Status and perspectives of the ACTARSim simulation

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GENP, Univ. de Santiago de Compostela
on behalf of the ACTAR-TPC collaboration

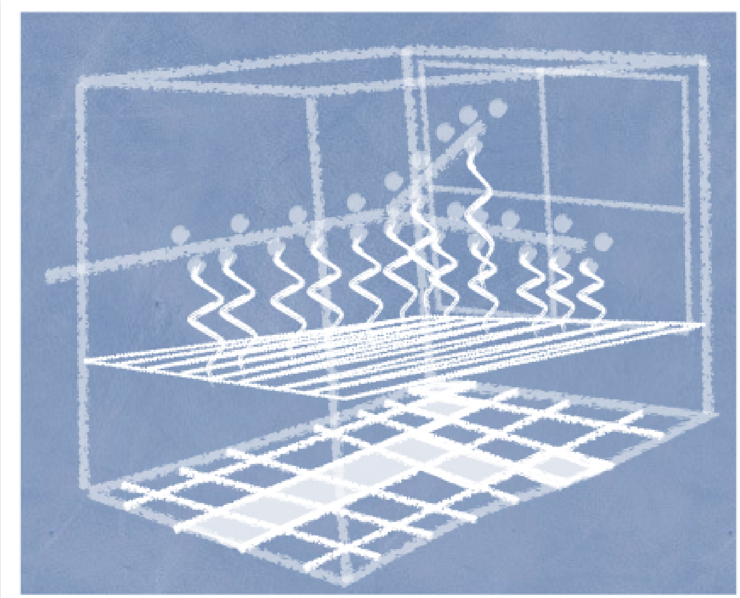
GDS Topical Meeting: GDS coupling to auxiliary detection systems,
INFN Laboratori Nazionali di Legnaro, 27th January 2017

Context and acknowledgement

Status and perspectives of the ACTARSim simulation

Topics covered:

- Active Targets: detector diversity.
- Demands for simulation.
- ACTARSim for the ACTAR TPC program.
- ACTARSim status.
- Energy loss and track fit.
- Perspectives.



This project has received funding from the **European Union's Horizon 2020** research and innovation programme under grant agreement No 654002 and **Xunta de Galicia "Proxectos Plan Galego IDT"**, project 2013-PG015: "Física de núcleos exóticos con Detectores Activos".

Active Target concept for exotic nuclei

In short: the detection gas is the target itself.

- High geometric efficiency. High detection efficiency.
- High thickness. High luminosity.
- Control on the reaction energy. Very low threshold.
- Full 3D tracking of participant particles.
- In many cases, close to zero background. Ideal for low statistics reactions and short-lived species.

But many complications:

- Gas detector control, gain stability, large dynamic range required, ...
- Many channels for high resolution, complex electronics, ...
- Difficult reconstruction.

Active Target concept. What for?

Direct and resonant reactions in direct and inverse kinematics, for nuclear structure, astrophysics and applications:

- **Elastic scattering**: matter distributions in stable and exotic nuclei, exploring halo nuclei, ...
- **Inelastic scattering**: probe of the nuclear equation of state, giant n-pole resonances, structure...
- **Transfer**: fine nuclear structure probe, pairing or 3body interactions, ...
- **Fusion** reactions: cross sections, ...
- **Fission** characterization, fission barriers: control of the excitation energy.
- **Resonant scattering**: astrophysical interest reactions, clusters or quasi-molecular structures in light nuclei, ...
- ...

Active Target concept: detectors

A non-comprehensive list of Active Target detectors in operation or being constructed:

Active targets in operation or being constructed.

Name	Lab	Gas ampl.	Volume (cm^3)	Pressure (atm)	Energy (MeV/n)	Electronics	Number of chan.	Status[a]
Ikar	GSI	NA	$60 \cdot 20^2\pi$	10	$\gtrsim 700$	FADC	6*3	O
Maya	GANIL	Wire	$30 \cdot 28.3^2$	0.02–2	2–60	Gassiplex	1024	O
ACTAR	GANIL	μmegas	20^3	0.01–3	2–60	GET	16,000	C, P
MSTPC[b]	CNS	Wires	$70 \cdot 15 \cdot 20$[c]	<0.3	0.5–5	FADC	128	O
CAT	CNS	GEM	$10 \cdot 10 \cdot 25$	0.2–1	100–200	FADC	400	T
MAIKo	RNCP	μ-PIC	14^3	0.4–1	10–100	FADC	2×256	T
pAT-TPC	MSU	μmegas	$50 \cdot 12.5^2\pi$	0.01–1	1–10	GET	256	T, O
AT-TPC	FRIB	μmegas	$100 \cdot 25^2\pi$	0.01–1	1–100	GET	10,240	O
TACTIC	TRIUMF	GEM	$24 \cdot 10^2\pi$	0.25–1	1–10	FADC	48	T
ANASEN	FSU/LSU	Wires	$43 \cdot 10^2\pi$	0.1–1	1–10	ASIC	512	O
MINOS	IRFU	μmegas	6000	1	>120	Feminos	5000	O
O-TPC	TUNL	Grid	$21 \cdot 30^2$	0.1	~10	Optical CCD	$2048 \cdot 2048$ pixels	O

[a] O: operational, C: under construction, P: Project, T: test device.
[b] Two GEM versions: GEM-MSTPC (CNS) [19,20] GEM-MSTPC (KEK) [21,22].
[c] GEM-MSTPC (CNS): $23.5 \cdot 29.5 \cdot 10.0$, GEM-MSTPC (KEK): $10.0 \cdot 10.0 \cdot 10.0$.

Review: Active targets for the study of nuclei far from stability.

S. Beceiro-Novo, T. Ahn, D. Bazin, W. Mittig, Progress in Particle and Nuclear Physics 84 (2015) 124–165.

Active Target concept: detectors

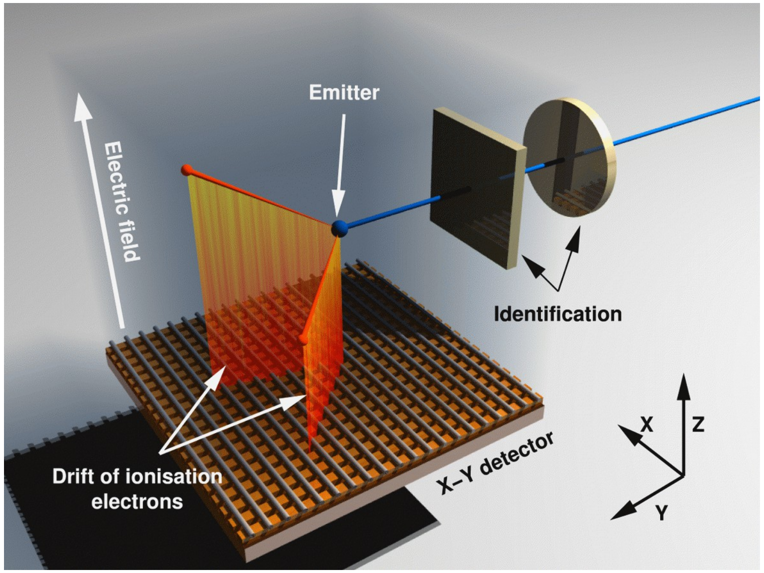
Some **selected examples** of different Active Target geometries and concepts:

CENBG TPC (from 2005):

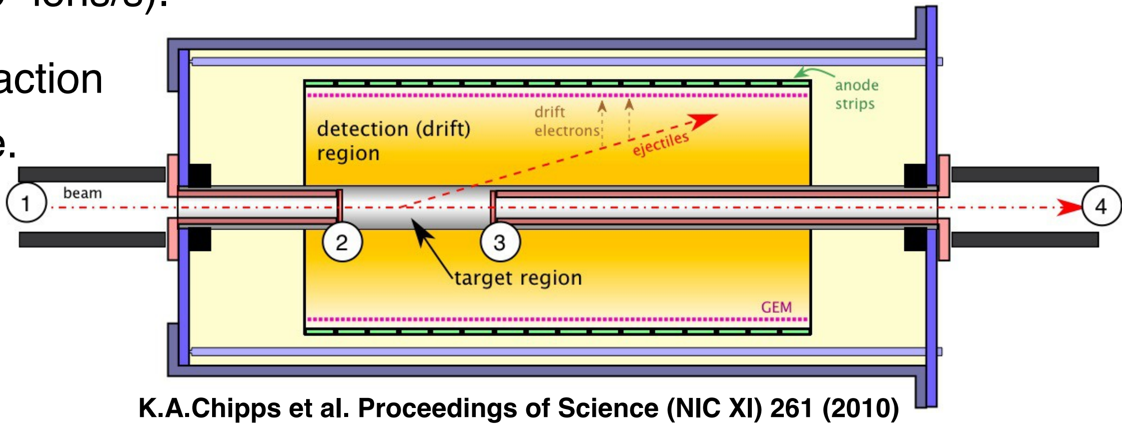
- For two-proton radioactivity.
- Energies and angles between protons.
- GEM's + 200 µm pitch µ-grooves.

TACTIC (from 2007):

- Astrophysical interest reactions.
- Ready for high intensities (10^7 ions/s).
- Target gas isolated and interaction vertex ionization not reachable.



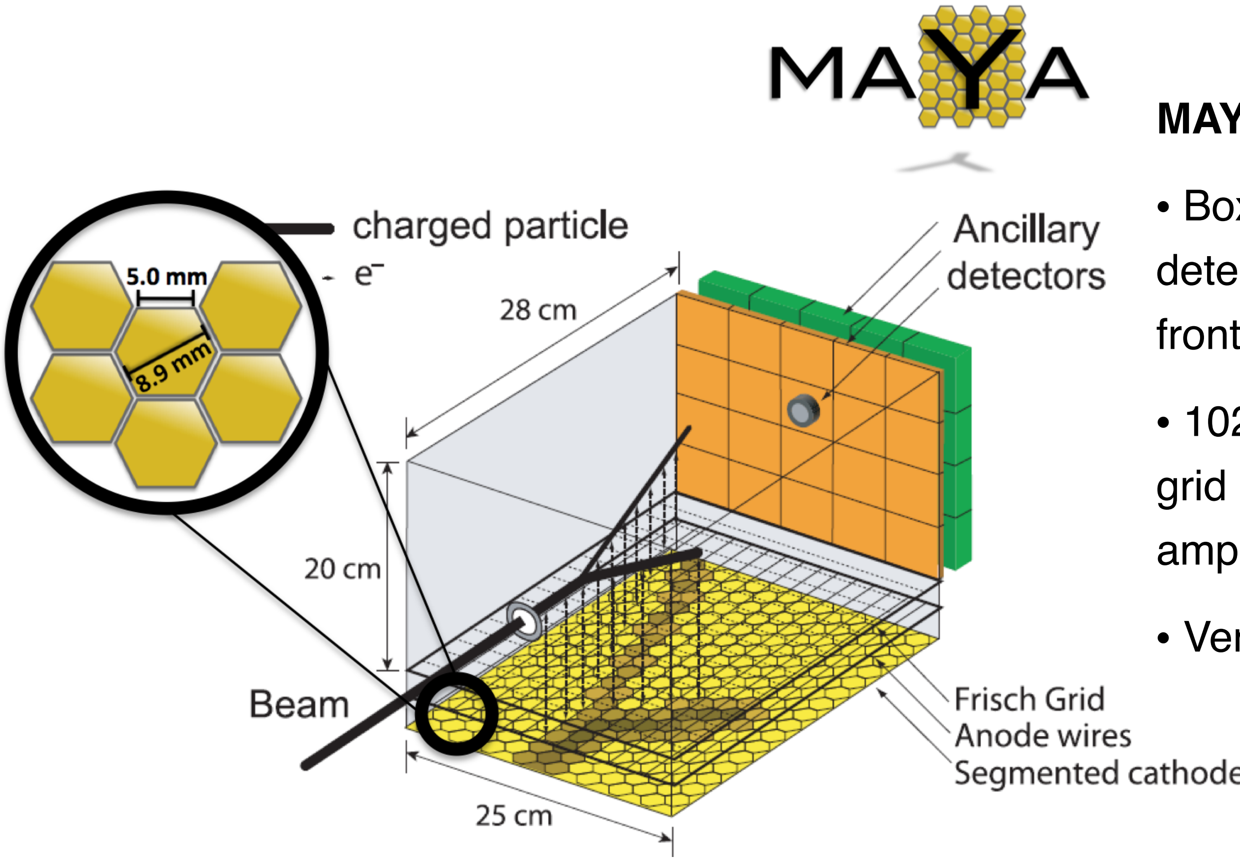
B.Blank et al. Nucl. Instrum. Meth. Phys. Res. A 613, 65 (2010)



K.A.Chipps et al. Proceedings of Science (NIC XI) 261 (2010)

Active Target concept: detectors

Some selected examples of different Active Target geometries and concepts:



MAYA main characteristics:

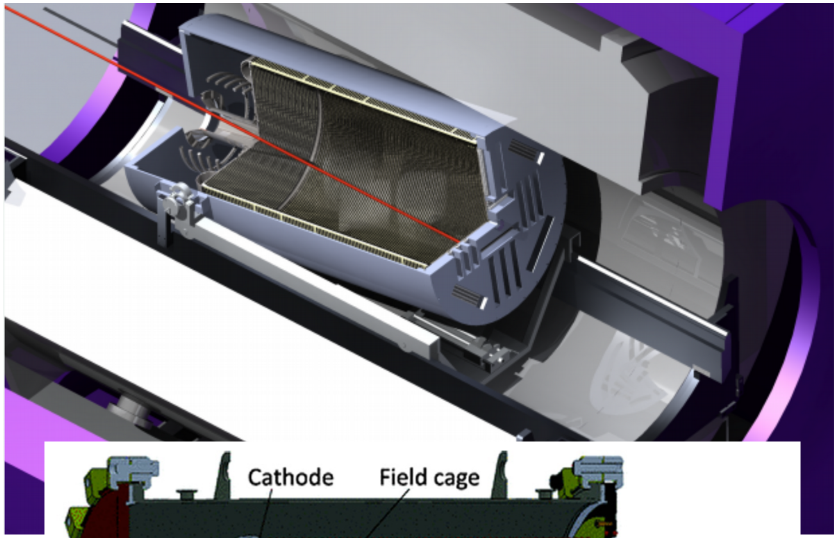
- Box-like geometry with ancillary detectors (Si and CsI[Tl]) in the front wall.
- 1024 hexagonal pads with Frisch grid and proportional wire amplification.
- Versatile multipurpose design.

