# SuperB IFR electronics: update

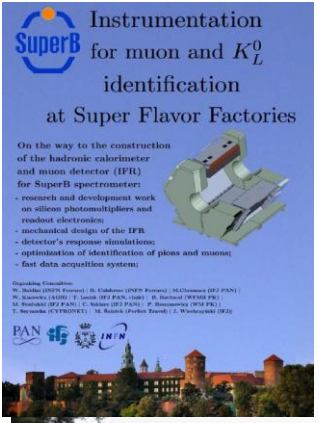
Angelo Cotta Ramusino
on behalf of the IFR collaboration

# SuperB IFR electronics: update

- Highlights from the workshop: **"Instrumentation for muon and KOL identification at Super Flavor Factories"**, 6-10 Sep 2012, Institute of Nuclear Physics, Polish Academy of Sciences, Kraków, Poland

- Preparatory work for the design of a prototype IFR frontend ASIC

# SuperB IFR electronics: highlights from the IFR workshop in Krakow




## Instrumentation for muon and K0L identification at Super Flavor Factories

6-10 September 2012 *Institute of Nuclear Physics, Polish Academy of Sciences*

Europe/Warsaw timezone

Overview

Scientific Programme

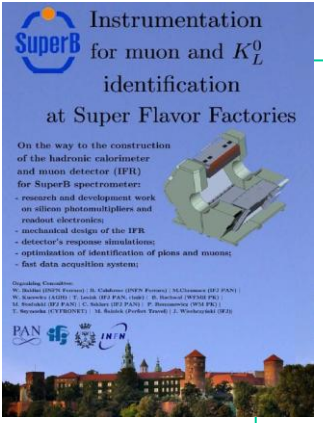

### Current registrants (31)

| name | institution | position | city | country/region |
|---|---|---|---|---|
| BALDINI, Wander | INFN-Ferrara | | Ferrara | ITALY |
| Mr. BASZCZYK, Mateusz | AGH-University of Science and Technology | PhD student | Krakow | POLAND |
| BENETTONI, Massimo | INFN PD | | Padova | ITALY |
| CALABRESE, Roberto | FE | | Ferrara | ITALY |
| Dr. CARASSITI, Vittore | INFN FE | mechanical enigineer | Ferrara | ITALY |
| CHRZASZCZ, Marcin | IFJ PAN | | Kraków | POLAND |
| CIBINETTO, Gianluigi | INFN | | Ferrara | ITALY |
| COTTA RAMUSINO, Angelo | INFN-Ferrara | | Ferrara | ITALY |
| Mr. DOROSZ, Piotr | AGH University of Science & Technology | PhD Student | Krakow | POLAND |
| Dr. KOLODZIEJ, Jacek | AGH-University of Science and Technology | | Krakow | POLAND |
| Mr. KOTULA, Jerzy | The Henryk Niewodniczanski Institute of Nuclear Physics Polish Academy of Sciences | | Cracow | POLAND |
| Prof. KUCEWICZ, Wojciech | AGH-University of Science and Technology | | Kraków | POLAND |
| Prof. LESIAK, Tadeusz | Inst. Nucl. Phys. PAS | | Krakow | POLAND |
| Mr. LUDWIN, Jaromir | IFJ-PAN | | Kraków | POLAND |
| Prof. LUPPI, Eleonora | University of Ferrara & INFN | | Ferrara | ITALY |
| Prof. MARCELLO, Simonetta | Torino University and INFN | professor | Torino | ITALY |
| Mr. MICHALOWSKI, Jerzy | IFJ-PAN | | Kraków | POLAND |
| Dr. MONTANARI, Alessandro | INFN-Bologna | | Bologna | ITALY |
| POSOCCO, Mario | PD | | Padova | ITALY |
| Mr. RACHWAL, Bartlomiej | Cracow University of Technology | PhD student | Krakow | POLAND |
| Dr. ROTONDO, Marcello | INFN Padova | | Padova | ITALY |
| Mr. STODULSKI, Marek | the H. Niewodniczanski Institute of Nuclear Physics Polish Academy of Sciences | | Krakow | POLAND |
| Prof. STROILI, Roberto | Università di Padova & INFN | | Padova | ITALY |
| Dr. SZYBINSKI, Bogdan | Cracow University of Technology | | Krakow | POLAND |
| Dr. SZYMOCHA, Tadeusz | ACK Cyfronet AGH | | Kraków | POLAND |
| TELLARINI, Giulia | FE | | Ferrara | ITALY |
| Dr. TOMASSETTI, Luca | University of Ferrara and INFN | | Ferrara | ITALY |
| Dr. WIECHCZYNSKI, Jaroslaw | Institute of Nuclear Physics, Cracow | | Cracow | POLAND |
| Dr. WITEK, Mariusz | IFJ PAN Krakow | | Krakow | POLAND |
| Mr. ZDYBAL, Milosz | Institute of Nuclear Physics PAN | | Krakow | POLAND |
| Mr. ZIOLKOWSKI, Pawel | IFJ-PAN | | Kraków | POLAND |

INFN Istituto Nazionale di Fisica Nucleare



SuperB

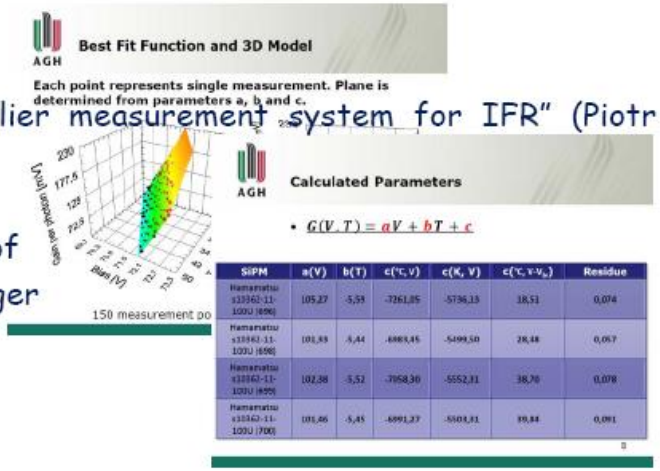



# SuperB IFR electronics: summary of electronics sessions at IFR workshop in Krakow

## Friday morning electronic I

- Presentations reviewed and discussed
  - "Thermal Stabilization of Silicon Photomultiplier measurement system for IFR" (Piotr Dorosz)

...”We can use few sample SiPMs, calculate a set of parameters and then use this parameters for larger group of SiPMs”...



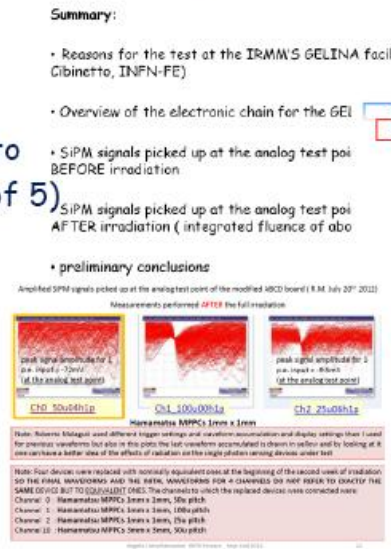

- "SiPM test with thermal neutrons at the IRMM" ( A. Cotta Ramusino)

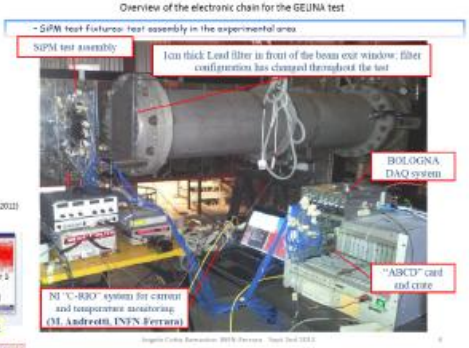
... Low energy neutron are not as harmless as one could think..

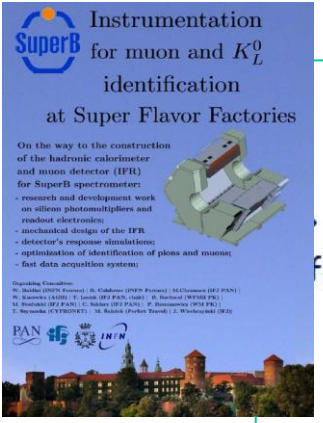
... Analysis on-going on the effects of shielding ...

... After a thermal neutron irradiation equivalent to 2 years of SuperB operation (with safety factor of 5) SiPM dark rate has increased and pile up effect occur -> constraints on shaping time of front end electronics

... pulse height for single p.e. remains constant





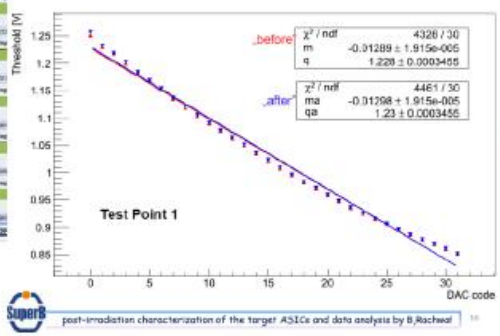

# SuperB IFR electronics: summary of electronics sessions at IFR workshop in Krakow

## Friday morning electronic I

- "CLARO and RAPSODI ASICs irradiation at the CN facility of the INFN-LNL" (A. Cotta Ramusino, Bartłomiej Rachwał )

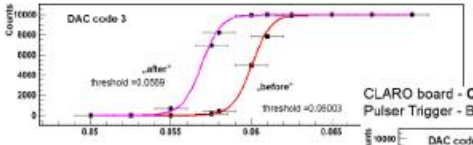
...No Single Event Effect, no Single Event Latchup, no permanent effects from total integrated dose Observed for the CLARO chip...


CLARO board - Linear characterization
Threshold Voltage vs. DAC code

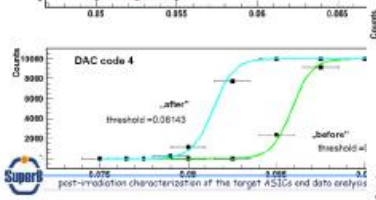


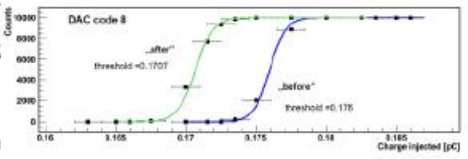

post-irradiation characterization of the target ASICs and data analysis by B.Rachwal

