The SREFT (Spatially REsolving Fission Tracker) Time Projection Chamber

US National Nuclear Data Week 2019

Esther Leal Cidoncha, Christopher Prokop,
Kyle Schmitt and Shea Mosby

4-8 November 2019

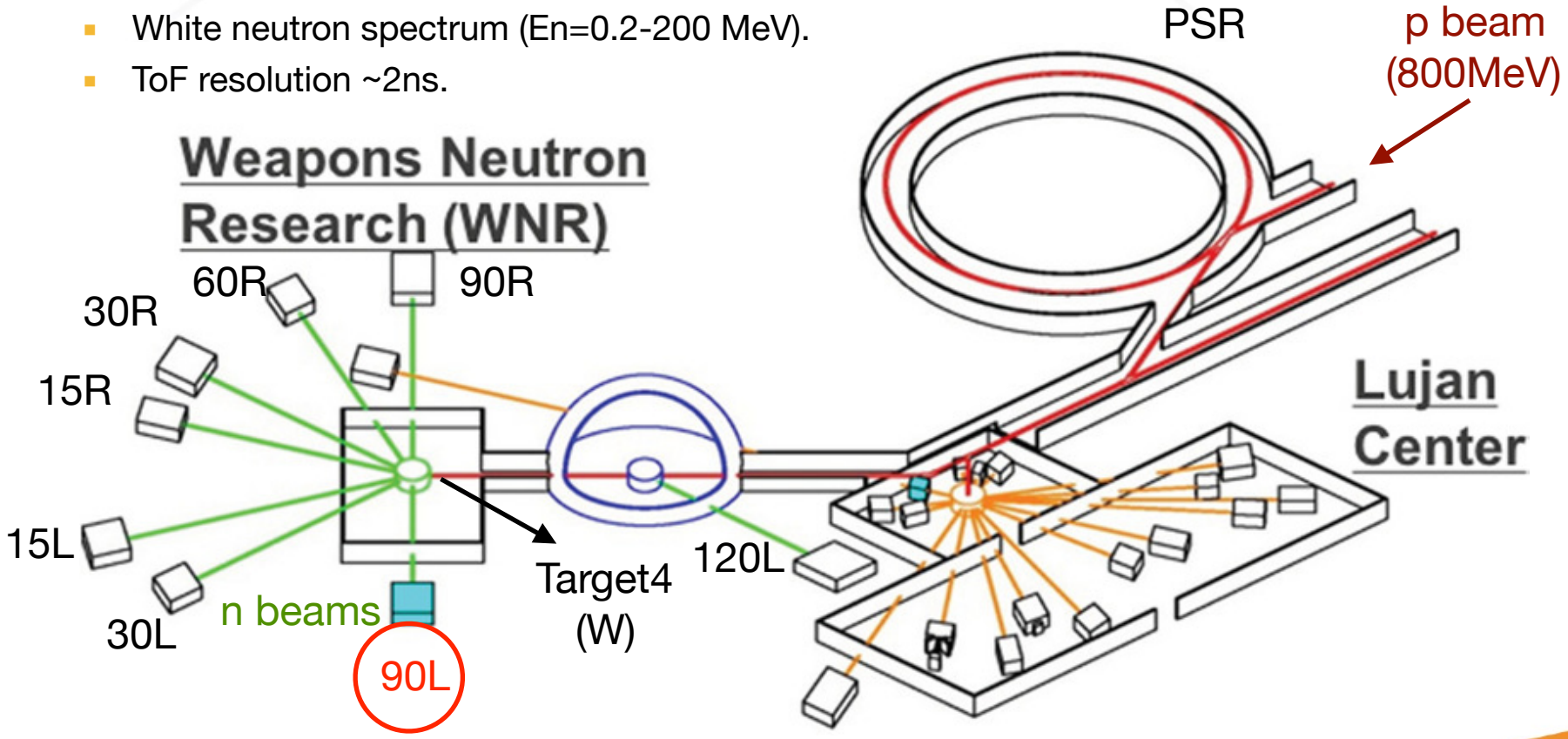
UNCLASSIFIED

Motivation

- New fission tracking detector at LANSCE.
- To measure …
  - Neutron beam imaging and flux monitoring.
  - Fission Fragments Total Kinetic Energy measurements (TKE) for hot samples and Fission Product Yields (FPY).
  - Minor actinide fission Cross Section ratios.
  - Fission Fragment Angular Distributions (FFAD) and anisotropies.
  - (n,α) and (n,xα) reactions.
- Low cost and relatively easy construction.
- Small size for supporting measurements inside another detector.

