Università degli Studi della Campania *Luigi Vanvitelli*

UNIVERSITÀ DEGLI STUDI DELLA CAMPANIA
LUIGI VANVITELLI
SCUOLA POLITECNICA E DELLE SCIENZE DI BASE
DIPARTIMENTO DI MATEMATICA E FISICA

INFN

"A proton irradiation facility for radiobiological studies at CIRCE laboratory"

Neptune Kick-off meeting

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14 December 2018 - Catania

CIRCE
Center for Isotopic Research on Cultural and Environmental heritage

Director : Prof. Lucio Gialanella - Viale Carlo III di Borbone, 153, 81020 San Nicola La Strada CE - http://www.circe.unicampania.it/

CIRCE
Center for Isotopic Research on Cultural and Environmental heritage

- Tandem Accelerator Laboratory
- IRMS & ICP - MS
- ^{14}C sample preparation Laboratory
- Chemical preparation Laboratory
- Environmental radioprotection
- Laser spectroscopy

TAL - Tandem Accelerator Laboratory

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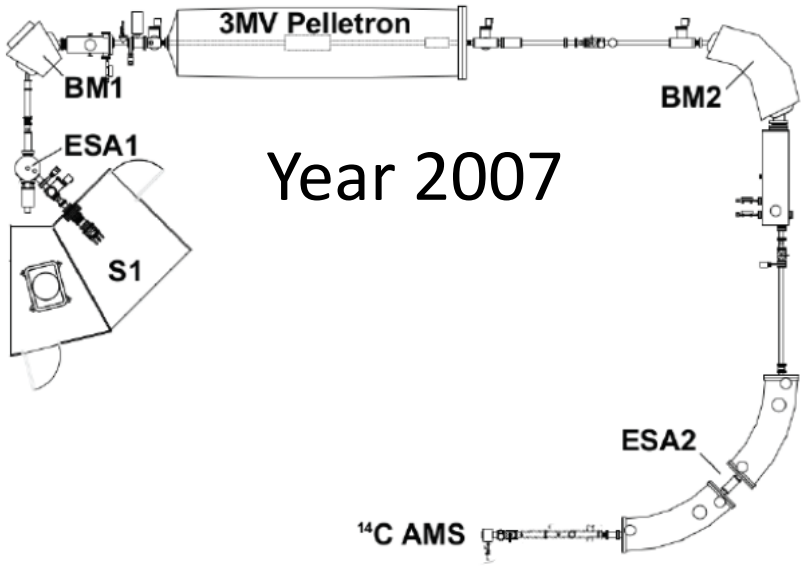
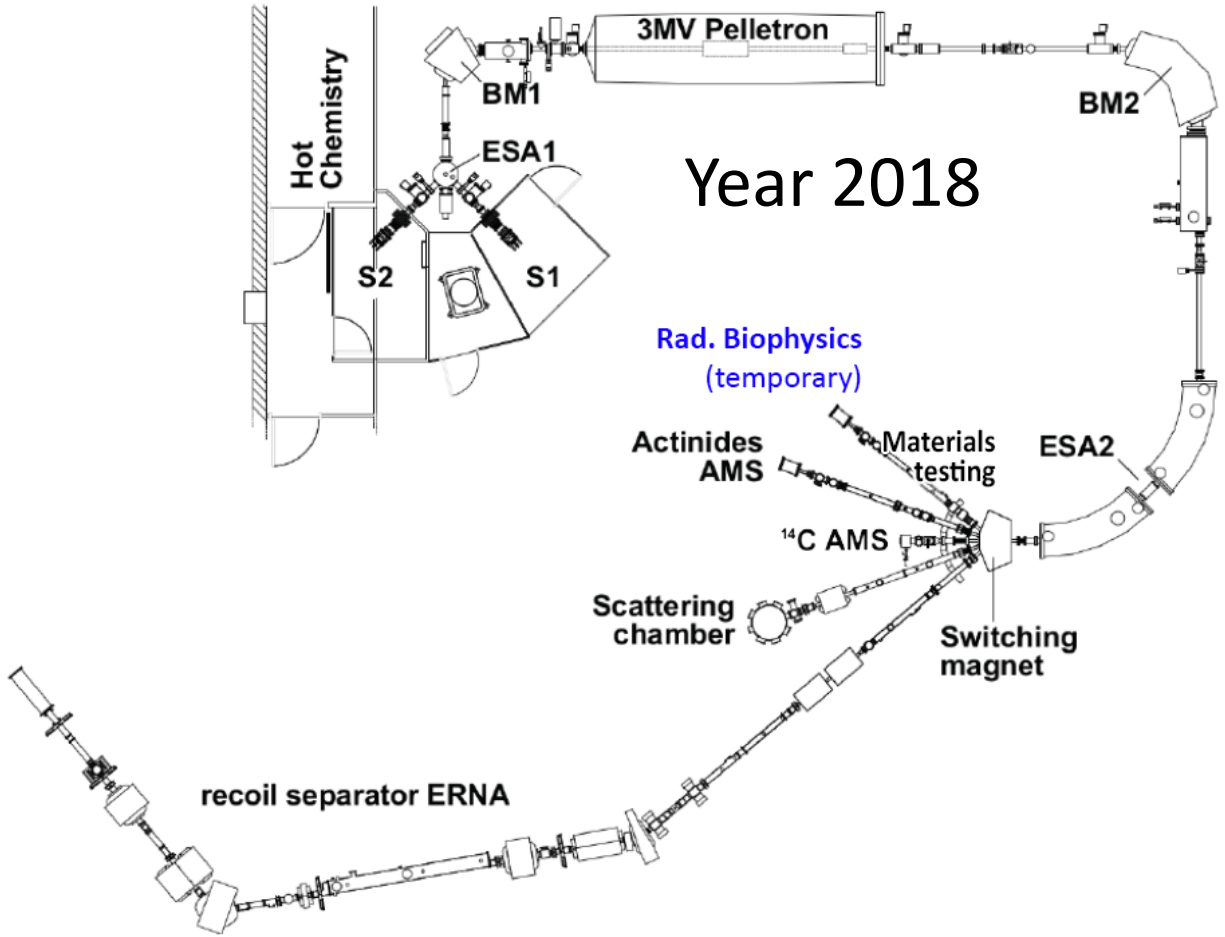


Ongoing research programs:

- ^{14}C AMS

TAL - Tandem Accelerator Laboratory



Ongoing research programs:

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- Nuclear Astrophysics
- Actinides AMS
- Material Science
- ^{7}Be Implantation
- Radiation Biophysics

