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Front end electronics for the Advanced Implantation Detector Array (AIDA) detector in DESPEC at NUSTAR

Presented by Ian Lazarus

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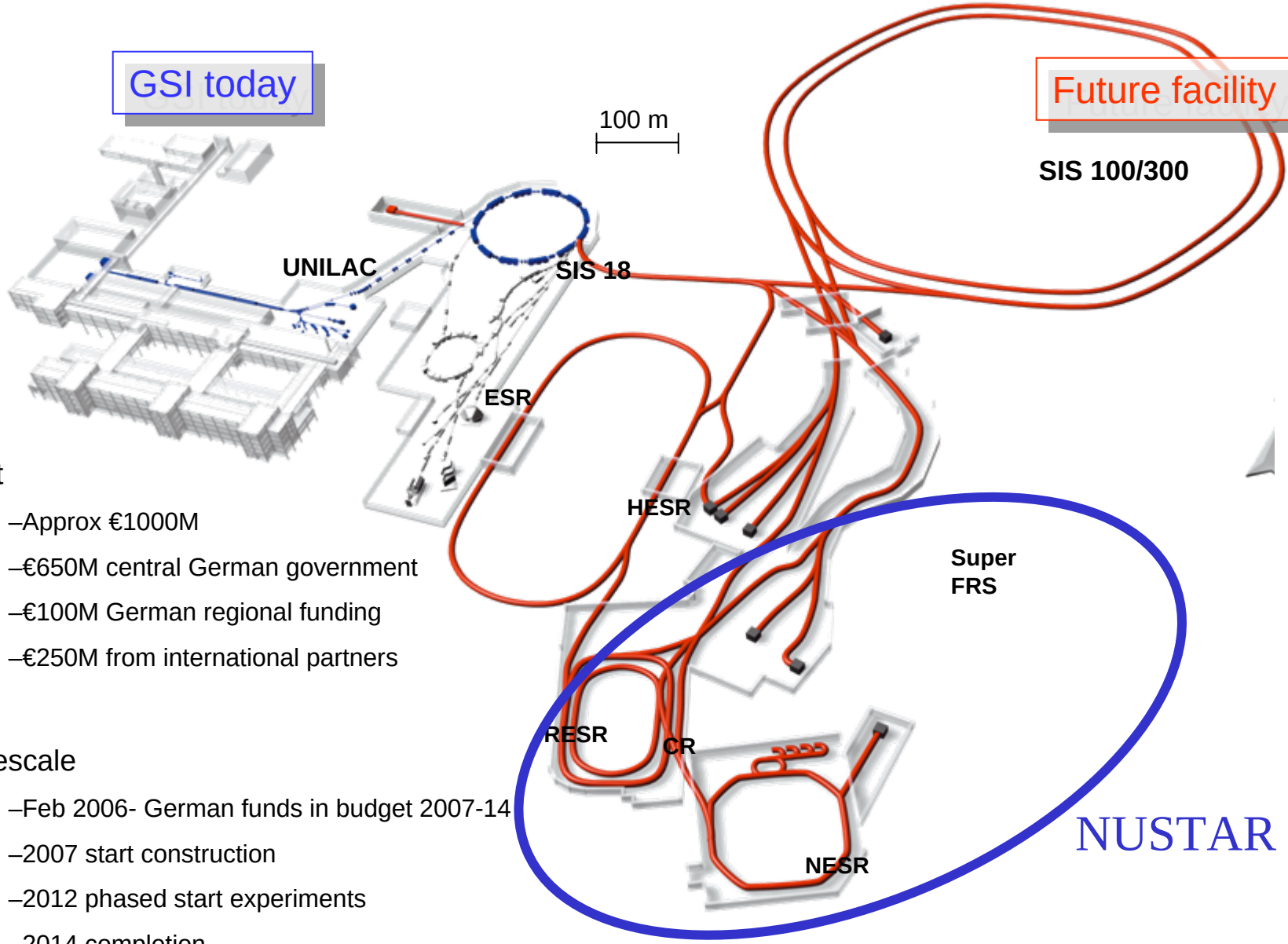
FAIR - Facility for Antiproton and Ion Research



- Cost
  - –Approx €1000M
  - –€650M central German government
  - –€100M German regional funding
  - –€250M from international partners
- Timescale
  - –Feb 2006- German funds in budget 2007-14
  - –2007 start construction
  - –2012 phased start experiments
  - –2014 completion

