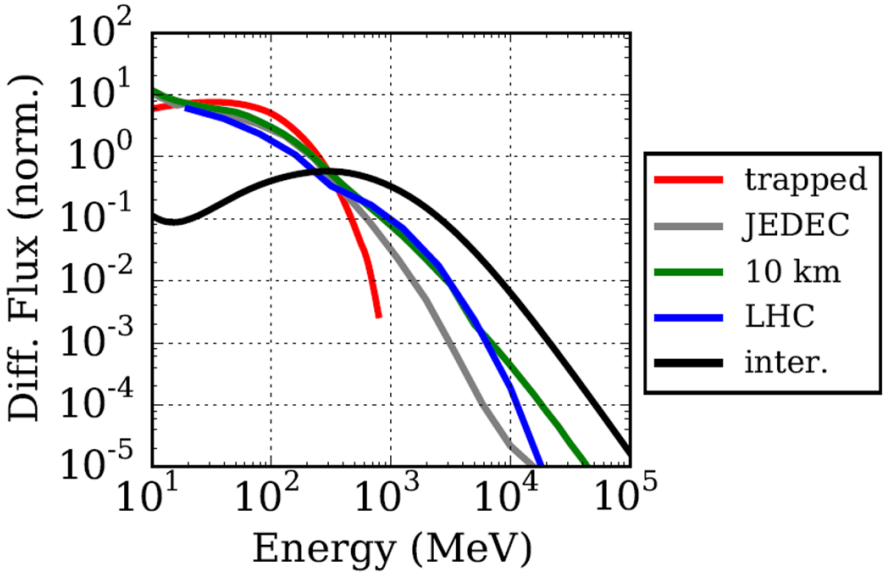
Ultra-High Energy heavy ion test campaigns at CHARM and North Area CERN Facilities

Maria Kastriotou, Pablo Fernandez Martinez, on behalf of the STI/BMI – R2E unit

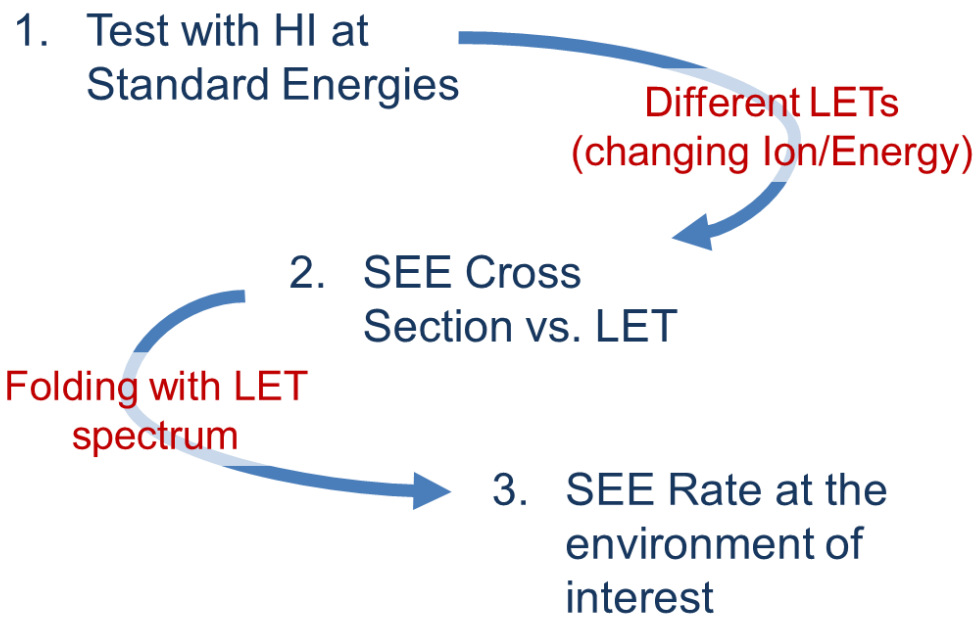
Indico link: https://indico.cern.ch/event/760345/

Interest in heavy ions



- Roughly 20% of the hadron flux in the LHC tunnel has energies greater than 1 GeV
- Heavy ions can be used for soft error evaluation and part screening for destructive events.
- Insensitivity to heavy ions of large enough LET grants insensitivity to protons and mixed field environments

Why heavy ion testing?