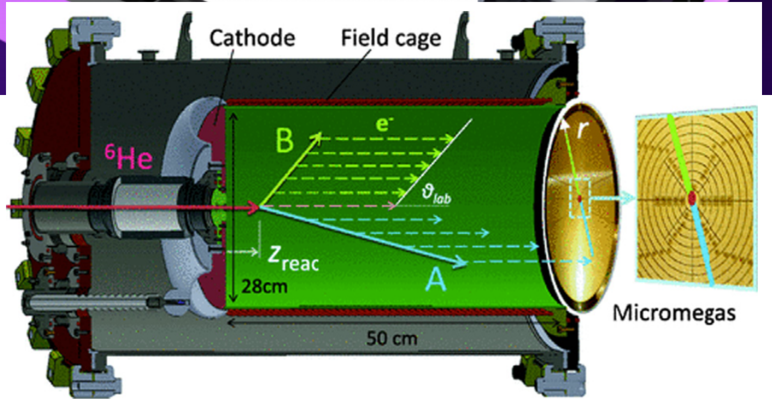
C.E.Demonchy et al. Nucl. Instrum. Meth. Phys. Res. A 583, 341 (2007)

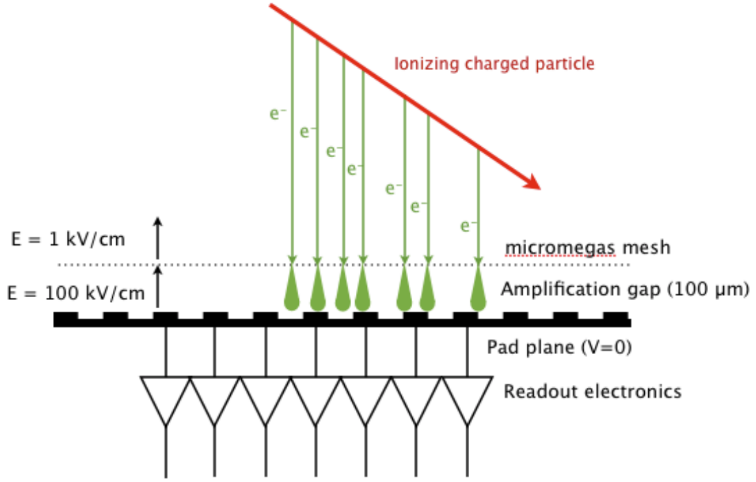
Some selected examples of different Active Target geometries and concepts:

ATTPC:

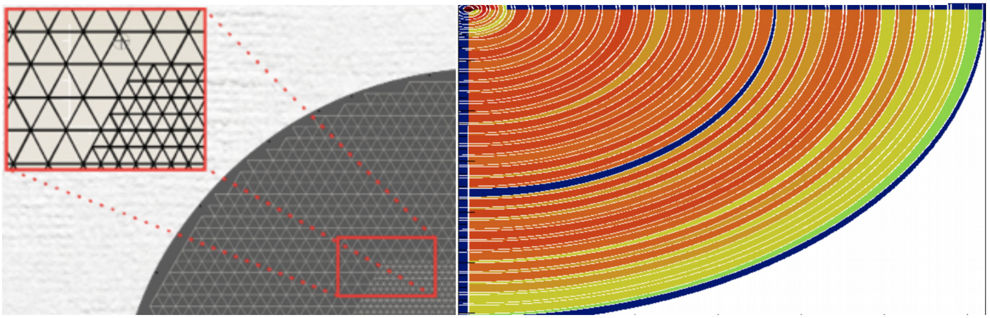
- Cylindrical-radial geometry and field.
- Micromegas + thick GEM readout.
- 10240 channels for the complete pad. plane, with complex geometries.
- GET electronics.







W. Mittig et al. NIM A 784 (2015) 494–498



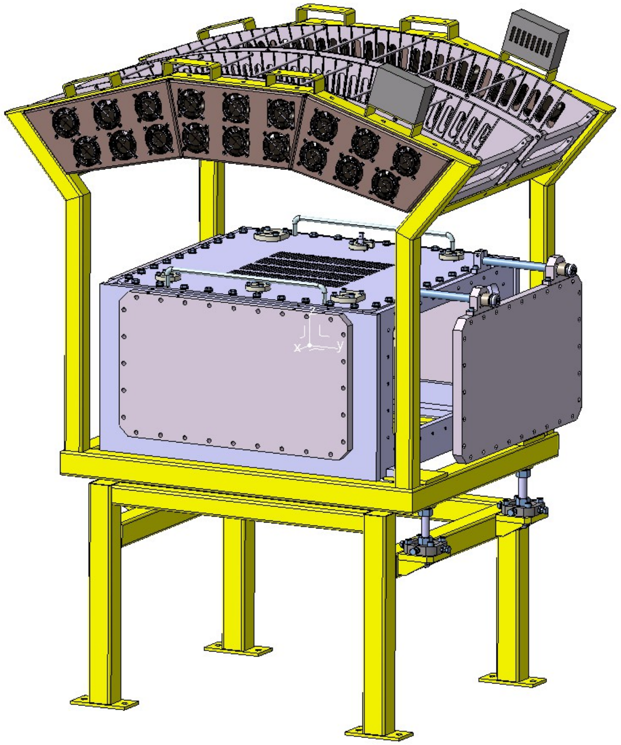
The ACTAR TPC project

The ACTAR TPC detector

Leading a new generation of Active target devices, it overcomes many of the limitations with present devices, funded via an ERC Starting grant (2014-2019).

Physics cases:

- One and two nucleon transfer reactions.
- Rare and exotic nuclear decay (2p, β-2p, …).
- Transfer-induced fission.
- Inelastic scattering and giant resonances.
- Resonant scattering of astrophysics interest.



Detector Design:

- Amplification = MICROMEGAS (+ GEMs).
- Pad sizes of 2x2 mm^2: 16384 channels.
- ANR General Electronics for TPC’s (GET).
- Improved data throughput + internal trigger.

What do Active Targets require from a simulation?

Evaluation of the energy and time resolution, detection efficiency, reconstruction algorithm evaluation, trigger pattern efficiency, …, requiring:

• Complete geometrical description of the setup including ancillary detectors. Optimization for design phase.

• Accurate energy loss in the gas, windows, and additional media.

• Beam propagation and reaction model: 2-body and manybody kinematics.

• Electron transport model and parameters adjusted to the gas pressure and the fields in the chamber.

• Amplification model, including time formation of the signal at the pad plane.

• (3D)Reconstruction of the signal from the pad plane information.

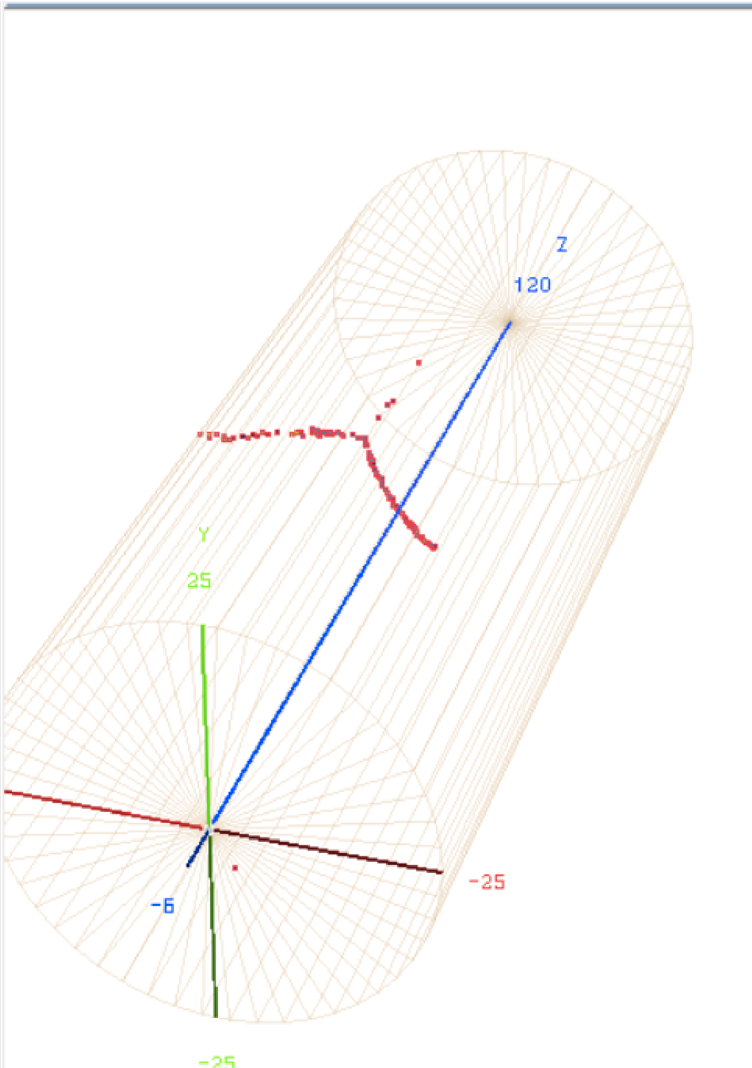
• Track model fit: energy loss, range, transformations to parameter space, …

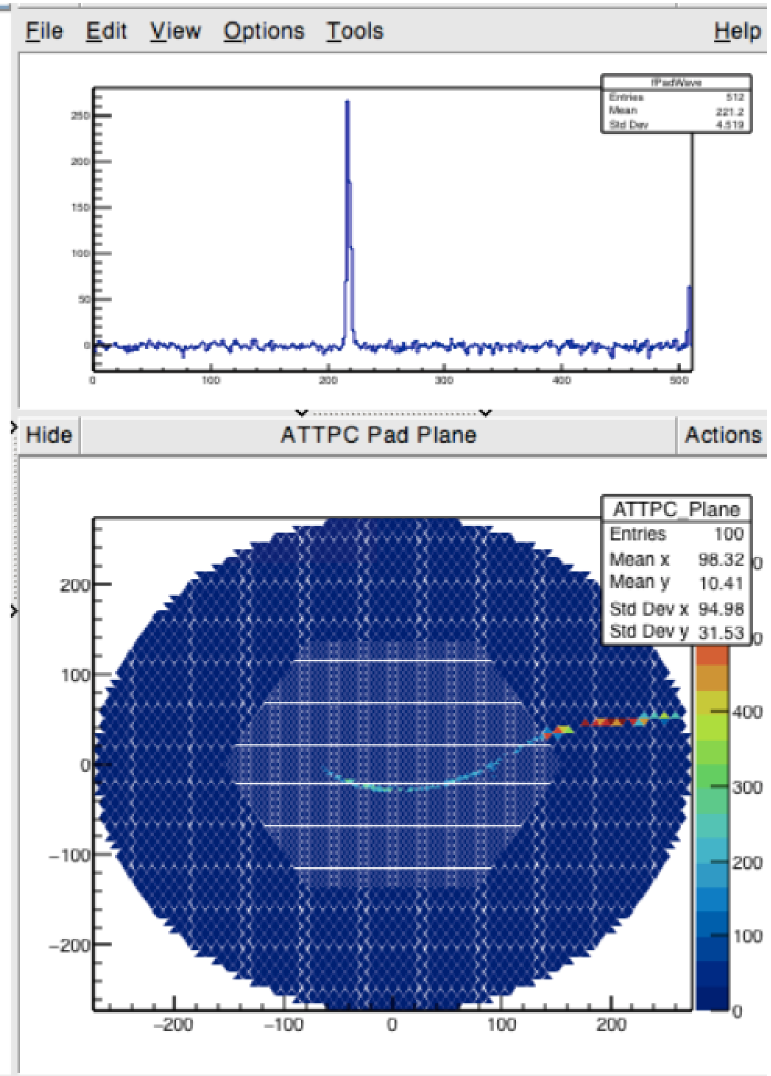
• Reconstruction for possible reactions covering/shadowing the search.

… And nice pics.

What do Active Targets require from a simulation?

Some nice pics...





Courtesy Y. Ayyad (MSU)

ACTARSim: a simulation code for ACTAR TPC

ACTARSim (since 2005)

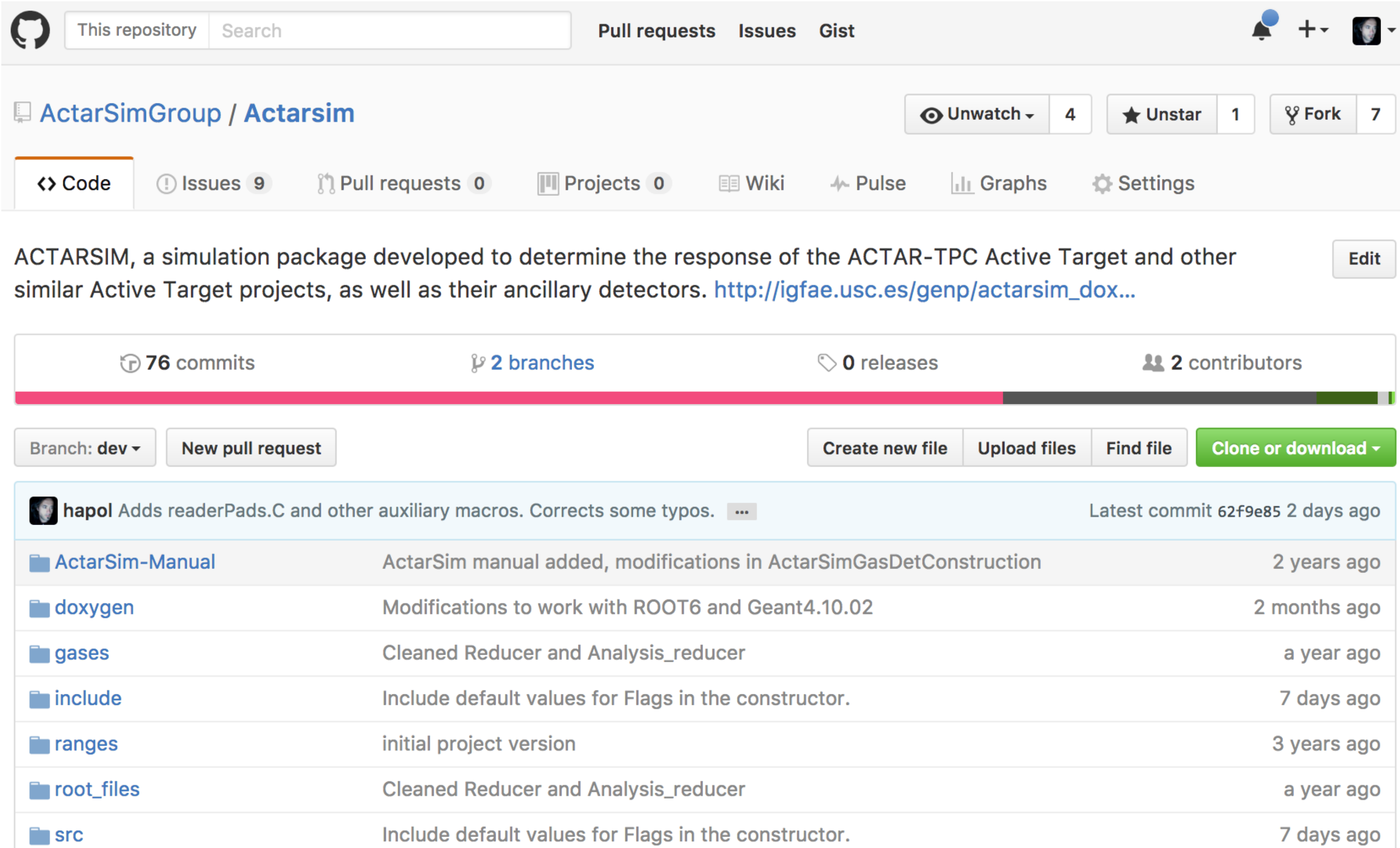
ACTARSim is a **Geant4 + ROOT** application for ACtive TARgets simulation.

- Developed for the ACTAR TPC design and MAYA analysis comparison.
- Initial development at USC, maintained and extended in GANIL since 2008.
- New developments ongoing during ACTAR-TPC construction period, responsabilities back to USC (2013).
- We acknowledge recent contributions from: T. Marchi (Leuven), P. Cabanelas (USC), Y. Ayyad (MSU).

GEANT4 is used for the production and tracking of primaries and secondaries above E_{cut} = 1 keV. ROOT is used for the calculation of the drift and diffusion of the electronic clouds, the induction in the pad plane, the visualization, ...

ACTARSim: a simulation code for ACTAR TPC

https://github.com/ActarSimGroup/Actarsim



ACTARSim: a simulation code for ACTAR TPC

http://igfae.usc.es/genp/actarsim_doxygen/

ACTARSim

ACTAR TPC Simulation Reference Guide

ACTARSim Home Page | Main Page | Related Pages | All Classes | Files | Release Notes | Search

ACTARSIM Reference Documentation

Introduction

Welcome to ACTARSIM

This documentation describes the software classes and functions that makes up the ACTARSIM simulation code. This is not an introduction of ACTARSIM, for this please refer to the ACTARSIM User Guides and Manuals. This documentation is generated directly from the source code using Doxygen and in principle is kept up to date. The version of ACTARSIM corresponding to this documentation is indicated at the page heading.

How to use this reference documentation

The full list of classes are available under the All Classes tab. The fully indexed list of all source code is available under the tab Files.

ACTARSIM provides other types of documentation:

- Ongoing work on additional documentation.

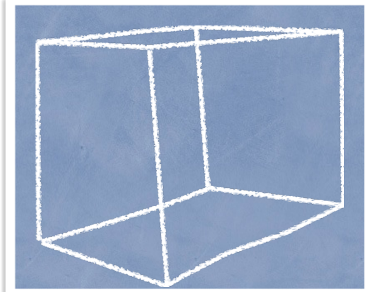
Caveat

We have moved recently to generate the documentation with Doxygen. To achieve this the comments in the source code needed to be formatted and written specifically for Doxygen to generated proper documentation. If you find missing documentation or inaccuracies please report them to our GitHub issues.