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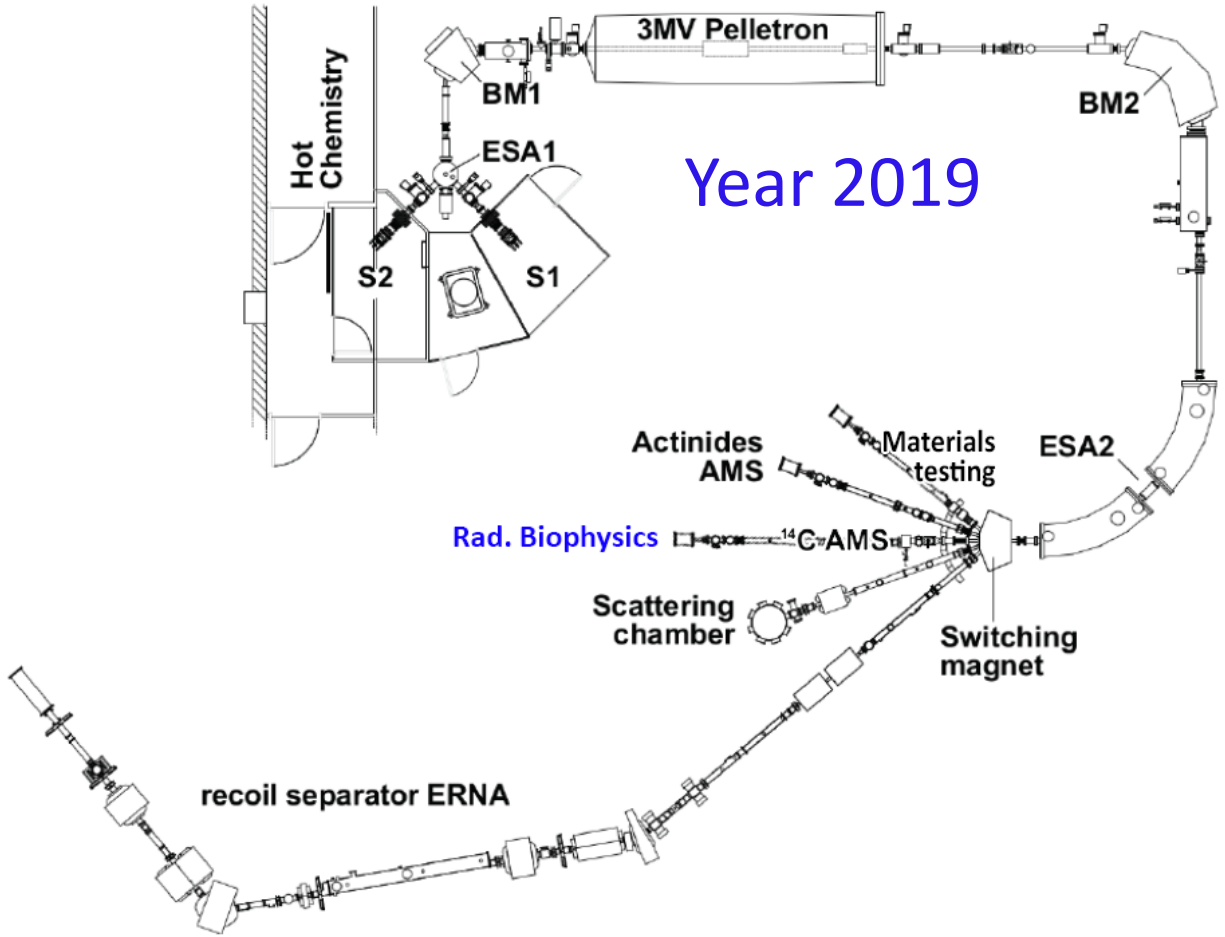

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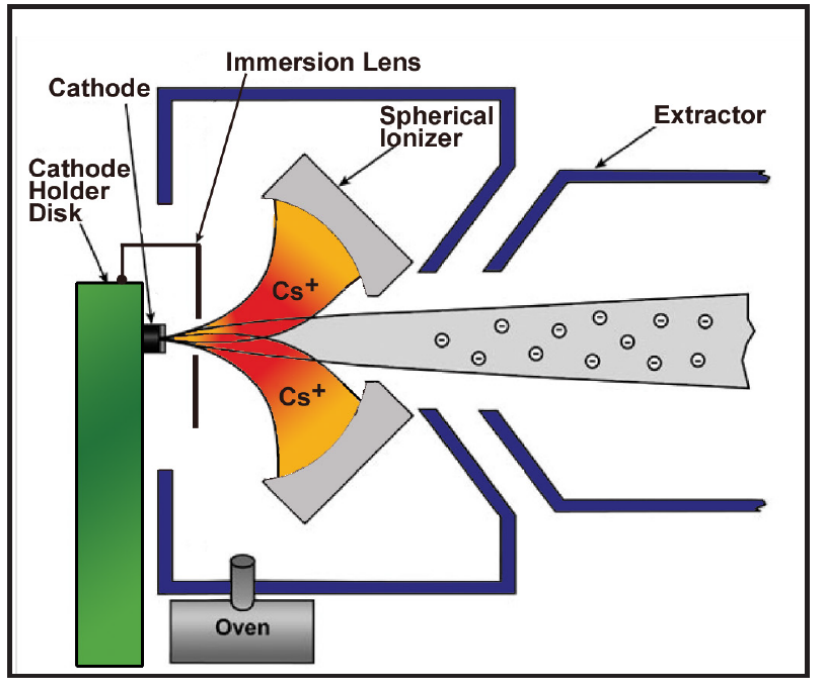
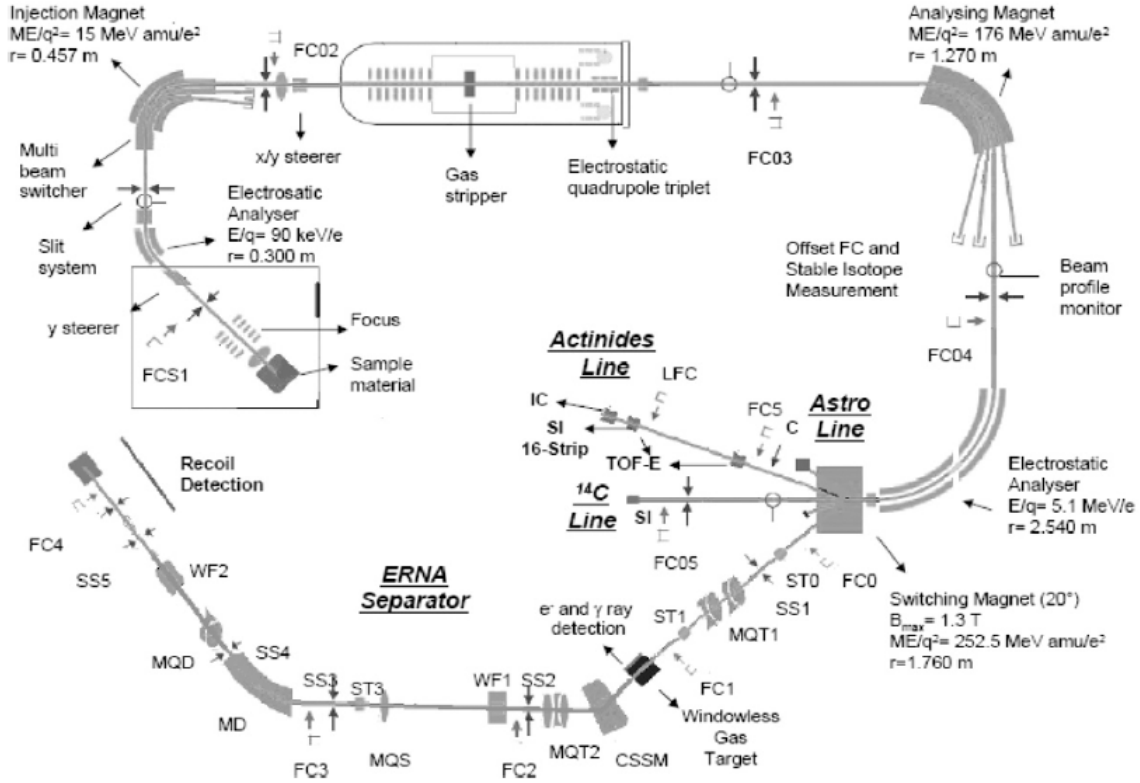
TAL - Tandem Accelerator Laboratory

ION SOURCE:

- MC-SNICS : Multi Cathode Source of Negative Ions by Cesium Sputtering
- H_2Ti cathod for proton beam





