Université Mohammed V
Faculté des Sciences
Rabat

High Energy Physics Workshop
Tanger

ESMAR Research activities

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27 October 2016
University Mohammed V in Rabat
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Plan

- ESMAR
- High Energy Physics Activities
- Astro-Particles Activities
- Conclusion

ESMAR

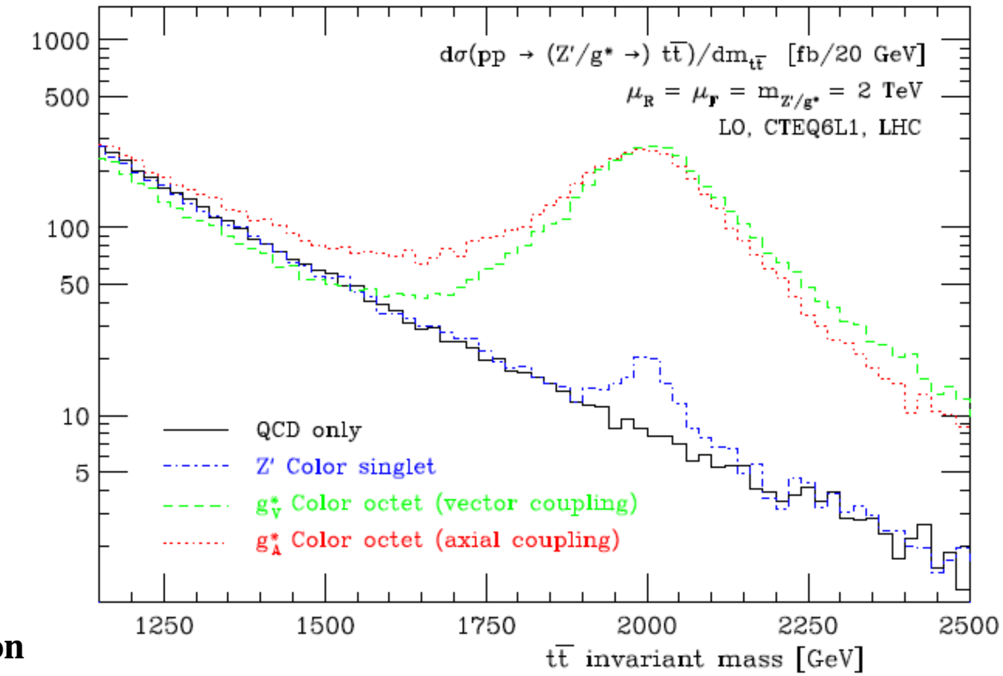
- **High Energy Physics and Astro-particules**
  - ATLAS, ANTARES, KM3NeT
- **Medical Physics**
  - Elekta
- **Theoretical Physics (M. El Baz talks)**
  - ICTP
- **Photonics, Phononics**

Manpower

- R. Cherkaoui El Moursli, F. Fassi, Yahya Tayalati
- Souad Batlamouss
- Salah Eddine Dahbi
- Hamdaoui Hassan
- El Jerrari Hassane
- Asmae Ettahiri
- Jihad Boumaaza
- Ngair Badr-Eddine (newcomer)
- Mohamed ZAAZOUA (newcomer)

Search for heavy resonances

- Top quarks are special
- Heavy! ⇒Very large Yukawa coupling
- Many BSM model predict enhanced coupling to 3rd generation
- Heavy mediators (H, A, Z', g_{KK}, G_{KK})
  Top partners (Vector-like quarks)



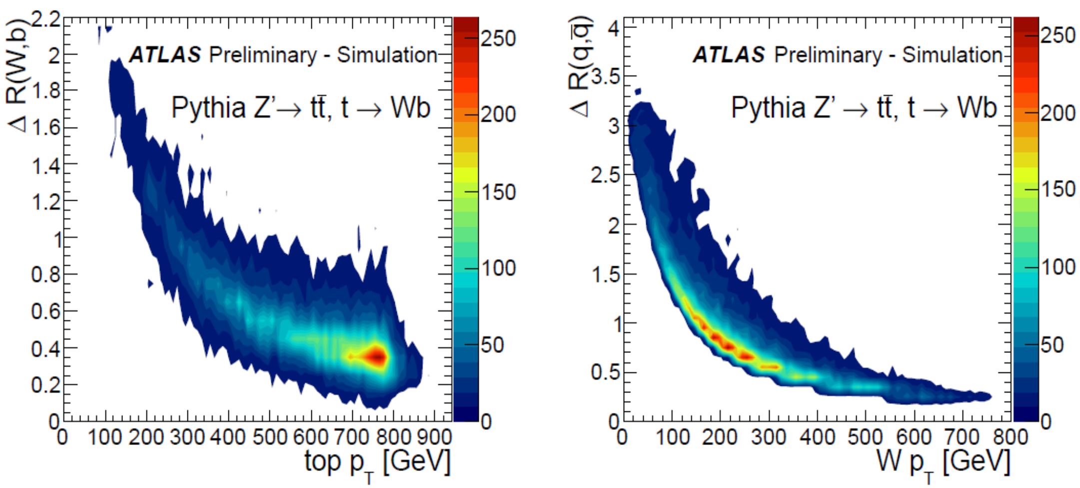
A search for top-antitop resonances using 3.2 fb^{-1} of proton-proton collisions at $\sqrt{s}$ = 13 TeV

Ch. Anders[he], M. Aoki[so], K. Behr[ox], C. Buttar[gl], S. Calvet[cf], C. Camincher[gr], H. Carson[az], J. Caudron[ma], S. Crépé-Renaudin[gr], A. Duncan[gl], J. Ferrando[gl], D. E. Ferreira de Lima[gl,he], F. Fassi[ra], O. Gabizon Shuldman[wu], S. Groh[ma], T. Heck[ma], Z. Idrissi[ra], C. Işsever[ox], K. Johns[az], A. Kilgallon[az], A. Kobayashi[to], P. Maettig[wu], L. Masetti[ma], R. Nayyar[az], T. Nobe[to], C. Pollard[gl], S. M. Romano Saez[cf], A. Schoening[he], D. Sosa[he], S. Suzuki[so], K. Terashi[to], J. Zhong[ox]

https://cds.cern.ch/record/2010613/files/ATL-COM-PHYS-2015-294.pdf

Singel lepton ttbar resonances

- With the increase of energy and luminosity at the LHC, decay of heavy resonances associated with new physics is in the multi-TeV mass range
  - Result in highly boosted very massive objects such as Top
    - Decay products of Boosted Tops collimated in direction of pT
    - Separation can be described according to ΔR ~ m/pT



(a) $t \to Wb$ ATLAS-CONF-2012-065 (b) $W \to q\bar{q}$

- Standard reconstruction methods are no longer sufficient for boosted top quarks
- Many new techniques are developed to reconstruct and identify boosted tops
  - Jet substructure → **fatjet**
  - Less-isolated leptons

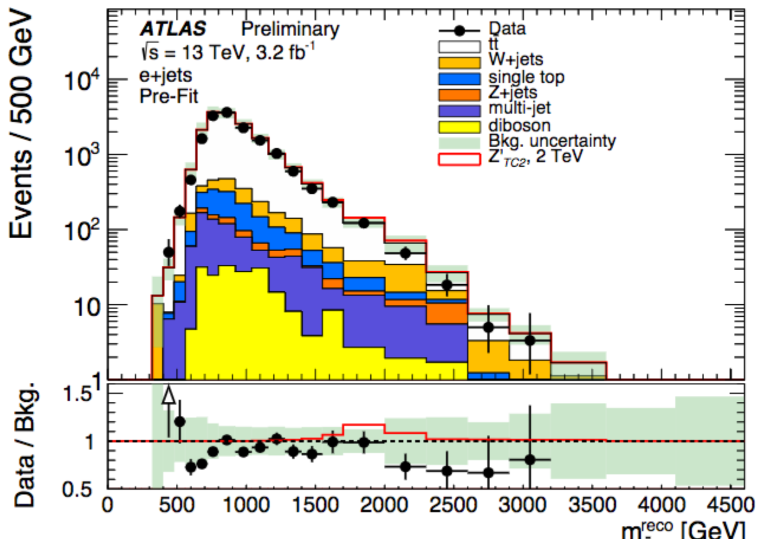
Singel lepton ttbar resonances

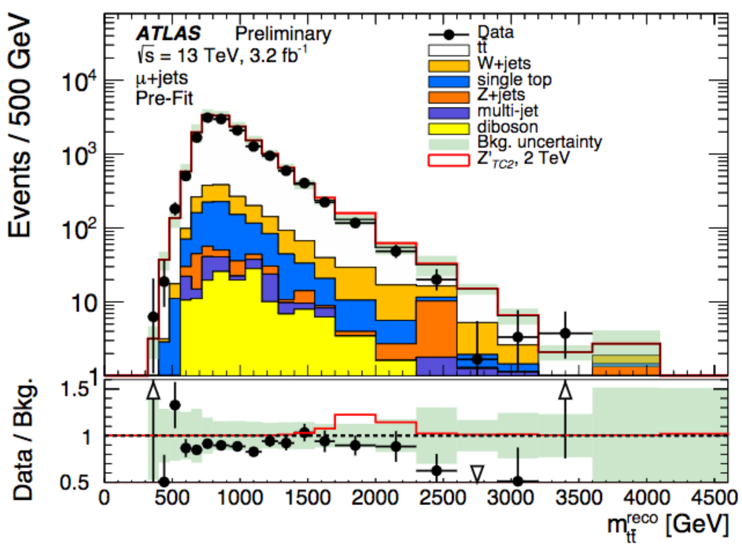
- **Analysis strategy**
- Top quark signature is difficult to reconstruct efficiently → Many objects
  - Adapt the event selection and reconstruction to the final configuration

