Laboratoire d'Annecy-le-Vieux
de Physique des Particules

Module Concept in the Alpine Layout
–
Necessary Materials and Infrastructure

With a focus on the spending profile 2015

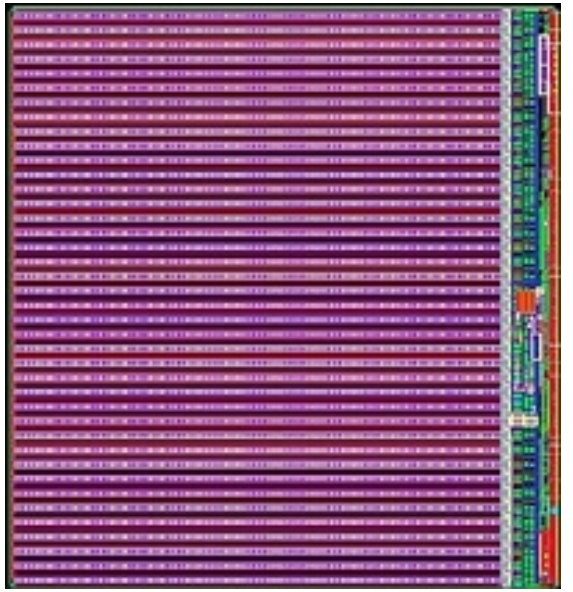
LAPP
28.4.2015

A. Rummler

UNIVERSITE CHAMBERY SAVOIE
cnrs IN2P3 Les deux infinis

FE Procurement 1/3

- 2 FE-I4B wafers through LPNHE from CMS surplus
  - Due to the very probable discontinuation of the process this was almost certainly the last FE-I4B production
    → All necessary FE-I4B have to be acquired now
  - For the foreseeable future all work will be done with FE-I4B as there is no schedule yet for a full production run of a hypothetical full sized FE-I5 (minimum 3 years ?)
  - General order to IZM for post processing has been issued (UBM, bump deposition, dicing) in December 2014
  - Latest information from Giovanni :
    - Wafers arrived at testing site, now to be characterized
    - Order to IZM has been issued



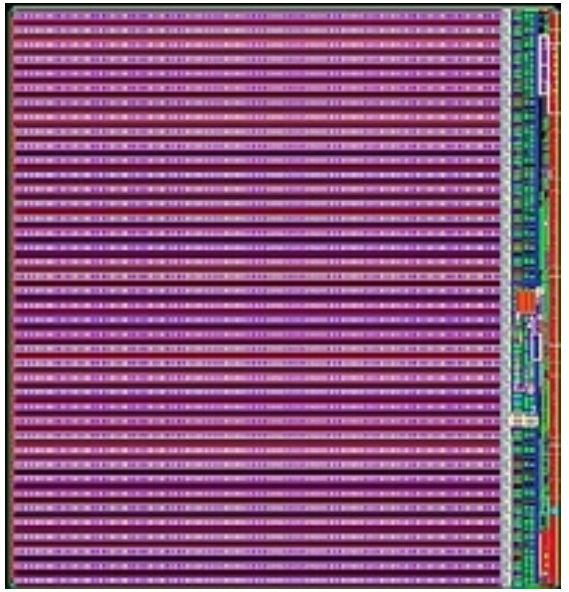
Frontend	9000€	14200€
Sum 2015	9000€	14200€

Frontend	0€	0€
Sum 2016	0€	0€

FE Procurement 2/3

- 2 FE-I4B wafers through LPNHE from CMS surplus
  - Have to decide which thickness is required in the end :
    - Unthinned (700 µm) → 0 € additional cost (5000$ wo VAT base price)
    - Thinning without a carrier wafer (450 µm) → 500 €
    - Thinning with a carrier wafer (150 µm) → 1200 € + 100 € / FE (laser realease)
  - Processing time ?
    Needs to be checked but probably not below 1.5 months :
    'Borrowed' FE-I4Bs for first production as an alternative → LPNHE will provide them
  - *60 chips per wafer*, assume a yield of 37 good chips
    (IBL is (61 ± 2) % green chips for 43 wafers, M. Backhaus, High bandwidth pixel detector modules for the ATLAS Insertable B-Layer, phd thesis)

