RADSAGA

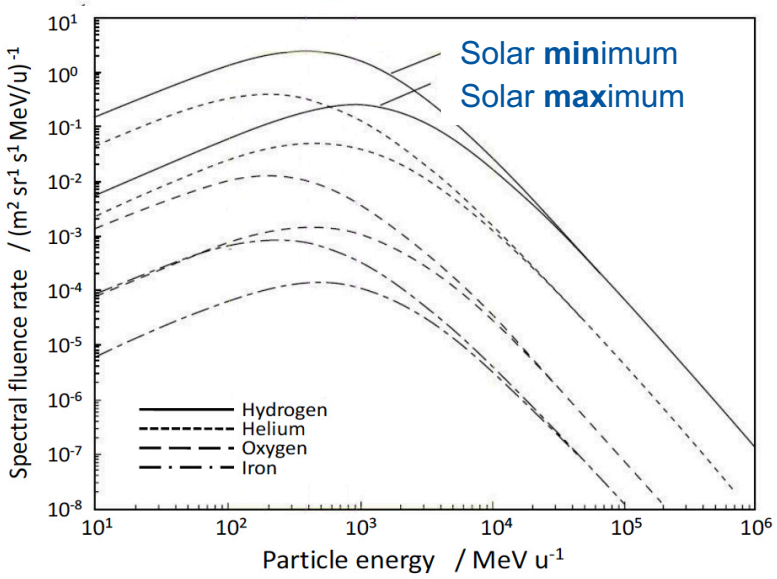
This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie-Sklodowska-Curie grant agreement number 721624.

Response of the Standard Radiation Environment Monitor mounted onboard the Rosetta mission to high energetic heavy ions

RADFAC Montpellier April 2018

RADSAGA Project ESR 04 - Vanessa Wyrwoll

Introduction



energy spektra GCR

E. R. Benton *et al.*

Galactic Cosmic Rays GCR

- Protons and ions primarily from Supernovae
- Isotropic Distribution with extremely high energies
  - Relevant: 10^6MeV/u
  - Measured: 10^{14}MeV/u
- Modulated by the solar cycle
  - Solar **max**imum
    ⇒ **min**imal flux
  - Solar **min**imum
    ⇒ **max**imal flux