- **Event selections:**
  - Resolved: standard top reconstruction with narrow jets
  - Boosted: using large-cone “fatjet to reconstruct the hadronic top

- **Event reconstruction:**
  - Combined limit of boosted and resolved selection:
    - Resolved selection mainly relevant at low mtt
    - Boosted selection relevant at high mtt

Singel lepton tt





	e+jets	μ+jets
$t\bar{t}$	3000 ± 700	3000 ± 700
W+jets	200 ± 140	200 ± 40
Single top	190 ± 40	180 ± 40
Z+jets	33 ± 12	26 ± 12
Multi-jet	130 ± 70	19 ± 11
Diboson	46 ± 11	37 ± 8
Total	3700 ± 800	3400 ± 800
Data	3352	3074

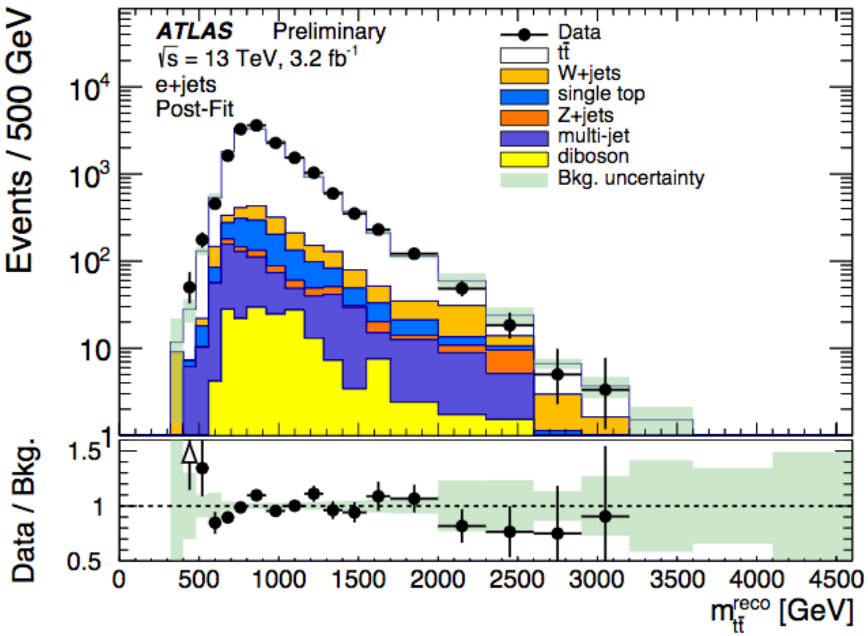
Background estimated from MC simulation, except

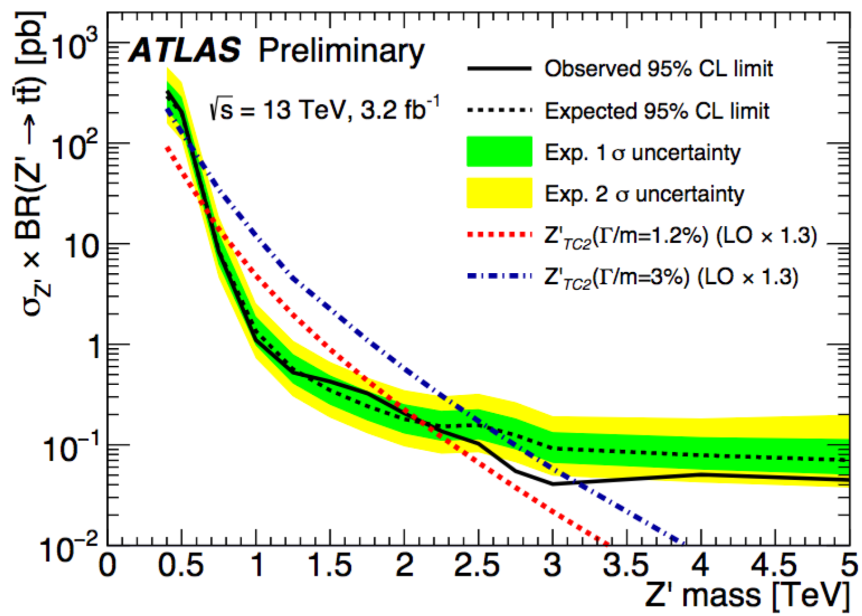
- *W*+jets normalization from data (charge asymmetry)
- Multijet estimated from data (matrix method)

Perform likelihood fit of m_{tt}^{reco}

- Most significant excess <1σ ⇒ Set limit
- Z'_{TC2} benchmark with Γ/m = 1.2% and 3%
- Assume no interference with SM

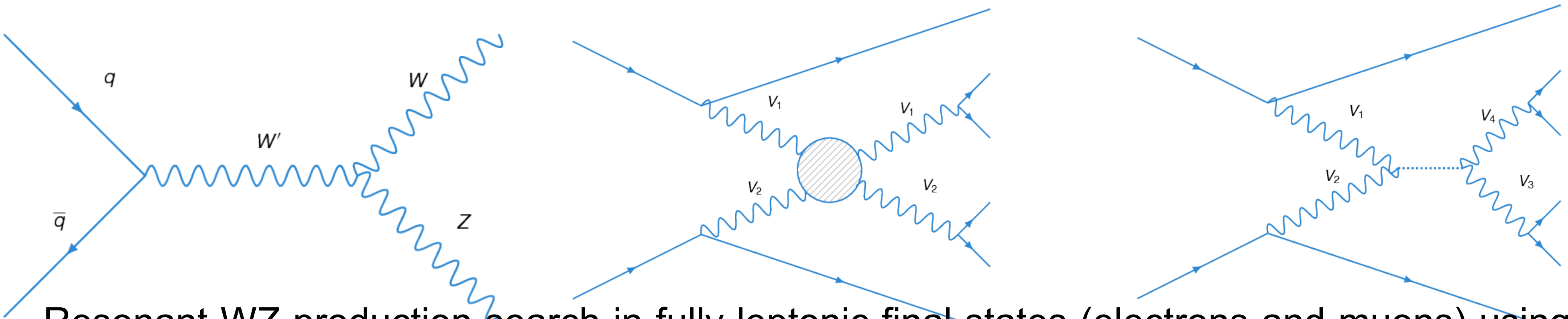
Singel lepton ttbar resonances





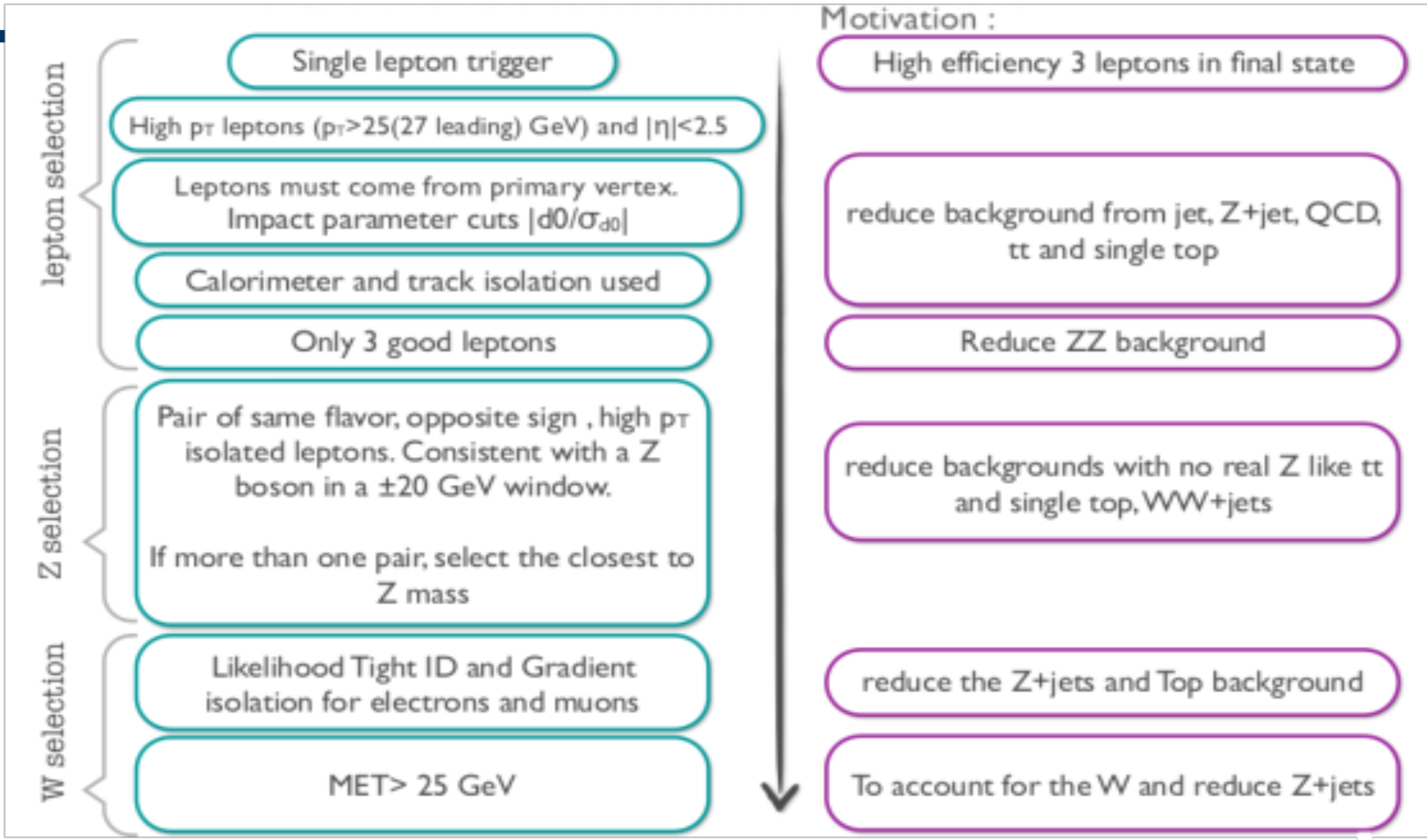
- Expected and observed upper cross section limits times ttbar branching ratio (95 % C.L.)

