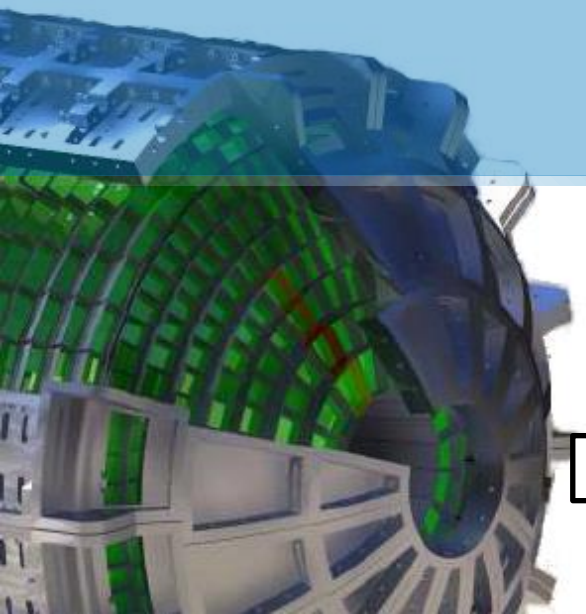
The R³B CALIFA Endcap

Design and expected performance



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CALIFA Working Group

USC-IEM-UVigo

GSI-TUM
EMMI-TUD

Chalmers
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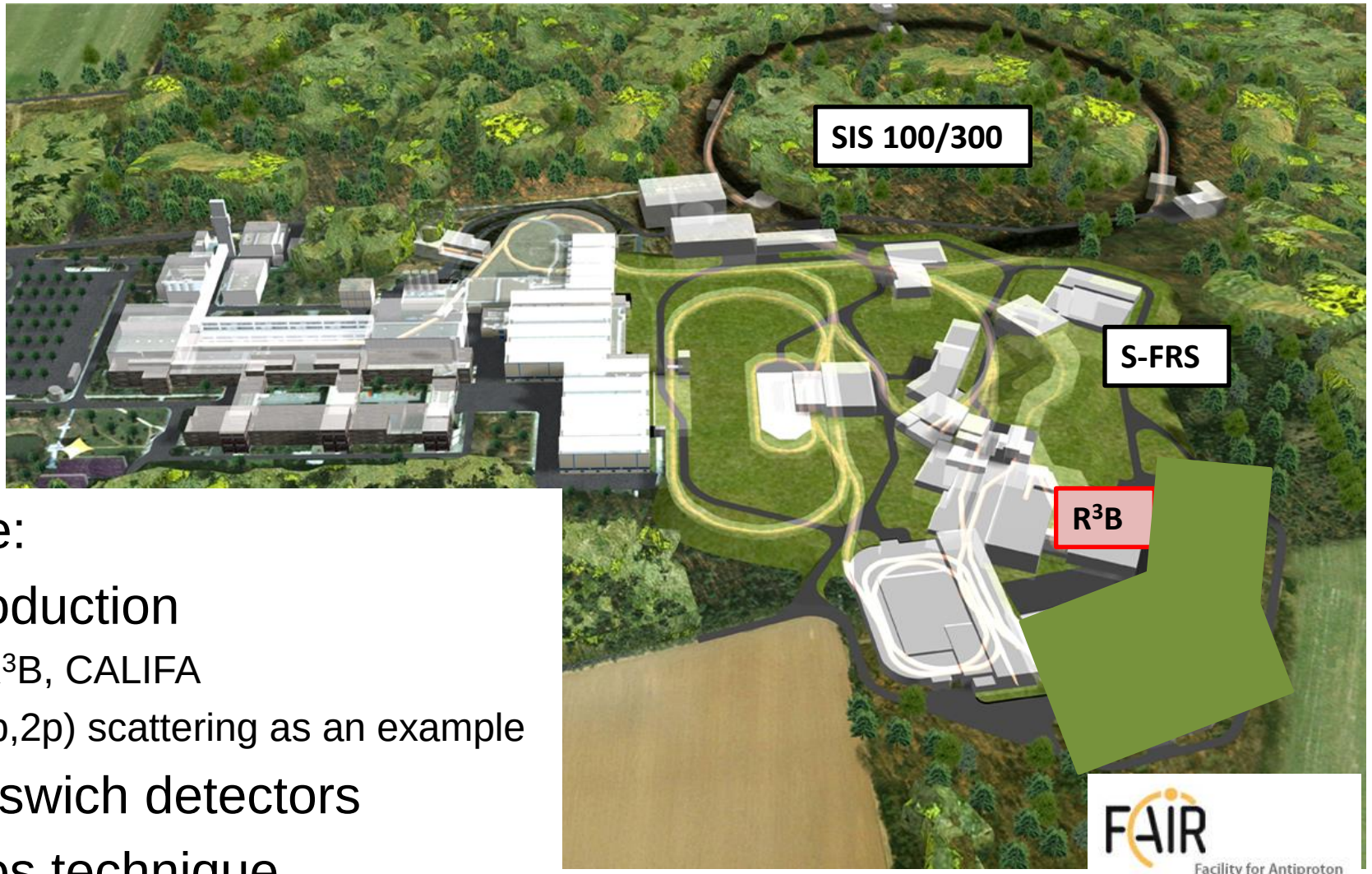
CFNUL

JINR - NRC

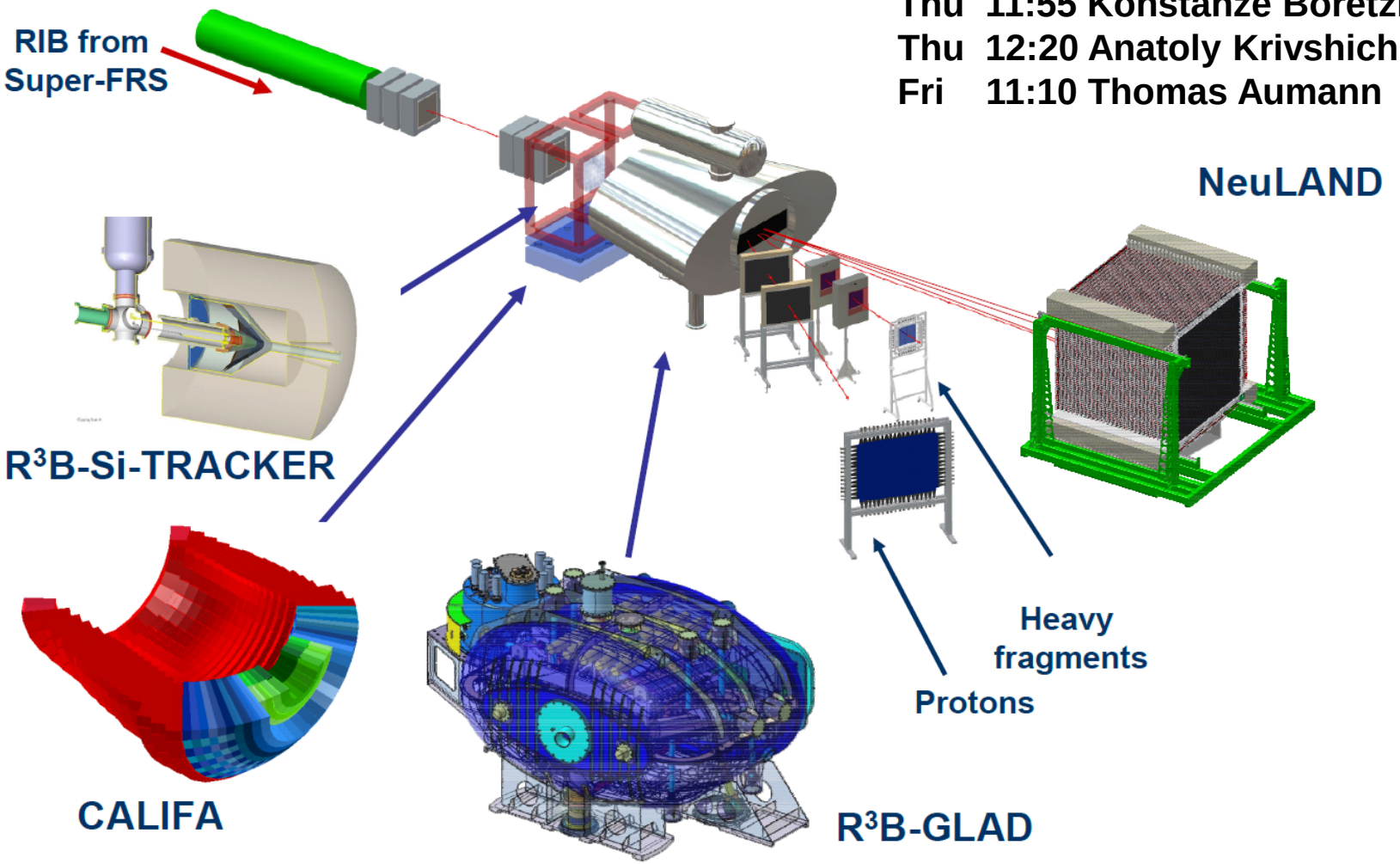
FAIR Facility for Anti-proton and Ion Research



Outline:

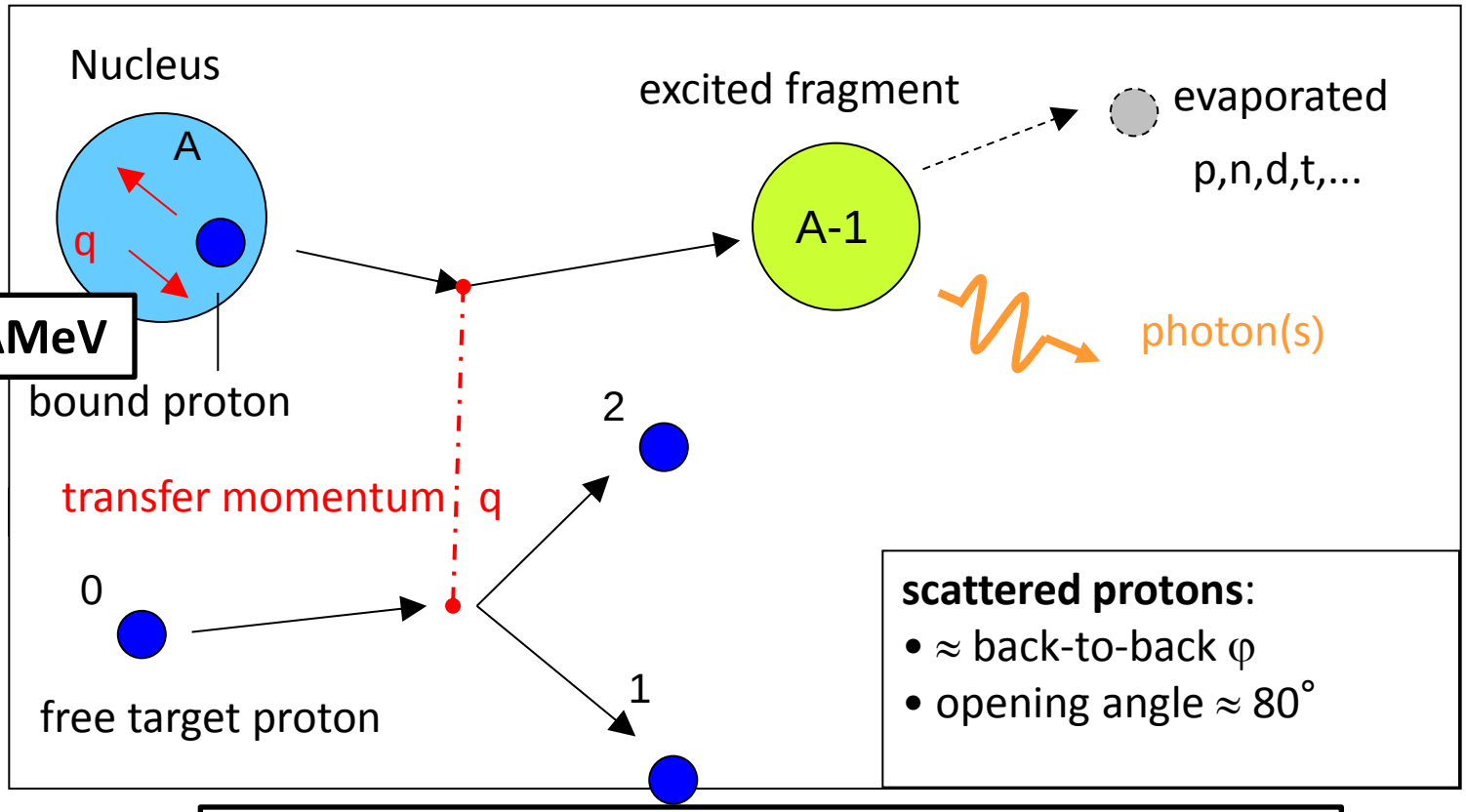
- Introduction
  - R^3B, CALIFA
  - (p,2p) scattering as an example
- Phoswich detectors
- iPhos technique
- Expected performance

