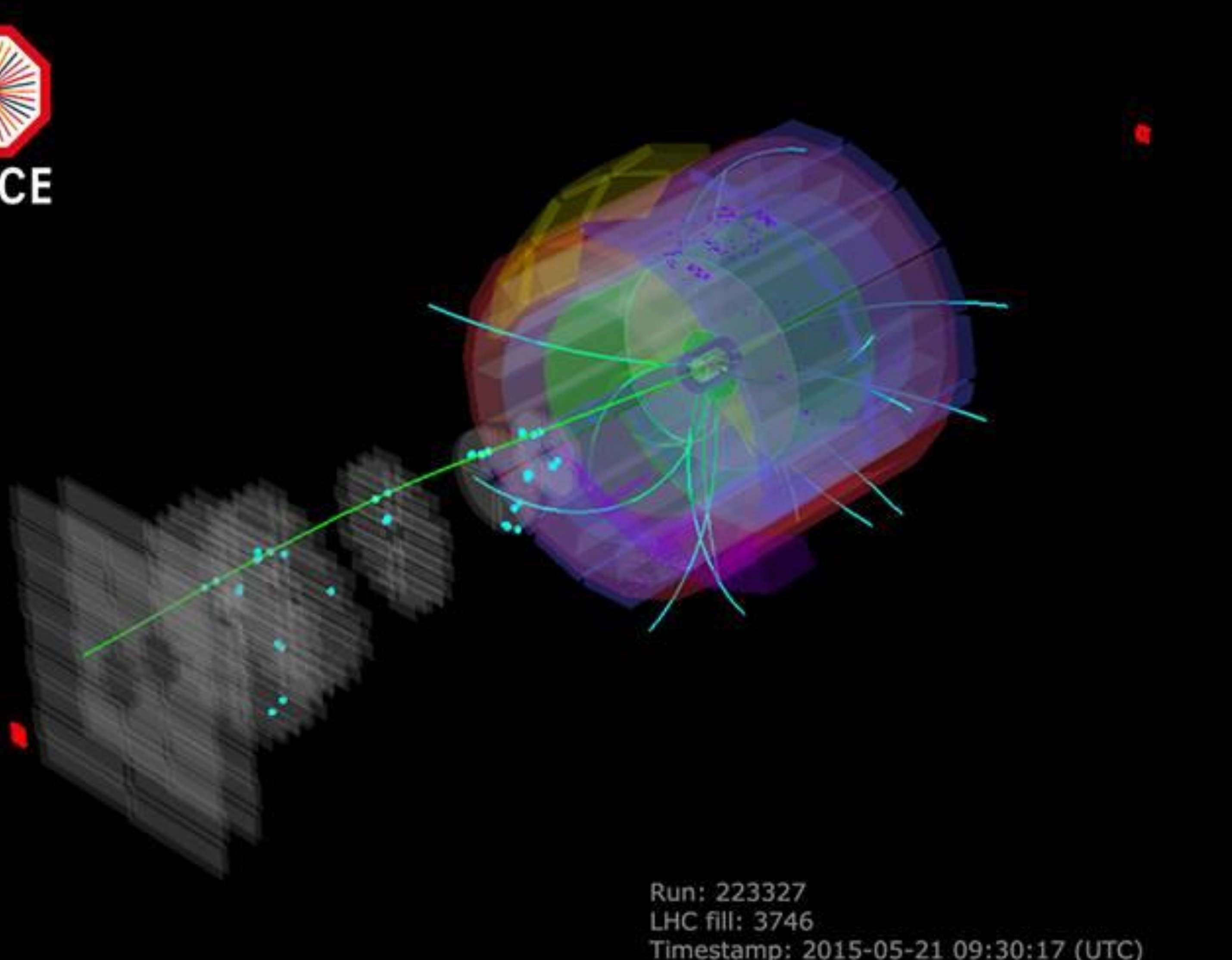
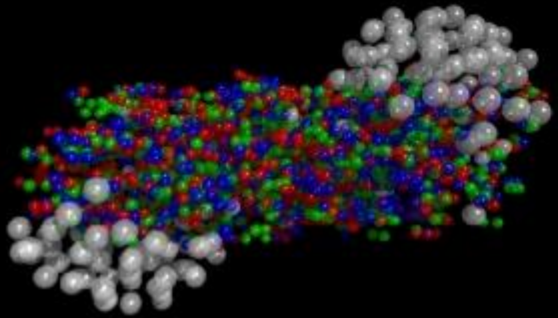
ALICE at the LHC beyond the Higgs

ALICE



Gerardo Herrera Corral CINVESTAV - México.

ALICE



$_{208}\mathbf{Pb}^{82+}$ $_{208}\mathrm{Pb}^{82+}$

fully stripped

In the same magnetic field as protons

$$E_{\mathrm{Pb}} = Z\,E_{\mathrm{p}} = 82 \times 7\ \mathrm{TeV} = 574\ \mathrm{TeV}$$

$$Pb = 82\,p + 126n$$

2.76 TeV/nucleon

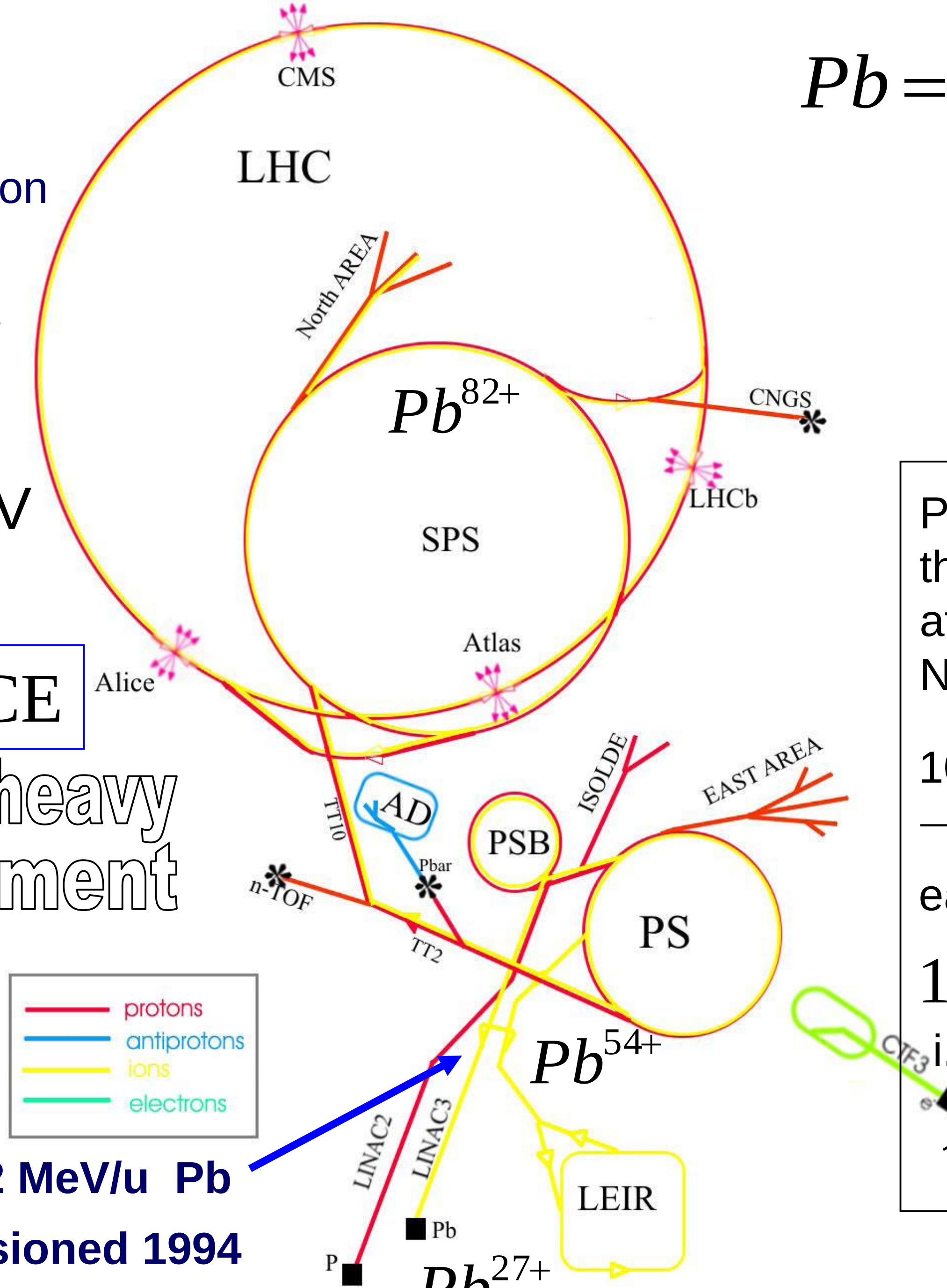
LARGE amounts of energy involved

$\sqrt{s} = 1154$ TeV

Pb – Pb collisions

ALICE

dedicated heavy ion experiment



4.2 MeV/u Pb

commissioned 1994

upgraded 2007

fully stripped Pb ions

$$Pb^{82+}$$

Previous project in the field RHIC at Brookhaven National Laboratory

100 GeV/nucleon
→ Gold nucleus

each nucleus

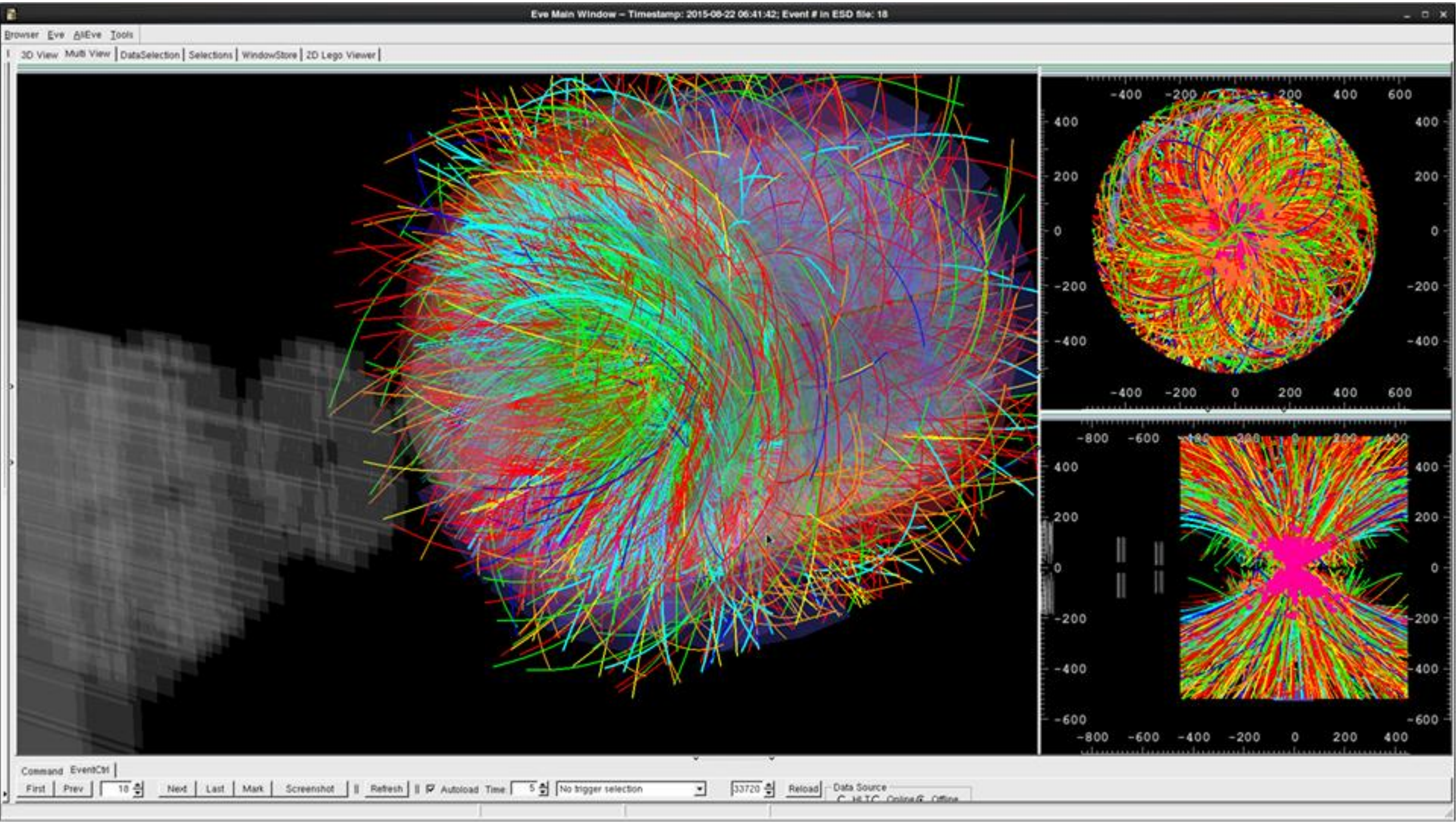
100×197 GeV

i.e. 19.7 TeV

$\sqrt{s} = 39.4$ TeV

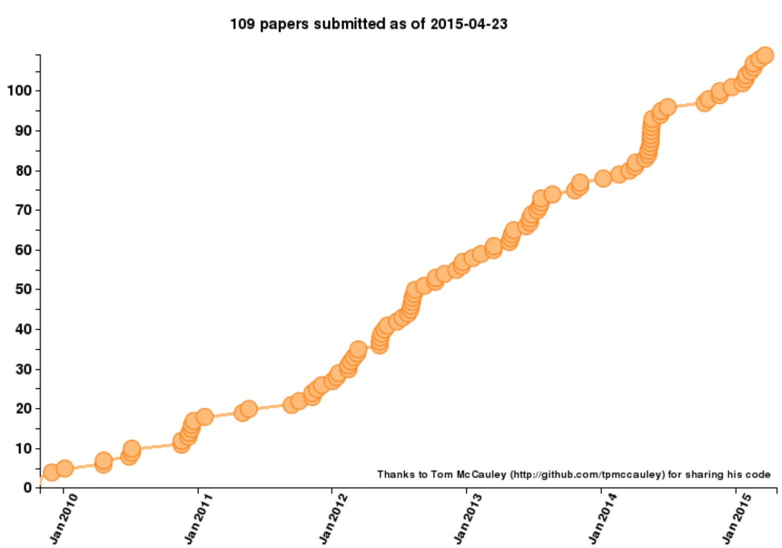

proton-proton a 14 TeV now at 8 TeV
ion-ion a 1150 TeV
en el centro de masa
MEYER

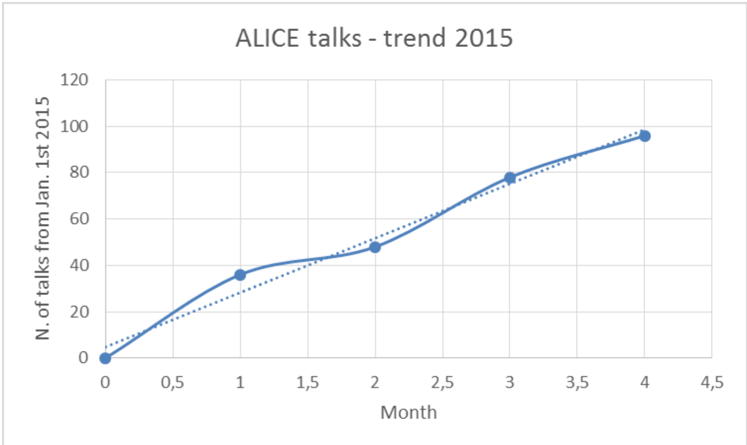
High pile up evento 22nd of agust 2015 6:42



Analysis of RUN1 data in full swing

- 110 papers
- Impact of the publications remains extremely high (3 out of10 of the top cited LHC physics papers)
- Strong presence at conferences.
  ~ 100 conference contributions in 2015 so far (over 400 in 2014).



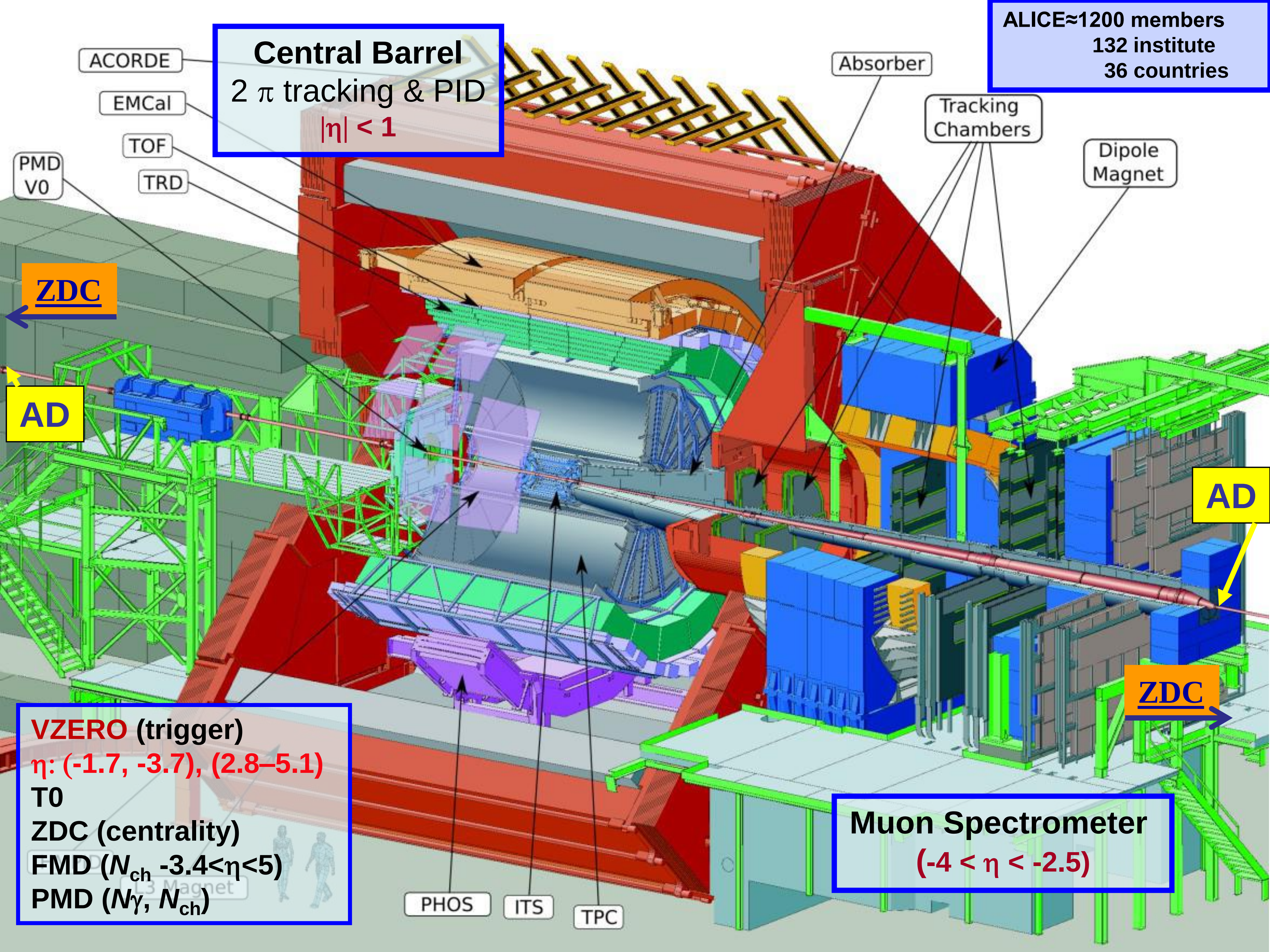


New Institutes

- **UC Berkeley (USA)**
  - New full member (in association with LBNL)
- **Technical University of Kosice (Slovakia)**
  - From associate member to full member in association with IEP Kosice
- **Calcutta University (India)**
  - New associate member
- **Excellence Cluster Universe, Technische Universität München, Munich (Germany)**
  - Full member in association with TUM

- **Vienna SMI (Austria)** and **MIPT (Russia)** will apply for full ALICE membership in June
- Discussions ongoing for the passage to full member of Bonn, Egypt and a group of Chilean Universities
- Discussions ongoing with new institutions in Azerbaijan, Bangladesh, Brazil, Malta, Pakistan, South Africa and the UK

ALICE continues to be very attractive!

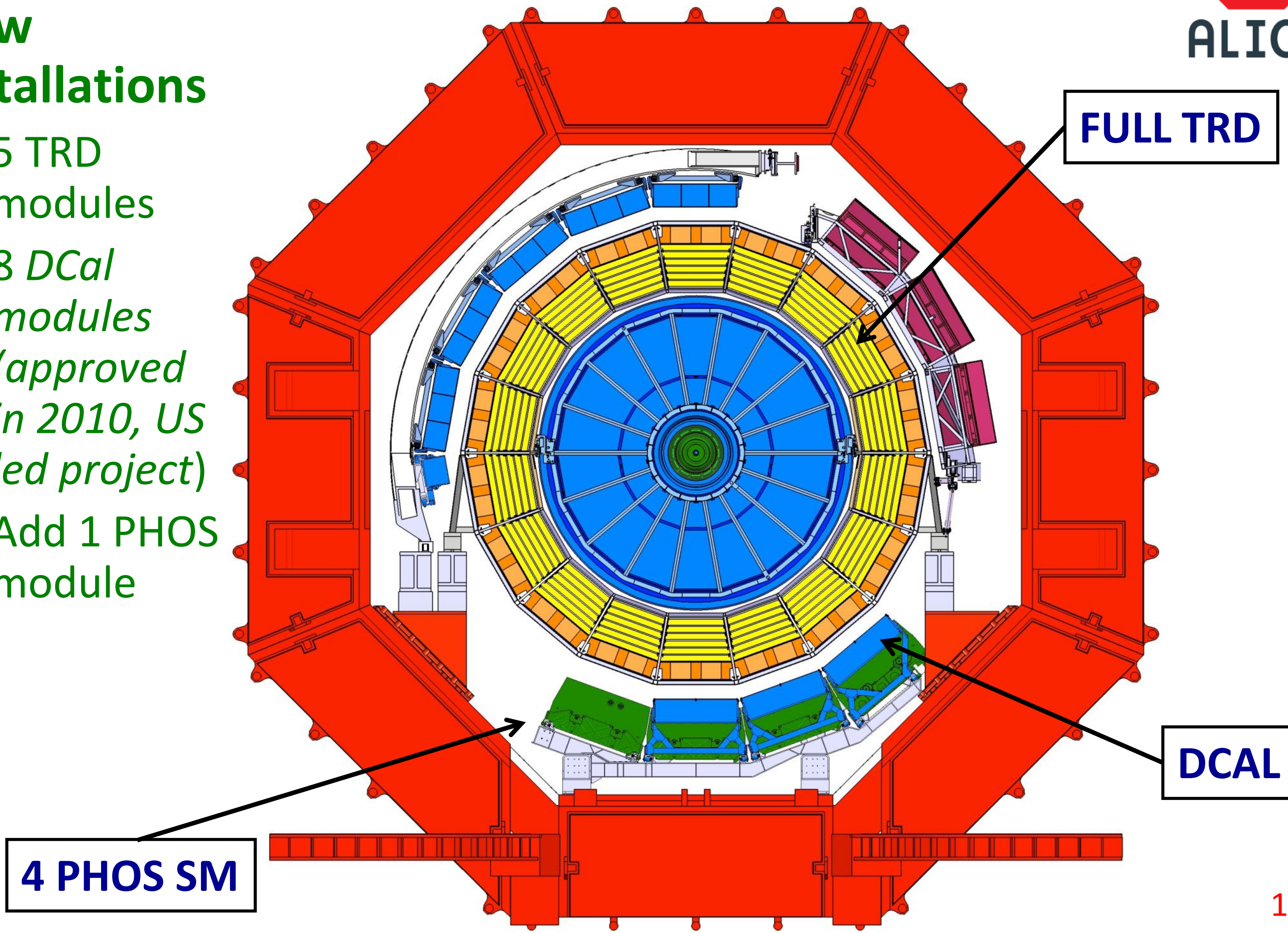


ALICE≈1200 members
132 institute
36 countries
Central Barrel
2 π tracking & PID
|η| < 1
ACORDE
EMCal
TOF
TRD
PMD
V0
Absorber
Tracking Chambers
Dipole Magnet
ZDC
AD
AD
ZDC
VZERO (trigger)
η: (-1.7, -3.7), (2.8–5.1)
T0
ZDC (centrality)
FMD (N_{ch} -3.4<η<5)
PMD ($N\gamma$, N_{ch})
L3 Magnet
PHOS
ITS
TPC
Muon Spectrometer
(-4 < η < -2.5)

ALICE detectors now vs. Feb. 2013

New installations

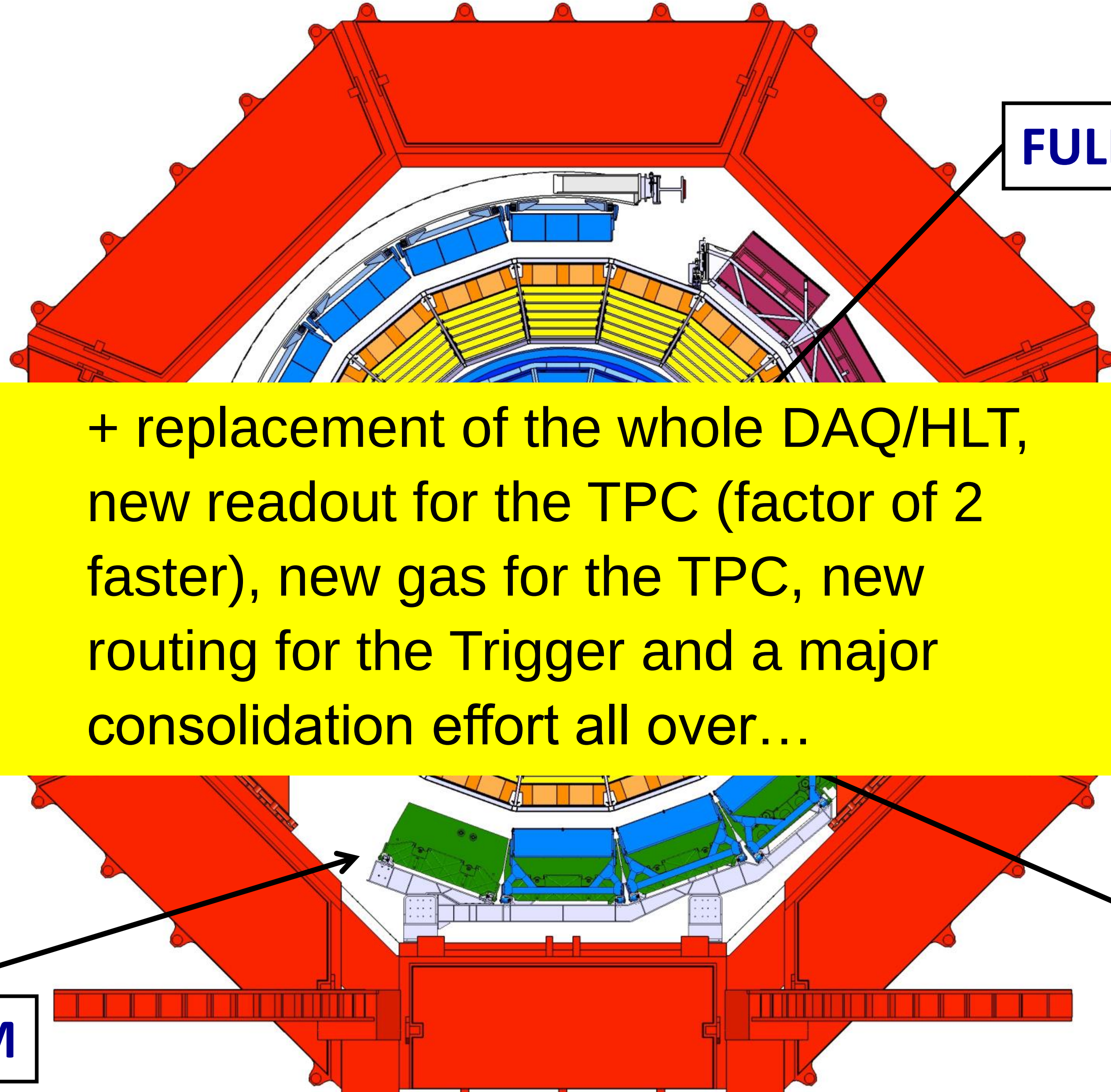
- 5 TRD modules
- 8 *DCal modules (approved in 2010, US led project*)
- Add 1 PHOS module



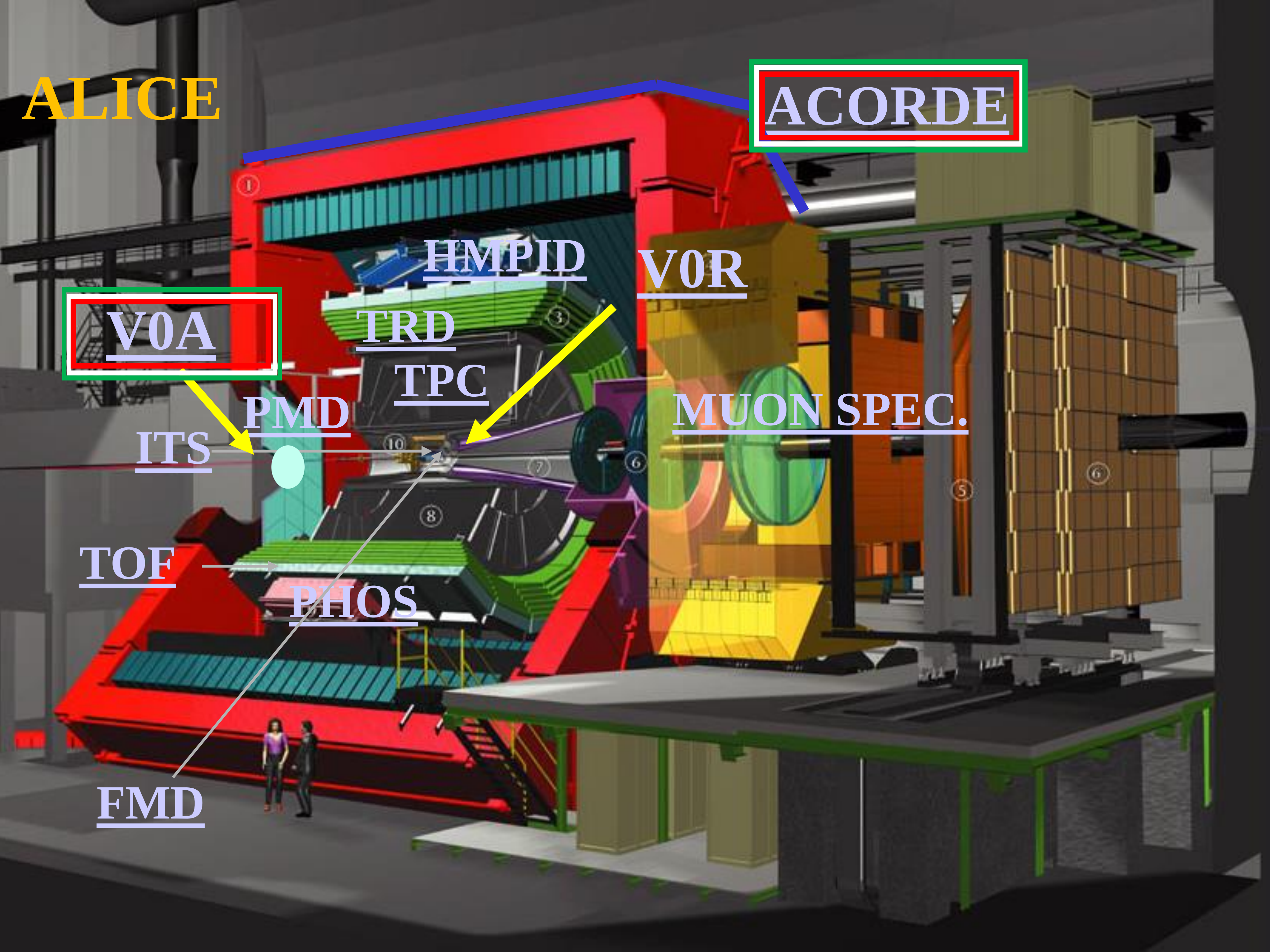
Short-term: LS1 plan, preparation for RUN2

New installations

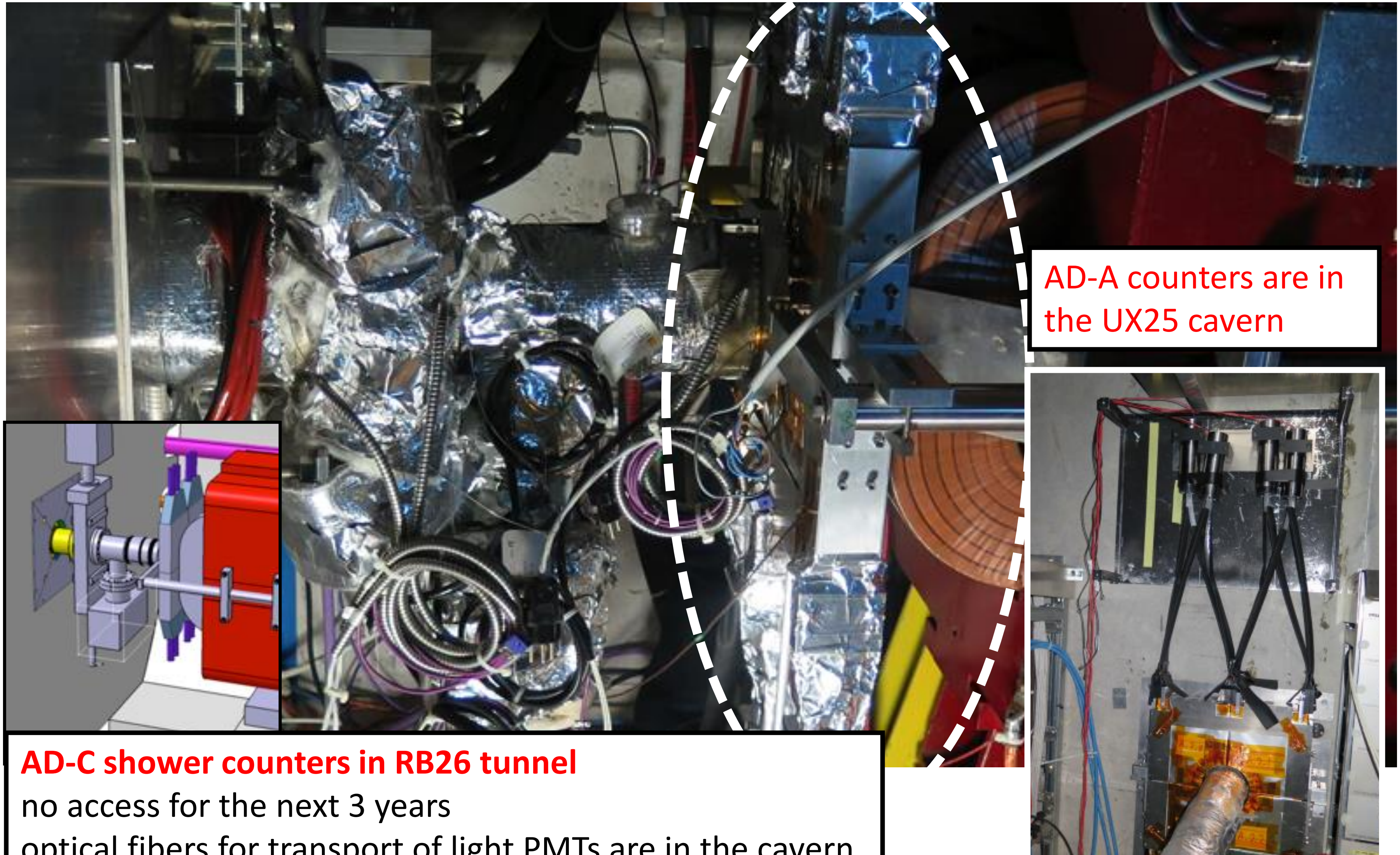
- 5 TRD modules
- 8 DCal modules (approved in 2010, US led project)
- Add 1 PHOS module



+ replacement of the whole DAQ/HLT, new readout for the TPC (factor of 2 faster), new gas for the TPC, new routing for the Trigger and a major consolidation effort all over…


ALICE
ACORDE
HMPID
V0R
V0A
TRD
TPC
PMD
MUON SPEC.
ITS
TOF
PHOS
FMD

ALICE Diffractive Detector - AD

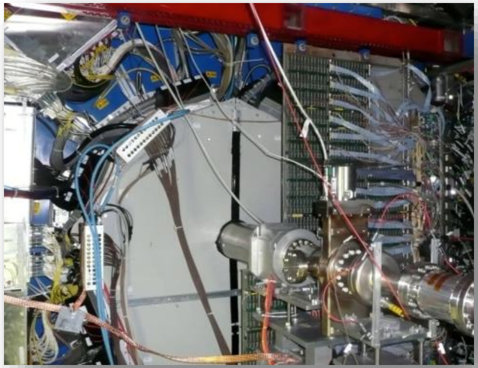


AD-A counters are in the UX25 cavern

AD-C shower counters in RB26 tunnel
no access for the next 3 years
optical fibers for transport of light PMTs are in the cavern