ACTARSIM - Reference Guide Generated on Fri Dec 2 2016 18:29:39 using Doxygen.

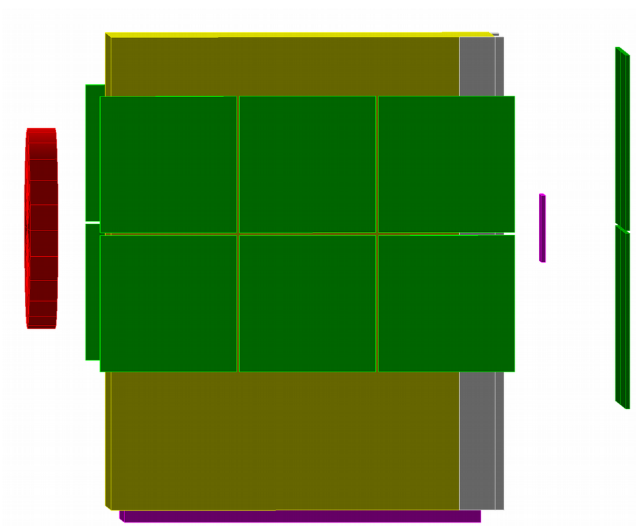
ACTARSim overview: the detectors in Geant4

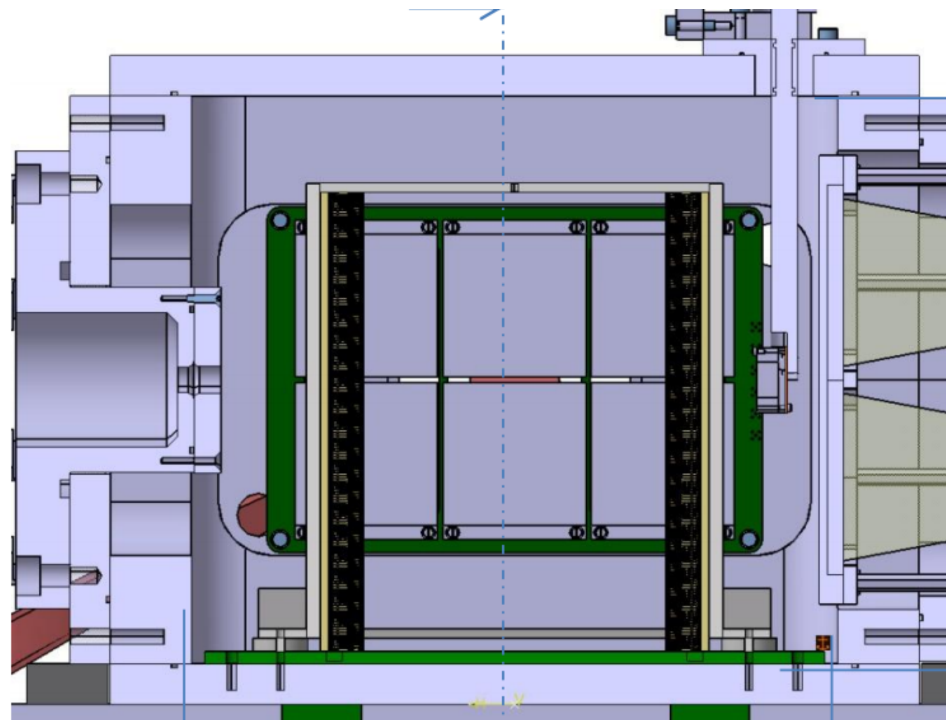
1. Detectors (gas box) geometry:



- General cube (MAYA or ACTAR-TPC).
- General cylinder (drift on endcaps or sides).
- Easy size modification for design.
- Predefined detectors with fixed configurations:

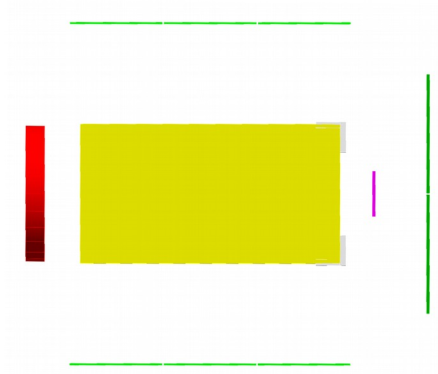
ACTAR TPC Demonstrator:

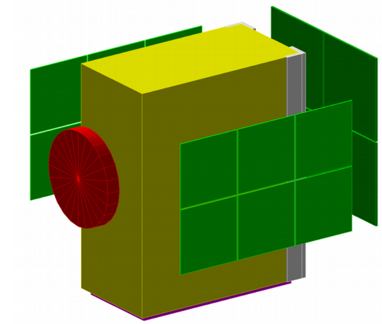


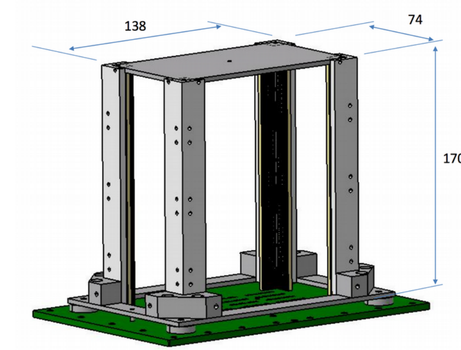


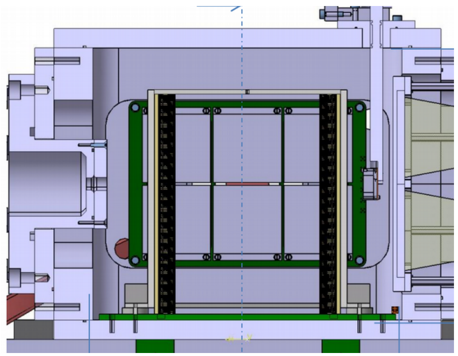
ACTARSim overview: the detectors in Geant4

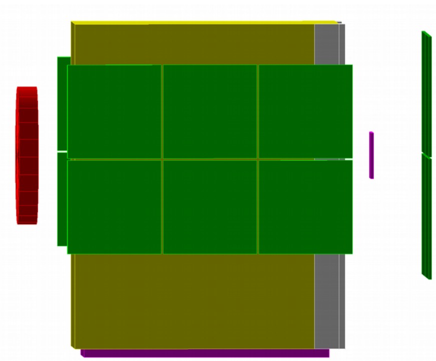
ACTAR TPC Demonstrator:

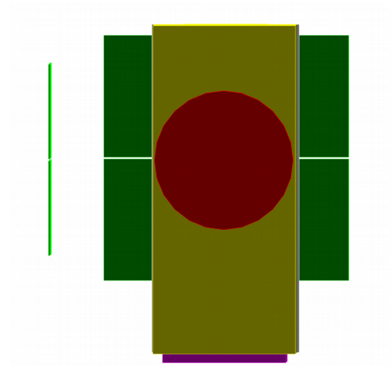


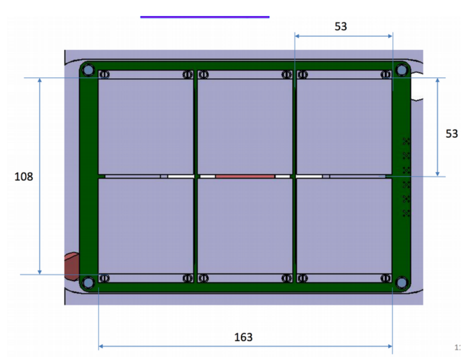


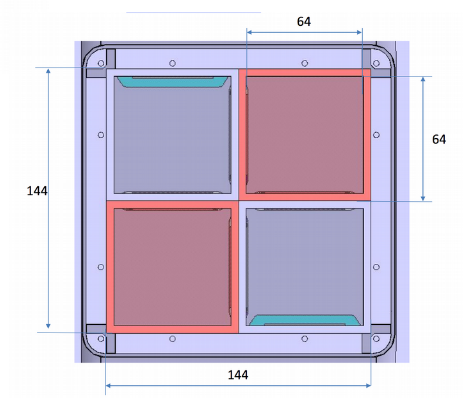




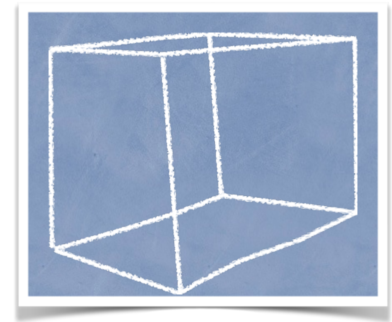








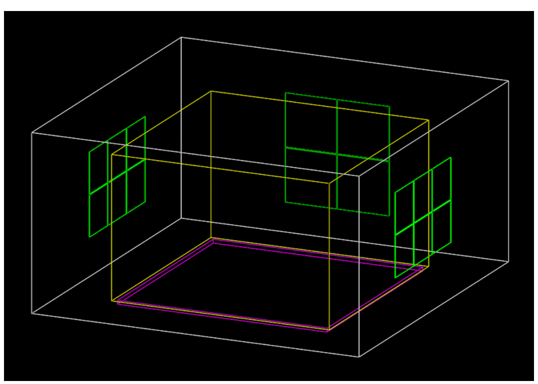
ACTARSim overview: the detectors in Geant4

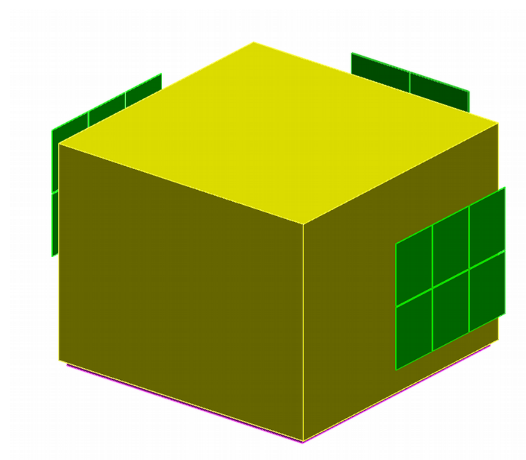


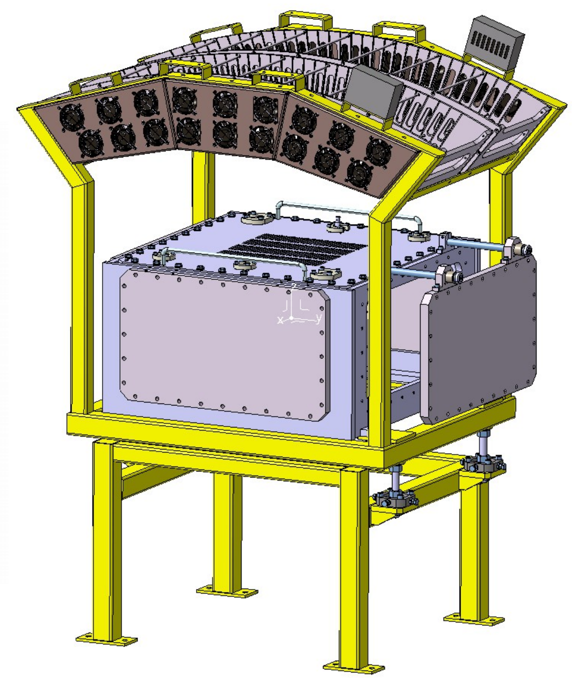
1. Detectors (gas box) geometry:

- General cube (MAYA or ACTAR-TPC).
- General cylinder (drift on endcaps or sides).
- Easy size modification for design.
- Predefined detectors with fixed configurations:

ACTAR TPC (full detector, preliminary version).







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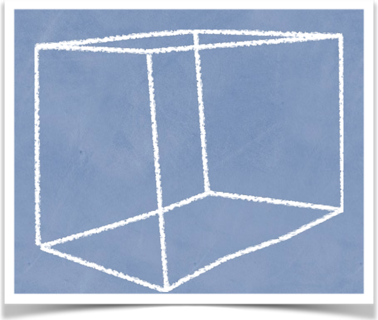
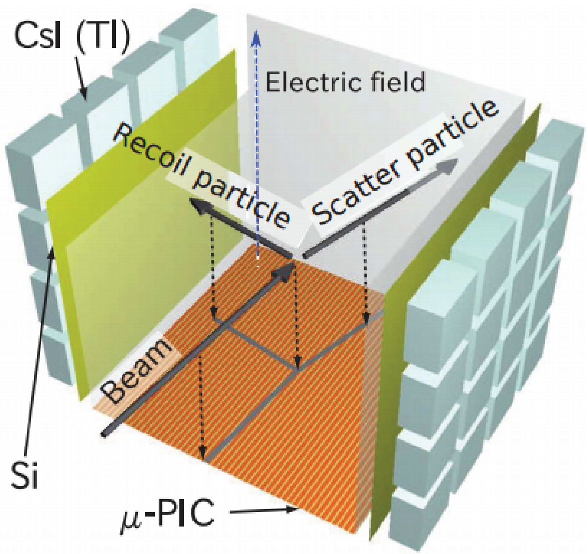
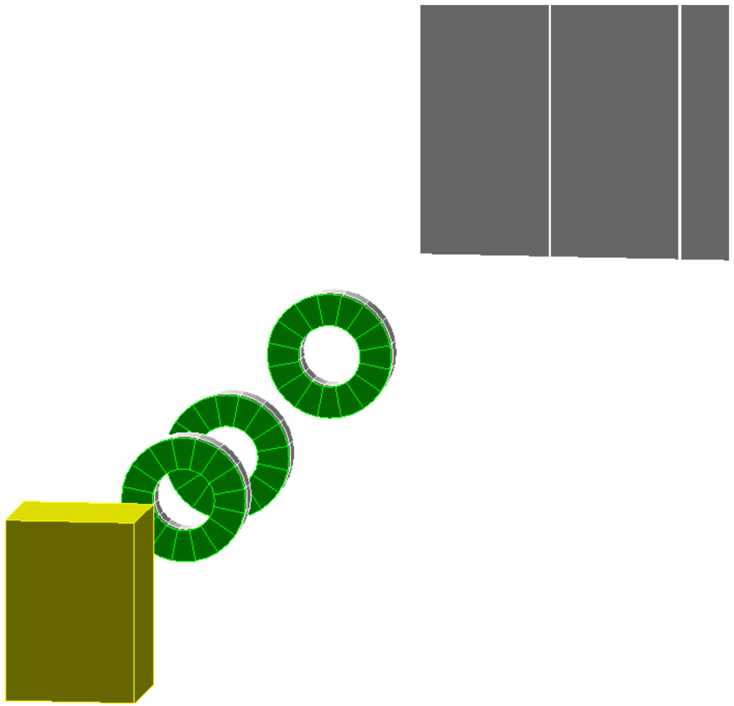


- General cube (MAYA or ACTAR-TPC).
- General cylinder (drift on endcaps or sides).
- Easy size modification for design.
- Predefined detectors with fixed configurations:

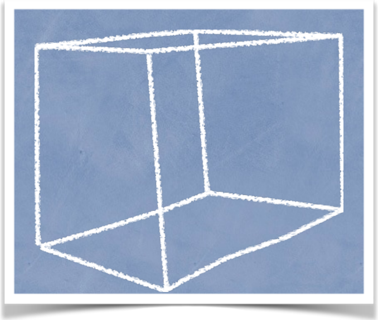
MAIKO (by Y. Ayyad, Osaka/MSU).