Standard heavy ion facilities:
~70-270 µm range of ions

- Component delidding (hazardous for the component, impossible in complex geometries)
- Non constant LET throughout the SV
- Tests in Vacuum

UHE ion testing provides a homogeneous LET without the need for component delidding, while introducing the possibility of parallel board testing.

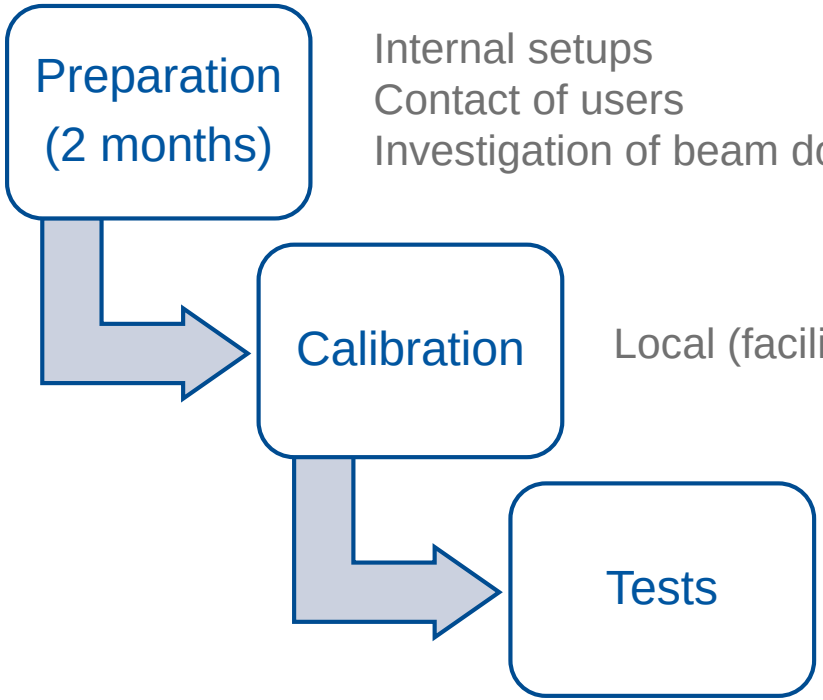
CHARM and North Area ion beams

Pb beam characteristics	CHARM	North Area
Energy (AGeV/c)	5.4	150
LET (MeVcm^2/mg)	8.0	8.8
Beam size (cm^2)	~5x5 - 8x8	Up to ~ 5x5
Pulse length (s)	~0.2	~10

Complementary facilities, with similar LET and different beam characteristics

- North Area provides lower fluxes, variable beam size/intensity possible to change in the control room, and frequent accesses
- CHARM is ideal for irradiation with higher particle fluences, provides good dosimetry and is adapted to electronic systems testing.
  Due to the large beam size, big/multiple components can be tested.
  The flux is high enough to perform displacement damage studies (F. Ravotti, I. Mateu)

Test practice



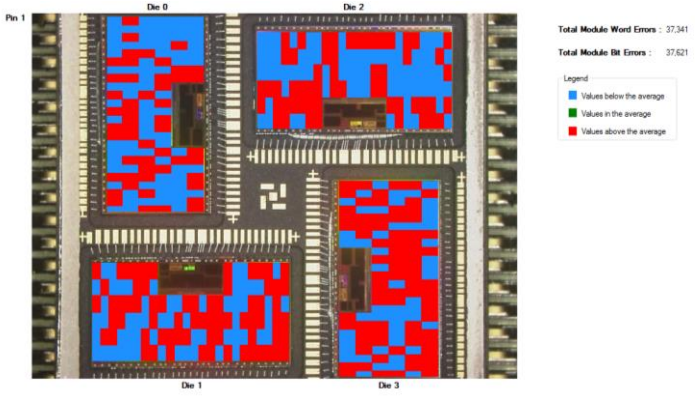
Internal setups
Contact of users
Investigation of beam dosimetry instruments and calibration methods