Detector construction

V0A



Trigger detector

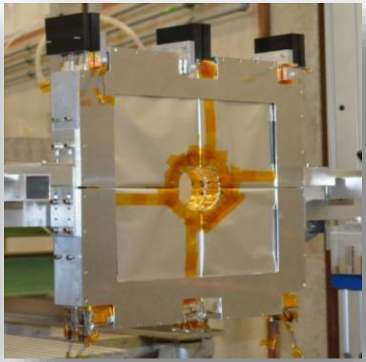
CINVESTAV
UNAM

ACORDE

A COsmic Ray DEtector

BUAP
CINVESTAV
UAS
UNAM

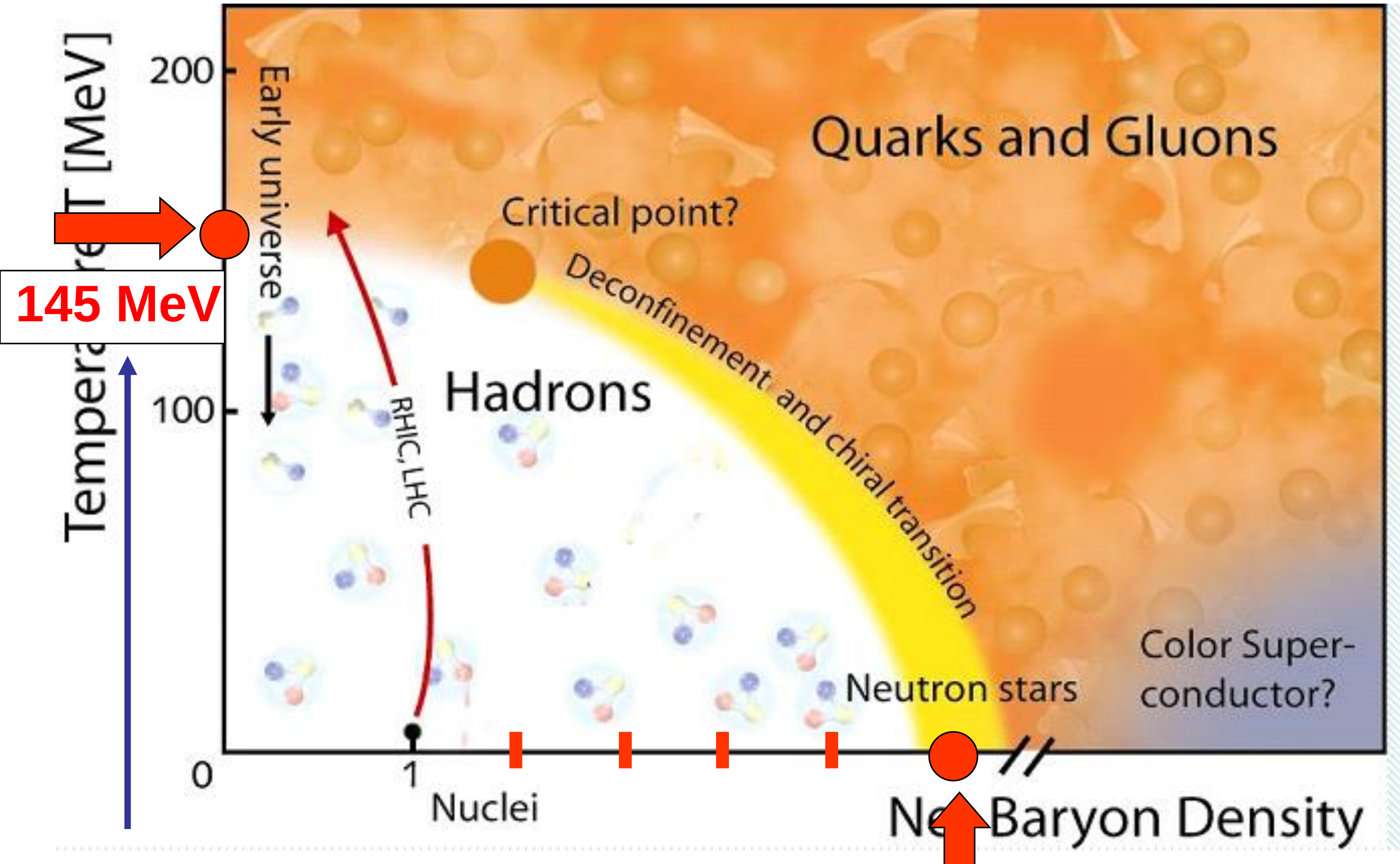
AD



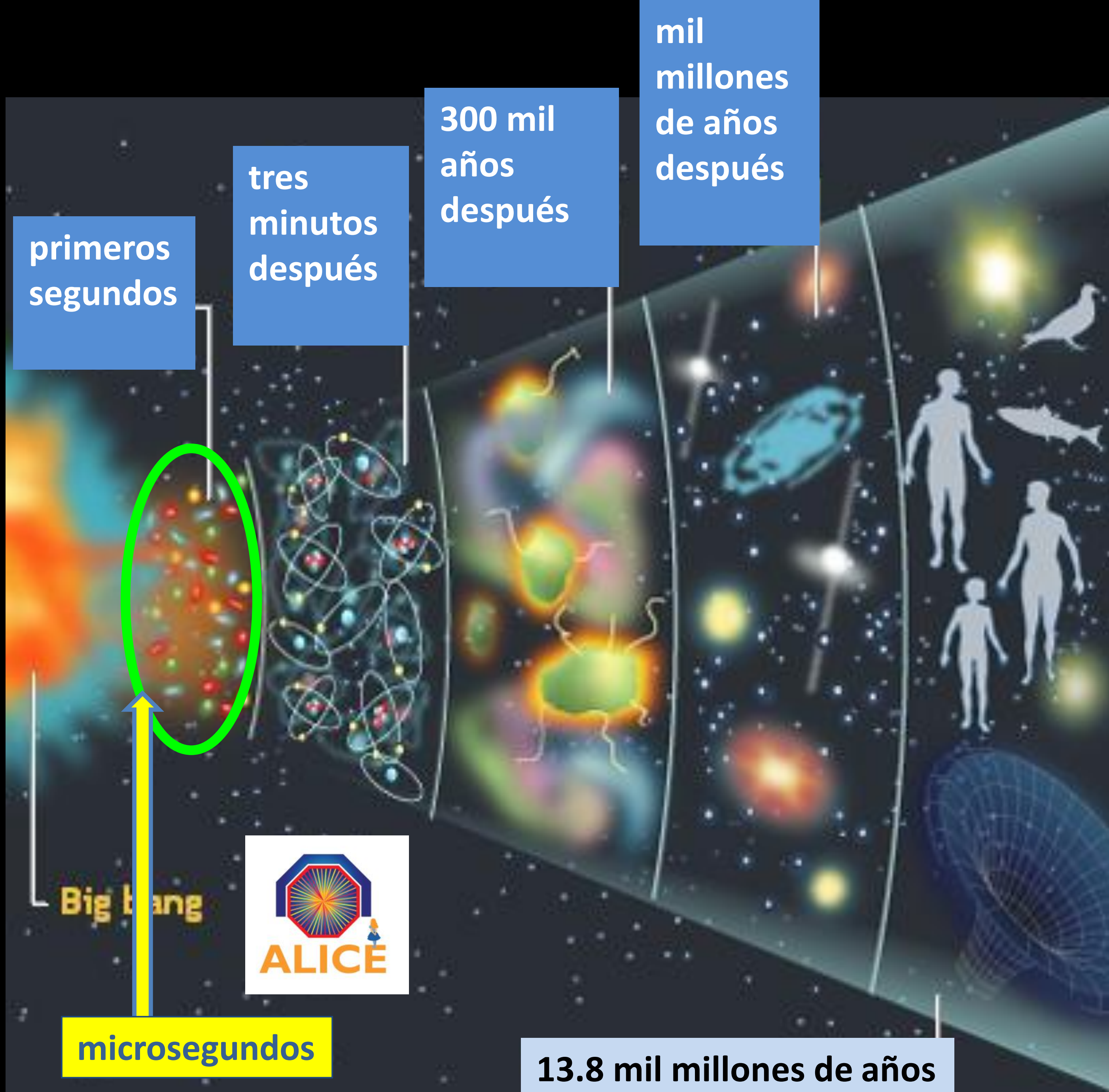
ALICE Diffractive

CINVESTAV
UAS
BUAP

Phase Diagram of QCD Matter



MIT Bag Model→ 0.72/0.14 = 5 nuclei


primeros segundos
tres minutos después
300 mil años después
mil millones de años después
Big bang
ALICE
microsegundos
13.8 mil millones de años

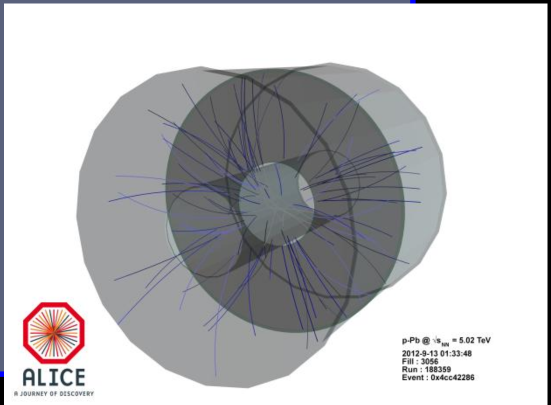
LHC heavy ion runs

- **Two heavy-ion runs at the LHC so far:**
  - 2010 – commissioning and first data taking
  - 2011 – above nominal instant luminosity

- **p–Pb next year – 2013**
  - plan for ~ 30 nb^{-1}

  pilot run September 12th successful !!!

- **Long Shutdown in 2013-2014**



year	system	Energy $\sqrt{s_{NN}}$ (TeV)	integrated luminosity
2010	**Pb – Pb**	**2.76**	**~ 10 μb^{-1}**
2011	**Pb – Pb**	**2.76**	**~ 0.1 nb^{-1}**
2013	**p – Pb**	**5.02**	**~ 30 nb^{-1}**

The program of ALICE

ALICE heavy-ion program approved for ~ 1 nb^{-1}:

- **2015 Pb–Pb at $\sqrt{s_{NN}}$ = 5.1 TeV**
- **2016–17 Pb–Pb at $\sqrt{s_{NN}}$ = 5.5 TeV**

- **2018 Long Shutdown 2**
- **2019 probably Ar–Ar high-luminosity run**
- **2020 p–Pb comparison run at full energy**
- **2021 Pb–Pb run to complete initial ALICE program**
- **2022 Long Shutdown 3**

This will improve statistical significance of our main results (~ x 3)

ALICE proton proton

Run 2 2015 – 2017:

- 2015 proton–proton at $\sqrt{s_{pp}}$ = 13 TeV
  starting at $\sqrt{s_{pp}}$ = 12 TeV -- 25 ns bunch spacing
- Possibility of low luminosity and low beam intensity
  Minimum Bias Trigger - OR
- Lab energy increases →
- Better pseudorapidity coverage →
- UPC cross section increase with energy ($J/\Psi, \Psi', \Upsilon$)

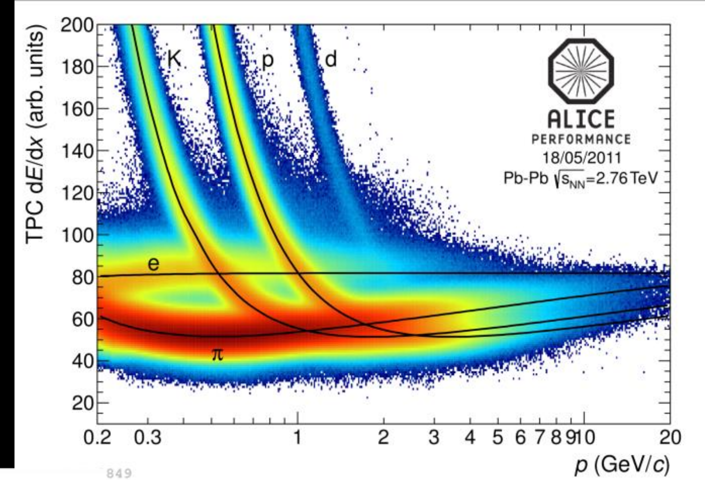
Run 3 2019 – 2021:

- proton–proton at $\sqrt{s_{pp}}$ = 14 TeV
- Upgraded ALICE detector (Calorimetry, faster read-out, new beam pipe, different Internal Tracking System etc.)
- New Trigger Detectors

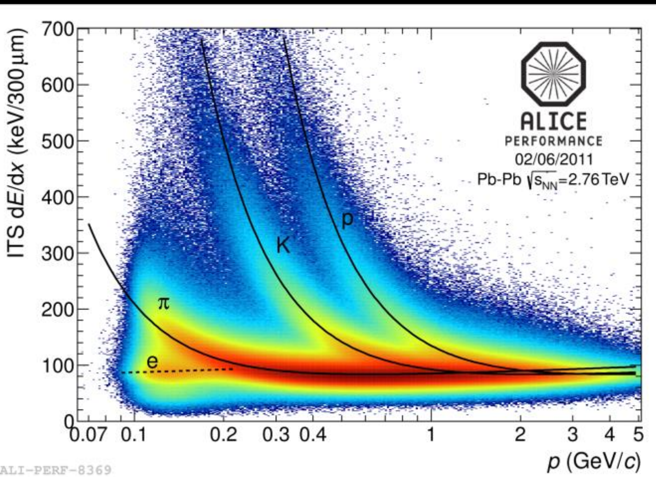
all known techniques for particle identification:

inclusive and exclusive particle production in centrally produced systems, in various channels …

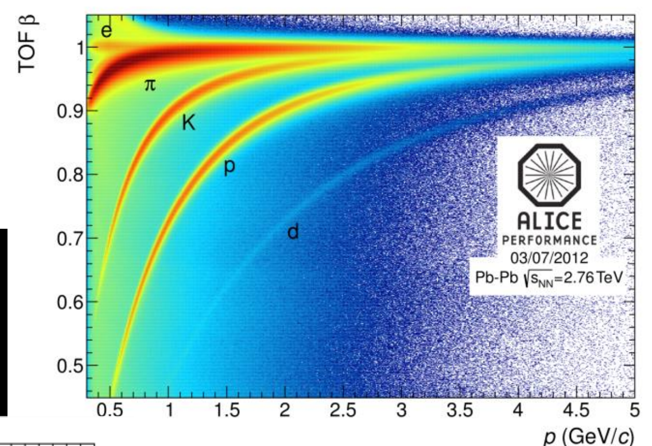
in progress



TPC

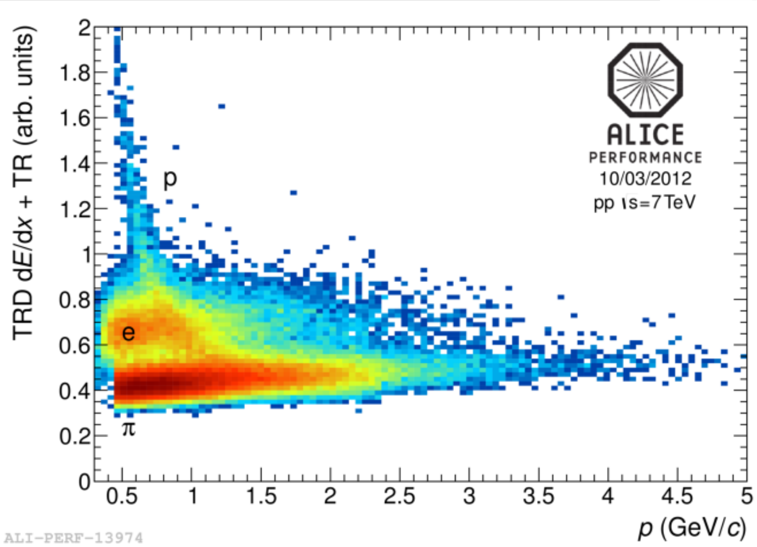


ITS

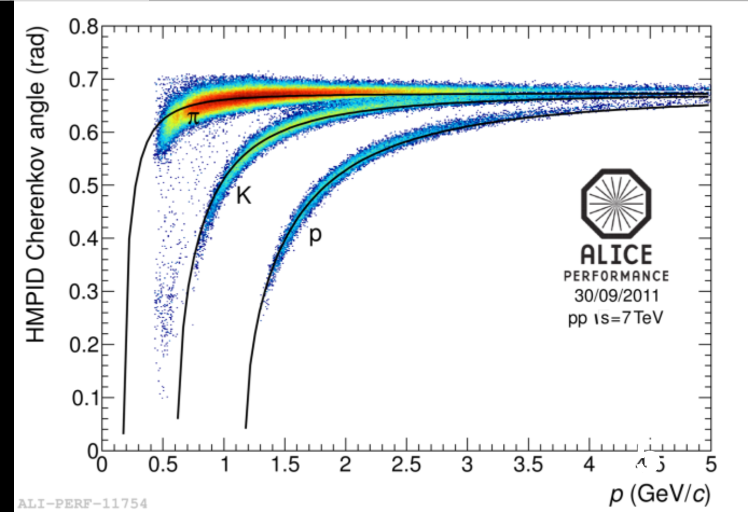


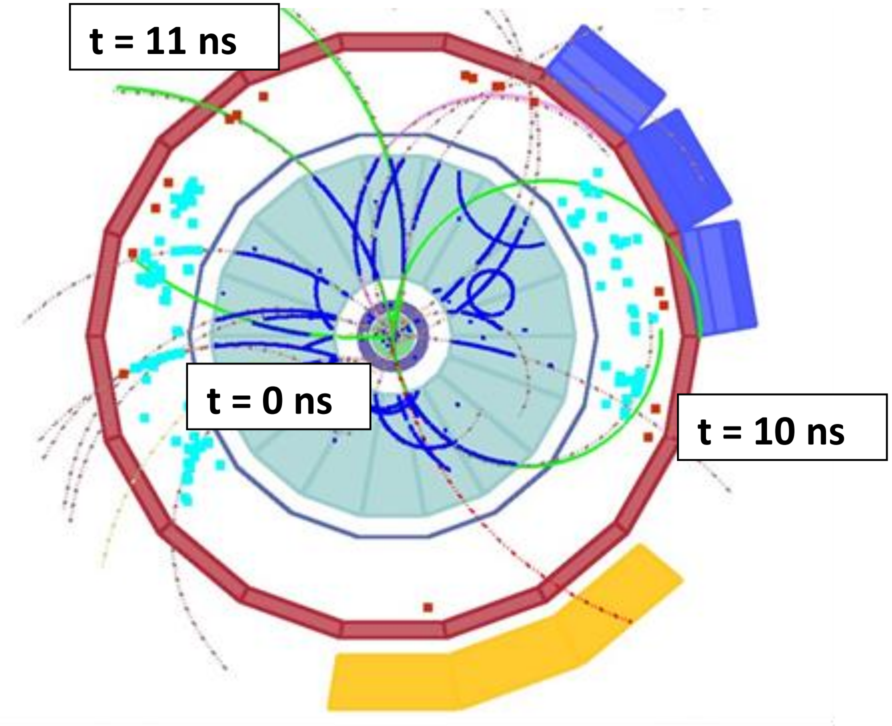
TOF

HMPID



TRD



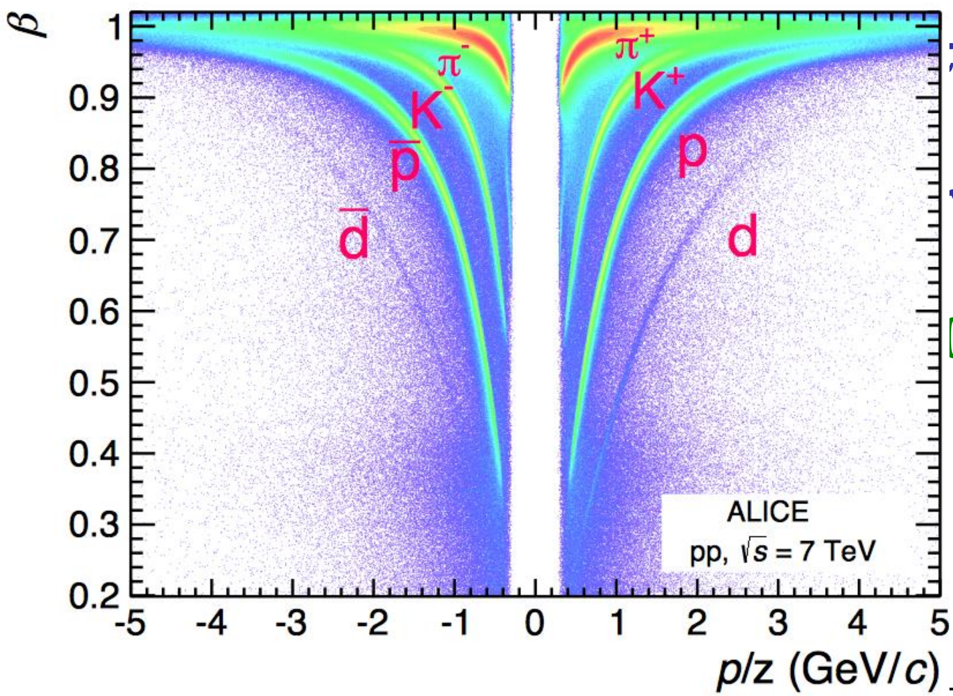


Resolución 80 ps

all known techniques for particle identification:

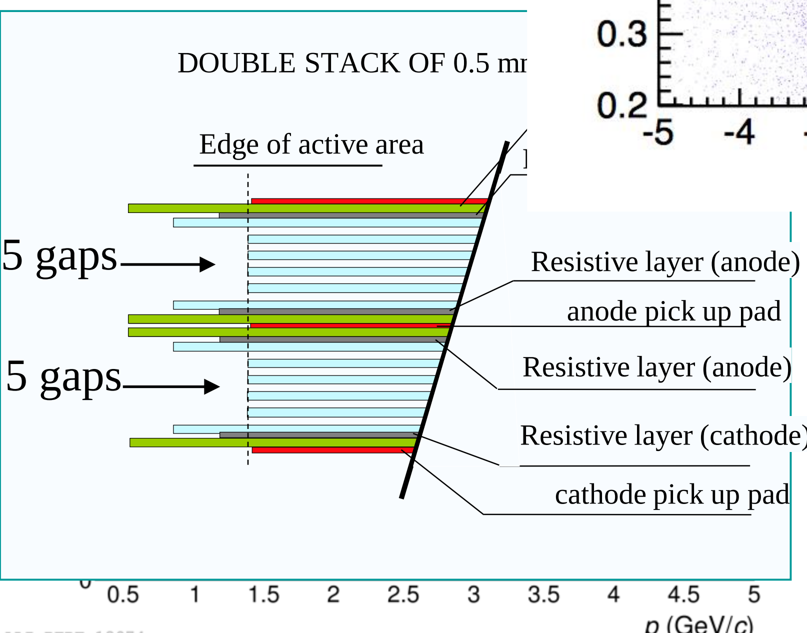
Time Of Flight

Multigap Resistiv
Plate
Chambers



, K, p PID
for p <2 GeV/c
p <4 GeV/c

.9 < η < 0.9
full ϕ

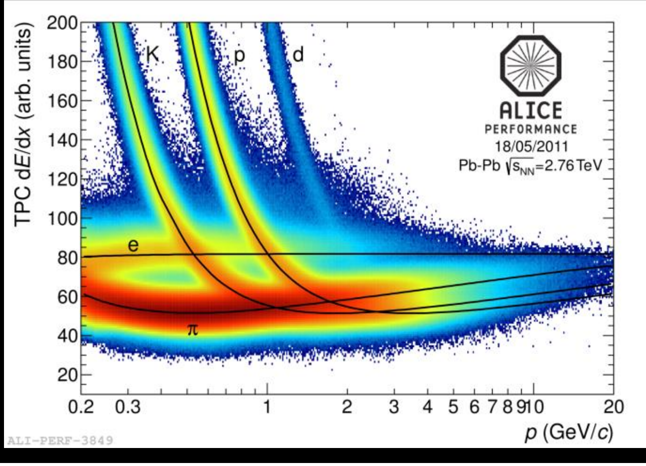


$$\Delta t = \frac{L}{\beta_1 c} - \frac{L}{\beta_2 c} = \frac{L}{c}\left(\sqrt{1+\left(\frac{m_1 c}{p}\right)^2} + \sqrt{1+\left(\frac{m_2 c}{p}\right)^2}\right)$$

Si $\quad p^2 \gg m^2c^2$

$$\Delta t \sim \frac{m_1^2 - m_2^2}{2p^2} Lc$$

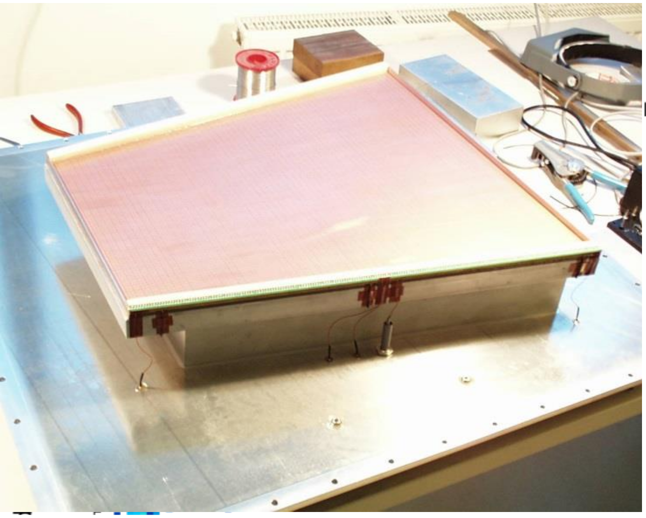
all known techniques for particle identification:

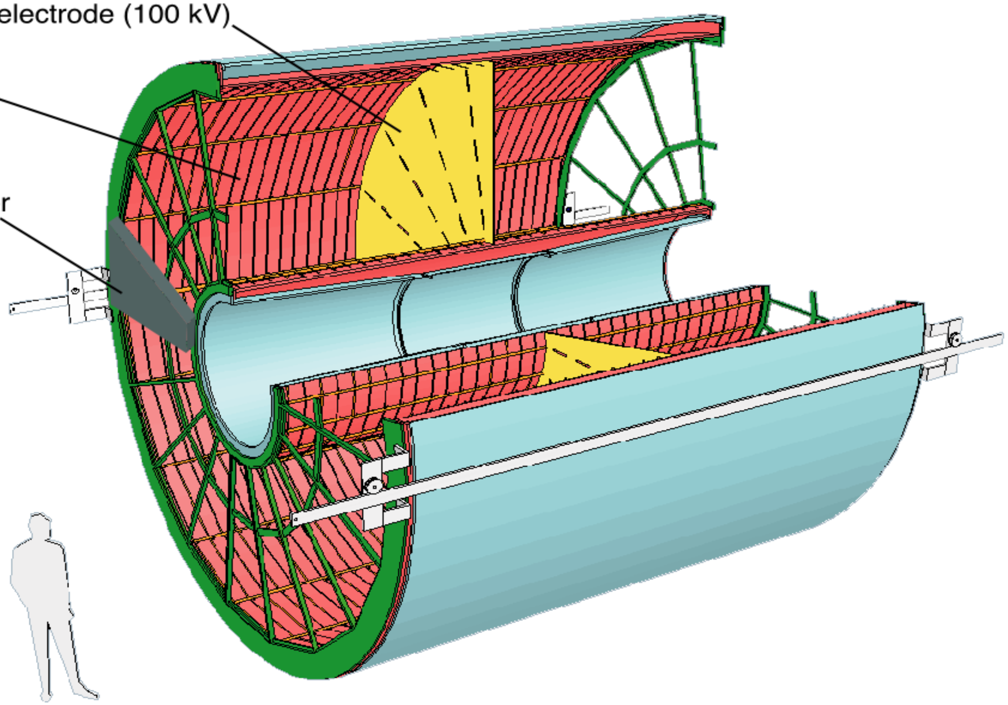


for tracking and PID via dE/dx

drift gas
90% Ne - 10%CO_2

$-0.9 < \eta < 0.9$





Time Projection Chamber
largest ever: 88 m^3, 570 k channels

nature physics

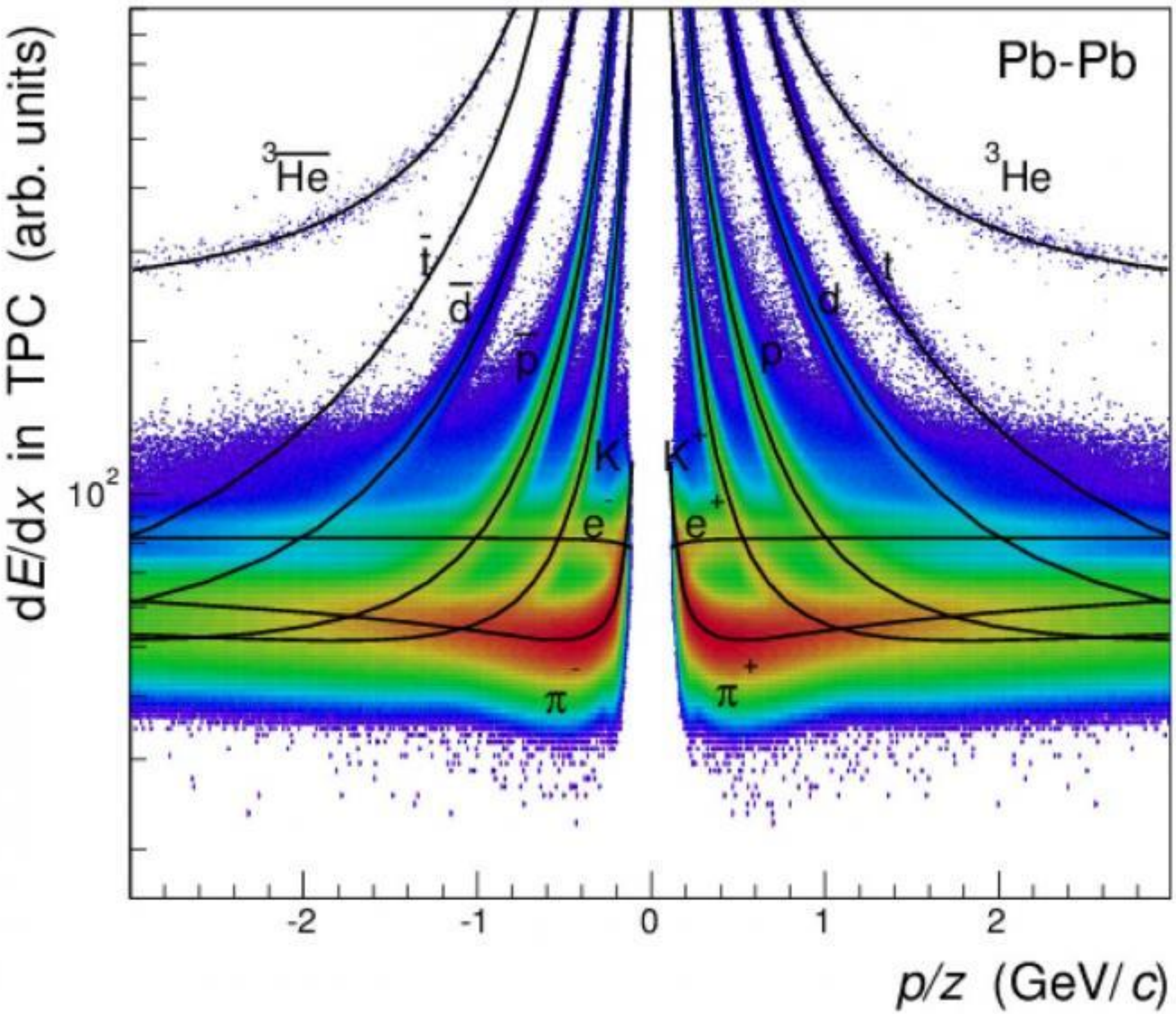
NATURE PHYSI

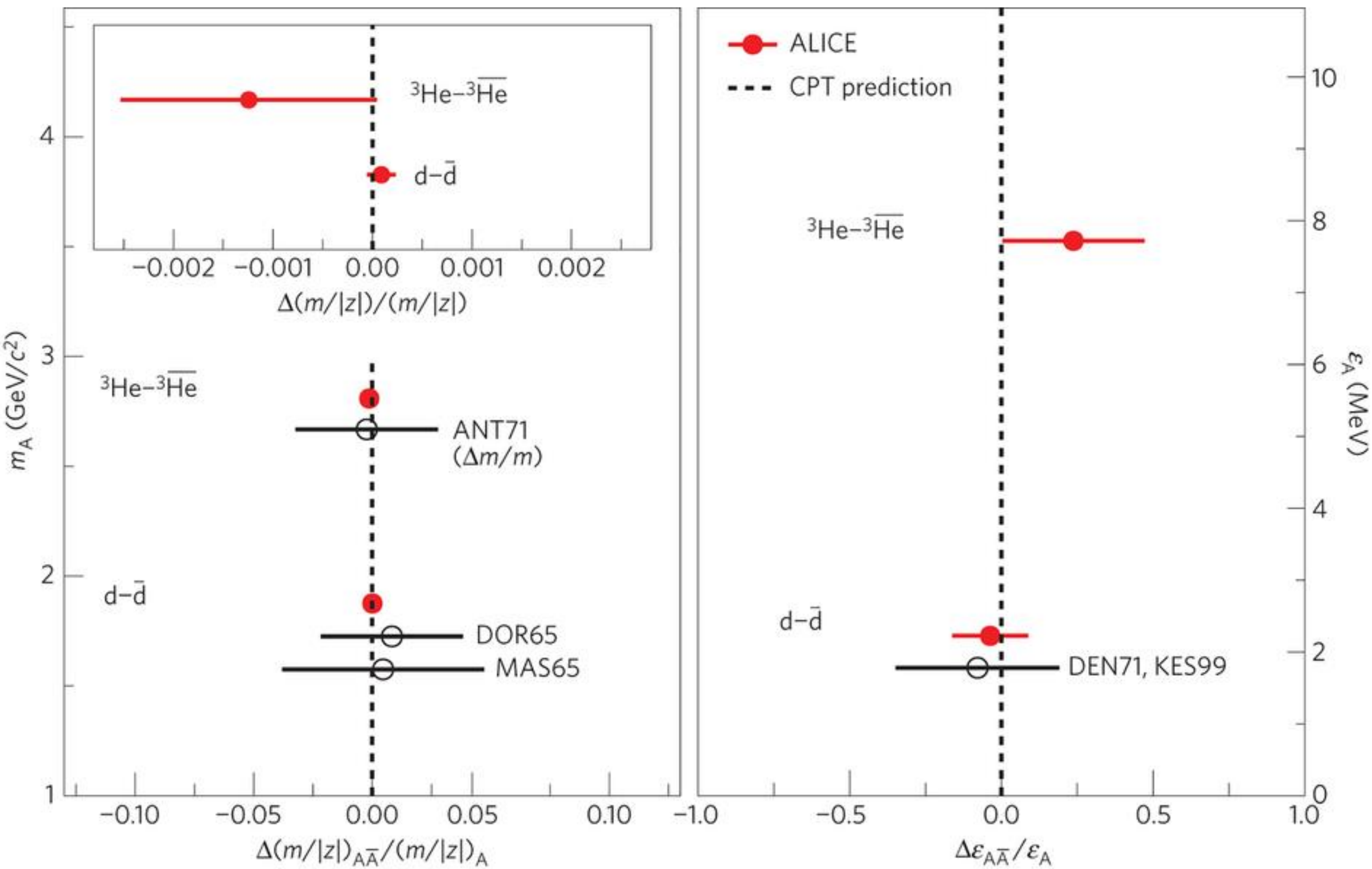
Precisior
between

ALICE Collabo

Affiliations | C

Nature Physics
Received 02 Ma

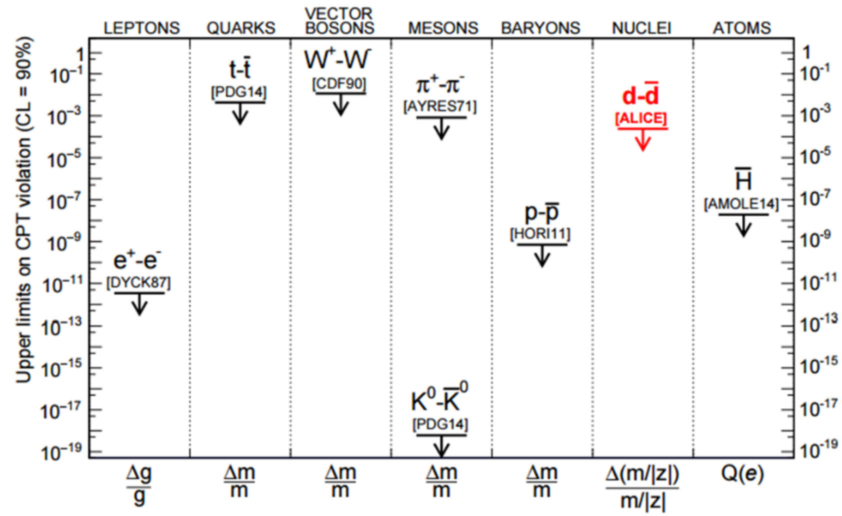




³He–³He̅
d–d̄
−0.002
−0.001
0.00
0.001
0.002
Δ(m/|z|)/(m/|z|)
m_A (GeV/c²)
4
3
2
1
³He–³He̅
ANT71
(Δm/m)
d–d̄
DOR65
MAS65
−0.10
−0.05
0.00
0.05
0.10
Δ(m/|z|)_AĀ/(m/|z|)_A
ALICE
CPT prediction
³He–³He̅
d–d̄
DEN71, KES99
−1.0
−0.5
0.0
0.5
1.0
Δε_AĀ/ε_A
ε_A (MeV)
10
8
6
4
2
0

CPT invarianz established 1955 by independentely **Wolfgang Pauli** **Gerhart Lüders**

P & CP breaks , but CPT does not .