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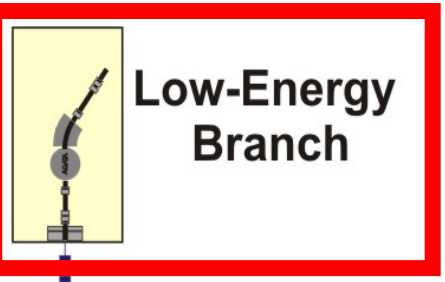
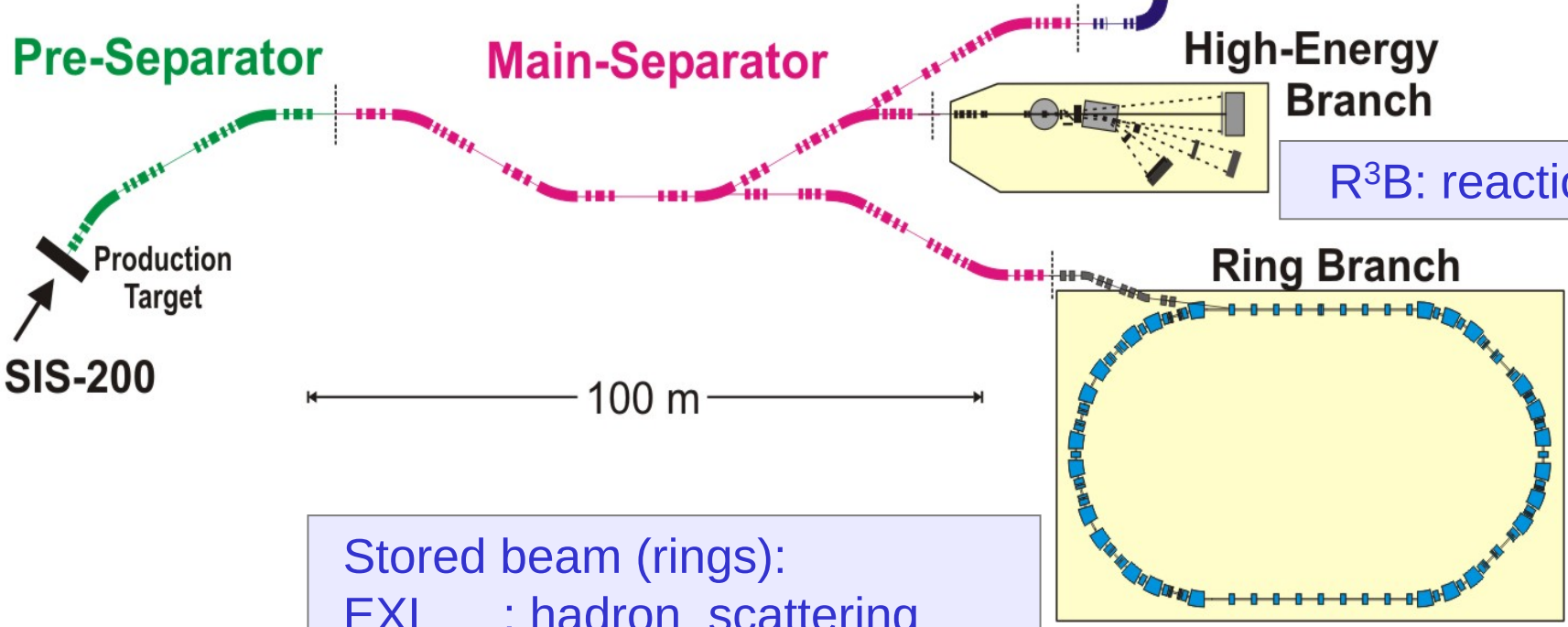
The NUSTAR facility (NUclear STructure Astrophysics and Reactions)

Exotic (radioactive) beams formed by fragmentation, selected by separator.

HiSpec :gamma spec
DeSpec :decay spec
LASPEC: laser spec
MATS: Penning traps





R^3B: reactions

Stored beam (rings):
EXL : hadron scattering
ELISe : electron scattering
AIC : antiproton scattering