LANSCE facility

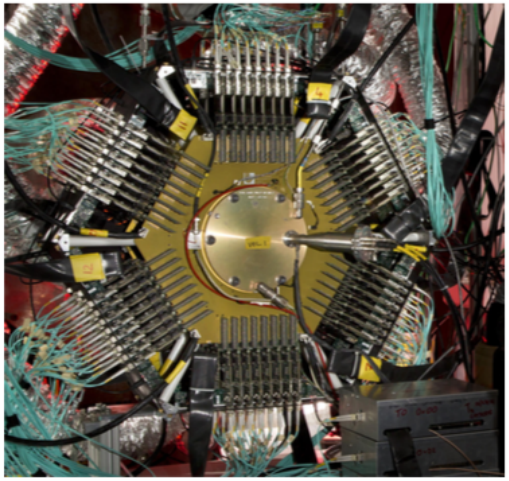
- Water-cooled W target.
- Flight path 90L (10 m).
- White neutron spectrum (En=0.2-200 MeV).
- ToF resolution ~2ns.



Fission tracking detectors at LANSCE

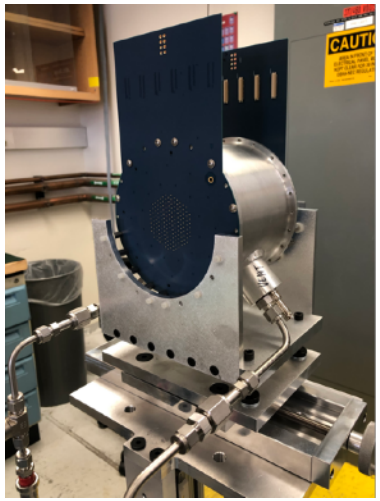
TPC*
(Time Projection Chamber)

- Very precise fission cross section ratios (unc. < 1%).
- ~3000 pads per anode = high number of channels needed.
- High power supply and cooling requirements.
- Custom DAQ system.



SREFT
(Spatially Resolving Fission Tracker)

- Minor actinide fission cross section ratios (unc. > 1%).
- 187 pads per anode => less channels needed.
- Limited cooling required and low power supply.
- Commercial DAQ system.