Local (facility) beam instruments and additional detectors

CHARM: 3 weeks (incl. calibration)
North Area: 1 week (incl. calibration)

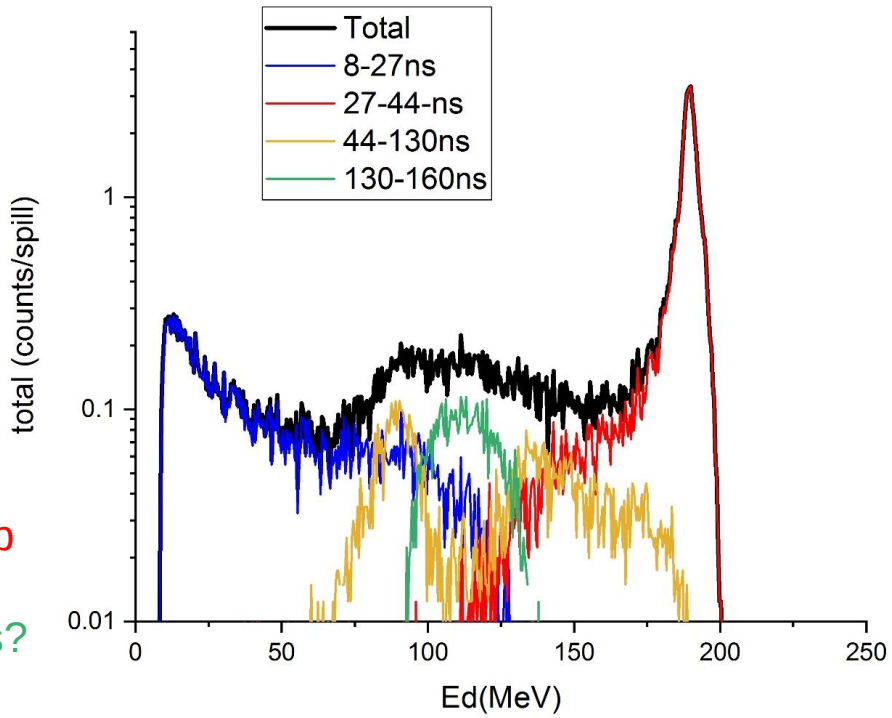
Beam attenuation in UHE

- 3 ESA monitors in parallel
- Well aligned beam
- Max attenuation of 20% in all cases
- ✓ Parallel board testing is possible, fluence calibration is preferable



Beam fragmentation in UHE

- Beam composition examined by a diode (C.Cazzaniga, ChipIr), following the setup with 3 sets of boards+plexiglass
- Beam fragmented, however the initial, high LET Pb ions still compose large part of the beam

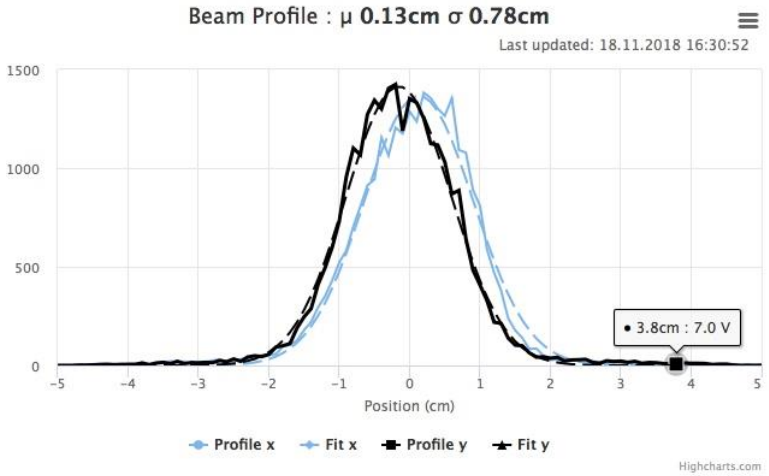


- Type1: fast signals: neutrons/light ions
- Type2: The main peak. Direct ionization of Pb
- Type3: Probably fission fragments?
- Type 4: Possibly a different kind of fragments?