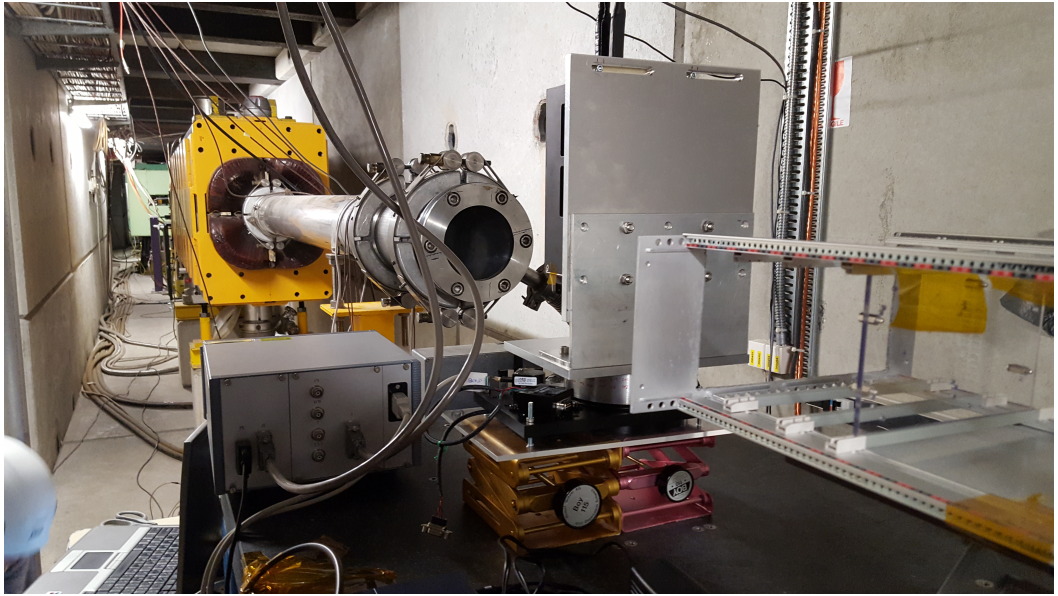
Introduction

Ultra - High Energetic Heavy Ion Tests at CERN

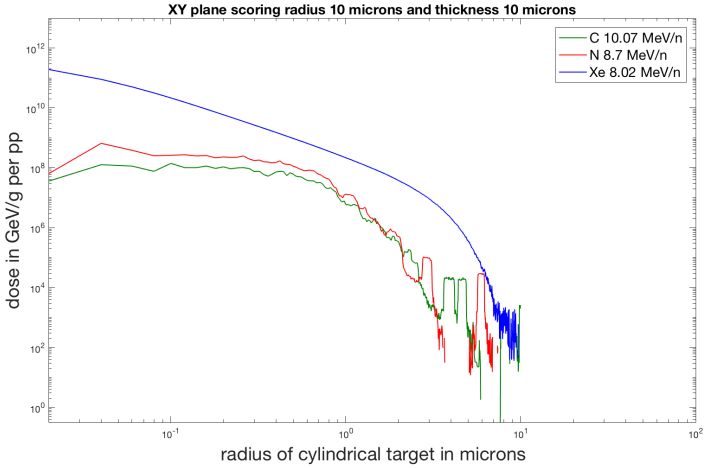
TCC2, the target hall of the SPS North Area © **1978-2018 CERN**

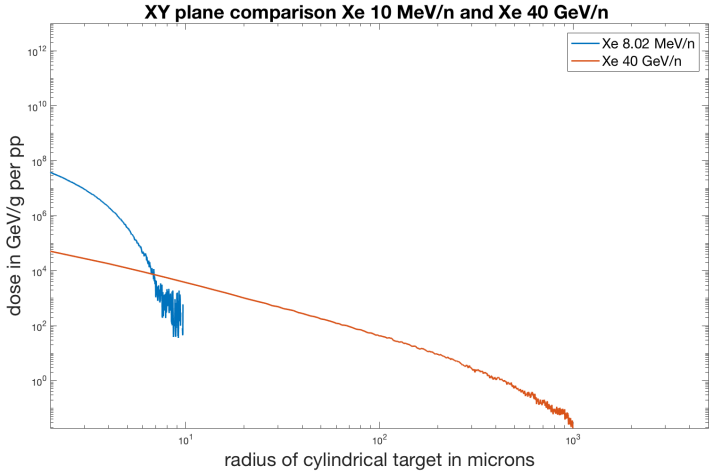
- High energetic component of GCR environment in space
- Complementary radiation with regard to standard energy tests (UCL,RADEF) 10 MeV/n
- Parts can be tested in air and without the need of opening/thinning them to expose sensitive area

North Area H8 40 GeV/n Xe Beam

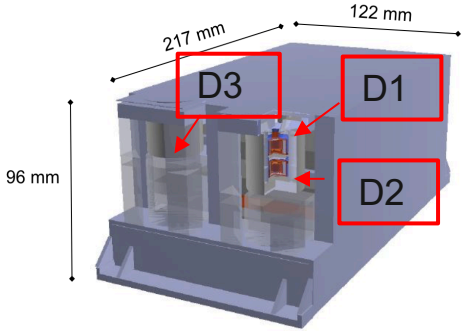


Dose Deposition Related to Particle Energy





SREM Detector



Developed by PSI, Contraves Space AG und European Space Agency (ESA)

- Proba-1, Integral, Rosetta, Herschel, Planck, Giove-B
- Electrons, protons and ions
- Detection range: 10MeV - several 100MeV for protons
- Sensors (Detector area: D1/D3 0,7 - D2 1 cm^2):
  - 3 semiconductor diodes
  - 2 in telescope configuration (coincidence)
- 15 discriminator channels used to count energy deposition events in the three detector areas

