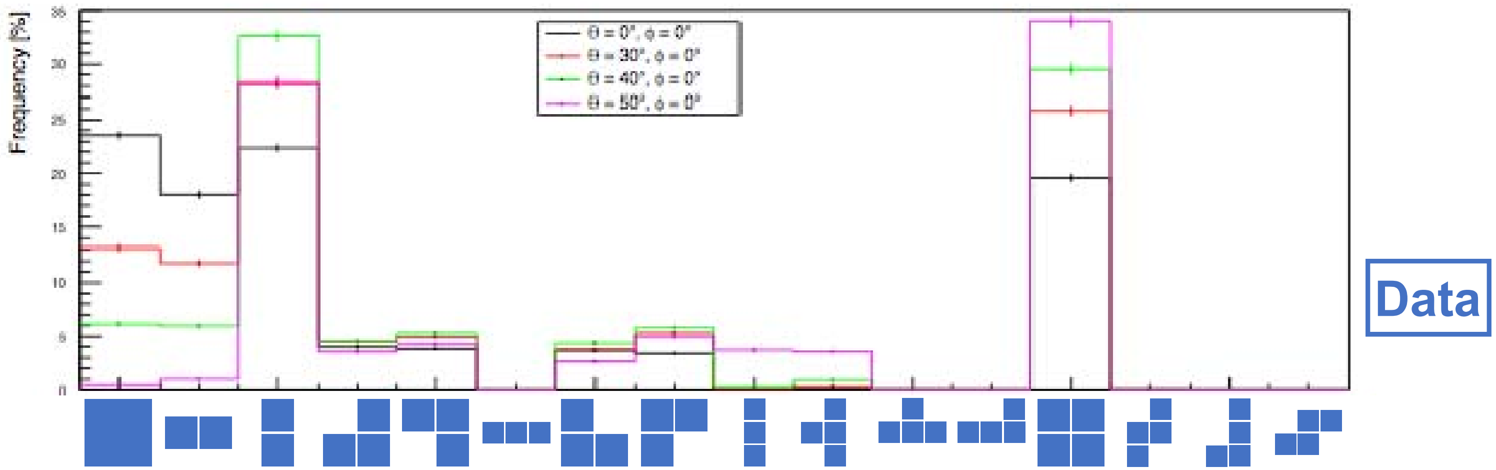


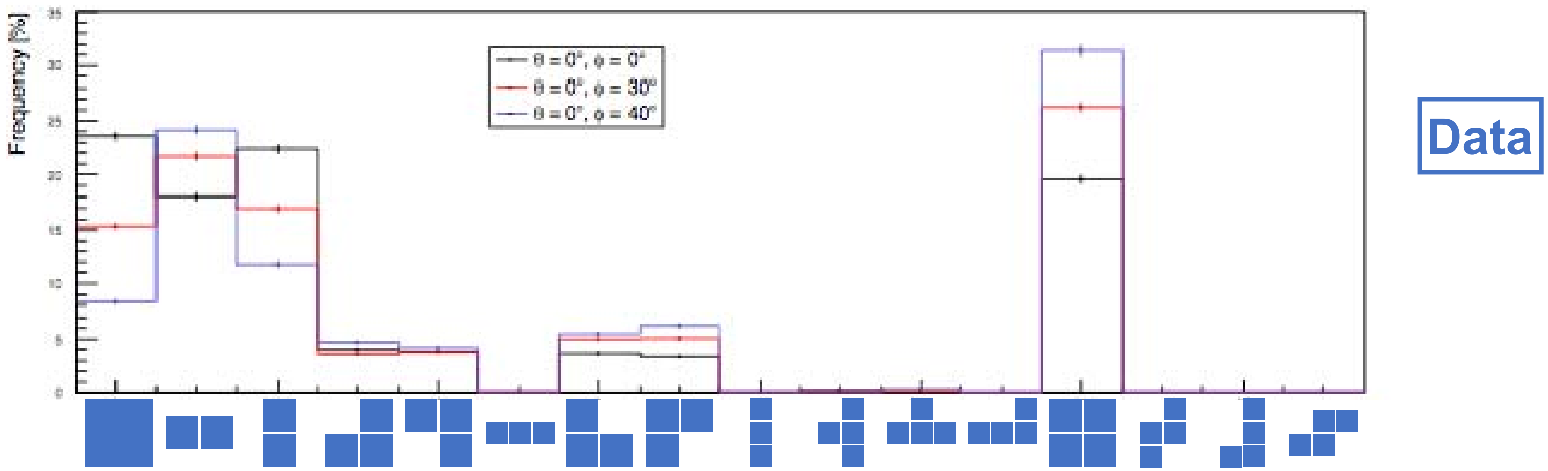
DATA



Cluster shape vs θ

- Study of the cluster shape vs the incidence angles ongoing



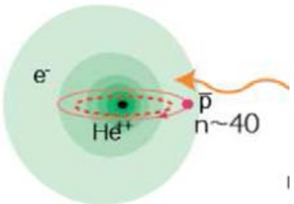


CONSUNTIVI SCIENTIFICI 2016

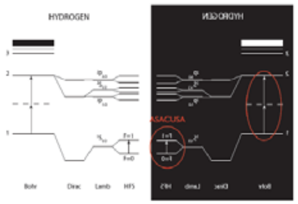
ASACUSA

3 different experiments:

$\overline{p}He^{+}$



$\overline{H}$



$\sigma_{ann}(\overline{p}A)$

ASACUSA Italia

cognome nome	TIPO	Ricercatori	Tecnologi	FTE
Baù Marco	assoc	Assegnista		50
Bianconi Andrea	assoc	Prof.Associato		70
Corradini Maurizio	assoc			
Ferrari Marco	assoc	Prof. Associato		50
Ferrari Vittorio	assoc	Prof. Ordinario		50
Leali Marco	assoc	Tecn.Laureato	x	100
Mascagna Valerio	assoc.	Assegnista		100
Solazzi Luigi assoc	assoc.	Ricercatore		50
Venturelli Luca assoc	assoc.	Prof. Ordinario		100

+ collaboratori Università dell'Insubria-Como & INFN Trieste

Pubblicazioni ASACUSA 2016

$\overline{H}$

- C. Sauerzopf et al. “Towards measuring the ground state hyperfine splitting of antihydrogen – a progress report” Hyperfine Interact 237 (2016) 103
- B. Radics et al. “Antihydrogen synthesis in a double-CUSP trap towards test of the CPT-symmetry” Hyperfine Interact 237 (2016) 156
- Y. Nagata et al. “Direct detection of antihydrogen atoms using a BGO crystal” NIM A 840 (2016) 153–159

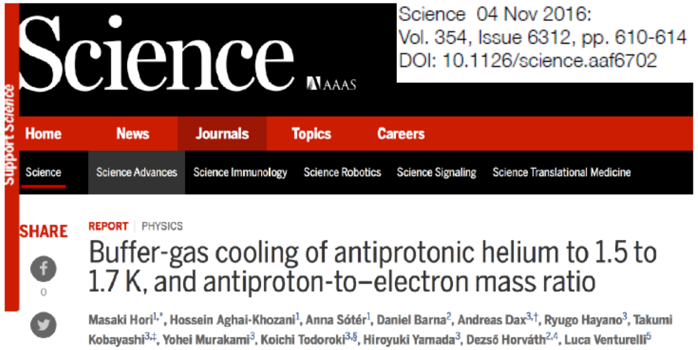
$\overline{p}He^{+}$

- M.Hori et al. “Buffer-gas cooling of antiprotonic helium to 1.5 to 1.7 K, and antiproton-to–electron mass ratio” **Science** 354 (2016) 610-614

$\sigma_{ann}\left(\overline{p}A\right)$

- K. Todoroki et al. “Instrumentation for measurement of in-flight annihilations of 130-keV antiprotons on target foils” NIM A (2016) 59256
- H. Aghai–Khozani et al. “New results of the antiproton-carbon annihilation cross section measurement at low energies” EPJ Web of Conf. 130, 07014 (2016)

$\overline{p}He^{+}$ ASACUSA CPT test


Science 04 Nov 2016:
Vol. 354, Issue 6312, pp. 610-614
DOI: 10.1126/science.aaf6702

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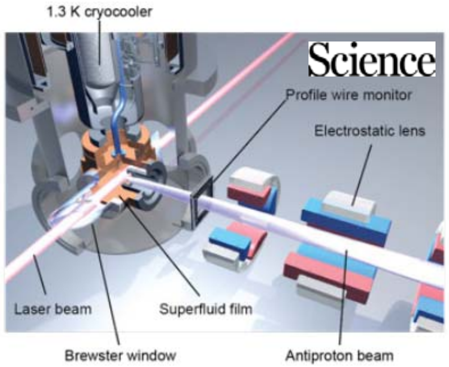
REPORT | PHYSICS

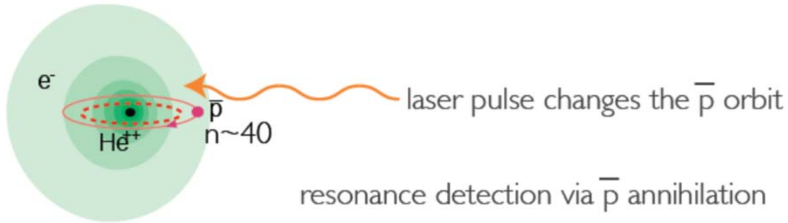
Buffer-gas cooling of antiprotonic helium to 1.5 to 1.7 K, and antiproton-to–electron mass ratio

Masaki Hori[1,*], Hossein Aghai-Khozani[1], Anna Sótér[1], Daniel Barna[2], Andreas Dax[3,†], Ryugo Hayano[3], Takumi Kobayashi[3,‡], Yohei Murakami[3], Koichi Todoroki[3,§], Hiroyuki Yamada[3], Dezső Horváth[2,4], Luca Venturelli[5]



In 2016

- we published in **Science** the ratio M $_{\overline{p}}$ /m_e with a fractional precision of 8 x 10^{-10} (single photon laser)
- Measurement of two-photon laser spectroscopy of $\overline{p}$ He$^+$ cooled to T = 1.5 K



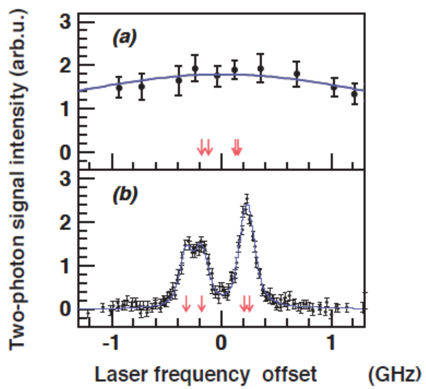
Frequency

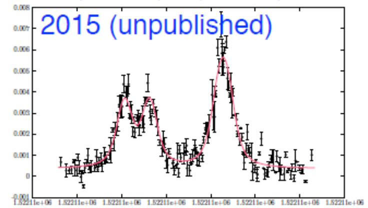
$$\nu_{n,\ell\rightarrow n',\ell'} = Rc\frac{m^*_{\overline{p}}}{m_e} Z^2_{\text{eff}} \left(\frac{1}{n'^2} - \frac{1}{n^2}\right) + QED$$