CLARO board - **Channel A**
Pulser Trigger - Burst 1E+4

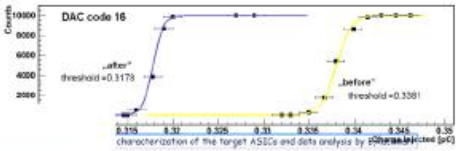



CLARO board - **Channel A**
Pulser Trigger - Burst 1E+4

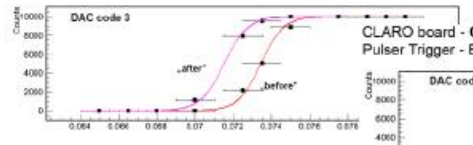


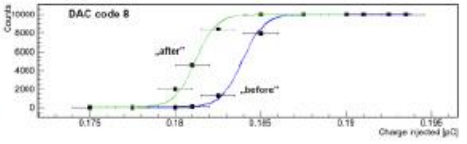

post-irradiation characterization of the target ASICs and data analysis

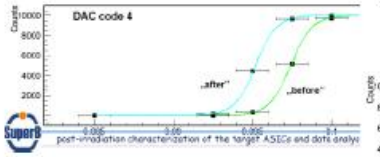



CLARO board - **Channel C**
Pulser Trigger - Burst 1E+4

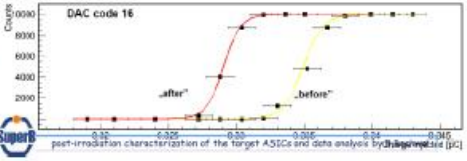



CLARO board - **Channel C**
Pulser Trigger - Burst 1E+4




post-irradiation characterization of the target ASICs and data analysis

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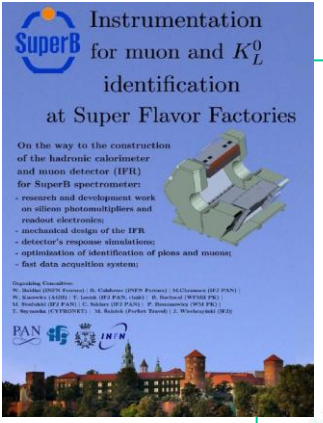
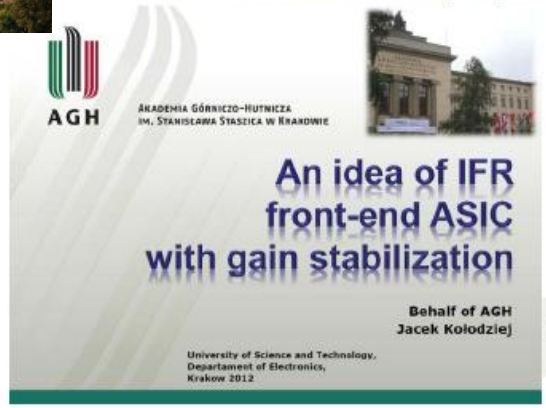
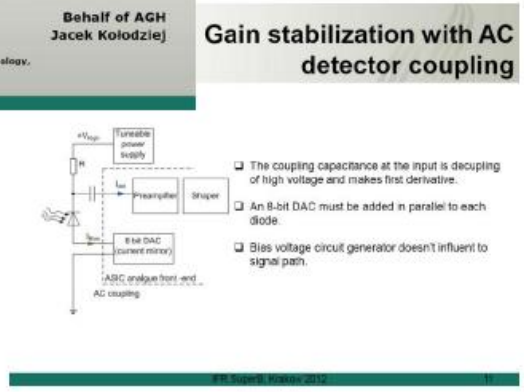



# SuperB IFR electronics: summary of electronics sessions at IFR workshop in Krakow

## Friday afternoon electronic II

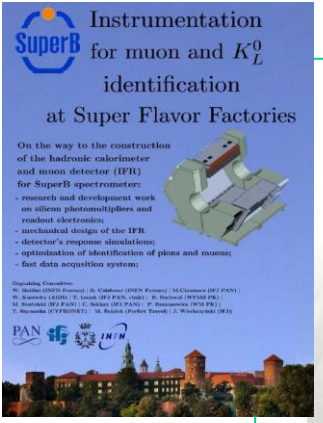
- Visit to Wojciech's laboratory at AGH
- Presentations reviewed and discussed
  - "An idea of IFR ASIC front-end with gain stabilization" (Juliusz Godek & Jacek Kołodziej) discussion on proposal with remote participation of Gianluigi Pessina and Claudio Gotti






.. the thouroghly prepared proposal opens perspectives toward the usage of a technology node which lower costs provides higher density and rad tolerance but it has, like all new things some disadvantages w.r.t. to the technology considered so far for front end ASIC... to be discussed further




# SuperB IFR electronics: summary of electronics sessions at IFR workshop in Krakow

## Friday afternoon electronic II

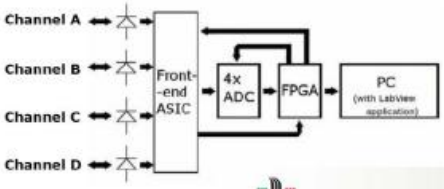
- "Characterization of RAPSODI ASICs after Irradiation" (Mateusz Baszczyk)

AGH University of Science and Technology

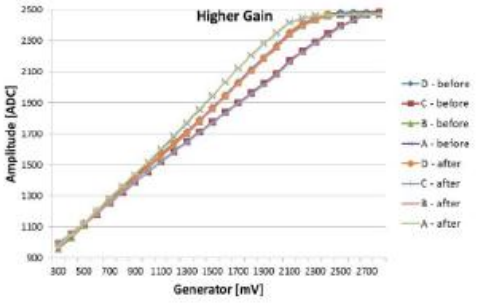
### Characterization of RAPSODI ASICs after Irradiation Tests

Mateusz Baszczyk, Piotr Dorosz
On behalf of AGH University of Science and Technology

### System of Data Acquisition

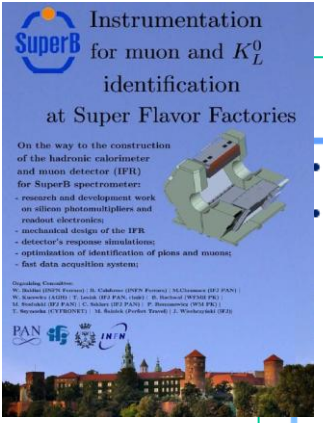



### Linearity after Irradiation – RAPSODI #16




### Conclusions

- There are no difference between linearity and standard deviation for measurements before irradiation and after.
- Mean value points before and after irradiation do not exceed each other standard deviation error bars.
- There are no noticeable differences between measurements of RAPSODI #16 (1,32e+12 neutrons/cm^2) and RAPSODI #30 (3,3e+13 neutrons/cm^2).




# SuperB IFR electronics: summary of electronics sessions at IFR workshop in Krakow

## Electronics parallel sessions summary

- Saturday morning joint electronics/mechanics
- Saturday morning joint electronics/R&D

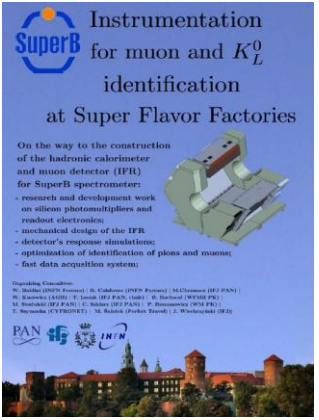
From these joint sessions good suggestions came regarding the subjects of:

- redundancy of SiPM
- machining of scintillating bars (grooves on top and bottom)

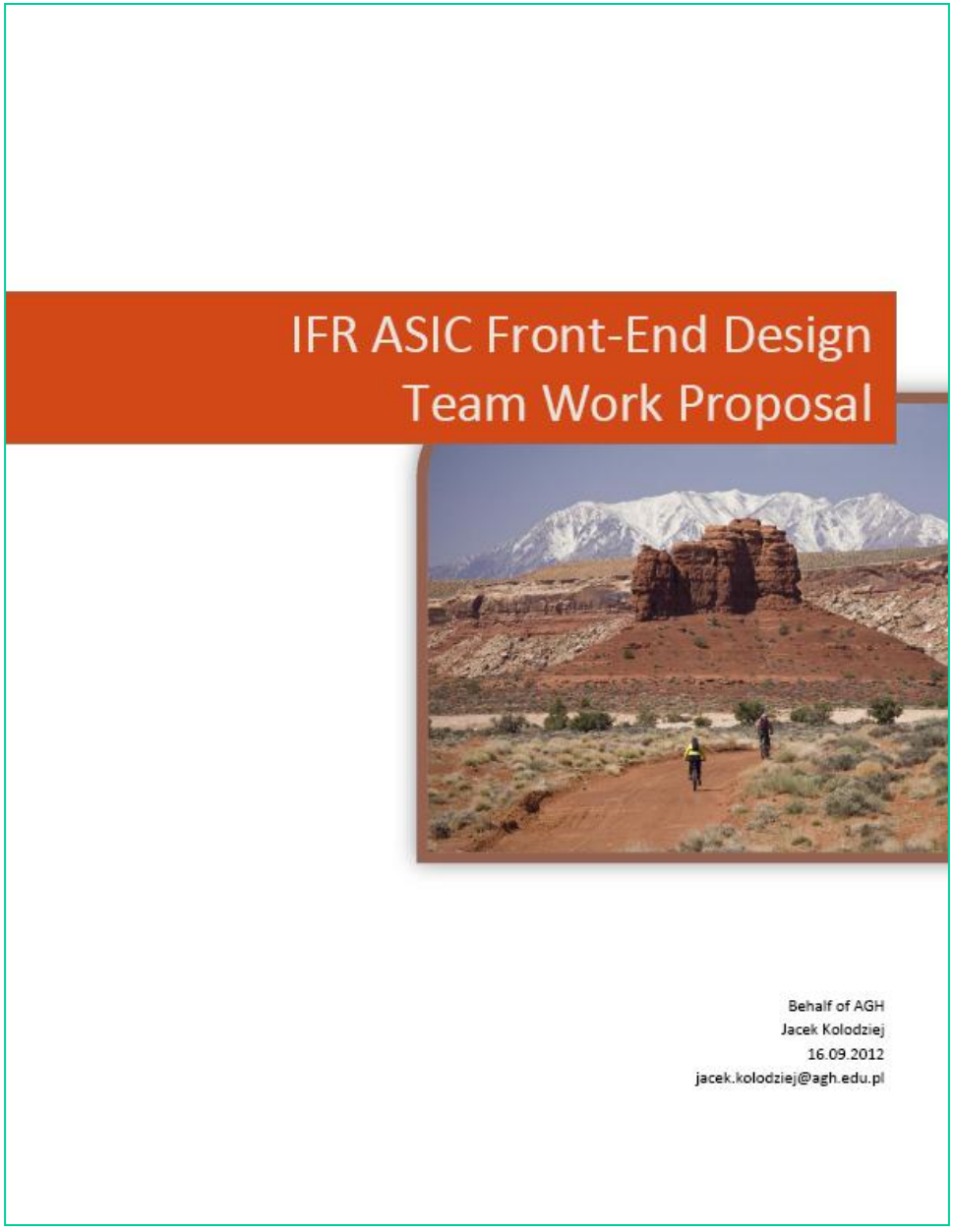
which have impact on the design of the detector electronics but could reduce the detector manufacturing time and improve the reliability of the overall system.