Wed 12:25 Roy Lemmon
Thu 11:55 Konstanze Boretzky
Thu 12:20 Anatoly Krivshich
Fri 11:10 Thomas Aumann



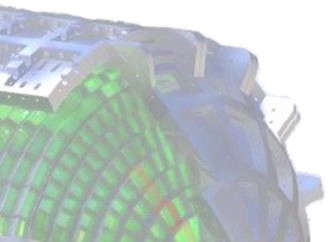
Experiment

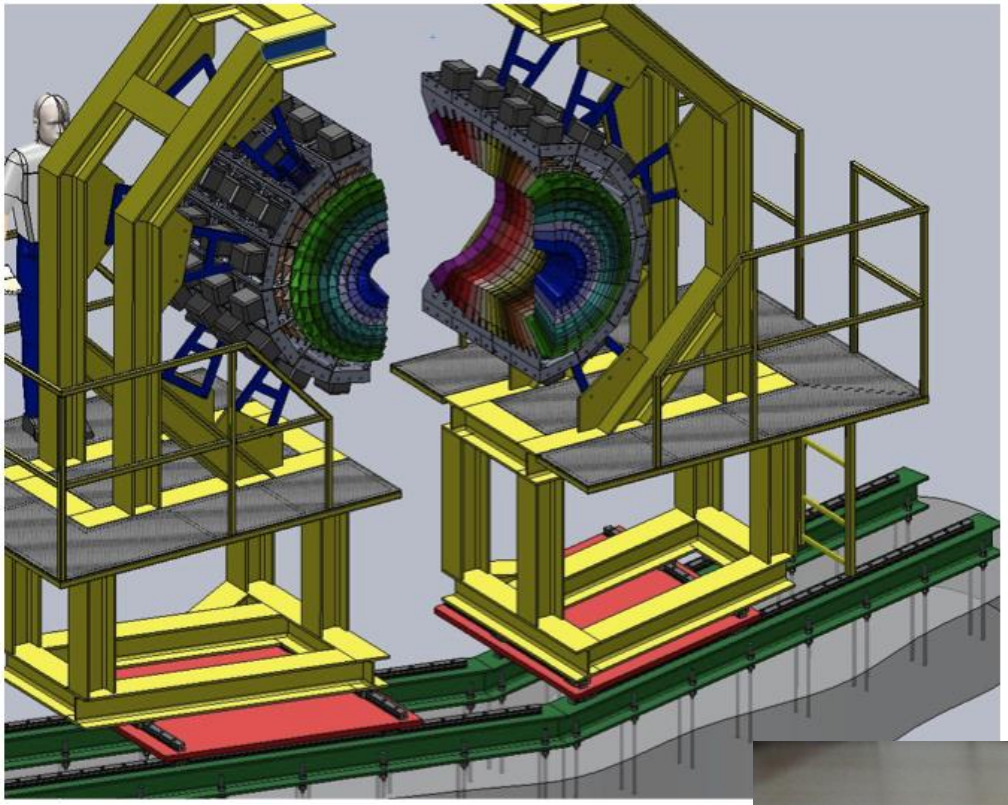
Quasi-free scattering of exotic nuclei in inverse kinematics



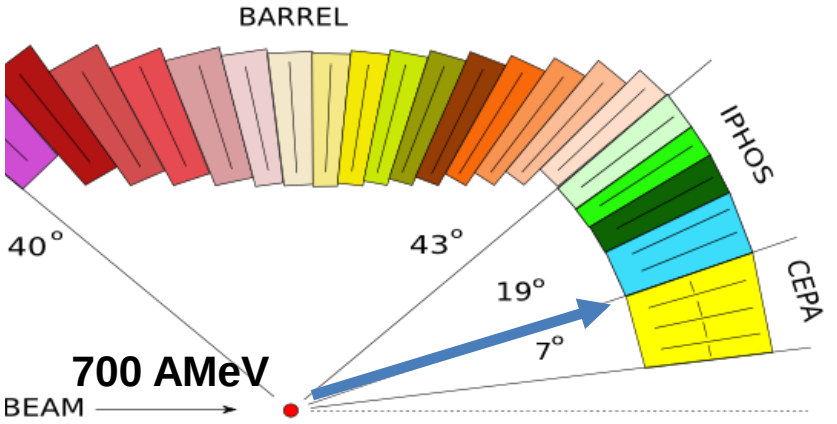
Requirements for CALIFA:

- high dynamic range
  100keV γ-rays – 700 AMeV charged particles
- high efficiency
- high granularity -> Doppler correction
- particle identification

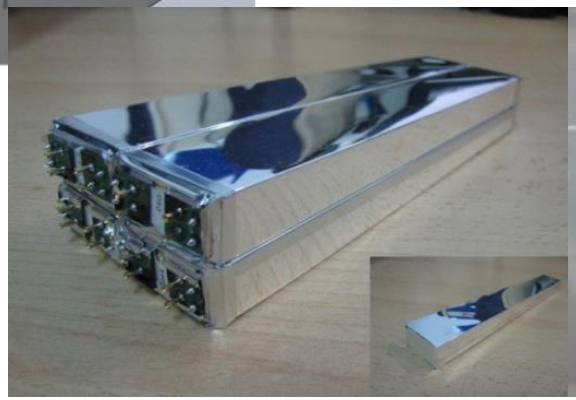


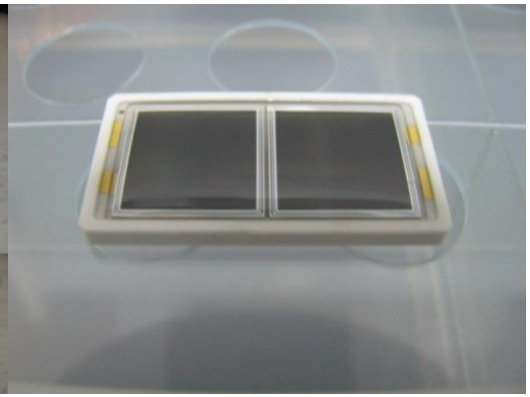


CALorimeter for In Flight detection of γ-rays and charged pArticles.



large solid angle
maximum efficiency
good resolution
easy access to target area





The Combined Concept

IPHOS
Intrinsic Phoswich Detectors

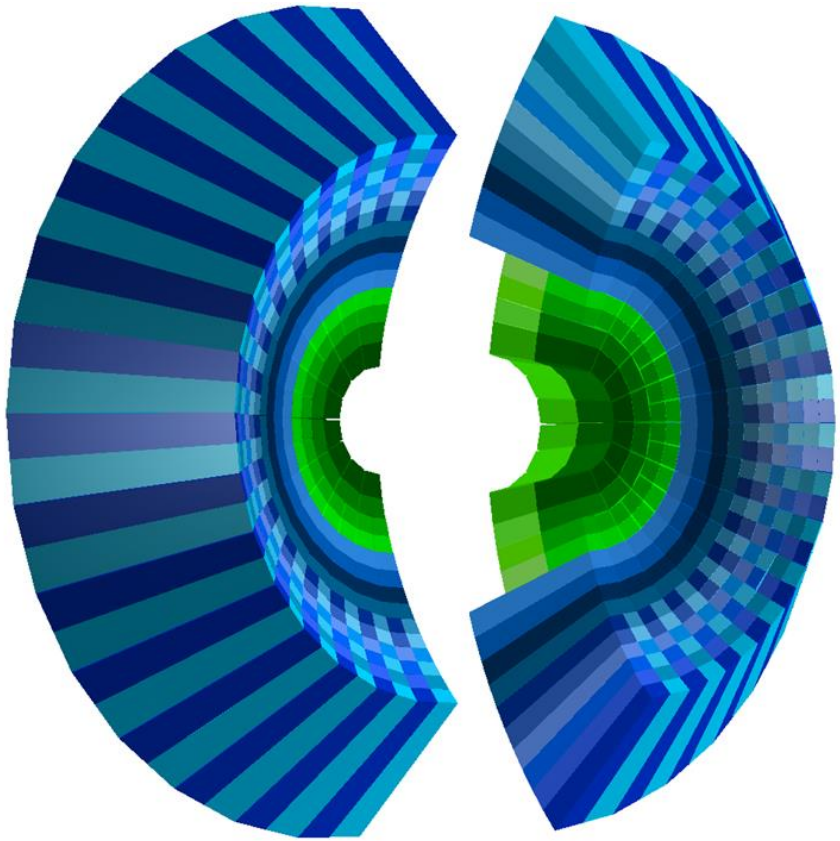
CEPA
Califa Endcap Phoswich Array

ΔE -> E
separate reactions

QFS @ 700AMeV

θ (°)	E_p (MeV)	Proton range(mm) in CsI(Tl)
7	686	718
15	637	645
20	592	597
30	480	421
40	356	264

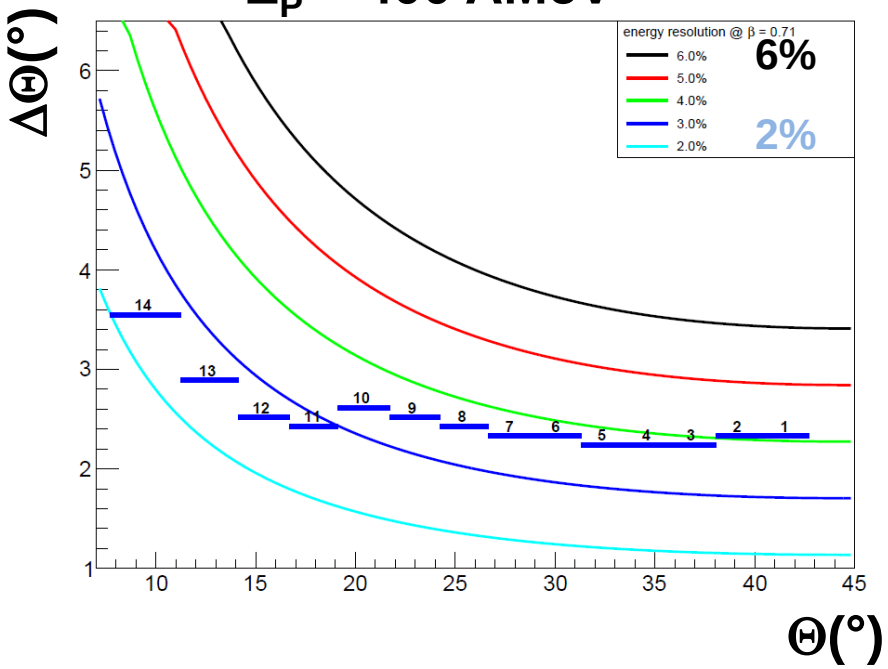
eff.
15%
..
50%



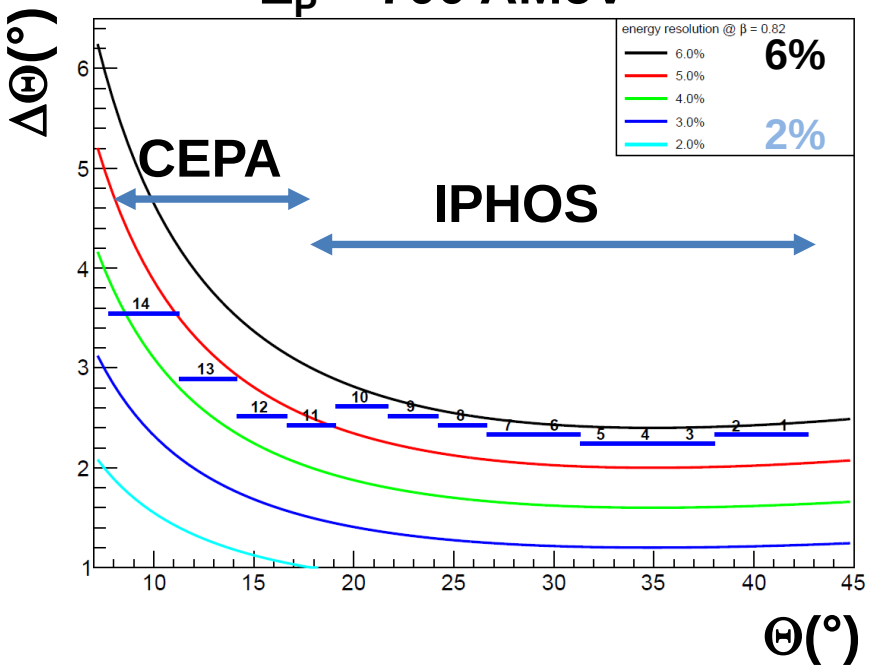
length limit 22cm:
- **geometrical space,**
- **light collection**
- **crystal properties**
- **efficiency and cost**

Segmentation and Doppler Broadening

E_P = 400 AMeV



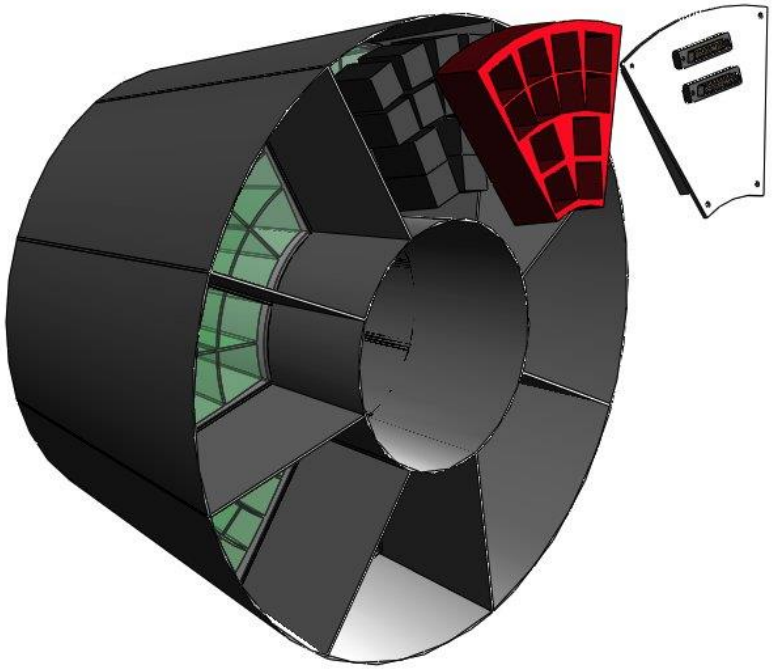
E_P = 700 AMeV

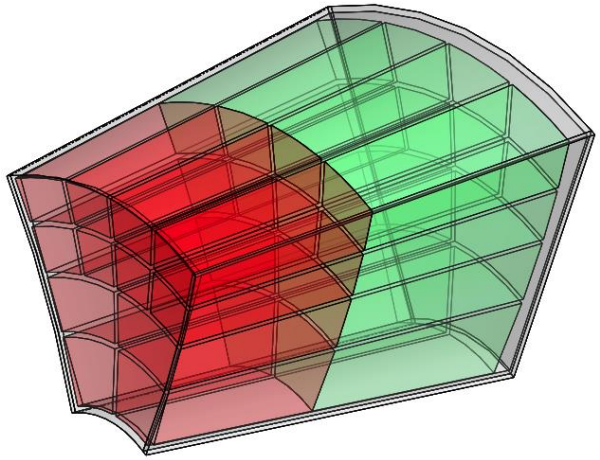


balance :

- **doppler broadening** ↑
- **rate /mult. capability** ↑
- **intrinsic resolution** ↓
- **calorimetric properties** ↓
- **costs** ↓
- **…..**

CEPA - the Phoswich Part

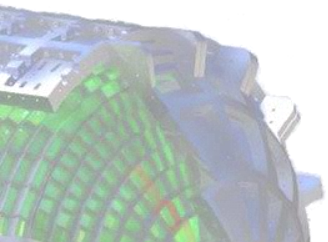




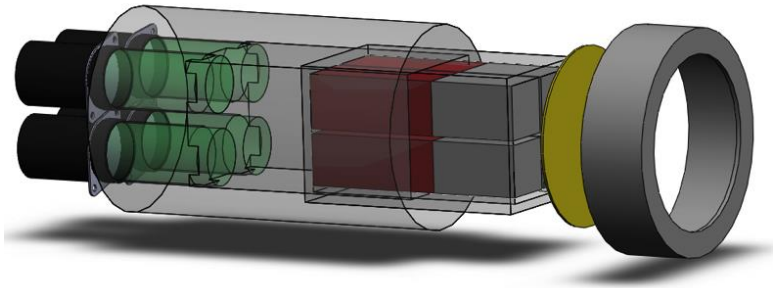
2 scintillators
1 readout
optical comp.

- **high rate capability**
- **best resolution**
- **high light yield**
- **depth information**
- **redundant ΔE for particles**

Materials	ΔE/E (% at 662 keV)	Light yield (photons/ keV)	Decay time (ns)	$\lambda_{emision}$
$LaBr_3$	2.9	63	16	380 nm
$LaCl_3$	3.8	49	28	350 nm



CEPA4: a bigger phoswich array

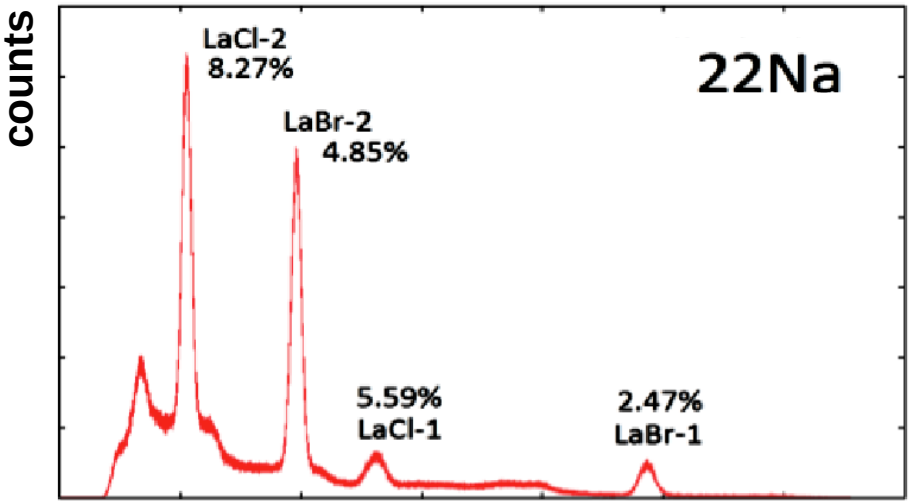


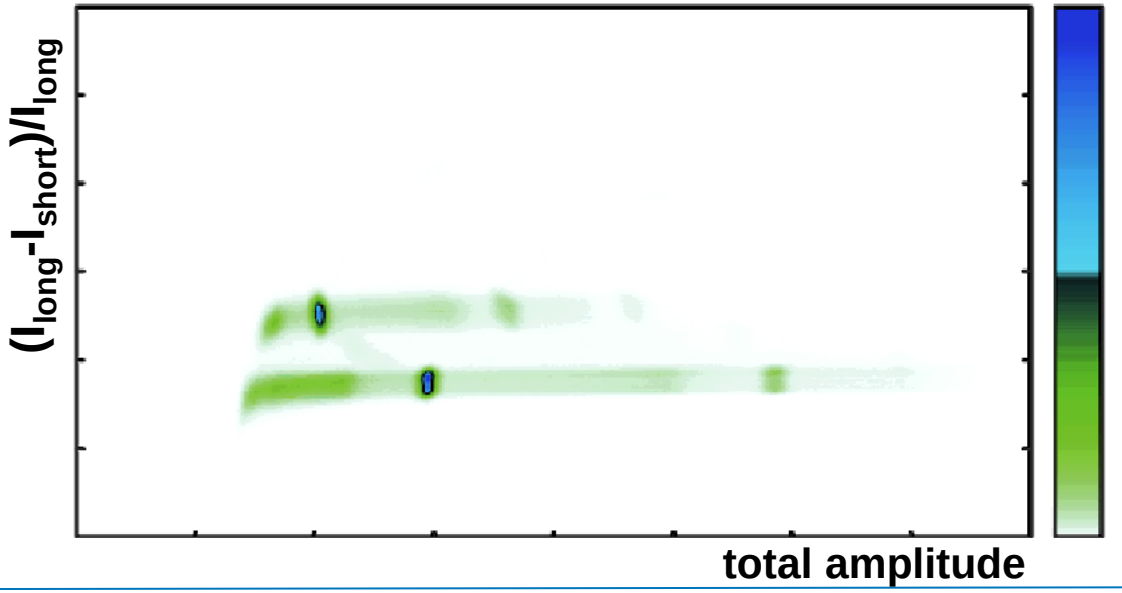
60mm $LaCl_3$

40mm $LaBr_3$

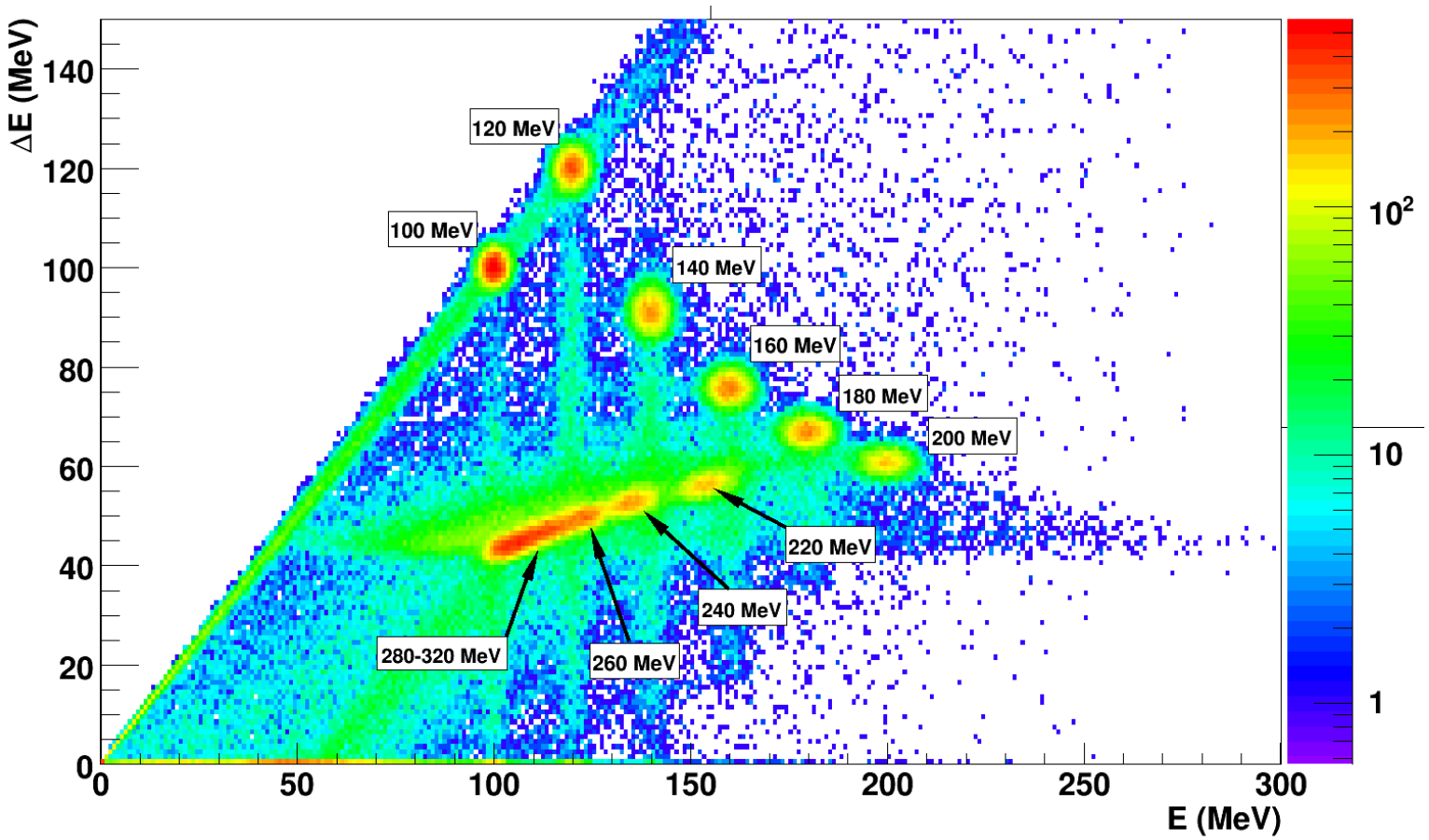
2 crystals with different light yield & different decay time with common readout

VME CAEN Flash ADC (V1742) to digitize the signals



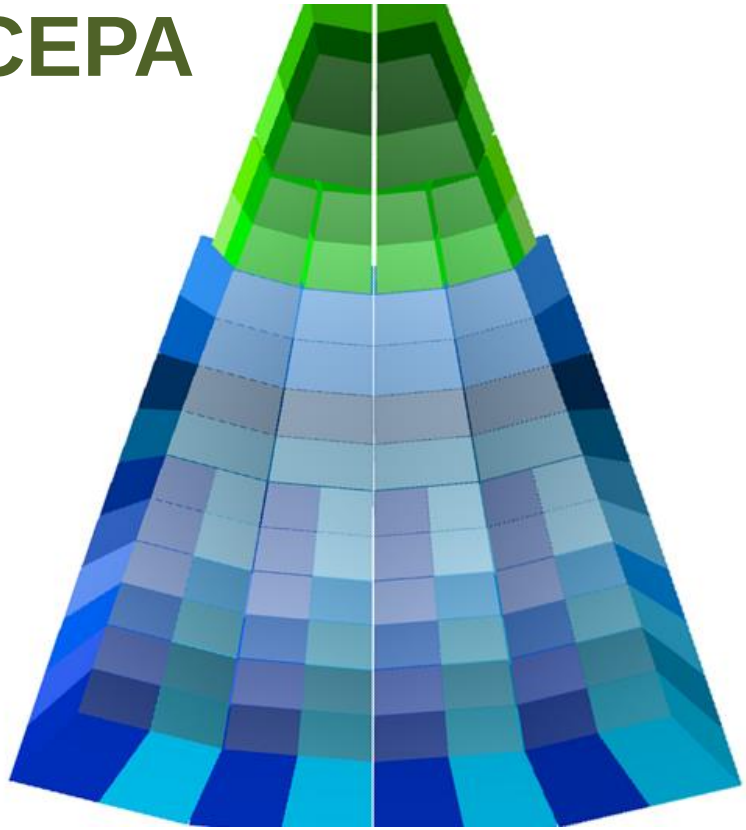


Reconstruct Proton Energy



IPHOS - CsI(Tl)

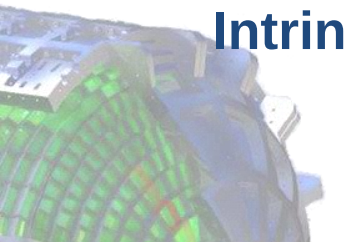
CEPA

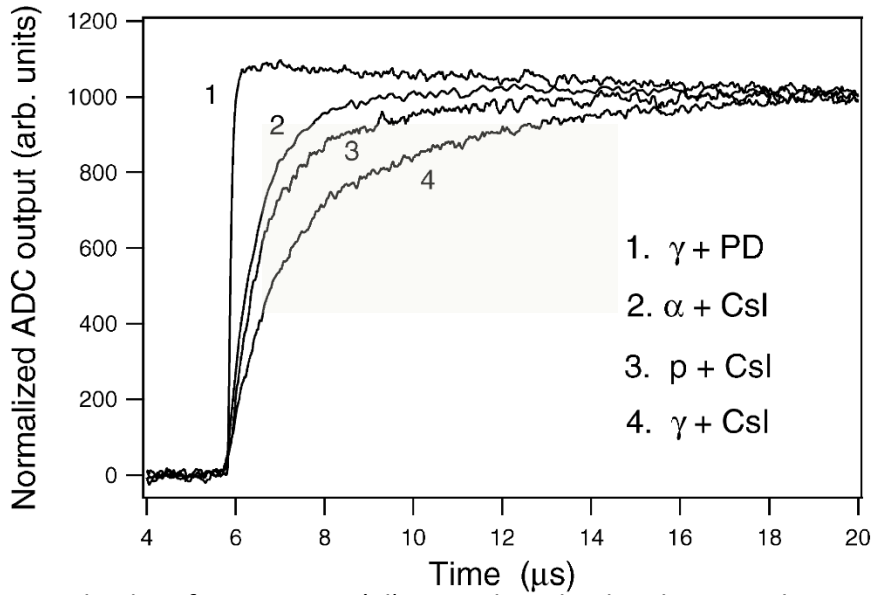


Inner radius	41 cm
Numb. of crystals	608
Diff. crystal geometries	18
Crystal volume (CsI(Tl))	$\approx$ 90.020 cm^3
Crystal weight (CsI(Tl))	$\approx$ 408 kg
Crystal volume ($LaBr_3/LaCl_3$)	$\approx$ 10.700 cm^3
Crystal weight ($LaBr_3/LaCl_3$)	$\approx$ 47 kg
Full operation system weight	$\approx$ 1100 kg

IPHOS

Intrinsic Phoswich array





Particle identification in CsI(Tl) using digital pulse shape analysis – W. Skulski, M. Momayezi, NIM A 458, (2001) 759-771

RPID particle identification

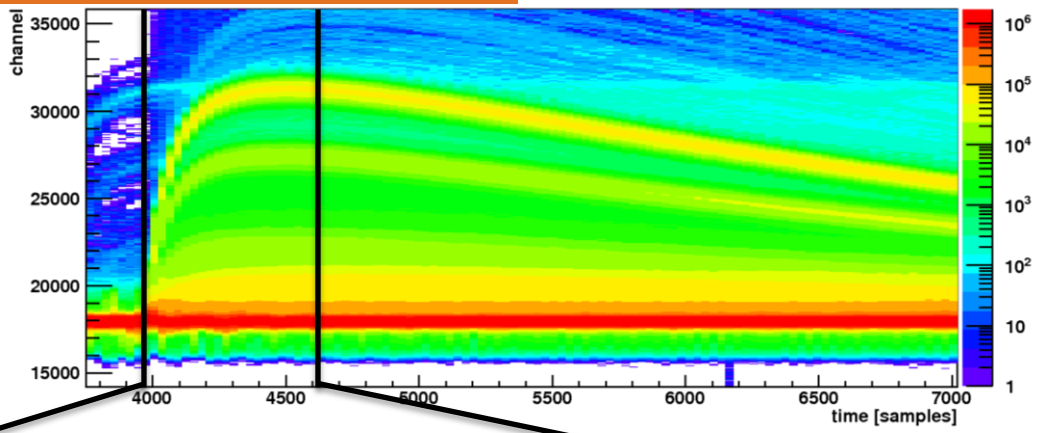
$$U_{ADC} = \int_0^t [F\exp(-\frac{t'}{\tau_f}) + S\exp(-\frac{t'}{\tau_s})] \quad \exp(-\frac{t-t'}{\tau_{Pream}})dt'$$

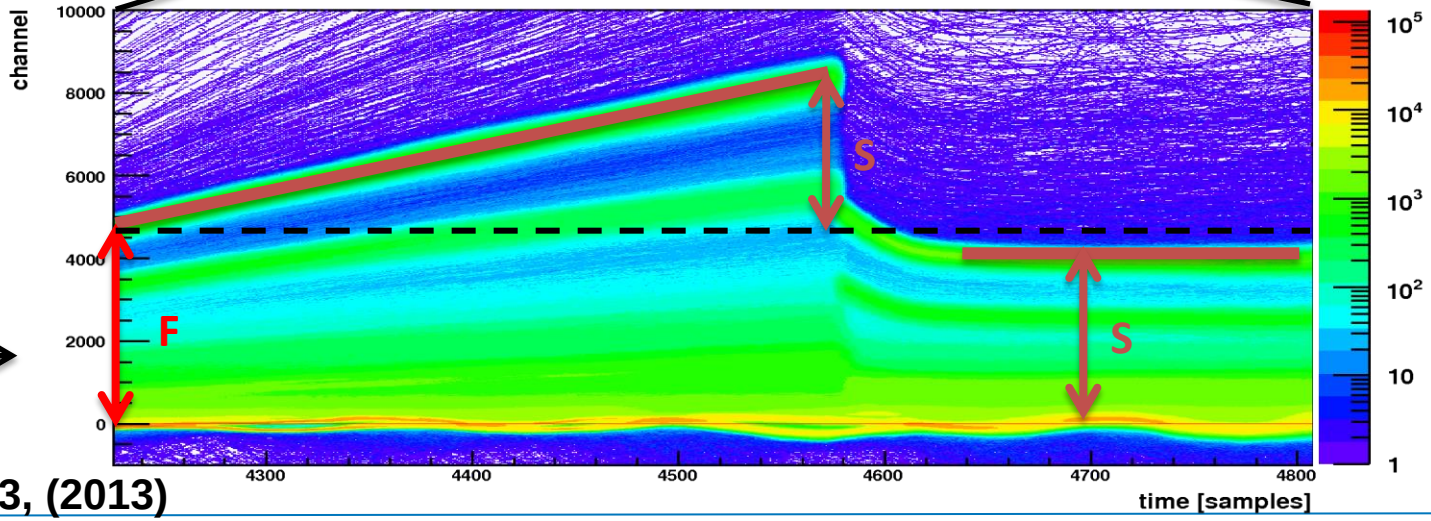
MWD

Differentiation

$$\frac{1}{\exp(-\frac{t}{\tau_s})}$$

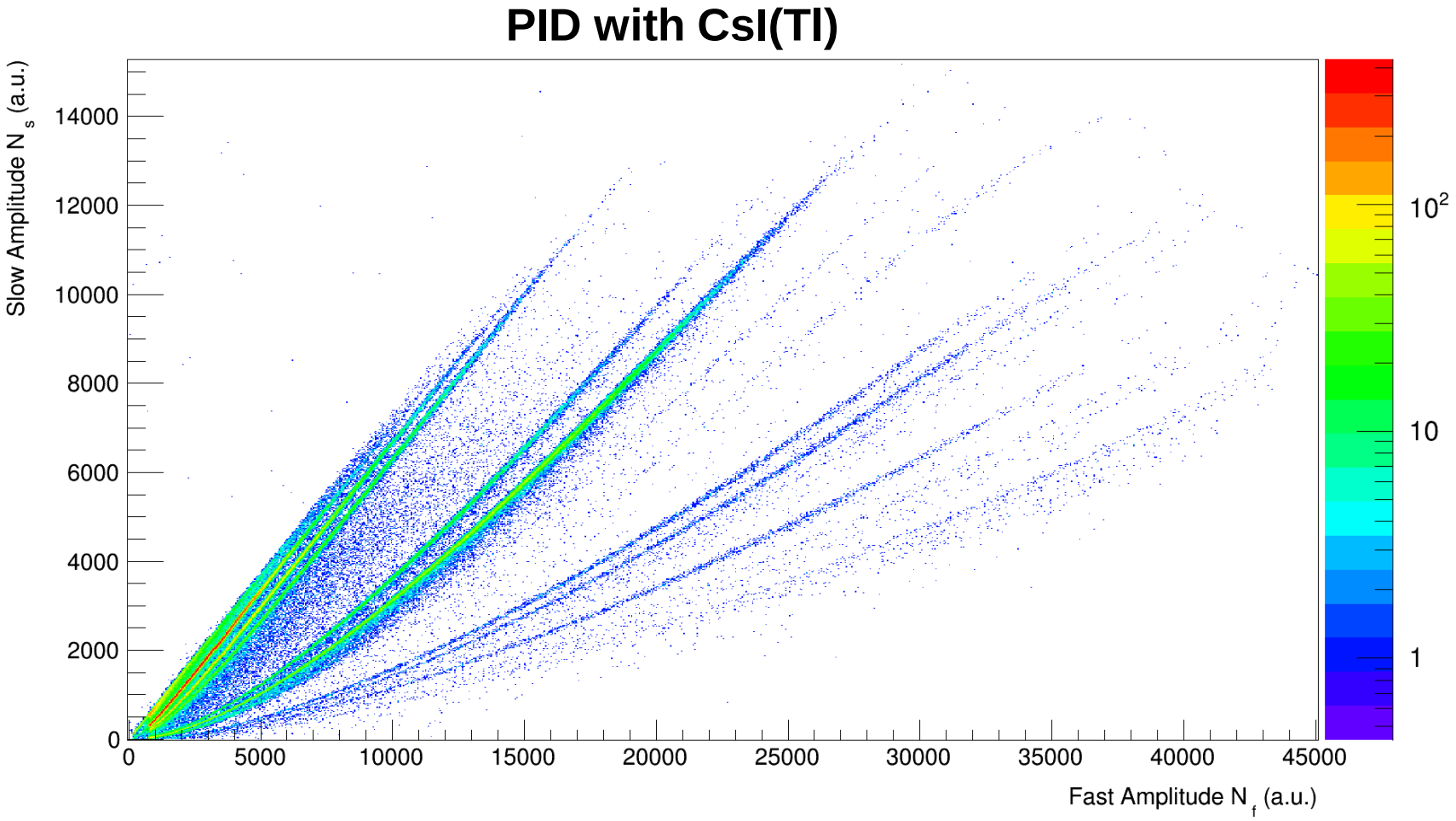
MWD





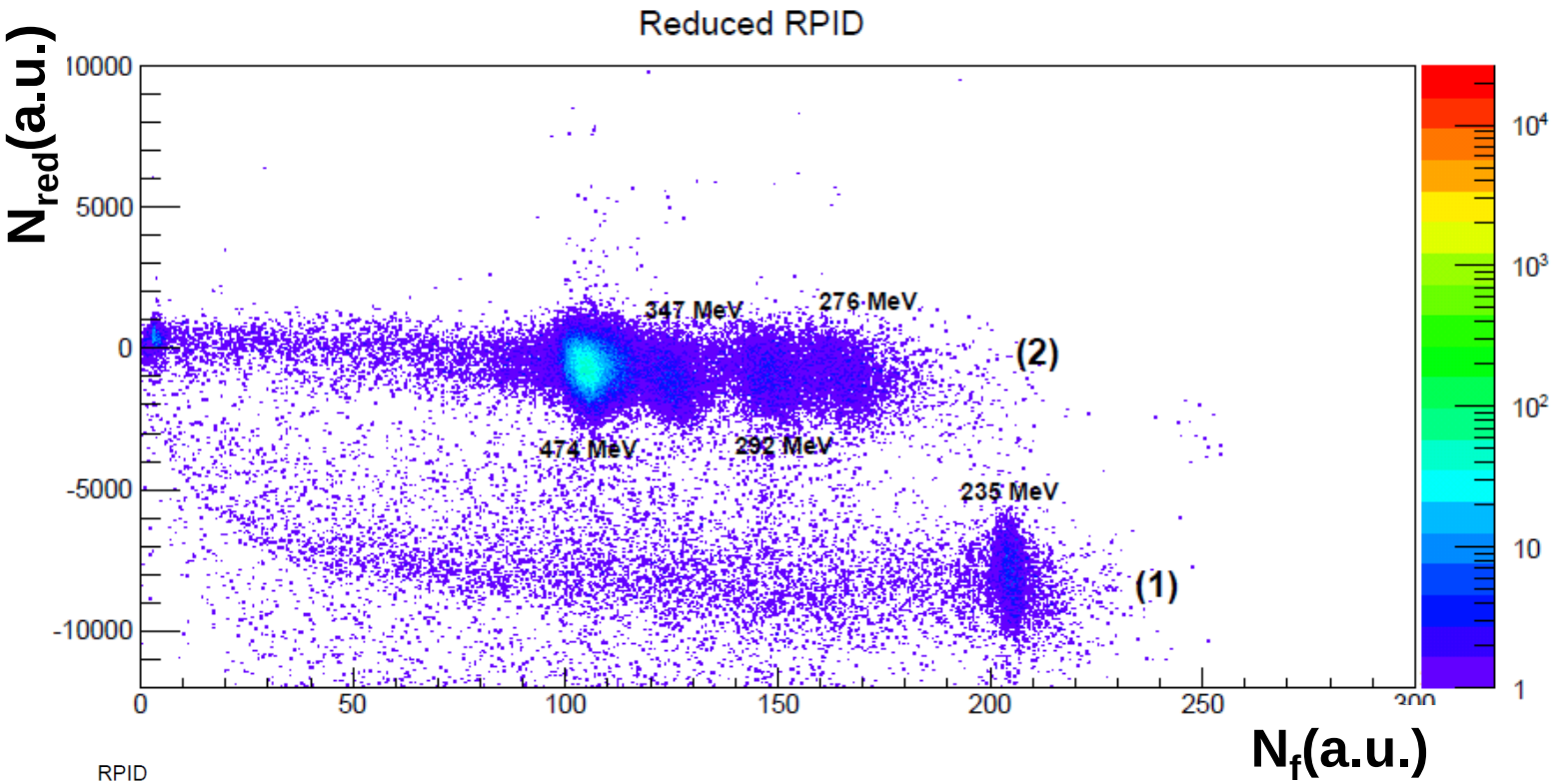
M. Bendel, RG, EPJA 63, (2013)

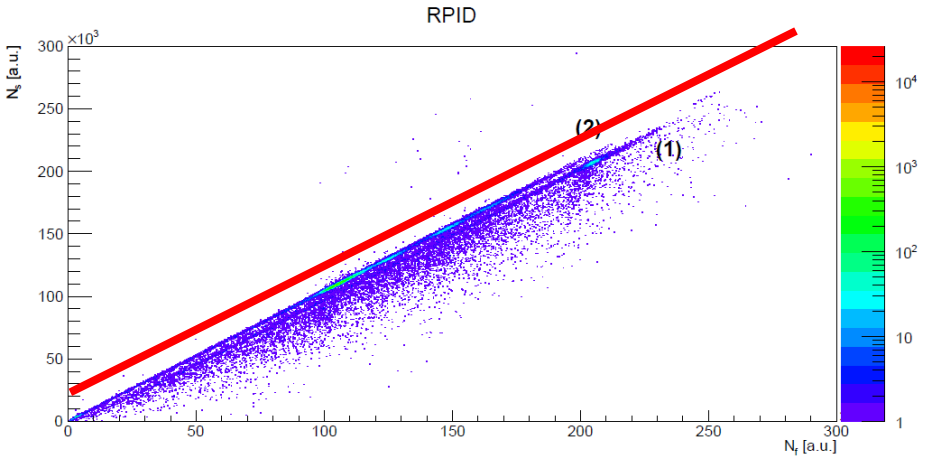
p(^{12}C,X) p‘ @ 80 AMeV (LNS, Catania, Italy)

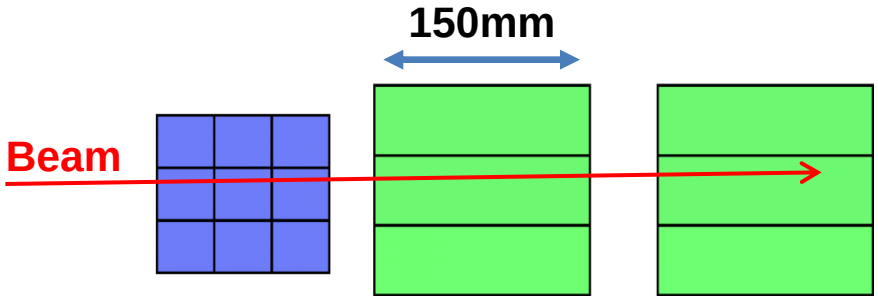


Nf / Ns depends on the ionization density?

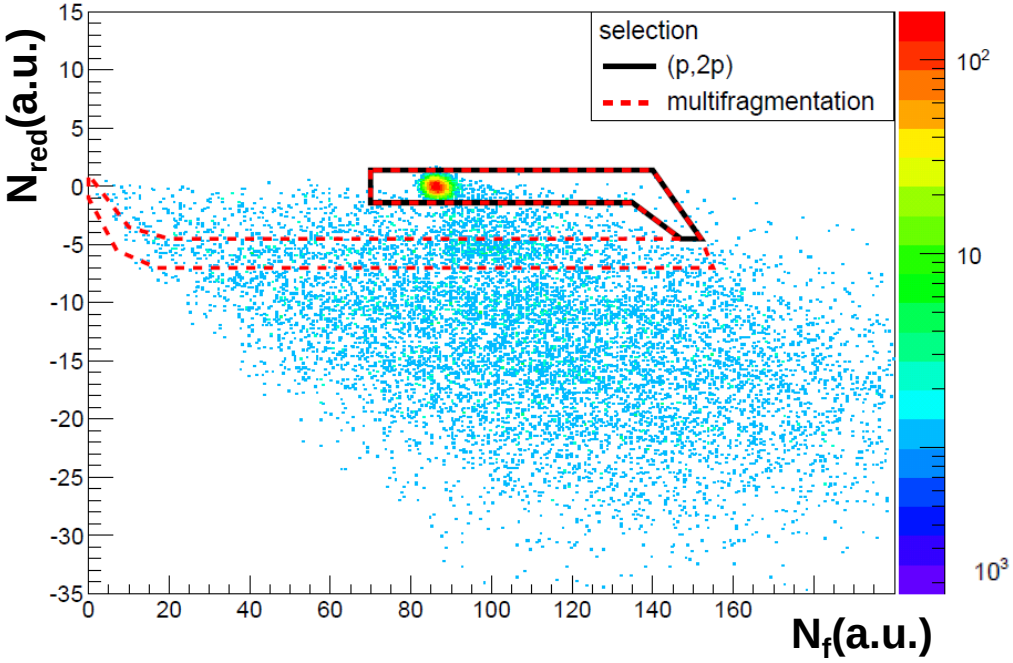
474 MeV Protons @ TRIUMF





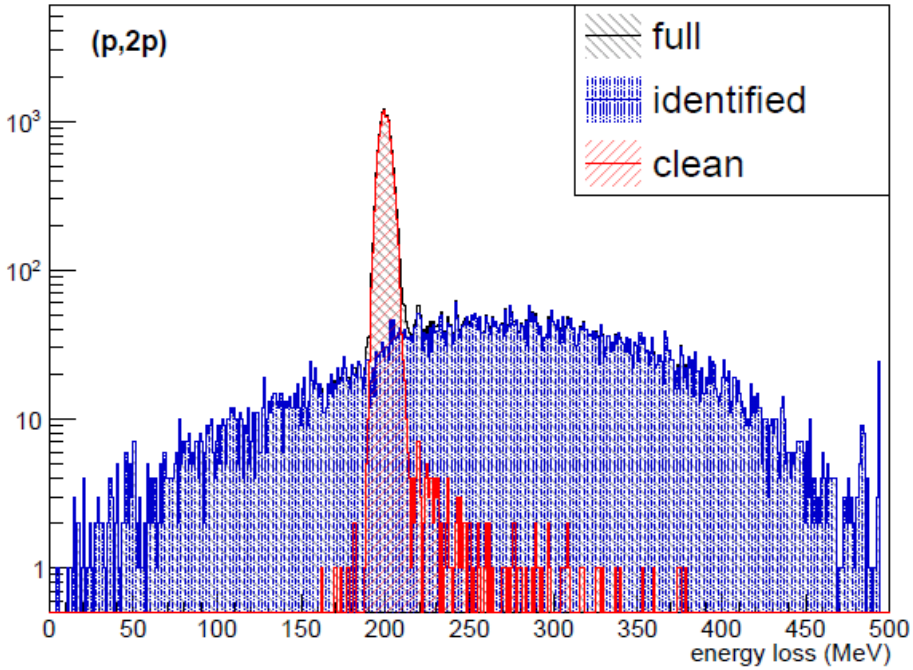


Select Reactions



Protons @500MeV

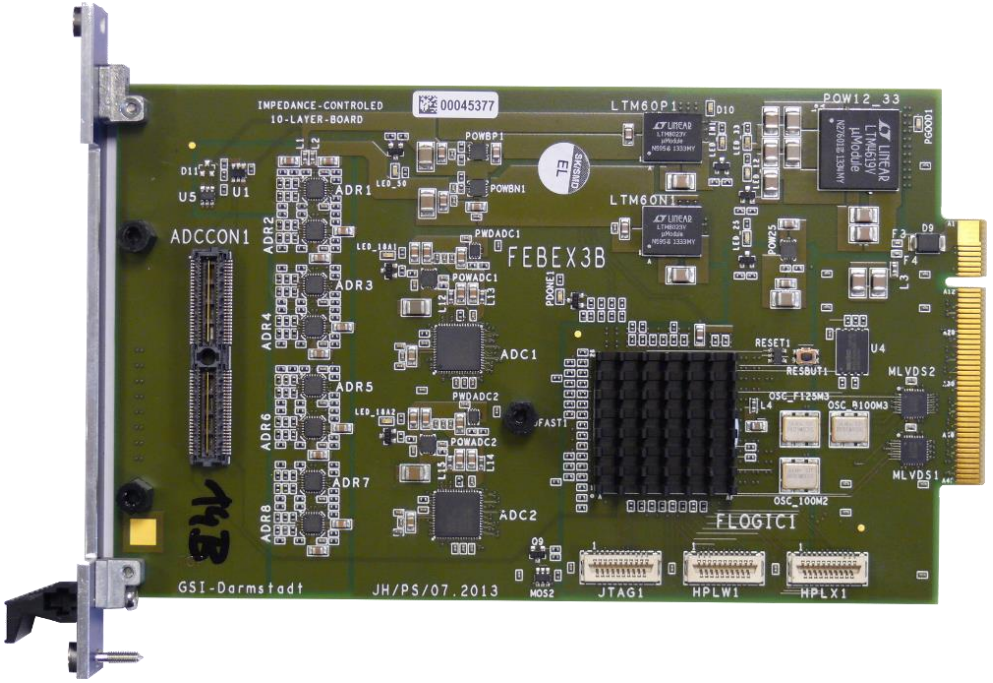
- **50% reactions (25cm)**
- **large background**
- **low (p, 2p) efficiency**



GSI FEBEX Readout

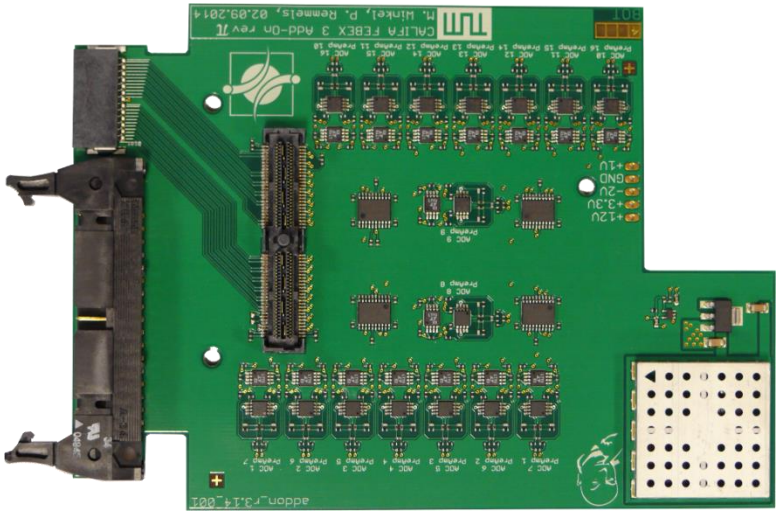
FEBEX3B:

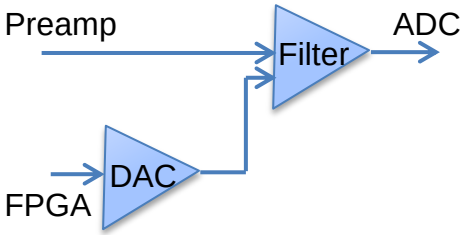
- ADC, 16 ch, 14 Bit, 50 MHz
- Lattice ECP3 150 FPGA
- Timestamp synchronization
- Programmable via GOSIP



FAB_ Addon:

- Digital to Analog converter for programmable baseline offset
- 25 MHz Bessel Nyquist filter

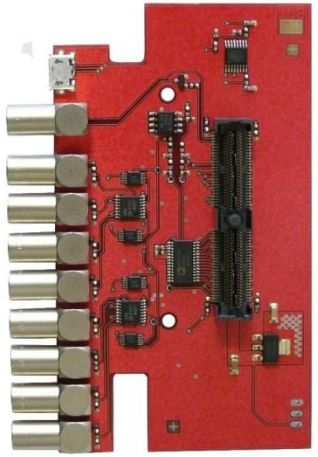


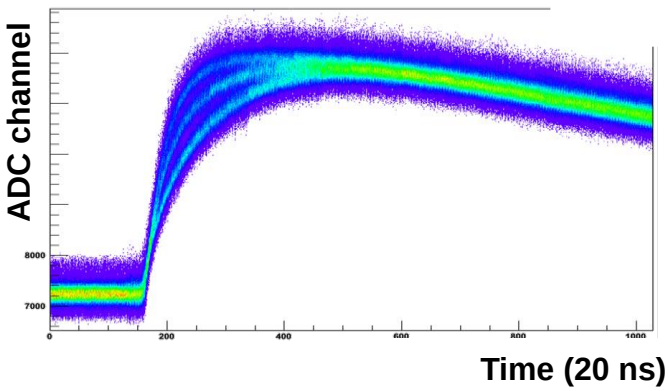


Add On Boards

Digital Pulse Generator

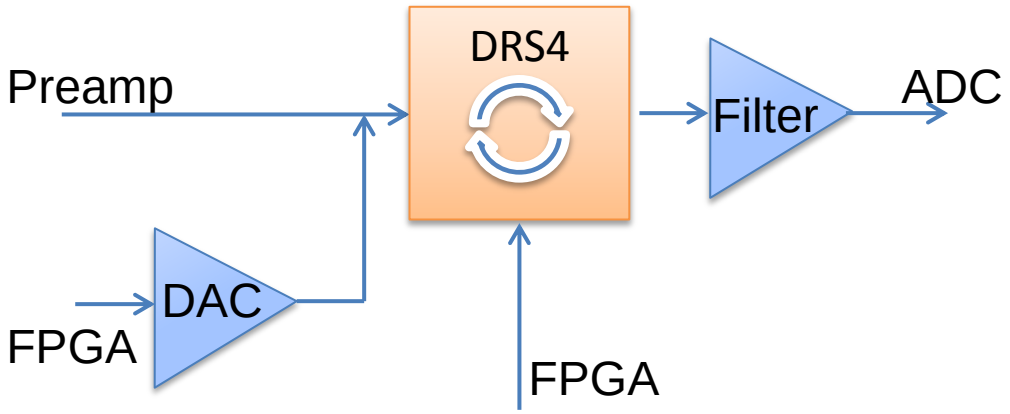
- 210 MS/s, 14 bit DAC
- 2-pole low-pass filter
- 8 channel analog multiplexer
- CsI(Tl) pulse form with adjustable PID
- controlled via USB or GOSIP
- generates DAQ trigger and SC event

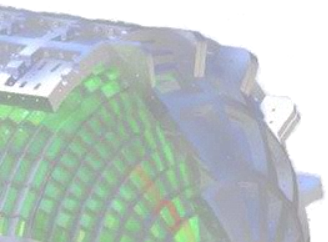




SCA Add-On Board

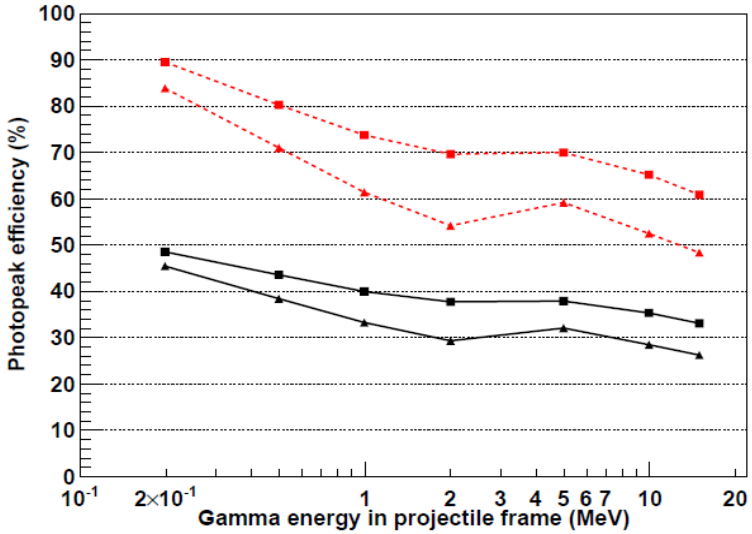
- Switched capacitor array
  (analog ringbuffer)
- PSI DRS4:
  Up to 5 GHz sampling
  33 MHz read out rate