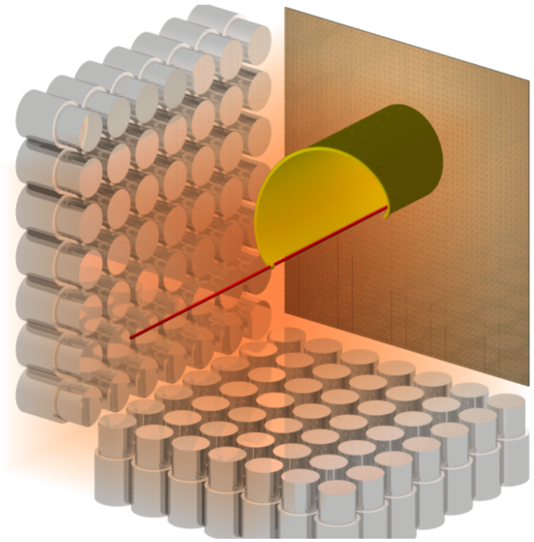
ACTARSim overview: the detectors in Geant4

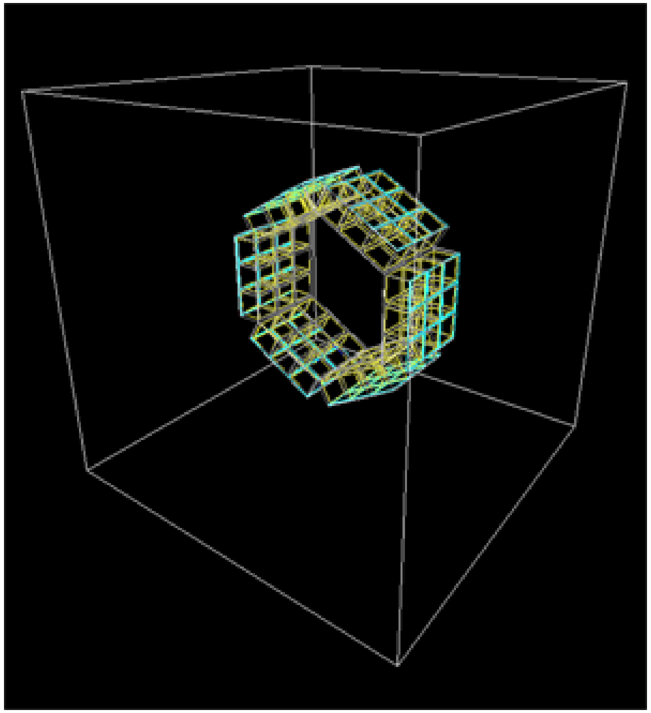
1. Detectors (gas box) geometry:



- General cube (MAYA or ACTAR-TPC).
- General cylinder (drift on endcaps or sides).
- Easy size modification for design.
- Predefined detectors with fixed configurations:

Spec MAT: (to be implemented)





SpecMATscint from O. Poleshchuk

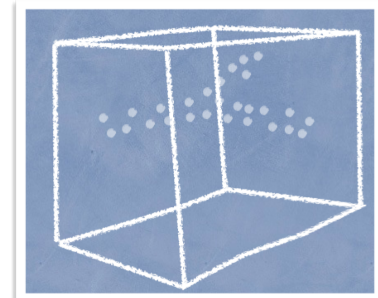
CeBr3 cubic scintillator 1.5"x1.5"x1.5", quarz window.

https://github.com/OPoleshchuk/SpecMATscint

ACTARSim overview: the detectors in Geant4

1. Detectors geometry: predefined or configurable.

2. Gas and pressure:



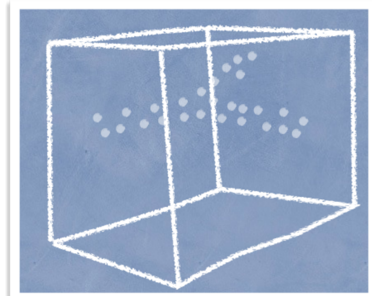
- Most gases of interest for AT predefined.
- Presure and temperature can be defined by the user:

▼ ActarSim
  ▼ det
    ▼ gas
      ▶ mixture
      setGasMat
      setGasPressure
      setGasTemperature

Command /ActarSim/det/gas/setGasPressure
Guidance : Select the Gas Pressure (for the Gas box and the Chamber).
Range of parameters : gasPressure>=0.

	Parameter	Guidance	Type	Ommitable	Default	Range	Candidate
1	gasPressure		d	False	1.01325		
2	Unit		s	True	bar		Pa bar atm pascal bar atmosphere

ACTARSim overview: the detectors in Geant4



1. Detectors geometry: predefined or configurable.

2. Gas and pressure:

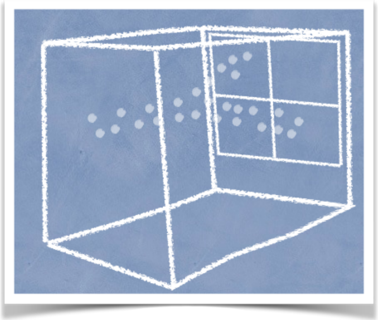
- Most gases of interest for AT predefined.
- Presure and temperature can be defined by the user.
- Mixtures can be defined now in the macro:

▼ ActarSim
  ▼ det
    ▼ gas
      ▼ mixture
        GasMixture
        setGasMix
      setGasMat

Command /ActarSim/det/gas/mixture/setGasMix
Guidance : Set a Gas Mixture (for the Gas box and the Chamber).
[usage] /ActarSim/det/gas/setGasMix GasNum GasMat GasRatio
GasNum:(int) GasNumber (from 1 to 7)
GasMat:(string) Gas Material from the list
GasRatio:(double) Gas Ratio in Mixture (from 0 to 1)

	Parameter	Guidance	Type	Ommitable	Default	Range	Candidate
1	GasNum		i	False	1	GasNum<10	
2	GasMat		s	False	D2		H2 D2 He Ar CF4 CH4 iC4H10
3	GasRatio		d	False	0	GasRatio<=1.	

ACTARSim overview: the detectors in Geant4



1. Detectors geometry: predefined or configurable.

2. Gas and pressure: pure or mixtures, selectable pressure.

3. Ancillary detectors:

- Configurable (standard MAYA) silicon DSSD layers.
- Configurable (standard MAYA) CsI[Tl] detectors.
- New ancillary should be included as soon as fixed or for specific setups.

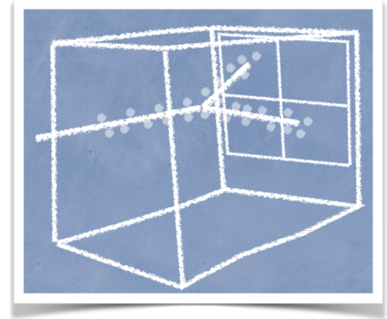
It should not be too complex to mix with other Geant4 simulated setups.

Command /ActarSim/det/sil/sideCoverage
Guidance : Selects the silicon coverage (default 1).
6 bits to indicate which sci wall is present (1) or absent (0). The order is:
bit1 (lsb) beam output wall
bit2 lower (gravity based) wall
bit3 upper (gravity based) wall
bit4 left (from beam point of view) wall
bit5 right (from beam point of view) wall
bit6 (msb) beam entrance wall
Convert the final binary to a decimal number (betwee 0 and 63) and set the coverage!

	Parameter	Guidance	Type	Ommitable	Default	Range	Candidate
1	type		i	False			

ACTARSim overview: the Geant4 transport

1. Kinematics calculator and particle gun:



- Event generator (2-body relativistic kinematics) with realistic vertex (position and energy after beam interaction in gas).
- … Or complete control over the particle triggered by the gun.

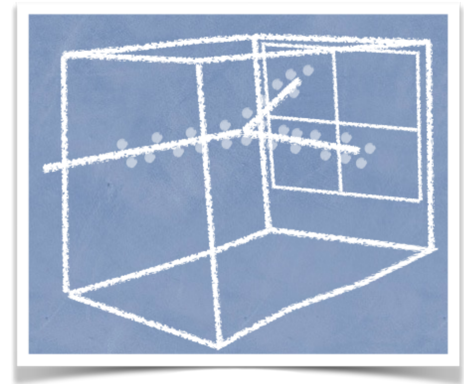
▼ Kine
- randomThetaCM
- randomPhiAngle
- randomThetaRange
- incidentIon
- targetIon
- scatteredIon
- recoilIon
- labEnergy
- userThetaCM
- userPhiAngle
- vertexPosition

Command /ActarSim/gun/Kine/incidentIon
Guidance : Set properties of incident ion to be generated.
[usage] /ActarSim/gun/Kine/incidentIon Z A Q E Mass
Z:(int) AtomicNumber
A:(int) AtomicMass (in Atomic mass unit u)
Q:(int) Charge of ion (in unit of e)
E:(double) Excitation energy (in MeV)
Mass:(double) mass in u

	Parameter	da	Type	Ommitable	Default	Range	Candidate
1	Z		i	False	1		
2	A		i	False	1		
3	Q		i	False	0		
4	E		d	True	0.0		
5	Mass		d	True	1.0		

ACTARSim overview: the Geant4 transport part

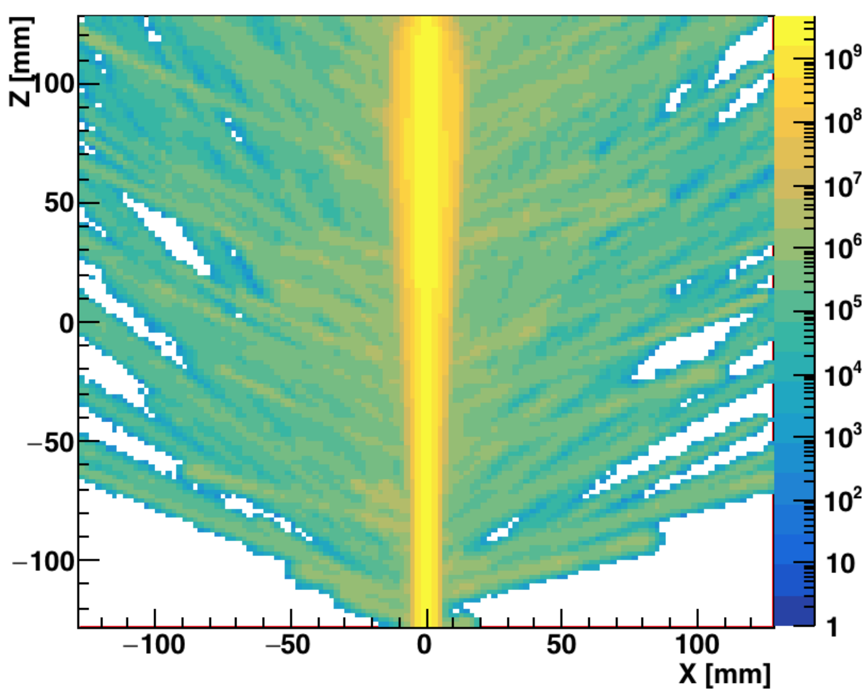
1. Kinematics calculator integrated and particles gun.



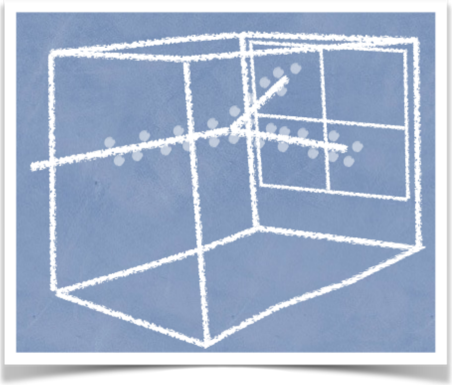
2. Physics interaction in Geant4:

- Realistic description of discrete and continuum processes.
- User selectable physics packages (in .mac configuration).
- Realistic beam-gas interaction with gaussian beam profile.
- (Old) beam shielding tube possible.

Color code: induced charge



ACTARSim overview: the Geant4 transport part



1. Kinematics calculator integrated and particles gun.

2. Physics interaction in Geant4.

3. Data output (standard ROOT TFile from Geant4):

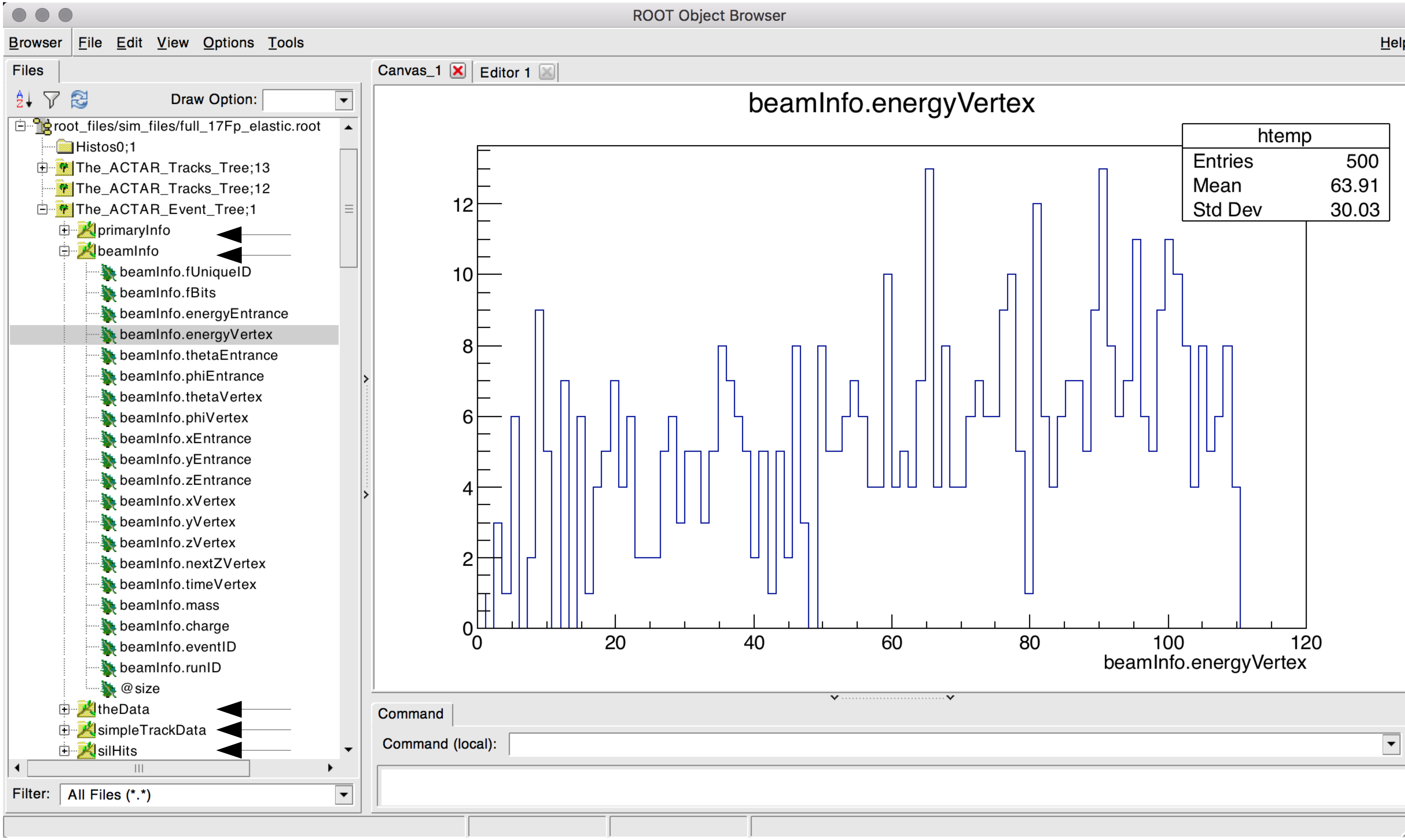
- Efficient TClonesArray in TTrees stored in ROOT TFiles.

- Storing strides (groups of steps) decreasing output size.

- Energy loss of beam and reaction primaries used for the calculation of the ionization in the gas.

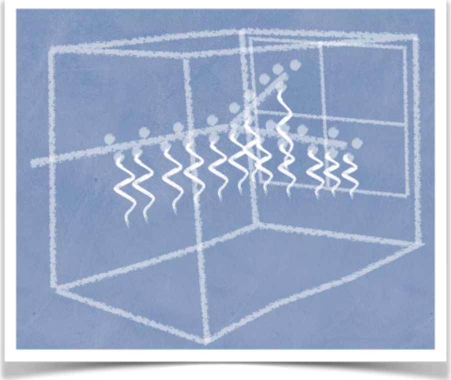
- The TTree also contains the Hits in the ancillary detectors and additional information (beamInfo, primaryInfo, ...).