The topic of Quality Control (Q.C.) was addressed at the joint electronics/R&D session: three steps were identified:

- quick verification, by means of test systems based on RAPSODI #2 chips, of SiPM gain @ nominal operating conditions
- Q.C. of assembled detector element: spectrum from $^{90}Sr$ sorce collected
- long term Q.C. of assembled module: cosmic ray spectrum acquired via the final readout chain while detector modules are in storage

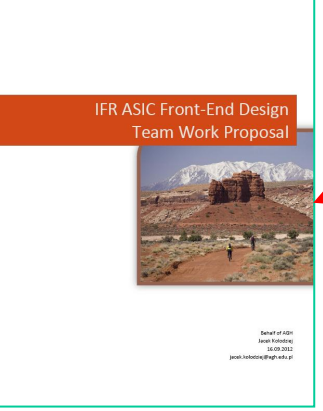



# SuperB IFR electronics: plans for the development of an IFR frontend ASIC outlined at IFR workshop in Krakow

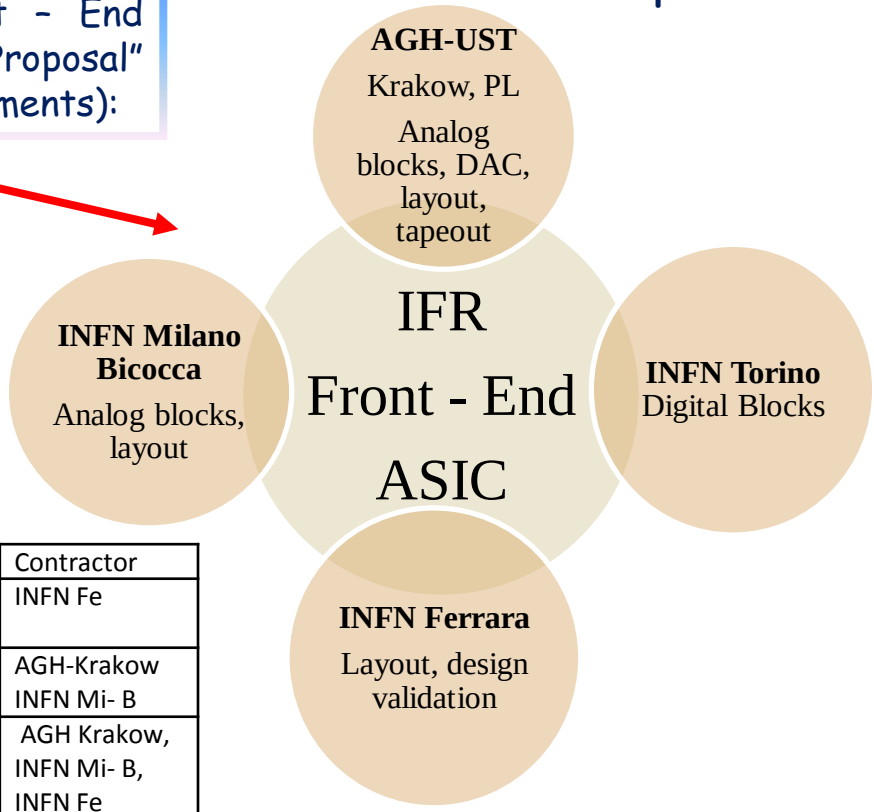



A summary of the colloquium was drafted by Jacek Kolodziej

# SuperB IFR electronics: plans for the development of an IFR frontend ASIC outlined at IFR workshop in Krakow



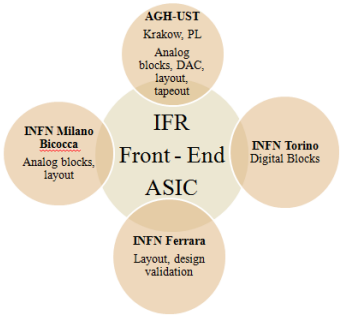

Excerpt from "IFR ASIC Front - End Design, Team Work Collaboration Proposal" Jacek Kolodziej (with some adjustments):




| LP | Tasks | Contractor |
|---|---|---|
| 1 | Detector measurement to assign time response that will be used in simulation by ASIC designers | INFN Fe |
| 2 | Independent design of key analogue ASIC part : preamplifier, shaper, buffer, comparator in 350nm AMS technology | AGH-Krakow INFN Mi- B |
| 3 | Simulation analysis of design | AGH Krakow, INFN Mi- B, INFN Fe |
| 4 | Prototype ASIC tapeout in AMS 350nm | AGH Krakow |
| 4 | Prototype ASIC tapeout in UMC2 180nm (migration path feasibility study) | AGH Krakow |
| 5 | Measurements of fabricated chips | |
| 6 | Digital part specification, FPGA implementation | |
| 7 | Brain storm, choosing the best solution , task allocation between participants | AGH Krakow, INFN Mi-B, INFN To, INFN Fe |
| 8 | Digital redesign and fabrication in AMS 350nm | INFN To |
| 9 | Full chip redesign and fabrication in AMS 350nm | all |
| 10 | Possible chip redesign and fabrication in UMC 180nm | AGH Krakow |

For the timeline see next page...

# SuperB IFR electronics: plans for the development of an IFR frontend ASIC outlined at IFR workshop in Krakow

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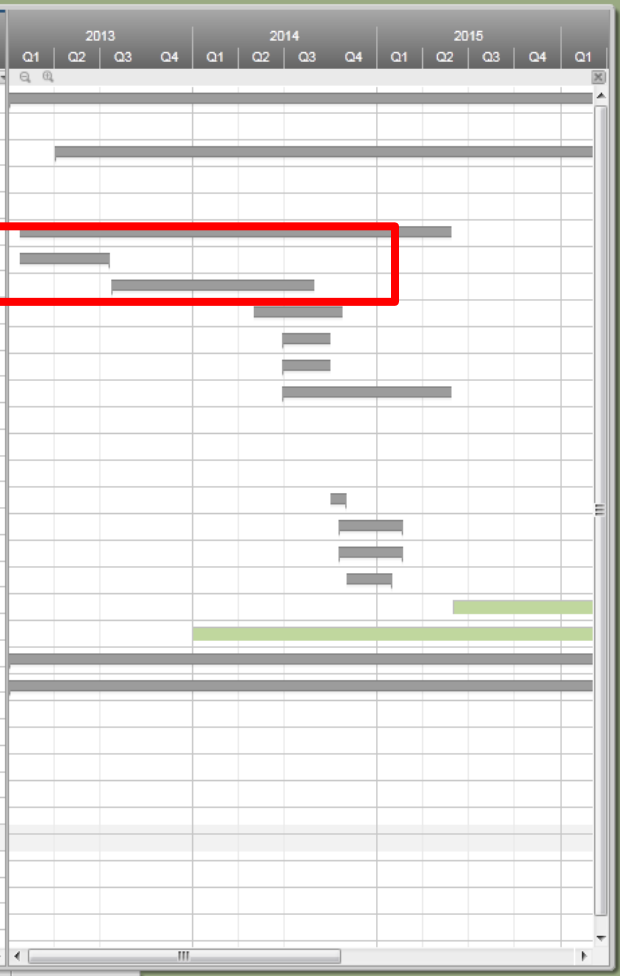
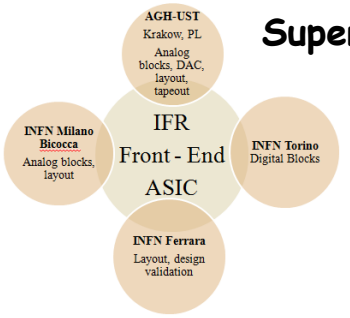
| | | | EDIA (mm) | Labor (mm) | M&S (kE) | Cont% | Tot M&S (kE) | Duration | Start | Finish |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.7 | Electronics | 702.1 | 383.8 | 9638.6 | | 6319.02 | 1413 | 01/01/13 | 05/31/18 |
| 2 | 1.7.1 | SVT | 15 | 30.5 | 467.6 | | 467.6 | | | |
| 19 | 1.7.2 | DCH | 55 | 81 | 3539.8 | | 219.925 | 1180 | 04/01/13 | 10/06/17 |
| 55 | 1.7.3 | PID Barrel (32k channels) | 136 | 18 | 510 | | 510 | | | |
| 75 | 1.7.4 | EMC | 110 | 164 | 2271.5 | | 2271.5 | | | |
| 93 | 1.7.5 | IFR | 32.1 | 48.3 | 337 | | 337 | 615 | 01/21/13 | 08/28/15 |
| 94 | 1.7.5.1 | "IFR Front End" ASIC small scale prototype | 6.6 | 4.2 | 8 | | 8 | 130 | 01/21/13 | 07/19/13 |
| 99 | 1.7.5.2 | "IFR Front End" ASIC full scale device (total need about 1000 pcs) | 7.1 | 9.5 | 35 | | 35 | 290 | 07/22/13 | 08/29/14 |
| 105 | 1.7.5.3 | "IFR Front End" cards (total need about 400) | 2.5 | 3 | 77 | | 77 | 128 | 04/30/14 | 10/24/14 |
| 112 | 1.7.5.4 | "IFR Front End" card installation fixtures for the BARREL section | 1.1 | 3.2 | 19 | | 19 | 68 | 06/27/14 | 09/30/14 |
| 116 | 1.7.5.5 | "IFR Front End" card cages (mechanics only) for the ENDCAPs | 0.9 | 2.4 | 13 | | 13 | 68 | 06/27/14 | 09/30/14 |
| 120 | 1.7.5.6 | "IFR data merger" cards (total need about 60) | 6.5 | 6.5 | 59 | | 59 | 241 | 06/27/14 | 05/29/15 |
| 128 | 1.7.5.7 | "IFR data merger" crates (total need 14; adapted from ATCA) | 3 | 4 | 56 | | 56 | | | |
| 134 | 1.7.5.8 | "detector and Front End" supply system (DEVELOPED BY THE SUPPLY GF | 0 | 0 | 110 | | 110 | | | |
| 137 | 1.7.5.9 | "data merger" supply system (DEVELOPED BY THE SUPPLY GROUP) | 0 | 0 | 14 | | 14 | | | |
| 139 | 1.7.5.10 | data (double shield. multi TP) cable assemblies (354 units) | 1.2 | 4.5 | 44 | | 44 | 24 | 09/30/14 | 10/31/14 |
| 145 | 1.7.5.11 | HV cables to "IFR Front End" cards, LSZH double shielded TP | 1.2 | 4.5 | 21 | | 21 | 91 | 10/17/14 | 02/20/15 |
| 151 | 1.7.5.12 | LV cables to the "IFR Front End" cards, LSZH, 2 cond, 2.5 sq.mm | 1.2 | 4.5 | 73 | | 73 | 91 | 10/17/14 | 02/20/15 |
| 157 | 1.7.5.13 | LV cables to the "Data Merger" crates, LSZH, 4 cond, 4 sq.mm | 0.8 | 2 | 8 | | 8 | 66 | 10/31/14 | 01/30/15 |
| 163 | 1.7.6 | Infrastructure | 4 | 36 | 262 | | 262 | 785 | 05/31/15 | 05/31/18 |
| 164 | 1.7.7 | Systems Engineering | 12 | 0 | 0 | | 0 | 1152 | 01/01/14 | 05/31/18 |
| 165 | 1.7.8 | Hardware Trigger | 120 | 0 | 564 | | 564 | 891 | 01/01/13 | 05/31/16 |
| 174 | 1.7.9 | ETD (without Trigger) | 218 | 6 | 1487 | | 1487 | 1152 | 01/01/13 | 05/31/17 |




Excerpt from the SuperB's Smartsheet time plan (a.c.r. Nov 2012)

# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC

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|---|---|---|
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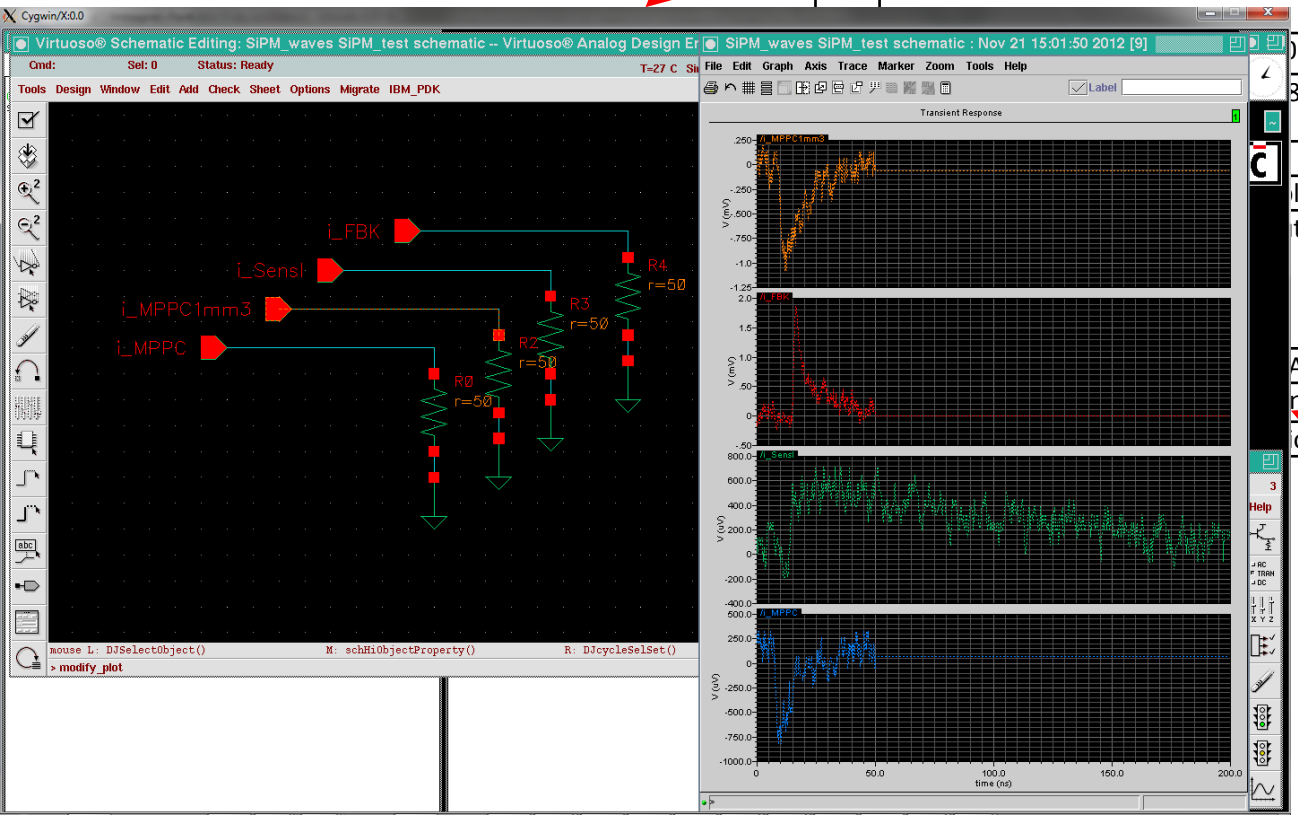
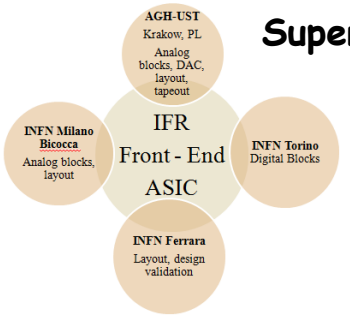
| 2 | Independent design of key analogue ASIC part : preamplifier, shaper, buffer, comparator in 350nm AMS technology | AGH-Krakow<br>INFN Mi- B |
| 3 | Simulation analysis of design | AGH Krakow,<br>INFN Mi- B,<br>INFN Fe |
| | )nm | AGH Krakow |
| | 30nm (migration path feasibility | AGH Krakow |
| | | |
| | lementation | |
| | tion , task allocation between | AGH Krakow,<br>INFN Mi-B,<br>INFN To,<br>INFN Fe |
| | AMS 350nm | INFN To |
| | n AMS 350nm | all |
| | on in UMC 180nm | AGH Krakow |




Excerpt from the thesis work: "Studio delle prestazioni di un sistema di amplificazione per fotorivelatori SiPM basato sul nuovo ASIC "CLARO" Enrico Calabrese, Dec 2012, Uni-Fe

The signals from three SiPM devices were provided to the ASIC designers of INFN-Mi Bicocca and AGH Krakow in the form of stimulus files in the format comaptibile with the Cadence Spectre simulator




# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC

| LP | Tasks | Contractor |
|---|---|---|
| 1 | Detector measurement to assign time response that will be used in simulation by ASIC designers | INFN Fe |
| 2 | Independent design of key analogue ASIC part : preamplifier, shaper, buffer, comparator in 350nm AMS technology | AGH-Krakow INFN Mi- B |
| 3 | Simulation analysis of design | AGH Krakow, INFN Mi- B, INFN Fe |
| | nm | AGH Krakow |
| | 0nm (migration path feasibility | AGH Krakow |
| | | |
| | ementation | |
| | ion , task allocation between | AGH Krakow, INFN Mi-B, INFN To, INFN Fe |
| | MS 350nm | INFN To |
| | AMS 350nm | all |
| | n in UMC 180nm | AGH Krakow |

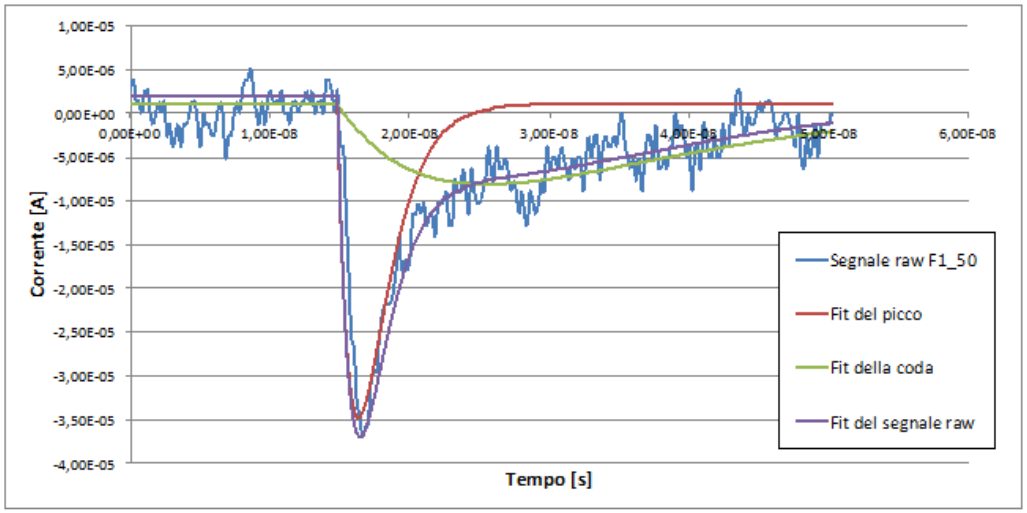


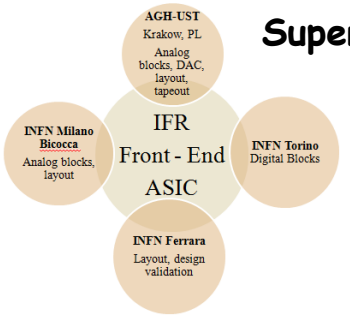

**Figura 5.16:** *F1_50 fit del segnale raw.*

Le costanti di tempo per il fit di picco sono $\tau_{rise}$=1,47ns e $\tau_{fall}$=1,55ns.

Per il fit della coda invece sono $\tau_{rise2}$=9,6ns e $\tau_{fall2}$=12ns.

Excerpt from the thesis work: "Studio delle prestazioni di un sistema di amplificazione per fotorivelatori SiPM basato sul nuovo ASIC "CLARO" Enrico Calabrese, Dec 2012, Uni-Fe

The signals from three SiPM devices were also provided to the ASIC designers of INFN-Mi Bicocca and AGH Krakow in the form of fitting functions based on linear combinations of exponential and Heaviside functions: here is shown the fitting function for an Advansid (FBK) 1mm sq, 50um pitch device




# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC

| LP | Tasks | Contractor |
|---|---|---|
| 1 | Detector measurement to assign time response that will be used in simulation by ASIC designers | INFN Fe |
| 2 | Independent design of key analogue ASIC part : preamplifier, shaper, buffer, comparator in 350nm AMS technology | AGH-Krakow INFN Mi- B |
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| | ]nm | AGH Krakow |
| | 80nm (migration path feasibility | AGH Krakow |
| | | |
| | lementation | |
| | tion , task allocation between | AGH Krakow, INFN Mi-B, INFN To, INFN Fe |
| | AMS 350nm | INFN To |
| | n AMS 350nm | all |
| | ion in UMC 180nm | AGH Krakow |

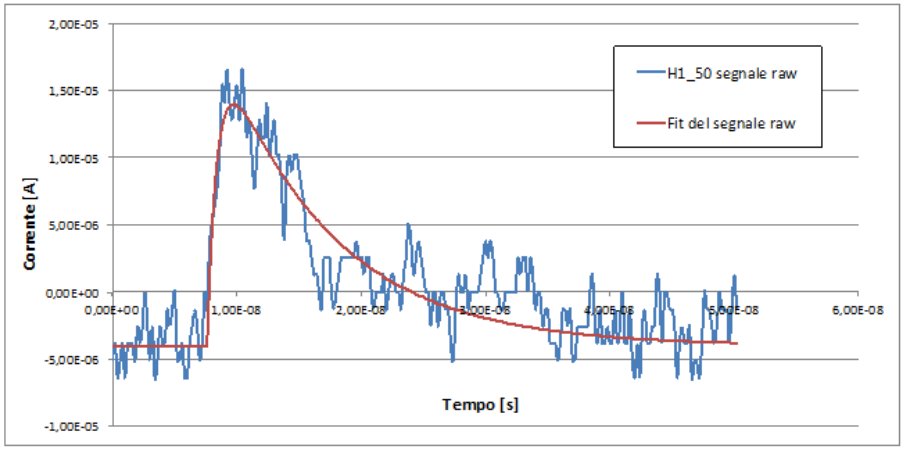
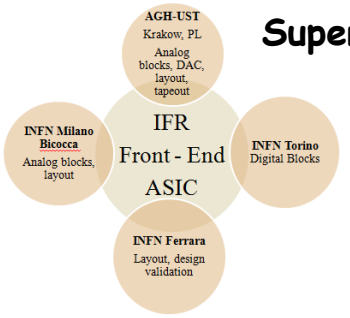



**Figura 5.17:** *H1_50 fit del segnale raw.*

Fig. 5.17 mostra il fit realizzato per l'MPPC H1_50; le costanti di tempo che caratterizzano la funzione sono $\tau_{rise}$=*0,8ns* e $\tau_{fall}$=*9ns* e in questo caso sono invertite perché il segnale è positivo.

Excerpt from the thesis work: "Studio delle prestazioni di un sistema di amplificazione per fotorivelatori SiPM basato sul nuovo ASIC "CLARO" Enrico Calabrese, Dec 2012, Uni-Fe

the fitting function for an Hamamatsu MPPC 1mm sq, 50um pitch device




# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC

| LP | Tasks | Contractor |
|---|---|---|
| 1 | Detector measurement to assign time response that will be used in simulation by ASIC designers | INFN Fe |
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| | AMS 350nm | INFN To |
| | in AMS 350nm | all |
| | ion in UMC 180nm | AGH Krakow |

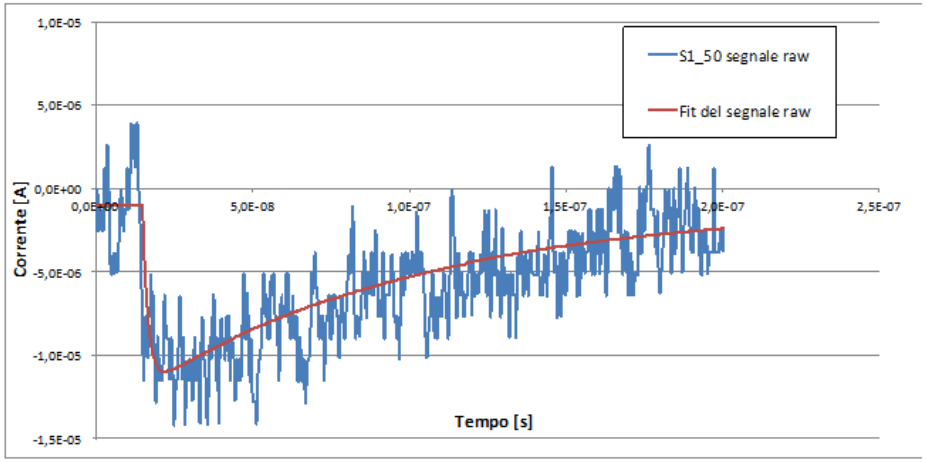


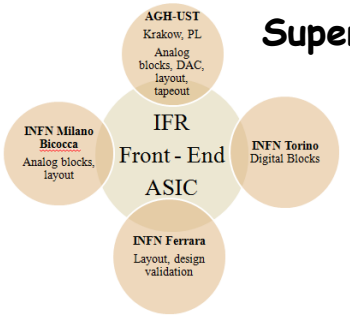

**Figura 5.18:** *S1_50 fit del segnale raw.*

In questo caso le costanti di tempo che hanno permesso di realizzare il fit sul segnale raw sono: sono $\tau_{rise}$=1,8ns e $\tau_{fall}$=90ns.