Search for WZ→ lνll resonances



- Resonant WZ production search in fully leptonic final states (electrons and muons) using 36.1 fb −1 of data collected at 13 TeV center of mass energy by the ATLAS detector at the LHC during the 2015 and 2016 runs.
- Aim of this analysis: fully leptonic WZ decay (e,μ) in exclusive qq̄ and VBS/VBF production modes.
- Clean signature:
  - ➔ 3 high p T and isolated leptons.
  - ➔ Missing transverse energy.
- Backgrounds: WZ SM (dominant), ZZ, Z+jets, Z+γ, VVV and Top.
- Two benchmark models:
  - ➔ Heavy Vector Triplets (HVT).
  - ➔ Georgi-Machacek (GM) Higgs Triplet Model H +5 .

CutFlow



Motivation :
lepton selection
Single lepton trigger
High p_T leptons (p_T>25(27 leading) GeV) and |η|<2.5
Leptons must come from primary vertex. Impact parameter cuts $|d0/\sigma_{d0}|$
Calorimeter and track isolation used
Only 3 good leptons
Z selection
Pair of same flavor, opposite sign , high p_T isolated leptons. Consistent with a Z boson in a ±20 GeV window.
If more than one pair, select the closest to Z mass
W selection
Likelihood Tight ID and Gradient isolation for electrons and muons
MET> 25 GeV
High efficiency 3 leptons in final state
reduce background from jet, Z+jet, QCD, tt and single top
Reduce ZZ background
reduce backgrounds with no real Z like tt and single top, WW+jets
reduce the Z+jets and Top background
To account for the W and reduce Z+jets

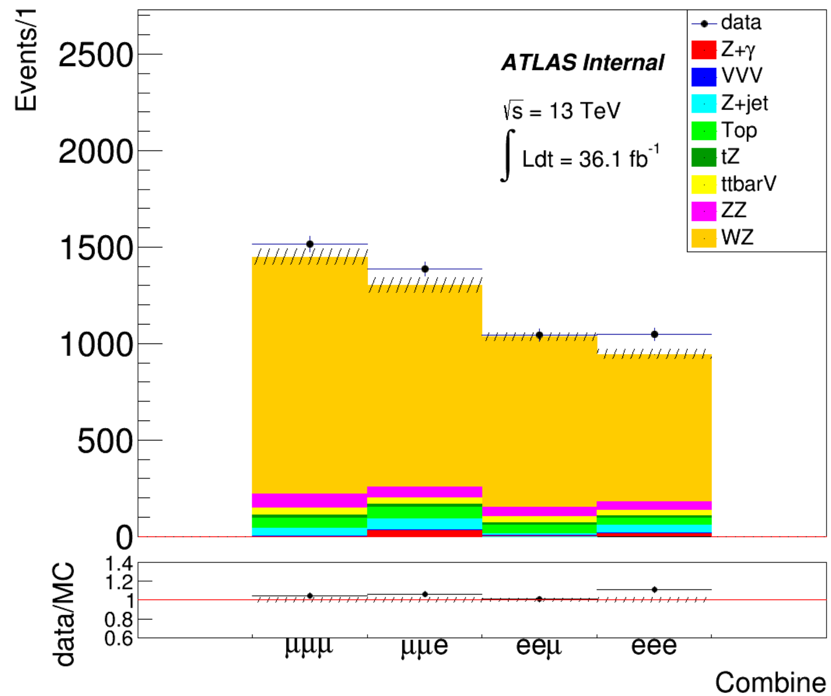
Background

90% Real leptons: Estimated using MC

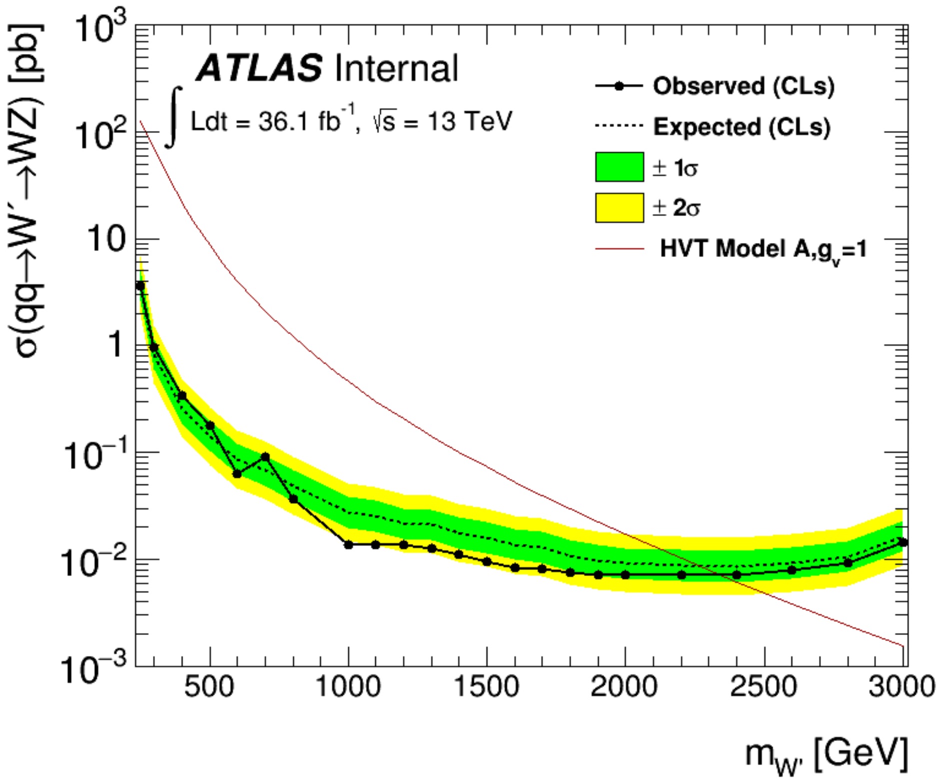
- WZ (QCD Sherpa 2.2.2, EWK Sherpa 2.1).
- ZZ (Powheg (qq) and Sherpa (gg)).
- ttbarV (V=Z,W) (MadGraphPythia).
- tZ (MadGraphPythia).
- VVV (V=Z,W) (Sherpa).

