FARCOS

Femtoscope Array for Correlations & Spectroscopy

- Overview of project and physics inputs
- Present status (mechanics, electronics) and perspectives for the use with GET electronics

G. Cardella, INFN-Catania

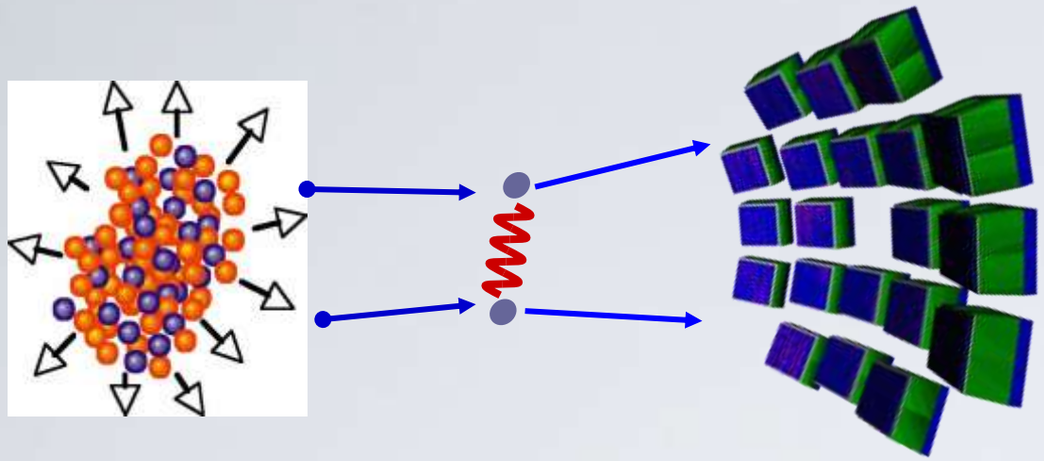
EXOCHIM collaboration, INFN (LNS-Ct-Me-Mi-Na)

GANIL, GEM-UHU, open collaboration

Physics topics

1. Heavy-ion collisions (stable and RI beams)
   - Dynamics (HBT, Femtoscopy)
     - Low & Intermediate energies: fusion, fission, DIC, Symmetry energy, Emission time-scales, probes of reaction models
   - Multi-particle correlation spectroscopy (MPCS) → cluster states
2. Direct reactions with RIBs
   - Inverse and direct kinematics
     - Nuclei close to drip lines

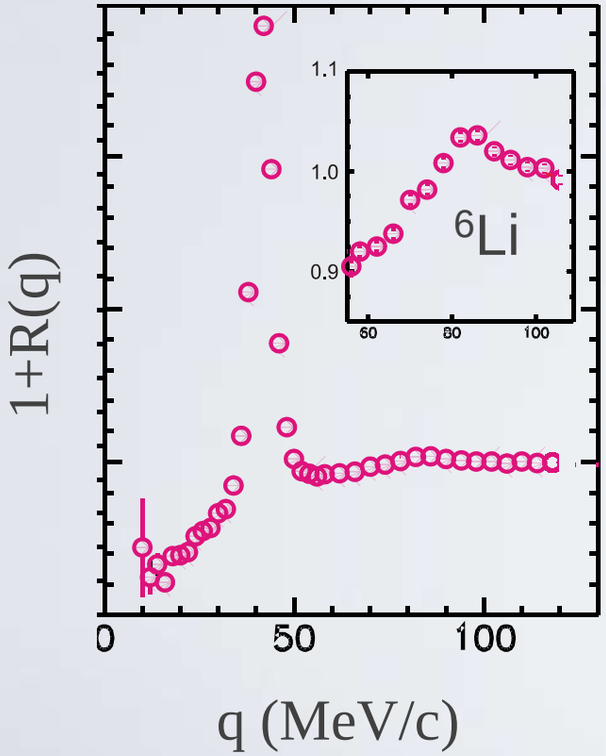
Relevance of angular resolution



deuteron-alpha

$$1 + R(q) = k \times \frac{SY_{coinc}\left(\vec{p}_1, \vec{p}_2\right)}{SY_{evt.mixing}\left(\vec{p}_1, \vec{p}_2\right)}$$

$$q = m\left|\vec{v}_1 - \vec{v}_2\right|$$

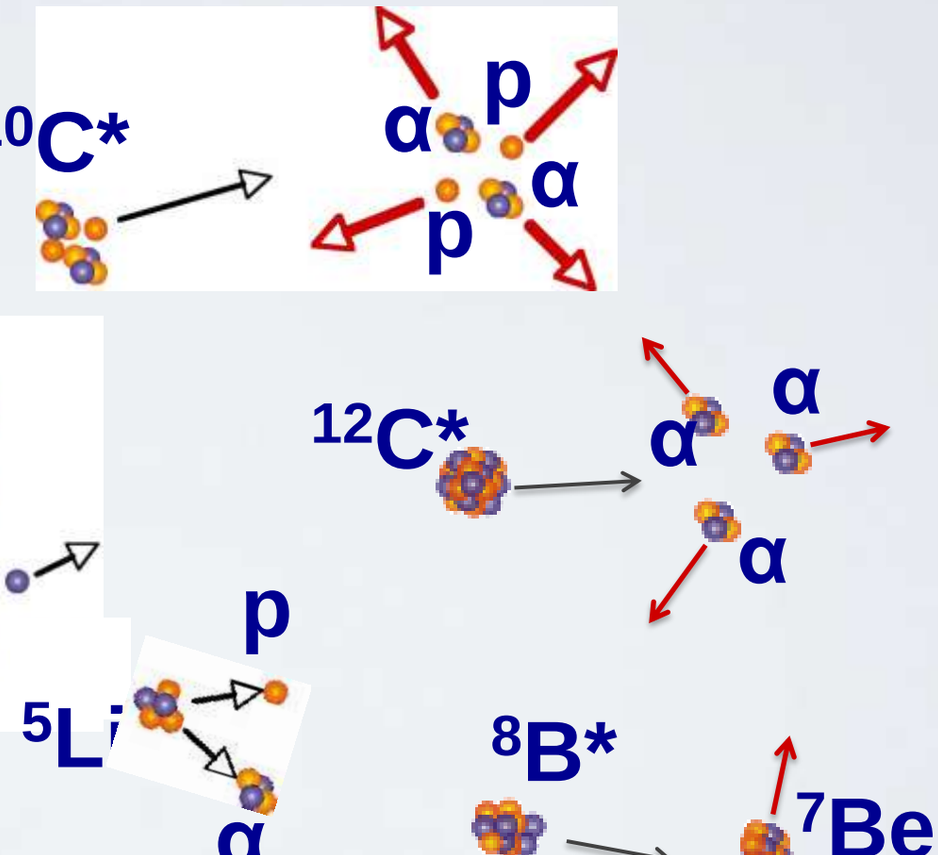


High angular resolution required:

→ Measurements at low q and sharp resonances

Multi-particle decay spectroscopy

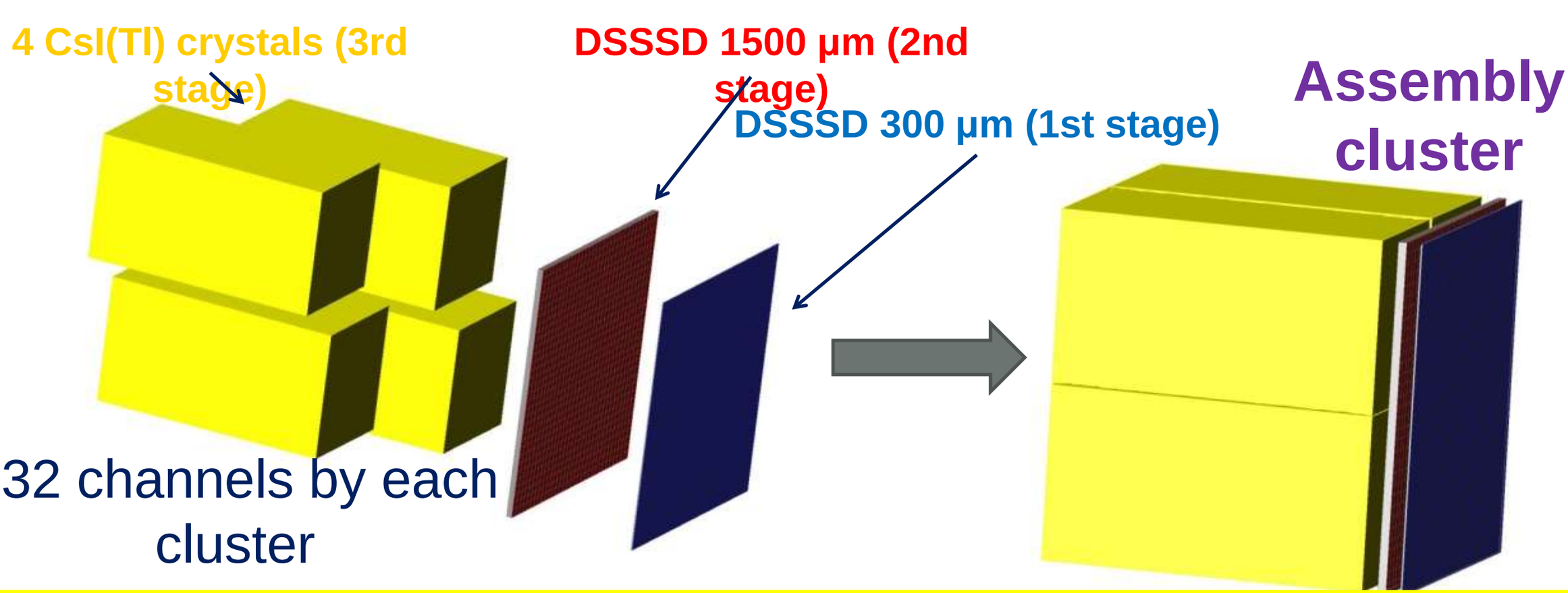
Using heavy-ion collisions as an explorative spectroscopy tool: several unbound species in one single experiment



4π Coverage + High angular resolution

FARCOS TELESCOPE – phase 1

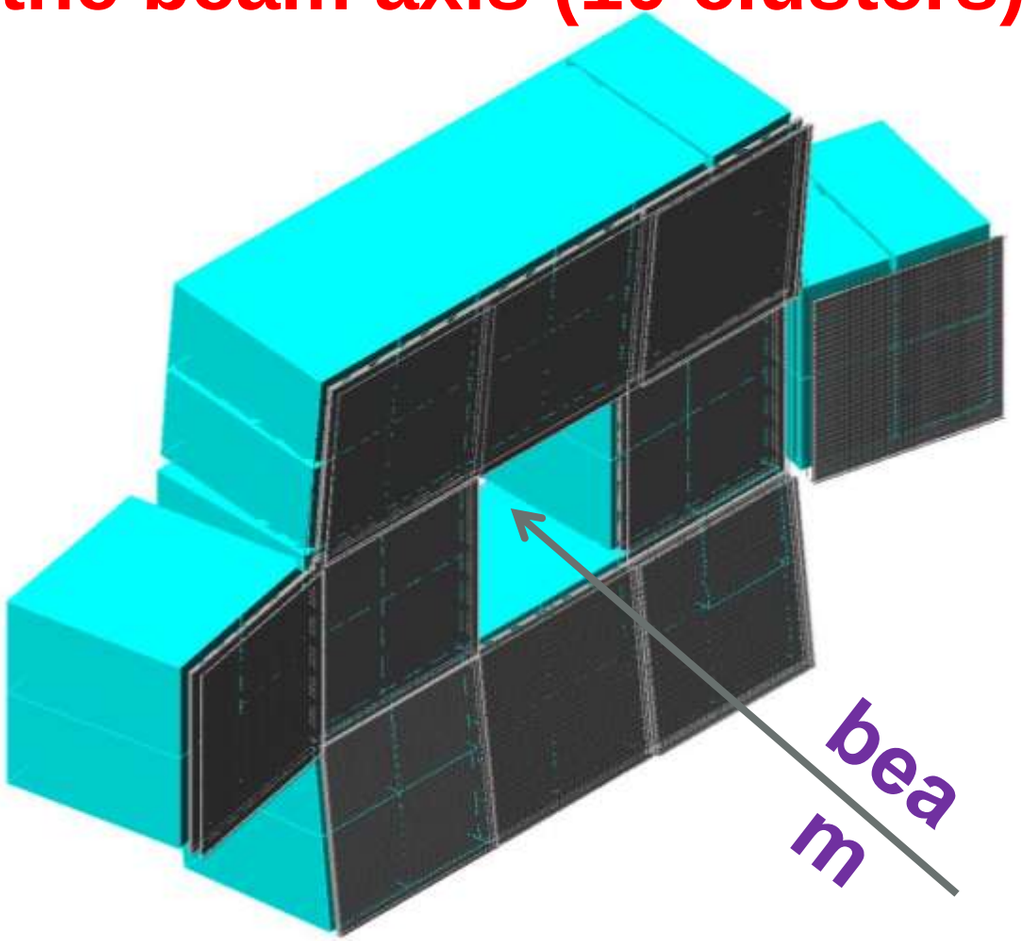
- Based on (62x64x64 mm^3) clusters
- 1 square (0.3x62x62 mm^3) DSSSD 32+32 strips
- 1 square (1.5x62x62 mm^3) DSSSD 32+32 strips
- 4 60x32x32 mm^3 CsI(Tl) crystals



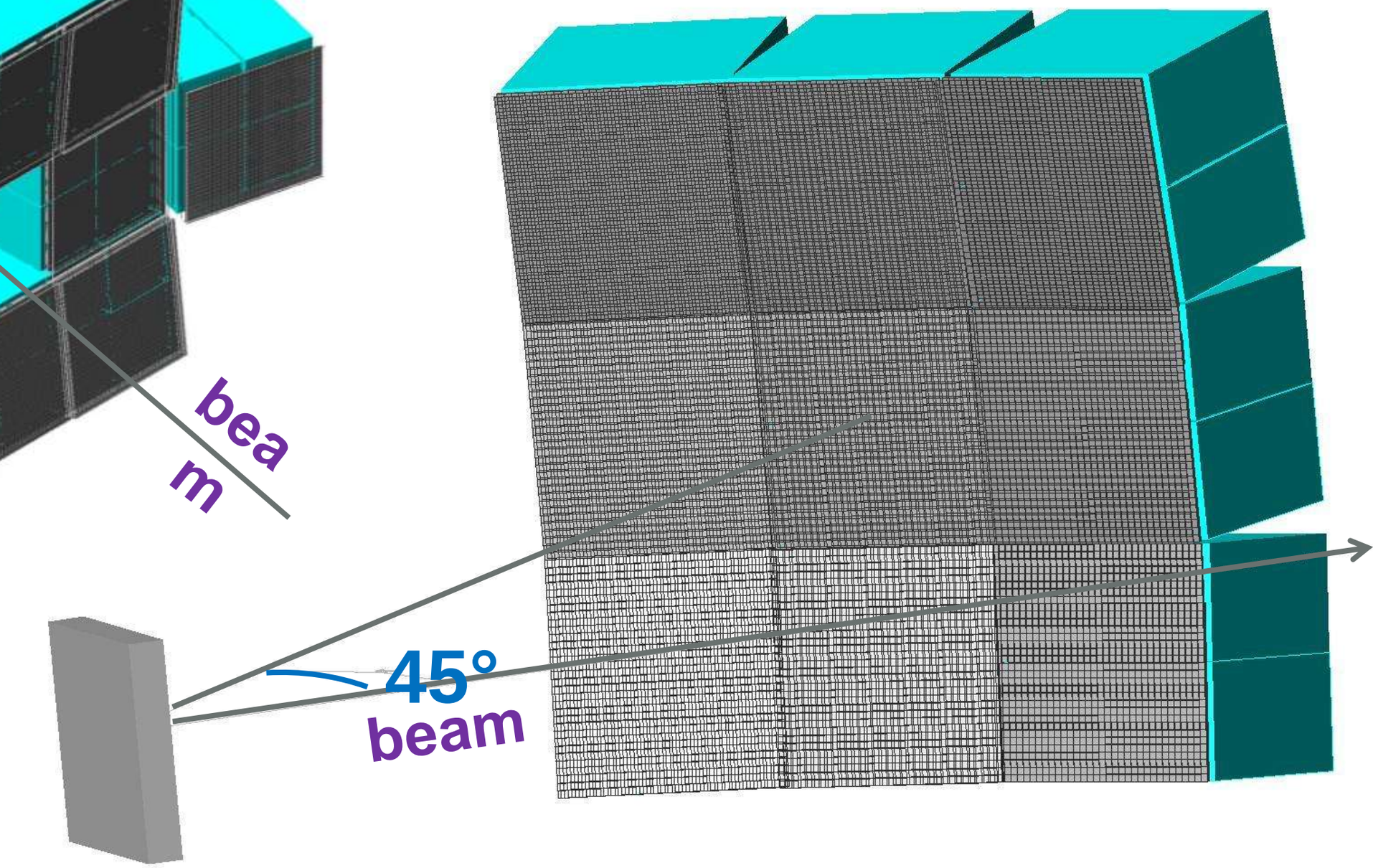
Fully reconfigurable (more Si layers, neutron and γ-detection, ..)

Geometric flexibility

Cross geometry centered on the beam axis (10 clusters)

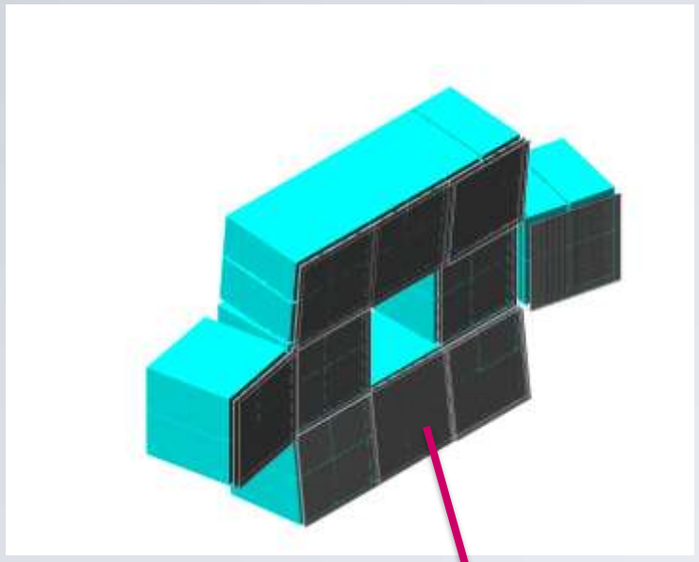


Wall geometry placed at 45° from beam axis (9 clusters)



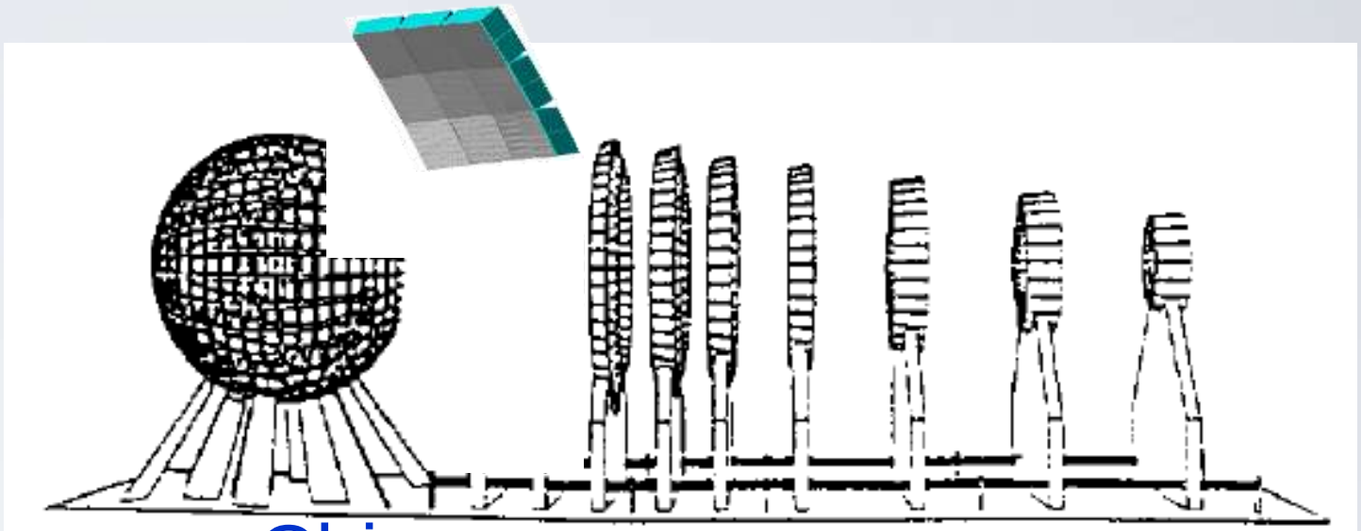
Transportability
Modularity

Planned geometries



Chimera rings

Farcos

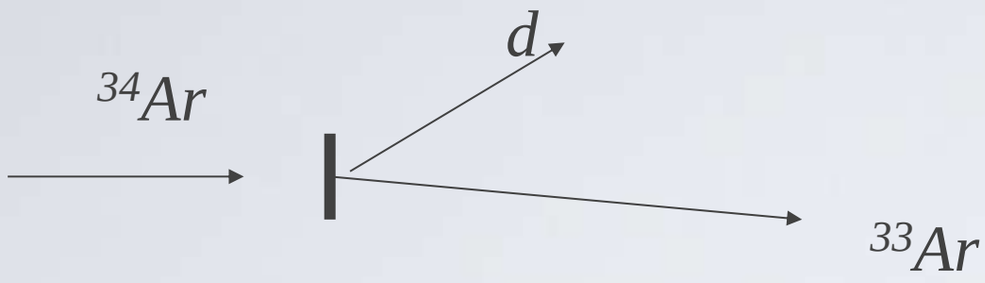


Chimera

- Correlations in central collisions (cluster states, HBT, Asy-EoS)
- Correlations in Quasi-Projectile breakup
- Spectroscopy with radioactive beams

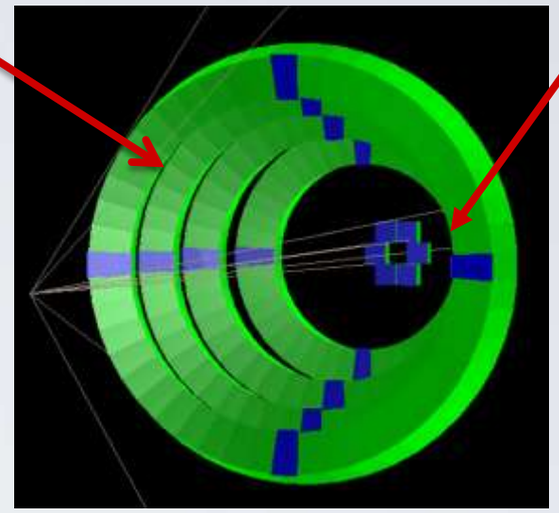
Direct reactions with exotic beams

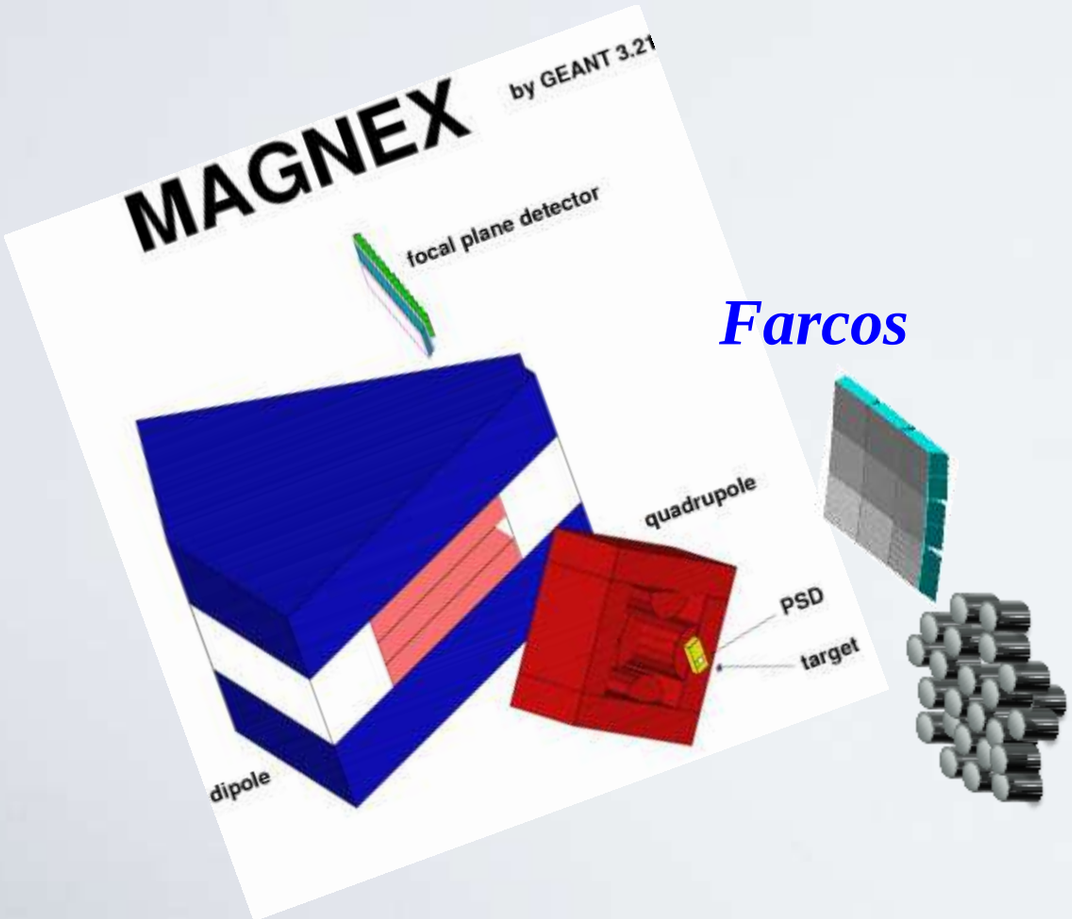
FRIBS exotic beams



Chimera (d)

Farcos (^{33}Ar residue)





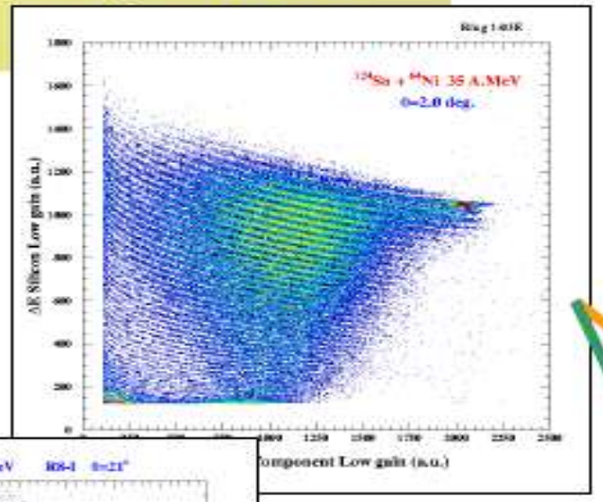
Coupling to spectrometers

Neutron detectors

Required identification performances (Chimera-like)

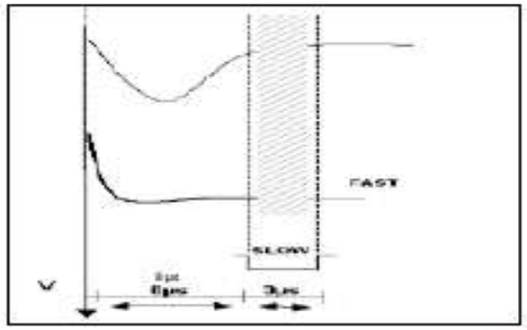
ΔE(Si)-E(CsI)

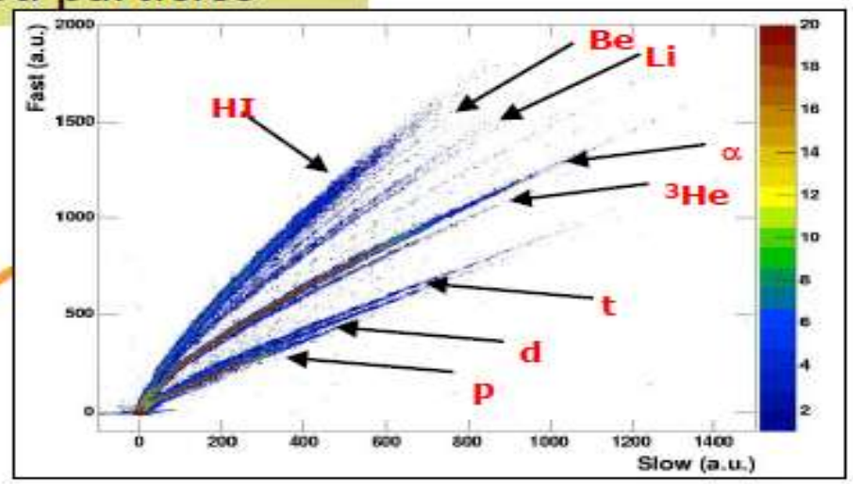
Charge Z for particles punching throught the Si detector

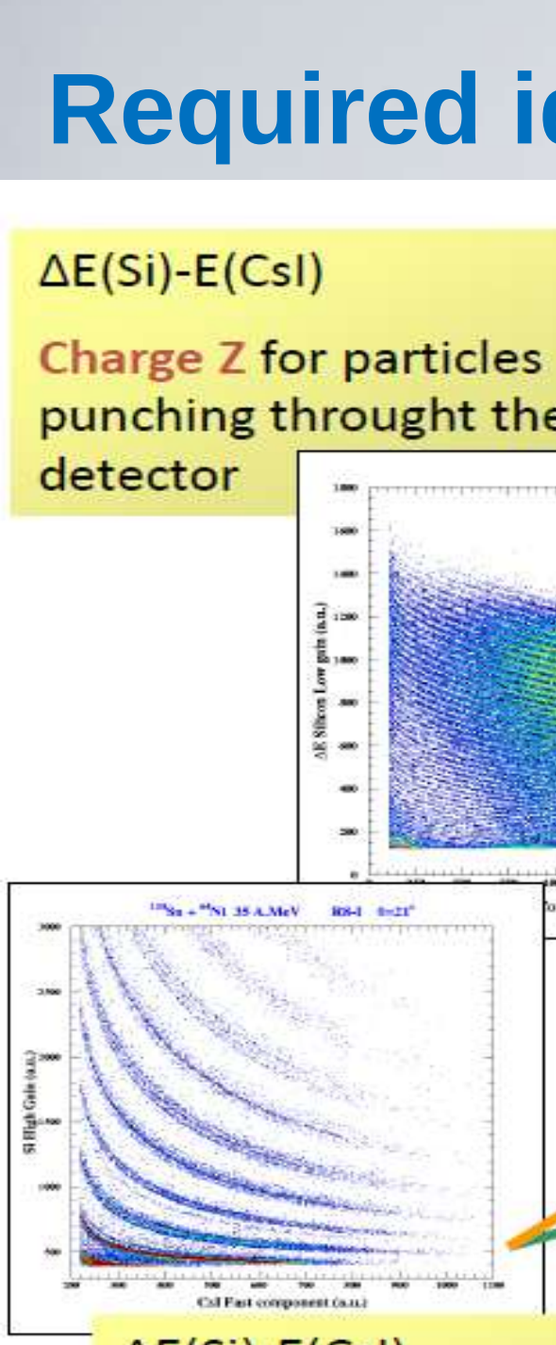


PSD in CsI(Tl)

Z and A for light charged particles







ΔE(Si)-E(CsI)

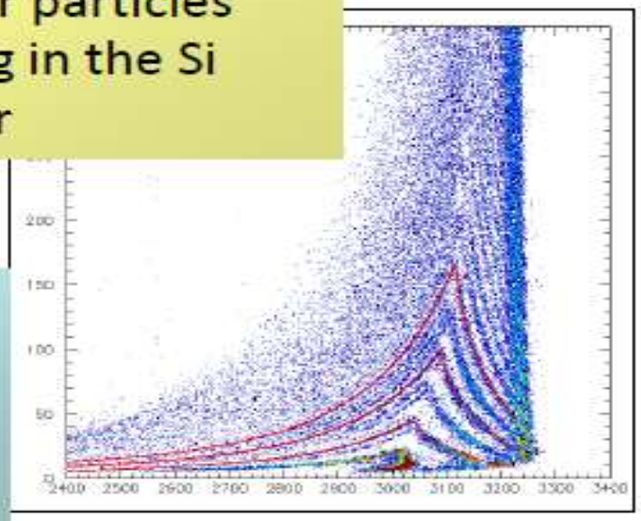
Charge Z and A for light ions (Z<9) punching throught the Si detector

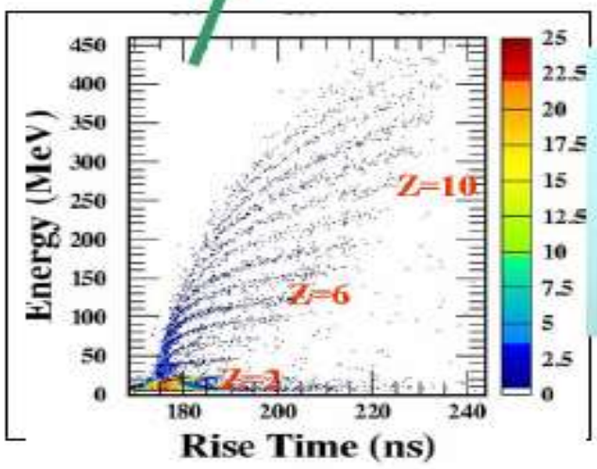
CsI(Tl)
3-12 cm

Si
~300 μm

ΔE(Si)-ToF

Mass for particles stopping in the Si detector



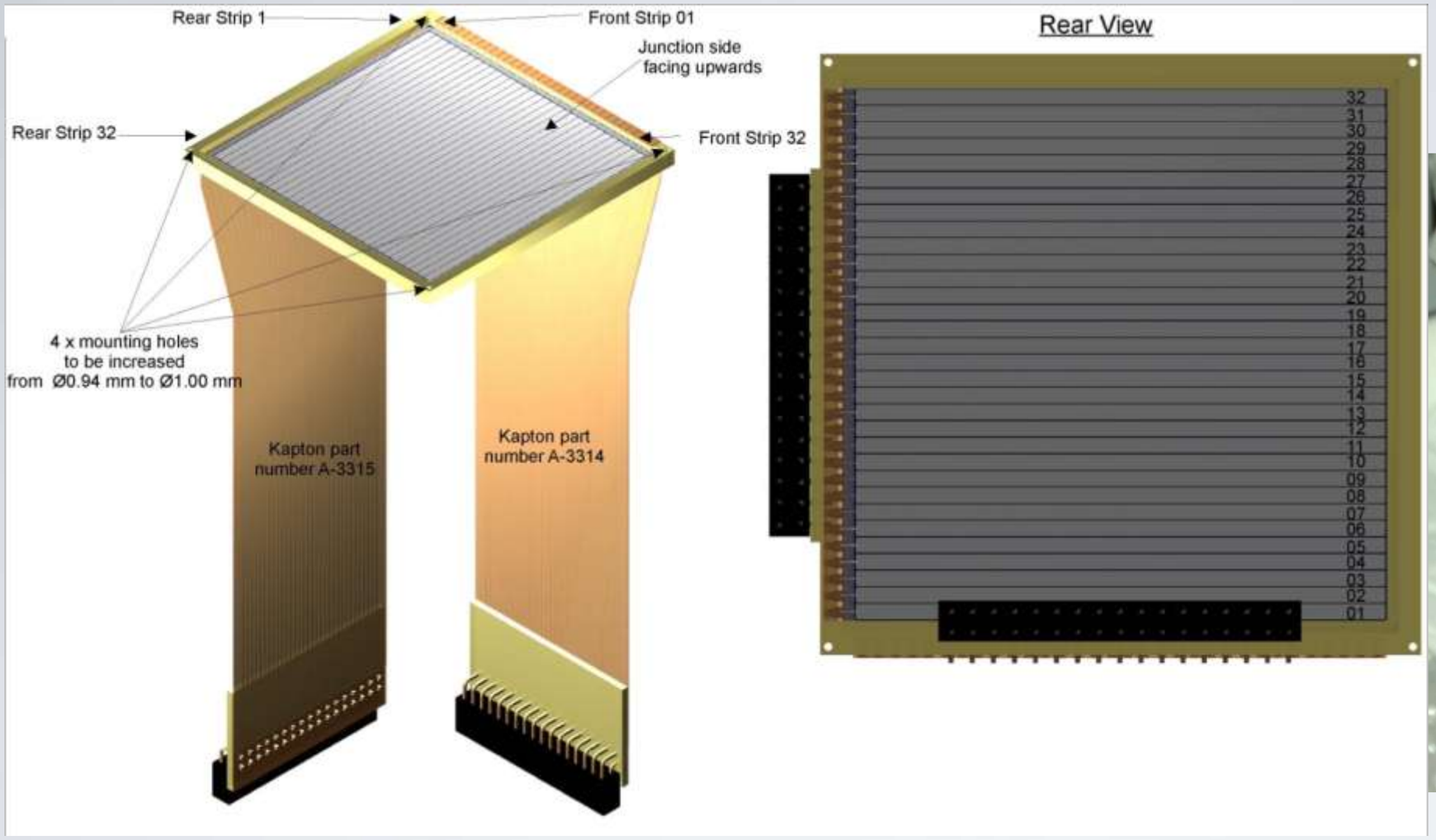


E(Si)-Rise time

Charge Z for particle stopping in Si detectors

Large dynamical range

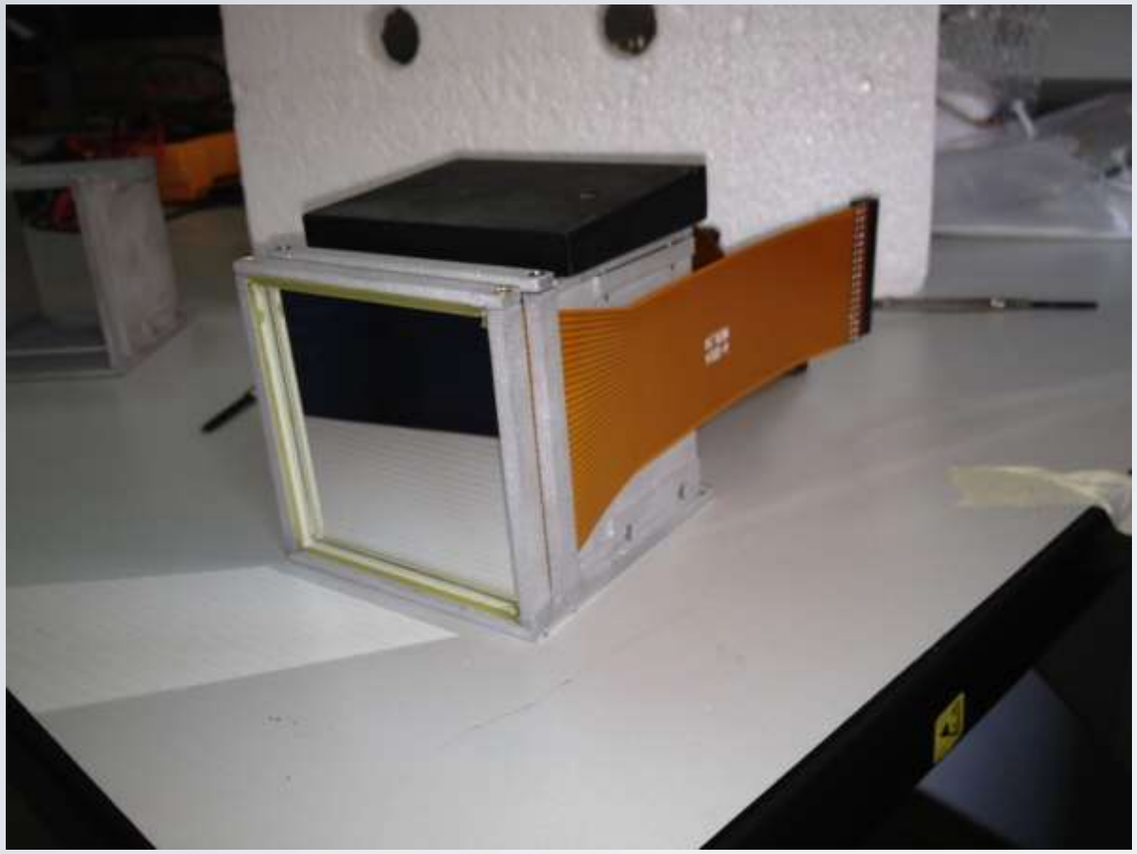
FARCOS detectors



- Double-Sided Silicon Strip Detectors
- 300 μm and 1500 μm
- kapton cable and 2x32pin connectors

- Highly homogenous CsI(Tl) crystals
- Wrapping: 0.12mm thick white reflector +50μm aluminized Mylar.
- 2μm thick aluminized Mylar window at the entrance (0.29 g/cm^2)
- Read-out by photo-diodes (300μm)

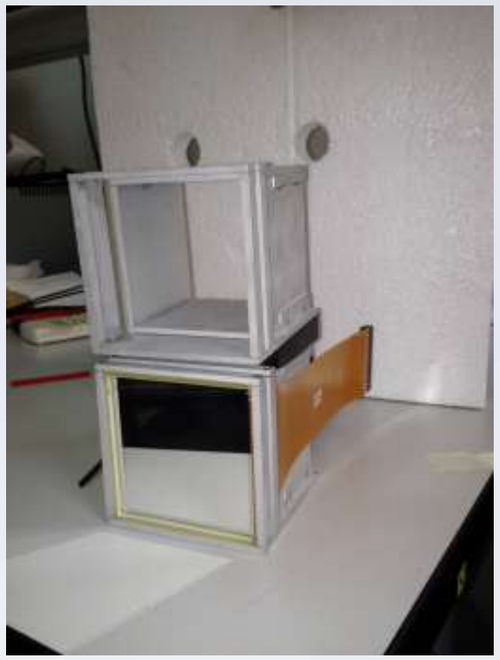
First prototype modules built



4 clusters ready
Experiments in Spring 2013 at LNS approved

Compact preamplifiers – Phase 1

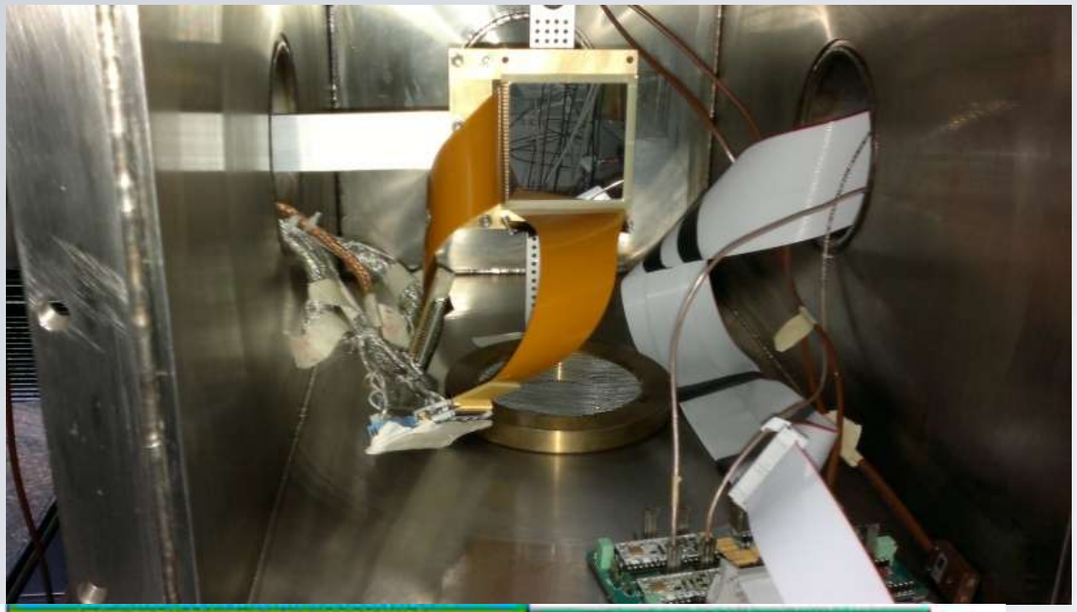
32 channels Hybrid charge preamplifiers in a volume of about 8cm x 10cm x 2mmm



- **Low power consumption:** ~750 mW pwe 32 channels (simplify cooling operations)
- **Rise-Time (pulser):** ~ 3-7 nsec for C_{input}=0-100pF
- **Energy resolution (pulser)** ~ 4-5 KeV for C_{input}=0-100pF
- **Available with several sensitivities** (5, 10, 45, 100 mV/MeV…)

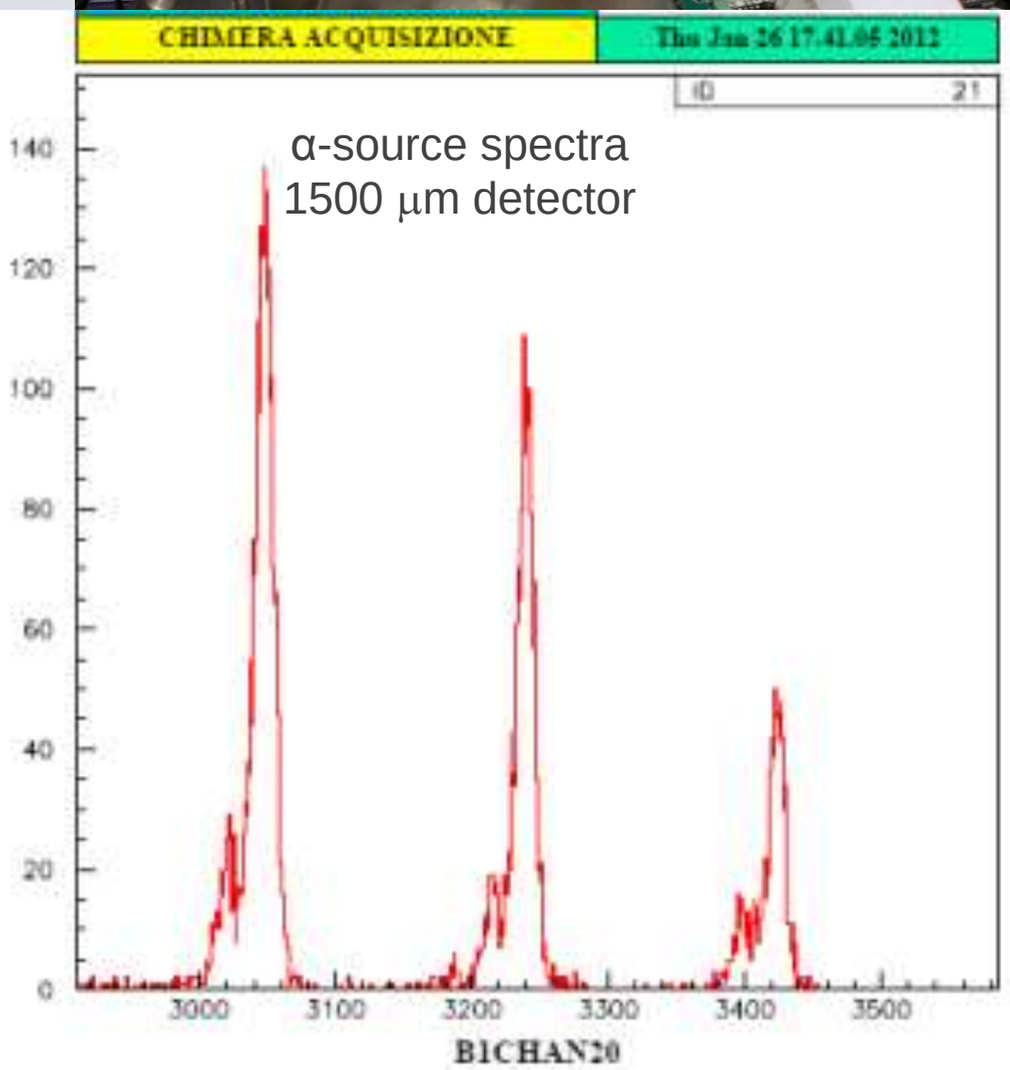
INFN, Milano – C. Boiano, R. Bassini

Si-strips α-source tests



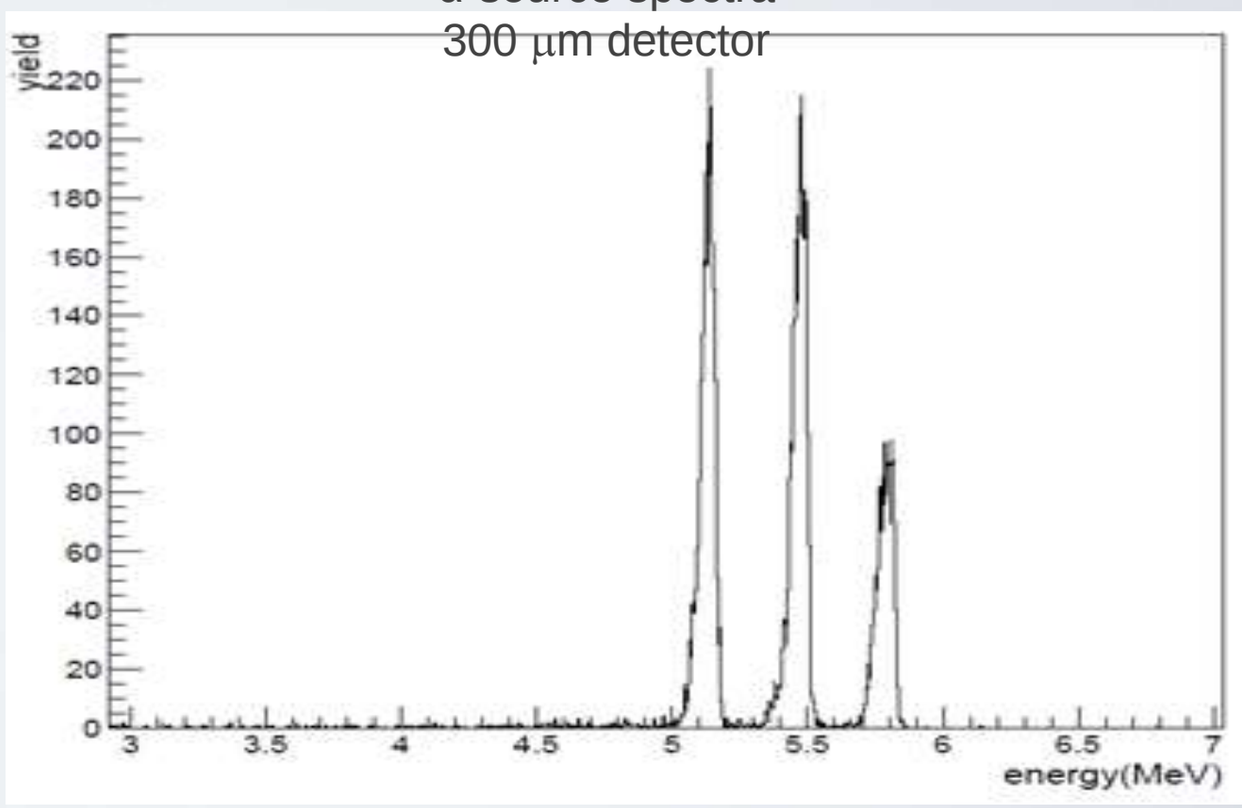
INFN-preamplifiers and Mesytec provide comparable E resolution (about 1% for the 300 μm strip .5% for 1500 μm)

INFN more compact, faster, less power consumption



α-source spectra
1500 μm detector

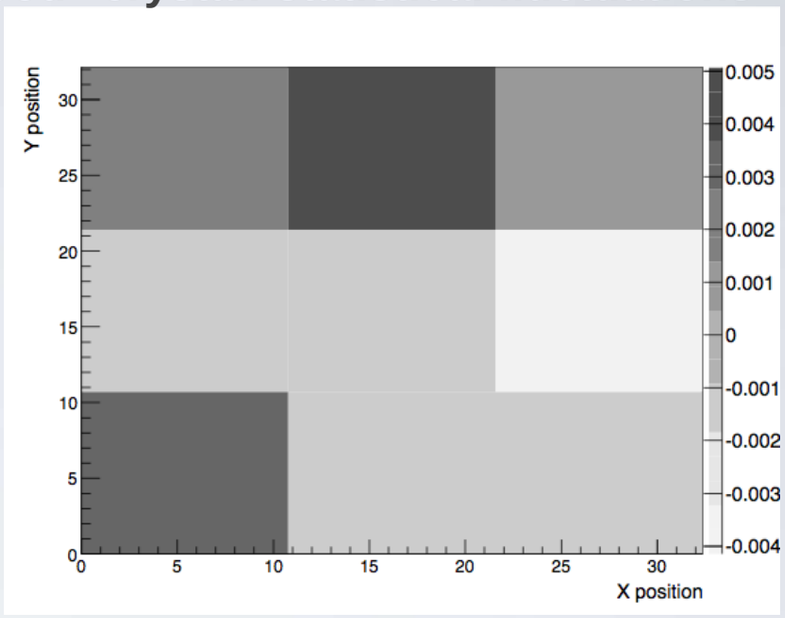
α-source spectra
300 μm detector



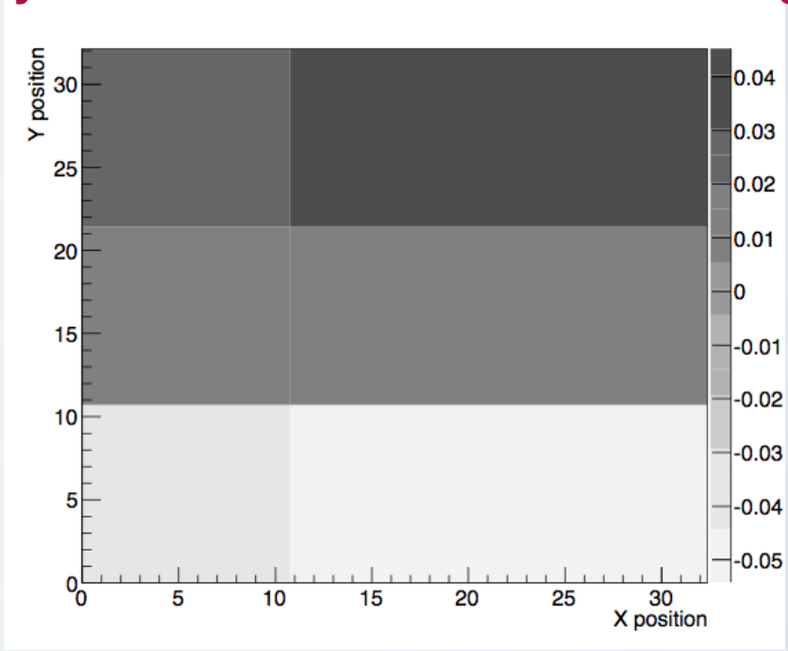
CsI(Tl) uniformity tests with α-source

Source moved along silicon face (front and back)

“Good” crystal: statistical fluctuations < 1%



“Bad” crystal: statistical fluctuations < 10% gradient

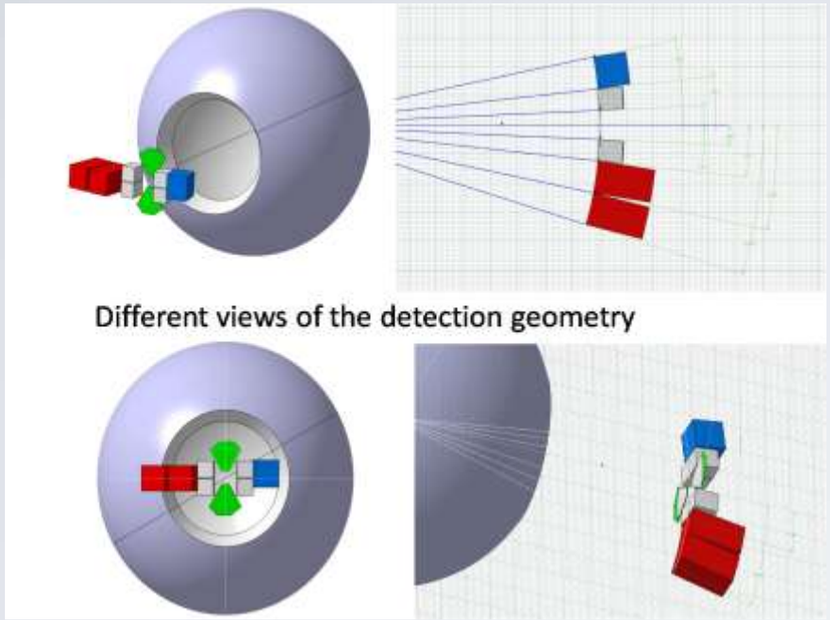


Non-uniformities (if systematic) can be corrected thanks to position sensitivity of silicon strips (for higher energy particles)

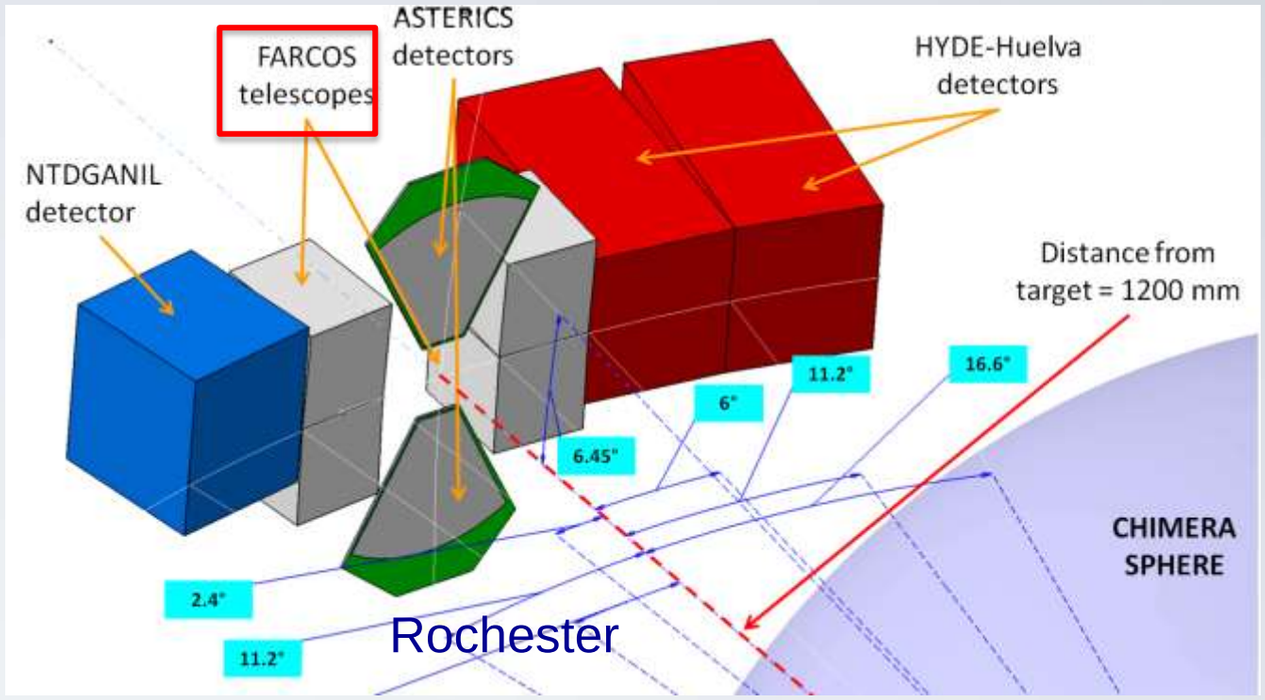
Improve resolution in beam experiments

First test beams – July2012 @ LNS

Chimera sphere view



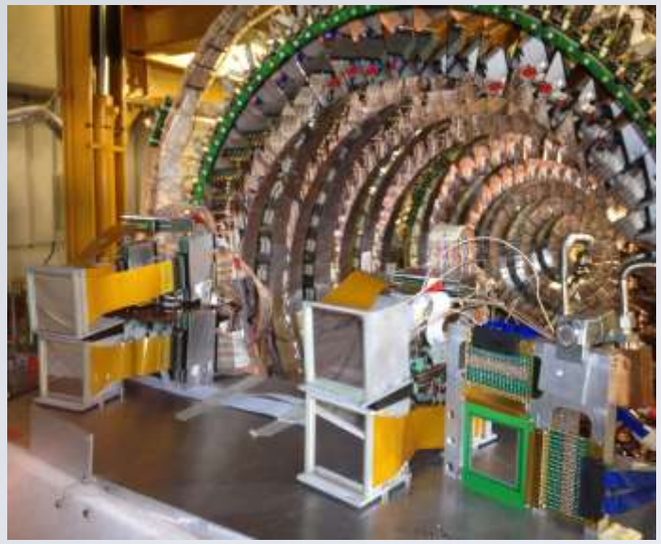
Different views of the detection geometry



p,α, Ne beams E/A=40, 20 MeV - Elastic scattering and Transfer reactions on various targets

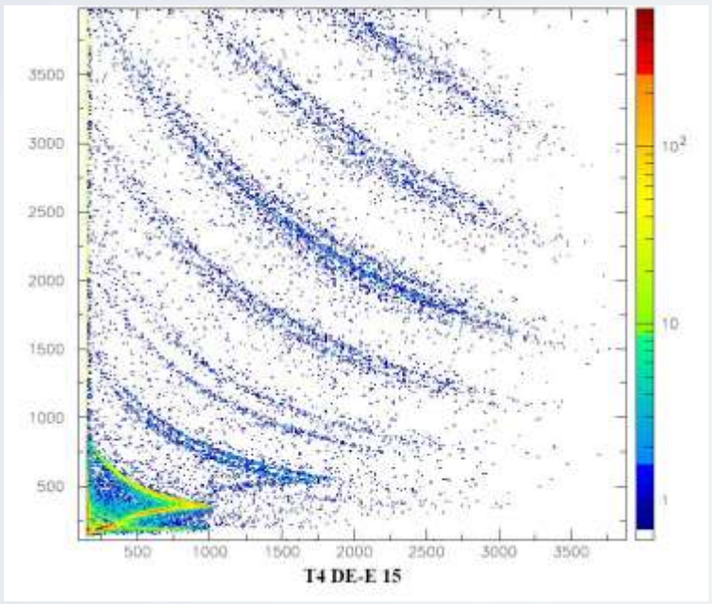
- **CsI(Tl) uniformity**
- **Silicon resolution**
- **Integrating DAQ into Chimera system**

Mounting of prototype telescopes

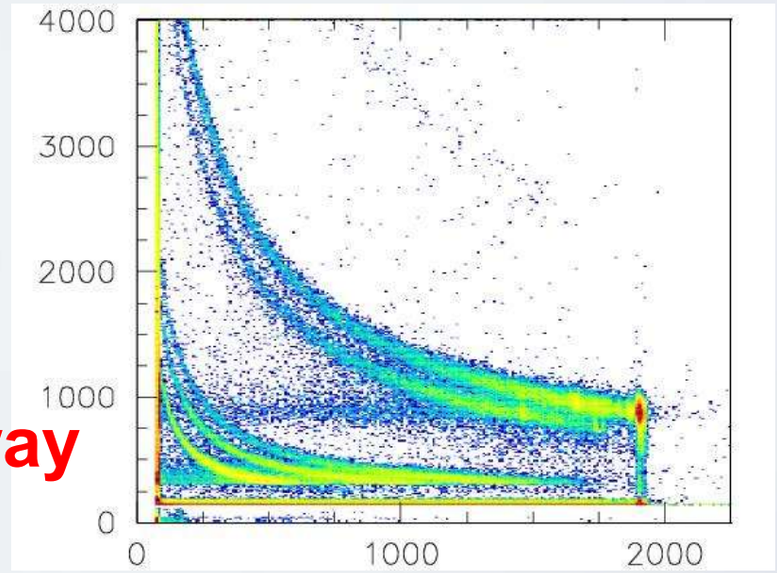


Pre-amplifier boxes

Si-Si matrix



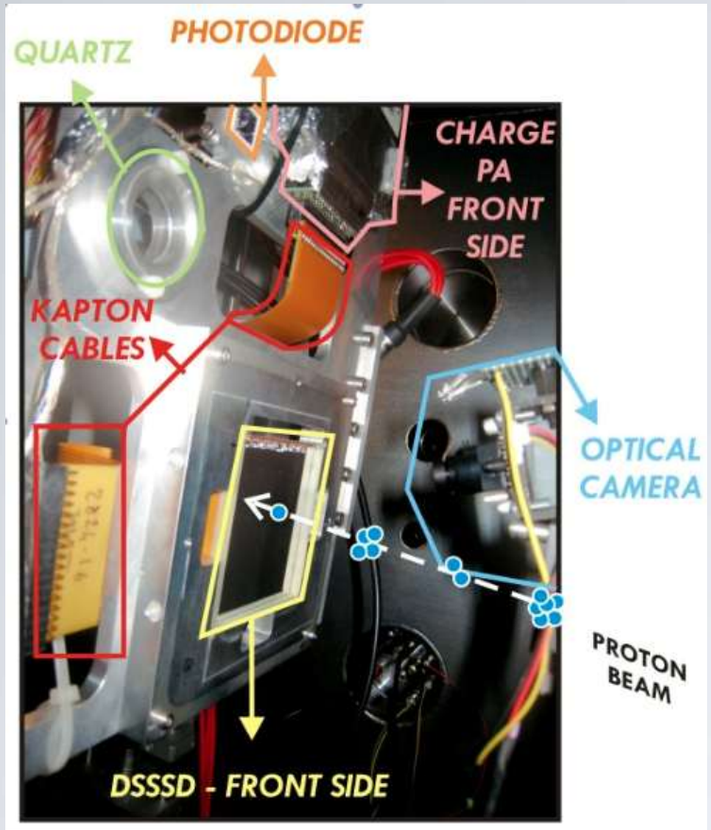
Si-CsI(Tl) matrix



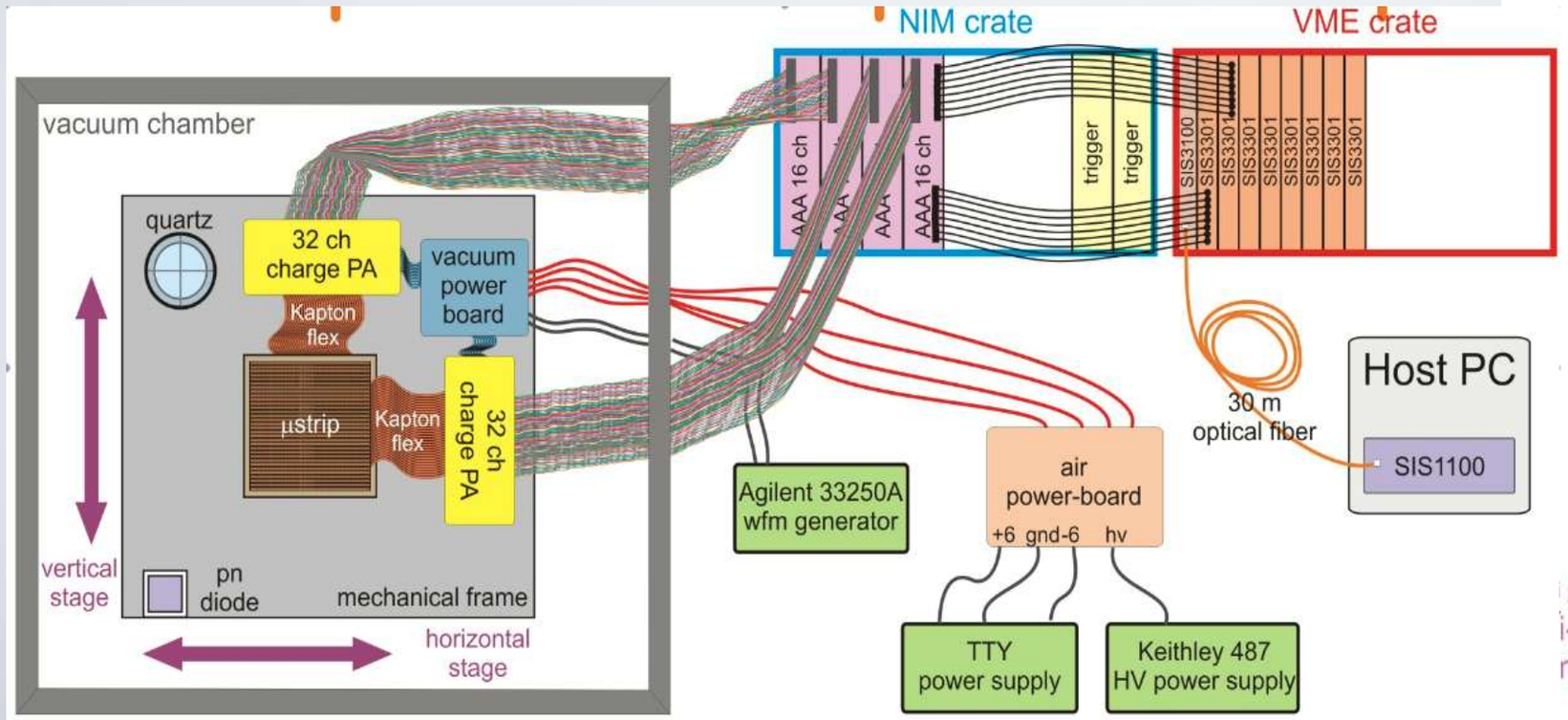
Preliminary results… analysis underway

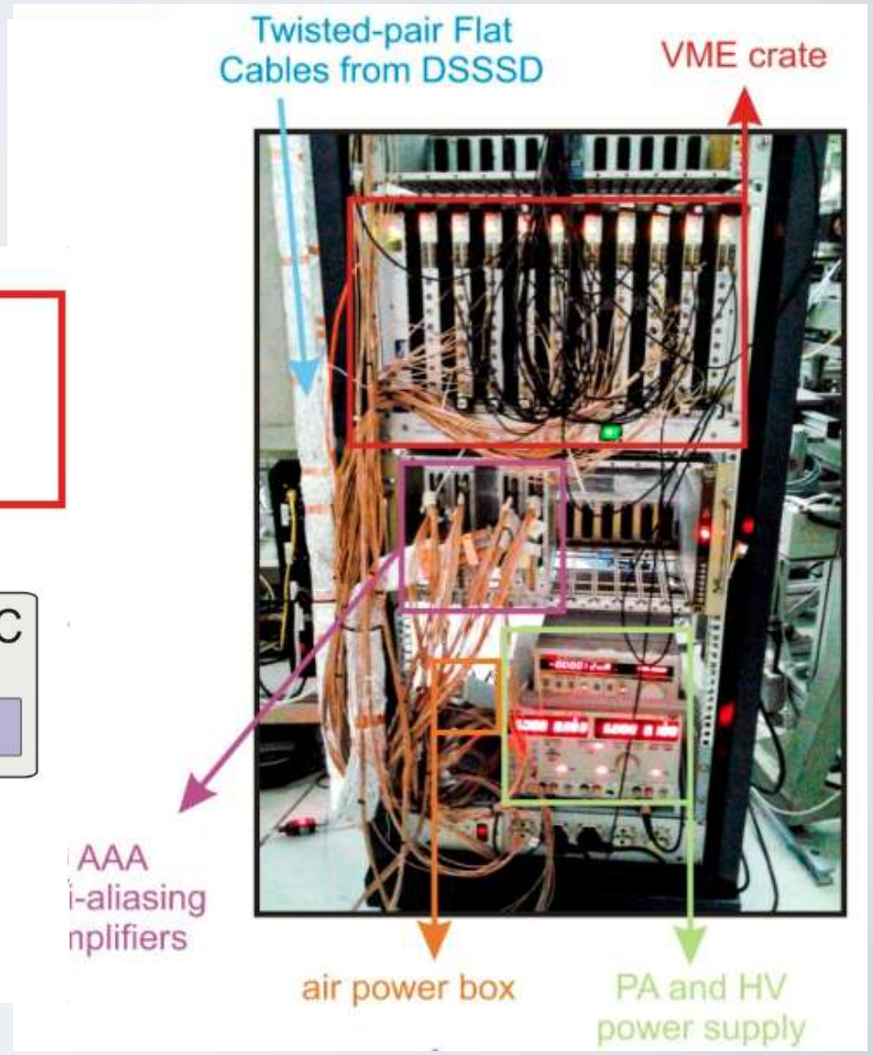
Ne + CH_2 → Multifragmentation

Silicon strips @ Labec (INFN-FI)



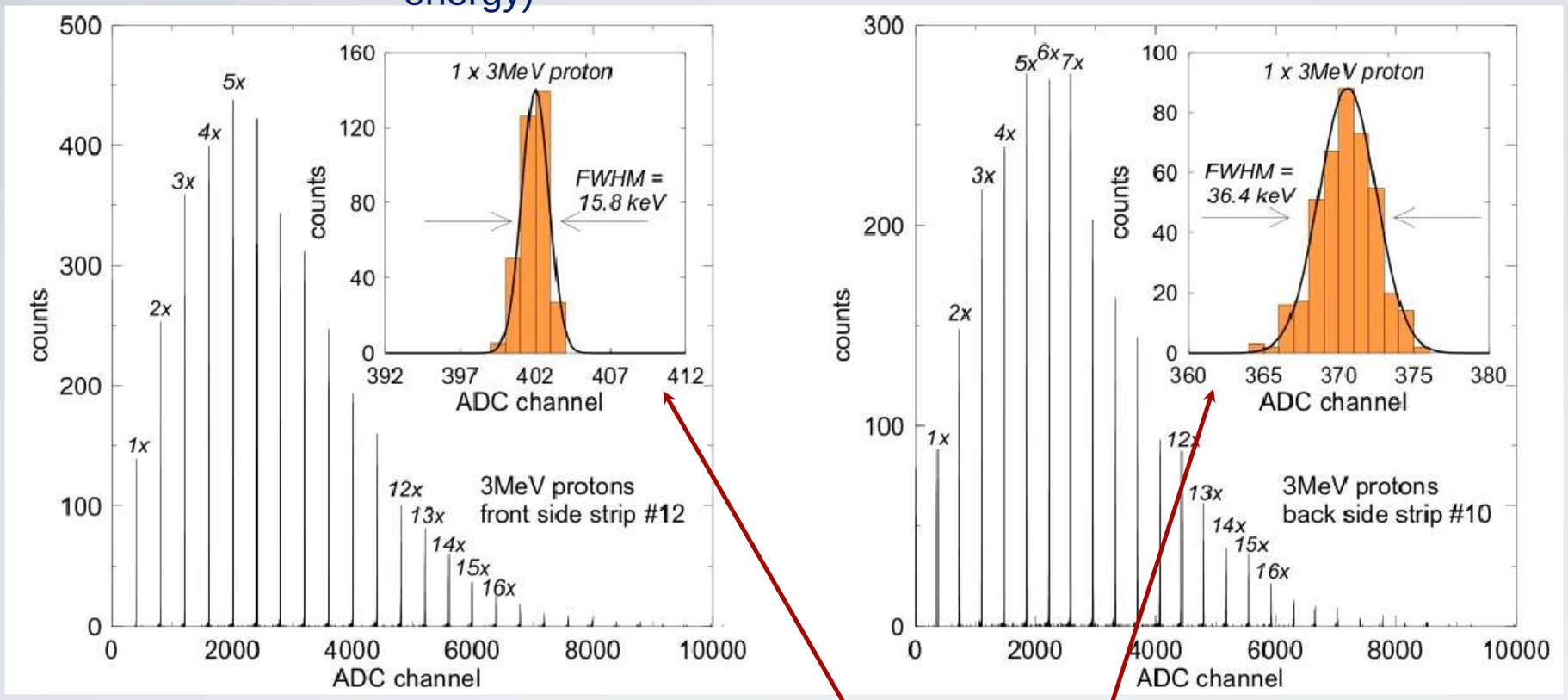
- INFN and Politecnico of Milan and Farcos collaboration
- Fast pulsed beamline DEFEL: variable and controllable number of particles/pulse
- Energy changed between 1 and 6 MeV
- Position resolution: 100μm x 100μm: scanning of strips and inter-strip regions
- Digitalization of silicon signals with commercial VME SIS 3301
  - 100 MHz – 14bit
  - 8 channels/module
  - Opt. Link to PCI





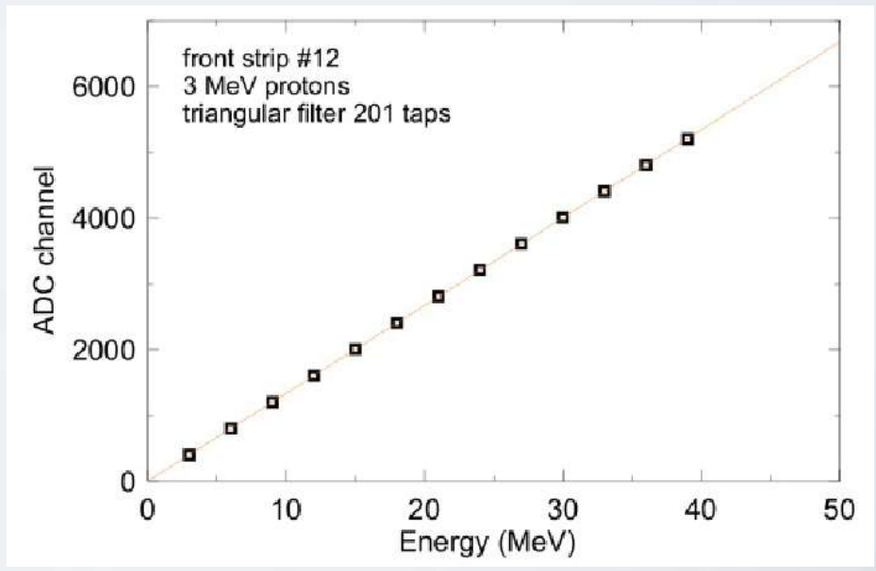
n-proton injection and resolution

Proton bunch multiplicity (deposited energy) →



***Resolution**: 0.5% Front - 1.2% Back*

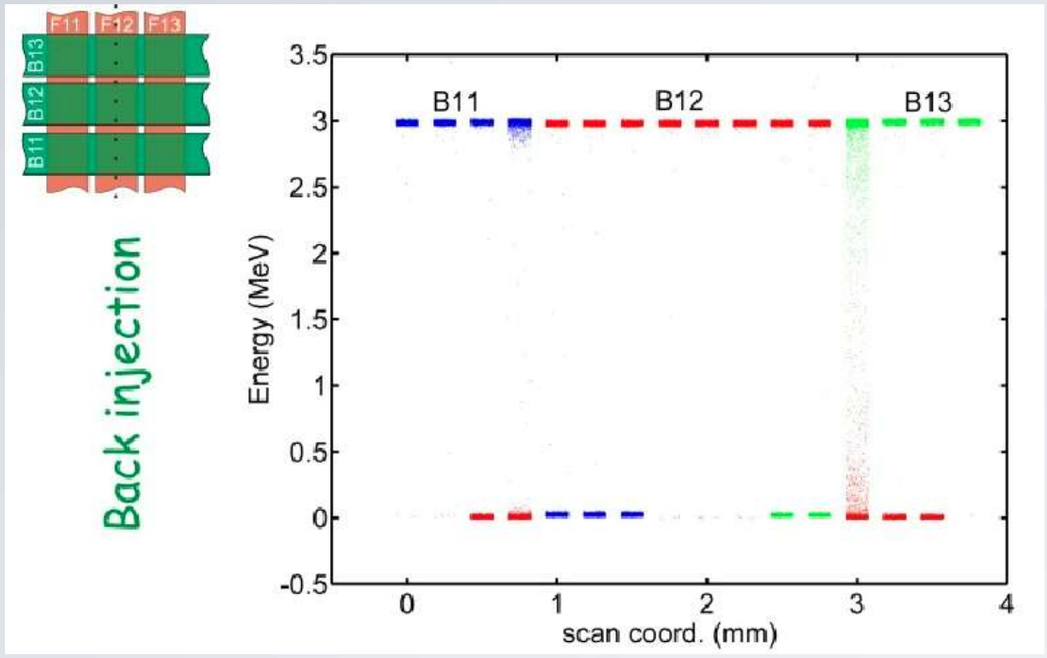
Test of linearity for Silicon+Preamplifier system



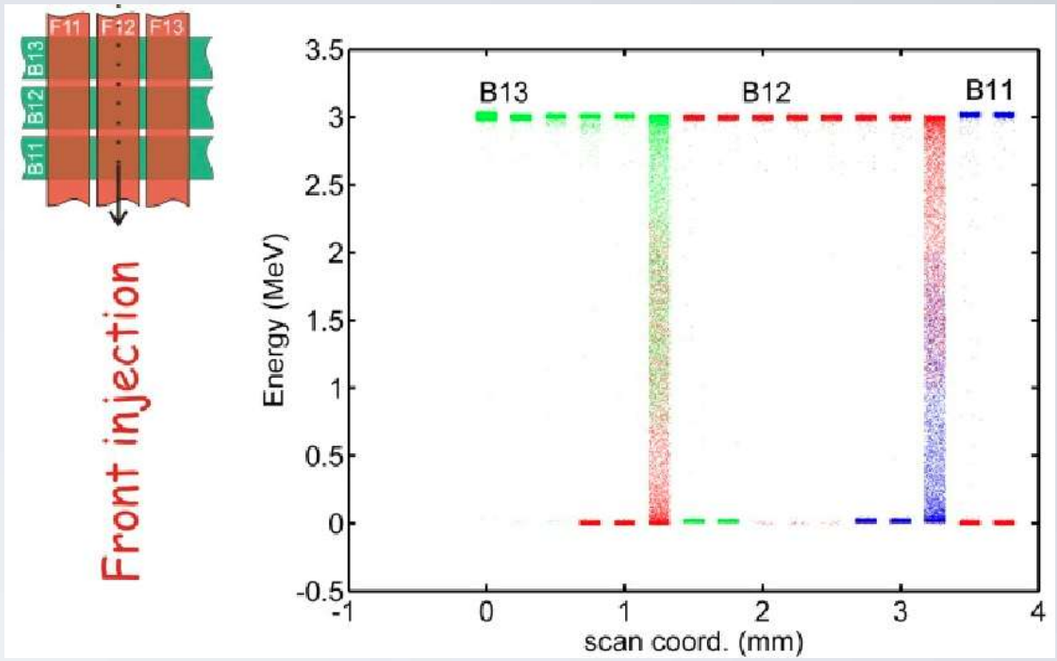
INFN and Politecnico, Milano for Farcos Collaboration

Interstrip energy sharing

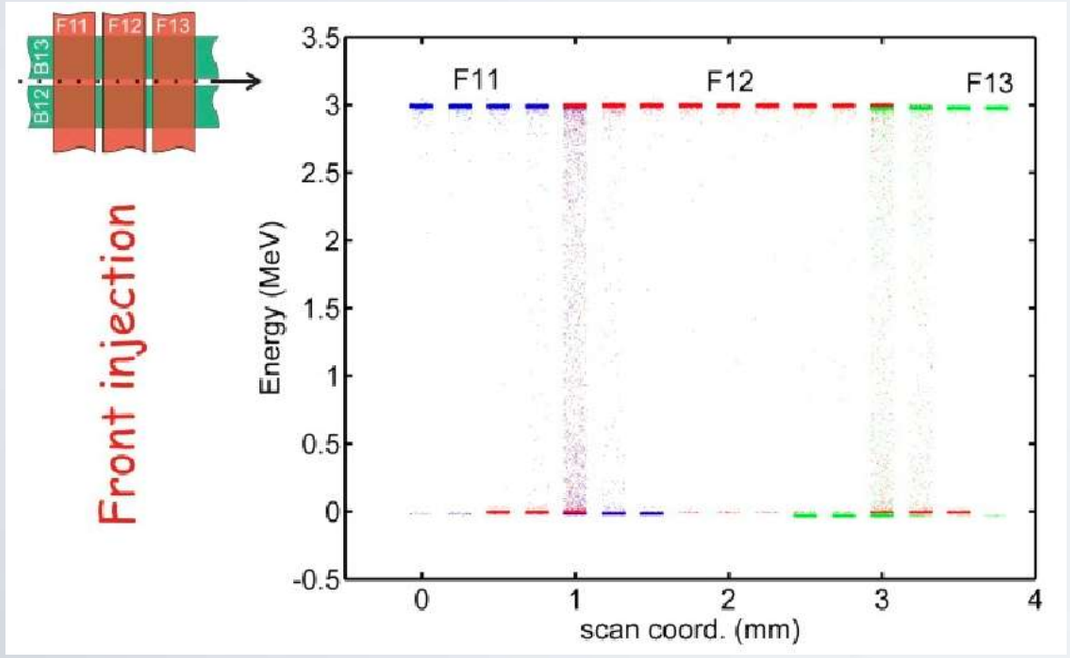
Back injection + Back strip/interstrip spanning



Front injection + Back strip/interstrip spanning



Front injection + Back interstrip spanning



Data analysis under way

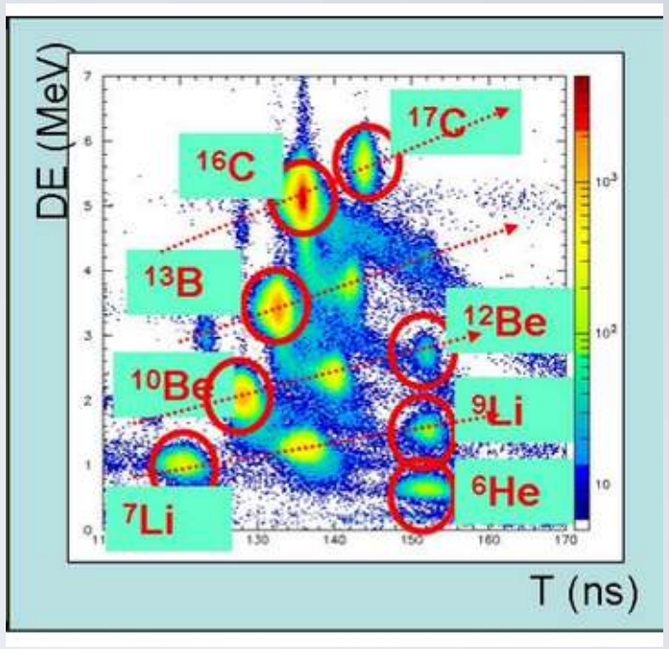
Study of energy sharing between neighboring strips

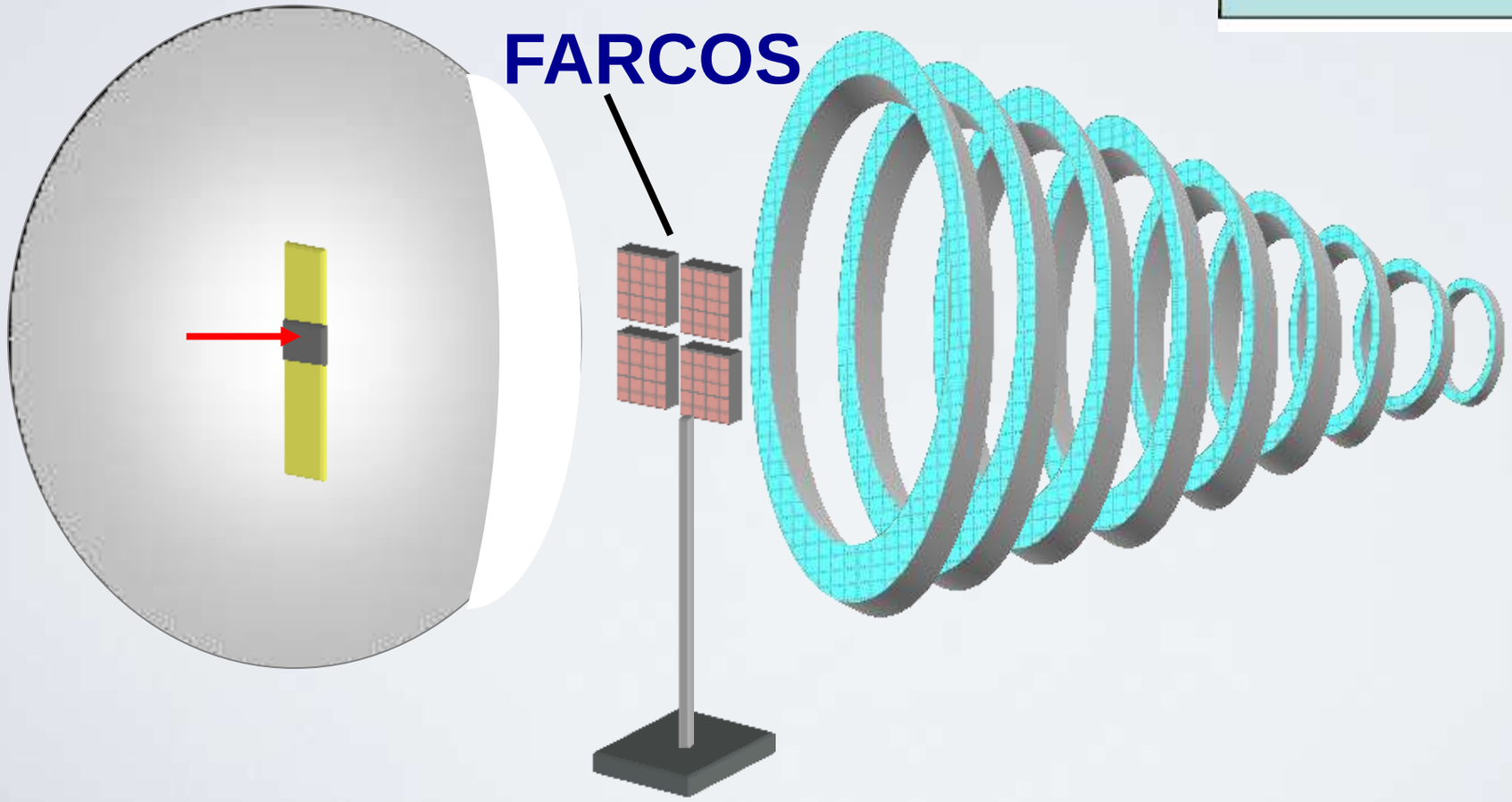
INFN and Politecnico, Milano for Farcos Collaboration

Experiments in 2013 @ LNS

CLIR: Clustering in Light Ion Reactions
16C + 12C→ 10Be + 6He
→ 12Be + 4He

16C from tagged FRIBS projectile fragmentation → 120 kHz

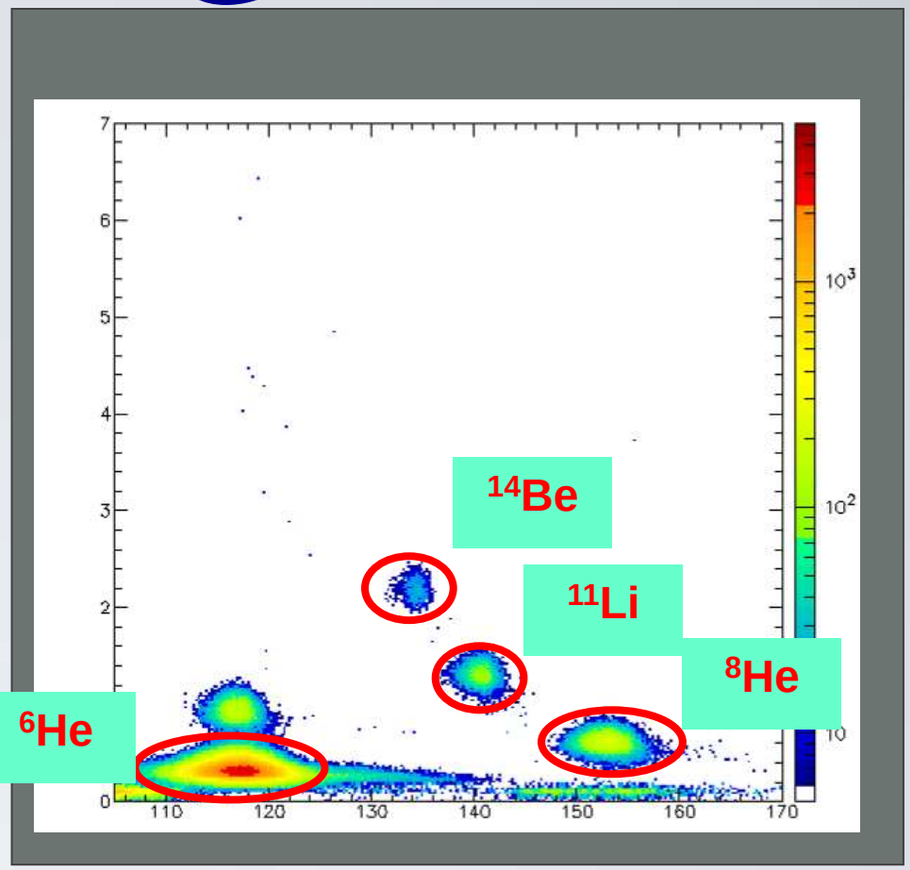


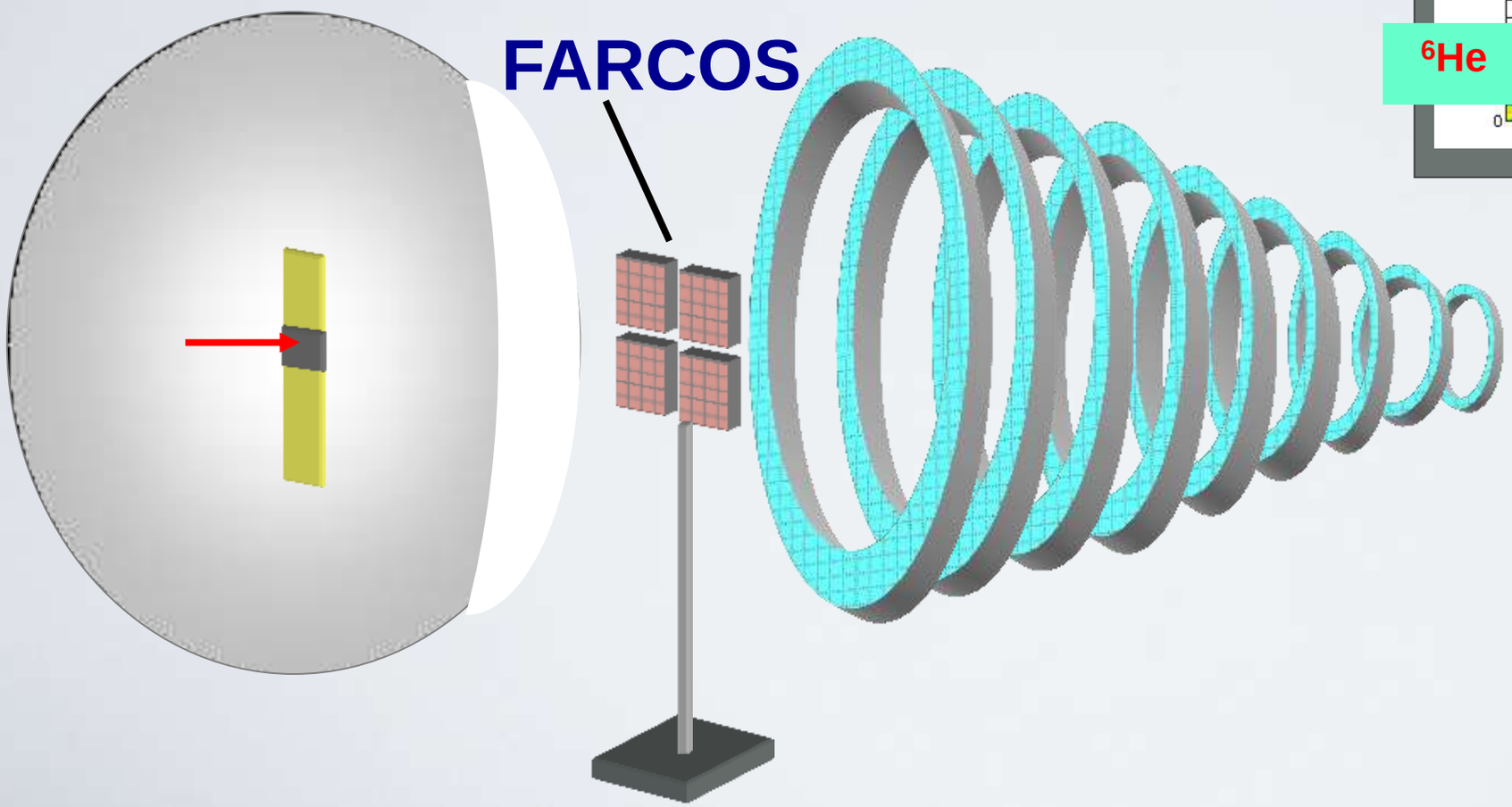


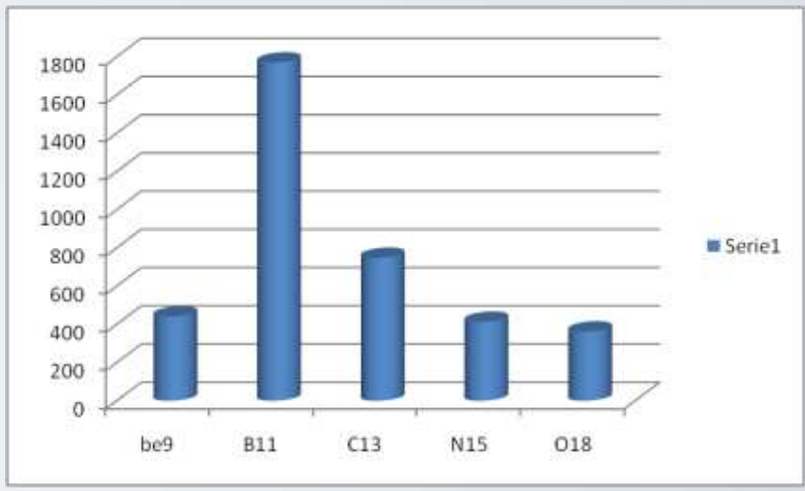
Experiments in 2013 @ LNS

8He: populations of resonances in 9He via d-p transfer reactions on 8He

16C from tagged FRIBS projectile fragmentation → 120 kHz

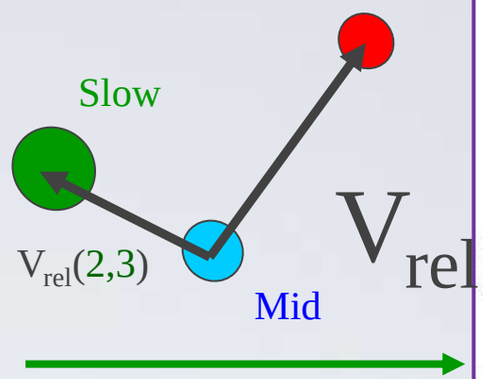


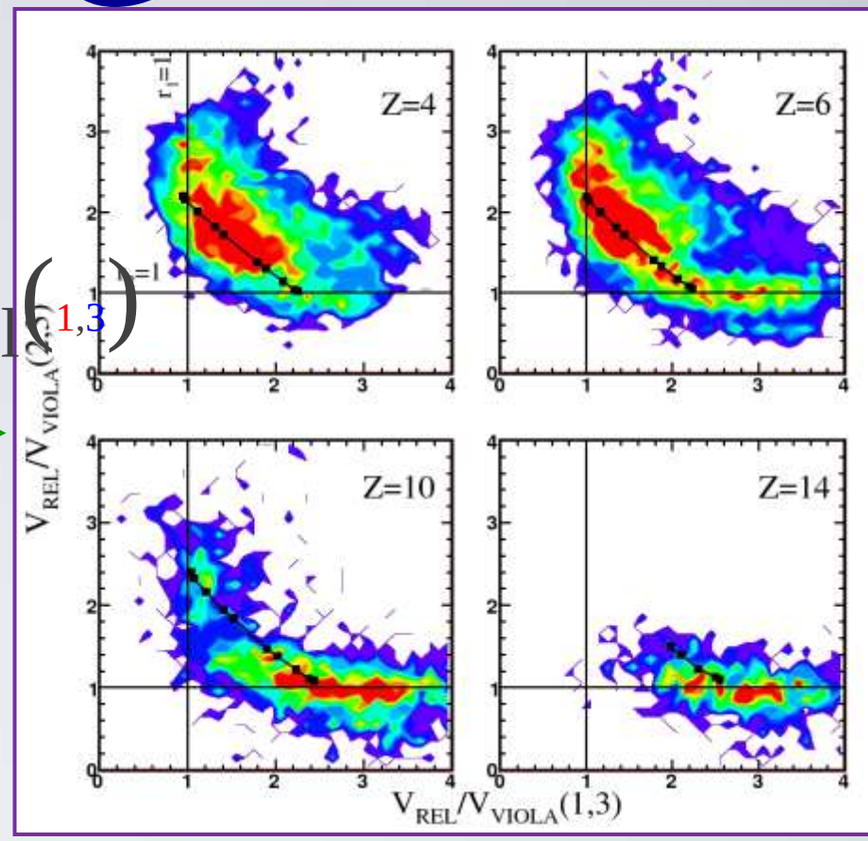


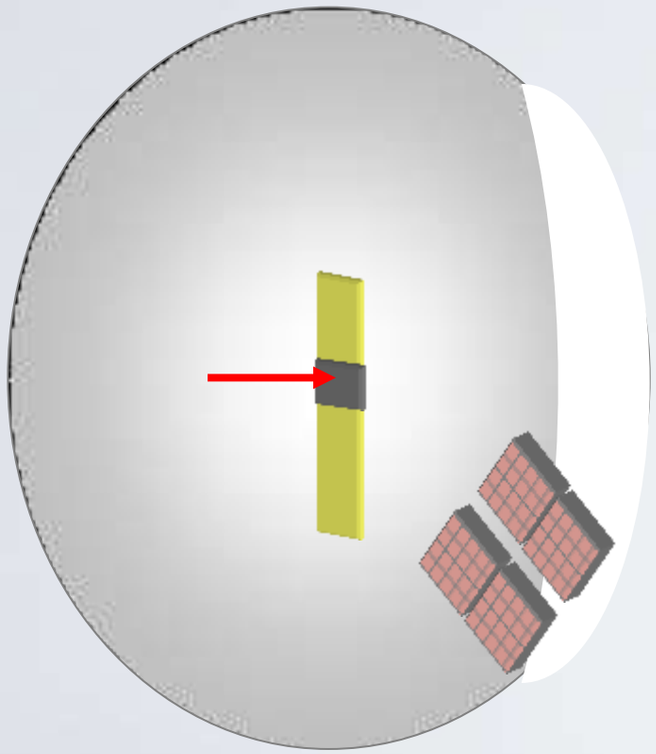


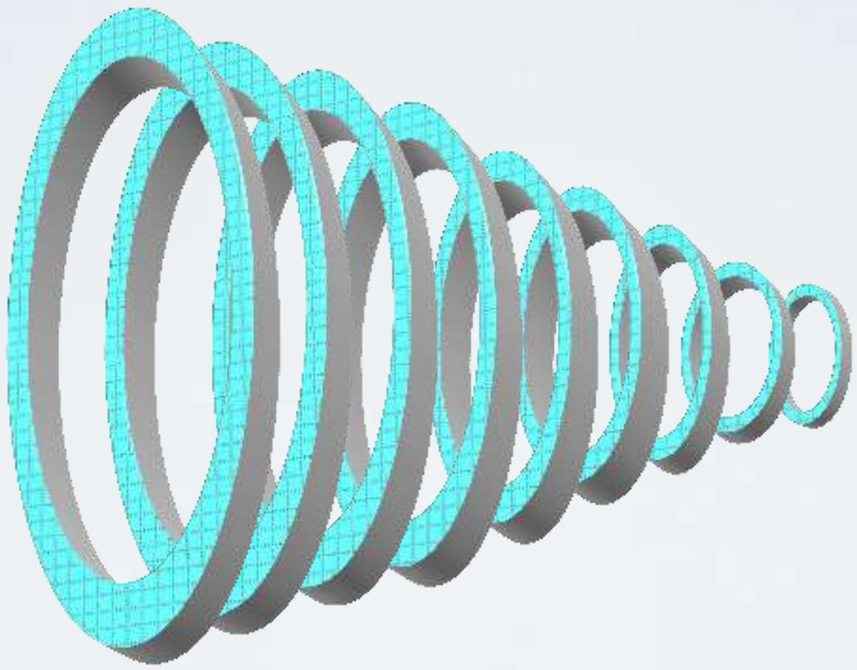
Experiments in 2013 @ LNS

inkinlsy mass and isospin dependence of reaction mechanism
Comparison of old 124Sn+64Ni data with 124Xe+64Zn
Use of farcos for p-p correlation for the comparison of source size and life-time

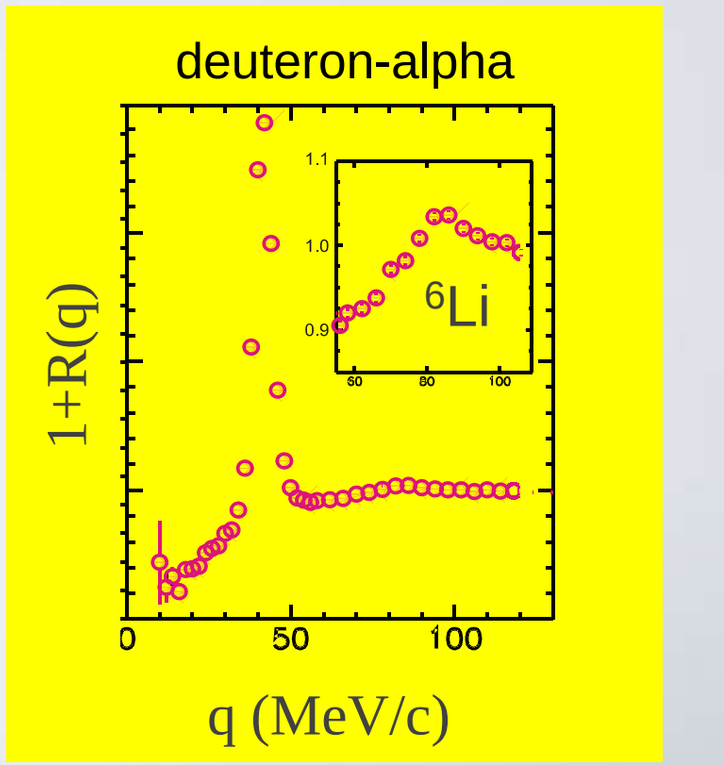








FARCOS



Electronics hopes for phase 2
20 telescopes??

- Pre-amplifiers with multiple gains and large dynamic range (MeV to GeV)
- VSLI, configurability, low power… oriented towards physics!
- Pulse-shape capabilities
  - ✓Low identification thresholds for low energy experiments
- Digitalization of detector signals
- Update possibilities
  - ✓Solid angle increase (20 telescopes?)
  - ✓Coupling to different detectors (in different laboratories)

Electronics hopes for phase 2 with GET

- 20 telescopes means – 2560 strips + 80 CsI channels
- Means (including spares) about :
- 60 AGET – 15 ASAD – 5 COBO – 2 MUTANT
- But preliminary test:
- Is the dynamical range and bit resolution enough?
- Do we need to use two cannels for each strip at least for front strips?
- Can you produce for us the electronics and what will be the price?
- Can we get the money from INFN?
- Can we couple the GET ACQ to CHIMERA ACQ?
- Fase 3?? Can we use GET or “upgraded-GET” to replace the old CHIMERA electronics (about 2400 channels CsI and silicon)?

Man power

- We are not too much
- For electronics:
- 1 staff engineer in Catania 3 students (Phd and postdoc levels) and some technicians no big experience in VLSI.
- Collaboration with 2 staff engineer and some students from Politecnico Milano with experience in VLSI.
- We are beginning some collaboration with Engineer department in Catania – experience on VLSI but not for nuclear physics.
- Some physicist experts in ACQ (1+1) and electronics (3 but 2 are the same of ACQ) help from some technicians.
- Available fellowships at INFN for engineers – possible collaborations with LNL expertise for SPES detector development.

Status and… coming up…!

- Farcos has a preliminary configuration allowing for experiments at LNS and other laboratories (ex. GANIL)

  ✓ Compact Preamplifiers, shapers, etc. for about 800 channels

  ✓ Limited digitalization capabilities already available

- The array is going to increase in size… need for integrated technology

  - GET solution after the front-end; new integrated front-end (GET, INFN Milan-Politecnico, …) we have to see if possible before the end of this year