NUSTAR Low energy branch

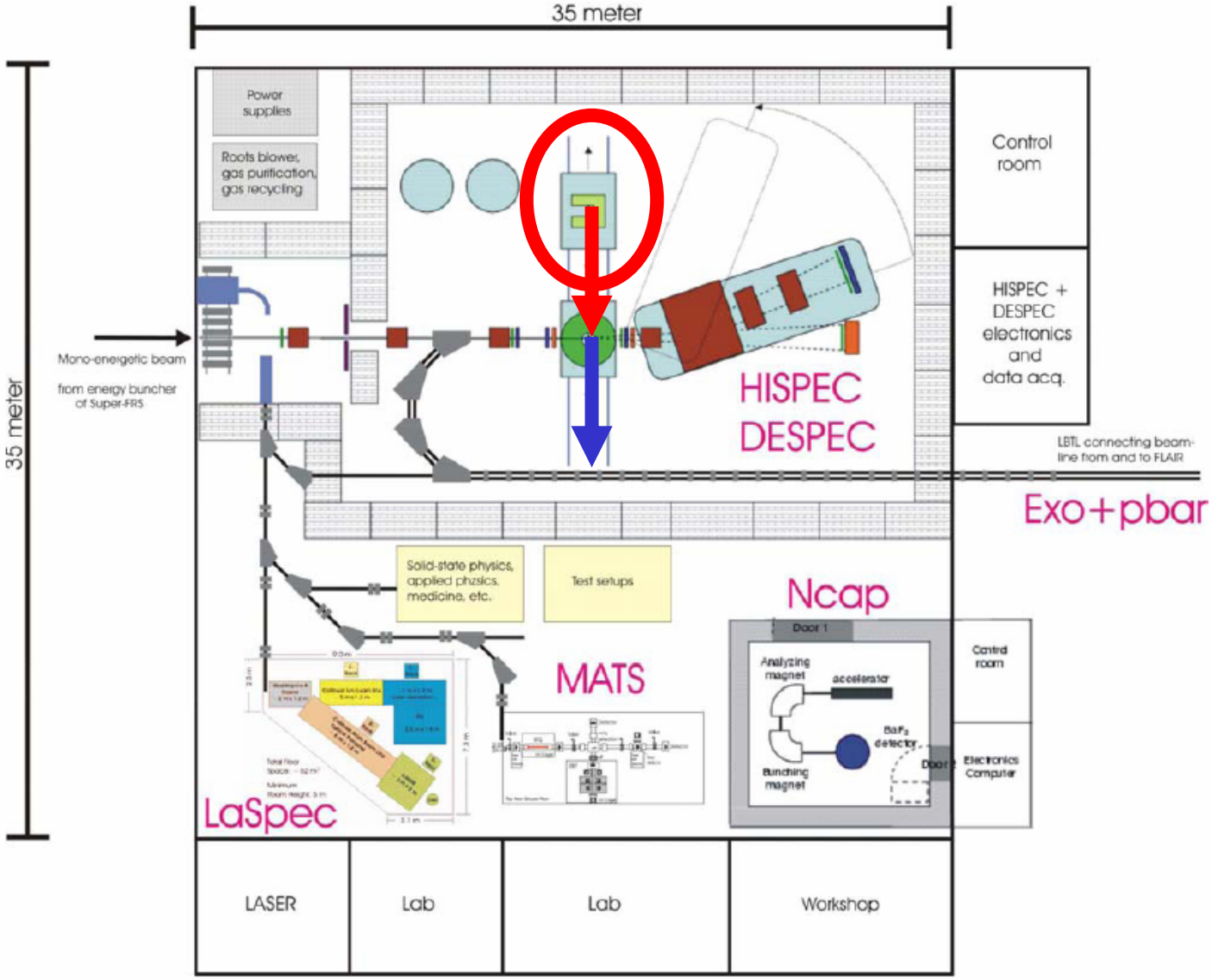
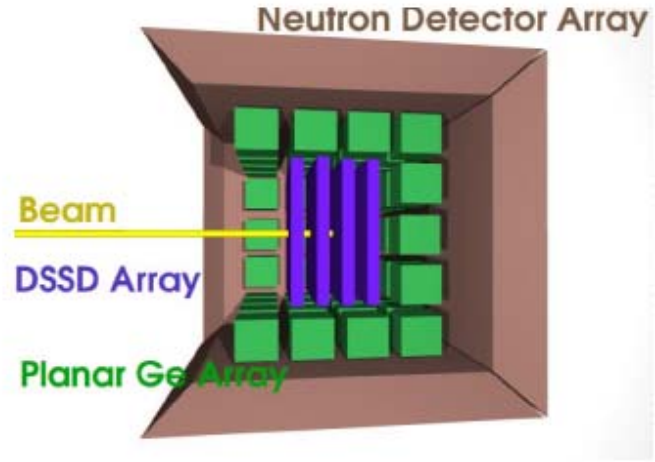


Fig. 1 Overview of the experimental area of the Low-Energy Branch

AIDA for DESPEC- the concept

Advanced Implantation Detector Array (AIDA)



- Super FRS Low Energy Branch (LEB)
- Exotic nuclei – energies ~50-150MeV/u
- Implanted into multi-plane DSSD array
- Implant - decay correlations
- Multi-GeV DSSD implantation events
- Observe subsequent p, 2p, α, β, γ, βp, βn … decays
- Measure half lives, branching ratios, decay energies …
- DSSD segmentation ensures average time between implants for given x,y quasi-pixel >> decay half life to be observed.
- Implies quasi-pixel dimensions ~ 0.5mm x 0.5mm