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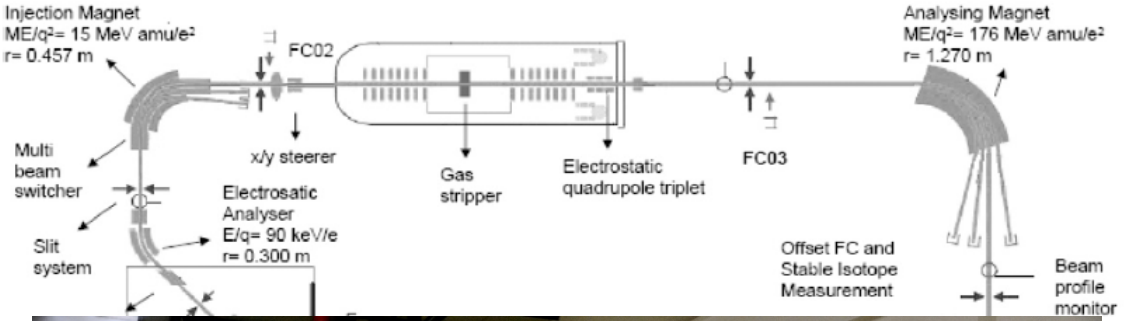
TANDEM ACCELERATOR

- NEC 9SDH-2 Pelletron Accelerator

$$V_{t\,max} = 3MV \quad \text{Typical ripple < 1 kV ptp}$$

- GVM feedback stabilizer -> Corona (2019)
- Ar stripper (P = 1.3 x 10^{-2} mbar)



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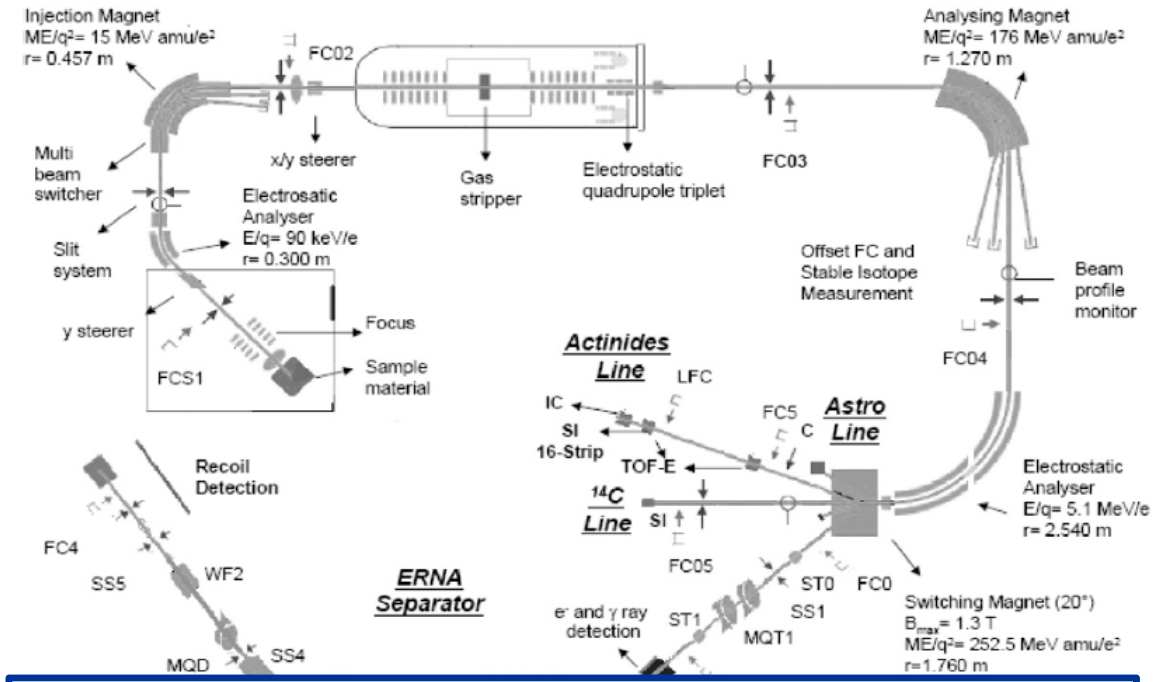

PROTON BEAM

- $\mathrm{E} = eV_t(q+1)$ $\quad E_{max} = 6\ MeV$ for protons
- $I_{range} = [1\ pA\ -10\ nA]$

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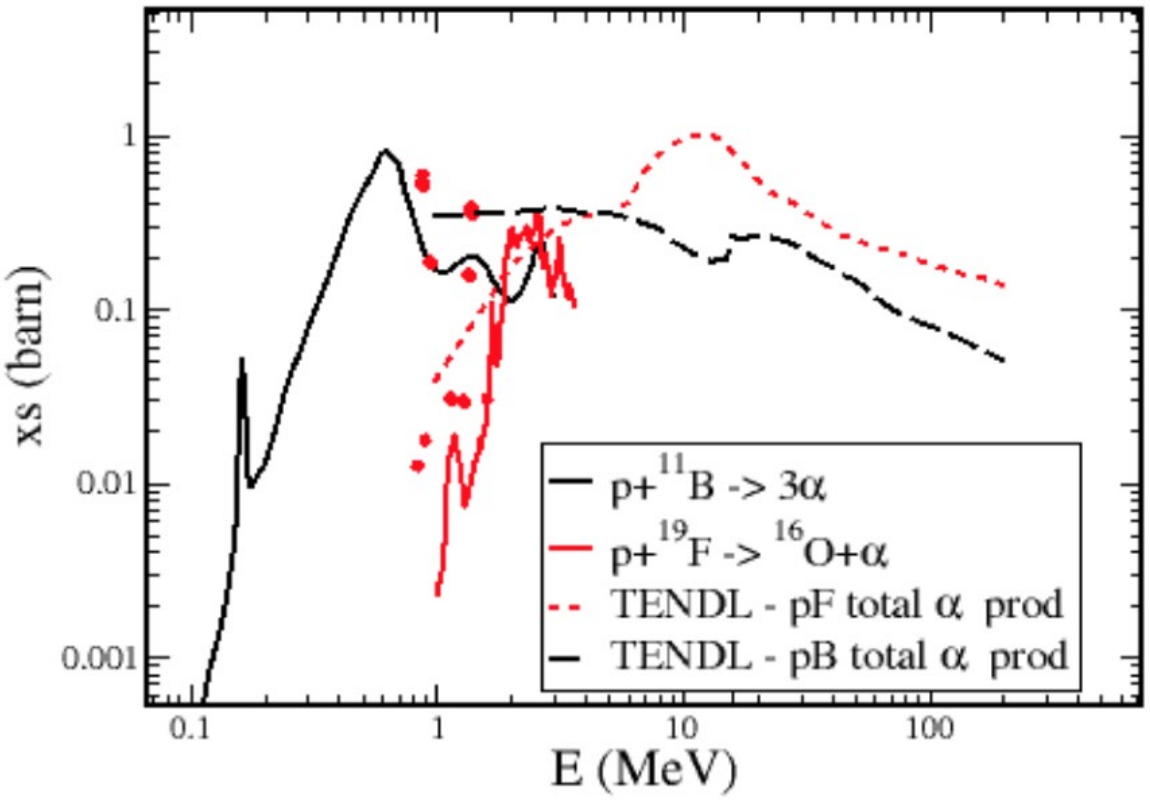