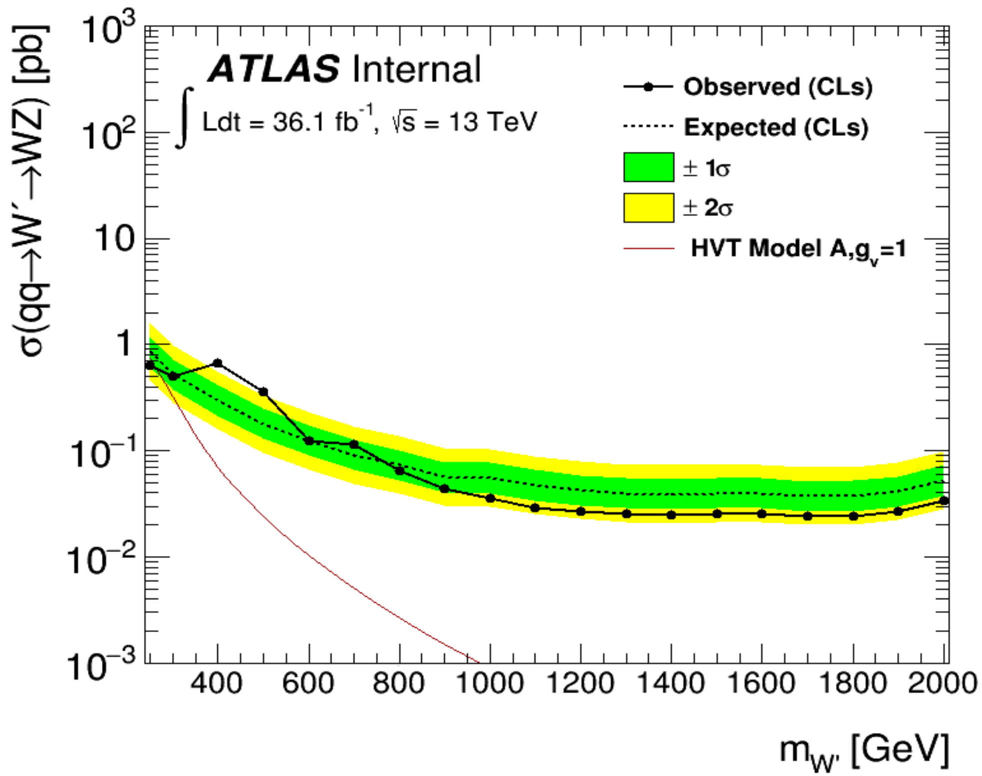
10% Fake leptons: Estimated using Matrix Method

- Z+jets (Sherpa 2.2.1).
- Top (Single top, ttbar) (PowhegPythia).
- Zγ (Sherpa).



Results





Collaboration with CEA, Saclay

Performance studies

Development of a track-based algorithm for MET TST systematic uncertainties

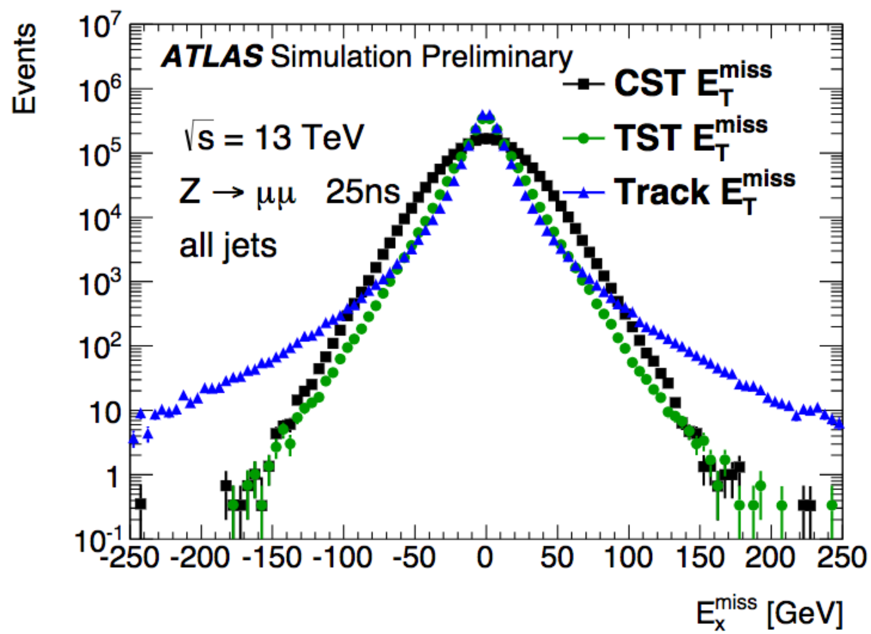
- **Missing transverse energy (MET) is a key observable for many analyses**
  - **Precision measurements and searches**

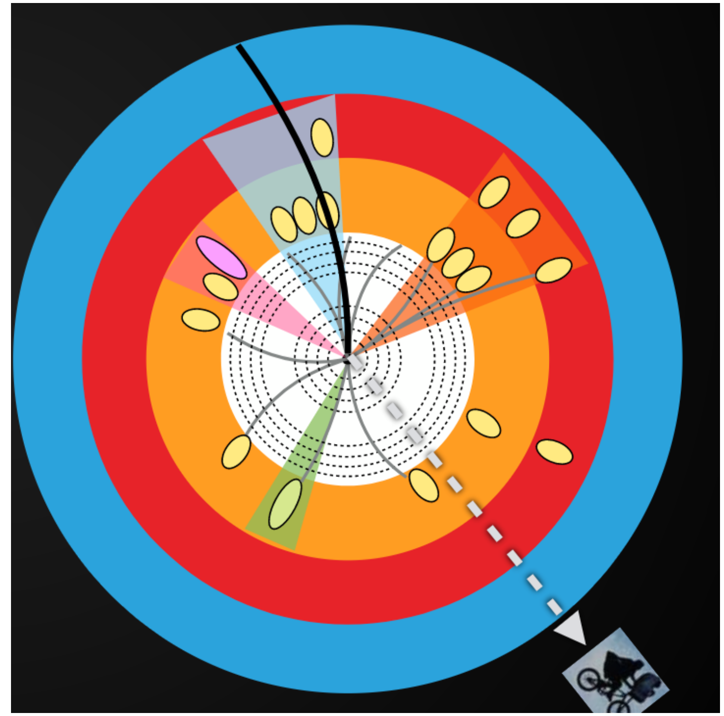
- **MET relies on full event information**
  - Objects need to be reconstructed/calibrated
  - Any overlap needs to be removed
  - MET reconstructed as $\sum_{\text{objects}} \mathbf{p}_{\mathrm{T}}$

- **Soft Term (ST) :**
  - Contribution to MET from all constituents that are not associated to hard objects

Performance studies

- **Calorimeter Soft Term (CST) :**
  - ST built with calorimeter clusters as constituents
- **Track Soft Term (TST) :**
  - ST built with tracks as constituent

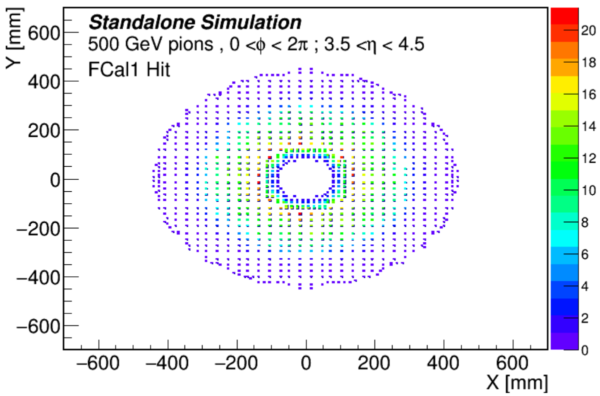


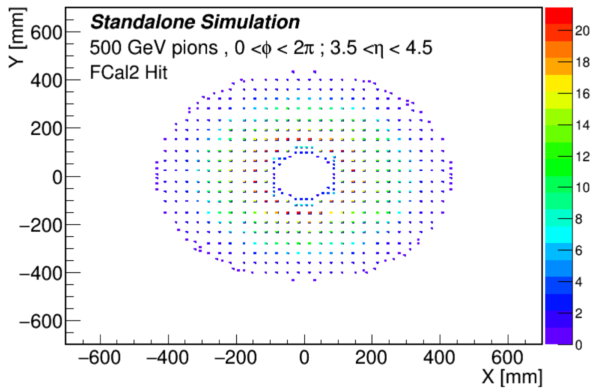


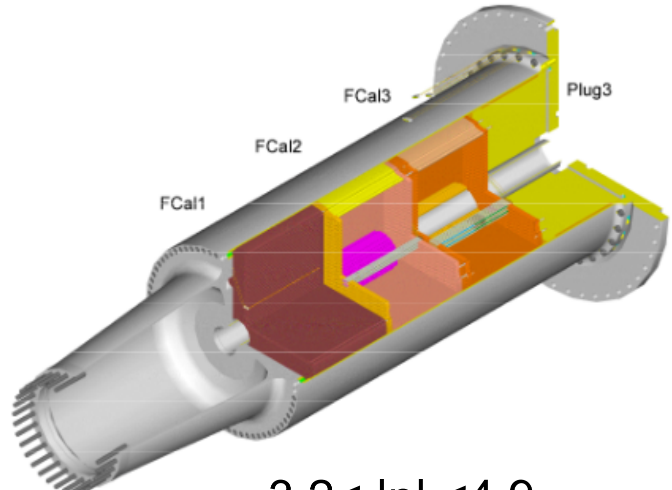
- **A framework for deriving a track-based TST systematic uncertainties in being developed using release 21**