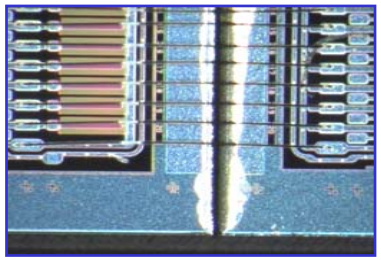
Original slide from Tom Davinson

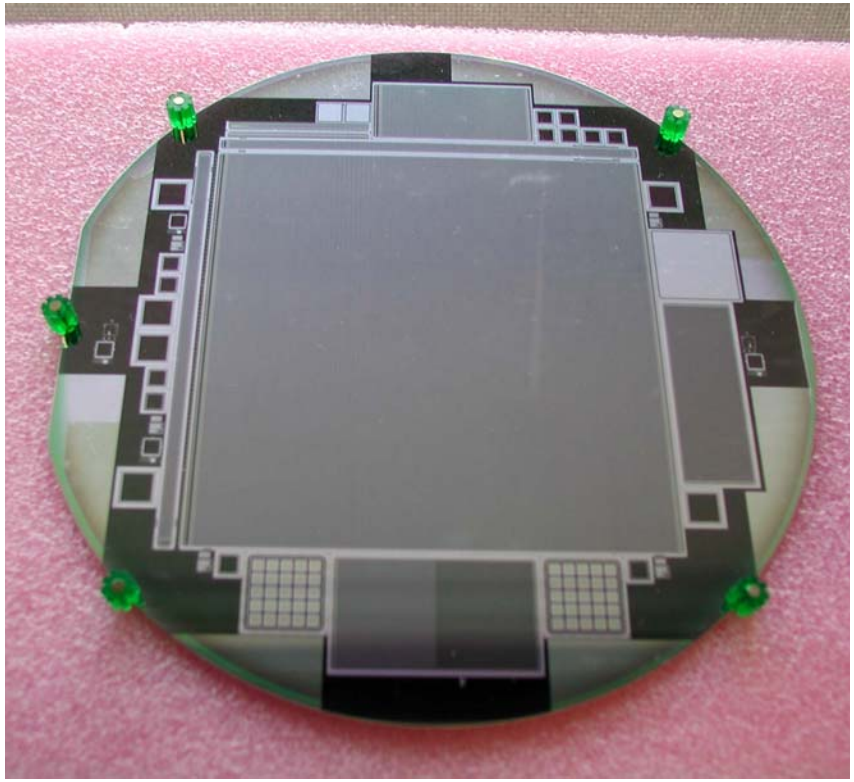
AIDA for DESPEC- the detector

DSSD

Technology well established
(e.g. GLAST LAT tracker)

- 6” wafer technology
  10cm x 10cm area
- 1mm wafer thickness
- Integrated components
  a.c. coupling
  polysilicon bias resistors
  … important for ASICs
- Series strip bonding