    → 74 chips (56 required for full L2 stave + ?? test modules + ?? stavelets)

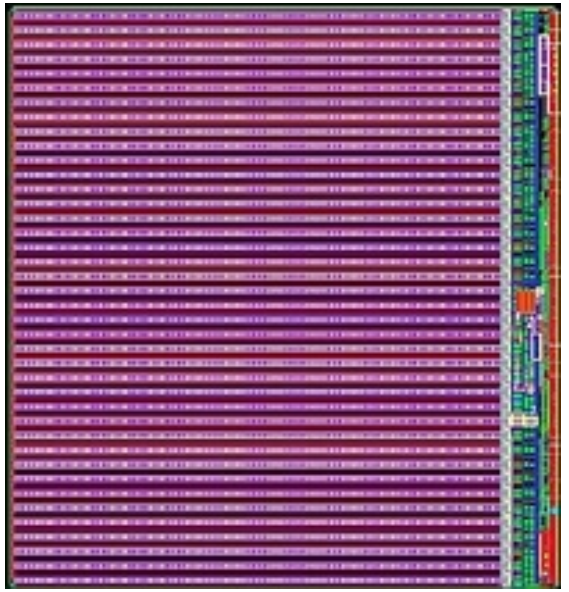


Frontend	9000€	14200€
Sum 2015	9000€	14200€

Frontend	0€	0€
Sum 2016	0€	0€

FE Procurement 3/3

- Alternatives to be considered :
  - Further wafers from CMS surplus (proposal by LPNHE, +2000€)?
  - Only process one wafer first ?
    - Schedule for module production pushed back → Schedule for full L2 prototype equally pushed back
    - Impact for cost → clarify with IZM
  - Thin wafers and save on laser release for first modules ?
- Spending 2015:
  - Pay for the two wafers: 4000€
  - Basic post processing: 5000€
  - Advanced thinning: 1200€
  - BCB participation: 3000€ – 4000€ ? (exact price to be clarified with LPNHE)



Frontend	9000€	14200€
Sum 2015	9000€	14200€

Frontend	0€	0€
Sum 2016	0€	0€

Sensor Procurement M4 1/2

- Sensors for plains modules : M4 (for full L2 stave : 7)
- Received 2 wafers from Liverpool (Cern Pixel IV production at Micron) :
  - Excellent Yield (10 sensors available)
  - No UBM yet / UBM for other wafers done at Advacam
    → have to check UBM mask situation
  - Minimum 1 month for UBM at IZM
    (or use Advacam...compatibility?) → checking with Liverpool
- Any other (upcoming) production ? Probably common wafer design by Anna Macchiolo ? → Probably on a future LPNHE production in late 2015