A theory is CPT invariant if:

- Invariant before Lorenz transformations
- Causality
- Locality

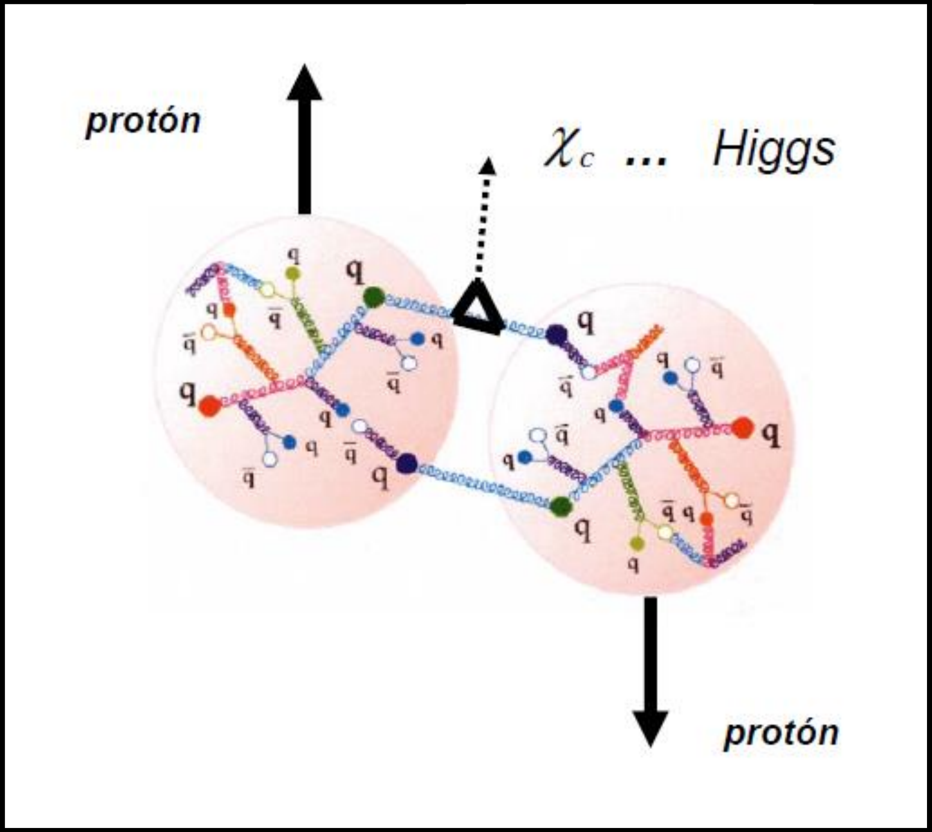
V.A. Kostelecky, N. Russell: *Data tables for Lorentz and CPT violation*. In: *Reviews of Modern Physics*. 83, Nr. 1, 2013, S. 11–31. arXiv:0801.0287. Bibcode: 2011RvMP...83...11K. doi:10.1103/RevModPhys.83.11.

ALICE

&

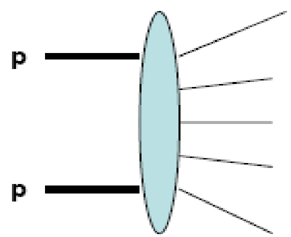
Diffractive Physics

Diffractive Physics

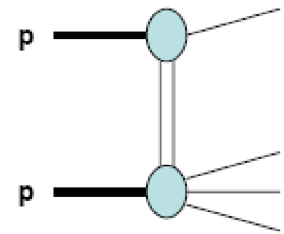


Diffractive and Non Diffractive Interactions

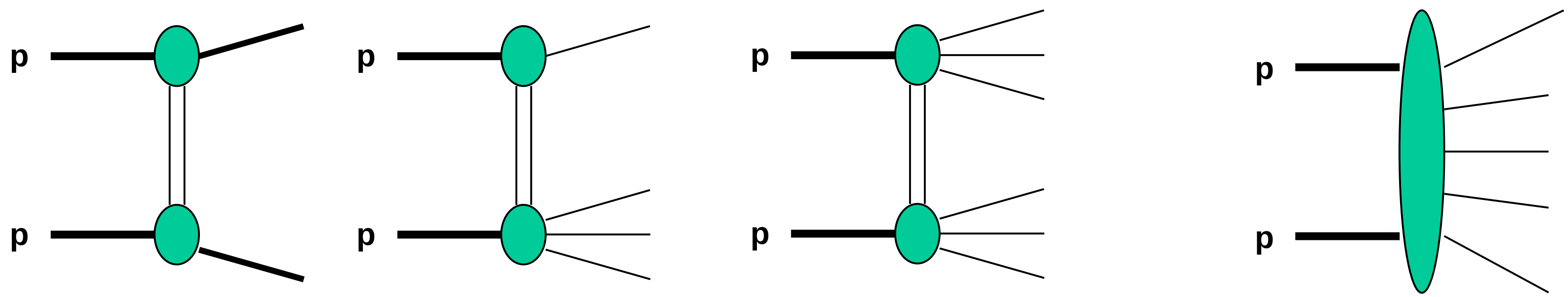
non diffractive → no gaps
color exchange



diffractive → gaps
colorless exchange



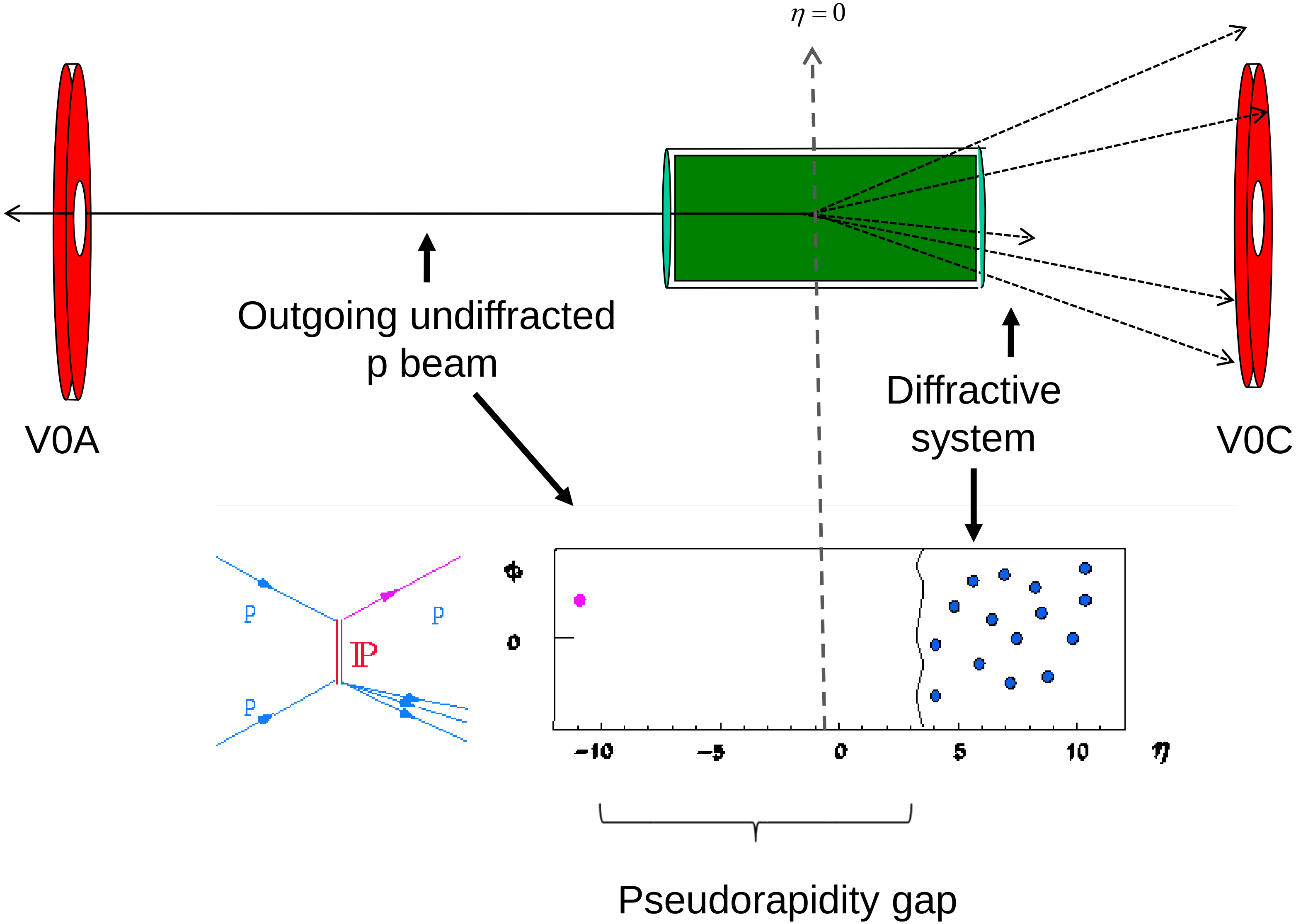
$$\sigma_{tot} = \sigma_{elastic} + \sigma_{single-diffractive} + \sigma_{double-diffractive} + \cdots + \sigma_{non-diffractive}$$



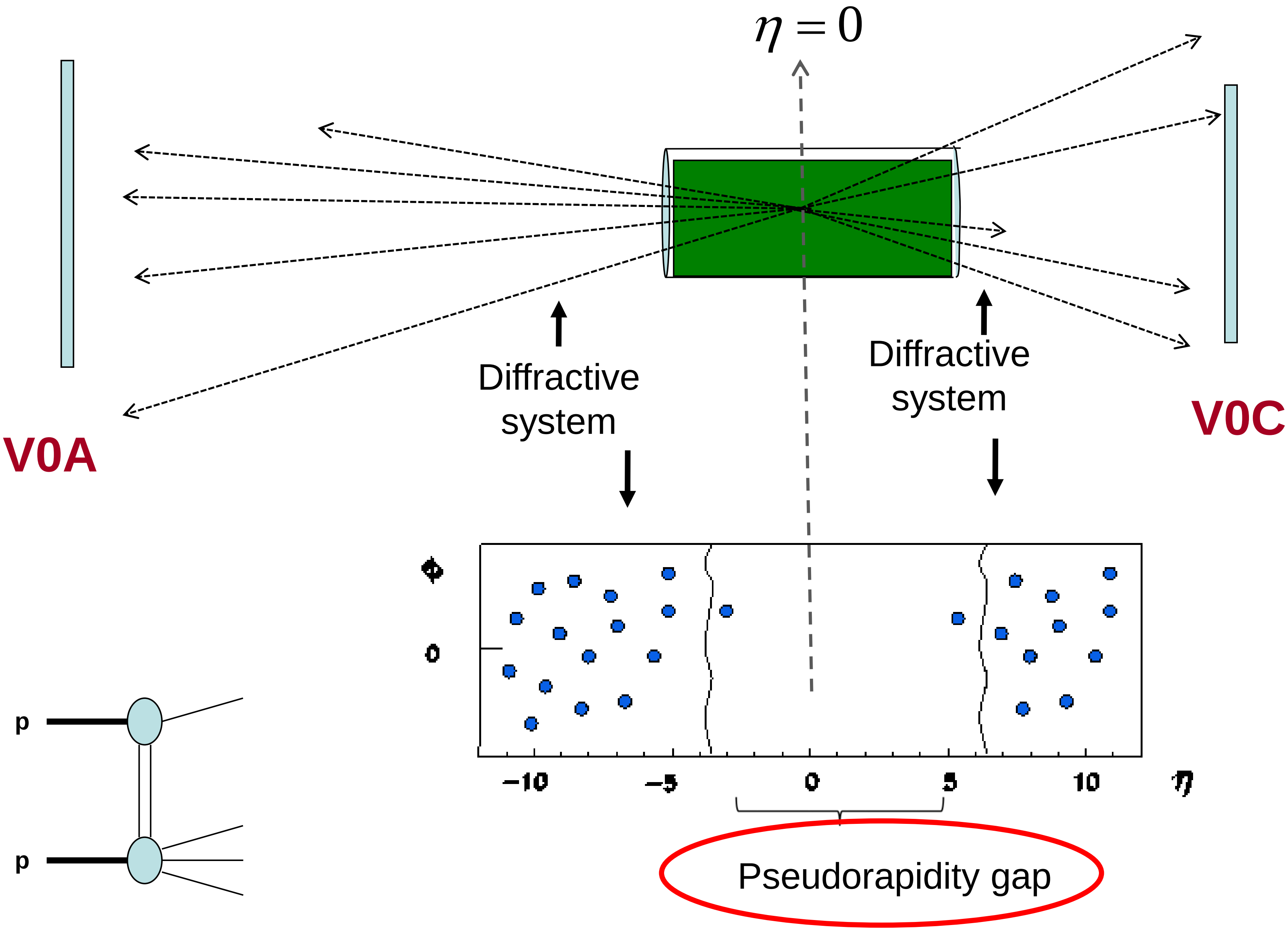
- True cross sections at LHC energies are not known
- Scaling of cross sections with energy is model dependent

PHOJET	Default fractions	PYTHIA
0.134	SD	0.187
0.063	DD	0.127

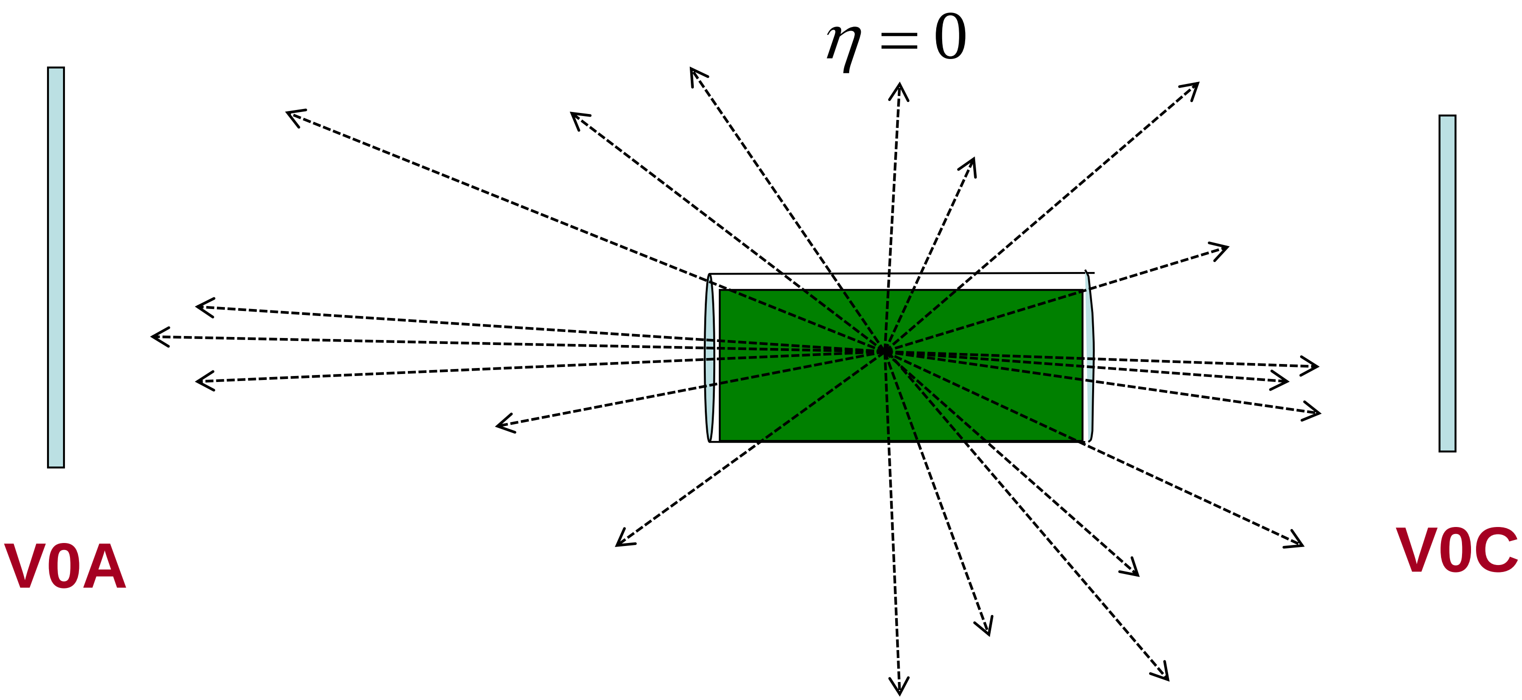
Single Diffraction (SD)

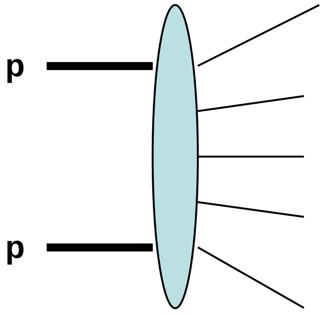


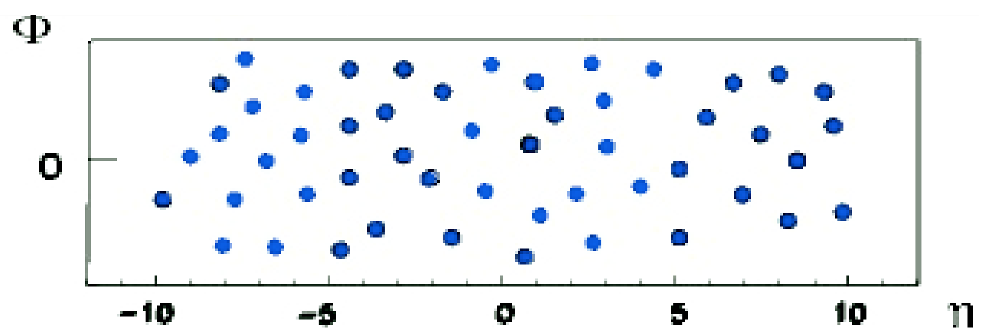
Double Diffraction (DD)



Non Diffractive (ND)



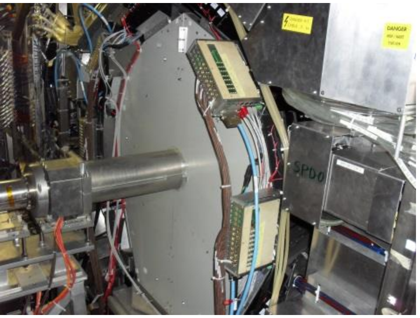




No pseudorapidity gap

Instrumentation for diffractive physics in ALICE - today

VZEROA

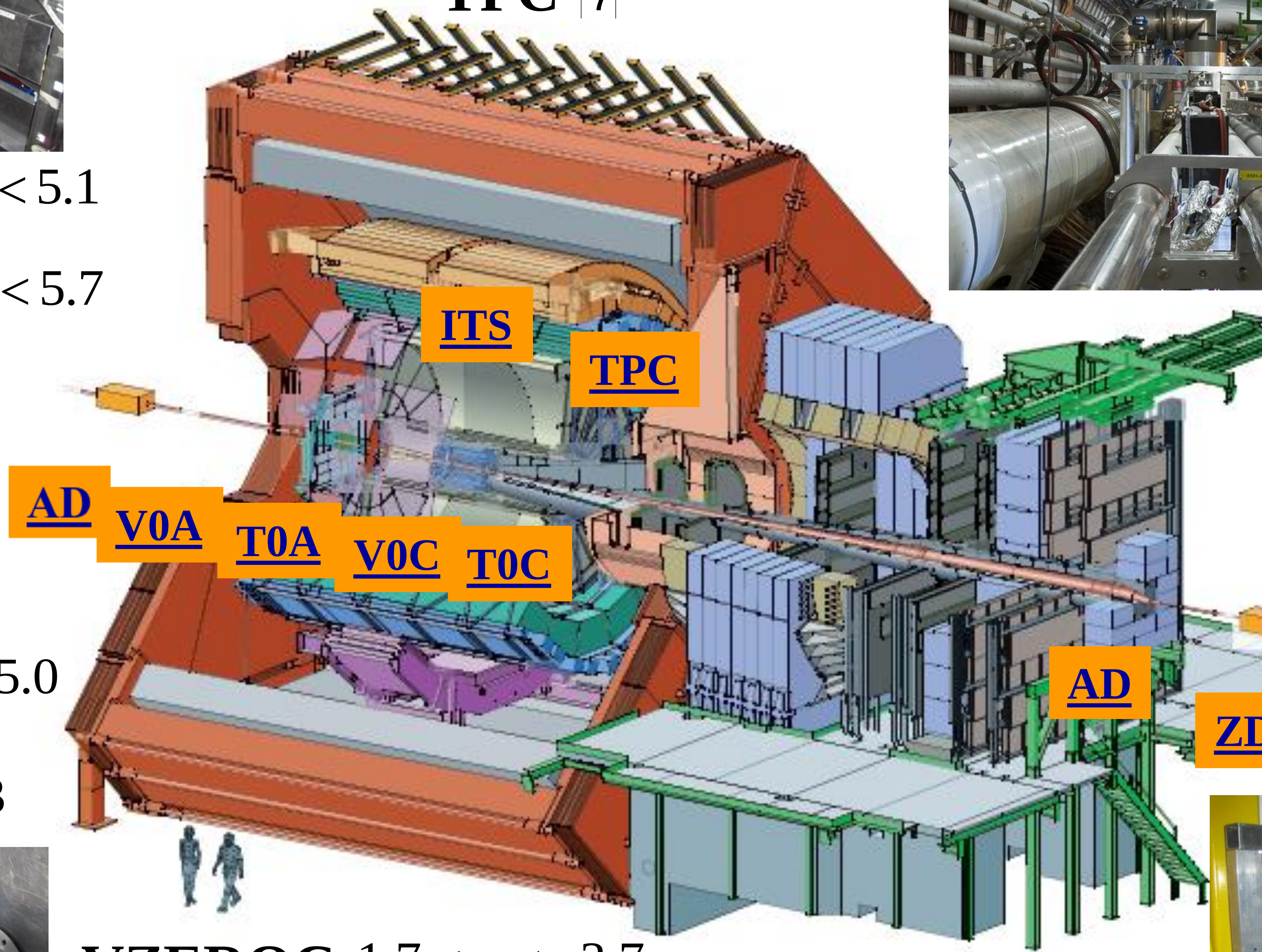


$2.8 < \eta < 5.1$

ZN $|\eta| > 8.7$ **ZP** $|\eta| > 8.4$

TPC $|\eta| < 0.9$

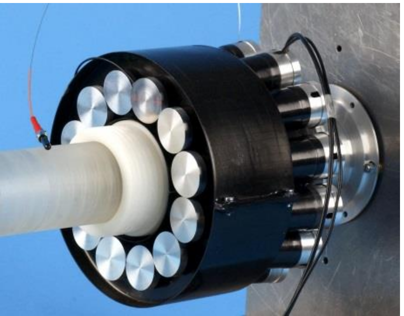
ZEM $4.8 < \eta < 5.7$



ITS
$|\eta| < 1.4$
$|\eta| < 2.0$

T0A $4.5 < \eta < 5.0$

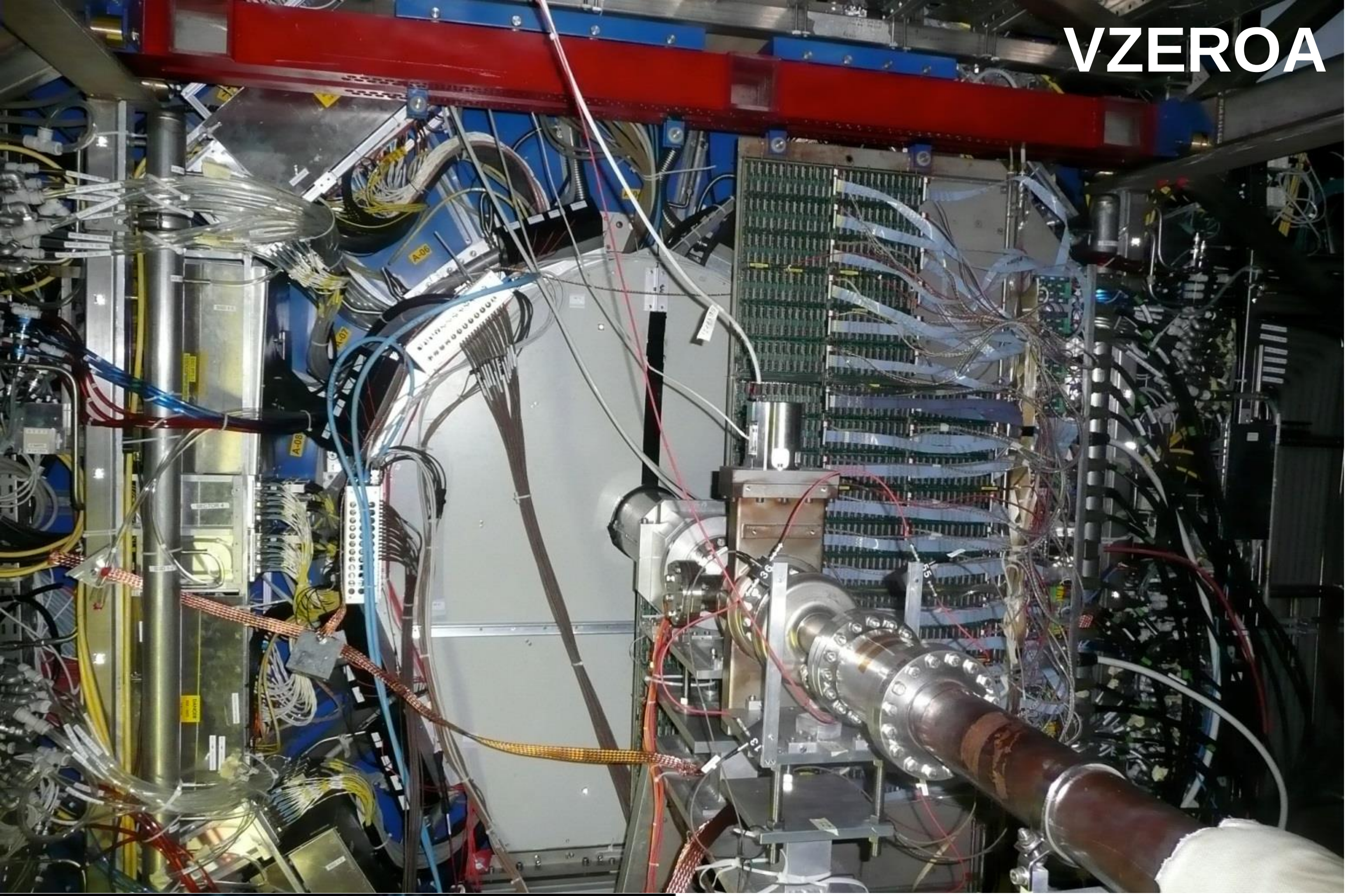
T0C
$-2.9 < \eta < -3.3$



VZEROC $-1.7 < \eta < -3.7$

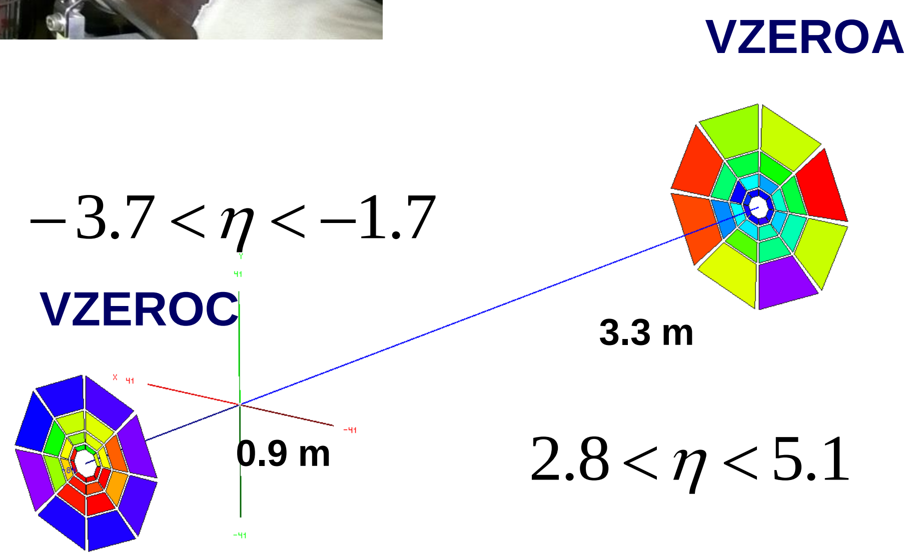
FMD $1.7 < \eta < 5.0 \quad -3.4 < \eta < -1.7$

ADD $-4.9 < \eta < -6.0$



- Trigger
- Centrality measurement
- Beam Gas suppresion
- Event plane determination

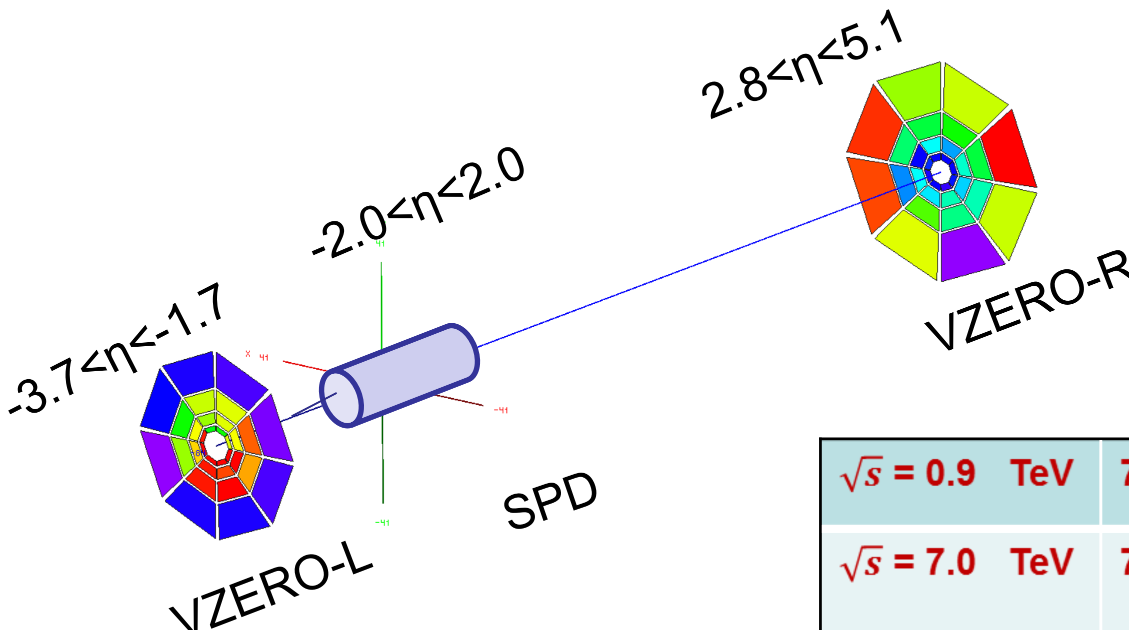
$-3.7 < \eta < -1.7$



$2.8 < \eta < 5.1$

Event samples

- Data at three energies : $\sqrt{s}$ = 0.9 2.76 7 TeV
- Low luminosity, low pile-up:
  average number of collisions per bunch crossing = 0.1
- Trigger used: Minimum Bias – OR i.e.
  at least one hit in SPD or VZERO
- VZERO signal should be in time with particles produced in the collisions



DATA

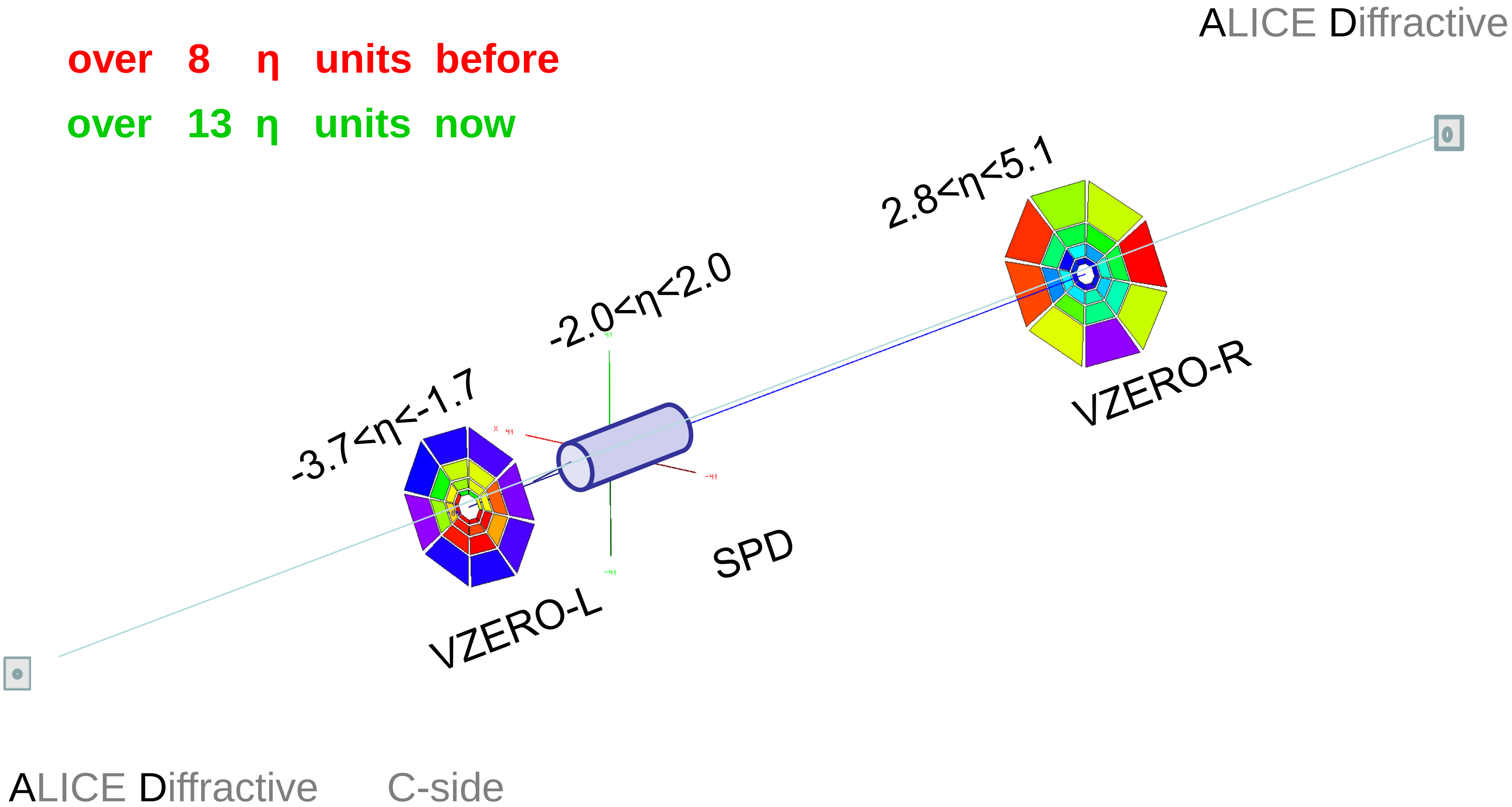
$\sqrt{s}$ = 0.9 TeV	7 $\times 10^6$ events
$\sqrt{s}$ = 7.0 TeV	75 $\times 10^6$ events
$\sqrt{s}$ = 2.76 TeV	23 $\times 10^6$ events

- Filled and empty bunch buckets used to measure beam induced background, accidentals due to electronics noise and cosmic showers

Minimum Bias Trigger - OR

over 8 η units before

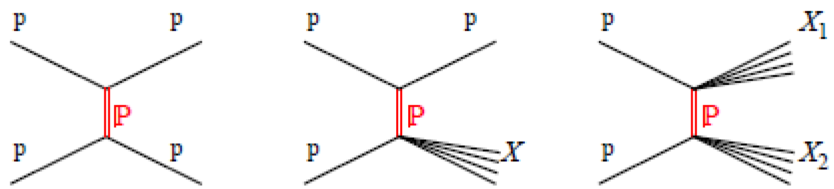
over 13 η units now



Summary of measurements on Diffractive Physics

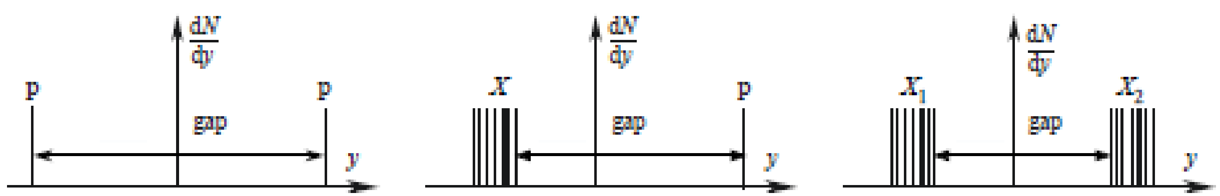
Measurements of Diffractive and Inelastic Cross Section