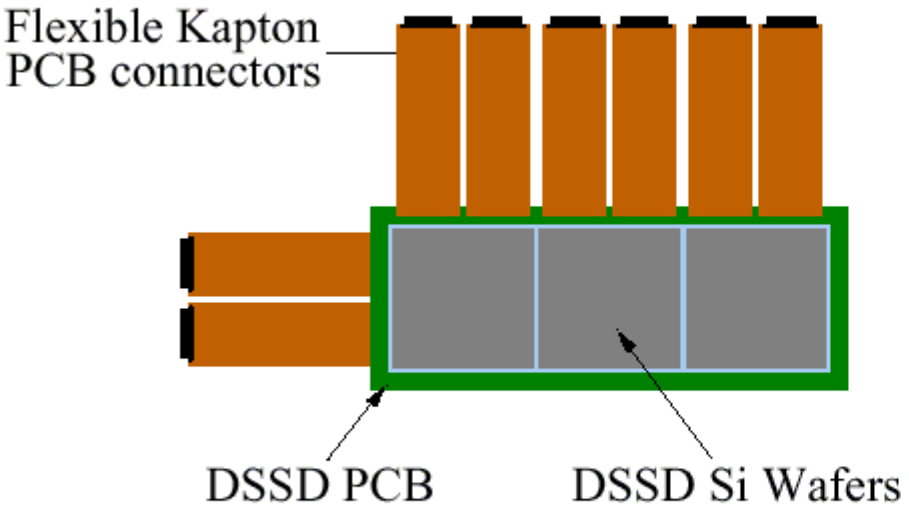


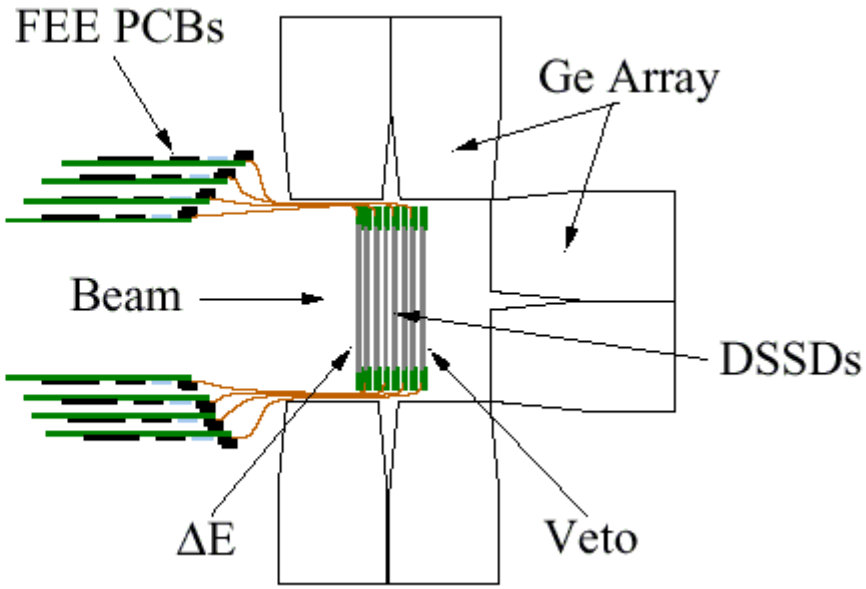
8.95 cm square Hamamatsu-Photonics SSD before cutting from the 6-inch wafer. The thickness is 400 microns, and the strip pitch is 228 microns.

Slide from Tom Davinson

AIDA for DESPEC

General Arrangement





Slide from Tom Davinson

AIDA for DESPEC- Instrumentation

Instrumentation

Why use of Application Specific Integrated Circuit (ASIC) technology?

- Large number of channels required (8 x (128+(3x128))= 4096)
- Limited available space
- Cost

Outline ASIC Specification

- Selectable gain: low 20GeV FSR
  high 20MeV FSR
- Noise σ ~ 5keV rms.
- Selectable threshold: minimum ~ 25keV @ high gain (assume 5σ)
- Integral and differential non-linearity
- Autonomous overload recovery ~μs
- Signal processing time <10μs (decay-decay correlations)
- Receive timestamp data
- Timing trigger for coincidences with other detector systems

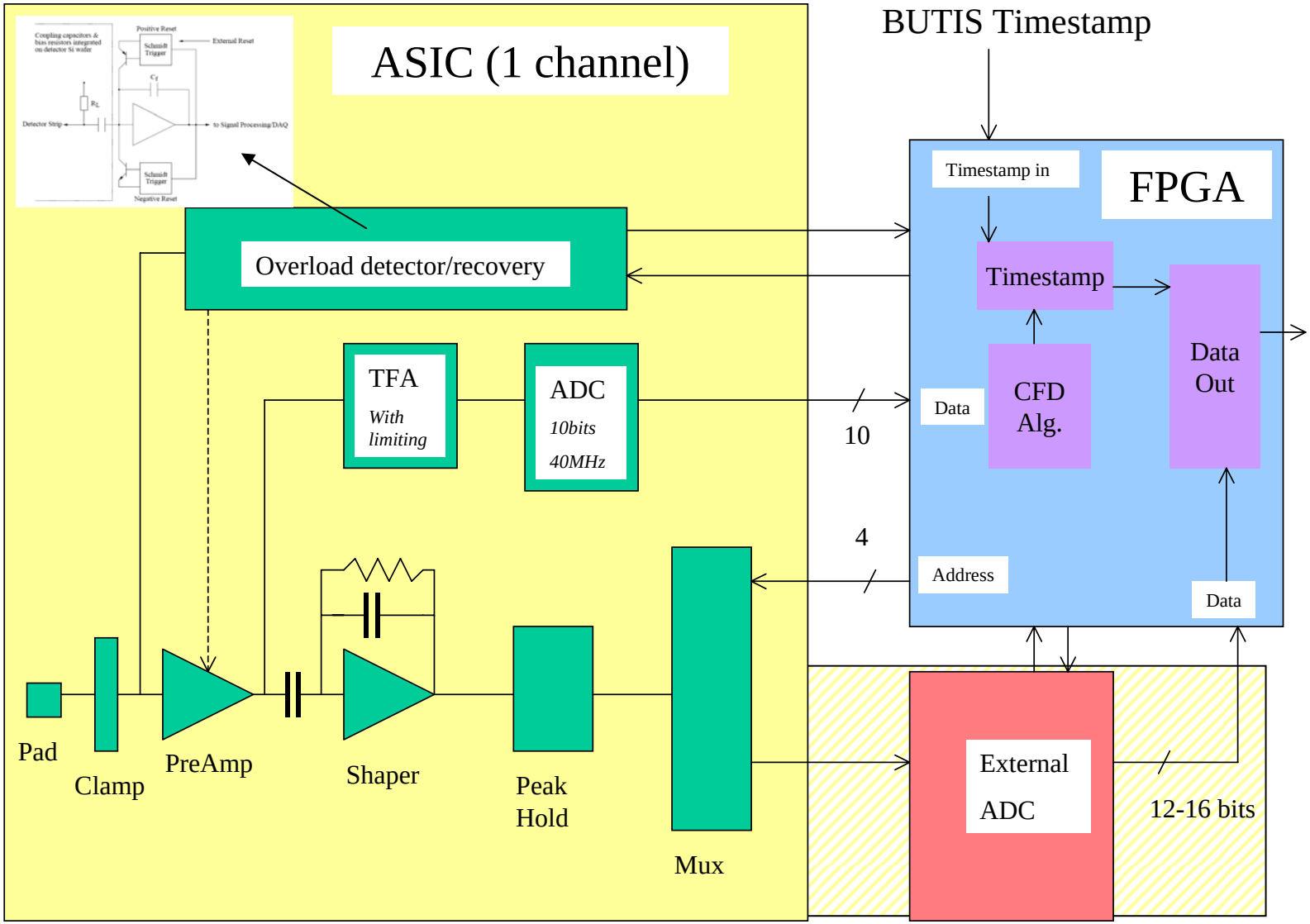
DSSD segmentation reduces input loading of preamplifier and enables excellent noise performance.