Frontend	9000€	14200€
M4 sensor	8000€	12000€
Sum 2015	17000€	26200€

Frontend	0€	0€
M4 sensor	0€	15000€
Sum 2016	0€	15000€

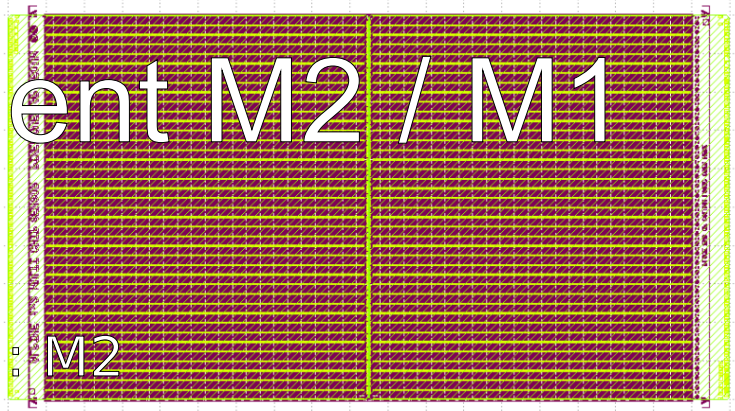
Sensor Procurement M4 2/2

- Spending 2015 (IZM scenario): (numbers are based on previous IZM quote, inter/extrapolation)
  - UBM Masks: 2000 € ?
  - UBM application: 3000 € ?
  - Assembly: 3000 € ? – 7000 € ? (depends on FE thickness)
- Spending 2016
  - New production (Potential cost sharing with LPNHE)?:
    - Unnecessary : 0 €
    - Only UBM and thick FE assembly : 6000 €
    - Only UBM and thin FE assembly : 10000 €
    - UBM masks, UBM and thin FE assembly : 12000 €
    - Participation in production costs, UBM masks, UBM and thin FE assembly,15000 €

Frontend	9000€	14200€
M4 sensor	8000€	12000€
Sum 2015	17000€	26200€

Frontend	0€	0€
M4 sensor	0€	15000€
Sum 2016	0€	15000€

Sensor Procurement M2 / M1 1/2

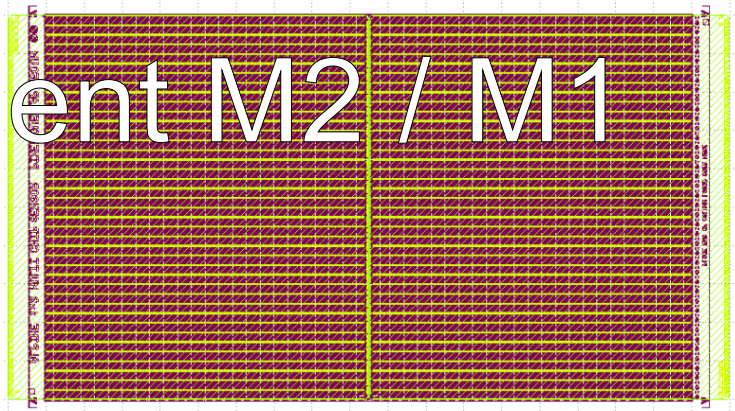


- Sensors for mountain modules (for full L2 stave : 13)
- Sensors for transition modules : M1 (for full L2 stave : 2)
- LPNHE production on 6'' n-in-p at FBK :
  - First production has finished
  - Testing is ongoing
  - UBM and dicing in February / March 2015
  - First production wo ganged pixels, keep handling wafer (thick) for test modules
  - Second production with ganged pixels, thin for L2 stave prototype → later this year at FBK

Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
Sum 2015	23200€	37400€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
Sum 2016	0€	15000€

Sensor Procurement M2 / M1 2/2



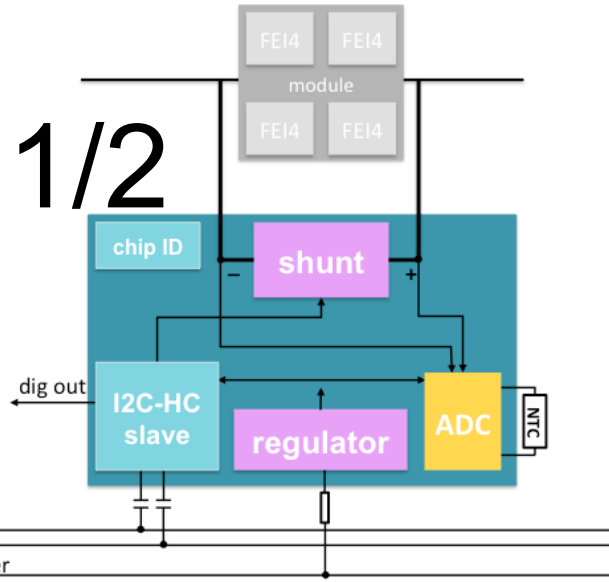
- CiS production on 6'' n-in-n (includes ganged pixels in the middle) at CiS → should be finished basically in the next days, do we want to process some ?
- Spending 2015:
  - If single chip sensor required : 1000 €
  - New production (Potential cost sharing with LPNHE, payment 2016)?:
    (numbers are based on previous IZM quote, inter/extrapolation, productions cost guessed : 3 wafers à 1000 €)
    - Only UBM and thin FE assembly :
      3000 € ? + 2200 € ? = 5200 € ?
    - UBM masks, UBM and thin FE assembly : 5200 € ? + 2000 € ? = 7200 € ?
    - Participation in production costs, UBM masks, UBM and thin FE assembly : 10200 € ??
  - X € CiS processing

Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
Sum 2015	23200€	37400€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
Sum 2016	0€	15000€

PSPP Procurement 1/2

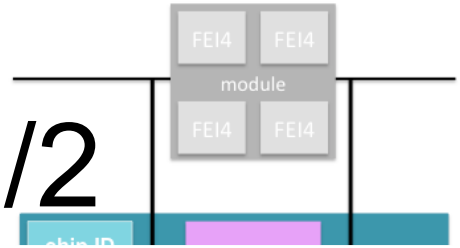
- One chip per module → 21 chips for L2 prototype (plus spares and testing)
- PSPPs from currently existing production : none
- 2. production run (was foreseen to start May/August 2015 → needs to discussed with Wuppertal), 160-320 CHF/chip
- 3. production run, only on our own probably together with another institute, unclear how long this technology still available



Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Sum 2015	28500€	46500€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Sum 2016	0€	15000€

PSPP Procurement 1/2



hallo Andre,

ich schreib direkt auf Englisch, falls du die email weiterleiten möchtest.

Some time ago you told us that you might be interested in some DCS chips. Is this still true? As we are going to submit the DCS chip in the beginning of May, we would like to know how many chips you would like to have for your tests at LAPP.
For these multi project wafers one has to think in the quantities of 40 chips. To give you a price estimate: we expect 7200 CHF for the submission itself, this includes one batch of 40 chips. Any further batch will cost the half (maybe less).

Please, let us know your wishes soon, as the submission is coming closer!

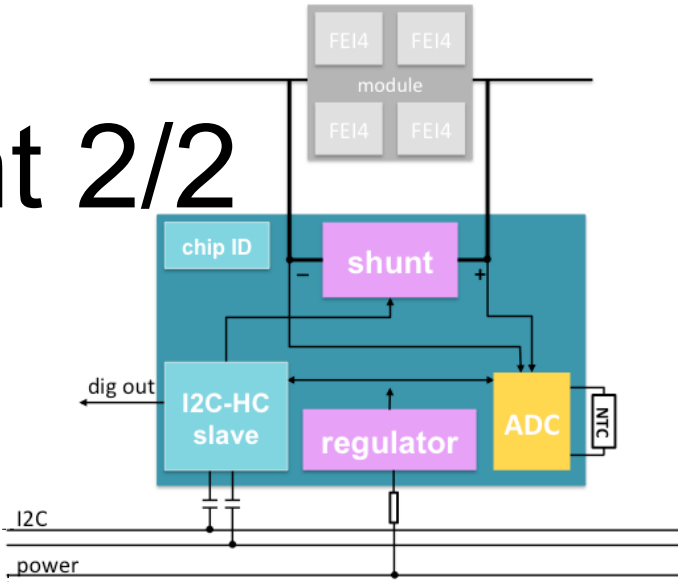
Best wishes, Susanne

Sum 2016	0€	15000€

PSPP Procurement 2/2

- Spending 2015:
  - Chips : 3800€ ? - 7600€ ? (assuming 25 chips, CHF ↔ EUR currency rate unclear, pricing not stable, Susanne Kersten rather sure it won't be more)
  - Packaging : (25*60€ ?) = 1500€ ? http://cmp.imag.fr/products/packaging/?p=prices

    otherwise additional costs for wirebonding COB
    depends on package type and pin number, average price, not significantly more per chip, might be cheaper in bulk / with different company