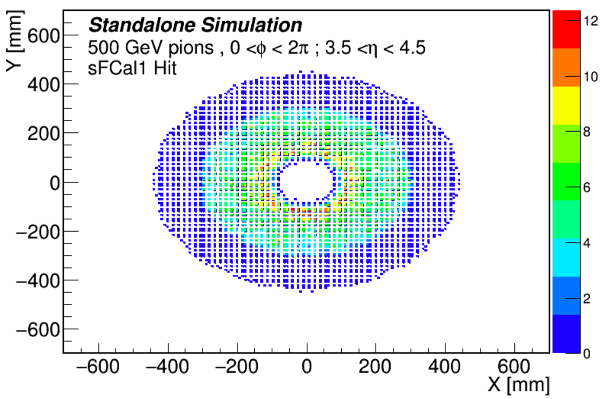
Performance studies

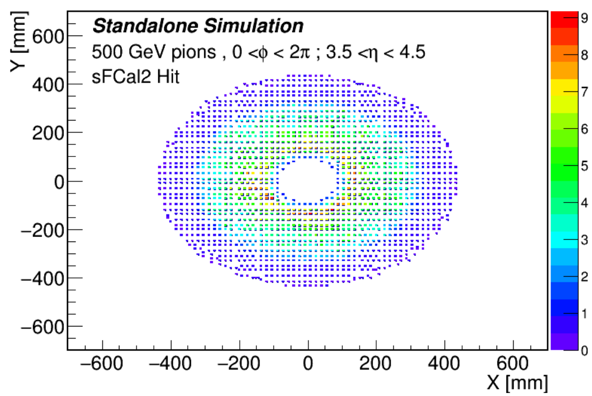
Performance studies of the sFCal granularity at HL-LHC











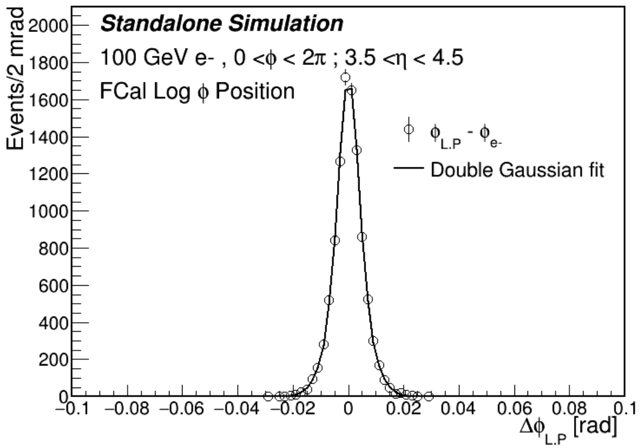
- $3.2 < |\eta| < 4.9$.
- FCal1 (Cu/LAr),
- FCal2 (W/LAr)
- FCal3 (W/Lar).

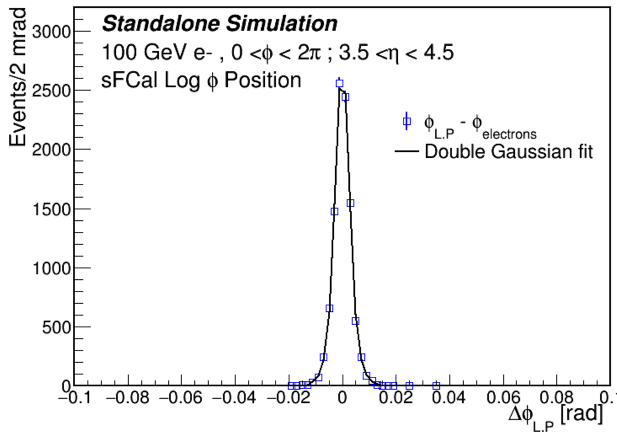
LAr annular gaps (FCal1: 0.27mm; FCal2: 0.37mm; FCal3: 0.5mm)

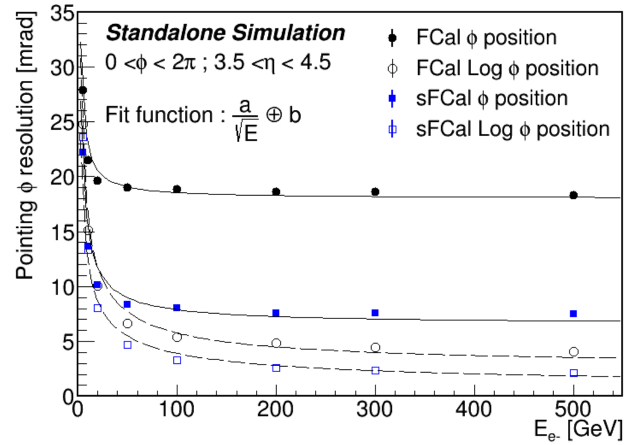
Performance studies

φ Pointing resolution :

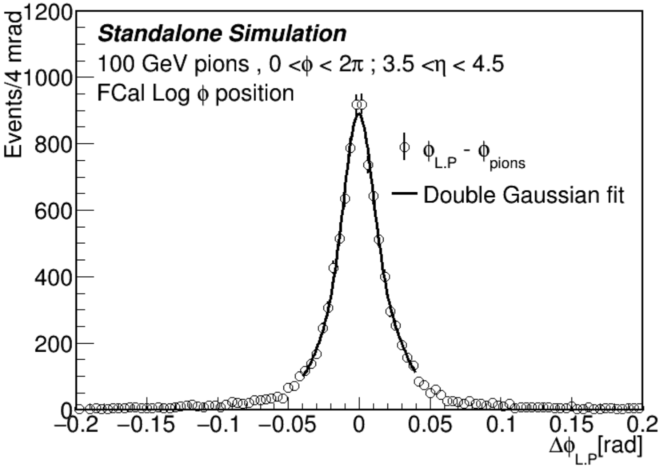
Electrons :

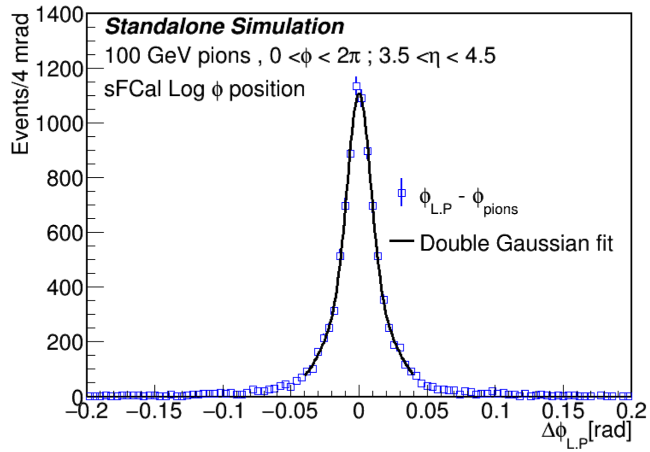


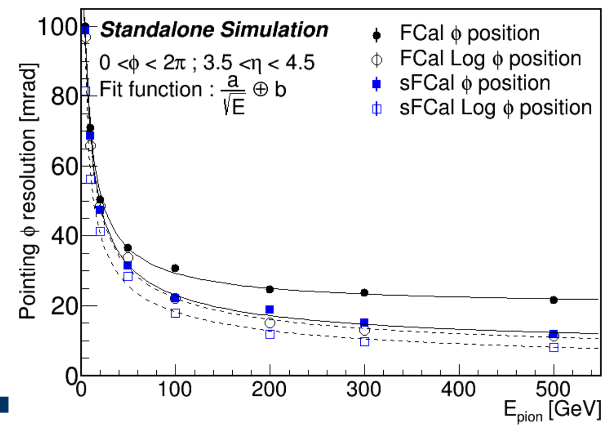




Pions:



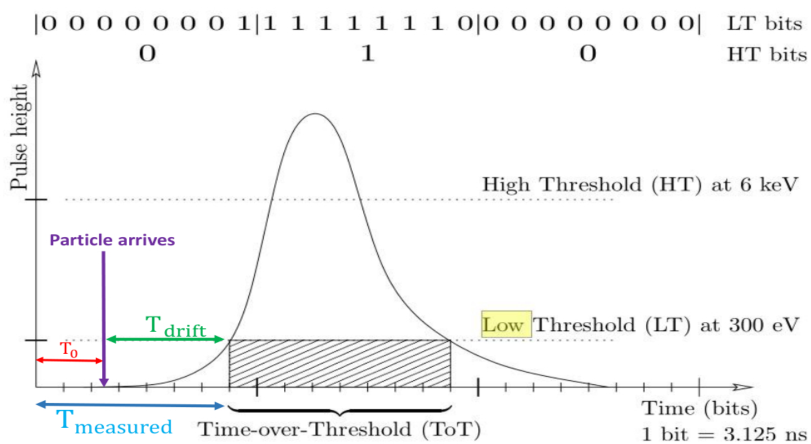


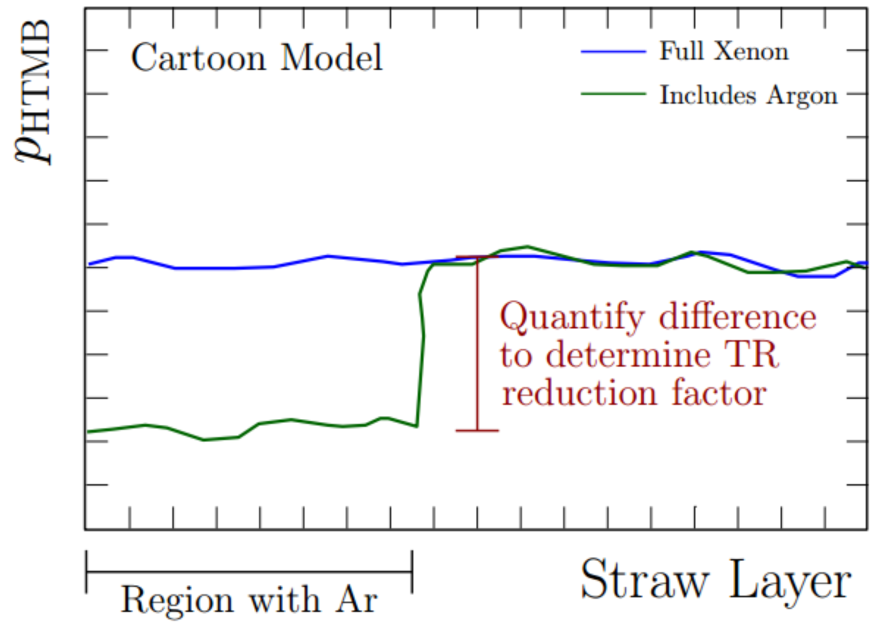


TRT Performance studies

Implementation

❶ Introduce new gas types in the ATLAS simulation framework
❷ Mimic the High Threshold response of the gas we wish to emulate
❸ Scale the TR absorption efficiency during the digitization by a TR efficiency reduction factor (TRERF)