Eur. Phys.J. C73 (2013) 2456



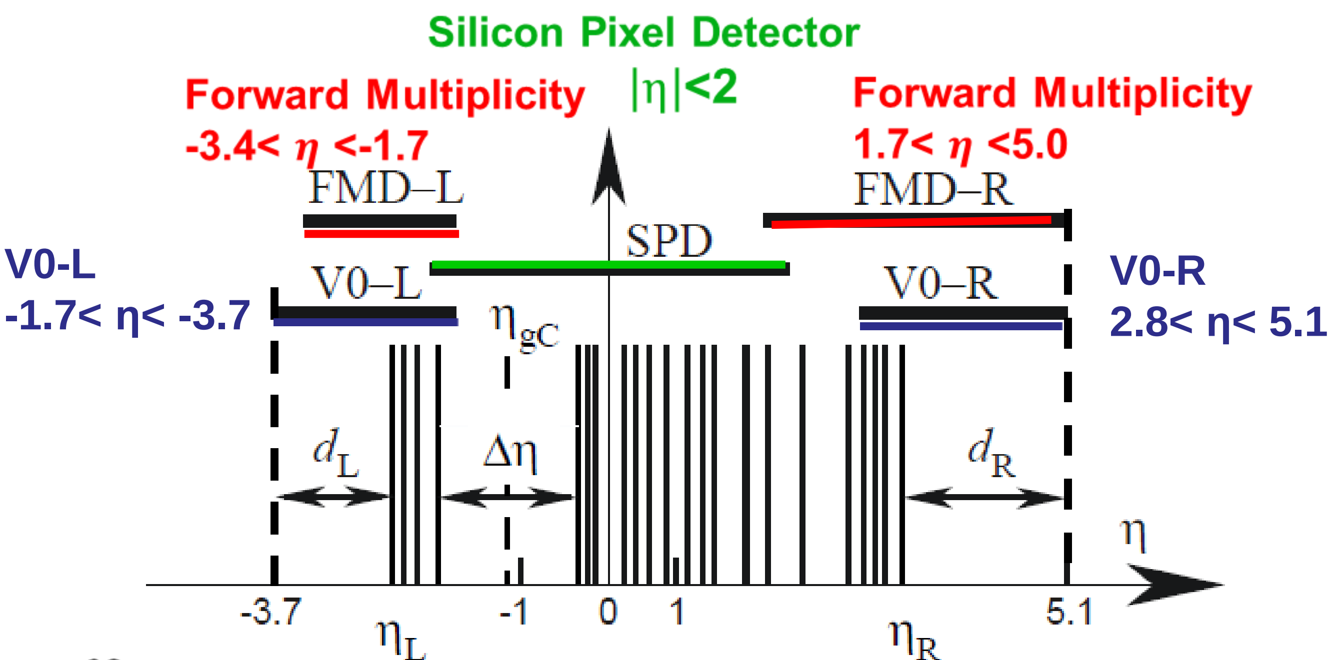
theory

elastic - single - double - diffractive proton-proton scattering



experiment

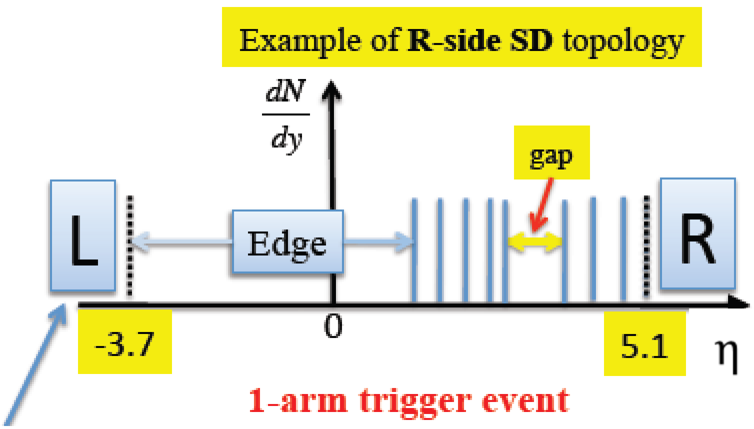
ALICE

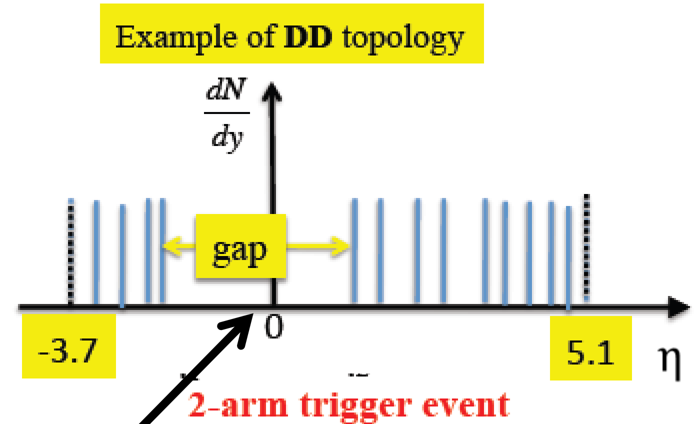


$$\eta_c = \frac{1}{2}(\eta_L + \eta_R)$$

η_L **lowest-** η_R **highest - pseudorapidity**

offline event clasification: “1 arm-L” “1 arm-R” “2 arm”





muon spectrometer

$$\eta_C = \frac{1}{2}(\eta_L + \eta_R)$$

$\eta_C < 0$	1-arm-L
$\eta_C > 0$	1-arm-R

if largest $\Delta\eta > d_L$ and d_R	2-arm
if both $-1 \leq \eta_L$ and $\eta_R \leq 1$	2-arm

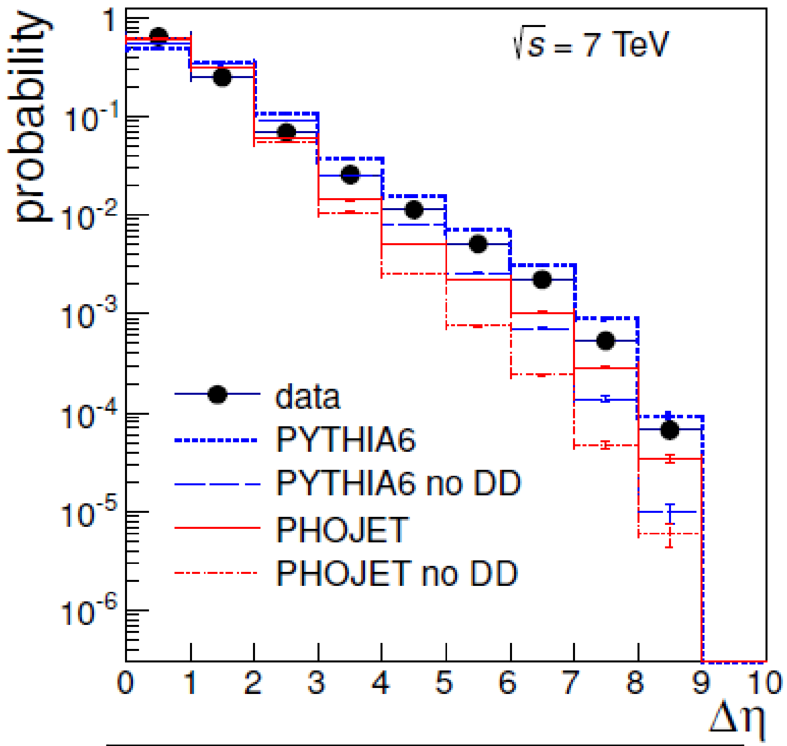
If	$\eta_R < 1$	1-arm-L
If	$\eta_L > -1$	1-arm-R

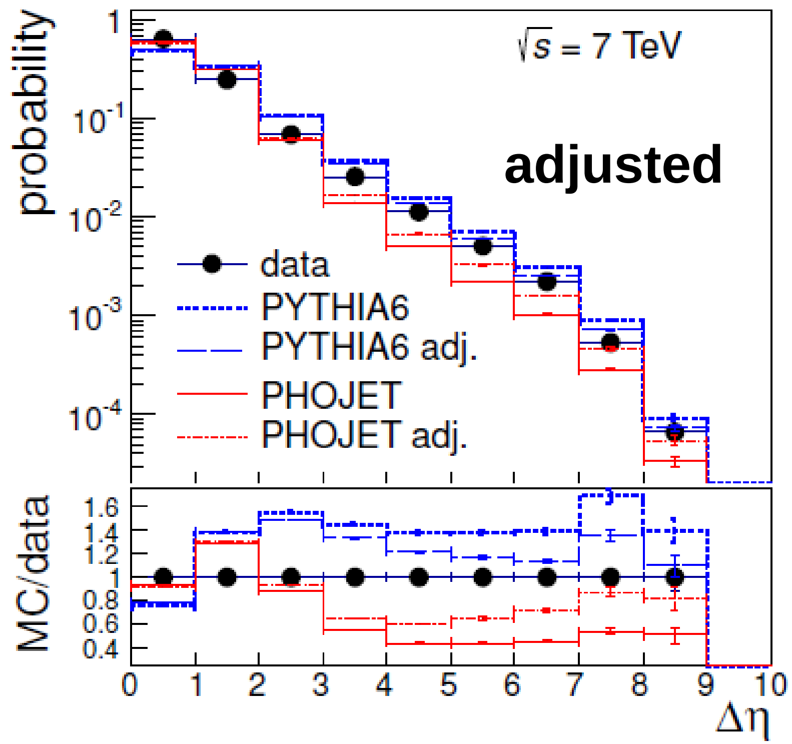
arXiv:1208.4968 [hep-ex]

2-arm events

largest $\Delta\eta$

tuning PYTHIA and PHOJET double diffraction to experimental width distribution of two arm events





$\sqrt{s}$ TeV	PYTHIA	PHOJET
0.9	0.12	0.06
7.0	0.13	0.05

→

$\sqrt{s}$ TeV	PHYTIA tuned	PHOJET tuned
0.9	0.10	0.11
7.0	0.09	0.07

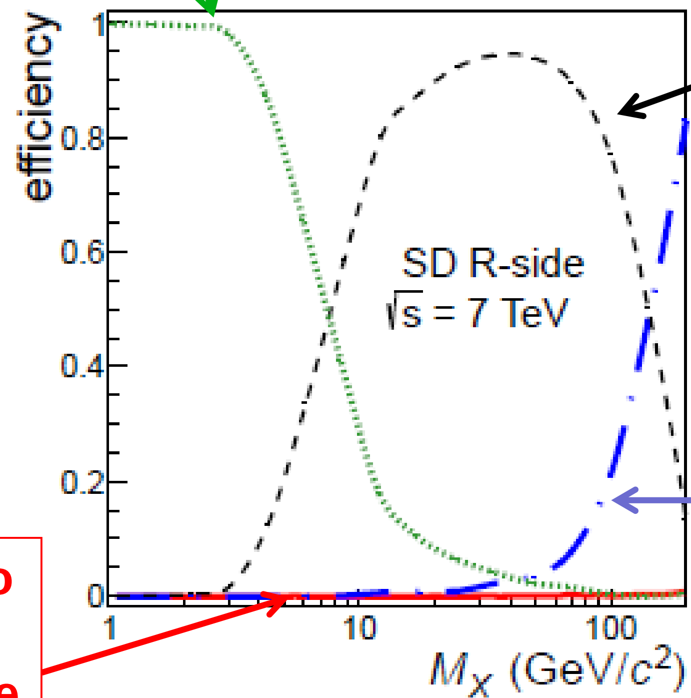
- **Once DD is chosen the ratios 1-arm-L and 1-arm-R to 2-arm can be used to compute SD fractions.**

- **efficiency/in-efficiency versus diffractive mass for SD :**

probability of not detecting

efficiency for a SD to be classified as 1-armL(R)

PYTHIA 6



efficiency to be classified as 2-arm

efficiency to be taken as the opposite

efficiencies used: mean between PYTHIA and PHOJET

efficiency of SD & NSD to be classified as 1-arm L(R), 2-arm at high energy the ratio remains constant

$\sqrt{s}$ (TeV)	ratio definition	ratio	side	$\sigma_{SD}/\sigma_{INEL}$ per side	total
0.9	1-arm-L/2-arm	0.0576 ± 0.0002	L-side	0.10 ± 0.02	0.21 ± 0.03
	1-arm-R/2-arm	0.0906 ± 0.0003	R-side	0.11 ± 0.02	
2.76	1-arm-L/2-arm	0.0543 ± 0.0004	L-side	0.09 ± 0.03	$0.20^{+0.07}_{-0.08}$
	1-arm-R/2-arm	0.0791 ± 0.0004	R-side	$0.11^{+0.04}_{-0.05}$	
7	1-arm-L/2-arm	0.0458 ± 0.0001	L-side	$0.10^{+0.02}_{-0.04}$	$0.20^{+0.04}_{-0.07}$
	1-arm-R/2-arm	0.0680 ± 0.0001	R-side	$0.10^{+0.02}_{-0.03}$	

consistent with UA5 $p\,\bar{p}$

results symmetric despite different acceptance from ALICE

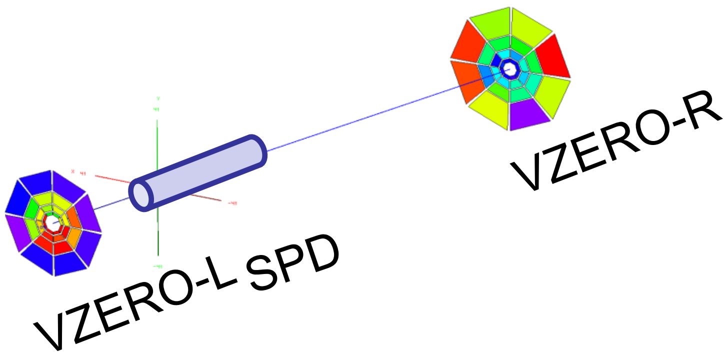
corrected for acceptance, efficiency, beam background, electronic noise and collision pileup

DD events defined as NSD with large gap

$\sqrt{s}$ (TeV)	$\sigma_{DD}/\sigma_{INEL}$
0.9	0.11 ± 0.03
2.76	0.12 ± 0.05
7	$0.12^{+0.05}_{-0.04}$

with $\Delta\eta > 3$

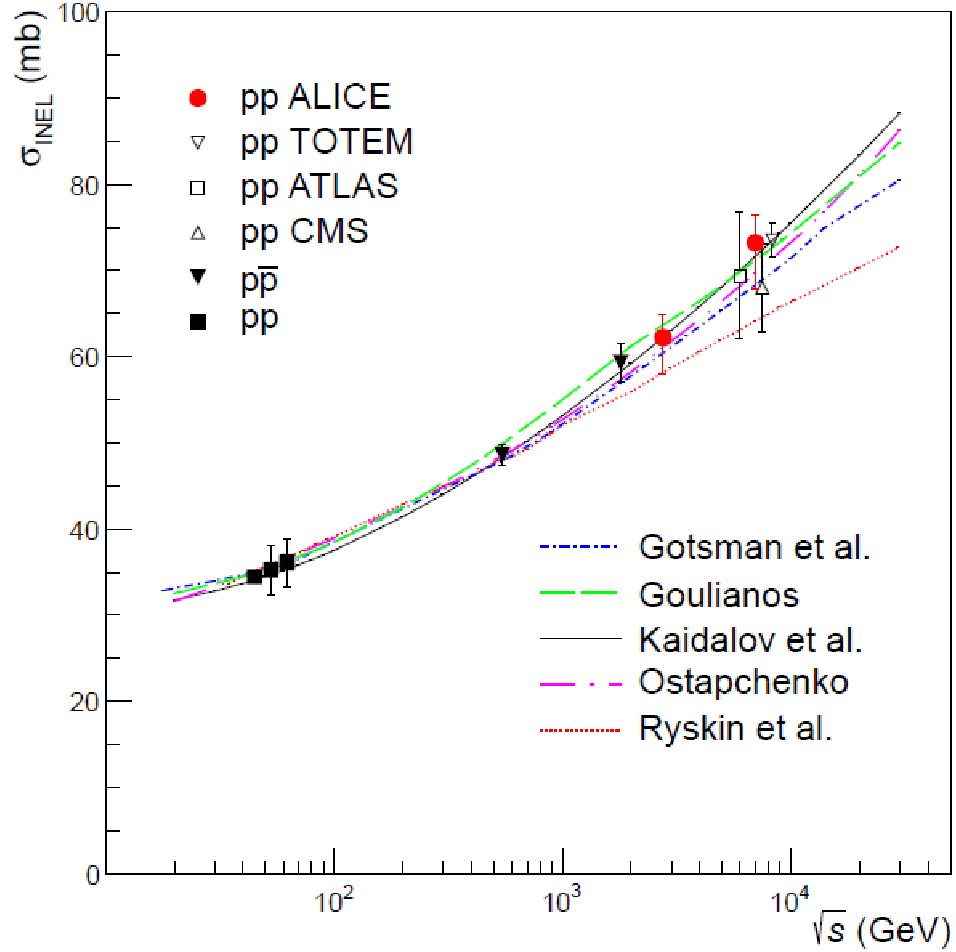
Measurement of Inelastic Cross Section



MB-and : coincidence of VZERO-L and –R in a van der Meer scan

$$\frac{dN(MBand)}{dt} = A \times \sigma_{inel} \times L$$

acc. and eff. determined with adjusted simulation



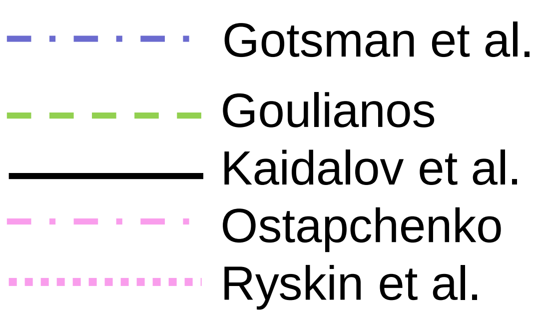
Experiment	σ_{INEL} (mb)
ALICE	$73.2^{+2.0}_{-4.6}(model) \pm 2.6(lumi)$
ATLAS [19]	$69.4 \pm 6.9(model) \pm 2.4(exp)$
CMS [20]	$68.0 \pm 4.0(model) \pm 2.0(syst) \pm 2.4(lumi)$
TOTEM [21]	$73.5^{+1.8}_{-1.3}(syst) \pm 0.6(stat)$

Measurements of Diffractive Cross Section

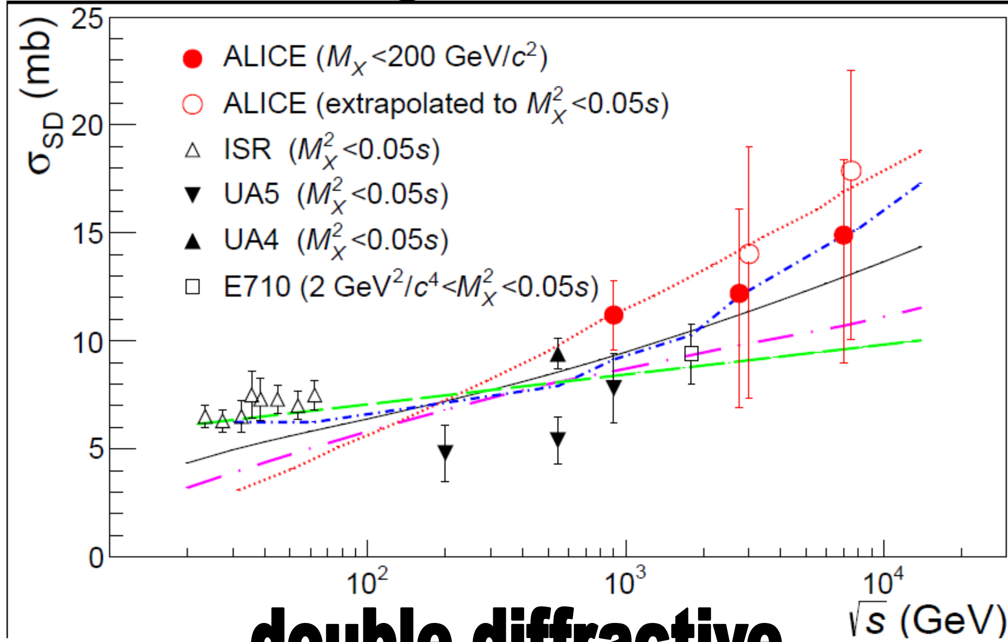
with inelastic cross section and relative rates we obtain SD and DD cross sections

for $\sqrt{s} = 0.9\ TeV$ we do not have vdM scan and σ_{inel} from UA5 was used

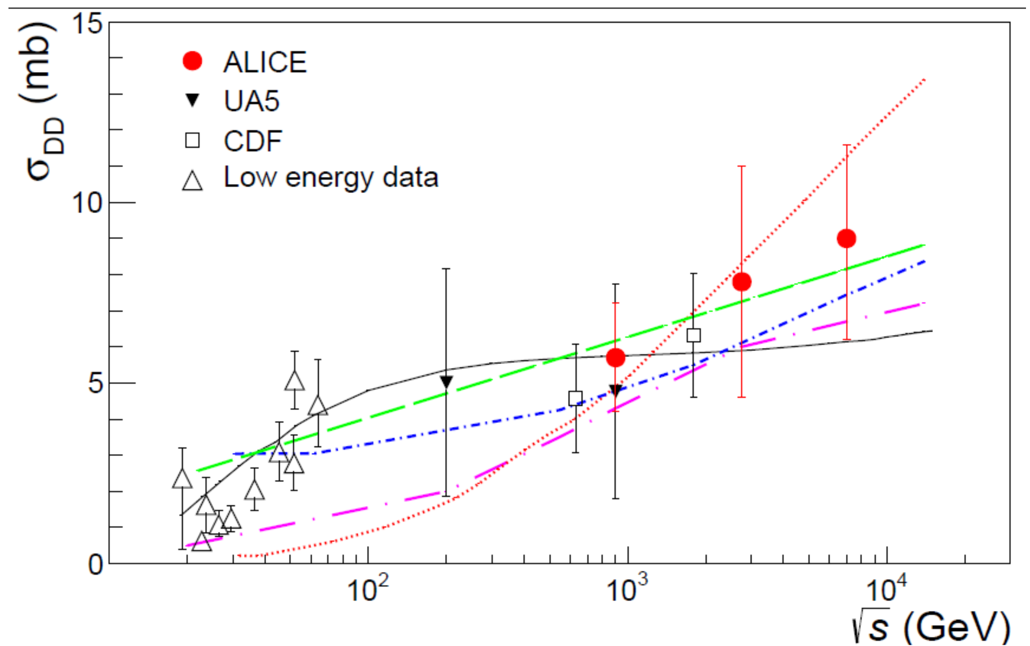
$$\sigma_{INEL} = 52.5^{+2}_{-3.3}\ mb$$



single diffractive



double diffractive



Measurement of the cross section

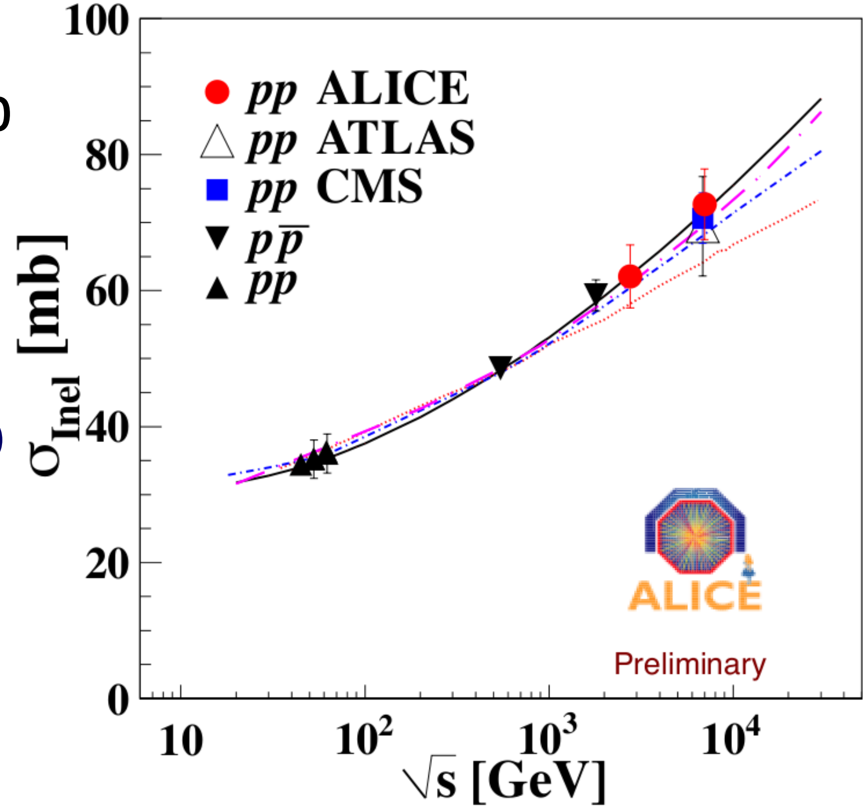
σ_{inel} proton proton @ 7 TeV

ALICE	72.7 $\pm$ 1.1 $\pm$ 5.1 mb	
ATLAS	69.4 $\pm$ 2.4 $\pm$ 6.9 mb	(arXiv:1104.0326)
CMS	70.4 $\pm$ 1.1 $\pm$ 3.5 mb	(M. Marone, DIS'11)

σ_{inel} proton proton @ 2.76 TeV

ALICE 62.1 $\pm$ 1.6 $\pm$ 4.3 mb

extrapolation 64 $\pm$ 5 mb



Gotsman et al., arXiv:1010.5323, EPJ. C74, 1553 (2011)
Kaidalov et al., arXiv:0909.5156, EPJ. C67, 397 (2010)
Ostapchenko, arXiv:1010.1869, PR D83 114018 (2011)
Khoze et al., EPJ. C60 249 (2009), C71 1617 (2011)

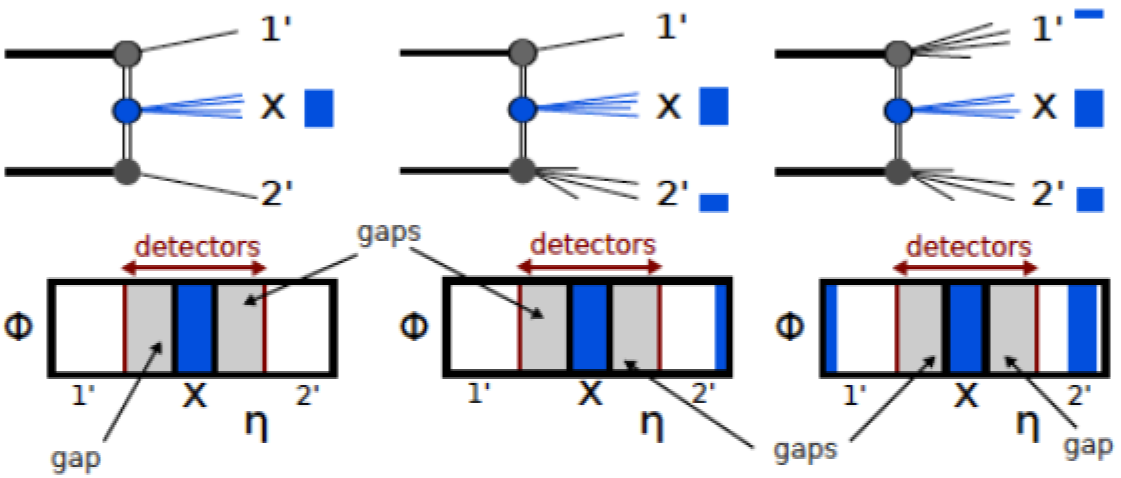
Luminosity - Van der Meer Scans

Central Diffractive Physics

Central diffraction in proton proton collisions at $\sqrt{s}$ = 7 TeV

Double Gap topology as a filter for Central Diffraction

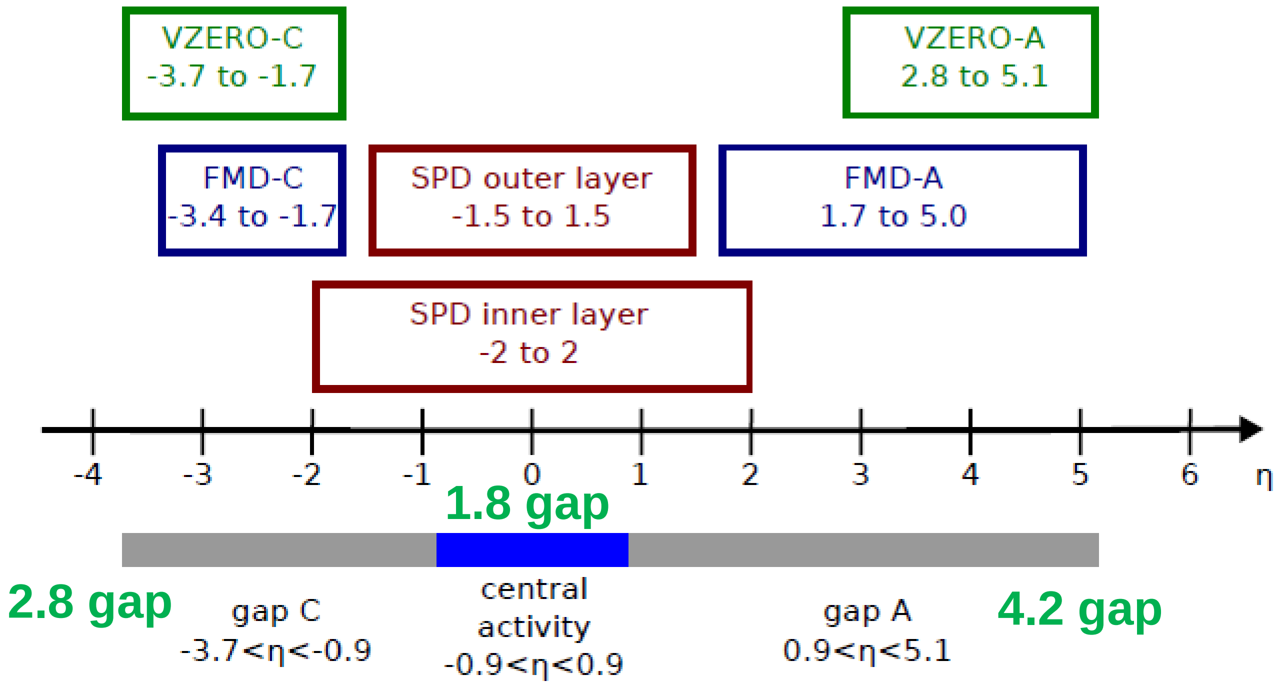
Central Diffraction | **CD with single Diffractive dissociation** | **CD with double Diffractive dissociation**



Low mass central diffractive final states decaying into a small number of particles production of meson states: glueballs, hybrids,

A search for structure in the mass spectra of exclusive decays such as $\pi^+ \pi^-$ $K^+ K^-$ $2\pi^+ 2\pi^-$ $K^+ K^- \pi^+ \pi^-$ etc.

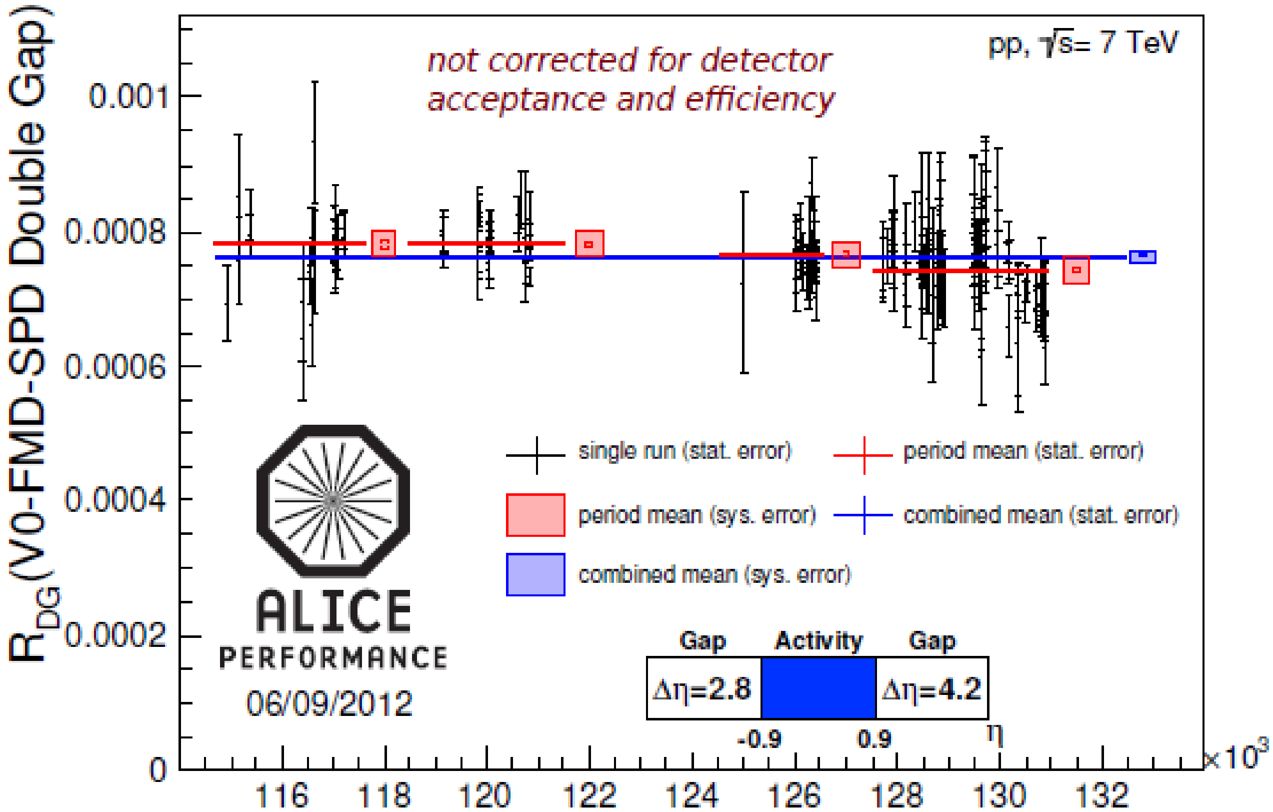
Double Gap topology



$$N_{DG} = \frac{\text{Number of Double Gap events}}{\text{Number of VZERO-L –R coincidence}}$$

Potential measure of the amount of Central Diffractive events in Minimum Bias data

Double Gap fraction in proton proton $\sqrt{s} = 7\ TeV$



systematic error estimated from the spread of the period means, doesn't include detector effects

- fraction uniform over several data taking periods

Next:

turn it into a cross section

$$\frac{N_{DG}}{N_{\text{MBand}}} = (7.63 \pm 0.02(stat.) \pm 0.95(syst.)) \cdot 10^{-4}$$

we are exploring the invariant mass distribution

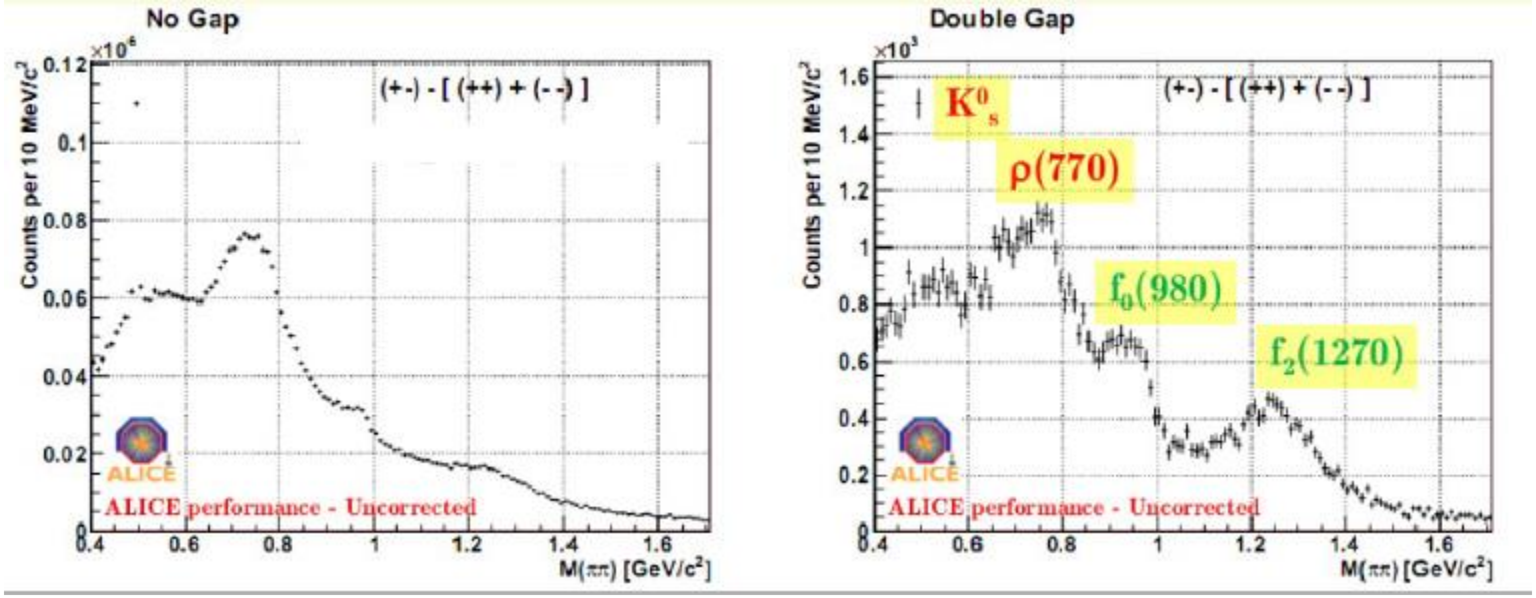
2011 data

361 M events with the Minimum Bias Trigger

32.3 M events with primary vertex and exactly 2 tracks in the TPC+ITS

29.2 M events with no gaps

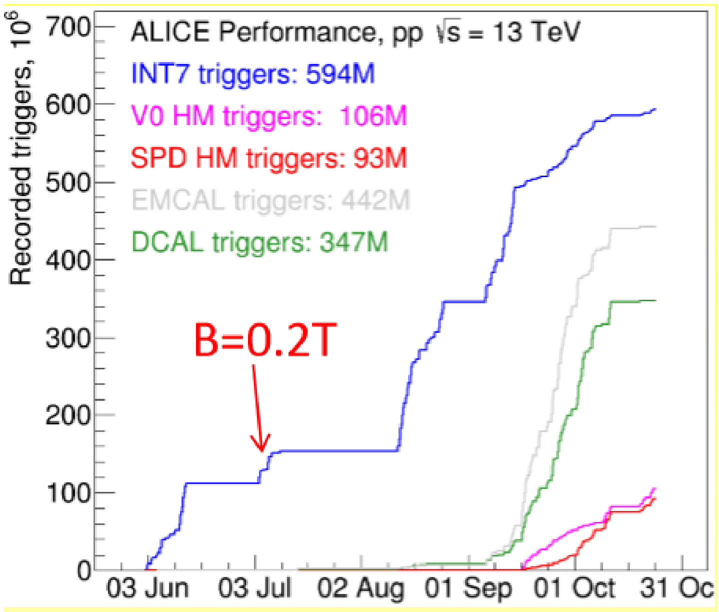
Exclusive resonance production in proton proton at 7 TeV cms

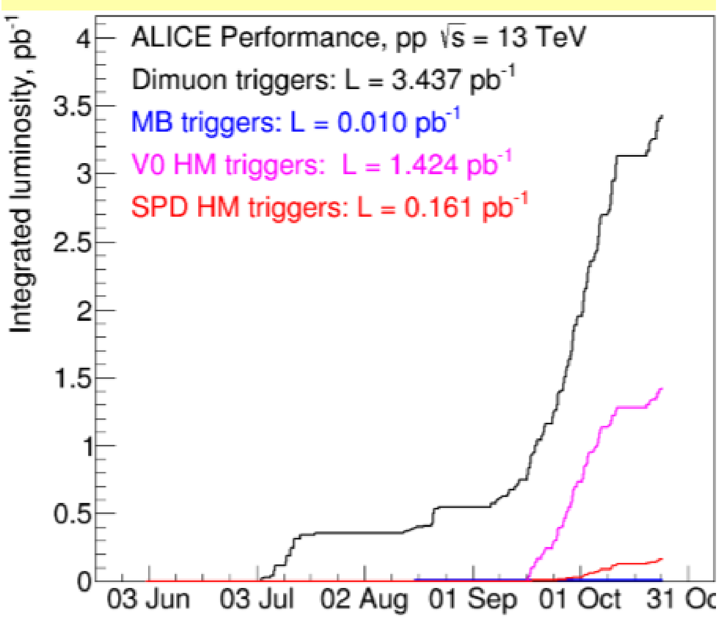


M_{inv} for two track events with-out gaps.