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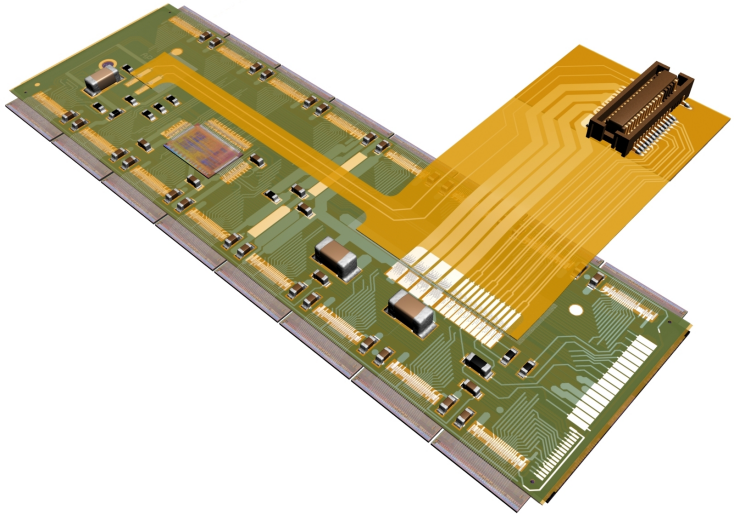
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Sum 2015	28500€	46500€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Sum 2016	0€	15000€

Module Flexes



- Double sided flex
- Specific requirements due to spatial restrictions:
  - Design is evolving
  - Tries to avoid necessity of a pig tail
  - Need to take care of loading capability particularly for transition modules
- Preliminary mechanical design has been defined
- Needs input from PSPP investigation :
  - Form factor : Packaged or COB
  - Schematic : Necessity of workarounds
- Spending 2015:
  - Module flexes: 5000€ ??
    (very rough estimate based on 2€/cm², depends on technology and how well the single flexes fit on one panel with a hefty safety factor included for a potential second iteration, probably less)

Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Mod. flexes	5000€	5000€
Sum 2015	33500€	51500€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Mod. flexes	0€	0€
Sum 2016	0€	15000€

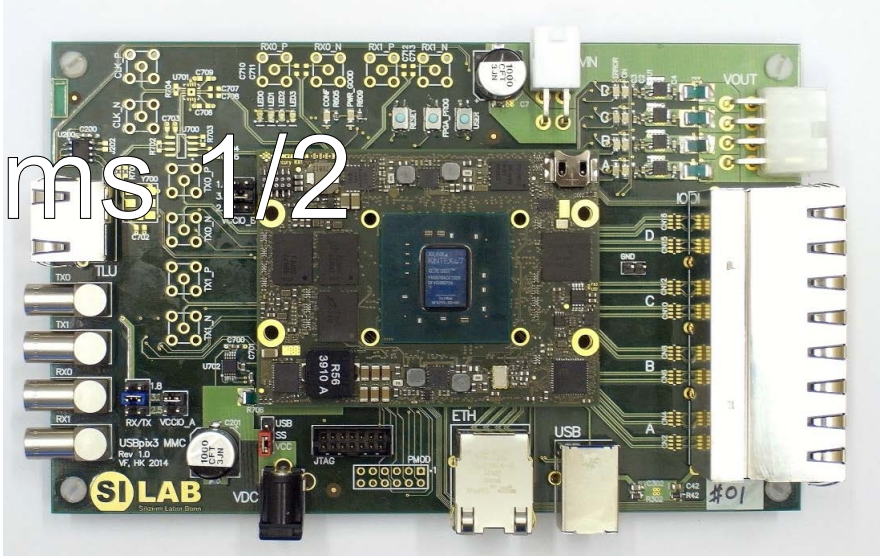
Module Construction

- Loading of flexes
- Tooling for the (manual) gluing of the flex on top the assembly
- Investigate automatization potential
- Wire bonding
- Spending (2015):
  - Tooling, Glue, Fridge etc.: 3000€ ???
  - Wirebonding: 5000€ ???
  - Mostly guess work, wire bonding needs offer, possibility to do it at CERN bonding lab ?

Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Mod. flexes	5000€	5000€
Mod. const.	8000€	8000€
Sum 2015	41500€	59500€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Mod. flexes	0€	0€
Mod. const.	0€	0€
Sum 2016	0€	15000€

Readout Systems 1/2

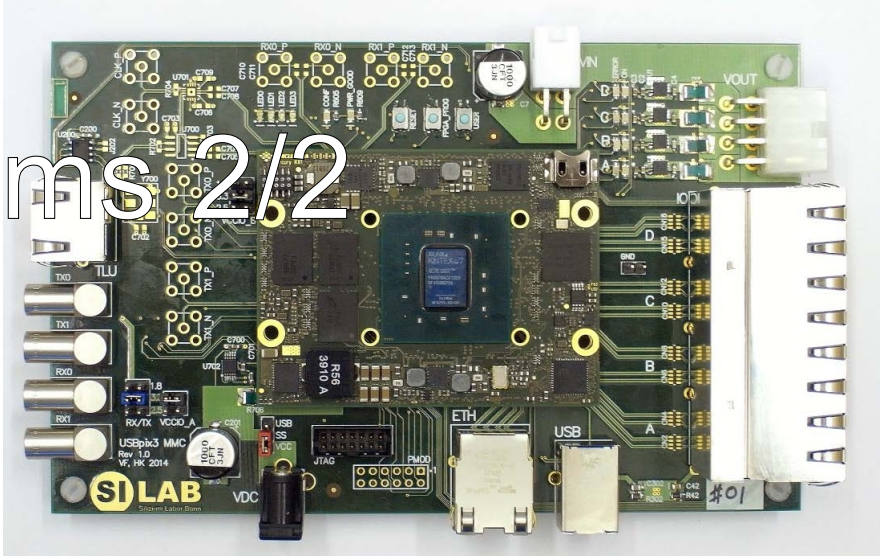


- USBpix3
  - Maximum 16 FEs (= 4 M4) with MMC3 (Instead of MIO3 with BIC)
  - Fabian : First delivered in March 2015 → obviously delayed, asked for new date, no answer yet

Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Mod. flexes	5000€	5000€
Mod. const.	8000€	8000€
Readout	3000€	3000€
Sum 2015	47900€	65900€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Mod. flexes	0€	0€
Mod. const.	0€	0€
Readout	5400€	10400€
Sum 2016	5400€	25400€

Readout Systems 2/2



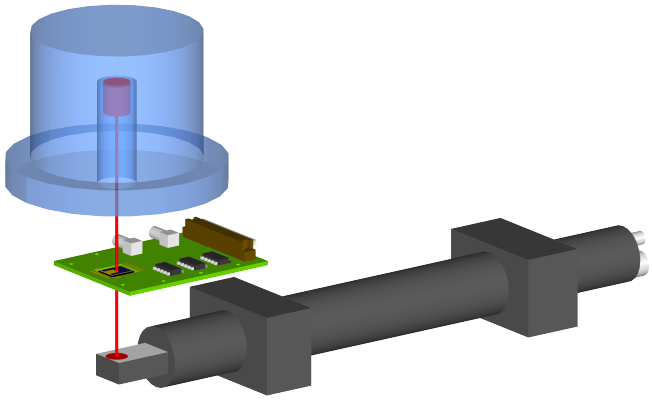
- Spending 2015:
  - 3 * USBpix3 (MMC3): 3000€ ??
    (no official numbers yet)
  - Adapter cards : 400 € ?
    (guess based on Sebastriens guess, two cards)
- Spending 2016
  - COB : 10000€ ?? with ATCA crate
    5000€ ?? wo ATCA crate
  - guess based on :
    - Small ATCA 5000€, found 3500€ for two slot model on indico.cern.ch/event/117795/contribution/3/material/slides/1.pdf
    - COB 3000€-4000€, DTM 700$, gueses in the discussion during the last ITK week by Su Dong, what is necessary is not yet completely clear, development ongoing
  - Adapter cards: 400 €

Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Mod. flexes	5000€	5000€
Mod. const.	8000€	8000€
Readout	6400€	6400€
Sum 2015	47900€	65900€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Mod. flexes	0€	0€
Mod. const.	0€	0€
Readout	5400€	10400€
Sum 2016	5400€	25400€