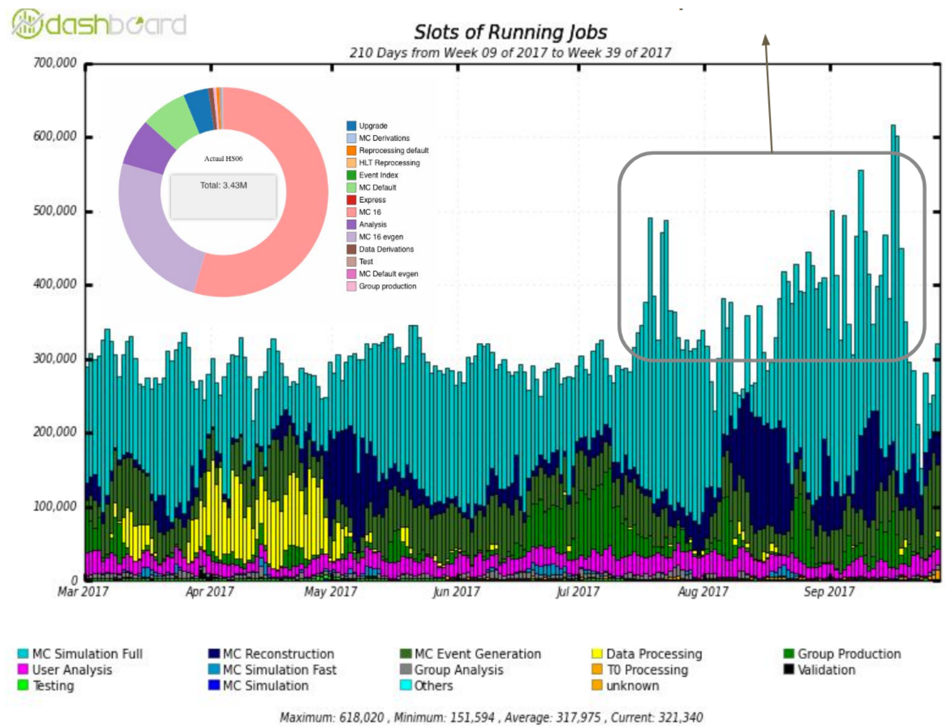




Distributed Computing

- **Distributed Production And Analysis expert team (DPA)**
  - The responsibility of DPA team is to guarantee the smooth execution of production and user analysis requests on all available computing resources

- Over 300k slots of running jobs
  - Pledges 2017: ~230k slots
- And more with opportunistic resources:
  - HPCs
    - Provide large resources. Big potential, but more effort needed.
    - Commercial and Private clouds
    - ATLAS@Home
- Jobs:
  - Large mixture of highly diverse type of jobs: multi-core, single-core, multi-core high memory...



ATLAS/Shifts

Class 2

Task / Year	2011	2012	2013	Total
ADCoS Senior shifts			4.68	4.68
ADCoS Trainee shifts				0.00
Simulation and Digitization	11.50	11.50	1.50	24.50

Class 2

System	Activity	Task	2017	Total
TRT	Detector Operation	TRT Offline Shifter	7.00	7.00
Total			7.00	7.00

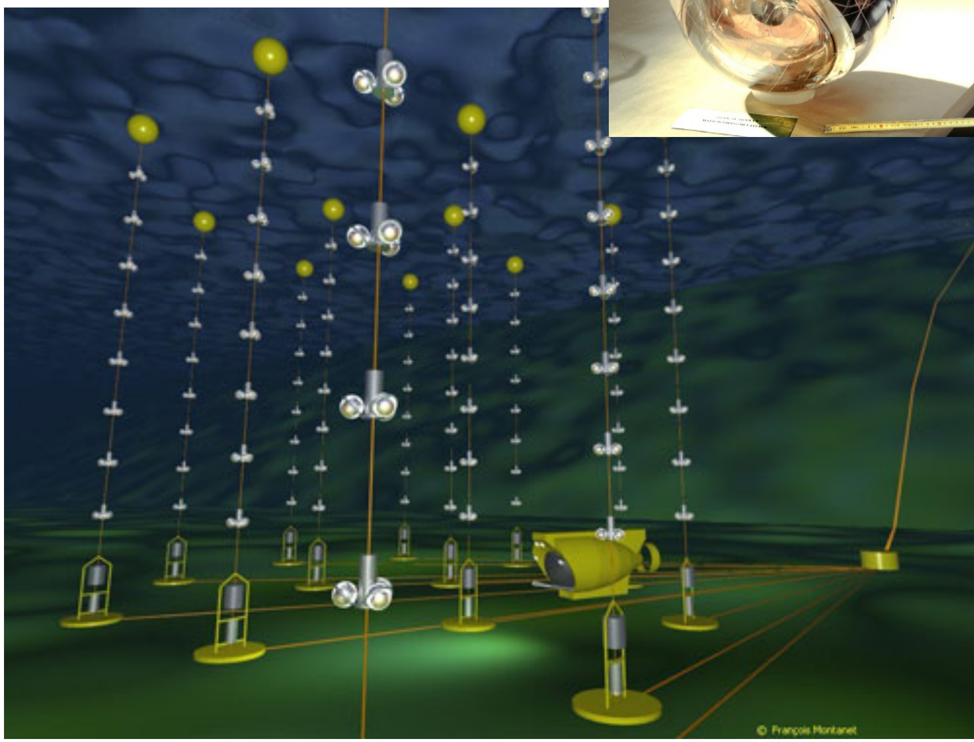
Class 2

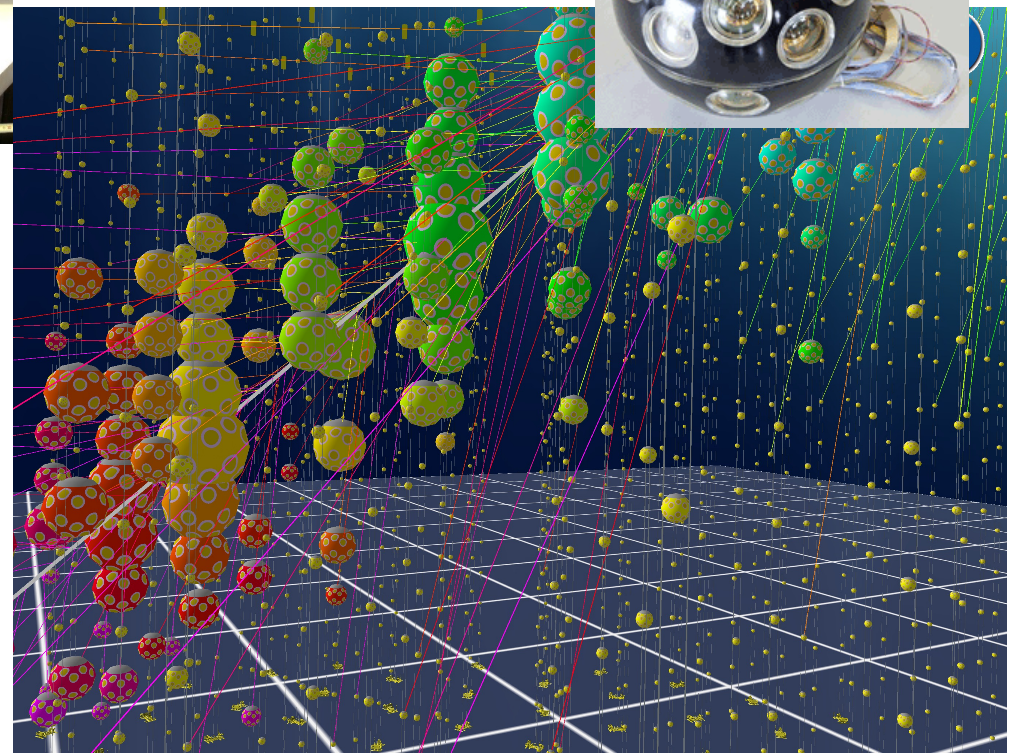
System	Activity	Task	2011	2012	2013	2014	2015	2016	2017	Total
General Tasks	Computing/Software	ADCoS Trainee shifts								0.00
General Tasks	Computing/Software	Distributed Analysis Trainee Shifts	3.50							3.50
General Tasks	Computing/Software	Distributed Analysis Shifts 1st level	10.00	51.00	69.00	40.00	95.00	76.00	41.00	382.00
General Tasks	Computing/Software	Distributed Analysis Shifts 2nd level	3.50			23.00	3.00	2.50		32.00
Total			17.00	51.00	69.00	63.00	98.00	78.50	41.00	417.50

Class 3

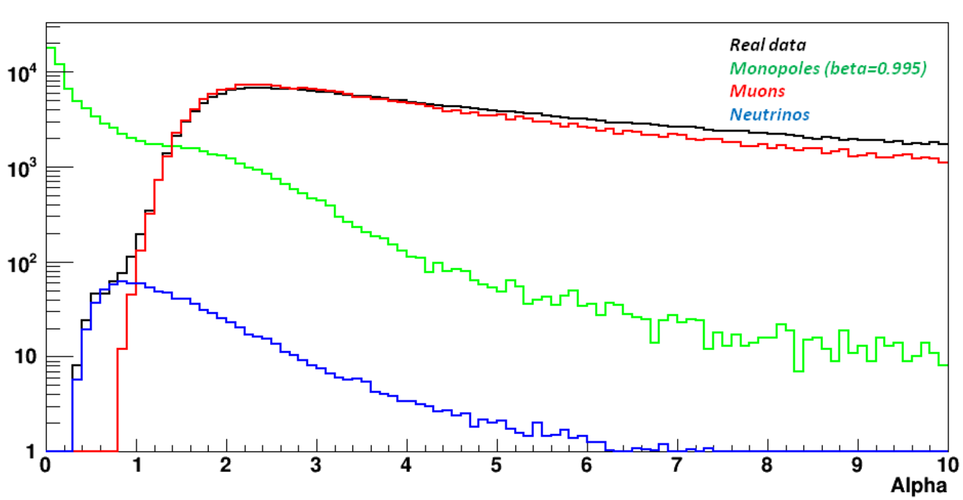
System	Activity	Task	2011	2012	2013	2014	2015	2016	2017	Total
General Tasks	Computing/Software	Computing Shifts Organization			0.10	0.10	0.10	0.15	0.20	0.65
General Tasks	Computing/Software	Grid Data Processing & Analysis				0.05	0.10	0.25	0.25	0.65
General Tasks	Computing/Software	Group activities			0.05					0.05
Total					0.15	0.15	0.20	0.40	0.45	1.35

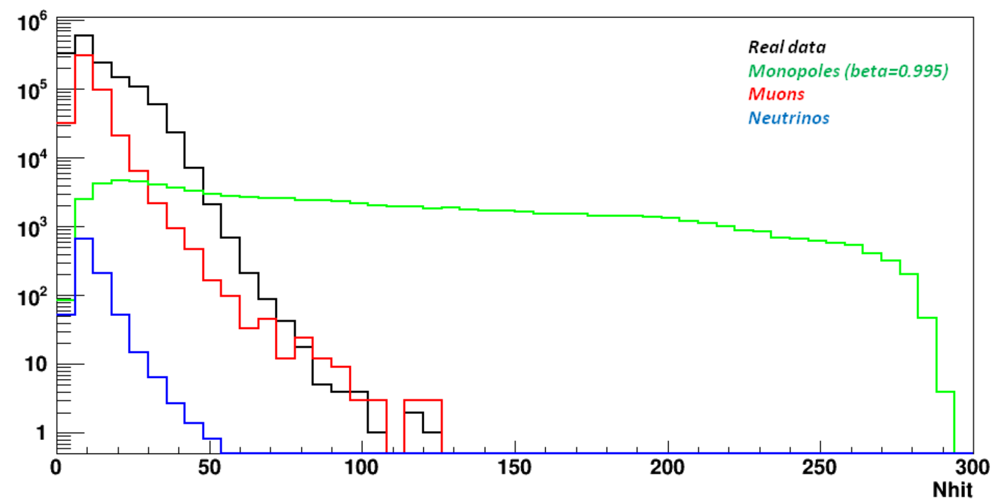
ANTARES/KM3NeT





Search for Magnetic Monopoles



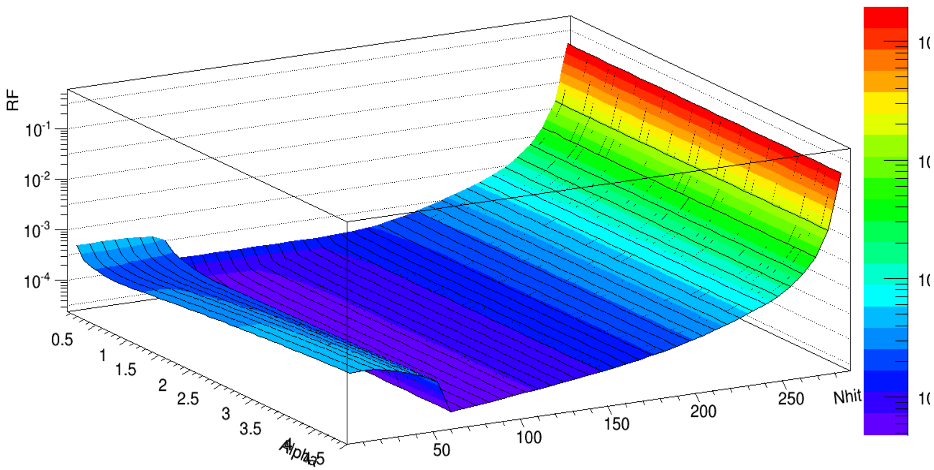


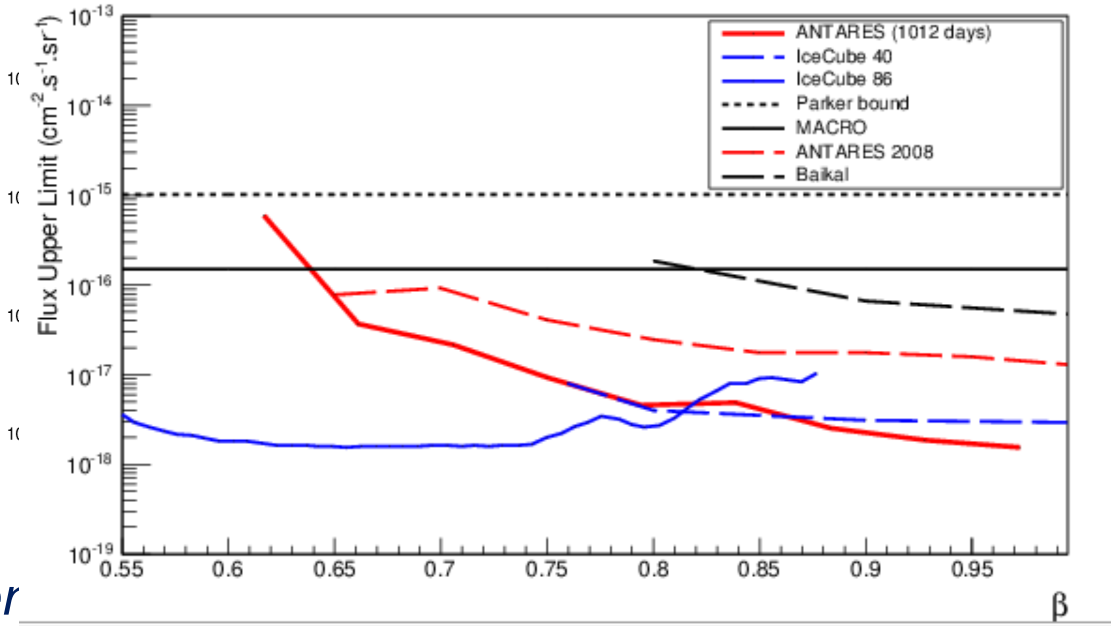
$$\alpha = \frac{t\chi^2}{1.3 + (0.04 \times (Nhit - 5))^2}$$

90% C.L, Feldman-Cousins formula :

$$S_{90\%}(cm^{-2}.s^{-1}.sr^{-1}) = \frac{\bar{\mu}_{90}(n_b)}{S_{eff}(cm^2.sr) \times T(s)}$$

Search for Monopoles





- *5 years of data collected betweer*
- *No significant signal observed above the atmospheric background (muons and neutrinos) expectation.*
- *New limits on flux have been established (red graph) for relativistic monopoles.*
- *Paper published in JHEP* :
https://link.springer.com/article/10.1007/JHEP07(2017)054

ANTARES/KM3NeT

ELOGANTARES

ANTARES | ANTARES_ARCHIVE_B | INTEGRATION_CPPM | INTEGRATION_DAPNIA | ANALYSIS | INTEGRATION_FOSELEV | TAToO | ANTA

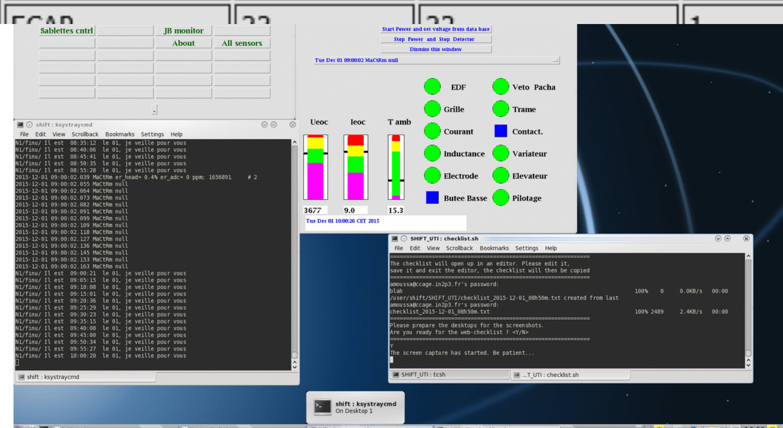
ANTARES_KM3NeT | shiftlist_2013_2014 | shiftlist_2014 | shiftlist_2015 | shiftlist_2016

ANTARES shift list : From December 2014 to January 2016, Page 1 of 1

List | Find |

INSTITUTE	SHIFT QUOTA	SHIFTS SCHEDULED	REMAINING SHIFTS
APC	12	9	3
Bari	1	1	0
Bologna	5	6	-1
LNS-Catania	13	13	0
CEA	5	5	0
Clermont-Ferrand	1	0	1
MIO	1	1	0
CPPM	14	14	0
ECAP	[illegible]	[illegible]	1

INSTITUTE	SHIFT QUOTA	SHIFTS SCHEDULED	REMAINING SHIFTS
IPHC	1	1	0
LAM	4	4	0
ISS	4	4	0
NIKHEF	12	12	0
Roma	5	6	-1
UPV	6	6	0
Oujda	1	4	-3
Naples	4	4	0

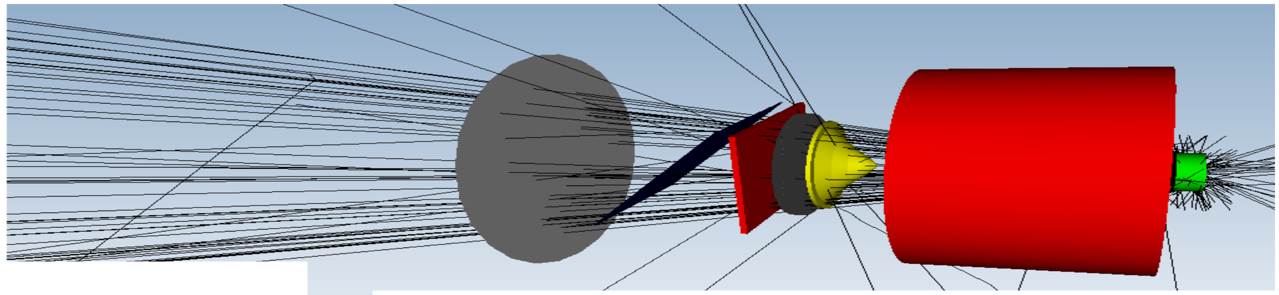


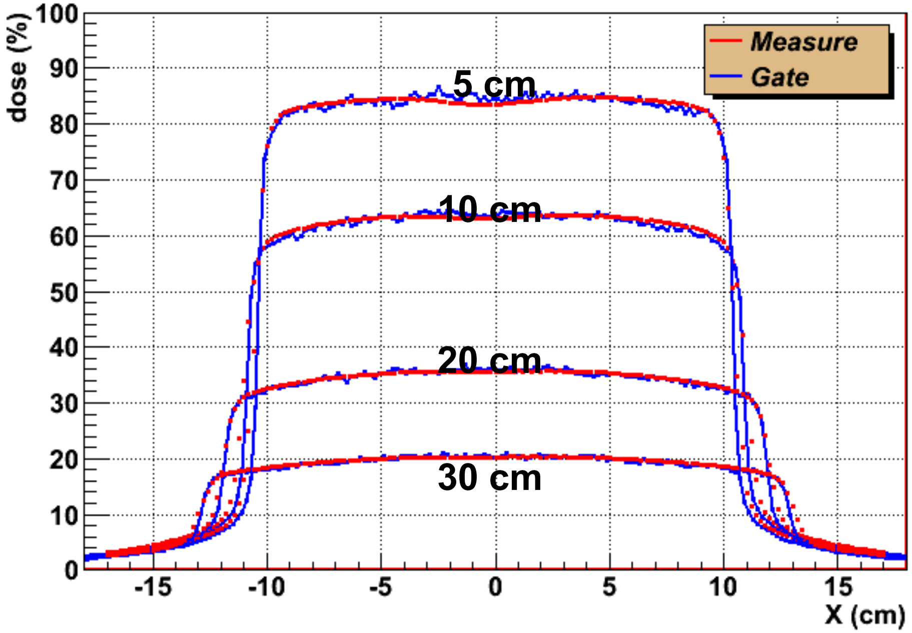
Shifters:

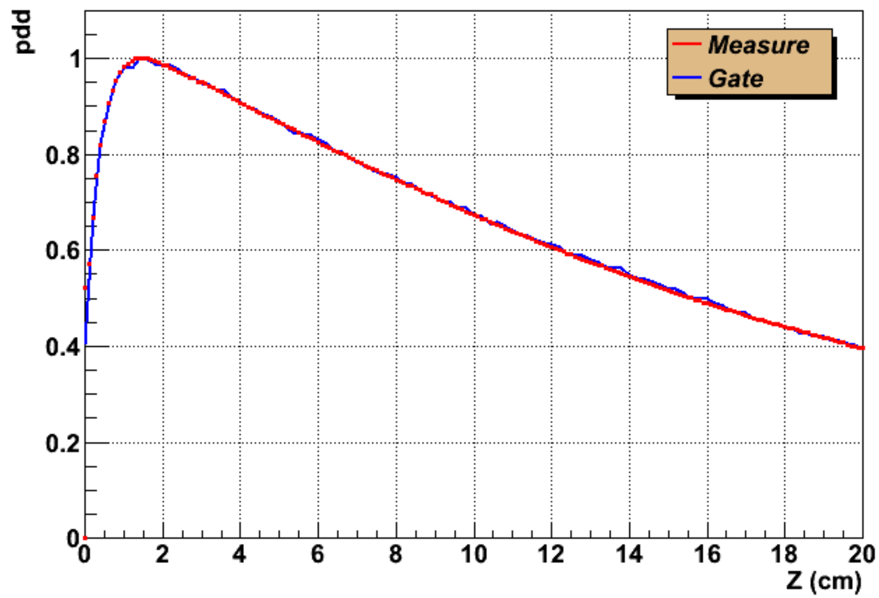
Imad Elbojaddaini
Abdellilah Moussa
Yahya Tayalati

Medical Physics

Samir Didi : Simulation de Linac Elekta Synergy



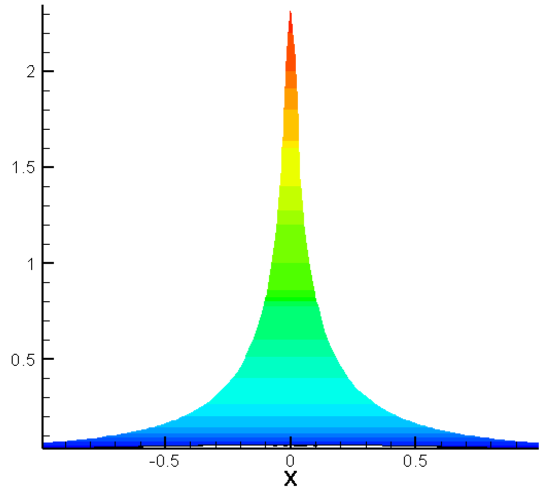


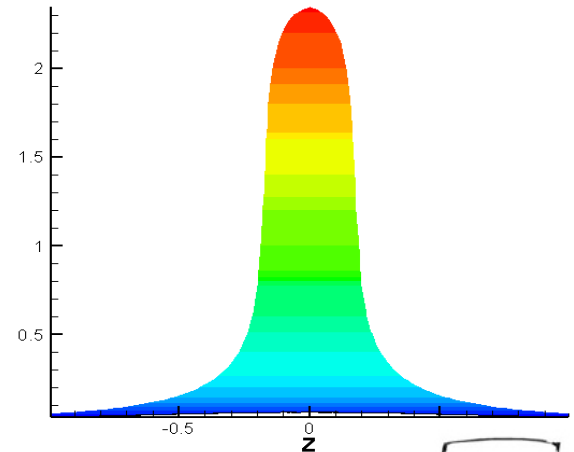


Recherche

Physique Médicale (Curiethérapie)

Irridium source simulated by MCNPX





Donnée Expérimental

Conclusion

HEP: ATLAS

Astroparticles : ANTARES/KM3NeT