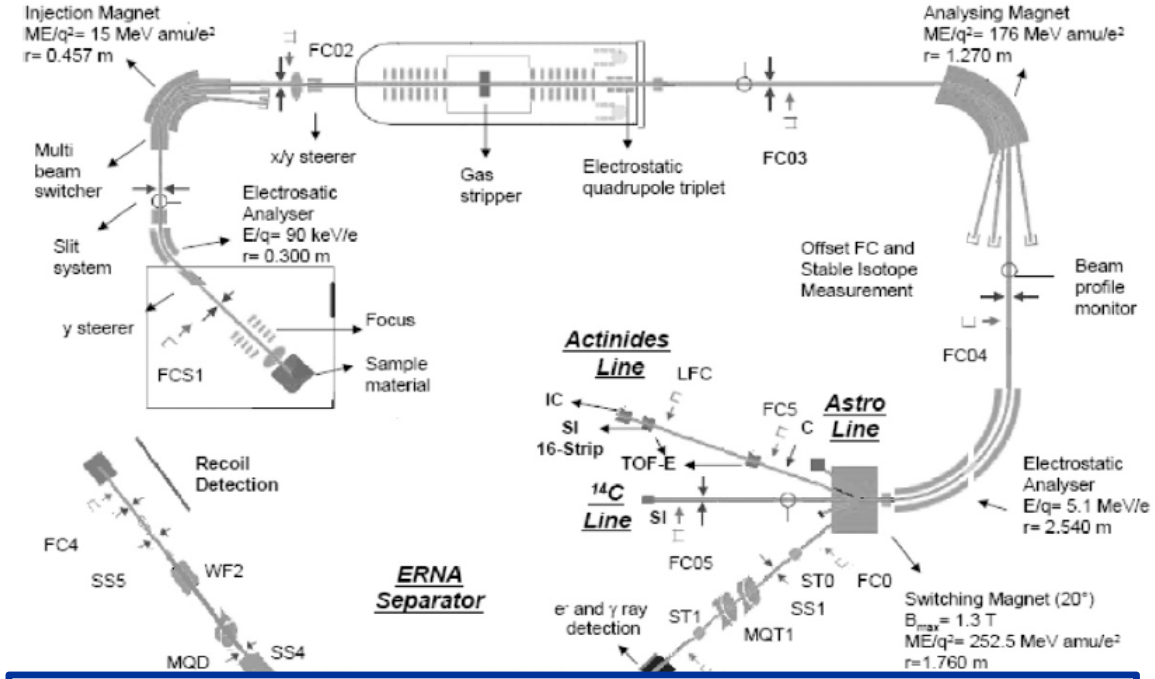

PROTON BEAM

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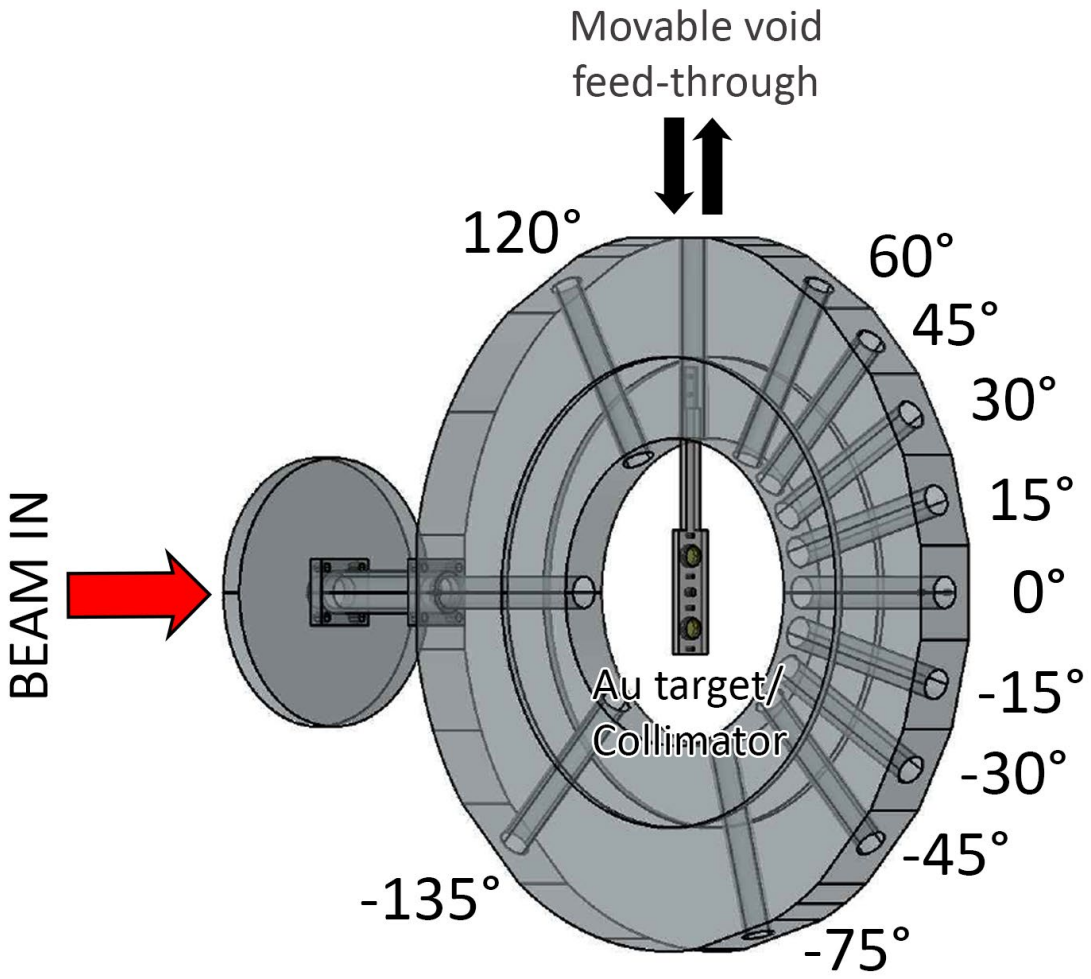
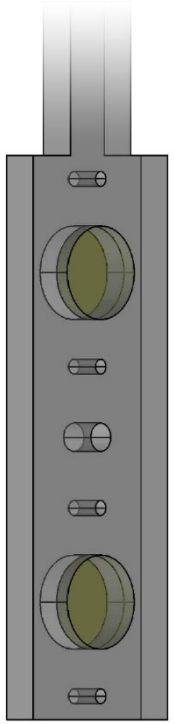
Radiation Biophysics BeamLine - Scattering chamber