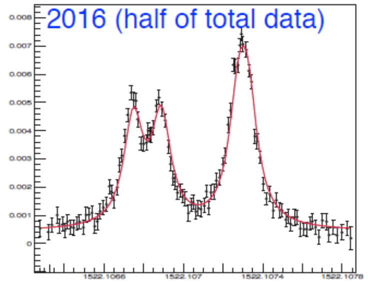
$\overline{p}$ (p) - e mass ratio | Theory

Korobov

Two-photon resonance 4He (36,34)->(34,32)

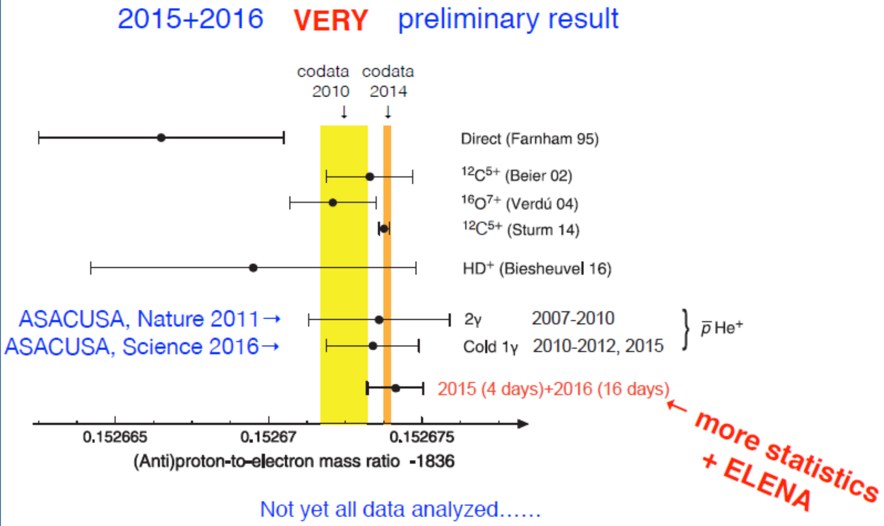


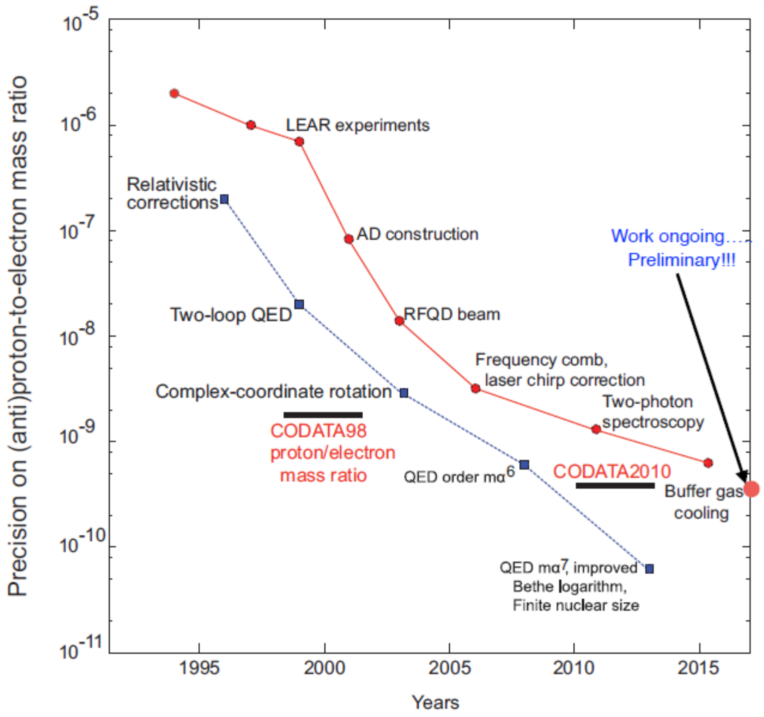




Improved experimental precision (2.5x-3x higher precision?)

$\bar{p}He^+$ ASACUSA



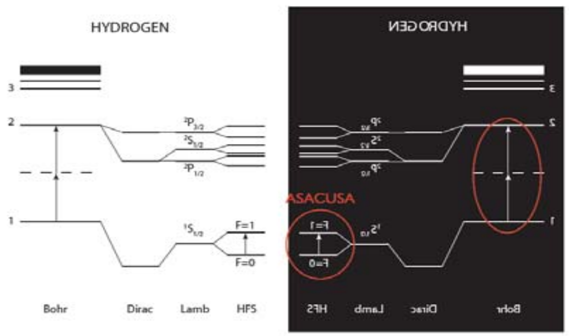


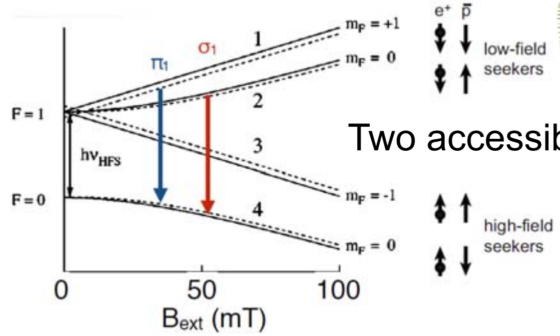
In 2017 and beyond

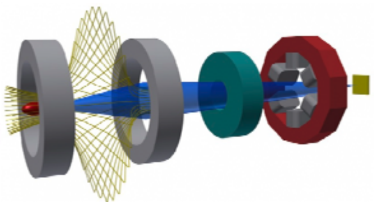
-Measurement of 3 two-photon transitions of $\bar{p}$ He^+ cooled to T = 1.5 K. In principle → ratio $M_{\bar{p}}/m_e$ with a fractional precision of 3×10^{-10}

-with ELENA (2021→) in principle possible to improve precision by factor 100

ASACUSA Toward H̄ GSHFS Spectroscopy







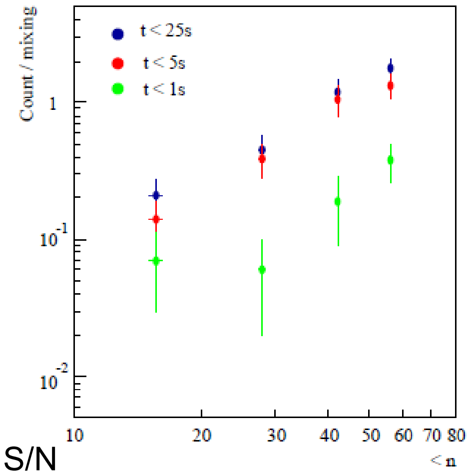
Two accessible transitions: σ_1 & π_1

CPT test

- In 2016, ASACUSA achieved:

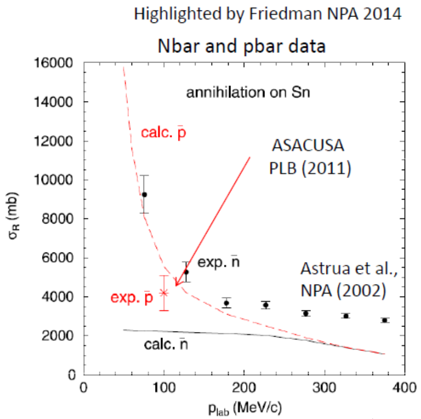
-10,000 s of p̄ lifetime

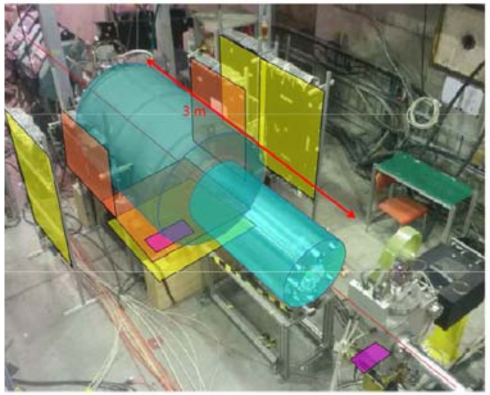
- lowering p̄ transport energy
  (from 20 eV → 10, 5, 2.5, 1.5, and 1 eV)
- measurement of energy spread of p̄ beams
- H̄ production with 1.5 eV
- optimization of H̄ production
- H̄ production localized within 0-5 s → better S/N
- measurement of n (fraction within 5 s is at *n < 14*)

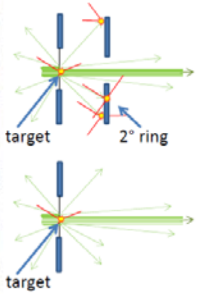


- 2017 and beyond
- H̄ beam optimization
- → ground-state hyperfine spectroscopy

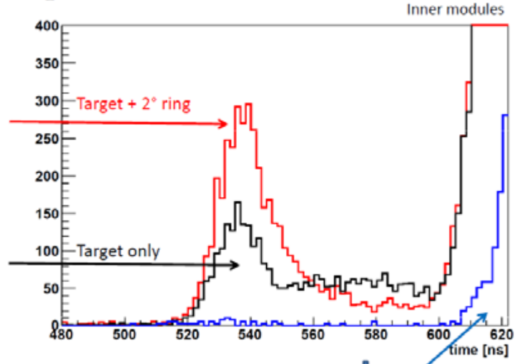
$\sigma_{ann}(\bar{p}A)$ ASACUSA

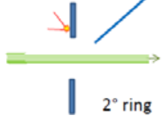




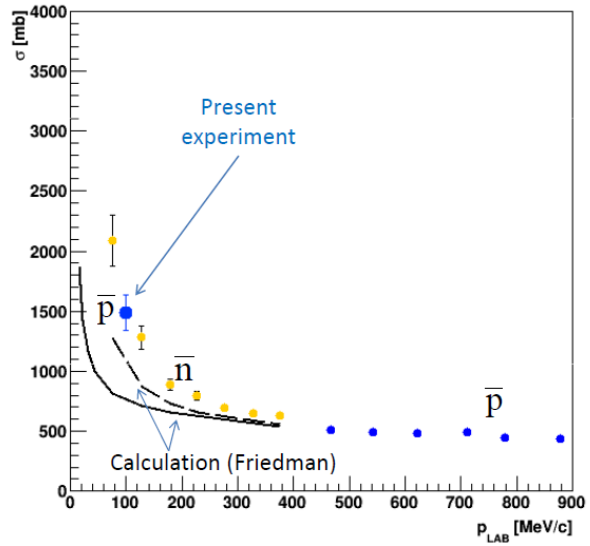


p̄ annihilation times





n̄ behaves like p̄ at ~ 5 MeV: why?



In 2016
- Analysis of the data collected in 2015 for the p̄ -carbon annihilation cross section at 5.3 MeV (as a benchmark to understand energy and mass number dependence of antinucleon annihilations at low energies - puzzle with antineutrons)

In 2018 and beyond
- Measurement with Al, Ni targets at 5.3 MeV ?
- with ELENA (2021→) measurments at 100 keV ?

Consuntivi FAMU 2016

CdS, 5 giugno 2016

Motivazioni: il puzzle del raggio del protone

- Si considerano le distribuzioni di carica, $\rho_E(r)$ e magnetica, $\rho_M(r)$.
  $R_Z = \int(\int\rho_E(r') \, \rho_M(r-r') \, d^3r') \, r \, d^3r$ - $\Delta E^{HFS}_{1S} = 184.087X - 1.281Y \, R_Z$ meV.
  La teoria prevede $X \approx 15$, $Y < 10$.

