MINISTERUL CERCETĂRII ȘI INOVĂRII

IFIN-HH

www.ifin.ro

- *Activities and achievements in the past year*
- *Remarks on additional activities*
- *2018 perspectives*

HADRON PHYSICS DEPARTMENT

Natinal Institute for Physics and Nuclear Engineering – IFIN-HH

http://niham.nipne.ro

ISAB Meeting, October 26, 2017

Highlights of accomplishments in the last year

- **Physics**

- Studies for obtaining p_T spectra simultaneously conditioned on multiplicity, directivity and within same-side, away side and in between relative to the leading particle for identified charged hadrons in pp collisions at $\sqrt{s}$ = 7 TeV

- Finalization of the charged particle p_T spectra as a function of multiplicity in pp collisions at $\sqrt{s}$ = 7 TeV which are included in the long paper on multiplicity dependence

- Studies of two charged particles correlations as a function of multiplicity and directivity in pp collisions at $\sqrt{s}$ = 7 TeV

- "Core-corona interplay in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV"
M. Petrovici, I. Berceanu, A. Pop, M. Târzila, and C. Andrei
Phys.Rev. C96(2017)014908

- Extracting core information at LHC and RHIC energies

- 12 presentations in ALICE meetings (Spectra PAG, PWG-LF, TPCU)
- 1 Internal Note
- Contribution to 17 conference presentations
- Co-authors to 30 ALICE published papers

- "From pp to AA ultra-relativistic collisions"
M. Petrovici , A. Pop , C. Andrei , I. Berceanu , A. Bercuci , A. Herghelegiu , and M. Tarzila
AIP Conference Proceedings 1852 , 050003 (2017); doi: 10.1063/1.4984864; http://dx.doi.org/10.1063/1.4984864
- "Multi-differential analysis of pT spectra of π, K and p in pp collisions at 7 TeV"
C. Andrei, High-Multiplicity 'mini-workshop', 5 May 2017, CERN, Geneva
- "Two-particle correlations in pp collisions at 7 TeV measured with ALICE at LHC",
M.Tarzila, Scientific Communications Session of the Bucharest Faculty of Physics, June 23rd 2017

- Institutional Review
- PC members

Highlights of accomplishments in the last year

- **ALICE upgrade**

- The necessary infrastructure in terms of cleanliness of different rooms of the Detector Laboratory, equipment, tools and specific consumables were finalized
- An OROC was assembled at GSI by a joint German-Romanian team
- The components of other 2 OROCs arrived, they were properly prepared and fixed in order to start the assembling and tests
- Three OROC in-house test boxes - produced
- The construction and test of other three in-house test boxes is in progress
- Three new special top covers for these boxes were produced
- A prototype of a transport box was designed, realised and successfully tested.

- **Computing**

- Maintaining NIHAM in a leading position among Tier2s ALICE GRID centres, NAF efficient management

- **ALICE shifts**

- 40 shifts booked, 18 made - according to the schedule

- **Teaching & Outreach**

- Summer student program: 8 participants (2-Birmingham University, 2-Oxford University, 2-"Babes-Bolyai" University-Cluj-Napoca, 1-Bucharest Technical University and 1-Physics Faculty of Bucharest University)
  - 2 decided to continue their master thesis with us
  - 1 decided to continue the diploma thesis with us
- Numerous visits of Romanian and foreign delegations, Romanian pupils winners of International Competitions in Physics, students of the Romanian Physics Faculties - Pentagon − network
- "My experience within the ALICE experiment at LHC", A. Herghelegiu, Summer School for pupils, prepared for International Competitions in Physics, Busteni, July 25-26, 2017
- Interview for TVR International

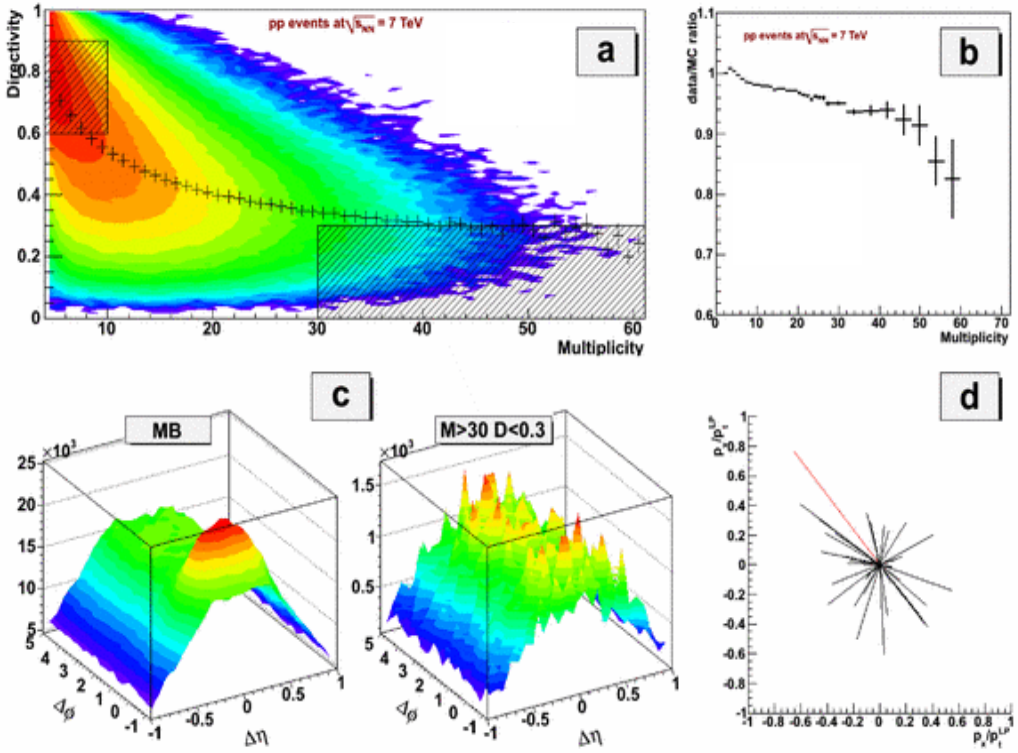
pp @ 7 TeV – identified charged hadrons
Charged particles multiplicity & event shape

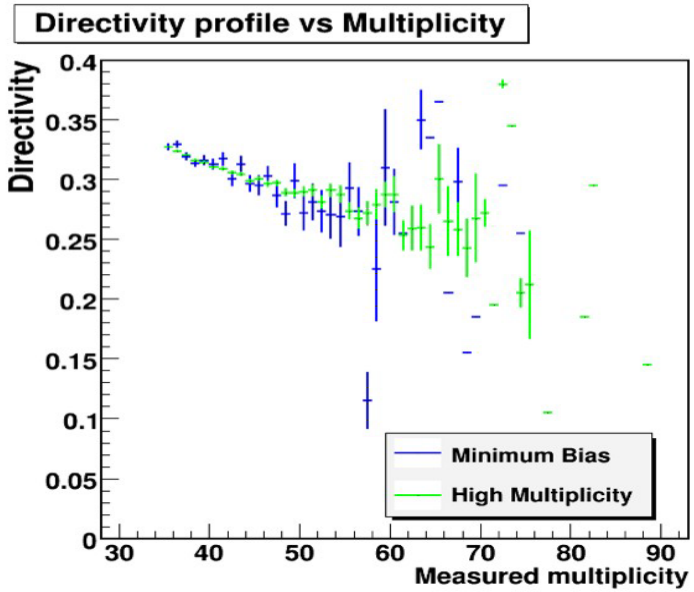
Directivity

$$D^{\pm} = \frac{|\sum_i \vec{p}_{t,i}|}{\sum_i |\vec{p}_{t,i}|}\Big|_{\eta^{pos/neg}}$$

D → 1 = jetty-like events
D → 0 = "azimuthal isotropic" events

For the spectra we used an "AND" condition for D^+ and D^- ($|\eta| < 0.8$)

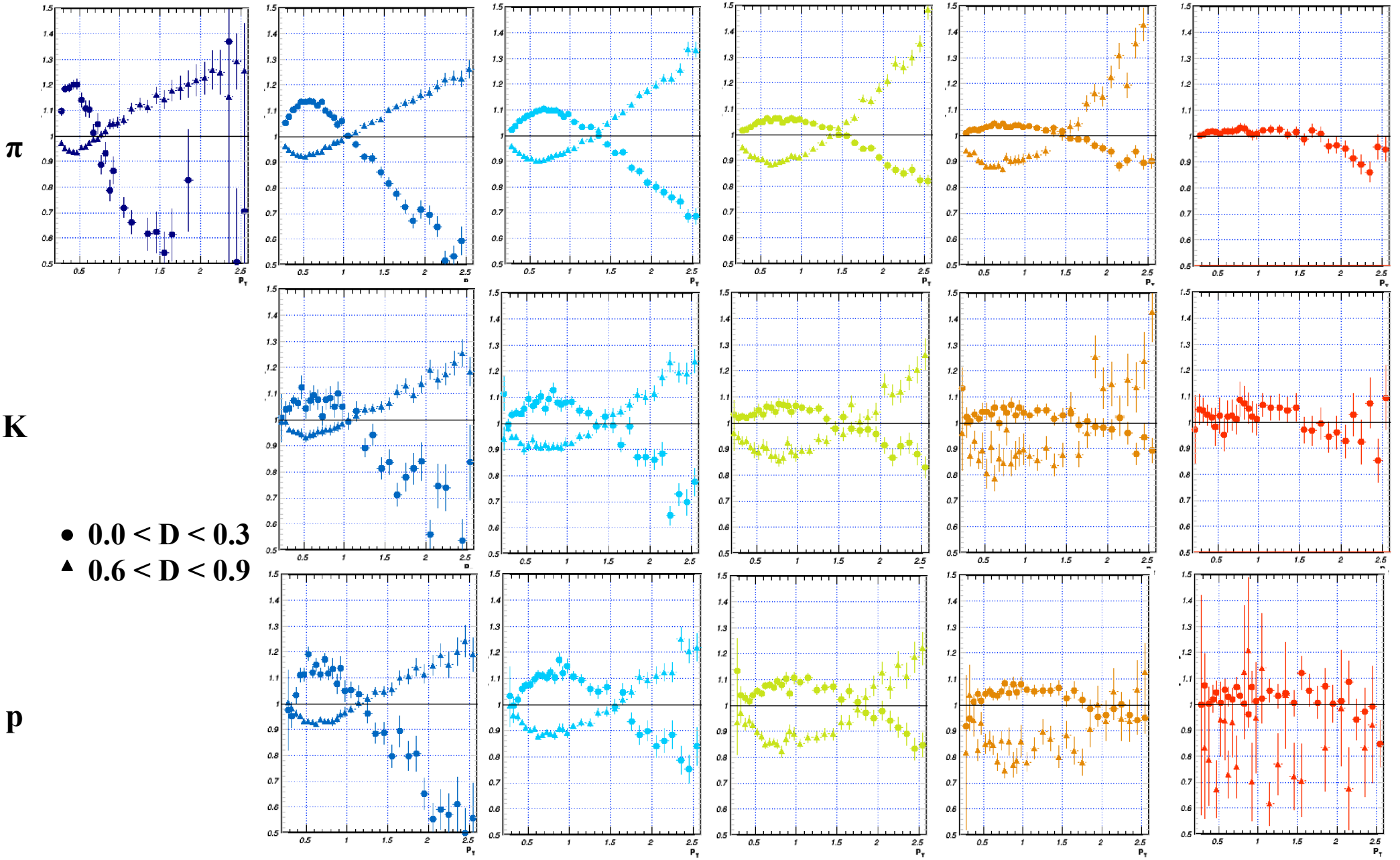




ALICE PWG2 November 9. 2010
ALICE PF March 15, 2011

p_T Spectra

pp @ 7 TeV – identified charged hadrons
Charged particles multiplicity & event shape



pp @ 7 TeV – identified charged hadrons
Charged particles multiplicity & event shape

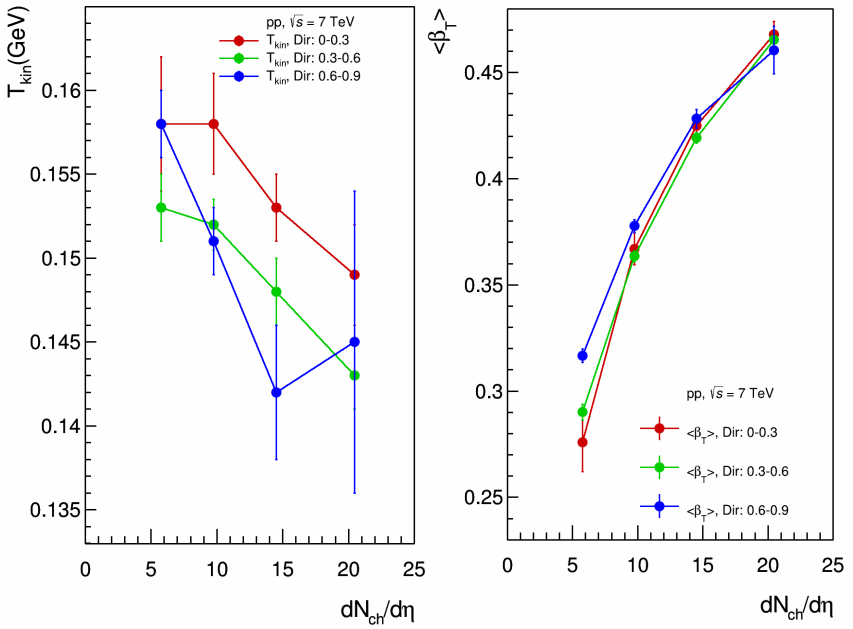
BGBW fit results

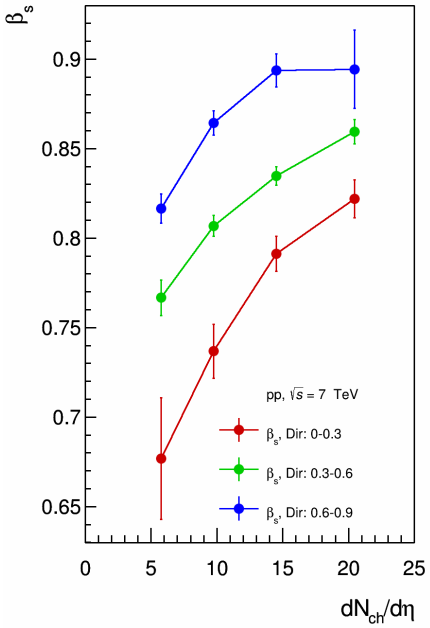
$$E\frac{d^3N}{dp^3} \sim f(p_t) = \int_0^R m_T K_1(m_T cosh\rho/T_{fo}) I_0(p_T sinh\rho/T_{fo}) r dr$$

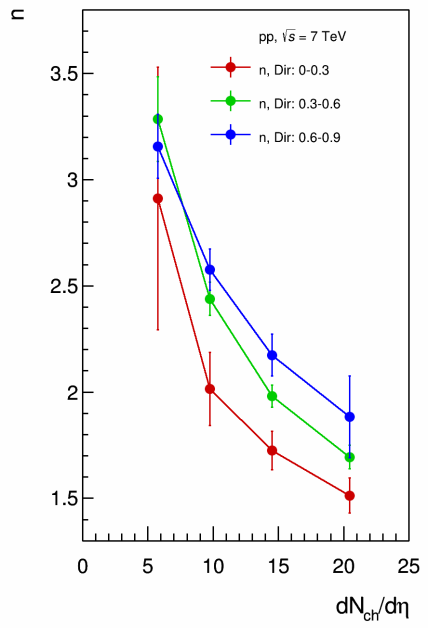
$$m_T = \sqrt{m^2 + p_T^2}$$

$$\rho = tanh^{-1}\beta_r$$

$$\beta_r(r) = \beta_s\left(\frac{r}{R}\right)^n$$



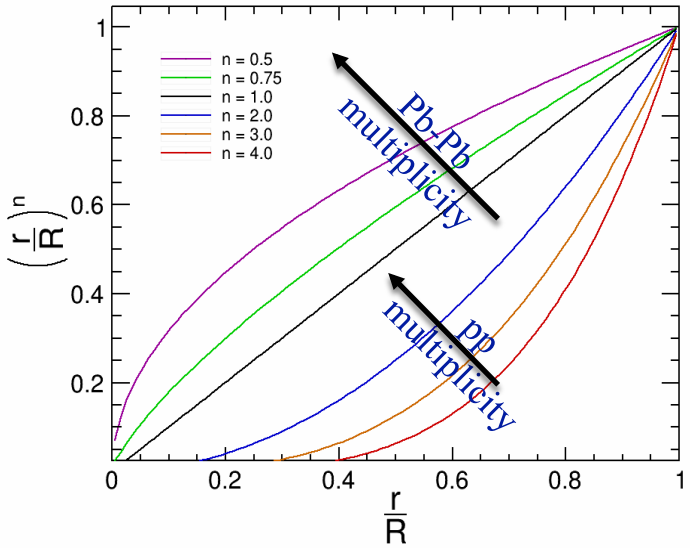




Pb-Pb 2.76 TeV

Centrality	n
0–5%	$0.712 \pm 0.019 \pm 0.086$
5–10%	$0.723 \pm 0.019 \pm 0.116$
10–20%	$0.738 \pm 0.020 \pm 0.118$
20–30%	$0.779 \pm 0.022 \pm 0.133$
30–40%	$0.841 \pm 0.025 \pm 0.168$
40–50%	$0.944 \pm 0.029 \pm 0.142$
50–60%	$1.099 \pm 0.038 \pm 0.187$
60–70%	$1.292 \pm 0.052 \pm 0.194$
70–80%	$1.578 \pm 0.081 \pm 0.205$
80–90%	$2.262 \pm 0.191 \pm 0.498$