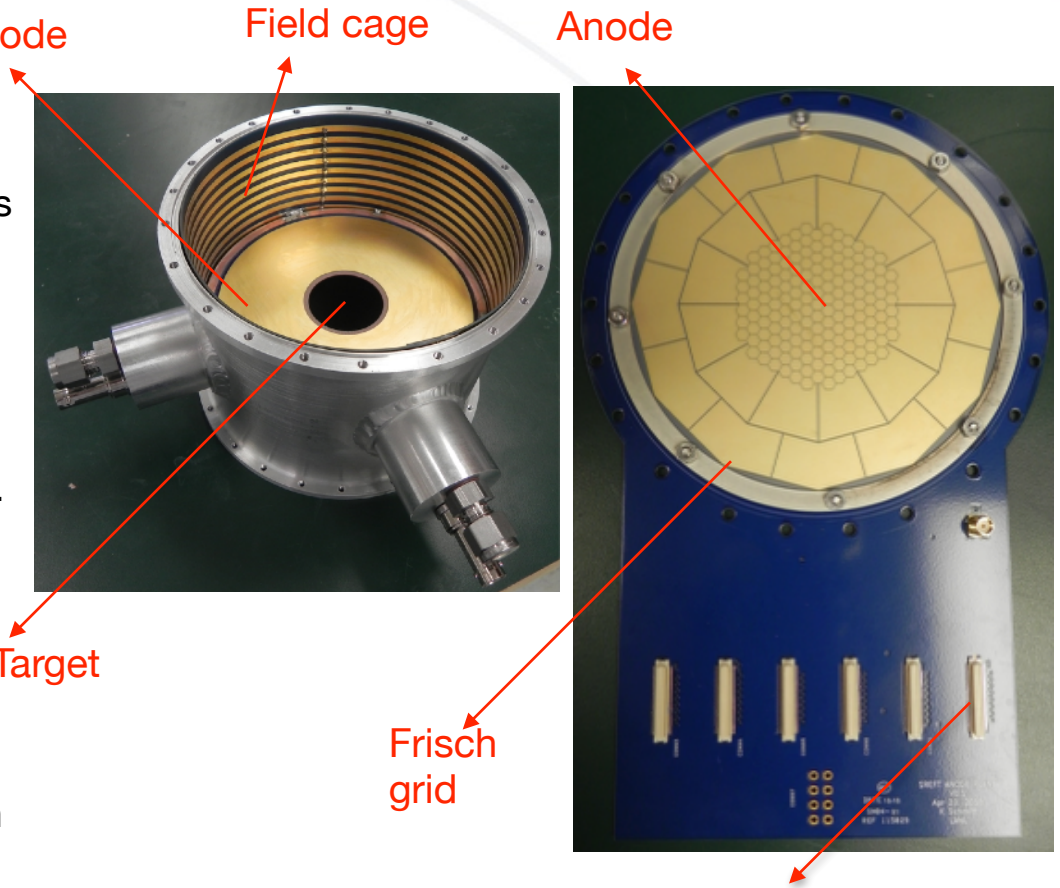


- Digitizers out of the beam

* NIFFTE Collaboration

SREFT setup

- Gas-filled with P-10 (10% Ar, 90% CH_4) at 1 atm.
- Measurements with two samples at both sides of the cathode plane -> cross section ratios.
  - Thick Al backing (0.25 mm) => only one FF measured from each target reaction.
- Measurements with one sample.
  - Thin C backing (0.5 μm) => the two FF are measured.
- A Frisch grid is placed in the anode.
- 187 pads per anode:
  - Center hexagonal pads with lower size for a better resolution.
  - Peripheral pads ~trapezoid with larger size.



SREFT goals

- Thin-walled chamber to allow good auxiliary detector efficiency for outgoing neutrons and gamma rays.
- E resolution ~1 MeV for FF.
- Angular resolution ~3°, vertex resolution ~1 mm.
- Target imaging makes it possible mounting a ^{252}Cf source close to the sample for in-situ energy calibration.
- Good alpha particle rejection.