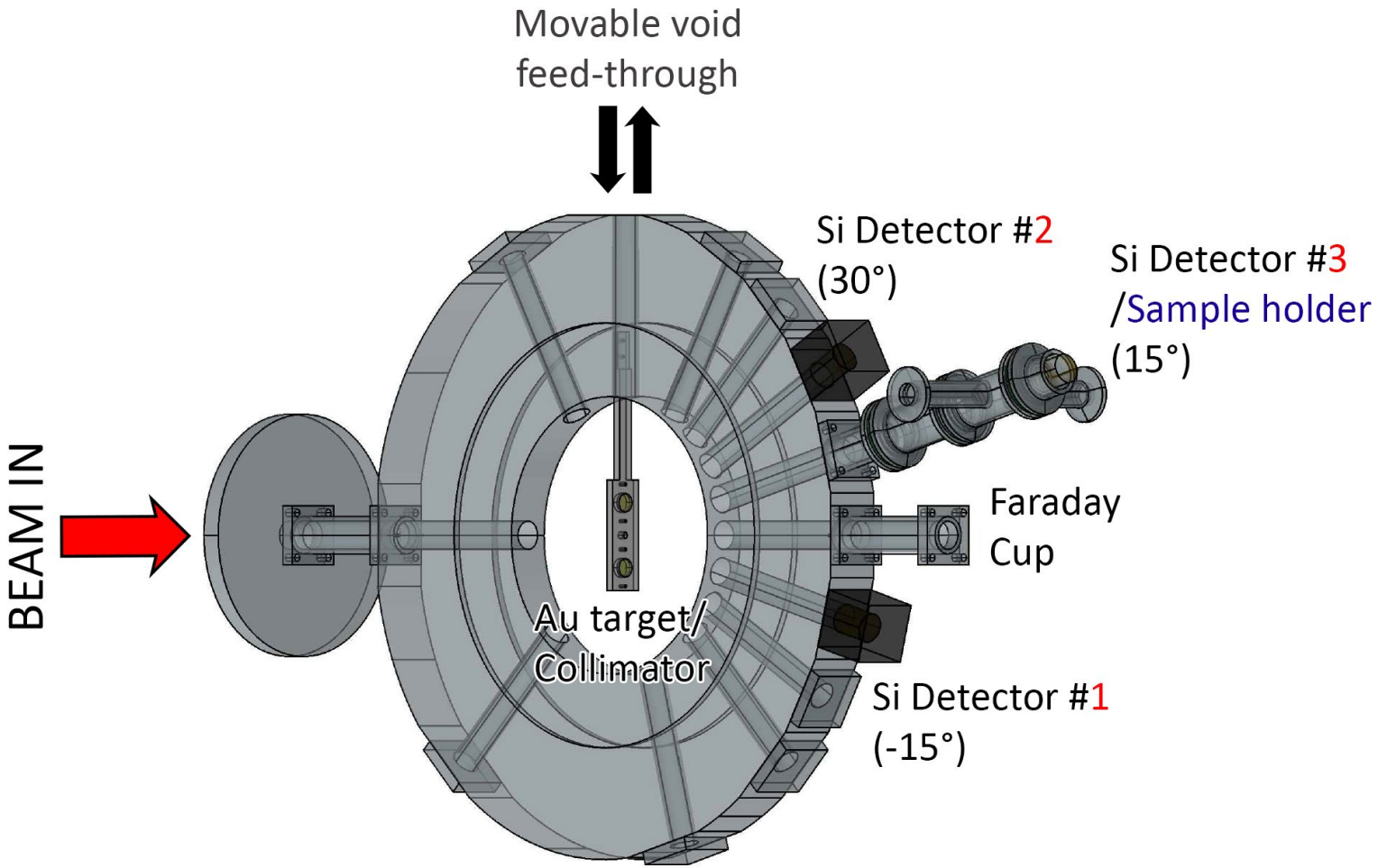
TARGET HOLDER

Collimator
Diameter = 3.0 mm

2x Au Target
Diameter = 10.0 mm
Thickness = 1 µm

Connected to a current digitizer for beam focusing and control

Radiation Biophysics BeamLine - Scattering chamber



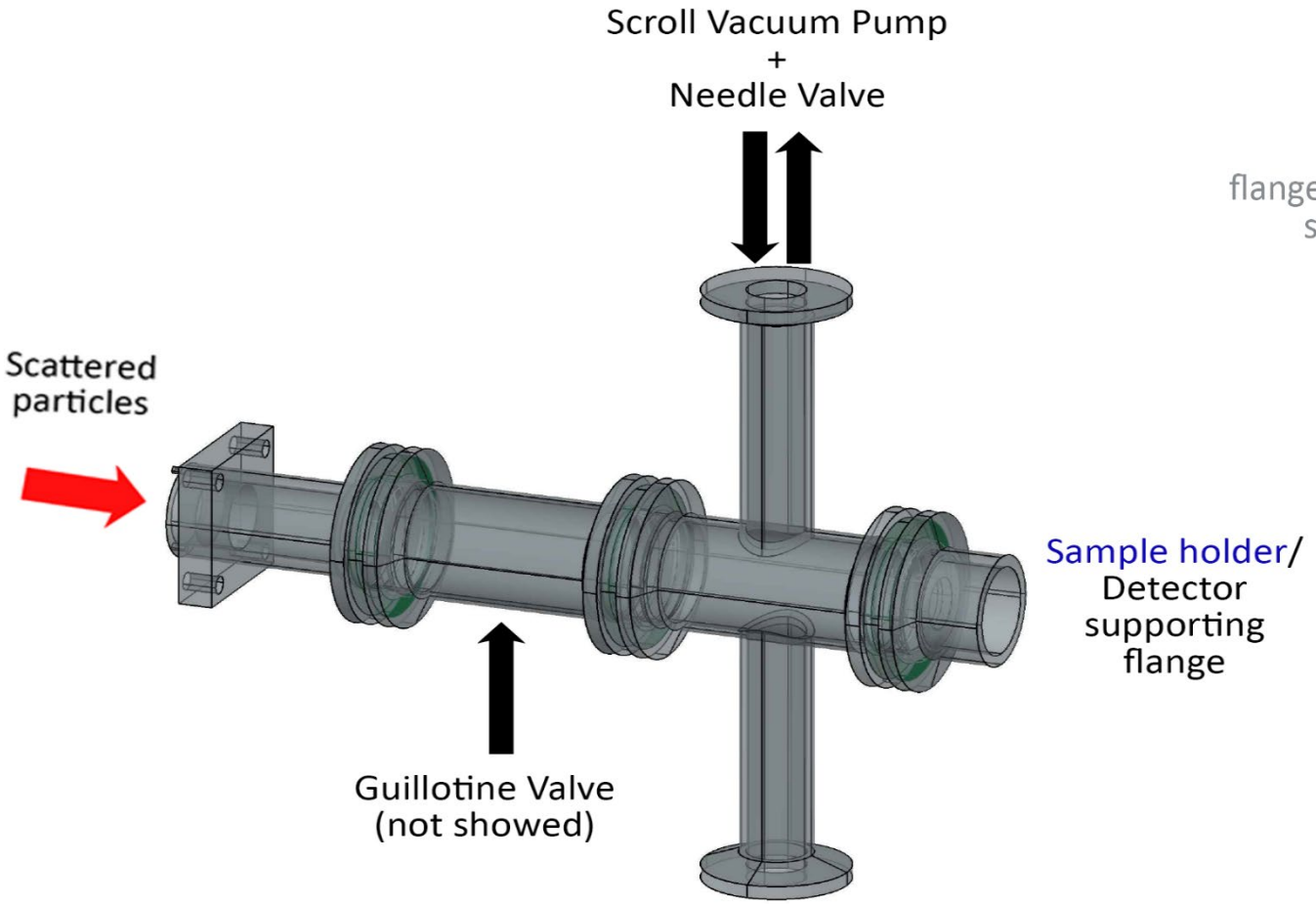
DETECTOR POSITIONS

Si #1
θ = -15° ; dist = 173,5 ± 0,1 mm

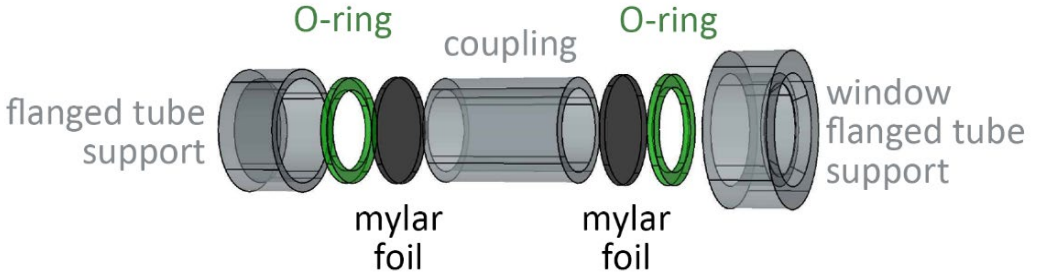
Si #2
θ = 30° ; dist = 173,5 ± 0,1 mm

Si #3 - Cell Sample position
θ = 15° ; dist = 329,4 ± 0,1 mm

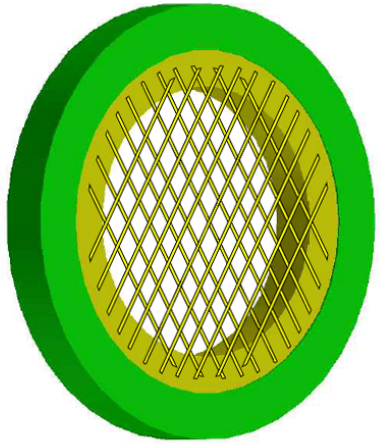
Radiation Biophysics BeamLine - Scattering chamber