Phys Rev C 88, 044910 (2013)



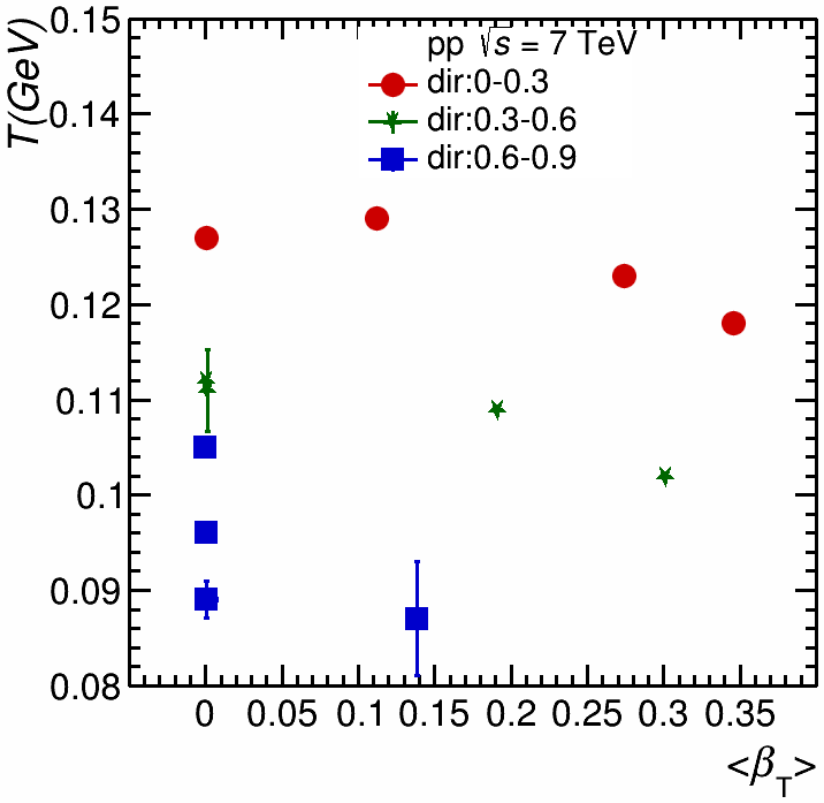
pp @ 7 TeV – identified charged hadrons
Charged particles multiplicity & event shape

Tsallis Blast Wave fit results

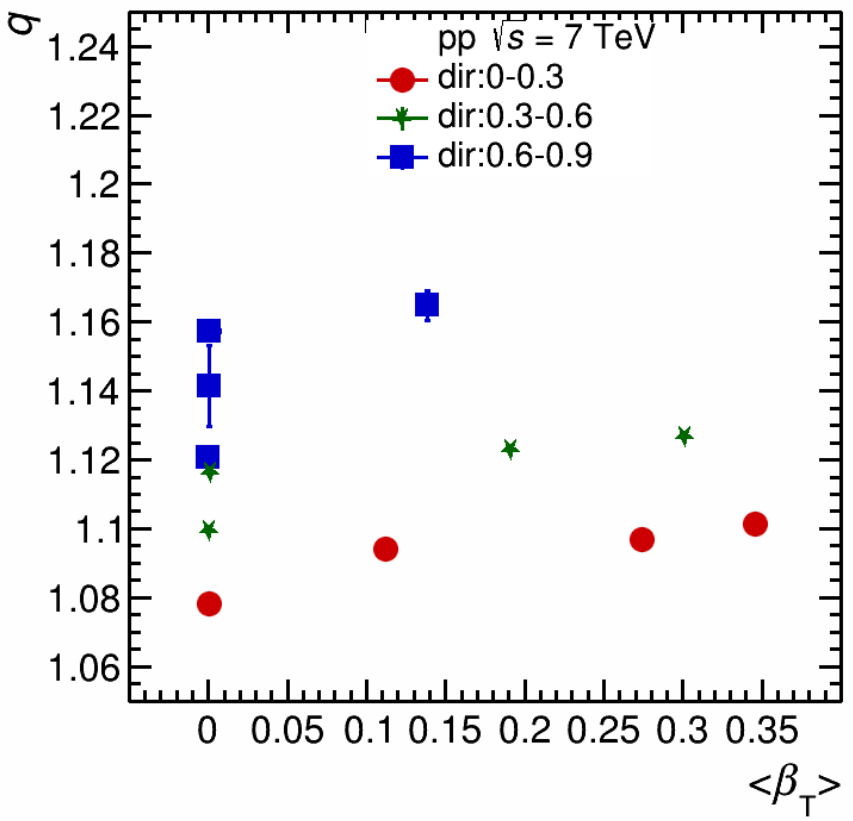
$$f(p_t) = m_t \int_{-Y}^{Y} cosh(y)dy \int_{-\pi}^{\pi} d\phi \int_{0}^{R} rdr\left(1+\frac{q-1}{T}(m_t cosh(y)cosh(\rho) - p_t sinh(\rho)cos(\phi))\right)^{-1/(q-1)}$$

$$\rho = tanh^{-1}\beta_r \qquad \beta_r(r) = \beta_s\left(\frac{r}{R}\right)$$

T - <β_T> correlation

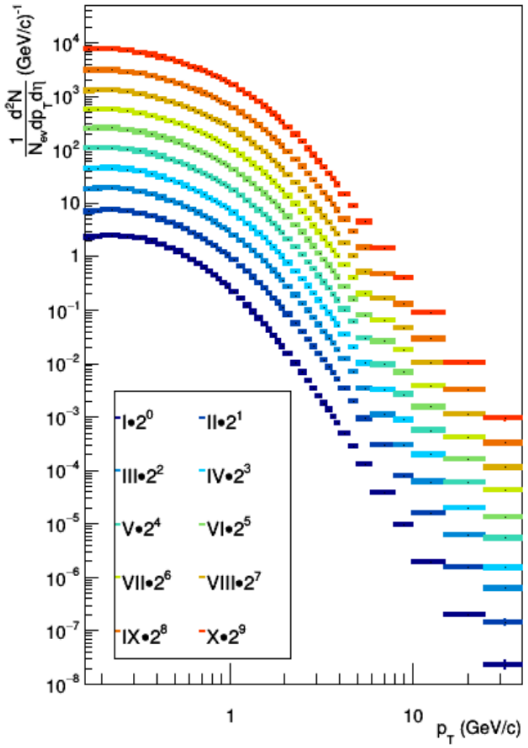


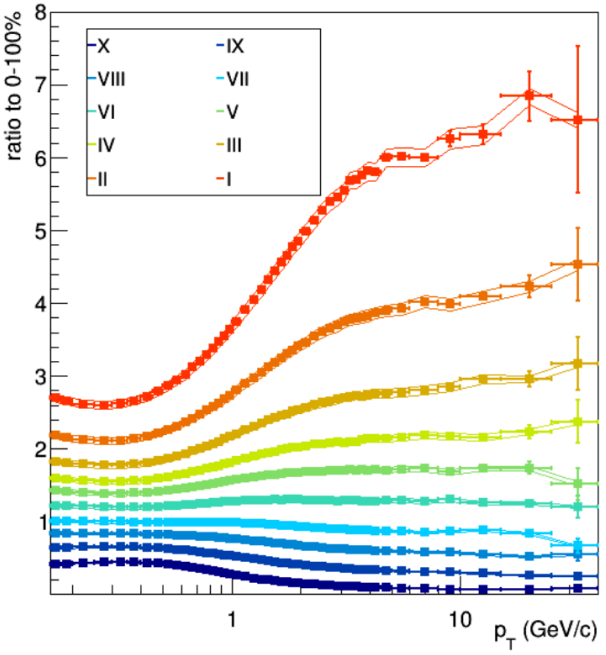
q - <β_T> correlation

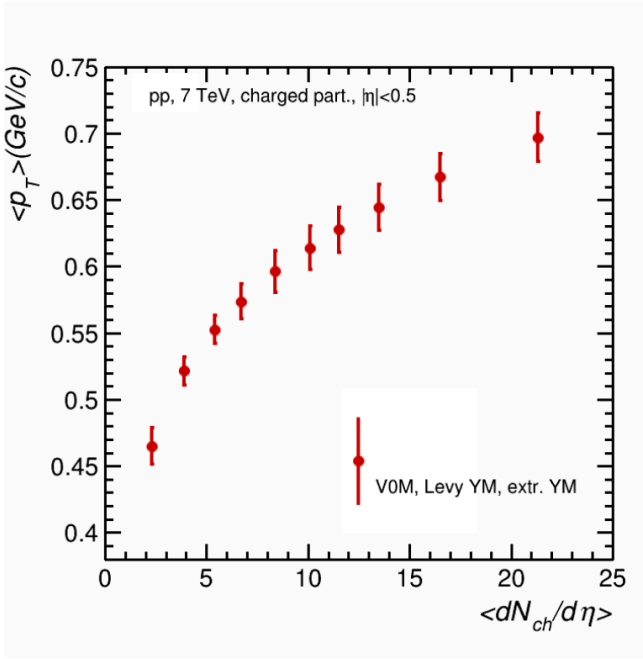


- **towards "azimuthal isotropy" T and <β_T> increase**
- **towards "azimuthal isotropy" q decreases, i.e. non-extensive Tsallis → extensive BG**

pp @ 7 TeV
Charged particles p_T spectra & $\langle p_T \rangle$ - multiplicity dependence
Approved ALICE plots







In progress

$$D^{\pm} = \frac{|\sum_i \vec{p}_{t,i}|}{\sum_i |\vec{p}_{t,i}|}|_{\eta^{pos/neg}}$$

Directivity multiplicity dependence

$$T = \underset{\vec{n}}{max} \frac{\sum_i |\vec{p}_{t,i} \cdot \vec{n}_T|}{\sum_i |\vec{p}_{t,i}|}$$

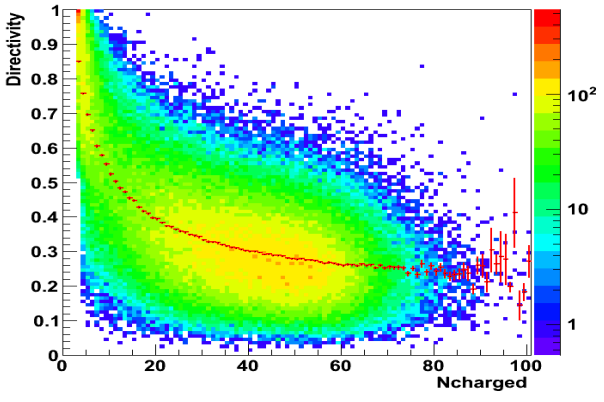
Thrust multiplicity dependence

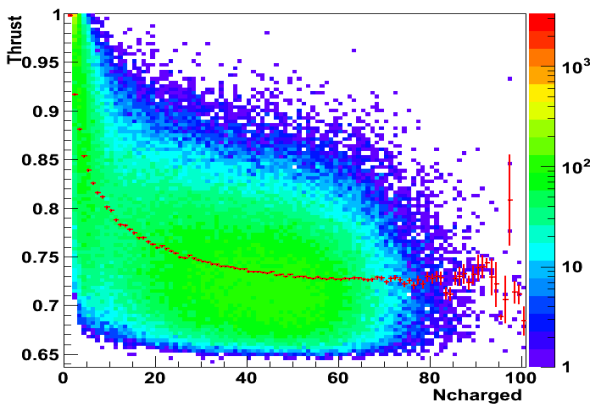
$$S_{xy} = \sum_i \begin{pmatrix} p_x^{(i)2} & p_x^{(i)} p_y^{(i)} \\ p_x^{(i)} p_y^{(i)} & p_y^{(i)2} \end{pmatrix}$$

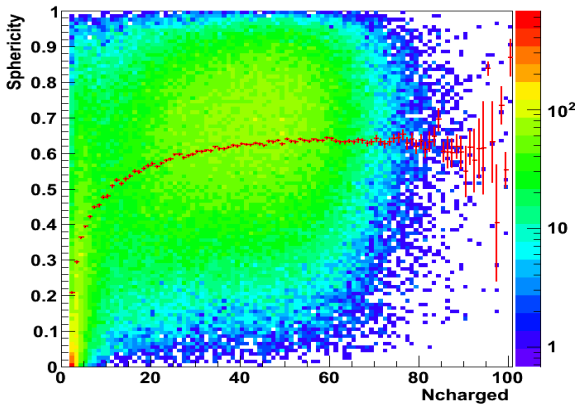
$$S_{\perp} \equiv \frac{2\lambda_2}{\lambda_2 + \lambda_1}$$