Module Testing

- Module test stand :
  - Design and production yet to be done
  - High voltage supply K487 and ISEG exists
  - Light tight box
  - Procurement of radioactive sources ^{90}Sr (later probably also ^{241}Am) ongoing
- Test beam @ CERN SPS
  - With existing PPS infrastructure
  - Needs specific frames for mounting
- Spending 2015:
  - Teststand: 1000€ ???
  - Source: 5000€ ???
  - Shot in the dark, source seems reasonable, heard about this magnitude a long time ago, test stand place holder for mechanical work, monitoring, check for HV supply



Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Mod. flexes	5000€	5000€
Mod. const.	8000€	8000€
Readout	6400€	6400€
Mod. test.	6000€	6000€
Sum 2015	53900€	74900€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Mod. flexes	0€	0€
Mod. const.	0€	0€
Readout	5400€	10400€
Mod. test.	0€	0€
Sum 2016	5400€	25400€

Stave Characterization

- Test stand similar to module test stand but larger
- HSIO-II / COB based readout
- Automatized source scan
- Monitoring for thermo electrical tests (e.g switching of modules)
- Test beam
- Spending 2015:
  - Test stand mechanics : 3000 € ???
  - Linear table : 3000 € ???
  - Humidity sensors : 2000 € ???
  - Computer : 500 € ?
  - Completely guessed as there is no design yet and we have not even fixed our requirements
  - Might be pushed partially into 2016, although it might be interesting to have the test stand already in 2015 for stavelet based work
- Spending 2016:
  - Stave test beam setup: 3000€ ???
  - Completely guessed as there is no design yet and we have not even fixed our requirements

Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Mod. flexes	5000€	5000€
Mod. const.	8000€	8000€
Readout	6400€	6400€
Mod. test.	6000€	6000€
Stave test.	8500€	8500€
Sum 2015	62400€	80400€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Mod. flexes	0€	0€
Mod. const.	0€	0€
Readout	5400€	10400€
Mod. test.	0€	0€
Stave test.	3000€	3000€
Sum 2016	8400€	28400€

Miscellaneous

- Tools, connectors, cables, tape, etc.
- Spending 2015:
  - Etc. : 500 € ???
  - placeholder
- Spending 2016:
  - Etc.: 500€ ???
  - placeholder

Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Mod. flexes	5000€	5000€
Mod. const.	8000€	8000€
Readout	6400€	6400€
Mod. test.	6000€	6000€
Stave test.	8500€	8500€
Miscellaneous	500€	500€
Sum 2015	62900€	80900€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Mod. flexes	0€	0€
Mod. const.	0€	0€
Readout	5400€	10400€
Mod. test.	0€	0€
Stave test.	3000€	3000€
Miscellaneous	500€	500€
Sum 2016	8900€	28900€

Summary

- Disclaimer :
  - Various wild guesses included
  - Currently unforeseen contingencies & unclear needs (e.g. optical inspection, etc.)
  - Spending might be shifted more to 2016 depending on time scales and required spending profile