- Misura dello splitting iperfine (HFS) nello stato base dell'idrogeno muonico, legato al raggio Zemach del protone dal HFS del $(\mu^- p)_{1S}$

- Esperimento basato sul Lamb Shift nel $\mu^- p$ al PSI (2010):
  $r_{ch} = 0.84089(39)$ fm
- Discrepanza di 7σ da CODATA-2010:
  $r_{ch} = 0.87750(510)$ fm basato su scattering e-p e spettroscopia H.

- Necessità di una misura conclusiva: FAMU @RIKEN-RAL muon facility.

Metodologia

- L'atomo di μp assorbe un fotone da un laser IR alla lunghezza d'onda della risonanza $\lambda_0 = hc/DE^{1S}_{HFS} \approx 6.8\ \mu m$ della transizione da singoletto a tripletto (spin flip).

- Quando l'atomo viene de-eccitato collisionalmente allo stato 1S, viene accelerato di 0.12 eV ($\approx$2/3 dell'energia di transizione iperfine).

- Questa sequenza di processi viene rivelata tramite i prodotti di reazioni la cui rate dipende dalla velocita' del μp.

- In particolare, viene osservato il trasferimento del μ dal protone a nuclei di un gas pesante appropriato, che abbia una dipendenza importante dell'energia dalla rate di trasferimento.

- Il trasferimento del μ è identificato da raggi X caratteristici emessi durante la diseccitazione dell'atomo muonico piu pesante.

- λ_0 (da cui si ricava ΔE^{1S}_{HFS}) viene identificata dalla risposta massimale.

La Collaborazione FAMU (2016)

- Responsabile Nazionale: *Andrea Vacchi (INFN Trieste)*
- Sezioni di: *Bologna, Milano, Milano Bicocca, Pavia, Roma 3, Trieste* **(dal 2017: Napoli)**
- Collaborazioni estere: *Krakow (Pol.), Sofia (Bul.)*
- FAMU-Pavia: *1.8 FTE, 5 persone (2 ricercatori, 3 tecnologi)*
  (+0.3 FTE rispetto al 2015)
- Finanziamenti PV 2016: Missioni 11 k€, Consumo 2 k€, Trasporti 1 k€

- Pubblicazioni 2016:

A. Adamczak et al., "*Steps towards the hyperfine splitting measurement of the muonic hydrogen ground state: pulsed muon beam and detection system characterization*", Journal of Instrumentation, Volume 11(5) P05007 (2016).

R. Bertoni et al., "*Characterization of Pr:LuAG scintillating crystals for X-ray spectroscopy*", Nucl. Instr. Meth. A824, 212-214 (2016).

- Conferenze 2016:

"The construction of the Fiber-SiPM beam monitor system of the R484 and R582 experiments at the RIKEN-RAL muon facility", IPRD2016 (Siena, Italy) (M. Bonesini et al.)

Run FAMU 2014: primi risultati

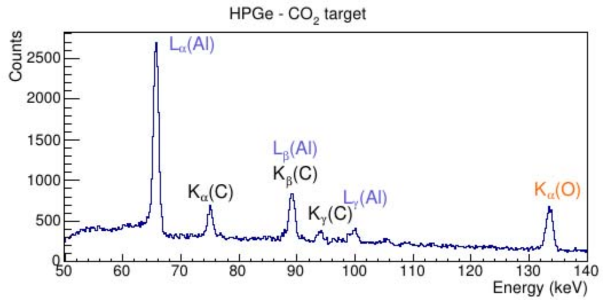
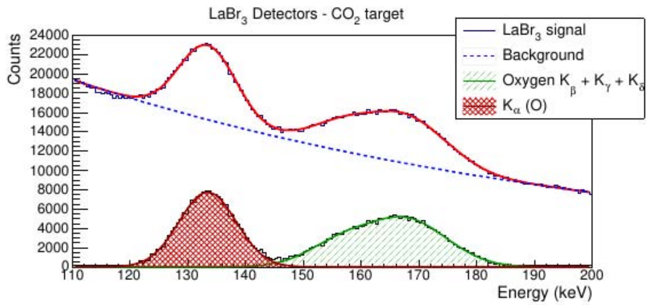
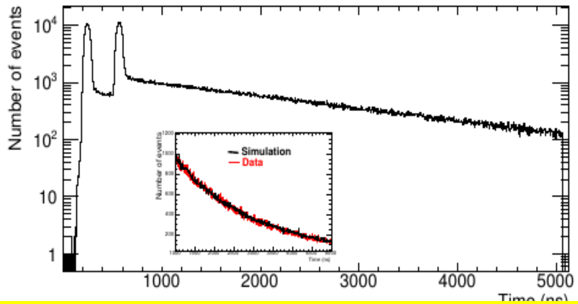


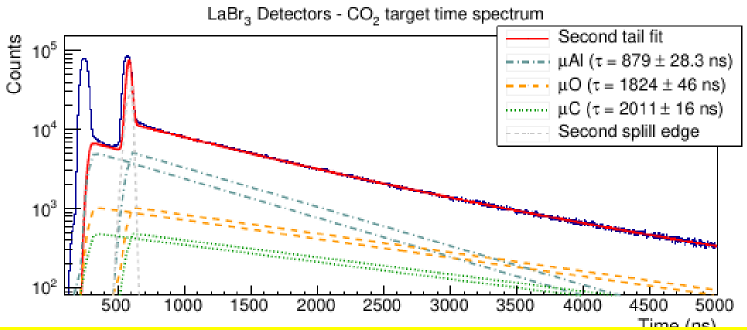
Figure 8. Energy spectrum as measured by the GLP HPGe detector with the H_2+4%CO_2 gas target in the region of K spectral lines from μAl to μO. Detected spectral lines are labeled. From this comparison it can be noticed that there was not gas contamination and all measured events in μO spectral lines originated in the gas target.



Linee dell'Ossigeno individuate(H2+CO2)



Tempi di arrivo dei raggi X (coda dovuta agli X ritardati) - grafite

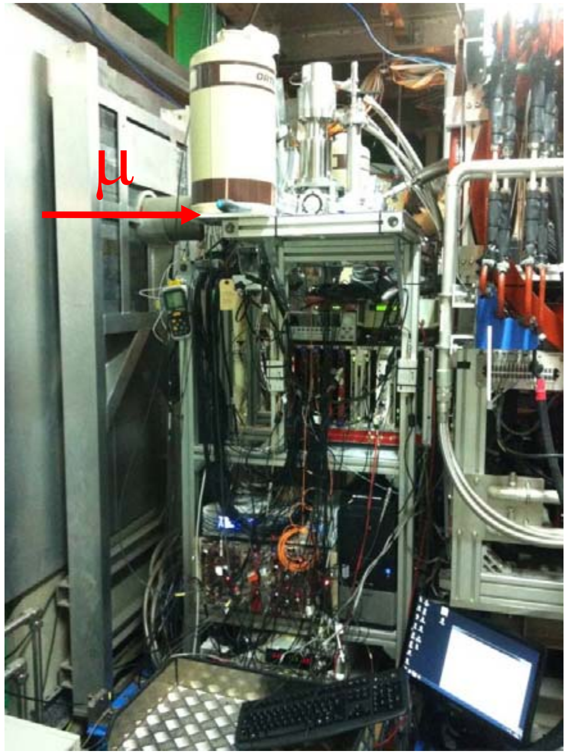


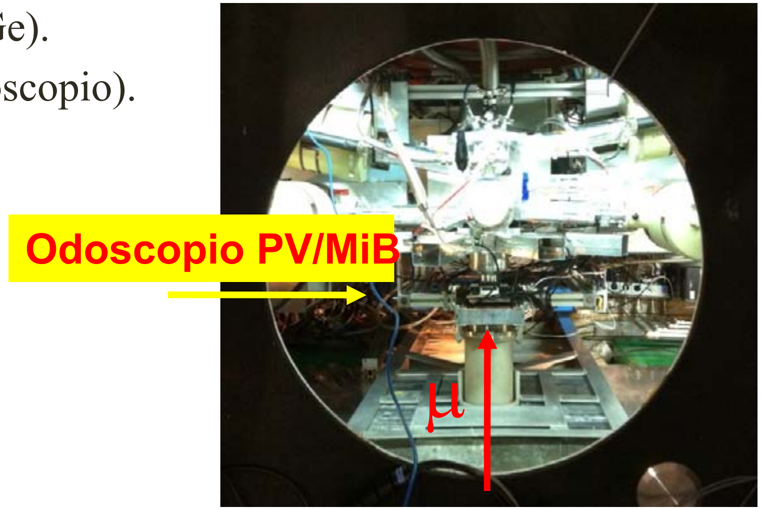
Coda dello spettro temporale compatibile con le catture su O e C!

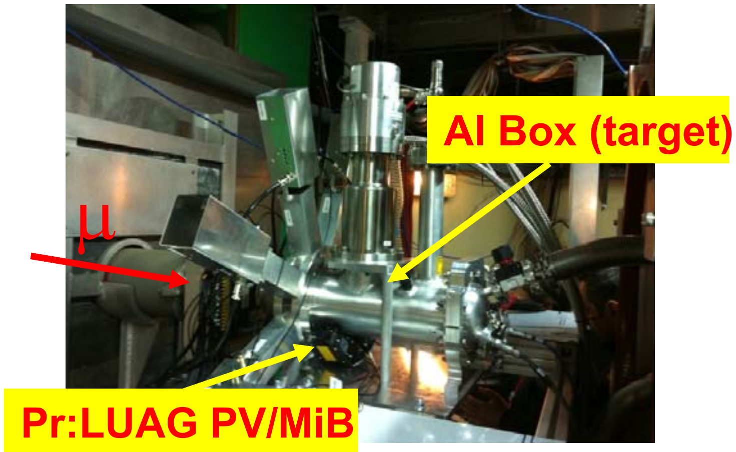
A. Adamczak et al., "*Steps towards the hyperfine splitting measurement of the muonic hydrogen ground state: pulsed muon beam and detection system characterization*", Journal of Instrumentation, Volume 11, May 2016.

RUN FAMU 2016

- Test run su fascio di muoni a RIKEN RAL (febbraio 2016) per misura di rate trasferimento di muoni da idrogeno muonico ad atomi pesanti: sono state variate pressione, la temperatura e la concentrazione dei nuclei in diverse miscele di gas.
- Test rivelatori (LaBr3, Pr:LUAG, HPGe).
- Test monitor dei muoni del fascio (odoscopio).



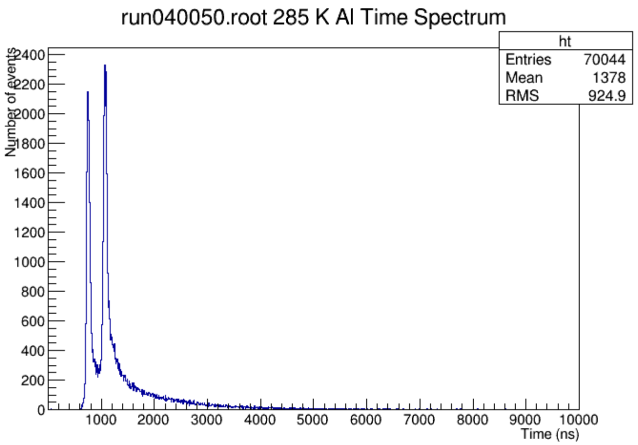




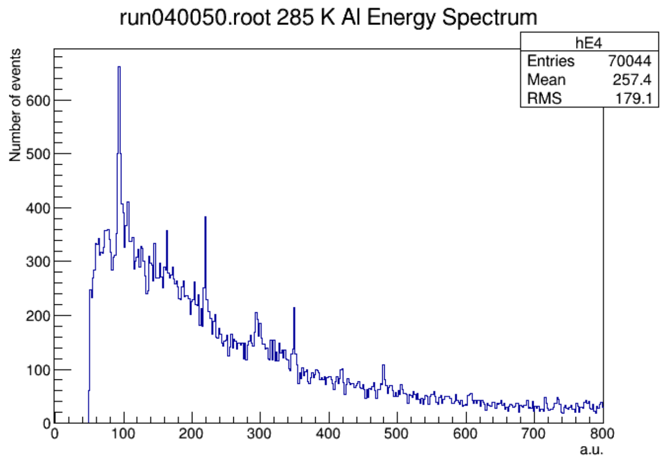
Test sul cristallo+riflettore+SiPM array (2015/2016)

- Installazione 4 Pr:LuAG e 2 CeCAGG e presa dati presso RIKEN-RAL nei test run di Dicembre 2015 e Febbraio 2016 (in collaborazione con INFN-MiB).