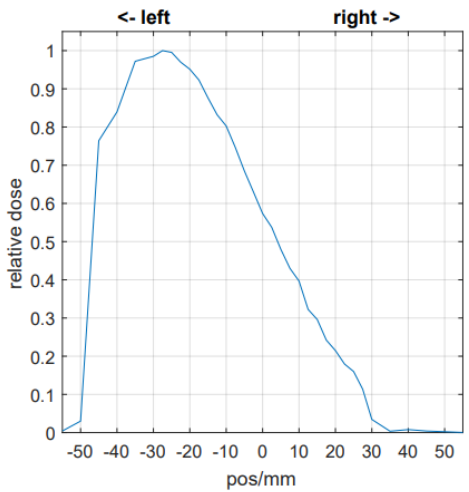
Challenges faced in the North Area

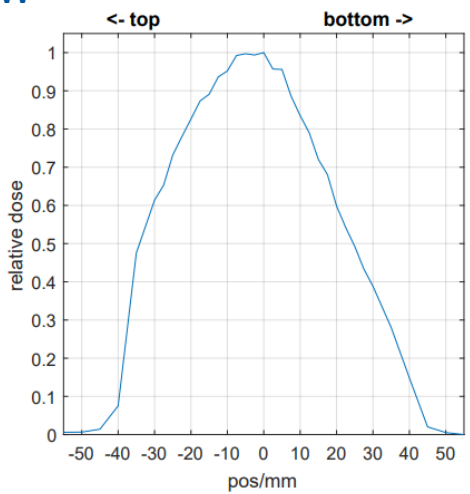
- Facility provided instruments: DWC (delay wire chamber - beam size), scintillator (counts and composition)
- Measurements with other detectors imply that the beam size is different than the one suggested by the DWC. Still under investigation (large deam divergence due to a defocused beam?)