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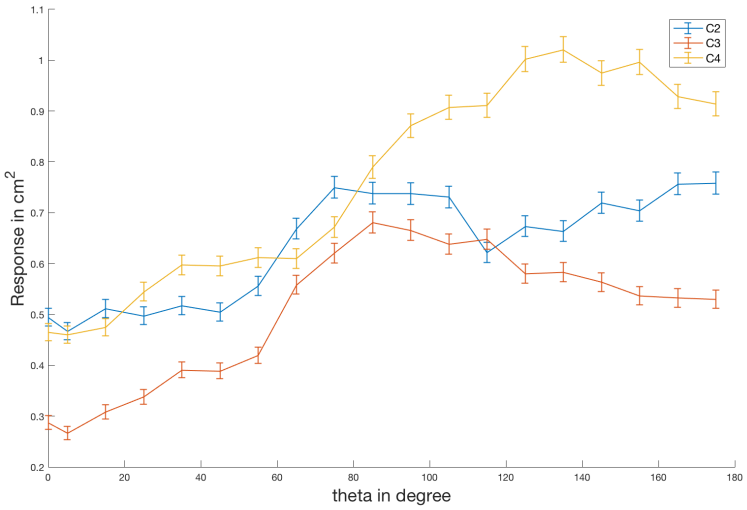
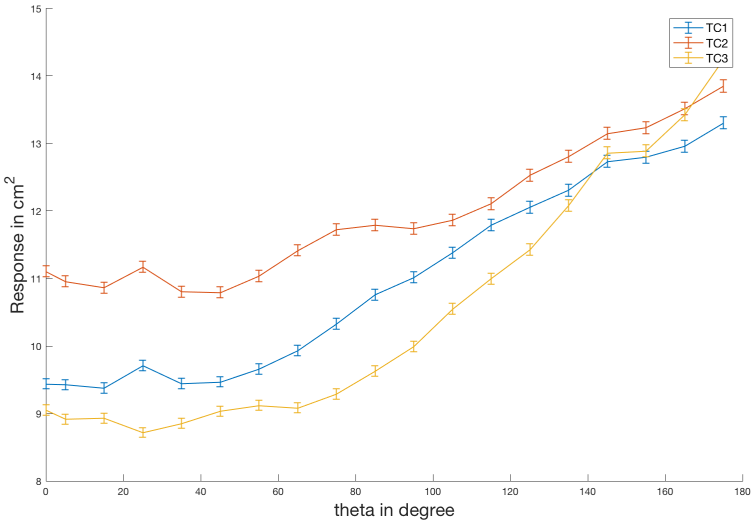
Detector Logic

Channel	Detector	Energy Threshold ΔE > XX (MeV)	Proton Energy Min (MeV)	Proton Energy Max (MeV)
TC1	D1	0.085	27	∞
S12	D1	0.25	26	∞
S13	D1	0.6	27	∞
S14	D1	2.0	24	542
S15	D1	3.0	23	434
TC2	D2	0.085	49	∞
S25	D2	9.0	48	270
C1	D1 x D2	0.6, 2.0	43	86
C2	D1 x D2	0.6, 1.1-2.0	52	278
C3	D1 x D2	0.6, 0.6-1.1	76	450
C4	D1 x D2	0.085-0.6, 0.085-0.6	164	∞
TC3	D3	0.085	12	∞
S32	D3	0.25	12	∞
S33	D3	0.75	12	∞
S34	D3	2.0	12	∞

Response Functions





Flux Calculation

- **Calibration Factor 40 GeV/n : 2,49 x 10^{-2} [Xe Ions / Scint Counts / cm2]**
- **Each spill last approx. 8s and happen approx. every 45s**

$$Flux\ [\frac{ions}{cm^2 x\ spill}] = \text{Spill Intensity [Scint. Counts] x CF}$$

$$Fluence\ \left[\frac{ions}{cm^2}\right] = \sum_{Spills} Flux = \sum_{Spills} (Spill\ Intensity\ x\ CF)$$