ACTARSim overview: the Geant4 transport part



ACTARSim overview: ROOT digitization part

1. Drift and diffusion in the electric field:



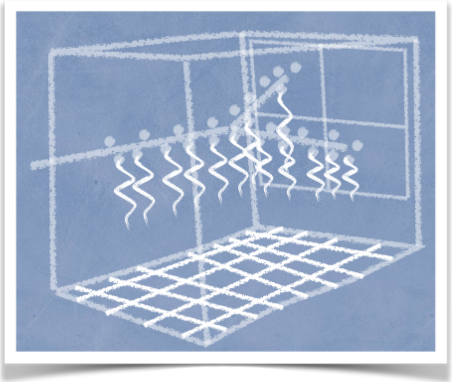
• Drift by constant electric field included. Modular to introduce other drift models for different magnetic and electric drifts.

• Drift (velocity, diffusion) parameters required as user input.

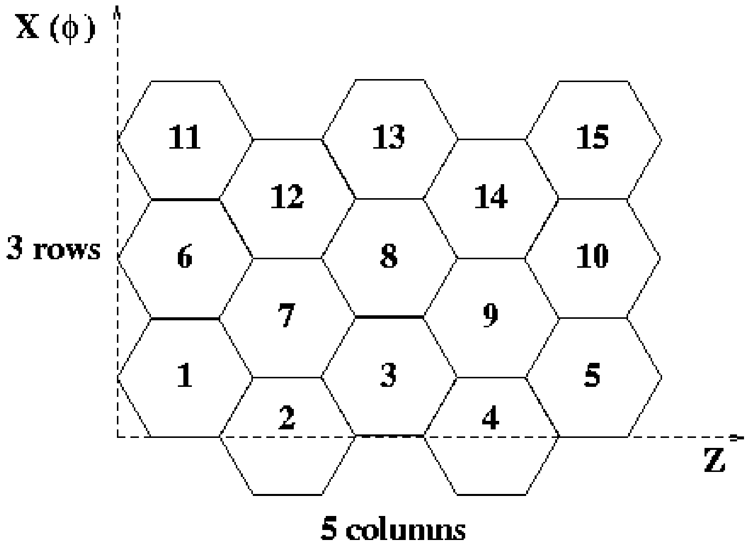
```
gSystem->Load("libactar.sl");
gROOT->ProcessLine(".L digitizationMacro.C+");
thePadsGeometry.SetGeometryValues("ActarTPC");
theDriftManager.SetDriftVelocity(50.0e-3);
theDriftManager.SetDiffusionParameters(5.e-4, 5.e-4);
digitEvents("root_files/sim_files/full_17Fp_elastic_simple.root",
            "root_files/dig_files/full_17Fp_elastic_simple_digi2.root");
```

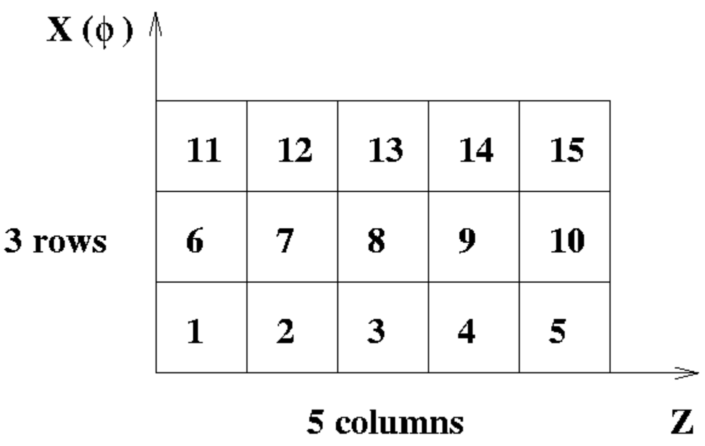
1. **Drift and diffusion in the electric field:**

2. **Amplification and pad induction:**



- GEM, micromegas and wires amplification schemes included, as well as the induction in the pad plane.
- Variable size, hexagonal- or square-shaped pad planes.
- Predefined pad plane geometry for ACTAR TPC and MAYA.



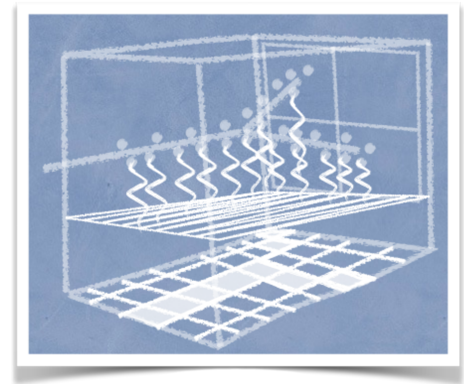


ACTARSim overview: ROOT digitization part

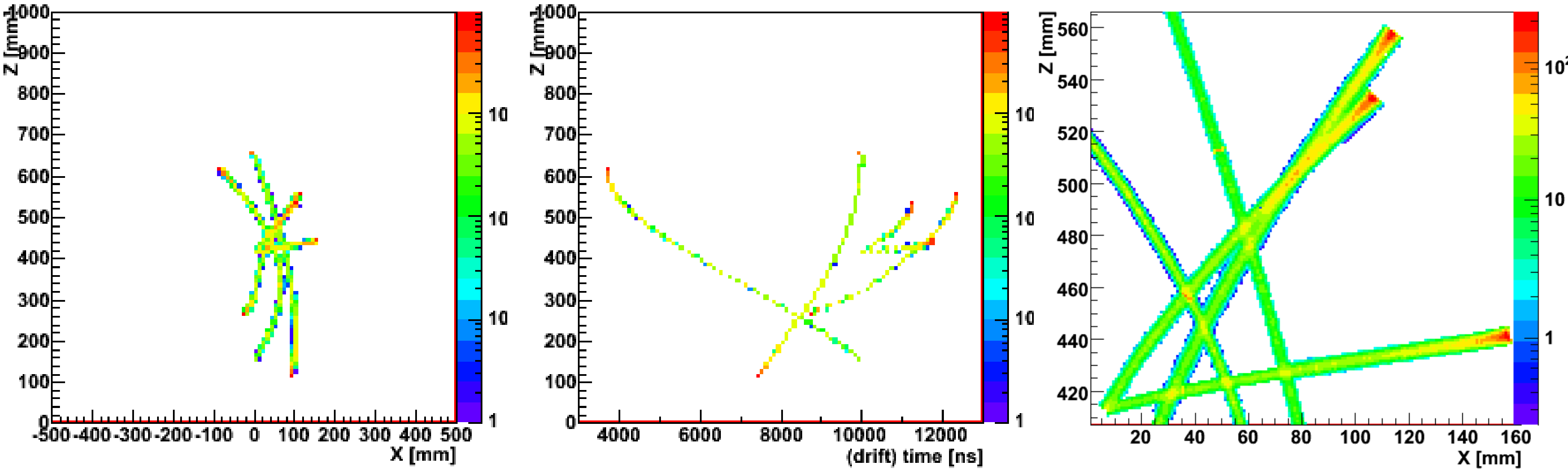
1. Drift and diffusion in the electric field.

2. Amplification and pad induction.

3. Induction calculation and pad signal output:



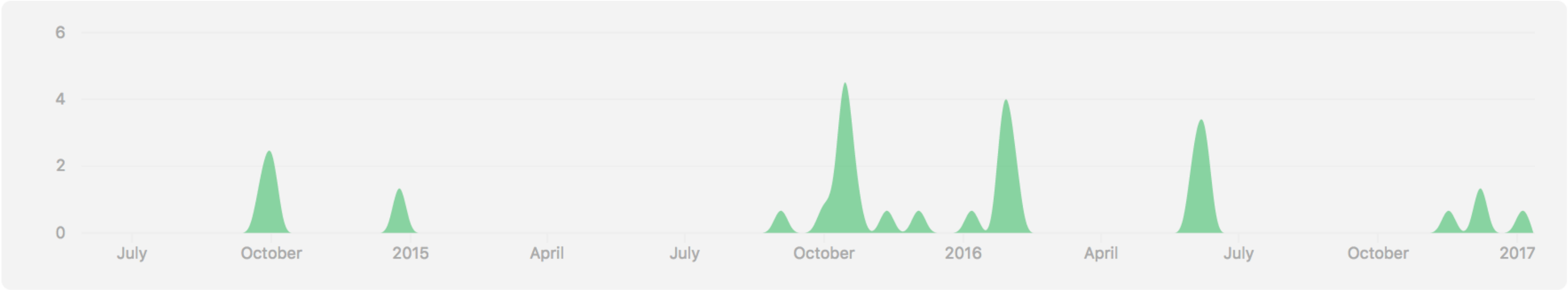
- The induced charge in each pad is calculated including timing.
- Results are stored in a TTree (TClonesArray) of pads with signal, ready for further analysis.



Examples with different pad plane resolution.

ACTARSim overview: recent work

- Recently upgrade to ROOT6 and Geant4.10.2 (or Geant4.10.3 from 12/16).
- Pad visualization and helper macros for digitization and visualization now included in the ActarSim/dev distribution.
- Complete doxygen documentation (developers): **http://igfae.usc.es/genp/actarsim_doxygen/**
- Active development, 33 commits since January 2016, 3 main contributors.
- ACTARSim publications almost ready.
- Evaluation of the energy loss in gas compared with other simulations and experiment data.
- Evaluation of the track parameters reconstruction for a 3-alpha source.



ACTARSim: evaluation of energy loss in gas

Evaluation of the energy loss properties of the physics libraries in Geant4:

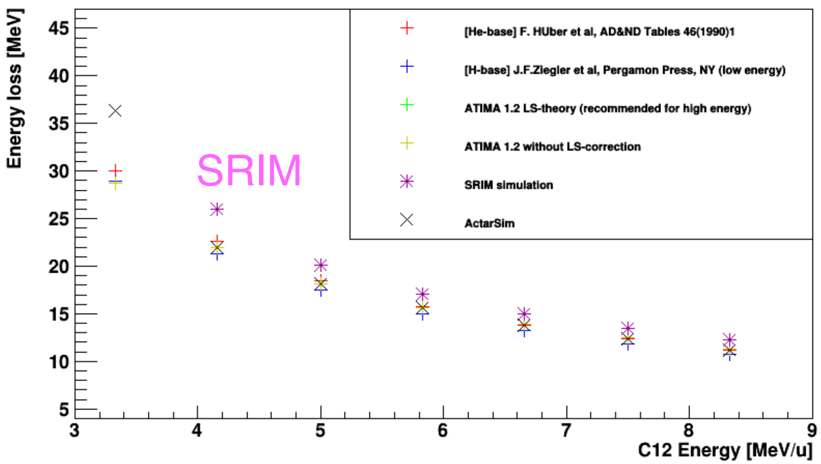
- **Energy loss** obtained from the step energy loss sum in 300 mm.
- **Energy straggling** as RMS of the energy loss distribution.
- **Angular straggling** given by the step angle at the end of the absorber.
- **Lateral spread** given by the sigma of the position distribution (x-position in the XZ plane) at the end of the absorber.
- D_2, H_2, iC_4H_{10} as target gases, 1 atm. Range larger than the gas volume.
- p, ^{4}He, ^{12}C, ^{24}Mg, ^{56}Fe as projectiles.
- Geant4 libraries: emstandard_opt3 and ionGasModels.

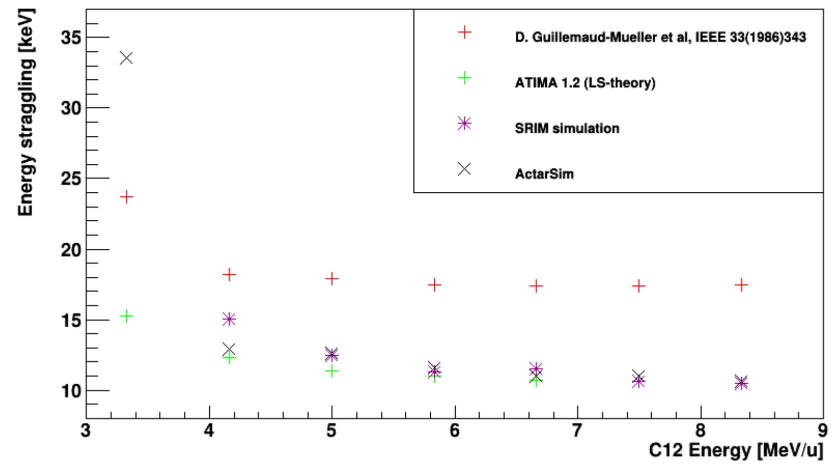
Energy loss and energy straggling match pretty good in all cases, angular straggling and lateral spread match better at higher energy for heavier ions.

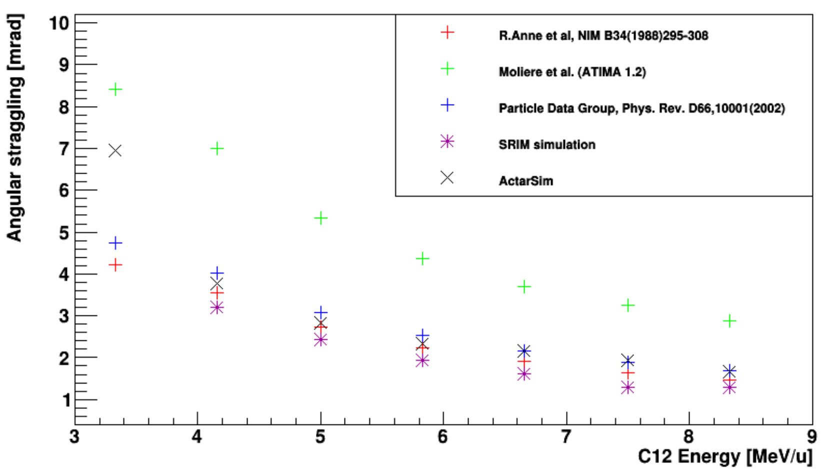
Analysis by Piotr Konczykowski (USC).

ACTARSim: evaluation of energy loss in gas

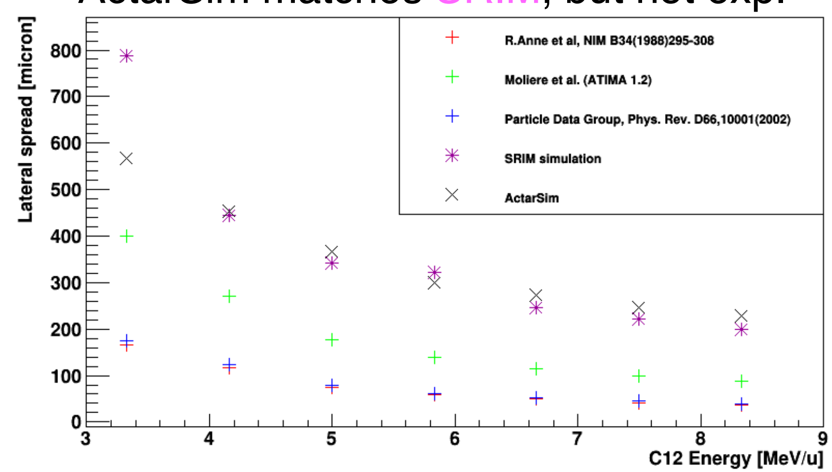
^{12}C on deuterium gas STP:







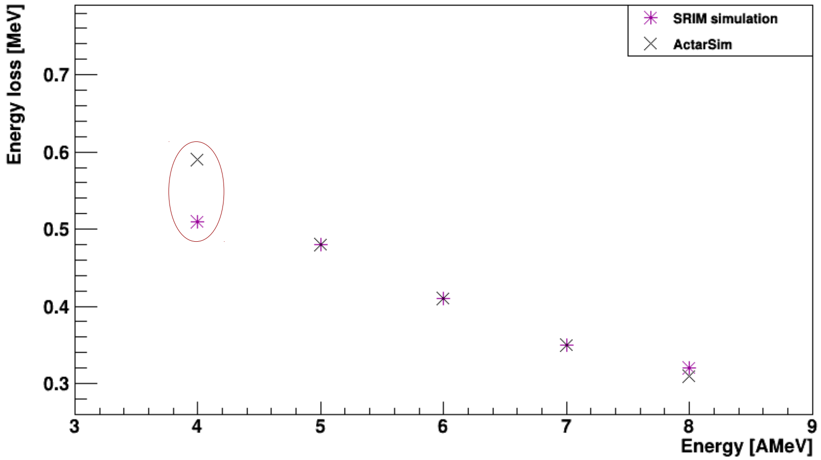
ActarSim matches SRIM, but not exp.