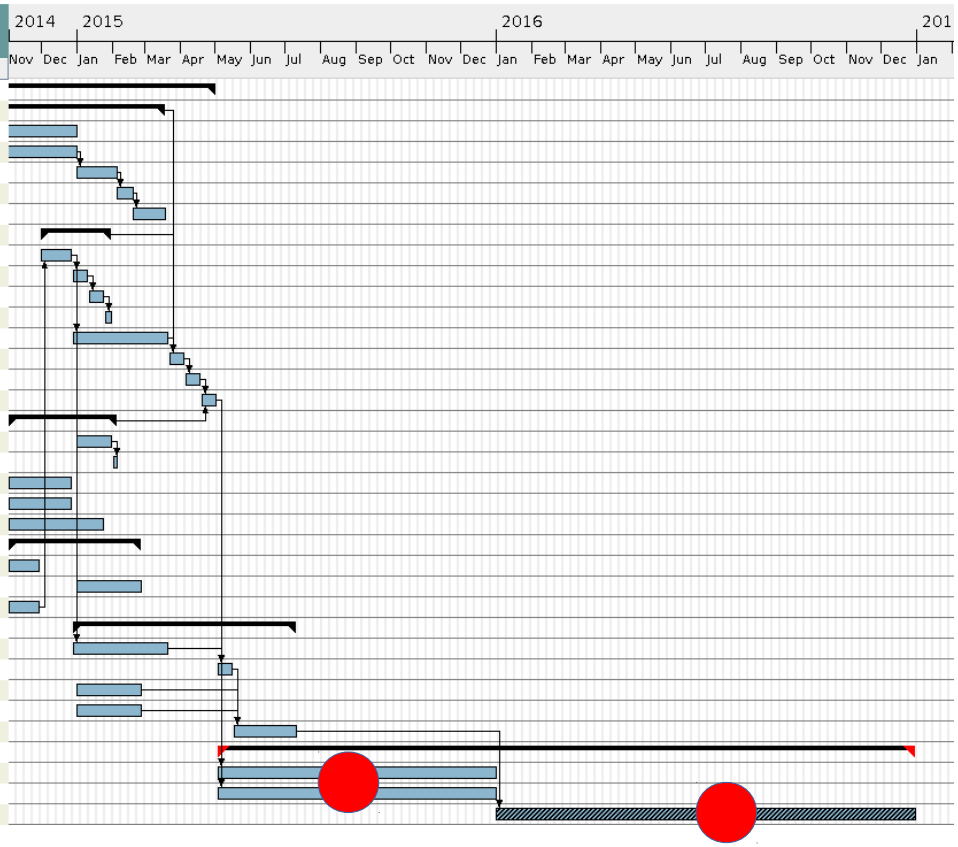
Frontend	9000€	14200€
M4 sensor	8000€	12000€
M2/M1 sensor	6200€	11200€
PSPP	5300€	9100€
Mod. flexes	5000€	5000€
Mod. const.	8000€	8000€
Readout	6400€	6400€
Mod. test.	6000€	6000€
Stave test.	8500€	8500€
Miscellaneous	500€	500€
Sum 2015	62900€	80900€

Frontend	0€	0€
M4 sensor	0€	15000€
M2/M1 sensor	0€	0€
PSPP	0€	0€
Mod. flexes	0€	0€
Mod. const.	0€	0€
Readout	5400€	10400€
Mod. test.	0€	0€
Stave test.	3000€	3000€
Miscellaneous	500€	500€
Sum 2016	8900€	28900€

Backup

Time Schedule

Name	Begin date	End date
Module production	01/07/14	01/05/15
Sensor procurement	01/07/14	18/03/15
Sensor production (CiS)	01/07/14	31/12/14
Sensor production (FBK)	01/07/14	31/12/14
UBM (IZM)	01/01/15	04/02/15
Dicing (IZM)	05/02/15	18/02/15
Characterization	19/02/15	18/03/15
Flex procurement	01/12/14	30/01/15
Flex design	01/12/14	26/12/14
Flex production	29/12/14	09/01/15
Flex loading	12/01/15	23/01/15
Flex testing	26/01/15	30/01/15
Flex glueing tooling	29/12/14	20/03/15
Glue flex on assembly	23/03/15	03/04/15
Wirebond FE and PSPP	06/04/15	17/04/15
Module testing	20/04/15	01/05/15
Module test stand preparation	03/11/14	04/02/15
Purchase USBpix system	01/01/15	30/01/15
Installation USBpix system	02/02/15	04/02/15
Design module test stand mechanics	03/11/14	26/12/14
PM/Scintillator	03/11/14	26/12/14
Radioactive source	03/11/14	23/01/15
PSPP	03/11/14	25/02/15
Test with minimum PSPP	03/11/14	28/11/14
Purchase all required PSPPs	01/01/15	25/02/15
Temperature workaround	03/11/14	28/11/14
Stave	29/12/14	10/07/15
Module loading tooling	29/12/14	20/03/15
Module loading	04/05/15	15/05/15
Purchase HSIO-II	01/01/15	25/02/15
Design stave test stand	01/01/15	25/02/15
Stave test	18/05/15	10/07/15
Test beam	04/05/15	30/12/16
Modules	04/05/15	31/12/15
Stavelet	04/05/15	31/12/15
Stave	01/01/16	30/12/16



- Modules go into beam in 2. half-year 2015
- Stave test beam in 2016
- Already horribly out-dated