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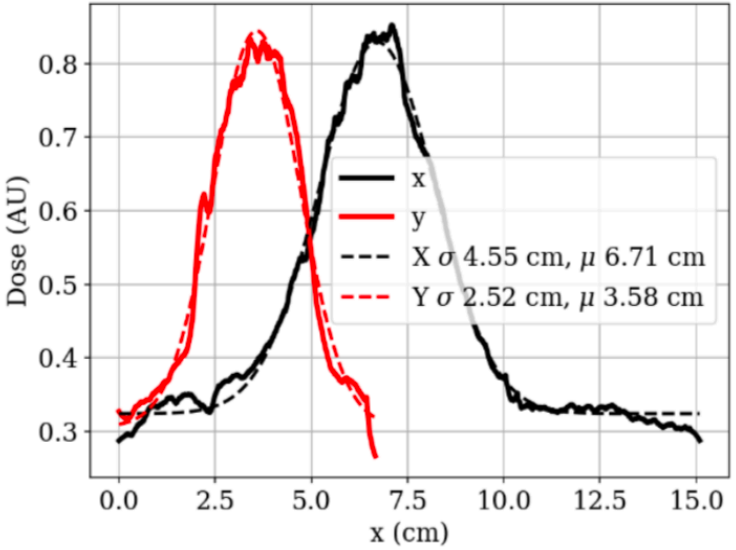
Flux Calculation

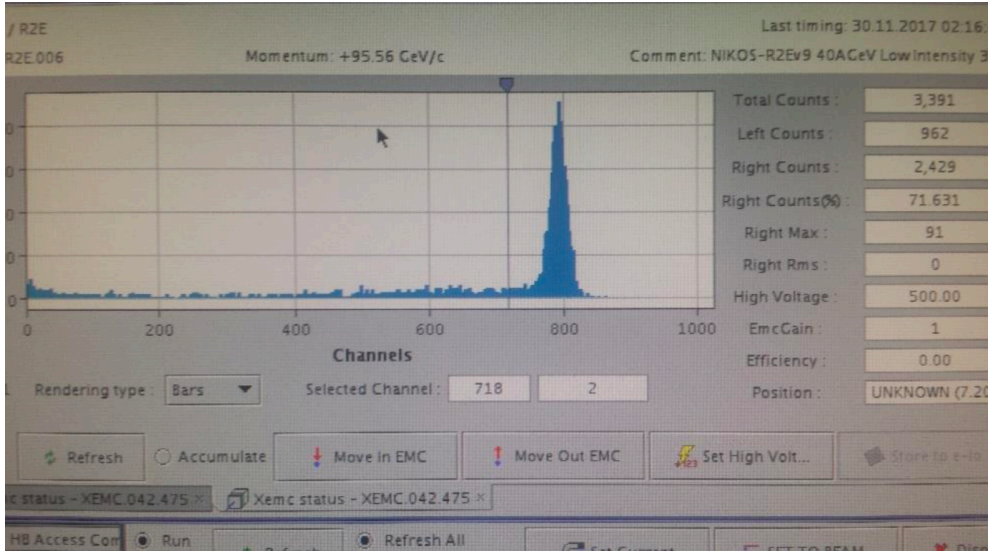
High intensity Xe beam profiles



- *Horizontal (black) and vertical (red) planes*
- *Extracted from different signatures on radiochromic films*
- *Gaussian shape is generally obtained*