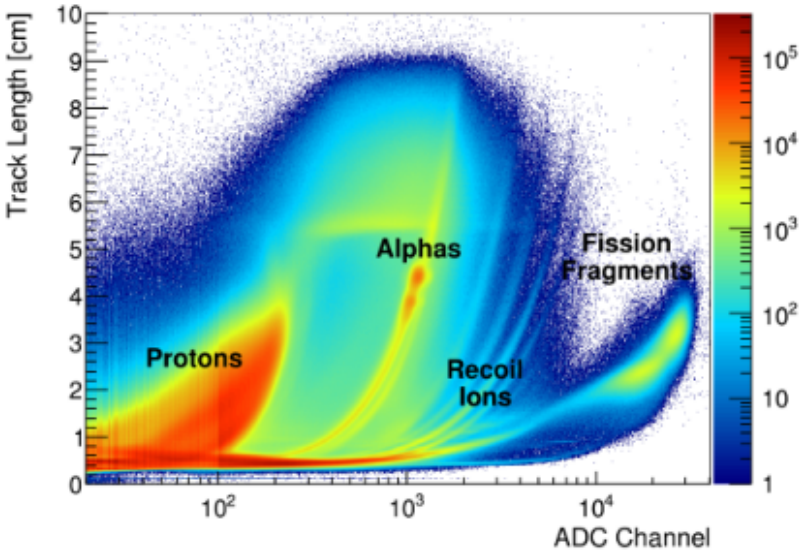
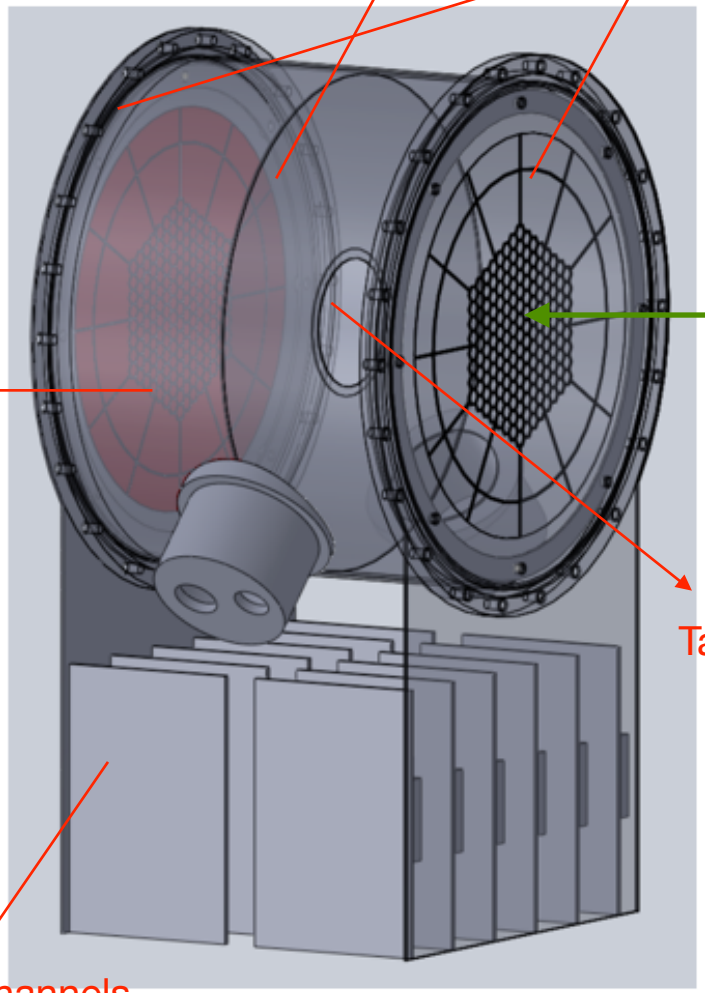