Excerpt from the thesis work: "Studio delle prestazioni di un sistema di amplificazione per fotorivelatori SiPM basato sul nuovo ASIC "CLARO" Enrico Calabrese, Dec 2012, Uni-Fe

the fitting function for a Sensl 1mm sq, 50um pitch device

# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC




| LP | Tasks | Contractor |
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| 1 | Detector measurement to assign time response that will be used in simulation by ASIC designers | INFN Fe |
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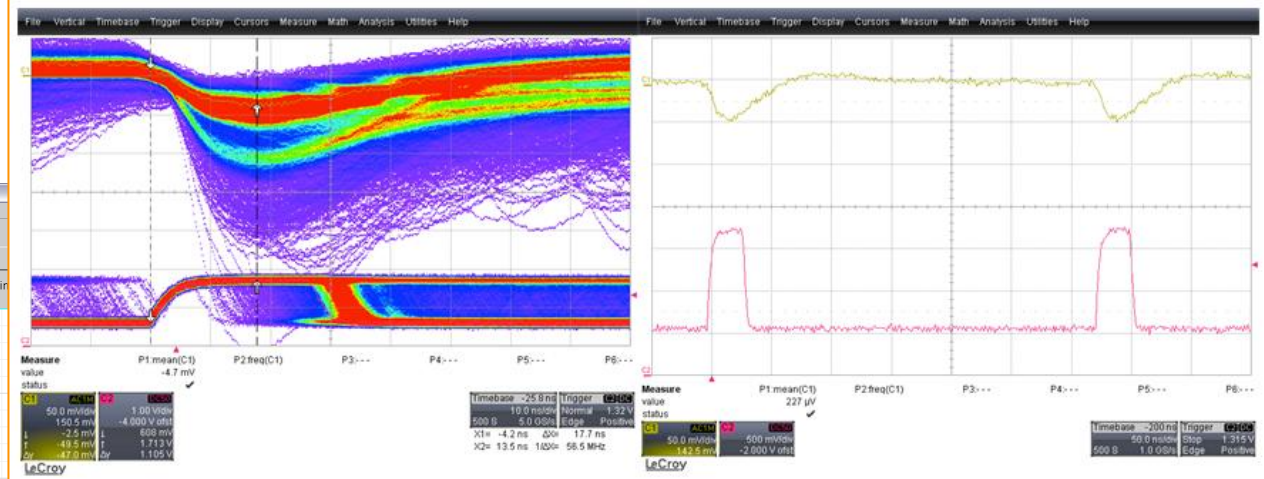
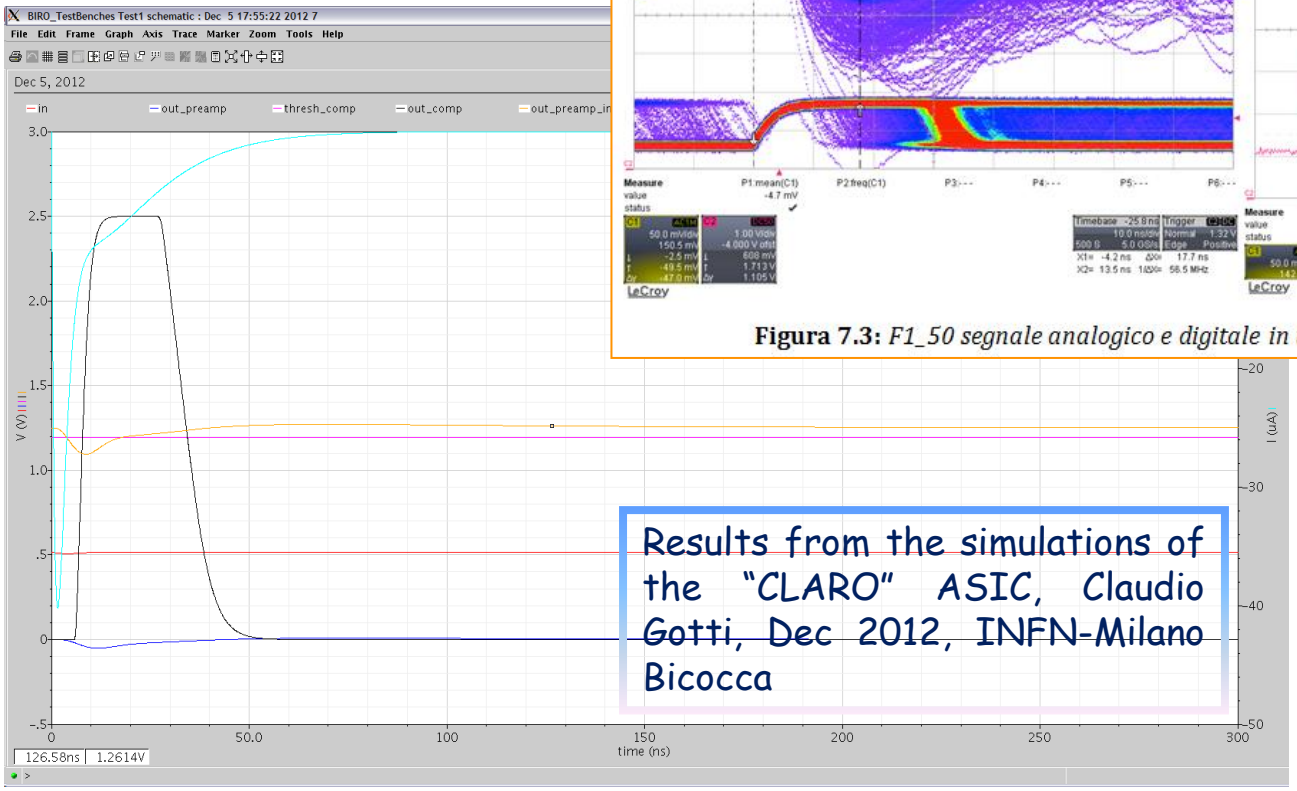



**Figura 7.3:** *F1_50 segnale analogico e digitale in uscita dal CLARO, accumulato e singolo.*

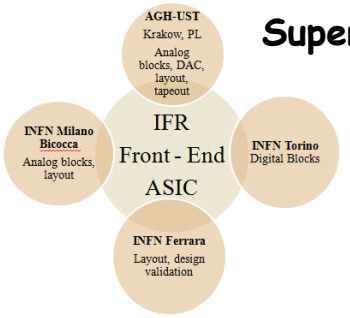



Results from the simulations of the "CLARO" ASIC, Claudio Gotti, Dec 2012, INFN-Milano Bicocca

Excerpt from the thesis work: "Studio delle prestazioni di un sistema di amplificazione per fotorivelatori SiPM basato sul nuovo ASIC "CLARO" Enrico Calabrese, Dec 2012, Uni-Fe

Response to the 1 photoelectron signal from an Advansid 1mm sq, 50um pitch device

# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC




| LP | Tasks | Contractor |
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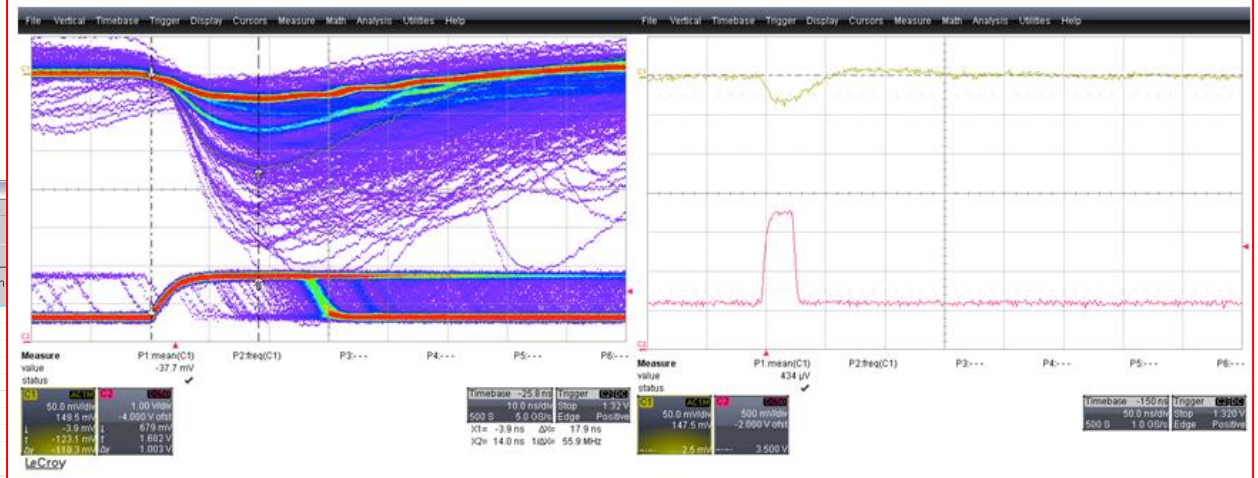
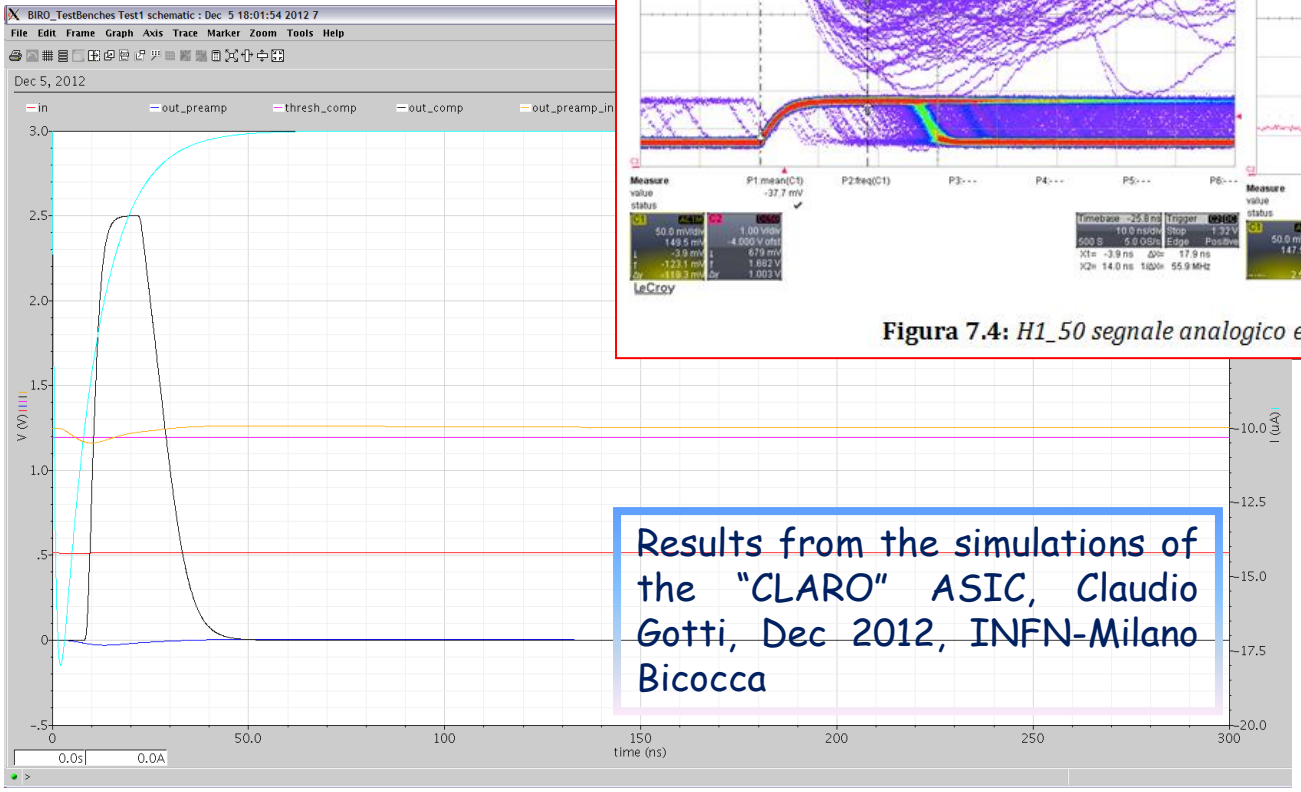