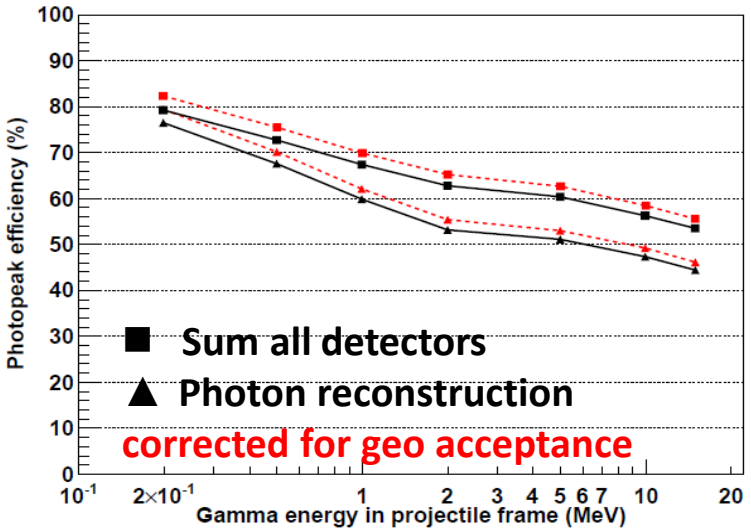


Photopeak Efficiency

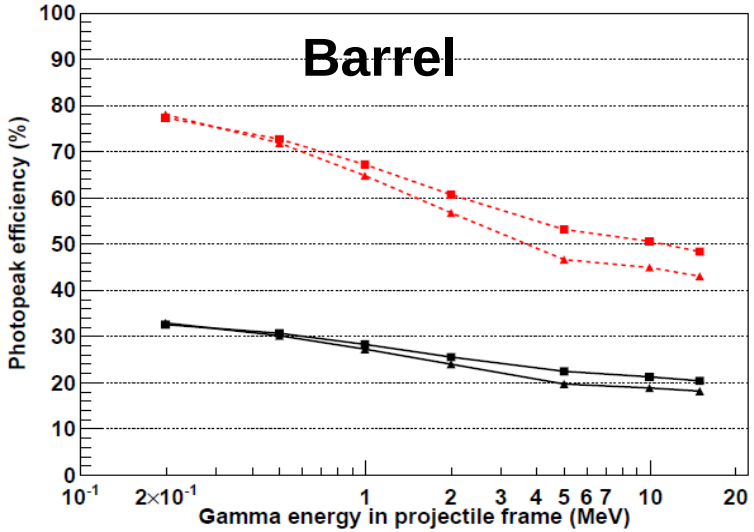
Endcap



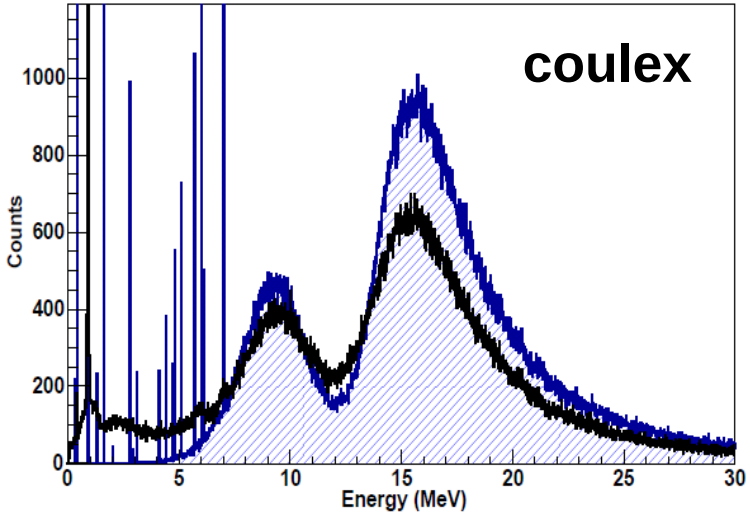
Califa Barrel + Endcap



Barrel

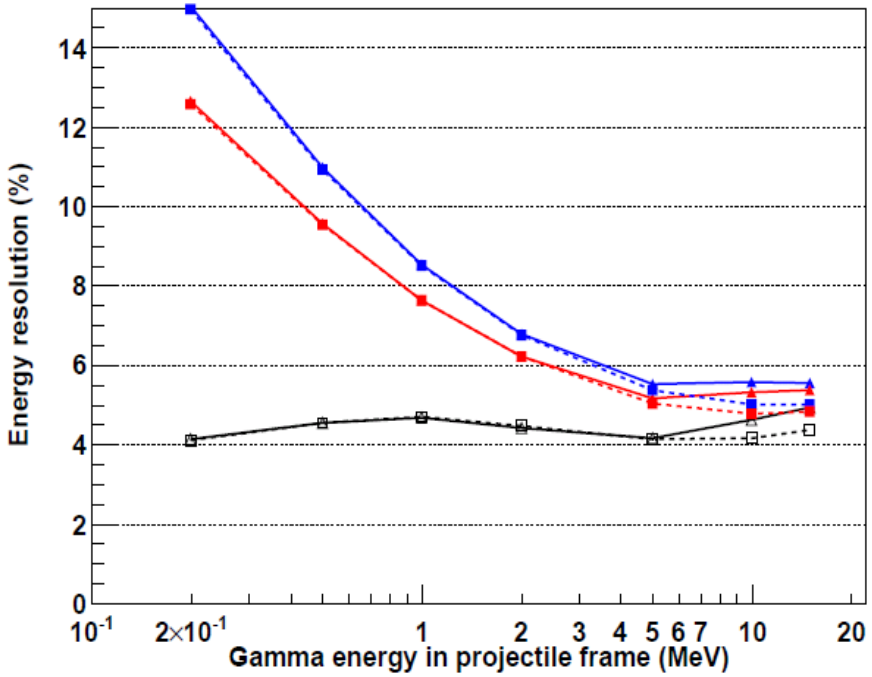


coulex

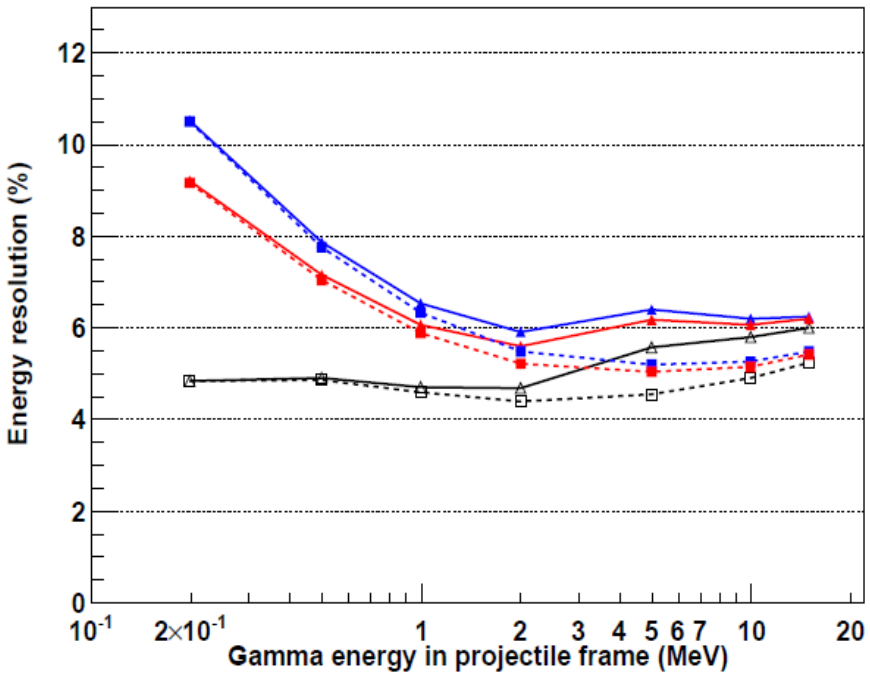


Energy Resolution

Barrel



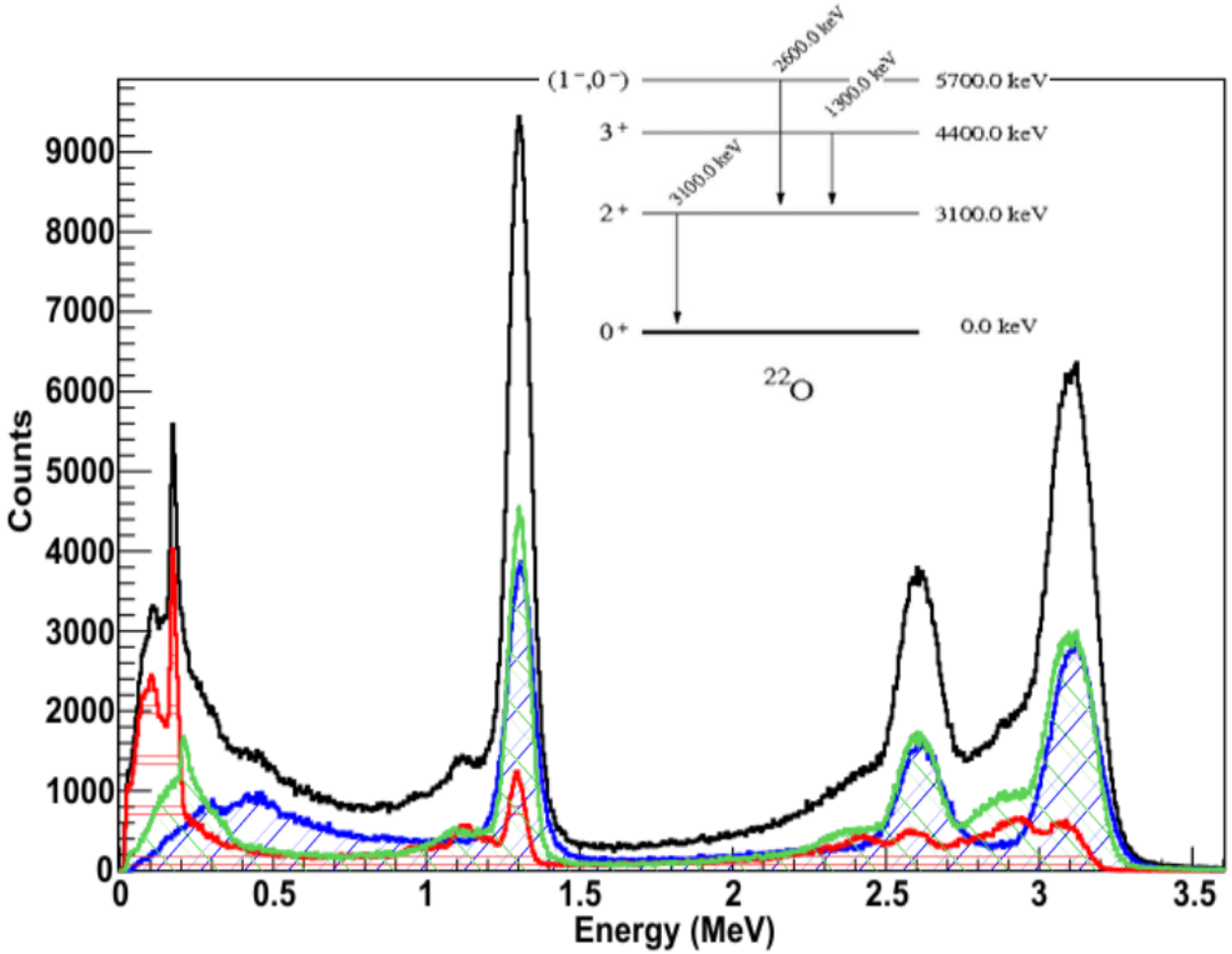
Endcap



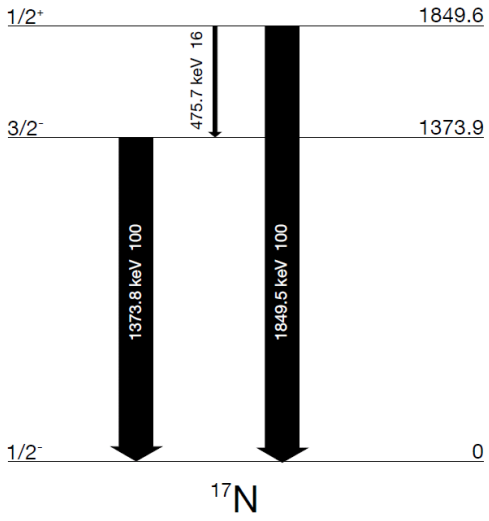
β = 0.82, projectile frame
perfect detectors
5% CsI(Tl) resolution
6% CsI(Tl) resolution @ 1MeV

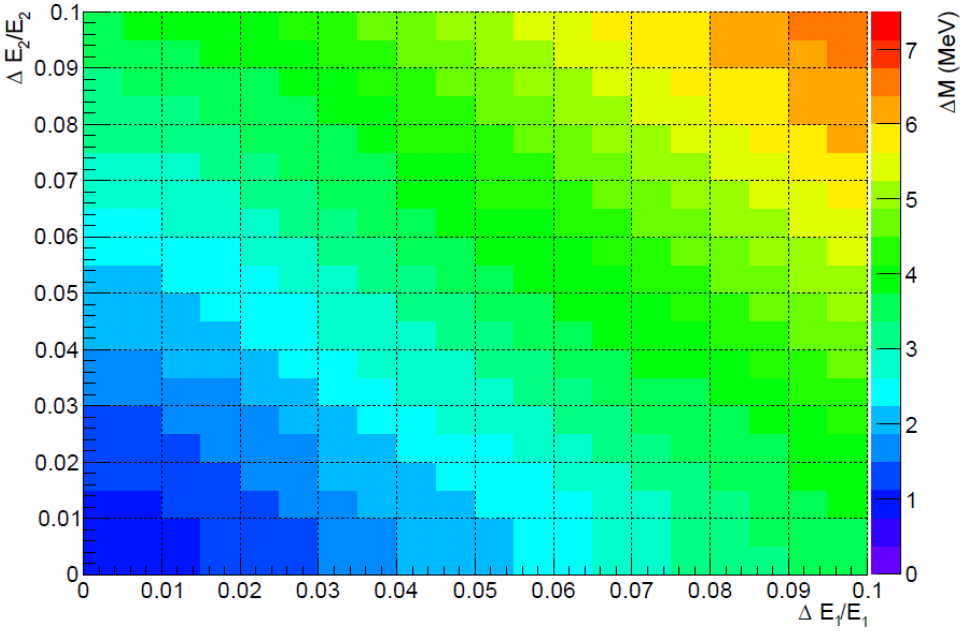
γ-ray Spectroscopy

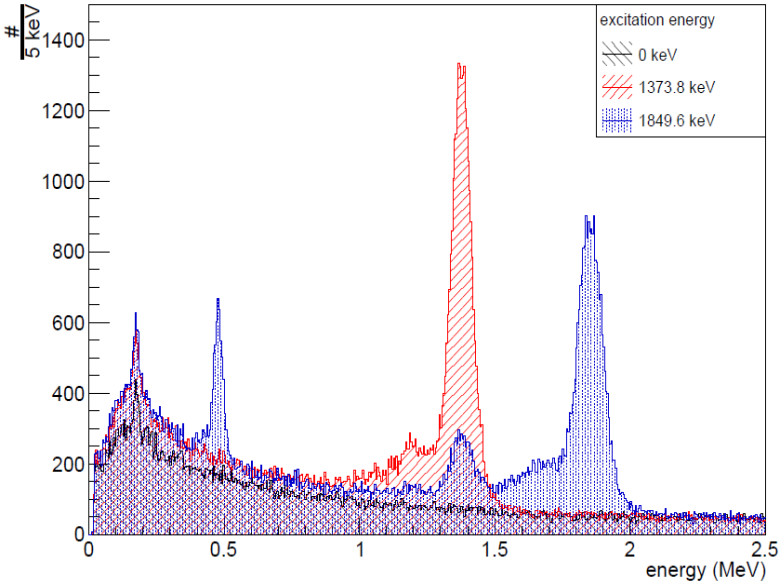
One Neutron Knockout from ^{23}O

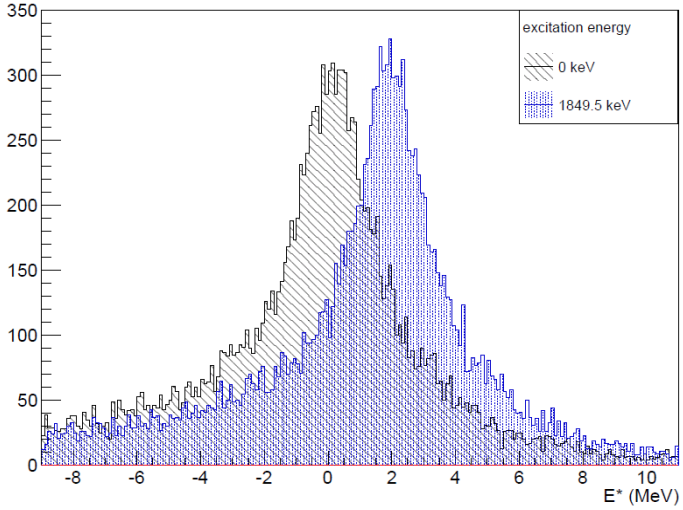


$^{18}O(p,2p)^{17}N$


1/2+
1849.6
475.7 keV 16
3/2-
1373.9
1373.8 keV 100
1849.5 keV 100
1/2-
0
17N


Δ E2/E2
Δ E1/E1
ΔM (MeV)

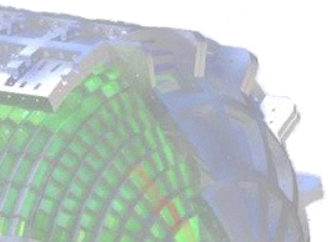

excitation energy
0 keV
1373.8 keV
1849.6 keV
/ 5 keV
energy (MeV)


excitation energy
0 keV
1849.5 keV
E* (MeV)

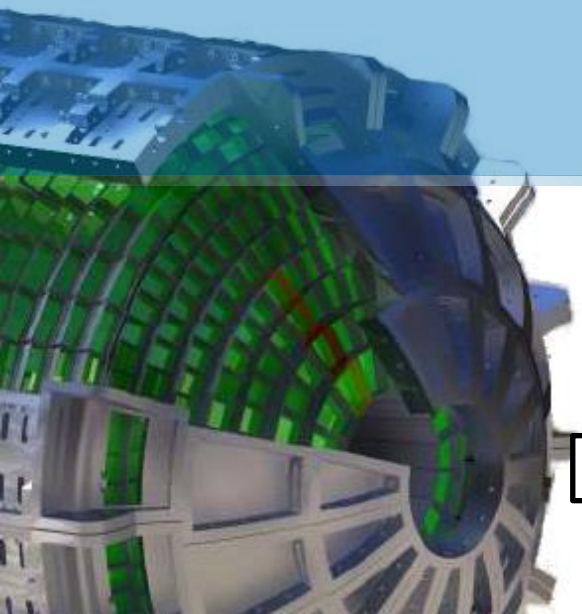
Summary & Outlook

- Very good efficiency up to 15MeV
- 6% resolution above 1MeV
- iPhos method for reconstruction of high energy particles proven
- CEPA Demonstator successfully tested

- TDR for the CALIFA Endcap handed in Nov. 2014
- start construction in 2015
- setup and commissioning 2017
- day-0 experiments in 2018



Thank you very much for your attention



CALIFA Working Group

USC-IEM-UVigo

GSI-TUM
EMMI-TUD

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