Sphericity multiplicity dependence

& Fox-Wolfram moments





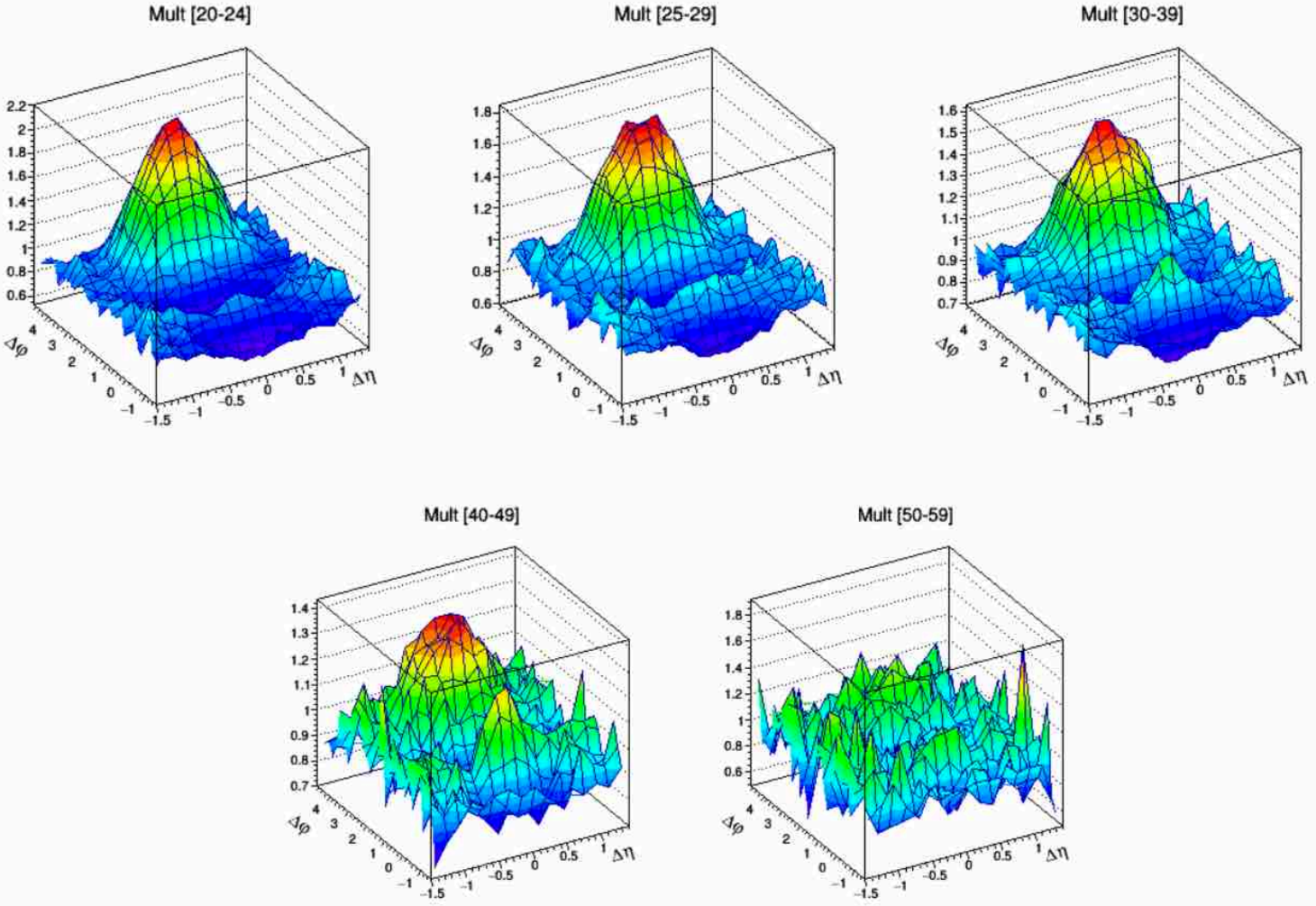


Two particle correlations
In progress

$(\Delta\eta,\Delta\varphi)$ – correlations

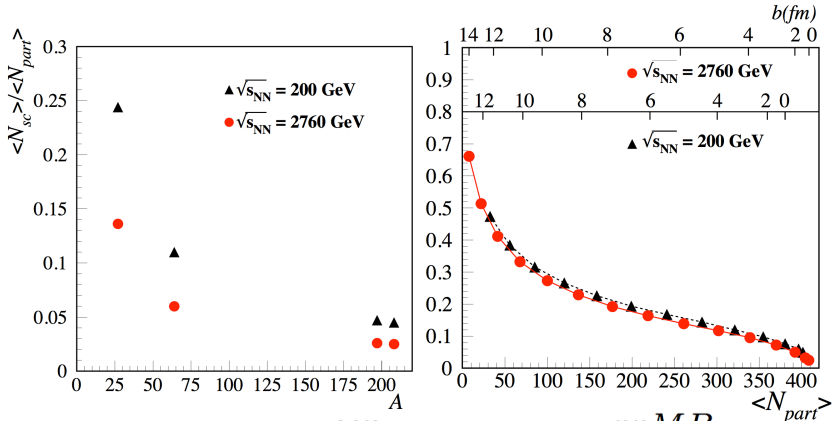
$0.0 \leq \text{Directivity} \leq 0.3$

$1 \leq p_T \leq 2$ GeV/c

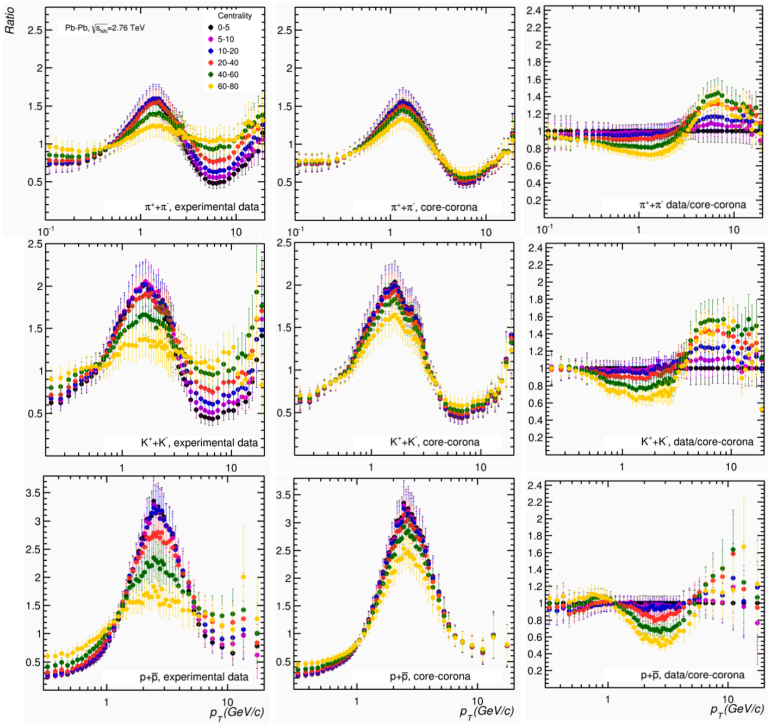


Core-Corona effect

Glauber MC

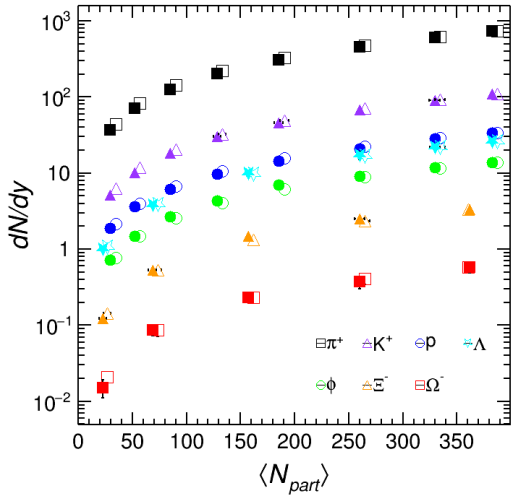


$$\left(\frac{\frac{d^2N}{dydp_T}}{\langle\frac{dN_{ch}}{d\eta}\rangle}\right)_i^{cen} \Big/ \left(\frac{\frac{d^2N}{dydp_T}}{\langle\frac{dN_{ch}}{d\eta}\rangle}\right)_i^{ppMB}$$



$$\left(\frac{dN}{dy}\right)_i^{cen} = N_{part}[(1-f_{core})M_i^{ppMB} + f_{core}M_i^{core}]$$

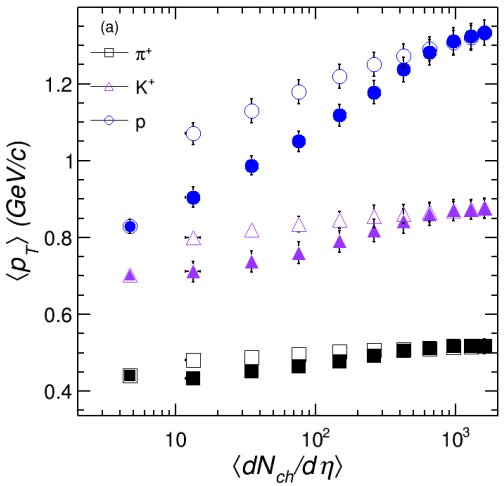
$$M_i^{ppMB} = \frac{1}{2}(dN/dy)_i^{ppMB}$$

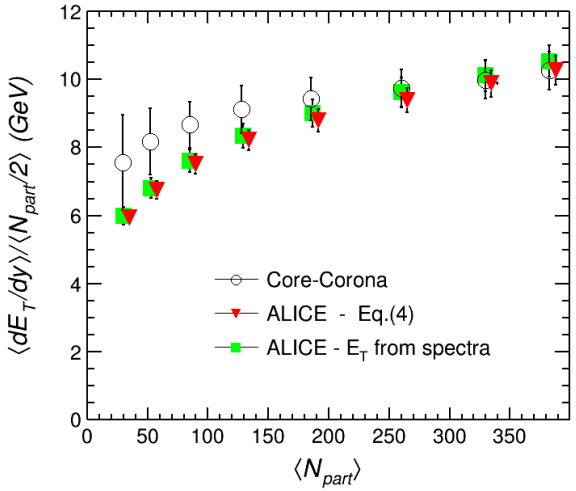


$$\langle p_T\rangle_i^{cen} = \frac{f_{core}\langle p_T\rangle_i^{core}M_i^{core} + (1-f_{core})\langle p_T\rangle_i^{ppMB}M_i^{ppMB}}{f_{core}M_i^{core} + (1-f_{core})M_i^{ppMB}}$$

$$\frac{dE_T}{dy} \approx 3\left(\frac{dE_T}{dy}\right)_{\pi^+} + 4\left(\frac{dE_T}{dy}\right)_{K^+,p,\Xi^-} + 2\left(\frac{dE_T}{dy}\right)_{\Lambda,\Omega^-}$$

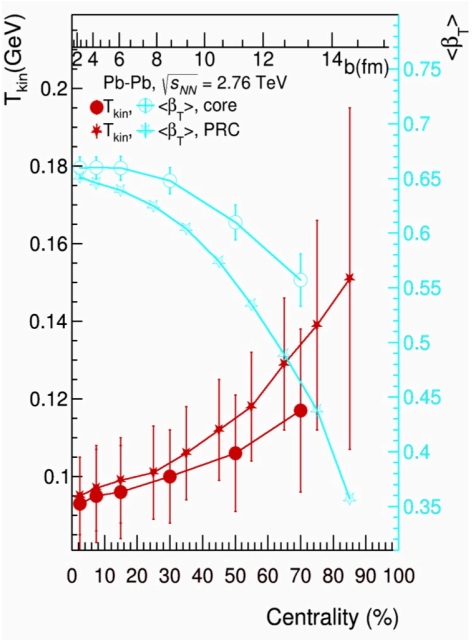
$$\frac{dE_T}{dy} = \langle m_T\rangle\frac{dN}{dy} \quad \langle m_T\rangle = \sqrt{\langle p_T\rangle^2 + m^2}$$

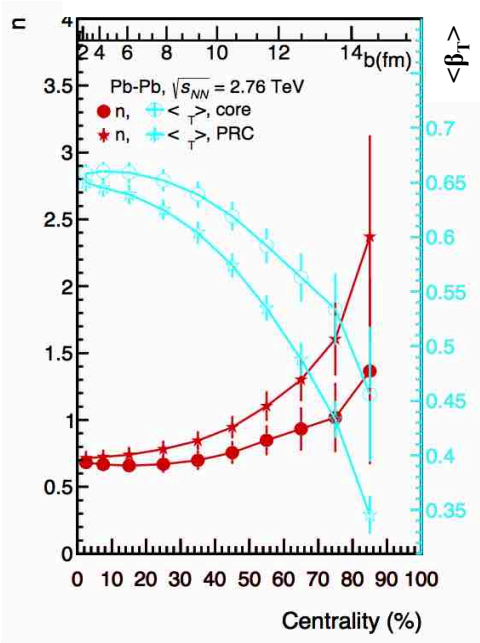


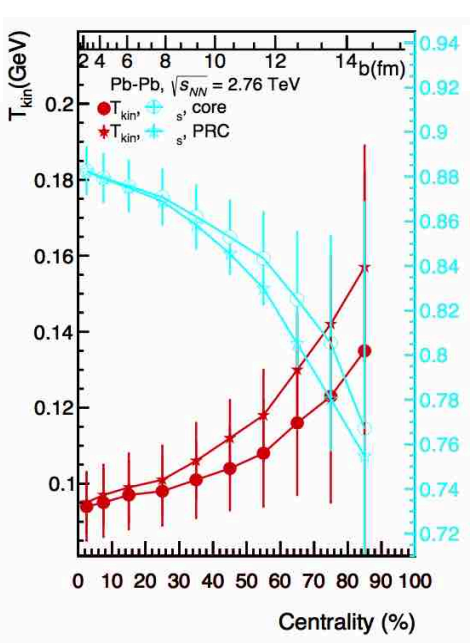


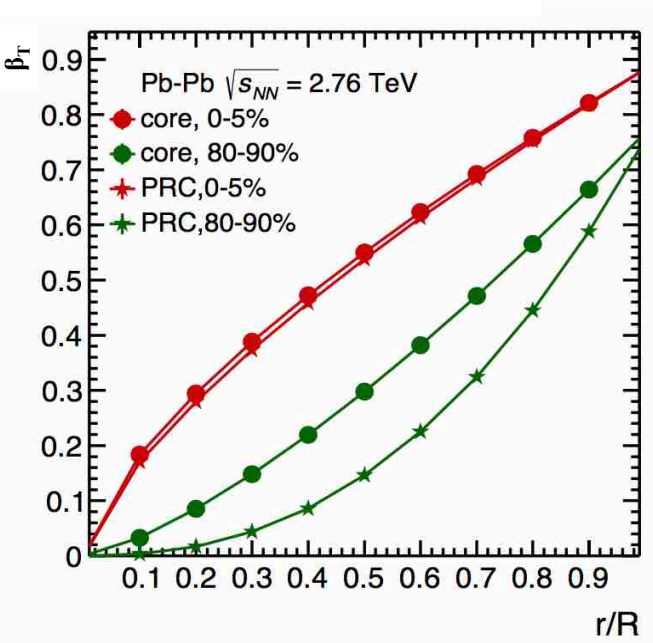
M. Petrovici, I. Berceanu, A. Pop, M. Târzila, and C. Andrei
Phys.Rev. C96(2017)014908