SAMPLE HOLDER



O-ring



W-Re GRID

Wire thickness = 0,02 mm
OPACITY = 4.0 ± 0.8 %

Radiation Biophysics BeamLine – Beam monitoring / Dosimetry

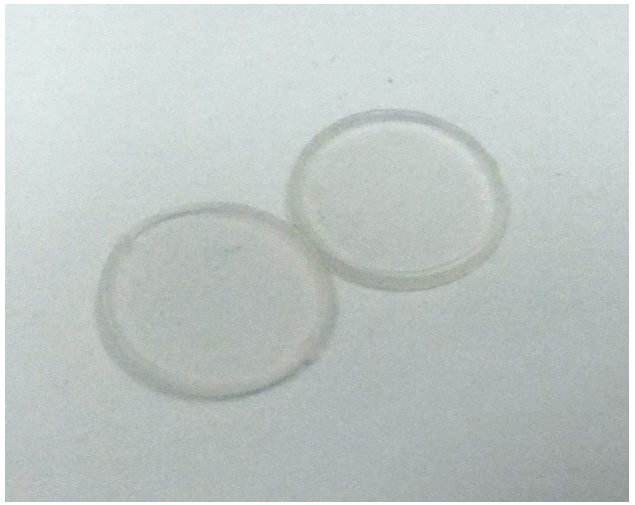
Silicon detectors

Thickness = 300 µm

A = 154 mm^2

Resolution ≈ 25 keV

CR39 Solid State Track Detectors



Plastic polimer ($C_{12}H_{18}O_7$)
A = 100 mm^2
Beam fluence and uniformity measurements

Charged particle leave a track visible after etching process

$$D\ [Gy] = 1.6\ \times 10^{-9} \cdot LET\ \left[\frac{keV}{\mu m}\right] \cdot Fluence\ [cm^{-2}]$$

LET values are derived from software SRIM

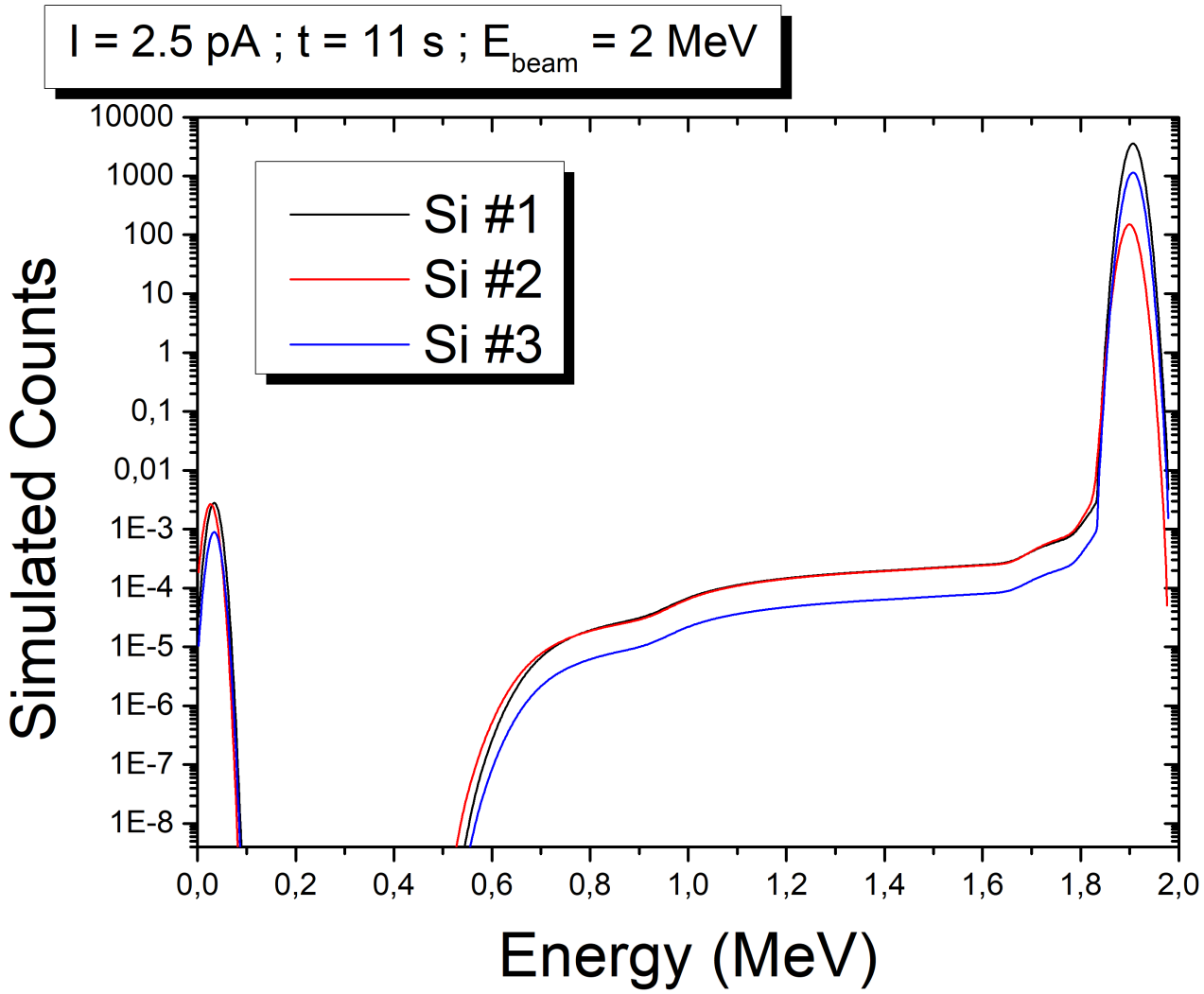
Simulations and Preliminary results

#Si	θ (°)	σ_{diff} (barn)	ε_g	E_{peak} (MeV)	Counts
1	-15	$6{,}98 \cdot 10^3$	$(7.3 \pm 0.9) \cdot 10^{-4}$	1,906	62704,9 ± 0,9
2	30	$4{,}52 \cdot 10^2$	$(4.9 \pm 0.6) \cdot 10^{-4}$	1,899	2807,6 ± 0,3
3 (Cellule)	15	$6{,}98 \cdot 10^3$	$(2.3 \pm 0.3) \cdot 10^{-4}$	1,906	20204,93 ± 0,12