**Figura 7.4:** *H1_50 segnale analogico e digitale, accumulato e singolo.*

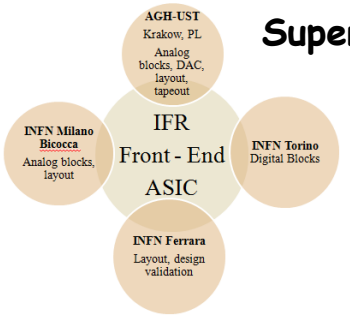



Results from the simulations of the "CLARO" ASIC, Claudio Gotti, Dec 2012, INFN-Milano Bicocca

Excerpt from the thesis work: "Studio delle prestazioni di un sistema di amplificazione per fotorivelatori SiPM basato sul nuovo ASIC "CLARO" Enrico Calabrese, Dec 2012, Uni-Fe

Response to the 1 photoelectron signal from an MPPC 1mm sq, 50um pitch device

# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC




| LP | Tasks | Contractor |
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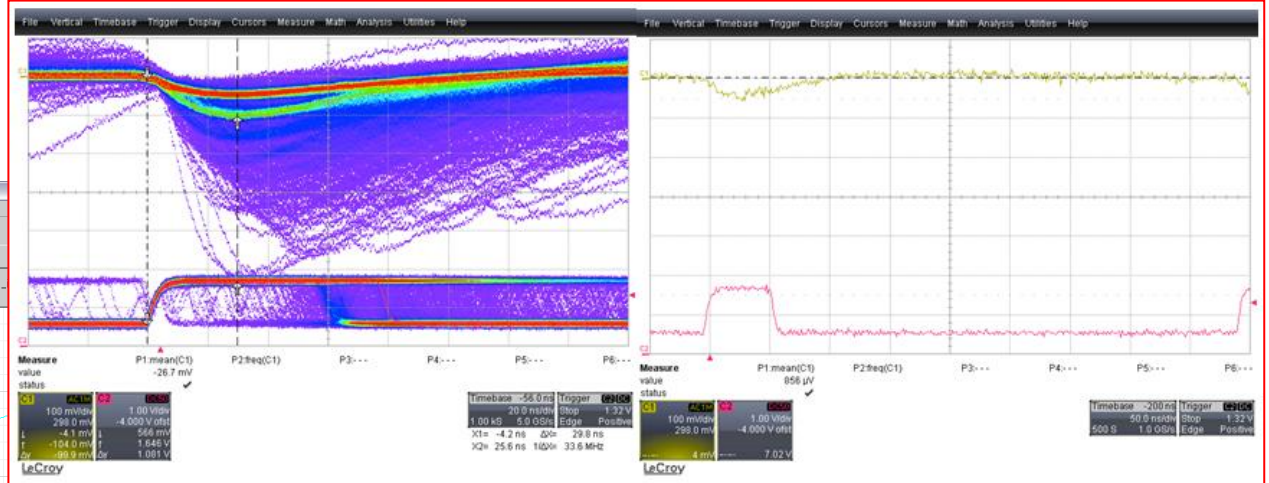
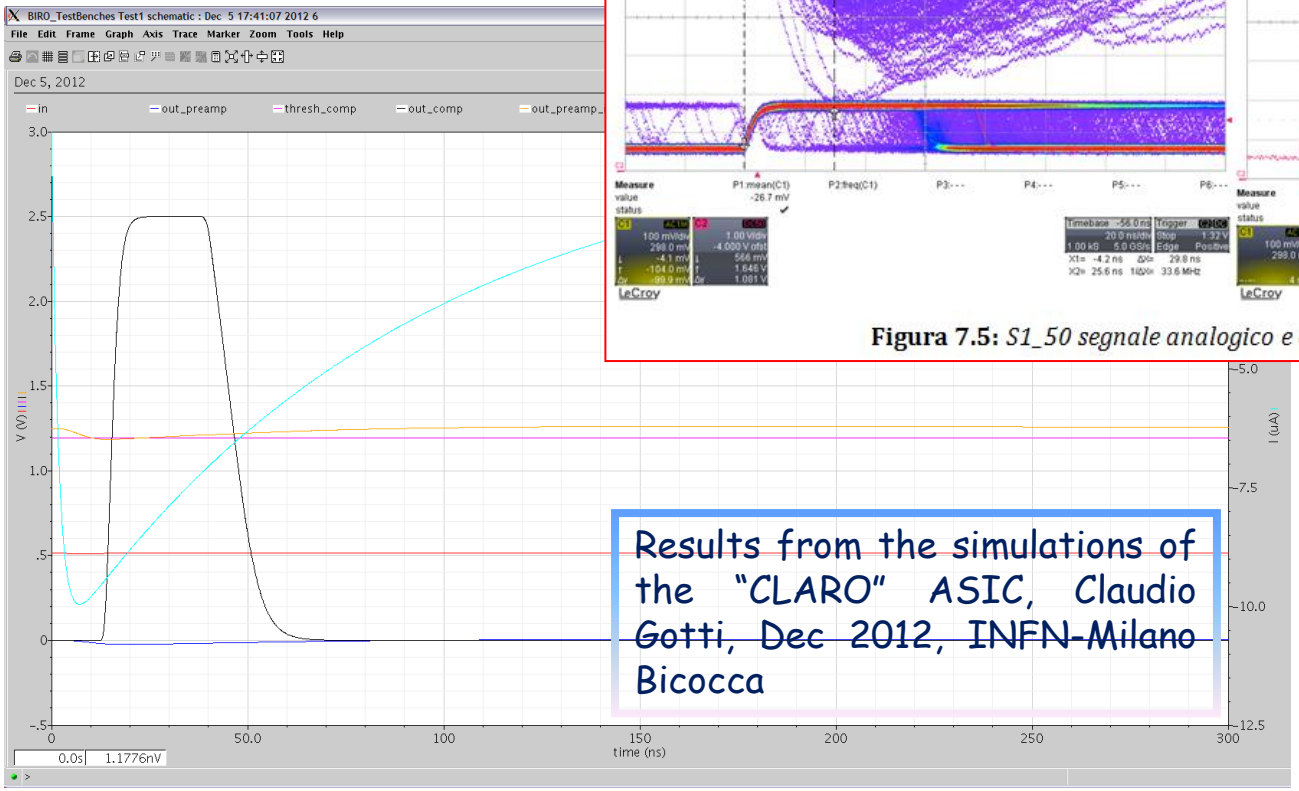


**Figura 7.5:** *S1_50 segnale analogico e digitale, accumulato e singolo.*




Results from the simulations of the "CLARO" ASIC, Claudio Gotti, Dec 2012, INFN-Milano Bicocca

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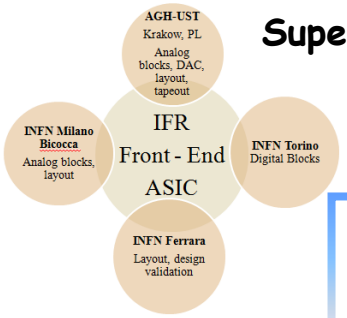
Response to the 1 photoelectron signal from a SensL 1mm sq, 50um pitch device

# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC

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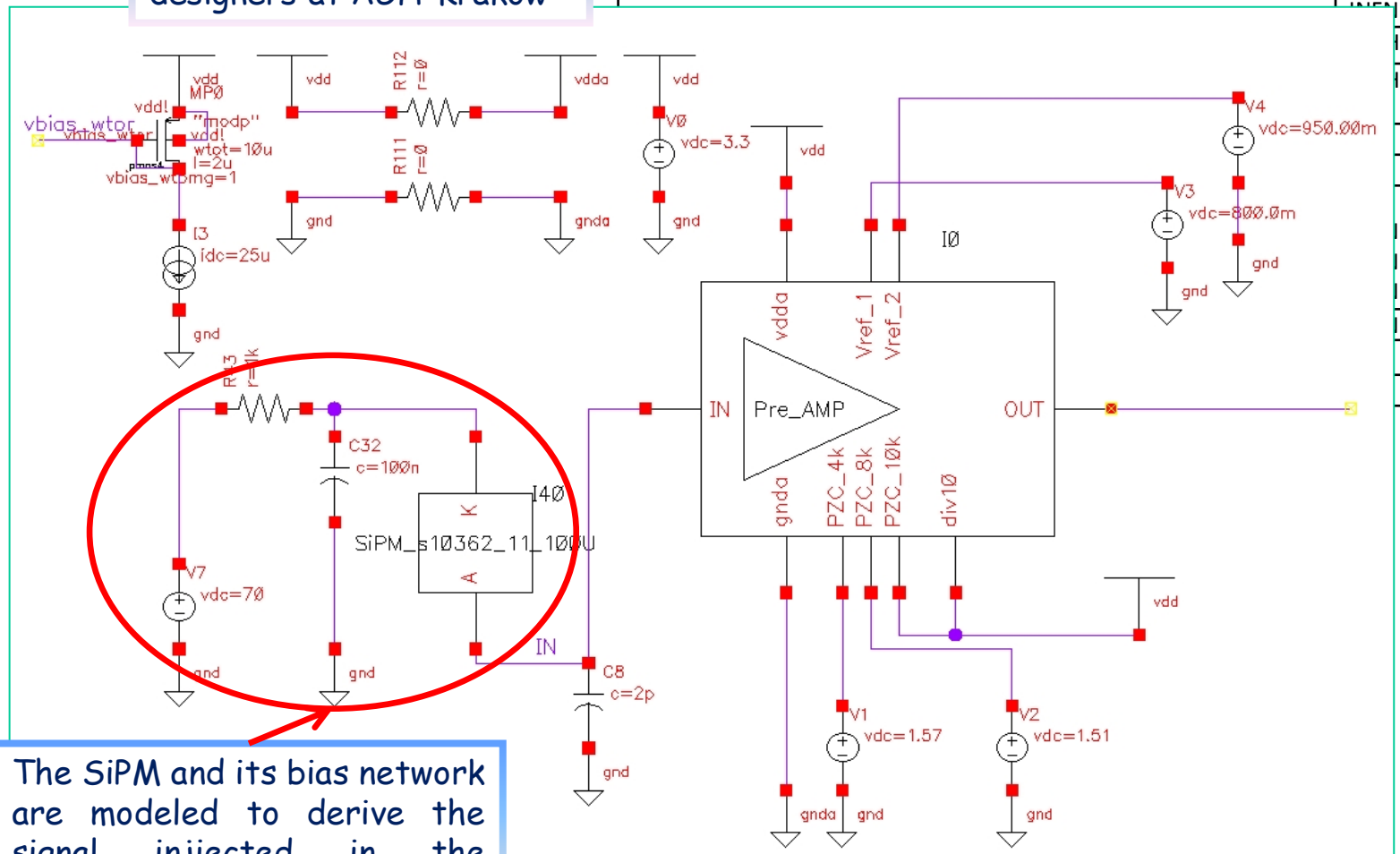
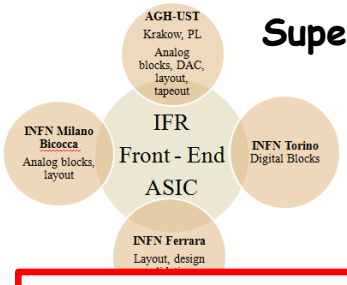
| | Simulation analysis of design | AGH Krakow, INFN Mi- B, INFN Fe |
| | | I Krakow |
| | | I Krakow |
| | | |
| | | |
| | | Krakow, I Mi-B, I To, I Fe |
| | | I To |
| | | |
| | | Krakow |