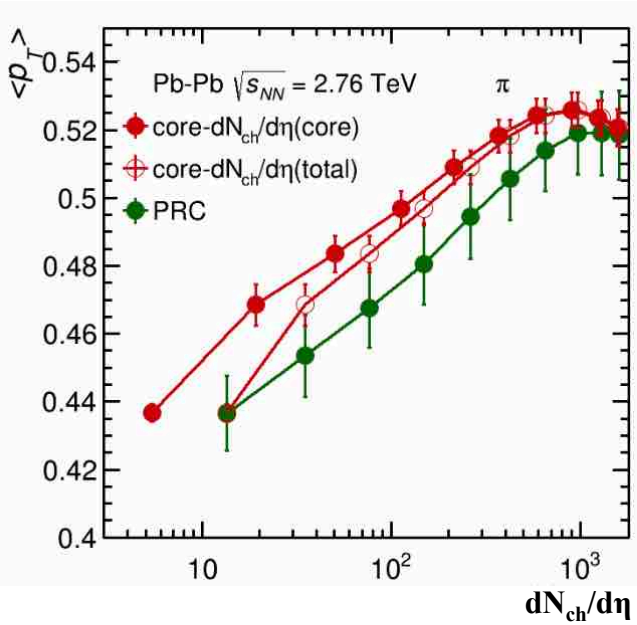
Core properties
In progress

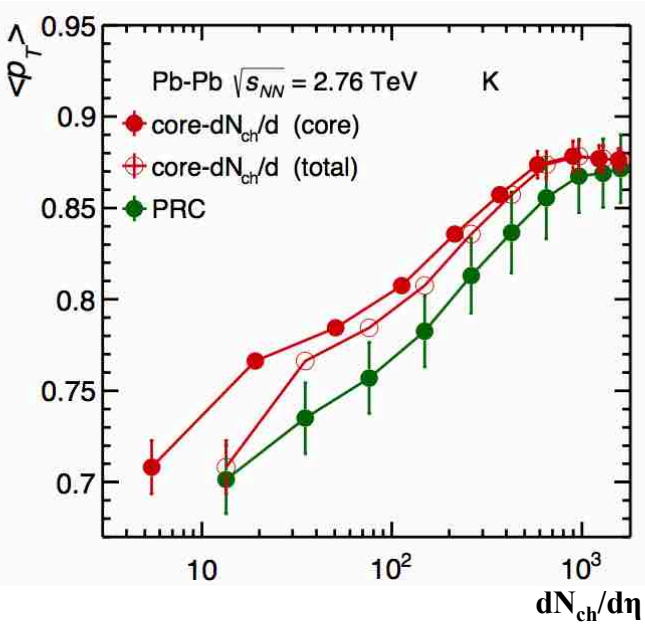


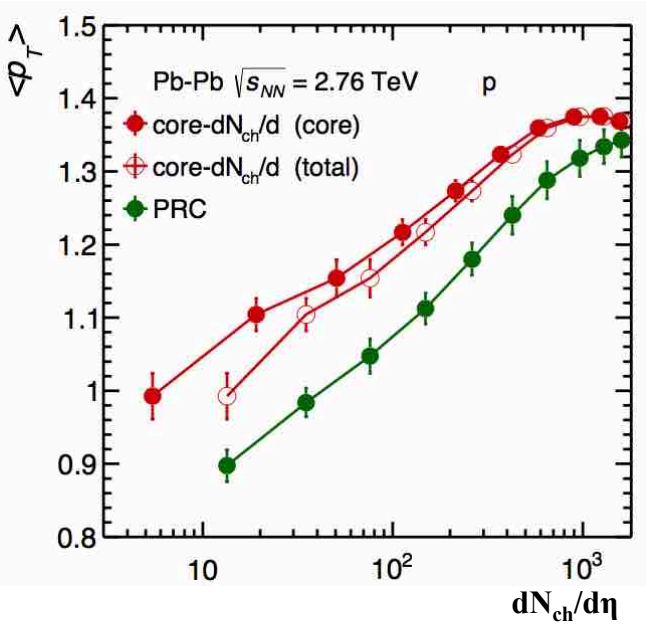




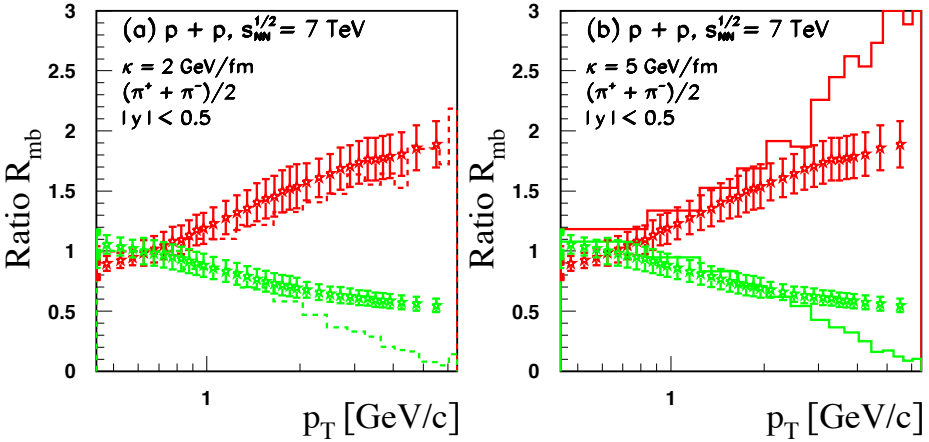


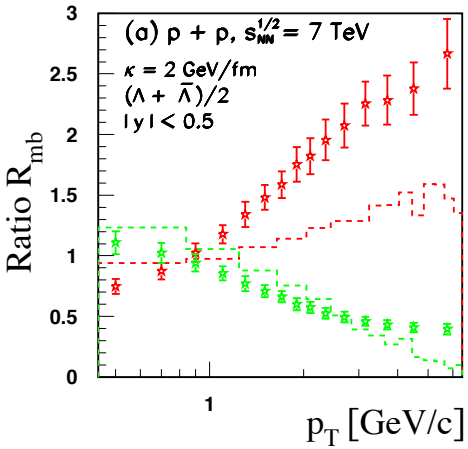


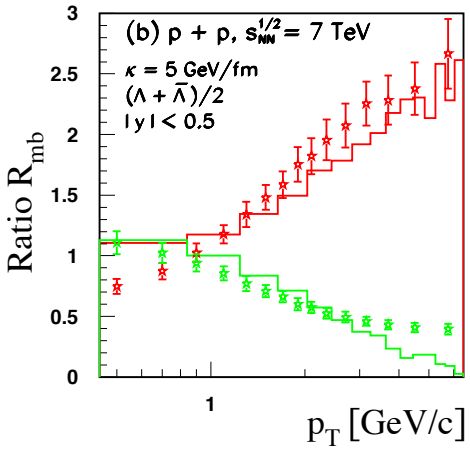


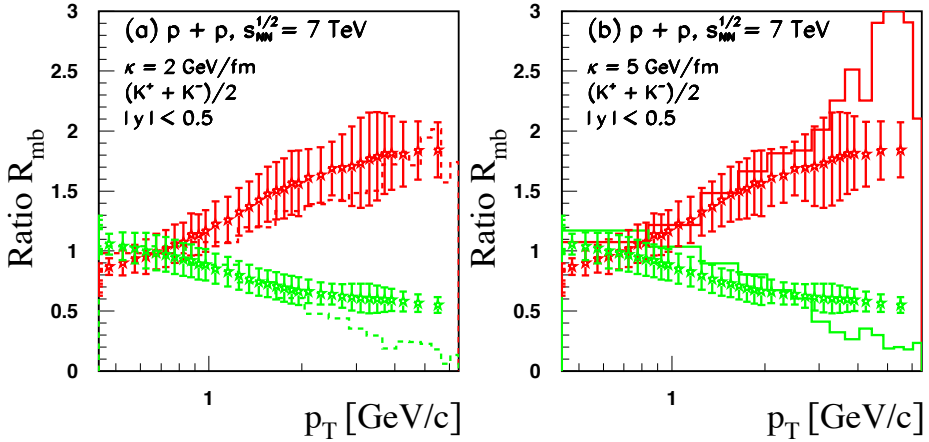


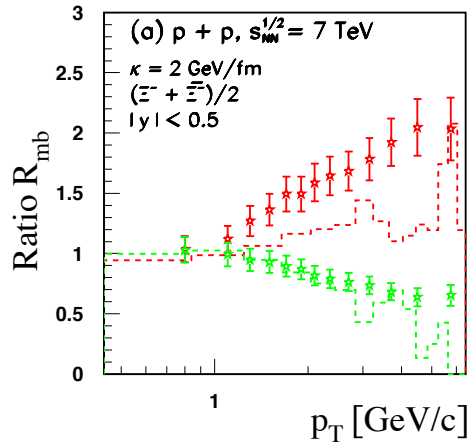
Systematic HIJING calculations

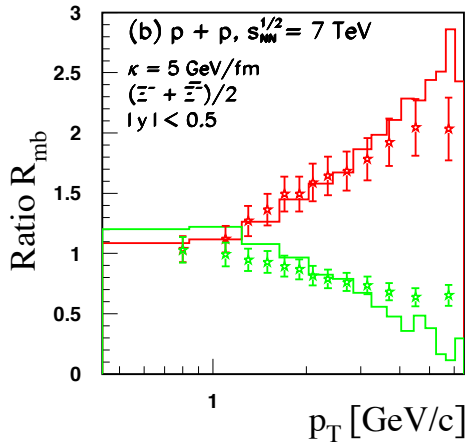


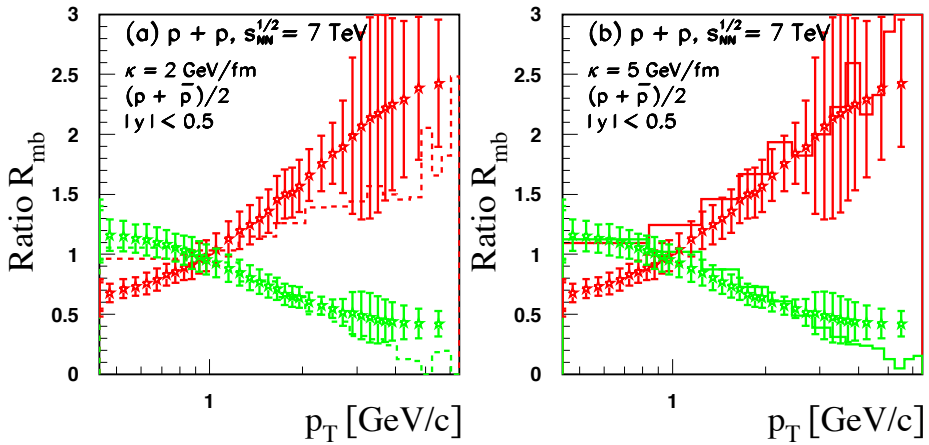


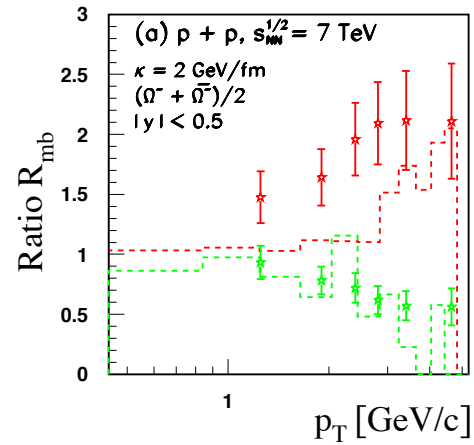


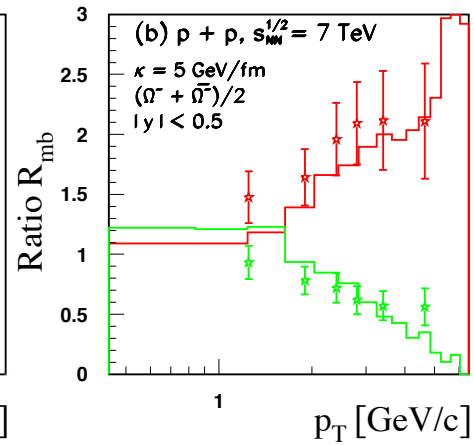






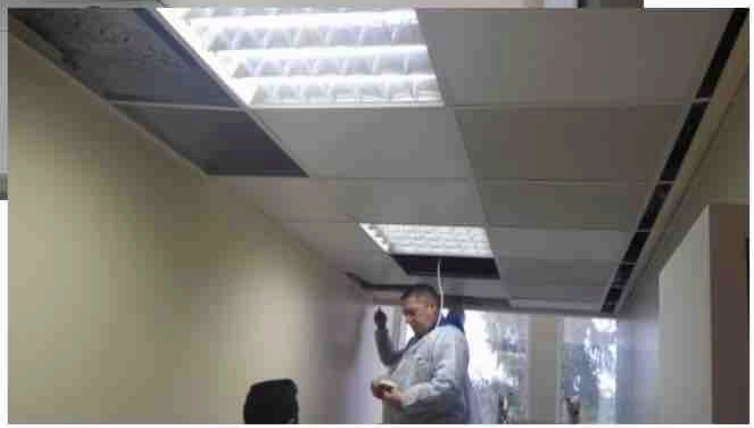






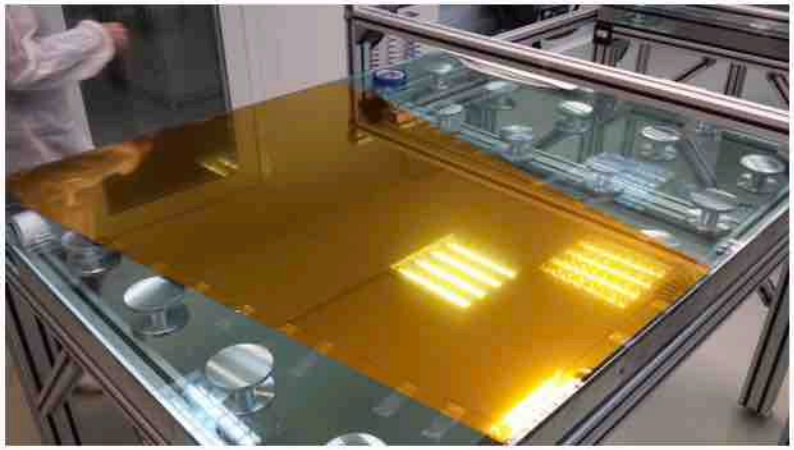
ALICE-TPC Upgrade

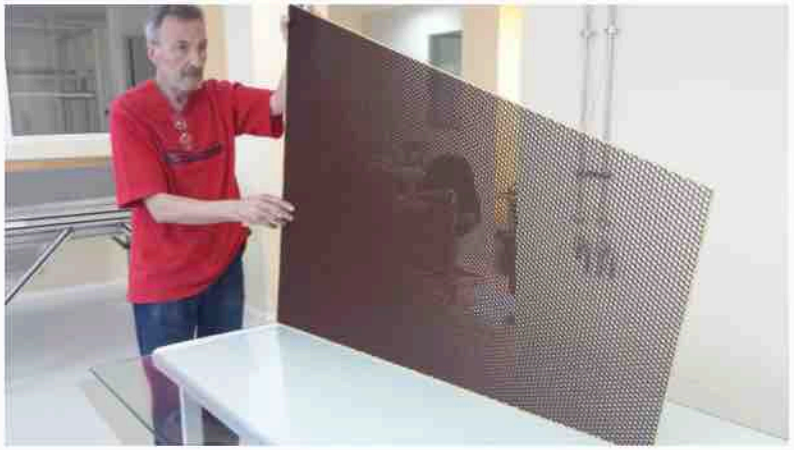
Upgrading the DetLab ceiling

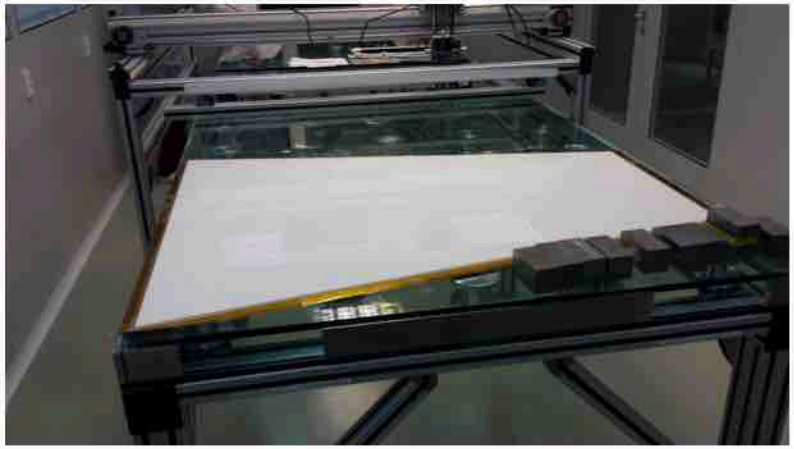


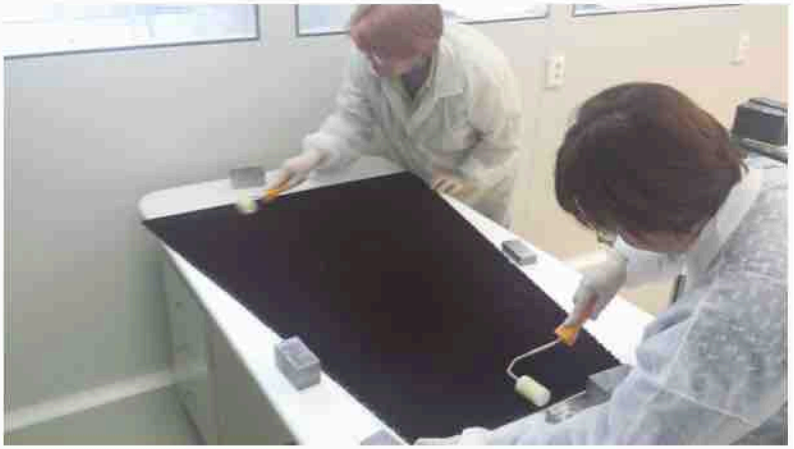
ALICE-TPC Upgrade

In-house test box-top cover





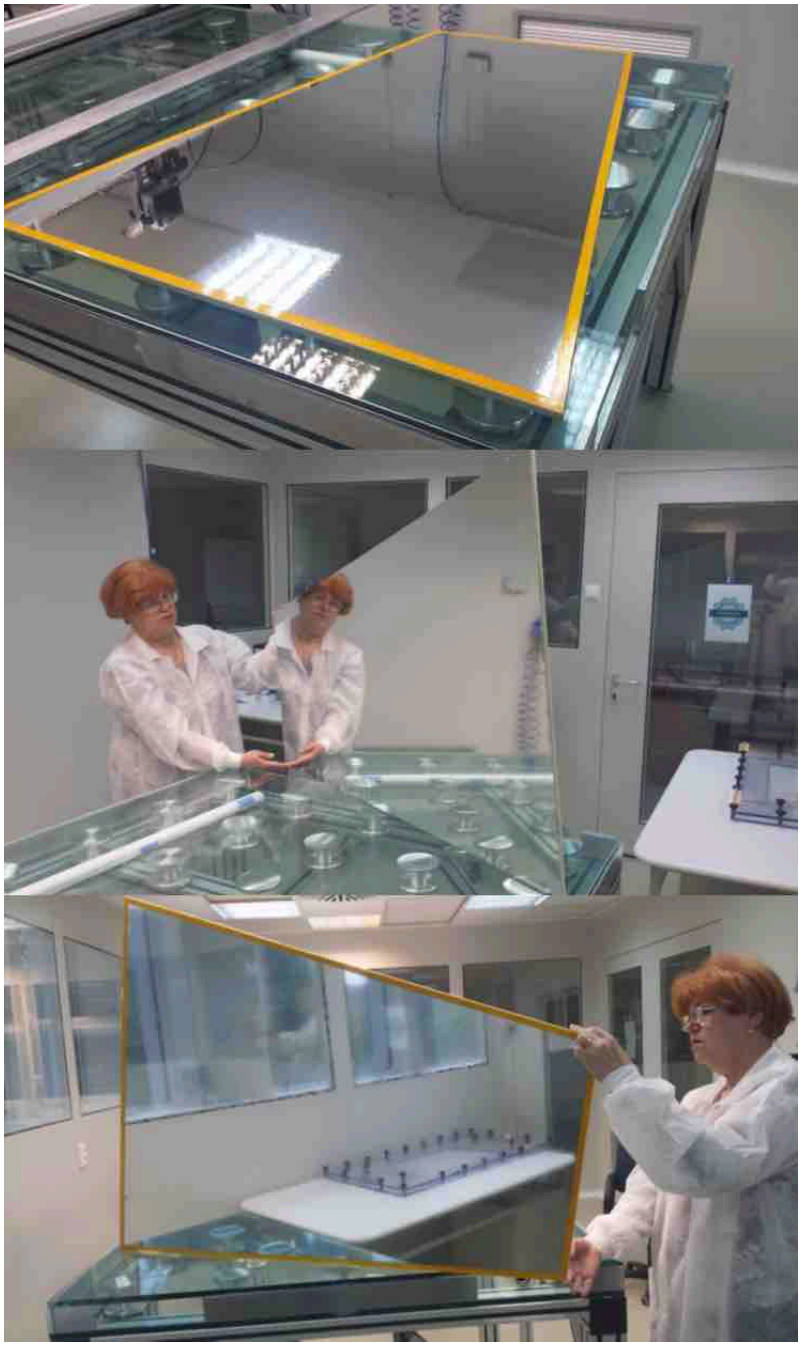