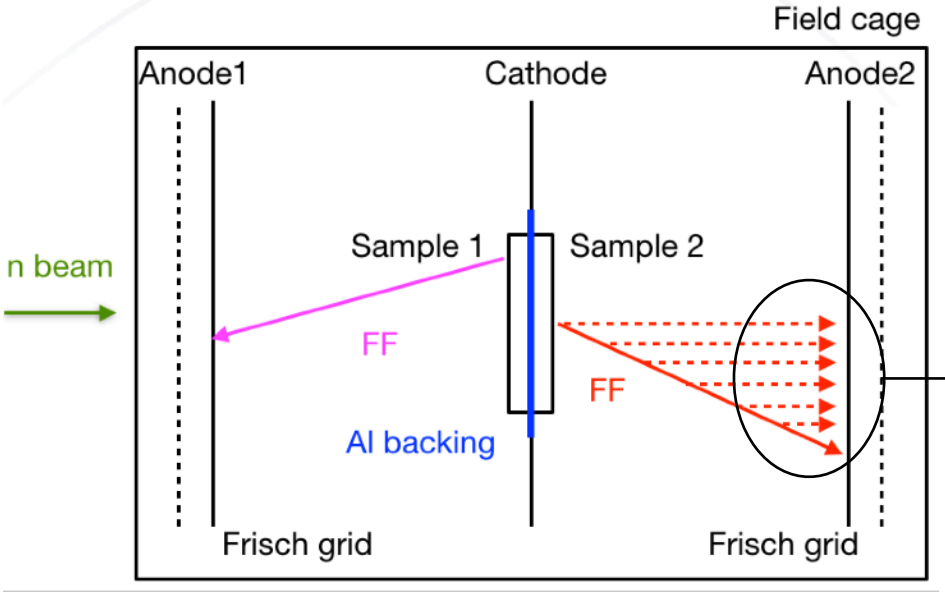
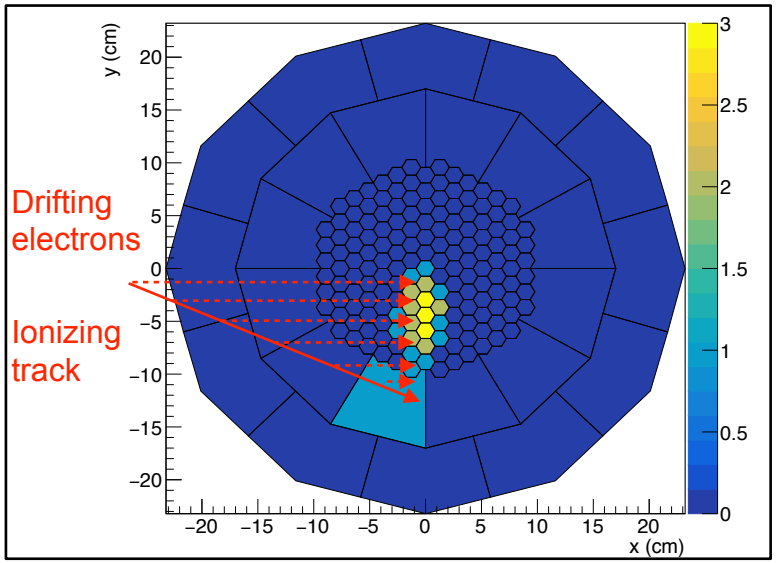