Flux Calculation

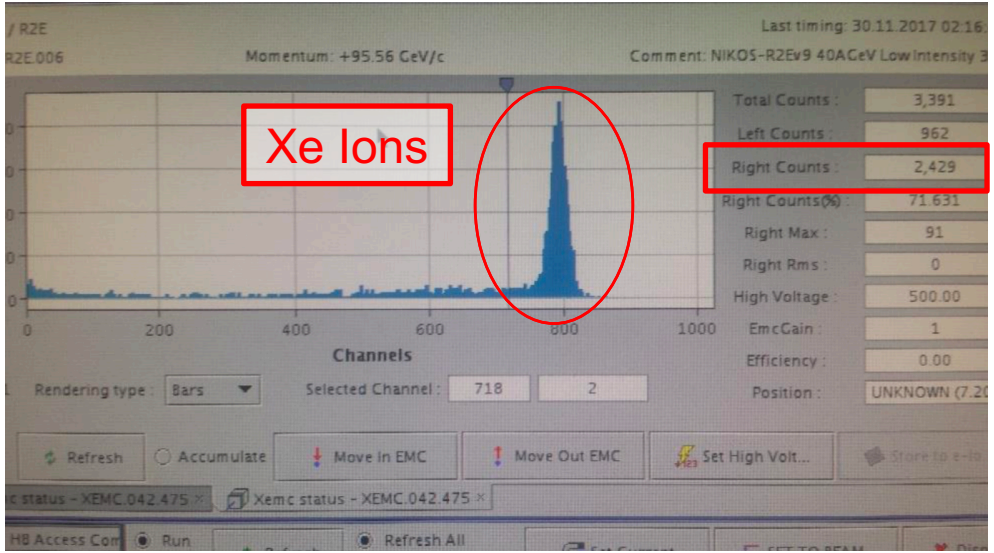
Pulse Height Analysis



- *PHA of the Xe beam*
- *obtained with the scintillator located 45 m downstream the test position*

Flux Calculation

Pulse Height Analysis

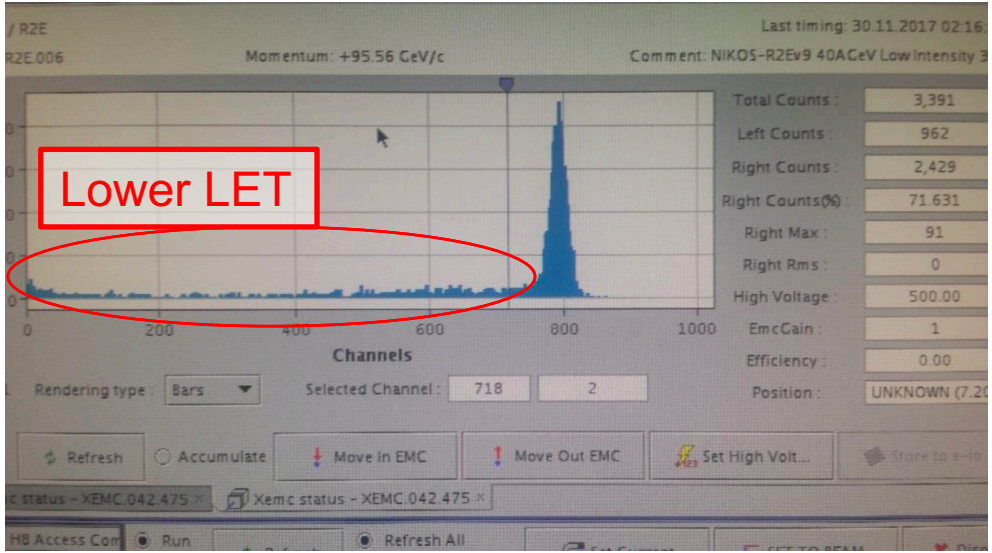


- *Contribution of the Xe ions:*

72% of the integrated number of counts

Flux Calculation

Pulse Height Analysis



- *Clearly distinguished from lower LET contributions*

Count Rate Modulation

Assumption: „Isotropic“ radiation:
count rate in **channel i**:

$$c_i(t) = \sum_{q=1}^{92} \int F_q(E,t) R_{q,i}(E) dE$$

***i* = 1-15**

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Count Rate Modulation

Assumption: „Isotropic“ radiation:
count rate in **channel i**:

Response function of channels **i** to particle **q**
here: simulation

$$c_i(t) = \sum_{q=1}^{92} \int F_q(E,t) R_{q,i}(E) dE$$

***i* = 1-15**

Count Rate Modulation

Assumption: „Isotropic“ radiation:
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***i* = 1-15**

Flux
here: experimental

Count Rate Modulation

Assumption: „Isotropic“ radiation:
count rate in **channel i**:

Response function of channels **i** to particle **q**
here: simulation

$$c_i(t) = \sum_{q=1}^{92} \int F_q(E,t) R_{q,i}(E) dE$$

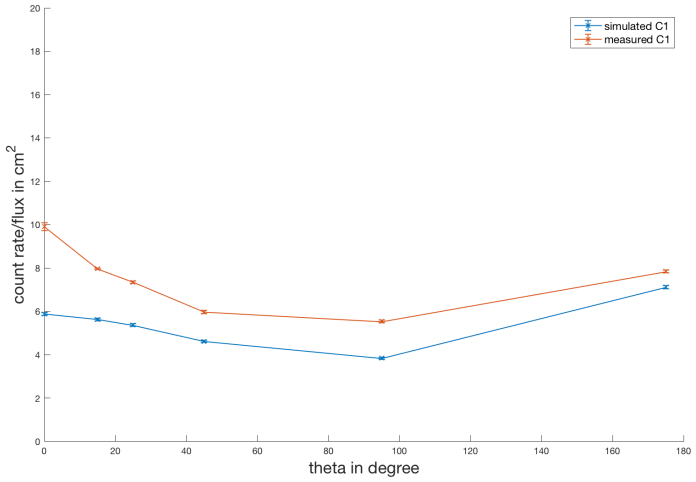
***i* = 1-15**

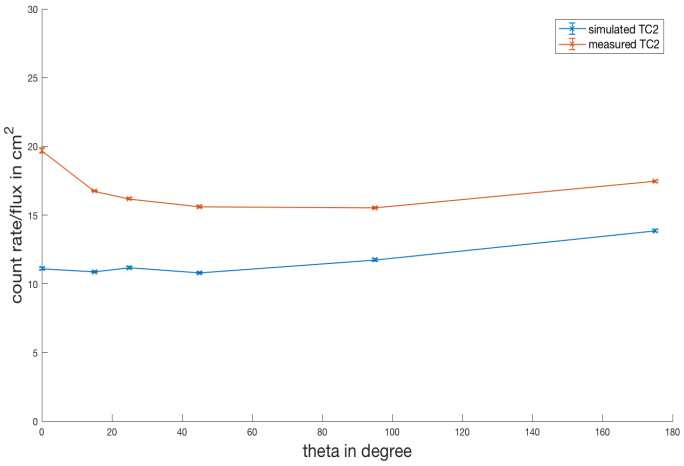
q: Charge of particle

here: Xe q = 54

Flux
here: experimental

Comparison Count Rates





- experimental data follows the angular dependence expected by simulations
  - possibly relation to contribution of lower LET fragments

Outlook

- Experiment NA H8 using Pb 159 GeV/n in Nov 2018: SREM
- MC simulations using GRAS and FLUKA of 159 GeV/u Pb beam various angles

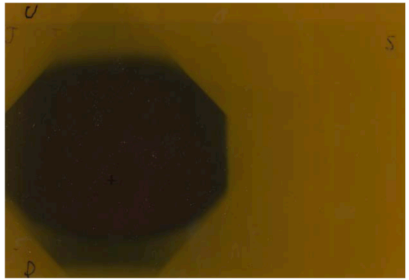
Thank you for your attention!

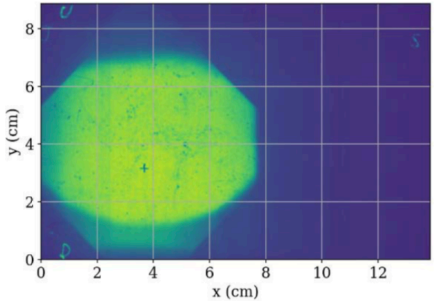
Back Up Slides

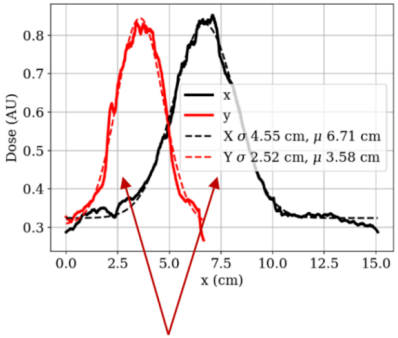
Beam Profile: Radiochromic Films

- Placed at the precise DUT location
- Good picture of the beam size and shape
- Information not available for any desired period of irradiation

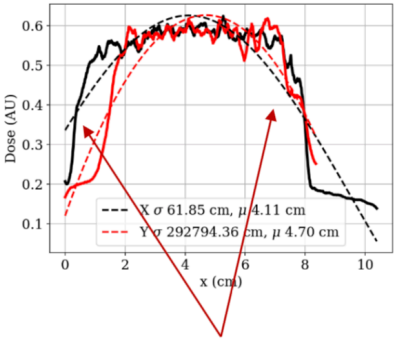
  - Specifically, for the external users runs