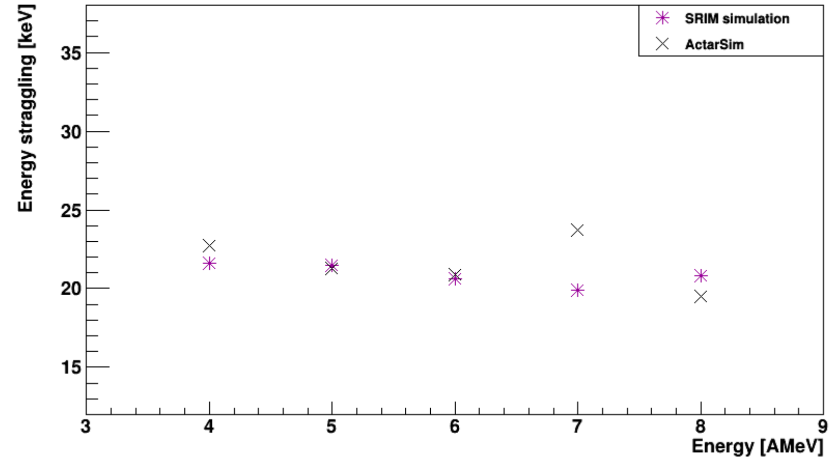


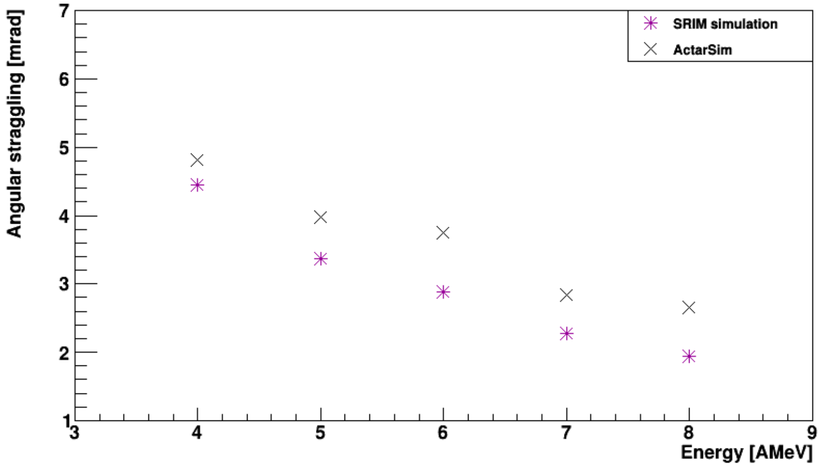
Courtesy Piotr Konczykowski (USC)

ACTARSim: evaluation of energy loss in gas

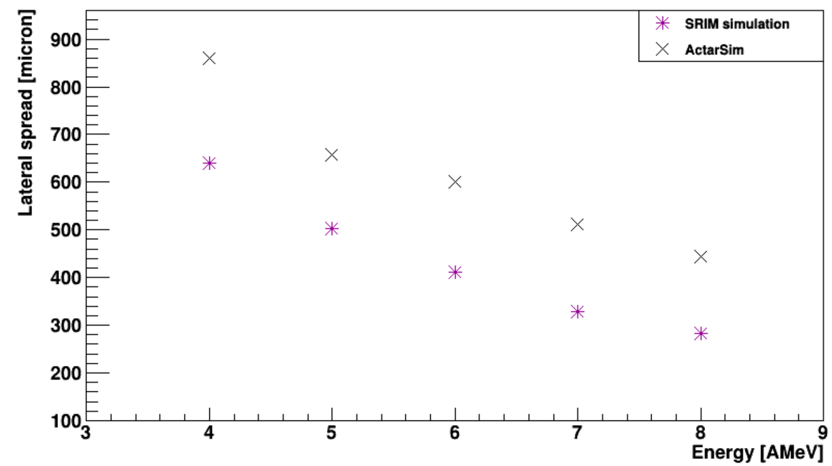
Proton on deuterium gas STP:





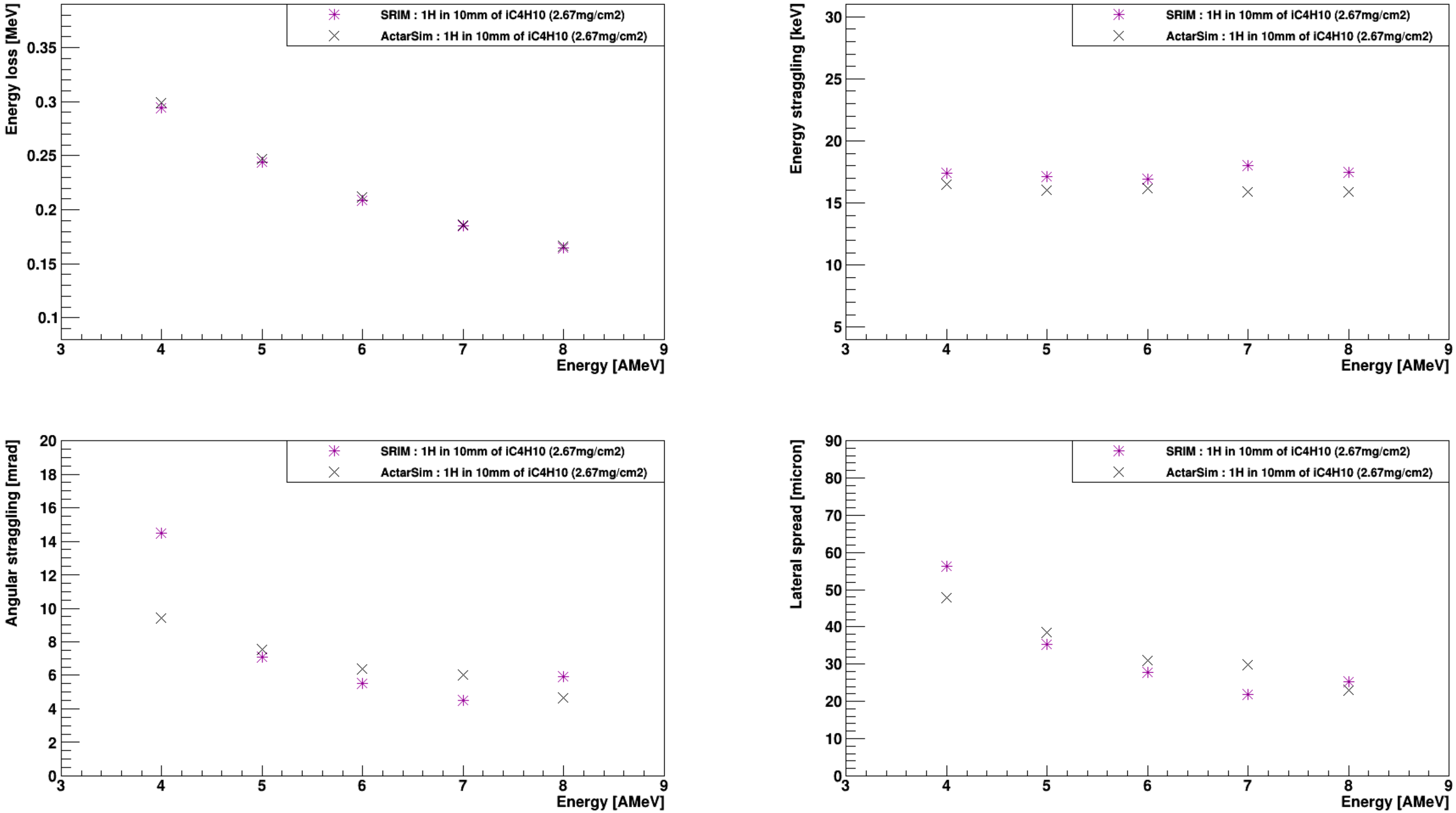


~20-25% difference



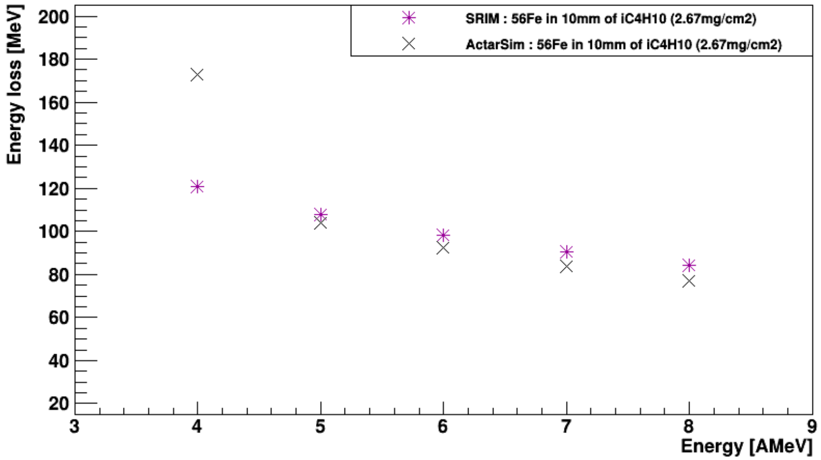
ACTARSim: evaluation of energy loss in gas

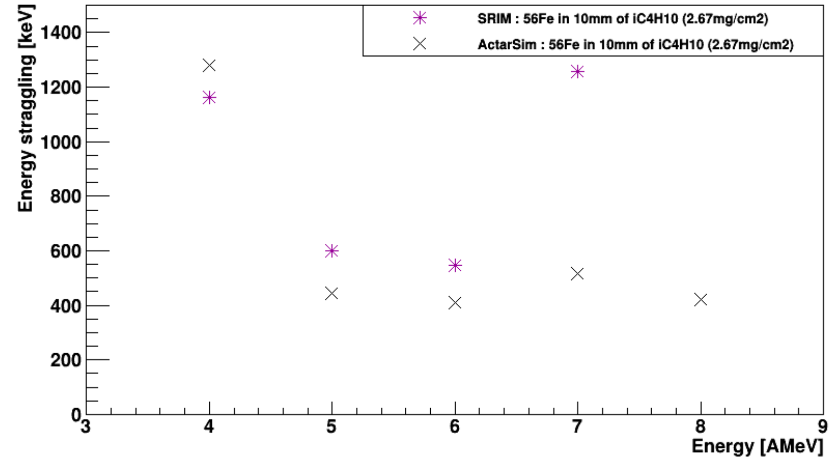
Proton on $i\text{-}C_4H_{10}$ gas STP:

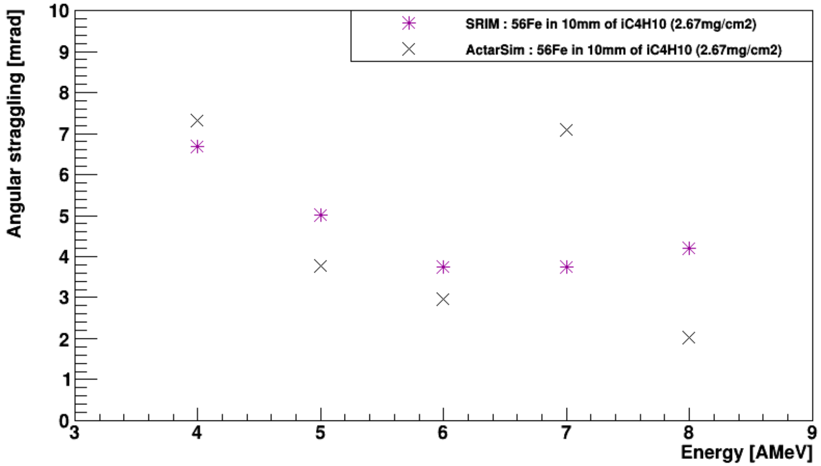


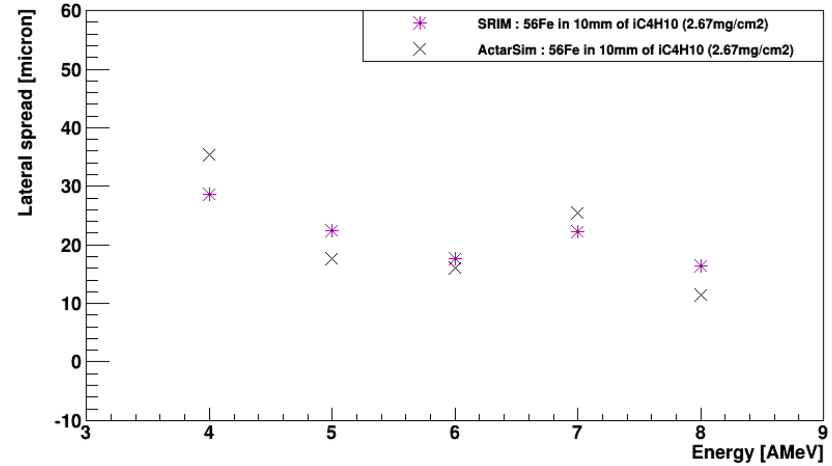
ACTARSim: evaluation of energy loss in gas

^{56}Fe on i-C_4H_{10} gas STP:









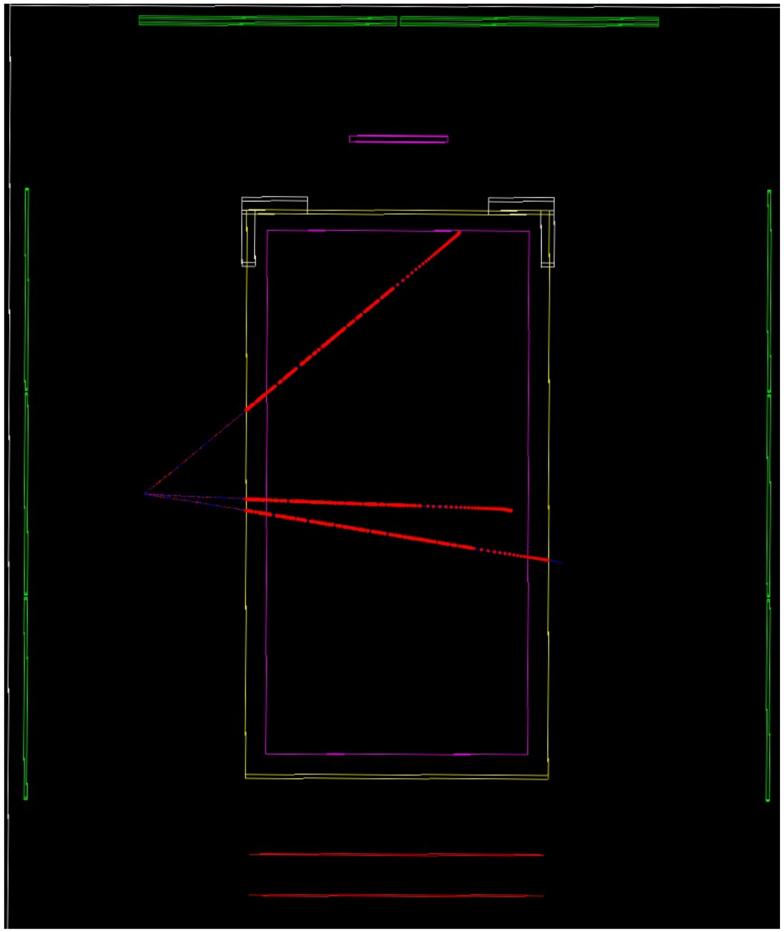
ACTARSim: triple α analysis

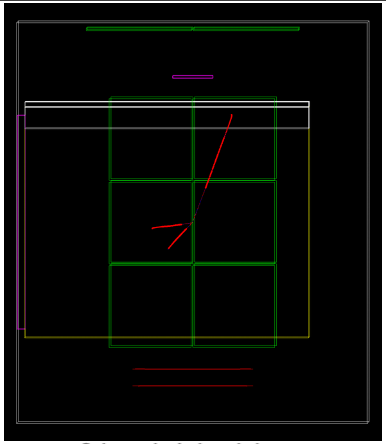
Real data + simulation test of range and energy loss reconstruction:

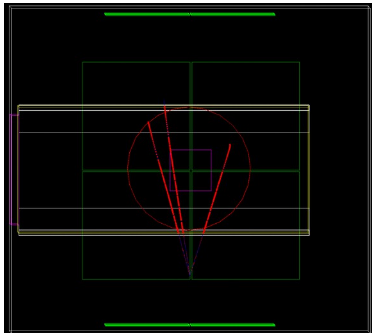
- **ACTAR TPC Demonstrator** with a 3-alpha source (^{239}Pu, ^{241}Am and ^{244}Cm with energies of 5.15, 5.48 and 5.8 MeV respectively) located outside the field cage.
- Trigger on central pads (reduced angular acceptance to $\theta<4^o$ and $\Phi<15^o$).
- The gas used for the experiment was iC_4H_{10} at 105.6 mbar (W=23eV in sim).
- Usual cathode voltages of -2500 V and thin wires at -350 V (to guide the field lines homogeneously to the Micromegas mesh). GET Frontend electronics.
- Signal threshold of 10 times above the noise level (~2000 electrons???).
- Sampled at a frequency of 25 MHz and recorded in a 12-bit ADC.
- **Regarding simulation**: ACTARSim reproduction of the Demonstrator setup with a 3-alpha source generator. Geant4 with emstandard opt3 physics list.
- Electron drift parameters according to the reduced electric field from MAGBOLZ.
- Trajectories obtained by a 3-Dimensional linear least squares fit.