ε_g = Calculated with $^{239}Pu/^{241}Am$ α source

From simulations

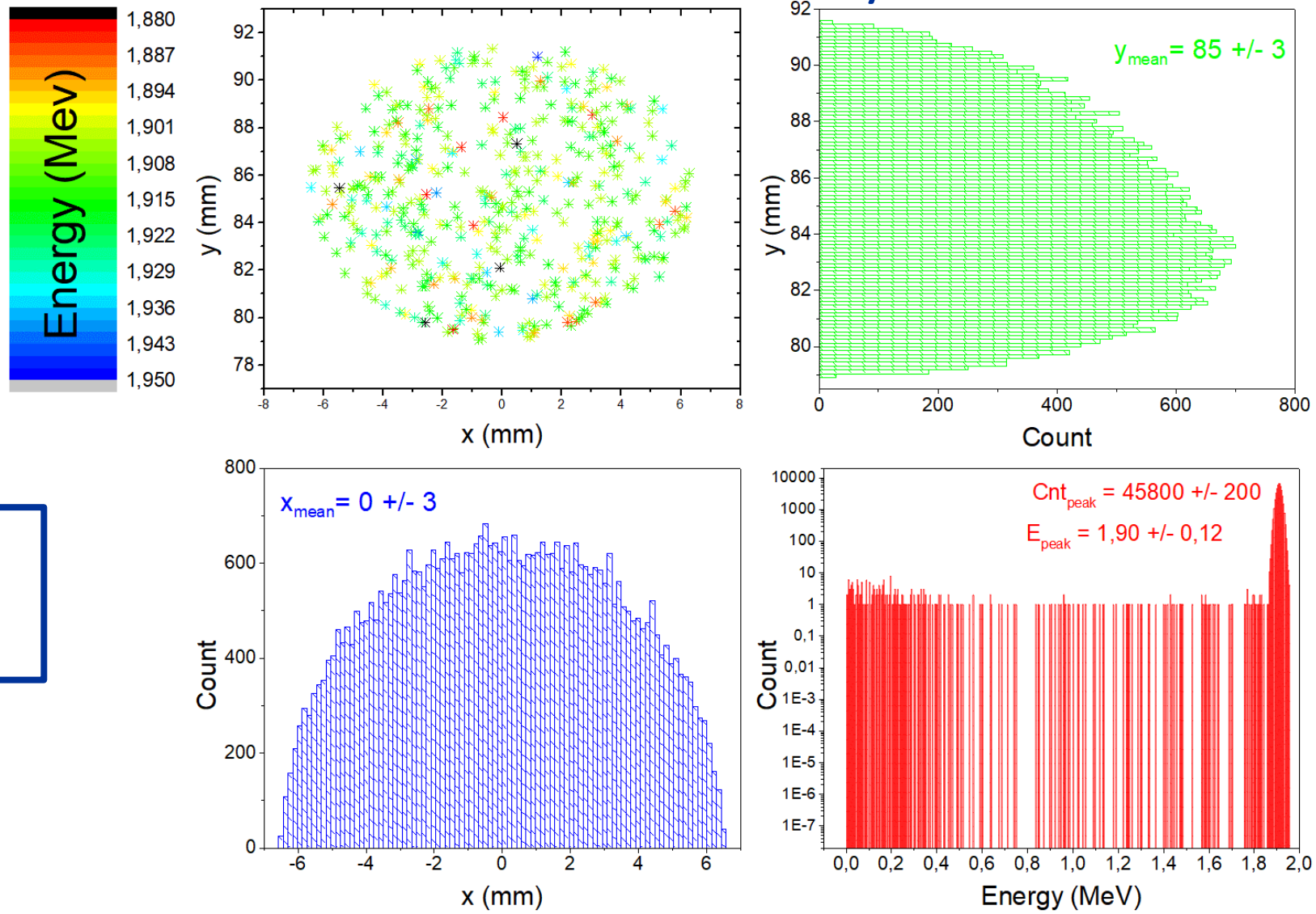
$$\frac{Counts_{Si\#3}}{Counts_{Si\#1}} = 0{,}3222 \pm 0{,}0002$$



SIM-NRA simulation

Simulations and Preliminary results

Geant4 simulation
N = 10^9 *protons*
$E_{beam} = 2\ MeV$



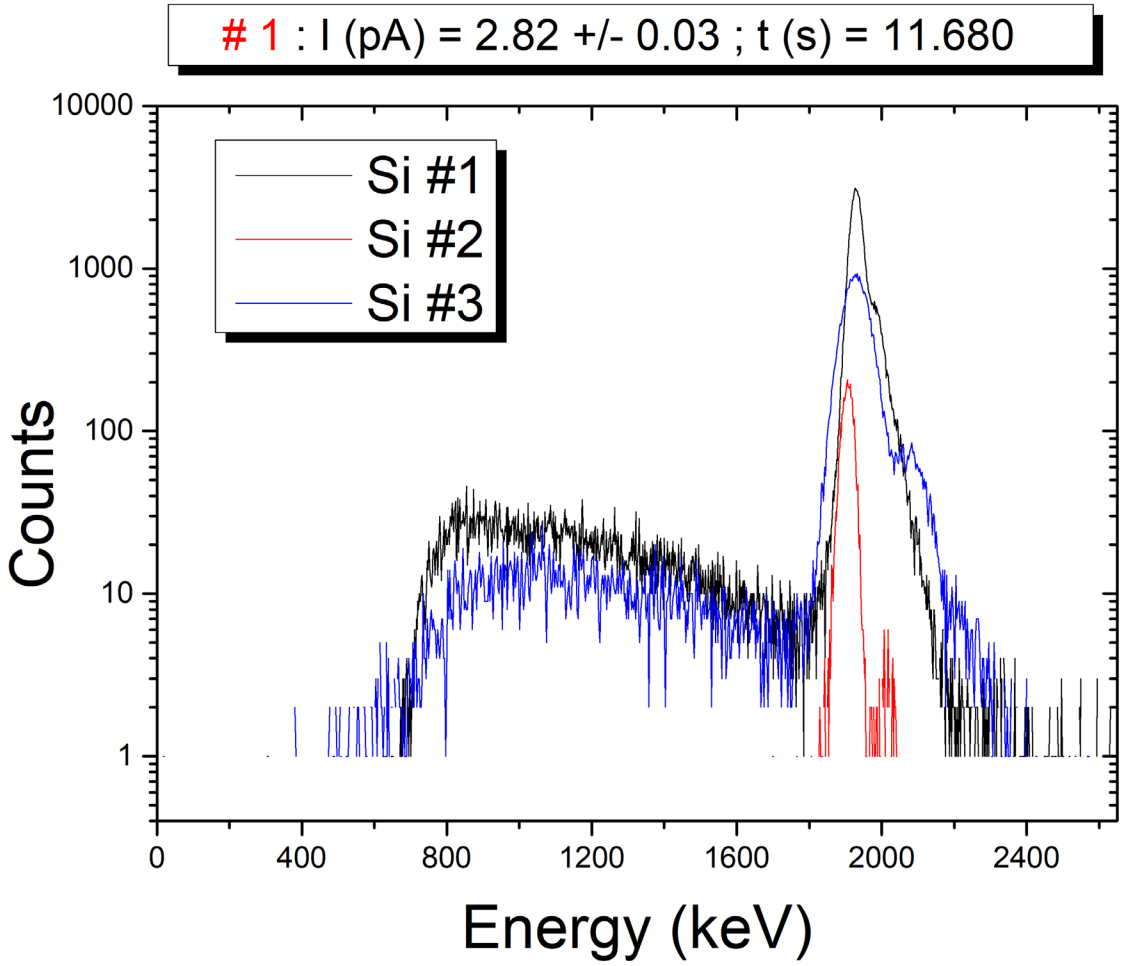
Simulations and Preliminary results

I (pA)	3,4 ± 0,4				
#Si	Dist. (mm)	θ (°)	Live Time (s)	E_{peak} (keV)	C_{Total}
1	173.4	-15°	10,7 ± 0,3	1901 ± 3	$(9.9 \pm 1.1)\cdot10^4$
2	173.4	30°	11,4 ± 0,3	1896,2 ± 1,3	$(4.2 \pm 0.6)\cdot10^3$
3 (Cellule)	329.4	15°	11,1 ± 0,4	1902 ± 3	$(3.8 \pm 0.5)\cdot10^4$