M_{inv} for two track events with gaps on both sides

Data Taking 2015





- Isolated bunches:

diffractive data taking with global OR triggers: (V0 | AD | ZDC |SPD).
Planned 100M, **Collected 165 M**

- 50ns ramp-up: muon data taking.

- 25ns ramp-up: minimum bias data taking at low μ. Muon data taking in parallel.
Collected up to now 587M, Planned 600M

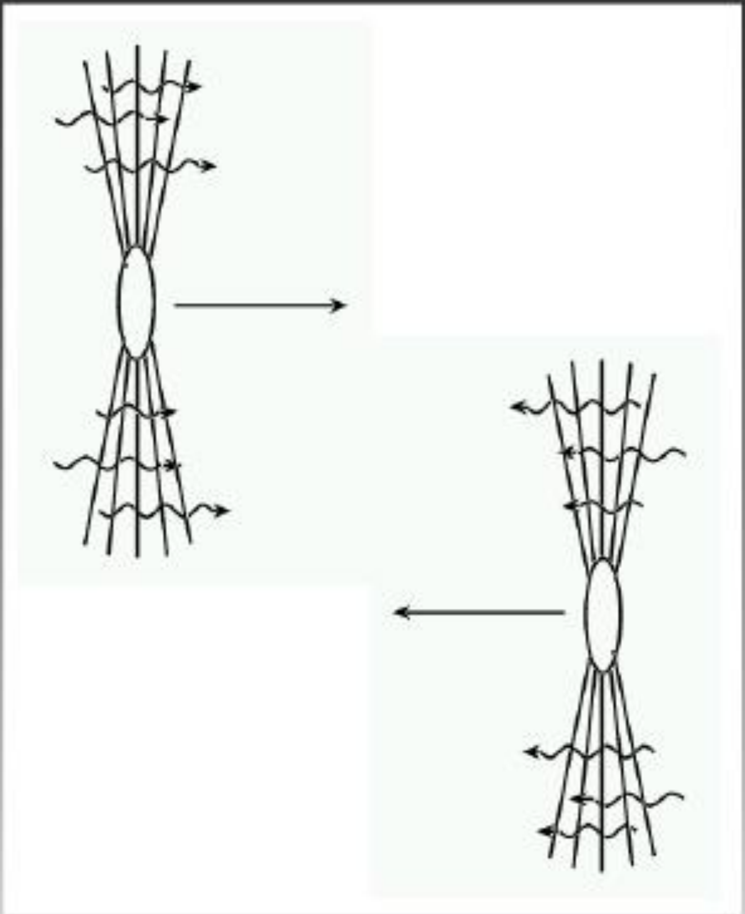
- 90m run:

diffractive data taking ~250 nb-1 of integrated lumi with ~30 nb-1 double gap diffractive triggers (preliminary estimations)

now: taking data at 5 Hz/mb with rates up to 300 kHz with rare triggers.
Target 2015 statistics:
– 4pb-1 muon triggers
– 2pb-1 high multiplicity triggers

Studies in Ultra Peripheral Colisions

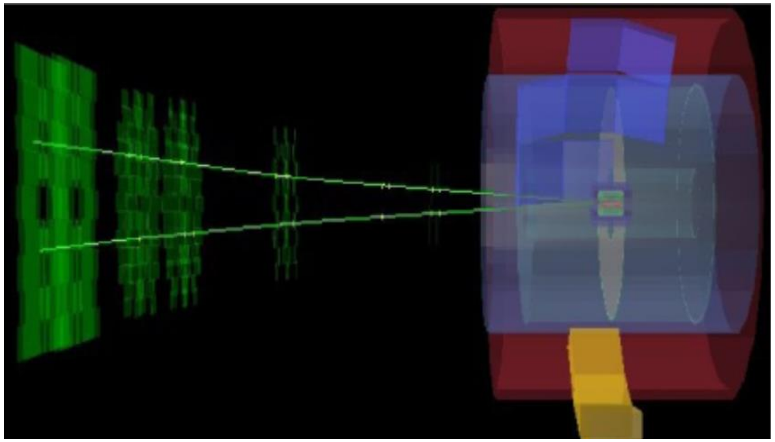
Ultra-peripheral heavy-ion collisions



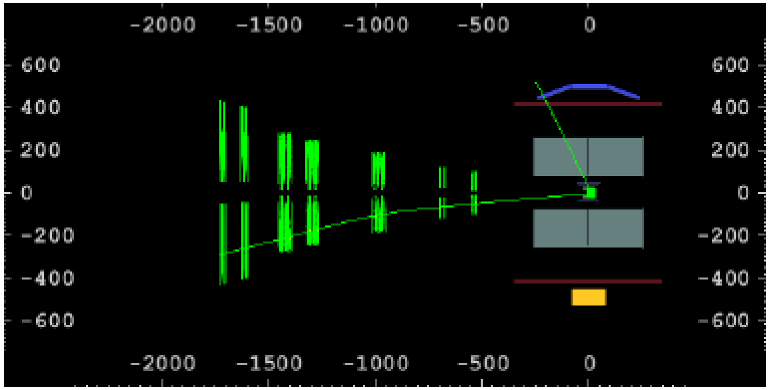
Two ions (or protons) pass by each other with impact parameters $b > 2R$

Only Electromagnetic interactions are possible

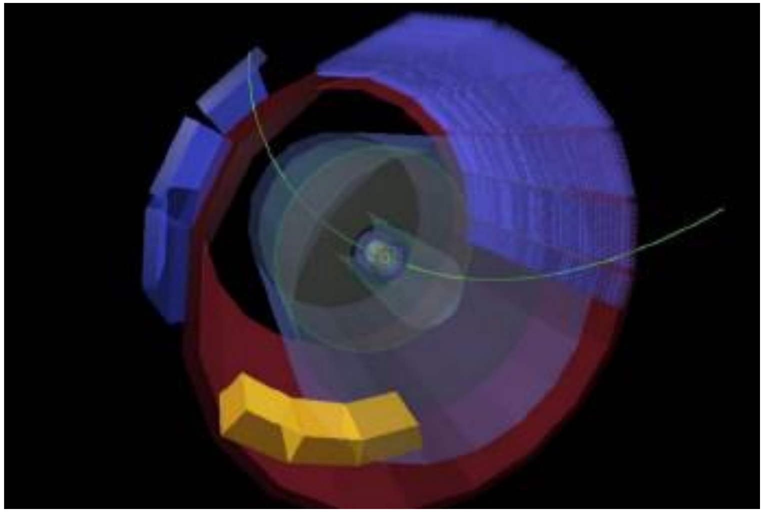
Number of photons scales like Z^2 for a single source ⇒ exclusive particle production in heavy-ion collisions dominated by electromagnetic interactions.



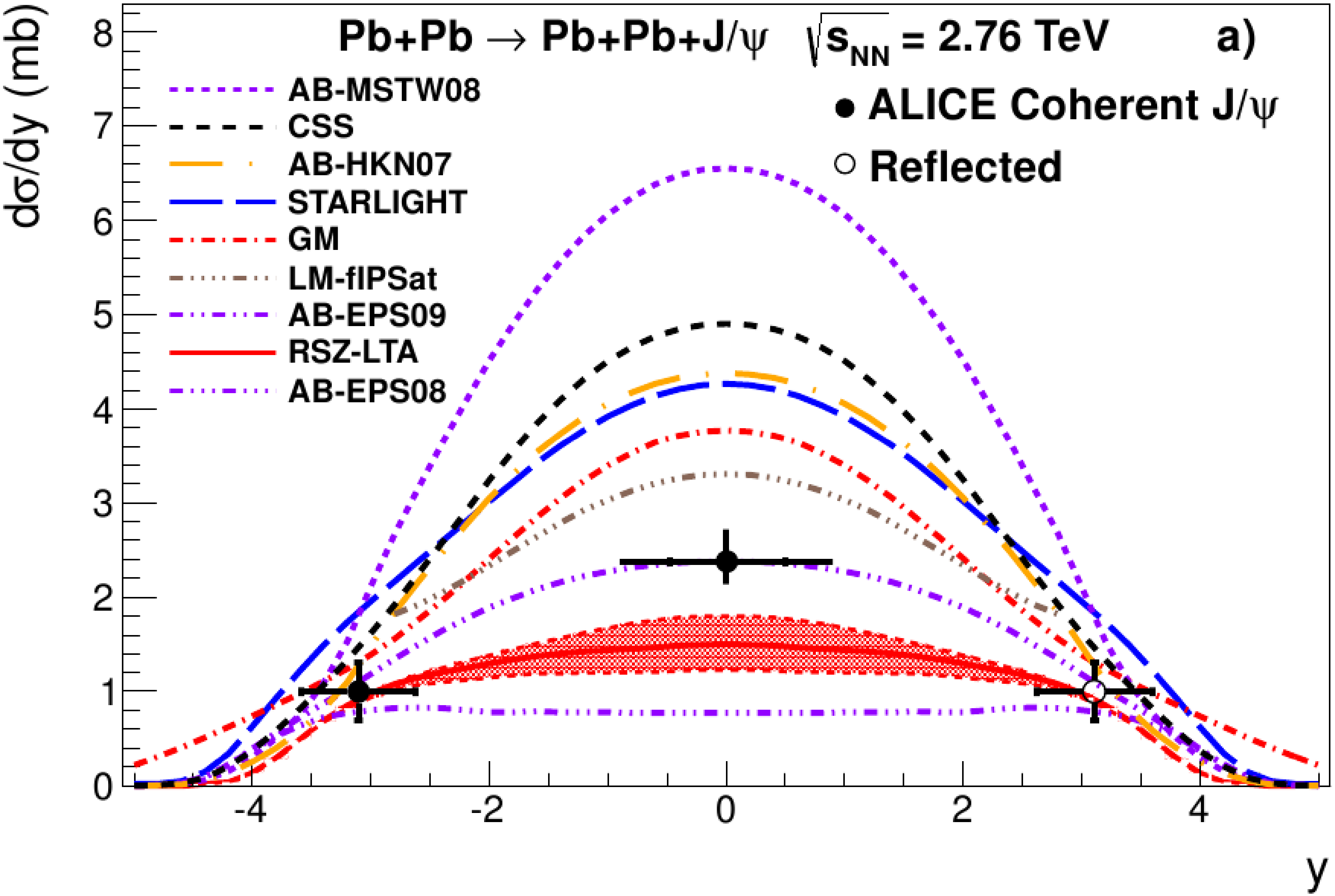
two muons in the muon arm



one muon in the muon arm one in the barrel



two muons in the barrel

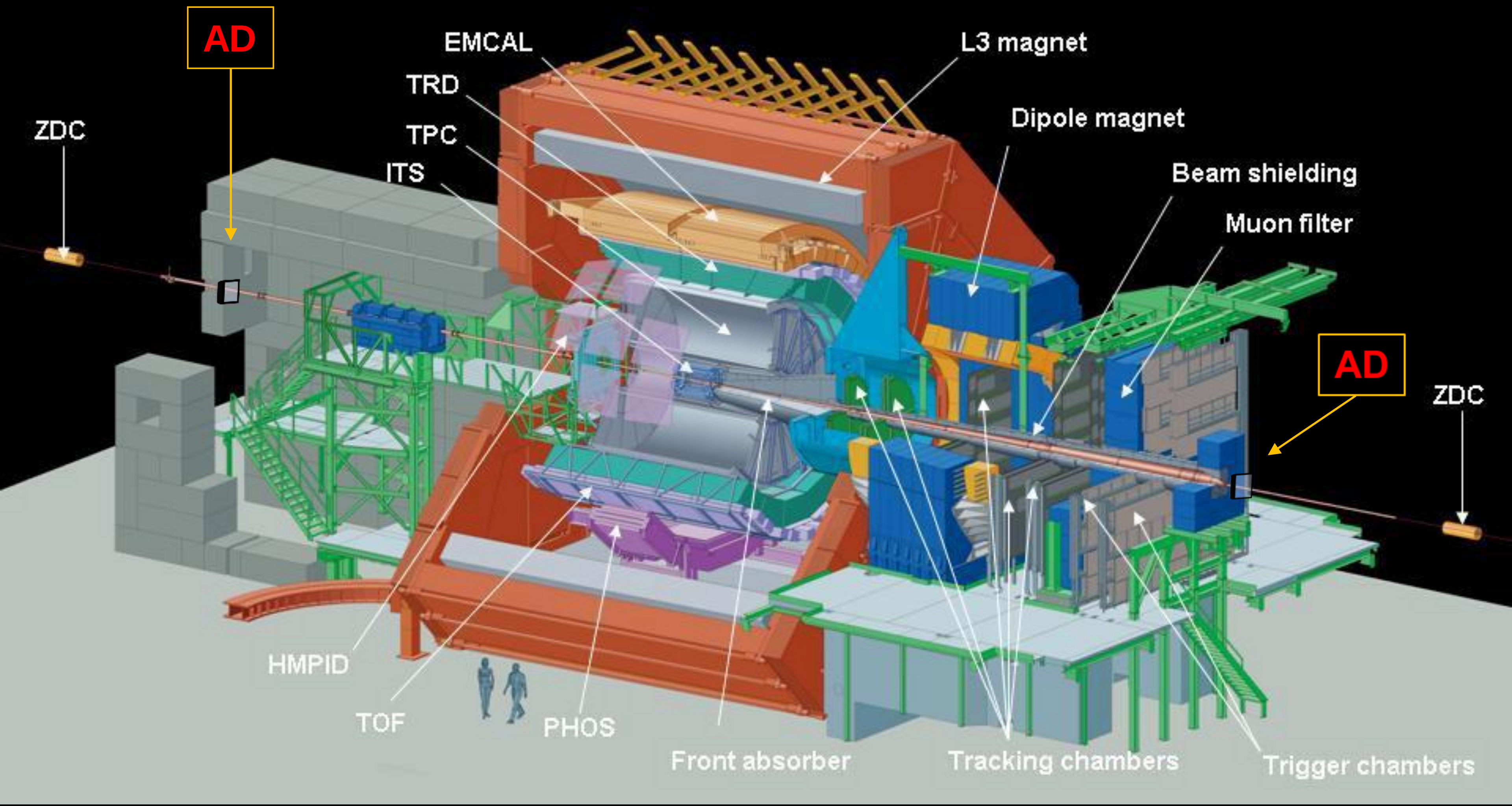


In agreement with models that include moderate gluon shadowing:

AB EPS09 parametrization

A LICE D iffractive Detector for Run 2

ALICE



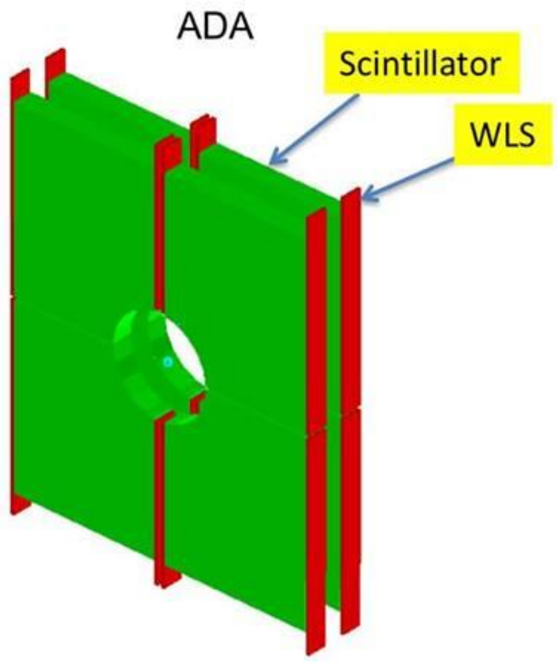
the 19th system of ALICE

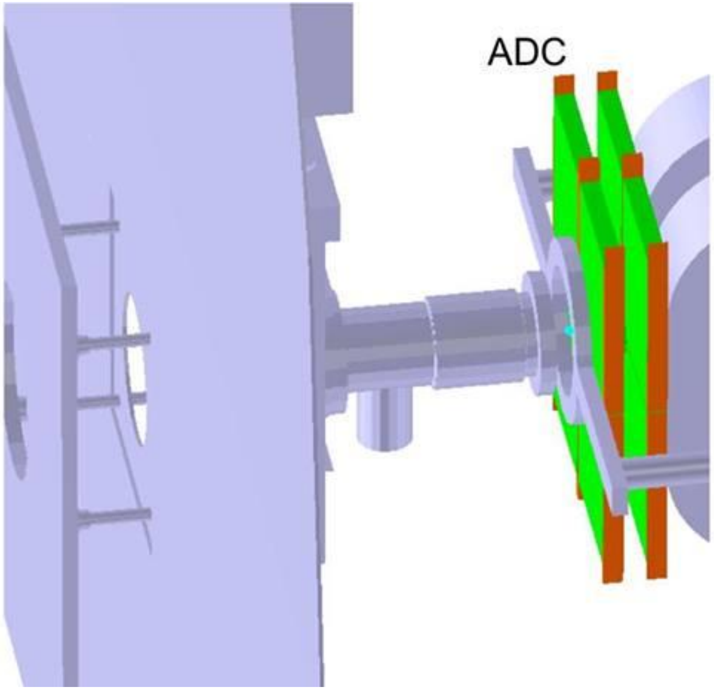
Date: Wed, 1 Jul 2009 11:29:53 +0200
From: Jurgen Schukraft <Jurgen.Schukraft@cern.ch>
To: Gerardo Herrera Corral <gerardo.herrera@cern.ch>
Subject: chat

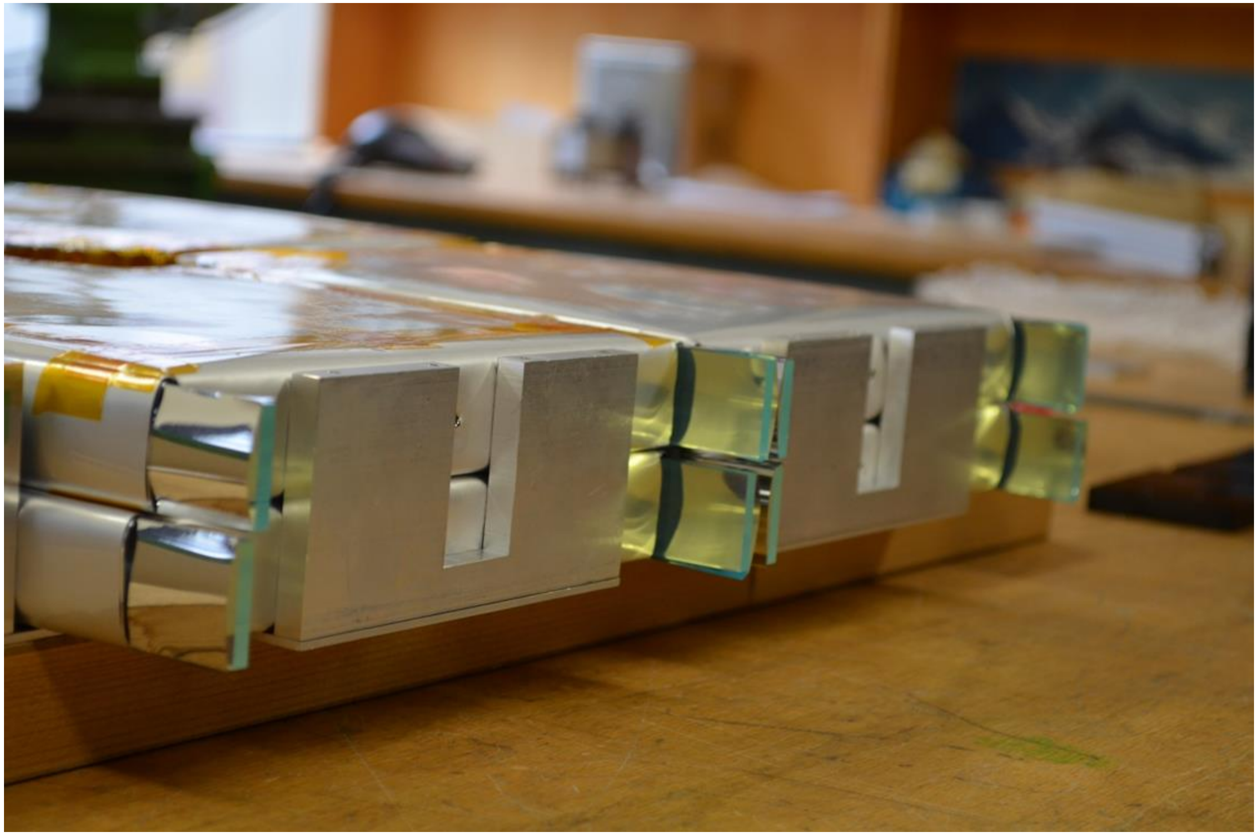
Gerardo,
where can i find you today for a short chat (on a new 'V0D' detector)
??
Jurgen

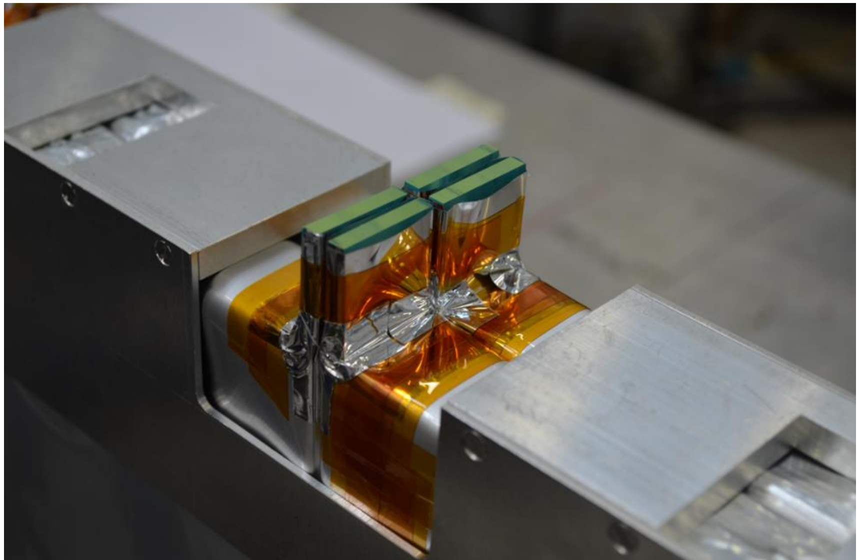
Jurgen Schukraft   CERN/Div. EP CH-1211 Geneva 23
Tel: +41-22-767-5955/ ... 5857 (secr)
Fax: +41-22-767-9480

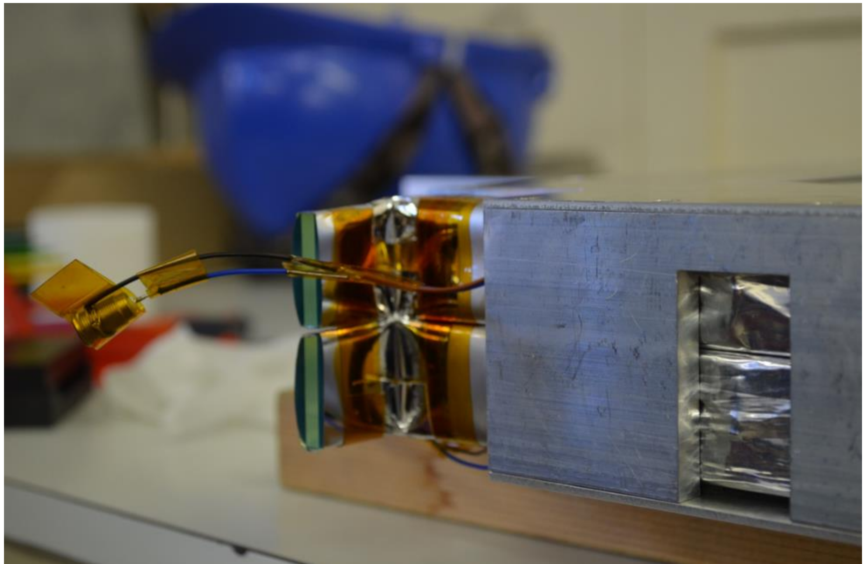
A new sub-system for diffractive physics, bringing the total number of sub-detectors which make up ALICE to 19



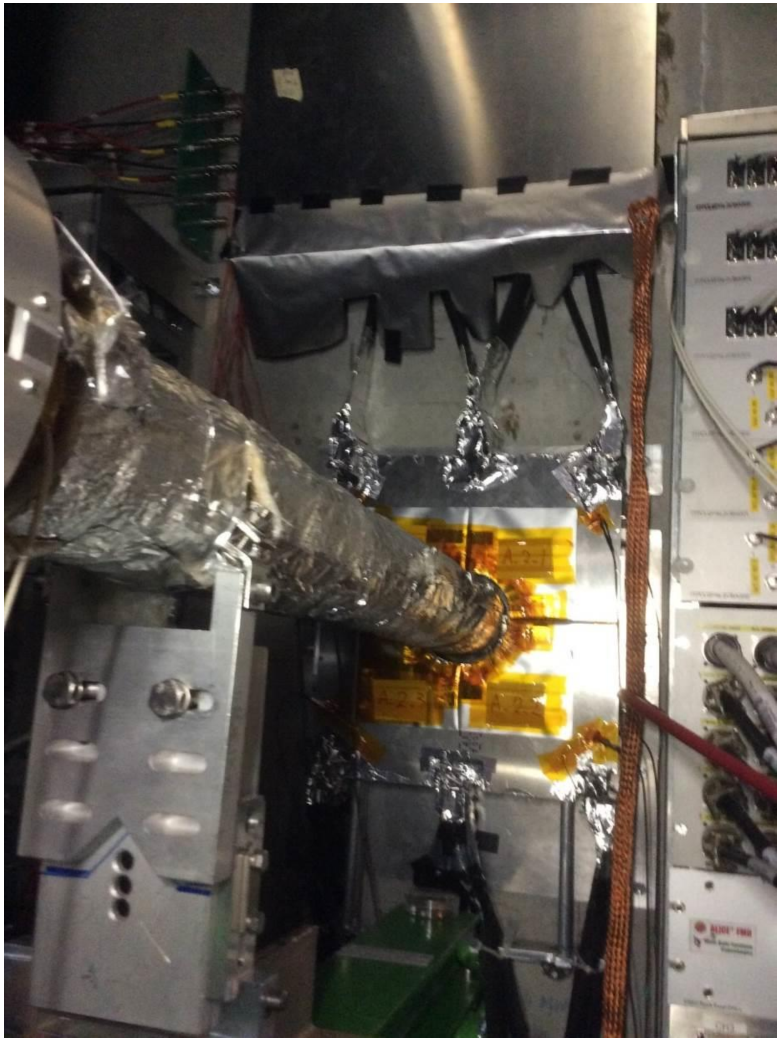








Final position
A side

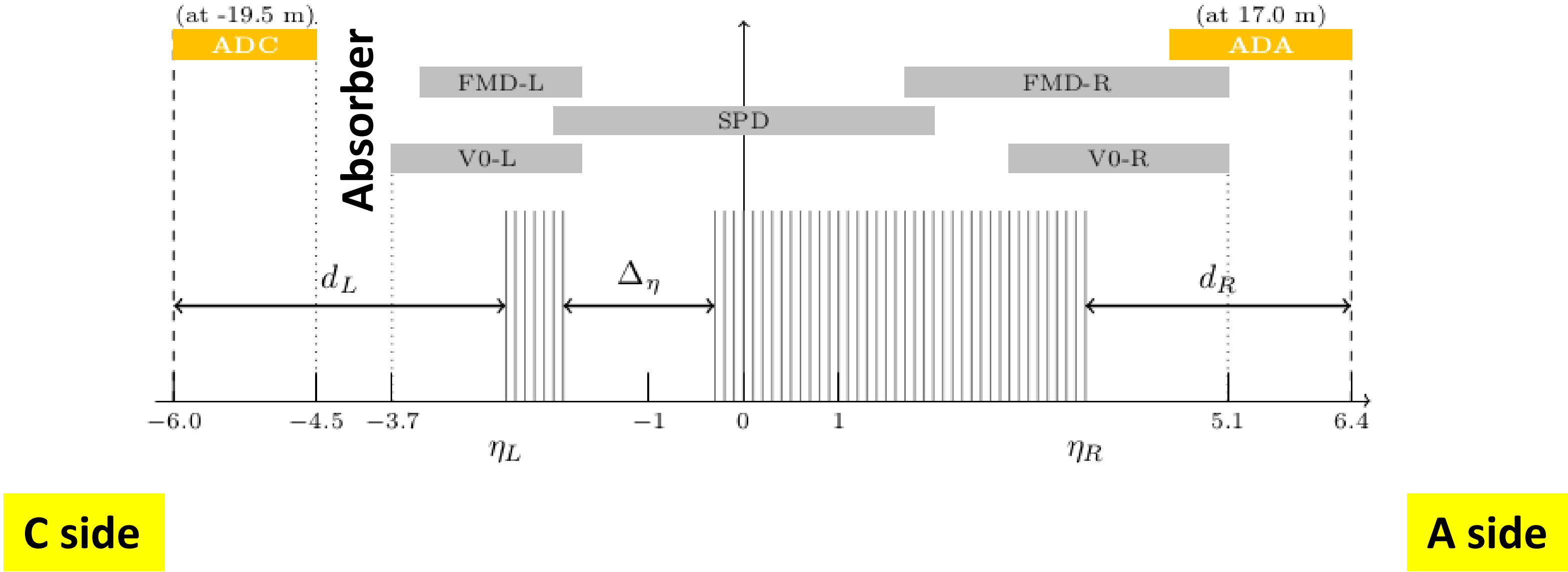


ADA/ADC layer positions

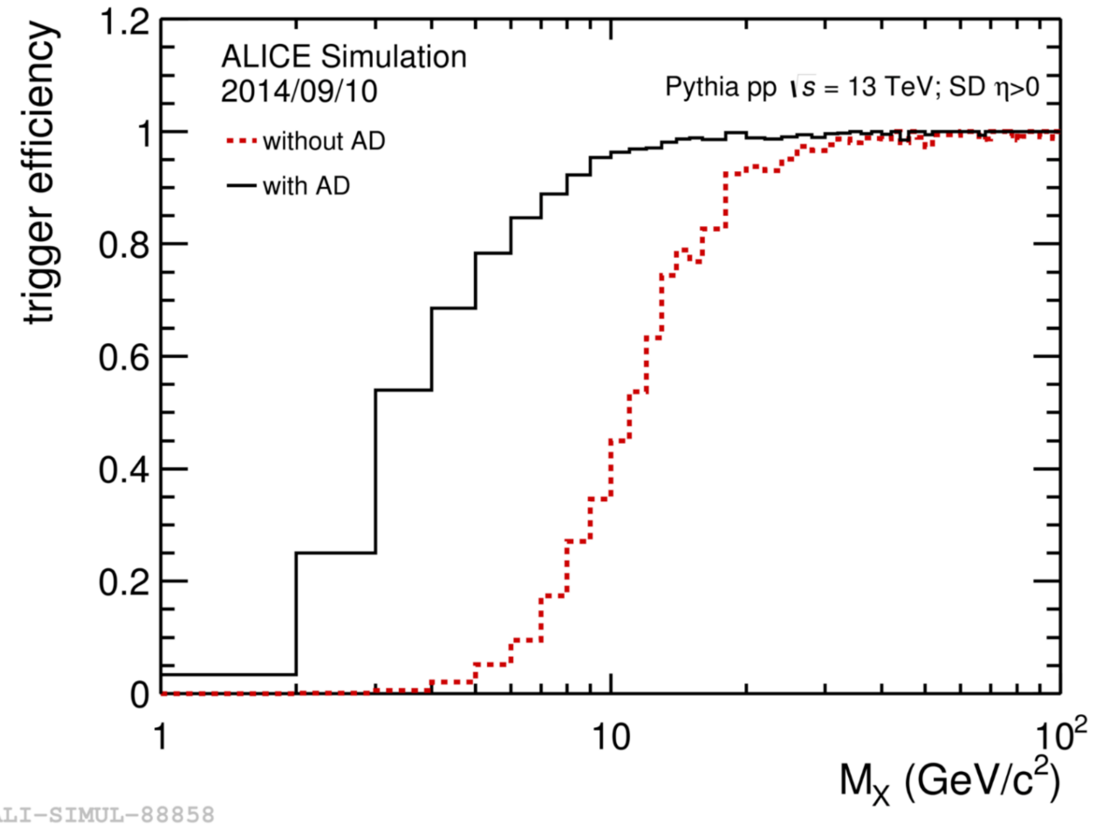
Station	Inner radius (cm)	η_{min}	η_{max}	Z (cm)
ADC layer 0	3.7	-6.96	-4.92	-1955.75
ADC layer 1	3.7	-6.96	-4.92	-1953.05
ADA layer 2	6.2	+4.77	+6.30	+1693.65
ADA layer 3	6.2	+4.77	+6.30	+1696.35

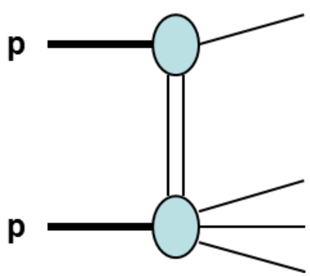
Run 2: Diffraction (SD and DD)

ADA and ADC counters increase the **pseudorapidity coverage from 8.8 to 13.2**

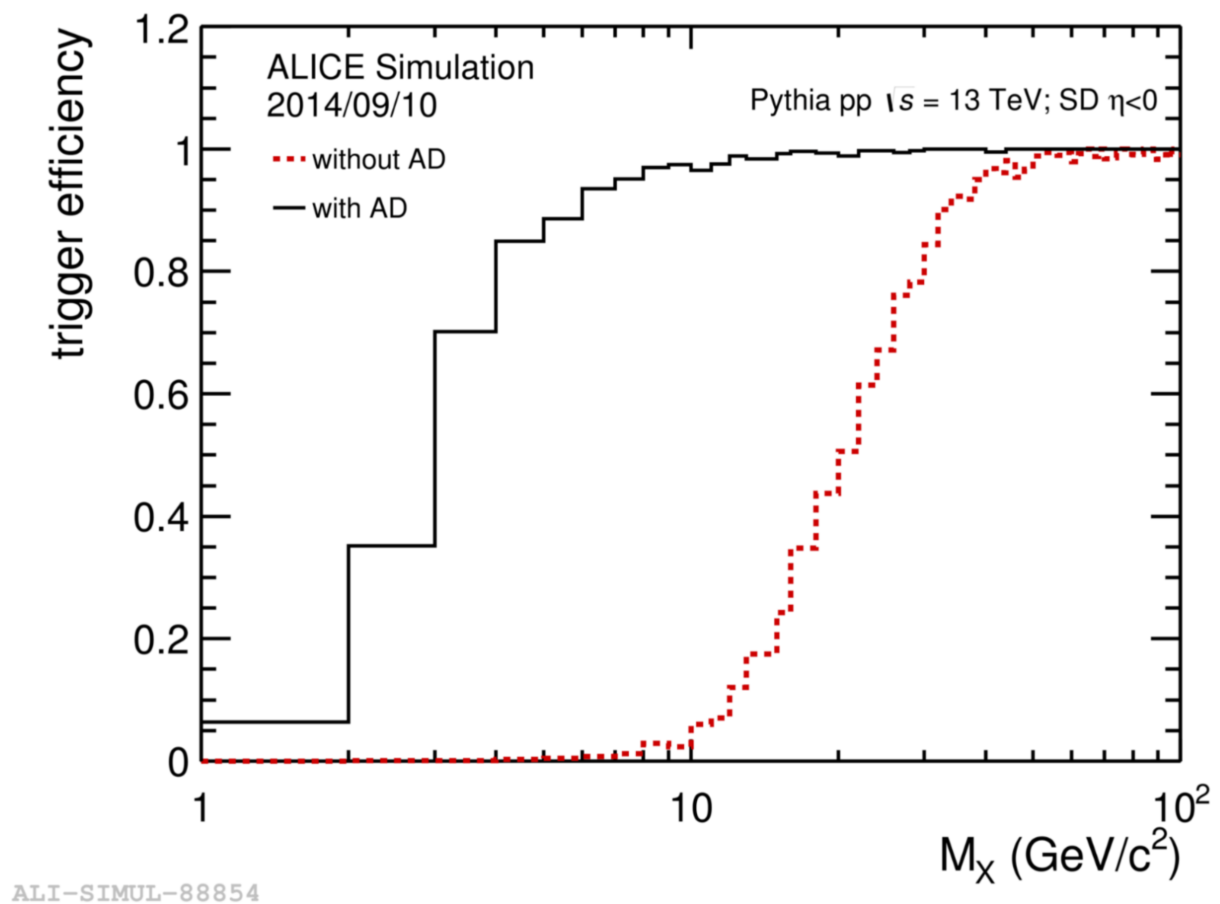


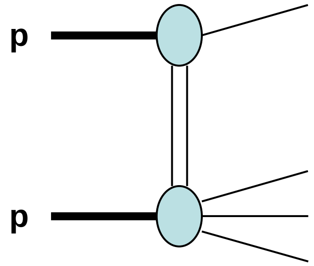
Integration of AD-L and AD-R in ALICE would enhance considerably the efficiency at low diffractive mass.