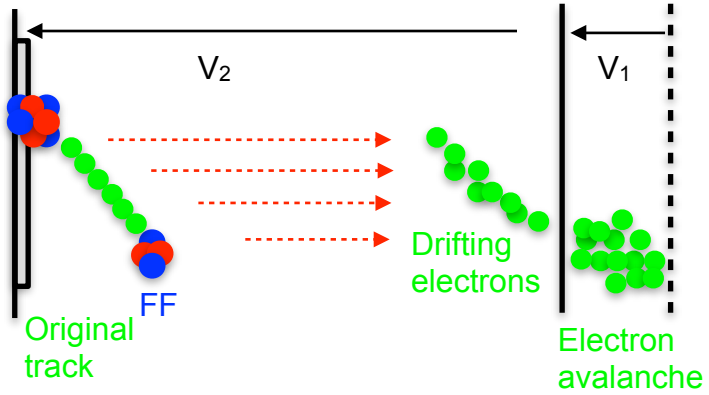
Fig. from NIFFTE Collaboration (TPC data)



SREFT functioning principle







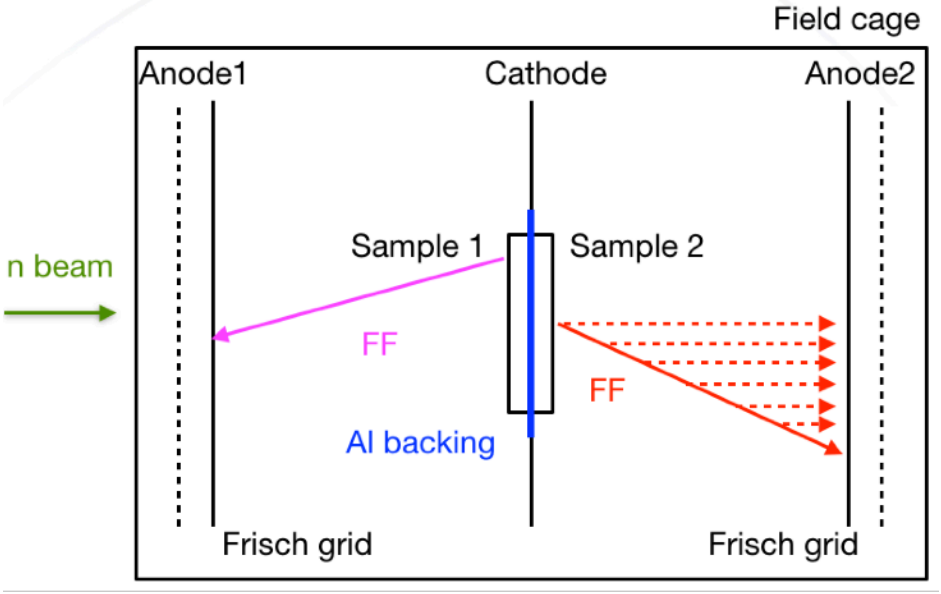
Distance cathode/anode = 5.4 cm

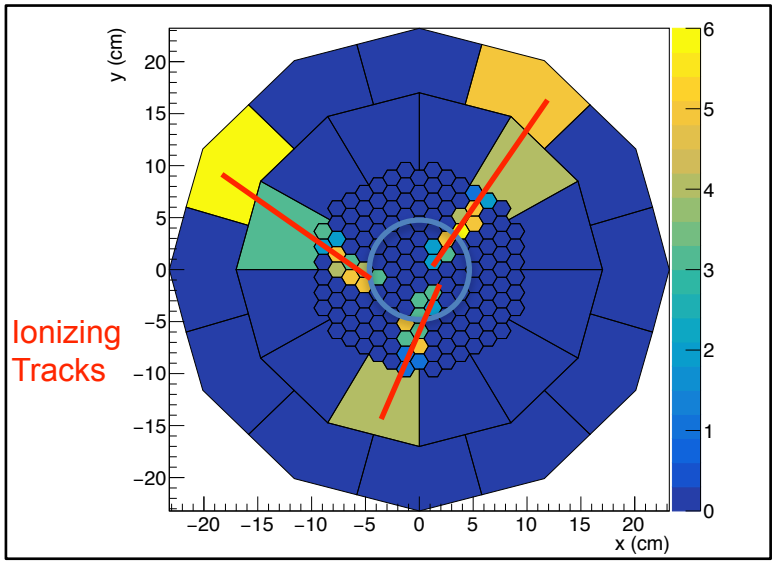
Distance frisch grid/anode = 2 mm

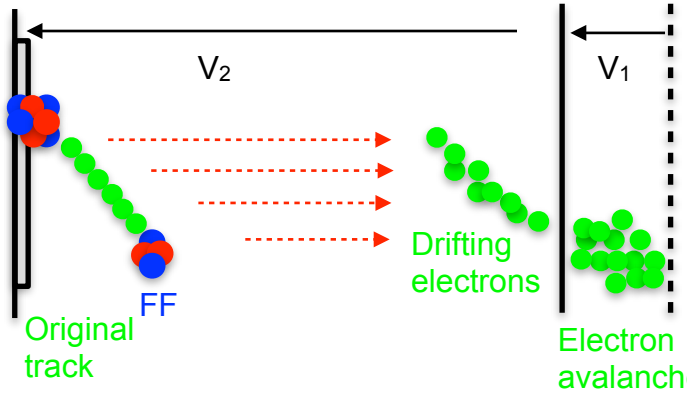
Chamber diameter = 13.7 cm

V_1 = 1 kV/cm; V_2 = 500 V/cm

SREFT functioning principle







Distance cathode/anode = 5.4 cm

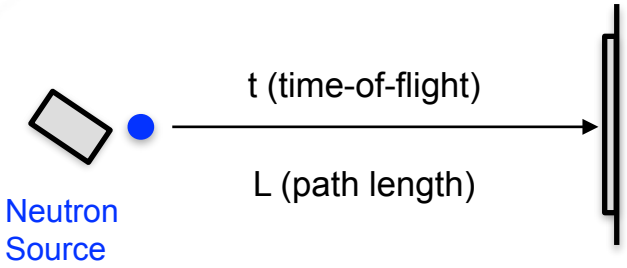
Distance frisch grid/anode = 2 mm

Chamber diameter = 13.7 cm

V_1 = 1 kV/cm; V_2 = 500 V/cm

Possible calculations

- Good particle identification (PID) from track reconstruction.
- **Cross section ratio** calculation vs incident neutron energy through the time-of-flight technique.