A different approach has been followed by the designers at AGH-Krakow




The SiPM and its bias network are modeled to derive the signal injected in the RAPSODI Pre-AMP

# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC

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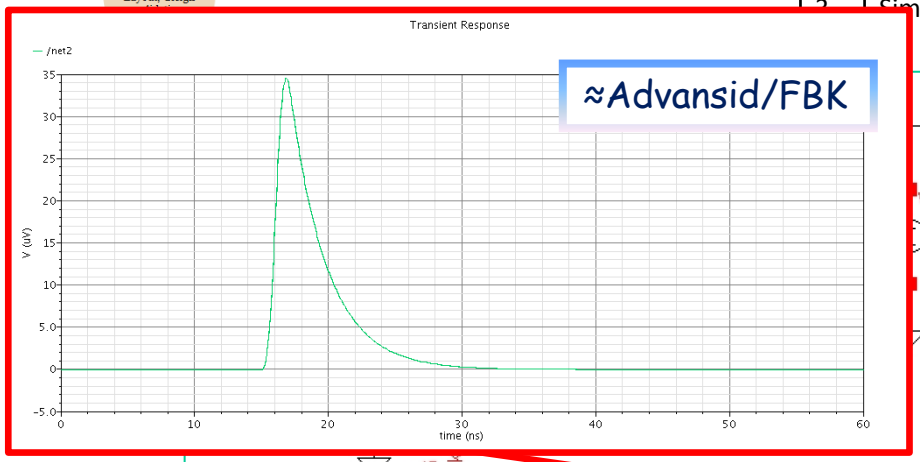
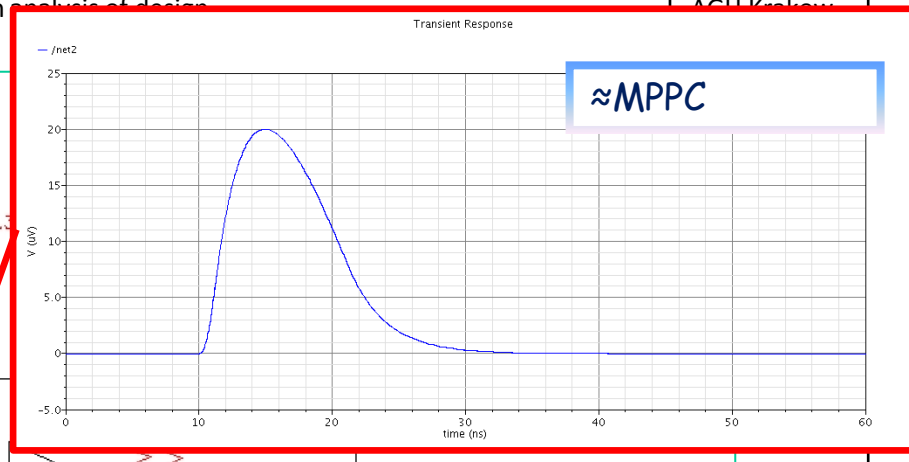
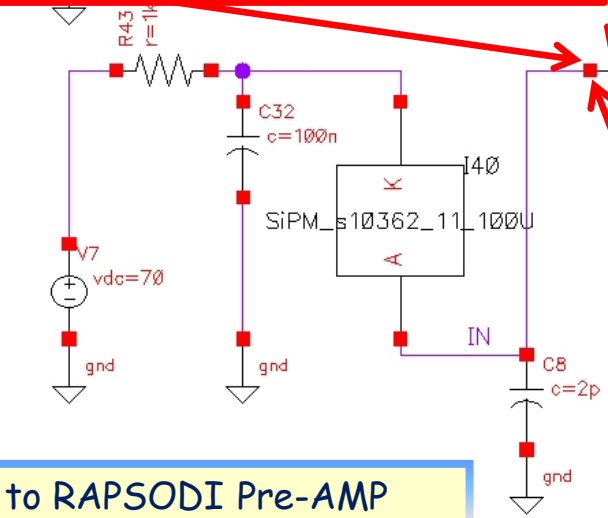


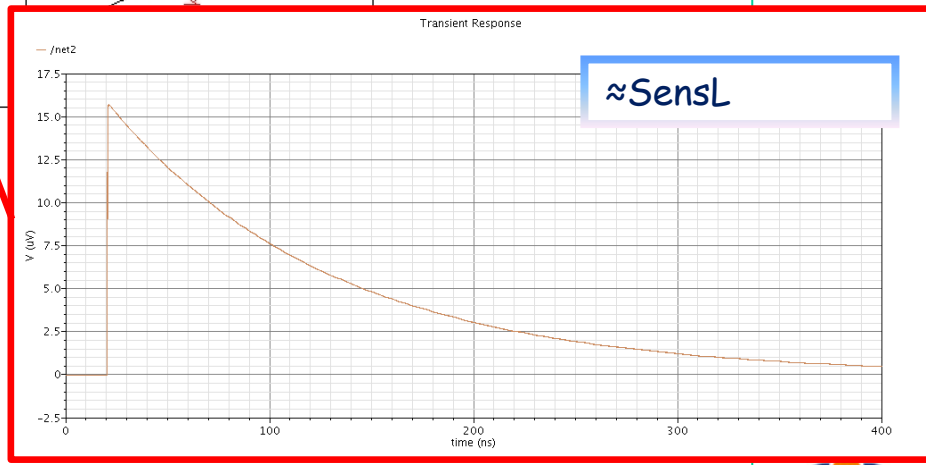

≈Advansid/FBK




≈MPPC



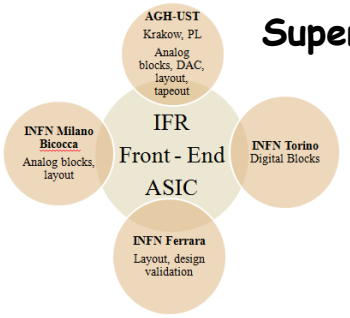

Krakow




≈SensL

Input signals to RAPSODI Pre-AMP

# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC

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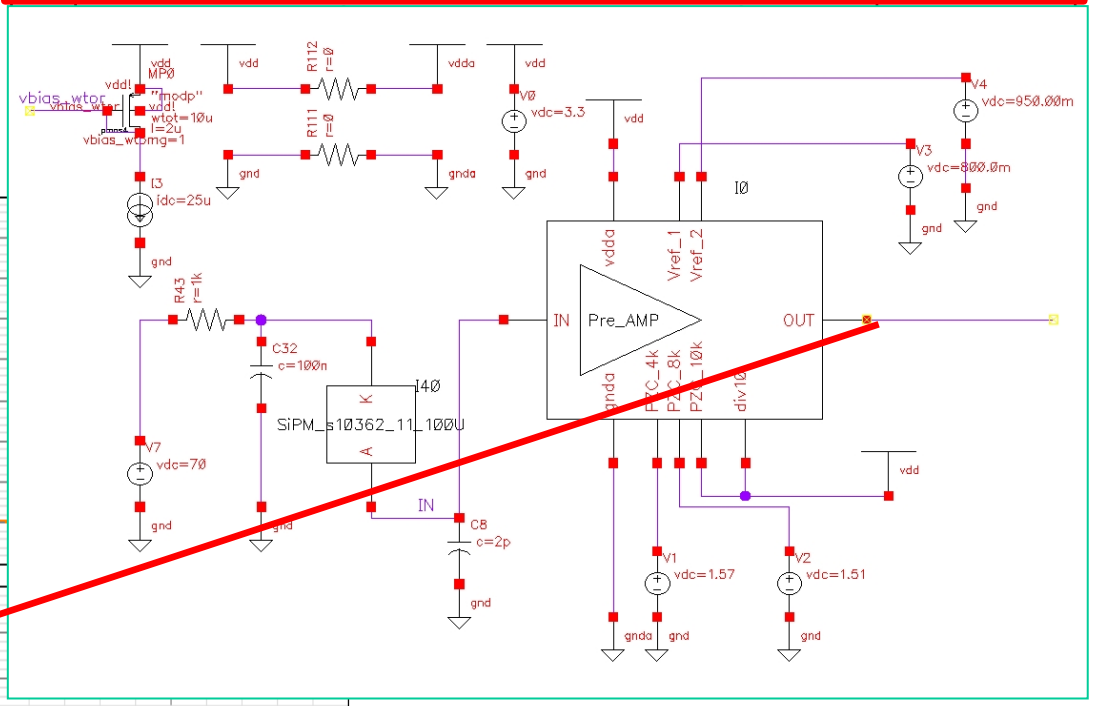
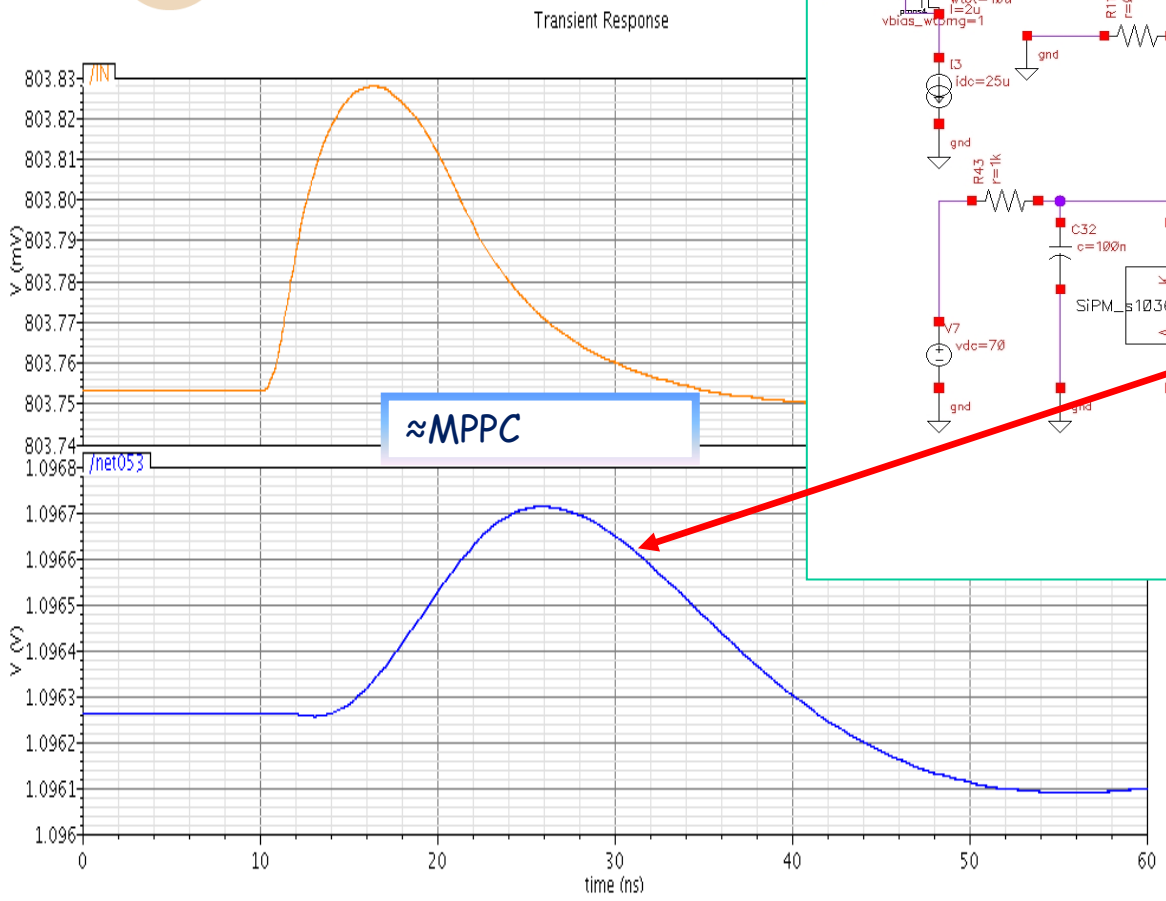
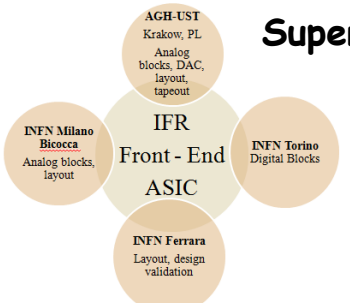