DWC



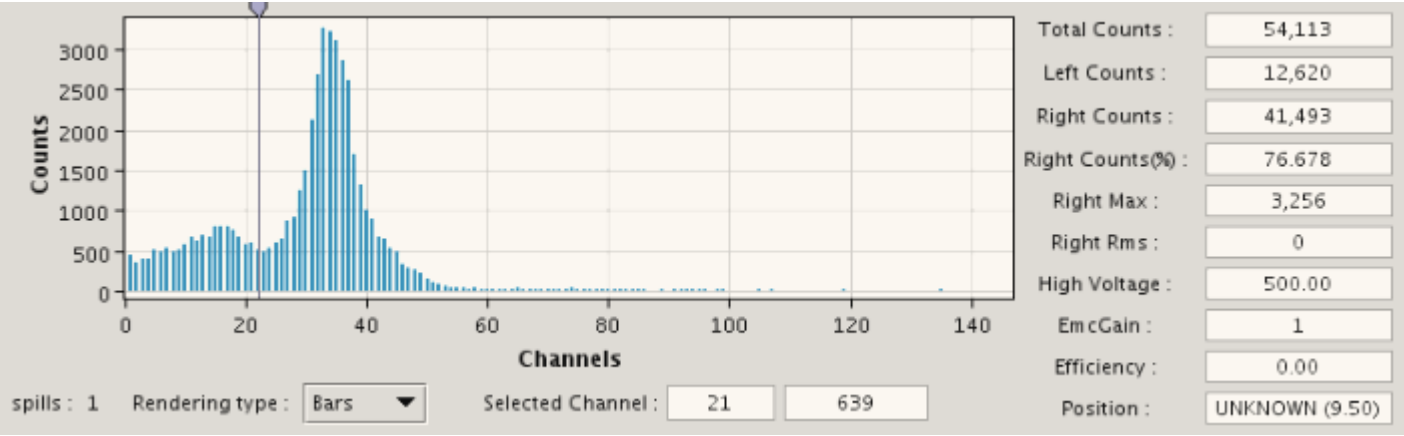
PTW





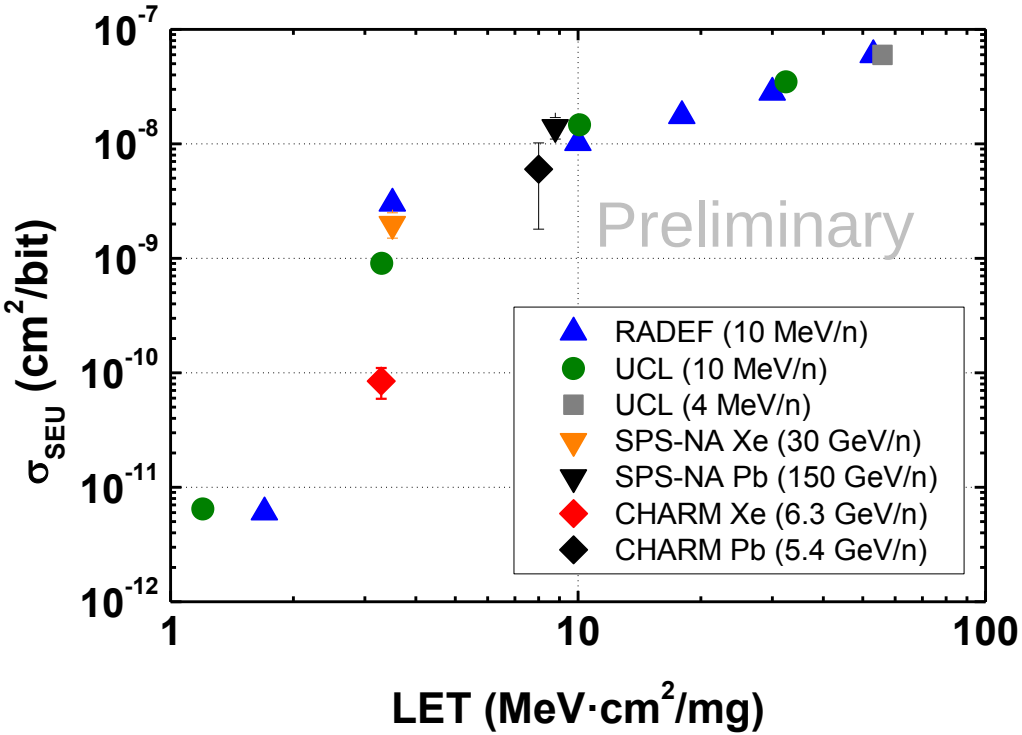
Challenges faced in the North Area

- Facility provided instruments: DWC (delay wire chamber - beam size), scintillator (counts and composition)
- The scintillator pulse height analysis, showing the beam fragmentation, does not contain the full energy window (different to previous diode measurements).



Performed tests

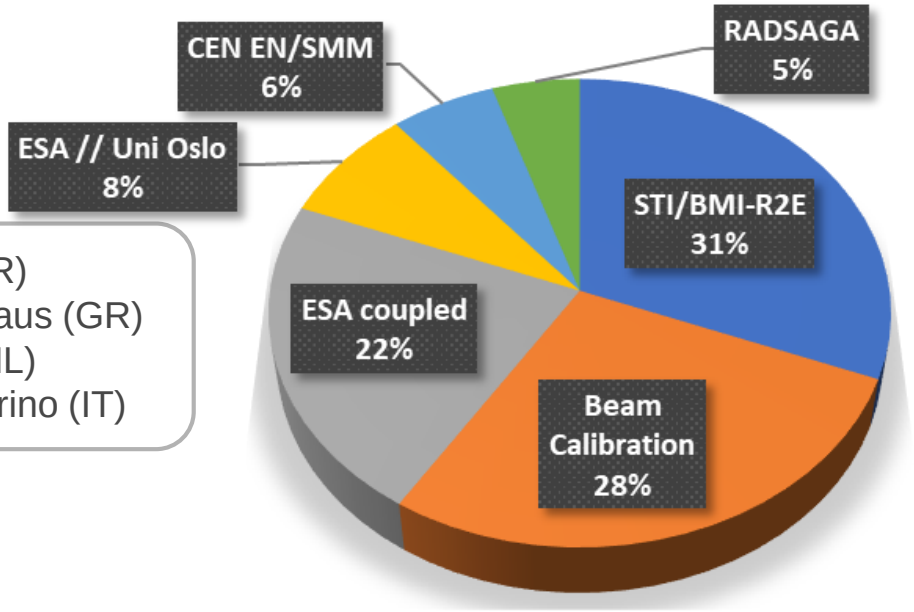
- In both facilities, under UHE heavy ion beam, STI/BMI tests included:
  - ESA SEU monitor
  - SRAM memories (Samsung, Alliance, Brilliance, Lyontek, Cypress 65 & 90 nm)
  - Power MOSFETs (see P. Fernandez Martinez's talk)
  - GaN devices
- Data analysis pending
- Preliminary results show great agreement with past studies