Analysis Piotr Konczykowski (USC), data from G. Grinyer, J. Pancin, T. Roger (GANIL)

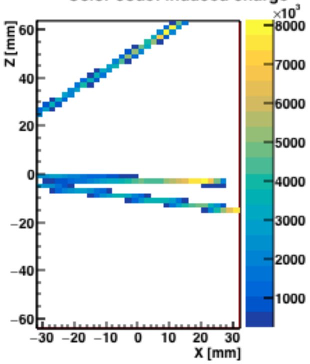
ACTARSim: triple α analysis



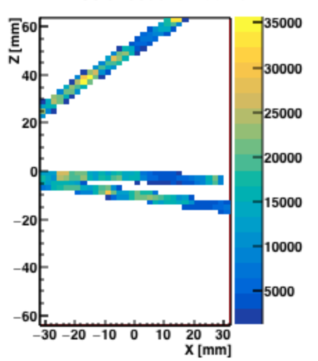




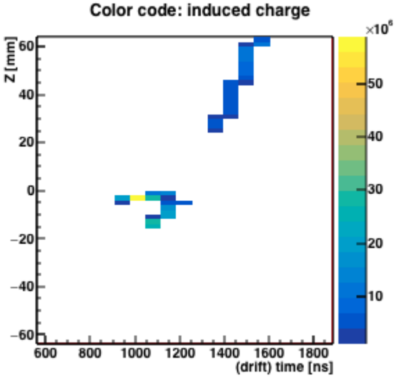
Color code: induced charge

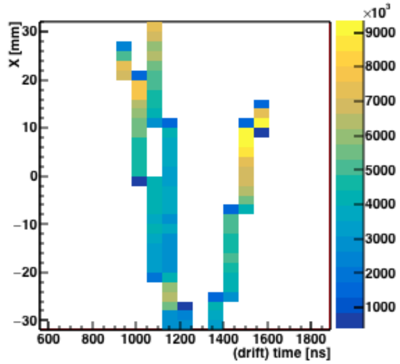


Color code: drift time



Color code: induced charge

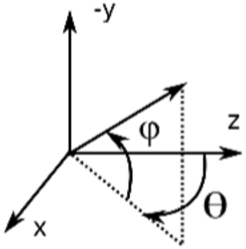


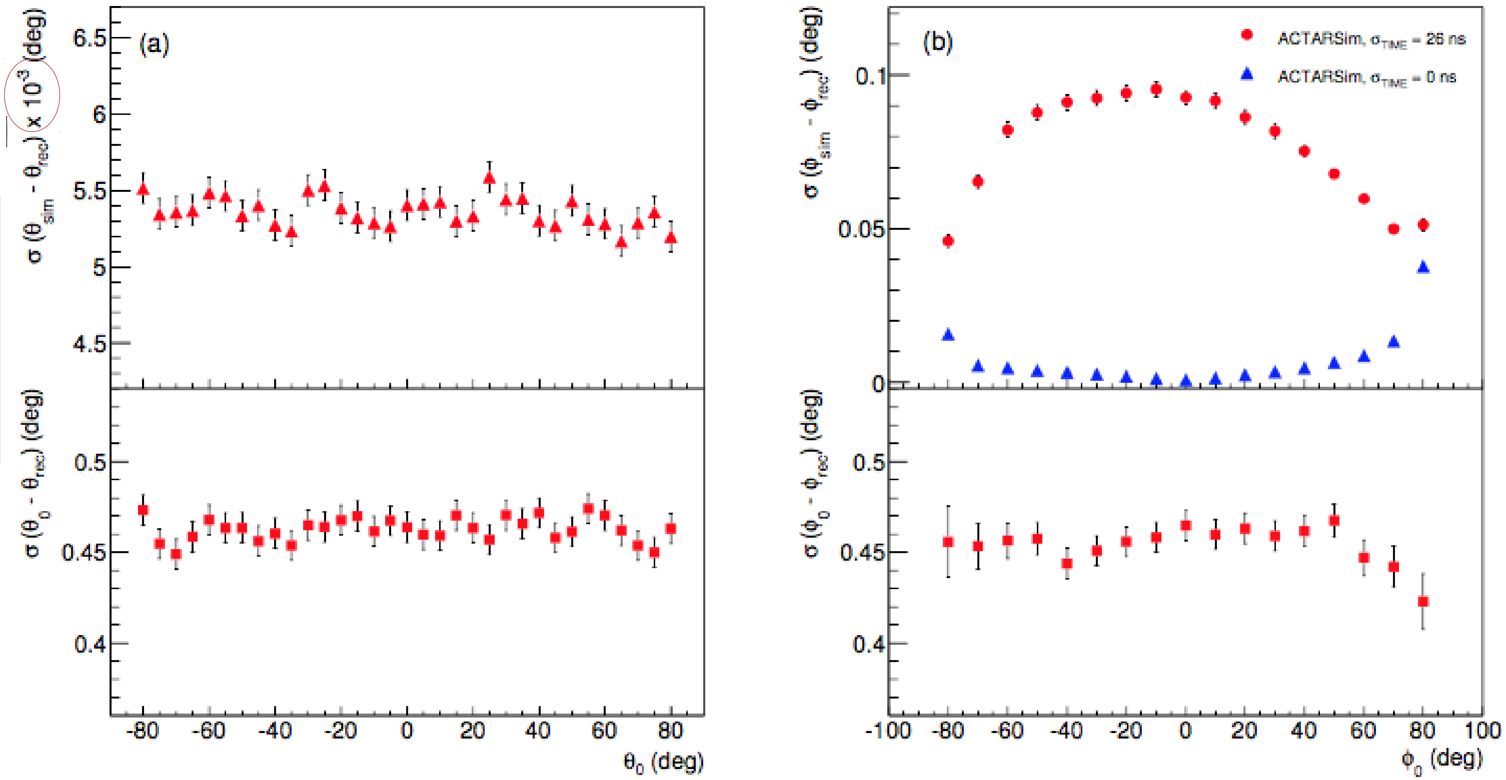


ACTARSim: triple α analysis

Reconstruction using a 3D linear least squares fit: evaluated in simulation comparing the initial (θ_0, Φ_0) and simulation (θ_{sim}, Φ_{sim}) with fit angles (θ_{rec}, Φ_{rec}).

- The reconstructed horizontal angle (θ) resolution is in the order of 5×10^{-3} deg.
- The vertical angular (Φ) resolution depends on the initial angle (as the number of active pads change). For σ_{TIME}=26ns (pulser), flattens to 0.01 deg.

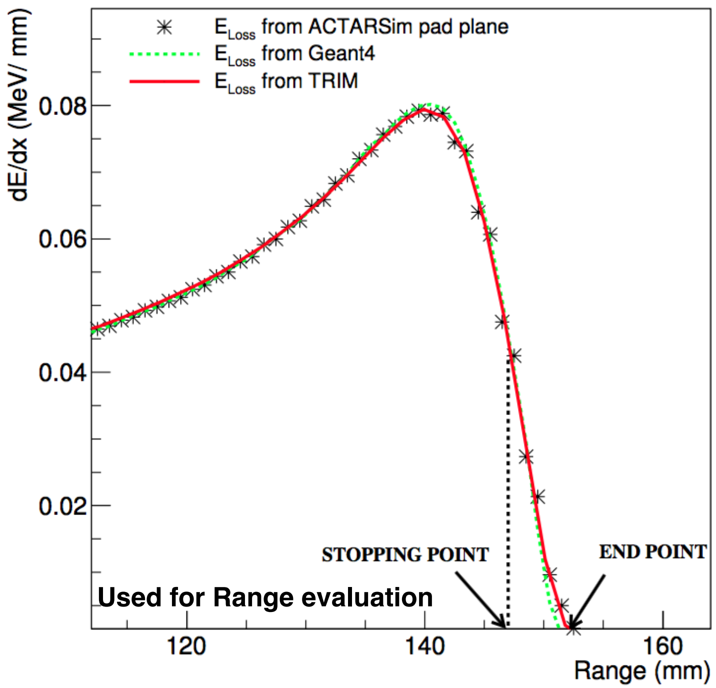




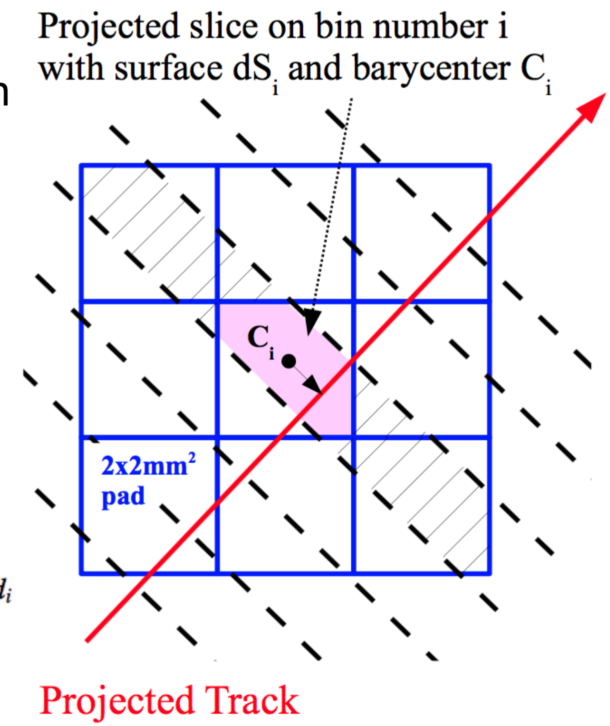
ACTARSim: triple α analysis

Energy loss profile: is constructed on each bin of the 3D-track projection by adding the slices carrying a portion of the charge Q_{pad} proportional to their surface dS_i (pink).

- The total charge in each bin is the sum over slices. A 2mm binning was used here with good results.
- "Average" profile fixing the end point (avoid straggling).



$$Q_{bin} = \sum_{i=1}^{N} \frac{dS_i}{S_{pad}} Q_{pad_i}$$



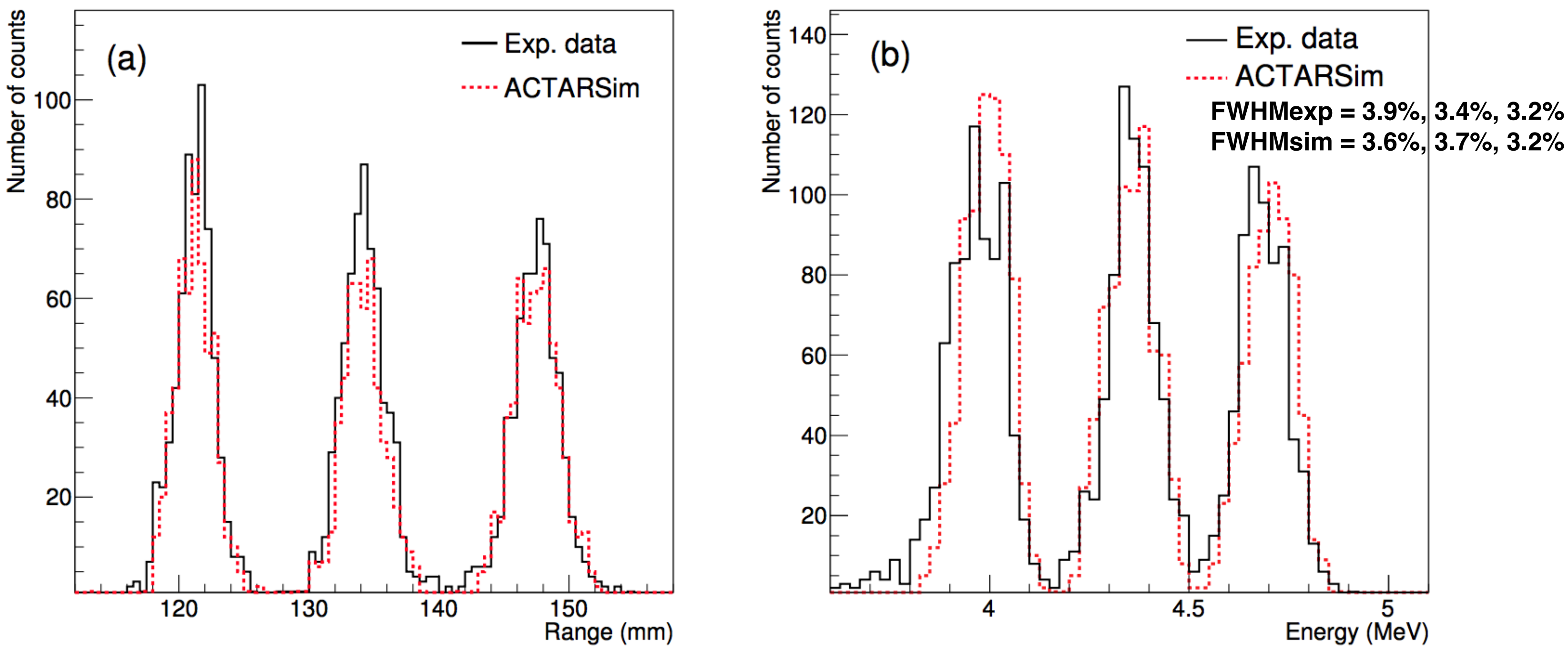
To study the electron transverse diffusion, we plotted the standard deviation of the barycenters of each slice:

$$\sigma_T = \sqrt{\frac{1}{Q_{bin}} \sum_{i=1}^{N} Q_{pad_i} (C_i - \mu)^2}$$

ACTARSim: triple α analysis

- **Exp. vs sim. results**: a very good agreement in range and reconstructed energy.
- Sim. range includes a 1mm global offset (possibly an error in source positioning).