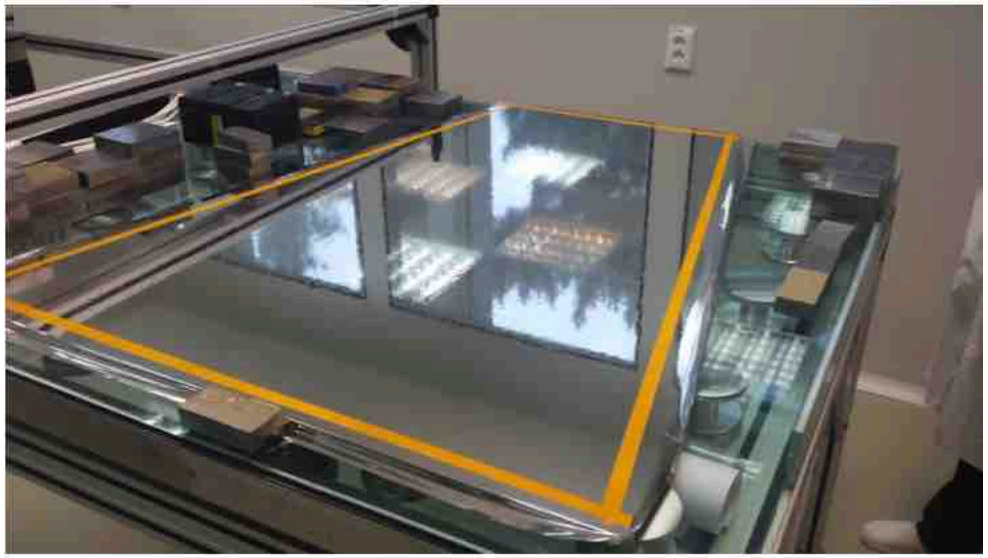


ALICE-TPC Upgrade

In-house test box-top cover

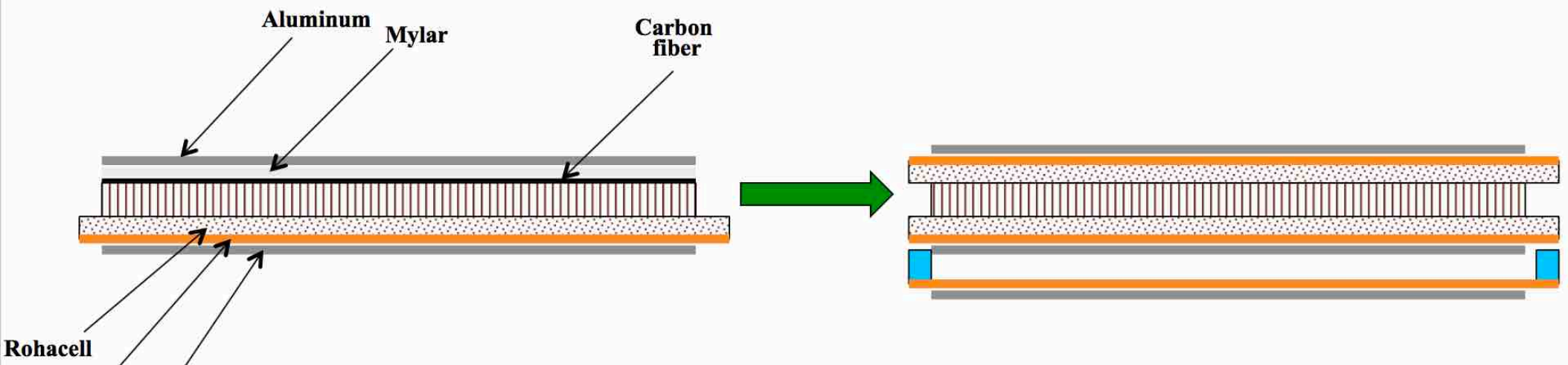
2 delivered to GSI





ALICE-TPC Upgrade

In-house box remained in HPD

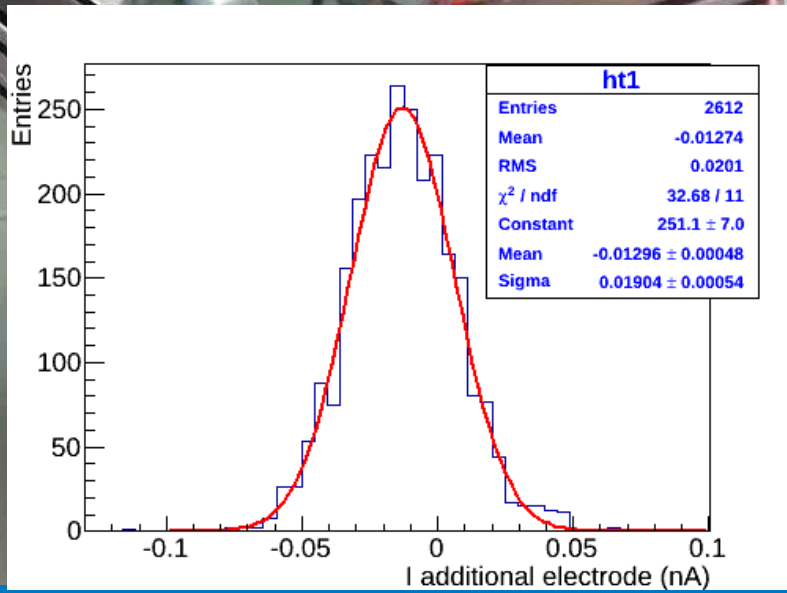


The trovidur rim used to increase the drift zone

Test housing box before assembling the extra drift electrode

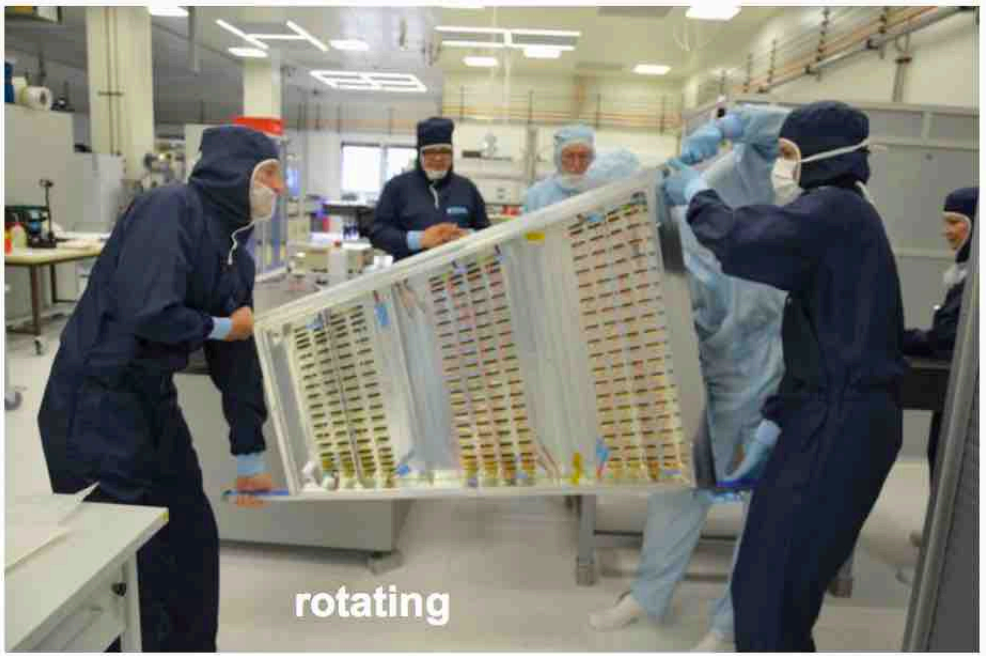
Extra drift electrode assembled

Results


ht1
Entries 2612
Mean -0.01274
RMS 0.0201
χ² / ndf 32.68 / 11
Constant 251.1 ± 7.0
Mean -0.01296 ± 0.00048
Sigma 0.01904 ± 0.00054
Entries
250
200
150
100
50
0
-0.1
-0.05
0
0.05
0.1
I additional electrode (nA)

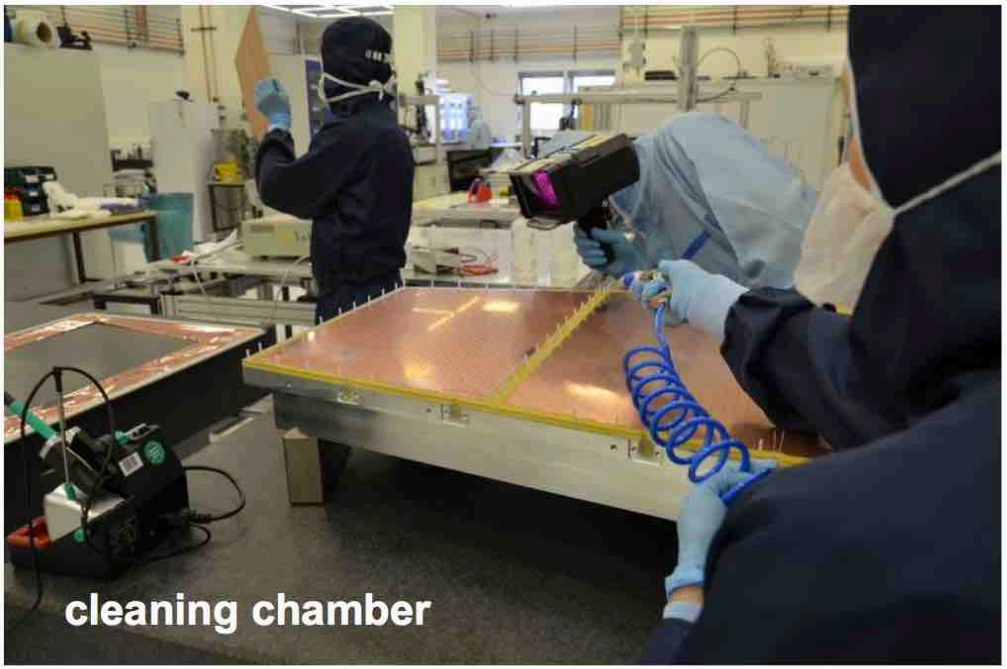
ALICE-TPC Upgrade

OROC assembling @ GSI
GSI_HPD joint activity

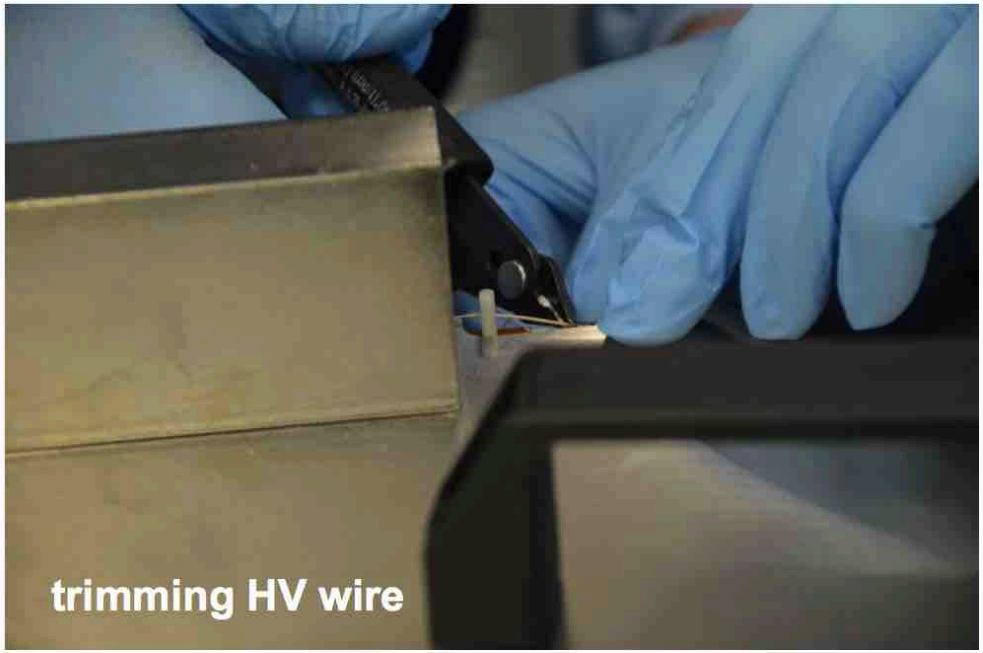


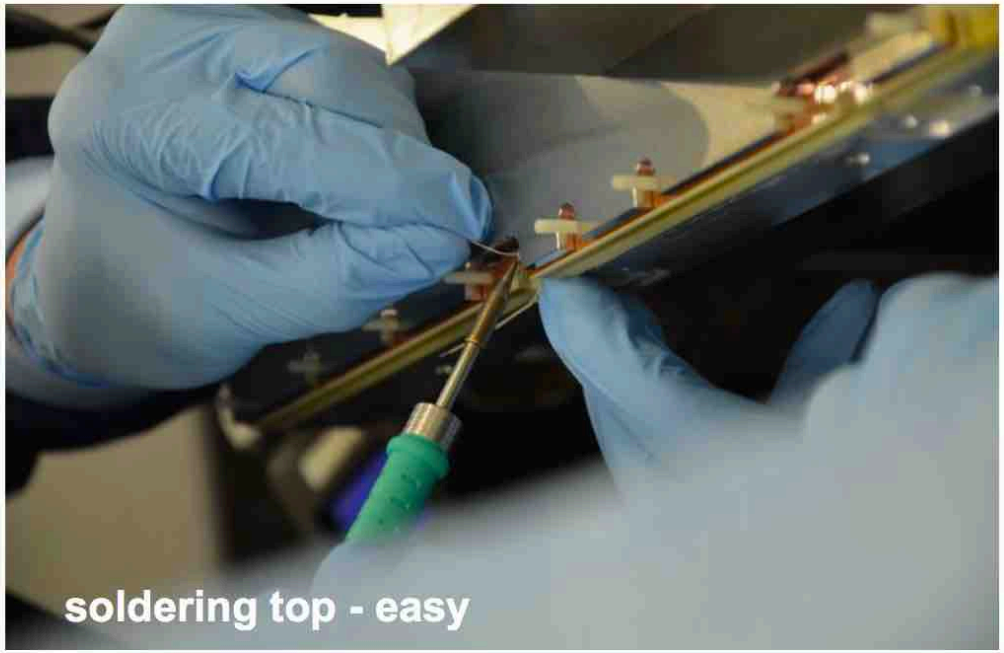
ALICE-TPC Upgrade

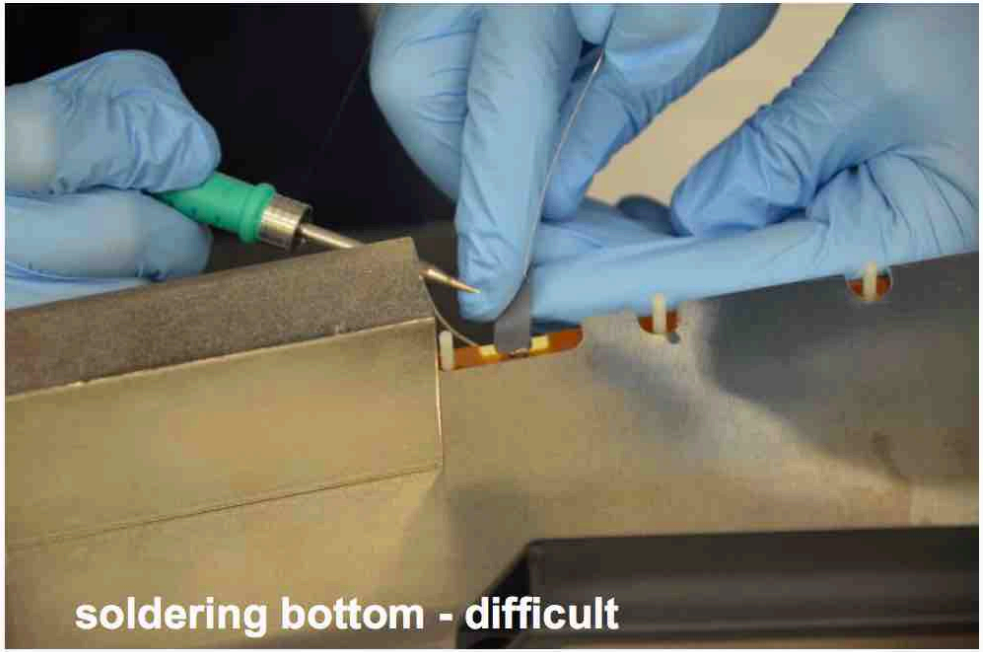
OROC assembling @ GSI
GSI_HPD joint activity