Integration of AD-L and AD-R in ALICE would enhance considerably the efficiency at low diffractive mass.





VZERO, SPD & FMD
VZERO, SPD & FMD+2 stations
VZERO, SPD & FMD+4 stations

PHOJET 7 TeV

trigger	Efficiency Pure–events (%)	Efficiency Minimum–Bias (%)	Purity (%)
$SD\text{-}L_0$	13.14	1.26	71.44
$SD\text{-}L_1$	27.66	2.25	84.33
$SD\text{-}L_2$	31.15	2.45	87.48
$SD\text{-}R_0$	19.68	1.98	68.45
$SD\text{-}R_1$	30.92	2.55	83.17
$SD\text{-}R_2$	33.47	2.66	86.57
DD_0	4.69	0.45	51.57
DD_1	13.60	0.99	68.37
DD_2	16.35	1.14	71.37
CD_0	3.28	0.11	55.55
CD_1	3.11	0.06	97.29
CD_2	3.10	0.06	98.73

PYTHIA 6 7 TeV

trigger	Efficiency Pure–events(%)	Efficiency Minimum–Bias (%)	Purity (%)
$SD\text{-}L_0$	11.30	1.80	59.95
$SD\text{-}L_1$	26.38	3.23	78.18
$SD\text{-}L_2$	31.54	3.56	84.84
$SD\text{-}R_0$	16.73	2.96	54.08
$SD\text{-}R_1$	29.05	3.76	74.01
$SD\text{-}R_2$	32.93	3.85	81.84
DD_0	5.31	1.00	64.96
DD_1	16.80	2.63	78.43
DD_2	21.93	3.28	82.15

PYTHIA 6 7 TeV

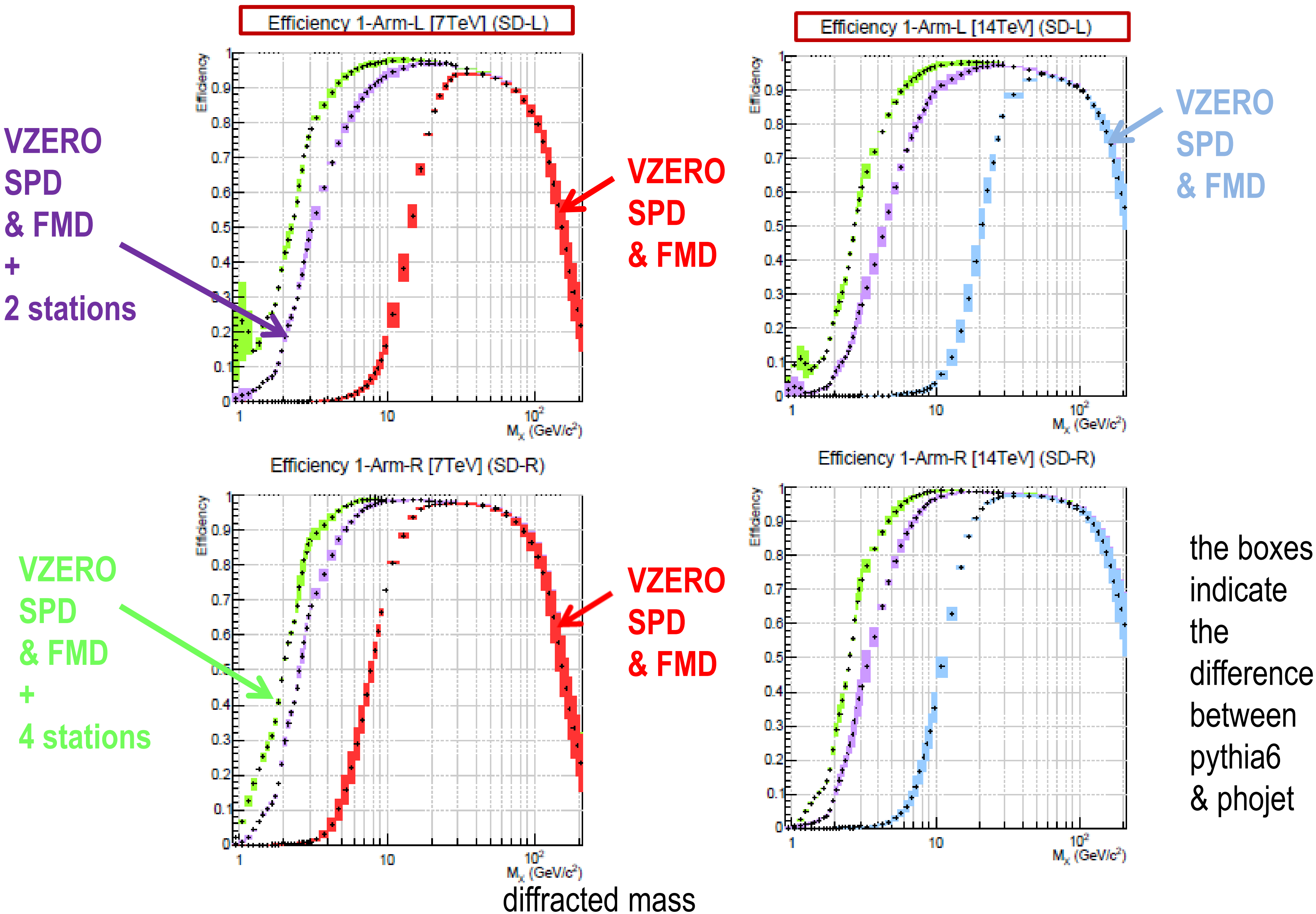
trigger	Efficiency Pure–events(%)	Efficiency Minimum–Bias(%)	Purity (%)
1–Arm–L_0	23.61	3.87	58.36
1–Arm–L_1	38.60	4.77	77.42
1–Arm–L_2	41.25	4.71	83.84
1–Arm–R_0	30.23	5.79	49.93
1–Arm–R_1	40.96	5.49	71.37
1–Arm–R_2	42.79	5.17	79.14

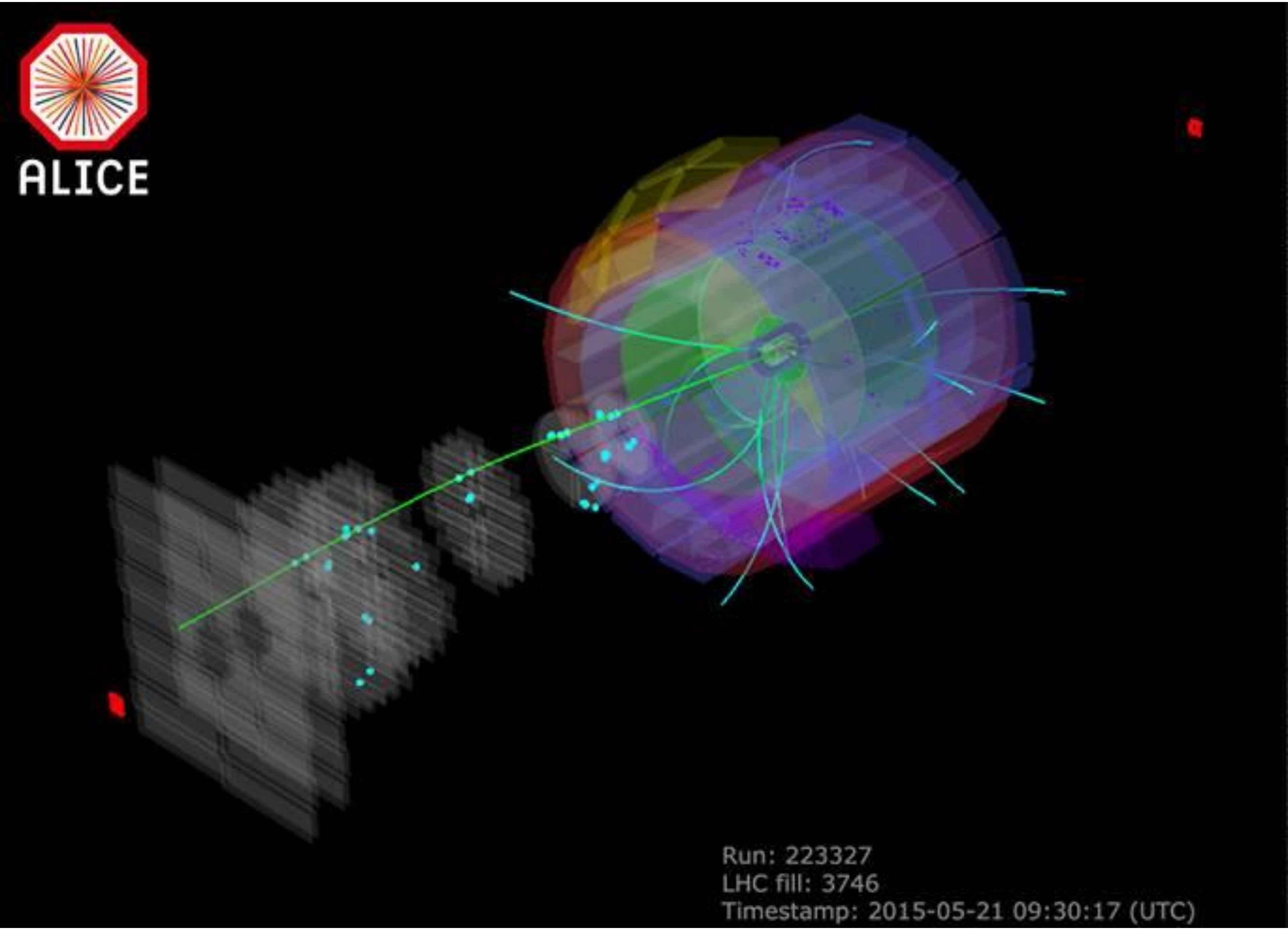
VZERO, SPD & FMD
VZERO, SPD & FMD+2 stations
VZERO, SPD & FMD+4 stations

PHOJET 7 TeV

trigger	Efficiency Pure–events(%)	Efficiency Minimum–Bias(%)	Purity(%)
1–Arm–L_0	27.01	2.87	64.67
1–Arm–L_1	41.38	3.67	77.37
1–Arm–L_2	44.85	3.82	80.59
1–Arm–R_0	35.10	3.97	60.73
1–Arm–R_1	46.00	4.19	75.49
1–Arm–R_2	48.53	4.21	79.17

As defined in the recent paper: arXiv:1208.4968 accepted in Eur. Phys. J. C

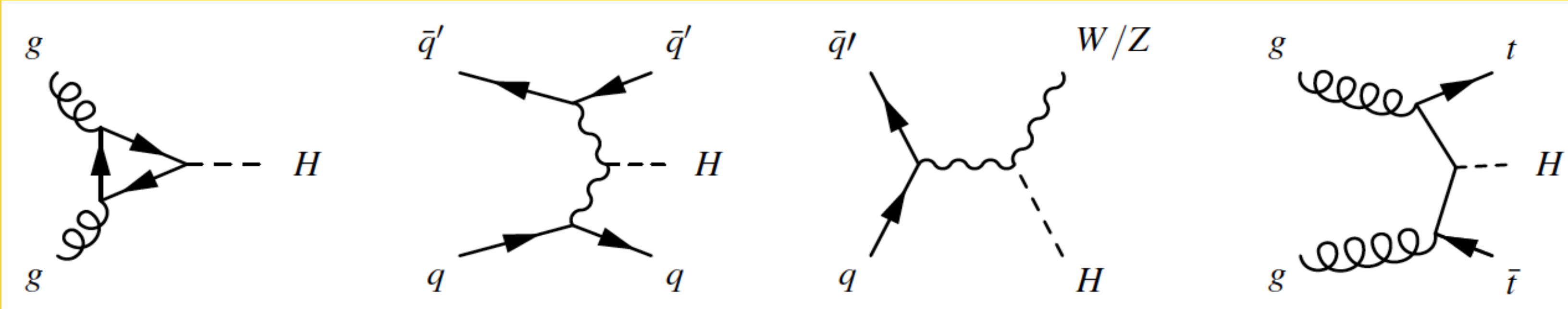

Efficiency 1-Arm-L [7TeV] (SD-L)
Efficiency 1-Arm-L [14TeV] (SD-L)
Efficiency 1-Arm-R [7TeV] (SD-R)
Efficiency 1-Arm-R [14TeV] (SD-R)
Efficiency
M_x (GeV/c²)
VZERO
SPD
& FMD
+
2 stations
VZERO
SPD
& FMD
VZERO
SPD
& FMD
VZERO
SPD
& FMD
+
4 stations
VZERO
SPD
& FMD
the boxes
indicate
the
difference
between
pythia6
& phojet
diffracted mass


ALICE
Run: 223327
LHC fill: 3746
Timestamp: 2015-05-21 09:30:17 (UTC)

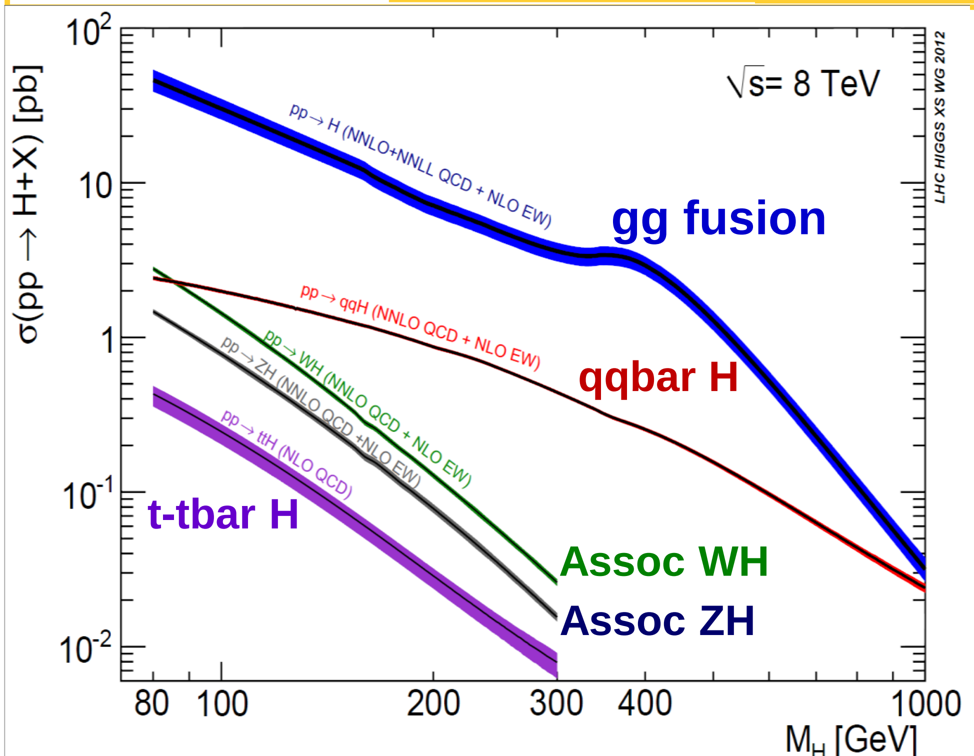
Diffractive Physics
&
Higgs

Higgs Production at the LHC

Run 1: 7-8 TeV pp Collisions; 13 TeV at Run2

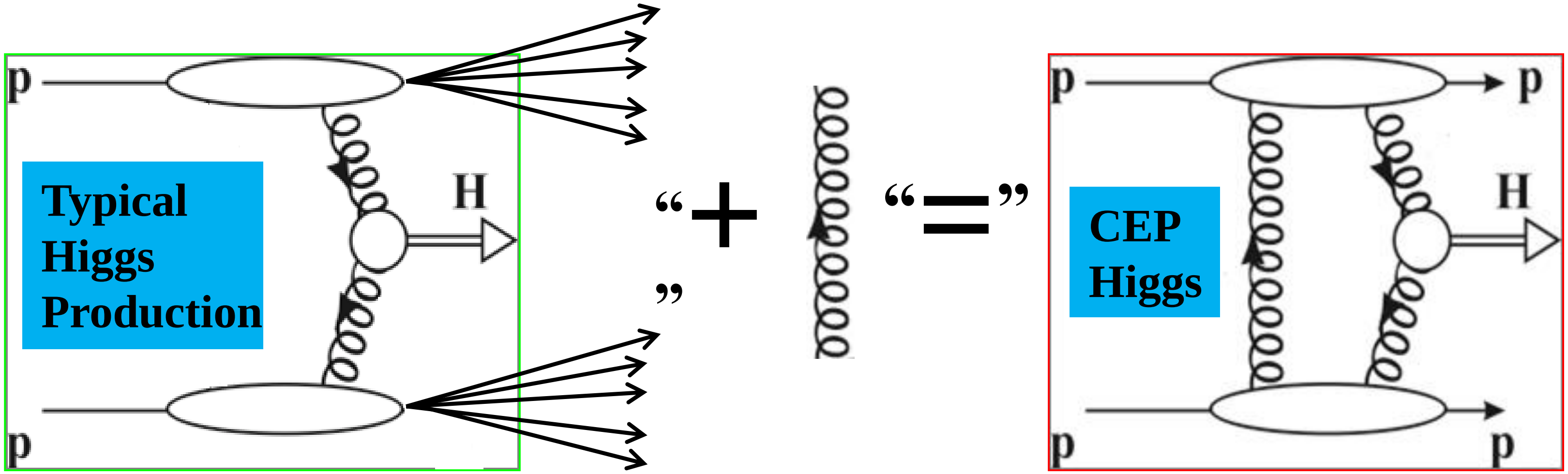


gg fusion gg→ H	VB fusion (VBF)	Assoc Prod: WH, ZH	Assoc. Prod: t-tbar H



NNLO+ QCD + NLO Elwk

Central Exclusive Production: Higgs

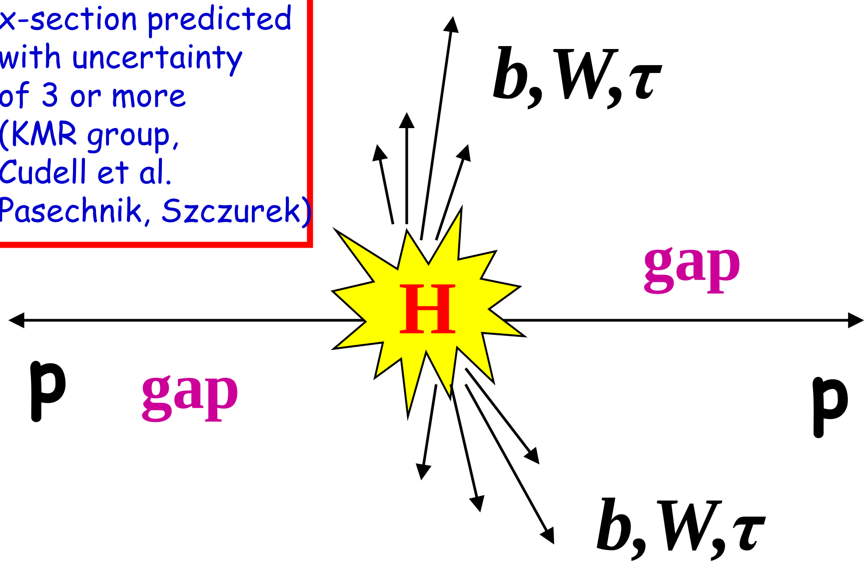


pp → gg → H +x

pp → p+H+p

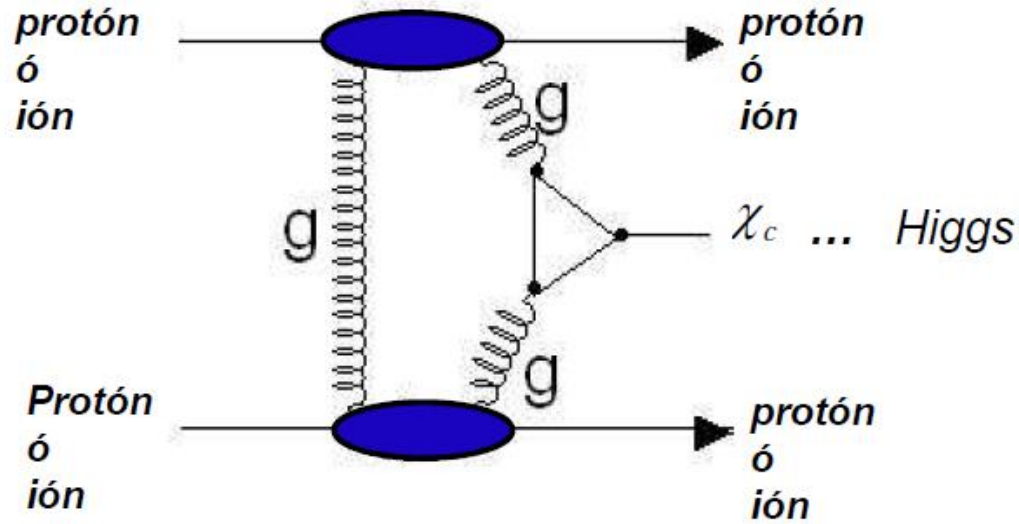
Extra screening gluon conserves color, keeps proton intact (and reduces your σ)

x-section predicted with uncertainty of 3 or more (KMR group, Cudell et al. Pasechnik, Szczurek)



This process was the core of the physics case of Forward Detector in ATLAS & CMS

1) **Protons remain intact and can be detected in forward detectors**
2) **Rapidity gaps between leading protons and Higgs decay products**


protón
ó
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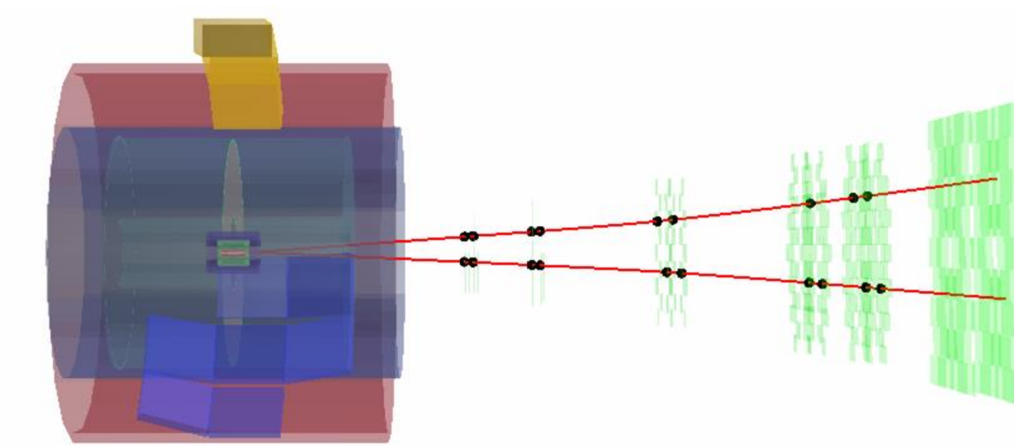
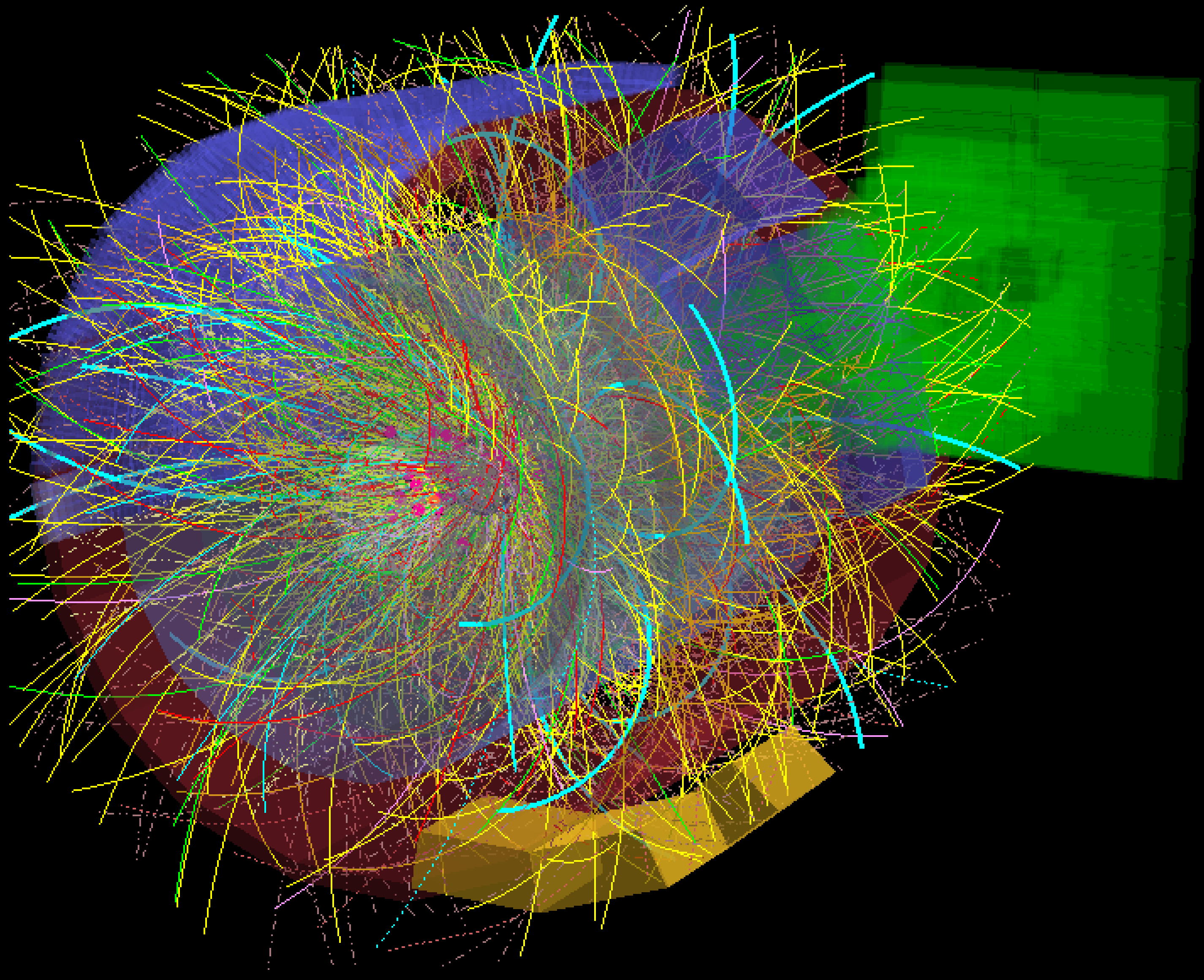
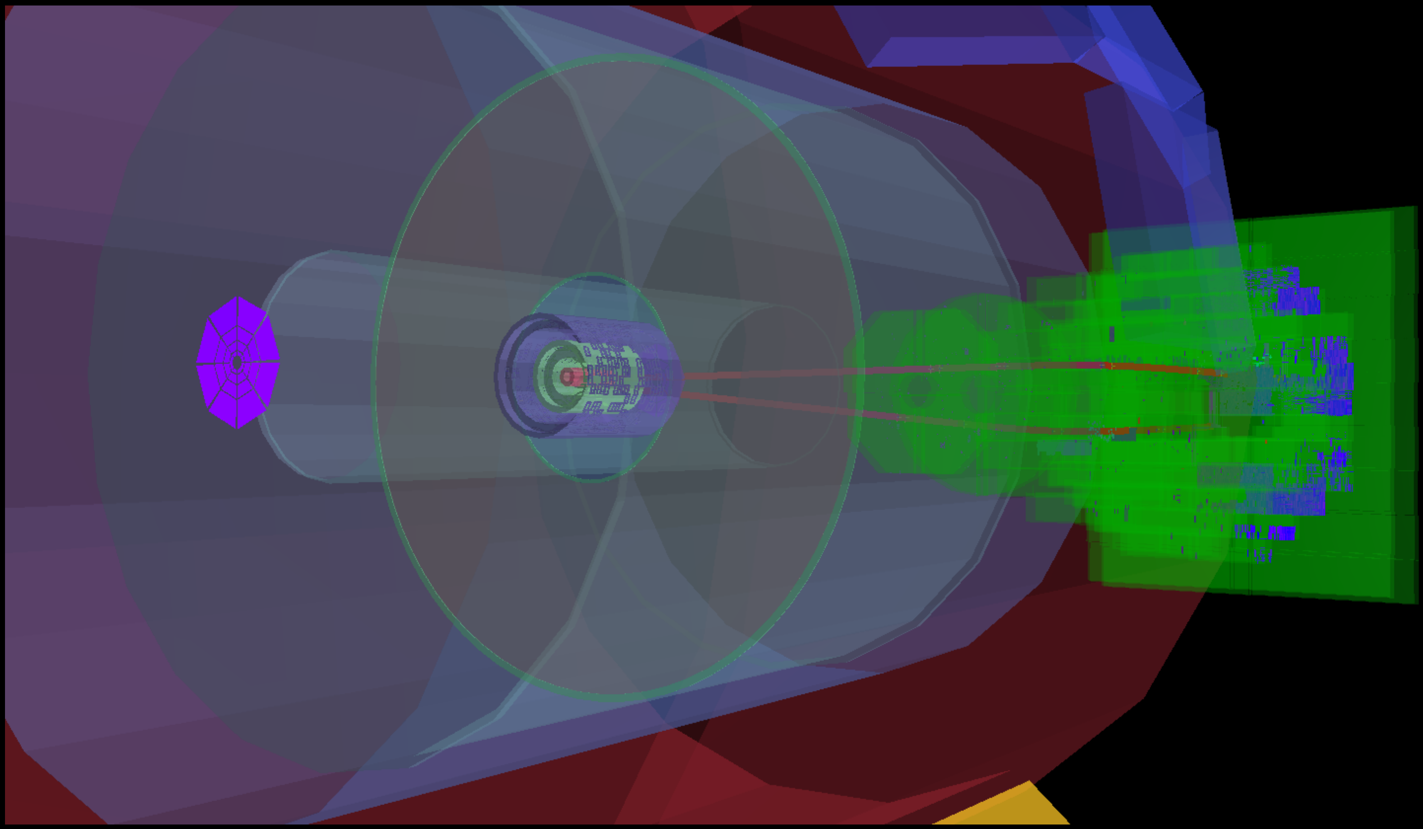
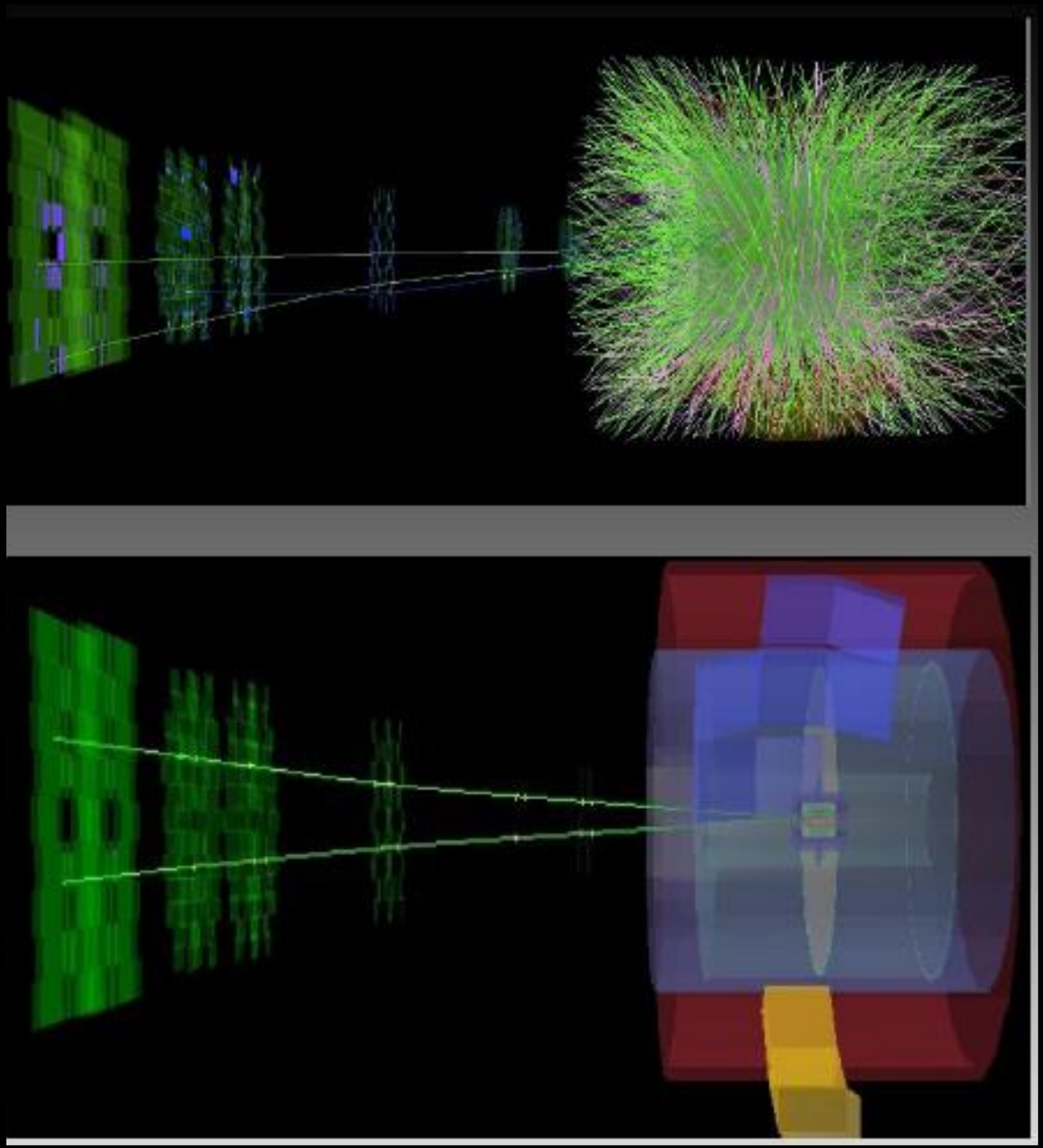
protón
ó
ión
g
g
χ_c ... Higgs
g
Protón
ó
ión
protón
ó
ión









interacción
inelástica

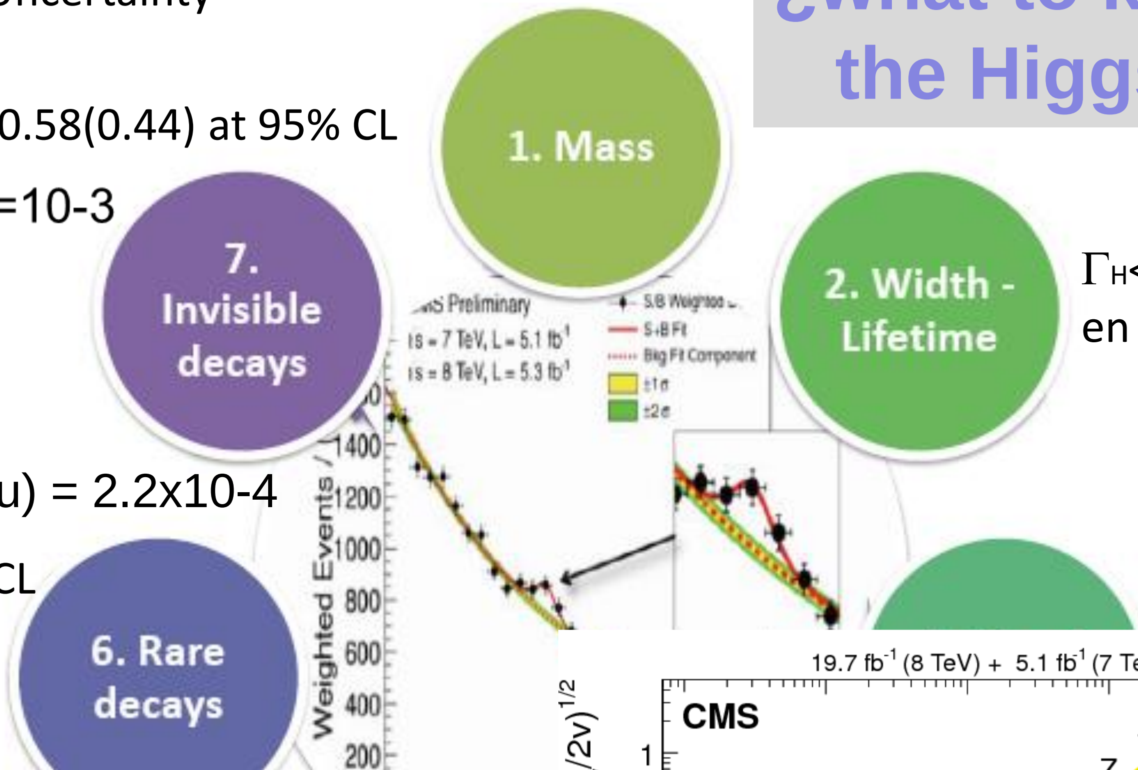
m_H=125.09±0.21±0.11 GeV

0.19 % Uncertainty

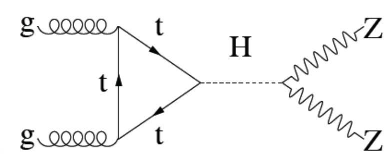
¿what to know about the Higgs?

B(H→Invisible)<0.58(0.44) at 95% CL

B(H->ZZ->4ν)=10-3



Γ_H< 22 MeV at 95% CL en ZZ

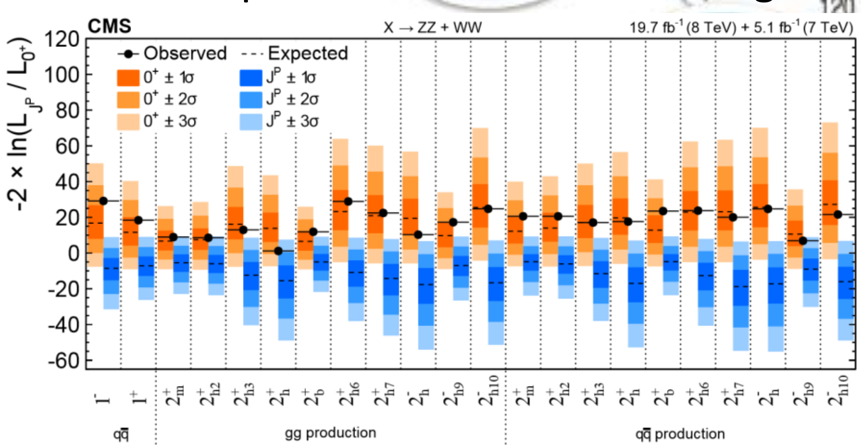


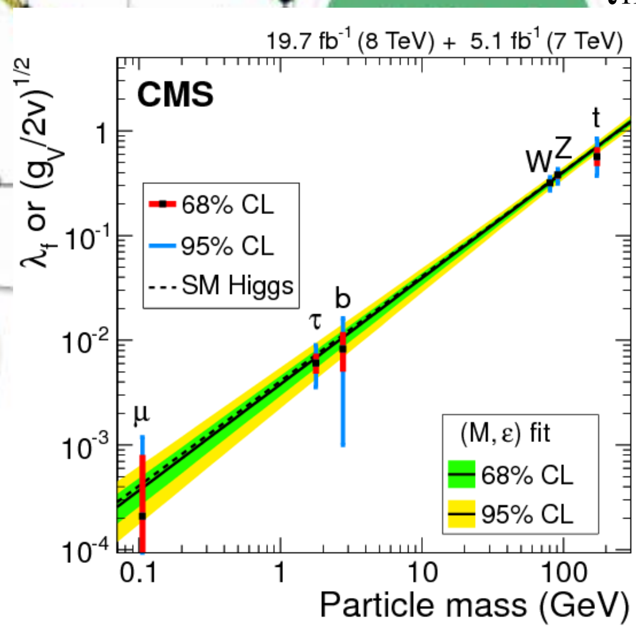
BSM(H->mumu) = 2.2x10-4

B(<0.0016, 95% CL

τ_H<1.9x10-13 s 95% CL

Data are compatible with 0_+ within ~ 1sigma





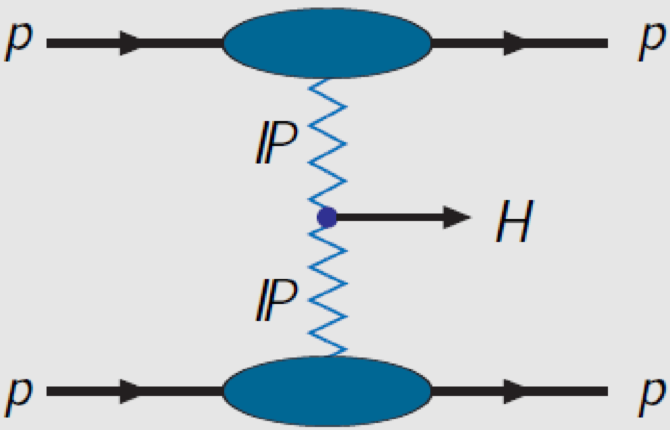
.09 (stat.) ±

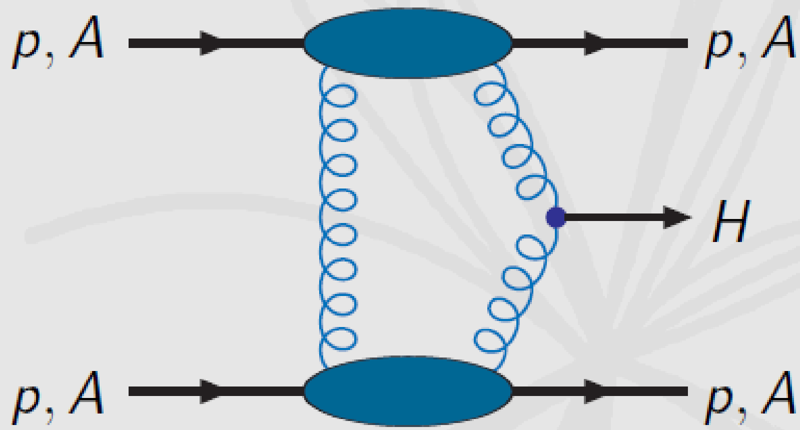
ry) ± 0.07 (syst.)

tainty

Diffractive Higgs production in *pp* and *AA* collisions

- **1991**: Bialas and Landshoff — PLB **256** (1991) 540
  - Regge Theory → **non-perturbative gluons**
- **1997**: Khoze, Martin and Ryskin — PLB **401** (1997) 330
  2007: Levin and Miller — arXiv:0801.3593[hep-ph]
  - QCD Pomeron → **hard-gluon exchange**

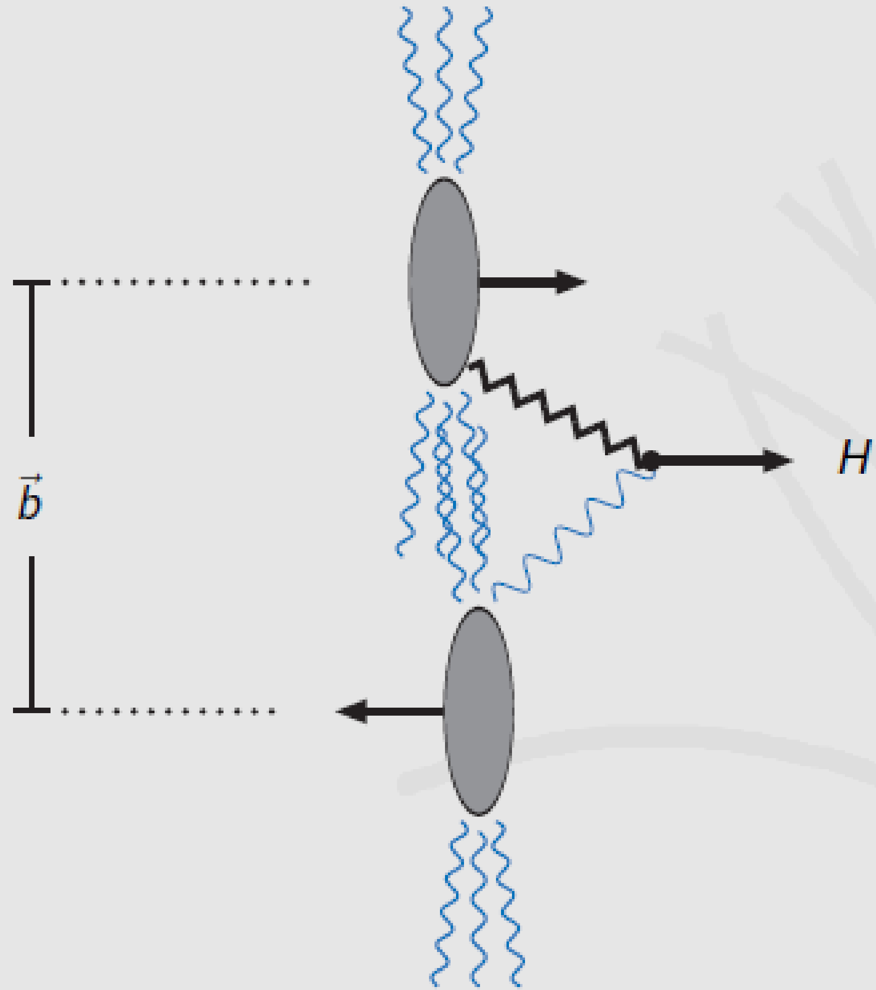




$M_H = 150$ GeV, $\sqrt{s} = 16$ TeV $\{$ **BL** : $\sigma_{pp} = 0.1$ pb

$M_H = 120$ GeV, $\sqrt{s} = 14$ / 8.8 (5.5) TeV/A $\{$ **KMR** : $\sigma_{pp}^{exc/inc} \sim$ **3 fb**/300 fb; **LM** : $\sigma_{pA(AA)} =$ **0.1 pb** (3.9 pb)

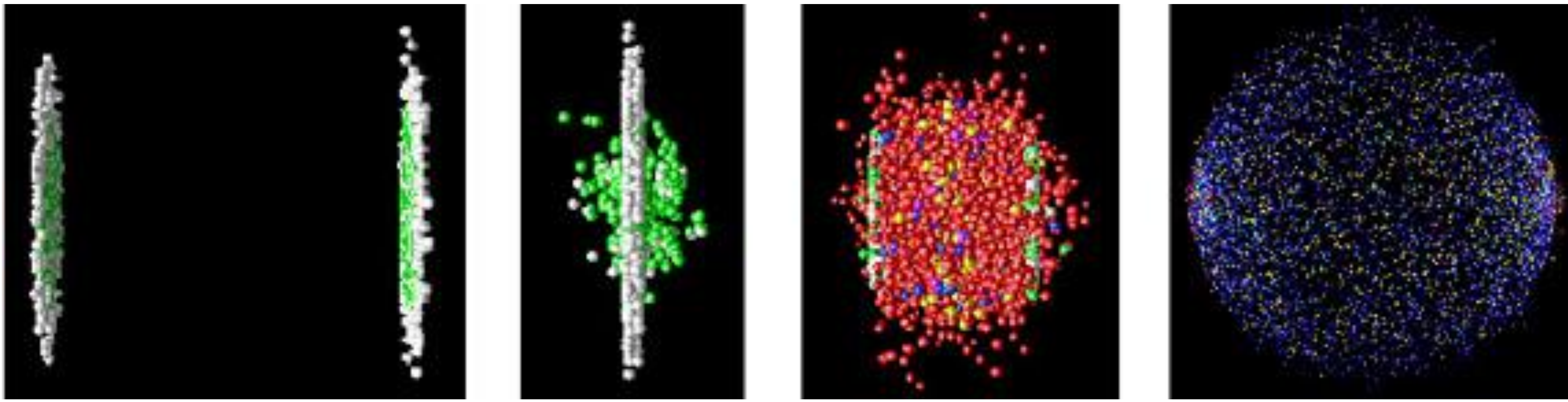
The γp process is a subprocess in Ultraperipheral collisions.

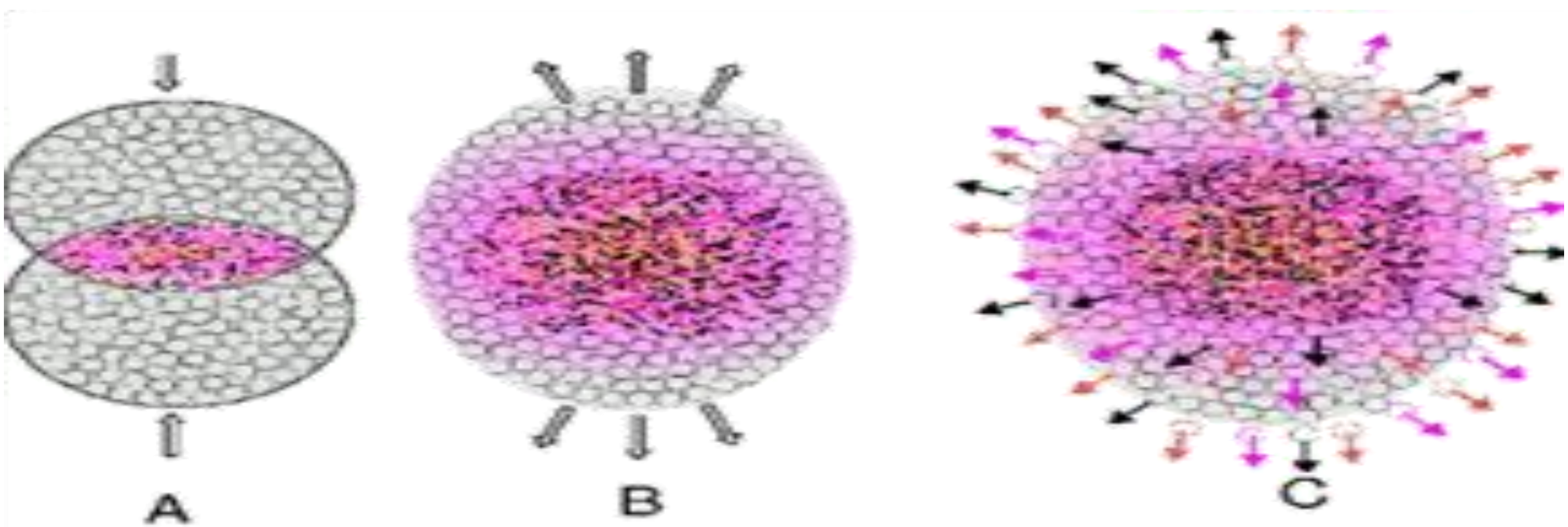


ALICE

beyond the Higgs

colliding heavy iones





String theory

Substructure

Hidden symmetries

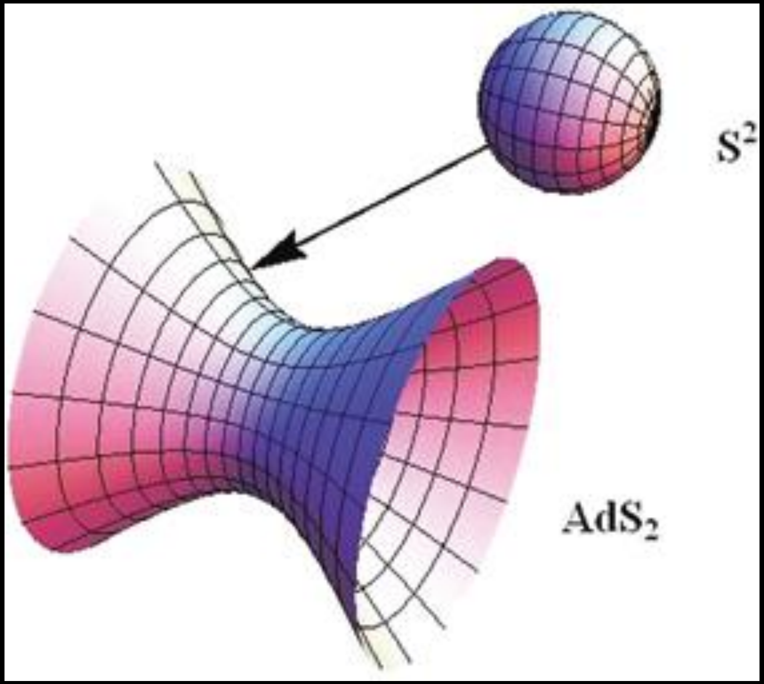
Extradimensions

Vacum

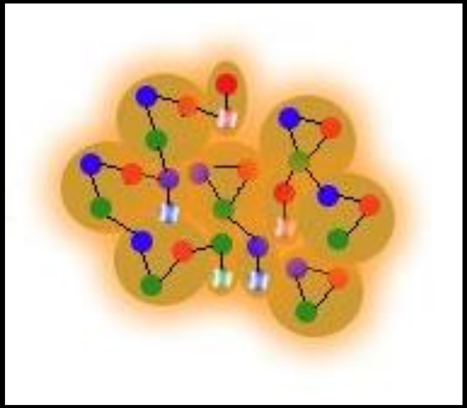
Duality

Maldacena Duality

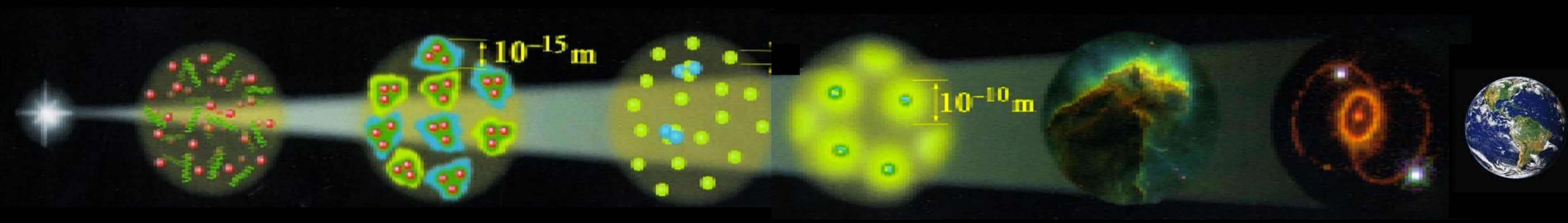
De Sitter



Anti-De Sitter



Big Bang | Plasma de Quarks y Gluones | Protones neutrones | Núcleos ligeros | Átomos neutros | Formación de estrellas | Elementos pesados | HOY



5.5 °C billones

1000 °C millones

3000 °C

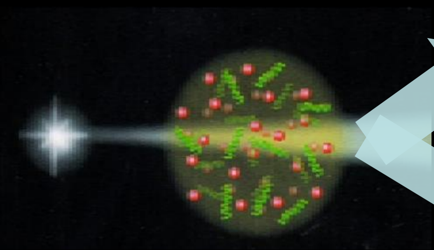
-255 °C

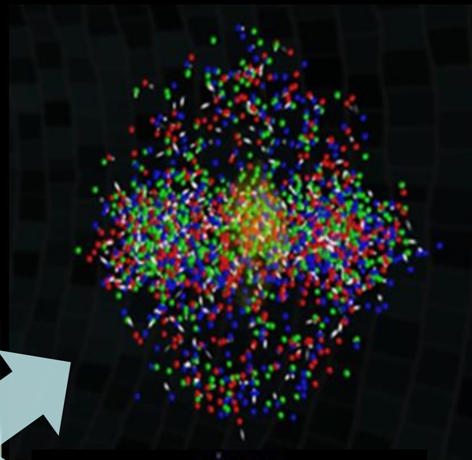
-268 °C

-270 °C

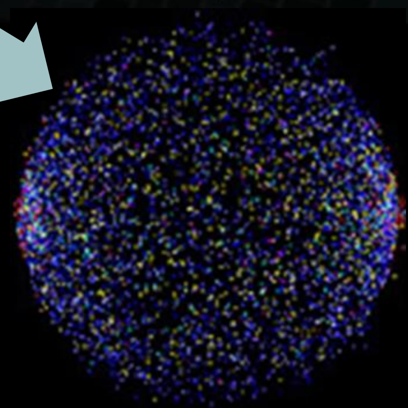
Big Bang

Plasma de Quarks y Gluones



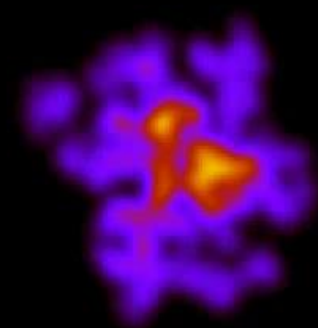


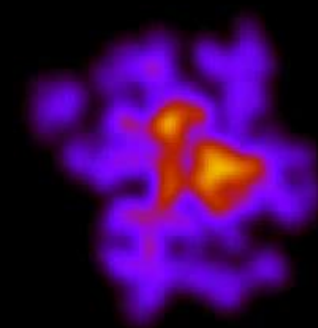
LIQUIDO



GAS

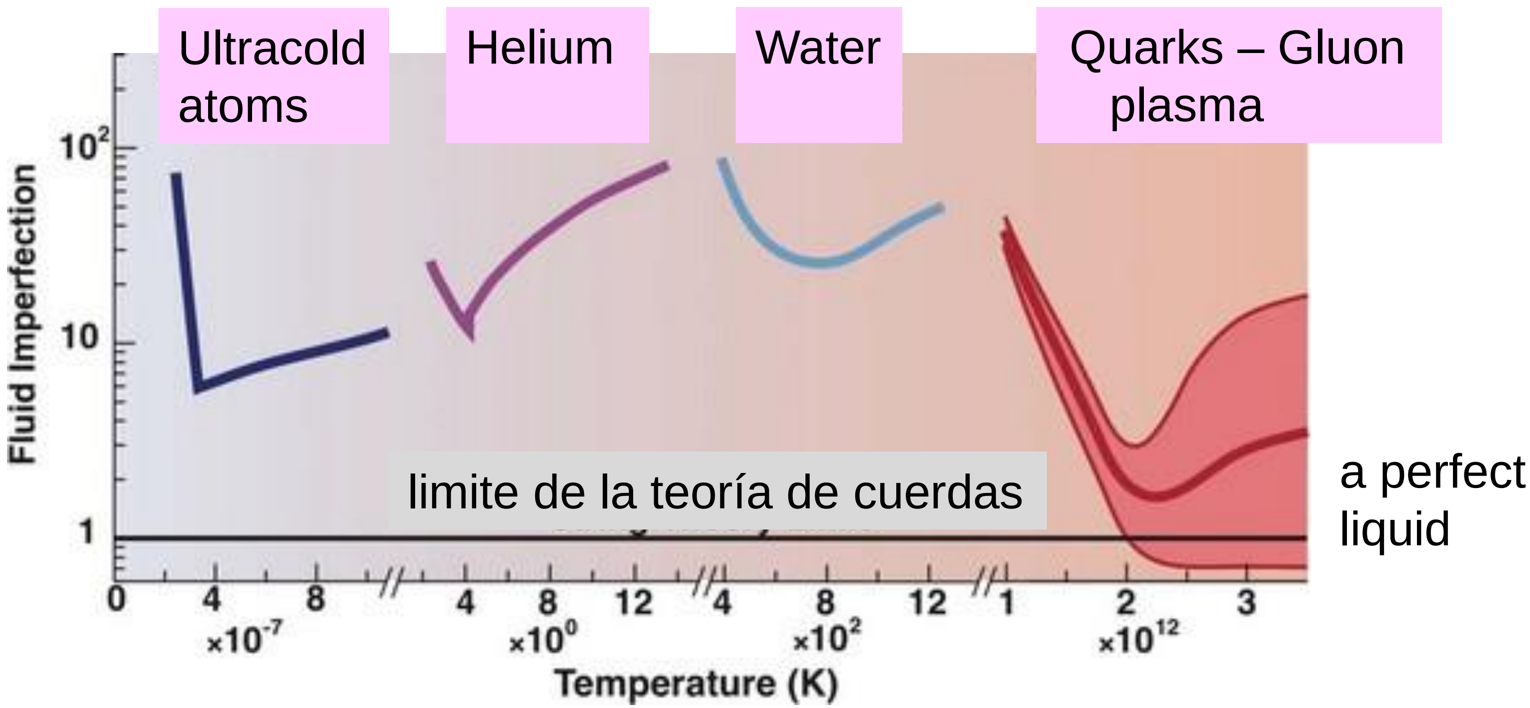
5.5 ℃ billones



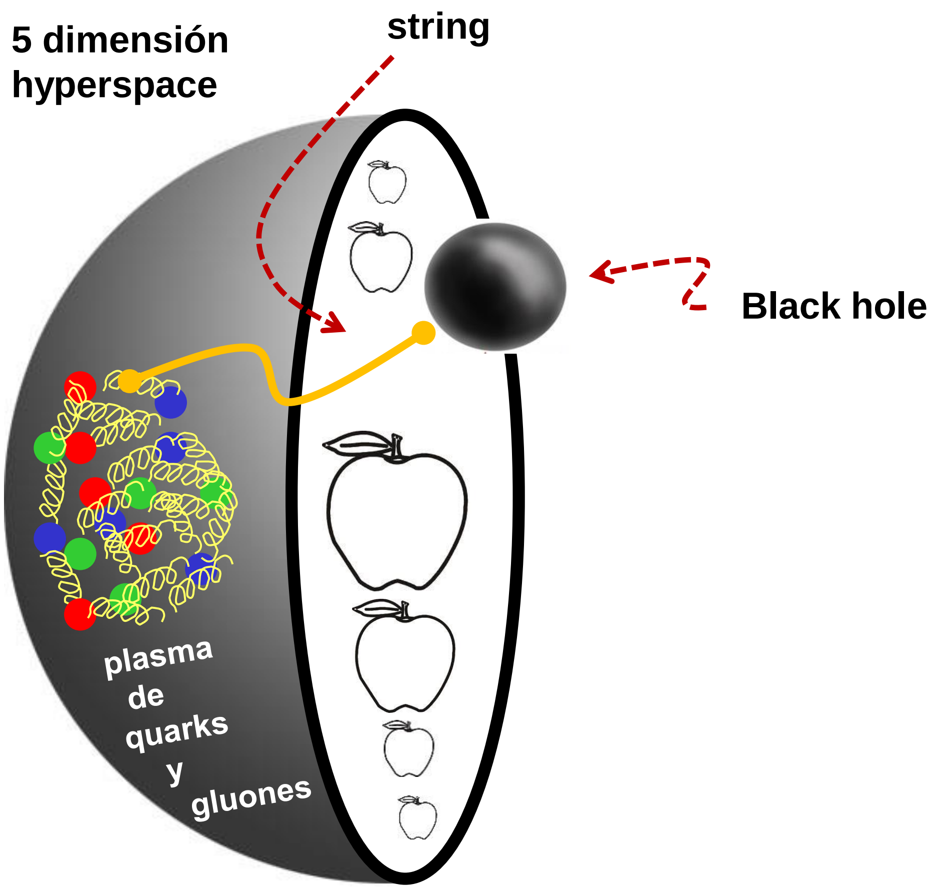


t = 0.5 fm/c

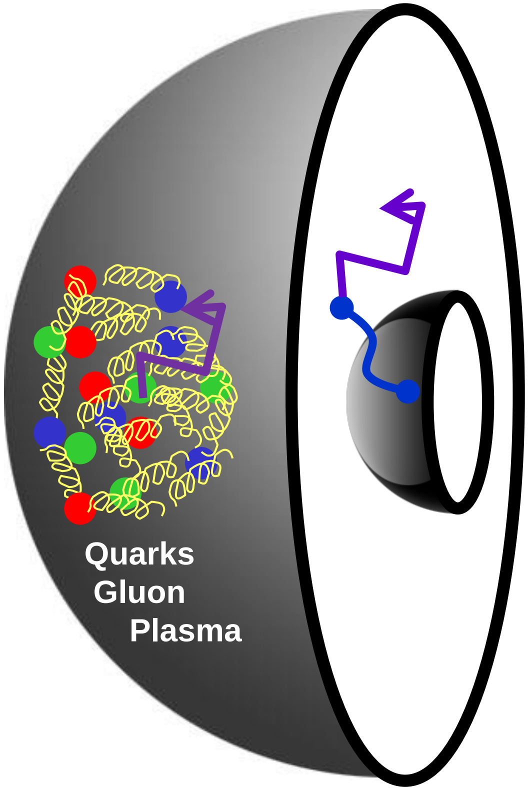
A hydrodynamic simulation of QGP evolution


Ultracold atoms
Helium
Water
Quarks – Gluon plasma
Fluid Imperfection
10^2
10
1
limite de la teoría de cuerdas
a perfect liquid
0
4
8
4
8
12
4
8
12
1
2
3
$\times 10^{-7}$
$\times 10^{0}$
$\times 10^{2}$
$\times 10^{12}$
Temperature (K)

The liquid may be described by a string theory: AdS/CFT



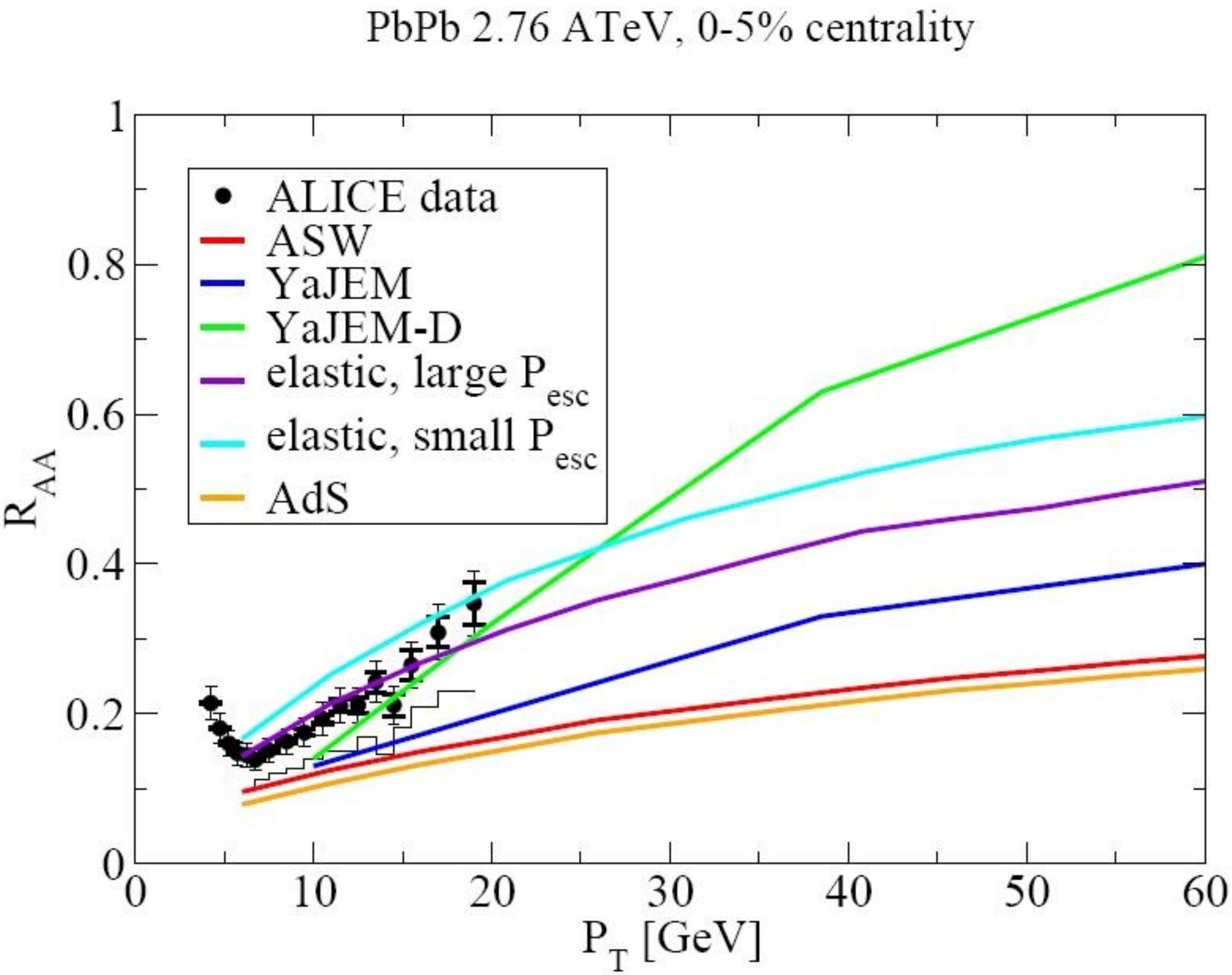
… the quark propagate through the plasma according to the movement of a string in a 5 dimensinal anti-de-Sitter space



Talk given at Quark Matter 2011, 22-28 May 2011, Annecy, France

High Energy Physics - Phenomenology (hep-ph)

arXiv:1106.2392 [hep-ph]



Models we tested (ASW, AdS and YaJEM-D) remain viable with the data, although in each case only in combination with a particular hydrodynamical evolution model.

Diferent opinions about the question on how string theory
and heavy ion collisions are related, - if they are actualy related -

… does not matter it is the area of closer approach
between string theory and experimental physics today

Steven S. Gubser

ALICE upgrade

- luminosity upgrade – 50 kHz for Pb–Pb collisions and 2 MHz in pp
- improved vertex measurement and tracking at low p_T
- preserve particle-identification capability
- high-luminosity operation without dead-time
- new, smaller radius beam pipe
- new inner tracker (ITS) (performance and rate upgrade)
- high-rate upgrade for the readout of the TPC, TRD, TOF, CALs, DAQ-HLT, Muon-Arm and Trigger detectors
- Muon Forward Tracker (MFT)
- Forward Calorimeter (FoCal)

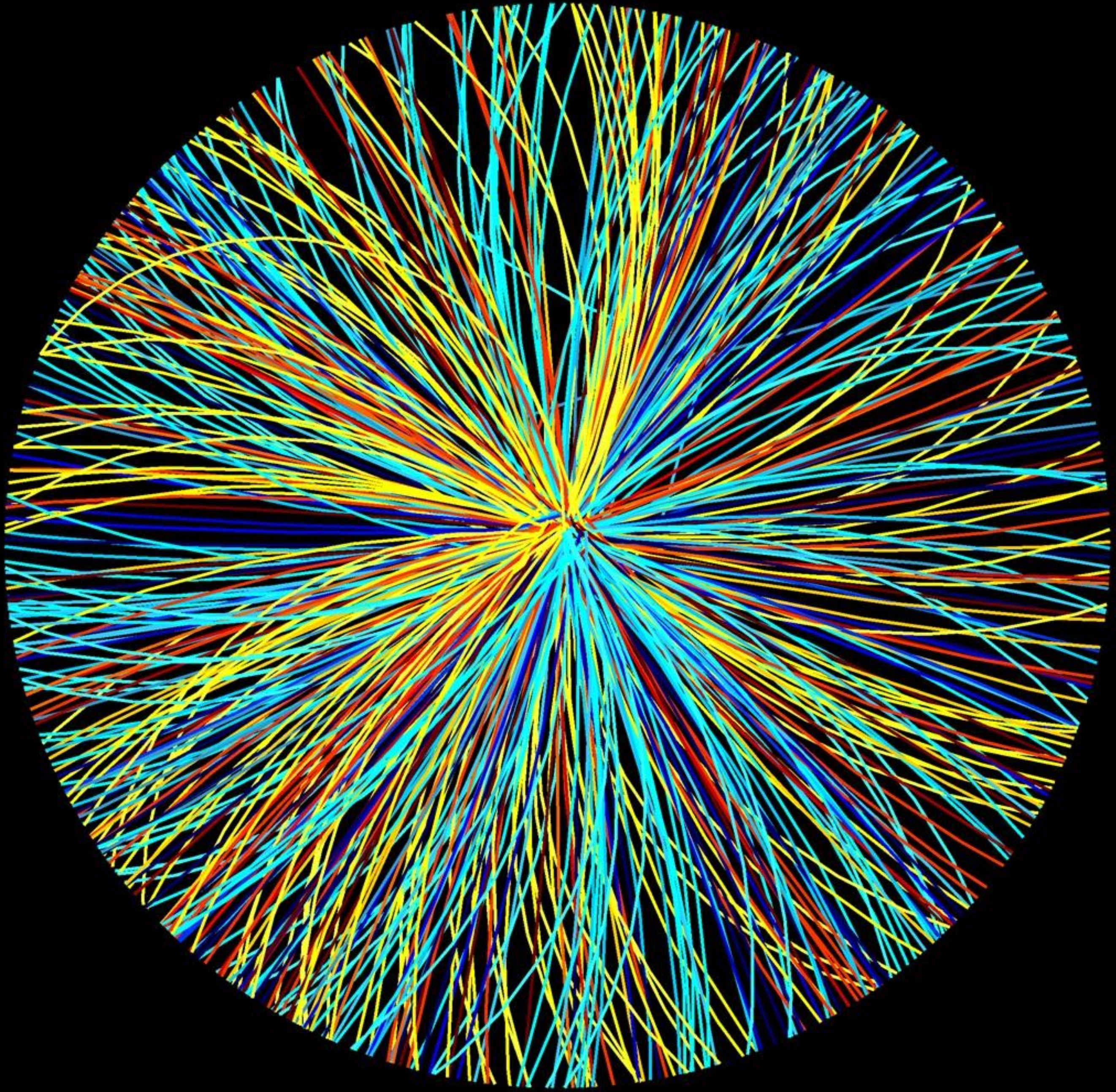
- target for installation and commissioning LS2 (2018)
- collect more than 10 nb^{-1} of integrated luminosity
  - implies running with heavy ions for a few years after LS3
- physics program – factor > 100 increase in statistics
  - (today maximum readout ALICE ~ 500 Hz)
- for triggered probes increase in statistics by factor > 10
- ALICE upgrade Letter Of Intent submitted to LHCC

Conclusions

- A rich program on Pb–Pb, proton-Pb and proton proton in Run 2.

- Low p_T , photon induced and diffractive physics obtains now a boost with the installation of a new detector that enhances the potential of ALICE.

  AD forward detector is now taking data. We are in the process of evaluating the performance (efficiency, purity for selecting Diffractive events but also as a general trigger system for ALICE)



gracias

Backup

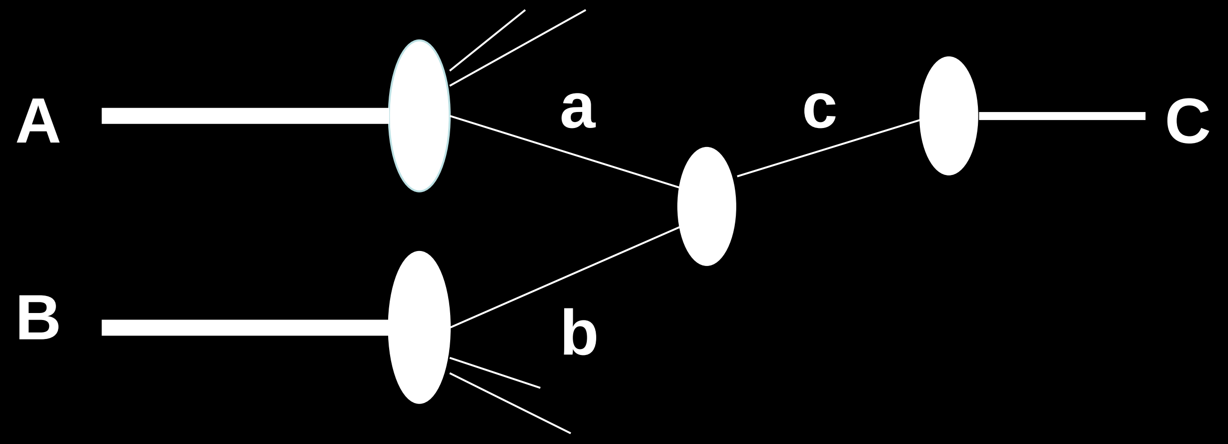
$$A + B \rightarrow C + X$$

$$\sigma(AB \rightarrow CX) = \sum_{ab} C_{ab} \int dx_a dx_b dz f_{a/A}(x_a) f_{b/B}(x_b) \hat{\sigma}(ab \rightarrow cX) D_c^{\,C}(z)$$

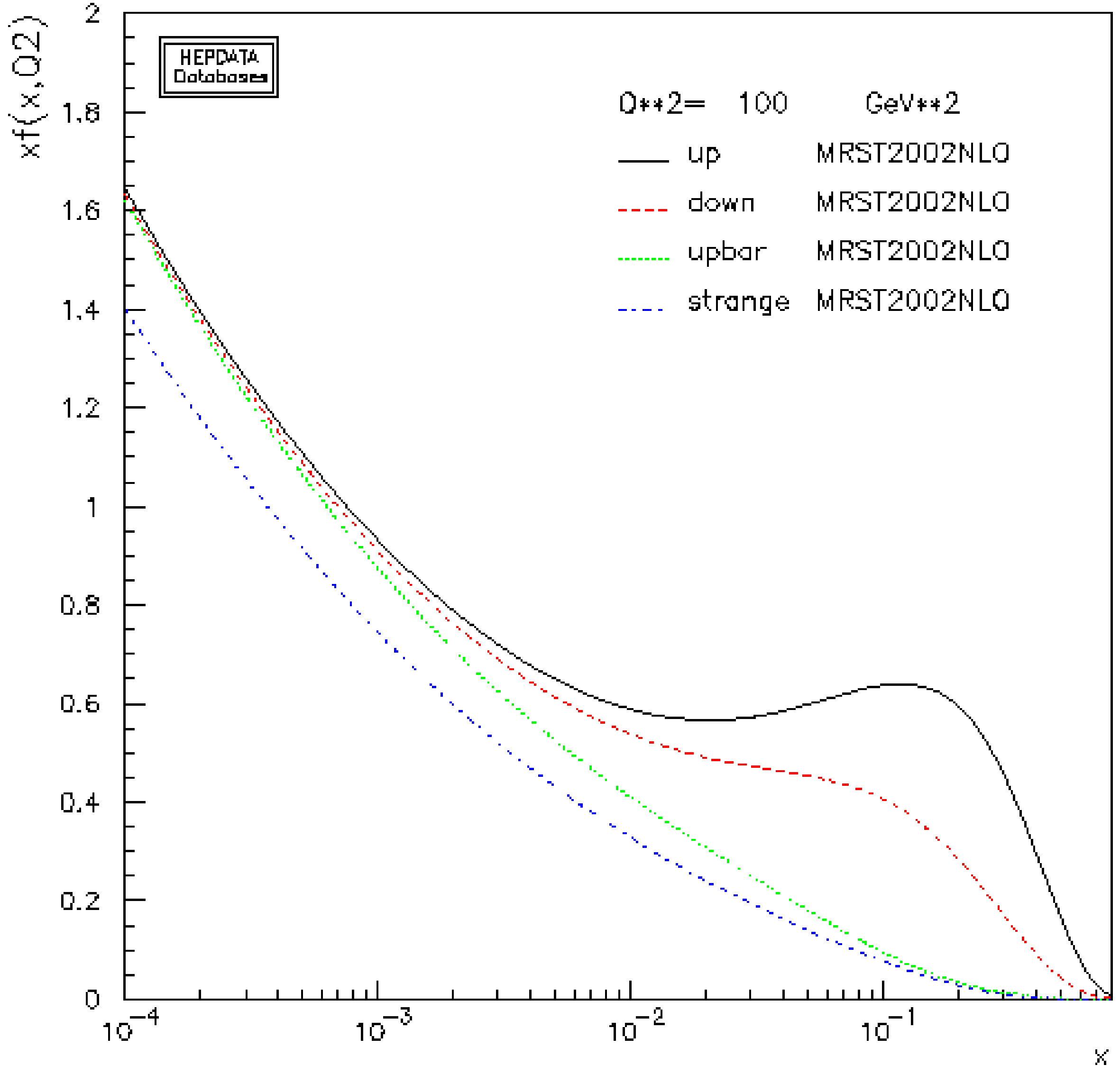
$f_{a/A}(x_a)$ probabilidad de encontrar un partón a en A con fracción de momento x_a

$\hat{\sigma}(ab \rightarrow cX)$ sección eficaz de las reacción de partones

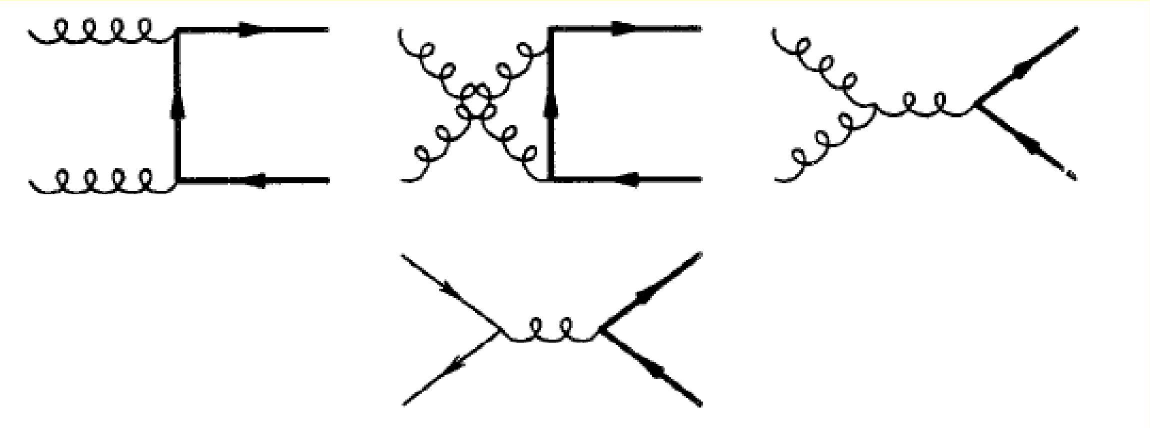
$D_c^{\,C}(z)$ probabilidad de encontrar al partón c en el hadron C con fracción del momento del partón z



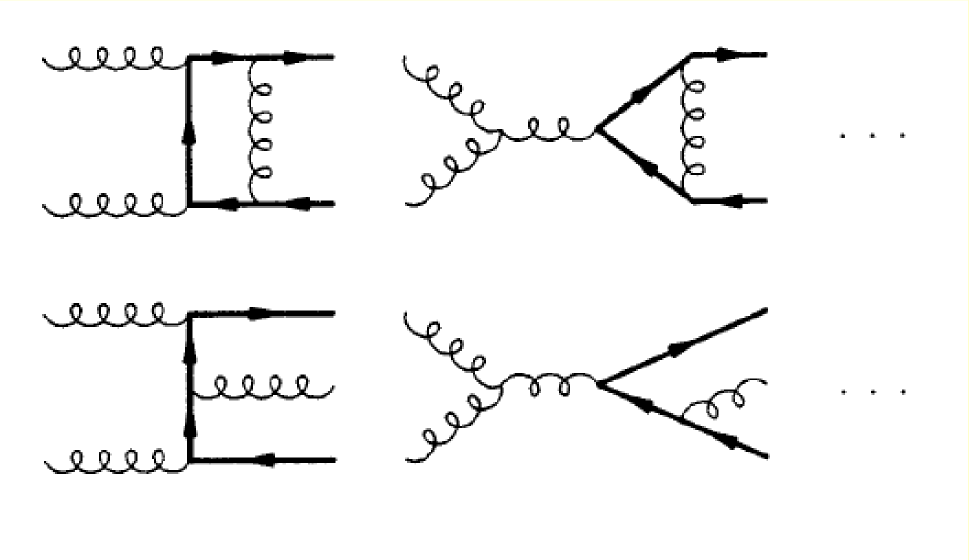
$$f_{a/A}(x_a)$$



http://durpdg.dur.ac.uk/hepdata/pdf3.html gráficas que contribuyen a mas bajo orden



ejemplo de gráficas que contribuyen a orden α_s^3



$$\hat{\sigma}(ab \to cX)$$

$$D_c^C(z)$$

Función de fragmentación de Peterson

$$D_{H/c}(z) = \frac{N}{z\left[1 - \frac{1}{z} - \frac{\varepsilon_Q}{1-z}\right]^2}$$

$$\sum \int dz D_Q^H(z) = 1$$

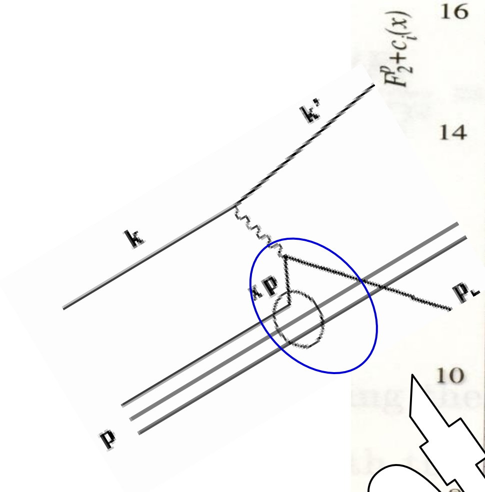
$$\varepsilon_Q = 0.143$$

$$m_{D^-, D^+} = 1.8694 GeV$$

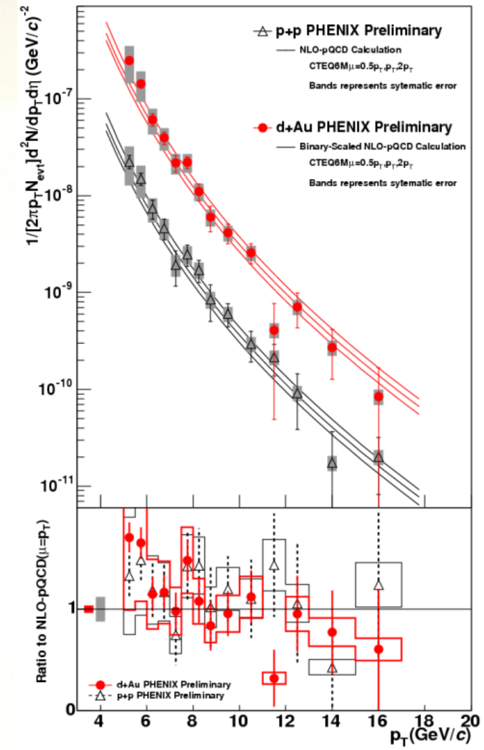
$$m_{\overline{D}^0, D^0} = 1.8646 GeV$$

C. Peterson, et al., *Phys. Rev.D*, **27**:105, 1993

$$F_2(x,Q^2) = x\sum_q e_q^2 q(x,Q^2)$$



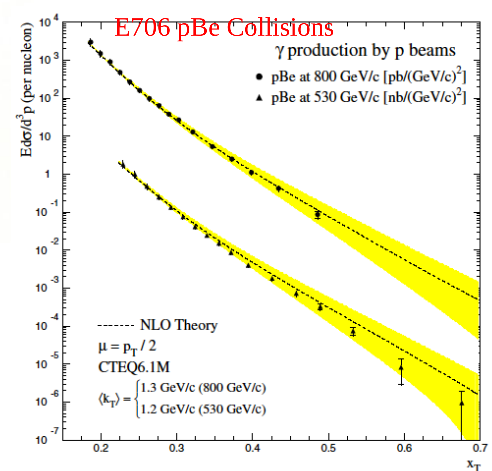
Factorización



sello de garantía

que da confianza

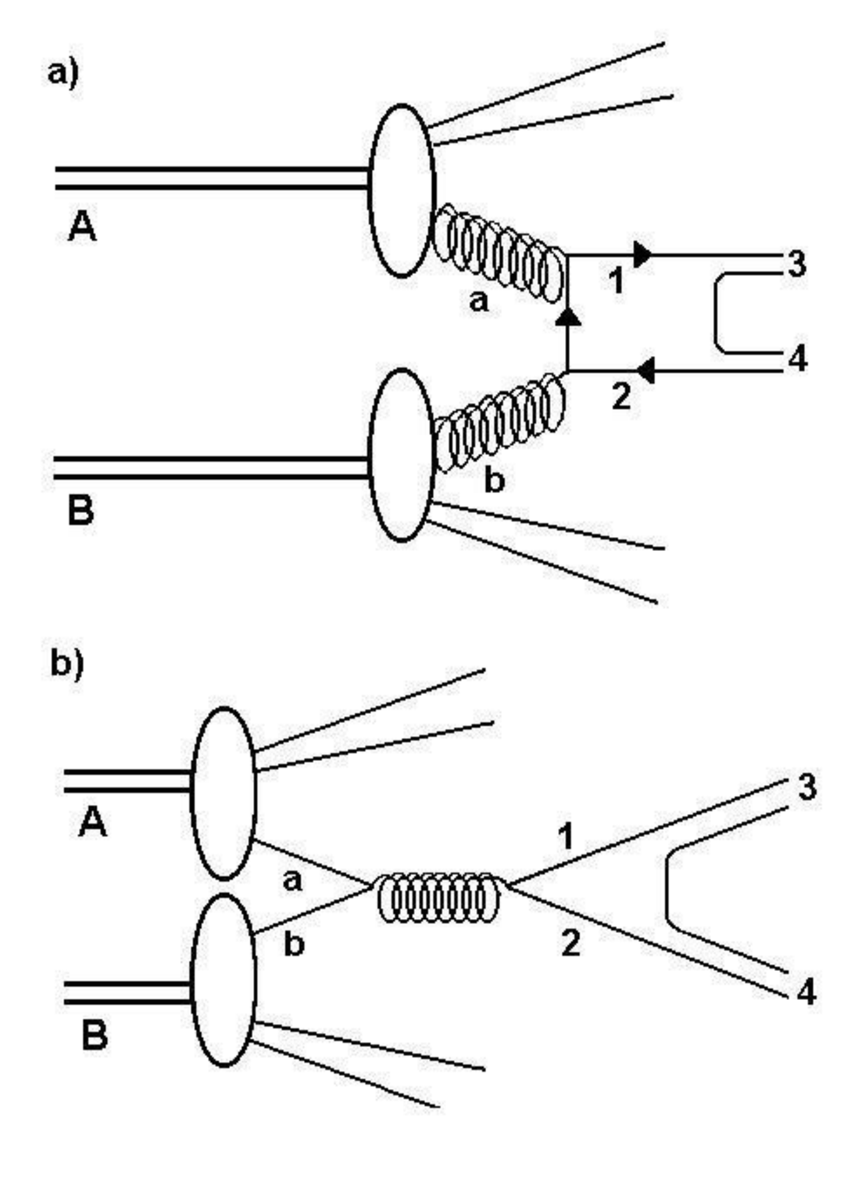
PRD70(2004)092009



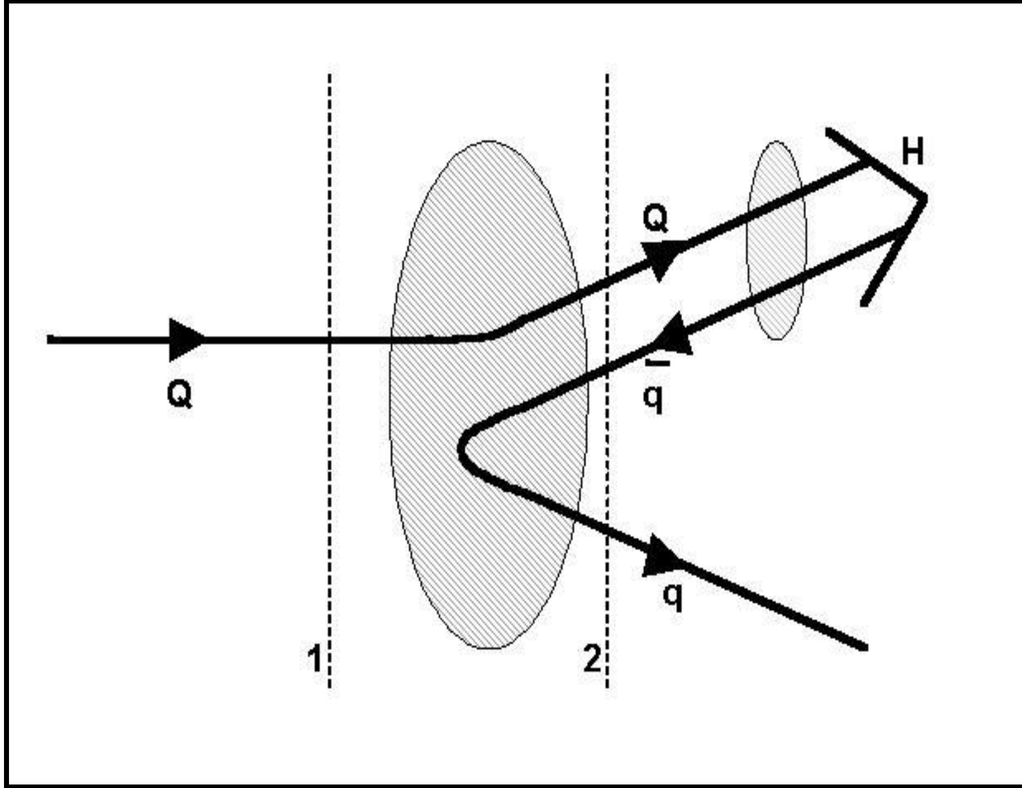
FNAL　E706実験では、pBe散乱からの直接光子測定により、初期パートンの横運動量にして1.3GeV/c程度の原子核効果があると結論。

… and yet factorization breaks !!

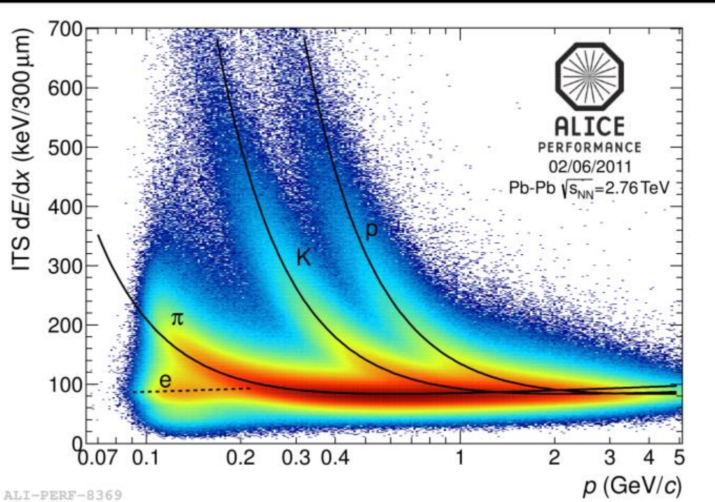
Fragmentation

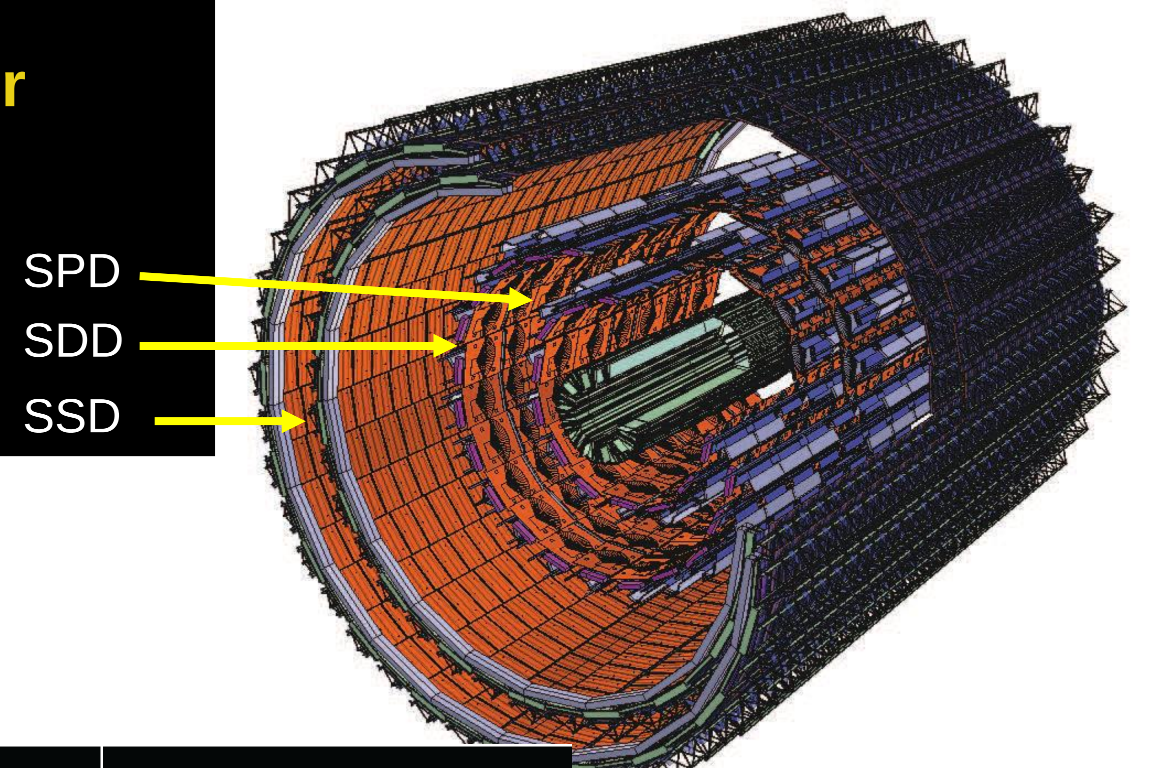


¿Higer order QCD?
Non perturbative effects …
¿ Recombination ?



all known techniques for particle identification:





Layer	Det. Type	Radius (cm)	Length (cm)	Resolution (μm)	
				rφ	z
1	pixel	3.9	28.2	12	100
2	pixel	7.6	28.2	12	100
3	drift	15.0	44.4	35	25
4	drift	23.9	59.4	35	25
5	strip	38.0	86.2	20	830
6	strip	43.0	97.8	20	830

Inner Tracking System

3 silicon technologies

low momentum acceptance

high granularity

low material budget

all known techniques for particle identification:

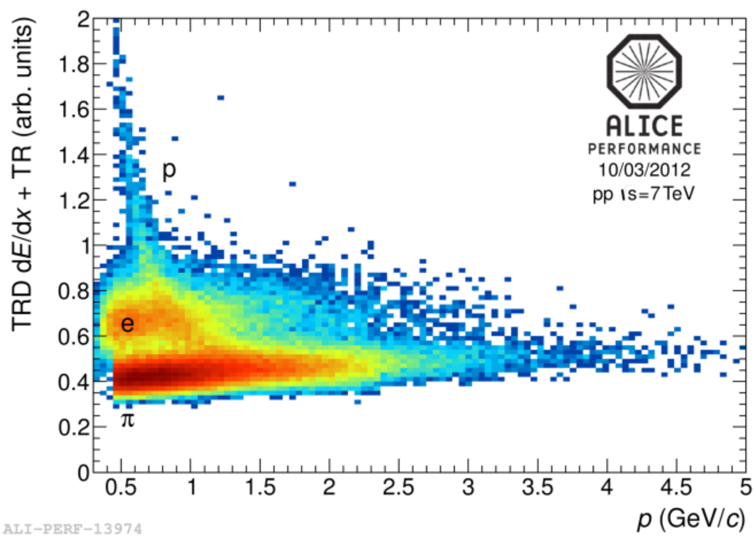
$-0.9 < \eta < 0.9$

Transition Radiation Detector

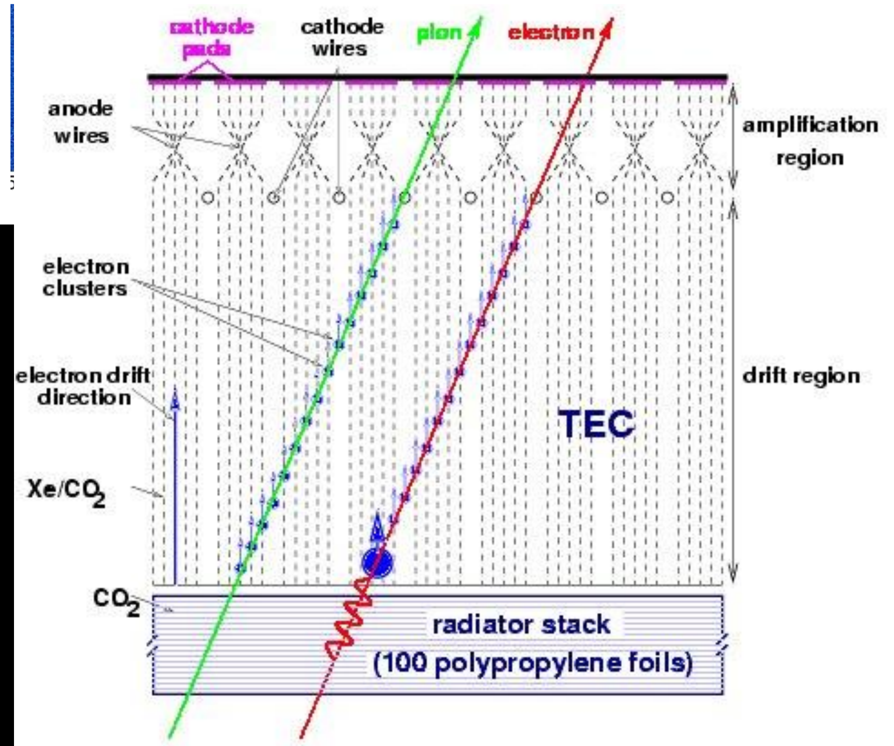
for e PID, p>1 GeV/c for e and high p_t trigger, p>3 GeV/c

Large (800 m^2), high granularity (> 1M ch.)

fiber radiator to induce TR (γ > 2000)



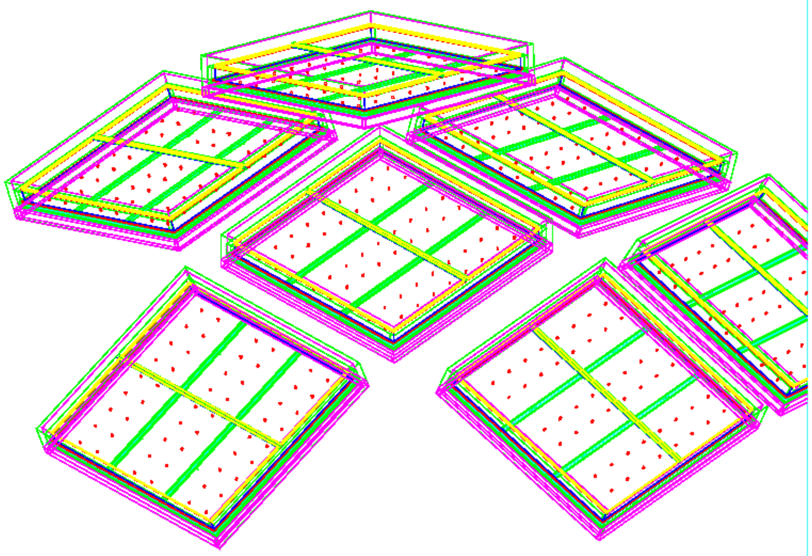
TRD

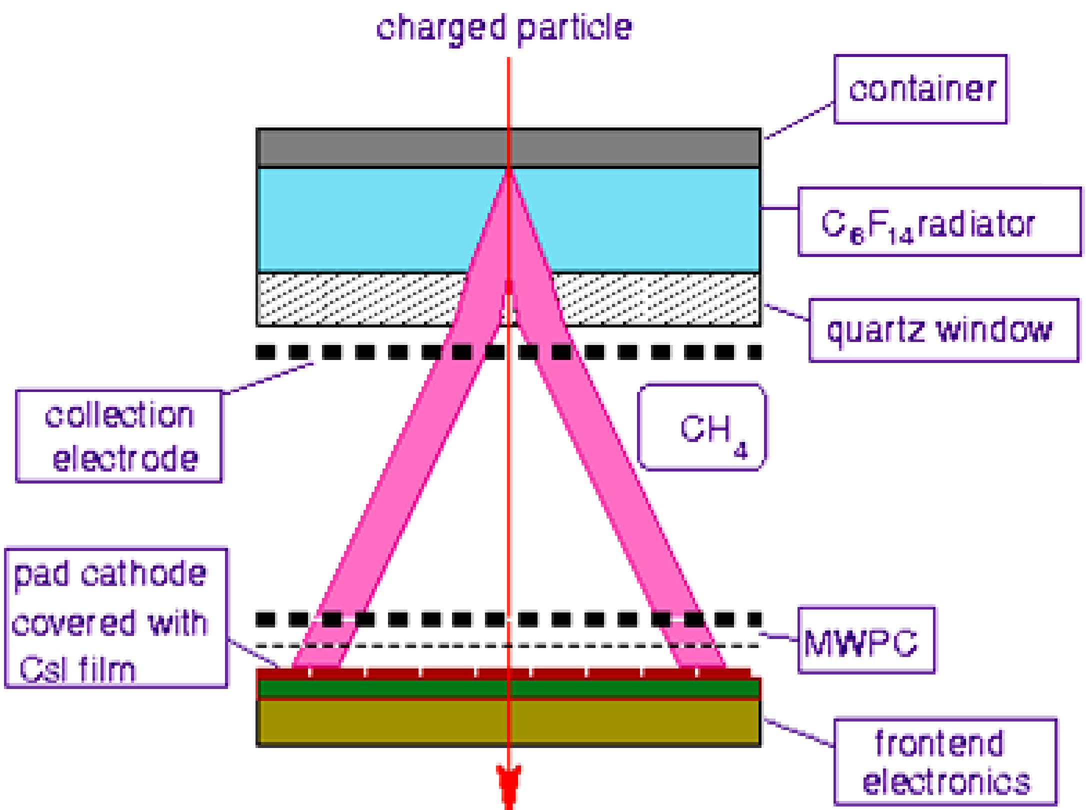


all known techniques for particle identification:

High Momentum Particle Identification

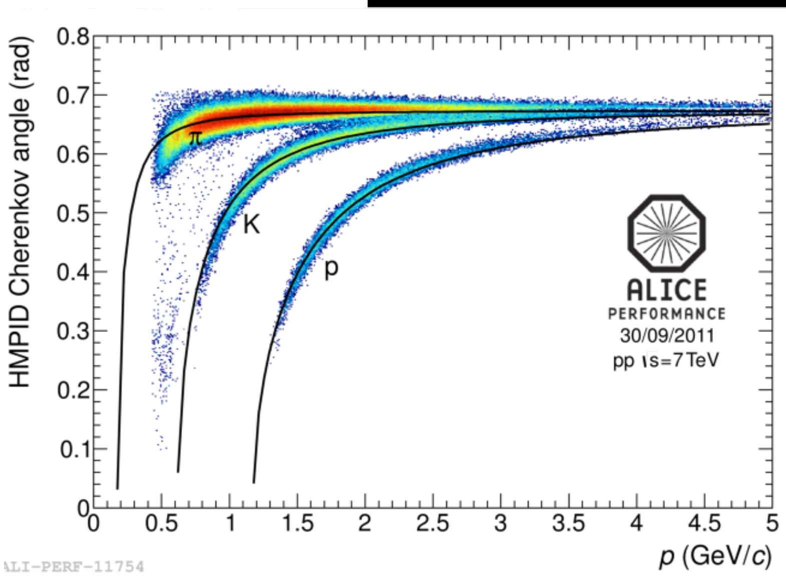
7 modules, each ~1.5 x 1.5 m^2





RICH

HMPID



Graduados a febrero 2015: 699 de los cuales

Maestría: 435 (57mujeres) Doctorado: 264 (37mujeres)

- Dr. Bernardo José Luis Arauz Lara (1986)
- Dr. Gabino Torres Vega (1987)
- Dr. Alejandro Vizcarra Rendón (1990)
- Dr. Roberto Enrique Martínez (1991)
- Dr. Héctor Hugo García Compean (1995)
- Dr. José Herman Muñoz (1998)
- Dr. Juan Eloy Ayón Beato (2001)
- Dr. Luis Arturo Ureña López (2002)
- Dr. Alfredo López Ortega (2006)
- **Dra. Mercedes Paulina Velázquez Quesada (2012)**