- Collaborazione all'analisi dei dati in corso: tre pubblicazioni in fase di finalizzazione.



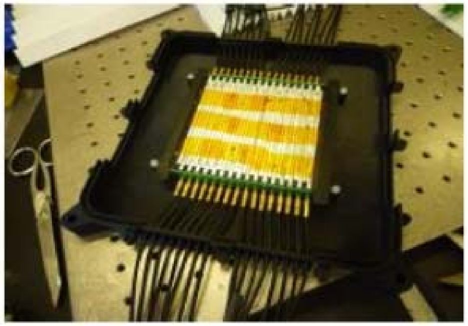
Spettro temporale CeCAGG (risolti i due picchi relativi ai bunch del fascio distanti 320 ns).

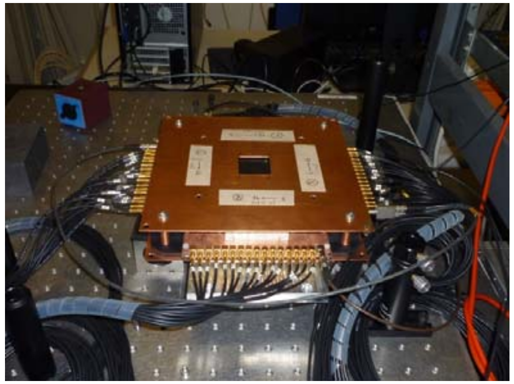


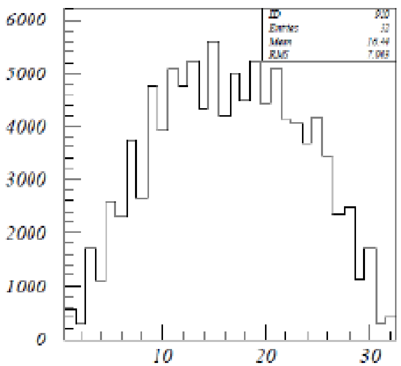
Spettro totale CeCAGG (non calibrato): righe di atomi muonici evidenti.

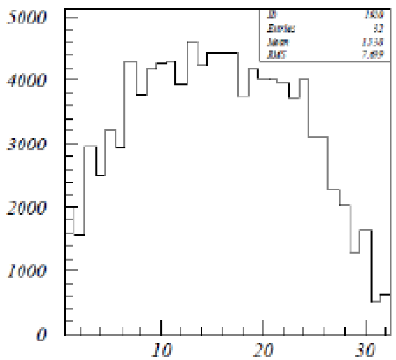
Attività FAMU-PV 2016: nuovo monitor di fascio

- 2 piani x/y di fibre scintillanti BCF12 (diametro 1 mm) lette da SiPM Advansid 1x1 mm^2 con celle da 40 μm.
- Boards per alloggiamento SiPM disegnate e realizzate dal Servizio Elettronico della Sezione di Pavia. Meccanica stampata su stampante 3D a Pavia su CAD di INFN Milano Bicocca.





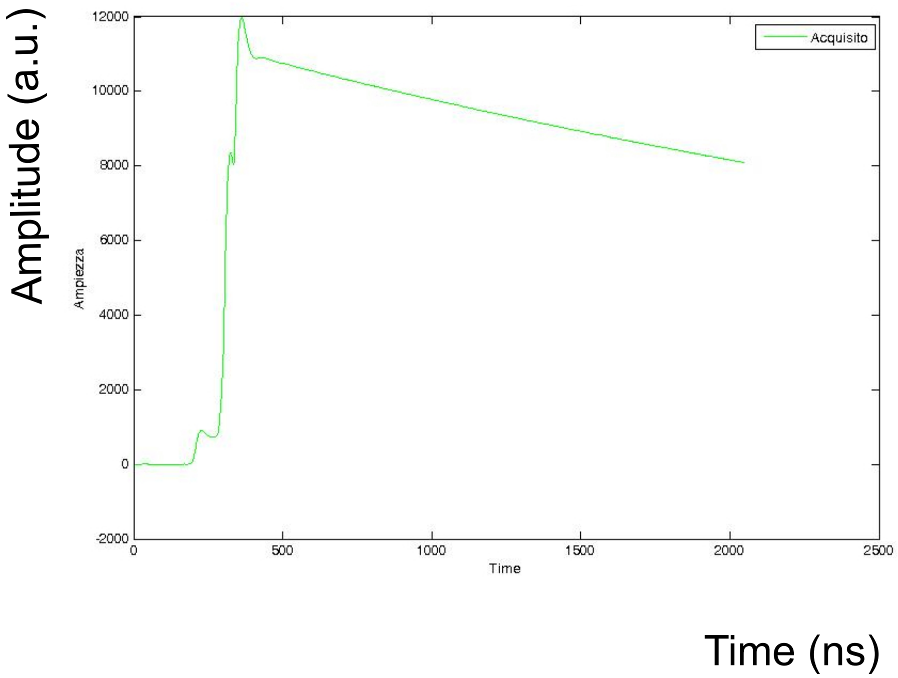




Profilo del fascio (X,Y) misurato dall'odoscopio a 61 MeV/c. RMS del fascio < 1 cm in entrambe le coordinate.

Attività FAMU-PV 2016: elettronica per Germanio MiB

- Disegno e realizzazione da parte del Servizio Elettronico dello stadio di pre-amplificazione per i rivelatori a Germanio di INFN Milano Bicocca in vista dei test run autunno 2016 e 2017.

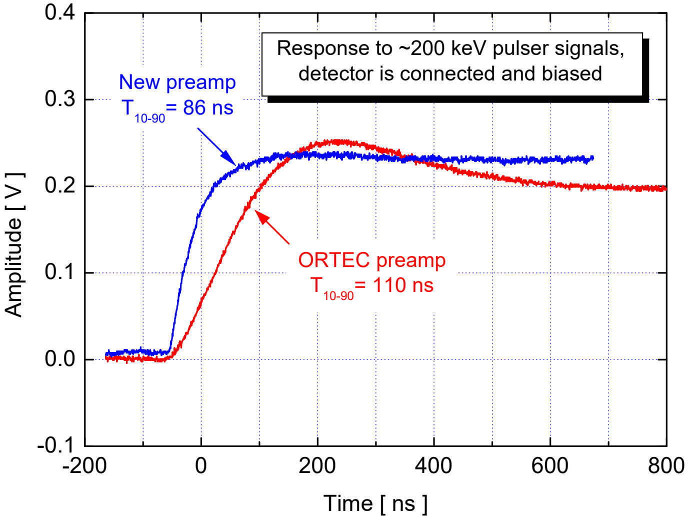


- Esempio di segnale acquisito durante i run di FAMU a RIKEN-RAL con l'attuale elettronica di amplificazione Ortec:

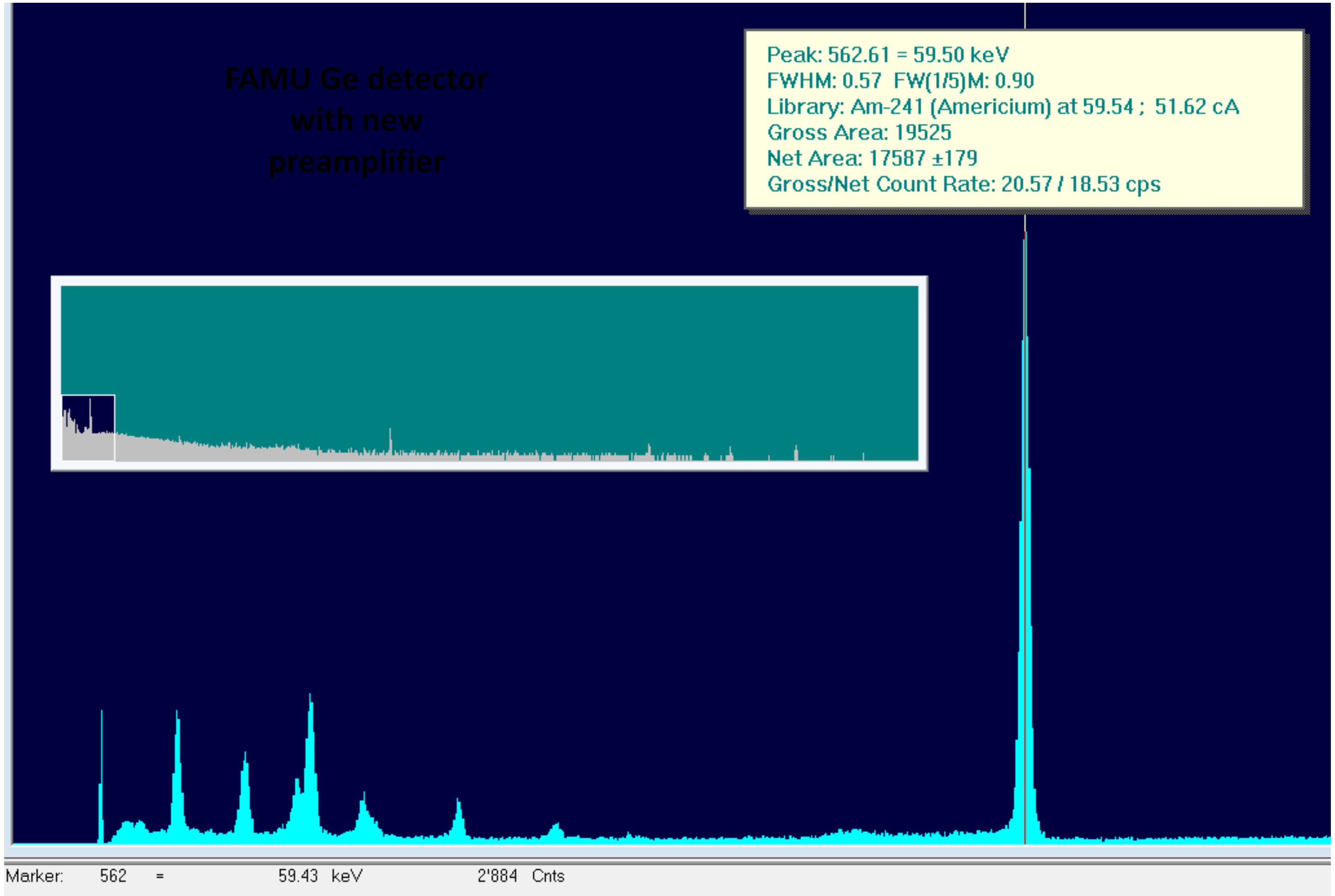
- tempo di salita elevato, non permette di distinguere tra fotoni X primari e ritardati.

Serve una risoluzione temporale di qualche decina di ns.

- Il gruppo FAMU-PV ha iniziato a sviluppare un pre-amplificatore per arrivare a tempi di salita sotto i 100 ns. I test sono iniziati con la realizzazione di un pre-amplificatore simil Ortec da utilizzare come punto di partenza:



- Il nuovo preamplificatore è molto più veloce e non mostra overshoot.



Prossimo passo: test su fascio a RIKEN-RAL.

MAMBO

MAMiBOnn

Studio di fotoreazioni indotte su nucleoni e nuclei utilizzando gli acceleratori

- **MAMI** $E_\gamma \leq 1.6$ **GeV (Mainz)**
  A2 Collaboration (spokepersons : A. Thomas Mainz
  (circa 80 persone) P. Pedroni INFN-PV)
- **ELSA** $E_\gamma \leq 3.0$ **GeV (Bonn)**
  BGO-OD collaboration (spokepersons : H. Schmieden Bonn
  (circa 60 persone) P. LeviSandri INFN-LNF)

Sezioni INFN Partecipanti: CT (Me), ISS, LNF, PV, RM2, TO

COLLABORAZIONE MAMBO

Responsabile Nazionale: PAOLO LEVI SANDRI

Sezioni INFN partecipanti:

ROMA TOV	**Responsabile Locale**	**RACHELE DI SALVO**
LNF	**Responsabile Locale**	**PAOLO LEVI SANDRI**
MESSINA	**Responsabile Locale**	**GIUSEPPE MANDAGLIO**
PAVIA	**Responsabile Locale**	**PAOLO PEDRONI**
ISS-RM	**Responsabile Locale**	**FRANCESCO GHIO**
TORINO	**Responsabile Locale**	**GIANPIERO GERVINO**

21 ricercatori; 11.2 FTE

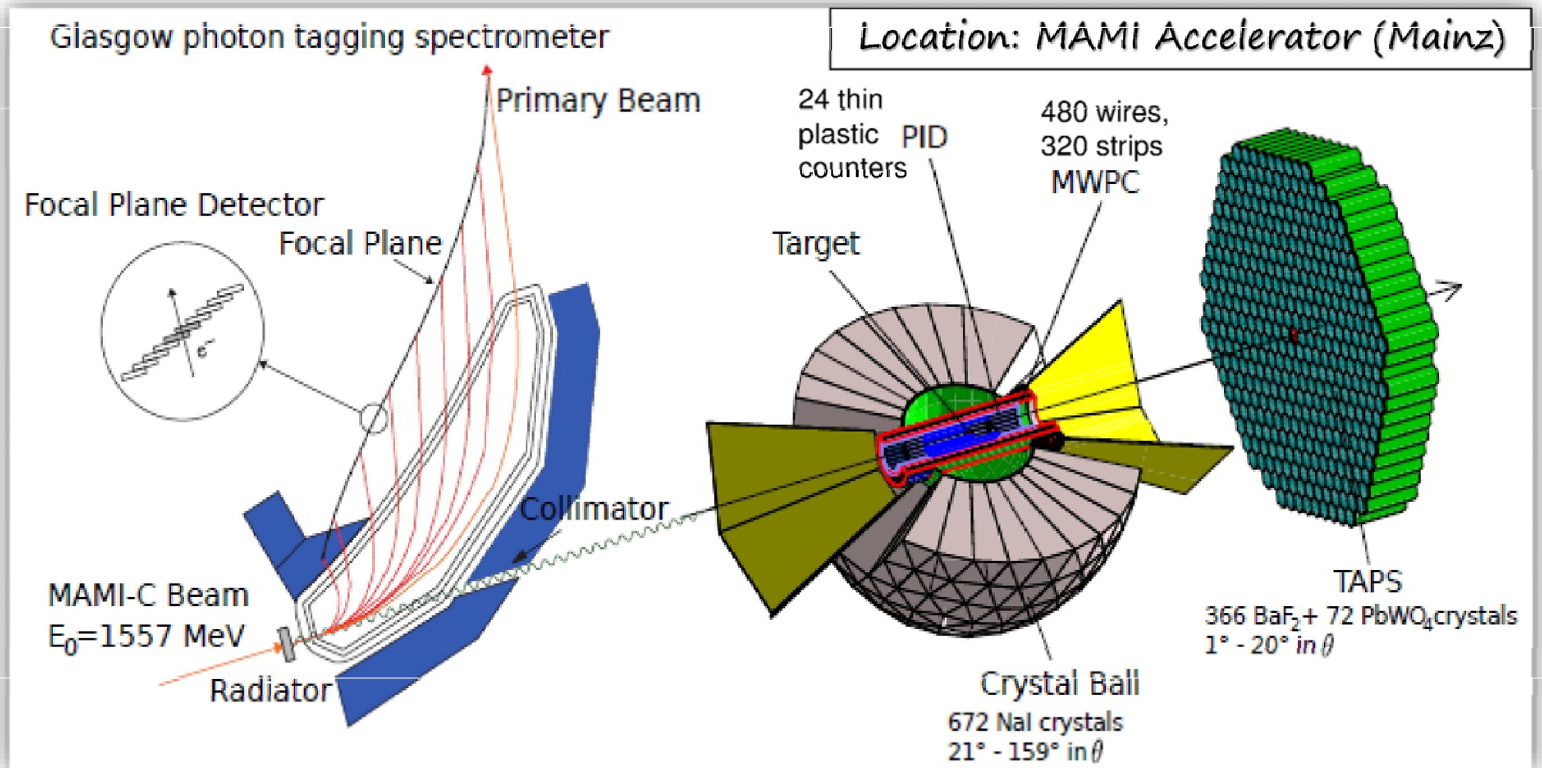
MAMBO- Physics Topics

(mainly involving low cross sections and/or precision measurements)

- **Threshold meson production:** (test of LET/ ChPT):
  Strangeness (γ N $\rightarrow \Lambda$K)
  π^0 meson photoproduction at threshold
- **Ambiguity free amplitude analysis of meson photoproduction**
  Requires Double polarization measurements:
  $\gamma N \rightarrow N\pi(\pi)$; N$\eta$ (ρ,...) channels
- **Tests of fundamental symmetries (C,CP,CPT...)**
  (Rare) η, η' decays
- **In medium properties of hadrons & nuclear physics:**
  Meson photo production on nuclei
- **Search for "missing" baryon resonances**
  Vector meson (ϕ, ω) photo production

Use of state-the-art technology (circularly and linearly polarised photon beams; longitudinally and transverse polrised proton/deuteron/3He targets) is required

A2@MAMI: detector overview

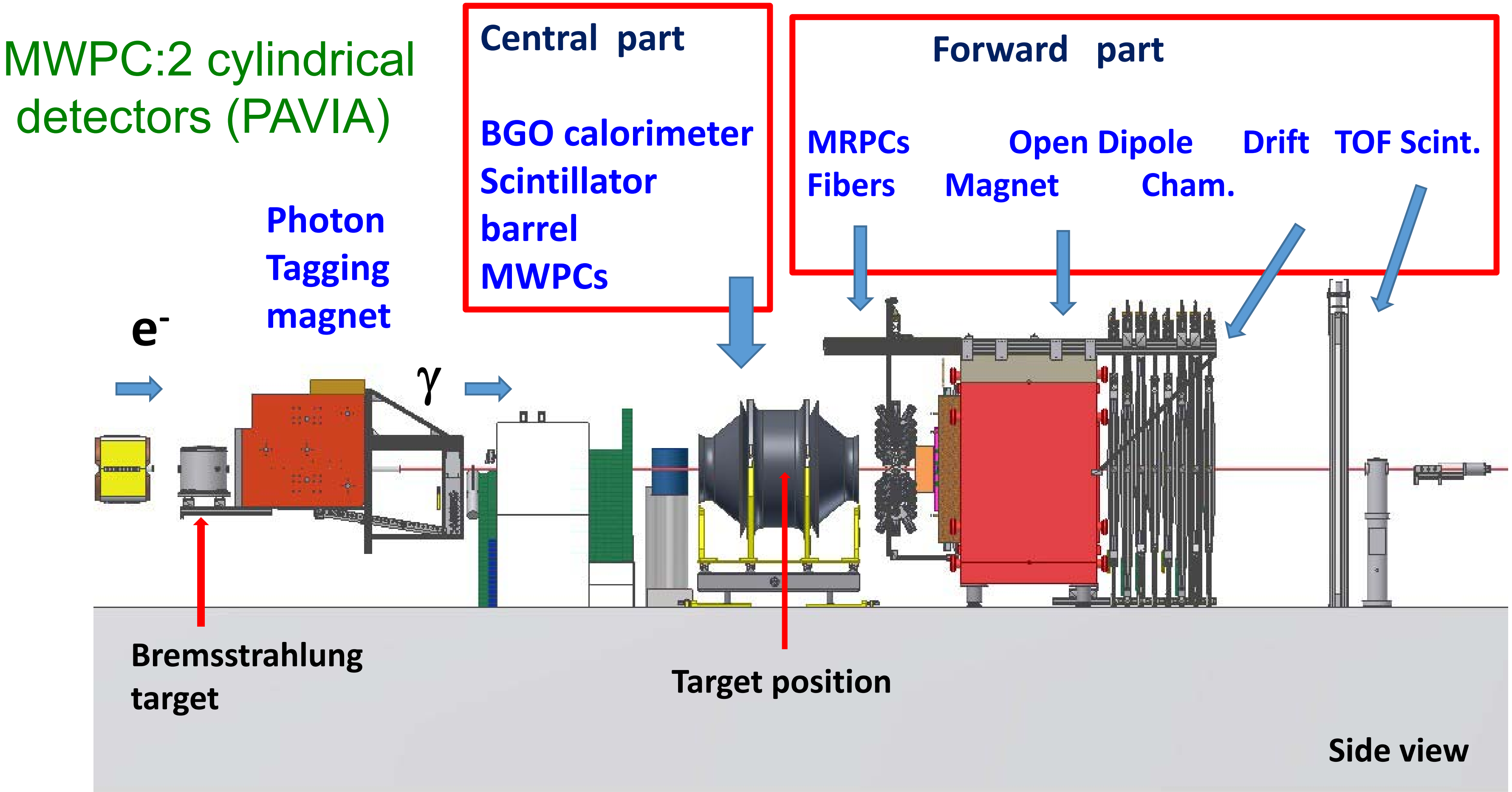


MWPC:2 cylindrical detectors (PAVIA)

Beam:

- *photon beam produced by bremsstrahlung process and tagged by the magnetic spectrometer*
- E_γ < 1.5 GeV, ΔE_γ = 2 - 4 MeV
- *Linear and circular polarisations available*

MAMBO – Bonn - Apparato

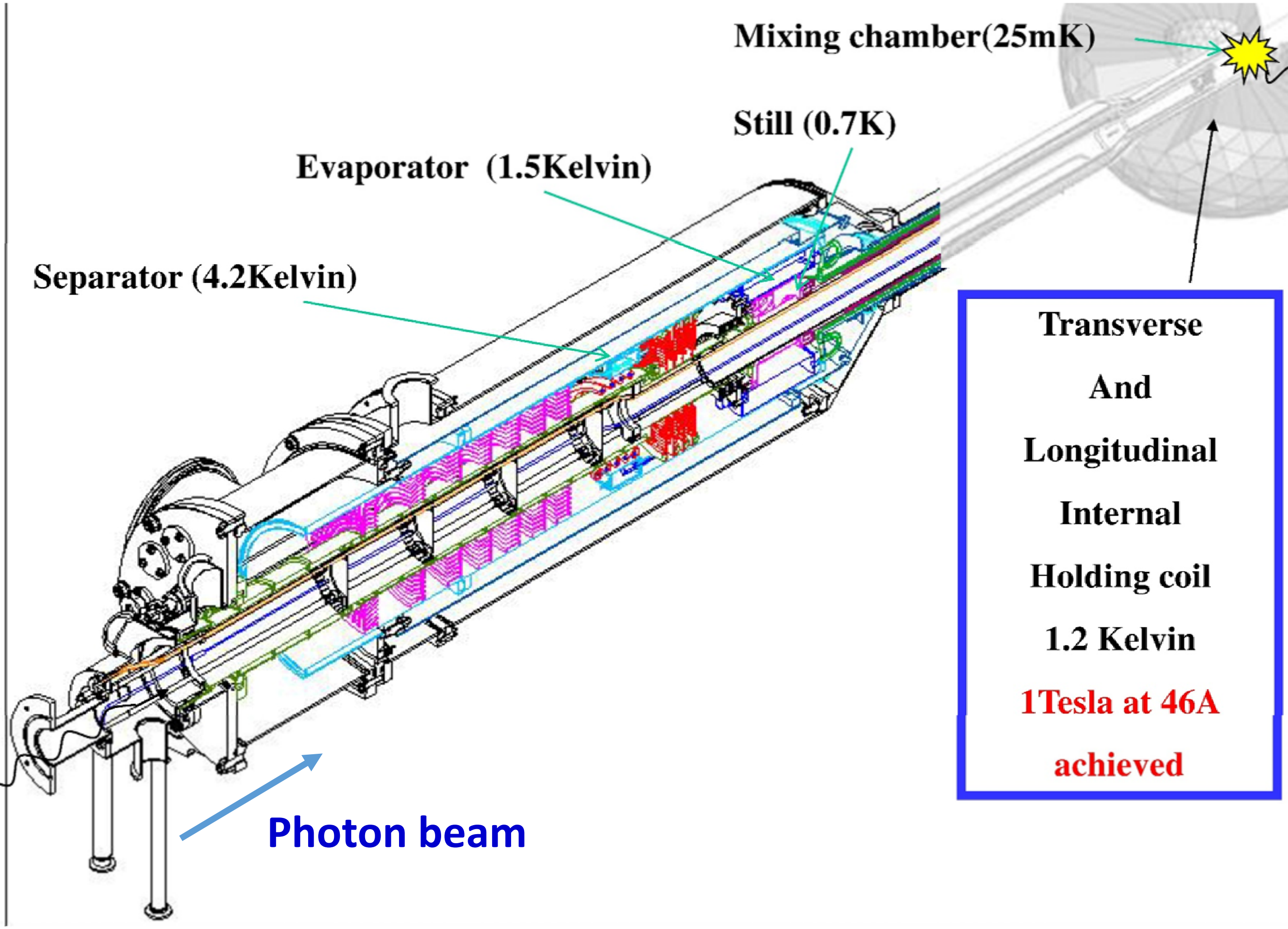


Attività svolta 2016-2017

- **Mainz** : -) manutenzione e riparazione camere a fili
  -) Prese dati con:
  =) bersaglio attivo e polarizzato di protoni
  =) bersaglio L ^{1}H (misura della polarizzazione dei protoni nella reazione $\gamma p \rightarrow p\pi^{0}$; scattering Compton)
  =) bersaglio L^{4}He (modifica delle proprietà delle risonanze adroniche nella materia nucleare)

- **Bonn** : -) Fine commissioning del sistema MWPCs
  -) Prese dati in fascio e con camere a fili e con fotoni linearmente polarizzati (fotoproduzione di mesoni η ed η')

Polarized Nucleon Target



A2 «frozen spin» polarized nucleon (i.e. butanol- $C_4OH(D)_{10}$) target

Problems: for

$$\gamma p \rightarrow p\gamma'$$

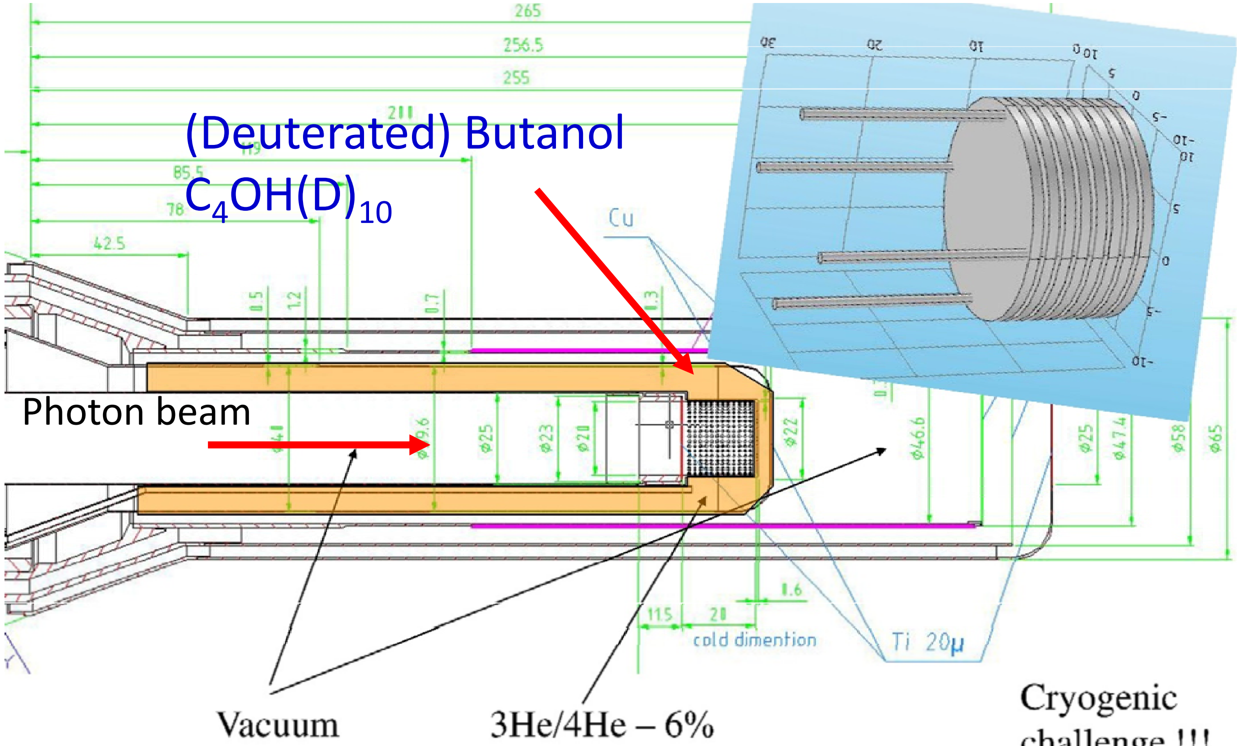
and for

$$\gamma p \rightarrow p\pi^0$$

$$\gamma p \rightarrow n\pi^+$$

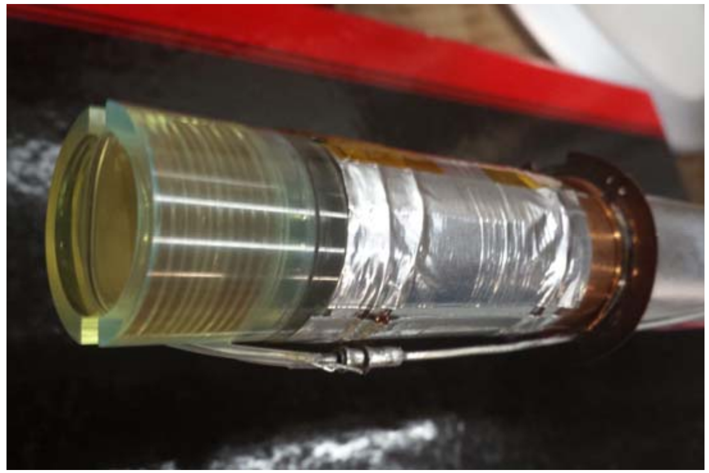
close to threshold region (interesting for χ_{PT} checks): charged particles are (mostly) absorbed within the target

Solution: **Polarized and Active Proton Target**

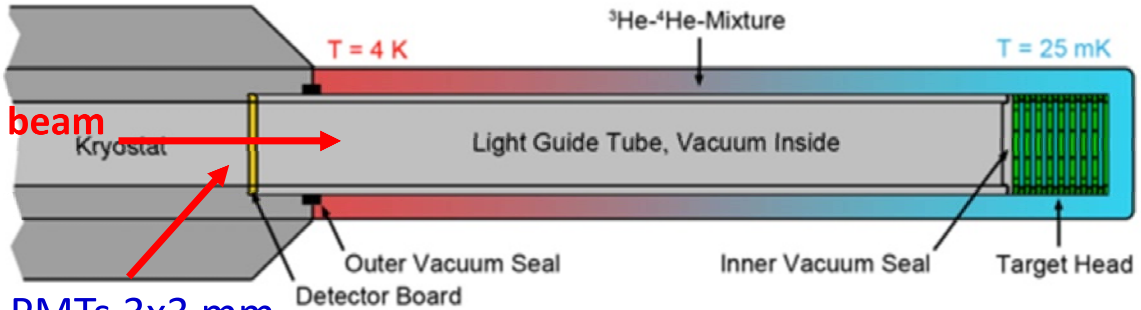


Cryogenic challenge !!!