Collaboration with external R2E teams

Knowledge Transfer – Testing opportunities – CERN Visibility

North Area tests



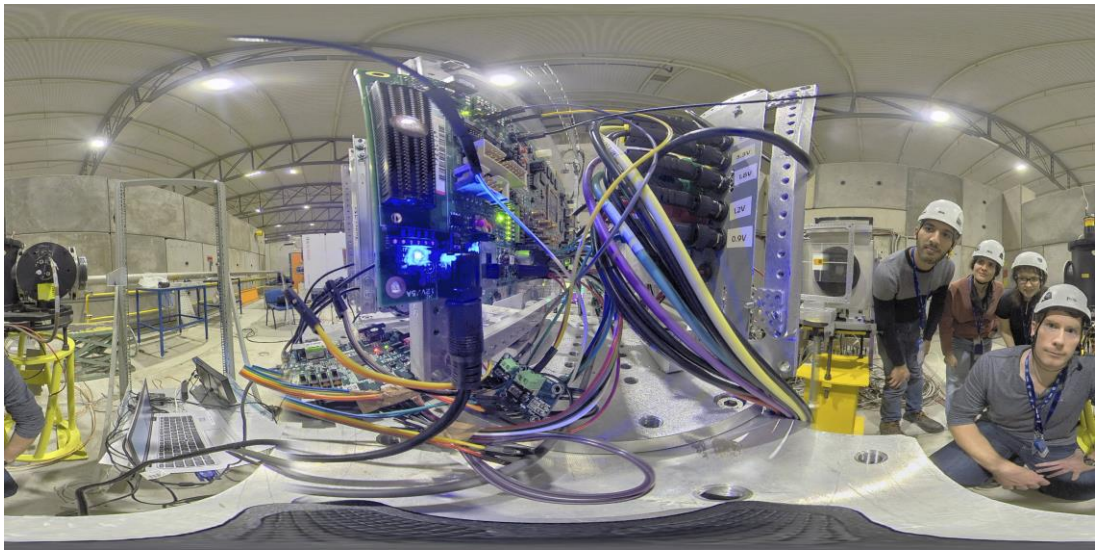
JALIKO (IR)
University of Pireaus (GR)
TU Delft (NL)
Politecnico di Torino (IT)

In CHARM tests the CERN:externals ratio is 60:40

(CHARM tests summarized by S. Danzeca in “CERN facilities* ”)

*https://indico.cern.ch/event/760345/contributions/3159586/attachments/1769002/2873455/Facility_R2E_Annual_Meeting_2018_mb_ch.pdf

CERN/facilities visibility



CERN/ESA/INTEL
Myriad 2 radiation test

Google news
International (+NL, IRL, IT, SE, GR) websites

Outlook

- Measured results to be coupled with FLUKA simulations
- During LS2 a large data acquisition in different heavy ion facilities is being planned
- CHARM is an independent facility dedicated to electronics testing. We should use CHARM experience to prepare future UHE ion tests in the North Area:
  - Communication/agreement with EN/EA
  - Selection and upgrade of a location that can support electronics testing:
    - Independent line (accesses)
    - Shielding (high intensities)
    - Beam Instruments appropriate and calibrated for UHE heavy ions

Summary

- UHE heavy ions constitute a very useful tool for electronic component evaluation
- UHE heavy ion beams are highly interesting for component testing in view of the HL-LHC high radiation levels
- CERN heavy beams have been greatly appreciated by the external R2E community
- Careful preparation will contribute to take even greater advantage of the North Area beam

Thank you !