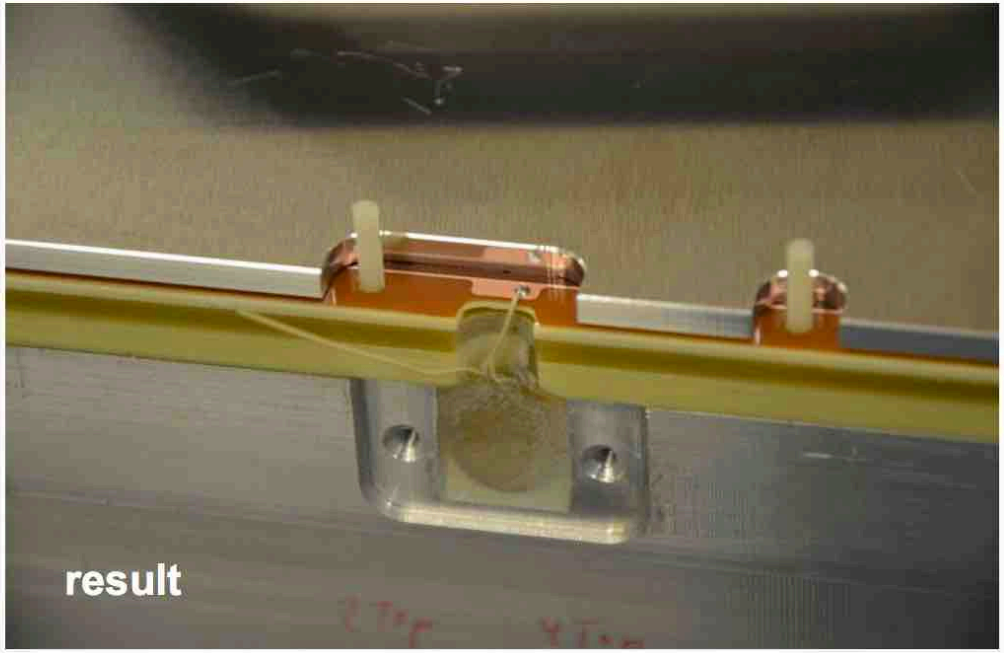


OROC assembling @ GSI
GSI_HPD joint activity







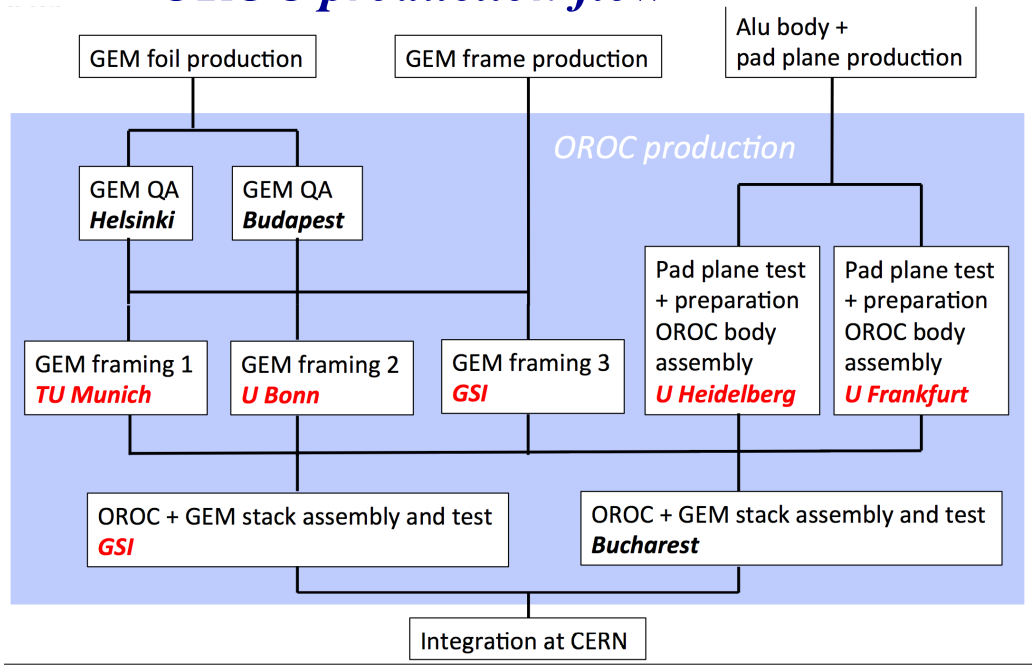


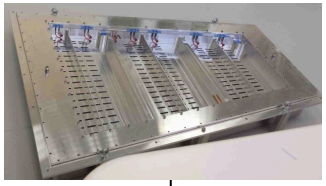
ALICE-TPC Upgrade

OROC assembling @ GSI
GSI_HPD joint acivity

ALICE-TPC Upgrade

OROC production flow





Heidelberg
add cooling pipe
register in DB

Frankfurt
glue strongback
glue padplane HV cables
leak test
mark serial no

Heidelberg
glue studs

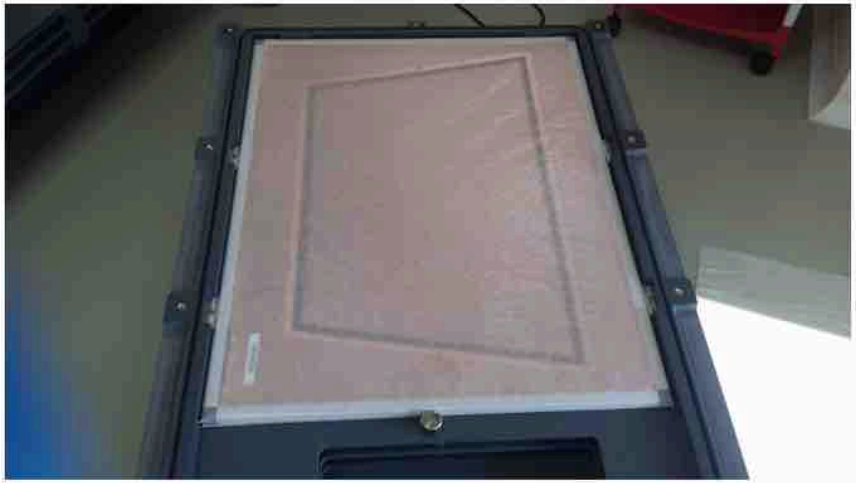
Alubody within transport boxes, Framed GEMs assembling components from: Bonn, Frankfurt, Heidelberg or Munich

GSI and Bucharest
test HV cables
assemble stacks
survey geometry
commission & test

CERN
initial test
store
test
install

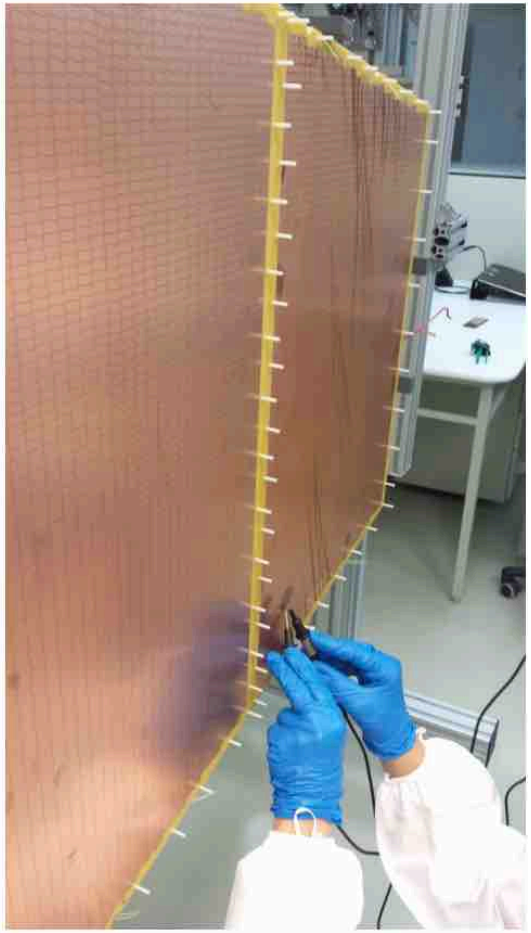
ALICE-TPC Upgrade

Unpacking and storage of the framed GEM storage

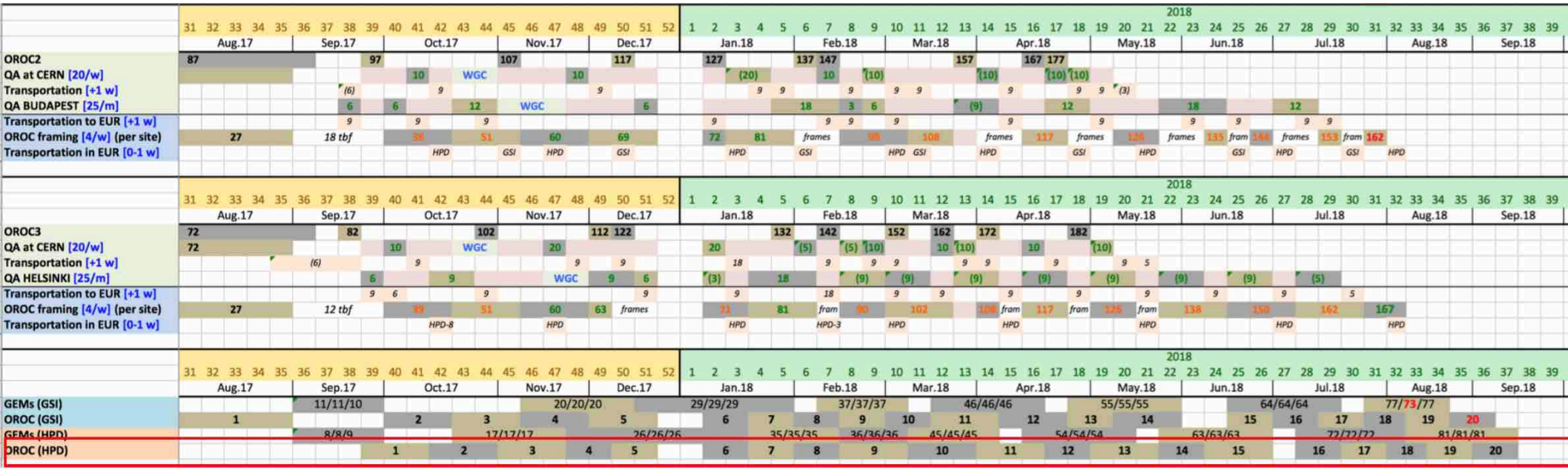


ALICE-TPC Upgrade

Cleaning and connectivity tests of the padplane glued on the Alubody



ALICE-TPC Upgrade



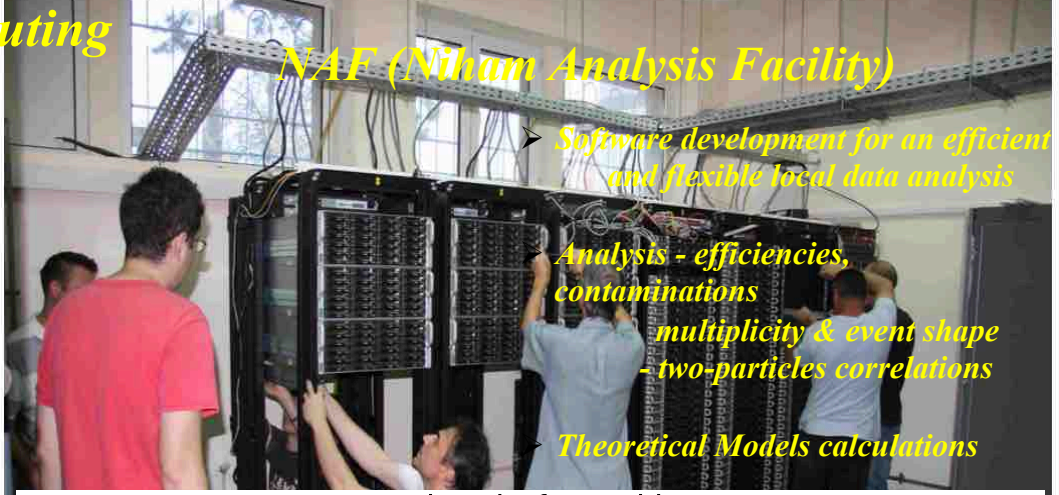
ALICE-TPC Upgrade

Ready for starting the assembling & tests on a regular basis

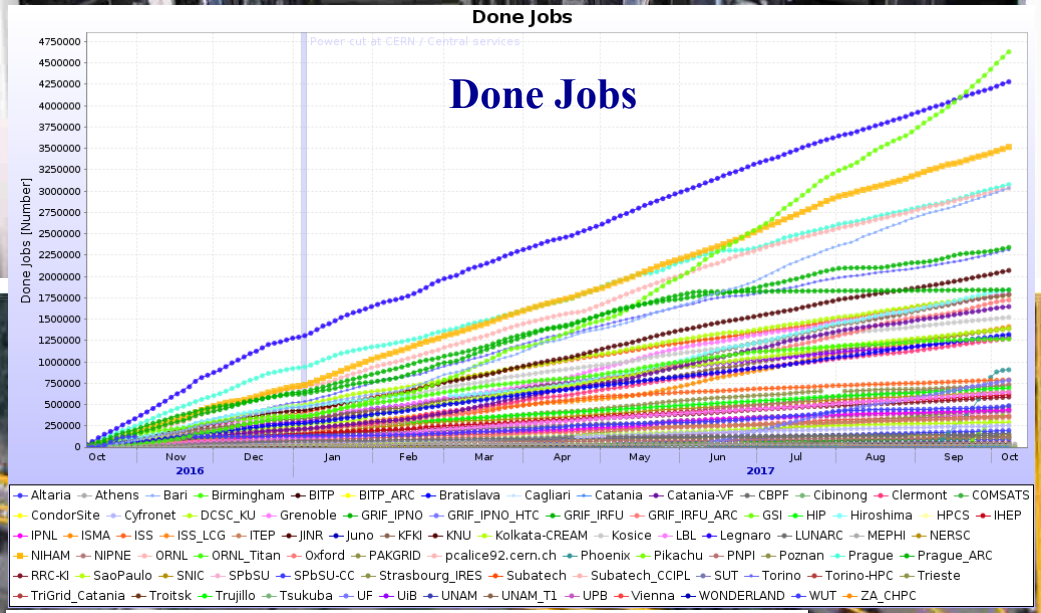
Computing

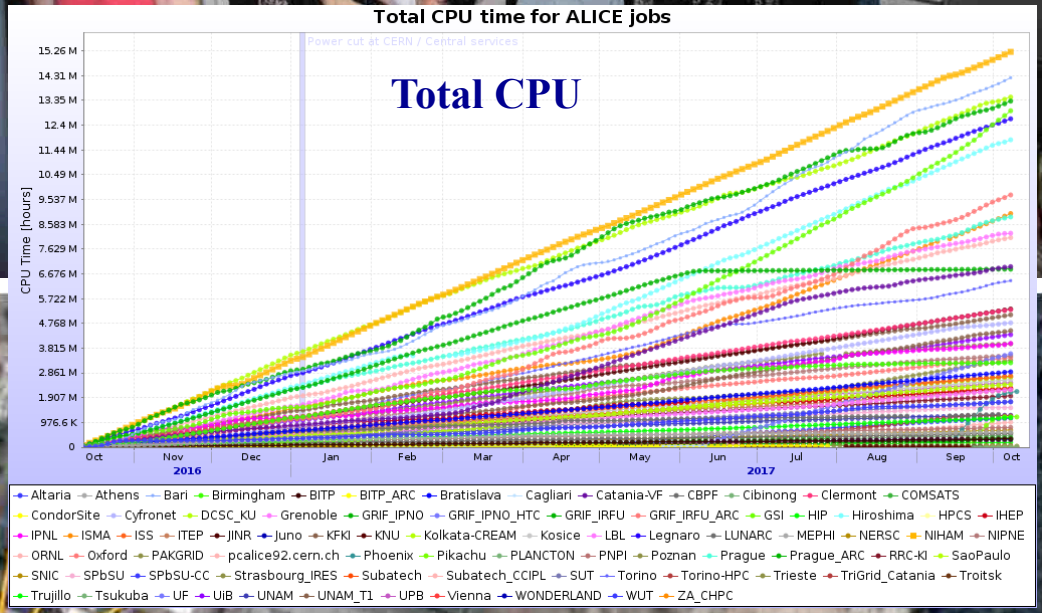
NIHAM
Tier2 component of ALICE GRID

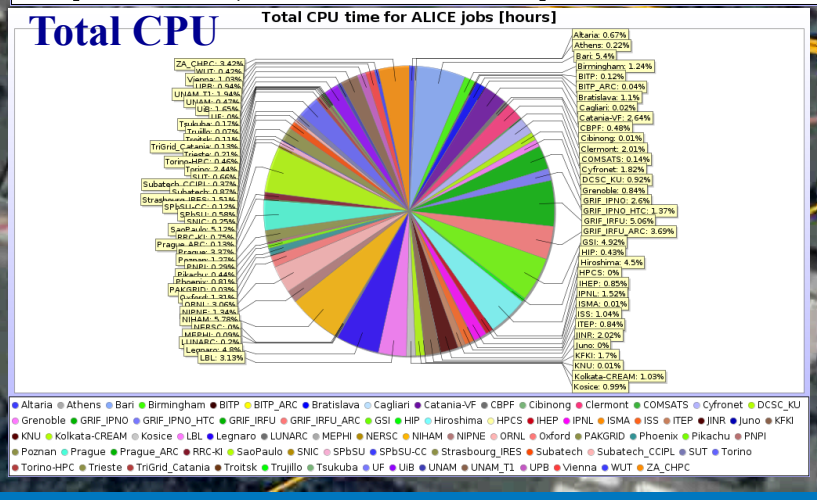
NAF (Niham Analysis Facility)



- Software development for an efficient and flexible local data analysis
- Analysis - efficiencies, contaminations
  - multiplicity & event shape
  - two-particles correlations
- Theoretical Models calculations







5.8% of Tier2 contributions

Papers and talks in the last year

Papers

- Coauthors at 30 ALICE papers

- Core-corona interplay in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV
M. Petrovici, I. Berceanu, A. Pop, M. Târzila, and C. Andrei
Phys.Rev. C96(2017)014908

Conferences

- Overview of Light-Flavor Hadron Production at ALICE,
33rd Winter Workshop on Nuclear Dynamics - WWND2017 (Snowbird Resort, Utah, USA, 2017-01-08)
- Transverse momentum spectra of primary charged particles in pp collisions measured by ALICE at the LHC - poster, QM 2017 (Chicago, USA, 2017-02-06)
- Multiplicity dependence of identified particle production in pp collisions with ALICE, QM 2017 (Chicago, USA, 2017-02-06)
- Energy and multiplicity dependence of the inclusive charged particle production in pp collisions, QM 2017 (Chicago, USA, 2017-02-06)
- The ALICE TPC Upgrade Project, QM 2017 (Chicago, USA, 2017-02-06)
- Light flavour results in pp, p-Pb and Pb-Pb collisions at ALICE,
QCD challenges in pp, pA and AA collisions at high energies (ECT*, Trento, 2017-02-27)
- Multiplicity dependence of identified particle production and strangeness in pp collisions with ALICE, Rencontres de Moriond (QCD) 2017 (La Thuile, Aosta valley, Italy, 2017-03-25)
- Light-flavour particle production in pp, p-Pb and Pb-Pb collisions with ALICE at the LHC, 2017 KPS Spring Meeting (Daejeon Convention Center in South Korea, 2017-04-19)
- Multiplicity dependence of particle production,
The fifth annual Large Hadron Collider Physics (LHCP2017) conference (Shanghai, 2017-05-15)
- New results on collectivity with ALICE,
The fifth annual Large Hadron Collider Physics (LHCP2017) conference (Shanghai, 2017-05-15)

- New results on the multiplicity and centre-of-mass energy dependence of identified particle production in pp collisions with ALICE
European Physical Society Conference on High Energy Physics 2017 (EPS-HEP) (Venice, Italy, 2017-07-05)
- Energy and multiplicity dependence of inclusive and identified particle production, 17th International Conference on Strangeness in Quark Matter (SQM 2017) (Utrecht University, 2017-07-10)
- Multiplicity dependence of pion, kaon and proton production in pp collision at $\sqrt{s}$ = 7 and 13 TeV-poster, 17th International Conference on Strangeness in Quark Matter (SQM 2017) (Utrecht University, 2017-07-10)
- Energy and multiplicity dependence of strange and non-strange particle production in pp collisions at the LHC with ALICE, 17th International Conference on Strangeness in Quark Matter (SQM 2017) (Utrecht University, 2017-07-10)
- Small systems at the LHC, 17th International Conference on Strangeness in Quark Matter (SQM 2017) (Utrecht University, 2017-07-10)
- Collectivity and blast-wave in pp, p-Pb and Pb-Pb collisions with the ALICE experiment, 4th International Conference on the Initial Stages in High-Energy Nuclear Collisions (Cracow, Poland, 2017-09-18)
- ALICE results on small systems, 4th International Conference on the Initial Stages in High-Energy Nuclear Collisions (Cracow, Poland, 2017-09-18)

- From pp to AA ultra-relativistic collisions
M. Petrovici, A. Pop, C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu and M. Tarzila, AIP Conference Proceedings 1852, 050003 (2017); doi: http://dx.doi.org/10.1063/1.4984864

Papers and talks in the last year

ALICE PAGs and PWG

- Charged particle p_T spectra as a function of multiplicity in pp collisions at 7 TeV
A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop; PWG-LF meeting, December 12th 20
https://indico.cern.ch/event/592525/contributions/2391768/

- Charged particle p_T spectra as a function of multiplicity in pp collisions at 7 TeV
A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop; Long Paper meeting, December 9th 2016
https://indico.cern.ch/event/594220/contributions/2401609/

- Charged particle pT spectra as a function of multiplicity in pp collisions at 7 TeV
A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop; Long Paper meeting, December 2nd 2016
https://indico.cern.ch/event/591686/contributions/2392100/

- Charged particle pT spectra as a function of multiplicity in pp collisions at 7 TeV
A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop; PWG-LF meeting, November 21st 2016
https://indico.cern.ch/event/586662/contributions/2363596/

- Charged particle pT spectra as a function of multiplicity in pp collisions at 7 TeV
A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop; Spectra meeting, November 19th 2016
https://indico.cern.ch/event/589439/contributions/2376714/

TPC U&P

- OROC assembly and commissioning – 29.08.2017
https://indico.cern.ch/event/653116/contributions/2696256/attachments/1515035/2364028/2017-08-29.pdf

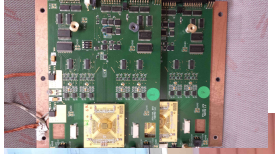
- Reconditioning of the OROC test box in Bucharest – 22.08.2017
https://indico.cern.ch/event/651102/contributions/2697357/attachments/1510963/2356275/in-house-test-box_with__extra_drift_electrode_220817.pdf

- 1st OROC assembly in GSI – 04.07.2017
https://indico.cern.ch/event/651095/contributions/2649952/attachments/1487387/2310508/2017-07-04.pdf

- Status of the polycarbonate transport box – 23.05.2017
https://indico.cern.ch/event/623136/contributions/2603465/attachments/1533391/2401026/transport_box_300517.pdf

- OROC transportation box: flange, vessel, design/order – 16.05.2017
https://indico.cern.ch/event/623135/contributions/2594211/attachments/1460452/2255638/new_design_alu_flange.pdf

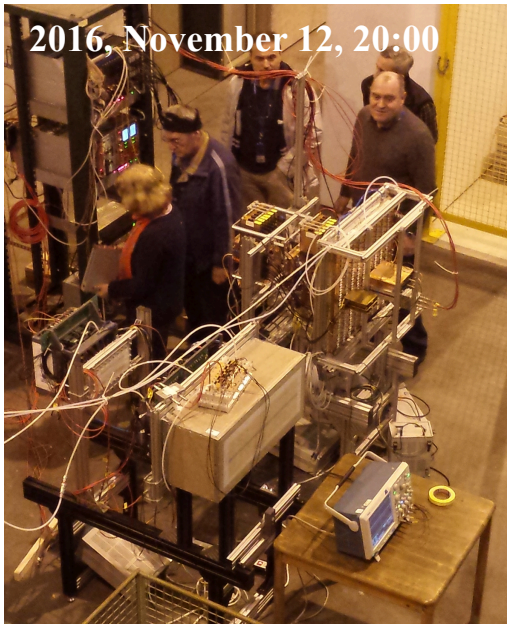
- Progress report from HPD Bucharest – 11.04.2017
https://indico.cern.ch/event/623130/contributions/2553491/attachments/1443021/2401028/changes_test_box.pdf

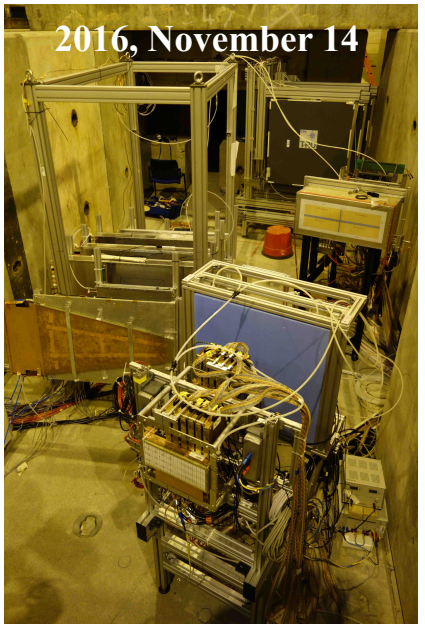


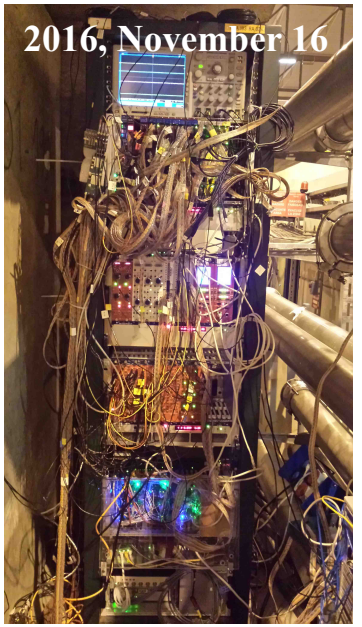
Further activities

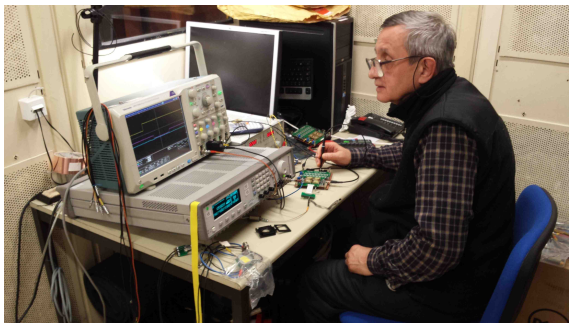
R&D

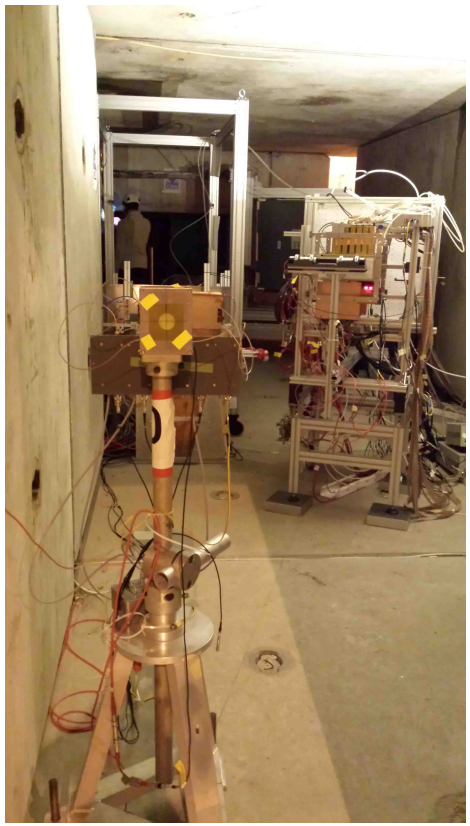
November-December 2016 in-beam tests @ SPS

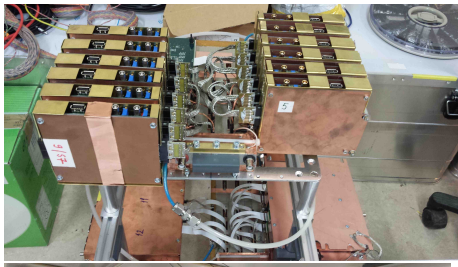








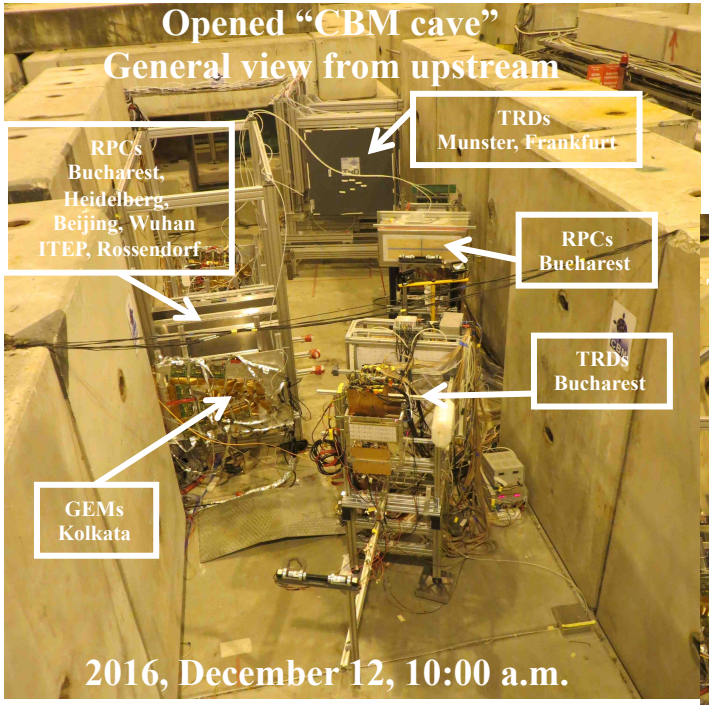


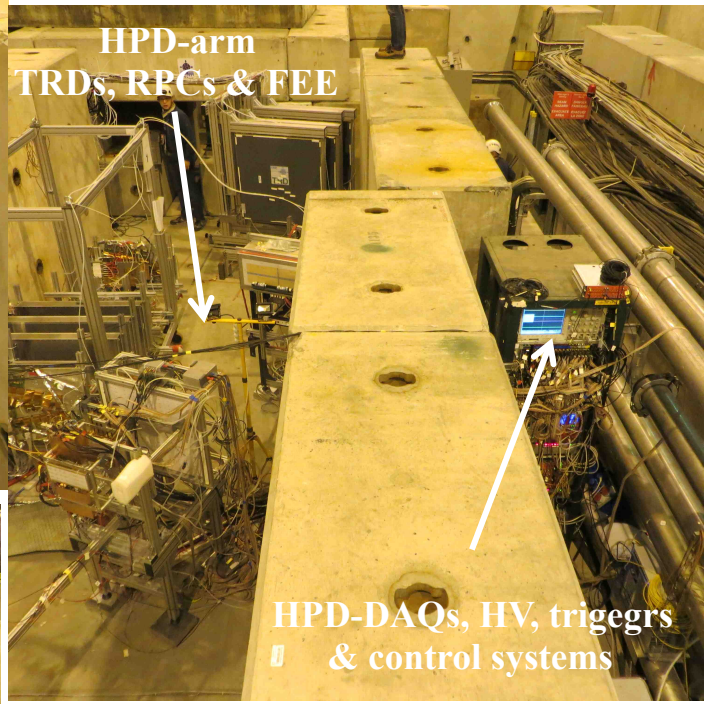


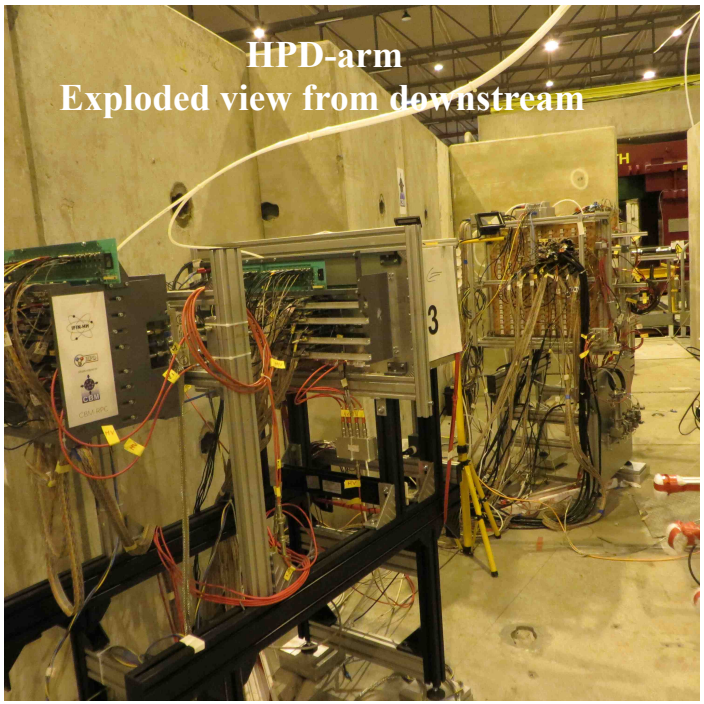
Further activities

R&D

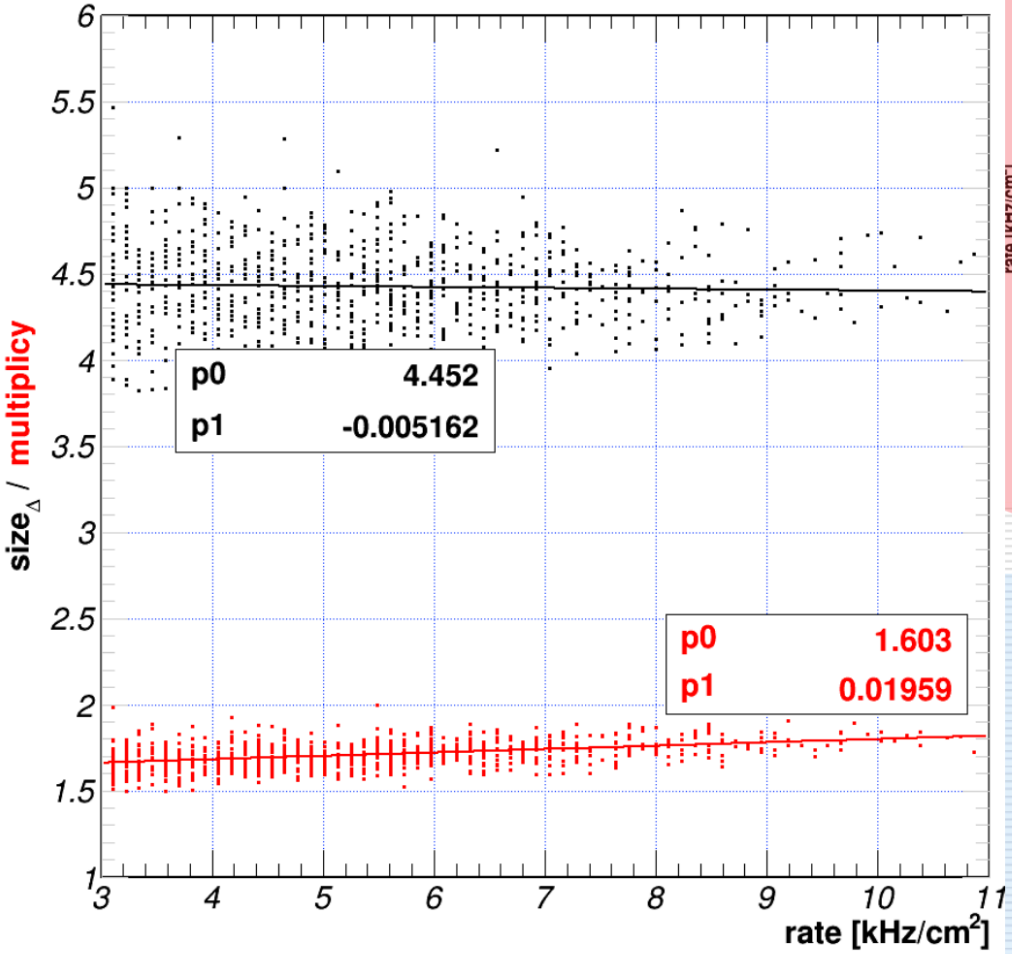
November-December 2016 in-beam tests @ SPS

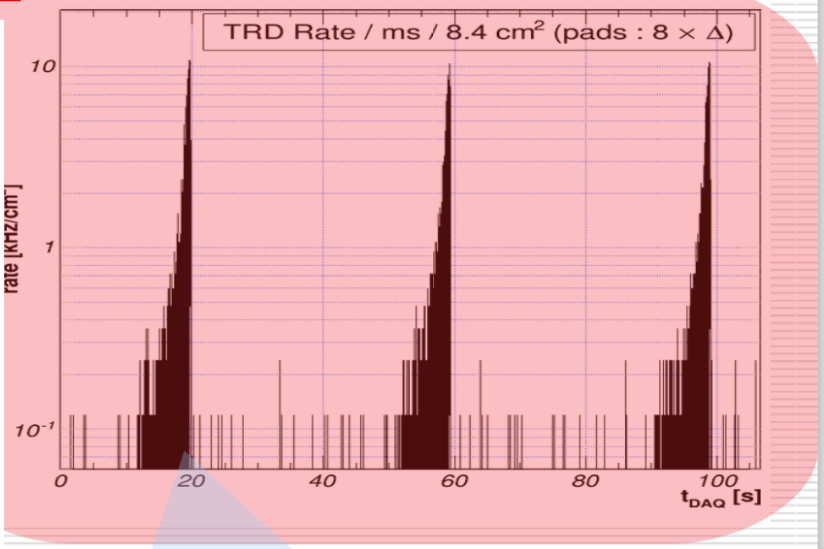


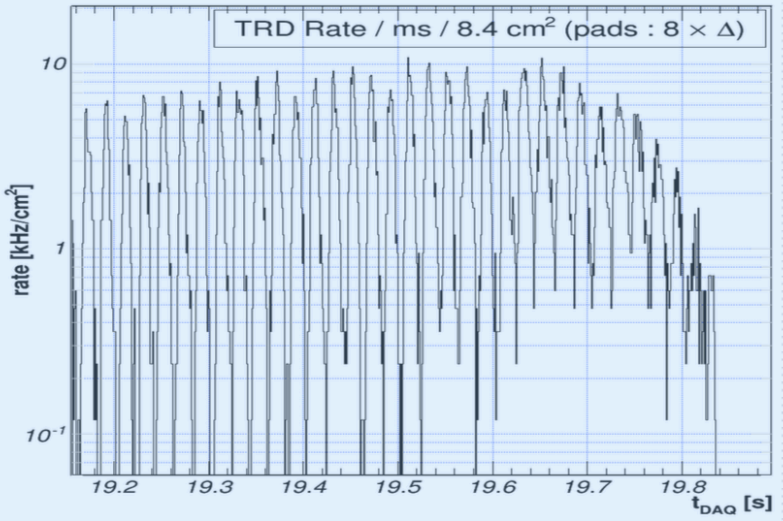




Rates @ SPS '16 :: *Clusters*

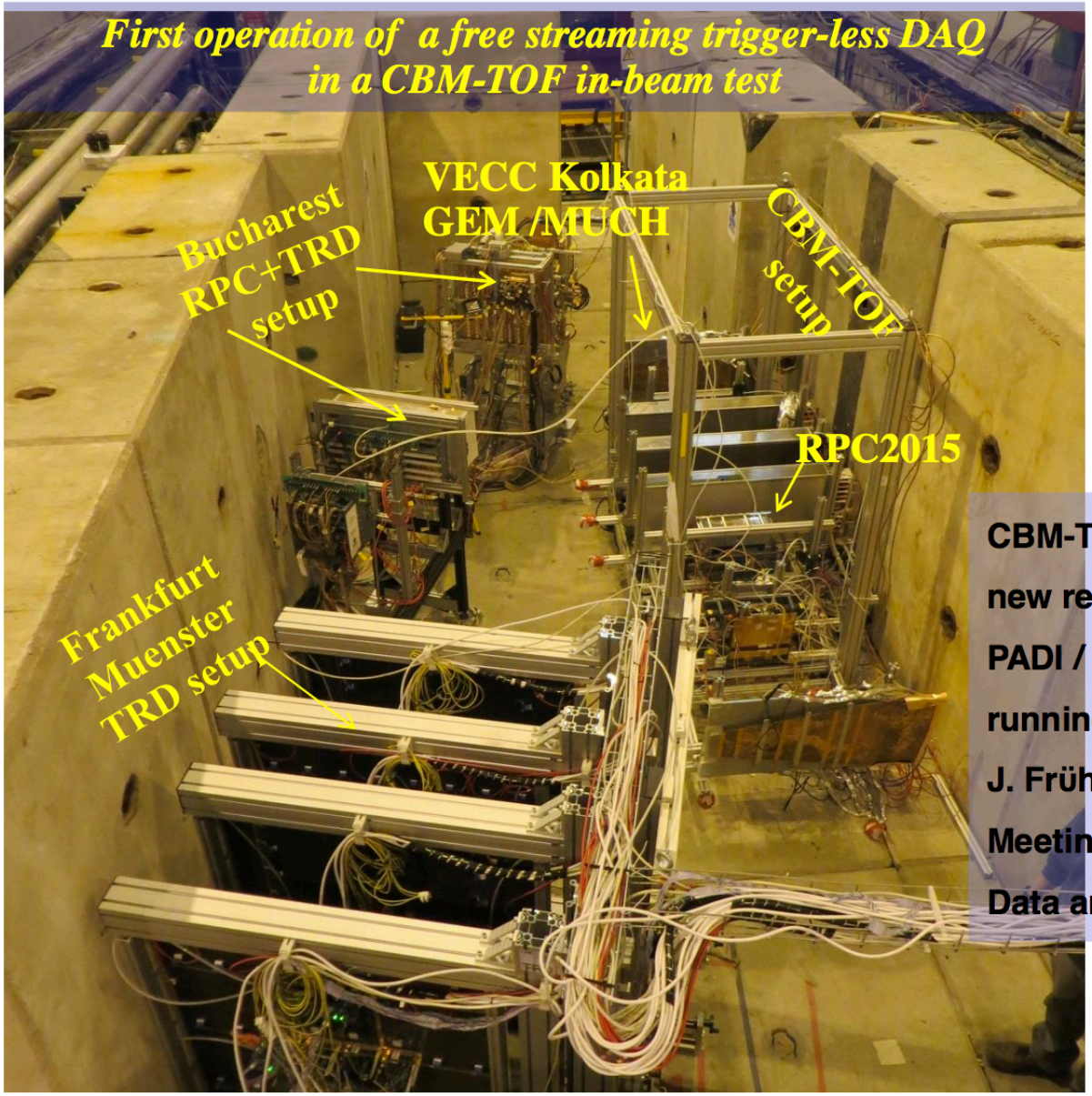


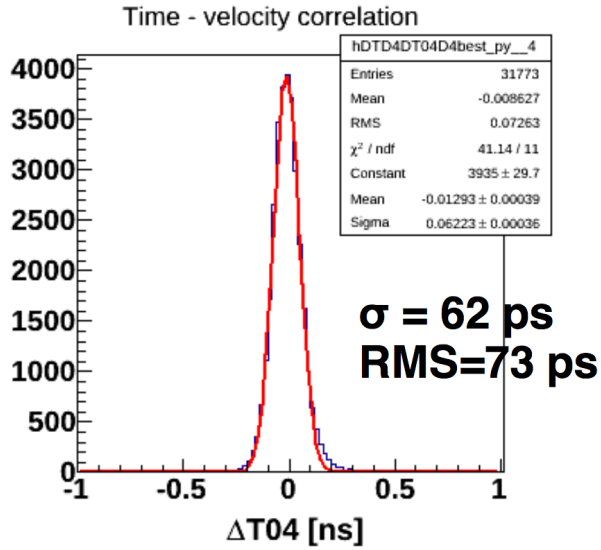




Fall 2016 CERN - SPS in-beam tests

Pb beam of 13/30/150 AGeV on a Pb target





σ = 62 ps
RMS=73 ps

CBM-TOF readout ~ 500 Channels with a new readout-chain based on:

PADI / GET4 / AFCK / FLIB => DAQ was running stable.

J. Frühauf, 29th CBM Collaboration Meeting, March 2017.

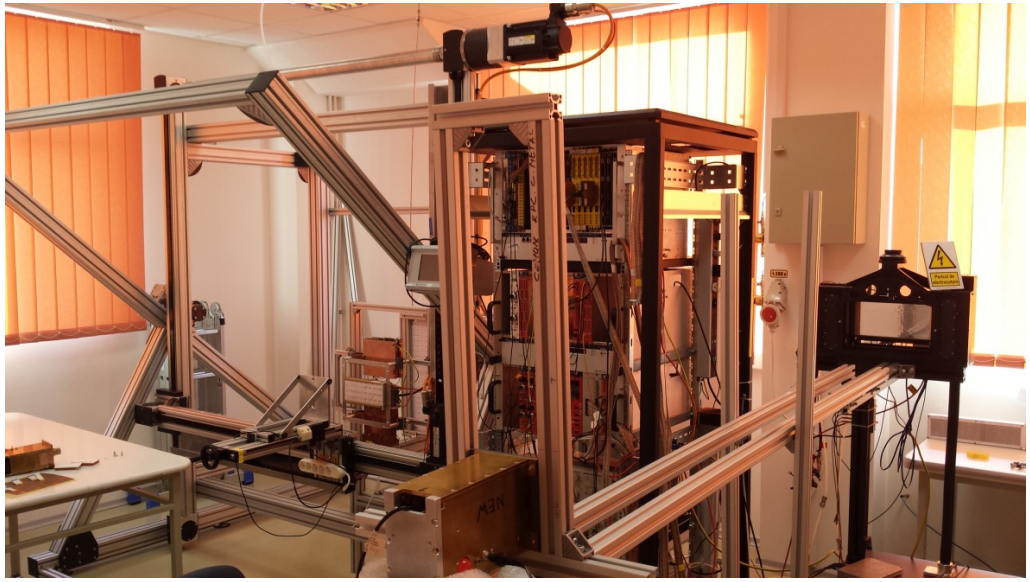
Data analysis is still on going work.

Efficiency: 0.965
Cluster Size: 1.9 - 1.7

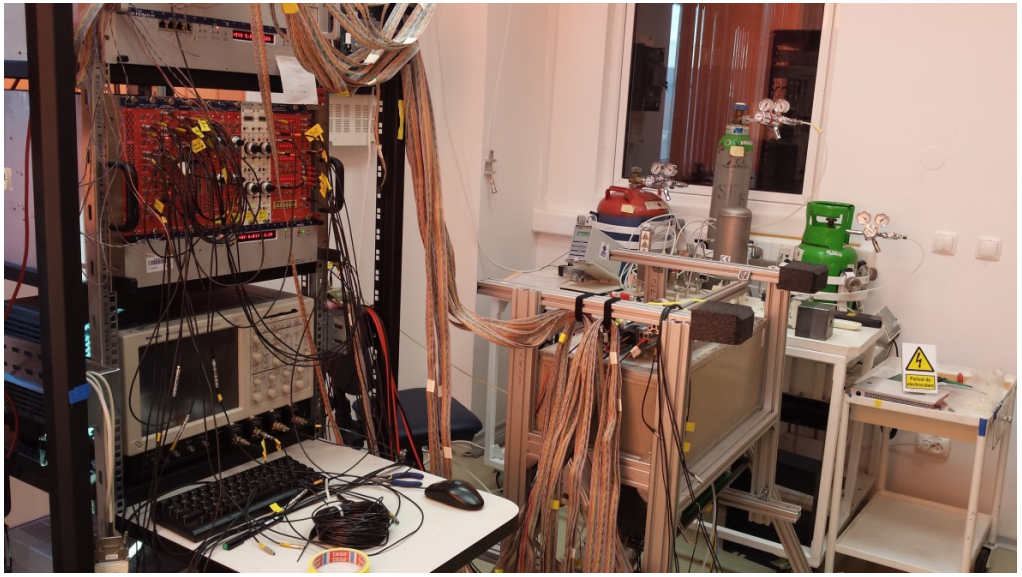
Further activities

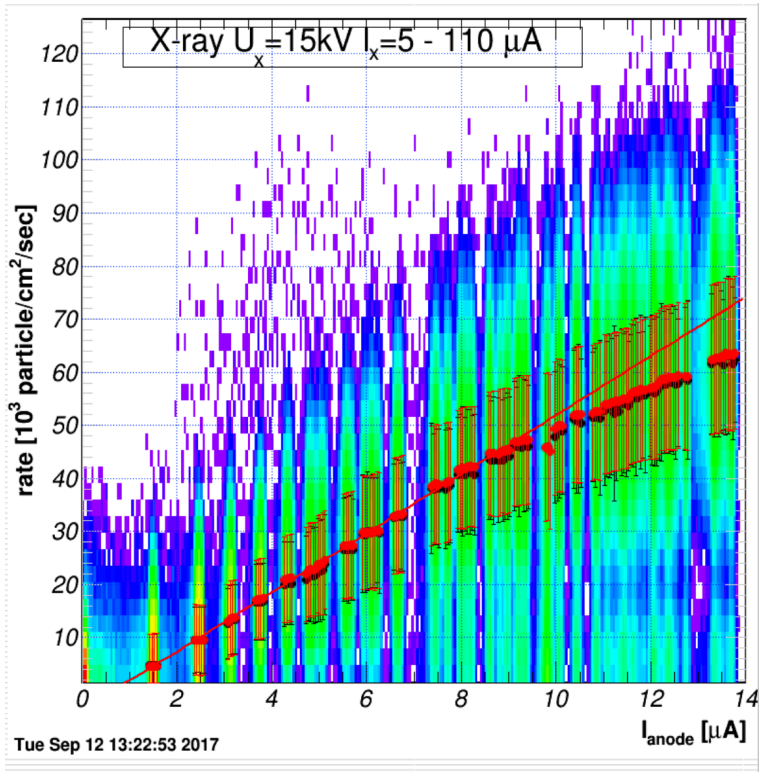
R&D *In-house tests*

TRD



RPC



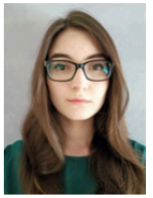


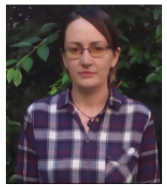
$$eff = \frac{RPC\ \&\ PMT(1\&2)\&\ PMT(3\&4)}{PMT(1\&2)\&\ PMT(3\&4)}$$

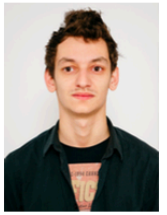
$$eff = \frac{84\ events}{90\ events} = \mathbf{93.3\ \%}$$

Outreach

Summer Student Program







Outreach

- *Interview on TVR International*

- *Numerous visits of Romanian and foreign delegations, gymnasium pupils, students of the Romanian Physics Faculties network*

- *Posters at Researchers Night, September 2017*

Scientific objectives for the next year

- Multi differential analysis of charged particles and identified charged hadrons p_T spectra as a function of:
  - charged particle multiplicity
  - event shape
  - azimuthal angle relative to the leading particle
  - detailed studies of the dependence of corrections applied to raw spectra on the event shape global variables

- Two particle correlation studies as a function of charged particle multiplicity and event shape

- Detailed comparisons of PYTHIA and HIJING model predictions with experimental data

- Detailed studies of core properties in A+A collisions at RHIC-BES and LHC energies

- Preliminary results on core-corona effects in p+Pb and pp collisions at LHC energies

- Contribution to the detector operation in Run2

- TPC-OROC assembling and tests

- Operating NIHAM data center – component of ALICE GRID at its standard efficiency

- Outreach activities

- Summer Student Program

They are the main actors !