Slide from Tom Davinson

ASIC for RDT- design challenge

- Problem
  - Multi GeV implant followed by decay in region of 1MeV e.g. 20GeV/1MeV = 2.10^4 dynamic range
- Some possible solutions
  - Logarithmic preamps
    - Makes analysis difficult
  - High/low gain preamp pairs (with clamping)
    - Doubles power, halves packing density
  - Fast recovery from saturation
    - Look at this one first

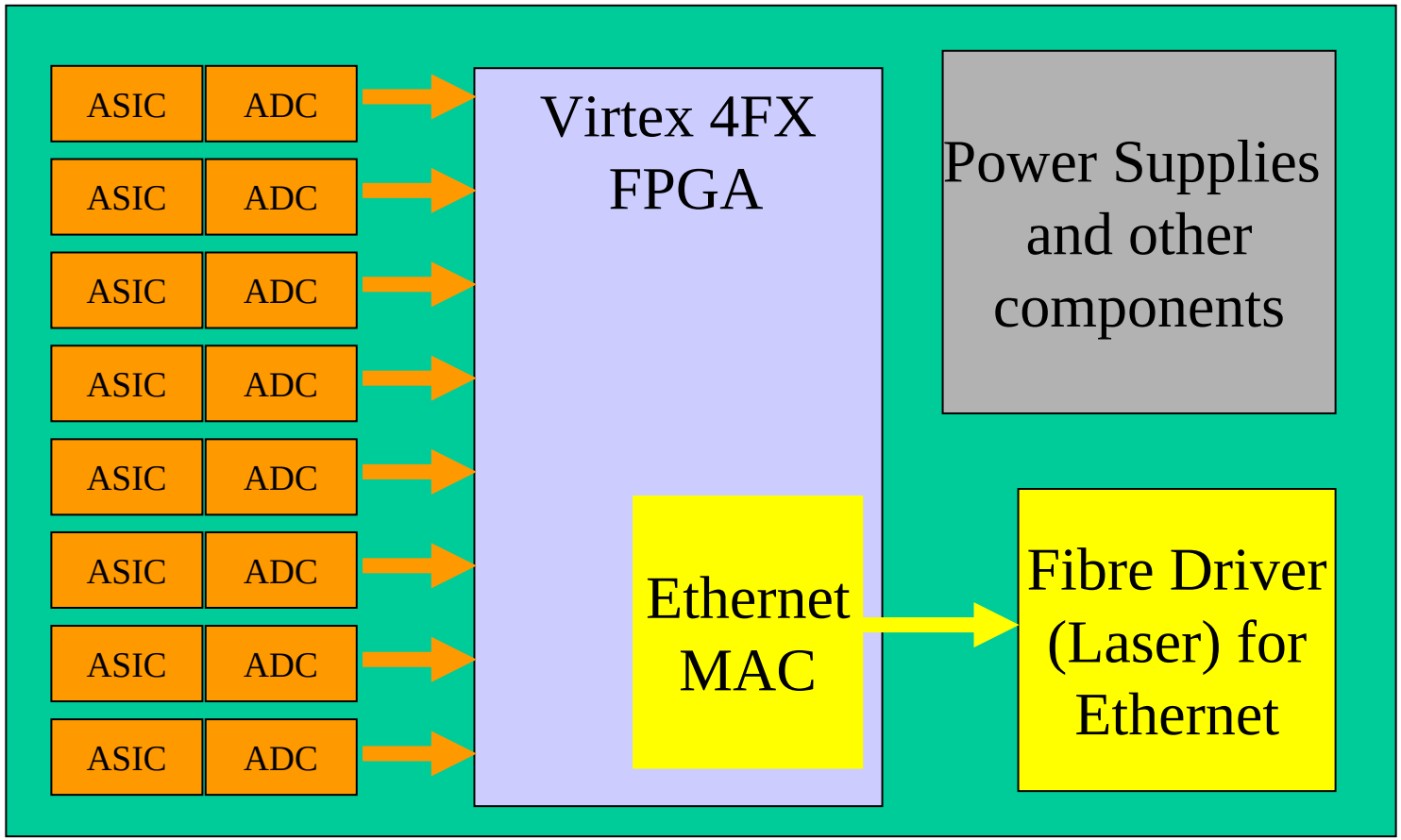
1 of the 16 channels in the DESPEC Implantation Detector ASIC (shown with external FPGA and ADC)