Output response of RAPSODI Pre-AMP to single p.e. signals

# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC




| LP | Tasks | Contractor |
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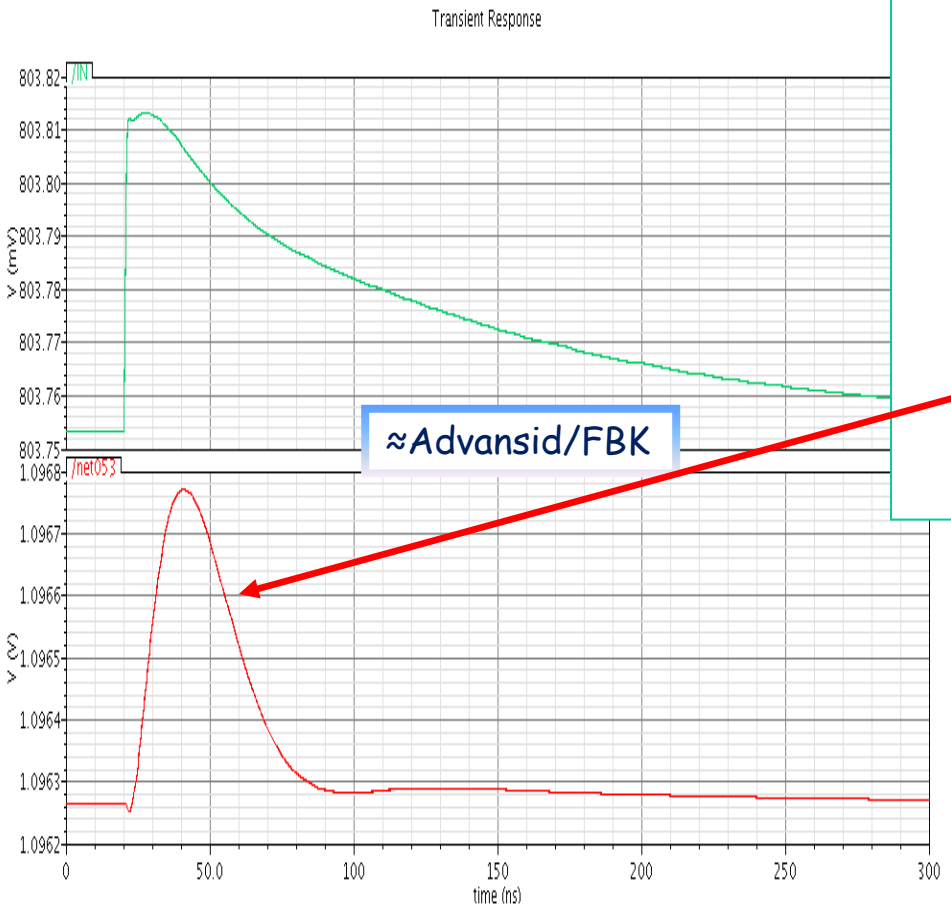
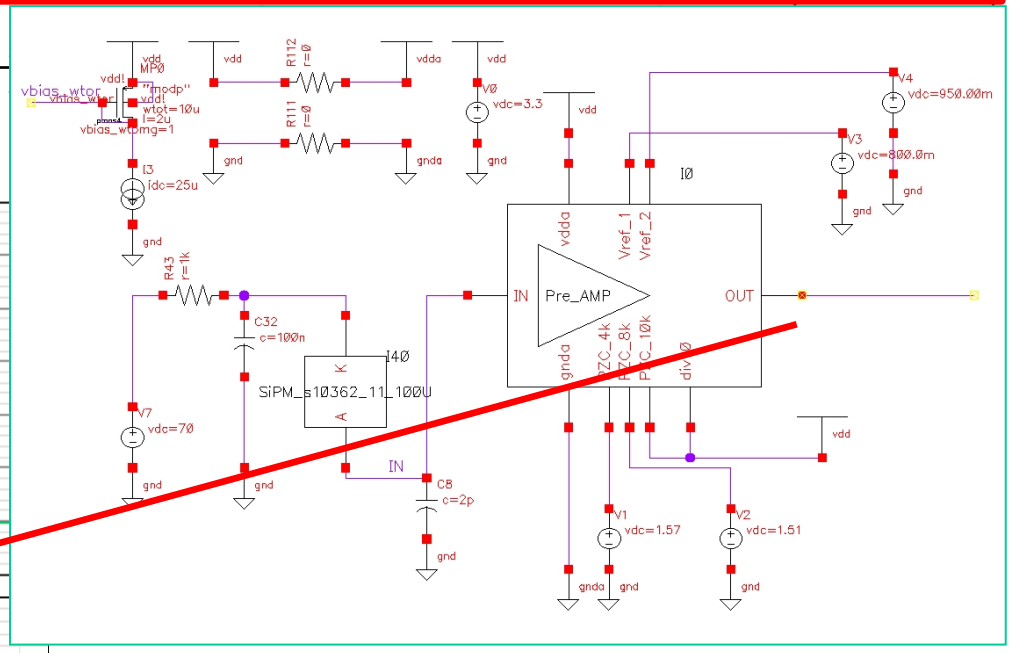



≈Advansid/FBK

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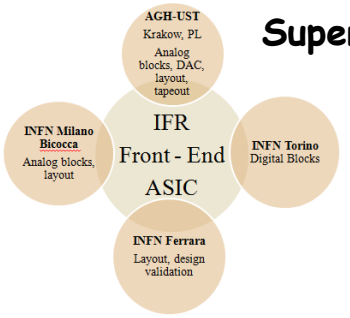
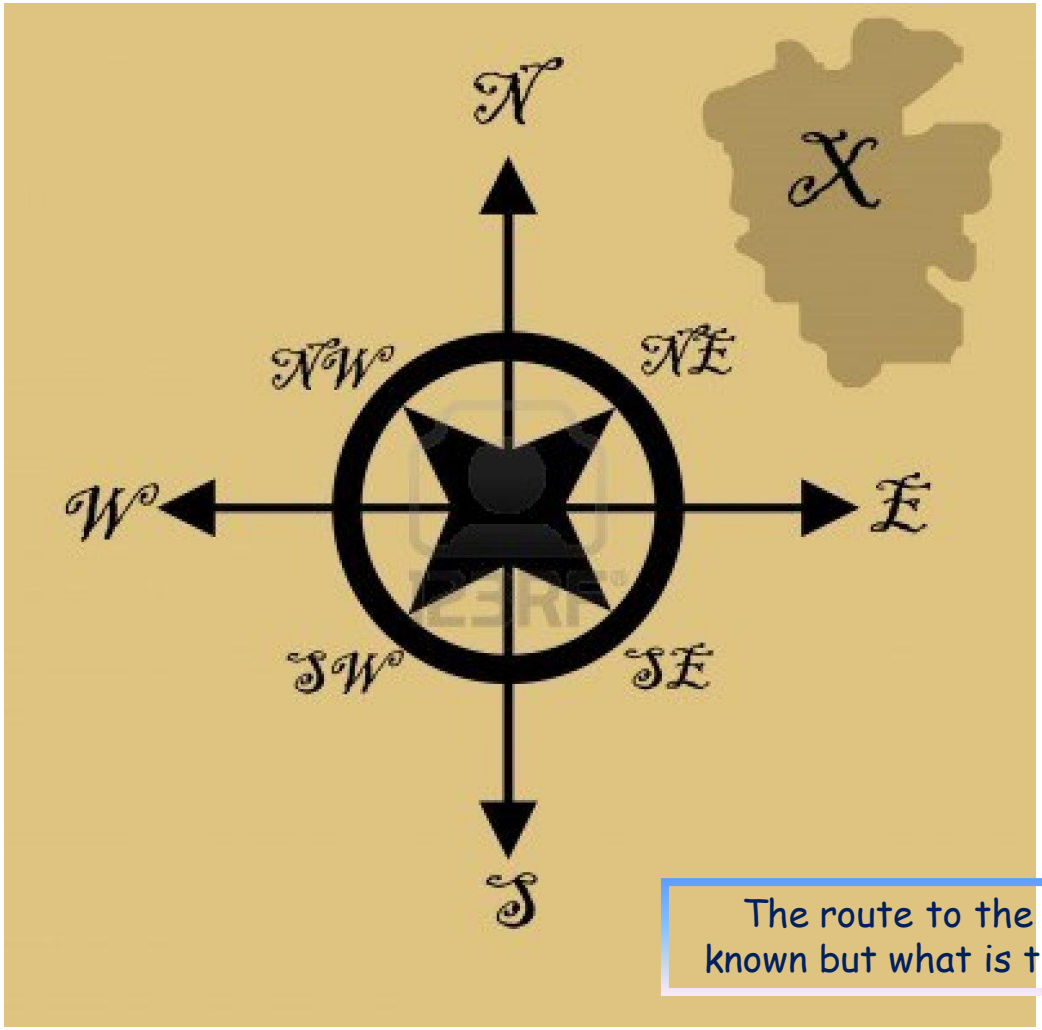



# SuperB IFR electronics: Preparatory work for the design of a prototype IFR frontend ASIC




The route to the next milestones is known but what is the final destination?