Target rings made of polystyrene (CH) doped with TEMPO –free radical- ($C_9H_{16}NO_2$)



Photon beam



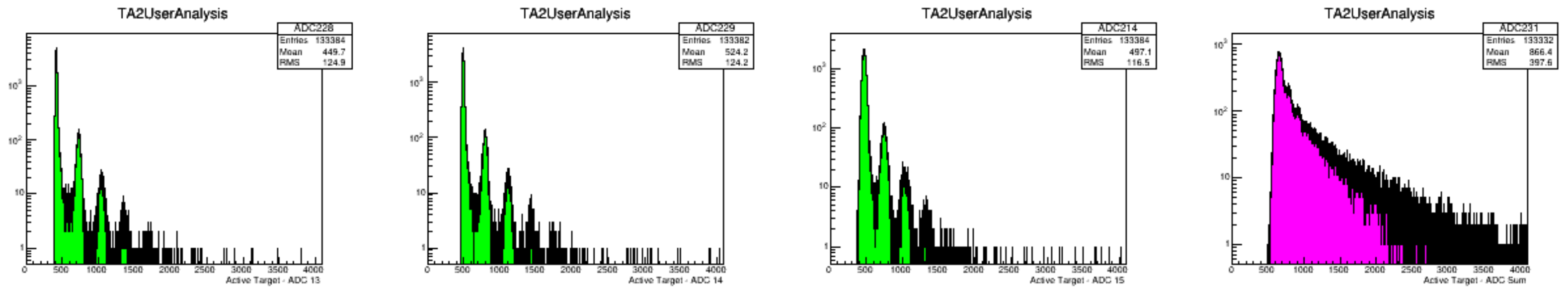
15 Si-PMTs 3x3 mm

Polarized Nucleon Target

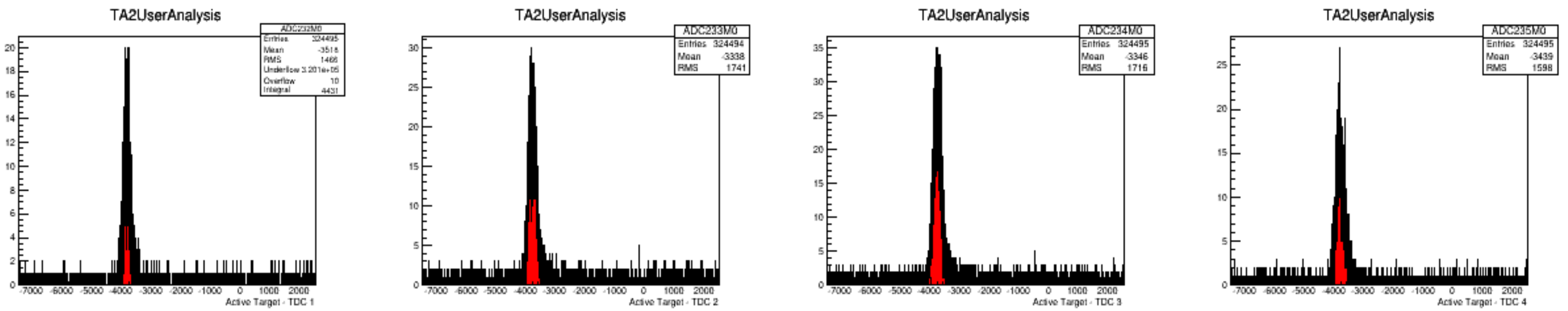
Very first Results from the 2016 Beam time

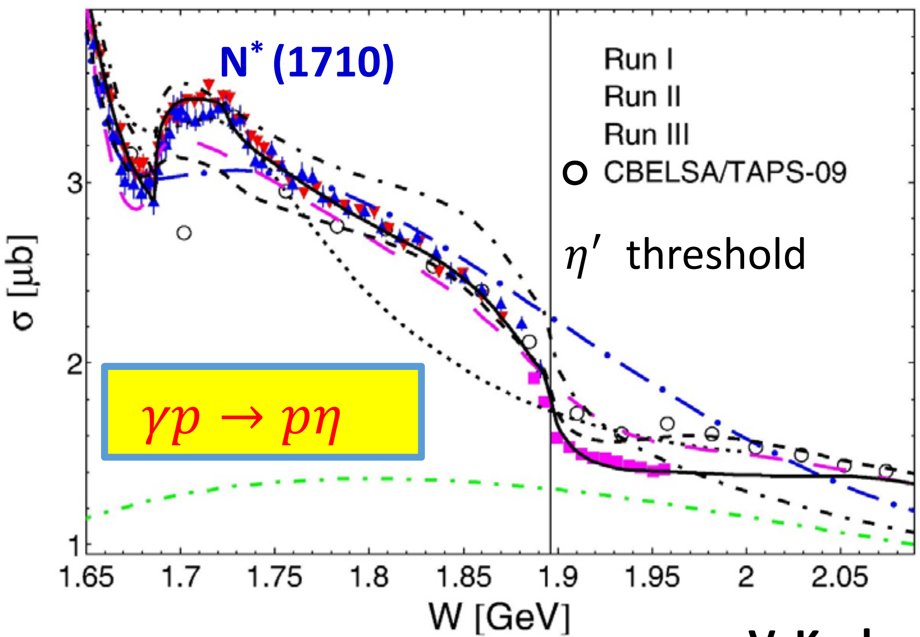
- Maximal polarization: about 70% with a relaxation time of 80 hrs
- ADC spectra

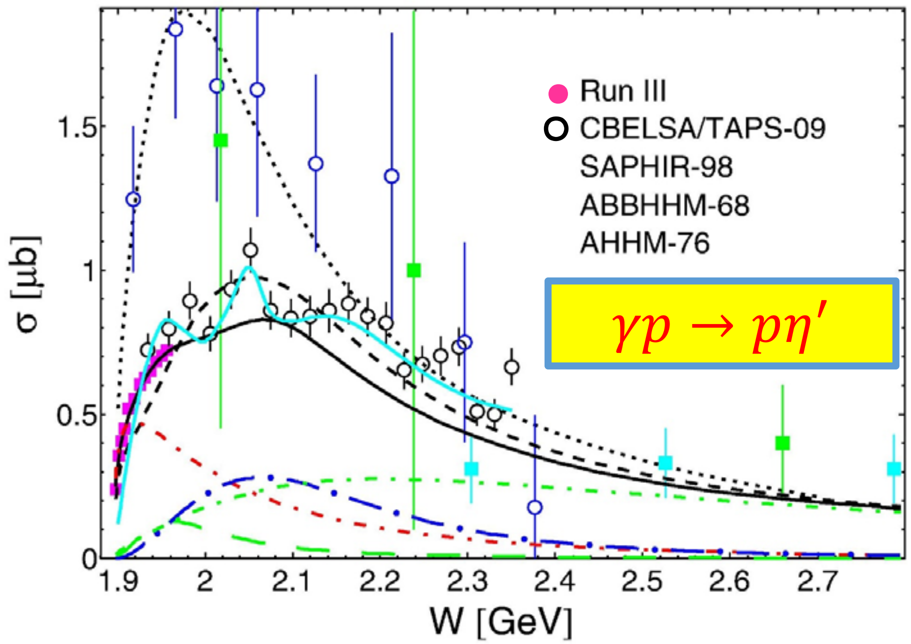
individual PMTs sum of all PMTs



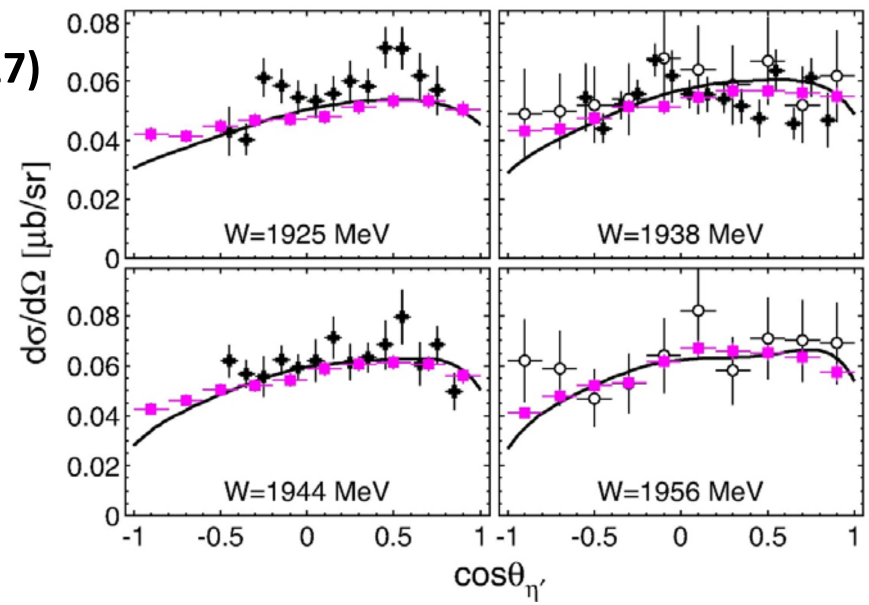
- Time Spectra (individual TDCs)







V. Kashevarov et al
PRL 118, 212001 (2017)

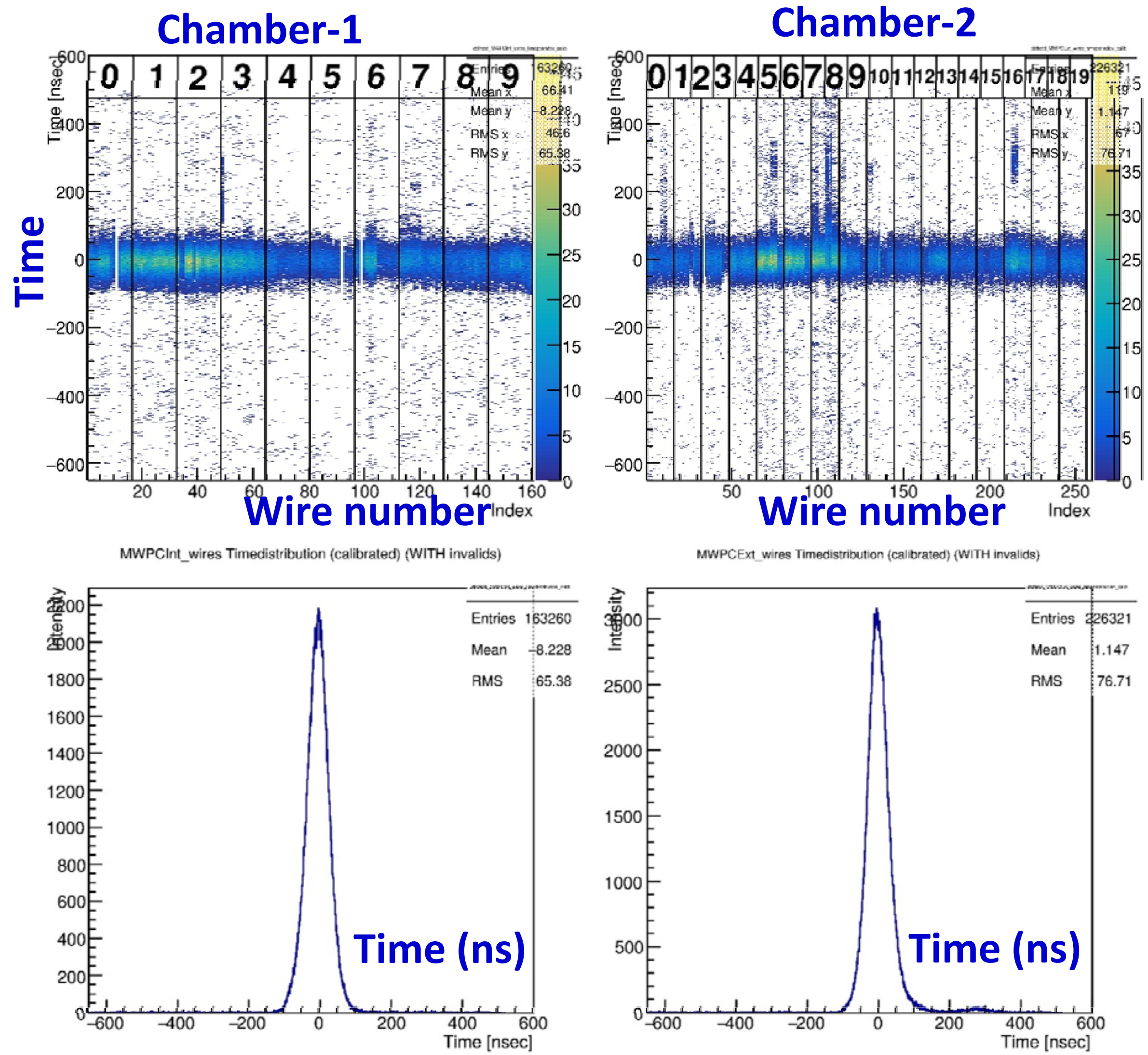


$\boldsymbol{\eta}$; $\boldsymbol{\eta'}$: I=J=0

- rare decays: C; CP ; G-parity violation
- χ_{PT} tests
- determination of the photon to meson TFFs ($\gamma\gamma^* \to M$; important QCD parameter) via the decay:

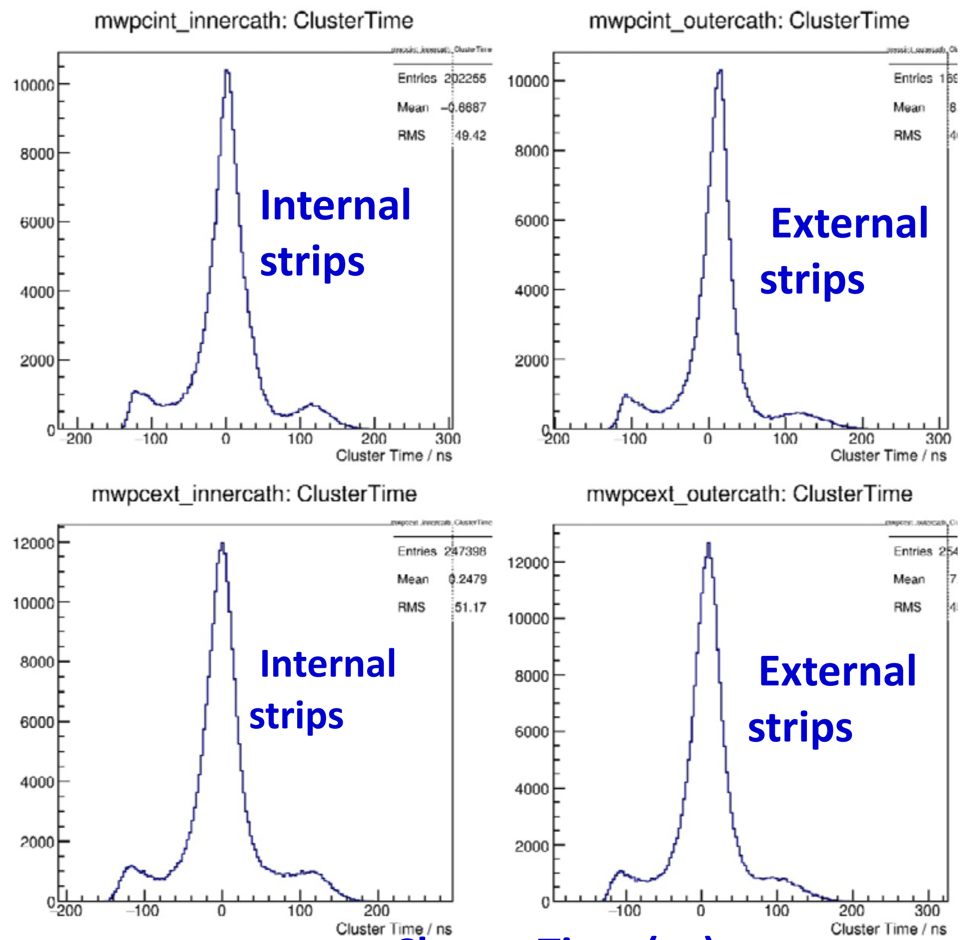
$$\eta^{(\prime)} \to \gamma\, e^+e^-$$

Bonn – April beam time wire signals



Grazie al prezioso lavoro di Domenico Calabrò ed alla valida collaborazione di Roberto Nardò è stato possibile risolvere i grossi problemi di rumore/malfunzionamento delle schede con preamplificatori fili costruite da INR-Mosca

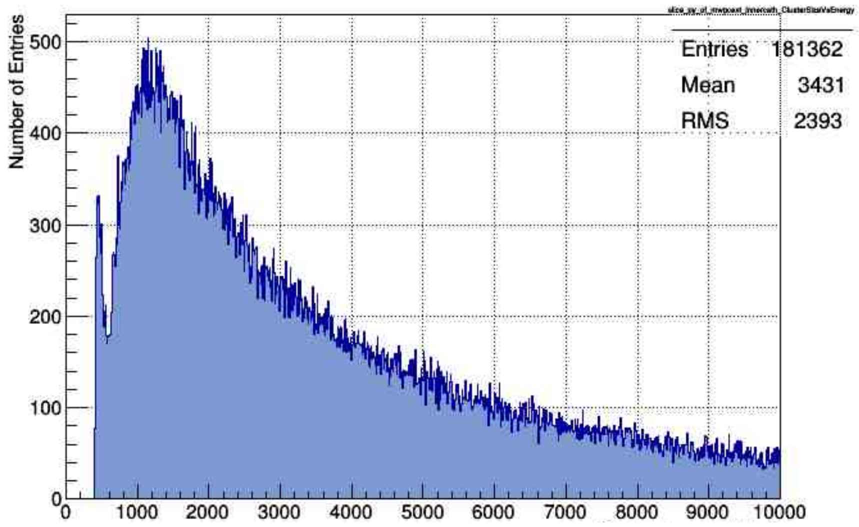
Bonn – April beam time strip signals



Chamber-1

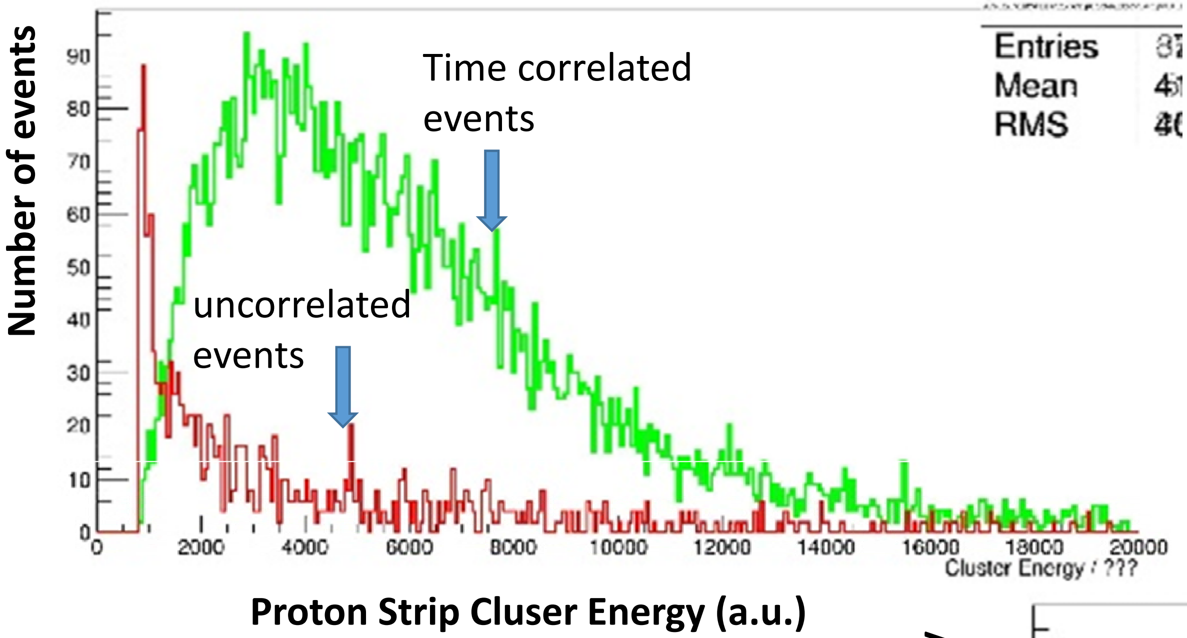
Chamber-2

Cluster Time (ns)



Cluster energy (a.u.)

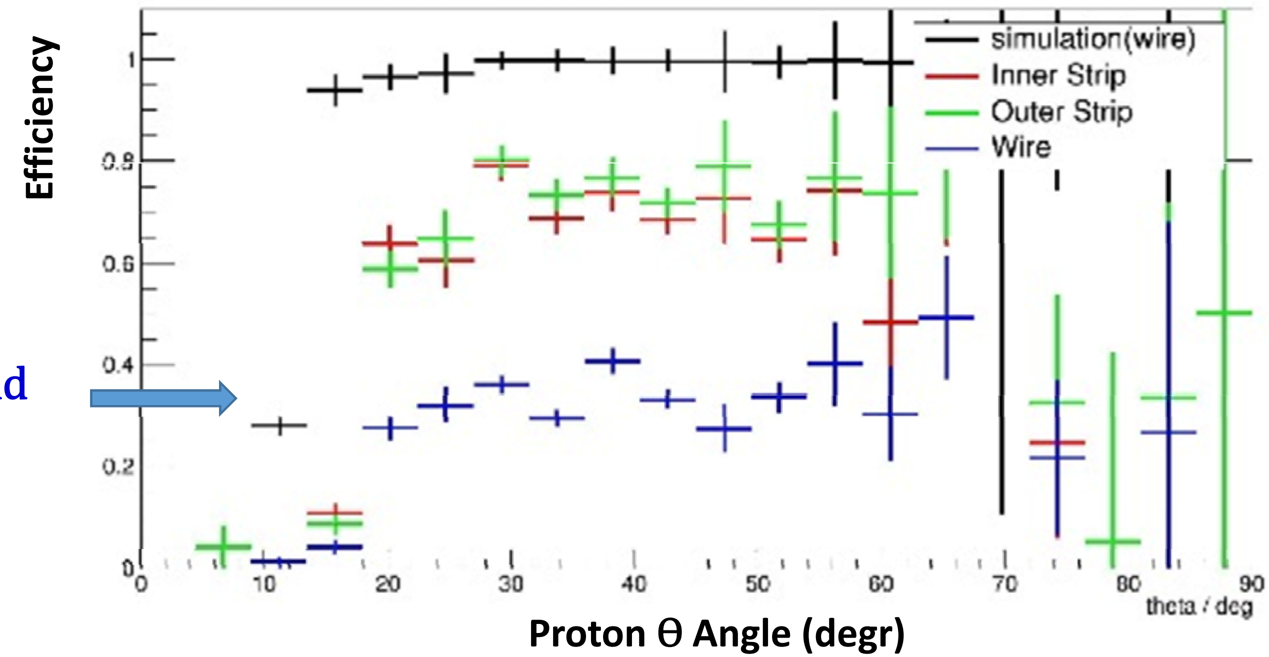
Test beam time – february 2017



Offline analyses : $\gamma p \rightarrow p\pi^0$
(event selection performed using other detectors)

Kinematically allowed θ Proton region:
θ < 70 degr.

Only about 50% of the wire signals were read



Publications
(refereed journals)

2011: 4 (1 PLB)
2012: 4 (1 PLB)
2013 10 (2 PRL; 4 PLB)
2014 11 (4 PRL; 1 PLB)
2015 10 (1 PRL; 2 PLB)
2016 7 (1 PRL)

Attività prevista 2017-2018

- **Mainz** : -) **manutenzione camere a fili**
  -) **analisi dati offline**
  -) test nuovo rivelatore (TPC attiva) (su fascio di elettroni !)
  -) commissioning nuovo rivelatore di Tagging (352 scintillatori)
  -) Prese dati con bersagli protone/deuterio non polarizzati (scattering Compton,…)

- **Bonn** : -) **manutenzione camere a fili**
  -) **analisi dati offline**
  -) Continuazione dei runs di misura con rivelatore al completo (MRPC) (fotoproduzione mesoni eta/eta’ con fotoni linearmente polarizzati)