128 Channel FEE Card for DESPEC

16 ch ASIC (with ADC?)

128 detector signals in; 1 data fibre out



Estimated size: 80x220mm,
Estimated power 25W per 128ch (800W total)

NUSTAR- Defining 3 common interfaces or docking stations

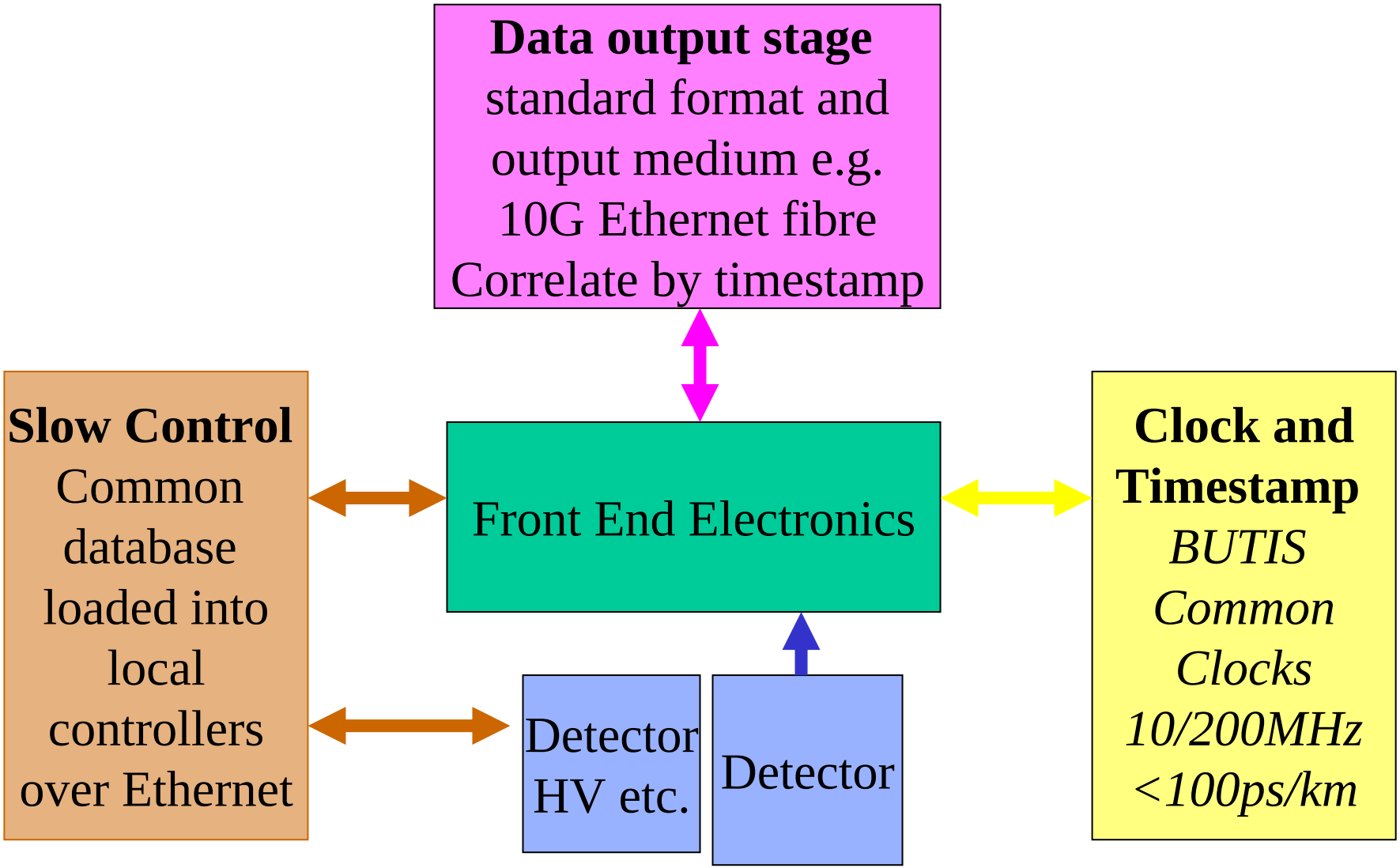
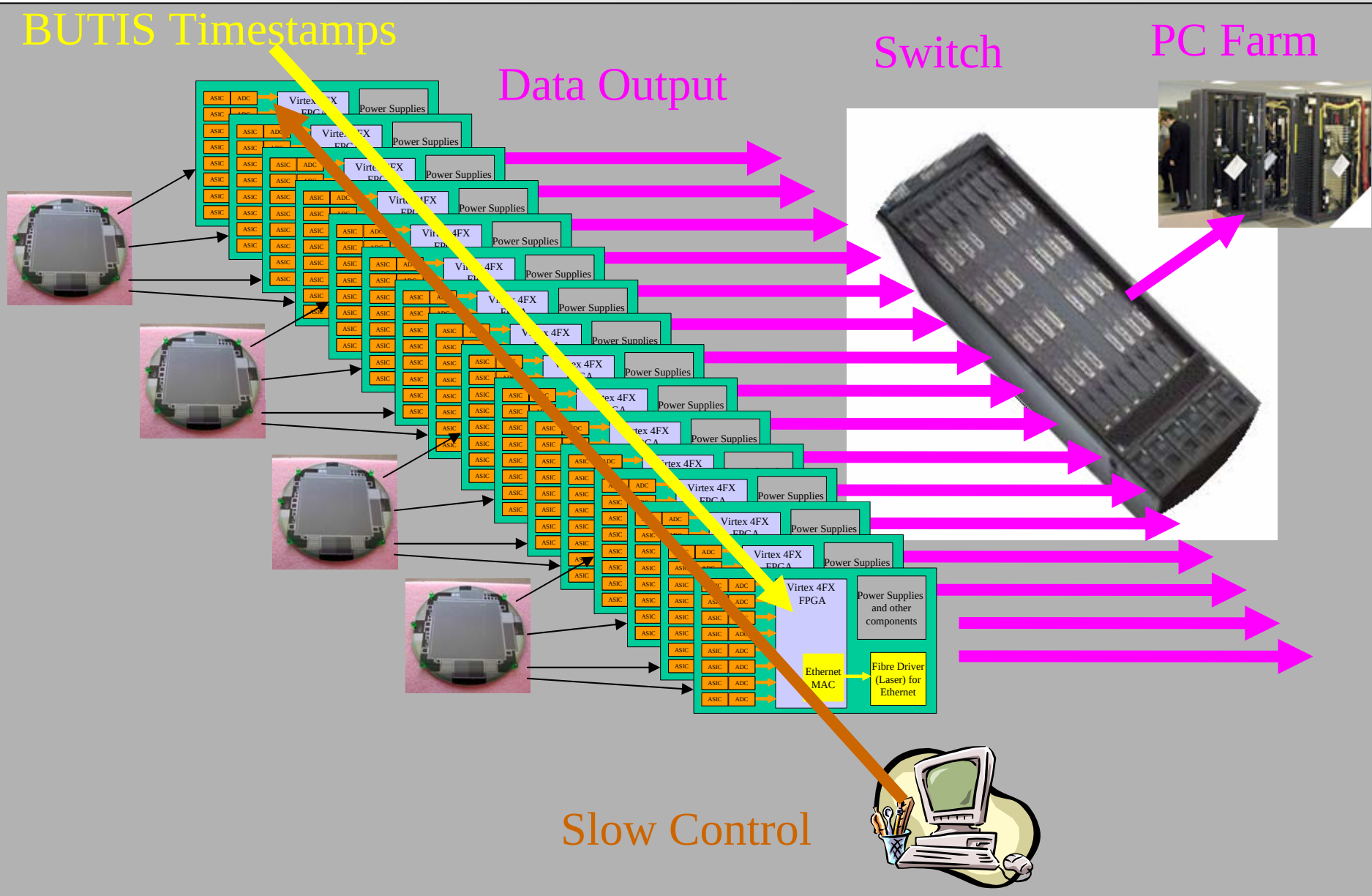


Diagram of half of AIDA system



The AIDA project- summary

- Objective:
  - To construct a new generation ASIC-based Double-sided Silicon Strip Detector system for decay spectroscopy experiments of exotic nuclei on the new FAIR accelerator facility at GSI, Darmstadt, Germany.
  - To commission and test this system in-beam, and perform ongoing implantation-decay experiments, primarily at GSI, prior to the availability of beams from FAIR.

- 4 years funding from 2006-2010 announced May 2006

- Collaboration:
  - Detectors and project management- University of Edinburgh
  - FEE, ASIC, DAQ - CCLRC
  - Postdoc (detector/physics) Mechanics- University of Liverpool
  - Total 35 – 40 FTE allocated to this project (scientists, engineers, mechanical designers, technicians)