#Si	C_{peak}	C_{tail}	Ratio C_{tail}/C_{peak}
1	$(8.9 \pm 1,1)\cdot10^4$	$(1,02 \pm 0,13)\cdot10^3$	0,11 ± 0,02
2	$(4.2 \pm 0,6)\cdot10^3$	-	-
3 (Cellule)	$(3,4 \pm 0,5)\cdot10^3$	$(3,9 \pm 0,5)\cdot10^3$	0,11 ± 0,02

$$Mean\ \frac{Counts_{Si\#3}}{Counts_{Si\#1}} = 0,31 \pm 0,02$$

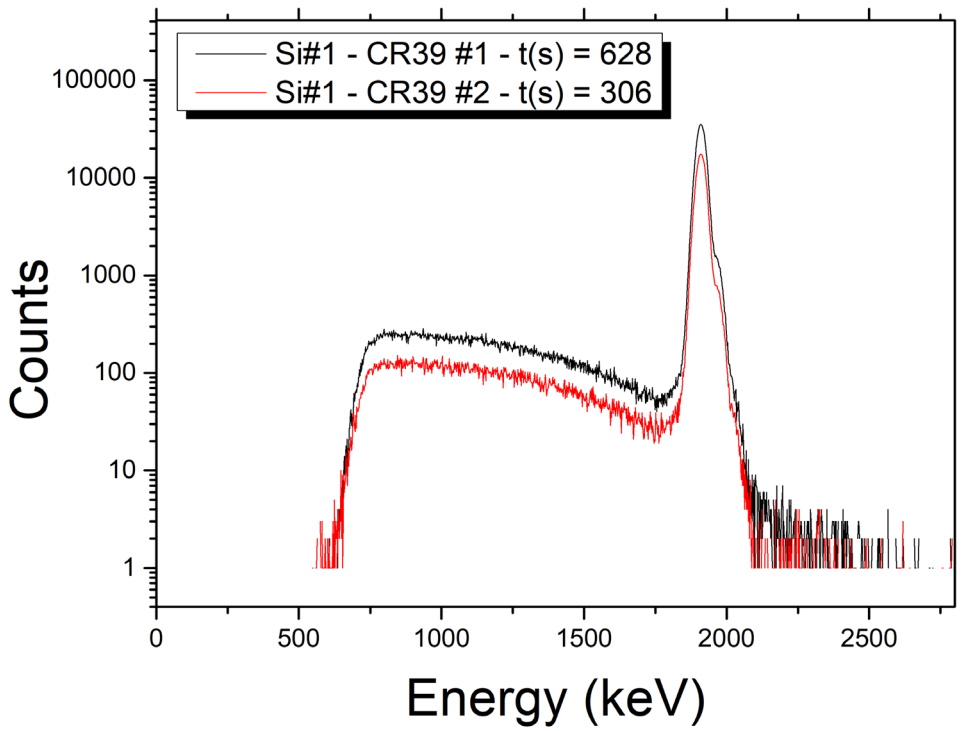
Calibration with $^{239}Pu/^{241}Am$ α source



Simulations and Preliminary results

#CR39	#Si 1 C_{peak}	CR39 expected C_{peak}	#Si 1 C_{tail}	CR39 expected C_{tail}	CR39 expected C_{total}
1	$(7781 \pm 9)\cdot 10^2$	$(2399 \pm 8)\cdot 10^2$	$(943 \pm 3)\cdot 10^2$	$(281 \pm 2)\cdot 10^2$	$(2680 \pm 7)\cdot 10^2$
2	$(3904 \pm 6)\cdot 10^2$	$(1206 \pm 4)\cdot 10^2$	$(475 \pm 2)\cdot 10^2$	$(141{,}7 \pm 1{,}3)\cdot 10^2$	$(1345 \pm 4)\cdot 10^2$

Calibration with $^{239}Pu/^{241}Am$ α source



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Simulations and Preliminary results

#CR39	#Si 1 C_{peak}	CR39 expected C_{peak}	#Si 1 C_{tail}	CR39 expected C_{tail}	CR39 expected C_{total}
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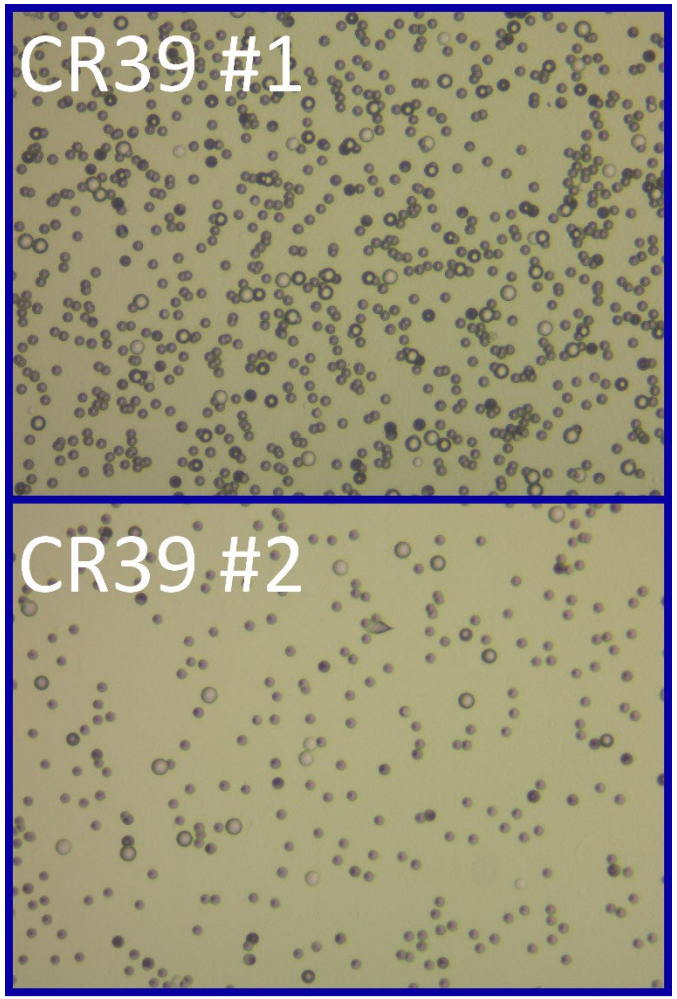
#CR39	C_{peak}	expected C_{peak}	C_{tail}	expected C_{tail}
1	$(23 \pm 4)\cdot 10^4$	$(2399 \pm 8)\cdot 10^2$	$(4{,}4 \pm 1{,}2)\cdot 10^4$ *	$(281 \pm 2)\cdot 10^2$
2	$(10{,}1 \pm 1{,}5)\cdot 10^4$	$(1206 \pm 4)\cdot 10^2$	$(1{,}6 \pm 0{,}5)\cdot 10^4$	$(141{,}7 \pm 1{,}3)\cdot 10^2$
#CR39	C_{total}	expected C_{total}	C_{tail}/C_{peak}	expected C_{tail}/C_{peak}
1	$(27 \pm 4)\cdot 10^4$	$(2680 \pm 7)\cdot 10^2$	$0{,}20 \pm 0{,}06$	$0{,}1050 \pm 0{,}0010$
2	$(11{,}7 \pm 1{,}6)\cdot 10^4$	$(1345 \pm 4)\cdot 10^2$	$0{,}16 \pm 0{,}06$	$0{,}1053 \pm 0{,}0010$

$$Mean\ \frac{Counts_{Si\#3}}{Counts_{Si\#1}} = 0{,}31 \pm 0{,}02$$



20X magnification

Next steps

- Collimator system on scattering chamber channels and mylar thickness simulation for beam degradation (January 2019);

- Simulation and calculation of beam transport for the new beamline (0°) with COSY Infinity software (already in progress)

  - Magnetic quadrupole doublet for beam focusing and shaping before scattering chamber;

- Cells sample irradiation (Spring 2019)

Thanks for your attention