- Relativistic eq.:

$$E_n = m \cdot c^2 \cdot (\gamma - 1)$$

$$\gamma = (1 - v^2/c^2)^{-1/2}$$

- Non-relativistic eq. (En < few MeV):

$$E_n = \frac{L^2}{t^2} \cdot \alpha^2$$

$$72.29(eV^{1/2} \cdot \mu s)/m$$

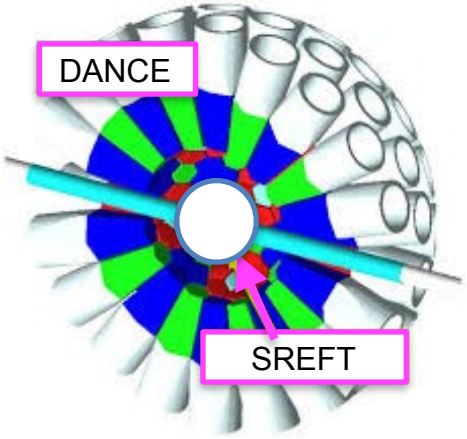
- **TKE** calculation from the K of the individual FF.
- **Mass fission yields** calculation through the 2E-method from the K of the individual fragments using the momentum and mass conservation.
- Mass resolution within ~4-5 amu.

Other possibilities

- To be used in parallel with other detectors for combined measurements.

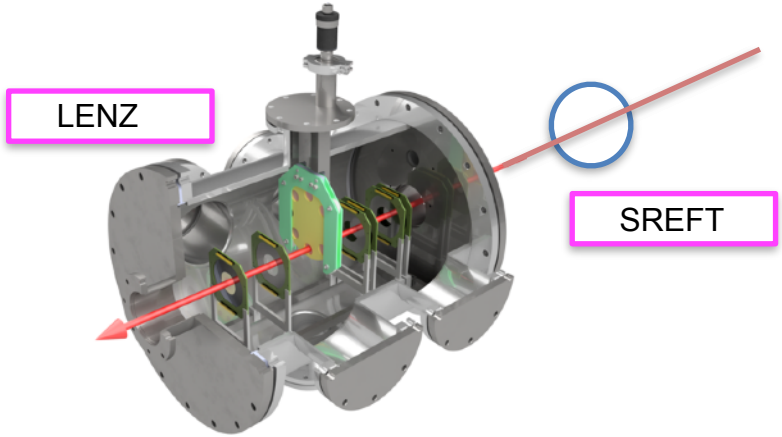
DANCE

- (n,γ) reactions.
- Placing SREFT inside DANCE we can measure also (n,f) reactions.
- This would provide information of the gammas emitted from fission reactions.



LENZ

- (n,z) reactions.
- With SREFT we can provide a measurement of the beam profile and flux in support for LENZ experiment.



Conclusions and future work

- New fission tracking detector SREFT at LANSCE.
- Cross section ratios, FFAD, TKE and FPY measurements.
- Mounting in process: chamber, gas system and electronics (on going).
- Test with ^{252}Cf source planned for the beginning of 2020.
- Future measurements with minor actinides.
- On beam test planned for next campaign (summer 2020).

Extra slides

	NIFFTE TPC	SREFT	Ionization Chamber
Position resolution	0.3 mm	1 mm	None
Gas pressure	1-10 atm	1 atm	1-2 atm
Anode size	11 cm diameter	12 cm diameter	
Channel count	6000	400	<10
Dynamic range per pad	0.01-100MeV	0.5-100MeV	1-100MeV
Gas gain	~50	1	1
Gas mixture	Ar+CO_2,…	P-10	P-10