In general, Gaussian shape



For the broadest beams, collimation cuts led to rectangular shape

*** Note: σ = var./2**

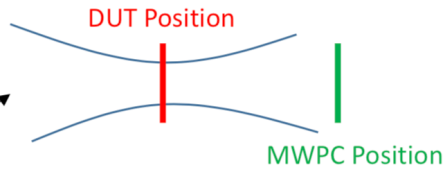
Calculated beam size

Date	Beam Energy [GeV/n]	Av. Spill Intensity [<Counts SCI.475>]	X-Width [mm]	Y-Width [mm]
20-Nov.	30	3E+6	46	62
21-Nov.	30	5E+6	76	66
22-Nov.	30	5E+6	79	68
24-Nov.	30	2E+3	35	60
30-Nov.	40	4e+5	40	53

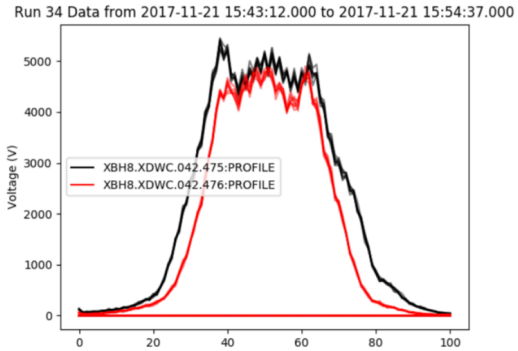
Settings for Very High Intensity led to broad beams (not applied for the users runs)

Settings for low and medium intensity (from 1e3 up to 3e6) led to a ~ 40 × 60 mm^2 beam

Beam Profile: MWPC



- Placed relatively far from DUT location (45 m downs.)
  - *Measured Shape and size might be different due to defocusing.*
- Information available for any desired period of irradiation
  - *Specifically, for the external users runs*



			Radiochromic Film		DWC	
Date	Beam Energy [GeV/n]	Av. Spill Intensity [<Counts SCI.475>]	X-Width [mm]	Y-Width [mm]	X-Width [mm]	Y-Width [mm]
20-Nov.	30	3E+6	46	62	37	35
21-Nov. 14:24 – 14:28	30	5E+6	76	66	45	38
21-Nov. 14:24 – 15:51	30	5e+6	76	66	45	36
22-Nov. 20:03 – 08:15	30	5E+6	79	68	-	-
24-Nov. 09:50 – 11:14	30	4E+4	-	-	37	35
24-Nov. 13:48 – 14:07	30	1e+6	-	-	37	37
24-Nov. 15:59 – 16:43	30	3e+5	-	-	34	33
24-Nov. 20:22 – 18:26 (+1)	30	2e+3	35	60	37	37
30-Nov.	40	4e+5	40	53	34	32

Coincidence in MWPC size using same settings (same optics), different beam intensities

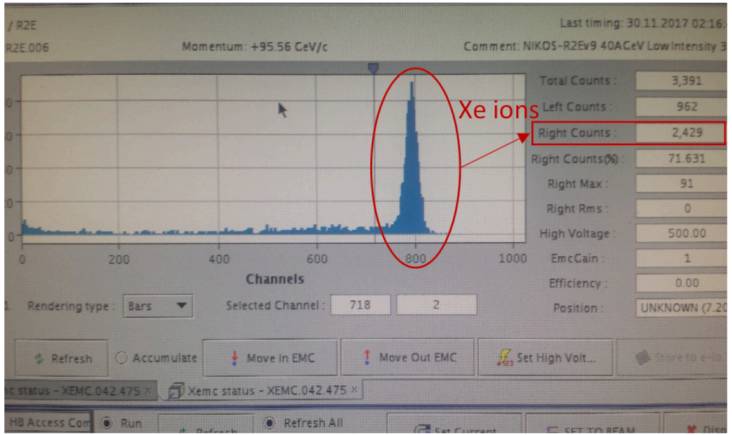
- For a given period of test:
  - *we analyze the MWPC readout, and*
  - *correlate it with size measured on a radiochromic film in a given period with the same MWPC readout*

Beam Intensity: Scintillators

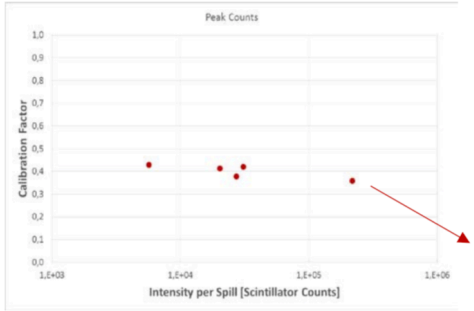
- Two Scintillators (27 m ups, and 45 m downs.)
  - *beam intensity ≡ scintillator counts per spill*
- Information available for any desired period of irradiation
  - *Specifically, for the external users runs*

1) This is not the ion fluence
2) The ion fluence cannot directly retrieved from this
3) Calibration required

PHA performed on the 2nd Scintillator signal (not logged)



TimeStamp	Energy [GeV]	PHA Signal [Counts]	PHA Peak [Counts]	Logged Intens. [Counts]	Conversion Factor
30-11-17 02:16	40	3391	2429	5651	0.430
01-12-17 10:35	40	16900	10289	27229	0.378
01-12-17 10:57	40	123107	78197	218292	0.358
02-12-17 11:24	40	17835	12918	30725	0.420
03-12-17 12:06	40	11341	8349	20202	0.413

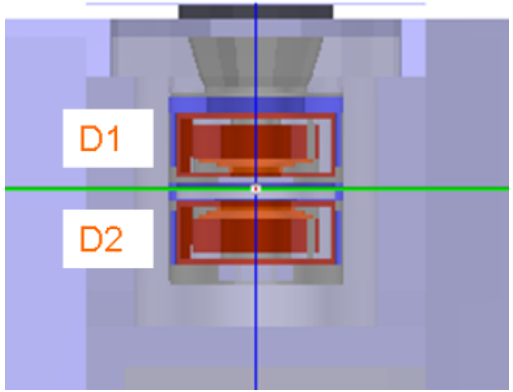


Conversion Factor:

- Proportion of total counts attributed to Xe ions
- ~ **0.4** [ions/scint. count]
- Stable with beam intensity

Example Energy Threshold

Channel	Detector	Energy Threshold ΔE > XX (MeV)	Proton Energy Min (MeV)	Max (MeV)
TC2	D2	0.085 MeV	49	∞

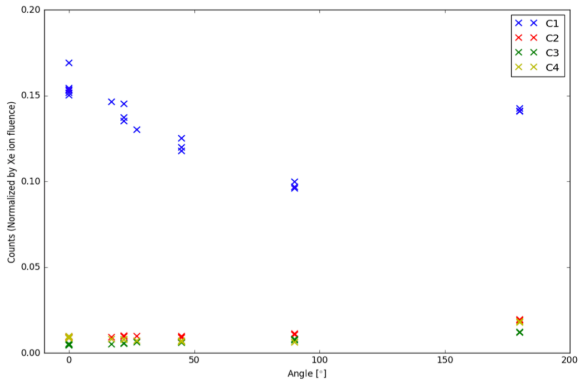


- Able to detect protons over 49 MeV/u
- Not electrons (shielding)

SREM

Results

- Comparison to simulations performed using radiation analysis tools (GRAS & FLUKA)
- Calculate response from counts rates caused by flux Xe ion beam in H8 (Beam not only Xe ions, but also other particles in the beam itself, secondaries from vacuum lids, …)



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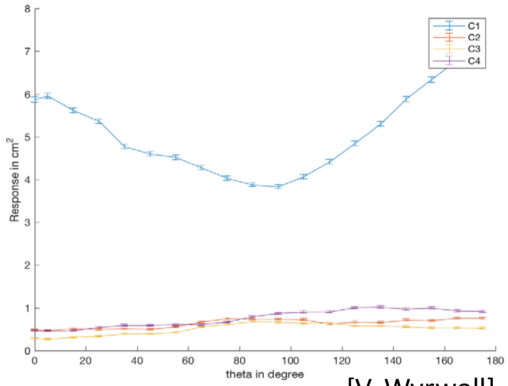

[V. Wyrwoll]

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