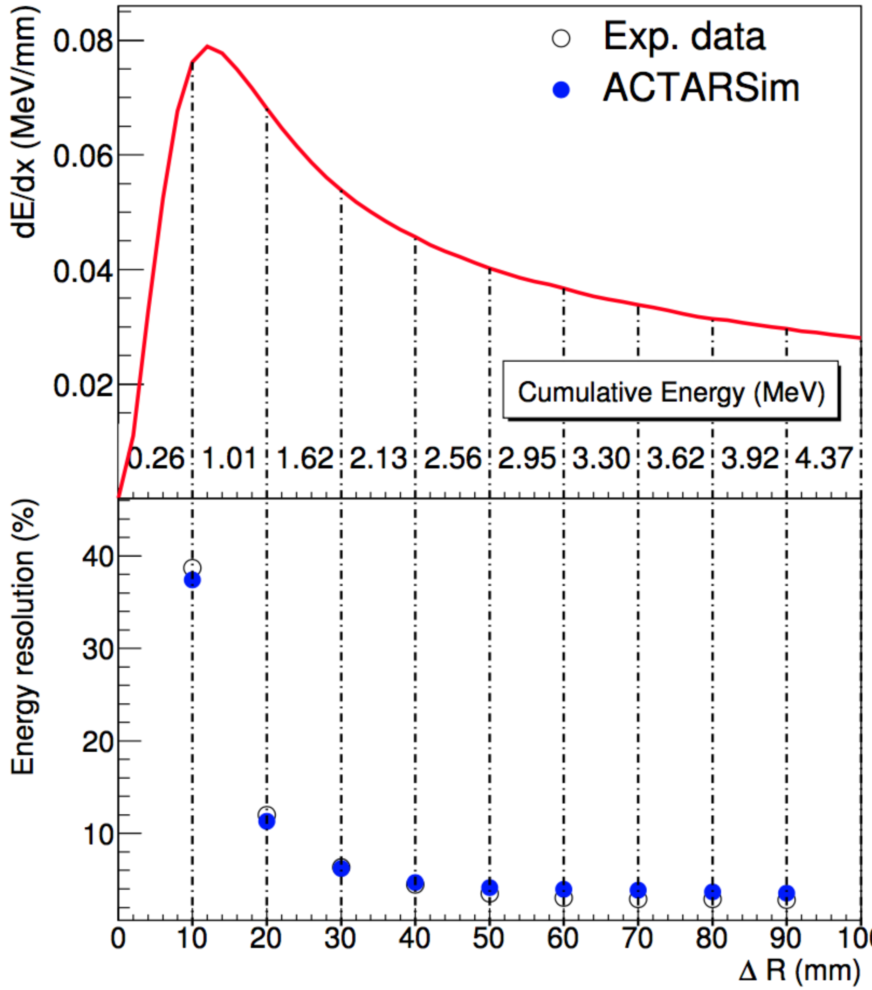
Isotopes	Eα (MeV)	R^{exp} (mm)	σ_R^{exp} (mm)	R^{sim} (mm)	σ_R^{sim}	R^{TRIM} (mm)	σ_R^{TRIM} (mm)
^{239}Pu	5.15	121.2(6)	1.41(5)	122.5(7)	1.45(7)	121	1.34
^{241}Am	5.48	134.1(7)	1.61(6)	135.3(8)	1.64(8)	134	1.48
^{244}Cm	5.80	147.5(7)	1.65(7)	148.4(8)	1.69(8)	147	1.69



ACTARSim: triple α analysis

Energy resolution (lower plot) as a function of the distance (ΔR) from the end of the Brag peak (upper plot). This is equivalent to study the **energy resolution as a function of the alpha's energy**.

- For ΔR =10 mm the resolution is high due to the important straggling effect.
- For ΔR > 40 mm, after the Bragg maximum, energy resolution stabilizes around 4% (FWHM).

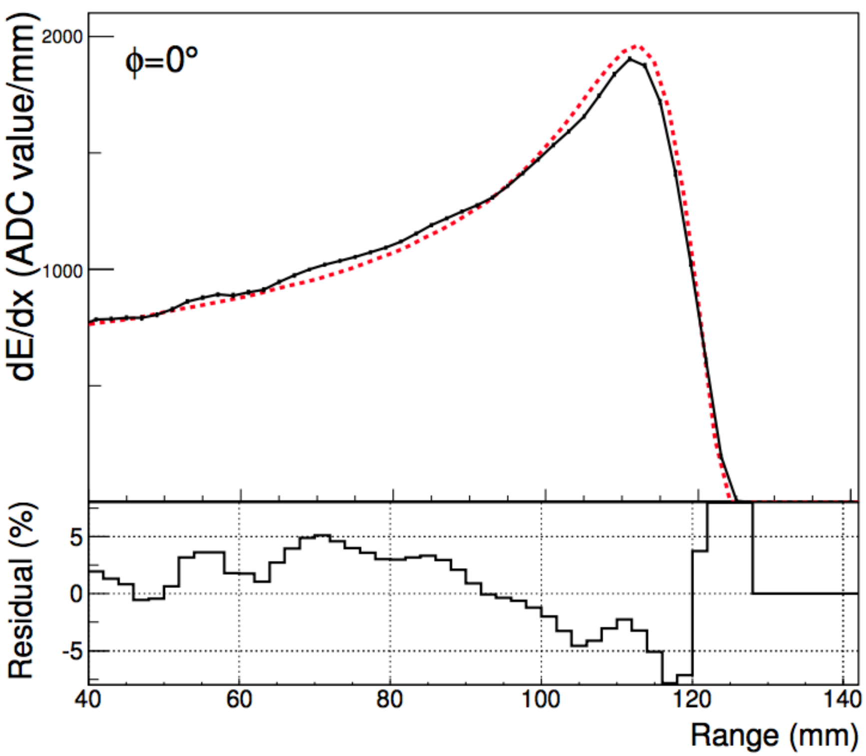


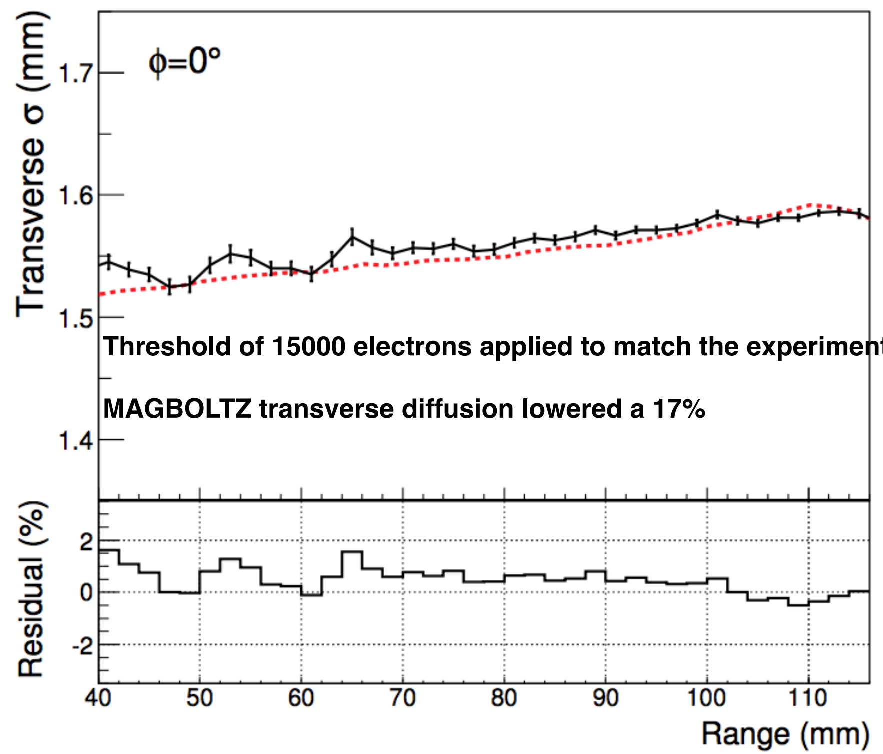
ACTARSim: triple α analysis

- Exp. profile fit: cumulated exp. profiles using a χ^2 minimization with 2 parameters (height and longitudinal shift).

  The fitted simulation profiles are slightly more peaked which makes the end point shorter than in the data. Fit is robust for different vertical angle(Φ).

- Transversal fit depends on the vertical angle (Φ), exp. pad threshold and D_T.





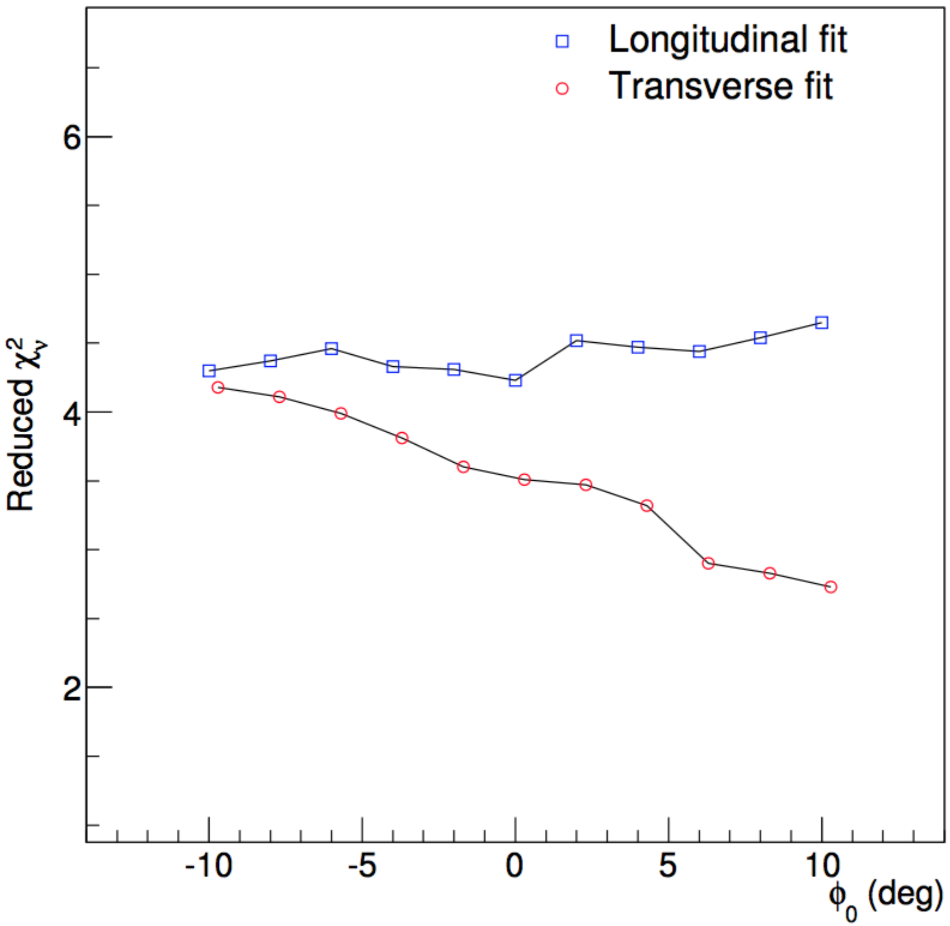
ACTARSim: triple α analysis

Reduced χ^2 defined respectively as:

$$\chi^2_{red} = \frac{1}{N-2}\sum \frac{(\frac{dE}{dx}^{exp} - \frac{dE}{dx}^{sim})^2}{N_e} \qquad \chi^2_{red} = \frac{1}{N-2}\sum \frac{(\sigma_T^{exp} - \sigma_T^{sim})^2}{\varepsilon^2_{\sigma_T}}$$

Where N_e, the number of electrons in the pad, is estimated from the experimental signal amplitude.

- The profile binning is proportional to cos Φ for comparing similar slices.
- Some effects not account for in simulation results in a dependence of the transverse fit with angle Φ.



ACTARSim: perspectives

- ActarSim moving from simulation to global analysis framework.
- Other frameworks in the market: FAIRRoot-based (see next slide!).
- Detailed implementation of ACTAR TPC and a set of possible ancillary detectors. Different choices for the user.
- Complete test of Geant4 physics libraries: evaluation for heavy ions using the emstandard opt3 physics list.
- Advanced event generators, n-body phase space,
- User documentation!

ACTARSim: perspectives

FAIRRoot frameworks:

- ATTPC (Yassid Ayyad, MSU)
- ACTAF in R3BRoot, using GARFIELD within G4 (mail from Oleg Kiselev, GSI):

1) The package R3BRoot + Garfield itself is made running.

2) The first version of the small chamber geometry within R3BRoot + Garfield is made.

3) Some changes made – different gas, correct potentials, etcetera.

4) Different particle guns are tried – simple beam and ASCII file made by the external generator.

5) Influence of the energy threshold for the electron production in gas is observed. High threshold – fast tracking but no e-ion pairs in gas, low threshold – very slow simulations.

6) Signals on the readout pads are observed.

7) Electric field calculations with ANSYS made. Investigation of the field profiles shown some field deformations. The optimization of the potentials on the field-forming circles are needed.

8) Simulations with the ANSYS field maps are coming.

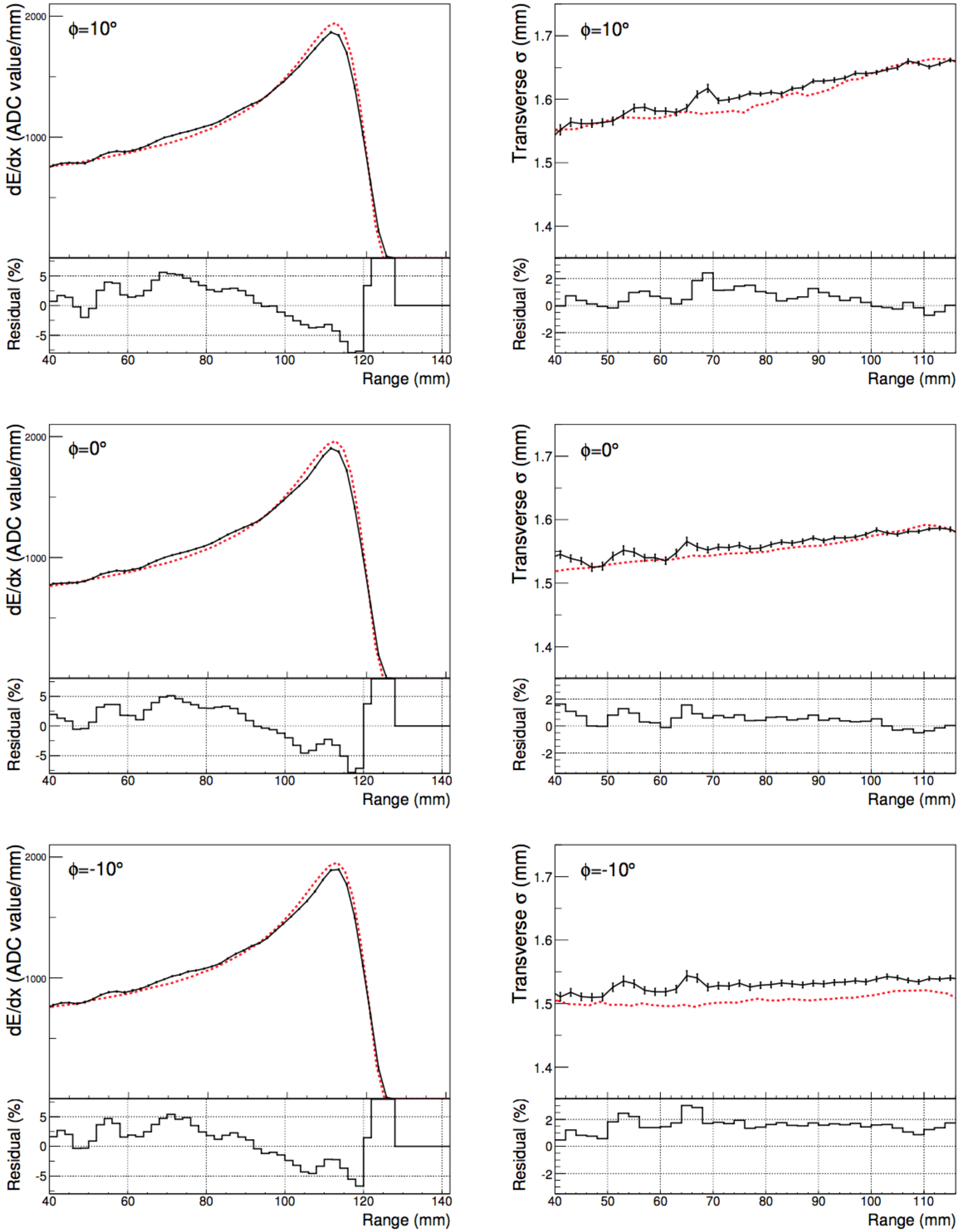
Two real problems are found: very slow (minutes up to hours per event) simulation in case of low-energy electron production in gas; the geometry needs to be made twice – for R3BRoot and Garfield.

To conclude:

- Simulations ready for the use with different active targets.
- Ongoing work on evaluation, still a long way to walk...
- Users and testers welcome.

Thank you very much for your attention!

Additional slides


ϕ=10°
dE/dx (ADC value/mm)
Residual (%)
Range (mm)
Transverse σ (mm)
ϕ=0°
ϕ=-10°

ACTAR-TPC demonstrator in ACTARSim: